PHILIPS

Data handbook

PHILIPS Electronic components and materials

Semiconductors and integrated circuits

Part 2 January 1973

Low frequency transistors

Low frequency power transistors

Deflection transistors

SEMICONDUCTORS AND INTEGRATED CIRCUITS

Part 2 January 1973

General

Low frequency transistors

Low frequency power transistors

Deflection transistors

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September 1972

DATA HANDBOOK SYSTEM

Our Data Handbook System is a comprehensive source of information on electronic components, subassemblies and materials; it is made up of three series of handbooks each comprising several parts.

ELECTRON TUBES	**BLUE**
SEMICONDUCTORS AND INTEGRATED CIRCUITS	**RED**
COMPONENTS AND MATERIALS	**GREEN**

The several parts contain all pertinent data available at the time of publication, and each is revised and reissued periodically.

Where ratings or specifications differ from those published in the preceding edition they are pointed out by arrows. Where application information is given it is advisory and does not form part of the product specification.

If you need confirmation that the published data about any of our products are the latest available, please contact our representative. He is at your service and will be glad to answer your inquiries.

ELECTRON TUBES (BLUE SERIES)

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

Part 1	**Transmitting tubes (Tetrodes, Pentodes); Amplifier circuit assemblies**	**January 1972**
Part 2	**Tubes for microwave equipment**	**February 1972**
Part 3	**Special Quality tubes; Miscellaneous devices**	**March 1972**
Part 4	**Receiving tubes**	**June 1972**
Part 5	**Cathode-ray tubes; Photo tubes; Camera tubes**	**July 1972**
Part 6	**Devices for nuclear equipment** Photomultiplier tubes Channel electron multipliers Scintillators Photoscintillators Radiation counter tubes Semicinductor radiation detectors Neutron generator tubes Photo diodes	**September 1972**
Part 7	**Gas-filled tubes** Voltage stabilizing and reference tubes Counter, selector, and indicator tubes Trigger tubes Switching diodes Thyratrons Ignitrons Industrial rectifying tubes High-voltage rectifying tubes	**October 1972**
Part 8	**T.V.Picture tubes**	**November 1972**
Part 9	**Transmitting tubes (Triodes) ; Tubes for r.f. heating (Triodes)**	**December 1971**

SEMICONDUCTORS AND INTEGRATED CIRCUITS (RED SERIES)

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

Part 1a Rectifier diodes and thyristors — **December 1972**

Rectifier diodes
Voltage regulator diodes
Transient suppressor diodes
Thyristors, diacs, triacs
Ignistors
Rectifier stacks

Part 1b Diodes — **December 1972**

Small signal germanium diodes
Small signal silicon diodes
Special diodes
Voltage regulator diodes
Voltage reference diodes
Tuner diodes

Part 2 Low frequency and deflection transistors — **January 1973**

Part 3 High frequency and switching transistors — **November 1971**

Part 4 Special types — **December 1971**

Transmitting transistors
Microwave devices
Field effect transistors
Dual transistors
Microminiature devices for thick- and thin-film circuits
Photoconductive devices
Photodiodes
Phototransistors
Light emitting diodes
Infra-red sensitive devices

Part 5 Linear integrated circuits — **February 1972**

Part 6 Digital integrated circuits — **March 1972**

DTL (FC family)
DTL/HNIL (FZ family)
TTL (FJ family)
TTL (GJ family)
CML (GH family)
MOS (FD family)

COMPONENTS AND MATERIALS (GREEN SERIES)

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

Part 1 Circuit Blocks, Input/Output Devices, Electro-mechanical Components, Peripheral Devices — **December 1972**

Circuit blocks 40-Series and CSA70
Counter modules 50-Series
Norbits 60-Series, 61- Series
Circuit blocks 90-Series
Input/output devices
Electro-mechanical components
Peripheral devices

Part 2 Resistors, Capacitors — **December 1971**

Fixed resistors
Variable resistors
Non-linear resistors
Ceramic capacitors
Paper capacitors and film capacitors
Electrolytic capacitors
Variable capacitors

Part 3 Radio, Audio, Television — **February 1972**

FM tuners
Coil assemblies
Piezoelectric ceramic resonators and filters
Loudspeakers
Audio and mains transformers
Television tuners, aerial input assemblies
Components for black and white television
Components for colour television
Deflection assemblies for camera tubes

Part 4 Magnetic Materials, Piezoelectric Ceramics, Ni Cd cells — **May 1972**

Ferrites for radio, audio and television
Small coils and assembling parts
Ferroxcube potcores and square cores
Ferroxcube transformer cores
Piezoelectric ceramics
Permanent magnet materials
Cylindrical nickel cadmium cells *)

Part 5 Memory Products, Magnetic Heads, Quartz Crystals, Microwave Devices, Variable Transformers — **August 1972**

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

Part 6 Electric Motors and Accessories, Timing and Control Devices — **October 1972**

Small synchronous motors
Stepper motors
D.C. motors
D.C. tachogenerators
Asynchronous motors
Indicators for built-in test equipment
Time indicators, timers, timing motors
Aircraft electronic clock system

Part 7 Circuit Blocks — **September 1971**

Circuit blocks 100 kHz Series
Circuit blocks 1-Series
Circuit blocks 10-Series
Circuit blocks for ferrite core memory drive

*) These items have been discontinued

General

Type designation
Rating systems
Letter symbols
SOAR curves

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

[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 ($R_{th\ j\text{-}mb} > 15\ ^oC/W$)
- D Power transistor for a.f. applications ($R_{th\ j\text{-}mb} \leq 15\ ^oC/W$)
- E Tunnel diode
- F Transistor for h.f. applications ($R_{th\ j\text{-}mb} > 15\ ^oC/W$)
- 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 ($R_{th\ j\text{-}mb} \leq 15\ ^oC/W$)
- M Hall generator in a closed electrically energised magnetic circuit, e.g. Hall modulator or multiplier
- → N Photocoupler
- P Radiation sensitive device [1)]
- Q Radiation generating device
- R Electrically triggered controlling and switching device having a breakdown characteristic ($R_{th\ j\text{-}mb} > 15\ ^oC/W$)
- S Transistor for switching applications ($R_{th\ j\text{-}mb} > 15\ ^oC/W$)
- T Electrically, or by means of light, triggered controlling and switching power device having a breakdown characteristic ($R_{th\ j\text{-}mb} \leq 15\ ^oC/W$)[1)]
- U Power transistor for switching applications ($R_{th\ j\text{-}mb} \leq 15\ ^oC/W$)
- 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.

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

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.

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

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.

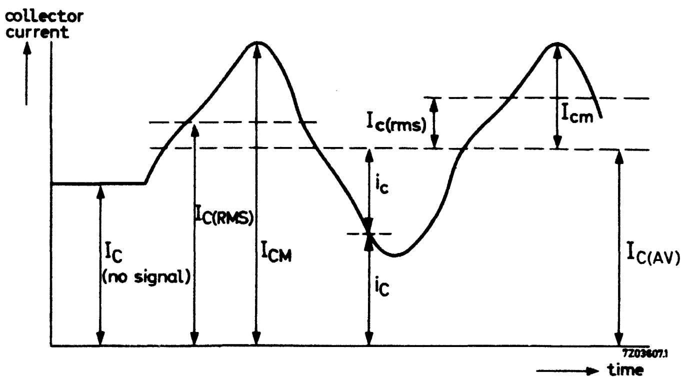


Fig. 1

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}	Input susceptance	
g_{ib}, g_{ie}, g_{is}	Input conductance	
C_{ib}, C_{ie}, C_{is}	Input capacitance	
φ_{ib}, φ_{ie}, φ_{is}	Phase angle of input admittance	
y_{fb}, y_{fe}, y_{fs}	Transfer admittance	Output short circuited to a.c.
b_{fb}, b_{fe}, b_{fs}	Transfer susceptance	
g_{fb}, g_{fe}, g_{fs}	Transfer conductance	
C_{fb}, C_{fe}, C_{fs}	Transfer capacitance	
φ_{fb}, φ_{fe}, φ_{fs}	Phase angle of transfer admittance	
y_{ob}, y_{oe}, y_{os}	Output admittance	Input short circuited to a.c.
b_{ob}, b_{oe}, b_{os}	Output susceptance	
g_{ob}, g_{oe}, g_{os}	Output conductance	
C_{ob}, C_{oe}, C_{os}	Output capacitance	
φ_{ob}, φ_{oe}, φ_{os}	Phase angle of output admittance	
y_{rb}, y_{re}, y_{rs}	Feedback admittance	Input short circuited to a.c.
b_{rb}, b_{re}, b_{rs}	Feedback susceptance	
g_{rb}, g_{re}, g_{rs}	Feedback conductance	
C_{rb}, C_{re}, C_{rs}	Feedback capacitance	
φ_{rb}, φ_{re}, φ_{rs}	Phase angle of feedback admittance	
Z_{th}	Transient thermal **impedance**	

SAFE OPERATING AREA CURVES

1. D.C. SOAR

The d.c. safe operating area (SOAR) of a transistor is limited on the current axis by $I_{C\,max}$ and on the voltage axis by V_{CEOmax}. Intersecting these two is a third limit defined by $P_{tot\,max}$. These limits can be superimposed on the normal I_C-V_{CE} curve as in Fig. 1, but are better shown on a double logarithmic scale as in Fig. 2; the $P_{tot\,max}$ limit then appears as a straight line at 45^0 to the axes.

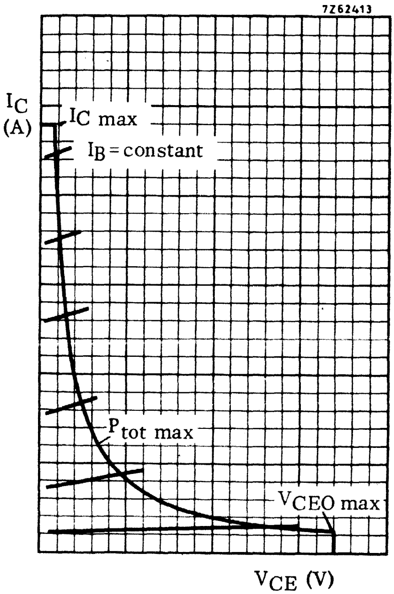


Fig. 1

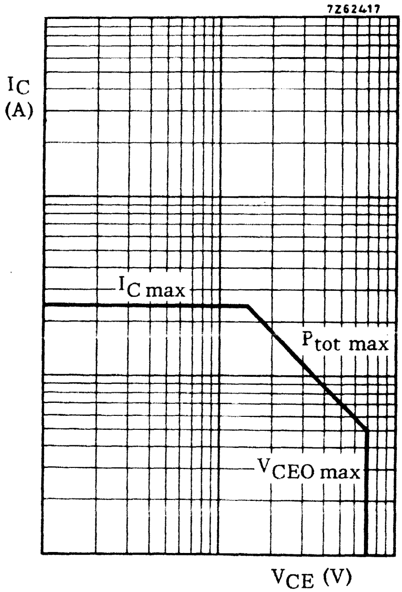


Fig. 2. D.C. SOAR curve

For steady state conditions there is a linear relation between the power dissipated at the junction and the temperature difference between junction and mounting base:

$$T_j - T_{mb} = C \cdot P_{tot},$$

where $C = R_{th\,j\text{-}mb}$, i.e. the thermal resistance from junction to mounting base.

$$T_j - T_{mb} = P_{tot} \cdot R_{th\,j\text{-}mb} \quad (1)$$

In terms of maximum allowable junction temperature eq. (1) can be written as:

$$T_{j\,max} - T_{mb} = P_{tot\,max} \cdot R_{th\,j\text{-}mb} \quad (1a)$$

The data sheets give an upper limit for $P_{tot\ max}$ which applies up to a temperature T_1. These relations are shown in Fig. 3 where the upper limit for $P_{tot\ max}$ has been chosen as 100%.

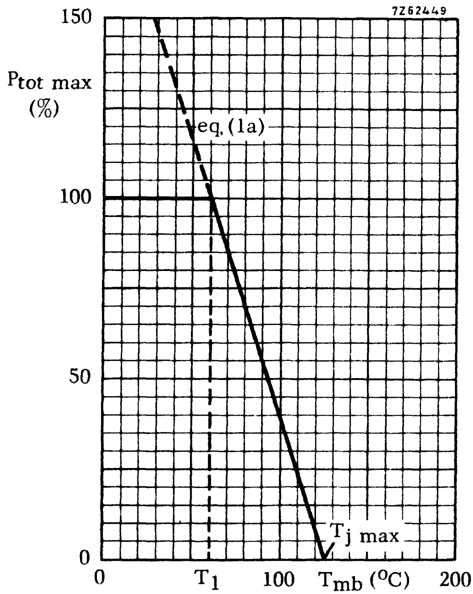


Fig. 3

So far we have discussed only d.c. conditions; it will be obvious that under pulse conditions a higher $P_{tot\ max}$ can be permitted.

2. Extension of the SOAR for pulse power

When pulse power is applied to a transistor the junction temperature will rise in a series of steps until a steady state condition is reached. See Fig. 4.
For this steady state, eq. (1) can be modified to:

$$T_{j\ peak} - T_{mb} = P_{peak} \cdot Z_{th\ j\text{-}mb} \qquad (2)$$

where $Z_{th\ j\text{-}mb}$ is the transient thermal impedance from junction to mounting base and is dependent not only on $R_{th\ j\text{-}mb}$, but also on pulse width (t_p) and period (T). $Z_{th\ j\text{-}mb}$ is generally published in the form of Fig. 5.

In terms of maximum allowable junction temperature eq. (2) can be written as:

$$T_{j\ max} - T_{mb} = P_{peak\ max} \cdot Z_{th\ j\text{-}mb} \qquad (2a)$$

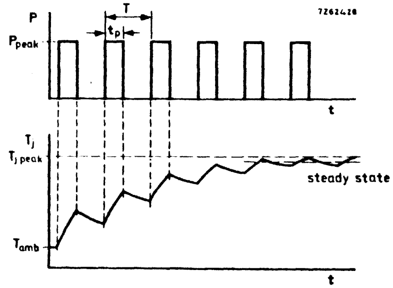


Fig. 4

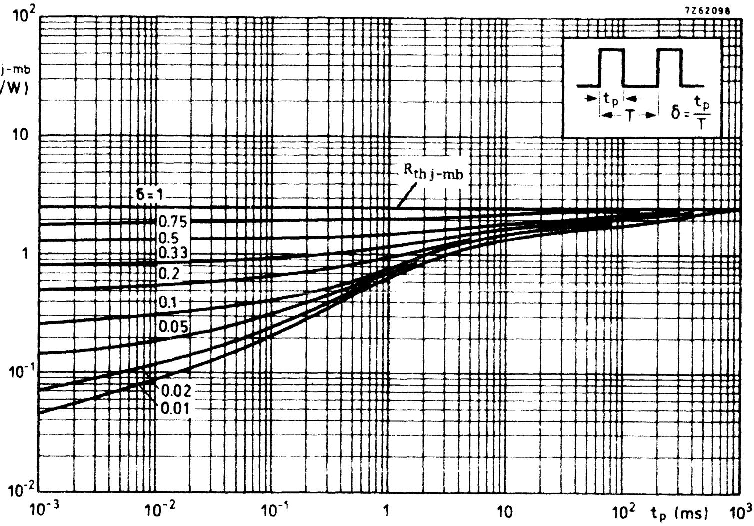


Fig. 5

Dividing eq. (2a) by eq. (1a), leads to:

$$P_{peak\,max} = P_{tot\,max}\ \frac{R_{th\ j\text{-}mb}}{Z_{th\ j\text{-}mb}} = P_{tot\,max} \cdot M_p. \qquad (3)$$

This means that the $P_{tot\,max}$ curve can be shifted by the factor M_p, see the sloping part of the thick dashed line of Fig. 6. M_p is known as the 'power multiplying factor'.
The horizontal part of the dashed line of Fig. 6 is the rating I_{CMmax}; it is the upper limit of the SOAR for pulse conditions.
In addition to the limits set by the SOAR the average current $I_{C(AV)}$ with an averaging time t_{av} of 50 ms should not exceed the maximum permissible d.c. current I_{Cmax}. Averaging is only unneccessary when SOAR limits lower than the rated I_{CMmax} are indicated for different pulse durations.

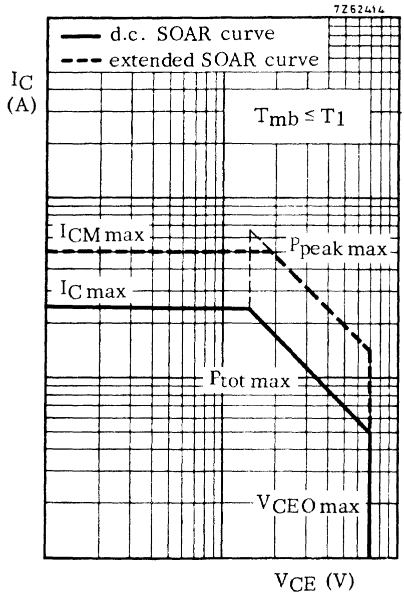


Fig. 6

3. Second Breakdown

3.1 The phenomenon

Primary breakdown is a sudden increase in I_C as a result of avalanche action within the crystal. If the collector current is increased further a critical condition can be reached at which the voltage across the crystal drops to a very low level. This phenomenon is known as second breakdown. It is initiated by a current contraction that leads to local heating within the crystal. The higher the voltage (before second breakdown) the lower the power at which the contraction occurs. If a single point on the crystal exceeds $T_{j\,max}$, the transistor characteristics may be permanently affected; further current contraction will lead to increased temperature and consequent second breakdown, which will destroy the transistor.

The SOAR curve must define an area that not only precludes second breakdown but also the current contraction that precedes it.

3.2 Second breakdown and the d.c. SOAR

A transistor's susceptibility to second breakdown is investigated by d.c. loading up to current contraction. With different combinations of I_C and V_{CE}, points are plotted at which current contraction is observed. A limit is then defined that precludes current contraction. This line lowers the original SOAR curve (see Fig. 7). The final d.c. SOAR curve is that shown in Fig. 8. In general the second breakdown limit is independent of the mounting base temperature.
The thermal resistance $R_{th\,j\text{-}mb}$ is guaranteed for all I_C-V_{CE} combinations within the d.c. SOAR.

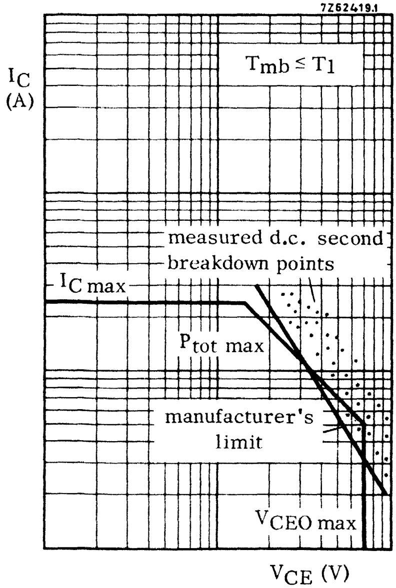


Fig. 7

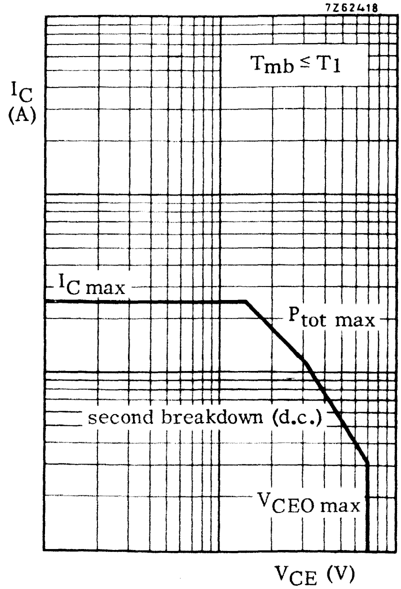


Fig. 8

3.3 Fixing the second breakdown line for pulses, in the SOAR curve

In section 3.1 it was suggested that second breakdown occurs when a single point of the junction (crystal) reaches a critical temperature. It is really the thermal conditions in the crystal itself that determine the point of second breakdown - the thermal resistance (R_{th} crystal) and the thermal impedance ($Z_{th\ crystal}$) between the hottest part of the crystal and the rest. $Z_{th\ crystal}$ is dependent on $R_{th\ crystal}$, δ, t_p, and the relation I_C-V_{CE}.

As with M_p, a multiplying factor M_{SB} can be derived to fix the second breakdown line for pulse conditions. However, for second breakdown two multiplying factors are given; $M_{SB(I)}$ is the voltage multiplying factor at the I_{Cmax} level: $M_{SB(V)}$ is the current multiplying factor at the $V_{CEO\ max}$ level.

Knowing δ and t_p, one can find $M_{SB(I)}$ and $M_{SB(V)}$ from two curves published in the data sheets, Figs 9a and 9b being examples. The voltage value at which the d.c. second breakdown line intersects the $I_{C\ max}$ line is then multiplied by $M_{SB(I)}$. In Fig. 10 the d.c. intersection is shown as point C, and a new intersection for specific pulse conditions as point C'. In the same way $M_{SB(V)}$ is used to find D' from D, which is the point at which the d.c. second breakdown line intersects the $V_{CEO\ max}$ line. The line that passes through C' and D' defines the second breakdown limit for given values of δ and t_p.

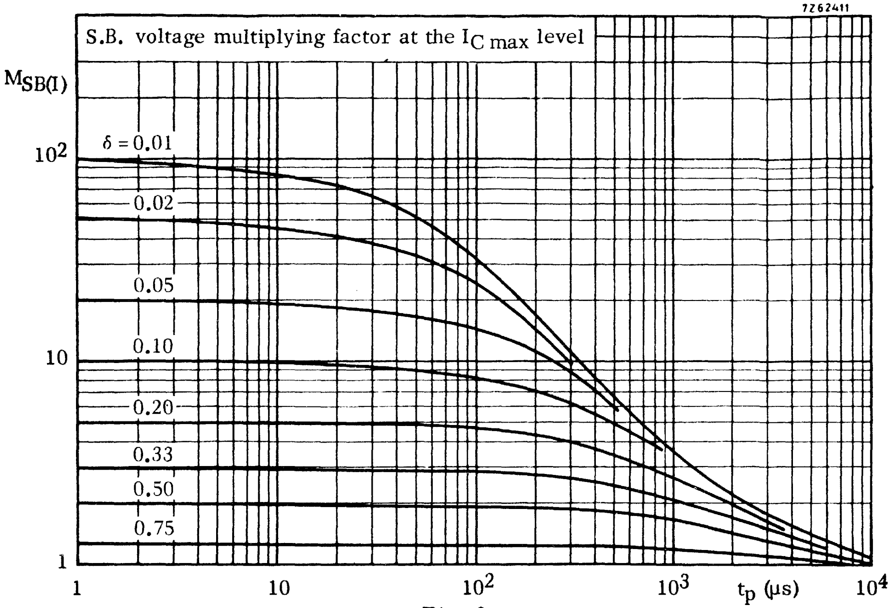

7Z62411
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
δ = 0.01
0.02
0.05
0.10
0.20
0.33
0.50
0.75
1
10
10^2
10^3
t_p (μs)
10^4

Fig. 9a

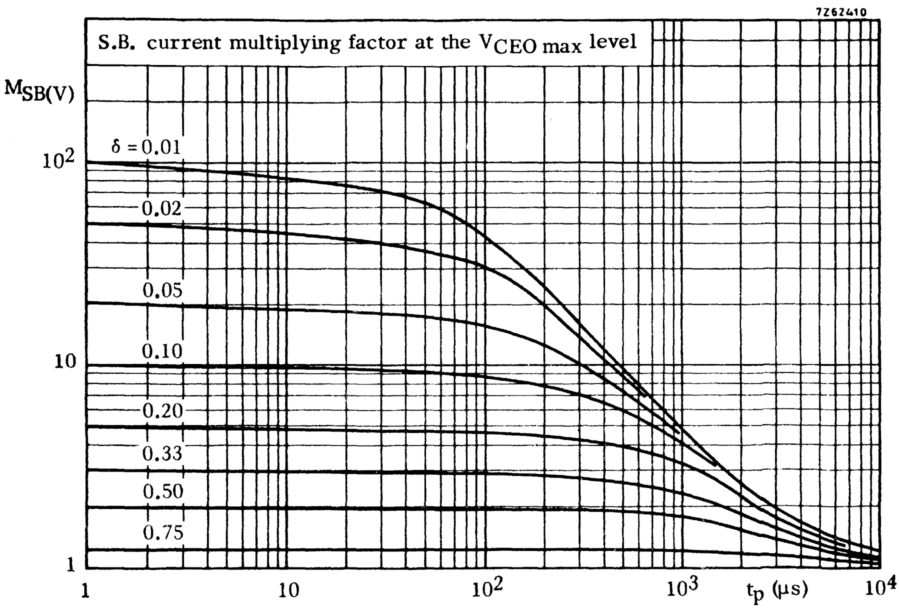

7Z62410
S.B. current multiplying factor at the $V_{CEO\,max}$ level
$M_{SB(V)}$
10^2
10
1
δ = 0.01
0.02
0.05
0.10
0.20
0.33
0.50
0.75
1
10
10^2
10^3
t_p (μs)
10^4

Fig. 9b

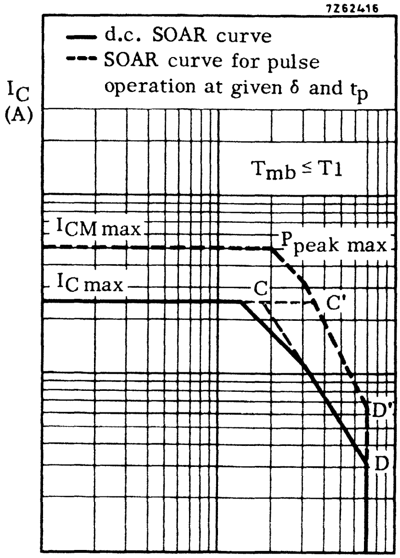


Fig. 10 V_{CE} (V)

A transistor can be safely operated under pulse conditions within the area bounded by I_{CMmax}, $P_{peak\,max}$, pulse SB limit, and V_{CEOmax}, provided the mounting base temperature does not exceed T_1. If the mounting base temperature does exceed T_1, M_p must be reduced by a factor derived from Fig. 3 (see section 1) but M_{SB} need not be changed.

The SOAR curve for one specific duty cycle (δ) is given in the data sheets, but with the aid of curves Z_{th}, $M_{SB(I)}$, $M_{SB(V)}$ and the d.c. SOAR, a pulse condition SOAR can be constructed for any duty cycle.

4. Example of how to use the published SOAR information

4.1 Statement of the problem

The driver- and output-stage of an audio amplifier are given in Fig. 11. We shall investigate whether the driver transistor TR3 operates safely under worst case conditions.

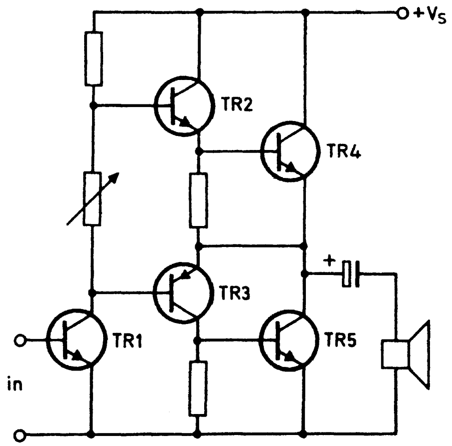


Fig. 11

The loudspeaker impedance is such that worst case conditions occur when the amplifier is overdriven by about 20 times the input signal necessary for full output power at a frequency of 750 Hz. Fig. 12 gives V_{CE} and I_C of TR3 under these conditions. The mounting base temperature of TR3 under these conditions is found to be 85 °C.

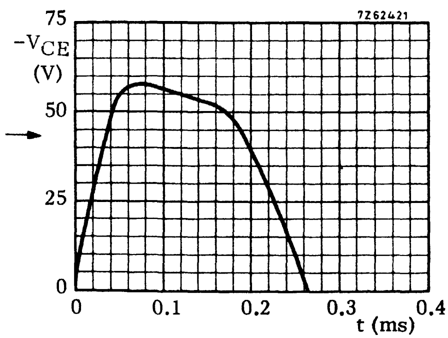


Fig. 12a

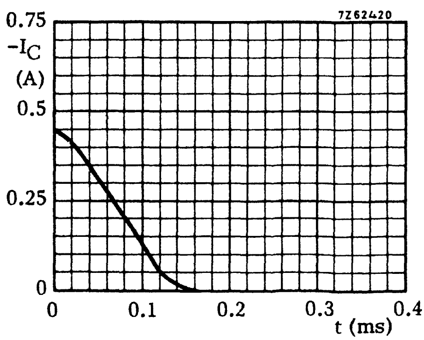


Fig. 12b

4.2 Information obtained from the published data of TR3

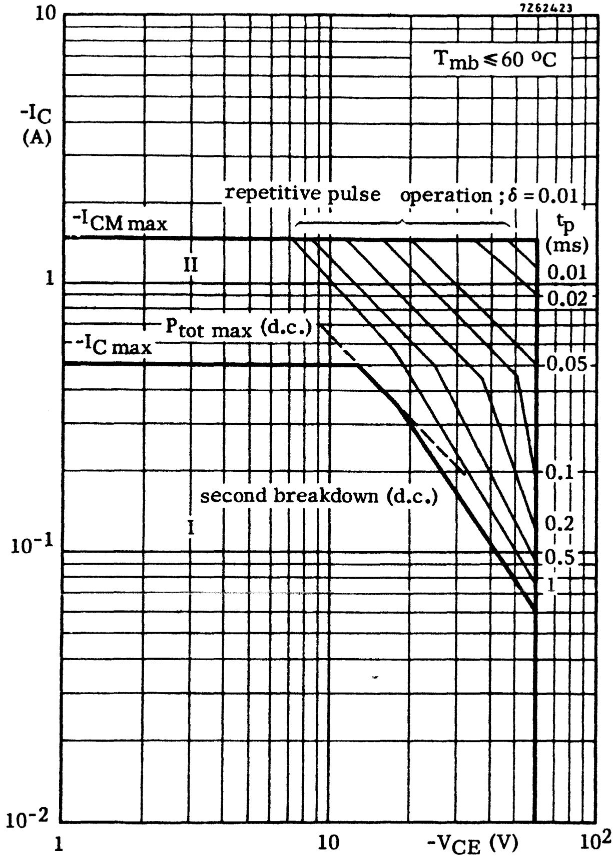
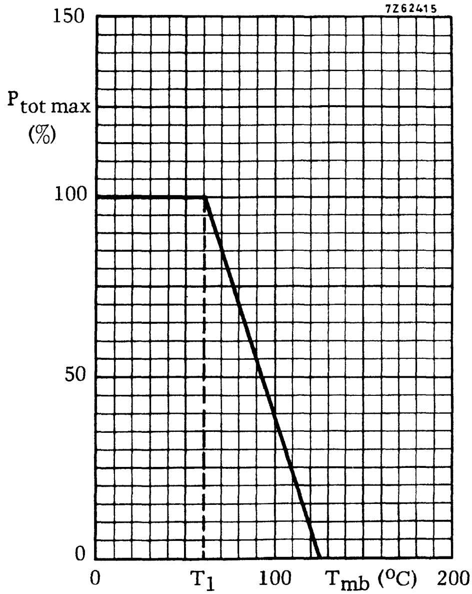


Fig. 13. Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation.



$T_{j\,max}$ = 125 °C

$R_{th\,j\text{-}mb}$ = 10 °C/W

Fig. 14

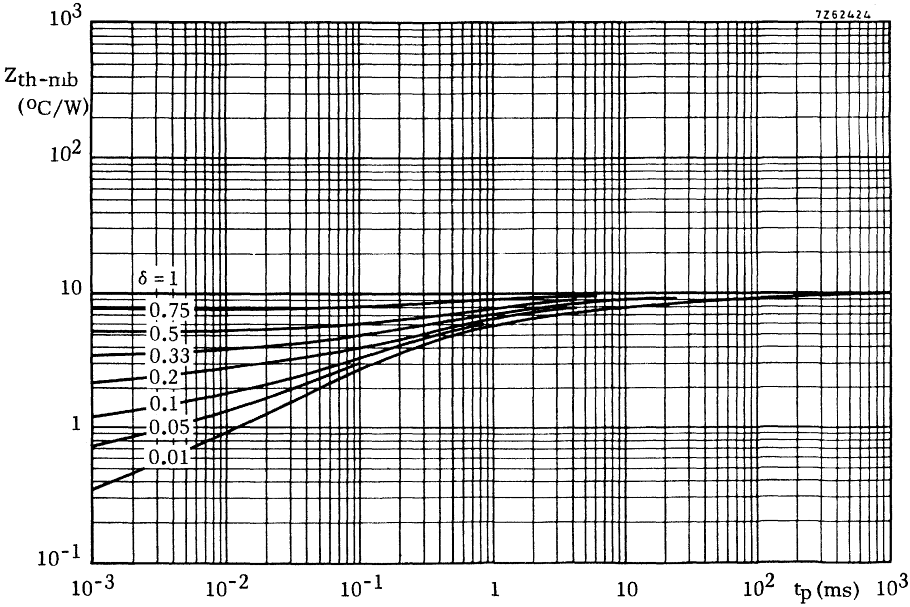


Fig. 15

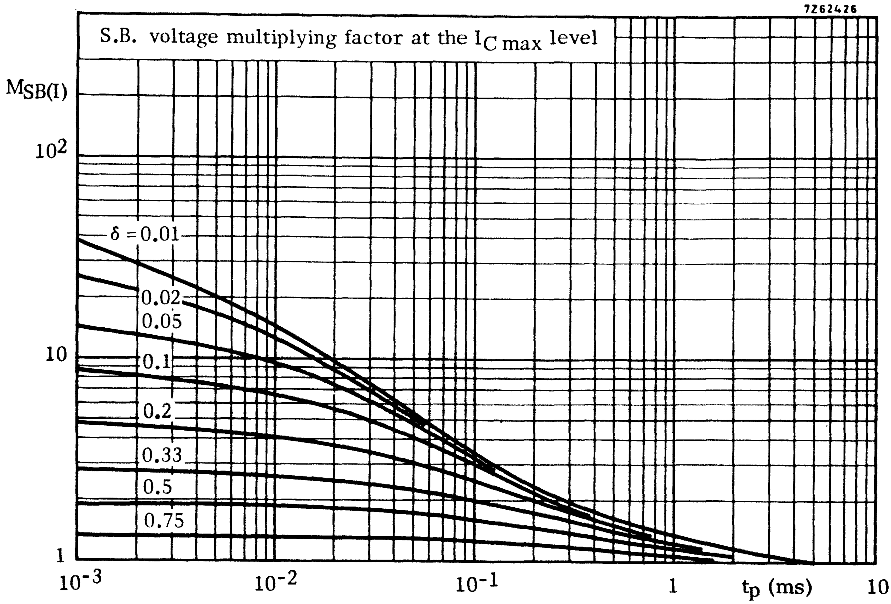

7Z62426
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
δ = 0.01
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

Fig. 16

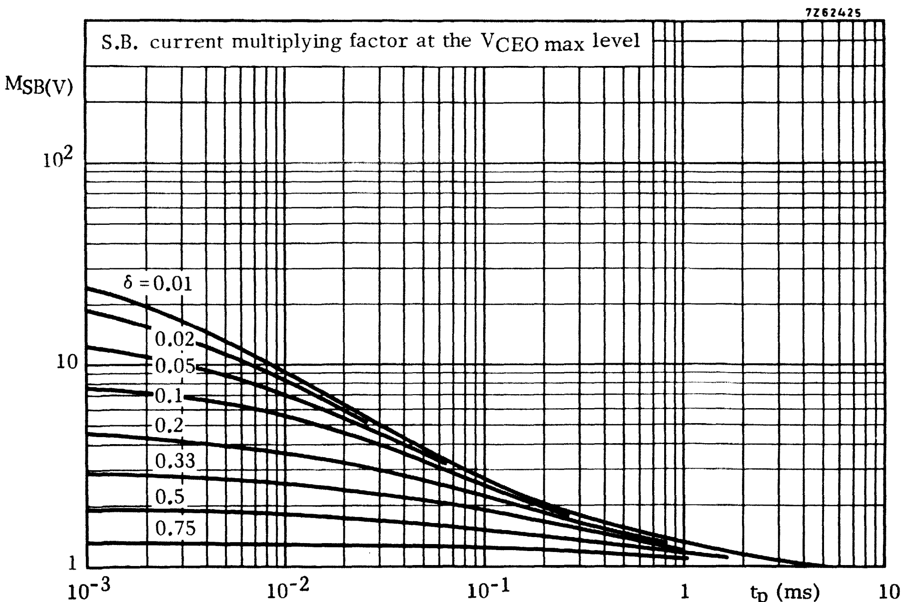

7Z62425
S.B. current multiplying factor at the $V_{CEO\,max}$ level
$M_{SB(V)}$
10^2
10
1
δ = 0.01
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

Fig. 17

4.3 Construction of the pulse SOAR of TR3 in this application

4.3.1

Plot the power curve obtained by multiplying the two curves of Fig. 12 and construct an equivalent rectangular power pulse with the same peak value and area as the original pulse. The result is given in Fig. 18.

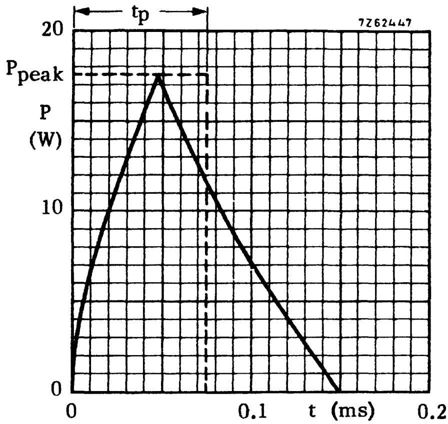


Fig. 18

4.3.2

Ascertain t_p, T, $\delta = t_p/T$ and P peak. The results are:

$t_p = 75\ \mu s$

$T = \frac{1}{750} = 1.33$ ms

$\delta = 0.056$

$P_{peak} = 17.5$ W

4.3.3

Refer to Fig. 14 and determine the derating factor for $P_{tot\ max}$ at 85 °C. The result is 0.6.

Refer to Fig. 15 and determine $M_p = \frac{R_{th\ j\text{-}mb}}{Z_{th\ j\text{-}mb}}$ for $t_p = 75\ \mu s$ and $\delta = 0.056$.

$R_{th\ j\text{-}mb} = 10\ ^oC/W$

$Z_{th\ j\text{-}mb} = 2.75\ ^oC/W$

$M_p = \frac{10}{2.75} = 3.64$

4.3.4

Refer to Fig. 16 and 17 and ascertain the M_{SB} factors for t_p = 75 µs and δ = 0.056. The results are:

$M_{SB(I)} = 3.6$

$M_{SB(V)} = 2.8$

4.3.5

Refer to Fig. 13 and construct the pulse extension of the d.c. SOAR for t_p = 75 µs and δ = 0.056 according to the following rules (see Fig. 19).

- Multiply the value of the voltage at point A by the derating factor obtained from Fig. 14 (0.6) and by M_p = 3.64 to obtain A'.
  V_A = 13 V

  V_A' = 13 V x 0.6 x 3.64 = 28.4 V
- Through point A' construct a line of constant power (45°)

  $P_{peak\ max}$ = 28.4 x $I_{C\ max}$ = 14.2 W.
- Multiply the value of V_{CE} at point C by $M_{SB(I)}$ = 3.6 (see 4.3.4), to obtain C'.
- Multiply the value of I_C at point D by $M_{SB(V)}$ = 2.8 (see 4.3.4), to obtain D'.
- Construct a new limit for second breakdown by drawing a line through point C' and D'.
- The SOAR for this particular case is formed by the $I_{CM\ max}$ line, the maximum peak dissipation line through A', the second breakdown limit line C'- D' and the V_{CEO} line.

4.3.6

Plot the I_C - V_{CE} excursion as found from Fig. 12a and b in Fig. 19 and check if every point of this excursion is inside the SOAR.
In this particular example the $P_{peak\ max}$ limit is exceeded, while the SB-limit is not exceeded. A solution for this case is to decrease the mounting base temperature, T_{mb}, by enlarging the heatsink.

4.3.7

The new permissible mounting base temperature, $T_{mb\ max}$, can be calculated as follows

$$T_{mb\ max} = T_{j\ max} - P_{peak} \cdot Z_{th\ j\text{-}mb}$$

P_{peak} = 17.5 W (see 4.3.2)

$Z_{th\ j\text{-}mb}$ = 2.75 °C/W

Therefore:

$$T_{mb\ max} = 125 - 17.5 \times 2.75 = 77\ ^{o}C$$

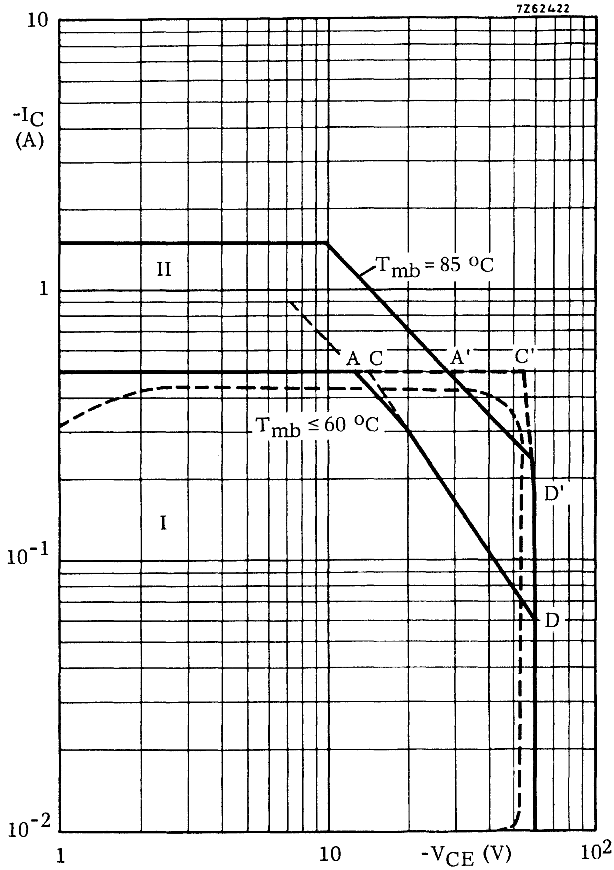


Fig. 19

I Region of permissible operation up to T_{mb} = 60 ^{o}C

II Permissible extension for t_p = 75 μs, δ = 0.056 and T_{mb} = 85 ^{o}C

4.3.8

For calculation of the heatsink the power may be averaged provided the period T does not exceed the thermal time constant of the transistor.

Then $T_{mb} - T_{amb} = \delta . P_{peak} . R_{th\ mb\text{-}a}$.

If $T_{mb\ max}$ and P_{peak} are known, the max. allowable $R_{th\ mb\text{-}a}$ may be calculated with

$$R_{th\ mb\text{-}a\ max} = \frac{T_{mb\ max} - T_{amb}}{\delta\ .\ P_{peak}}$$

In our example $R_{th\ mb\text{-}a\ max} = \frac{77 - 25}{0.056 \times 17.5} = 53\ ^{o}C/W$

Low frequency transistors

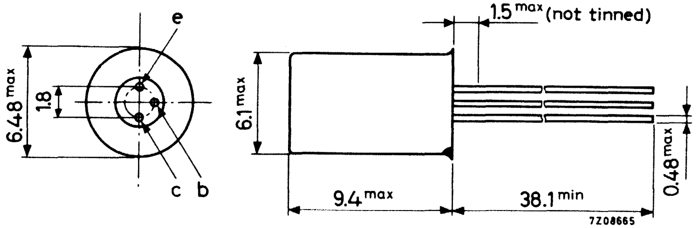
GERMANIUM ALLOY TRANSISTOR

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}	> typ.	50 100	
Small signal current gain at T_{amb} = 25 °C				
I_E = 2 mA; $-V_{CB}$ = 5 V; f = 1 kHz	h_{fe}	typ. 80 to	125 170	
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 $R_{BE} < 1$ kΩ	$-V_{CER}$	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

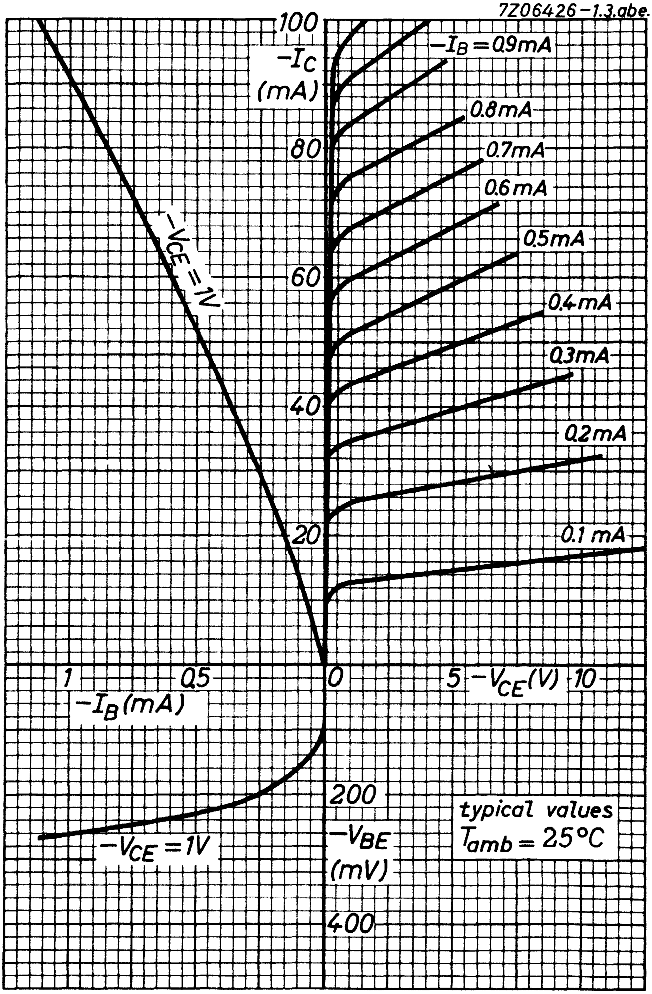
Collector cut-off current				
$I_E = 0$; $-V_{CB} = 10$ V	$-I_{CBO}$	<	10	μA
$I_E = 0$; $-V_{CB} = 32$ V; $T_j = 75$ °C	$-I_{CBO}$	<	800	μA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 5$ V; $T_j = 75$ °C	$-I_{EBO}$	<	550	μA
Emitter-base voltage				
$I_E = 2$ mA; $-V_{CB} = 5$ V	V_{EB}	typ.	105	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

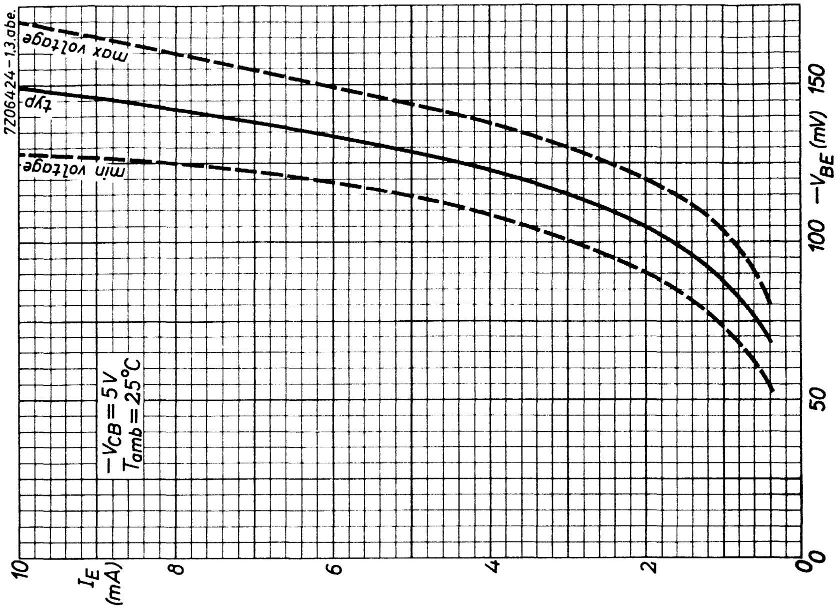
CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

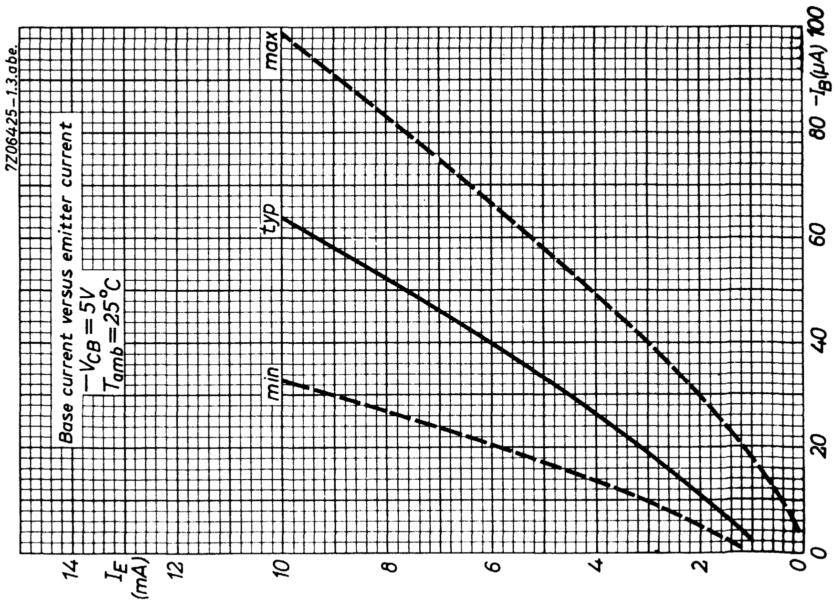
h parameters at f = 1 kHz

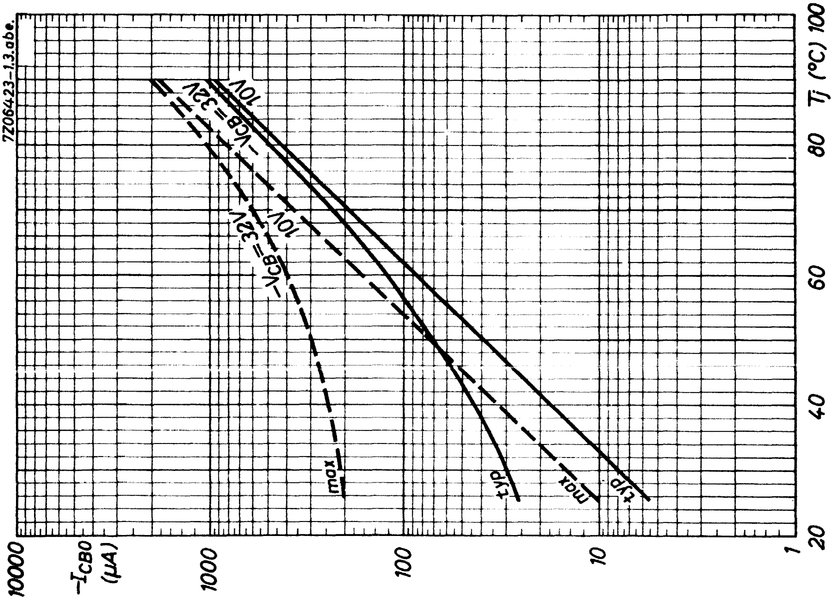
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V

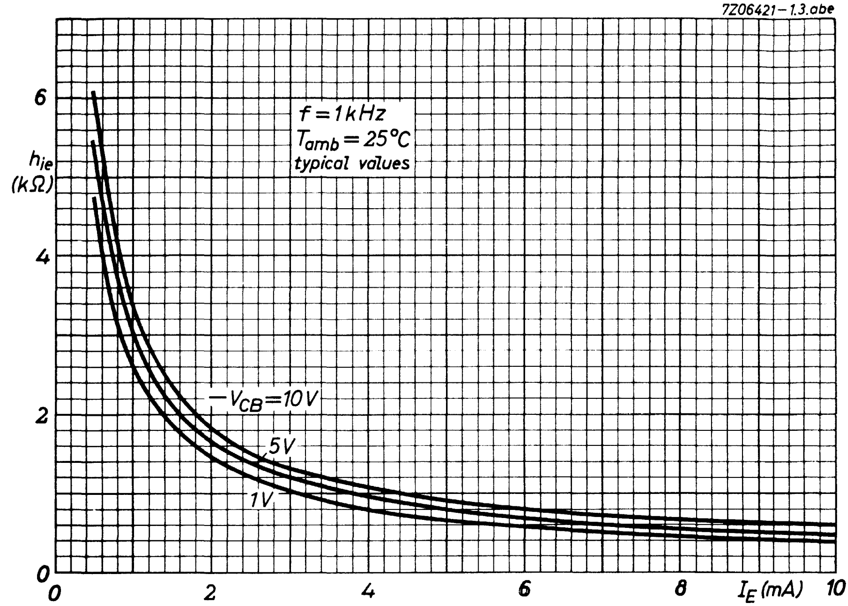
Input impedance	h_{ie}	typ. 1.7 1.1 to 2.5	kΩ kΩ
Reverse voltage transfer	h_{re}	typ. 6.5 < 8.5	10^{-4} 10^{-4}
Small signal current gain	h_{fe}	typ. 125 80 to 170	
Output admittance	h_{oe}	typ. 80 < 110	$\mu\Omega^{-1}$ $\mu\Omega^{-1}$

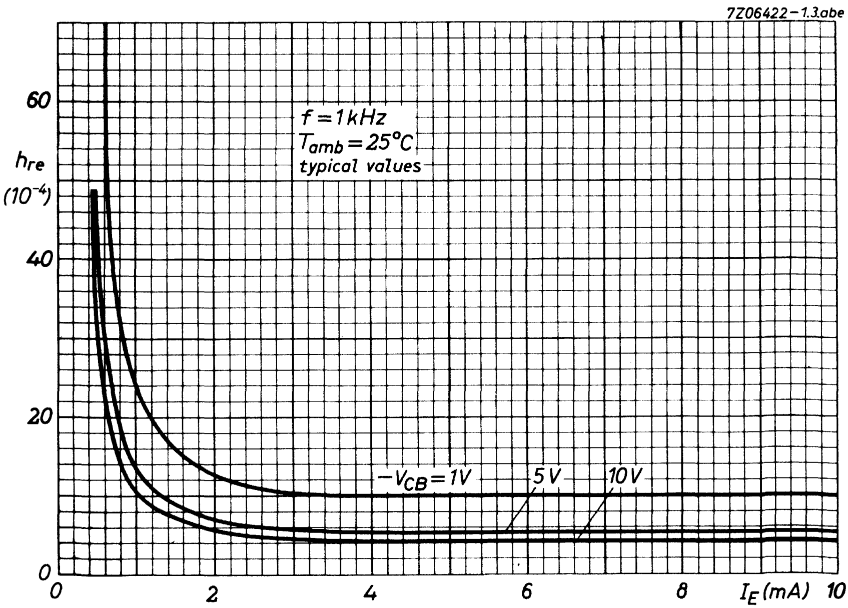

7Z06426-1.3.abe.
100
$-I_C$
(mA)
80
60
40
20
$-I_B$ = 0.9mA
0.8mA
0.7mA
0.6mA
0.5mA
0.4mA
0.3mA
0.2mA
0.1 mA
$-V_{CE}$ = 1V
1
0.5
0
5
$-V_{CE}$(V)
10
$-I_B$(mA)
200
$-V_{BE}$
(mV)
400
$-V_{CE}$ = 1V
typical values
T_{amb} = 25°C

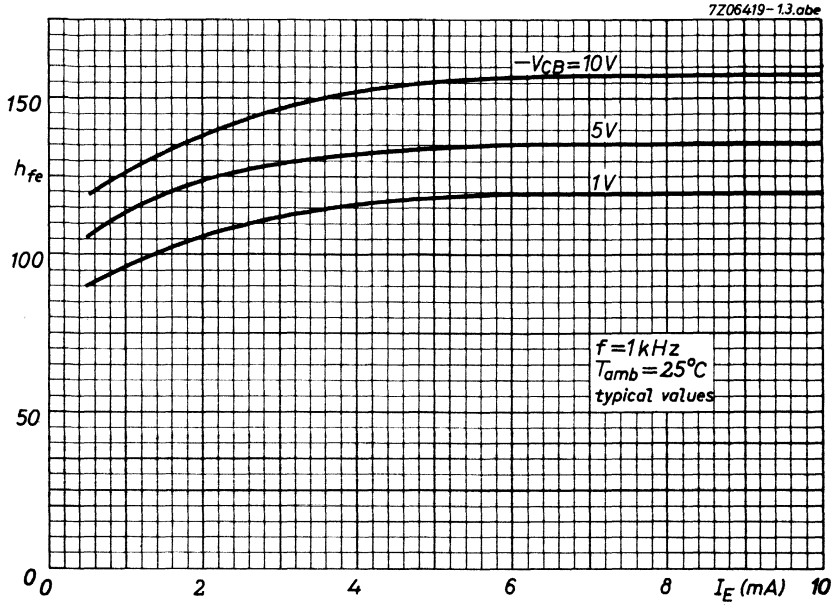

7Z06424-1.3.abe.
max voltage
typ
min voltage
$-V_{CB} = 5\,V$
$T_{amb} = 25\,°C$
I_E (mA)
10
8
6
4
2
0
0
50
100
150
$-V_{BE}$ (mV)

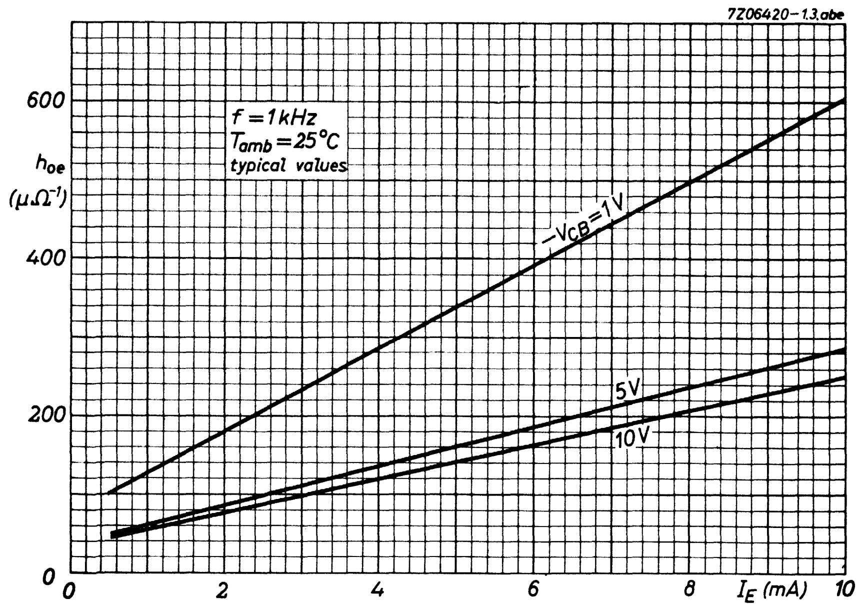

7Z06425-1.3.abe.
Base current versus emitter current
$-V_{CB} = 5\,V$
$T_{amb} = 25\,°C$
max
typ
min
14
I_E (mA)
12
10
8
6
4
2
0
0
20
40
60
80
100
$-I_B$ (µA)

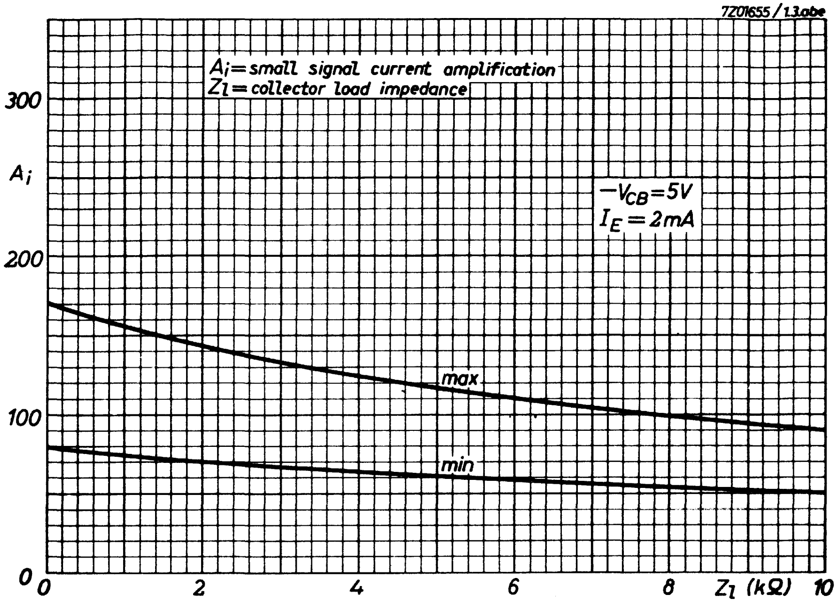

7Z06423-1.3.abe.
$-I_{CBO}$ (μA)
10000
1000
100
10
1
T_j (°C)
20
40
60
80
100
$-V_{CB}$ = 32V
10V
$-V_{CB}$ = 32V
10V
max
typ
max
typ

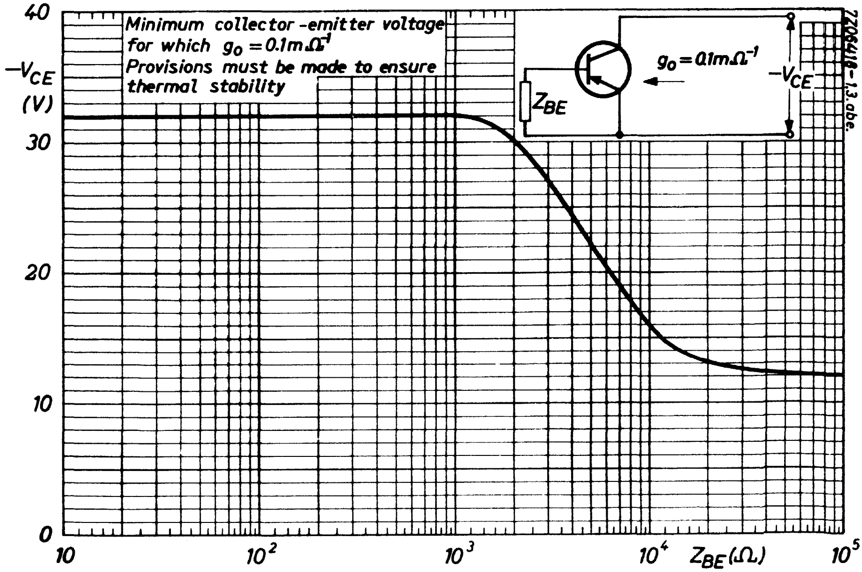

7Z06421-1.3.abe
f = 1 kHz
T_{amb} = 25°C
typical values
h_{ie}
(kΩ)
$-V_{CB}$=10V
5V
1V
0
2
4
6
0
2
4
6
8
I_E (mA)
10


7Z06422-1.3.abe
f = 1 kHz
T_{amb} = 25°C
typical values
h_{re}
(10^{-4})
$-V_{CB}$=1V
5V
10V
0
20
40
60
0
2
4
6
8
I_E (mA)
10


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


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


7Z01655/1.3.abe
A_i = small signal current amplification
Z_l = collector load impedance
300
A_i
200
100
0
$-V_{CB}$ = 5V
I_E = 2mA
max
min
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
40
$-V_{CE}$
(V)
30
20
10
0
Z_{BE}
$g_o = 0.1 m\Omega^{-1}$
$-V_{CE}$
10
10^2
10^3
10^4
Z_{BE} (Ω)
10^5

GERMANIUM ALLOY TRANSISTOR

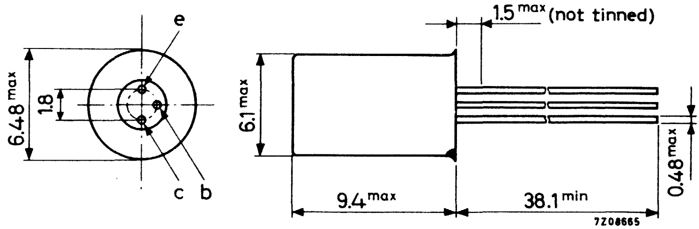
P-N-P transistor in a TO-1 metal envelope intended for use in pre-amplifier or driver stages.

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 $R_{BE} < 1$ kΩ	$-V_{CER}$	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

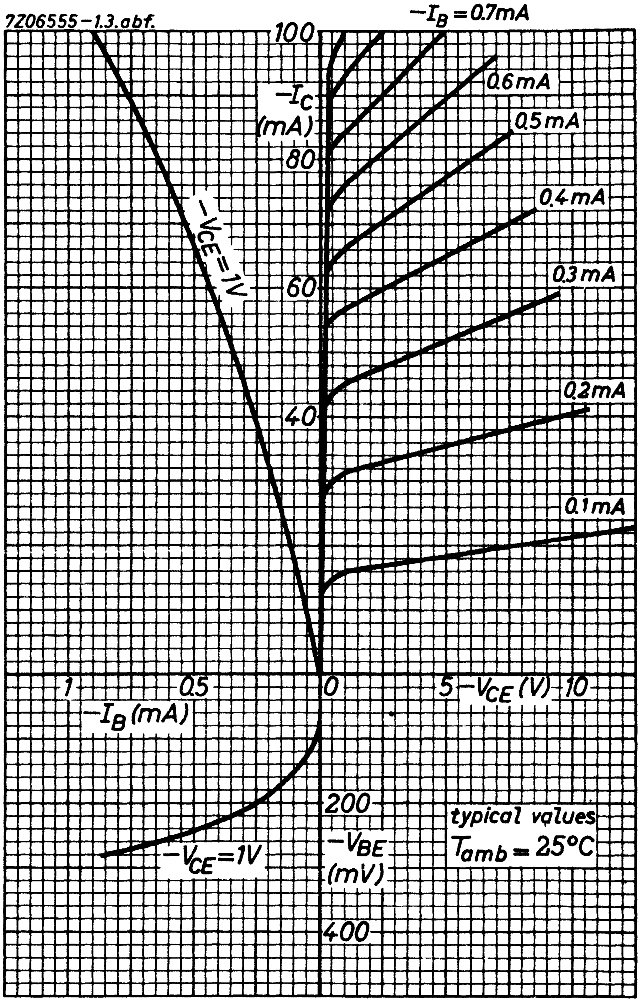
Collector cut-off current				
$I_E = 0$; $-V_{CB} = 10$ V	$-I_{CBO}$	<	10	μA
$I_E = 0$; $-V_{CB} = 32$ V; $T_j = 75$ °C	$-I_{CBO}$	<	800	μA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 5$ V; $T_j = 75$ °C	$-I_{EBO}$	<	550	μA
Emitter-base voltage				
$I_E = 2$ mA; $-V_{CB} = 5$ V	V_{EB}	typ.	105	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}	> 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	$\|z_{rb}\|$	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; $R_S = 500$ Ω Bandwidth = 200 Hz	F	typ. <	4 10	dB dB

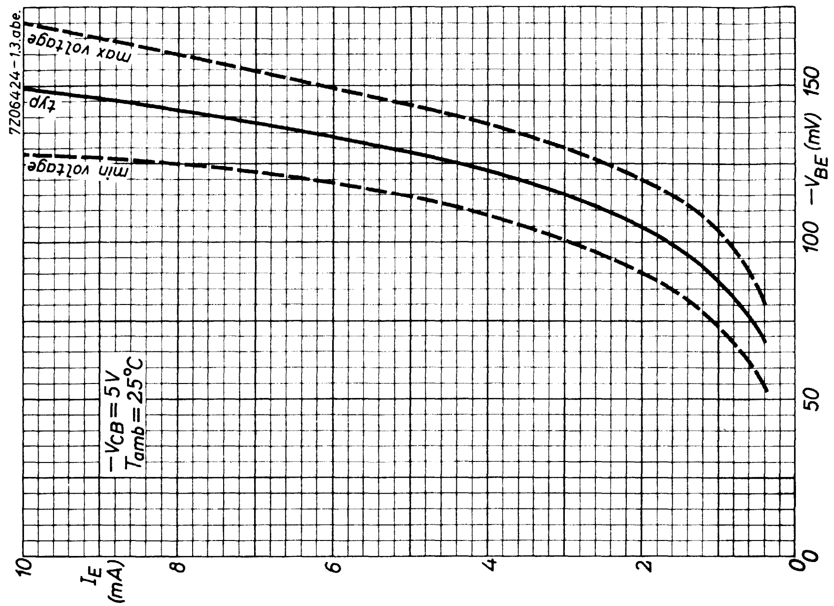
CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

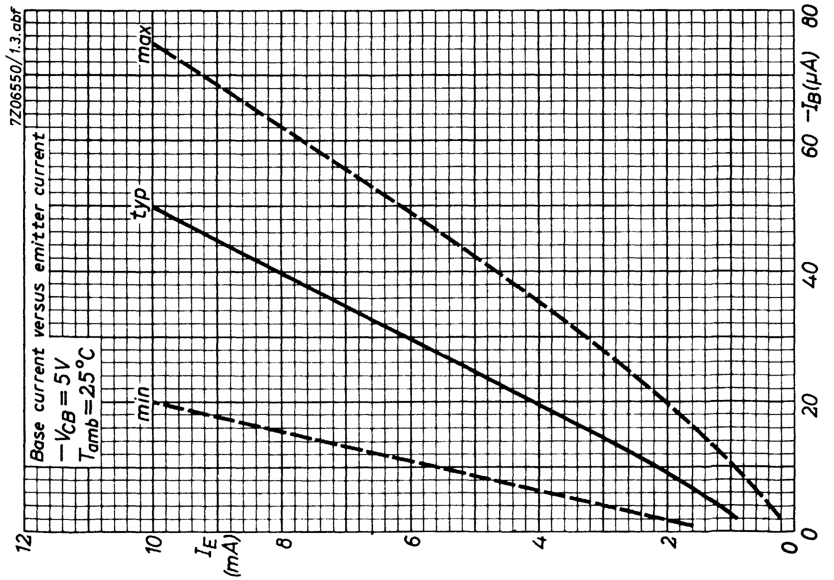
h parameters at f = 1 kHz

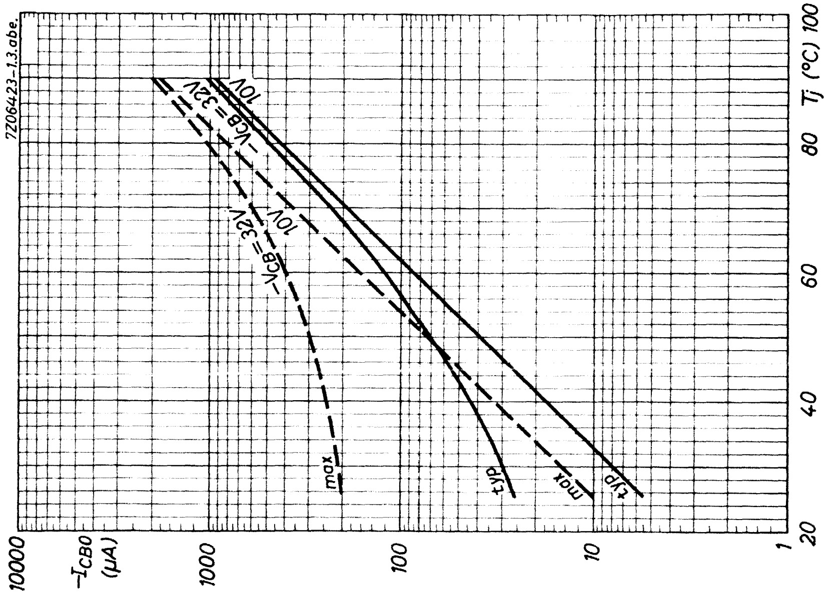
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V

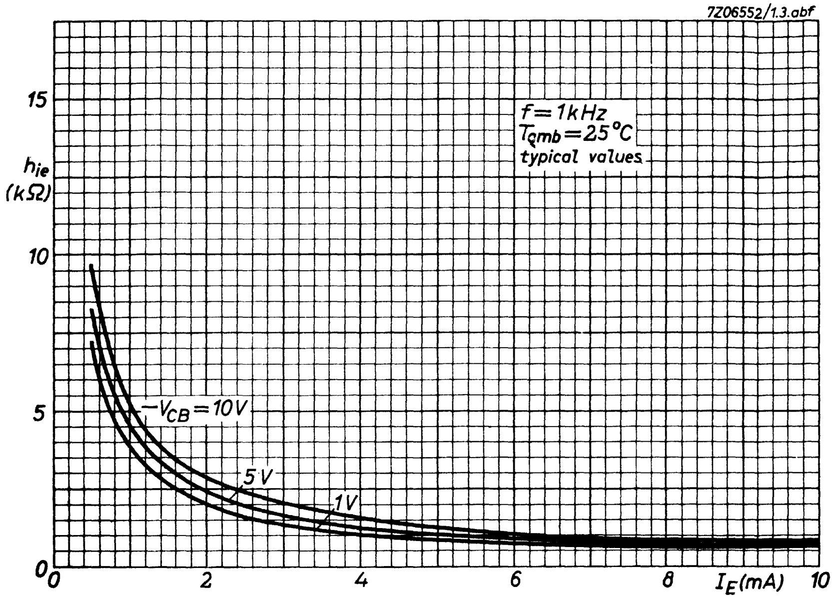
Input impedance	h_{ie}	typ.	2.4	kΩ
		1.7 to 3.8		kΩ
Reverse voltage transfer	h_{re}	typ.	8.0	10^{-4}
		<	13.0	10^{-4}
Small signal current gain	h_{fe}	typ.	180	
		130 to 300		
Output admittance	h_{oe}	typ.	100	$\mu\Omega^{-1}$
		<	170	$\mu\Omega^{-1}$

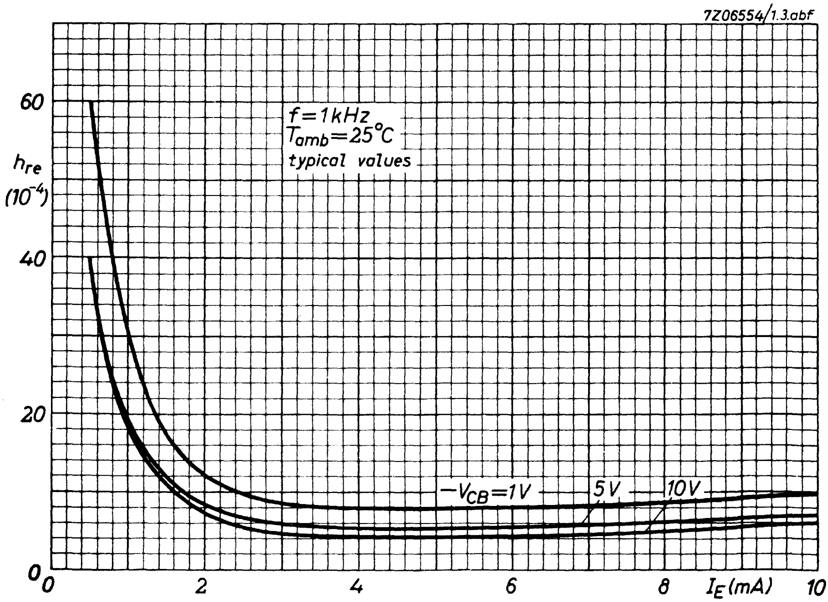

7Z06555-1.3.abf.
100
80
60
40
$-I_C$ (mA)
$-I_B = 0.7mA$
0.6 mA
0.5 mA
0.4 mA
0.3 mA
0.2 mA
0.1 mA
$-V_{CE}=1V$
1
0.5
0
5
10
$-V_{CE}$ (V)
$-I_B$ (mA)
200
400
$-V_{BE}$ (mV)
$-V_{CE}=1V$
typical values
$T_{amb} = 25°C$


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

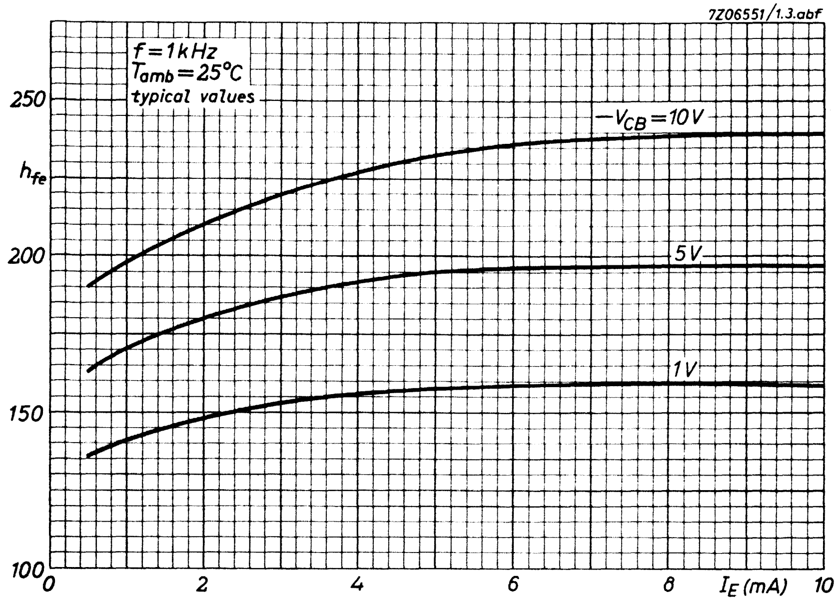

7Z06550/1.3.abf
Base current versus emitter current
$-V_{CB} = 5 V$
$T_{amb} = 25 °C$
max
typ
min
I_E (mA)
12
10
8
6
4
2
0
0
20
40
60
80
$-I_B$ (μA)


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

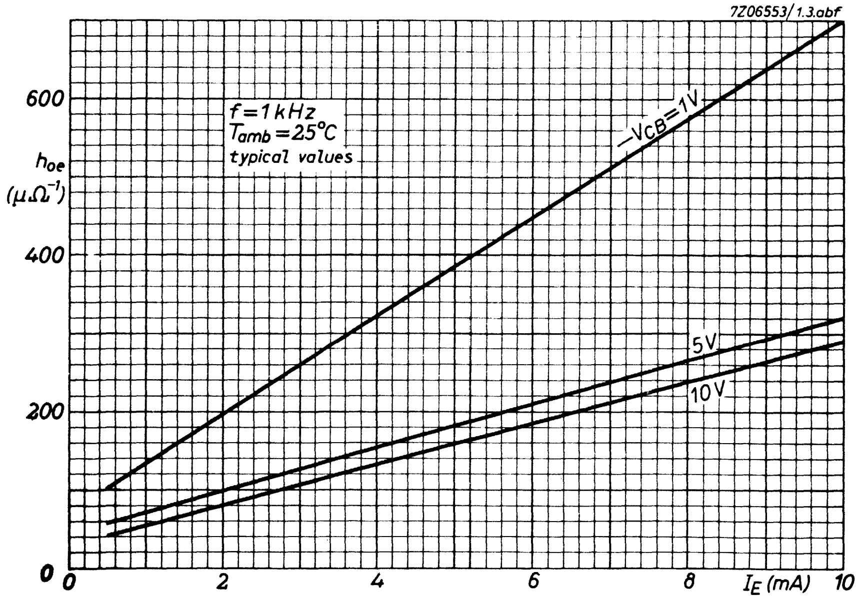

7Z06552/1.3.abf
f = 1kHz
Tamb = 25°C
typical values
hie
(kΩ)
15
10
5
0
−VCB = 10V
5V
1V
0
2
4
6
8
IE(mA)
10

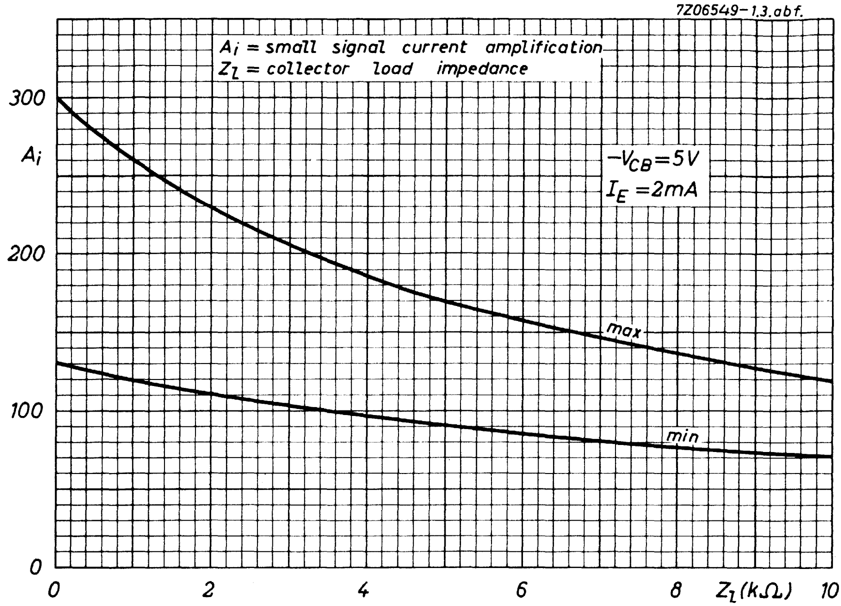

7Z06554/1.3.abf
f = 1kHz
Tamb = 25°C
typical values
hre
(10⁻⁴)
60
40
20
0
−VCB = 1V
5V
10V
0
2
4
6
8
IE(mA)
10

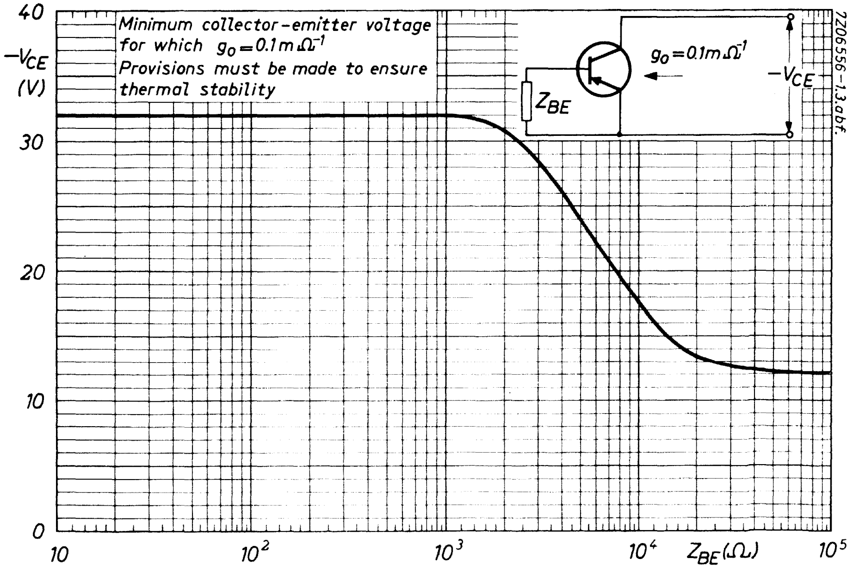
7Z06551/1.3.abf



7Z06553/1.3.abf




7Z06549-1.3.abf.
A_i = small signal current amplification
Z_l = collector load impedance
$-V_{CB}=5V$
$I_E=2mA$
300
A_i
200
100
0
max
min
0
2
4
6
8
Z_l (kΩ)
10


Minimum collector-emitter voltage for which $g_o=0.1m\Omega^{-1}$
Provisions must be made to ensure thermal stability
$g_o=0.1m\Omega^{-1}$
Z_{BE}
$-V_{CE}$
7Z06556-1.3.abf.
40
$-V_{CE}$ (V)
30
20
10
0
10
10^2
10^3
10^4
Z_{BE} (Ω)
10^5

GERMANIUM ALLOY TRANSISTORS

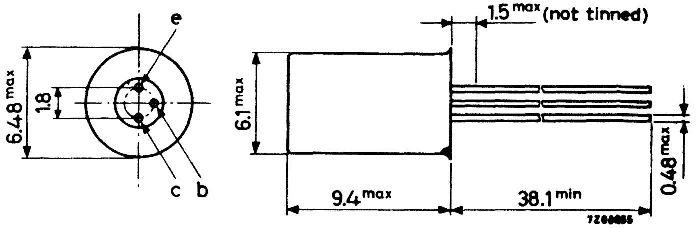
The AC127 is an n-p-n audio transistor in a TO-1 metal envelope.
The AC127 is intended for use together with the p-n-p transistors AC128 or AC132 as matched pair in class B output stages with complementary symmetry or in driver stages.
The AC127/01 is electrically equivalent to the AC127, constructed 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

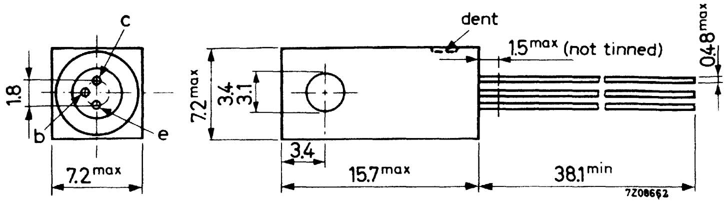


The coloured dot indicates the collector

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

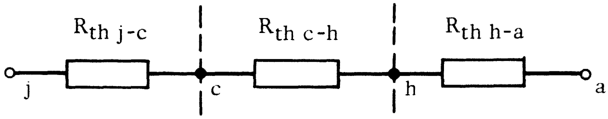
Temperatures

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	°C/W
with cooling clip 56227 on 1.5 mm blackened Al. heatsink of 12.5 cm^2	$R_{th\ j\text{-}a}$	= 160	150	°C/W
with cooling clip 56227 on infinite heatsink	$R_{th\ j\text{-}a}$	= 125		°C/W
From junction to case	$R_{th\ j\text{-}c}$	= 110	115	°C/W



	$R_{th\ j\text{-}c}$	$R_{th\ c\text{-}h}$	$R_{th\ h\text{-}a}$	
AC127 with clip 56227	110	15		°C/W
AC127/01	115	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}	<	15	μA
$I_E = 0$; $V_{CB} =$ 32 V; $T_j = 75$ °C	I_{CBO}	<	1100	μA

Emitter cut-off current

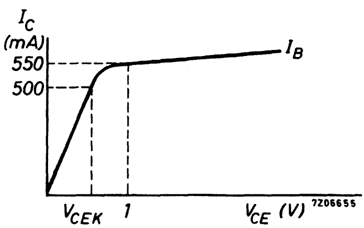
$I_C = 0$; $V_{EB} = 5$ V; $T_j = 75$ °C	I_{EBO}	<	550	μA

Emitter-base voltage

$-I_E =$ 2 mA; $V_{CB} = 5$ V	$-V_{EB}$	typ.	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

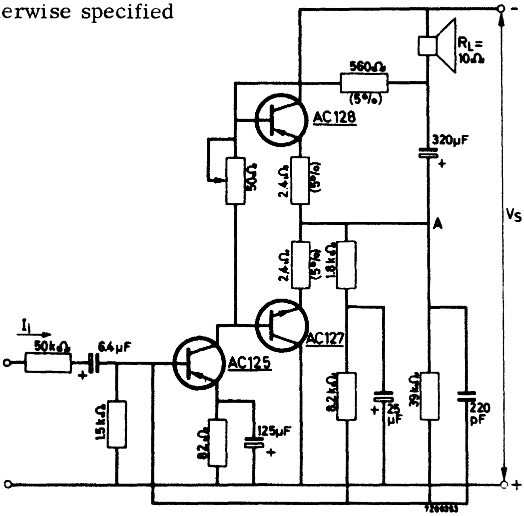
matched pair AC127/AC132

$\|I_C\|$ = 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.

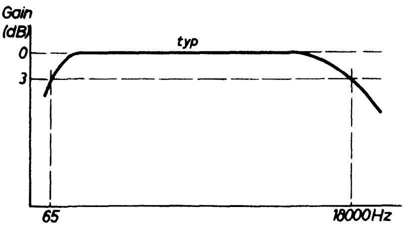
Tolerance of resistors:
10% unless otherwise specified



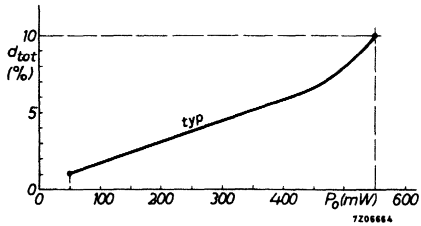
Stable continuous operation is ensured up to an ambient temperature of 45 °C, provided each transistor is mounted with a cooling fin type No. 56226.

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

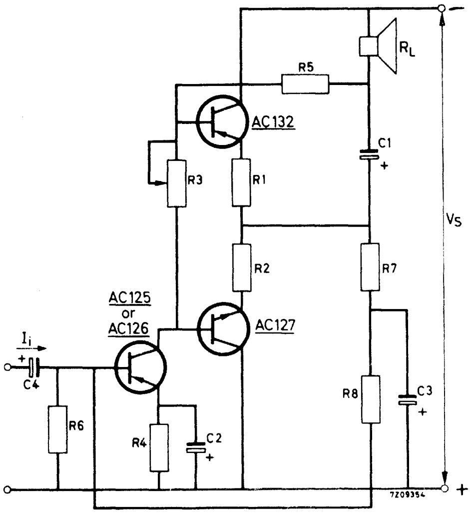
Driver stage

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

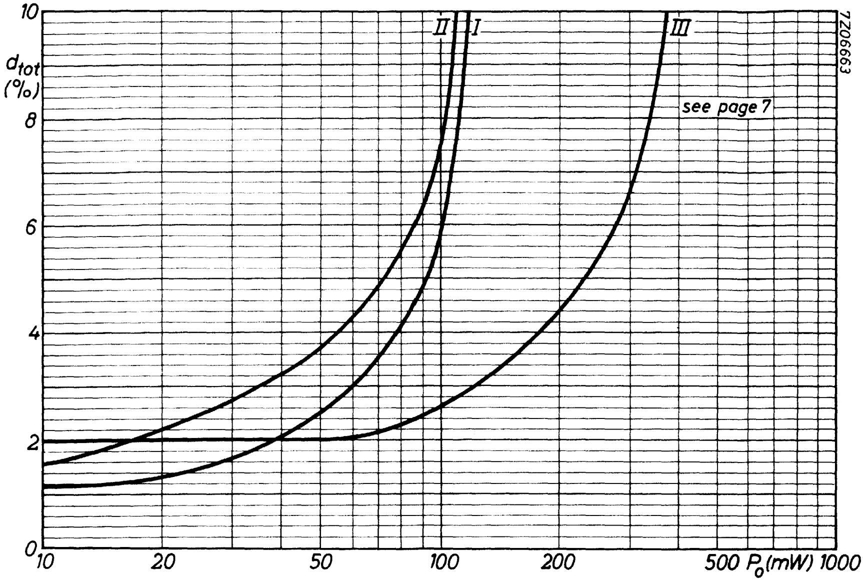
2. AC127/AC132 as matched pair in a class B amplifier with complementary symmetry delivering an output power of 370 mW.

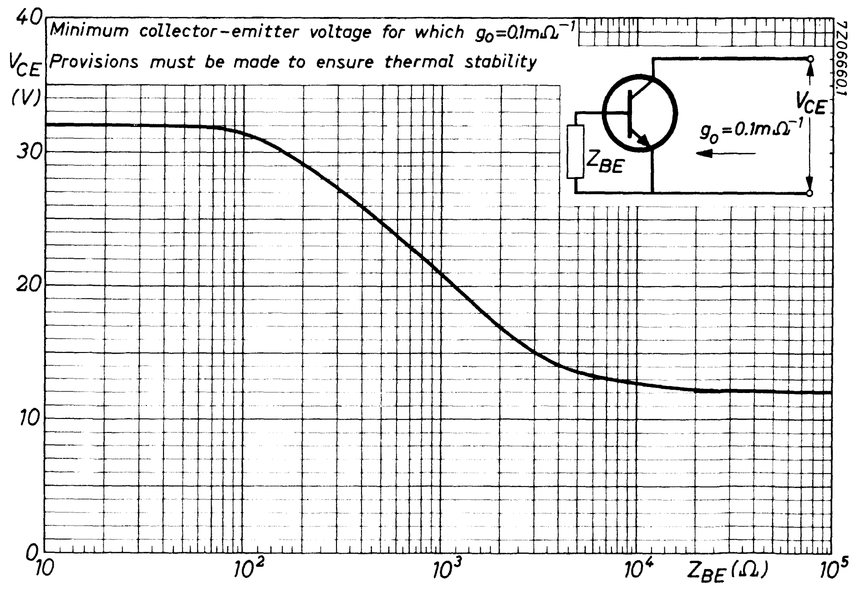


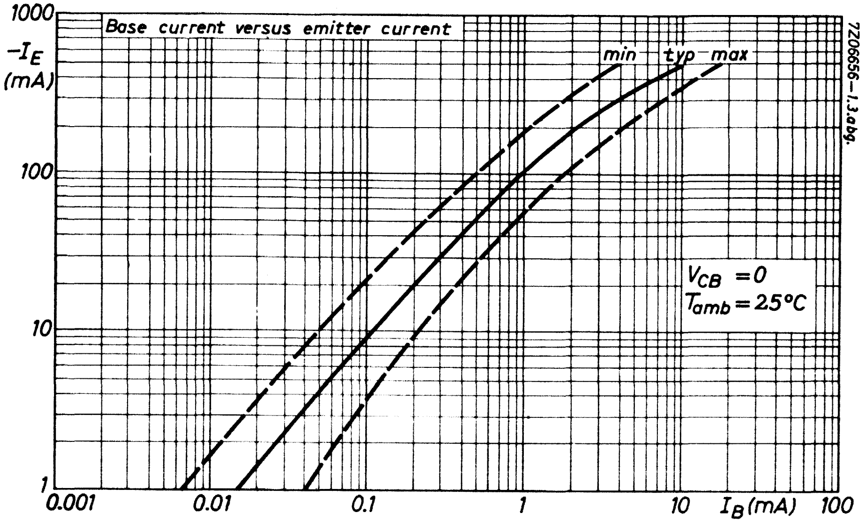
Stable continuous operation is ensured up to an ambient temperature of 45 °C, provided each transistor is mounted with a cooling fin.

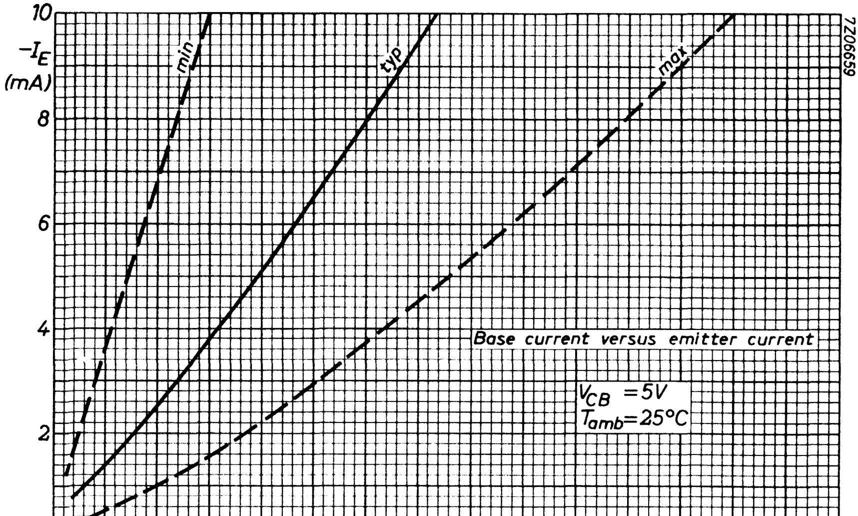
APPLICATION INFORMATION (continued)

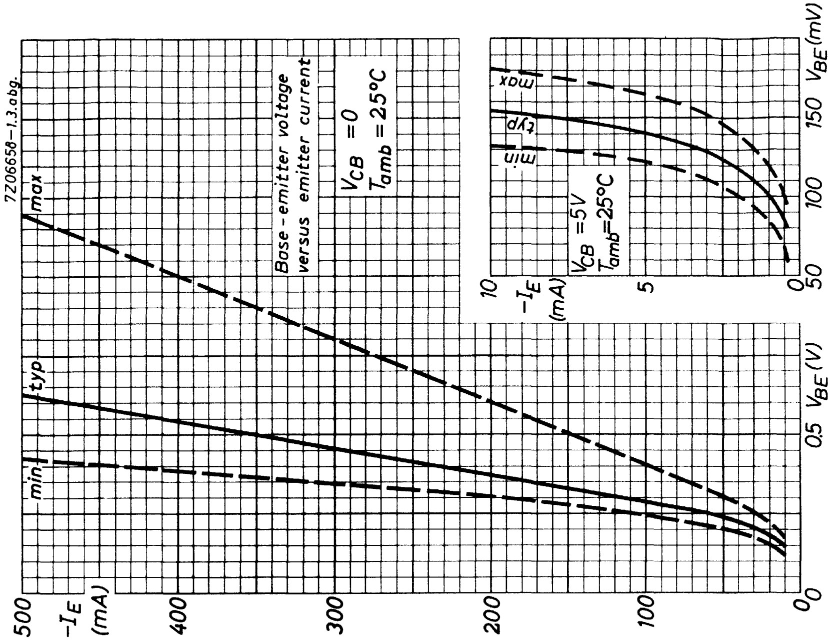
			I	II	III	
Supply voltage	V_S	=	6	9	9	V
Output power (at d = 10%)	P_o	typ.	115	110	370	mW
		>	105	100	300	mW
Distortion	d_{tot}	See page 8				
Output stage						
Emitter current (zero signal)	I_{E1}	=	2	2	2	mA
	$-I_{E2}$	=	2	2	2	mA
Emitter resistors	R1	=	3.3	4.7	3.9	Ω
	R2	=	3.3	4.7	3.9	Ω
Bias resistor	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.	$\lvert I_{CM}\rvert$	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	%

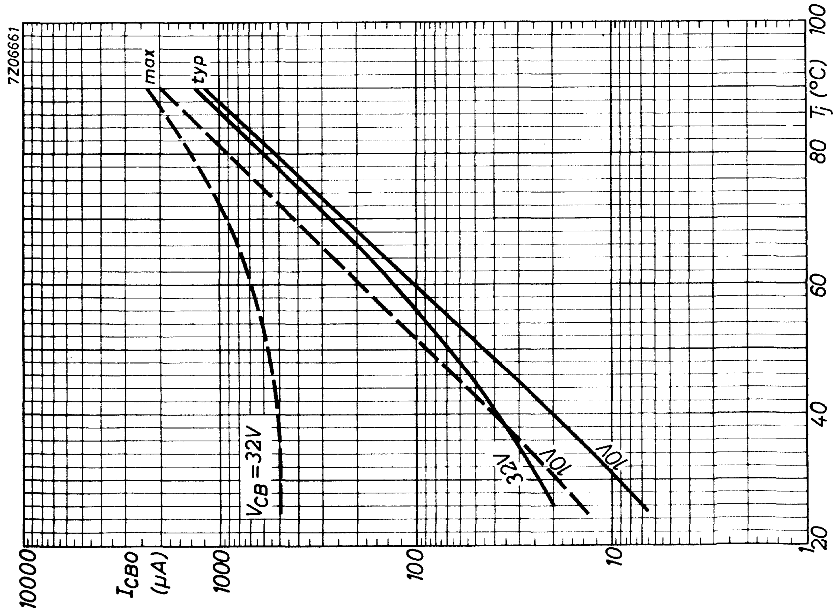

7Z06663
d_{tot} (%)
10
8
6
4
2
0
II
I
III
see page 7
10
20
50
100
200
500 P_o(mW) 1000


7Z06601
Minimum collector-emitter voltage for which $g_o = 0.1 m\Omega^{-1}$
Provisions must be made to ensure thermal stability
V_{CE} (V)
40
30
20
10
0
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
1000
$-I_E$
(mA)
100
10
1
0.001
0.01
0.1
1
10
I_B(mA)
100
min
typ
max
V_{CB} = 0
T_{amb} = 25°C
7Z06656-1.3.abg.


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


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
0.5
V_{BE} (V)
V_{CB} = 5V
T_{amb} = 25°C
10
5
0
50
100
150
V_{BE} (mV)


7Z06661
max
typ
V_{CB} = 32V
32V
10V
10V
I_{CBO} (µA)
10000
1000
100
10
1
20
40
60
80
100
T_j (°C)

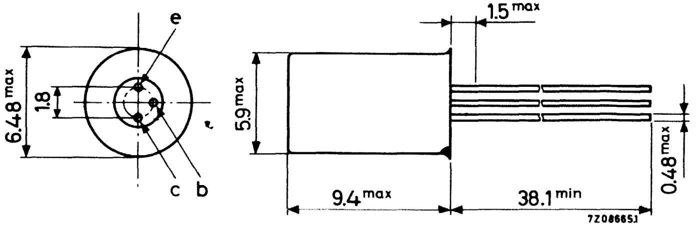
GERMANIUM ALLOY TRANSISTORS

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

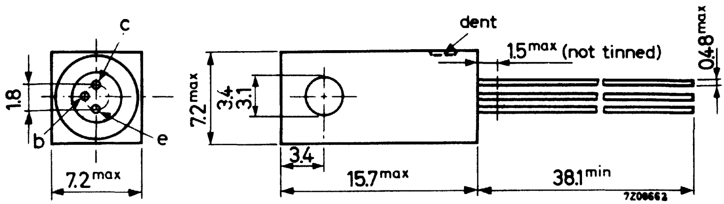


The coloured dot indicates the collector

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

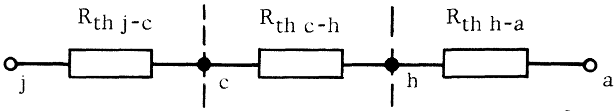
Total power dissipation up to T_{amb} = 20 °C with cooling fin 56227 on a 1.5 mm blackened Al. heatsink of at least 12.5 cm^2	P_{tot}	max.	1000	mW

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air		AC128	AC128/01	
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 blackened Al. 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



	$R_{th\ j\text{-}c}$	$R_{th\ c\text{-}h}$	$R_{th\ h\text{-}a}$	
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

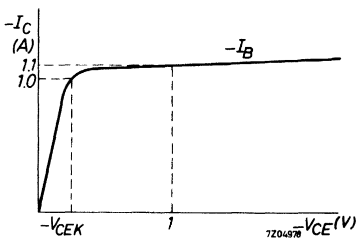
$I_C = 0$; $-V_{EB} = 10$ V	$-I_{EBO}$	<	200	µA
$I_C = 0$; $-V_{EB} = 5$ V; $T_j = 75$ °C	$-I_{EBO}$	<	500	µA

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



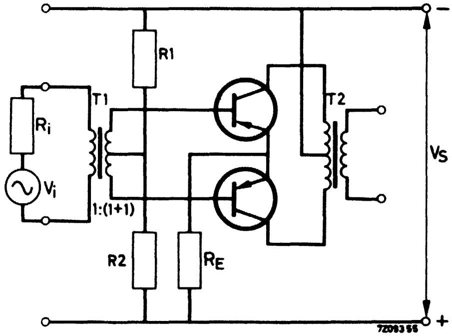
CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

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] $\lambda_{500} = \frac{A_i \text{ at 500 mA}}{A_{i\,max}}$, 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	%

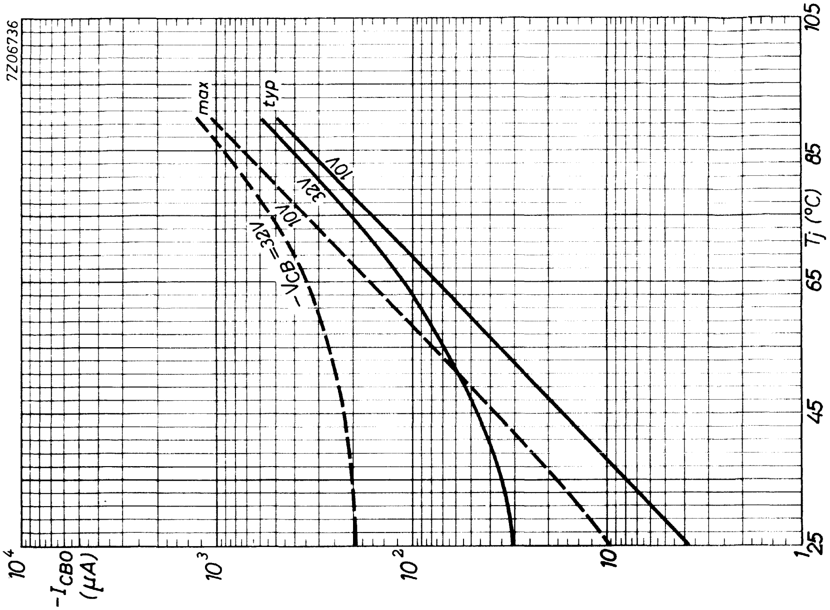
[1]) Tolerance of bias resistors: 5 %

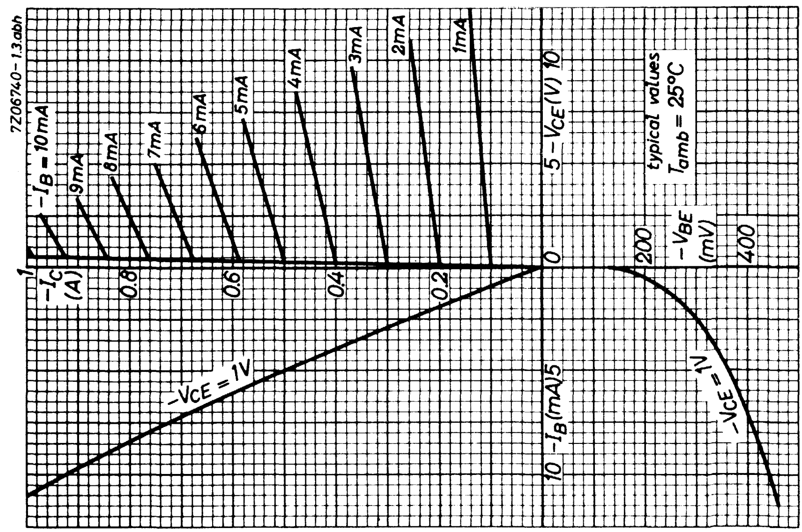
[2]) Variable resistor

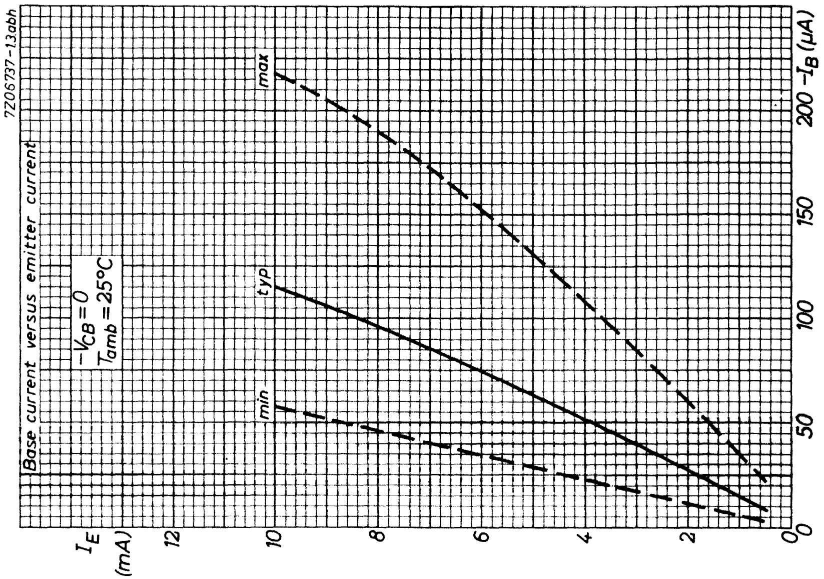
[3]) This resistance is composed of a 68 Ω resistor in parallel with a 130Ω NTC resistor. Code number 2322 610 12131.

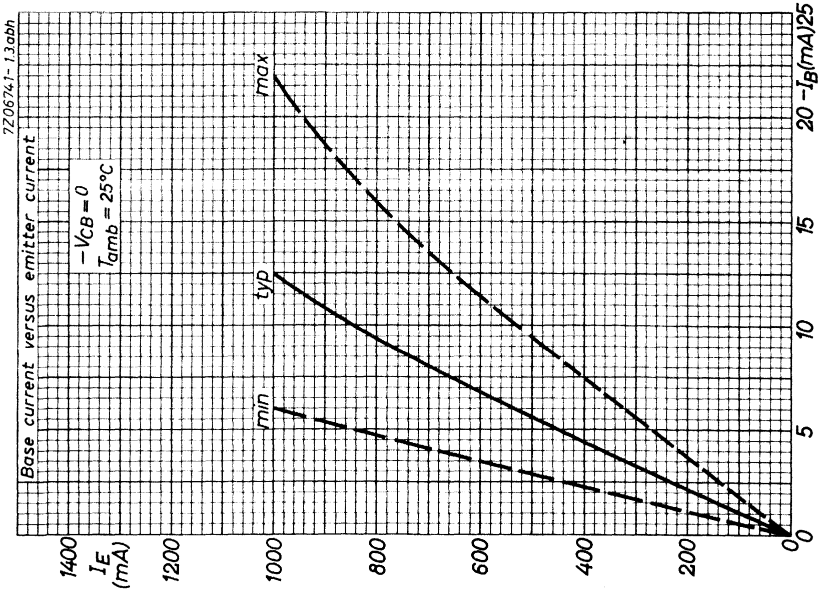
[4]) Mounted on cooling fin 56227 at T_{amb} up to 20 °C.

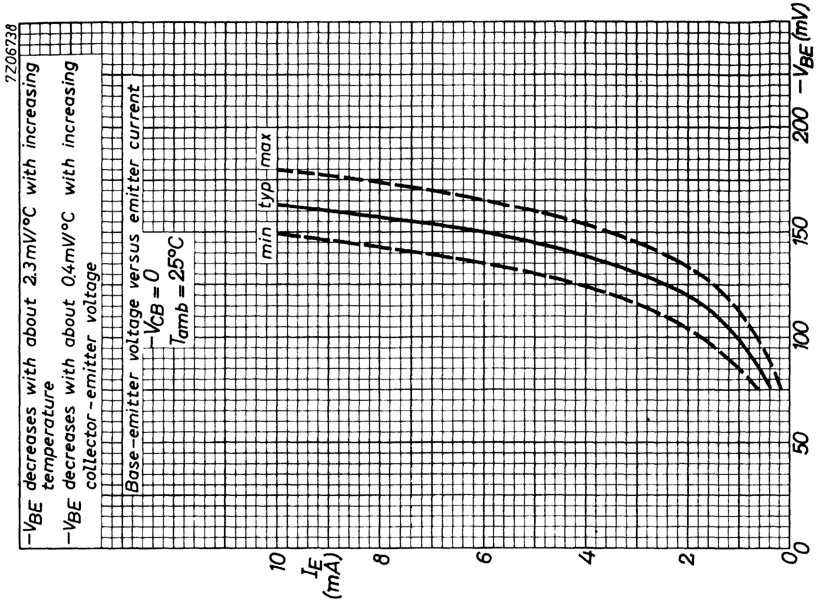
[5]) Losses in the driver transformer are not taken into account.

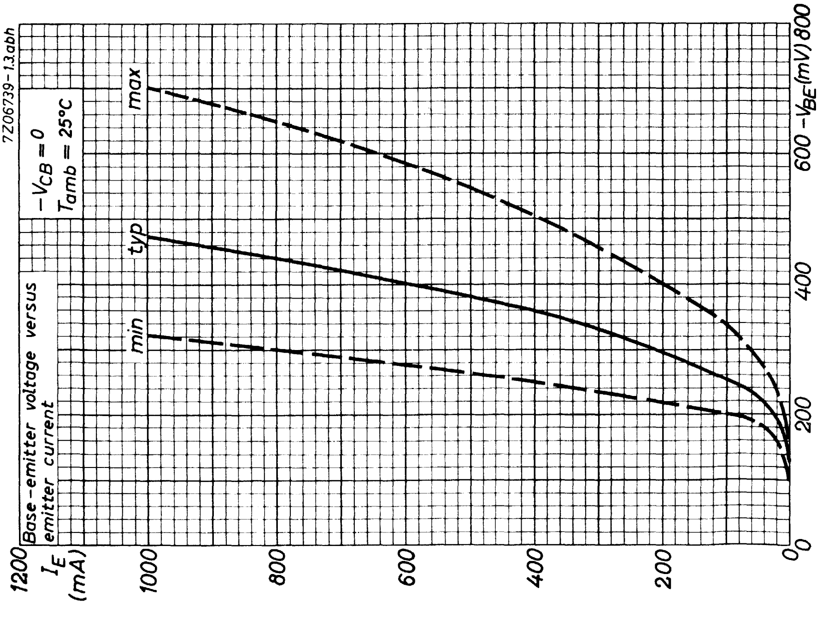

7Z06736
max
typ
10V
32V
$-V_{CB} = 32V$
10V
10^4
10^3
10^2
10
1
$-I_{CBO}$ (μA)
25
45
65
85
105
T_j (°C)

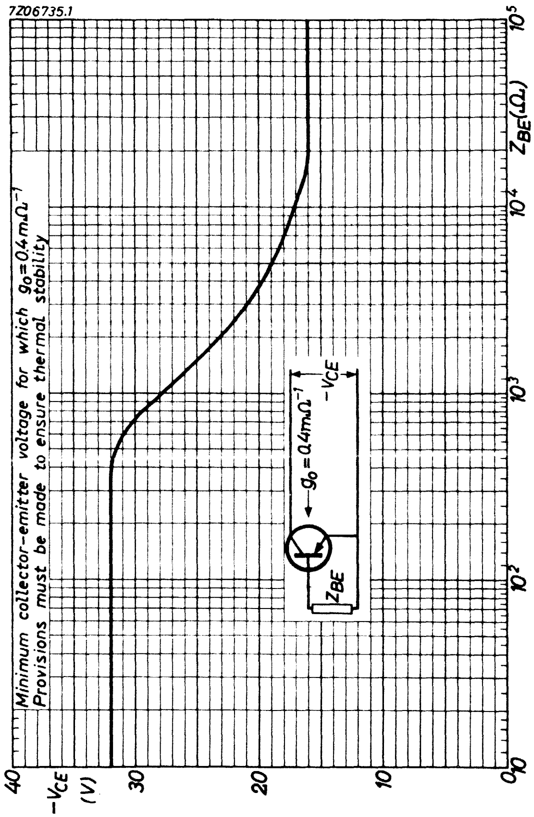

7Z06740–1.3.abh
$-I_B = 10mA$
9mA
8mA
7mA
6mA
5mA
4mA
3mA
2mA
1mA
$-I_C$ (A)
1
0.8
0.6
0.4
0.2
0
5
10
$-V_{CE}$ (V)
typical values
$T_{amb} = 25°C$
$-V_{BE}$ (mV)
200
400
$-V_{CE} = 1V$
$-V_{CE} = 1V$
$-I_B$ (mA)
5
10

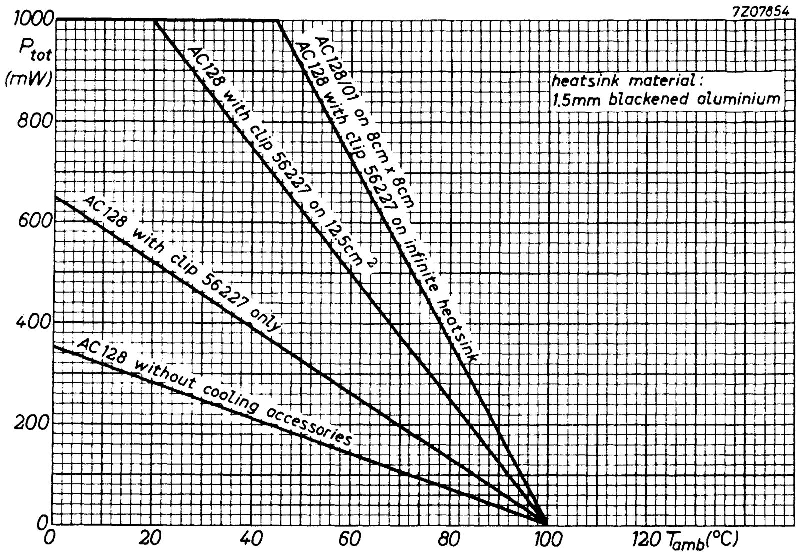

7Z06737-1.3abh
Base current versus emitter current
−V_CB = 0
T_amb = 25°C
max
typ
min
I_E (mA)
12
10
8
6
4
2
0
0
50
100
150
200 −I_B (μA)

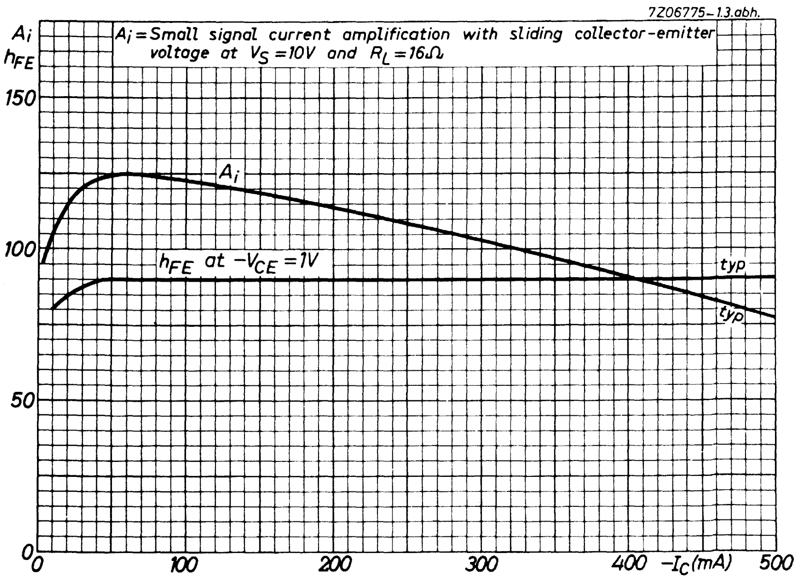

7Z06741-1.3abh
Base current versus emitter current
−V_CB = 0
T_amb = 25°C
max
typ
min
1400
I_E (mA)
1200
1000
800
600
400
200
0
0
5
10
15
20 −I_B(mA) 25


7Z06738
$-V_{BE}$ decreases with about 2.3mV/°C with increasing temperature
$-V_{BE}$ decreases with about 0.4mV/°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)


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


7Z06735.1
Minimum collector-emitter voltage for which $g_o = 0.4 m\Omega^{-1}$
Provisions must be made to ensure thermal stability
$g_o = 0.4 m\Omega^{-1}$
$-V_{CE}$
Z_{BE}
$-V_{CE}$ (V)
40
30
20
10
0
10
10^2
10^3
10^4
10^5
Z_{BE} (Ω)


7Z07854
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
500
$-I_C$(mA)
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

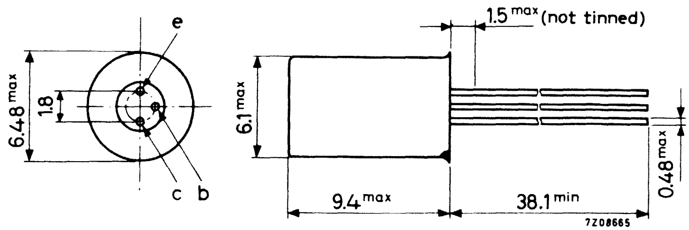
GERMANIUM ALLOY TRANSISTORS

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

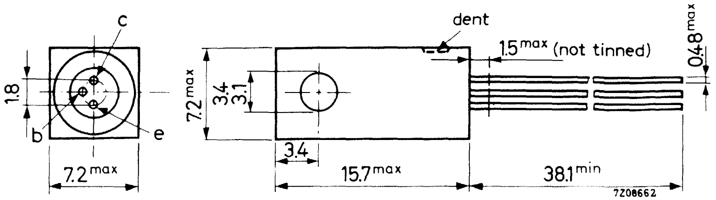


The coloured dot indicates the collector

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

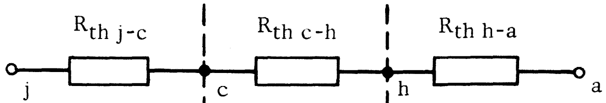
Temperatures

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

		AC132	AC132/01	
From junction to ambient in free air				
without cooling clip	$R_{th\ j\text{-}a}$ =	300	190	°C/W
with cooling clip 56227 on 1.5 mm blackened Al. heatsink of 12.5 cm^2	$R_{th\ j\text{-}a}$ =	90	80.5	°C/W
with cooling clip 56227 on infinite heatsink	$R_{th\ j\text{-}a}$ =	65		°C/W
From junction to case	$R_{th\ j\text{-}c}$ =	50	55	°C/W



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

CHARACTERISTICS

T_{amb} = 25 °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; $T_j = 75$ °C	$-I_{CBO}$	<	800	μA

Emitter cut-off current

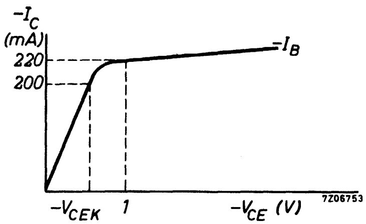
$I_C = 0$; $-V_{EB} = 5$ V; $T_j = 75$ °C	$-I_{EBO}$	<	550	μA

Emitter-base voltage

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

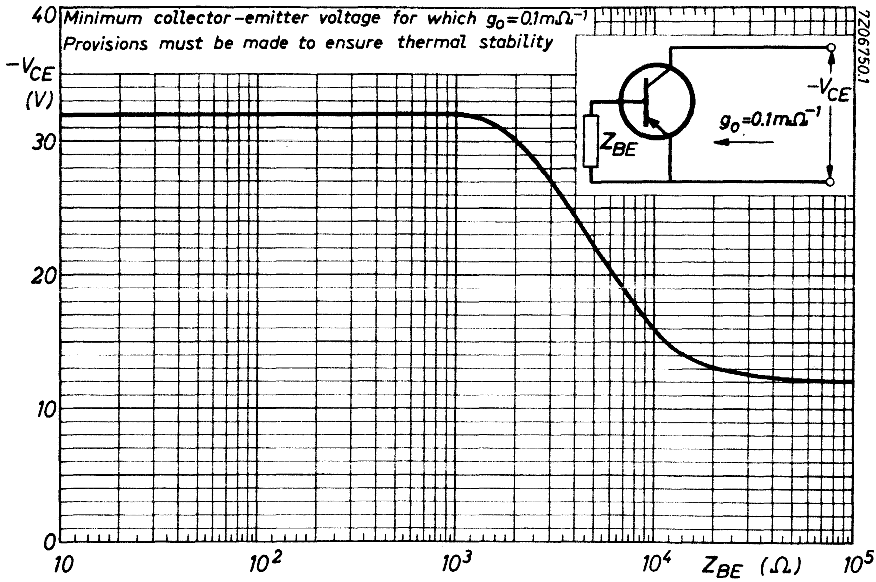
Knee voltage

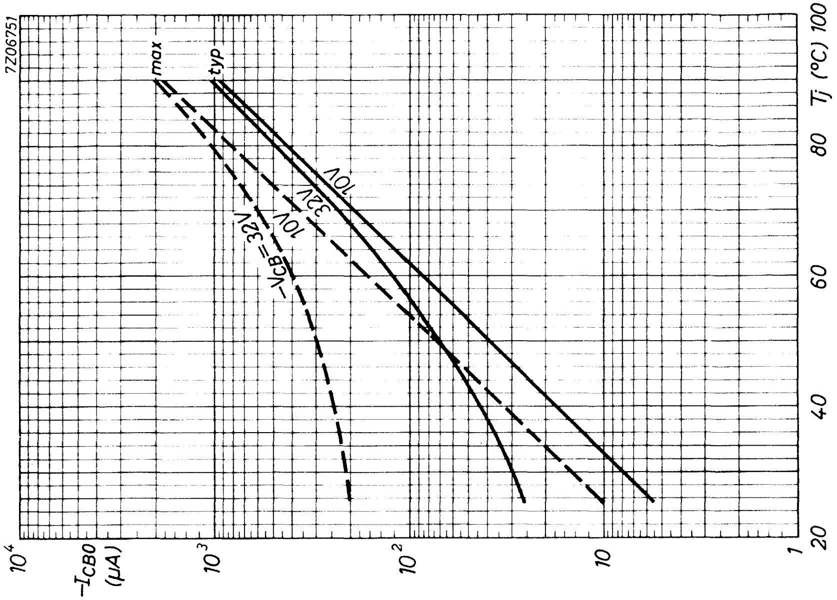
$-I_C = 200$ mA; $-I_B$ = value for which $-I_C = 220$ mA at $-V_{CE} = 1$ V	$-V_{CEK}$	<	350	mV

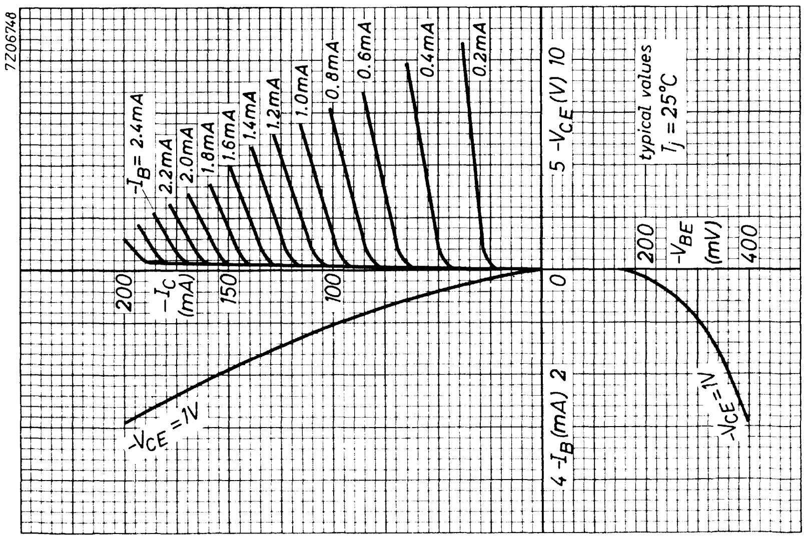


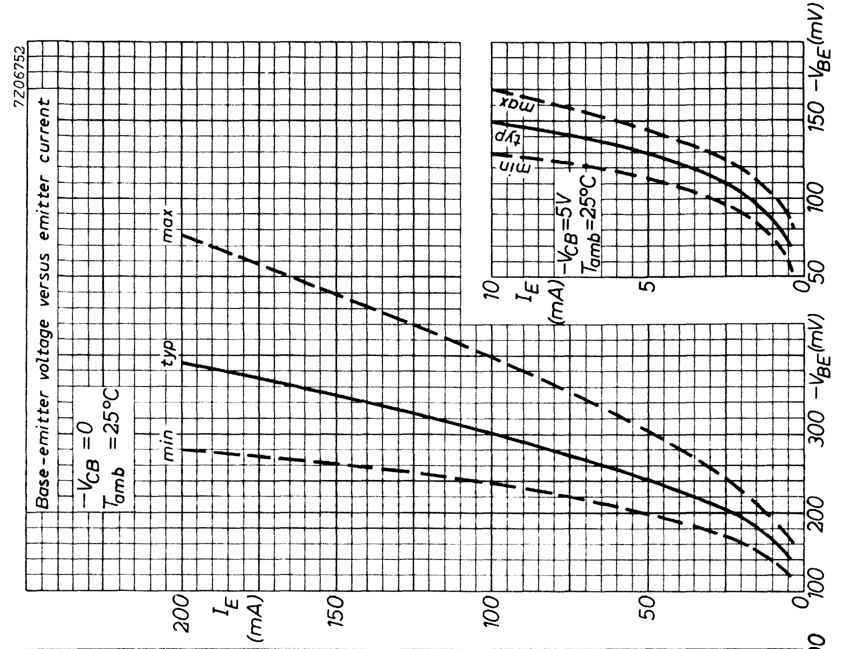
CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

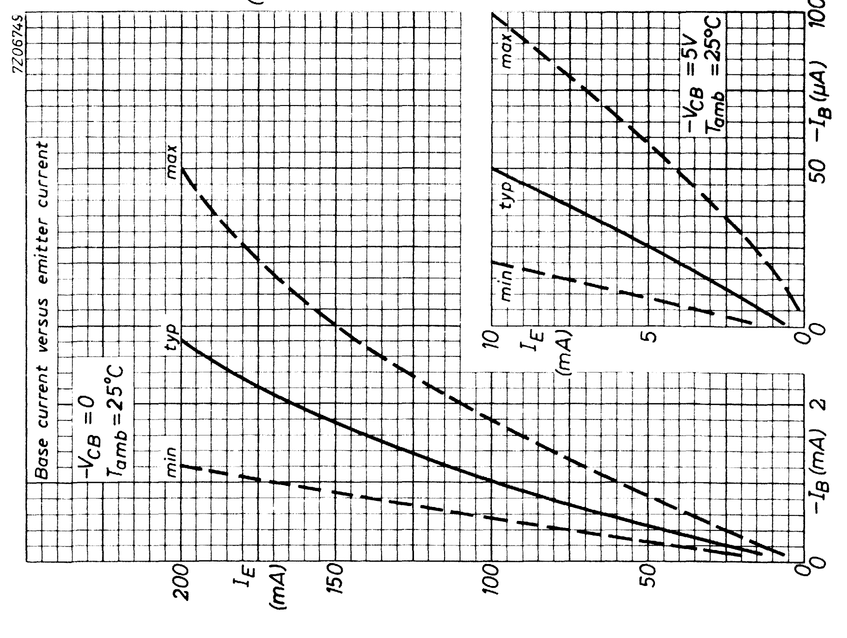
D.C. current gain				
$-I_C$ = 20 mA; V_{CB} = 0	h_{FE}	typ.	135	
$-I_C$ = 50 mA; V_{CB} = 0	h_{FE}	typ.	115	
$-I_C$ = 200 mA; V_{CB} = 0	h_{FE}	typ.	70	
Collector capacitance at f = 0.45 MHz				
$I_E = I_e$ = 0; $-V_{CB}$ = 5 V	C_c	typ.	40	pF
Feedback impedance at f = 0.45 MHz				
$-I_C$ = 1 mA; $-V_{CE}$ = 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=0.1mΩ⁻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=0.1mΩ⁻¹


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

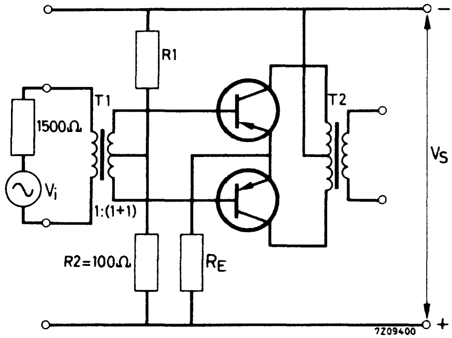

7Z06748
$-I_B$= 2.4mA
2.2mA
2.0mA
1.8mA
1.6mA
1.4mA
1.2mA
1.0mA
0.8mA
0.6mA
0.4mA
0.2mA
5 $-V_{CE}$ (V) 10
typical values
T_j = 25°C
200
$-I_C$ (mA)
150
100
0
200
$-V_{BE}$ (mV)
400
$-V_{CE}$=1V
4 $-I_B$ (mA) 2
$-V_{CE}$=1V


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


7Z06745
Base current versus emitter current
$-V_{CB} = 0$
$T_{amb} = 25°C$
max
typ
min
$-V_{CB} = 5V$
$T_{amb} = 25°C$
I_E (mA)
$-I_B$ (mA)
$-I_B$ (μA)
0
50
100
150
200
2
5
10
50
100

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 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.

