PHILIPS

DATA
HANDBOOK

PHILIPS ELECTRONIC COMPONENTS AND MATERIALS

SEMICONDUCTORS AND INTEGRATED CIRCUITS

PART 2 OCTOBER 1970

Low frequency transistors

Low frequency power transistors

Deflection transistors

Accessories

SEMICONDUCTORS AND INTEGRATED CIRCUITS

Part 2 **October 1970**

DATA HANDBOOK SYSTEM

To provide you with a comprehensive source of information on electronic components, subassemblies and materials, our Data Handbook System is made up of three series of handbooks, each comprising several parts.
The three series, identified by the colours noted, are:

ELECTRON TUBES	(9 parts)	BLUE
SEMICONDUCTORS AND INTEGRATED CIRCUITS	(5 parts)	RED
COMPONENTS AND MATERIALS	(5 parts)	GREEN

The several parts contain all pertinent data available at the time of publication, and each is revised and reissued annually; the contents of each series are summarized on the following pages.
We have made every effort to ensure that each series is as accurate, comprehensive and up-to-date as possible, and we hope you will find it to be a valuable source of reference. Where ratings or specifications quoted differ from those published in the preceding edition they will be pointed out by arrows. You will understand that we can not guarantee that all products listed in any one edition of the handbook will remain available, or that their specifications will not be changed, before the next edition is published. If you need confirmation that the pusblished data about any of our products are the latest available, may we ask that you contact our representative. He is at your service and will be glad to answer your inquiries.

January 1970

ELECTRON TUBES (BLUE SERIES)

This series consists of the following parts, issued on the dates indicated.

Part 1 — **January 1970**

Transmitting tubes (Tetrodes, Pentodes)
Associated accessories

Part 2 — **February 1970**

Tubes for microwave equipment

Part 3 — **March 1970**

Special Quality tubes
Miscellaneous devices

Part 4 — **April 1970**

Receiving tubes

Part 5 — **May 1970**

Cathode-ray tubes
Photo tubes
Camera tubes
Photoconductive devices
Associated accessories

Part 6 — **June 1970**

Photomultiplier tubes
Scintillators
Photoscintillators
Radiation counter tubes
Semiconductor radiation detectors
Neutron generator tubes
Associated accessories

Part 7 — **July 1970**

Voltage stabilizing and reference tubes
Counter, selector, and indicator tubes
Trigger tubes
Switching diodes
Thyratrons
Ignitrons
Industrial rectifying tubes
High-voltage rectifying tubes

Part 8 — **August 1970**

T.V. Picture tubes

Part 9 — **December 1969**

Transmitting tubes (Triodes)
Tubes for R.F. heating (Triodes)
Associated accessories

SEMICONDUCTORS AND INTEGRATED CIRCUITS (RED SERIES)

This series consists of the following parts, issued on the dates indicated.

Part 1 Diodes and Thyristors — **September 1970**

General
Signal diodes
Tunnel diodes
Variable capacitance diodes
Voltage regulator diodes
Rectifier diodes
Thyristors, diacs, triacs
Rectifier stacks
Accessories
Heatsinks

Part 2 Low frequency; Deflection — **October 1970**

General
Low frequency transistors (low power)
Low frequency power transistors
Deflection transistors
Accessories

Part 3 High frequency; Switching — **November 1969**

General
High frequency transistors
Switching transistors
Accessories

Part 4 Special types — **December 1969**

General
Transmitting transistors
Field effect transistors
Dual transistors
Diodes and transistors for thick-and thin-film circuits
Photo devices
Accessories

Part 5 Integrated Circuits — **February 1970**

General
Digital integrated circuits
- FC family; standard temperature range
- FC family; extended temperature range
- FD family
- FJ family; standard temperature range

Linear integrated circuits

COMPONENTS AND MATERIALS (GREEN SERIES)

This series consists of the following parts, issued on the dates indicated.

Part 1 Circuit Blocks, Input/Output Devices **September 1970**

Circuit blocks 100kHz Series
Circuit blocks 1-Series
Circuit blocks 10-Series
Circuit blocks 20-Series
Circuit blocks 40-Series
Counter modules 50-Series
Norbits 60-Series, 61-Series
Circuit blocks 90-Series
Circuit blocks for ferrite core memory drive
Input/output devices

Part 2 Resistors, Capacitors **November 1969**

Fixed resistors
Variable resistors
Non-linear resistors
Ceramic capacitors
Polycarbonate, paper, mica, polystyrene capacitors
Electrolytic capacitors
Variable capacitors

Part 3 Radio, Audio, Television **January 1970**

FM tuners
Coils
Piezoelectric ceramic resonators and filters
Loudspeakers
Electronic organ assemblies
Television tuners
Components for black and white television
Components for colour television
Deflection assemblies for camera tubes
Audio and mains transformers

Part 4 Magnetic Materials, White Ceramics **March 1970**

Ferrites for radio, audio and television
Ferroxcube potcores and square cores
Microchokes
Ferroxcube transformer cores
Piezoxide
Permanent magnet materials

Part 5 Memory Products, Magnetic Heads, Quartz Crystals, Microwave Devices, Variable Transformers, Electro-mechanical Components **June 1970**

Ferrite memory cores
Matrix planes, matrix stacks
Complete memories
Magnetic heads
Quartz crystal units, crystal filters
Isolators, circulators
Variable mains transformers
Electro-mechanical components

General

Type designation
Rating systems
Letter symbols

PRO ELECTRON TYPE DESIGNATION CODE

FOR SEMICONDUCTOR DEVICES

This type designation code applies to discrete devices and to multiple devices [1)]

The type designation consists of:

TWO LETTERS FOLLOWED BY A SERIAL NUMBER

The first letter gives an indication of the material

A Material with a band gap of 0.6 to 1.0 eV, such as germanium

B Material with a band gap of 1.0 to 1.3 eV, such as silicon

C Material with a band gap of 1.3 eV and more, such as gallium arsenide

D Material with a band gap of less than 0.6 eV, such as indium antimonide

R Compound material as employed in Hall generators and photoconductive cells

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[1)] A multiple device is defined as a combination of similar or dissimilar active devices, contained in a common encapsulation that cannot be dismantled, and of which all electrodes of the individual devices are accessible from the outside.

Multiples of similar devices as well as multiples consisting of a main device and an auxiliary device are designated according to the code for discrete devices described above.
Multiples of dissimilar devices of other nature are designated by the second letter G.

The second letter indicates primarily the main application respectively main application and construction if a further differentiation is essential

A	Detection diode, switching diode, mixer diode
B	Variable capacitance diode
C	Transistor for a.f. applications ($R_{th\ j\text{-}mb} > 15\ ^{o}C/W$)
D	Power transistor for a.f. applications ($R_{th\ j\text{-}mb} \leq 15\ ^{o}C/W$)
E	Tunnel diode
F	Transistor for h.f. applications ($R_{th\ j\text{-}mb} > 15\ ^{o}C/W$)
G	Multiple of dissimilar devices (see note on page 1); Miscellaneous
H	Magnetic sensitive diode; Field probe
K	Hall generator in an open magnetic circuit, e.g. magnetogram or signal probe
L	Power transistor for h.f. applications ($R_{th\ j\text{-}mb} \leq 15\ ^{o}C/W$)
M	Hall generator in a closed electrically energised magnetic circuit, e.g. Hall modulator or multiplier
P	Radiation sensitive device [1)]
Q	Radiation generating device
R	Electrically triggered controlling and switching device having a break-down characteristic ($R_{th\ j\text{-}mb} > 15\ ^{o}C/W$)
S	Transistor for switching applications ($R_{th\ j\text{-}mb} > 15\ ^{o}C/W$)
T	Electrically, or by means of light, triggered controlling and switching power device having a breakdown characteristic ($R_{th\ j\text{-}mb} \leq 15\ ^{o}C/W$) [1)]
U	Power transistor for switching applications ($R_{th\ j\text{-}mb} \leq 15\ ^{o}C/W$)
X	Multiplier diode, e.g. varactor, step recovery diode
Y	Rectifying diode, booster diode, efficiency diode [1)]
Z	Voltage reference or voltage regulator diode [1)]

1) For the type designation of a range see page 4.

The serial number consists of:

Three figures for semiconductor devices designed primarily for use in domestic equipment

One letter and two figures for semiconductor devices designed primarily for use in professional equipment

VERSION LETTER

A version letter can be used, for instance, for a diode with up-rated voltage, for a sub-division of a transistor type in different gain ranges, a low noise version of an existing transistor and for a diode, transistor, or thyristor with minor mechanical differences, such as finish of the leads, length of the leads etc. The letters never have a fixed meaning, the only exception being the letter R.

EXAMPLES

AC187	Germanium low power a.f. transistor intended primarily for domestic equipment
BYX27	Silicon rectifying diode intended primarily for professional equipment

TYPE DESIGNATION FOR A RANGE OF SEMICONDUCTOR DEVICES

The type designation of a range of variants of:

a) voltage reference or voltage regulator diodes (second letter Z)

b) rectifying diodes (second letter Y)

c) thyristors (second letter T)

d) radiation detectors

distinctly belonging to one basic type may be qualified by a suffix part which is clearly separated from the basic part by a dash (-)
The basic part being the same for the whole range, is in accordance with the designation code for discrete devices.

The suffix part consists of:

a) for voltage reference or voltage regulator diodes

one letter followed by the typical zener voltage and where appropriate the letter R [1])
The first letter indicates the nominal tolerance of the zener voltage in %

A	1%
B	2%
C	5%
D	10%
E	15%

The typical zener voltage is related to the nominal current rating for the whole range. The letter V is used to denote the decimal point when this occurs.

b) for rectifying diodes

a number and where appropriate the letter R [1])
The number generally indicates the maximum repetitive peak reverse voltage
For controlled avalanche types it indicates the maximum crest working reverse voltage

c) for thyristors

a number and where appropriate the letter R [1])
The number generally indicates either the maximum repetitive peak reverse voltage or the maximum repetitive peak off-state voltage, whichever is lower
For controlled avalanche types it indicates the maximum crest working reverse voltage

[1]) The letter R indicates reverse polarity (anode to stud). The normal polarity (cathode to stud) and symmetrical executions are not specially indicated.

d) for radiation detectors

a figure giving the depth of the depletion layer in μm and where appropriate a version letter if there are differences in resolution.

EXAMPLES

BZY88series	Range of silicon voltage regulator diodes for professional equipment
BZY88-C9V1	The particular type out of the range with a typical zener voltage of 9.1 V ± 5%
BYX13-1200	The particular normal polarity type out of the BYX13series with a maximum repetitive peak reverse voltage of 1200 V
BTX64-200R	The particular reverse polarity type out of the BTX64 thyristor range of which the lower maximum repetitive peak voltage is 200 V

RATING SYSTEMS

ACCORDING TO I.E.C. PUBLICATION 134

1. DEFINITIONS OF TERMS USED

1.1 Electronic device. An electronic tube or valve, transistor or other semiconductor device.
Note: This definition excludes inductors, capacitors, resistors and similar components.

1.2 Characteristic. A characteristic is an inherent and measurable property of a device. Such a property may be electrical, mechanical, thermal, hydraulic, electro-magnetic, or nuclear, and can be expressed as a value for stated or recognized conditions. A characteristic may also be a set of related values, usually shown in graphical form.

1.3 Bogey electronic device. An electronic device whose characteristics have the published nominal values for the type. A bogey electronic device for any particular application can be obtained by considering only those characteristics which are directly related to the application.

1.4 Rating. A value which establishes either a limiting capability or a limiting condition for an electronic device. It is determined for specified values of environment and operation, and may be stated in any suitable terms.
Note: Limiting conditions may be either maxima or minima.

1.5 Rating system. The set of principles upon which ratings are established and which determine their interpretation.
Note: The rating system indicates the division of responsibility between the device manufacturer and the circuit designer, with the object of ensuring that the working conditions do not exceed the ratings.

2. ABSOLUTE MAXIMUM RATING SYSTEM

Absolute maximum ratings are limiting values of operating and environmental conditions applicable to any electronic device of a specified type as defined by its published data, which should not be exceeded under the worst probable conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking no responsibility for equipment variations, environmental variations, and the effects of changes in operating conditions due to variations in the characteristics of the device under consideration and of all other electronic devices in the equipment.

p.t.o.

The equipment manufacturer should design so that, initially and throughout life, no absolute maximum value for the intended service is exceeded with any device under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, equipment control adjustment, load variations, signal variation, environmental conditions, and variations in characteristics of the device under consideration and of all other electronic devices in the equipment.

3. DESIGN MAXIMUM RATING SYSTEM

Design maximum ratings are limiting values of operating and environmental conditions applicable to a bogey electronic device of a specified type as defined by its published data, and should not be exceeded under the worst probable conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device, taking responsibility for the effects of changes in operating conditions due to variations in the characteristics of the electronic device under consideration.

The equipment manufacturer should design so that, initially and throughout life, no design maximum value for the intended service is exceeded with a bogey device under the worst probable operating conditions with respect to supply voltage variation, equipment component variation, variation in characteristics of all other devices in the equipment, equipment control adjustment, load variation, signal variation and environmental conditions.

4. DESIGN CENTRE RATING SYSTEM

Design centre ratings are limiting values of operating and environmental conditions applicable to a bogey electronic device of a specified type as defined by its published data, and should not be exceeded under normal conditions.

These values are chosen by the device manufacturer to provide acceptable serviceability of the device in average applications, taking responsibility for normal changes in operating conditions due to rated supply voltage variation, equipment component variation, equipment control adjustment, load variation, signal variation, environmental conditions, and variations in the characteristics of all electronic devices.

The equipment manufacturer should design so that, initially, no design centre value for the intended service is exceeded with a bogey electronic device in equipment operating at the stated normal supply voltage.

NOTE

It is common use to apply the Absolute Maximum System in semiconductor published data.

LETTER SYMBOLS

LETTER SYMBOLS FOR SEMICONDUCTOR DEVICES
excluding rectifier diodes, thyristors and integrated circuits

This system is based on the Recommendations of the INTERNATIONAL ELECTROTECHNICAL COMMISSION as published in I.E.C. Publication 148.

QUANTITY SYMBOLS

1. Instantaneous values of current, voltage and power, which vary with time are represented by the appropriate lower case letter.

   Examples: i, v, p

2. Maximum (peak), average, d.c. and root-mean-square values are represented by the appropriate upper case letter.

   Examples: I, V, P

SUBSCRIPTS FOR QUANTITY SYMBOLS

1. Total values are indicated by upper case subscripts.

   Examples: I_C, I_{CM}, $I_{C(AV)}$, i_C, V_{EB}

2. Values of varying components are indicated by lower case subscripts.

   Examples: i_c, I_c, v_{eb}, V_{eb}

3. To distinguish between maximum (peak), average, d.c. and root-mean-square values, the following subscripts are added:

For maximum (peak) values	: M or m
For average values	: (AV) or (av) (only if it is necessary to distinguish between d.c. and average)
For d.c. values	: no additional subscript
For root-mean-square values	: (RMS) or (rms)

   Examples: I_C, I_{cm}, $I_{C(AV)}$, $I_{c(rms)}$, $I_{C(RMS)}$

4. List of subscripts (examples, see figure 1)

A, a	= Anode terminal
K, k	= Cathode terminal
E, e	= Emitter terminal
B, b	= Base terminal or Substrate for MOS devices
C, c	= Collector terminal
D, d	= Drain terminal
(BR)	= Break-down
X, x	= Specified circuit
M, m	= Maximum (peak) value
(AV), (av)	= Average value
(RMS), (rms)	= R.M.S. value
F, f	= Forward
G, g	= Gate terminal
R, r	= As first subscript: Reverse. As second subscript: Repetitive
O, o	= As third subscript: The terminal not mentioned is open circuited
S, s	= As first or second subscript: Source terminal (for FETS only) As second subscript: **Non-repetitive** (not for FETS) As third subscript : Short circuit between the terminal not mentioned and the reference terminal
Z, z	= Zener. (Replaces R to indicate the actual zener voltage, current or power of voltage reference or voltage regulator diodes)

5. Examples of the application of the rules:
Figure 1 represents a transistor collector current, consisting of a direct current and a signal, as a function of time.

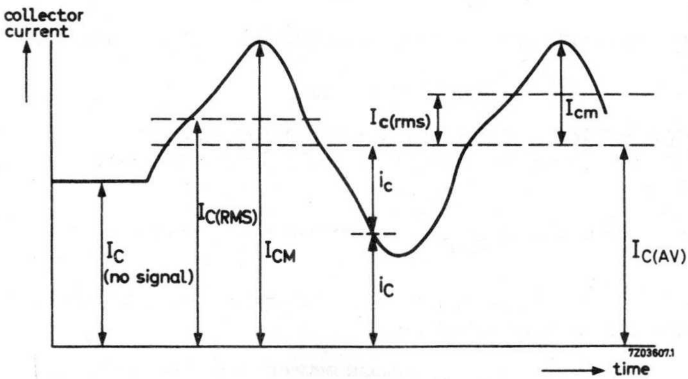


Fig.1

CONVENTIONS FOR SUBSCRIPT SEQUENCE

1. Currents

For transistors — the first subscript indicates the terminal carrying the current (conventional current flow from the external circuit into the terminal is positive)

For diodes — a forward current (conventional current flow into the anode terminal) is represented by the subscript F or f; a reverse current (conventional current flow out of the anode terminal) is represented by the subscript R or r.

2. Voltages

For transistors — normally, two subscripts are used to indicate the points between which the voltage is measured. The first subscript indicates one terminal point and the second the reference terminal.
Where there is no possibility of confusion, the second subscript may be omitted.

For diodes — a forward voltage (anode positive with respect to cathode) is represented by the subscript F or f and a reverse voltage (anode negative with respect to cathode) by the subscript R or r.

3. Supply voltages

Supply voltages may be indicated by repeating the terminal subscript.

Examples: V_{EE}, V_{CC}, V_{BB}

The reference terminal may then be indicated by a third subscript.

Examples: V_{EEB}, V_{CCB}, V_{BBC}

4. In devices having more than one terminal of the same type, the terminal subscripts are modified by adding a number following the subscript and on the same line.

Example: V_{B2-E} voltage between second base and emitter

In multiple unit devices, the terminal subscripts are modified by a number preceding the terminal subscripts:

Example: V_{1B-2B} voltage between the base of the first unit and that of the second one.

ELECTRICAL PARAMETER SYMBOLS

1. The values of four pole matrix parameters or other resistances, impedances admittances, etc... inherent in the device, are represented by the lower case symbol with the appropriate subscripts.

   Examples: h_{ib}, z_{fb}, y_{oc}, h_{FE}

2. The four pole matrix parameters of external circuits and of circuits in which the device forms only a part are represented by the upper case symbols with the appropriate subscripts.

   Examples: H_i, Z_o, H_F, Y_R

SUBSCRIPTS FOR PARAMETER SYMBOLS

1. The static values of parameters are indicated by upper case subscripts.

   Examples: h_{IB}, h_{FE}

Note The static value is the slope of the line from the origin to the operating point on the appropriate characteristic curve, i.e. the quotient of the appropriate electrical quantities at the operating point.

2. The small-signal values of parameters are indicated by lower case subscripts.

   Examples: h_{ib}, z_{ob}

3. The first subscript, in matrix notation identifies the element of the four pole matrix.

   i (for 11) = input
   o (for 22) = output
   f (for 21) = forward transfer
   r (for 12) = reverse transfer

   Examples:
   $$V_1 = h_i I_1 + h_r V_2$$
   $$I_2 = h_f I_1 + h_o V_2$$

Notes 1) The voltage and current symbols in matrix notation are indicated by a single digit subscript.
The subscript 1 = input; the subscript 2 = output

2) The voltages and currents in these equations may be complex quantities.

4. The second subscript identifies the circuit configuration.

e = common emitter
b = common base
c = common collector
j = common terminal, general

Examples: (common base)

$$I_1 = y_{ib} V_{1b} + y_{rb} V_{2b}$$
$$I_2 = y_{fb} V_{1b} + y_{ob} V_{2b}$$

When the common terminal is understood, the second subscript may be omitted.

5. If it is necessary to distinguish between real and imaginary parts of the four pole parameters, the following notations may be used.

$Re(h_{ib})$ etc.. for the real part

$Im(h_{ib})$ etc.. for the imaginary part

LIST OF LETTER SYMBOLS IN ALPHABETICAL ORDER

Letter symbol	Definition
B	Bandwidth
b_{ib}, b_{ie}, b_{is}, b_{fb}, b_{fe}, b_{fs}, b_{ob}, b_{oe}, b_{os}, b_{rb}, b_{re}, b_{rs}	See y parameters
C_c 1)	Collector capacitance (emitter open-circuited to a.c. and d.c.)
C_d 1)	Diode capacitance
C_e 1)	Emitter capacitance (collector open-circuited to a.c. and d.c.)
C_{ib}, C_{ie}, C_{is}, C_{fb}, C_{fe}, C_{fs}, C_{ob}, C_{oe}, C_{os}, C_{rb}, C_{re}, C_{rs}	See y parameters
d	Distortion
F	Noise figure
f	Frequency
f_{hfb}, f_{hfe}, f_{yfe}	Cut-off frequency (frequency at which the parameter indicated by the subscript is 0.7 of its low frequency value)
f_T	Transition frequency (Gain-bandwidth product)
g_{ie}, g_{ib}, g_{oe}, g_{ob}	See y parameters
G_p	Power gain
G_S	Source conductance
G_{tr}	Transducer gain
G_{UM}	Maximum unilateralised power gain
G_v	Voltage gain

1) As an exception to the general rule for electrical parameters capacitances are represented by the upper-case letter.

Letter symbol	Definition
h_{FB}, h_{FC}, h_{FE}	D.C. current gain (static value of the forward current transfer ratio; output voltage held constant)
h_{fb}, h_{fc}, h_{fe}	Small-signal current gain (small-signal value of the forward current transfer ratio; output short-circuited to a.c.)
h_{IB}, h_{IC}, h_{IE}	Static value of the input resistance (output voltage held constant)
h_{ib}, h_{ic}, h_{ie}	Small-signal value of the input impedance (output short-circuited to a.c.)
h_{OB}, h_{OC}, h_{OE}	Static value of the output conductance (input current held constant)
h_{ob}, h_{oc}, h_{oe}	Small-signal value of the output admittance (input open-circuited to a.c.)
h_{RB}, h_{RC}, h_{RE}	Static value of the reverse voltage transfer ratio (input current held constant)
h_{rb}, h_{rc}, h_{re}	Small-signal value of the reverse voltage transfer ratio (input open-circuited to a.c.)
I_B, I_C, I_D, I_E, I_G, I_S	Total d.c. (or average) current
I_b, I_c, I_d, I_e, I_g, I_s	Varying component of the current
i_B, i_C, i_D, i_E, i_G, i_S	Instantaneous total value of the current
i_b, i_c, i_d, i_e, i_g, i_s	Instantaneous value of the varying component of the current
$I_{B(AV)}$, $I_{C(AV)}$, $I_{E(AV)}$	Total average current (to distinguish between average and d.c. if necessary)
I_{BEX}, I_{CEX}	Total base, respectively collector current under specified conditions. These symbols are commonly used in case of a reverse biased emitter junction
I_{BM}, I_{CM}, I_{EM}	Maximum (peak) value of the total current
I_{bm}, I_{cm}, I_{em}	Maximum (peak) value of the varying component of the current
I_{CBO}	Collector cut-off current (open emitter)
I_{CEO}	Collector cut-off current (open base)
I_{CBS} or I_{CES}	Collector cut-off current (emitter short-circuited to base)

Letter symbol	Definition
I_{DSS}	Drain current (source short-circuited to gate)
I_{EBO}	Emitter cut-off current (open collector)
I_F	Total forward current of a diode (d.c. or average)
i_F	Instantaneous total value of the forward current of a diode
$I_{F(AV)}$	Total average forward current of a diode (to distinguish between average and d.c. if necessary)
I_{FM}	Peak forward current of a diode
I_{GSS}	Gate cut-off current (source short-circuited to drain)
I_i, I_o	Input, respectively output current of a specified circuit
I_R	Total reverse (cut-off) current of a diode
i_R	Instantaneous total value of the reverse current of a diode
I_{RRM}	Repetitive peak reverse current of a diode
I_{RSM}	Non-repetitive peak reverse current of a diode
I_{SDS}	Source cut-off current (drain short-circuited to gate)
I_Z	Zener current (d.c. or average)
I_{ZM}	Peak zener current
I_{ZS}	Non-repetitive zener current
P_i, P_o	Input, respectively output power of a specified circuit
P_{tot}	Total power dissipation in the device
P_Z	Zener power dissipation
P_{ZM}	Peak zener power dissipation
P_{ZSM}	Non-repetitive peak zener power dissipation
Q_s	Reverse recovery charge

Letter symbol	Definition
r_D	Diode (internal) series resistance
r_{DS}	Drain-source resistance
r_{GS}	Gate-source resistance
R_L	Load resistance
R_S	Source resistance
R_{th}	Thermal resistance
$R_{th\ j\text{-}a}$	Thermal resistance from junction to ambient
$R_{th\ j\text{-}mb}$	Thermal resistance from junction to mounting base
$R_{th\ j\text{-}c}$	Thermal resistance from junction to case
$R_{th\ mb\text{-}h}$	Thermal resistance from mounting base to heatsink (contact thermal resistance)
r_z	Dynamic-slope resistance of a zener diode
S_z	Temperature coefficient of the operating voltage of a zener diode
T_{amb}	Ambient temperature
T_{case}	Case temperature
t_d ; t_f	Delay time; fall time
t_{fr}	Forward recovery time of a diode
T_j	Junction temperature
t_{off}	Turn-off time ($t_{off} = t_s + t_f$)
t_{on}	Turn-on time ($t_{on} = t_d + t_r$)
t_r	Rise time
t_{rr}	Reverse recovery time of a diode
t_s	Storage time
T_{stg}	Storage temperature
V_{BB}, V_{CC}, V_{EE}	Supply voltage
V_{BE}, V_{CB}, V_{CE}, V_{EB}	Total value of the voltage (d.c. or average)
V_{be}, V_{cb}, V_{ce}, V_{eb}	Varying component of the voltage
v_{BE}, v_{CB}, v_{CE}, v_{EB}	Instantaneous value of the total voltage
v_{be}, v_{cb}, v_{ce}, v_{eb}	Instantaneous value of the varying component of the voltage

Letter symbols	Definition
V_{BEfl}	Base-emitter floating voltage (open base)
V_{BEsat}	Saturation voltage at specified bottoming conditions
$V_{(BR)}$	Breakdown voltage
$V_{(BR)CBO}$, $V_{(BR)CEO}$, $V_{(BR)EBO}$	Breakdown voltage between the terminal indicated by the first subscript and the reference terminal (second subscript) when the third terminal is open circuited
$V_{(BR)CER}$	Collector-emitter breakdown voltage with a specified resistance between emitter and base
$V_{(BR)CES}$	Collector-emitter breakdown voltage with the emitter short circuited to the base
V_{CBO}, V_{CEO}, V_{DGO}, V_{EBO}, V_{GSO}	Voltage of the terminal indicated by the first subscript w.r.t. the reference terminal (second subscript) with the third terminal open circuited
V_{CBOM}, V_{CEOM}	Peak value of V_{CBO}, V_{CEO}
V_{CEK}	Knee voltage at specified conditions
V_{CER}	Collector-emitter voltage with a specified resistance between emitter and base
V_{CERM}	Peak value of V_{CER}
V_{CES}	Collector-emitter voltage with the emitter short circuited to the base
V_{CEsat}	Saturation voltage at specified bottoming conditions
$V_{CE.sust}$	Collector-emitter sustaining voltage under the condition, indicated by the third subscript
V_{CEX}	Collector-emitter voltage in a specified circuit. This symbol is commonly used to indicate a reverse biased emitter junction
V_{DSS}	Drain-source voltage with the source short-circuited to the gate
V_{EBfl}	Emitter-base floating voltage (open emitter)
V_F	Continuous forward voltage of a diode
V_{FM}	Peak forward voltage of a diode

Letter symbol	Definition	
V_i, V_o	Input, respectively output voltage of a specified circuit	
$V_{(P)GS}$	Gate-source cut-off voltage	
V_R	Continuous reverse voltage of a diode	
V_{RM}	Peak reverse voltage of a diode	
V_{RSM}	Non-repetitive peak reverse voltage of a diode	
V_Z	Operating voltage (zener voltage) of a zener diode	
y_{ib}, y_{ie}, y_{is}	Input admittance	Output short circuited to a.c.
b_{ib}, b_{ie}, b_{is}		Output short circuited to a.c.
g_{ib}, g_{ie}, g_{is}	Input conductance	Output short circuited to a.c.
C_{ib}, C_{ie}, C_{is}	Input capacitance	Output short circuited to a.c.
φ_{ib}, φ_{ie}, φ_{is}	Phase angle of input admittance	Output short circuited to a.c.
y_{fb}, y_{fe}, y_{fs}	Transfer admittance	Output short circuited to a.c.
b_{fb}, b_{fe}, b_{fs}		Output short circuited to a.c.
g_{fb}, g_{fe}, g_{fs}	Transfer conductance	Output short circuited to a.c.
C_{fb}, C_{fe}, C_{fs}	Transfer capacitance	Output short circuited to a.c.
φ_{fb}, φ_{fe}, φ_{fs}	Phase angle of transfer admittance	Output short circuited to a.c.
y_{ob}, y_{oe}, y_{os}	Output admittance	Input short circuited to a.c.
b_{ob}, b_{oe}, b_{os}		Input short circuited to a.c.
g_{ob}, g_{oe}, g_{os}	Output conductance	Input short circuited to a.c.
C_{ob}, C_{oe}, C_{os}	Output capacitance	Input short circuited to a.c.
φ_{ob}, φ_{oe}, φ_{os}	Phase angle of output admittance	Input short circuited to a.c.
y_{rb}, y_{re}, y_{rs}	Feedback admittance	Input short circuited to a.c.
b_{rb}, b_{re}, b_{rs}		Input short circuited to a.c.
g_{rb}, g_{re}, g_{rs}	Feedback conductance	Input short circuited to a.c.
C_{rb}, C_{re}, C_{rs}	Feedback capacitance	Input short circuited to a.c.
φ_{rb}, φ_{re}, φ_{rs}	Phase angle of feedback admittance	Input short circuited to a.c.
Z_{th}	Transient thermal impedance	

LETTER SYMBOLS
FOR RECTIFIER DIODES AND THYRISTORS

This system is based on the Recommendations of the INTERNATIONAL ELECTROTECHNICAL COMMISSION.

QUANTITY SYMBOLS

1. Instantaneous values of current, voltage and power, which vary with time are represented by the appropriate lower case letter.

   Examples: i, v, p

2. Maximum (peak or crest), average, d. c. and root-mean-square values are represented by the appropriate upper case letter.

   Examples: I, V, P

SUBSCRIPTS FOR QUANTITY SYMBOLS

1. Total values are indicated by upper case subscripts.
2. Values of varying components are indicated by lower case subscripts.
3. For power rectifier diodes and thyristors the **terminals** are not indicated in the subscripts, except for the gate-terminal of thyristors.
4. List of subscripts:

G, g	=	Gate terminal
F, f	=	Forward [1])
D, d	=	Forward off-state [1]); non trigger (gate voltage or current)
T, t	=	Forward on-state [1]); trigger (gate voltage or current)
R, r	=	As first subscript; Reverse As second subscript: Repetitive
(AV), (av)	=	Average value
M, m	=	Maximum (peak or crest) value
(RMS), (rms)	=	R.M.S. value
(BR)	=	Breakdown
(BO)	=	Breakover
H	=	Holding
L	=	Latching
Q, q	=	Turn-off
S, s	=	As a second subscript: Non-repetitive
W	=	Working

[1]) For the anode-cathode voltage of thyristors F is replaced either by D or by T, to distinguish between "off-state" (non triggered) and "on-state" (triggered).

Low frequency transistors

GERMANIUM P-N-P TRANSISTOR

Low noise germanium transistor in all glass envelope for use as input stage of tape recorders with a speed of up to 19 cm/s.

RATINGS (Limiting values)

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	15	V
Collector-emitter voltage with R_{BE} < 1.5 kΩ	$-V_{CER}$	max.	15	V
Collector current (peak value)	$-I_{CM}$	max.	10	mA
Total dissipation up to T_{amb} = 25 °C	P_{tot}	max.	80	mW
Junction temperature	T_j	max.	75	°C

CHARACTERISTICS T_j = 25 °C

Small signal current gain

$-I_C$ = 0.3 mA; $-V_{CE}$ = 5 V	h_{fe}	typ. 60 35 to 160		

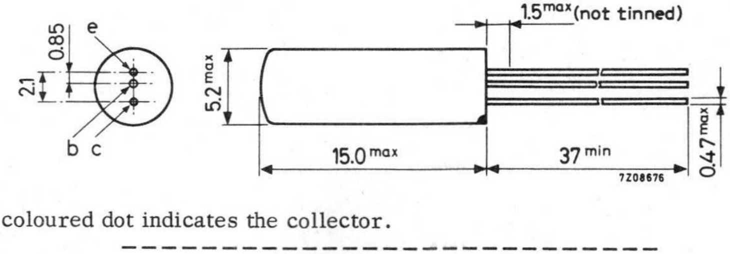
Cut-off frequency

I_E = 0.3 mA; $-V_{CB}$ = 5 V	f_{hfb}	>	2	MHz

Noise figure at f = 30 Hz to 15 kHz

I_E = 0.3 mA; $-V_{CB}$ = 5 V; R_S = 1.5 kΩ	F	<	5	dB

MECHANICAL DATA Dimensions in mm



The coloured dot indicates the collector.

FOR NEW DESIGN THE SUCCESSOR
TYPES BC179 AND BC159 ARE RECOMMENDED

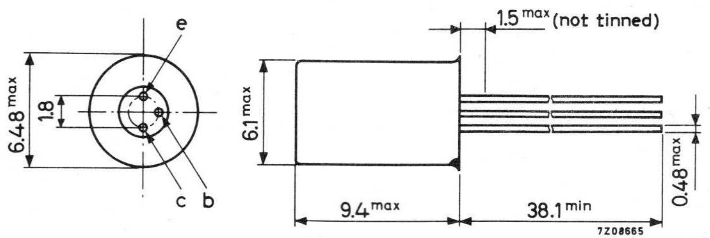
GERMANIUM ALLOY TRANSISTOR

P-N-P transistor in a TO-1 metal envelope intended for use in pre-amplifier or driver stages.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	12	V
Collector current (d.c.)	$-I_C$	max.	100	mA
Total power dissipation up to T_{amb} = 45 °C with cooling fin No. 56227 on a heatsink of at least 12.5 cm^2	P_{tot}	max.	500	mW
Junction temperature	T_j	max.	90	°C
D.C. current gain at T_{amb} = 25 °C				
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{FE}	>	50	
		typ.	100	
Small signal current gain at T_{amb} = 25 °C				
I_E = 2 mA; $-V_{CB}$ = 5 V; f = 1 kHz	h_{fe}	typ.	125	
			80 to 170	
Transition frequency				
$-I_C$ = 10 mA; $-V_{CE}$ = 2 V	f_T	typ.	1.7	MHz

MECHANICAL DATA Dimensions in mm

TO-1



The coloured dot indicates the collector

Accessories available: 56200, 56208, 56209, 56210, 56226, 56227

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	12	V
Collector-emitter voltage with $R_{BE} < 1\ k\Omega$	$-V_{CER}$	max.	32	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	10	V

Currents

Collector current (d.c.)	$-I_C$	max.	100	mA
Emitter current (peak value)	I_{EM}	max.	200	mA

Power dissipation

Total power dissipation up to T_{amb} = 45 °C with cooling fin No. 56227 mounted on a heatsink of at least 12.5 cm^2	P_{tot}	max.	500	mW

Temperatures

Storage temperature	T_{stg}		-55 to +90	°C
Junction temperature	T_j	max.	90	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.3	°C/mW
From junction to ambient with cooling fin No. 56227 mounted on a heatsink of at least 12.5 cm^2	$R_{th\ j\text{-}a}$	=	0.09	°C/mW

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

CHARACTERISTICS T_{amb} = 25 °C unless otherwise specified

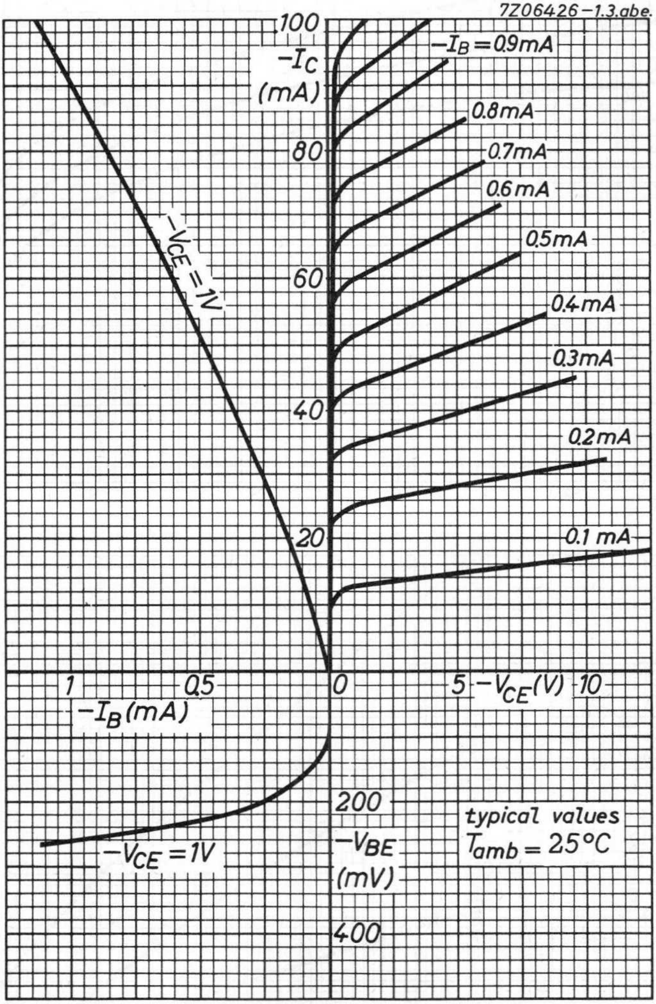
Collector cut-off current				
$I_E = 0$; $-V_{CB} = 10$ V	$-I_{CBO}$	<	10	μA
$I_E = 0$; $-V_{CB} = 32$ V; $T_j = 75$ °C	$-I_{CBO}$	<	800	μA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 5$ V; $T_j = 75$ °C	$-I_{EBO}$	<	550	μA
Emitter-base voltage				
$I_E = 2$ mA; $-V_{CB} = 5$ V	V_{EB}	typ.	105	mV
$I_E = 100$ mA; $V_{CB} = 0$	V_{EB}	<	400	mV
D.C. current gain				
$-I_C = 2$ mA; $-V_{CE} = 5$ V	h_{FE}	>	50	
		typ.	100	
$-I_C = 50$ mA; $V_{CB} = 0$	h_{FE}	typ.	95	
$-I_C = 100$ mA; $V_{CB} = 0$	h_{FE}	typ.	80	
Collector capacitance at f = 0.45 MHz				
$I_E = I_e = 0$; $-V_{CB} = 5$ V	C_c	typ.	40	pF
		<	50	pF
Feedback impedance at f = 0.45 MHz				
$-I_C = 1$ mA; $-V_{CE} = 5$ V	$\|z_{rb}\|$	typ.	90	Ω
Transition frequency				
$-I_C = 10$ mA; $-V_{CE} = 2$ V	f_T	>	1.3	MHz
		typ.	1.7	MHz
Cut-off frequency				
$-I_C = 10$ mA; $-V_{CE} = 2$ V	f_{hfe}	>	10	kHz
		typ.	17	kHz
Noise figure at f = 1 kHz				
$-I_C = 0.5$ mA; $-V_{CE} = 5$ V; $R_S = 500$ Ω Bandwidth = 200 Hz	F	typ.	4	dB
		<	10	dB

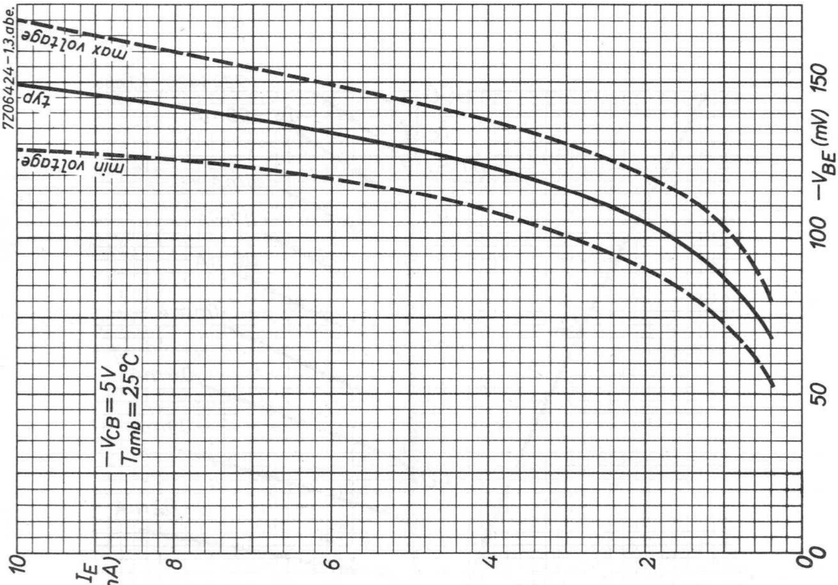
CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

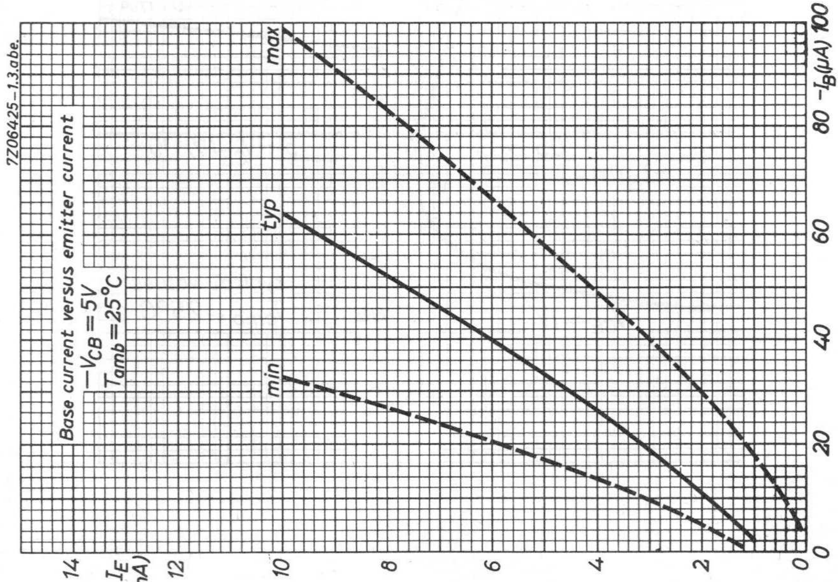
h parameters at f = 1 kHz

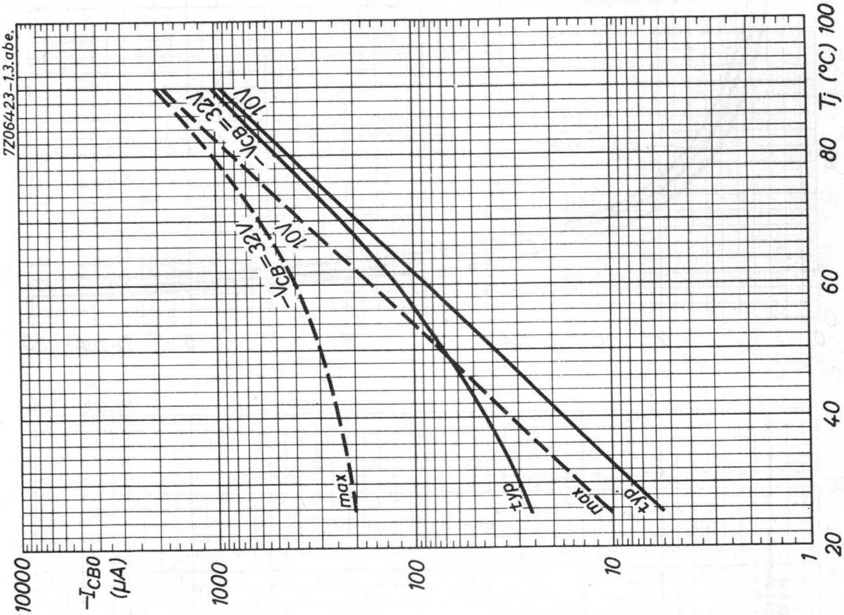
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V

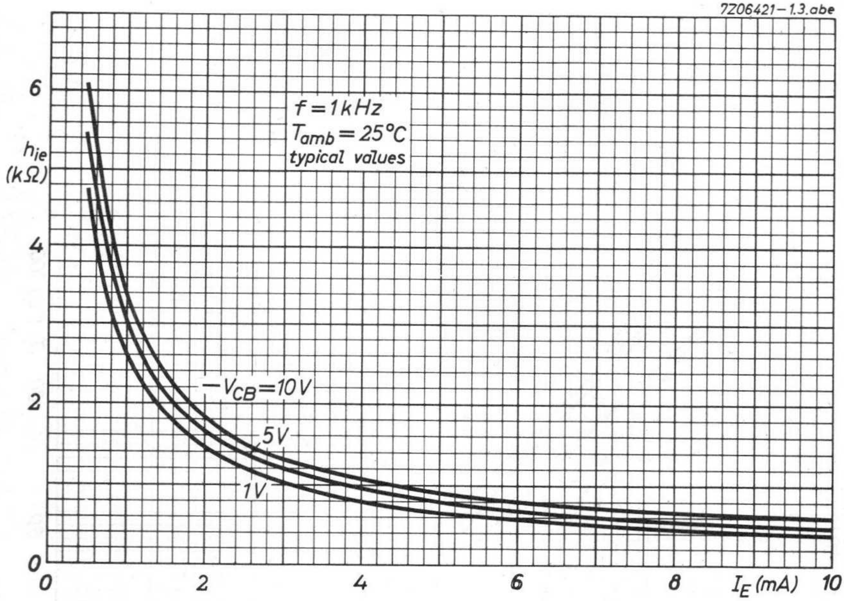
Input impedance	h_{ie}	typ.	1.7	kΩ
			1.1 to 2.5	kΩ
Reverse voltage transfer	h_{re}	typ.	6.5	10^{-4}
		<	8.5	10^{-4}
Small signal current gain	h_{fe}	typ.	125	
			80 to 170	
Output admittance	h_{oe}	typ.	80	$\mu\Omega^{-1}$
		<	110	$\mu\Omega^{-1}$


7Z06426-1.3.abe.
100
$-I_C$
(mA)
80
60
40
20
$-I_B = 0.9mA$
0.8mA
0.7mA
0.6mA
0.5mA
0.4mA
0.3mA
0.2mA
0.1 mA
$-V_{CE} = 1V$
1
0.5
0
5
$-V_{CE}$(V)
10
$-I_B$(mA)
200
$-V_{BE}$
(mV)
400
$-V_{CE} = 1V$
typical values
$T_{amb} = 25°C$

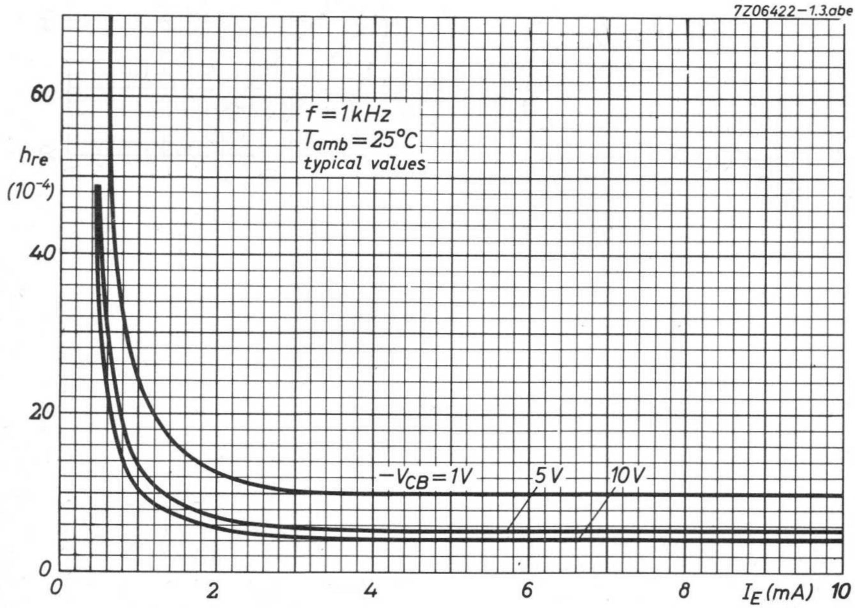

7Z06424-1.3.abe.
max voltage
typ
min voltage
$-V_{CB} = 5V$
$T_{amb} = 25°C$
I_E (mA)
10
8
6
4
2
0
0
50
100
150
$-V_{BE}$ (mV)


7Z06425-1.3.abe.
Base current versus emitter current
$-V_{CB} = 5V$
$T_{amb} = 25°C$
max
typ
min
I_E (mA)
14
12
10
8
6
4
2
0
0
20
40
60
80
100
$-I_B$ (μA)

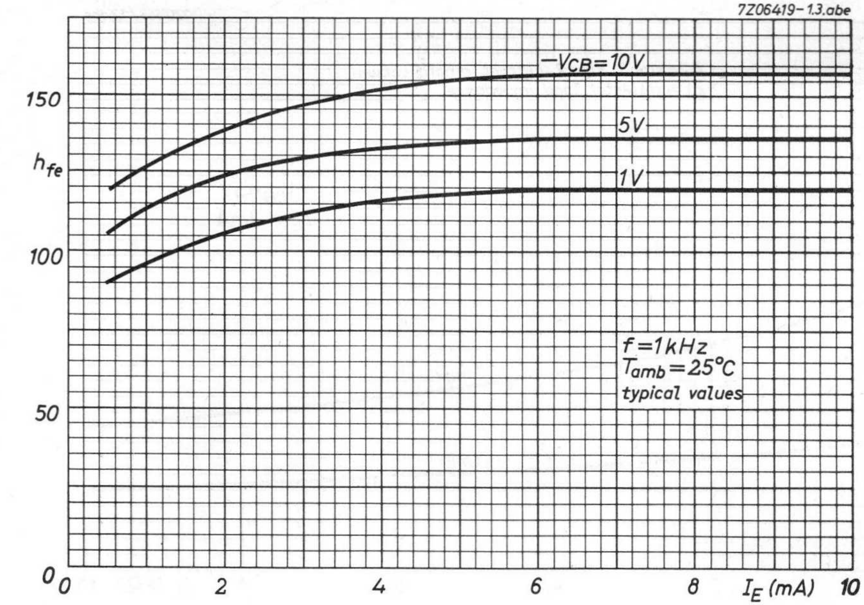

7Z06423-1.3.abe.
10000
1000
100
10
1
−ICBO (μA)
20
40
60
80
100
Tj (°C)
−VCB = 32V
10V
max
typ

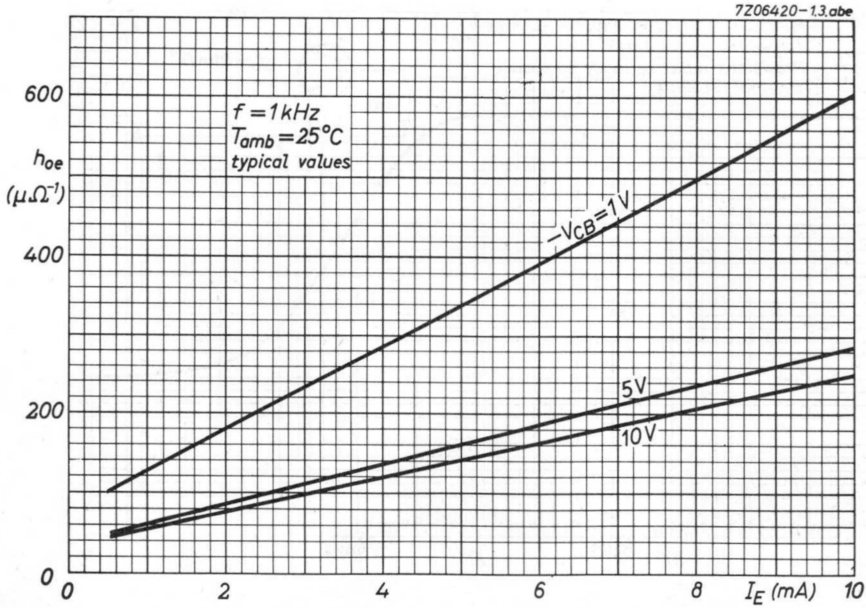


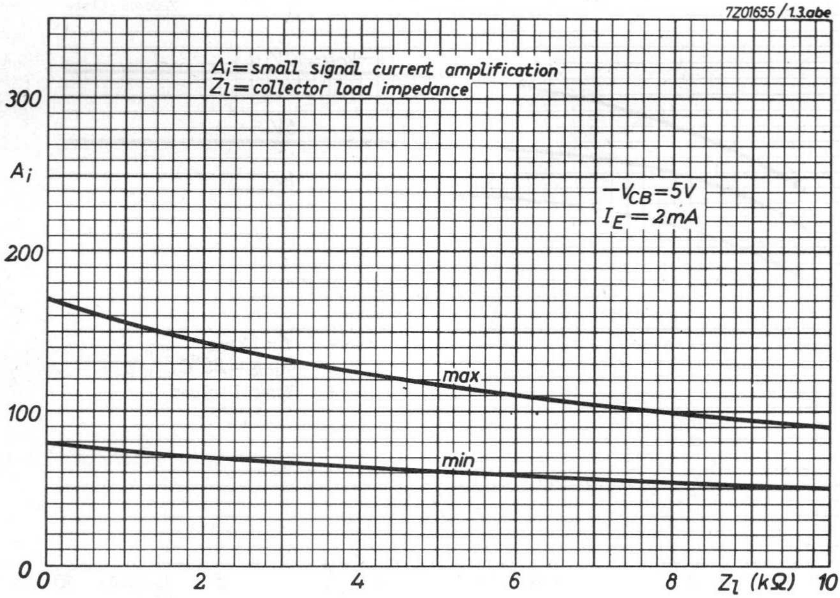
7Z06421-1.3.abe
f = 1 kHz
Tamb = 25°C
typical values
hie
(kΩ)
−VCB=10V
5V
1V
IE (mA)
0
2
4
6
8
10

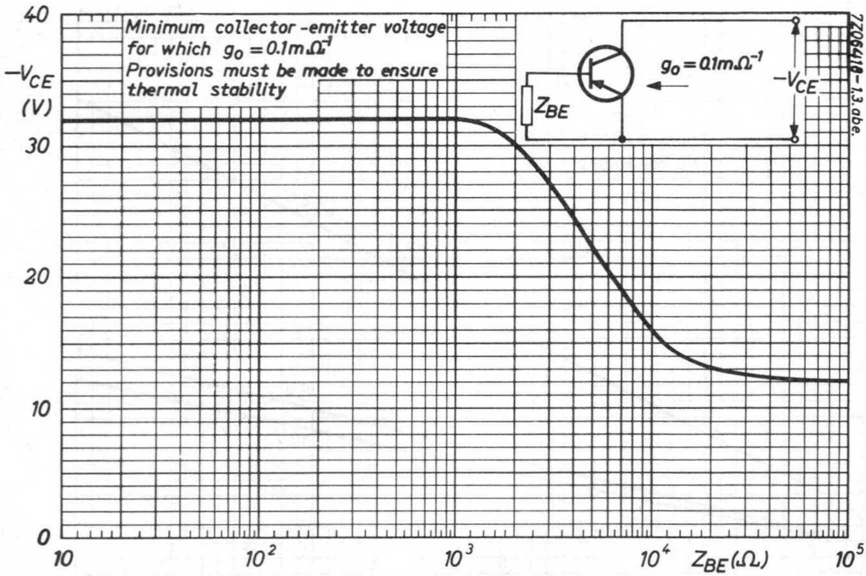


7Z06422-1.3.abe
f = 1 kHz
Tamb = 25°C
typical values
hre
(10−4)
−VCB=1V
5V
10V
IE (mA)
0
20
40
60
2
4
6
8
10


7Z06419-1.3.abe
150
h_{fe}
100
50
0
0
2
4
6
8
I_E (mA)
10
$-V_{CB}$=10V
5V
1V
f=1kHz
T_{amb}=25°C
typical values


7Z06420-1.3.abe
600
h_{oe}
($\mu\Omega^{-1}$)
400
200
0
0
2
4
6
8
I_E (mA)
10
f=1kHz
T_{amb}=25°C
typical values
$-V_{CB}$=1V
5V
10V


7Z01655 / 1.3.abe
A_i = small signal current amplification
Z_l = collector load impedance
$-V_{CB}$ = 5V
I_E = 2mA
max
min
A_i
300
200
100
0
0
2
4
6
8
Z_l (kΩ)
10


Minimum collector-emitter voltage for which $g_o = 0.1 m\Omega^{-1}$
Provisions must be made to ensure thermal stability
$g_o = 0.1 m\Omega^{-1}$
Z_{BE}
$-V_{CE}$
$-V_{CE}$ (V)
40
30
20
10
0
10
10^2
10^3
10^4
Z_{BE} (Ω)
10^5

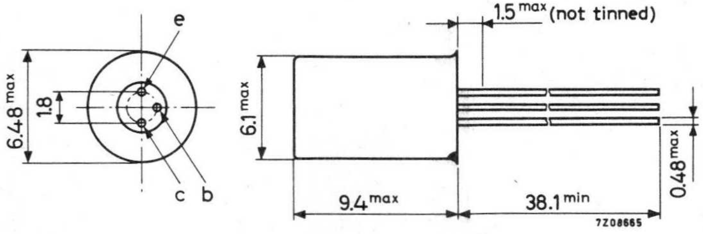
GERMANIUM ALLOY TRANSISTOR

P-N-P transistor in a TO-1 metal envelope intended for use in pre-amplifier or driver stages.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	12	V
Collector current (d.c.)	$-I_C$	max.	100	mA
Total power dissipation up to T_{amb} = 45 °C with cooling fin No. 56227 on a heatsink of at least 12.5 cm^2	P_{tot}	max.	500	mW
Junction temperature	T_j	max.	90	°C
D.C. current gain at T_{amb} = 25 °C				
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{FE}	>	65	
		typ.	140	
Small signal current gain at T_{amb} = 25 °C				
I_E = 2 mA; $-V_{CB}$ = 5 V; f = 1 kHz	h_{fe}	typ.	180	
		130 to	300	
Transition frequency				
$-I_C$ = 10 mA; $-V_{CE}$ = 2 V	f_T	typ.	2.3	MHz

MECHANICAL DATA Dimensions in mm

TO-1



The coloured dot indicates the collector

Accessories available: 56200, 56208, 56209, 56210, 56226, 56227

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	12	V
Collector-emitter voltage with $R_{BE} < 1\ k\Omega$	$-V_{CER}$	max.	32	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	10	V

Currents

Collector current (d.c.)	$-I_C$	max.	100	mA
Emitter current (peak value)	I_{EM}	max.	200	mA

Power dissipation

Total power dissipation up to T_{amb} = 45 °C with cooling fin No. 56227 mounted on a heatsink of at least 12.5 cm^2	P_{tot}	max.	500	mW

Temperatures

Storage temperature	T_{stg}		-55 to +90	°C
Junction temperature	T_j	max.	90	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.3	°C/mW
From junction to ambient with cooling fin No. 56227 mounted on a heatsink of at least 12.5 cm^2	$R_{th\ j\text{-}a}$	=	0.09	°C/mW

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

CHARACTERISTICS $T_{amb} = 25\ ^{o}C$ unless otherwise specified

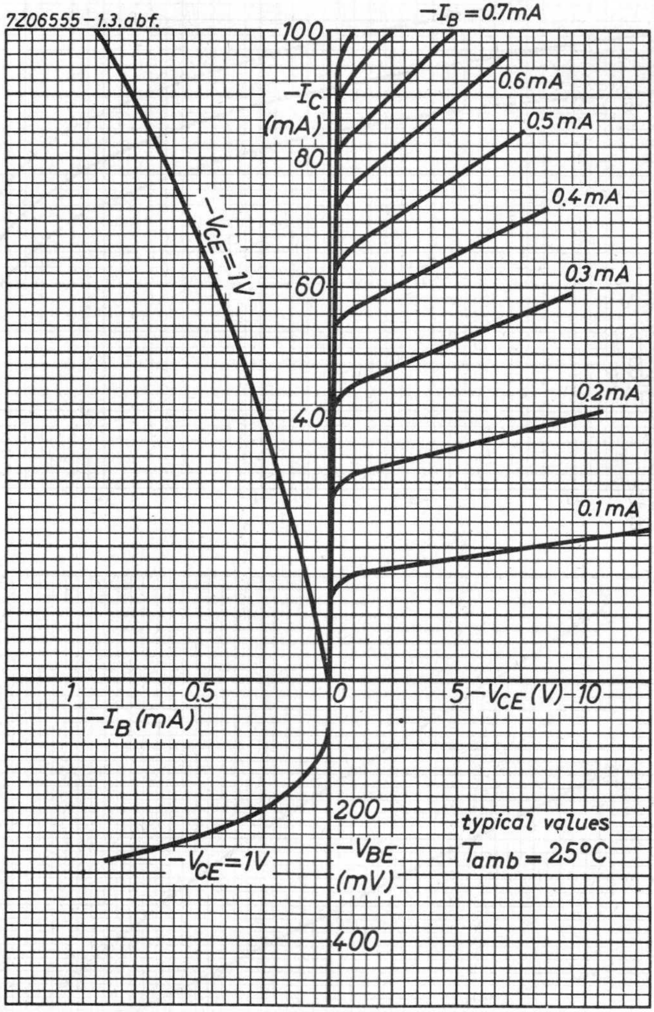
Collector cut-off current				
$I_E = 0$; $-V_{CB} = 10$ V	$-I_{CBO}$	<	10	μA
$I_E = 0$; $-V_{CB} = 32$ V; $T_j = 75\ ^{o}C$	$-I_{CBO}$	<	800	μA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 5$ V; $T_j = 75\ ^{o}C$	$-I_{EBO}$	<	550	μA
Emitter-base voltage				
$I_E = 2$ mA; $-V_{CB} = 5$ V	V_{EB}	typ.	105	mV
$I_E = 100$ mA; $V_{CB} = 0$	V_{EB}	<	400	mV
D.C. current gain				
$-I_C = 2$ mA; $-V_{CE} = 5$ V	h_{FE}	> typ.	65 140	
$-I_C = 50$ mA; $V_{CB} = 0$	h_{FE}	typ.	135	
$-I_C = 100$ mA; $V_{CB} = 0$	h_{FE}	typ.	105	
Collector capacitance at f = 0.45 MHz				
$I_E = I_e = 0$; $-V_{CB} = 5$ V	C_c	typ. <	40 50	pF pF
Feedback impedance at f = 0.45 MHz				
$-I_C = 1$ mA; $-V_{CE} = 5$ V	$\lvert z_{rb} \rvert$	typ.	90	Ω
Transition frequency				
$-I_C = 10$ mA; $-V_{CE} = 2$ V	f_T	> typ.	1.7 2.3	MHz MHz
Cut-off frequency				
$-I_C = 10$ mA; $-V_{CE} = 2$ V	f_{hfe}	> typ.	10 17	kHz kHz
Noise figure at f = 1 kHz				
$-I_C = 0.5$ mA; $-V_{CE} = 5$ V; $R_S = 500\ \Omega$ Bandwidth = 200 Hz	F	typ. <	4 10	dB dB

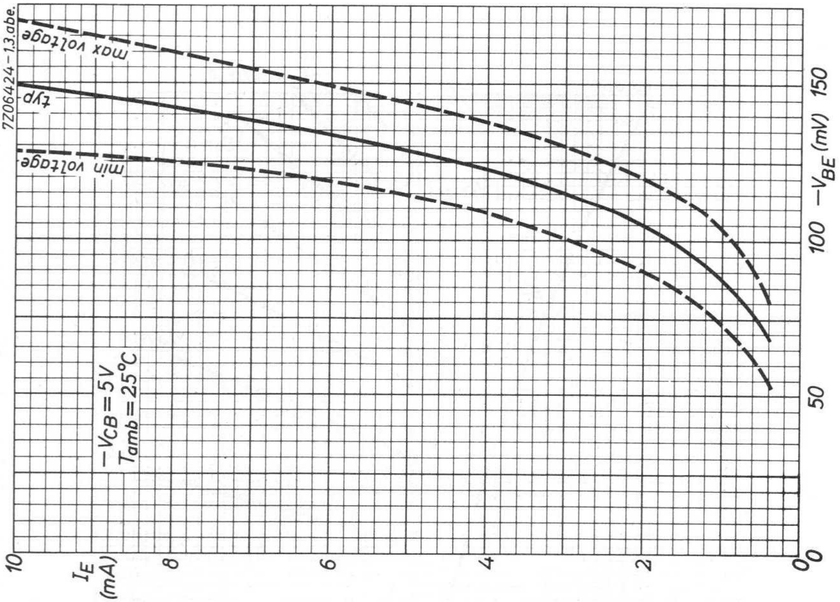
CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

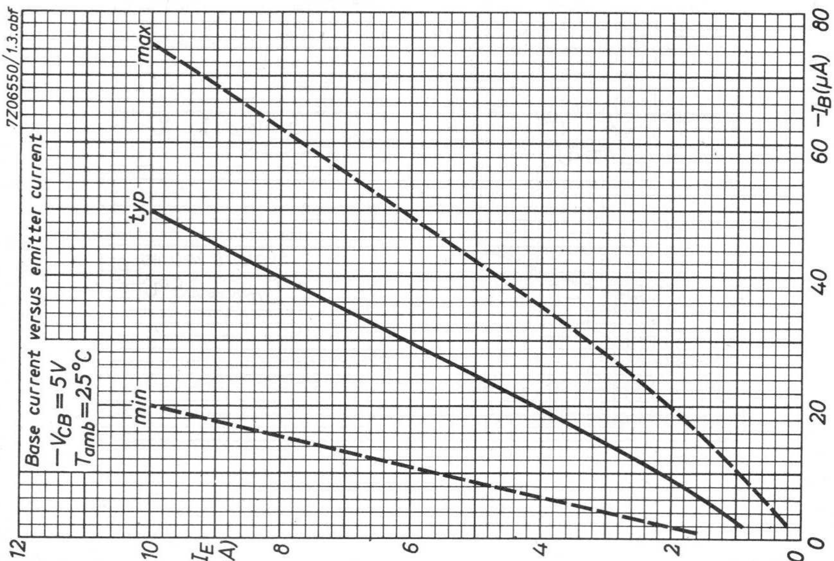
h parameters at f = 1 kHz

$-I_C$ = 2 mA; $-V_{CE}$ = 5 V

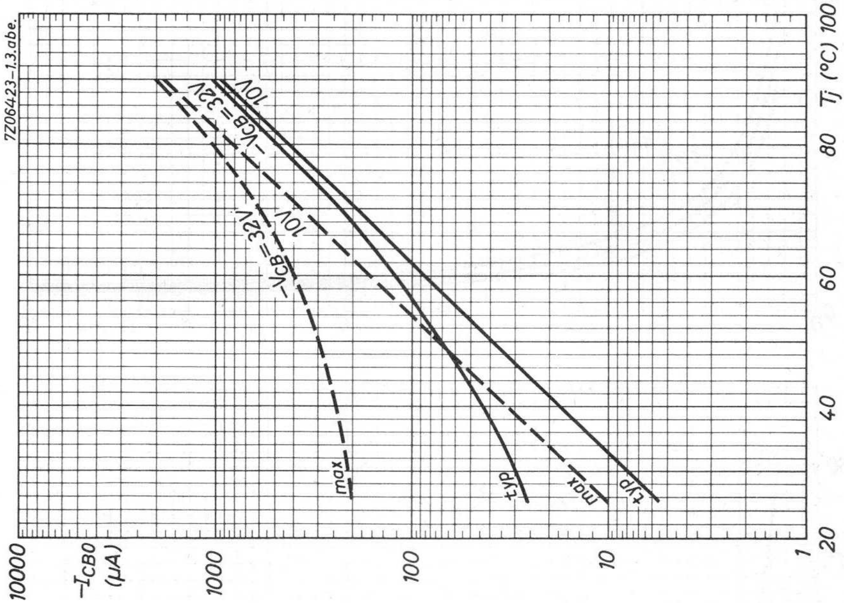
Input impedance	h_{ie}	typ.	2.4	kΩ
		1.7 to	3.8	kΩ
Reverse voltage transfer	h_{re}	typ.	8.0	10^{-4}
		<	13.0	10^{-4}
Small signal current gain	h_{fe}	typ.	180	
		130 to	300	
Output admittance	h_{oe}	typ.	100	$\mu\Omega^{-1}$
		<	170	$\mu\Omega^{-1}$

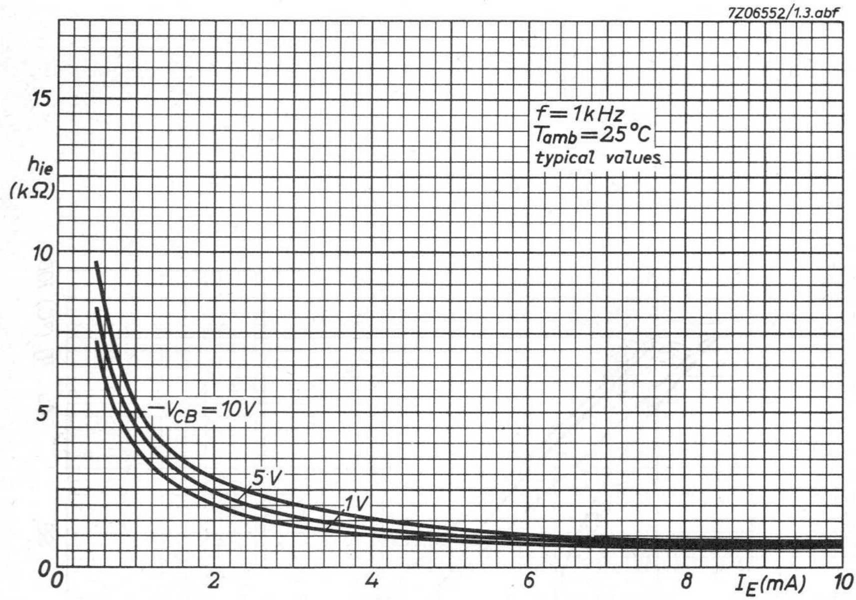

7Z06555-1.3.abf.
$-I_B = 0.7mA$
0.6 mA
0.5 mA
0.4 mA
0.3 mA
0.2 mA
0.1 mA
100
$-I_C$ (mA)
80
60
40
$-V_{CE} = 1V$
1
0.5
0
5
$-V_{CE}$ (V)
10
$-I_B$ (mA)
200
$-V_{BE}$ (mV)
400
$-V_{CE} = 1V$
typical values
$T_{amb} = 25°C$

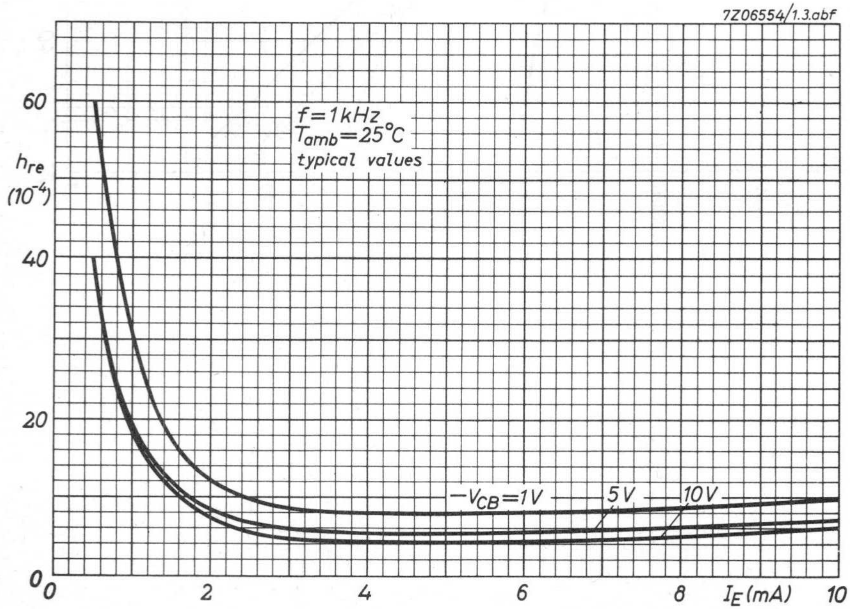


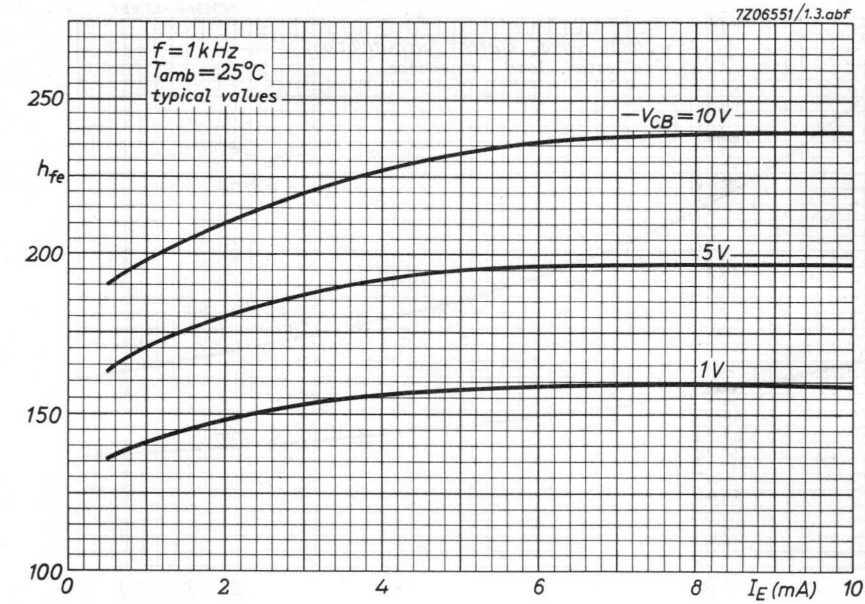


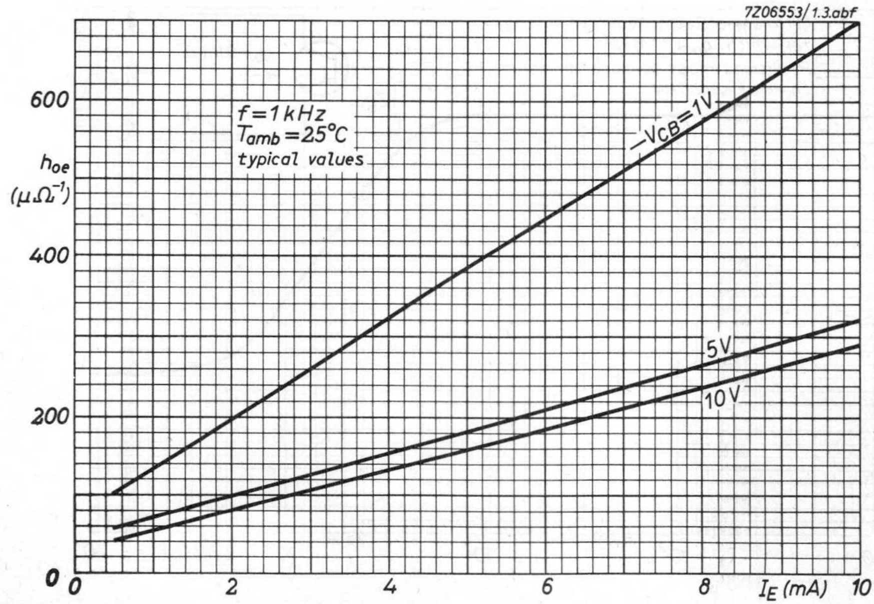
Base current versus emitter current

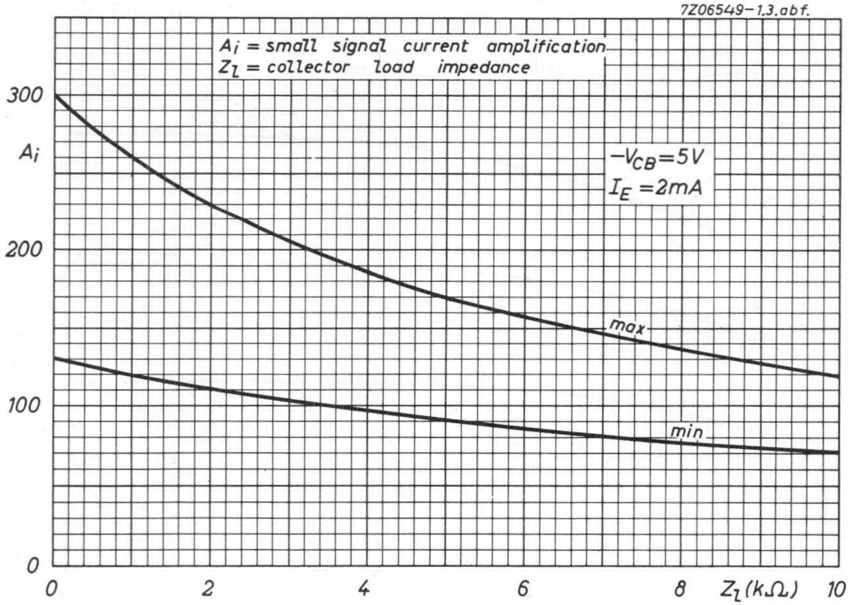

7Z06423-1.3.abe.
$-I_{CBO}$ (μA)
10000
1000
100
10
1
T_j (°C)
20
40
60
80
100
$-V_{CB}$ = 32V
10V
max
typ

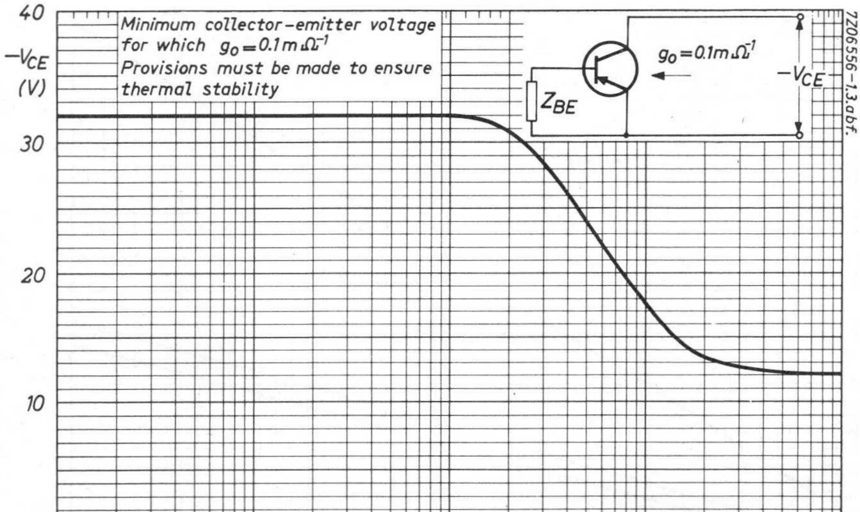

7Z06552/1.3.abf
f = 1 kHz
Tamb = 25 °C
typical values
hie
(kΩ)
15
10
5
0
−VCB = 10 V
5 V
1 V
0
2
4
6
8
IE (mA)
10


7Z06554/1.3.abf
f = 1 kHz
Tamb = 25 °C
typical values
hre
(10⁻⁴)
60
40
20
0
−VCB = 1 V
5 V
10 V
0
2
4
6
8
IE (mA)
10


7Z06551/1.3.abf
f = 1 kHz
T_{amb} = 25°C
typical values
$-V_{CB}$ = 10 V
5 V
1 V
h_{fe}
250
200
150
100
0
2
4
6
8
10
I_E (mA)


7Z06553/1.3.abf
f = 1 kHz
T_{amb} = 25°C
typical values
$-V_{CB}$ = 1 V
5 V
10 V
h_{oe}
($\mu\Omega^{-1}$)
600
400
200
0
2
4
6
8
10
I_E (mA)


7Z06549-1.3.abf.
Ai = small signal current amplification
Zl = collector load impedance
300
Ai
200
100
0
−VCB=5V
IE =2mA
max
min
0
2
4
6
8
Zl(kΩ)
10


40
−VCE
(V)
30
20
10
0
Minimum collector-emitter voltage
for which go=0.1mΩ-1
Provisions must be made to ensure
thermal stability
ZBE
go=0.1mΩ-1
−VCE
7Z06556-1.3.abf.
10
10²
10³
10⁴
ZBE(Ω)
10⁵

GERMANIUM ALLOY TRANSISTORS

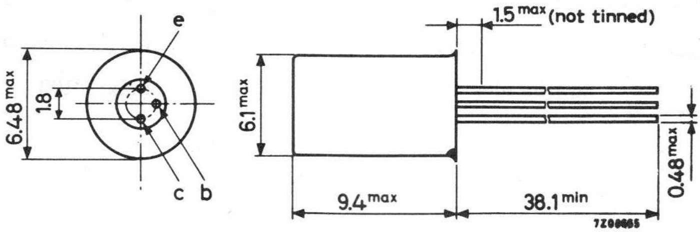
The AC127 is an n-p-n audio transistor in a TO-1 metal envelope.
The AC127 is intended for use together with the p-n-p transistors AC128 or AC132 as matched pair in class B output stages with complementary symmetry or in driver stages.
The AC127/01 is electrically equivalent to the AC127, constructed integrally with a heat conducting block, which gives better heat transfer.
The thermal resistance from junction to heatsink shows an improvement (≈ 10 °C/W) as compared with that obtained with the AC127 when using heat conducting clip 56227.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	32	V
Collector-emitter voltage (open base)	V_{CEO}	max.	12	V
Collector current (d.c.)	I_C	max.	500	mA
Total power dissipation up to T_{amb} = 45 °C with cooling fin on a heatsink of at least 12.5 cm^2	P_{tot}	max.	340	mW
Junction temperature (incidentally)	T_j	max.	100	°C
D.C. current gain at T_{amb} = 25 °C I_C = 20 mA; V_{CB} = 0	h_{FE}	typ.	100	
Transition frequency I_C = 10 mA; V_{CB} = 2 V	f_T	typ.	2.5	MHz

MECHANICAL DATA Dimensions in mm

AC127

TO-1

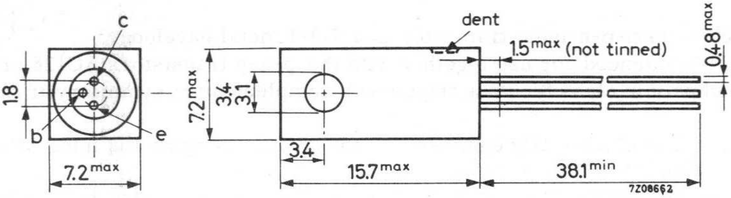


The coloured dot indicates the collector

Accessories available: 56200, 56208, 56209, 56210, 56226, 56227

MECHANICAL DATA (continued) Dimensions in mm

AC127/01



The dent indicates the collector

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	32	V
Collector-emitter voltage (open base)	V_{CEO}	max.	12	V
Collector-emitter voltage with $R_{BE} < 70\ \Omega$	V_{CER}	max.	32	V
Emitter-base voltage (open collector)	V_{EBO}	max.	10	V

Currents

Collector current (d.c.)	I_C	max.	500	mA
Base current (d.c.)	I_B	max.	25	mA

Power dissipation

Total power dissipation up to T_{amb} = 45 °C with cooling fin mounted on a heatsink of at least 12.5 cm^2	P_{tot}	max.	340	mW

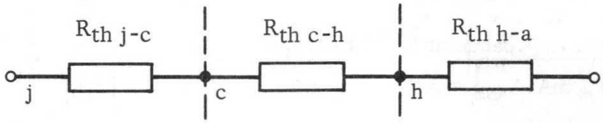
Temperatures

Storage temperature	T_{stg}		-55 to +90	°C
Junction temperature: continuous	T_j	max.	90	°C
incidentally	T_j	max.	100	°C

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

THERMAL RESISTANCE

From junction to ambient in free air		AC127	AC127/01	
without cooling clip	$R_{th\ j\text{-}a}$ =	370	250	$^oC/W$
with cooling clip 56227 on 1.5 mm blackened Al. heatsink of 12.5 cm^2	$R_{th\ j\text{-}a}$ =	160		$^oC/W$
with cooling clip 56227 on infinite heatsink	$R_{th\ j\text{-}a}$ =	125		$^oC/W$
From junction to case	$R_{th\ j\text{-}c}$ =	110	115	$^oC/W$



	$R_{th\ j\text{-}c}$	$R_{th\ c\text{-}h}$	$R_{th\ h\text{-}a}$	
AC127 with clip 56227	110	15		$^oC/W$
AC127/01	115	0.5		$^oC/W$

CHARACTERISTICS T_{amb} = 25 ^oC unless otherwise specified

Collector cut-off current

$I_E = 0$; $V_{CB} = 0.5$ V	I_{CBO}	<	10	μA
$I_E = 0$; $V_{CB} = 32$ V; $T_j = 75\ ^oC$	I_{CBO}	<	1100	μA

Emitter cut-off current

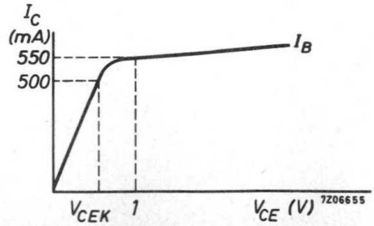
$I_C = 0$; $V_{EB} = 5$ V; $T_j = 75\ ^oC$	I_{EBO}	<	550	μA

Emitter-base voltage

$-I_E = 2$ mA; $V_{CB} = 5$ V	$-V_{EB}$	typ.	120	mV
$-I_E = 500$ mA; $V_{CB} = 0$	$-V_{EB}$	<	1200	mV

Knee voltage

$I_C = 500$ mA; I_B = value for which $I_C = 550$ mA at $V_{CE} = 1$ V	V_{CEK}	<	1	V



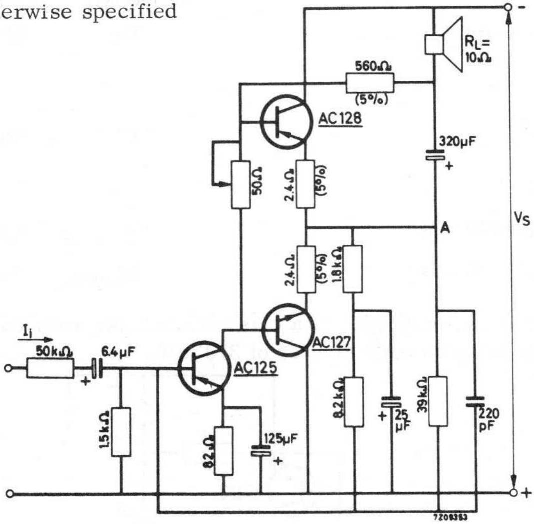
CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

D.C. current gain				
I_C = 20 mA; V_{CB} = 0	h_{FE}	typ.	100	
I_C = 50 mA; V_{CB} = 0	h_{FE}	typ.	105	
I_C = 200 mA; V_{CB} = 0	h_{FE}	typ.	90	
I_C = 500 mA; V_{CB} = 0	h_{FE}	typ.	50	
Collector capacitance at f = 0.45 MHz				
$I_E = I_e = 0$; V_{CB} = 5 V	C_c	typ.	70	pF
Feedback impedance at f = 0.45 MHz				
I_C = 1 mA; V_{CE} = 5 V	$\|z_{rb}\|$	typ.	70	Ω
Transition frequency				
I_C = 10 mA; V_{CE} = 2 V	f_T	>	1.5	MHz
		typ.	2.5	MHz
Cut-off frequency				
I_C = 10 mA; V_{CE} = 2 V	f_{hfe}	>	10	kHz
		typ.	20	kHz
Noise figure at f = 1 kHz				
I_C = 0.5 mA; V_{CE} = 5 V; R_S = 500 Ω; Bandwidth = 200 Hz	F	typ.	4	dB
		<	10	dB
D.C. current gain ratio of matched pair AC127/AC128				
$\|I_C\|$ = 300 mA; V_{CB} = 0	h_{FE1}/h_{FE2}	typ.	1.1	
matched pair AC127/AC132				
$\|I_C\|$ = 50 mA; V_{CB} = 0	h_{FE1}/h_{FE2}	typ.	1.1	
		<	1.25	

APPLICATION INFORMATION

1. AC127/AC128 as matched pair in a class B amplifier with complementary symmetry delivering an output power of 550 mW.

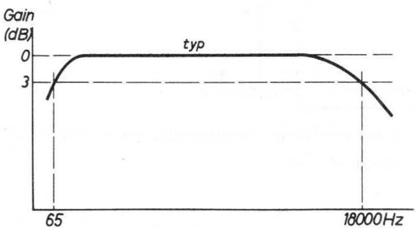
Tolerance of resistors:
10% unless otherwise specified



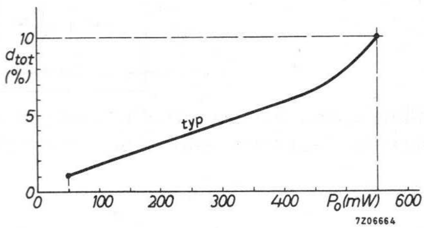
Stable continuous operation is ensured up to an ambient temperature of 45 °C, provided each transistor is mounted with a cooling fin type No. 56226.

OPERATING CHARACTERISTICS T_{amb} = 25 °C

Supply voltage	V_S	=	9	V
Output power (d_{tot} = 10%)	P_o	>	500	mW
		typ.	550	mW



Typical frequency response



Typical distortion as a function of output power

APPLICATION INFORMATION (continued)

Output stage

Emitter current (zero signal)	$\lvert I_E \rvert$	=	3	mA
Collector current (peak value)	$\lvert I_{CM} \rvert$	typ.	300	mA
Midtap voltage at point A	V_A	typ.	4.9	V

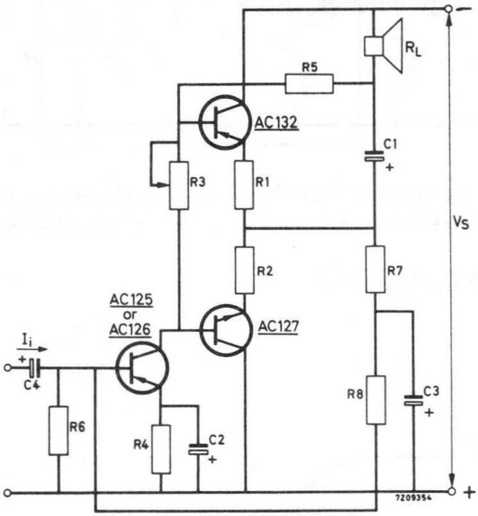
Driver stage

Collector current	$-I_C$	typ.	7	mA

Sensitivity

Input current (P_o = 550 mW)	$I_{i(rms)}$	typ.	120	μA
Input current (P_o = 50 mW)	$I_{i(rms)}$	typ.	35	μA

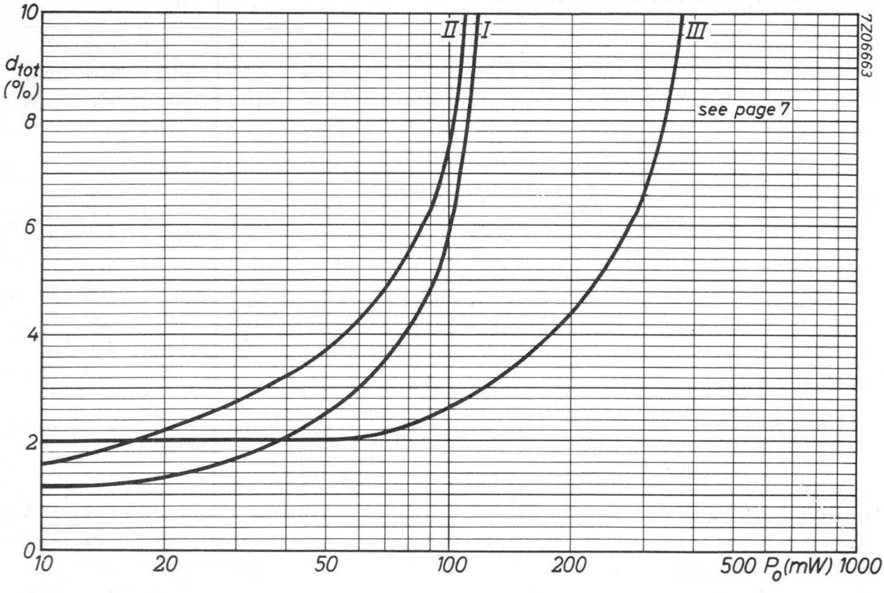
2. AC127/AC132 as matched pair in a class B amplifier with complementary symmetry delivering an output power of 370 mW.

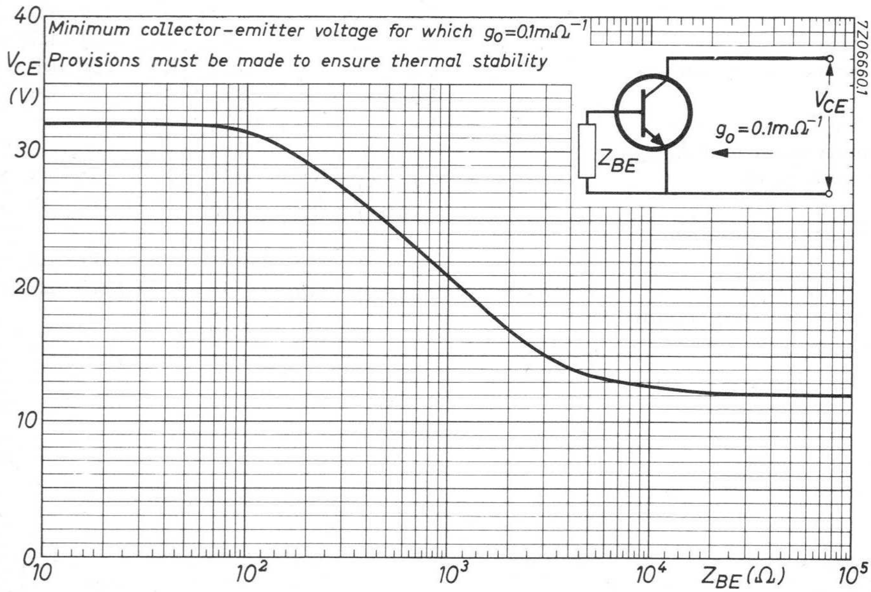


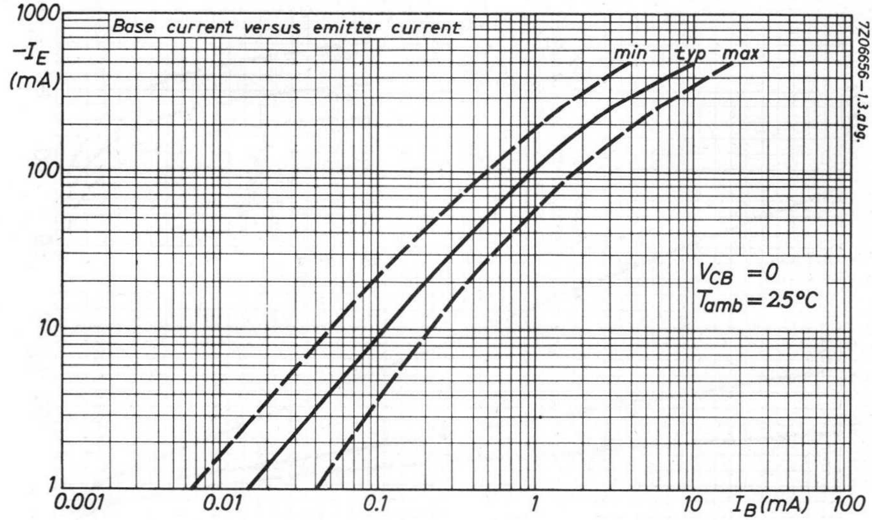
Stable continuous operation is ensured up to an ambient temperature of 45 °C, provided each transistor is mounted with a cooling fin.

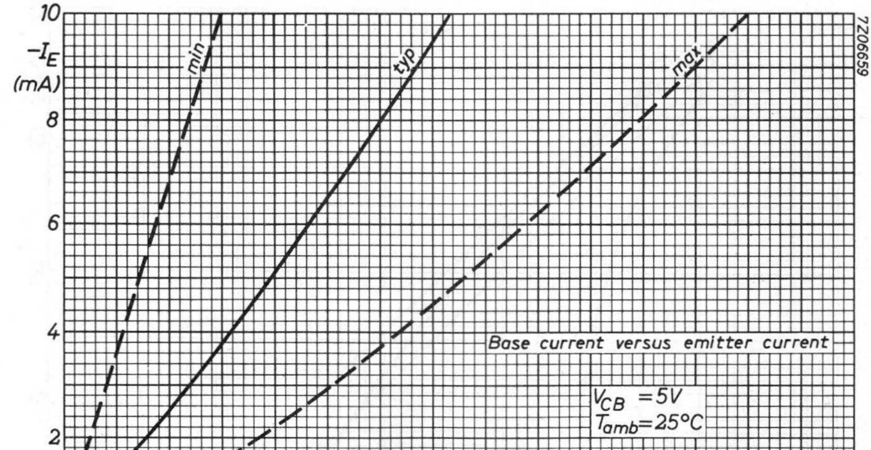
APPLICATION INFORMATION (continued)

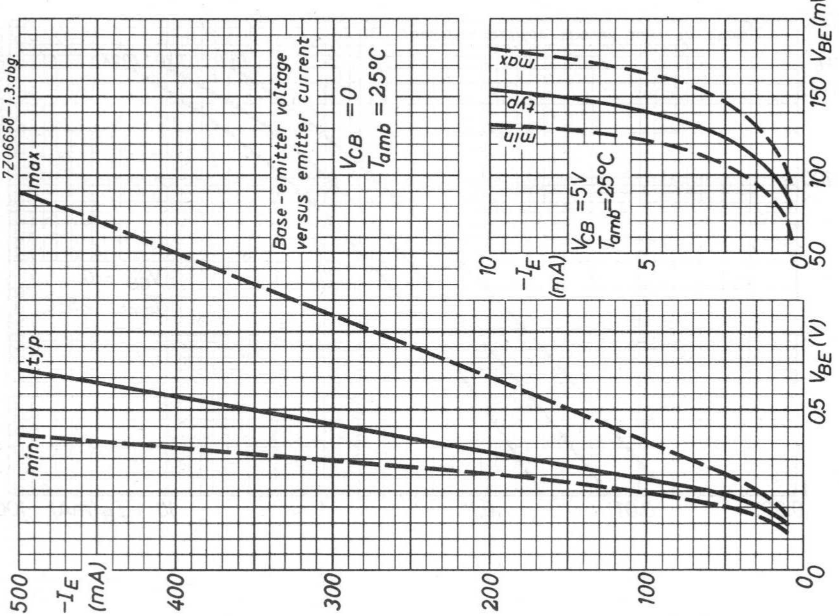
			I	II	III	
Supply voltage	V_S	=	6	9	9	V
Output power (at d = 10%)	P_o	typ.	115	110	370	mW
		>	105	100	300	mW
Distortion	d_{tot}	See page 8				
Output stage						
Emitter current (zero signal)	I_{E1}	=	2	2	2	mA
	$-I_{E2}$	=	2	2	2	mA
Emitter resistors	R1	=	3.3	4.7	3.9	Ω
	R2	=	3.3	4.7	3.9	Ω
Bias resistor	R3	<	100	250	50	Ω
Coupling capacitor	C1	=	200	64	320	μF
Load resistance	R_L	=	25	70	15	Ω
Collector current (peak value) at P_o max.	$\|I_{CM}\|$	typ.	90	50	200	mA
Driver stage						
Collector current	$-I_C$	typ.	2.7	1.2	7.6	mA
Emitter resistor	R4	=	180	680	82	Ω
Collector resistor	R5	=	910	3300	510	Ω
Bias resistors	R6	=	4.7	6.8	1.8	kΩ
	R7	=	3.9	4.7	2.2	kΩ
	R8	=	15	24	6.8	kΩ
Decoupling capacitors	C2	=	40	25	120	μF
	C3	=	25	25	25	μF
Coupling capacitor	C4	=	6.4	6.4	6.4	μF
Input current at P_o max.						
with AC125	$I_{i(rms)}$	typ.	20	10	55	μA
with AC126	$I_{i(rms)}$	typ.	15	8	40	μA
Input current at P_o = 50 mW						
with AC125	$I_{i(rms)}$	typ.	11.5	6	17	μA
with AC126	$I_{i(rms)}$	typ.	9	4.5	12.5	μA
Total harmonic distortion at P_o = 50 mW	d_{tot}	typ.	2.5	3.8	2.0	%

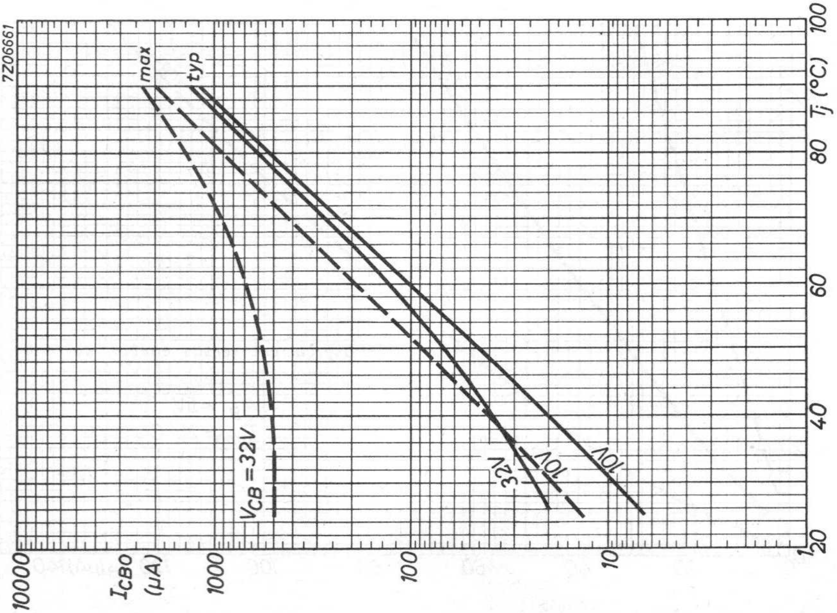

10
d_{tot}
(%)
8
6
4
2
0
II
I
III
7Z06663
see page 7
10
20
50
100
200
500 P_o(mW) 1000


40
V_{CE}
(V)
30
20
10
0
Minimum collector-emitter voltage for which $g_o = 0.1 m\Omega^{-1}$
Provisions must be made to ensure thermal stability
7Z06601
V_{CE}
$g_o = 0.1 m\Omega^{-1}$
Z_{BE}
10
10^2
10^3
10^4
Z_{BE} (Ω)
10^5


Base current versus emitter current
7Z06656—1.3.abg.
1000
$-I_E$
(mA)
100
10
1
min
typ
max
V_{CB} = 0
T_{amb} = 25°C
0.001
0.01
0.1
1
10
I_B (mA)
100


7Z06659
10
$-I_E$
(mA)
8
6
4
2
0
min
typ
max
Base current versus emitter current
V_{CB} = 5V
T_{amb} = 25°C
0
20
40
60
80
100
120
I_B (μA)
140


7Z06658-1.3.abg.
Base-emitter voltage versus emitter current
V_CB = 0
T_amb = 25°C
max
typ
min
-I_E (mA)
500
400
300
200
100
0
0.5
V_BE (V)
V_CB = 5V
T_amb = 25°C
10
5
0
50
100
150
V_BE (mV)


7Z06661
max
typ
I_CBO (μA)
10000
1000
100
10
1
20
40
60
80
100
T_j (°C)
V_CB = 32V
32V
10V
10V

GERMANIUM ALLOY TRANSISTORS

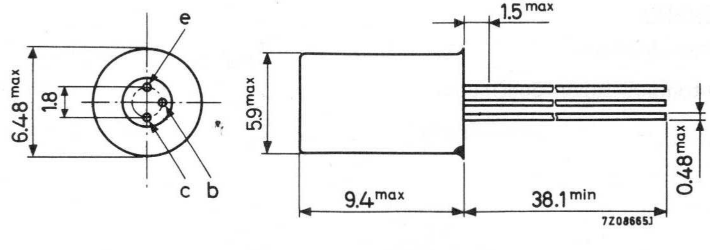
The AC128 is a p-n-p audio transistor in a TO-1 metal envelope.
The AC128 is intended for use in class A or class B output stages with battery voltages up to 14 V and an output power of up to 4 W.
Type 2-AC128 consists of 2 transistors AC128 selected for operation in a low distortion class B amplifier.
The AC128/01 is electrically equivalent to the AC128, constructed integrally with a heat conducting block which gives better heat transfer.
The thermal resistance from junction to heatsink shows an improvement (≈ 10 °C/W) as compared with that obtained with the AC128 when using heat conducting clip 56227.
Type 2-AC128 and type 2-AC128/01 consist of 2 transistors AC128 and AC128/01 resp. selected for operation in a low distortion class B amplifier.

QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	16	V
Collector current (d.c.)	$-I_C$	max.	1	A
Total power dissipation up to T_{amb} = 20 °C with cooling fin 56227 on a blackened Al. heatsink of at least 12.5 cm^2	P_{tot}	max.	1	W
Junction temperature (incidentally)	T_j	max.	100	°C
D.C. current gain at T_{amb} = 25 °C, $-I_C$ = 50 mA; V_{CB} = 0	h_{FE}	typ.	90	
			55 to 175	
Transition frequency, $-I_C$ = 10 mA; $-V_{CE}$ = 2 V	f_T	typ.	1.5	MHz

MECHANICAL DATA Dimensions in mm

AC128
TO-1

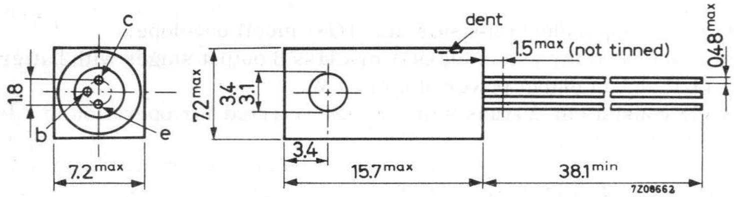


The coloured dot indicates the collector

Accessories available: 56200, 56208, 56209, 56210, 56226, 56227

MECHANICAL DATA (continued) Dimensions in mm

AC128/01



The dent indicates the collector

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC 134).

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	16	V
Collector-emitter voltage with $R_{BE} < 400\ \Omega$	$-V_{CER}$	max.	32	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	10	V

Currents

Collector current (d.c.)	$-I_C$	max.	1000	mA
Collector current (peak value)	$-I_{CM}$	max.	2000	mA
Emitter current (peak value)	I_{EM}	max.	2000	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C with cooling fin 56227 mounted on a blackened Al. heatsink of at least 12.5 cm^2	P_{tot}	max.	1000	mW

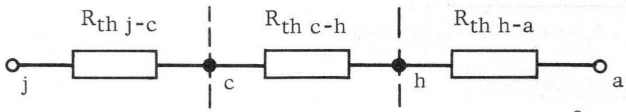
Temperatures

Storage temperature	T_{stg}		-55 to +100	°C
Junction temperature: continuous	T_j	max.	90	°C
incidentally	T_j	max.	100	°C

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

THERMAL RESISTANCE

		AC128	AC128/01	
From junction to ambient in free air				
without cooling clip	$R_{th\ j-a}$ =	290	180	°C/W
with cooling clip 56227	$R_{th\ j-a}$ =	140		°C/W
with cooling clip 56227 on 1.5 mm blackened Al. heatsink of 12.5 cm^2	$R_{th\ j-a}$ =	80		°C/W
with cooling clip 56227 on infinite heatsink	$R_{th\ j-a}$ =	55		°C/W
From junction to case	$R_{th\ j-c}$ =	40	45	°C/W



	$R_{th\ j-c}$	$R_{th\ c-h}$	
AC128 with clip 56227	40	15	°C/W
AC128/01	45	0.5	°C/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $-V_{CB} = 10$ V	$-I_{CBO}$	<	10	μA
$I_E = 0$; $-V_{CB} = 32$ V	$-I_{CBO}$	<	200	μA

Emitter cut-off current

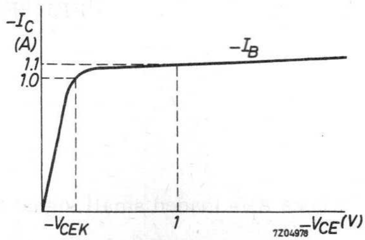
$I_C = 0$; $-V_{EB} = 10$ V	$-I_{EBO}$	<	200	μA
$I_C = 0$; $-V_{EB} = 5$ V; $T_j = 75$ °C	$-I_{EBO}$	<	500	μA

Emitter-base voltage

$I_E = 50$ mA; $V_{CB} = 0$	V_{EB}	<	300	mV
$I_E = 300$ mA; $V_{CB} = 0$	V_{EB}	<	450	mV

Knee voltage

$-I_C = 1$ A; $-I_B$ = value for which $-I_C = 1.1$ A at $-V_{CE} = 1$ V	$-V_{CEK}$	<	0.6	V



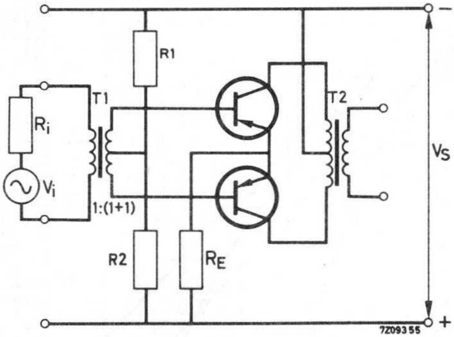
CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

D.C. current gain		
$-I_C$ = 50 mA; V_{CB} = 0	h_{FE}	typ. 90 55 to 175
$-I_C$ = 300 mA; V_{CB} = 0	h_{FE}	typ. 90 60 to 175
$-I_C$ = 1 A; V_{CB} = 0	h_{FE}	typ. 80 45 to 165
Collector capacitance		
$I_E = I_e = 0$; $-V_{CB}$ = 5 V	C_c	typ. 100 pF
Base resistance		
$-I_C$ = 1 mA; $-V_{CE}$ = 5 V	$r_{bb'}$	typ. 25 Ω
Transition frequency		
$-I_C$ = 10 mA; $-V_{CE}$ = 2 V	f_T	> 1.0 MHz typ. 1.5 MHz
Cut-off frequency		
$-I_C$ = 10 mA; $-V_{CE}$ = 2 V	f_{hfe}	> 10 kHz typ. 15 kHz
Small signal current gain linearity		
(see also page 10)	λ_{500}	> 0.50 [1] typ. 0.60 [1]
D.C. current gain ratio of matched pair AC127/AC128		
$\|I_C\|$ = 300 mA; V_{CB} = 0	h_{FE1}/h_{FE2}	typ. 1.1
matched pair 2-AC128		
$\|I_C\|$ = 50 mA; V_{CB} = 0	h_{FE1}/h_{FE2}	typ. 1.1 < 1.25
$\|I_C\|$ = 300 mA; V_{CB} = 0	h_{FE1}/h_{FE2}	typ. 1.1 < 1.25

[1] $\lambda_{500} = \frac{A_i \text{ at } 500 \text{ mA}}{A_{i\,max}}$, where A_i = loaded small signal current amplification.

APPLICATION INFORMATION

Class B operation with matched pair 2-AC128



To provide stability the total resistance in the base circuit of each transistor should be less than 100 Ω.

Supply voltage	V_S	=	6	9	9	V
Ambient temperature	T_{amb}	up to	55	55	45	°C
Emitter current (zero signal)	I_E	=	2x3	2x3	2x3	mA
Bias resistor [1]	R1	=	2.0	2.2	3.5[2]	kΩ
Bias resistor [1]	R2	=	47	39	[3]	Ω
Common emitter resistor	R_E	=	2.2	3.9	1.5	Ω
Input (source) resistance	R_i	=	1.5	1.5	1.0	kΩ
Load resistance	$R_{cc\sim}$	=	65	98	62	Ω
Dissipation (two transistors) [4]	P_{tot}	typ.	2x0.425	2x0.65	2x1.05	W
Power delivered to transformer	P_o	typ.	0.75	1.1	1.9	W
Collector current (peak value) at P_o max	$-I_{CM}$	typ.	300	300	500	mA
Collector current at P_o max	$-I_C$	typ.	2x95	2x95	2x150	mA
Input voltage at P_o max	V_i	typ.	5.5	6.0	6.6[5]	V
Total harmonic distortion at P_o max	d_{tot}	typ.	3.5	4.0	5.5	%
Input voltage at P_o = 50 mW	V_i	typ.	1.6	1.4	1.1[5]	V
Total harmonic distortion at P_o = 50 mW	d_{tot}	typ.	2.0	2.0	2.5	%

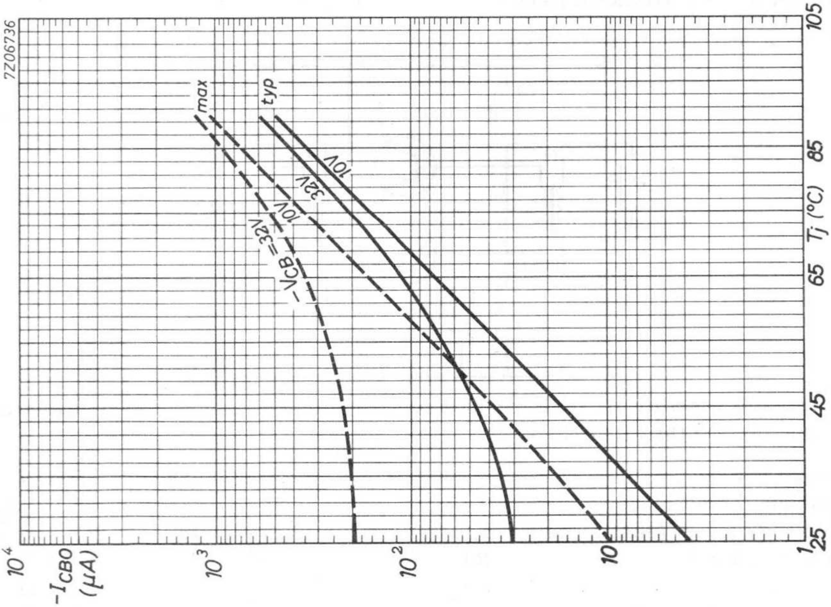
[1]) Tolerance of bias resistors: 5 %

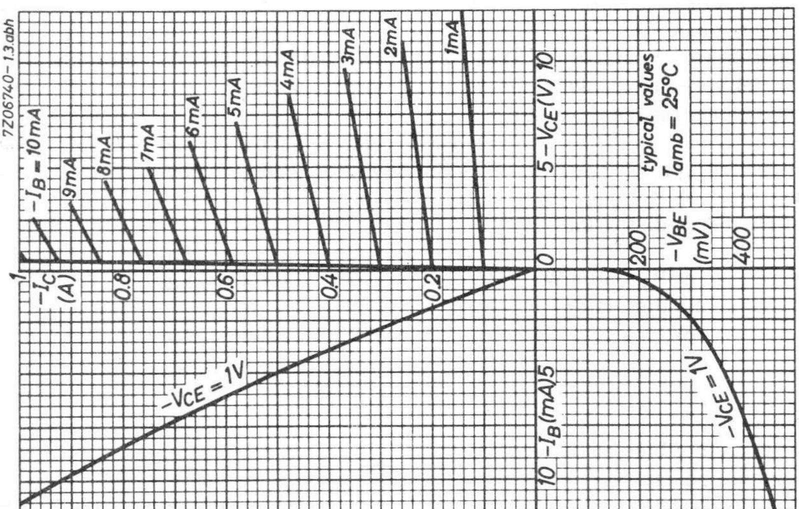
[2]) Variable resistor

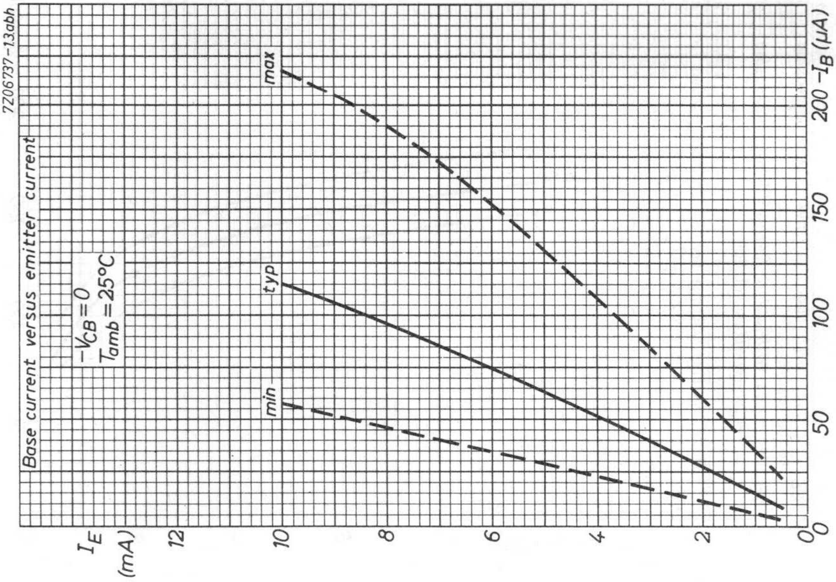
[3]) This resistance is composed of a 68 Ω resistor in parallel with a 130 Ω NTC resistor. Code number 2322 610 12131.

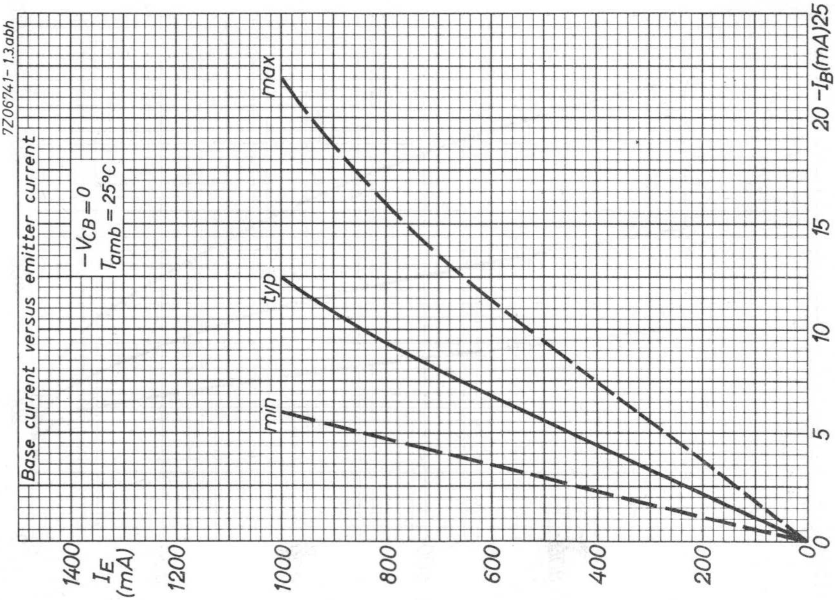
[4]) Mounted on cooling fin 56227 at T_{amb} up to 20 °C.

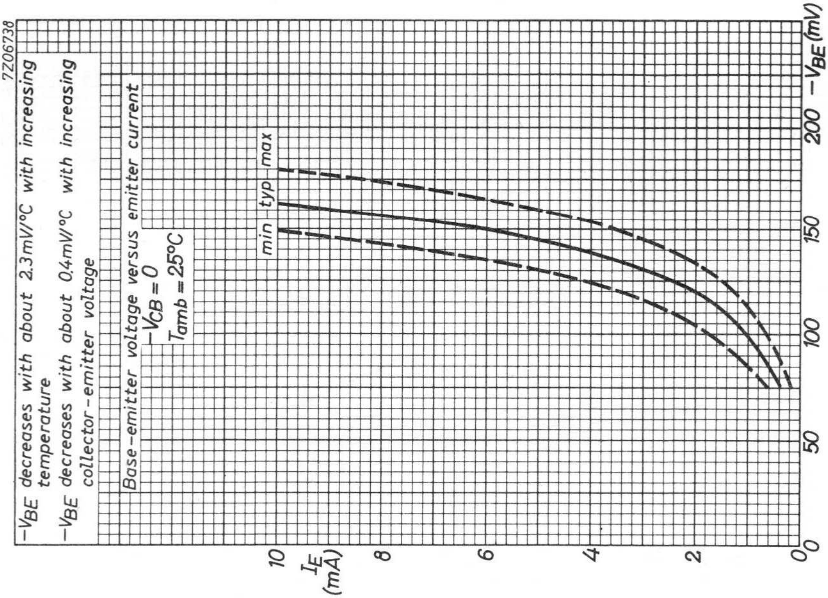
[5]) Losses in the driver transformer are not taken into account.

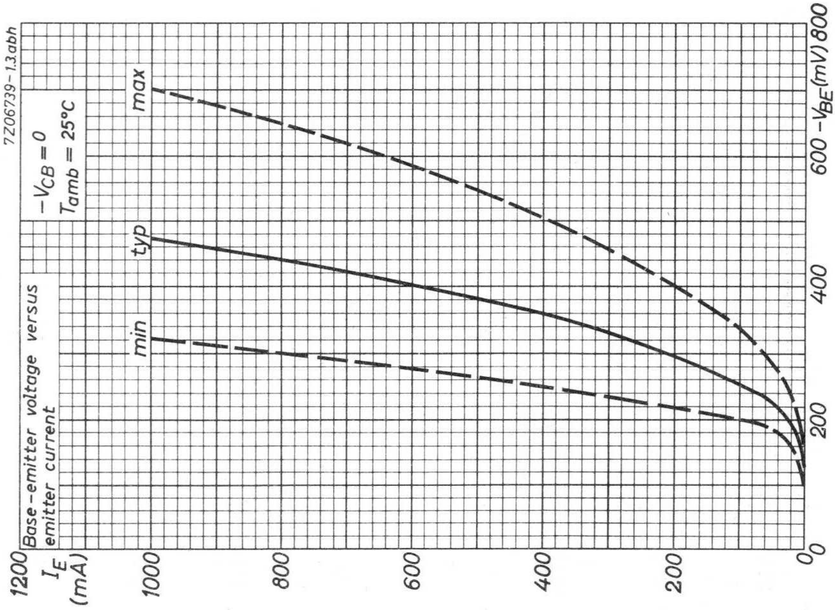

7Z06736
max
typ
10V
32V
10V
$-V_{CB} = 32V$
T_j (°C)
25
45
65
85
105
$-I_{CBO}$ (μA)
10^4
10^3
10^2
10
1

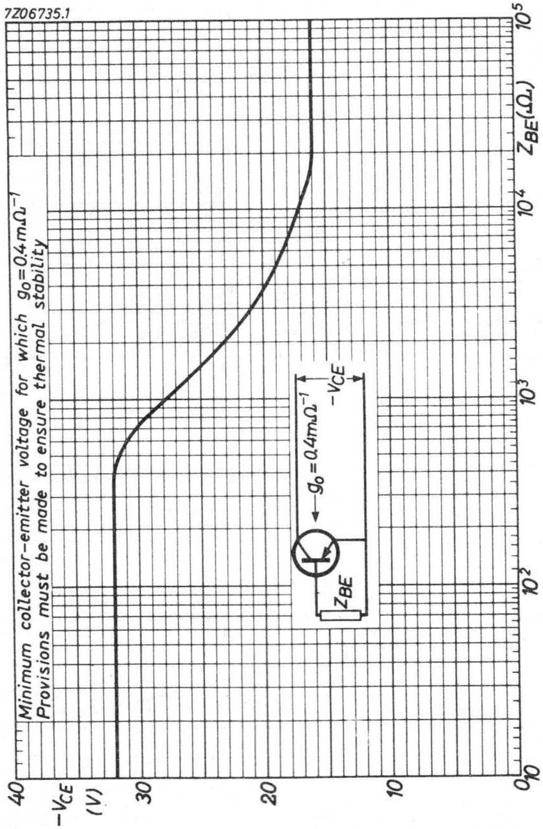

7Z06740-1.3.abh
$-I_B = 10mA$
9mA
8mA
7mA
6mA
5mA
4mA
3mA
2mA
1mA
$-I_C$ (A)
1
0.8
0.6
0.4
0.2
0
5
$-V_{CE}$ (V)
10
$-V_{CE} = 1V$
10
$-I_B$ (mA)
5
typical values
$T_{amb} = 25°C$
200
$-V_{BE}$ (mV)
400
$-V_{CE} = 1V$

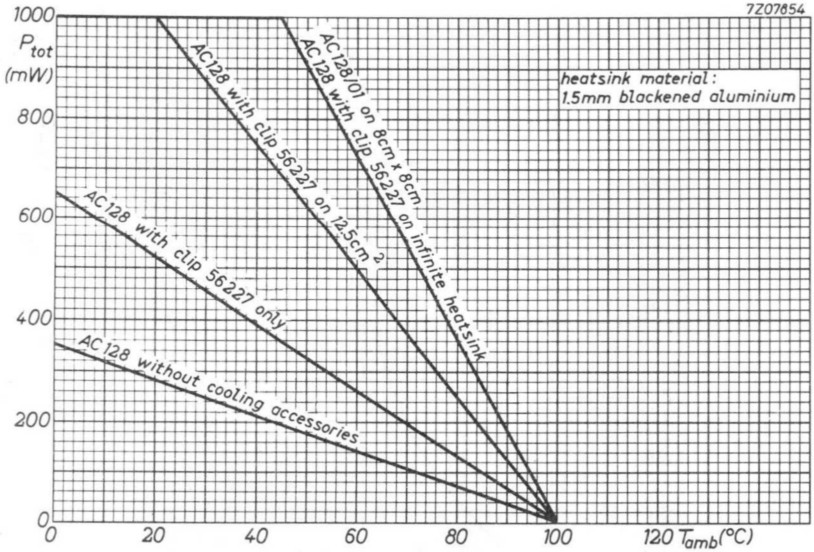

7Z06737-1.3abh
Base current versus emitter current
$-V_{CB} = 0$
$T_{amb} = 25°C$
max
typ
min
I_E (mA)
12
10
8
6
4
2
0
0
50
100
150
200
$-I_B$ (μA)

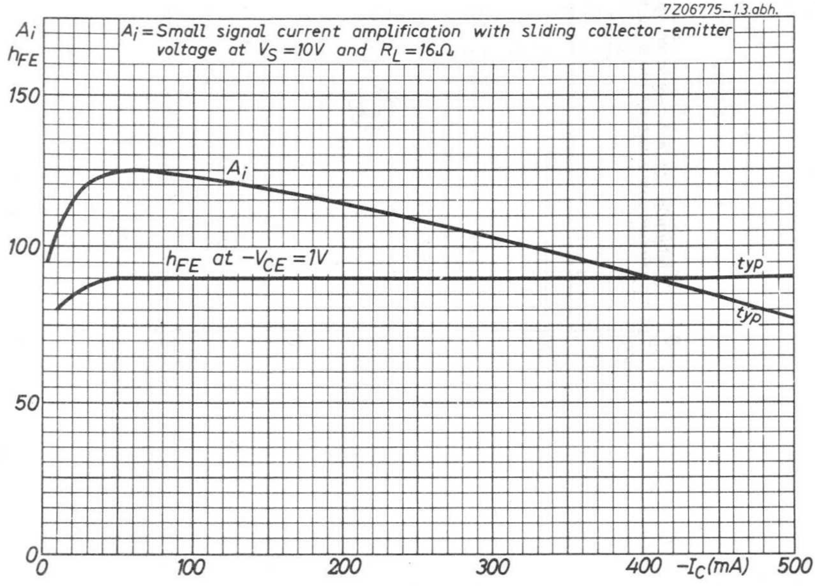

7Z06741-1.3abh
Base current versus emitter current
$-V_{CB} = 0$
$T_{amb} = 25°C$
max
typ
min
1400
I_E (mA)
1200
1000
800
600
400
200
0
0
5
10
15
20
$-I_B$(mA)25


7Z06738
$-V_{BE}$ decreases with about 2.3 mV/°C with increasing temperature
$-V_{BE}$ decreases with about 0.4 mV/°C with increasing collector-emitter voltage
Base-emitter voltage versus emitter current
$-V_{CB} = 0$
$T_{amb} = 25°C$
min
typ
max
I_E (mA)
10
8
6
4
2
0
0
50
100
150
200
$-V_{BE}$ (mV)


7Z06739-1.3abh
Base-emitter voltage versus emitter current
$-V_{CB} = 0$
$T_{amb} = 25°C$
min
typ
max
I_E (mA)
1200
1000
800
600
400
200
0
0
200
400
600
800
$-V_{BE}$ (mV)


7Z06735.1
Minimum collector-emitter voltage for which g0=0.4mΩ-1
Provisions must be made to ensure thermal stability
-VCE
(V)
40
30
20
10
0
10
10²
10³
10⁴
10⁵
ZBE(Ω)
-g0=0.4mΩ-1
-VCE
ZBE


7Z07654
1000
P_{tot}
(mW)
800
600
400
200
0
0
20
40
60
80
100
120 T_{amb}(°C)
heatsink material:
1.5mm blackened aluminium
AC128/01 on 8cm x 8cm
AC128 with clip 56227 on infinite heatsink
AC128 with clip 56227 on 12.5cm²
AC128 with clip 56227 only
AC128 without cooling accessories


7Z06775–1.3.abh.
A_i
h_{FE}
150
100
50
0
0
100
200
300
400 $-I_C$(mA)
500
A_i = Small signal current amplification with sliding collector-emitter voltage at V_S = 10V and R_L = 16Ω
A_i
h_{FE} at $-V_{CE}$ = 1V
typ
typ

GERMANIUM ALLOY TRANSISTORS

The AC132 is a p-n-p audio transistor in a TO-1 metal envelope.
The AC132 is intended for use together with the n-p-n transistor AC127 as matched pair AC127/AC132 in class B output stages with complementary symmetry.
The 2-AC132 consists of 2 transistors AC132 selected for operation in class B output stages.
The AC132/01 is electrically equivalent to the AC132, constructed integrally with a heat conducting block which gives better heat transfer.
The thermal resistance from junction to heatsink shows an improvement (≈ 10 °C/W) as compared with that obtained with the AC132 when using heat conducting clip 56227.

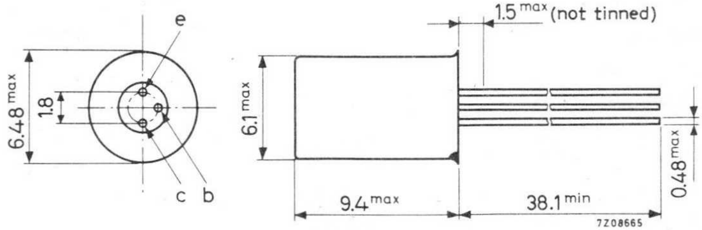
QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	12	V
Collector current (d.c.)	$-I_C$	max.	200	mA
Total power dissipation up to T_{amb} = 45 °C with cooling fin on a heatsink of at least 12.5 cm^2	P_{tot}	max.	500	mW
Junction temperature	T_j	max.	90	°C
D.C. current gain at T_{amb} = 25 °C; $-I_C$ = 20 mA; V_{CB} =0	h_{FE}	typ.	135	
Transition frequency; $-I_C$ = 10 mA; $-V_{CE}$ = 2 V	f_T	typ.	2.0	MHz

MECHANICAL DATA

Dimensions in mm

AC132

TO-1



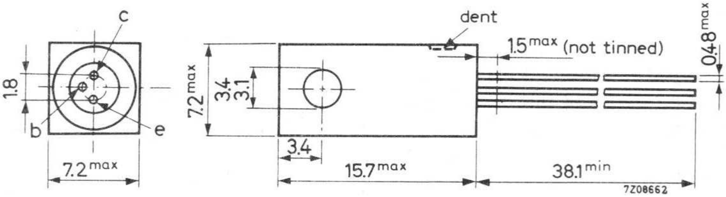
The coloured dot indicates the collector

Accessories available: 56200, 56208, 56209, 56210, 56226, 56227

MECHANICAL DATA (continued)

Dimensions in mm

AC132/01



The dent indicates the collector

RATINGS (Limiting values) [1]

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	12	V
Collector-emitter voltage with $R_{BE} < 1$ kΩ	$-V_{CER}$	max.	32	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	10	V

Currents

Collector current (d.c.)	$-I_C$	max.	200	mA
Emitter current (peak value)	I_{EM}	max.	200	mA

Power dissipation

Total power dissipation up to $T_{amb} = 45$ °C with cooling fin mounted on a heatsink of at least 12.5 cm^2	P_{tot}	max.	500	mW

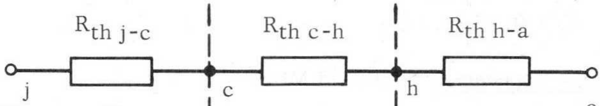
Temperatures

Storage temperature	T_{stg}		−55 to +90	°C
Junction temperature	T_j	max.	90	°C

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

THERMAL RESISTANCE

From junction to ambient in free air		AC132	AC132/01	
without cooling clip	$R_{th\ j-a}$	= 300	190	$^{o}C/W$
with cooling clip 56227 on 1.5 mm blackened Al. heatsink of 12.5 cm^2	$R_{th\ j-a}$	= 90		$^{o}C/W$
with cooling clip 56227 on infinite heatsink	$R_{th\ j-a}$	= 65		$^{o}C/W$
From junction to case	$R_{th\ j-c}$	= 50	55	$^{o}C/W$



	$R_{th\ j-c}$	$R_{th\ c-h}$	$R_{th\ h-a}$	
AC132 with clip 56227	50	15		$^{o}C/W$
AC132/01	55	0.5		$^{o}C/W$

CHARACTERISTICS

T_{amb} = 25 ^{o}C unless otherwise specified

Collector cut-off current

$I_E = 0$; $-V_{CB} = 0.5$ V	$-I_{CBO}$	<	10	μA
$I_E = 0$; $-V_{CB} = 32$ V; $T_j = 75$ ^{o}C	$-I_{CBO}$	<	800	μA

Emitter cut-off current

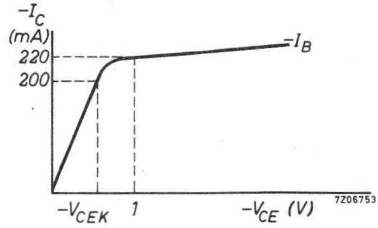
$I_C = 0$; $-V_{EB} = 5$ V; $T_j = 75$ ^{o}C	$-I_{EBO}$	<	550	μA

Emitter-base voltage

$I_E = 2$ mA; $-V_{CB} = 5$ V	V_{EB}	typ.	105	mV
$I_E = 200$ mA; $V_{CB} = 0$	V_{EB}	<	550	mV

Knee voltage

$-I_C = 200$ mA; $-I_B$ = value for which $-I_C = 220$ mA at $-V_{CE} = 1$ V	$-V_{CEK}$	<	350	mV



CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

D.C. current gain

$-I_C$ = 20 mA; V_{CB} = 0	h_{FE}	typ.	135	
$-I_C$ = 50 mA; V_{CB} = 0	h_{FE}	typ.	115	
$-I_C$ = 200 mA; V_{CB} = 0	h_{FE}	typ.	70	

Collector capacitance at f = 0.45 MHz

$I_E = I_e$ = 0; $-V_{CB}$ = 5 V	C_c	typ.	40	pF

Feedback impedance at f = 0.45 MHz

$-I_C$ = 1 mA; $-V_{CE}$ = 5 V	$\lvert z_{rb} \rvert$	typ.	90	Ω

Transition frequency

$-I_C$ = 10 mA; $-V_{CE}$ = 2 V	f_T	>	1.3	MHz
		typ.	2.0	MHz

Cut-off frequency

$-I_C$ = 10 mA; $-V_{CE}$ = 2 V	f_{hfe}	>	10	kHz
		typ.	17	kHz

Noise figure at f = 1 kHz

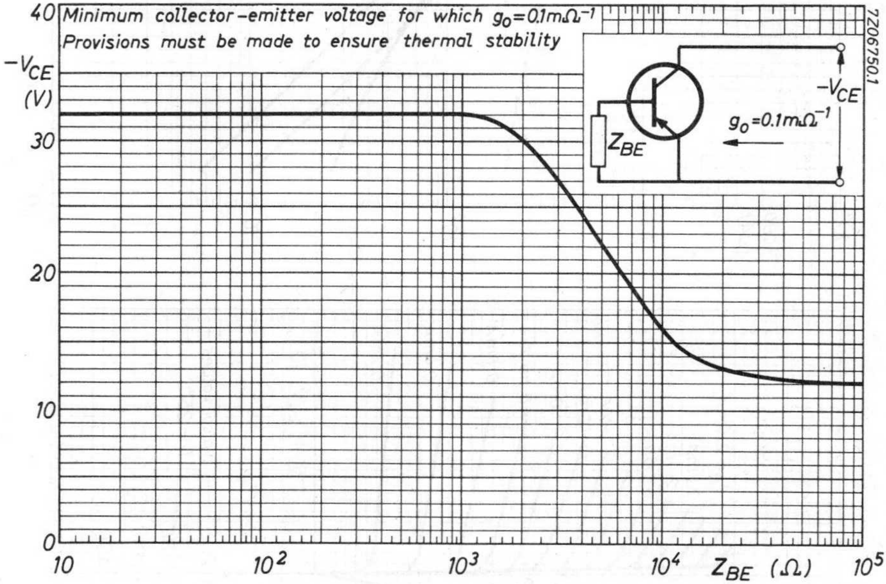
$-I_C$ = 0.5 mA; $-V_{CE}$ = 5 V; R_S = 500 Ω Bandwidth = 200 Hz	F	typ.	4	dB
		<	10	dB

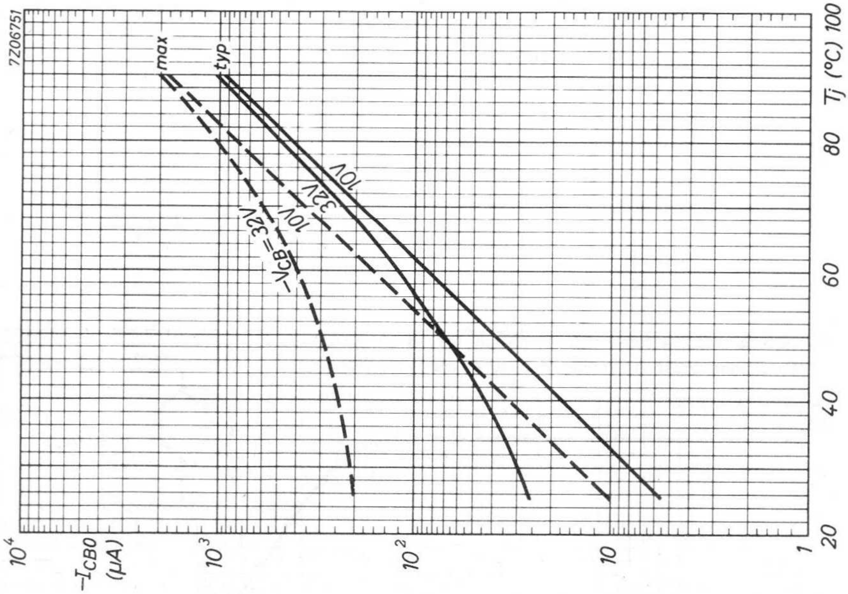
D.C. current gain ratio of
matched pair AC127/AC132

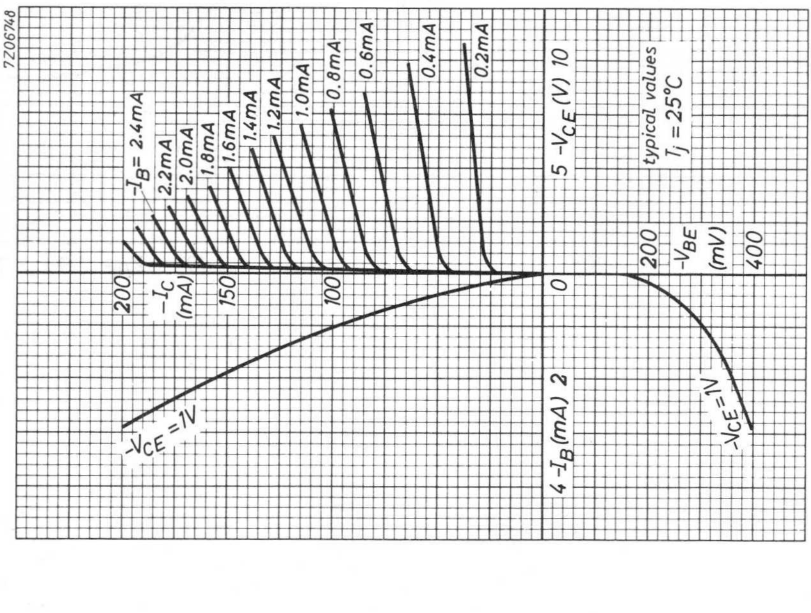
$\lvert I_C \rvert$ = 50 mA; V_{CB} = 0	h_{FE1}/h_{FE2}	typ.	1.1
		<	1.25

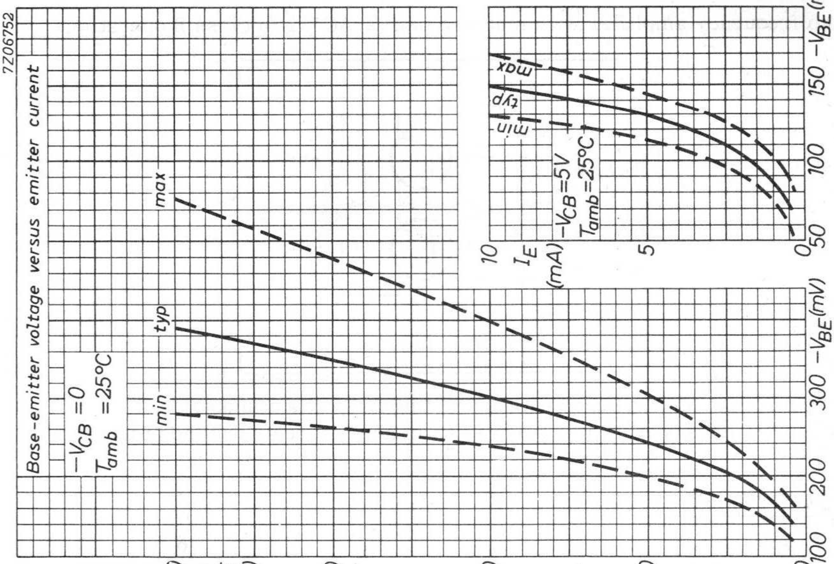
matched pair 2-AC132

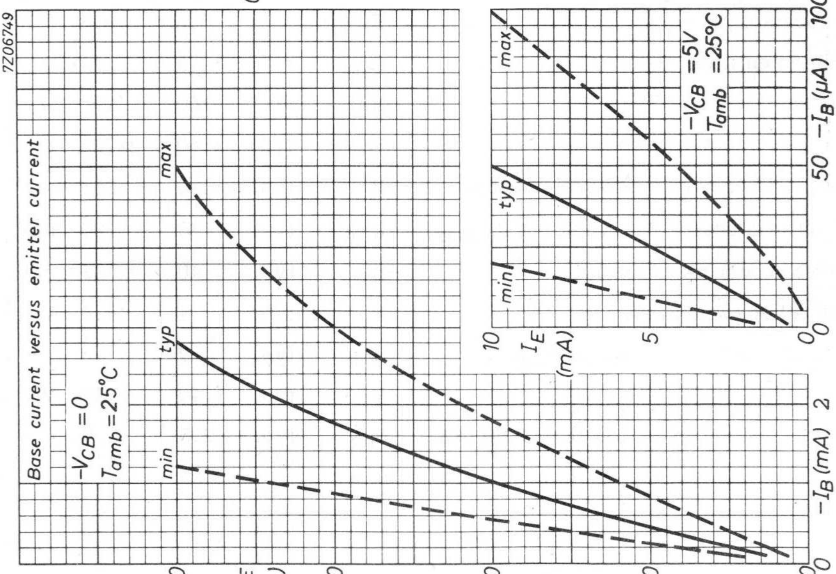
$\lvert I_C \rvert$ = 20 mA; V_{CB} = 0	h_{FE1}/h_{FE2}	typ.	1.1
		<	1.25
$\lvert I_C \rvert$ = 200 mA; V_{CB} = 0	h_{FE1}/h_{FE2}	typ.	1.1
		<	1.25


Minimum collector-emitter voltage for which $g_o = 0.1 m\Omega^{-1}$
Provisions must be made to ensure thermal stability
7Z06750.1
$-V_{CE}$ (V)
40
30
20
10
0
10
10^2
10^3
10^4
10^5
Z_{BE} (Ω)
Z_{BE}
$-V_{CE}$
$g_o = 0.1 m\Omega^{-1}$


7Z06751
$-I_{CBO}$ (μA)
10^4
10^3
10^2
10
1
max
typ
10V
32V
10V
$-V_{CB}$ = 32V
20
40
60
80
T_j (°C) 100

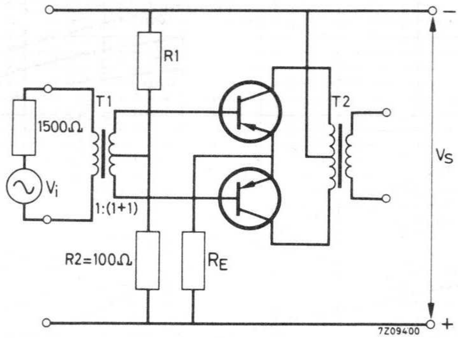

7Z06748
$-I_B$ = 2.4mA
2.2mA
2.0mA
1.8mA
1.6mA
1.4mA
1.2mA
1.0mA
0.8mA
0.6mA
0.4mA
0.2mA
200
$-I_C$ (mA)
150
100
0
5 $-V_{CE}$ (V) 10
4 $-I_B$ (mA) 2
$-V_{CE}$ = 1V
200
$-V_{BE}$ (mV)
400
$-V_{CE}$ = 1V
typical values
T_j = 25°C


7Z06752
Base-emitter voltage versus emitter current
$-V_{CB} = 0$
$T_{amb} = 25^{\circ}C$
min
typ
max
I_E (mA)
$-V_{BE}$ (mV)
$-V_{CB} = 5V$
$T_{amb} = 25^{\circ}C$
0
50
100
150
200
300
10
5


7Z06749
Base current versus emitter current
$-V_{CB} = 0$
$T_{amb} = 25^{\circ}C$
min
typ
max
I_E (mA)
$-I_B$ (mA)
$-I_B$ (μA)
$-V_{CB} = 5V$
$T_{amb} = 25^{\circ}C$
0
2
50
100
150
200
10
5

APPLICATION INFORMATION

Audio frequency amplifier with matched pair 2-AC132 in class B operation.