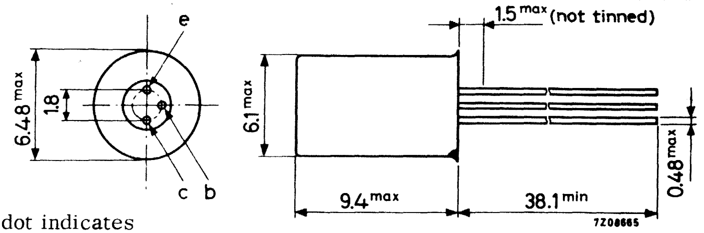
QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector current (peak value)	I_{CM}	max.	2	A
Total power dissipation up to T_{amb} = 35 °C	P_{tot}	max.	1.0	W
Junction temperature	T_j	max.	90	°C
D.C. current gain 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

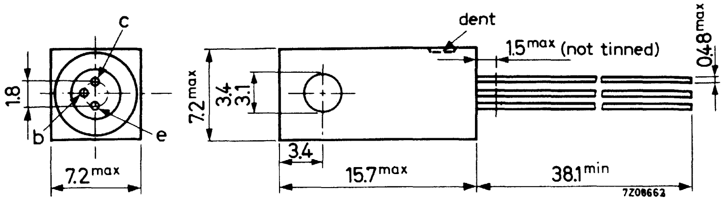


The coloured dot indicates the collector

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} = 35 °C [1])	P_{tot}	max.	1.0	W

Temperatures

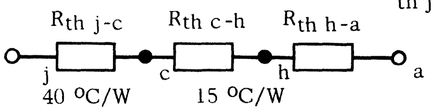
Storage temperature	T_{stg}		−55 to +75	°C
Junction temperature	T_j	max.	90	°C

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

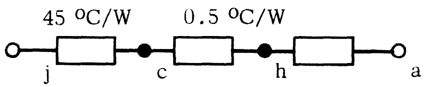
THERMAL RESISTANCE

		AC187	AC187/01	
From junction to ambient in free air				
without cooling clip	$R_{th\ j\text{-}a}$ =	290	180	°C/W
with cooling clip 56227	$R_{th\ j\text{-}a}$ =	140		°C/W
with cooling clip 56227 on 1.5mm blackened Al. 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

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

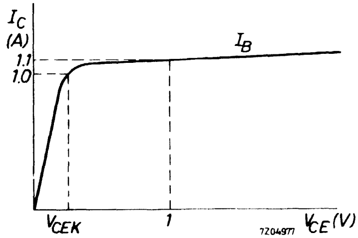
Emitter-base floating voltage

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

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

Knee voltage

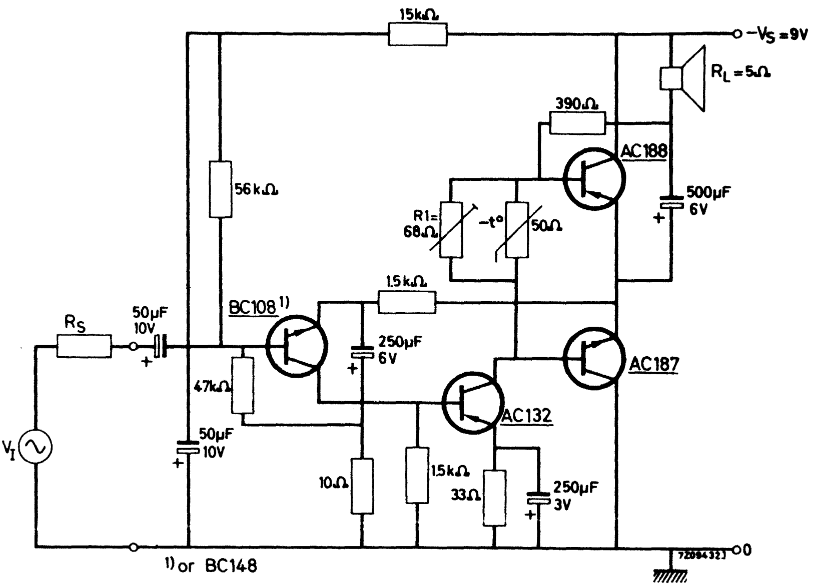
I_C = 1 A; I_B = value for which I_C = 1.1 A at V_{CE} = 1 V	V_{CEK}	<	800	mV



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	

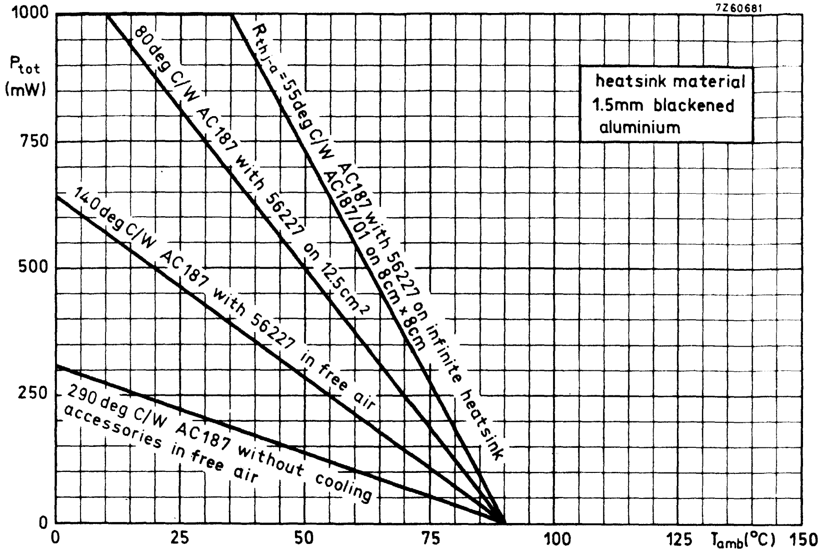
APPLICATION INFORMATION

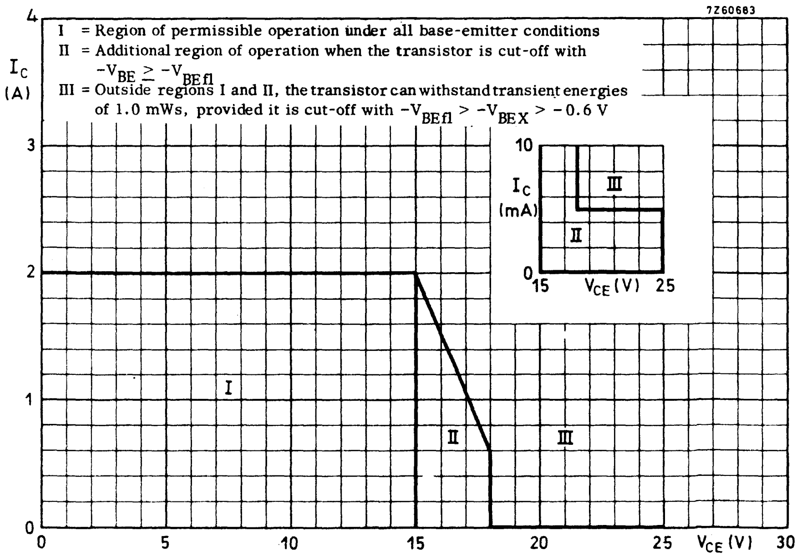
1.5 W transformerless audio frequency amplifier with matched pair AC187/AC188 in complementary symmetry class B output stage up to T_{amb} = 45 °C.

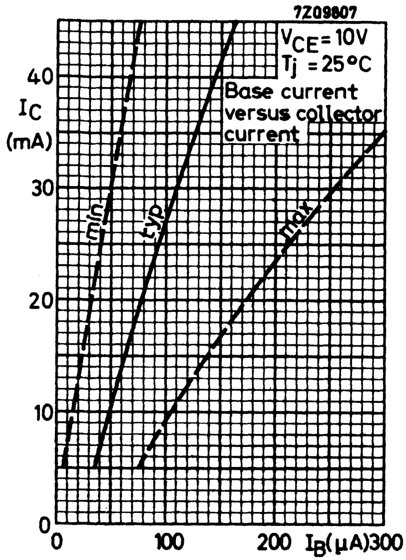


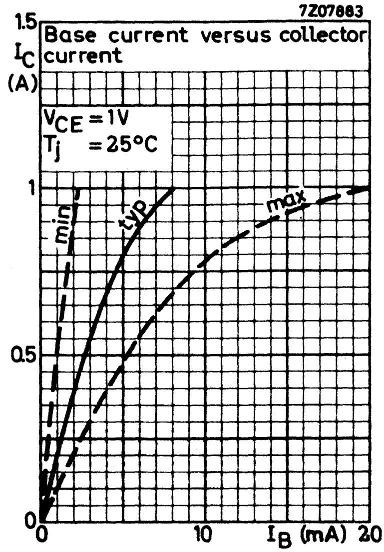
Typical input requirements for an output power of 50 mW	$V_{i\,(rms)}$ R_i	= 4 mV; $I_{i\,(rms)}$ = 0.12 μA; = 33 kΩ
Typical input requirements for an output power of 1.5 W	$V_{i\,(rms)}$ R_i	= 22 mV; $I_{i\,(rms)}$ = 0.66 μA; = 33 kΩ
Typical bandwidth (3 dB); R_S = 0	B	= 60 Hz to 65 kHz
Typical bandwidth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

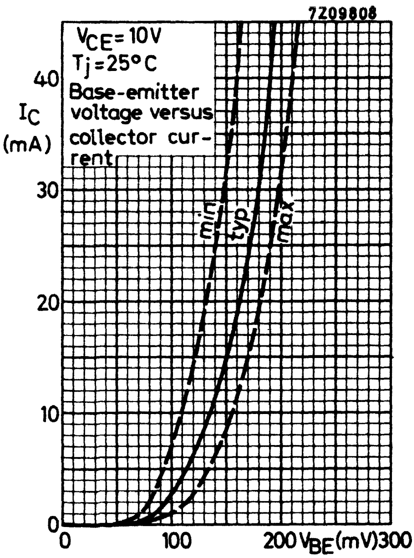
When using AC187 and AC188 each transistor should be mounted with cooling clip 56227 on 1.5 mm blackened Al. heatsink of 3 cm x 3 cm.
When using AC187/01 and AC188/01 each transistor should be mounted on 1.5 mm blackened Al. heatsink of 2.5 cm x 2.5 cm.

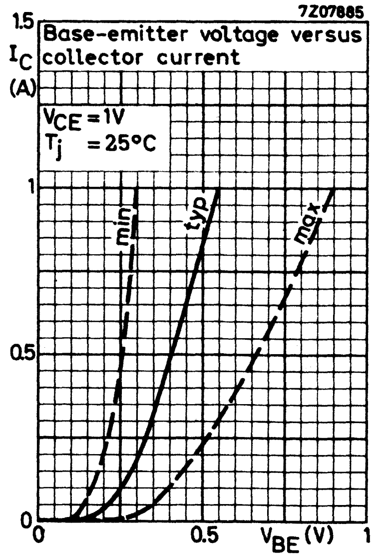

7Z60681
1000
P_{tot} (mW)
750
500
250
0
0
25
50
75
100
125
T_{amb}(°C)
150
heatsink material 1.5mm blackened aluminium
R_{thj-a} = 55deg C/W AC187 with 56227 on infinite heatsink
AC187/01 on 8cm x 8cm
80deg C/W AC187 with 56227 on 12.5cm²
140deg C/W AC187 with 56227 in free air
290 deg C/W AC187 without cooling accessories in free air

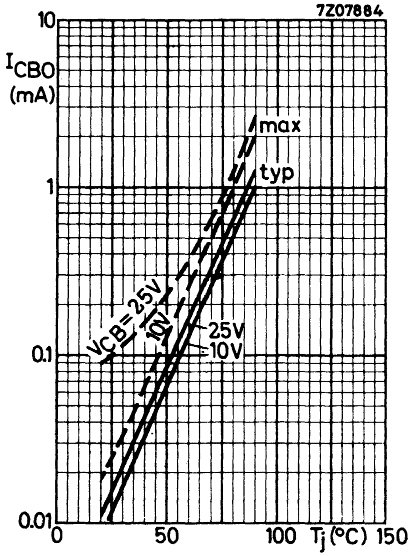

7Z60683
4
I_C (A)
3
2
1
0
0
5
10
15
20
25
V_{CE} (V)
30
I = Region of permissible operation under all base-emitter conditions
II = Additional region of operation when the transistor is cut-off with $-V_{BE} \geq -V_{BEfl}$
III = Outside regions I and II, the transistor can withstand transient energies of 1.0 mWs, provided it is cut-off with $-V_{BEfl} > -V_{BEX} > -0.6$ V
I
II
III
10
I_C (mA)
0
15
V_{CE} (V)
25


7Z09807
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


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


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


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


7Z07884
I_{CBO} (mA)
10
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

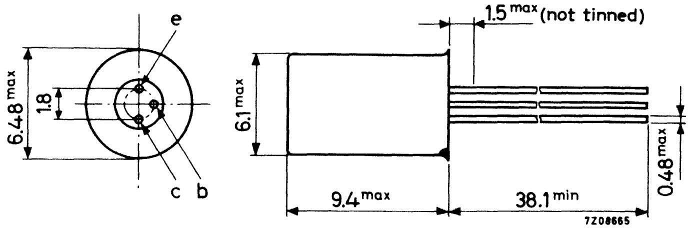
The AC188 is a p-n-p audio transistor in a TO-1 metal envelope.
The AC188 is primarily intended for use as matched pair 2-AC188 or together with the n-p-n medium power transistor AC187 as matched pair AC187/AC188 in class B output stages with outputs up to about 3 W.
The AC188/01 is electrically equivalent 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 (≈ 10 °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} = 35 °C	P_{tot}	max.	1.0	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.	10	kHz

MECHANICAL DATA

AC188

TO-1

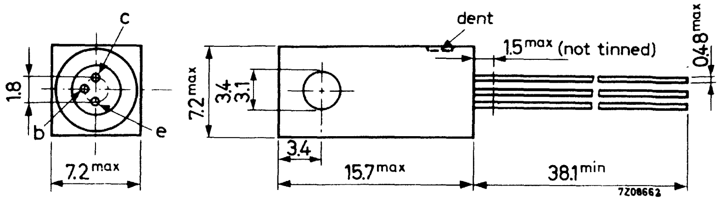


The coloured dot indicates the collector

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 $T_{amb} = 35\ ^oC$ [1])	P_{tot}	max.	1.0	W

Temperatures

Storage temperature	T_{stg}		−55 to +75	^oC
Junction temperature	T_j	max.	90	^oC

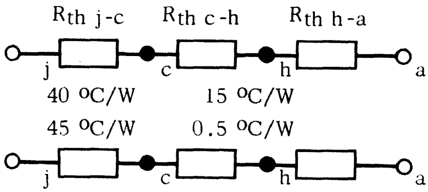
[1]) The allowable peak power in class B speach and musical driven amplifiers is 1.1 W

THERMAL RESISTANCE

		AC188	AC188/01	
From junction to ambient in free air				
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

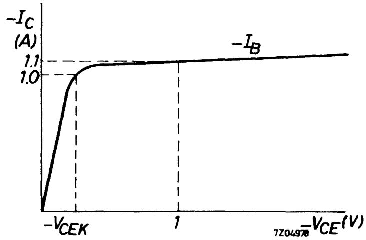
T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $-V_{CB} = 25$ 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
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 10$ 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
Base-emitter voltage				
$-I_C$ = 5 mA; $-V_{CE}$ = 10 V	$-V_{BE}$	115 to 145		mV
$-I_C$ = 300 mA; $-V_{CE}$ = 1 V	$-V_{BE}$	<	450	mV
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	$-V_{CEK}$	<	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

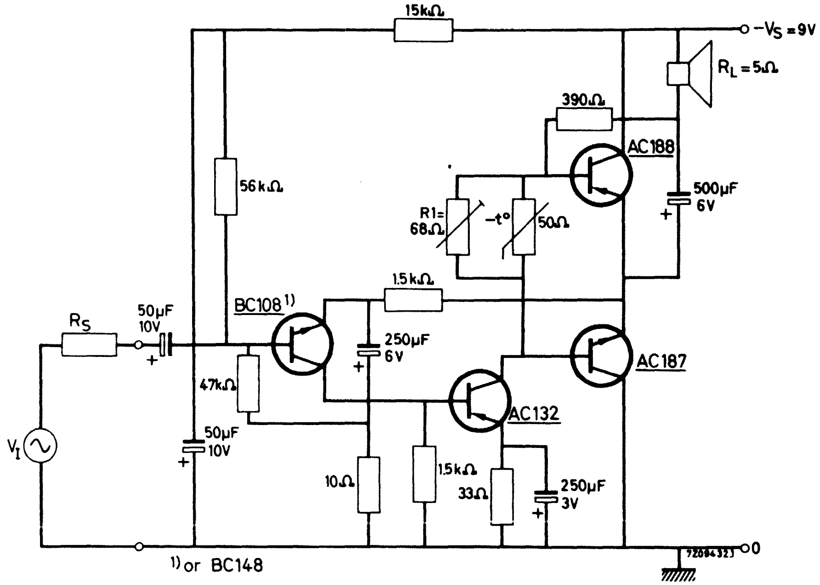
$\lvert I_C \rvert$ = 500 mA; $\lvert V_{CE} \rvert$ = 1 V	h_{FE1}/h_{FE2}	<	1.25

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

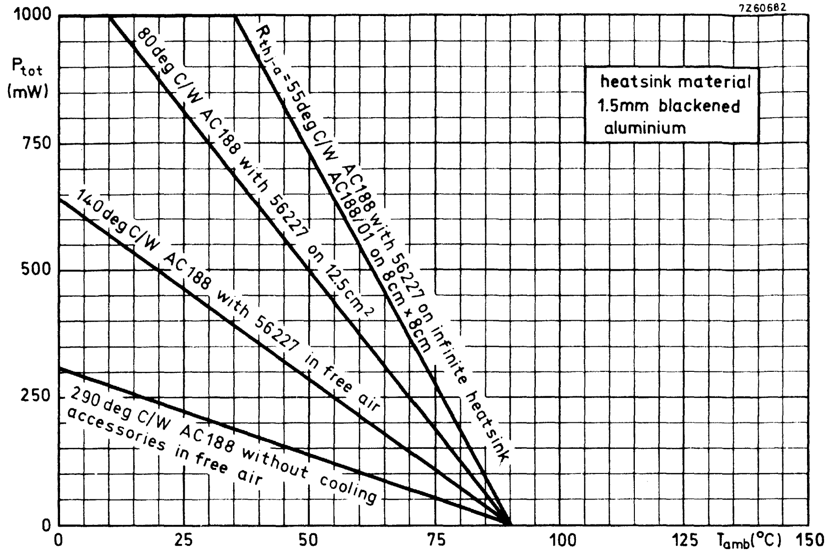
APPLICATION INFORMATION

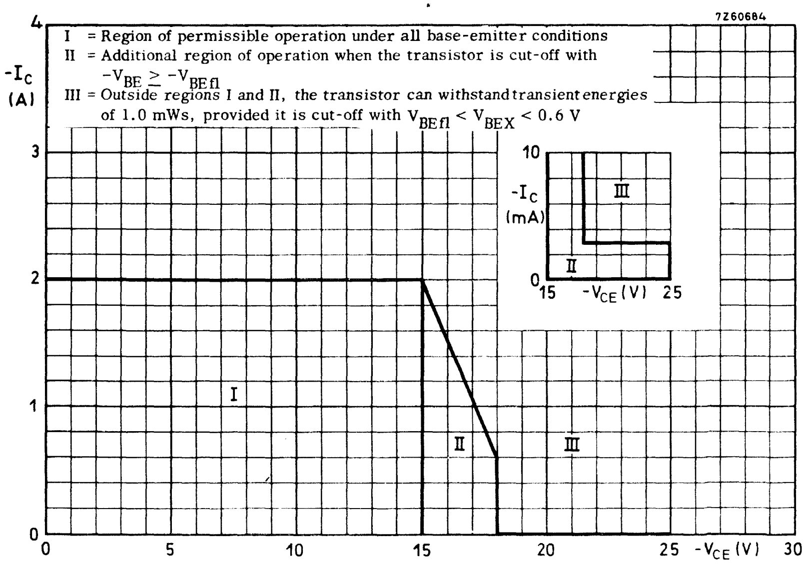
1.5 W transformerless audio frequency amplifier with matched pair AC187/AC188 in complementary symmetry class B output stage up to T_{amb} = 45 °C

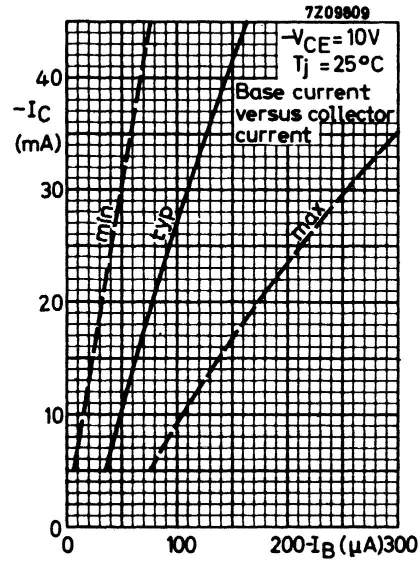


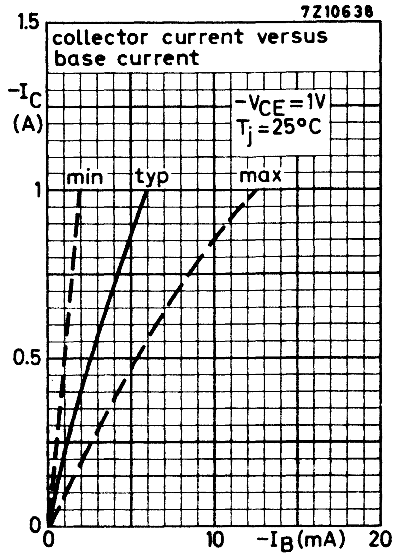
Typical input requirements for an output power of 50 mW	$V_{i(rms)}$ R_i	= 4 mV; $I_{i(rms)}$ = 0.12 μA; = 33 kΩ
Typical input requirements for an output power of 1.5 W	$V_{i(rms)}$ R_i	= 22 mV; $I_{i(rms)}$ = 0.66 μA; = 33 kΩ
Typical bandwidth (3 dB); R_S = 0	B	= 60 Hz to 65 kHz
Typical bandwidth (3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

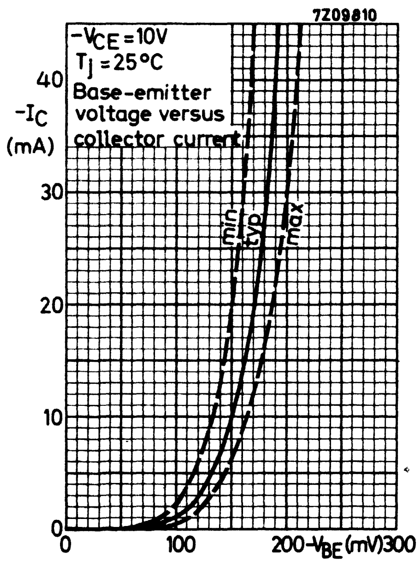
When using AC187 and AC188 each transistor should be mounted with cooling clip 56227 on 1.5 mm blackened Al. heatsink of 3 cm x 3 cm.
When using AC187/01 and AC188/01 each transistor should be mounted on 1.5 mm blackened Al. heatsink of 2.5 cm x 2.5 cm.

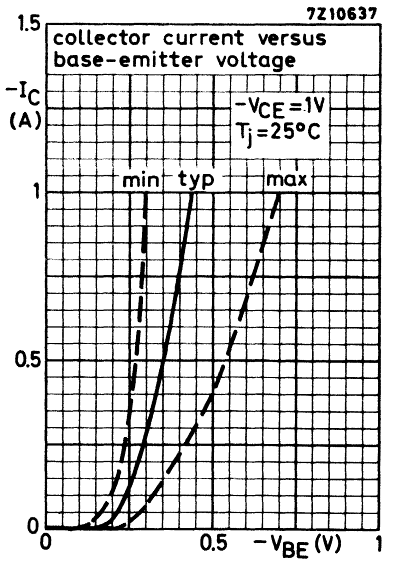

7Z60682
1000
P_{tot} (mW)
750
500
250
0
0
25
50
75
100
125
T_{amb}(°C)
150
heatsink material 1.5mm blackened aluminium
R_{thj-a}=55deg C/W AC188 with 56227 on infinite heatsink
AC188/01 on 8cm x 8cm
80deg C/W AC188 with 56227 on 12.5cm²
140deg C/W AC188 with 56227 in free air
290 deg C/W AC188 without cooling accessories in free air

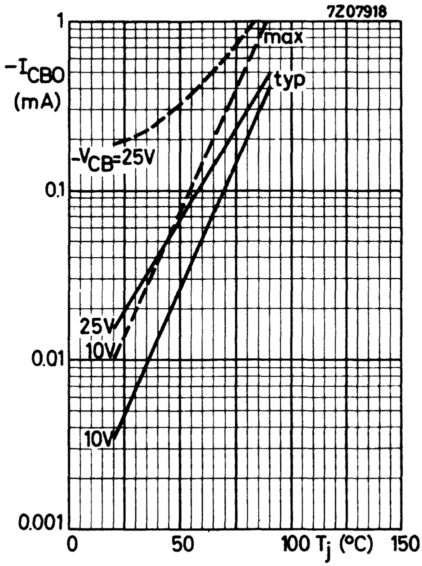

7Z60684
I = Region of permissible operation under all base-emitter conditions
II = Additional region of operation when the transistor is cut-off with $-V_{BE} \geq -V_{BEfl}$
III = Outside regions I and II, the transistor can withstand transient energies of 1.0 mWs, provided it is cut-off with $V_{BEfl} < V_{BEX} < 0.6$ V
4
$-I_C$ (A)
3
2
1
0
0
5
10
15
20
25
$-V_{CE}$ (V)
30
I
II
III
10
$-I_C$ (mA)
0
15
$-V_{CE}$ (V)
25


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
collector current versus base 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
collector current versus base-emitter voltage
$-V_{CE}$ = 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

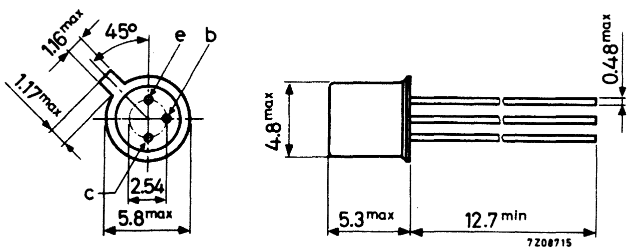
N-P-N transistors in a TO-18 metal envelope with the collector connected to the case.
The BC107 is primarily intended for use in driver stages of audio amplifiers and in signal processing circuits of television receivers.
The BC108 is suitable for a multitude of low voltage applications e.g. driver stages 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	$R_{th\ j\text{-}a}$	=	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; T_j = 150 °C	I_{CBO}	<	15	μA

Base-emitter voltage [1])

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

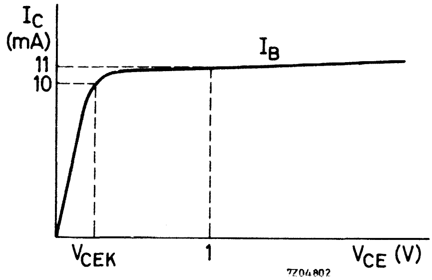
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

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

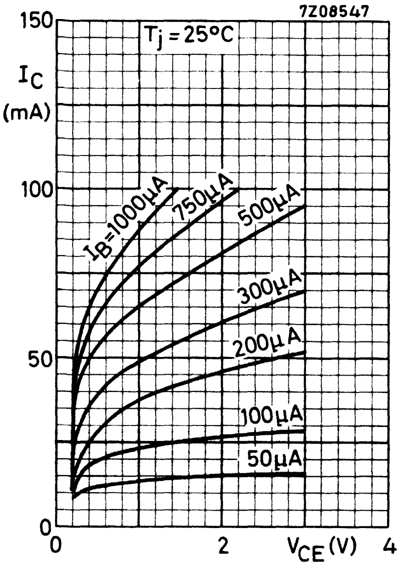
			BC107	BC108	BC109	
I_C = 2 mA; V_{CE} = 5 V	h_{fe}	>	125	125	240	
		<	500	900	900	
Noise figure at R_S = 2 kΩ; I_C = 200 μA; V_{CE} = 5 V						
f = 30 Hz to 15 kHz	F	typ.			1.4	dB
		<			4	dB
f = 1 kHz; B = 200 Hz	F	typ.	2	2	1.2	dB
		<	10	10	4	dB

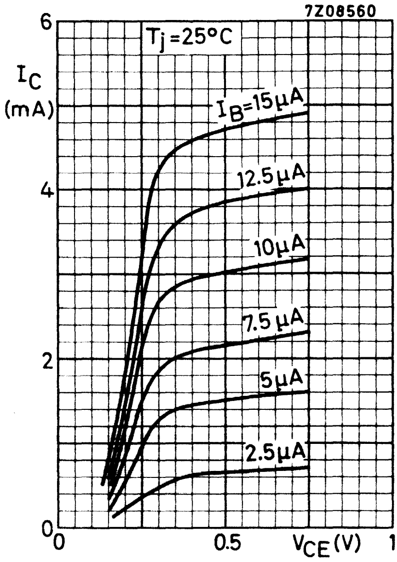
[1]) V_{BEsat} decreases by about 1.7 mV/°C with increasing temperature.

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

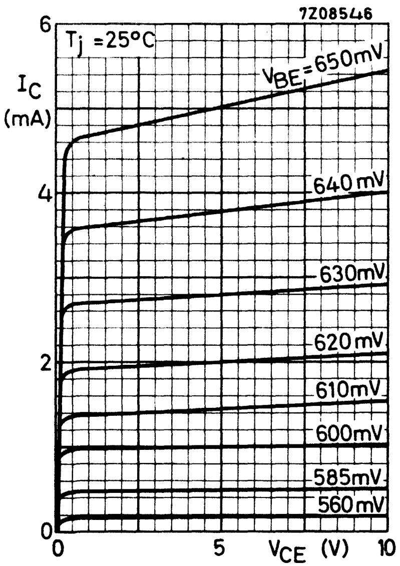
			BC107A BC108A	BC107B BC108B BC109B	BC108C BC109C	
D.C. current gain						
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	>		40	100	
		typ.	90	150	270	
I_C = 2 mA; V_{CE} = 5 V	h_{FE}	>	110	200	420	
		typ.	180	290	520	
		<	220	450	800	
h parameters at f = 1 kHz (common emitter)						
I_C = 2 mA; V_{CE} = 5 V						
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	$\mu\Omega^{-1}$

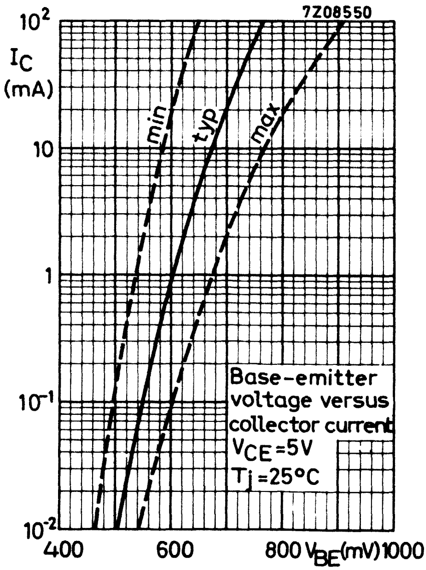
Typical behaviour of collector current versus collector-emitter voltage

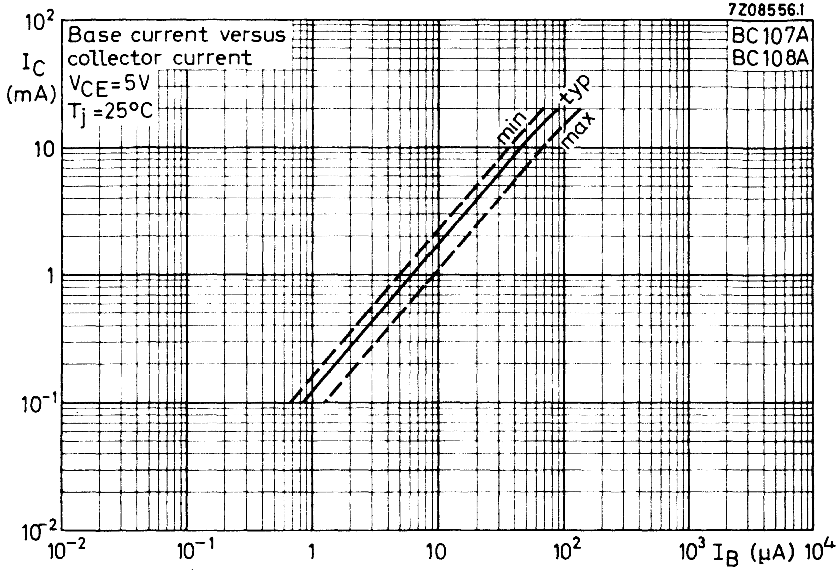


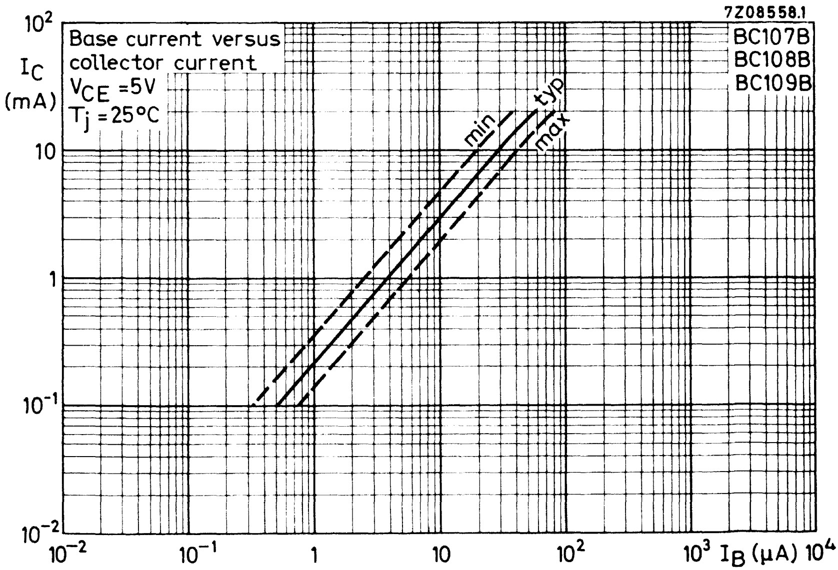


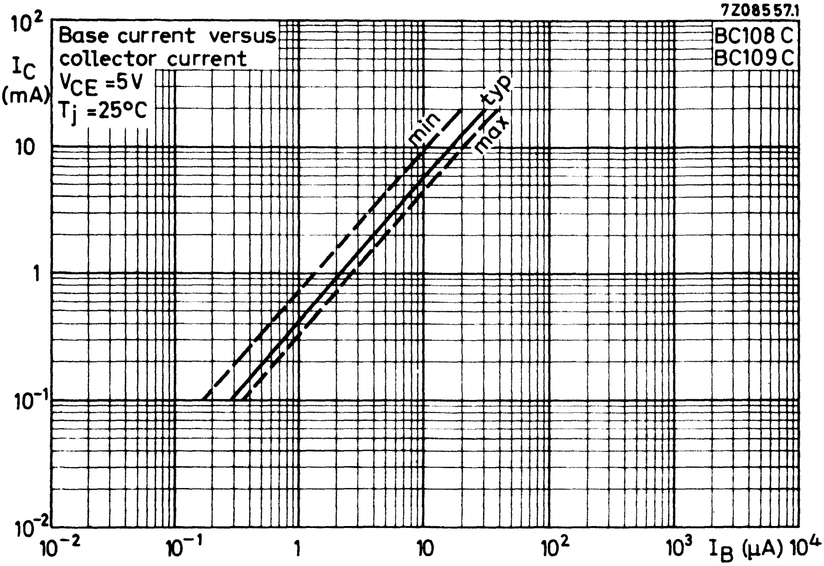
Typical behaviour of collector current versus collector-emitter voltage

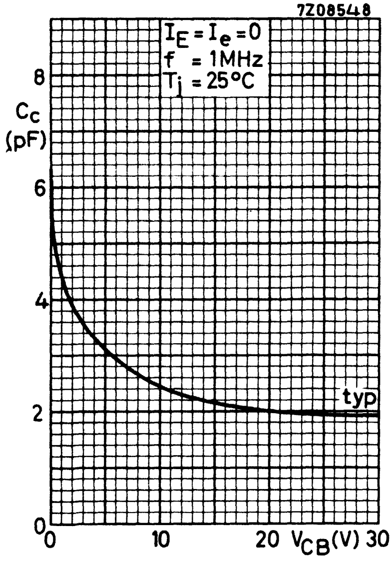


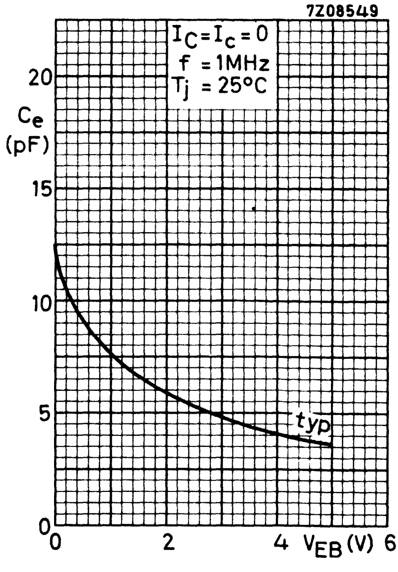


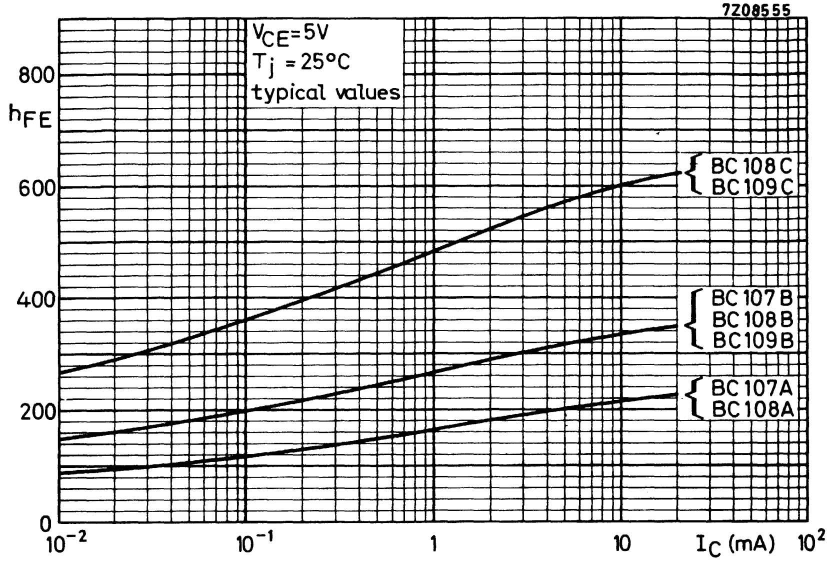

7Z08556.1
BC107A
BC108A
Base current versus collector current
V_{CE} = 5V
T_j = 25°C
I_C (mA)
10^2
10
1
10^{-1}
10^{-2}
min
typ
max
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (μA)
10^4

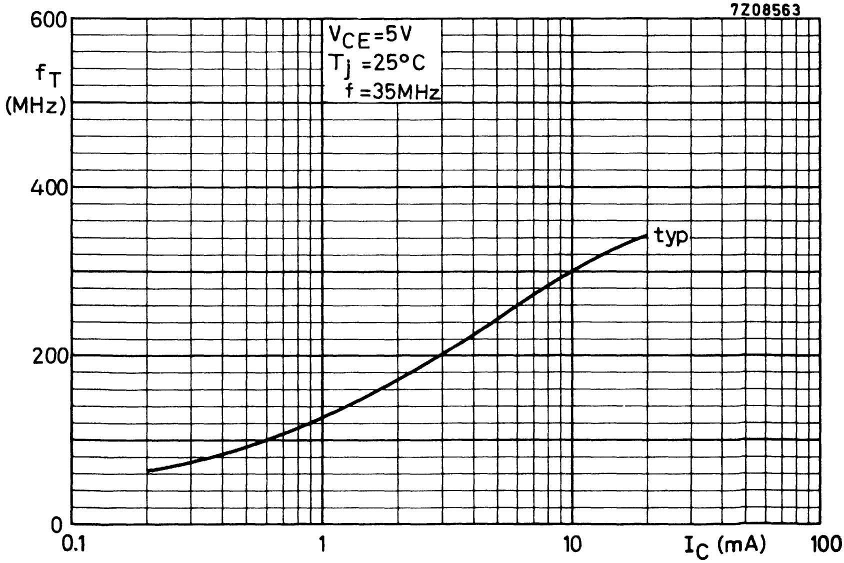

7Z08558.1
BC107B
BC108B
BC109B
Base current versus collector current
V_{CE} = 5V
T_j = 25°C
I_C (mA)
10^2
10
1
10^{-1}
10^{-2}
min
typ
max
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (μA)
10^4


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

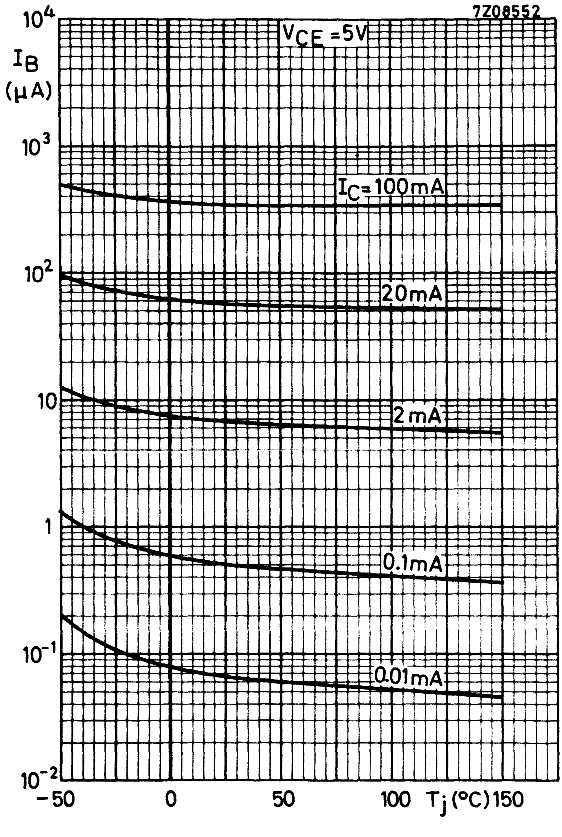

7Z08548
$I_E = I_e = 0$
f = 1 MHz
T_j = 25 °C
C_c (pF)
8
6
4
2
0
typ
0
10
20
V_{CB} (V)
30

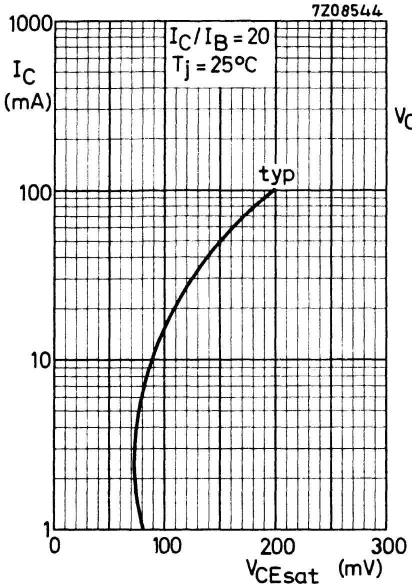

7Z08549
$I_C = I_c = 0$
f = 1 MHz
T_j = 25 °C
C_e (pF)
20
15
10
5
0
typ
0
2
4
V_{EB} (V)
6

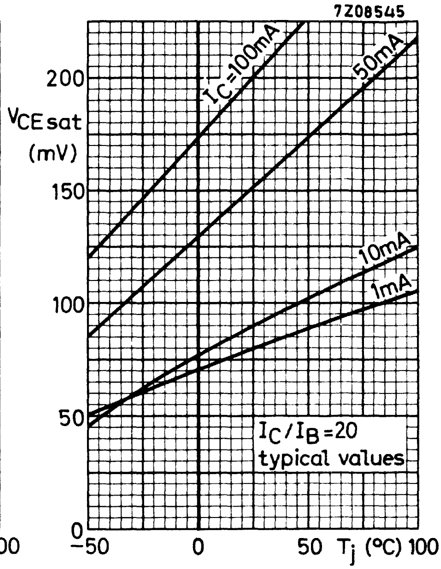

7Z08555
V_{CE}=5V
T_j = 25°C
typical values
800
h_{FE}
600
400
200
0
BC 108 C
BC 109 C
BC 107 B
BC 108 B
BC 109 B
BC 107 A
BC 108 A
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

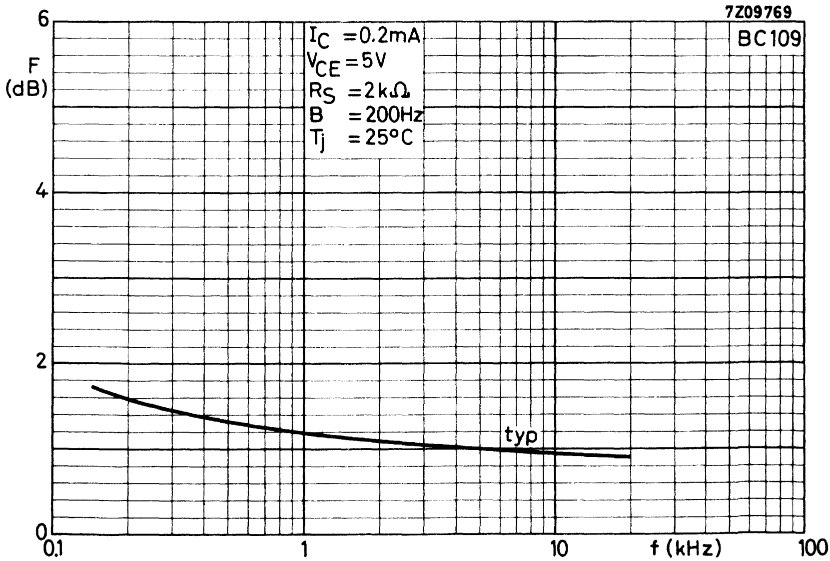

7Z08563
600
f_T
(MHz)
V_{CE}=5V
T_j =25°C
f =35MHz
400
typ
200
0
0.1
1
10
I_C (mA)
100

Typical behaviour of base current versus junction temperature

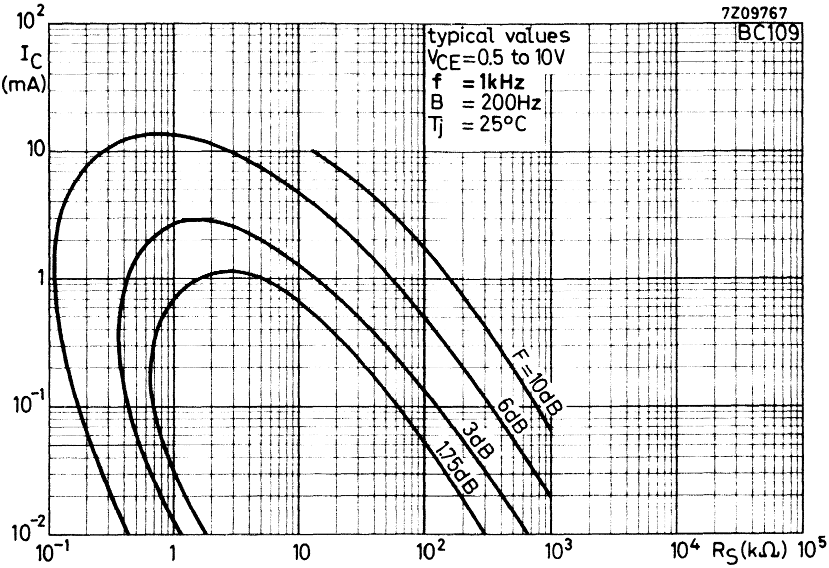


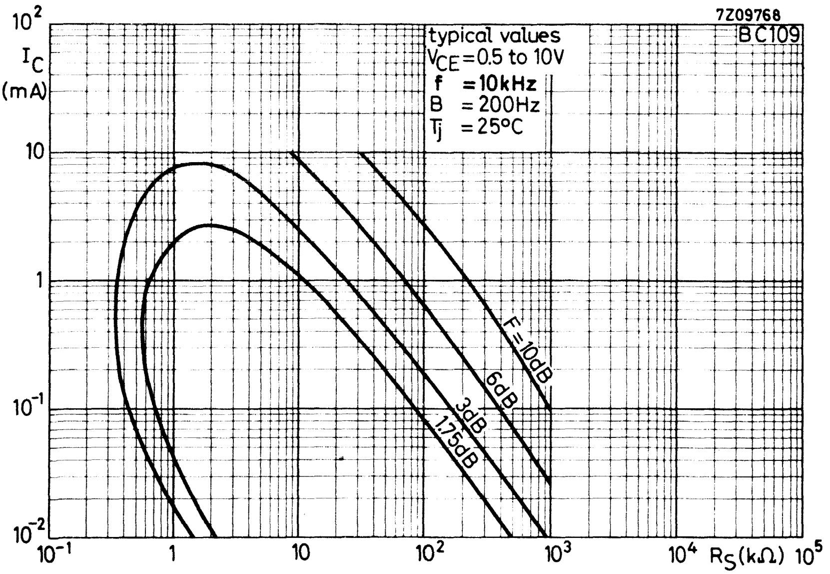

7Z08544
I_C (mA)
1000
100
10
1
$I_C/I_B = 20$
$T_j = 25°C$
typ
0
100
200
300
V_{CEsat} (mV)

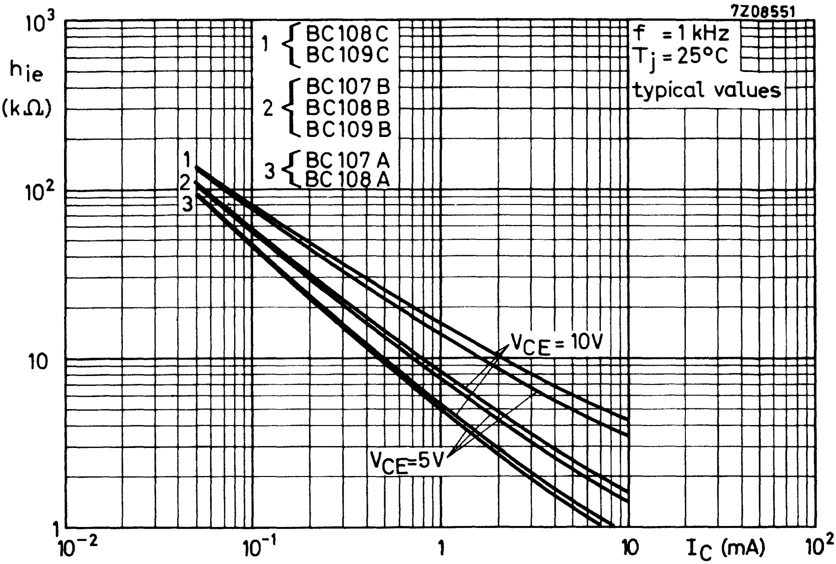

7Z08545
V_{CEsat} (mV)
200
150
100
50
0
$I_C = 100mA$
50mA
10mA
1mA
$I_C/I_B = 20$
typical values
−50
0
50
T_j (°C)
100

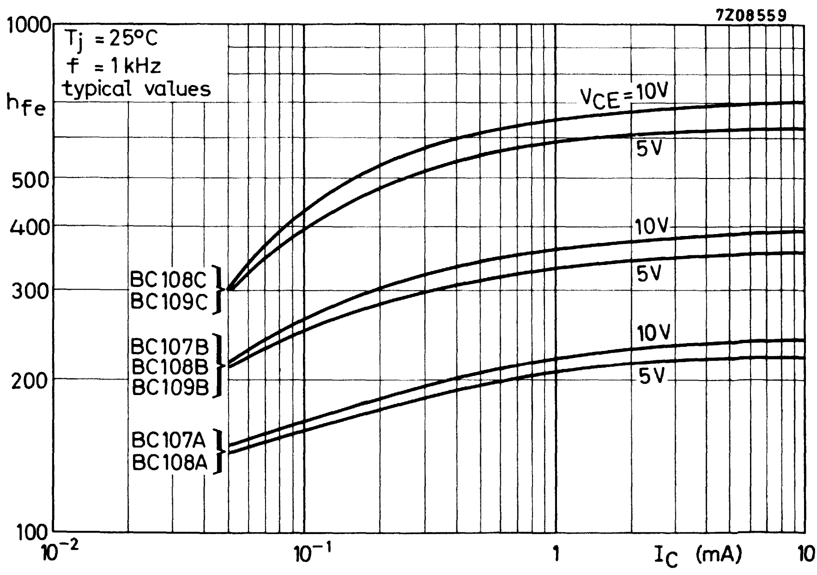

7Z09769
BC109
F (dB)
6
4
2
0
I_C = 0.2mA
V_{CE} = 5V
R_S = 2kΩ
B = 200Hz
T_j = 25°C
typ
0.1
1
10
f (kHz)
100

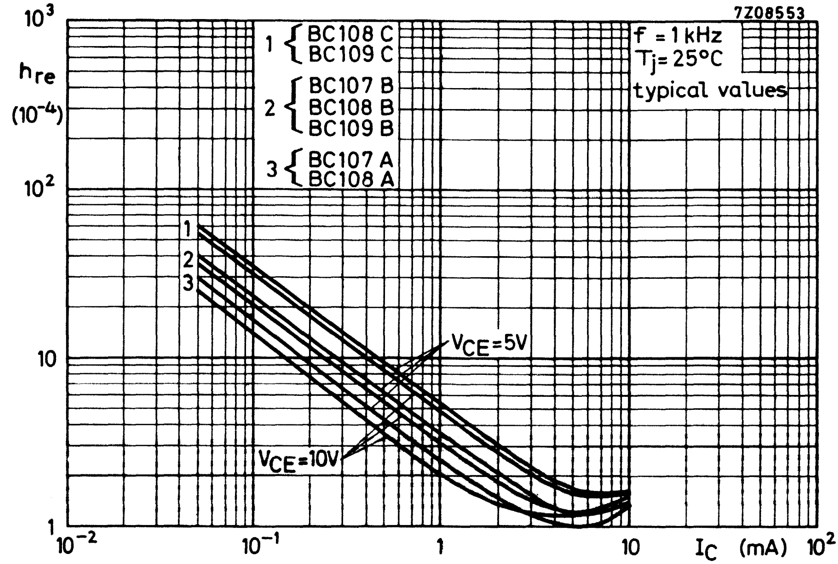
Curves of constant noise figure

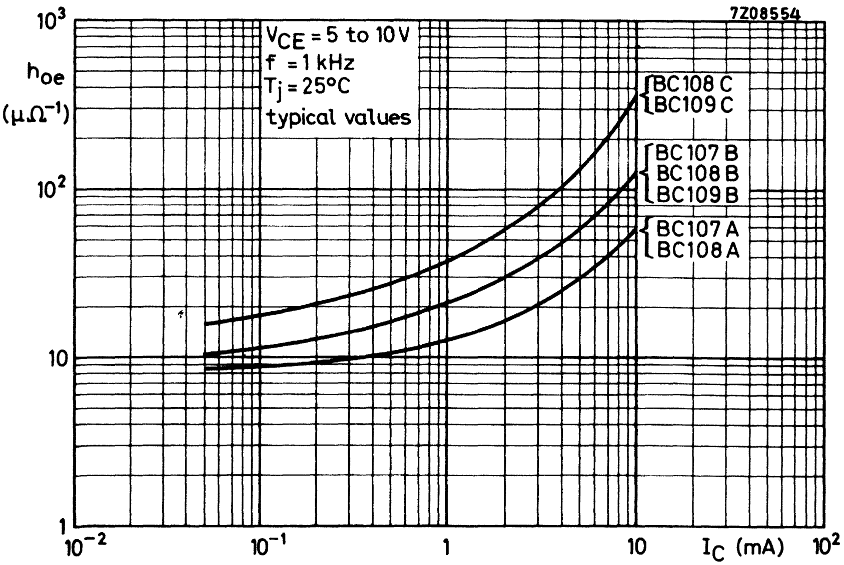


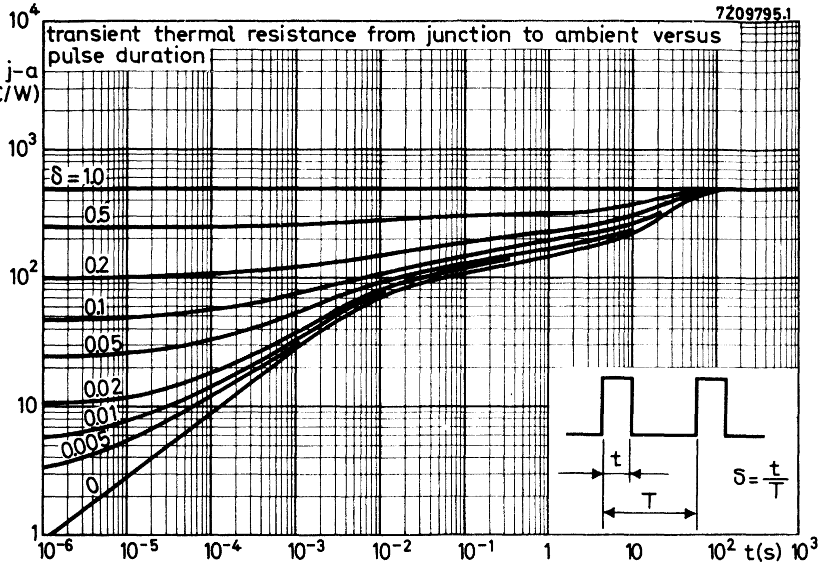



7Z08551
10^3
h_{ie}
(kΩ)
10^2
10
1
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2
1 { BC108C BC109C
2 { BC107B BC108B BC109B
3 { BC107A BC108A
f = 1 kHz
T_j = 25°C
typical values
V_{CE} = 10V
V_{CE}=5V
1
2
3


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


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
VCE = 5V
VCE = 10V
1
2
3
10^3
10^2
10
1
10^{-2}
10^{-1}
1
10
IC (mA)
10^2


7Z08554
h_{oe}
$(\mu\Omega^{-1})$
VCE = 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
10^3
10^2
10
1
10^{-2}
10^{-1}
1
10
IC (mA)
10^2


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

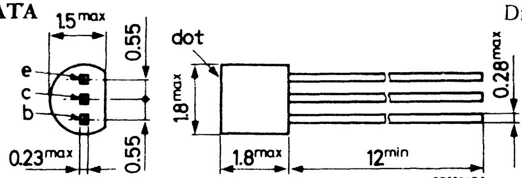
N-P-N transistor in a microminiature plastic envelope. The BC146 is designed for hearing aids, watches and other equipment where small size is of paramount importance.

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

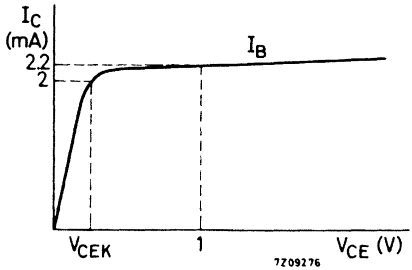
CHARACTERISTICS T_j = 25 °C unless otherwise specified

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

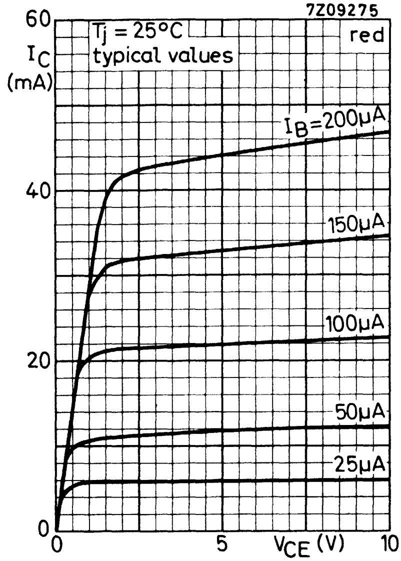
I_E = I_e = 0; V_{CB} = 5 V	C_c	typ.	4	pF

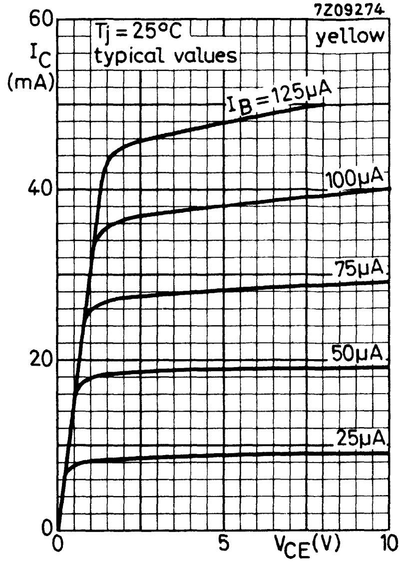
Transition frequency

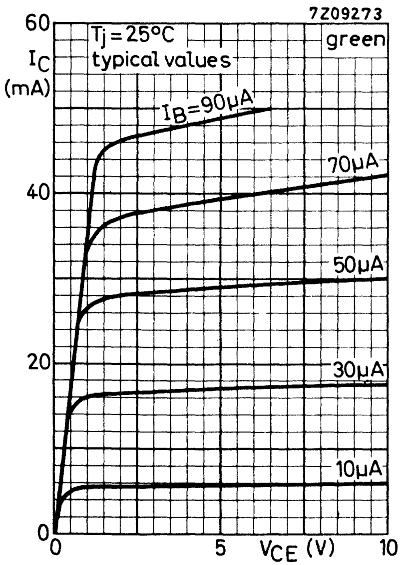
I_C = 2 mA; V_{CE} = 5 V	f_T	typ.	150	MHz

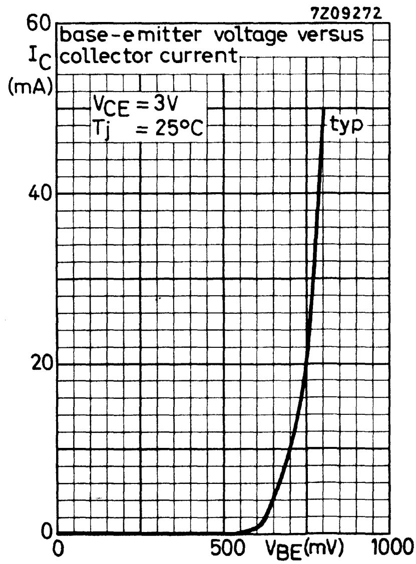
D.C. current gain

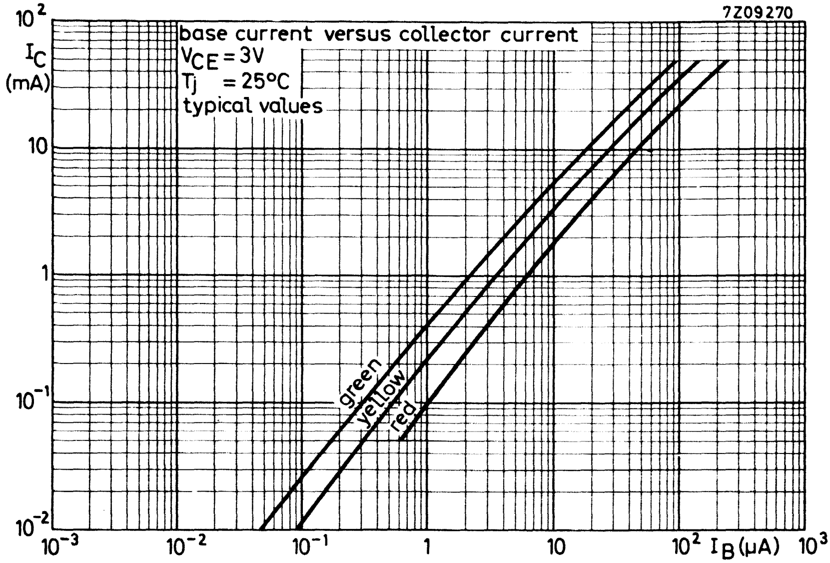
			red	yellow	green	
I_C = 0.2 mA; V_{CE} = 0.5 V	h_{FE}	typ.	115	220	380	
			80 to 200	140 to 350	280 to 550	
I_C = 2 mA; V_{CE} = 1 V	h_{FE}	>	100	140	280	
Noise figure						
I_C = 0.2 mA; V_{CE} = 5 V; R_S = 2 kΩ; Bandwidth: f = 30 Hz to 15 kHz	F	typ.	2	1.5	2	dB
		<	–	4	–	dB
h parameters at f = 1 kHz						
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	$\mu\Omega^{-1}$

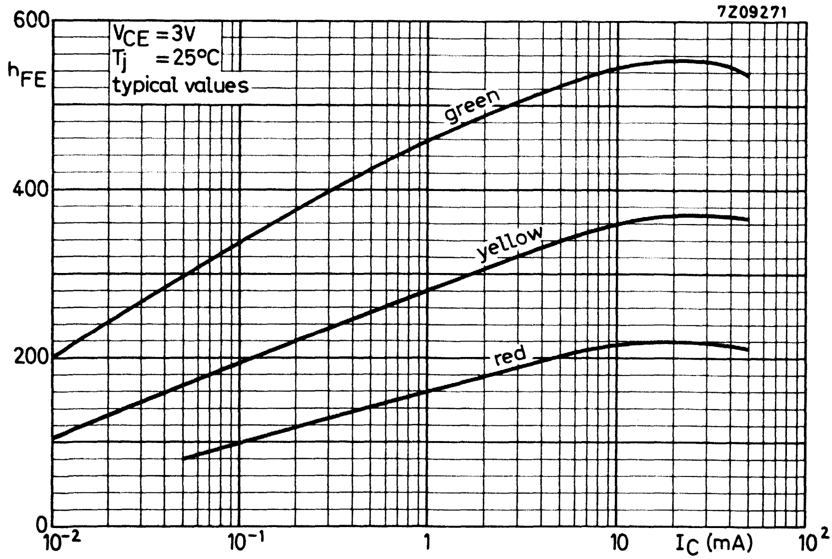

7Z09275
60
I_C
(mA)
T_j = 25°C
typical values
red
I_B=200μA
150μA
100μA
50μA
25μA
40
20
0
0
5
V_{CE} (V)
10


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


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


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


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

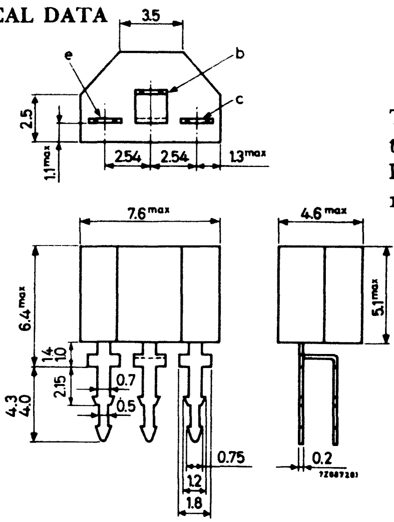
A.F. SILICON PLANAR EPITAXIAL TRANSISTORS

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.	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	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

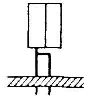
MECHANICAL DATA Dimensions in mm



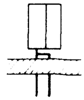
The envelope fulfils the accelerated damp heat test described in IEC publication 68-2 (test D, severity IV, 6 cycles)

MOUNTING INSTRUCTIONS

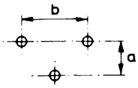
1. Thickness of printed board: max. 1.1 mm
   Hole diameter 0.77 to 0.83 mm



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.	300	mW

Temperatures

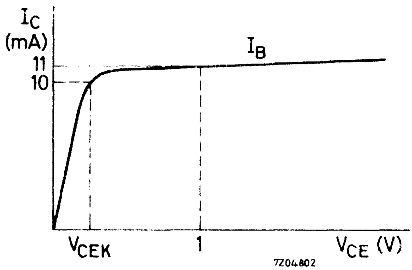
Storage temperature	T_{stg}		-65 to +125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

→ From junction to ambient in free air	$R_{th\ j-a}$	=	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}	<	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

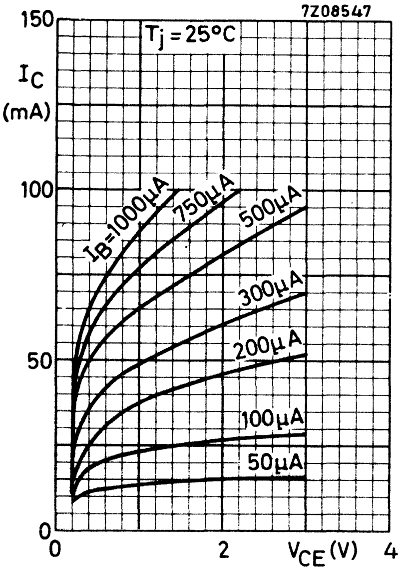
1) V_{BE} decreases by about 2 mV/°C with increasing temperature.
2) V_{BEsat} decreases by about 1.7 mV/°C with increasing temperature.

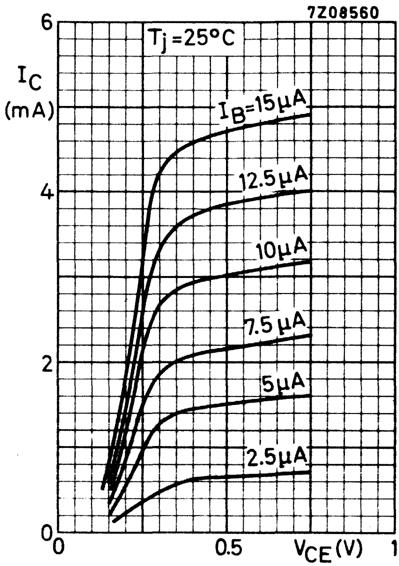
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

			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

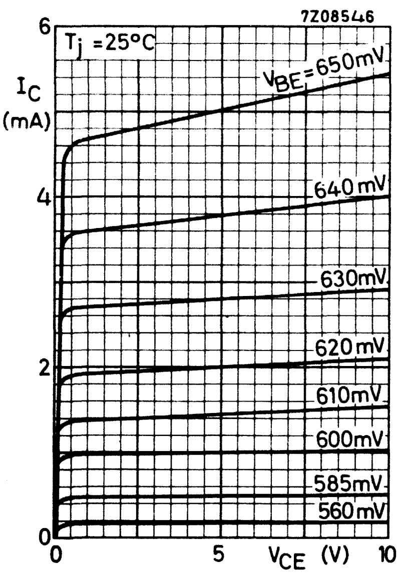
			BC147A BC148A	BC147B BC148B BC149B	BC148C BC149C
D.C. current gain					
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	typ.	90	150	270
		>	110	200	420
I_C = 2 mA; V_{CE} = 5 V	h_{FE}	typ.	180	290	520
		<	220	450	800
h parameters at f = 1 kHz (common emitter)					
I_C = 2 mA; V_{CE} = 5 V					
		>	1.6	3.2	6 kΩ
Input 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 $\mu\Omega^{-1}$

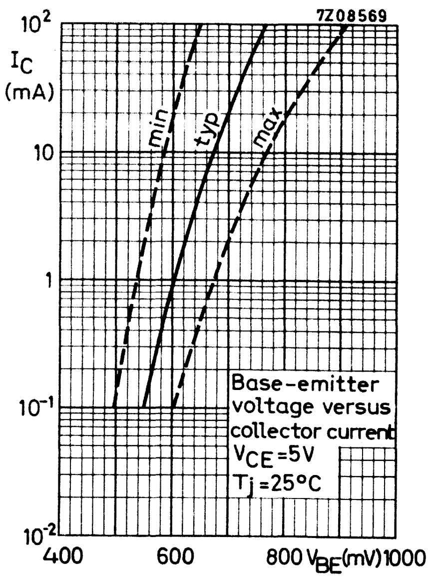
Typical behaviour of collector current versus collector-emitter voltage

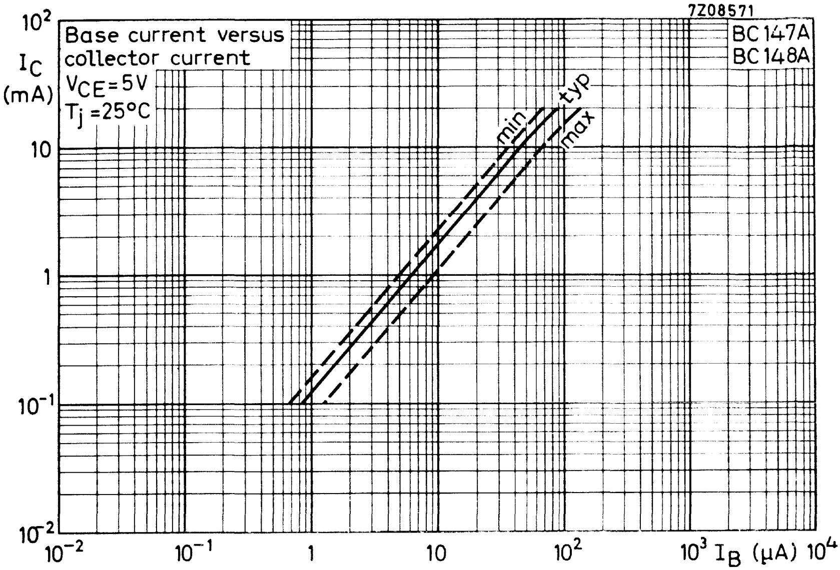


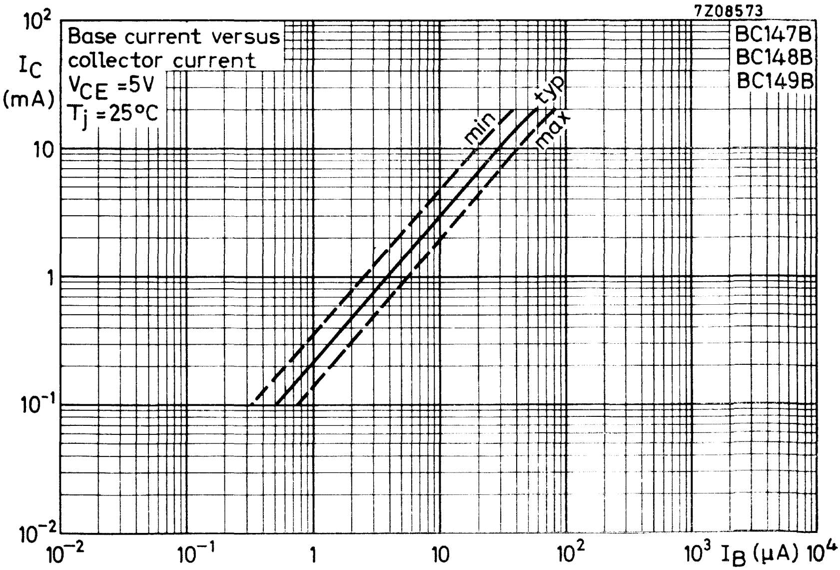


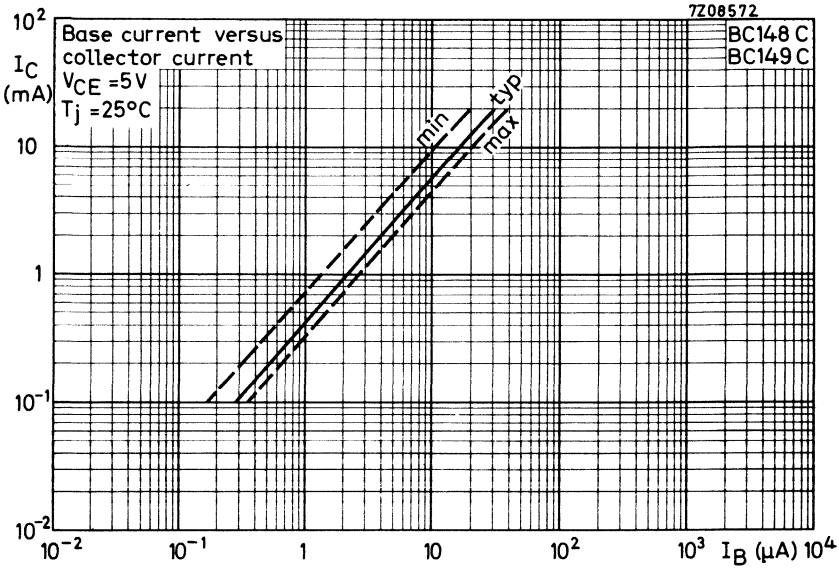
Typical behaviour of collector current versus collector-emitter voltage

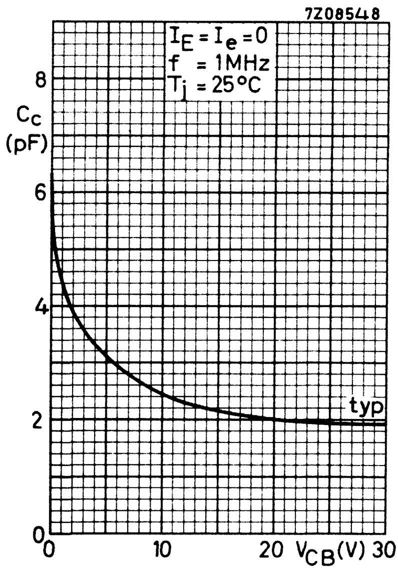


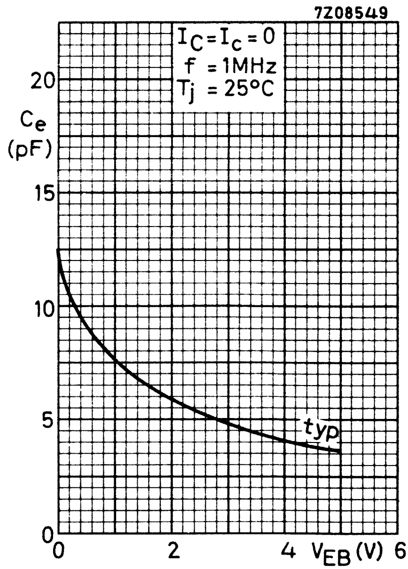


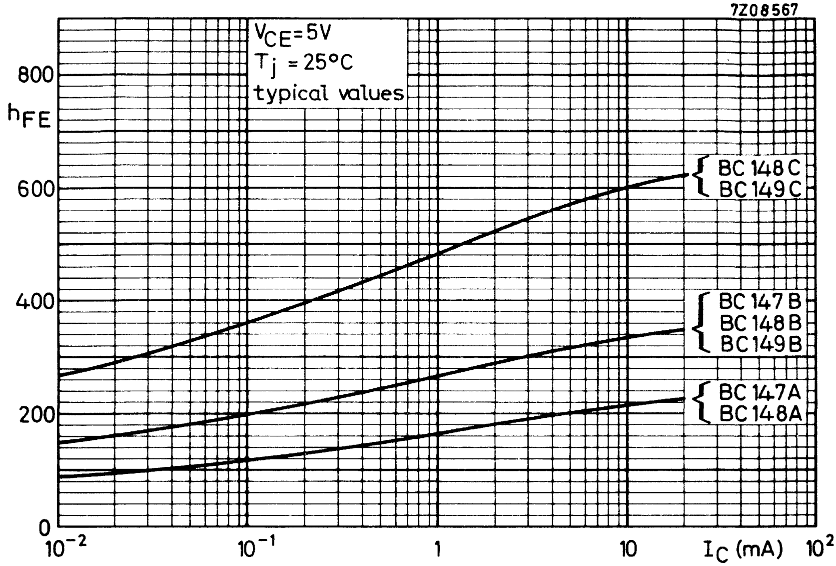

7Z08571
Base current versus
collector current
V_{CE} = 5 V
T_j = 25 °C
BC147A
BC148A
I_C
(mA)
10^2
10
1
10^{-1}
10^{-2}
min
typ
max
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (μA)
10^4

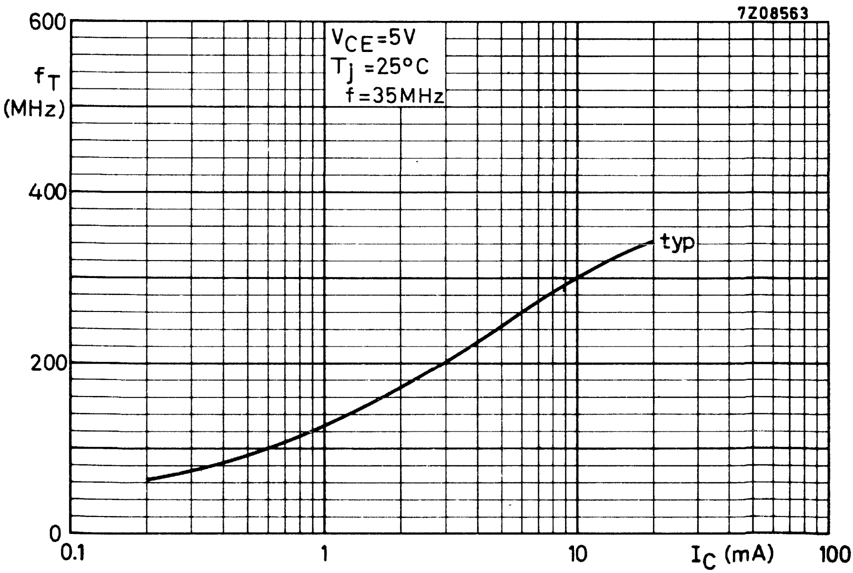

7Z08573
Base current versus
collector current
V_{CE} = 5 V
T_j = 25 °C
BC147B
BC148B
BC149B
I_C
(mA)
10^2
10
1
10^{-1}
10^{-2}
min
typ
max
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (μA)
10^4


7Z08572
Base current versus
collector current
VCE =5V
Tj =25°C
BC148 C
BC149 C
IC
(mA)
10²
10
1
10⁻¹
10⁻²
min
typ
max
10⁻²
10⁻¹
1
10
10²
10³
IB (µA)
10⁴

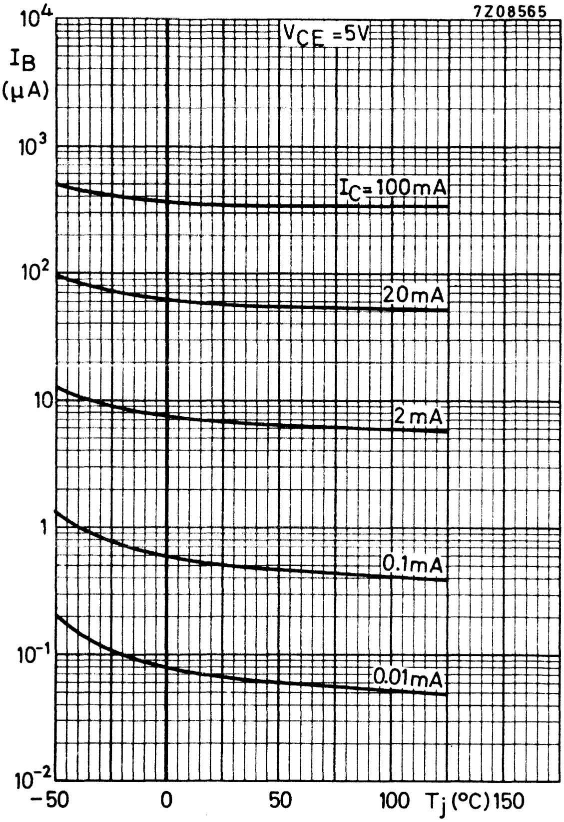

7Z08548
IE = Ie = 0
f = 1MHz
Tj = 25°C
Cc
(pF)
8
6
4
2
0
typ
0
10
20
VCB (V)
30

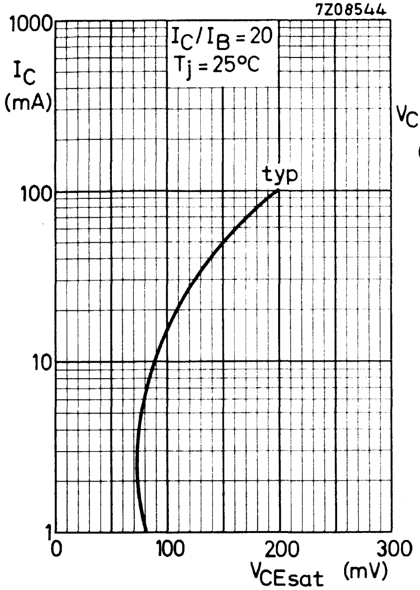

7Z08549
IC = Ic = 0
f = 1MHz
Tj = 25°C
Ce
(pF)
20
15
10
5
0
typ
0
2
4
VEB (V)
6

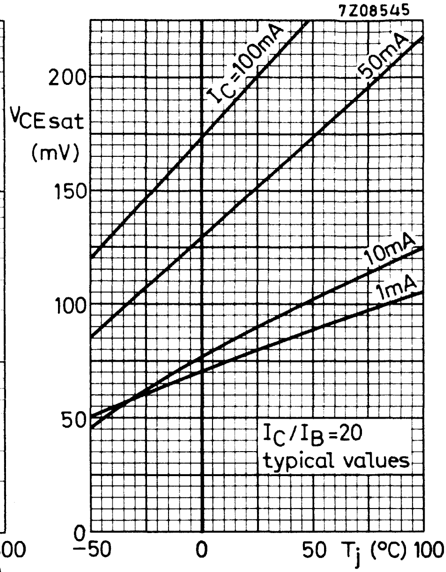

7Z08567
VCE=5V
Tj =25°C
typical values
800
hFE
600
400
200
0
BC148C
BC149C
BC147B
BC148B
BC149B
BC147A
BC148A
10−2
10−1
1
10
IC (mA)
102

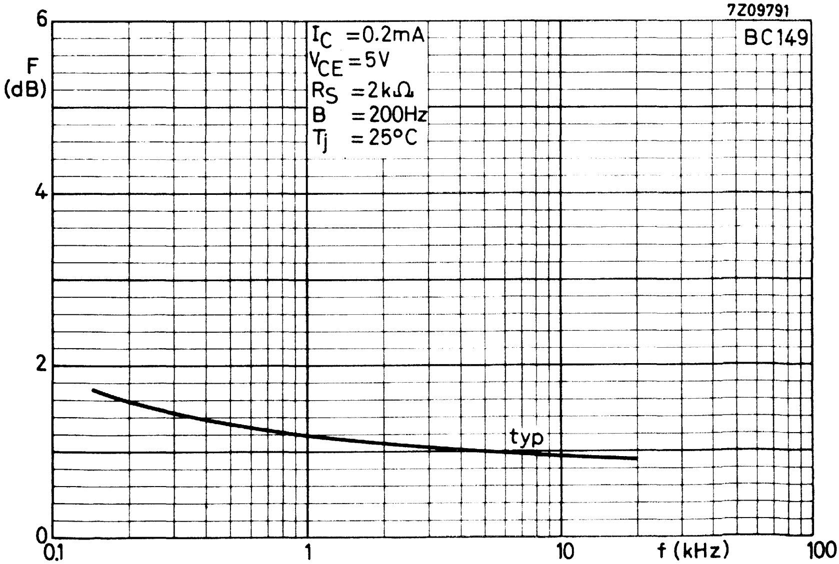

7Z08563
VCE=5V
Tj =25°C
f =35MHz
600
fT
(MHz)
400
200
0
typ
0.1
1
10
IC (mA)
100

Typical behaviour of base current versus junction temperature

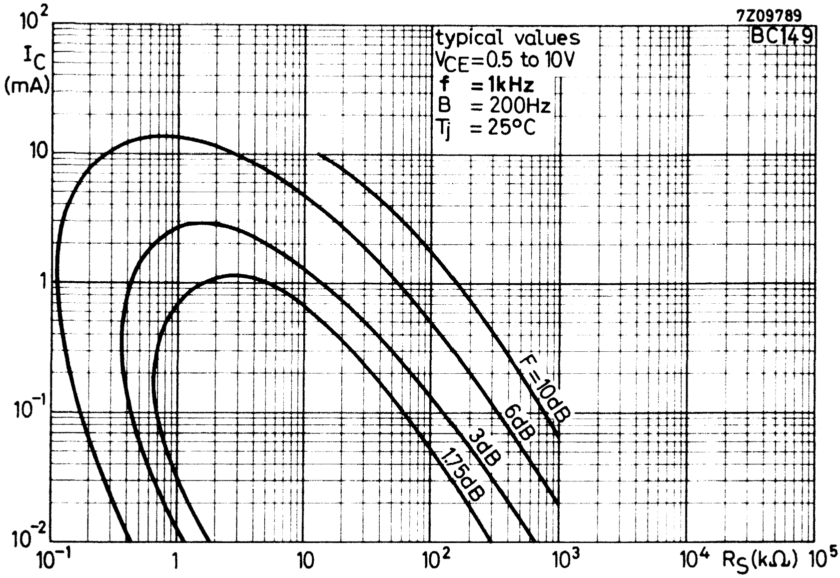


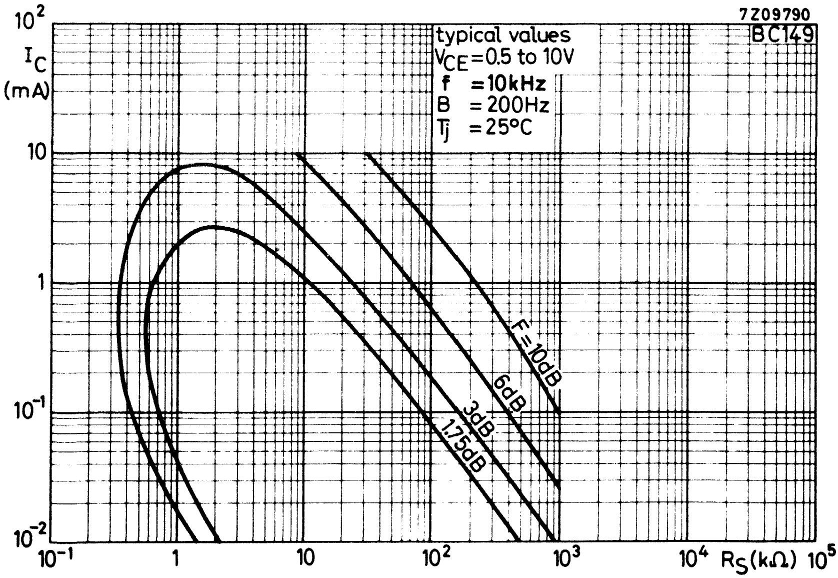

7Z08544
$I_C/I_B = 20$
$T_j = 25°C$
I_C (mA)
1000
100
10
1
typ
0
100
200
300
V_{CEsat} (mV)

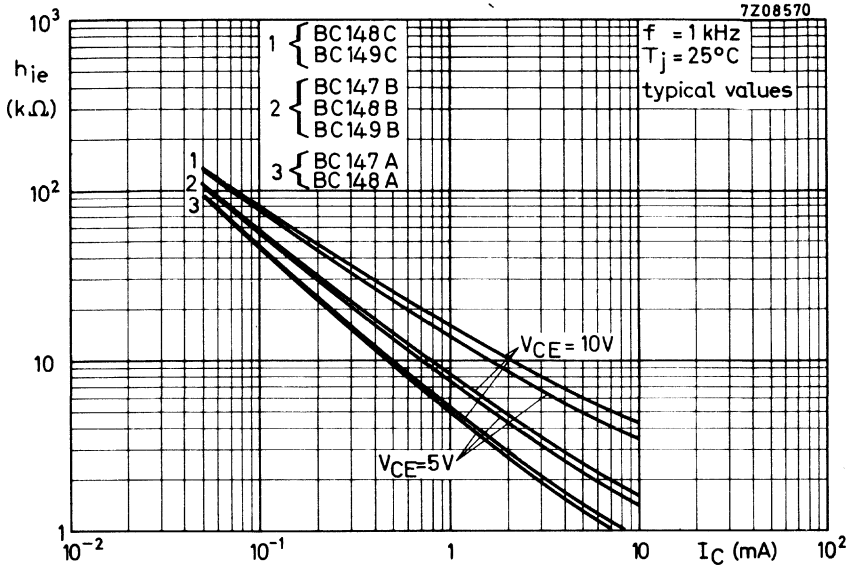

7Z08545
V_{CEsat} (mV)
200
150
100
50
0
I_C=100mA
50mA
10mA
1mA
I_C/I_B=20
typical values
−50
0
50
T_j (°C)
100

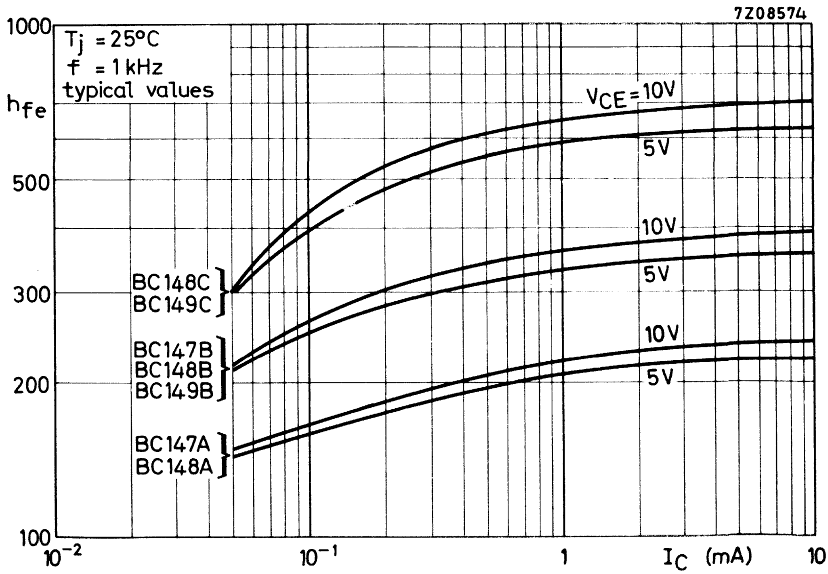

7Z09791
BC149
I_C =0.2mA
V_{CE} =5V
R_S =2kΩ
B =200Hz
T_j =25°C
F (dB)
6
4
2
0
typ
0.1
1
10
f (kHz)
100

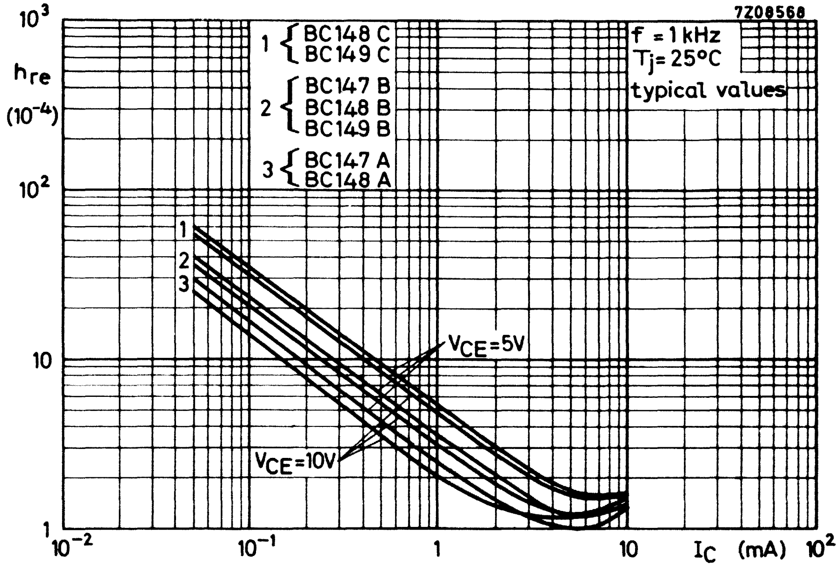
Curves of constant noise figure

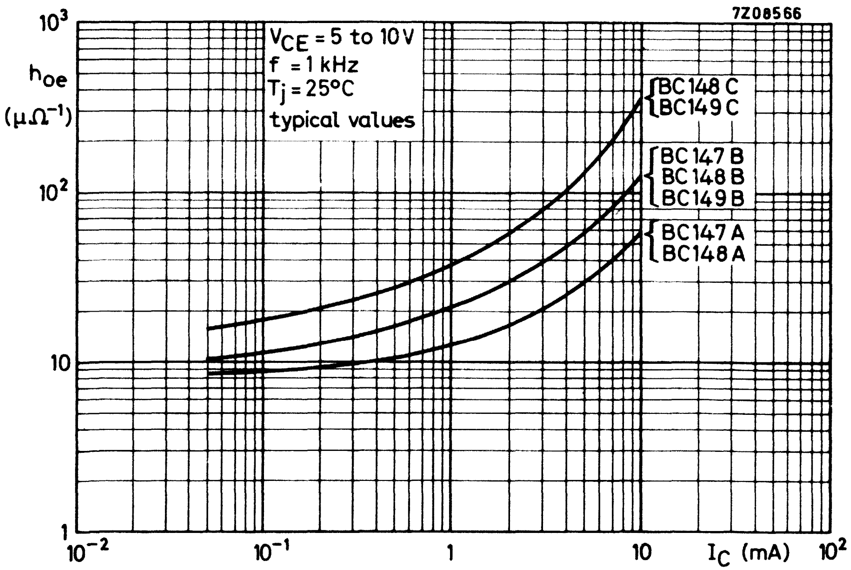


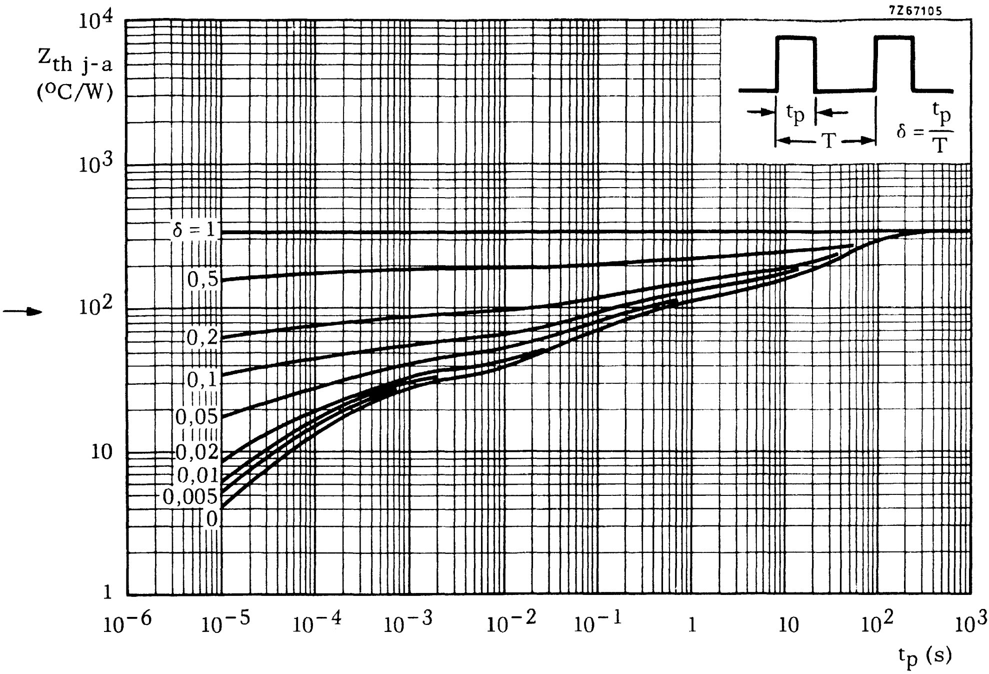



7Z08570
10^3
h_{ie}
(kΩ)
1 { BC148C BC149C
2 { BC147B BC148B BC149B
3 { BC147A BC148A
f = 1 kHz
T_j = 25°C
typical values
10^2
10
1
V_{CE} = 10V
V_{CE}=5V
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2


7Z08574
1000
T_j = 25°C
f = 1 kHz
typical values
h_{fe}
500
300
200
100
V_{CE} = 10V
5V
10V
5V
10V
5V
BC148C
BC149C
BC147B
BC148B
BC149B
BC147A
BC148A
10^{-2}
10^{-1}
1
I_C (mA)
10


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)


7Z67105
$Z_{th\ j-a}$ (°C/W)
10^4
10^3
10^2
10
1
δ = 1
0,5
0,2
0,1
0,05
0,02
0,01
0,005
0
t_p
T
$\delta = \frac{t_p}{T}$
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (s)

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.

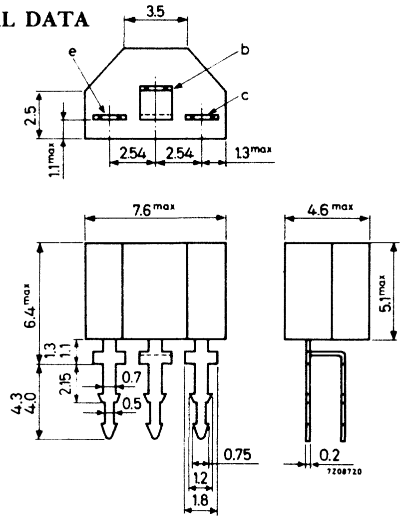
The BC158 is suitable for a multitude of low voltage applications e.g. driver stages or audio pre-amplifiers and in signal processing circuits of television receivers.

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.	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}	>	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

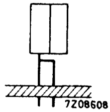
MECHANICAL DATA Dimensions in mm



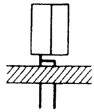
The envelope fulfils the accelerated damp heat test described in IEC publication 68-2 (test D, severity IV, 6 cycles).

MOUNTING INSTRUCTIONS

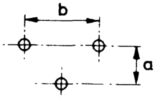
1. Thickness of printed board: max. 1.1 mm
   Hole diameter 0.77 to 0.83 mm



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 côllector)	$-V_{EBO}$	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 +125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

→ From junction to ambient in free air	$R_{th\ j-a}$	=	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 = 25 °C	$-I_{CBO}$	typ.	1	nA
		<	100	nA
T_j = 125 °C	$-I_{CBO}$	<	4	μA

Base-emitter voltage [1]

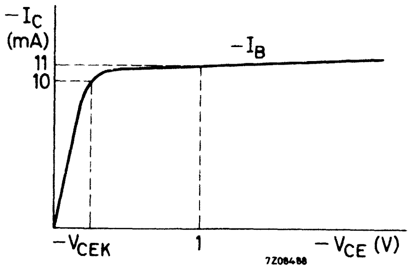
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	$-V_{BE}$	typ.	650	mV
		600 to	750	mV

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

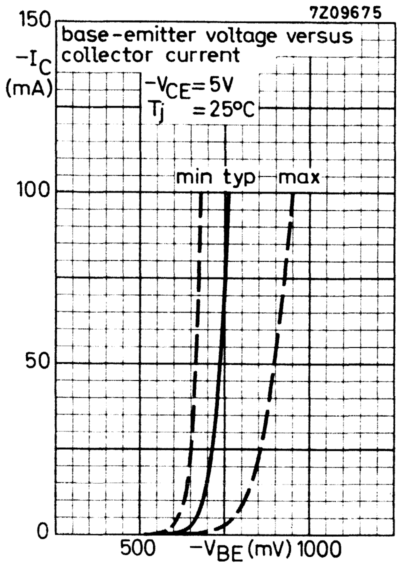
$-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.	150	MHz

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

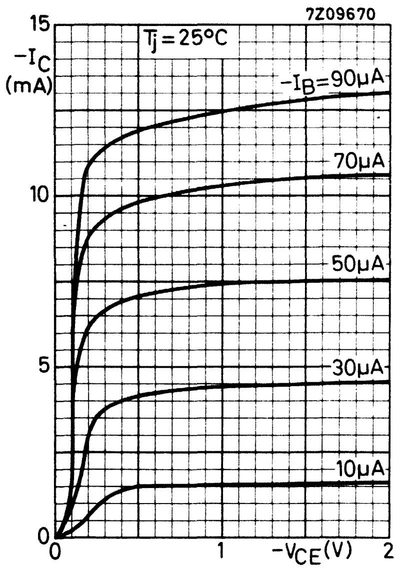
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

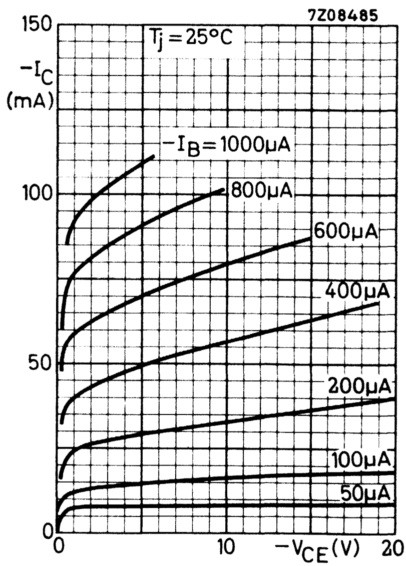
			BC157	BC158	BC159	
Small signal current gain at f = 1 kHz						
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{fe}	>	75	75	125	
		<	260	500	500	
Noise figure at R_S = 2 kΩ						
$-I_C$ = 200 μA; $-V_{CE}$ = 5 V						
f = 30 Hz to 15 kHz	F	typ.			1.2	dB
		<			4	dB
f = 1 kHz; B = 200 Hz	F	typ.	2	2	1	dB
		<	10	10	4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

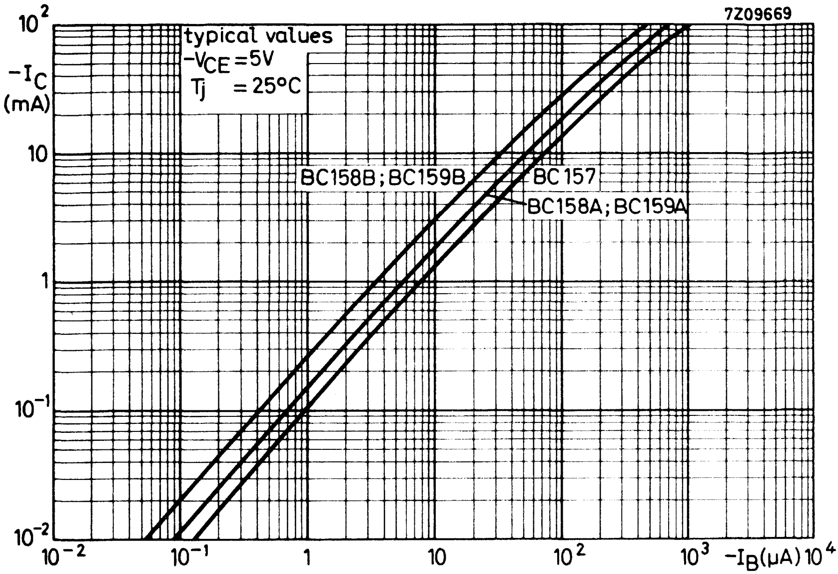
			BC157	BC158A BC159A	BC158B BC159B
D.C. current gain					
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{FE}	typ.	140	180	290
Small signal current gain at f = 1 kHz					
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{fe}	>	75	125	240
		<	260	260	500

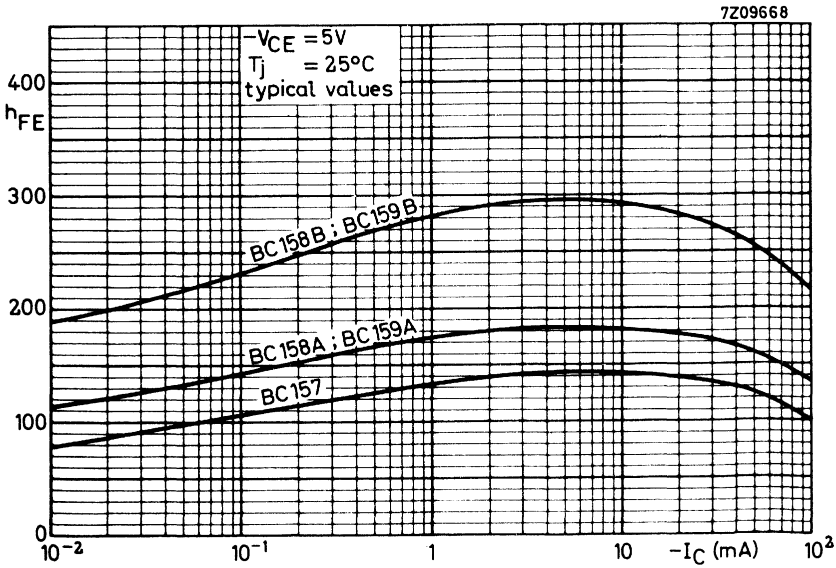


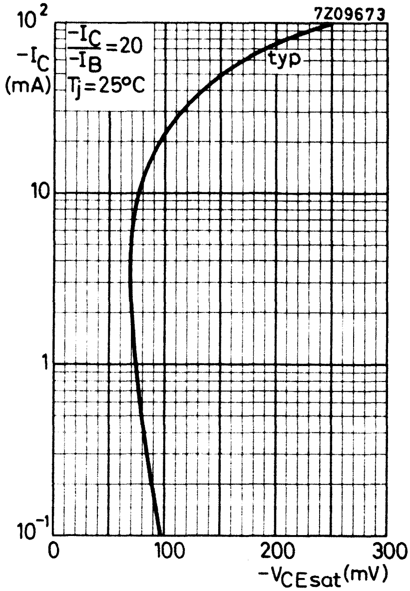
Typical behaviour of collector current versus collector-emitter voltage

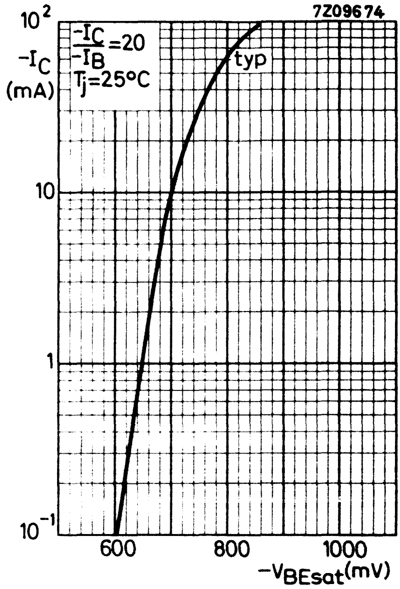


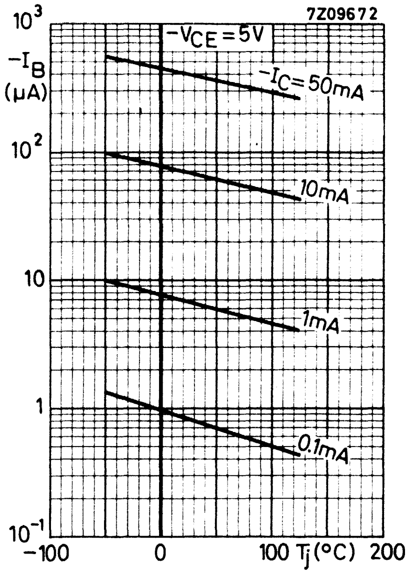



7Z09669
typical values
$-V_{CE}$ = 5V
T_j = 25°C
$-I_C$ (mA)
10^2
10
1
10^{-1}
10^{-2}
BC158B; BC159B
BC157
BC158A; BC159A
10^{-2}
10^{-1}
1
10
10^2
10^3
$-I_B$(μA) 10^4

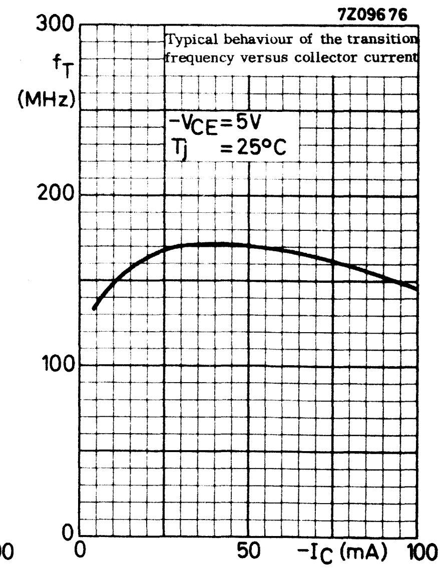

7Z09668
$-V_{CE}$ = 5V
T_j = 25°C
typical values
h_{FE}
400
300
200
100
0
BC158B; BC159B
BC158A; BC159A
BC157
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2



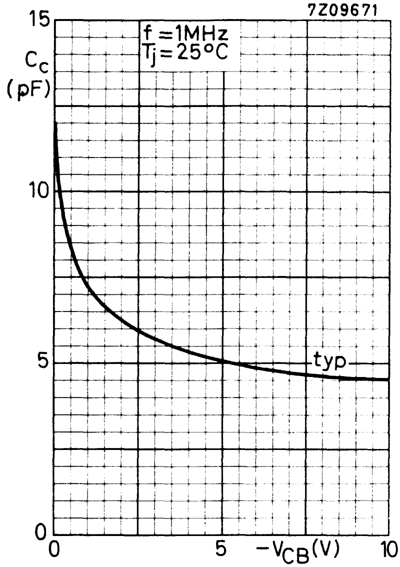


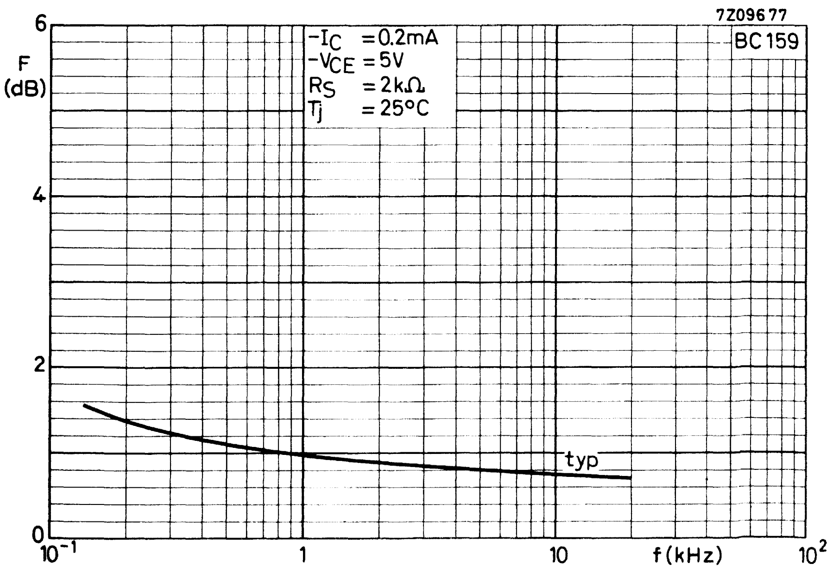


Typical behaviour of base current versus junction temperature

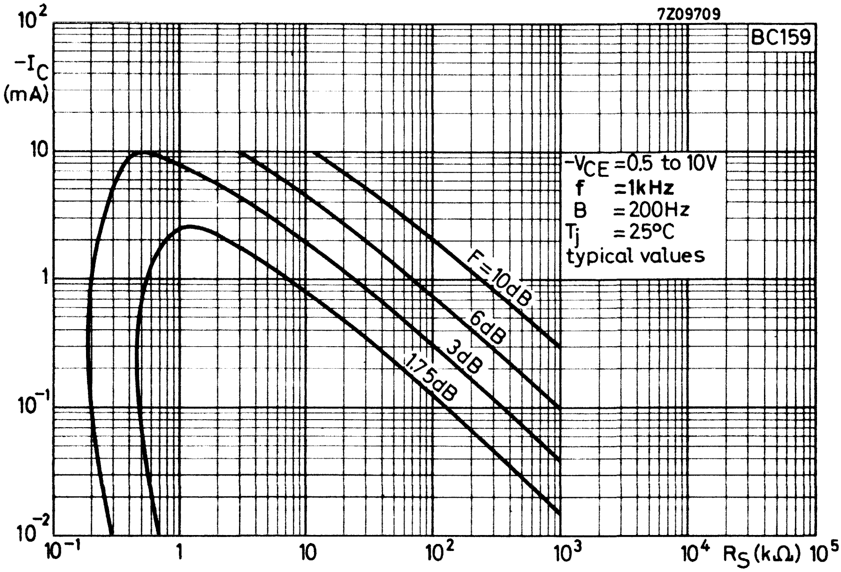


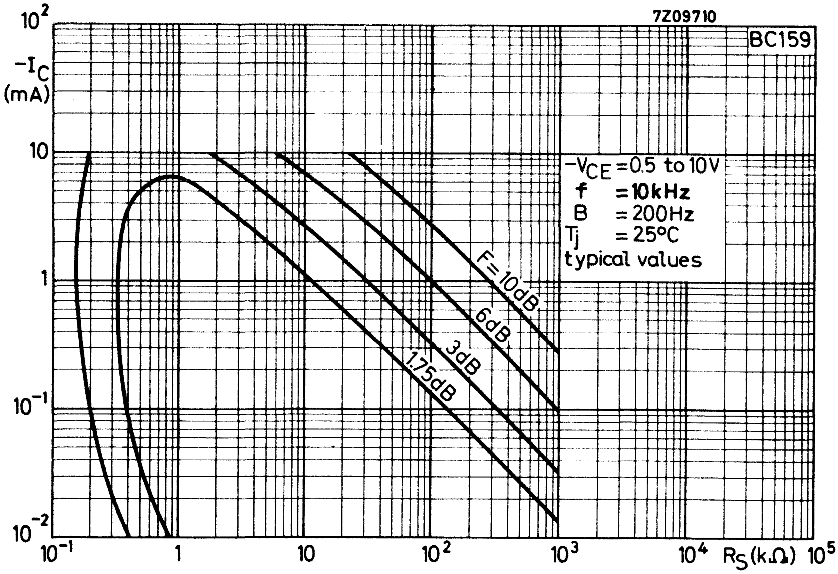
Typical behaviour of the transition frequency versus collector current

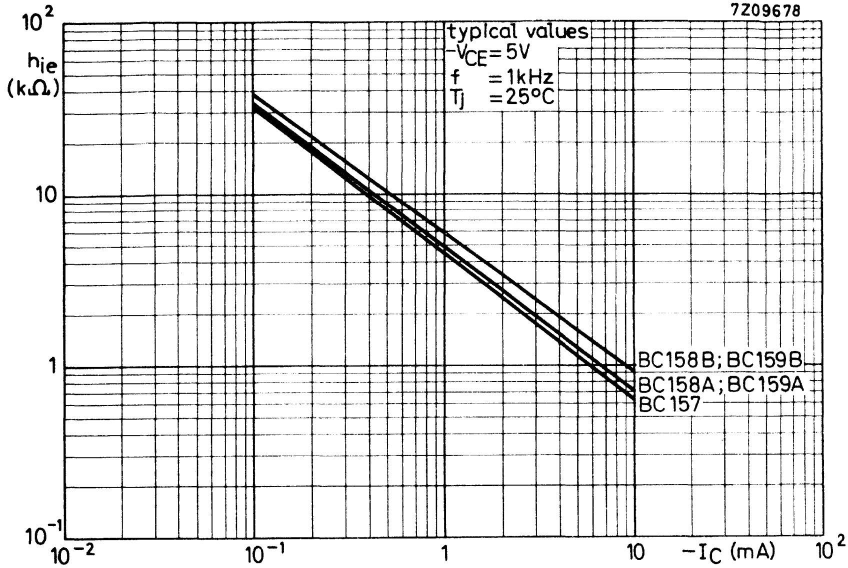

7Z09671
f = 1MHz
Tj = 25°C
Cc
(pF)
15
10
5
0
typ
0
5
−VCB(V)
10

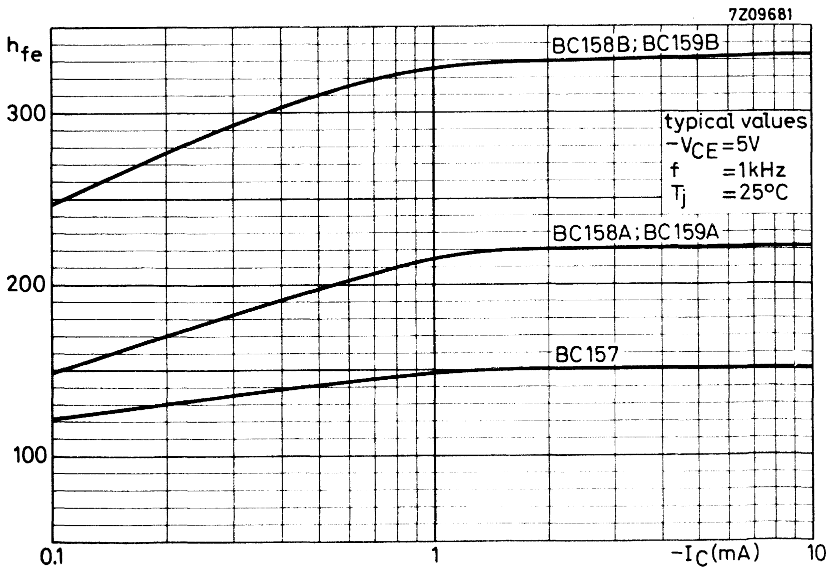

7Z09677
BC 159
−IC = 0.2mA
−VCE = 5V
RS = 2kΩ
Tj = 25°C
F
(dB)
6
4
2
0
typ
10−1
1
10
f (kHz)
10²

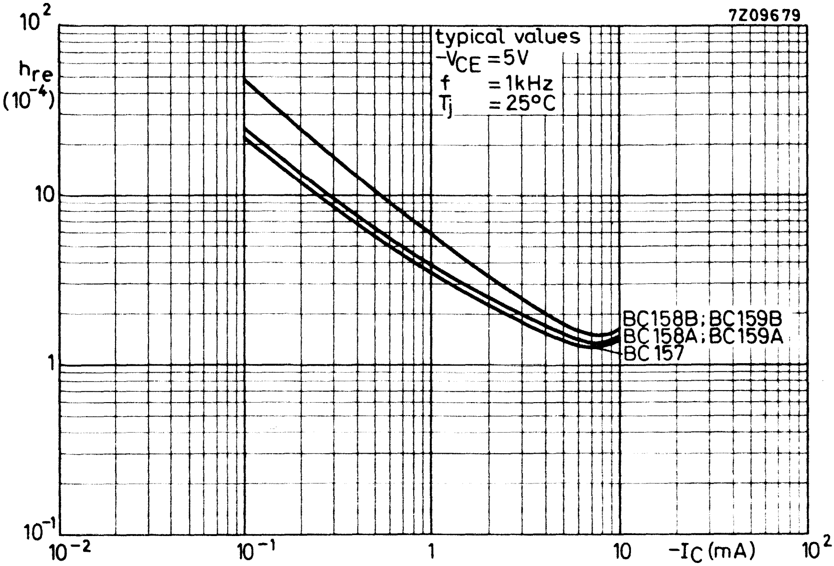
Curves of constant noise figure

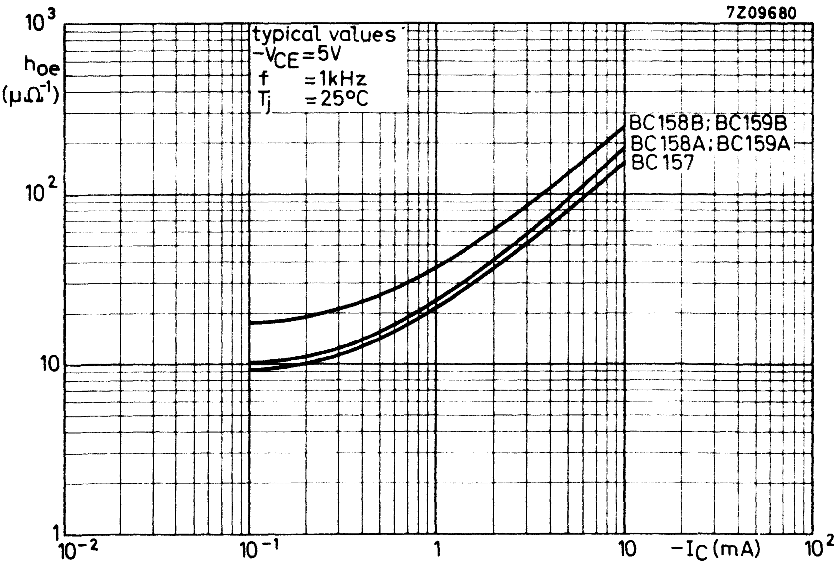


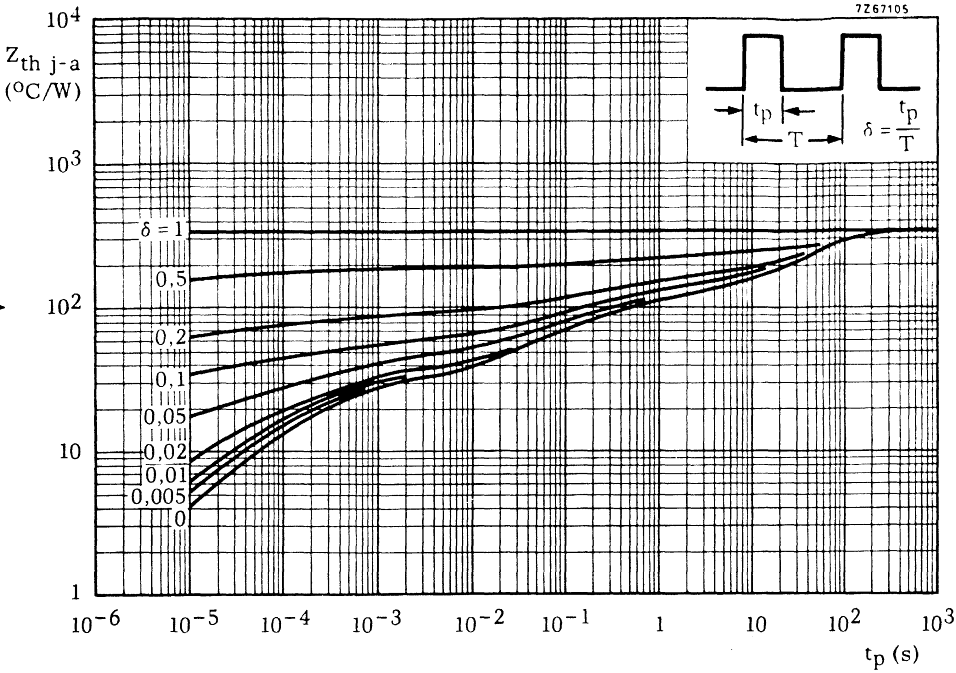



7Z09678
10^2
h_{ie} (kΩ)
10
1
10^{-1}
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
BC158B; BC159B
BC158A; BC159A
BC157


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


7Z67105
10^4
$Z_{th\ j-a}$ (°C/W)
10^3
10^2
10
1
δ = 1
0,5
0,2
0,1
0,05
0,02
0,01
0,005
0
t_p
T
$\delta = \frac{t_p}{T}$
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (s)

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.

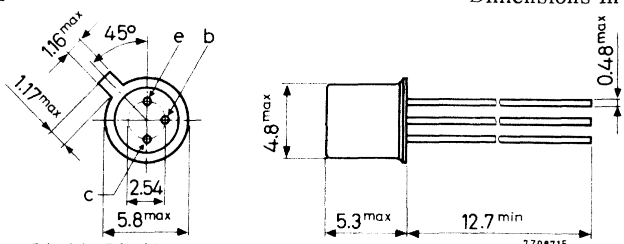
QUICK REFERENCE DATA

			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.