The transistors may be used without cooling fins or heatsinks.
Stable continuous operation is ensured at an ambient temperature of up to 45 °C.

CHARACTERISTICS T_{amb} = 25 °C

Supply voltage	V_S	=	6	9	V
Emitter current (zero signal)	I_E	=	2x1.5	2x1.5	mA
Bias resistor	R_1	=	5.6	6.8	kΩ
Common emitter resistor	R_E	=	5	14	Ω
Load resistance	$R_{cc\sim}$	=	160	292	Ω
Total power dissipation	P_{tot}	typ.	2x180	2x220	mW
Power delivered to transformer output	P_o	typ.	310	365	mW
Collector current (peak value) at $P_{o\ max}$	$-I_{CM}$	typ.	125	100	mA
Collector current at $P_{o\ max}$	$-I_C$	typ.	40	32	mA
Input voltage at $P_{o\ max}$	V_i	typ.	4	3.8	V
Total harmonic distortion at $P_{o\ max}$	d_{tot}	typ.	7	6	%
Input voltage at P_o = 50 mW	V_i	typ.	1.40	1.35	V
Total harmonic distortion at P_o = 50 mW	d_{tot}	typ.	2.5	3.0	%

GERMANIUM ALLOY TRANSISTOR

N-P-N transistor in a TO-1 metal envelope intended for use in low noise pre-amplifiers.

RATINGS Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	32	V
Collector-emitter voltage (open base)	V_{CEO}	max.	12	V
Collector-emitter voltage with $R_{BE} < 70\,\Omega$	V_{CER}	max.	32	V
Emitter-base voltage (open collector)	V_{EBO}	max.	10	V

Current

Collector current (d.c.)	I_C	max.	10	mA

Power dissipation

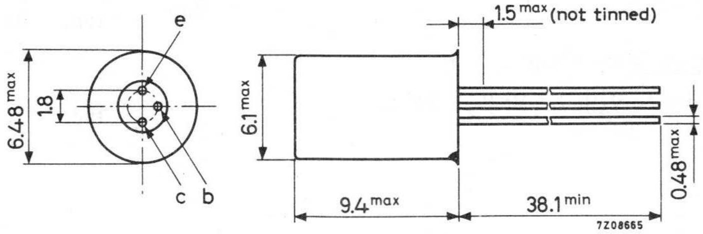
Total power dissipation up to $T_{amb} = 25\,^oC$	P_{tot}	max.	200	mW

Temperatures

Storage temperature	T_{stg}		-55 to +90	^oC
Junction temperature: continuous	T_j	max.	90	^oC
incidentally	T_j	max.	100	^oC

MECHANICAL DATA Dimensions in mm

TO-1



The coloured dot indicates the collector

Accessories available: 56200, 56208, 56209, 56210, 56226, 56227

FOR NEW DESIGN THE SUCCESSOR TYPES
BC109 OR BC149 ARE RECOMMENDED

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$ =	0.37 ^{o}C/mW

CHARACTERISTICS T_j = 25 ^{o}C unless otherwise specified

Collector cut-off current				
I_E = 0; V_{CB} = 10 V	I_{CBO}	<	10	μA
I_E = 0; V_{CB} = 32 V; T_j = 75 ^{o}C	I_{CBO}	<	900	μA
Emitter cut-off current				
I_C = 0; V_{EB} = 10 V	I_{EBO}	<	200	μA
I_C = 0; V_{EB} = 5 V; T_j = 75 ^{o}C	I_{EBO}	<	550	μA
Small signal current gain at f = 1 kHz				
I_C = 500 μA; V_{CE} = 5 V	h_{fe}	45 to 110		
Collector capacitance at f = 0.45 MHz				
I_E = I_e = 0; V_{CB} = 5 V	C_c	typ.	70	pF
Feedback impedance at f = 0.45 MHz				
I_C = 1 mA; V_{CE} = 5 V	$\|z_{rb}\|$	typ.	70	Ω
Transition frequency				
I_C = 10 mA; V_{CE} = 2 V	f_T	>	1.5	MHz
		typ.	2.5	MHz
Cut-off frequency				
I_C = 10 mA; V_{CE} = 2 V	f_{hfe}	>	10	kHz
		typ.	20	kHz
Noise figure at f = 1 kHz				
I_C = 0.5 mA; V_{CE} = 5 V; R_S = 500 Ω Bandwidth = 200 Hz	F	typ.	3	dB
		<	4	dB

GERMANIUM ALLOYED MEDIUM POWER TRANSISTORS

The AC187 is a n-p-n audio transistor in a TO-1 metal envelope.
The AC187 is primarily intended for use together with the p-n-p medium power transistor AC188 as matched pair AC187/AC188 in class B output stages with outputs up to about 3W.
The AC187/01 is electrically equivalent to the AC187, constructed integrally with a heat conducting block, which gives better heat transfer.
The thermal resistance from junction to heatsink shows an improvement (≈10 °C/W) as compared with that of the AC187 with heat conducting clip 56227.
The AC187/01 is also available as matched pair with the AC188/01.

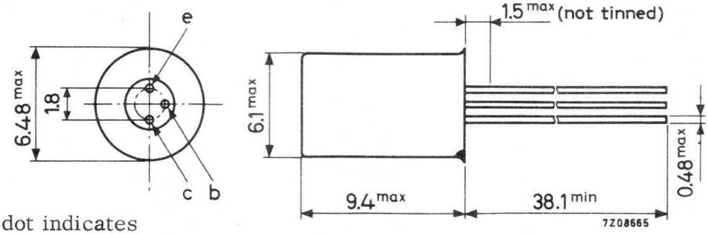
QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector current (peak value)	I_{CM}	max.	2	A
Total power dissipation up to T_{amb} = 46 °C	P_{tot}	max.	0.8	W
Junction temperature	T_j	max.	90	°C
D.C. current gain at T_j = 25 °C				
I_C = 300 mA; V_{CE} = 1 V	h_{FE}		100 to 500	
Cut-off frequency				
I_C = 10 mA; V_{CE} = 2 V	f_{hfe}	typ.	20	kHz

MECHANICAL DATA

Dimensions in mm

AC187

TO-1

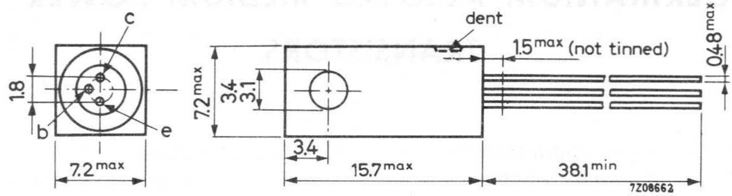


The coloured dot indicates the collector

Accessories available: 56200; 56208; 56209; 56210; 56226; 56227

MECHANICAL DATA (continued) Dimensions in mm

AC187/01



The dent indicates the collector

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector-emitter voltage $I_C \leq 600$ mA; $R_{BE} \leq 1\ \Omega$	V_{CER}	max.	18	V
Emitter-base voltage (open collector)	V_{EBO}	max.	10	V

Currents

Collector current (d.c. or average over any 50 ms period)	I_C	max.	1	A
Collector current (peak value)	I_{CM}	max.	2	A

Power dissipation

Total power dissipation up to T_{amb} = 46 °C [1])	P_{tot}	max.	0.8	W

Temperatures

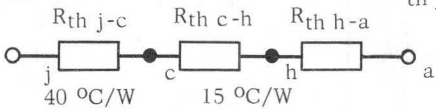
Storage temperature	T_{stg}		-55 to +75	°C
Junction temperature	T_j	max.	90	°C

1) The allowable peak power in class B speach and musical driven amplifiers is 1.1 W

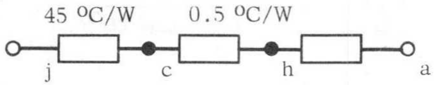
THERMAL RESISTANCE

		AC187	AC187/01	
From junction to ambient in free air				
without cooling clip	$R_{th\ j-a}$ =	290	180	°C/W
with cooling clip 56227	$R_{th\ j-a}$ =	140		°C/W
with cooling clip 56227 on 1.5mm blackened Al. heatsink of 12.5 cm^2	$R_{th\ j-a}$ =	80	70.5	°C/W
with cooling clip 56227 on infinite heatsink	$R_{th\ j-a}$ =	55		°C/W
From junction to case	$R_{th\ j-c}$ =	40	45	°C/W

AC187 with cooling clip 56227



AC187/01



CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current

I_E = 0; V_{CB} = 25 V	I_{CBO}	typ.	15	µA
		<	100	µA
I_E = 0; V_{CB} = 25 V; T_j = 90 °C	I_{CBO}	<	2.5	mA
$-V_{BE}$ = 1.0 V; V_{CE} = 25 V	I_{CEX}	<	100	µA

Emitter cut-off current

I_C = 0; V_{EB} = 10 V	I_{EBO}	typ.	15	µA
		<	100	µA
I_C = 0; V_{EB} = 10 V; T_j = 90 °C	I_{EBO}	typ.	1.2	mA
		<	2.5	mA

Base-emitter voltage

I_C = 5 mA; V_{CE} = 10 V	V_{BE}		95 to 135	mV
I_C = 300 mA; V_{CE} = 1 V	V_{BE}	<	550	mV

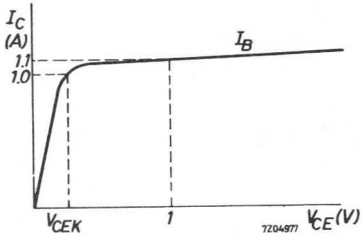
Emitter-base floating voltage

I_E = 0; V_{CB} = 25 V; T_j = 90 °C	V_{EBfl}	<	400	mV

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Knee voltage

I_C = 1 A; I_B = value for which I_C = 1.1 A at V_{CE} = 1 V	V_{CEK}	<	800	mV



D.C. current gain

I_C = 5 mA; V_{CE} = 10 V	h_{FE}	>	70	
I_C = 300 mA; V_{CE} = 1 V	h_{FE}	typ.	200	
		100 to	500	
I_C = 1 A; V_{CE} = 1 V	h_{FE}	>	50	

Collector capacitance at f = 450 kHz

$I_E = I_e = 0$; V_{CB} = 5 V	C_c	typ.	150	pF
		<	180	pF

Transition frequency

I_C = 10 mA; V_{CE} = 2 V	f_T	>	1	MHz
		typ.	5	MHz

Cut-off frequency

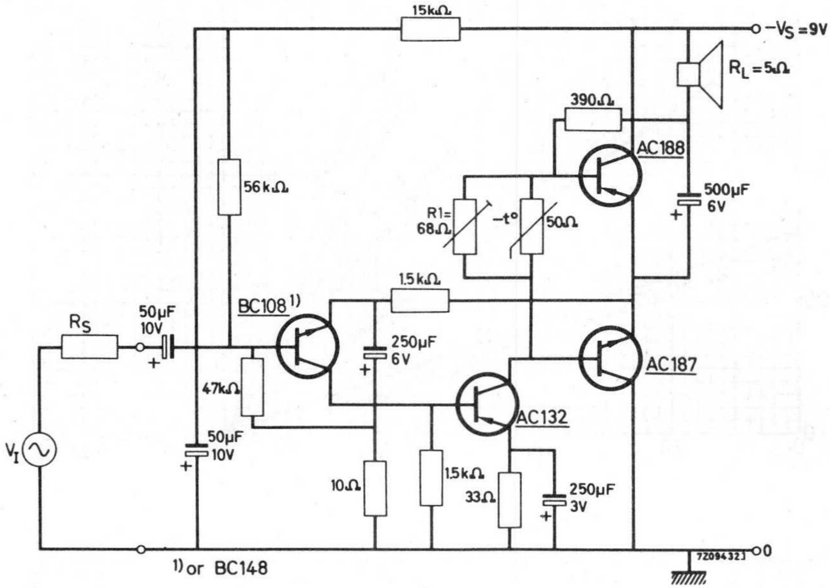
I_C = 10 mA; V_{CE} = 2 V	f_{hfe}	typ.	20	kHz

D.C. current gain ratio of matched pairs/AC187/AC188; AC187/01/AC188/01

I_C = 500 mA; V_{CE} = 1 V	h_{FE1}/h_{FE2}	<	1.25

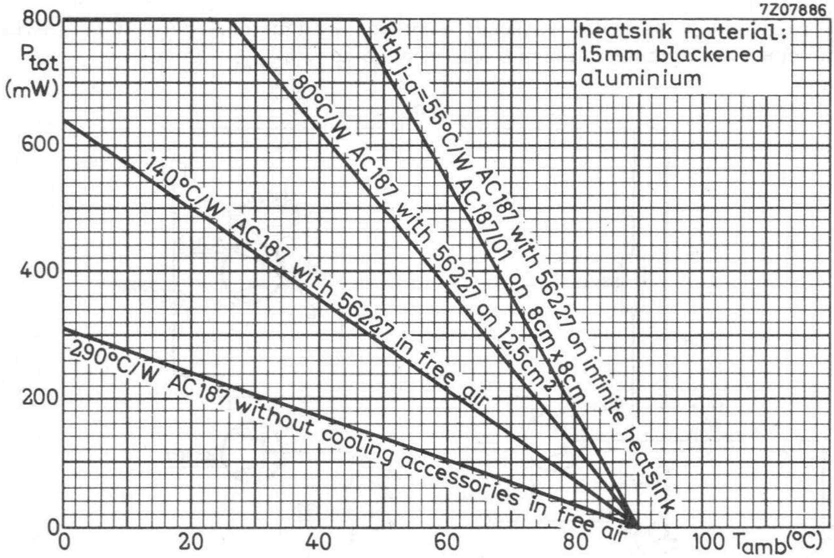
APPLICATION INFORMATION

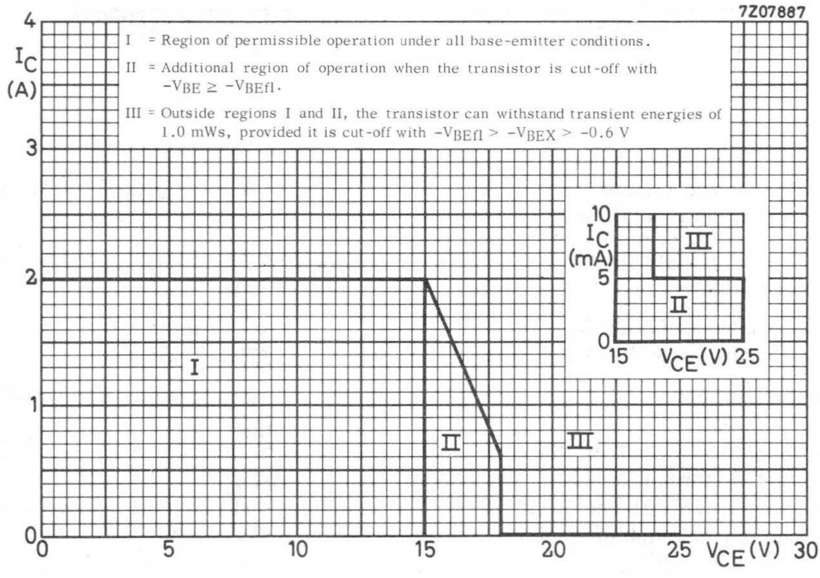
1.5 W transformerless audio frequency amplifier with matched pair AC187/AC188 in complementary symmetry class B output stage up to T_{amb} = 45 °C.

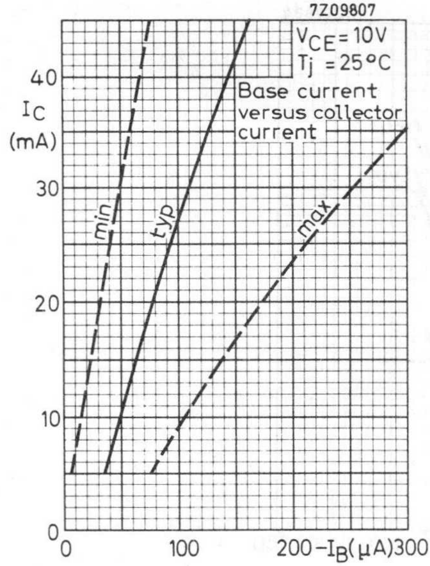


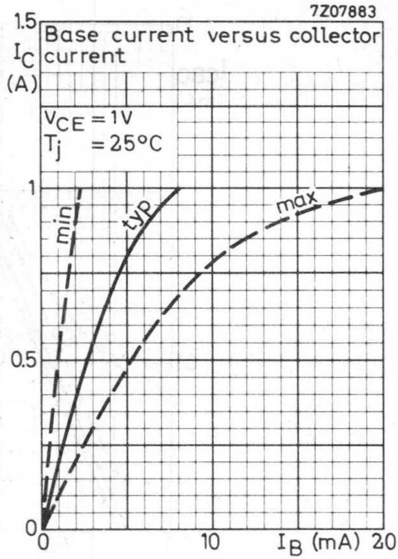
Typical input requirements for an output power of 50 mW	$V_{i\,(rms)}$ R_i	= 4 mV; $I_{i\,(rms)}$ = 0.12 μA; = 33 kΩ
Typical input requirements for an output power of 1.5 W	$V_{i\,(rms)}$ R_i	= 22 mV; $I_{i\,(rms)}$ = 0.66 μA; = 33 kΩ
Typical bandwidth (3 dB); R_S = 0	B	= 60 Hz to 65 kHz
Typical bandwidth (3 dB); R_S = 50 kΩ	B	= 65 Hz to 35 kHz
Quiescent current	$\lvert I_{cq} \rvert$	= 5 mA, adjustable with R1

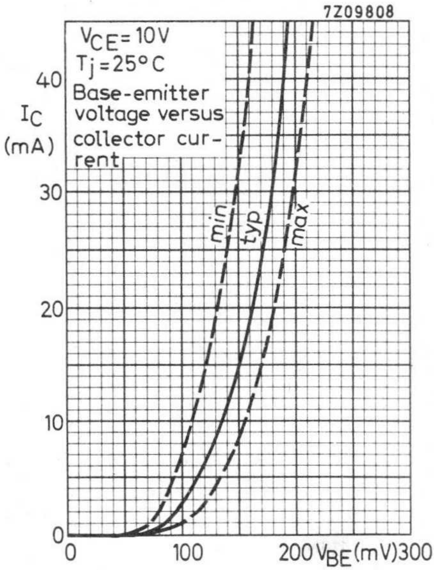
When using AC187 and AC188 each transistor should be mounted with cooling clip 56227 on 1.5 mm blackened Al. heatsink of 3 cm x 3 cm.
When using AC187/01 and AC188/01 each transistor should be mounted on 1.5 mm blackened Al. heatsink of 2.5 cm x 2.5 cm.

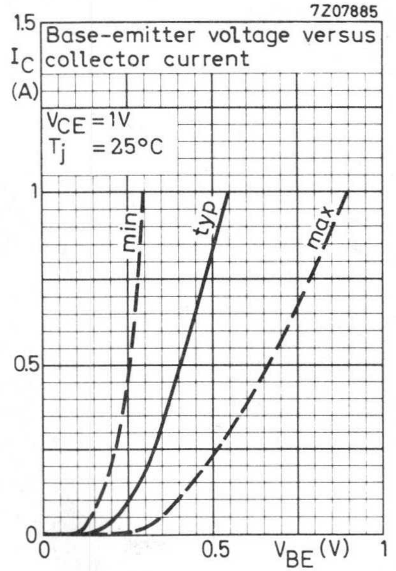

7Z07886
800
600
400
200
0
P_{tot} (mW)
heatsink material:
1.5mm blackened
aluminium
Rth j-a=55°C/W AC187 with 56227 on infinite heatsink
AC187/01 on 8cm x 8cm
80°C/W AC187 with 56227 on 12.5cm²
140°C/W AC187 with 56227 in free air
290°C/W AC187 without cooling accessories in free air
0
20
40
60
80
100 T_{amb} (°C)

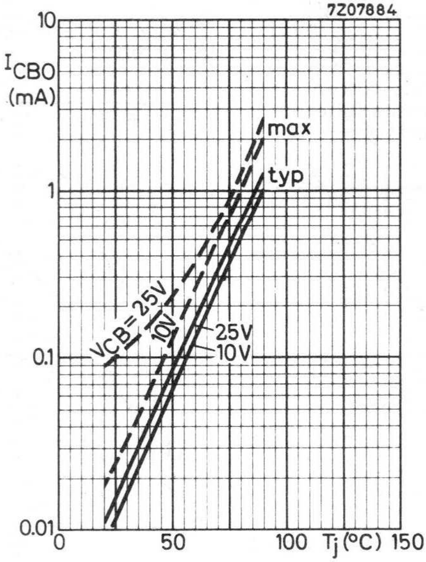

7Z07887
4
3
2
1
0
I_C (A)
I = Region of permissible operation under all base-emitter conditions.
II = Additional region of operation when the transistor is cut-off with $-V_{BE} \geq -V_{BEfl}$.
III = Outside regions I and II, the transistor can withstand transient energies of 1.0 mWs, provided it is cut-off with $-V_{BEfl} > -V_{BEX} > -0.6$ V
I
II
III
10
5
0
I_C (mA)
III
II
15
V_{CE} (V)
25
0
5
10
15
20
25 V_{CE} (V) 30


7Z09807
V_{CE} = 10V
T_j = 25°C
Base current versus collector current
I_C (mA)
min
typ
max
0
10
20
30
40
100
200
300
$-I_B$ (μA)


7Z07883
Base current versus collector current
I_C (A)
V_{CE} = 1V
T_j = 25°C
min
typ
max
0
0.5
1
1.5
10
20
I_B (mA)


7Z09808
V_{CE} = 10V
T_j = 25°C
Base-emitter voltage versus collector current
I_C (mA)
min
typ
max
0
10
20
30
40
100
200
300
V_{BE} (mV)


7Z07885
Base-emitter voltage versus collector current
I_C (A)
V_{CE} = 1V
T_j = 25°C
min
typ
max
0
0.5
1
1.5
V_{BE} (V)


7Z07884
10
I_{CBO}
(mA)
1
0.1
0.01
0
50
100
T_j (°C)
150
max
typ
V_{CB}= 25V
10V
25V
10V

GERMANIUM ALLOYED MEDIUM POWER TRANSISTORS

The AC188 is a p-n-p audio transistor in a TO-1 metal envelope.
The AC188 is primarily intended for use as matched pair 2-AC188 or together with the n-p-n medium power transistor AC187 as matched pair AC187/AC188 in class B output stages with outputs up to about 3 W.
The AC188/01 is electrically equivalent to the AC188, constructed integrally with a heat conducting block, which gives better heat transfer.
The thermal resistance from junction to heatsink shows an improvement ($\approx 10\ ^{o}C/W$) as compared with that of the AC188 with heat conducting clip 56227. The AC188/01 is also available as matched pair with the AC187/01 or as 2-AC188/01.

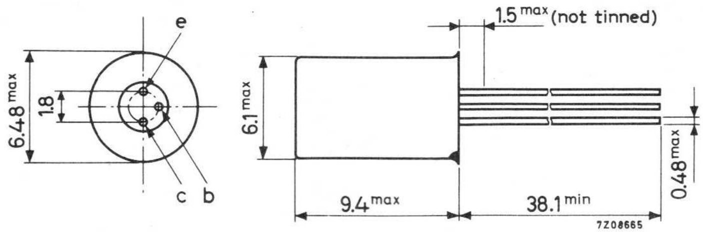
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	15	V
Collector current (peak value)	$-I_{CM}$	max.	2	A
Total power dissipation up to $T_{amb} = 46\ ^{o}C$	P_{tot}	max.	0.8	W
Junction temperature	T_j	max.	90	^{o}C
D.C. current gain at $T_j = 25\ ^{o}C$				
$-I_C = 300$ mA; $-V_{CE} = 1$ V	h_{FE}	100 to 500		
Cut-off frequency				
$-I_C = 10$ mA; $-V_{CE} = 2$ V	f_{hfe}	typ.	10	kHz

MECHANICAL DATA

AC188

TO-1

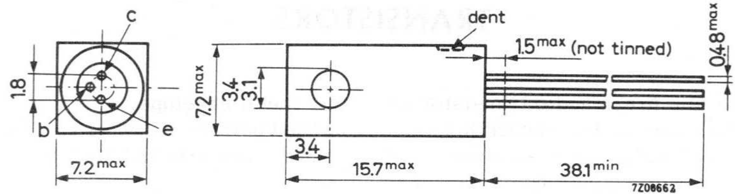


The coloured dot indicates the collector

Accessories available: 56200; 56208; 56209; 56210; 56226; 56227

MECHANICAL DATA (continued) Dimensions in mm

AC188/01



The dent indicates the collector

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	15	V
Collector-emitter voltage $-I_C \leq 600$ mA; $R_{BE} \leq 1\ \Omega$	$-V_{CER}$	max.	18	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	10	V

Currents

Collector current (d.c. or average over any 50 ms period)	$-I_C$	max.	1	A
Collector current (peak value)	$-I_{CM}$	max.	2	A

Power dissipation

Total power dissipation up to $T_{amb} = 46$ °C [1])	P_{tot}	max.	0.8	W

Temperatures

Storage temperature	T_{stg}		-55 to +75	°C
Junction temperature	T_j	max.	90	°C

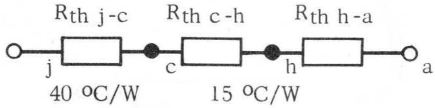
[1]) The allowable peak power in class B speach and musical driven amplifiers is 1.1 W

THERMAL RESISTANCE

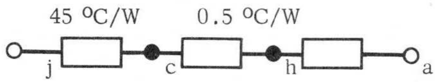
From junction to ambient in free air

			AC188	AC188/01	
without cooling clip	$R_{th\ j\text{-}a}$	=	290	180	°C/W
with cooling clip 56227	$R_{th\ j\text{-}a}$	=	140		°C/W
with cooling clip 56227 on 1.5 mm Al blackened heatsink of 12.5 cm^2	$R_{th\ j\text{-}a}$	=	80	70.5	°C/W
with cooling clip 56227 on infinite heatsink	$R_{th\ j\text{-}a}$	=	55		°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	40	45	°C/W

AC188 with cooling clip 56227



AC188/01



CHARACTERISTICS

T_j = 25 °C unless otherwise specified

<u>Collector cut-off current</u>

$I_E = 0$; $-V_{CB} = 25$ V	$-I_{CBO}$	typ.	20	μA
		<	200	μA
$I_E = 0$; $-V_{CB} = 25$ V; $T_j = 90$ °C	$-I_{CBO}$	<	1.4	mA
$+V_{BE} = 1.0$ V; $-V_{CE} = 25$ V	$-I_{CEX}$	<	200	μA

<u>Emitter cut-off current</u>

$I_C = 0$; $-V_{EB} = 10$ V	$-I_{EBO}$	typ.	15	μA
		<	200	μA
$I_C = 0$; $-V_{EB} = 10$ V; $T_j = 90$ °C	$-I_{EBO}$	typ.	0.4	mA
		<	1.4	mA

<u>Base-emitter voltage</u>

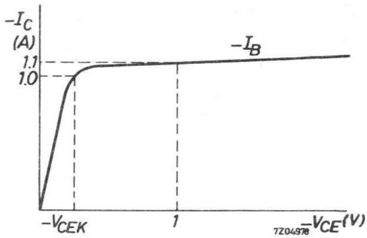
$-I_C = 5$ mA; $-V_{CE} = 10$ V	$-V_{BE}$	115 to 145		mV
$-I_C = 300$ mA; $-V_{CE} = 1$ V	$-V_{BE}$	<	450	mV

<u>Emitter-base floating voltage</u>

$I_E = 0$; $-V_{CB} = 25$ V; $T_j = 90$ °C	$-V_{EBfl}$	<	400	mV

CHARACTERISTICS (continued) $T_j = 25\,^oC$ unless otherwise specified

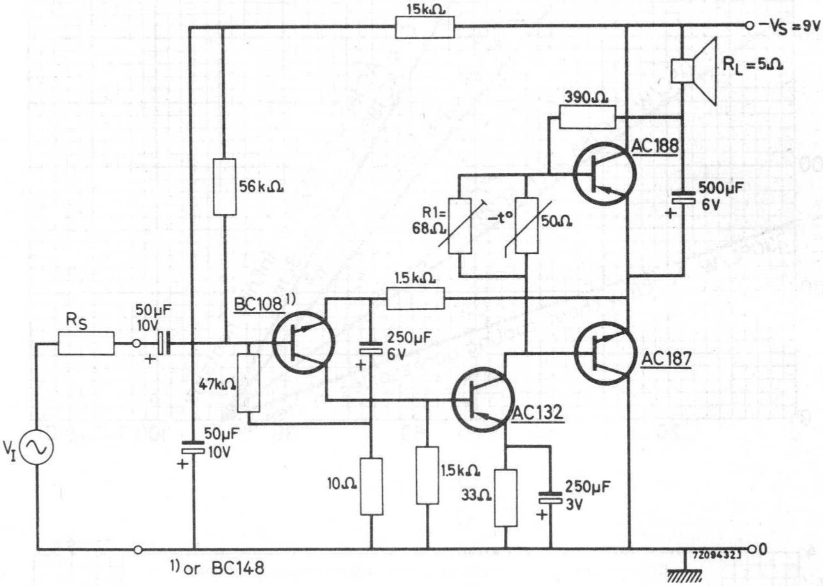
Knee voltage				
$-I_C$ = 1 A; $-I_B$ = value for which $-I_C$ = 1.1 A at $-V_{CE}$ = 1 V	$-V_{CEK}$	<	600	mV



D.C. current gain				
$-I_C$ = 5 mA; $-V_{CE}$ = 10 V	h_{FE}	>	70	
$-I_C$ = 300 mA; $-V_{CE}$ = 1 V	h_{FE}	typ. 100 to	200 500	
$-I_C$ = 1 A; $-V_{CE}$ = 1 V	h_{FE}	>	80	
Collector capacitance at f = 450 kHz				
$I_E = I_e = 0$; $-V_{CB}$ = 5 V	C_c	typ. <	90 110	pF pF
Transition frequency				
$-I_C$ = 10 mA; $-V_{CE}$ = 2 V	f_T	> typ.	1 1.5	MHz MHz
Cut-off frequency				
$-I_C$ = 10 mA; $-V_{CE}$ = 2 V	f_{hfe}	typ.	10	kHz
D.C. current gain ratio of matched pairs AC187/AC188; AC187/01/AC188/01				
$\lvert I_C \rvert$ = 500 mA; $\lvert V_{CE} \rvert$ = 1 V	h_{FE1}/h_{FE2}	<	1.25	
matched pairs 2-AC188; 2-AC188/01				
$-I_C$ = 50 mA; $-V_{CE}$ = 1 V	h_{FE1}/h_{FE2}	<	1.25	
$-I_C$ = 500 mA; $-V_{CE}$ = 1 V	h_{FE1}/h_{FE2}	<	1.25	

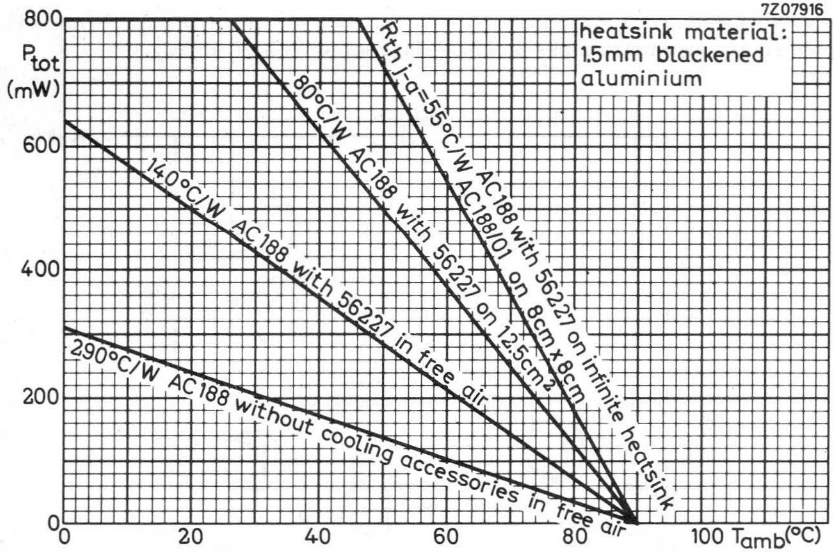
APPLICATION INFORMATION

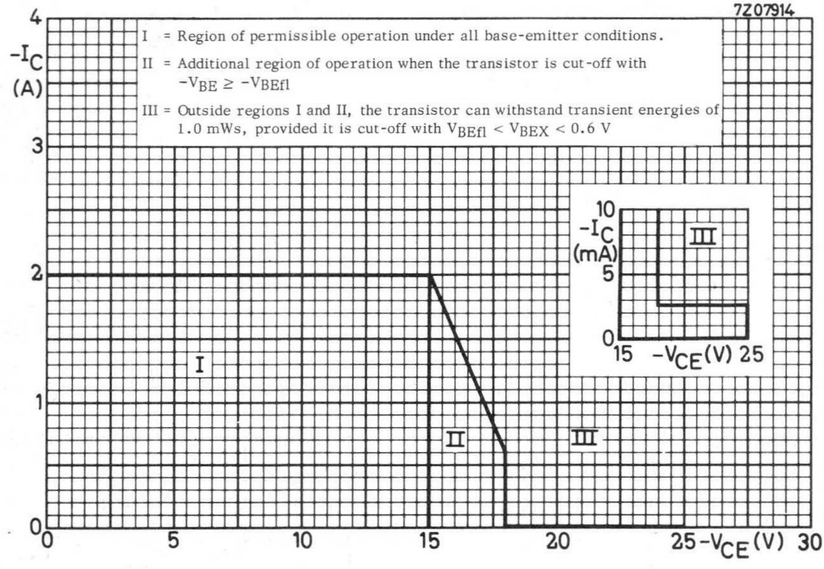
1.5 W transformerless audio frequency amplifier with matched pair AC187/AC188 in complementary symmetry class B output stage up to T_{amb} = 45 °C

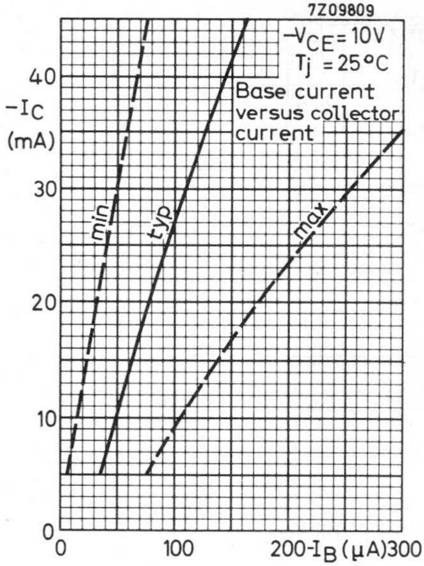


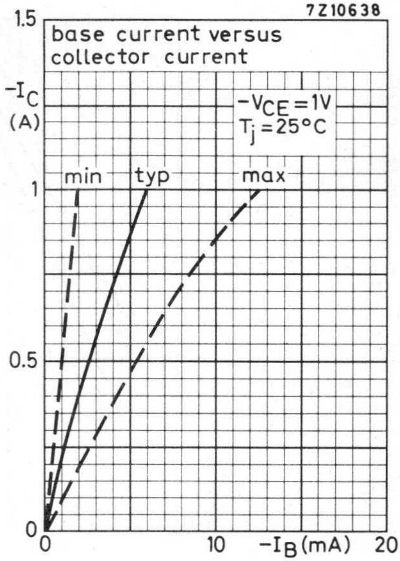
Typical input requirements for an output power of 50 mW	$V_{i(rms)}$ R_i	= 4 mV; $I_{i(rms)}$ = 0.12 µA; = 33 kΩ
Typical input requirements for an output power of 1.5 W	$V_{i(rms)}$ R_i	= 22 mV; $I_{i(rms)}$ = 0.66 µA; = 33 kΩ
Typical bandwidth (3 dB); R_S = 0	B	= 60 Hz to 65 kHz
Typical bandwidth (3 dB); R_S = 50 kΩ	B	= 65 Hz to 35 kHz
Quiescent current	$\lvert I_{cq} \rvert$	= 5 mA, adjustable with R1

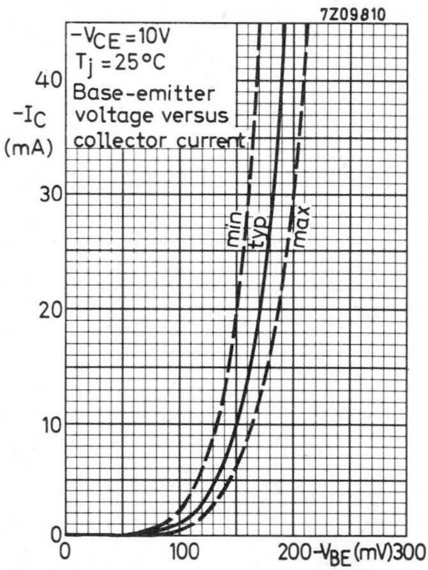
When using AC187 and AC188 each transistor should be mounted with cooling clip 56227 on 1.5 mm blackened Al. heatsink of 3 cm x 3 cm.
When using AC187/01 and AC188/01 each transistor should be mounted on 1.5 mm blackened Al. heatsink of 2.5 cm x 2.5 cm.

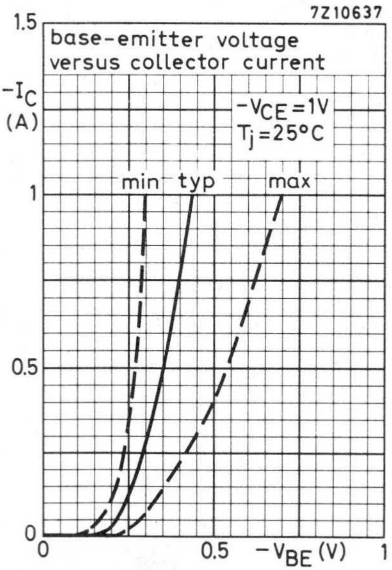

7Z07916
800
P_{tot}
(mW)
600
400
200
0
0
20
40
60
80
100 T_{amb}(°C)
heatsink material:
1.5mm blackened
aluminium
Rth j-a=55°C/W AC188 with 56227 on infinite heatsink
AC188/01 on 8cm x 8cm
80°C/W AC188 with 56227 on 12.5cm²
140°C/W AC188 with 56227 in free air
290°C/W AC188 without cooling accessories in free air

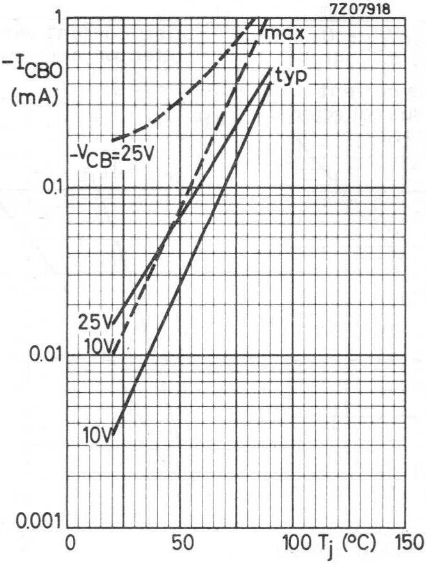

7Z07914
4
$-I_C$
(A)
3
2
1
0
0
5
10
15
20
25 $-V_{CE}$ (V) 30
I = Region of permissible operation under all base-emitter conditions.
II = Additional region of operation when the transistor is cut-off with $-V_{BE} \geq -V_{BEfl}$
III = Outside regions I and II, the transistor can withstand transient energies of 1.0 mWs, provided it is cut-off with $V_{BEfl} < V_{BEX} < 0.6$ V
I
II
III
10
$-I_C$
(mA)
5
0
15
$-V_{CE}$(V)
25
III


7Z09809
$-V_{CE}$ = 10V
T_j = 25 °C
Base current versus collector current
$-I_C$ (mA)
$-I_B$ (μA)
min
typ
max
0
10
20
30
40
100
200
300


7Z10638
base current versus collector current
$-V_{CE}$ = 1V
T_j = 25 °C
$-I_C$ (A)
$-I_B$ (mA)
min
typ
max
0
0.5
1
1.5
10
20


7Z09810
$-V_{CE}$ = 10V
T_j = 25 °C
Base-emitter voltage versus collector current
$-I_C$ (mA)
$-V_{BE}$ (mV)
min
typ
max
0
10
20
30
40
100
200
300


7Z10637
base-emitter voltage versus collector current
$-V_{CE}$ = 1V
T_j = 25 °C
$-I_C$ (A)
$-V_{BE}$ (V)
min
typ
max
0
0.5
1
1.5


7Z07918
$-I_{CBO}$ (mA)
1
0.1
0.01
0.001
max
typ
$-V_{CB}$=25V
25V
10V
10V
0
50
100 T_j (°C)
150

A.F. SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a TO-18 metal envelope with the collector connected to the case; the same transistors are available in lock-fit encapsulation under the type numbers BC147 to BC149.
The BC107 is primarily intended for use in driver stages of audio amplifiers and in signal processing circuits of television receivers.
The BC108 is suitable for a multitude of low voltage applications e.g. driver stages or audio pre-amplifiers and in signal processing circuits of television receivers.
The BC109 is primarily intended for low noise input stages in tape recorders, hi-fi amplifiers and other audio frequency equipment.

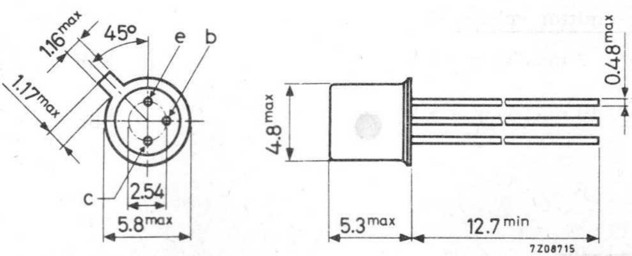
QUICK REFERENCE DATA

			BC107	BC108	BC109	
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	50	30	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	20	20	V
Collector current (peak value)	I_{CM}	max.	200	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	300	300	mW
Junction temperature	T_j	max.	175	175	175	°C
Small signal current gain at T_j = 25 °C I_C = 2 mA; V_{CE} = 5 V; f = 1 kHz	h_{fe}	> <	125 500	125 900	240 900	
Transition frequency at f = 35 MHz I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	300	300	300	MHz
Noise figure at R_S = 2 kΩ I_C = 200 μA; V_{CE} = 5 V f = 30 Hz to 15 kHz	F	typ. <			1.4 4	dB dB
f = 1 kHz; B = 200 Hz	F	typ.	2	2	1.2	dB

MECHANICAL DATA

Dimensions in mm

Collector connected to case
TO-18



Accessories available: 56246; 56263

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

			BC107	BC108	BC109	
Collector-base voltage (open emitter)	V_{CBO}	max.	50	30	30	V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	50	30	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	20	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	5	5	V

Currents

Collector current (d.c.)	I_C	max.	100	mA
Collector current (peak value)	I_{CM}	max.	200	mA
Emitter current (peak value)	$-I_{EM}$	max.	200	mA
Base current (peak value)	I_{BM}	max.	200	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	mW

Temperatures

Storage temperature	T_{stg}		-65 to +175	°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.5	°C/mW
From junction to case	$R_{th\ j-c}$	=	0.2	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

I_E = 0; V_{CB} = 20 V; T_j = 150 °C	I_{CBO}	<	15	μA

Base-emitter voltage [1]

I_C = 2 mA; V_{CE} = 5 V	V_{BE}	typ.	620	mV
		550 to	700	mV
I_C = 10 mA; V_{CE} = 5 V	V_{BE}	<	770	mV

[1] V_{BE} decreases by about 2 mV/°C with increasing temperature.

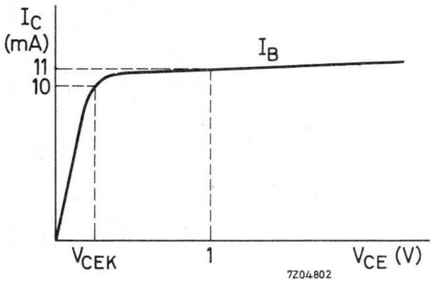
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Saturation voltages [1]

I_C = 10 mA; I_B = 0.5 mA	V_{CEsat}	typ.	90	mV
		<	250	mV
	V_{BEsat}	typ.	700	mV
I_C = 100 mA; I_B = 5 mA	V_{CEsat}	typ.	200	mV
		<	600	mV
	V_{BEsat}	typ.	900	mV

Knee voltage

I_C = 10 mA; I_B = value for which I_C = 11 mA at V_{CE} = 1 V	V_{CEK}	typ.	300	mV
		<	600	mV



Collector capacitance at f = 1 MHz

$I_E = I_e$ = 0; V_{CB} = 10 V	C_c	typ.	2.5	pF
		<	4.5	pF

Emitter capacitance at f = 1 MHz

$I_C = I_c$ = 0; V_{EB} = 0.5 V	C_e	typ.	9	pF

Transition frequency at f = 35 MHz

I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	300	MHz

Small signal current gain at f = 1 kHz

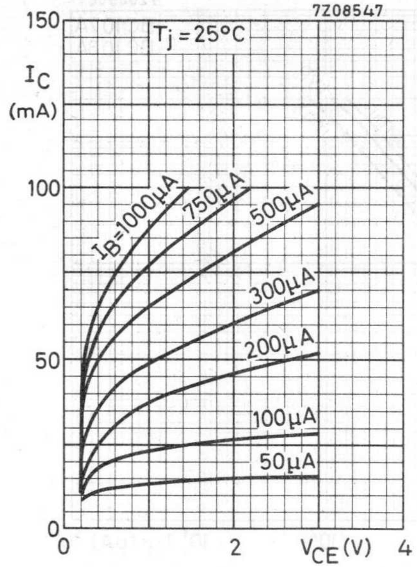
			BC107	BC108	BC109	
I_C = 2 mA; V_{CE} = 5 V	h_{fe}	>	125	125	240	
		<	500	900	900	
Noise figure at R_S = 2 kΩ; I_C = 200 μA; V_{CE} = 5 V						
f = 30 Hz to 15 kHz	F	typ.			1.4	dB
		<			4	dB
f = 1 kHz; B = 200 Hz	F	typ.	2	2	1.2	dB
		<	10	10	4	dB

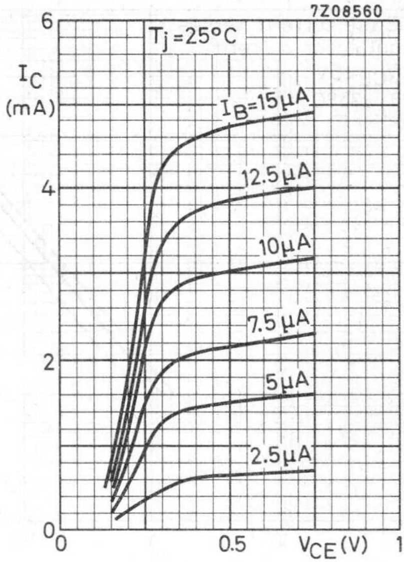
[1] V_{BEsat} decreases by about 1.7 mV/°C with increasing temperature.

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

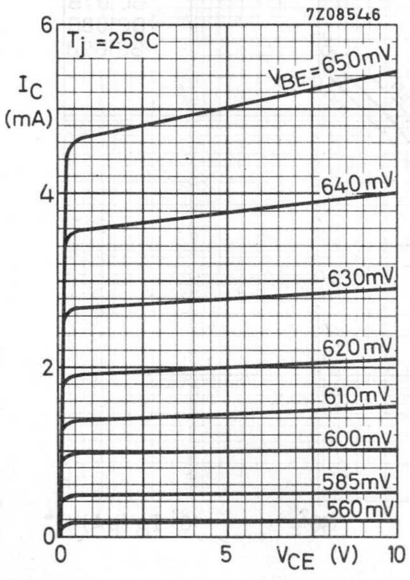
			BC107A BC108A	BC107B BC108B BC109B	BC108C BC109C	
D.C. current gain						
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	>		40	100	
		typ.	90	150	270	
I_C = 2 mA; V_{CE} = 5 V	h_{FE}	>	110	200	420	
		typ.	180	290	520	
		<	220	450	800	
h parameters at f = 1 kHz (common emitter)						
I_C = 2 mA; V_{CE} = 5 V						
Input impedance	h_{ie}	>	1.6	3.2	6	kΩ
		typ.	2.7	4.5	8.7	kΩ
		<	4.5	8.5	15	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	1.5	2	3	10^{-4}
Small signal current gain	h_{fe}	>	125	240	450	
		typ.	220	330	600	
		<	260	500	900	
Output admittance	h_{oe}	typ.	18	30	60	$\mu\Omega^{-1}$
		<	30	60	110	$\mu\Omega^{-1}$

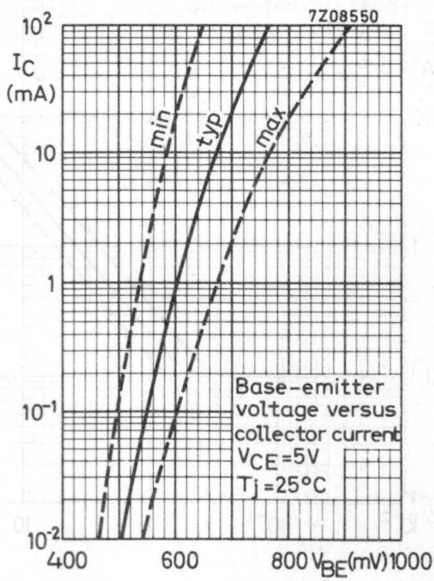
Typical behaviour of collector current versus collector-emitter voltage



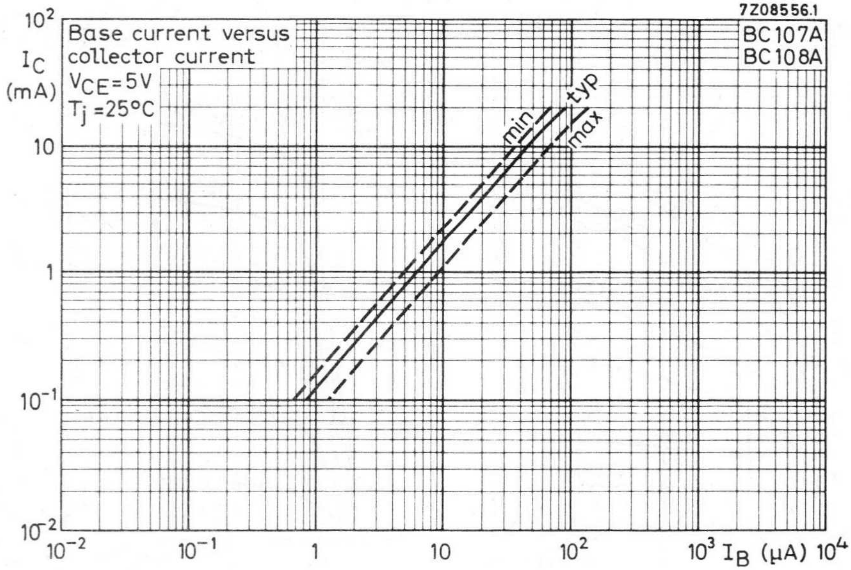


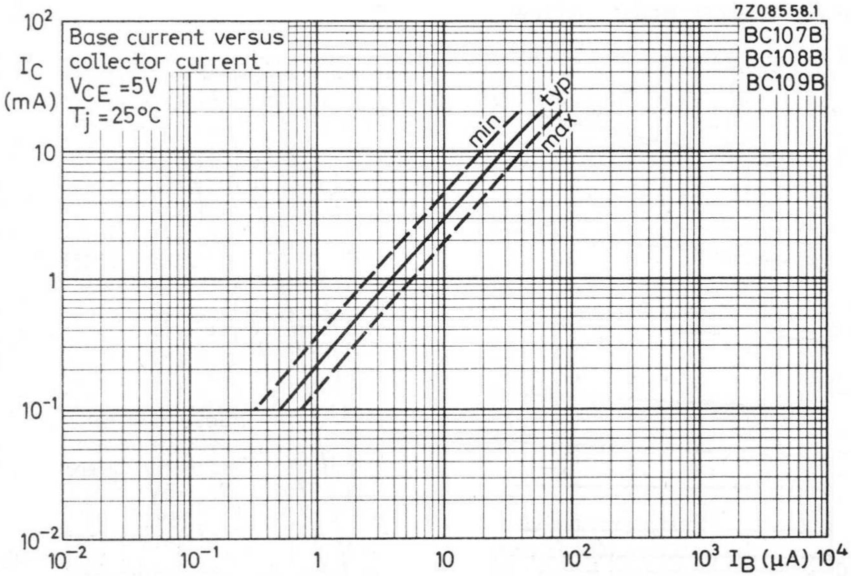
Typical behaviour of collector current versus collector-emitter voltage

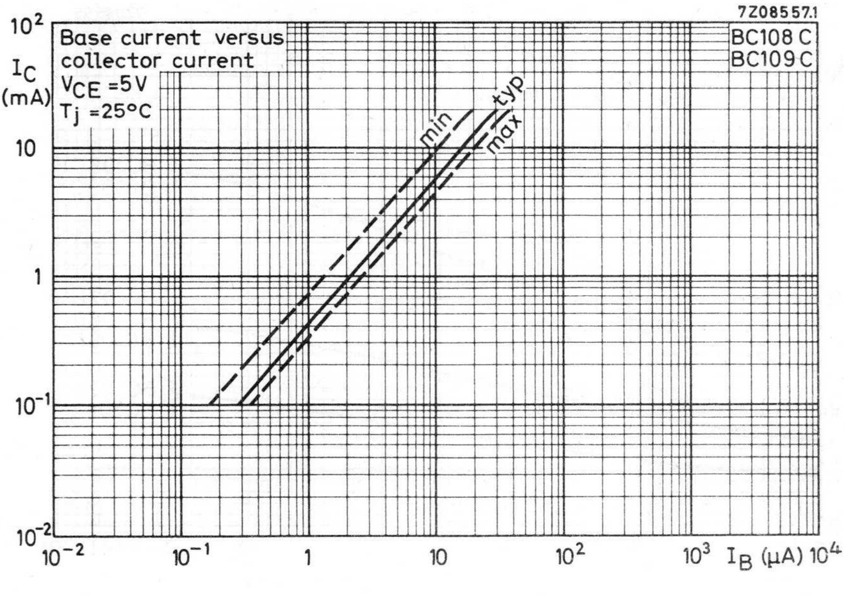


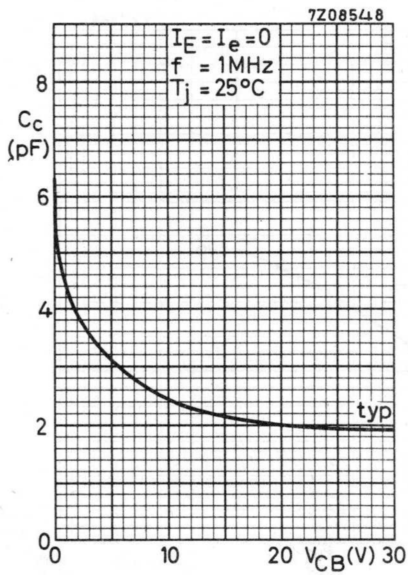


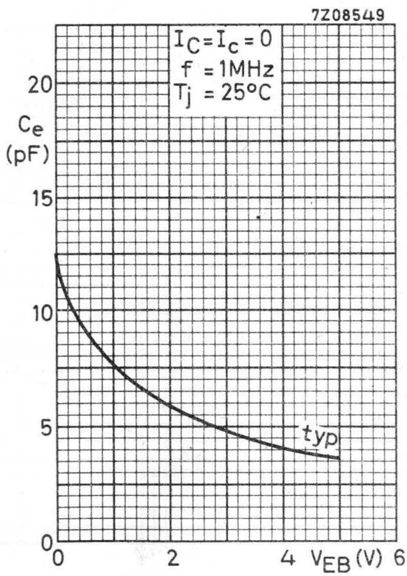
Base-emitter voltage versus collector current
V_{CE} = 5V
T_j = 25°C

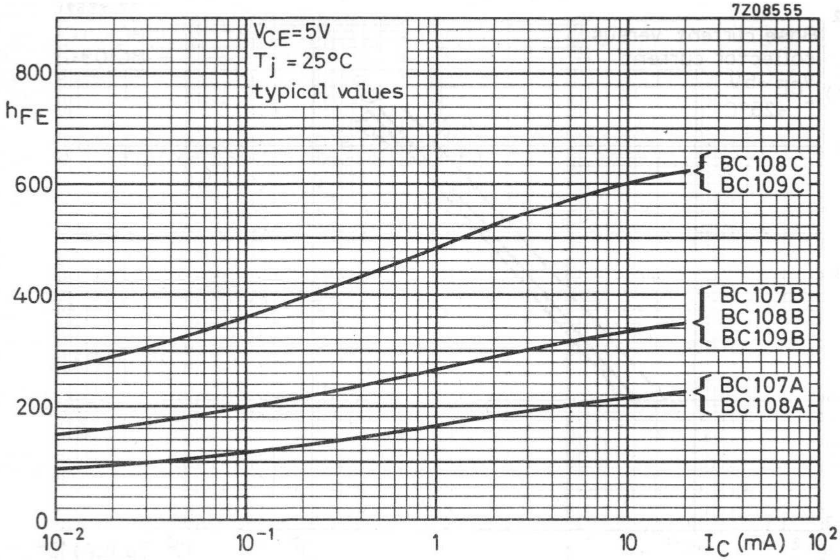

7Z08556.1
Base current versus collector current
V_{CE}=5V
T_j=25°C
BC107A
BC108A
I_C (mA)
I_B (μA)
min
typ
max
10^2
10
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1
10
10^2
10^3
10^4

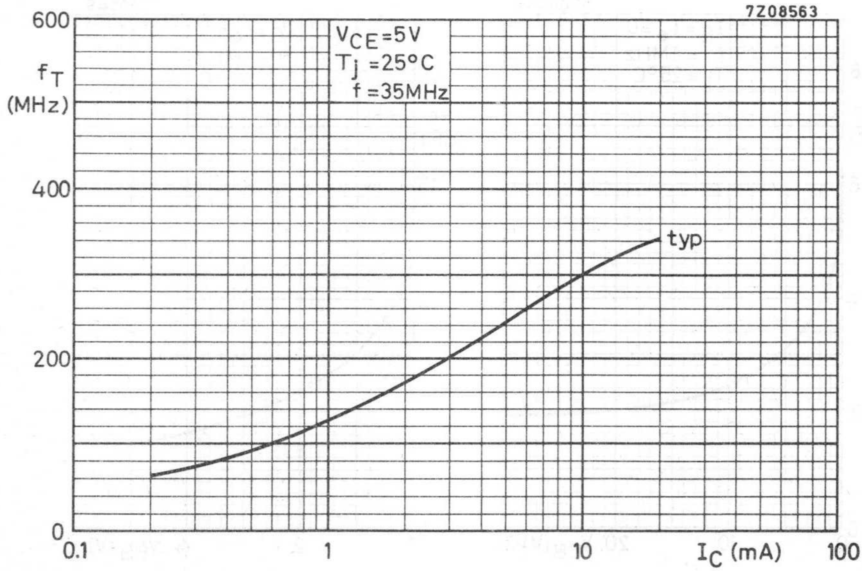

7Z08558.1
Base current versus collector current
V_{CE}=5V
T_j=25°C
BC107B
BC108B
BC109B
I_C (mA)
I_B (μA)
min
typ
max
10^2
10
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1
10
10^2
10^3
10^4


7Z08557.1
Base current versus
collector current
V_{CE} =5V
T_j =25°C
BC108 C
BC109 C
10^2
I_C
(mA)
10
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (μA) 10^4
min
typ
max

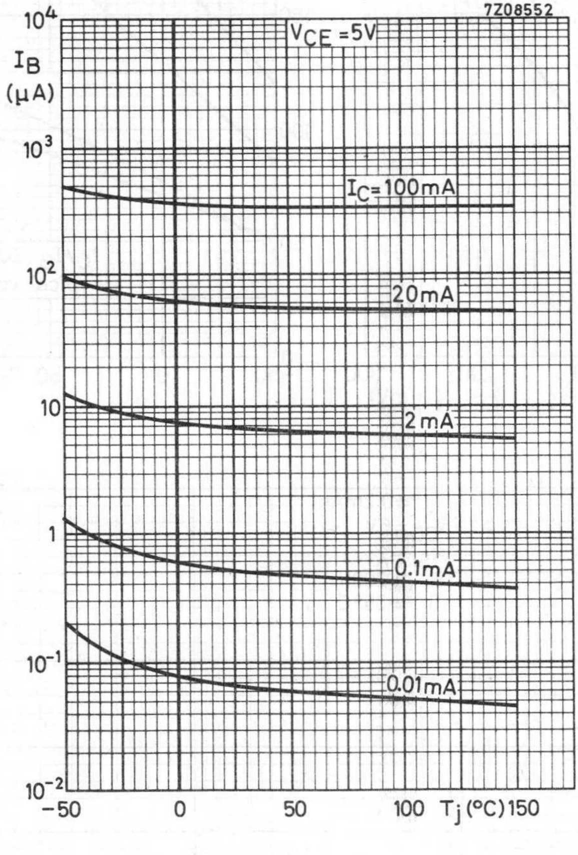

7Z08548
$I_E = I_e = 0$
f = 1MHz
T_j = 25°C
C_c
(pF)
8
6
4
2
0
0
10
20
V_{CB}(V) 30
typ

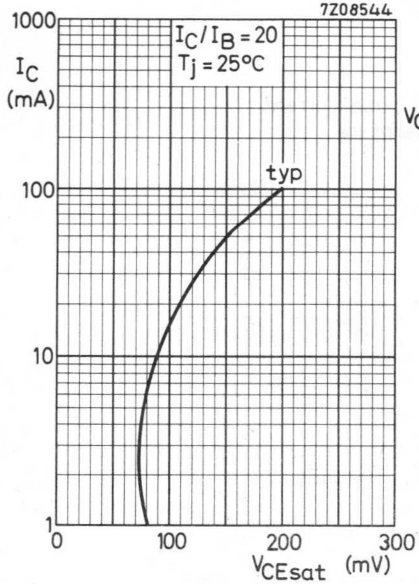

7Z08549
$I_C = I_c = 0$
f = 1MHz
T_j = 25°C
C_e
(pF)
20
15
10
5
0
0
2
4
V_{EB} (V) 6
typ

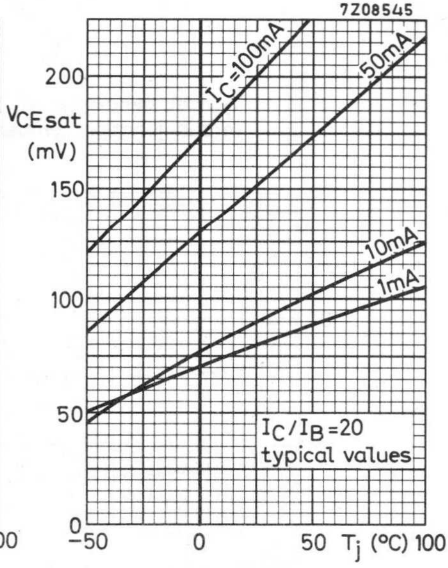

7Z08555
V_{CE}=5V
T_j = 25°C
typical values
h_{FE}
800
600
400
200
0
BC 108 C
BC 109 C
BC 107 B
BC 108 B
BC 109 B
BC 107 A
BC 108 A
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

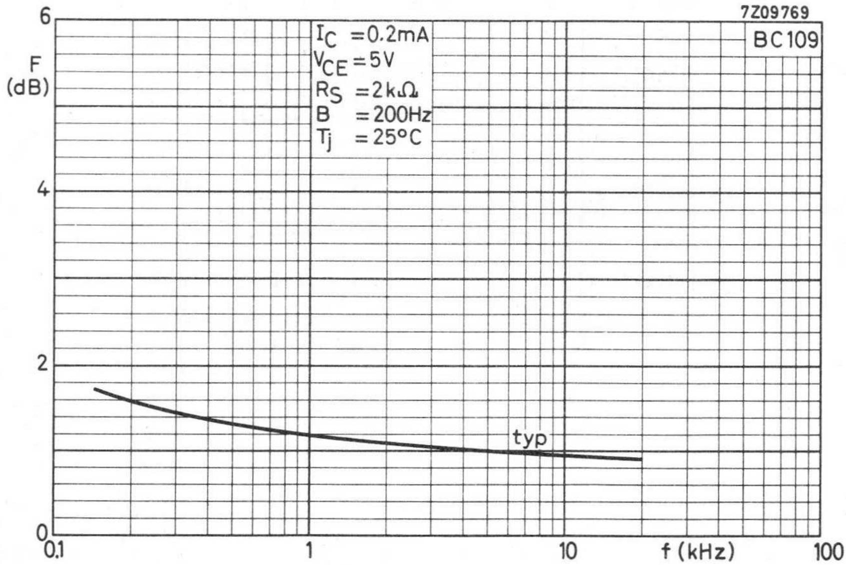

7Z08563
V_{CE}=5V
T_j =25°C
f =35MHz
f_T
(MHz)
600
400
200
0
typ
0.1
1
10
I_C (mA)
100

Typical behaviour of base current versus junction temperature

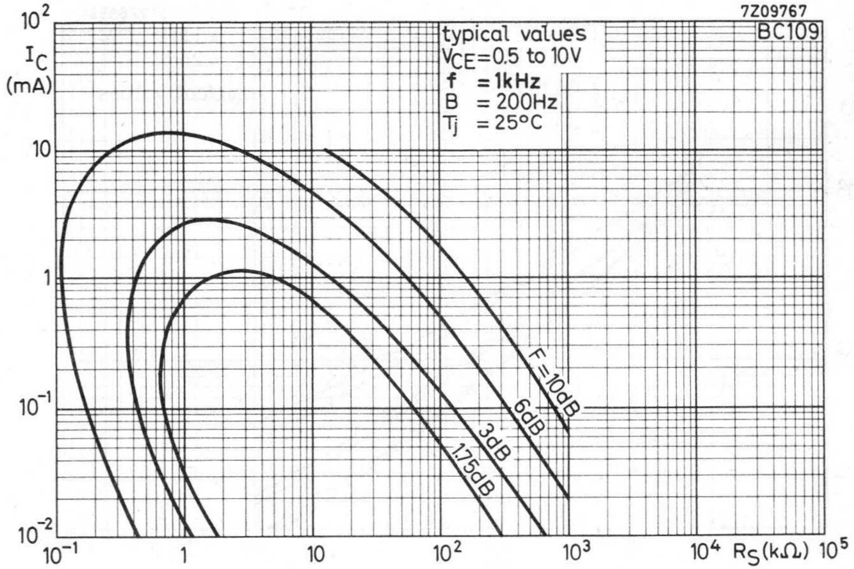


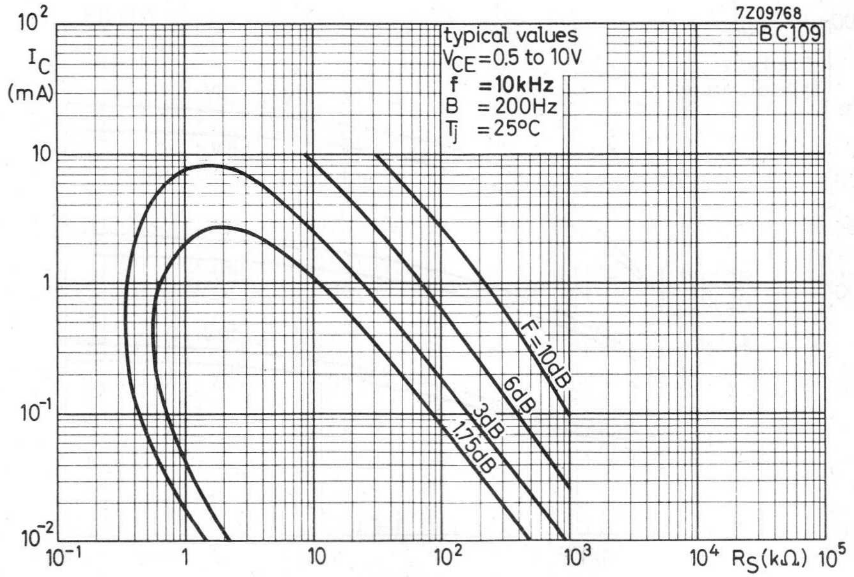

7Z08544
1000
I_C
(mA)
100
10
1
0
100
200
300
V_{CEsat} (mV)
$I_C/I_B = 20$
$T_j = 25°C$
typ

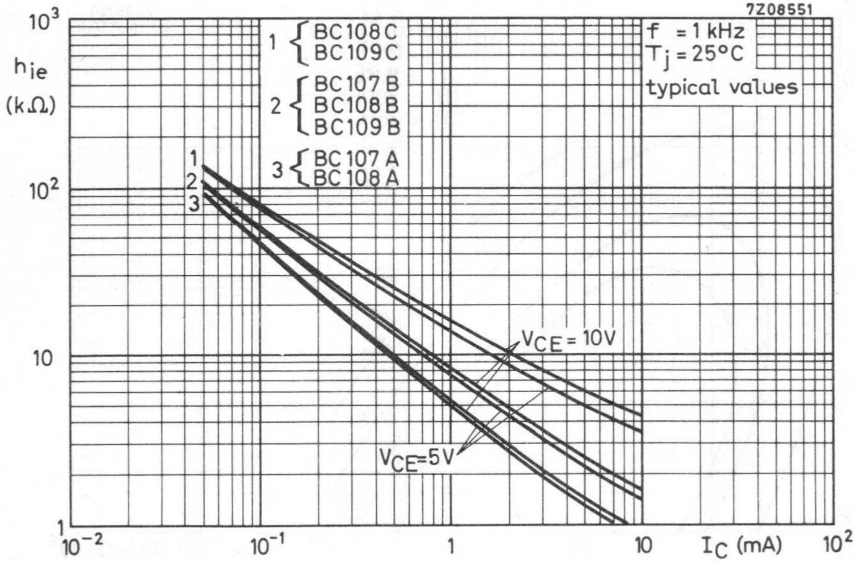

7Z08545
200
V_{CEsat}
(mV)
150
100
50
0
−50
0
50
T_j (°C)
100
I_C=100mA
50mA
10mA
1mA
I_C/I_B=20
typical values

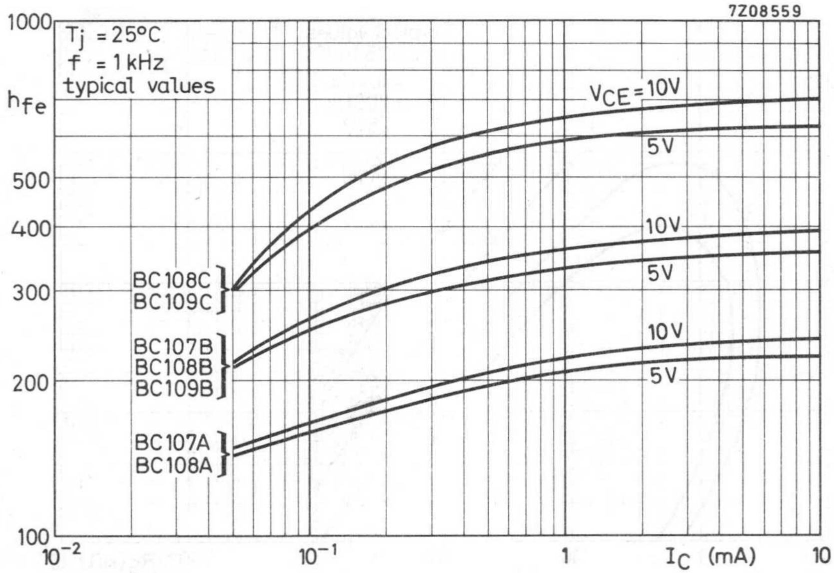

7Z09769
BC109
6
F
(dB)
4
2
0
0.1
1
10
f (kHz)
100
I_C = 0.2mA
V_{CE} = 5V
R_S = 2kΩ
B = 200Hz
T_j = 25°C
typ

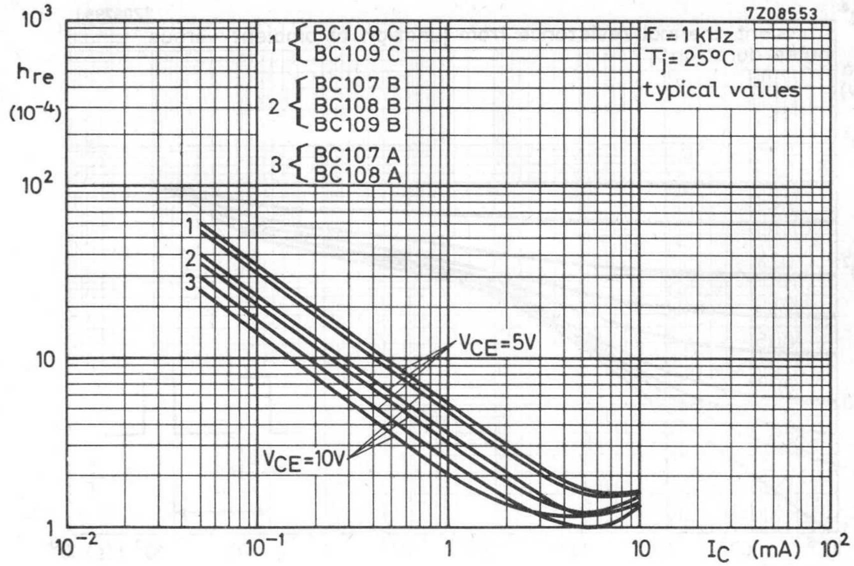
Curves of constant noise figure

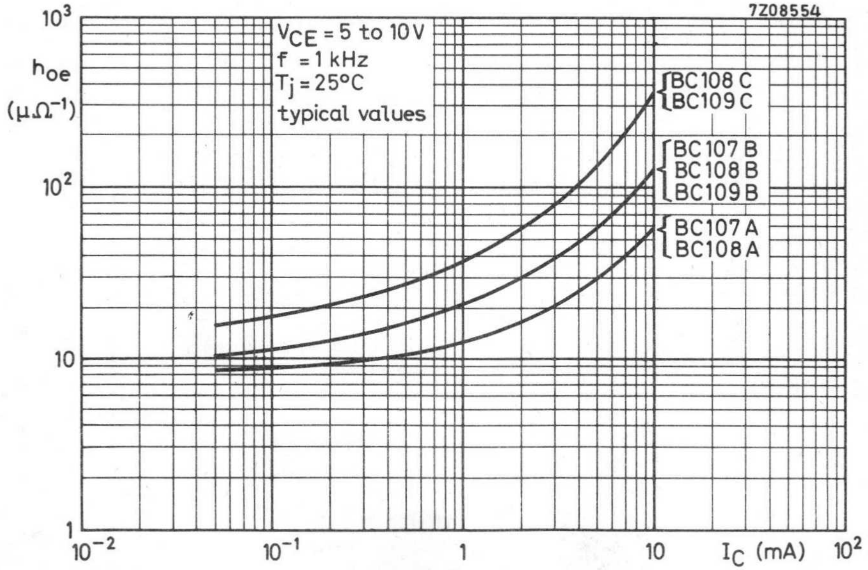


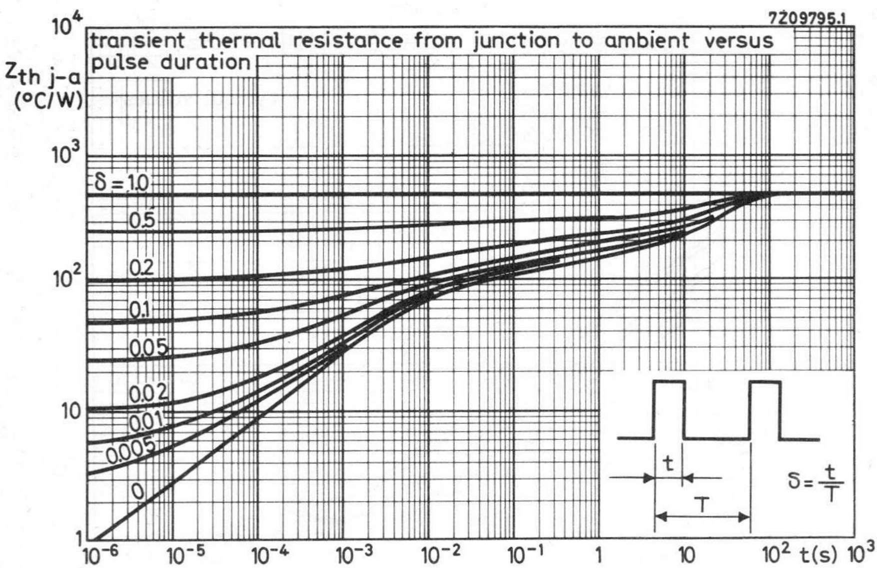



7Z08551
f = 1 kHz
T_j = 25°C
typical values
1 { BC108C BC109C
2 { BC107B BC108B BC109B
3 { BC107A BC108A
h_{ie} (kΩ)
V_{CE} = 10V
V_{CE}=5V
I_C (mA)
10^3
10^2
10
1
10^{-2}
10^{-1}
1
10
10^2


7Z08559
T_j = 25°C
f = 1 kHz
typical values
h_{fe}
V_{CE} = 10V
5V
10V
5V
10V
5V
BC108C BC109C
BC107B BC108B BC109B
BC107A BC108A
I_C (mA)
1000
500
400
300
200
100
10^{-2}
10^{-1}
1
10


7Z08553
h_{re}
(10^{-4})
1 { BC108 C BC109 C
2 { BC107 B BC108 B BC109 B
3 { BC107 A BC108 A
f = 1 kHz
Tj = 25°C
typical values
V_{CE}=5V
V_{CE}=10V
I_C (mA)


7Z08554
h_{oe}
$(\mu\Omega^{-1})$
V_{CE} = 5 to 10 V
f = 1 kHz
Tj = 25°C
typical values
BC108 C BC109 C
BC107 B BC108 B BC109 B
BC107 A BC108 A
I_C (mA)


7Z09795.1
transient thermal resistance from junction to ambient versus pulse duration
$Z_{th\ j-a}$ (°C/W)
10^4
10^3
10^2
10
1
δ = 1.0
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t(s)
10^3
t
T
δ = t/T

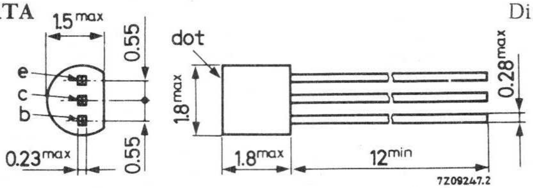
SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a microminiature plastic envelope. The BC146 is designed for hearing aids, watches and other equipment where small size is of paramount importance.

QUICK REFERENCE DATA

			red	yellow	green	
Collector-base voltage (open emitter)	V_{CBO}	max.	20	20	20	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	20	20	V
Collector current (d.c.)	I_C	max.	50	50	50	mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	50	50	50	mW
Junction temperature	T_j	max.	125	125	125	°C
D.C. current gain I_C = 0.2 mA; V_{CE} = 0.5 V	h_{FE}	>	80	140	280	
		<	200	350	550	
Noise figure at R_S = 2 kΩ I_C = 0.2 mA; V_{CE} = 5 V Bandwidth: f = 30 Hz to 15 kHz	F	typ.	2	1.5	2	dB
		<	-	4	-	dB

MECHANICAL DATA Dimensions in mm



Coloured dot on top of the black body

MOUNTING INSTRUCTIONS

To avoid damaging the transistor, welded or soldered connections must be made with care; the following general recommendations should be observed:

1. The temperature of the soldering iron must be less than 250 °C and the soldering time less than 3 seconds at a lead length of not less than 1.5 mm.
2. To keep the heat capacity low, the smallest possible amount of solder should be used.
3. If the plastic capsule of the transistor makes contact with any other structure, care must be taken that its temperature never exceeds 125 °C.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	20	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4	V

Currents

Collector current (d.c.)	I_C	max.	50	mA
Collector current (peak value)	I_{CM}	max.	50	mA

Power dissipation

Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	50	mW

Temperatures

→ Storage temperature	T_{stg}		−65 to +125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	1.6	°C/mW

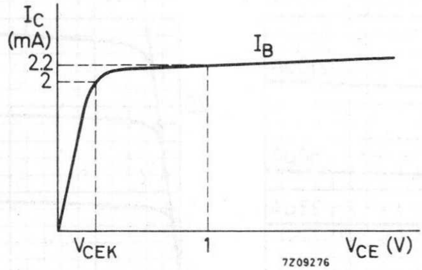
CHARACTERISTICS T_j = 25 °C unless otherwise specified

Base-emitter voltage

I_C = 0.2 mA; V_{CE} = 0.5 V	V_{BE}	typ.	570	mV
I_C = 2 mA; V_{CE} = 1 V	V_{BE}	typ.	630	mV

Knee voltage

I_C = 2 mA; I_B = value for which
I_C = 2.2 mA at V_{CE} = 1 V — V_{CEK} typ. 180 mV



Collector capacitance at f = 1 MHz

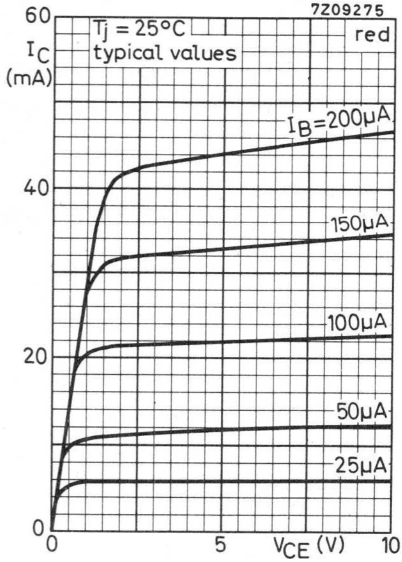
I_E = I_e = 0; V_{CB} = 5 V — C_c typ. 4 pF

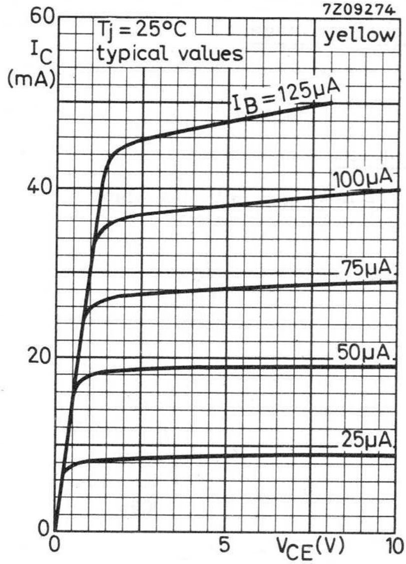
Transition frequency

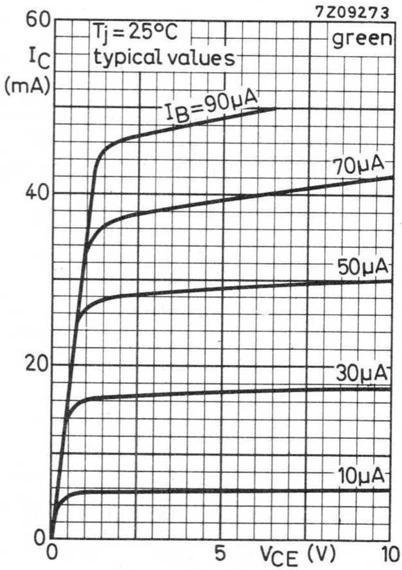
I_C = 2 mA; V_{CE} = 5 V — f_T typ. 150 MHz

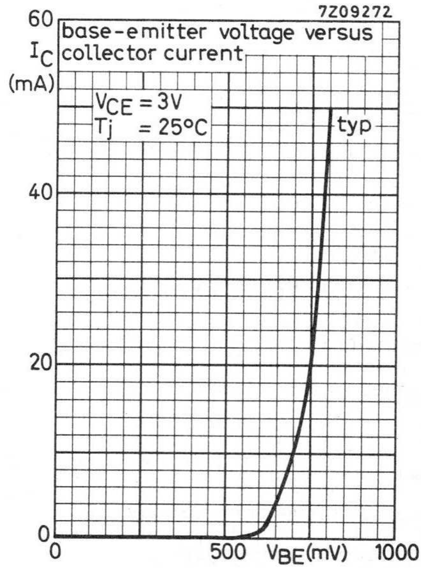
D.C. current gain

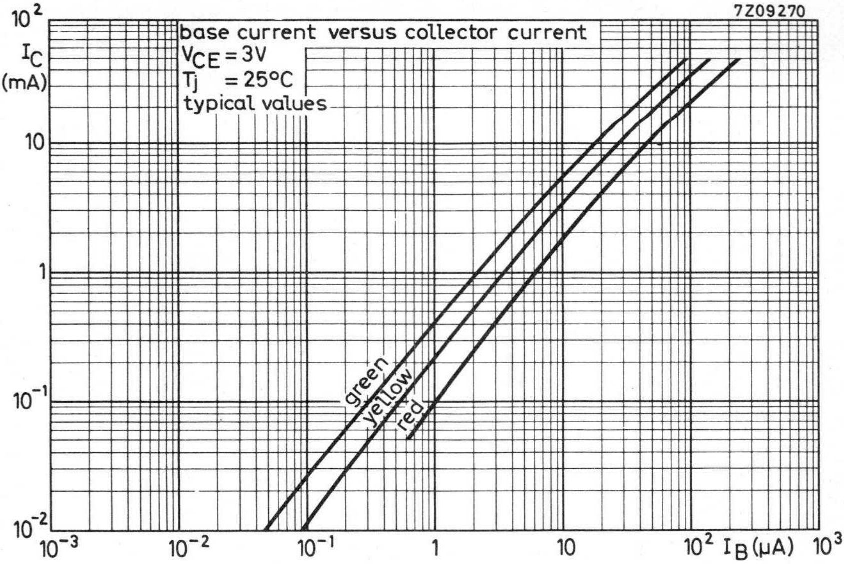
			red	yellow	green	
I_C = 0.2 mA; V_{CE} = 0.5 V	h_{FE}	typ.	115	220	380	
			80 to 200	140 to 350	280 to 550	
I_C = 2 mA; V_{CE} = 1 V	h_{FE}	>	100	140	280	
Noise figure						
I_C = 0.2 mA; V_{CE} = 5 V; R_S = 2 kΩ; Bandwidth: f = 30 Hz to 15 kHz	F	typ.	2	1.5	2	dB
		<	–	4	–	dB
h parameters at f = 1 kHz; I_C = 0.2 mA; V_{CE} = 0.5 V						
Input impedance	h_{ie}	typ.	20	30	45	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	15	25	40	10^{-4}
Small signal current gain	h_{fe}	typ.	130	220	380	
Output admittance	h_{oe}	typ.	15	20	35	$\mu\Omega^{-1}$

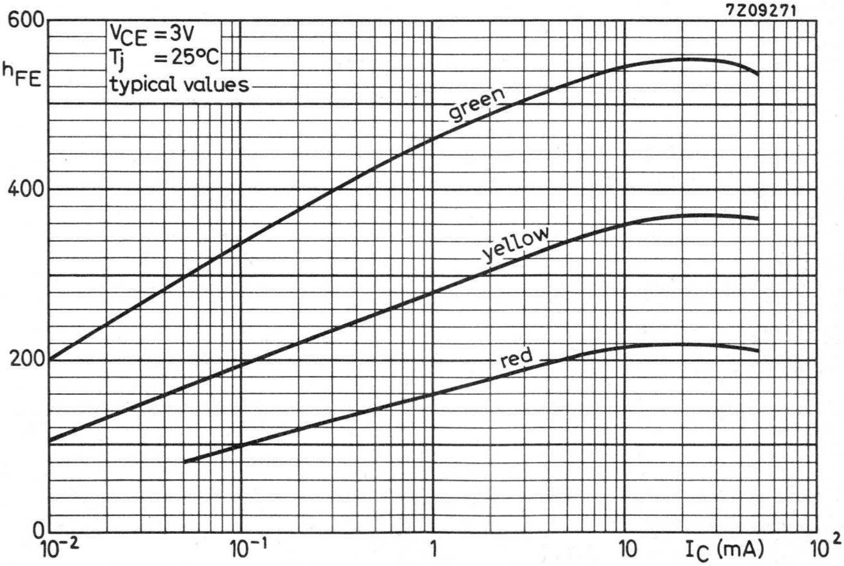

7Z09275
Tj = 25°C
typical values
red
I_C (mA)
I_B=200µA
150µA
100µA
50µA
25µA
V_{CE} (V)
0
5
10
20
40
60


7Z09274
Tj = 25°C
typical values
yellow
I_C (mA)
I_B=125µA
100µA
75µA
50µA
25µA
V_{CE} (V)
0
5
10
20
40
60


7Z09273
Tj = 25°C
typical values
green
I_C (mA)
I_B=90µA
70µA
50µA
30µA
10µA
V_{CE} (V)
0
5
10
20
40
60


7Z09272
base-emitter voltage versus
collector current
I_C (mA)
V_{CE} = 3V
Tj = 25°C
typ
V_{BE}(mV)
0
500
1000
20
40
60


7Z09270
base current versus collector current
$V_{CE} = 3V$
$T_j = 25°C$
typical values
I_C (mA)
10^2
10
1
10^{-1}
10^{-2}
green
yellow
red
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
I_B (μA)
10^3


7Z09271
$V_{CE} = 3V$
$T_j = 25°C$
typical values
h_{FE}
600
400
200
0
green
yellow
red
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

A.F. SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a plastic envelope with stiff, self-locking pins suitable for use with standard printed boards.

The BC147 is primarily intended for use in driver stages of audio amplifiers and in signal processing circuits of television receivers.

The BC148 is suitable for a multitude of low voltage applications e.g. driver stages or audio pre-amplifiers and in signal processing circuits of television receivers.

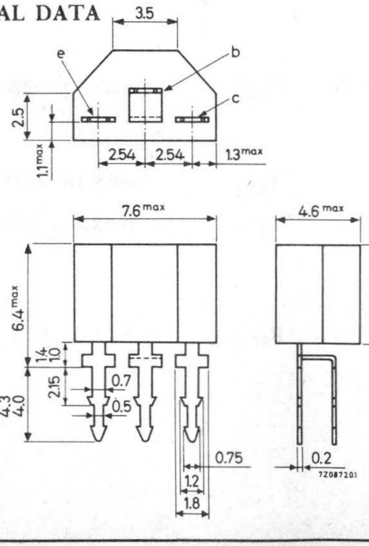
The BC149 is primarily intended for low noise input stages in tape recorders, hi-fi amplifiers and other audio frequency equipment.

QUICK REFERENCE DATA

			BC147	BC148	BC149	
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	50	30	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	20	20	V
Collector current (peak value)	I_{CM}	max.	200	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	250	250	250	mW
Junction temperature	T_j	max.	125	125	125	°C
Small signal current gain at T_j = 25 °C						
I_C = 2 mA; V_{CE} = 5 V; f = 1 kHz	h_{fe}	>	125	125	240	
		<	500	900	900	
Transition frequency at f = 35 MHz						
I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	300	300	300	MHz
Noise figure at R_S = 2 kΩ						
I_C = 200 μA; V_{CE} = 5 V						
f = 30 Hz to 15 kHz	F	typ.			1.4	dB
		<			4	dB
f = 1 kHz; B = 200 Hz	F	typ.	2	2	1.2	dB

MECHANICAL DATA

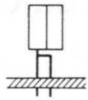
Dimensions in mm



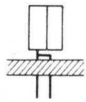
The envelope fulfils the accelerated damp heat test described in IEC publication 68-2 (test D, severity IV, 6 cycles)

MOUNTING INSTRUCTIONS

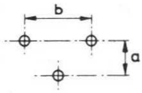
1. Thickness of printed board: max. 1.1 mm
   Hole diameter 0.77 to 0.83 mm



2. Thickness of printed board: max. 1.7 mm
   Hole diameter 1.25 to 1.35 mm



Bore plan



a = 2.49 to 2.59 mm
b = 5.03 to 5.13 mm

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

			BC147	BC148	BC149	
Collector-base voltage (open emitter)	V_{CBO}	max.	50	30	30	V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	50	30	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	20	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	5	5	V

Currents

Collector current (d.c.)	I_C	max.	100	mA
Collector current (peak value)	I_{CM}	max.	200	mA
Emitter current (peak value)	$-I_{EM}$	max.	200	mA
Base current (peak value)	I_{BM}	max.	200	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	250	mW

Temperatures

Storage temperature	T_{stg}		-65 to +125	°C
Junction temperature	T_j	max.	125	°C

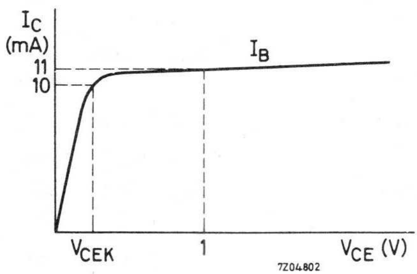
THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.4	°C/mW

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 125\ ^oC$	I_{CBO}	<	5	μA
Base-emitter voltage [1]				
$I_C = 2$ mA; $V_{CE} = 5$ V	V_{BE}	typ.	620	mV
		550 to	700	mV
$I_C = 10$ mA; $V_{CE} = 5$ V	V_{BE}	<	770	mV
Saturation voltages [2]				
$I_C = 10$ mA; $I_B = 0.5$ mA	V_{CEsat}	typ.	90	mV
		<	250	mV
	V_{BEsat}	typ.	700	mV
$I_C = 100$ mA; $I_B = 5$ mA	V_{CEsat}	typ.	200	mV
		<	600	mV
	V_{BEsat}	typ.	900	mV
Knee voltage				
$I_C = 10$ mA; I_B = value for which $I_C = 11$ mA at $V_{CE} = 1$ V	V_{CEK}	typ.	300	mV
		<	600	mV



Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	2.5	pF
		<	4.5	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	typ.	9	pF
Transition frequency at f = 35 MHz				
$I_C = 10$ mA; $V_{CE} = 5$ V	f_T	typ.	300	MHz

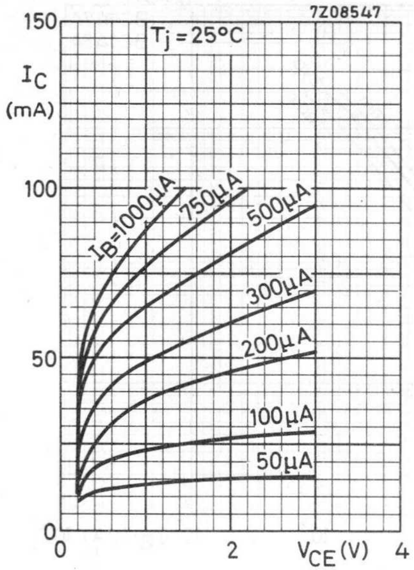
1) V_{BE} decreases by about 2 mV/^oC with increasing temperature.
2) V_{BEsat} decreases by about 1.7 mV/^oC with increasing temperature.

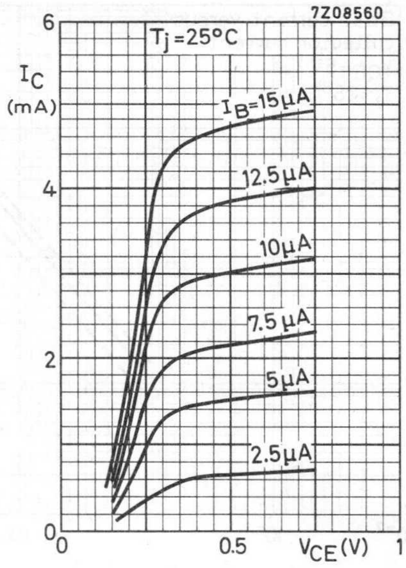
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

			BC147	BC148	BC149
Small signal current gain at f = 1 kHz					
I_C = 2 mA; V_{CE} = 5 V	h_{fe}	>	125	125	240
		<	500	900	900
Noise figure at R_S = 2 kΩ					
I_C = 200 μA; V_{CE} = 5 V					
f = 30 Hz to 15 kHz	F	typ.			1.4 dB
		<			4 dB
f = 1 kHz; B = 200 Hz	F	typ.	2	2	1.2 dB
		<	10	10	4 dB

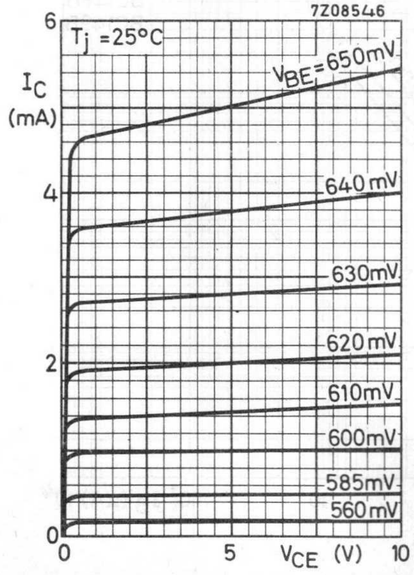
			BC147A BC148A	BC147B BC148B BC149B	BC148C BC149C
D.C. current gain					
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	typ.	90	150	270
		>	110	200	420
I_C = 2 mA; V_{CE} = 5 V	h_{FE}	typ.	180	290	520
		<	220	450	800
h parameters at f = 1 kHz (common emitter)					
I_C = 2 mA; V_{CE} = 5 V					
		>	1.6	3.2	6 kΩ
Input impedance	h_{ie}	typ.	2.7	4.5	8.7 kΩ
		<	4.5	8.5	15 kΩ
Reverse voltage transfer ratio	h_{re}	typ.	1.5	2	3 10^{-4}
		>	125	240	450
Small signal current gain	h_{fe}	typ.	220	330	600
		<	260	500	900
Output admittance	h_{oe}	typ.	18	30	60 $\mu\Omega^{-1}$
		<	30	60	110 $\mu\Omega^{-1}$

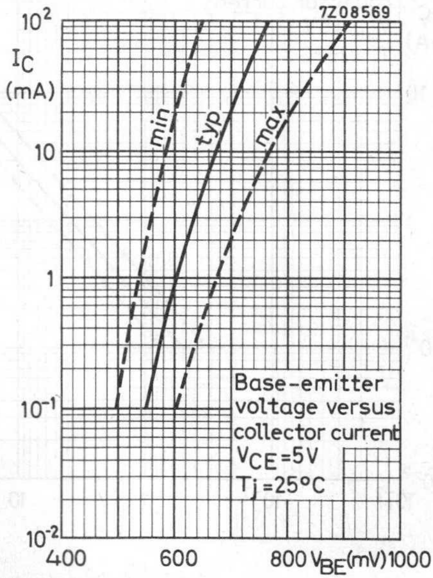
Typical behaviour of collector current versus collector-emitter voltage

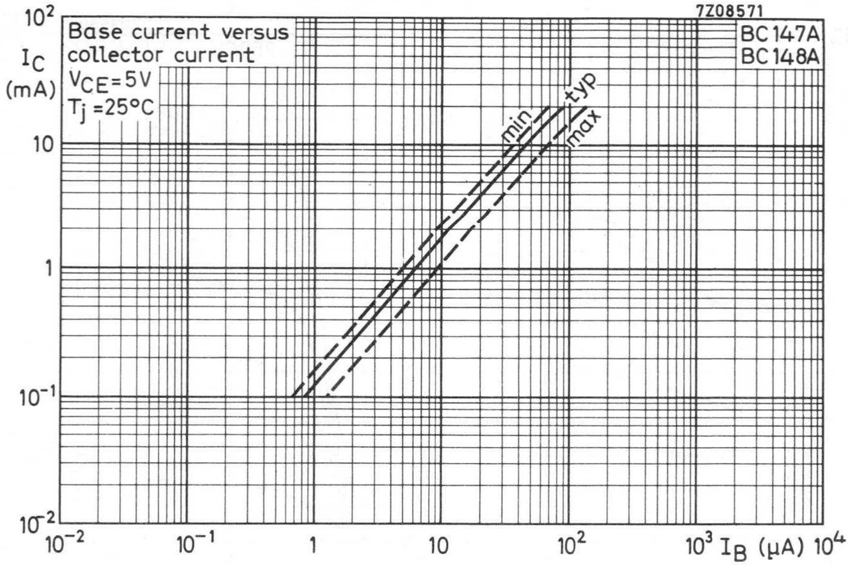


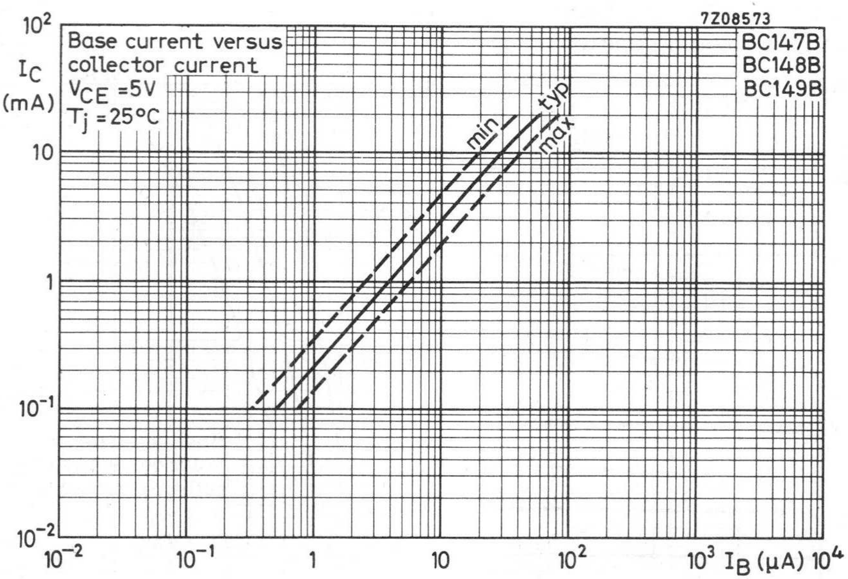


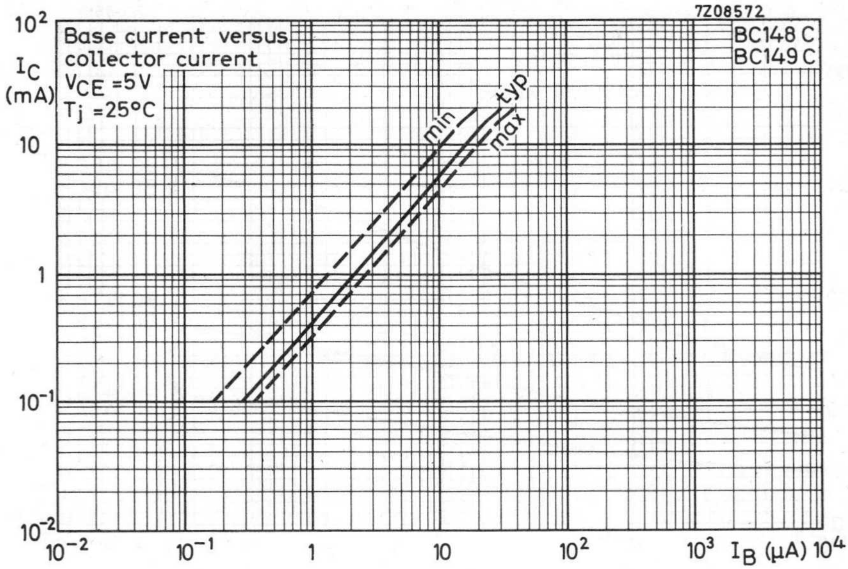
Typical behaviour of collector current versus collector-emitter voltage

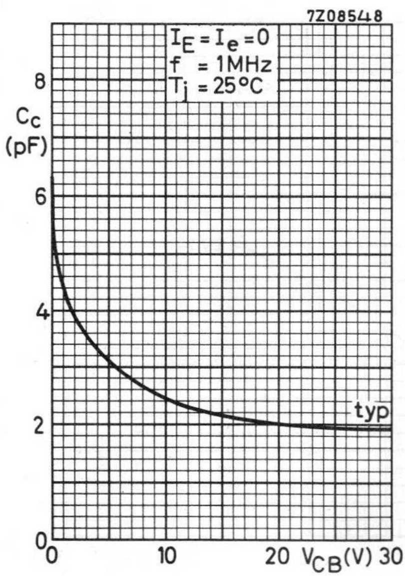


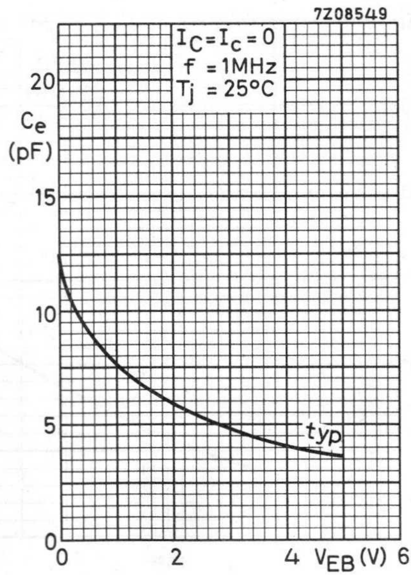


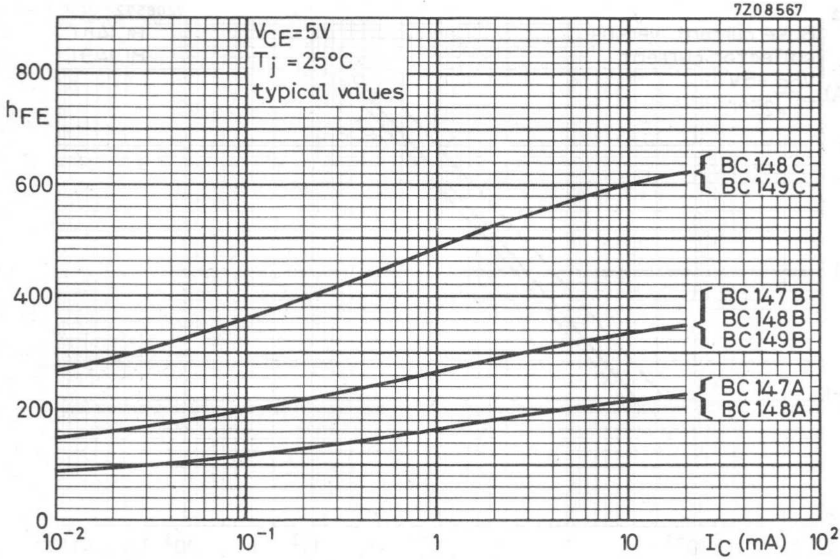

7Z08571
Base current versus collector current
V_{CE}=5V
T_j =25°C
BC147A
BC148A
min
typ
max
I_C (mA)
10^2
10
1
10^{-1}
10^{-2}
1
10
10^2
10^3
I_B (μA)
10^4

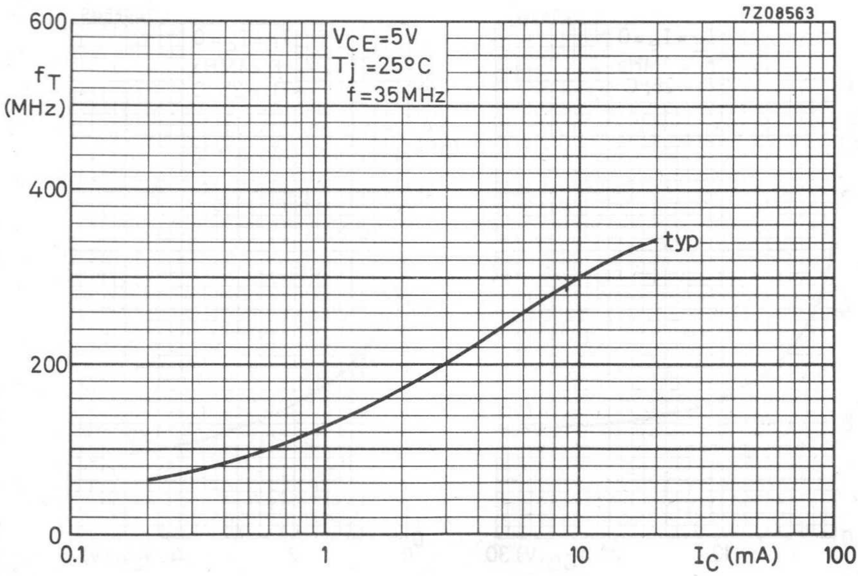

7Z08573
Base current versus collector current
V_{CE} =5V
T_j =25°C
BC147B
BC148B
BC149B
min
typ
max
I_C (mA)
10^2
10
1
10^{-1}
10^{-2}
1
10
10^2
10^3
I_B (μA)
10^4


7Z08572
Base current versus collector current
V_{CE} = 5 V
T_j = 25 °C
BC148 C
BC149 C
I_C (mA)
10^2
10
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (µA)
10^4
min
typ
max

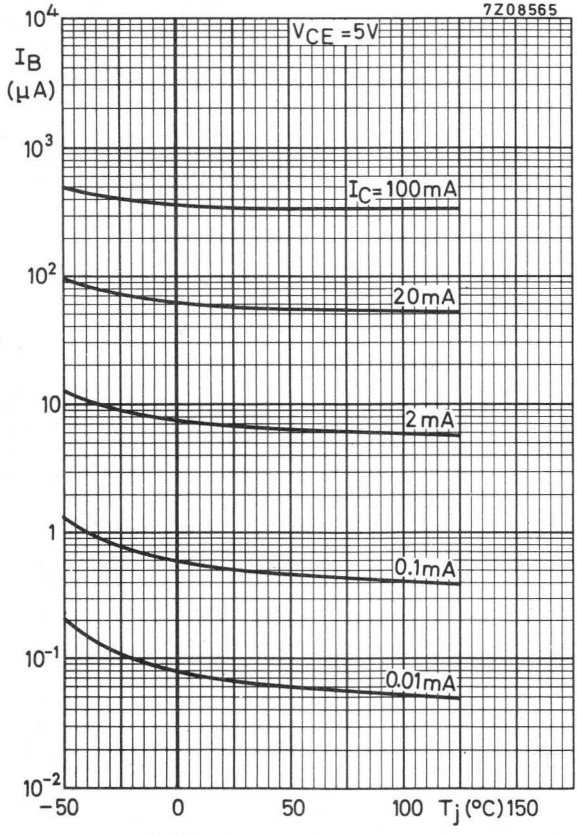

7Z08548
$I_E = I_e = 0$
f = 1 MHz
T_j = 25 °C
C_c (pF)
8
6
4
2
0
0
10
20
V_{CB} (V)
30
typ

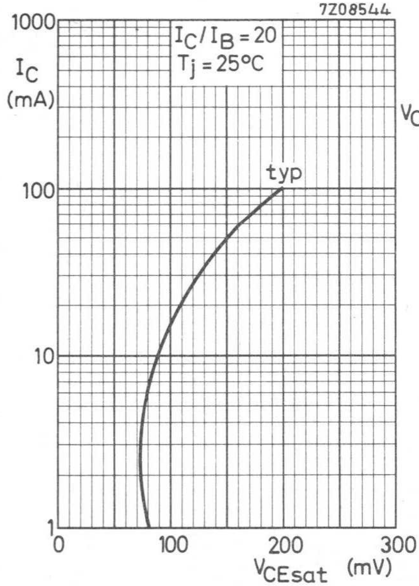

7Z08549
$I_C = I_c = 0$
f = 1 MHz
T_j = 25 °C
C_e (pF)
20
15
10
5
0
0
2
4
V_{EB} (V)
6
typ

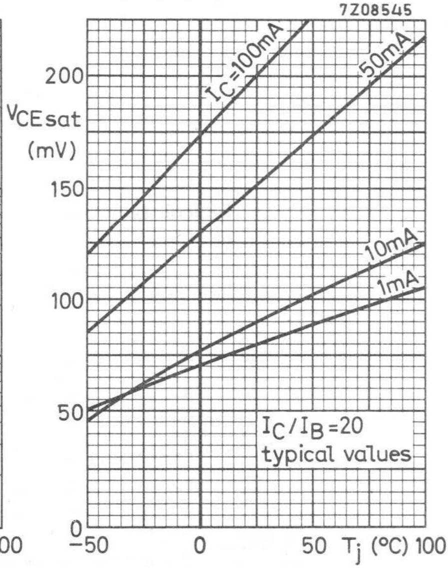

7Z08567
V_{CE}=5V
T_j =25°C
typical values
800
h_{FE}
600
400
200
0
BC 148 C
BC 149 C
BC 147 B
BC 148 B
BC 149 B
BC 147A
BC 148A
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

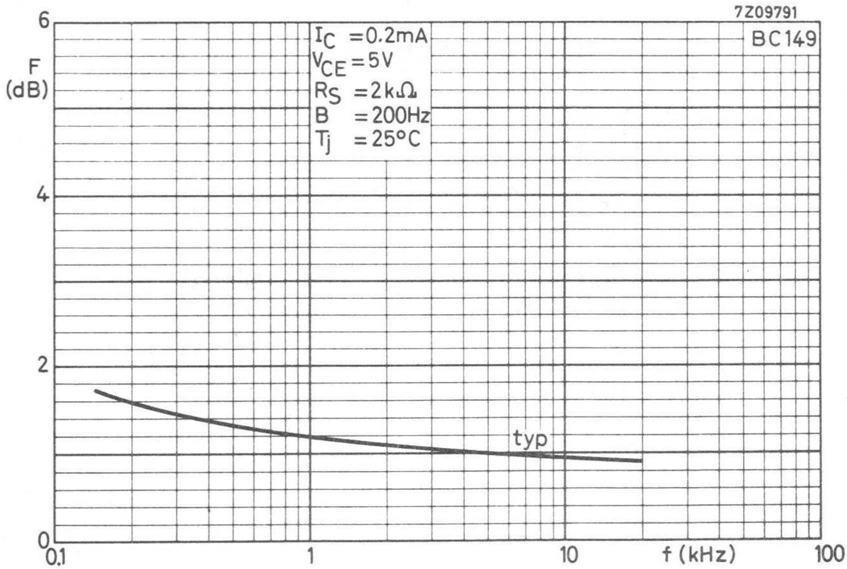

7Z08563
600
f_T
(MHz)
400
200
0
V_{CE}=5V
T_j =25°C
f=35MHz
typ
0.1
1
10
I_C (mA)
100

Typical behaviour of base current
versus junction temperature

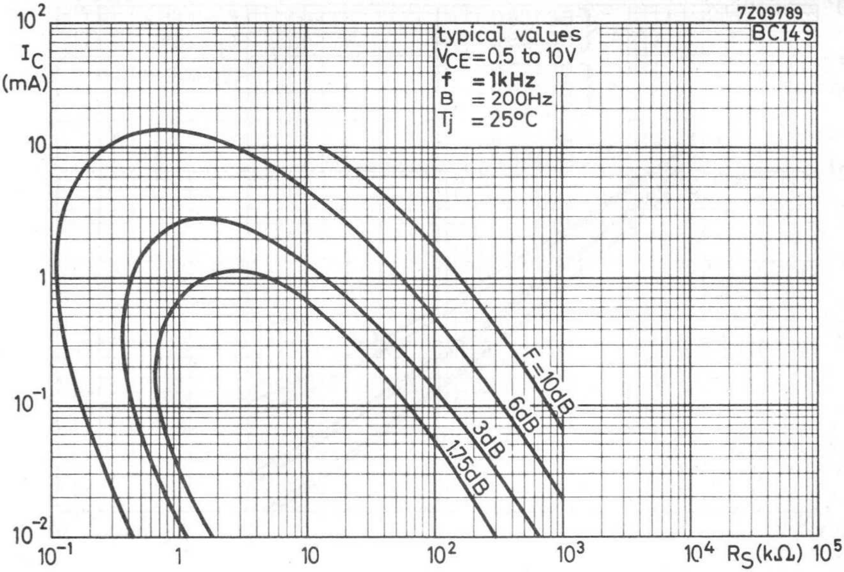


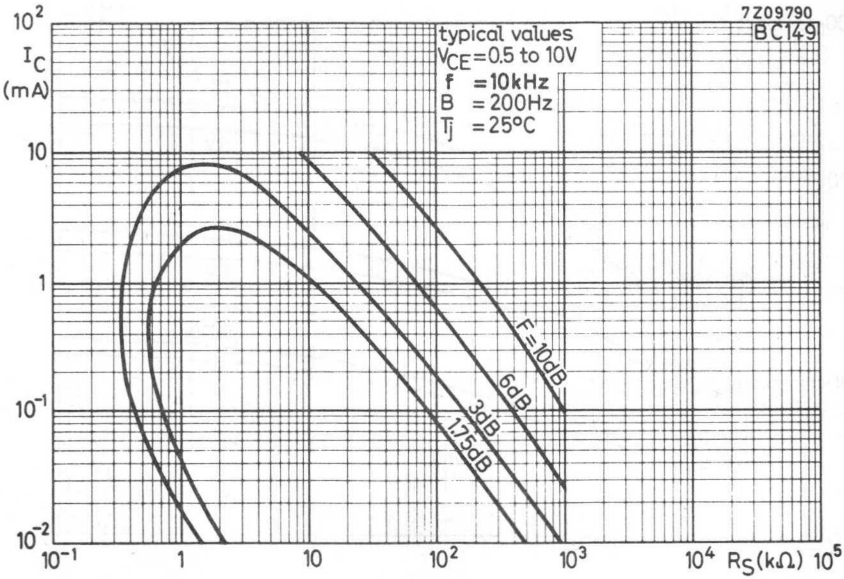

7Z08544
$I_C/I_B = 20$
$T_j = 25°C$
I_C (mA)
1000
100
10
1
typ
0
100
200
300
V_{CEsat} (mV)

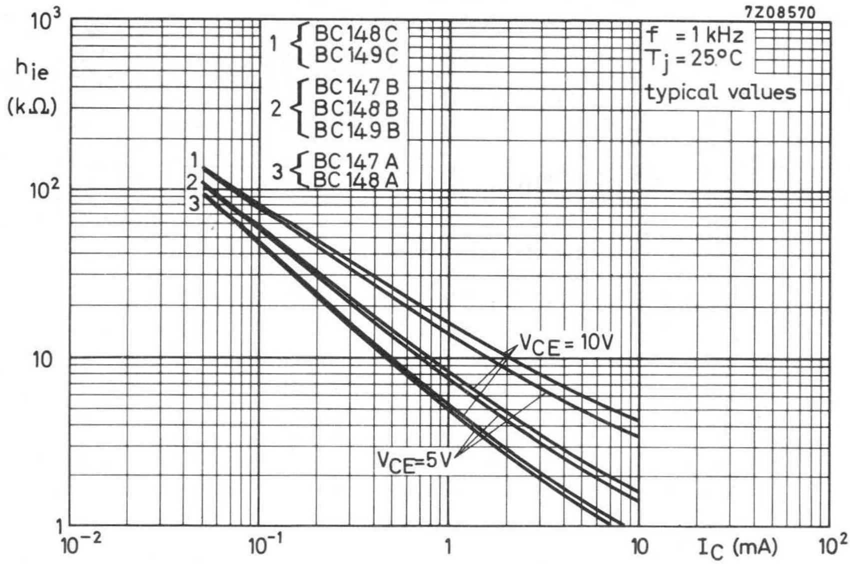

7Z08545
V_{CEsat} (mV)
200
150
100
50
0
I_C=100mA
50mA
10mA
1mA
I_C/I_B=20
typical values
−50
0
50
T_j (°C)
100

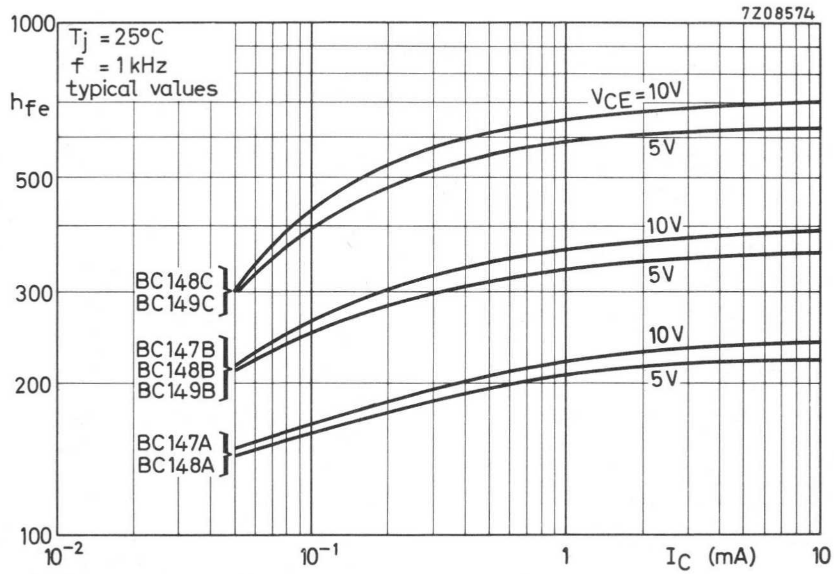

7Z09791
BC149
I_C = 0.2mA
V_{CE} = 5V
R_S = 2kΩ
B = 200Hz
T_j = 25°C
F (dB)
6
4
2
0
typ
0.1
1
10
f (kHz)
100

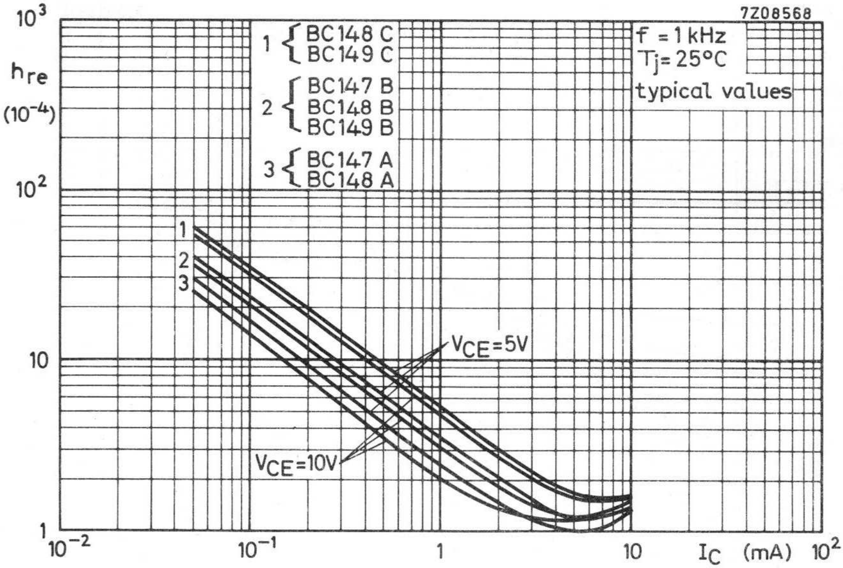
Curves of constant noise figure

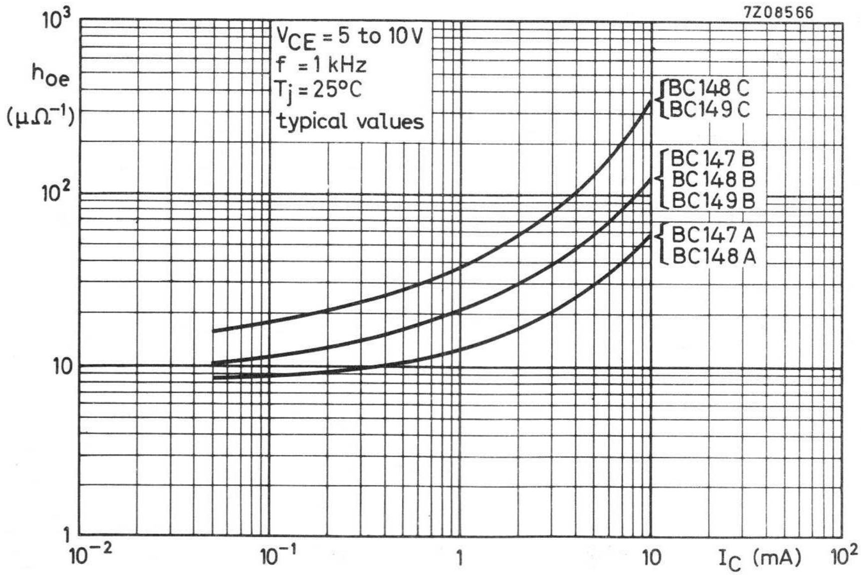


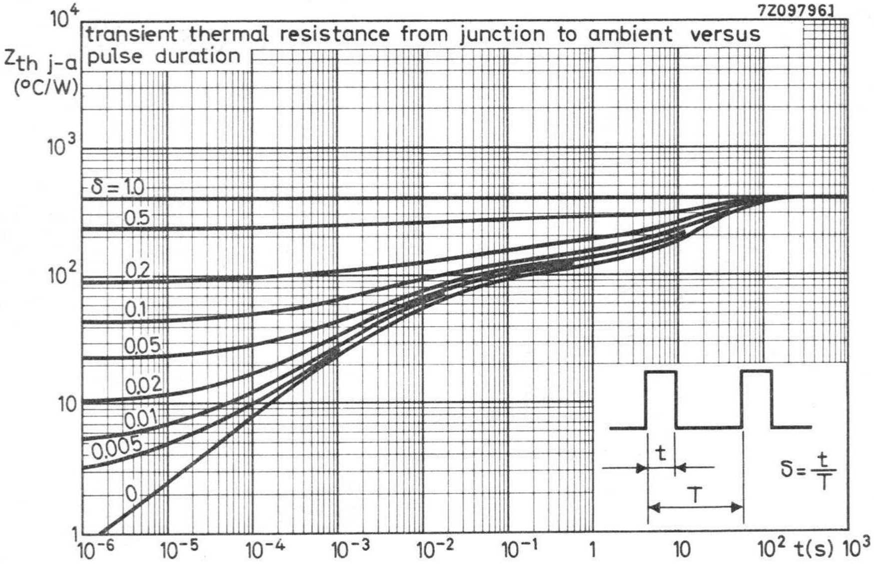



7Z08570
h_{ie} (kΩ)
1 { BC148C BC149C
2 { BC147B BC148B BC149B
3 { BC147A BC148A
f = 1 kHz
T_j = 25 °C
typical values
V_{CE} = 10V
V_{CE}=5V
I_C (mA)


7Z08574
T_j = 25 °C
f = 1 kHz
typical values
h_{fe}
V_{CE} = 10V
5V
10V
5V
10V
5V
BC148C
BC149C
BC147B
BC148B
BC149B
BC147A
BC148A
I_C (mA)


7Z08568
h_{re} (10^{-4})
1 { BC148 C BC149 C
2 { BC147 B BC148 B BC149 B
3 { BC147 A BC148 A
f = 1 kHz
Tj = 25°C
typical values
VCE = 5V
VCE = 10V
I_C (mA)


7Z08566
h_{oe} ($\mu\Omega^{-1}$)
VCE = 5 to 10 V
f = 1 kHz
Tj = 25°C
typical values
{BC148 C BC149 C
{BC147 B BC148 B BC149 B
{BC147 A BC148 A
I_C (mA)


7Z09796.1
transient thermal resistance from junction to ambient versus pulse duration
$Z_{th\ j-a}$ (°C/W)
10^4
10^3
10^2
10
1
δ = 1.0
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0
t
T
δ = t/T
10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 1 10 10^2 t(s) 10^3

A.F. SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in a plastic envelope with stiff self-locking pins suitable for use with standard printed boards.

The BC157 is a high voltage type and primarily intended for use in driver stages of audio amplifiers and in signal processing circuits of television receivers.

The BC158 is suitable for a multitude of low voltage applications e.g. driver stages or audio pre-amplifiers and in signal processing circuits of television receivers.

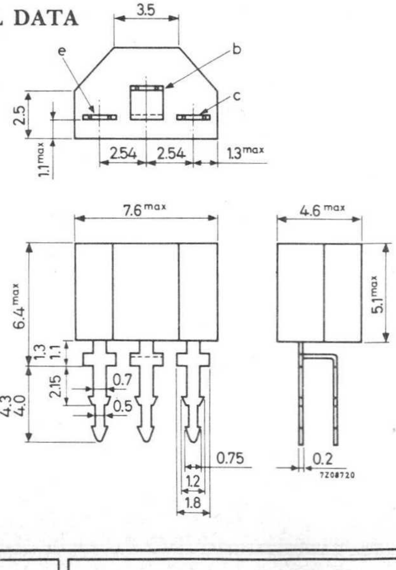
The BC159 is primarily intended for low noise input stages in tape recorders, hi-fi amplifiers and other audio frequency equipment.

QUICK REFERENCE DATA

			BC157	BC158	BC159	
Collector-emitter voltage ($+V_{BE}$ = 1 V)	$-V_{CEX}$	max.	50	30	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	25	20	V
Collector current (peak value)	$-I_{CM}$	max.	200	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	250	250	250	mW
Junction temperature	T_j	max.	125	125	125	°C
Small signal current gain at T_j = 25 °C						
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V; f = 1 kHz	h_{fe}	>	75	75	125	
		<	260	500	500	
Transition frequency at f = 35 MHz						
$-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.	150	150	150	MHz
Noise figure at R_S = 2 kΩ						
$-I_C$ = 200 μA; $-V_{CE}$ = 5 V						
f = 30 Hz to 15 kHz	F	typ.			1.2	dB
		<			4	dB
f = 1 kHz; B = 200 Hz	F	<	10	10	4	dB

MECHANICAL DATA

Dimensions in mm

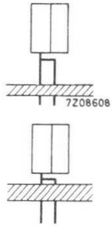


The envelope fulfils the accelerated damp heat test described in IEC publication 68-2 (test D, severity IV, 6 cycles).

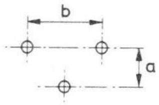
MOUNTING INSTRUCTIONS

1. Thickness of printed board: max. 1.1 mm
   Hole diameter 0.77 to 0.83 mm

2. Thickness of printed board: max. 1.7 mm
   Hole diameter 1.25 to 1.35 mm



Bore plan



a = 2.49 to 2.59 mm
b = 5.03 to 5.13 mm

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

			BC157	BC158	BC159	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	50	30	25	V
Collector-emitter voltage ($+V_{BE}$ = 1 V)	$-V_{CEX}$	max.	50	30	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	25	20	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V

Currents

Collector current (d.c.)	$-I_C$	max.	100	mA
Collector current (peak value)	$-I_{CM}$	max.	200	mA
Emitter current (peak value)	I_{EM}	max.	200	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	250	mW

Temperatures

Storage temperature	T_{stg}		-65 to +125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.4	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $-V_{CB} = 20$ V; $T_j = 25$ °C	$-I_{CBO}$	typ.	1	nA
		<	100	nA
$T_j = 125$ °C	$-I_{CBO}$	<	4	μA

Base-emitter voltage [1]

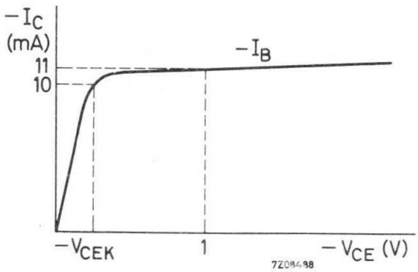
$-I_C = 2$ mA; $-V_{CE} = 5$ V	$-V_{BE}$	typ.	650	mV
		600 to	750	mV

Saturation voltages

$-I_C = 10$ mA; $-I_B = 0.5$ mA	$-V_{CEsat}$	typ.	75	mV
		<	300	mV
	$-V_{BEsat}$	typ.	700	mV
$-I_C = 100$ mA; $-I_B = 5$ mA	$-V_{CEsat}$	typ.	250	mV
	$-V_{BEsat}$	typ.	850	mV

Knee voltage

$-I_C = 10$ mA; $-I_B$ = value for which $-I_C = 11$ mA at $-V_{CE} = 1$ V	$-V_{CEK}$	typ.	250	mV
		<	600	mV



Collector capacitance at f = 1 MHz

$I_E = I_e = 0$; $-V_{CB} = 10$ V	C_c	typ.	4.5	pF

Transition frequency at f = 35 MHz

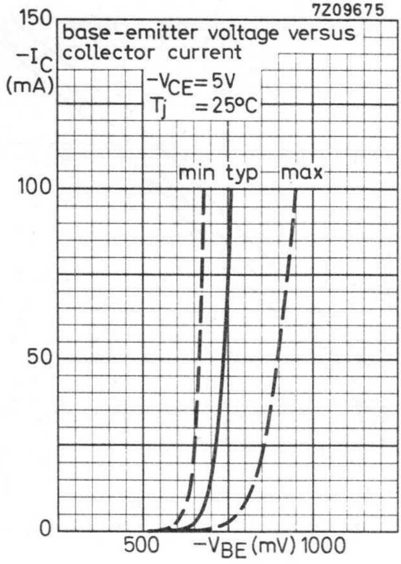
$-I_C = 10$ mA; $-V_{CE} = 5$ V	f_T	typ.	150	MHz

[1] $-V_{BE}$ decreases by about 2 mV/°C with increasing temperature.

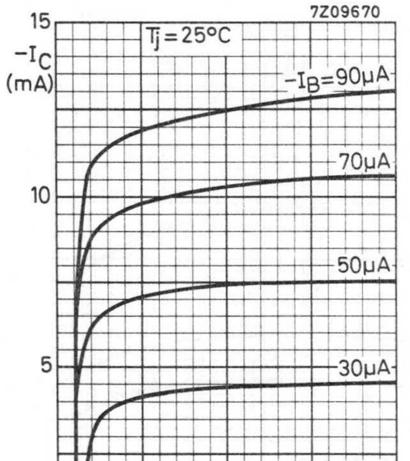
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

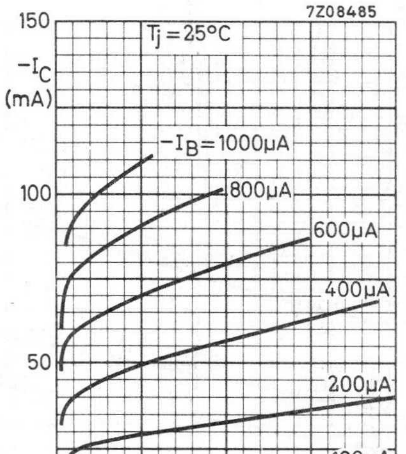
			BC157	BC158	BC159	
Small signal current gain at f = 1 kHz						
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{fe}	>	75	75	125	
		<	260	500	500	
Noise figure at R_S = 2 kΩ						
$-I_C$ = 200 μA; $-V_{CE}$ = 5 V						
f = 30 Hz to 15 kHz	F	typ.			1.2	dB
		<			4	dB
f = 1 kHz; B = 200 Hz	F	typ.	2	2	1	dB
		<	10	10	4	dB

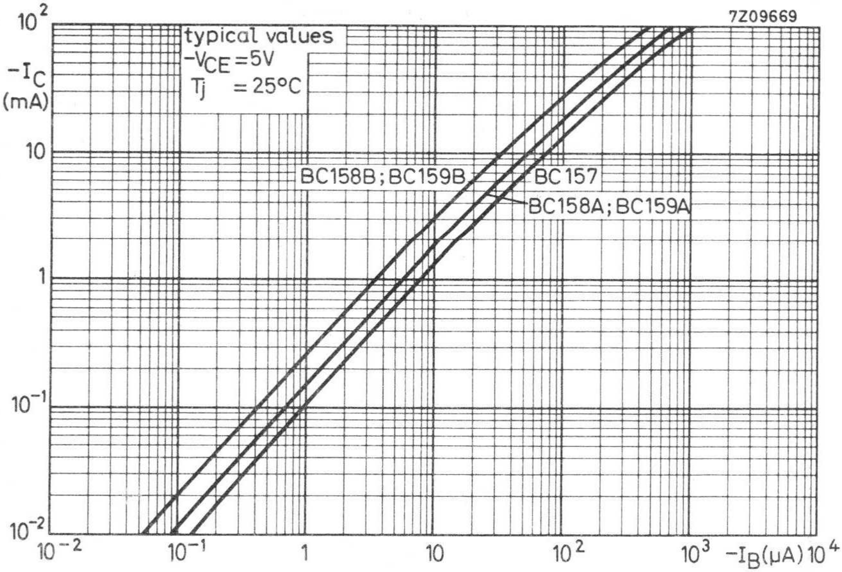
			BC157	BC158A BC159A	BC158B BC159B
D.C. current gain					
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{FE}	typ.	140	180	290
Small signal current gain at f = 1 kHz					
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{fe}	>	75	125	240
		<	260	260	500

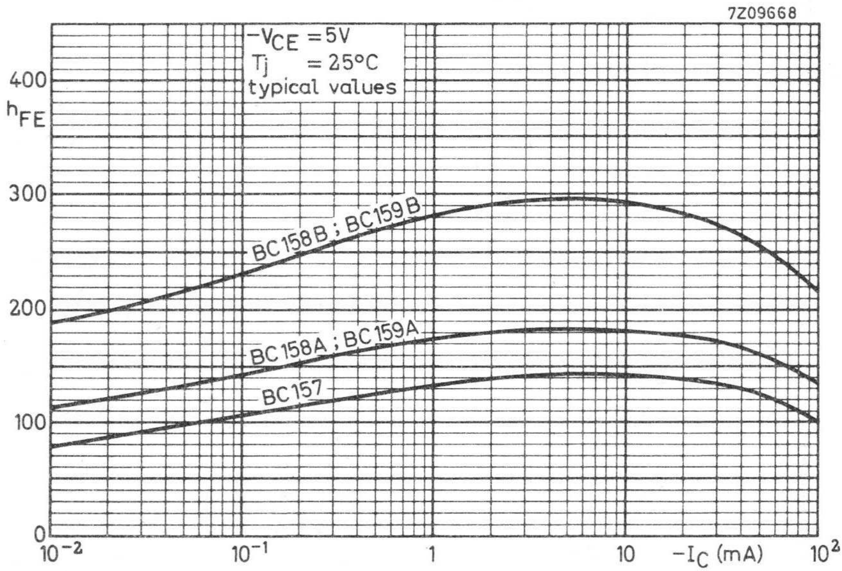


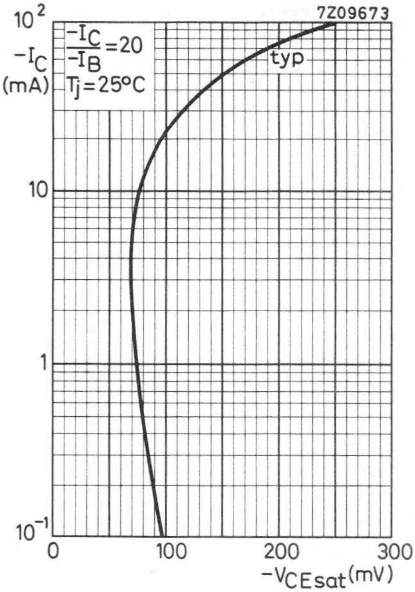
Typical behaviour of collector current versus collector-emitter voltage

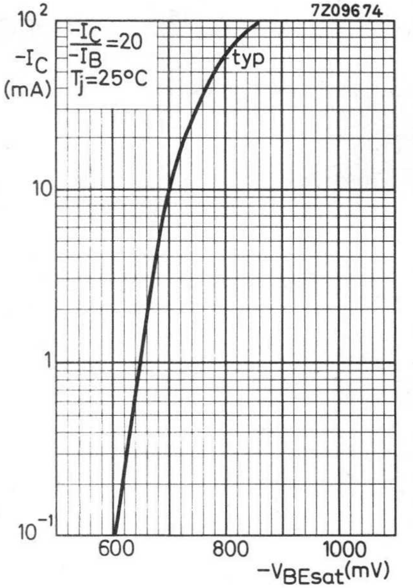


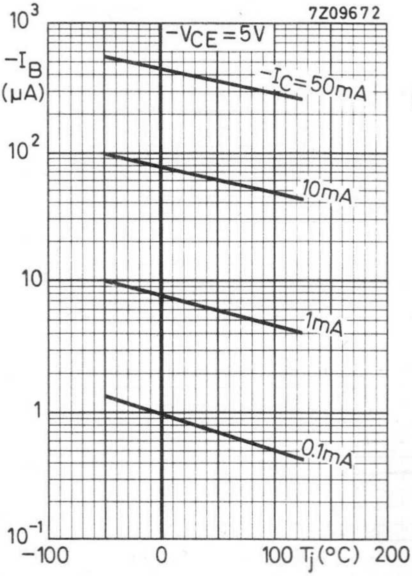



7Z09669
typical values
$-V_{CE} = 5V$
$T_j = 25°C$
$-I_C$ (mA)
10^2
10
1
10^{-1}
10^{-2}
BC158B; BC159B
BC157
BC158A; BC159A
10^{-2}
10^{-1}
1
10
10^2
10^3
$-I_B$ (μA)
10^4

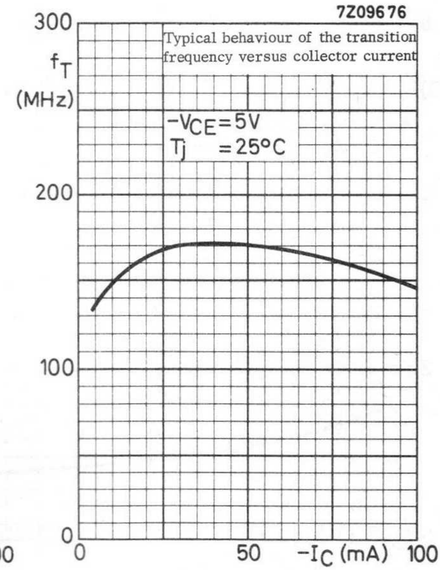

7Z09668
$-V_{CE} = 5V$
$T_j = 25°C$
typical values
h_{FE}
400
300
200
100
0
BC158B; BC159B
BC158A; BC159A
BC157
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2



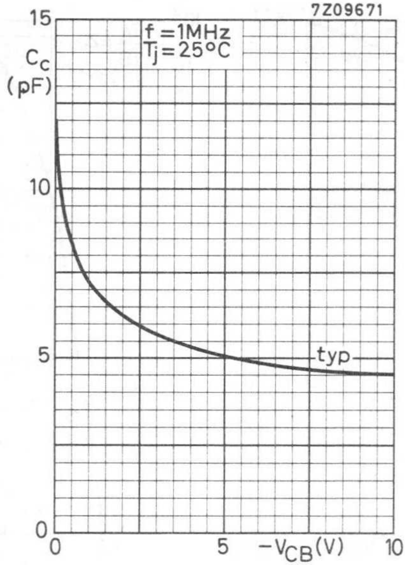


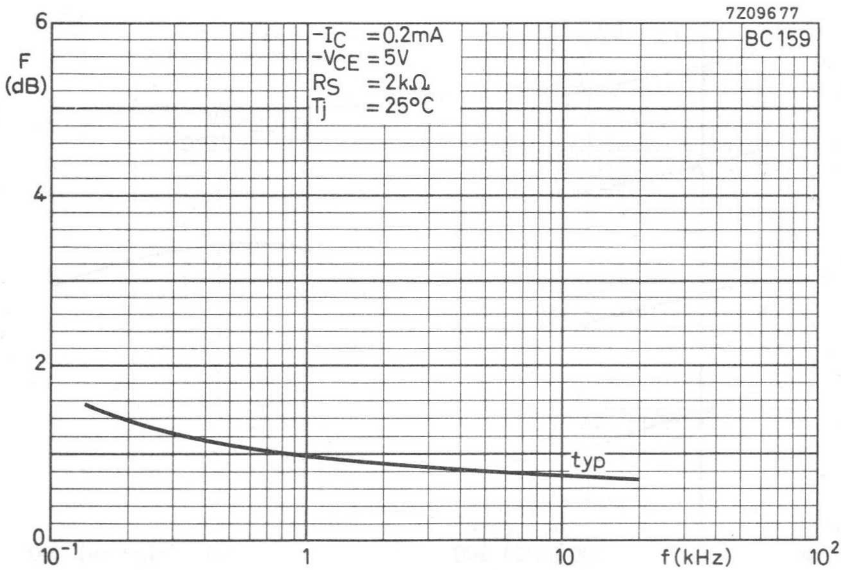


Typical behaviour of base current versus junction temperature

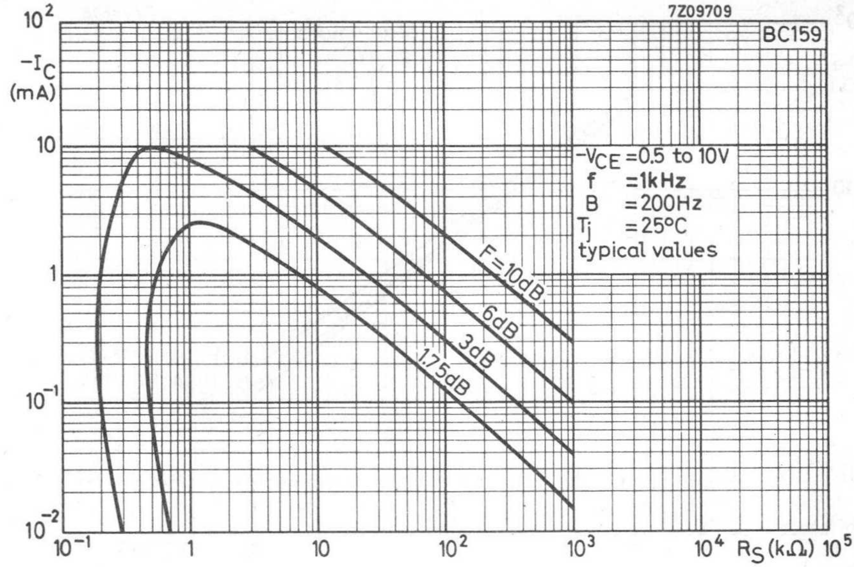


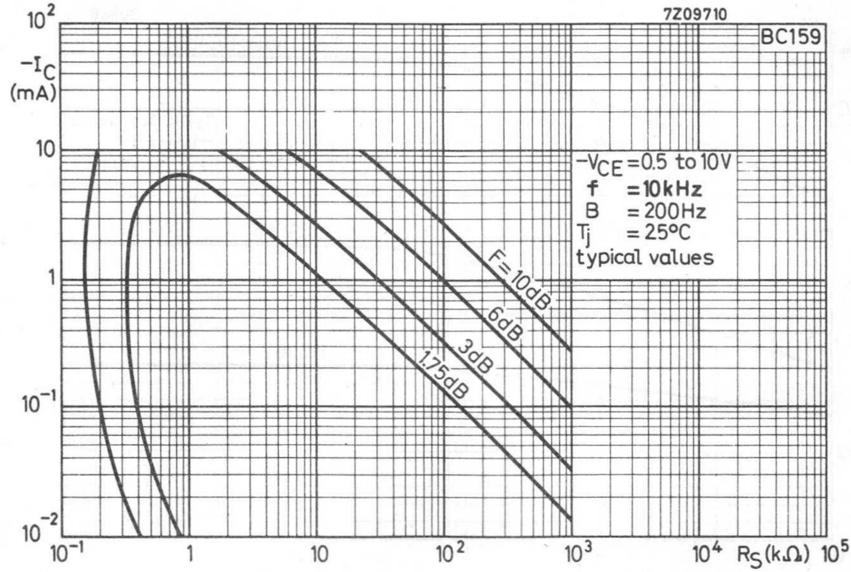
Typical behaviour of the transition frequency versus collector current

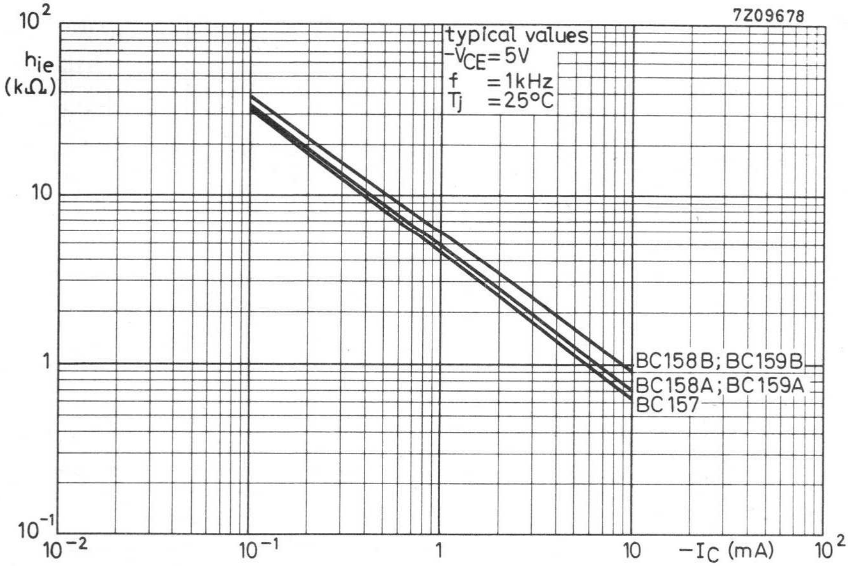

7Z09671
15
C_c
(pF)
f = 1MHz
T_j = 25°C
10
5
typ
0
0
5
$-V_{CB}$(V)
10

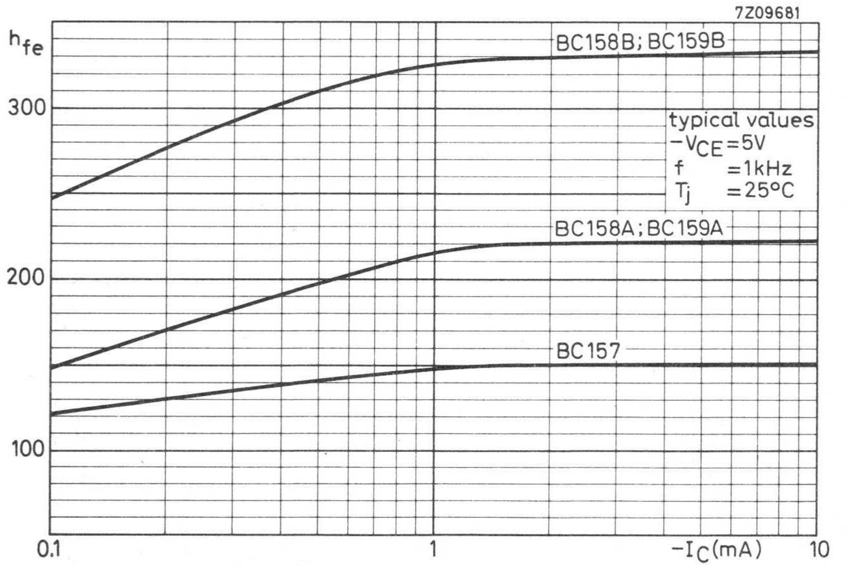

7Z09677
BC159
6
F
(dB)
$-I_C$ = 0.2mA
$-V_{CE}$ = 5V
R_S = 2kΩ
T_j = 25°C
4
2
typ
0
10^{-1}
1
10
f(kHz)
10^2

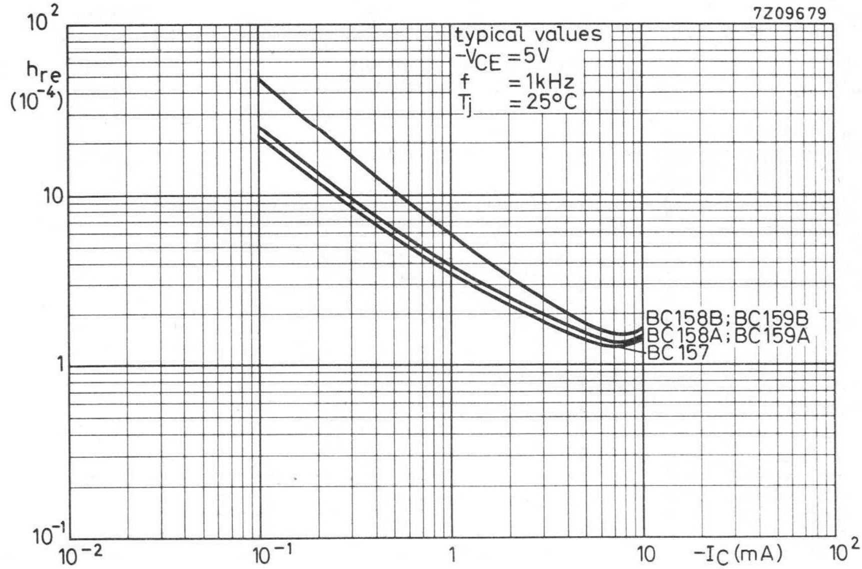
Curves of constant noise figure

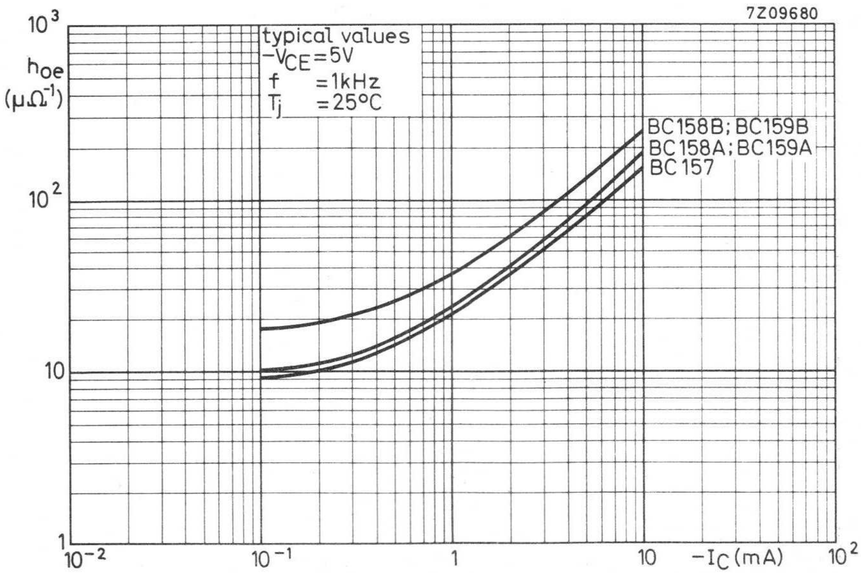


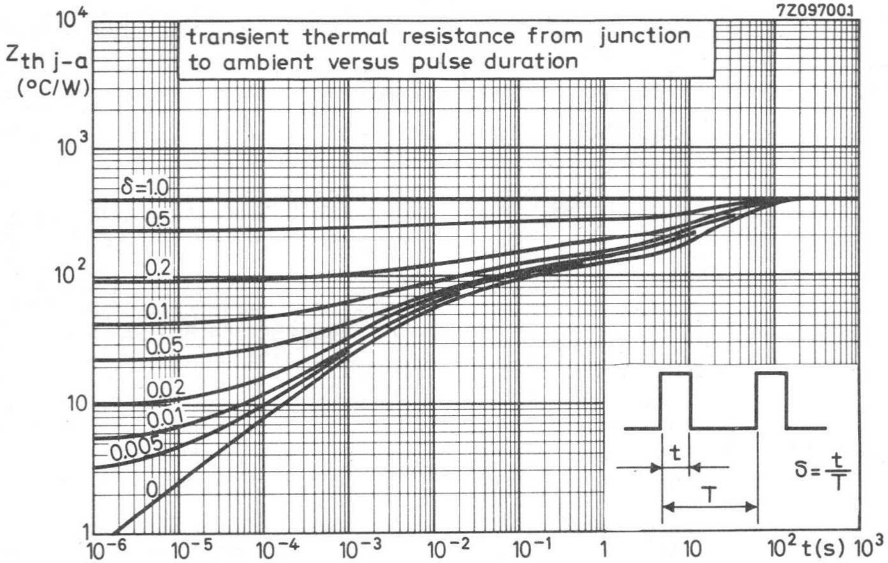



7Z09678
10^2
h_{ie}
(kΩ)
10
1
10^{-1}
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
BC158B; BC159B
BC158A; BC159A
BC157


7Z09681
h_{fe}
300
200
100
0.1
1
$-I_C$(mA)
10
BC158B; BC159B
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
BC158A; BC159A
BC157


7Z09679
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
h_{re} (10^{-4})
10^2
10
1
10^{-1}
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2
BC158B; BC159B
BC158A; BC159A
BC157


7Z09680
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
h_{oe} $(\mu\Omega^{-1})$
10^3
10^2
10
1
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2
BC158B; BC159B
BC158A; BC159A
BC157


7Z097001
transient thermal resistance from junction to ambient versus pulse duration
$Z_{th\ j-a}$ (°C/W)
10^4
10^3
10^2
10
1
δ=1.0
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0
10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 1 10 10^2 t(s) 10^3
t
T
δ = t/T

A.F. SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in a TO-18 metal envelope with the collector connected to the case. The BC177 is a high voltage type and primarily intended for use in driver stages of audio amplifiers and in signal processing circuits of television receivers.
The BC178 is suitable for a multitude of low voltage applications e.g. driver stages or audio pre-amplifiers and in signal processing circuits of television receivers.
The BC179 is primarily intended for low noise input stages in tape recorders, hi-fi amplifiers and other audio frequency equipment.
Moreover they are intended as complementary types for the BC107, BC108 and BC109.

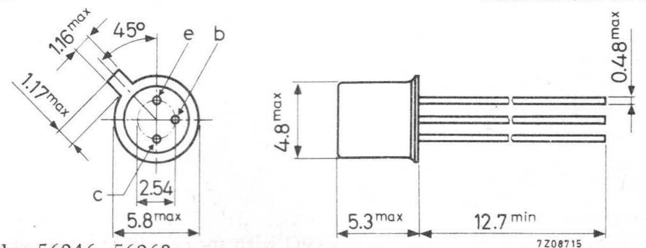
QUICK REFERENCE DATA

			BC177	BC178	BC179	
Collector-emitter voltage ($+V_{BE}$ = 1 V)	$-V_{CEX}$	max.	50	30	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	25	20	V
Collector current (peak value)	$-I_{CM}$	max.	200	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	300	300	mW
Junction temperature	T_j	max.	175	175	175	°C
Small signal current gain at T_j = 25 °C						
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V; f = 1 kHz	h_{fe}	>	75	75	125	
		<	260	500	500	
Transition frequency at f = 35 MHz						
$-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.	150	150	150	MHz
Noise figure at R_S = 2 kΩ						
$-I_C$ = 200 μA; $-V_{CE}$ = 5 V						
f = 30 Hz to 15 kHz	F	typ.			1.2	dB
		<			4	dB
f = 1 kHz; B = 200 Hz	F	<	10	10	4	dB

MECHANICAL DATA

Dimensions in mm

TO-18
Collector connected to case



Accessories available: 56246, 56263

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134).

Voltages			BC177	BC178	BC179	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	50	30	25	V
Collector-emitter voltage ($+V_{BE}$ = 1 V)	$-V_{CEX}$	max.	50	30	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	25	20	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V

Currents				
Collector current (d.c.)	$-I_C$	max.	100	mA
Collector current (peak value)	$-I_{CM}$	max.	200	mA
Emitter current (peak value)	I_{EM}	max.	200	mA
Power dissipation				
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	mW
Temperatures				
Storage temperature	T_{stg}		-65 to +175	°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.5	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0.2	°C/mW

CHARACTERISTICS

Collector cut-off current				
$I_E = 0$; $-V_{CB}$ = 20 V; T_j = 25 °C	$-I_{CBO}$	typ.	1	nA
		<	100	nA
T_j = 150 °C	$-I_{CBO}$	<	10	μA
Base-emitter voltage [1]				
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V; T_j = 25 °C	$-V_{BE}$	typ.	650	mV
			600 to 750	mV

[1]) $-V_{BE}$ decreases by about 2 mV/°C with increasing temperature.

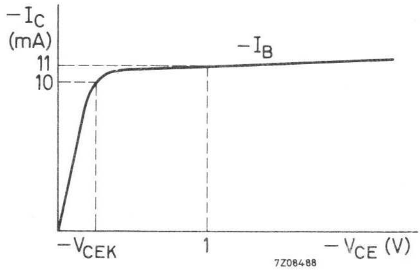
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Saturation voltages

$-I_C$ = 10 mA; $-I_B$ = 0.5 mA	$-V_{CEsat}$	typ.	75	mV
		<	300	mV
	$-V_{BEsat}$	typ.	700	mV
$-I_C$ = 100 mA; $-I_B$ = 5 mA	$-V_{CEsat}$	typ.	250	mV
	$-V_{BEsat}$	typ.	850	mV

Knee voltage

$-I_C$ = 10 mA; $-I_B$ = value for which $-I_C$ = 11 mA at $-V_{CE}$ = 1 V	$-V_{CEK}$	typ.	250	mV
		<	600	mV



Collector capacitance at f = 1 MHz

$I_E = I_e = 0$; $-V_{CB}$ = 10 V — C_c typ. 4.0 pF

Transition frequency at f = 35 MHz

$-I_C$ = 10 mA; $-V_{CE}$ = 5 V — f_T typ. 150 MHz

Small signal current gain at f = 1 kHz

			BC177	BC178	BC179	
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{fe}	>	75	75	125	
		<	260	500	500	

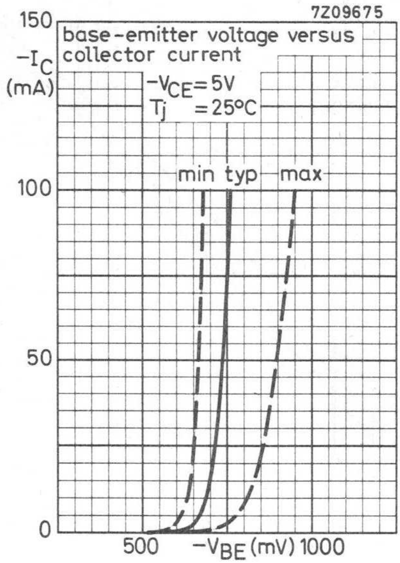
Noise figure at R_S = 2 kΩ

$-I_C$ = 200 μA; $-V_{CE}$ = 5 V

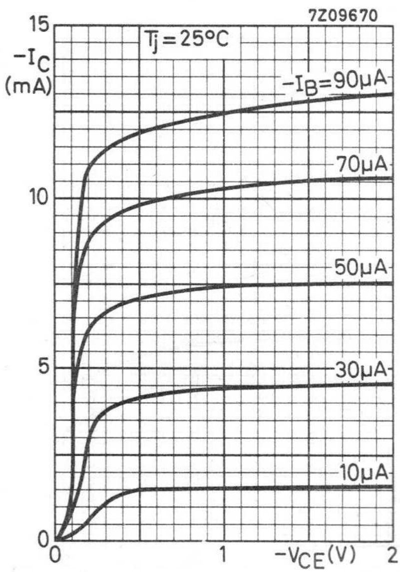
			BC177	BC178	BC179	
f = 30 Hz to 15 kHz	F	typ.			1.2	dB
		<			4	dB
f = 1 kHz; B = 200 Hz	F	typ.	2	2	1	dB
		<	10	10	4	dB

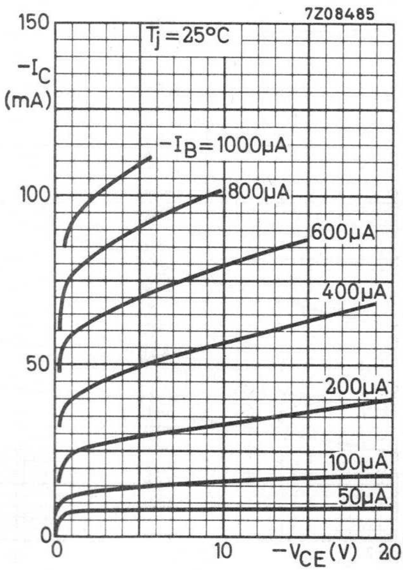
CHARACTERISTICS (continued)

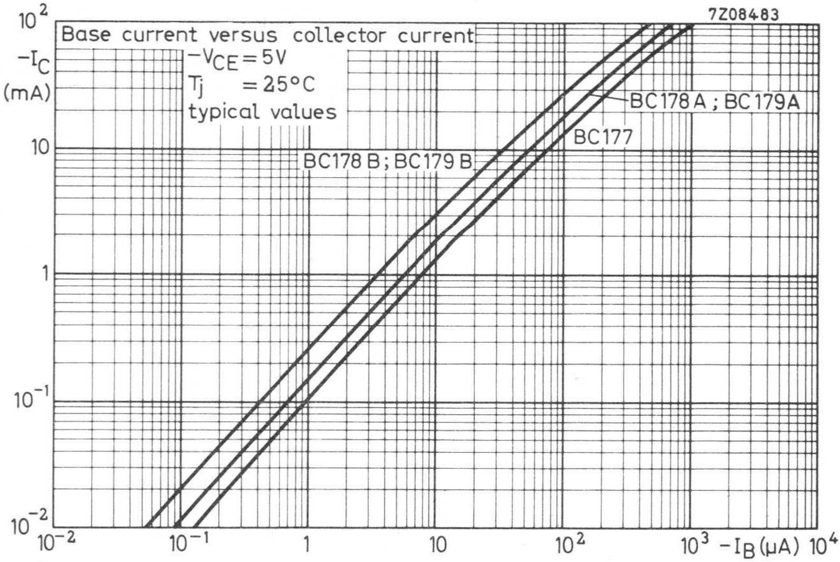
			BC177	BC178A BC179A	BC178B BC179B
D.C. current gain					
$-I_C = 2$ mA; $-V_{CE} = 5$ V	h_{FE}	typ.	140	180	290
Small signal current gain at f = 1 kHz					
$-I_C = 2$ mA; $-V_{CE} = 5$ V	h_{fe}	>	75	125	240
		<	260	260	500

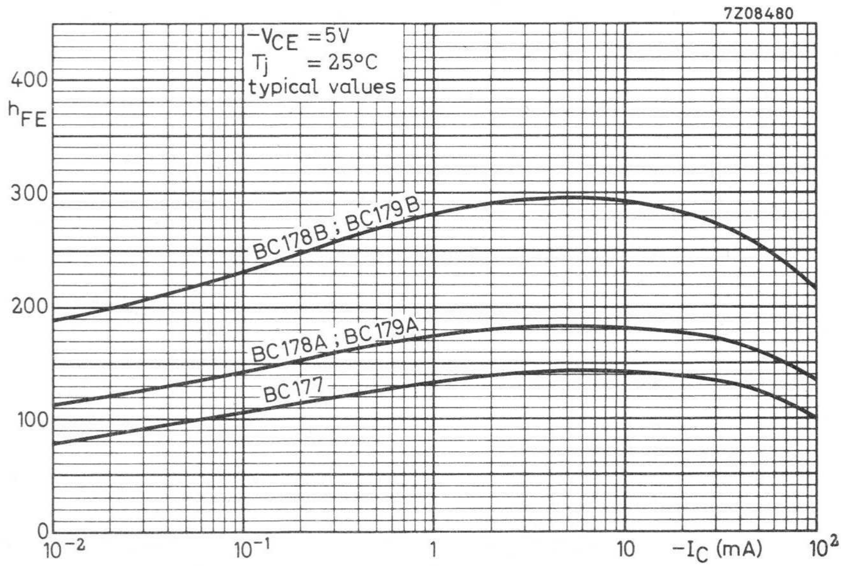


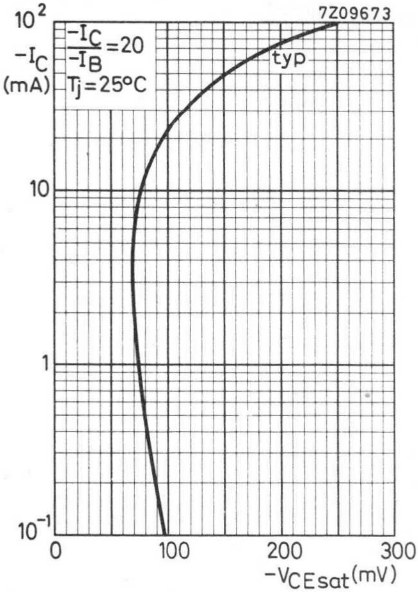
Typical behaviour of collector current versus collector-emitter voltage

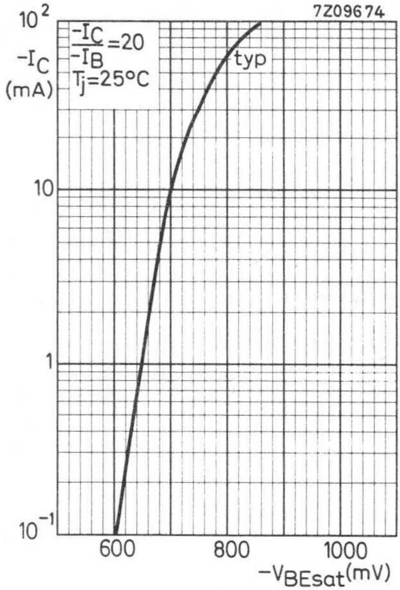


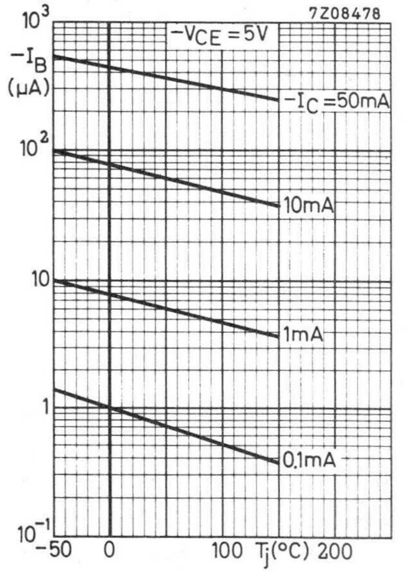



7Z08483
Base current versus collector current
$-V_{CE} = 5V$
$T_j = 25°C$
typical values
$-I_C$ (mA)
10^2
10
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1
10
10^2
10^3
$-I_B$ (μA)
10^4
BC178A ; BC179A
BC177
BC178B ; BC179B

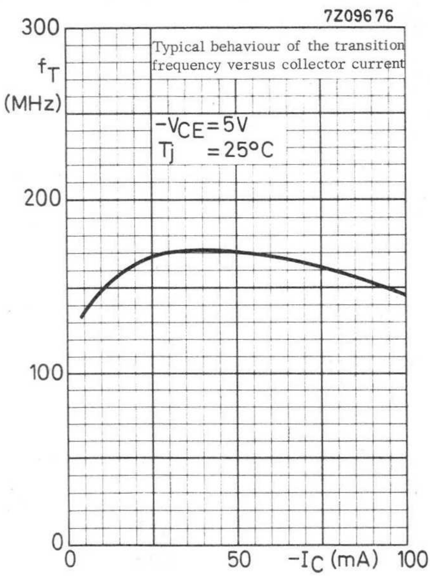

7Z08480
$-V_{CE} = 5V$
$T_j = 25°C$
typical values
h_{FE}
400
300
200
100
0
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2
BC178B ; BC179B
BC178A ; BC179A
BC177



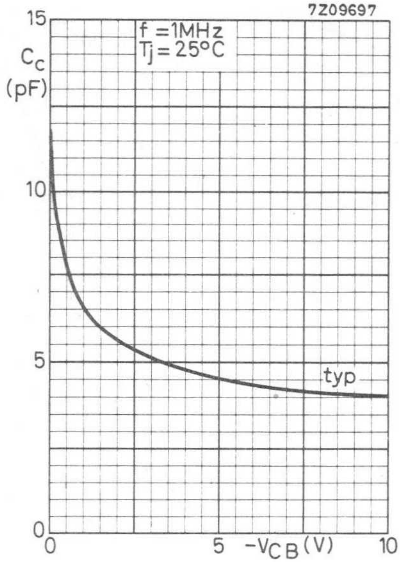


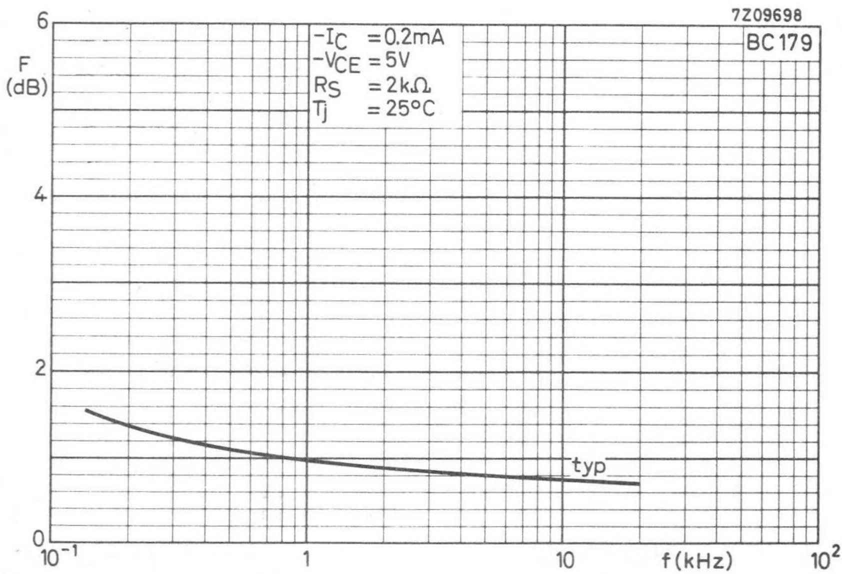


Typical behaviour of base current versus junction temperature

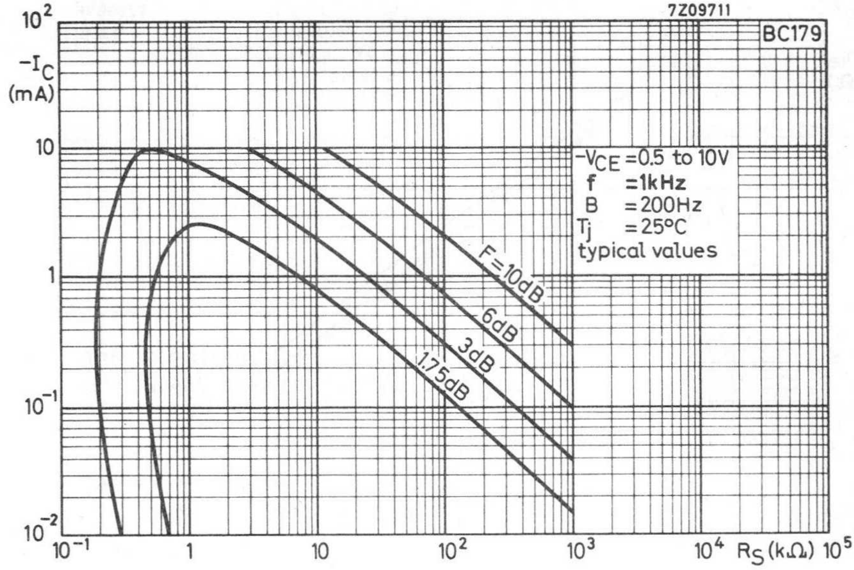


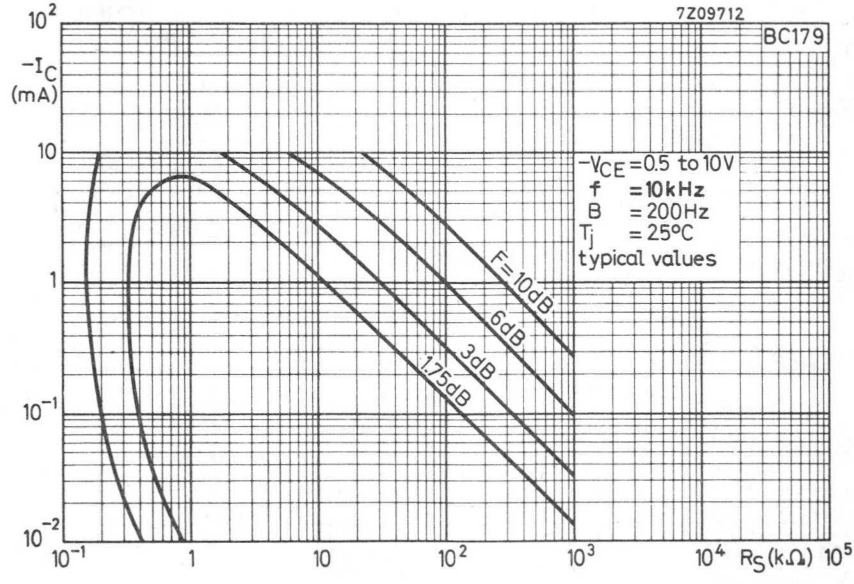
Typical behaviour of the transition frequency versus collector current

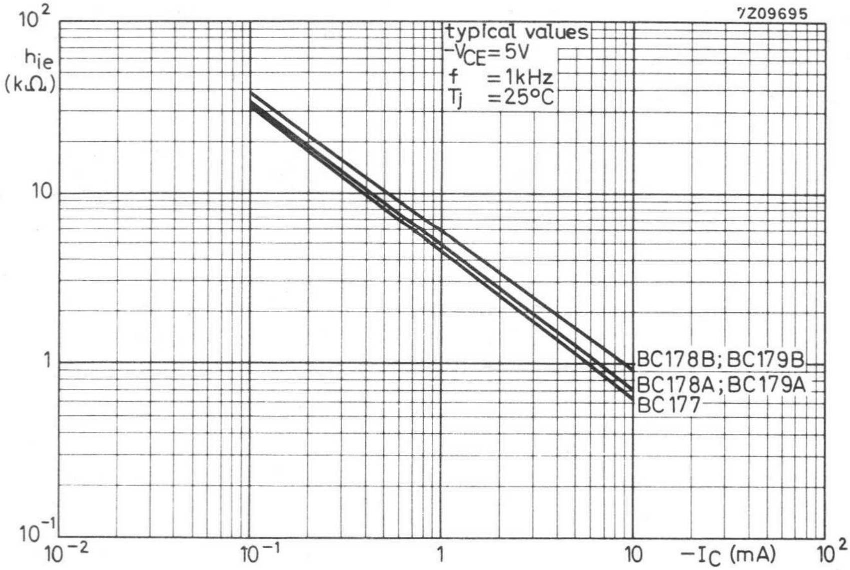

7Z09697
f = 1MHz
Tj = 25°C
Cc
(pF)
15
10
5
0
0
5
−VCB (V)
10
typ

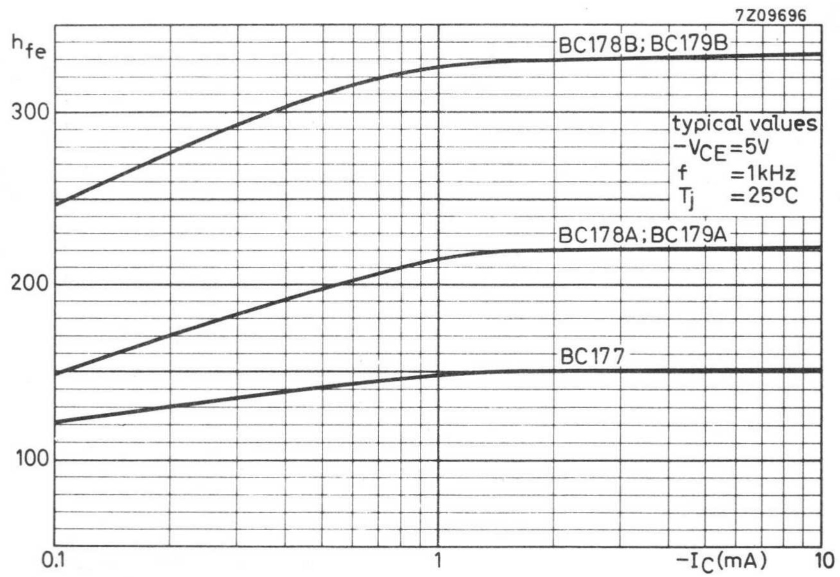

7Z09698
BC179
−IC = 0.2mA
−VCE = 5V
RS = 2kΩ
Tj = 25°C
F
(dB)
6
4
2
0
10−1
1
10
f (kHz)
10²
typ

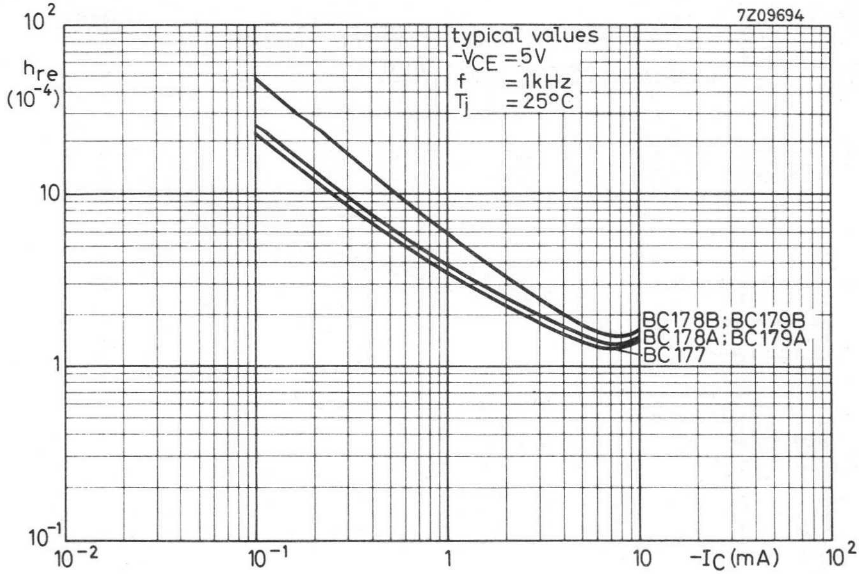
Curves of constant noise figure

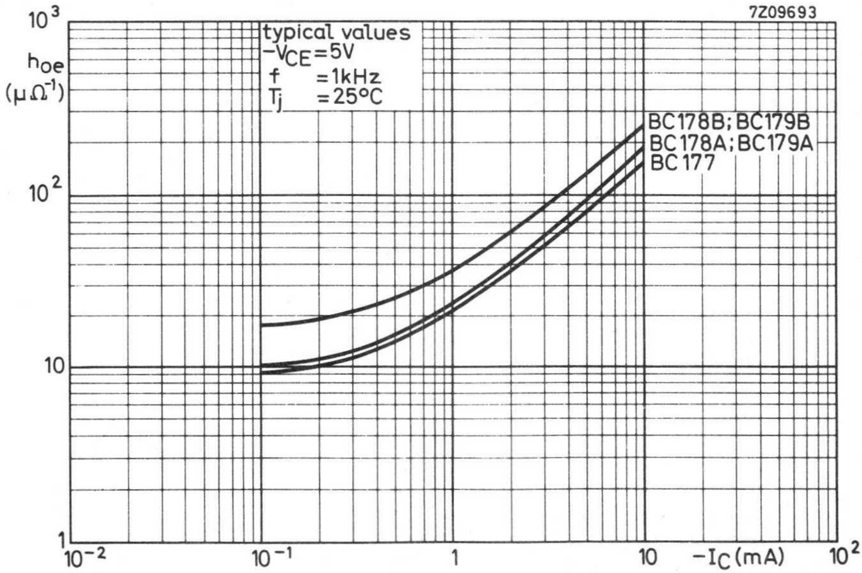


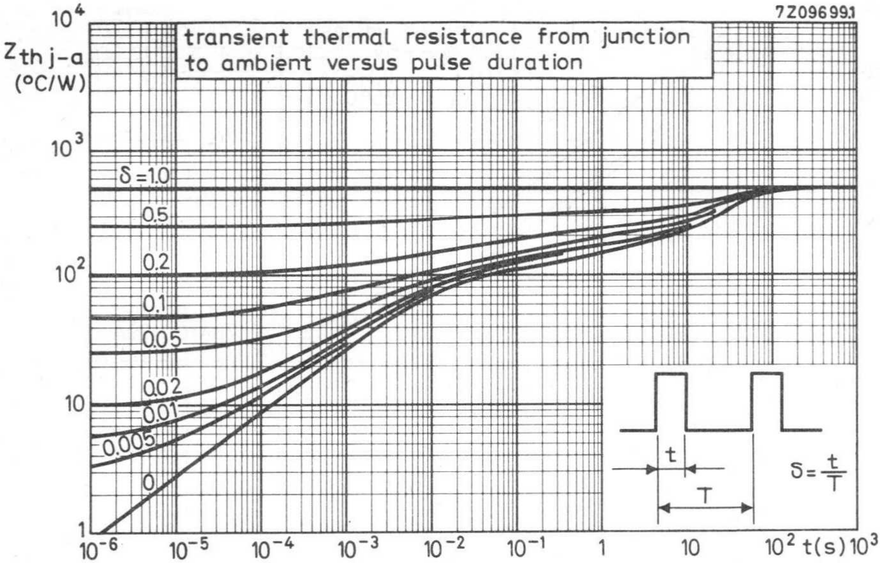



7Z09695
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
h_{ie} (kΩ)
10^2
10
1
10^{-1}
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2
BC178B; BC179B
BC178A; BC179A
BC177


7Z09696
h_{fe}
300
200
100
BC178B; BC179B
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
BC178A; BC179A
BC177
0.1
1
$-I_C$(mA)
10


7Z09694
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
h_{re} (10^{-4})
10^2
10
1
10^{-1}
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2
BC178B; BC179B
BC178A; BC179A
BC177


7Z09693
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
h_{oe} ($\mu\Omega^{-1}$)
10^3
10^2
10
1
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2
BC178B; BC179B
BC178A; BC179A
BC177


7Z09699.1
transient thermal resistance from junction to ambient versus pulse duration
$Z_{th\ j-a}$ (°C/W)
10^4
10^3
10^2
10
1
δ = 1.0
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t(s)
10^3
t
T
$\delta = \frac{t}{T}$

SILICON PLANAR EPITAXIAL TRANSISTOR

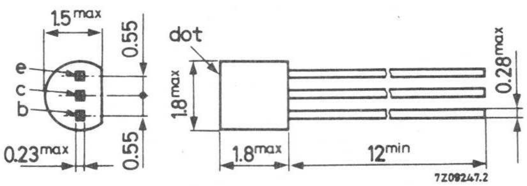
P-N-P transistor in a microminiature plastic envelope. The transistor is designed for use in hearing aids, watches and other equipment where small size is of paramount importance.

QUICK REFERENCE DATA

			red	yellow	green	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	20	20	20	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20	20	20	V
Collector current (d.c.)	$-I_C$	max.	50	50	50	mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	50	50	50	mW
Junction temperature	T_j	max.	125	125	125	°C
D.C. current gain at T_j = 25 °C; $-I_C$ = 0.2 mA; $-V_{CE}$ = 0.5 V	h_{FE}	>	50	85	165	
		<	105	200	400	
Noise figure at R_S = 2 kΩ; $-I_C$ = 0.2 mA; $-V_{CE}$ = 5 V; Bandwidth: f = 30 Hz to 15 kHz	F	typ.	2	1.5	2	dB
		<	-	4	-	dB

MECHANICAL DATA

Dimensions in mm



Coloured dot on top of the blue body

MOUNTING INSTRUCTIONS

To avoid damaging the transistor, welded or soldered connections must be made with care; the following general recommendations should be observed:

1. The temperature of the soldering iron must be less than 250 °C and the soldering time less than 3 seconds at a lead length of not less than 1.5 mm.
2. To keep the heat capacity low, the smallest possible amount of solder should be used.
3. If the plastic capsule of the transistor makes contact with any other structure, care must be taken that its temperature never exceeds 125 °C.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	20	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	V

Currents

Collector current (d.c.)	$-I_C$	max.	50	mA
Collector current (peak value)	$-I_{CM}$	max.	50	mA

Power dissipation

Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	50	mW

Temperatures

Storage temperature	T_{stg}	-65 to +125		°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	1.6	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

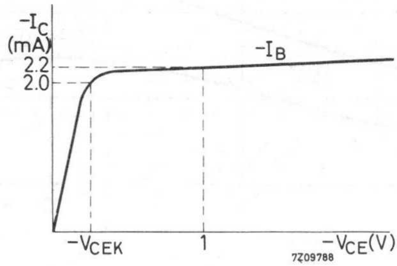
$I_E = 0$; $-V_{CB} = 20$ V	$-I_{CBO}$	<	100	nA
$I_E = 0$; $-V_{CB} = 20$ V; $T_j = 125$ °C	$-I_{CBO}$	<	1	μA

Base-emitter voltage

$-I_C = 0.2$ mA; $-V_{CE} = 0.5$ V	$-V_{BE}$	typ.	580	mV
$-I_C = 2$ mA; $-V_{CE} = 1$ V	$-V_{BE}$	typ.	650	mV

Knee voltage

$-I_C = 2$ mA; $-I_B$ = value for which $-I_C = 2.2$ mA at $-V_{CE} = 1$ V	$-V_{CEK}$	typ.	200	mV



Collector capacitance at f = 1 MHz

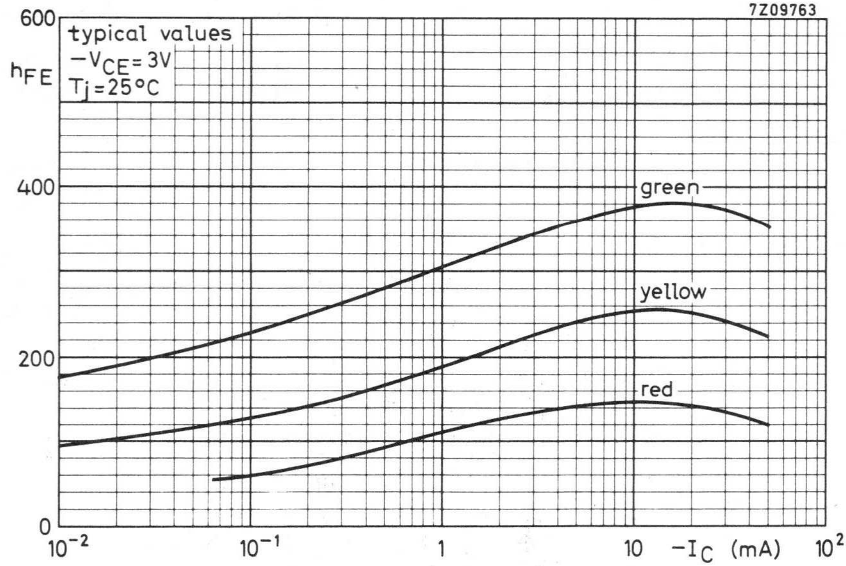
$I_E = I_e = 0$; $-V_{CB} = 5$ V	C_c	typ.	5	pF

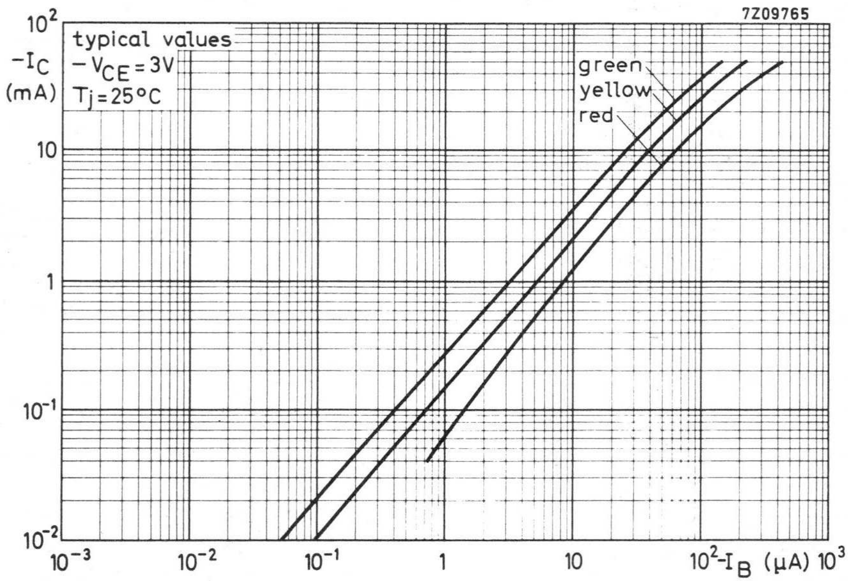
Transition frequency at f = 100 MHz

$-I_C = 2$ mA; $-V_{CE} = 5$ V	f_T	typ.	90	MHz

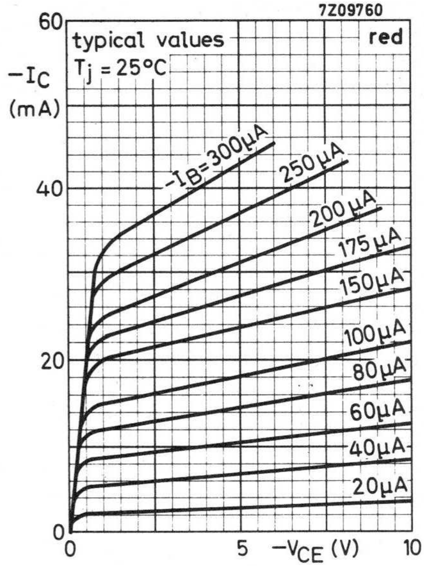
D.C. current gain

			red	yellow	green	
$-I_C = 0.2$ mA; $-V_{CE} = 0.5$ V	h_{FE}	typ.	75	140	250	
			50 to 105	85 to 200	165 to 400	
$-I_C = 2$ mA; $-V_{CE} = 1$ V	h_{FE}	>	60	100	175	
h parameters at f = 1 kHz						
$-I_C = 0.2$ mA; $-V_{CE} = 0.5$ V						
Input impedance	h_{ie}	typ.	12	15	20	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	13	25	40	10^{-4}
Small signal current gain	h_{fe}	typ.	75	140	250	
Output admittance	h_{oe}	typ.	13	18	33	$\mu\Omega^{-1}$
Noise figure						
$-I_C = 0.2$ mA; $-V_{CE} = 5$ V; $R_S = 2$ kΩ						
Bandwidth: f = 30 Hz to 15 kHz	F	typ.	2	1.5	2	dB
		<	–	4	–	dB

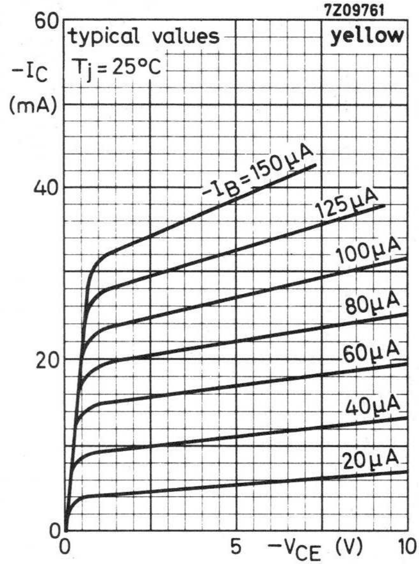

7Z09763
typical values
$-V_{CE} = 3V$
$T_j = 25°C$
h_{FE}
600
400
200
0
green
yellow
red
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2


7Z09765
typical values
$-V_{CE} = 3V$
$T_j = 25°C$
$-I_C$ (mA)
10^2
10
1
10^{-1}
10^{-2}
green
yellow
red
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
$-I_B$ (μA)
10^3

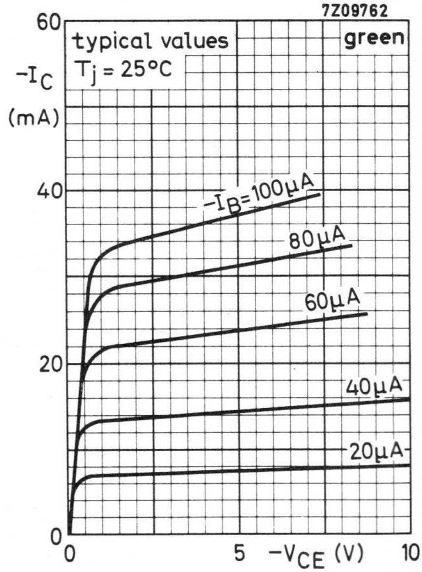
7Z09760



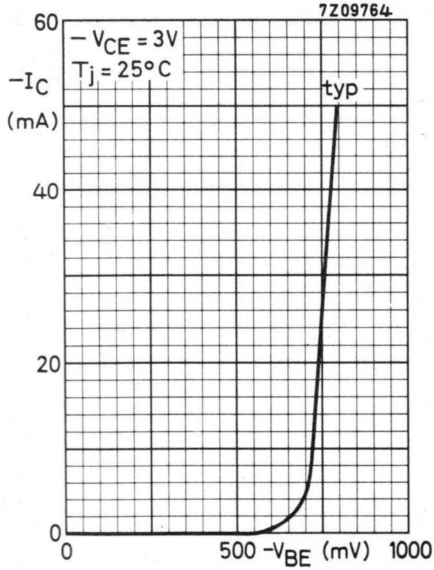
7Z09761



7Z09762



7Z09764



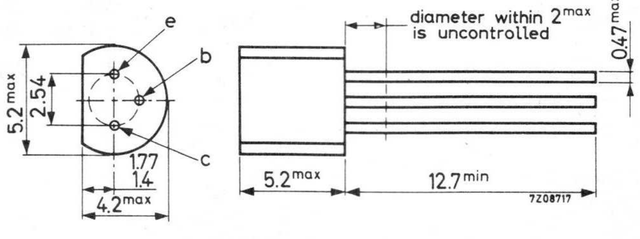
A.F. SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a plastic envelope.
The BC237 is primarily intended for use in driver stages of audio amplifiers and in signal processing circuits of television receivers.
The BC238 is suitable for a multitude of low voltage applications e.g. driver stages or audio pre-amplifiers and in signal processing circuits of television receivers.
The BC239 is primarily intended for low noise input stages in tape recorders, hi-fi amplifiers and other audio frequency equipment.

QUICK REFERENCE DATA

			BC237	BC238	BC239	
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	50	30	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	20	20	V
Collector current (peak value)	I_{CM}	max.	200	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	300	300	mW
Junction temperature	T_j	max.	125	125	125	°C
Small signal current gain at T_j = 25 °C I_C = 2 mA; V_{CE} = 5 V; f = 1 kHz	h_{fe}	> <	125 500	125 900	240 900	
Transition frequency at f = 35 MHz I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	300	300	300	MHz
Noise figure at R_S = 2 kΩ I_C = 200 μA; V_{CE} = 5 V						
f = 30 Hz to 15 kHz	F	typ. <			1.4 4	dB dB
f = 1 kHz; B = 200 Hz	F	typ.	2	2	1.2	dB

MECHANICAL DATA Dimensions in mm



RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

			BC237	BC238	BC239	
Collector-base voltage (open emitter)	V_{CBO}	max.	50	30	30	V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	50	30	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	20	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	5	5	V

Currents

Collector current (d.c.)	I_C	max.	100	mA
Collector current (peak value)	I_{CM}	max.	200	mA
Emitter current (peak value)	$-I_{EM}$	max.	200	mA
Base current (peak value)	I_{BM}	max.	200	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	mW

Temperatures

Storage temperature	T_{stg}		−65 to +125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.33	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

I_E = 0; V_{CB} = 20 V; T_j = 125 °C	I_{CBO}	<	15	μA

Base-emitter voltage [1])

I_C = 2 mA; V_{CE} = 5 V	V_{BE}	typ.	620	mV
		550 to	700	mV
I_C = 10 mA; V_{CE} = 5 V	V_{BE}	<	770	mV

[1]) V_{BE} decreases by about 2 mV/°C with increasing temperature.

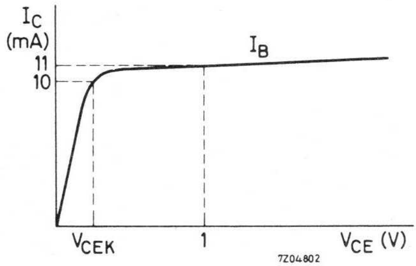
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Saturation voltages [1])

I_C = 10 mA; I_B = 0.5 mA	V_{CEsat}	typ.	90	mV
		<	250	mV
	V_{BEsat}	typ.	700	mV
I_C = 100 mA; I_B = 5 mA	V_{CEsat}	typ.	200	mV
		<	600	mV
	V_{BEsat}	typ.	900	mV

Knee voltage

I_C = 10 mA; I_B = value for which I_C = 11 mA at V_{CE} = 1 V	V_{CEK}	typ.	330	mV
		<	600	mV



Collector capacitance at f = 1 MHz

$I_E = I_e$ = 0; V_{CB} = 10 V	C_c	typ.	2.5	pF
		<	4.5	pF

Emitter capacitance at f = 1 MHz

$I_C = I_c$ = 0; V_{EB} = 0.5 V	C_e	typ.	9	pF

Transition frequency at f = 35 MHz

I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	300	MHz

Small signal current gain at f = 1 kHz

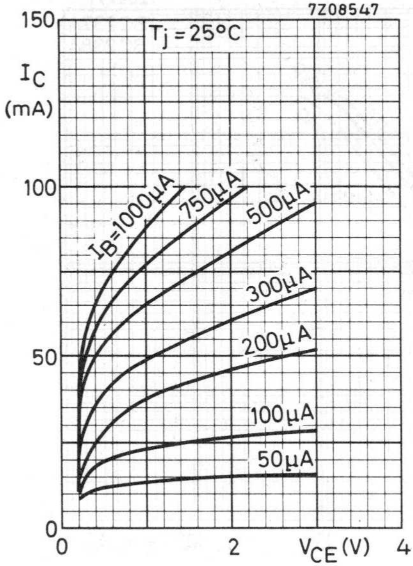
			BC237	BC238	BC239	
I_C = 2 mA; V_{CE} = 5 V	h_{fe}	>	125	125	240	
		<	500	900	900	
Noise figure at R_S = 2 kΩ; I_C = 200 μA; V_{CE} = 5 V						
f = 30 Hz to 15 kHz	F	typ.			1.4	dB
		<			4	dB
f = 1 kHz; B = 200 Hz	F	typ.	2	2	1.2	dB
		<	10	10	4	dB

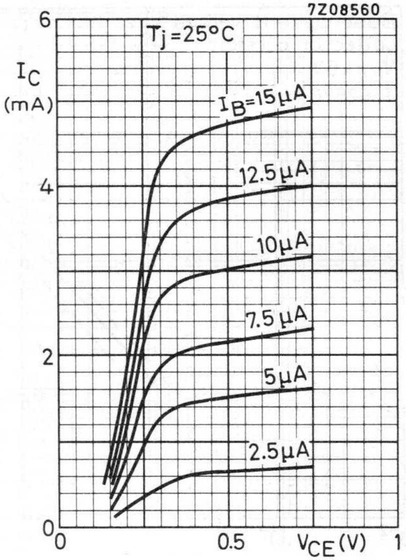
[1]) V_{BEsat} decreases by about 1.7 mV/°C with increasing temperature.

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

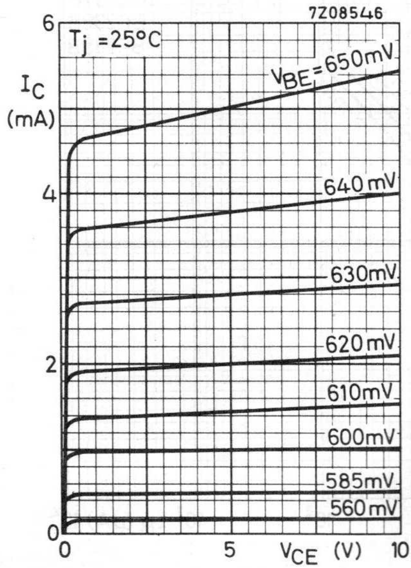
			BC237A BC238A	BC237B BC238B BC239B	BC238C BC239C	
D.C. current gain						
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	typ.	90	150	270	
		>	110	200	420	
I_C = 2 mA; V_{CE} = 5 V	h_{FE}	typ.	180	290	520	
		<	220	450	800	
h parameters at f = 1 kHz (common emitter)						
I_C = 2 mA; V_{CE} = 5 V						
		>	1.6	3.2	6	kΩ
Input impedance	h_{ie}	typ.	2.7	4.5	8.7	kΩ
		<	4.5	8.5	15	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	1.5	2	3	10^{-4}
		>	125	240	450	
Small signal current gain	h_{fe}	typ.	220	330	600	
		<	260	500	900	
Output admittance	h_{oe}	typ.	18	30	60	$\mu\Omega^{-1}$
		<	30	60	110	$\mu\Omega^{-1}$

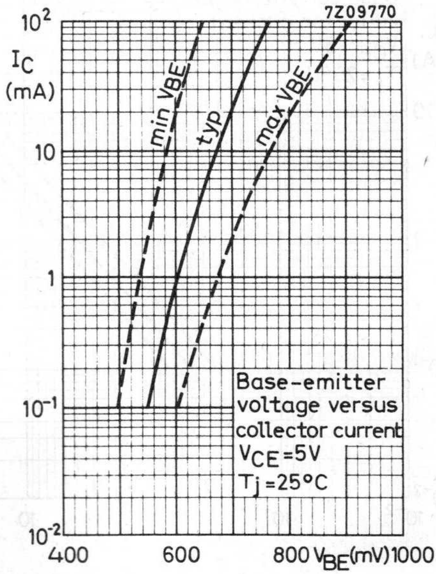
Typical behaviour of collector current versus collector-emitter voltage



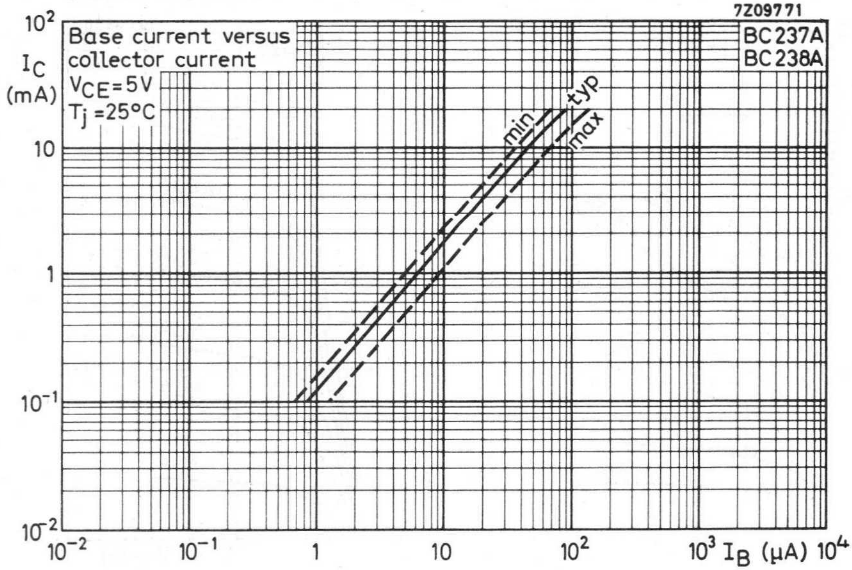


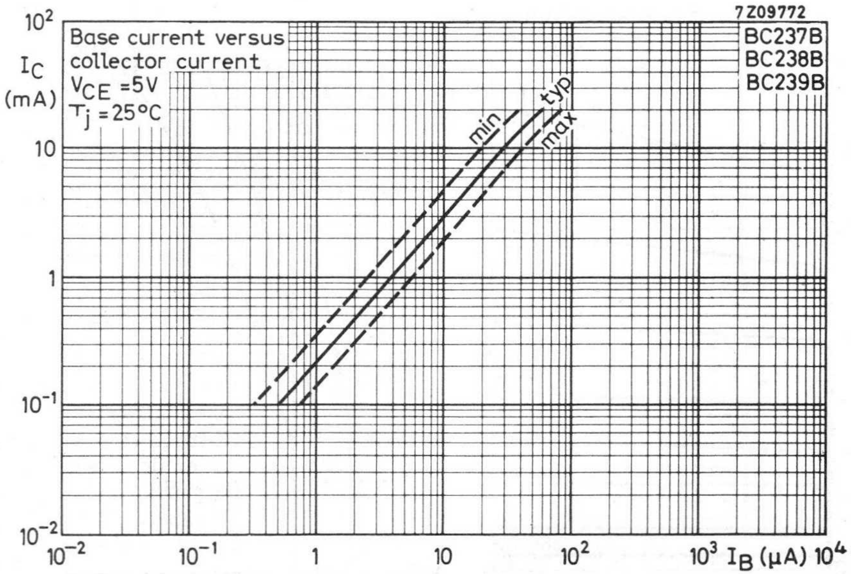
Typical behaviour of collector current versus collector-emitter voltage

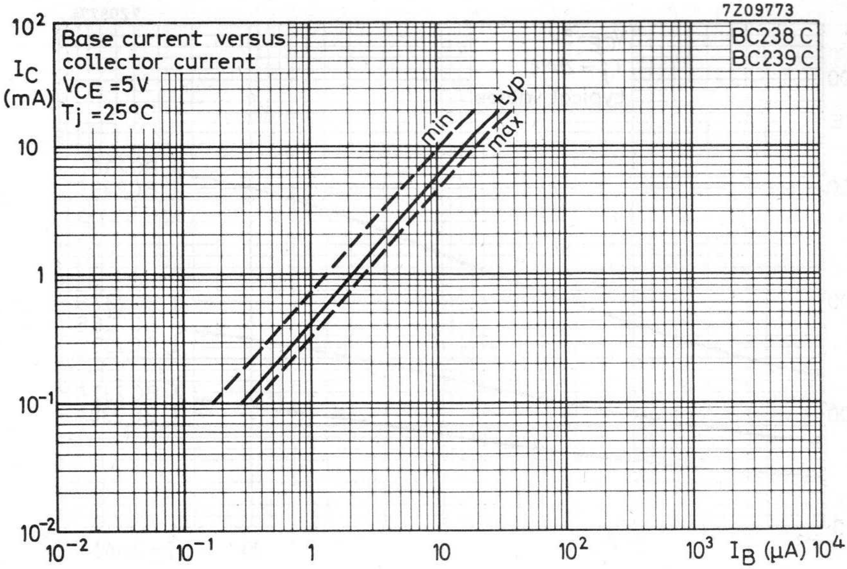


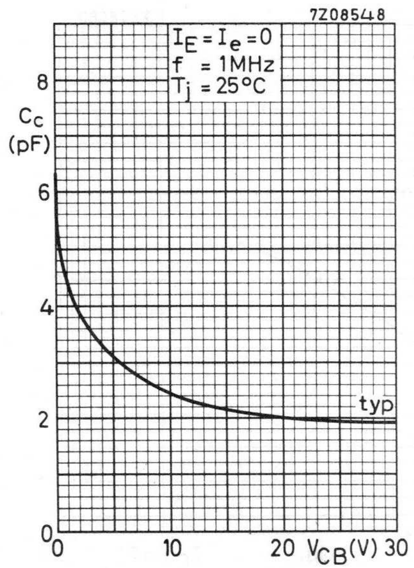


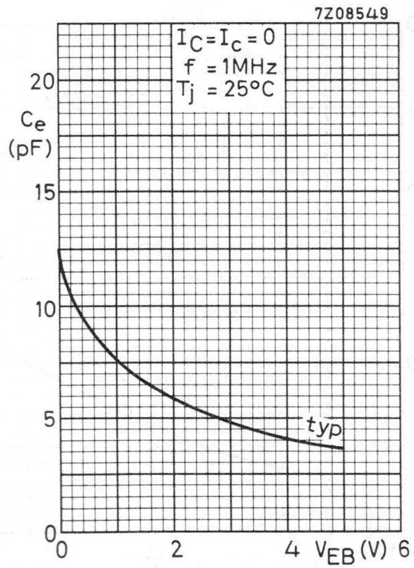
Base-emitter voltage versus collector current
$V_{CE} = 5V$
$T_j = 25°C$

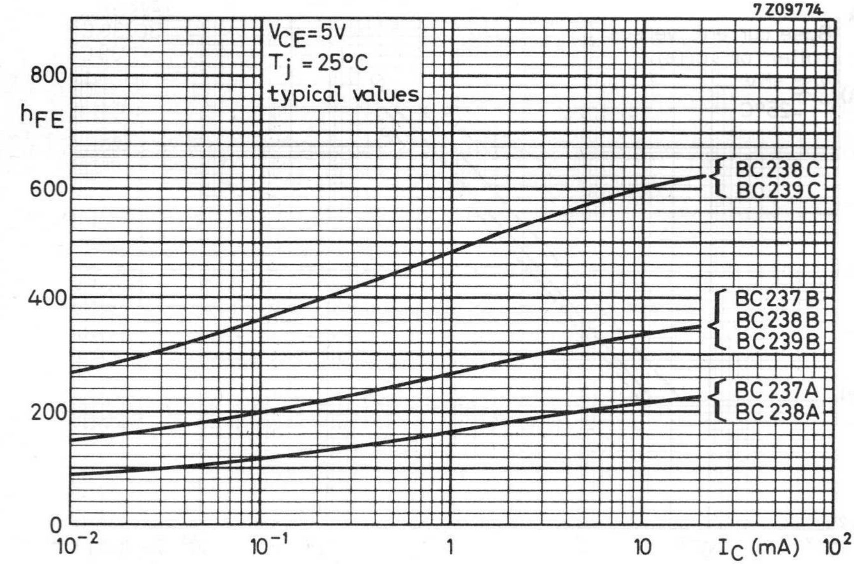

7Z09771
Base current versus
collector current
V_{CE}=5V
T_j =25°C
BC237A
BC238A
I_C
(mA)
10^2
10
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1
10
10^2
10^3 I_B (μA) 10^4
min
typ
max

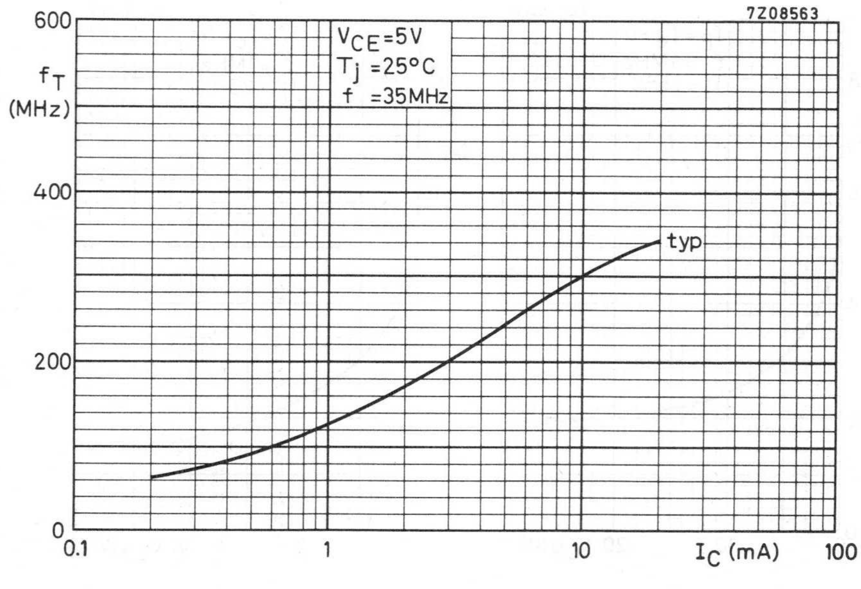

7Z09772
Base current versus
collector current
V_{CE} =5V
T_j =25°C
BC237B
BC238B
BC239B
I_C
(mA)
10^2
10
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1
10
10^2
10^3 I_B (μA) 10^4
min
typ
max

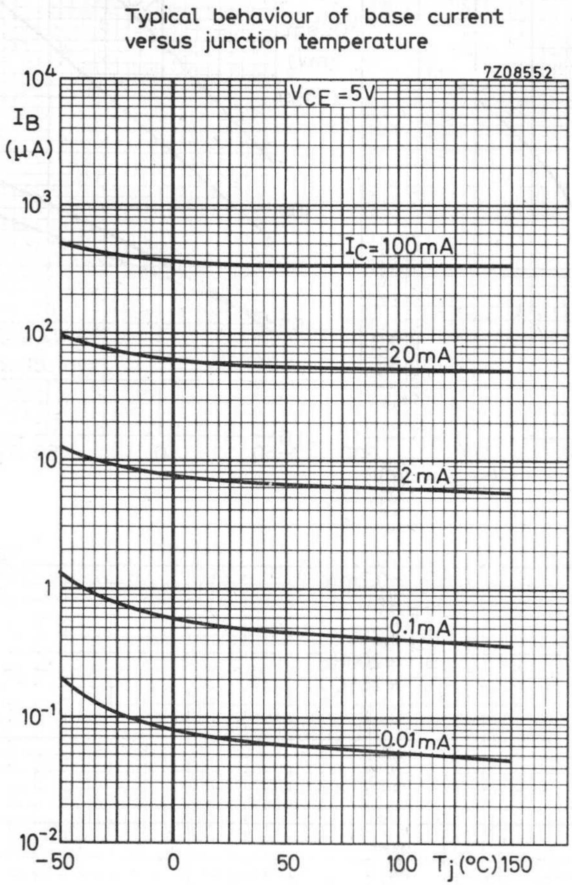

7Z09773
Base current versus collector current
V_{CE} = 5 V
T_j = 25 °C
BC238 C
BC239 C
I_C (mA)
10^2
10
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (μA)
10^4
min
typ
max


7Z08548
$I_E = I_e = 0$
f = 1 MHz
T_j = 25 °C
C_c (pF)
8
6
4
2
0
0
10
20
V_{CB} (V)
30
typ

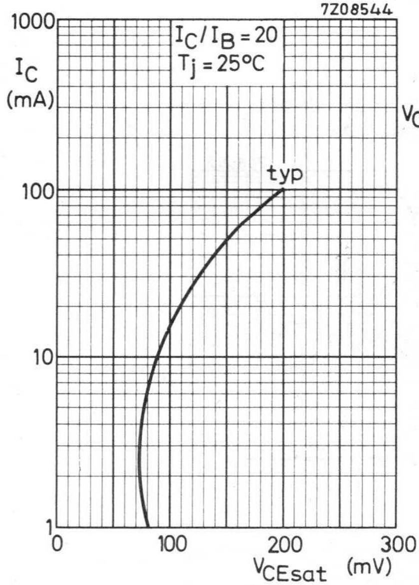

7Z08549
$I_C = I_c = 0$
f = 1 MHz
T_j = 25 °C
C_e (pF)
20
15
10
5
0
0
2
4
V_{EB} (V)
6
typ

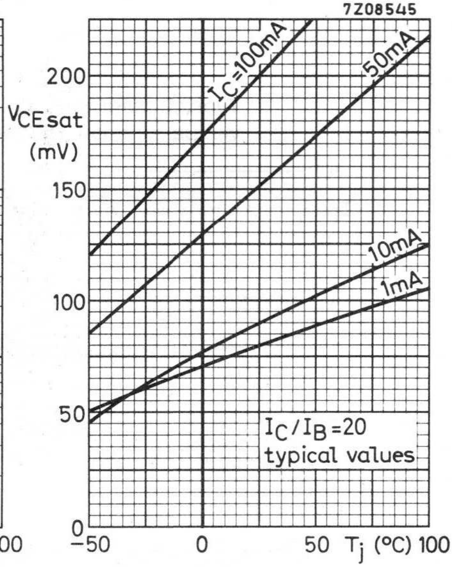

7Z09774
V_{CE}=5V
T_j = 25°C
typical values
h_{FE}
800
600
400
200
0
BC238C
BC239C
BC237B
BC238B
BC239B
BC237A
BC238A
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

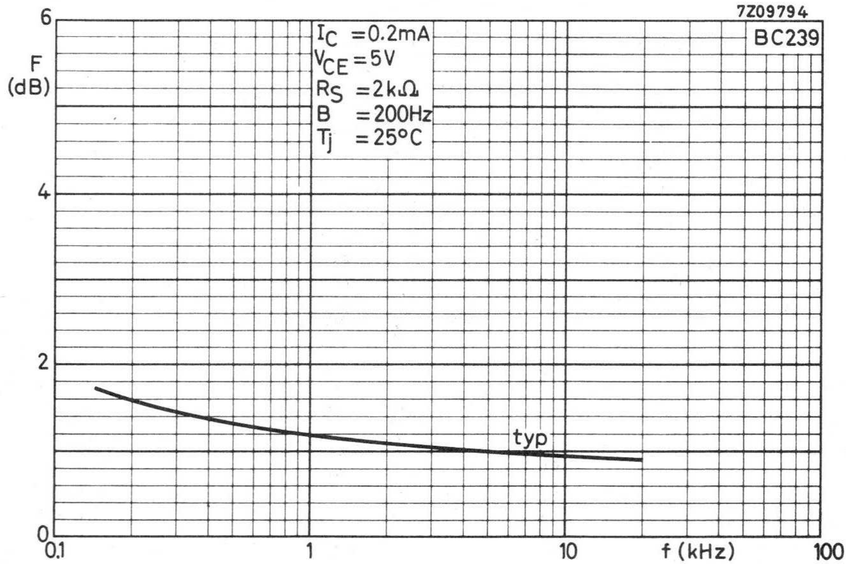

7Z08563
V_{CE}=5V
T_j =25°C
f =35MHz
f_T
(MHz)
600
400
200
0
typ
0.1
1
10
I_C (mA)
100



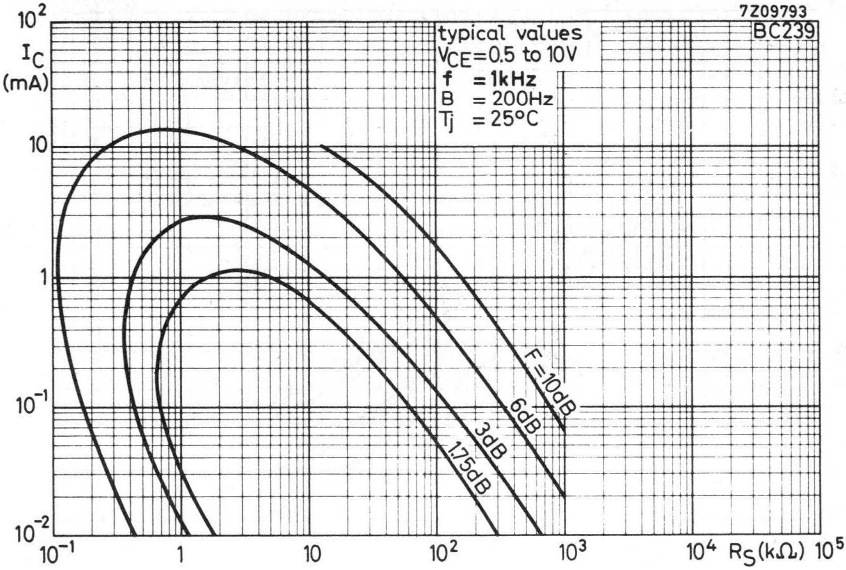
Typical behaviour of base current versus junction temperature
7Z08552
V_{CE} = 5V
I_B (μA)
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}
I_C = 100mA
20mA
2 mA
0.1mA
0.01mA
-50
0
50
100
T_j (°C) 150

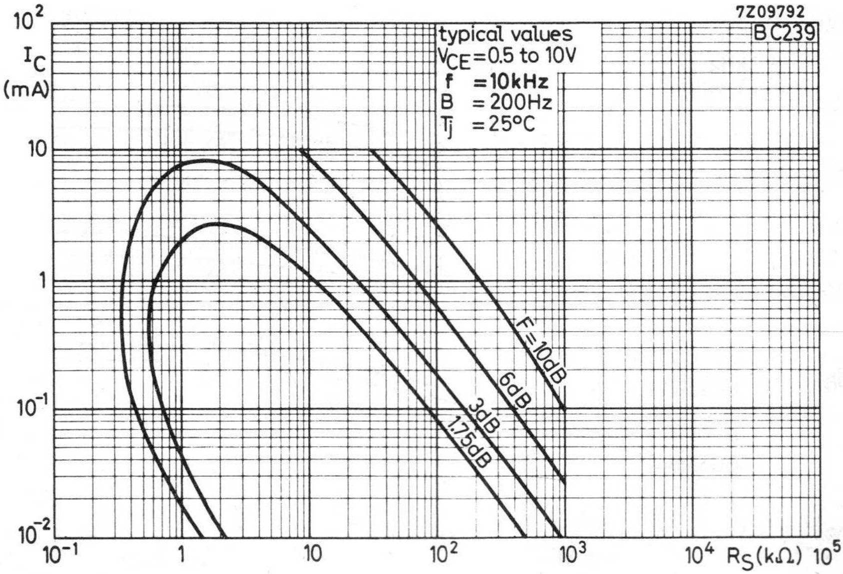

7Z08544
$I_C/I_B = 20$
$T_j = 25$°C
I_C (mA)
1000
100
10
1
typ
0
100
200
300
V_{CEsat} (mV)

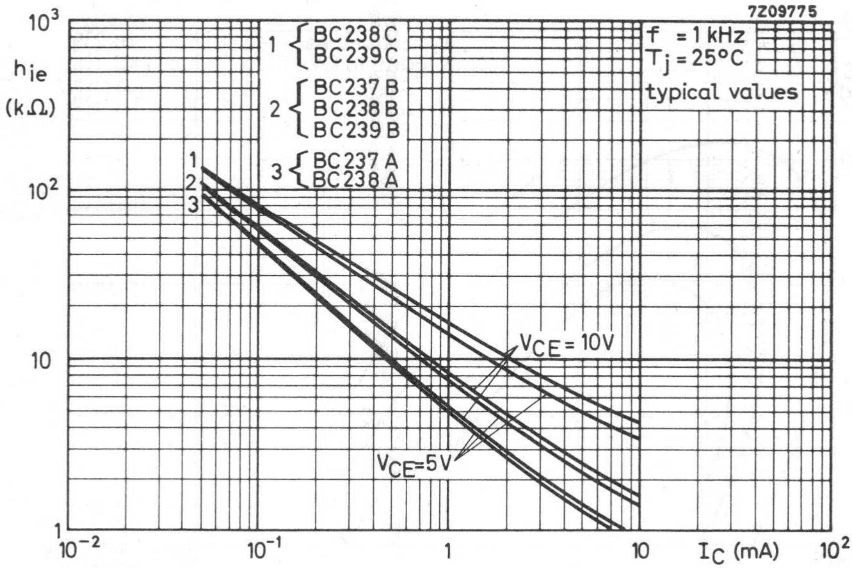

7Z08545
V_{CEsat} (mV)
200
150
100
50
0
I_C=100mA
50mA
10mA
1mA
I_C/I_B=20
typical values
−50
0
50
T_j (°C)
100

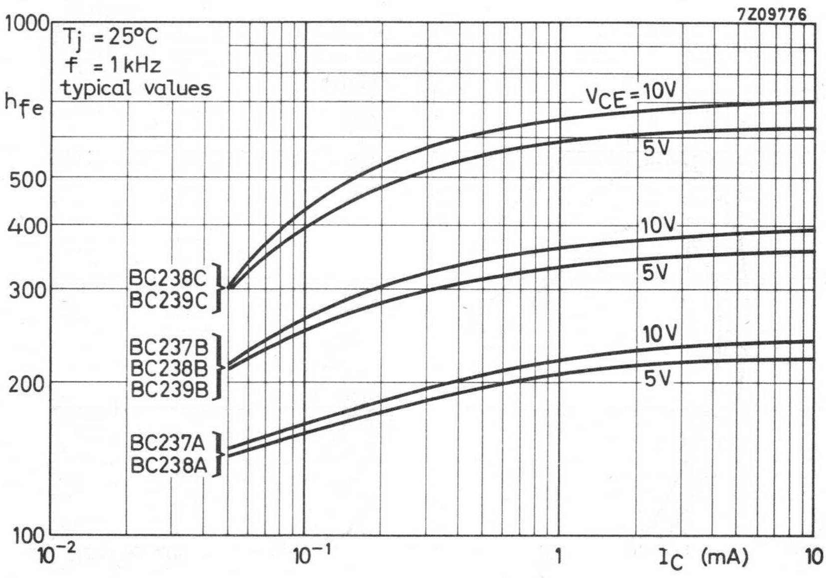

7Z09794
BC239
I_C = 0.2mA
V_{CE} = 5V
R_S = 2kΩ
B = 200Hz
T_j = 25°C
F (dB)
6
4
2
0
typ
0.1
1
10
f (kHz)
100

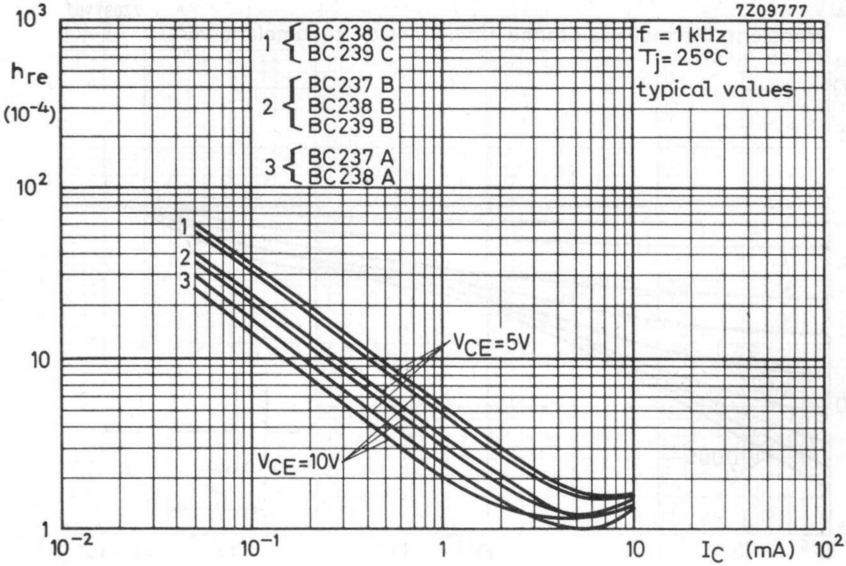
Curves of constant noise figure

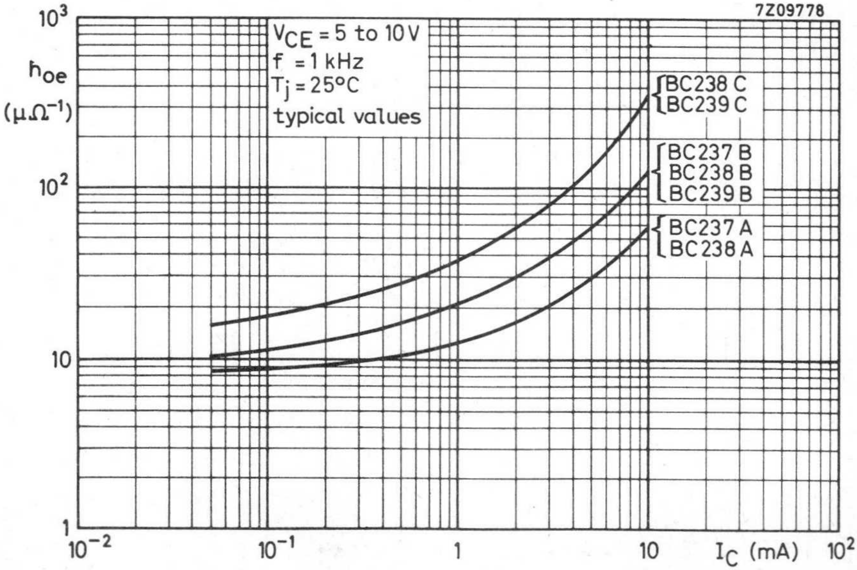


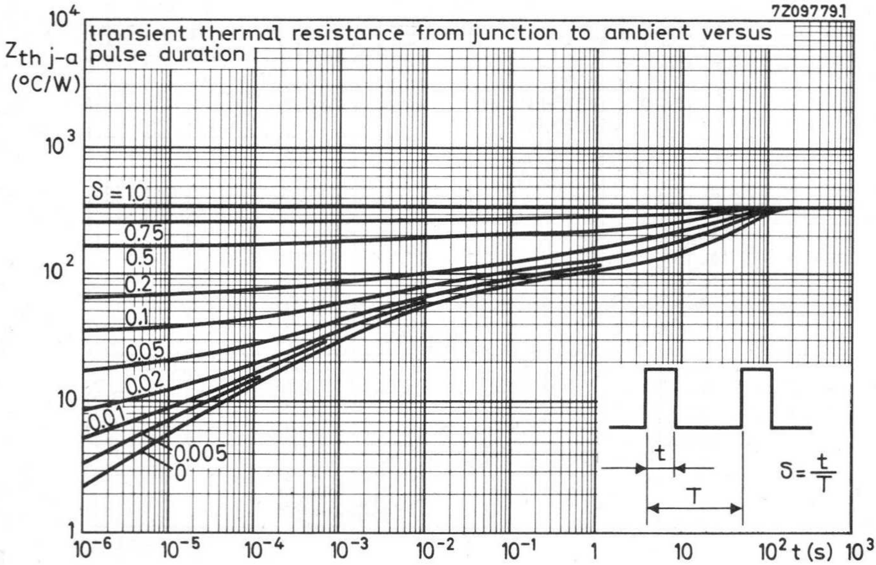



7Z09775
h_ie (kΩ)
1 { BC238C BC239C
2 { BC237B BC238B BC239B
3 { BC237A BC238A
f = 1 kHz
Tj = 25°C
typical values
VCE = 10V
VCE=5V
IC (mA)
10^3
10^2
10
1
10^-2
10^-1
1
10
10^2


7Z09776
Tj = 25°C
f = 1 kHz
typical values
h_fe
VCE = 10V
5V
10V
5V
10V
5V
BC238C
BC239C
BC237B
BC238B
BC239B
BC237A
BC238A
IC (mA)
1000
500
400
300
200
100
10^-2
10^-1
1
10


7Z09777
h_{re}
(10^{-4})
1 { BC238 C, BC239 C
2 { BC237 B, BC238 B, BC239 B
3 { BC237 A, BC238 A
f = 1 kHz
T_j = 25°C
typical values
V_{CE}=5V
V_{CE}=10V
I_C (mA)
10^3
10^2
10
1
10^{-2}
10^{-1}
1
10
10^2


7Z09778
h_{oe}
$(\mu\Omega^{-1})$
V_{CE} = 5 to 10 V
f = 1 kHz
T_j = 25°C
typical values
BC238 C, BC239 C
BC237 B, BC238 B, BC239 B
BC237 A, BC238 A
I_C (mA)
10^3
10^2
10
1
10^{-2}
10^{-1}
1
10
10^2


7Z09779.1
transient thermal resistance from junction to ambient versus pulse duration
$Z_{th\ j\text{-}a}$ (°C/W)
10^4
10^3
10^2
10
1
δ = 1.0
0.75
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0
10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 1 10 10^2 t (s) 10^3
t
T
δ = t/T

P-N-P SILICON TRANSISTOR

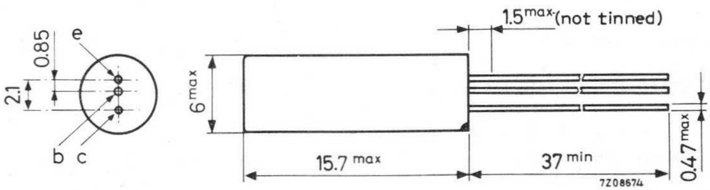
P-N-P alloy transistor in a metal envelope. It is intended for medium voltage and current industrial applications.

QUICK REFERENCE DATA

			BCY10	BCY11	BCY12	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	60	32	V
Collector current (peak value)	$-I_{CM}$	max.		500		mA
Total power dissipation up to T_{amb} = 25 °C with cooling fin on a heatsink	P_{tot}	max.		415		mW
Junction temperature	T_j	max.		150		°C
			BCY10	BCY11	BCY12	
D.C. current gain at T_j = 25 °C; $-I_C$ = 150 mA; $-V_{CE}$ = 1 V	h_{FE}	typ.	15	15	25	
Transition frequency; $-I_C$ = 1 mA; $-V_{CE}$ = 6 V	f_T	typ.	1.5	1.5	2.0	MHz

MECHANICAL DATA

Dimensions in mm



The coloured dot indicates the collector side

Accessories available: 56200; 56208; 56209; 56210; 56226; 56227.

RATINGS (Limiting values) [1])

Voltages

		BCY10	BCY11	BCY12	
Collector-base voltage (open emitter)	$-V_{CBO}$	max. 32	60	32	V
Collector-emitter voltage ($V_{BE} = 0$)	$-V_{CES}$	max. 32	60	32	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max. 12	12	12	V

Currents

Collector current (d.c. or average over any 20 ms period)	$-I_C$	max.	250	mA
Collector current (peak value)	$-I_{CM}$	max.	500	mA
Base current (d.c.)	$-I_B$	max.	125	mA
Emitter current (d.c. or average over any 20 ms period)	I_E	max.	250	mA
Emitter current (peak value)	I_{EM}	max.	500	mA

Power dissipation

Total power dissipation up to $T_{amb} = 25\ ^oC$ with a cooling fin on 1.6 mm Al. heatsink of 7 cm x 7 cm	P_{tot}	max.	415	mW

Temperatures

Storage temperature	T_{stg}		-55 to +150	^oC
Junction temperature	T_j	max.	150	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.4	$^oC/mW$
From junction to ambient with a cooling fin on a 1.6 mm Al. heatsink of 7 cm x 7 cm	$R_{th\ j-a}$	=	0.3	$^oC/mW$
From junction to case	$R_{th\ j-c}$	=	0.25	$^oC/mW$

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $-V_{CB} = 6$ V	$-I_{CBO}$	typ.	20	nA
		<	100	nA

Emitter cut-off current

$I_C = 0$; $-V_{EB} = 6$ V	$-I_{EBO}$	typ.	20	nA
		<	100	nA

Base-emitter voltage at $-I_C$ = 150 mA

BCY10; BCY11	$-V_{CE} = 2$ V	$-V_{BE}$	typ.	1.0	V
BCY12	$-V_{CE} = 1$ V		<	1.6	V

			BCY10	BCY11	BCY12	
Saturation voltage						
$-I_C = 125$ mA; $-I_B = 17$ mA	$-V_{CEsat}$	typ.	250	250	250	mV
		<	–	–	500	mV
D.C. current gain						
$-I_C = 30$ mA; $-V_{CE} = 2$ V	h_{FE}	>	12	12	–	
		typ.	24	24	40	
$-I_C = 150$ mA; $-V_{CE} = 1$ V	h_{FE}	>	10	10	–	
		typ.	15	15	25	
$-I_C = 300$ mA; $-V_{CE} = 6$ V	h_{FE}	>	–	–	10	
		typ.	–	–	15	
Transition frequency						
$-I_C = 1$ mA: $-V_{CE} = 6$ V	f_T	typ.	1.5	1.5	2.0	MHz

Collector-base capacitance

$I_E = 0$; $-V_{CE} = 6$ V	$C_{b'c}$	typ.	90	pF

Base resistance

$-I_C = 1$ mA; $-V_{CE} = 6$ V	$r_{bb'}$	typ.	100	Ω

Noise figure at R_S = 500 Ω

$-I_C = 500$ μA; $-V_{CE} = 2$ V	F	typ.	7	dB
		<	20	dB

Small signal current gain

$-I_C = 10$ mA; $-V_{CE} = 6$ V	h_{fe}	typ.	40	

P-N-P SILICON TRANSISTORS

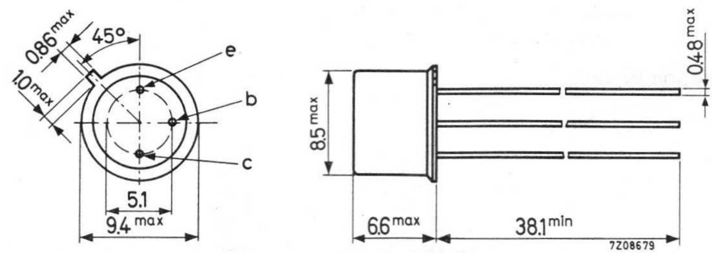
Silicon alloy p-n-p transistors in TO-5 metal case with insulated leads for relay switching, resistor logic circuits and general industrial applications.

QUICK REFERENCE DATA

			BCY 30	BCY 31	BCY 32	BCY 33	BCY 34	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	64	64	64	32	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	50	50	50	25	25	V
Collector current (peak value)	$-I_{CM}$	max.	100	100	100	100	100	mA
Total power dissipation up to T_{case} = 62.5 °C	P_{tot}	max.	250	250	250	250	250	mW
Junction temperature	T_j	max.	150	150	150	150	150	°C
Small signal current gain f = 1 kHz; T_j = 25 °C $-I_C$ = 1 mA; $-V_{CE}$ = 6 V	h_{fe}	typ.	25	35	55	25	35	
Transition frequency $-I_C$ = 1 mA; $-V_{CE}$ = 6 V	f_T	typ.	1.2	1.7	2.5	1.5	2.4	MHz
Thermal resistance	$R_{th\ j\text{-}a}$	=	0.5	0.5	0.5	0.5	0.5	°C/mW

MECHANICAL DATA Dimensions in mm

TO-5



Accessories available: 56218, 56245, 56265

RATINGS (Limiting values) [1]

Voltages

			BCY 30	BCY 31	BCY 32	BCY 33	BCY 34	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	64	64	64	32	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	50	50	50	25	25	V
Collector-emitter voltage (cut-off; see page 9)	$-V_{CEX}$	max.	64	64	64	32	32	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	45	45	32	16	16	V

Currents

Collector current (d.c. or average over any 20 ms period)	$-I_C$	max.	50	mA
Collector current (peak value)	$-I_{CM}$	max.	100	mA
Base current (d.c. or average over any 20 ms period)	$-I_B$	max.	15	mA
Base current (peak value)	$-I_{BM}$	max.	50	mA

Power dissipation

Total power dissipation up to T_{case} = 62.5 ^{o}C	P_{tot}	max.	250	mW

Temperatures

Storage temperature	T_{stg}		-55 to +150	^{o}C
Junction temperature	T_j	max.	150	^{o}C

THERMAL RESISTANCE

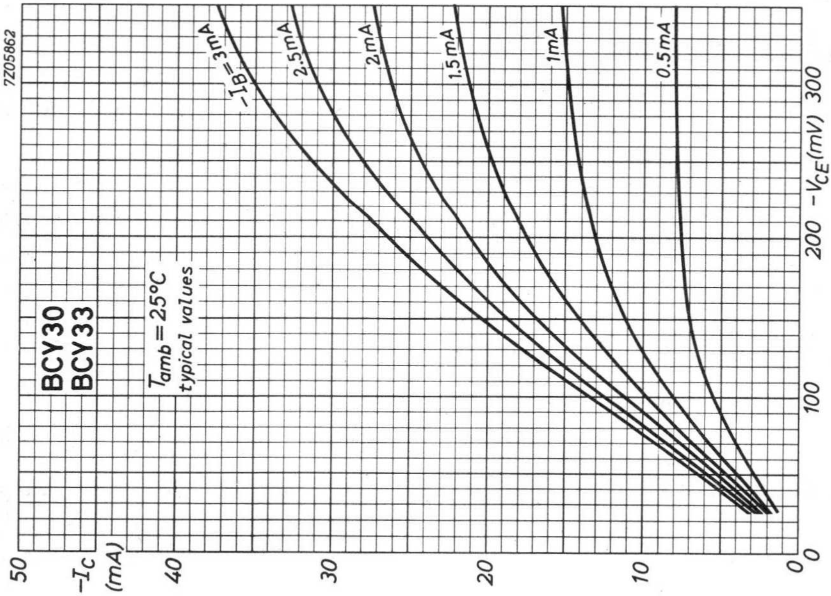
From junction to ambient in free air without cooling clip	$R_{th\ j-a}$	=	0.5	^{o}C/mW
From junction to case	$R_{th\ j-c}$	=	0.35	^{o}C/mW

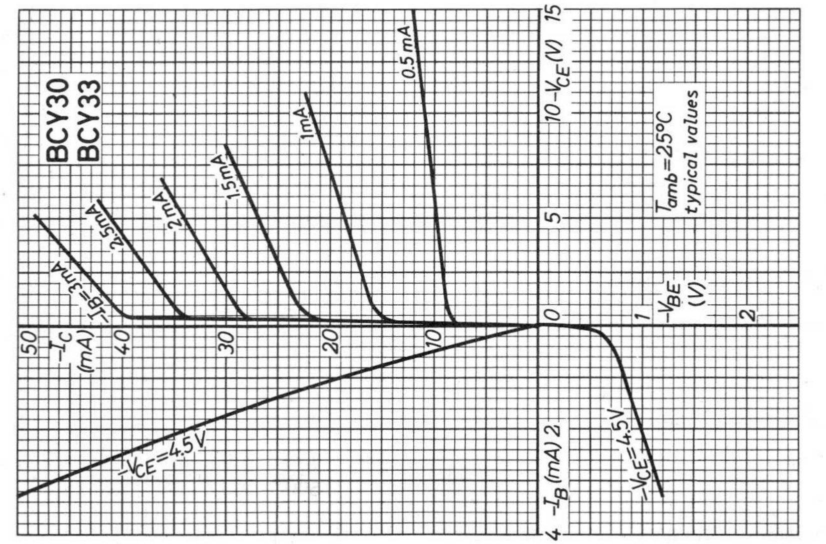
[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

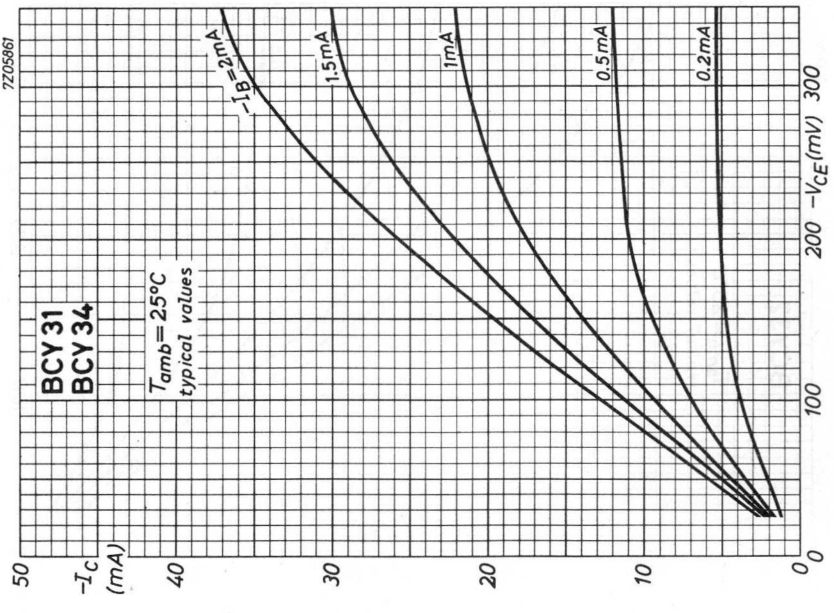
CHARACTERISTICS T_{amb} = 25 °C unless otherwise specified

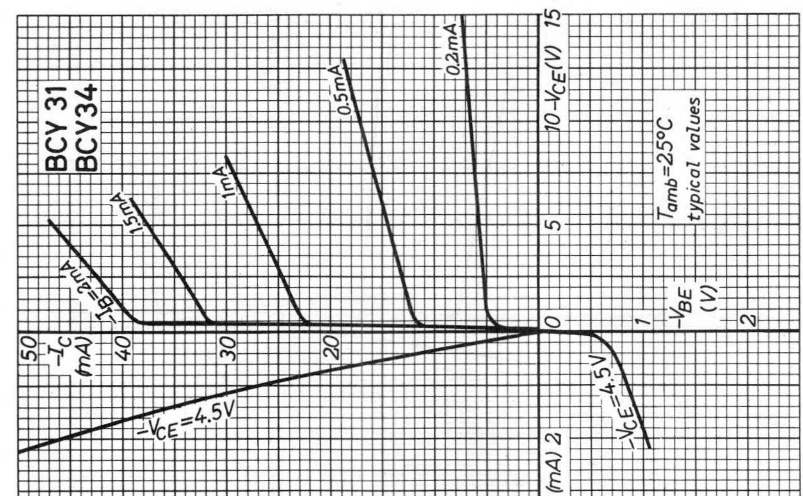
Collector cut-off current				
$I_E = 0$; $-V_{CB} = 6$ V	$-I_{CBO}$	typ.	1.0	nA
		<	50	nA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 6$ V	$-I_{EBO}$	typ.	1.0	nA
		<	50	nA
$I_C = 0$; $-V_{EB} = 6$ V; $T_j = 100$ °C	$-I_{EBO}$	typ.	0.1	µA
		<	2.5	µA
Saturation voltages				
$-I_C = 20$ mA; $-I_B = 3$ mA	$-V_{CEsat}$	typ.	160	mV
		<	550	mV
	$-V_{BEsat}$	typ.	0.8	V
		<	1.25	V
Collector capacitance				
$I_E = I_e = 0$; $-V_{CB} = 6$ V	C_c	>	15	pF
		typ.	28	pF
		<	60	pF
Noise figure at f = 1 kHz				
$I_E = 500$ µA; $-V_{CE} = 2$ V; $R_S = 500\ \Omega$	F	typ.	8.0	dB
		<	20	dB

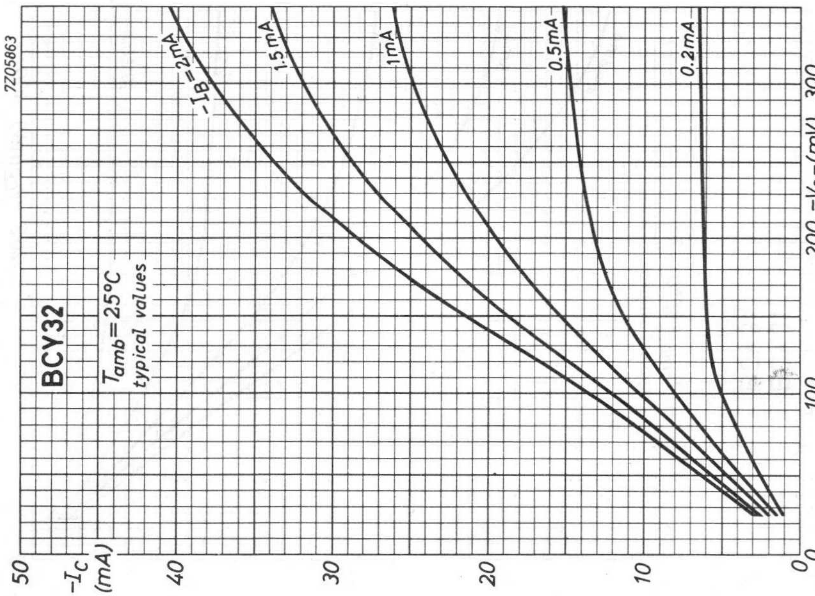
			BCY 30	BCY 31	BCY 32	BCY 33	BCY 34	
D.C. current gain								
$-I_C = 20$ mA; $-V_{CE} = 4.5$ V	h_{FE}	>	10	15	20	10	15	
		typ.	18	28	35	18	28	
		<	35	60	70	35	60	
Small signal current gain								
$-I_C = 1$ mA; $-V_{CE} = 6$ V; f = 1 kHz	h_{fe}	>	15	25	35	15	25	
		typ.	25	35	55	25	35	
		<	35	60	80	35	60	
Feedback impedance								
$-I_C = 1$ mA; $-V_{CE} = 6$ V; f = 1 kHz	$\lvert z_{rb} \rvert$	typ.	160	220	230	190	235	Ω
		<	500	500	500	500	500	Ω
Transition frequency								
$-I_C = 1$ mA; $-V_{CE} = 6$ V	f_T	>	0.25	0.25	0.25	0.4	0.6	MHz
		typ.	1.2	1.7	2.5	1.5	2.4	MHz

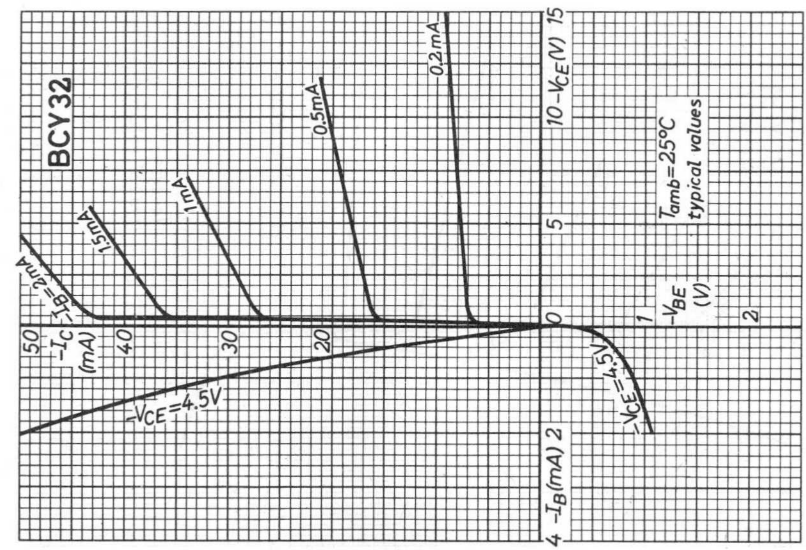

7Z05862
BCY30
BCY33
$T_{amb} = 25°C$
typical values
$-I_B = 3mA$
2.5 mA
2 mA
1.5 mA
1mA
0.5 mA
$-I_C$ (mA)
50
40
30
20
10
0
0
100
200
300
$-V_{CE}$ (mV)

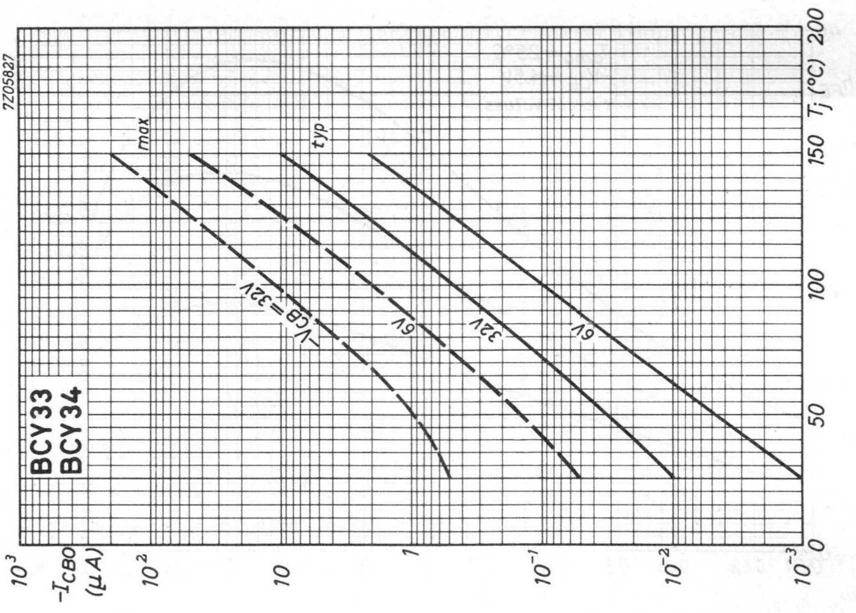

BCY30
BCY33
$T_{amb}=25°C$
typical values
$-I_B=3mA$
2.5mA
2mA
1.5mA
1mA
0.5 mA
$-I_C$ (mA)
50
40
30
20
10
0
5
10
15
$-V_{CE}$ (V)
$-V_{CE}=4.5V$
$-V_{CE}=4.5V$
$-I_B$ (mA) 2
4
1
2
$-V_{BE}$ (V)

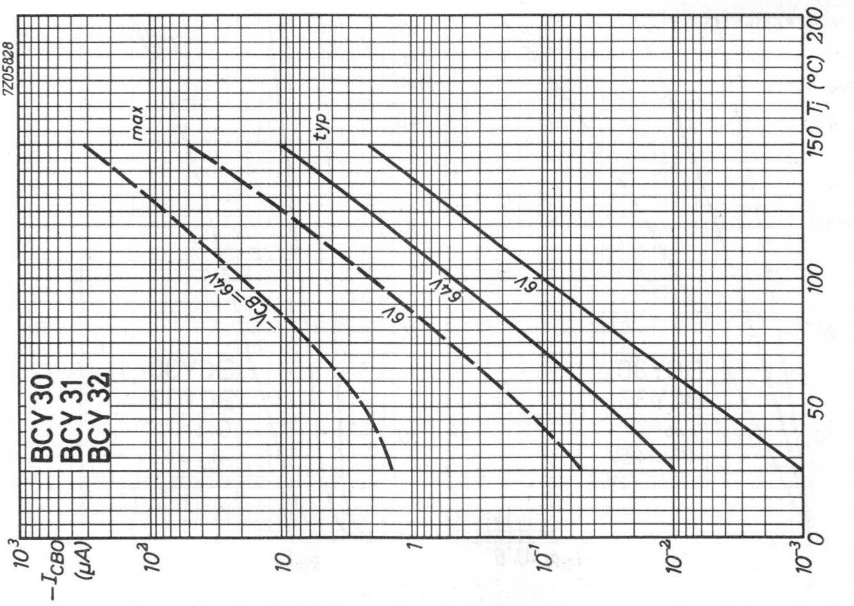

7Z05861
BCY 31
BCY 34
T_{amb}=25°C
typical values
$-I_B$=2mA
1.5mA
1mA
0.5mA
0.2mA
$-I_C$
(mA)
50
40
30
20
10
0
0
100
200
$-V_{CE}$(mV)
300

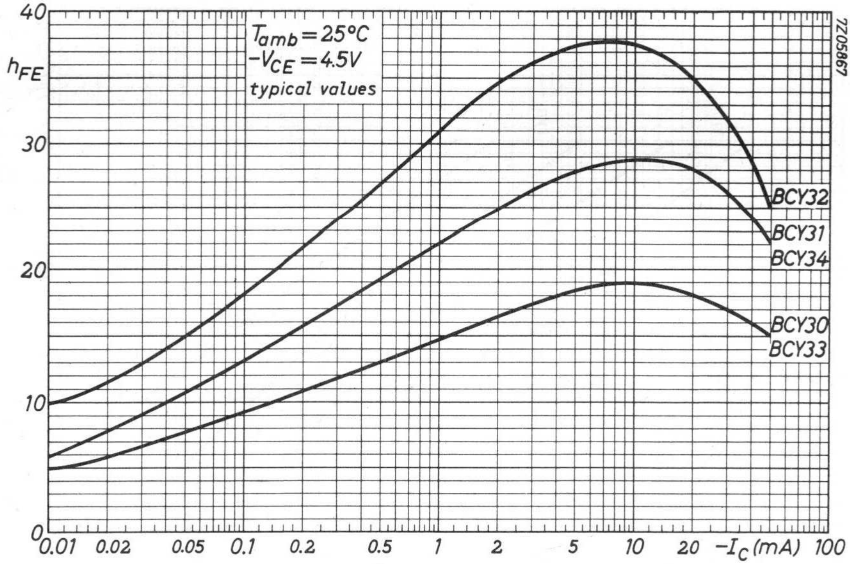

BCY 31
BCY34
T_{amb}=25°C
typical values
$-I_B$=2mA
1.5mA
1mA
0.5mA
0.2mA
$-I_C$
(mA)
50
40
30
20
0
5
10
$-V_{CE}$(V)
15
$-V_{CE}$=4.5V
$-V_{CE}$=4.5V
$-V_{BE}$
(V)
1
2
4
$-I_B$ (mA)
2

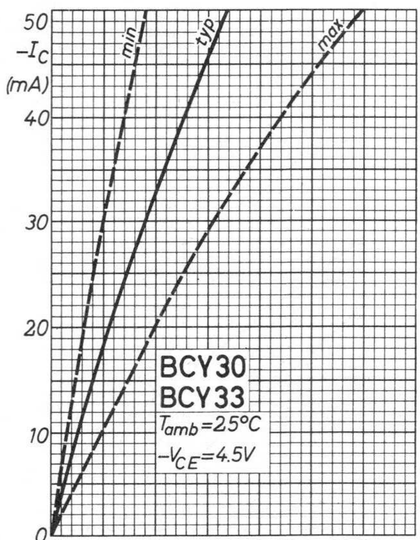

7Z05863
BCY32
Tamb=25°C
typical values
-IB=2mA
1.5mA
1mA
0.5mA
0.2mA
50
-IC (mA)
40
30
20
10
0
0
100
200
300
-VCE(mV)

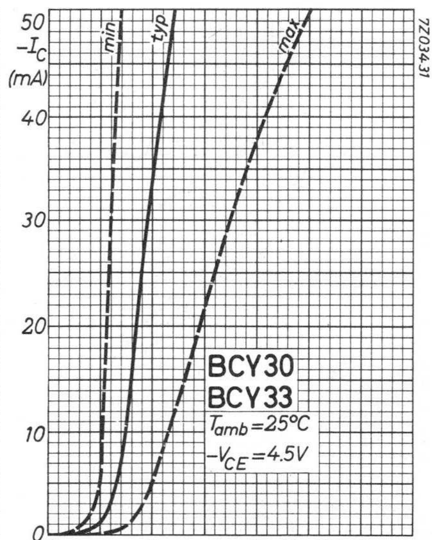

BCY32
-IB=2mA
1.5mA
1mA
0.5mA
0.2mA
50
-IC (mA)
40
30
20
0
5
10 -VCE(V) 15
Tamb=25°C
typical values
-VCE=4.5V
-VCE=4.5V
1
-VBE (V)
2
4 -IB(mA) 2

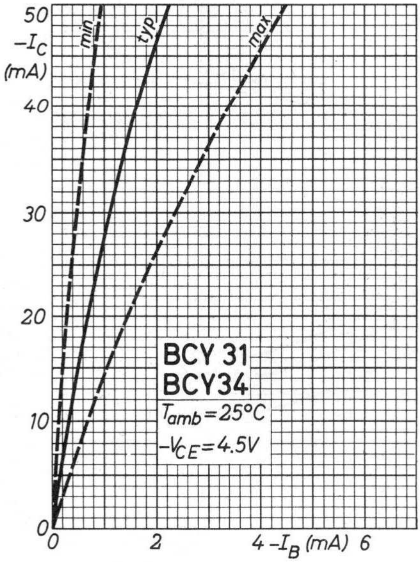

7Z05827
BCY33
BCY34
max
typ
−VCB = 32V
6V
32V
6V
−ICBO (μA)
10³
10²
10
1
10⁻¹
10⁻²
10⁻³
0
50
100
150
200
Tj (°C)

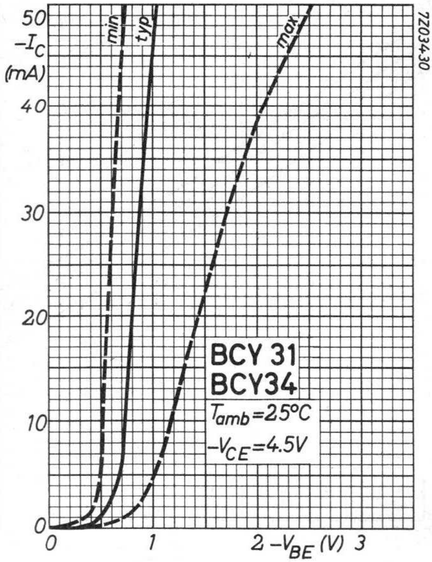

7Z05828
BCY30
BCY31
BCY32
max
typ
−VCB = 64V
6V
64V
6V
−ICBO (μA)
10³
10²
10
1
10⁻¹
10⁻²
10⁻³
0
50
100
150
200
Tj (°C)

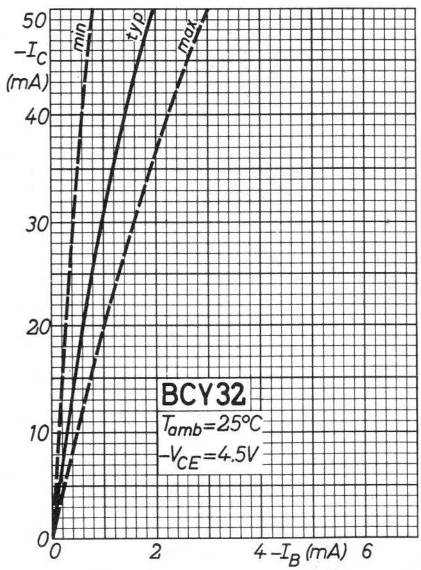

7Z05867
T_{amb} = 25°C
$-V_{CE}$ = 4.5V
typical values
h_{FE}
BCY32
BCY31
BCY34
BCY30
BCY33
0.01 0.02 0.05 0.1 0.2 0.5 1 2 5 10 20 $-I_C$ (mA) 100

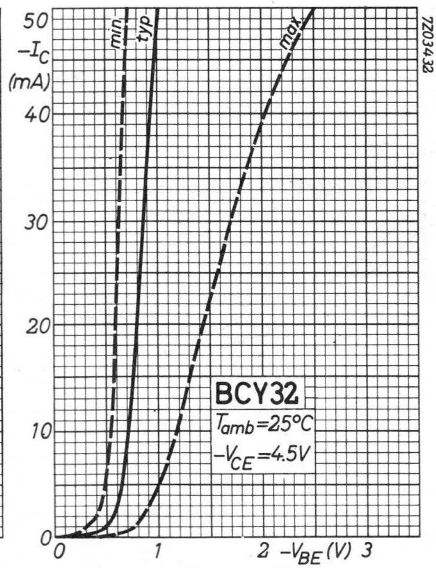

min
typ
max
$-I_C$ (mA)
BCY30
BCY33
T_{amb}=25°C
$-V_{CE}$=4.5V
$-I_B$(mA)

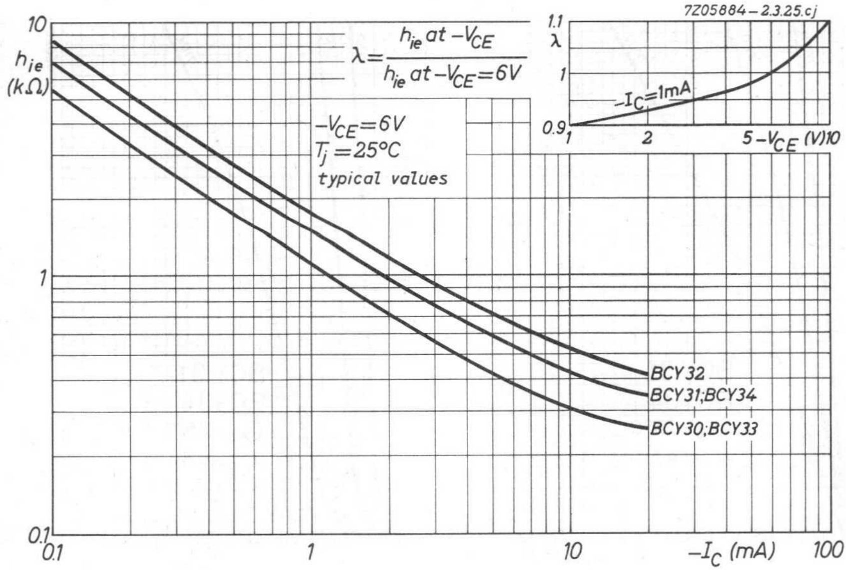

7Z034 31
min
typ
max
$-I_C$ (mA)
BCY30
BCY33
T_{amb}=25°C
$-V_{CE}$=4.5V
$-V_{BE}$(V)

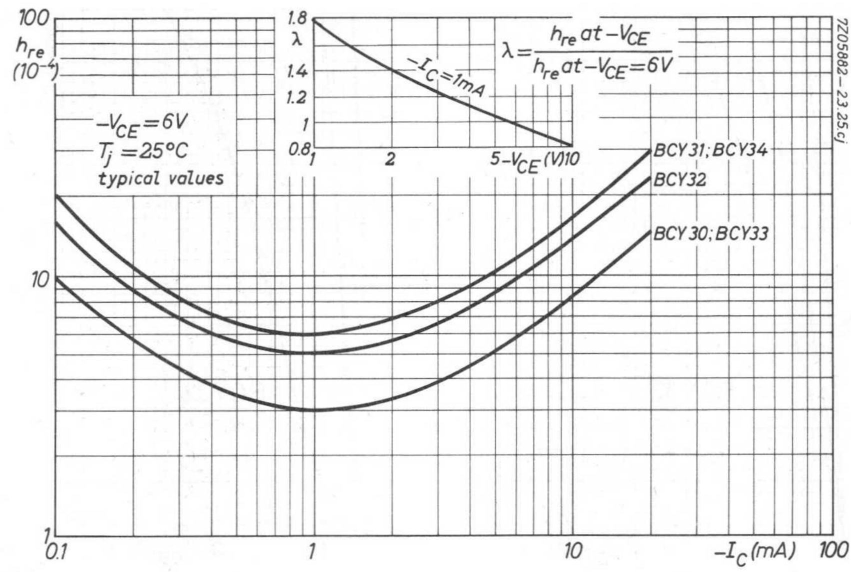

50
$-I_C$
(mA)
40
30
20
10
0
min
typ
max
BCY 31
BCY34
T_{amb}=25°C
$-V_{CE}$=4.5V
0
2
4 $-I_B$ (mA) 6

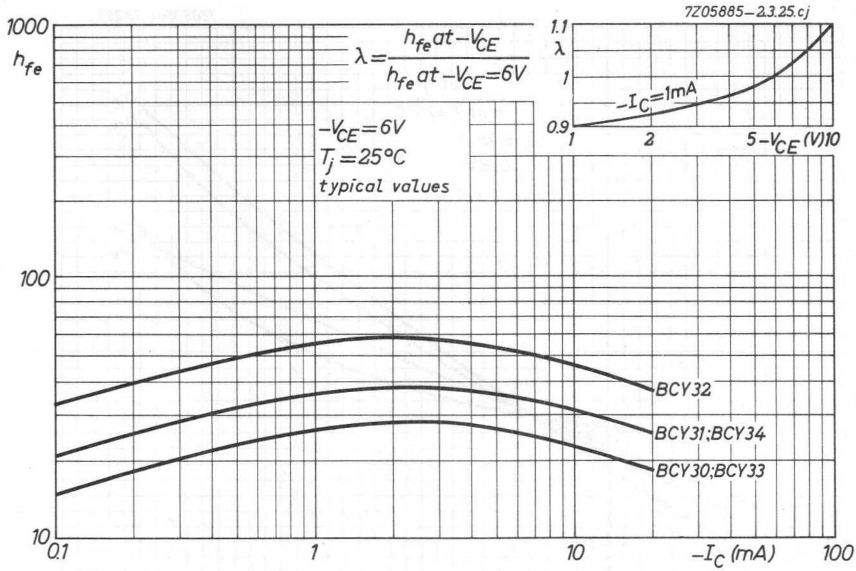

7Z03430
50
$-I_C$
(mA)
40
30
20
10
0
min
typ
max
BCY 31
BCY34
T_{amb}=25°C
$-V_{CE}$=4.5V
0
1
2 $-V_{BE}$ (V) 3

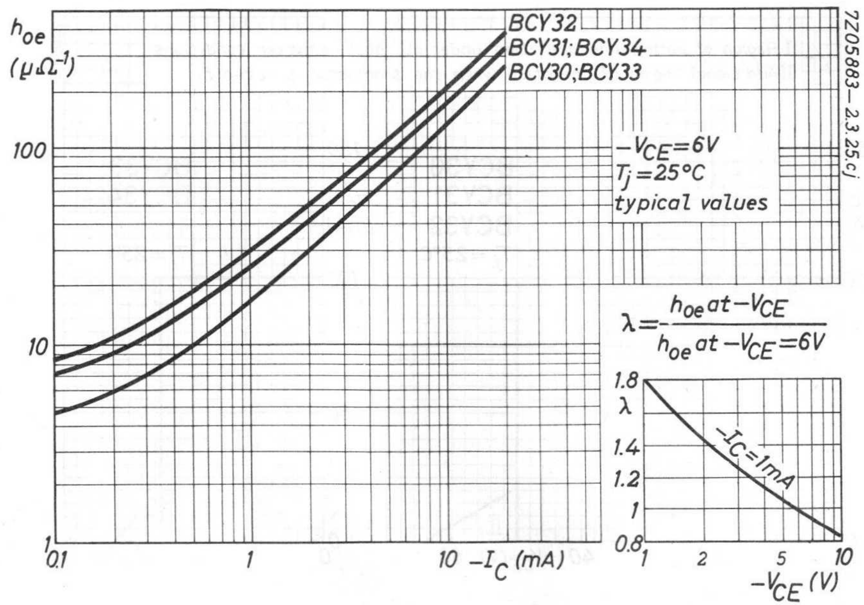

50
$-I_C$
(mA)
40
30
20
10
0
min
typ
max
BCY32
T_{amb}=25°C
$-V_{CE}$=4.5V
0
2
4 $-I_B$ (mA) 6

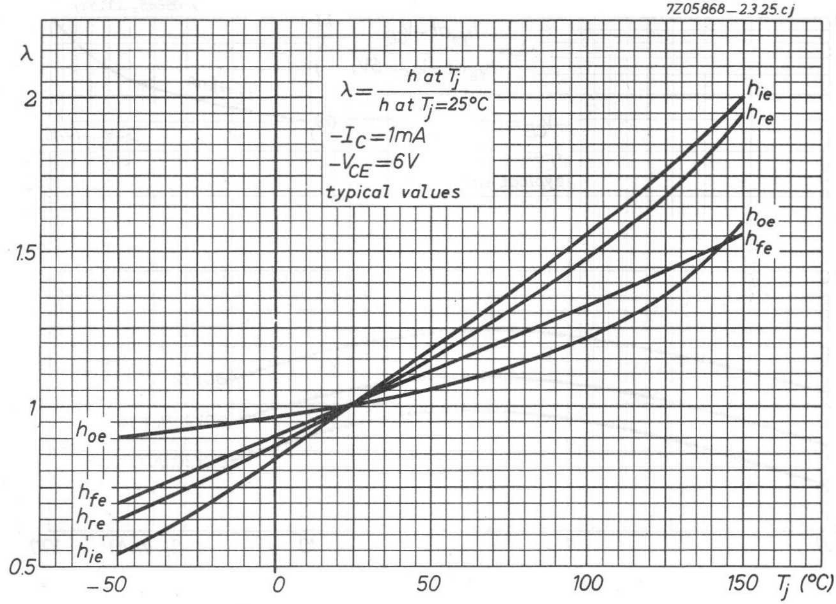

7Z03432
50
$-I_C$
(mA)
40
30
20
10
0
min
typ
max
BCY32
T_{amb}=25°C
$-V_{CE}$=4.5V
0
1
2 $-V_{BE}$ (V) 3

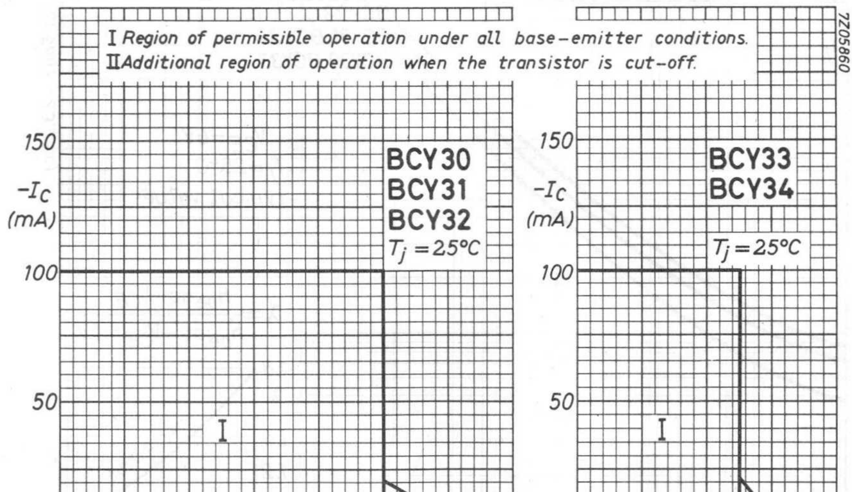

7Z05884 – 2.3.25.cj
10
h_{ie}
(kΩ)
1
0.1
0.1
1
10
$-I_C$ (mA)
100
$\lambda = \frac{h_{ie} \text{ at } -V_{CE}}{h_{ie} \text{ at } -V_{CE} = 6V}$
$-V_{CE} = 6V$
$T_j = 25°C$
typical values
1.1
λ
1
0.9
$-I_C = 1mA$
1
2
5 $-V_{CE}$ (V) 10
BCY32
BCY31;BCY34
BCY30;BCY33


7Z05882 – 2.3.25.cj
100
h_{re}
(10^{-4})
10
1
0.1
1
10
$-I_C$ (mA)
100
$\lambda = \frac{h_{re} \text{ at } -V_{CE}}{h_{re} \text{ at } -V_{CE} = 6V}$
$-V_{CE} = 6V$
$T_j = 25°C$
typical values
1.8
λ
1.4
1.2
1
0.8
$-I_C = 1mA$
1
2
5 $-V_{CE}$ (V) 10
BCY31; BCY34
BCY32
BCY30; BCY33


7Z05885–2.3.25.cj
1000
h_{fe}
100
10
0.1
1
10
$-I_C$ (mA)
100
$\lambda = \frac{h_{fe} \text{ at } -V_{CE}}{h_{fe} \text{ at } -V_{CE} = 6V}$
$-V_{CE} = 6V$
$T_j = 25°C$
typical values
1.1
λ
1
0.9
$-I_C = 1mA$
1
2
5
$-V_{CE}$ (V)
10
BCY32
BCY31; BCY34
BCY30; BCY33


h_{oe}
($\mu\Omega^{-1}$)
100
10
1
0.1
1
10
$-I_C$ (mA)
BCY32
BCY31; BCY34
BCY30; BCY33
7Z05883–2.3.25.cj
$-V_{CE} = 6V$
$T_j = 25°C$
typical values
$\lambda = \frac{h_{oe} \text{ at } -V_{CE}}{h_{oe} \text{ at } -V_{CE} = 6V}$
1.8
λ
1.4
1.2
1
0.8
$-I_C = 1mA$
1
2
5
10
$-V_{CE}$ (V)


7Z05868–2.3.25.cj
λ
$\lambda = \frac{h \text{ at } T_j}{h \text{ at } T_j = 25°C}$
$-I_C = 1mA$
$-V_{CE} = 6V$
typical values
h_{ie}
h_{re}
h_{oe}
h_{fe}
2
1.5
1
0.5
-50
0
50
100
150
T_j (°C)


7Z05860
I Region of permissible operation under all base-emitter conditions.
II Additional region of operation when the transistor is cut-off.
BCY30
BCY31
BCY32
$T_j = 25°C$
$-I_C$ (mA)
150
100
50
0
I
II
0
20
40
$-V_{CE}$ (V)
60
BCY33
BCY34
$T_j = 25°C$
20
40

P-N-P SILICON TRANSISTORS

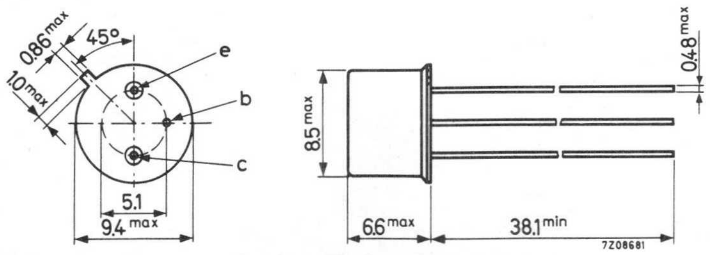
P-N-P alloy transistors in a TO-5 metal envelope with the base connected to the case. They are intended for relay switching, resistor logic circuits and general industrial applications.