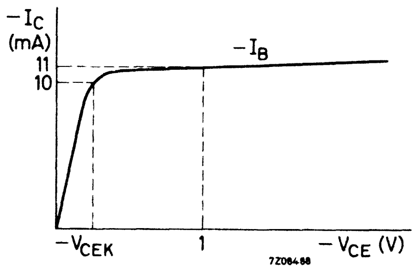
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

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	

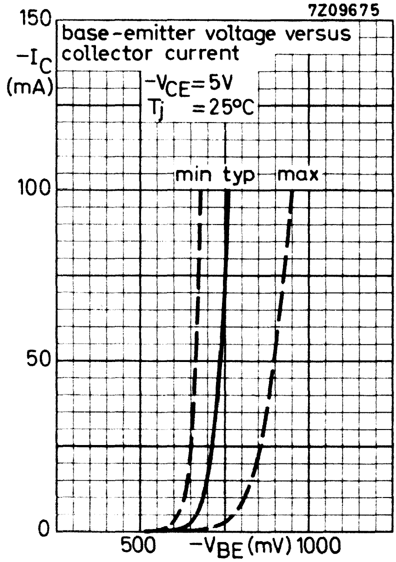
Noise figure at R_S = 2 kΩ

$-I_C$ = 200 μA; $-V_{CE}$ = 5 V

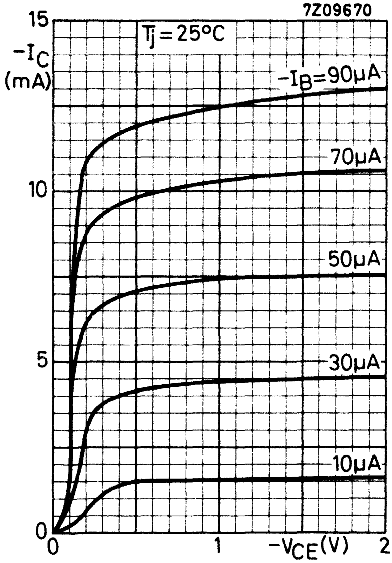
			BC177	BC178	BC179	
f = 30 Hz to 15 kHz	F	typ.			1.2	dB
		<			4	dB
f = 1 kHz; B = 200 Hz	F	typ.	2	2	1	dB
		<	10	10	4	dB

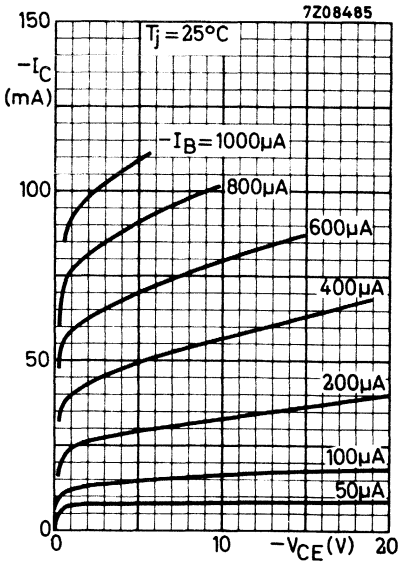
CHARACTERISTICS (continued)

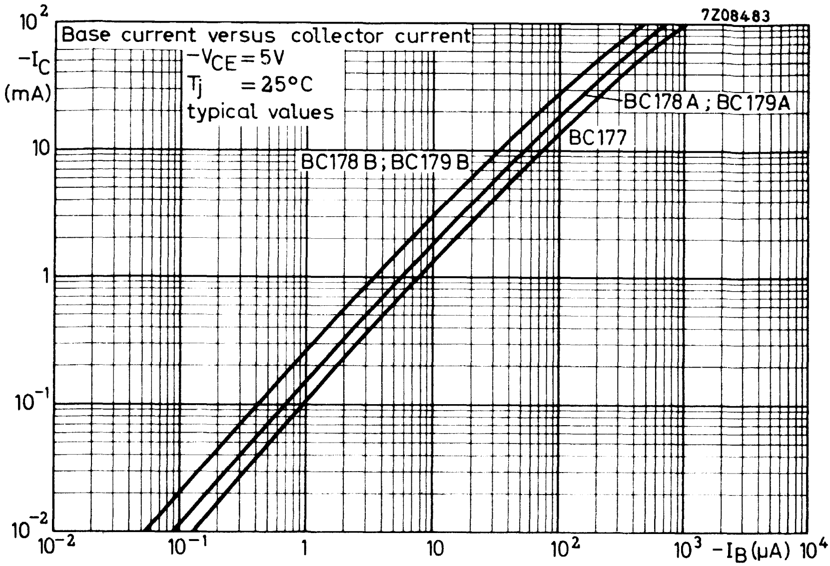
			BC177	BC178A BC179A	BC178B BC179B
D.C. current gain					
$-I_C = 2$ mA; $-V_{CE} = 5$ V	h_{FE}	typ.	140	180	290
Small signal current gain at f = 1 kHz					
$-I_C = 2$ mA; $-V_{CE} = 5$ V	h_{fe}	>	75	125	240
		<	260	260	500

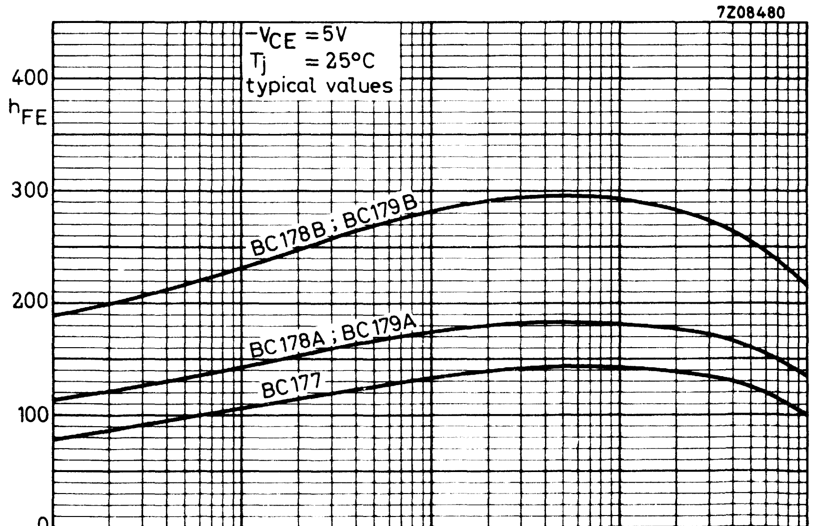


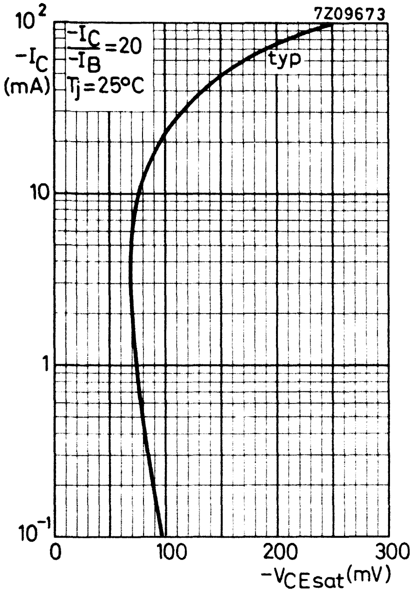
Typical behaviour of collector current versus collector-emitter voltage

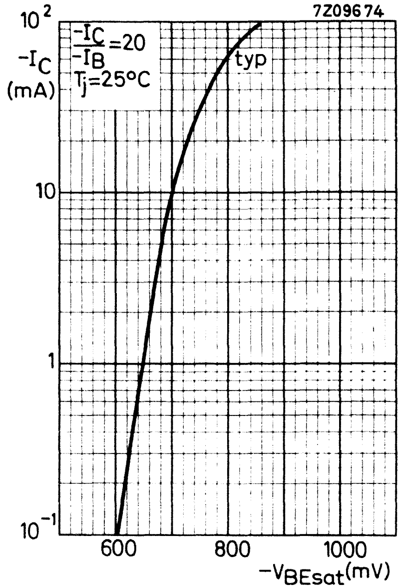


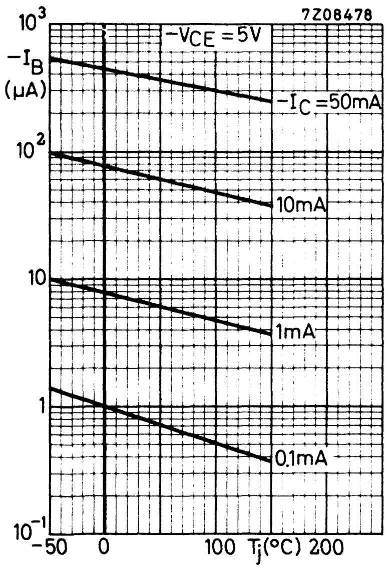



7Z08483
Base current versus collector current
$-V_{CE} = 5V$
$T_j = 25°C$
typical values
$-I_C$ (mA)
BC178 A ; BC179 A
BC177
BC178 B ; BC179 B
$-I_B$ (μA)

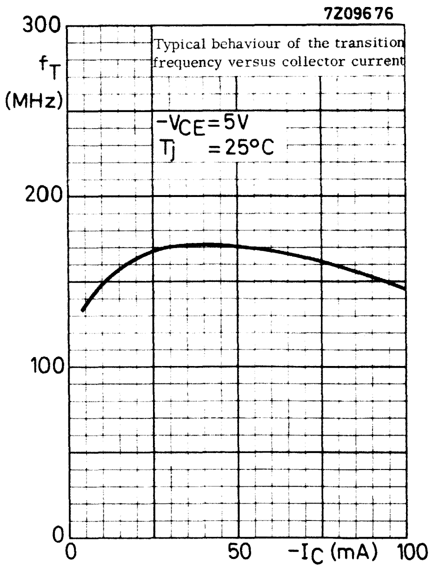

7Z08480
$-V_{CE} = 5V$
$T_j = 25°C$
typical values
h_{FE}
BC178B ; BC179B
BC178A ; BC179A
BC177
$-I_C$ (mA)



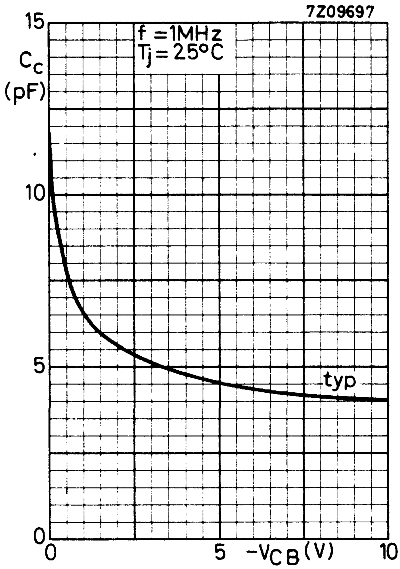


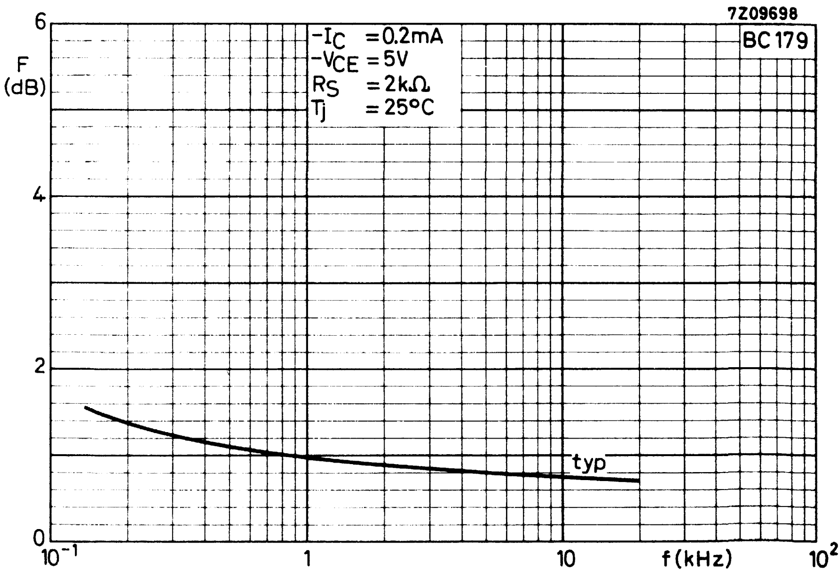


Typical behaviour of base current versus junction temperature

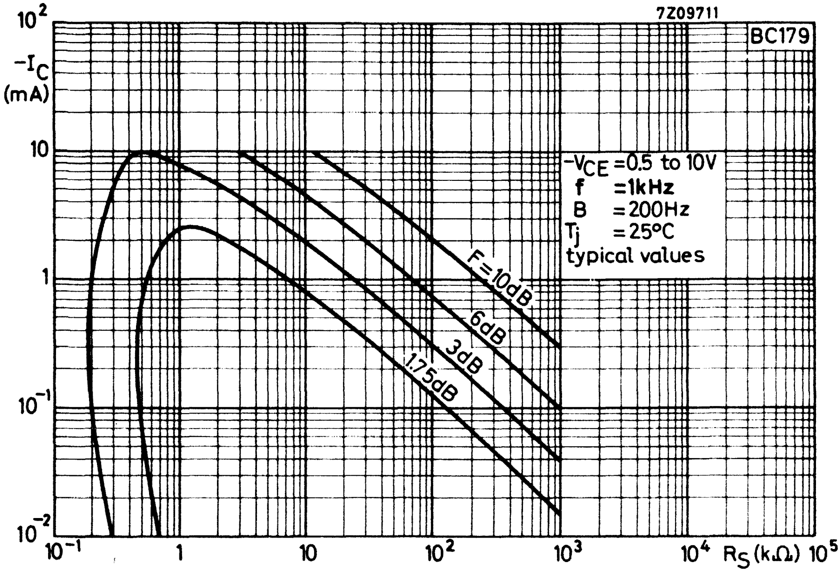


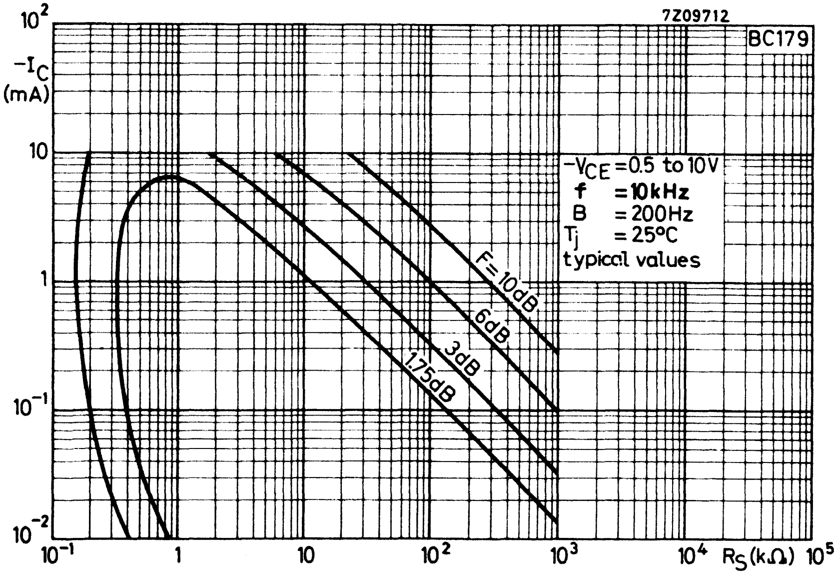
Typical behaviour of the transition frequency versus collector current

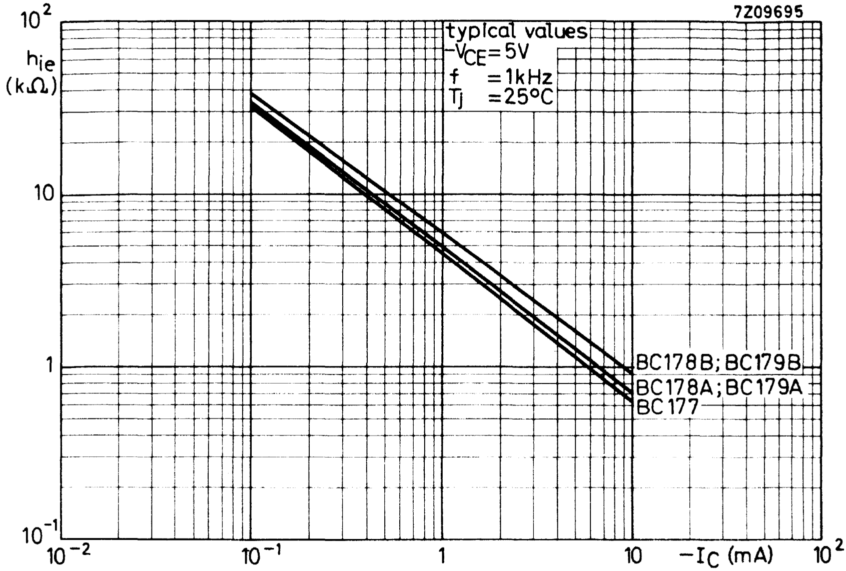

7Z09697
f = 1MHz
Tj = 25°C
Cc
(pF)
15
10
5
0
typ
0
5
-VCB (V)
10

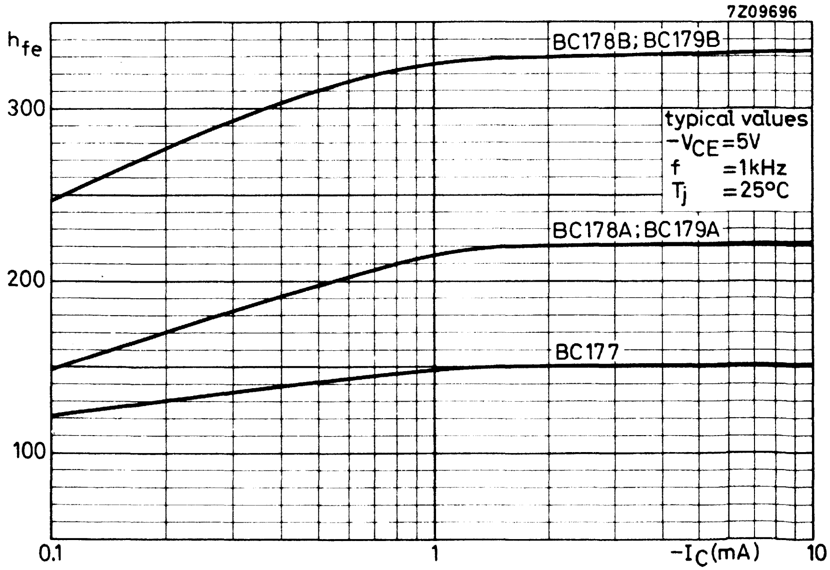

7Z09698
BC 179
-IC = 0.2mA
-VCE = 5V
RS = 2kΩ
Tj = 25°C
F
(dB)
6
4
2
0
typ
10⁻¹
1
10
f (kHz)
10²

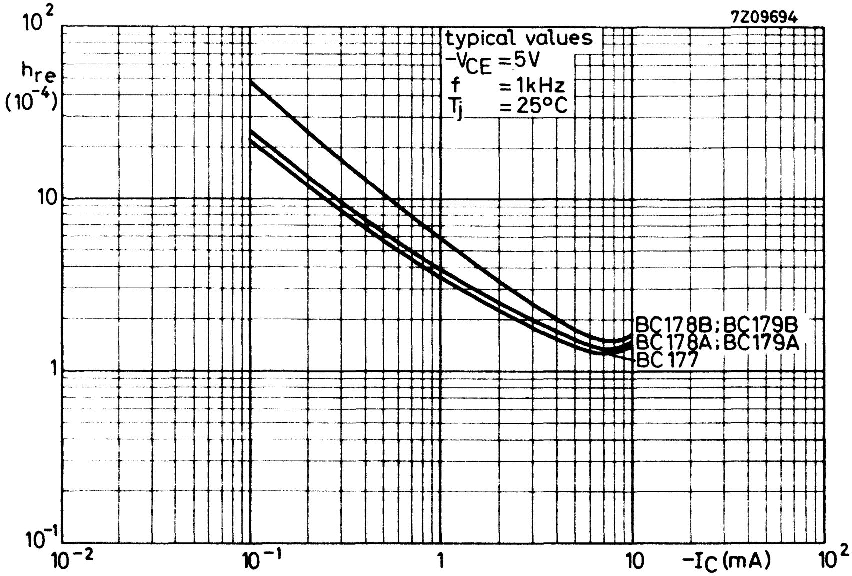
Curves of constant noise figure

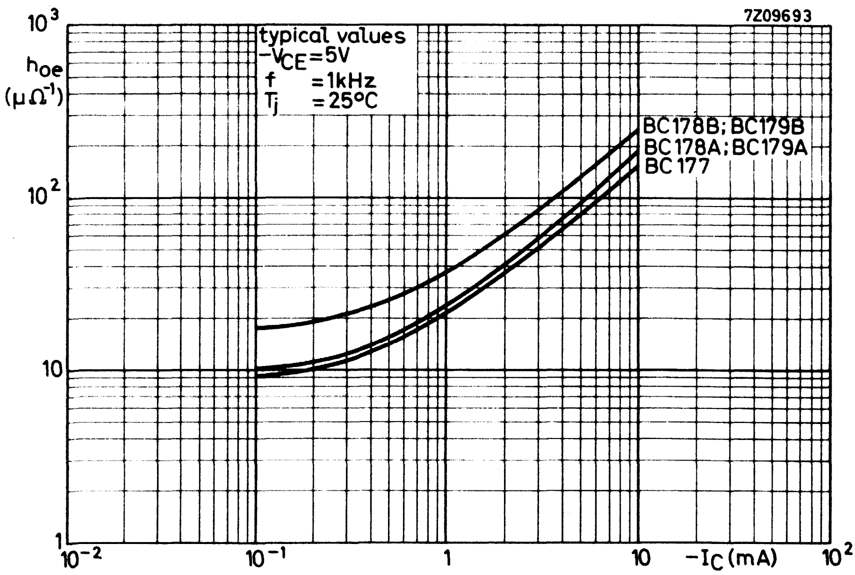


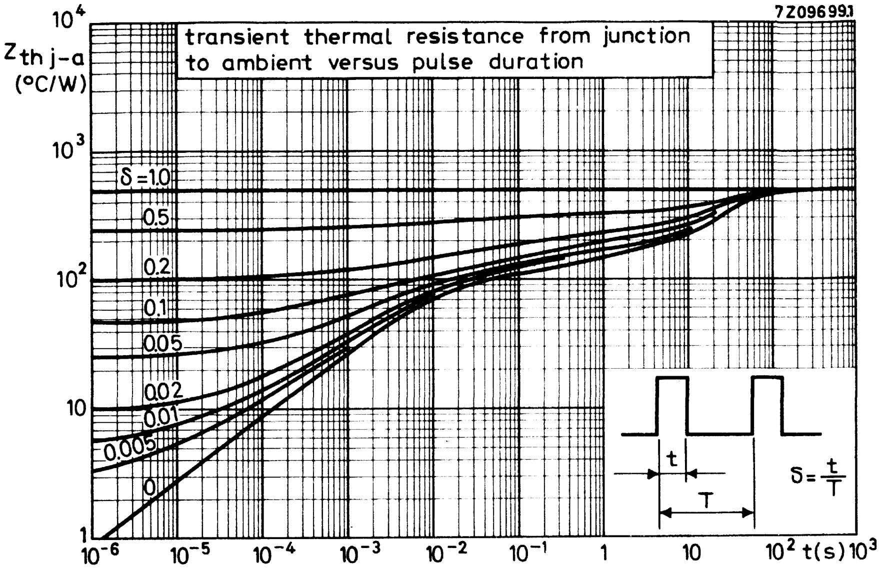



7Z09695
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
h_{ie} (kΩ)
10^2
10
1
10^{-1}
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2
BC178B; BC179B
BC178A; BC179A
BC177


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


7Z09694
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
h_{re} (10^{-4})
BC178B; BC179B
BC178A; BC179A
BC 177
$-I_C$ (mA)
10^2
10
1
10^{-1}
10^{-2}
10^{-1}
1
10
10^2


7Z09693
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
h_{oe} ($\mu\Omega^{-1}$)
BC178B; BC179B
BC178A; BC179A
BC 177
$-I_C$ (mA)
10^3
10^2
10
1
10^{-2}
10^{-1}
1
10
10^2



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

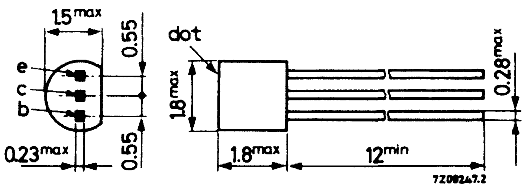
P-N-P transistor in a microminiature plastic envelope. The transistor is designed for use in hearing aids, watches and other equipment where small size is of paramount importance.

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

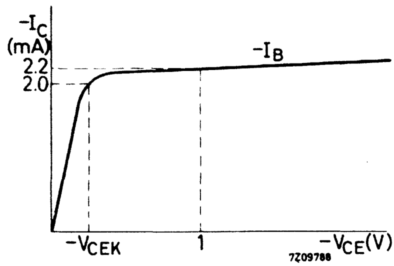
$I_E = 0$; $-V_{CB} = 20$ V	$-I_{CBO}$	<	100	nA
$I_E = 0$; $-V_{CB} = 20$ V; $T_j = 125$ °C	$-I_{CBO}$	<	1	μA

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



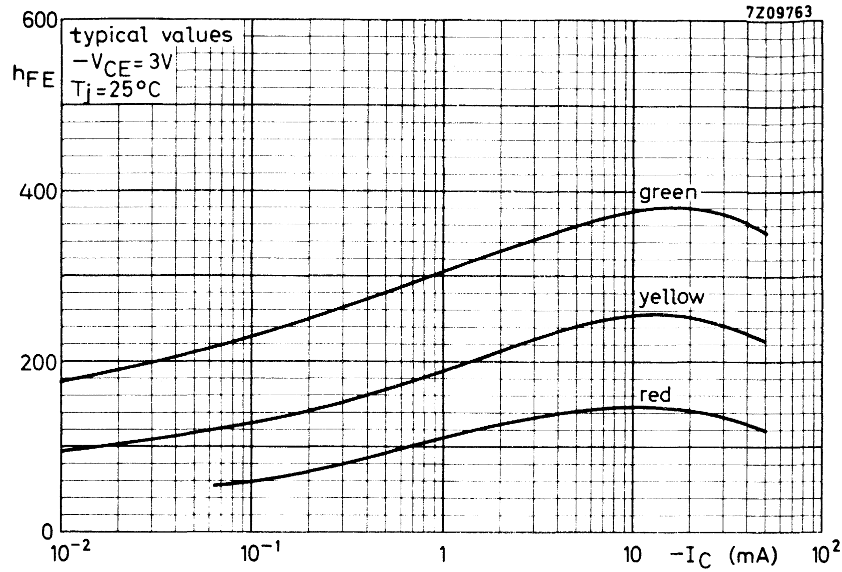
Collector capacitance at f = 1 MHz

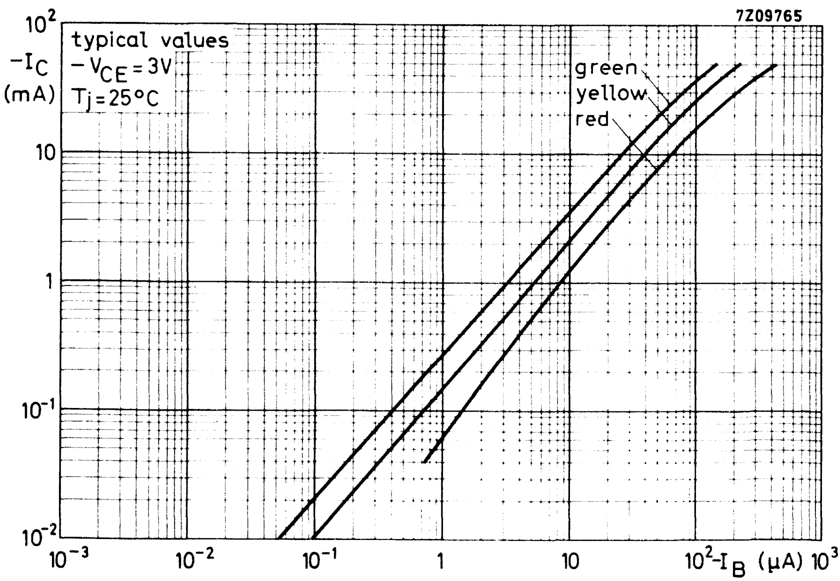
$I_E = I_e = 0$; $-V_{CB} = 5$ V	C_c	typ.	5	pF

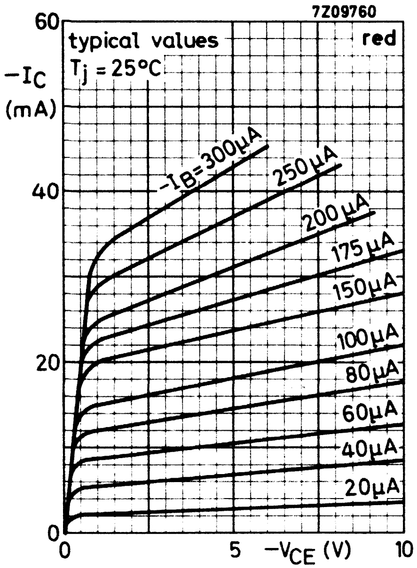
Transition frequency at f = 100 MHz

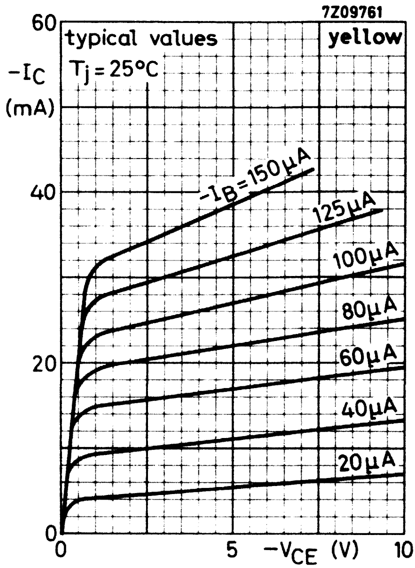
$-I_C = 2$ mA; $-V_{CE} = 5$ V	f_T	typ.	90	MHz

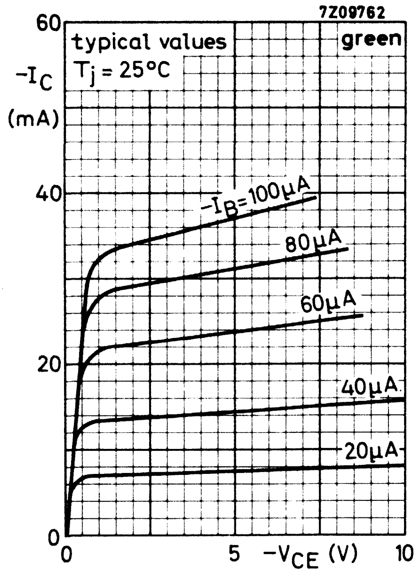
D.C. current gain			red	yellow	green	
$-I_C = 0.2$ mA; $-V_{CE} = 0.5$ V	h_{FE}	typ.	75	140	250	
			50 to 105	85 to 200	165 to 400	
$-I_C = 2$ mA; $-V_{CE} = 1$ V	h_{FE}	>	60	100	175	
h parameters at f = 1 kHz						
$-I_C = 0.2$ mA; $-V_{CE} = 0.5$ V						
Input impedance	h_{ie}	typ.	12	15	20	kΩ
Reverse 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

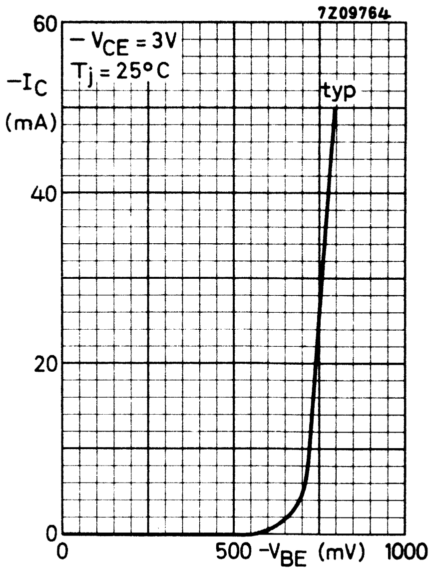

7Z09763
typical values
$-V_{CE} = 3V$
$T_j = 25°C$
h_{FE}
600
400
200
0
green
yellow
red
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2


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
typical values
red
Tj = 25°C
−IC (mA)
−IB=300µA
250µA
200µA
175µA
150µA
100µA
80µA
60µA
40µA
20µA
60
40
20
0
0
5
10
−VCE (V)


7Z09761
typical values
yellow
Tj = 25°C
−IC (mA)
−IB=150µA
125µA
100µA
80µA
60µA
40µA
20µA
60
40
20
0
0
5
10
−VCE (V)


7Z09762
typical values
green
Tj = 25°C
−IC (mA)
−IB=100µA
80µA
60µA
40µA
20µA
60
40
20
0
0
5
10
−VCE (V)


7Z09764
− VCE = 3V
Tj = 25°C
−IC (mA)
typ
60
40
20
0
0
500
1000
−VBE (mV)

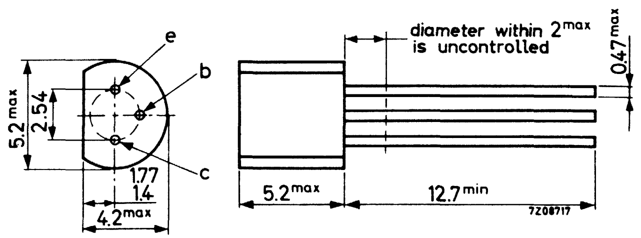
A.F. SILICON PLANAR EPITAXIAL TRANSISTORS

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	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



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}	<	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

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

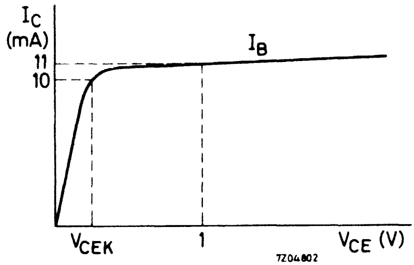
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

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

			BC237	BC238	BC239	
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

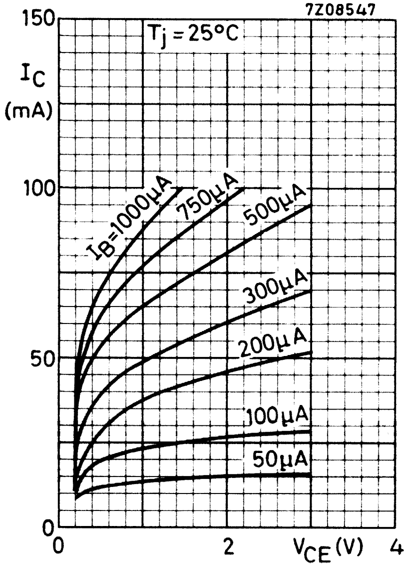
[1]) V_{BEsat} decreases by about 1.7 mV/°C with increasing temperature.

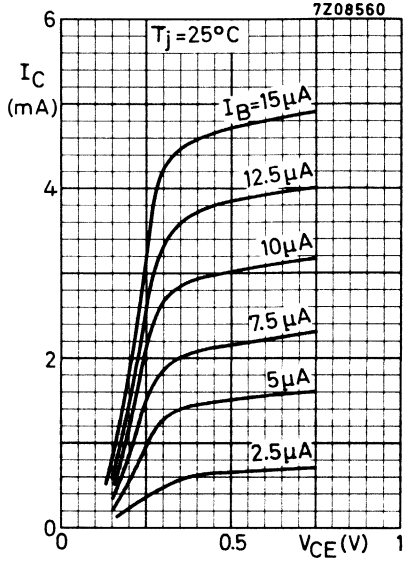
CHARACTERISTICS (continued)

T_j = 25 °C unless otherwise specified

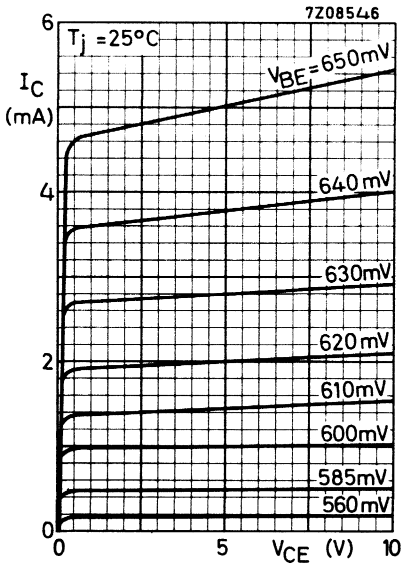
			BC237A BC238A	BC237B BC238B BC239B	BC238C BC239C	
D.C. current gain						
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	typ.	90	150	270	
		>	110	200	420	
I_C = 2 mA; V_{CE} = 5 V	h_{FE}	typ.	180	290	520	
		<	220	450	800	
h parameters at f = 1 kHz (common emitter)						
I_C = 2 mA; V_{CE} = 5 V						
		>	1.6	3.2	6	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	$\mu\Omega^{-1}$

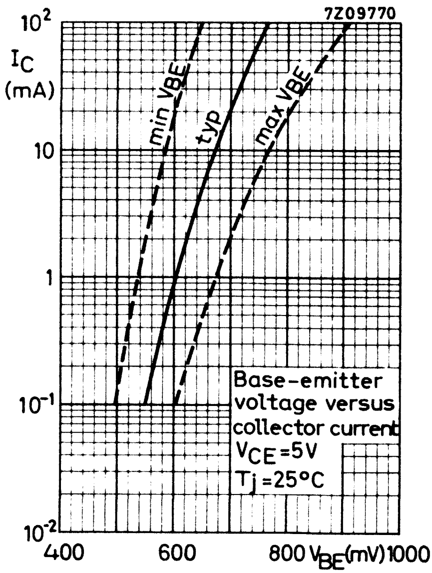
Typical behaviour of collector current versus collector-emitter voltage

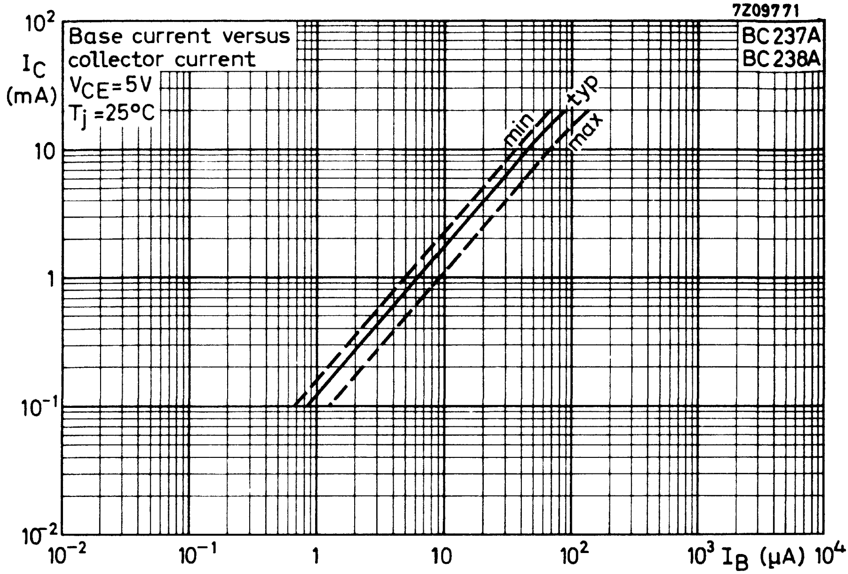


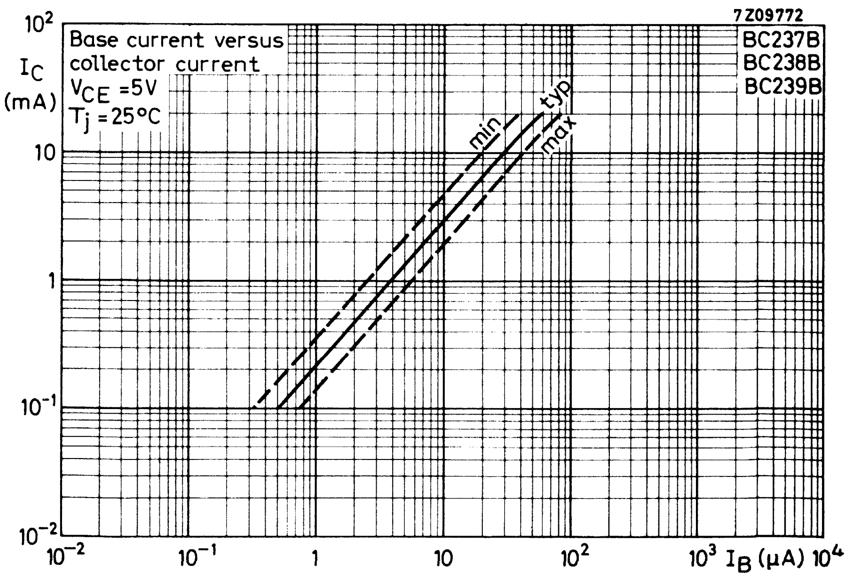


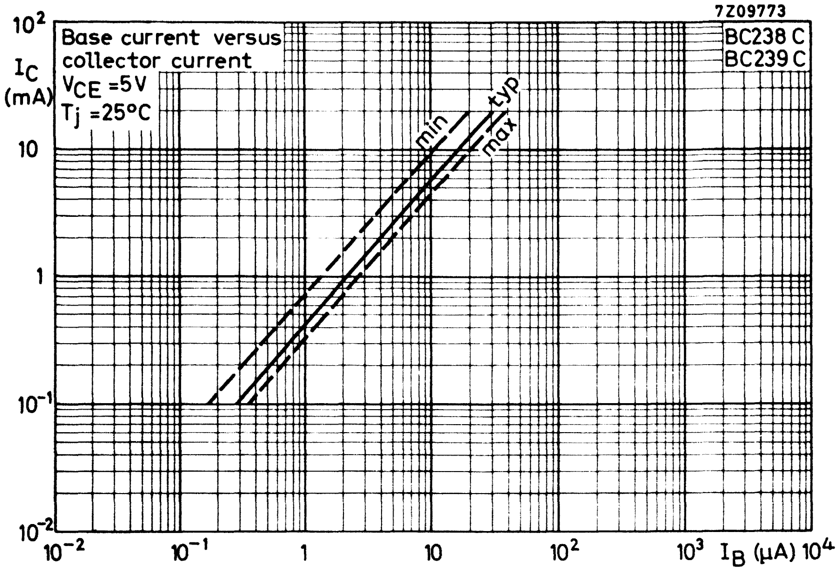
Typical behaviour of collector current versus collector-emitter voltage

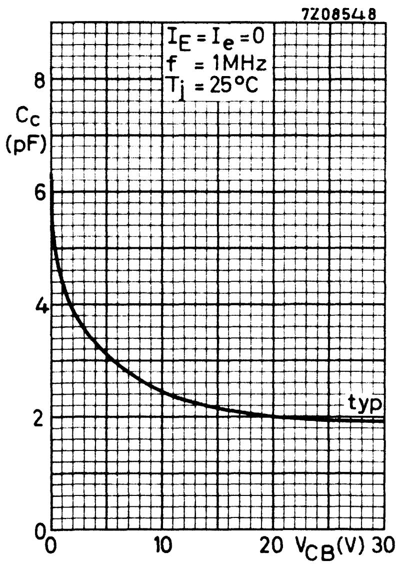


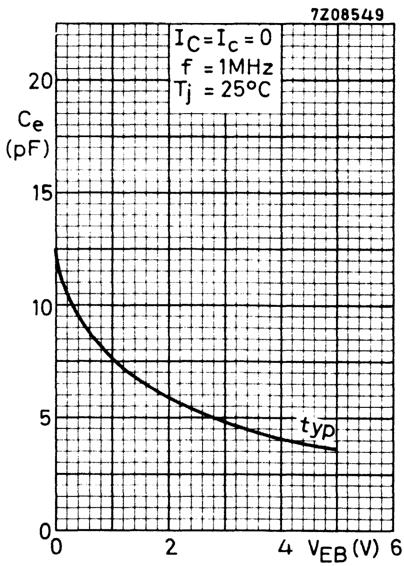


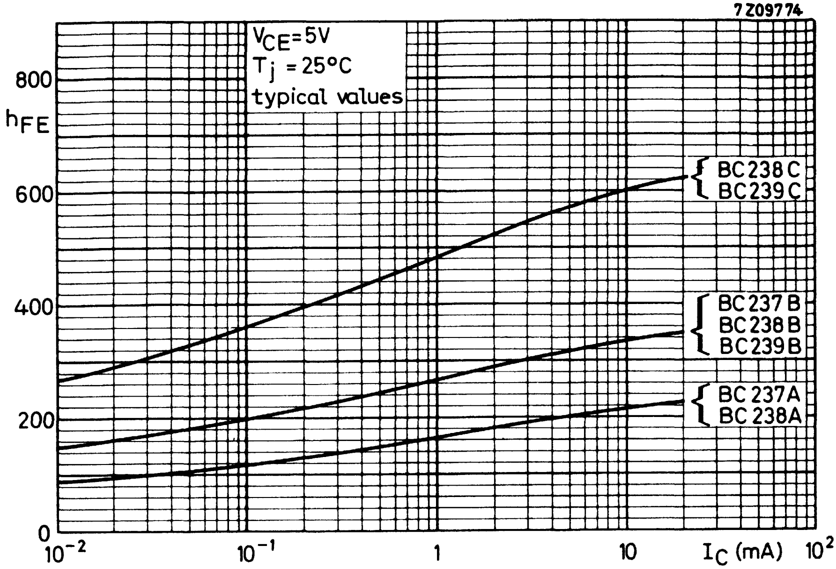

7Z09771
BC237A
BC238A
Base current versus collector current
V_{CE} = 5 V
T_j = 25 °C
I_C (mA)
10^2
10
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (μA)
10^4
min
typ
max

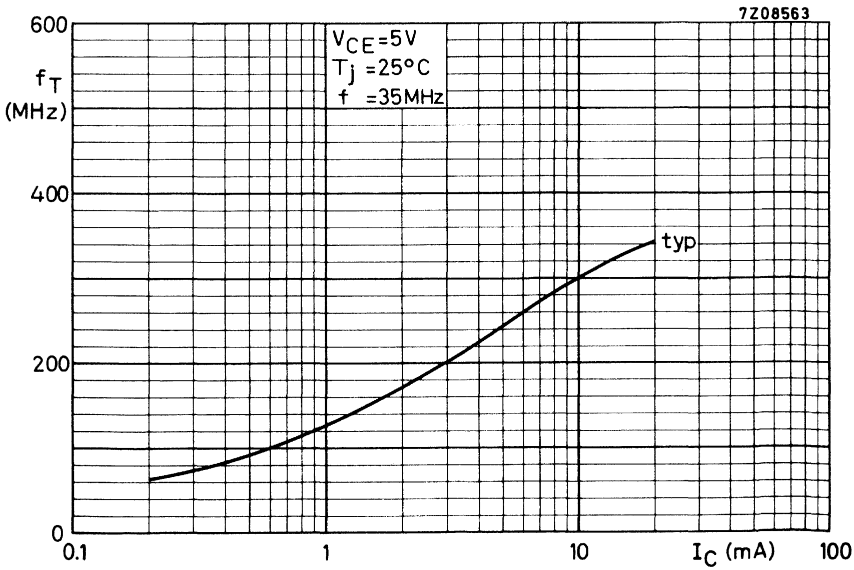

7Z09772
BC237B
BC238B
BC239B
Base current versus collector current
V_{CE} = 5 V
T_j = 25 °C
I_C (mA)
10^2
10
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (μA)
10^4
min
typ
max


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}
min
typ
max
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (μA)
10^4

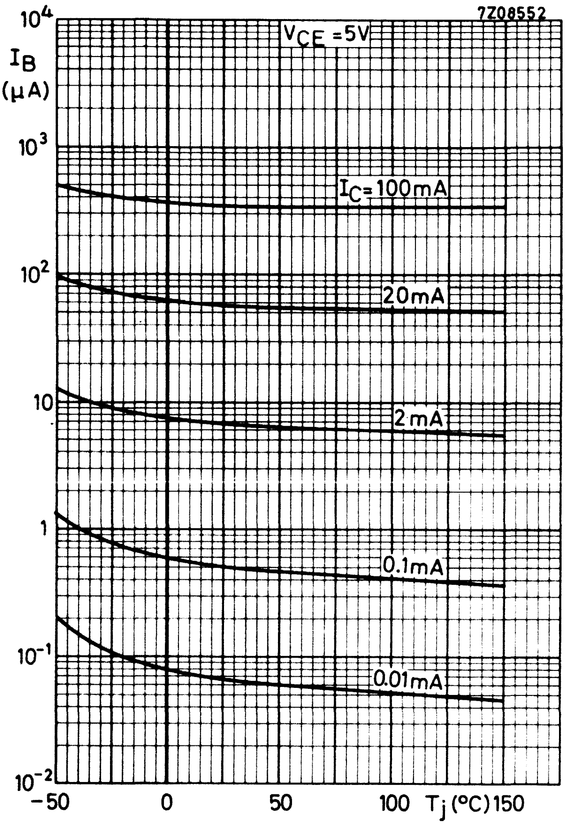

7Z08548
$I_E = I_e = 0$
f = 1 MHz
T_j = 25 °C
C_c (pF)
8
6
4
2
0
typ
0
10
20
V_{CB} (V)
30

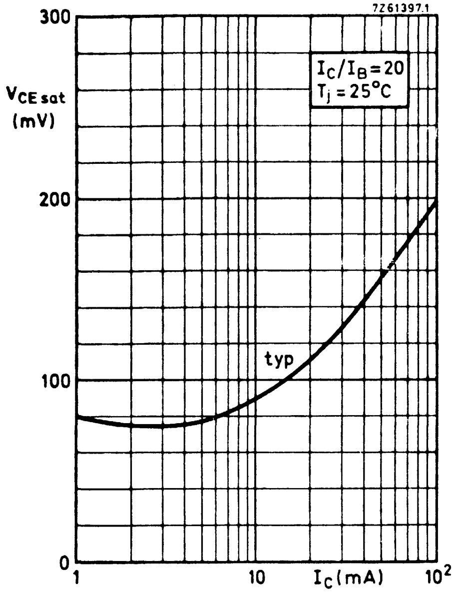

7Z08549
$I_C = I_c = 0$
f = 1 MHz
T_j = 25 °C
C_e (pF)
20
15
10
5
0
typ
0
2
4
V_{EB} (V)
6

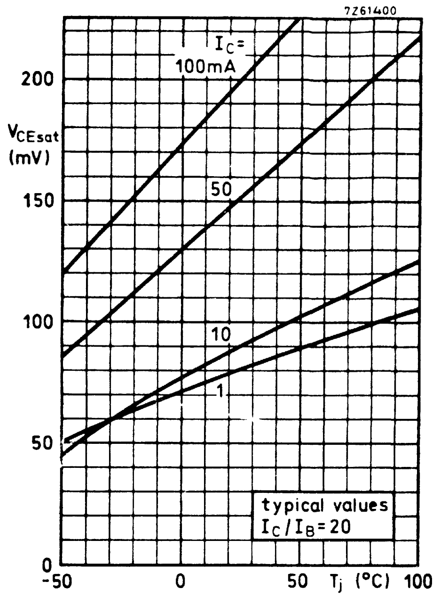

7Z09774
V_{CE}=5V
T_j = 25°C
typical values
800
h_{FE}
600
400
200
0
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2
BC238C
BC239C
BC237B
BC238B
BC239B
BC237A
BC238A

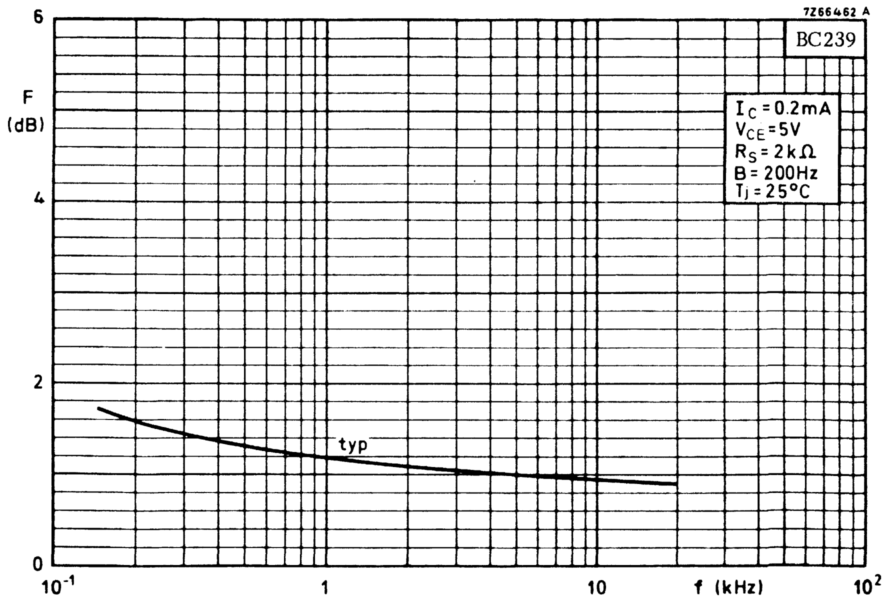

7Z08563
V_{CE}=5V
T_j =25°C
f =35MHz
600
f_T
(MHz)
400
200
0
0.1
1
10
I_C (mA)
100
typ

Typical behaviour of base current versus junction temperature

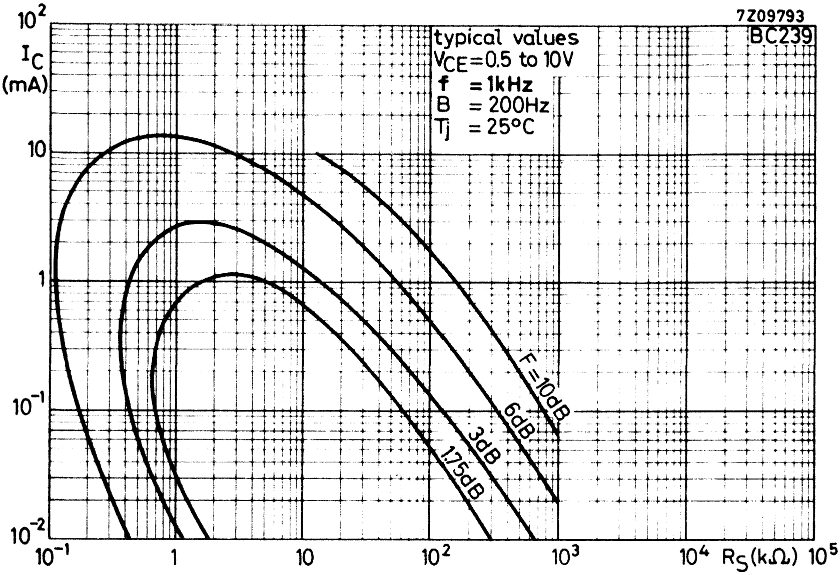


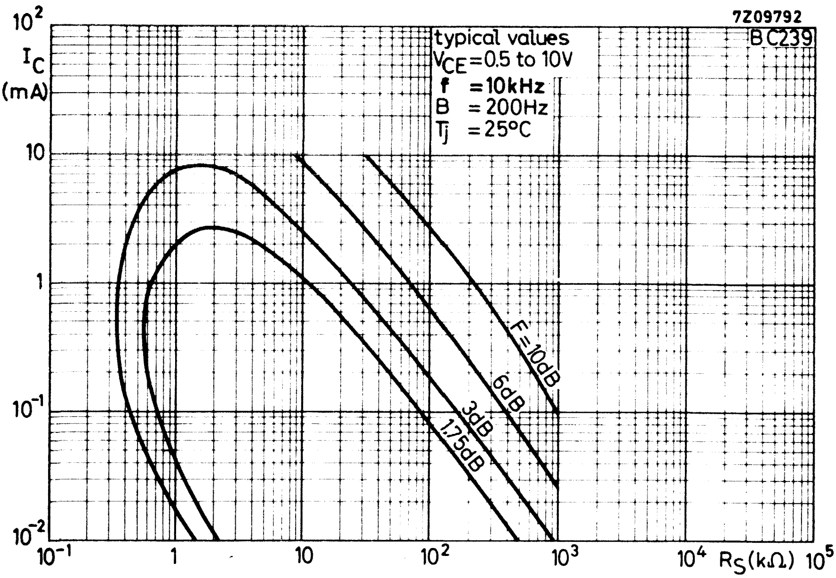

7Z61397.1
300
200
100
0
$V_{CE sat}$
(mV)
$I_C/I_B = 20$
$T_j = 25°C$
typ
1
10
I_C (mA)
10^2

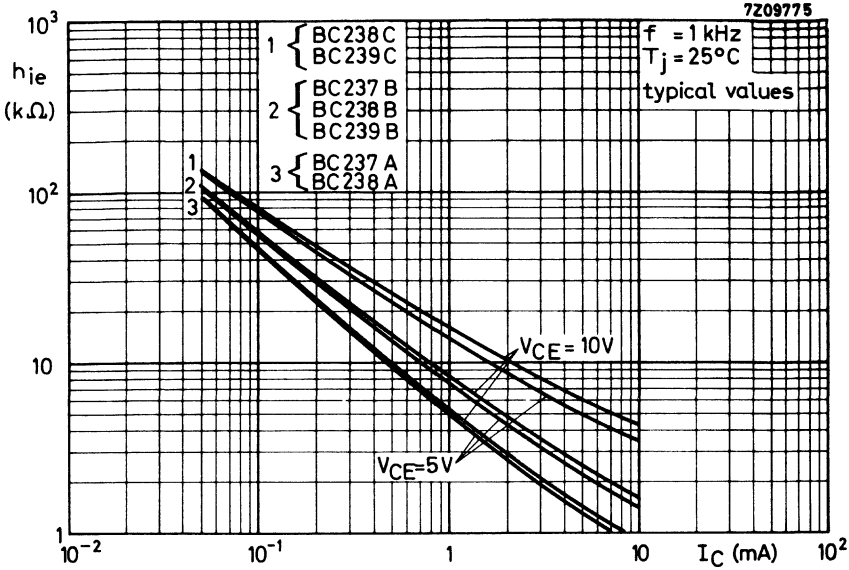

7Z61400
200
150
100
50
0
V_{CEsat}
(mV)
I_C =
100mA
50
10
1
typical values
$I_C/I_B = 20$
-50
0
50
T_j (°C)
100

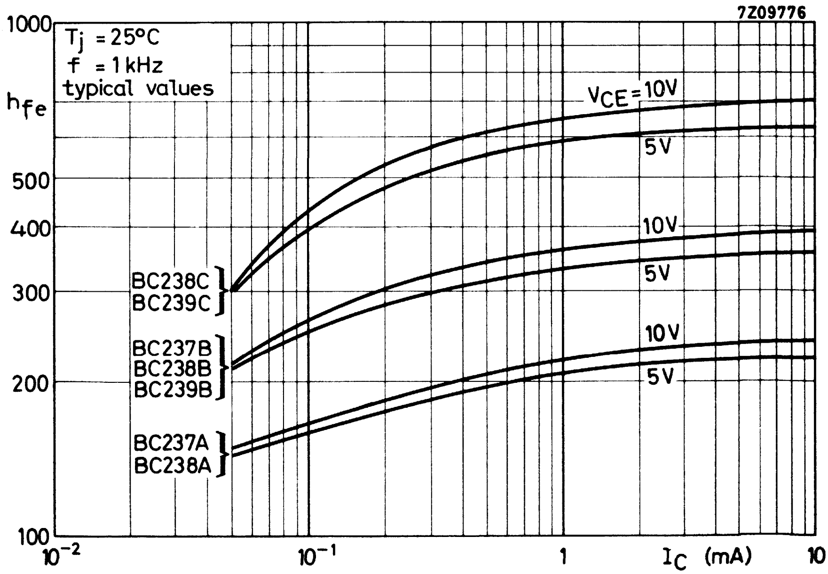

7Z66462 A
BC239
6
4
2
0
F
(dB)
$I_C = 0.2mA$
$V_{CE} = 5V$
$R_S = 2k\Omega$
B = 200Hz
$T_j = 25°C$
typ
10^{-1}
1
10
f (kHz)
10^2

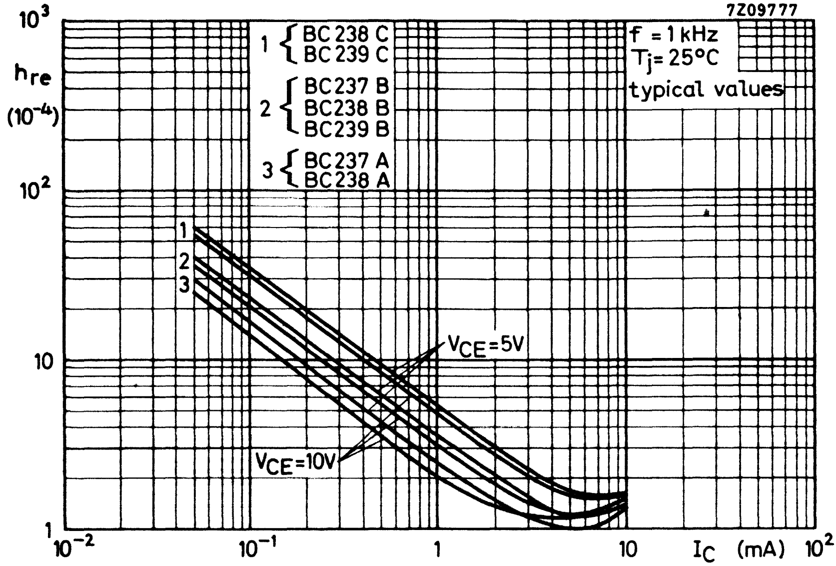
Curves of constant noise figure

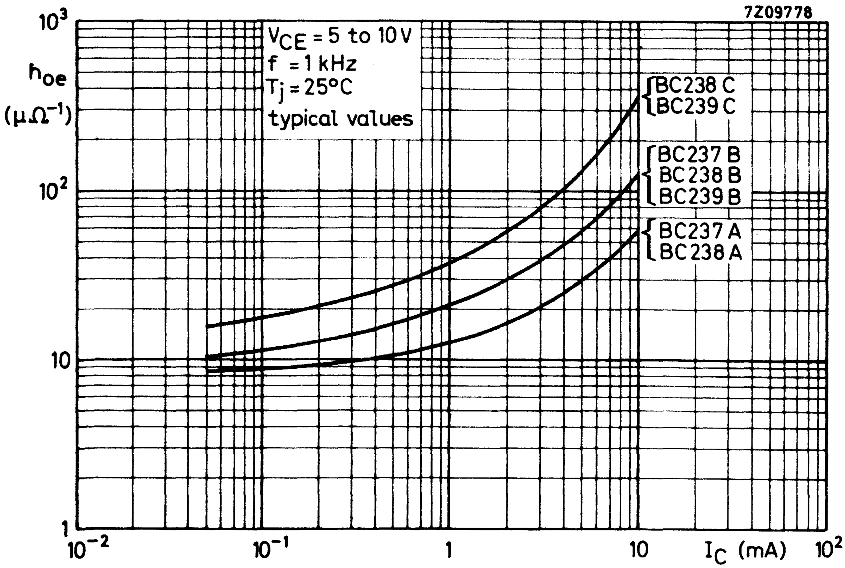


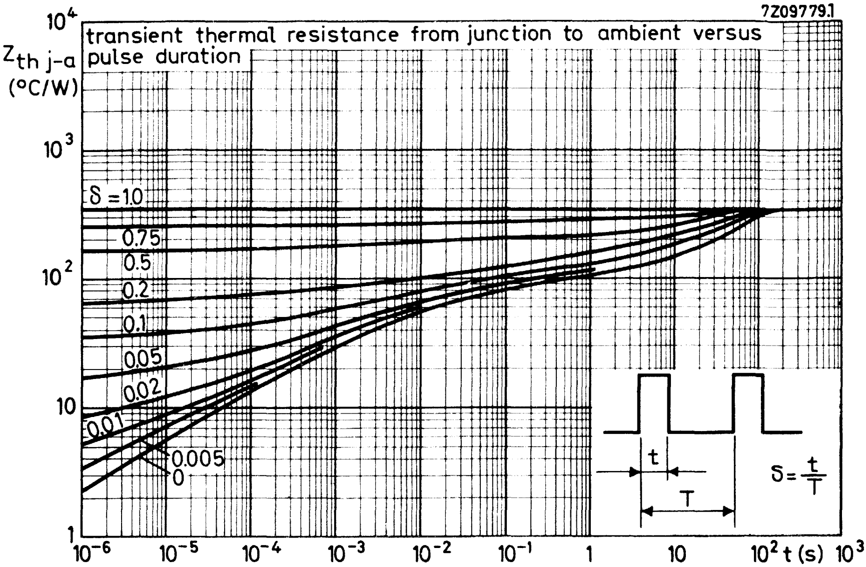



7Z09775
1 { BC238C BC239C
2 { BC237B BC238B BC239B
3 { BC237A BC238A
f = 1 kHz
Tj = 25°C
typical values
hie (kΩ)
VCE = 10V
VCE = 5V
IC (mA)
10^3
10^2
10
1
10^-2
10^-1
1
10
10^2


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


7Z09777
h_{re} (10^{-4})
1 { BC 238 C
BC 239 C
2 { BC 237 B
BC 238 B
BC 239 B
3 { BC 237 A
BC 238 A
f = 1 kHz
T_j = 25°C
typical values
V_{CE}=5V
V_{CE}=10V
10^3
10^2
10
1
10^{-2}
10^{-1}
1
10
I_C (mA)
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
10^3
10^2
10
1
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2


7Z09779.1
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
0.75
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
$\delta = \frac{t}{T}$

A.F. SILICON PLANAR EPITAXIAL TRANSISTORS

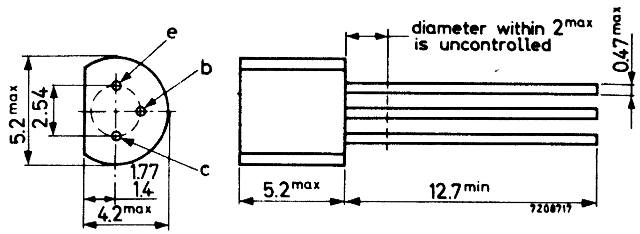
P-N-P transistors in a plastic envelope.
The BC307 is a high voltage type and primarily intended for use in driver stages of audio amplifiers and in signal processing circuits of television receivers.
The BC308 is suitable for a multitude of low voltage applications e.g. driver stages or audio pre-amplifiers and in signal processing circuits of television receivers.
The BC309 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 BC 237, BC 238 and BC 239.

QUICK REFERENCE DATA

			BC307	BC308	BC309	
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.	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



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

Voltages

			BC307	BC308	BC309	
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 ^oC	P_{tot}	max.	300	mW

Temperatures

Storage temperature	T_{stg}		-65 to +125	^oC
Junction temperature	T_j	max.	125	^oC

THERMAL RESISTANCE

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

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

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

Base-emitter voltage [1]

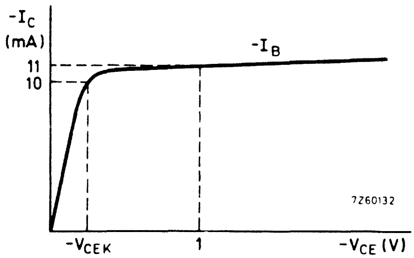
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	$-V_{BE}$	typ.	650	mV
		600 to	750	mV

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

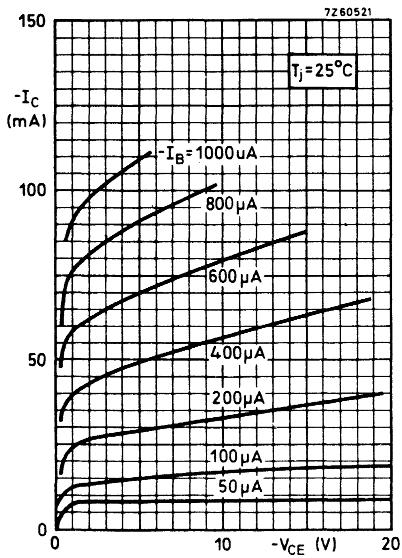
[1]) $-V_{BE}$ decreases by about 2 mV/°C with increasing temperature.

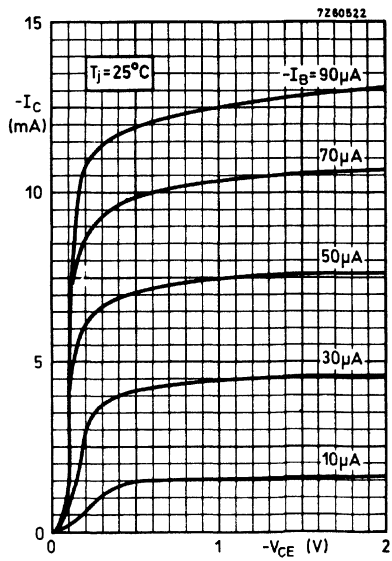
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

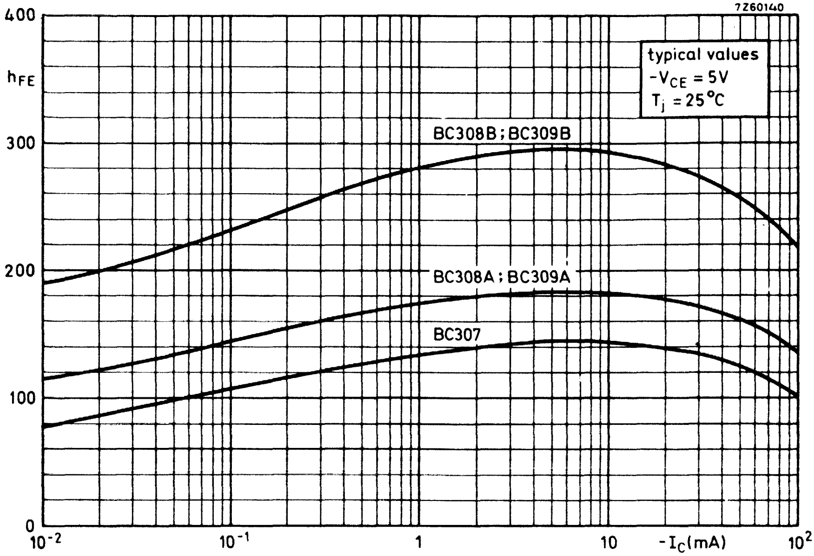
			BC307	BC308	BC309	
Small signal current gain at f = 1 kHz						
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{fe}	>	75	75	125	
		<	260	500	500	
Noise figure at R_S = 2 kΩ						
$-I_C$ = 200 μA; $-V_{CE}$ = 5 V						
f = 30 Hz to 15 kHz	F	typ.			1.2	dB
		<			4	dB
f = 1 kHz; B = 200 Hz	F	typ.	2	2	1	dB
		<	10	10	4	dB

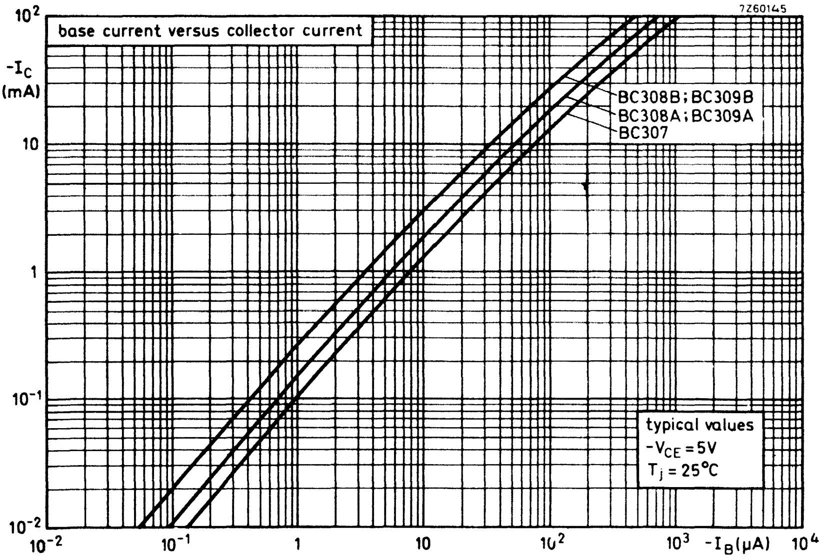
			BC307	BC308A BC309A	BC308B BC309B
D.C. current gain					
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{FE}	typ.	140	180	290
Small signal current gain at f = 1 kHz					
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{fe}	>	75	125	240
		<	260	260	500

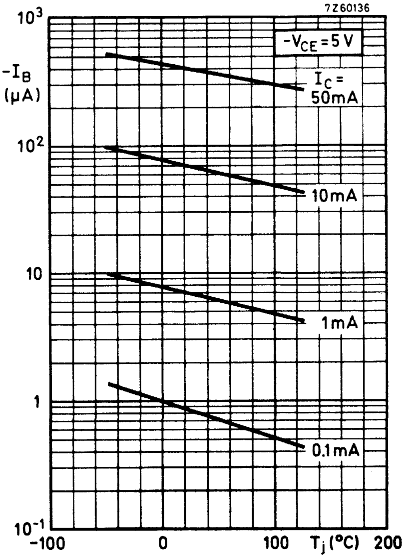
Typical behaviour of collector current versus collector-emitter voltage



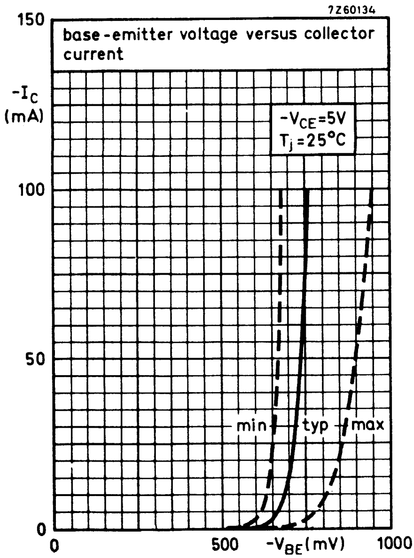


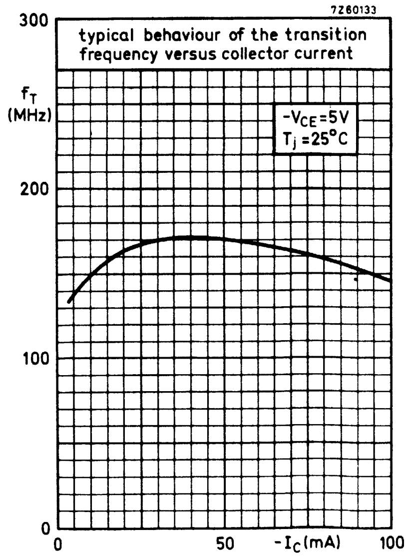

7Z60140
typical values
$-V_{CE} = 5V$
$T_j = 25°C$
BC308B; BC309B
BC308A; BC309A
BC307
h_{FE}
400
300
200
100
0
10^{-2}
10^{-1}
1
10
$-I_C$(mA)
10^2

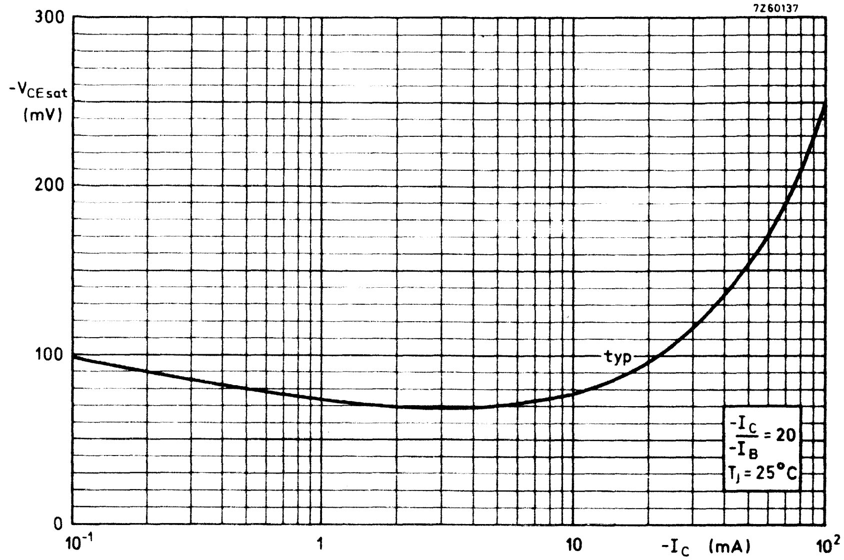

7Z60145
base current versus collector current
$-I_C$ (mA)
BC308B; BC309B
BC308A; BC309A
BC307
typical values
$-V_{CE} = 5V$
$T_j = 25°C$
10^2
10
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1
10
10^2
10^3
$-I_B$(μA)
10^4

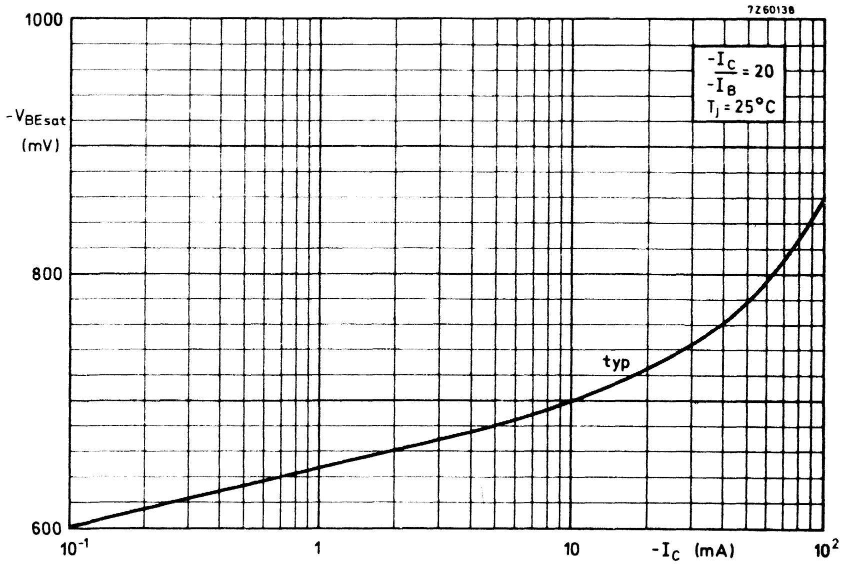


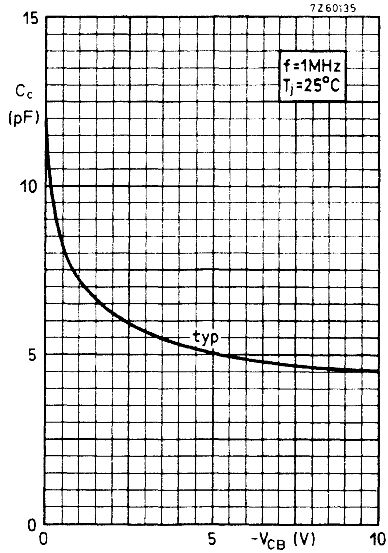
typical behaviour of base current versus junction temperature

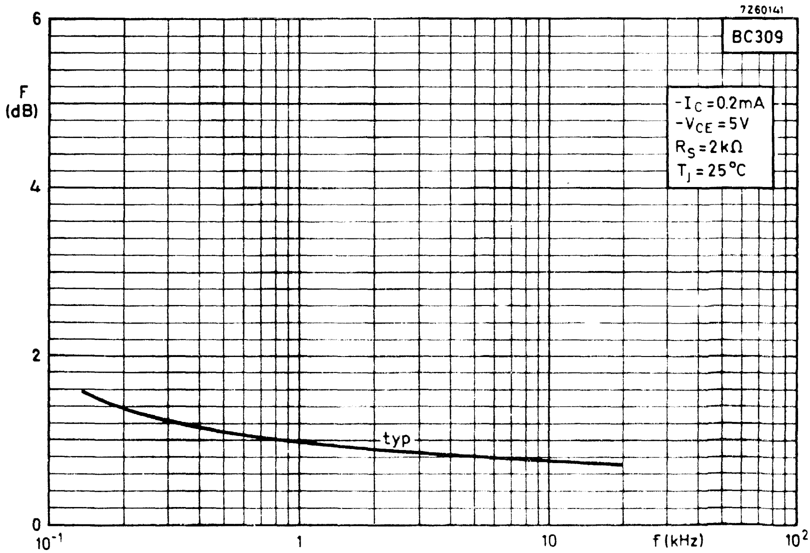




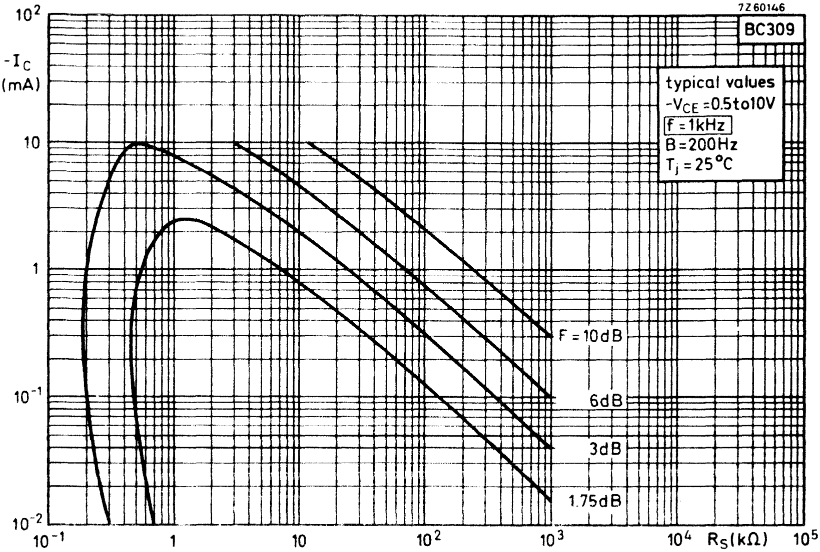

7Z60137
300
-V_CEsat
(mV)
200
100
0
typ
-I_C / -I_B = 20
T_j = 25°C
10^-1
1
10
-I_C (mA)
10^2

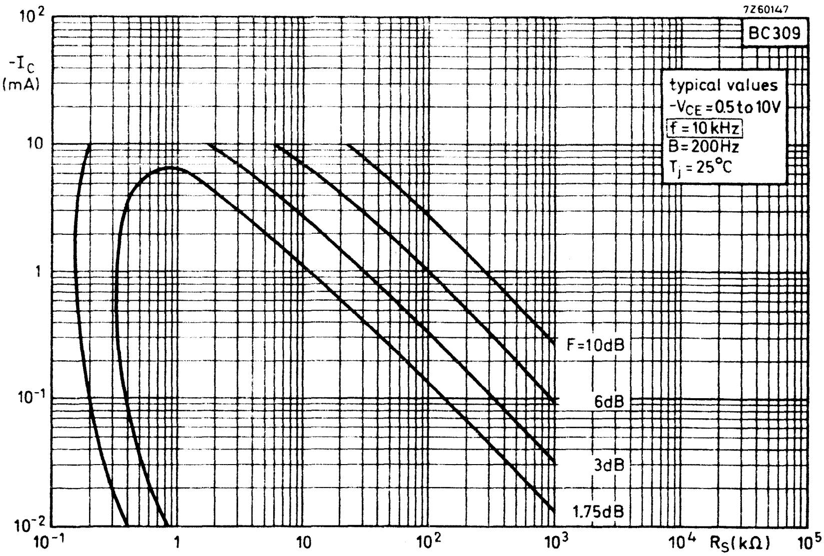

7Z60138
1000
-V_BEsat
(mV)
800
600
-I_C / -I_B = 20
T_j = 25°C
typ
10^-1
1
10
-I_C (mA)
10^2

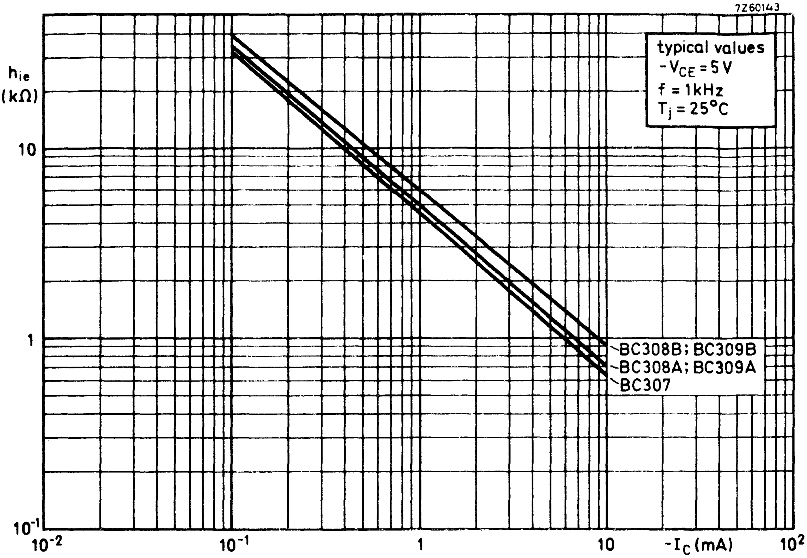

7Z60135
f = 1MHz
T_j = 25°C
C_c (pF)
15
10
5
0
typ
0
5
$-V_{CB}$ (V)
10

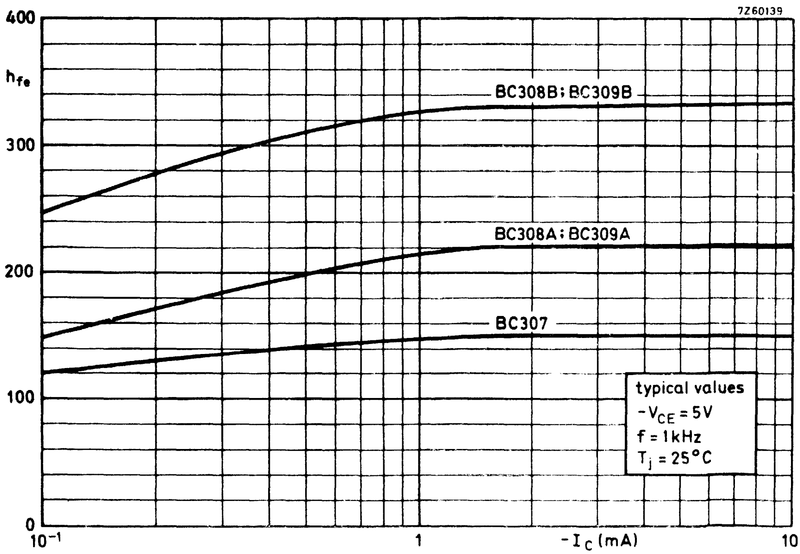

7Z60141
BC309
$-I_C$ = 0.2mA
$-V_{CE}$ = 5V
R_S = 2kΩ
T_j = 25°C
F (dB)
6
4
2
0
typ
10^{-1}
1
10
f (kHz)
10^2

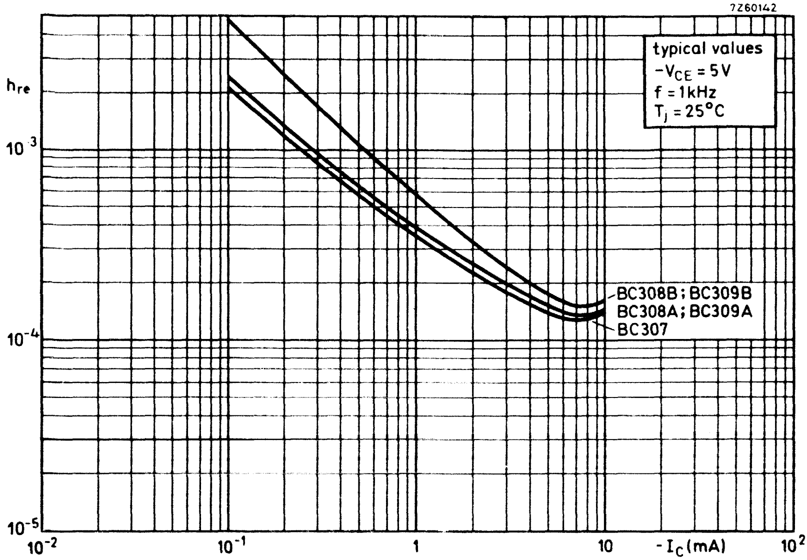
curves of constant noise figure

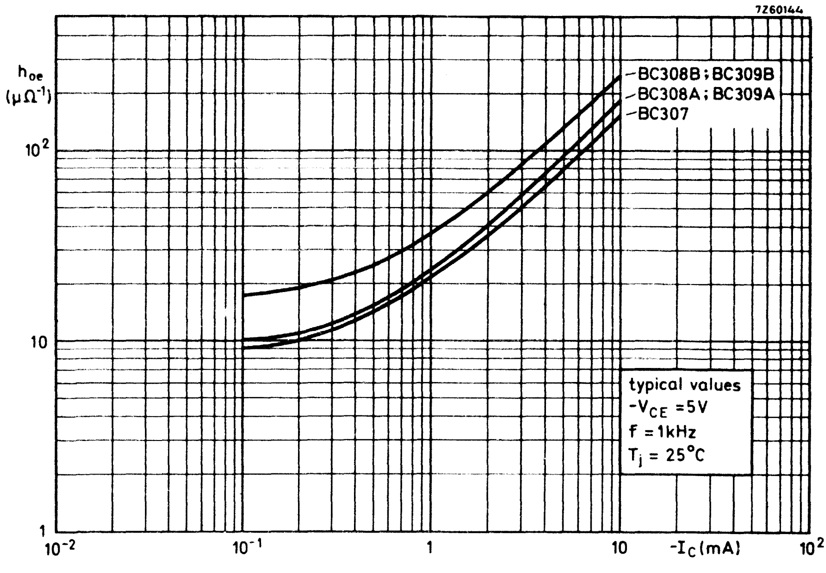


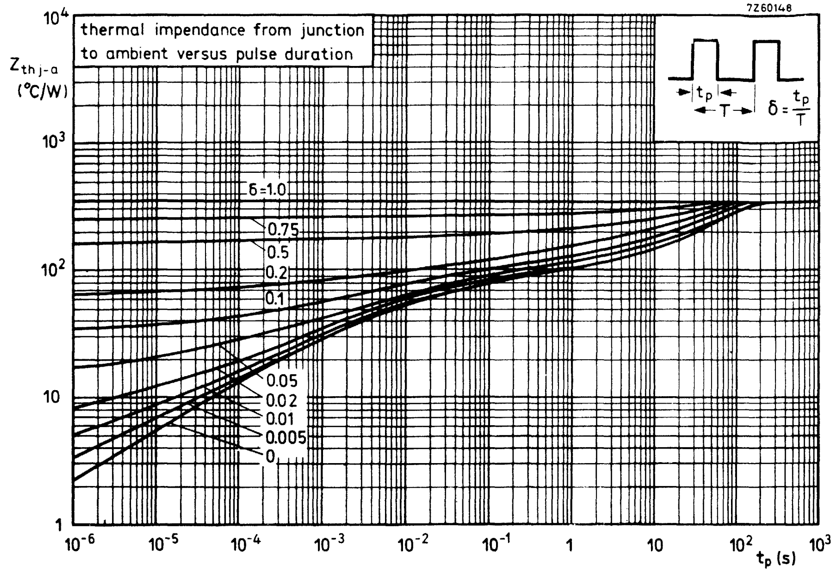



7Z60143
typical values
$-V_{CE} = 5$ V
f = 1 kHz
$T_j = 25$ °C
h_{ie}
(kΩ)
10
1
10^{-1}
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2
BC308B; BC309B
BC308A; BC309A
BC307


7Z60139
400
h_{fe}
300
200
100
0
BC308B; BC309B
BC308A; BC309A
BC307
typical values
$-V_{CE} = 5$ V
f = 1 kHz
$T_j = 25$ °C
10^{-1}
1
$-I_C$ (mA)
10


7Z60142
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
h_{re}
10^{-3}
10^{-4}
10^{-5}
BC308B; BC309B
BC308A; BC309A
BC307
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2


7Z60144
h_{oe}
($\mu\Omega^{-1}$)
10^2
10
1
BC308B; BC309B
BC308A; BC309A
BC307
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2



7Z60148
thermal impendance 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
10^3
t_p (s)
t_p
T
$\delta = \frac{t_p}{T}$

A.F. SILICON PLANAR EPITAXIAL TRANSISTORS

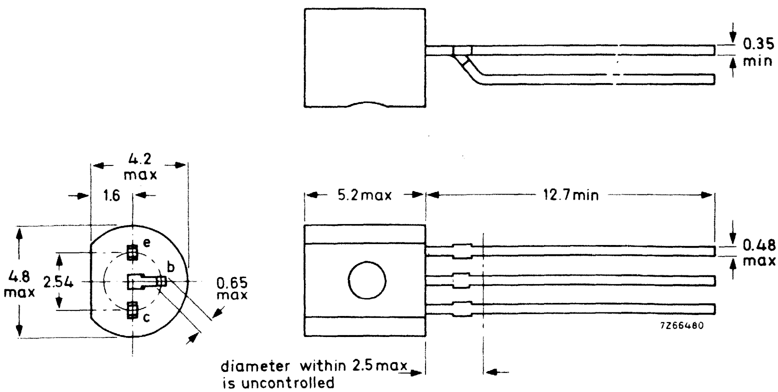
P-N-P transistors in a plastic TO-92 variant primarily intended for use in driver and output stages of audio amplifiers.
The BC327 and BC328 are complementary to the BC337 and BC338 respectively.

QUICK REFERENCE DATA

			BC327	BC328	
Collector-emitter voltage (V_{BE} = 0)	$-V_{CES}$	max.	50	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	25	V
Collector current (peak value)	$-I_{CM}$	max.	1000		mA
Total power dissipation up to T_{case} = 45 °C	P_{tot}	max.	625		mW
Junction temperature	T_j	max.	150		°C
Transition frequency					
$-I_C$ = 10 mA; $-V_{CE}$ = 5 V; f = 35 MHz	f_T	typ.	100		MHz

MECHANICAL DATA Dimensions in mm

TO-92 variant



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

Voltages

			BC327	BC328	
Collector-emitter voltage (V_{BE} = 0)	$-V_{CES}$	max.	50	30	V
Collector-emitter voltage (open base) $-I_C$ = 10 mA	$-V_{CEO}$	max.	45	25	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	V

Currents

Collector current (d.c.)	$-I_C$	max.	500	mA
Collector current (peak value)	$-I_{CM}$	max.	1000	mA
Emitter current (peak value)	I_{EM}	max.	1000	mA
Base current (d.c.)	$-I_B$	max.	100	mA
Base current (peak value)	$-I_{BM}$	max.	200	mA

Power dissipation

Total power dissipation at T_{amb} = 25 °C	P_{tot}	max.	500	mW
up to T_{amb} = 25 °C	P_{tot}	max.	625	mW [1])
up to T_{case} = 45 °C	P_{tot}	max.	625	mW

Temperatures

Storage temperature	T_{stg}	-65	to	+150	°C
Junction temperature	T_j	max.		150	°C

THERMAL RESISTANCE

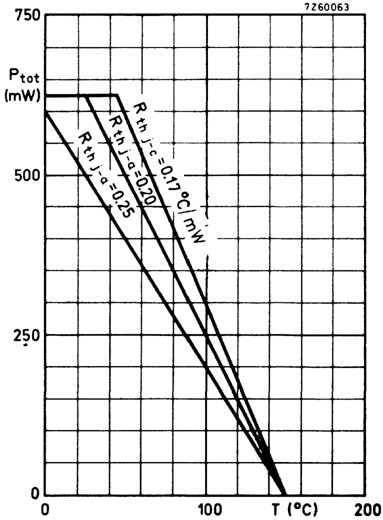
From junction to ambient in free air	$R_{th\ j-a}$	=	0.25	°C/mW
From junction to ambient	$R_{th\ j-a}$	=	0.20	°C/mW [1])
From junction to case	$R_{th\ j-c}$	=	0.17	°C/mW

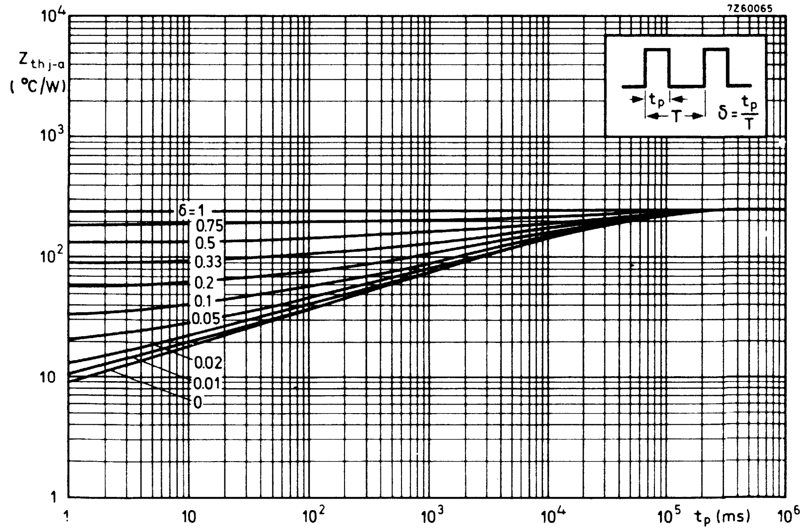
[1]) Transistor mounted on printed circuit board, max. lead length 3 mm, mounting pad for collector lead min. 10 mm x 10 mm.

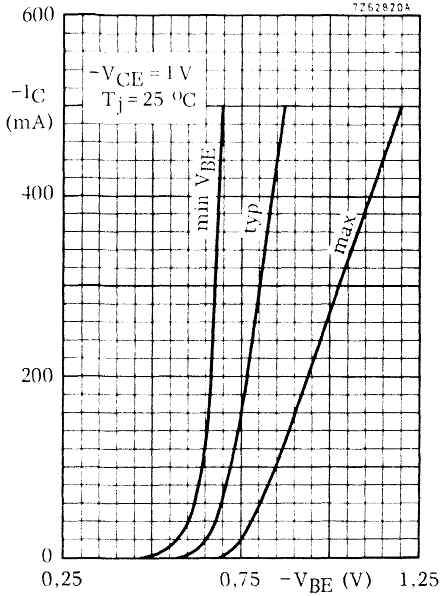
CHARACTERISTICS T_j = 25 °C unless otherwise specified

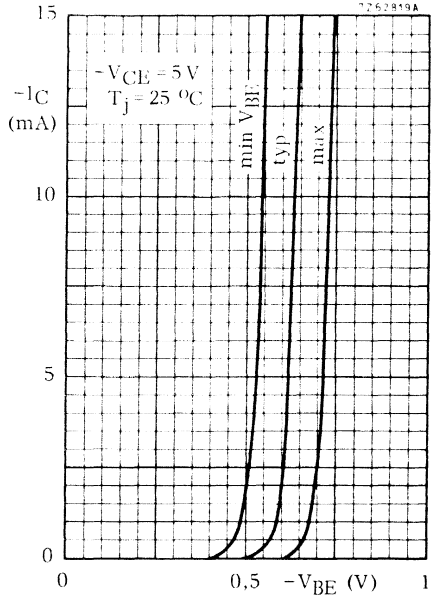
Collector cut-off current				
$I_E = 0$; $-V_{CB} = 20$ V; $T_j = 25$ °C	$-I_{CBO}$	<	100	nA
$I_E = 0$; $-V_{CB} = 20$ V; $T_j = 150$ °C	$-I_{CBO}$	<	5	μA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	10	μA
Base emitter voltage [1]				
$-I_C = 500$ mA; $-V_{CE} = 1$ V	$-V_{BE}$	<	1.2	V ←
Saturation voltage				
$-I_C = 500$ mA; $-I_B = 50$ mA	$-V_{CEsat}$	<	700	mV
D.C. current gain				
$-I_C = 500$ mA; $-V_{CE} = 1$ V	h_{FE}	>	40	←
$-I_C = 100$ mA; $-V_{CE} = 1$ V; BC327; BC328	h_{FE}	100 to 600		
BC327-16, BC328-16	h_{FE}	100 to 250		
BC327-25, BC328-25	h_{FE}	160 to 400		
Transition frequency at f = 35 MHz				
$-I_C = 10$ mA; $-V_{CE} = 5$ V	f_T	typ.	100	MHz
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $-V_{CB} = 10$ V	C_c	typ.	8	pF
D.C. current gain ratio of matched pair BC327/BC337, BC328/BC338				
$\|I_C\| = 100$ mA; $\|V_{CE}\| = 1$ V	h_{FE1}/h_{FE2}	typ.	1.25	
		<	1.40	

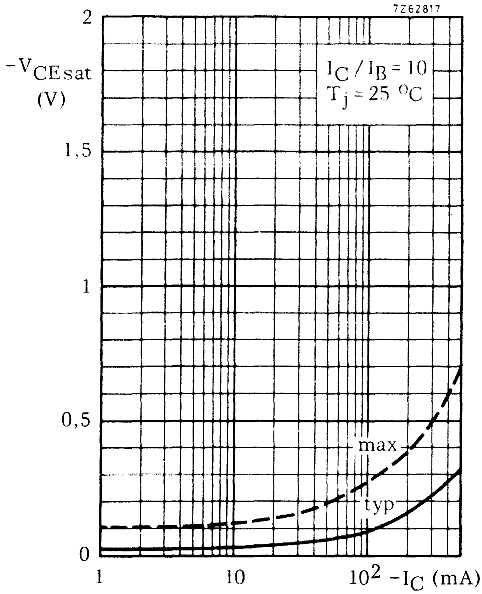
1) $-V_{BE}$ decreases by about 2 mV/°C with increasing temperature.

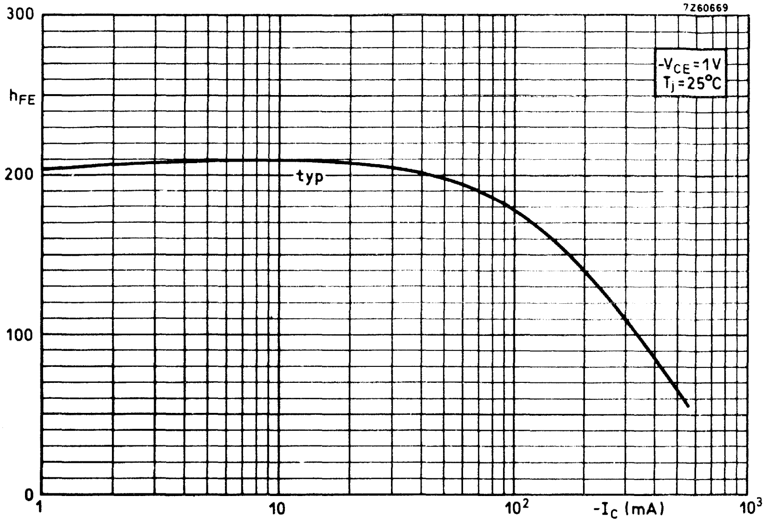

7Z60063
750
Ptot
(mW)
500
250
0
0
100
T (°C)
200
R th j-c = 0.17 °C/mW
R th j-a = 0.20
R th j-a = 0.25

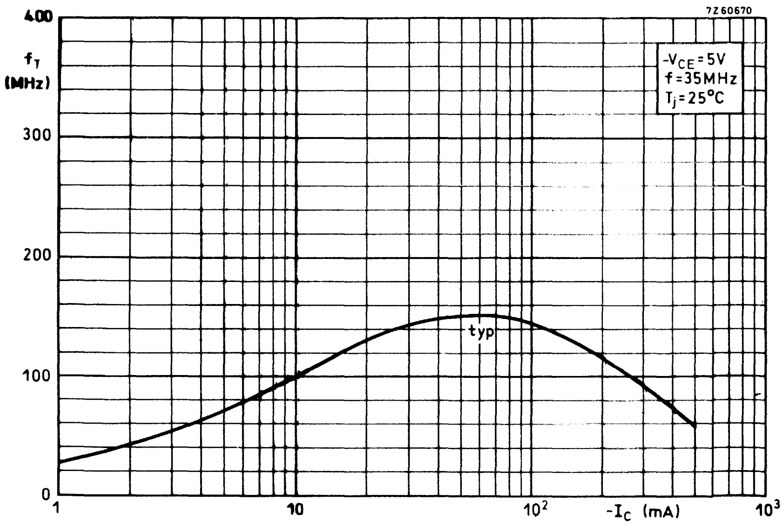

7Z60065
10⁴
Z th j-a
(°C/W)
10³
10²
10
1
1
10
10²
10³
10⁴
10⁵
tp (ms)
10⁶
δ = 1
0.75
0.5
0.33
0.2
0.1
0.05
0.02
0.01
0
tp
T
δ = tp/T


7Z62820A
$-V_{CE} = 1$ V
$T_j = 25$ °C
$-I_C$ (mA)
600
400
200
0
min V_{BE}
typ
max
0,25
0,75
$-V_{BE}$ (V)
1,25


7Z62819A
$-V_{CE} = 5$ V
$T_j = 25$ °C
$-I_C$ (mA)
15
10
5
0
min V_{BE}
typ
max
0
0,5
$-V_{BE}$ (V)
1

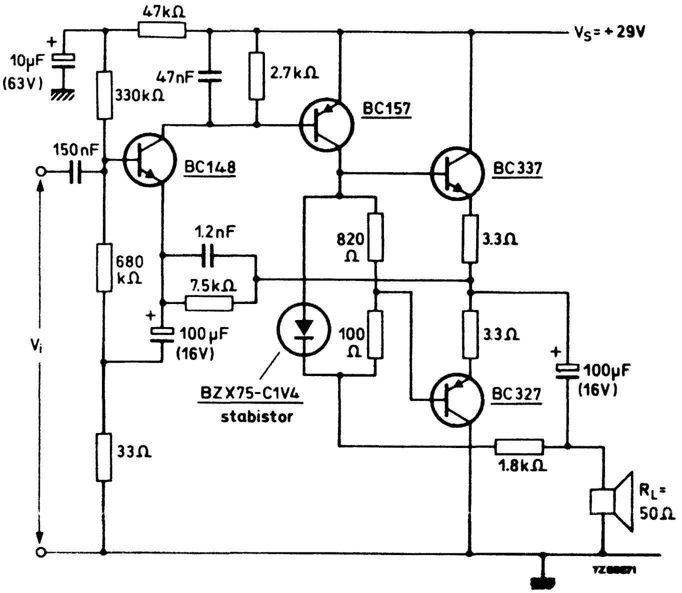

7Z62817
$I_C / I_B = 10$
$T_j = 25$ °C
$-V_{CEsat}$ (V)
2
1,5
1
0,5
0
max
typ
1
10
10^2
$-I_C$ (mA)


7Z60669
300
h_{FE}
200
100
0
1
10
10^2
$-I_C$ (mA)
10^3
$-V_{CE}$ = 1 V
T_j = 25 °C
typ


7Z60670
400
f_T
(MHz)
300
200
100
0
1
10
10^2
$-I_C$ (mA)
10^3
$-V_{CE}$ = 5 V
f = 35 MHz
T_j = 25 °C
typ

APPLICATION INFORMATION

2.2 W transformerless audio frequency amplifier with matched pair BC327/BC337 in complementary class B output stage up to T_{amb} = 50 °C.

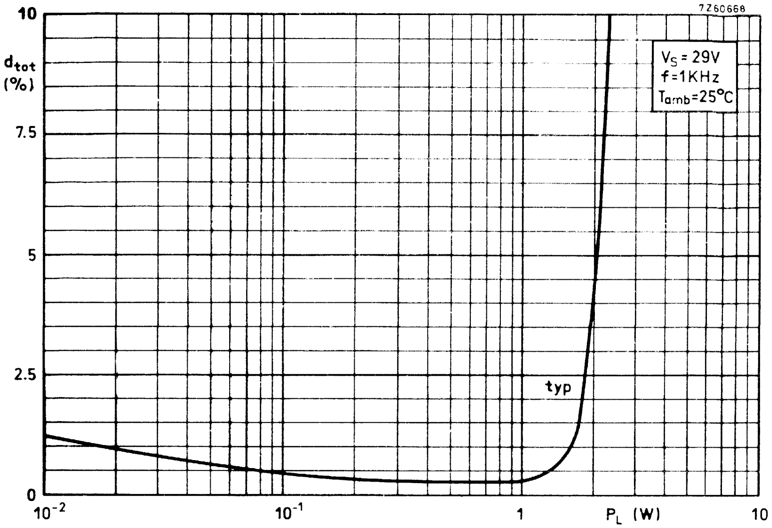


Performance at V_S = 29 V; R_L = 50 Ω

Collector quiescent current of BC337	I_{CQ}	typ.	1	mA
Input voltage for P_o = 50 mW	V_i	typ.	7	mV
Input voltage for P_o = 2 W	V_i	typ.	46	mV
Output power at f = 1 kHz; d_{tot} = 10%	P_o	typ.	2.2	W
Frequency response (3 dB)			50 to 15000	Hz

This amplifier needs no external cooling fin, provided each output transistor is mounted with its leads not longer than 3 mm. The collector lead must, in addition, be soldered to a copper area of at least 10 mm x 10 mm. (See page 2).

APPLICATION INFORMATION (continued)



A.F. SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in plastic TO-92 variant primarily intended for use in driver and output stages of audio amplifiers.
The BC337 and BC338 are complementary to the BC327 and BC328 respectively.

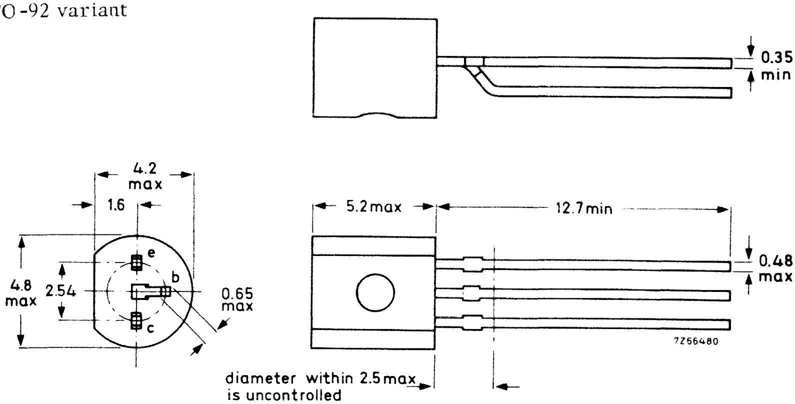
QUICK REFERENCE DATA

			BC337	BC338	
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	50	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	25	V
Collector current (peak value)	I_{CM}	max.	1000		mA
Total power dissipation up to T_{case} = 45 °C	P_{tot}	max.	625		mW
Junction temperature	T_j	max.	150		°C
Transition frequency					
I_C = 10 mA; V_{CE} = 5 V; f = 35 MHz	f_T	typ.	200		MHz

MECHANICAL DATA

Dimensions in mm

TO-92 variant



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

Voltages			BC337	BC338	
Collector-emitter voltage ($V_{BE} = 0$)	V_{CES}	max.	50	30	V
Collector-emitter voltage (open base) $I_C = 10$ mA	V_{CEO}	max.	45	25	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	V

Currents

Collector current (d.c.)	I_C	max.	500	mA
Collector current (peak value)	I_{CM}	max.	1000	mA
Emitter current (peak value)	$-I_{EM}$	max.	1000	mA
Base current (d.c.)	I_B	max.	100	mA
Base current (peak value)	I_{BM}	max.	200	mA

Power dissipation

Total power dissipation at $T_{amb} = 25\ ^oC$	P_{tot}	max.	500	mW
up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	625	mW [1]
up to $T_{case} = 45\ ^oC$	P_{tot}	max.	625	mW

Temperatures

Storage temperature	T_{stg}		−65 to +150	^oC
Junction temperature	T_j	max.	150	^oC

THERMAL RESISTANCE

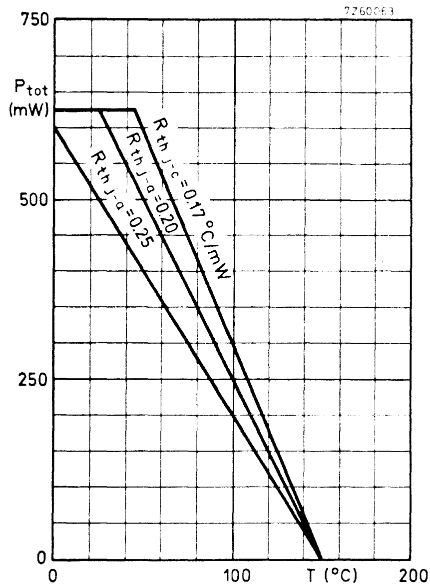
From junction to ambient in free air	$R_{th\ j-a}$	=	0.25	^oC/mW
From junction to ambient	$R_{th\ j-a}$	=	0.20	^oC/mW [1]
From junction to case	$R_{th\ j-c}$	=	0.17	^oC/mW

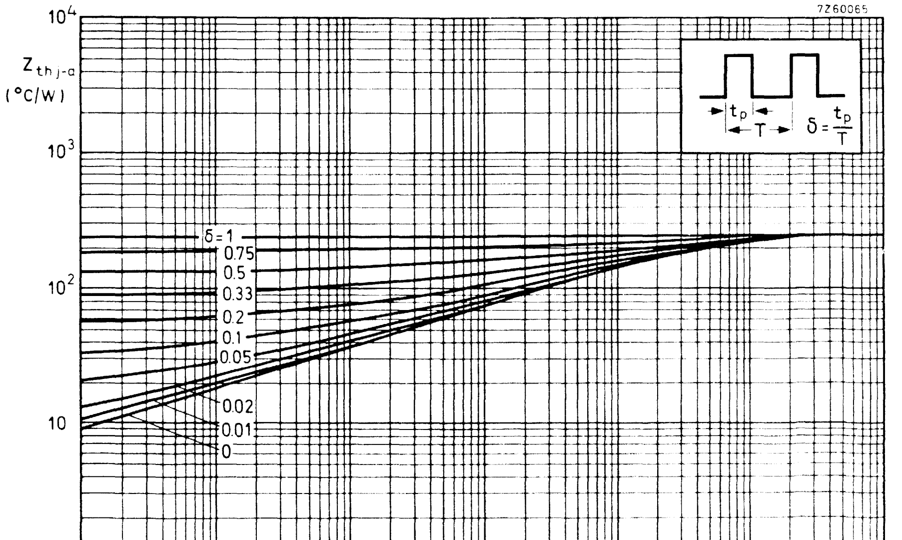
[1] Transistor mounted on printed circuit board, max. lead length 3 mm, mounting pad for collector lead min. 10 mm x 10 mm.

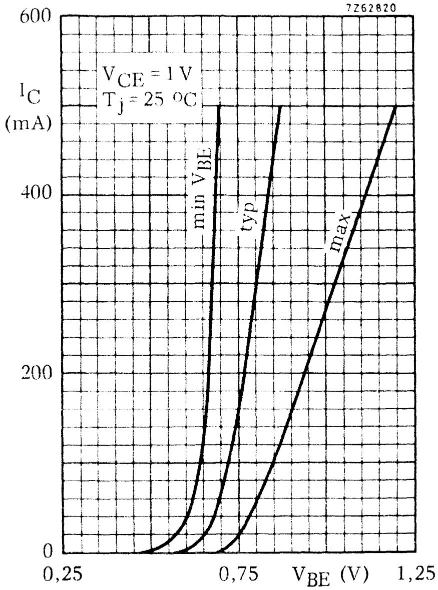
CHARACTERISTICS T_j = 25 °C unless otherwise specified

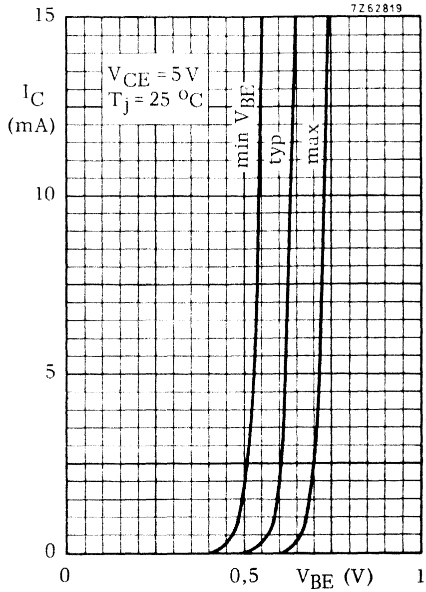
Collector cut-off current				
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 25$ °C	I_{CBO}	<	100	nA
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 150$ °C	I_{CBO}	<	5	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	μA
Base emitter voltage [1]				
$I_C = 500$ mA; $V_{CE} = 1$ V	V_{BE}	<	1.2	V ←
Saturation voltage				
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	700	mV
D.C. current gain				
$I_C = 500$ mA; $V_{CE} = 1$ V	h_{FE}	>	40	←
$I_C = 100$ mA; $V_{CE} = 1$ V; BC337; BC338	h_{FE}		100 to 600	
BC337-16, BC338-16	h_{FE}		100 to 250	
BC337-25, BC338-25	h_{FE}		160 to 400	
Transition frequency at f = 35 MHz				
$I_C = 10$ mA; $V_{CE} = 5$ V	f_T	typ.	200	MHz
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	5	pF
D.C. current gain ratio of matched pair BC337/BC327, BC338/BC328				
$\|I_C\| = 100$ mA; $\|V_{CE}\| = 1$ V	h_{FE1}/h_{FE2}	typ.	1.25	
		<	1.40	

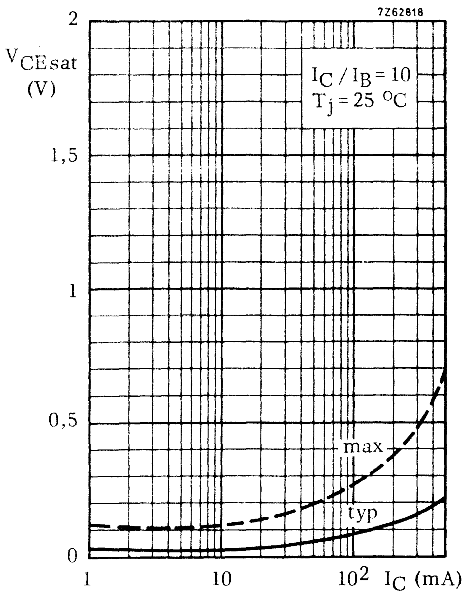
1) V_{BE} decreases by about 2 mV/°C with increasing temperature.

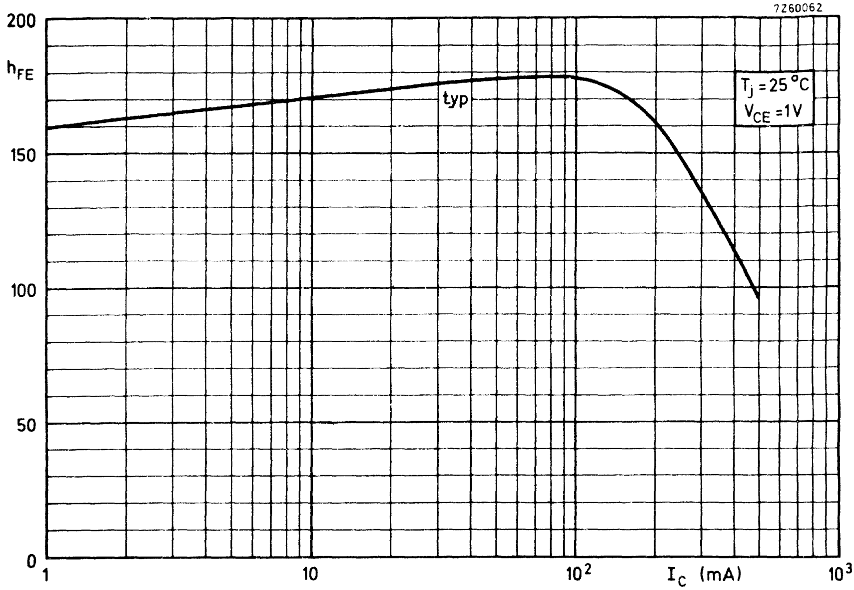

7Z60063
750
Ptot
(mW)
500
250
0
0
100
T (°C)
200
Rth j-c = 0.17 °C/mW
Rth j-a = 0.20
Rth j-a = 0.25

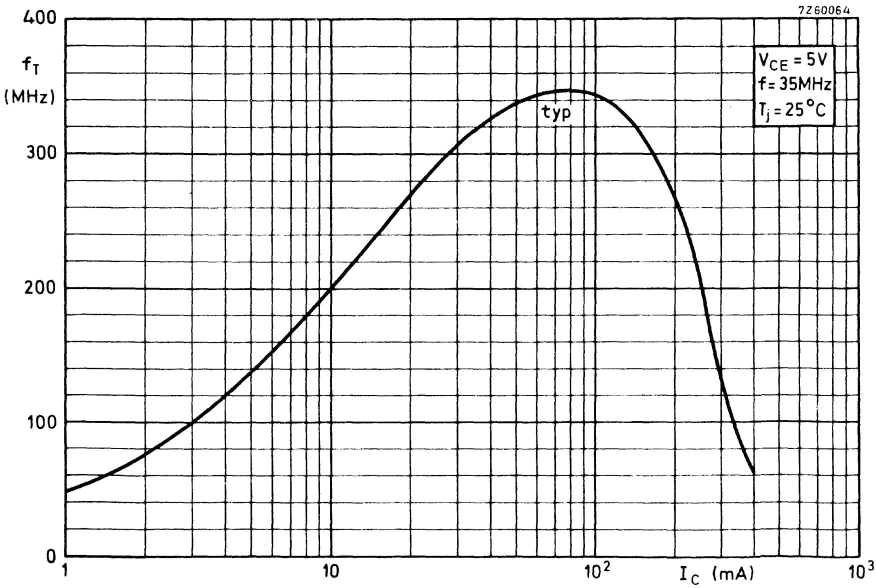

7Z60065
10^4
Zth j-a
(°C/W)
10^3
10^2
10
1
1
10
10^2
10^3
10^4
10^5
tp (ms)
10^6
δ = 1
0.75
0.5
0.33
0.2
0.1
0.05
0.02
0.01
0
tp
T
δ = tp/T


7Z62820
600
400
200
0
I_C (mA)
V_{CE} = 1 V
T_j = 25 °C
min V_{BE}
typ
max
0,25
0,75
1,25
V_{BE} (V)


7Z62819
15
10
5
0
I_C (mA)
V_{CE} = 5 V
T_j = 25 °C
min V_{BE}
typ
max
0
0,5
1
V_{BE} (V)


7Z62818
2
1,5
1
0,5
0
V_{CEsat} (V)
I_C / I_B = 10
T_j = 25 °C
max
typ
1
10
10^2
I_C (mA)


7Z60062
200
h_{FE}
150
100
50
0
1
10
10^2
I_C (mA)
10^3
typ
$T_j = 25\,^\circ C$
$V_{CE} = 1 V$


7Z60064
400
f_T
(MHz)
300
200
100
0
1
10
10^2
I_C (mA)
10^3
typ
$V_{CE} = 5 V$
f = 35MHz
$T_j = 25\,^\circ C$

A.F. SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a plastic TO-92 variant.
The BC547 is primarily intended for use in driver stages of audio amplifiers and in signal processing circuits of television receivers.
The BC548 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 BC549 is primarily intended for low noise input stages in tape recorders, hi-fi amplifiers and other audio frequency equipment.

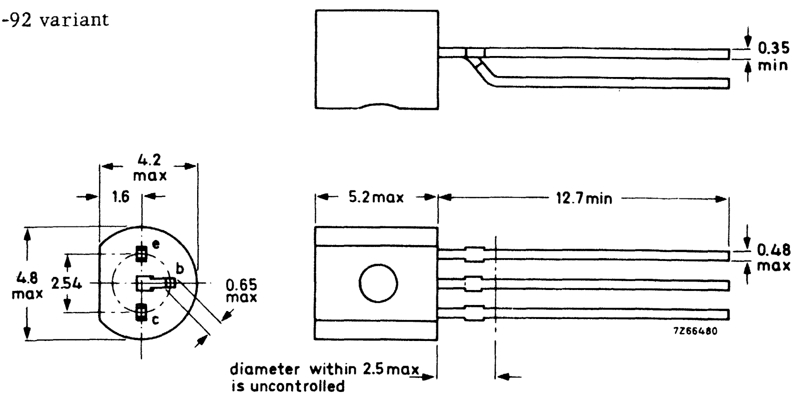
QUICK REFERENCE DATA

			BC547	BC548	BC549	
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} = 75 °C	P_{tot}	max.	300	300	300	mW
Junction temperature	T_j	max.	150	150	150	°C
Small signal current gain						
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

TO-92 variant



RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltage

			BC547	BC548	BC549	
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

Current

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} = 75 ^oC	P_{tot}	max.	300	mW

Temperature

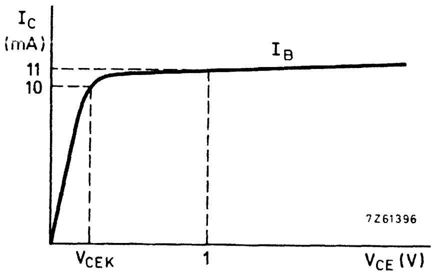
Storage temperature	T_{stg}		−65 to +150	^oC
Junction temperature	T_j	max.	150	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.25	$^oC/mW$
From junction to case	$R_{th\ j-c}$	=	0.17	$^oC/mW$

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}	<	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



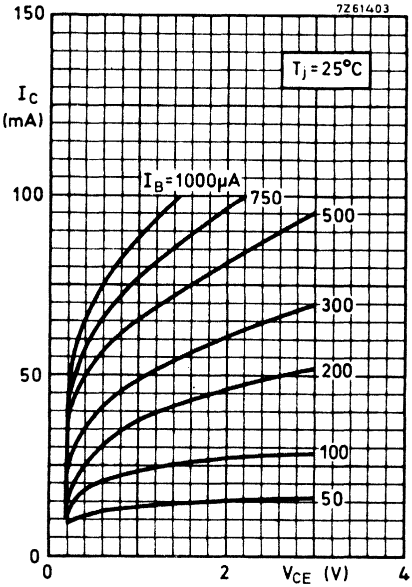
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	2.5	pF
		<	4.5	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	typ.	9	pF
Transition frequency at f = 35 MHz				
$I_C = 10$ mA; $V_{CE} = 5$ V	f_T	typ.	300	MHz

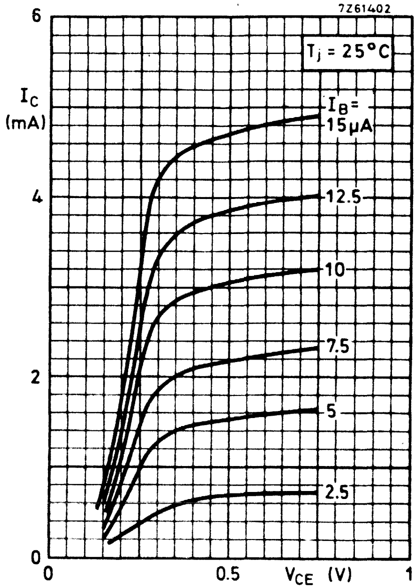
1) V_{BE} decreases by about 2 mV/°C with increasing temperature.
2) V_{BEsat} decreases by about 1.7 mV/°C with increasing temperature.

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

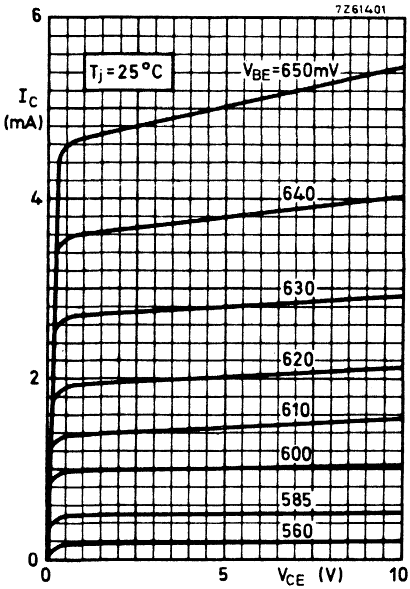
			BC547	BC548	BC549
Small signal current gain at f = 1 kHz					
I_C = 2 mA; V_{CE} = 5 V	h_{fe}	>	125	125	240
		<	500	900	900
Noise figure at R_S = 2 kΩ					
I_C = 200 μA; V_{CE} = 5 V					
f = 30 Hz to 15 kHz	F	typ.			1.4 dB
		<			4 dB
f = 1 kHz; B = 200 Hz	F	typ.	2	2	1.2 dB
		<	10	10	4 dB

			BC547A BC548A	BC547B BC548B BC549B	BC548C BC549C
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 $\mu\Omega^{-1}$

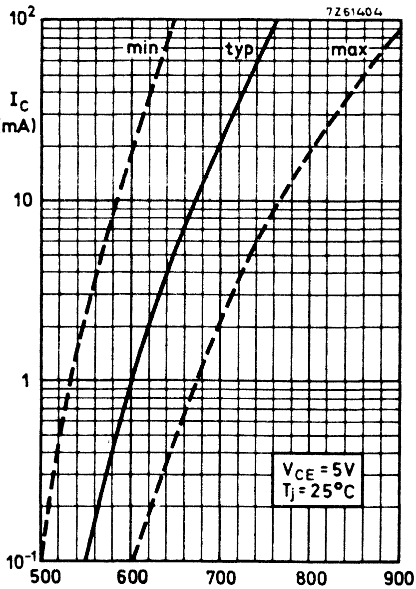




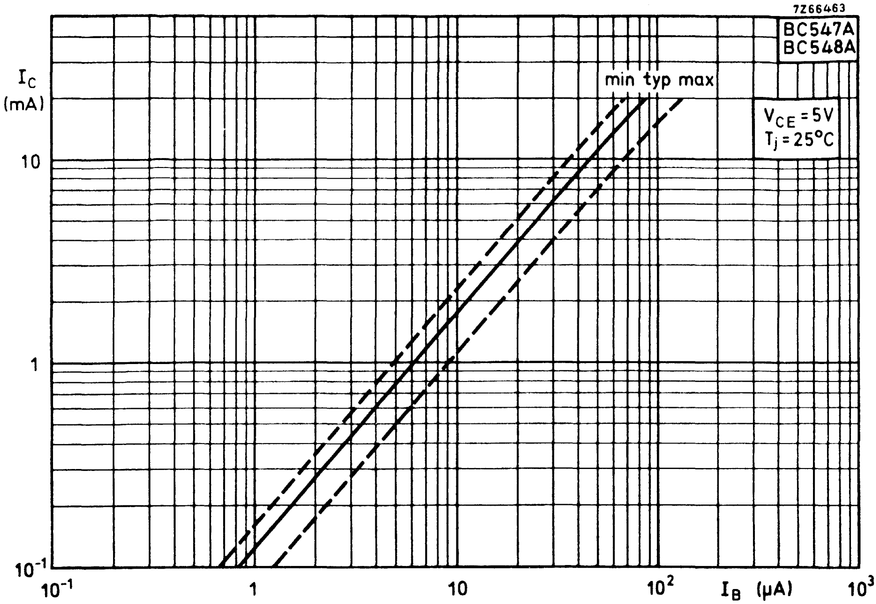
Typical behaviour of collector current versus collector-emitter voltage



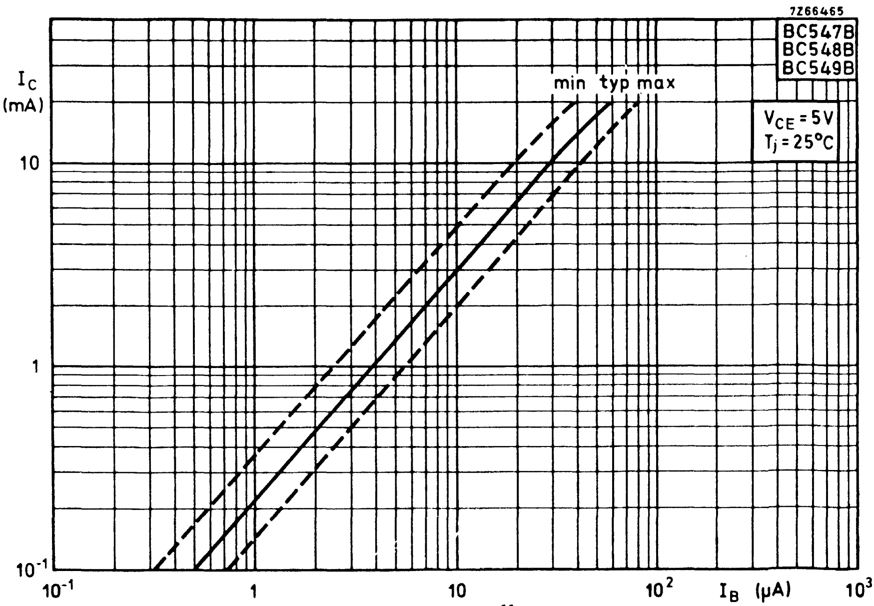
Typical behaviour of collector current versus collector-emitter voltage



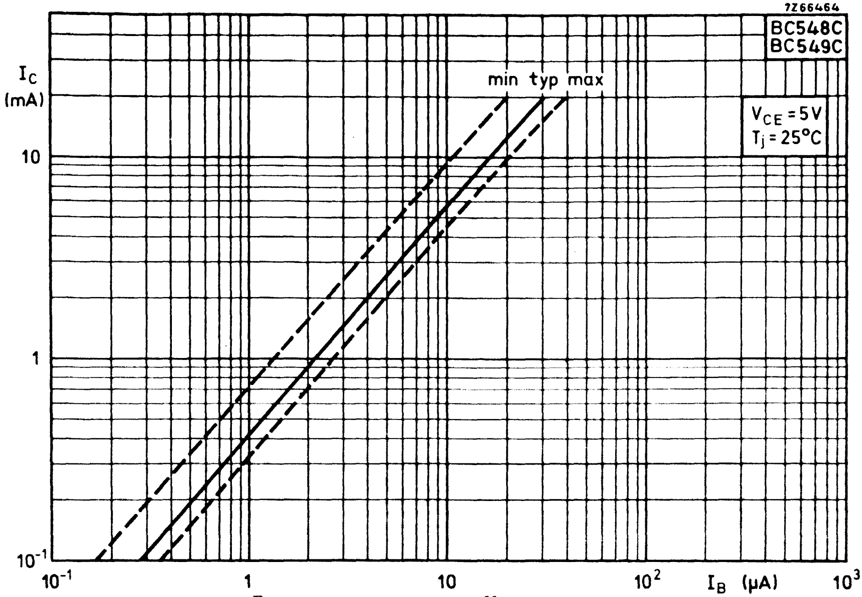
Base-emitter voltage versus collector current



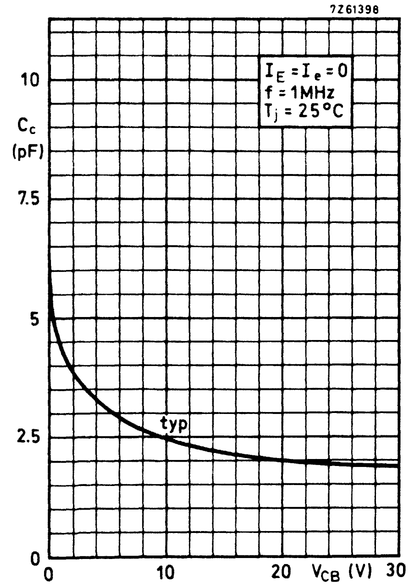
Base current versus collector current

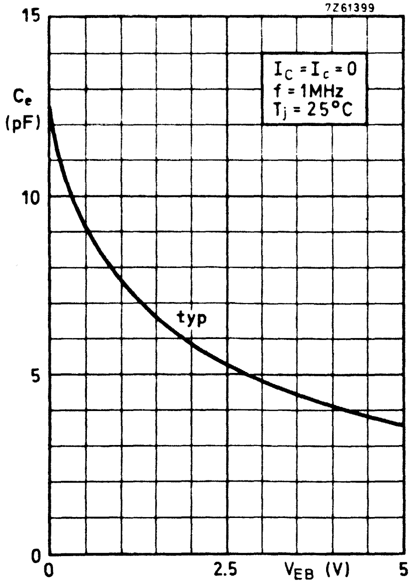


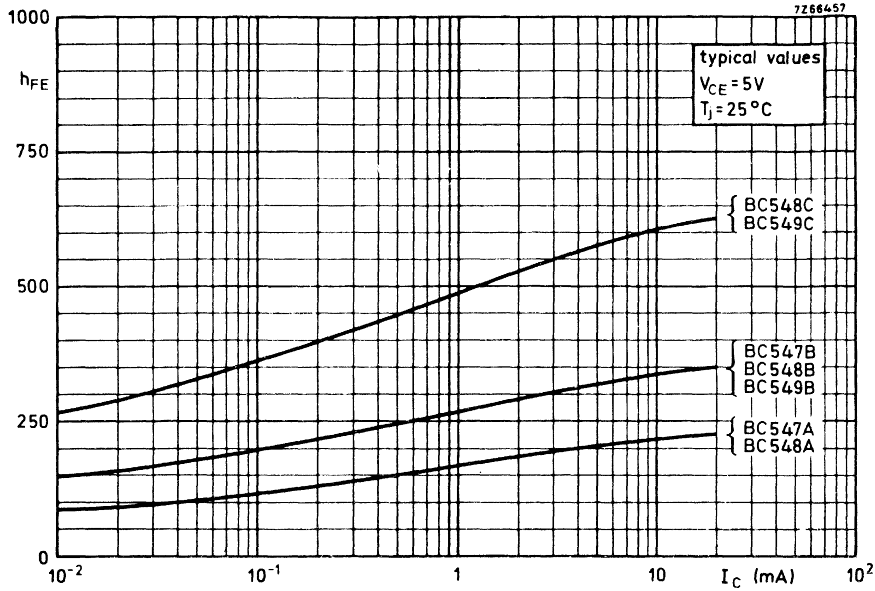
Base current versus collector current

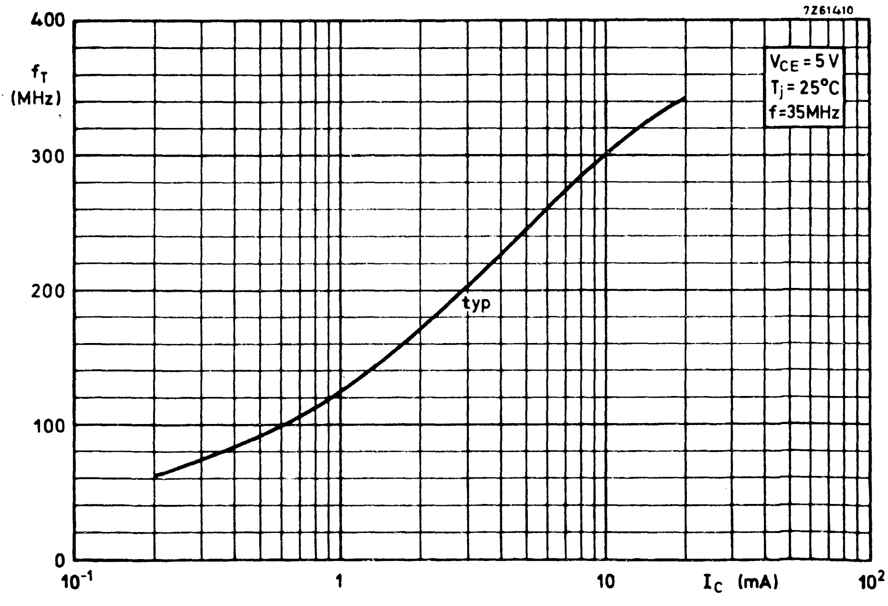


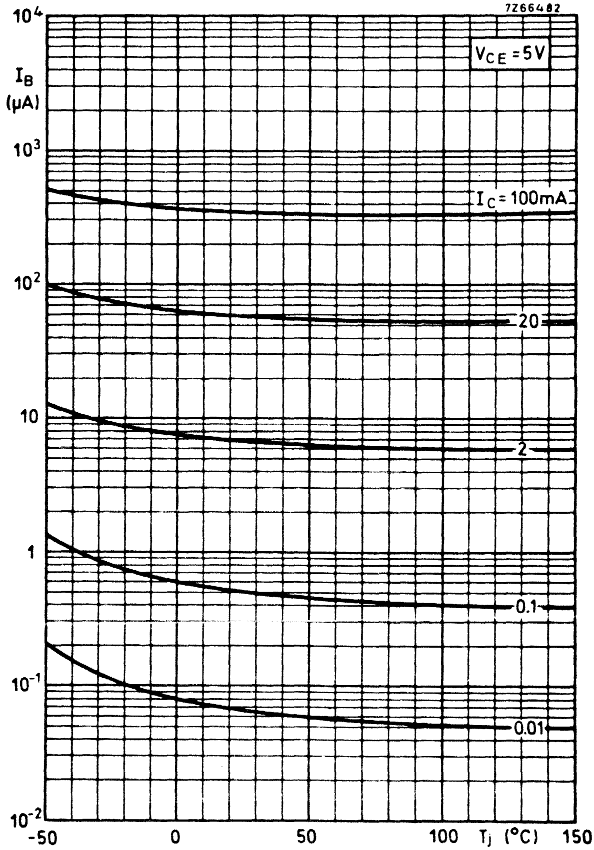
Base current versus collector current



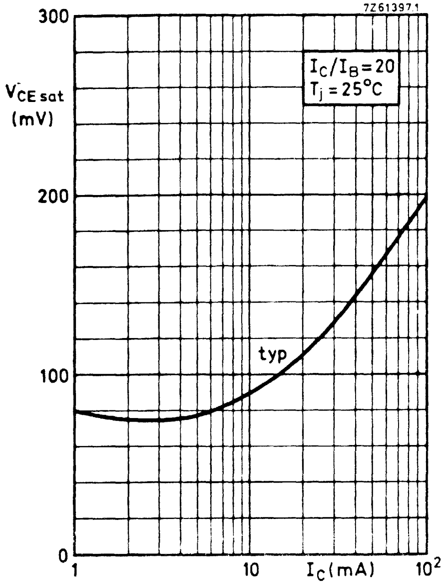


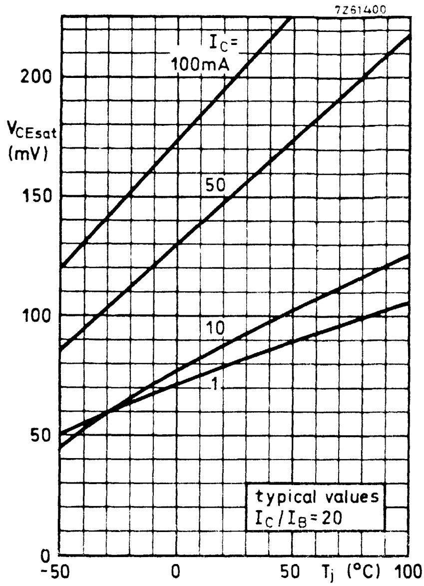

7Z66457
1000
h_{FE}
750
500
250
0
typical values
V_{CE} = 5V
T_j = 25 °C
BC548C
BC549C
BC547B
BC548B
BC549B
BC547A
BC548A
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

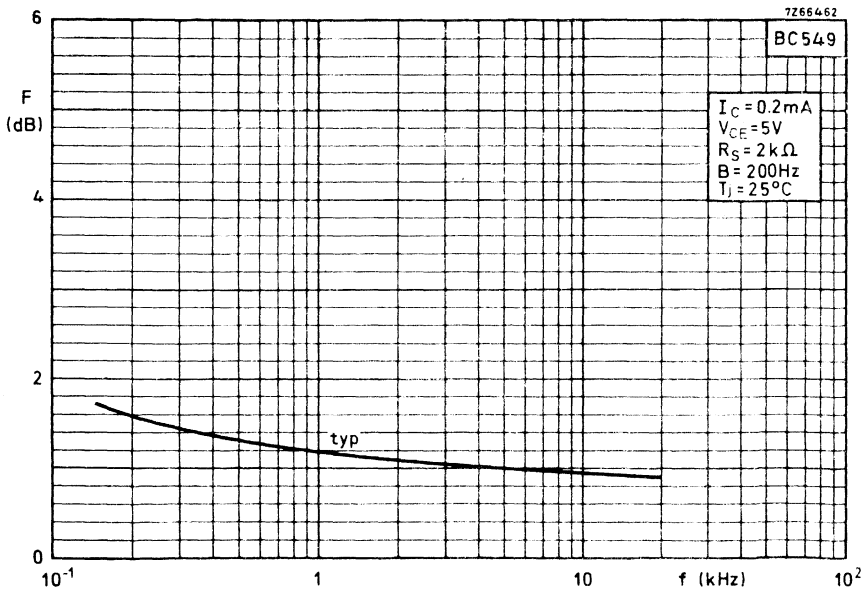

7Z61410
400
f_T
(MHz)
300
200
100
0
V_{CE} = 5 V
T_j = 25°C
f = 35MHz
typ
10^{-1}
1
10
I_C (mA)
10^2

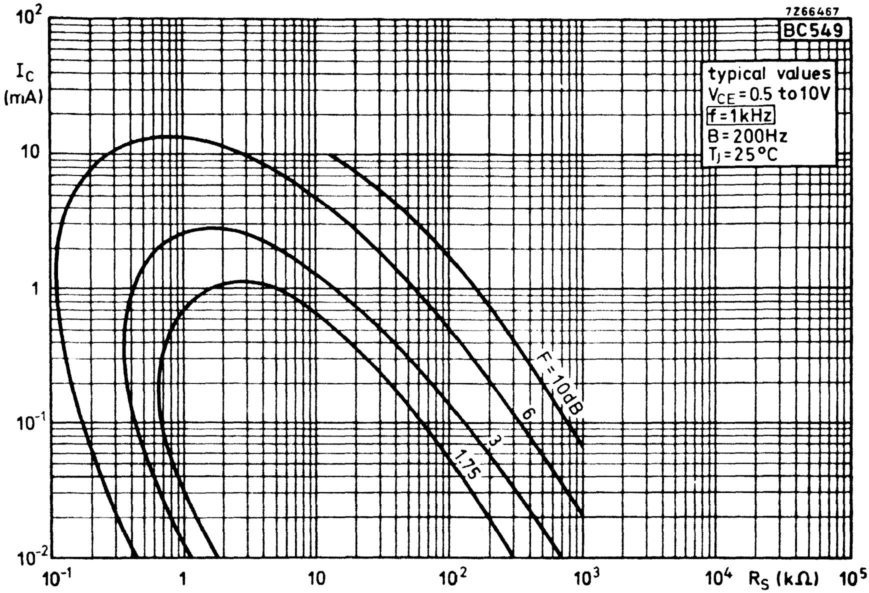


Typical behaviour of base current versus junction temperature

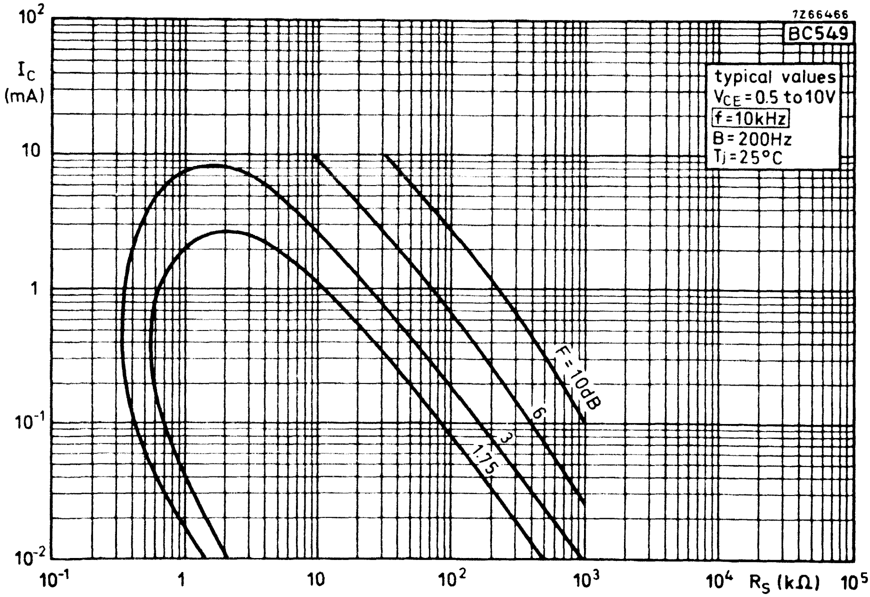

7Z61397.1
V_{CEsat} (mV)
$I_C/I_B = 20$
$T_j = 25°C$
typ
I_C (mA)
300
200
100
0
1
10
10^2


7Z61400
V_{CEsat} (mV)
I_C = 100mA
50
10
1
typical values
$I_C/I_B = 20$
T_j (°C)
200
150
100
50
0
-50
0
50
100

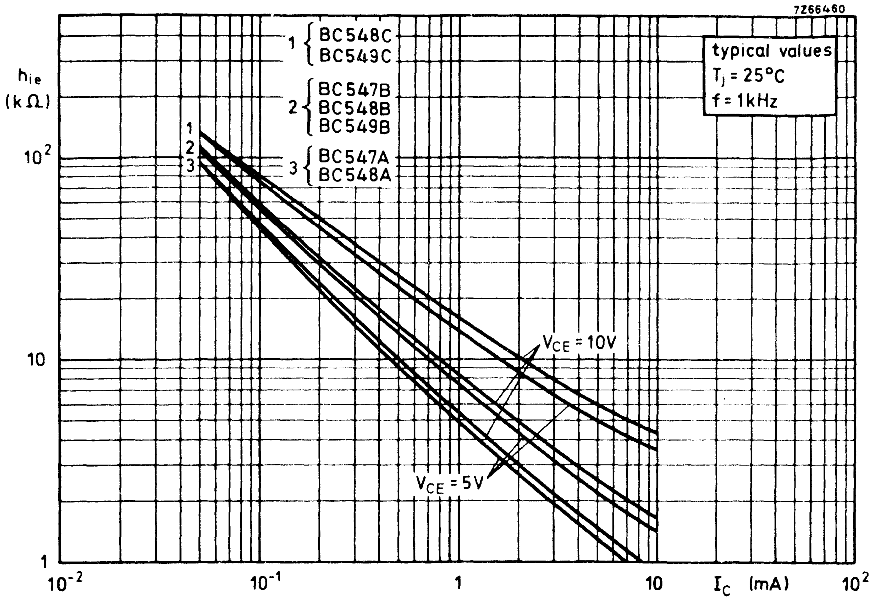

7Z66462
BC549
F (dB)
$I_C = 0.2mA$
$V_{CE} = 5V$
$R_S = 2k\Omega$
B = 200Hz
$T_j = 25°C$
typ
f (kHz)
6
4
2
0
10^{-1}
1
10
10^2

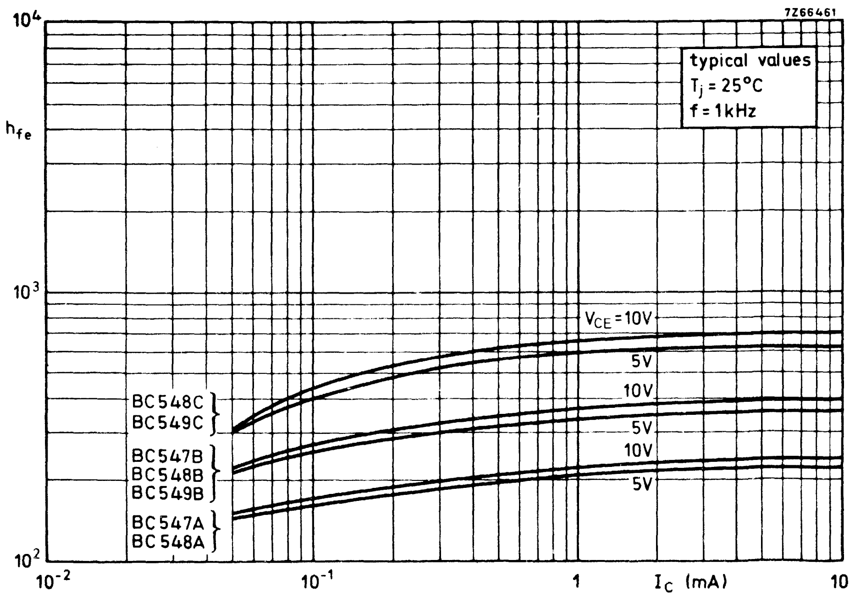


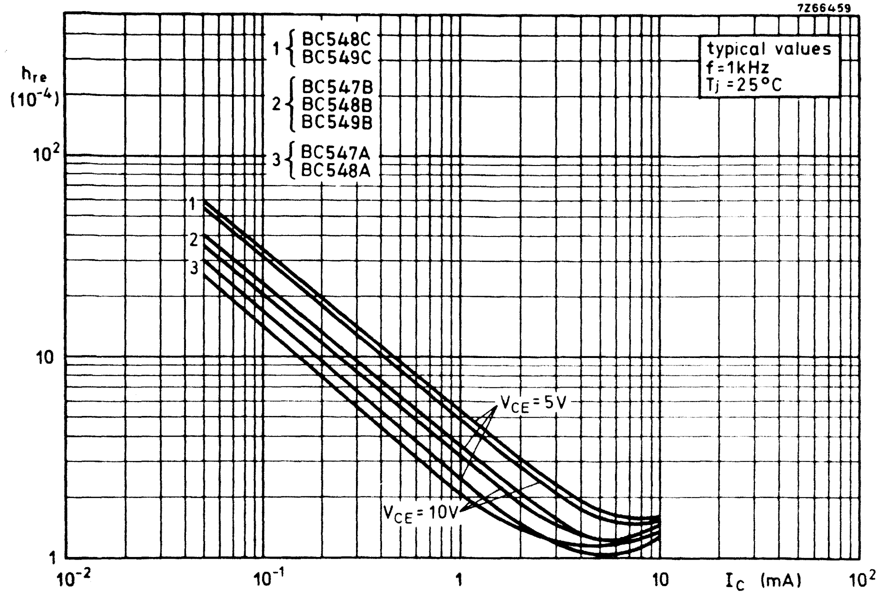
Curves of constant noise figure

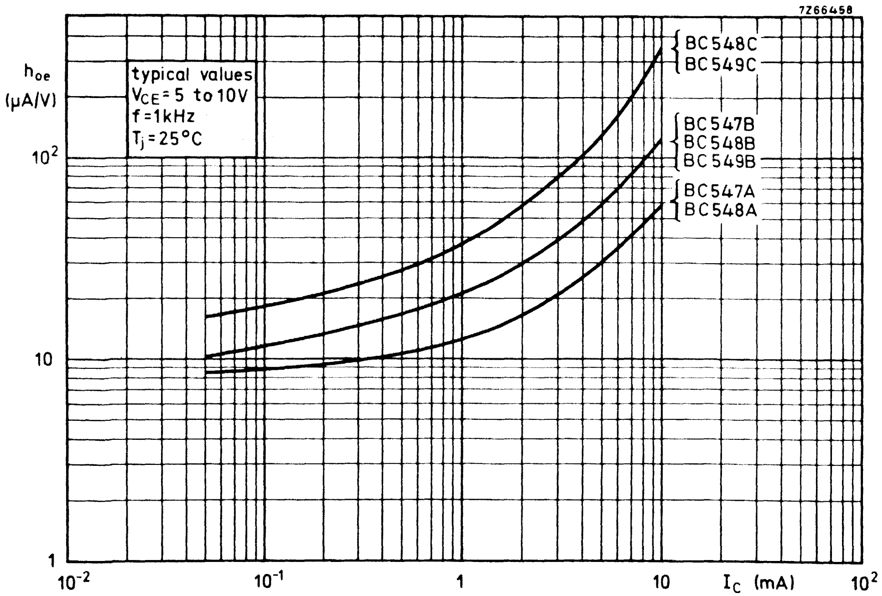


Curves of constant noise figure


7Z66460
h_{ie} (kΩ)
1 { BC548C BC549C
2 { BC547B BC548B BC549B
3 { BC547A BC548A
typical values
T_j = 25°C
f = 1kHz
V_{CE} = 10V
V_{CE} = 5V
10^2
10
1
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2


7Z66461
h_{fe}
typical values
T_j = 25°C
f = 1kHz
V_{CE} = 10V
5V
10V
5V
10V
5V
BC548C BC549C
BC547B BC548B BC549B
BC547A BC548A
10^4
10^3
10^2
10^{-2}
10^{-1}
1
I_C (mA)
10


7Z66459
h_{re}
(10^{-4})
1 { BC548C BC549C
2 { BC547B BC548B BC549B
3 { BC547A BC548A
typical values
f = 1kHz
T_j = 25°C
V_{CE} = 5V
V_{CE} = 10V
10^2
10
1
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2


7Z66458
h_{oe}
(μA/V)
typical values
V_{CE} = 5 to 10V
f = 1kHz
T_j = 25°C
{ BC548C BC549C
{ BC547B BC548B BC549B
{ BC547A BC548A
10^2
10
1
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

A.F. SILICON PLANAR EPITAXIAL TRANSISTORS

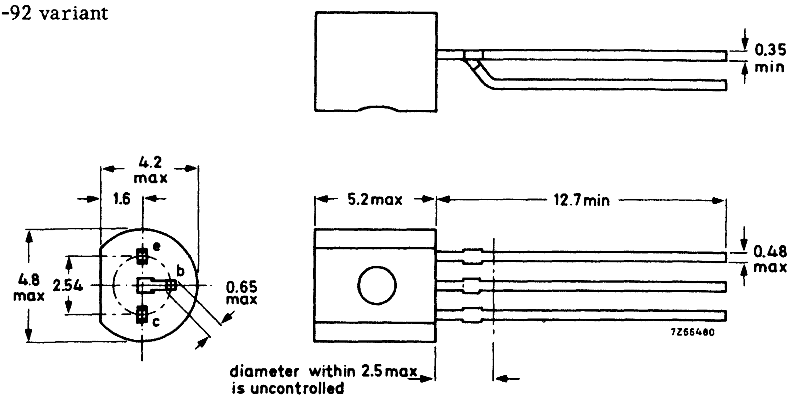
P-N-P transistors in a plastic TO-92 variant.
The BC557 is a high voltage type and primarily intended for use in driver stages of audio amplifiers and in signal processing circuits of television receivers.
The BC558 is suitable for a multitude of low voltage applications e.g. driver stages or audio pre-amplifiers and in signal processing circuits of television receivers.
The BC559 is primarily intended for low noise input stages in tape recorders, hi-fi amplifiers and other audio frequency equipment.

QUICK REFERENCE DATA

			BC557	BC558	BC559	
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} = 75 °C	P_{tot}	max.	300	300	300	mW
Junction temperature	T_j	max.	150	150	150	°C
Small signal current gain at T_j = 25 °C $-I_C$ = 2 mA; $-V_{CE}$ = 5 V; f = 1 kHz	h_{fe}	> <	75 260	75 500	125 500	
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 4	dB dB
f = 1 kHz; B = 200 Hz	F	<	10	10	4	dB

MECHANICAL DATA Dimensions in mm

TO-92 variant



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

Voltages			BC557	BC558	BC559	
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
Base current (peak value)	$-I_{BM}$	max.	200	mA

Power dissipation				
Total power dissipation up to T_{amb} = 75 °C	P_{tot}	max.	300	mW

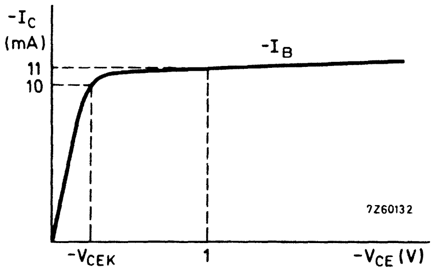
Temperatures				
Storage temperature	T_{stg}		−65 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.25	°C/mW
From junction to case	$R_{th\ j-c}$	=	0.17	°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
$-I_C = 10$ mA; $-V_{CE} = 5$ V	$-V_{BE}$	<	820	mV
Saturation voltages 2)				
$-I_C = 10$ 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
		<	650	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 frequnecy 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.
2) $-V_{BEsat}$ decreases by about 1.7 mV/°C with increasing temperature.

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

Small signal current gain at f = 1 kHz

			BC557	BC558	BC559	
$-I_C$ = 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

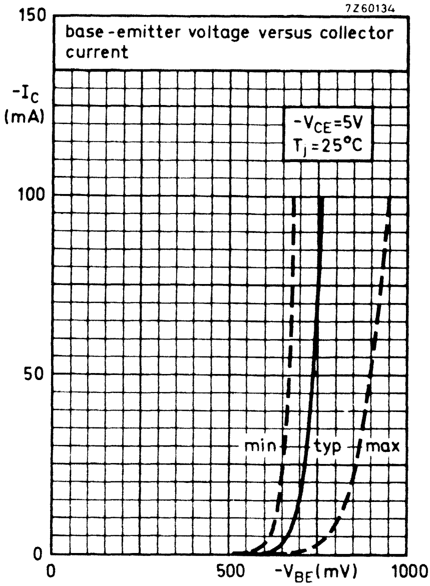
			BC557	BC558	BC559	
f = 30 Hz to 15 kHz	F	typ.			1.2	dB
		<			4	dB
f = 1 kHz; B = 200 Hz	F	typ.	2	2	1	dB
		<	10	10	4	dB

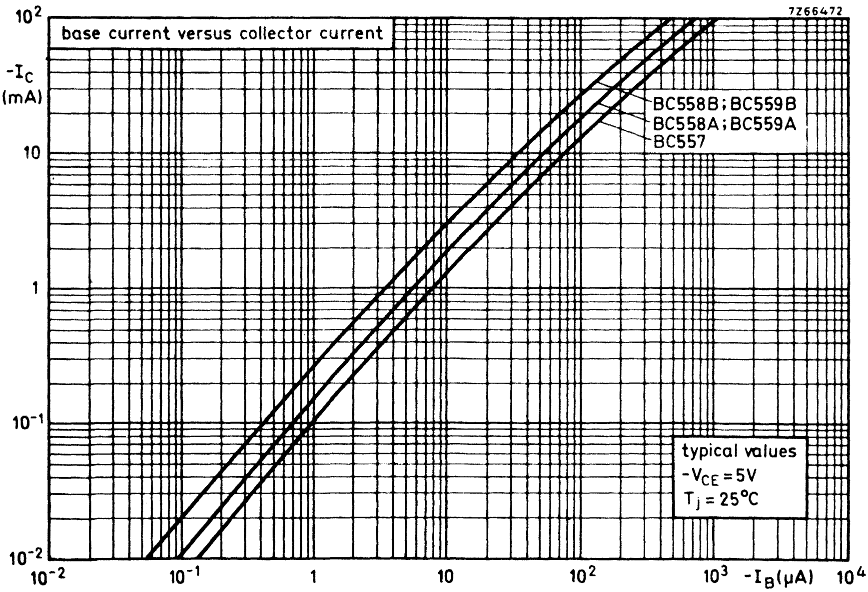
D.C. current gain

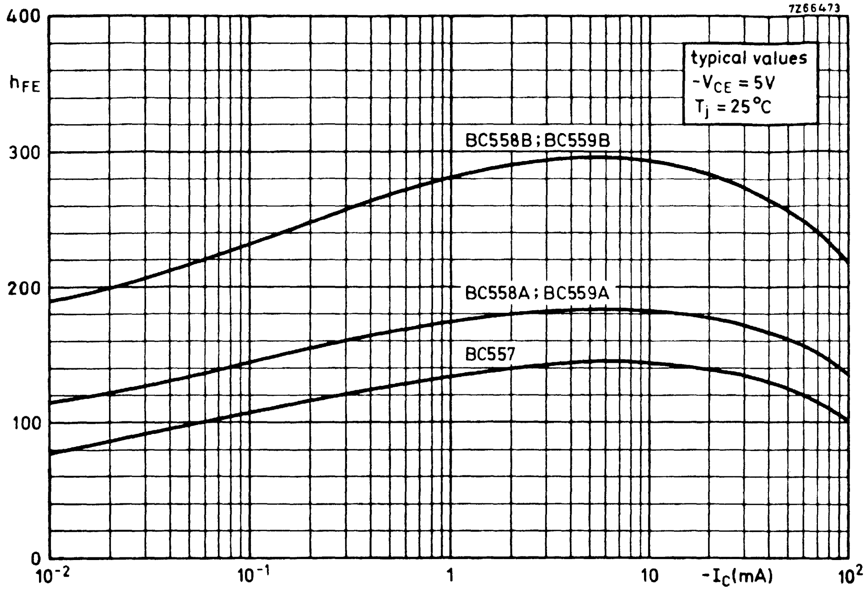
			BC557	BC558A BC559A	BC558B BC559B
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{FE}	typ.	140	180	290

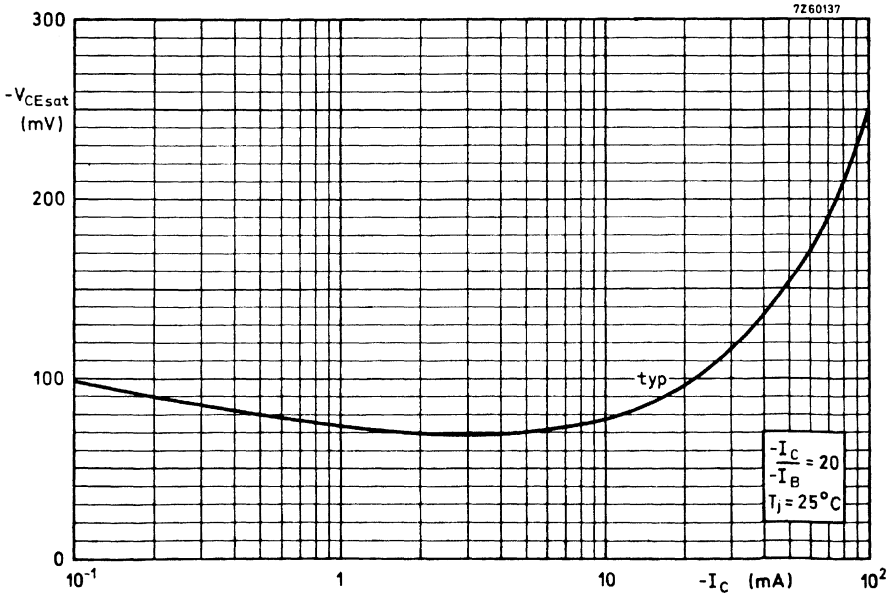
Small signal current gain at f = 1 kHz

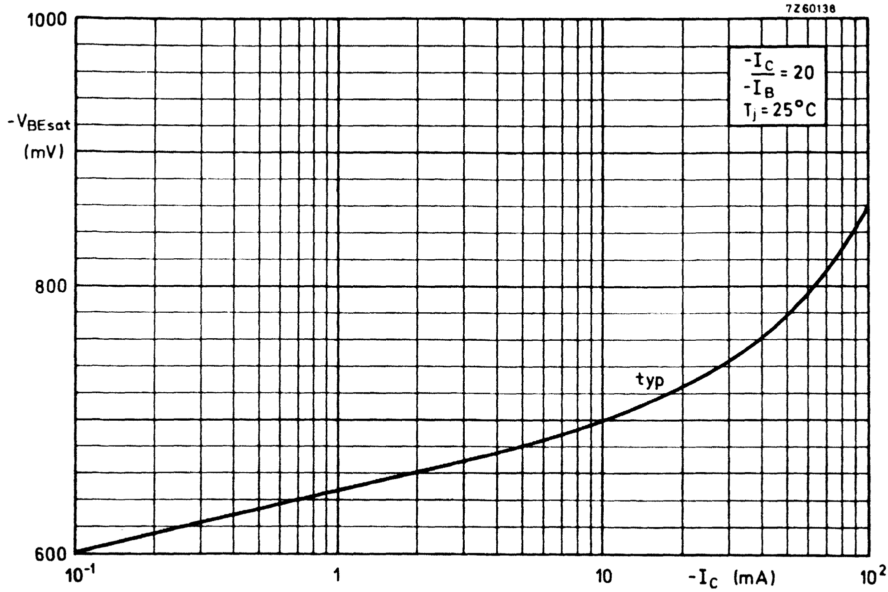
			BC557	BC558A BC559A	BC558B BC559B
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{fe}	>	75	125	240
		<	260	260	500

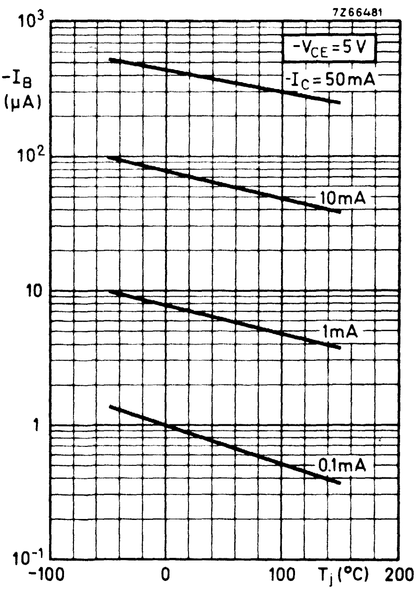

7Z60134
base-emitter voltage versus collector current
$-I_C$ (mA)
150
100
50
0
$-V_{CE}$ = 5V
T_j = 25°C
min
typ
max
0
500
$-V_{BE}$ (mV)
1000


7Z66472
base current versus collector current
$-I_C$ (mA)
10^2
10
1
10^{-1}
10^{-2}
BC558B; BC559B
BC558A; BC559A
BC557
typical values
$-V_{CE}$ = 5V
T_j = 25°C
10^{-2}
10^{-1}
1
10
10^2
10^3
$-I_B$ (μA)
10^4

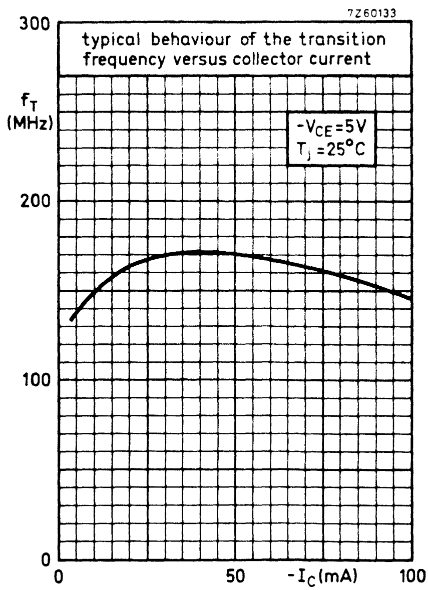

7Z66473
400
300
200
100
0
h_{FE}
typical values
$-V_{CE} = 5V$
$T_j = 25°C$
BC558B; BC559B
BC558A; BC559A
BC557
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2

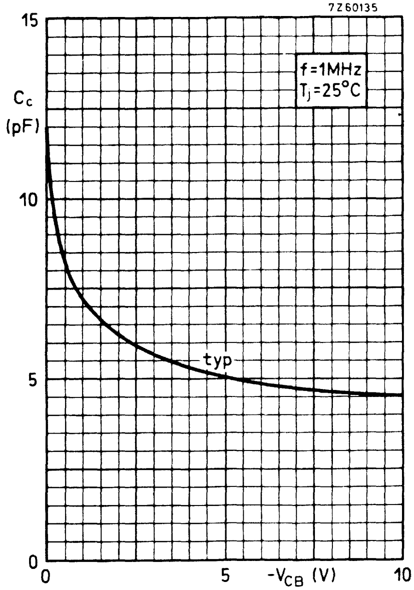

7Z60137
300
200
100
0
$-V_{CEsat}$ (mV)
typ
$\frac{-I_C}{-I_B} = 20$
$T_j = 25°C$
10^{-1}
1
10
$-I_C$ (mA)
10^2

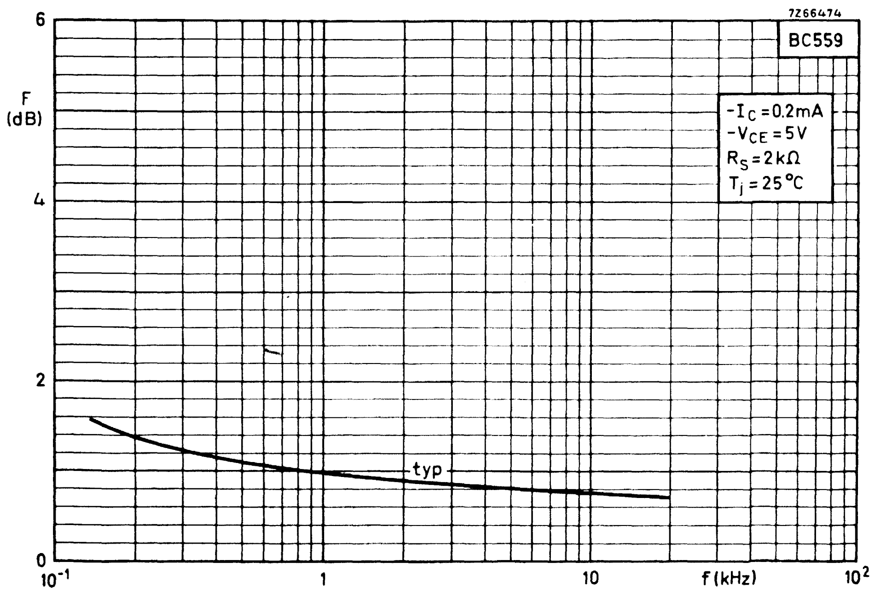


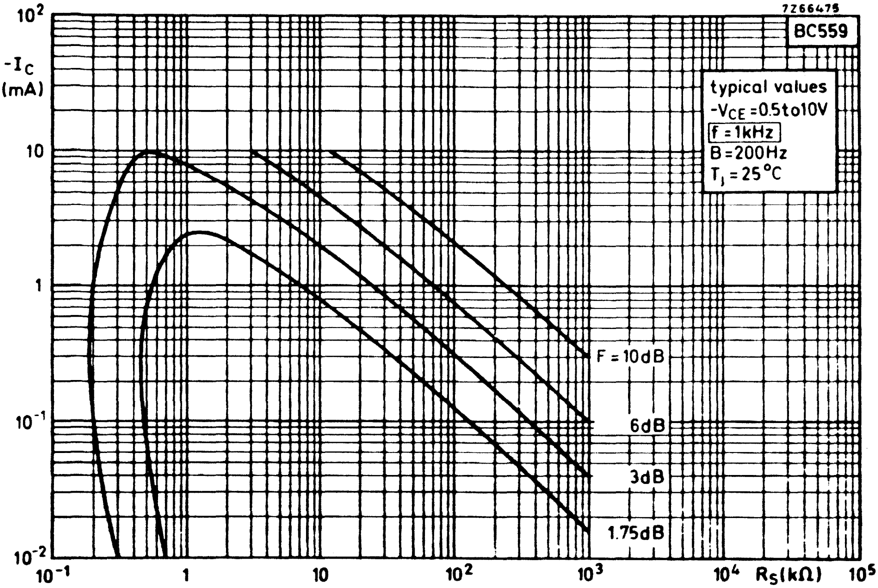


Typical behaviour of base current versus junction temperature

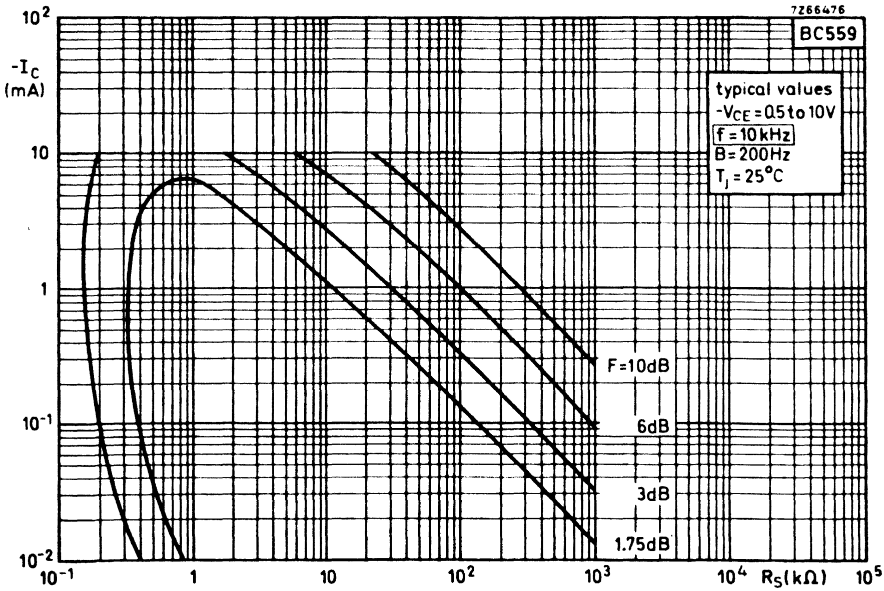



7Z60135
f = 1MHz
T_j = 25°C
C_c
(pF)
15
10
5
0
typ
0
5
$-V_{CB}$ (V)
10

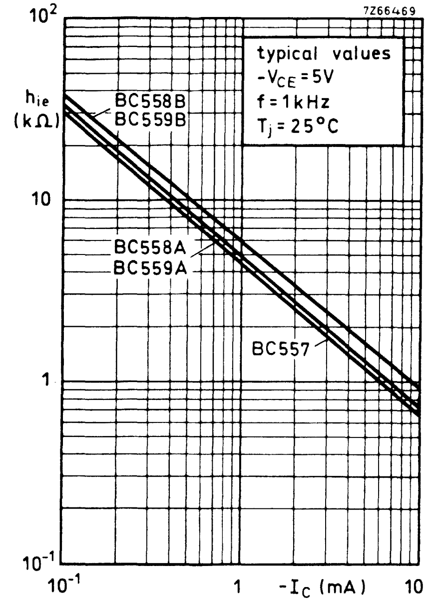

7Z66474
BC559
$-I_C$ = 0.2mA
$-V_{CE}$ = 5V
R_S = 2kΩ
T_j = 25°C
F
(dB)
6
4
2
0
typ
10^{-1}
1
10
f (kHz)
10^2

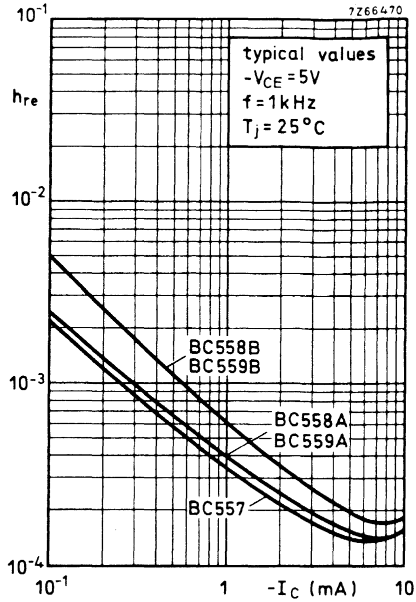


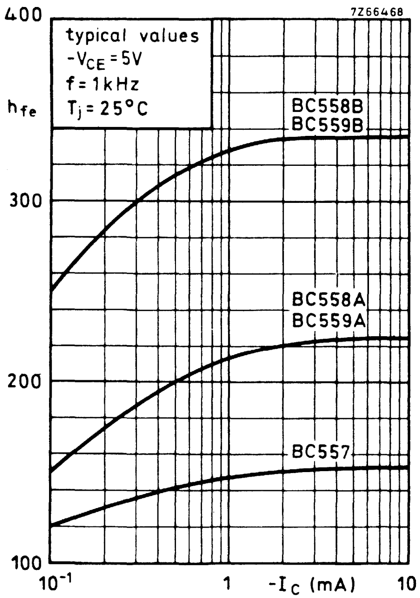
Curves of constant noise figure

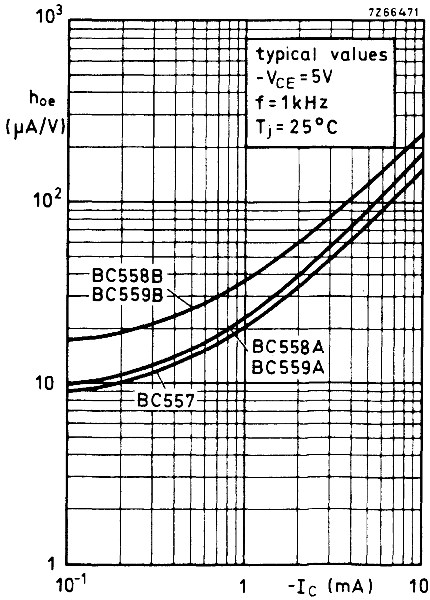


Curves of constant noise figure


7Z66469
typical values
$-V_{CE}$ = 5V
f = 1 kHz
T_j = 25 °C
h_{ie} (kΩ)
BC558B
BC559B
BC558A
BC559A
BC557
10^2
10
1
10^{-1}
10^{-1}
1
$-I_C$ (mA)
10


7Z66470
typical values
$-V_{CE}$ = 5V
f = 1 kHz
T_j = 25 °C
h_{re}
BC558B
BC559B
BC558A
BC559A
BC557
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-1}
1
$-I_C$ (mA)
10


7Z66468
typical values
$-V_{CE}$ = 5V
f = 1 kHz
T_j = 25 °C
h_{fe}
BC558B
BC559B
BC558A
BC559A
BC557
400
300
200
100
10^{-1}
1
$-I_C$ (mA)
10


7Z66471
typical values
$-V_{CE}$ = 5V
f = 1 kHz
T_j = 25 °C
h_{oe} (μA/V)
BC558B
BC559B
BC558A
BC559A
BC557
10^3
10^2
10
1
10^{-1}
1
$-I_C$ (mA)
10

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a plastic envelope intended for amplifier and switching applications.

QUICK REFERENCE DATA

			BCW46	BCW47	BCW48 BCW49	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	50	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	45	20	V

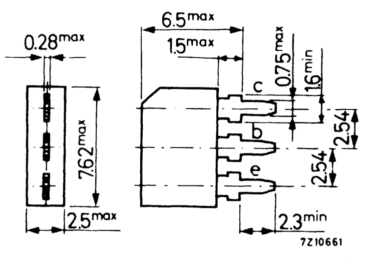
Collector current (peak value)	I_{CM}	max.	200	mA
Total power dissipation up to T_{amb} = 50 °C	P_{tot}	max.	200	mW
Junction temperature	T_j	max.	150	°C

			BCW46A BCW47A BCW48A	BCW46B BCW47B BCW48B BCW49B	BCW48C BCW49C
Small signal current gain at f = 1 kHz I_C = 2 mA; V_{CE} = 5 V	h_{fe}	>	125	240	450
		<	260	500	900

Transition frequency at f = 100 MHz I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	300	MHz

MECHANICAL DATA

Dimensions in mm



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

			BCW46	BCW47	BCW48 BCW49	
Voltages						
Collector-base voltage (open emitter)	V_{CBO}	max.	80	50	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	45	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	6	5	V

Currents				
Collector current (d.c. or average)	I_C	max.	100	mA
Collector current (peak value)	I_{CM}	max.	200	mA
Base current (peak value)	I_{BM}	max.	200	mA
Power dissipation				
Total power dissipation up to T_{amb} = 50 °C	P_{tot}	max.	200	mW
Temperatures				
Storage temperature	T_{stg}		-65 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

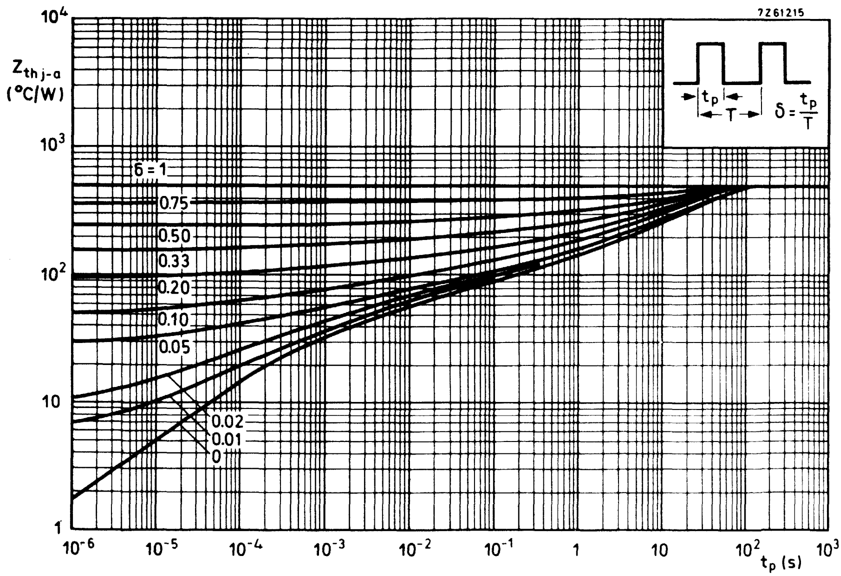
From junction to ambient in free air $R_{th\ j\text{-}a}$ = 0.5 °C/mW

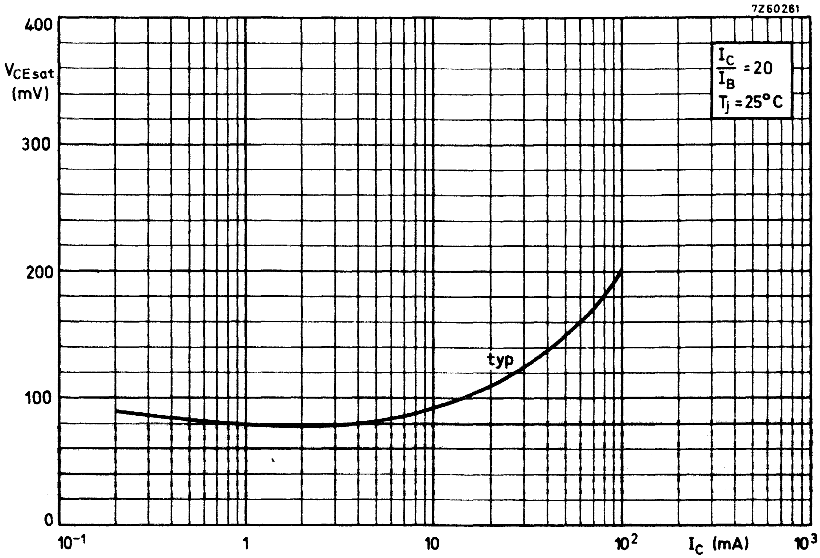
CHARACTERISTICS T_j = 25 °C unless otherwise specified

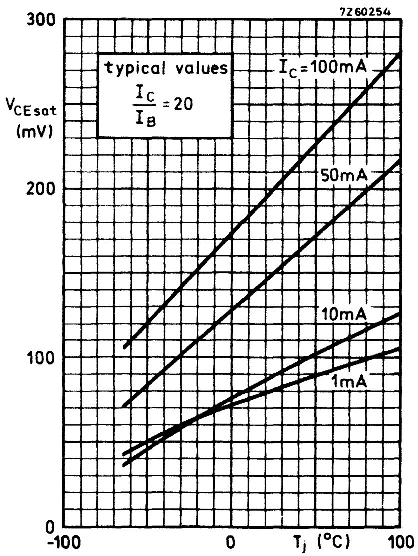
<u>Collector cut-off currents</u>				
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	10	μA
$V_{CE} = 20$ V; $V_{BE} = 0$	I_{CES}	typ.	2	nA
		<	100	nA
$V_{CE} = V_{CEOmax}$; $V_{BE} = 0$; $T_j = 100$ °C	I_{CES}	<	10	μA
<u>Emitter cut-off current</u>				
$I_C = 0$; $V_{EB} = 4$ V	I_{EBO}	<	100	nA
$I_C = 0$; $V_{EB} = V_{EBOmax}$	I_{EBO}	<	10	μA
<u>Base-emitter voltages</u>				
$I_C = 2$ mA; $V_{CE} = 5$ V	V_{BE}	550 to	700	mV
$I_C = 10$ mA; $V_{CE} = 5$ V	V_{BE}	<	770	mV
<u>Saturation voltages</u>				
$I_C = 10$ mA; $I_B = 0.5$ mA	V_{CEsat}	typ.	90	mV
		<	250	mV
$I_C = 100$ mA; $I_B = 5$ mA	V_{CEsat}	typ.	200	mV
		<	600	mV
<u>Collector capacitance</u> at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	2.5	pF
<u>Emitter capacitance</u> at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	typ.	9	pF
<u>Transition frequency</u> at f = 100 MHz				
$I_C = 10$ mA; $V_{CE} = 5$ V	f_T	typ.	300	MHz
<u>Noise figure</u>			<u>BCW49</u>	
$I_C = 200$ μA; $V_{CE} = 5$ V; $R_S = 2$ kΩ				
f = 1 kHz; bandwidth: 200 Hz	F	typ.	1.4	dB
		<	4	dB
f = 30 to 15 000 Hz	F	typ.	1.2	dB
		<	4	dB

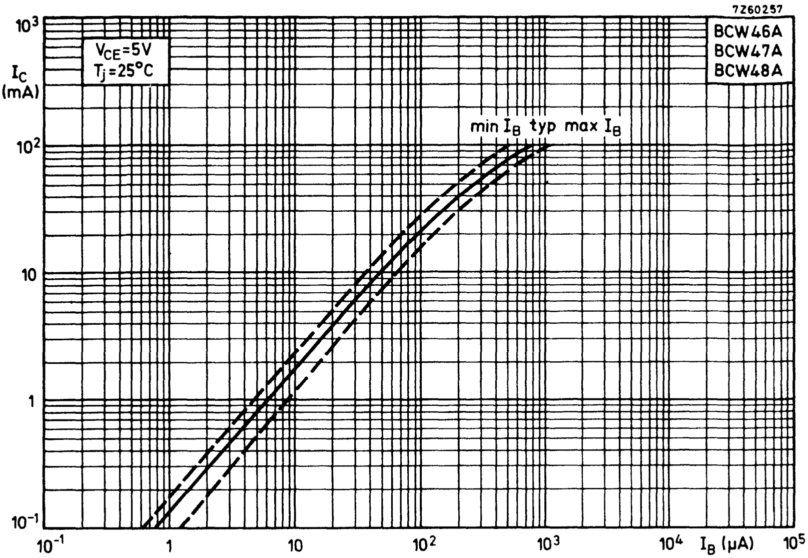
CHARACTERISTICS (continued)

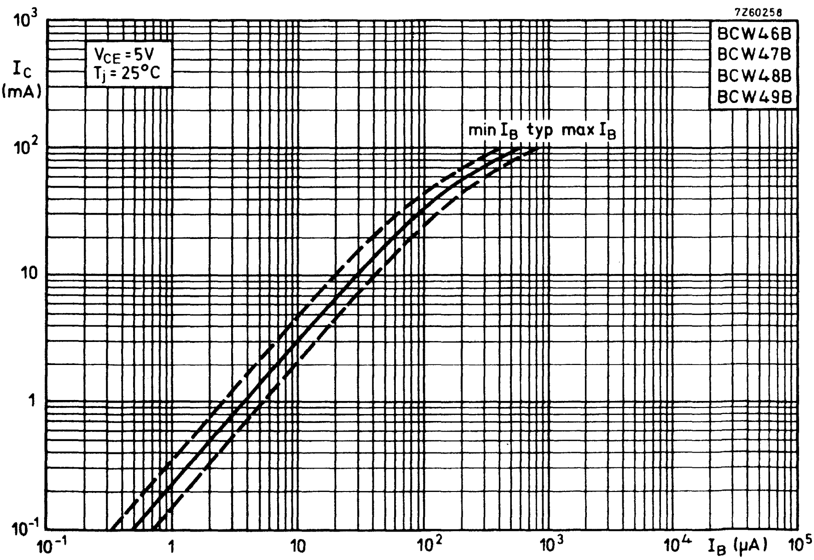
			BCW46A BCW47A BCW48A	BCW46B BCW47B BCW48B BCW49B	BCW48C BCW49C	
D.C. current gain						
I_C = 10 μA ; V_{CE} = 5 V	h_{FE}	typ.	90	150	270	
I_C = 2 mA; V_{CE} = 5 V	h_{FE}	>	110	200	420	
		<	220	450	800	
I_C = 10 mA; V_{CE} = 5 V	h_{FE}	typ.	215	340	600	
h parameters at f = 1 kHz						
I_C = 2 mA; V_{CE} = 5 V						
Input impedance	h_{ie}	typ.	2.7	4.5	8.7	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	1.5	2.0	3.0	10^{-4}
Small signal current gain	h_{fe}	>	125	240	450	
		<	260	500	900	
Output admittance	h_{oe}	typ.	18	30	60	$\mu\Omega^{-1}$

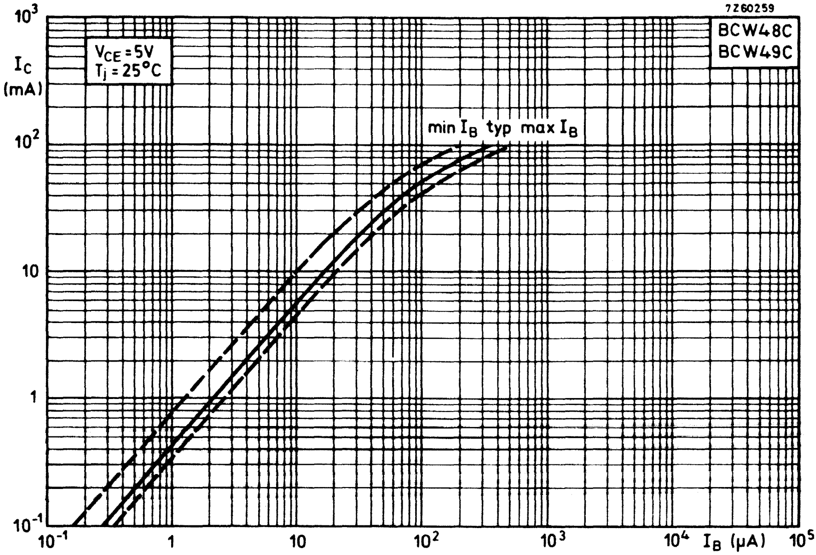


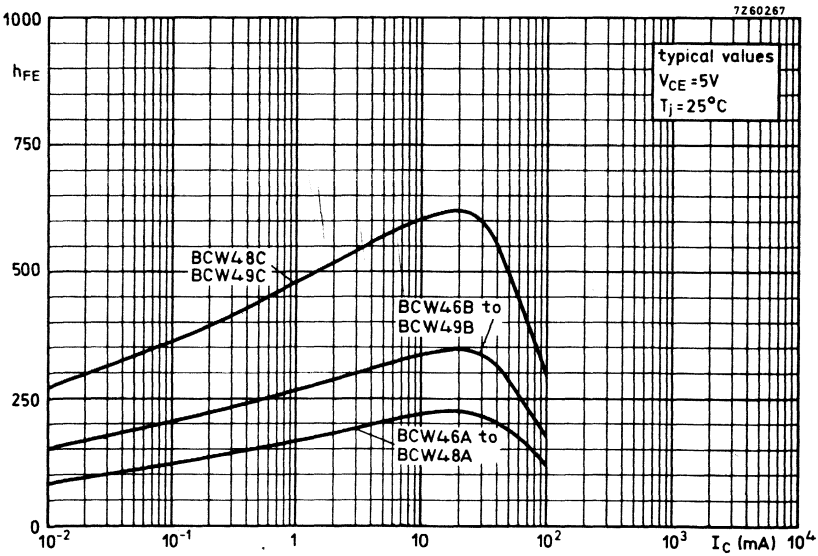

7Z60261
400
V_{CEsat}
(mV)
300
200
100
0
$\frac{I_C}{I_B}$ = 20
T_j = 25°C
typ
10^{-1}
1
10
10^2
I_C (mA)
10^3

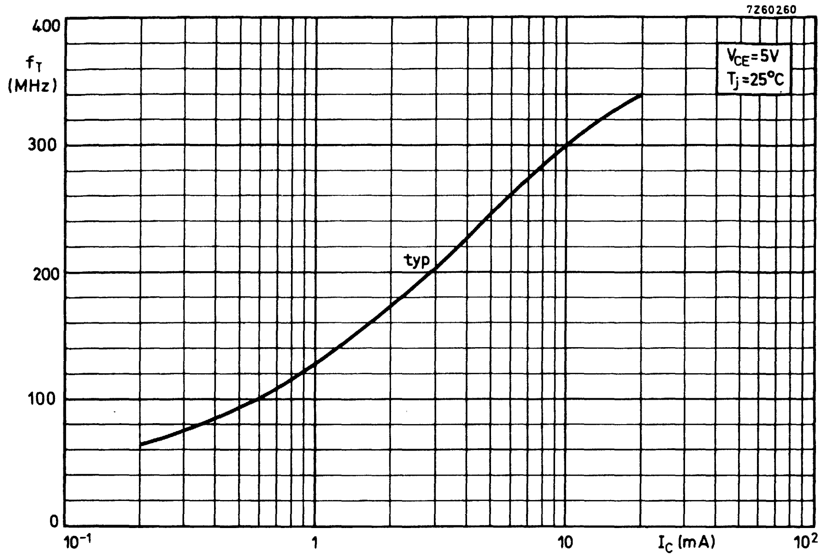

7Z60254
300
V_{CEsat}
(mV)
200
100
0
typical values
$\frac{I_C}{I_B}$ = 20
I_C = 100mA
50mA
10mA
1mA
-100
0
T_j (°C)
100

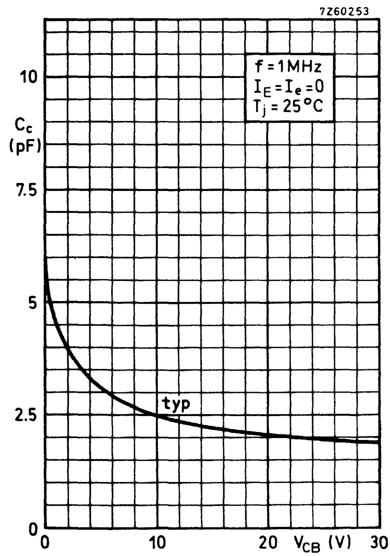

7Z60257
BCW46A
BCW47A
BCW48A
V_{CE}=5V
T_j=25°C
I_C (mA)
min I_B typ max I_B
10^3
10^2
10
1
10^{-1}
10^{-1}
1
10
10^2
10^3
10^4
I_B (μA)
10^5

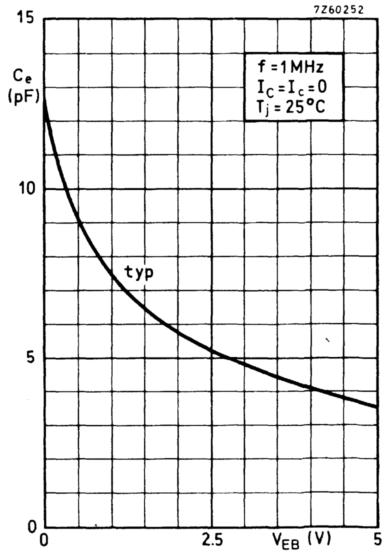

7Z60258
BCW46B
BCW47B
BCW48B
BCW49B
V_{CE} = 5V
T_j = 25°C
I_C (mA)
min I_B typ max I_B
10^3
10^2
10
1
10^{-1}
10^{-1}
1
10
10^2
10^3
10^4
I_B (μA)
10^5

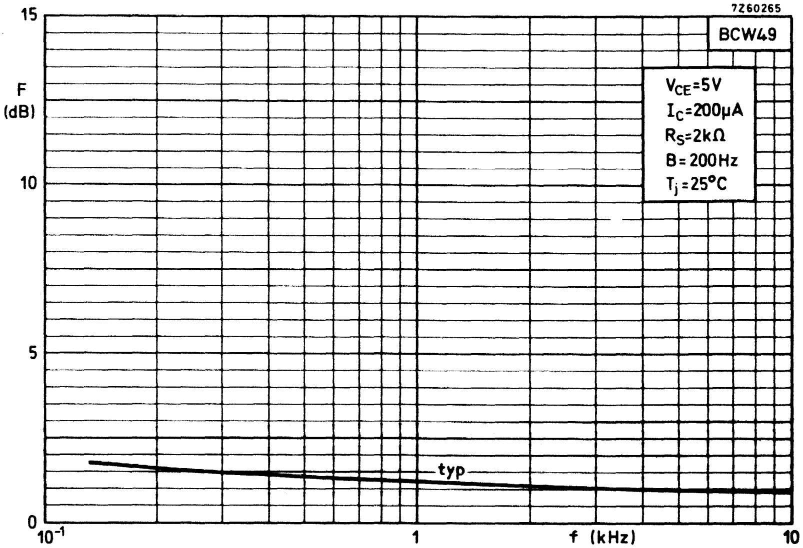

7Z60259
BCW48C
BCW49C
V_{CE} = 5V
T_j = 25°C
I_C
(mA)
min I_B typ max I_B
10^3
10^2
10
1
10^{-1}
10^{-1}
1
10
10^2
10^3
10^4
I_B (μA)
10^5

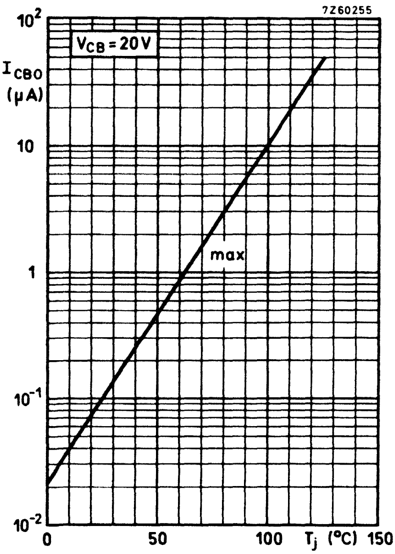

7Z60267
typical values
V_{CE} = 5V
T_j = 25°C
h_{FE}
1000
750
500
250
0
BCW48C
BCW49C
BCW46B to
BCW49B
BCW46A to
BCW48A
10^{-2}
10^{-1}
1
10
10^2
10^3
I_C (mA)
10^4

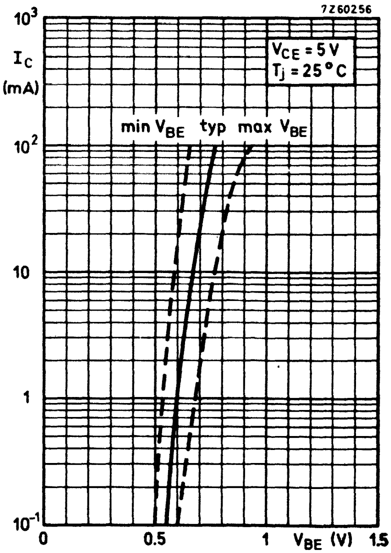

7Z60260
400
300
200
100
0
f_T
(MHz)
V_{CE} = 5V
T_j = 25°C
typ
10^{-1}
1
10
I_C (mA)
10^2

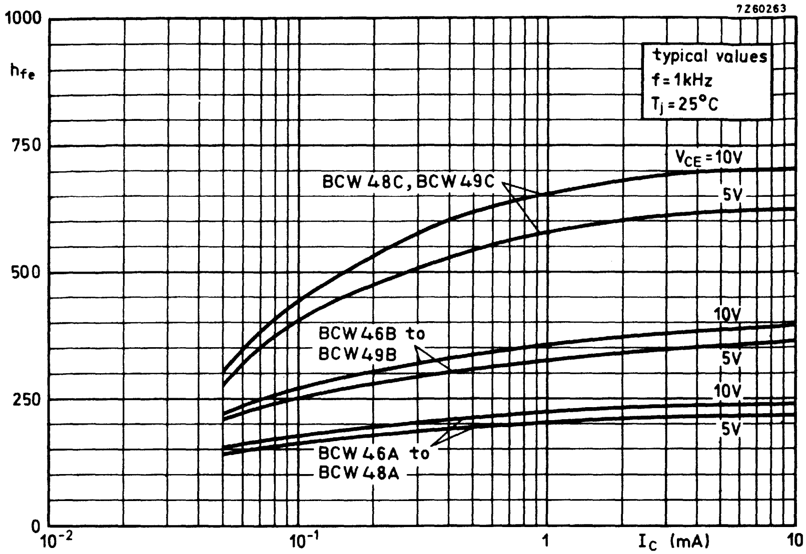

7Z60253
10
C_c
(pF)
7.5
5
2.5
0
f = 1MHz
$I_E = I_e = 0$
T_j = 25°C
typ
0
10
20
V_{CB} (V)
30

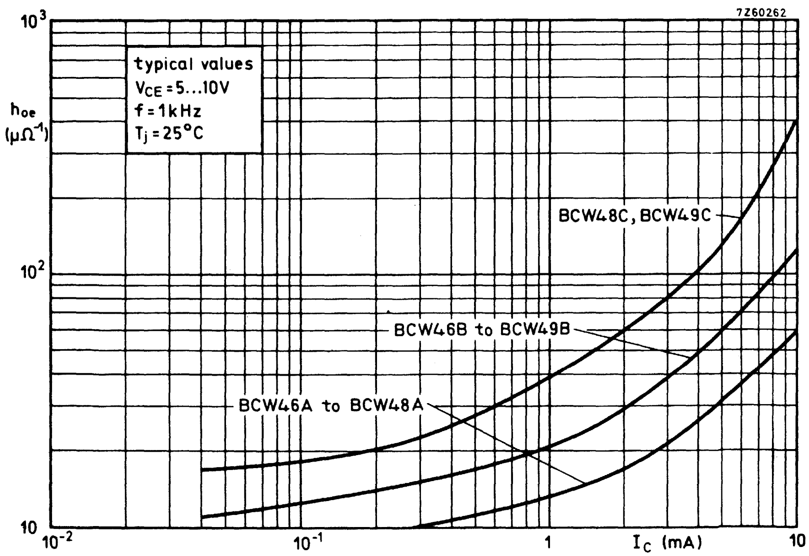

7Z60252
15
C_e
(pF)
10
5
0
f = 1MHz
$I_C = I_c = 0$
T_j = 25°C
typ
0
2.5
V_{EB} (V)
5

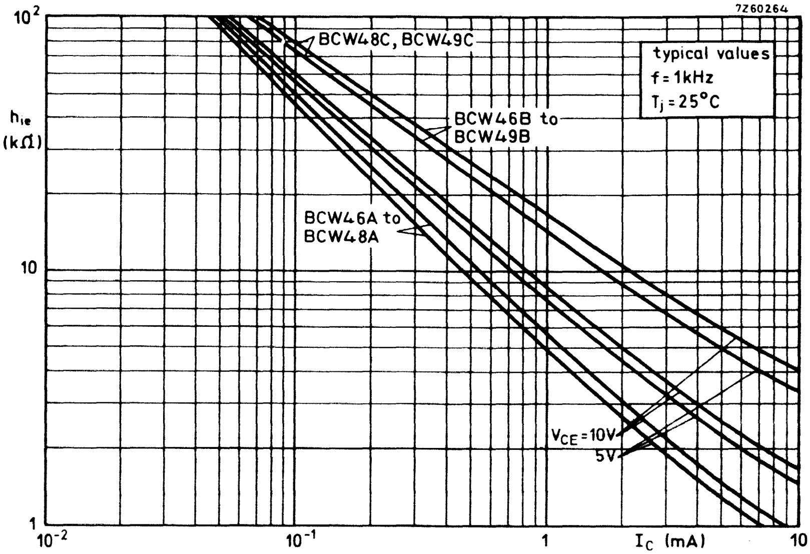

7Z60265
BCW49
V_{CE}=5V
I_C=200μA
R_S=2kΩ
B=200Hz
T_j=25°C
F
(dB)
15
10
5
0
typ
10^{-1}
1
f (kHz)
10

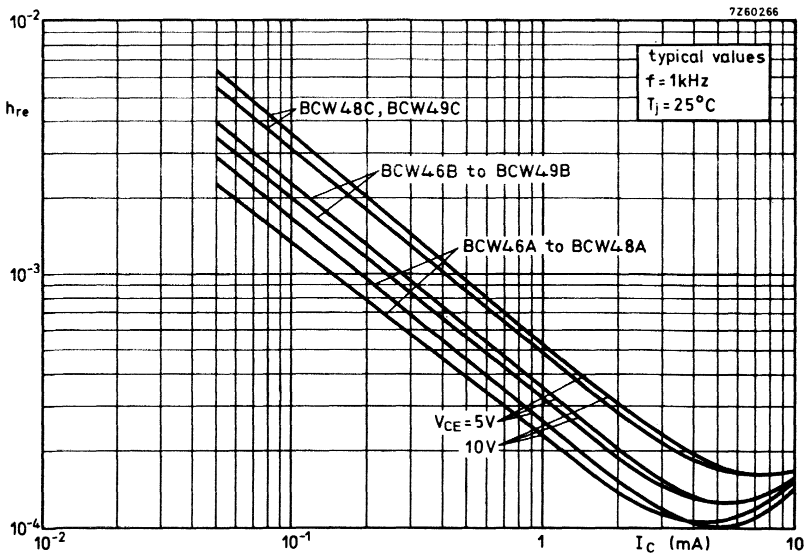

7Z60255
V_{CB}=20V
I_{CBO}
(μA)
10^2
10
1
10^{-1}
10^{-2}
max
0
50
100
T_j (°C)
150


7Z60256
V_{CE} = 5 V
T_j = 25 °C
I_C
(mA)
10^3
10^2
10
1
10^{-1}
min V_{BE}
typ
max V_{BE}
0
0.5
1
V_{BE} (V)
1.5


7Z60263
1000
750
500
250
0
h_{fe}
typical values
f = 1kHz
T_j = 25°C
V_{CE} = 10V
5V
10V
5V
10V
5V
BCW 48C, BCW 49C
BCW 46B to
BCW 49B
BCW 46A to
BCW 48A
10^{-2}
10^{-1}
1
I_C (mA)
10


7Z60262
10^3
10^2
10
h_{oe}
($\mu\Omega^{-1}$)
typical values
V_{CE} = 5...10V
f = 1kHz
T_j = 25°C
BCW48C, BCW49C
BCW46B to BCW49B
BCW46A to BCW48A
10^{-2}
10^{-1}
1
I_C (mA)
10


7Z60264
typical values
f = 1kHz
Tj = 25°C
BCW48C, BCW49C
BCW46B to BCW49B
BCW46A to BCW48A
VCE = 10V
5V
hie (kΩ)
Ic (mA)
10^2
10
1
10^-2
10^-1
1
10


7Z60266
typical values
f = 1kHz
Tj = 25°C
BCW48C, BCW49C
BCW46B to BCW49B
BCW46A to BCW48A
VCE = 5V
10V
hre
Ic (mA)
10^-2
10^-3
10^-4
10^-2
10^-1
1
10

SILICON PLANAR EPITAXIAL TRANSISTORS

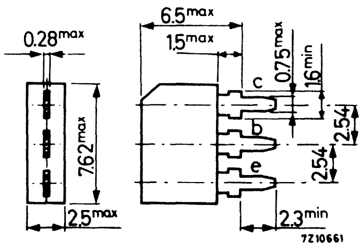
P-N-P transistors in a plastic envelope intended for amplifier and switching applications.

QUICK REFERENCE DATA

			BCW56	BCW57	BCW58 BCW59	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80	50	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	45	20	V
Collector current (peak value)	$-I_{CM}$	max.	200			mA
Total power dissipation up to T_{amb} = 50 °C	P_{tot}	max.	200			mW
Junction temperature	T_j	max.	150			°C

			BCW56A BCW57A BCW58A BCW59A	BCW58B BCW59B
Small signal current gain at f = 1 kHz $-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{fe}	>	125	240
		<	260	500
Transition frequency at f = 100 MHz $-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.	150	MHz

MECHANICAL DATA Dimensions in mm



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

Voltages			BCW56	BCW57	BCW58 BCW59	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80	50	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	45	20	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	6	6	5	V

Currents

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

Power dissipation

Total power dissipation up to T_{amb} = 50 °C	P_{tot}	max.	200	mW

Temperatures

Storage temperature	T_{stg}		-65 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

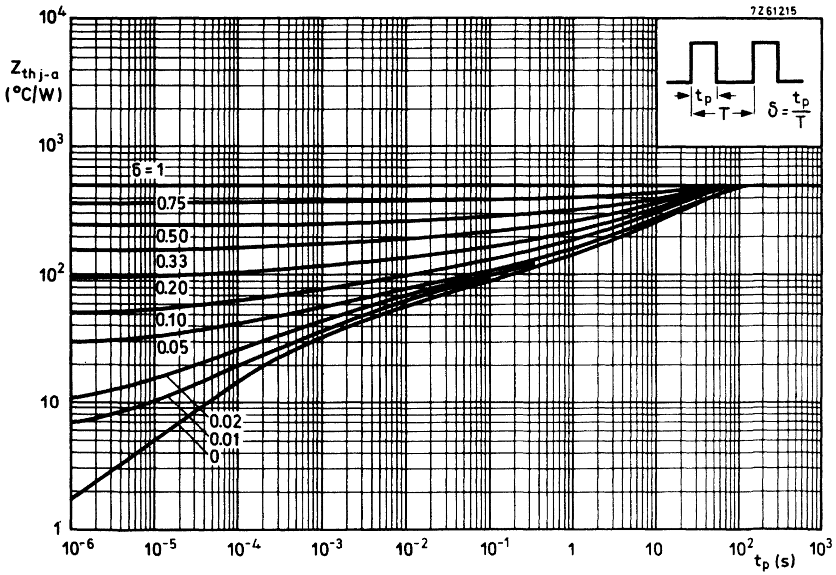
From junction to ambient in free air	$R_{th\ j-a}$	=	0.5	°C/mW

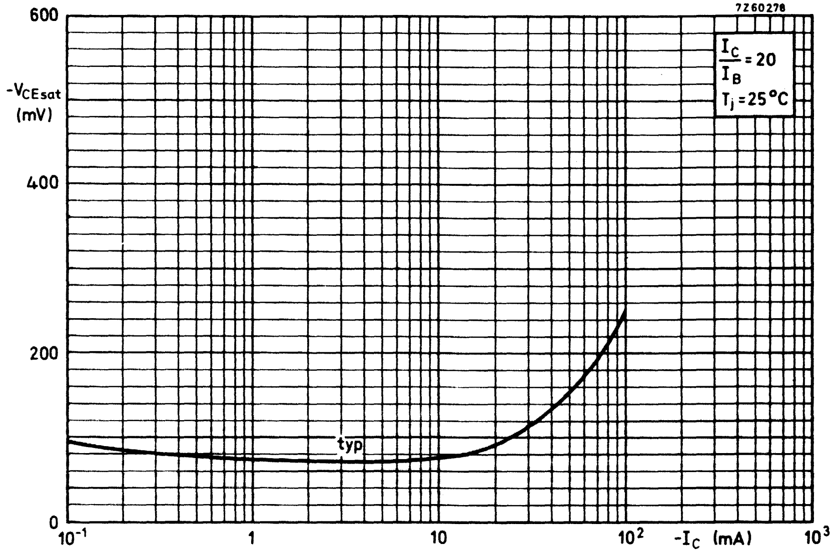
CHARACTERISTICS T_j = 25 °C unless otherwise specified

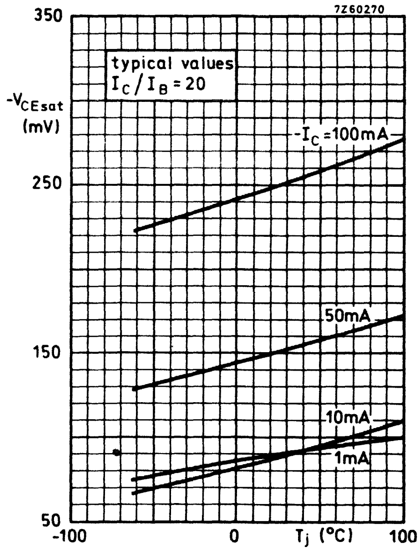
Conditions	Symbol		Value	Unit
Collector cut-off currents				
$-I_E = 0$; $-V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	10	μA
$-V_{CE} = 20$ V; $V_{BE} = 0$	$-I_{CES}$	typ.	2	nA
		<	100	nA
$-V_{CE} = -V_{CEOmax}$; $V_{BE} = 0$; $T_j = 100$ °C	$-I_{CES}$	<	10	μA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 4$ V	$-I_{EBO}$	<	100	nA
$I_C = 0$; $-V_{EB} = -V_{EBOmax}$	$-I_{EBO}$	<	10	μA
Base-emitter voltages				
$-I_C =$ 2 mA; $-V_{CE} = 5$ V	$-V_{BE}$		600 to 750	mV
$-I_C =$ 10 mA; $-V_{CE} = 5$ V	$-V_{BE}$	typ.	690	mV
Saturation voltages				
$-I_C =$ 10 mA; $-I_B = 0.5$ mA	$-V_{CEsat}$	typ.	75	mV
		<	300	mV
$-I_C =$ 100 mA; $-I_B =$ 5 mA	$-V_{CEsat}$	typ.	250	mV
		<	700	mV
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $-V_{CB} = 10$ V	C_c	typ.	4.5	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $-V_{EB} = 0.5$ V	C_e	typ.	11.5	pF
Transition frequency at f = 100 MHz				
$-I_C =$ 10 mA; $-V_{CE} = 5$ V	f_T	typ.	150	MHz
Noise figure			BCW59	
$-I_C = 200$ μA; $-V_{CE} = 5$ V; $R_S = 2$ kΩ				
f = 1 kHz; bandwidth: 200 Hz	F	typ.	1.2	dB
		<	4	dB
f = 30 to 15 000 Hz	F	typ.	1.0	dB
		<	4	dB

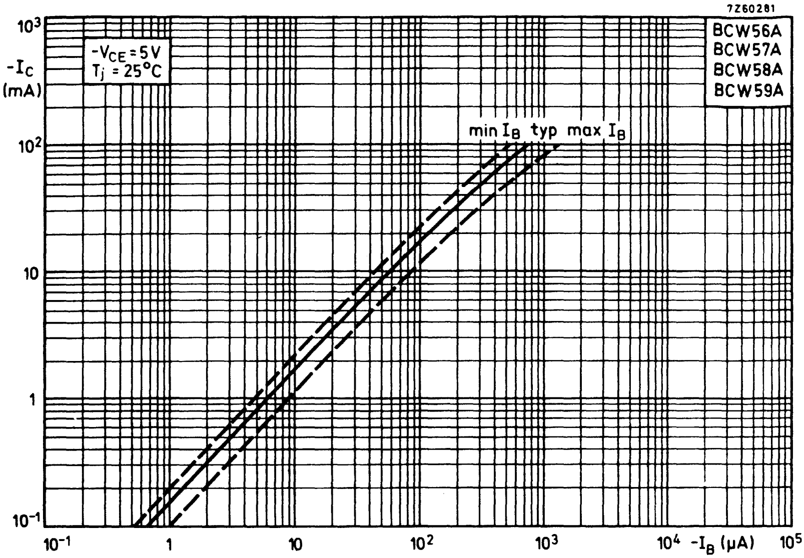
CHARACTERISTICS (continued)

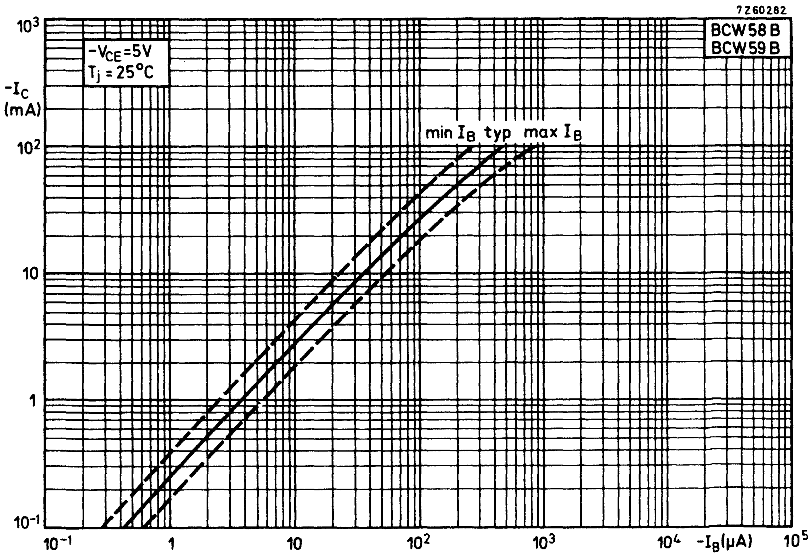
			BCW56A BCW57A BCW58A BCW59A	BCW58B BCW59B	
D.C. current gain					
$-I_C$ = 10 μA; $-V_{CE}$ = 5 V	h_{FE}	typ.	100	200	
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{FE}	>	110	200	
		<	220	450	
$-I_C$ = 10 mA; $-V_{CE}$ = 5 V	h_{FE}	typ.	180	290	
h parameters at f = 1 kHz					
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V					
Input impedance	h_{ie}	typ.	2.7	3.5	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	2.5	3.5	10^{-4}
Small signal current gain	h_{fe}	>	125	240	
		<	260	500	
Output admittance	h_{oe}	typ.	40	60	$\mu\Omega^{-1}$

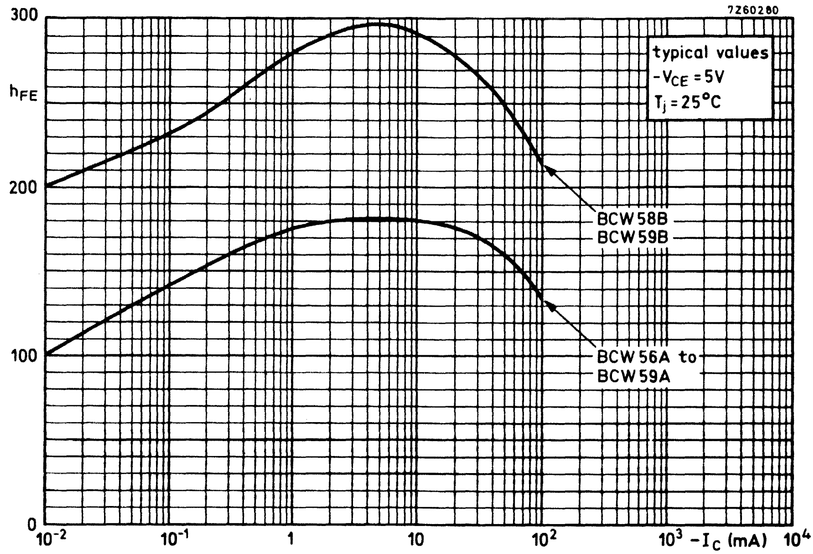


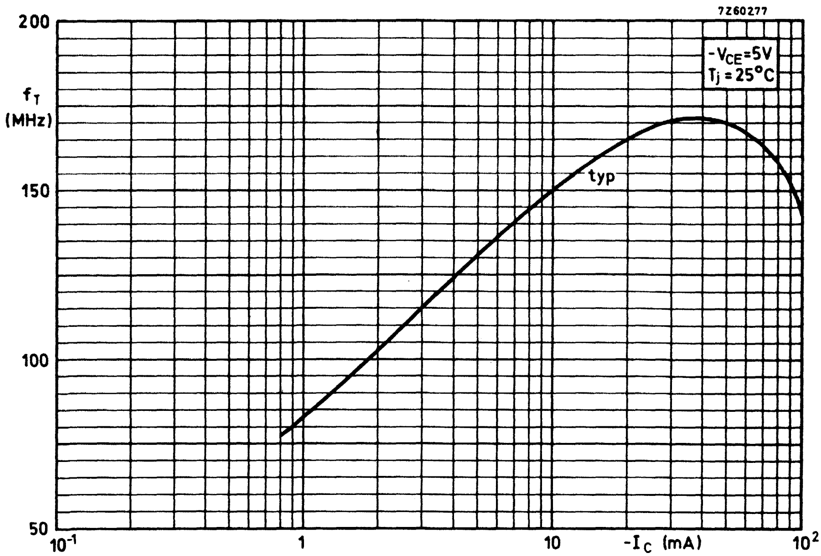

7Z60278
600
400
200
0
$-V_{CEsat}$ (mV)
$\frac{I_C}{I_B}$ = 20
T_j = 25 °C
typ
10^{-1}
1
10
10^2
$-I_C$ (mA)
10^3

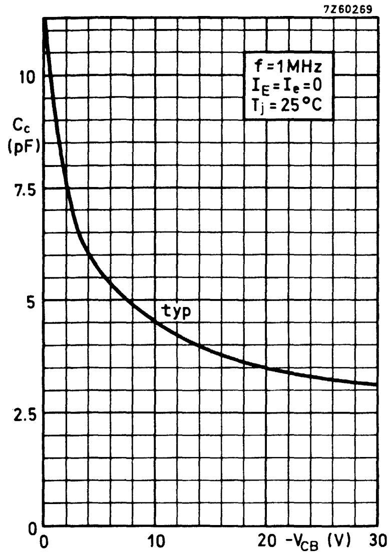

7Z60270
350
250
150
50
$-V_{CEsat}$ (mV)
typical values
I_C/I_B = 20
$-I_C$ = 100mA
50mA
10mA
1mA
-100
0
T_j (°C)
100

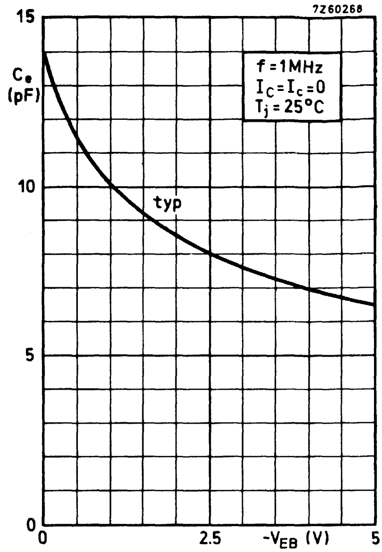

7Z60281
BCW56A
BCW57A
BCW58A
BCW59A
$-V_{CE}$ = 5 V
T_j = 25 °C
$-I_C$ (mA)
min I_B typ max I_B
$-I_B$ (μA)
10^{-1}
1
10
10^2
10^3
10^4
10^5

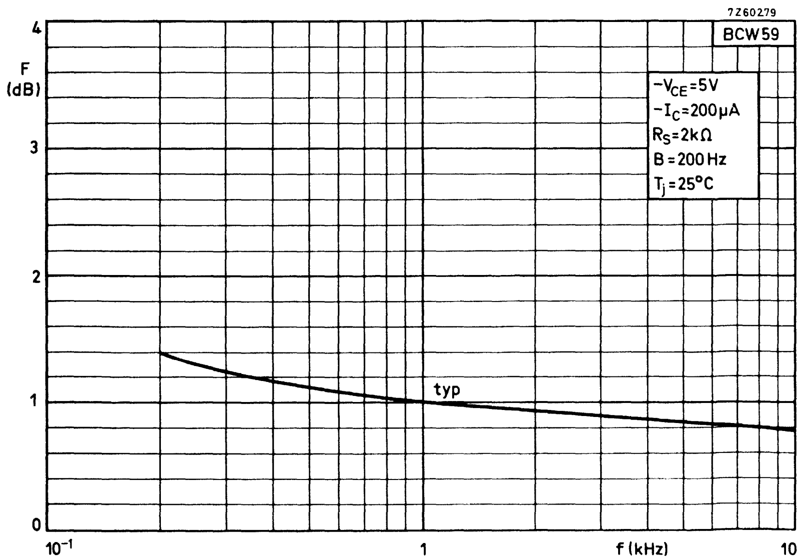

7Z60282
BCW58B
BCW59B
$-V_{CE}$ = 5 V
T_j = 25 °C
$-I_C$ (mA)
min I_B typ max I_B
$-I_B$ (μA)
10^{-1}
1
10
10^2
10^3
10^4
10^5

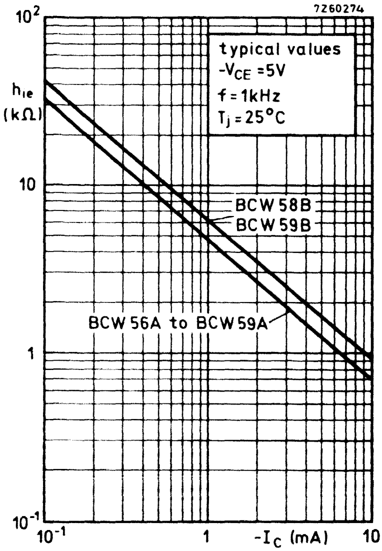

7Z60280
typical values
$-V_{CE} = 5V$
$T_j = 25°C$
h_{FE}
300
200
100
0
BCW58B
BCW59B
BCW56A to
BCW59A
10^{-2}
10^{-1}
1
10
10^2
10^3
$-I_C$ (mA)
10^4

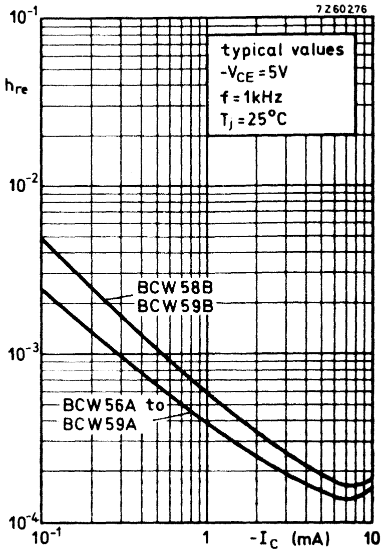

7Z60277
$-V_{CE}=5V$
$T_j = 25°C$
f_T
(MHz)
200
150
100
50
typ
10^{-1}
1
10
$-I_C$ (mA)
10^2

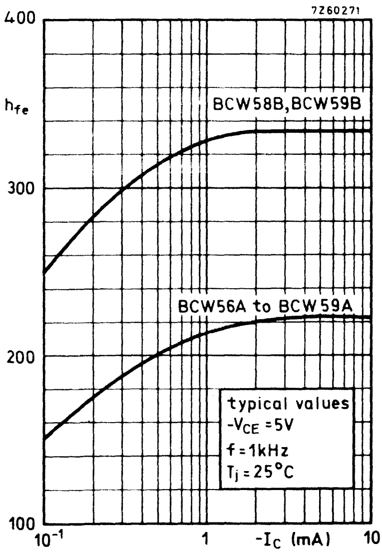

7Z60269
f = 1MHz
I_E = I_e = 0
T_j = 25 °C
C_c (pF)
typ
-V_CB (V)
0
2.5
5
7.5
10
10
20
30

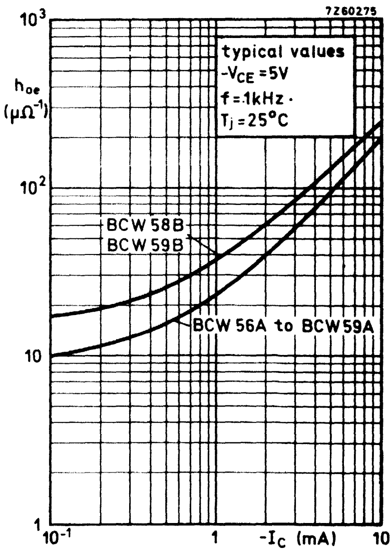

7Z60268
f = 1MHz
I_C = I_c = 0
T_j = 25 °C
C_e (pF)
typ
-V_EB (V)
0
5
10
15
2.5
5

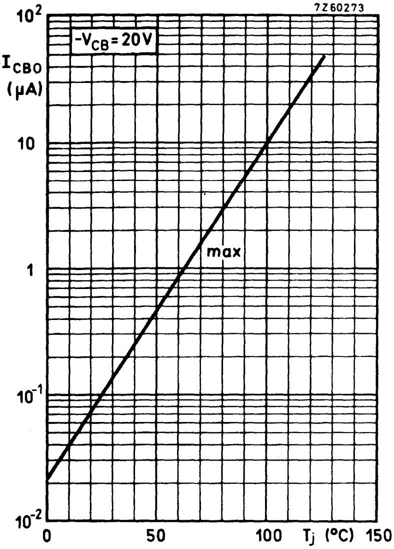

7Z60279
BCW59
-V_CE = 5V
-I_C = 200 μA
R_S = 2kΩ
B = 200 Hz
T_j = 25°C
F (dB)
typ
f (kHz)
0
1
2
3
4
10^-1
1
10

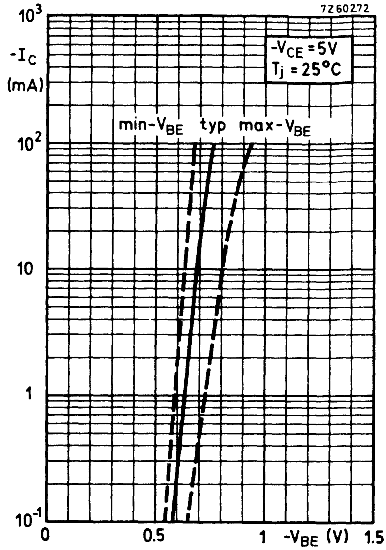

7Z60274
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
h_{ie} (kΩ)
BCW58B
BCW59B
BCW56A to BCW59A
$-I_C$ (mA)


7Z60276
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
h_{re}
BCW58B
BCW59B
BCW56A to
BCW59A
$-I_C$ (mA)


7Z60271
h_{fe}
BCW58B,BCW59B
BCW56A to BCW59A
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
$-I_C$ (mA)


7Z60275
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
h_{oe} (μΩ⁻¹)
BCW58B
BCW59B
BCW56A to BCW59A
$-I_C$ (mA)


7Z60273
10^2
$-I_{CBO}$ (μA)
$-V_{CB} = 20 V$
10
max
1
10^{-1}
10^{-2}
0
50
100
T_j (°C)
150


7Z60272
10^3
$-I_C$ (mA)
$-V_{CE} = 5 V$
$T_j = 25 °C$
min-V_{BE}
typ
max-V_{BE}
10^2
10
1
10^{-1}
0
0.5
1
$-V_{BE}$ (V)
1.5

P-N-P SILICON TRANSISTOR

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

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134).

Voltage

			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

Current

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

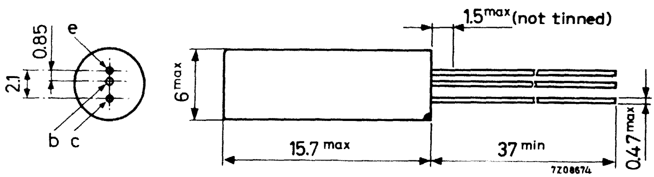
Power dissipation

Total power dissipation up to T_{amb} = 25 °C with a cooling fin on 1,6 mm Al. heatsink of 7 cm x 7 cm	P_{tot}	max.	415	mW

Temperature

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

MECHANICAL DATA Dimensions in mm



The coloured dot indicates the collector side

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\,j\text{-}a}$	=	0,4	°C/mW
From junction to ambient with a cooling fin on a 1,6 mm Al heatsink of 7 cm x 7 cm	$R_{th\,j\text{-}a}$	=	0,3	°C/mW
From junction to case	$R_{th\,j\text{-}c}$	=	0,25	°C/mW

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

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	-	
$-I_C$ = 300 mA; $-V_{CE}$ = 6 V	h_{FE}	>	-	-	10	
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.

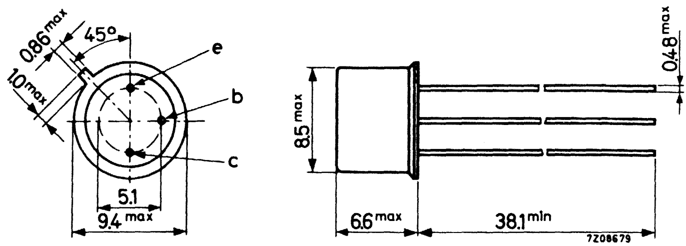
QUICK REFERENCE DATA

			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 °C	P_{tot}	max.	250	mW

Temperatures

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

THERMAL RESISTANCE

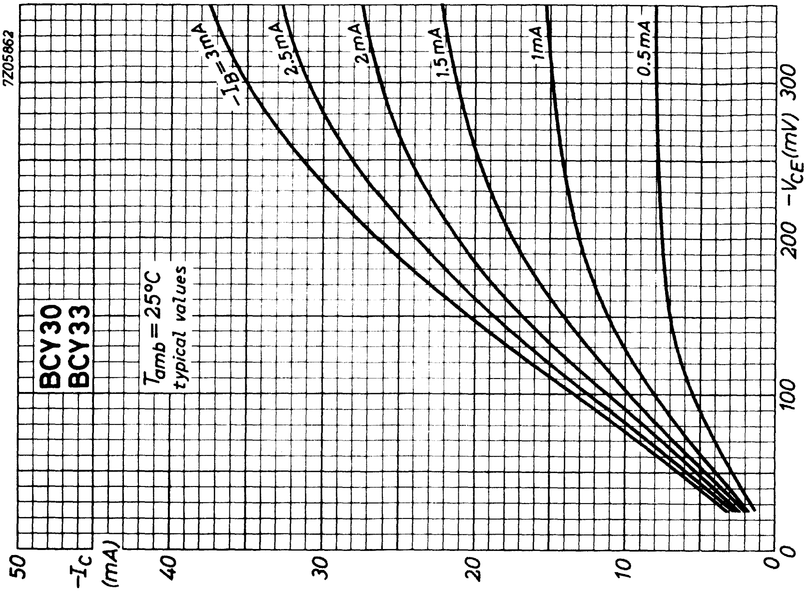
From junction to ambient in free air without cooling clip	$R_{th\ j-a}$	=	0.5	°C/mW
From junction to case	$R_{th\ j-c}$	=	0.35	°C/mW

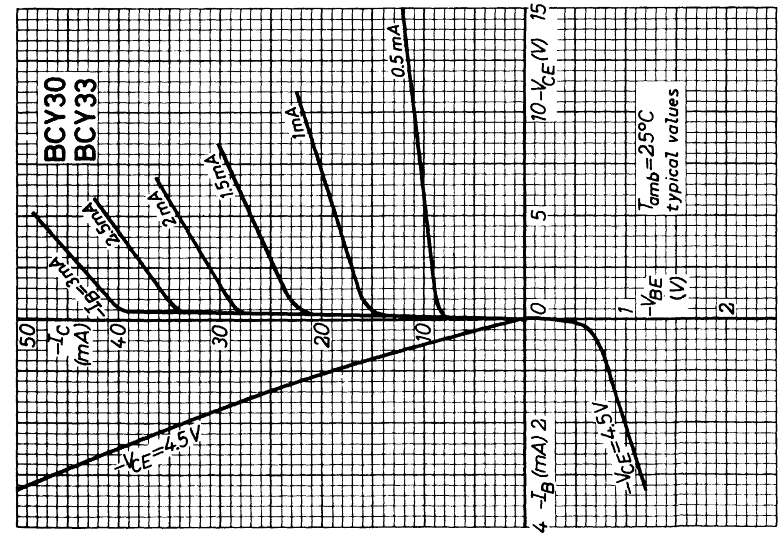
[1] Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

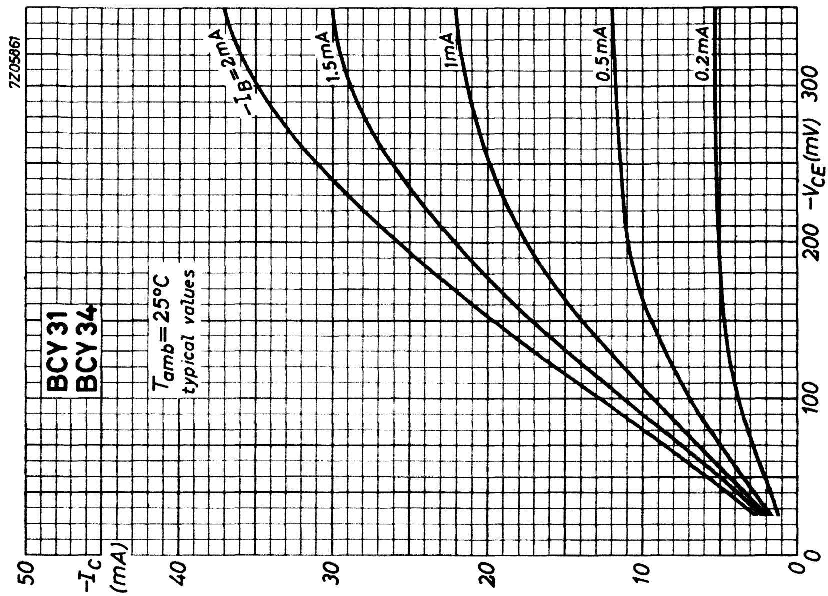
CHARACTERISTICS T_{amb} = 25 °C unless otherwise specified

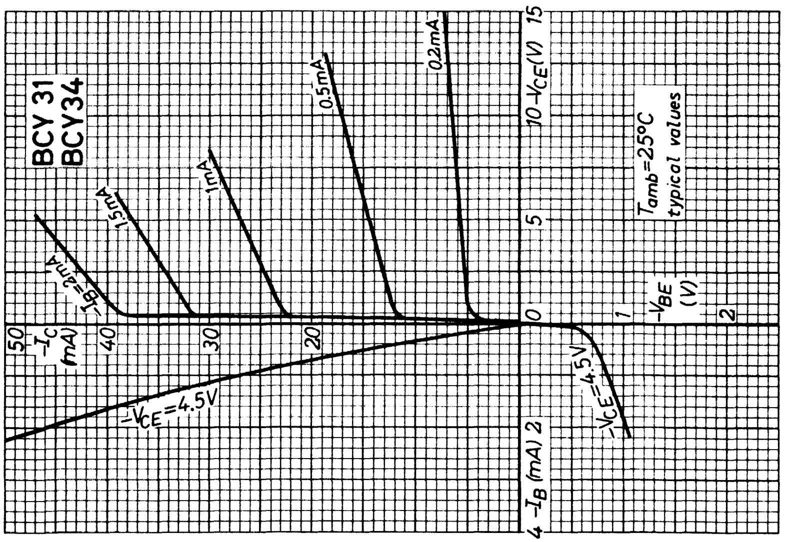
Collector cut-off current				
I_E = 0; $-V_{CB}$ = 6 V	$-I_{CBO}$	typ.	1.0	nA
		<	50	nA
Emitter cut-off current				
I_C = 0; $-V_{EB}$ = 6 V	$-I_{EBO}$	typ.	1.0	nA
		<	50	nA
I_C = 0; $-V_{EB}$ = 6 V; T_j = 100 °C	$-I_{EBO}$	typ.	0.1	μA
		<	2.5	μA
Saturation voltages				
$-I_C$ = 20 mA; $-I_B$ = 3 mA	$-V_{CEsat}$	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 Ω	F	typ.	8.0	dB
		<	20	dB

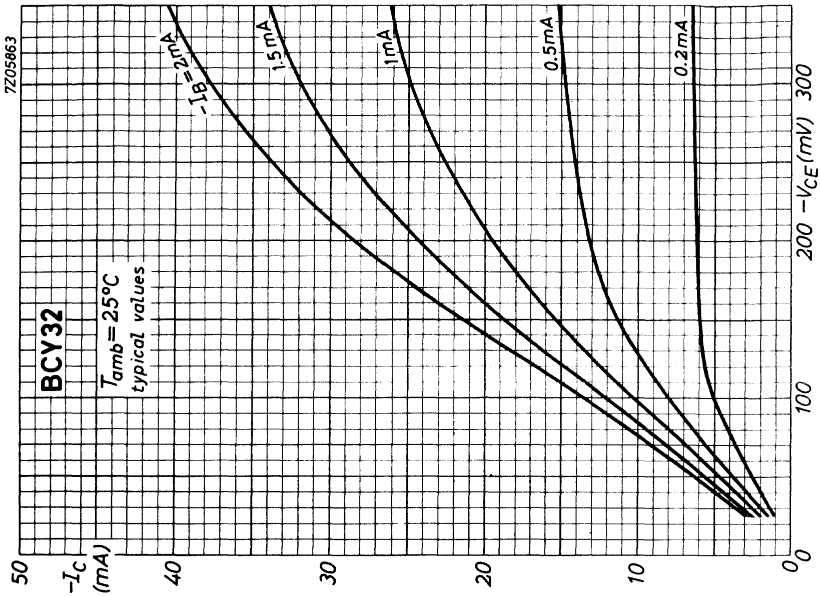
			BCY 30	BCY 31	BCY 32	BCY 33	BCY 34	
D.C. current gain								
$-I_C$ = 20 mA; $-V_{CE}$ = 4.5 V	h_{FE}	>	10	15	20	10	15	
		typ.	18	28	35	18	28	
		<	35	60	70	35	60	
Small signal current gain								
$-I_C$ = 1 mA; $-V_{CE}$ = 6 V; f = 1 kHz	h_{fe}	>	15	25	35	15	25	
		typ.	25	35	55	25	35	
		<	35	60	80	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

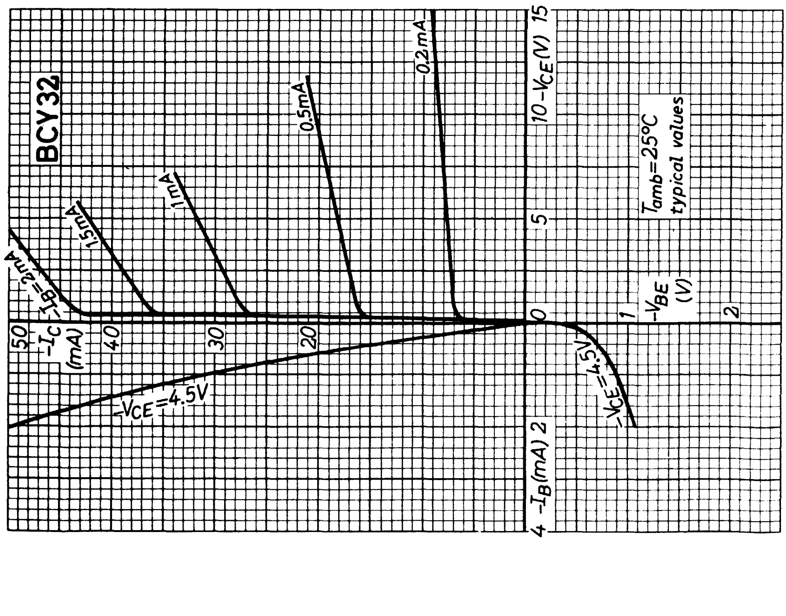

7Z05862
BCY30
BCY33
$T_{amb} = 25°C$
typical values
$-I_B = 3mA$
2.5mA
2mA
1.5mA
1mA
0.5mA
$-I_C$ (mA)
50
40
30
20
10
0
0
100
200
300
$-V_{CE}$ (mV)

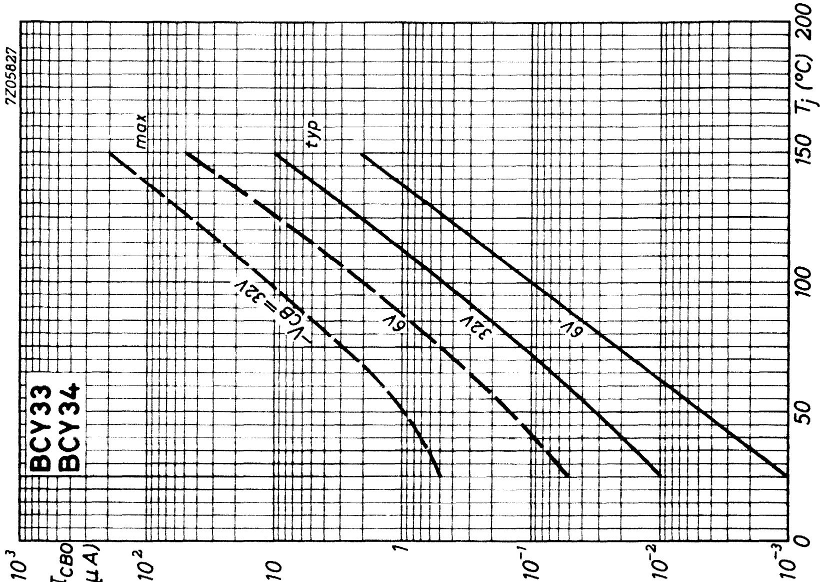

BCY30
BCY33
$T_{amb} = 25°C$
typical values
$-I_B = 3mA$
2.5mA
2mA
1.5mA
1mA
0.5mA
$-I_C$ (mA)
50
40
30
20
10
0
5
10
15
$-V_{CE}$ (V)
$-V_{BE}$ (V)
1
2
$-V_{CE} = 4.5V$
$-V_{CE} = 4.5V$
$-I_B$ (mA)
2
4

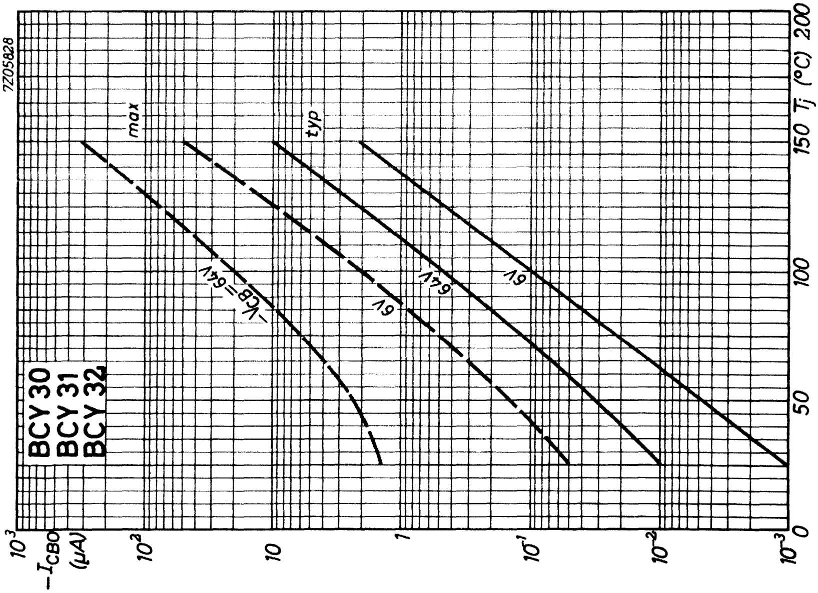

7Z05861
BCY 31
BCY 34
T_{amb}=25°C
typical values
$-I_B$=2mA
1.5mA
1mA
0.5mA
0.2mA
$-I_C$ (mA)
50
40
30
20
10
0
0
100
200
300
$-V_{CE}$(mV)

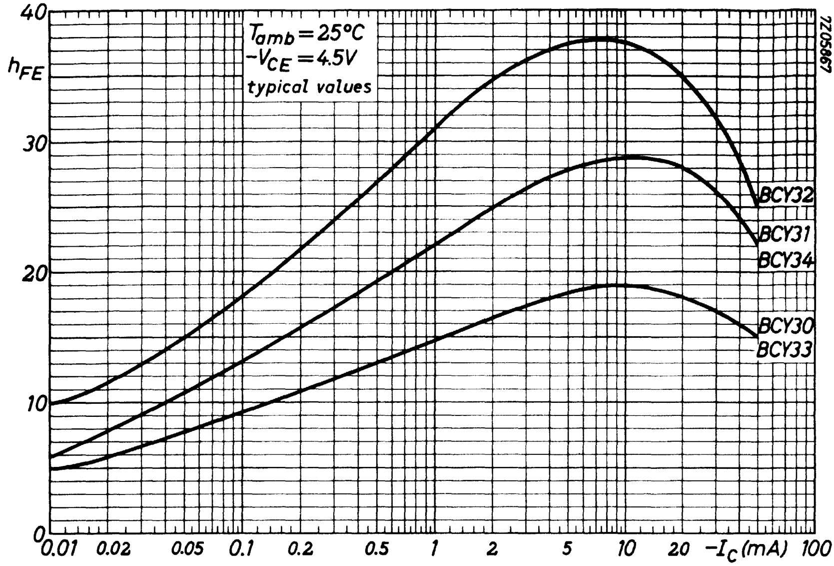

BCY 31
BCY34
T_{amb}=25°C
typical values
$-I_B$=2mA
1.5mA
1mA
0.5mA
0.2mA
$-I_C$ (mA)
50
40
30
20
0
5
10
$-V_{CE}$(V)
15
1
2
$-V_{BE}$ (V)
$-V_{CE}$=4.5V
$-V_{CE}$=4.5V
4
$-I_B$ (mA)
2

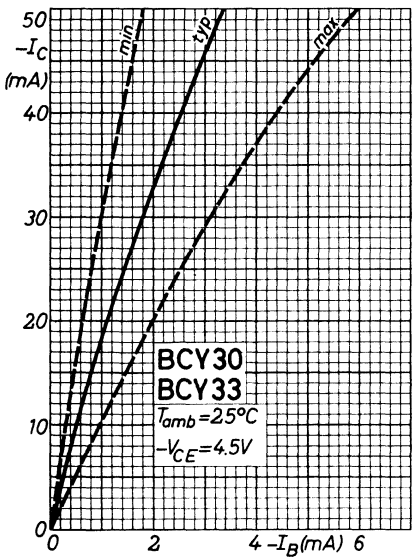

7Z05863
BCY32
T_{amb}=25°C
typical values
$-I_B$=2mA
1.5mA
1mA
0.5mA
0.2mA
$-I_C$ (mA)
50
40
30
20
10
0
100
200
300
$-V_{CE}$ (mV)

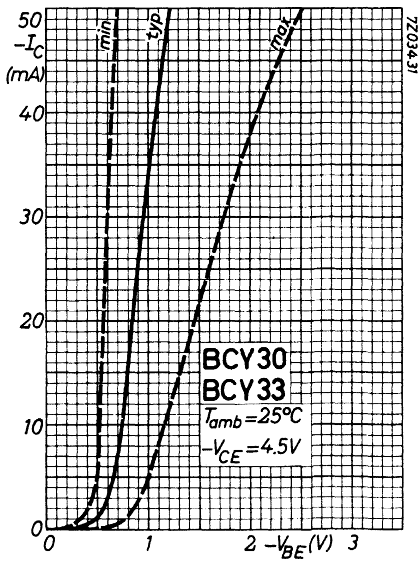

BCY32
T_{amb}=25°C
typical values
$-I_B$=2mA
1.5mA
1mA
0.5mA
0.2mA
$-I_C$ (mA)
50
40
30
20
0
5
10
15
$-V_{CE}$ (V)
$-V_{CE}$=4.5V
$-V_{CE}$=4.5V
$-V_{BE}$ (V)
1
2
$-I_B$ (mA)
2
4

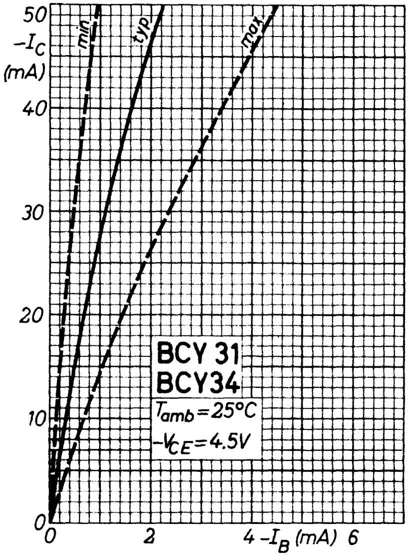

7Z05827
BCY33
BCY34
max
typ
$-V_{CB}$ = 32V
6V
32V
6V
$-I_{CBO}$ (μA)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
0
50
100
150
200
T_j (°C)

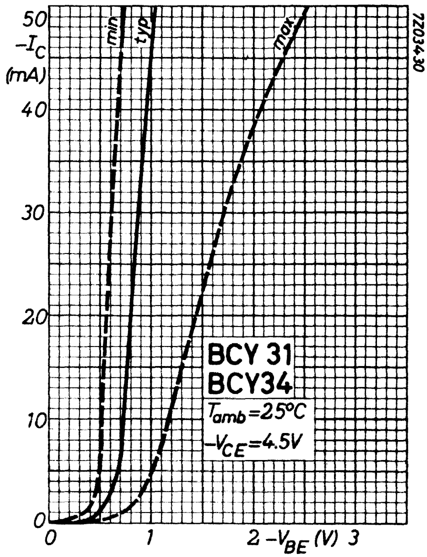

7Z05828
BCY30
BCY31
BCY32
max
typ
$-V_{CB}$ = 64V
6V
64V
6V
$-I_{CBO}$ (μA)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
0
50
100
150
200
T_j (°C)

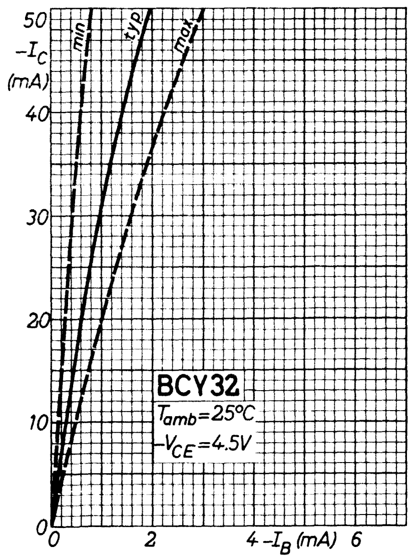

40
h_{FE}
30
20
10
0
$T_{amb} = 25°C$
$-V_{CE} = 4.5V$
typical values
7Z05867
BCY32
BCY31
BCY34
BCY30
BCY33
0.01 0.02 0.05 0.1 0.2 0.5 1 2 5 10 20 $-I_C$(mA) 100

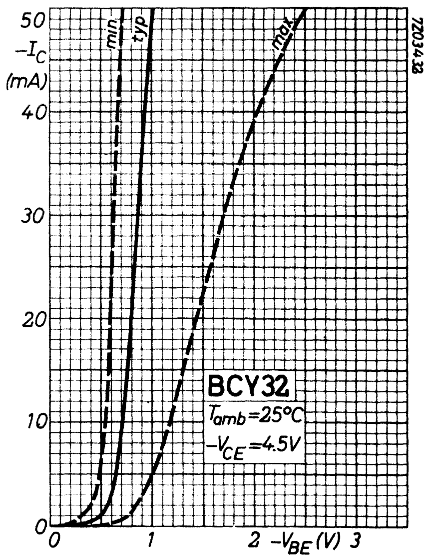

50
$-I_C$
(mA)
40
30
20
10
0
min
typ
max
BCY30
BCY33
$T_{amb}=25°C$
$-V_{CE}=4.5V$
0 2 4 $-I_B$(mA) 6

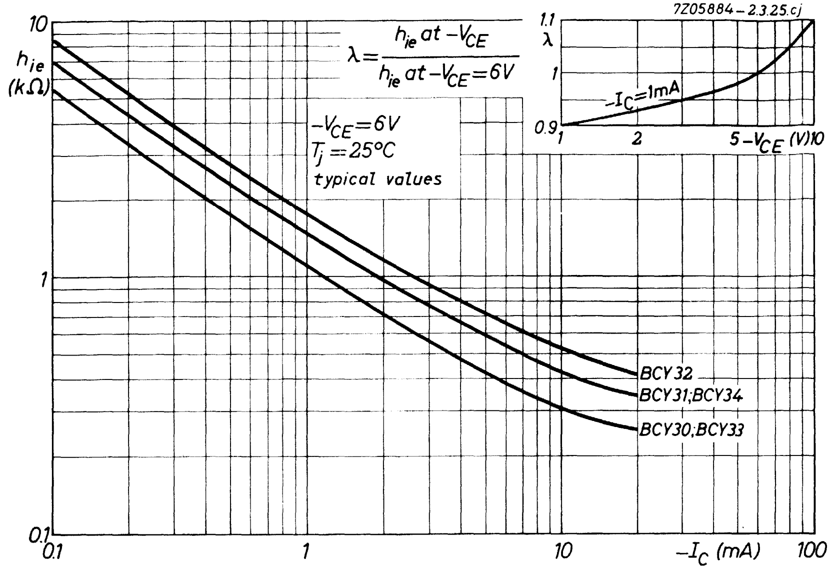

50
$-I_C$
(mA)
40
30
20
10
0
min
typ
max
7Z03431
BCY30
BCY33
$T_{amb}=25°C$
$-V_{CE}=4.5V$
0 1 2 $-V_{BE}$(V) 3

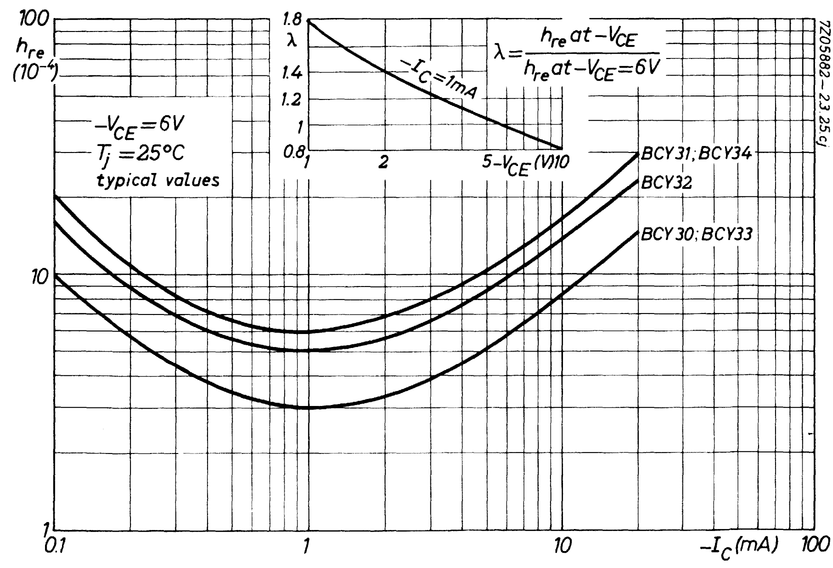

50
$-I_C$
(mA)
40
30
20
10
0
min
typ
max
BCY 31
BCY34
$T_{amb}=25°C$
$-V_{CE}=4.5V$
0
2
4 $-I_B$ (mA) 6

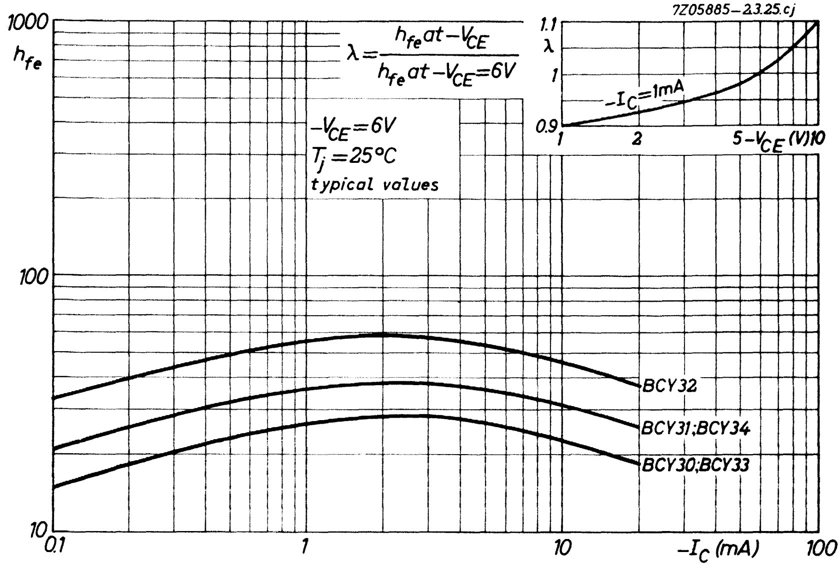

7Z03430
50
$-I_C$
(mA)
40
30
20
10
0
min
typ
max
BCY 31
BCY34
$T_{amb}=25°C$
$-V_{CE}=4.5V$
0
1
2 $-V_{BE}$ (V) 3

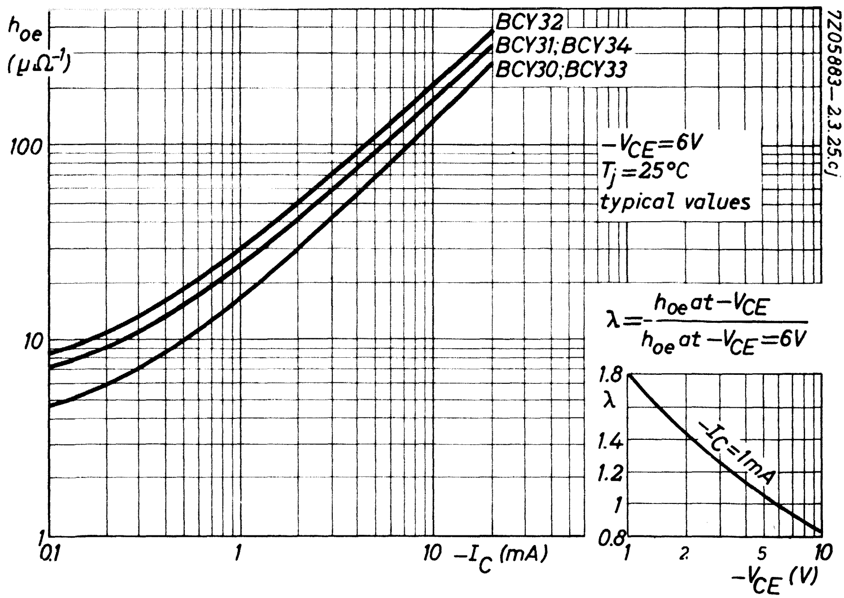

50
$-I_C$
(mA)
40
30
20
10
0
min
typ
max
BCY32
$T_{amb}=25°C$
$-V_{CE}=4.5V$
0
2
4 $-I_B$ (mA) 6

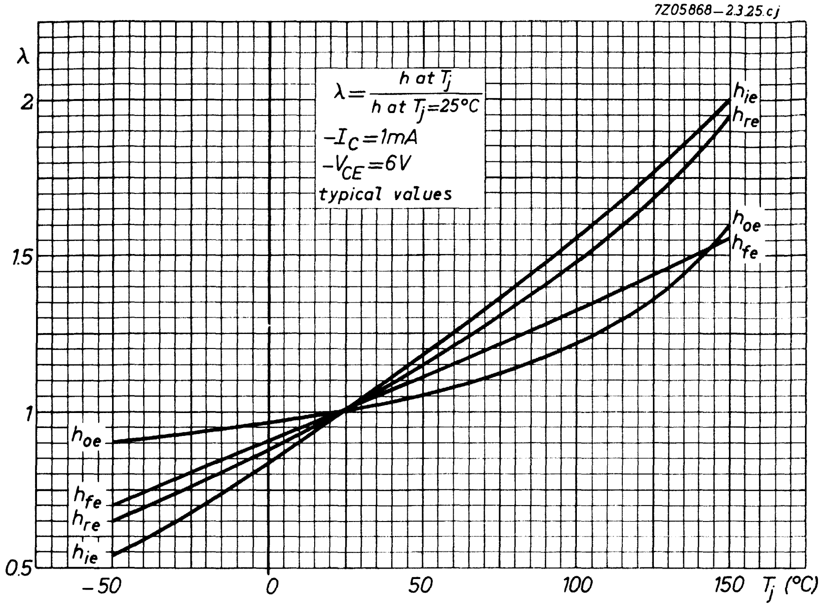

7Z03432
50
$-I_C$
(mA)
40
30
20
10
0
min
typ
max
BCY32
$T_{amb}=25°C$
$-V_{CE}=4.5V$
0
1
2 $-V_{BE}$ (V) 3

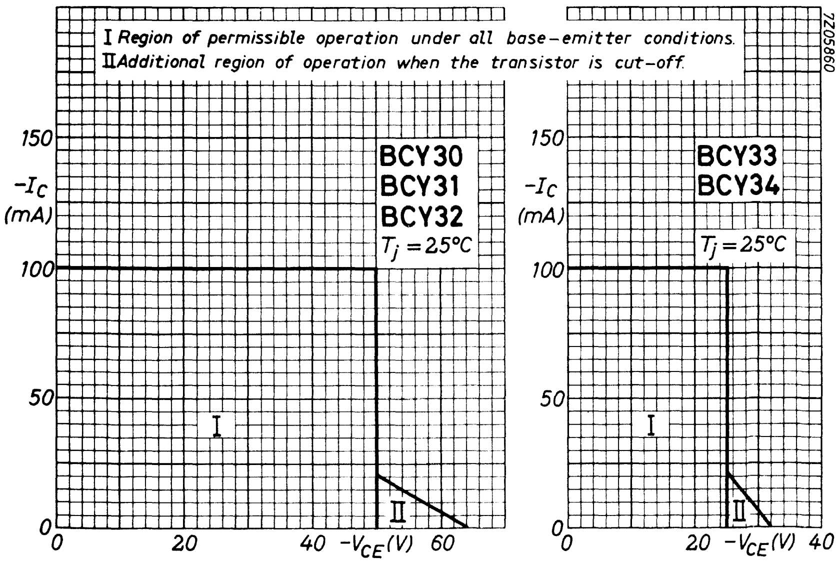

7Z05884 – 2.3.25.cj
h_{ie} (kΩ)
$\lambda = \frac{h_{ie} \text{ at } -V_{CE}}{h_{ie} \text{ at } -V_{CE} = 6V}$
$-V_{CE} = 6V$
$T_j = 25°C$
typical values
$-I_C = 1mA$
$5 - V_{CE}$ (V)
BCY32
BCY31;BCY34
BCY30;BCY33
$-I_C$ (mA)


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


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


7Z05883–2.3.25.cj
h_{oe}
($\mu\Omega^{-1}$)
100
10
1
0.1
1
10
$-I_C$ (mA)
BCY32
BCY31;BCY34
BCY30;BCY33
$-V_{CE} = 6V$
$T_j = 25°C$
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
λ = h at Tj / h at Tj=25°C
−IC=1mA
−VCE=6V
typical values
hie
hre
hoe
hfe
2
1.5
1
0.5
−50
0
50
100
150
Tj (°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
Tj = 25°C
BCY33
BCY34
Tj = 25°C
−IC
(mA)
150
100
50
0
I
II
20
40
60
−VCE(V)

P-N-P SILICON TRANSISTORS

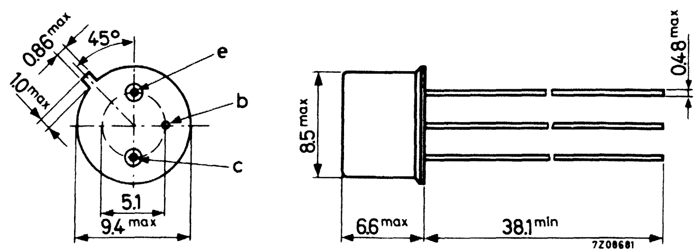
P-N-P alloy transistors in a TO-5 metal envelope with the base connected to the case. They are intended for relay switching, resistor logic circuits and general industrial applications.