QUICK REFERENCE DATA

			BCY 38	BCY 39	BCY 40	BCY 54	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	64	32	50	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	24	60	24	50	V
Collector current (peak value)	$-I_{CM}$	max.	500	500	500	500	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	410	410	410	410	mW
Junction temperature	T_j	max.	150	150	150	150	°C
D.C. current gain at T_{amb} = 25 °C $-I_C$ = 150 mA; $-V_{CE}$ = 1 V	h_{FE}	>	10	10	15	12	
		<	30	50	120	70	
Transition frequency $-I_C$ = 1 mA; $-V_{CE}$ = 6 V	f_T	typ.	1.5	1.5	2.5	2.0	MHz

MECHANICAL DATA Dimensions in mm

TO-5
Base connected to case



Accessories available: 56218, 56245, 56265

RATINGS (Limiting values) [1]

Voltages			BCY 38	BCY 39	BCY 40	BCY 54	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	64	32	50	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	24	60	24	50	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	12	12	12	12	V

Currents				
Collector current (d.c. or average over any 20 ms period)	$-I_C$	max.	250	mA
Collector current (peak value)	$-I_{CM}$	max.	500	mA
Base current (d.c.)	$-I_B$	max.	125	mA
Base current	$-I_{BM}$	max.	125	mA
Power dissipation				
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	410	mW
Temperatures				
Storage temperature	T_{stg}		-55 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.3	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0.12	°C/mW

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

CHARACTERISTICS T_{amb} = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $-V_{CB} = 6$ V	$-I_{CBO}$	typ.	1	nA
		<	100	nA
$I_E = 0$; $-V_{CB} = 6$ V; $T_j = 100$ °C	$-I_{CBO}$	typ.	0.1	μA
		<	2.5	μA

Emitter cut-off current

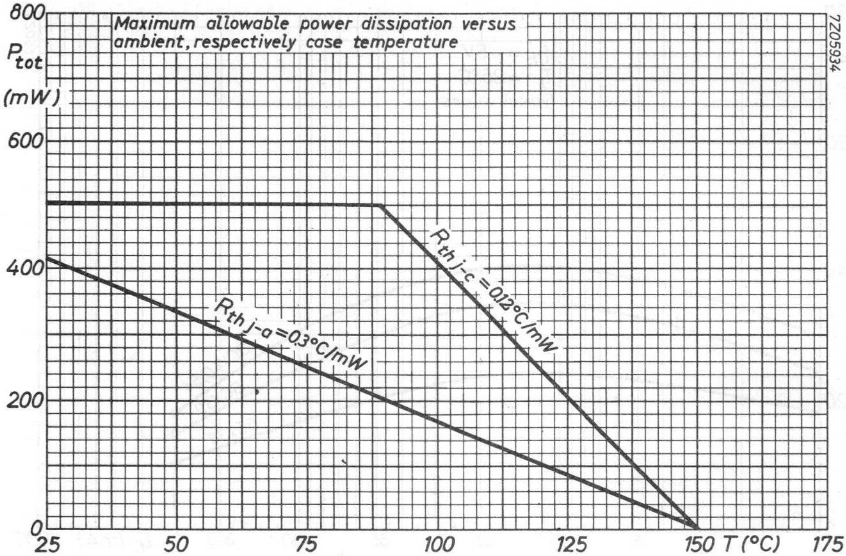
$I_C = 0$; $-V_{EB} = 6$ V	$-I_{EBO}$	typ.	1	nA
		<	100	nA
$I_C = 0$; $-V_{EB} = 6$ V; $T_j = 100$ °C	$-I_{EBO}$	typ.	0.1	μA
		<	2.5	μA

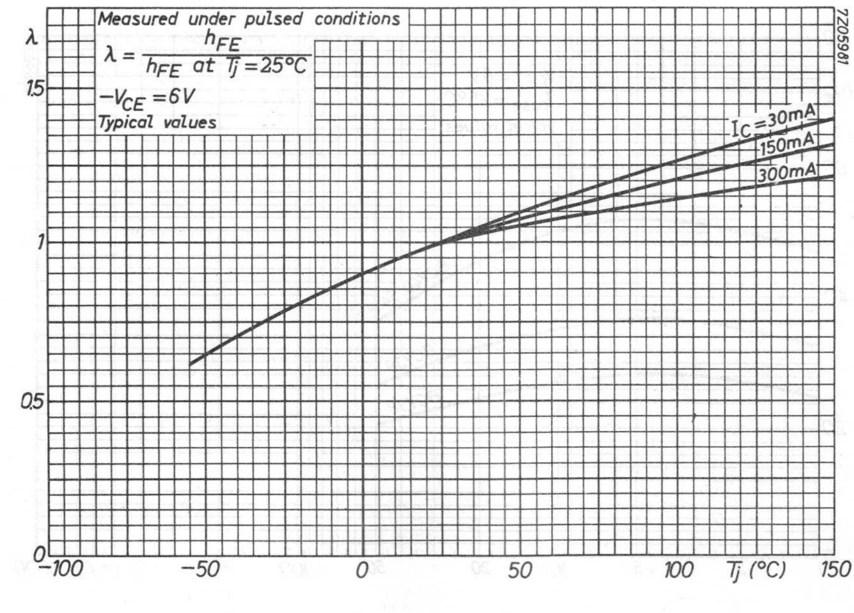
			BCY38	BCY39	BCY40	BCY54	
Base current							
$V_{CB} = 0$; $I_E = 150$ mA	$-I_B$	>	5	3	1.25	2	mA
		<	14	14	9	12	mA
Base-emitter voltage							
$-I_C = 150$ mA; $-V_{CE} = 1$ V	$-V_{BE}$	typ.	1.5	1.5	1.4	1.4	V
		<	1.9	1.9	1.9	1.9	V
Saturation voltages							
$-I_C = 150$ mA; $-I_B = 15$ mA	$-V_{CEsat}$	typ.	580	460	440	440	mV
		<	1100	1100	1100	1100	mV
D.C. current gain							
$-I_C = 30$ mA; $-V_{CE} = 1$ V	h_{FE}	>	12	12	22	20	
		typ.	20	30	35	35	
		<	-	-	-	100	
$-I_C = 150$ mA; $-V_{CE} = 1$ V	h_{FE}	>	10	10	15	12	
		typ.	13	19	23	23	
		<	30	50	120	70	
$-I_C = 300$ mA; $-V_{CE} = 6$ V [1]	h_{FE}	>	-	-	10	-	
		typ.	10	15	18	18	

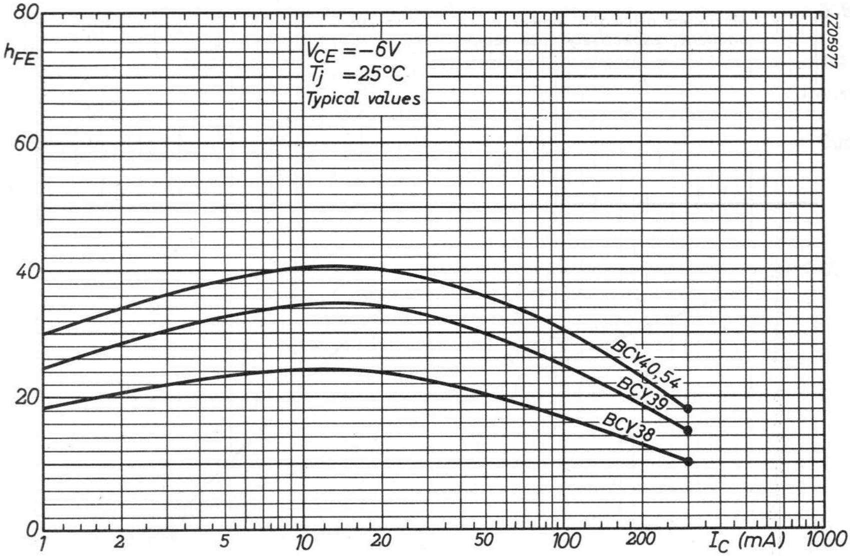
[1]) Measured under pulsed conditions to prevent excessive dissipation.

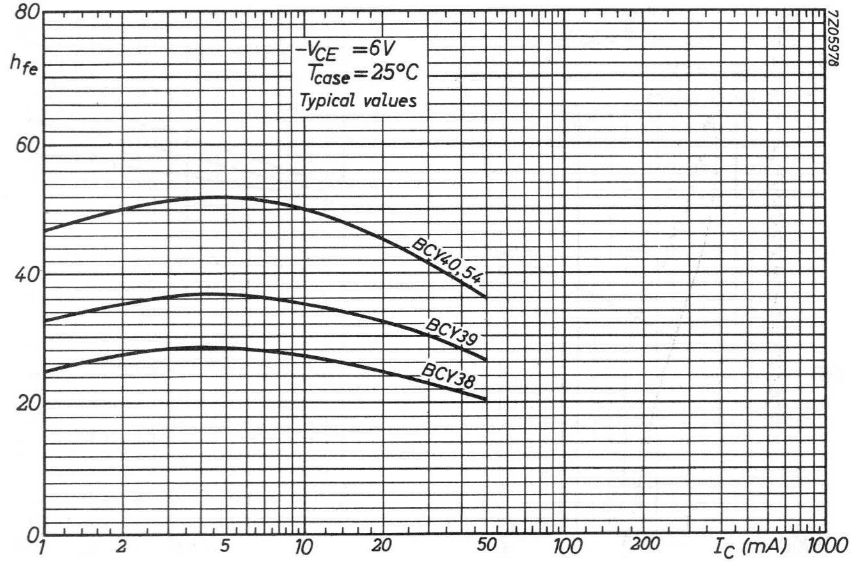
CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

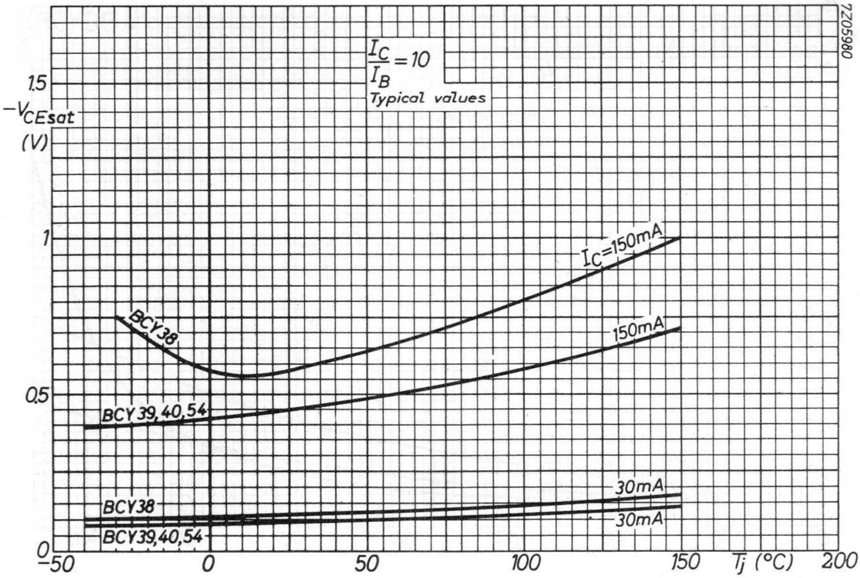
			BCY38	BCY39	BCY40	BCY54	
Collector capacitance at f = 0.5 MHz							
$I_E = I_e = 0$; $-V_{CB} = 6$ V	C_c	typ.	60	60	60	60	pF
		<	150	150	150	150	pF
Transition frequency							
$-I_C = 1$ mA; $-V_{CE} = 6$ V	f_T	>	0.45	0.45	0.85	0.45	MHz
		typ.	1.5	1.5	2.5	2.0	MHz
Feedback impedance at f = 0.5 MHz							
$-I_C = 1$ mA; $-V_{CE} = 6$ V	$\|z_{rb}\|$	typ.	100	110	140	130	Ω
		<	250	250	250	250	Ω
Noise figure at f = 1 kHz							
$-I_C = 500$ µA; $-V_{CE} = 2$ V; $R_S = 500$ Ω	F	typ.	8	8	8	8	dB
		<	20	20	20	20	dB
Small signal current gain at f = 1 kHz		>	15	15	30	20	
$-I_C = 10$ mA; $-V_{CE} = 6$ V	h_{fe}	typ.	27	35	50	50	
		<	100	100	160	120	

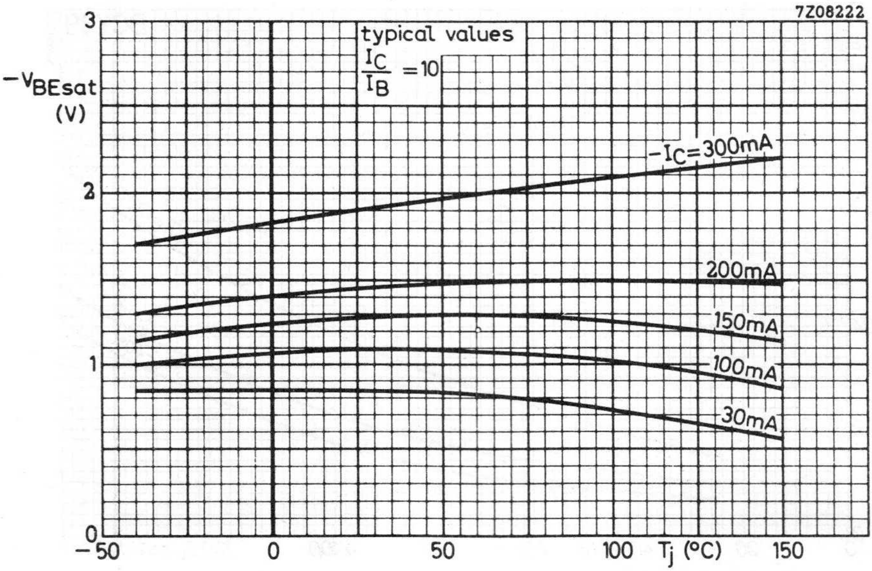

Maximum allowable power dissipation versus ambient, respectively case temperature
7Z05934
P_{tot} (mW)
800
600
400
200
0
25
50
75
100
125
150
175
T (°C)
$R_{th\ j-c}$ = 0.12°C/mW
$R_{th\ j-a}$ = 0.3°C/mW

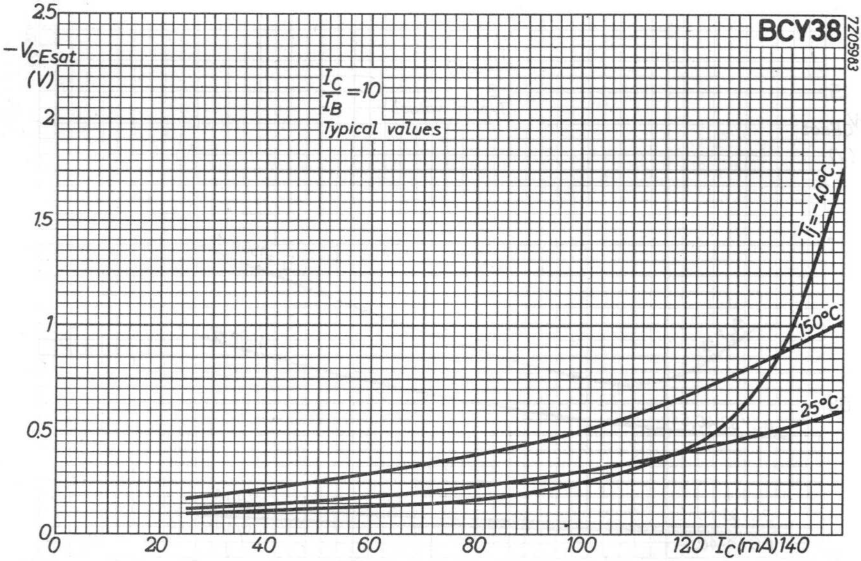

Measured under pulsed conditions
$\lambda = \frac{h_{FE}}{h_{FE} \text{ at } T_j = 25°C}$
$-V_{CE}$ = 6V
Typical values
7Z05981
λ
1.5
1
0.5
0
−100
−50
0
50
100
150
T_j (°C)
I_C = 30mA
150mA
300mA

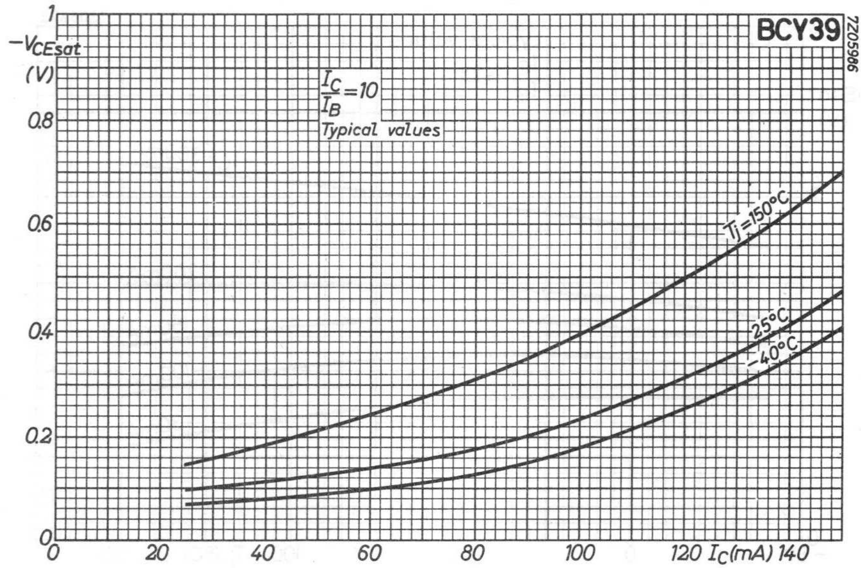

7Z05977
$V_{CE} = -6V$
$T_j = 25°C$
Typical values
h_{FE}
80
60
40
20
0
BCY40,54
BCY39
BCY38
1
2
5
10
20
50
100
200
I_C (mA)
1000

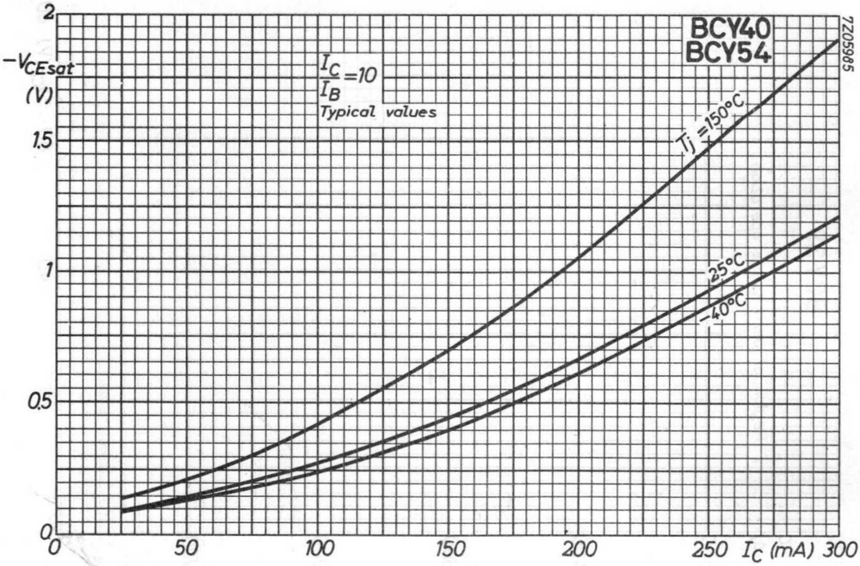

7Z05978
$-V_{CE} = 6V$
$T_{case} = 25°C$
Typical values
h_{fe}
80
60
40
20
0
BCY40,54
BCY39
BCY38
1
2
5
10
20
50
100
200
I_C (mA)
1000

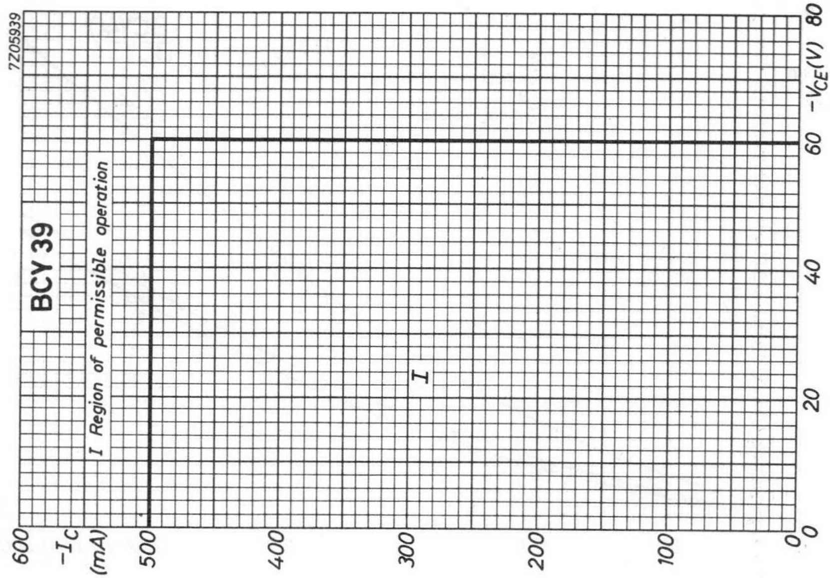

7Z05980
$\frac{I_C}{I_B} = 10$
Typical values
1.5
$-V_{CEsat}$ (V)
1
0.5
0
I_C=150mA
150mA
BCY38
BCY39,40,54
30mA
30mA
BCY38
BCY39,40,54
−50
0
50
100
150
T_j (°C)
200

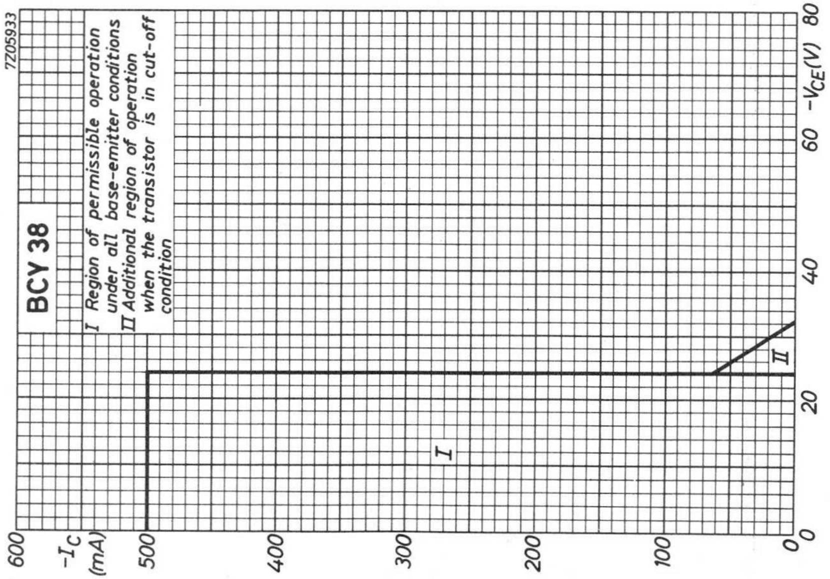

7Z08222
typical values
$\frac{I_C}{I_B} = 10$
3
$-V_{BEsat}$ (V)
2
1
0
$-I_C$=300mA
200mA
150mA
100mA
30mA
−50
0
50
100
T_j (°C)
150

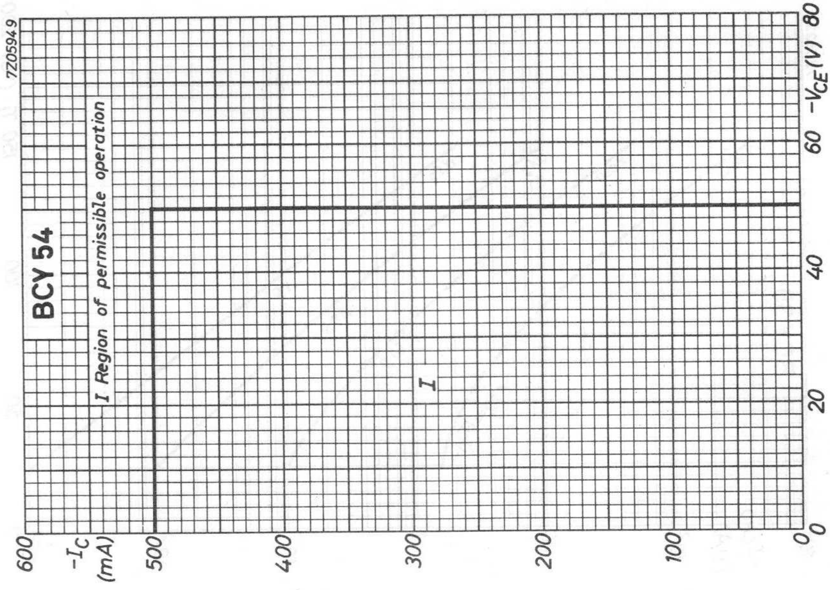

BCY38
7Z05983
$-V_{CEsat}$ (V)
2.5
2
1.5
1
0.5
0
$\frac{I_C}{I_B}=10$
Typical values
$T_j = -40°C$
150°C
25°C
0
20
40
60
80
100
120
I_C(mA)
140

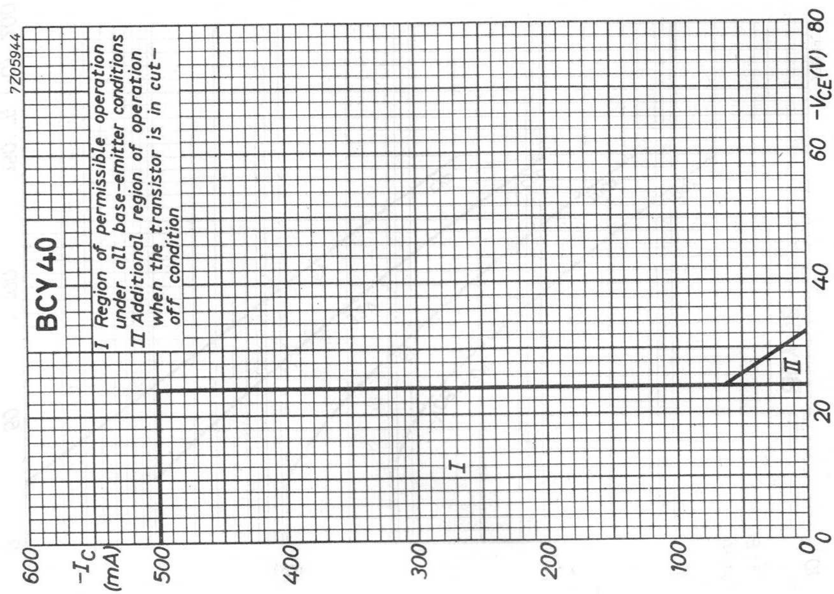

BCY39
7Z05986
$-V_{CEsat}$ (V)
1
0.8
0.6
0.4
0.2
0
$\frac{I_C}{I_B}=10$
Typical values
$T_j=150°C$
25°C
−40°C
0
20
40
60
80
100
120
I_C(mA)
140

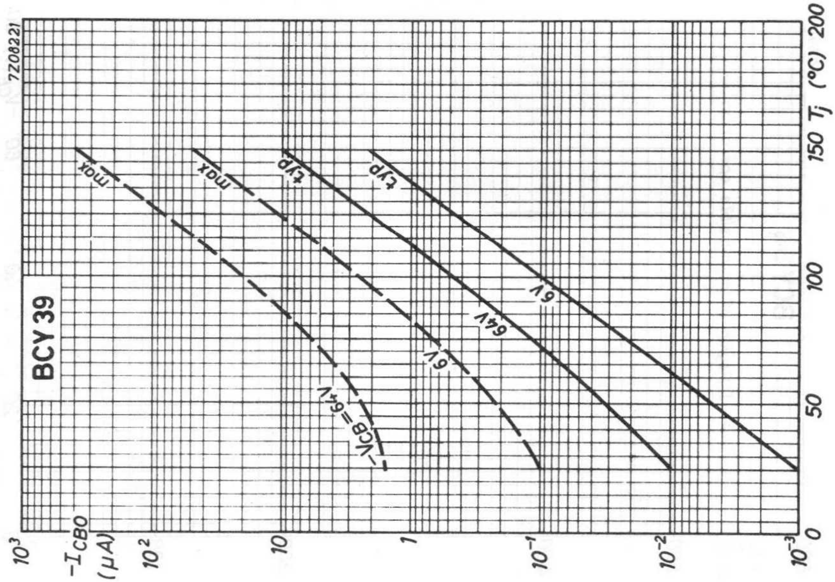

BCY40
BCY54
7Z05985
$-V_{CEsat}$ (V)
$\frac{I_C}{I_B}=10$
Typical values
$T_j=150°C$
25°C
−40°C
I_C (mA)
0
0.5
1
1.5
2
50
100
150
200
250
300

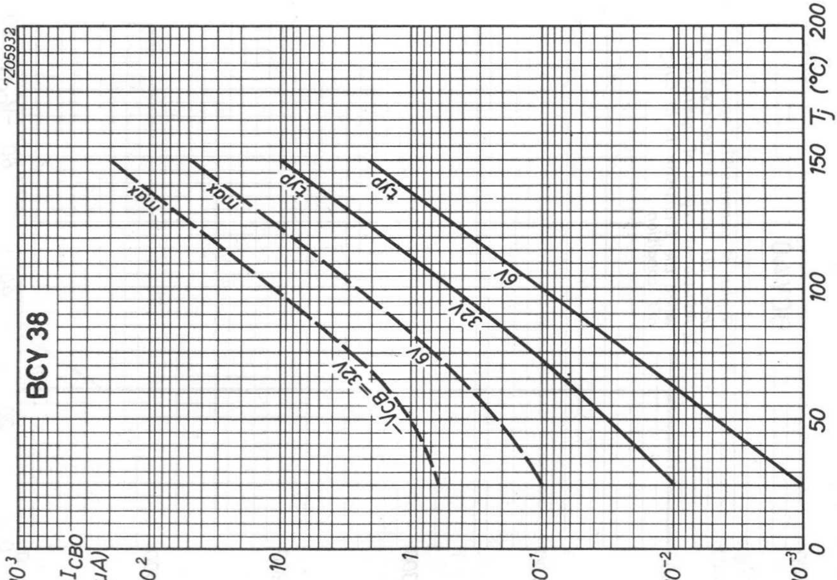

7Z05939
BCY 39
I Region of permissible operation
I
$-I_C$ (mA)
600
500
400
300
200
100
0
0
20
40
60
80
$-V_{CE}$(V)

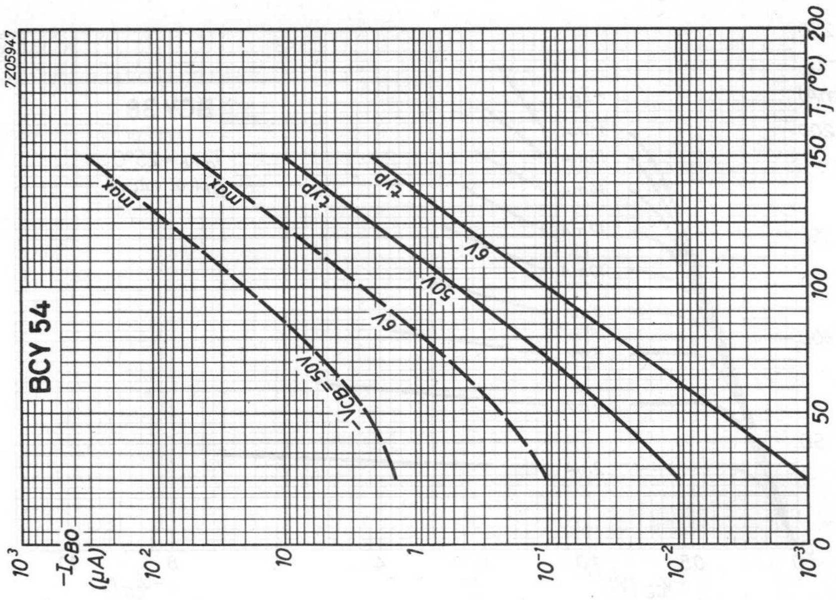

7Z05933
BCY 38
I Region of permissible operation under all base-emitter conditions
II Additional region of operation when the transistor is in cut-off condition
I
II
$-I_C$ (mA)
600
500
400
300
200
100
0
0
20
40
60
80
$-V_{CE}$(V)

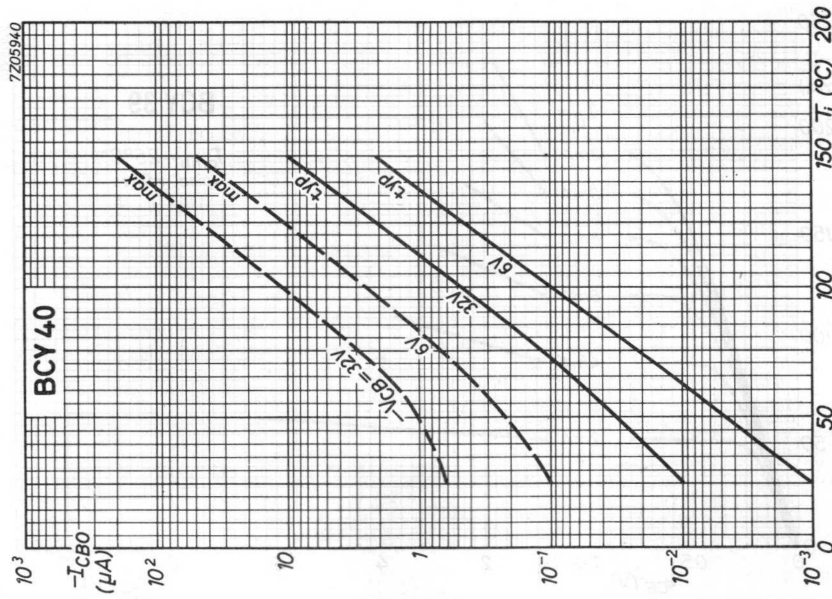

7Z05949
BCY 54
I Region of permissible operation
I
600
$-I_C$
(mA)
500
400
300
200
100
0
0
20
40
60
$-V_{CE}$(V)
80

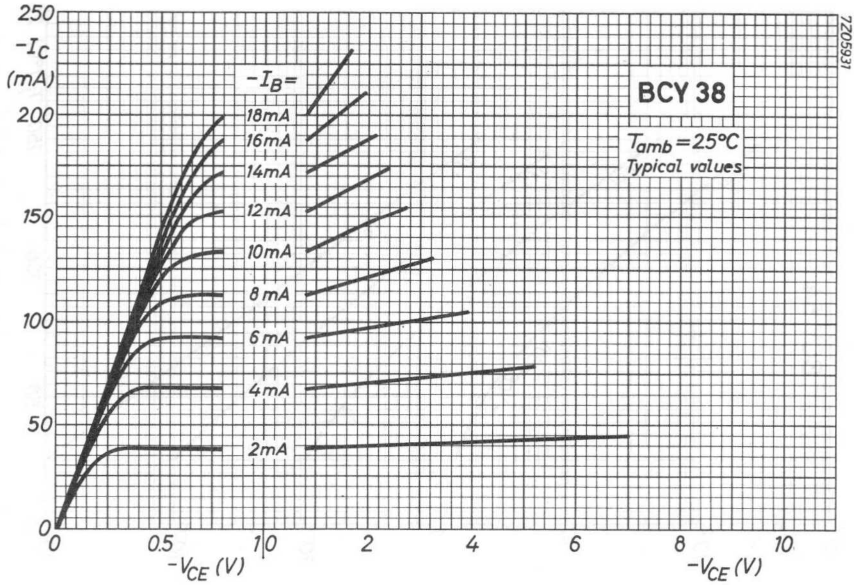

7Z05944
BCY 40
I Region of permissible operation under all base-emitter conditions
II Additional region of operation when the transistor is in cut-off condition
I
II
600
$-I_C$
(mA)
500
400
300
200
100
0
0
20
40
60
$-V_{CE}$(V)
80

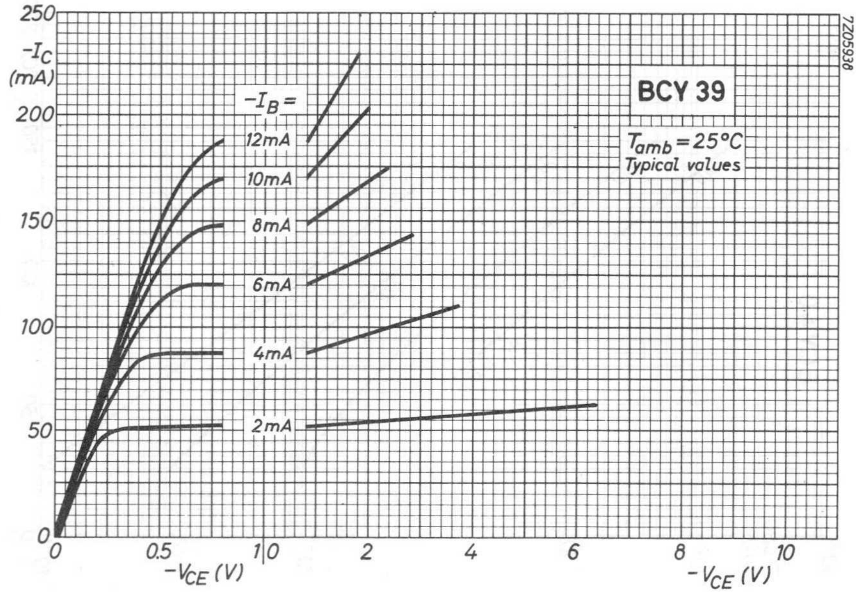

7Z08221
BCY 39
$-I_{CBO}$ (μA)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
0
50
100
150
200
T_j (°C)
max
max
typ
typ
6V
64V
6V
$-V_{CB}$ = 64V

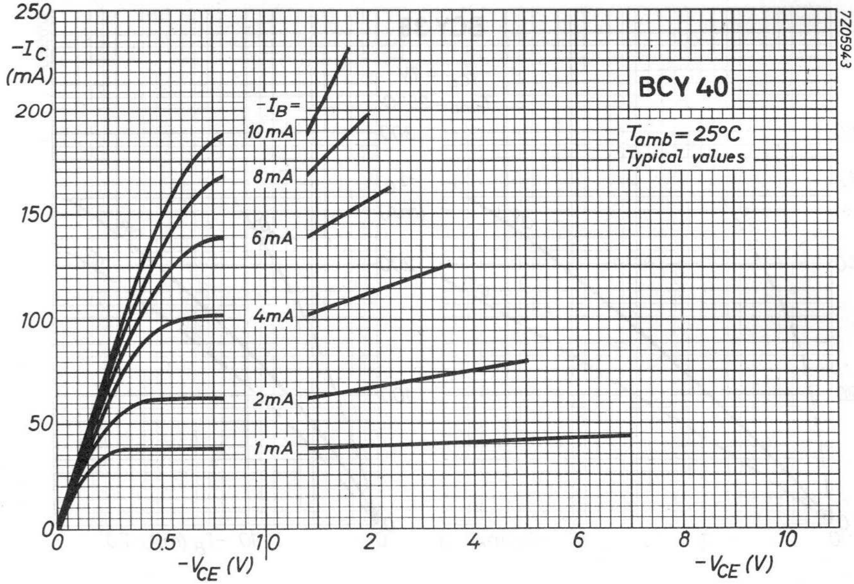

7Z05932
BCY 38
$-I_{CBO}$ (μA)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
0
50
100
150
200
T_j (°C)
max
max
typ
typ
6V
32V
6V
$-V_{CB}$ = 32V

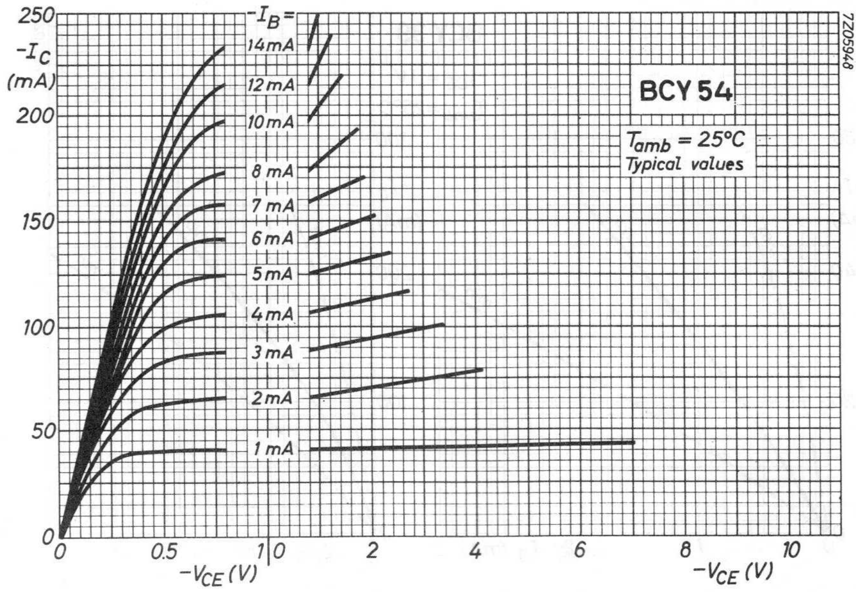

BCY 54
7Z05947
$-I_{CBO}$ (μA)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
0
50
100
150
200
T_j (°C)
max
max
typ
typ
6V
50V
6V
$-V_{CB}$ = 50V

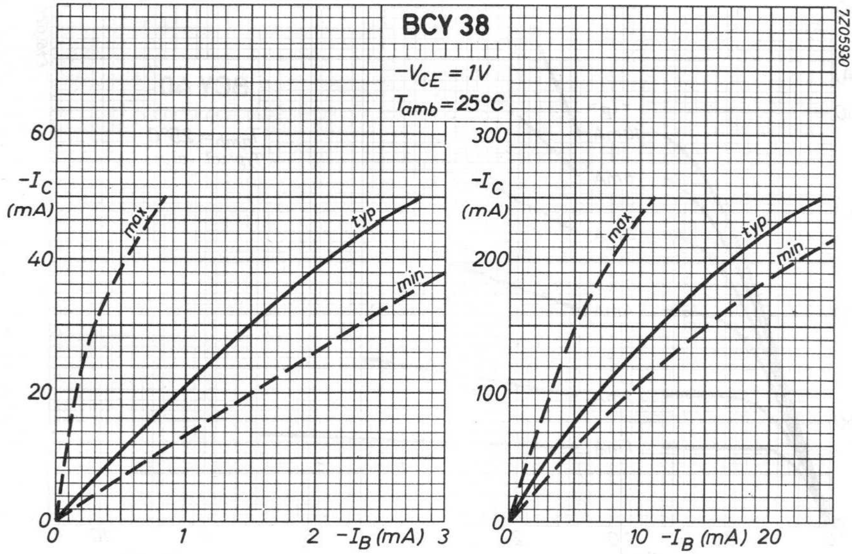

BCY 40
7Z05940
$-I_{CBO}$ (μA)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
0
50
100
150
200
T_j (°C)
max
max
typ
typ
6V
32V
6V
$-V_{CB}$ = 32V

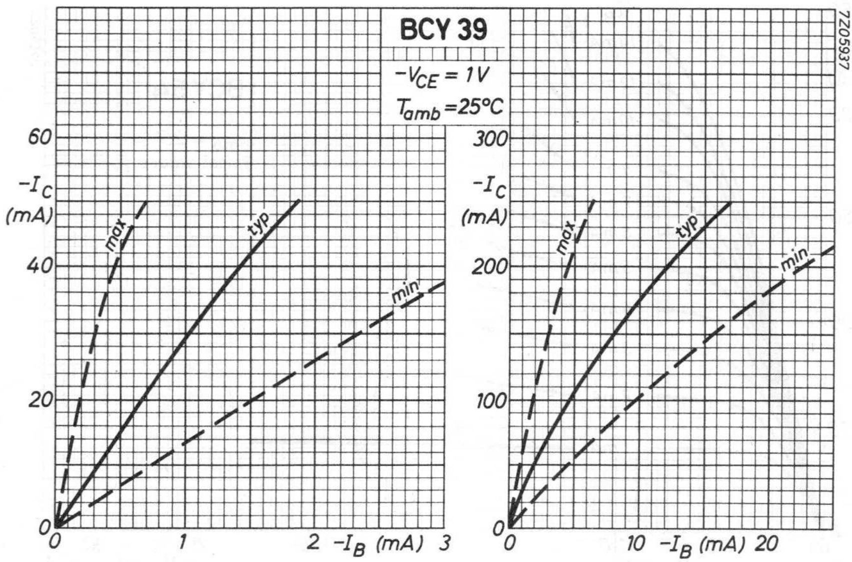

250
$-I_C$
(mA)
200
150
100
50
0
$-I_B=$
18mA
16mA
14mA
12mA
10mA
8 mA
6 mA
4mA
2mA
BCY 38
$T_{amb}=25°C$
Typical values
7Z05931
0
0.5
1.0
2
4
6
8
10
$-V_{CE}$ (V)
$-V_{CE}$ (V)

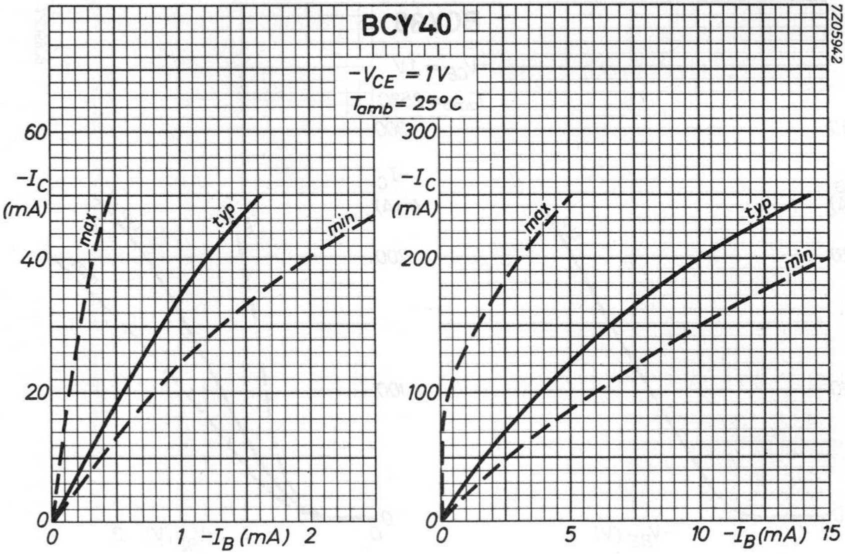

250
$-I_C$
(mA)
200
150
100
50
0
$-I_B=$
12mA
10mA
8mA
6mA
4mA
2mA
BCY 39
$T_{amb}=25°C$
Typical values
7Z05938
0
0.5
1.0
2
4
6
8
10
$-V_{CE}$ (V)
$-V_{CE}$ (V)

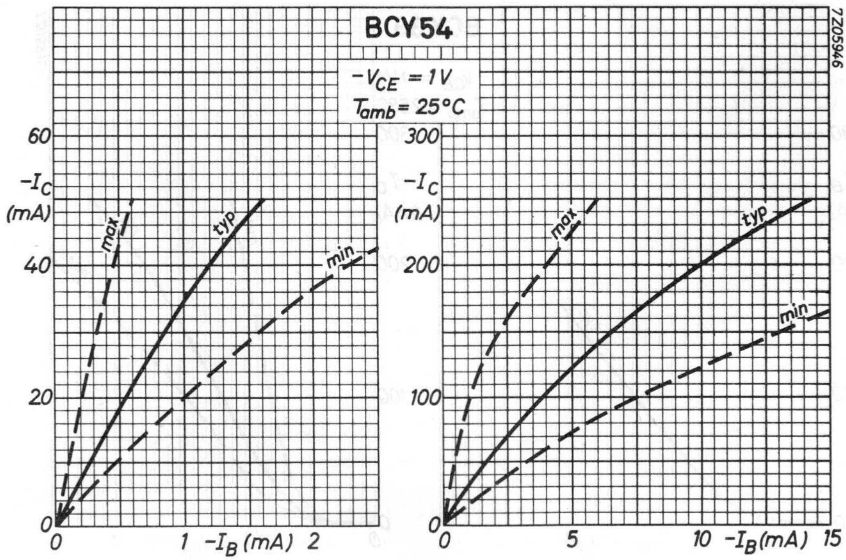

BCY 40
T_{amb} = 25°C
Typical values
$-I_B$ =
10 mA
8 mA
6 mA
4 mA
2 mA
1 mA
$-I_C$ (mA)
$-V_{CE}$ (V)
7Z05943

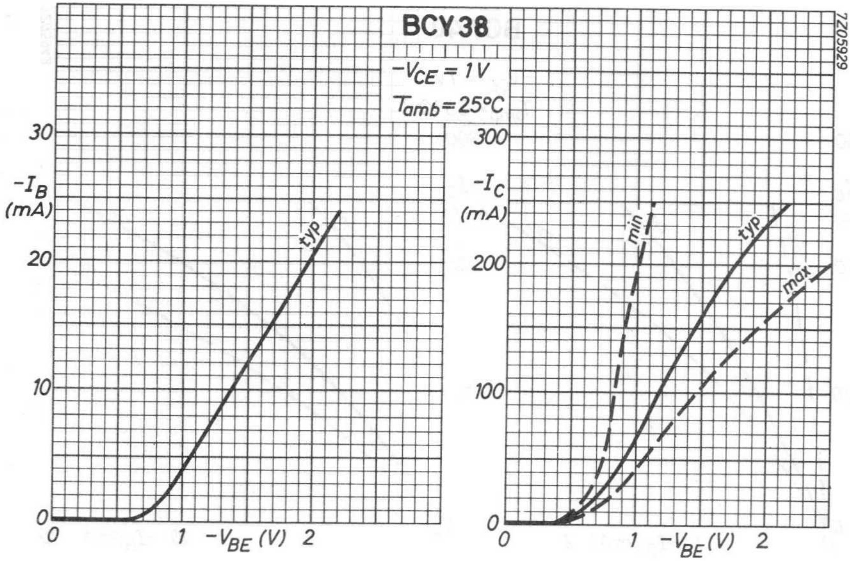

BCY 54
T_{amb} = 25°C
Typical values
$-I_B$ =
14 mA
12 mA
10 mA
8 mA
7 mA
6 mA
5 mA
4 mA
3 mA
2 mA
1 mA
$-I_C$ (mA)
$-V_{CE}$ (V)
7Z05948

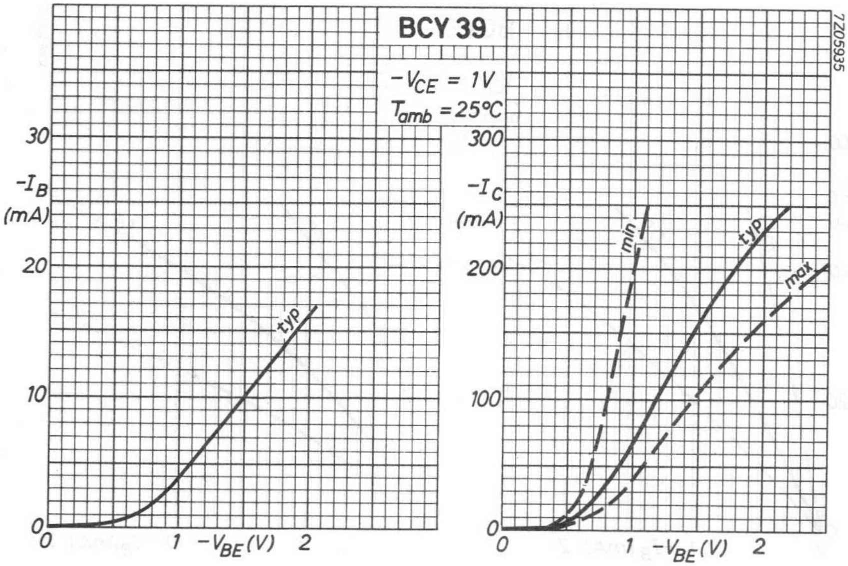

BCY 38
$-V_{CE}$ = 1V
T_{amb} = 25°C
$-I_C$ (mA)
60
40
20
0
max
typ
min
0
1
2
$-I_B$ (mA)
3
300
200
100
10
20
7Z05930

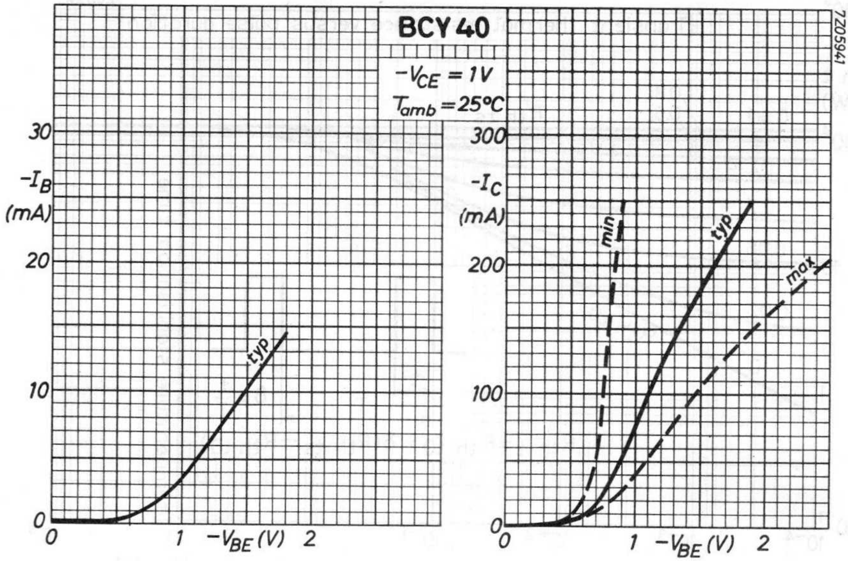

BCY 39
$-V_{CE}$ = 1V
T_{amb} = 25°C
$-I_C$ (mA)
60
40
20
0
max
typ
min
0
1
2
$-I_B$ (mA)
3
300
200
100
10
20
7Z05937

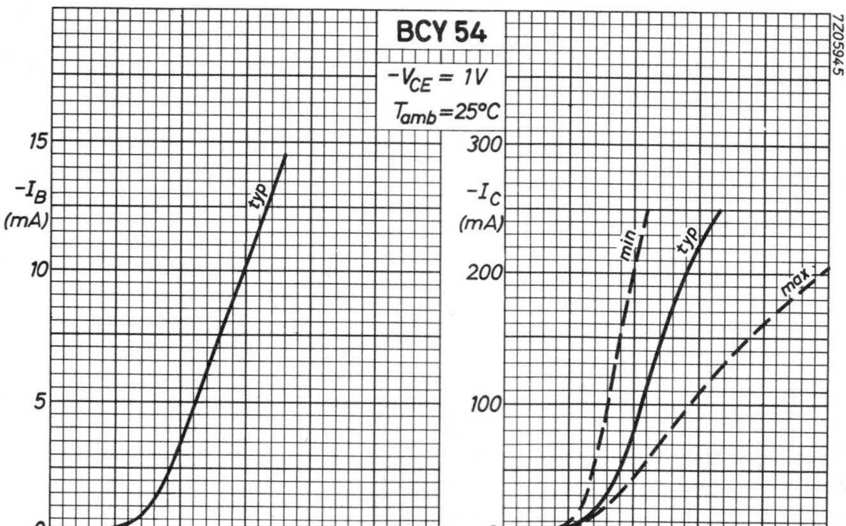

BCY40
$-V_{CE} = 1V$
$T_{amb} = 25°C$
7Z05942
$-I_C$ (mA)
$-I_B$ (mA)
max
typ
min
0
20
40
60
100
200
300
1
2
5
10
15

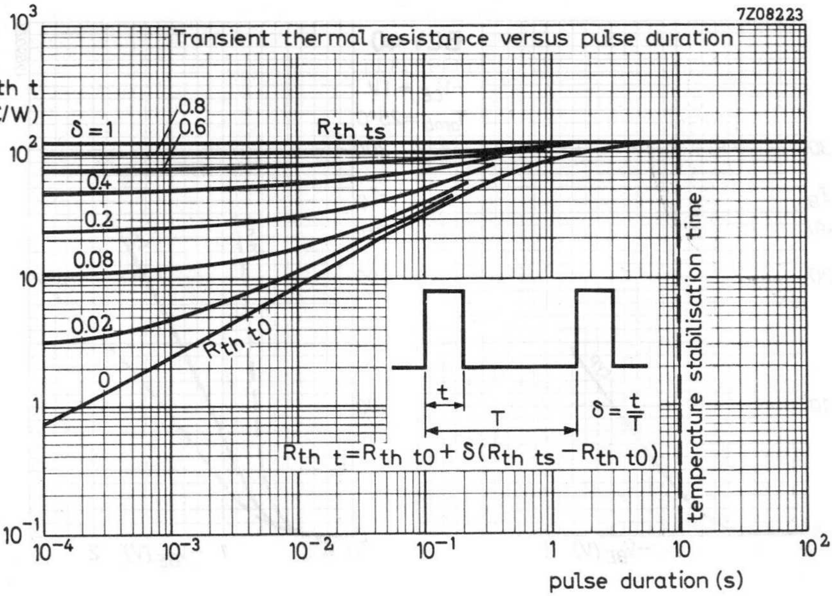

BCY54
$-V_{CE} = 1V$
$T_{amb} = 25°C$
7Z05946
$-I_C$ (mA)
$-I_B$ (mA)
max
typ
min
0
20
40
60
100
200
300
1
2
5
10
15


BCY 38
7Z05929
$-V_{CE} = 1V$
$T_{amb} = 25°C$
$-I_B$ (mA)
$-I_C$ (mA)
typ
min
max
$-V_{BE}$ (V)
0
1
2
10
20
30
100
200
300


BCY 39
7Z05935
$-V_{CE} = 1V$
$T_{amb} = 25°C$
$-I_B$ (mA)
$-I_C$ (mA)
typ
min
max
$-V_{BE}$ (V)
0
1
2
10
20
30
100
200
300


7Z05941
BCY 40
$-V_{CE} = 1V$
$T_{amb} = 25°C$
$-I_B$ (mA)
30
20
10
0
0
1
2
$-V_{BE}$ (V)
typ
$-I_C$ (mA)
300
200
100
0
min
typ
max


7Z05945
BCY 54
$-V_{CE} = 1V$
$T_{amb} = 25°C$
$-I_B$ (mA)
15
10
5
0
0
1
2
$-V_{BE}$ (V)
typ
$-I_C$ (mA)
300
200
100
0
min
typ
max

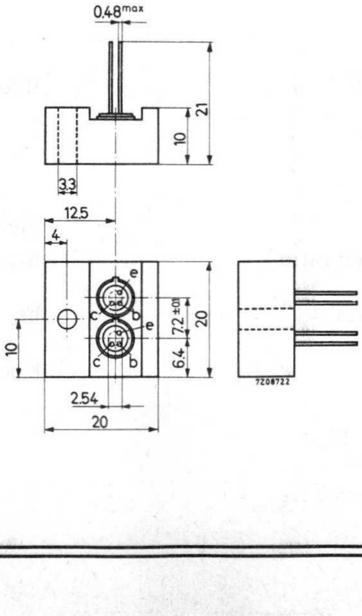

7Z08223
Transient thermal resistance versus pulse duration
$R_{th\ t}$ (°C/W)
$\delta = 1$
0.8
0.6
$R_{th\ ts}$
0.4
0.2
0.08
0.02
0
$R_{th\ t0}$
t
T
$\delta = \frac{t}{T}$
$R_{th\ t} = R_{th\ t0} + \delta(R_{th\ ts} - R_{th\ t0})$
temperature stabilisation time
pulse duration (s)

N-P-N SILICON PLANAR LOW-LEVEL DUAL TRANSISTORS FOR DIFFERENTIAL AMPLIFIERS

Two special matched transistors in a TO-18 metal envelope, housed together in an aluminium cube.
The BCY55 is intended for very low level, low noise and low drift differential amplifiers.

QUICK REFERENCE DATA				
Equivalent differential voltage change referred to the input				
$\lvert I_{1E} + I_{2E} \rvert \leq 200\ \mu A$				
$V_{1C\text{-}1E} = V_{2C\text{-}2E} \leq 20\ V$	$\left\lvert \frac{\Delta V}{\Delta T} \right\rvert$	typ.	1	$\mu V/^{o}C$
$\lvert V_{1B\text{-}1E} - V_{2B\text{-}2E} \rvert \leq 100\ \mu V$		<	3	$\mu V/^{o}C$
T_{amb}: −20 to +90 °C				
Equivalent differential current change referred to the input				
$I_{1C} + I_{2C} = 100\ \mu A$	$\left\lvert \frac{\Delta I}{\Delta T} \right\rvert$	typ.	0.5	$nA/^{o}C$
T_{amb}: −20 to +90 °C		<	1.5	$nA/^{o}C$

MECHANICAL DATA Dimensions in mm



CHARACTERISTICS of the individual transistors T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 45$ V	I_{CBO}	<	10	nA
$I_E = 0$; $V_{CB} = 20$ V; $T_{amb} = 90$ °C	I_{CBO}	<	5	nA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	nA
Emitter-base voltage				
$-I_E = 0.5$ mA; $V_{CB} = 5$ V	$-V_{EB}$	600 to 800		mV
Saturation voltages				
$I_C = 10$ mA; $I_B = 0.5$ mA	V_{CEsat}	<	1.0	V
	V_{BEsat}	0.6 to 1.0		V
D.C. current gain				
$I_C = 10$ μA; $V_{CE} = 5$ V	h_{FE}	100 to 300		
$I_C = 10$ mA; $V_{CE} = 5$ V	h_{FE}	200 to 600		
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	<	8	pF
Transition frequency				
$I_C = 0.5$ mA; $V_{CE} = 5$ V	f_T	>	50	MHz
		typ.	80	MHz
Cut-off frequency				
$I_C = 0.5$ mA; $V_{CE} = 5$ V	f_{hfe}	>	100	kHz
h parameters at f = 1 kHz				
$I_C = 1$ mA; $V_{CE} = 5$ V				
Input impedance	h_{ie}	typ.	10.0	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	5.5	10^{-4}
Small signal current gain	h_{fe}	typ.	350	
		150 to 600		
Output admittance	h_{oe}	typ.	25	$\mu\Omega^{-1}$
Noise figure				
$I_C = 10$ μA; $V_{CE} = 5$ V; $R_S = 10$ kΩ; B = 10 to 15000 Hz	F	typ.	2	dB
		<	3	dB

CHARACTERISTICS of the complete device

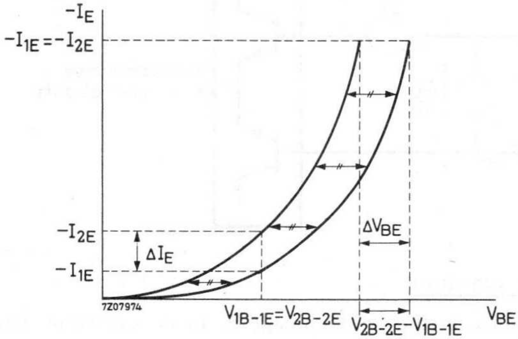
Ratio of collector currents

$V_{1B-1E} = V_{2B-2E}$
Emitter currents of each transistor up to 100 μA — $\frac{I_{1C}}{I_{2C}}$ 0.85 to 1, typ. 0.93

Difference of base-emitter voltages

$-I_{1E} = -I_{2E}$ up to 100 μA
T_{amb}: −20 to +90 °C — $|V_{1B-1E} - V_{2B-2E}|$ typ. 2 mV, < 4 mV

Illustration of matching characteristics:



$$\frac{I_{2E}}{I_{1E}} = \exp.\ \frac{q}{kT} \cdot \Delta V_{BE}$$

$\frac{I_{2E}}{I_{1E}}$ measured at $\Delta V_{BE} = 0$

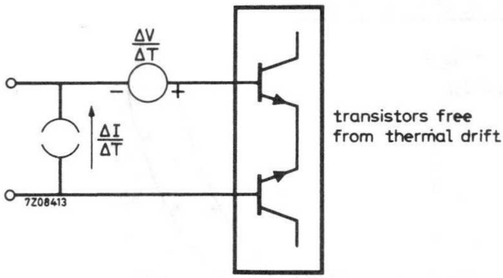
ΔV_{BE} measured at $\frac{I_{2E}}{I_{1E}} = 1$

CHARACTERISTICS of the complete device (continued)

Equivalent circuit for drift

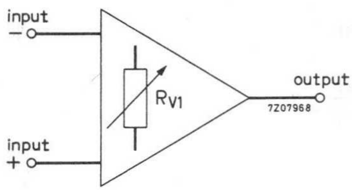
In the equivalent circuit the transistors are considered to be drift free. All temperature coefficients are concentrated in the voltage source $\frac{\Delta V}{\Delta T}$ and in the current source $\frac{\Delta I}{\Delta T}$.

It should be noted that the differential current change given is only valid when the source resistances are almost equal; the differential voltage change only when the base-emitter voltages are almost equal.



Block symbol of test amplifier

The test amplifier, used in the tests on page 5, is described on pages 6 and 7. It is represented by the following amplifier symbol:



CHARACTERISTICS of the complete device (continued)

Equivalent differential voltage change with temperature referred to the input.

$|I_{1E} + I_{2E}| \leq 200\ \mu A$; $V_{1C-1E} = V_{2C-2E} \leq 20$ V

$|V_{1B-1E} - V_{2B-2E}| \leq 100\ \mu V$; T_j: -20 to $+90$ °C

BCY55 unit (wires included) mounted in a small metal or plastic box for shielding against direct heat radiation.

$\left\|\frac{\Delta V}{\Delta T}\right\|$	typ.	1	μV/°C
	<	3	μV/°C

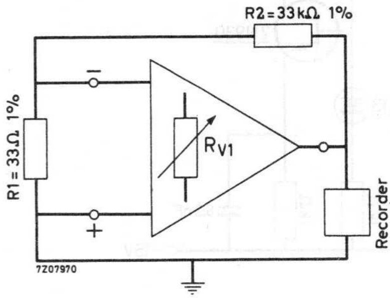
Equivalent differential current change with temperature referred to the input.

$I_{1C} + I_{2C} = 100\ \mu A$

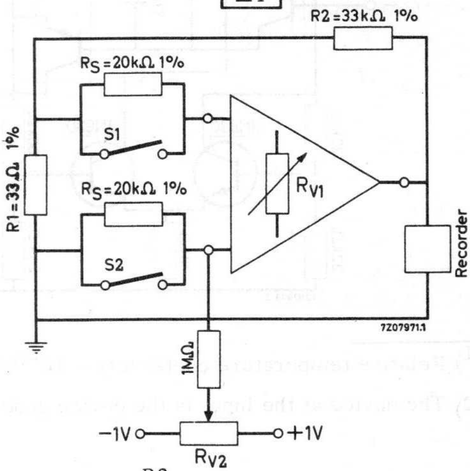
$\frac{\Delta I}{\Delta T}$	typ.	0.5	nA/°C
	<	1.5	nA/°C

Test methods

$\frac{\Delta V}{\Delta T}$



$\frac{\Delta I}{\Delta T}$



NOTE

To prevent contact potentials, connections should be soldered.

Amplification factor determined by feedback circuit: $\frac{R2}{R1} = 1000$

Output voltage against time is recorded.

The temperature of the amplifier is adjusted to T_1 between -20 and $+90$ °C. When it has stabilized, the output voltage is brought to zero ($|V_{T1}| < 100$ mV)[1]. The amplifier temperature is then adjusted to T_2 between -20 and $+90$ °C. When it has stabilized the output voltage can be read off.

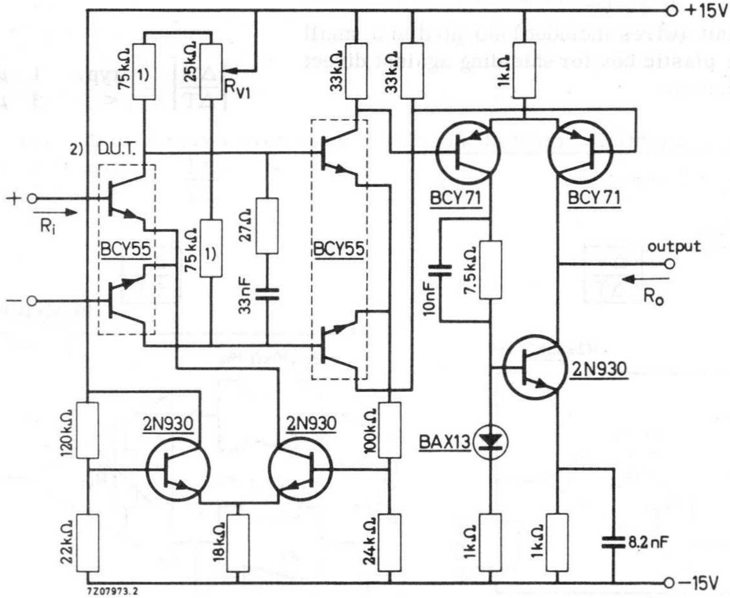
Then: $\frac{\Delta V}{\Delta T} = \frac{V_{T2} - V_{T1}}{T_2 - T_1} \cdot \frac{R1}{R2}$ or $\frac{\Delta I}{\Delta T} = \frac{V_{T2} - V_{T1}}{T_2 - T_1} \cdot \frac{R1}{R2} \cdot \frac{1}{2R_S}$

[1]) For $\frac{\Delta V}{\Delta T}$: adjusted by R_{V1}

For $\frac{\Delta I}{\Delta T}$: first by R_{V1} with S1 and S2 closed, then by R_{V2} with the switches open.

Differential test-amplifier

The test amplifier (including feedback resistors, source-resistors and biasing-resistors) should be mounted in a small box to ensure a uniform temperature throughout.

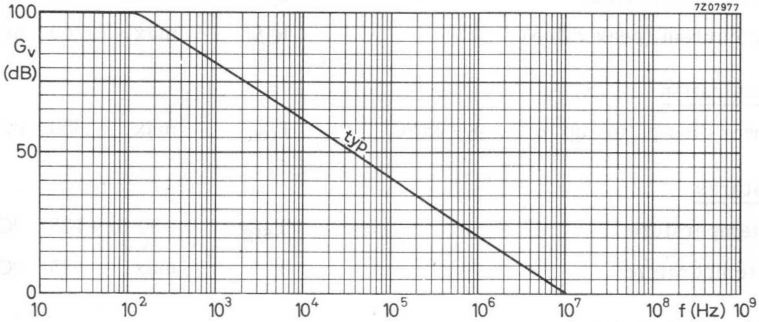


1) Relative temperature coefficient < $10^{-5}/^{o}C$

2) The device at the input is the device under test

Performance of the test amplifier

Open loop voltage gain (Z_L = 10 kΩ)	G_V	typ.	10^5	
Frequency at which G_V = 1	f_1	typ.	10	MHz
Max. common mode input voltage range			±10	V
Max. output current			±2.5	mA
Max. output voltage			±10	V
Input resistance	R_i	≥	100	kΩ
Output resistance	R_o	typ.	20	kΩ



RATINGS of the individual transistors (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	45	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	V
Collector-emitter voltage with $V_{BE} = 0$	V_{CES}	max.	45	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Currents

Collector currents (d.c. or average over any 50 ms period)	I_C	max.	30	mA
Collector current (peak value)	I_{CM}	max.	60	mA

Power dissipation

Total power dissipation up to $T_{amb} = 25\,^oC$	P_{tot}	max.	300	mW

Temperatures

Storage temperature	T_{stg}		-50 to +125	^oC
Junction temperature	T_j	max.	125	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.33	$^oC/mW$

(This value applies to one transistor at equal dissipation or difference in dissipation < 20% in both transistors of the unit)

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

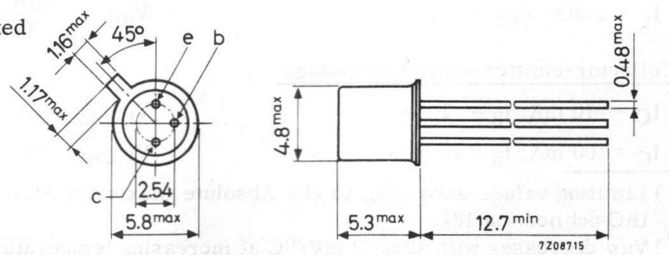
SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistor in a TO-18 metal envelope with the collector connected to the case.
They are intended for general purpose very high gain low level and low noise applications.
Moreover, they are also suitable for low speed switching applications.

QUICK REFERENCE DATA			BCY56	BCY57	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	20	V
Collector current (d.c.)	I_C	max.	100	100	mA
Total power dissipation up to $T_{amb} = 25\,^oC$	P_{tot}	max.	300	300	mW
Junction temperature	T_j	max.	175	175	^oC
D.C. current gain at $T_j = 25\,^oC$					
$I_C = 10\,\mu A$; $V_{CE} = 5$ V	h_{FE}	>	40	100	
$I_C = 2$ mA; $V_{CE} = 5$ V	h_{FE}		100 to 450	200 to 800	
Transition frequency					
$I_C = 0.5$ mA; $V_{CE} = 5$ V	f_T	typ.	85	100	MHz
Noise figure					
$I_C = 200\,\mu A$; $V_{CE} = 5$ V					
$R_S = 2\,k\Omega$; f = 30 Hz to 15.7 kHz	F	typ.	1.5	1.5	dB
		<	5	5	dB

MECHANICAL DATA Dimensions in mm

Collector connected to case
TO-18



Accessories available: 56246, 56263.

RATINGS (Limiting values) [1]

Voltages

			BCY56	BCY57	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	V

Currents

Collector current (d.c.)	I_C	max.	100	mA
Collector current (peak value)	I_{CM}	max.	100	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	mW

Temperatures

Storage temperature	T_{stg}		-65 to +175	°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.5	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0.2	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

I_E = 0; V_{CB} = 20 V	I_{CBO}	<	100	nA

Emitter cut-off current

I_C = 0; V_{EB} = 5 V	I_{EBO}	<	100	nA

Base-emitter voltage [2]

I_C = 2 mA; V_{CE} = 5 V	V_{BE}	typ.	650	mV
			600 to 700	mV

Collector-emitter saturation voltage

I_C = 10 mA; I_B = 1 mA	V_{CEsat}	typ.	80	mV
I_C = 100 mA; I_B = 10 mA	V_{CEsat}	typ.	200	mV

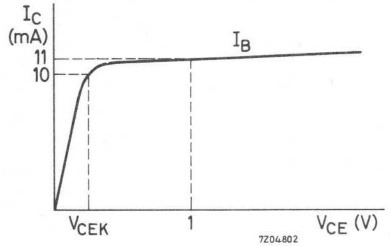
[1] Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

[2] V_{BE} decreases with about 2 mV/°C at increasing temperature.

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Knee voltage

I_C = 10 mA; I_B = value for which I_C = 11 mA at V_{CE} = 1 V	V_{CEK}	typ.	300	mV
		<	600	mV



			BCY56	BCY57	
D.C. current gain					
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	>	40	100	
I_C = 2 mA; V_{CE} = 5 V	h_{FE}	typ.	200	400	
			100 to 450	200 to 800	
I_C = 10 mA; V_{CE} = 5 V	h_{FE}	>	100	200	
Transition frequency					
I_C = 0.5 mA; V_{CE} = 5 V	f_T	typ.	85	100	MHz
I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	250	350	MHz
h parameters at f = 1 kHz					
I_C = 2 mA; V_{CE} = 5 V					
Input impedance	h_{ie}	typ.	3.5	7.5	kΩ
Reverse voltage transfer	h_{re}	typ.	1.75	3.5	10^{-4}
Small signal current gain	h_{fe}	typ.	250	500	
			125 to 500	240 to 900	
Output admittance	h_{oe}	typ.	17.5	35	$\mu\Omega^{-1}$
Collector capacitance at f = 1 MHz					
$I_E = I_e$ = 0; V_{CB} = 5 V	C_c	typ.	4.5	4.5	pF
Noise figure					
I_C = 200 μA; V_{CE} = 5 V; R_S = 2 kΩ					
f = 30 Hz to 15.7 kHz	F	typ.	1.5	1.5	dB
		<	5	5	dB

P-N-P SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in a TO-18 metal envelope intended for general purpose industrial applications.

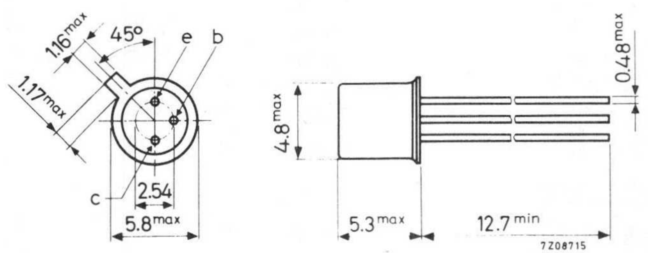
QUICK REFERENCE DATA

			BCY70	BCY71	BCY72	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	50	45	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	45	25	V
Collector current (peak value)	$-I_{CM}$	max.	200	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	350	350	350	mW
Junction temperature	T_j	max.	200	200	200	°C
D.C. current gain						
$-I_C$ = 0.1 mA; $-V_{CE}$ = 1.0 V	h_{FE}	>	40	80		
$-I_C$ = 10 mA; $-V_{CE}$ = 1.0 V	h_{FE}	>	50	100	50	

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-18



Accessories available: 56246, 56263

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages			BCY70	BCY71	BCY72	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	50	45	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	45	25	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5.0	5.0	5.0	V

Current				
Collector current (peak value)	$-I_{CM}$	max.	200	mA
Emitter current (peak value)	I_{EM}	max.	200	mA
Power dissipation				
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	350	mW
Temperatures				
Storage temperature	T_{stg}		-65 to +200	°C
Junction temperature	T_j	max.	+200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.5	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0.15	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current			BCY70	BCY71	BCY72	
I_E = 0; $-V_{CB}$ = 20 V	$-I_{CBO}$	<			50	nA
I_E = 0; $-V_{CB}$ = 20 V; T_j = 100 °C	$-I_{CBO}$	<			2	μA
I_E = 0; $-V_{CB}$ = 25 V	$-I_{CBO}$	<			500	nA
I_E = 0; $-V_{CB}$ = 40 V	$-I_{CBO}$	<	10	50		nA
I_E = 0; $-V_{CB}$ = 40 V; T_j = 100 °C	$-I_{CBO}$	<	0.5	2		μA
I_E = 0; $-V_{CB}$ = 45 V	$-I_{CBO}$	<		500		nA
I_E = 0; $-V_{CB}$ = 50 V	$-I_{CBO}$	<	500			nA
$-V_{CE}$ = 50 V; $-V_{EB}$ = 3.0 V	$-I_{CEX}$	<	20			nA
Emitter cut-off current						
I_C = 0; $-V_{EB}$ = 4.0 V	$-I_{EBO}$	<	10	10	10	nA
I_C = 0; $-V_{EB}$ = 4.0 V; T_j = 100 °C	$-I_{EBO}$	<	2	2	2	μA
I_C = 0; $-V_{EB}$ = 5.0 V	$-I_{EBO}$	<	500	500	500	nA
Saturation voltages						
$-I_C$ = 10 mA; $-I_B$ = 1.0 mA	$-V_{CEsat}$	<	0.25	0.25	0.25	V
	$-V_{BEsat}$		0.6 to 0.9	0.6 to 0.9		V
$-I_C$ = 50 mA; $-I_B$ = 5.0 mA	$-V_{CEsat}$	<	0.50	0.50	0.50	V
	$-V_{BEsat}$	<	1.2	1.2	1.2	V

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

			BCY70	BCY71	BCY72	
D.C. current gain						
$-I_C$ = 10 µA; $-V_{CE}$ = 1.0 V	h_{FE}	>		40		
$-I_C$ = 0.1 mA; $-V_{CE}$ = 1.0 V	h_{FE}	>	40	80		
$-I_C$ = 1.0 mA; $-V_{CE}$ = 1.0 V	h_{FE}	>	45	90	40	
$-I_C$ = 10 mA; $-V_{CE}$ = 1.0 V	h_{FE}	>	50	100	50	
		<		600		
$-I_C$ = 50 mA; $-V_{CE}$ = 1.0 V	h_{FE}	>	15			
Collector capacitance at f = 1 MHz						
$I_E = I_e$ = 0; $-V_{CB}$ = 10 V	C_c	<	6.0	6.0	6.0	pF
Emitter capacitance at f = 1 MHz						
$I_C = I_c$ = 0; $-V_{EB}$ = 1.0 V	C_e	<	8.0	8.0	8.0	pF
Transition frequency at T_{amb} = 25 °C						
$-I_C$ = 10 mA; $-V_{CE}$ = 20 V; f = 100 MHz	f_T	>	250	200	200	MHz
$-I_C$ = 0.1 mA; $-V_{CE}$ = 20 V; f = 10.7 MHz	f_T	>		15		MHz
Noise figure						
$-I_C$ = 100 µA; $-V_{CE}$ = 5 V f = 10 Hz to 10 kHz; R_S = 2 kΩ	F	<	6	2	6	dB

h parameters at f = 1 kHz (common emitter)

$-I_C$ = 1 mA; $-V_{CE}$ = 10 V; T_{amb} = 25 °C		BCY71	
Input impedance	h_{ie}	2 to 12	kΩ
Reverse voltage transfer ratio	h_{re}	< 20	10^{-4}
Small signal current gain	h_{fe}	100 to 400	
Output admittance	h_{oe}	10 to 60	$\mu\Omega^{-1}$

CHARACTERISTICS (continued)

SWITCHING CHARACTERISTICS of the BCY70 and BCY72

Turn on time when switched to $+V_{BE}$ = 2 V to $-I_C$ = 10 mA; $-I_B$ = 1 mA

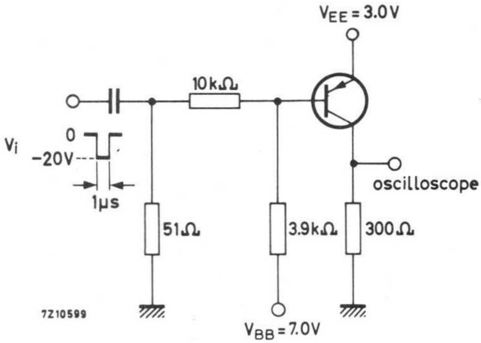
delay time	t_d	typ.	23	ns
		<	35	ns
rise time	t_r	typ.	25	ns
		<	35	ns
turn on time	t_{on}	typ.	48	ns
		<	65	ns

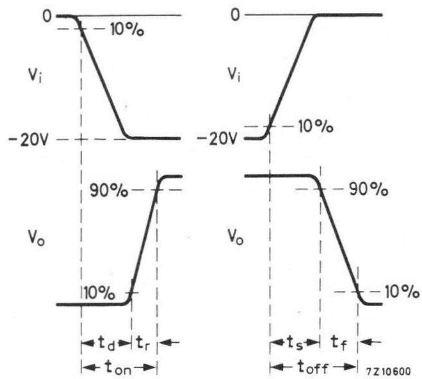
Turn off time when switched from

$-I_C$ = 10 mA; $-I_B$ = 1 mA to $+V_{BE}$ = 2 V with $+I_{BM}$ = 1 mA

storage time	t_s	typ.	270	ns
		<	350	ns
fall time	t_f	typ.	50	ns
		<	80	ns
turn off time	t_{off}	typ.	320	ns
		<	420	ns

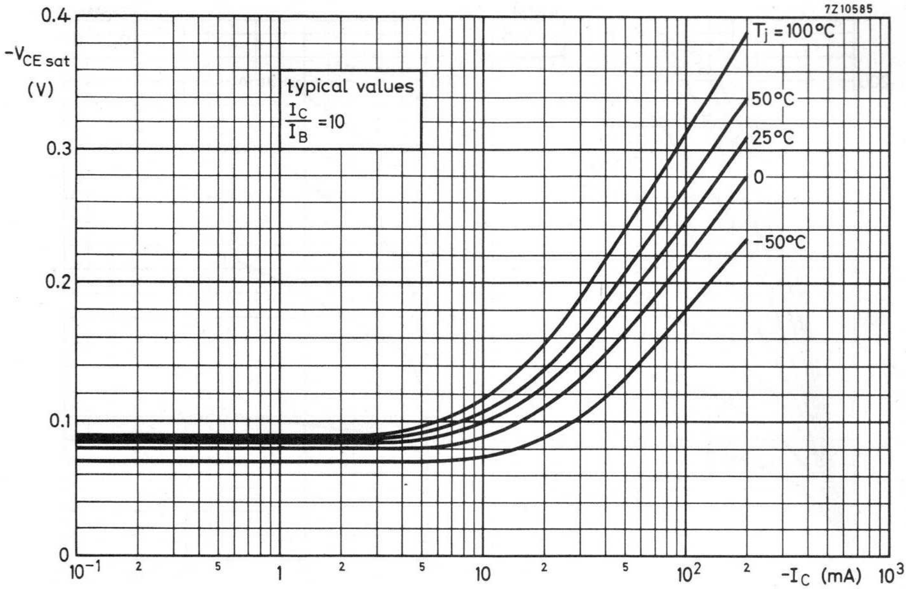
Test circuit:

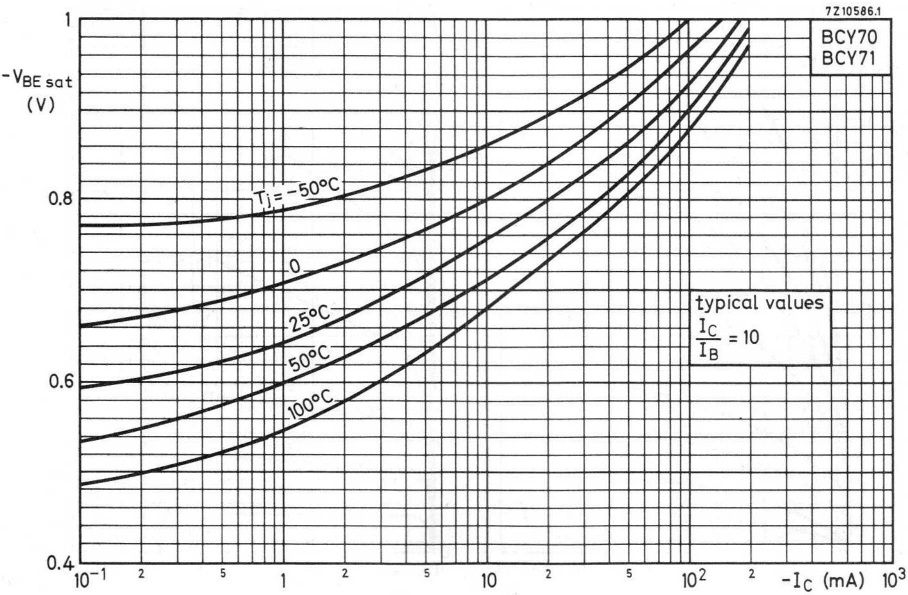


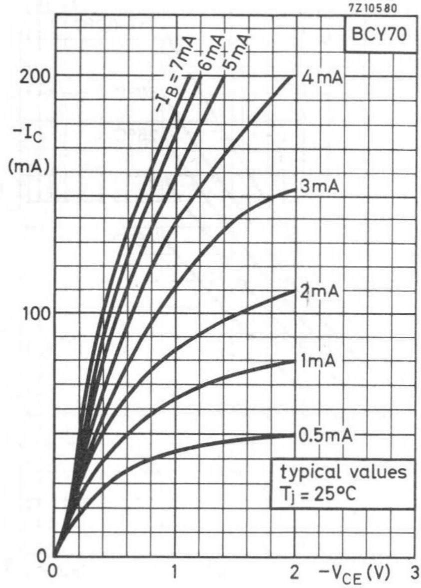


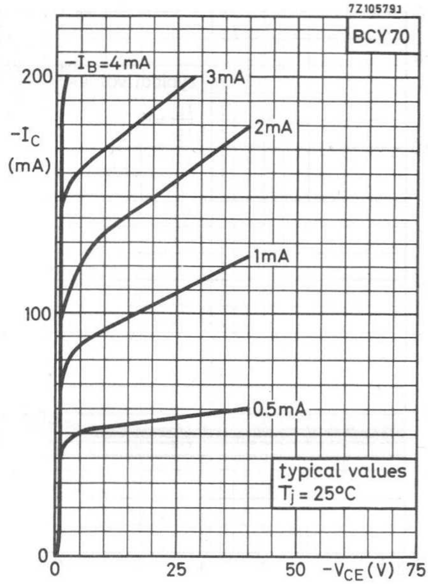
Note:

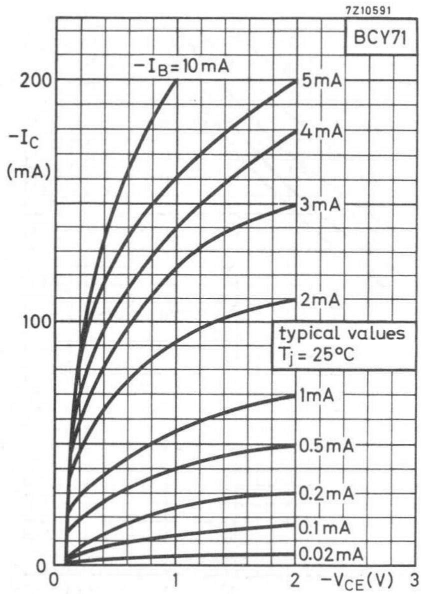
$+I_{BM}$ is the reverse current that can flow during switching off. The indicated $+I_{BM}$ is determined and limited by the applied cut-off voltage and series resistance.

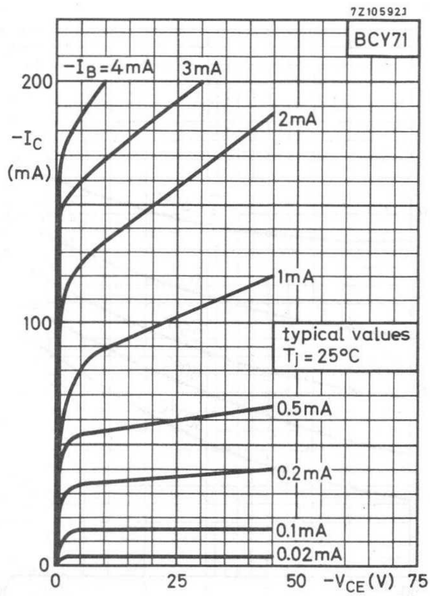

7Z10585
$-V_{CE\,sat}$ (V)
typical values
$\frac{I_C}{I_B} = 10$
$T_j = 100\,°C$
50 °C
25 °C
0
−50°C
$-I_C$ (mA)
0.4
0.3
0.2
0.1
0
10^{-1} 2 5 1 2 5 10 2 5 10^2 2 10^3

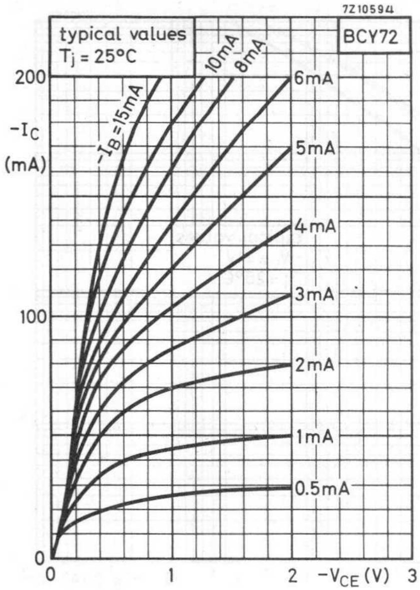

7Z10586.1
BCY70
BCY71
$-V_{BE\,sat}$ (V)
typical values
$\frac{I_C}{I_B} = 10$
$T_j = -50°C$
0
25°C
50°C
100°C
$-I_C$ (mA)
1
0.8
0.6
0.4
10^{-1} 2 5 1 2 5 10 2 5 10^2 2 10^3

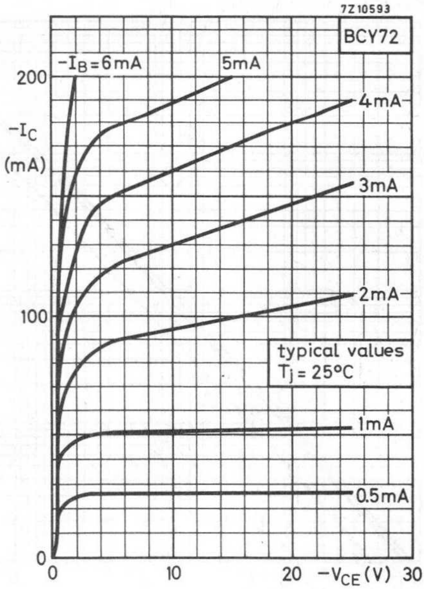

7Z10580
BCY70
200
-IC
(mA)
100
0
-IB = 7mA
6mA
5mA
4mA
3mA
2mA
1mA
0.5mA
typical values
Tj = 25°C
0
1
2
-VCE (V)
3

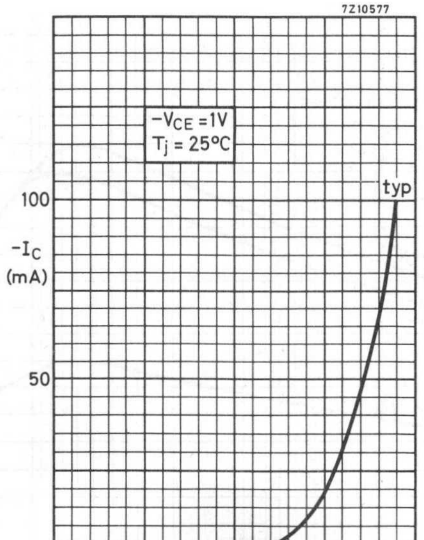

7Z10579J
BCY70
200
-IC
(mA)
100
0
-IB=4mA
3mA
2mA
1mA
0.5mA
typical values
Tj = 25°C
0
25
50
-VCE (V)
75

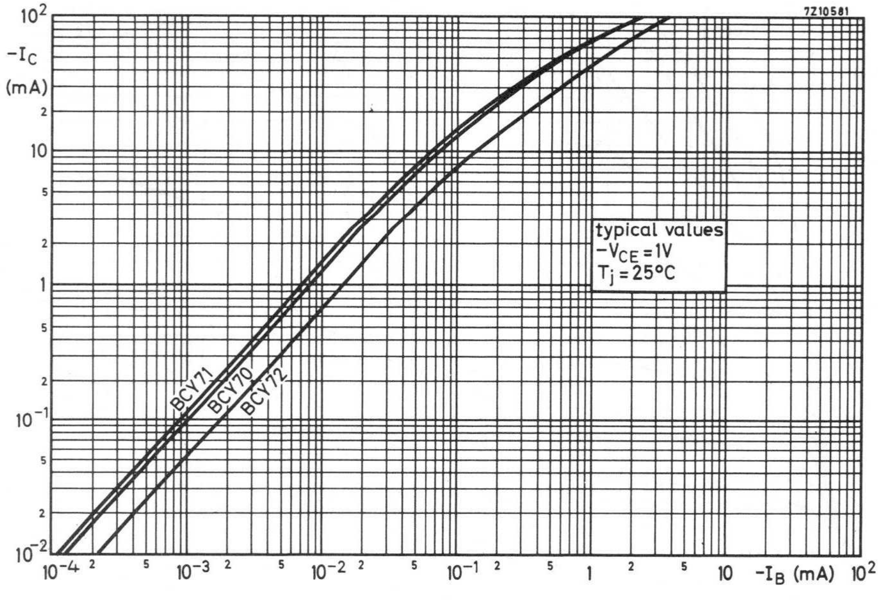

7Z10591
BCY71
200
-IC
(mA)
100
0
-IB=10mA
5mA
4mA
3mA
2mA
typical values
Tj = 25°C
1mA
0.5mA
0.2mA
0.1mA
0.02mA
0
1
2
-VCE (V)
3

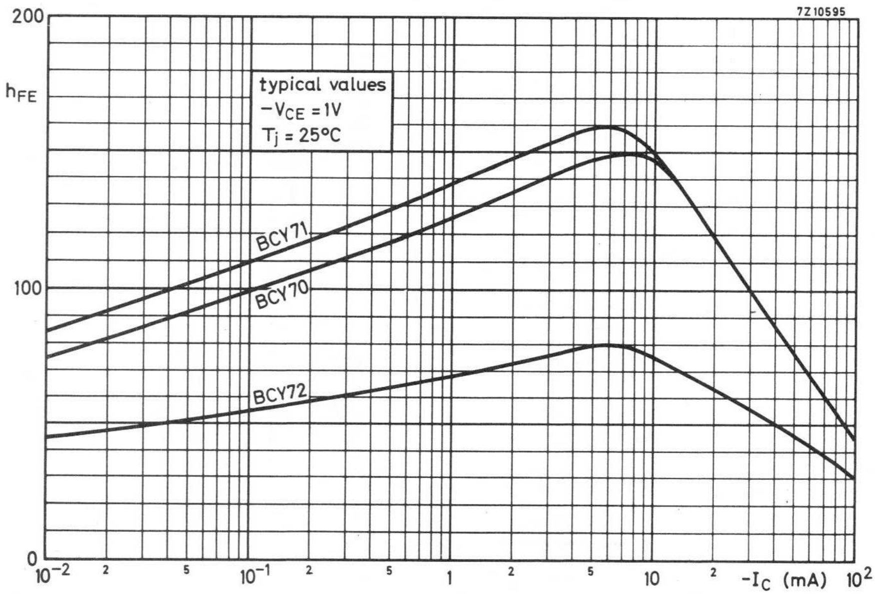

7Z10592J
BCY71
200
-IC
(mA)
100
0
-IB=4mA
3mA
2mA
1mA
typical values
Tj = 25°C
0.5mA
0.2mA
0.1mA
0.02mA
0
25
50
-VCE (V)
75

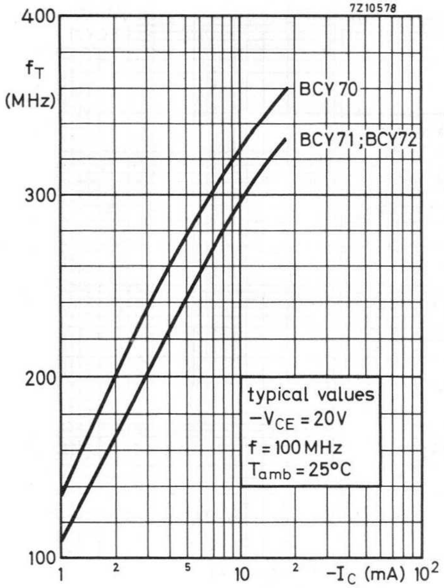

7Z10594
typical values
Tj = 25°C
BCY72
-IC
(mA)
-IB = 15mA
10mA
8mA
6mA
5mA
4mA
3mA
2mA
1mA
0.5mA
-VCE (V)
0
1
2
3
100
200

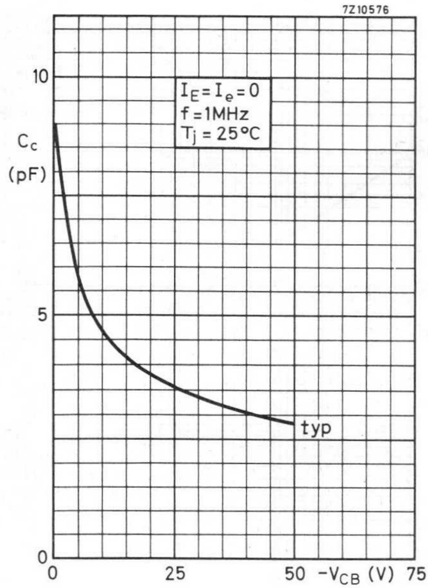

7Z10593
BCY72
-IB = 6mA
5mA
4mA
3mA
2mA
1mA
0.5mA
typical values
Tj = 25°C
-IC
(mA)
-VCE (V)
0
10
20
30
100
200

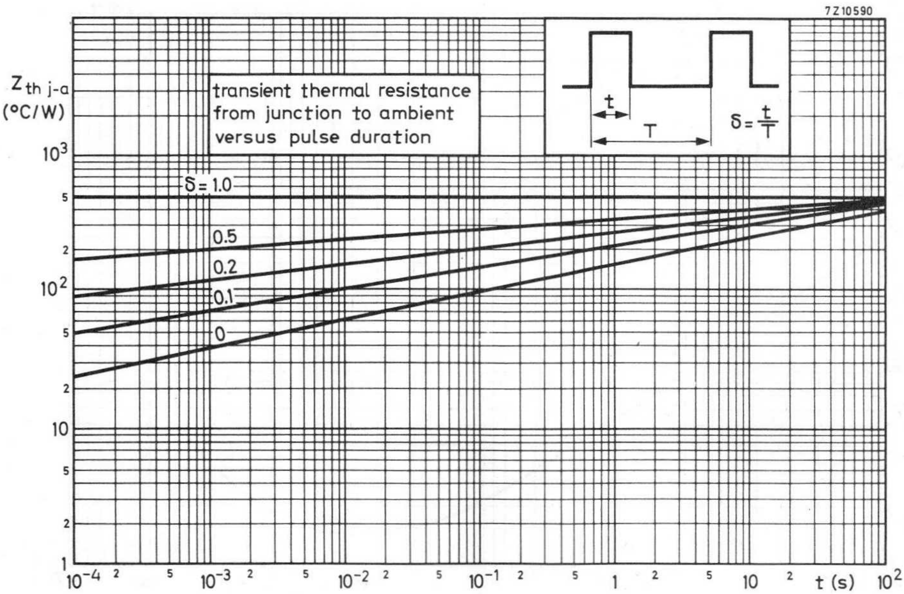

7Z10577
-VCE = 1V
Tj = 25°C
typ
-IC
(mA)
-VBE (V)
0.4
0.6
0.8
0
50
100

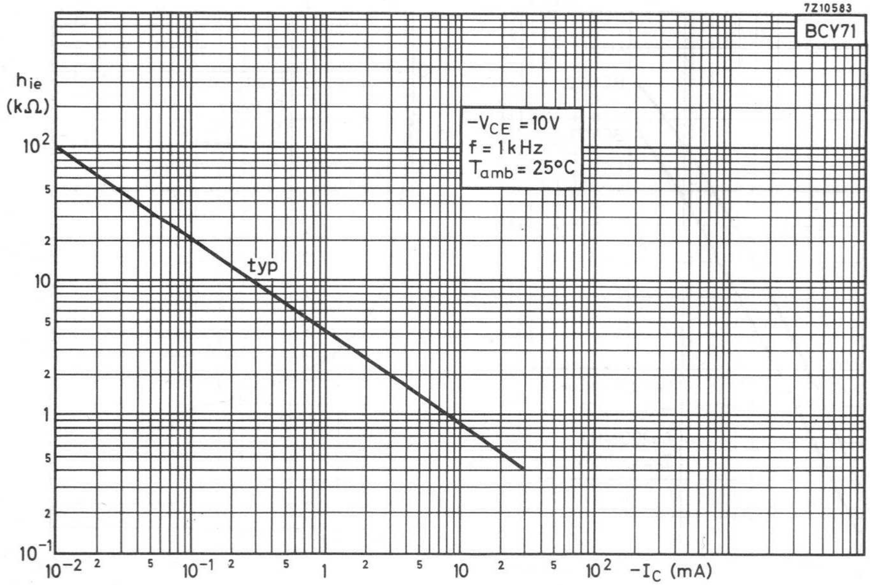

7Z10581
$-I_C$ (mA)
10^2
10
1
10^{-1}
10^{-2}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
$-I_B$ (mA)
10^2
typical values
$-V_{CE}$ = 1V
T_j = 25°C
BCY71
BCY70
BCY72

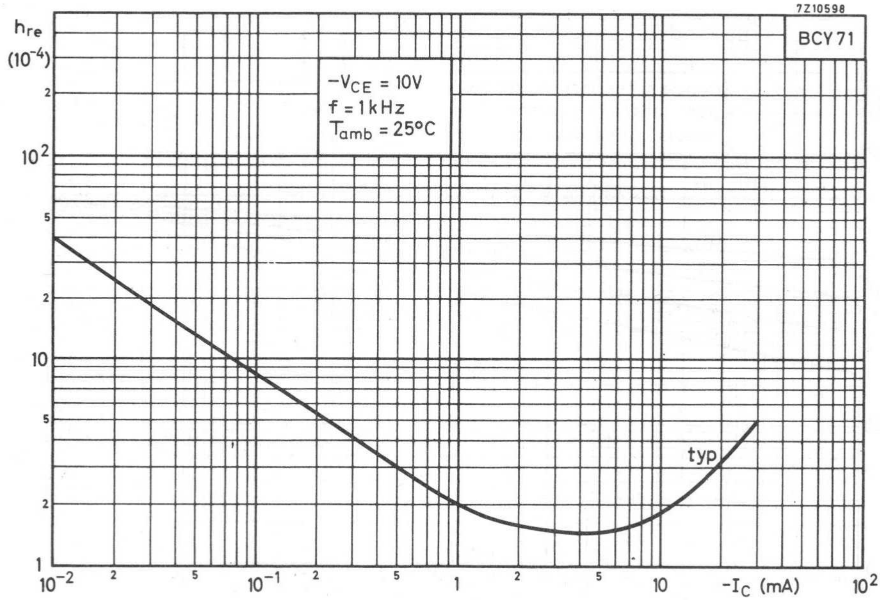

7Z10595
200
h_{FE}
100
0
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2
typical values
$-V_{CE}$ = 1V
T_j = 25°C
BCY71
BCY70
BCY72

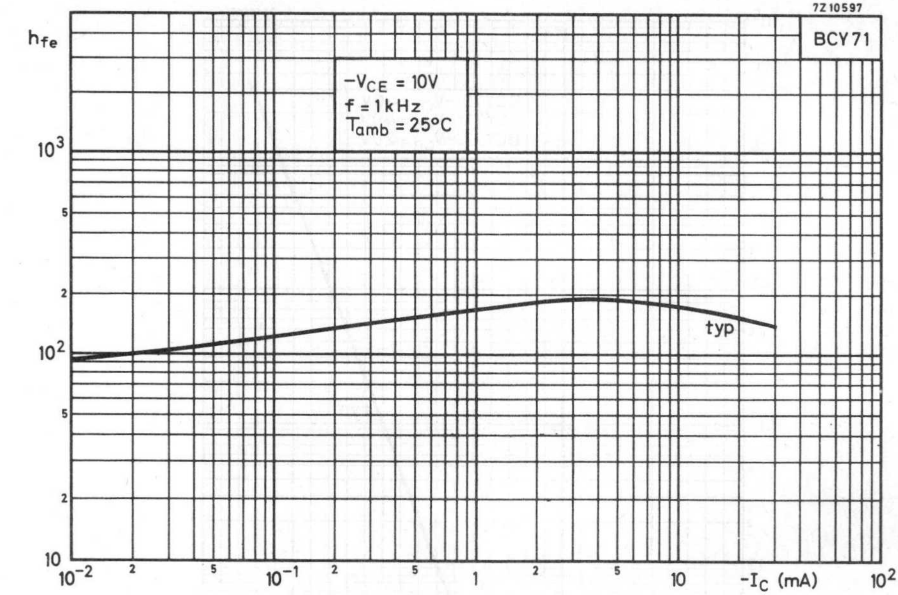

7Z10578
400
f_T
(MHz)
300
200
100
BCY 70
BCY71; BCY72
typical values
$-V_{CE} = 20V$
f = 100 MHz
$T_{amb} = 25°C$
1
2
5
10
2
$-I_C$ (mA) 10^2

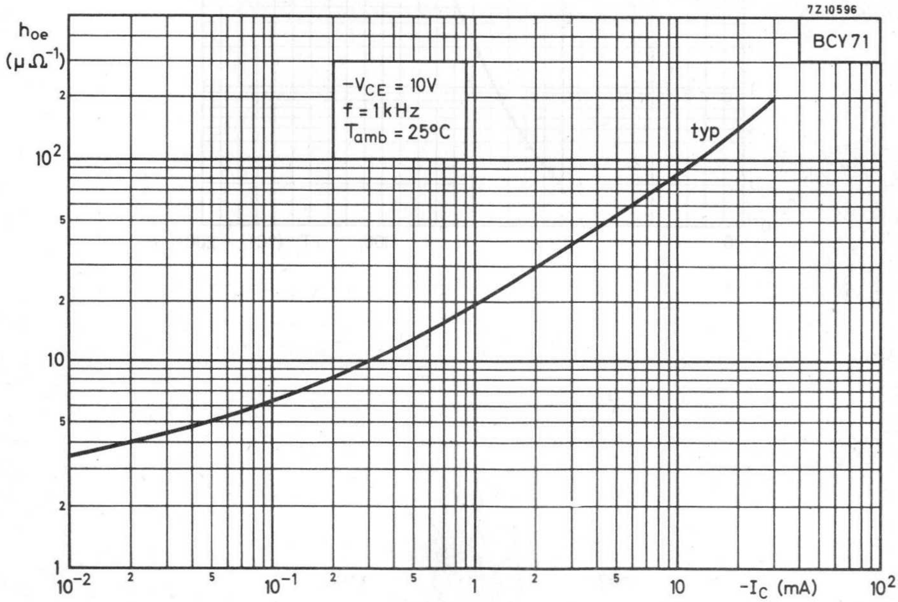

7Z10576
10
C_c
(pF)
5
0
$I_E = I_e = 0$
f = 1MHz
$T_j = 25°C$
typ
0
25
50 $-V_{CB}$ (V) 75

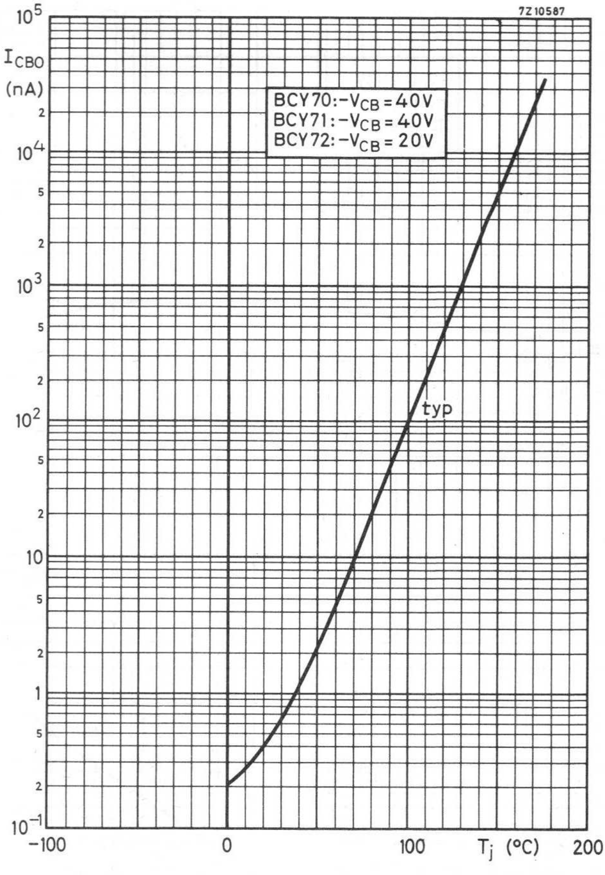

7Z10590
$Z_{th\ j-a}$
(°C/W)
10^3
5
2
10^2
5
2
10
5
2
1
transient thermal resistance
from junction to ambient
versus pulse duration
δ = 1.0
0.5
0.2
0.1
0
t
T
$\delta = \frac{t}{T}$
10^{-4}
2
5
10^{-3}
2
5
10^{-2}
2
5
10^{-1}
2
5
1
2
5
10
2
t (s) 10^2

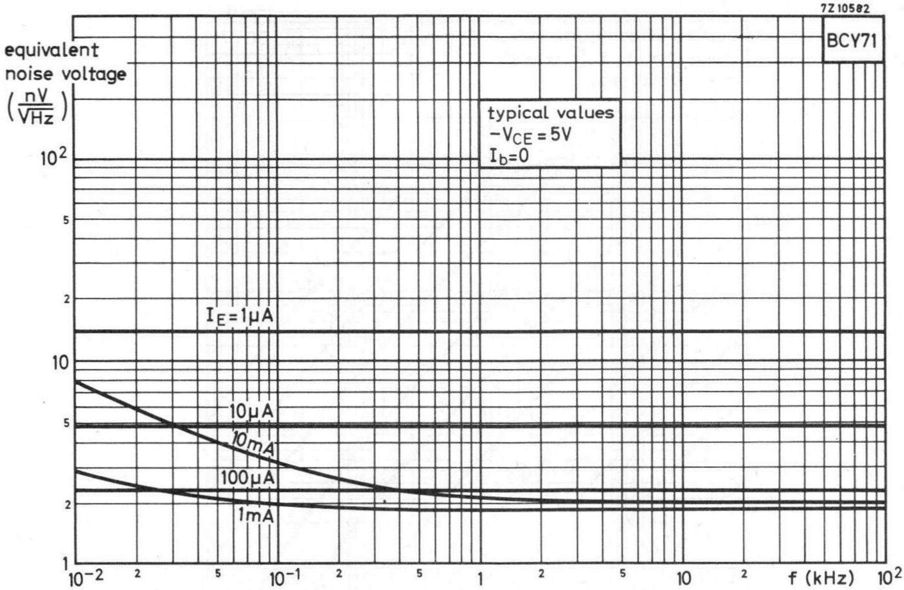

7Z10583
BCY71
h_{ie} (kΩ)
$-V_{CE}$ = 10V
f = 1kHz
T_{amb} = 25°C
typ
10^2
5
2
10
5
2
1
5
2
10^{-1}
10^{-2}
2
5
10^{-1}
2
5
1
2
5
10
2
5
10^2
$-I_C$ (mA)

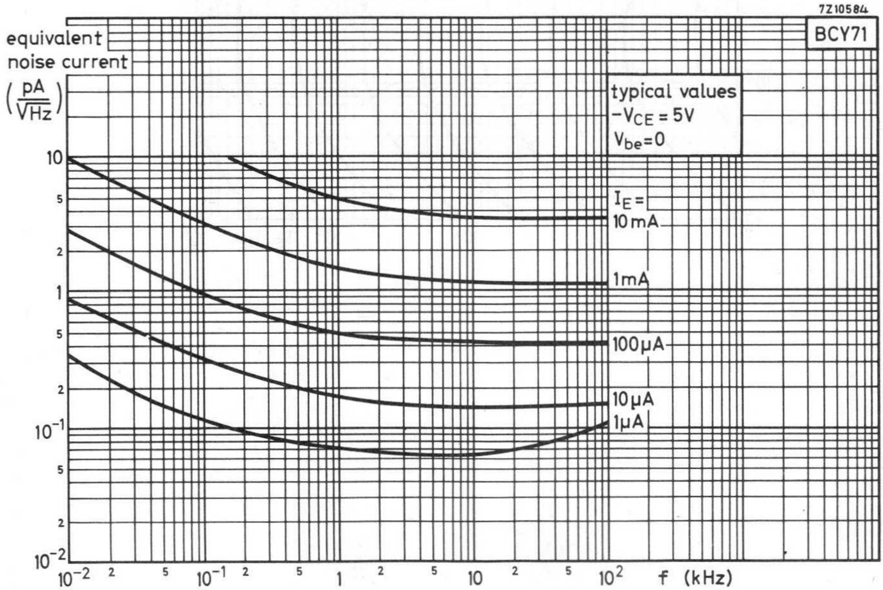

7Z10598
BCY71
h_{re} (10^{-4})
$-V_{CE}$ = 10V
f = 1kHz
T_{amb} = 25°C
typ
2
10^2
5
2
10
5
2
1
10^{-2}
2
5
10^{-1}
2
5
1
2
5
10
$-I_C$ (mA)
10^2

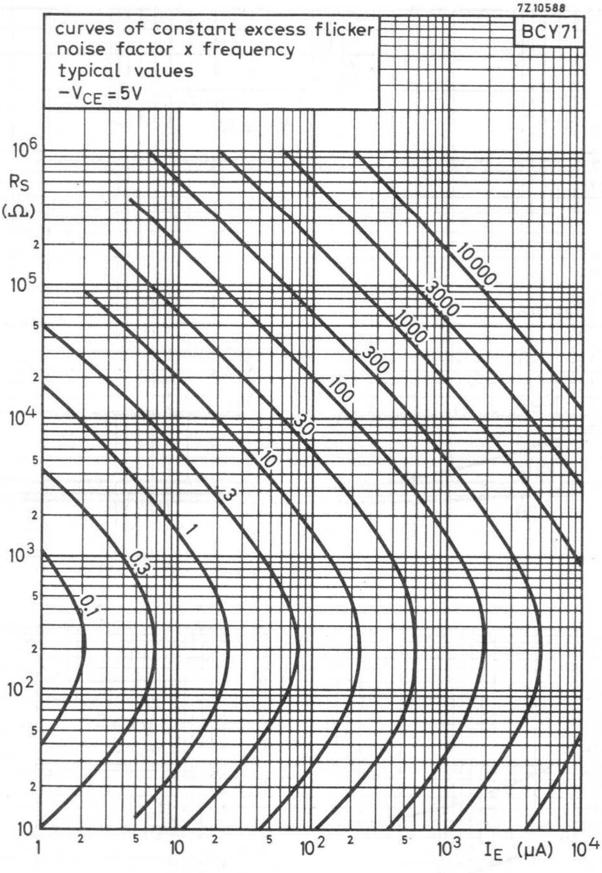

7Z10597
BCY71
h_{fe}
$-V_{CE}$ = 10V
f = 1kHz
T_{amb} = 25°C
typ
10^3
10^2
10
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2

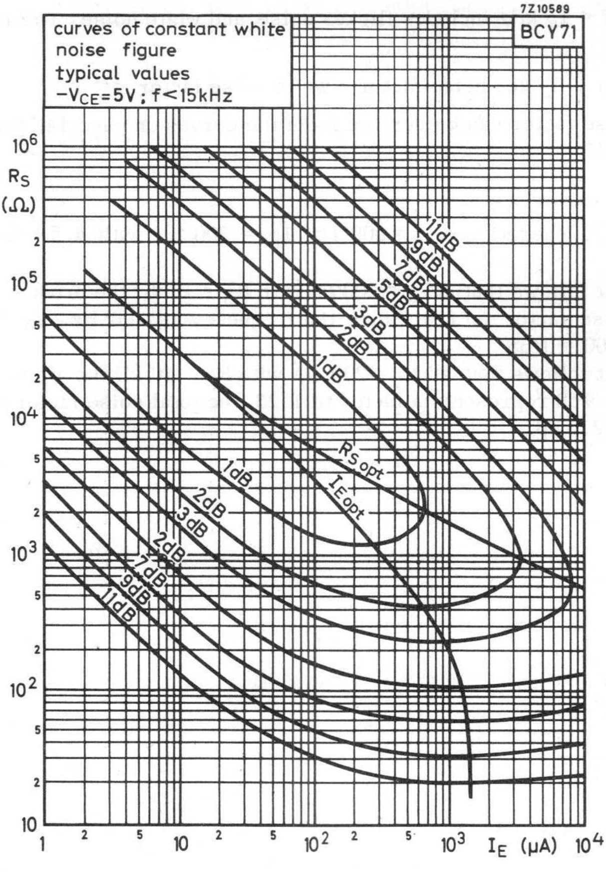

7Z10596
BCY71
h_{oe} ($\mu\Omega^{-1}$)
$-V_{CE}$ = 10V
f = 1kHz
T_{amb} = 25°C
typ
10^2
10
1
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2


7Z10587
I_{CBO} (nA)
10^5
2
10^4
5
2
10^3
5
2
10^2
5
2
10
5
2
1
5
2
10^{-1}
−100
0
100
200
T_j (°C)
BCY70: $-V_{CB}$ = 40 V
BCY71: $-V_{CB}$ = 40 V
BCY72: $-V_{CB}$ = 20 V
typ


7Z10582
BCY71
equivalent noise voltage
(nV/√Hz)
typical values
$-V_{CE}$ = 5V
I_b=0
I_E=1μA
10μA
10mA
100μA
1mA
f (kHz)


7Z10584
BCY71
equivalent noise current
(pA/√Hz)
typical values
$-V_{CE}$ = 5V
V_{be}=0
I_E = 10 mA
1mA
100μA
10μA
1μA
f (kHz)


7Z10588
curves of constant excess flicker noise factor x frequency
typical values
$-V_{CE} = 5V$
BCY71
R_S (Ω)
I_E (μA)
10000
3000
1000
300
100
30
10
3
1
0.3
0.1


7Z10589
BCY71
curves of constant white noise figure
typical values
$-V_{CE}=5V$; $f<15kHz$
10^6
R_S
(Ω)
2
10^5
5
2
10^4
5
2
10^3
5
2
10^2
5
2
10
1
2
5
10
2
5
10^2
2
5
10^3
I_E (μA)
10^4
11dB
9dB
7dB
5dB
3dB
2dB
1dB
$R_{S\,opt}$
$I_{E\,opt}$
1dB
2dB
3dB
2dB
7dB
9dB
11dB

Determination of total noise figure

Total noise at $f < 15$ kHz includes flicker noise and white noise. The relation is as follows:

Noise factor = 1 + flicker noise factor + white noise factor

The flicker noise factor can be derived from the curves on page 14, the white noise factor on page 15.

Example:

Assume a BCY71 operating at $f = 200$ Hz; $I_E = 200$ μA with a source resistance $R_S = 10$ kΩ.
From page 14 it follows that at $I_E = 200$ μA with $R_S = 10$ kΩ the product of frequency and flicker noise factor is 110. Since the frequency is 200 Hz, the flicker noise factor is 110/200 = 0.55
From page 15 it follows that at $I_E = 200$ μA with $R_S = 10$ kΩ the white noise figure 0.9 dB. Since 0.9 dB represents a factor of 1.23, the total noise factor = 0.55 + 1.23 = 1.78, that is 2.5 dB.

N-P-N SILICON PLANAR DUAL TRANSISTORS FOR DIFFERENTIAL AMPLIFIERS

Matched dual n-p-n transistors in a TO-71 metal envelope with all leads insulated from the case. They are primarily intended for differential amplifier applications in general industrial service; e.g. instrumentation and control.
The product is divided in three types according to their matching accuracy.
The BCY87 and BCY88 are intended for applications in prestages of differential amplifiers where low offset, drift and noise are of prime importance. The BCY89 is for second stages, long tail pairs and more general purposes.

QUICK REFERENCE DATA

Ratings

Collector-base voltage (open emitter)	V_{CBO}	max.	45	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	V
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	mW
Junction temperature	T_j	max.	175	°C

Characteristics of the complete device with collector-base voltage of 10 V and sum of emitter currents from 10 to 100 μA.

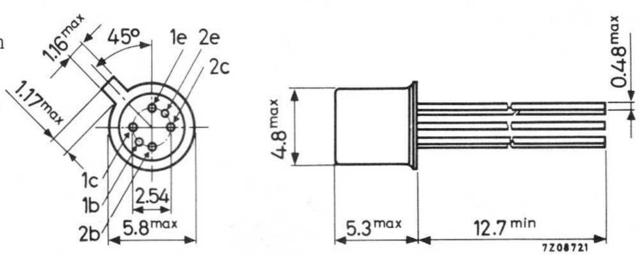
			BCY87	BCY88	BCY89	
Ratio of collector currents at $V_{1B-1E} = V_{2B-2E}$	I_{1C}/I_{2C}		0.9-1.11	0.8-1.25	0.67-1.5	
Base current difference at $V_{1B-1E} = V_{2B-2E}$	$\lvert I_{1B}-I_{2B}\rvert$	<	25	80	300	nA
Equivalent differential voltage change with temperature	$\left\lvert \frac{\Delta V}{\Delta T} \right\rvert$ 1)	<	3	6	10	μV/°C
Equivalent differential current change with temperature	$\left\lvert \frac{\Delta I}{\Delta T} \right\rvert$ 1)	<	0.5	2	10	nA/°C

MECHANICAL DATA

Dimensions in mm

TO-71
All leads insulated from the case

Accessories available: 56263



1) T_{amb} = -20 to +90 °C

RATINGS see page 7

CHARACTERISTICS of the individual transistors

T_{amb} = 25 °C unless otherwise specified

			BCY87	BCY88	BCY89	
Collector cut-off currents						
$I_E = 0$; $V_{CB} = 20$ V; $T_{amb} = 90$ °C	I_{CBO}	<	5	20	–	nA
$I_E = 0$; $V_{CB} = 20$ V	I_{CBO}	<	–	–	10	nA
D.C. current gain						
$I_C = 5$ μA; $V_{CB} = 10$ V	h_{FE}	>	80	–	–	
$I_C = 50$ μA; $V_{CB} = 10$ V	h_{FE}	>	100	100	100	
		<	450	450	450	
$I_C = 500$ μA; $V_{CB} = 10$ V	h_{FE}	>	–	120	–	
		<	–	600	–	
$I_C = 10$ mA; $V_{CB} = 10$ V	h_{FE}	>	–	–	100	
		<	–	–	600	
Transition frequency						
$-I_E = 50$ μA; $V_{CB} = 10$ V	f_T	>	10	10	10	MHz
$-I_E = 500$ μA; $V_{CB} = 10$ V	f_T	>	50	50	50	MHz
Collector capacitance at f = 1 MHz						
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	3.5	3.5	3.5	pF
Noise figures						
$I_C = 50$ μA; $V_{CE} = 5$ V; $R_S = 10$ kΩ Bandwidth 10 Hz to 15 kHz	F	<	3	4	4	dB
1 kHz spot noise figure $I_C = 50$ μA; $V_{CE} = 5$ V; R_S = opt. Bandwidth = 200 Hz	F	<	4	5	5	dB

CHARACTERISTICS of the complete device.

These characteristics are valid under the following conditions:

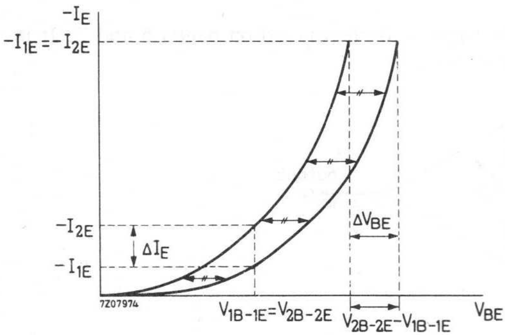
a. Collector-base voltage of both transistors not exceeding 10 V ($V_{1C-1B} = V_{2C-2B} \leq 10$ V)

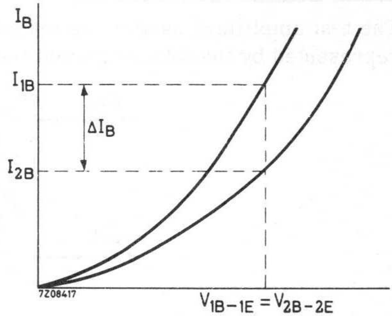
b. Sum of the emitter currents from 10 to 100 μA
$-(I_{1E} + I_{2E}) = 10$ to 100 μA

MATCHING CHARACTERISTICS

			BCY87	BCY88	BCY89	
Ratio of collector currents						
$V_{1B-1E} = V_{2B-2E}$	I_{1C}/I_{2C}		0.9-1.11	0.8-1.25	0.67-1.5	
Difference between base-emitter voltages						
$I_{1C} = I_{2C}$	$\lvert V_{1B-1E} - V_{2B-2E} \rvert$	<	3	6	10	mV
Difference between base currents						
$V_{1B-1E} = V_{2B-2E}$	$\lvert I_{1B} - I_{2B} \rvert$	<	25	80	300	nA

Illustration of matching characteristics:





$$\frac{I_{2E}}{I_{1E}} = \exp. \frac{q}{KT} \cdot \Delta V_{BE}$$

$\frac{I_{2E}}{I_{1E}}$ measured at $\Delta V_{BE} = 0$

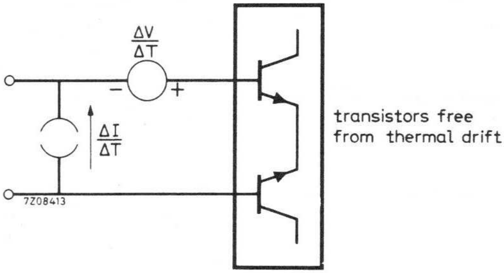
ΔV_{BE} measured at $\frac{I_{2E}}{I_{1E}} = 1$

CHARACTERISTICS of the complete device (continued)

Equivalent circuit for drift

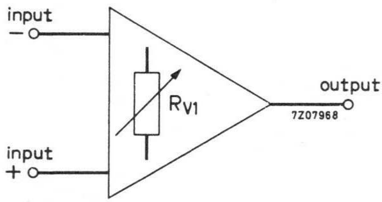
In the equivalent circuit the transistors are considered to be drift free. All temperature coefficients are concentrated in the voltage source $\frac{\Delta V}{\Delta T}$ and in the current source $\frac{\Delta I}{\Delta T}$.

It should be noted that the differential current change given is only valid when the source resistances are almost equal; the differential voltage change only when the base-emitter voltages are almost equal.



Block symbol of test amplifier

The test amplifier, used in the tests on page 5, is described on pages 6 and 7. It is represented by the following amplifier symbol:



CHARACTERISTICS of the complete device (continued)

Equivalent differential voltage change with temperature

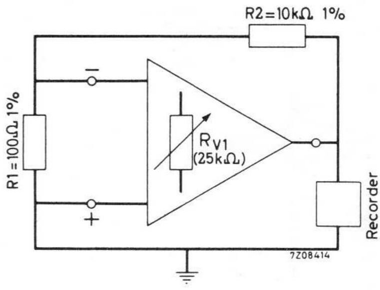
			BCY87	BCY88	BCY89	
$T_{amb} = -20$ to $+90$ °C	$\left\|\frac{\Delta V}{\Delta T}\right\|$	typ.	1	2	4	µV/°C
		<	3	6	10	µV/°C

Equivalent differential current change with temperature

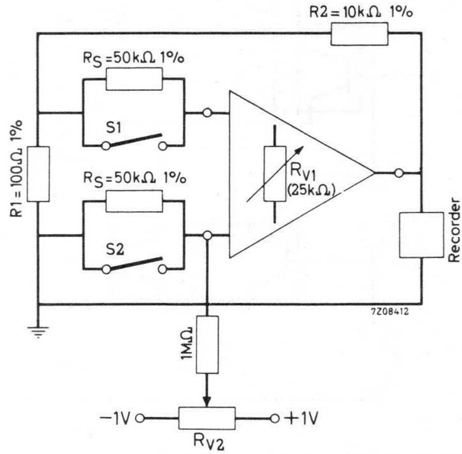
			BCY87	BCY88	BCY89	
$T_{amb} = -20$ to $+90$ °C	$\left\|\frac{\Delta I}{\Delta T}\right\|$	<	0.5	2	10	nA/°C

Test methods

$\frac{\Delta V}{\Delta T}$



$\frac{\Delta I}{\Delta T}$



NOTE

To prevent contact potentials, connections should be soldered.

Amplification factor determined by feedback circuit: $\frac{R2}{R1} = 100$

Output voltage against time is recorded.

The temperature of the amplifier is adjusted to T_1 between −20 and +90 °C. When it has stabilized, the output voltage is brought to zero ($|V_{T1}| < 1$ mV)[1]). The amplifier temperature is then adjusted to T_2 between −20 and +90 °C. When it has stabilized the output voltage can be read off.

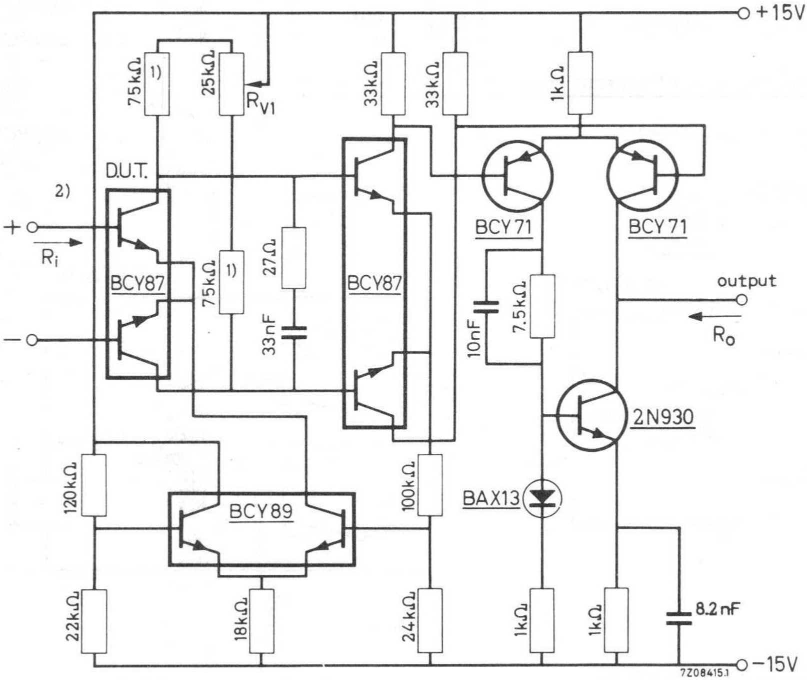
Then: $\frac{\Delta V}{\Delta T} = \frac{V_{T2} - V_{T1}}{T_2 - T_1} \cdot \frac{R1}{R2}$ or $\frac{\Delta I}{\Delta T} = \frac{V_{T2} - V_{T1}}{T_2 - T_1} \cdot \frac{R1}{R2} \cdot \frac{1}{2R_S}$

[1]) For $\frac{\Delta V}{\Delta T}$: adjusted by R_{V1}

For $\frac{\Delta I}{\Delta T}$: first by R_{V1} with S1 and S2 closed, then by R_{V2} with the switches open.

Differential test-amplifier

The test amplifier (including feedback resistors, source-resistors and biasing-resistors) should be mounted in a small box to ensure a uniform temperature throughout.

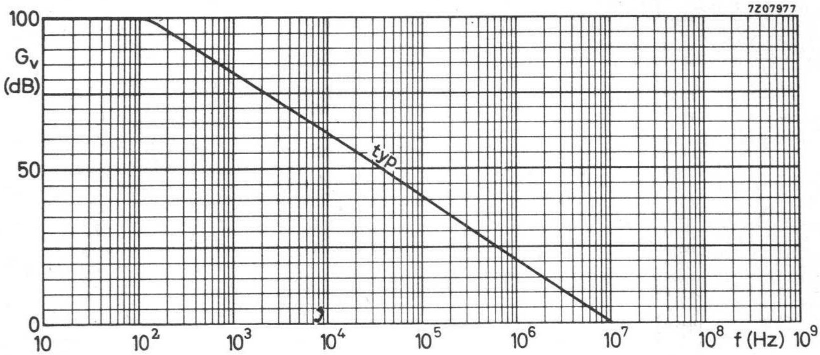


[1]) Relative temperature coefficient < $10^{-5}/^{o}C$

[2]) The device at the input is the device under test

Performance of the test amplifier

Open loop voltage gain (Z_L = 10 kΩ)	G_v	typ.	10^5	
Frequency at which G_v = 1	f_1	typ.	10	MHz
Max. common mode input voltage range			±10	V
Max. output current			±2.5	mA
Max. output voltage			±10	V
Input resistance	R_i		100	kΩ
Output resistance	R_o	typ.	20	kΩ
Common mode rejection ratio			10^5	



RATINGS (Limiting values) [1])

Voltages (each transistor)

Collector-base voltage (open emitter)	V_{CBO}	max.	45	V
Collector-emitter voltage (open base) I_C = 10 mA	V_{CEO}	max.	40	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Currents (each transistor)

Collector current (d.c.)	I_C	max.	30	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	mW

Temperatures

Storage temperature	T_{stg}	max.	175	°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

From junction to ambient	$R_{th\ j\text{-}a}$	=	1	°C/mW

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

P-N-P SILICON TRANSISTORS

P-N-P silicon transistors in an all-glass construction with external metal can. They are intended for use in audio amplifiers and general industrial applications.

RATINGS (Limiting values)

			BCZ10	BCZ11	BCZ12	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	25	25	60	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	25	25	60	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	20	20	30	V

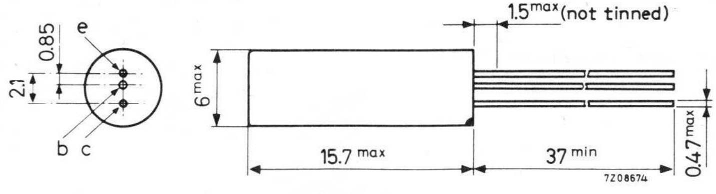
Collector current (d.c. or average over any 20 ms period)	$-I_C$	max.	50	mA
Collector current (peak value)	$-I_{CM}$	max.	50	mA
Base current (d.c. or average over any 20 ms period)	$-I_B$	max.	15	mA
Base current (peak value)	$-I_{BM}$	max.	15	mA
Total power dissipation up to T_{amb} = 25 °C in free air	P_{tot}	max.	250	mW
Storage temperature	T_{stg}		-55 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.5	°C/mW
From junction to ambient with cooling fin 56210	$R_{th\ j-a}$	=	0.42	°C/mW
From junction to case	$R_{th\ j-c}$	=	0.35	°C/mW

MECHANICAL DATA

Dimensions in mm



The coloured dot indicates the collector

Accesssories available: 56200; 56208; 56209; 56210; 56226; 56227.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BCZ10	BCZ11	BCZ12	
Collector cut-off current						
$I_E = 0$; $-V_{CB} = 10$ V	$-I_{CBO}$	typ.	1	1	10	nA
		<	100	100	100	nA
$I_E = 0$; $-V_{CB} = 10$ V; $T_j = 100$ °C	$-I_{CBO}$	typ.	0.1	0.1	0.1	μA
		<	10	10	10	μA
Emitter cut-off current						
$I_C = 0$; $-V_{EB} = 10$ V	$-I_{EBO}$	typ.	1	1	10	nA
		<	100	100	100	nA
$I_C = 0$; $-V_{EB} = 10$ V; $T_j = 100$ °C	$-I_{EBO}$	typ.	0.1	0.1	0.1	μA
		<	10	10	10	μA
Knee voltage						
$-I_C = 7$ mA; $-I_B = 1$ mA	$-V_{CEsat}$	typ.	130	100	130	mV
		<	320	320	320	mV
Collector-base capacitance						
$-I_C = 1$ mA; $-V_{CE} = 6$ V	$C_{b'c}$	typ.	45	50	40	pF
		<	80	80	80	pF
Cut-off frequency						
		>	0.3	1.0	-	MHz
$-I_C = 1$ mA; $-V_{CE} = 6$ V	f_{hfb}	typ.	1.0	1.5	1.0	MHz
		<	3.5	-	-	MHz
Base resistance						
$-I_C = 1$ mA; $-V_{CE} = 6$ V	$r_{bb'}$	typ.	125	125	125	Ω
		<	350	350	350	Ω
Emitter resistance						
$-I_C = 1$ mA; $-V_{CE} = 6$ V	$Re(h_{ib})$	typ.	-	-	25	Ω
Noise figure at f = 1 kHz						
$-I_C = 0.5$ mA; $-V_{CE} = 2$ V; $R_S = 500$ Ω	F	typ.	8.0	6.0	8.0	dB
Small signal current gain at f = 1 kHz						
		>	15	25	10	
$-I_C = 1$ mA; $-V_{CE} = 6$ V	h_{fe}	typ.	20	35	15	
		<	60	60	-	

GERMANIUM TRANSISTORS

P-N-P transistors in a metal envelope intended for a.f. medium power class A and B output stages.
Type 2-OC72 consists of two transistors OC72 selected for low distortion class B operation.

RATINGS (Limiting values)

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	16	V
Collector-emitter voltage (R_{BE} < 1 kΩ)	$-V_{CER}$	max.	32	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	10	V

Currents

Collector current (d.c. or average over any 20 ms period)	$-I_C$	max.	125	mA
Collector current (peak value)	$-I_{CM}$	max.	250	mA
Emitter current (peak value)	I_{EM}	max.	250	mA
Base current (peak value)	$\|I_{BM}\|$	max.	125	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C with cooling fin 56200	P_{tot}	max.	165	mW

Temperatures

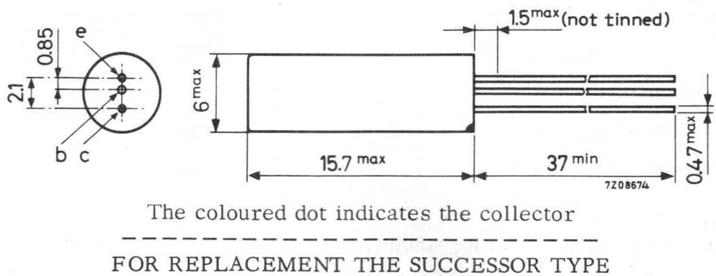
Storage temperature	T_{stg}	-55 to +75		°C
Junction temperature: continuous	T_j	max.	75	°C
incidentally	T_j	max.	90	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.4	°C/mW
From junction to ambient with cooling fin 56200 on a heatsink 12.5 cm^2	$R_{th\ j\text{-}a}$	=	0.3	°C/mW

MECHANICAL DATA

Dimensions in mm



The coloured dot indicates the collector

FOR REPLACEMENT THE SUCCESSOR TYPE
2-AC132 IS RECOMMENDED

CHARACTERISTICS $T_{amb} = 25\ ^oC$

Collector cut-off currents

$I_E = 0$; $-V_{CB} = 10$ V	$-I_{CBO}$	typ.	4.5	μA
		<	10	μA
$I_B = 0$; $-V_{EB} = 6$ V	$-I_{CEO}$	typ.	125	μA
			50 to 300	μA

Emitter cut-off current

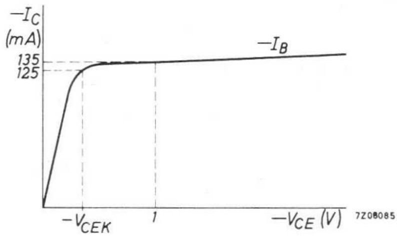
$I_C = 0$; $-V_{EB} = 10$ V	$-I_{EBO}$	typ.	4.5	μA
		<	10	μA

Base-emitter voltage

$-I_C = 1.5$ mA; $-V_{CE} = 6$ V	$-V_{BE}$		130 to 170	mV
$-I_C = 80$ mA; $-V_{CE} = 0.7$ V	$-V_{BE}$	<	450	mV
$-I_C = 125$ mA; $-V_{CE} = 0.7$ V	$-V_{BE}$	<	700	mV

Knee voltage

$-I_C = 125$ mA; $-I_B$ = value for which $-I_C = 135$ mA at $-V_{CE} = 1$ V	$-V_{CEK}$	<	400	mV



D.C. current gain

$-I_C = 10$ mA; $-V_{CE} = 5.4$ V	h_{FE}	typ.	70
			45 to 120
$-I_C = 80$ mA; $-V_{CE} = 0.7$ V	h_{FE}	typ.	50
			30 to 90
$-I_C = 125$ mA; $-V_{CE} = 0.7$ V	h_{FE}	>	25
$-I_C = 250$ mA; $-V_{CE} = 1$ V	h_{FE}	>	15

Cut-off frequencies

$I_E = 10$ mA; $-V_{CB} = 6$ V	f_{hfb}	>	350	kHz
$-I_C = 10$ mA; $-V_{CE} = 6$ V	f_{hfe}	>	8	kHz

Noise figure at f = 1 kHz

$I_E = 0.5$ mA; $-V_{CE} = 2$ V; $R_S = 500\ \Omega$	F	<	15	dB

D.C. current gain ratio of matched pair 2-OC72	h_{FE1}/h_{FE2}	typ.	1.15
			1.0 to 1.3

GERMANIUM TRANSISTORS

P-N-P transistors in all-glass construction with metal cover. They are intended for class A and B output stages at battery voltages up to 9 V and power outputs up to 1 W. Type 2-OC74 consists of 2 transistors OC74 selected for low distortion class B operation with low spread in base-emitter voltages.

RATINGS (Limiting values)

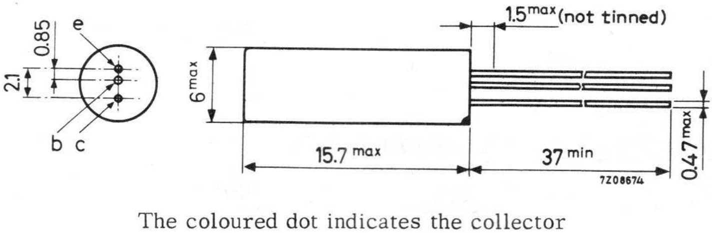
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	20	V
Collector-emitter voltage (R_{BE} < 500 Ω)	$-V_{CER}$	max.	20	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	6	V
Collector current (d.c. or average over any 20 ms period)	$-I_C$	max.	300	mA
Emitter current (d.c. or average over any 20 ms period)	I_E	max.	310	mA
Total power dissipation up to T_{amb} = 25 °C with cooling fin 56200 on heatsink ≥ 12.5 cm^2	P_{tot}	max.	550	mW
Storage temperature	T_{stg}		-55 to +75	°C
Junction temperature: continuous	T_j	max.	75	°C
incidentally	T_j	max.	90	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.22	°C/mW
From junction to ambient with cooling fin 56200 on heatsink ≥ 12.5 cm^2	$R_{th\ j-a}$	=	0.09	°C/mW

MECHANICAL DATA

Dimensions in mm



The coloured dot indicates the collector

FOR REPLACEMENT THE SUCCESSOR TYPES AC128, AC188 ARE RECOMMENDED

CHARACTERISTICS T_{amb} = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $-V_{CB} = 9$ V	$-I_{CBO}$	<	20	μA
$I_E = 0$; $-V_{CB} = 9$ V; $T_j = 60$ °C	$-I_{CBO}$	<	330	μA

Emitter cut-off current

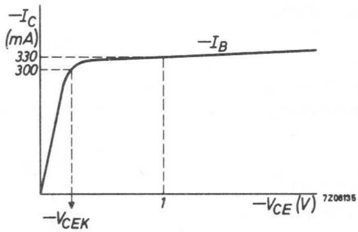
$I_C = 0$; $-V_{EB} = 6$ V	$-I_{EBO}$	<	20	μA
$I_C = 0$; $-V_{EB} = 6$ V; $T_j = 60$ °C	$-I_{EBO}$	<	300	μA

Base-emitter voltage [1]

$-I_C$ = 5 mA; $-V_{CE} = 6$ V	$-V_{BE}$		135 to 175	mV
$-I_C$ = 50 mA; $-V_{CE} = 6$ V	$-V_{BE}$	<	300	mV
$-I_C$ = 300 mA; $-V_{CE} = 1$ V	$-V_{BE}$	<	700	mV

Knee voltage

$-I_C$ = 300 mA; $-I_B$ = value for which $-I_C$ = 330 mA at $-V_{CE} = 1$ V	$-V_{CEK}$	<	600	mV



D.C. current gain

$-I_C$ = 5 mA; $-V_{CE} = 6$ V	h_{FE}	40 to 200
$-I_C$ = 50 mA; $-V_{CE} = 6$ V	h_{FE}	60 to 150
$-I_C$ = 300 mA; $-V_{CE} = 1$ V	h_{FE}	40 to 100

Cut-off frequency

$-I_C$ = 50 mA; $-V_{CE} = 6$ V	f_{hfe}	>	8	kHz

Noise figure at f = 1 kHz

I_E = 5 mA; $-V_{CB} = 6$ V	F	<	27	dB

D.C. current gain ratio of matched pair 2-OC74

$-I_C$ = 50 mA; $-V_{CE} = 6$ V	h_{FE1}/h_{FE2}	typ.	1.15
		<	1.3
$-I_C$ = 300 mA; $-V_{CE} = 1$ V	h_{FE1}/h_{FE2}	typ.	1.15
		<	1.3

1) $-V_{BE}$ decreases by about 2.3 mV/°C with increasing temperature.

GERMANIUM P-N-P TRANSISTOR

Germanium transistor of the p-n-p type in all glass construction with metal envelope. It is meant for class A output and driver stages at battery voltages of up to 12 V.

RATINGS (Limiting values)

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	26	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	13	V
Collector current (d.c. and average)	$-I_C$	max.	300	mA
Total dissipation up to T_{amb} = 25 °C	P_{tot}	max.	550	mW
Junction temperature: continuous	T_j	max.	75	°C
incidentally	T_j	max.	90	°C

THERMAL RESISTANCE

From junction to ambient	$R_{th\ j\text{-}a}$	=	0.22	°C/mW

CHARACTERISTICS

D.C. current gain at T_j = 25 °C

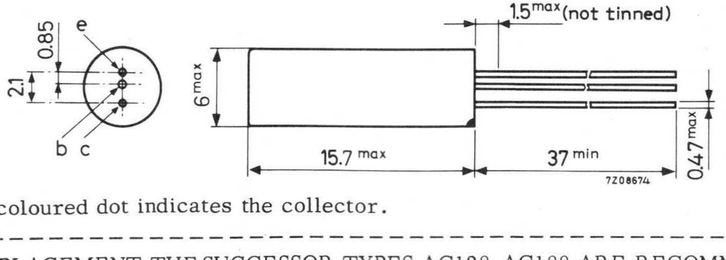
$-I_C$ = 5 mA; $-V_{CE}$ = 6 V	h_{FE}	typ.	50	
			25 to 125	
$-I_C$ = 50 mA; $-V_{CE}$ = 6 V	h_{FE}	typ.	60	
			40 to 100	
$-I_C$ = 300 mA; $-V_{CE}$ = 1 V	h_{FE}	typ.	40	
			25 to 75	

Cut-off frequency

$-I_C$ = 50 mA; $-V_{CE}$ = 6 V	f_{hfe}	typ.	16	kHz
		>	8	kHz

MECHANICAL DATA

Dimensions in mm



The coloured dot indicates the collector.

FOR REPLACEMENT THE SUCCESSOR TYPES AC128, AC188 ARE RECOMMENDED

SILICON N-P-N PLANAR TRANSISTORS

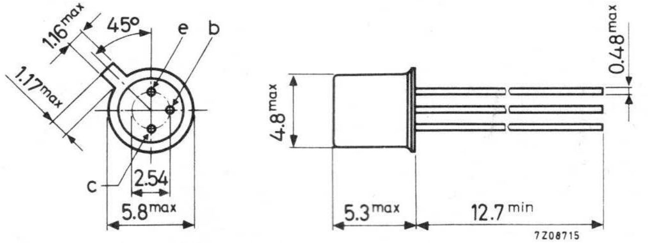
N-P-N transistors in a TO-18 metal envelope with the collector connected to the case.
These devices are primarily intended for use in high performance, low level, low noise amplifier applications both for direct current and for frequencies of up to 100 MHz

QUICK REFERENCE DATA

			2N929	2N930	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	45	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	45	V
Collector current (peak value)	I_{CM}	max.	60	60	mA
Total dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	300	mW
Junction temperature	T_j	max.	175	175	°C
D.C. current gain at T_j = 25 °C					
I_C = 10 μA; V_{CE} = 5 V	h_{FE}		40 to 120	100 to 300	
I_C = 10 mA; V_{CE} = 5 V	h_{FE}		100 to 350	150 to 600	
Transition frequency					
I_C = 0.5 mA; V_{CE} = 5 V	f_T	typ.	80	80	MHz
Noise figure (f = 10 Hz to 15 kHz)					
I_C = 10 μA; V_{CE} = 5 V; R_S = 10 kΩ	F	typ.	2.5	2	dB
		<	4	3	dB

MECHANICAL DATA Dimensions in mm

Collector connected to case
TO-18



Accessories available: 56246, 56263.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	45	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	V
Collector-emitter voltage at $V_{EB} = 0$	V_{CES}	max.	45	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Currents

Collector current (d.c. or average over any 50 ms period)	I_C	max.	30	mA
Collector current (peak value)	I_{CM}	max.	60	mA
Emitter current (d.c. or average over any 50 ms period)	$-I_E$	max.	35	mA
Emitter current (peak value)	$-I_{EM}$	max.	70	mA

Power dissipation

Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	300	mW

Temperatures

Storage temperature	T_{stg}	-65 to +175		^oC
Junction temperature	T_j	max.	175	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.5	$^oC/mW$
From junction to case	$R_{th\ j-c}$	=	0.25	$^oC/mW$

CHARACTERISTICS $T_j = 25\,^{o}C$ unless otherwise specified

Collector cut-off current

$I_E = 0$; $V_{CB} = 45$ V	I_{CBO}	< 10	nA
$I_B = 0$; $V_{CE} = 5$ V	I_{CEO}	< 2	nA
$V_{EB} = 0$; $V_{CB} = 45$ V	I_{CES}	< 10	nA

Emitter cut-off current

$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	< 10	nA

Emitter-base voltage

$-I_E = 0.5$ mA; $V_{CB} = 5$ V	$-V_{EB}$	0.6 to 0.8	V

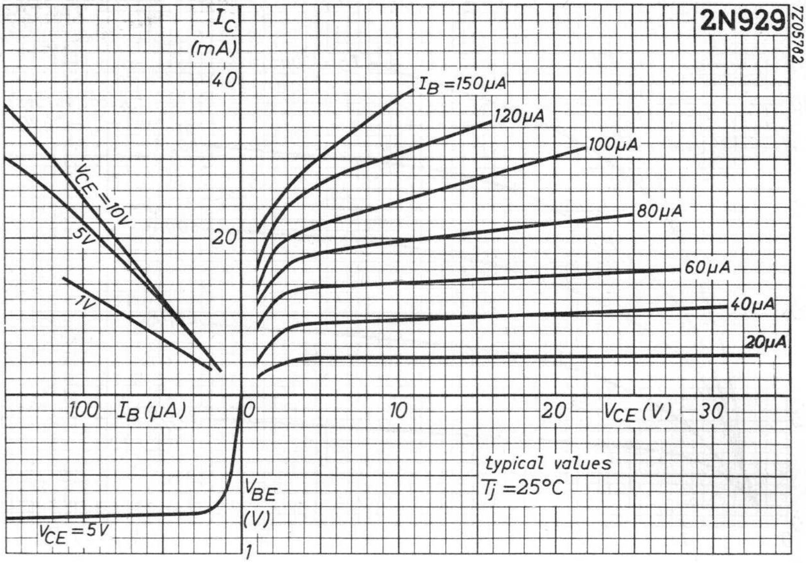
Saturation voltages

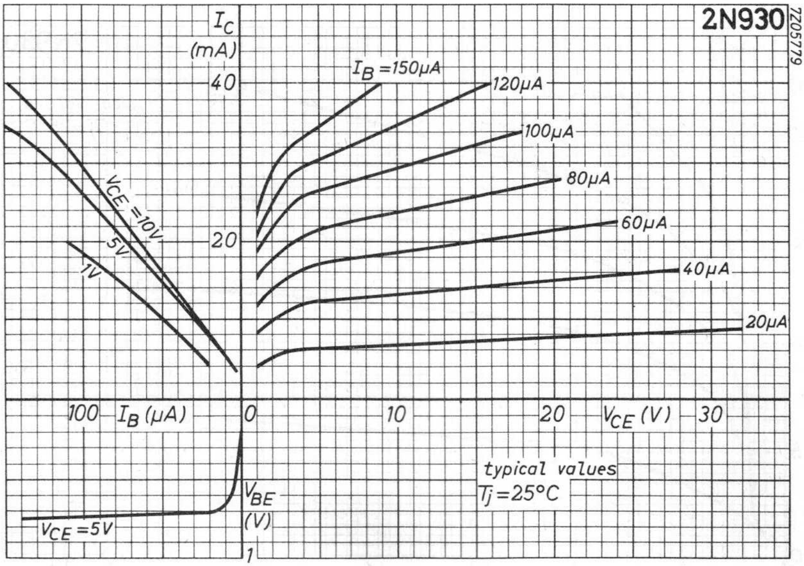
$I_C = 10$ mA; $I_B = 0.5$ mA	V_{CEsat}	< 1	V
	V_{BEsat}	0.6 to 1	V

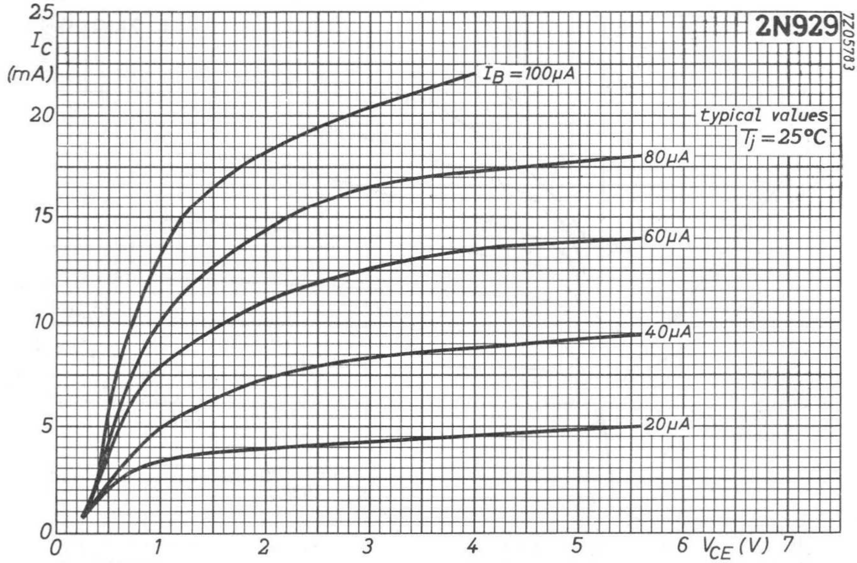
		2N929	2N930	
D.C. current gain				
$I_C = 10\ \mu A$; $V_{CE} = 5$ V	h_{FE}	40 to 120	100 to 300	
$I_C = 10\ \mu A$; $V_{CE} = 5$ V; $T_j = -55\,^{o}C$	h_{FE}	> 10	> 20	
$I_C = 500\ \mu A$; $V_{CE} = 5$ V	h_{FE}	> 60	> 150	
$I_C = 10$ mA; $V_{CE} = 5$ V	h_{FE}	100 to 350	150 to 600	
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	< 8	< 8	pF
Transition frequency				
$I_C = 0.5$ mA; $V_{CE} = 5$ V	f_T	> 50	> 50	MHz
Cut-off frequency				
$I_C = 0.5$ mA; $V_{CE} = 5$ V	f_{hfe}	> 200	> 100	kHz

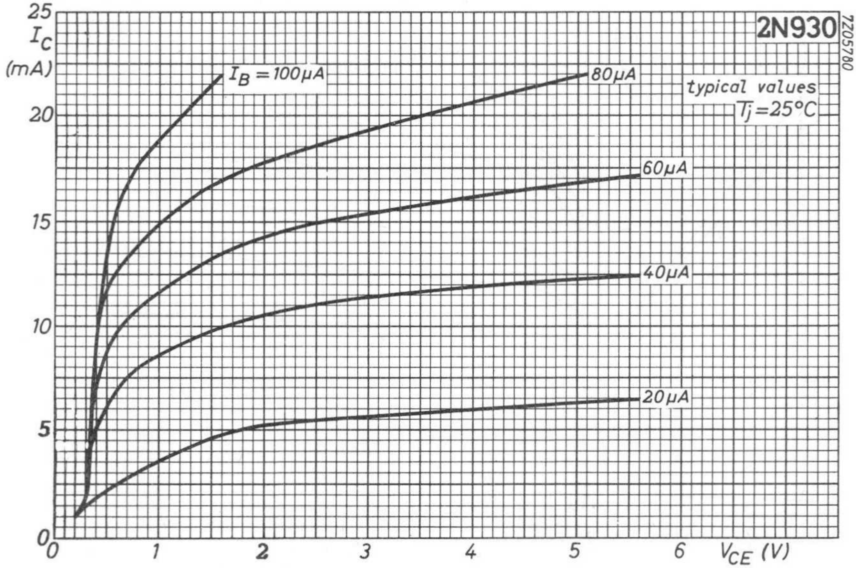
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

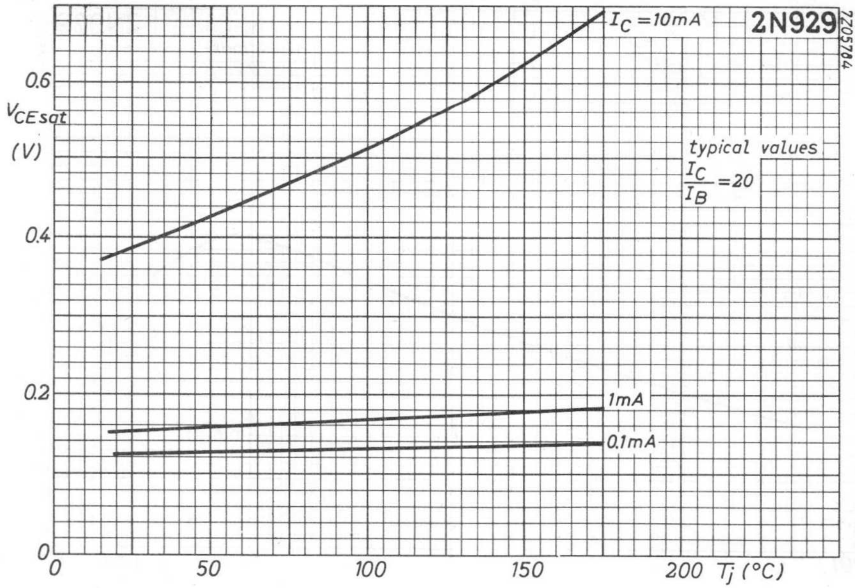
		2N929	2N930	
Noise figure (f = 10 Hz to 15 kHz)				
I_C = 10 μA; V_{CE} = 5 V; R_S = 10 kΩ	F	typ. 2.5	2	dB
		< 4	3	dB
h parameters at f = 1 kHz				
I_C = 1 mA; V_{CE} = 5 V				
Input impedance	h_{ie}	typ. 5.0	10.0	kΩ
Reverse voltage transfer	h_{re}	typ. 2.5	5.5	10^{-4}
Small signal current gain	h_{fe}	typ. 200	350	
		60 to 350	150 to 600	
Output admittance	h_{oe}	typ. 14	25	$\mu\Omega^{-1}$

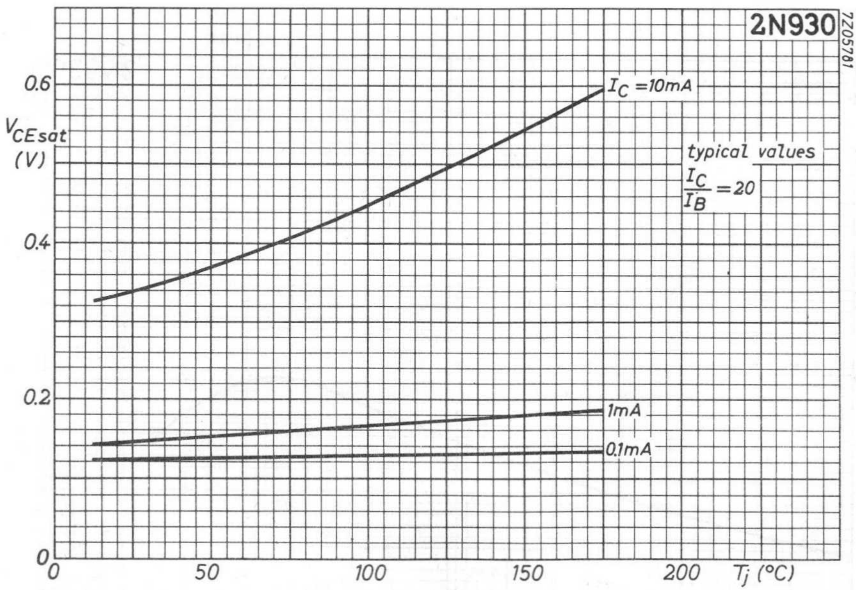

2N929
7Z05782
I_C (mA)
40
20
I_B =150µA
120µA
100µA
80µA
60µA
40µA
20µA
V_{CE} =10V
5V
1V
100
I_B (µA)
0
10
20
V_{CE} (V)
30
typical values
T_j =25°C
V_{BE} (V)
1
V_{CE} =5V

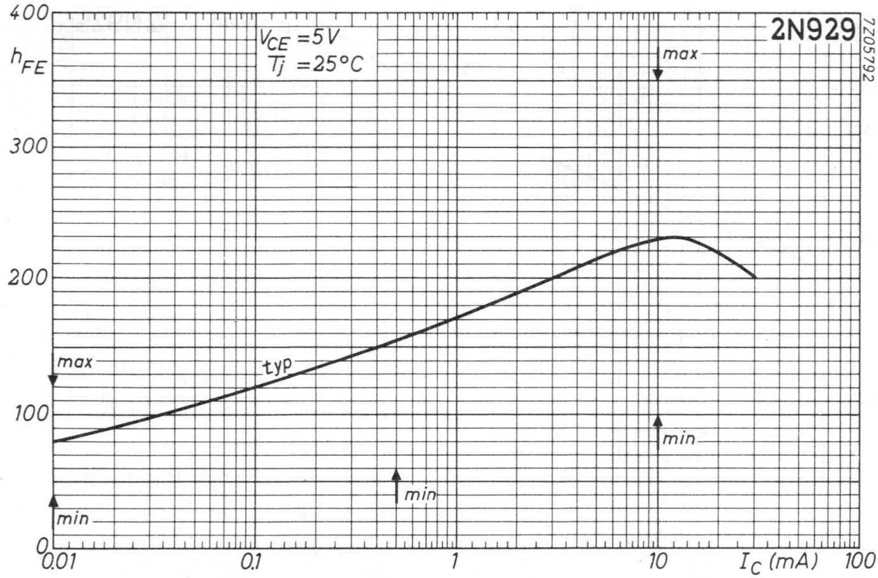

2N930
7Z05779
I_C (mA)
40
20
I_B =150µA
120µA
100µA
80µA
60µA
40µA
20µA
V_{CE} =10V
5V
1V
100
I_B (µA)
0
10
20
V_{CE} (V)
30
typical values
T_j =25°C
V_{BE} (V)
1
V_{CE} =5V

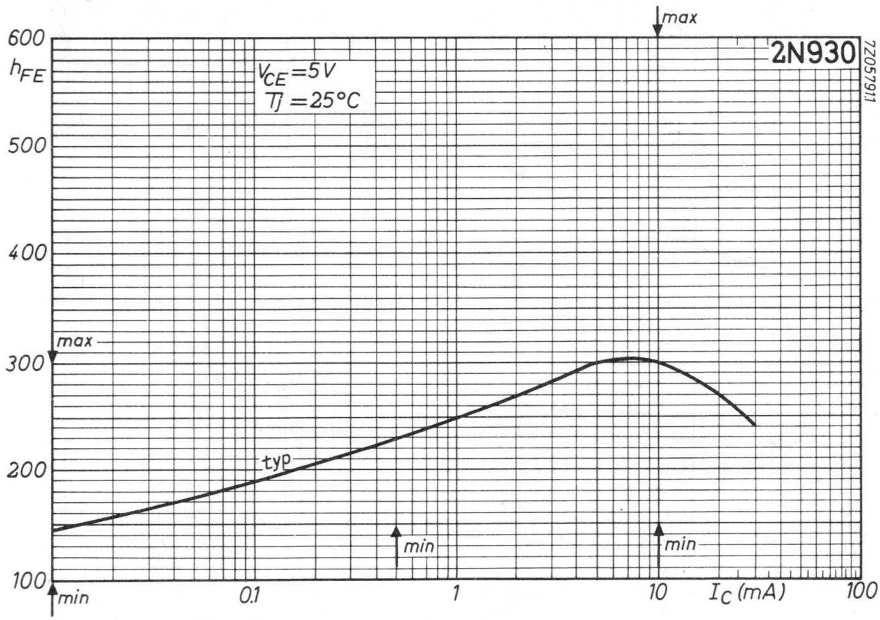

2N929
7Z05783
I_C (mA)
I_B = 100μA
80μA
60μA
40μA
20μA
typical values
T_j = 25°C
V_{CE} (V)

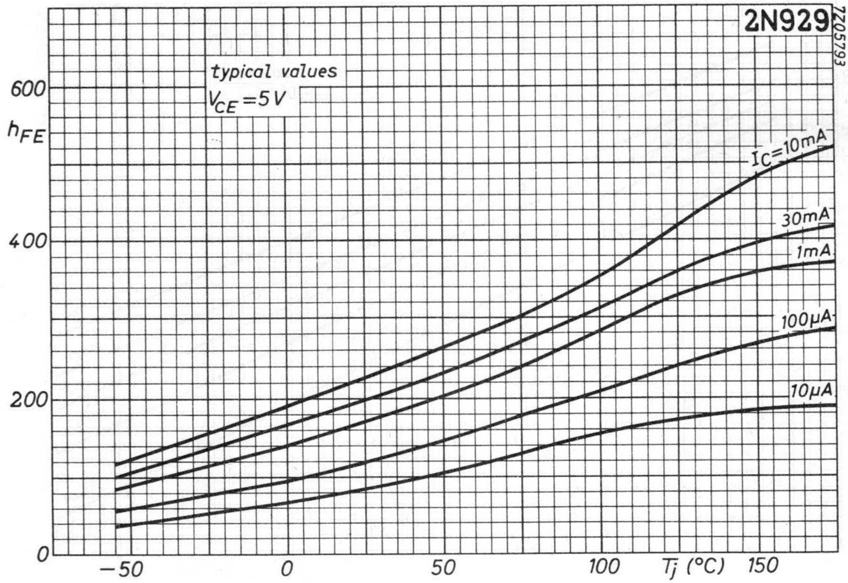

2N930
7Z05780
I_C (mA)
I_B = 100μA
80μA
60μA
40μA
20μA
typical values
T_j = 25°C
V_{CE} (V)

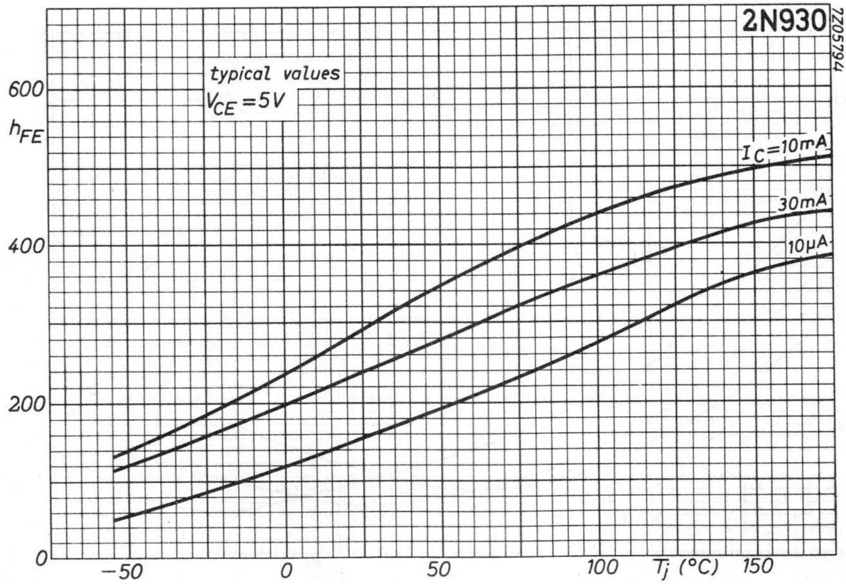

2N929
7Z05784
$I_C = 10mA$
1mA
0.1mA
typical values
$\frac{I_C}{I_B} = 20$
V_{CEsat} (V)
0.6
0.4
0.2
0
0
50
100
150
200
T_j (°C)

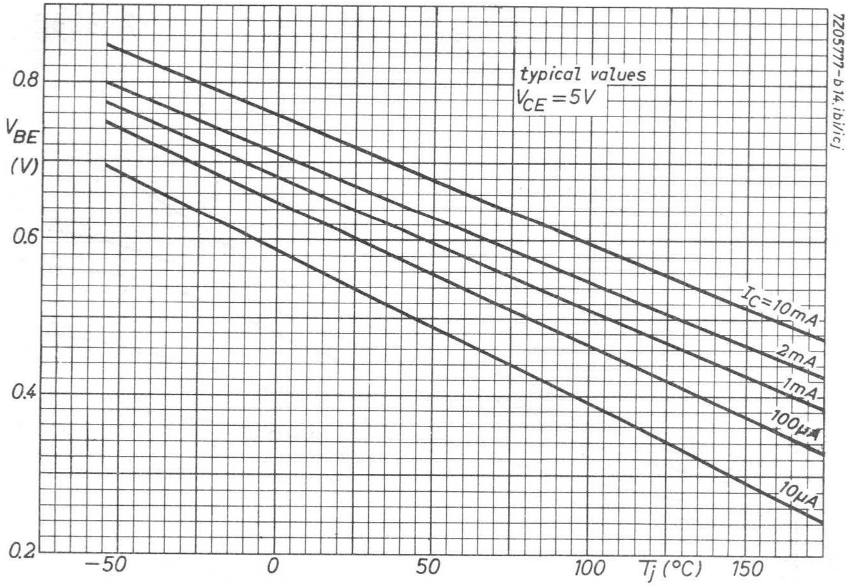

2N930
7Z05781
$I_C = 10mA$
1mA
0.1mA
typical values
$\frac{I_C}{I_B} = 20$
V_{CEsat} (V)
0.6
0.4
0.2
0
0
50
100
150
200
T_j (°C)

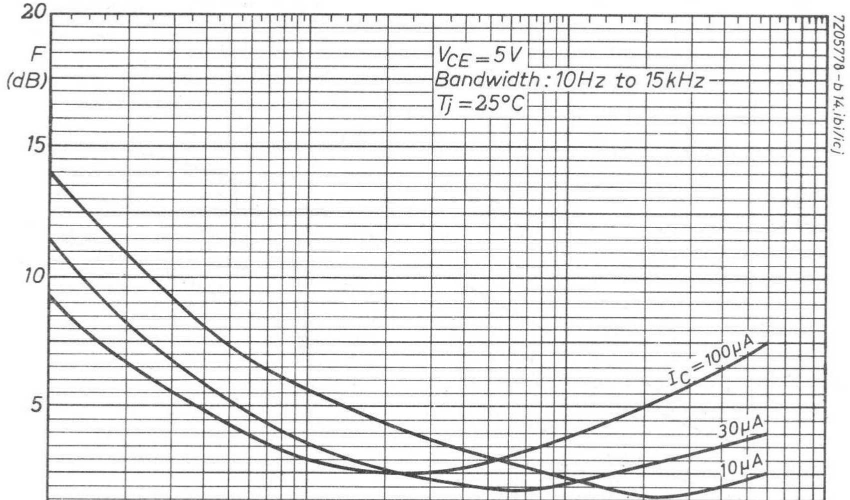

400
300
200
100
0
h_{FE}
V_{CE} = 5 V
T_j = 25 °C
2N929
7Z05792
max
typ
min
0.01
0.1
1
10
I_C (mA)
100

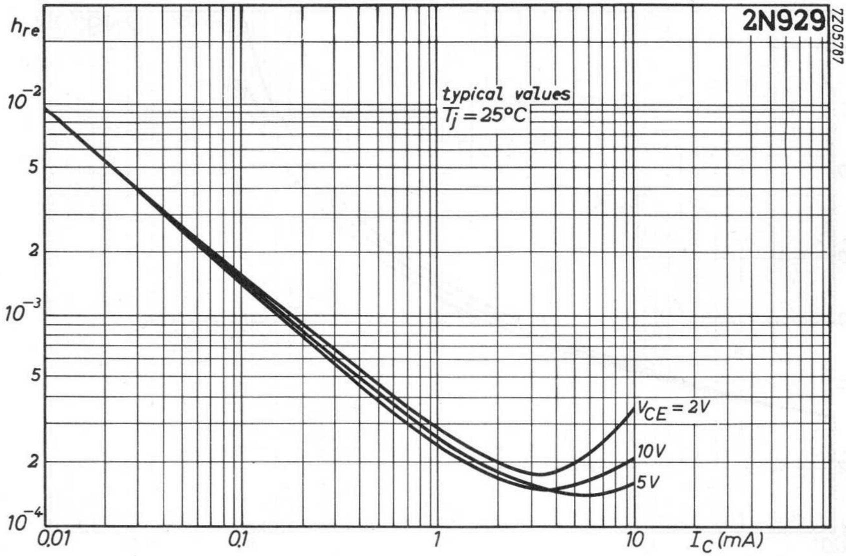

600
500
400
300
200
100
h_{FE}
V_{CE} = 5 V
T_j = 25 °C
2N930
7Z05791.1
max
typ
min
0.1
1
10
I_C (mA)
100

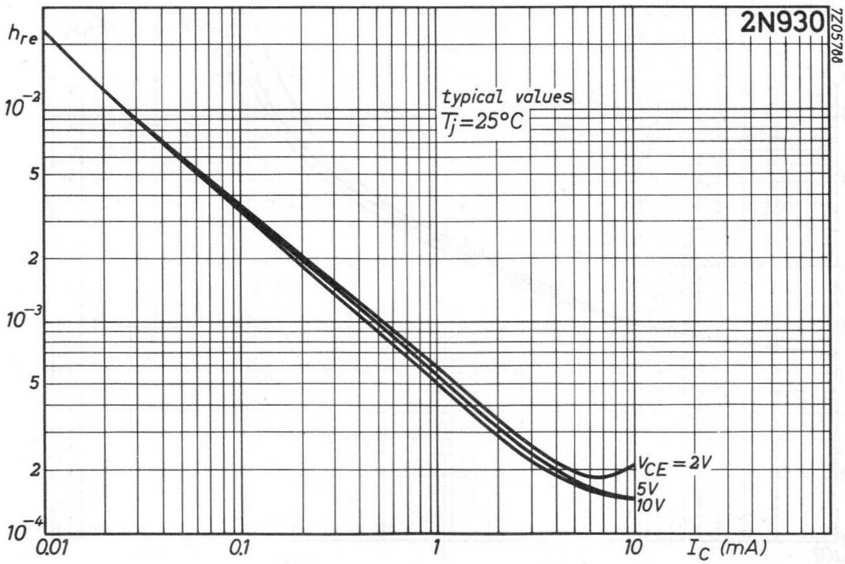

2N929
7Z05793
typical values
V_{CE} = 5 V
600
h_{FE}
400
200
0
I_C = 10 mA
30 mA
1 mA
100 µA
10 µA
−50
0
50
100
T_j (°C)
150

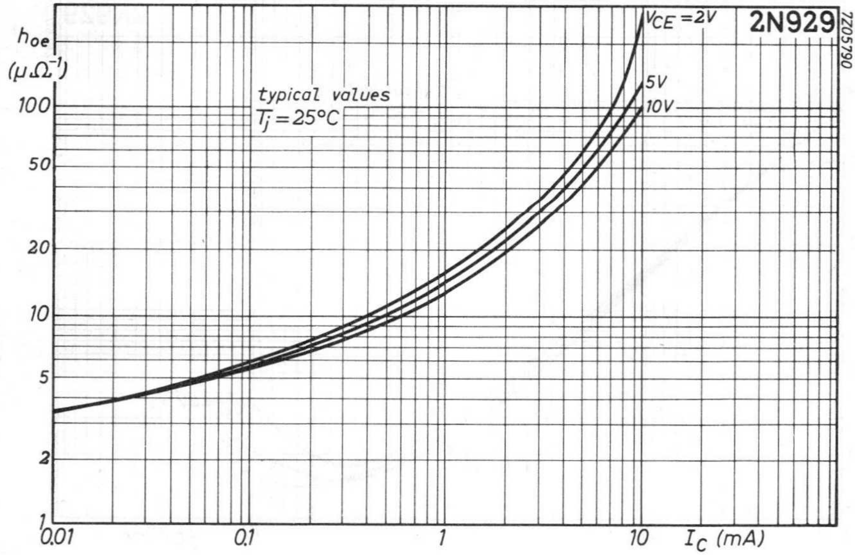

2N930
7Z05794
typical values
V_{CE} = 5 V
600
h_{FE}
400
200
0
I_C = 10 mA
30 mA
10 µA
−50
0
50
100
T_j (°C)
150

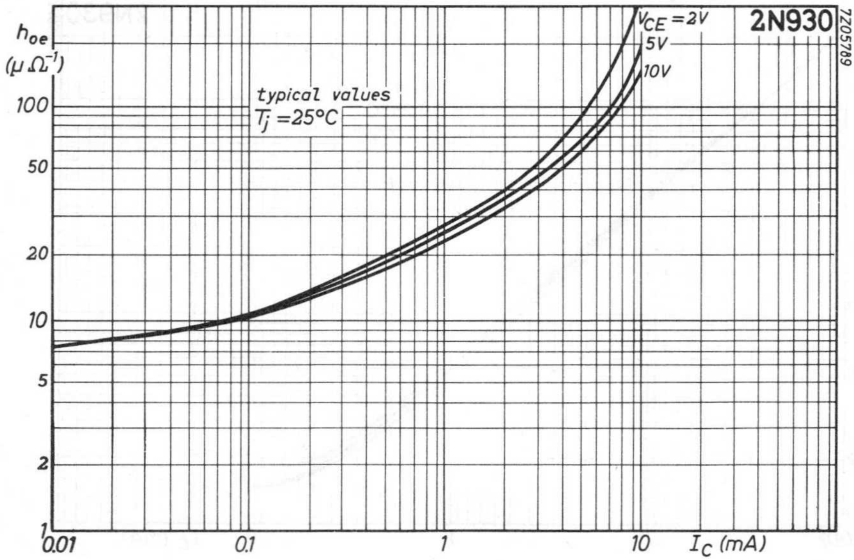

7Z05777-b14.ibi/ic)
typical values
$V_{CE} = 5V$
0.8
V_{BE}
(V)
0.6
0.4
0.2
$I_C = 10mA$
2mA
1mA
100μA
10μA
−50
0
50
100
T_j (°C)
150

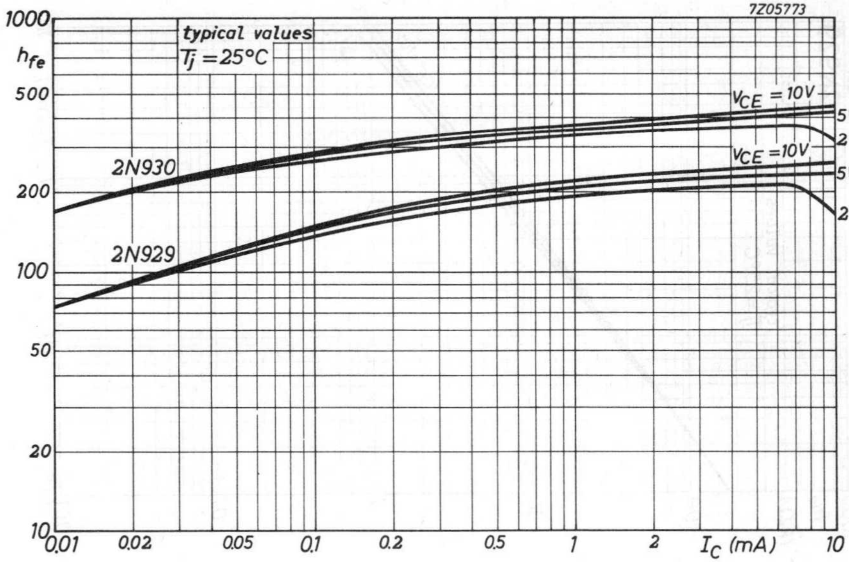

7Z05778-b14.ibi/ic)
$V_{CE} = 5V$
Bandwidth: 10Hz to 15kHz
$T_j = 25°C$
20
F
(dB)
15
10
5
0
$I_C = 100μA$
30μA
10μA
0.1
0.2
0.5
1
2
5
10
20
R_S (kΩ)
100

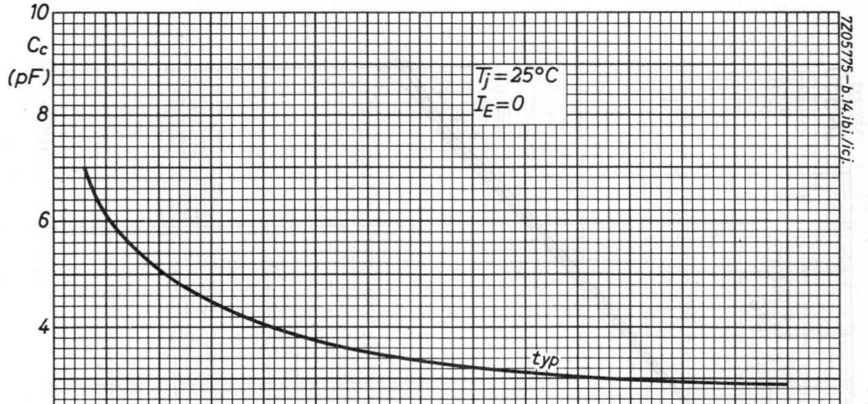

2N929
7Z05787
typical values
$T_j = 25°C$
h_{re}
10^{-2}
5
2
10^{-3}
5
2
10^{-4}
0.01
0.1
1
10
I_C (mA)
$V_{CE} = 2V$
10V
5V

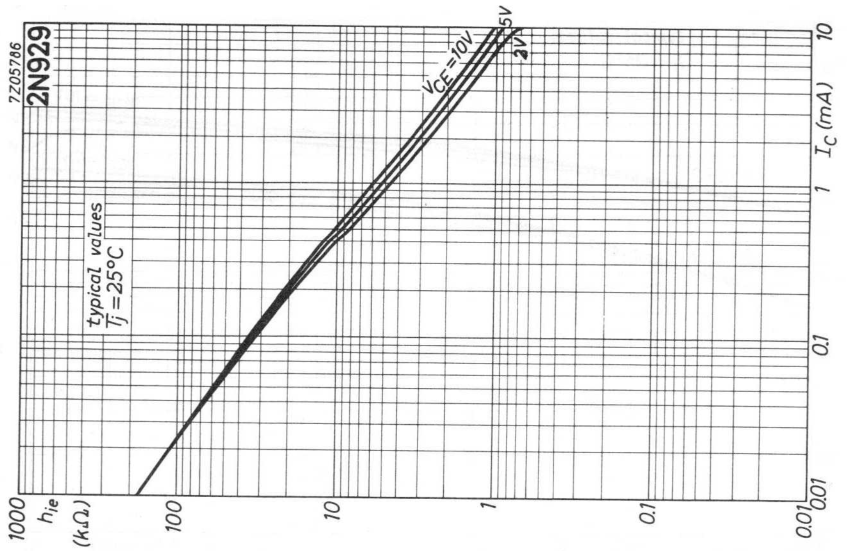

2N930
7Z05788
typical values
$T_j = 25°C$
h_{re}
10^{-2}
5
2
10^{-3}
5
2
10^{-4}
0.01
0.1
1
10
I_C (mA)
$V_{CE} = 2V$
5V
10V

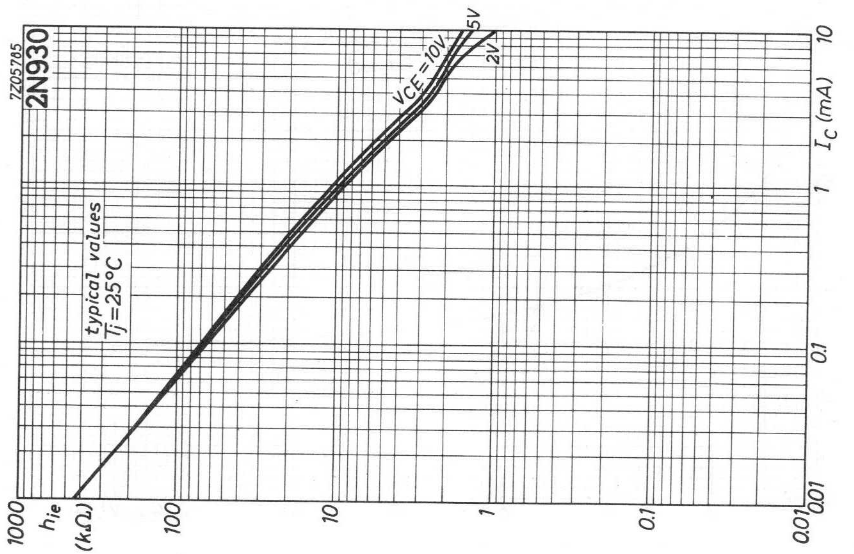

h_{oe}
$(\mu\Omega^{-1})$
typical values
$T_j = 25°C$
$V_{CE} = 2V$
5V
10V
2N929
7Z05790
100
50
20
10
5
2
1
0.01
0.1
1
10
I_C (mA)

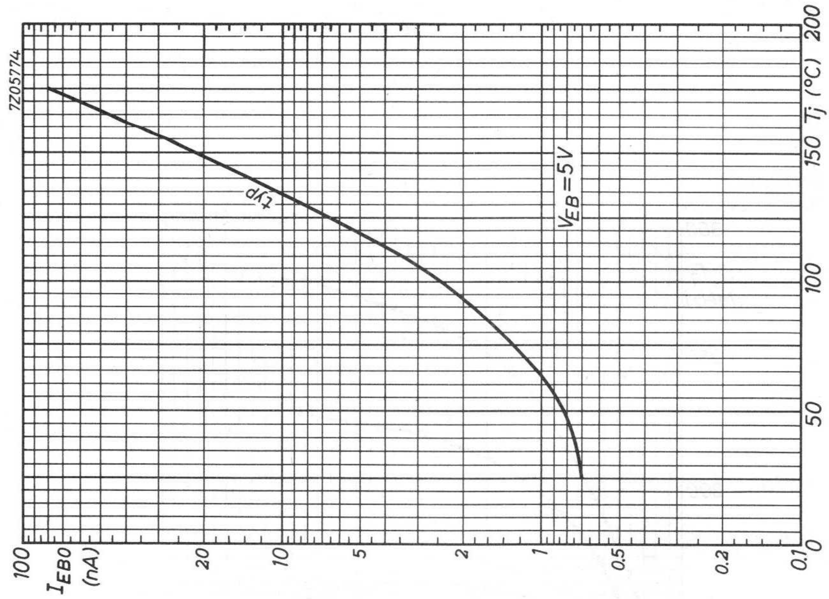

h_{oe}
$(\mu\Omega^{-1})$
typical values
$T_j = 25°C$
$V_{CE} = 2V$
5V
10V
2N930
7Z05789
100
50
20
10
5
2
1
0.01
0.1
1
10
I_C (mA)

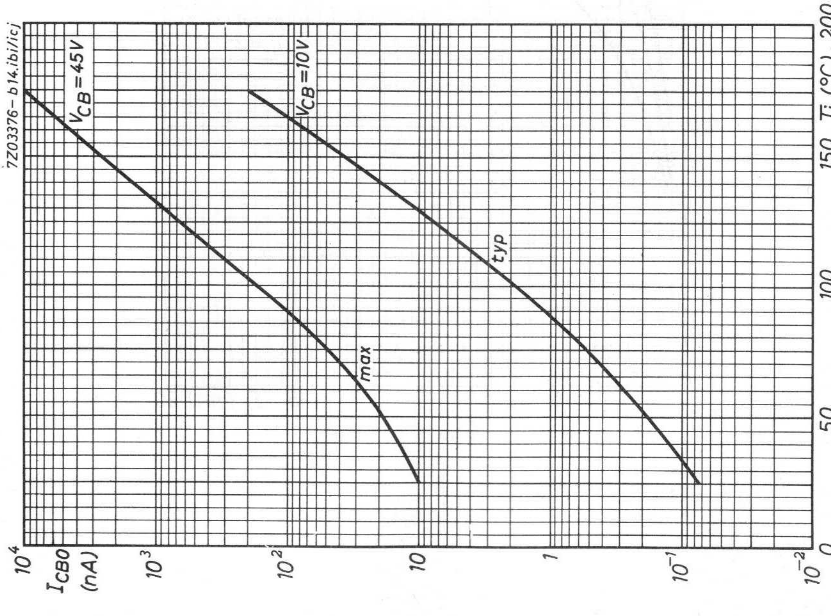

7Z05773
typical values
$T_j = 25°C$
1000
h_{fe}
500
200
100
50
20
10
$V_{CE} = 10V$
5V
2V
2N930
$V_{CE} = 10V$
5V
2V
2N929
0.01
0.02
0.05
0.1
0.2
0.5
1
2
I_C (mA)
10

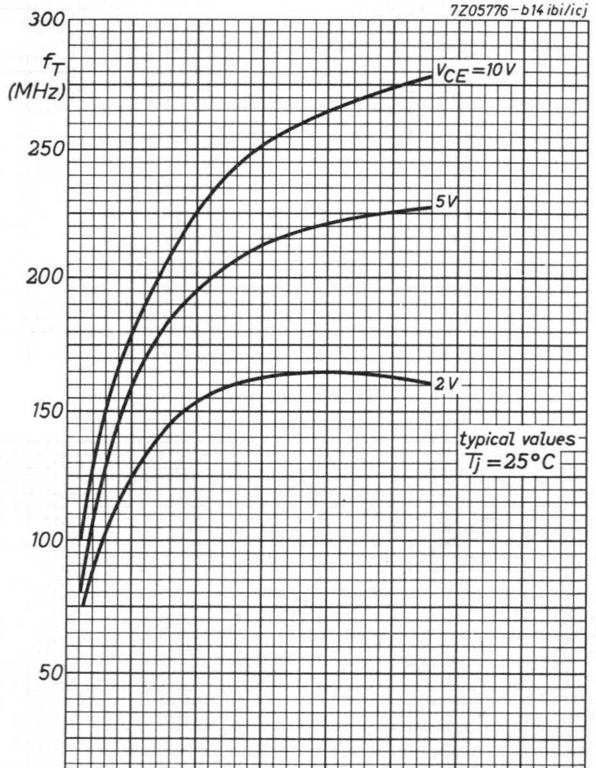

7Z05775-b.14.ibi./ici.
$T_j = 25°C$
$I_E = 0$
10
C_c
(pF)
8
6
4
2
0
typ
0
2
4
6
8
10
12
V_{CB}(V)
14


7Z05786
2N929
typical values
Tj = 25°C
VCE = 10V
5V
2V
hie
(kΩ)
1000
100
10
1
0.1
0.01
0.01
0.1
1
10
IC (mA)


7Z05785
2N930
typical values
Tj = 25°C
VCE = 10V
5V
2V
hie
(kΩ)
1000
100
10
1
0.1
0.01
0.01
0.1
1
10
IC (mA)


7Z05774
I_{EBO} (nA)
100
20
10
5
2
1
0.5
0.2
0.1
0
50
100
150
200
T_j (°C)
typ
$V_{EB}=5V$


7Z03376-b14.ibi/icj
I_{CBO} (nA)
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}
0
50
100
150
200
T_j (°C)
$V_{CB}=45V$
max
$V_{CB}=10V$
typ


7Z05776-b14 ibi/icj
300
f_T
(MHz)
250
200
150
100
50
0
0
5
10
15
I_C (mA)
20
V_{CE}=10V
5V
2V
typical values
T_j=25°C

AUDIO FREQUENCY PACKAGE

The package 40809 comprises 4 transistors, intended for application in audio frequency d.c.-coupled amplifiers with complementary output stages with power outputs up to 1200 mW.

The matched pair AC127/AC128 (NPN/PNP, marked 3) consists of two transistors with high values of the d.c. amplification factor h_{FE}.

The AC128 (PNP, marked 2) should be used in the drive stage.

The AC127 (NPN, marked 1) is meant for use in the pre-amplifier stage.

APPLICATIONS

On the following pages four circuits are described in detail

QUICK REFERENCE DATA

Circuit		I	II	III	IV	
Supply voltage	V_S	6	6	9	9	V
Maximum output power (d_{tot} = 10%)	$P_{o\ max}$	350	700	650	1200	mW
Required input voltage (P_o = 50 mW) [1]						
without feedback	$V_{i(rms)}$	1.8	2.1	1.0	1.2	mV
with 6 dB feedback	$V_{i(rms)}$	3.5	5.0	2.5	2.0	mV

FOR DATA OF THE INDIVIDUAL TRANSISTORS
REFER TO THE DATA SHEETS OF THE AC127 AND THE AC128

[1]) Spread of input sensitivity < 3 dB

TYPICAL OPERATION CHARACTERISTICS (f = 1 kHz)

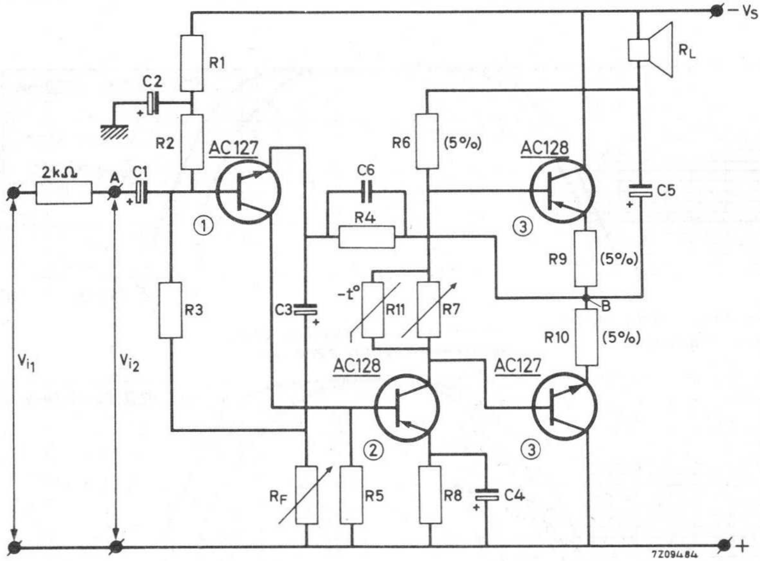
Circuit		I	II	III	IV	
Supply voltage	V_S	6	6	9	9	V
Max. output power at d_{tot} = 10%	$P_{o\ max}$	350	700	650	1200	mW
Input voltage at P_o = 50 mW						
without feedback	$V_{i(rms)}$	1.8	2.1	1.0	1.2	mV
with 6 dB feedback	$V_{i(rms)}$	3.5	5.0	2.5	2.0	mV
Input voltage at P_o = max.						
without feedback	$V_{i(rms)}$	5.3	8.6	4.6	5.6	mV
with 6 dB feedback	$V_{i(rms)}$	10.7	20.7	10.4	10.2	mV
Zero signal collector currents [1]) of transistors 3	$\lvert I_C \rvert$	4	5	3	5	mA
Collector peak current at $P_{o\ max}$	I_{CM}	260	500	300	470	mA
Collector current of the driver transistor 2	$-I_C$	4.6	8.3	5.4	7.7	mA
Midtap voltage at B	V	3.3	3.6	4.9	4.9	V
Typical input resistance at A						
without feedback	R_i	3.8	6.0	3.3	2.8	kΩ
with 6 dB feedback	R_i	7.3	11.5	6.4	4.3	kΩ

Stable continuous operation is ensured up to T_{amb} = 45 °C, provided the output transistors are mounted as indicated in the following table

	I	II	III	IV
AC127	A	C	B	C
AC128	A	A	A	B

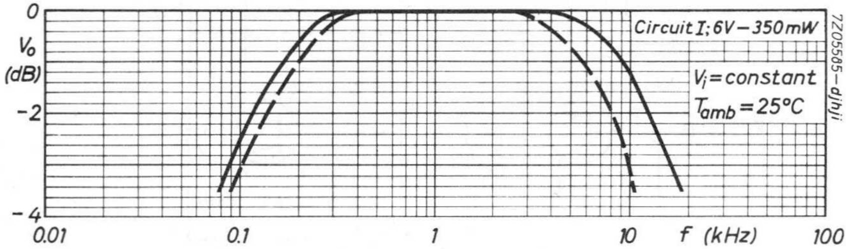
A = without cooling fin or heatsink in free air
B = with cooling fin (Type No.56227)
C = with cooling fin (Type No.56227) mounted on a 1.5 mm aluminium heatsink of at least 12.5 cm^2

[1]) To be adjusted with R7



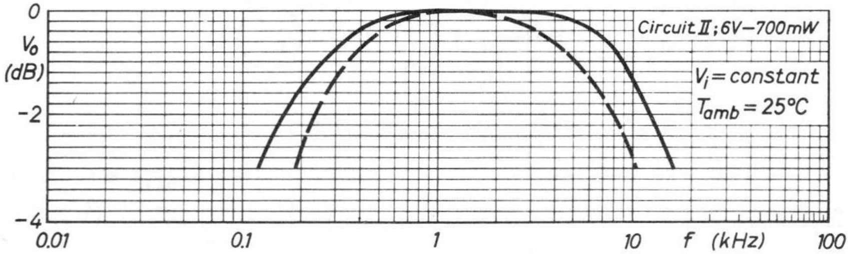
List of components

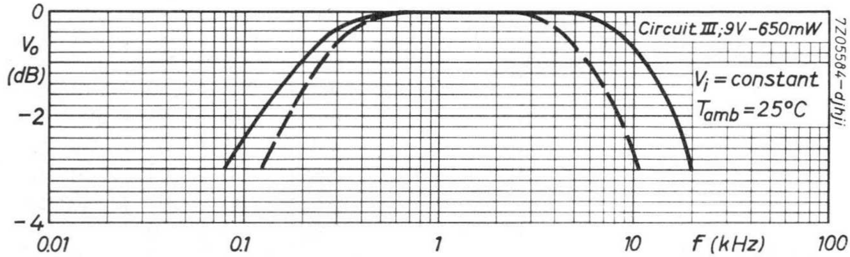
	Circuit	I	II	III	IV	
	R1	1.2	2.7	6.8	2.2	kΩ
	R2	22	18	33	18	kΩ
	R3	15	15	22	15	kΩ
	R4	2.2	2.2	3.3	2.2	kΩ
	R5	1.5	2.2	1.8	1.5	kΩ
	R6 (5%)	560	270	750	510	Ω
	R7	100	75	75	100	Ω
	R8	68	75	100	39	Ω
	R9 = R10 (5%)	1.5	0	2.4	0	Ω
	R11 (NTC)	–	130	–	130	Ω
	R_L	8	4	10	8	Ω
without feedback	R_F	0	0	0	0	
with 6 dB feedback	R_F	5.6	12	5.6	2.7	Ω
	C1	6.4	6.4	6.4	6.4	μF
Tolerance of resistors:	C2	100	100	100	100	μF
10 % unless otherwise	C3	320	125	320	400	μF
specified	C4	200	160	125	200	μF
	C5	400	1000	320	400	μF
	C6	-	3900	–	–	pF



Normalised output voltage versus frequency

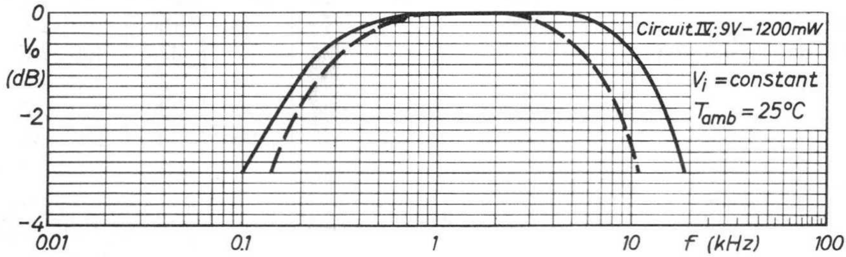
– – – without feedback
—— with feedback

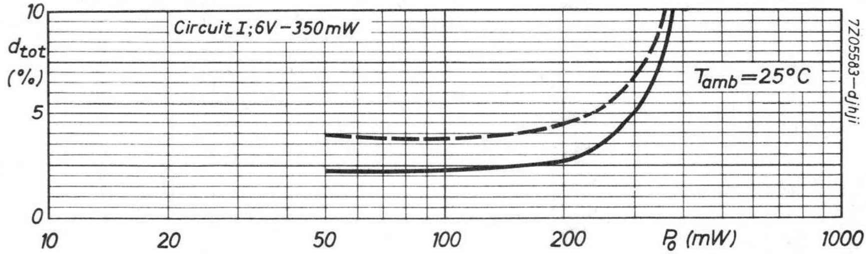




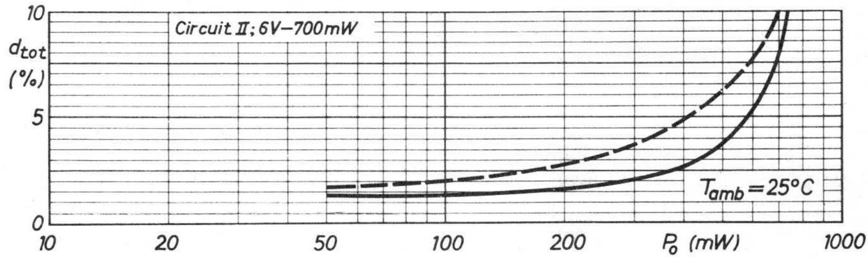
Normalised output voltage versus frequency

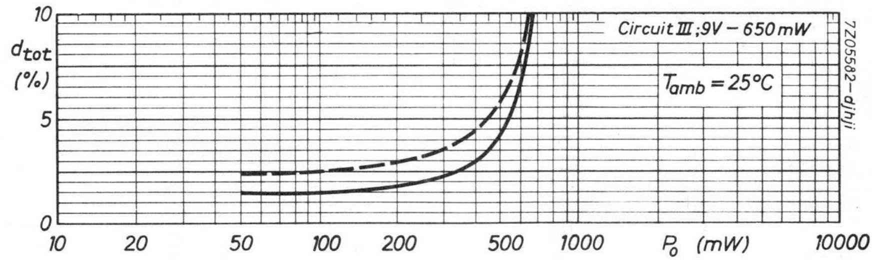
– – – without feedback
—— with feedback



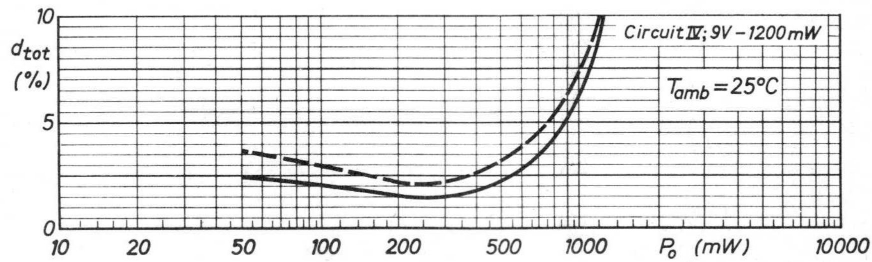


Typical values — — — without feedback
——— with feedback





Typical values — — — without feedback
——— with feedback



AUDIO FREQUENCY PACKAGE

The package 40819 comprises 4 transistors, selected on h_{FE} to give a low quiescent current of the driver stage and a low gain spread.
The package contains:

- AC187 - pre-amplifier transistor
- AC188 - driver transistor
- AC187/01 and AC188/01 - complementary output transistors.

QUICK REFERENCE DATA

The transistors are coded in red with the numerals given below.

Type number	code numeral	h_{FE} at I_C = 500 mA V_{CE} = 1 V	envelope	function
AC187	1	100 to 200	TO-1	pre-amplifier
AC188	2	100 to 200	TO-1	driver
AC187/01	3	150 to 500	cooling block	output stage
AC188/01	3	150 to 500	cooling block	output stage

FOR DATA OF THE INDIVIDUAL TRANSISTORS
REFER TO THE DATA SHEETS OF THE AC187; AC187/01 and AC188; AC188/01

APPLICATION INFORMATION $T_{amb} = 25\ ^oC$

Package 40819 in a.f. amplifier

Circuit		I	II	
Supply voltage	V_S	6	15	V
Max. output power at $d_{tot} = 10\ \%$	P_{omax}	1	3	W
Input voltage at $P_o = 50$ mW				
without feedback	$V_{i(rms)}$		0.7	mV
with feedback	$V_{i(rms)}$	10	1.2	mV
Input voltage at $P_o = P_{omax}$				
without feedback	$V_{i(rms)}$		5.5	mV
with feedback	$V_{i(rms)}$	41	10	mV
Zero signal collector current of transistors 3 (adjusted with R8)	$\lvert I_C \rvert$	5	5	mA
Collector current (peak value) at $P_o = P_{omax}$ of transistors 3	I_{CM}	710	750	mA
Collector current of the driver transistor 2	$-I_C$	10	9	mA
Midtap voltage at point A	V	3.2	8	V
Typical input resistance at point B				
without feedback	R_i		7	kΩ
with feedback	R_i	8	11	kΩ

Notes

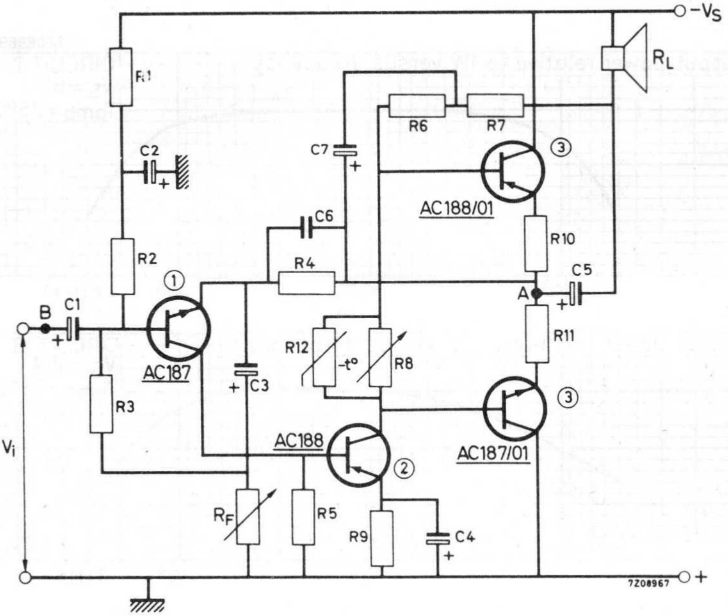
1. Stable continuous operation is ensured up to $T_{amb} = 45\ ^oC$, provided the output transistors are mounted as specified below:

   Circuit I:
   For the AC187/01 and AC188/01 the Al. blackened heatsinks should have an area of approximately 5 cm^2 and a thickness of 1.5 mm.

   Circuit II:
   For the AC187/01 the Al. blackened heatsink should have an area of approximately 65 cm^2 and a thickness of 1.5 mm.
   For the AC188/01 the Al. blackened heatsink should have an area of approximately 20 cm^2 and a thickness of 1.5 mm.

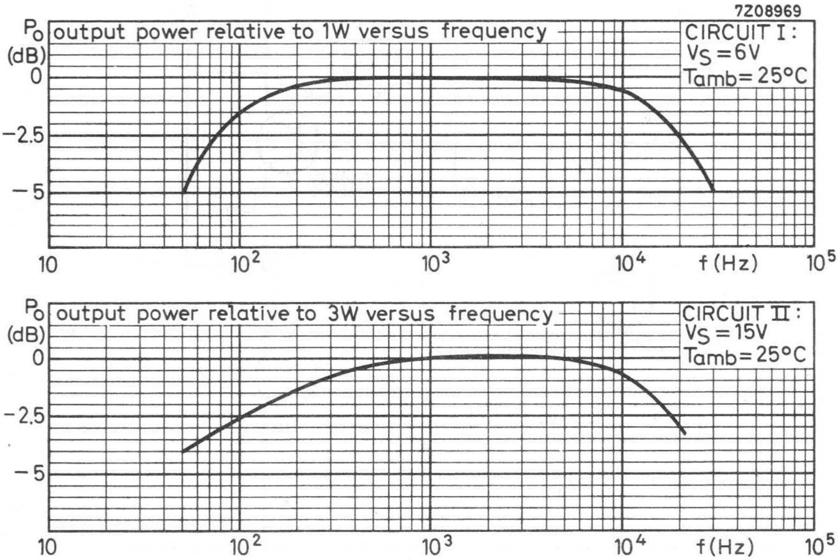
2. Figures and curves are typical ones unless otherwise specified.

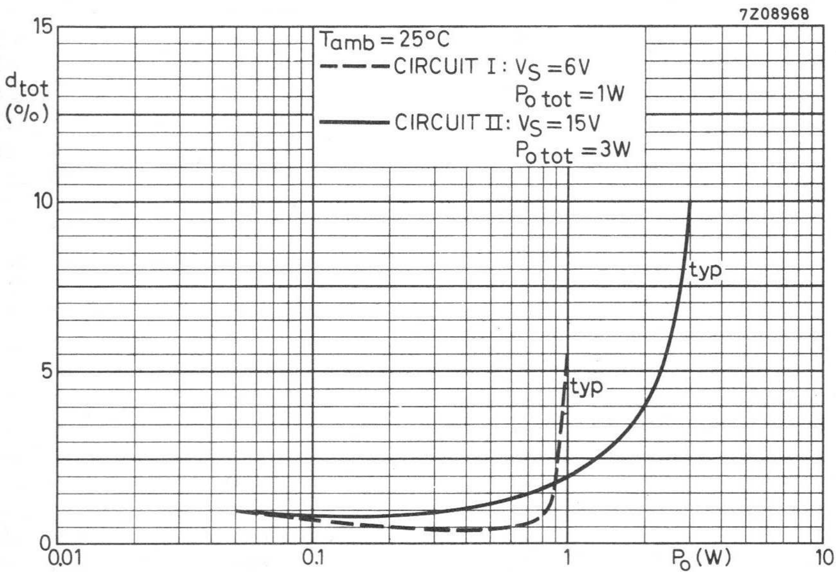
3. A.C. information is given at f = 1 kHz unless otherwise specified.



List of components [1]	Circuit	I	II	
	R1	5.6	2.7	kΩ
	R2	10	47	kΩ
	R3	12	47	kΩ
	R4	2.2	1.8	kΩ
	R5	820	820	Ω
	R6	0	390	Ω
	R7	270	390	Ω
	R8	100	150	Ω
	R9	0	12	Ω
	R10 = R11	0	1	Ω
	R12 (NTC)	130	50	Ω
	R_L	4	8	Ω
without feedback	R_F	0	0	
with feedback	R_F	36	1.5	Ω
	C1	6.4	40	μF
	C2	50	125	μF
	C3	50	1000	μF
	C4	0	64	μF
	C5	1000	800	μF
	C6	3300	4700	pF
	C7	0	80	μF

[1]) Tolerance of the resistors is 5%


7Z08969
Po (dB)
output power relative to 1W versus frequency
CIRCUIT I:
VS = 6V
Tamb = 25°C
0
−2.5
−5
10
10²
10³
10⁴
f (Hz)
10⁵
Po (dB)
output power relative to 3W versus frequency
CIRCUIT II:
VS = 15V
Tamb = 25°C
0
−2.5
−5
10
10²
10³
10⁴
f (Hz)
10⁵


7Z08968
dtot (%)
Tamb = 25°C
CIRCUIT I: VS = 6V
Po tot = 1W
CIRCUIT II: VS = 15V
Po tot = 3W
typ
typ
15
10
5
0
0.01
0.1
1
Po (W)
10

Low frequency power transistors

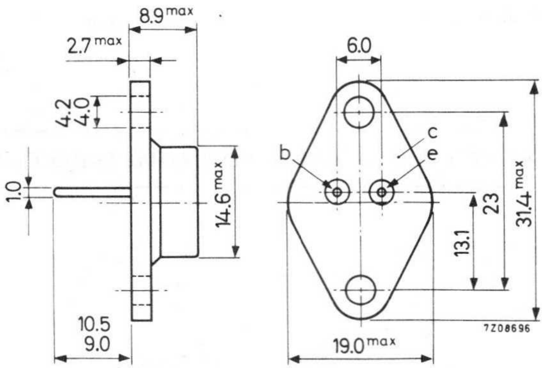
GERMANIUM ALLOYED POWER TRANSISTOR

P-N-P power transistor in a metal envelope with the collector connected to the mounting base.
It is primarily intended for use as matched pair 2-AD139 in low distortion class B push-pull output stages.

QUICK REFERENCE DATA			
Collector-base voltage (open emitter)	$-V_{CBO}$	max. 32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max. 16	V
Collector current (peak value)	$-I_{CM}$	max. 3	A
Total power dissipation up to T_{mb} = 45 °C	P_{tot}	max. 13	W
Junction temperature (incidentally)	T_j	max. 100	°C
D.C. current gain at T_j = 25 °C			
$-I_C$ = 1.0 A; V_{CB} = 0	h_{FE}	30 to 110	
Cut-off frequency			
$-I_C$ = 0.1 A; $-V_{CE}$ = 2 V	f_{hfe}	typ. 10	kHz

MECHANICAL DATA Dimensions in mm

Collector connected to mounting base



Accessories available: 56203

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	16	V
Collector-emitter voltage with $R_{BE} < 50\ \Omega$	$-V_{CER}$	max.	32	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	10	V

Currents

Collector current (d.c. or average over any 50 ms period)	$-I_C$	max.	1	A
Collector current (peak value)	$-I_{CM}$	max.	3	A

Power dissipation

Total power dissipation up to $T_{mb} = 45\ ^{o}C$	P_{tot}	max.	13	W

Temperatures

Storage temperature	T_{stg}		-55 to +75	^{o}C
Junction temperature: continuous	T_j	max.	90	^{o}C
incidentally	T_j	max.	100	^{o}C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	4.0	$^{o}C/W$
From mounting base to heatsink with mica washer	$R_{th\ mb-h}$	=	1.5	$^{o}C/W$
without mica washer	$R_{th\ mb-h}$	=	0.5	$^{o}C/W$

FOR NEW DESIGN THE SUCESSOR TYPE AD162 IS RECOMMENDED

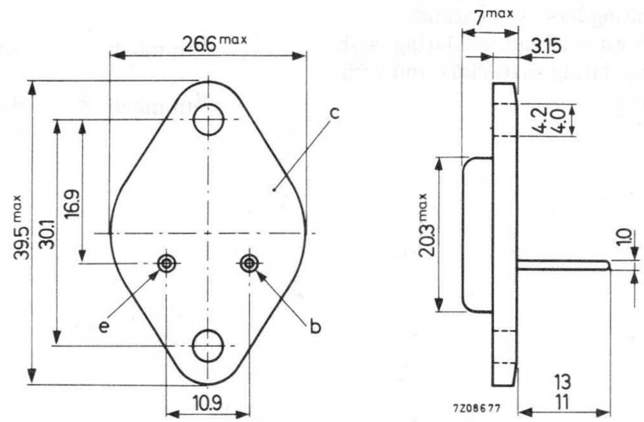
GERMANIUM ALLOYED POWER TRANSISTORS

P-N-P power transistor in a metal envelope with the collector connected to the mounting base.
It is primarily intended for use as matched pair 2-AD149 in class B push-pull output stages with an output power of up to 20 W.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	50	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30	V
Collector current (d.c.)	$-I_C$	max.	3.5	A
Total power dissipation up to T_{mb} = 45 °C	P_{tot}	max.	32.5	W
Junction temperature (incidentally)	T_j	max.	110	°C
D.C. current gain at T_j = 25 °C				
$-I_C$ = 1 A; V_{CB} = 0 V	h_{FE}		30 to 100	
Cut-off frequency				
$-I_C$ = 0.5 A; $-V_{CE}$ = 2 V	f_{hfe}	typ.	10	kHz

MECHANICAL DATA Dimensions in mm

Collector connected to mounting base



Accessories available: 56201

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	50	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30	V
Collector-emitter voltage with $R_{BE} < 175\ \Omega$	$-V_{CER}$	max.	50	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	20	V

Currents

Collector current (d.c.)	$-I_C$	max.	3.5	A
Base current (d.c.)	$-I_B$	max.	0.5	A

Power dissipation

Total power dissipation up to T_{mb} = 45 °C	P_{tot}	max.	32.5	W

Temperatures

Storage temperature	T_{stg}		-65 to +100	°C
Junction temperature: continuous	T_j	max.	100	°C
incidentally	T_j	max.	110	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2	°C/W
From mounting base to heatsink with mica washer and insulating bush	$R_{th\ mb\text{-}h}$	=	0.5	°C/W
without insulating materials and with lead washer	$R_{th\ mb\text{-}h}$	=	0.2	°C/W

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $-V_{CB} = 50$ V	$-I_{CBO}$	<	3	mA
$I_E = 0$; $-V_{CB} = 14$ V; $T_j = 90$ °C	$-I_{CBO}$	<	5	mA

Emitter cut-off current

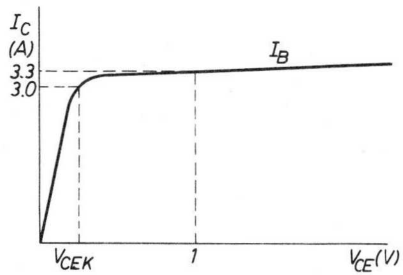
$I_C = 0$; $-V_{EB} = 20$ V	$-I_{EBO}$	<	3	mA

Base-emitter voltage

$-I_C = 15$ mA; $-V_{CE} = 14$ V	$-V_{BE}$		135 to 175	mV
$-I_C = 200$ mA; $-V_{CE} = 1$ V	$-V_{BE}$	<	300	mV
$-I_C = 3.5$ A; $-V_{CE} = 1$ V	$-V_{BE}$	<	1200	mV

Knee voltage

$-I_C = 3$ A; $-I_B$ = value for which
$-I_C = 3.3$ A at $-V_{CE} = 1$ V — $-V_{CEK}$ < 0.7 V



D.C. current gain

$-I_C = 1$ A; $V_{CB} = 0$	h_{FE}	30 to 100
$-I_C = 3$ A; $V_{CB} = 0$	h_{FE}	20 to 85

Collector capacitance at f = 450 kHz

$I_E = I_e = 0$; $-V_{CB} = 5$ V — C_c typ. 220 pF

Emitter capacitance at f = 450 kHz

$I_C = I_c = 0$; $-V_{EB} = 5$ V — C_e typ. 140 pF

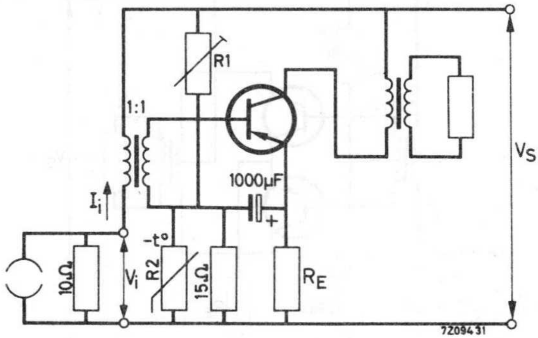
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Transition frequency					
$-I_C$ = 0.5 A; $-V_{CE}$ = 2 V		f_T	>	300	kHz
			typ.	500	kHz
Cut-off frequency					
$-I_C$ = 0.5 A; $-V_{CE}$ = 2 V		f_{hfe}	>	7	kHz
			typ.	10	kHz
Feedback impedance at f = 450 kHz					
I_E = 1 mA; $-V_{CB}$ = 5 V		$\|z_{rb}\|$	typ.	30	Ω
Small signal current gain linearity [1]					
(See page 10)		λ_{3A}	>	0.2	
			typ.	0.35	
D.C. current gain ratio of matched pair 2-AD149	$-I_C$ = 0.3 A	h_{FE1}/h_{FE2}	typ.	1.1	
			<	1.25	
	$-I_C$ = 3 A	h_{FE1}/h_{FE2}	typ.	1.1	
			<	1.25	

[1]) $\lambda_{3A} = \frac{A_i \text{ at } -I_C = 3\text{ A}}{A_{i\,max}}$

APPLICATION INFORMATION

AD149 in a class A output amplifier.



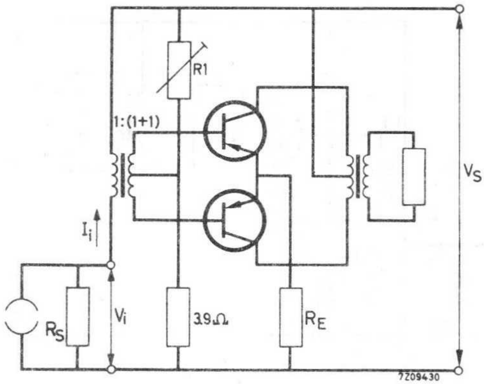
Stable continuous operation is ensured at an ambient temperature up to 55 °C provided each transistor is mounted on a 1.5 mm copper heatsink of at least 18 cm x 18 cm (circuit I) or 15 cm x 15 cm (circuit II).

Characteristics			I	II	
Supply voltage	V_S	=	7	14	V
		<	8	16	V
Collector current (zero signal)	$-I_C$	=	1.8	0.72	A
Bias resistor	R1	=	50	200	Ω
NTC resistor [1]	R2	=	50	50	Ω
Emitter resistor	R_E	=	0.3	0.5	Ω
Collector resistance	$R_{c\sim}$	=	4	23	Ω
Total power dissipation of the transistor	P_{tot}	<	4.3	4.1	W
Output power delivered to transformer	P_o	<	4	4	W
Input voltage (peak value) at P_o = 4 W	V_{IM}	typ.	0.48	0.40	V
Input current (peak value) at P_o = 4 W	I_{IM}	typ.	35	12	mA
Total distortion at P_o = 4 W	d_{tot}	typ.	9.5	7.5	%
Input current (peak value) at P_o = 50 mW	I_{IM}	typ.	2.5	1.0	mA
Total distortion at P_o = 50 mW	d_{tot}	typ.	2.5	1.5	%

[1]) NTC resistor should be mounted on the heatsink, close to the transistor. Code number 2322 610 11509.

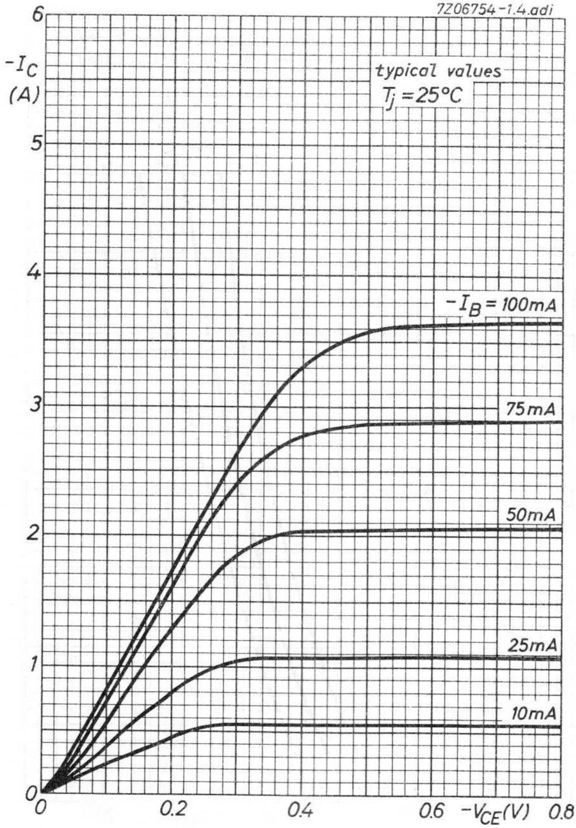
APPLICATION INFORMATION

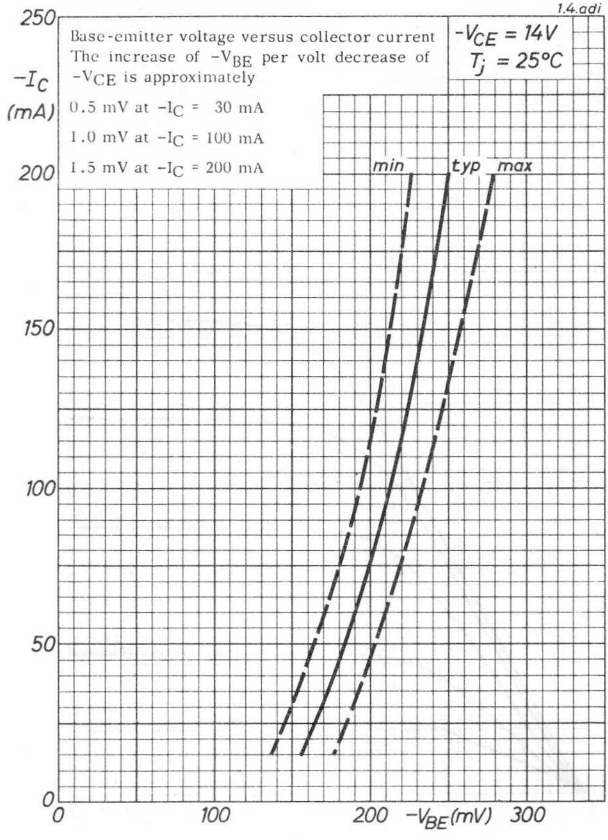
2-AD149 in a class B output amplifier.

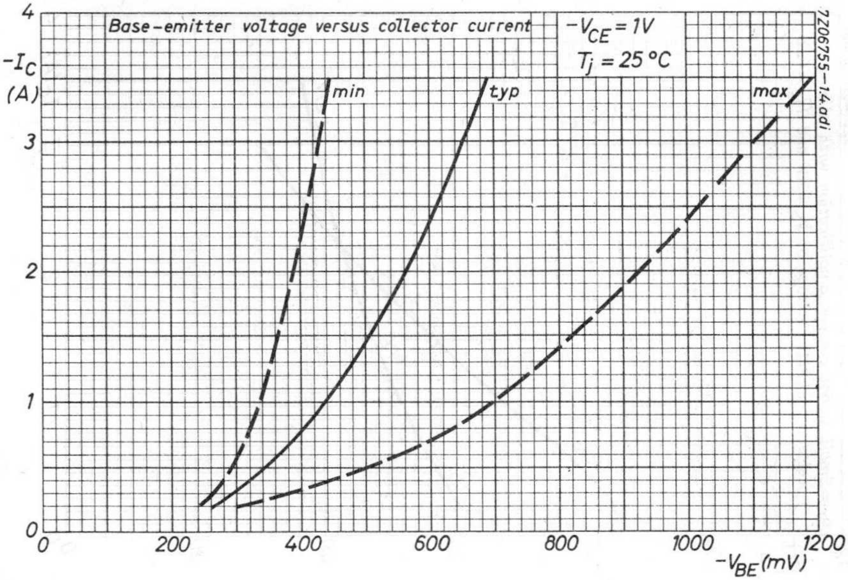


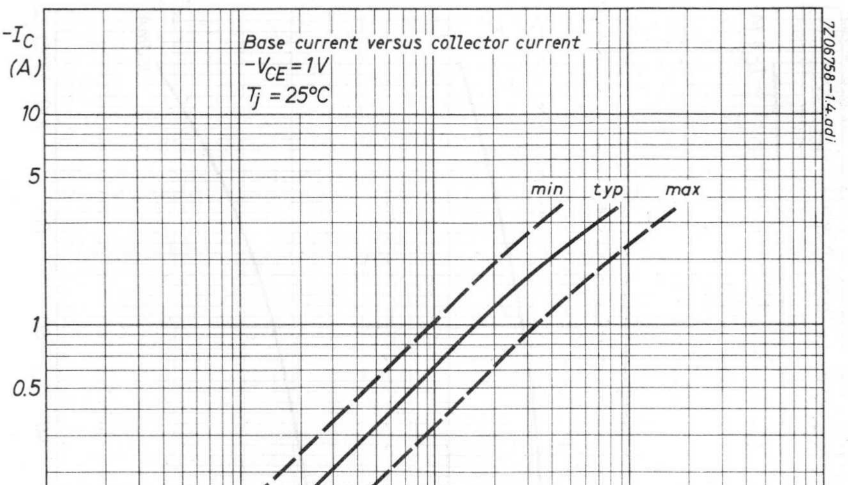
Stable continuous operation is ensured at an ambient temperature up to 55 °C provided each transistor is mounted on a 1.5 mm copper heatsink of at least 5 cm x 5 cm (circuit I) or 6 cm x 6 cm (circuit II).

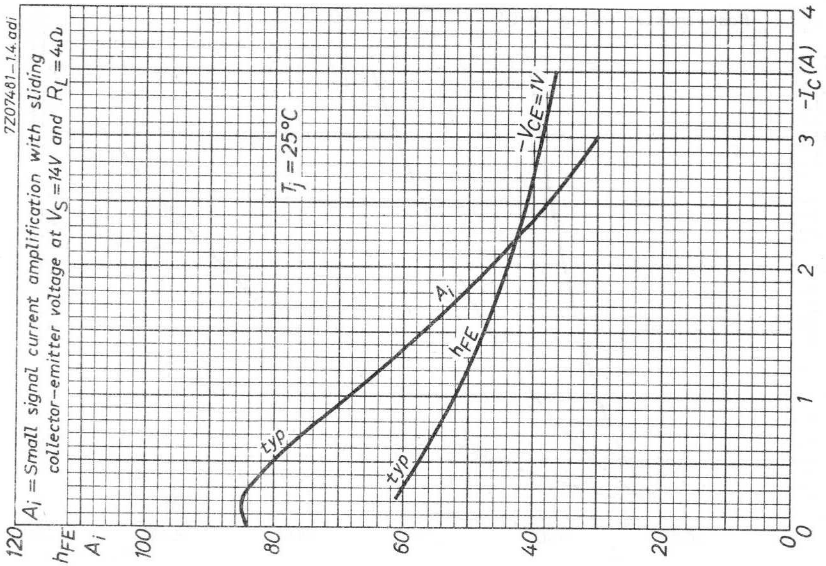
Characteristics			I	II	
Supply voltage	V_S	=	7	14	V
		<	8	16	V
Collector current (zero signal)	$-I_C$	=	60	60	mA
Bias resistor	R1	=	200	350	Ω
Emitter resistor	R_E	=	0	0.47	Ω
Source resistance	R_S	=	450	370	Ω
Collector resistance	$R_{cc\sim}$	=	9	16	Ω
Total power dissipation of the transistors	P_{tot}	<	9.75	20	W
Output power delivered to transformer	P_o	<	9.75	17.9	W
Collector current (peak value) at P_o max	$-I_{CM}$	typ.	3	3	A
Collector current at P_o max	$-I_C$	typ.	0.95	0.95	A
Input voltage (peak value) at P_o max	V_{IM}	typ.	0.81	2.2	V
Input current (peak value) at P_o max	I_{IM}	typ.	75	75	mA
Total distortion at P_o max	d_{tot}	typ.	10	10	%
Input current (peak value) at P_o = 50 mW	I_{IM}	typ.	4	2.5	mA
Total distortion at P_o = 50 mW	d_{tot}	typ.	2.5	2	%

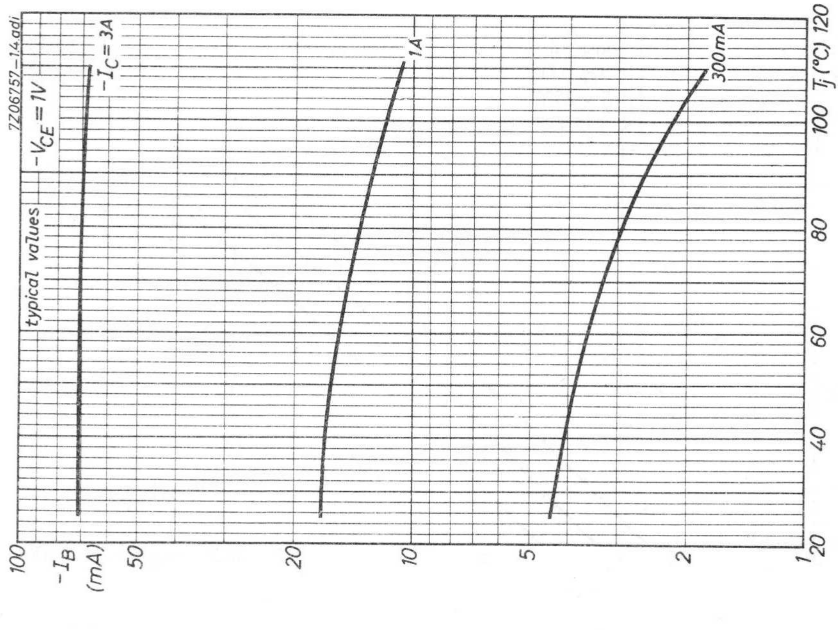

7Z06754-1.4.adi
typical values
$T_j = 25°C$
$-I_C$ (A)
6
5
4
3
2
1
0
$-I_B = 100mA$
75mA
50mA
25mA
10mA
0
0.2
0.4
0.6
$-V_{CE}(V)$
0.8

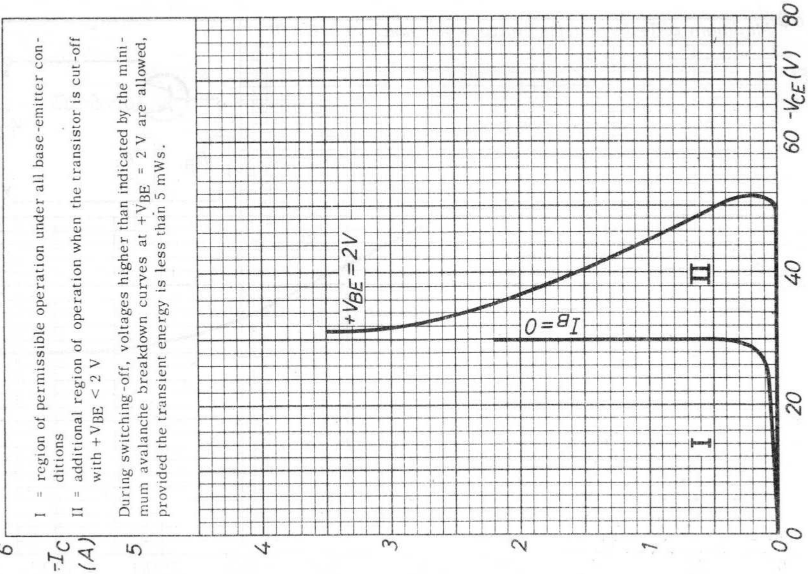

1.4.adi
Base-emitter voltage versus collector current
The increase of $-V_{BE}$ per volt decrease of $-V_{CE}$ is approximately
0.5 mV at $-I_C$ = 30 mA
1.0 mV at $-I_C$ = 100 mA
1.5 mV at $-I_C$ = 200 mA
$-V_{CE}$ = 14V
T_j = 25°C
$-I_C$ (mA)
250
200
150
100
50
0
min
typ
max
0
100
200
$-V_{BE}$(mV)
300

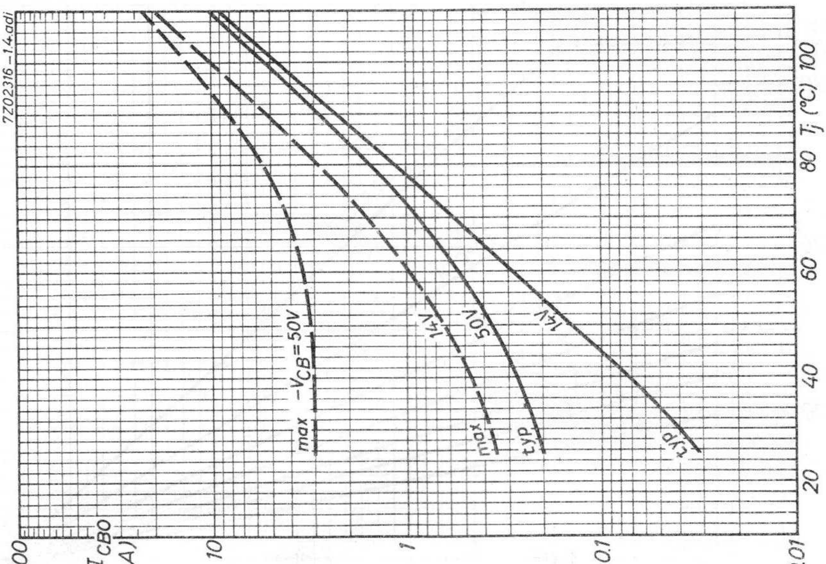

Base-emitter voltage versus collector current
$-V_{CE} = 1V$
$T_j = 25\,°C$
7Z06755-1.4.adi
$-I_C$ (A)
4
3
2
1
0
min
typ
max
0
200
400
600
800
1000
1200
$-V_{BE}$ (mV)

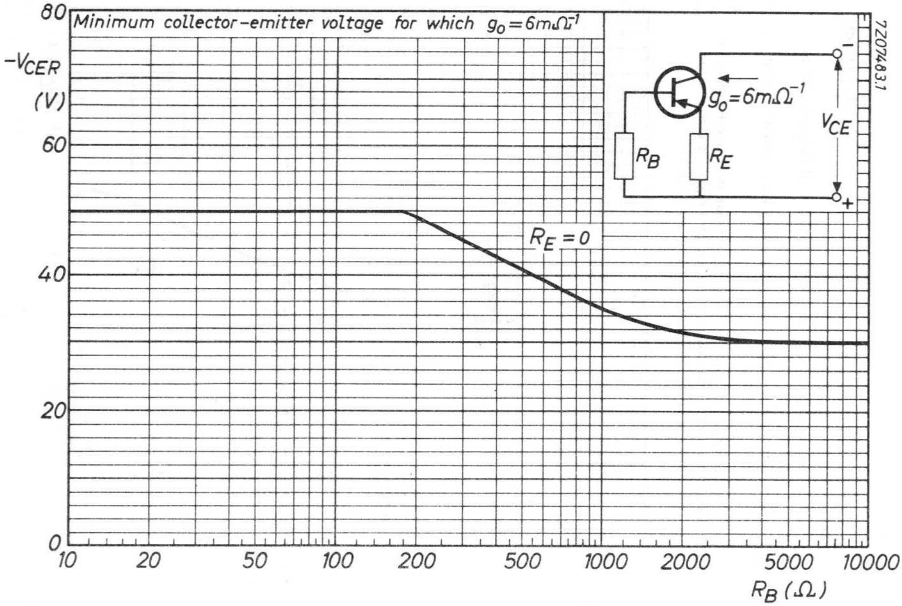

Base current versus collector current
$-V_{CE} = 1V$
$T_j = 25°C$
7Z06758-1.4.adi
$-I_C$ (A)
10
5
1
0.5
0.1
min
typ
max
0.1
0.5
1
5
10
50
100
$-I_B$ (mA)
1000

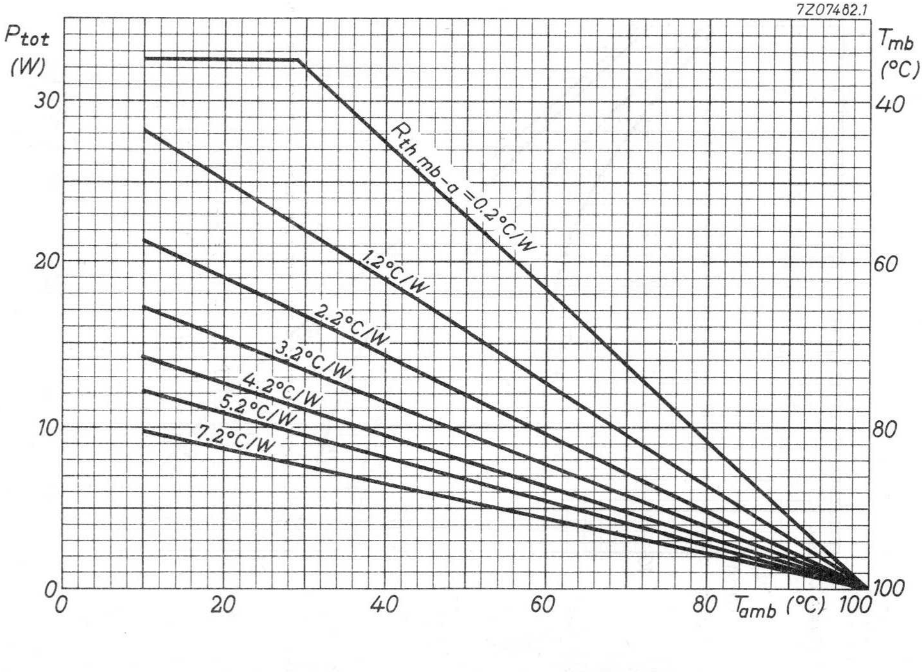

7Z07481-1.4.adi
Ai = Small signal current amplification with sliding collector-emitter voltage at VS = 14V and RL = 4Ω
Tj = 25°C
−VCE = 1V
Ai
hFE
typ
typ
hFE
Ai
−IC (A)
120
100
80
60
40
20
0
0
1
2
3
4


7Z06757-1.4.adi
typical values
−VCE = 1V
−IC = 3A
1A
300mA
−IB (mA)
Tj (°C)
100
50
20
10
5
2
1
20
40
60
80
100
120


7Z07484 – 1.4.adi
I = region of permissible operation under all base-emitter conditions
II = additional region of operation when the transistor is cut-off with +VBE < 2 V
During switching-off, voltages higher than indicated by the minimum avalanche breakdown curves at +VBE = 2 V are allowed, provided the transient energy is less than 5 mWs.
-IC (A)
+VBE=2V
IB=0
I
II
-VCE (V)
0
1
2
3
4
5
6
20
40
60
80


7Z02316 – 1.4.adi
-ICBO (mA)
100
10
1
0.1
0.01
max -VCB=50V
max 14V
typ 50V
typ 14V
Tj (°C)
20
40
60
80
100


Minimum collector-emitter voltage for which $g_o = 6m\Omega^{-1}$
$-V_{CER}$ (V)
80
60
40
20
0
$R_E = 0$
$g_o = 6m\Omega^{-1}$
R_B
R_E
V_{CE}
–
+
10
20
50
100
200
500
1000
2000
5000
10000
R_B (Ω)
7Z07483.1


7Z07482.1
P_{tot} (W)
T_{mb} (°C)
30
20
10
0
40
60
80
100
$R_{th\ mb-a}$ = 0.2°C/W
1.2°C/W
2.2°C/W
3.2°C/W
4.2°C/W
5.2°C/W
7.2°C/W
0
20
40
60
80
T_{amb} (°C)
100

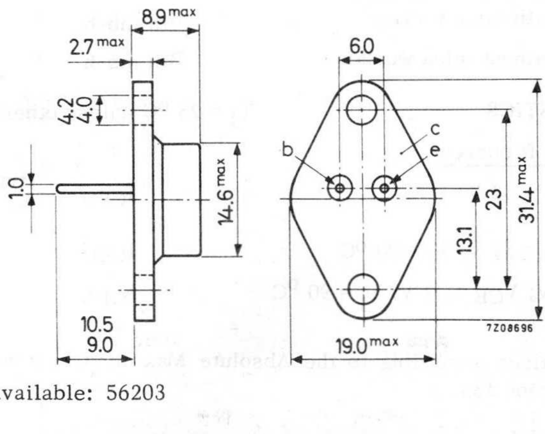
GERMANIUM ALLOYED POWER TRANSISTOR

N-P-N power transistor in a metal envelope with the collector connected to the mounting base.
The AD161 is primarily intended for use together with the p-n-p power transistor AD162 as matched pair AD161/AD162 in 10 W complementary symmetry class B output stages of mains operated amplifiers and radio receivers.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	32	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector current (peak value)	I_{CM}	max.	3	A
Total power dissipation up to $T_{mb} = 75\,^oC$	P_{tot}	max.	4	W
Junction temperature (incidentally)	T_j	max.	100	^oC
D.C. current gain at $T_j = 25\,^oC$				
$I_C = 0.5$ A; $V_{CE} = 1$ V	h_{FE}		80 to 320	
Cut-off frequency				
$I_C = 0.3$ A; $V_{CE} = 2$ V	f_{hfe}	typ.	35	kHz

MECHANICAL DATA Dimensions in mm

Collector connected to mounting base



Accessories available: 56203

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	32	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector-emitter voltage with $-V_{BE} = 0.6$ V (See also page 4)	V_{CEX}	max.	32	V
Emitter-base voltage (open collector)	V_{EBO}	max.	10	V

Currents

Collector current (d.c. or average over any 50 ms period)	I_C	max.	1	A
Collector current (peak value)	I_{CM}	max.	3	A

Power dissipation

Total power dissipation up to T_{mb} = 72 °C	P_{tot}	max.	4	W

Temperatures

Storage temperature	T_{stg}		-65 to +90	°C
Junction temperature: continuous	T_j	max.	90	°C
incidentally	T_j	max.	100	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	4.5	°C/W
From mounting base to heatsink with mica washer	$R_{th\ mb\text{-}h}$	=	1.5	°C/W
without mica washer	$R_{th\ mb\text{-}h}$	=	0.5	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $V_{CB} = 32$ V	I_{CBO}	typ.	20	μA
		<	500	μA
$I_E = 0$; $V_{CB} = 32$ V; $T_j = 90$ °C	I_{CBO}	<	3	mA
$-V_{BE} = 0.6$ V; $V_{CE} = 32$ V; $T_j = 90$ °C	I_{CEX}	<	3	mA

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Emitter cut-off current

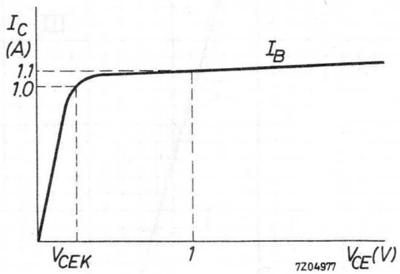
I_C = 0; V_{EB} = 10 V	I_{EBO}	typ. <</br>	20 200	μA μA
I_C = 0; V_{EB} = 10 V; T_j = 90 °C	I_{EBO}	<	2	mA

Base-emitter voltage [1]

I_C = 5 mA; V_{CE} = 10 V	V_{BE}	110 to	140	mV
I_C = 50 mA; V_{CE} = 1 V	V_{BE}	<	300	mV
I_C = 500 mA; V_{CE} = 1 V	V_{BE}	<	650	mV
I_C = 2 A; V_{CE} = 1 V	V_{BE}	<	1100	mV

Knee voltage

I_C = 1 A; I_B = value for which
I_C = 1.1 A at V_{CE} = 1 V — V_{CEK} < 600 mV



Floating voltage

I_E = 0; V_{CB} = 32 V; T_j = 90 °C	V_{EBfl}	<	400	mV

Collector capacitance at f = 450 kHz

$I_E = I_e$ = 0; V_{CB} = 5 V	C_c	typ.	150	pF

D.C. current gain

I_C = 5 mA; V_{CE} = 10 V	h_{FE}	>	55
I_C = 50 mA; V_{CE} = 1 V	h_{FE}	74 to	300
I_C = 500 mA; V_{CE} = 1 V	h_{FE}	typ. 80 to	150 320
I_C = 2 A; V_{CE} = 1 V	h_{FE}	>	40

[1] V_{BE} decreases by about 2 mV/°C with increasing temperature.

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Transition frequency

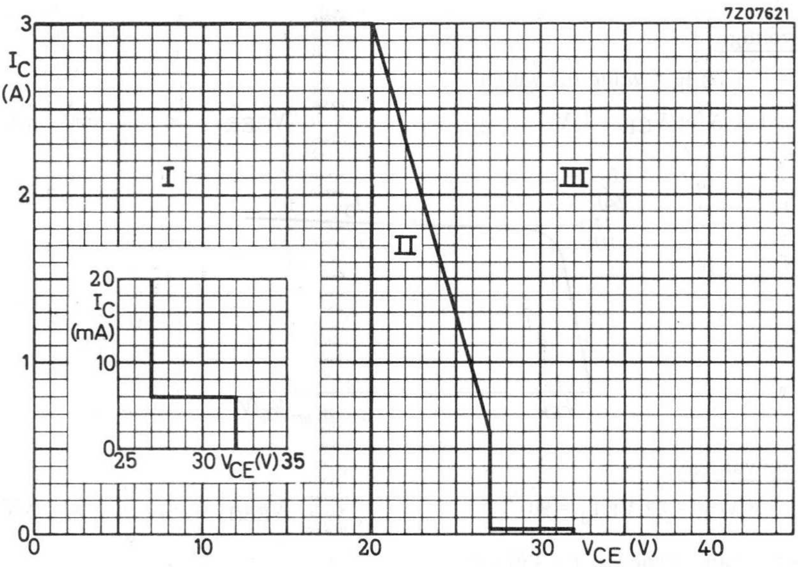
I_C = 10 mA; V_{CE} = 2 V	f_T	typ.	3	MHz

Cut-off frequency

I_C = 300 mA; V_{CE} = 2 V	f_{hfe}	>	20	kHz
		typ.	35	kHz

D.C. current gain ratio of matched pair AD161/AD162

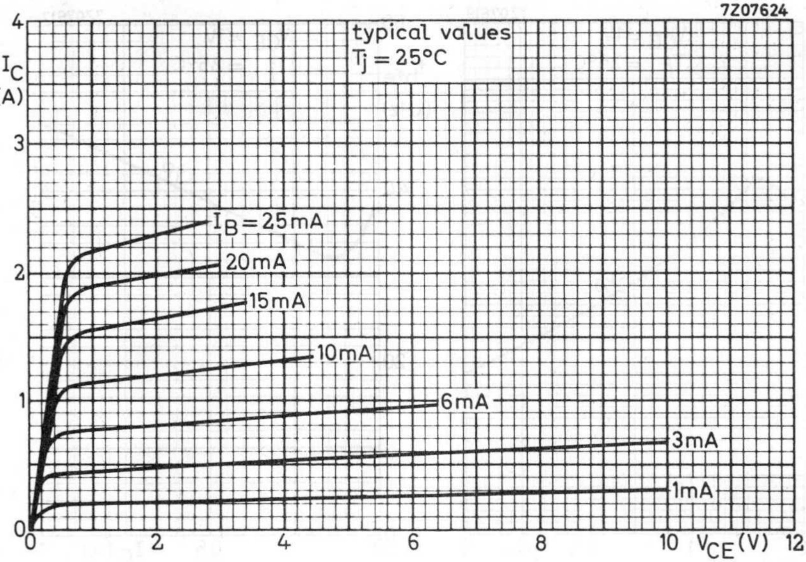
$\|I_C\|$ = 500 mA; $\|V_{CE}\|$ = 1 V	h_{FE1}/h_{FE2}	typ.	1.1
		<	1.25

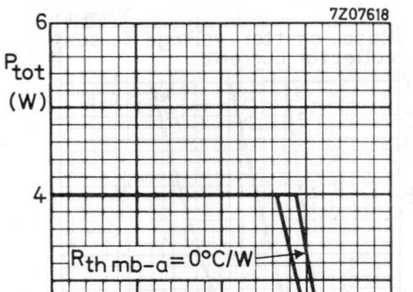


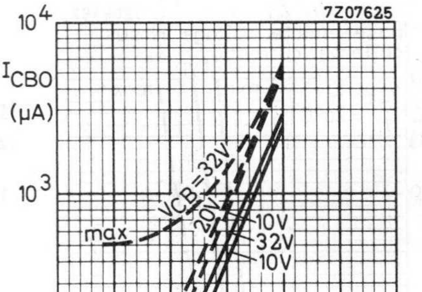
I = Region of permissible operation under all base-emitter conditions.

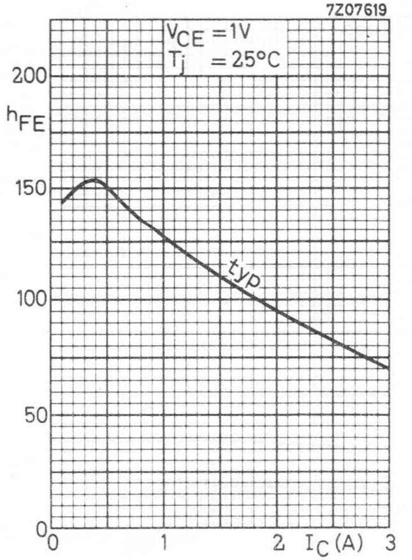
II = Additional region of operation when the transistor is cut-off with $-V_{BE} \geq -V_{BEfl}$.

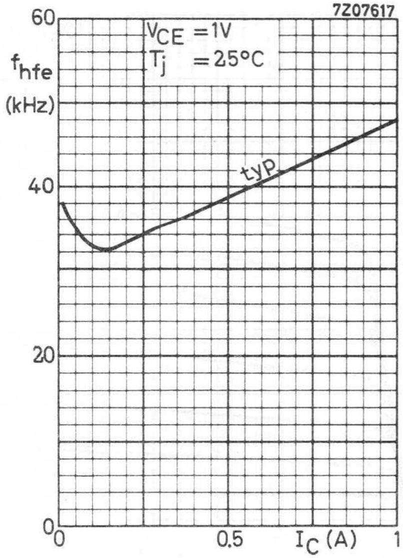
III = Outside regions I and II, the transistor can withstand transient energies of 1 mWs, provided it is cut-off with $-V_{BB} \leq 0.6$ V; R_i = 18 Ω.

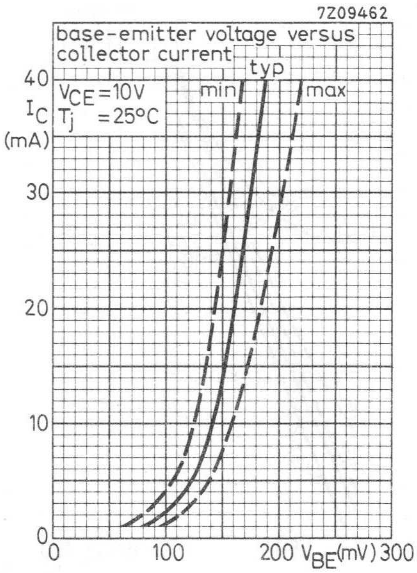

7Z07624
typical values
$T_j = 25°C$
I_C (A)
$I_B = 25mA$
20mA
15mA
10mA
6mA
3mA
1mA
0 2 4 6 8 10 12
V_{CE} (V)

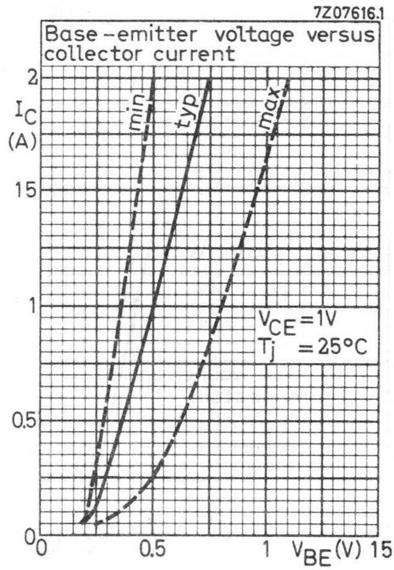

7Z07618
P_{tot} (W)
$R_{th\,mb-a} = 0°C/W$
With mica washer on infinite heatsink
0 50 100
T_{amb} (°C)

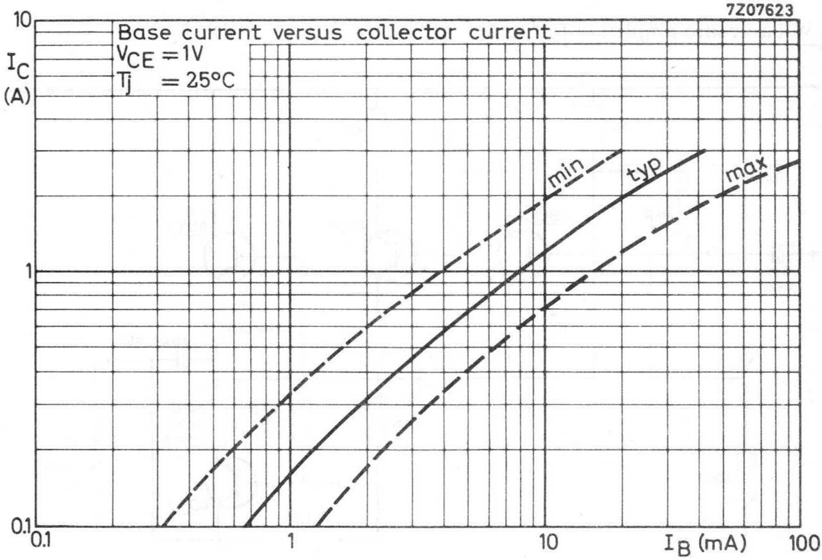

7Z07625
I_{CBO} (µA)
10^4
10^3
10^2
10
max
$V_{CB} = 32V$
20V
10V
32V
10V
max
max
typ
0 50 100 150
T_j (°C)

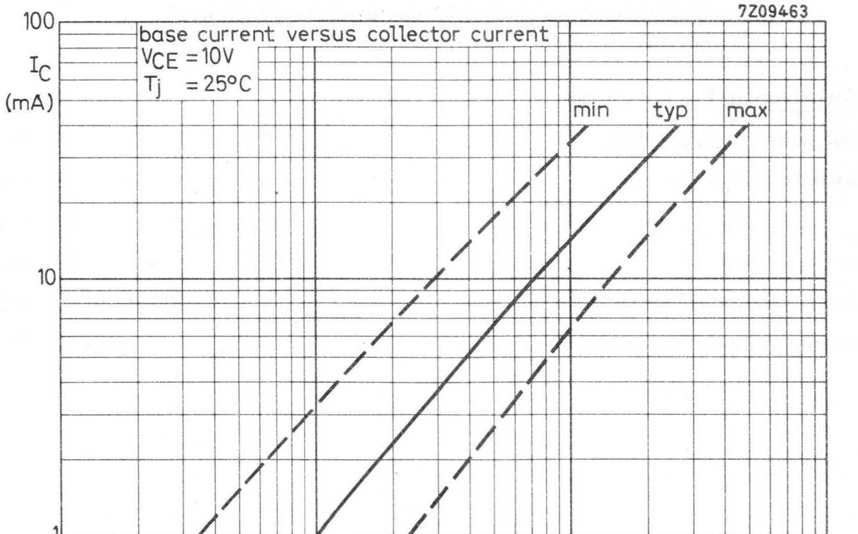

7Z07619
V_{CE} = 1V
T_j = 25°C
h_{FE}
200
150
100
50
0
typ
0
1
2
I_C (A)
3


7Z07617
V_{CE} = 1V
T_j = 25°C
f_{hfe}
(kHz)
60
40
20
0
typ
0
0.5
I_C (A)
1


7Z09462
base-emitter voltage versus collector current
V_{CE} = 10V
T_j = 25°C
I_C
(mA)
40
30
20
10
0
min
typ
max
0
100
200
V_{BE} (mV)
300

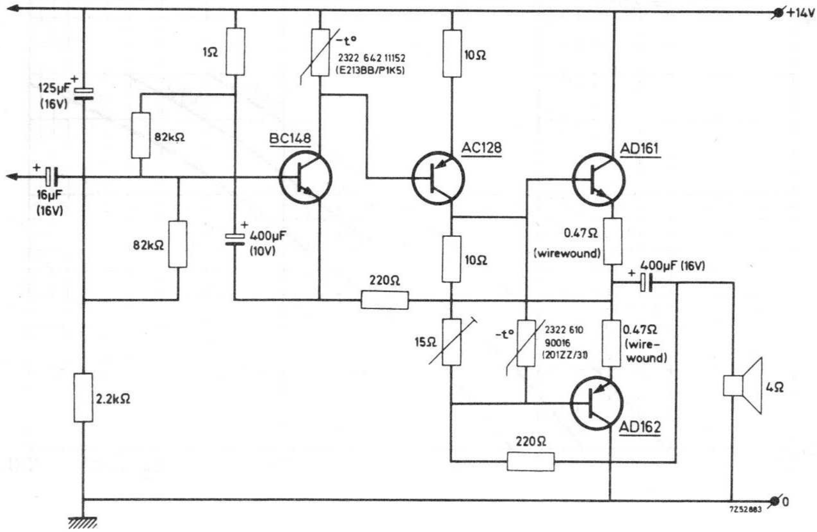

7Z07616.1
Base-emitter voltage versus collector current
I_C
(A)
2
1.5
1
0.5
0
min
typ
max
V_{CE} = 1V
T_j = 25°C
0
0.5
1
V_{BE} (V)
1.5


7Z07623
Base current versus collector current
V_{CE} = 1V
T_j = 25°C
I_C (A)
I_B (mA)
min
typ
max
10
1
0.1
0.1
1
10
100


7Z09463
base current versus collector current
V_{CE} = 10V
T_j = 25°C
I_C (mA)
I_B (μA)
min
typ
max
100
10
1
1
10
100
1000

APPLICATION INFORMATION

A. 4 W car radio amplifier for 12 V

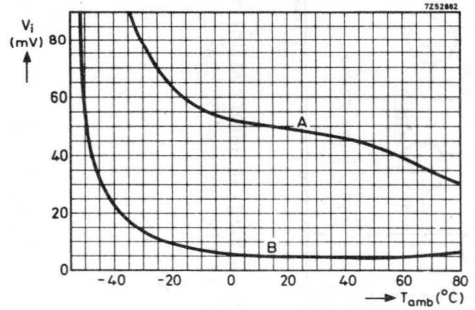


All transistors mounted on one heatsink which has a thermal resistance of $R_{th\ h\text{-}a} \leq 5.5$ °C/W

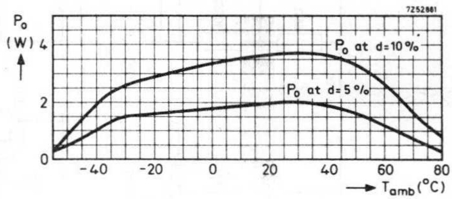
Performance at T_{amb} = 25 °C

Output power at d_{tot} = 10%	P_o	=	4	W
Sensitivity at P_o = 50 mW	V_i	=	5	mV
P_o = 4 W	V_i	=	48	mV
Input impedance	Z_i	=	10	kΩ
Frequency response (−3 dB)			200 Hz to 20	kHz
Operating ambient temperature	T_{amb}		20 to 70	°C

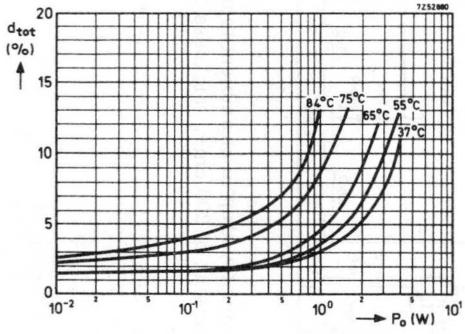
APPLICATION INFORMATION (continued)

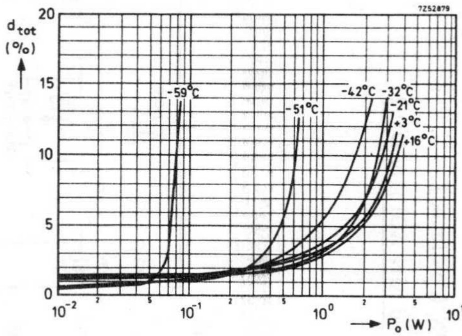


Input sensitivity at various ambient temperatures. Curve A for maximum output power at a distortion of 10%. Curve B for an output power of 50 mW.



The output power at two distortion levels as a function of the ambient temperature.

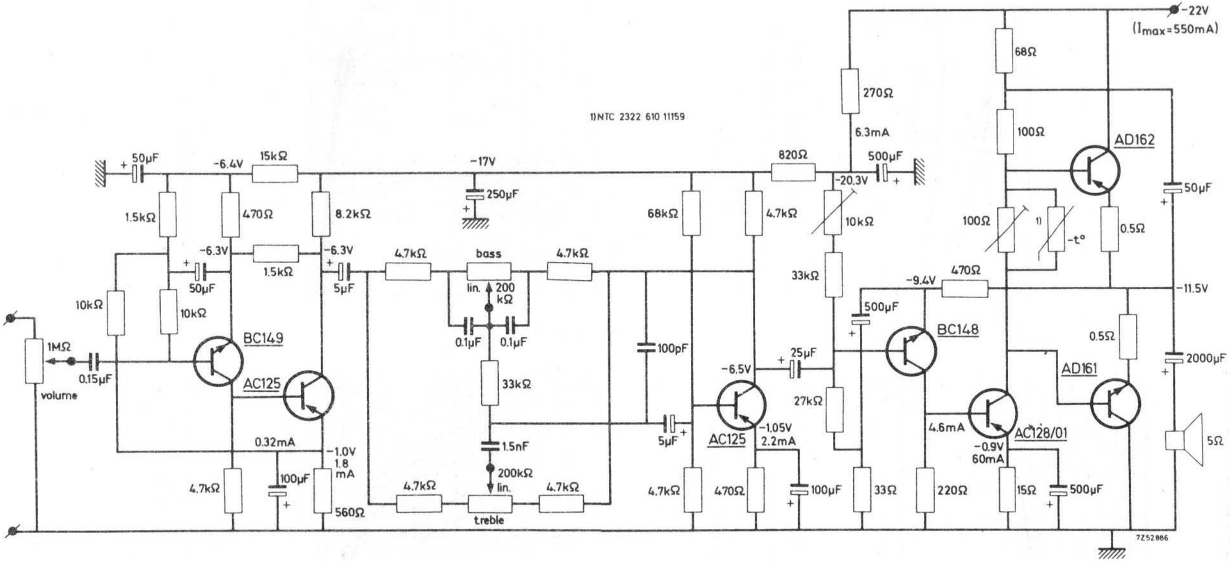




The distortion as a function of the output power at several ambient temperatures.

APPLICATION INFORMATION (continued)

B. 8 W amplifier with matched pair AD161/AD162



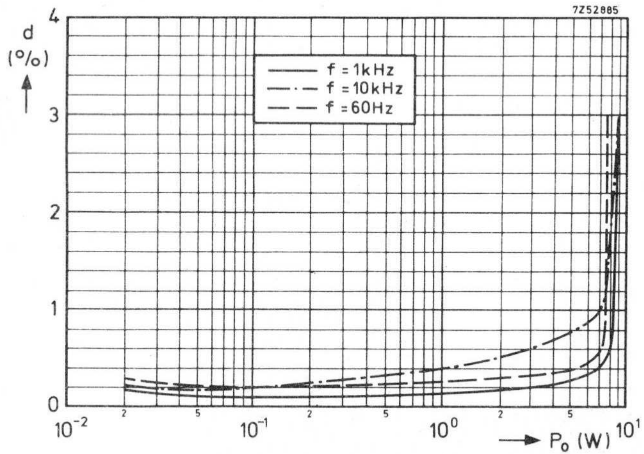
This amplifier can safely be employed up to an ambient temperature of 45 °C, provided the transistors AD161 and AD162 are mounted on a common heatsink of 200 cm^2, thickness 2 mm and the AC128/01 on a heatsink of 50 cm^2.

APPLICATION INFORMATION (continued)

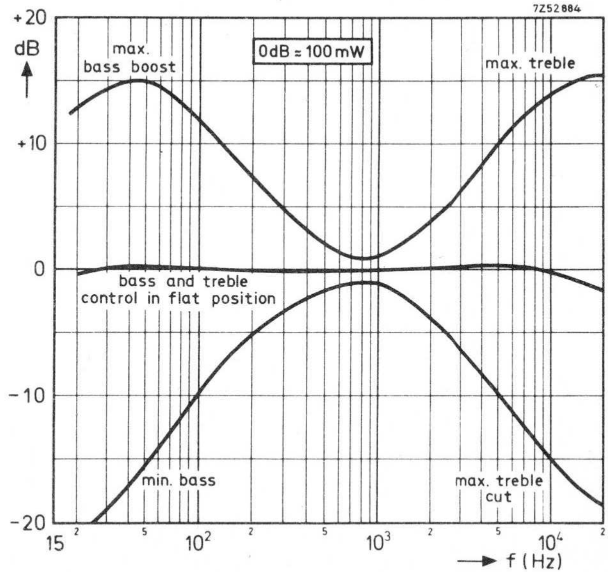
Performance

Output power at onset of clipping d_{tot} = 0.6%; f = 1 kHz	P_o	=	8	W
Sensitivity at P_o = 50 mW	V_i	=	8.7	mV
P_o = 8.7 W	V_i	=	110	mV
Input impedance	Z_i	=	500	kΩ

Signal-noise ratio at P_o = 8.7 W				
power supply unstabilized	S/N	=	56	dB
stabilized	S/N	=	70	dB
Frequency response (−3 dB)			20 Hz to 20	kHz
Bass control at 45 Hz			−16.5 to +15	dB
Treble control at 20 kHz			−18 to +15.5	dB



The distortion as function of the output power at three different frequencies.