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	$R_{th\ j-a}$	=	0.3	°C/mW
From junction to case	$R_{th\ j-c}$	=	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

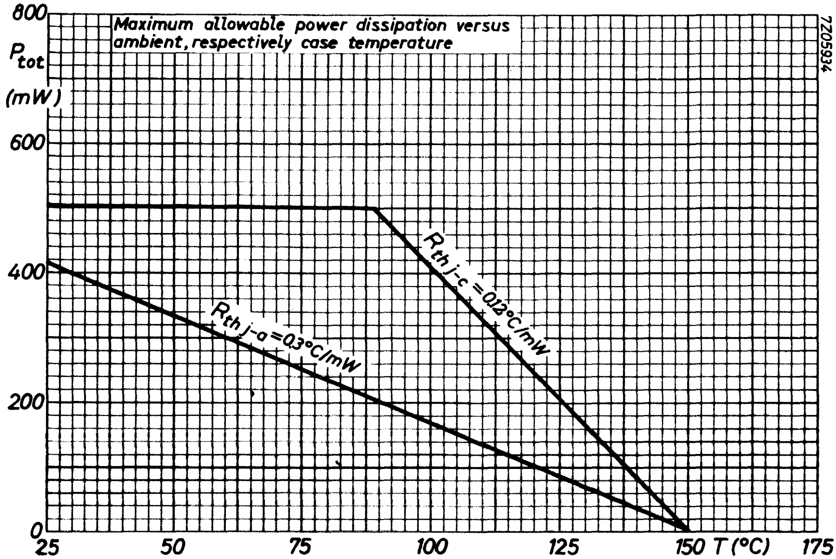
$I_C = 0$; $-V_{EB} = 6$ V	$-I_{EBO}$	typ.	1	nA
		<	100	nA
$I_C = 0$; $-V_{EB} = 6$ V; $T_j = 100$ °C	$-I_{EBO}$	typ.	0.1	μA
		<	2.5	μA

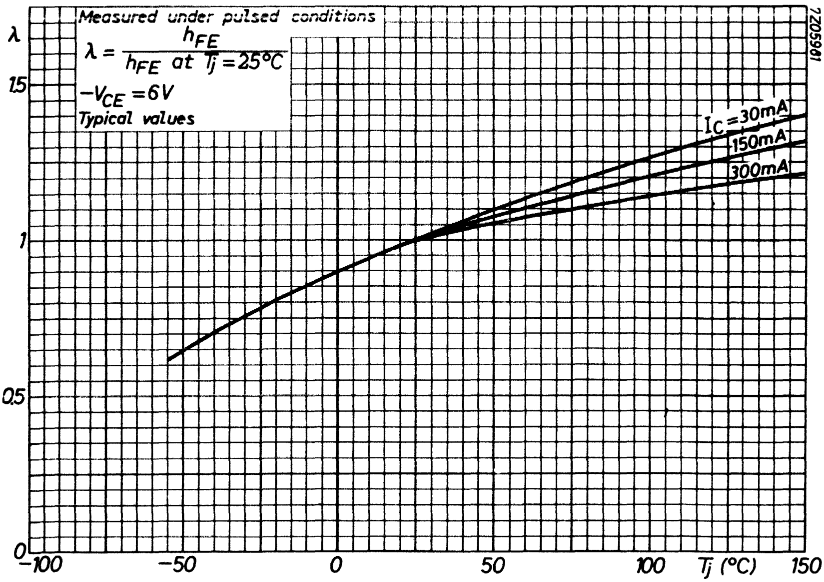
			BCY38	BCY39	BCY40	BCY54	
Base current							
$V_{CB} = 0$; $I_E = 150$ mA	$-I_B$	>	5	3	1.25	2	mA
		<	14	14	9	12	mA
Base-emitter voltage							
$-I_C = 150$ mA; $-V_{CE} = 1$ V	$-V_{BE}$	typ.	1.5	1.5	1.4	1.4	V
		<	1.9	1.9	1.9	1.9	V
Saturation voltages							
$-I_C = 150$ mA; $-I_B = 15$ mA	$-V_{CEsat}$	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	

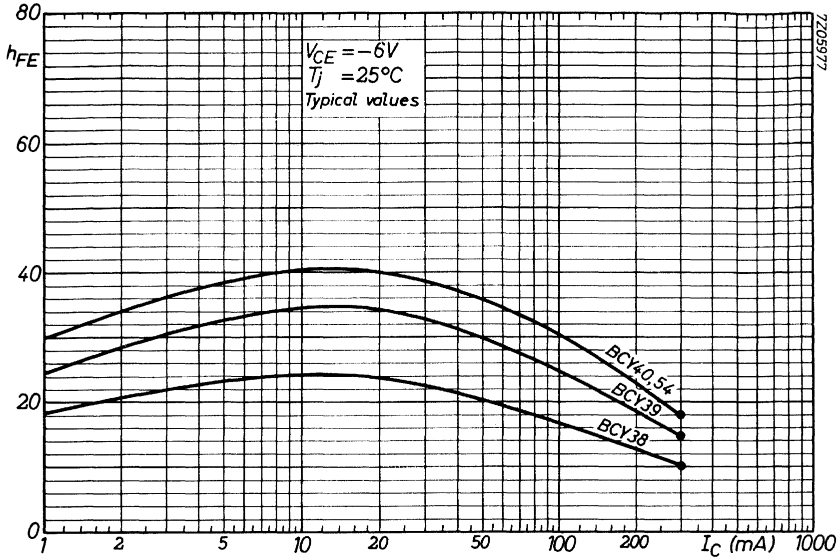
[1]) Measured under pulsed conditions to prevent excessive dissipation.

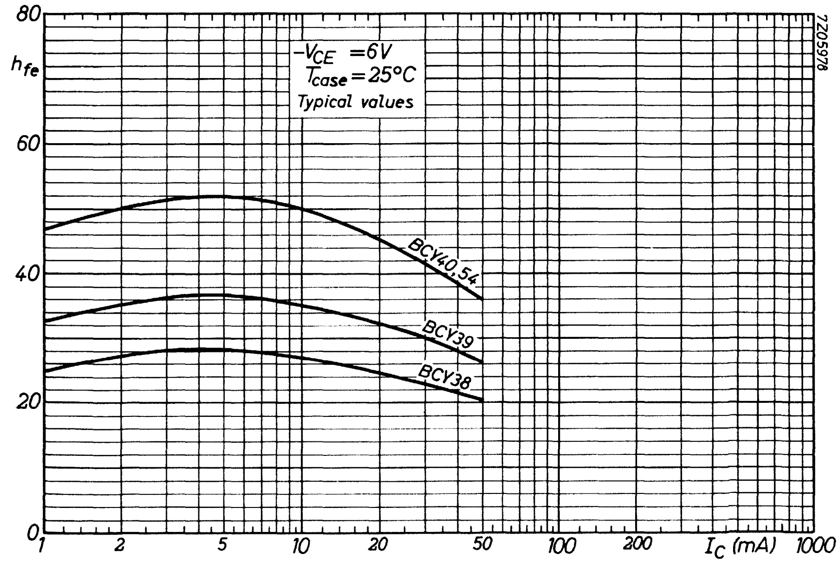
CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

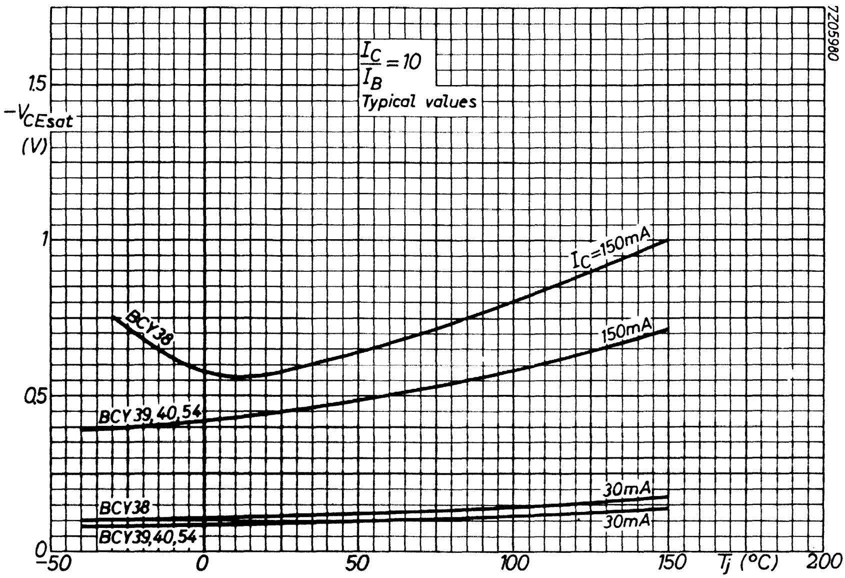
			BCY38	BCY39	BCY40	BCY54	
Collector capacitance at f = 0.5 MHz							
$I_E = I_e = 0$; $-V_{CB} = 6$ V	C_c	typ.	60	60	60	60	pF
		<	150	150	150	150	pF
Transition frequency							
$-I_C = 1$ mA; $-V_{CE} = 6$ V	f_T	>	0.45	0.45	0.85	0.45	MHz
		typ.	1.5	1.5	2.5	2.0	MHz
Feedback impedance at f = 0.5 MHz							
$-I_C = 1$ 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							
$-I_C = 10$ mA; $-V_{CE} = 6$ V	h_{fe}	>	15	15	30	20	
		typ.	27	35	50	50	
		<	100	100	160	120	

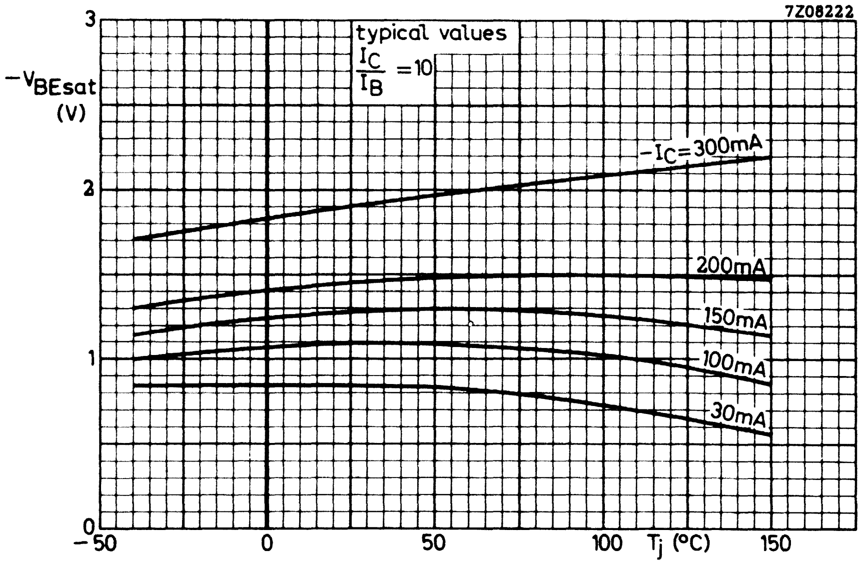

Maximum allowable power dissipation versus ambient, respectively case temperature
7Z05934
P_{tot} (mW)
800
600
400
200
0
$R_{th\ j\text{-}c}$ = 0.2°C/mW
$R_{th\ j\text{-}a}$ = 0.3°C/mW
25
50
75
100
125
150
T (°C)
175

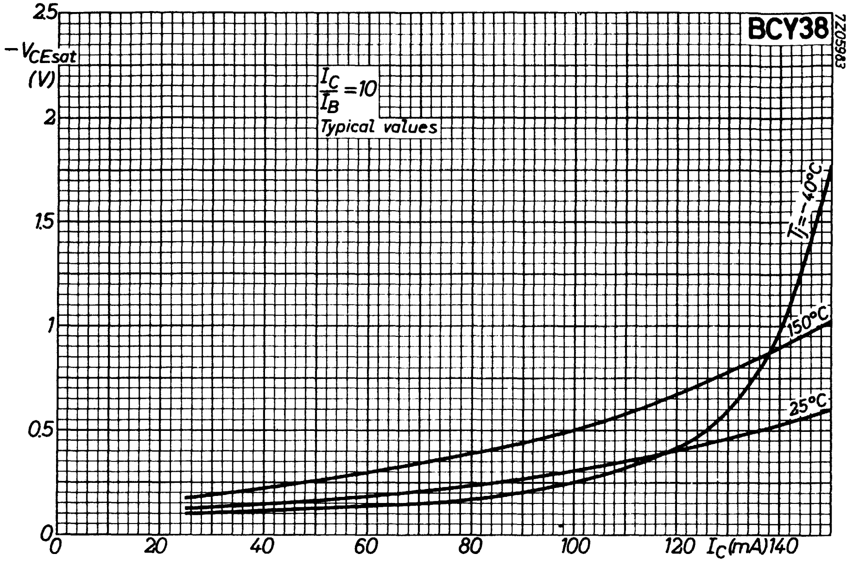

Measured under pulsed conditions
$\lambda = \frac{h_{FE}}{h_{FE} \text{ at } T_j = 25°C}$
$-V_{CE}$ = 6V
Typical values
7Z05981
λ
1.5
1
0.5
0
I_C = 30mA
150mA
300mA
−100
−50
0
50
100
T_j (°C)
150

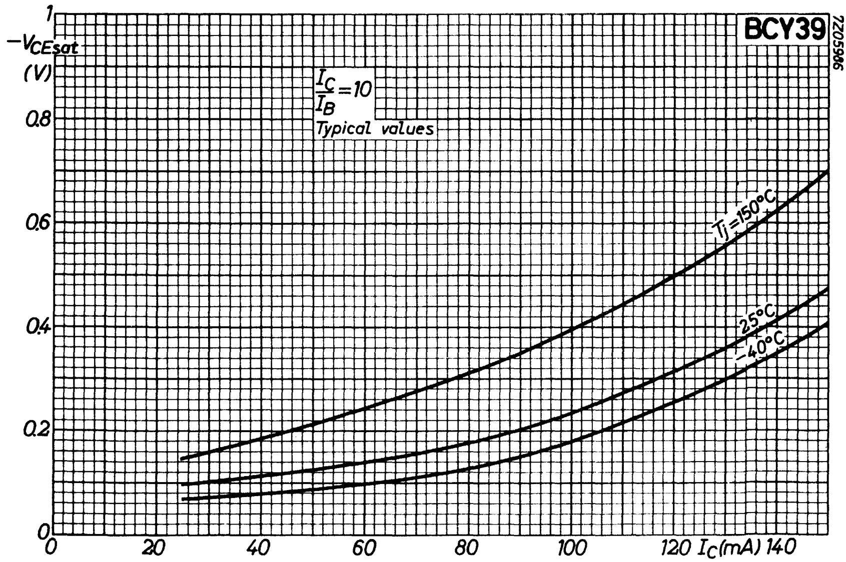

7Z05977
V_{CE} = −6V
T_j = 25°C
Typical values
h_{FE}
BCY40,54
BCY39
BCY38
I_C (mA)
0
20
40
60
80
1
2
5
10
20
50
100
200
1000

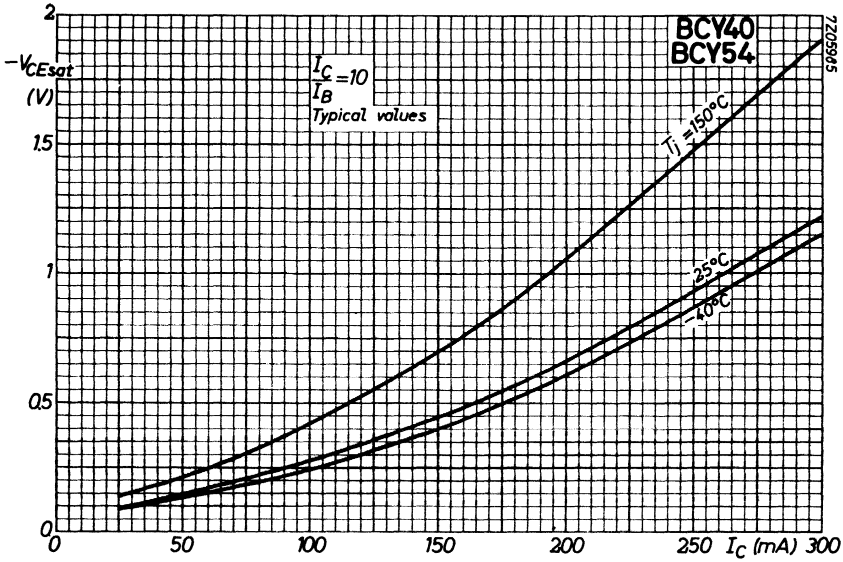

7Z05978
$-V_{CE}$ = 6V
T_{case} = 25°C
Typical values
h_{fe}
BCY40,54
BCY39
BCY38
I_C (mA)
0
20
40
60
80
1
2
5
10
20
50
100
200
1000

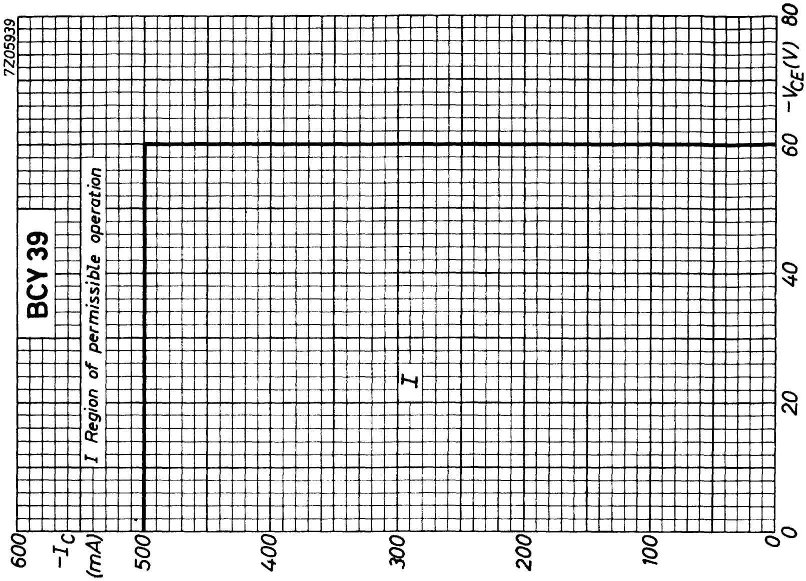

7Z05980
$\frac{I_C}{I_B}$ = 10
Typical values
1.5
$-V_{CEsat}$
(V)
1
0.5
0
I_C=150mA
BCY38
150mA
BCY39,40,54
30mA
BCY38
30mA
BCY39,40,54
−50
0
50
100
150
T_j (°C)
200

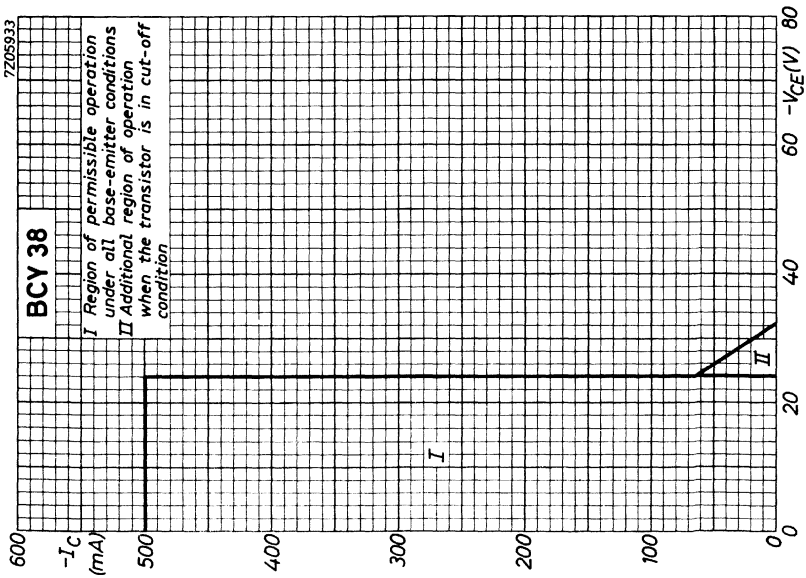

7Z08222
typical values
$\frac{I_C}{I_B}$ = 10
3
$-V_{BEsat}$
(V)
2
1
0
$-I_C$=300mA
200mA
150mA
100mA
30mA
−50
0
50
100
T_j (°C)
150

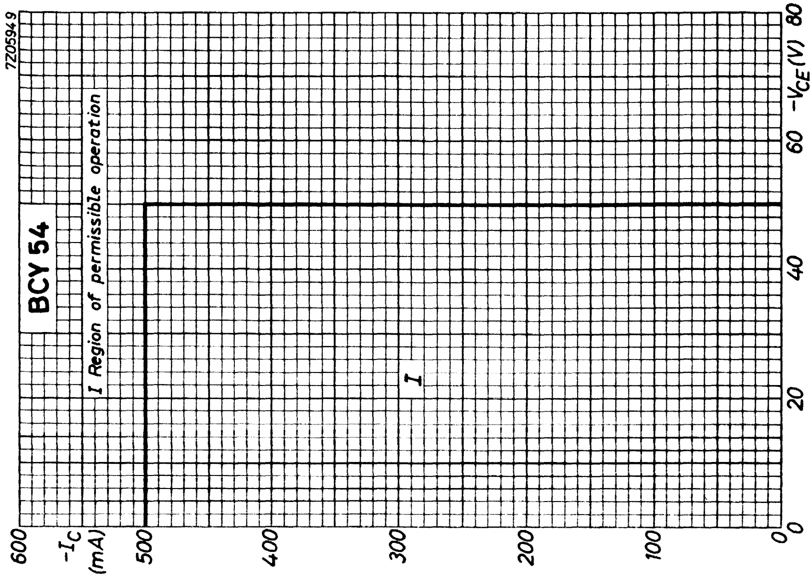

BCY38
7Z05983
$-V_{CEsat}$ (V)
2.5
2
1.5
1
0.5
0
$\frac{I_C}{I_B} = 10$
Typical values
$T_j = -40°C$
150°C
25°C
0
20
40
60
80
100
120
I_C(mA)
140

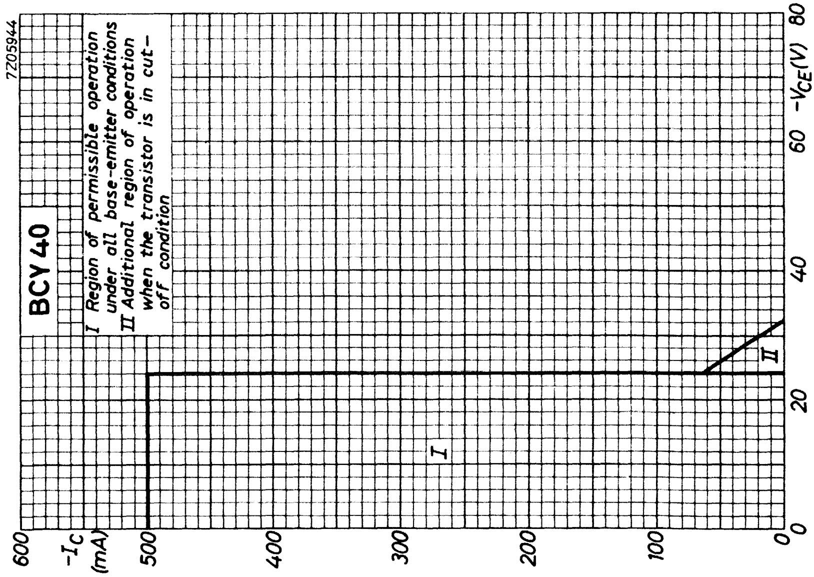

BCY39
7Z05986
$-V_{CEsat}$ (V)
1
0.8
0.6
0.4
0.2
0
$\frac{I_C}{I_B} = 10$
Typical values
$T_j = 150°C$
25°C
−40°C
0
20
40
60
80
100
120
I_C(mA)
140

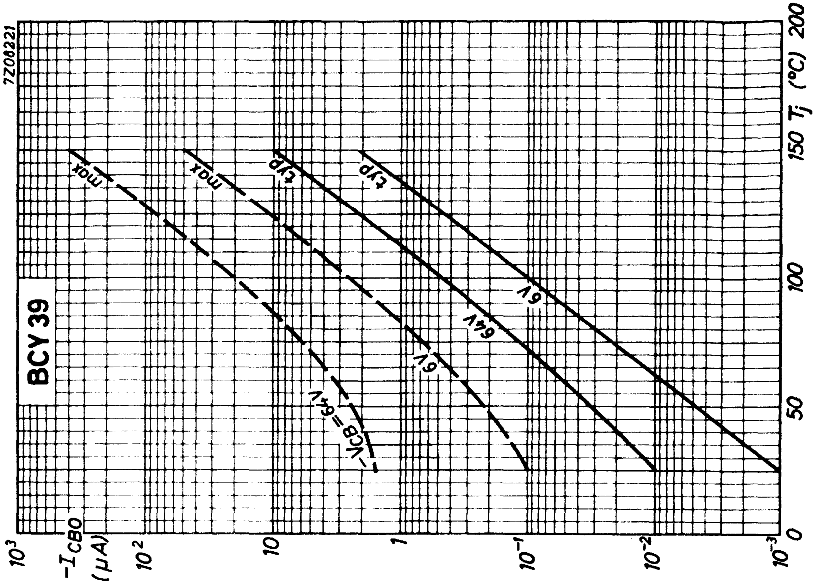

BCY40
BCY54
7Z05965
$-V_{CEsat}$ (V)
$\frac{I_C}{I_B}=10$
Typical values
$T_j=150°C$
25°C
−40°C
I_C (mA)
0
0.5
1
1.5
2
50
100
150
200
250
300

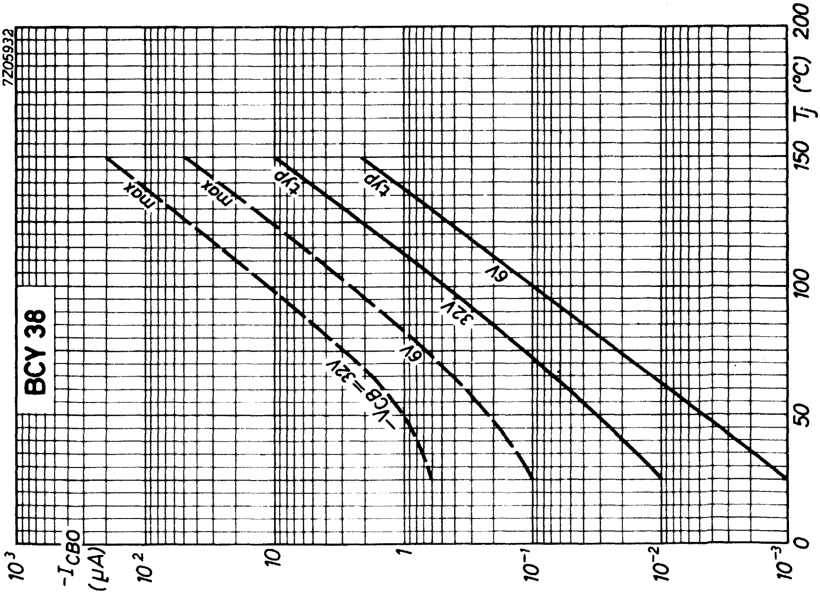

7Z05939
BCY 39
I Region of permissible operation
I
$-I_C$ (mA)
600
500
400
300
200
100
0
$-V_{CE}$(V)
0
20
40
60
80

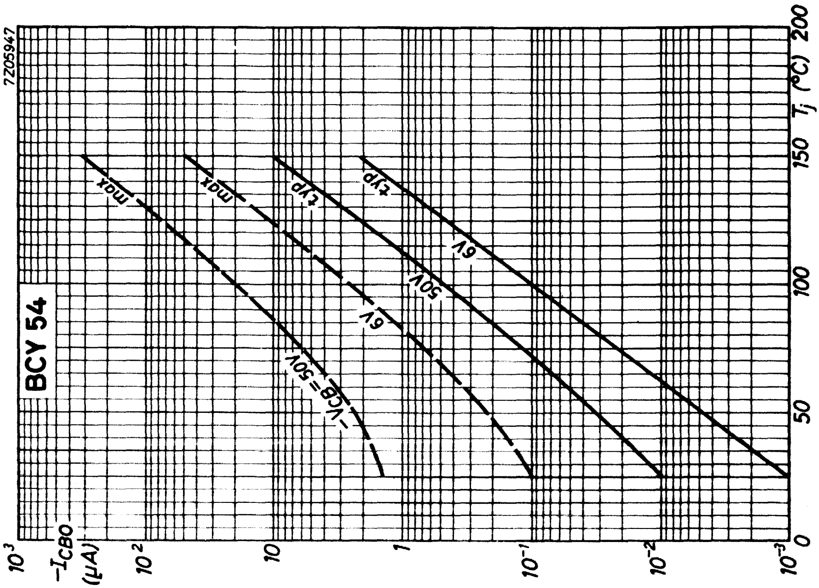

7Z05933
BCY 38
I Region of permissible operation under all base-emitter conditions
II Additional region of operation when the transistor is in cut-off condition
I
II
$-I_C$ (mA)
600
500
400
300
200
100
0
$-V_{CE}$(V)
0
20
40
60
80

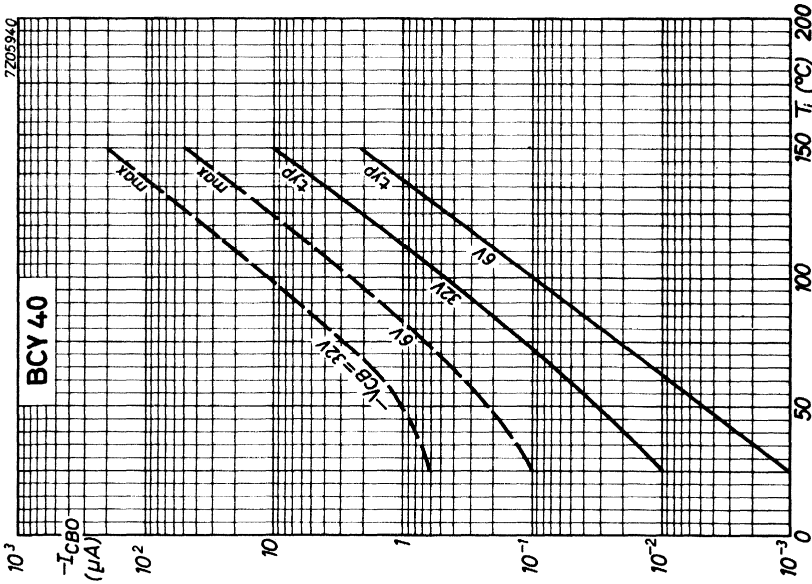

7Z05949
BCY 54
I Region of permissible operation
I
$-I_C$ (mA)
600
500
400
300
200
100
0
0
20
40
60
80
$-V_{CE}$ (V)

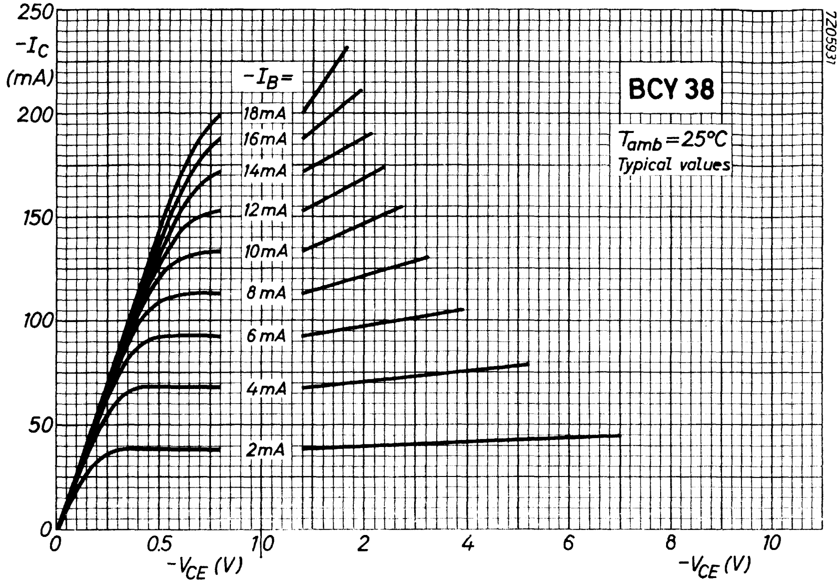

7Z05944
BCY 40
I Region of permissible operation under all base-emitter conditions
II Additional region of operation when the transistor is in cut-off condition
I
II
$-I_C$ (mA)
600
500
400
300
200
100
0
0
20
40
60
80
$-V_{CE}$ (V)

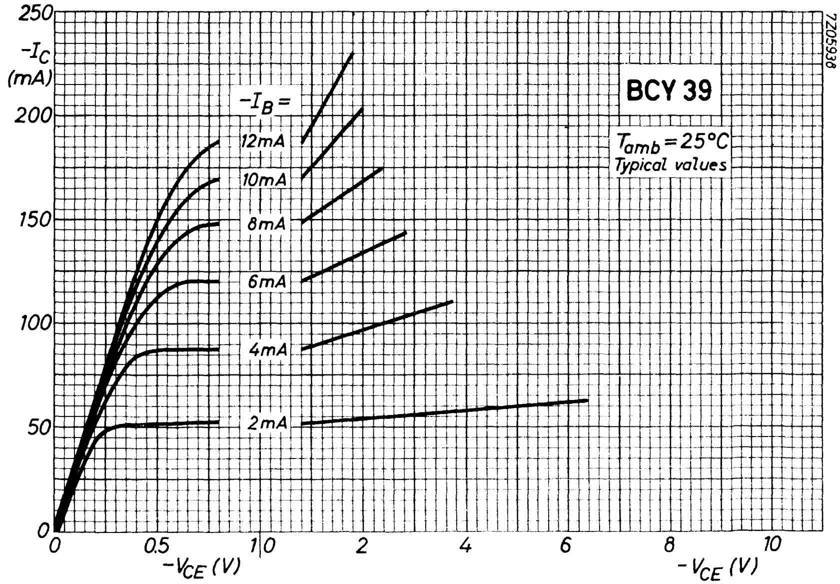

BCY 39
7Z08221
$-I_{CBO}$ (μA)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
0
50
100
150
200
T_j (°C)
max
max
typ
typ
$-V_{CB}$ = 64V
6V
64V
6V

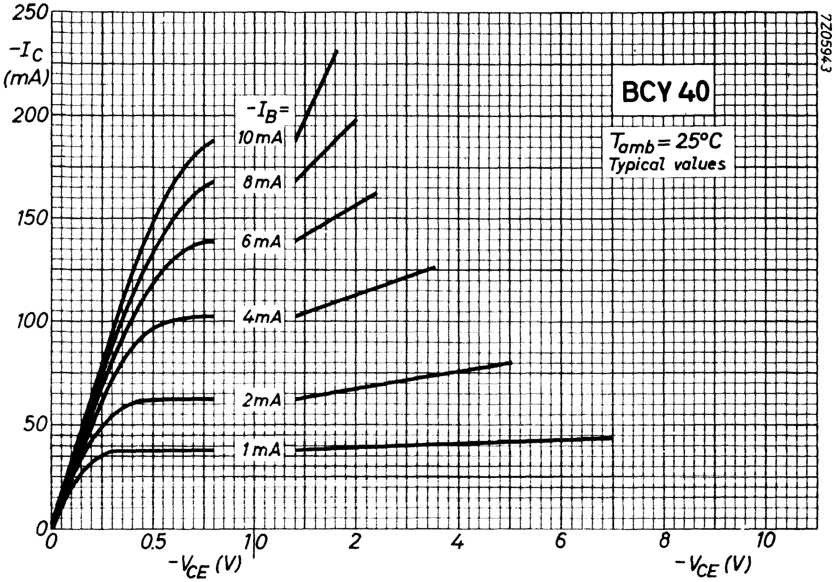

BCY 38
7Z05932
$-I_{CBO}$ (μA)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
0
50
100
150
200
T_j (°C)
max
max
typ
typ
$-V_{CB}$ = 32V
6V
32V
6V

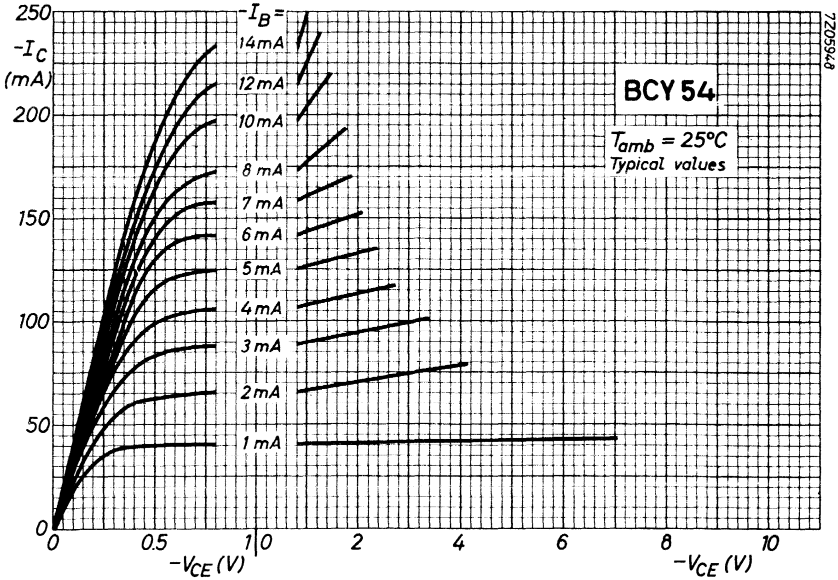

7Z05947
BCY 54
−I_CBO (μA)
10^3
10^2
10
1
10^-1
10^-2
10^-3
T_j (°C)
0
50
100
150
200
max
max
typ
typ
−V_CB = 50V
6V
50V
6V

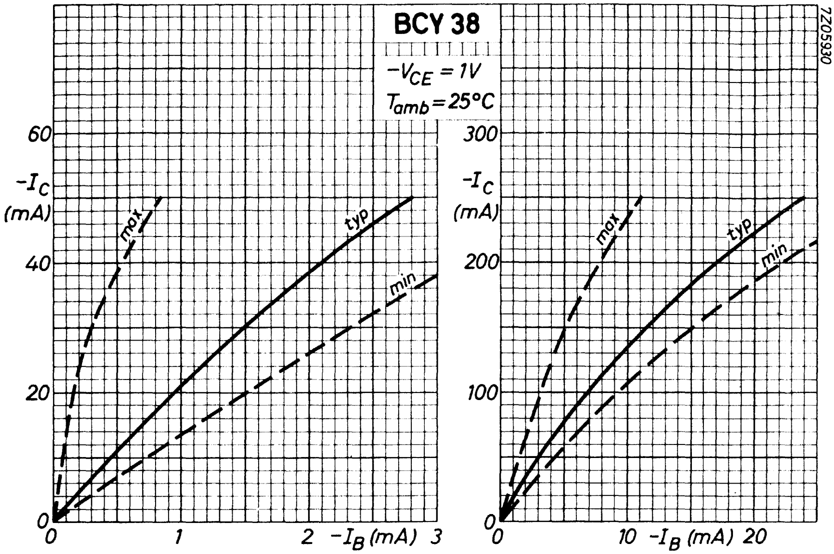

7Z05940
BCY 40
−I_CBO (μA)
10^3
10^2
10
1
10^-1
10^-2
10^-3
T_j (°C)
0
50
100
150
200
max
max
typ
typ
−V_CB = 32V
6V
32V
6V

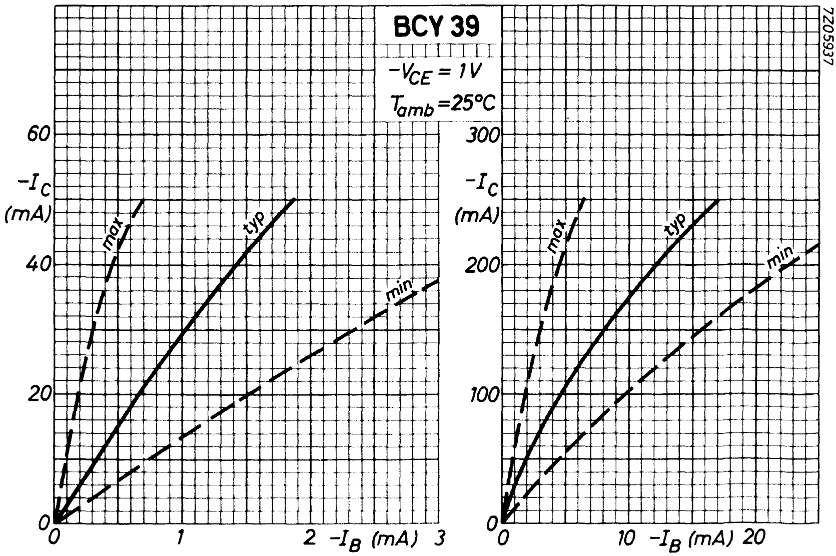

7Z05931
BCY 38
T_{amb} = 25°C
Typical values
$-I_C$ (mA)
250
200
150
100
50
0
$-I_B$ =
18mA
16mA
14mA
12mA
10mA
8mA
6mA
4mA
2mA
0
0.5
1.0
2
4
6
8
10
$-V_{CE}$ (V)
$-V_{CE}$ (V)

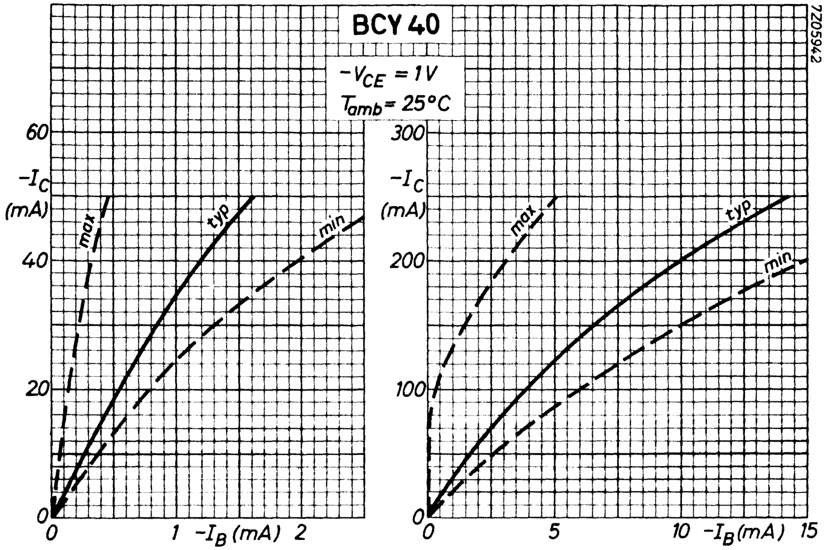

7Z05936
BCY 39
T_{amb} = 25°C
Typical values
$-I_C$ (mA)
250
200
150
100
50
0
$-I_B$ =
12mA
10mA
8mA
6mA
4mA
2mA
0
0.5
1.0
2
4
6
8
10
$-V_{CE}$ (V)
$-V_{CE}$ (V)

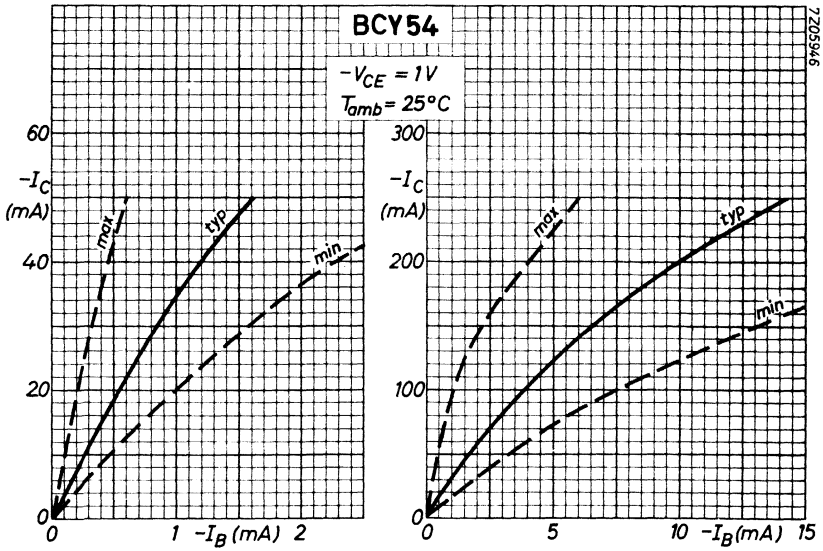

250
$-I_C$
(mA)
200
150
100
50
0
BCY 40
$T_{amb} = 25°C$
Typical values
$-I_B =$
10 mA
8 mA
6 mA
4 mA
2 mA
1 mA
0
0.5
1.0
2
4
6
8
10
$-V_{CE}$ (V)
$-V_{CE}$ (V)
7Z05943

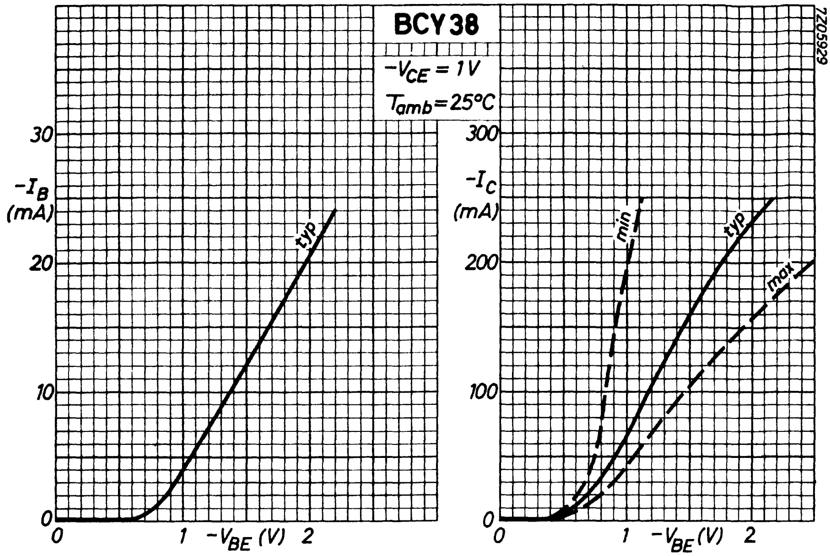

250
$-I_C$
(mA)
200
150
100
50
0
BCY 54
$T_{amb} = 25°C$
Typical values
$-I_B =$
14 mA
12 mA
10 mA
8 mA
7 mA
6 mA
5 mA
4 mA
3 mA
2 mA
1 mA
0
0.5
1.0
2
4
6
8
10
$-V_{CE}$ (V)
$-V_{CE}$ (V)
7Z05948

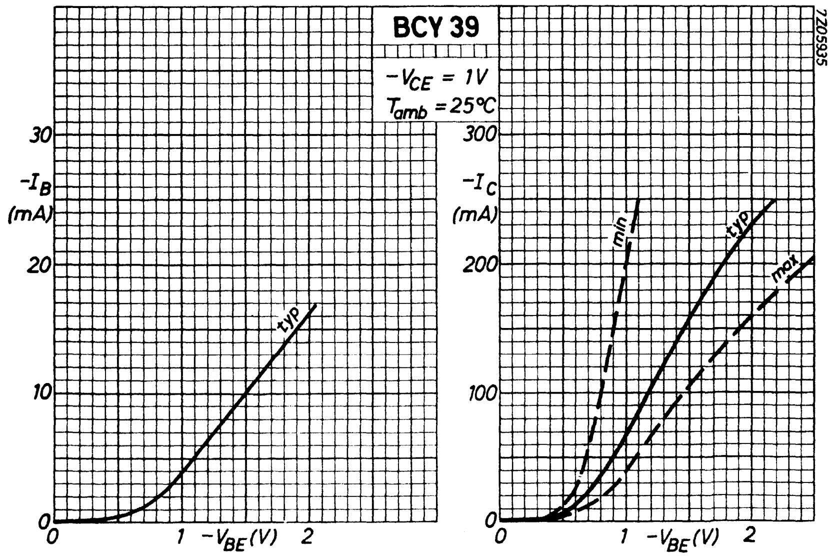

BCY 38
$-V_{CE} = 1V$
$T_{amb} = 25°C$
7Z05930
60
40
20
0
$-I_C$ (mA)
max
typ
min
0
1
2
3
$-I_B$ (mA)
300
200
100
10
20

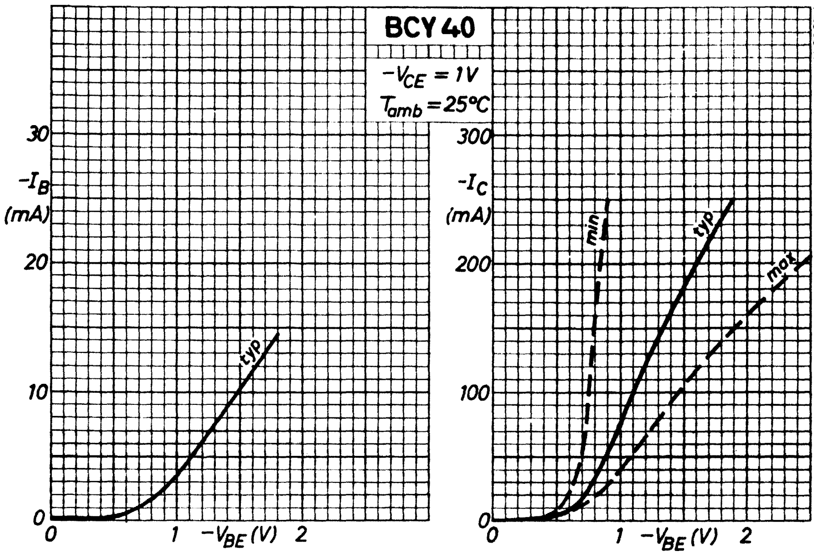

BCY 39
$-V_{CE} = 1V$
$T_{amb} = 25°C$
7Z05937
60
40
20
0
$-I_C$ (mA)
max
typ
min
0
1
2
3
$-I_B$ (mA)
300
200
100
10
20

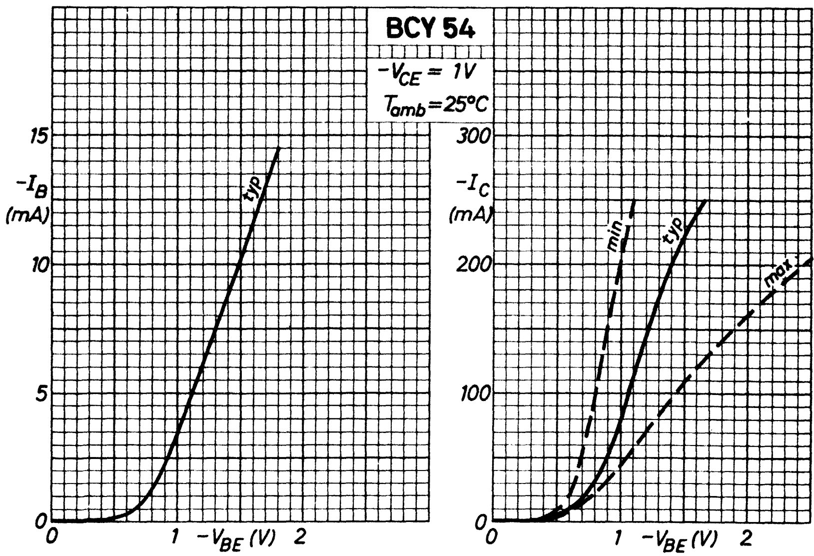

BCY 40
$-V_{CE} = 1V$
$T_{amb} = 25°C$
$-I_C$ (mA)
max
typ
min
$-I_B$ (mA)
7Z05942

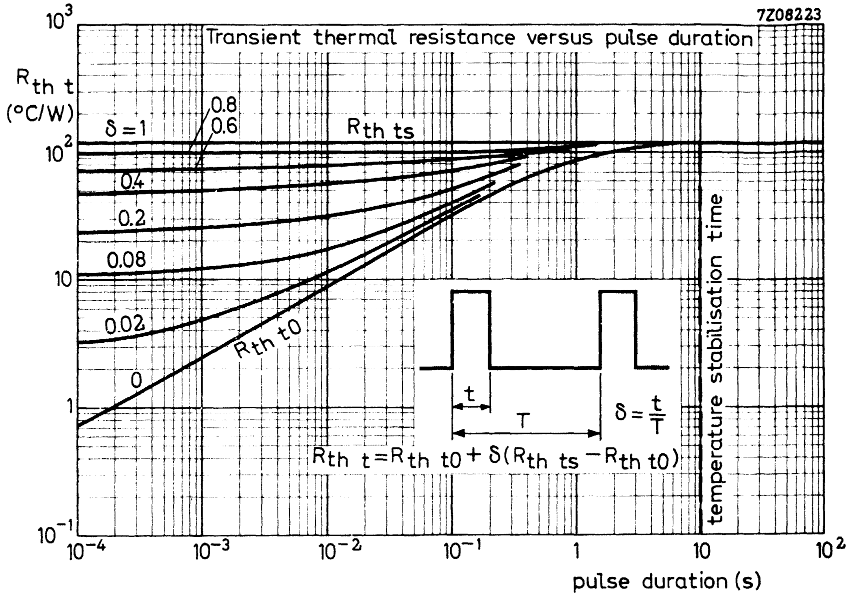

BCY54
$-V_{CE} = 1V$
$T_{amb} = 25°C$
$-I_C$ (mA)
max
typ
min
$-I_B$ (mA)
7Z05946


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


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


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


BCY 54
$-V_{CE} = 1V$
$T_{amb} = 25°C$
7Z05945
15
$-I_B$
(mA)
10
5
0
0
1
$-V_{BE}$ (V)
2
typ
300
$-I_C$
(mA)
200
100
0
0
1
$-V_{BE}$ (V)
2
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
10^3
10^2
10
1
10^{-1}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
pulse duration (s)

SILICON PLANAR EPITAXIAL TRANSISTORS

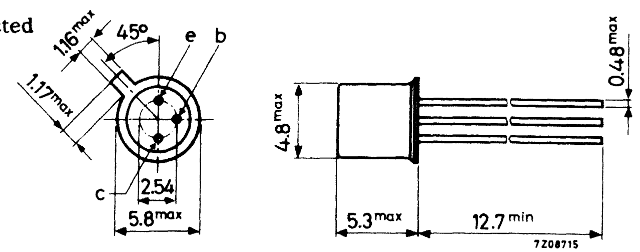
N-P-N transistor in a TO-18 metal envelope with the collector connected to the case.
They are intended for general purpose very high gain low level and low noise applications.
Moreover, they are also suitable for low speed switching applications.

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 °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	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 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

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

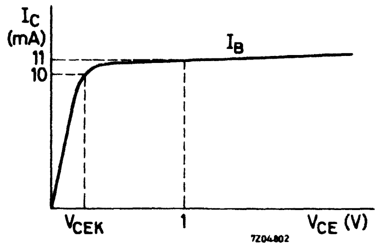
[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

[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. 200 100 to 450	400 200 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. 250 125 to 500	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

PLANAR EPITAXIAL TRANSISTORS

N-P-N silicon transistors in a TO-18 metal envelope with the collector connected to the case, for use in amplifier and switching applications.

QUICK REFERENCE DATA

			BCY58	BCY59	
Collector-emitter voltage (open base)	V_{CEO}	max.	32	45	V
Collector current	I_C	max.	200	200	mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	330	330	mW
T_{case} = 45 °C	P_{tot}	max.	1000	1000	mW
Junction temperature	T_j	max.	200	200	°C

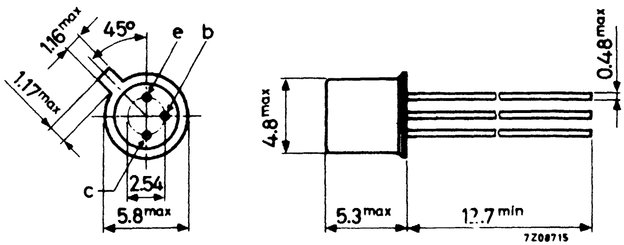
		BCY58 VII BCY59 VII	BCY58 VIII BCY59 VIII	BCY58 IX BCY59 IX	BCY58 X BCY59 X
Small signal current gain at T_j = 25 °C I_C = 2 mA; V_{CE} = 5 V; f = 1 kHz	h_{fe}	> 125 < 250	175 350	250 500	350 700

Transition frequency at f = 100 MHz I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	280	MHz
Noise figure at R_S = 2 kΩ I_C = 200 μA; V_{CE} = 5 V f = 1 kHz; B = 200 Hz	F	typ.	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)

			BCY58	BCY59	
Voltages					
Collector-emitter voltage ($V_{BE} = 0$)	V_{CES}	max.	32	45	V
Collector-emitter voltage (open base)	V_{CEO}	max.	32	45	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	7	V
Currents					
Collector current	I_C	max.	200		mA
Base current	I_B	max.	50		mA
Power dissipation					
Total power dissipation up to $T_{case} = 45\ ^oC$	P_{tot}	max.	1000		mW
Temperatures					
Storage temperature	T_{stg}	− 65	to +200		^oC
Junction temperature	T_j	max.	200		^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.45	$^oC/mW$
From junction to case	$R_{th\ j\text{-}c}$	=	0.15	$^oC/mW$

CHARACTERISTICS — $T_j = 25^oC$ unless otherwise specified

			BCY58	BCY59	
Collector cut-off currents					
$V_{CE} = 32\ V$; $V_{BE} = 0$	I_{CES}	typ.	0.2		nA
		<	10		nA
$V_{CE} = 45\ V$; $V_{BE} = 0$	I_{CES}	typ.		0.2	nA
		<		10	nA
$V_{CE} = 32\ V$; $V_{BE} = 0$; $T_j = 150\ ^oC$	I_{CES}	typ.	0.2		μA
		<	10		μA
$V_{CE} = 45\ V$; $V_{BE} = 0$; $T_j = 150\ ^oC$	I_{CES}	typ.		0.2	μA
		<		10	μA
Emitter cut-off current					
$I_C = 0$; $V_{EB} = 5\ V$	I_{EBO}	<	10	10	nA
Collector-emitter breakdown voltage					
$I_B = 0$; $I_C = 2\ mA$	$V_{(BR)CEO}$	>	32	45	V
Emitter-base breakdown voltage					
$I_C = 0$; $I_E = 1\ \mu A$	$V_{(BR)EBO}$	>	7	7	V

Base emitter voltage				
$I_C = 10\ \mu A$; $V_{CE} = 5\ V$	V_{BE}	typ.	0.5	V
$I_C = 20\ \mu A$; $V_{CE} = V_{CEO\,max}$; $T_j = 100\ ^oC$	V_{BE}	>	0.2	V
$I_C = 2\ mA$; $V_{CE} = 5\ V$	V_{BE}	typ.	0.62	V
			0.55 to 0.70	V
$I_C = 10\ mA$; $V_{CE} = 1\ V$	V_{BE}	typ.	0.70	V
$I_C = 100\ mA$; $V_{CE} = 1\ V$	V_{BE}	typ.	0.76	V
Saturation voltages				
$I_C = 10\ mA$; $I_B = 0.25\ mA$	V_{CEsat}	typ.	100	mV
			50 to 350	mV
	V_{BEsat}	typ.	700	mV
			600 to 850	mV
$I_C = 100\ mA$; $I_B = 2.5\ mA$	V_{CEsat}	typ.	250	mV
			150 to 700	mV
	V_{BEsat}	typ.	875	mV
			750 to 1200	mV

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

Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; V_{CB} = 10 V	C_c	typ.	3.0	pF
		<	5.0	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; V_{EB} = 0.5 V	C_e	typ.	10	pF
		<	15	pF
Transition frequency at f = 100 MHz				
I_C = 10 mA; V_{CE} = 5 V	f_T	>	150	MHz
		typ.	280	MHz
Noise figure at R_S = 2 kΩ				
I_C = 200 μA; V_{CE} = 5 V				
f = 1 kHz; B = 200 Hz	F	typ.	2	dB
		<	6	dB

			BCY58VII BCY59VII	BCY58VIII BCY59VIII	BCY58IX BCY59IX	BCY58X BCY59X	
D. C. current gain							
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	>	–	20	40	100	
		typ.	20	95	190	300	
I_C = 2 mA; V_{CE} = 5 V	h_{FE}	>	120	180	250	380	
		typ.	170	250	350	500	
		<	220	310	460	630	
I_C = 10 mA; V_{CE} = 1 V	h_{FE}	>	80	120	160	240	
		typ.	250	300	390	550	
		<	–	400	630	1000	
I_C = 100 mA; V_{CE} = 1 V	h_{FE}	>	40	45	60	60	
h parameters at f = 1 kHz							
I_C = 2 mA; V_{CE} = 5 V							
Input impedance	h_{ie}	>	1.6	2.5	3.2	4.5	kΩ
		typ.	2.7	3.6	4.5	7.5	kΩ
		<	4.5	6.0	8.5	12	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	1.5	2	3	3	10^{-4}
Small signal current gain	h_{fe}	>	125	175	250	350	
		typ.	200	260	330	520	
		<	250	350	500	700	
Output admittance	h_{oe}	typ.	18	24	30	50	μA/V
		<	30	50	60	100	μA/V

CHARACTERISTICS (continued)

Switching times

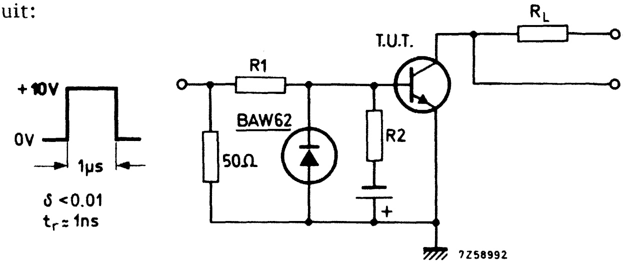
I_C = 10 mA; I_B = 1 mA; $-I_{BM}$ = 1 mA
R1 = 5 kΩ; R2 = 5 kΩ; R_L = 990 Ω
V_{BB} = 3.6 V

delay time	t_d	typ.	35	ns
rise time	t_r	typ.	50	ns
turn on time	t_{on}	typ.	85	ns
		<	150	ns
storage time	t_s	typ.	400	ns
fall time	t_f	typ.	80	ns
turn off time	t_{off}	typ.	480	ns
		<	800	ns

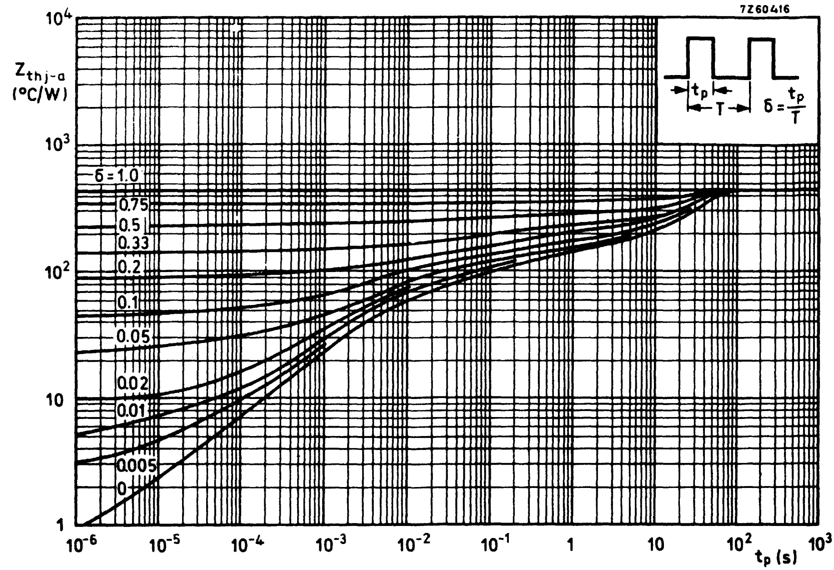
I_C = 100 mA; I_B = 10 mA; $-I_{BM}$ = 10 mA
R1 = 500 Ω; R2 = 700 Ω; R_L = 98 Ω
V_{BB} = 5 V

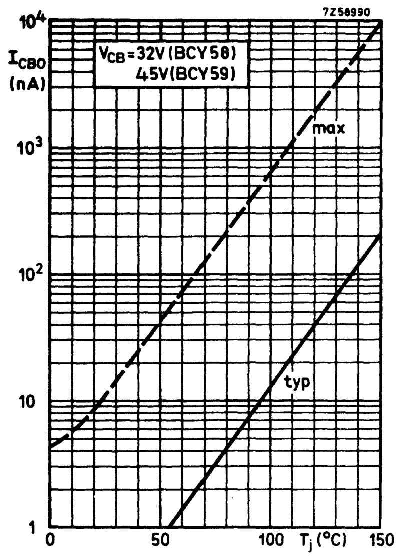
delay time	t_d	typ.	5	ns
rise time	t_r	typ.	50	ns
turn on time	t_{on}	typ.	55	ns
		<	150	ns
storage time	t_s	typ.	250	ns
fall time	t_f	typ.	200	ns
turn off time	t_{off}	typ.	450	ns
		<	800	ns

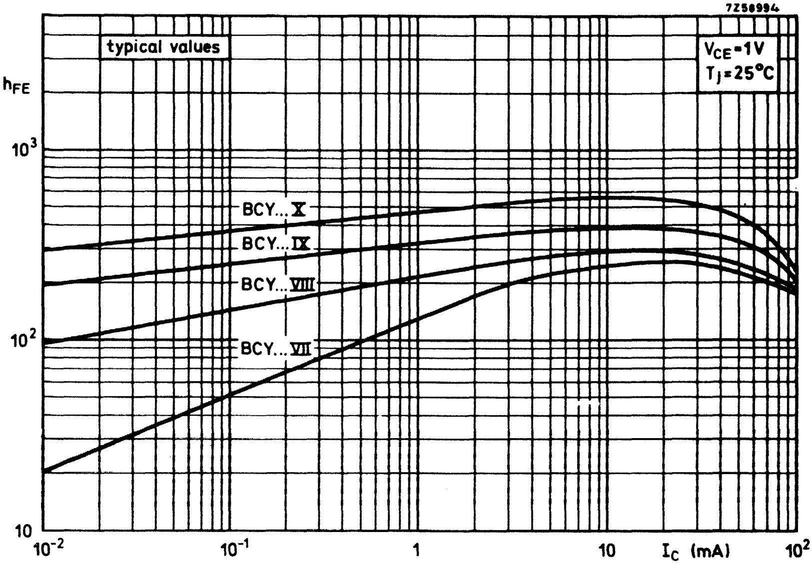
Test circuit:

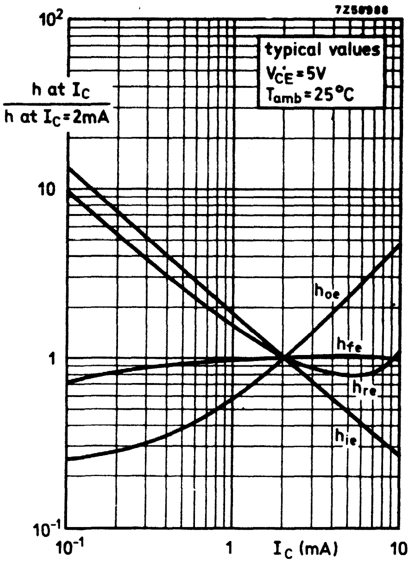


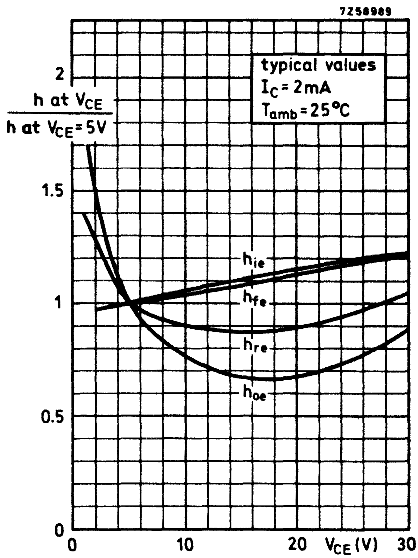
Oscilloscope:
R_i > 100 kΩ
t_r < 15 ns

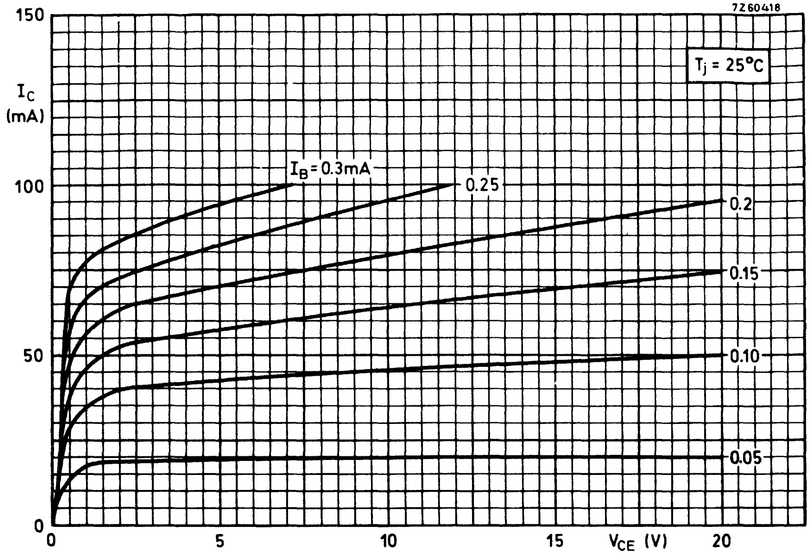

7Z60416
$Z_{th\,j\text{-}a}$ (°C/W)
$\delta = \frac{t_p}{T}$
t_p
T
δ = 1.0
0.75
0.5
0.33
0.2
0.1
0.05
0.02
0.01
0.005
0
10^4
10^3
10^2
10
1
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (s)

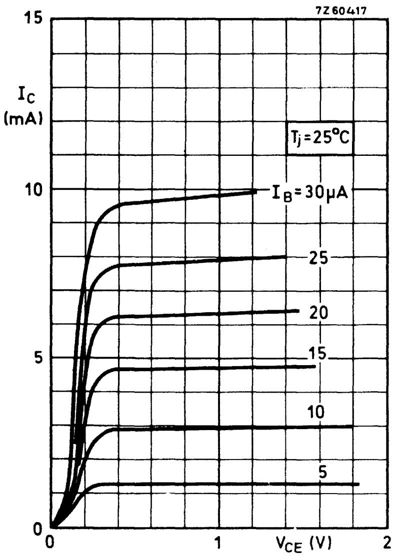

7Z58990
I_{CBO} (nA)
V_{CB} = 32V (BCY58)
45V (BCY59)
max
typ
10^4
10^3
10^2
10
1
0
50
100
T_j (°C)
150

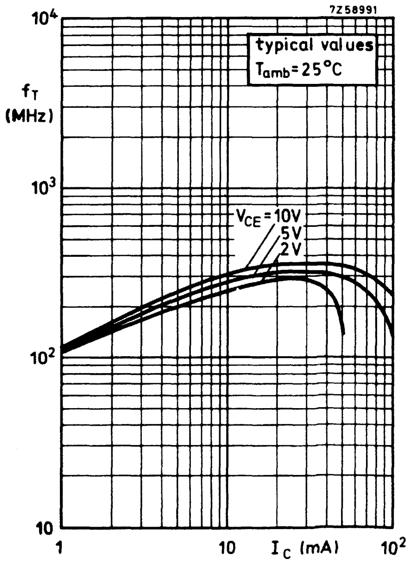

7Z58994
typical values
V_{CE} = 1V
T_j = 25°C
h_{FE}
10^3
10^2
10
BCY... X
BCY... IX
BCY... VIII
BCY... VII
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

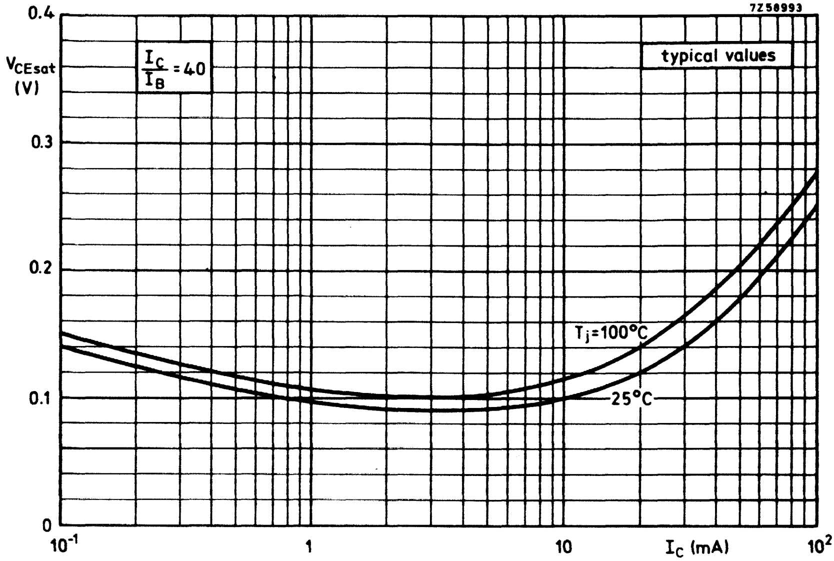

7Z58988
typical values
V_{CE} = 5V
T_{amb} = 25°C
h at I_C / h at I_C = 2mA
10^2
10
1
10^{-1}
h_{oe}
h_{fe}
h_{re}
h_{ie}
10^{-1}
1
I_C (mA)
10

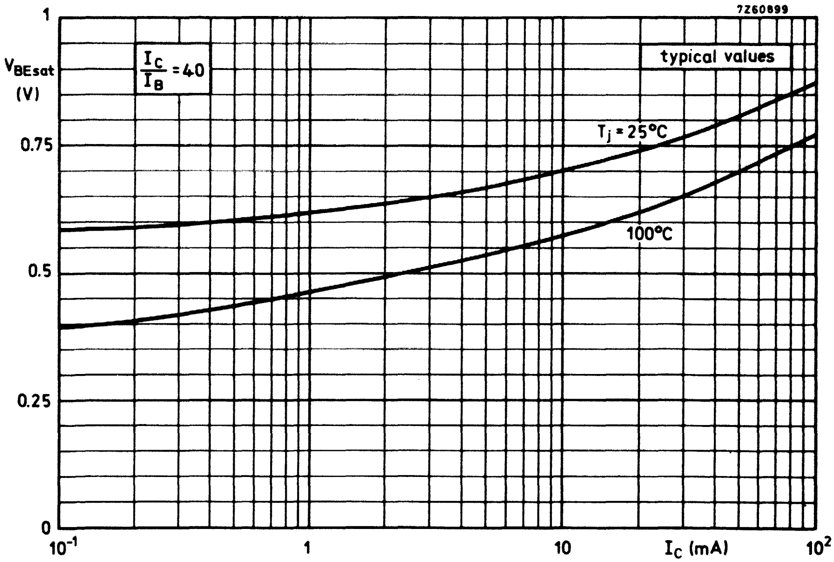

7Z58989
typical values
I_C = 2mA
T_{amb} = 25°C
h at V_{CE} / h at V_{CE} = 5V
2
1.5
1
0.5
0
h_{ie}
h_{fe}
h_{re}
h_{oe}
0
10
20
V_{CE} (V)
30


7Z60418
T_j = 25°C
I_C (mA)
I_B = 0.3mA
0.25
0.2
0.15
0.10
0.05
V_{CE} (V)
0
5
10
15
20
50
100
150


7Z60417
T_j = 25°C
I_C (mA)
I_B = 30μA
25
20
15
10
5
V_{CE} (V)
0
1
2
5
10
15


7Z58991
typical values
T_{amb} = 25°C
f_T (MHz)
V_{CE} = 10V
5V
2V
I_C (mA)
1
10
10^2
10^3
10^4


7Z58993
V_{CEsat} (V)
$\frac{I_C}{I_B} = 40$
typical values
$T_j = 100°C$
25°C
0.4
0.3
0.2
0.1
0
10^{-1}
1
10
I_C (mA)
10^2


7Z60899
V_{BEsat} (V)
$\frac{I_C}{I_B} = 40$
typical values
$T_j = 25°C$
100°C
1
0.75
0.5
0.25
0
10^{-1}
1
10
I_C (mA)
10^2

P-N-P SILICON PLANAR EPITAXIAL TRANSISTORS

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

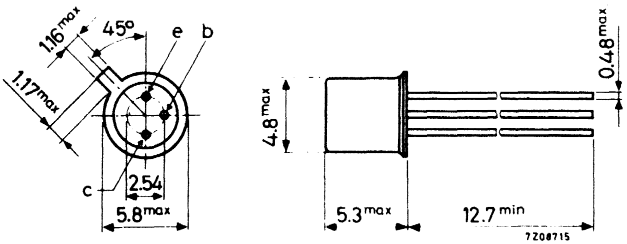
QUICK REFERENCE DATA

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

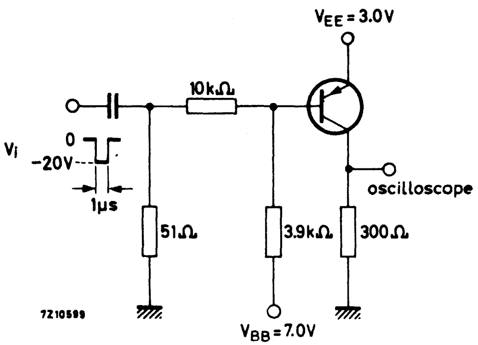
delay time	t_d	typ.	23	ns
		<	35	ns
rise time	t_r	typ.	25	ns
		<	35	ns
turn on time	t_{on}	typ.	48	ns
		<	65	ns

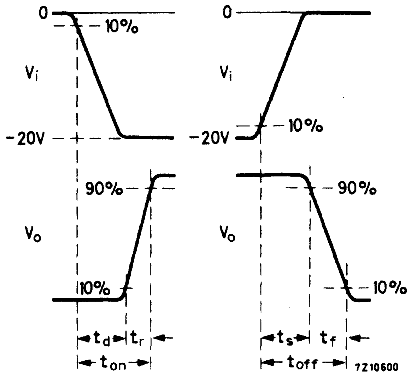
Turn off time when switched from

$-I_C$ = 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

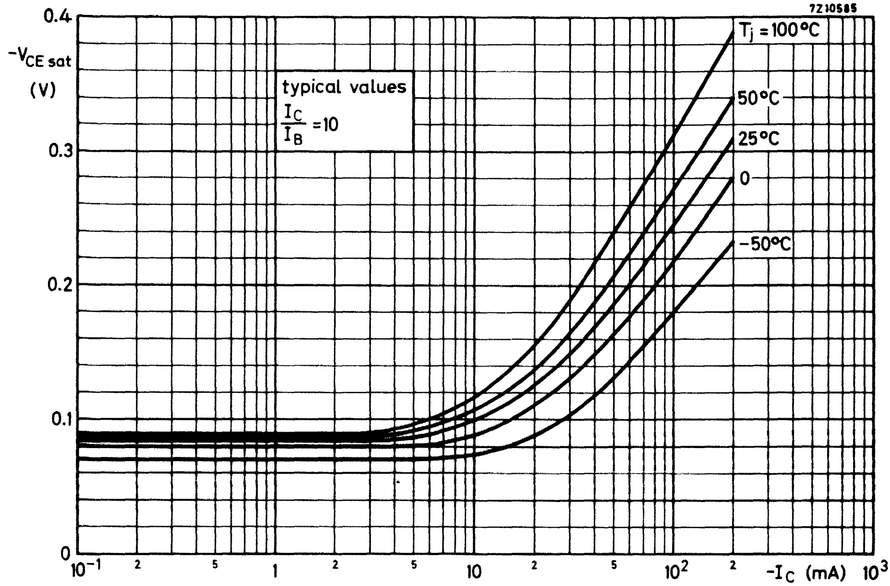
Test circuit:

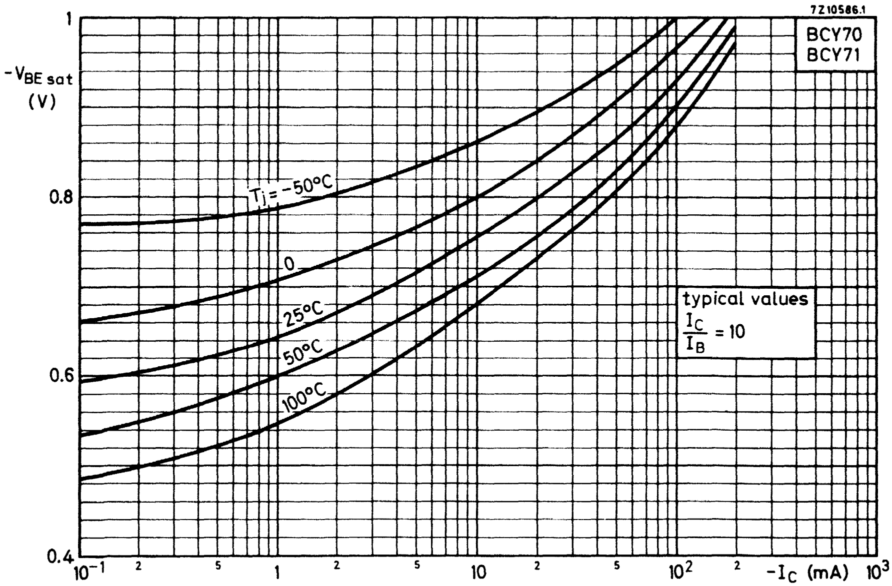


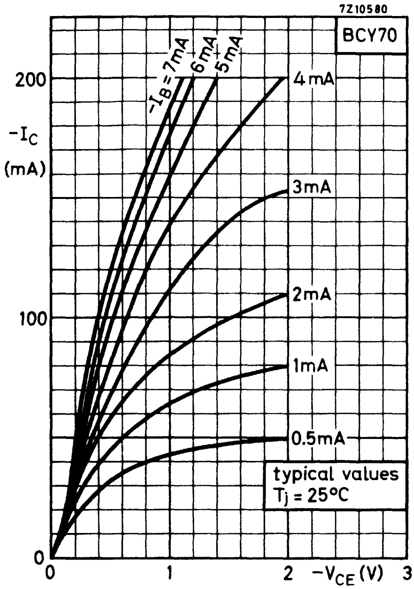


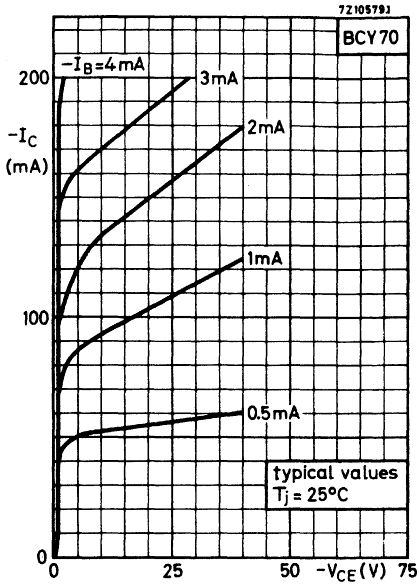
Note:

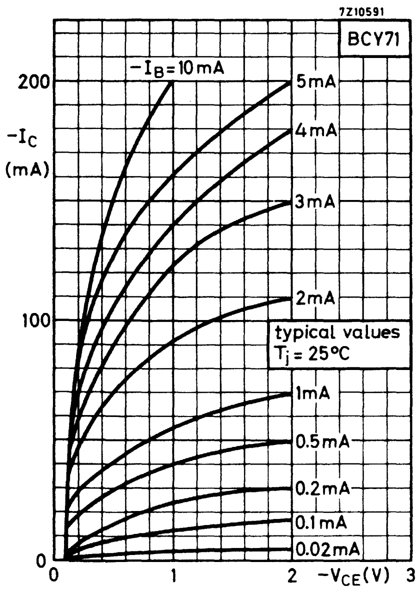
$+I_{BM}$ is the reverse current that can flow during switching off. The indicated $+I_{BM}$ is determined and limited by the applied cut-off voltage and series resistance.

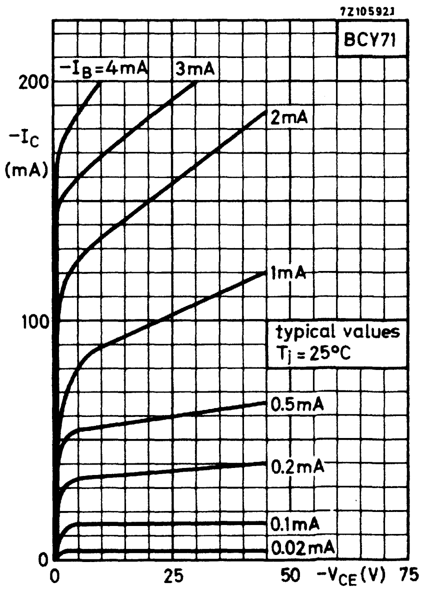

7Z10585
0.4
$-V_{CE\,sat}$
(V)
0.3
0.2
0.1
0
typical values
$\frac{I_C}{I_B} = 10$
$T_j = 100\,^\circ C$
50 °C
25 °C
0
−50 °C
10^{-1}
2
5
1
2
5
10
2
5
10^2
2
$-I_C$ (mA)
10^3

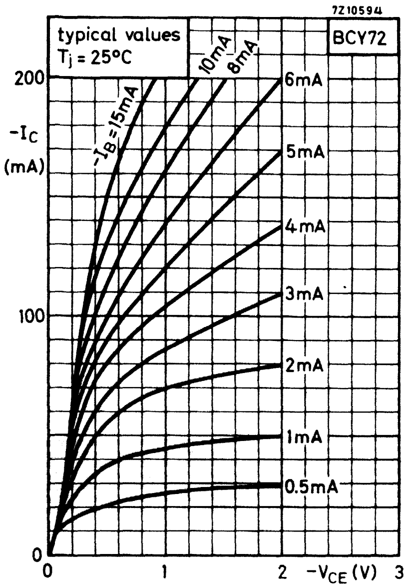

7Z10586.1
1
$-V_{BE\,sat}$
(V)
0.8
0.6
0.4
BCY70
BCY71
$T_j = -50\,^\circ C$
0
25 °C
50 °C
100 °C
typical values
$\frac{I_C}{I_B} = 10$
10^{-1}
2
5
1
2
5
10
2
5
10^2
2
$-I_C$ (mA)
10^3

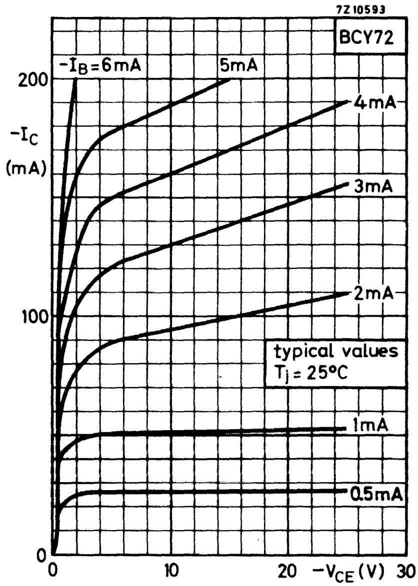

7Z10580
BCY70
$-I_B$ = 7mA
6mA
5mA
4 mA
3mA
2mA
1mA
0.5mA
typical values
T_j = 25°C
200
$-I_C$
(mA)
100
0
0
1
2
$-V_{CE}$ (V)
3

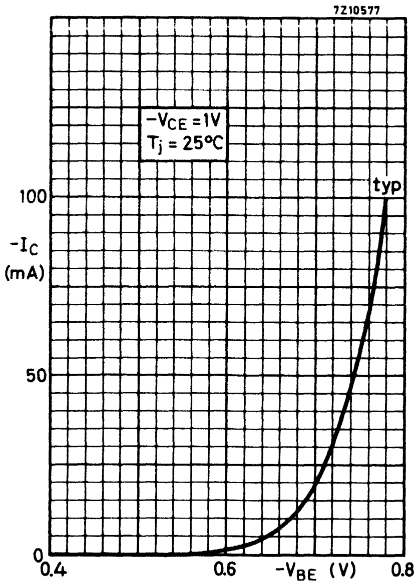

7Z10579J
BCY70
$-I_B$ = 4mA
3mA
2mA
1mA
0.5mA
typical values
T_j = 25°C
200
$-I_C$
(mA)
100
0
0
25
50
$-V_{CE}$ (V)
75

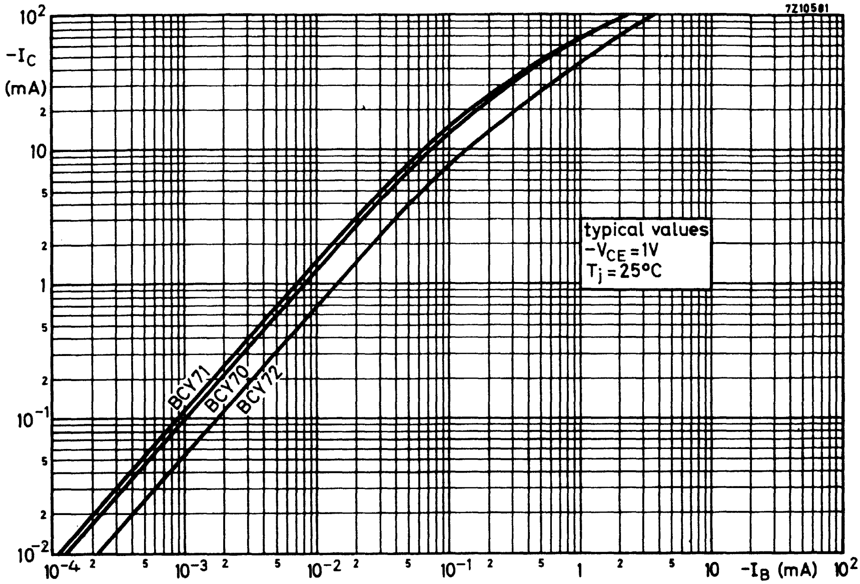

7Z10591
BCY71
$-I_B$ = 10 mA
5mA
4mA
3mA
2mA
1mA
0.5mA
0.2mA
0.1mA
0.02mA
typical values
T_j = 25°C
200
$-I_C$
(mA)
100
0
0
1
2
$-V_{CE}$ (V)
3

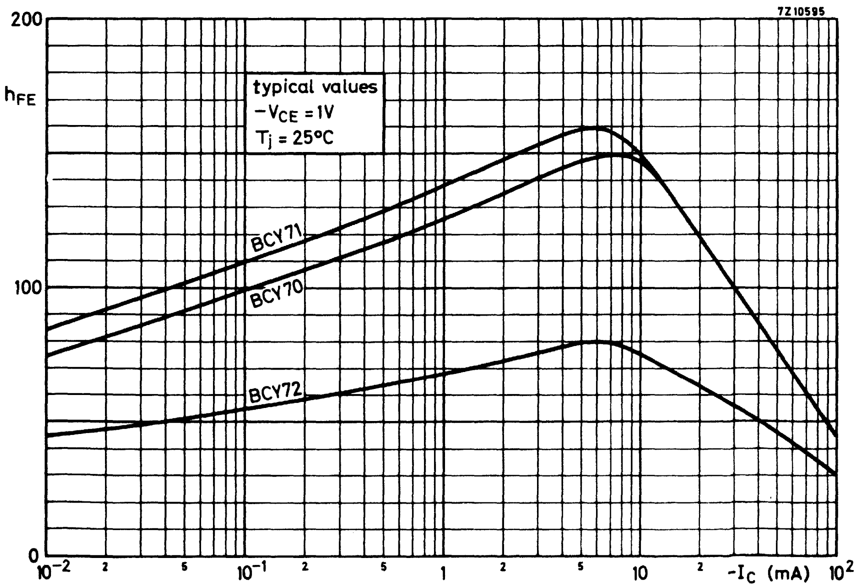

7Z10592J
BCY71
$-I_B$ = 4mA
3mA
2mA
1mA
0.5mA
0.2mA
0.1mA
0.02mA
typical values
T_j = 25°C
200
$-I_C$
(mA)
100
0
0
25
50
$-V_{CE}$ (V)
75

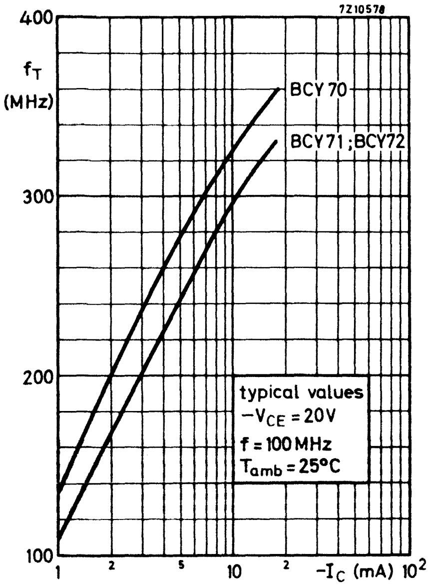

7Z10594
typical values
T_j = 25°C
BCY72
$-I_B$ = 15mA
10mA
8mA
6mA
5mA
4mA
3mA
2mA
1mA
0.5mA
200
100
0
$-I_C$
(mA)
0
1
2
3
$-V_{CE}$ (V)

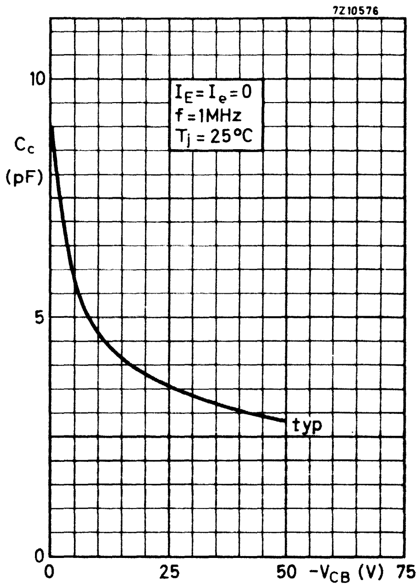

7Z10593
BCY72
$-I_B$ = 6mA
5mA
4mA
3mA
2mA
1mA
0.5mA
typical values
T_j = 25°C
200
100
0
$-I_C$
(mA)
0
10
20
30
$-V_{CE}$ (V)

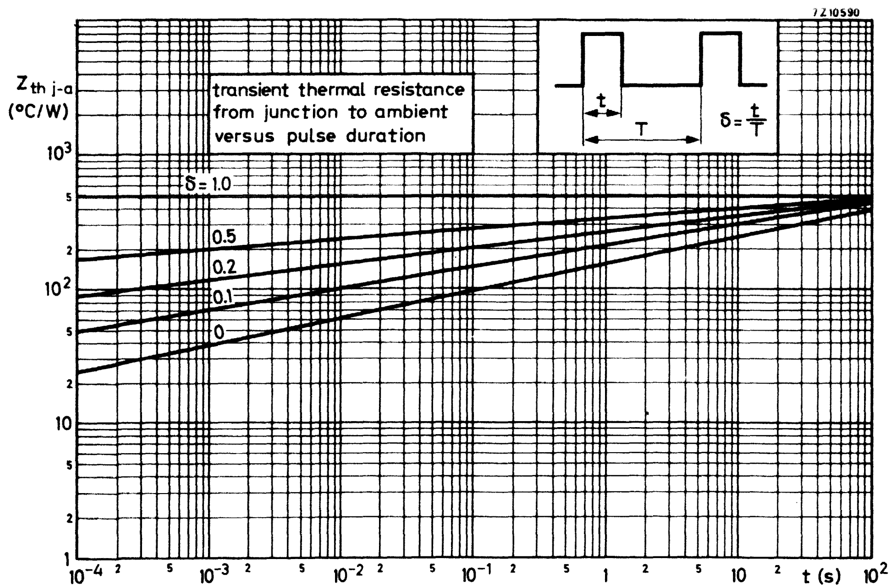

7Z10577
$-V_{CE}$ = 1V
T_j = 25°C
typ
100
50
0
$-I_C$
(mA)
0.4
0.6
0.8
$-V_{BE}$ (V)

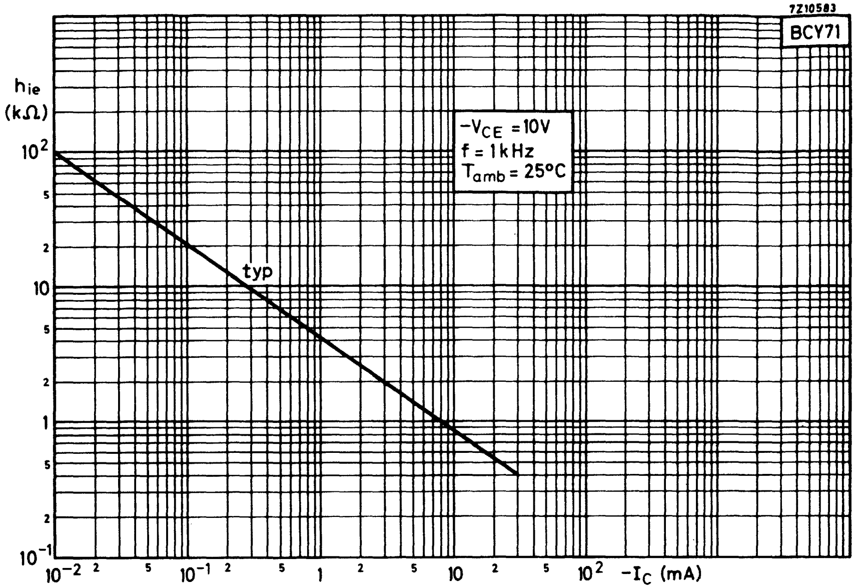

7Z10581
10^2
$-I_C$
(mA)
typical values
$-V_{CE} = 1V$
$T_j = 25°C$
BCY71
BCY70
BCY72
$-I_B$ (mA)

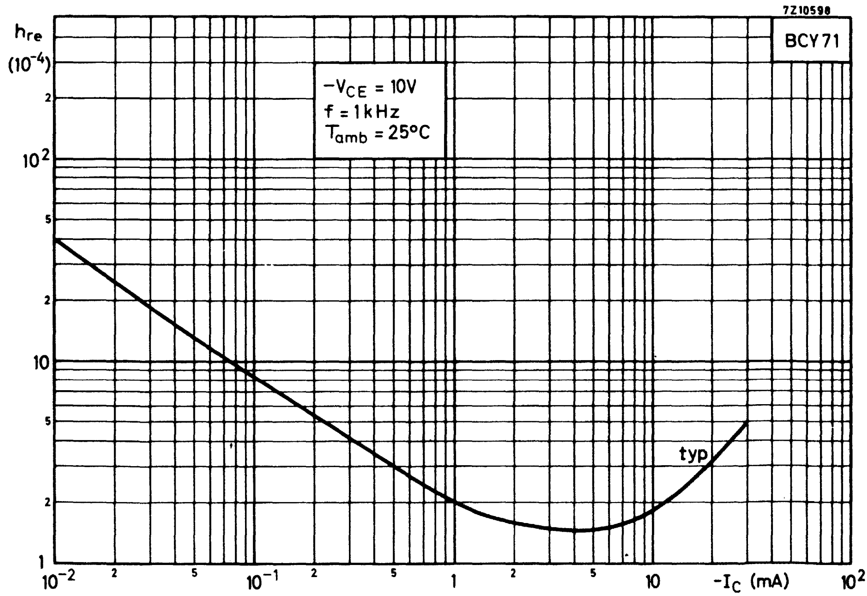

7Z10595
200
h_{FE}
typical values
$-V_{CE} = 1V$
$T_j = 25°C$
BCY71
BCY70
BCY72
100
0
$-I_C$ (mA)

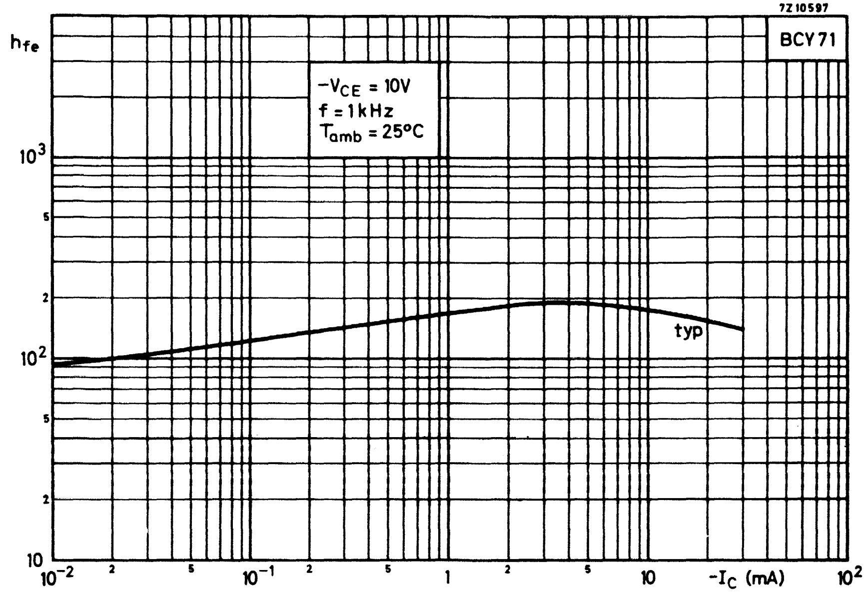

7Z10578
400
300
200
100
f_T
(MHz)
BCY70
BCY71;BCY72
typical values
$-V_{CE} = 20V$
f = 100 MHz
$T_{amb} = 25°C$
1
2
5
10
2
$-I_C$ (mA) 10^2

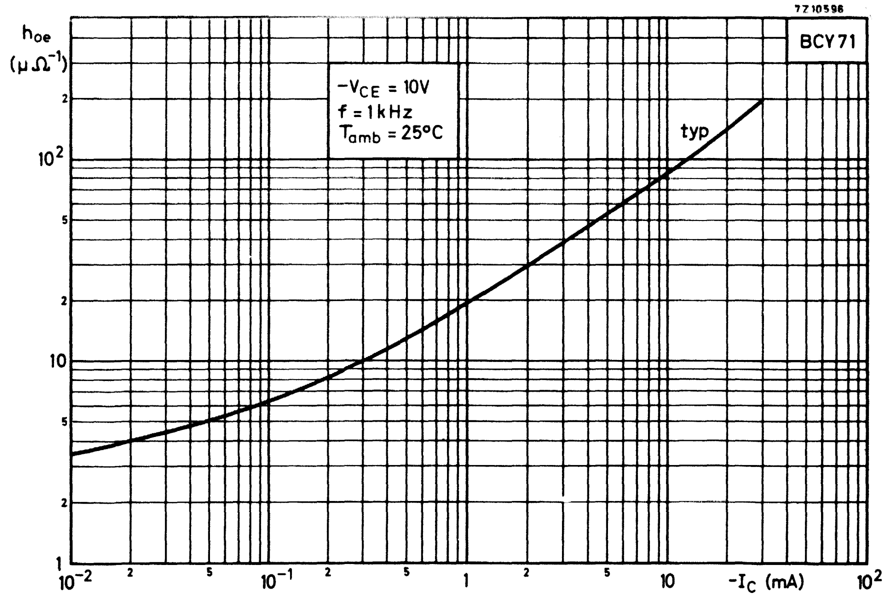

7Z10576
10
5
0
C_c
(pF)
$I_E = I_e = 0$
f = 1MHz
$T_j = 25°C$
typ
0
25
50
$-V_{CB}$ (V)
75

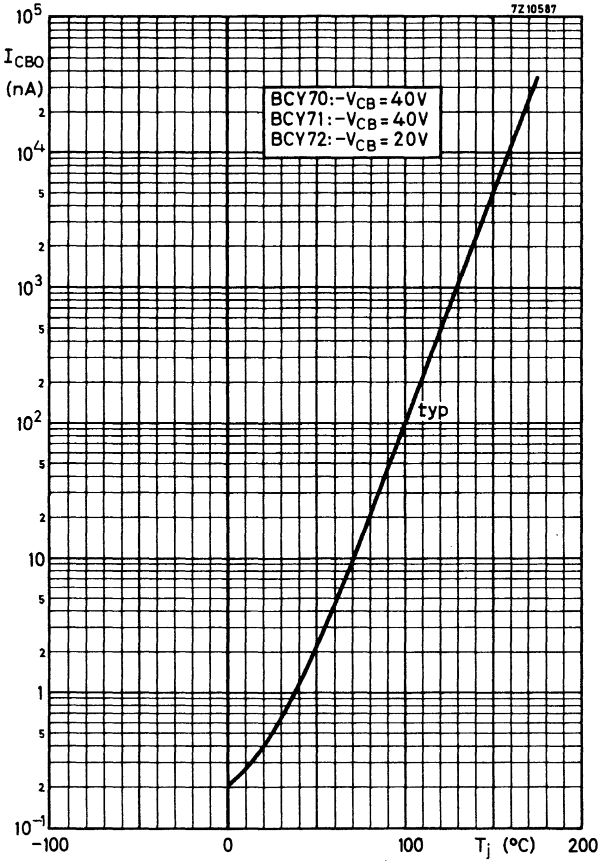

7Z10590
$Z_{th\ j-a}$
(°C/W)
transient thermal resistance
from junction to ambient
versus pulse duration
t
T
$\delta = \frac{t}{T}$
10^3
δ = 1.0
0.5
0.2
0.1
0
10^2
10
1
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
t (s)
10^2

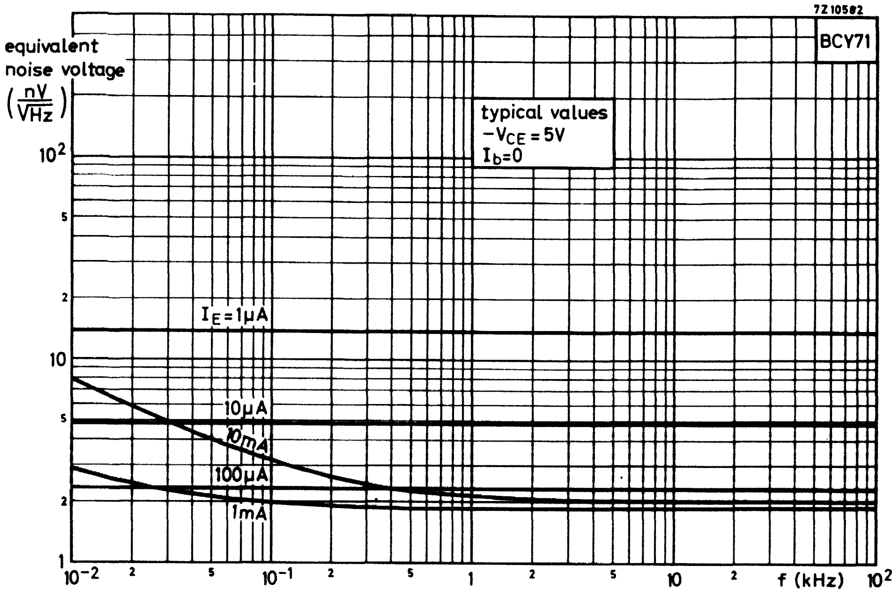

7Z10583
BCY71
h_{ie} (kΩ)
$-V_{CE}$ = 10V
f = 1 kHz
T_{amb} = 25°C
typ
$-I_C$ (mA)

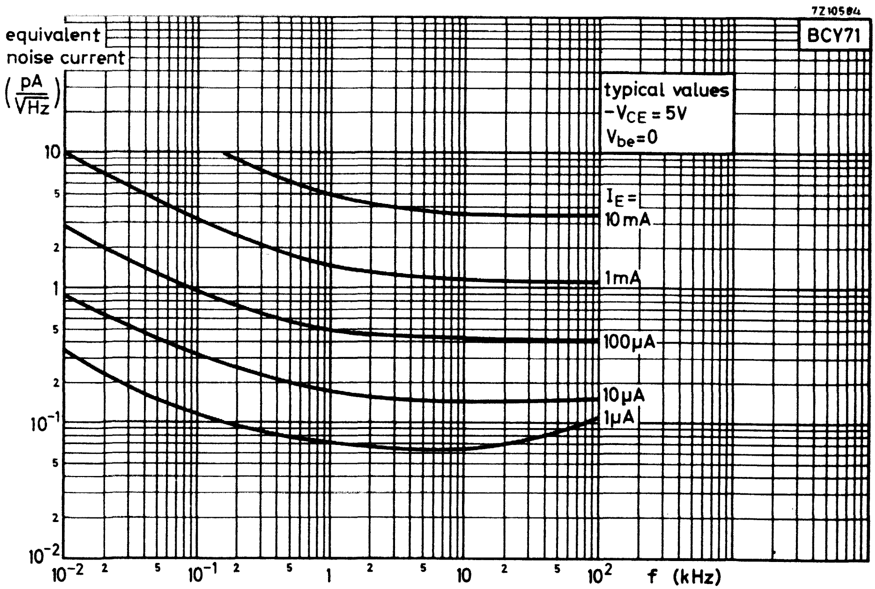

7Z10598
BCY71
h_{re} (10^{-4})
$-V_{CE}$ = 10V
f = 1 kHz
T_{amb} = 25°C
typ
$-I_C$ (mA)

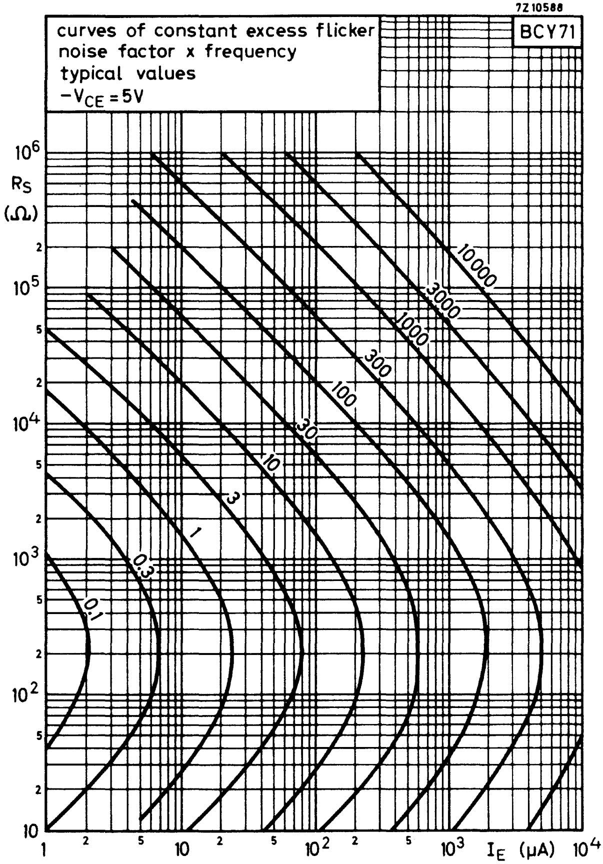

7Z10597
BCY71
h_{fe}
$-V_{CE}$ = 10V
f = 1kHz
T_{amb} = 25°C
typ
10^3
5
2
10^2
5
2
10
10^{-2}
2
5
10^{-1}
2
5
1
2
5
10
$-I_C$ (mA)
10^2

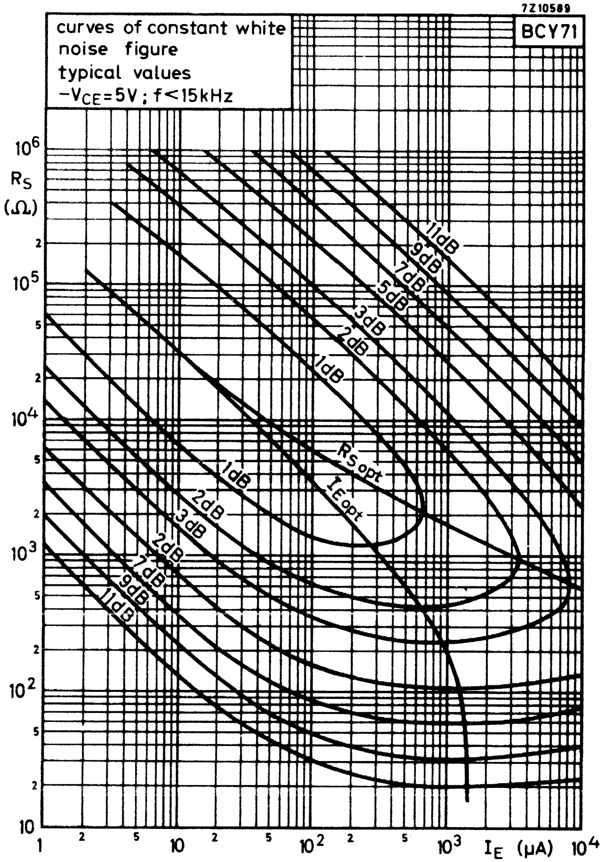

7Z10596
BCY71
h_{oe}
($\mu\Omega^{-1}$)
$-V_{CE}$ = 10V
f = 1kHz
T_{amb} = 25°C
typ
2
10^2
5
2
10
5
2
1
10^{-2}
2
5
10^{-1}
2
5
1
2
5
10
$-I_C$ (mA)
10^2


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


7Z10582
BCY71
equivalent noise voltage
(nV/√Hz)
typical values
−VCE = 5V
Ib=0
IE=1μA
10μA
10mA
100μA
1mA
10²
5
2
10
5
2
1
10⁻²
2
5
10⁻¹
2
5
1
2
5
10
2
f (kHz)
10²


7Z10584
BCY71
equivalent noise current
(pA/√Hz)
typical values
−VCE = 5V
Vbe=0
IE =
10 mA
1mA
100μA
10μA
1μA
10
5
2
1
5
2
10⁻¹
5
2
10⁻²
10⁻²
2
5
10⁻¹
2
5
1
2
5
10
2
5
10²
f (kHz)


7Z10588
curves of constant excess flicker noise factor x frequency
typical values
$-V_{CE} = 5V$
BCY71
R_S (Ω)
10^6
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
10000
3000
1000
300
100
30
10
3
1
0.3
0.1


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

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; $I_E = 200\ \mu A$ with a source resistance $R_S = 10\ k\Omega$.
From page 14 it follows that at $I_E = 200\ \mu A$ with $R_S = 10\ k\Omega$ 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 $I_E = 200\ \mu A$ with $R_S = 10\ k\Omega$ 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.