Control facilities of the 8 W amplifier.

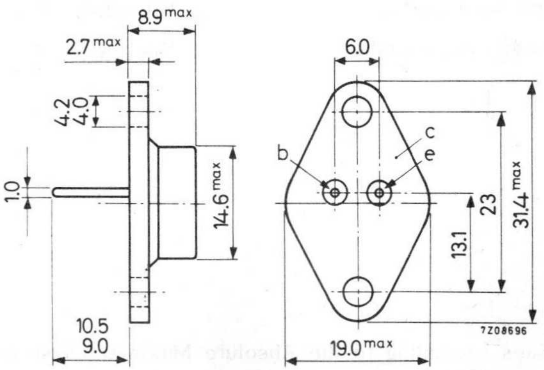
GERMANIUM ALLOYED POWER TRANSISTOR

P-N-P power transistor in a metal envelope with the collector connected to the mounting base.
It is primarily intended for use as matched pair 2-AD162 in class B push-pull output stages and together with the n-p-n power transistor AD161 as matched pair AD161/AD162 in 10 W complementary symmetry class B output stages of mains operated amplifiers and radio receivers.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20	V
Collector current (peak value)	$-I_{CM}$	max.	3	A
Total power dissipation up to T_{mb} = 63 °C	P_{tot}	max.	6	W
Junction temperature (incidentally)	T_j	max.	100	°C
D.C. current gain at T_j = 25 °C				
$-I_C$ = 0.5 A; $-V_{CE}$ = 1 V	h_{FE}	80 to 320		
Cut-off frequency				
$-I_C$ = 0.3 A; $-V_{CE}$ = 2 V	f_{hfe}	typ.	15	kHz

MECHANICAL DATA Dimensions in mm

Collector connected to mounting base



Accessories available: 56203

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20	V
Collector-emitter voltage with $+V_{BE}$ = 0.6 V (See also page 4)	$-V_{CEX}$	max.	32	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	10	V

Currents

Collector current (d.c. or average over any 50 ms period)	$-I_C$	max.	1	A
Collector current (peak value)	$-I_{CM}$	max.	3	A

Power dissipation

Total power dissipation up to T_{mb} = 63 °C	P_{tot}	max.	6	W

Temperatures

Storage temperature	T_{stg}		-65 to +90	°C
Junction temperature: continuous	T_j	max.	90	°C
incidentally	T_j	max.	100	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	4.5	°C/W
From mounting base to heatsink with mica washer	$R_{th\ mb-h}$	=	1.5	°C/W
without mica washer	$R_{th\ mb-h}$	=	0.5	°C/W

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $-V_{CB} = 32$ V	$-I_{CBO}$	typ. <	15 200	μA μA
$I_E = 0$; $-V_{CB} = 32$ V; $T_j = 90$ °C	$-I_{CBO}$	<	2	mA
$+V_{BE} = 0.6$ V; $-V_{CE} = 32$ V; $T_j = 90$ °C	$-I_{CEX}$	<	2	mA

Emitter cut-off current

$I_C = 0$; $-V_{EB} = 10$ V	$-I_{EBO}$	typ. <	15 200	μA μA
$I_C = 0$; $-V_{EB} = 10$ V; $T_j = 90$ °C	$-I_{EBO}$	<	2	mA

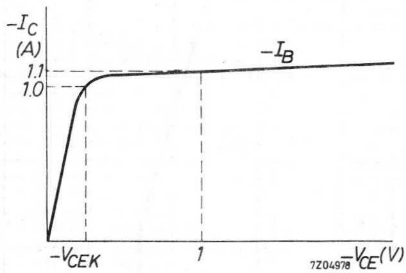
Base-emitter voltage [1])

$-I_C$ = 5 mA; $-V_{CE}$ = 10 V	$-V_{BE}$	115 to	145	mV
$-I_C$ = 50 mA; $-V_{CE}$ = 1 V	$-V_{BE}$	<	300	mV
$-I_C$ = 500 mA; $-V_{CE}$ = 1 V	$-V_{BE}$	<	550	mV
$-I_C$ = 2 A; $-V_{CE}$ = 1 V	$-V_{BE}$	<	850	mV

Knee voltage

$-I_C$ = 1 A; $-I_B$ = value for which

$-I_C$ = 1.1 A at $-V_{CE}$ = 1 V $\quad -V_{CEK}$ < 400 mV



Floating voltage

$I_E = 0$; $-V_{CB} = 32$ V; $T_j = 90$ °C	$-V_{EBfl}$	<	400	mV

Collector capacitance at f = 450 kHz

$I_E = I_e = 0$; $-V_{CB} = 5$ V	C_c	typ.	115	pF

[1]) $-V_{BE}$ decreases by about 2 mV/°C with increasing temperature.

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

D.C. current gain

$-I_C$ = 5 mA; $-V_{CE}$ = 10 V	h_{FE}	> 60
$-I_C$ = 50 mA; $-V_{CE}$ = 1 V	h_{FE}	74 to 300
$-I_C$ = 500 mA; $-V_{CE}$ = 1 V	h_{FE}	typ. 150 80 to 320
$-I_C$ = 2 A ; $-V_{CE}$ = 1 V	h_{FE}	> 60

Transition frequency

$-I_C$ = 10 mA; $-V_{CE}$ = 2 V	f_T	typ. 1.5 MHz

Cut-off frequency

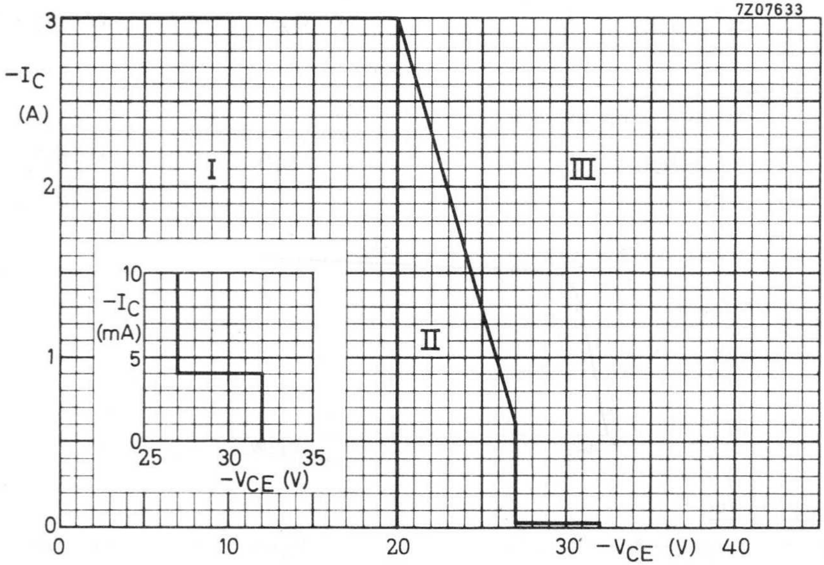
$-I_C$ = 300 mA; $-V_{CE}$ = 2 V	f_{hfe}	> 8 kHz typ. 15 kHz

D.C. current gain ratio of matched pair AD161/AD162

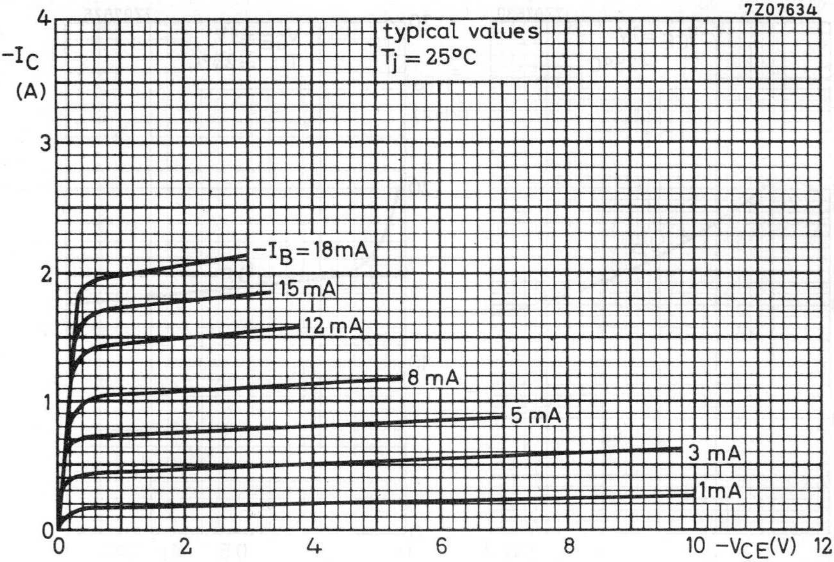
$\|I_C\|$ = 500 mA; $\|V_{CE}\|$ = 1 V	h_{FE1}/h_{FE2}	typ. 1.1 < 1.25

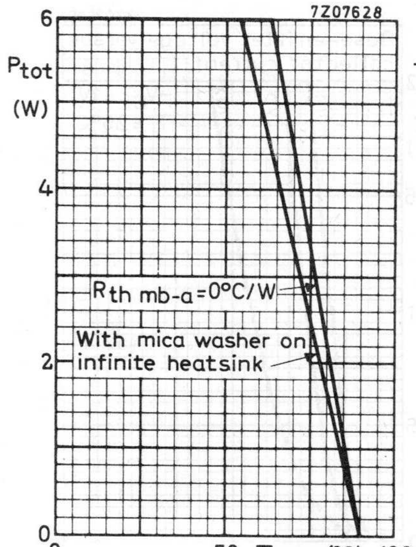
matched pair 2-AD162

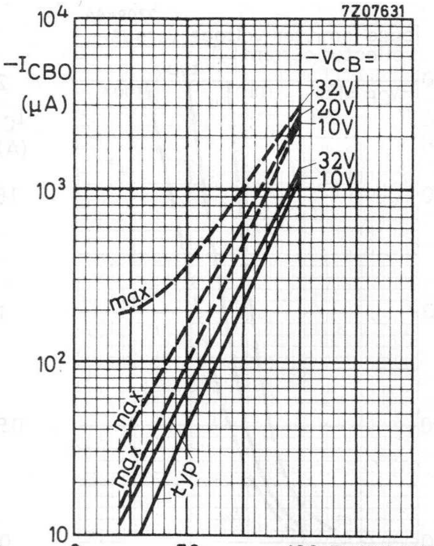
$-I_C$ = 50 mA; $-V_{CE}$ = 1 V $-I_C$ = 500 mA; $-V_{CE}$ = 1 V	h_{FE1}/h_{FE2}	typ. 1.1 < 1.25

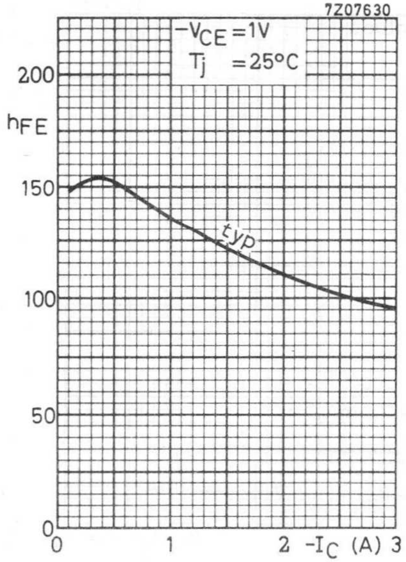


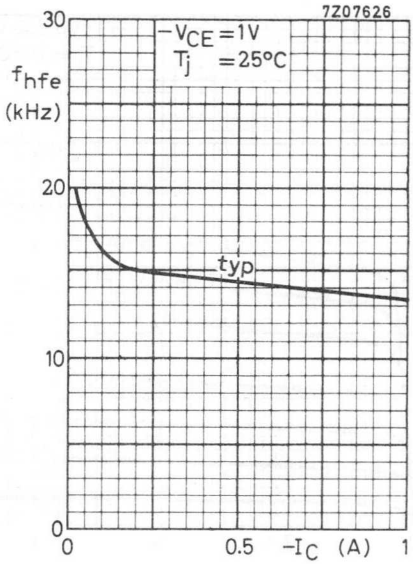
I Region of permissible operation under all base-emitter conditions.
II Additional region of operation when the transistor is cut-off with $V_{BE} \geq V_{BEfl}$.
III Outside regions I and II, the transistor can withstand transient energies of 4.5 mWs, provided it is cut-off with $+V_{BB}$ < 0.6 V; R_i = 18 Ω.

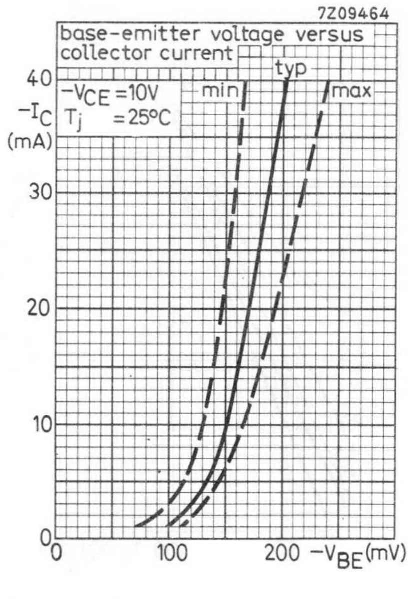

7Z07634
typical values
Tj = 25°C
−IC
(A)
−IB = 18mA
15 mA
12 mA
8 mA
5 mA
3 mA
1mA
−VCE(V)
0
2
4
6
8
10
12
1
3

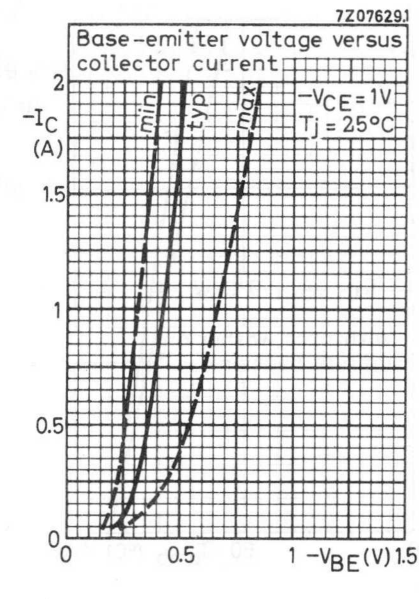

7Z07628
Ptot
(W)
Rth mb-a = 0°C/W
With mica washer on
infinite heatsink
Tamb (°C)
0
50
100
2
4
6

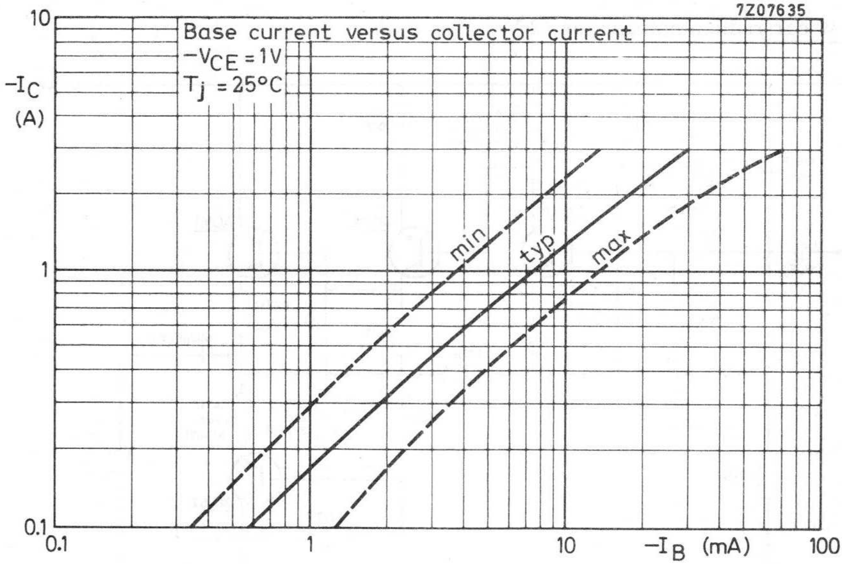

7Z07631
−ICBO
(μA)
−VCB =
32V
20V
10V
32V
10V
max
max
max
typ
Tj (°C)
0
50
100
150
10
10²
10³
10⁴

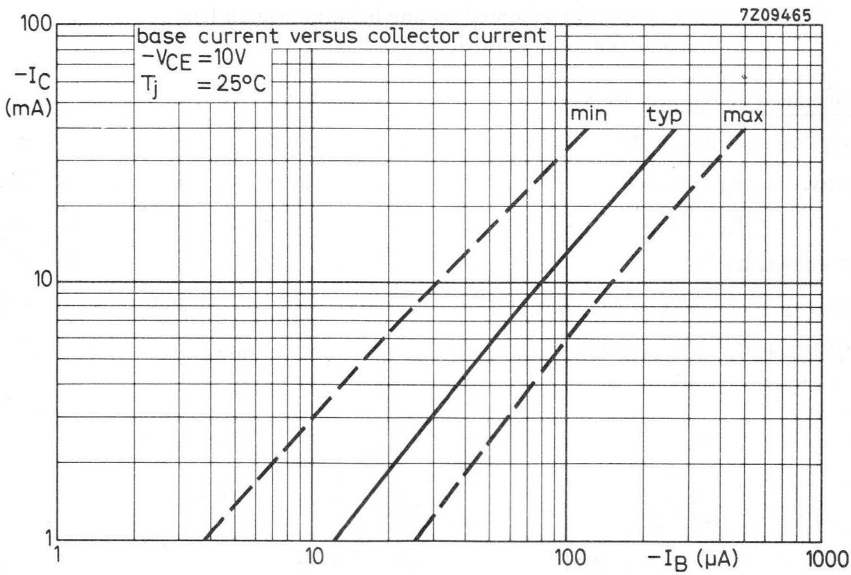

7Z07630
$-V_{CE}$ = 1V
T_j = 25°C
h_{FE}
typ
200
150
100
50
0
0
1
2
3
$-I_C$ (A)


7Z07626
$-V_{CE}$ = 1V
T_j = 25°C
f_{hfe}
(kHz)
typ
30
20
10
0
0
0.5
1
$-I_C$ (A)


7Z09464
base-emitter voltage versus collector current
$-V_{CE}$ = 10V
T_j = 25°C
$-I_C$
(mA)
min
typ
max
40
30
20
10
0
0
100
200
$-V_{BE}$(mV)

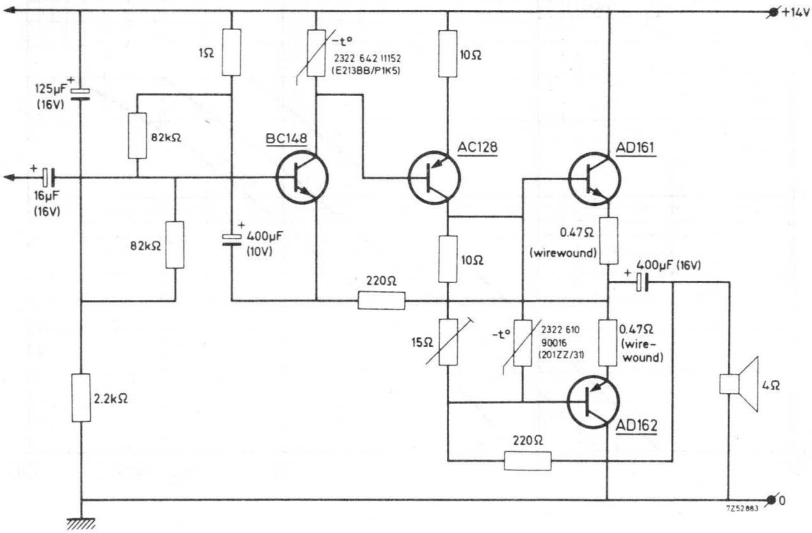

7Z07629.1
Base-emitter voltage versus collector current
$-V_{CE}$ = 1V
T_j = 25°C
$-I_C$
(A)
min
typ
max
2
1.5
1
0.5
0
0
0.5
1
1.5
$-V_{BE}$ (V)


7Z07635
Base current versus collector current
$-V_{CE}$ = 1V
T_j = 25°C
$-I_C$
(A)
10
1
0.1
0.1
1
10
100
$-I_B$ (mA)
min
typ
max


7Z09465
base current versus collector current
$-V_{CE}$ = 10V
T_j = 25°C
$-I_C$
(mA)
100
10
1
1
10
100
1000
$-I_B$ (μA)
min
typ
max

APPLICATION INFORMATION

A. 4 W car radio amplifier for 12 V

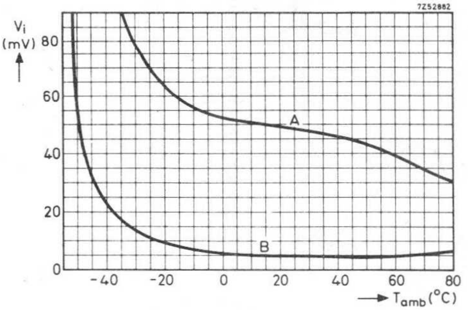


All transistors mounted on one heatsink which has a thermal resistance of $R_{th\ h\text{-}a} \leq 5.5\ ^{o}C/W$

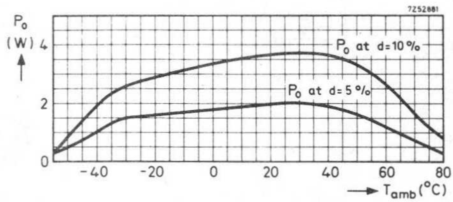
Performance at $T_{amb} = 25\ ^{o}C$

Output power at d_{tot} = 10%	P_o	=	4	W
Sensitivity at P_o = 50 mW	V_i	=	5	mV
P_o = 4 W	V_i	=	48	mV
Input impedance	Z_i	=	10	kΩ
Frequency response (−3 dB)			200 Hz to 20	kHz
Operating ambient temperature	T_{amb}		20 to 70	^{o}C

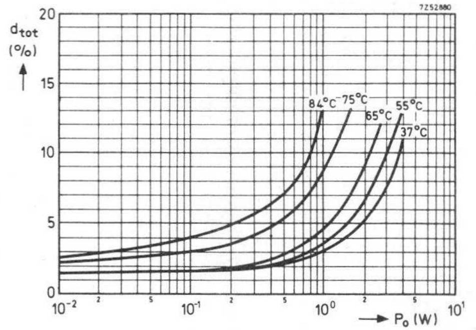
APPLICATION INFORMATION (continued)

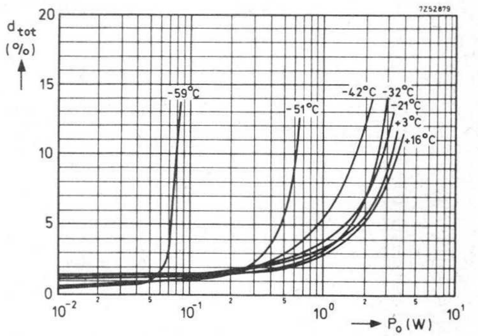


Input sensitivity at various ambient temperatures. Curve A for maximum output power at a distortion of 10%. Curve B for an output power of 50 mW.



The output power at two distortion levels as a function of the ambient temperature.

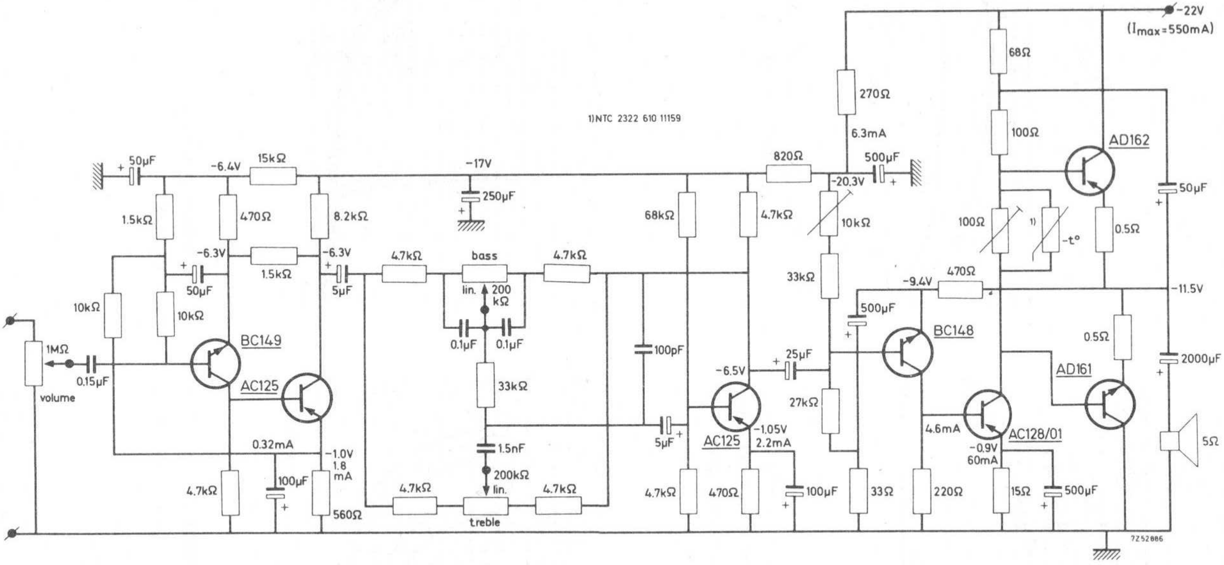




The distortion as a function of the output power at several ambient temperatures.

APPLICATION INFORMATION (continued)

B. 8 W amplifier with matched pair AD161/AD162

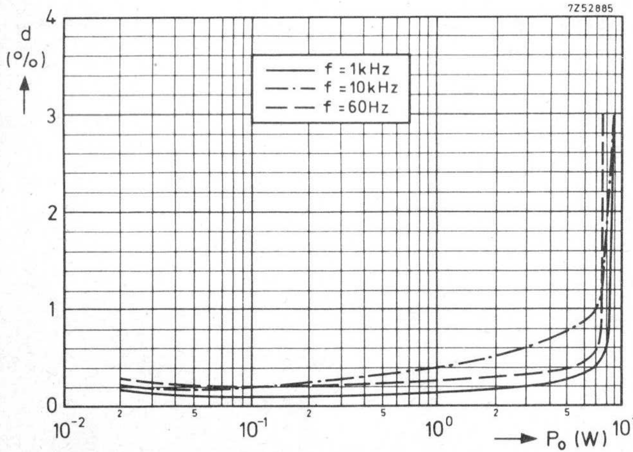


This amplifier can safely be employed up to an ambient temperature of 45 °C, provided the transistors AD161 and AD162 are mounted on a common heatsink of 200 cm^2, thickness 2 mm and the AC128/01 on a heatsink of 50 cm^2.

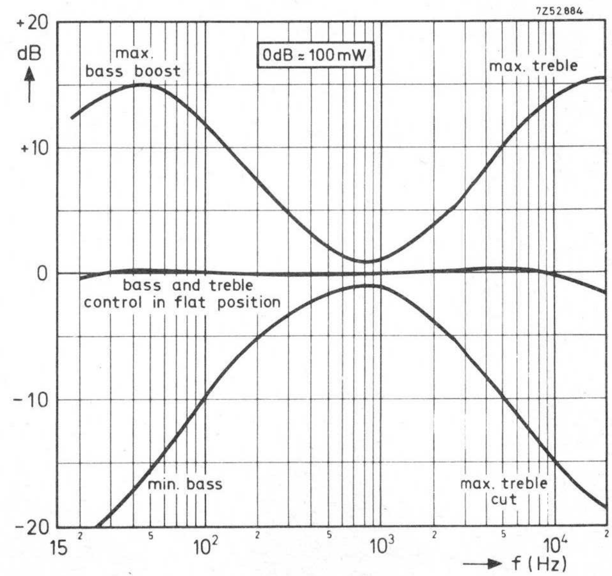
APPLICATION INFORMATION (continued)

Performance

Output power at onset of clipping d_{tot} = 0.6%; f = 1 kHz	P_o =	8 W
Sensitivity at P_o = 50 mW	V_i =	8.7 mV
P_o = 8.7 W	V_i =	110 mV
Input impedance	Z_i =	500 kΩ
Signal-noise ratio at P_o = 8.7 W power supply unstabilized	S/N =	56 dB
stabilized	S/N =	70 dB
Frequency response (−3 dB)		20 Hz to 20 kHz
Bass control at 45 Hz		−16.5 to +15 dB
Treble control at 20 kHz		−18 to +15.5 dB



The distortion as function of the output power at three different frequencies.



Control facilities of the 8 W amplifier.

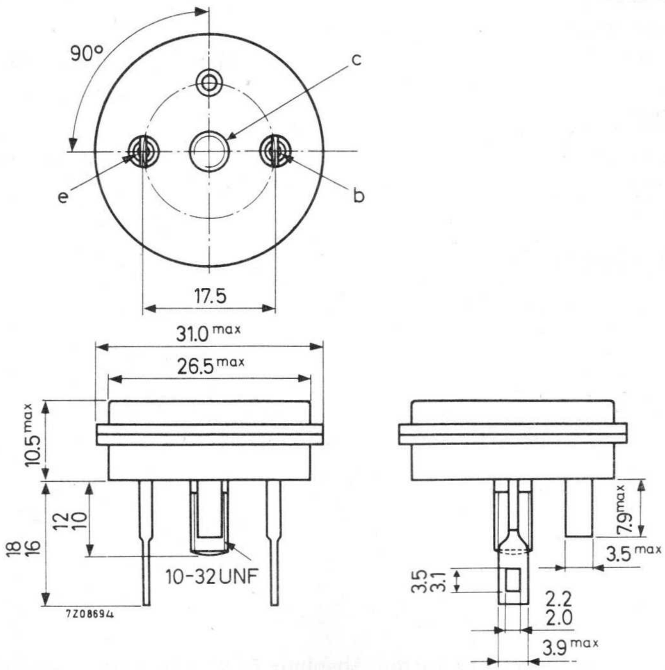
P-N-P POWER TRANSISTOR

Germanium alloy transistor in a TO-36 metal envelope. The ADY26 is primarily intended for high power and high current application.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	40	V
Collector current (peak value)	$-I_{CM}$	max.	30	A
Total power dissipation up to T_{mb} = 30 °C	P_{tot}	max.	100	W
Junction temperature	T_j	max.	90	°C
D.C. current gain at T_j = 25 °C I_E = 25 A; V_{CB} = 0	h_{FE}	>	15	

MECHANICAL DATA Dimensions in mm

TO-36



Diameter of hole in heatsink: max. 5.2 mm
Supplied with device: 56213

Torque on nut: min. 8 cmkg
max. 17 cmkg

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80	V
Collector-emitter voltage (open base) see also page 10	$-V_{CEO}$	max.	60	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	40	V

Currents

Collector current (averaged over any 20 ms period)	$-I_C$	max.	25	A
Collector current (peak value)	$-I_{CM}$	max.	30	A
Base current (averaged over any 20 ms period)	$-I_B$	max.	3	A
Base current (peak value)	$-I_{BM}$	max.	5	A

Power dissipation

Total power dissipation up to T_{mb} = 30 °C see also page 11	P_{tot}	max.	100	W

Temperatures

Storage temperature	T_{stg}		-55 to +90	°C
Junction temperature	T_j	max.	90	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	0.6	°C/W

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

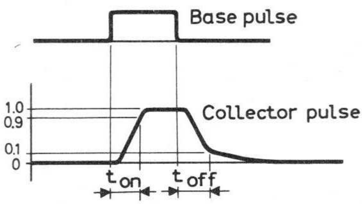
CHARACTERISTICS T_j = 25 °C unless otherwise specified

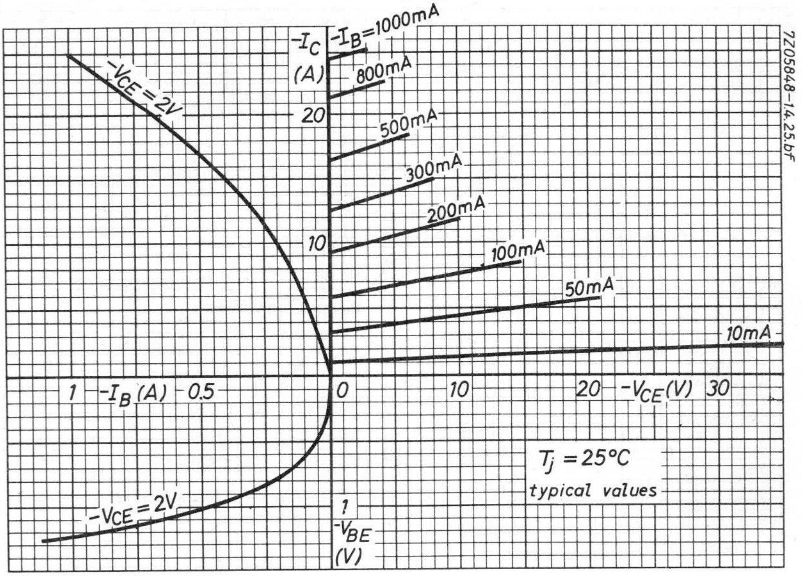
Collector cut-off current			
$I_E = 0$; $-V_{CB} = 2$ V	$-I_{CBO}$	typ. <	50 μA 200 μA
$I_E = 0$; $-V_{CB} = 80$ V	$-I_{CBO}$	typ. <	0.5 mA 4 mA
Emitter cut-off current			
$I_C = 0$; $-V_{EB} = 2$ V	$-I_{EBO}$	typ. <	50 μA 200 μA
$I_C = 0$; $-V_{EB} = 40$ V	$-I_{EBO}$	typ. <	0.5 mA 4 mA
Currents at reverse biased emitter junction			
$+V_{BE} = 1$ V; $-V_{CE} = 80$ V; $T_j = 90$ °C	$-I_{CEX}$	typ.	3 mA
Sustaining voltage			
$-I_C = 25$ A; $+V_{BE} = 2$ V	$-V_{CEXsust}$	>	40 V
Base-emitter voltage			
$I_E = 5$ A; $V_{CB} = 0$	$-V_{BE}$	typ. <	0.6 V 1 V
$I_E = 25$ A; $V_{CB} = 0$ [1]	$-V_{BE}$	typ. <	1.2 V 2 V
Saturation voltage [1]			
$-I_C = 25$ A; $-I_B = 2.5$ A	$-V_{CEsat}$	typ. <	0.15 V 0.5 V
Emitter floating voltage			
$I_E = 0$; $-V_{CB} = 80$ V	$-V_{EBfl}$	typ. <	0.2 V 1.0 V
D.C. current gain			
$I_E = 5$ A; $V_{CB} = 0$	h_{FE}	typ. 40 to	60 120
$I_E = 25$ A; $V_{CB} = 0$ [1]	h_{FE}	> typ.	15 25
Collector capacitance			
$I_E = I_e = 0$; $-V_{CB} = 12$ V	C_c	typ.	350 pF

[1] Measured under pulsed conditions to prevent excessive dissipation.

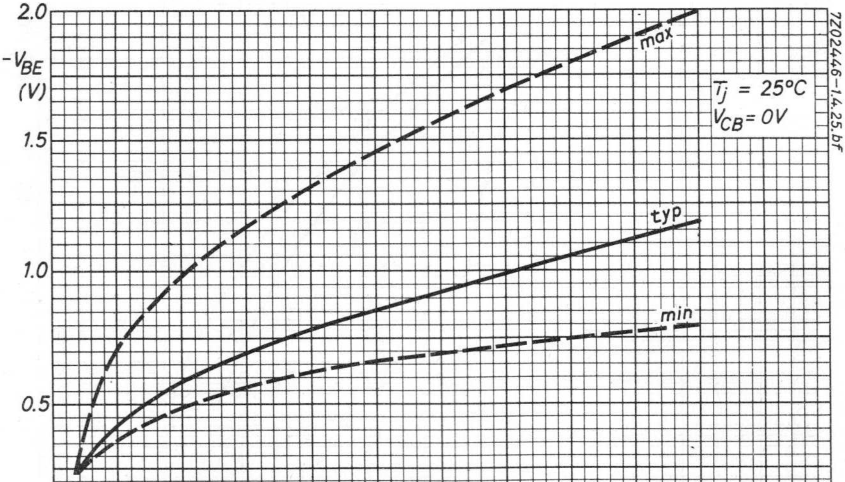
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Small signal current gain				
$-I_C$ = 1 A; $-V_{CE}$ = 12 V; f = 100 kHz	h_{fe}	>	1.0	
		typ.	1.7	
Turn on time				
$-I_C$ = 25 A; $-I_B$ = 2 A; $-V_{CC}$ = 18 V	t_{on}	typ.	25	µs
Turn off time				
$-I_C$ = 25 A; V_{BEoff} = 6 V; R_{BE} = 10 Ω	t_{off}	typ.	75	µs

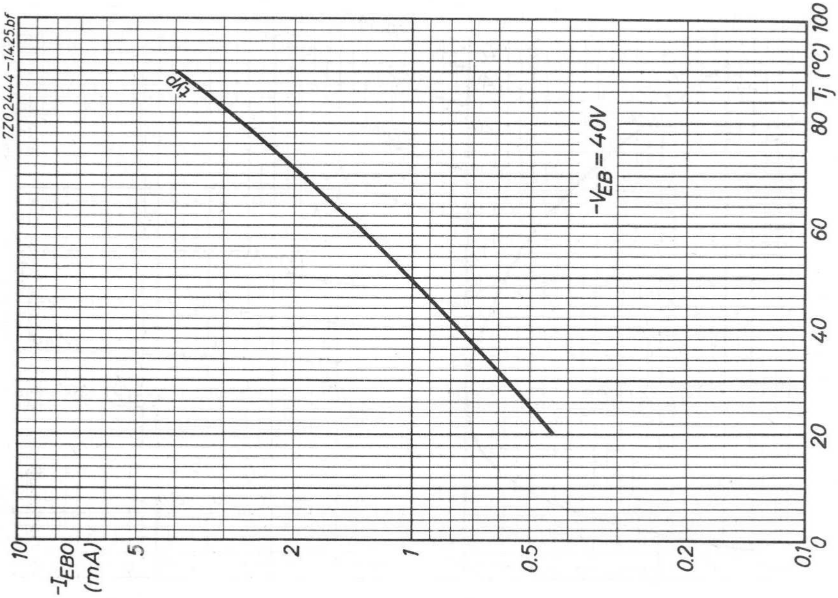


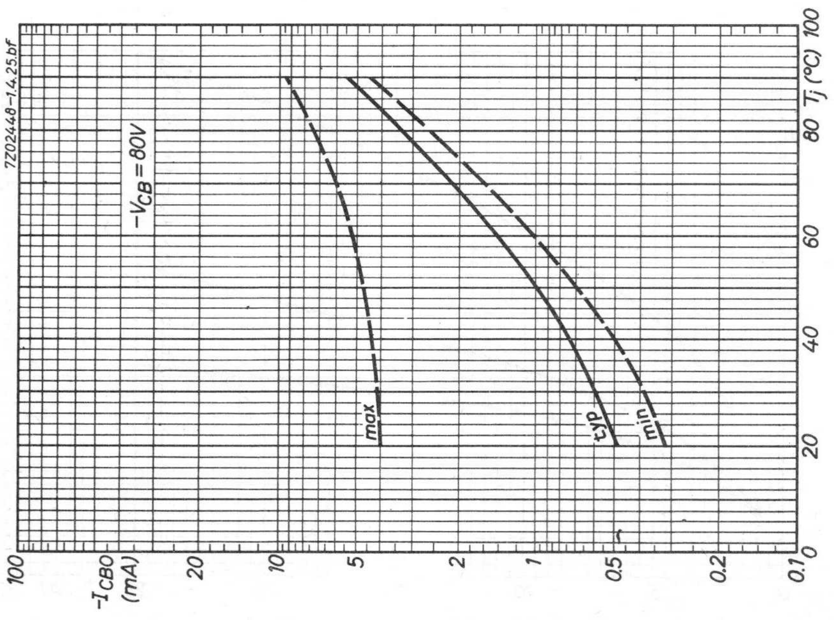


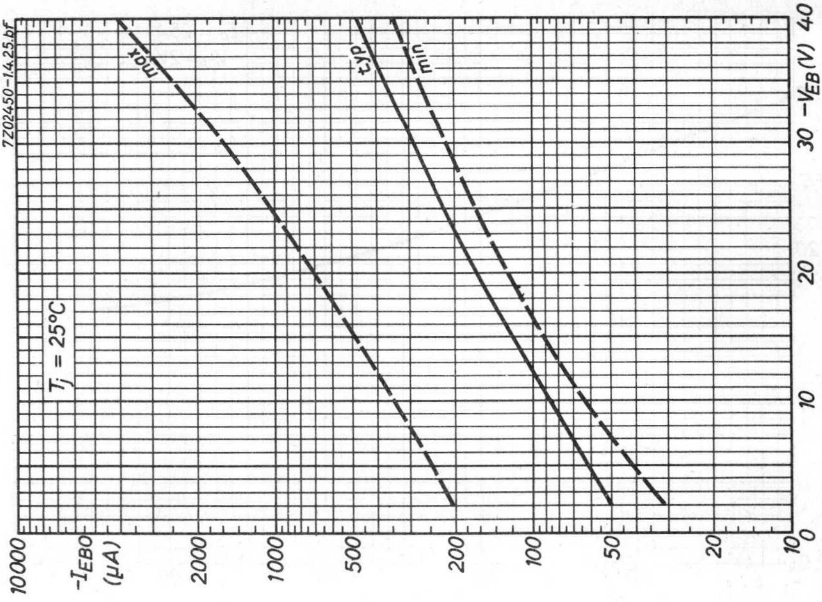
$-I_C$ (A)
$-I_B$=1000mA
800mA
500mA
300mA
200mA
100mA
50mA
10mA
20
10
$-V_{CE}$ = 2V
1
$-I_B$ (A)
0.5
0
10
20
$-V_{CE}$ (V)
30
T_j = 25°C
typical values
$-V_{CE}$ = 2V
1
$-V_{BE}$ (V)
7Z05848-1.4.25.bf

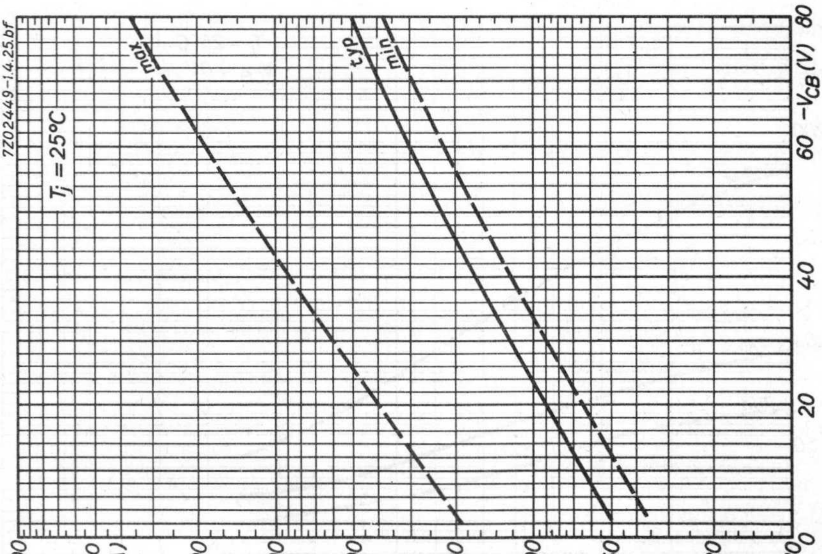


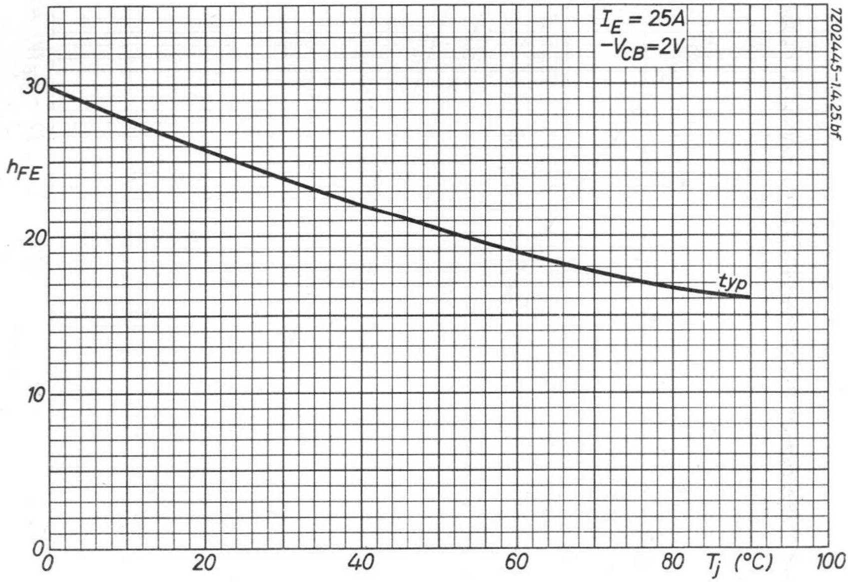
2.0
$-V_{BE}$ (V)
1.5
1.0
0.5
0
max
typ
min
T_j = 25°C
V_{CB} = 0V
0
5
10
15
20
25
I_E (A)
30
7Z02446-1.4.25.bf

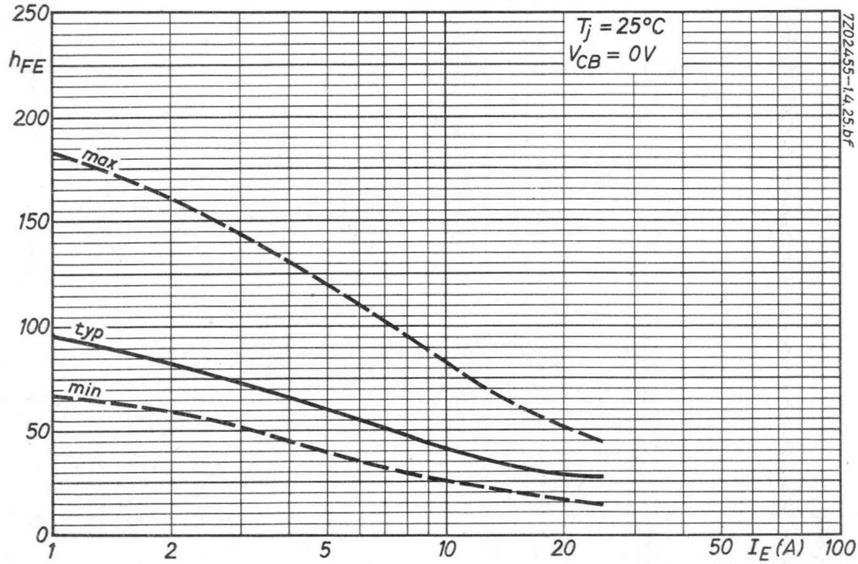

7Z02444-1.4.25.bf
$-I_{EBO}$ (mA)
$-V_{EB} = 40V$
typ
T_j (°C)
10
5
2
1
0.5
0.2
0.1
0
20
40
60
80
100

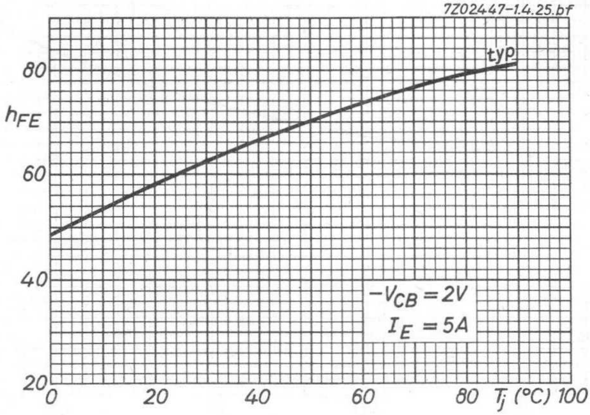

7Z02448-1.4.25.bf
$-I_{CBO}$ (mA)
$-V_{CB} = 80V$
max
typ
min
T_j (°C)
100
20
10
5
2
1
0.5
0.2
0.1
0
20
40
60
80
100

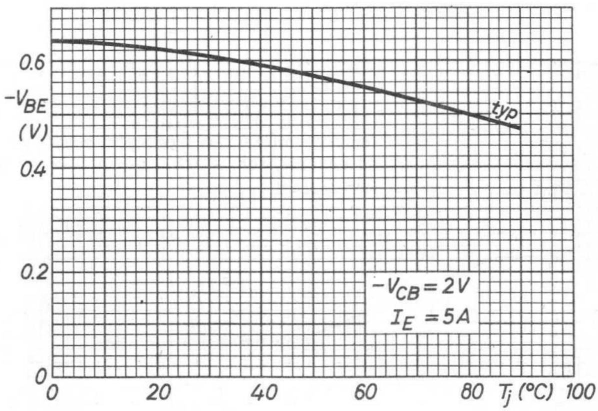

7Z02450-1.4.25.bf
T_j = 25°C
$-I_{EBO}$ (μA)
10000
2000
1000
500
200
100
50
20
10
$-V_{EB}$ (V)
0
10
20
30
40
max
typ
min

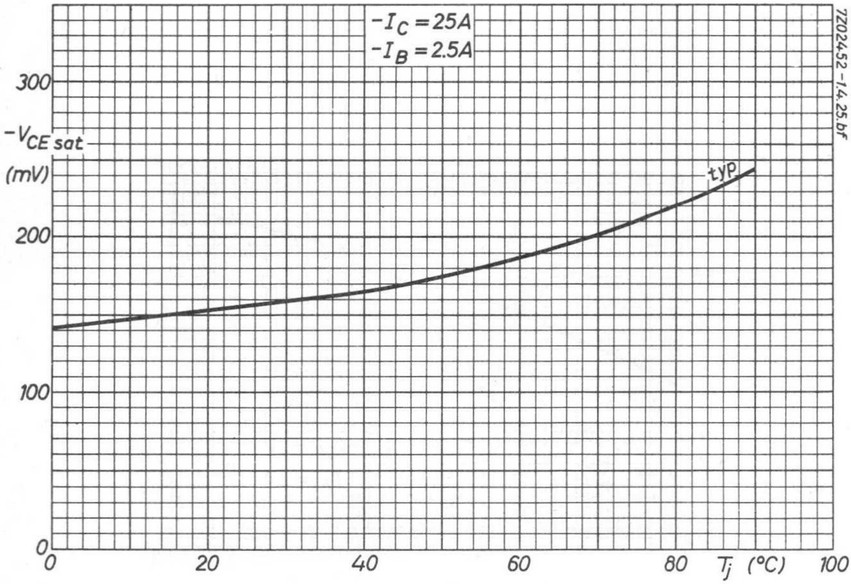

7Z02449-1.4.25.bf
T_j = 25°C
$-I_{CBO}$ (μA)
10000
2000
1000
500
200
100
50
20
10
$-V_{CB}$ (V)
0
20
40
60
80
max
typ
min


I_E = 25A
$-V_{CB}$=2V
7Z02445-1.4.25.bf
h_{FE}
30
20
10
0
0
20
40
60
80
T_j (°C)
100
typ

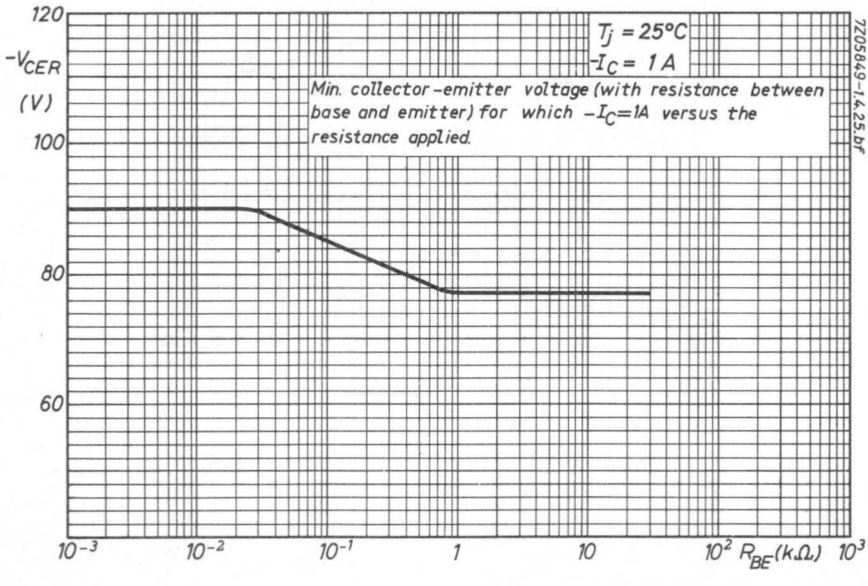

T_j = 25°C
V_{CB} = 0V
7Z02455-1.4.25.bF
h_{FE}
250
200
150
100
50
0
1
2
5
10
20
50
I_E (A)
100
max
typ
min


7Z02447-1.4.25.bf
typ
80
h_{FE}
60
40
20
0
20
40
60
80
T_j (°C)
100
$-V_{CB} = 2V$
$I_E = 5A$

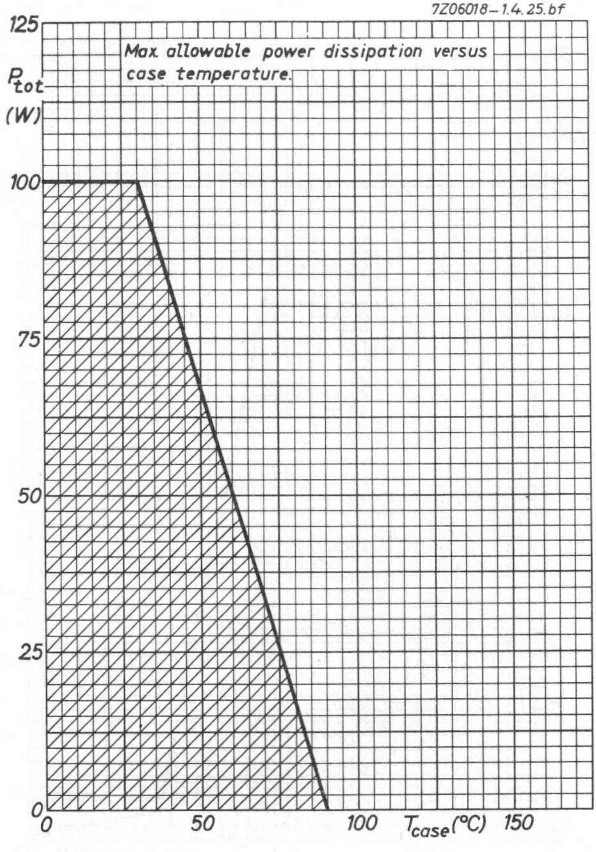

0.6
$-V_{BE}$
(V)
0.4
0.2
0
typ
0
20
40
60
80
T_j (°C)
100
$-V_{CB} = 2V$
$I_E = 5A$

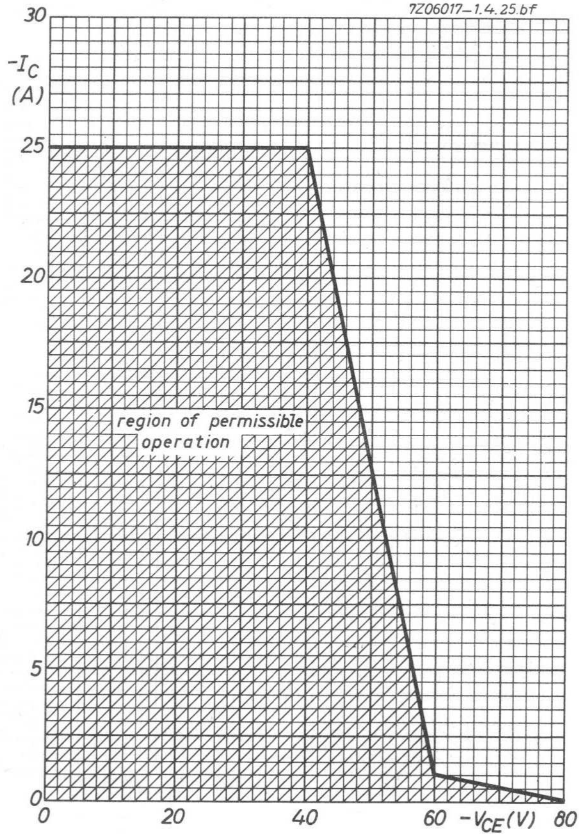


$-I_C = 25A$
$-I_B = 2.5A$
7Z02452-1.4.25.bf
300
$-V_{CE\,sat}$
(mV)
200
100
0
typ
0
20
40
60
80
T_j (°C)
100



120
$-V_{CER}$
(V)
100
80
60
$T_j = 25°C$
$-I_C = 1\,A$
Min. collector-emitter voltage (with resistance between base and emitter) for which $-I_C$=1A versus the resistance applied.
7Z05849-1.4.25.bf
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
R_{BE} (kΩ)
10^3


7Z06018-1.4.25.bf
Max. allowable power dissipation versus case temperature.
125
P_{tot}
(W)
100
75
50
25
0
0
50
100
T_{case}(°C)
150


7Z06017-1.4.25.bf
30
$-I_C$
(A)
25
20
15
10
5
0
0
20
40
60
$-V_{CE}(V)$
80
region of permissible operation

GERMANIUM ALLOYED POWER TRANSISTORS

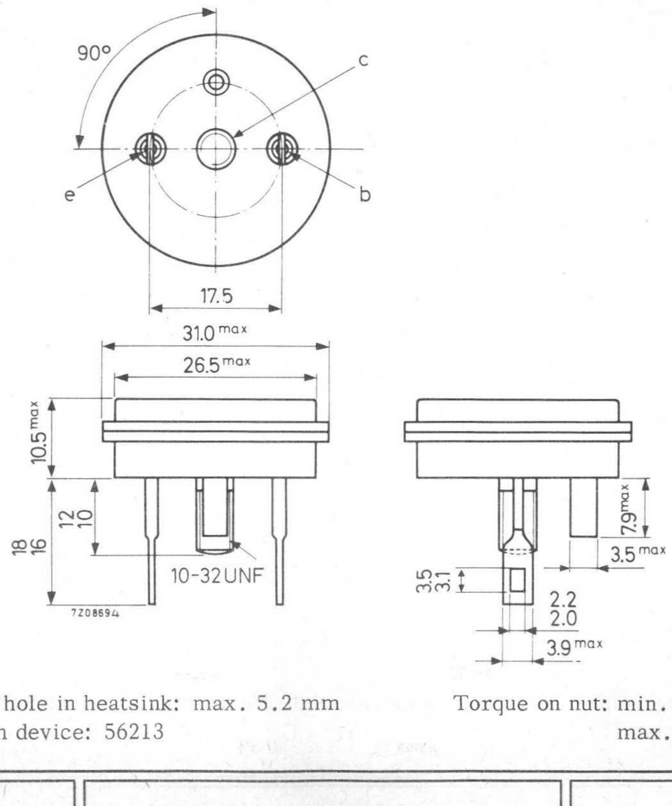
P-N-P transistors in a TO-36 metal envelope.
The ADZ11 and ADZ12 are primarily intended for use in a.f. applications.

QUICK REFERENCE DATA

			ADZ11	ADZ12	
Collector-base voltage (open-emitter)	$-V_{CBO}$	max.	50	80	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	V
Collector current (peak value)	$-I_{CM}$	max.	20		A
Total power dissipation up to T_{mb} = 55 °C	P_{tot}	max.	45		W
Junction temperature	T_j	max.	90		°C
D.C. current gain at T_j = 25 °C; $-I_C$ = 1.2 A; V_{CB} = 0	h_{FE}		40 to 120		
Cut-off frequency I_E = 1 A; $-V_{CB}$ = 12 V — ADZ11	f_{hfe}	>	80		kHz
Cut-off frequency I_E = 1 A; $-V_{CB}$ = 12 V — ADZ12	f_{hfe}	>	100		kHz

MECHANICAL DATA Dimensions in mm

TO-36



Diameter of hole in heatsink: max. 5.2 mm
Supplied with device: 56213

Torque on nut: min. 8 cmkg
max. 17 cmkg

RATINGS (Limiting values) [1]

Voltages

			ADZ11	ADZ12	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	50	80	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	30	50	V

Currents

Collector current (d.c.)	$-I_C$	max.	15	A
Collector current (peak value)	$-I_{CM}$	max.	20	A
Base current (d.c.)	$-I_B$	max.	2	A
Base current (peak value)	$-I_{BM}$	max.	4	A

Power dissipation

Total power dissipation up to T_{mb} = 55 ^oC	P_{tot}	max.	45	W

Temperatures

Storage temperature	T_{stg}		-55 to +75	^oC
Junction temperature	T_j	max.	90	^oC

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	0.8	$^oC/W$

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

CHARACTERISTICS T_{mb} = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $-V_{CB} = 2$ V	$-I_{CBO}$	<	0.2	mA
$I_E = 0$; $-V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	8	mA

Emitter cut-off current

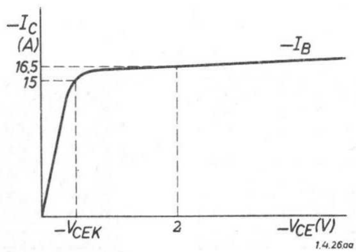
$I_C = 0$; $-V_{EB} = 2$ V	$-I_{EBO}$	<	0.2	mA
$I_C = 0$; $-V_{EB} = -V_{EBOmax}$	$-I_{EBO}$	<	8	mA

Emitter-base voltage

$-I_C$ = 1.2 A; $V_{CB} = 0$	V_{EB}	<	0.7	V
$-I_C$ = 5 A; $V_{CB} = 0$	V_{EB}	<	1.2	V
$-I_C$ = 15 A; $V_{CB} = 0$	V_{EB}	<	2	V

Knee voltage

$-I_C$ = 15 A; $-I_B$ = value for which $-I_C$ = 16.5 A at $-V_{CE}$ = 2 V	$-V_{CEK}$	<	1	V



Emitter floating voltage

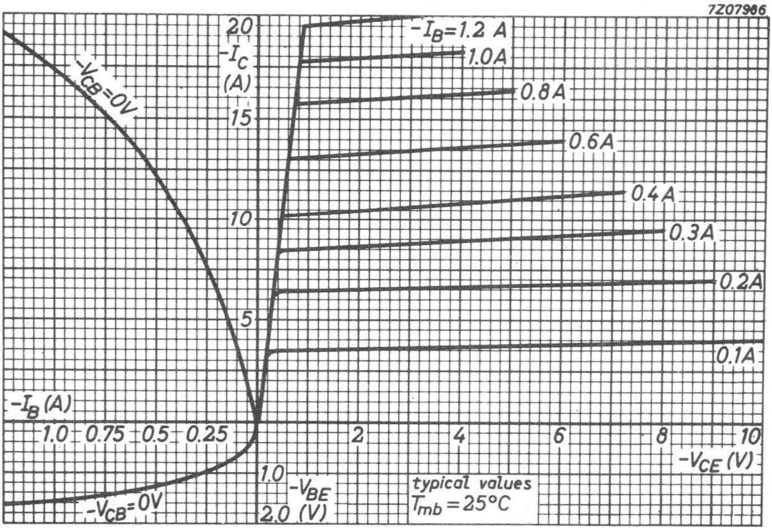
$I_E = 0$; $-V_{CB} = -V_{CBOmax}$	$-V_{EBfl}$	<	1	V

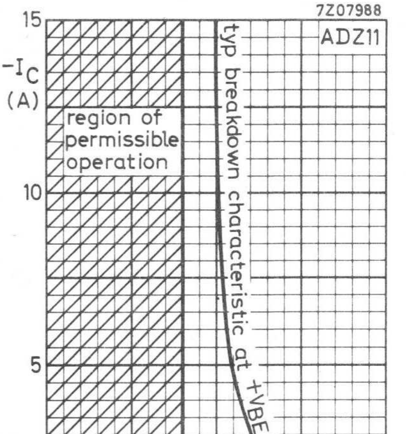
D.C. current gain

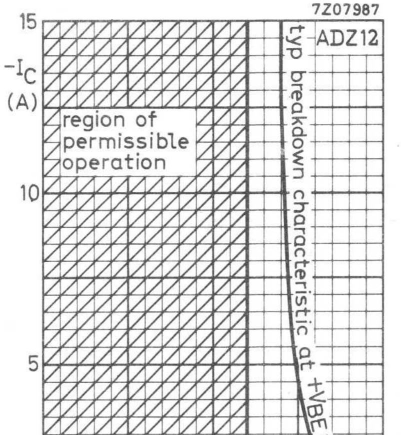
$-I_C$ = 1.2 A; $V_{CB} = 0$	h_{FE}		40 to 120
$-I_C$ = 5 A; $V_{CB} = 0$	h_{FE}	>	25
$-I_C$ = 15 A; $V_{CB} = 0$	h_{FE}	>	15

Cut-off frequency

I_E = 1 A; $-V_{CB}$ = 12 V	ADZ11:	f_{hfe}	>	80	kHz
	ADZ12:	f_{hfe}	>	100	kHz


7Z07986
$-I_C$ (A)
20
15
10
5
$-I_B$ = 1.2 A
1.0 A
0.8 A
0.6 A
0.4 A
0.3 A
0.2 A
0.1 A
$-V_{CB}$ = 0V
$-I_B$ (A)
1.0 0.75 0.5 0.25
2 4 6 8 10
$-V_{CE}$ (V)
1.0
2.0
$-V_{BE}$ (V)
typical values
T_{mb} = 25°C


7Z07988
ADZ11
$-I_C$ (A)
15
10
5
0
region of permissible operation
typ breakdown characteristic at +VBE = 2V
0 50 100
$-V_{CE}$ (V)


7Z07987
ADZ12
$-I_C$ (A)
15
10
5
0
region of permissible operation
typ breakdown characteristic at +VBE = 2V
0 50 100
$-V_{CE}$ (V)

POWER SWITCHING TRANSISTORS

P-N-P germanium low spread medium gain power transistors in a TO-3 metal case for power switching at high currents.

QUICK REFERENCE DATA

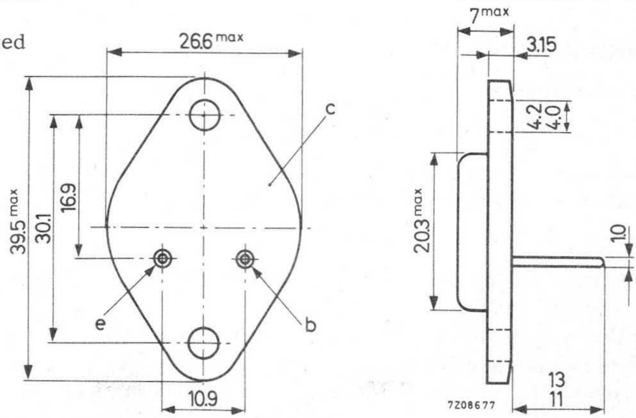
			ASZ 15	ASZ 16	ASZ 17	ASZ 18	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	100	60	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	32	32	32	V
Total power dissipation up to T_{mb} = 45 °C	P_{tot}	max.	30	30	30	30	W
Junction temperature	T_j	max.	90	90	90	90	°C
D.C. current gain at T_j = 25 °C							
$-I_C$ = 1 A; $-V_{CE}$ = 1 V	h_{FE}	>	20	45	25	30	
		<	55	130	75	110	
$-I_C$ = 6 A; $-V_{CE}$ = 1 V	h_{FE}	>	15	35	20	20	
		<	30	80	45	65	
Transition frequency							
$-I_C$ = 1 A; $-V_{CE}$ = 5 V	f_T	typ.	200	250	220	220	kHz

MECHANICAL DATA

Dimensions in mm

TO-3

Collector connected to mounting base



Accessories available: 56201e

RATINGS (Limiting values) [1])

Voltages			ASZ 15	ASZ 16	ASZ 17	ASZ 18	
Collector-base voltage (open emitter) [2])	$-V_{CBO}$	max.	100	60	60	100	V
Collector-emitter voltage (open base) (see also pages 12 and 13)	$-V_{CEO}$	max.	60	32	32	32	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	40	20	20	40	V

Currents				
Collector current (d.c.)	$-I_C$	max.	8	A
Collector current (peak value)	$-I_{CM}$	max.	10	A
Emitter current (d.c.)	I_E	max.	9	A
Emitter current (peak value	I_{EM}	max.	12	A
Base current (d.c.)	$-I_B$	max.	1	A
Base current (peak value)	$-I_{BM}$	max.	2	A
Power dissipation (see also page 9)				
Total power dissipation up to T_{mb} = 45 °C	P_{tot}	max.	30	W
Temperatures				
Storage tmperature	T_{stg}		-65 to +90	°C
Junction temperature: continuous	T_j	max.	90	°C
incidentally	T_j	max.	100	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1.5	°C/W
From mounting base to heatsink	$R_{th\ mb\text{-}h}$	=	0.2	°C/W
From mounting base to heatsink with lead washer and mica washer	$R_{th\ mb\text{-}h}$	=	0.5	°C/W

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[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

[2]) When switched from a thermally stable on state with max. junction temperature to a not stabilized cut-off condition, $-V_{CBOmax}$ is allowed, provided T_{amb} < 55 °C and $R_{th\ j\text{-}a}$ < 9 °C/W for ASZ16 and ASZ17
$R_{th\ j\text{-}a}$ < 5 °C/W for ASZ15 and ASZ18

CHARACTERISTICS $T_j = 25\ ^oC$ unless otherwise specified

Collector current

$I_E = 0; -V_{CB} = 0.5$ V	$-I_{CBO}$	<	0.1	mA
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	3.0	mA
$I_E = 0; -V_{CB} = -V_{CBOmax}$; $T_j = 100\ ^oC$	$-I_{CBO}$	<	30	mA

Emitter current

$I_C = 0; -V_{EB} = -V_{EBOmax}$	$-I_{EBO}$	<	3.0	mA

			ASZ15	ASZ16	ASZ17	ASZ18	
Base current							
$I_E = 1$ A; $V_{CB} = 0$	$-I_B$	>	17.5	7.2	13	9	mA
		<	50	21.5	38	33	mA
$I_E = 6$ A; $V_{CB} = 0$	$-I_B$	>	190	73	130	90	mA
		<	375	165	285	285	mA
Emitter-base voltage							
$I_E = 6$ A; $V_{CB} = 0$	V_{EB}	>	0.6	-	0.4	-	V
		<	1.6	1.4	1.4	1.6	V
Saturation voltages							
$-I_C = 10$ A; $-I_B = 1$ A	$-V_{CEsat}$	<	0.4	0.4	0.4	0.4	V
	$-V_{BEsat}$	<	1.4	1.4	1.4	1.4	V
Emitter-base floating voltage							
$I_E = 0; -V_{CB} = 60$ V	$-V_{EBfl}$	<	0.5	-	-	0.5	V
$I_E = 0; -V_{CB} = 48$ V	$-V_{EBfl}$	<	-	0.5	0.5	-	V
D.C. current gain							
$-I_C = 1$ A; $-V_{CE} = 1$ V	h_{FE}	>	20	45	25	30	
		<	55	130	75	110	
$-I_C = 6$ A; $-V_{CE} = 1$ V	h_{FE}	>	15	35	20	20	
		<	30	80	45	65	
Transition frequency							
$-I_C = 1$ A; $-V_{CE} = 5$ V	f_T	typ.	200	250	220	220	kHz
Collector capacitance (f = 500 kHz)							
$I_E = I_e = 0; -V_{CB} = 5$ V	C_c	typ.	190	190	190	190	pF
Emitter capacitance (f = 500 kHz)							
$I_C = I_c = 0; -V_{EB} = 5$ V	C_e	typ.	150	150	150	150	pF

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

D.C. current gain ratio
of matched pairs

$-I_C$ = 0.3 A	h_{FE1}/h_{FE2}	<	1.25
$-I_C$ = 6.0 A	h_{FE1}/h_{FE2}	<	1.25

Switching times

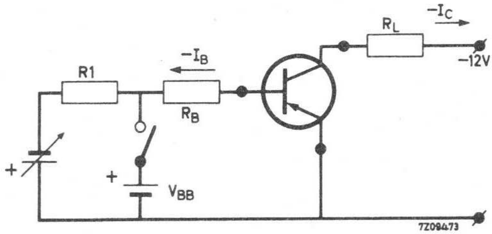
Circuit I: R_B = 10 Ω; R1 = 220 Ω; R_L = 12 Ω

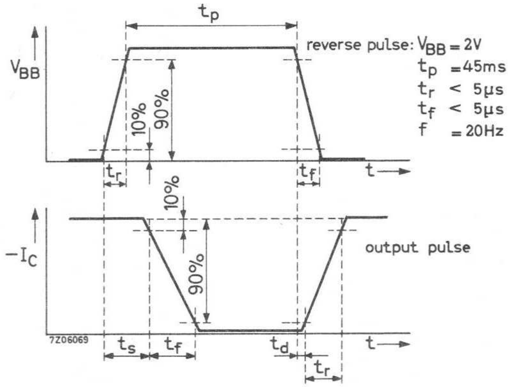
ASZ15: $-I_B$ = 75 mA	$-I_C$ = 1 A	delay time	t_d	<	2	μs
ASZ16: $-I_B$ = 35 mA		rise time	t_r	<	25	μs
ASZ17: $-I_B$ = 60 mA		storage time	t_s	<	10	μs
ASZ18: $-I_B$ = 50 mA		fall time	t_f	<	20	μs

Circuit II: R_B = 1 Ω; R1 = 13 Ω; R_L = 1.2 Ω

ASZ15: $-I_B$ = 1.35 A	$-I_C$ = 10 A	delay time	t_d	<	1	μs
ASZ16: $-I_B$ = 0.6 A		rise time	t_r	<	20	μs
ASZ17: $-I_B$ = 1.0 A		storage time	t_s	<	15	μs
ASZ18: $-I_B$ = 1.0 A		fall time	t_f	<	35	μs

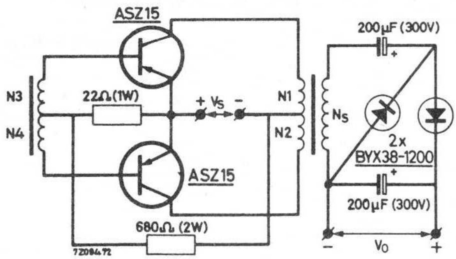
Test circuit:





APPLICATION INFORMATION

Typical operation in a d.c. to d.c. converter



The data below have been designed for continuous operation up to T_{amb} = 55 °C. Incidentally, operation up to T_{amb} = 60 °C is permitted.
(Based on $R_{th\ j\text{-}a}$ = 15 °C/W per transistor)

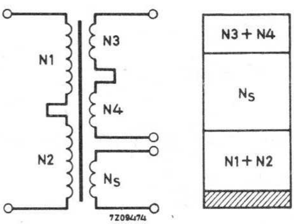
V_S	=	28	V
I_S	=	2.5	A
P_S	=	70	W
V_O	=	220	V
I_O	=	270	mA
P_O	=	60	W
η	=	86	%
f	=	450	Hz

Losses

In transistors	:	2x2	W
In diodes	:	2x0.3	W
In biasing resistors	:	1.7	W
In transformer	:	3.7	W

Transformer data

The transformer core consists of square loop material
(Telcon HCR alloy type 227)
Stacking height = 15 mm



N1 + N2
N3 + N4 are bifilarly wound

N1 = N2 = 46 turns of enamelled copper wire, 1 mm

N3 = N4 = 5 turns of enamelled copper wire, 0.5 mm

N_S = 190 turns of enamelled copper wire, 0.5 mm

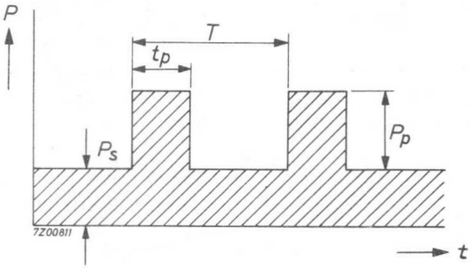
OPERATING NOTES

Determination of peak power ratings under fault conditions and/or surge operation shorter than the temperature stabilisation time

$$P_p = \frac{T_{j\,max} - T_{amb} - (R_{th\,j\text{-}mb} + R_{th\,mb\text{-}h} + R_{th\,h\text{-}a}) \cdot P_s}{R_{th\,t} + \delta \cdot R_{th\,h\text{-}a}}$$

For a pulse duration, longer than the temperature stabilisation time

$$P_p = \frac{T_{j\,max} - T_{amb}}{R_{th\,j\text{-}mb} + R_{th\,mb\text{-}h} + R_{th\,h\text{-}a}} - P_s$$



Where:

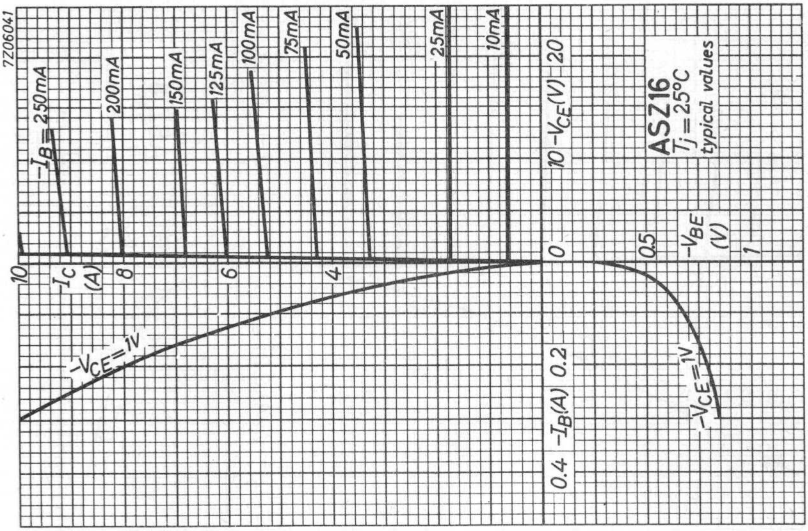
t_p = pulse duration
T = pulse period
δ = duty cycle = t_p/T
P_s = steady state power dissipation
P_p = permissible pulse power dissipation over P_s
$R_{th\,j\text{-}mb}$ = thermal resistance from junction to mounting base
$R_{th\,mb\text{-}h}$ = thermal resistance from mounting base to heatsink
$R_{th\,h\text{-}a}$ = thermal resistance from heatsink to ambient
$R_{th\,t}$ = transient thermal resistance = $f(t, \delta)$; see page 14
(for durations longer than the temperature stabilisation time
$R_{th\,t} = R_{th\,j\text{-}h} = R_{th\,j\text{-}mb} + R_{th\,mb\text{-}h}$)
$T_{j\,max}$ = maximum permissible junction temperature
T_{amb} = ambient temperature

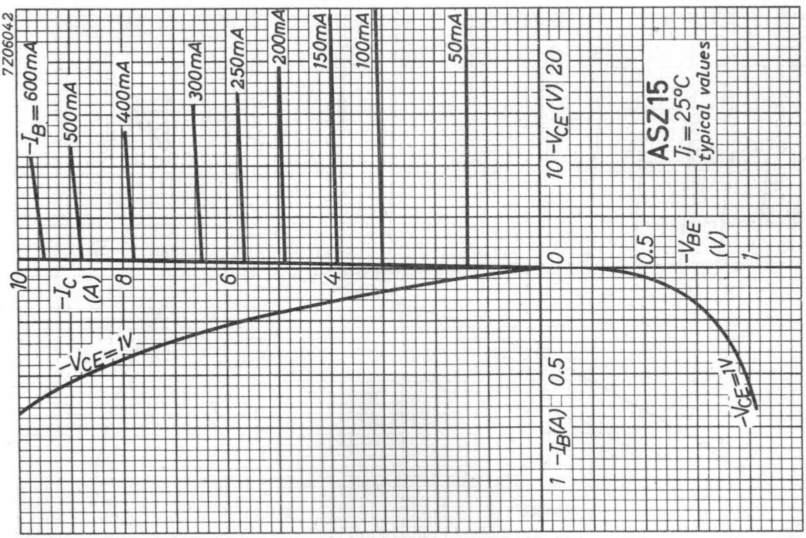
Temperature stabilisation time = 1 s (see page 14)

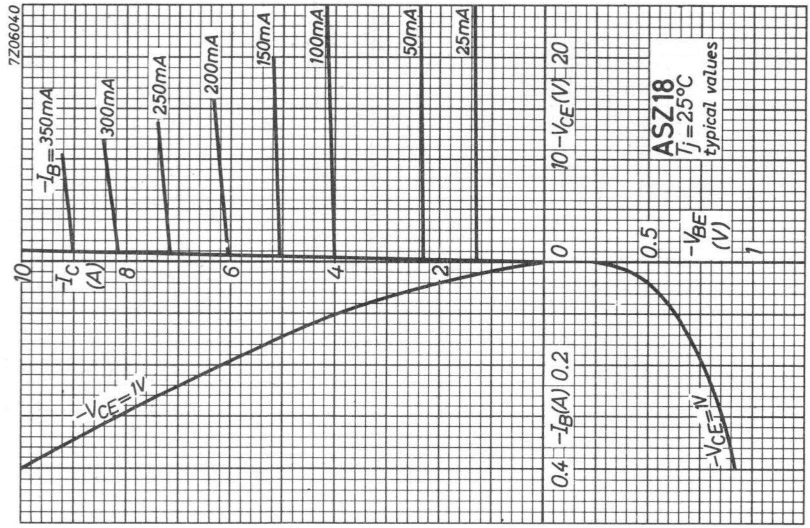
Example: $P_s = 5$ W, $t = 1$ ms, $\delta = 0.1$, $R_{th\,mb\text{-}h} = 0.5$ °C/W, $R_{th\,h\text{-}a} = 4.25$ °C/W and $T_{amb} = 25$ °C

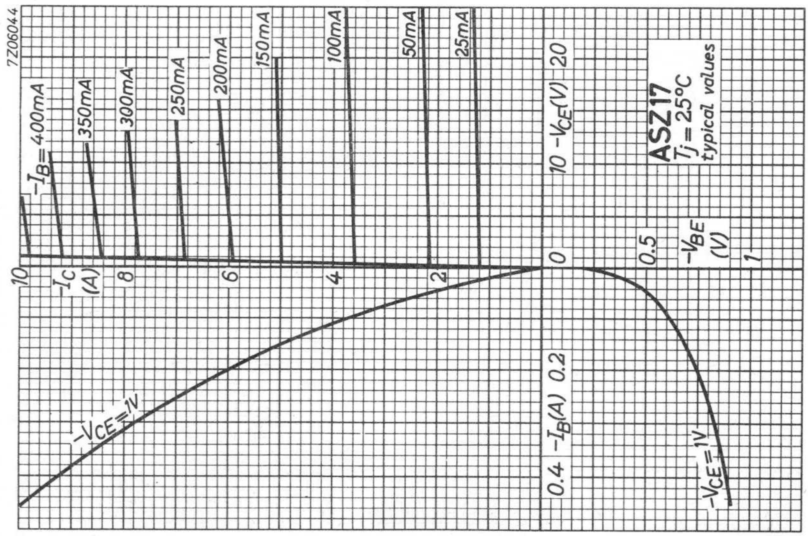
From $t = 1$ ms and $\delta = 0.1$ it follows that $R_{th\,t} = 0.28$ °C/W(page 14)

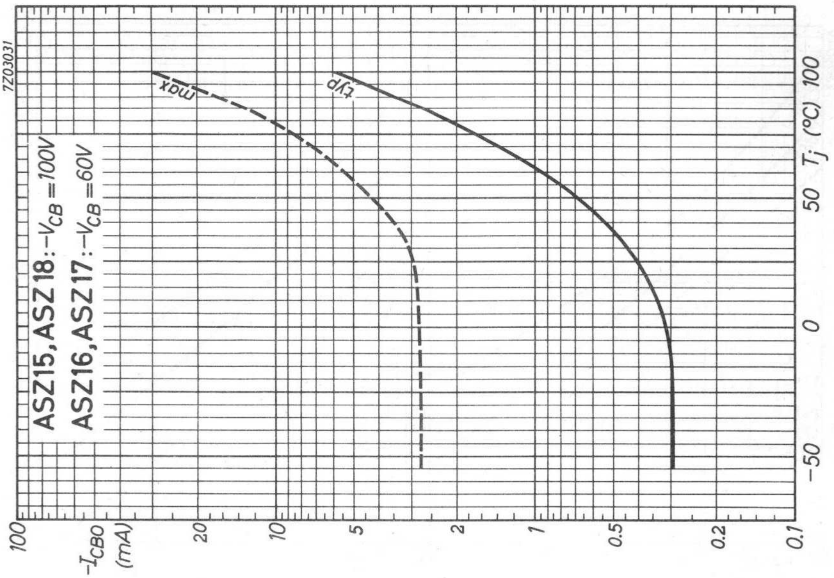
Then $P_p = \dfrac{90 - 25 - (1.5 + 0.5 + 4.25) \times 5}{0.28 + 0.1 \times 4.25} \approx 47.5$ W

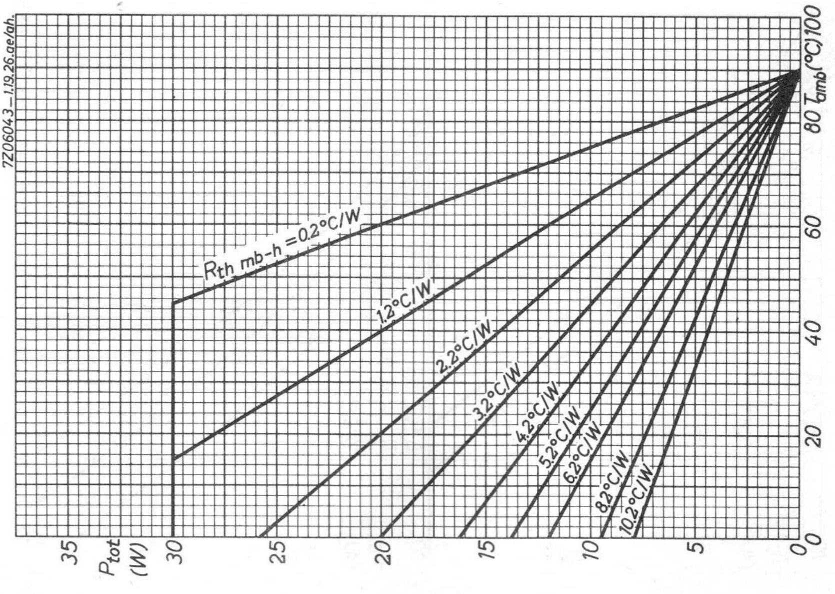

7Z06041
$-I_B$ = 250mA
200mA
150mA
125mA
100mA
75mA
50mA
25mA
10mA
10
$-I_C$ (A)
8
6
4
0
10 $-V_{CE}$(V) 20
0.5
$-V_{BE}$ (V)
1
$-V_{CE}$=1V
0.4 $-I_B$(A) 0.2
$-V_{CE}$=1V
ASZ16
T_j = 25°C
typical values

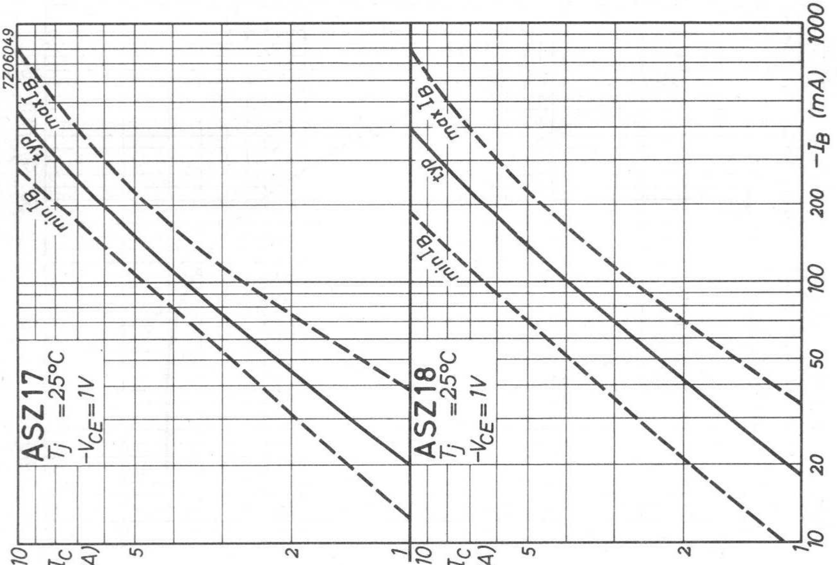

7Z06042
$-I_B$ = 600mA
500mA
400mA
300mA
250mA
200mA
150mA
100mA
50mA
10
$-I_C$ (A)
8
6
4
0
10 $-V_{CE}$(V) 20
0.5
$-V_{BE}$ (V)
1
$-V_{CE}$=1V
1 $-I_B$(A) 0.5
$-V_{CE}$=1V
ASZ15
T_j = 25°C
typical values

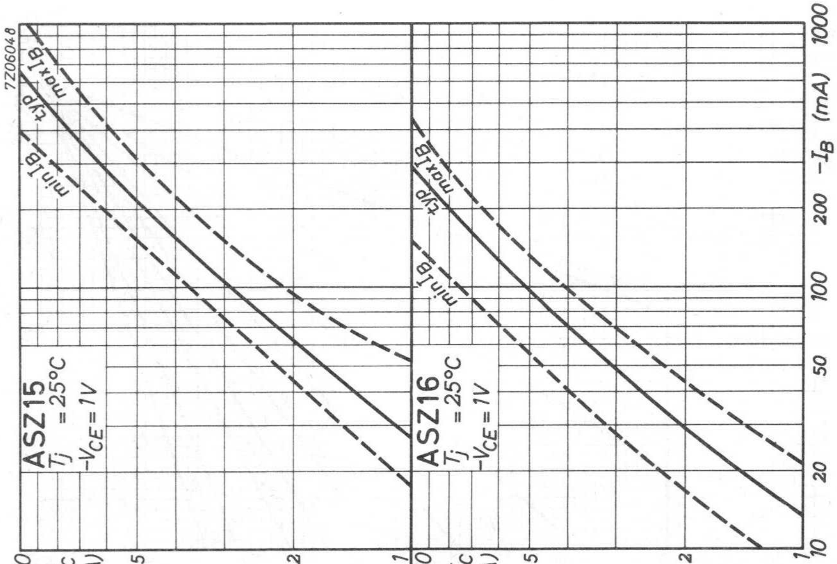

7Z06040
ASZ18
$T_j = 25°C$
typical values
$-I_B = 350mA$
300mA
250mA
200mA
150mA
100mA
50mA
25mA
$-I_C$ (A)
$-V_{CE}$ (V)
$-I_B$ (A)
$-V_{BE}$ (V)
$-V_{CE} = 1V$
$-V_{CE} = 1V$

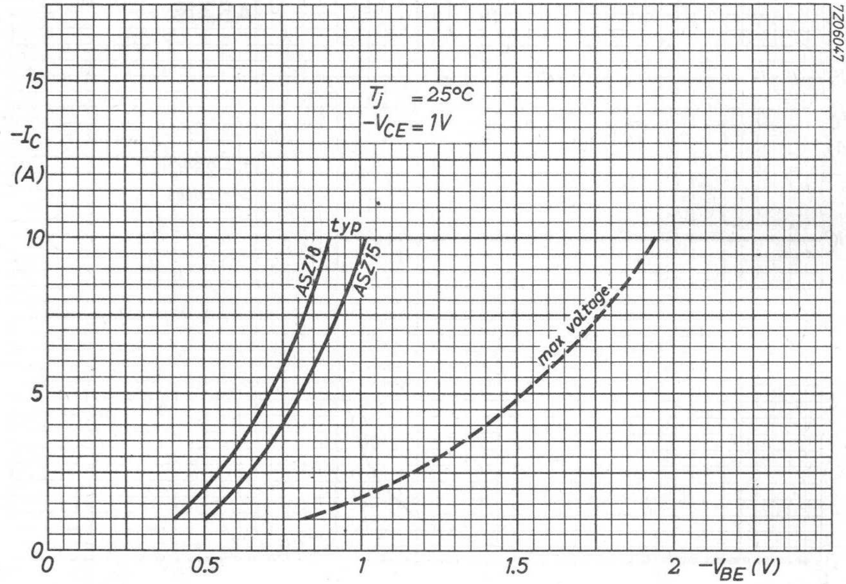

7Z06044
ASZ17
$T_j = 25°C$
typical values
$-I_B = 400mA$
350mA
300mA
250mA
200mA
150mA
100mA
50mA
25mA
$-I_C$ (A)
$-V_{CE}$ (V)
$-I_B$ (A)
$-V_{BE}$ (V)
$-V_{CE} = 1V$
$-V_{CE} = 1V$

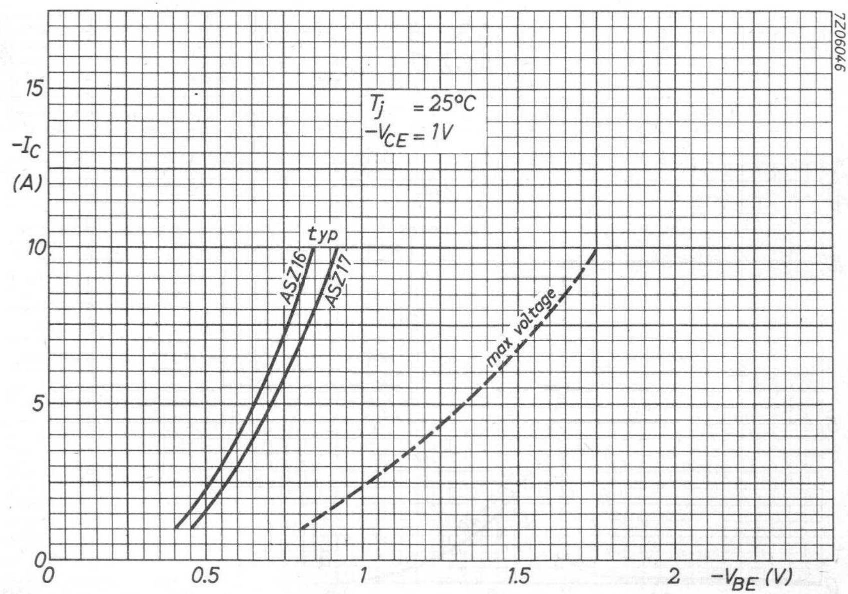

7Z03031
ASZ15, ASZ18: $-V_{CB} = 100V$
ASZ16, ASZ17: $-V_{CB} = 60V$
max
typ
$-I_{CBO}$ (mA)
T_j (°C)

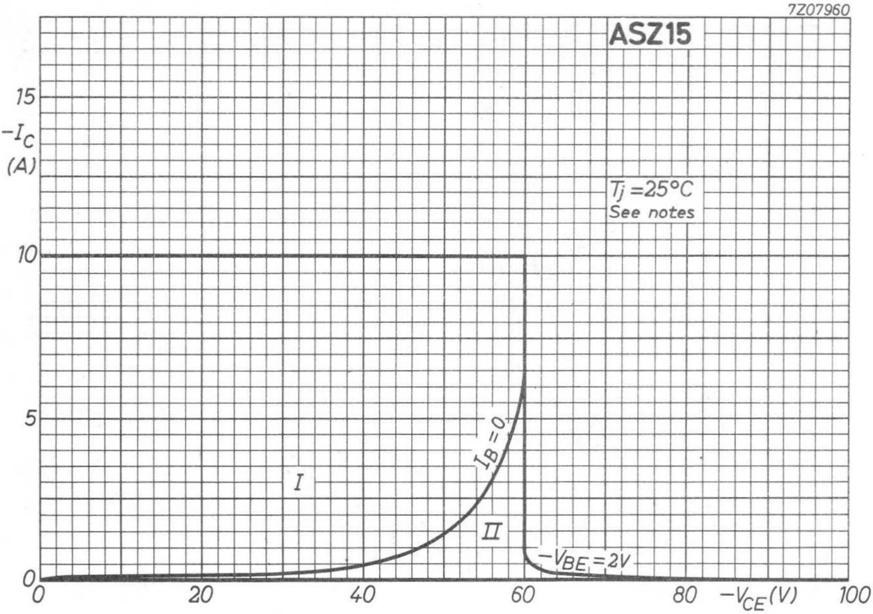

7Z0604 3—1.19.26.ae/ah.
$R_{th\ mb-h} = 0.2$°C/W
1.2°C/W
2.2°C/W
3.2°C/W
4.2°C/W
5.2°C/W
6.2°C/W
8.2°C/W
10.2°C/W
P_{tot} (W)
T_{amb} (°C)


7Z06049
ASZ17
T_j = 25°C
$-V_{CE}$ = 1V
ASZ18
T_j = 25°C
$-V_{CE}$ = 1V
max I_B
typ
min I_B
$-I_C$ (A)
$-I_B$ (mA)
10
5
2
1
10
20
50
100
200
1000

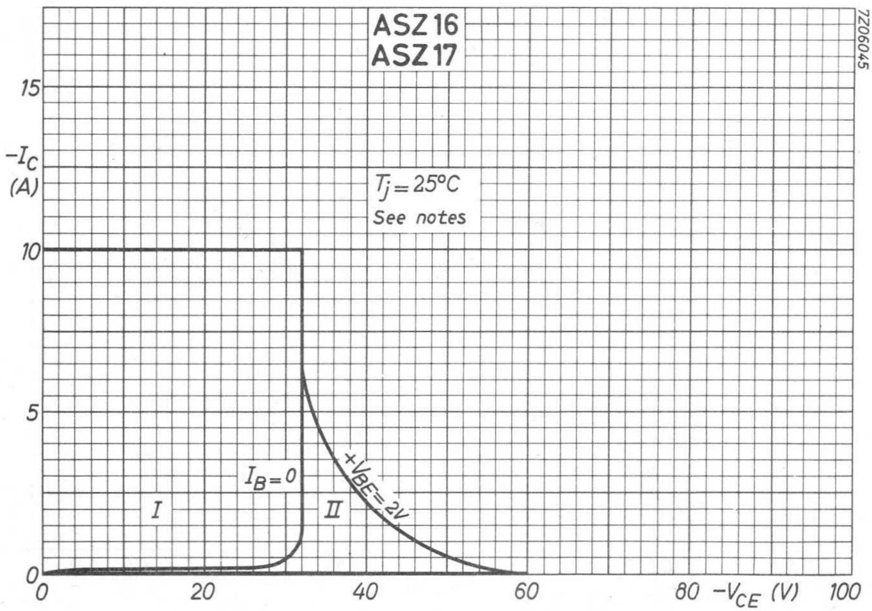

7Z06048
ASZ15
T_j = 25°C
$-V_{CE}$ = 1V
ASZ16
T_j = 25°C
$-V_{CE}$ = 1V
max I_B
typ
min I_B
$-I_C$ (A)
$-I_B$ (mA)
10
5
2
1
10
20
50
100
200
1000


7Z06047
T_j = 25°C
$-V_{CE}$ = 1V
$-I_C$
(A)
15
10
5
0
typ
ASZ18
ASZ15
max voltage
0
0.5
1
1.5
2
$-V_{BE}$ (V)

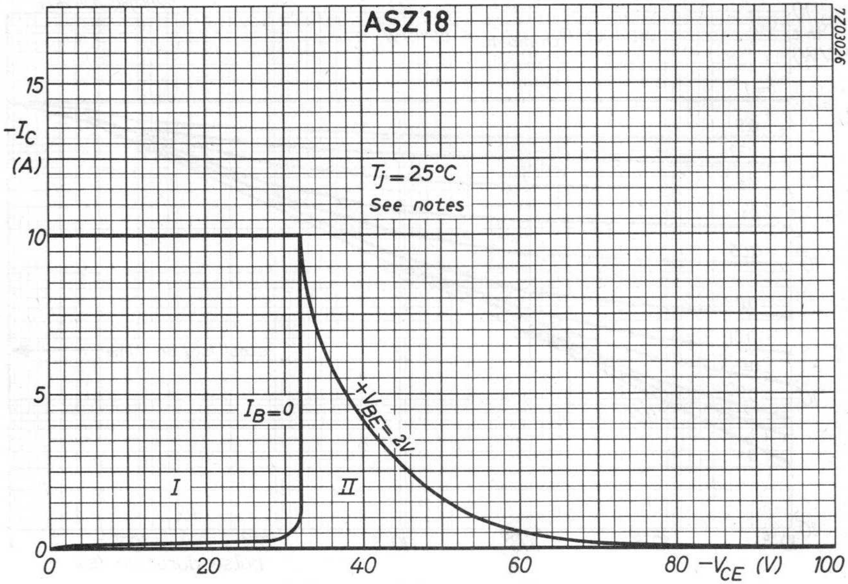

7Z06046
T_j = 25°C
$-V_{CE}$ = 1V
$-I_C$
(A)
15
10
5
0
typ
ASZ16
ASZ17
max voltage
0
0.5
1
1.5
2
$-V_{BE}$ (V)



7Z07960
ASZ15
15
$-I_C$
(A)
T_j =25°C
See notes
10
5
0
I_B=0
I
II
$-V_{BE}$=2V
0
20
40
60
80
$-V_{CE}$(V)
100



7Z06045
ASZ16
ASZ17
15
$-I_C$
(A)
T_j= 25°C
See notes
10
5
0
I_B=0
I
II
$+V_{BE}$=2V
0
20
40
60
80
$-V_{CE}$ (V)
100

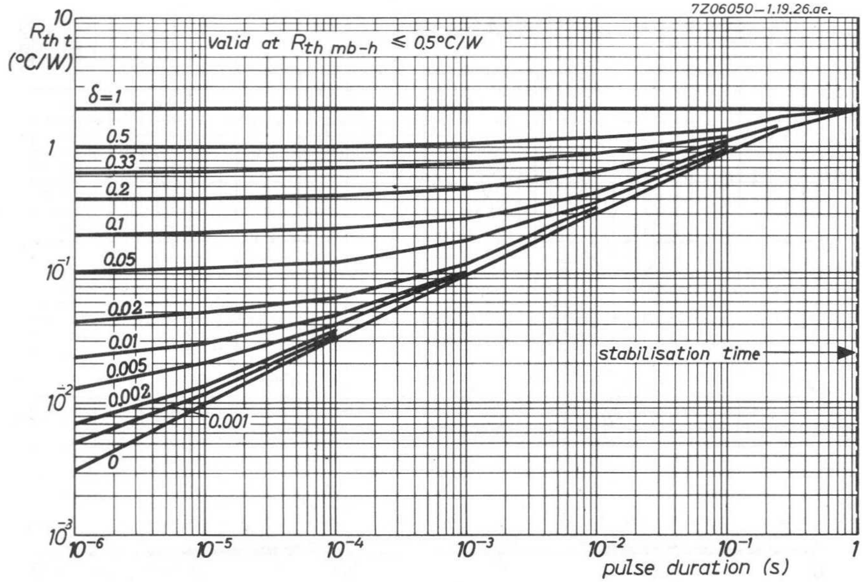


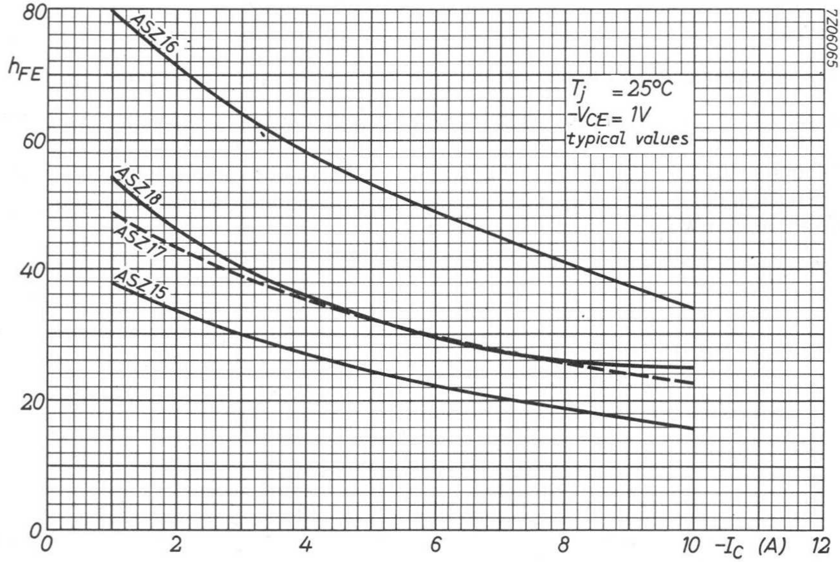
NOTES

I region of permissible operation under all base-emitter conditions

II additional region of operation when the transistor is cut-off with $+V_{BE}$ = 2 V

During switching-off, voltages higher than indicated by the minimum avalanche breakdown curves at $+V_{BE}$ = 2 V are allowed, provided the transient energy is less than 8 mWs.


7Z06050-1.19.26.ae.
$R_{th\,t}$ (°C/W)
Valid at $R_{th\,mb-h} \leqslant 0.5$°C/W
δ=1
0.5
0.33
0.2
0.1
0.05
0.02
0.01
0.005
0.002
0.001
0
stabilisation time
pulse duration (s)


7Z06065
h_{FE}
ASZ16
ASZ18
ASZ17
ASZ15
T_j = 25°C
$-V_{CE}$ = 1V
typical values
$-I_C$ (A)

POWER SWITCHING TRANSISTOR

P-N-P alloy diffused transistor for non-saturated switching.

RATINGS [1])

Voltages

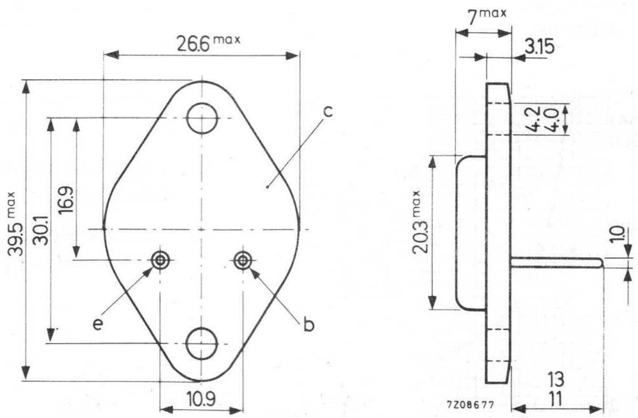
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	70	V
Collector-emitter voltage with $+V_{BE} > 0.2$ V	$-V_{CEX}$	max.	60	V
Currents				
Collector current (d.c.)	$-I_C$	max.	700	mA
Emitter current (d.c.)	I_E	max.	750	mA
Reverse emitter current	$-I_E$	max.	50	mA
Base current (peak value)	$-I_{BM}$	max.	750	mA
Power dissipation				
Total power dissipation up to $T_{mb} = 50$ °C	P_{tot}	max.	6	W
Temperatures				
Storage temperature	T_{stg}	-55 to +75		°C
Junction temperature	T_j	max.	75	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	4	°C/W
From mounting base to heatsink with lead washer and mica washer	$R_{th\ mb\text{-}h}$	=	0.5	°C/W

MECHANICAL DATA

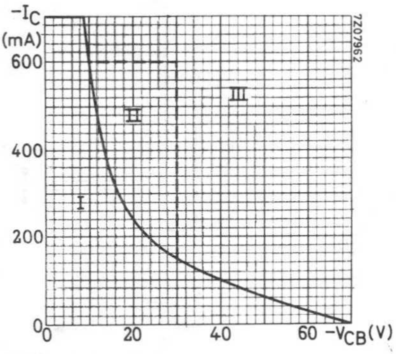
Collector connected to mounting base



[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off currents				
$I_E = 0$; $-V_{CB} = 60$ V; $T_j = 75$ °C	$-I_{CBO}$	<	4.5	mA
$R_{BE} = 56\ \Omega$; $-V_{CE} = 60$ V; $T_{mb} = 60$ °C	$-I_{CER}$	<	2	mA
Currents at reverse biased emitter junction				
$+V_{BE} = 1$ V; $-V_{CE} = 60$ V; $T_{mb} = 60$ °C	$-I_{CEX}$	<	1	mA
	$+I_{BEX}$	<	1	mA
Emitter-base voltage				
$I_E = 600$ mA; $-V_{CB} = 10$ V; $T_{mb} = 60$ °C	V_{EB}	>	0.1	V
$I_E = 600$ mA; $-V_{CB} = 10$ V; $T_{mb} = 25$ °C	V_{EB}	<	0.45	V
D.C. current gain				
$I_E = 600$ mA; $-V_{CB} = 10$ V; $T_{mb} = 25$ °C	h_{FE}	>	40	
$I_E = 600$ mA; $-V_{CB} = 30$ V; $T_j = 75$ °C	h_{FE}	>	100	
Collector capacitance				
$I_E = I_e = 0$; $-V_{CB} = 10$ V	C_c	<	85	pF
$I_E = I_e = 0$; $-V_{CB} = 30$ V	C_c	<	45	pF
Transition frequency				
$-I_C = 300$ mA; $-V_{CE} = 10$ V	f_T	>	60	MHz
		typ.	120	MHz
Switching times				
delay time	t_d	<	0.2	μs
rise time	t_r	<	0.2	μs
fall time	t_f	<	0.2	μs



I Region of permissible d.c. operation up to T_j = 75 °C

II Additional region of permissible pulse operation $t_p < 10$ μs; $\delta < 0.25$

III Permissible at switching off, provided $L < 250$ μH; $t_{off} < 15$ μs

HIGH VOLTAGE SILICON TRANSISTOR

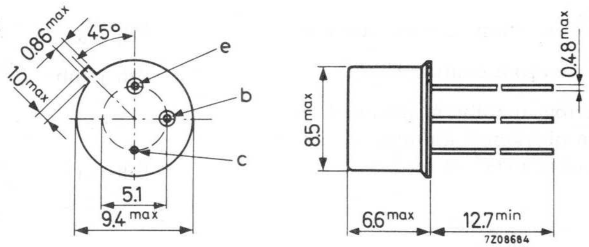
N-P-N silicon planar transistor in a TO-39 metal envelope with the collector connected to the case.
The transistor is intended for use in high voltage 2 W class A output stages of a.f. amplifiers, video amplifiers in colour television receivers including grid drive and in driver stages of high voltage line-deflection circuits.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	245	V
Collector-emitter voltage (open base)	V_{CEO}	max.	180	V
Collector current (peak value)	I_{CM}	max.	200	mA
Total power dissipation up to T_{amb} = 50 °C (device mounted on a heatsink)	P_{tot}	max.	6	W
D.C. current gain at T_j = 25 °C; I_C = 50 mA; V_{CE} = 100 V	h_{FE}	>	22	
		typ.	60	

MECHANICAL DATA

Dimensions in mm

Collector connected to case
TO-39



Accessories available: 56218; 56245; 56265

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	245	V [1]
Collector-emitter voltage (open base) (See also page 4)	V_{CEO}	max.	180	V
Collector-emitter voltage with $R_{BE} \leq 1$ kΩ	V_{CER}	max.	245	V [1]
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Currents

Collector current (d.c.)	I_C	max.	150	mA
Collector current (peak value)	I_{CM}	max.	200	mA

Power dissipation

Total power dissipation up to T_{amb} = 50 °C mounted on a 1.5 mm Al. blackened heatsink of at least 30 cm² (See also page 4)	P_{tot}	max.	6	W

Temperatures

Storage temperature	T_{stg}		-55 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

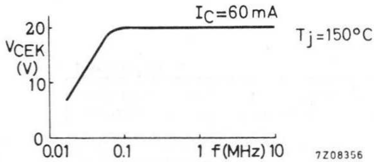
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	200	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	12.5	°C/W
From junction to ambient mounted on a 1.5 mm blackened aluminium heatsink of at least 30 cm²	$R_{th\ j\text{-}a}$	=	25	°C/W

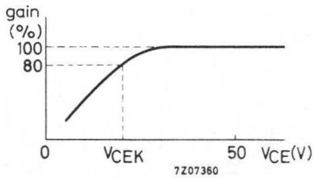
[1]) During switching on, a supply voltage of 1.2 times the rated V_{CER} value is permitted. The current must be limited so that maximum dissipation and maximum junction temperature are not exceeded.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 200$ V; $T_j = 200$ °C	I_{CBO}	typ.	550	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	100	μA
Base-emitter voltage [1]				
$I_C = 50$ mA; $V_{CE} = 100$ V	V_{BE}	<	1	V
Saturation voltage				
$I_C = 100$ mA; $I_B = 10$ mA	V_{CEsat}	typ.	6.5	V
		<	9	V
High frequency knee voltage at $T_j = 150$ °C				
$I_C = 60$ mA	V_{CEK}	typ.	20	V

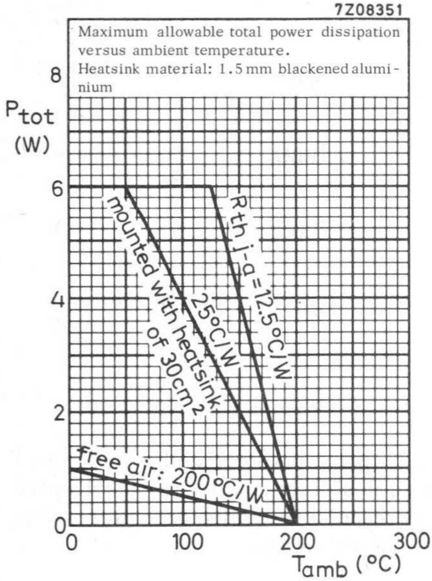
The high frequency knee voltage of a transistor is that value of the collector-emitter voltage at which the small signal gain, measured in a practical circuit, has dropped to 80% of the gain at $V_{CE} = 50$ V. A further decrease of the collector-emitter voltage results in a rapid increase of the distortion of the signal.

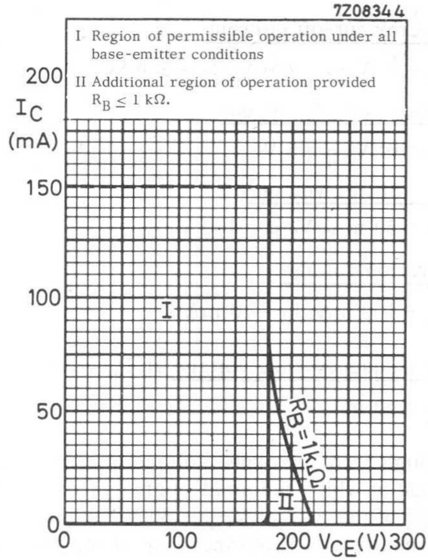


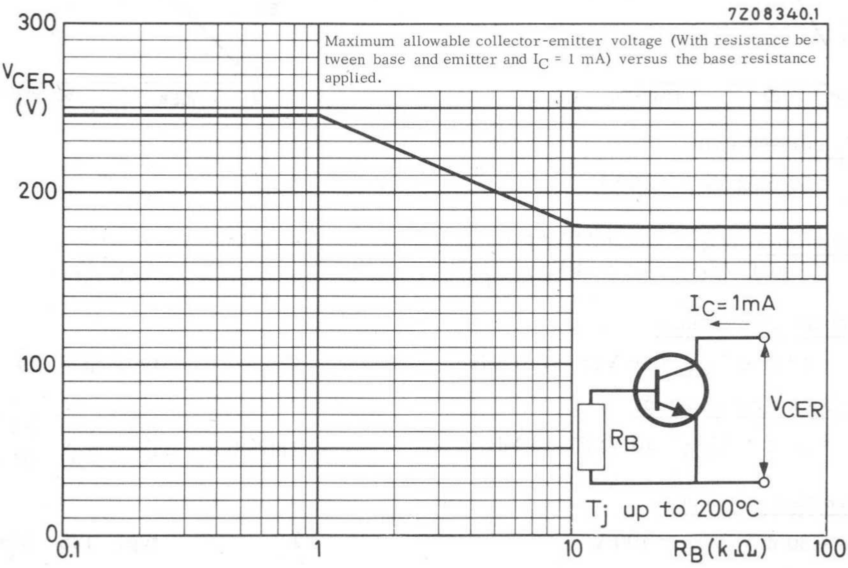


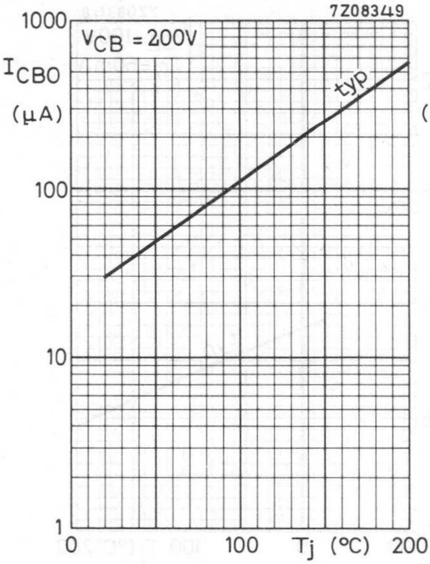
D.C. current gain				
$I_C = 50$ mA; $V_{CE} = 100$ V	h_{FE}	>	22	
		typ.	60	
Ratio of h_{FE} at $I_C = 100$ mA; $V_{CE} = 15$ V and at $I_C = 10$ mA; $V_{CE} = 165$ V		typ.	1.1	
Feedback capacitance				
$I_C = 10$ mA; $V_{CE} = 20$ V; f = 1.0 MHz	$-C_{re}$	typ.	3.5	pF
Feedback time constant				
$-I_E = 10$ mA; $V_{CB} = 10$ V; f = 10 MHz	$r_{bb'}C_{b'c}$	typ.	30	ps
		<	100	ps
Transition frequency				
$I_C = 30$ mA; $V_{CE} = 100$ V	f_T	typ.	145	MHz

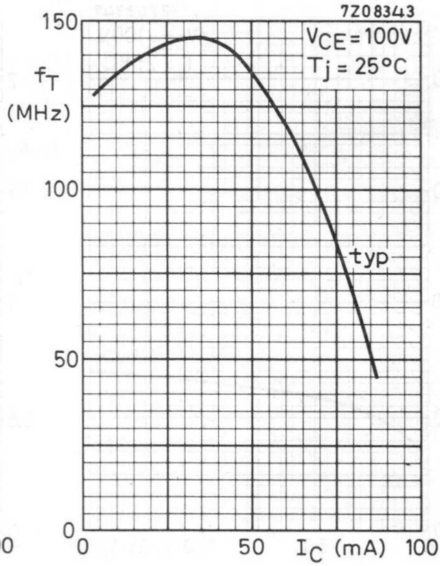
[1] V_{BE} decreases by about 2 mV/°C with increasing temperature.

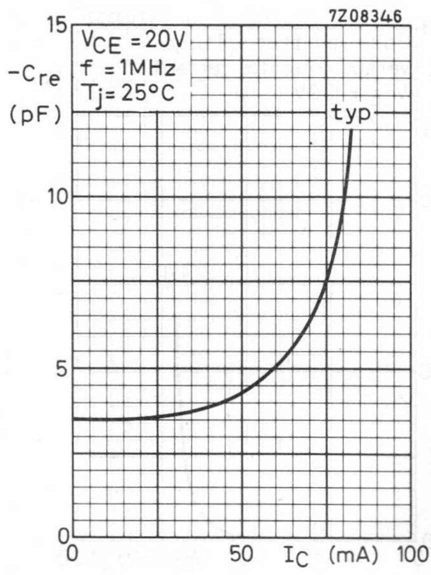

7Z08351
Maximum allowable total power dissipation versus ambient temperature.
Heatsink material: 1.5 mm blackened aluminium
Ptot (W)
Rth j-a = 12.5 °C/W
25 °C/W mounted with heatsink of 30cm2
free air: 200 °C/W
Tamb (°C)

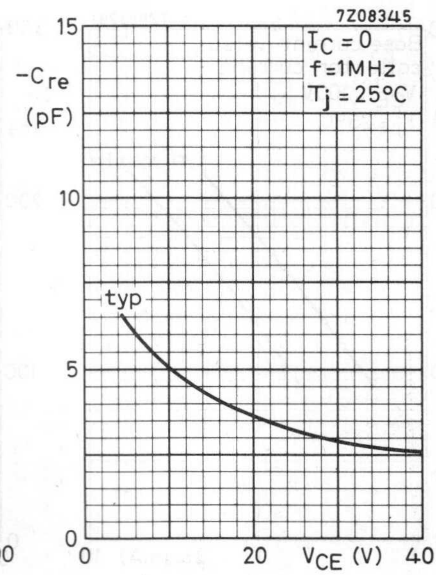

7Z08344
I Region of permissible operation under all base-emitter conditions
II Additional region of operation provided RB ≤ 1 kΩ.
IC (mA)
I
II
RB = 1kΩ
VCE (V)

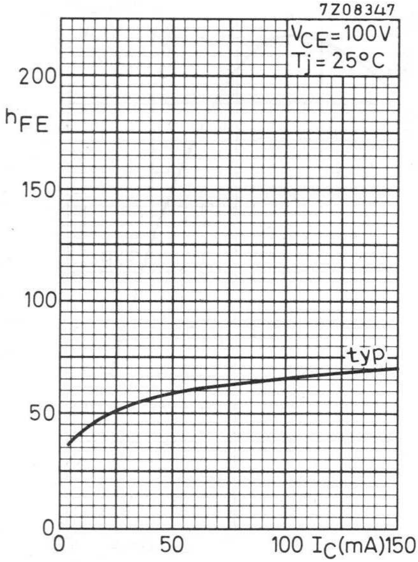

7Z08340.1
Maximum allowable collector-emitter voltage (With resistance between base and emitter and IC = 1 mA) versus the base resistance applied.
VCER (V)
IC = 1mA
VCER
RB
Tj up to 200°C
RB (kΩ)

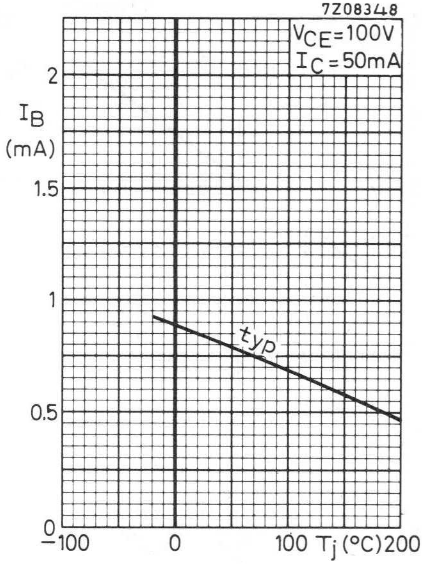

7Z08349
V_{CB} = 200V
I_{CBO}
(μA)
typ
1000
100
10
1
0
100
200
T_j (°C)

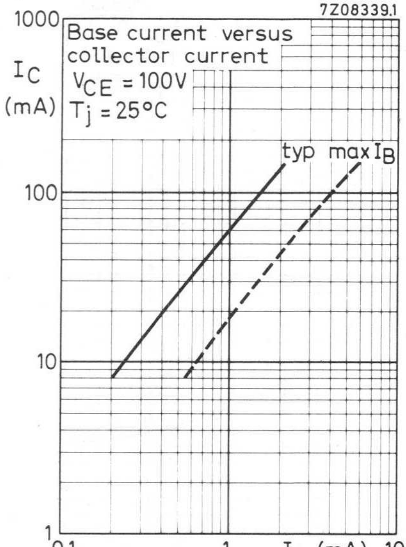

7Z08343
V_{CE} = 100V
T_j = 25°C
f_T
(MHz)
typ
150
100
50
0
50
100
I_C (mA)

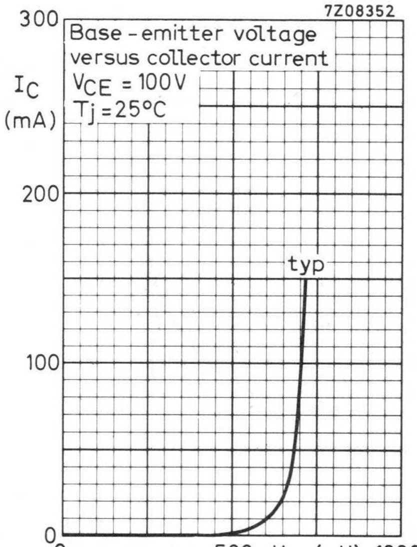

7Z08346
V_{CE} = 20V
f = 1MHz
T_j = 25°C
$-C_{re}$
(pF)
typ
15
10
5
0
50
100
I_C (mA)

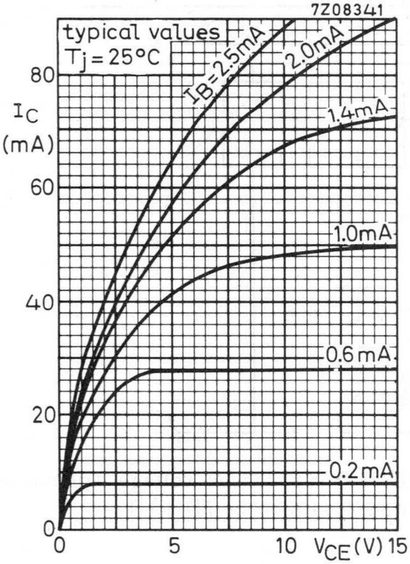

7Z08345
I_C = 0
f = 1MHz
T_j = 25°C
$-C_{re}$
(pF)
typ
15
10
5
0
20
40
V_{CE} (V)

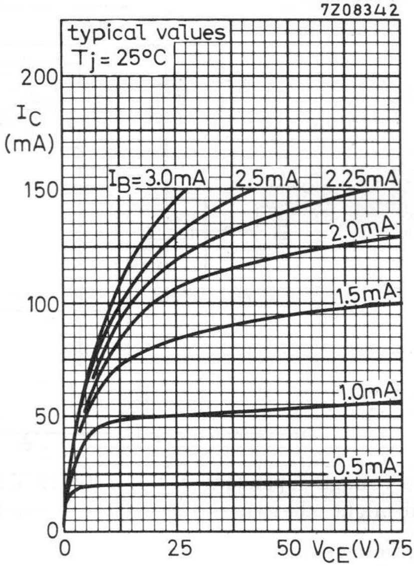

7Z08347
V_{CE} = 100 V
T_j = 25 °C
200
h_{FE}
150
100
50
0
typ
0
50
100 I_C (mA) 150

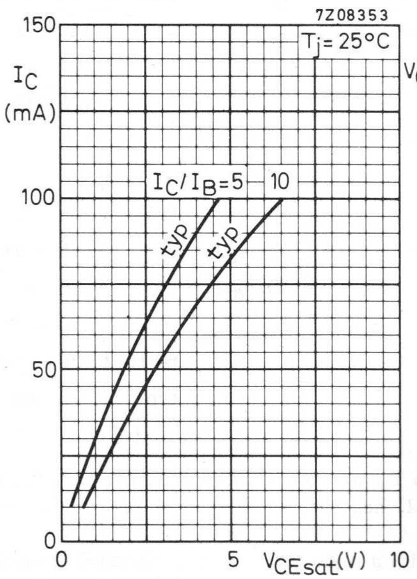

7Z08348
V_{CE} = 100 V
I_C = 50 mA
2
I_B
(mA)
1.5
1
0.5
0
typ
−100
0
100 T_j (°C) 200

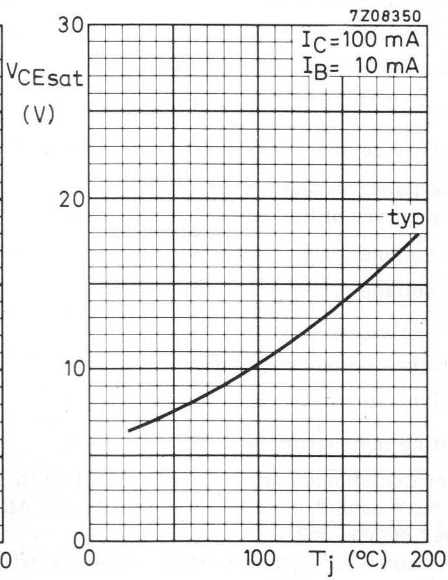

7Z08339.1
1000
Base current versus
collector current
V_{CE} = 100 V
T_j = 25 °C
I_C
(mA)
typ
max I_B
100
10
1
0.1
1
I_B (mA) 10


7Z08352
300
Base-emitter voltage
versus collector current
V_{CE} = 100 V
T_j = 25 °C
I_C
(mA)
200
typ
100
0
0
500 V_{BE} (mV) 1000

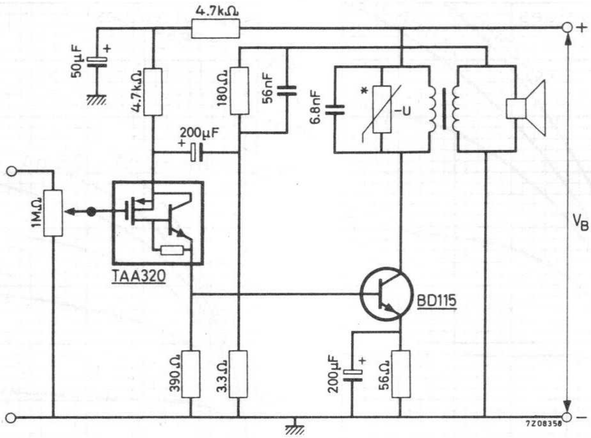

7Z08341
typical values
Tj = 25°C
IB = 2.5mA
2.0mA
1.4mA
1.0mA
0.6mA
0.2mA
IC
(mA)
80
60
40
20
0
0
5
10
VCE (V) 15


7Z08342
typical values
Tj = 25°C
IB = 3.0mA
2.5mA
2.25mA
2.0mA
1.5mA
1.0mA
0.5mA
IC
(mA)
200
150
100
50
0
0
25
50
VCE (V) 75


7Z08353
Tj = 25°C
IC/IB = 5
10
typ
typ
IC
(mA)
150
100
50
0
0
5
VCEsat (V)
10


7Z08350
IC = 100 mA
IB = 10 mA
typ
VCEsat
(V)
30
20
10
0
0
100
Tj (°C)
200

APPLICATION INFORMATION 2 W audio amplifier with TAA320 and BD115



(* The voltage dependent resistor (2322 552 03381) suppresses voltage transients that might otherwise exceed the safe operating limits of the BD115.)

Supply voltage	V_B		100	V
Collector current of BD115	I_C	typ.	50	mA
Drain current of TAA320	$-I_D$	typ.	9.5	mA
Primary d.c. resistance of output transformer			140	Ω
Primary inductance of output transformer			2.7	H
A.C. collector load for BD115			1.8	kΩ

Performance at f = 1 kHz; feedback = 16 dB

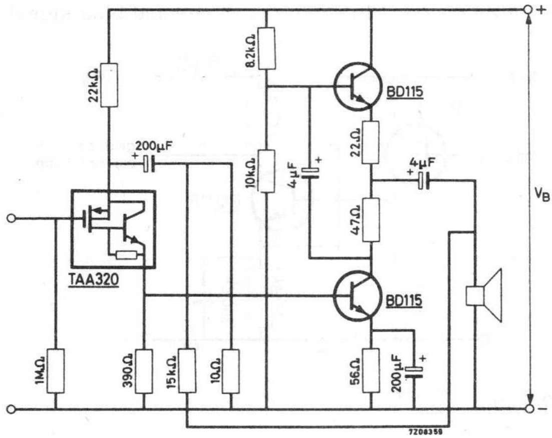
Output power at d_{tot} = 10% (on primary of the output transformer)	P_o	typ.	2.6	W
Input voltage for P_o = 50 mW	$V_{i(rms)}$	typ.	13.5	mV
Input voltage for P_o = 2 W	$V_{i(rms)}$	typ.	86	mV
Total distortion at P_o = 2 W	d_{tot}	typ.	3.6	%
Frequency response (-3 dB)		60 Hz to 20		kHz
Signal-noise ratio at P_o = 2 W		typ.	73	dB

Mounting instruction for BD115

Proper continuous operation is ensured up to T_{amb} = 50 °C, provided the BD115 is directly mounted on a 1.5 mm blackened Al. heatsink of 30 cm^2 with a clamping washer of type 56218.
If the transistor is mounted on a heatsink with a mica washer, the heatsink should have an area of 50 cm^2.
Recommended diameter of hole in heatsink: 7.7 mm.

APPLICATION INFORMATION (continued)

4 W audio amplifier with TAA320 and 2 transistors of type BD115.

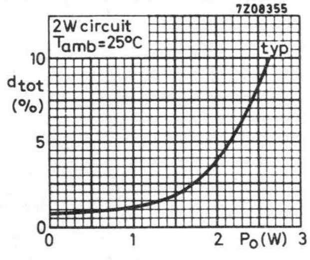


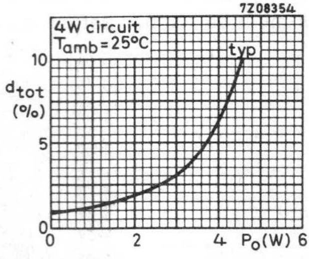
Supply voltage	V_B		200	V
Collector current of a BD115	I_C	typ.	52	mA
Drain current of TAA320	$-I_D$	typ.	8.6	mA

Performance at f = 1 kHz; feedback = 12 dB

Output power at d_{tot} = 10%	P_o	typ.	4.5	W
Input voltage for P_o = 50 mW	$V_{i(rms)}$	typ.	7.5	mV
Input voltage for P_o = 4 W	$V_{i(rms)}$	typ.	67	mV
Total distortion at P_o = 4 W	d_{tot}	typ.	6	%
Frequency response (-3 dB)		50 Hz to 20		kHz
Signal-noise ratio at P_o = 4 W		typ.	73	dB

Mounting instruction for BD115 see page 8

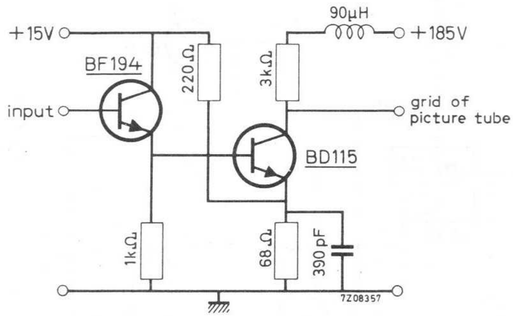




APPLICATION INFORMATION (continued)

Grid-driver circuit for colour picture tubes.

Three identical circuits are used for the red, green and blue signal respectively.



Performance up to T_{amb} = 55 °C

Voltage gain	G_v	60	
Output voltage (video information)	V_o	120	V
(peak-peak)	$V_{o(p-p)}$	150	V
Bandwidth (−3 dB)		> 4	MHz
Rise time	t_r	< 80	ns
Overshoot		< 5	%

Note

1. The maximum dissipation of the output transistor is 3.3 W.
   In order not to exceed the junction temperature rating, the thermal resistance from junction to ambient should be: $R_{th\ j-a} < 45$ °C/W.
   To ensure the above mentioned performance for bandwidth and transient response, the contribution of the heatsink to the total output capacitance of the device should not exceed 4 pF.

2. For grid drive of the picture tube, the sync pulses must be negative going.
   To avoid driving the output transistor into the high frequency knee voltage, the sync pulses must be clipped before the output stage.

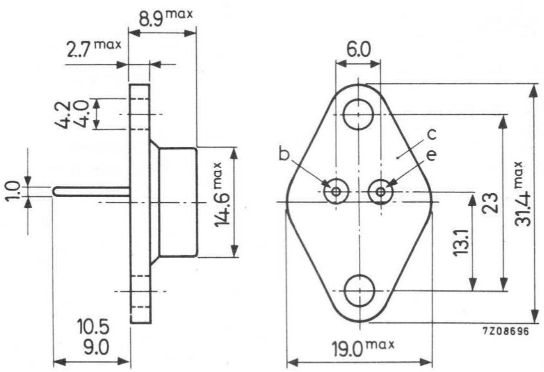
SILICON PLANAR EPITAXIAL POWER TRANSISTOR

N-P-N silicon power transistor in a metal envelope with the collector connected to the case. It is primarily intended for quasi-complementary output stages up to 15 W in audio applications, such as hi-fi amplifiers.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	70	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	V
Collector current (peak value)	I_{CM}	max.	4.0	A
Total power dissipation up to T_{mb} = 62.5 °C	P_{tot}	max.	15	W
D.C. current gain I_C = 2 A; V_{CE} = 5 V	h_{FE}	> typ.	25 50	
Transition frequency at f = 35 MHz I_C = 250 mA; V_{CE} = 5 V	f_T	typ.	120	MHz

MECHANICAL DATA Dimensions in mm

Collector connected to the case



Accessories available: 56203

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	70	V
Collector-emitter voltage (open base) [2])	V_{CEO}	max.	45	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6.0	V

Currents

Collector current (d.c. and average)	I_C	max.	2.0	A
Collector current (peak value)	I_{CM}	max.	4.0	A
Non repetitive peak overload current [3])				
at V_{CE} = 7 V; t = 1 ms	I_{CSM}	max.	5	A
V_{CE} = 20 V; t = 100 μs	I_{CSM}	max.	5	A
V_{CE} = 35 V; t = 10 μs	I_{CSM}	max.	4	A
Emitter current (peak value)	$-I_{EM}$	max.	4.0	A

Power dissipation

Total power dissipation up to T_{mb} = 62.5 °C (see also page 4 and 5)	P_{tot}	max.	15	W

Temperatures

Storage temperature	T_{stg}		-65 to +175	°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	7.5	°C/W
From mounting base to heatsink			
without accessory	$R_{th\ mb\text{-}h}$	0.5	°C/W
with accessory 56203	$R_{th\ mb\text{-}h}$	1.5	°C/W

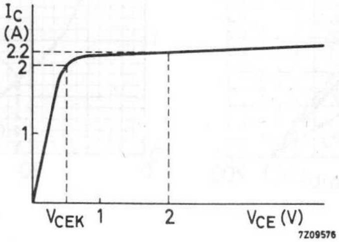
1) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

2) At I_C = 200 mA.

3) Prior to non repetitive peak overload current: T_j = 175 °C

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 45$ V	I_{CBO}	typ.	0.5	μA
		<	2	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	typ.	0.1	μA
		<	2	μA
Base-emitter voltage [1]				
$I_C = 50$ mA; $V_{CE} = 5$ V	V_{BE}	typ.	0.7	V
$I_C = 2$ A; $V_{CE} = 5$ V	V_{BE}	typ.	1.0	V
Knee voltage				
$I_C = 2$ A; I_B = value for which $I_C = 2.2$ A at $V_{CE} = 2$ V	V_{CEK}	typ.	1.0	V
		<	1.9	V

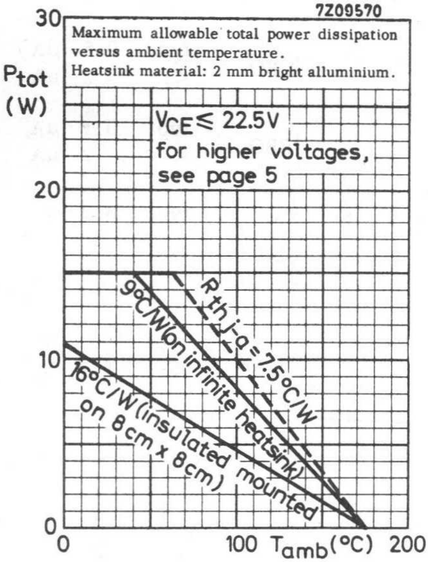


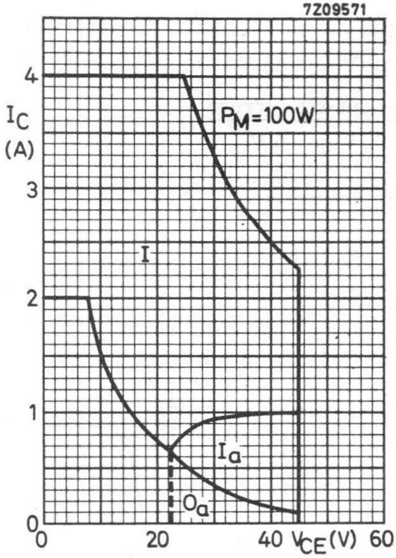
D.C. current gain				
$I_C = 50$ mA; $V_{CE} = 5$ V	h_{FE}	>	25	
		typ.	60	
$I_C = 0.5$ A ; $V_{CE} = 5$ V	h_{FE}	>	35	
		typ.	75	
$I_C = 2$ A ; $V_{CE} = 5$ V	h_{FE}	>	25	
		typ.	50	
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	55	pF
Transition frequency at f = 35 MHz				
$I_C = 250$ mA; $V_{CE} = 5$ V	f_T	typ.	120	MHz

MATCHING CHARACTERISTICS

Base current difference				
$I_C = 0.5$ A; $V_{CE} = 5$ V	$\lvert I_{B1} - I_{B2} \rvert$	<	2	mA
Resulting ratio of d.c. current gain				
for low gain devices		<	1.2	
for typical gain devices		<	1.3	
for high gain devices		<	1.5	

1) V_{BE} decreases by about 1.6 mV/°C with increasing temperature.





Region I: $\Delta T_{j\text{-}mb} = T_{j\,peak} - T_{mb}$ max. 115 °C

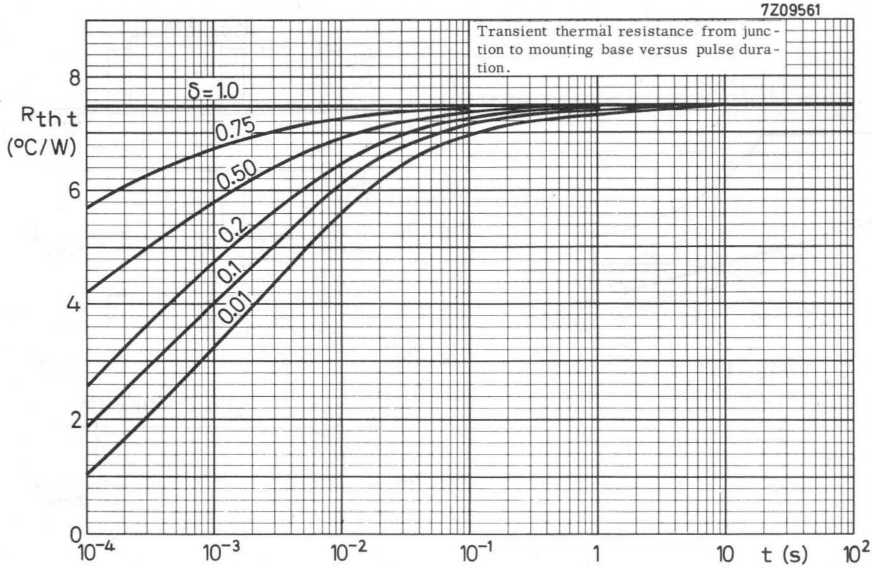
Make use of transient thermal resistance graph on page 5.

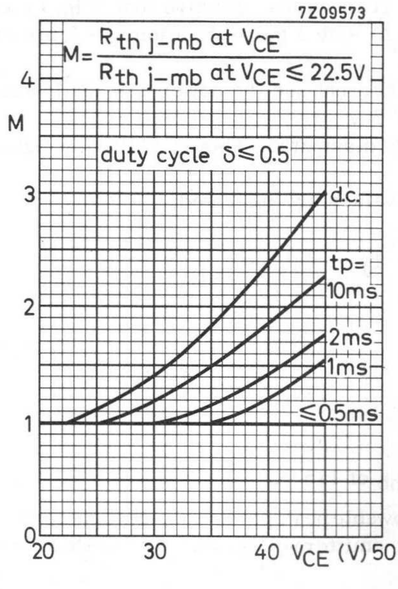
Regions O_a and I_a

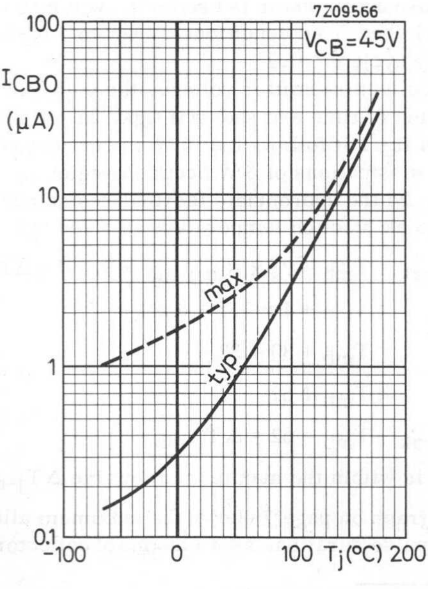
To prevent damage due to second breakdown effects, transistors may only be operated in these regions if the increased thermal resistance at higher voltages is taken into account.

Region O_a: The steady state value of the thermal resistance from junction to mounting base should be multiplied by factor M taken from lower graph left hand side on page 5.

Region I_a : $\Delta T_{j\text{-}mb}$ max. 115 °C
Dependent on voltage, pulse time and duty cycle, the transient thermal resistance value from junction to mounting base should be multiplied by factor M taken from lower graph left hand side on page 5.


7Z09561
Transient thermal resistance from junction to mounting base versus pulse duration.
$R_{th\,t}$ (°C/W)
δ = 1.0
0.75
0.50
0.2
0.1
0.01
t (s)
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^{2}
0
2
4
6
8


7Z09573
$M = \frac{R_{th\ j-mb} \text{ at } V_{CE}}{R_{th\ j-mb} \text{ at } V_{CE} \leq 22.5V}$
M
duty cycle δ ≤ 0.5
d.c.
tp=
10ms
2ms
1ms
≤0.5ms
V_{CE} (V)
20
30
40
50
0
1
2
3
4


7Z09566
V_{CB}=45V
I_{CBO} (μA)
max
typ
T_j (°C)
−100
0
100
200
0.1
1
10
100

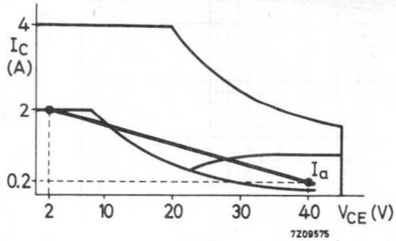


Fig. 1

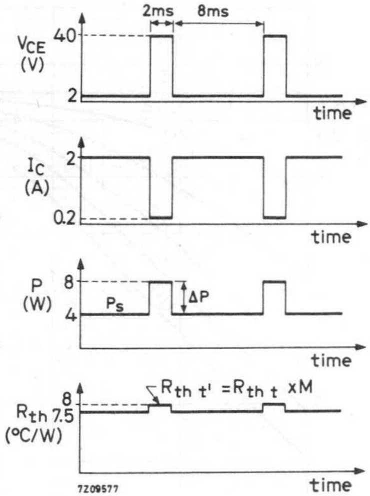


Fig. 2a

Fig. 2b

Fig. 2c

Fig. 2d

Calculation example

Suppose a transistor is used in a switching circuit with a resistive load (fig. 1) and is switched from conditions 2V-2A to 40V-0.2A with a pulse duration t_p = 2 ms and a duty cycle δ = 0.2.

The collector-emitter voltage, the collector current and the power dissipation as a function of time are shown if figs. 2a, 2b and 2c.

From fig. 1 it follows that 4 W is continuously dissipated. This is plotted in fig. 2c. Peak dissipations of 8 W occur in region I_a.

In fig. 2d the appropriate thermal resistance values are indicated.

The peak junction temperature is given by:

$$T_{j\ peak} = T_{mb} + P_s \times R_{th\ j\text{-}mb} + R_{th\ t'} \times \Delta P \ ^{1)}$$

$$= T_{mb} + 4 \times 7.5 + 8 \times 4$$

$$= T_{mb} + 30 + 32$$

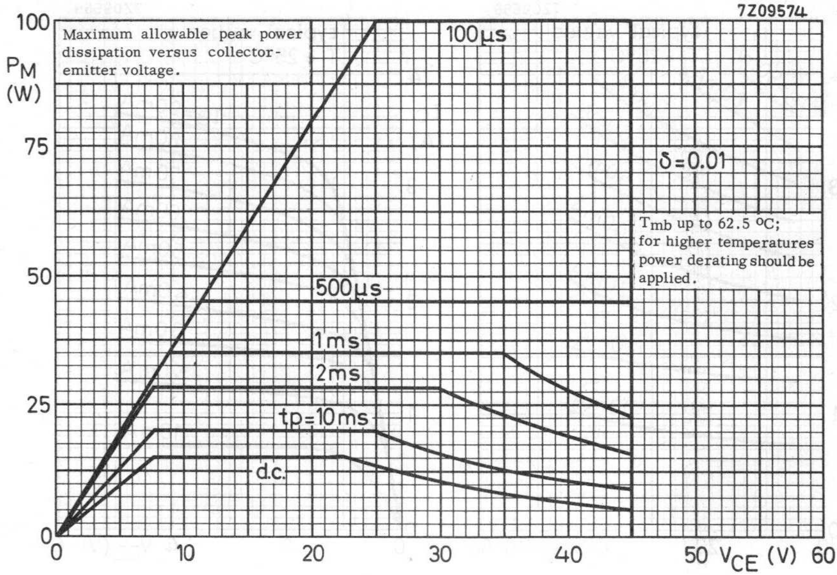
$$= T_{mb} + 62$$

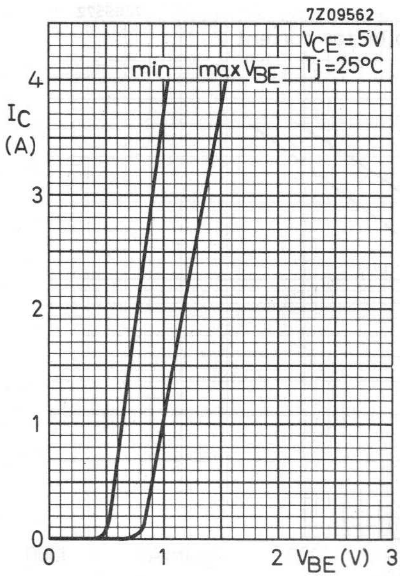
$$T_{j\ peak} - T_{mb} = 62 = \Delta T_{j\text{-}mb}$$

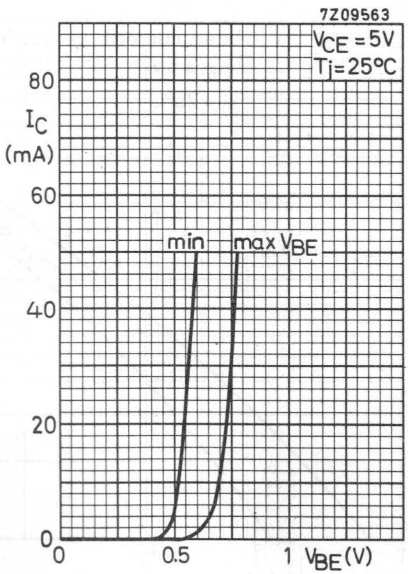
This is within the maximum allowable $\Delta T_{j\text{-}mb}$ of 115 °C

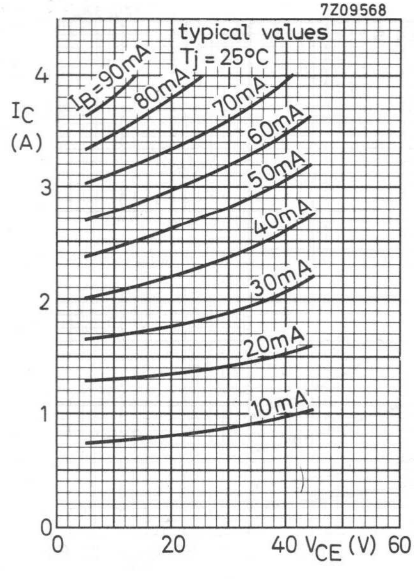
The graph on page 7 shows the maximum allowable peak power dissipations for various pulse durations as a function of collector-emitter voltage for a duty cycle of 0.01.

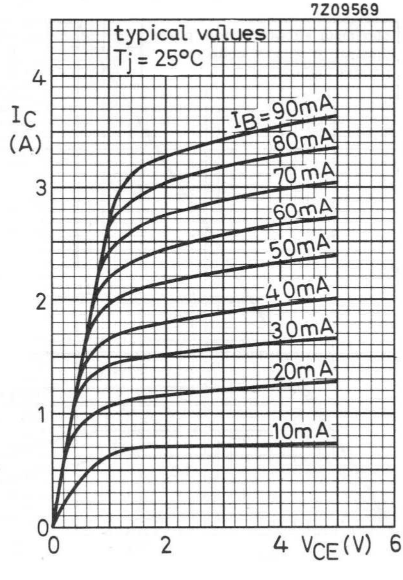
1) $R_{th\ t'} = R_{th\ t} \times M$ (for $R_{th\ t}$ see page 5)

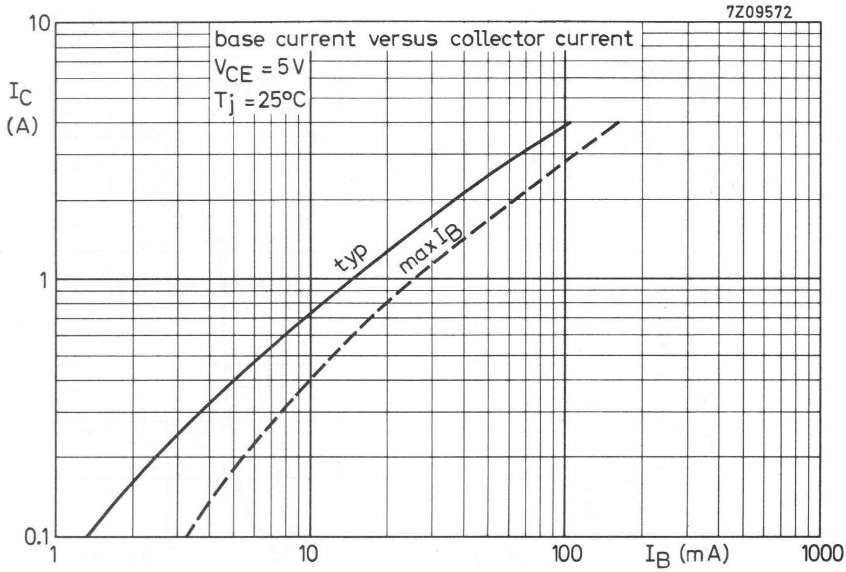

7Z09574
Maximum allowable peak power dissipation versus collector-emitter voltage.
P_M (W)
100µs
δ=0.01
T_{mb} up to 62.5 °C; for higher temperatures power derating should be applied.
500µs
1ms
2ms
tp=10ms
d.c.
V_{CE} (V)
0
25
50
75
100
10
20
30
40
50
60

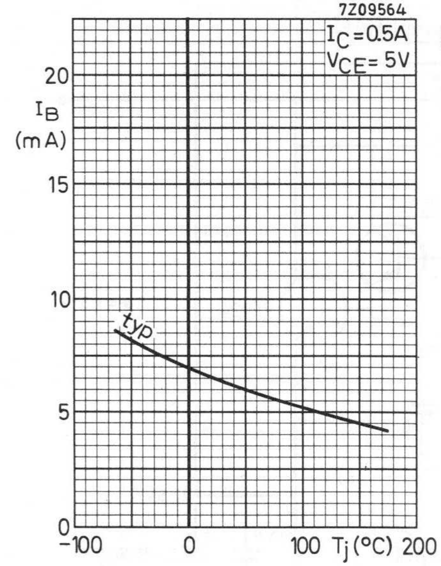

7Z09562
V_{CE} = 5V
T_j = 25°C
min
max V_{BE}
I_C (A)
V_{BE} (V)
0
1
2
3
4

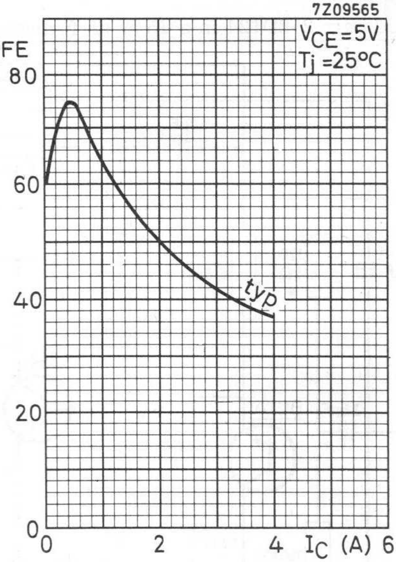

7Z09563
V_{CE} = 5V
T_j = 25°C
min
max V_{BE}
I_C (mA)
V_{BE} (V)
0
20
40
60
80
0.5
1

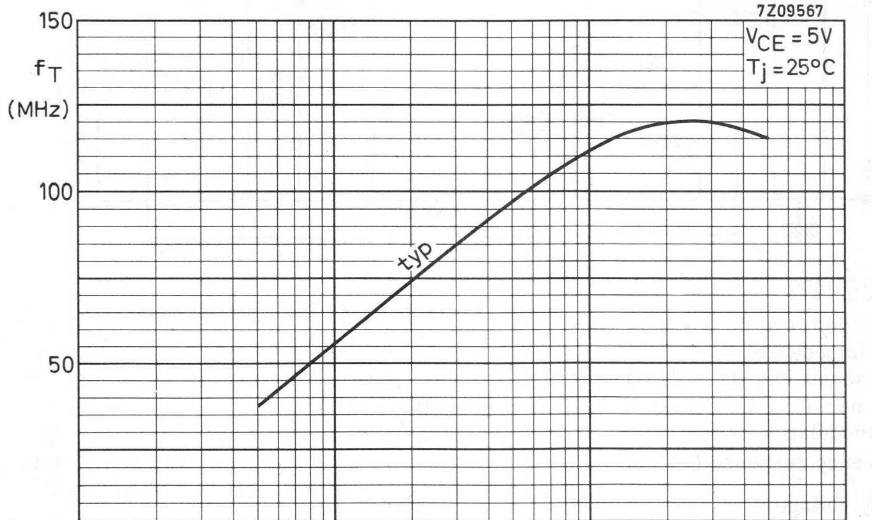

7Z09568
typical values
Tj = 25°C
IB=90mA
80mA
70mA
60mA
50mA
40mA
30mA
20mA
10mA
IC
(A)
VCE (V)


7Z09569
typical values
Tj = 25°C
IB=90mA
80mA
70mA
60mA
50mA
40mA
30mA
20mA
10mA
IC
(A)
VCE (V)


7Z09572
base current versus collector current
VCE = 5 V
Tj = 25°C
typ
max IB
IC
(A)
IB (mA)

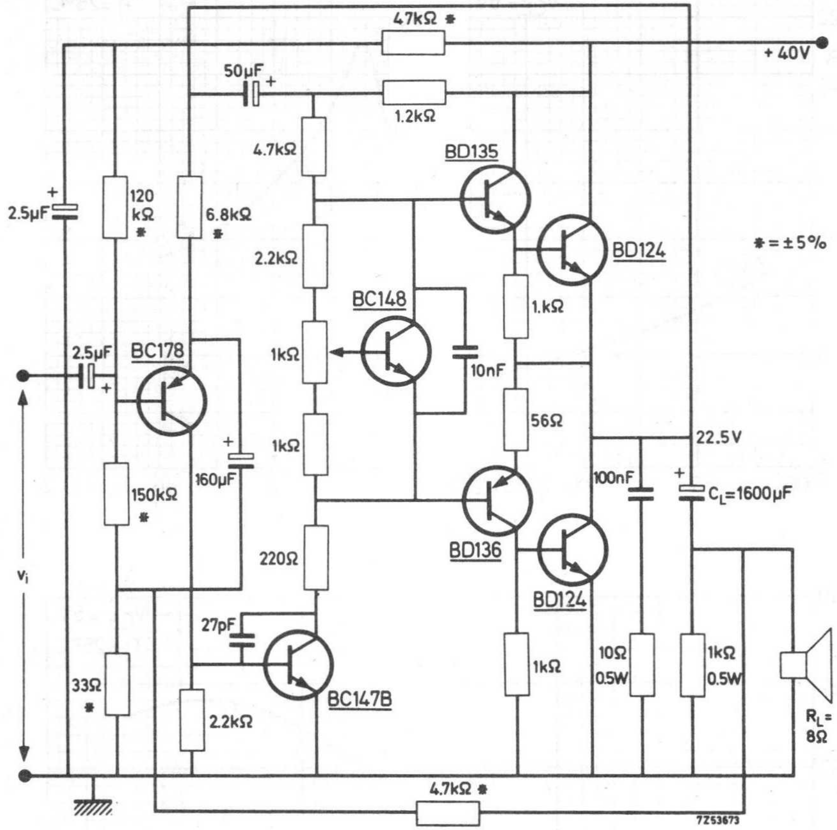

7Z09564
I_C = 0.5A
V_{CE} = 5V
I_B
(mA)
20
15
10
5
0
typ
−100
0
100
T_j (°C)
200


7Z09565
V_{CE} = 5V
T_j = 25°C
h_{FE}
80
60
40
20
0
typ
0
2
4
I_C (A)
6


7Z09567
V_{CE} = 5V
T_j = 25°C
f_T
(MHz)
150
100
50
0
typ
1
10
100
I_C (mA)
1000

APPLICATION INFORMATION

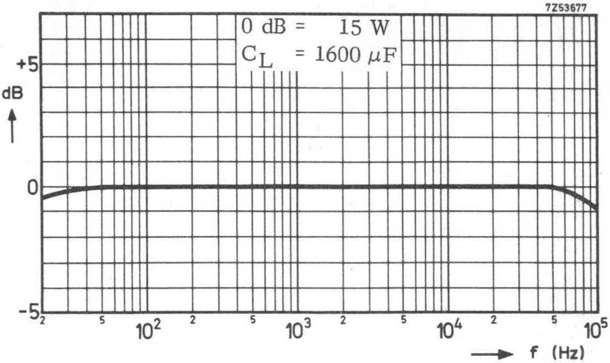
Matched pair 2-BD124 in a 15 W hi-fi audio amplifier.

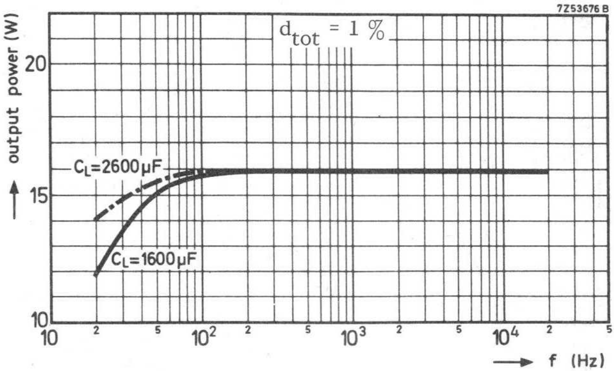


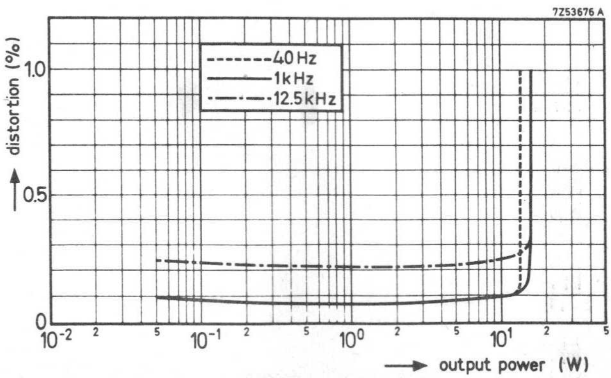
Performance

Output power at f = 1 kHz; d_{tot} = 1 %	15.8 W
Input impedance	100 kΩ
Input sensitivity (P_o = 15 W)	140 mV
Total harmonic distortion at onset of clipping (f = 1 kHz)	0.15 %
Intermodulation distortion	0.6 %
Frequency response (–1 dB)	20 Hz to 90 kHz
Supply voltage	nom. 40 V max. 45 V
Collector quiescent current of BD124	40 mA

APPLICATION INFORMATION (continued)







SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a TO-126 plastic envelope; with their complements, the BD136 (for the BD135), the BD138 (for the BD137) and the BD140 (for the BD139), they are primarily intended for complementary driver stages in hi-fi amplifiers.
They are also recommended as single drivers where voltage and dissipation are high.
The devices are also suitable for television circuits.

QUICK REFERENCE DATA

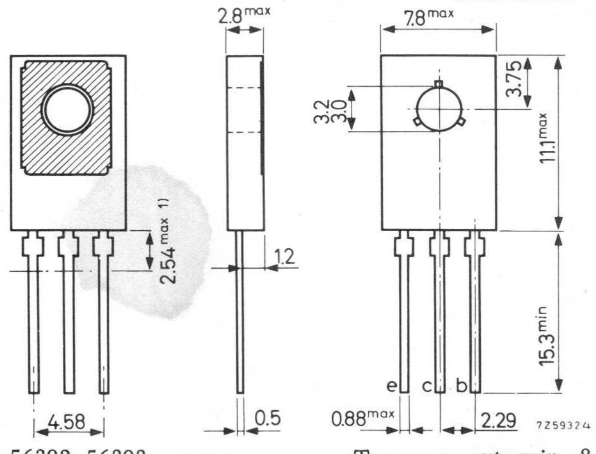
			BD135	BD137	BD139	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	–	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	–	–	100	V
Collector-current (peak value)	I_{CM}	max.	1.5	1.5	1.5	A
Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max.	6.5	6.5	6.5	W
Junction temperature	T_j	max.	125	125	125	°C
D.C. current gain I_C = 150 mA; V_{CE} = 2 V	h_{FE}	>	40	40	40	
		<	250	160	160	
Transition frequency at f = 35 MHz I_C = 50 mA; V_{CE} = 5 V	f_T	typ.	250	250	250	MHz

MECHANICAL DATA

Dimensions in mm

TO-126

Collector connected to metal part of mounting surface



Accessories available: 56302; 56303

Torque on nut: min. 8 cm kg
max. 9 cm kg

1) Within this region the cross-section of the leads is uncontrolled.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

			BD135	BD137	BD139	
Voltages						
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	–	V
Collector-emitter voltage (open base) [1]	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	–	–	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V
Currents						
Collector current (d.c.)	I_C	max.	0.5	0.5	0.5	A
Collector current (peak value)	I_{CM}	max.	1.5	1.5	1.5	A

Power dissipation

Total power dissipation up to T_{mb} = 60 °C (see also pages 4, 5 and 6)	P_{tot}	max.	6.5	W

Temperatures

Storage temperature	T_{stg}		−55 to +125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	100	°C/W
From junction to mounting base	$R_{th\ j-mb}$	10	°C/W
From mounting base to heatsink			
with mica washer 56302	$R_{th\ mb-h}$	6	°C/W
without mica washer	$R_{th\ mb-h}$	1	°C/W

[1] At I_C = 30 mA

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $V_{CB} = 30$ V	I_{CBO}	<	100	nA
$I_E = 0$; $V_{CB} = 30$ V; $T_j = 125$ °C	I_{CBO}	<	10	µA

Emitter cut-off current

$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	µA

Base emitter voltage

$I_C = 500$ mA; $V_{CE} = 2$ V	V_{BE}	<	1	V

Saturation voltage

$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	0.5	V

D.C. current gain

			BD135	BD137	BD139
$I_C = 5$ mA; $V_{CE} = 2$ V	h_{FE}	>	25	25	25
$I_C = 150$ mA; $V_{CE} = 2$ V	h_{FE}	>	40	40	40
		<	250	160	160
$I_C = 500$ mA; $V_{CE} = 2$ V	h_{FE}	>	25	25	25

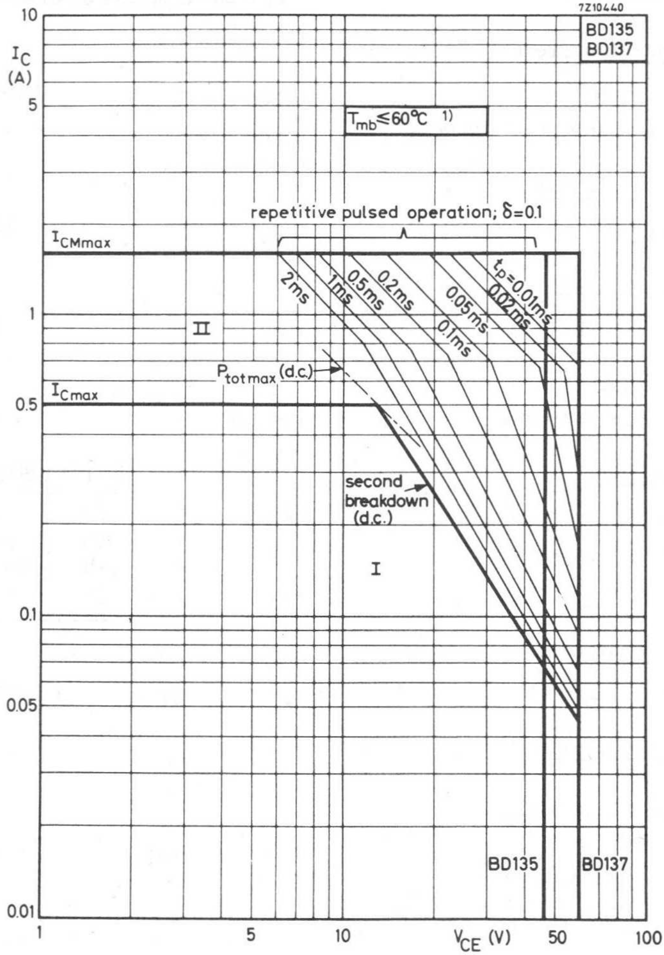
Transition frequency at f = 35 MHz

$I_C = 50$ mA; $V_{CE} = 5$ V	f_T	typ.	250	MHz

D.C. current gain ratio of matched pairs

BD135/BD136; BD137/BD138
BD139/BD140

$\lvert I_C \rvert = 150$ mA; $\lvert V_{CE} \rvert = 2$ V	h_{FE1}/h_{FE2}	typ.	1.3
		<	1.6

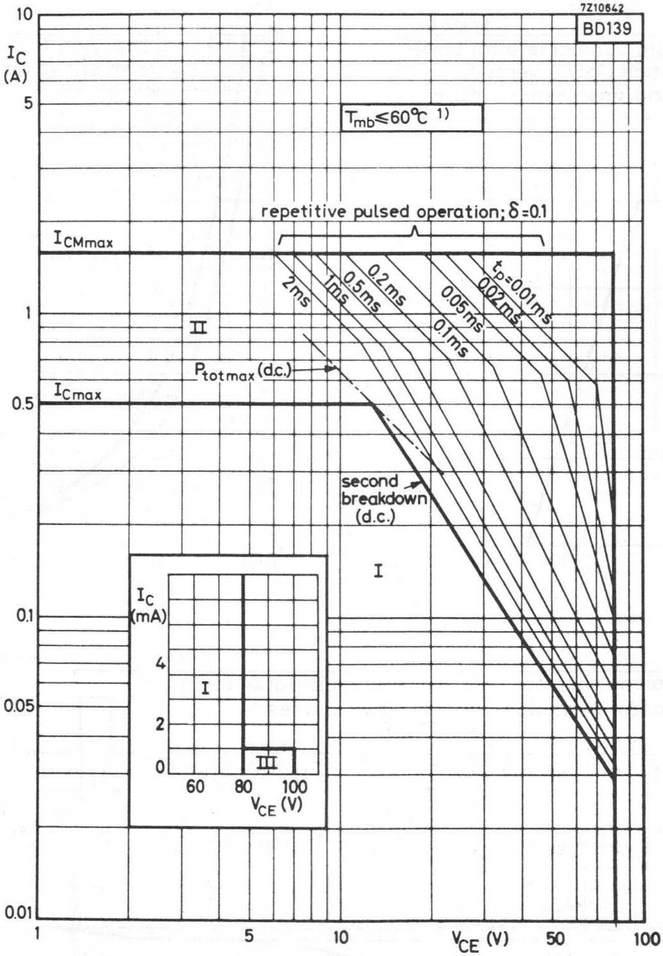


Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulsed operation

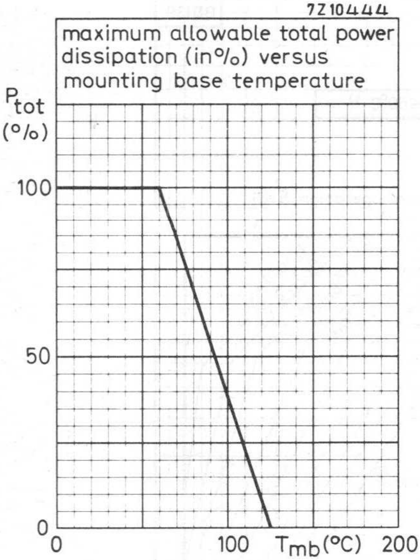
1) To derate $P_{tot\,max}$ for higher temperatures see page 6.
Ratings for second breakdown are independent of temperature.

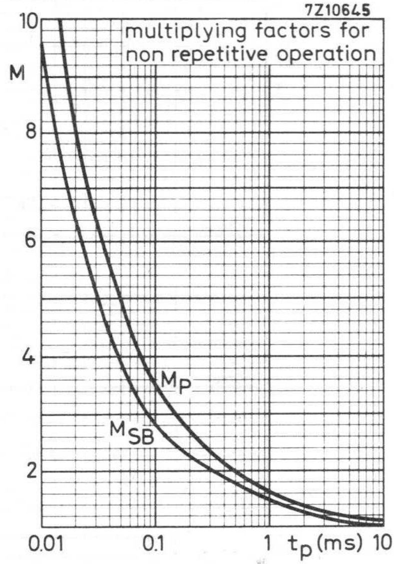


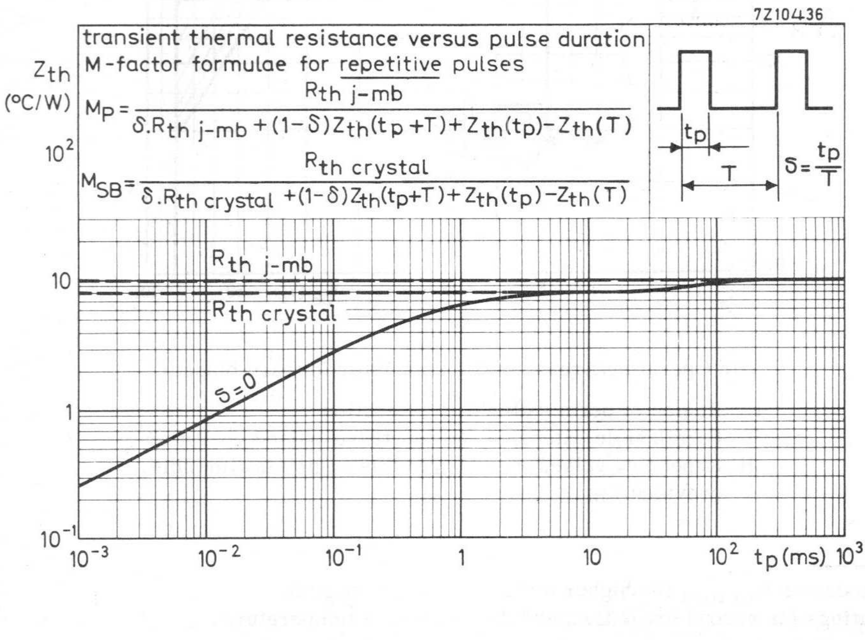
Safe Operating Area with the transistor forward biased

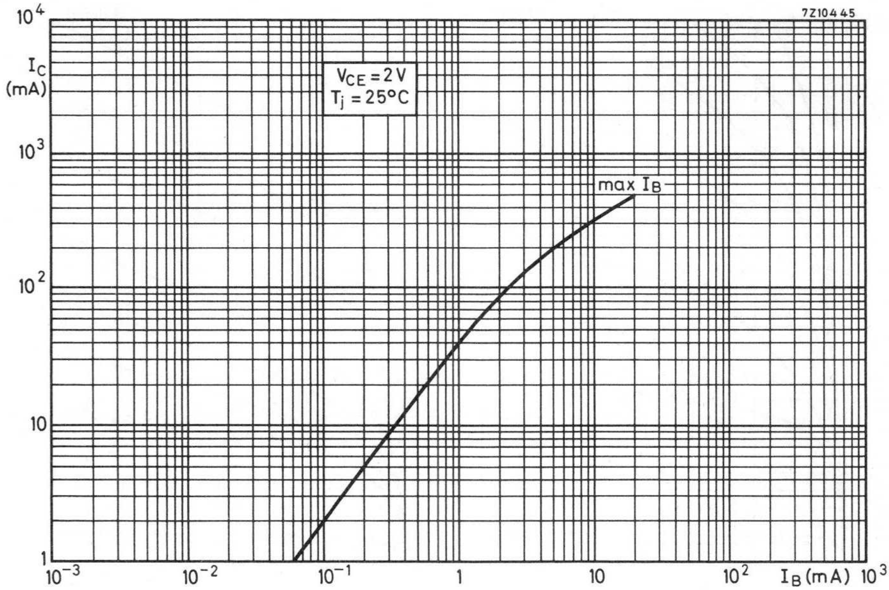
I Region of permissible d.c. operation
II Permissible extension for repetitive pulsed operation
III Repetitive pulsed operation in this region is allowable, provided $R_{BE} \leq 1\ k\Omega$

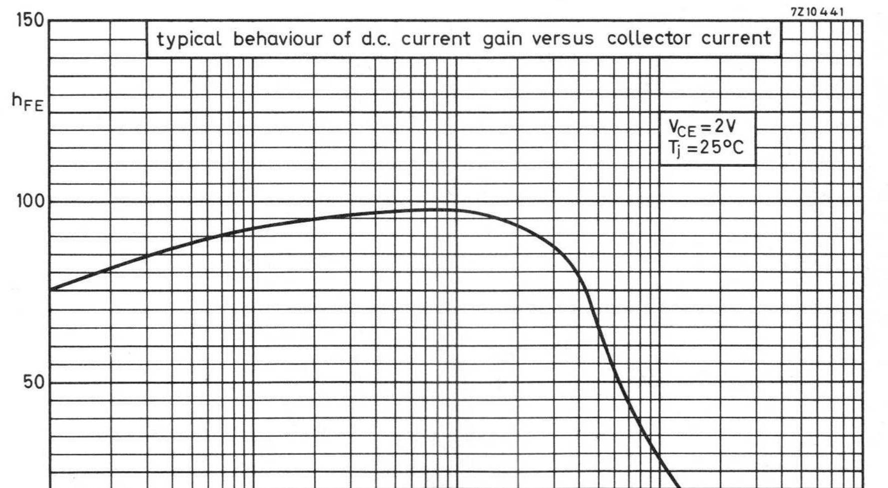
1) To derate $P_{tot\ max}$ for higher temperatures see page 6. Ratings for second breakdown are independent of temperature.


7Z10444
maximum allowable total power dissipation (in%) versus mounting base temperature
Ptot
(%)
100
50
0
0
100
Tmb(°C)
200

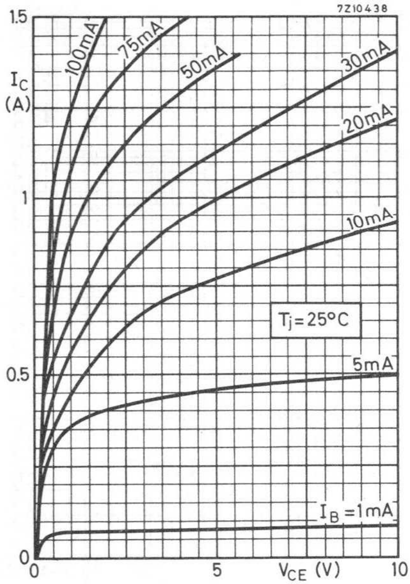

7Z10645
multiplying factors for non repetitive operation
M
10
8
6
4
2
MP
MSB
0.01
0.1
1
tp (ms)
10

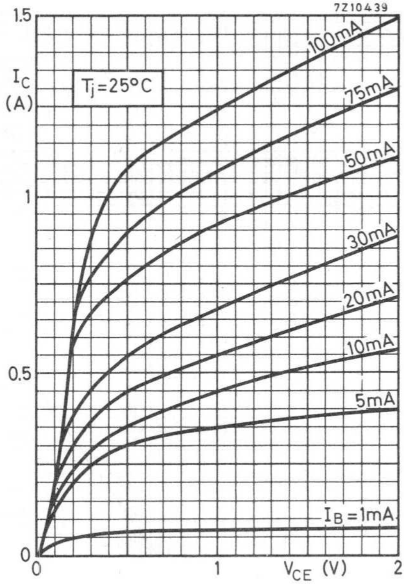

7Z10436
transient thermal resistance versus pulse duration
M-factor formulae for repetitive pulses
Zth
(°C/W)
$M_P = \frac{R_{th\ j\text{-}mb}}{\delta . R_{th\ j\text{-}mb} + (1-\delta) Z_{th}(t_p + T) + Z_{th}(t_p) - Z_{th}(T)}$
$M_{SB} = \frac{R_{th\ crystal}}{\delta . R_{th\ crystal} + (1-\delta) Z_{th}(t_p + T) + Z_{th}(t_p) - Z_{th}(T)}$
tp
T
$\delta = \frac{t_p}{T}$
10²
10
1
10⁻¹
Rth j-mb
Rth crystal
δ=0
10⁻³
10⁻²
10⁻¹
1
10
10²
tp (ms)
10³

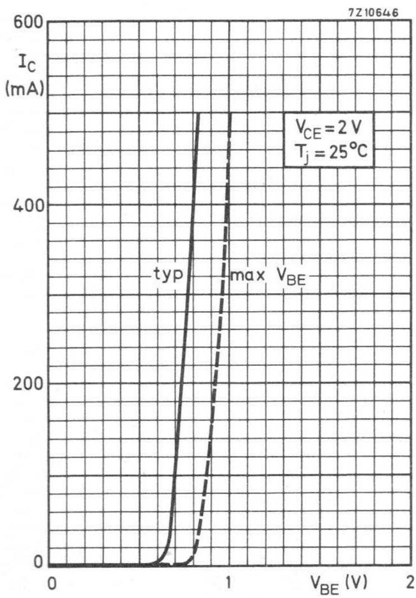

7Z10445
V_{CE} = 2 V
T_j = 25°C
max I_B
I_C (mA)
10^4
10^3
10^2
10
1
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
I_B (mA)
10^3

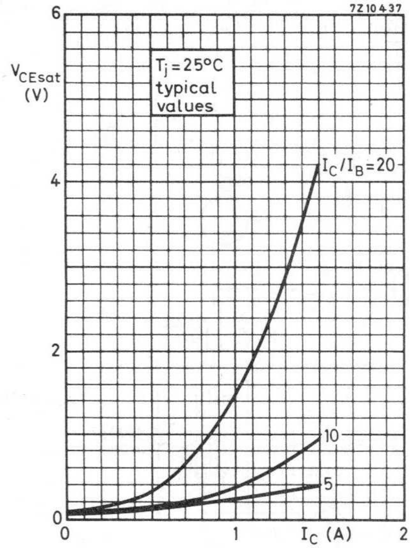

7Z10441
typical behaviour of d.c. current gain versus collector current
V_{CE} = 2V
T_j = 25°C
h_{FE}
150
100
50
0
1
10
10^2
10^3
I_C (mA)
10^4

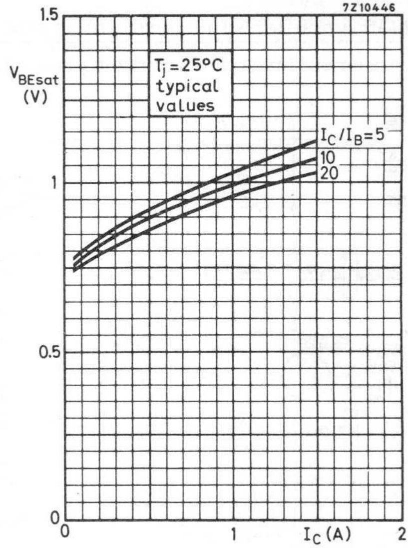
typical behaviour of collector current versus collector-emitter voltage

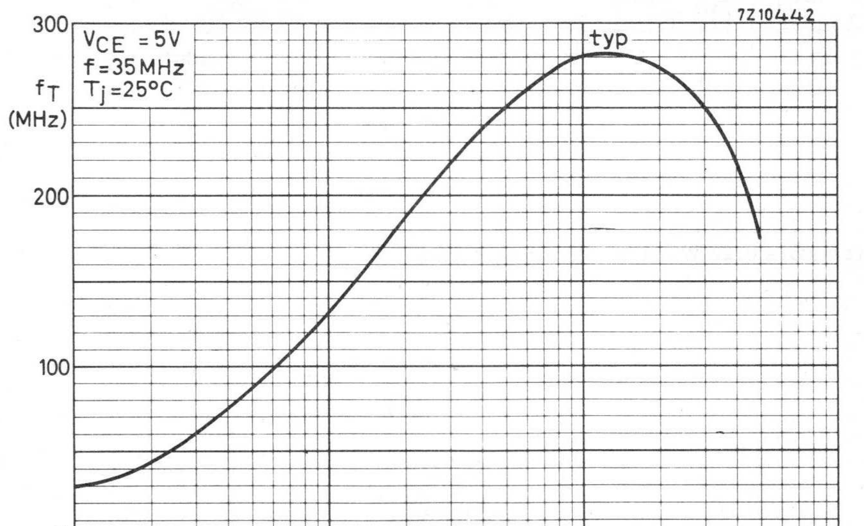







7Z10437
V_{CEsat} (V)
$T_j = 25°C$
typical
values
$I_C/I_B = 20$
10
5
6
4
2
0
0
1
I_C (A)
2

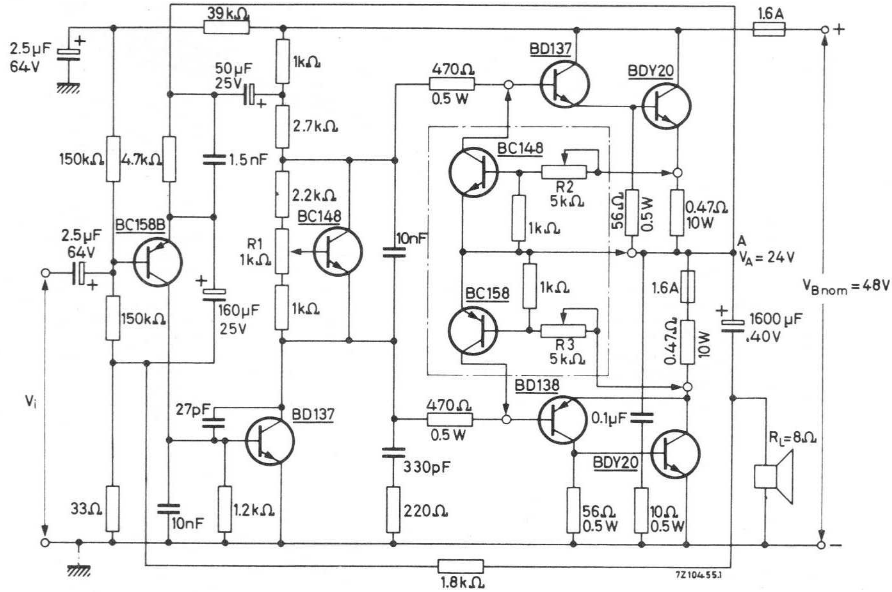

7Z10446
V_{BEsat} (V)
$T_j = 25°C$
typical
values
$I_C/I_B = 5$
10
20
1.5
1
0.5
0
0
1
I_C (A)
2


7Z10442
f_T (MHz)
$V_{CE} = 5V$
$f = 35 MHz$
$T_j = 25°C$
typ
300
200
100
0
1
10
100
I_C (mA)
1000

APPLICATION INFORMATION

25 W hi-fi amplifier with short circuit protection

(Broken line encloses short circuit protection)



All resistors 0.25 W unless otherwise stated.

APPLICATION INFORMATION (continued)

Performance at V_{Bnom} = 48 V; R_L = 8 Ω

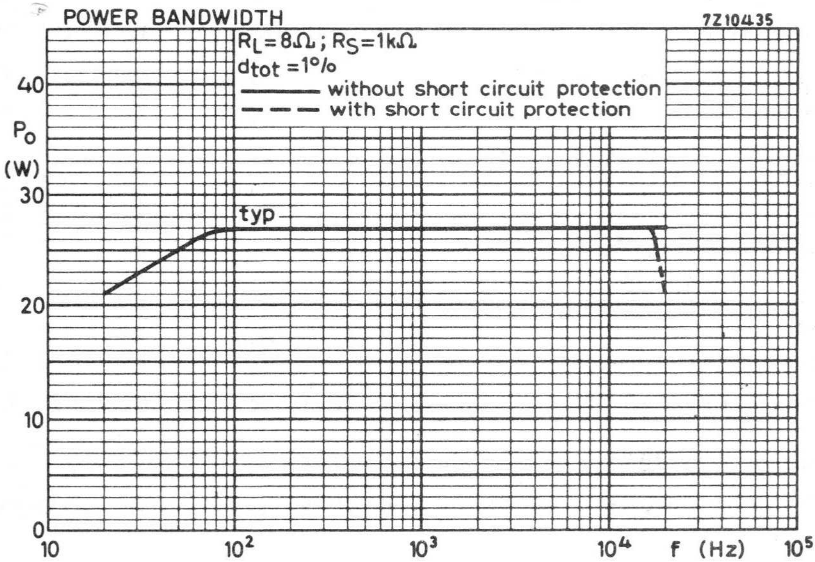
Collector quiescent current of BDY20	I_{cq}	typ.	40	mA
Total current drain at f = 1 kHz; P_o = 25 W	I_{tot}	typ.	830	mA
Input impedance	$\|Z_i\|$	typ.	150	kΩ
Output power at f = 1 kHz; d_{tot} = 1%	P_o	typ.	27	W
Input voltage for P_o = 25 W	V_i	typ.	350	mV
Total harmonic distortion at P_o = 25 W				
without protection circuit	d_{tot}	typ.	0.1	%
with protection circuit	d_{tot}	typ.	0.25	%
Intermodulation distortion at P_o = 27 W				
f_1 = 250 Hz; f_2 = 8 kHz				
V_i at f_1 : V_i at f_2 = 4 : 1				
without protection circuit	d_{im}	typ.	0.6	%
with protection circuit	d_{im}	typ.	1.2	%
Frequency response (−1 dB)		20 Hz to	35	kHz

Short circuit protection

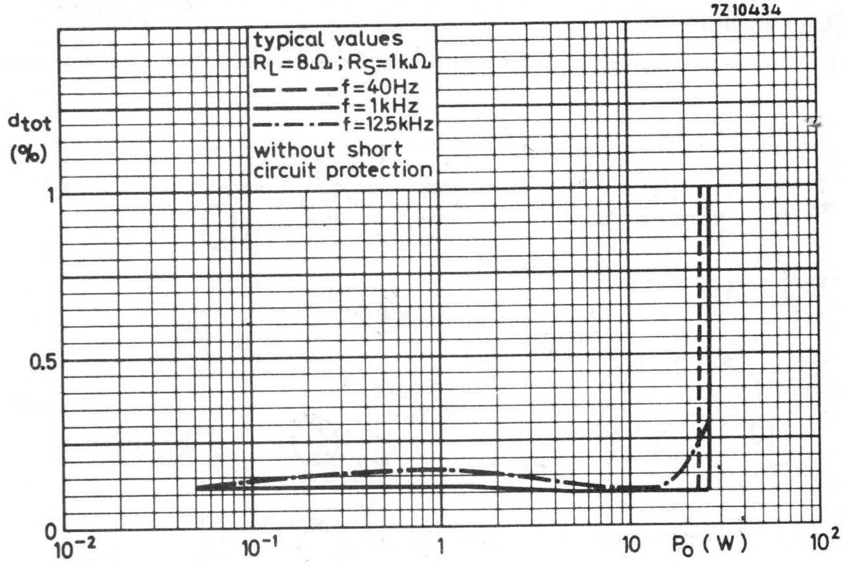
R_2 and R_3 to be adjusted so as to protect the output stage against current peaks higher than I_{CM} = 4 A.

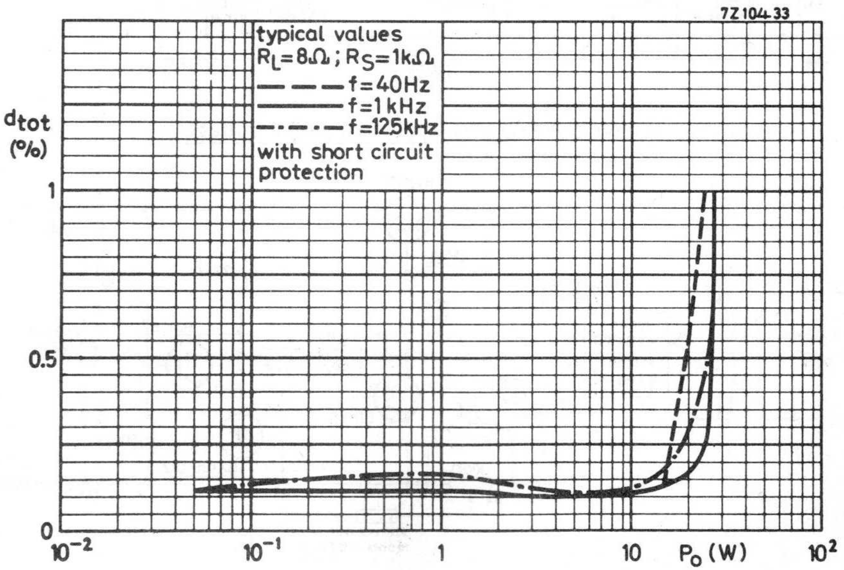
APPLICATION INFORMATION (continued)

25 W hi-fi amplifier (continued)



APPLICATION INFORMATION (continued)

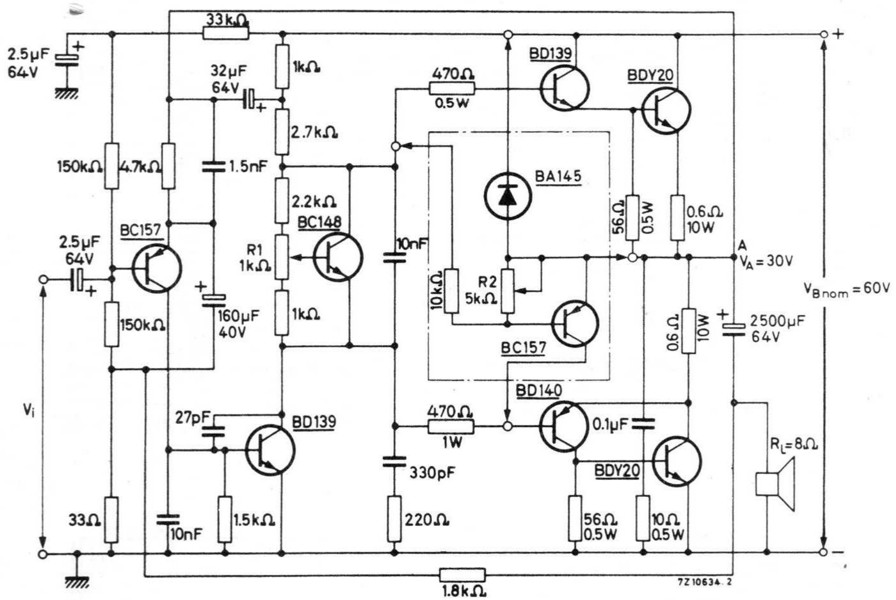




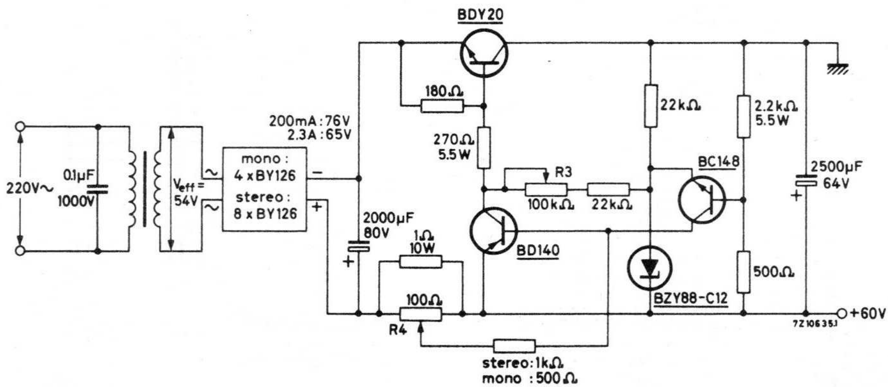
APPLICATION INFORMATION (continued)

40 W hi-fi amplifier

Together with regulated supply, part within broken lines provides short circuit protection



Short circuit protected power supply with regulated output voltage



All resistors 0.25 W unless otherwise stated.

APPLICATION INFORMATION (continued)

Performance at V_B = 60 V; R_L = 8 Ω

Collector quiescent current of BDY20	I_{cq}	typ.	40	mA
Total current drain at f = 1 kHz; P_o = 40 W	I_{tot}	typ.	1.1	A
Input impedance	$\|Z_i\|$	typ.	150	kΩ
Output power at f = 1 kHz; d_{tot} = 1%	P_o	typ.	40	W
Input voltage for P_o = 40 W	V_i	typ.	440	mV
Total harmonic distortion at P_o = 40 W	d_{tot}	typ.	0.2	%
Intermodulation distortion at P_o = P_{omax} f_1 = 250 Hz; f_2 = 8 kHz V_i at f_1 : V_i at f_2 = 4 : 1	d_{im}	typ.	0.8	%
Frequency response (−1 dB)		10 Hz to	33	kHz

Short circuit protection

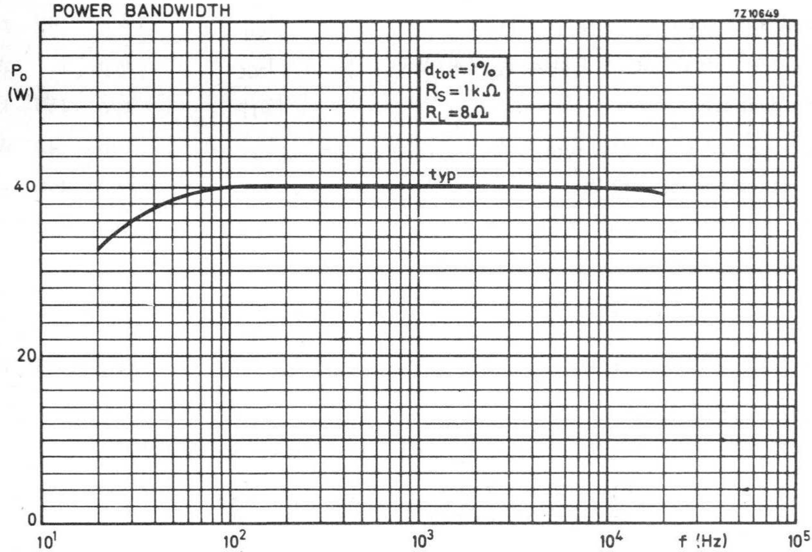
The average supply current is limited by R_4 (lower figure opposite)

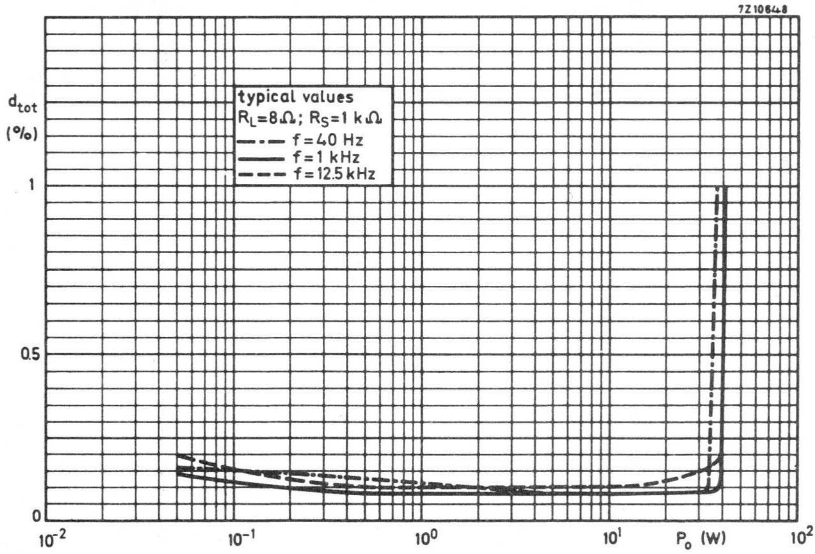
to 1.3 A for mono
or 2.3 A for stereo where R_L = 8 Ω

R_2 is then adjusted so that the peak collector current of the lower BDY20 in the 40 W circuit is limited to I_{CM} = 4 A (normal sine wave overdrive conditions; R_L = 6 Ω).

APPLICATION INFORMATION (continued)

40 W hi-fi amplifier (continued)





SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in a TO-126 plastic envelope; with their complements, the BD135 (for the BD136), the BD137 (for the BD138) and the BD139 (for the BD140), they are primarily intended for complementary driver stages in hi-fi amplifiers.
They are also recommended as single drivers where voltage and dissipation are high. The devices are also suitable for television circuits.

QUICK REFERENCE DATA

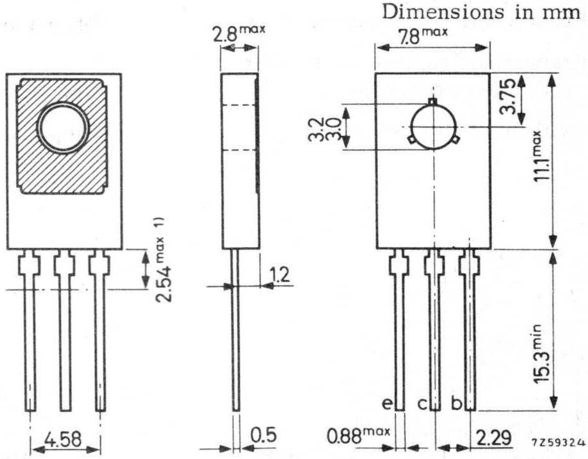
			BD136	BD138	BD140	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	-	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	-	-	100	V
Collector-current (peak value)	$-I_{CM}$	max.	1.5	1.5	1.5	A
Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max.	6.5	6.5	6.5	W
Junction temperature	T_j	max.	125	125	125	°C
D.C. current gain $-I_C$ = 150 mA; $-V_{CE}$ = 2 V	h_{FE}	>	40	40	40	
		<	250	160	160	
Transition frequency at f = 35 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 5 V	f_T	typ.	75	75	75	MHz

MECHANICAL DATA

Dimensions in mm

TO-126

Collector connected to metal part of mounting surface



Accessories available: 56302; 56303

Torque on nut: min. 8 cm kg
max. 9 cm kg

1) Within this region the cross-section of the leads is uncontrolled.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

			BD136	BD138	BD140	
Voltages						
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	–	V
Collector-emitter voltage (open base)[1]	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	–	–	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V
Currents						
Collector current (d.c.)	$-I_C$	max.	0.5	0.5	0.5	A
Collector current(peak value)	$-I_{CM}$	max.	1.5	1.5	1.5	A

Power dissipation

Total power dissipation up to T_{mb} = 60 °C (see also pages 4, 5 and 6)	P_{tot}	max.	6.5	W

Temperatures

Storage temperature	T_{stg}		−55 to + 125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

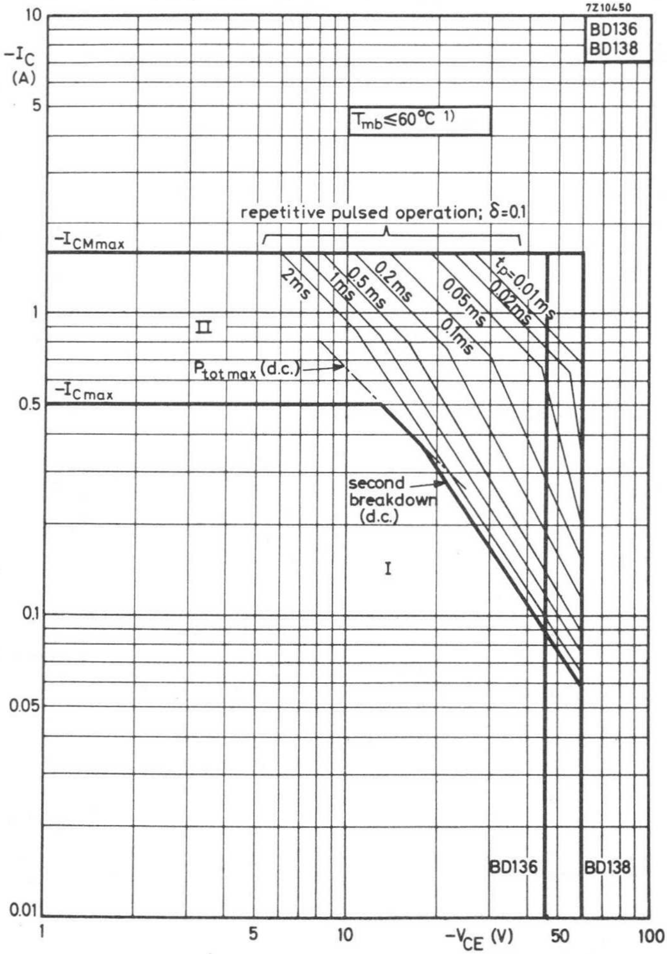
From junction to ambient in free air	$R_{th\ j\text{-}a}$	100	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	10	°C/W
From mounting base to heatsink with mica washer 56302	$R_{th\ mb\text{-}h}$	6	°C/W
without mica washer	$R_{th\ mb\text{-}h}$	1	°C/W

[1]) At $-I_C$ = 30 mA

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current						
$I_E = 0$; $-V_{CB} = 30$ V	$-I_{CBO}$	<		100		nA
$I_E = 0$; $-V_{CB} = 30$ V; $T_j = 125\ ^oC$	$-I_{CBO}$	<		10		μA
Emitter cut-off current						
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<		10		μA
Base emitter voltage						
$-I_C = 500$ mA; $-V_{CE} = 2$ V	$-V_{BE}$	<		1		V
Saturation voltage						
$-I_C = 500$ mA; $-I_B = 50$ mA	$-V_{CEsat}$	<		0.5		V
D.C. current gain			BD136	BD138	BD140	
$-I_C = 5$ mA; $-V_{CE} = 2$ V	h_{FE}	>	25	25	25	
$-I_C = 150$ mA; $-V_{CE} = 2$ V	h_{FE}	>	40	40	40	
		<	250	160	160	
$-I_C = 500$ mA; $-V_{CE} = 2$ V	h_{FE}	>	25	25	25	
Transition frequency at f = 35 MHz						
$-I_C = 50$ mA; $-V_{CE} = 5$ V	f_T	typ.		75		MHz
D.C. current gain ratio of matched pairs BD135/BD136; BD137/BD138 BD139/BD140						
$\|I_C\| = 150$ mA; $\|V_{CE}\| = 2$ V	h_{FE1}/h_{FE2}	typ.		1.3		
		<		1.6		

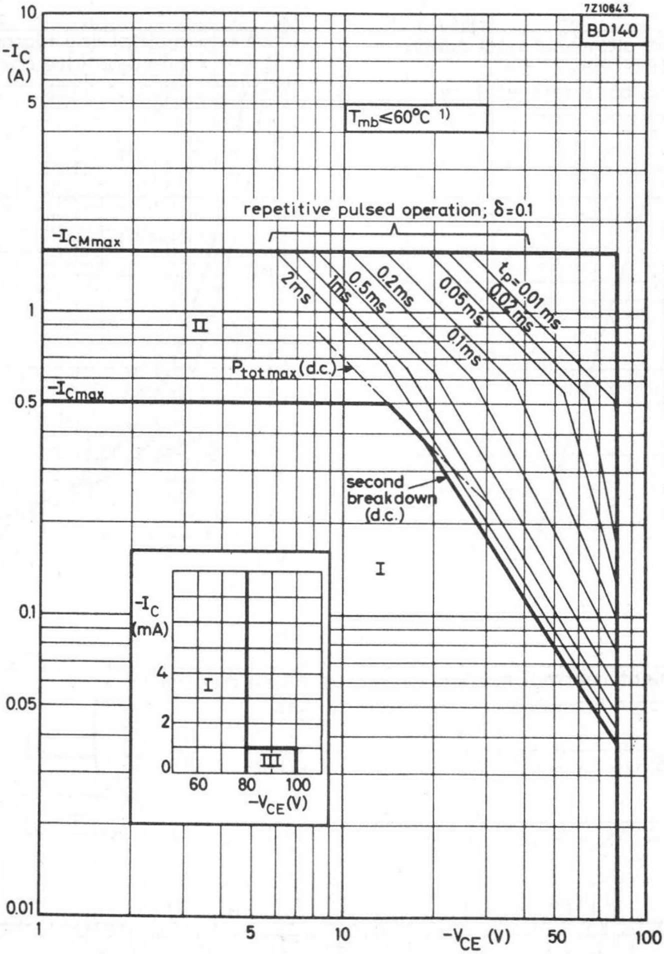


Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulsed operation

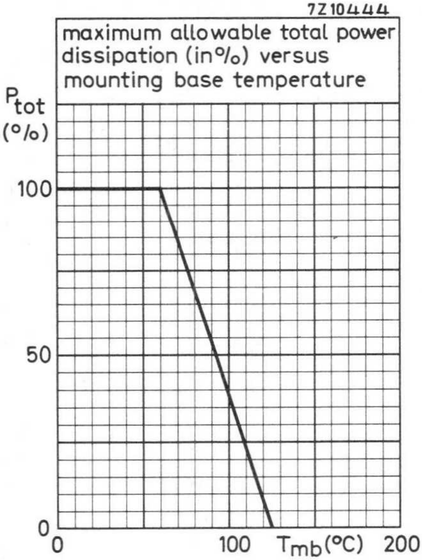
1) To derate $P_{tot\ max}$ for higher temperatures see page 6.
Ratings for second breakdown are independent of temperature.

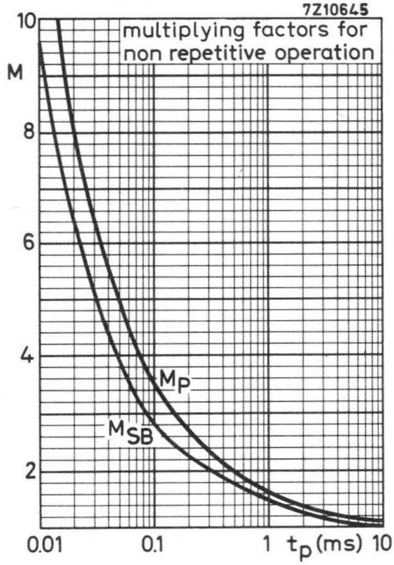


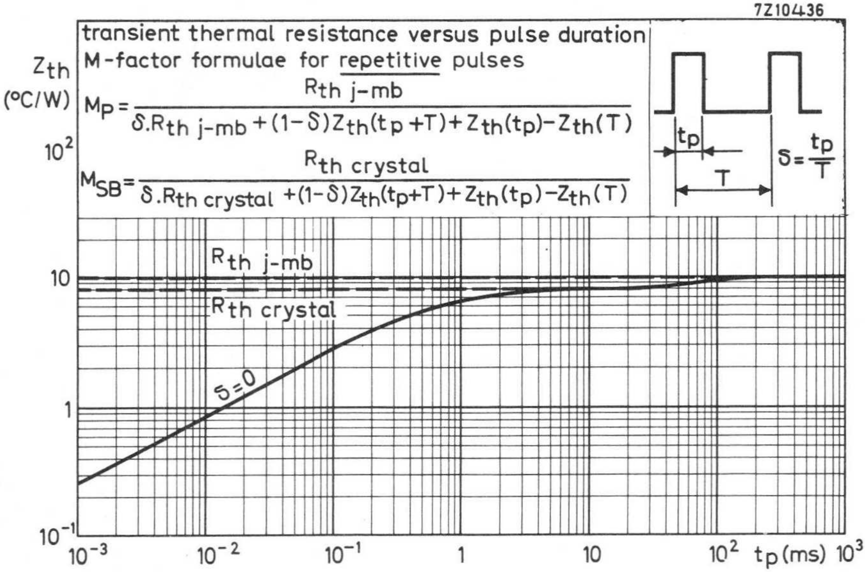
Safe Operating Area with the transistor forward biased

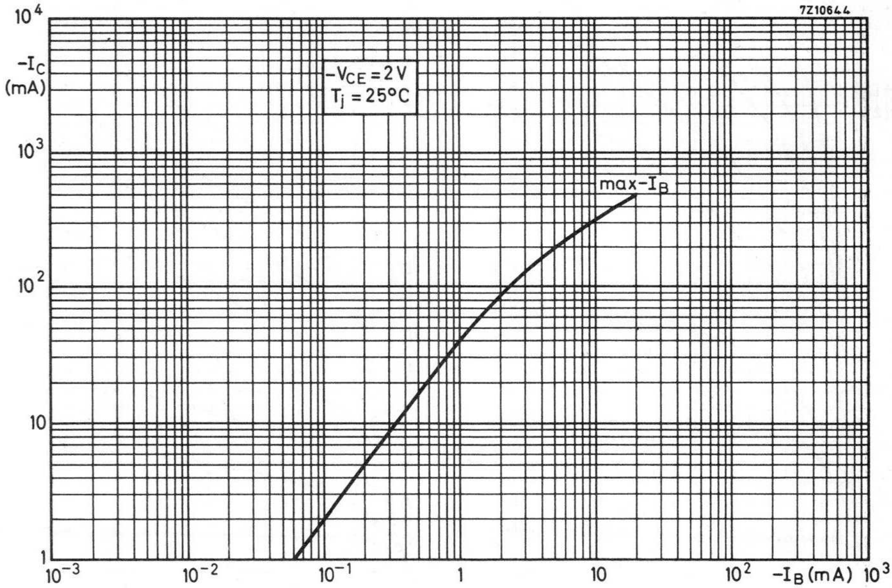
I Region of permissible d.c. operation
II Permissible extension for repetitive pulsed operation
III Repetitive pulsed operation in this region is allowable, provided $R_{BE} \leq 1\ k\Omega$.

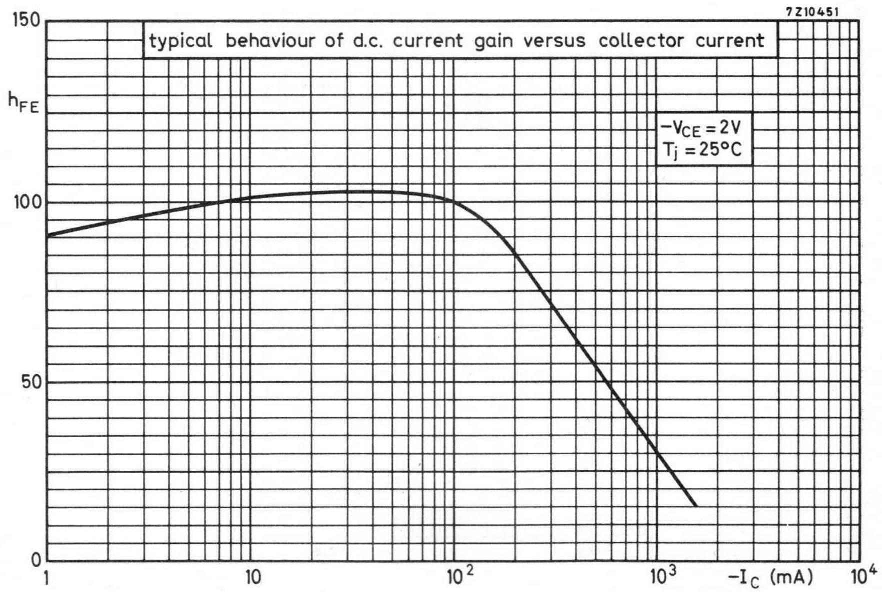
1) To derate $P_{tot\,max}$ for higher temperatures see page 6.
Ratings for second breakdown are independent of temperature.


7Z10444
maximum allowable total power dissipation (in%) versus mounting base temperature
Ptot (%)
100
50
0
0
100
Tmb(°C)
200

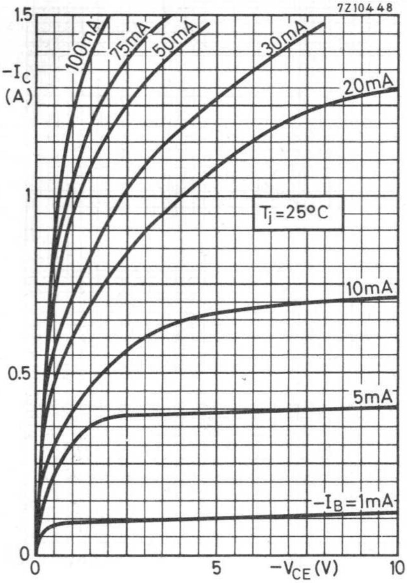

7Z10645
multiplying factors for non repetitive operation
M
10
8
6
4
2
MP
MSB
0.01
0.1
1
tp(ms)
10

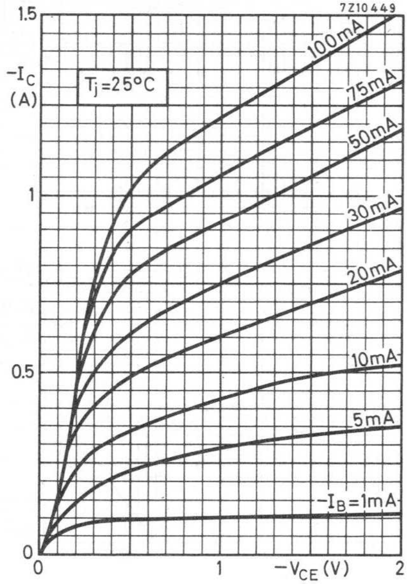

7Z10436
transient thermal resistance versus pulse duration
M-factor formulae for repetitive pulses
MP = Rth j-mb / (δ.Rth j-mb + (1−δ) Zth(tp+T) + Zth(tp) − Zth(T))
MSB = Rth crystal / (δ.Rth crystal + (1−δ) Zth(tp+T) + Zth(tp) − Zth(T))
tp
T
δ = tp/T
Zth (°C/W)
10²
10
1
10⁻¹
Rth j-mb
Rth crystal
δ=0
10⁻³
10⁻²
10⁻¹
1
10
10²
tp (ms)
10³

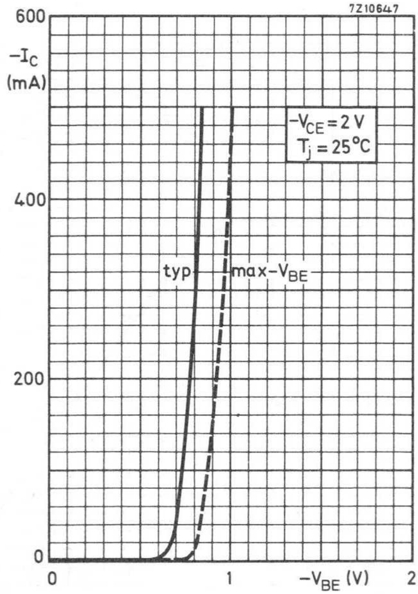

7Z10644
$-I_C$ (mA)
$-V_{CE} = 2$ V
$T_j = 25$ °C
max $-I_B$
$-I_B$ (mA)

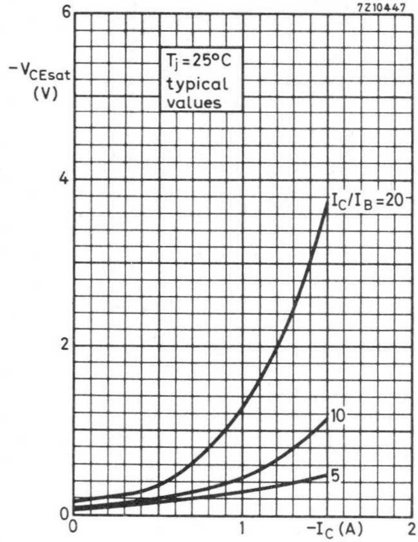

7Z10451
typical behaviour of d.c. current gain versus collector current
h_{FE}
$-V_{CE} = 2$ V
$T_j = 25$ °C
$-I_C$ (mA)

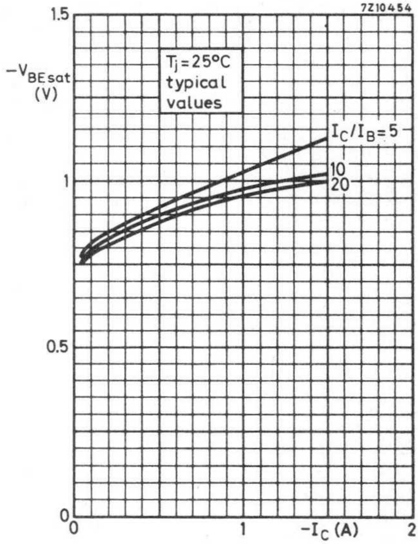
typical behaviour of collector current versus collector-emitter voltage

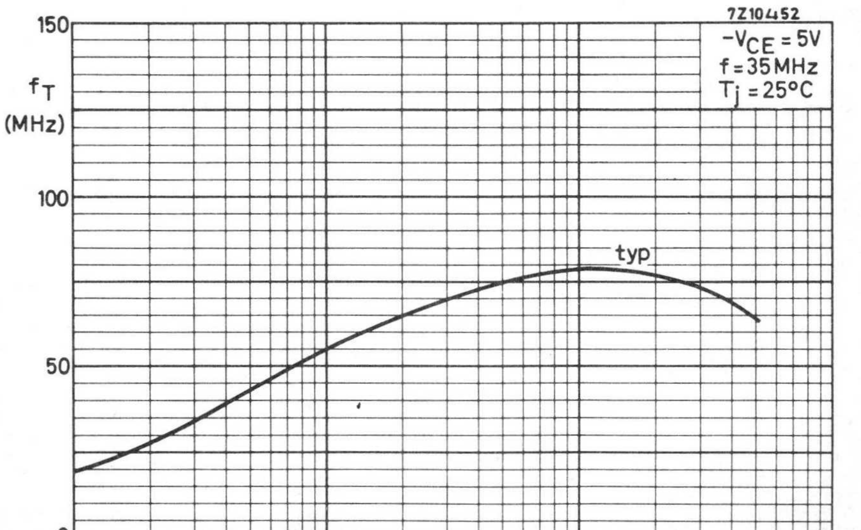












APPLICATION INFORMATION See BD135; BD137; BD139 pages 10 to 16

SILICON DIFFUSED POWER TRANSISTORS

N-P-N transistors in a TO-3 metal envelope with the collector connected to the case. The BDY10 and BDY11 are primarily intended for high and medium power audio frequency applications. Moreover they are extremely suitable for d.c. converters and solenoid drivers. These electrically robust transistors are, to a very high degree, free of second breakdown.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

			BDY10	BDY11	
Collector-base voltage (open emitter)	V_{CBO}	max.	50	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	70	V
Collector-emitter voltage with V_{BE} = 0	V_{CES}	max.	50	100	V
Collector current (d.c.)	I_C	max.		2	A
Collector current (peak value)	I_{CM}	max.		4	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.		125	W
Storage temperature	T_{stg}			−55 to + 175	°C
Junction temperature	T_j	max.		175	°C

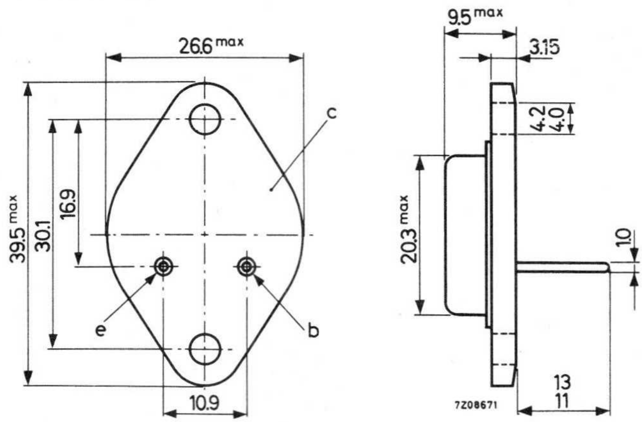
THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	40	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1	°C/W
From mounting base to heatsink	$R_{th\ mb\text{-}h}$	=	0.2	°C/W

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-3



Accessories available: 56201e.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current					
$I_E = 0$; $V_{CB} = 50$ V	BDY10	I_{CBO}	typ. <	10 300	μA μA
$I_E = 0$; $V_{CB} = 100$ V	BDY11	I_{CBO}	typ. <	4.5 300	μA μA
$I_E = 0$; $V_{CB} = V_{CBOmax}$; $T_j = 175$ °C		I_{CBO}	typ. <	2 30	mA mA
$V_{EB} = 0$; $V_{CB} = V_{CBOmax}$		I_{CES}	<	1	mA
Emitter cut-off current					
$I_C = 0$; $V_{EB} = 5$ V		I_{EBO}	typ. <	0.5 1	nA mA
$I_C = 0$; $V_{EB} = 5$ V; $T_j = 175$ °C		I_{EBO}	typ. <	65 30	μA mA
Base-emitter voltage					
$I_C = 0.2$ A; $V_{CE} = 2$ V		V_{BE}	<	1.5	V
$I_C = 2$ A; $V_{CE} = 2$ V		V_{BE}	typ. <	1.2 3	V V
Saturation voltage					
$I_C = 2$ A; $I_B = 0.4$ A		V_{CEsat}	<	0.7	V
Emitter-base floating voltage					
$I_E = 0$; $V_{CB} = V_{CBOmax}$; $T_j = 150$ °C		V_{EBfl}	<	1	V
D.C. current gain					
$I_C = 0.2$ A; $V_{CE} = 2$ V		h_{FE}	> typ.	20 100	
$I_C = 2$ A; $V_{CE} = 2$ V		h_{FE}	typ.	25 10 to 50	
$I_C = 4$ A; $V_{CE} = 2$ V		h_{FE}	typ.	10	
Collector capacitance at f = 1 MHz					
$I_E = I_e = 0$; $V_{CB} = 20$ V		C_c	typ. <	350 500	pF pF
Transition frequency					
$I_C = 0.2$ A; $V_{CE} = 5$ V		f_T	>	1	MHz

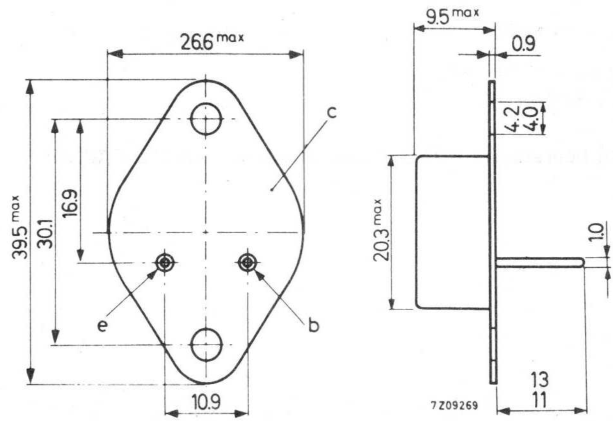
SILICON DIFFUSED POWER TRANSISTORS

N-P-N transistor in a TO-3 metal envelope, intended for use in linear applications such as hi-fi amplifiers and signal processing circuits.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	V
Collector current (peak value)	I_{CM}	max.	15	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	115	W
Junction temperature	T_j	max.	200	°C
D.C. current gain I_C = 4 A; V_{CE} = 4 V	h_{FE}	20 to	70	
Transition frequency at f = 1 MHz I_C = 1 A; V_{CE} = 4 V	f_T	typ.	1	MHz

MECHANICAL DATA Dimensions in mm

Collector connected to envelope
TO-3



Accessories available: 56201e (for insulated mounting on a 2 mm heatsink).

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltages				
Collector-base voltage (open emitter)	V_{CBO}	max.	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	V [1]
Collector-emitter voltage (R_{BE} = 100 Ω)	V_{CER}	max.	70	V [1]
Emitter-base voltage (open collector)	V_{EBO}	max.	7	V
Currents				
Collector current (d.c.)	I_C	max.	15	A
Collector current (peak value)	I_{CM}	max.	15	A
Emitter current (peak value)	$-I_{EM}$	max.	15	A
Power dissipation				
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	115	W
Temperatures				
Storage temperature	T_{stg}		-65 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	40	°C/W
From junction to mounting base	$R_{th\ j-mb}$	=	1.5	°C/W
From mounting base to heatsink	$R_{th\ mb-h}$	=	0.5	°C/W
From mounting base to heatsink with accessory 56201e	$R_{th\ mb-h}$	=	0.75	°C/W

The appropriate heatsink(s) will be found in the section HEATSINKS.

[1]) I_C = 0.2 A

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off currents		
I_E = 0; V_{CB} = 100 V	I_{CBO}	typ. 3 μA < 5 mA
I_B = 0; V_{CE} = 30 V	I_{CEO}	< 0.7 mA
$-V_{BE}$ = 1.5 V; V_{CE} = 100 V	I_{CEX}	typ. 4 μA < 5 mA
$-V_{BE}$ = 1.5 V; V_{CE} = 100 V; T_j = 150 °C	I_{CEX}	typ. 0.3 mA < 10 mA
Emitter cut-off current		
I_C = 0; V_{EB} = 7 V	I_{EBO}	typ. 1 nA < 5 mA
Base-emitter voltage		
I_C = 4 A; V_{CE} = 4 V	V_{BE}	typ. 1.1 V < 1.8 V
Collector-emitter saturation voltage		
I_C = 4 A; I_B = 0.4 A	V_{CEsat}	typ. 0.4 V < 1.1 V
Knee voltage		
I_C = 10 A; I_B = value for which I_C = 11 A at V_{CE} = 5 V	V_{CEK}	< 3.0 V
D.C. current gain		
I_C = 4 A; V_{CE} = 4 V	h_{FE}	20 to 70
Collector capacitance at f = 1 MHz		
I_E = I_e = 0; V_{CB} = 20 V	C_c	typ. 250 pF
Transition frequency at f = 1 MHz		
I_C = 1 A; V_{CE} = 4 V	f_T	typ. 1 MHz
Cut-off frequency		
I_C = 1 A; V_{CE} = 4 V	f_{hfe}	typ. 9 kHz
D.C. current gain ratio of matched pair 2-BDY20		
I_C = 0.4 A; V_{CE} = 4 V	h_{FE1}/h_{FE2}	< 1.6
I_C = 4 A; V_{CE} = 4 V	h_{FE1}/h_{FE2}	< 1.3

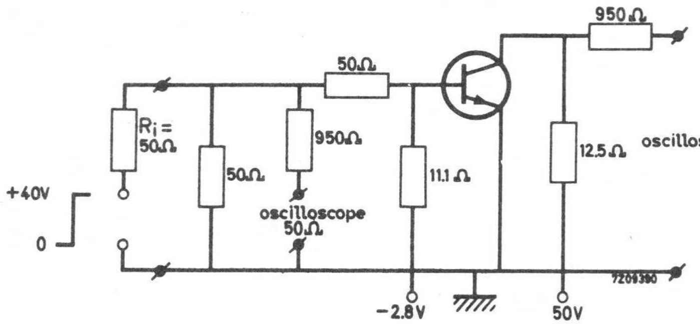
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Switching times

I_C = 4 A; I_B = $-I_{BM}$ = 400 mA

Delay time	t_d	typ. 0.4	μs
Rise time	t_r	typ. 2	μs
Storage time	t_s	typ. 2	μs
Fall time	t_f	typ. 2.5	μs

Test circuit:

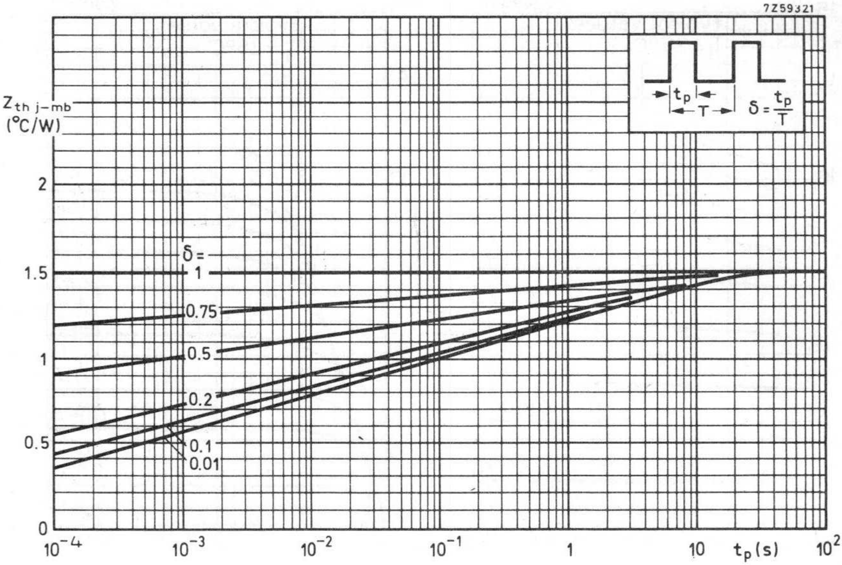


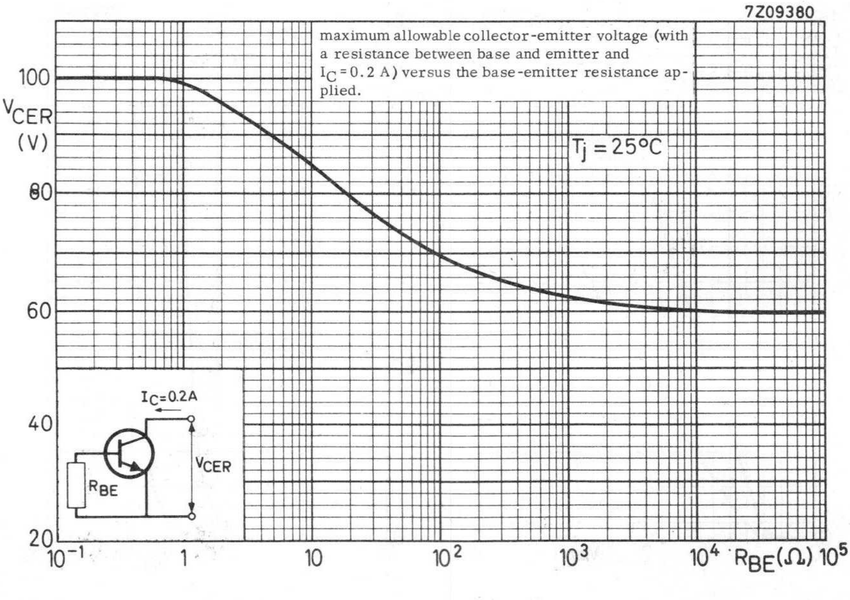
Pulse generator:

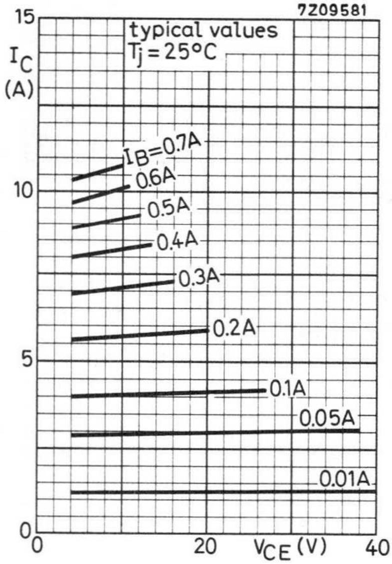
Pulse duration	t	>	10	μs
Rise time	t_r	≤	10	ns

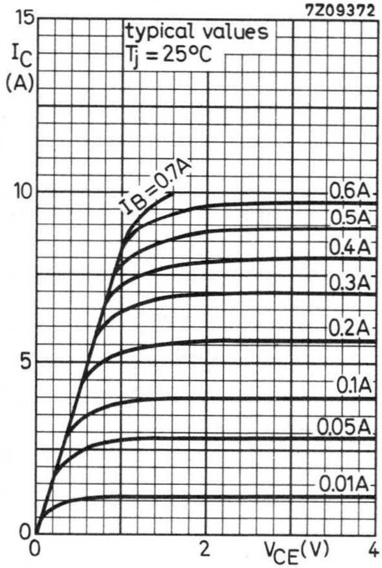
Oscilloscope:

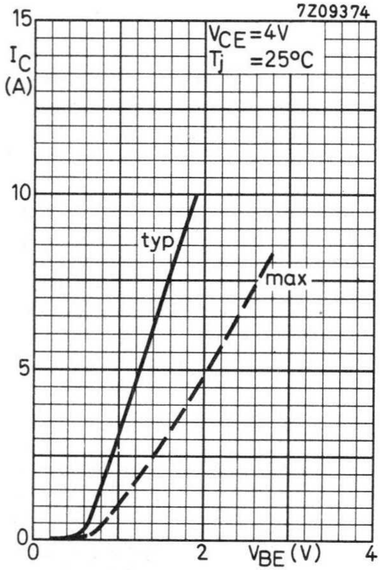
Rise time	t_r	≤	10	ns
Input resistance	R_i	=	50	Ω

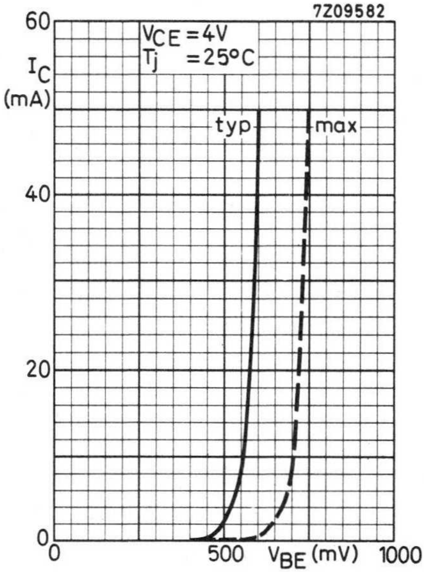

7Z59321
$Z_{th\ j-mb}$ (°C/W)
2
1.5
1
0.5
0
δ =
1
0.75
0.5
0.2
0.1
0.01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
t_p(s)
10^2

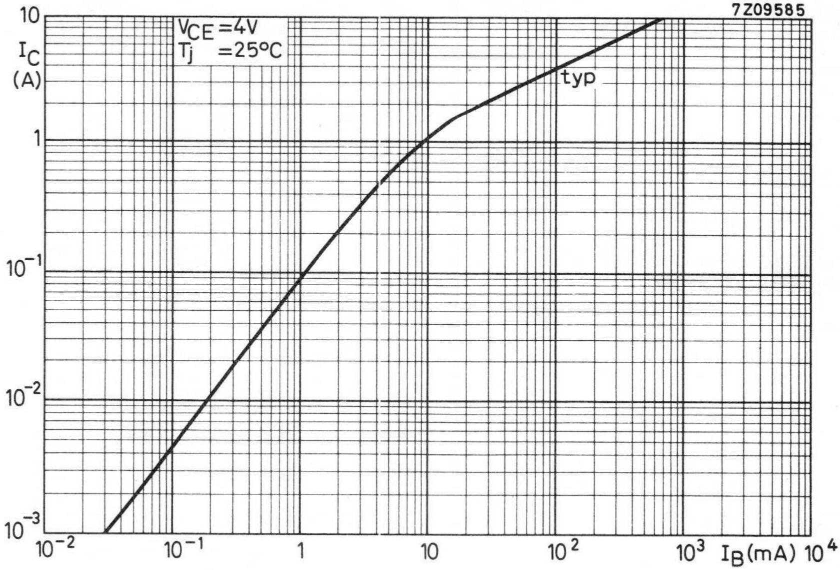

7Z09380
maximum allowable collector-emitter voltage (with a resistance between base and emitter and $I_C = 0.2$ A) versus the base-emitter resistance applied.
$T_j = 25$°C
100
V_{CER} (V)
80
60
40
20
$I_C = 0.2$A
R_{BE}
V_{CER}
10^{-1}
1
10
10^2
10^3
10^4
R_{BE}(Ω)
10^5

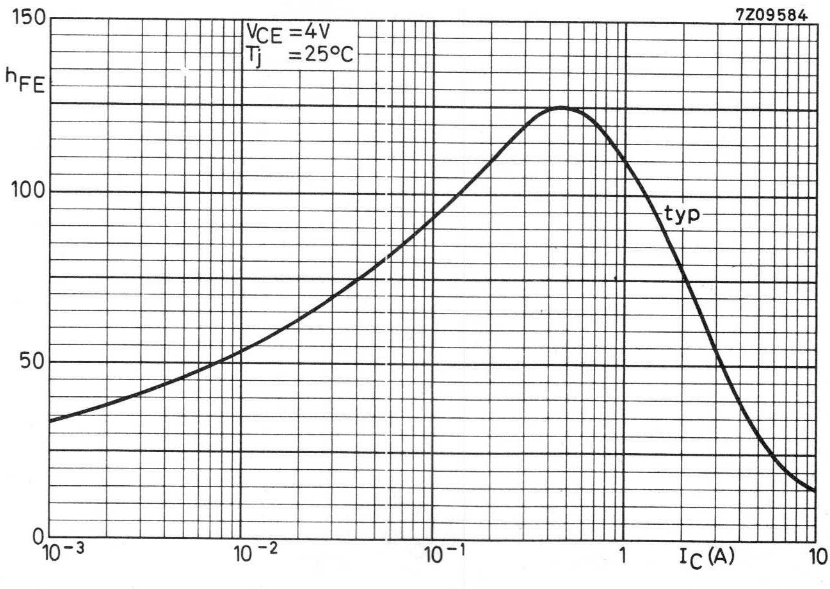

7Z09581
typical values
$T_j = 25°C$
I_C (A)
I_B=0.7A
0.6A
0.5A
0.4A
0.3A
0.2A
0.1A
0.05A
0.01A
V_{CE} (V)
0
5
10
15
20
40

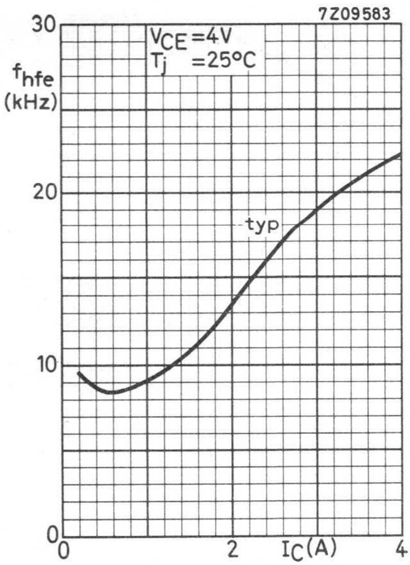

7Z09372
typical values
$T_j = 25°C$
I_C (A)
I_B=0.7A
0.6A
0.5A
0.4A
0.3A
0.2A
0.1A
0.05A
0.01A
V_{CE}(V)
0
2
4
5
10
15

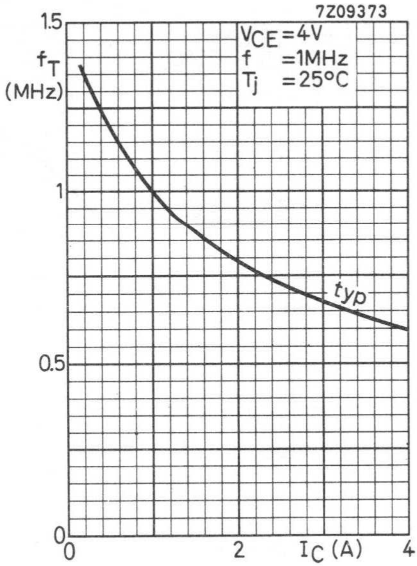

7Z09374
V_{CE}=4V
T_j =25°C
I_C (A)
typ
max
V_{BE} (V)
0
2
4
5
10
15

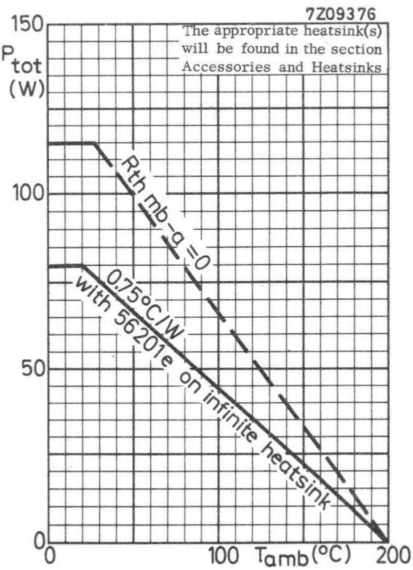

7Z09582
V_{CE}=4V
T_j =25°C
I_C (mA)
typ
max
V_{BE} (mV)
0
500
1000
20
40
60

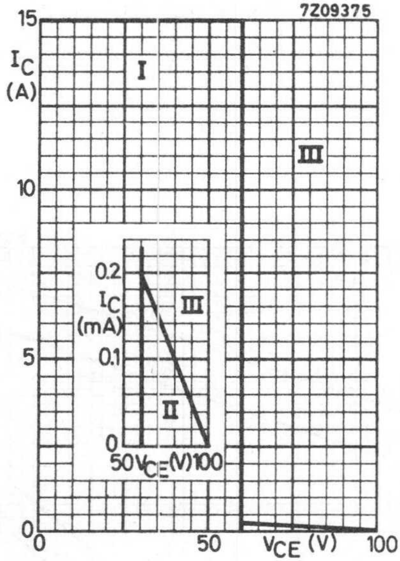

7Z09585
V_{CE} = 4V
T_j = 25°C
I_C (A)
typ
I_B (mA)
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3
10^4


7Z09584
V_{CE} = 4V
T_j = 25°C
h_{FE}
typ
I_C (A)
150
100
50
0
10^{-3}
10^{-2}
10^{-1}
1
10


7Z09583
30
20
10
0
f_{hfe} (kHz)
V_{CE} = 4V
T_j = 25°C
typ
0
2
4
I_C (A)


7Z09373
1.5
1
0.5
0
f_T (MHz)
V_{CE} = 4V
f = 1MHz
T_j = 25°C
typ
0
2
4
I_C (A)

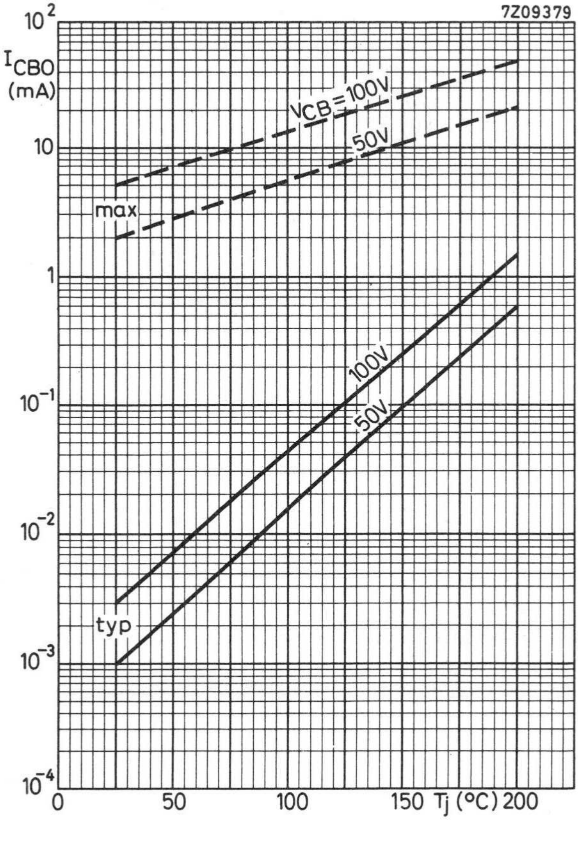

7Z09376
150
100
50
0
P_{tot} (W)
The appropriate heatsink(s) will be found in the section Accessories and Heatsinks
Rth mb-a = 0
0.75°C/W
with 56201e on infinite heatsink
0
100
200
T_{amb} (°C)



I Region of permissible operation under all base-emitter conditions provided no limiting values are exceeded.

II Additional region of operation when the transistor is cut-off with $-V_{BE} \leq 1.5$ V.

III Operation during switching off is allowed, provided the transistor is cut-off with $-V_{BE} \leq 1.5$ V and the transient energy does not exceed 75 mWs.


7Z09379
I_{CBO} (mA)
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
V_{CB} = 100V
50V
max
100V
50V
typ
0
50
100
150
T_j (°C)
200

SILICON DIFFUSED POWER TRANSISTORS

N-P-N transistor in a TO-3 metal envelope, intended for use in linear applications such as hi-fi amplifiers and signal processing circuits.

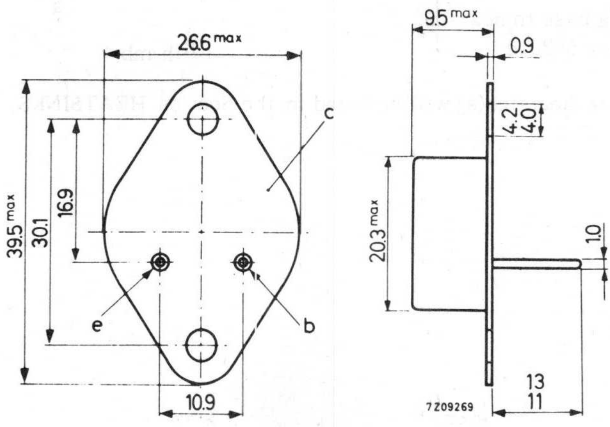
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	50	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	V
Collector current (peak value)	I_{CM}	max.	6	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	115	W
Junction temperature	T_j	max.	200	°C
D.C. current gain I_C = 2 A; V_{CE} = 4 V	h_{FE}	>	30	
Transition frequency at f = 1 MHz I_C = 1 A; V_{CE} = 4 V	f_T	typ.	1	MHz

MECHANICAL DATA Dimensions in mm

Collector connected to the envelope

TO-3



Accessories available: 56201e (for insulated mounting on a 2 mm heatsink)

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	50	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	V [1]
Emitter-base voltage (open collector)	V_{EBO}	max.	7	V

Currents

Collector current (d.c.)	I_C	max.	6	A
Collector current (peak value)	I_{CM}	max.	6	A
Emitter current (peak value)	$-I_{EM}$	max.	8	A

Power dissipation

Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	115	W

Temperatures

Storage temperature	T_{stg}	-65 to +200		°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

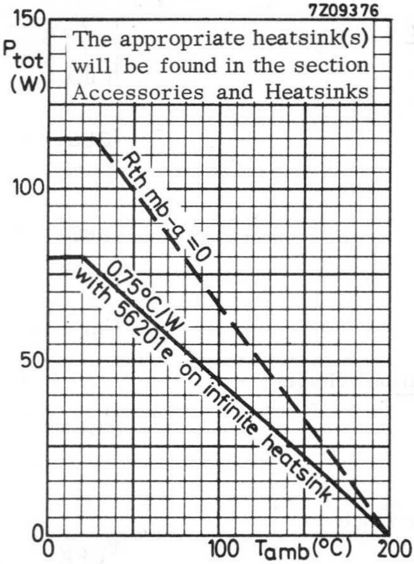
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	40	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1.5	°C/W
From mounting base to heatsink	$R_{th\ mb\text{-}h}$	=	0.5	°C/W
From mounting base to heatsink with accessory 56201e	$R_{th\ mb\text{-}h}$	=	0.75	°C/W

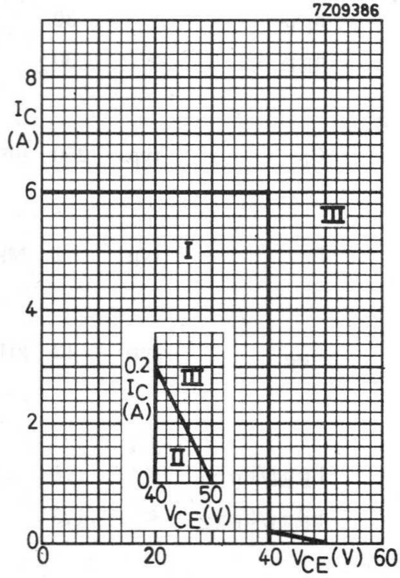
The appropriate heatsink(s) will be found in the Section HEATSINKS.

1) I_C = 0.2 A.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 50$ V	I_{CBO}	typ.	3	μA
		<	1	mA
$V_{BE} = 0$; $V_{CE} = 50$ V	I_{CES}	typ.	3	μA
		<	1	mA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 7$ V	I_{EBO}	typ.	1	nA
		<	5	mA
Base-emitter voltage				
$I_C = 2$ A; $V_{CE} = 4$ V	V_{BE}	<	2	V
Collector-emitter saturation voltage				
$I_C = 2$ A; $I_B = 0.2$ A	V_{CEsat}	<	0.7	V
Knee voltage				
$I_C = 6$ A; I_B = value for which $I_C = 6.6$ A and $V_{CE} = 2$ V	V_{CEK}	<	1.5	V
D.C. current gain				
$I_C = 0.2$ A; $V_{CE} = 4$ V	h_{FE}	>	30	
$I_C = 2$ A; $V_{CE} = 4$ V	h_{FE}	>	30	
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 20$ V	C_c	typ.	250	pF
Transition frequency at f = 1 MHz				
$I_C = 1$ A; $V_{CE} = 4$ V	f_T	typ.	1	MHz
Cut-off frequency				
$I_C = 1$ A; $V_{CE} = 4$ V	f_{hfe}	typ.	12	kHz
D.C. current gain ratio of matched pair 2-BDY38				
$I_C = 0.2$ A; $V_{CE} = 4$ V	h_{FE1}/h_{FE2}	<	1.5	
$I_C = 2$ A; $V_{CE} = 4$ V	h_{FE1}/h_{FE2}	<	1.2	

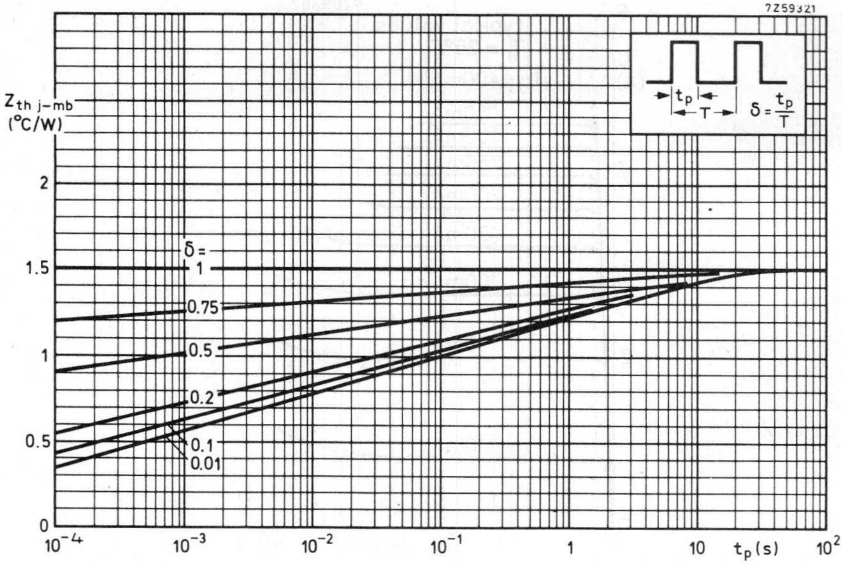


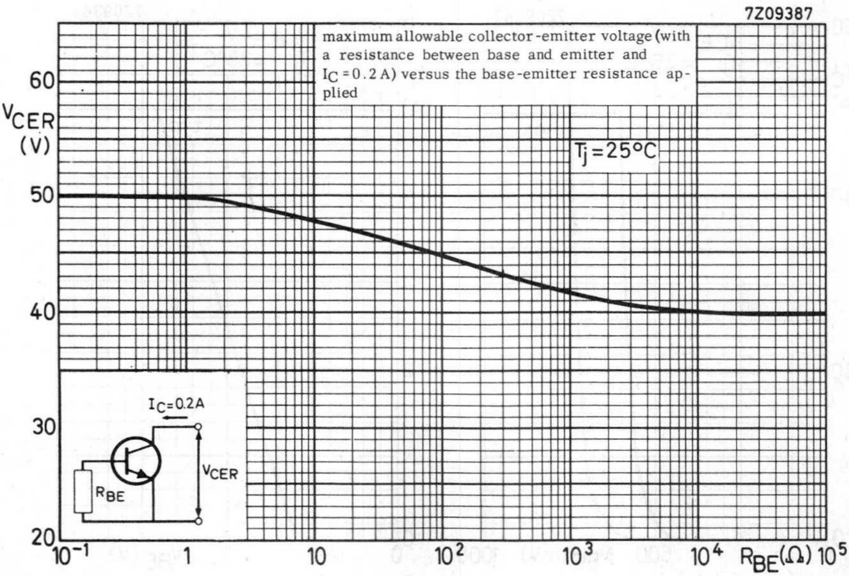


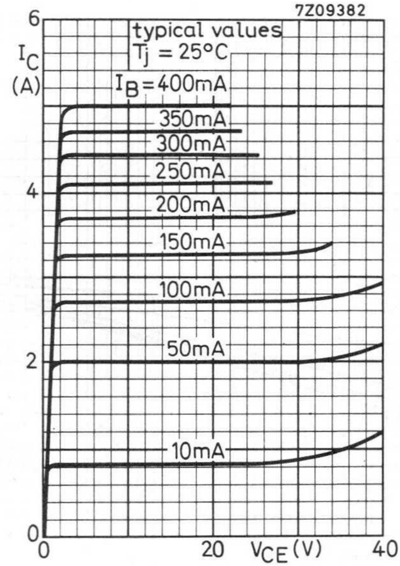
I Region of permissible operation under all base-emitter conditions provided no limiting values are exceeded.

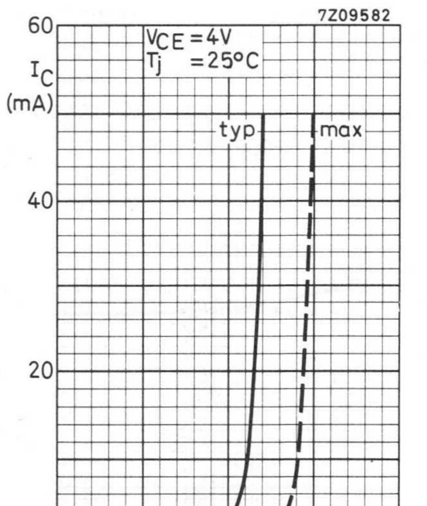
II Additional region of operation when the transistor is cut-off with $-V_{BE} \leq 1.5$ V.

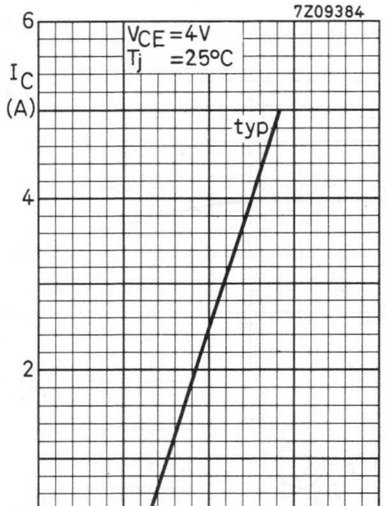
III Operation during switching-off is allowed, provided the transistor is cut-off with $-V_{BE} \leq 1.5$ V and the transient energy does not exceed 75 mWs.

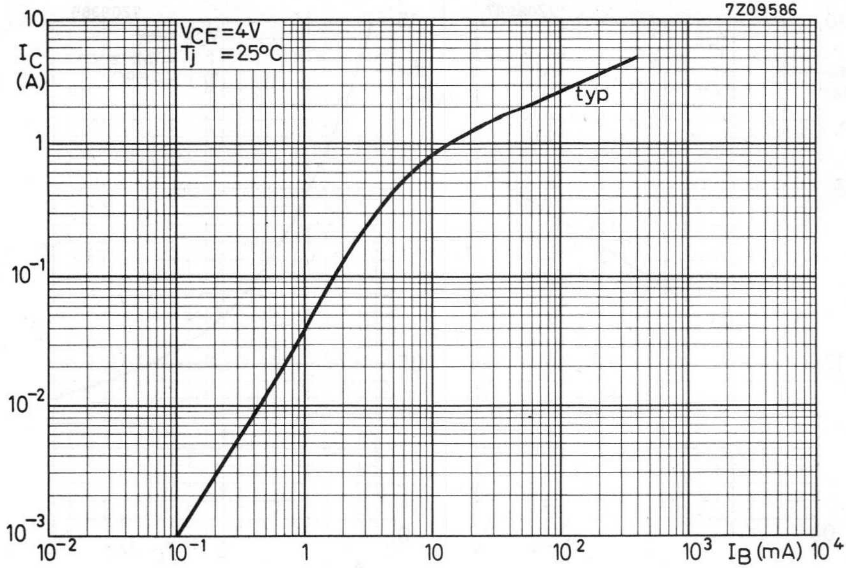

7Z59321
$Z_{th\ j-mb}$ (°C/W)
δ =
1
0.75
0.5
0.2
0.1
0.01
t_p
T
$\delta = \frac{t_p}{T}$
t_p (s)
0
0.5
1
1.5
2
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2

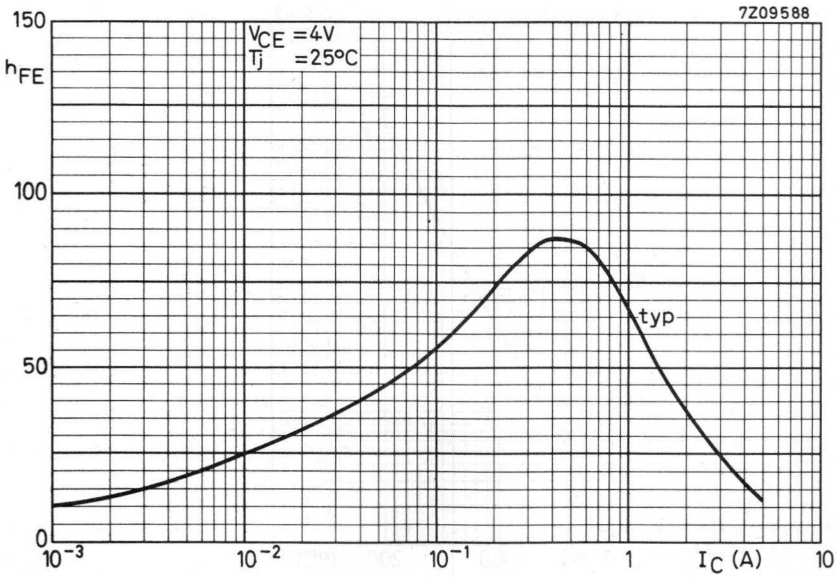

7Z09387
maximum allowable collector-emitter voltage (with a resistance between base and emitter and I_C = 0.2 A) versus the base-emitter resistance applied
T_j = 25°C
V_{CER} (V)
I_C = 0.2A
R_{BE}
V_{CER}
R_{BE} (Ω)
20
30
40
50
60
10^{-1}
1
10
10^2
10^3
10^4
10^5

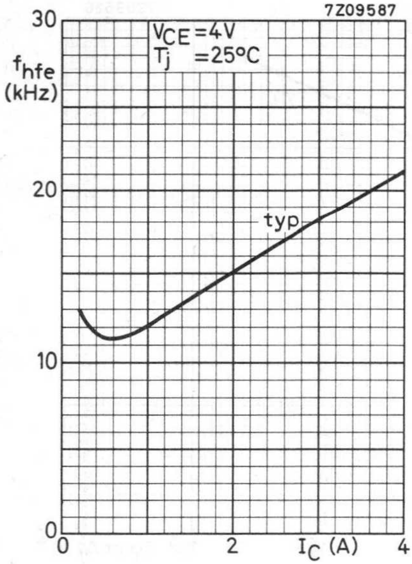

7Z09382
typical values
Tj = 25°C
IC (A)
IB = 400mA
350mA
300mA
250mA
200mA
150mA
100mA
50mA
10mA
VCE (V)
0
2
4
6
0
20
40

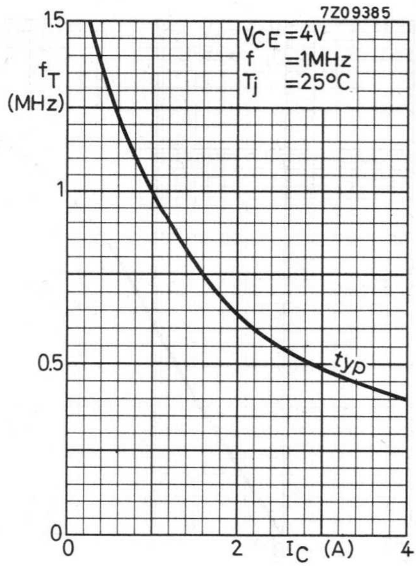

7Z09582
VCE = 4V
Tj = 25°C
IC (mA)
typ
max
VBE (mV)
0
20
40
60
0
500
1000

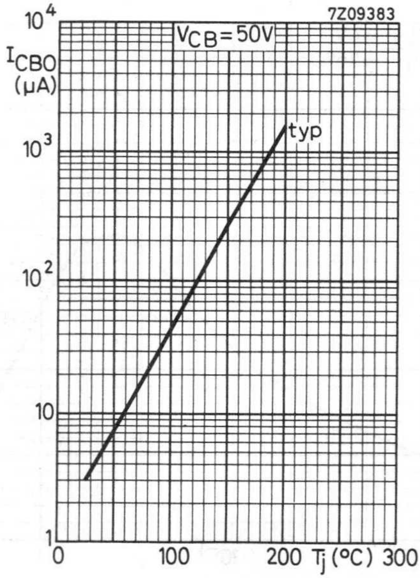

7Z09384
VCE = 4V
Tj = 25°C
IC (A)
typ
VBE (V)
0
2
4
6
0
1
2


7Z09586
V_{CE} = 4V
T_j = 25°C
I_C (A)
typ
I_B (mA)
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3
10^4


7Z09588
V_{CE} = 4V
T_j = 25°C
h_{FE}
typ
I_C (A)
150
100
50
0
10^{-3}
10^{-2}
10^{-1}
1
10


7Z09587
30
20
10
0
f_{hfe} (kHz)
V_{CE} = 4V
T_j = 25°C
typ
0
2
4
I_C (A)


7Z09385
1.5
1
0.5
0
f_T (MHz)
V_{CE} = 4V
f = 1MHz
T_j = 25°C
typ
0
2
4
I_C (A)


7Z09383
10^4
10^3
10^2
10
1
I_{CBO} (μA)
V_{CB} = 50V
typ
0
100
200
300
T_j (°C)

P-N-P POWER TRANSISTORS

High frequency power transistors in a metal envelope for use in high speed industrial switching applications.
The OC22 is intended for use in digital computers and high quality audio amplifiers.
The OC23 is intended for use as pulse generator for a ferrite store.
The OC24 is intended for use in digital computers, medium frequency transmitters and carrier telephony applications.

RATINGS (Limiting values) [1]

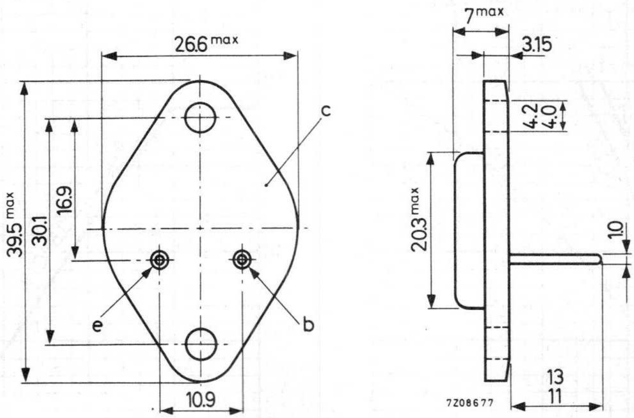
			OC22	OC23 OC24	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	40	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	24	16	V
Collector current (peak value)	$-I_{CM}$	max.	2.0		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	21.5		W
Junction temperature	T_j	max.	90		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	3.0	°C/W
From mounting base to heatsink without mica insulation	$R_{th\ mb\text{-}h}$	=	0.2	°C/W

MECHANICAL DATA Dimensions in mm

Collector connected to mounting base



[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

CHARACTERISTICS

T_{mb} = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $-V_{CB} = 10$ V	$-I_{CBO}$	typ.	20	μA
		<	100	μA

Base-emitter voltage

$-I_C = 100$ mA; $-V_{CE} = 2$ V	$-V_{BE}$	typ.	0.25	V
$-I_C = 1$ A ; $-V_{CE} = 2$ V	$-V_{BE}$	typ.	0.8	V

D.C. current gain

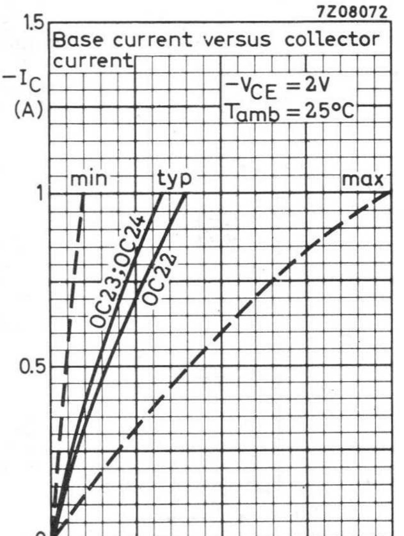
			OC22	OC23 OC24
$-I_C = 100$ mA; $-V_{CE} = 2$ V	h_{FE}	typ.	170	200
$-I_C = 1$ A; $-V_{CE} = 2$ V	h_{FE}	>	50	50
		typ.	125	150

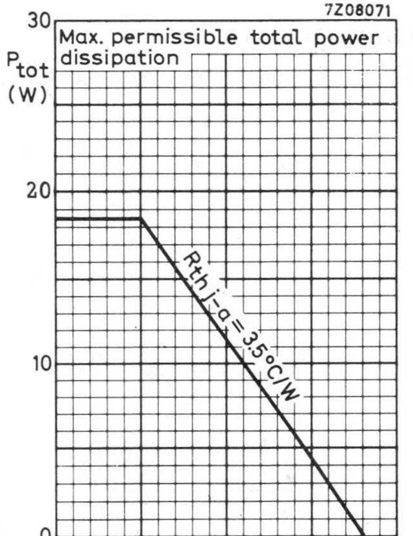
Cut-off frequency

$-I_C = 400$ mA; $-V_{CE} = 2$ V	f_{hfb}	typ.	2.5	MHz

Small signal current gain

$-I_C = 400$ mA; $-V_{CE} = 2$ V	h_{fe}	typ.	180





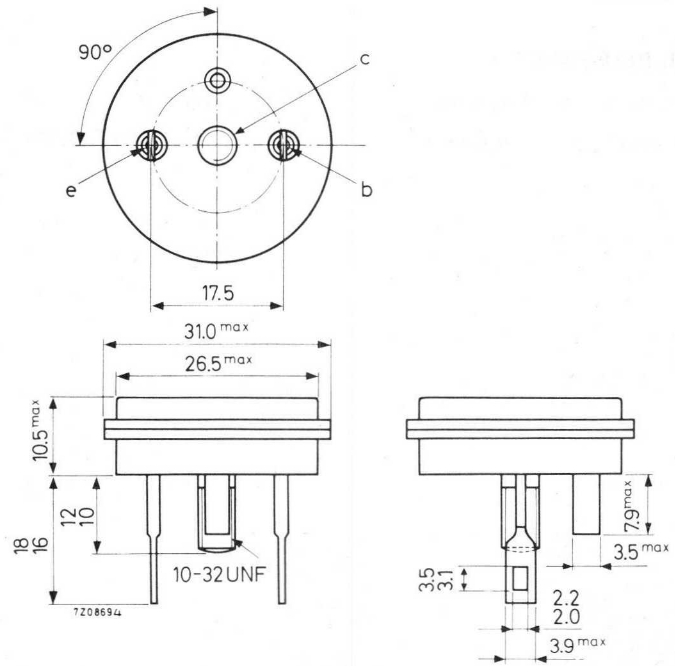
GERMANIUM POWER TRANSISTOR

P-N-P alloy transistor in a TO-36 metal envelope with the collector connected to the mounting base.

QUICK REFERENCE DATA				
Collector-base voltage ($+V_{BE}$ = 1.5 V)	$-V_{CBX}$	max.	80	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	60	V
Emitter current (d.c.)	I_E	max.	15	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	150	W
Junction temperature	T_j	max.	100	°C
D.C. current gain at T_j = 25 °C				
$-I_C$ = 5 A; $-V_{CE}$ = 2 V	h_{FE}	>	25	
Cut-off frequency				
$-I_C$ = 5 A; $-V_{CE}$ = 6 V	f_{hfe}	typ.	10	kHz

MECHANICAL DATA Dimensions in mm

TO-36



Diameter of hole in heatsink: max. 5.2 mm

Supplied with device: 56213

Torque on nut: min. 8 cm kg
max. 17 cm kg

RATINGS (Limiting values) [1]

Voltages

Collector-base voltage ($+V_{BE}$ = 1.5 V)	$-V_{CBX}$	max.	80	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	60	V

Currents

Emitter current (d.c.)	I_E	max.	15	A
Base current (d.c.)	$-I_B$	max.	4	A

Power dissipation

Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	150	W

Temperatures

Storage temperature	T_{stg}	-65 to +100		°C
Junction temperature	T_j	max.	100	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	0.5	°C/W
Thermal capacity (1 to 10 ms)			0.075	Ws/°C

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

CHARACTERISTICS T_{amb} = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0; -V_{CB} = 2$ V	$-I_{CBO}$	typ.	100	μA
$I_E = 0; -V_{CB} = 80$ V	$-I_{CBO}$	typ.	2	mA
		<	8	mA
$I_E = 0; -V_{CB} = 80$ V; $T_j = 70$ °C	$-I_{CBO}$	<	15	mA
Emitter cut-off current				
$I_C = 0; -V_{EB} = 60$ V	$-I_{EBO}$	typ.	1	mA
		<	8	mA
Breakdown voltages				
$-I_C = 1$ A; $I_B = 0$	$-V_{(BR)CEO}$	>	55	V
$-I_C = 300$ mA; $V_{BE} = 0$	$-V_{(BR)CES}$	>	70	V
Base-emitter voltage				
$-I_C = 5$ A; $-V_{CE} = 2$ V	$-V_{BE}$	typ.	0.65	V
		<	0.9	V
Saturation voltages				
$-I_C = 12$ A; $-I_B = 2$ A	$-V_{CEsat}$	typ.	0.3	V
		<	0.9	V
Emitter-base floating voltage				
$I_E = 0; -V_{CB} = 80$ V	$-V_{EBfl}$	<	1	V
D.C. current gain				
$-I_C = 5$ A; $-V_{CE} = 2$ V	h_{FE}		25 to 50	
$-I_C = 12$ A; $-V_{CE} = 2$ V	h_{FE}	typ.	20	
Cut-off frequency				
$-I_C = 5$ A; $-V_{CE} = 6$ V	f_{hfe}	typ.	10	kHz
Rise time				
$-I_C = 12$ A; $-I_B = 2$ A; $-V_{CE} = 12$ V	t_r	typ.	15	μs
Fall time				
$I_C = 0; +V_{BE} = 6$ V; $R_{BE} = 10\ \Omega$	t_f	typ.	15	μs

GERMANIUM POWER TRANSISTOR

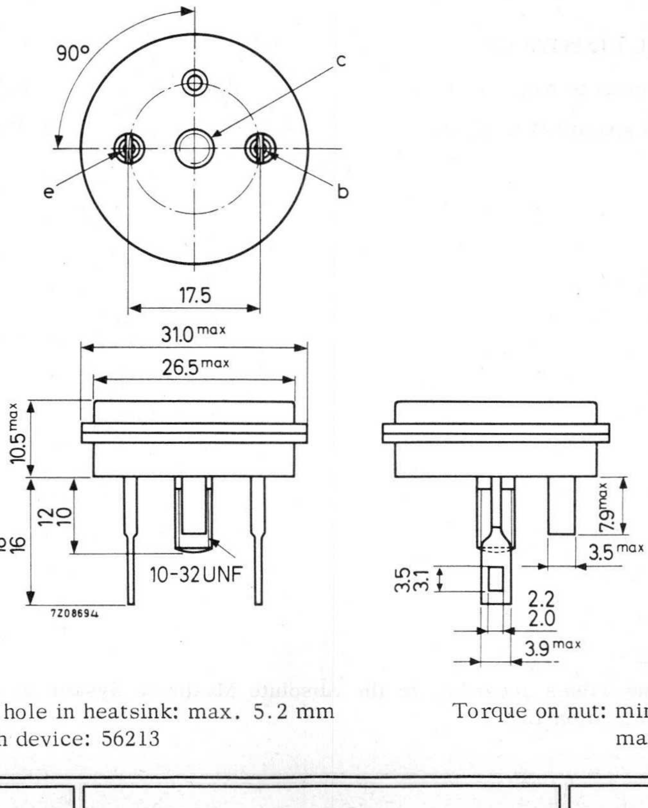
P-N-P alloy transistor in a TO-36 metal envelope with the collector connected to the mounting base.

QUICK REFERENCE DATA				
Collector-base voltage ($+V_{BE}$ = 1.5 V)	$-V_{CBX}$	max.	40	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	20	V
Emitter current (d.c.)	I_E	max.	15	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	150	W
Junction temperature	T_j	max.	100	°C
D.C. current gain at T_j = 25 °C				
$-I_C$ = 5 A; $-V_{CE}$ = 2 V	h_{FE}	>	35	
Cut-off frequency				
$-I_C$ = 5 A; $-V_{CE}$ = 6 V	f_{hfe}	typ.	10	kHz

MECHANICAL DATA

TO-36

Dimensions in mm



Diameter of hole in heatsink: max. 5.2 mm

Supplied with device: 56213

Torque on nut: min. 8 cm kg
max. 17 cm kg

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage ($+V_{BE}$ = 1.5 V)	$-V_{CBX}$	max.	40	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	20	V

Currents

Emitter current (d.c.)	I_E	max.	15	A
Base current (d.c.)	$-I_B$	max.	4	A

Power dissipation

Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	150	W

Temperatures

Storage temperature	T_{stg}		−65 to +100	°C
Junction temperature	T_j	max.	100	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\,j\text{-}mb}$	=	0.5	°C/W
Thermal capacity (1 to 10 ms)			0.075	Ws/°C

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $-V_{CB} = 2$ V	$-I_{CBO}$	typ.	100	μA
$I_E = 0$; $-V_{CB} = 40$ V	$-I_{CBO}$	typ. <	2 8	mA mA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 20$ V	$-I_{EBO}$	typ. <	1 8	mA mA
Breakdown voltages				
$-I_C = 300$ mA; $I_B = 0$	$-V_{BR(CEO)}$	typ.	40	V
$-I_C = 300$ mA; $V_{BE} = 0$	$-V_{BR(CES)}$	>	40	V
Base-emitter voltage				
$-I_C = 5$ A; $-V_{CE} = 2$ V	$-V_{BE}$	typ.	0.65	V
Saturation voltages				
$-I_C = 12$ A; $-I_B = 2$ A	$-V_{CEsat}$	typ.	0.3	V
Punch through voltage	V_{pt}	>	40	V
Emitter-base floating voltage				
$I_E = 0$; $-V_{CB} = 40$ V	$-V_{EBfl}$	<	1	V
D.C. current gain				
$-I_C = 5$; $-V_{CE} = 2$ V	h_{FE}		35 to 70	
$-I_C = 12$; $-V_{CE} = 2$ V	h_{FE}	typ.	25	
Cut-off frequency				
$-I_C = 5$ A; $-V_{CE} = 6$ V	f_{hfe}	typ.	10	kHz
Rise time				
$-I_C = 12$ A; $-I_B = 2$ A; $-V_{CE} = 12$ V	t_r	typ.	15	μs
Fall time				
$I_C = 0$; $+V_{BE} = 6$ V; $R_{BE} = 10\ \Omega$	t_f	typ.	15	μs

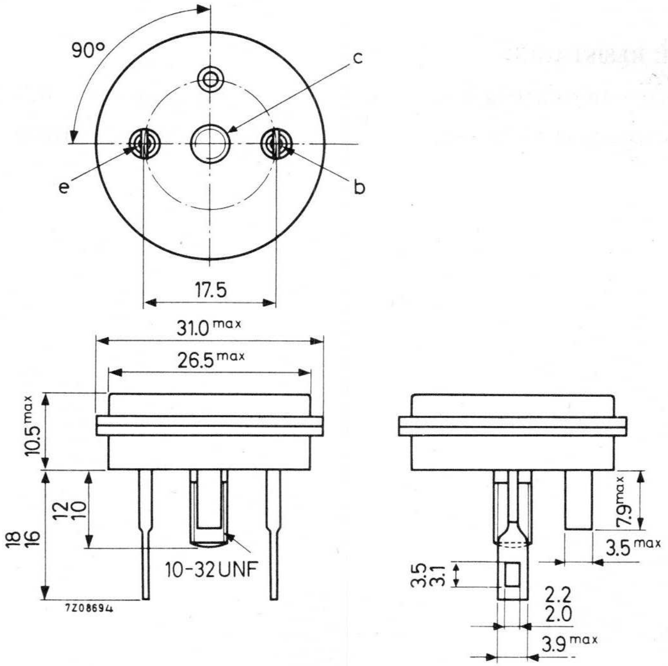
GERMANIUM POWER TRANSISTOR

P-N-P alloy transistor in a TO-36 metal envelope with the collector connected to the mounting base.