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

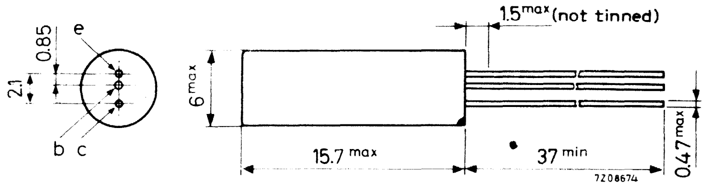
Collector current (d.c. or average over any 20 ms period)	$-I_C$	max.	50	mA
Collector current (peak value)	$-I_{CM}$	max.	50	mA
Base current (d.c. or average over any 20 ms period)	$-I_B$	max.	15	mA
Base current (peak value)	$-I_{BM}$	max.	15	mA
Total power dissipation up to T_{amb} = 25 °C in free air	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	-	

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

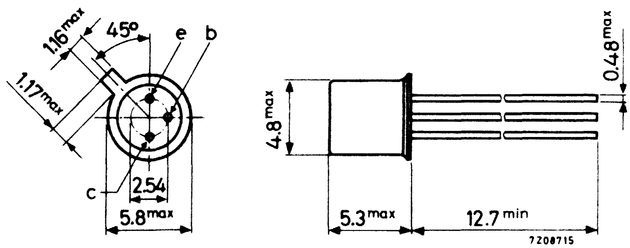
QUICK REFERENCE DATA

			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	$^oC/mW$

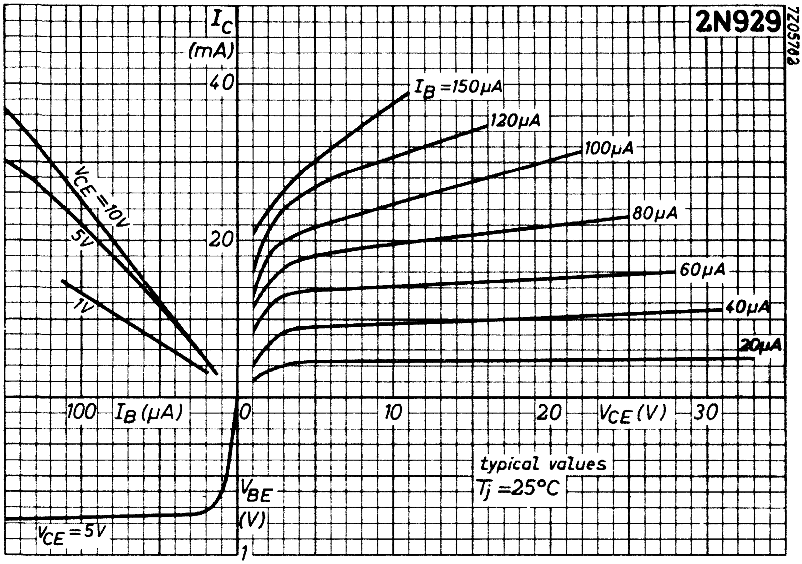
CHARACTERISTICS T_j = 25 °C unless otherwise specified

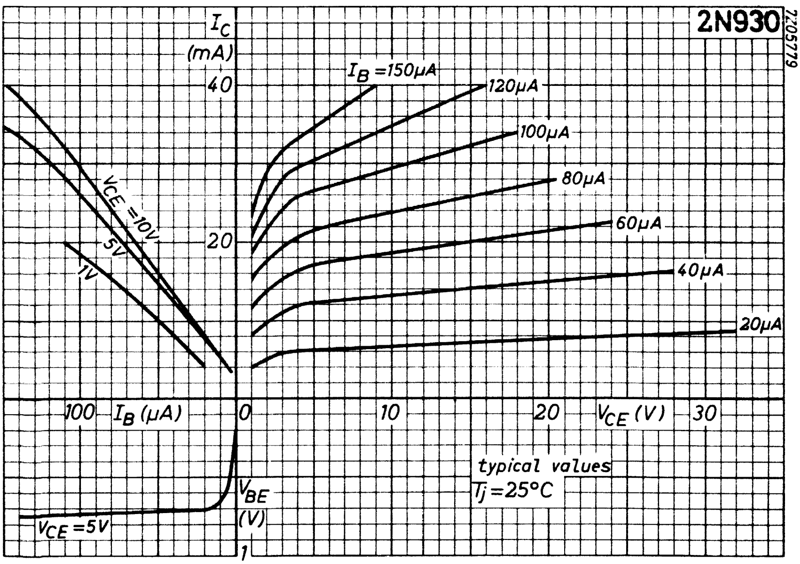
Collector cut-off current			
I_E = 0; V_{CB} = 45 V	I_{CBO}	< 10	nA
I_B = 0; V_{CE} = 5 V	I_{CEO}	< 2	nA
V_{EB} = 0; V_{CB} = 45 V	I_{CES}	< 10	nA
Emitter cut-off current			
I_C = 0; V_{EB} = 5 V	I_{EBO}	< 10	nA
Emitter-base voltage			
$-I_E$ = 0.5 mA; V_{CB} = 5 V	$-V_{EB}$	0.6 to 0.8	V
Saturation voltages			
I_C = 10 mA; I_B = 0.5 mA	V_{CEsat}	< 1	V
	V_{BEsat}	0.6 to 1	V

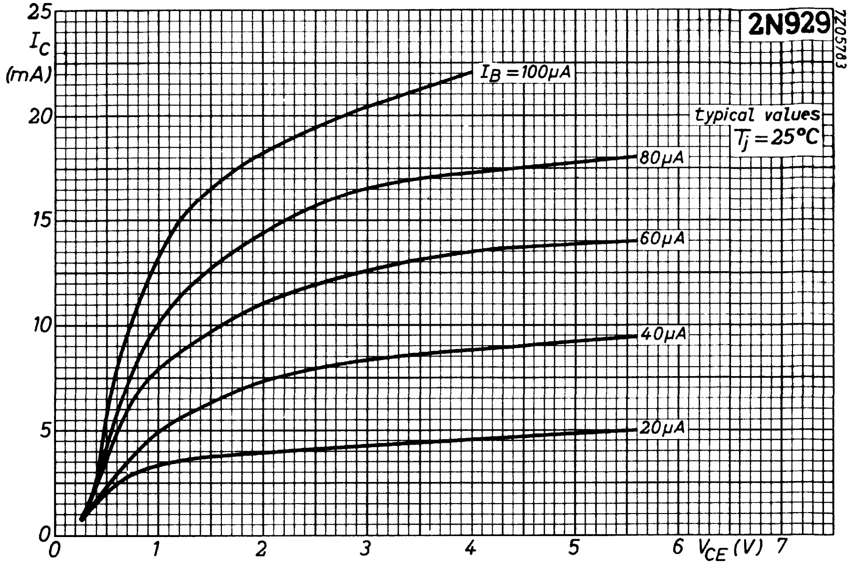
D.C. current gain		2N929	2N930	
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	40 to 120	100 to 300	
I_C = 10 μA; V_{CE} = 5 V; T_j = −55 °C	h_{FE}	> 10	> 20	
I_C = 500 μA; V_{CE} = 5 V	h_{FE}	> 60	> 150	
I_C = 10 mA; V_{CE} = 5 V	h_{FE}	100 to 350	150 to 600	
Collector capacitance at f = 1 MHz				
I_E = I_e = 0; 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

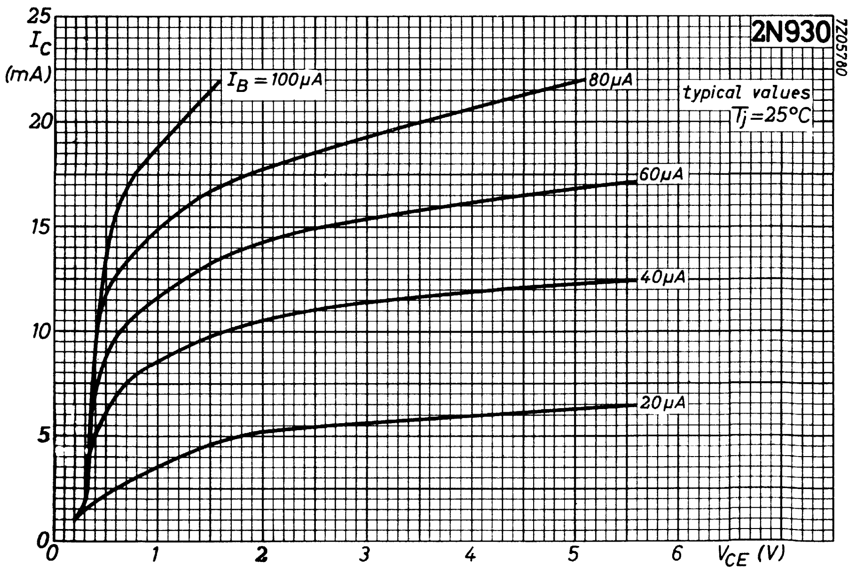
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

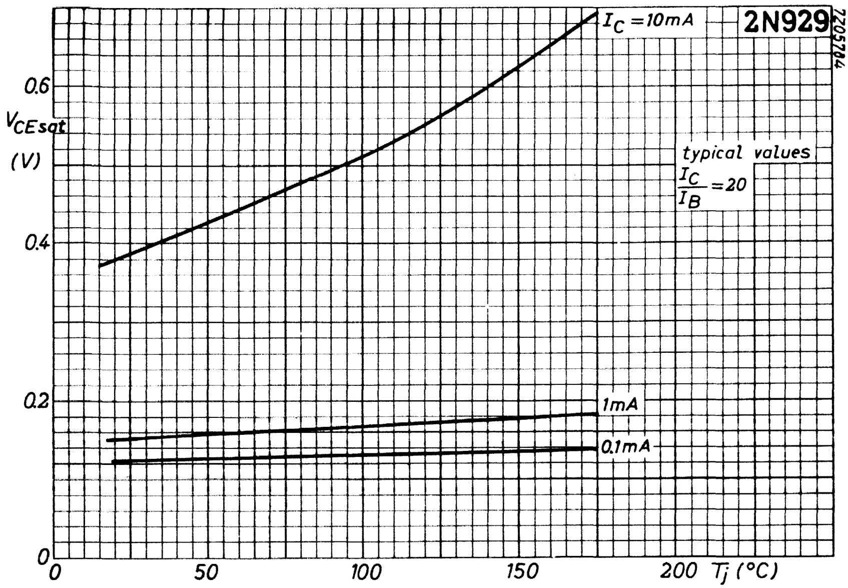
		2N929	2N930	
Noise figure (f = 10 Hz to 15 kHz)				
I_C = 10 μA; V_{CE} = 5 V; R_S = 10 kΩ	F	typ. 2.5	2	dB
		< 4	3	dB
h parameters at f = 1 kHz				
I_C = 1 mA; V_{CE} = 5 V				
Input impedance	h_{ie}	typ. 5.0	10.0	kΩ
Reverse voltage transfer	h_{re}	typ. 2.5	5.5	10^{-4}
Small signal current gain	h_{fe}	typ. 200	350	
		60 to 350	150 to 600	
Output admittance	h_{oe}	typ. 14	25	$\mu\Omega^{-1}$

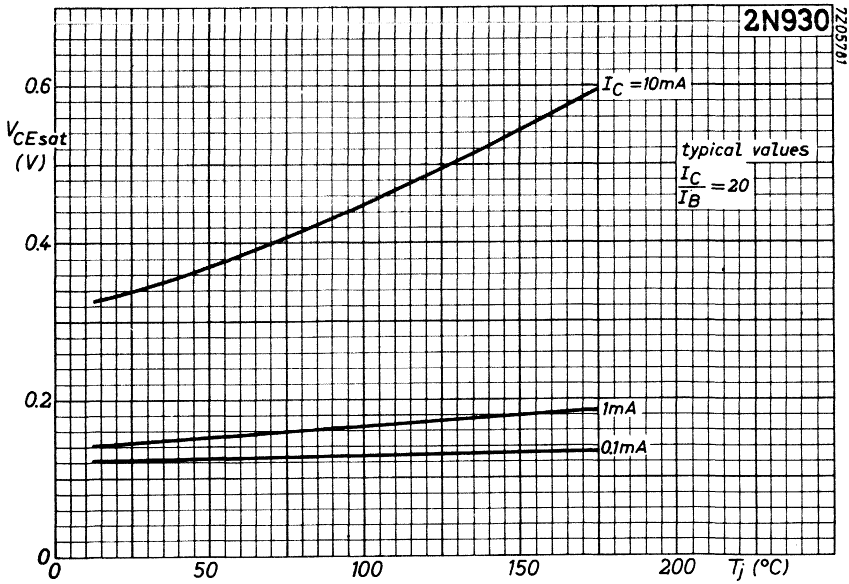

2N929
7Z05762
I_C (mA)
40
20
I_B =150μA
120μA
100μA
80μA
60μA
40μA
20μA
V_{CE} =10V
5V
1V
100
I_B (μA)
0
10
20
V_{CE} (V)
30
typical values
T_j =25°C
V_{BE} (V)
1
V_{CE} =5V

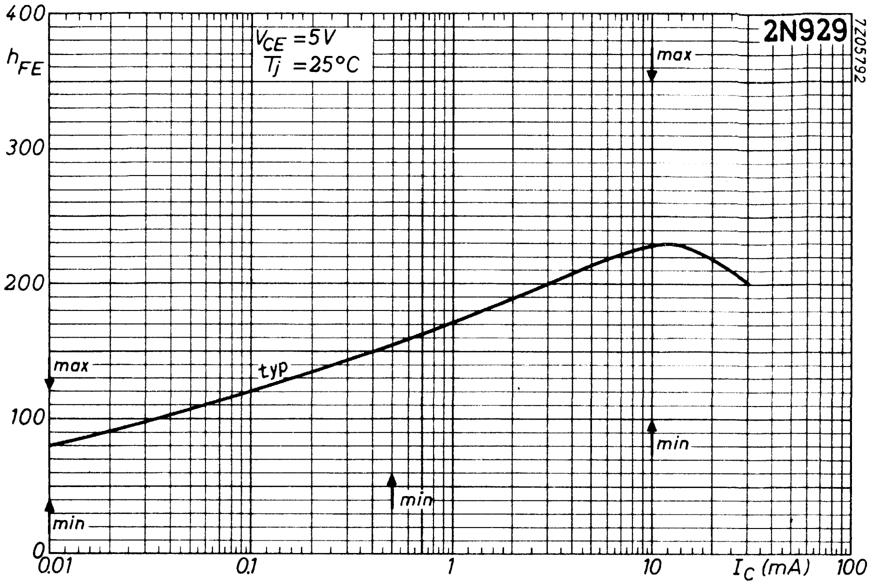

2N930
7Z05779
I_C (mA)
40
20
I_B =150μA
120μA
100μA
80μA
60μA
40μA
20μA
V_{CE} =10V
5V
1V
100
I_B (μA)
0
10
20
V_{CE} (V)
30
typical values
T_j =25°C
V_{BE} (V)
1
V_{CE} =5V

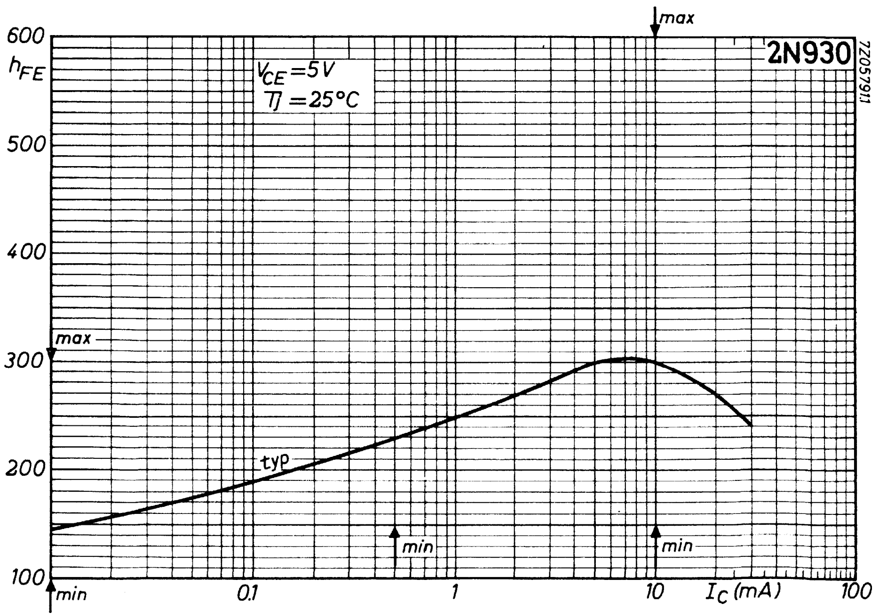

2N929
7Z05783
I_C (mA)
I_B = 100 μA
80 μA
60 μA
40 μA
20 μA
typical values
T_j = 25 °C
V_{CE} (V)
0
1
2
3
4
5
6
7
5
10
15
20
25

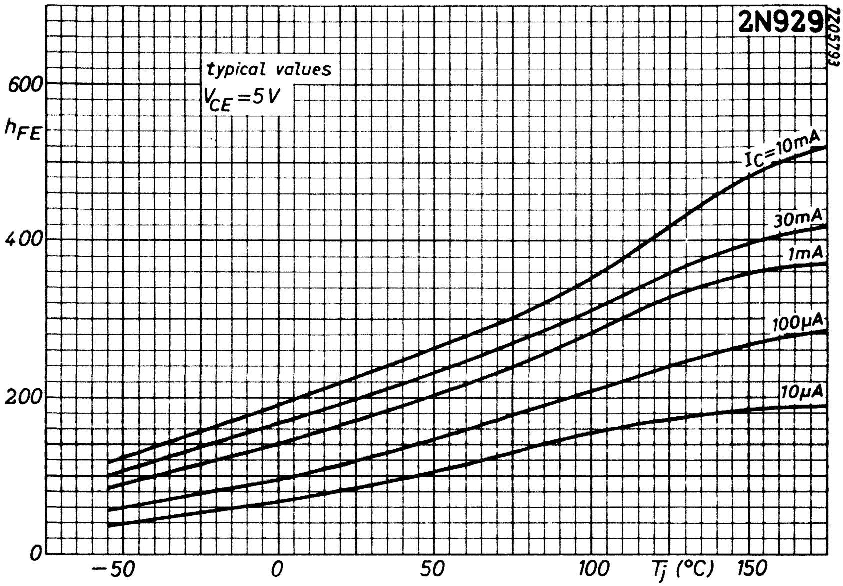

2N930
7Z05780
I_C (mA)
I_B = 100 μA
80 μA
60 μA
40 μA
20 μA
typical values
T_j = 25 °C
V_{CE} (V)
0
1
2
3
4
5
6
5
10
15
20
25

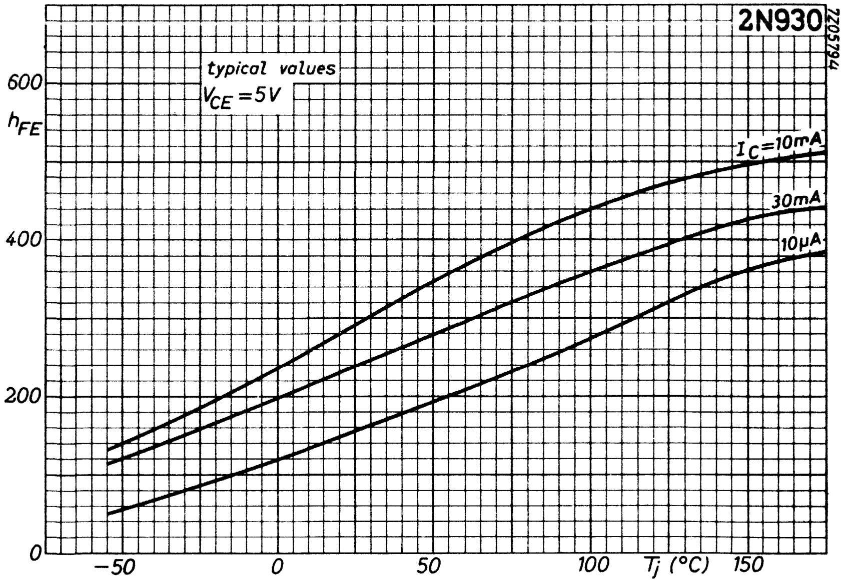

2N929
7205784
0.6
V_{CEsat}
(V)
0.4
0.2
0
I_C =10mA
1mA
0.1mA
typical values
$\frac{I_C}{I_B}$ =20
0
50
100
150
200
T_j (°C)

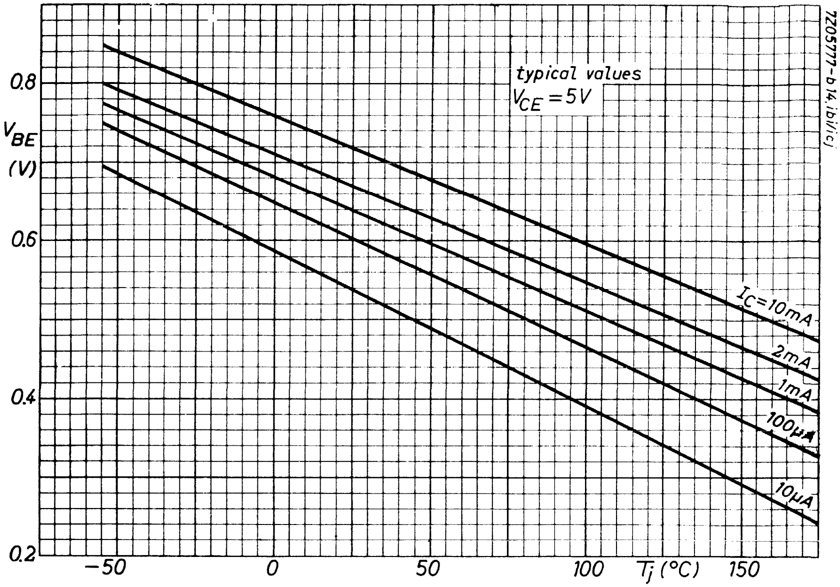

2N930
7205781
0.6
V_{CEsat}
(V)
0.4
0.2
0
I_C =10mA
1mA
0.1mA
typical values
$\frac{I_C}{I_B}$ =20
0
50
100
150
200
T_j (°C)

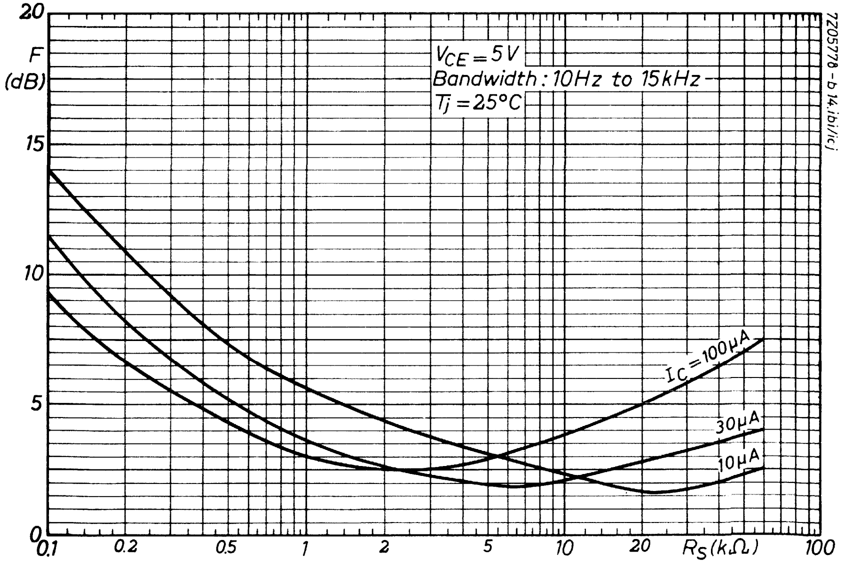

400
h_{FE}
300
200
100
0
V_{CE} = 5 V
T_j = 25 °C
2N929
7Z05792
max
min
typ
max
min
min
0.01
0.1
1
10
I_C (mA)
100

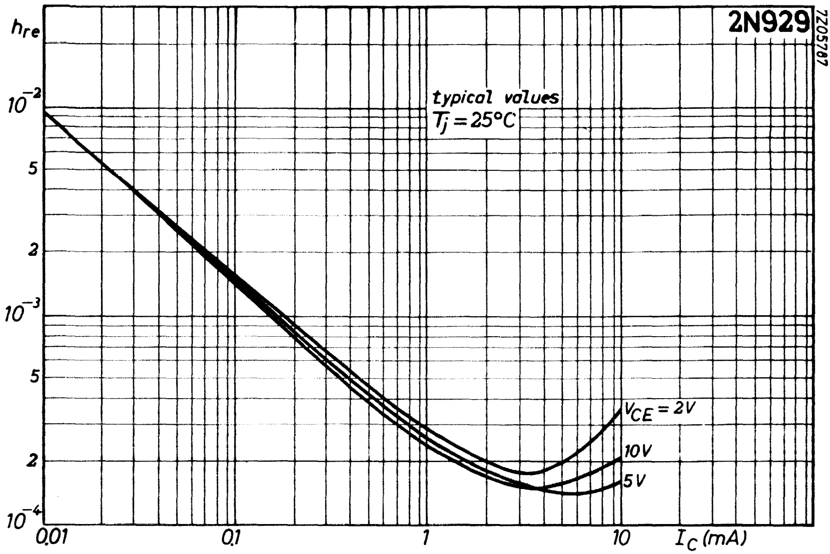

600
h_{FE}
500
400
300
200
100
V_{CE} = 5 V
T_j = 25 °C
2N930
7Z05791.1
max
max
typ
min
min
min
0.1
1
10
I_C (mA)
100

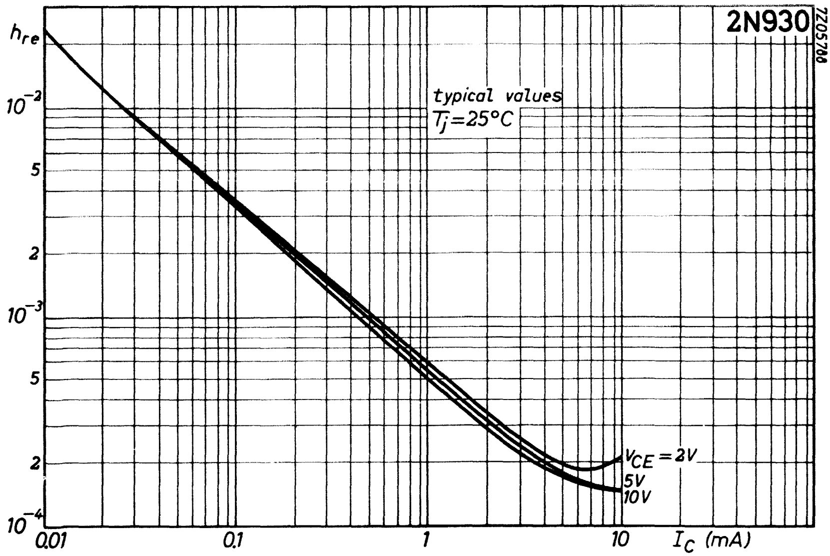

2N929
7Z05793
typical values
V_{CE} = 5 V
600
h_{FE}
400
200
0
I_C=10mA
30mA
1mA
100μA
10μA
−50
0
50
100
T_j (°C)
150

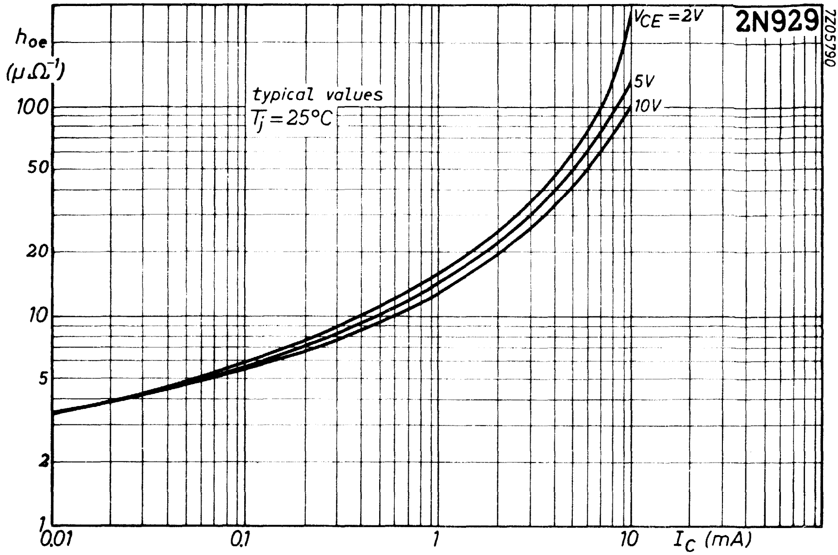

2N930
7Z05794
typical values
V_{CE} = 5 V
600
h_{FE}
400
200
0
I_C=10mA
30mA
10μA
−50
0
50
100
T_j (°C)
150

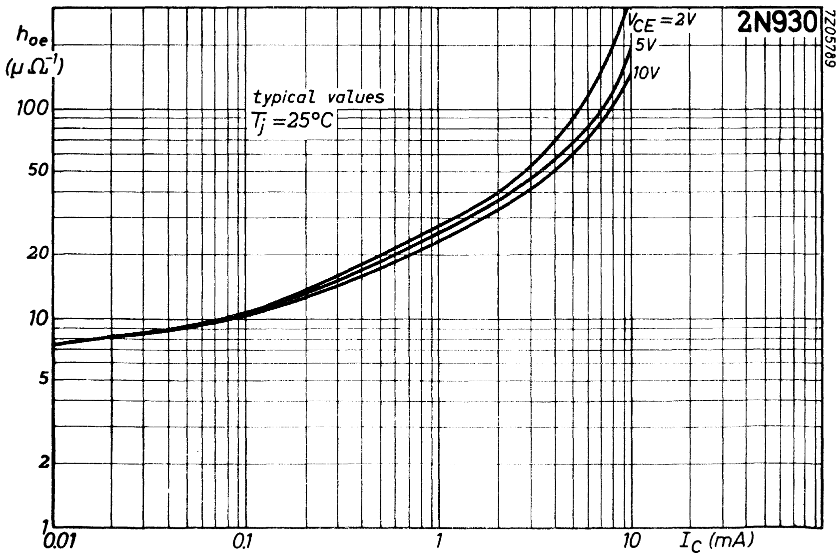

typical values
$V_{CE} = 5V$
0.8
V_{BE} (V)
0.6
0.4
0.2
−50
0
50
100
T_j (°C)
150
I_C=10mA
2mA
1mA
100μA
10μA
7Z05777-b14.ibl/ic)

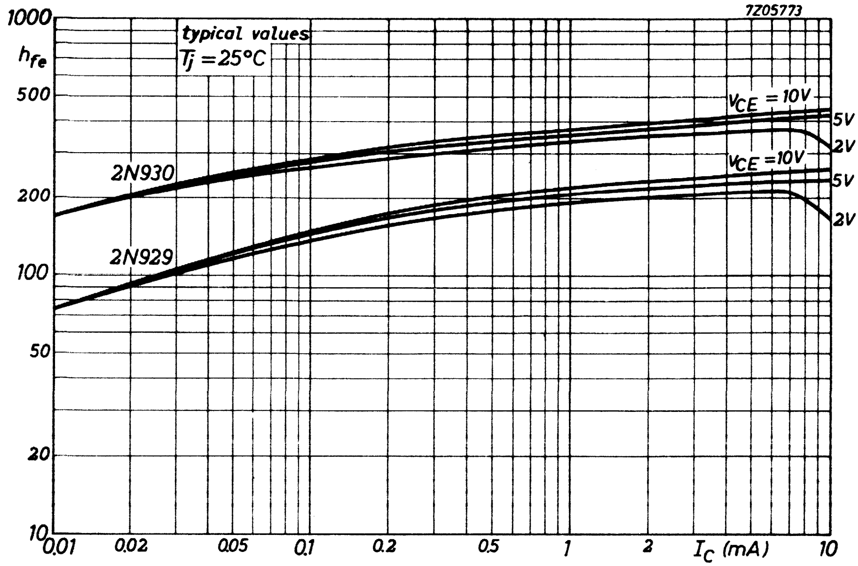

$V_{CE} = 5V$
Bandwidth: 10Hz to 15kHz
$T_j = 25°C$
20
F (dB)
15
10
5
0
0.1
0.2
0.5
1
2
5
10
20
R_S (kΩ)
100
I_C=100μA
30μA
10μA
7Z05778-b14.ibl/ic)

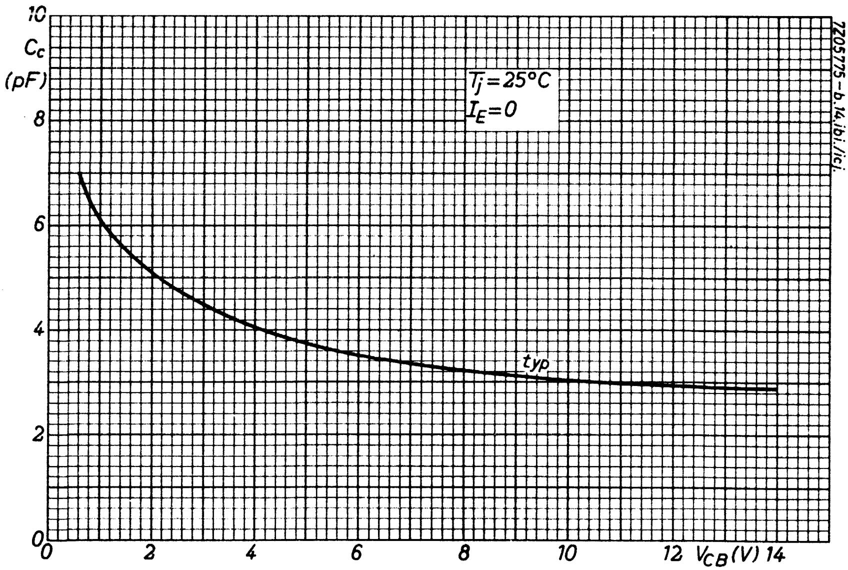

2N929
7Z05787
h_{re}
10^{-2}
5
2
10^{-3}
5
2
10^{-4}
typical values
$T_j = 25°C$
$V_{CE} = 2V$
10V
5V
0.01
0.1
1
10
I_C (mA)

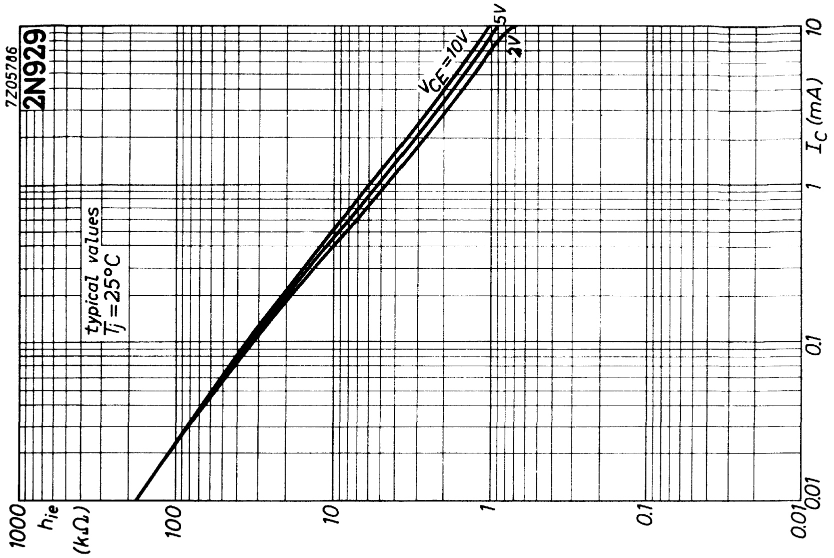

2N930
7Z05788
h_{re}
10^{-2}
5
2
10^{-3}
5
2
10^{-4}
typical values
$T_j = 25°C$
$V_{CE} = 2V$
5V
10V
0.01
0.1
1
10
I_C (mA)

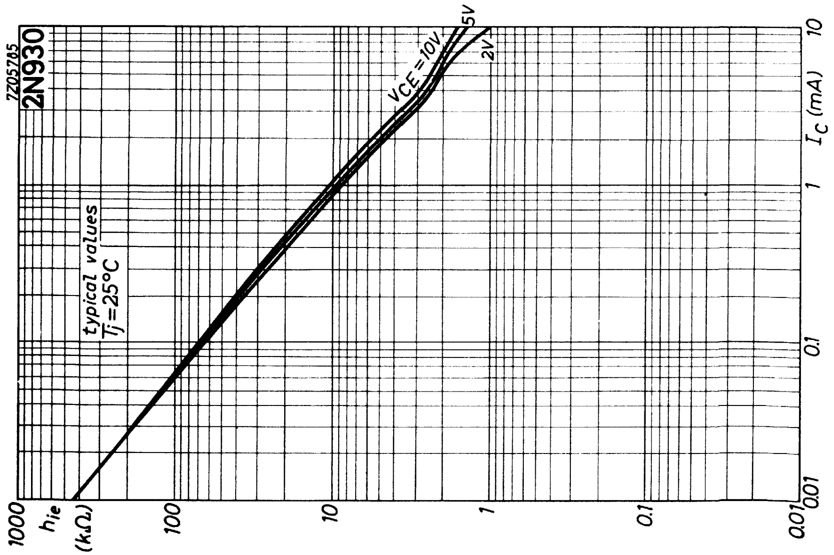

hoe
(μΩ⁻¹)
typical values
Tj = 25°C
VCE = 2V
5V
10V
2N929
7Z05790
100
50
20
10
5
2
1
0.01
0.1
1
10
IC (mA)

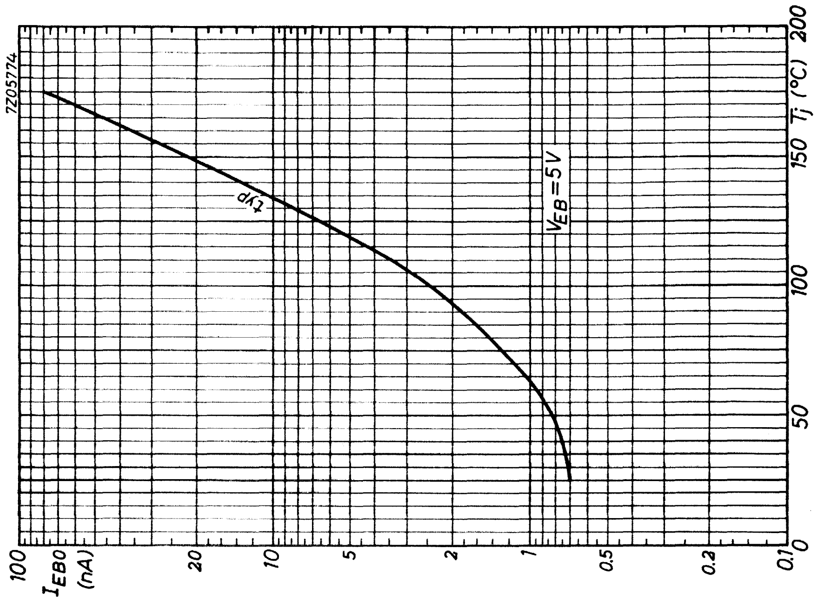

hoe
(μΩ⁻¹)
typical values
Tj = 25°C
VCE = 2V
5V
10V
2N930
7Z05789
100
50
20
10
5
2
1
0.01
0.1
1
10
IC (mA)

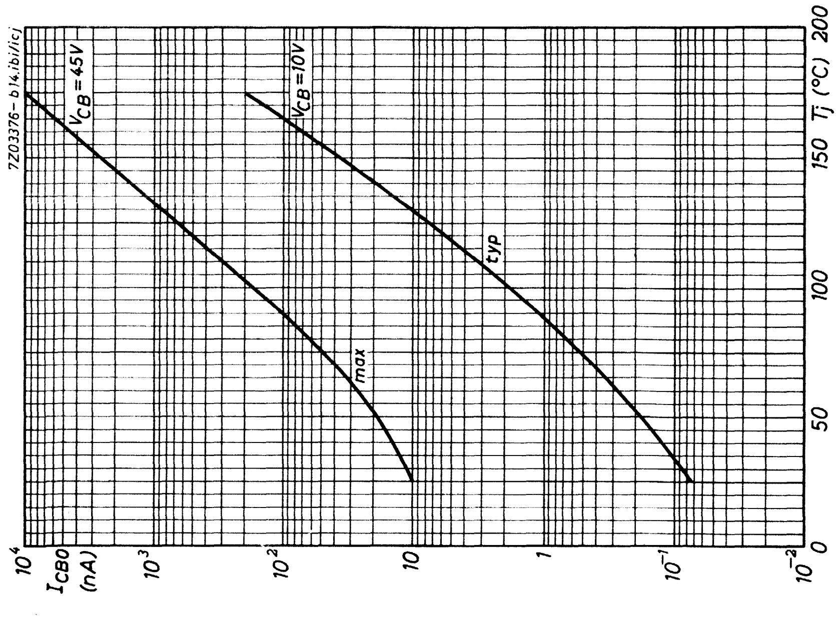

7Z05773
1000
h_{fe}
500
200
100
50
20
10
typical values
$T_j = 25°C$
$V_{CE} = 10V$
5V
2V
2N930
2N929
0.01
0.02
0.05
0.1
0.2
0.5
1
2
I_C (mA)
10

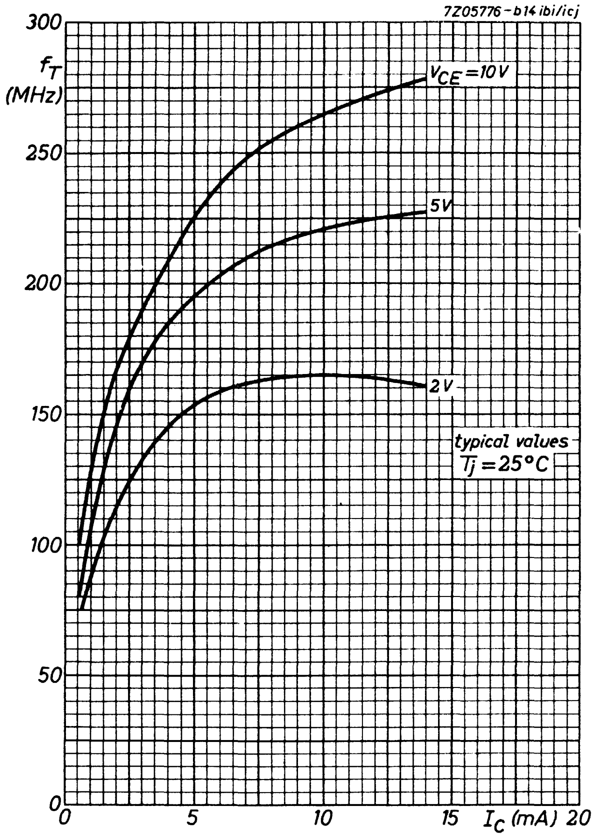

10
C_c
(pF)
8
6
4
2
0
7Z05775-b.14./bi./ci.
$T_j = 25°C$
$I_E = 0$
typ
0
2
4
6
8
10
12
V_{CB} (V)
14


7Z05786
2N929
typical values
$T_j = 25°C$
$V_{CE} = 10V$
5V
2V
h_{ie} (kΩ)
1000
100
10
1
0.1
0.01
I_C (mA)
0.01
0.1
1
10


7Z05785
2N930
typical values
$T_j = 25°C$
$V_{CE} = 10V$
5V
2V
h_{ie} (kΩ)
1000
100
10
1
0.1
0.01
I_C (mA)
0.01
0.1
1
10


7Z05774
I_{EBO} (nA)
100
20
10
5
2
1
0.5
0.2
0.1
typ
$V_{EB} = 5V$
T_j (°C)
0
50
100
150
200


7Z03376 - b14.ibi/icj
I_{CBO} (nA)
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}
$V_{CB} = 45V$
max
$V_{CB} = 10V$
typ
T_j (°C)
0
50
100
150
200


7Z05776-b14 ibi/icj
300
f_T
(MHz)
250
200
150
100
50
0
V_{CE} = 10 V
5 V
2 V
typical values
T_j = 25 °C
0
5
10
15
I_C (mA)
20

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)

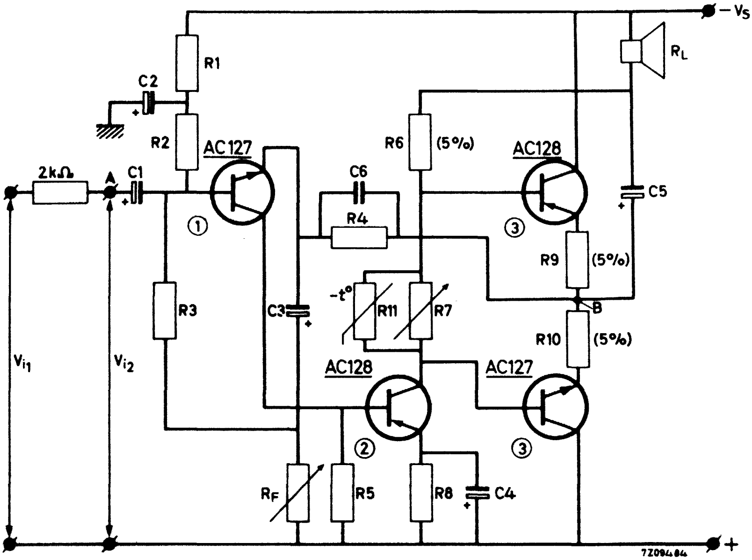
Circuit		I	II	III	IV	
Supply voltage	V_S	6	6	9	9	V
Max. output power at d_{tot} = 10%	$P_{o\,max}$	350	700	650	1200	mW
Input voltage at P_o = 50 mW						
without feedback	$V_{i(rms)}$	1.8	2.1	1.0	1.2	mV
with 6 dB feedback	$V_{i(rms)}$	3.5	5.0	2.5	2.0	mV
Input voltage at P_o = max.						
without feedback	$V_{i(rms)}$	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	$\|I_C\|$	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

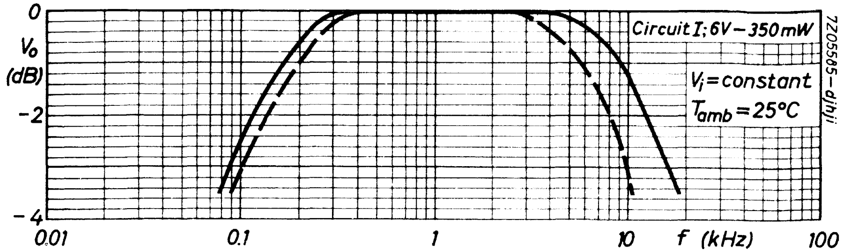
A = without cooling fin or heatsink in free air
B = with cooling fin (Type No.56227)
C = with cooling fin (Type No.56227) mounted on a 1.5 mm aluminium heatsink of at least 12.5 cm^2

[1]) To be adjusted with R7



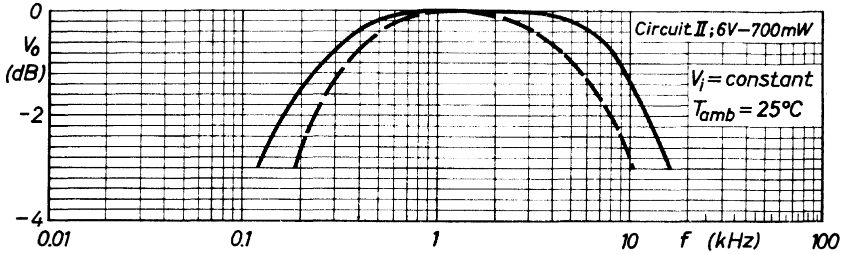
List of components

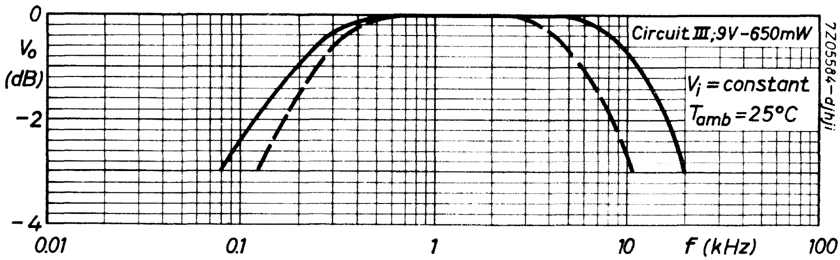
	Circuit	I	II	III	IV	
	R1	1.2	2.7	6.8	2.2	kΩ
	R2	22	18	33	18	kΩ
	R3	15	15	22	15	kΩ
	R4	2.2	2.2	3.3	2.2	kΩ
	R5	1.5	2.2	1.8	1.5	kΩ
	R6 (5%)	560	270	750	510	Ω
	R7	100	75	75	100	Ω
	R8	68	75	100	39	Ω
	R9 = R10 (5%)	1.5	0	2.4	0	Ω
	R11 (NTC)	–	130	–	130	Ω
	R_L	8	4	10	8	Ω
without feedback	R_F	0	0	0	0	
with 6 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

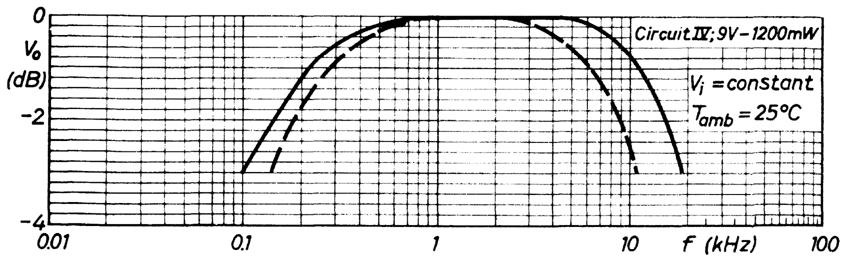
- - - - without feedback
—— with feedback

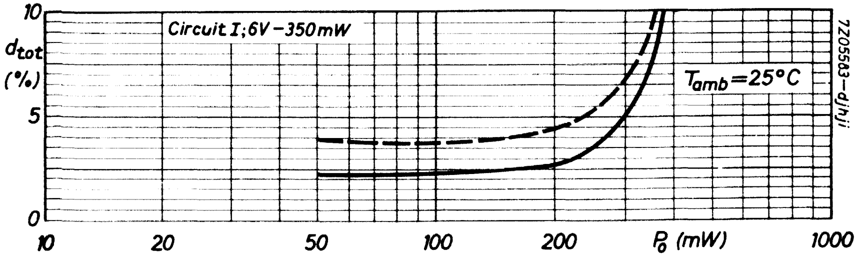




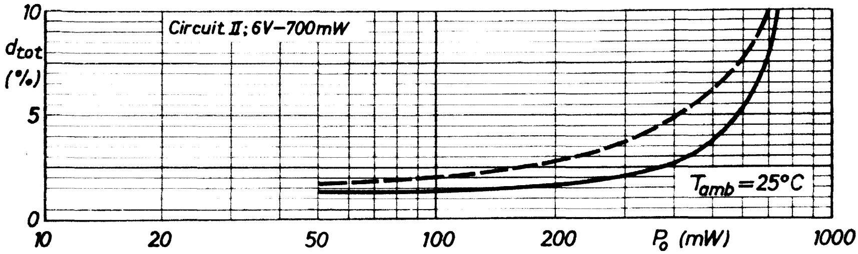
Normalised output voltage versus frequency

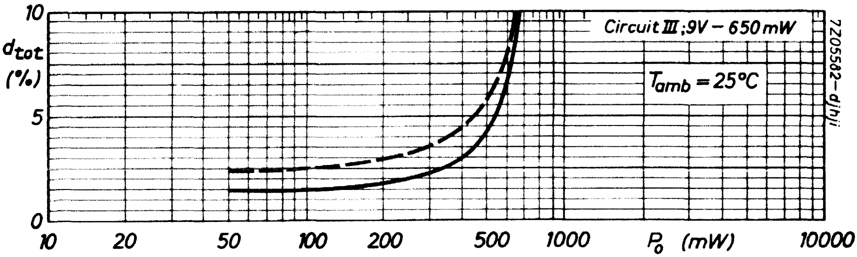
- - - - without feedback
—— with feedback



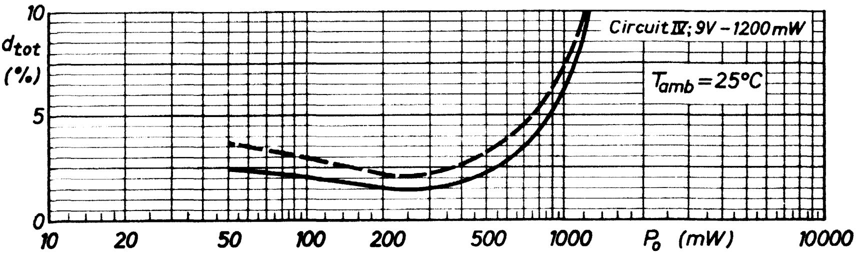


Typical values — — — without feedback
—— with feedback





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 °C

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)	$\|I_C\|$	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

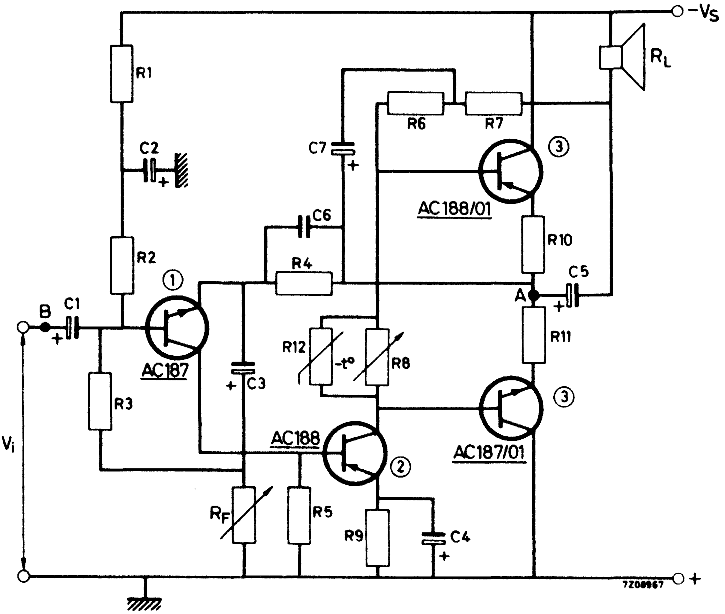
1. Stable continuous operation is ensured up to T_{amb} = 45 °C, provided the output transistors are mounted as specified below:

   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.

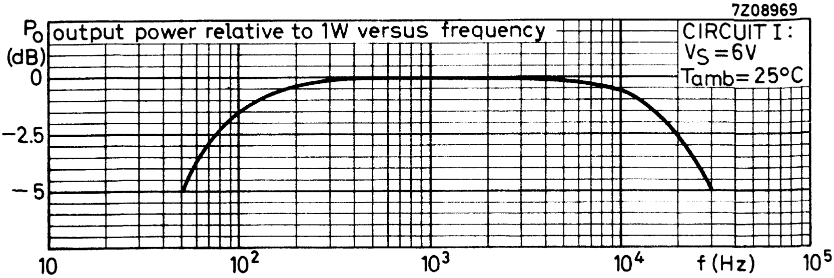
2. Figures and curves are typical ones unless otherwise specified.

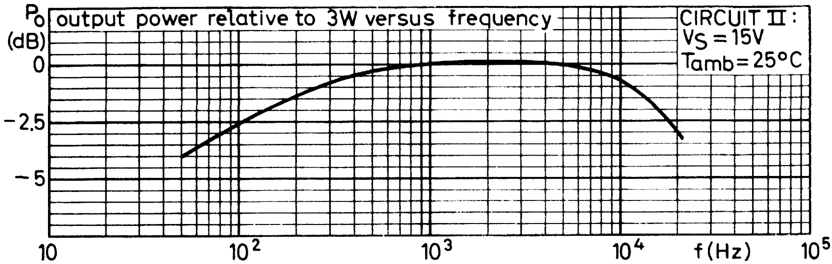
3. A.C. information is given at f = 1 kHz unless otherwise specified.

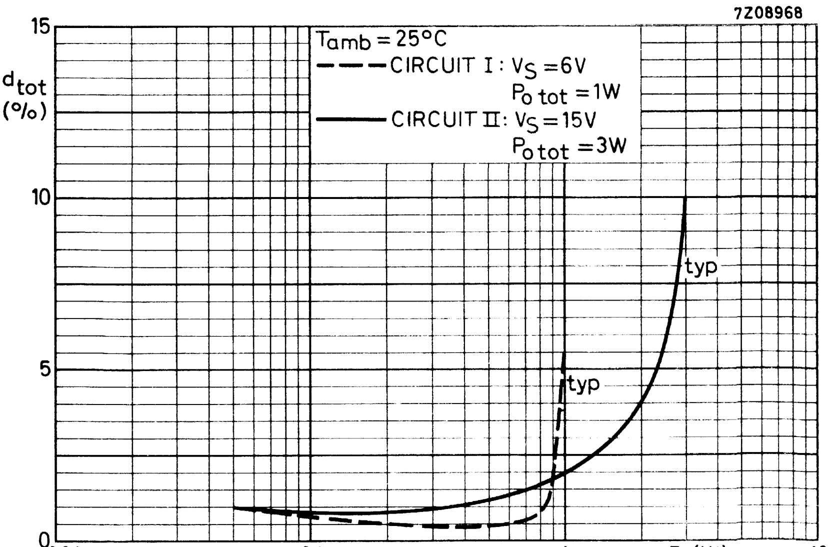


List of components 1)	Circuit	I	II
	R1	5.6	2.7 kΩ
	R2	10	47 kΩ
	R3	12	47 kΩ
	R4	2.2	1.8 kΩ
	R5	820	820 Ω
	R6	0	390 Ω
	R7	270	390 Ω
	R8	100	150 Ω
	R9	0	12 Ω
	R10 = R11	0	1 Ω
	R12 (NTC)	130	50 Ω
	R_L	4	8 Ω
without feedback	R_F	0	0
with feedback	R_F	36	1.5 Ω
	C1	6.4	40 μF
	C2	50	125 μF
	C3	50	1000 μF
	C4	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 (%)
15
10
5
0
Tamb = 25°C
CIRCUIT I: VS = 6V
Po tot = 1W
CIRCUIT II: VS = 15V
Po tot = 3W
typ
typ
0.01
0.1
1
Po (W)
10

Low frequency power transistors

GERMANIUM ALLOYED POWER TRANSISTOR

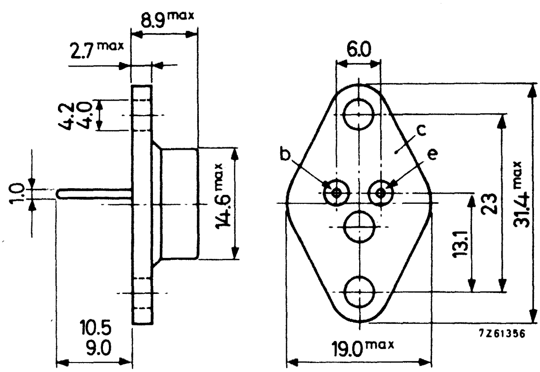
N-P-N power transistor in a metal envelope with the collector connected to the mounting base.
The AD161 is primarily intended for use together with the p-n-p power transistor AD162 as matched pair AD161/AD162 in 10 W complementary symmetry class B output stages of mains operated amplifiers and radio 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 $T_{mb} = 75\,^{o}C$	P_{tot}	max.	4	W
Junction temperature (incidentally)	T_j	max.	100	^{o}C
D.C. current gain at $T_j = 25\,^{o}C$				
$I_C = 0.5$ 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.	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

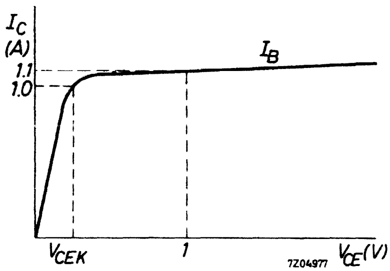
I_C = 0; V_{EB} = 10 V	I_{EBO}	typ.	20	μA
		<	200	μA
I_C = 0; V_{EB} = 10 V; T_j = 90 °C	I_{EBO}	<	2	mA

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

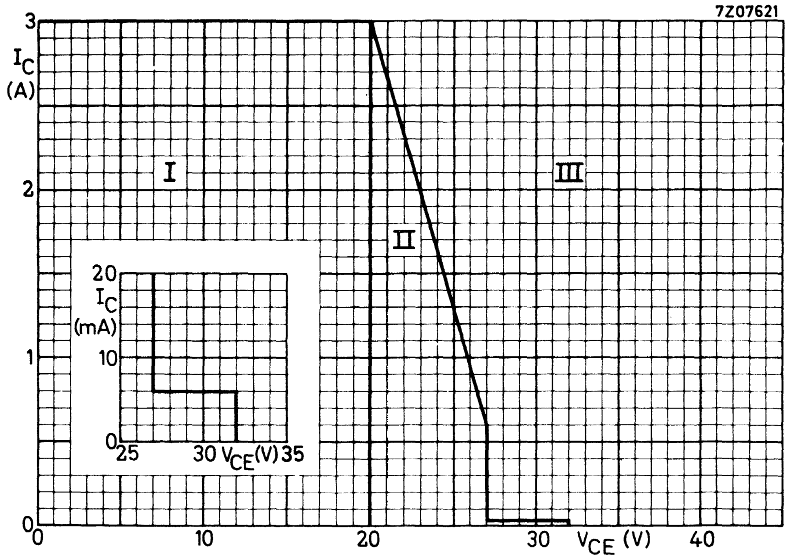
D.C. current gain

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.	150
		80 to	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

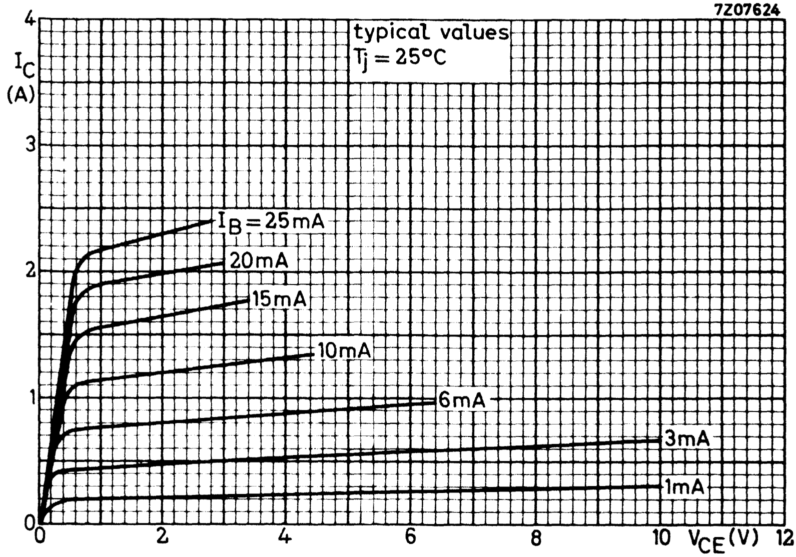
Transition frequency			
I_C = 10 mA; V_{CE} = 2 V	f_T	typ.	3 MHz
Cut-off frequency			
I_C = 300 mA; V_{CE} = 2 V	f_{hfe}	>	20 kHz
		typ.	35 kHz
D.C. current gain ratio of matched pair AD161/AD162			
$\lvert I_C \rvert$ = 500 mA; $\lvert V_{CE} \rvert$ = 1 V	h_{FE1}/h_{FE2}	typ.	1.1
		<	1.25

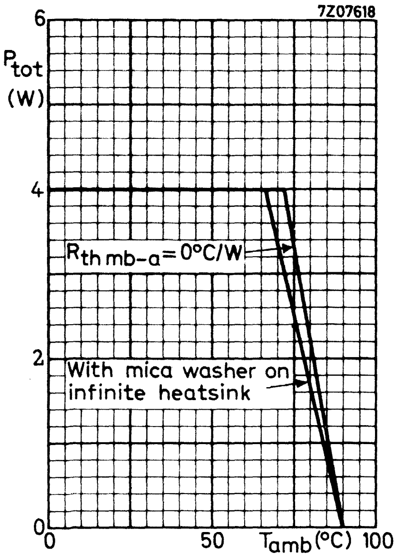


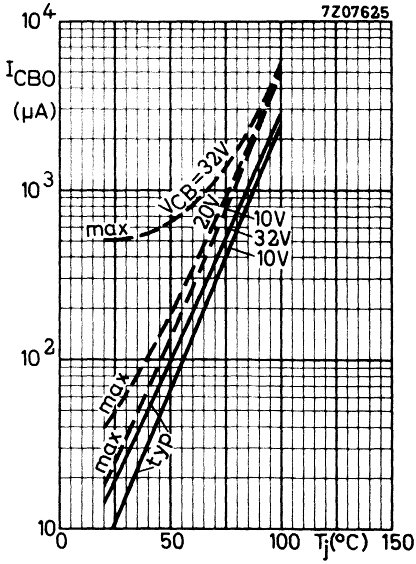
I = Region of permissible operation under all base-emitter conditions.

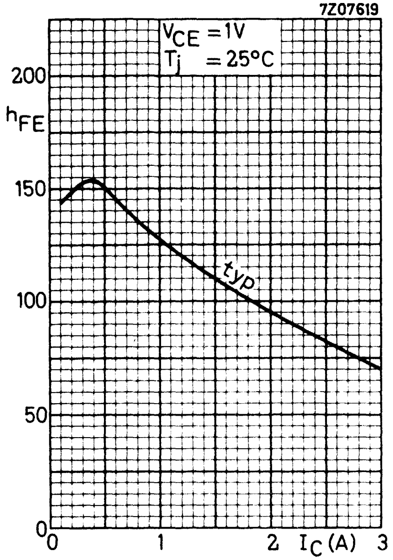
II = Additional region of operation when the transistor is cut-off with $-V_{BE} \geq -V_{BEfl}$.

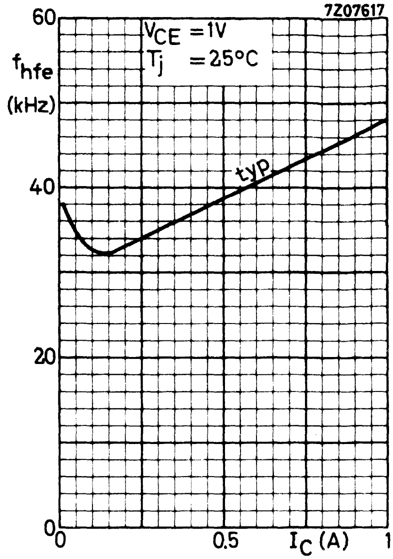
III = Outside regions I and II, the transistor can withstand transient energies of 1 mWs, provided it is cut-off with $-V_{BB} \leq 0.6$ V; R_i = 18 Ω.

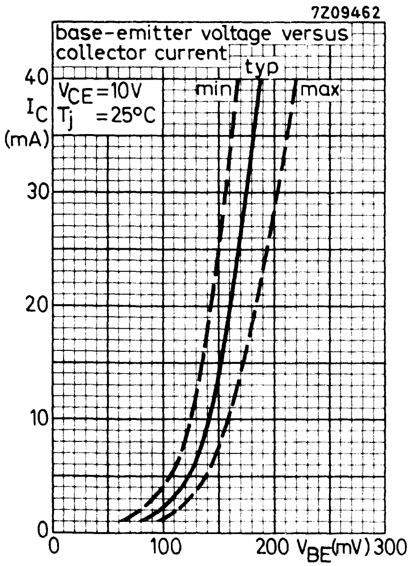

7Z07624
typical values
$T_j = 25°C$
I_C (A)
$I_B = 25mA$
20mA
15mA
10mA
6mA
3mA
1mA
V_{CE} (V)
0
1
2
3
4
0
2
4
6
8
10
12

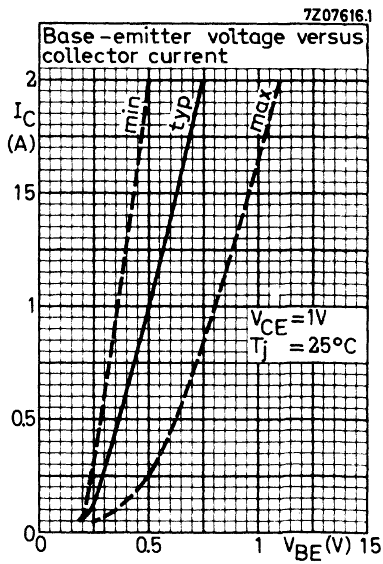

7Z07618
P_{tot} (W)
$R_{th\ mb-a} = 0°C/W$
With mica washer on
infinite heatsink
T_{amb} (°C)
0
2
4
6
0
50
100

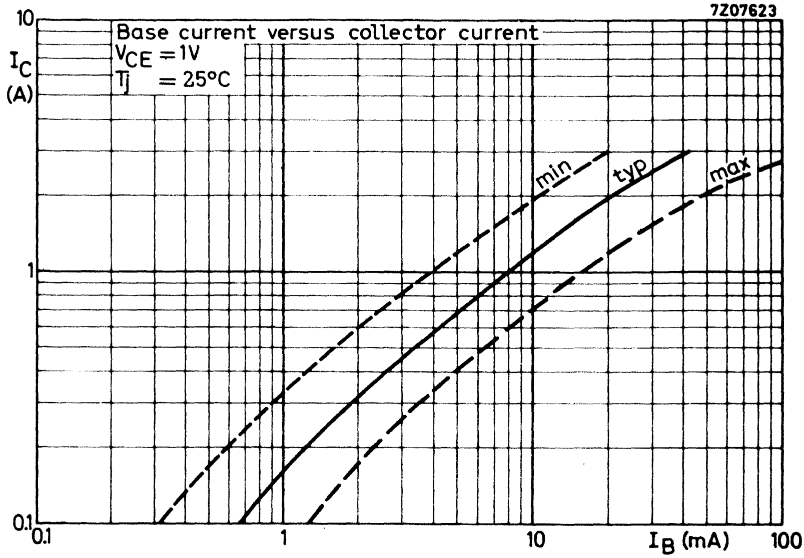

7Z07625
I_{CBO} (μA)
max
$V_{CB} = 32V$
20V
10V
32V
10V
max
max
typ
T_j (°C)
10
10^2
10^3
10^4
0
50
100
150

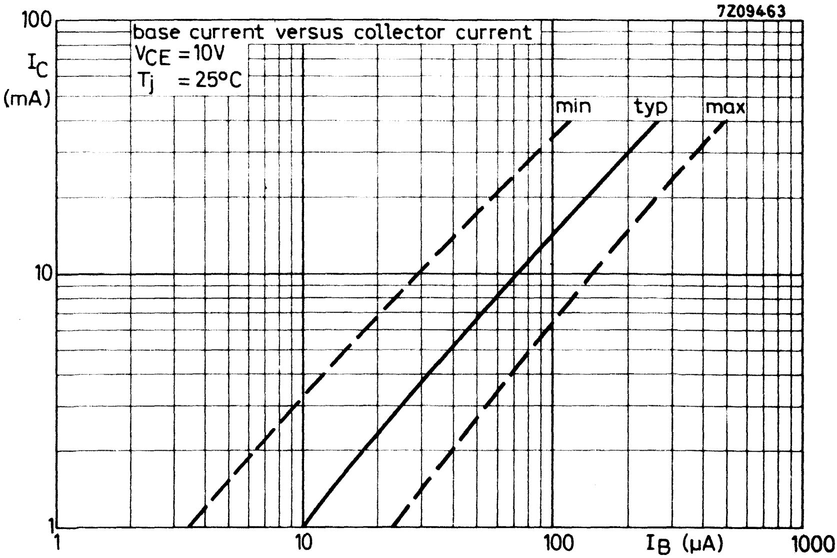

7Z07619
V_{CE} = 1V
T_j = 25°C
200
h_{FE}
150
100
50
0
typ
0
1
2
I_C (A)
3


7Z07617
60
V_{CE} = 1V
T_j = 25°C
f_{hfe}
(kHz)
40
typ
20
0
0
0.5
I_C (A)
1


7Z09462
base-emitter voltage versus
collector current
typ
min
max
40
I_C
(mA)
V_{CE} = 10V
T_j = 25°C
30
20
10
0
0
100
200 V_{BE}(mV) 300

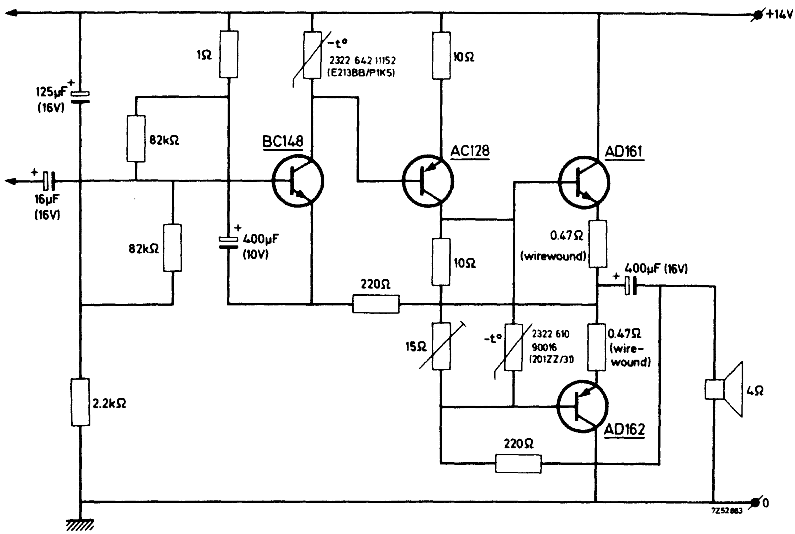

7Z07616.1
Base-emitter voltage versus
collector current
2
I_C
(A)
min
typ
max
1.5
1
V_{CE} = 1V
T_j = 25°C
0.5
0
0
0.5
1
V_{BE} (V) 1.5


7Z07623
Base current versus collector current
V_{CE} = 1V
T_j = 25°C
I_C (A)
10
1
0.1
0.1
1
10
100
I_B (mA)
min
typ
max


7Z09463
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

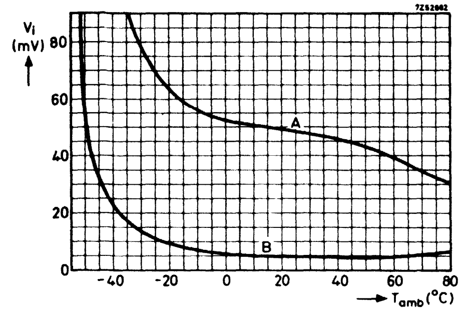


All transistors mounted on one heatsink which has a thermal resistance of $R_{th\ h-a} \leq 5.5\ ^{o}C/W$

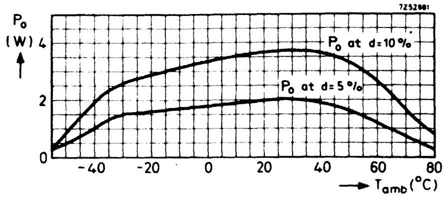
Performance at T_{amb} = 25 °C

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

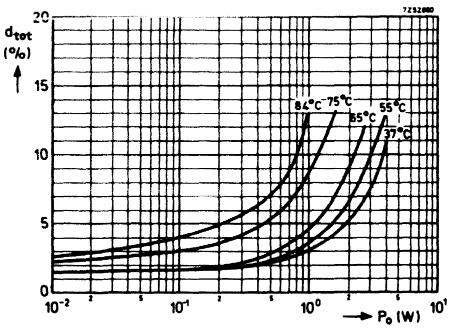
APPLICATION INFORMATION (continued)

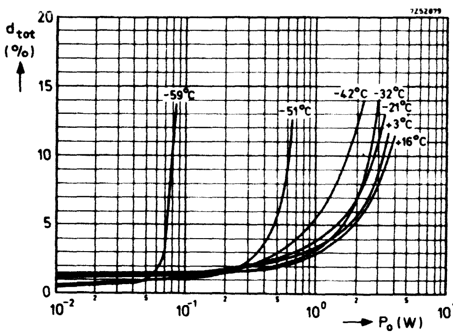


Input sensitivity at various ambient temperatures. Curve A for maximum output power at a distortion of 10%. Curve B for an output power of 50 mW.



The output power at two distortion levels as a function of the ambient temperature.

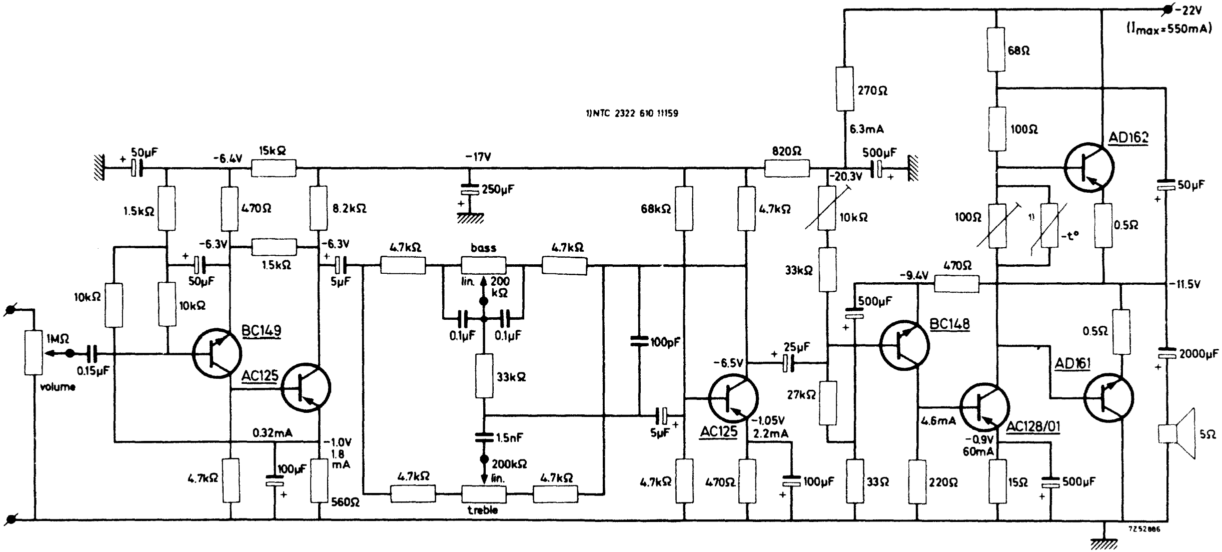




The distortion as a function of the output power at several ambient temperatures.

APPLICATION INFORMATION (continued)

B. 8 W amplifier with matched pair AD161/AD162



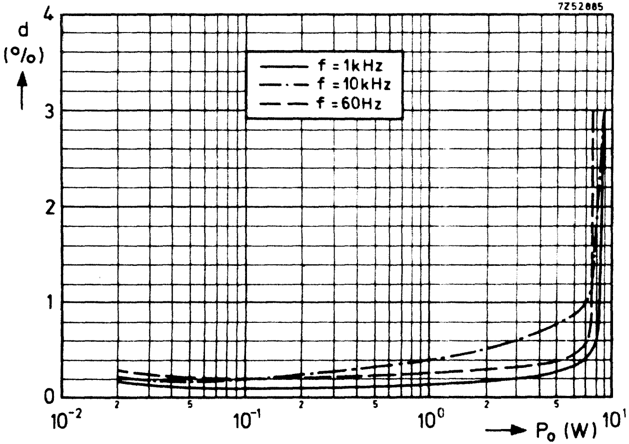
1) NTC 2322 610 11159

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.

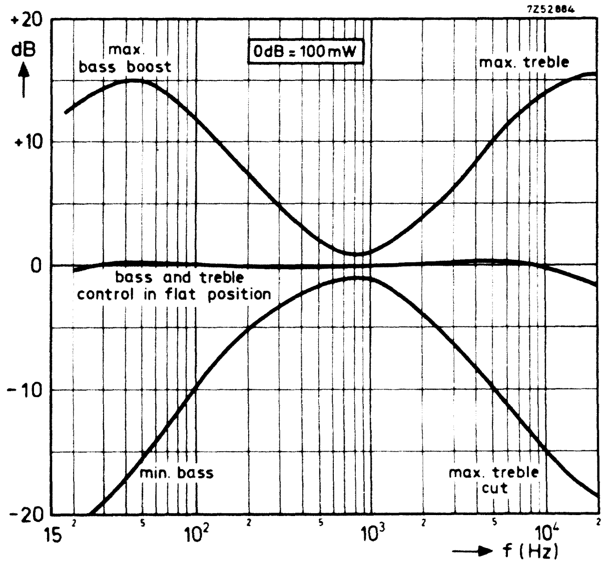
APPLICATION INFORMATION (continued)

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.

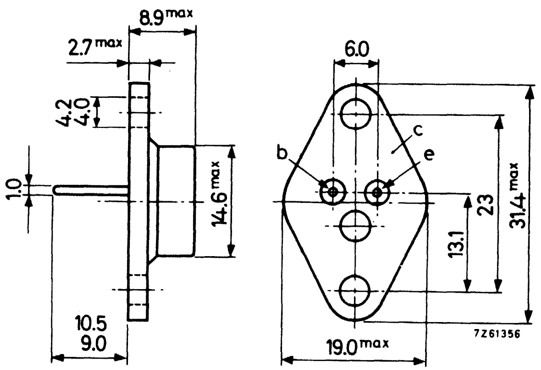
GERMANIUM ALLOYED POWER TRANSISTOR

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

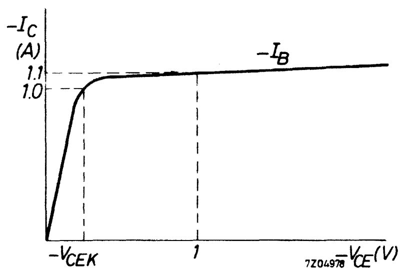
THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	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

[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	µA
		<	200	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	µA
		<	200	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	$-V_{CEK}$	<	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

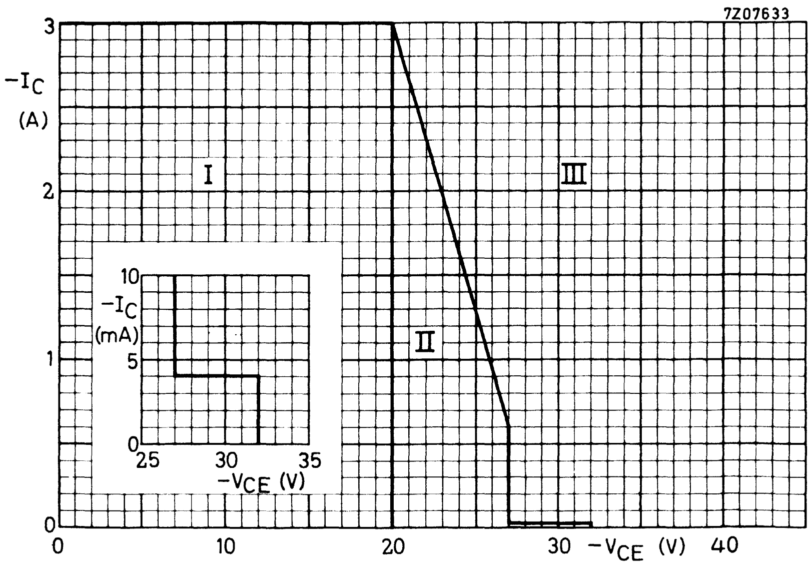
$-I_C$ = 10 mA; $-V_{CE}$ = 2 V	f_T	typ. 1.5 MHz

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

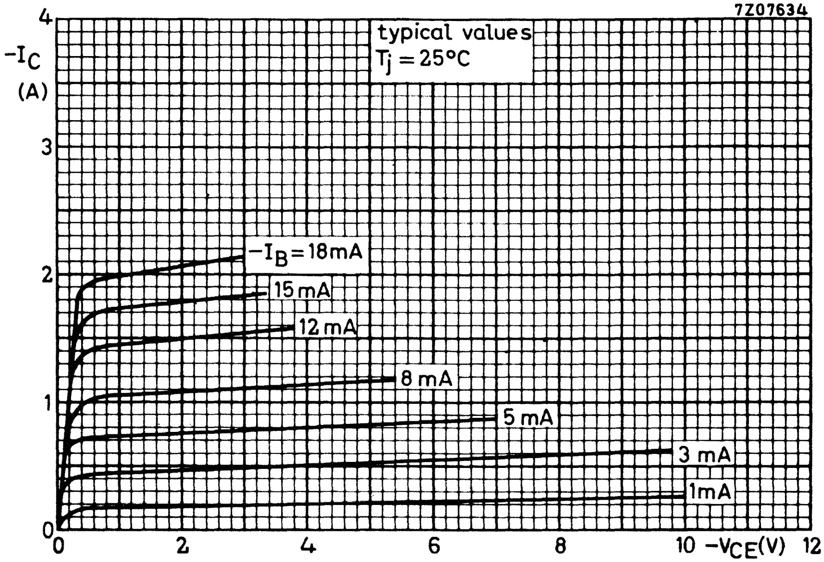
$\|I_C\|$ = 500 mA; $\|V_{CE}\|$ = 1 V	h_{FE1}/h_{FE2}	typ. 1.1 < 1.25
matched pair 2-AD162 $-I_C$ = 50 mA; $-V_{CE}$ = 1 V $-I_C$ = 500 mA; $-V_{CE}$ = 1 V	h_{FE1}/h_{FE2}	typ. 1.1 < 1.25

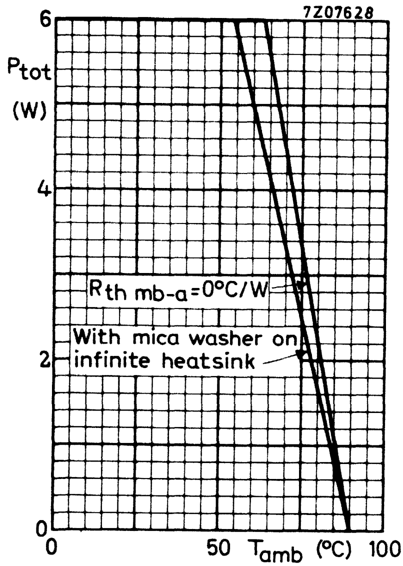


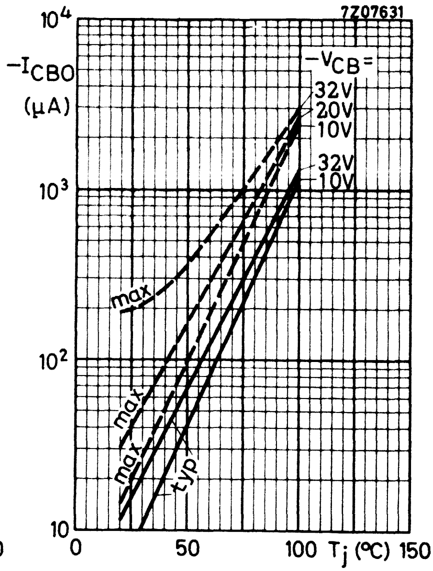
I Region of permissible operation under all base-emitter conditions.

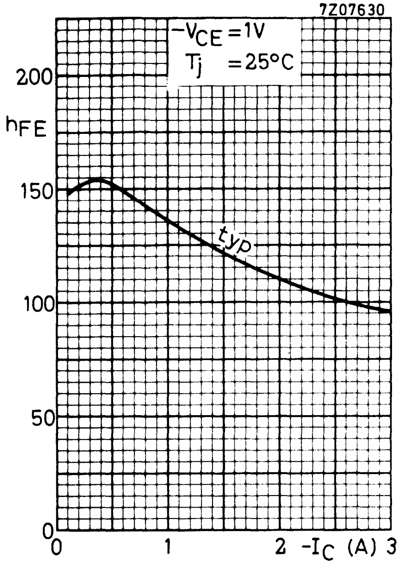
II Additional region of operation when the transistor is cut-off with $V_{BE} \geq V_{BEfl}$.

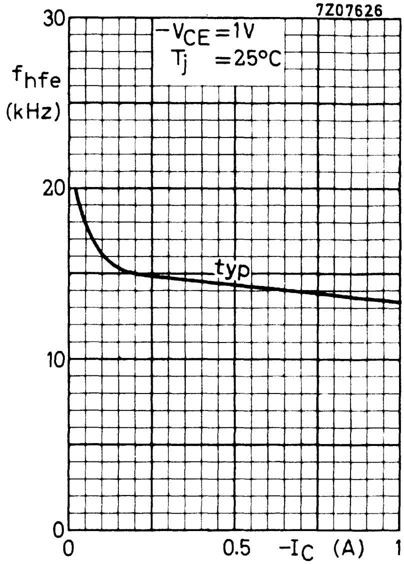
III Outside regions I and II, the transistor can withstand transient energies of 4.5 mWs, provided it is cut-off with $+V_{BB}$ < 0.6 V; R_i = 18 Ω.

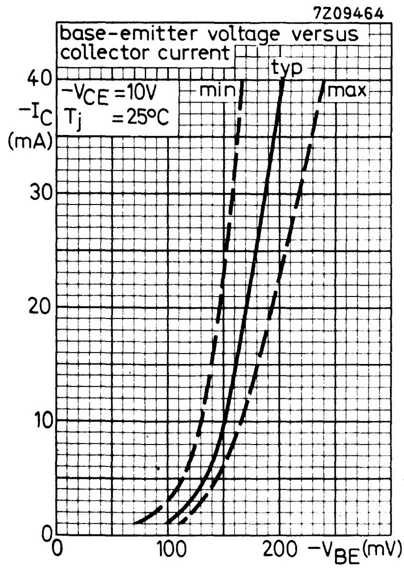

7Z07634
typical values
$T_j = 25°C$
$-I_C$ (A)
$-I_B = 18mA$
15 mA
12 mA
8 mA
5 mA
3 mA
1mA
$-V_{CE}$ (V)
0 2 4 6 8 10 12
0 1 2 3 4

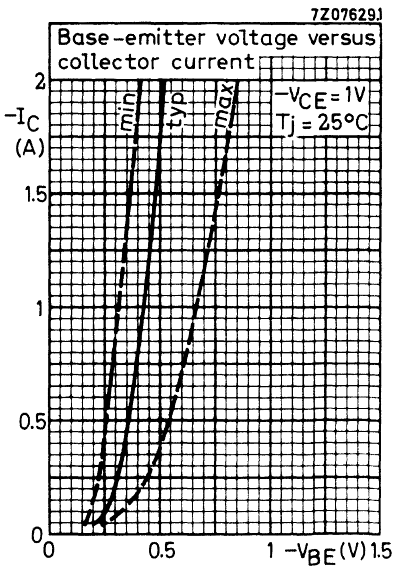

7Z07628
P_{tot} (W)
$R_{th\ mb-a} = 0°C/W$
With mica washer on infinite heatsink
T_{amb} (°C)
0 50 100
0 2 4 6

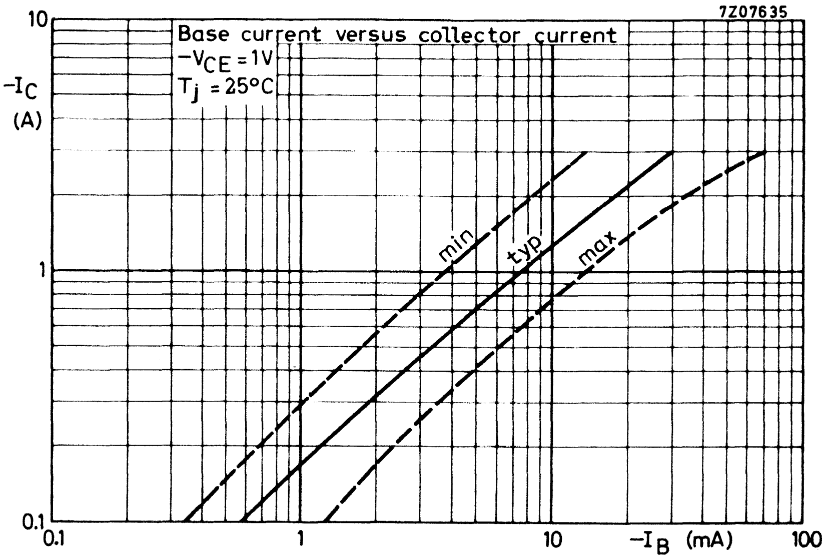

7Z07631
$-I_{CBO}$ (μA)
$-V_{CB} =$
32V
20V
10V
32V
10V
max
max
max
typ
T_j (°C)
0 50 100 150
10 10^2 10^3 10^4

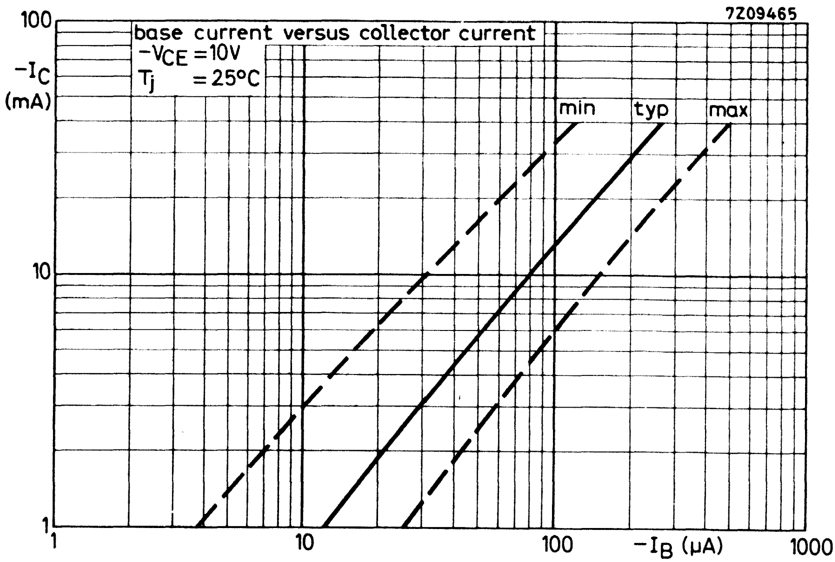

7Z07630
$-V_{CE}$ = 1V
T_j = 25°C
h_{FE}
200
150
100
50
0
typ
0
1
2
$-I_C$ (A)
3


7Z07626
$-V_{CE}$ = 1V
T_j = 25°C
f_{hfe}
(kHz)
30
20
10
0
typ
0
0.5
$-I_C$ (A)
1


7Z09464
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)


7Z07629.1
Base-emitter voltage versus
collector current
$-V_{CE}$ = 1V
T_j = 25°C
$-I_C$
(A)
2
1.5
1
0.5
0
min
typ
max
0
0.5
1
$-V_{BE}$ (V)
1.5





FOR APPLICATION INFORMATION SEE AD161

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

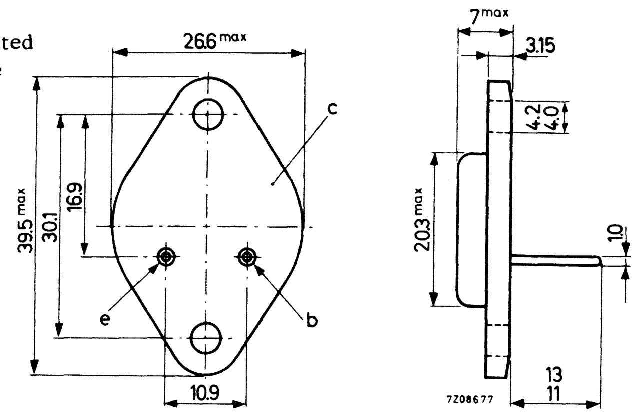
			ASZ 15	ASZ 16	ASZ 17	ASZ 18	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	100	60	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	32	32	32	V
Total power dissipation up to T_{mb} = 45 °C	P_{tot}	max.	30	30	30	30	W
Junction temperature	T_j	max.	90	90	90	90	°C
D.C. current gain 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])

			ASZ 15	ASZ 16	ASZ 17	ASZ 18	
Voltages							
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	$R_{th\ j-mb}$	=	1.5	°C/W

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 $R_{th\ j-a} < 9$ °C/W for ASZ16 and ASZ17
$R_{th\ j-a} < 5$ °C/W for ASZ15 and ASZ18

CHARACTERISTICS T_j = 25 °C 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
$I_E = 0; -V_{CB} = -V_{CBOmax}$; $T_j = 100$ °C	$-I_{CBO}$	<	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

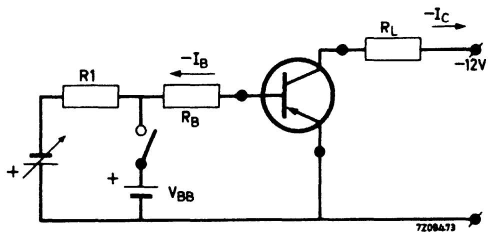
Circuit I: R_B = 10 Ω; R1 = 220 Ω; R_L = 12 Ω

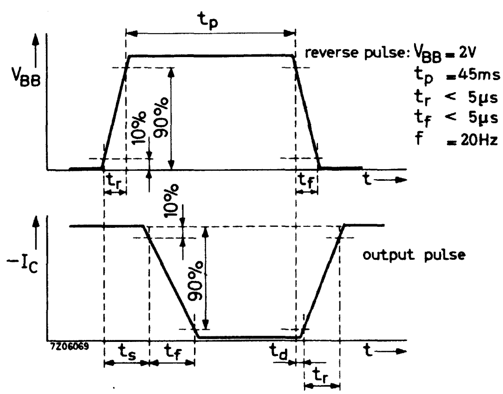
ASZ15: $-I_B$ = 75 mA	$-I_C$ = 1 A	delay time	t_d	<	2	µs
ASZ16: $-I_B$ = 35 mA		rise time	t_r	<	25	µs
ASZ17: $-I_B$ = 60 mA		storage time	t_s	<	10	µs
ASZ18: $-I_B$ = 50 mA		fall time	t_f	<	20	µs

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

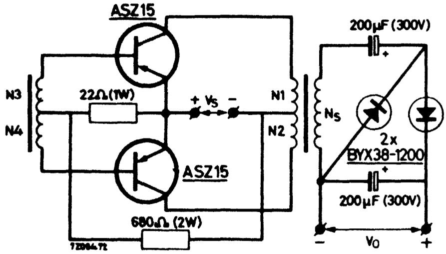
Test circuit:





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 $R_{th\ j-a}$ = 15 °C/W per transistor)

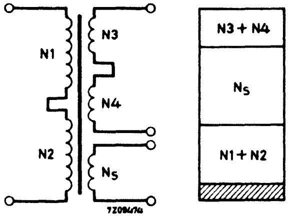
V_S	=	28	V
I_S	=	2.5	A
P_S	=	70	W
V_O	=	220	V
I_O	=	270	mA
P_O	=	60	W
η	=	86	%
f	=	450	Hz

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

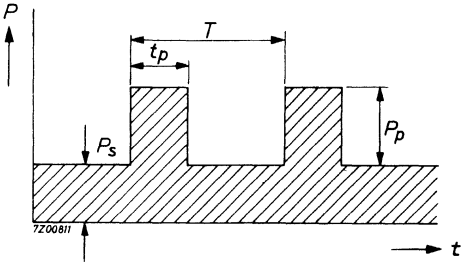
OPERATING NOTES

Determination of peak power ratings under fault conditions and/or surge operation shorter than the temperature stabilisation time

$$P_p = \frac{T_{j\,max} - T_{amb} - (R_{th\,j\text{-}mb} + R_{th\,mb\text{-}h} + R_{th\,h\text{-}a}) \cdot P_s}{R_{th\,t} + \delta . R_{th\,h\text{-}a}}$$

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:

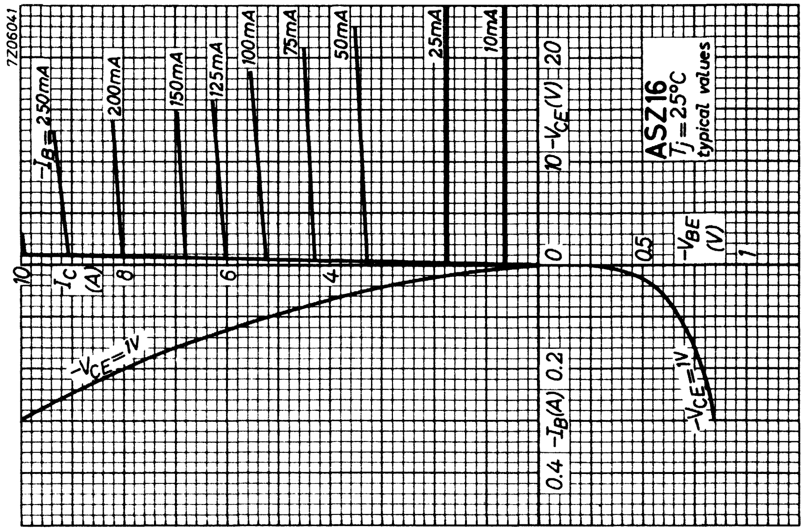
t_p	=	pulse duration
T	=	pulse period
δ	=	duty cycle = t_p/T
P_s	=	steady state power dissipation
P_p	=	permissible pulse power dissipation over P_s
$R_{th\,j\text{-}mb}$	=	thermal resistance from junction to mounting base
$R_{th\,mb\text{-}h}$	=	thermal resistance from mounting base to heatsink
$R_{th\,h\text{-}a}$	=	thermal resistance from heatsink to ambient
$R_{th\,t}$	=	transient thermal resistance = f(t, δ); 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

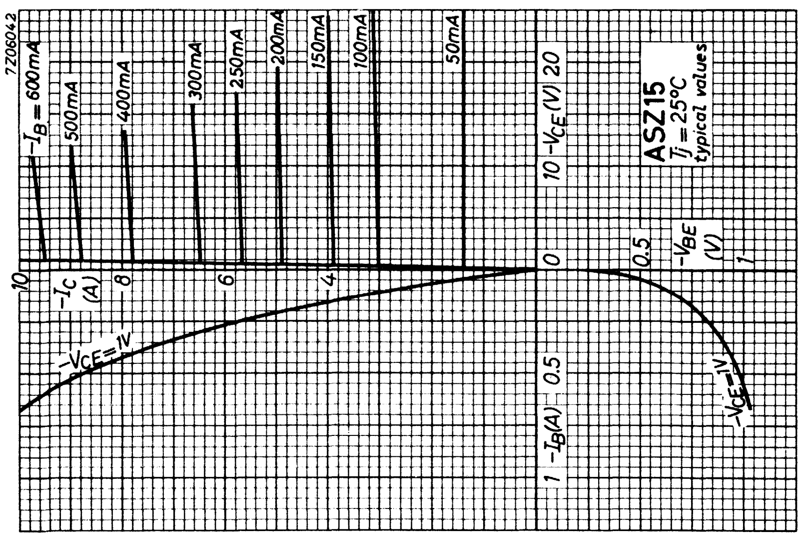
Temperature stabilisation time = 1 s (see page 14)

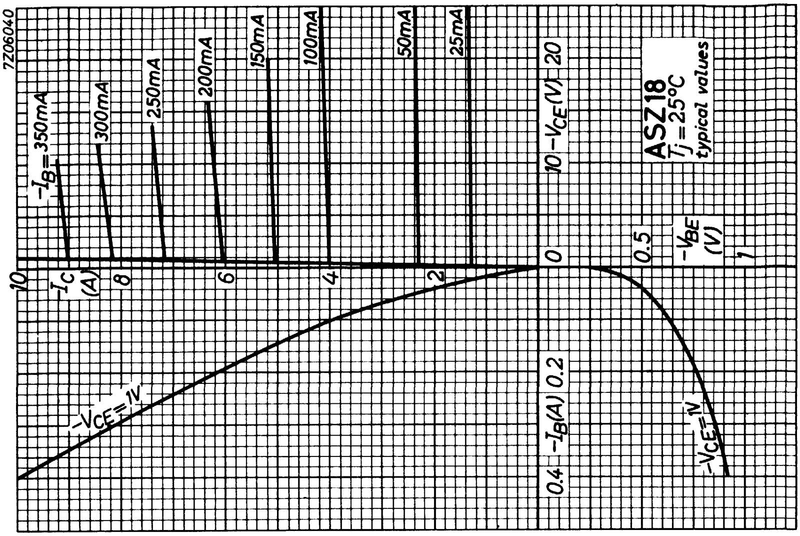
Example: P_s = 5 W, t = 1 ms, δ = 0.1, $R_{th\,mb\text{-}h}$ = 0.5 °C/W, $R_{th\,h\text{-}a}$ = 4.25 °C/W and T_{amb} = 25 °C

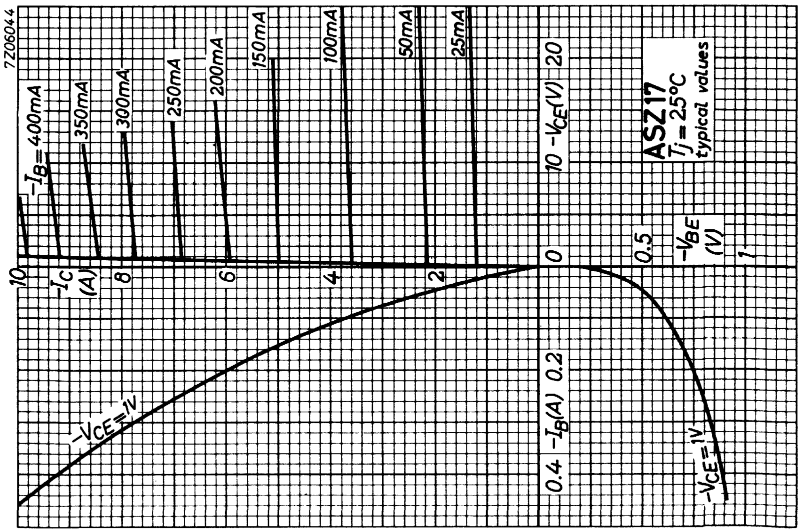
From t = 1 ms and δ = 0.1 it follows that $R_{th\,t}$ = 0.28 °C/W(page 14)

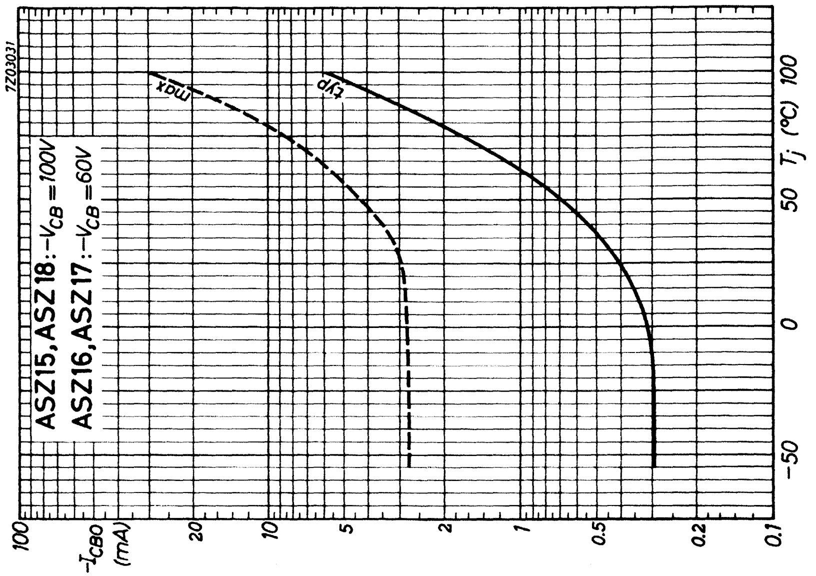
$$\text{Then } P_p = \frac{90 - 25 - (1.5 + 0.5 + 4.25) \times 5}{0.28 + 0.1 \times 4.25} \approx 47.5 \text{ W}$$

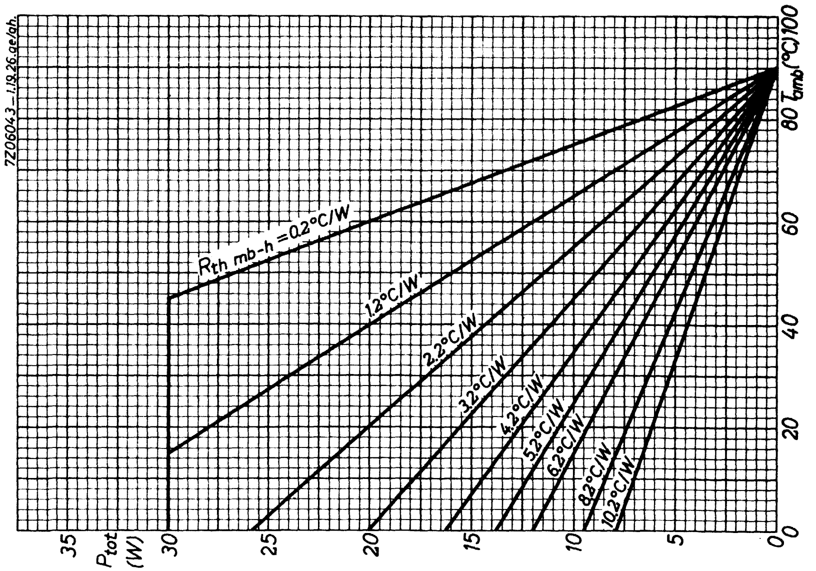

7Z06041
ASZ16
$T_j = 25°C$
typical values
$-I_B = 250mA$
200mA
150mA
125mA
100mA
75mA
50mA
25mA
10mA
$-V_{CE}(V)$
$-I_C$ (A)
$-V_{CE} = 1V$
$-I_B(A)$
$-V_{BE}$ (V)
$-V_{CE} = 1V$

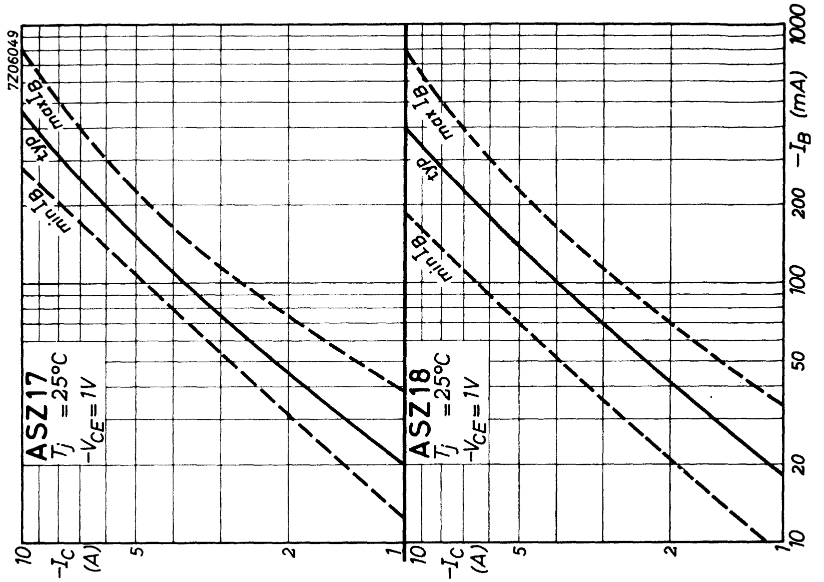

7Z06042
ASZ15
$T_j = 25°C$
typical values
$-I_B = 600mA$
500mA
400mA
300mA
250mA
200mA
150mA
100mA
50mA
$-V_{CE}(V)$
$-I_C$ (A)
$-V_{CE} = 1V$
$-I_B(A)$
$-V_{BE}$ (V)
$-V_{CE} = 1V$

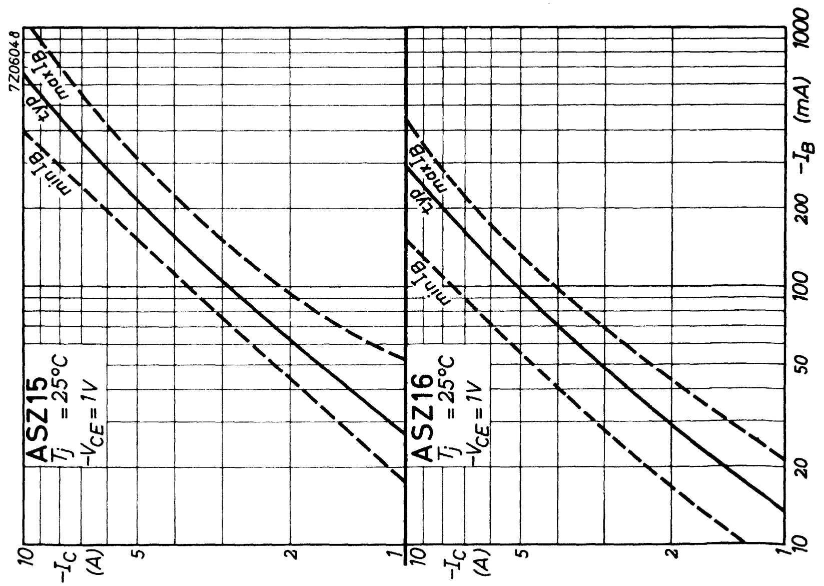

7Z06040
ASZ18
T_j = 25°C
typical values
$-I_B$ = 350mA
300mA
250mA
200mA
150mA
100mA
50mA
25mA
$-I_C$ (A)
$-V_{CE}$ (V)
$-I_B$ (A)
$-V_{BE}$ (V)
$-V_{CE}$ = 1V
$-V_{CE}$ = 1V
10
8
6
4
2
0
10
20
0.2
0.4
0.5
1

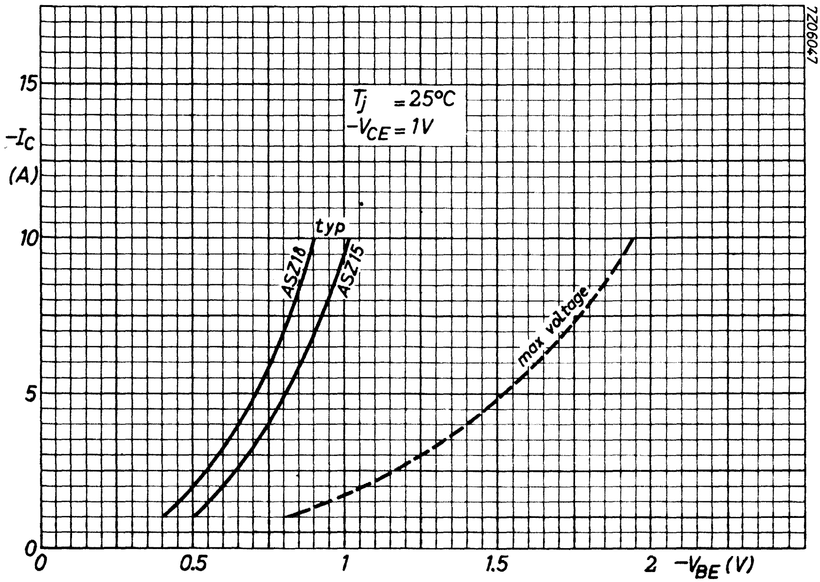

7Z06044
ASZ17
T_j = 25°C
typical values
$-I_B$ = 400mA
350mA
300mA
250mA
200mA
150mA
100mA
50mA
25mA
$-I_C$ (A)
$-V_{CE}$ (V)
$-I_B$ (A)
$-V_{BE}$ (V)
$-V_{CE}$ = 1V
$-V_{CE}$ = 1V
10
8
6
4
2
0
10
20
0.2
0.4
0.5
1

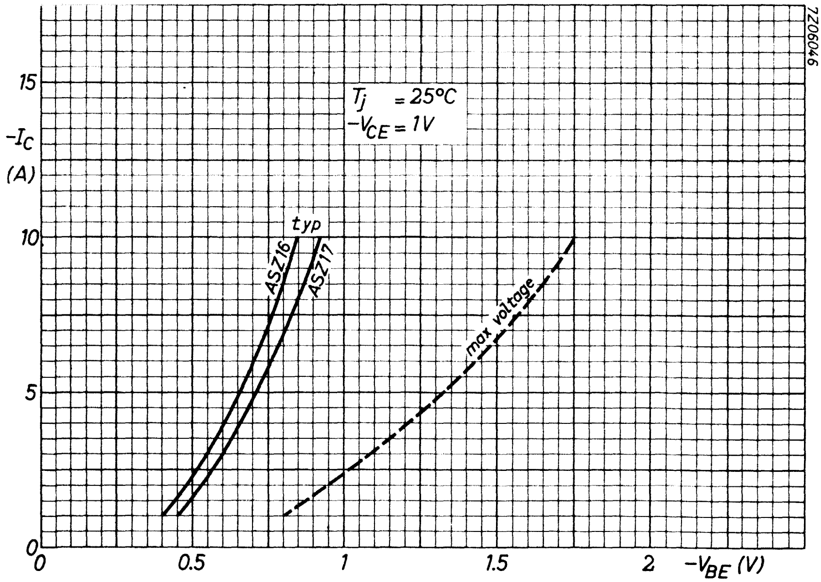

7Z03031
ASZ15, ASZ18: $-V_{CB}=100V$
ASZ16, ASZ17: $-V_{CB}=60V$
max
typ
$-I_{CBO}$ (mA)
100
20
10
5
2
1
0.5
0.2
0.1
T_j (°C)
-50
0
50
100

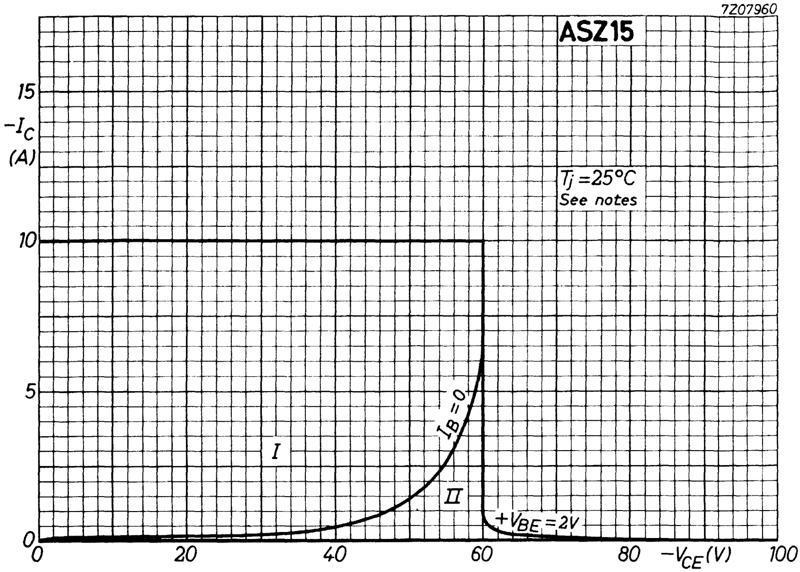

7Z06043-1.19.26.ae/ah.
$R_{th\ mb-h}=0.2°C/W$
1.2°C/W
2.2°C/W
3.2°C/W
4.2°C/W
5.2°C/W
6.2°C/W
8.2°C/W
10.2°C/W
P_{tot} (W)
35
30
25
20
15
10
5
0
T_{amb} (°C)
0
20
40
60
80
100

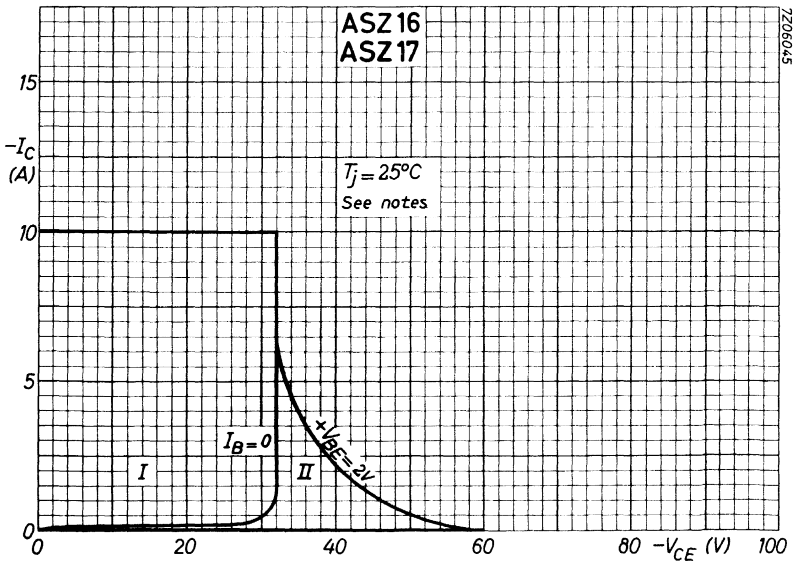

7Z06049
ASZ17
T_j = 25°C
$-V_{CE}$ = 1V
ASZ18
T_j = 25°C
$-V_{CE}$ = 1V
mox I_B
typ
min I_B
$-I_C$ (A)
$-I_B$ (mA)

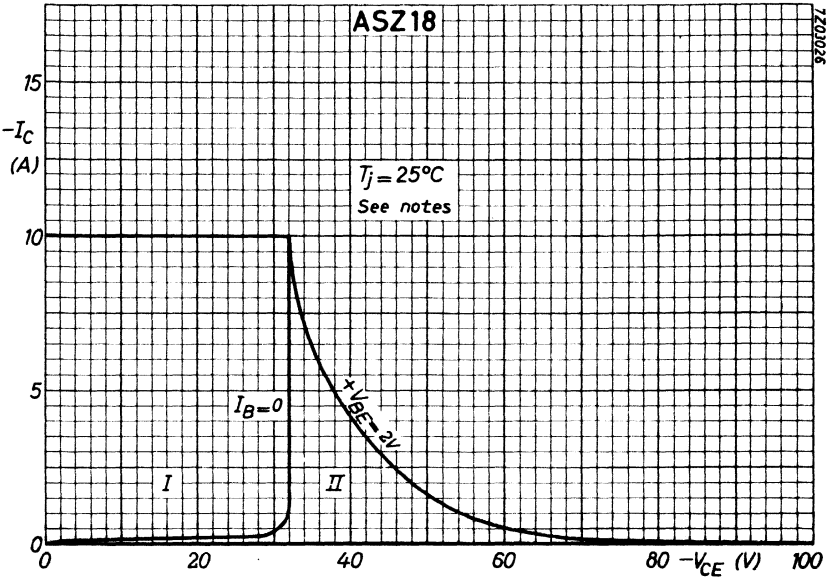

7Z06048
ASZ15
T_j = 25°C
$-V_{CE}$ = 1V
ASZ16
T_j = 25°C
$-V_{CE}$ = 1V
mox I_B
typ
min I_B
$-I_C$ (A)
$-I_B$ (mA)


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
$I_B = 0$
I
II
$+V_{BE} = 2V$
0
0
20
40
60
80
$-V_{CE}$ (V)
100


7Z06045
ASZ16
ASZ17
15
$-I_C$
(A)
$T_j = 25°C$
See notes
10
5
$I_B = 0$
I
II
$+V_{BE} = 2V$
0
0
20
40
60
80
$-V_{CE}$ (V)
100

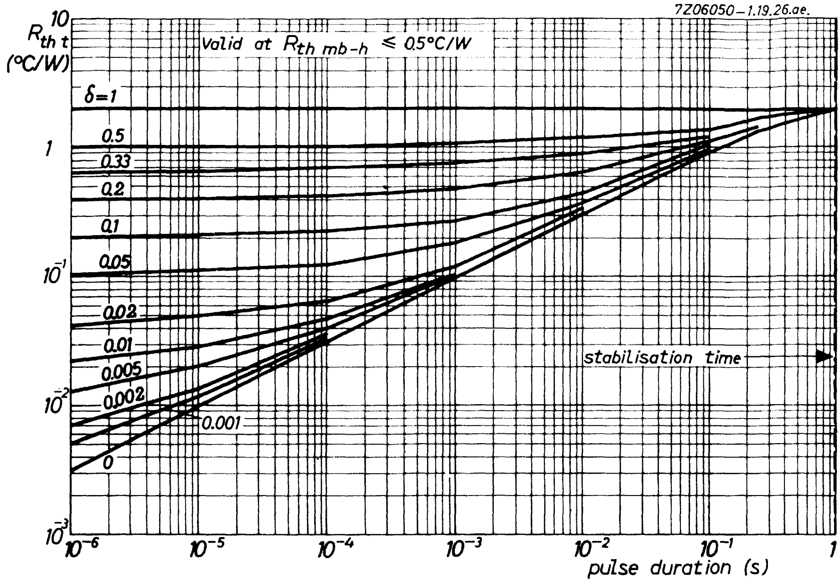


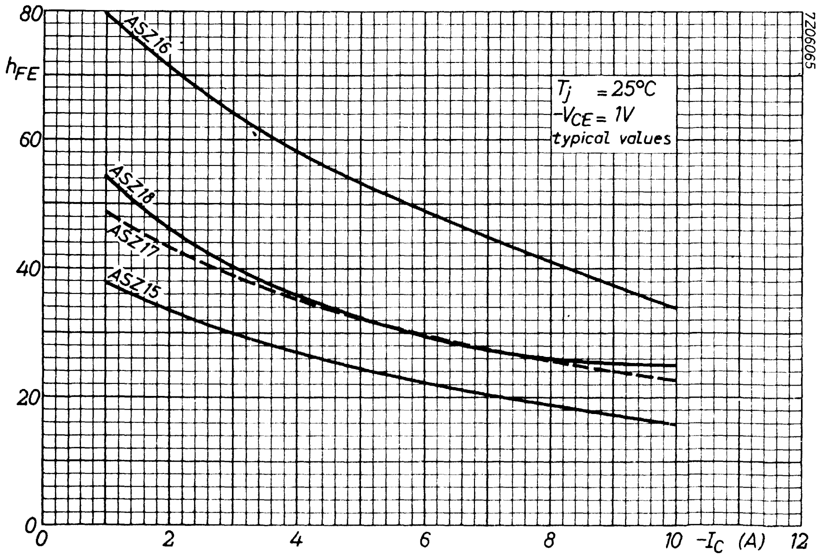
NOTES

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.
Rth t (°C/W)
Valid at Rth mb-h ≤ 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
10
1
10⁻¹
10⁻²
10⁻³
10⁻⁶
10⁻⁵
10⁻⁴
10⁻³
10⁻²
10⁻¹
1
pulse duration (s)


7Z06065
hFE
Tj = 25°C
-VCE = 1V
typical values
ASZ16
ASZ18
ASZ17
ASZ15
80
60
40
20
0
0
2
4
6
8
10
12
-IC (A)

HIGH VOLTAGE SILICON TRANSISTOR

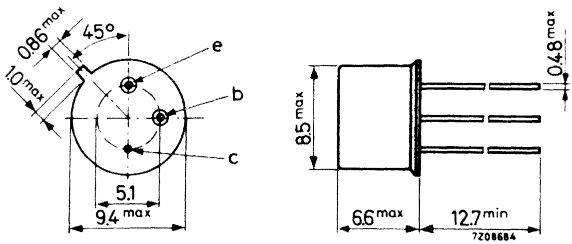
N-P-N silicon planar transistor in a TO-39 metal envelope with the collector connected to the case.
The transistor is intended for use in high voltage 2 W class A output stages of a.f. amplifiers, video amplifiers in colour television receivers including grid drive and in driver stages of high voltage 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 cm^2 (See also page 5)	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 cm^2	$R_{th\ j\text{-}a}$	=	25	°C/W

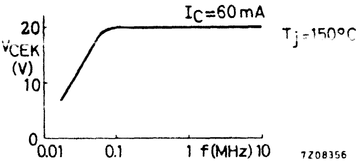
[1] During switching on, a supply voltage of 1.2 times the rated V_{CER} value is permitted. The current must be limited so that maximum dissipation and maximum junction temperature are not exceeded.

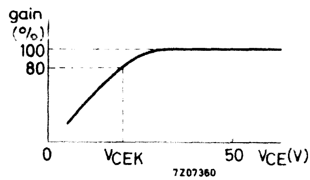
CHARACTERISTICS

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 9	V V
High frequency knee voltage at T_j = 150 °C				
I_C = 60 mA	V_{CEK}	typ.	20	V

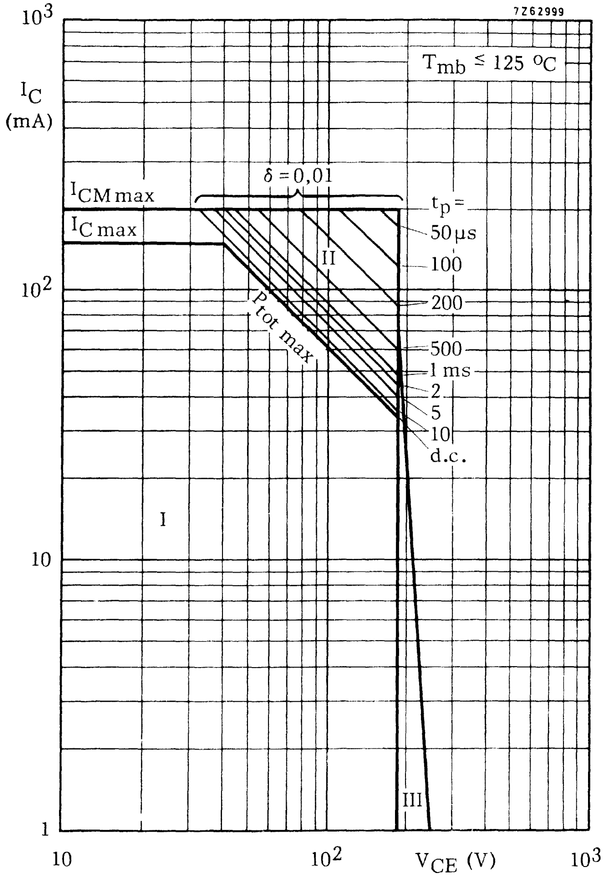
The high frequency knee voltage of a transistor is that value of the collector-emitter voltage at which the small signal gain, measured in a practical circuit, has dropped to 80% of the gain at V_{CE} = 50 V. A further decrease of the collector-emitter voltage results in a rapid increase of the distortion of the signal.





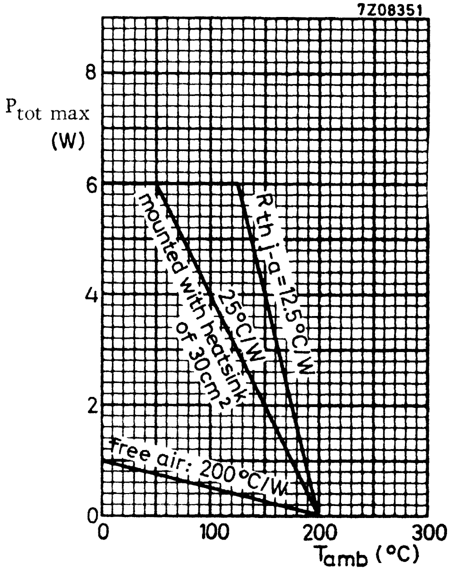
D.C. current gain				
I_C = 50 mA; V_{CE} = 100 V	h_{FE}	> typ.	22 60	
Ratio of h_{FE} at I_C = 100 mA; V_{CE} = 15 V and at I_C = 10 mA; V_{CE} = 165 V		typ.	1.1	
Feedback capacitance				
I_C = 10 mA; V_{CE} = 20 V; f = 1.0 MHz	$-C_{re}$	typ.	3.5	pF
Feedback time constant				
$-I_E$ = 10 mA; V_{CB} = 10 V; f = 10 MHz	$r_{bb'}C_{b'c}$	typ. <	30 100	ps 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.

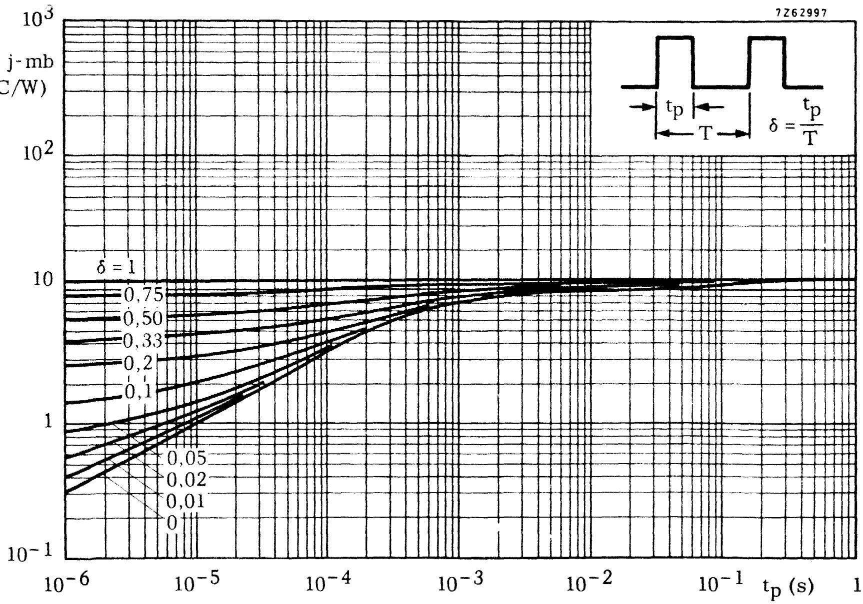


Safe Operating Area with the transistor forward biased

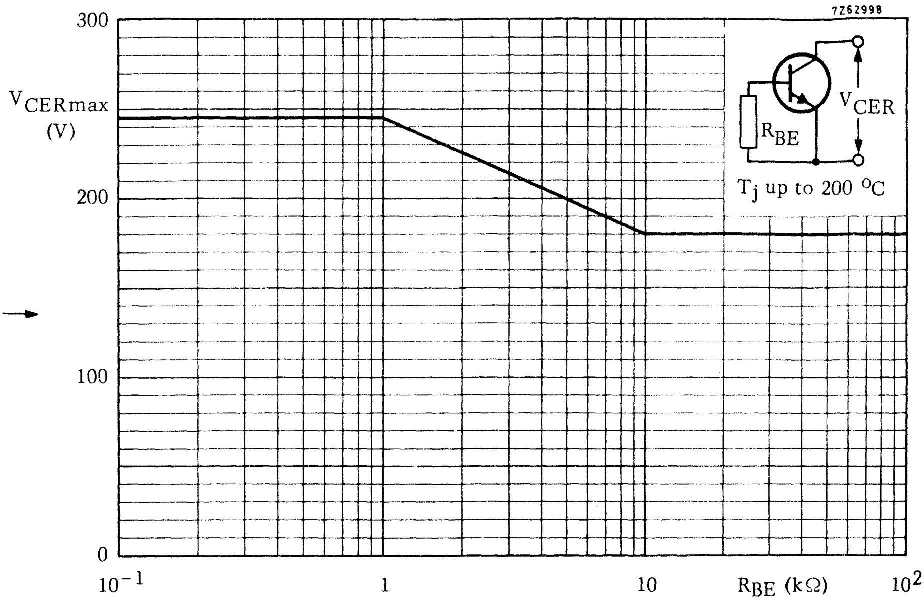
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation
III Operation in this region is allowable, provided $R_{BE} \leq 1\ k\Omega$. (See also note [1]) page 2.)

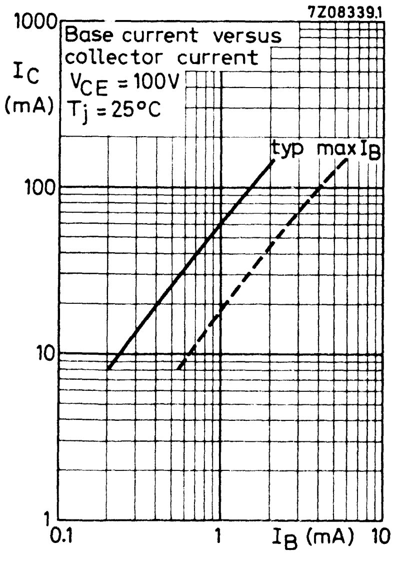


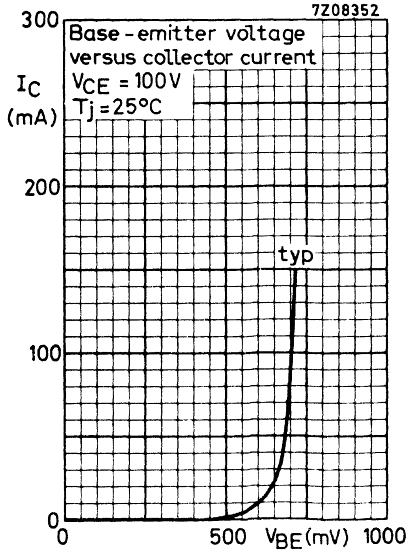
7Z08351
$P_{tot\ max}$ (W)
8
6
4
2
0
0
100
200
300
T_{amb} (°C)
R th j-a = 12.5°C/W
25°C/W
mounted with heatsink of 30cm²
free air: 200°C/W

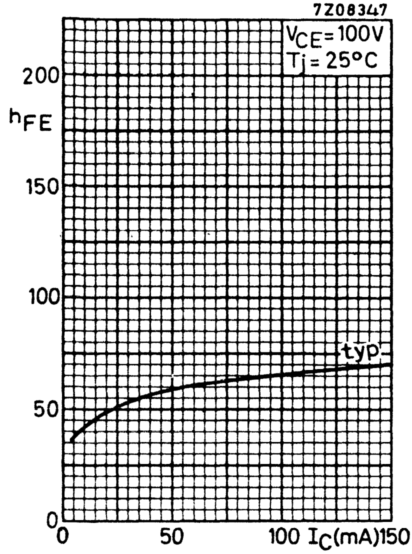


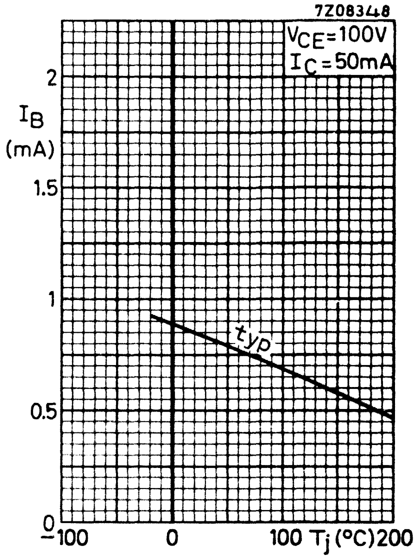
7Z62997
$Z_{th\ j\text{-}mb}$ (°C/W)
10^3
10^2
10
1
10^{-1}
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
t_p (s)
1
δ = 1
0,75
0,50
0,33
0,2
0,1
0,05
0,02
0,01
0
t_p
T
$\delta = \frac{t_p}{T}$

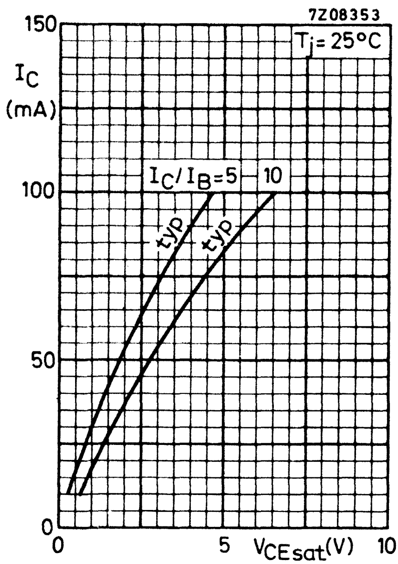

7Z62998
V_{CERmax} (V)
300
200
100
0
10^{-1}
1
10
R_{BE} (kΩ)
10^2
R_{BE}
V_{CER}
T_j up to 200 °C

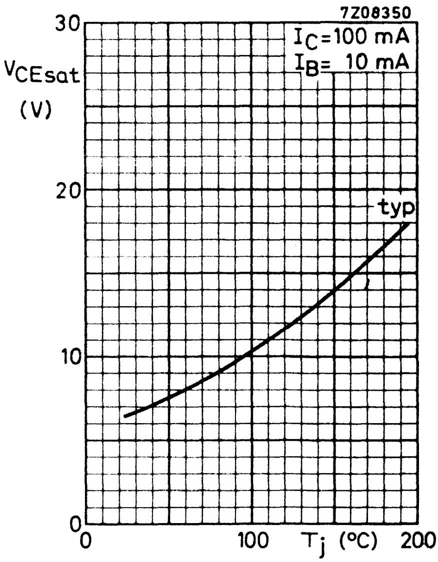

7Z08339.1
Base current versus collector current
V_{CE} = 100V
T_j = 25°C
I_C (mA)
1000
100
10
1
0.1
1
I_B (mA)
10
typ
max I_B

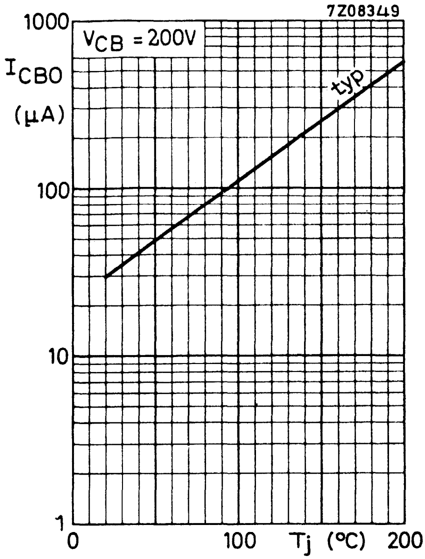

7Z08352
Base-emitter voltage versus collector current
V_{CE} = 100V
T_j = 25°C
I_C (mA)
300
200
100
0
0
500
V_{BE} (mV)
1000
typ

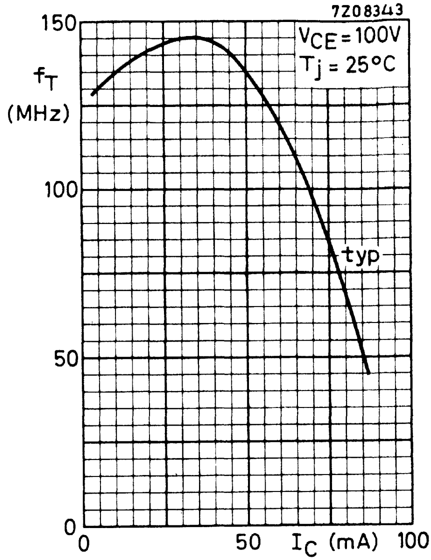

7Z08347
VCE=100V
Tj=25°C
200
hFE
150
100
50
0
typ
0
50
100 IC(mA)150

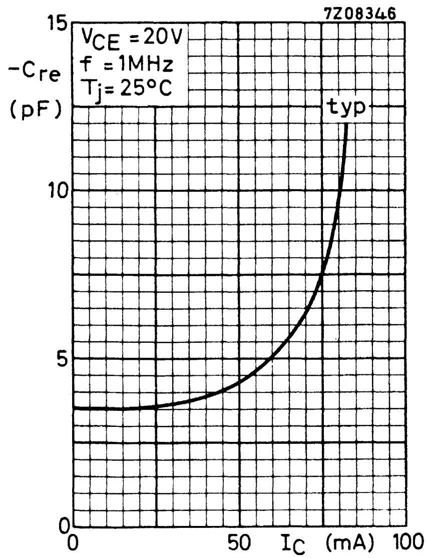

7Z08348
VCE=100V
IC=50mA
2
IB
(mA)
1.5
1
0.5
0
typ
−100
0
100 Tj (°C)200

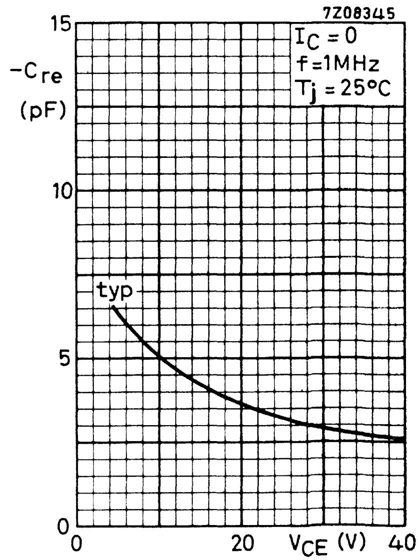

7Z08353
Tj=25°C
150
IC
(mA)
100
50
0
IC/IB=5
10
typ
typ
0
5 VCEsat(V) 10


7Z08350
IC=100 mA
IB= 10 mA
30
VCEsat
(V)
20
10
0
typ
0
100 Tj (°C) 200

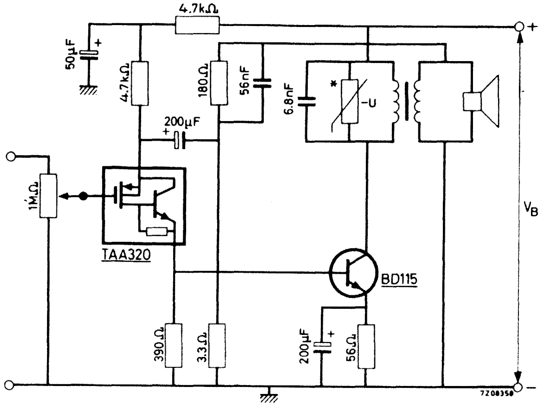

7Z08349
1000
I_{CBO}
(μA)
100
10
1
V_{CB} = 200V
typ
0
100
T_j (°C)
200


7Z08343
150
f_T
(MHz)
100
50
0
V_{CE} = 100V
T_j = 25°C
typ
0
50
I_C (mA)
100


7Z08346
15
$-C_{re}$
(pF)
10
5
0
V_{CE} = 20V
f = 1MHz
T_j = 25°C
typ
0
50
I_C (mA)
100


7Z08345
15
$-C_{re}$
(pF)
10
5
0
I_C = 0
f = 1MHz
T_j = 25°C
typ
0
20
V_{CE} (V)
40

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

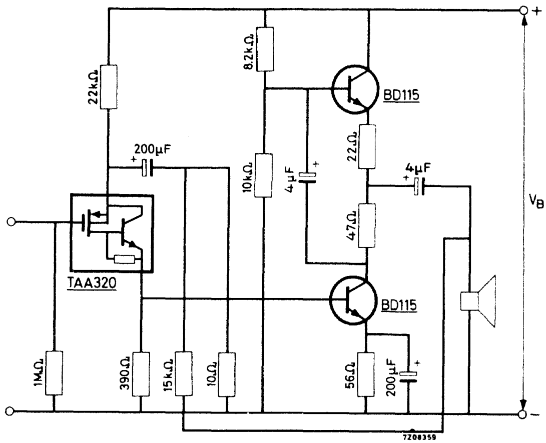
Output power at d_{tot} = 10% (on primary of the output transformer)	P_o	typ.	2.6	W
Input voltage for P_o = 50 mW	$V_{i(rms)}$	typ.	13.5	mV
Input voltage for P_o = 2 W	$V_{i(rms)}$	typ.	86	mV
Total distortion at P_o = 2 W	d_{tot}	typ.	3.6	%
Frequency response (-3 dB)			60 Hz to 20	kHz
Signal-noise ratio 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.