QUICK REFERENCE DATA				
Collector-base voltage ($+V_{BE}$ = 1.5 V)	$-V_{CBX}$	max.	40	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	20	V
Emitter current (d.c.)	I_E	max.	15	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	150	W
Junction temperature	T_j	max.	100	°C
D.C. current gain at T_j = 25 °C				
$-I_C$ = 5 A; $-V_{CE}$ = 2 V	h_{FE}	>	20	
Cut-off frequency				
$-I_C$ = 5 A; $-V_{CE}$ = 6 V	f_{hfe}	typ.	10	kHz

MECHANICAL DATA Dimensions in mm

TO-36



Diameter of hole in heatsink: max. 5.2 mm
Supplied with device: 56213

Torque on nut: min. 8 cm kg
max. 17 cm kg

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage ($+V_{BE}$ = 1.5 V)	$-V_{CBX}$	max.	40	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	20	V

Currents

Emitter current (d.c.)	I_E	max.	15	A
Base current (d.c.)	$-I_B$	max.	4	A

Power dissipation

Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	150	W

Temperatures

Storage temperature	T_{stg}		-65 to +100	°C
Junction temperature	T_j	max.	100	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	0.5	°C/W
Thermal capacity (1 to 10 ms)			0.075	Ws/°C

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $-V_{CB} = 2$ V	$-I_{CBO}$	typ.	100	μA
$I_E = 0$; $-V_{CB} = 40$ V	$-I_{CBO}$	typ. <	2 8	mA mA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 20$ V	$-I_{EBO}$	typ. <	1 8	mA mA
Breakdown voltages				
$-I_C = 300$ mA; $I_B = 0$	$-V_{BR(CEO)}$	typ.	40	V
$-I_C = 300$ mA; $V_{BE} = 0$	$-V_{BR(CES)}$	>	40	V
Base-emitter voltage				
$-I_C = 5$ A; $-V_{CE} = 2$ V	$-V_{BE}$	typ.	0.65	V
Saturation voltages				
$-I_C = 12$ A; $-I_B = 2$ A	$-V_{CEsat}$	typ.	0.3	V
Punch through voltage	V_{pt}	>	40	V
Emitter-base floating voltage				
$I_E = 0$; $-V_{CB} = 40$ V	$-V_{EBfl}$	<	1	V
D.C. current gain				
$-I_C = 5$ A; $-V_{CE} = 2$ V	h_{FE}		20 to 40	
$-I_C = 12$ A; $-V_{CE} = 2$ V	h_{FE}	typ.	20	
Cut-off frequency				
$-I_C = 5$ A; $-V_{CE} = 6$ V	f_{hfe}	typ.	10	kHz
Rise time				
$-I_C = 12$ A; $-I_B = 2$ A; $-V_{CE} = 12$ V	t_r	typ.	15	μs
Fall time				
$I_C = 0$; $+V_{BE} = 6$ V; $R_{BE} = 10\ \Omega$	t_f	typ.	15	μs

GERMANIUM POWER TRANSISTOR

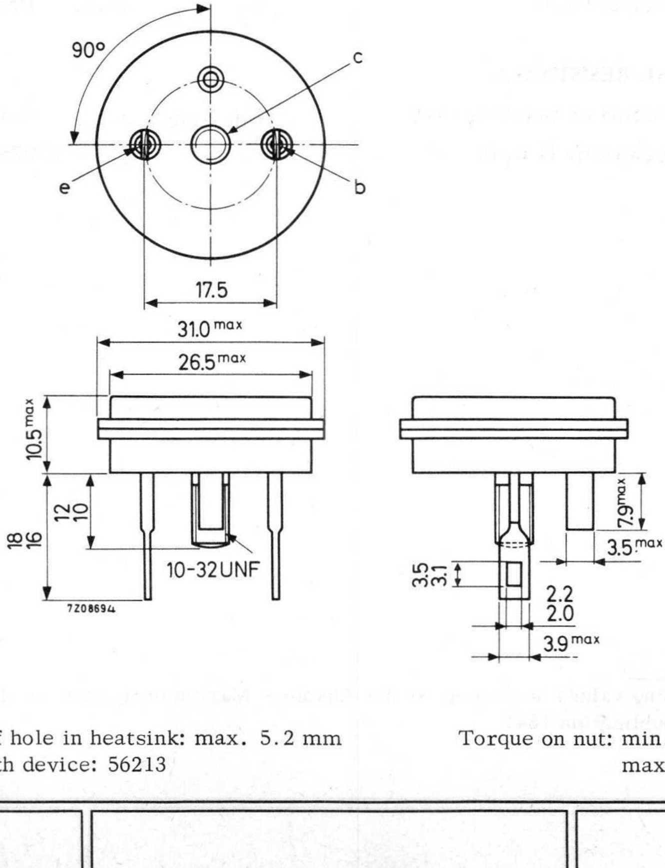
P-N-P alloy transistor in a TO-36 metal envelope with the collector connected to the mounting base.

QUICK REFERENCE DATA				
Collector-base voltage ($+V_{BE}$ = 1.5 V)	$-V_{CBX}$	max.	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	80	V
Emitter current (d.c.)	I_E	max.	15	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	150	W
Junction temperature	T_j	max.	100	°C
D.C. current gain at T_j = 25 °C				
$-I_C$ = 5 A; $-V_{CE}$ = 2 V	h_{FE}	>	25	
Cut-off frequency				
$-I_C$ = 5 A; $-V_{CE}$ = 6 V	f_{hfe}	typ.	10	kHz

MECHANICAL DATA

TO-36

Dimensions in mm



Diameter of hole in heatsink: max. 5.2 mm

Supplied with device: 56213

Torque on nut: min. 8 cm kg
max. 17 cm kg

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage ($+V_{BE}$ = 1.5 V)	$-V_{CBX}$	max.	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	80	V

Currents

Emitter current (d.c.)	I_E	max.	15	A
Base current (d.c.)	$-I_B$	max.	4	A

Power dissipation

Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	150	W

Temperatures

Storage temperature	T_{stg}		−65 to +100	°C
Junction temperature	T_j	max.	100	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	0.5	°C/W
Thermal capacity (1 to 10 ms)			0.075	Ws/°C

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

CHARACTERISTICS $T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current				
$I_E = 0$; $-V_{CB} = 2$ V	$-I_{CBO}$	typ.	100	μA
$I_E = 0$; $-V_{CB} = 100$ V	$-I_{CBO}$	<	8	mA
$I_E = 0$; $-V_{CB} = 100$ V; $T_j = 70\ ^oC$	$-I_{CBO}$	<	15	mA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 80$ V	$-I_{EBO}$	typ. <	1 8	mA mA
Breakdown voltages				
$-I_C = 1$ A; $I_B = 0$	$-V_{BR(CEO)}$	>	65	V
$-I_C = 300$ mA; $V_{BE} = 0$	$-V_{BR(CES)}$	>	80	V
Base-emitter voltage				
$-I_C = 5$ A; $-V_{CE} = 2$ V	$-V_{BE}$	typ. <	0.65 0.9	V V
Saturation voltages				
$-I_C = 12$ A; $-I_B = 2$ A	$-V_{CEsat}$	typ. <	0.3 0.7	V V
Emitter-base floating voltage				
$I_E = 0$; $-V_{CB} = 100$ V	$-V_{EBfl}$	<	1	V
D.C. current gain				
$-I_C = 5$ A; $-V_{CE} = 2$ V	h_{FE}		25 to 50	
$-I_C = 12$ A; $-V_{CE} = 2$ V	h_{FE}	typ.	20	
Cut-off frequency				
$-I_C = 5$ A; $-V_{CE} = 6$ V	f_{hfe}	typ.	10	kHz
Rise time				
$-I_C = 12$ A; $-I_B = 2$ A; $-V_{CE} = 12$ V	t_r	typ.	15	μs
Fall time				
$I_C = 0$; $+V_{BE} = 6$ V; $R_{BE} = 10\ \Omega$	t_f	typ.	15	μs

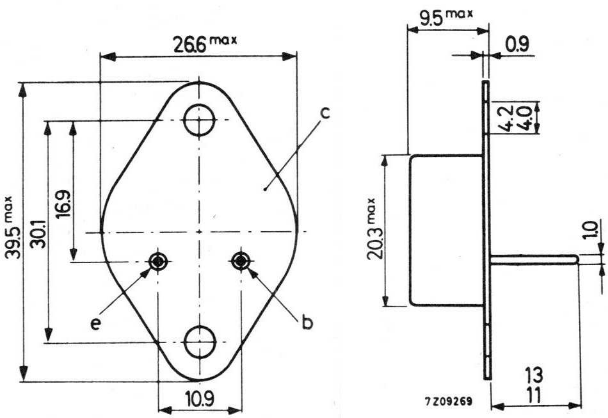
SILICON DIFFUSED POWER TRANSISTOR

N-P-N transistor in a TO-3 metal envelope, intended for use in linear applications such as hi-fi amplifiers and signal processing circuits.
Matched pairs are available.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	100	V
Collector-emitter voltage (R_{BE} = 100 Ω)	V_{CER}	max.	70	V
Collector current (d.c.)	I_C	max.	15	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	115	W
Junction temperature	T_j	max.	200	°C
D.C. current gain I_C = 4 A; V_{CE} = 4 V	h_{FE}		20 to 70	
Transition frequency at f = 1 MHz I_C = 1 A; V_{CE} = 4 V	f_T	>	0.8	MHz

MECHANICAL DATA Dimensions in mm

Collector connected to envelope
TO-3



Accessories available: 56201e (for insulated mounting on a 2 mm heatsink)

RATINGS (Limiting values) [1]

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	100	V
Collector-emitter voltage (R_{BE} = 100 Ω)	V_{CER}	max.	70	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	V

Currents

Collector current (d.c.)	I_C	max.	15	A
Base current (d.c.)	I_B	max.	7	A

Power dissipation

Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	115	W

Temperatures

Storage temperature	T_{stg}		-65 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1.5	°C/W

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off currents				
I_B = 0; V_{CE} = 30 V	I_{CEO}	<	1	mA
$-V_{BE}$ = 1.5 V; V_{CE} = 100 V	I_{CEX}	<	5	mA
$-V_{BE}$ = 1.5 V; V_{CE} = 100 V; T_j = 150 °C	I_{CEX}	<	10	mA
Emitter cut-off current				
I_C = 0; V_{EB} = 7 V	I_{EBO}	<	5	mA
Base-emitter voltage				
I_C = 4 A; V_{CE} = 4 V	V_{BE}	<	1.8	V
Collector-emitter saturation voltages				
I_C = 4 A; I_B = 0.4 A	V_{CEsat}	<	1.1	V
I_C = 10 A; I_B = 3.3 A	V_{CEsat}	<	4	V
Sustaining voltages				
I_C = 0.2 A; I_B = 0	$V_{CEOsust}$	>	60	V
I_C = 0.2 A; R_{BE} = 100 Ω	$V_{CERsust}$	>	70	V
D.C. current gain				
I_C = 4 A; V_{CE} = 4 V	h_{FE}	20 to	70	
Transition frequency at f = 1 MHz				
I_C = 1 A; V_{CE} = 4 V	f_T	>	0.8	MHz
Small signal current gain at f = 1 kHz				
I_C = 1 A; V_{CE} = 4 V	h_{fe}	>	15	

SILICON DIFFUSED POWER TRANSISTORS

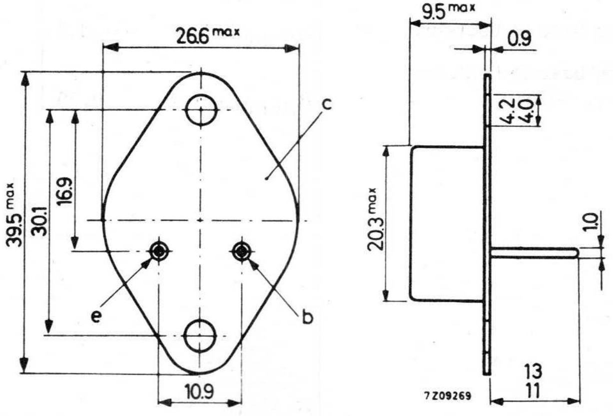
N-P-N transistors in a TO-3 metal envelope, intended for use in a wide variety of linear power applications in audio amplifiers, converters, voltage regulators, power supplies, etc.

QUICK REFERENCE DATA

			2N3442	2N4347	
Collector-base voltage (open emitter)	V_{CBO}	max.	160	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	140	120	V
Collector current (d.c.)	I_C	max.	10	5	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	117	100	W
Junction temperature	T_j	max.	200	200	°C
D.C. current gain					
I_C = 3 A; V_{CE} = 4 V	h_{FE}		20 to 70		
I_C = 4 A; V_{CE} = 4 V	h_{FE}			20 to 70	

MECHANICAL DATA Dimensions in mm

Collector connected to envelope
TO-3



Accessories supplied on request: 56201e

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

			2N3442	2N4347	
Collector-base voltage (open emitter)	V_{CBO}	max.	160	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	140	120	V
Collector-emitter voltage (R_{BE} = 100 Ω)	V_{CER}	max.	150	130	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	7	V

Currents

Collector current (d.c.)	I_C	max.	10	5	A
Collector current (peak value)	I_{CM}	max.	15	10	A
Base current (d.c.)	I_B	max.	7	3	A

Power dissipation

Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	117	100	W

Temperatures

Storage temperature	T_{stg}		-65 to +200	-65 to +200	°C
Junction temperature	T_j	max.	200	200	°C

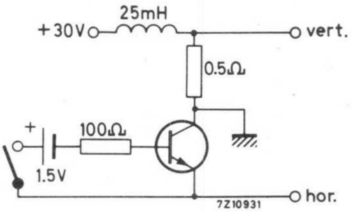
THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1.5	1.75	°C/W
From mounting base to heatsink	$R_{th\ mb\text{-}h}$	=	0.5	0.5	°C/W
From mounting base to heatsink with accessory 56201e	$R_{th\ mb\text{-}h}$	=	0.75	0.75	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			2N3442	2N4347	
Collector cut-off currents					
I_E = 0; V_{CB} = 140 V	I_{CBO}	typ.	50	50	μA
		<	1	1	mA
$-V_{BE}$ = 1.5 V; V_{CE} = 140 V	I_{CEX}	typ.	5		μA
		<	1		mA
$-V_{BE}$ = 1.5 V; V_{CE} = 140 V; T_{mb} = 150 °C	I_{CEX}	typ.	0.1		mA
		<	10		mA
$-V_{BE}$ = 1.5 V; V_{CE} = 120 V	I_{CEX}	typ.	1	5	μA
		<		2	mA
$-V_{BE}$ = 1.5 V; V_{CE} = 120 V; T_{mb} = 150 °C	I_{CEX}	typ.		0.1	mA
		<		10	mA
Emitter cut-off current					
I_C = 0; V_{EB} = 7 V	I_{EBO}	typ.	1	1	μA
		<	5	5	mA
Collector emitter breakdown voltage					
I_C = 0.1 A; R_{BE} = 100 Ω	$V_{(BR)CER}$	>	150	130	V
Collector-emitter sustaining voltages					
I_B = 0; I_C = 0.2 to 3.0 A	$V_{CEO(sust)}$	>	140	120	V
$-V_{BE}$ = 1.5 V; I_C = 0.1 to 1.5 A	$V_{CEX(sust)}$	>	160	140	V



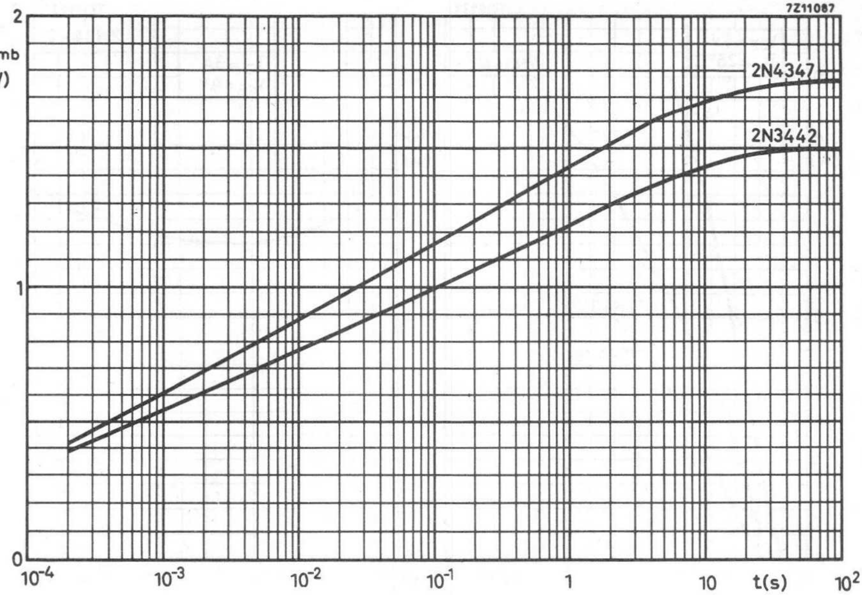
			2N3442	2N4347	
Base-emitter voltage [1]					
I_C = 2 A; V_{CE} = 4 V	V_{BE}	typ.		0.95	V
		<		2.0	V
I_C = 3 A; V_{CE} = 4 V	V_{BE}	typ.	1.15		V
		<	1.7		V
I_C = 5 A; V_{CE} = 4 V	V_{BE}	typ.		1.55	V
		<		4.0	V
I_C = 10 A; V_{CE} = 4 V	V_{BE}	typ.	2.8		V
		<	5.7		V

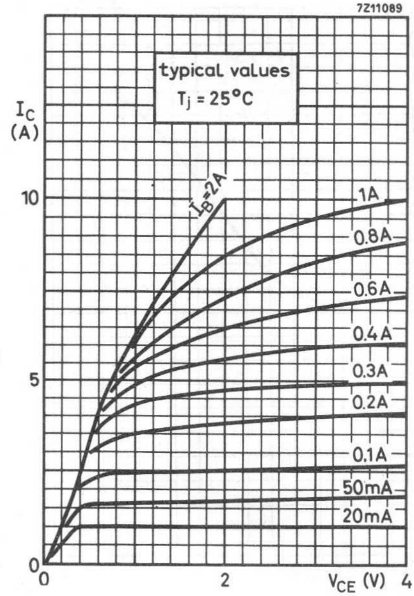
[1] t_p = 10 ms

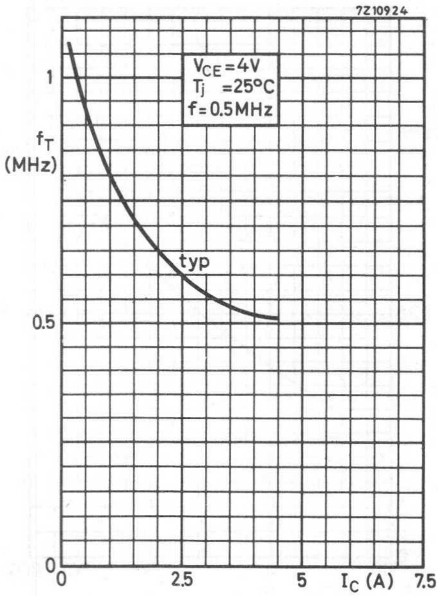
CHARACTERISTICS (continued) $T_j = 25\,^{o}C$ unless otherwise specified

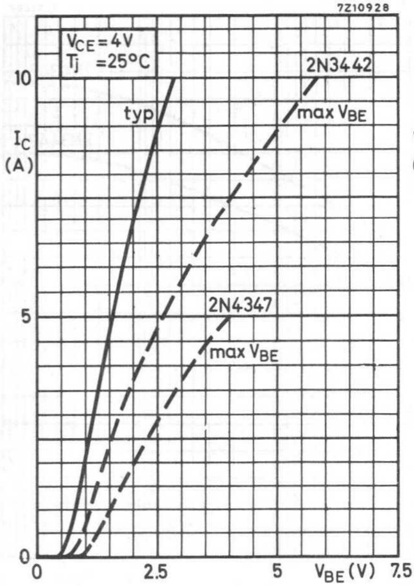
			2N3442	2N4347	
Saturation voltages [1]					
$I_C = 2$ A; $I_B = 0.2$ A	V_{CEsat}	<		1	V
$I_C = 3$ A; $I_B = 0.3$ A	V_{CEsat}	<	1		V
$I_C = 5$ A; $I_B = 1.0$ A	V_{CEsat}	<		5	V
$I_C = 10$ A; $I_B = 2.0$ A	V_{CEsat}	<	5		V
D.C. current gain [1]					
$I_C = 2$ A; $V_{CE} = 4$ V	h_{FE}	typ.		35	
				20 to 70	
$I_C = 3$ A; $V_{CE} = 4$ V	h_{FE}	typ.	25		
			20 to 70		
$I_C = 5$ A; $V_{CE} = 4$ V	h_{FE}	typ.		15	
		>		7.5	
$I_C = 10$ A; $V_{CE} = 4$ V	h_{FE}	typ.	10		
		>	7.5		
Small signal current gain					
$I_C = 2$ A; $V_{CE} = 4$ V					
f = 40 kHz	h_{fe}	typ.	9.5		
		>	2		
f = 1 kHz	h_{fe}	typ.	18		
			12 to 72		

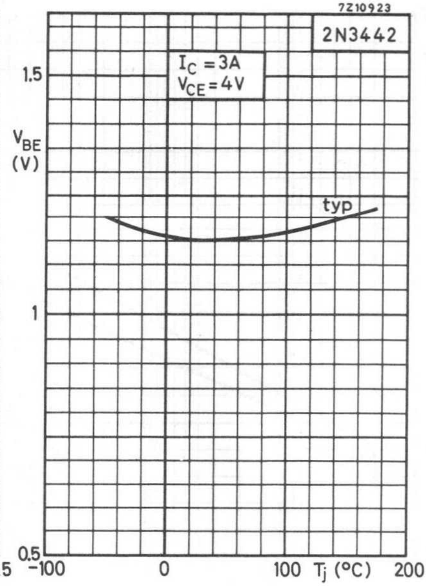
[1] $t_p = 10$ ms

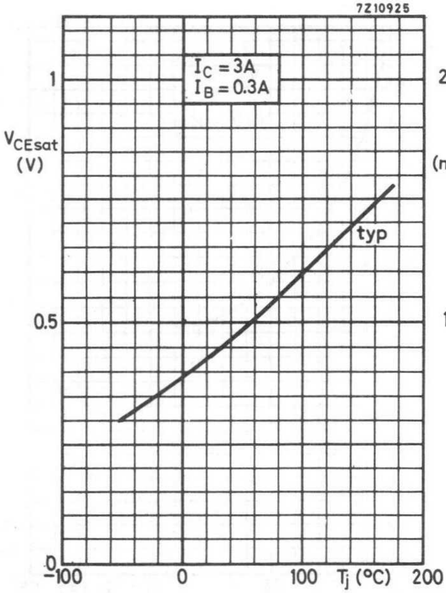

7Z11087
2
$Z_{th\,j-mb}$
(°C/W)
2N4347
2N3442
1
0
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
t(s)
10^{2}

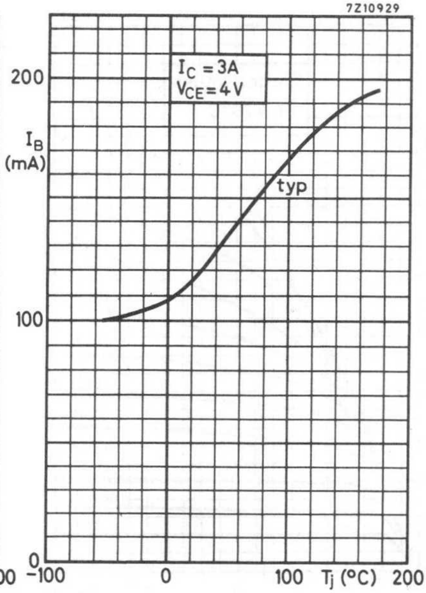

7Z11089
typical values
$T_j = 25°C$
I_C
(A)
10
I_B=2A
1A
0.8A
0.6A
0.4A
0.3A
0.2A
0.1A
50mA
20mA
5
0
0
2
V_{CE} (V)
4

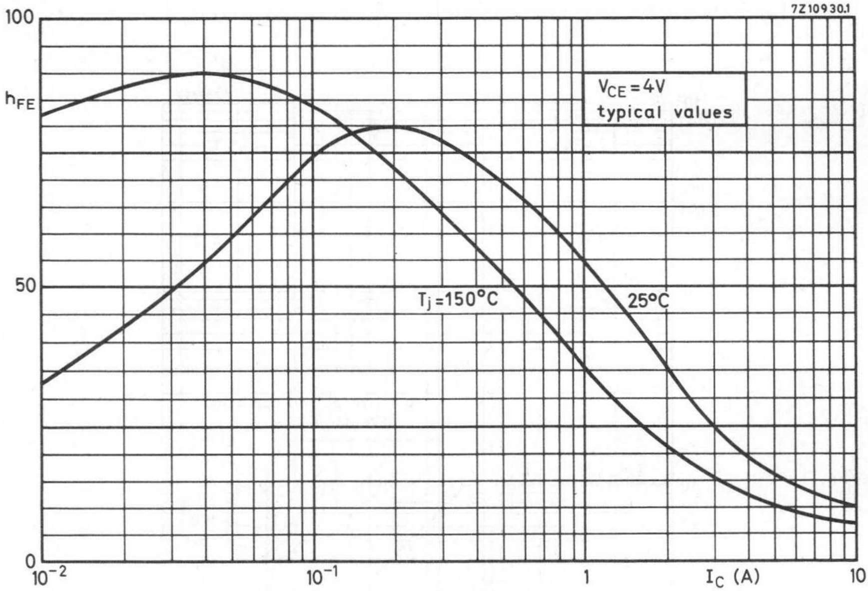

7Z10924
$V_{CE} = 4V$
$T_j = 25°C$
f = 0.5MHz
1
f_T
(MHz)
typ
0.5
0
0
2.5
5
I_C (A)
7.5

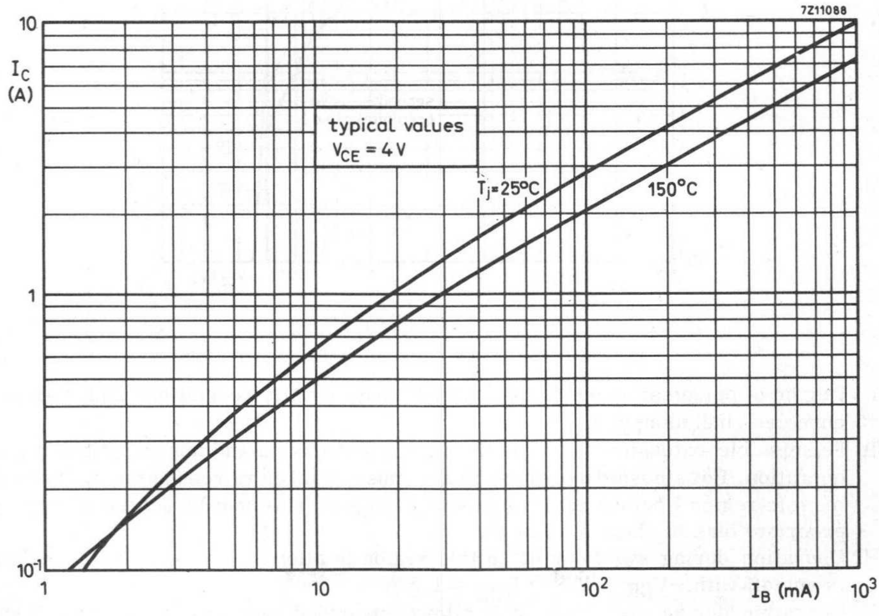

7Z10928
$V_{CE} = 4V$
$T_j = 25^oC$
typ
2N3442
max V_{BE}
2N4347
max V_{BE}
I_C (A)
10
5
0
0
2.5
5
V_{BE} (V)
7.5

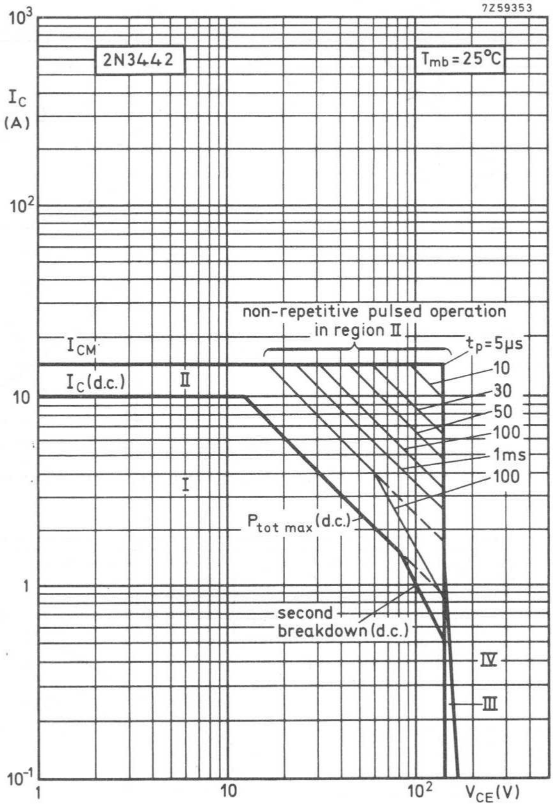

7Z10923
2N3442
$I_C = 3A$
$V_{CE} = 4V$
typ
V_{BE} (V)
1.5
1
0.5
−100
0
100
T_j (°C)
200


7Z10925
$I_C = 3A$
$I_B = 0.3A$
typ
V_{CEsat} (V)
1
0.5
0
−100
0
100
T_j (°C)
200


7Z10929
$I_C = 3A$
$V_{CE} = 4V$
typ
I_B (mA)
200
100
0
−100
0
100
T_j (°C)
200


7Z10930.1
100
h_{FE}
50
0
$V_{CE} = 4V$
typical values
$T_j = 150°C$
25°C
10^{-2}
10^{-1}
1
I_C (A)
10


7Z11088
10
I_C
(A)
1
10^{-1}
typical values
$V_{CE} = 4$ V
$T_j = 25°C$
150°C
1
10
10^2
I_B (mA)
10^3

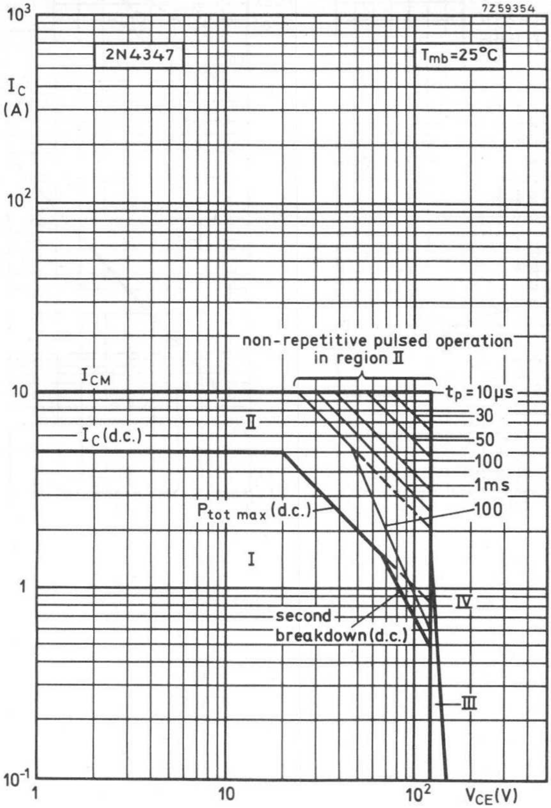


I Region of permissible operation under all base-emitter conditions and at all frequencies, including d. c.

II Permissible extension for repetitive pulsed operation and **non-repetitive** pulsed operation. For sinusoidal operation care must be taken to reduce the d. c. adjustment to region I before removing the a. c. signal. This may be achieved by an appropriate bias in class A, B or C.

III Operation during switching off in this region is allowed, provided the transistor is cut-off with $-V_{BE} \leq 1.5$ V; $I_{CM} < 1.5$ A.

IV Operation during switching off is allowed provided the transistor is cut-off with $-V_{BE} \leq 1.5$ V and the transient energy does not exceed 30 mWs.



I Region of permissible operation under all base-emitter conditions and at all frequencies, including d. c.

II Permissible extension for repetitive pulsed operation and **non-repetitive** pulsed operation. For sinusoidal operation care must be taken to reduce the d. c. adjustment to region I before removing the a. c. signal. This may be achieved by an appropriate bias in class A, B or C.

III Operation during switching off in this region is allowed, provided the transistor is cut-off with $-V_{BE} \leq 1.5$ V; $I_{CM} < 1.5$ A.

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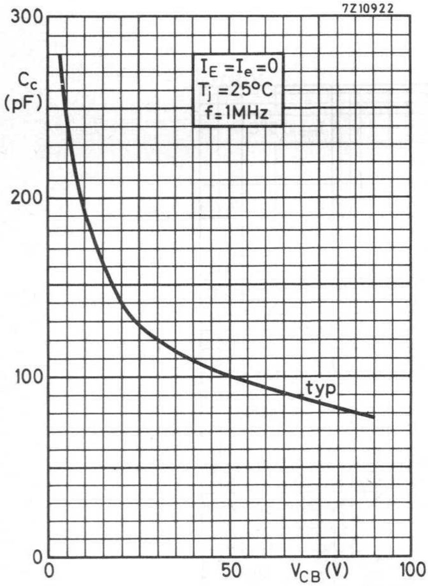
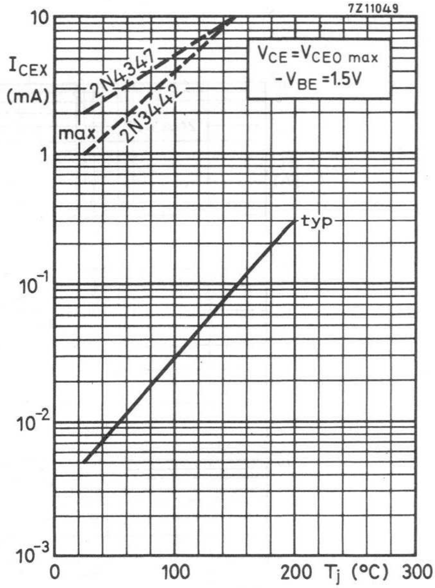

7Z10922
$I_E = I_e = 0$
$T_j = 25°C$
f = 1MHz
C_c
(pF)
typ
300
200
100
0
0
50
V_{CB} (V)
100


7Z11049
$V_{CE} = V_{CEO\ max}$
$-V_{BE} = 1.5V$
I_{CEX}
(mA)
2N4347
2N3442
max
typ
10
1
10^{-1}
10^{-2}
10^{-3}
0
100
200
T_j (°C)
300

Deflection transistors

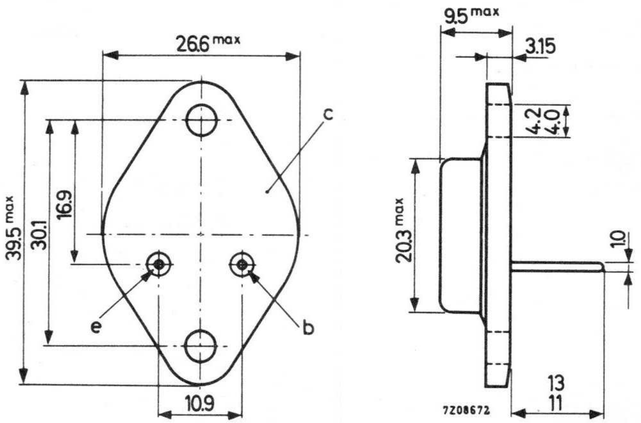
HIGH VOLTAGE SILICON POWER TRANSISTOR

N-P-N transistor in a TO-3 metal envelope with the collector connected to the case. It is intended for use in vertical deflection circuits of television receivers.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter) (peak value)	V_{CBOM}	max.	800	V
Collector-emitter voltage ($R_{BE} \leq 500\ \Omega$) (peak value)	V_{CERM}	max.	800	V
Collector current (peak value)	I_{CM}	max.	250	mA
Total power dissipation up to T_{mb} = 95 °C	P_{tot}	max.	8	W
Junction temperature	T_j	max.	135	°C
Transition frequency at f = 5 MHz I_C = 50 mA; V_{CE} = 5 V	f_T	typ.	12	MHz

MECHANICAL DATA Dimensions in mm

Collector connected to case
TO-3



Accessories available: 56201e

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

Collector-base voltage (open emitter) (peak value)	V_{CBOM}	max.	800	V
→ Collector-base voltage (open emitter) (d.c.)	V_{CBO}	max.	**250**	V
Collector-emitter voltage ($R_{BE} \leq 500\ \Omega$) (peak value)	V_{CERM}	max.	800	V
→ Collector-emitter voltage ($R_{BE} \leq 500\ \Omega$) (d.c.)	V_{CER}	max.	**250**	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Currents

Collector current (d.c.)	I_C	max.	250	mA
Collector current (peak value)	I_{CM}	max.	250	mA
Emitter current (d.c.)	$-I_E$	max.	250	mA
Emitter current (peak value)	$-I_{EM}$	max.	250	mA

Power dissipation

Total power dissipation up to T_{mb} = 95 °C	P_{tot}	max.	8	W

Temperatures

Storage temperature	T_{stg}		−65 to +135	°C
Junction temperature	T_j	max.	135	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	5	°C/W
From mounting base to heatsink with accessory 56201e	$R_{th\ mb\text{-}h}$	=	0.75	°C/W
with lead washer only	$R_{th\ mb\text{-}h}$	=	0.5	°C/W

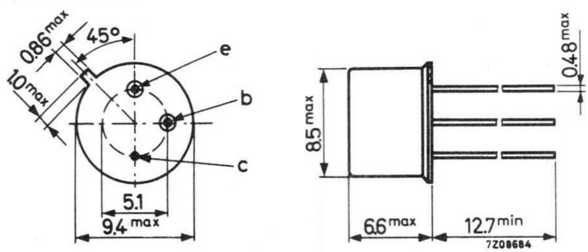
SILICON PLANAR TRANSISTOR

N-P-N transistor in a TO-39 metal envelope with the collector connected to the case. The BFW45 is primarily intended for the output stage of the horizontal deflection amplifier in wide band oscilloscopes.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	165	V
Collector-emitter voltage (open base)	V_{CEO}	max.	130	V
Collector current (peak value)	I_{CM}	max.	100	mA
Total power dissipation up to T_{mb} = 150 °C	P_{tot}	max.	2.5	W
Junction temperature	T_j	max.	200	°C
D.C. current gain I_C = 50 mA; V_{CE} = 20 V	h_{FE}	20 to 120		
Transition frequency at f = 100 MHz I_C = 10 mA; V_{CE} = 10 V	f_T	> typ.	80 120	MHz MHz
Feedback capacitance at f = 1 MHz I_C = 10 mA; V_{CE} = 20 V	$-C_{re}$	<	3.5	pF

MECHANICAL DATA Dimensions in mm

TO-39
Collector connected to case



Accessories available: 56218, 56245, 56265 (see page 8)

RATINGS (Limiting values) [1]

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	165	V
Collector-emitter voltage (open base)	V_{CEO}	max.	130	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Currents

Collector current (d.c.)	I_C	max.	50	mA
Collector current (peak value)	I_{CM}	max.	100	mA

Power dissipation

Total power dissipation up to T_{amb} = 40 °C	P_{tot}	max.	0.8	W
T_{mb} = 150 °C	P_{tot}	max.	2.5	W

Temperatures

Storage temperature	T_{stg}		−55 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	200	°C/W
From junction to mounting base	$R_{th\ j-mb}$	=	20	°C/W [2]
From junction to case	$R_{th\ j-c}$	=	25	°C/W [2]

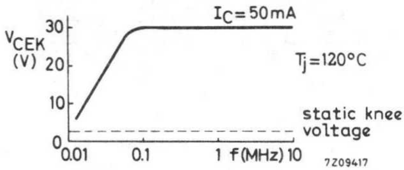
[1] Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

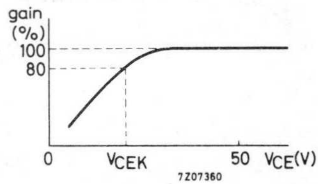
[2] See also page 8.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 100$ V	I_{CBO}	<	100	nA
$I_E = 0$; $V_{CB} = 100$ V; $T_j = 150$ °C	I_{CBO}	<	10	µA
Base-emitter voltage [1]				
$I_C = 50$ mA; $V_{CE} = 20$ V	V_{BE}	<	1.3	V
High frequency knee voltage at $T_j = 120$ °C				
$I_C = 50$ mA	V_{CEK}	<	27	V

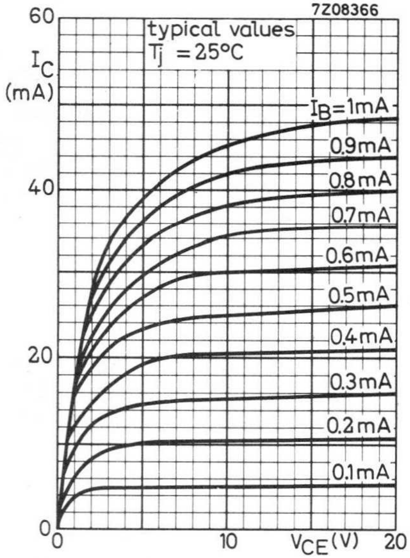
The high frequency knee voltage of a transistor is that value of the collector-emitter voltage at which the small signal gain, measured in a practical circuit, has dropped to 80% of the gain at V_{CE} = 50 V. A further decrease of the collector-emitter voltage results in a rapid increase of the distortion of the signal.

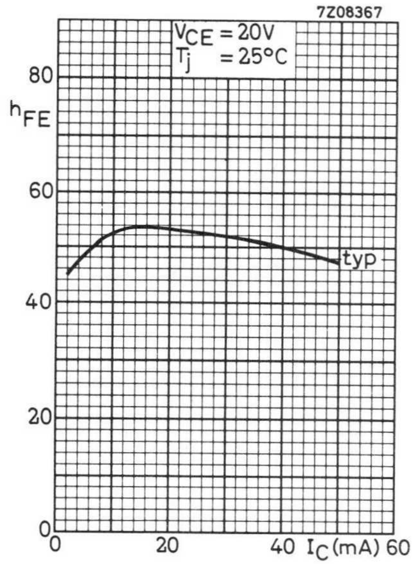


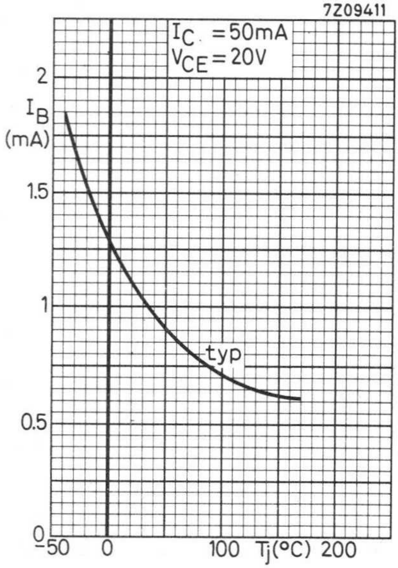


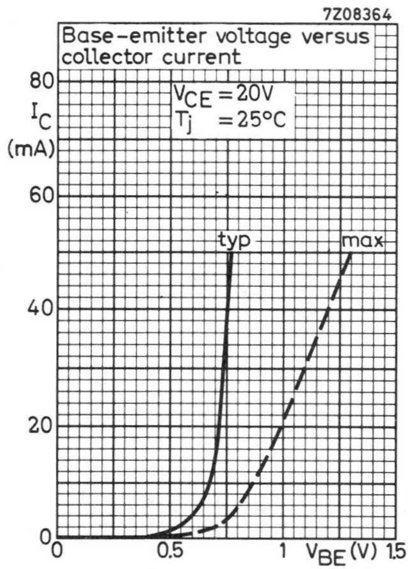
Collector-emitter saturation voltage				
$I_C = 10$ mA; $I_B = 1$ mA	V_{CEsat}	<	3	V
$I_C = 50$ mA; $I_B = 5$ mA	V_{CEsat}	<	10	V
D.C. current gain				
$I_C = 50$ mA; $V_{CE} = 20$ V	h_{FE}	20 to 120		
Feedback capacitance at f = 1 MHz				
$I_C = 10$ mA; $V_{CE} = 20$ V	$-C_{re}$	<	3.5	pF
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 20$ V	C_c	<	6	pF
Transition frequency at f = 100 MHz				
$I_C = 10$ mA; $V_{CE} = 10$ V	f_T	>	80	MHz
		typ.	120	MHz

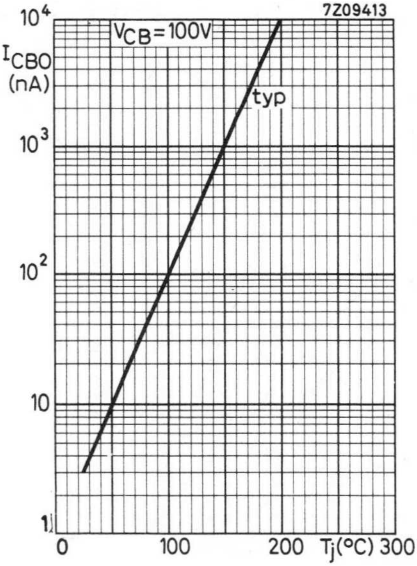
1) V_{BE} decreases by about 1.6 mV/°C with increasing temperature.

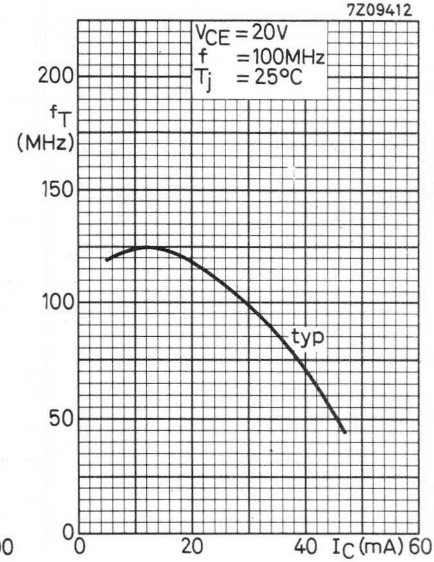

7Z08366
typical values
Tj = 25°C
IC (mA)
IB=1mA
0.9mA
0.8mA
0.7mA
0.6mA
0.5mA
0.4mA
0.3mA
0.2mA
0.1mA
VCE (V)
0
10
20
40
60

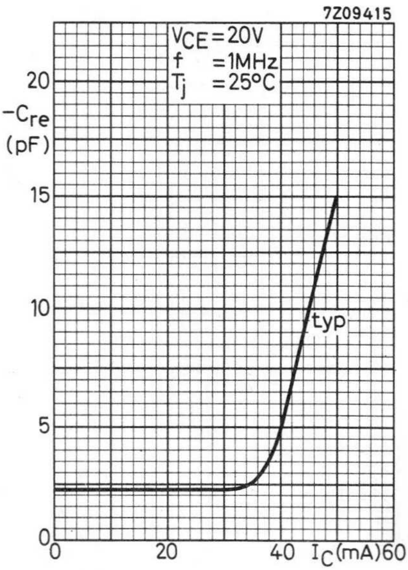

7Z08367
VCE = 20V
Tj = 25°C
hFE
typ
IC (mA)
0
20
40
60
80

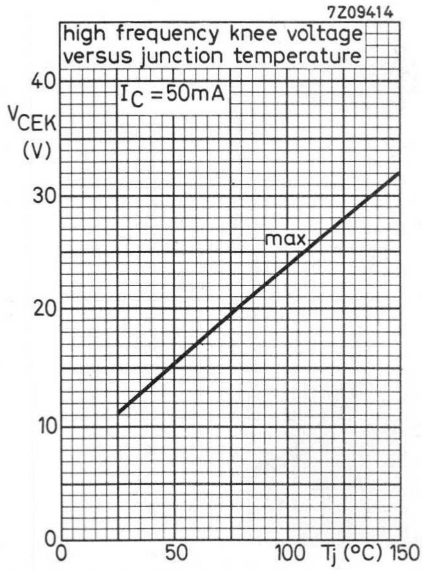

7Z09411
IC = 50mA
VCE = 20V
IB (mA)
typ
Tj (°C)
-50
0
100
200
0.5
1
1.5
2

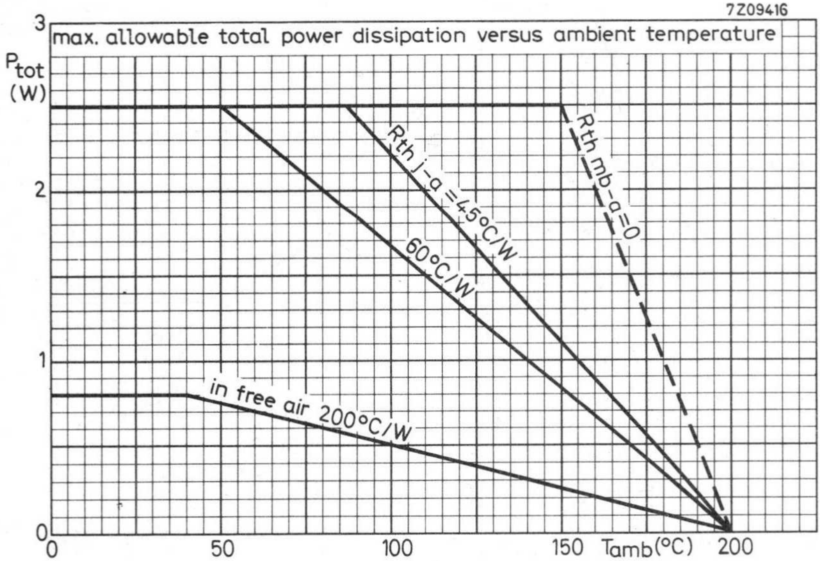

7Z08364
Base-emitter voltage versus collector current
VCE = 20V
Tj = 25°C
IC (mA)
typ
max
VBE (V)
0
0.5
1
1.5
20
40
60
80

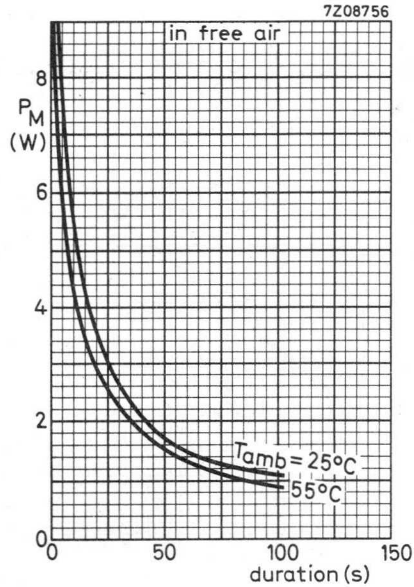

7Z09413
V_{CB}=100V
I_{CBO}
(nA)
10^4
10^3
10^2
10
1
typ
0
100
200
T_j(°C) 300

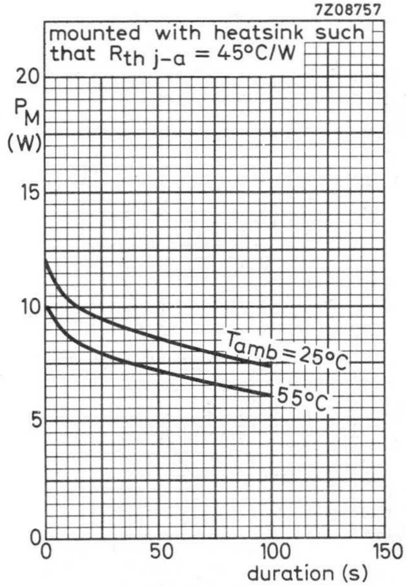

7Z09412
V_{CE} = 20V
f = 100MHz
T_j = 25°C
f_T
(MHz)
200
150
100
50
0
typ
0
20
40
I_C (mA) 60


7Z09415
V_{CE}=20V
f =1MHz
T_j =25°C
$-C_{re}$
(pF)
20
15
10
5
0
typ
0
20
40
I_C(mA)60


7Z09414
high frequency knee voltage
versus junction temperature
I_C =50mA
V_{CEK}
(V)
40
30
20
10
0
max
0
50
100
T_j (°C) 150



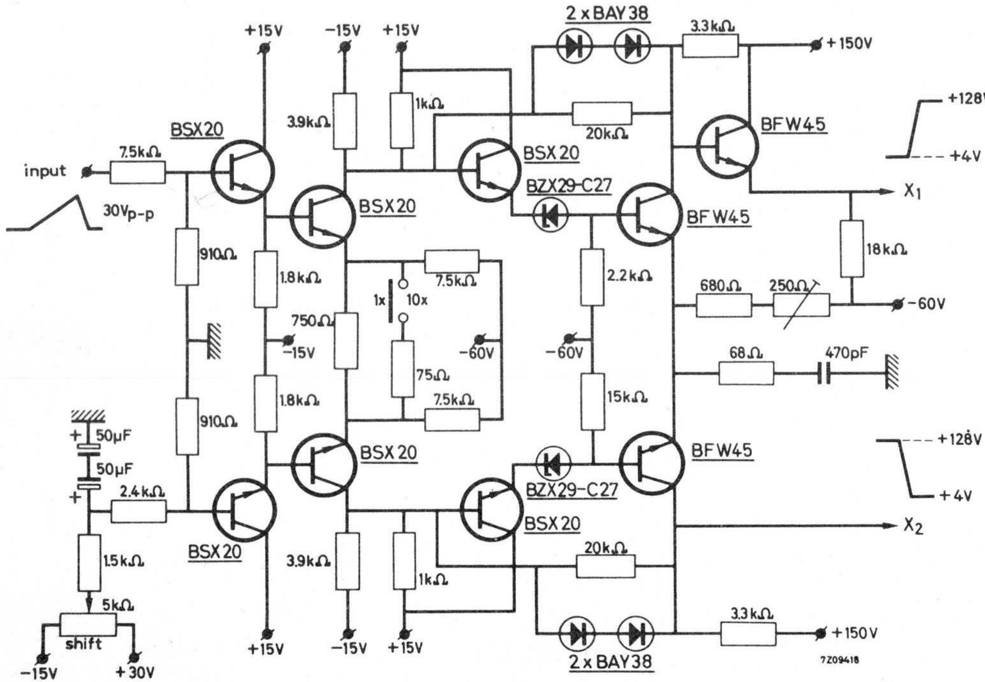




maximum allowable peak power dissipation versus duration

APPLICATION INFORMATION

Horizontal deflection amplifier for wide band oscilloscopes.



Total effective plate capacitance of the tube: 10 pF
Horizontal sensitivity of the tube: 18 V/cm

Performance

Maximum sweep rate of the amplifier: 5 ns/cm

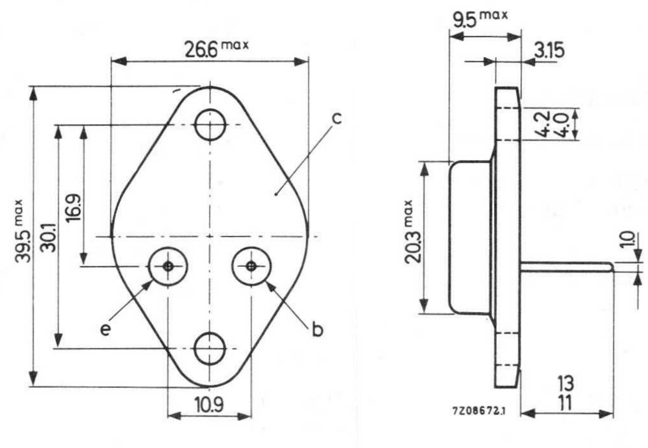
HIGH VOLTAGE SILICON POWER TRANSISTOR

N-P-N transistor in a metal envelope intended for use in horizontal deflection circuits of television receivers.

QUICK REFERENCE DATA				
Collector-base voltage (peak value)	V_{CBOM}	max.	1500	V
Collector-emitter voltage (peak value) $R_{BE} \leq 100\ \Omega$	V_{CERM}	max.	1500	V
Collector current (peak value)	I_{CM}	max.	2.5	A
Total power dissipation up to $T_{mb} = 90\ ^oC$	P_{tot}	max.	10	W
Collector-emitter saturation voltage $I_C = 2.5$ A; $I_B = 1.5$ A	V_{CEsat}	<	5	V
Fall time (with stabilized power supply) $I_{CMnom} = 2.0$ A; $I_{B(end)nom} = 1.5$ A	t_f	typ.	0.75	μs

MECHANICAL DATA Dimensions in mm

Collector connected to case



Accessories available: 56201e

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	750	V
Collector-base voltage (open emitter) peak value	V_{CBOM}	max.	1500	V
Collector-emitter voltage $R_{BE} \leq 100\ \Omega$	V_{CER}	max.	750	V
Collector-emitter voltage (peak value) $R_{BE} \leq 100\ \Omega$, see also safe operation area → I_C = 7.5 mA	V_{CERM}	max.	1500	V

Currents

Emitter current (d.c. and peak value)	$-I_E$, $-I_{EM}$	max.	4.0	A
Collector current (d.c. and peak value)	I_C, I_{CM}	max.	2.5	A
Base current (peak value)	I_{BM}	max.	2.5	A
Reverse base current (d.c. or average over any 20 ms period)	$-I_{BAV}$	max.	100	mA
Reverse base current (peak value)	$-I_{BM}$	max.	1.5	A [1]

Power dissipation

Total power dissipation up to T_{mb} = 90 °C	P_{tot}	max.	10	W

Temperatures

Storage temperature	T_{stg}		-65 to +115	°C
Junction temperature	T_j	max.	115	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	2.5	°C/W
From mounting base to heatsink with mica washer and lead washer (56201e)	$R_{th\ mb-h}$	0.75	°C/W
with lead washer only	$R_{th\ mb-h}$	0.5	°C/W

[1] Turn off current; e.g. in horizontal deflection circuits.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Emitter-base voltage (open collector)

I_C = 0; I_E = 100 mA	$+V_{EBO}$	>	5	V

Saturation voltages

I_C = 2.5 A; I_B = 1.5 A	V_{CEsat}	<	5	V
	V_{BEsat}	<	1.5	V

Transition frequency at f = 5 MHz

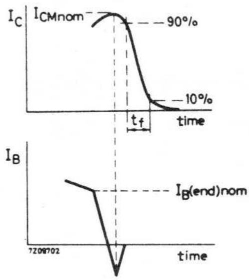
I_C = 0.1 A; V_{CE} = 5 V	f_T	typ.	7.5	MHz

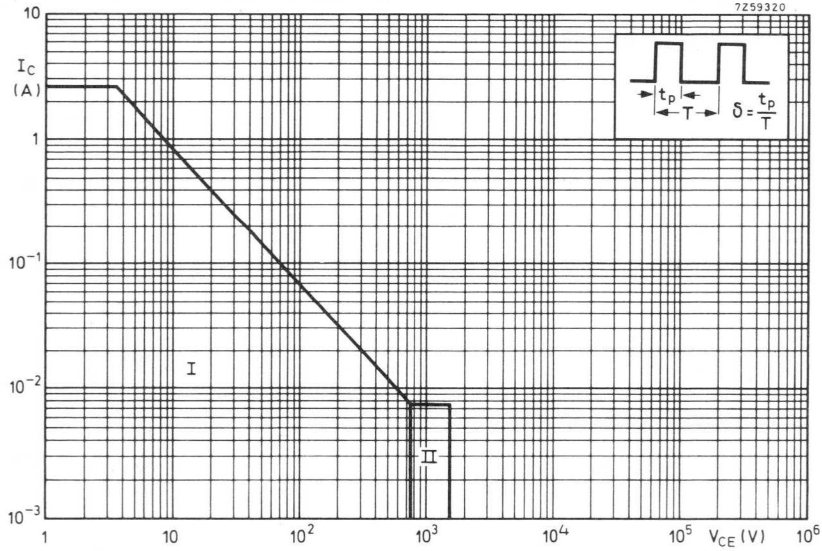
Collector capacitance at f = 1 MHz

I_E = I_e = 0; V_{CB} = 10 V	C_c	typ.	65	pF

Fall time (with stabilized power supply)

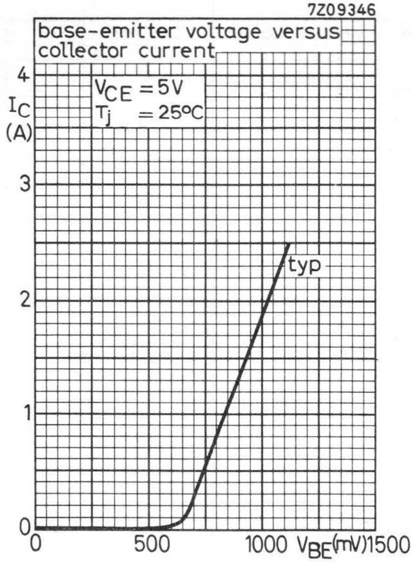
I_{CMnom} = 2.0 A; $I_{B(end)nom}$ = 1.5 A; L_B = 10 μH	t_f	typ.	0.75	μs

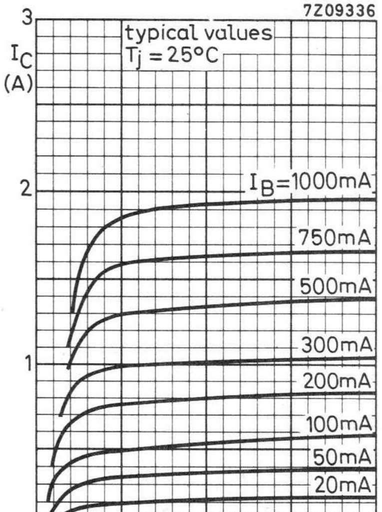


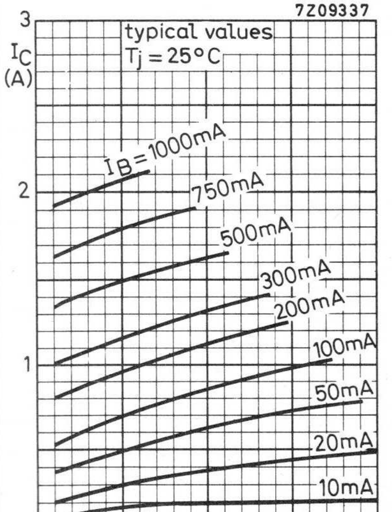


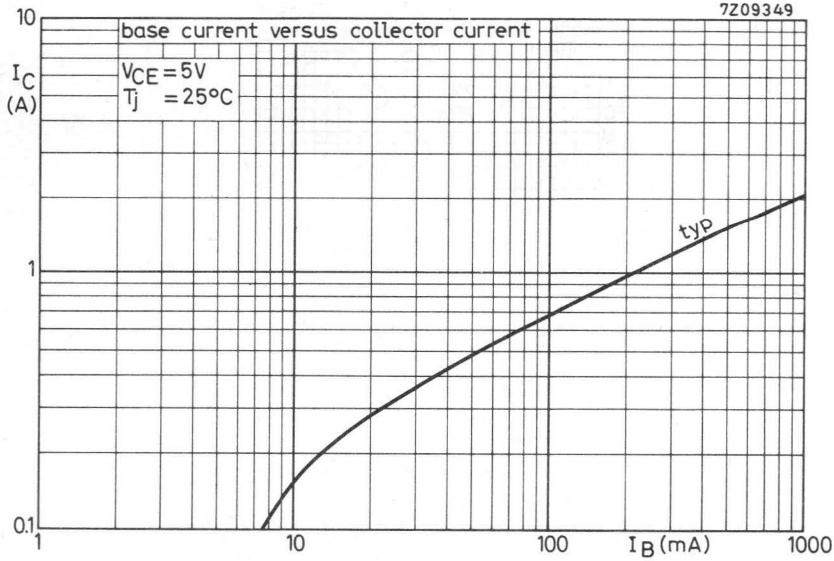
I Region of permissible operation under all base-emitter conditions.

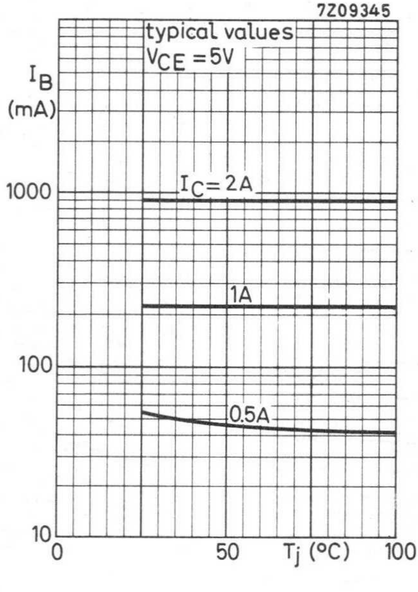
II Additional region of permissible operation for repetitive pulse conditions, provided $R_{BE} \leq 100\ \Omega$; $t_p \leq 20\ \mu s$; $\delta \leq 0.25$.

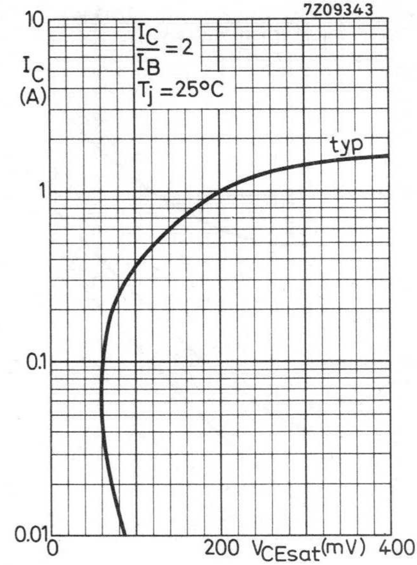

7Z09346
base-emitter voltage versus collector current
V_{CE} = 5 V
T_j = 25 °C
I_C (A)
4
3
2
1
0
typ
0
500
1000
V_{BE} (mV)
1500

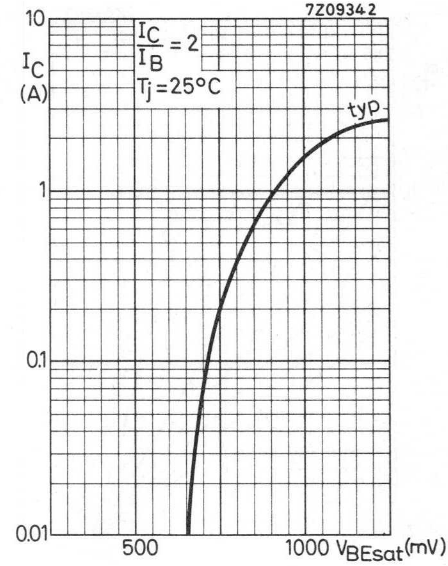

7Z09336
typical values
T_j = 25 °C
I_C (A)
3
2
1
0
I_B=1000mA
750mA
500mA
300mA
200mA
100mA
50mA
20mA
10mA
0
1
V_{CE} (V)
2

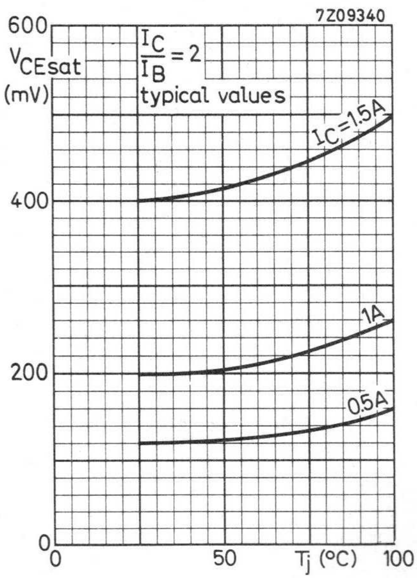

7Z09337
typical values
T_j = 25 °C
I_C (A)
3
2
1
0
I_B=1000mA
750mA
500mA
300mA
200mA
100mA
50mA
20mA
10mA
0
10
V_{CE} (V)
20

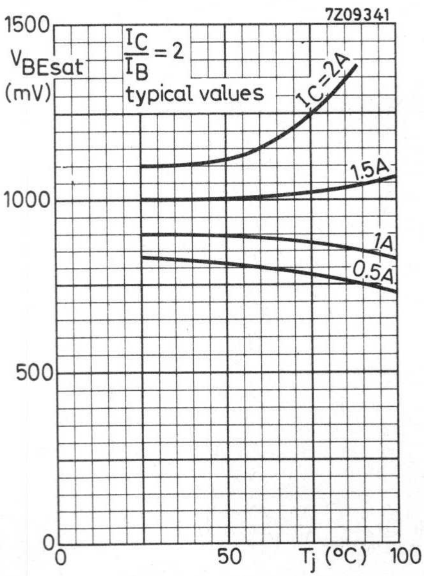

7Z09349
base current versus collector current
$V_{CE} = 5V$
$T_j = 25°C$
I_C (A)
10
1
0.1
typ
1
10
100
I_B (mA)
1000

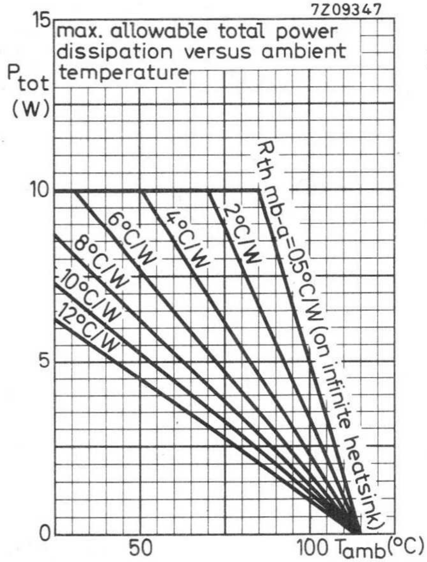

7Z09345
typical values
$V_{CE} = 5V$
I_B (mA)
1000
100
10
$I_C = 2A$
1A
0.5A
0
50
T_j (°C)
100

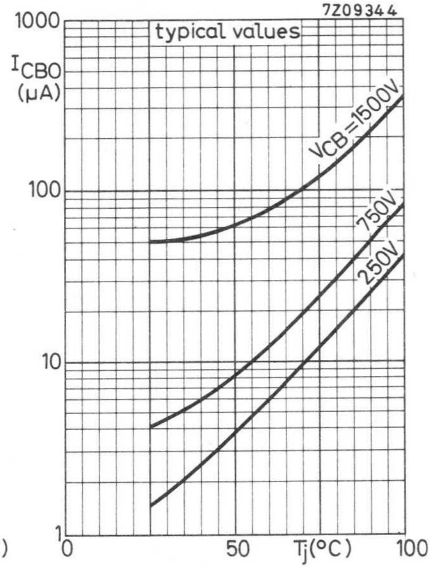

7Z09343
10
I_C
(A)
$\frac{I_C}{I_B} = 2$
$T_j = 25°C$
typ
1
0.1
0.01
0
200
V_{CEsat}(mV)
400


7Z09342
10
I_C
(A)
$\frac{I_C}{I_B} = 2$
$T_j = 25°C$
typ
1
0.1
0.01
500
1000
V_{BEsat}(mV)


7Z09340
600
V_{CEsat}
(mV)
$\frac{I_C}{I_B} = 2$
typical values
I_C=1.5A
400
1A
200
0.5A
0
0
50
T_j (°C)
100


7Z09341
1500
V_{BEsat}
(mV)
$\frac{I_C}{I_B} = 2$
typical values
I_C=2A
1.5A
1000
1A
0.5A
500
0
0
50
T_j (°C)
100


7Z09347
max. allowable total power dissipation versus ambient temperature
Ptot (W)
15
10
5
0
50
100
Tamb(°C)
Rth mb-a=0.5°C/W (on infinite heatsink)
2°C/W
4°C/W
6°C/W
8°C/W
10°C/W
12°C/W

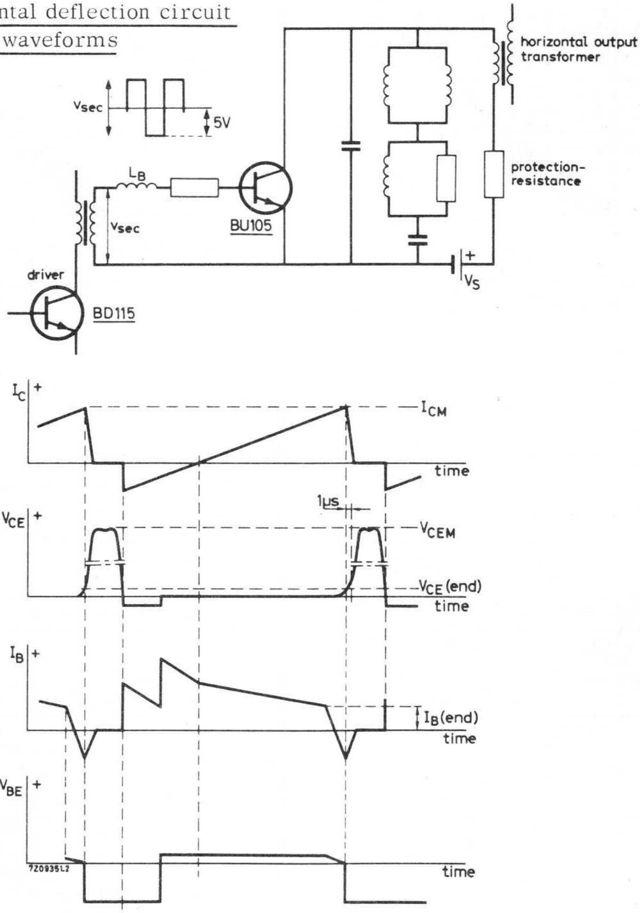

7Z09344
typical values
ICBO (μA)
1000
100
10
1
0
50
100
Tj(°C)
VCB=1500V
750V
250V

APPLICATION INFORMATION

Safety margins on I_{CM} and V_{CEM}

Because of component tolerances and supply voltage variations the values of I_{CM} and V_{CEM} encountered in a practical horizontal deflection output stage will usually differ from those of a nominal circuit under nominal conditions; the difference can be as much as 25% if a stabilized supply is used, or 35% for an unstabilized supply. For this reason, the nominal values of I_{CM} and V_{CEM} should be at least 25% (35% if the supply is unstabilized) below the absolute maximum ratings.

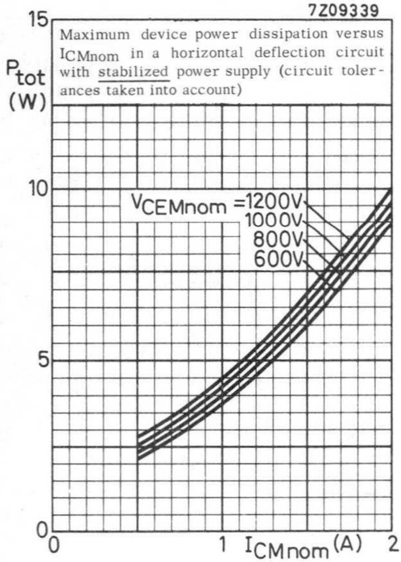
Simplified horizontal deflection circuit with fundamental waveforms

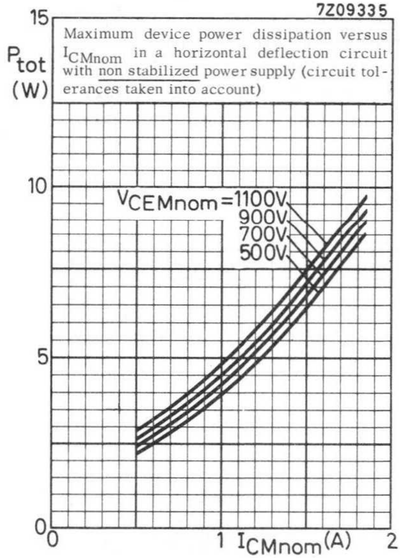


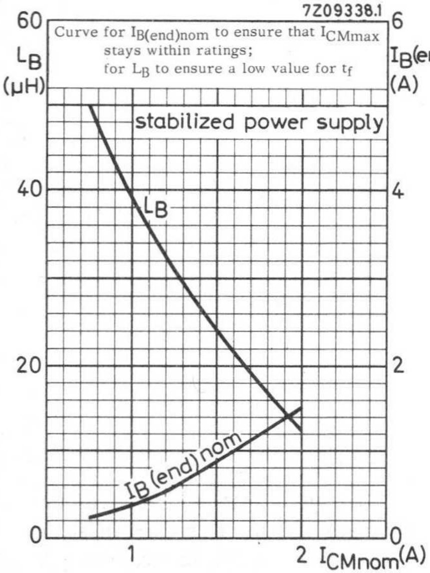
Remark:

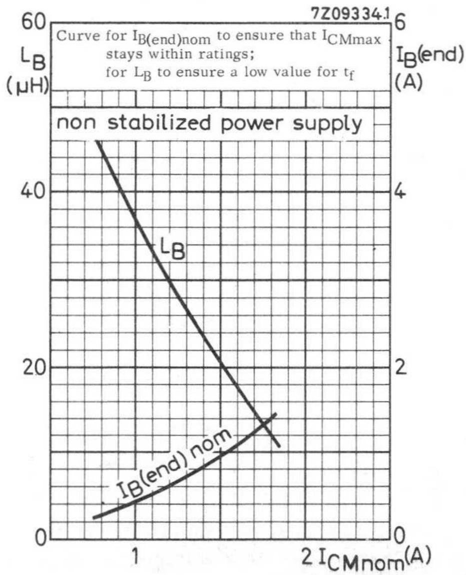
1. The driver and output stage should operate in a non-simultaneous mode i.e. the driver transistor should be conductive during flyback and the first part of scan.
2. The reverse bias voltage for the output transistor should be in the order of 5 V with a duty cycle $\delta \approx 0.5$.

APPLICATION INFORMATION (continued)

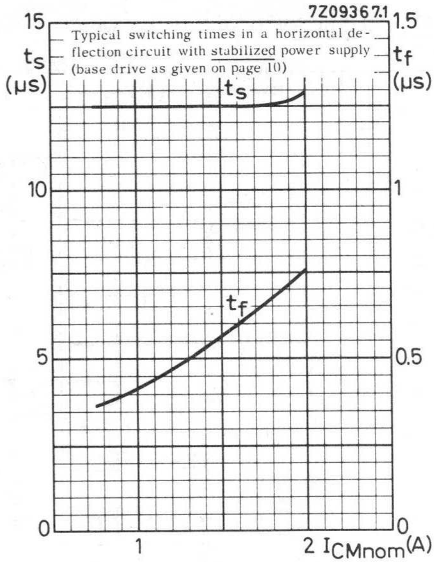


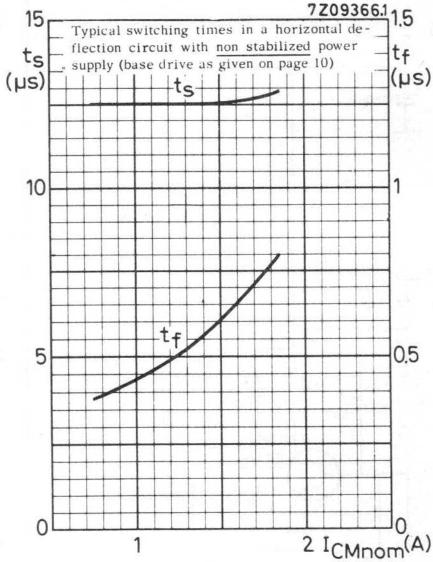






APPLICATION INFORMATION (continued)





EXAMPLE

Assuming a practical horizontal deflection output stage with
I_{CMnom} = 1.8 A and V_{CEMnom} = 1000 V
The following values will be derived from the curves:

a. Power dissipation

The maximum device power dissipation will be:
with stabilized power supply : P_{totmax} = 8.3 W
non stabilized power supply : P_{totmax} = 9.2 W

b. Maximum values (with safety margins as given on page 9)

with stabilized power supply : I_{CMmax} = 2.25 A; V_{CEM} = 1250 V
non stabilized power supply : I_{CMmax} = 2.4 A; V_{CEM} = 1350 V

c. Recommended nominal values are:

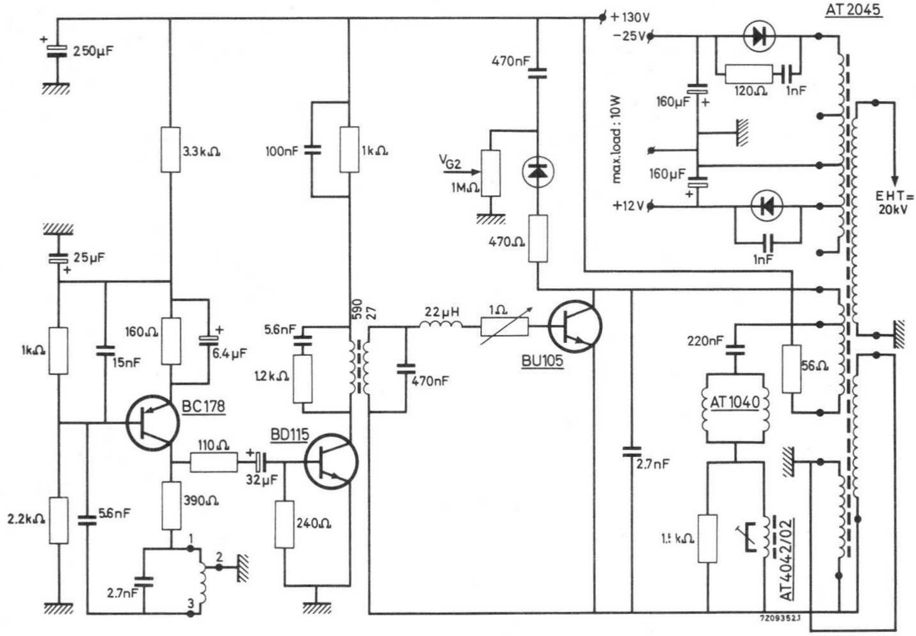
with stabilized power supply : $I_{B(end)nom}$ = 1.2 A; L_B = 17 μH
non stabilized power supply : $I_{B(end)nom}$ = 1.4 A; L_B = 12 μH

d. Switching times

Typical values under nominal conditions are:
with stabilized power supply : t_f typ. 0.7 μs; t_s typ. 12.5 μs
non stabilized power supply : t_f typ. 0.8 μs; t_s typ. 13 μs

APPLICATION INFORMATION (continued)

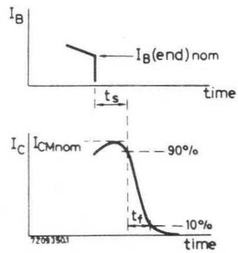
Horizontal deflection circuit with BC178, BD115 and BU105 (stabilized power supply)



The BU105 in the circuit above has been designed for I_{CMnom} = 1.6 A with recommended inductance L_B = 22 μH and I_B(end) = 1.0 A.

Performance:

Collector current before switching (peak value)	I_{CM}	typ.	1.6	A
Storage time at 90 % of I_{CM}	t_s	typ.	12.5	μs
Fall time at 10 % of I_{CM}	t_f	typ.	0.6	μs
Collector-emitter voltage at 1 μs before i_C = I_{CM}	V_{CE}(end)	typ.	1.5	V
Collector-emitter voltage (peak value)	V_{CEM}	typ.	950	V
Fly-back ratio		typ.	18	%
Period-time		typ.	64	μs



see also page 9

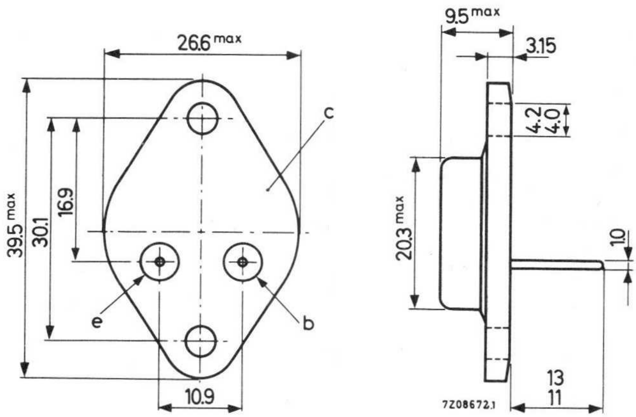
HIGH VOLTAGE SILICON POWER TRANSISTOR

N-P-N transistor in a metal envelope intended for use in horizontal deflection circuits of colour television receivers.

QUICK REFERENCE DATA				
Collector-base voltage (peak value)	V_{CBOM}	max.	1500	V
Collector-emitter voltage (peak value) $R_{BE} \leq 100\,\Omega$	V_{CERM}	max.	1500	V
Collector current (peak value)	I_{CM}	max.	5.0	A
Total power dissipation up to T_{mb} = 95 ^{o}C	P_{tot}	max.	12.5	W
Collector-emitter saturation voltage I_C = 4.5 A; I_B = 2.0 A	V_{CEsat}	<	5	V
Fall time when switched from I_{CMnom} = 4.5 A; $I_{B(end)nom}$ = 1.8 A; L_B = 10 μH	t_f	typ.	0.7	μs

MECHANICAL DATA Dimensions in mm

Collector connected to case



Accessories available: 56201e

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

Collector-base voltage (open emitter) peak value	V_{CBOM}	max.	1500	V
Collector-emitter voltage ($R_{BE} \leq 100\ \Omega$)	V_{CER}	max.	750	V
Collector-emitter voltage ($R_{BE} \leq 100\ \Omega$) I_C = 7.5 mA (peak value) See also safe operation area	V_{CERM}	max.	1500	V

Currents

Emitter current (d.c. and peak value)	$-I_E$; $-I_{EM}$	max.	7.0	A
Collector current (d.c. and peak value)	I_C; I_{CM}	max.	5.0	A
Reverse collector current (peak value)	$-I_{CM}$	max.	4.5	A
Base current (peak value)	I_{BM}	max.	4.0	A
Reverse base current (d.c. and average over any 20 ms period)	$-I_{BAV}$	max.	0.1	A
Reverse base current (peak value)	$-I_{BM}$	max.	2.5	A 1)

Power dissipation

Total power dissipation up to T_{mb} = 95 °C	P_{tot}	max.	12.5	W

Temperatures

Storage temperature	T_{stg}		-65 to +115	°C
Junction temperature	T_j	max.	115	°C

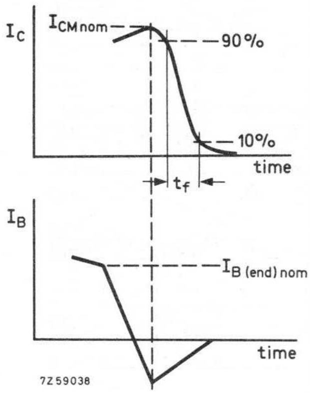
THERMAL RESISTANCE

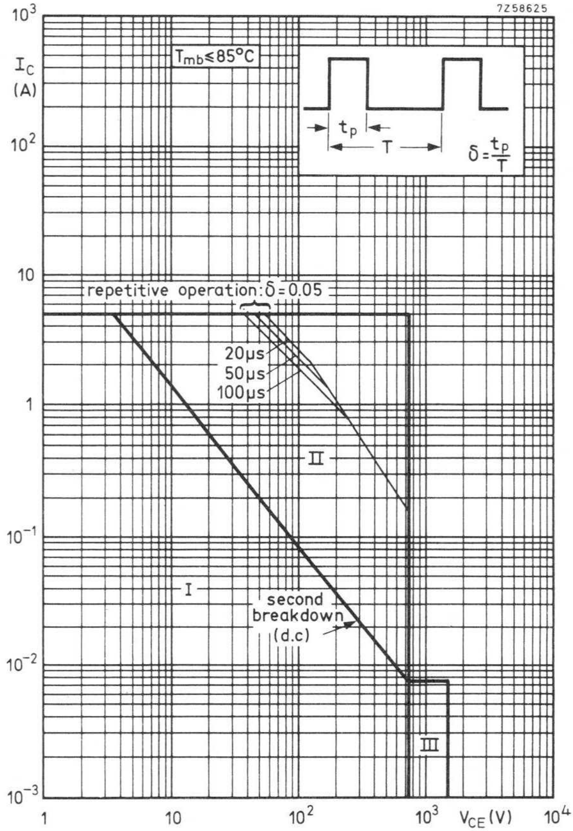
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1.6	°C/W
From mounting base to heatsink with mica washer and lead washer (56201e)	$R_{th\ mb\text{-}h}$	=	0.75	°C/W
with lead washer only	$R_{th\ mb\text{-}h}$	=	0.5	°C/W

1) Turn off current; e.g. in horizontal deflection circuits.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

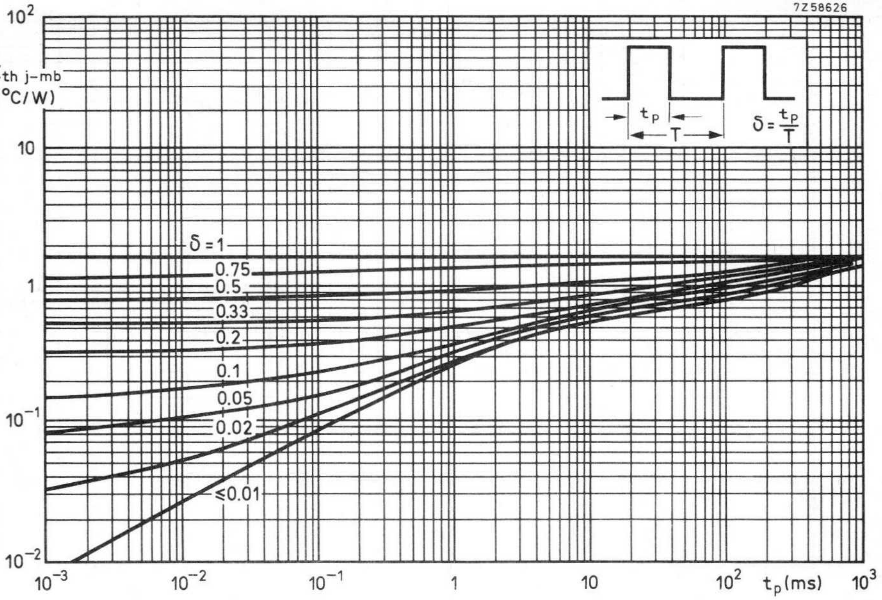
Emitter-base voltage (open collector)				
I_C = 0; I_E = 100 mA	$+V_{EBO}$	>	5	V
Saturation voltages				
I_C = 4.5 A; I_B = 2.0 A	V_{CEsat}	<	5	V
	V_{BEsat}	<	1.5	V
Transition frequency at f = 5 MHz				
I_C = 0.1 A; V_{CE} = 5 V	f_T	typ.	7	MHz
Collector capacitance at f = 1 MHz				
I_E = I_e = 0; V_{CB} = 10 V	C_c	typ.	125	pF
Fall time				
I_{CMnom} = 4.5 A; $I_{B(end)nom}$ = 1.8 A; L_B = 10 μH	t_f	typ.	0.7	μs
		<	1.0	μs

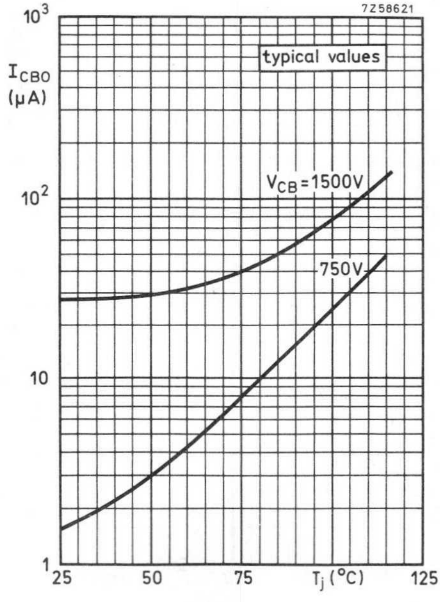


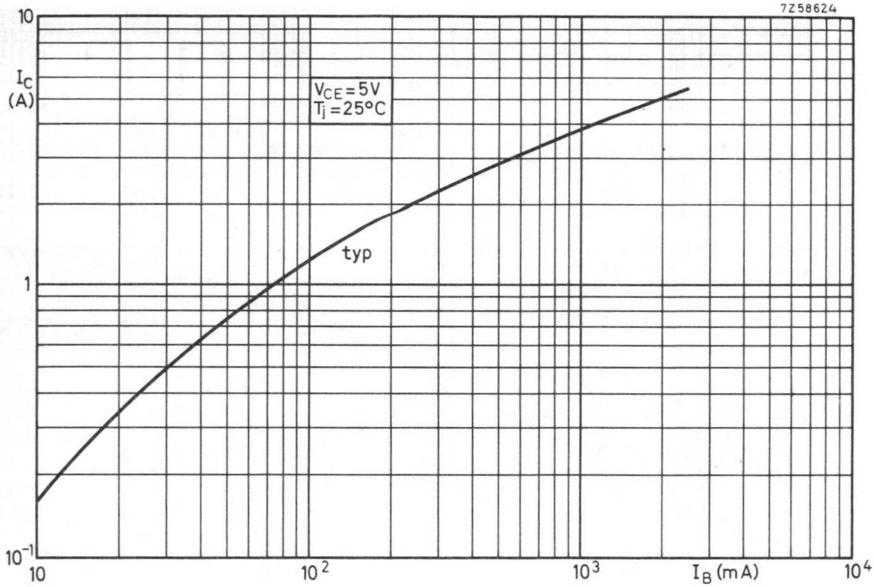


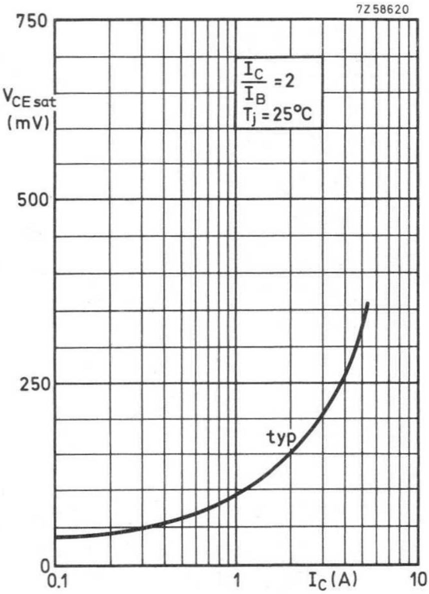
Safe Operating Area with the transistor forward biased

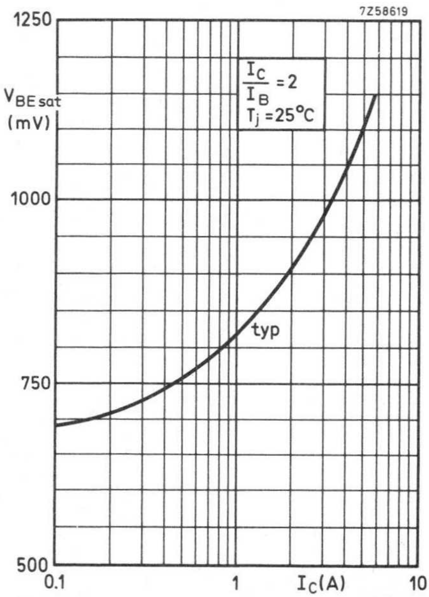
I Region of permissible d.c. operation
II Permissible extension for repetitive pulsed operation
III Repetitive pulsed operation in this region is allowable, provided $R_{BE} \leq 100\ \Omega$; $t_p \leq 20\ \mu s$; $\delta \leq 0.25$


7Z58626
10^2
$Z_{th\ j\text{-}mb}$ (°C/W)
10
1
10^{-1}
10^{-2}
$\delta = 1$
0.75
0.5
0.33
0.2
0.1
0.05
0.02
≤0.01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p(ms)
10^3


7Z58621
10^3
I_{CBO} (μA)
typical values
10^2
V_{CB} = 1500V
750V
10
1
25
50
75
T_j (°C)
125


7Z58624
10
I_C
(A)
V_{CE} = 5V
T_j = 25°C
typ
1
10^{-1}
10
10^2
10^3
I_B (mA)
10^4


7Z58620
750
V_{CEsat}
(mV)
$\frac{I_C}{I_B}$ = 2
T_j = 25°C
500
250
typ
0
0.1
1
I_C (A)
10

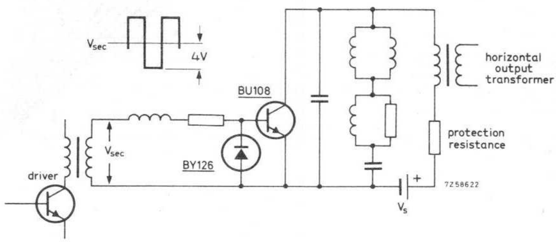

7Z58619
1250
V_{BEsat}
(mV)
$\frac{I_C}{I_B}$ = 2
T_j = 25°C
1000
typ
750
500
0.1
1
I_C(A)
10

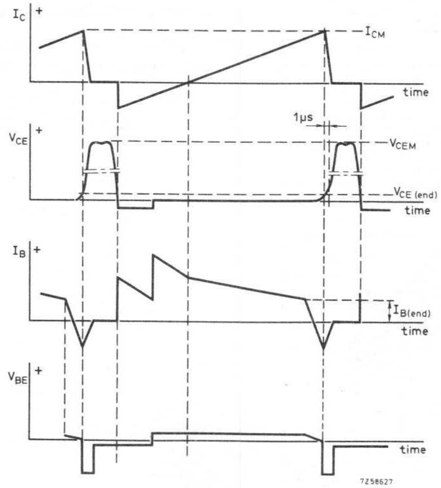
APPLICATION INFORMATION

Safety margins on I_{CM} and V_{CEM}

Because of component tolerances and supply voltage variations the values of I_{CM} and V_{CEM} encountered in a practical horizontal deflection output stage will usually differ from those of a nominal circuit under nominal conditions; the difference, due to component tolerances and operational variations, can be as much as 20% if a stabilized supply is used. The operational variations considered, are deviations of the horizontal time-base frequency of $\pm$ 5% with respect to the nominal value and EHT loading current up to an average of 1.5 mA. The allowance of 20% for V_{CEM} does not imply that the voltage rating for the final anode of the picture tube may be exceeded.

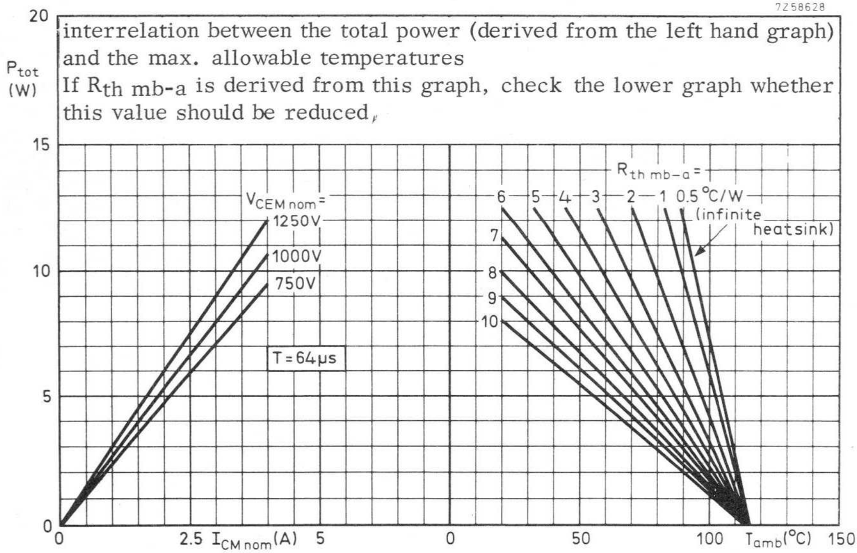
Simplified horizontal deflection circuit with fundamental waveforms



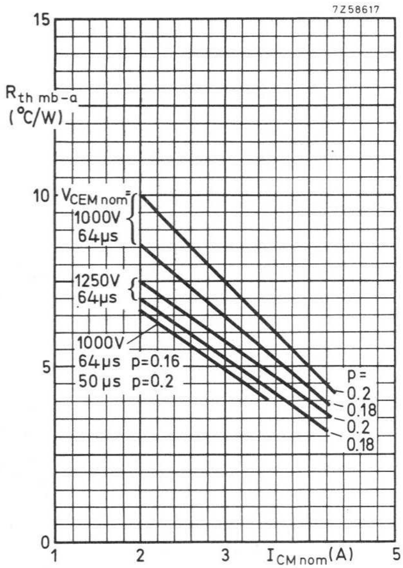


Remark:

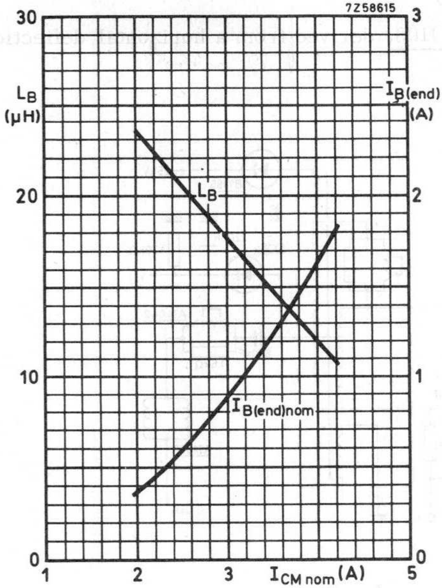
1. The driver and output stage should operate in a non-simultaneous mode i.e. the driver transistor should be conductive during flyback and the first part of scan.

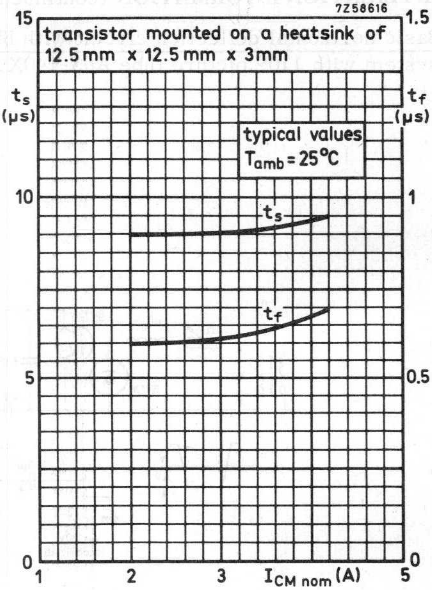


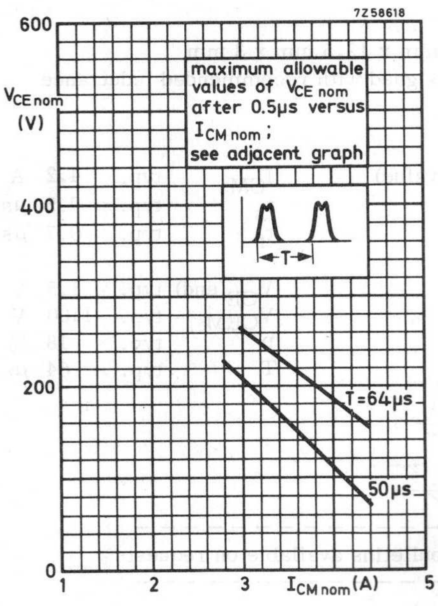
interrelation between the total power (derived from the left hand graph) and the max. allowable temperatures
If $R_{th\ mb-a}$ is derived from this graph, check the lower graph whether this value should be reduced.

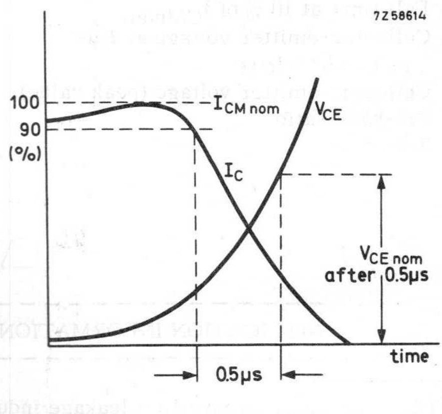


maximum allowable $R_{th\ mb-a}$ for various operating conditions. The values for V_{CEMnom} and I_{CMnom} referred to are normal operating conditions. The quantity 'p' denotes the ratio of the flyback pulse (t_p) over the period time (T).


7Z58615
L_B (μH)
$I_{B(end)}$ (A)
L_B
$I_{B(end)nom}$
$I_{CM\,nom}$ (A)

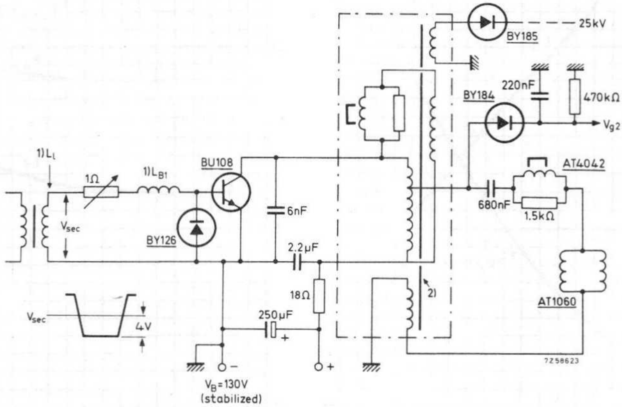

7Z58616
transistor mounted on a heatsink of 12.5 mm x 12.5 mm x 3mm
t_s (μs)
t_f (μs)
typical values
T_{amb} = 25°C
t_s
t_f
$I_{CM\,nom}$ (A)


7Z58618
$V_{CE\,nom}$ (V)
maximum allowable values of $V_{CE\,nom}$ after 0.5μs versus $I_{CM\,nom}$; see adjacent graph
T
T=64μs
50μs
$I_{CM\,nom}$ (A)


7Z58614
100
90
(%)
$I_{CM\,nom}$
V_{CE}
I_C
$V_{CE\,nom}$ after 0.5μs
time
0.5μs

APPLICATION INFORMATION (continued)

Basic horizontal deflection circuit with BU108, derived from a horizontal deflection system with 110° picture tube A65-140X.

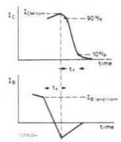


BU108 mounted on an Al. heatsink of 12.5 mm x 12.5 mm x 3 mm

The circuit above with BU108 has been designed with recommended inductance L_B = 11 µH and $I_{B(end)}$ = 1.8 A

Performance:

Collector current before switching (peak value)	I_{CM}	typ.	4.2	A
Storage time at 90 % of I_{CMnom}	t_s	typ.	9.5	µs
Fall time at 10 % of I_{CMnom}	t_f	typ.	0.7	µs
Collector-emitter voltage at 1 µs before i_C = I_{CM}	V_{CE}(end)	typ.	1.5	V
Collector-emitter voltage (peak value)	V_{CEM}	typ.	1100	V
Fly-back ratio	p	typ.	18	%
Period time	T	typ.	64	µs



APPLICATION INFORMATION bulletins available on request

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1) L_B = L_l + L_{B1} where L_l = leakage inductance

2) horizontal output transformer with fifth harmonic tuning

Accessories

Introduction

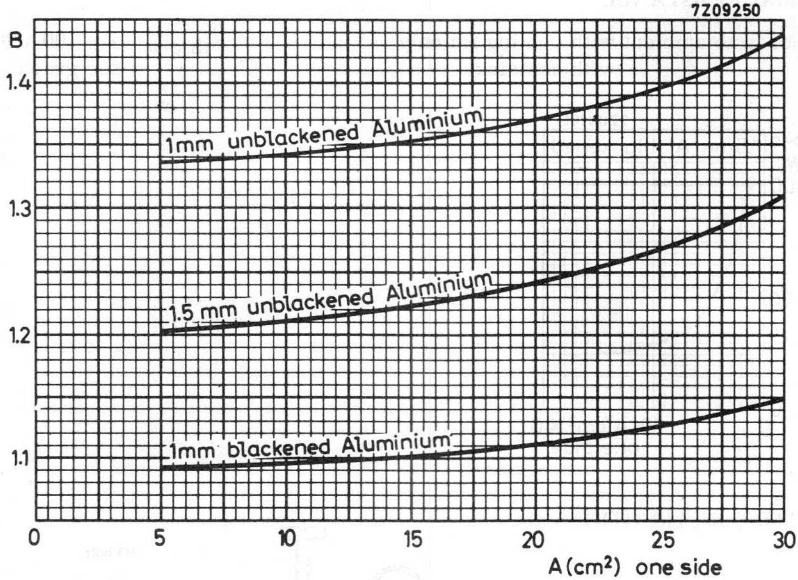
All information on thermal resistances of the accessories combined with flat heatsinks is valid for square heatsinks of 1.5 mm blackened aluminium.
For a few variations the thermal resistance may be derived as follows:

a. Rectangular heatsinks (sides a and 2a)

When mounted with long side horizontal, multiply by 0.95.
When mounted with short side horizontal, multiply by 1.10.

b. Unblackened or thicker heatsinks

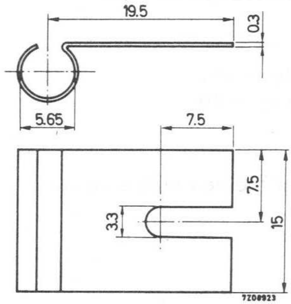
Multiply by the factor B given below as a function of the heatsink size A.



COOLING FIN

MECHANICAL DATA

Dimensions in mm

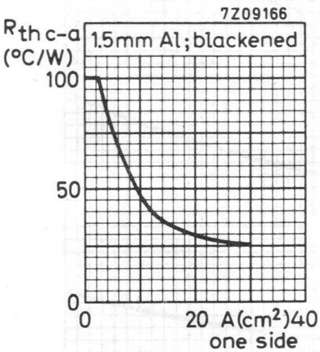


Fin material: brass, nickel plated

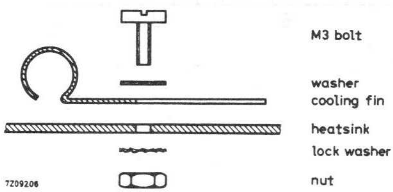
THERMAL RESISTANCE

From case to ambient with cooling fin only — $R_{th\ c-a}$ = 100 °C/W

with heatsink — see graph



MOUNTING INSTRUCTIONS

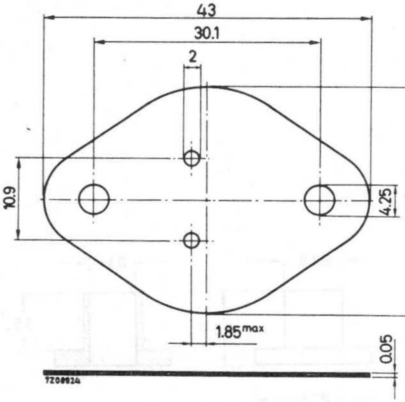


Torque on nut for good heat transfer: 5 cm kg

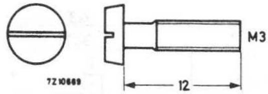
MOUNTING ACCESSORIES

MECHANICAL DATA

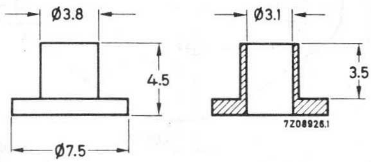
Dimensions in mm



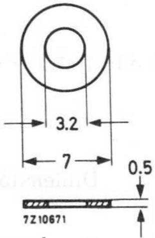
mica washer



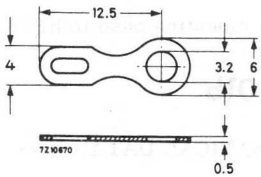
2 cheese head screws, slotted
material: brass, nickel plated



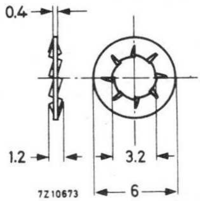
2 insulating bushes



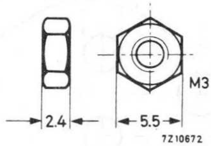
3 plain washers
material: brass, nickel plated



soldering tag



2 lock washers, internal teeth
material: steel, nickel plated



2 hexagon nuts
material: brass, nickel plated

THERMAL RESISTANCE

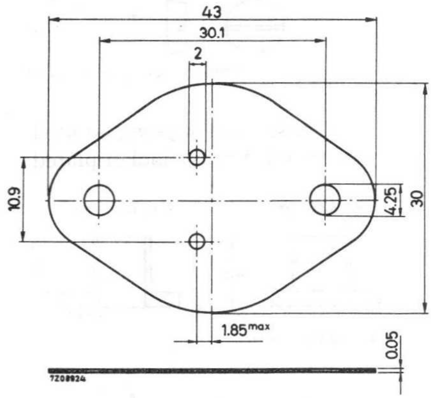
From mounting base to heatsink with mica washer $R_{th\ mb\text{-}h}$ = 1.0 °C/W

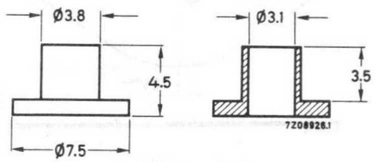
TEMPERATURES

Maximum allowable temperature T_{max} = 150 °C

56201a MICA WASHER AND 2 INSULATING BUSHES

MECHANICAL DATA Dimensions in mm



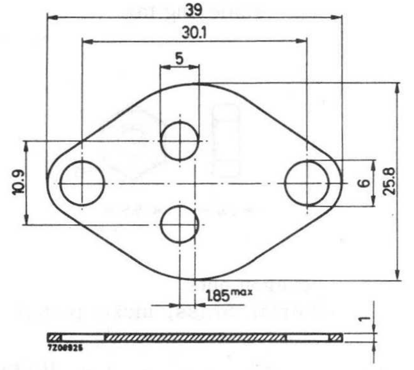


THERMAL RESISTANCE

From mounting base to heatsink $R_{th\ mb-h}$ = 1.0 °C/W

56201b LEAD WASHER

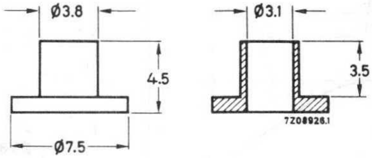
MECHANICAL DATA Dimensions in mm



56201c INSULATING BUSH

MECHANICAL DATA

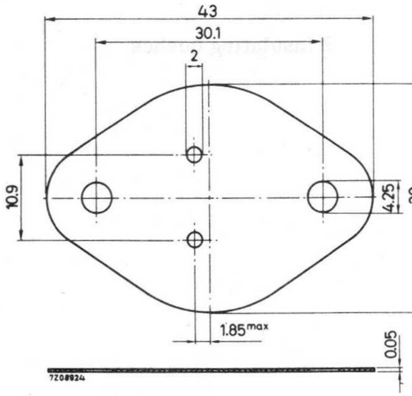
Dimensions in mm



56201d MICA WASHER

MECHANICAL DATA

Dimensions in mm

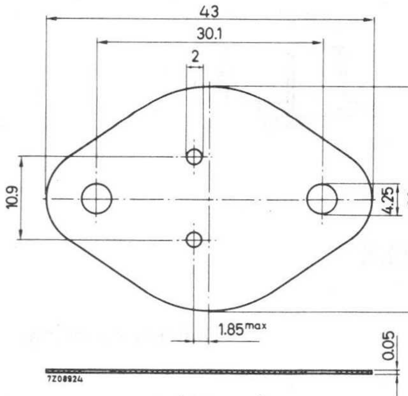


THERMAL RESISTANCE

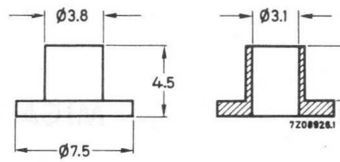
From mounting base to heatsink $R_{th\ mb-h} = 1.0\ ^oC/W$

MOUNTING ACCESSORIES

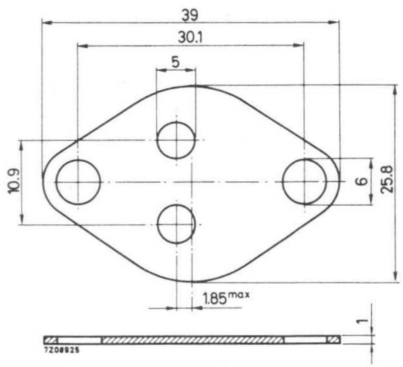
MECHANICAL DATA Dimensions in mm



mica washer



2 insulating bushes



lead washer

THERMAL RESISTANCE

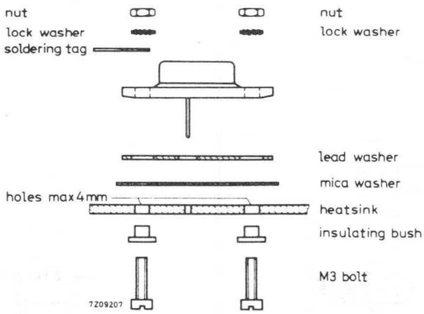
From mounting base to heatsink

with mica washer only	$R_{th\ mb-h}$	=	1.0	°C/W
with mica washer and lead washer	$R_{th\ mb-h}$	=	0.75	°C/W

TEMPERATURE

Maximum allowable temperature	T_{max}	=	150	°C

MOUNTING INSTRUCTIONS

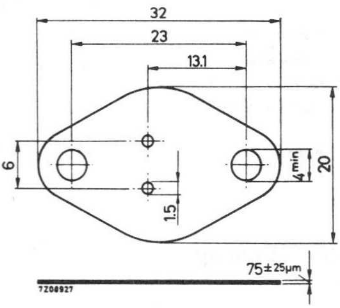


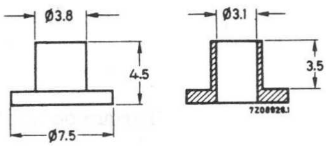
Torque on nut for good heat transfer : 5 cm kg

MICA WASHER AND 2 INSULATING BUSHES

MECHANICAL DATA

Dimensions in mm





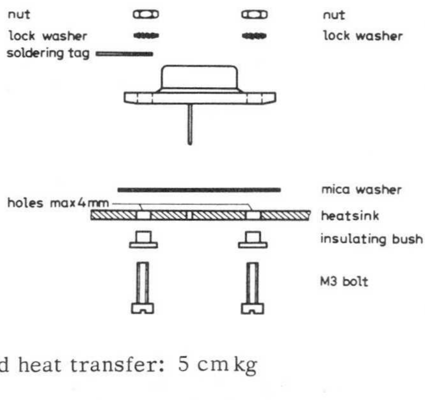
THERMAL RESISTANCE

From mounting base to heatsink $R_{th\ mb\text{-}h}$ = 1.5 °C/W

TEMPERATURE

Maximum allowable temperature T_{max} = 150 °C

MOUNTING INSTRUCTIONS

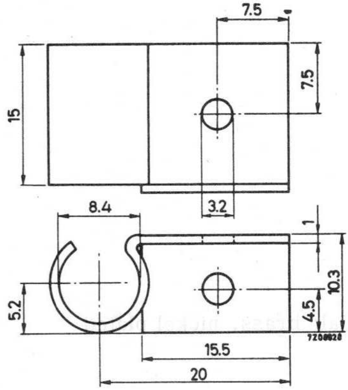


Torque on nut for good heat transfer: 5 cm kg

COOLING FIN

MECHANICAL DATA

Dimensions in mm

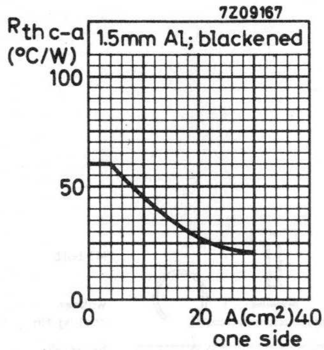


Fin material: aluminium, blackened

THERMAL RESISTANCE

From case to ambient with cooling fin only — $R_{th\ c\text{-}a}$ = 60 °C/W

with heatsink — see graph

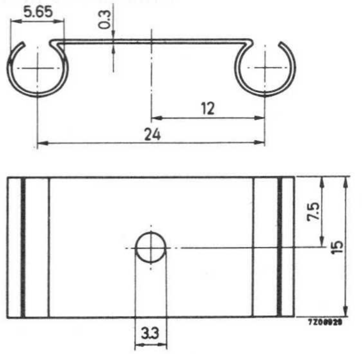


MOUNTING INSTRUCTIONS

Torque on M3 bolts for good heat transfer: 5 cmkg

COOLING FIN

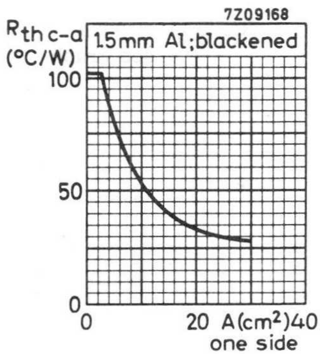
MECHANICAL DATA Dimensions in mm



Fin material: brass, nickel plated

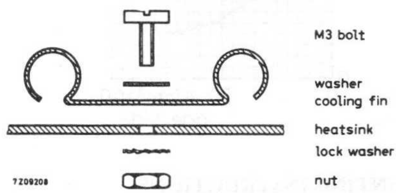
THERMAL RESISTANCE

From case to ambient with cooling fin only	$R_{th\ c\text{-}a}$	= 102 °C/W
with heatsink		see graph



R_{th} values apply to each transistor, provided the two transistors have been mounted so that the heat flow from each is equal.

MOUNTING INSTRUCTIONS

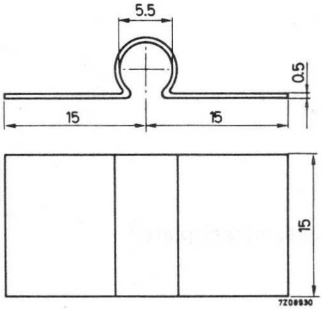


Torque on nut for good heat transfer: 5 cm kg

COOLING FIN

MECHANICAL DATA

Dimensions in mm



Fin material: brass, nickel plated

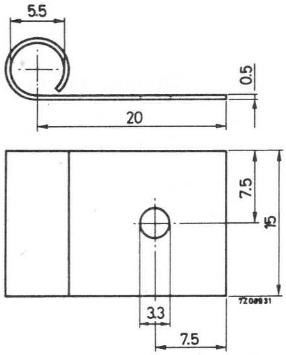
THERMAL RESISTANCE

From case to ambient with cooling fin only $R_{th\ c\text{-}a}$ = 75 °C/W

COOLING FIN

MECHANICAL DATA

Dimensions in mm

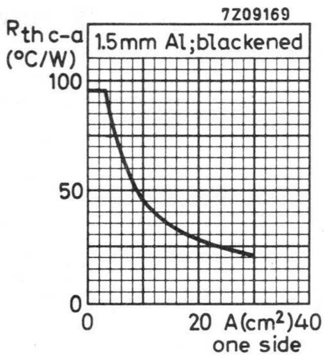


Fin material: brass, nickel plated

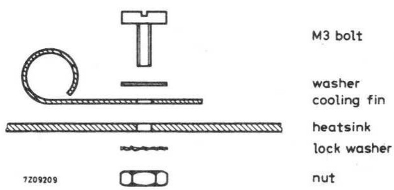
THERMAL RESISTANCE

From case to ambient with cooling fin only — $R_{th\ c\text{-}a}$ = 95 °C/W

with heatsink — see graph



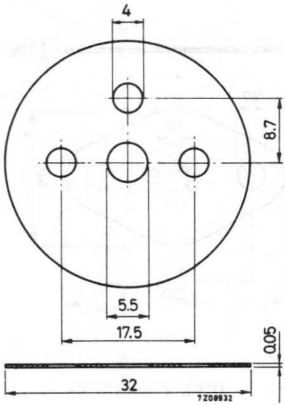
MOUNTING INSTRUCTIONS



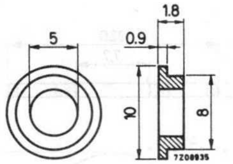
Torque on nut for good heat transfer: 5 cm kg

MOUNTING ACCESSORIES

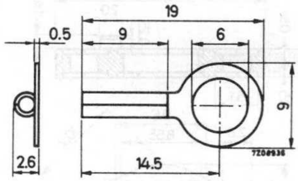
MECHANICAL DATA Dimensions in mm



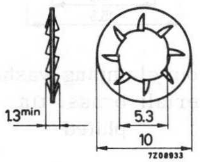
mica washer



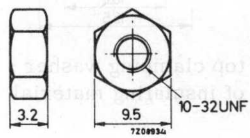
insulating ring



cable lug
material: brass, nickel plated



lock washer internal teeth
material: steel, nickel plated



hexagon nut
material: brass, nickel plated

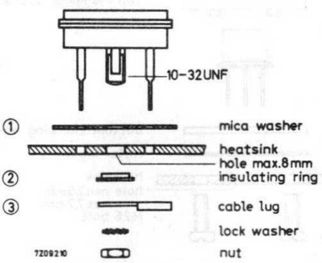
THERMAL RESISTANCE

From mounting base to heatsink $R_{th\ mb\text{-}h}$ = 1 °C/W

TEMPERATURE

Maximum allowable temperature T_{max} = 125 °C

MOUNTING INSTRUCTIONS



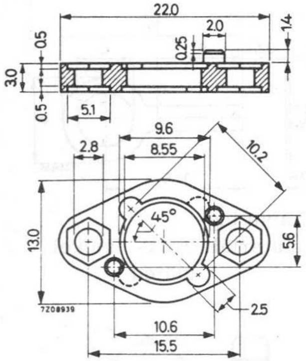
Torque on nut for good heat transfer: 20 cm

Non insulated mounting; without items 1, 2 and 3. (3 if necessary)

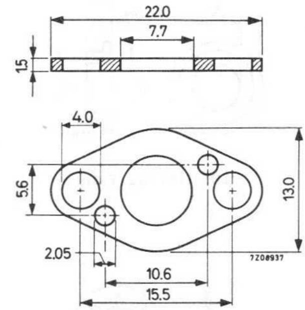
MOUNTING ACCESSORIES

MECHANICAL DATA

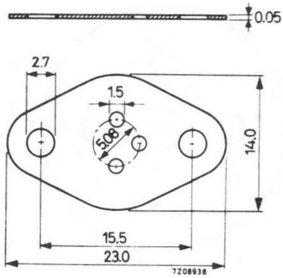
Dimensions in mm



top clamping washer
of insulating material



bottom clamping washer
material: brass, tin plated



mylar washer

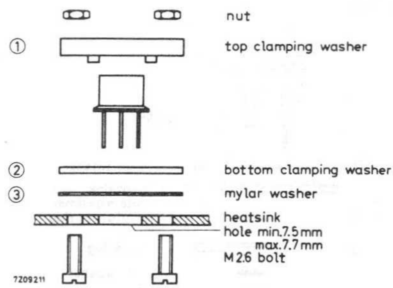
THERMAL RESISTANCE

From mounting base to heatsink non insulated mounting	$R_{th\ mb\text{-}h}$ = 3 °C/W
insulated mounting	$R_{th\ mb\text{-}h}$ = 6 °C/W

TEMPERATURE

Maximum allowable temperature T_{max} = 100 °C

MOUNTING INSTRUCTIONS

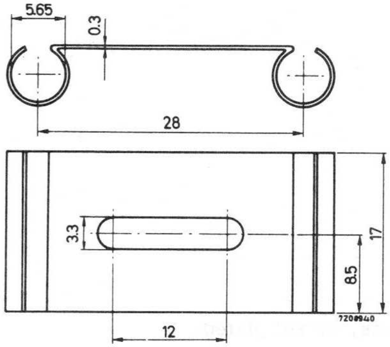


Non insulated mounting; without items 2 and 3. (Note: item 1 must than be mounted up-side down)

COOLING FIN

MECHANICAL DATA

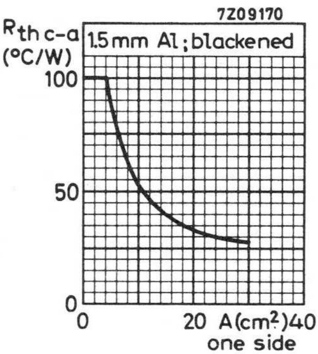
Dimensions in mm



Fin material: brass, nickel plated

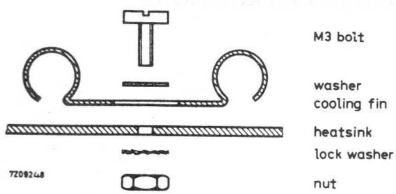
THERMAL RESISTANCE

From case to ambient with cooling fin only — $R_{th\ c\text{-}a}$ = 100 °C/W
with heatsink — see graph



R_{th} values apply to each transistor, provided the two transistors have been mounted so that the heat flow from each is equal.

MOUNTING INSTRUCTIONS

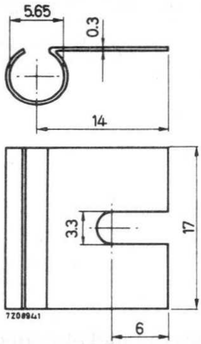


Torque on nut for good heat transfer: 5 cmkg

COOLING FIN

MECHANICAL DATA

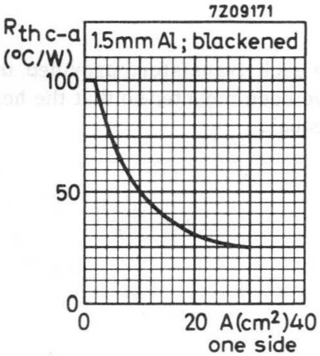
Dimensions in mm



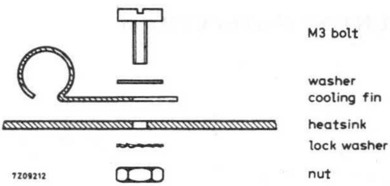
Fin material: brass, nickel plated

THERMAL RESISTANCE

From case to ambient with cooling fin only	$R_{th\ c\text{-}a}$	= 100 °C/W
with heatsink		see graph



MOUNTING INSTRUCTIONS

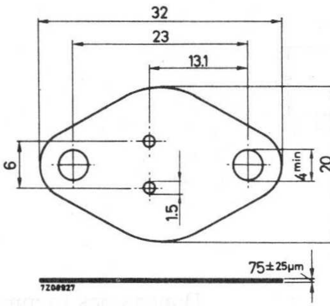


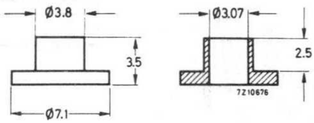
Torque on nut for good heat transfer: 5 cmkg

MICA WASHER AND 2 INSULATING BUSHES

56239

MECHANICAL DATA Dimensions in mm





THERMAL RESISTANCE

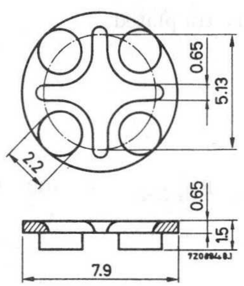
From mounting base to heatsink $R_{th\ mb\text{-}h}$ = 1.5 °C/W

TEMPERATURE

Maximum allowable temperature T_{max} = 150 °C

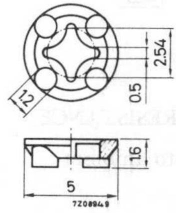
DISTANCE DISCS

56245



Insulating material

56246



Insulating material

TEMPERATURE

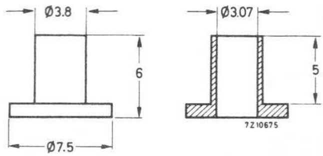
Maximum allowable temperature T_{max} = 100 °C

2 INSULATING BUSHES

56261

MECHANICAL DATA

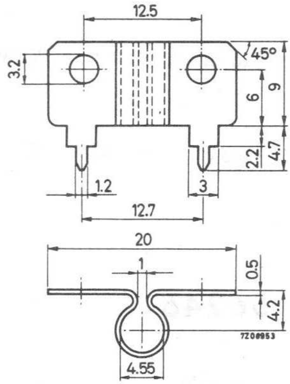
Dimensions in mm



56263 COOLING FIN

MECHANICAL DATA

Dimensions in mm



Fin material: copper, tin plated

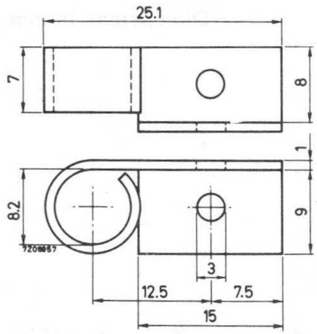
THERMAL RESISTANCE

From case to ambient $R_{th\ c-a}$ = 100 °C/W

COOLING FIN

MECHANICAL DATA

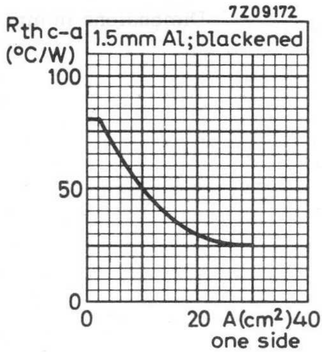
Dimensions in mm



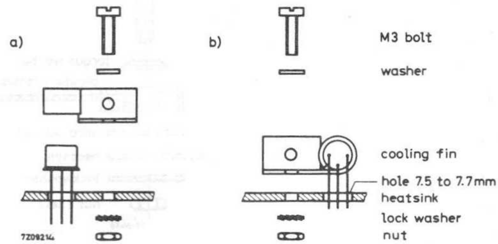
Fin material: aluminium, blackened

THERMAL RESISTANCE

From case to ambient with cooling fin only — $R_{th\ c-a}$ = 80 °C/W
with heatsink — see graph



MOUNTING INSTRUCTIONS

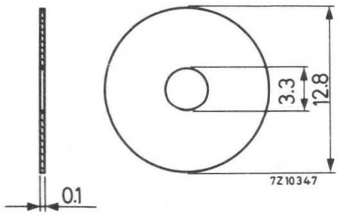


Torque on nut for good heat transfer: 5 cm kg

56302 MICA WASHER

MECHANICAL DATA

Dimensions in mm



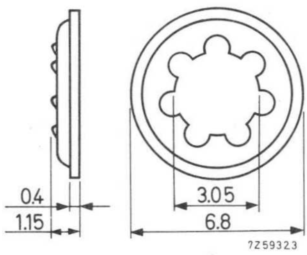
THERMAL RESISTANCE

From mounting base to heatsink $R_{th\ mb\text{-}h}$ = 6 °C/W

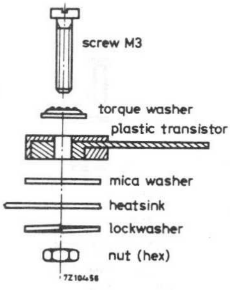
56303 TORQUE WASHER

MECHANICAL DATA

Dimensions in mm



MOUNTING INSTRUCTIONS



Torque on nut: min. 8 cm kg
max. 9 cm kg

INDEX OF TYPE NUMBERS

The inclusion of a type number in this publication does not necessarily imply its availability.

B = Beam lead devices
HF = High frequency transistors
LF = Low frequency transistors
Mm = Microminiature devices for thick- and thin-film circuits
Mw = Microwave devices
P = Low frequency power transistors
Sw = Switching transistors
Tr = Transmitting transistors

Type No.	Part	Section	Type No.	Part	Section	Type No.	Part	Section
BCY31	2	LF	BD139	2	P	BFS18	4	Mm
BCY32	2	LF	BD140	2	P	BFS19	4	Mm
BCY33	2	LF	BD144	2	Defl	BFS20	4	Mm
BCY34	2	LF	BDY10	2	P	BFS21	4	FET
BCY38	2	LF	BDY11	2	P	BFS21	4	Dual
BCY39	2	LF	BDY20	2	P	BFS21A	4	FET
BCY40	2	LF	BDY38	2	P	BFS21A	4	Dual
BCY54	2	LF	BF115	3	HF	BFS22	4	Tr
BCY55	2	LF	BF167	3	HF	BFS23	4	Tr
BCY55	4	Dual	BF173	3	HF	BFS28	4	FET
BCY56	2	LF	BF177	3	HF	BFS92	3	HF
BCY57	2	LF	BF178	3	HF	BFS93	3	HF
BCY70	2	LF	BF179	3	HF	BFS94	3	HF
BCY71	2	LF	BF180	3	HF	BFS95	3	HF
BCY72	2	LF	BF181	3	HF	BFW10	4	FET
BCY87	2	LF	BF182	3	HF	BFW11	4	FET
BCY87	4	Dual	BF183	3	HF	BFW16A	3	HF
BCY88	2	LF	BF184	3	HF	BFW17A	3	HF
BCY88	4	Dual	BF185	3	HF	BFW30	3	HF
BCY89	2	LF	BF186	3	HF	BFW45	2	Defl
BCY89	4	Dual	BF194	3	HF	BFW61	4	FET
BCZ10	2	LF	BF195	3	HF	BFW92	3	HF
BCZ11	2	LF	BF196	3	HF	BFX44	3	HF
BCZ12	2	LF	BF197	3	HF	BFX89	3	HF
BD115	2	P	BF200	3	HF	BFY10	3	HF
BD124	2	P	BF254	3	HF	BFY11	3	HF
BD135	2	P	BF255	3	HF	BFY44	4	Tr
BD136	2	P	BFR63	3	HF	BFY50	3	HF
BD137	2	P	BFR64	3	HF	BFY51	3	HF
BD138	2	P	BFS17	4	Mm	BFY52	3	HF

Defl = Deflection transistors
Dual = Dual transistors
FET = Field effect transistors
HF = High frequency transistors
LF = Low frequency transistors
Mm = Microminiature devices for thick- and thin-film circuits
P = Low frequency power transistors
Tr = Transmitting transistors

B = Beam lead devices
Defl = Deflection transistors
FET = Field effect transistors
HF = High frequency transistors
LF = Low frequency transistors
Mm = Microminiature devices for thick- and thin-film circuits
Mw = Microwave devices
P = Low frequency power transistors
Ph = Photo devices
Sw = Switching transistors
Tr = Transmitting transistors

A = Accessories
FET = Field effect transistors
HF = High frequency transistors
LF = Low frequency transistors
P = Low frequency power transistors
Ph = Photo devices
Sw = Switching transistors
Tr = Transmitting transistors

A = Accessories

Printed in The Netherlands

9399 251 14501