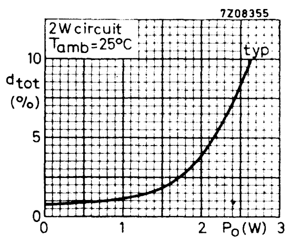


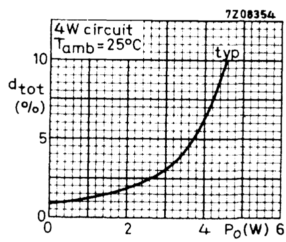
Supply voltage	V_B		200	V
Collector current of a BD115	I_C	typ.	52	mA
Drain current of TAA320	$-I_D$	typ.	8.6	mA

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

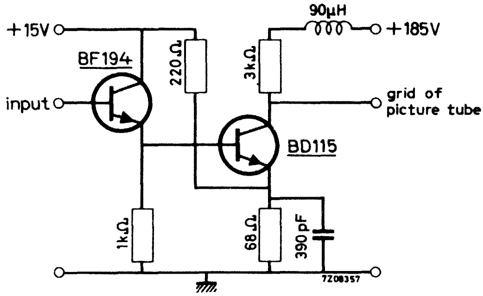




APPLICATION INFORMATION (continued)

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: $R_{th\ j\text{-}a} < 45$ °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.

OUTPUT POWER TRANSISTOR

N-P-N transistor in a SOT-32 plastic envelope. With its complement, the BD132, it is intended for complementary output stages in hi-fi amplifiers.

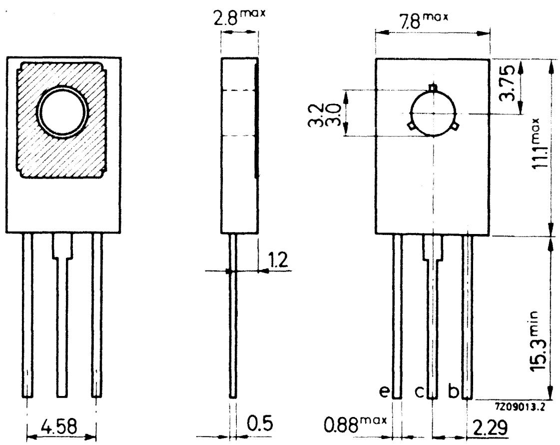
QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	70	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	V
Collector current (peak value)	I_{CM}	max.	6	A
Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max.	11	W
Junction temperature	T_j	max.	125	°C
D.C. current gain I_C = 0.5 A; V_{CE} = 12 V	h_{FE}	>	40	
Transition frequency at f = 35 MHz I_C = 0.25 A; V_{CE} = 5 V	f_T	>	60	MHz

MECHANICAL DATA

Dimensions in mm

SOT-32 (TO-126)

Collector connected to metal part of mounting surface



For mounting instructions see section Accessories type 56326 for non-insulated mounting and type 56333 for insulated mounting.

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

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	70 V
Collector-emitter voltage (open base)	V_{CEO}	max.	45 V
Emitter-base voltage (open collector)	V_{EBO}	max.	6 V

Currents

Collector current (d.c.)	I_C	max.	3 A
Collector current (peak value)	I_{CM}	max.	6 A
Base current (peak value)	I_{BM}	max.	0.5 A
Reverse base current (peak value)	$-I_{BM}$	max.	0.5 A

Power dissipation

Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max.	11 W

Temperatures

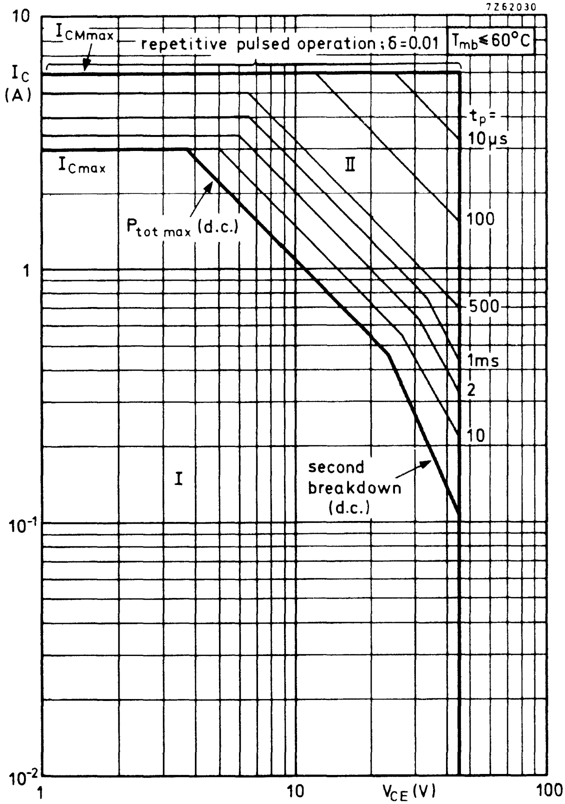
Storage temperature	T_{stg}		−55 to +125 °C
Junction temperature	T_j	max.	125 °C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	6 °C/W

CHARACTERISTICS $T_j = 25\ ^oC$ unless otherwise specified

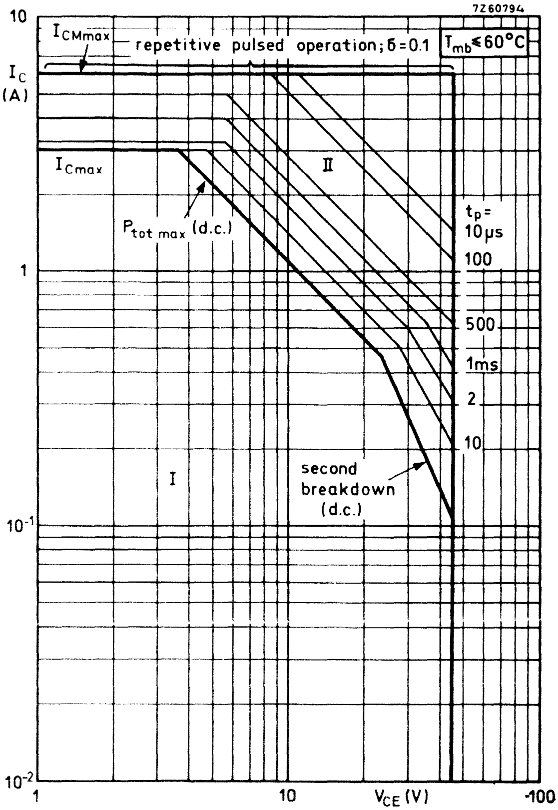
Collector cut-off current			
$I_E = 0;\ V_{CB} = 50$ V	I_{CBO}	<	5.0 µA
$I_E = 0;\ V_{CB} = 50$ V; $T_j = 125\ ^oC$	I_{CBO}	<	500 µA
Emitter cut-off current			
$I_C = 0;\ V_{EB} = 5$ V	I_{EBO}	<	5.0 µA
Saturation voltages			
$I_C = 0.5$ A; $I_B = 50$ mA	V_{CEsat}	<	0.4 V
	V_{BEsat}	<	1.2 V
$I_C = 2.0$ A; $I_B = 200$ mA	V_{CEsat}	<	0.9 V
	V_{BEsat}	<	1.5 V
D.C. current gain			
$I_C = 0.5$ A; $V_{CE} = 12$ V	h_{FE}	>	40
$I_C = 2.0$ A; $V_{CE} = 1.0$ V	h_{FE}	>	20
Collector capacitance at f = 1 MHz			
$I_E = I_e = 0;\ V_{CB} = 5$ V	C_c	<	60 pF
Transition frequency at f = 35 MHz			
$I_C = 0.25$ A; $V_{CE} = 5$ V	f_T	>	60 MHz
D.C. current gain ratio and difference in base currents $I_{B1} - I_{B2}$ of complementary pair BD131/BD132			
$\lvert I_C \rvert = 0.5$ A; $\lvert V_{CE} \rvert = 12$ V	h_{FE1}/h_{FE2}	<	1.2
	ΔI_B	<	1 mA
D.C. current gain of complementary pair BD131/BD132			
$\lvert I_C \rvert = 0.5$ A; $\lvert V_{CE} \rvert = 12$ V	h_{FE}	78 to	250
$\lvert I_C \rvert = 2.0$ A; $\lvert V_{CE} \rvert = 1.0$ V	h_{FE}	>	40
D.C. current gain ratio and difference in base currents $I_{B1} - I_{B2}$ of matched pair 2-BD131			
$I_C = 0.5$ A; $V_{CE} = 12$ V	h_{FE1}/h_{FE2}	<	1.2
	ΔI_B	<	2 mA
D.C. current gain of matched pair 2-BD131			
$I_C = 0.5$ A; $V_{CE} = 12$ V	h_{FE}	40 to	280



Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

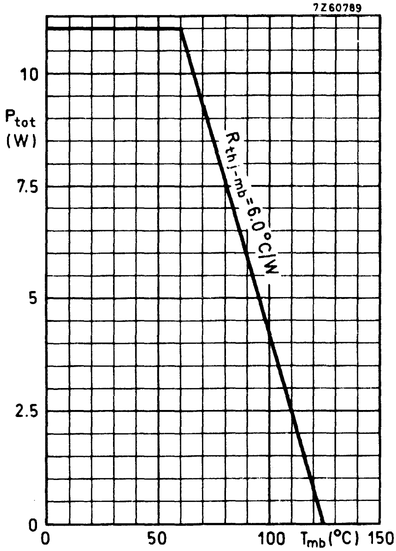
II Permissible extension for repetitive pulsed operation



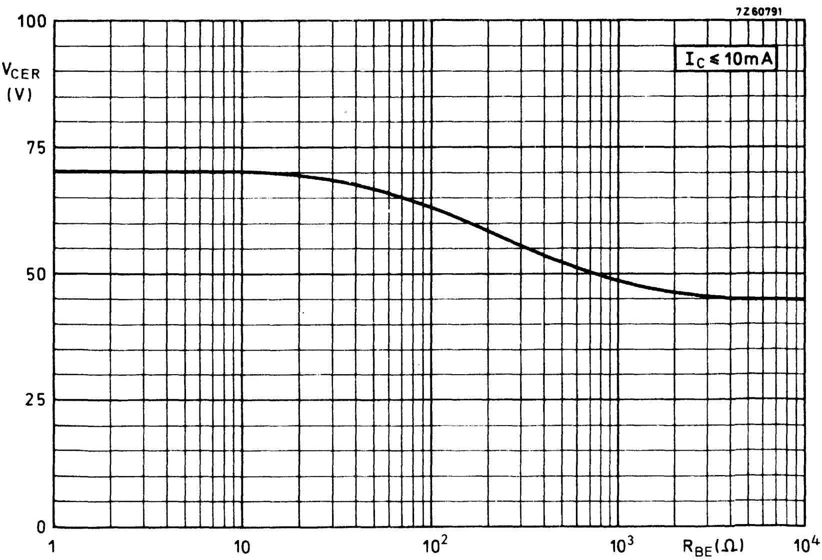
Safe Operating Area with the transistor forward biased

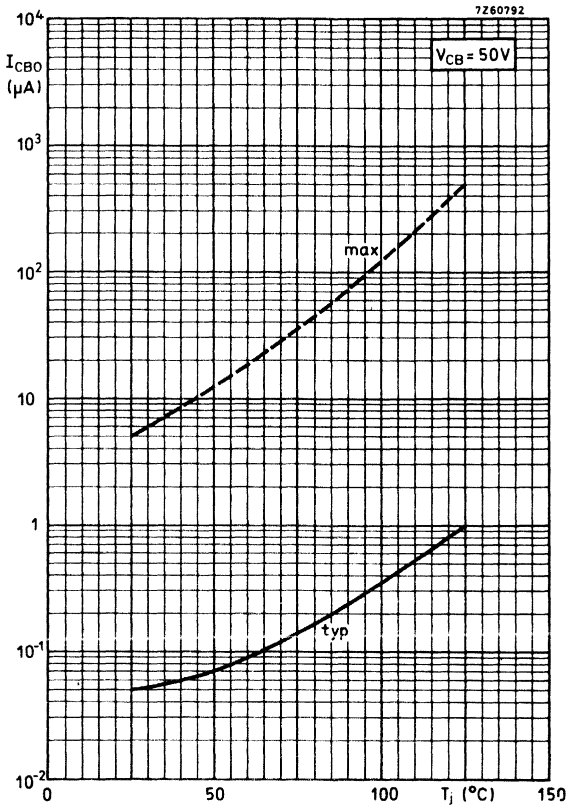
I Regio of permissible d.c. operation

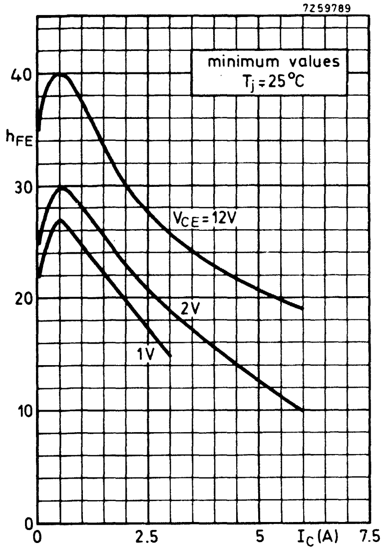
II Permissible extension for repetitive pulsed operation

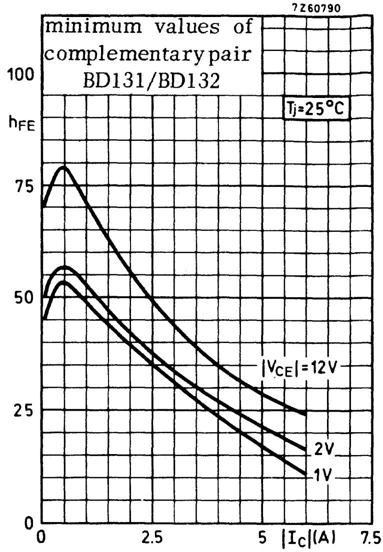


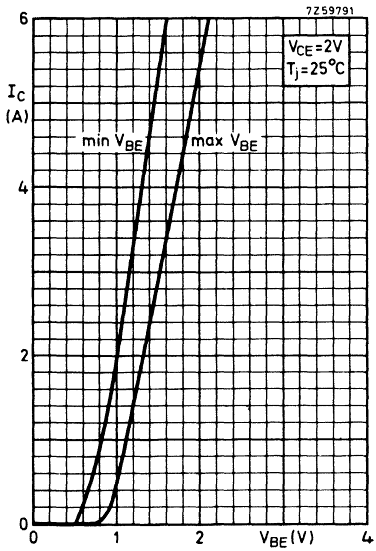
maximum allowable collector-emitter voltage versus base-emitter resistance

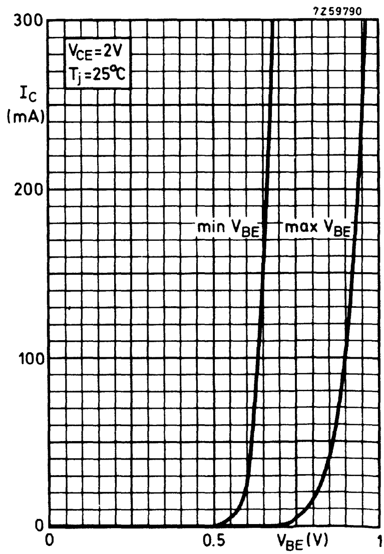



7Z60792
I_{CBO} (μA)
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}
V_{CB} = 50V
max
typ
0
50
100
T_j (°C)
150


7Z59789
minimum values
$T_j = 25\,^{\circ}C$
40
30
20
10
0
h_{FE}
$V_{CE} = 12V$
2V
1V
0
2.5
5
I_C (A)
7.5


7Z60790
minimum values of
complementary pair
BD131/BD132
$T_j = 25\,^{\circ}C$
100
75
50
25
0
h_{FE}
$|V_{CE}| = 12V$
2V
1V
0
2.5
5
$|I_C|$(A)
7.5


7Z59791
$V_{CE} = 2V$
$T_j = 25\,^{\circ}C$
6
4
2
0
I_C
(A)
min V_{BE}
max V_{BE}
0
1
2
V_{BE}(V)
4


7Z59790
$V_{CE} = 2V$
$T_j = 25\,^{\circ}C$
300
200
100
0
I_C
(mA)
min V_{BE}
max V_{BE}
0
0.5
V_{BE}(V)
1

OUTPUT POWER TRANSISTOR

P-N-P transistor in a SOT-32 plastic envelope. With its complement, the BD131, it is intended for complementary output stages in hi-fi amplifiers.

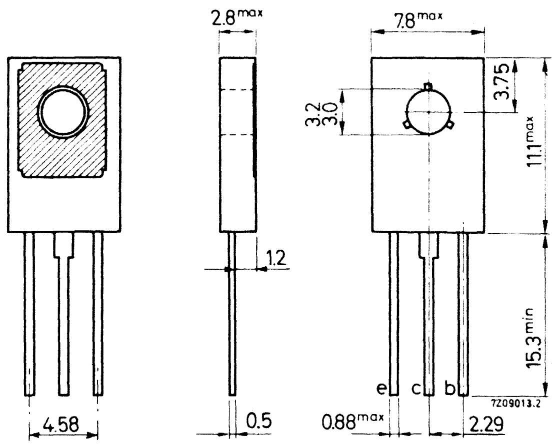
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	V
Colllector-emitter voltage (open base)	$-V_{CEO}$	max.	45	V
Collector current (peak value)	$-I_{CM}$	max.	6.0	A
Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max.	11	W
Junction temperature	T_j	max.	125	°C
D.C. current gain $-I_C$ = 0.5 A; $-V_{CE}$ = 12 V	h_{FE}	>	40	
Transition frequency at f = 35 MHz $-I_C$ = 0.25 A; $-V_{CE}$ = 5 V	f_T	>	60	MHz

MECHANICAL DATA

Dimensions in mm

SOT-32 (TO-126)
Collector connected to metal part of mounting surface



For mounting instructions see section Accessories type 56326 for non-insulated mounting and type 56333 for insulated mounting.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	4.0	V

Currents

Collector current (d.c.)	$-I_C$	max.	3.0	A
Collector current (peak value)	$-I_{CM}$	max.	6.0	A
Base current (peak value)	$-I_{BM}$	max.	0.5	A
Reverse base current (peak value)	$+I_{BM}$	max.	0.5	A

Power dissipation

Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max.	11	W

Temperatures

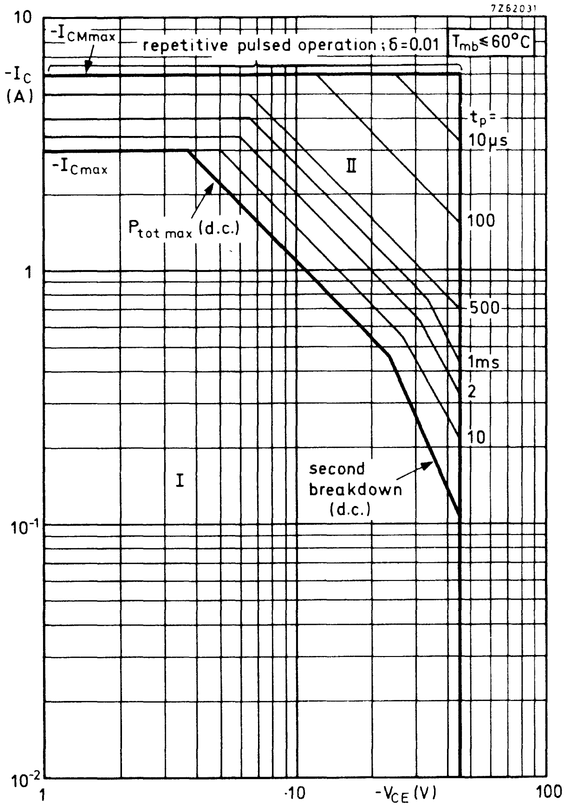
Storage temperature	T_{stg}	−55 to	+125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	6.0	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

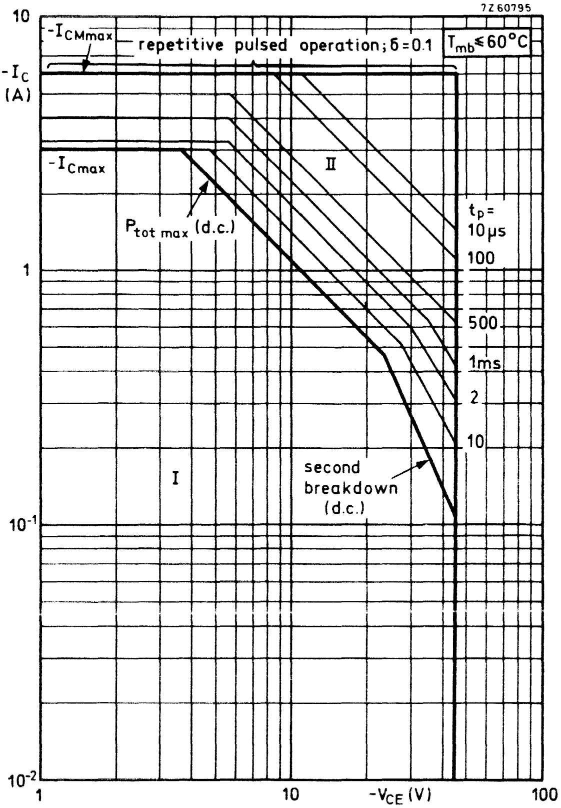
Collector cut-off current				
$I_E = 0$; $-V_{CB}$ = 40 V	$-I_{CBO}$	<	5.0	μA
$I_E = 0$; $-V_{CB}$ = 40 V; T_j = 125 °C	$-I_{CBO}$	<	500	μA
Emitter cut-off current				
$I_C = 0$; $-V_{EB}$ = 3.0 V	$-I_{EBO}$	<	5.0	μA
Saturation voltages				
$-I_C$ = 0.5 A; $-I_B$ = 50 mA	$-V_{CEsat}$	<	0.4	V
	$-V_{BEsat}$	<	1.2	V
$-I_C$ = 2.0 A; $-I_B$ = 200 mA	$-V_{CEsat}$	<	0.9	V
	$-V_{BEsat}$	<	1.5	V
D.C. current gain				
$-I_C$ = 0.5 A; $-V_{CE}$ = 12 V	h_{FE}	>	40	
$-I_C$ = 2.0 A; $-V_{CE}$ = 1.0 V	h_{FE}	>	20	
Transition frequency at f = 35 MHz				
$-I_C$ = 0.25 A; $-V_{CE}$ = 5 V	f_T	>	60	MHz
D.C. current gain ratio and difference in base currents $I_{B1} - I_{B2}$ of complementary pair BD131/BD132				
$\|I_C\|$ = 0.5 A; $\|V_{CE}\|$ = 12 V	h_{FE1}/h_{FE2}	<	1.2	
	ΔI_B	<	1	mA
D.C. current gain of complementary pair BD131/BD132				
$\|I_C\|$ = 0.5 A; $\|V_{CE}\|$ = 12 V	h_{FE}		78 to 250	
$\|I_C\|$ = 2 A; $\|V_{CE}\|$ = 1.0 V	h_{FE}	>	40	



Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

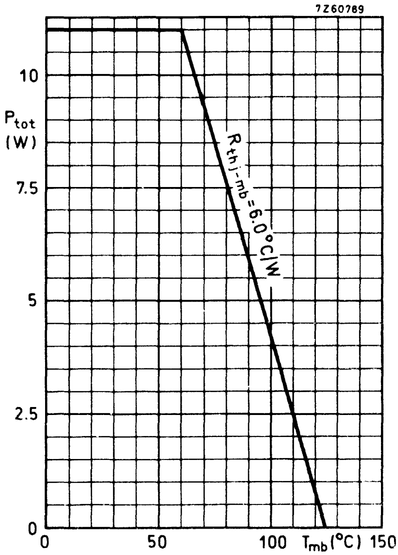
II Permissible extension for repetitive pulsed operation

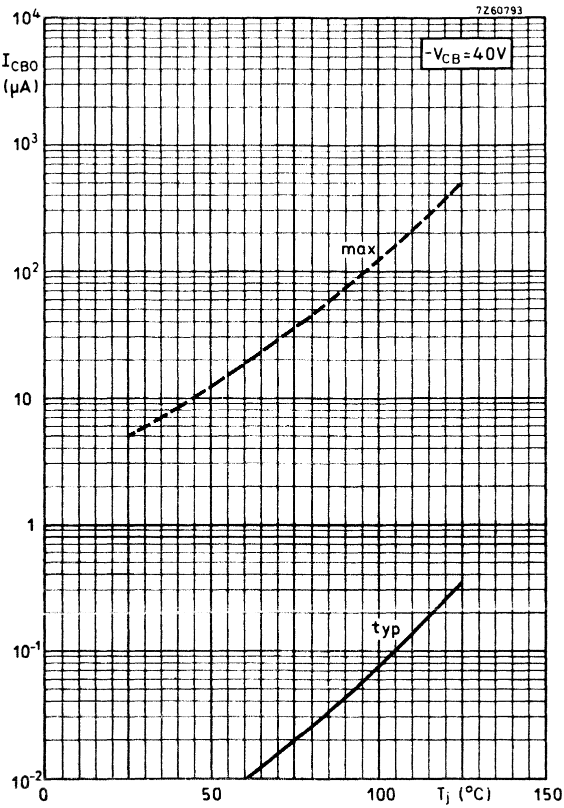


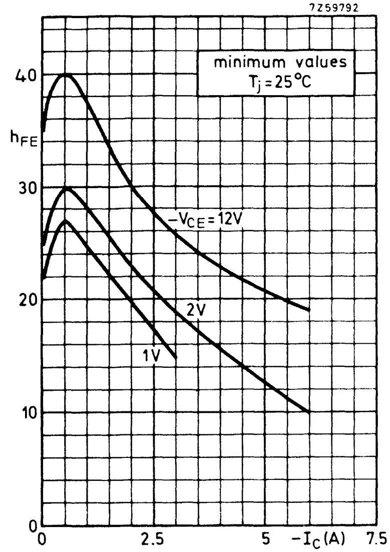
Safe Operating Area with the transistor forward biased

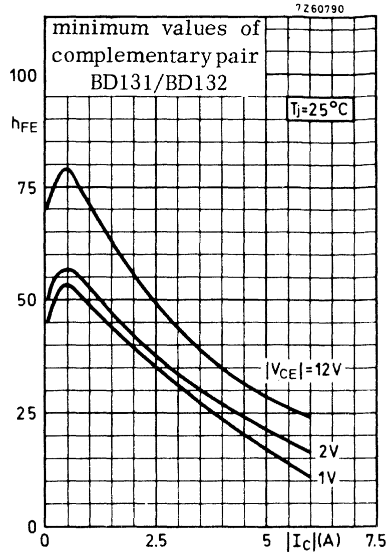
I Region of permissible d.c. operation

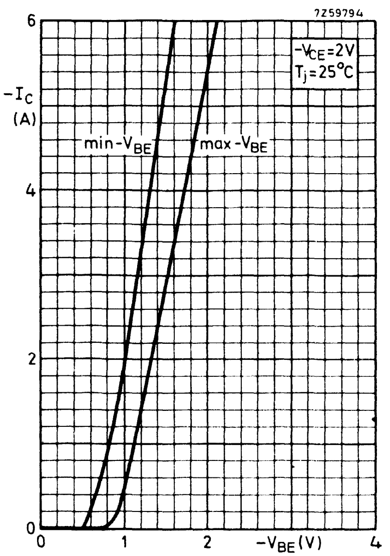
II Permissible extension for repetitive pulsed operation

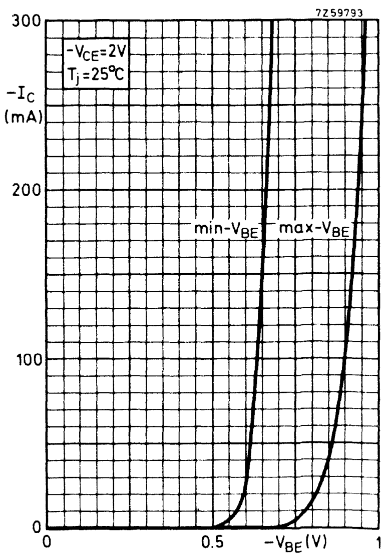

7Z60789
P_{tot}
(W)
10
7.5
5
2.5
0
0
50
100
150
T_{mb} (°C)
$R_{th\,j\text{-}mb}$ = 6.0°C/W


7Z60793
$-I_{CBO}$ (μA)
$-V_{CB} = 40V$
max
typ
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}
0
50
100
150
T_j (°C)


7Z59792
minimum values
$T_j = 25°C$
h_{FE}
$-V_{CE} = 12V$
2V
1V
$-I_C$ (A)


7Z60790
minimum values of complementary pair BD131/BD132
$T_j = 25°C$
h_{FE}
$|V_{CE}| = 12V$
2V
1V
$|I_C|$ (A)


7Z59794
$-V_{CE} = 2V$
$T_j = 25°C$
$-I_C$ (A)
min-V_{BE}
max-V_{BE}
$-V_{BE}$ (V)


7Z59793
$-V_{CE} = 2V$
$T_j = 25°C$
$-I_C$ (mA)
min-V_{BE}
max-V_{BE}
$-V_{BE}$ (V)

OUTPUT POWER TRANSISTOR

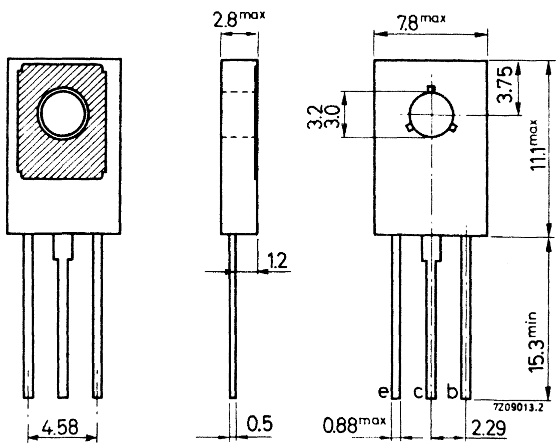
Silicon N-P-N planar epitaxial transistor for general purpose, medium power applications.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	90	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	V
Collector current (peak value)	I_{CM}	max.	6	A
Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max.	11	W
Junction temperature	T_j	max.	125	°C
D.C. current gain I_C = 0.5 A; V_{CE} = 12 V	h_{FE}	>	40	
Transition frequency at f = 35 MHz I_C = 0.25 A; V_{CE} = 5 V	f_T	>	60	MHz

MECHANICAL DATA

Dimensions in mm

SOT-32 (TO-126)
Collector connected to metal part of mounting surface



For mounting instructions see section Accessories type 56326 for non-insulated mounting and type 56333 for insulated mounting.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	90	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	V

Currents

Collector current (d.c.)	I_C	max.	3	A
Collector current (peak value)	I_{CM}	max.	6	A
Base current (peak value)	I_{BM}	max.	0.5	A
Reverse base current (peak value)	$-I_{BM}$	max.	0.5	A

Power dissipation

Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max.	11	W

Temperatures

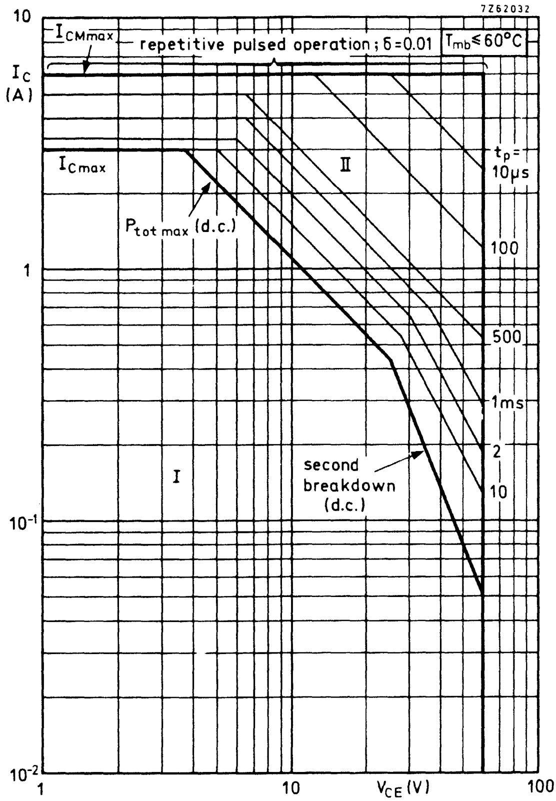
Storage temperature	T_{stg}		−55 to +125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	6	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

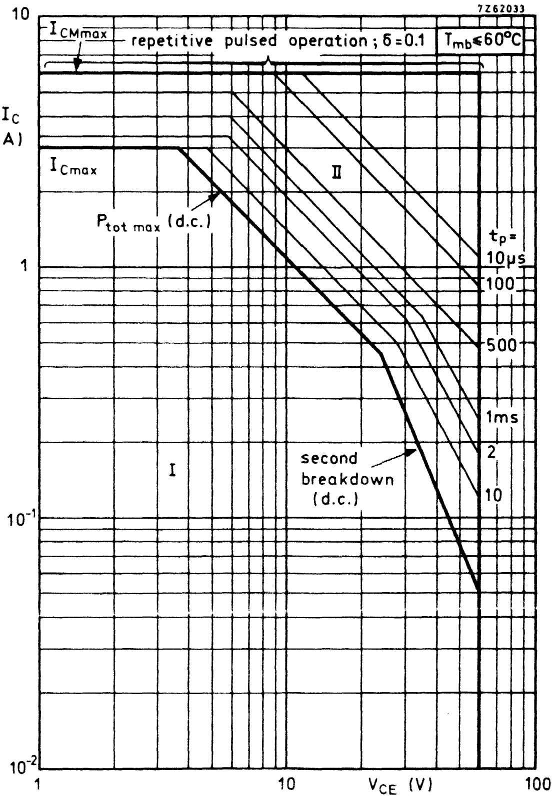
Collector cut-off current				
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	<	5.0	μA
$I_E = 0$; $V_{CB} = 60$ V; $T_j = 125\ ^{o}C$	I_{CBO}	<	500	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	5.0	μA
Saturation voltages				
$I_C = 0.5$ A; $I_B = 50$ mA	V_{CEsat}	<	0.4	V
	V_{BEsat}	<	1.2	V
$I_C = 2.0$ A; $I_B = 200$ mA	V_{CEsat}	<	0.9	V
	V_{BEsat}	<	1.5	V
D.C. current gain				
$I_C = 0.5$ A; $V_{CE} = 12$ V	h_{FE}	>	40	
$I_C = 2.0$ A; $V_{CE} = 1.0$ V	h_{FE}	>	20	
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	<	60	pF
Transition frequency at f = 35 MHz				
$I_C = 0.25$ A; $V_{CE} = 5$ V	f_T	>	60	MHz



Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

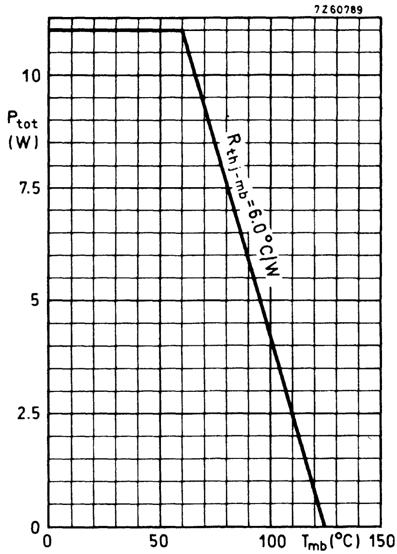
II Permissible extension for repetitive pulsed operation



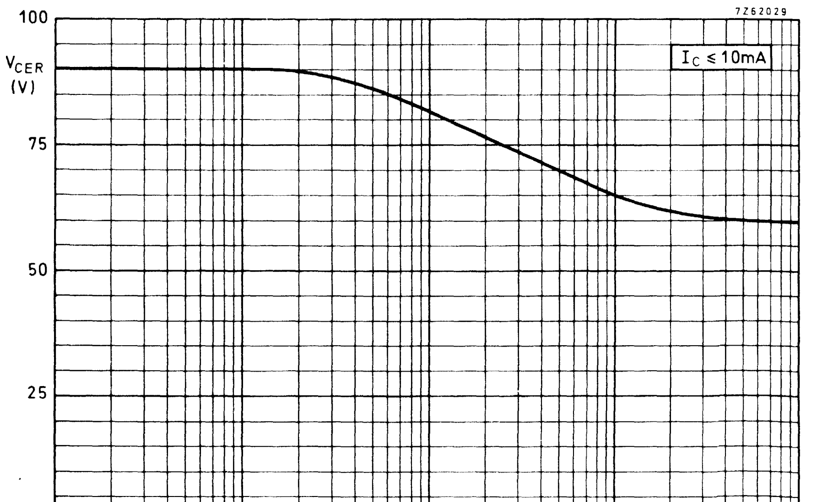
Safe Operating Area with the transistor forward biased

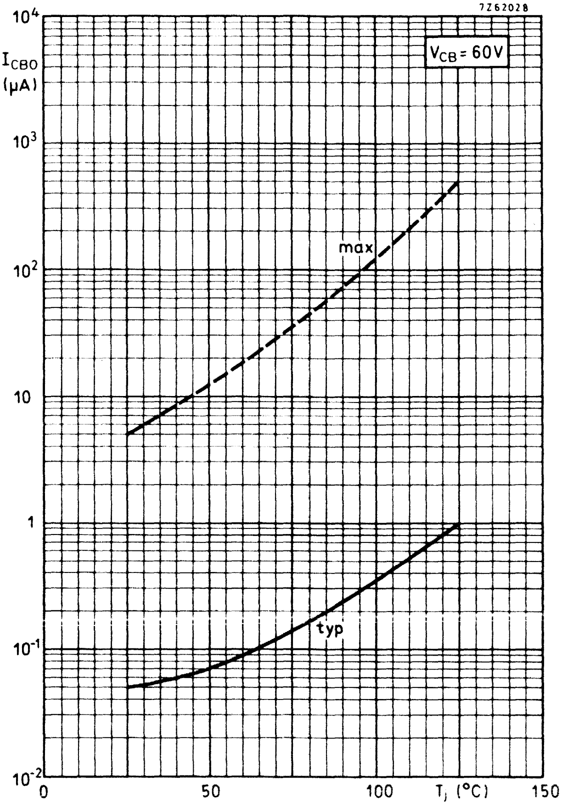
I Region of permissible d.c. operation

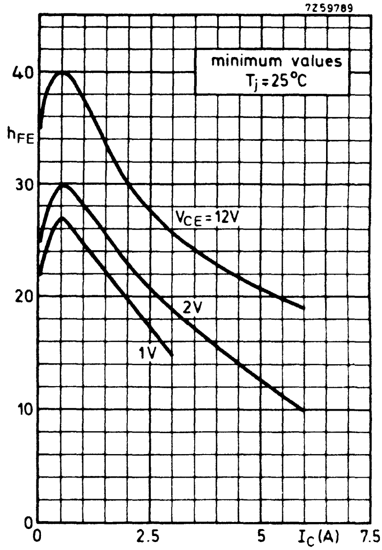
II Permissible extension for repetitive pulsed operation

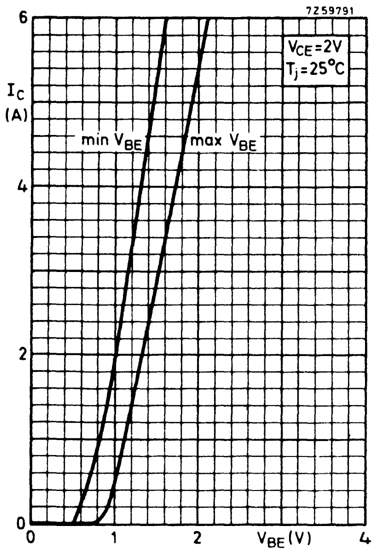


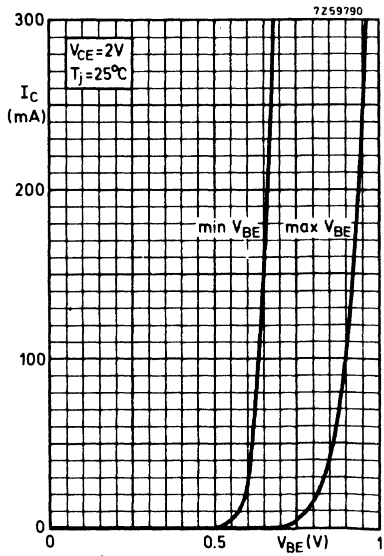
maximum allowable collector-emitter voltage versus base-emitter resistance




7Z62028
V_{CB} = 60V
I_{CBO} (μA)
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}
max
typ
0
50
100
T_j (°C)
150


7Z59789
minimum values
$T_j = 25\,^{\circ}C$
h_{FE}
40
30
20
10
0
$V_{CE} = 12V$
2V
1V
0
2.5
5
I_C (A)
7.5


7Z59791
$V_{CE} = 2V$
$T_j = 25\,^{\circ}C$
I_C
(A)
6
4
2
0
min V_{BE}
max V_{BE}
0
1
2
V_{BE} (V)
4


7Z59790
$V_{CE} = 2V$
$T_j = 25\,^{\circ}C$
I_C
(mA)
300
200
100
0
min V_{BE}
max V_{BE}
0
0.5
V_{BE} (V)
1

SILICON PLANAR EPITAXIAL TRANSISTORS

General purpose n-p-n transistors in SOT-32 plastic envelope, recommended for driver stages in hi-fi amplifiers and television circuits.
The BD136, BD138 and BD140 are complementary to the BD135, BD137 and BD139 respectively.

QUICK REFERENCE DATA

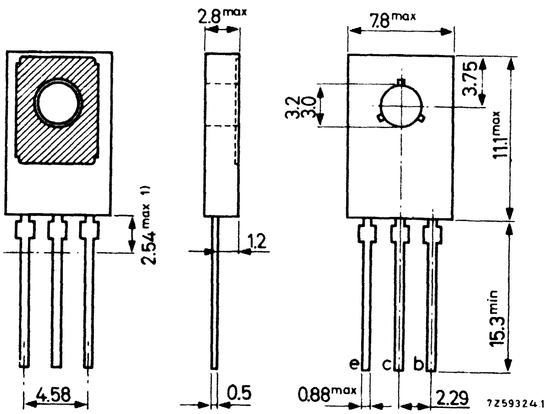
			BD135	BD137	BD139	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Collector-current (peak value)	I_{CM}	max.	1,5	1,5	1,5	A
Total power dissipation up to T_{mb} = 70 °C	P_{tot}	max.	8	8	8	W
Junction temperature	T_j	max.	150	150	150	°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

SOT-32 (TO-126)

Collector connected to metal part of mounting surface



For mounting instructions see section Accessories type 56326 for non-insulated mounting and type 56333 for insulated mounting.

1) Within this region the cross-section of the leads is uncontrolled.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltages

			BD135	BD137	BD139	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V

Currents

			BD135	BD137	BD139	
Collector current (d.c.)	I_C	max.	1,0	1,0	1,0	A
Collector current (peak value)	I_{CM}	max.	1,5	1,5	1,5	A

Power dissipation

Total power dissipation up to T_{mb} = 70 °C	P_{tot}	max.	8	W

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	$R_{th\ j-a}$	100	°C/W
From junction to mounting base	$R_{th\ j-mb}$	10	°C/W

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

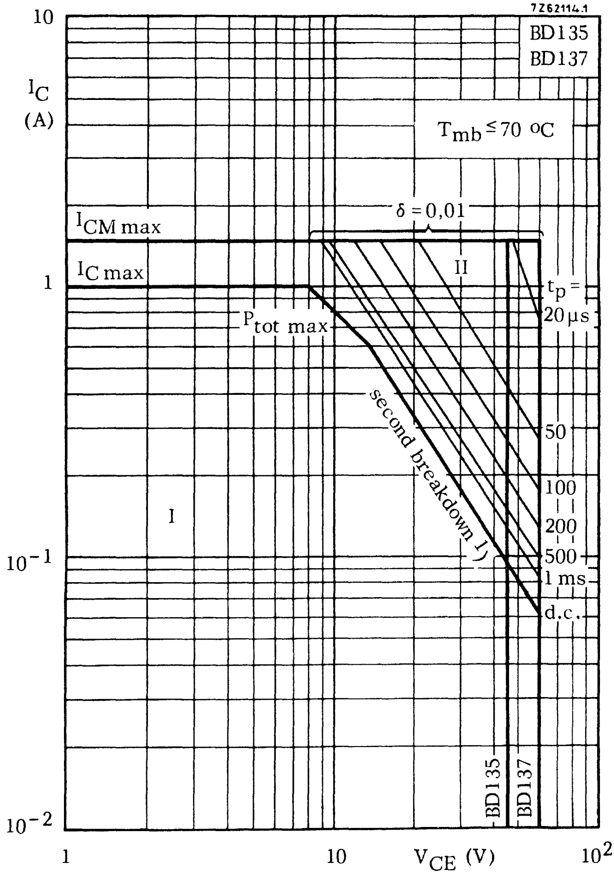
			BD135	BD137	BD139
$I_C = 5$ mA; $V_{CE} = 2$ V	h_{FE}	>	25	25	25
$I_C = 150$ mA; $V_{CE} = 2$ V	h_{FE}	>	40	40	40
		<	250	160	160
$I_C = 500$ mA; $V_{CE} = 2$ V	h_{FE}	>	25	25	25

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 pulse operation

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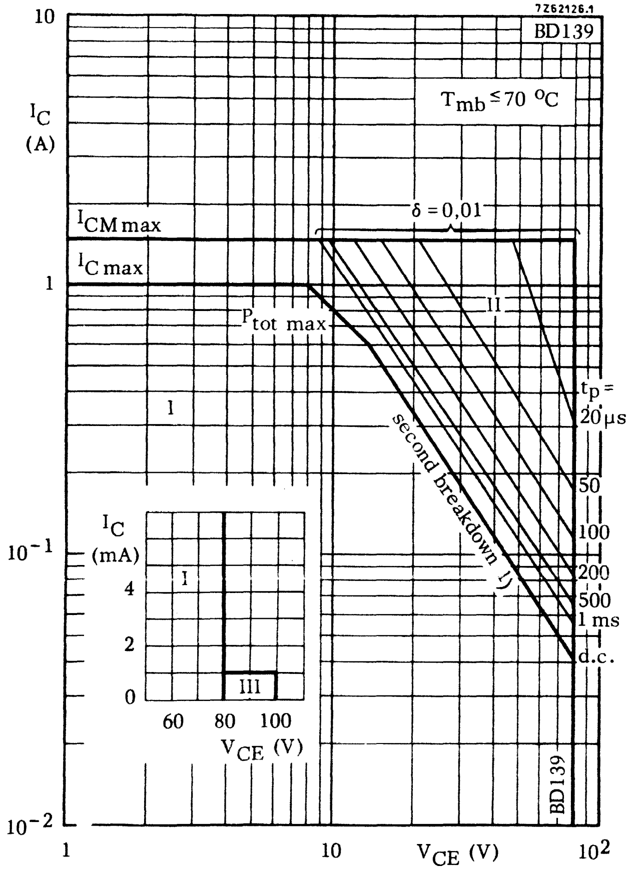
[1]) Independent of temperature

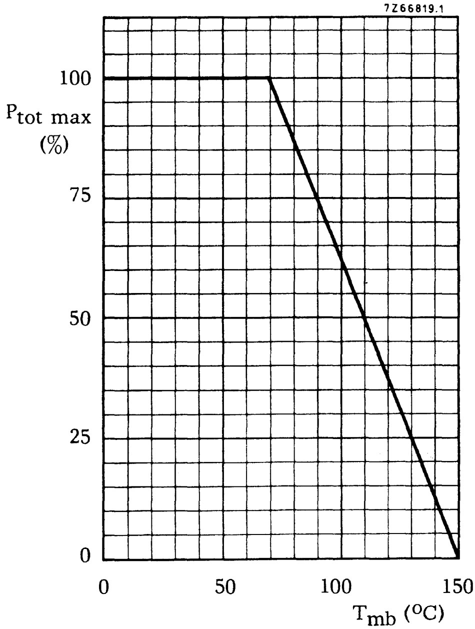


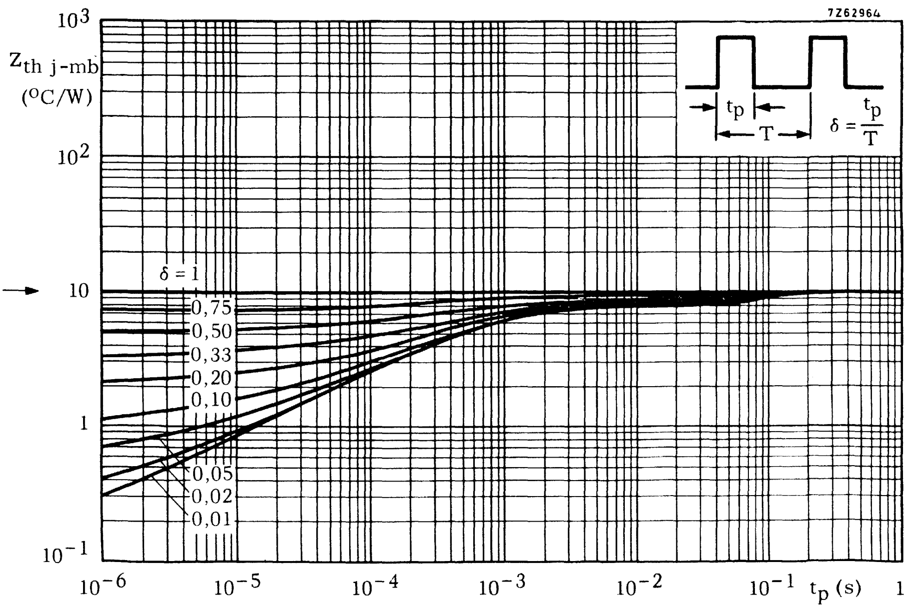
Safe Operating Area with the transistor forward biased

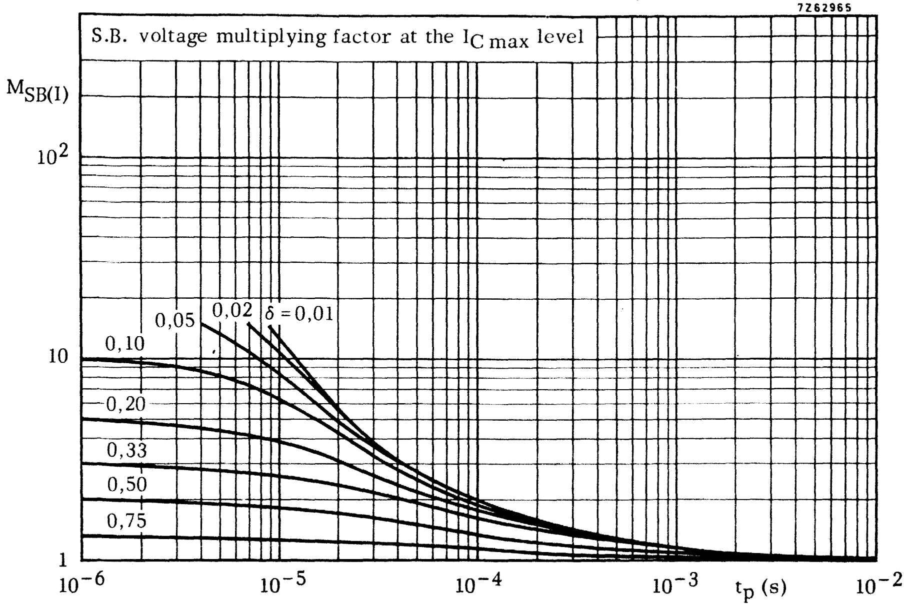
I Region of permissible d.c. operation
II Permissible extension for repetitive pulsed operation
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 1\ k\Omega$

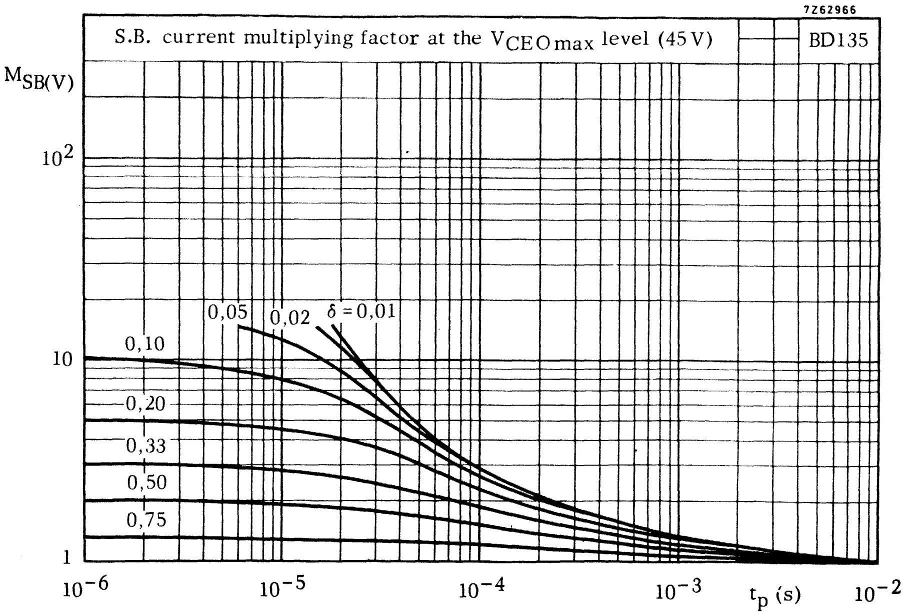
---

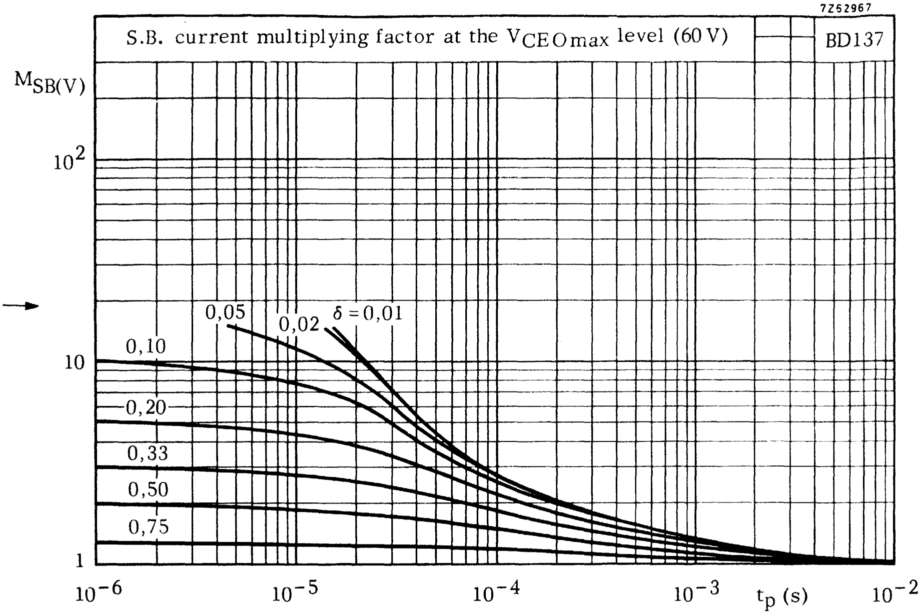
1) Independent of temperature

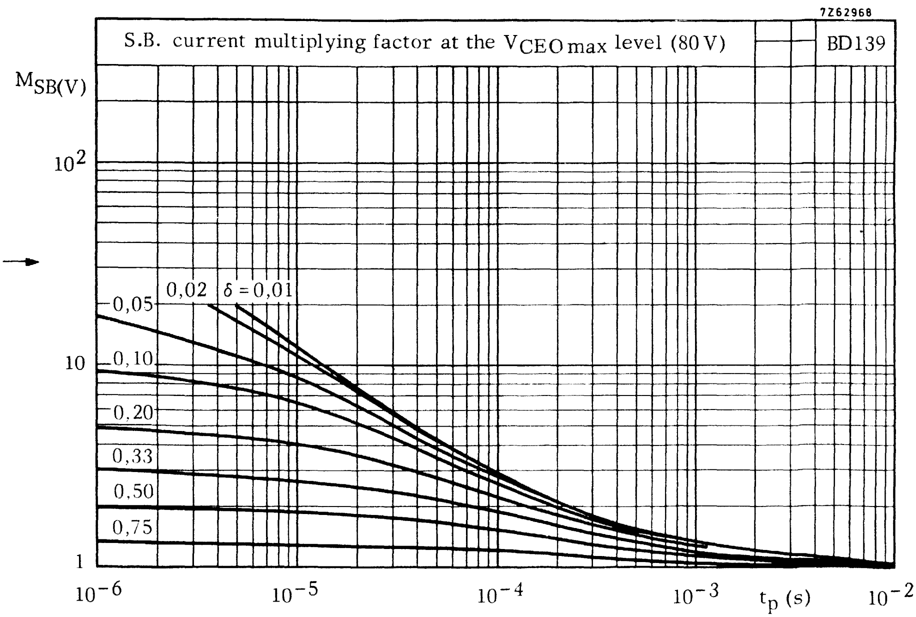

7Z66819.1
100
Ptot max
(%)
75
50
25
0
0
50
100
150
Tmb (°C)

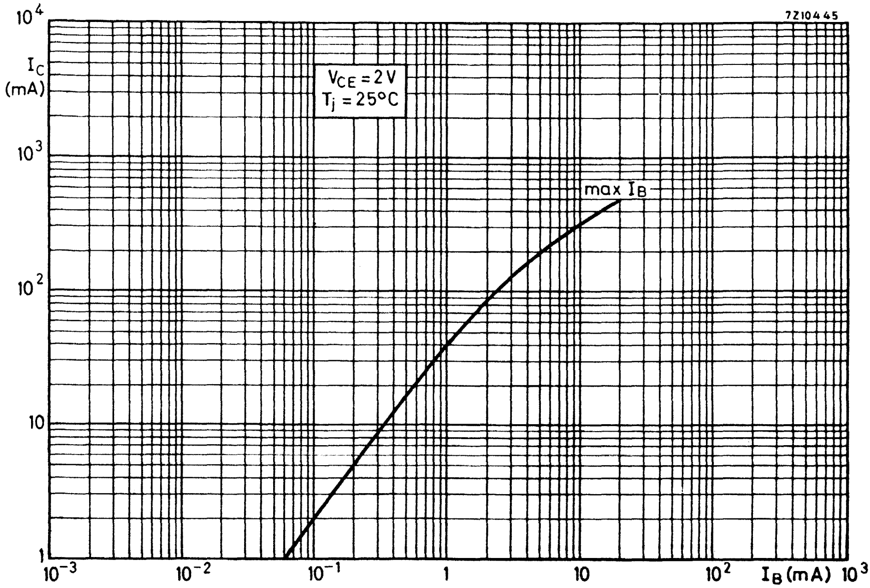

7Z62964
10^3
Zth j-mb
(°C/W)
10^2
10
1
10^{-1}
δ = 1
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
tp
T
δ = tp/T
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
tp (s)
1

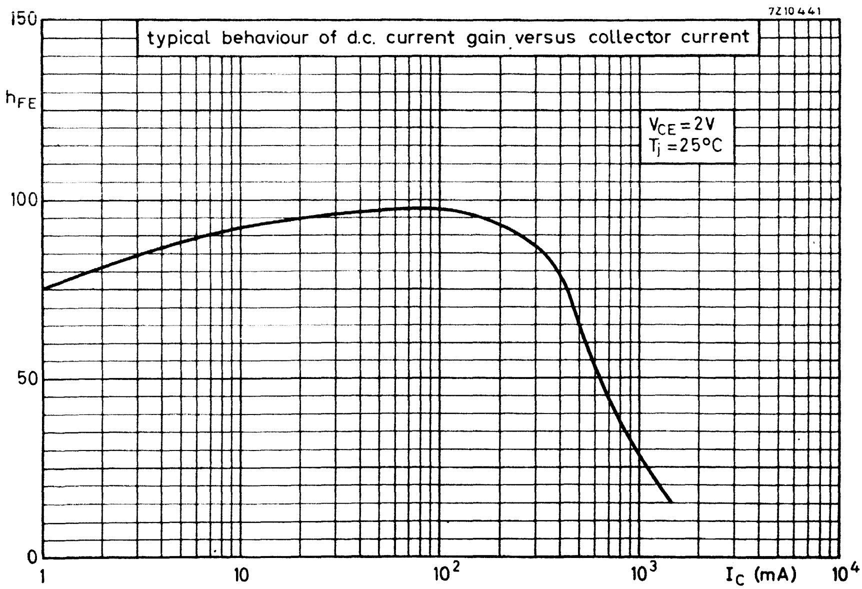

7Z62965
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

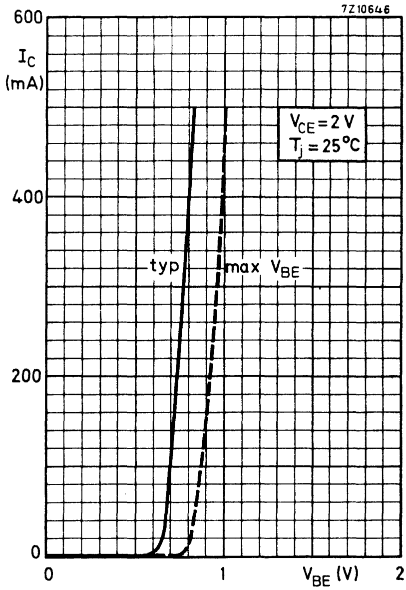

7Z62966
S.B. current multiplying factor at the $V_{CEO\,max}$ level (45 V)
BD135
$M_{SB(V)}$
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

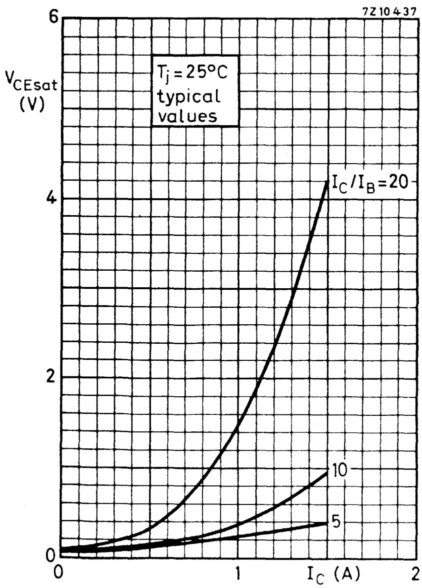

7Z62967
S.B. current multiplying factor at the VCEOmax level (60 V)
BD137
MSB(V)
10²
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10⁻⁶
10⁻⁵
10⁻⁴
10⁻³
tp (s)
10⁻²

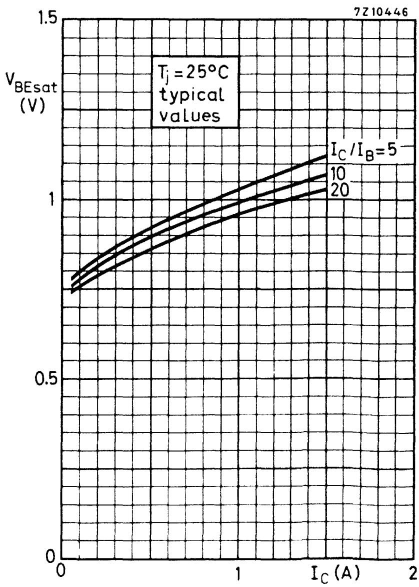

7Z62968
S.B. current multiplying factor at the VCEOmax level (80 V)
BD139
MSB(V)
10²
10
1
0,02
δ = 0,01
0,05
0,10
0,20
0,33
0,50
0,75
10⁻⁶
10⁻⁵
10⁻⁴
10⁻³
tp (s)
10⁻²

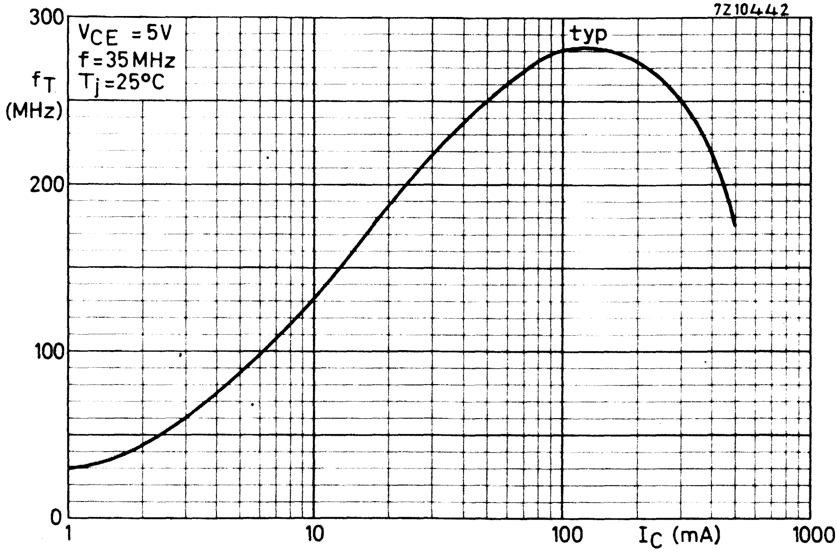

7Z10445
10^4
I_C (mA)
V_{CE} = 2 V
T_j = 25 °C
10^3
max I_B
10^2
10
1
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
I_B (mA)
10^3


7Z10441
typical behaviour of d.c. current gain versus collector current
150
h_{FE}
V_{CE} = 2 V
T_j = 25 °C
100
50
0
1
10
10^2
10^3
I_C (mA)
10^4


7Z10646
600
400
200
0
I_C
(mA)
$V_{CE} = 2$ V
$T_j = 25°C$
typ
max V_{BE}
0
1
V_{BE} (V)
2


7Z10437
6
4
2
0
V_{CEsat}
(V)
$T_j = 25°C$
typical
values
$I_C/I_B = 20$
10
5
0
1
I_C (A)
2

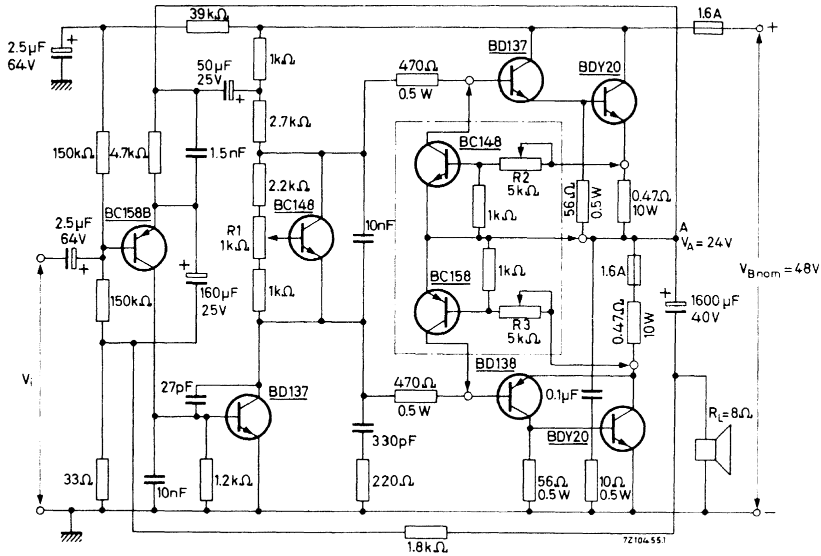

7Z10446
1.5
1
0.5
0
V_{BEsat}
(V)
$T_j = 25°C$
typical
values
$I_C/I_B = 5$
10
20
0
1
I_C (A)
2


7Z10442
V_{CE} = 5V
f = 35 MHz
T_j = 25°C
typ
f_T (MHz)
300
200
100
0
1
10
100
1000
I_C (mA)

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

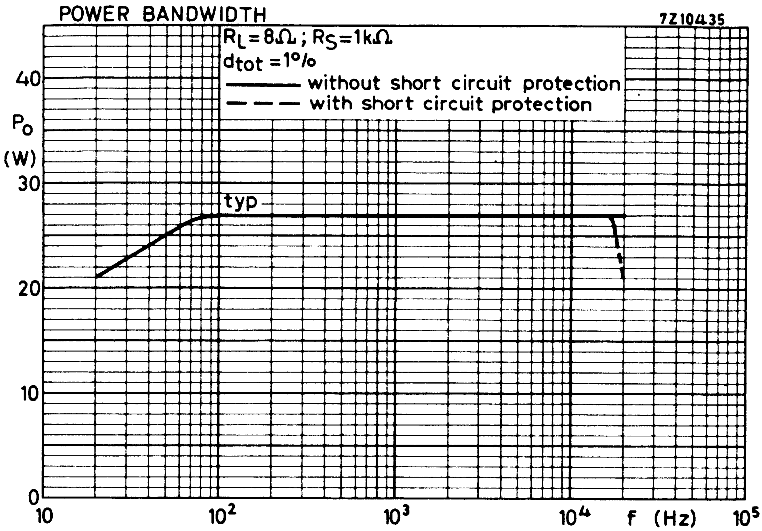
Collector quiescent current of BDY20	I_{CQ}	typ.	40	mA
Total current drain at f = 1 kHz; P_o = 25 W	I_{tot}	typ.	830	mA
Input impedance	$\|Z_i\|$	typ.	150	kΩ
Output power at f = 1 kHz; d_{tot} = 1%	P_o	typ.	27	W
Input voltage for P_o = 25 W	V_i	typ.	350	mV
Total harmonic distortion at P_o = 25 W				
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

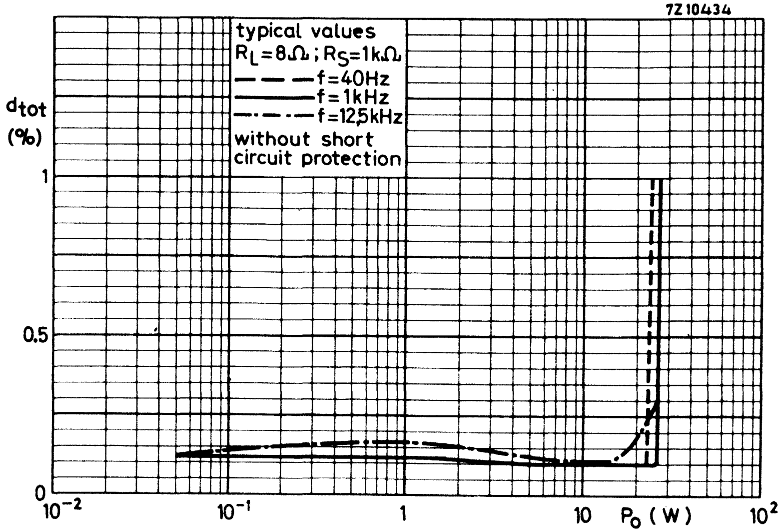
R_2 and R_3 to be adjusted so as to protect the output stage against current peaks higher than I_{CM} = 4 A.

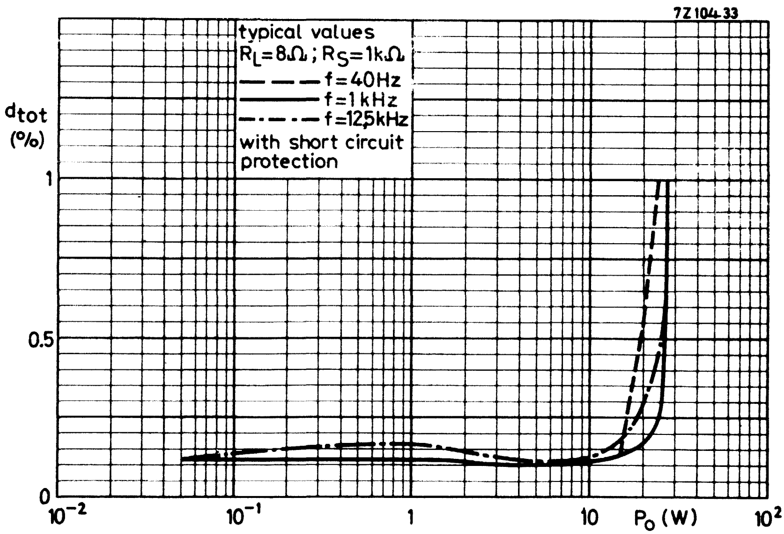
APPLICATION INFORMATION (continued)

25 W hi-fi amplifier (continued)



APPLICATION INFORMATION (continued)

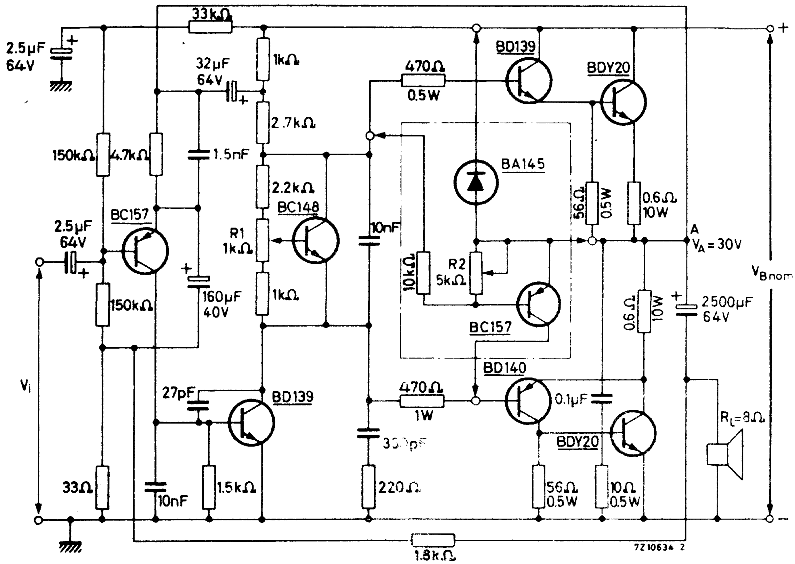




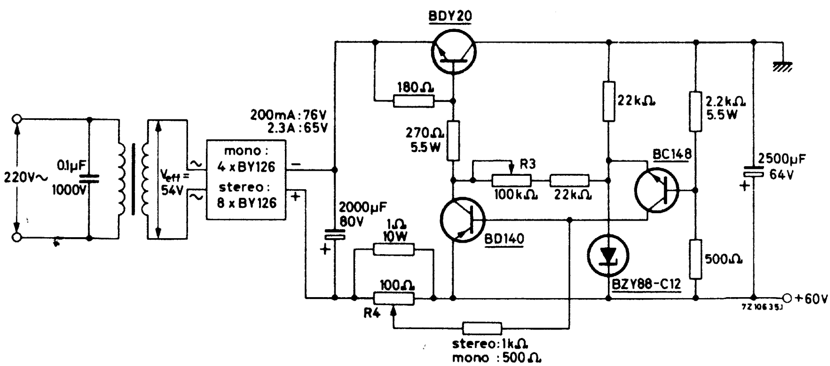
APPLICATION INFORMATION (continued)

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

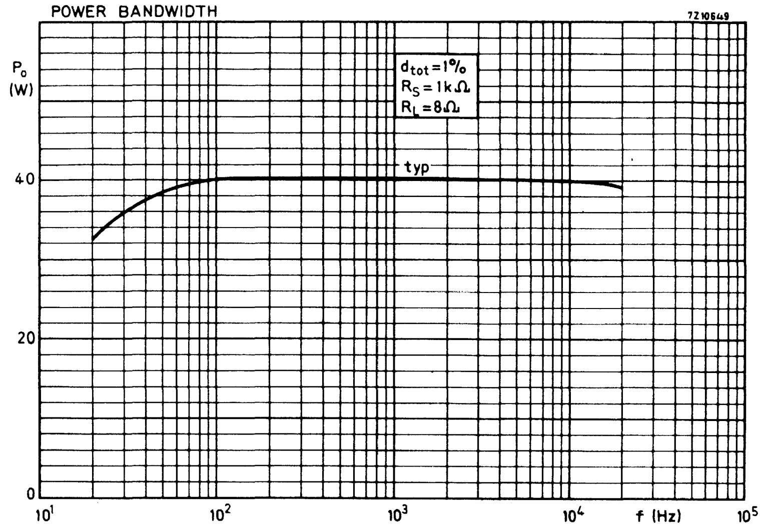
The average supply current is limited by R_4 (lower figure opposite)

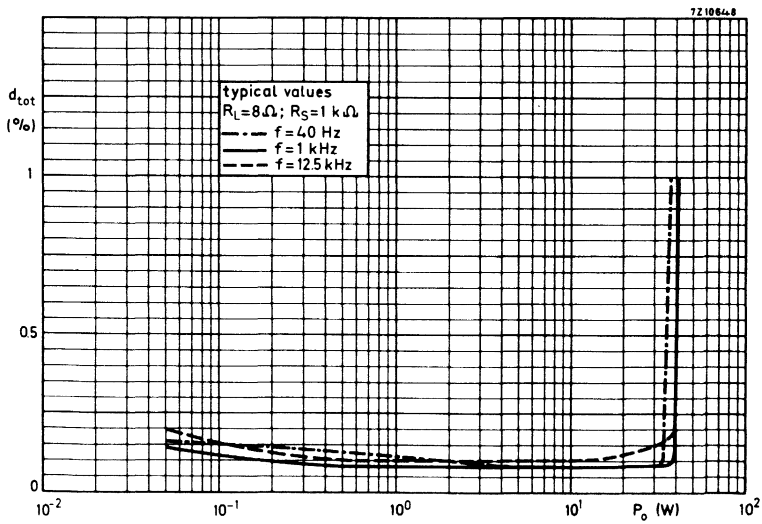
to 1,3 A for mono
or 2,3 A for stereo
where R_L = 8 Ω

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

General purpose p-n-p transistors in SOT-32 plastic envelope, recommended for driver stages in hi-fi amplifiers and television circuits.
The BD135, BD137 and BD139 are complementary to the BD136, BD138 and BD140 respectively.

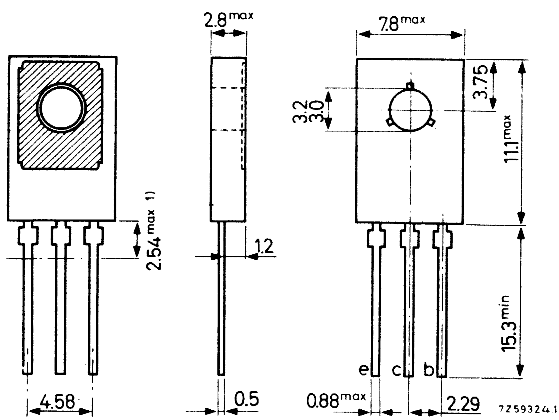
QUICK REFERENCE DATA

			BD136	BD138	BD140	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Collector-current (peak value)	$-I_{CM}$	max.	1,5	1,5	1,5	A
Total power dissipation up to T_{mb} = 70 °C	P_{tot}	max.	8	8	8	W
Junction temperature	T_j	max.	150	150	150	°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

SOT-32 (TO-126)
Collector connected to metal part of mounting surface



For mounting instructions see section Accessories type 56326 for non-insulated mounting and type 56333 for insulated mounting.

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	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V
Currents						
Collector current (d.c.)	$-I_C$	max.	1,0	1,0	1,0	A
Collector current (peak value)	$-I_{CM}$	max.	1,5	1,5	1,5	A

Power dissipation

Total power dissipation up to T_{mb} = 70 °C	P_{tot}	max.	8	W

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	$R_{th\ j-a}$	100	°C/W
From junction to mounting base	$R_{th\ j-mb}$	10	°C/W

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

			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

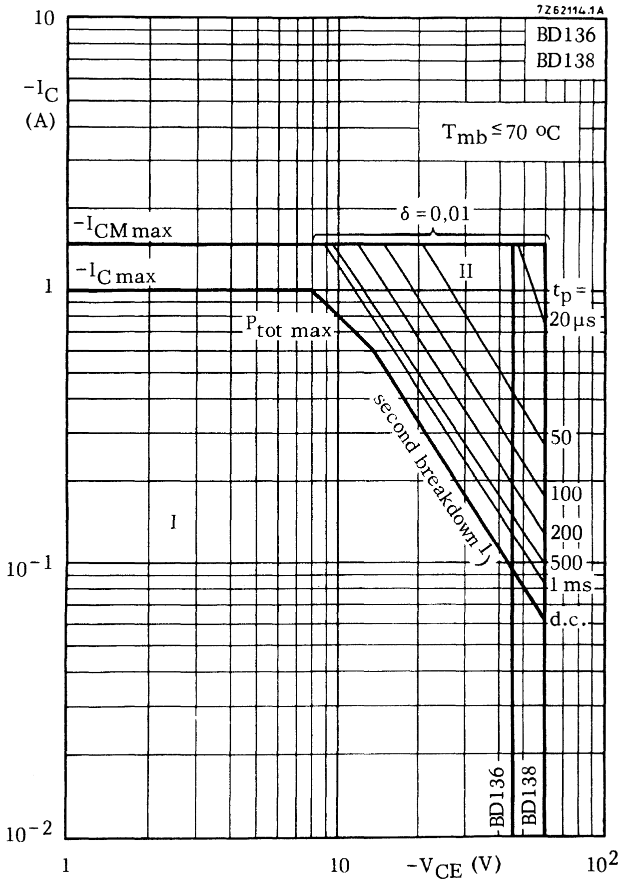
D.C. current gain ratio of

matched pairs

BD135/BD136; BD137/BD138

BD139/BD140

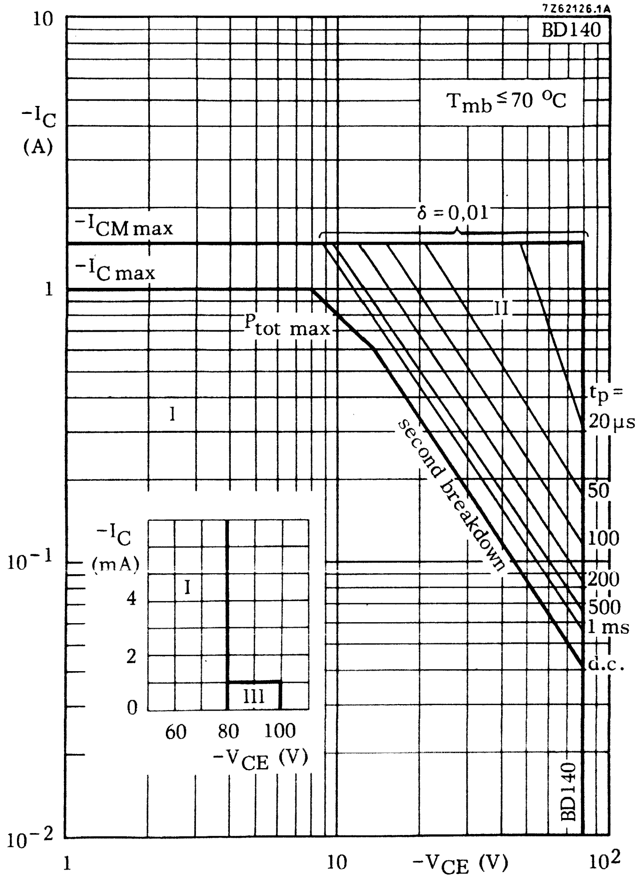
$\|I_C\|$ = 150 mA; $\|V_{CE}\|$ = 2 V	h_{FE1}/h_{FE2}	typ.	1,3
		<	1,6



Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation

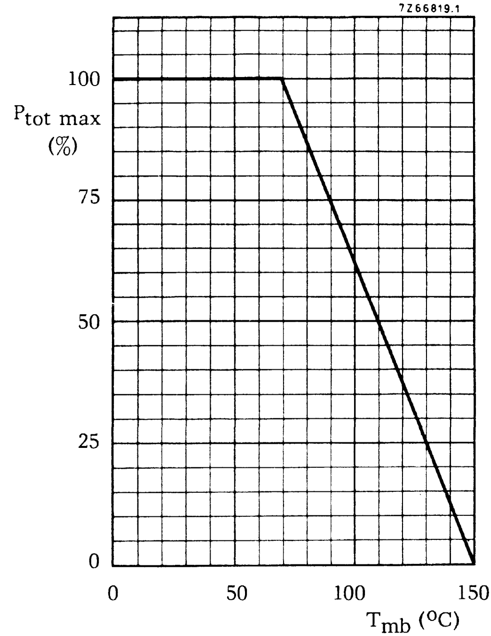
1) Independent of temperature

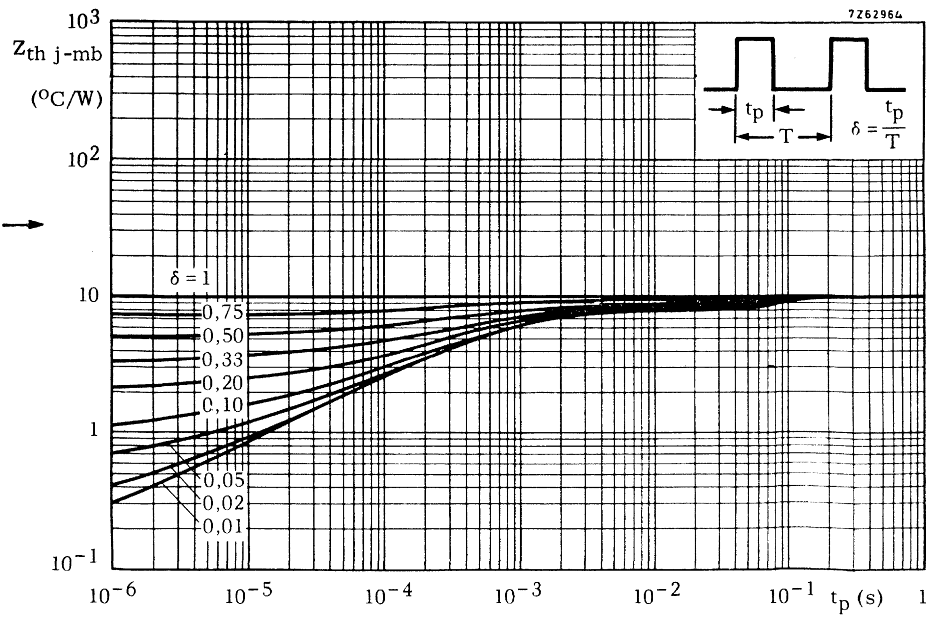


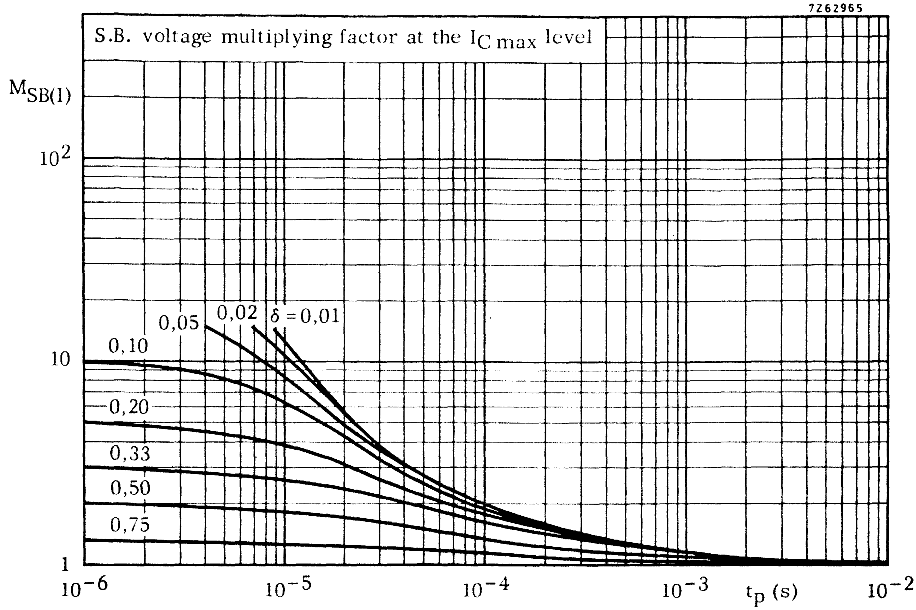
Safe Operating Area with the transistor forward biased

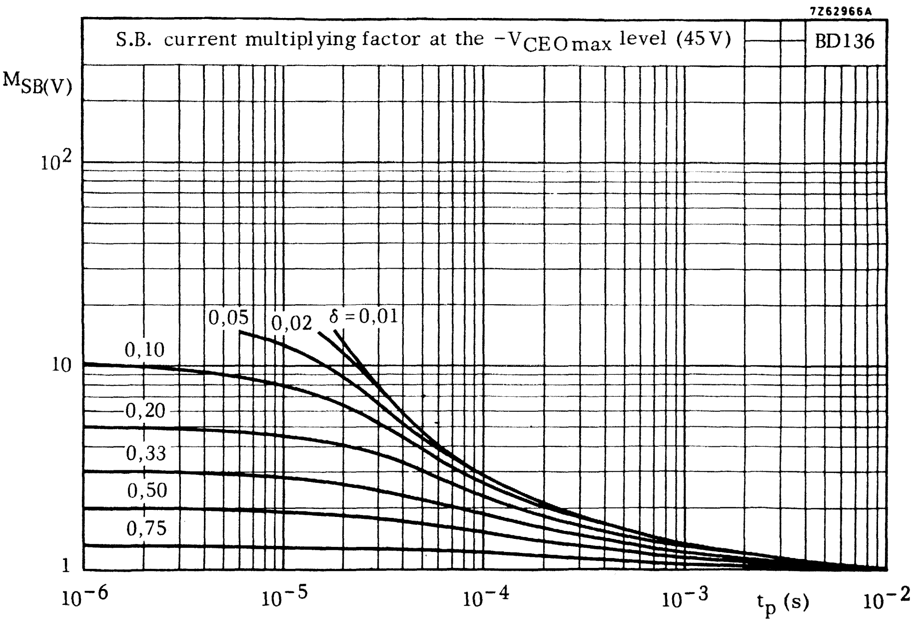
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 1$ kΩ.

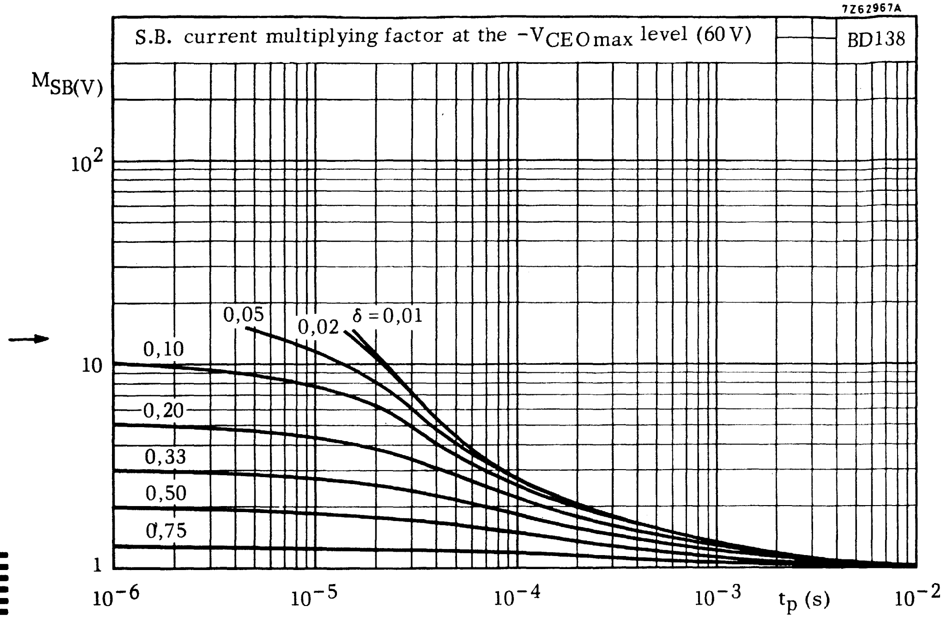
[1]) Independent of temperature

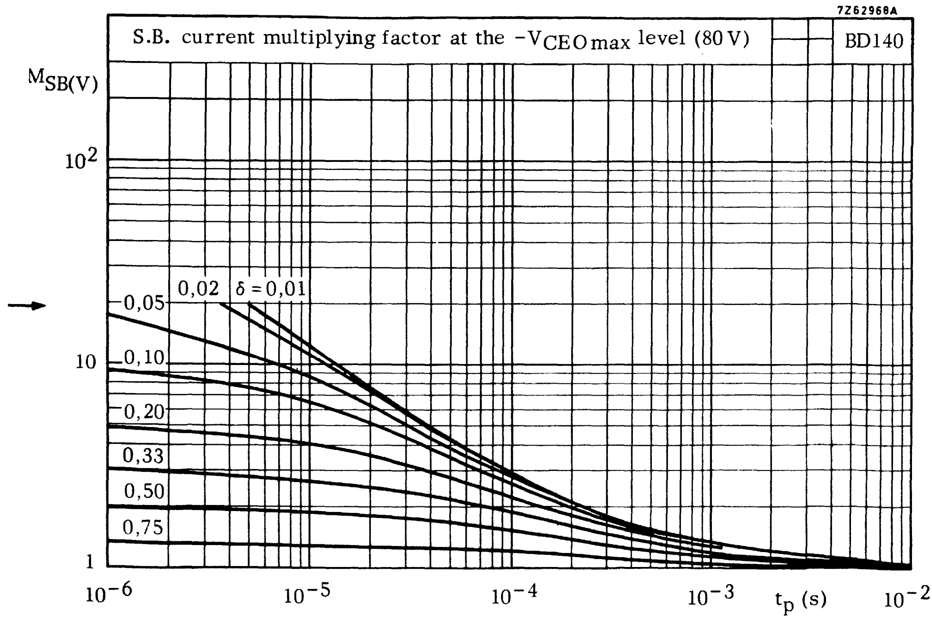

7Z66819.1
100
$P_{tot\ max}$
(%)
75
50
25
0
0
50
100
150
T_{mb} (°C)

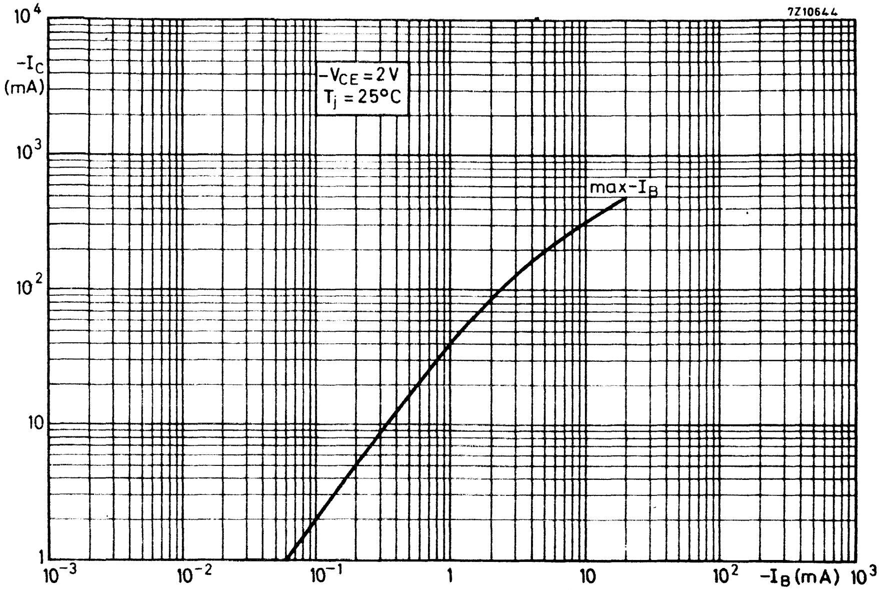

7Z62964
10^3
$Z_{th\ j\text{-}mb}$
(°C/W)
10^2
10
1
10^{-1}
$\delta = 1$
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
t_p (s)
1

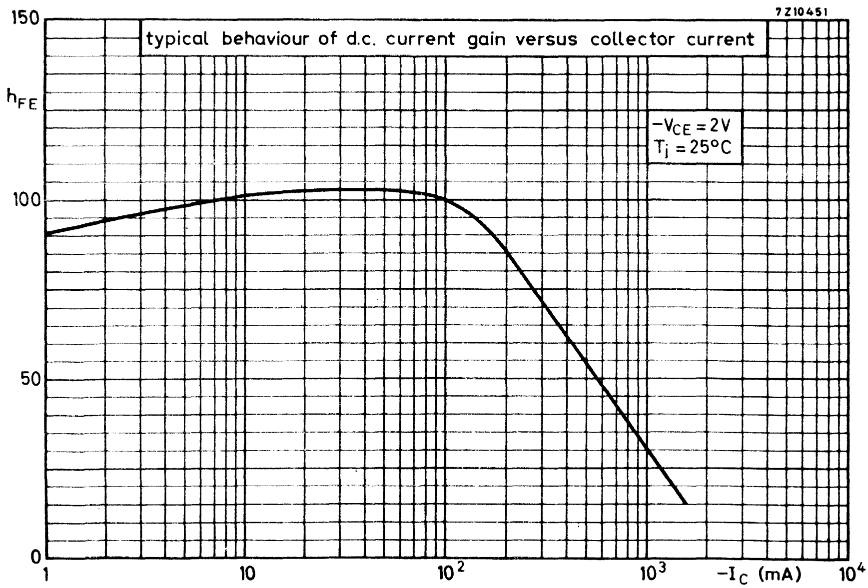

7Z62965
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

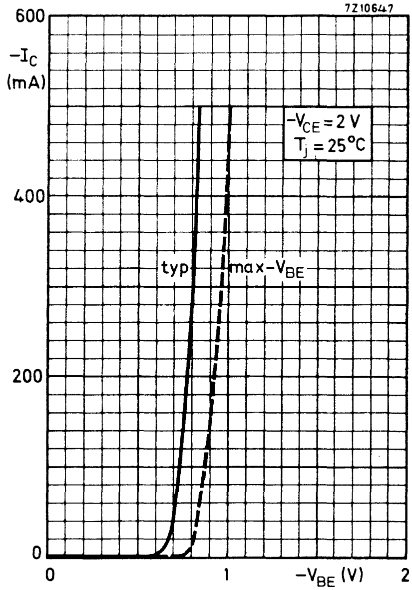

7Z62966A
S.B. current multiplying factor at the $-V_{CEO\,max}$ level (45 V)
BD136
$M_{SB(V)}$
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

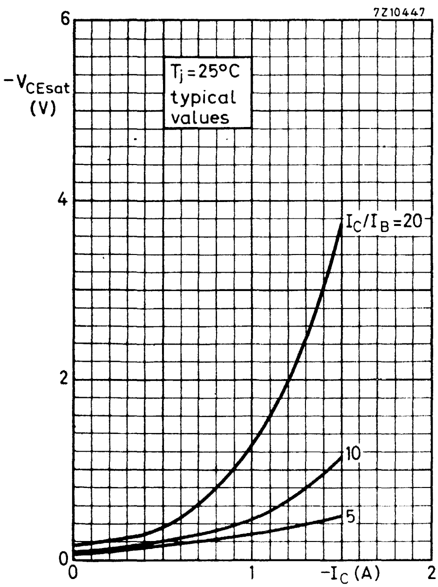

7Z62967A
S.B. current multiplying factor at the $-V_{CEOmax}$ level (60 V)
BD138
$M_{SB(V)}$
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

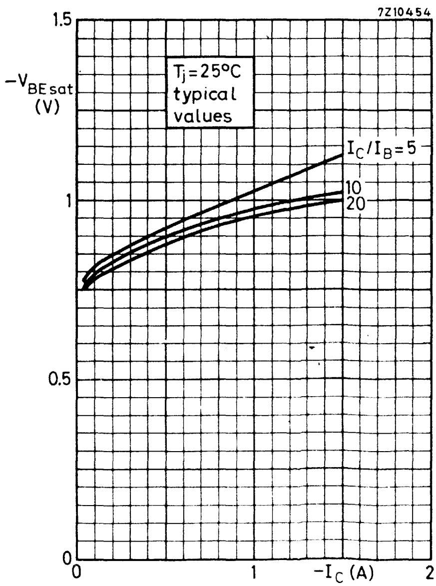

7Z62968A
S.B. current multiplying factor at the $-V_{CEOmax}$ level (80 V)
BD140
$M_{SB(V)}$
10^2
10
1
0,02
δ = 0,01
0,05
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

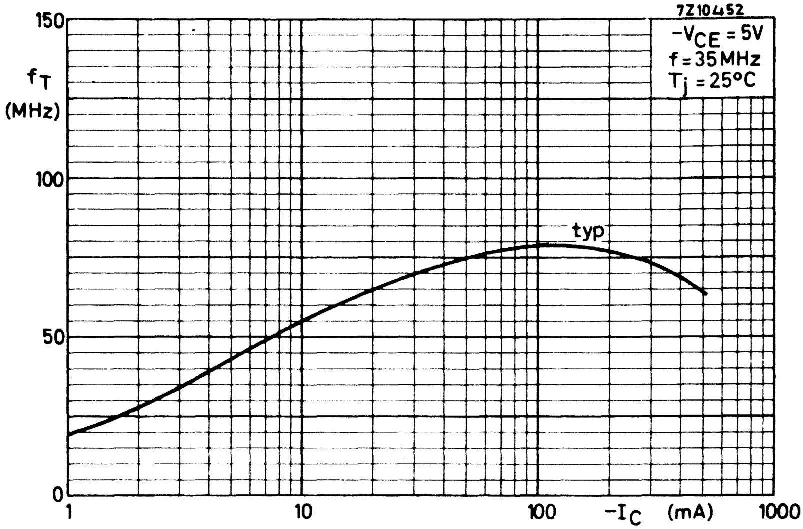

7Z10644
10^4
$-I_C$ (mA)
$-V_{CE} = 2$ V
$T_j = 25$°C
10^3
max-I_B
10^2
10
1
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
$-I_B$ (mA)
10^3


7Z10451
typical behaviour of d.c. current gain versus collector current
150
h_{FE}
$-V_{CE} = 2$ V
$T_j = 25$°C
100
50
0
1
10
10^2
10^3
$-I_C$ (mA)
10^4


7Z10647
600
$-I_C$
(mA)
400
200
0
0
1
$-V_{BE}$ (V)
2
$-V_{CE} = 2$ V
$T_j = 25$ °C
typ
max $-V_{BE}$


7Z10447
6
$-V_{CEsat}$
(V)
4
2
0
0
1
$-I_C$ (A)
2
$T_j = 25$ °C
typical
values
$I_C/I_B = 20$
10
5


7Z10454
1.5
$-V_{BEsat}$
(V)
1
0.5
0
0
1
$-I_C$ (A)
2
$T_j = 25$ °C
typical
values
$I_C/I_B = 5$
10
20



APPLICATION INFORMATION See BD135; BD137; BD139

AUDIO FREQUENCY POWER TRANSISTORS

N-P-N silicon diffused power transistors in a TO-3 metal envelope for use in hi-fi audio equipment.
The BD181 is intended for 20 W into 4 Ω as well as 15 W into 8 Ω.
The BD182 is intended for 40 W into 4 Ω.
The BD183 is intended for 40 W into 8 Ω.
The transistors are also available as matched pairs under the typenumbers 2-BD181, 2-BD182 and 2-BD183.

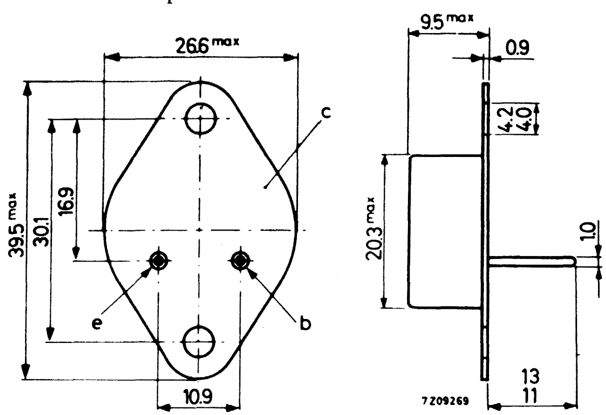
QUICK REFERENCE DATA

			BD181	BD182	BD183	
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 100 Ω)	V_{CER}	max.	55	70	85	V
Collector current (peak value)	I_{CM}	max.	15	15	15	A
Total power dissipation						
up to T_{mb} = 25 °C	P_{tot}	max.	–	117	117	W
up to T_{mb} = 83 °C	P_{tot}	max.	78	–	–	W
Junction temperature	T_j	max.	200	200	200	°C
D.C. current gain						
I_C = 3 A; V_{CE} = 4 V	h_{FE}		20 to 70	–	20 to 70	
I_C = 4 A; V_{CE} = 4 V	h_{FE}		–	20 to 70	–	
Cut-off frequency						
I_C = 0.3 A; V_{CE} = 4 V	f_{hfe}	>	15	15	15	kHz

MECHANICAL DATA Dimensions in mm

Collector connected to envelope

TO-3



Accessories supplied on request: 56201e (for insulated mounting on a 2 mm heatsink)

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

			BD181	BD182	BD183	
Voltages						
Collector-base voltage (open emitter)	V_{CBO}	max.	55	70	85	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 100 Ω)	V_{CER}	max.	55	70	85	V
Emitter-base voltage (open collector)	V_{EBO}	max,	7	7	7	V
Currents						
Collector current (d.c.)	I_C	max.	10	15	15	A
Collector current (peak value)	I_{CM}	max.	15	15	15	A
Emitter current (peak value)	$-I_{EM}$	max.	15	15	15	A
Base current (peak value)	I_{BM}	max.	7	7	7	A
Power dissipation						
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	–	117	117	W
up to T_{mb} = 83 °C	P_{tot}	max.	78	–	–	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
From junction to ambient	$R_{th\ j\text{-}a}$	=	45	°C/W
From mounting base to heatsink with accessory 56201e	$R_{th\ mb\text{-}h}$	=	0.75	°C/W

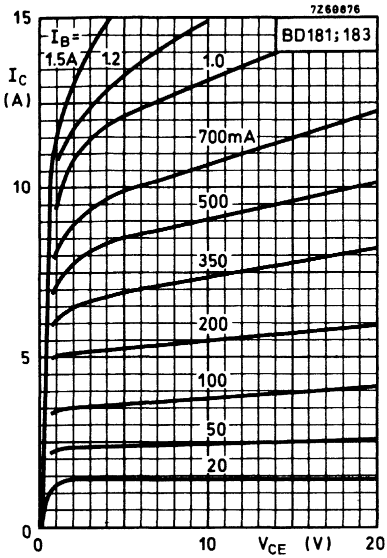
CHARACTERISTICS T_j = 25 °C unless otherwise specified

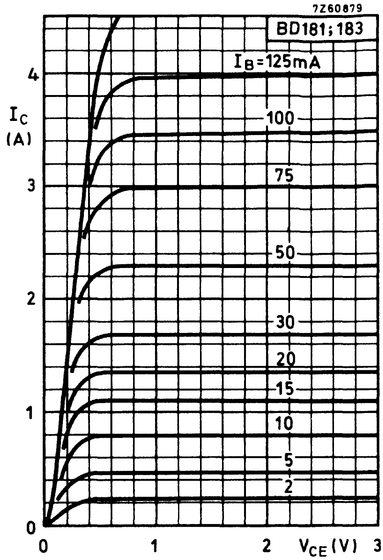
			BD181	BD182	BD183	
Collector cut-off current						
I_E = 0; V_{CB} = 45 V; T_j = 200 °C	I_{CBO}	<	2	–	–	mA
I_E = 0; V_{CB} = 60 V; T_j = 200 °C	I_{CBO}	<	–	5	–	mA
I_E = 0; V_{CB} = 80 V; T_j = 200 °C	I_{CBO}	<	–	–	5	mA

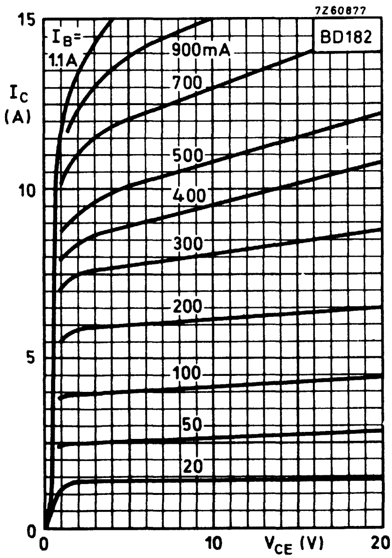
CHARACTERISTICS (continued) $T_j = 25\ ^oC$ unless otherwise specified

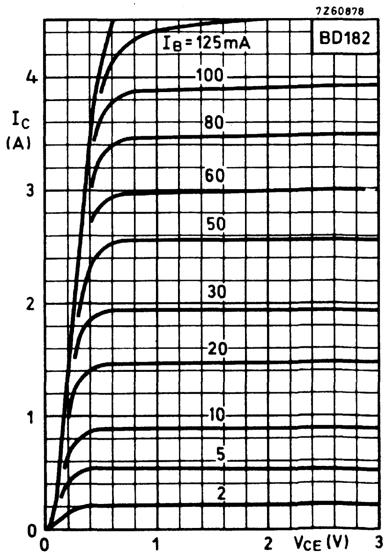
			BD181	BD182	BD183	
Emitter cut-off current						
$I_C = 0$; $V_{EB} = 7$ V	I_{EBO}	typ.	0.1	0.1	0.1	mA
		<	5	5	5	mA
Base-emitter voltage [1]						
$I_C = 3$ A; $V_{CE} = 4$ V	V_{BE}	typ.	1.15	–	1.15	V
		<	1.5	–	1.5	V
$I_C = 4$ A; $V_{CE} = 4$ V	V_{BE}	typ.	–	1.15	–	V
		<	–	1.5	–	V
Knee voltage						
$I_C = 3$ A; I_B = value for which $I_C = 3.3$ A at $V_{CE} = 1.5$ V	V_{CEK}	typ.	0.5	–	0.5	V
		<	1	–	1	V
$I_C = 4$ A; I_B = value for which $I_C = 4.4$ A at $V_{CE} = 1.5$ V	V_{CEK}	typ.	–	0.55	–	V
		<	–	1	–	V
D.C. current gain						
$I_C = 3$ A; $V_{CE} = 4$ V	h_{FE}	typ.	40	–	40	
			20 to 70	–	20 to 70	
$I_C = 4$ A; $V_{CE} = 4$ V	h_{FE}	typ.	–	40	–	
			–	20 to 70	–	
Linearity						
$V_{CE} = 4$ V						
$\frac{h_{FE} \text{ at } I_C = 0.3 \text{ A}}{h_{FE} \text{ at } I_C = 3 \text{ A}}$		typ.	2.5	–	2.5	
		<	3.5	–	3.5	
$\frac{h_{FE} \text{ at } I_C = 0.3 \text{ A}}{h_{FE} \text{ at } I_C = 4 \text{ A}}$		typ.	–	2.5	–	
		<	–	4.0	–	
Cut-off frequency						
$I_C = 0.3$ A; $V_{CE} = 4$ V	f_{hfe}	>	15	15	15	kHz
D.C. current gain ratio of matched pairs 2-BD181; 2-BD182 and 2-BD183						
$I_C = 3$ A; $V_{CE} = 4$ V	h_{FE1}/h_{FE2}	<	1.3	–	1.3	
$I_C = 4$ A; $V_{CE} = 4$ V	h_{FE1}/h_{FE2}	<	–	1.3	–	

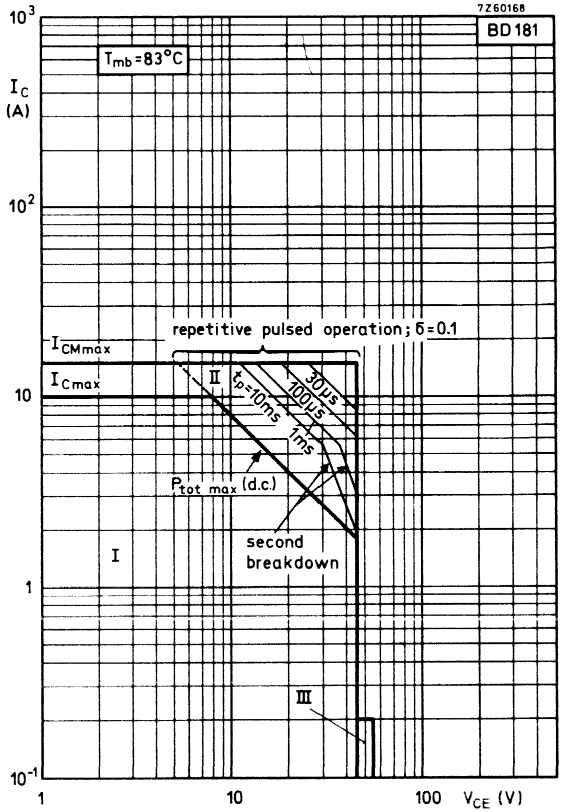
[1] V_{BE} decreases by about 2 mV/^oC with increasing temperature.


7Z60876
BD181; 183
I_B=
1.5A
1.2
1.0
700mA
500
350
200
100
50
20
I_C (A)
V_{CE} (V)
15
10
5
0
0
10
20


7Z60879
BD181; 183
I_B=125mA
100
75
50
30
20
15
10
5
2
I_C (A)
V_{CE} (V)
4
3
2
1
0
0
1
2
3


7Z60877
BD182
I_B=
1.1A
900mA
700
500
400
300
200
100
50
20
I_C (A)
V_{CE} (V)
15
10
5
0
0
10
20


7Z60878
BD182
I_B=125mA
100
80
60
50
30
20
10
5
2
I_C (A)
V_{CE} (V)
4
3
2
1
0
0
1
2
3

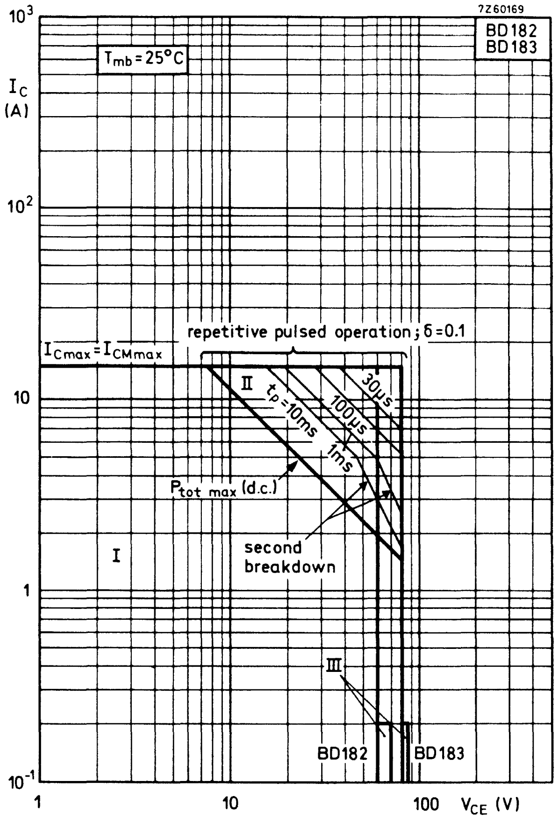


Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulsed operation

III Repetitive pulsed operation in this region is allowable, provided $R_{BE} \leq 100\Omega$

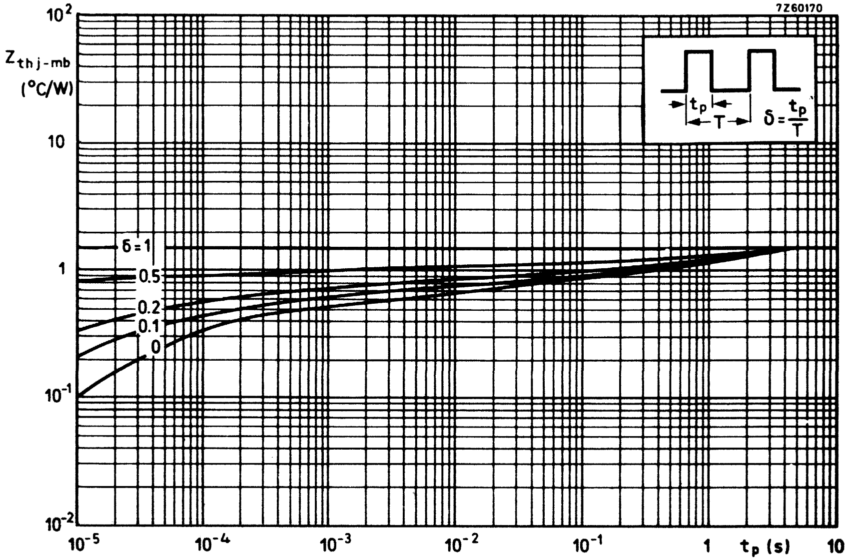


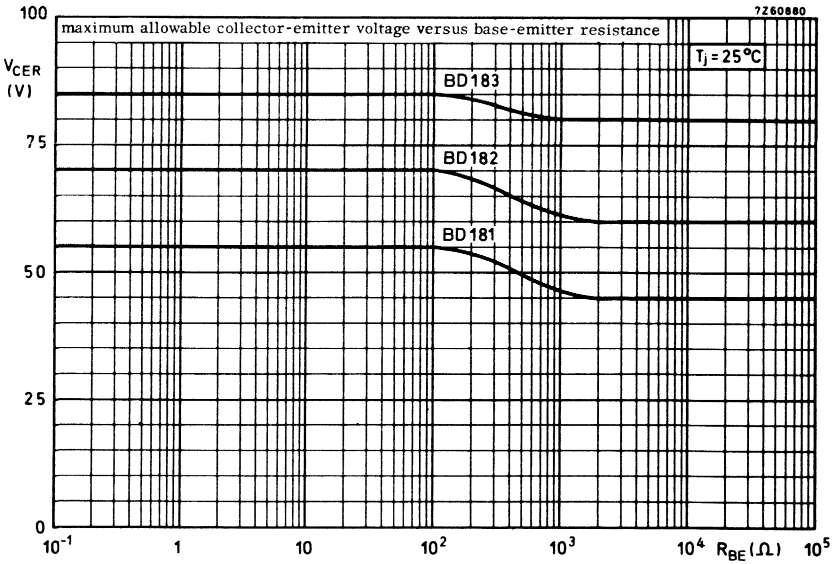
Safe Operating Area with the transistor forward biased

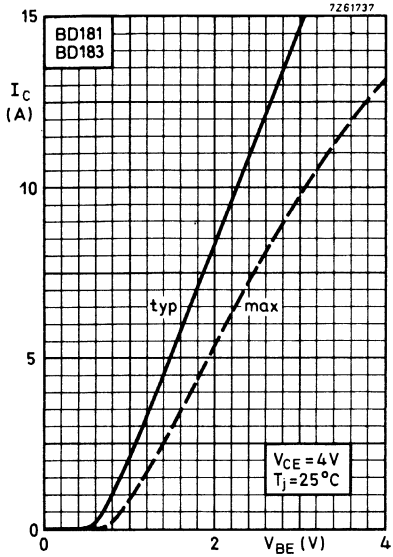
I Region of permissible d.c. operation

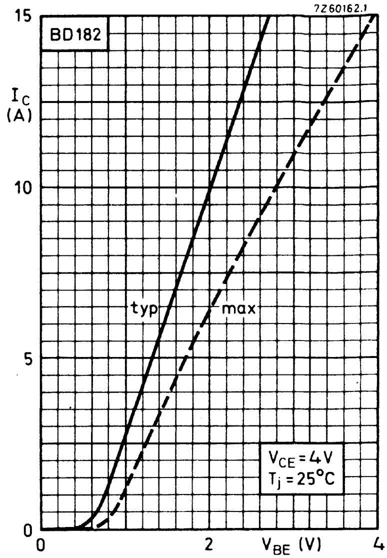
II Permissible extension for repetitive pulsed operation

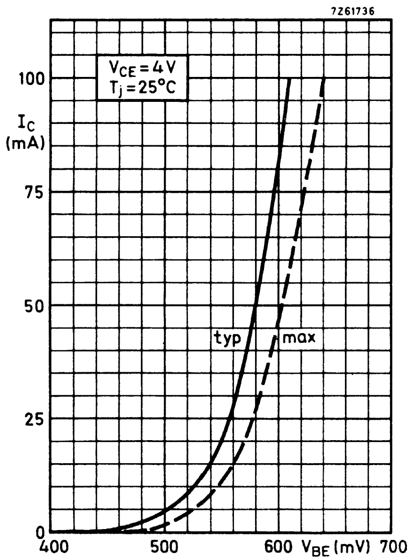
III Repetitive pulsed operation in this region is allowable, provided $R_{BE} \leq 100\Omega$

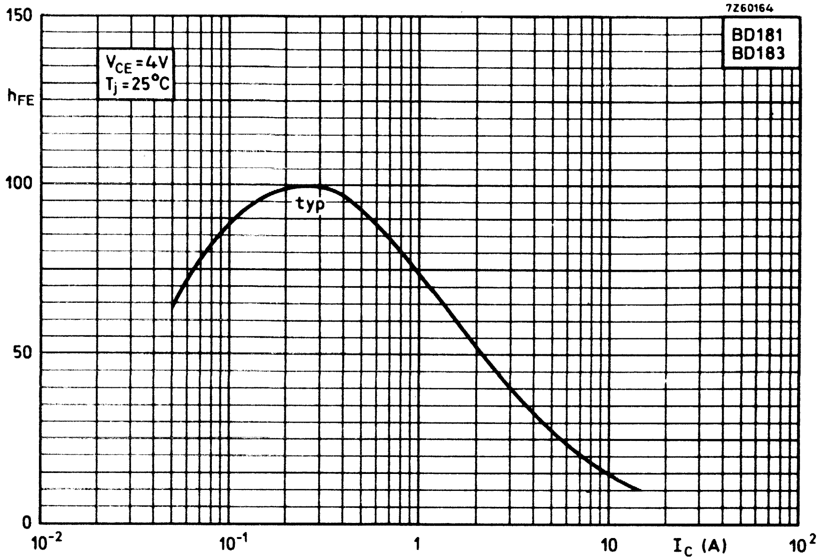

7Z60170
$Z_{th\,j-mb}$ (°C/W)
10^2
10
1
10^{-1}
10^{-2}
δ = 1
0.5
0.2
0.1
0
t_p
T
$\delta = \frac{t_p}{T}$
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t_p (s)
10

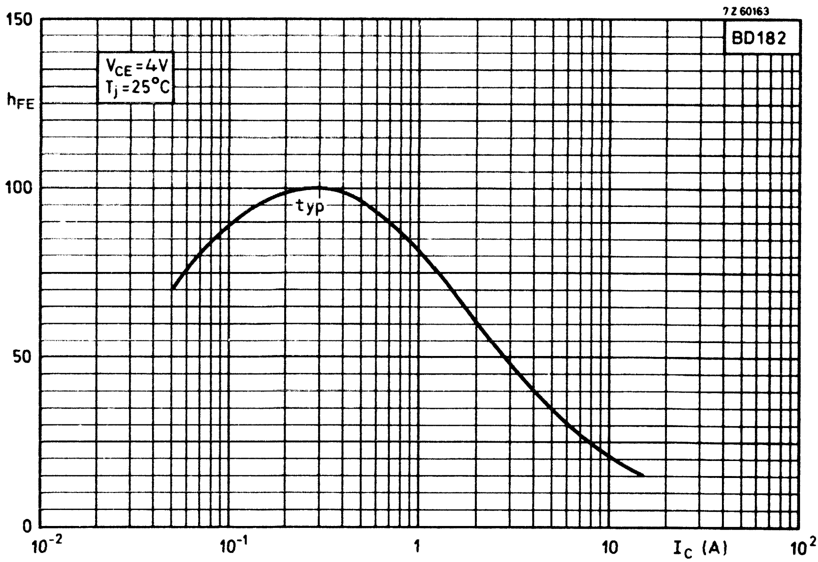

7Z60880
maximum allowable collector-emitter voltage versus base-emitter resistance
T_j = 25°C
V_{CER} (V)
100
75
50
25
0
BD183
BD182
BD181
10^{-1}
1
10
10^2
10^3
10^4
R_{BE} (Ω)
10^5

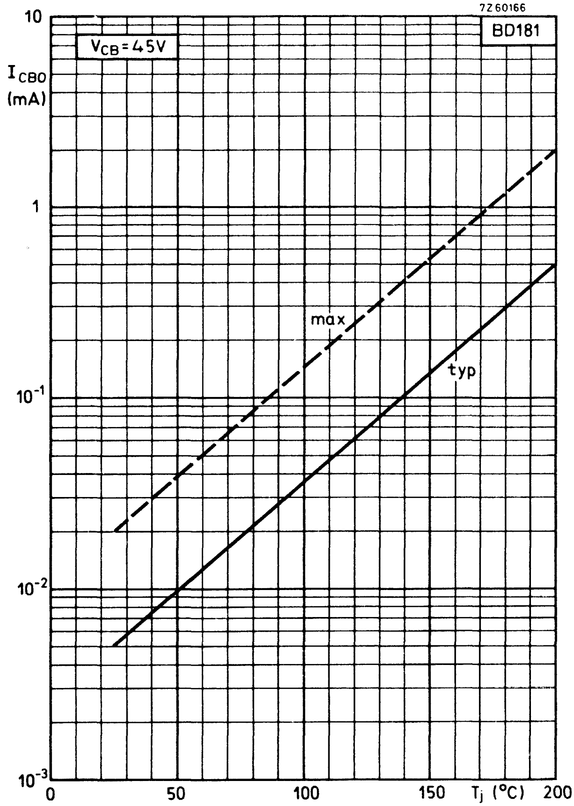

7Z61737
BD181
BD183
I_C
(A)
15
10
5
0
0
2
4
V_{BE} (V)
typ
max
V_{CE} = 4 V
T_j = 25 °C

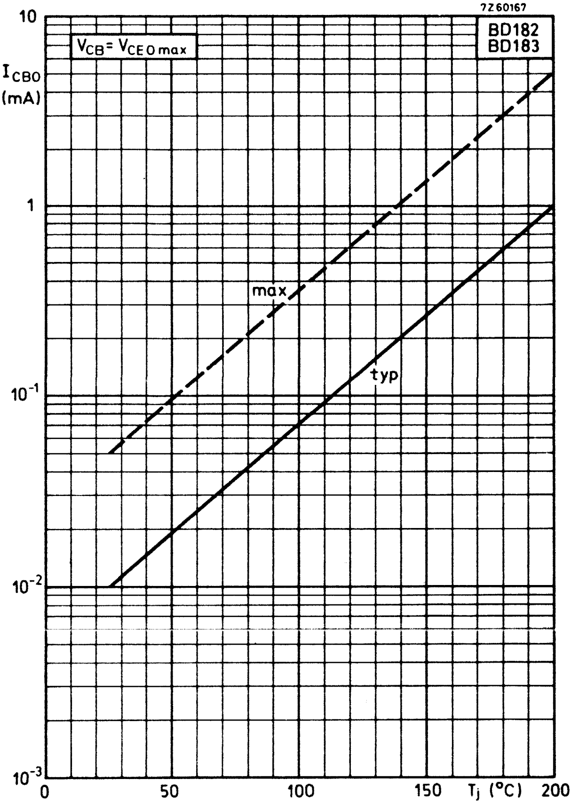

7Z60162.1
BD182
I_C
(A)
15
10
5
0
0
2
4
V_{BE} (V)
typ
max
V_{CE} = 4 V
T_j = 25 °C

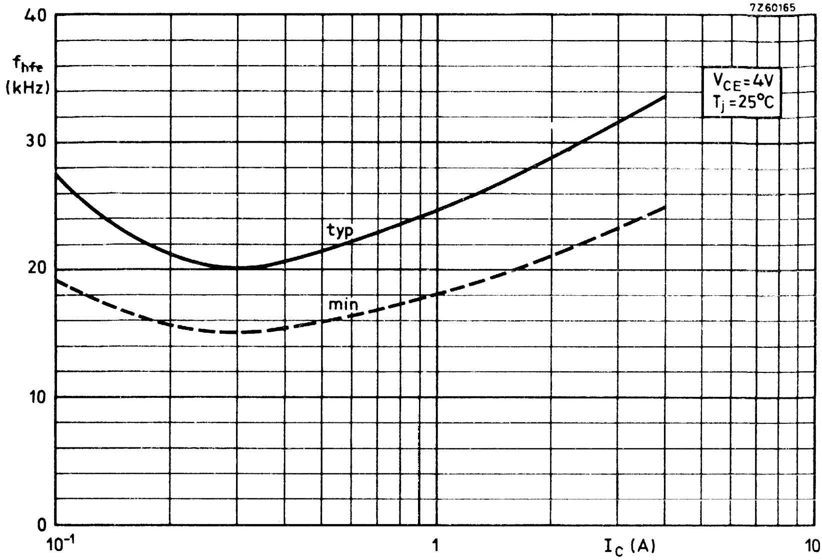

7Z61736
V_{CE} = 4 V
T_j = 25 °C
I_C
(mA)
100
75
50
25
0
400
500
600
700
V_{BE} (mV)
typ
max


7Z60164
BD181
BD183
V_{CE} = 4V
T_j = 25°C
h_{FE}
150
100
50
0
typ
10^{-2}
10^{-1}
1
10
I_C (A)
10^2


7Z60163
BD182
V_{CE} = 4V
T_j = 25°C
h_{FE}
150
100
50
0
typ
10^{-2}
10^{-1}
1
10
I_C (A)
10^2

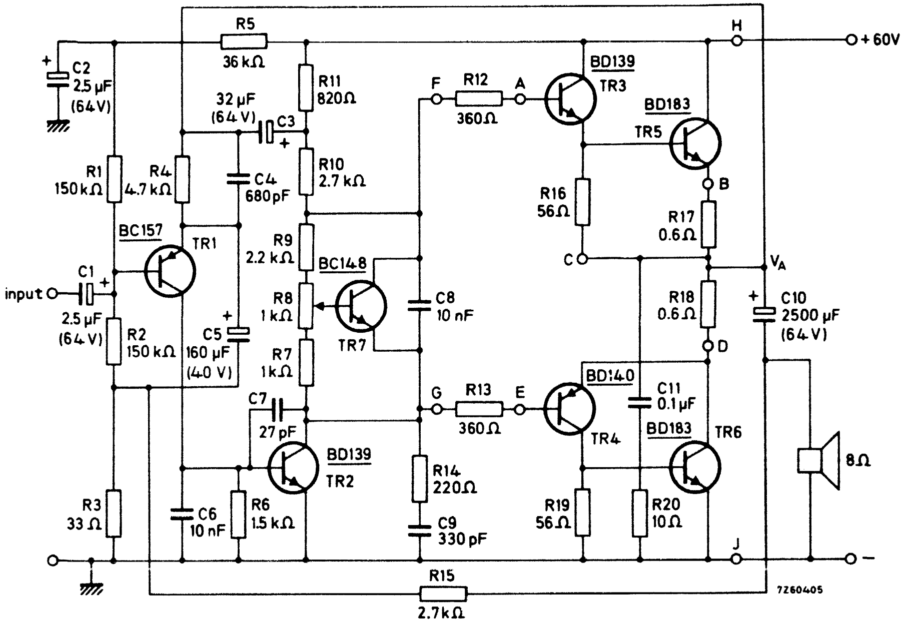

7Z60166
BD181
V_{CB} = 45V
I_{CBO} (mA)
10
1
10^{-1}
10^{-2}
10^{-3}
max
typ
0
50
100
150
T_j (°C)
200


7Z60167
BD182
BD183
V_CB = V_CEO max
I_CBO (mA)
10
1
10^-1
10^-2
10^-3
max
typ
0
50
100
150
T_j (°C)
200


7Z60165
f_{hfe} (kHz)
40
30
20
10
0
V_{CE} = 4V
T_j = 25°C
typ
min
10^{-1}
1
I_C (A)
10

APPLICATION INFORMATION

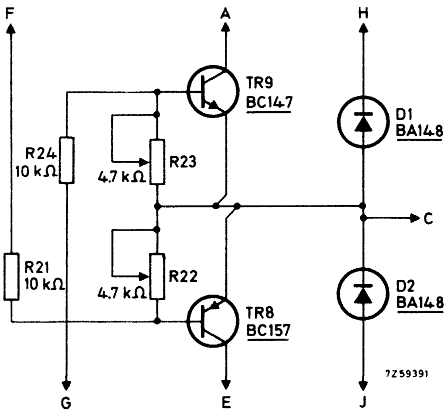
40 W hi-fi amplifier and applicable protection circuit.



Required heatsinks:

For each output transistor (TR5 or TR6) $R_{th\ h-a} \leq 7\ ^{o}C/W$

For each complementary transistor (TR3 or TR4) $R_{th\ h-a} \leq 72\ ^{o}C/W$



APPLICATION INFORMATION (continued)

Performance at V_B = 60V; R_L = 8Ω

Collector quiescent current of BD183	I_{cq}	typ.	40	mA
Total current drain at P_L = 40 W	I_{tot}	typ.	1.1	A
Input impedance	$\|Z_i\|$	typ.	130	kΩ
Output power at f = 1 kHz; d_{tot} = 1%	P_L	>	40	W
Input voltage at f = 1 kHz; P_L = 40 W	V_i	typ.	350	mV
Total harmonic distortion at P_L = 40 W; f = 1 kHz	d_{tot}	typ.	0.27	%
Intermodulation distortion at P_L = 40 W				
f_1 = 250 Hz; f_2 = 8 kHz				
V_i at f_1: V_i at f_2 = 4 : 1	d_{im}	typ.	1.0	%
Frequency response (−1 dB)		10 Hz to 70 kHz		
Unweighted signal-noise ratio (ref. P_L = 50 mW)		>	70	dB
Internal resistance at output socket		typ.	0.08	Ω

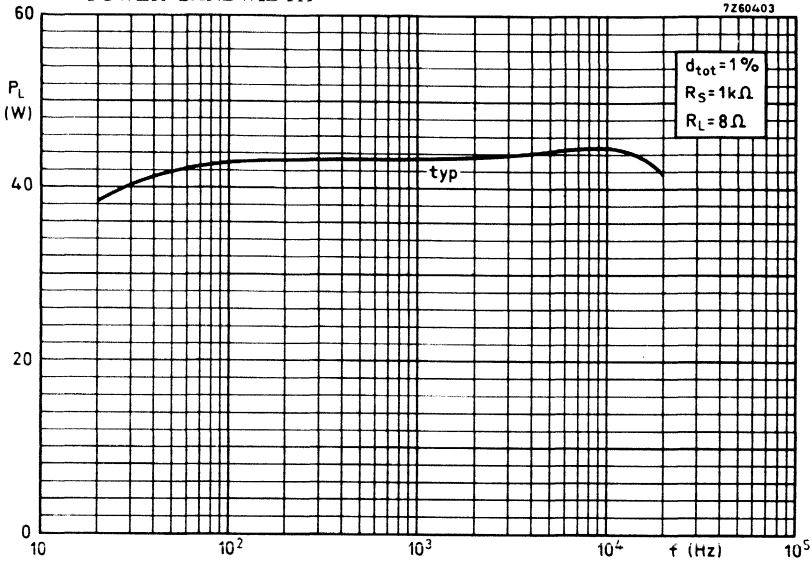
Short circuit protection

R22 and R23 must be adjusted so that the peak collector current of each output transistor (BD183) is limited to I_{CM} = 4.2 A.
Adjust with 2 Ω load resistor.

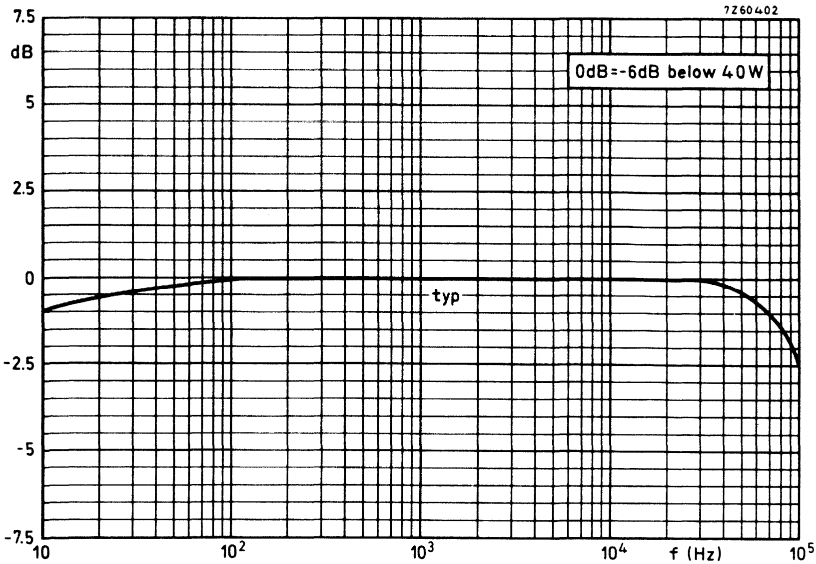
APPLICATION INFORMATION (continued)

40 W hi-fi amplifier (continued)

POWER BANDWIDTH

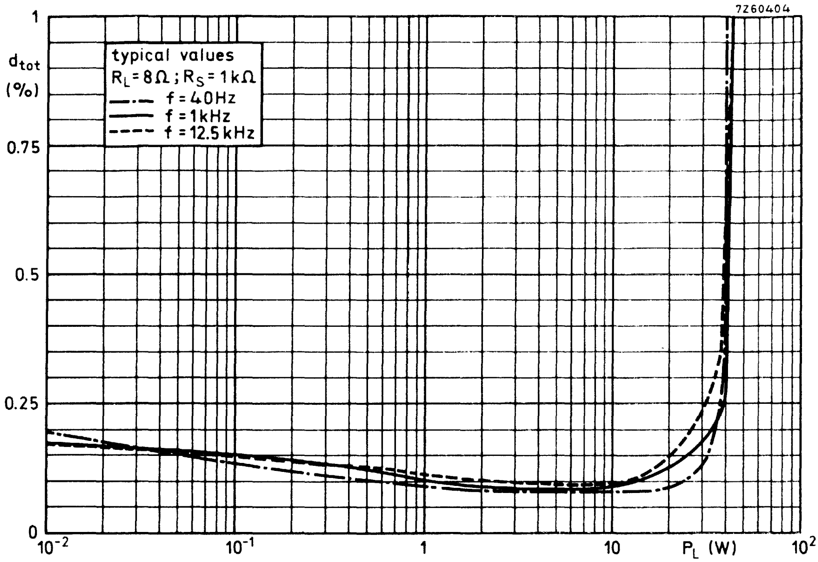


FREQUENCY CHARACTERISTICS



APPLICATION INFORMATION (continued)

40 W hi-fi amplifier (continued)



AUDIO FREQUENCY POWER TRANSISTORS

N-P-N silicon epitaxial-base power transistors in a plastic envelope. With their P-N-P complements BD202 and BD204 they are primarily intended for use in hi-fi equipment delivering an output of 15 W to 25 W into a 4 Ω or 8 Ω load.

QUICK REFERENCE DATA

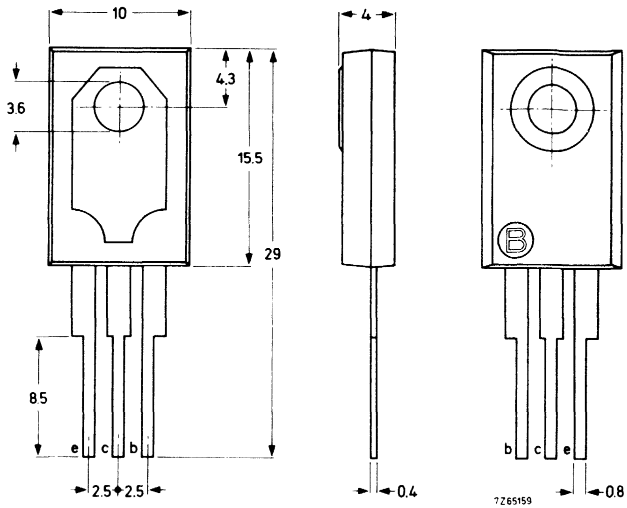
			BD201	BD203	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	60	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	V
Collector current (d.c.)	I_C	max.	8	8	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60	60	W
Junction temperature	T_j	max.	150	150	°C
D.C. current gain					
I_C = 3 A; V_{CE} = 2 V	h_{FE}	>	30	–	
I_C = 2 A; V_{CE} = 2 V	h_{FE}	>	–	30	
Cut-off frequency					
I_C = 0,3 A; V_{CE} = 3 V	f_{hfe}	>	25	25	kHz

MECHANICAL DATA (see page 2)

MECHANICAL DATA

Collector connected to metal part of mounting surface

Dimensions in mm



Accessories available: Insulating bush 56324 and mica washer 56325

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltage			BD201	BD203	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	60	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	V

Current				
Collector current (d.c.)	I_C	max.	8	A
Collector current (peak value, $t_p \leq 10$ ms)	I_{CM}	max.	12	A
Collector current (non-repetitive peak value, $t_p \leq 2$ ms)	I_{CSM}	max.	25	A

Temperature .				
Storage temperature	T_{stg}		−65 to +150	^oC
Junction temperature	T_j	max.	150	^oC

Power dissipation				
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.	60	W

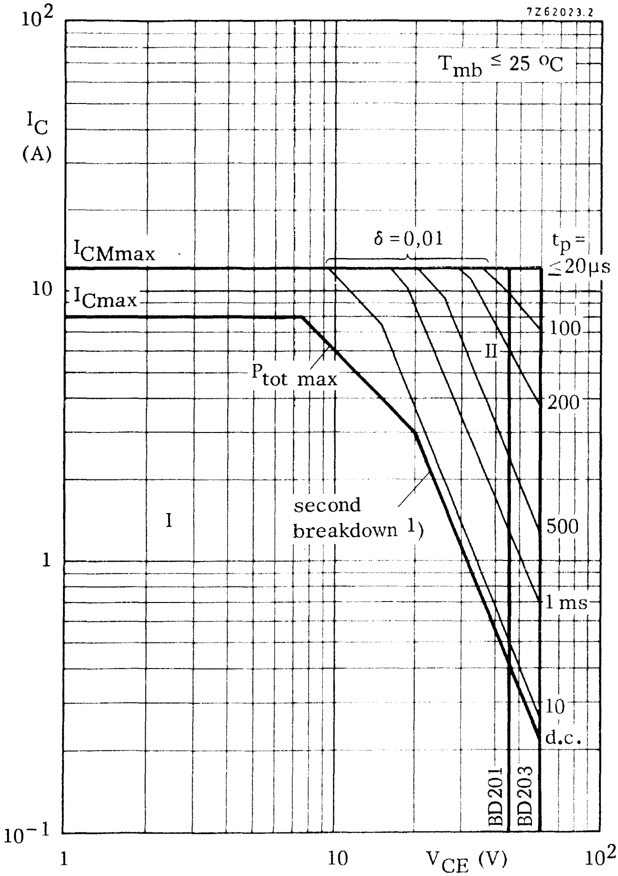
THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,08	$^oC/W$

CHARACTERISTICS $T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current				
$I_B = 0$; $V_{CE} = 30$ V	I_{CEO}	<	1	mA
$I_E = 0$; $V_{CB} = 40$ V; $T_j = 150\ ^oC$	I_{CBO}	<	1	mA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	5	mA
Base-emitter voltage [1])				
$I_C = 3$ A; $V_{CE} = 2$ V	V_{BE}	<	1,5	V
Knee voltage [1])				
$I_C = 3$ A; I_B = value for which $I_C = 3{,}3$ A at $V_{CE} = 2$ V	V_{CEK}	typ.	1	V
Saturation voltage [1])				
$I_C = 3$ A; $I_B = 0{,}3$ A	V_{CEsat}	<	1	V
D.C. current gain [1])				
BD201: $I_C = 3$ A; $V_{CE} = 2$ V	h_{FE}	>	30	
BD203: $I_C = 2$ A; $V_{CE} = 2$ V	h_{FE}	>	30	
$I_C = 1$ A; $V_{CE} = 2$ V	h_{FE}	>	30	
Cut-off frequency				
$I_C = 0{,}3$ A; $V_{CE} = 3$ V	f_{hfe}	>	25	kHz
Transition frequency at f = 1 MHz				
$I_C = 0{,}3$ A; $V_{CE} = 3$ V	f_T	>	3	MHz

[1]) Measured with pulses of 300 μs and with 2% duty cycle.

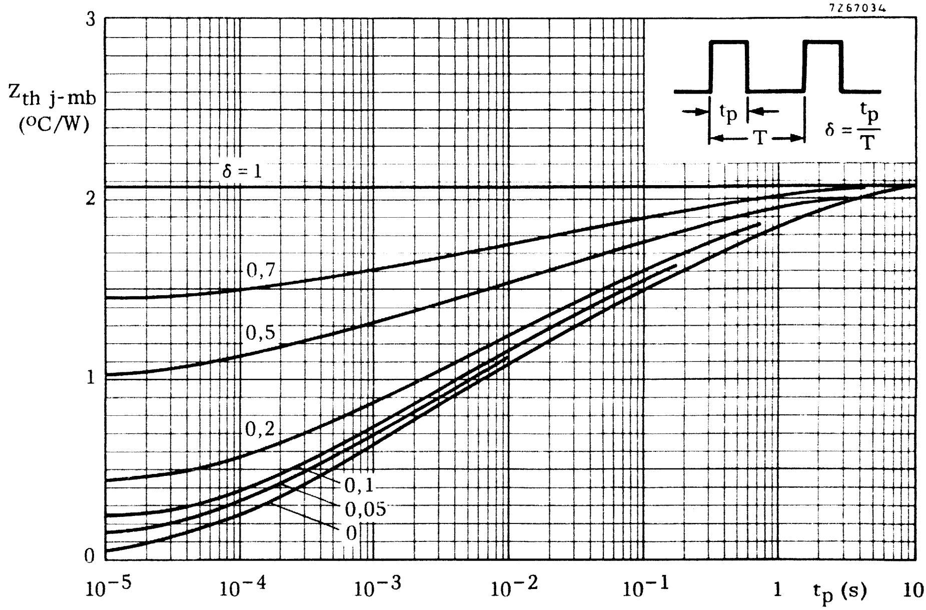


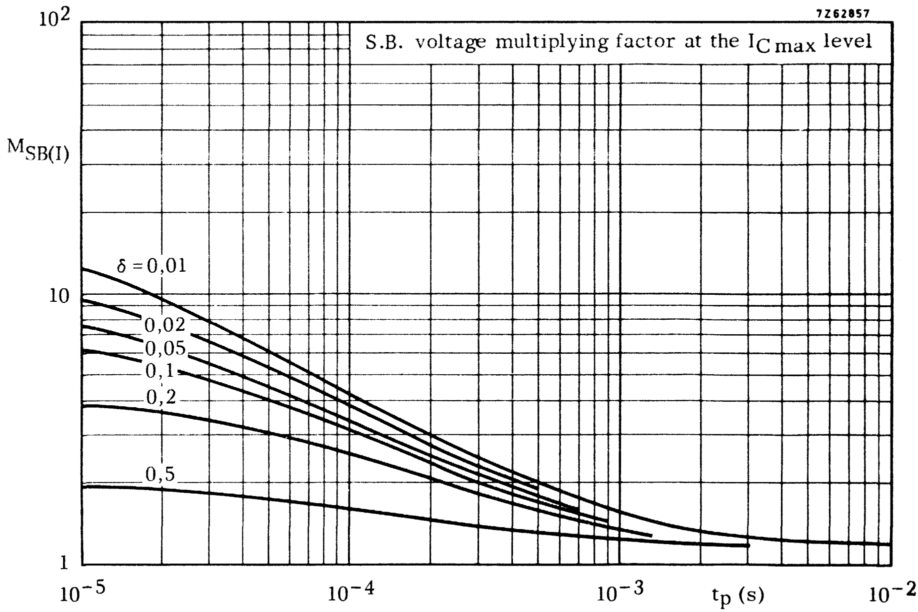
Safe Operating Area with the transistor forward biased

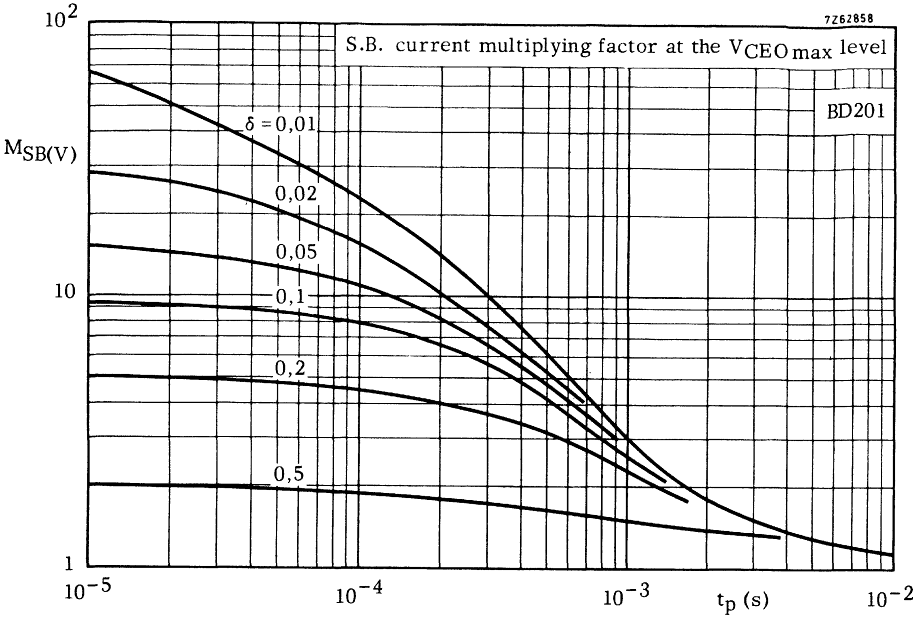
I   Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation

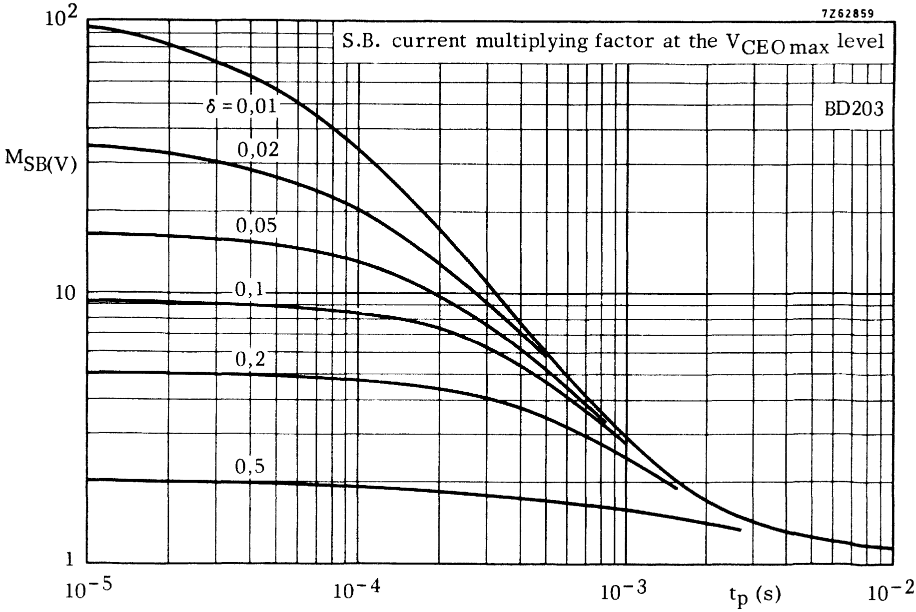
For $P_{tot\ max}$ versus T_{mb} see page 8.

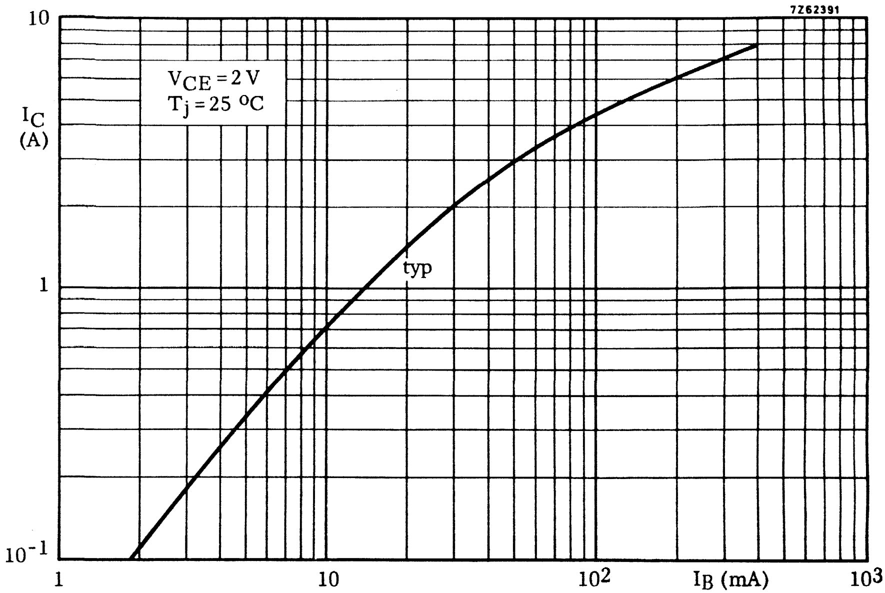
1) Independent of temperature.

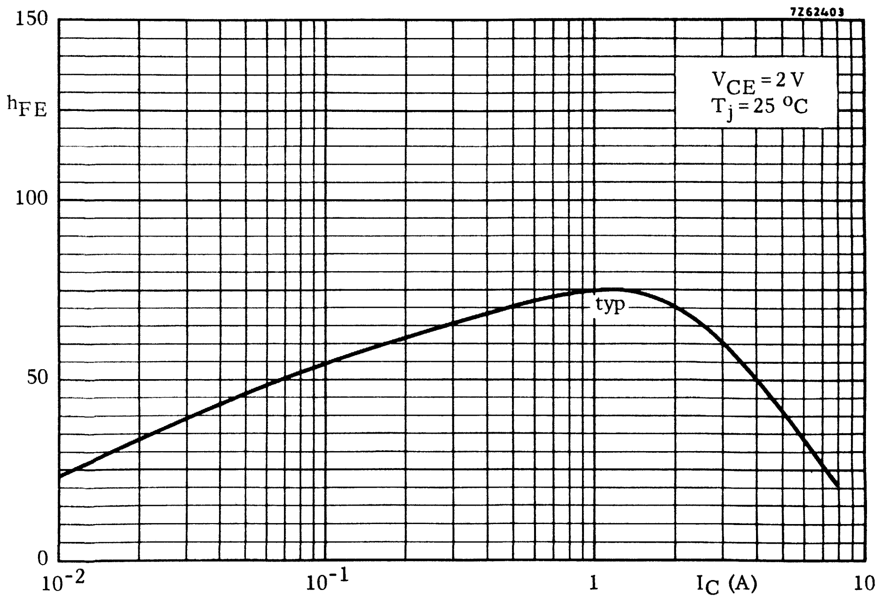

7Z67034
$Z_{th\ j-mb}$ (°C/W)
t_p
T
$\delta = \frac{t_p}{T}$
δ = 1
0,7
0,5
0,2
0,1
0,05
0
3
2
1
0
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t_p (s)
10

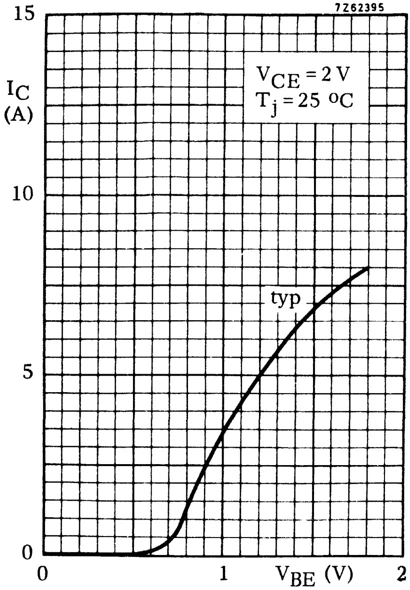

7Z62857
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
δ = 0,01
0,02
0,05
0,1
0,2
0,5
10^2
10
1
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

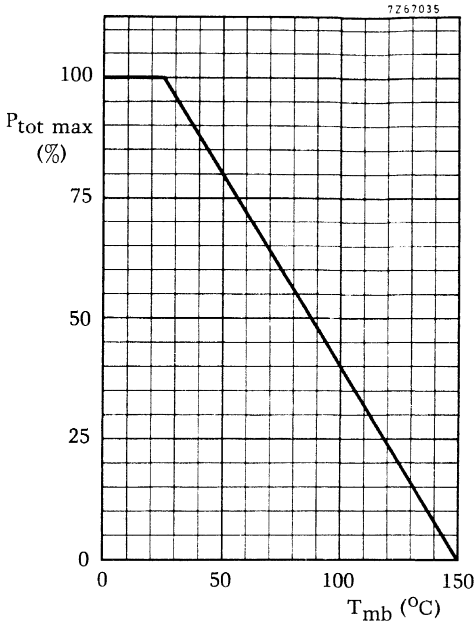

7Z62858
S.B. current multiplying factor at the VCEO max level
BD201
MSB(V)
δ = 0,01
0,02
0,05
0,1
0,2
0,5
10^2
10
1
10^-5
10^-4
10^-3
tp (s)
10^-2

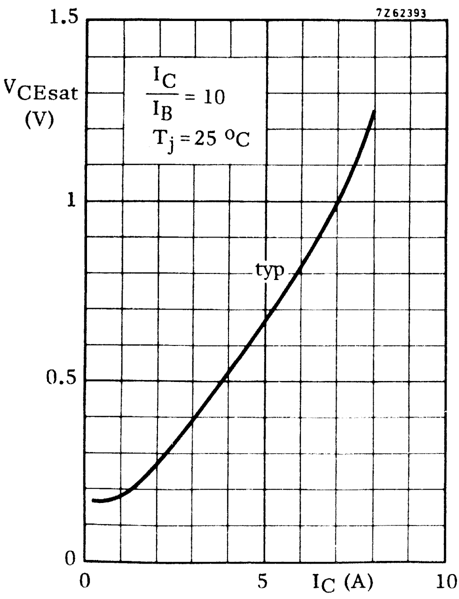

7Z62859
S.B. current multiplying factor at the VCEO max level
BD203
MSB(V)
δ = 0,01
0,02
0,05
0,1
0,2
0,5
10^2
10
1
10^-5
10^-4
10^-3
tp (s)
10^-2

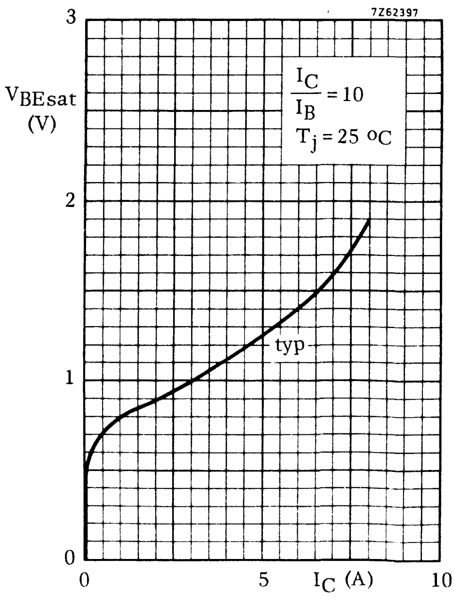

7Z62391
V_{CE} = 2 V
T_j = 25 °C
I_C (A)
10
1
10^{-1}
typ
1
10
10^2
I_B (mA)
10^3

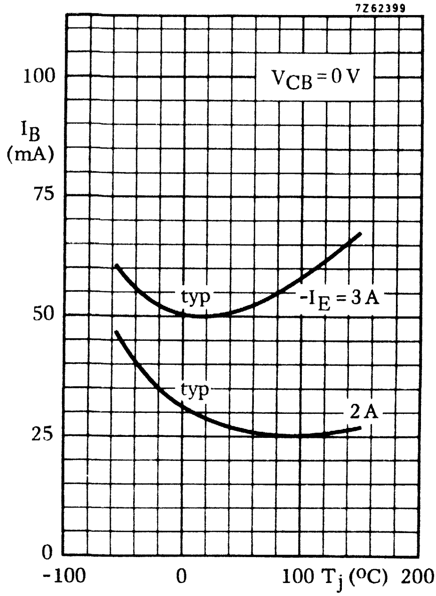

7Z62403
V_{CE} = 2 V
T_j = 25 °C
h_{FE}
150
100
50
0
typ
10^{-2}
10^{-1}
1
I_C (A)
10

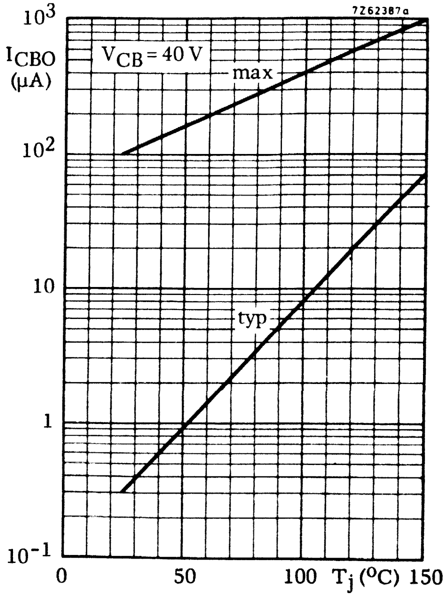

7Z62395
15
10
5
0
I_C (A)
$V_{CE} = 2$ V
$T_j = 25$ °C
typ
0
1
V_{BE} (V)
2

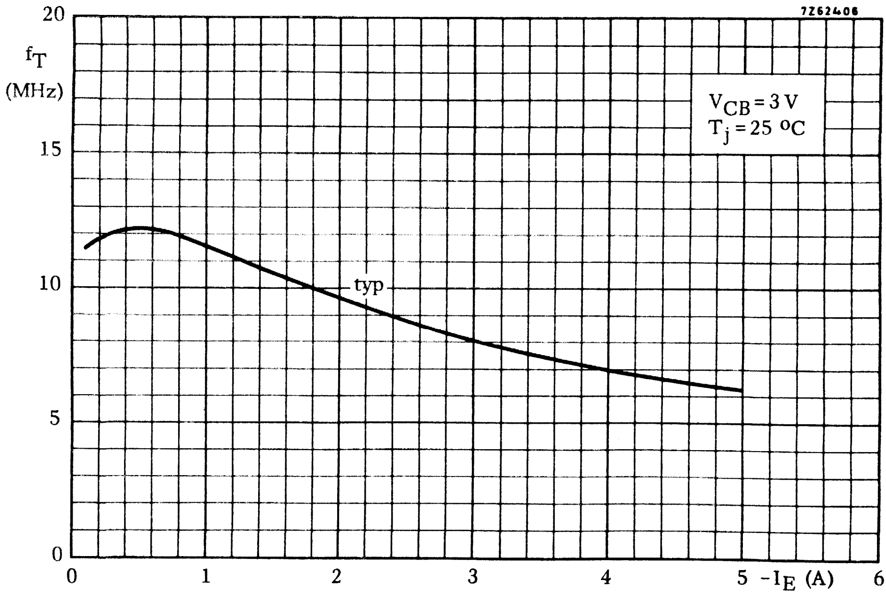

7Z67035
100
75
50
25
0
$P_{tot\ max}$ (%)
0
50
100
150
T_{mb} (°C)


7Z62393
1.5
1
0.5
0
V_{CEsat} (V)
$\frac{I_C}{I_B} = 10$
$T_j = 25$ °C
typ
0
5
I_C (A)
10


7Z62397
3
2
1
0
V_{BEsat} (V)
$\frac{I_C}{I_B} = 10$
$T_j = 25$ °C
typ
0
5
I_C (A)
10


7Z62399
I_B (mA)
100
75
50
25
0
$V_{CB} = 0$ V
typ
$-I_E = 3$ A
typ
2 A
-100
0
100
T_j (°C)
200


7Z62387a
I_{CBO} (μA)
10^3
10^2
10
1
10^{-1}
$V_{CB} = 40$ V
max
typ
0
50
100
T_j (°C)
150


7Z62406
f_T (MHz)
20
15
10
5
0
$V_{CB} = 3$ V
$T_j = 25$ °C
typ
0
1
2
3
4
5
$-I_E$ (A)
6

AUDIO FREQUENCY POWER TRANSISTORS

P-N-P silicon epitaxial-base power transistors in a plastic envelope. With their N-P-N complements BD201 and BD203 they are primarily intended for use in hi-fi equipment delivering an output power of 15 W to 25 W into a 4 Ω or 8 Ω load.

QUICK REFERENCE DATA

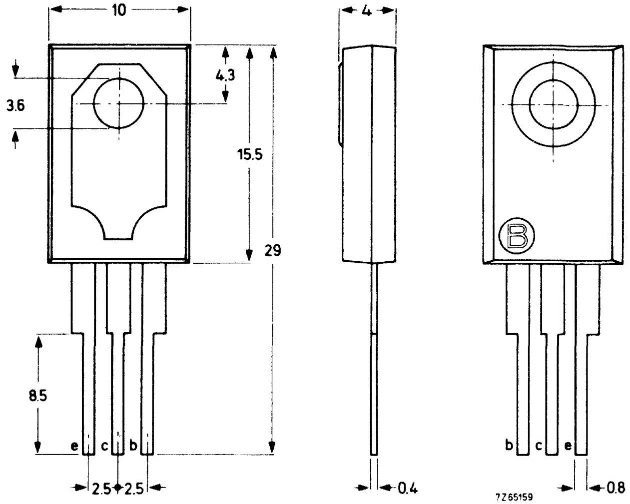
			BD202	BD204	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	60	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	V
Collector current (d.c.)	$-I_C$	max.	8	8	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60	60	W
Junction temperature	T_j	max.	150	150	°C
D.C. current gain					
$-I_C$ = 3 A; $-V_{CE}$ = 2 V	h_{FE}	>	30	–	
$-I_C$ = 2 A; $-V_{CE}$ = 2 V	h_{FE}	>	–	30	
Cutt-off frequency					
$-I_C$ = 0,3 A; $-V_{CE}$ = 3 V	f_{hfe}	>	25	25	kHz

MECHANICAL DATA (see page 2)

MECHANICAL DATA

Collector connected to metal part of mounting surface

Dimensions in mm



Accessories available: Insulating bush 56324 and mica washer 56325

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltage			BD202	BD204	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	60	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	V

Current				
Collector current (d.c.)	$-I_C$	max.	8	A
Collector current (peak value, $t_p \leq 10$ ms)	$-I_{CM}$	max.	12	A
Collector current (non-repetitive peak value, $t_p \leq 2$ ms)	$-I_{CSM}$	max.	25	A

Temperature				
Storage temperature	T_{stg}		−65 to +150	°C
Junction temperature	T_j	max.	150	°C

Power dissipation				
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60	W

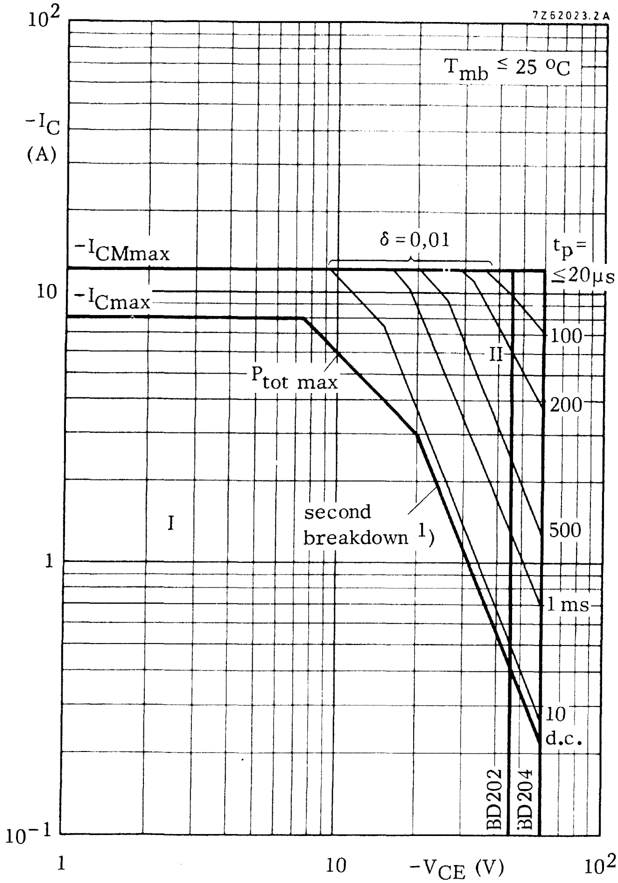
THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,08	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_B = 0; -V_{CE} = 30$ V	$-I_{CEO}$	<	1	mA
$I_E = 0; -V_{CB} = 40$ V; $T_j = 150$ °C	$-I_{CBO}$	<	1	mA
Emitter cut-off current				
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	5	mA
Base-emitter voltage [1]				
$-I_C = 3$ A; $-V_{CE} = 2$ V	$-V_{BE}$	<	1,5	V
Knee voltage [1]				
$-I_C = 3$ A; $-I_B$ = value at which $-I_C = 3{,}3$ A at $-V_{CE} = 2$ V	$-V_{CEK}$	typ.	1	V
Saturation voltage [1]				
$-I_C = 3$ A; $-I_B = 0{,}3$ A	$-V_{CEsat}$	<	1	V
D.C. current gain [1]				
BD202: $-I_C = 3$ A; $-V_{CE} = 2$ V	h_{FE}	>	30	
BD204: $-I_C = 2$ A; $-V_{CE} = 2$ V	h_{FE}	>	30	
$-I_C = 1$ A; $-V_{CE} = 2$ V	h_{FE}	>	30	
Cut-off frequency				
$-I_C = 0{,}3$ A; $-V_{CE} = 3$ V	f_{hfe}	>	25	kHz
Transition frequency at f = 1 MHz				
$-I_C = 0{,}3$ A; $-V_{CE} = 3$ V	f_T	>	3	MHz

[1]) Measured with pulses of 300 μs and with 2% duty cycle

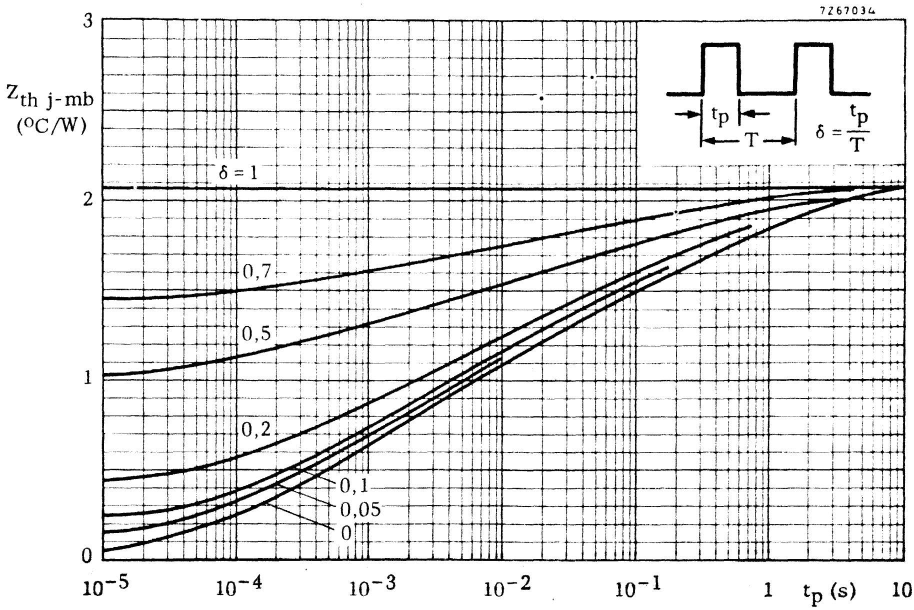


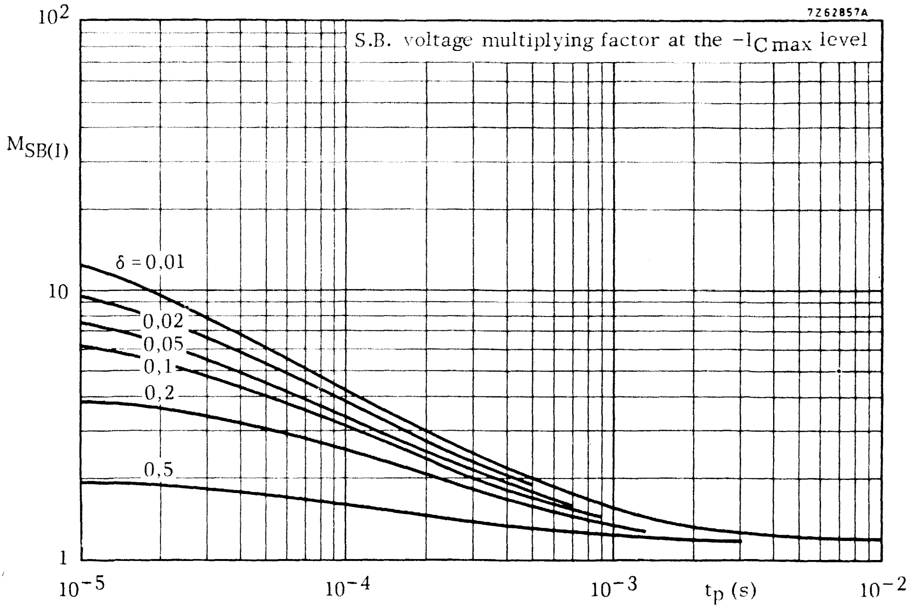
Safe Operating Area with the transistor forward biased

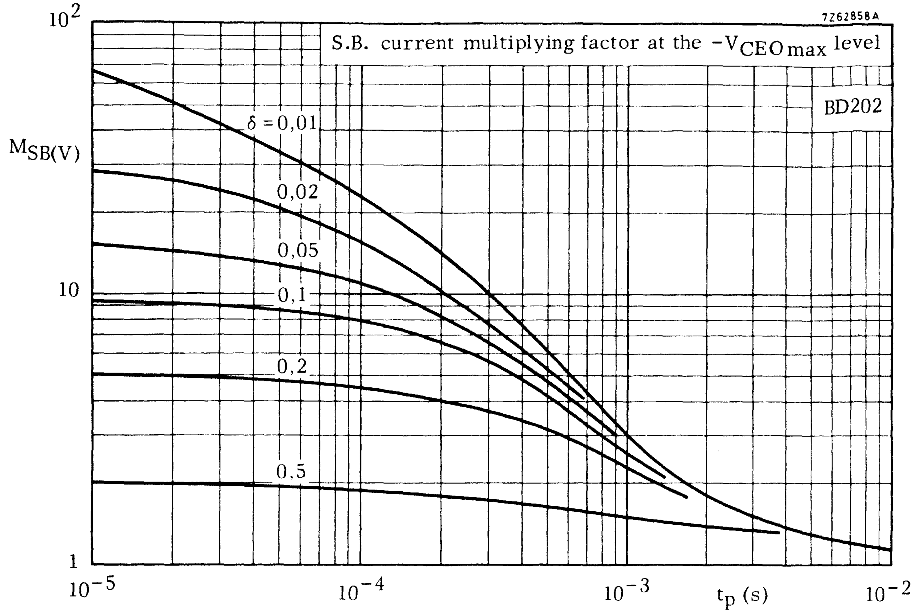
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation

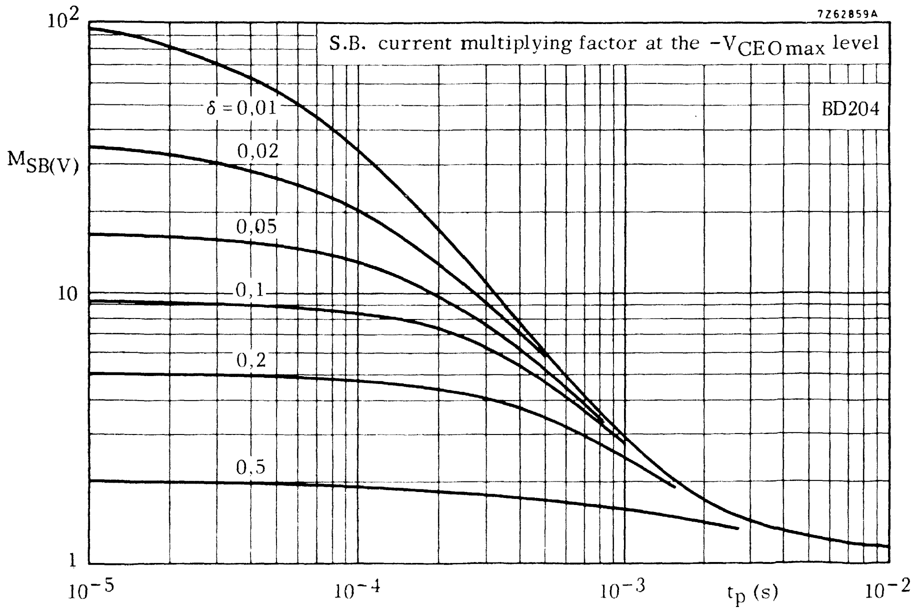
For $P_{tot\ max}$ versus T_{mb} see page 8.

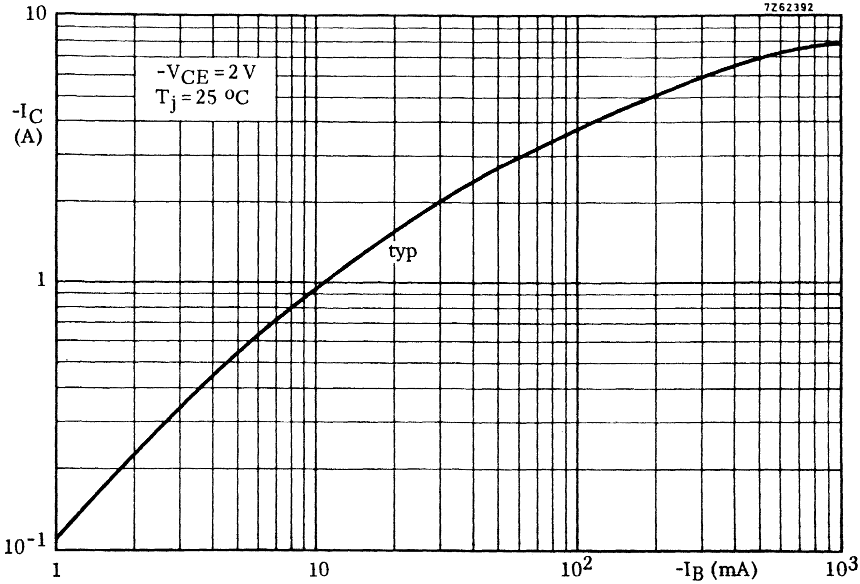
1) Independent of temperature.

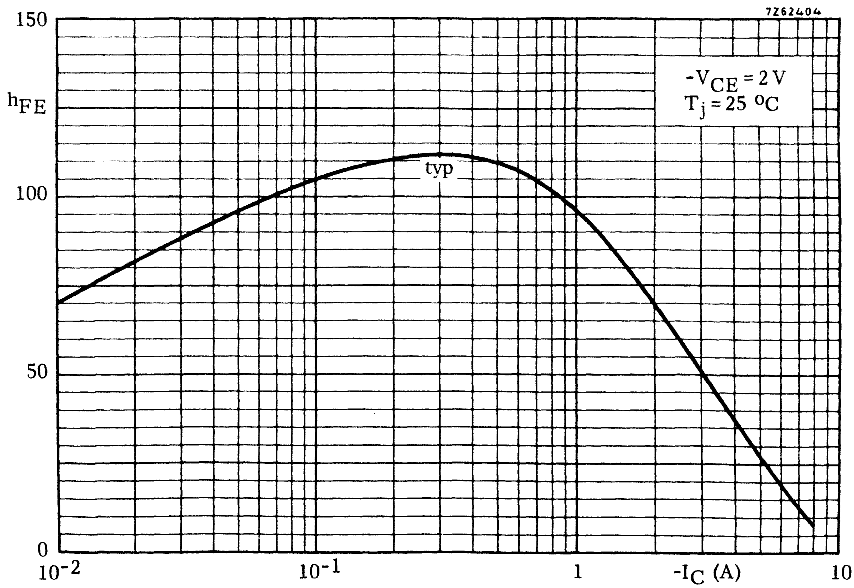

7Z67034
$Z_{th\ j-mb}$ ($^oC/W$)
3
2
1
0
δ = 1
0,7
0,5
0,2
0,1
0,05
0
t_p
T
$\delta = \frac{t_p}{T}$
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t_p (s)
10

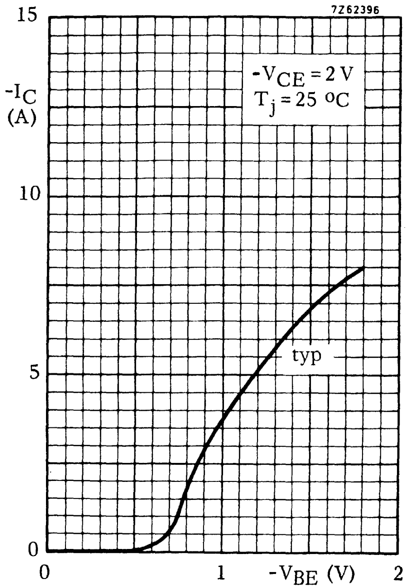

7Z62857A
S.B. voltage multiplying factor at the $-I_{C\,max}$ level
10^2
$M_{SB(I)}$
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,5
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

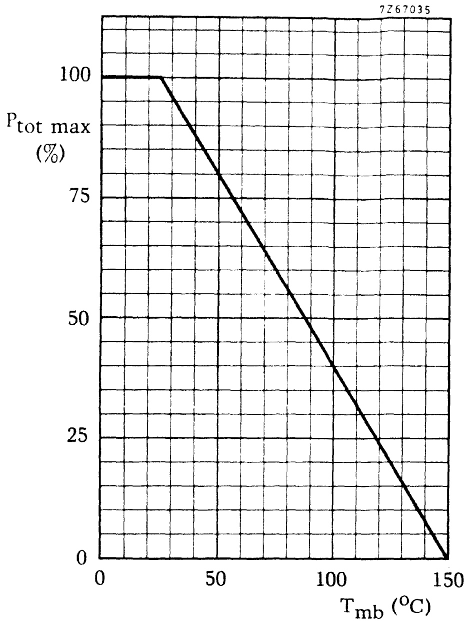

7Z62858A
S.B. current multiplying factor at the $-V_{CEO max}$ level
BD202
10^2
$M_{SB(V)}$
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0.5
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

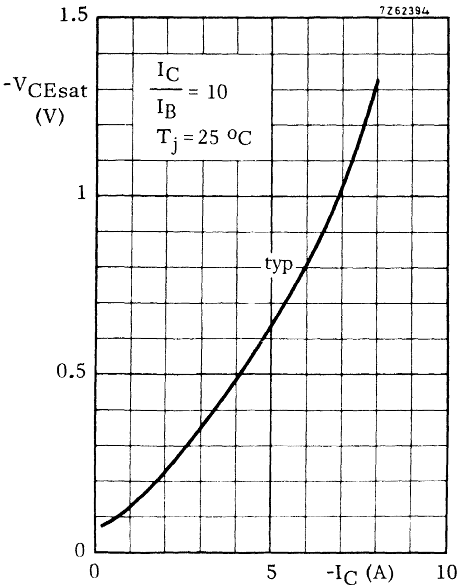

7Z62859A
S.B. current multiplying factor at the $-V_{CEO max}$ level
BD204
10^2
$M_{SB(V)}$
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,5
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

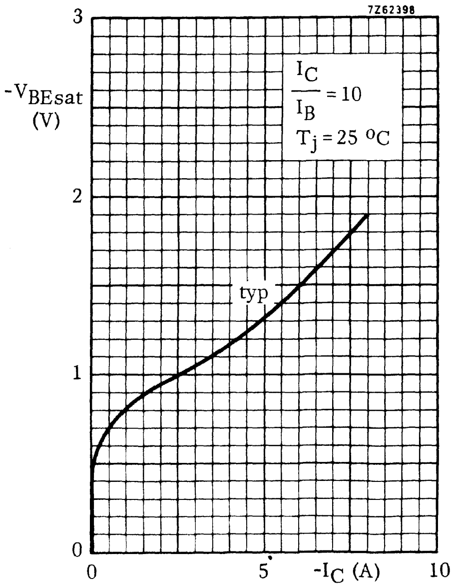

7Z62392
10
-V_{CE} = 2 V
T_j = 25 °C
$-I_C$
(A)
typ
1
10^{-1}
1
10
10^2
$-I_B$ (mA)
10^3

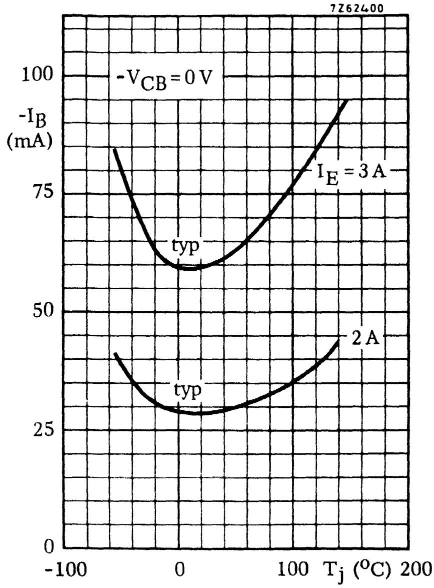

7Z62404
150
h_{FE}
-V_{CE} = 2 V
T_j = 25 °C
typ
100
50
0
10^{-2}
10^{-1}
1
$-I_C$ (A)
10

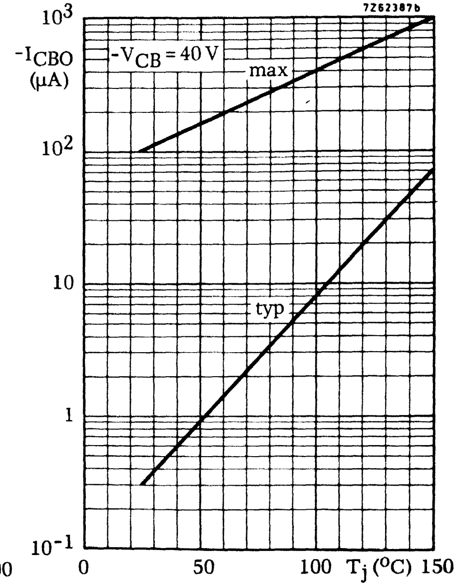

7Z62396
15
-I_C
(A)
10
5
0
$-V_{CE} = 2$ V
$T_j = 25$ °C
typ
0
1
$-V_{BE}$ (V)
2

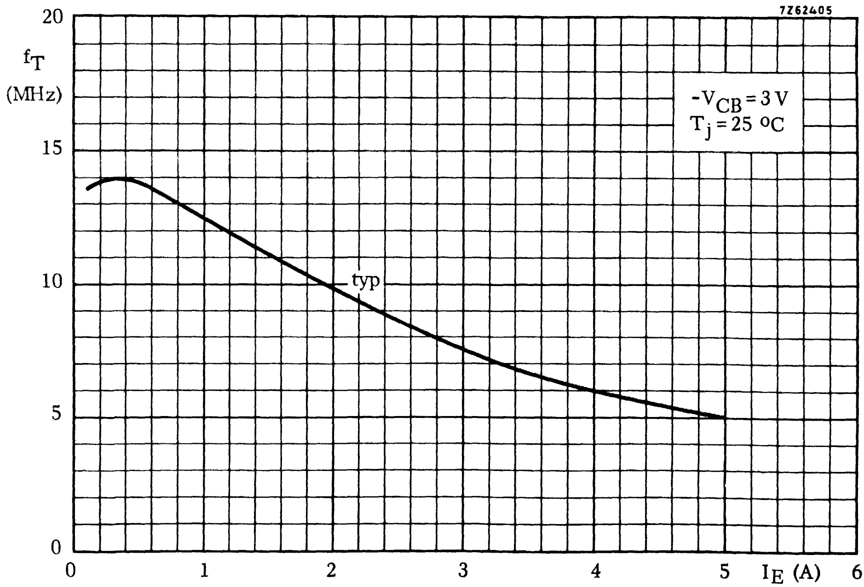

7Z67035
100
$P_{tot\ max}$
(%)
75
50
25
0
0
50
100
150
T_{mb} (°C)


7Z62394
1.5
$-V_{CEsat}$
(V)
1
0.5
0
$\frac{I_C}{I_B} = 10$
$T_j = 25$ °C
typ
0
5
$-I_C$ (A)
10


7Z62398
3
$-V_{BEsat}$
(V)
2
1
0
$\frac{I_C}{I_B} = 10$
$T_j = 25$ °C
typ
0
5
$-I_C$ (A)
10


7Z62400
-V_CB = 0 V
-I_B (mA)
100
75
50
25
0
I_E = 3 A
typ
2 A
typ
-100
0
100
T_j (°C)
200


7Z62387b
10^3
-I_CBO (μA)
-V_CB = 40 V
max
10^2
10
typ
1
10^-1
0
50
100
T_j (°C)
150


7Z62405
20
f_T (MHz)
15
10
5
0
-V_CB = 3 V
T_j = 25 °C
typ
0
1
2
3
4
5
I_E (A)
6

SILICON PLANAR EPITAXIAL TRANSISTORS

General purpose n-p-n transistors in a SOT-32 plastic envelope especially recommended for television circuits. Their complements are BD227, BD229 and BD231.

QUICK REFERENCE DATA

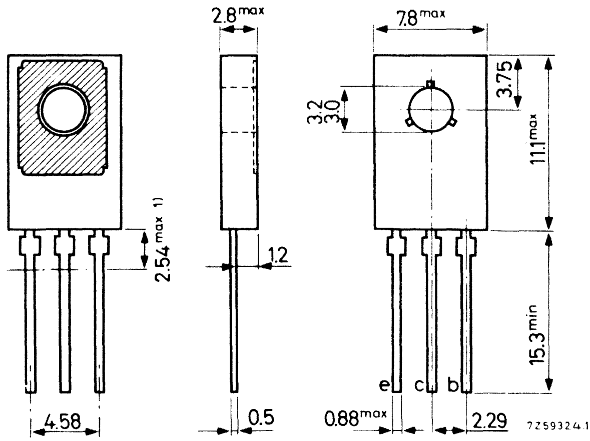
			BD226	BD228	BD230	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Collector-current (peak value)	I_{CM}	max.	3	3	3	A
Total power dissipation up to T_{mb} = 62 °C	P_{tot}	max.	12,5	12,5	12,5	W
Junction temperature	T_j	max.	150	150	150	°C
D.C. current gain						
I_C = 150 mA; V_{CE} = 2 V	h_{FE}	>	40	40	40	
		<	250	160	160	
I_C = 1 A ; 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.	125	125	125	MHz

MECHANICAL DATA

Dimensions in mm

SOT-32 (TO-126)

Collector connected to metal part of mounting surface



For mounting instructions see section Accessories type 56326 for non-insulated mounting and type 56333 for insulated mounting.

1) Within this region the cross-section of the leads is uncontrolled.

→ **RATINGS** Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltages			BD226	BD228	BD230	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V
Currents						
Collector current (d.c.)	I_C	max.	1,5	1,5	1,5	A
Collector current (peak value)	I_{CM}	max.	3	3	3	A
Power dissipation						
Total power dissipation up to T_{mb} = 62 °C	P_{tot}	max.		12,5		W
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	$R_{th\ j-a}$	=	100	°C/W
From junction to mounting base	$R_{th\ j-mb}$	=	7	°C/W

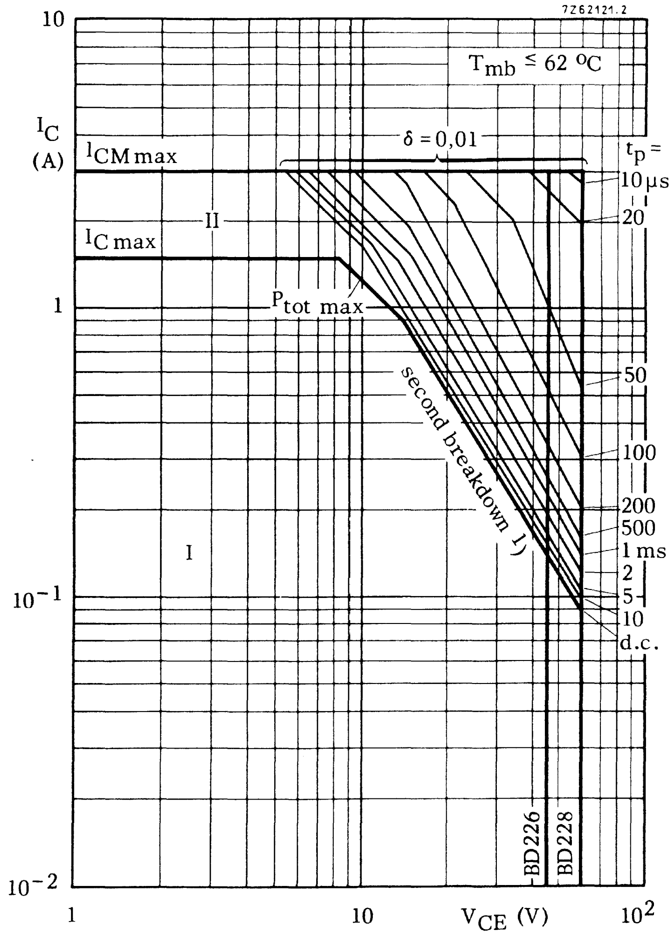
CHARACTERISTICS $T_j = 25\ ^oC$ unless otherwise specified

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 [1]				
$I_C = 1$ A; $V_{CE} = 2$ V	V_{BE}	<	1,3	V
Saturation voltage				
$I_C = 1$ A; $I_B = 0.1$ A	V_{CEsat}	<	0,8	V

D.C. current gain			BD226	BD228	BD230
$I_C = 5$ 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
$I_C = 1$ A; $V_{CE} = 2$ V	h_{FE}	>	25	25	25

Transition frequency at f = 35 MHz				
$I_C = 50$ mA; $V_{CE} = 5$ V	f_T	typ.	125	MHz
D.C. current gain ratio of matched pairs				
BD226/BD227; BD228/BD229;				
BD230/BD231				
$\lvert I_C \rvert = 150$ mA; $\lvert V_{CE} \rvert = 2$ V	h_{FE1}/h_{FE2}	typ.	1,3	
		<	1,6	

[1] V_{BE} decreases by about 2,3 mV/^oC with increasing temperature.

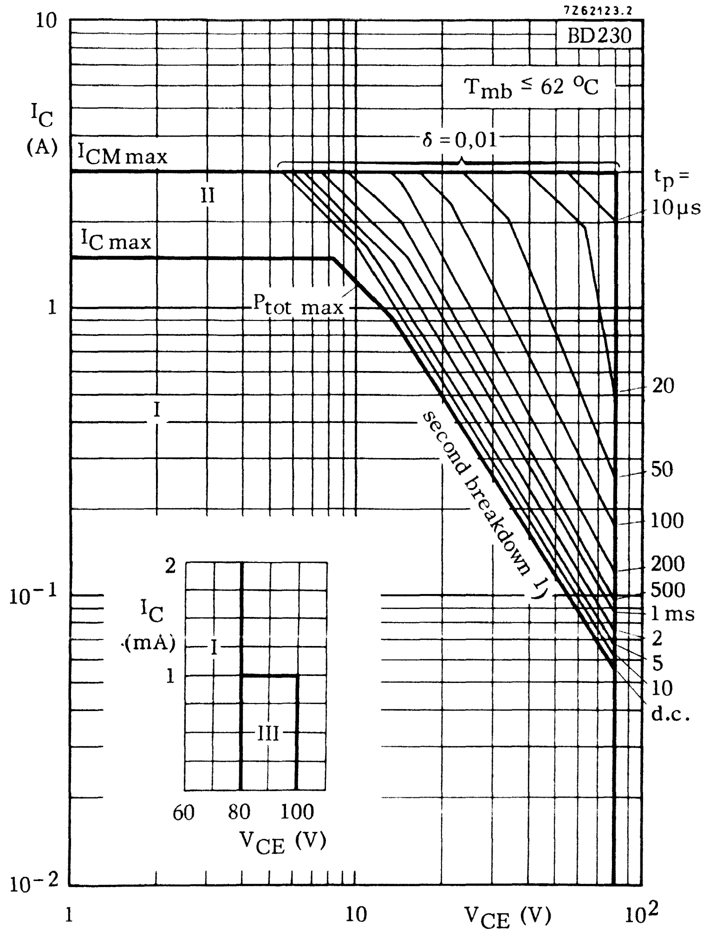


Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

1) Independent of temperature



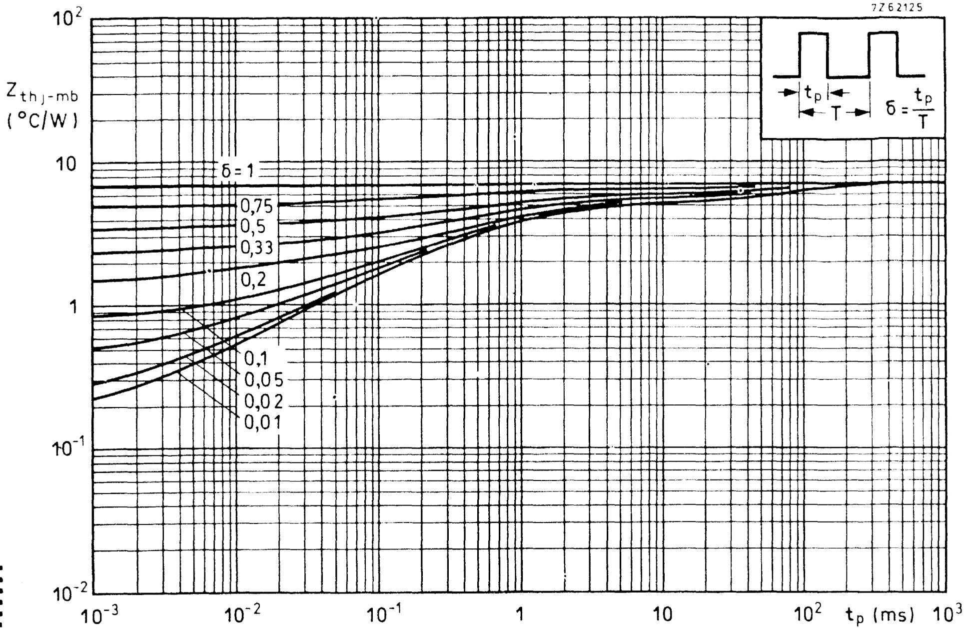
Safe Operating Area with the transistor forward biased

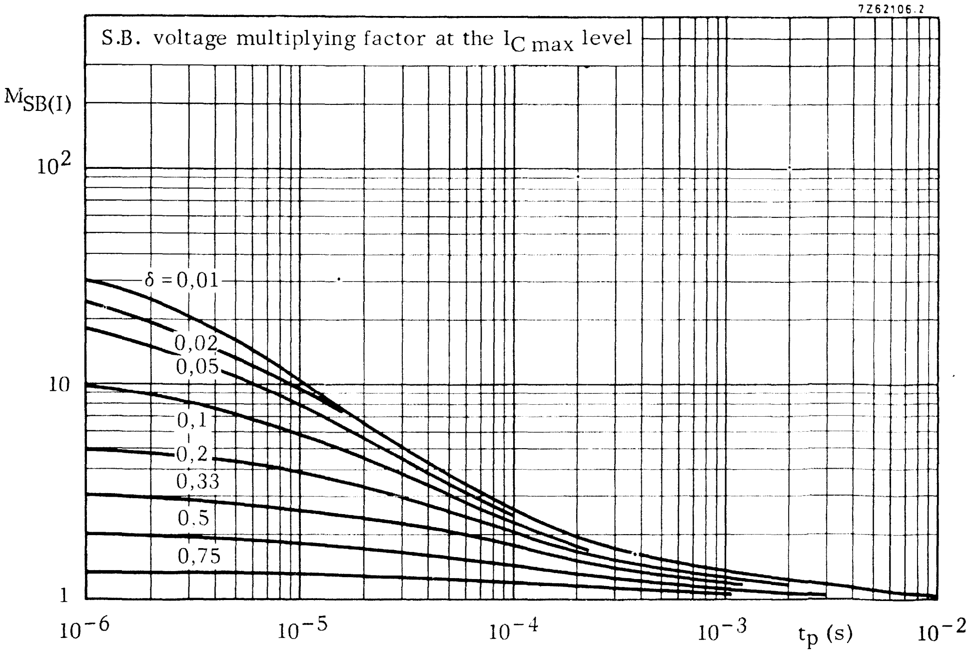
I Region of permissible d.c. operation

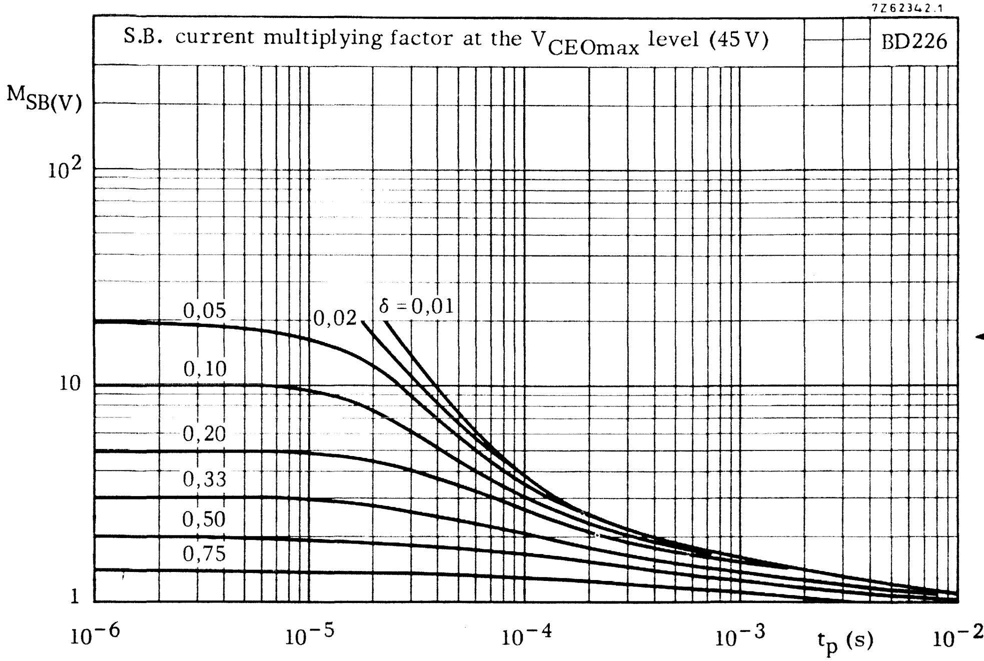
II Permissible extension for repetitive pulse operation

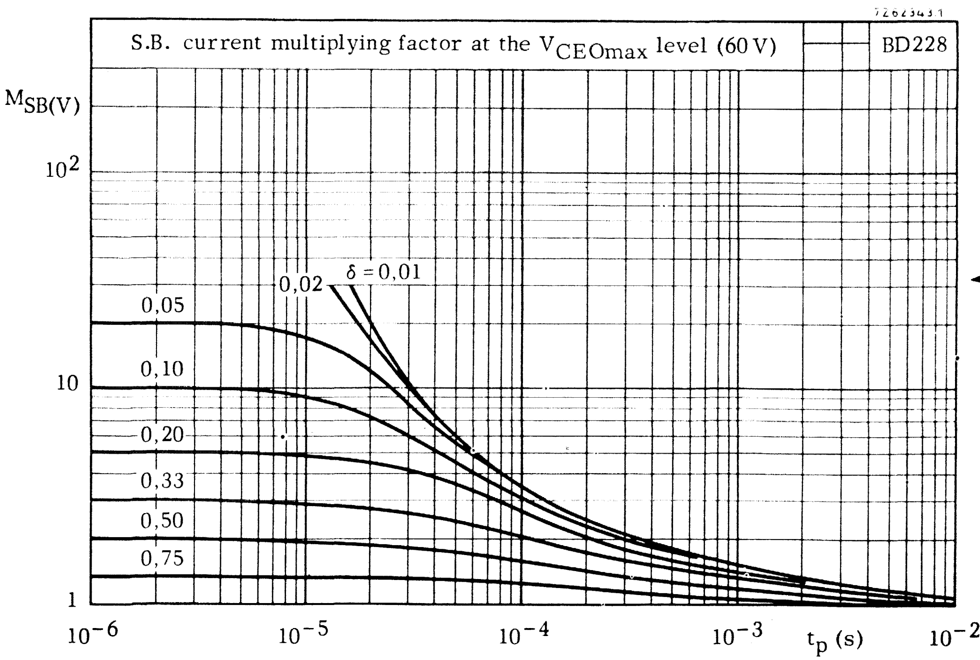
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 1$ kΩ

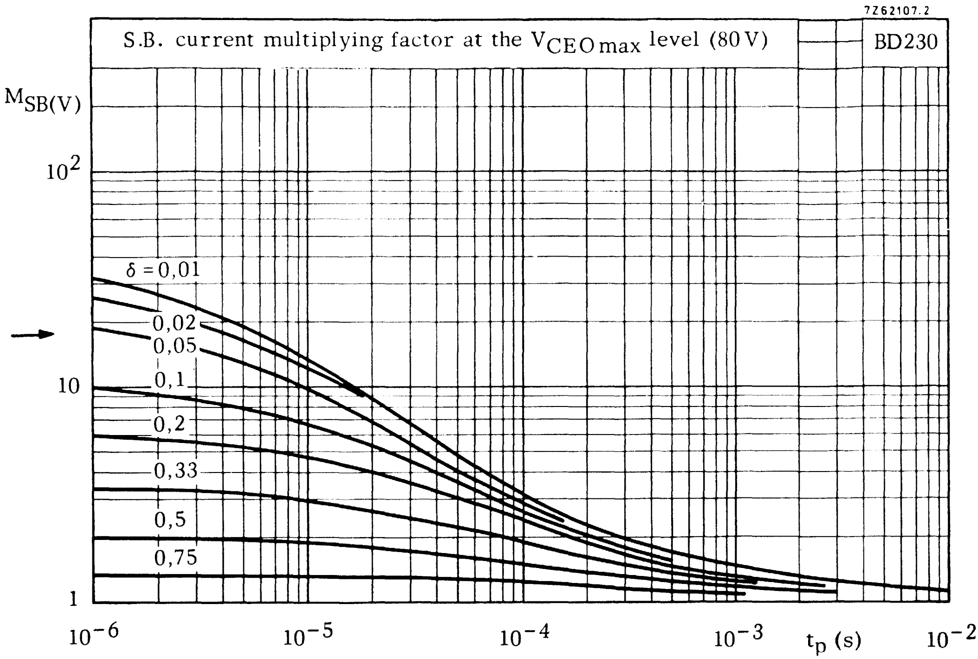
1) Independent of temperature

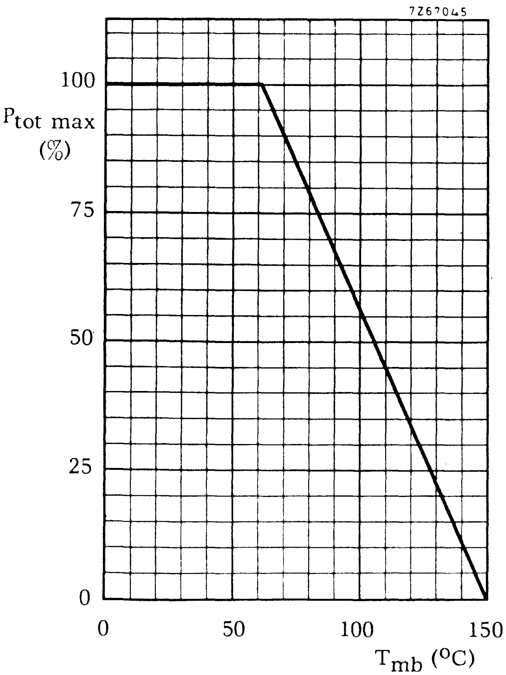

7Z62125
$Z_{th\,j-mb}$ (°C/W)
10^2
10
1
10^{-1}
10^{-2}
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3

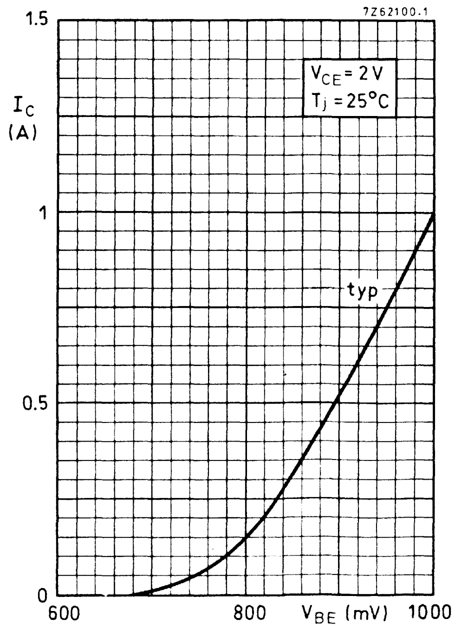

7Z62106.2
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0.5
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

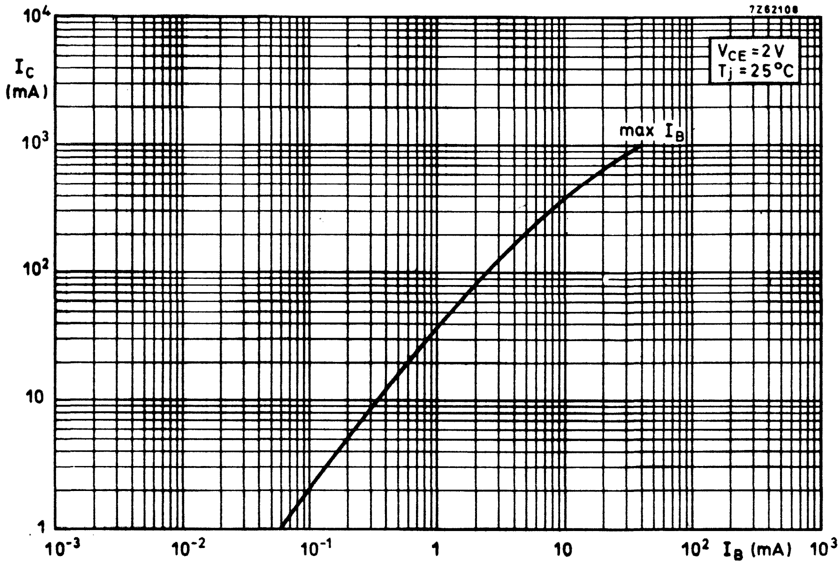

7Z62342.1
S.B. current multiplying factor at the V_{CEOmax} level (45 V)
BD226
$M_{SB(V)}$
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

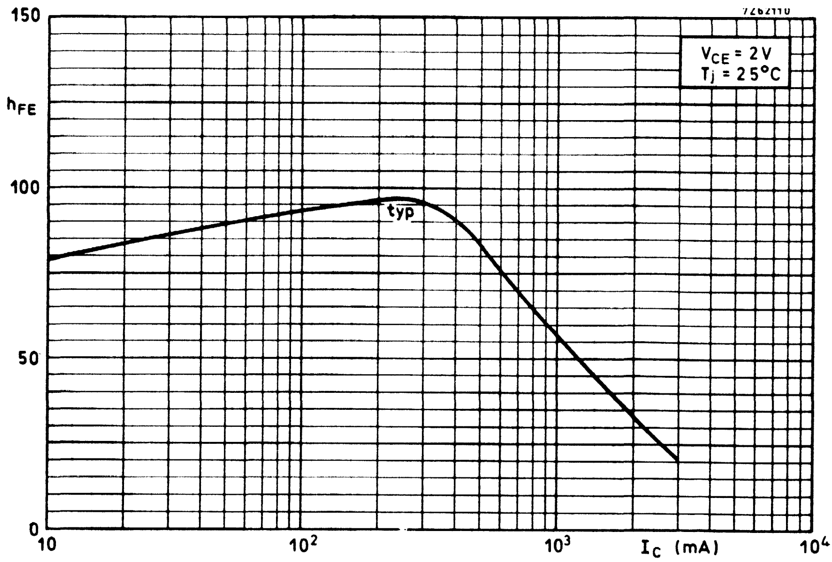

7Z62343.1
S.B. current multiplying factor at the V_{CEOmax} level (60 V)
BD228
$M_{SB(V)}$
10^2
10
1
0,02
δ = 0,01
0,05
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

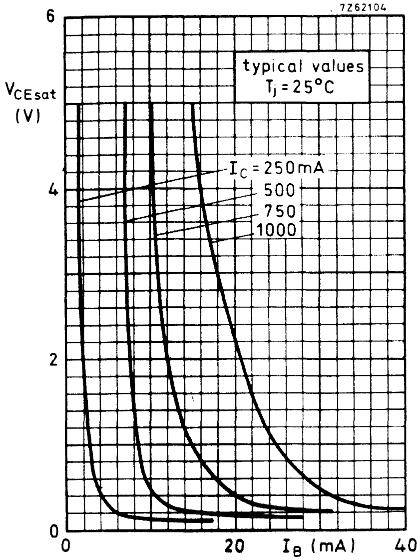

7Z62107.2
S.B. current multiplying factor at the VCEOmax level (80 V)
BD230
MSB(V)
10²
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10⁻⁶
10⁻⁵
10⁻⁴
10⁻³
tp (s)
10⁻²

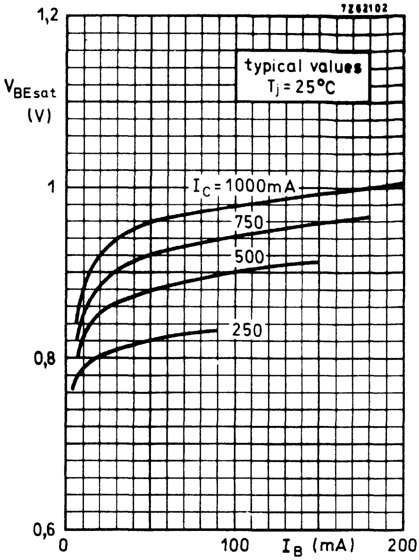

7Z67045
Ptot max
(%)
100
75
50
25
0
0
50
100
150
Tmb (°C)

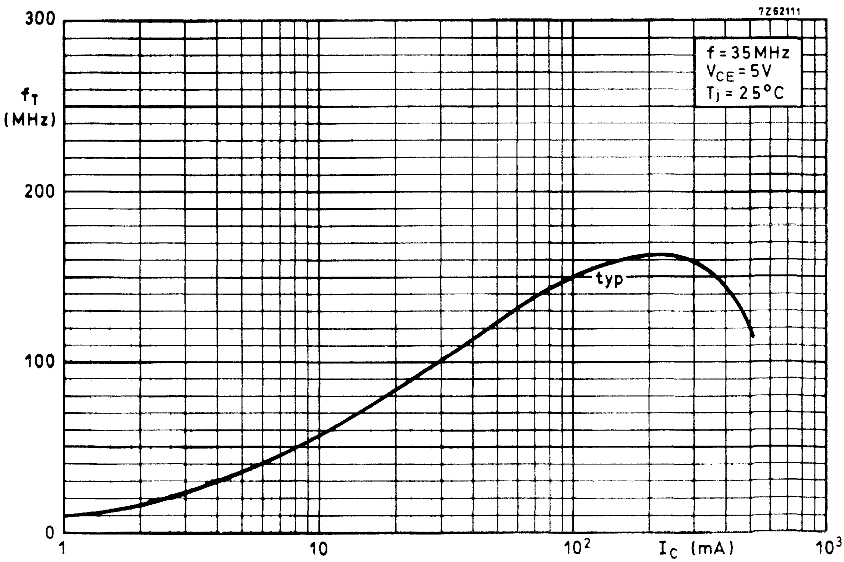

7Z62100.1
VCE = 2 V
Tj = 25°C
Ic
(A)
1.5
1
0.5
0
typ
600
800
VBE (mV)
1000


7Z62108
10^4
I_C (mA)
V_{CE} = 2 V
T_j = 25 °C
max I_B
10^3
10^2
10
1
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
I_B (mA)
10^3


150
h_{FE}
V_{CE} = 2 V
T_j = 25 °C
100
typ
50
0
10
10^2
10^3
I_C (mA)
10^4


7Z62104
typical values
$T_j = 25°C$
V_{CEsat}
(V)
$I_C = 250mA$
500
750
1000
6
4
2
0
0
20
I_B (mA)
40


7Z62102
typical values
$T_j = 25°C$
V_{BEsat}
(V)
$I_C = 1000mA$
750
500
250
1,2
1
0,8
0,6
0
100
I_B (mA)
200


7Z62111
f = 35 MHz
$V_{CE} = 5V$
$T_j = 25°C$
f_T
(MHz)
typ
300
200
100
0
1
10
10^2
I_C (mA)
10^3

SILICON PLANAR EPITAXIAL TRANSISTORS

General purpose p-n-p transistors in a SOT-32 plastic envelope especially recommended for television circuits. Their complements are BD226, BD228 and BD230.

QUICK REFERENCE DATA

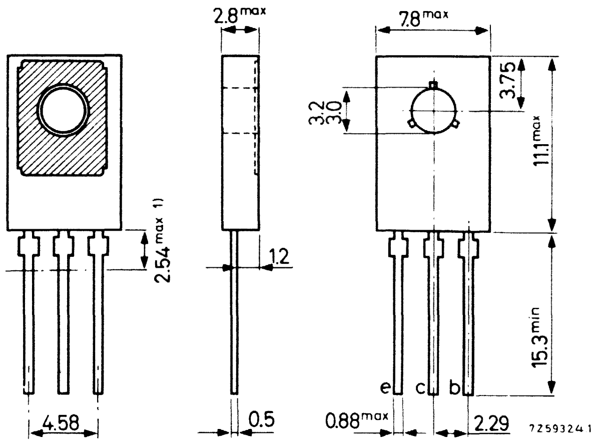
			BD227	BD229	BD231	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Collector current (peak value)	$-I_{CM}$	max.	3	3	3	A
Total power dissipation up to T_{mb} = 62 °C	P_{tot}	max.	12,5	12,5	12,5	W
Junction temperature	T_j	max.	150	150	150	°C
D.C. current gain						
$-I_C$ = 150 mA; $-V_{CE}$ = 2 V	h_{FE}	>	40	40	40	
		<	250	160	160	
$-I_C$ = 1 A ; $-V_{CE}$ = 2 V	h_{FE}	>	25	25	25	
Transition frequency at f = 35 MHz						
$-I_C$ = 50 mA; $-V_{CE}$ = 5 V	f_T	typ.	50	50	50	MHz

MECHANICAL DATA

Dimensions in mm

SOT-32 (TO-126)

Collector connected to metal part of mounting surface



For mounting instructions see section Accessories type 56326 for non-insulated mounting and type 56333 for insulated mounting.

1) Within this region the cross-section of the leads is uncontrolled.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

			BD227	BD229	BD231	
Voltages						
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V
Currents						
Collector current (d.c.)	$-I_C$	max.	1,5	1,5	1,5	A
Collector current (peak value)	$-I_{CM}$	max.	3	3	3	A

Power dissipation

Total power dissipation up to T_{mb} = 62 °C	P_{tot}	max.	12,5	W

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	$R_{th\ j-a}$	=	100	°C/W
From junction to mounting base	$R_{th\ j-mb}$	=	7	°C/W

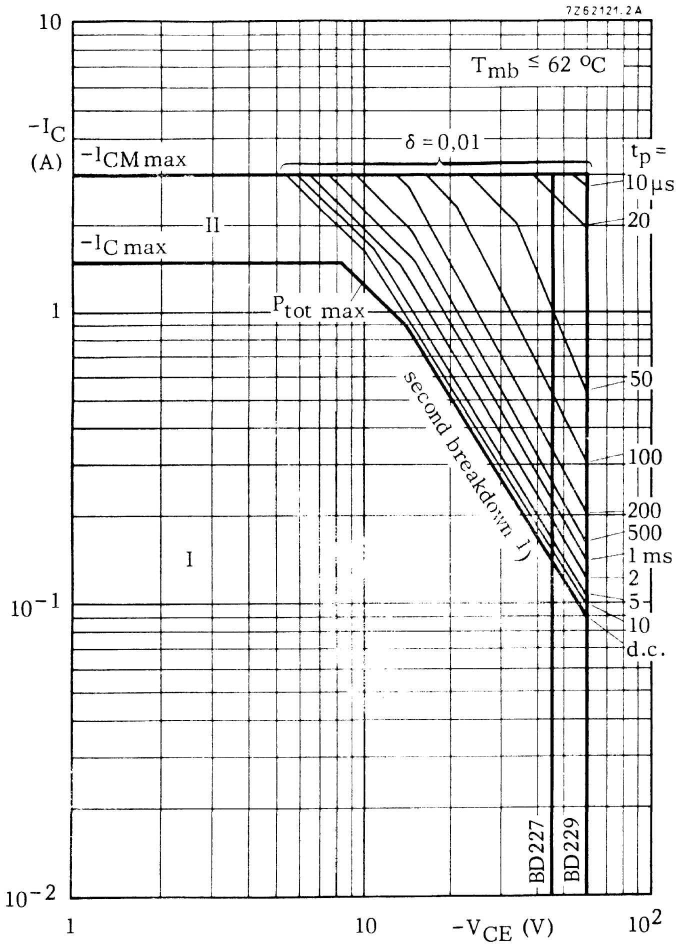
CHARACTERISTICS $T_j = 25\ ^oC$ unless otherwise specified

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 [1]				
$-I_C = 1$ A; $-V_{CE} = 2$ V	$-V_{BE}$	<	1,3	V
Saturation voltage				
$-I_C = 1$ A; $-I_B = 0.1$ A	$-V_{CEsat}$	<	0,8	V

D.C. current gain			BD227	BD229	BD231
$-I_C = 5$ 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
$-I_C = 1$ A ; $-V_{CE} = 2$ V	h_{FE}	>	25	25	25

Transition frequency at f = 35 MHz				
$-I_C = 50$ mA; $-V_{CE} = 5$ V	f_T	typ.	50	MHz
D.C. current gain ratio of matched pairs				
BD226/BD227; BD228/BD229; BD230/BD231				
$\|I_C\| = 150$ mA; $\|V_{CE}\| = 2$ V	h_{FE1}/h_{FE2}	typ.	1,3	
		<	1,6	

[1] $-V_{BE}$ decreases by about 2,3 mV/^oC with increasing temperature.

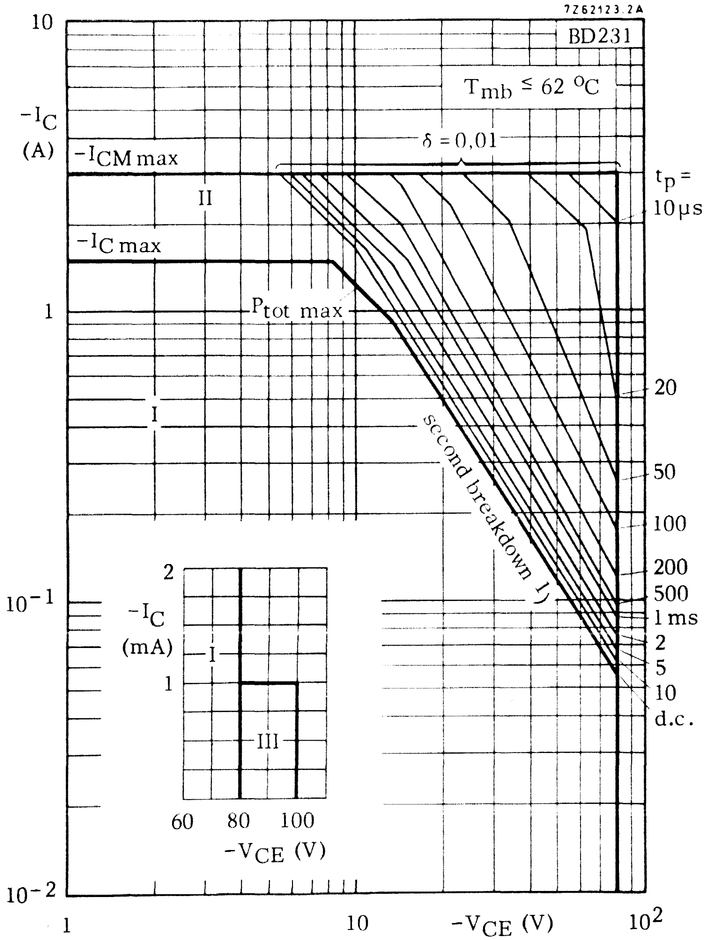


Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

1) Independent of temperature



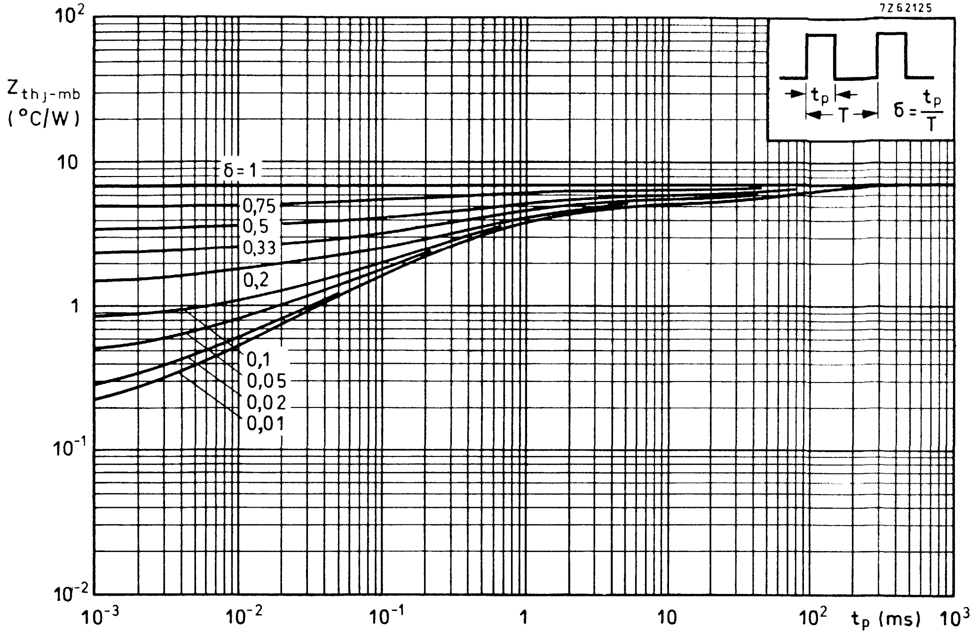
Safe Operating Area with the transistor forward biased

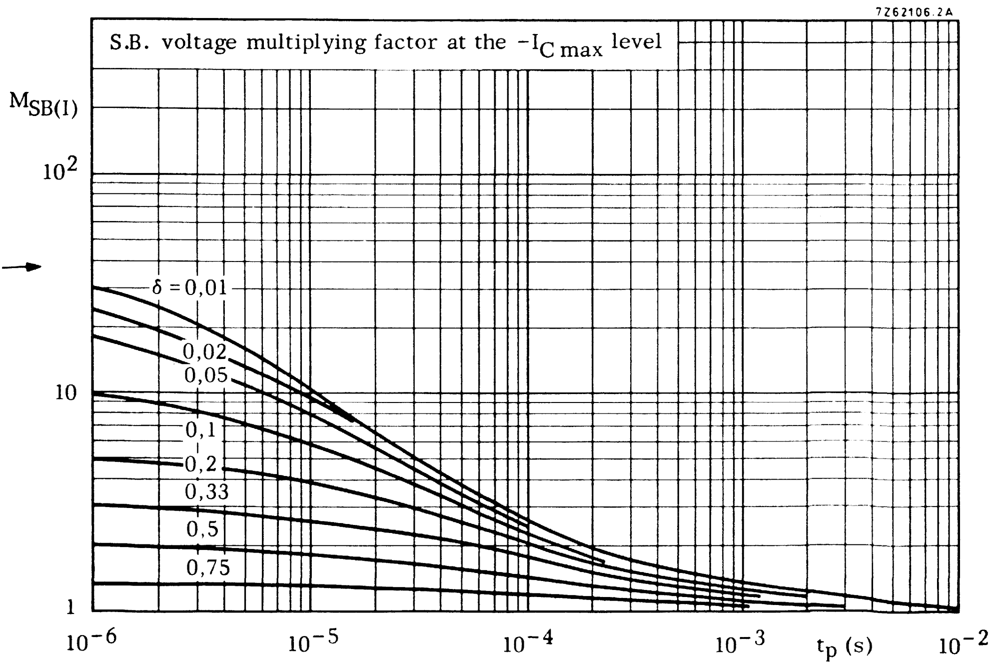
I Region of permissible d.c. operation

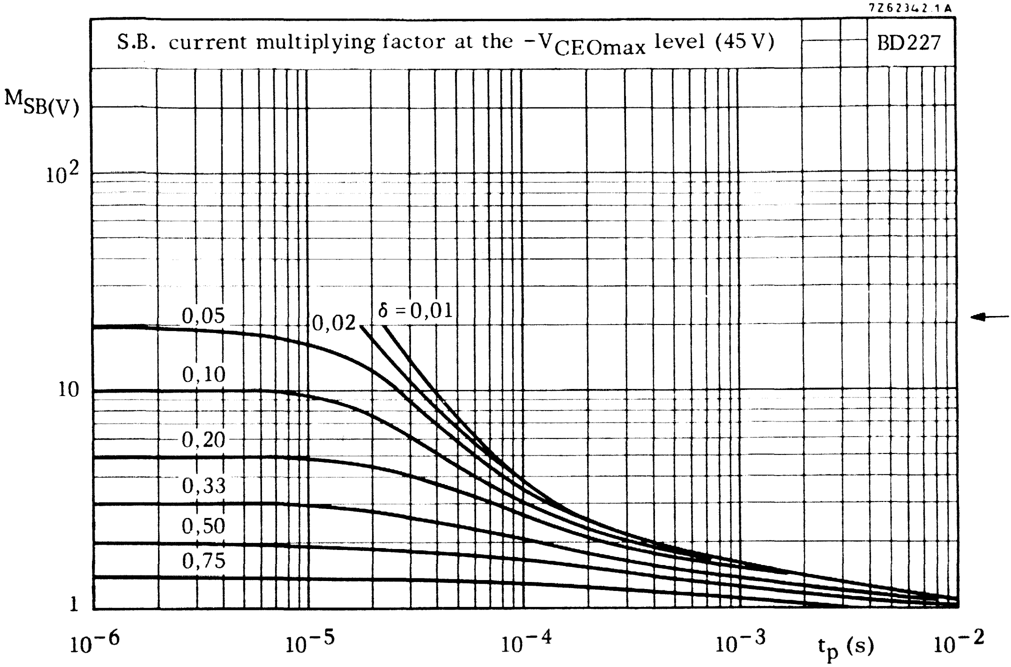
II Permissible extension for repetitive pulse operation

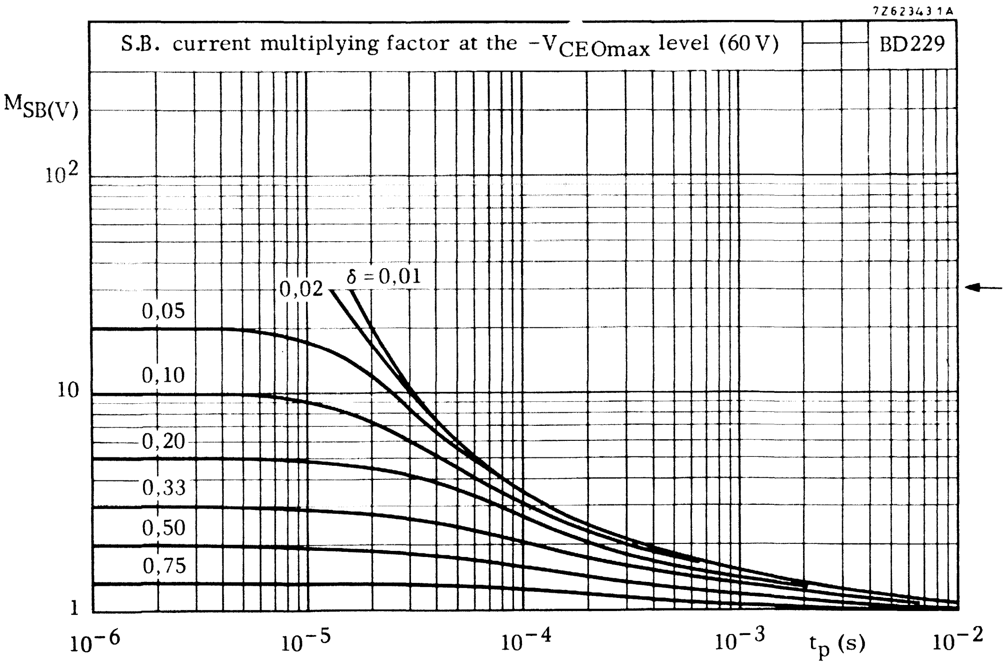
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \le 1\ k\Omega$

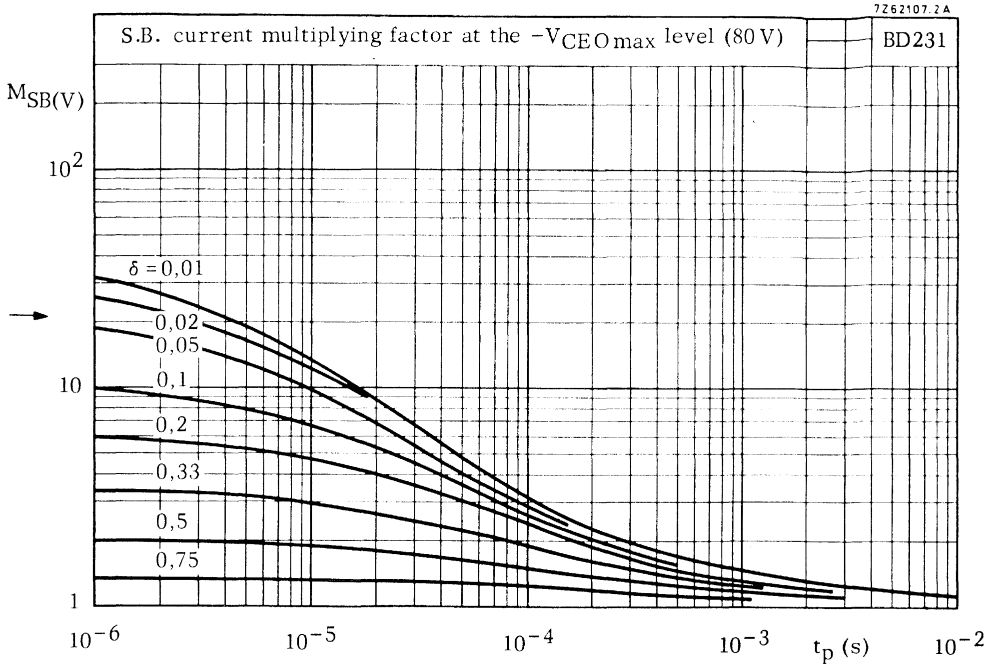
1) Independent of temperature

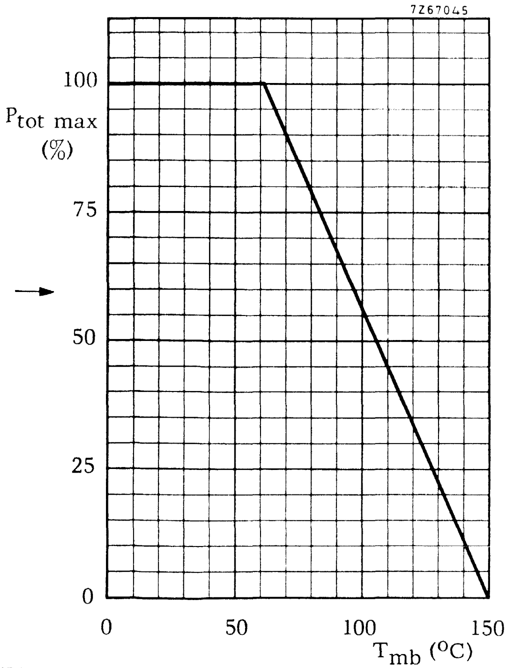

7Z62125
$Z_{th\,j\text{-}mb}$ (°C/W)
10^2
10
1
10^{-1}
10^{-2}
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3

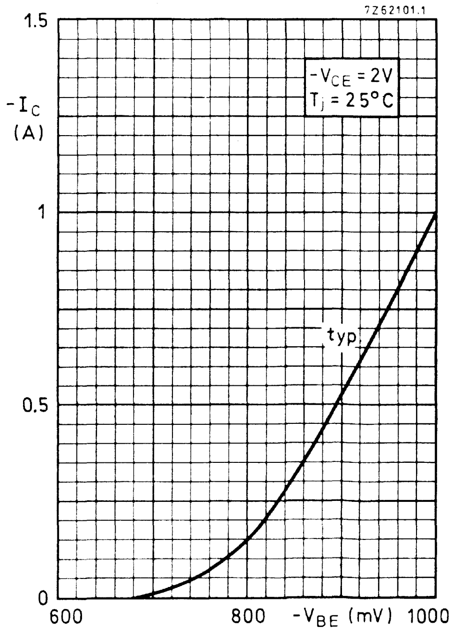

7Z62106.2A
S.B. voltage multiplying factor at the $-I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

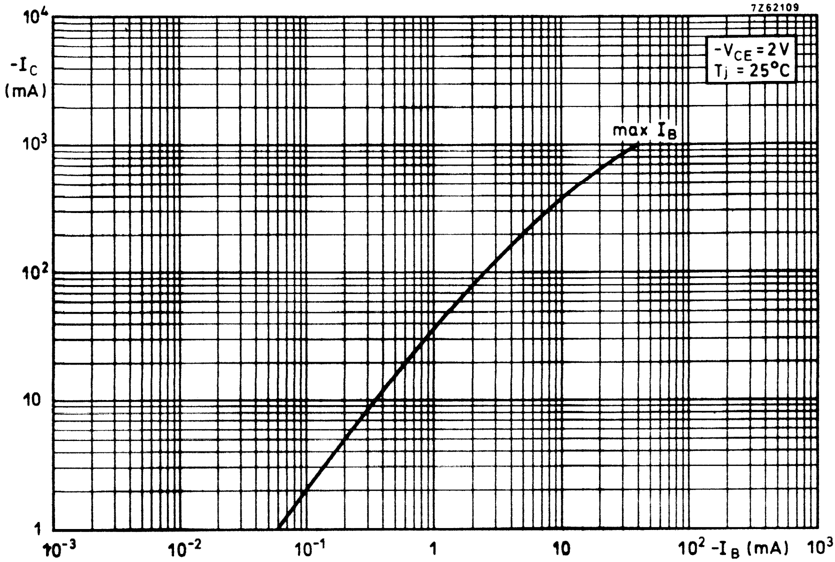

7Z62342.1A
S.B. current multiplying factor at the $-V_{CEOmax}$ level (45 V)
BD227
$M_{SB(V)}$
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

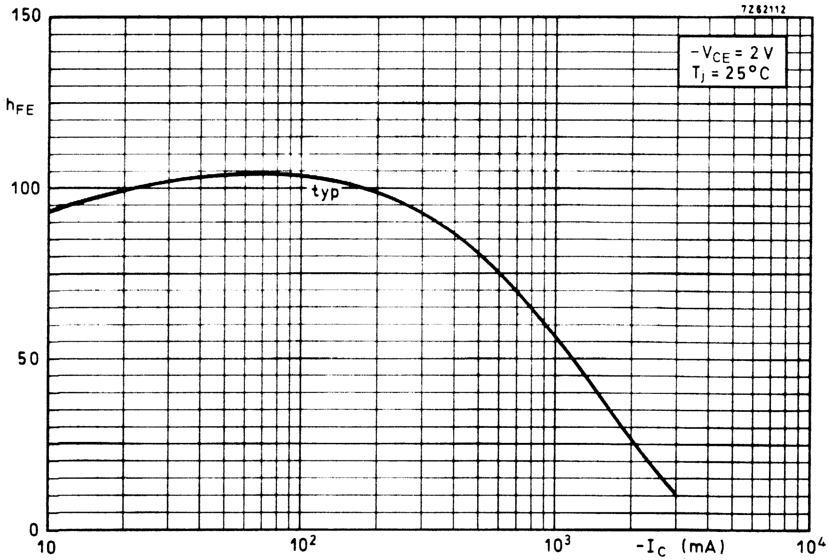

7Z62343.1A
S.B. current multiplying factor at the $-V_{CEOmax}$ level (60 V)
BD229
$M_{SB(V)}$
10^2
10
1
0,02
δ = 0,01
0,05
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

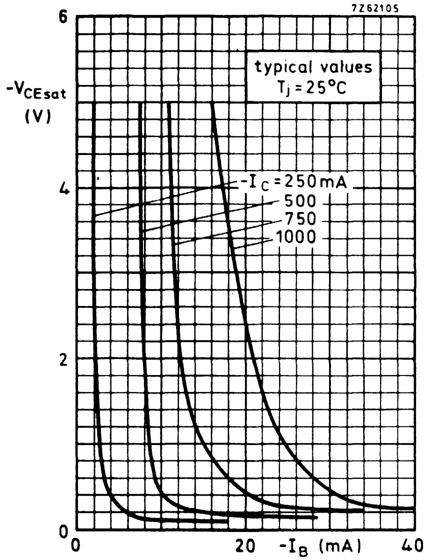

7Z62107.2A
S.B. current multiplying factor at the −VCEOmax level (80 V)
BD231
MSB(V)
10²
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10⁻⁶
10⁻⁵
10⁻⁴
10⁻³
tp (s)
10⁻²

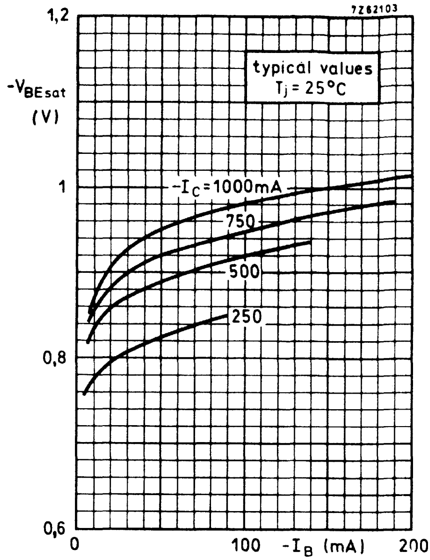

7Z67045
Ptot max (%)
100
75
50
25
0
0
50
100
150
Tmb (°C)

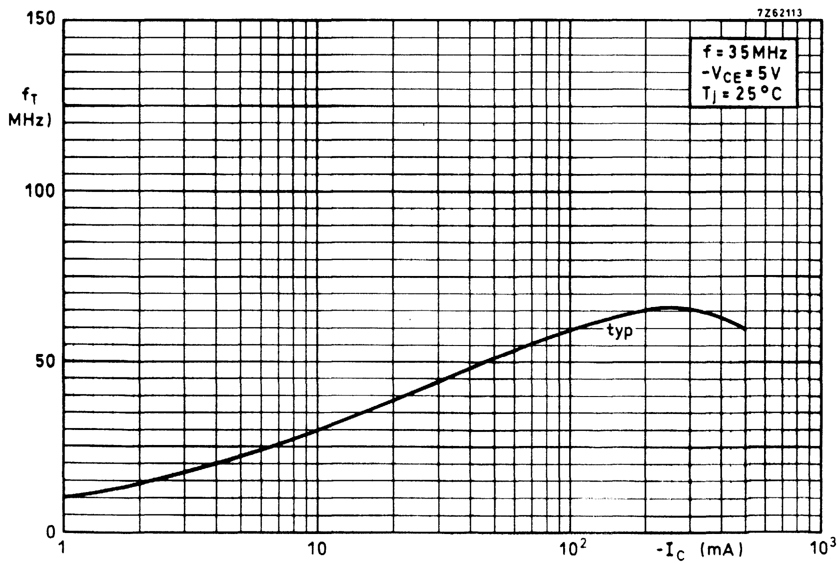

7Z62101.1
1.5
-IC (A)
1
0.5
0
-VCE = 2V
Tj = 25°C
typ
600
800
-VBE (mV)
1000


7Z62109
$-V_{CE} = 2\ V$
$T_j = 25\,°C$
$-I_C$ (mA)
max I_B
10^4
10^3
10^2
10
1
10^{-3}
10^{-2}
10^{-1}
1
10
10^2 $-I_B$ (mA)
10^3


7Z62112
$-V_{CE} = 2\ V$
$T_j = 25\,°C$
h_{FE}
typ
150
100
50
0
10
10^2
10^3
$-I_C$ (mA)
10^4


7Z62105
typical values
T_j = 25°C
$-V_{CEsat}$
(V)
$-I_C$ = 250 mA
500
750
1000
6
4
2
0
0
20
40
$-I_B$ (mA)


7Z62103
typical values
T_j = 25°C
$-V_{BEsat}$
(V)
$-I_C$ = 1000 mA
750
500
250
1,2
1
0,8
0,6
0
100
200
$-I_B$ (mA)


7Z62113
f = 35 MHz
$-V_{CE}$ = 5 V
T_j = 25 °C
f_T
MHz)
typ
150
100
50
0
1
10
10^2
10^3
$-I_C$ (mA)

HIGH VOLTAGE SILICON TRANSISTOR

Triple diffused N-P-N transistor in a SOT-32 plastic envelope intended for use as line driver in television receivers.

QUICK REFERENCE DATA

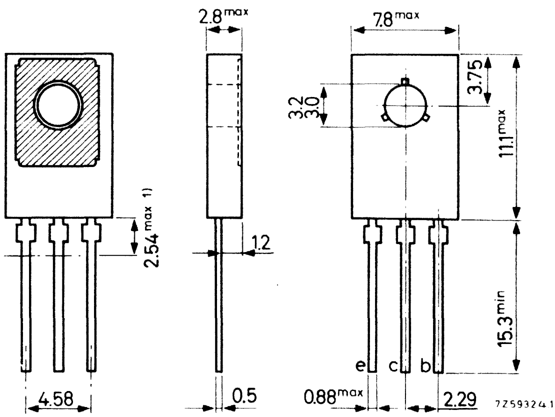
Collector-emitter voltage ($R_{BE} \leq 1$ kΩ) peak value	V_{CERM}	max.	500	V
Collector-emitter voltage (open base)	V_{CEO}	max.	300	V
Collector current (d.c.)	I_C	max.	0, 25	A
Collector current (peak value, $t_p \leq 1$ ms)	I_{CM}	max.	1	A
Total power dissipation up to T_{mb} = 62 °C	P_{tot}	max.	7	W
Junction temperature	T_j	max.	125	°C
D.C. current gain I_C = 150 mA; V_{CE} = 5 V	h_{FE}	>	20	
Transition frequency at f = 5 MHz I_C = 50 mA; V_{CE} = 10 V	f_T	typ.	20	MHz

MECHANICAL DATA

Dimensions in mm

SOT-32 (TO-126)

Collector connected to metal part of mounting surface



Accessories available: 56333 for insulated mounting; 56326 for non-insulated mounting.

1) Within this region the cross-section of the leads is uncontrolled.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltages

→ Collector-emitter voltage ($R_{BE} \leq 1$ kΩ) peak value	V_{CERM}	max.	500	V
Collector-emitter voltage (open base)	V_{CEO}	max.	300	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Currents

Collector current (d.c.)	I_C	max.	0, 25	A
Collector current (peak value, $t_p \leq 1$ ms)	I_{CM}	max.	1	A
Base current (d.c.)	I_B	max.	0, 25	A

Power dissipation

Total power dissipation up to $T_{mb} = 62$ °C	P_{tot}	max.	7	W

Temperatures

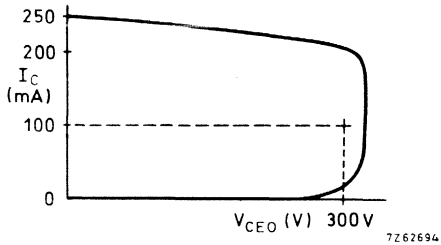
Storage temperature	T_{stg}		−55 to +125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

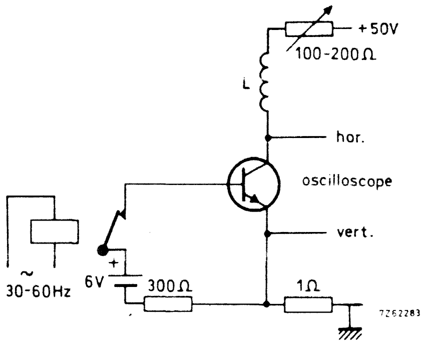
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	9	°C/W
From junction to ambient	$R_{th\ j\text{-}a}$	=	100	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current [1]				
V_{BE} = 0; V_{CE} = 500 V	I_{CES}	<	0.1	mA
V_{BE} = 0; V_{CE} = 500 V; T_j = 125 °C	I_{CES}	<	1	mA
D.C. current gain				
I_C = 50 mA; V_{CE} = 5 V	h_{FE}		25 to 150	
I_C = 150 mA; V_{CE} = 5 V	h_{FE}	>	20	
Base-emitter voltage				
I_C = 150 mA; V_{CE} = 5 V	V_{BE}	<	1	V
Collector-emitter saturation voltage				
I_C = 150 mA; I_B = 15 mA	V_{CEsat}	<	1	V
Collector-emitter sustaining voltage				
I_B = 0; I_C = 100 mA; L = 25 mH	$V_{CEOsust}$	>	300	V



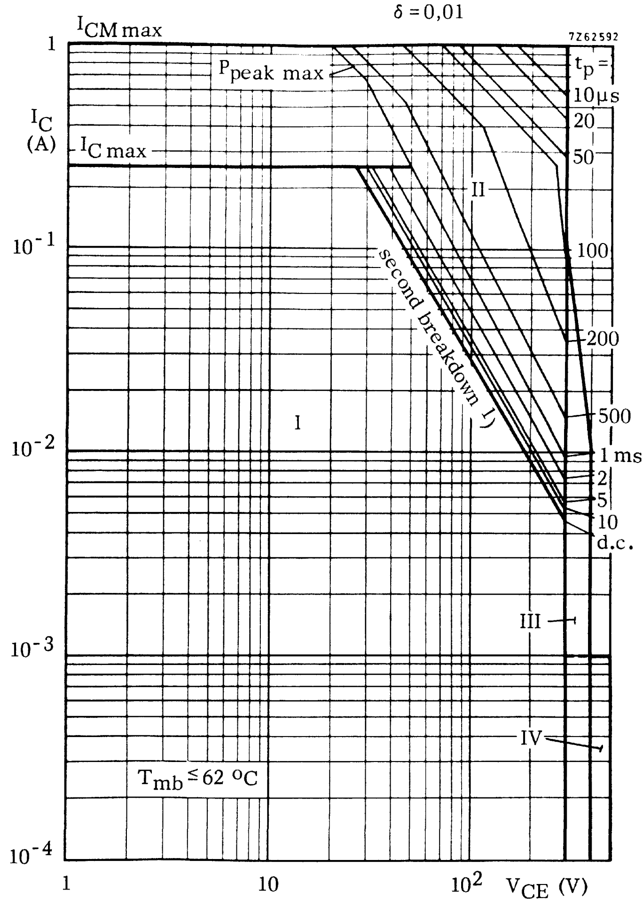
Oscilloscope display for $V_{CEOsust}$



Test circuit for $V_{CEOsust}$

Transition frequency at f = 5 MHz				
I_C = 50 mA; V_{CE} = 10 V	f_T	typ.	20	MHz

1) Measured with a half sine wave voltage (curve tracer).



Safe Operating Area (Regions I, II and III forward biased)

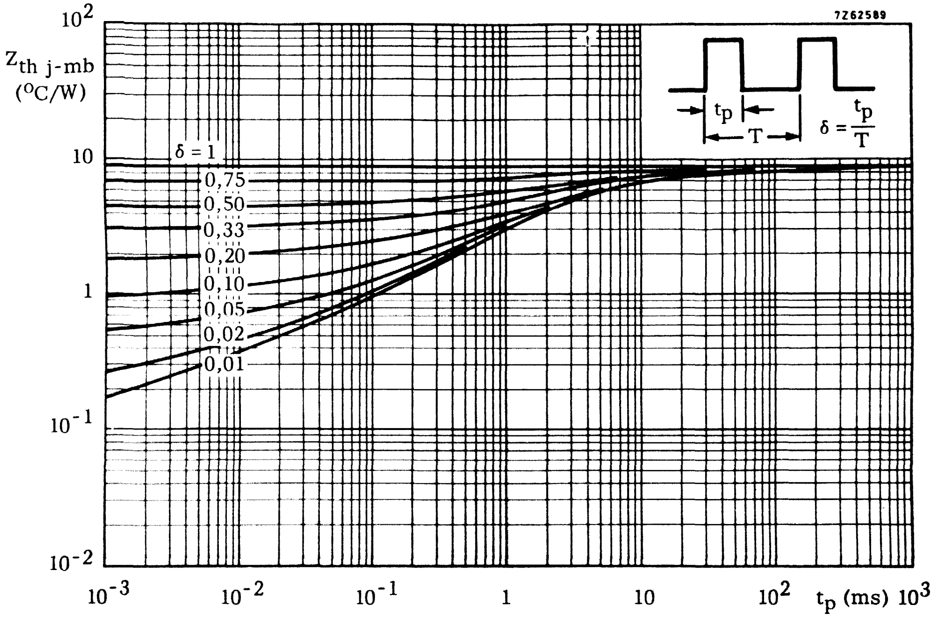
I Region of permissible d. c. operation

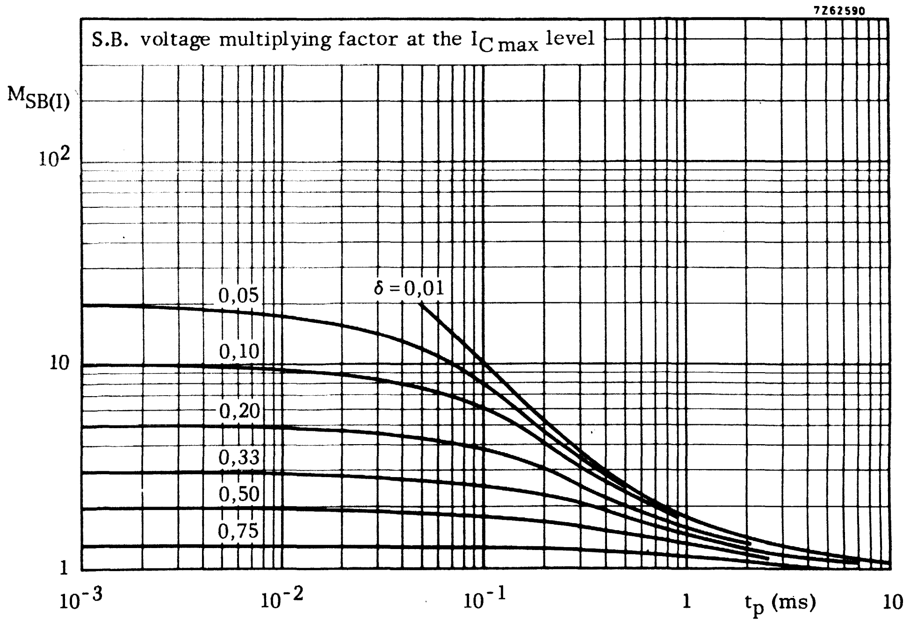
II Permissible extension for repetitive pulse operation

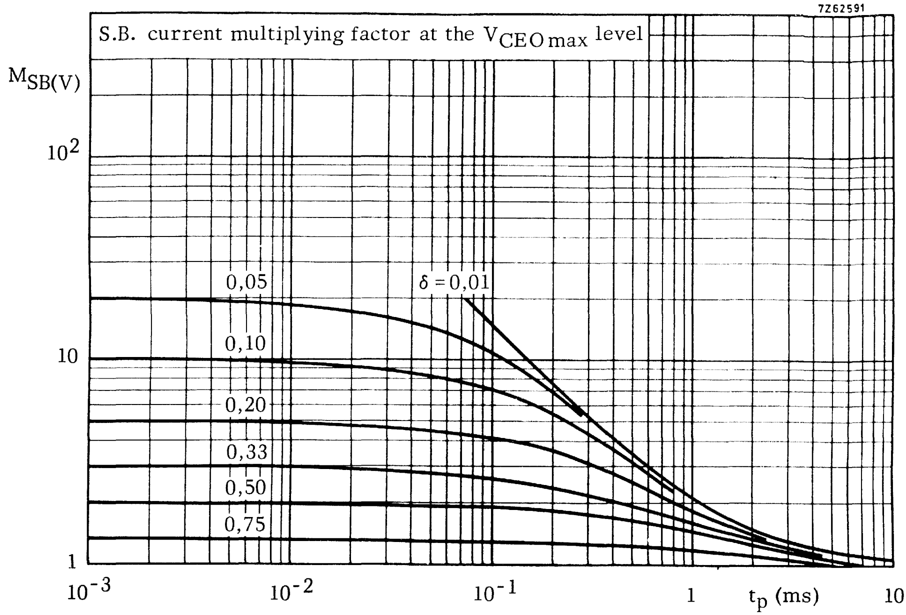
III Area of permissible operation during turn-on, provided $t_p \leq 0,3$ μs and $R_{BE} \leq 1$ kΩ

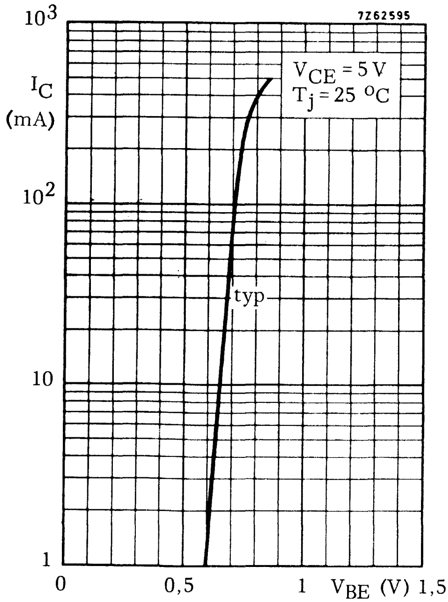
IV Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 1$ kΩ

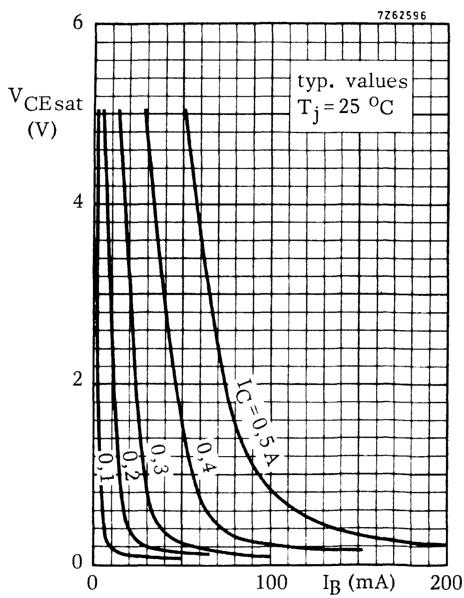
1) Independent of temperature.

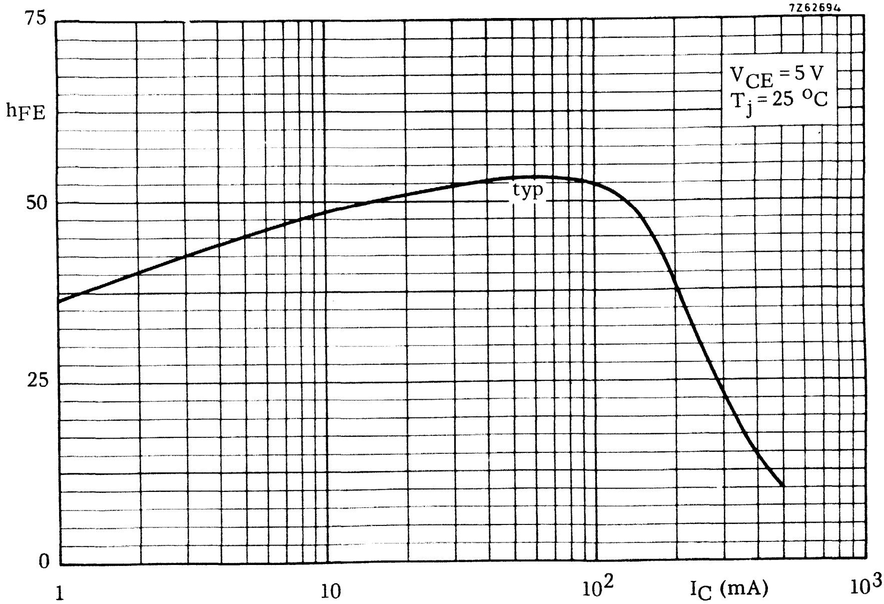

7Z62589
10^2
$Z_{th\ j-mb}$
($^oC/W$)
10
1
10^{-1}
10^{-2}
$\delta = 1$
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms) 10^3

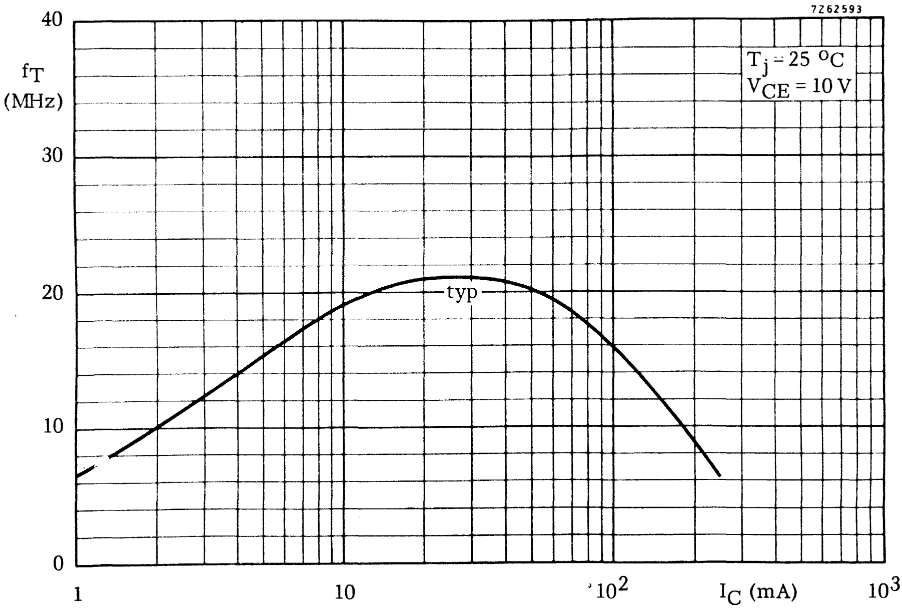

7Z62590
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
0,05
$\delta = 0,01$
0,10
0,20
0,33
0,50
0,75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10


7Z62591
S.B. current multiplying factor at the $V_{CEO max}$ level
$M_{SB(V)}$
10^2
10
1
0,05
$\delta = 0,01$
0,10
0,20
0,33
0,50
0,75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10


7Z62595
10^3
I_C (mA)
10^2
10
1
$V_{CE} = 5$ V
$T_j = 25$ °C
typ
0
0,5
1
V_{BE} (V)
1,5


7Z62596
6
V_{CEsat} (V)
4
2
0
typ. values
$T_j = 25$ °C
$I_C = 0,5$ A
0,4
0,3
0,2
0,1
0
100
I_B (mA)
200


7Z62694
75
h_{FE}
50
25
0
1
10
10^2
I_C (mA)
10^3
V_{CE} = 5 V
T_j = 25 °C
typ


7Z62593
40
f_T
(MHz)
30
20
10
0
1
10
10^2
I_C (mA)
10^3
T_j = 25 °C
V_{CE} = 10 V
typ

SILICON EPITAXIAL-BASE TRANSISTORS

N-P-N transistors in a SOT-32 plastic envelope intended for use in television and audio amplifier circuits where high peak powers can occur.

QUICK REFERENCE DATA

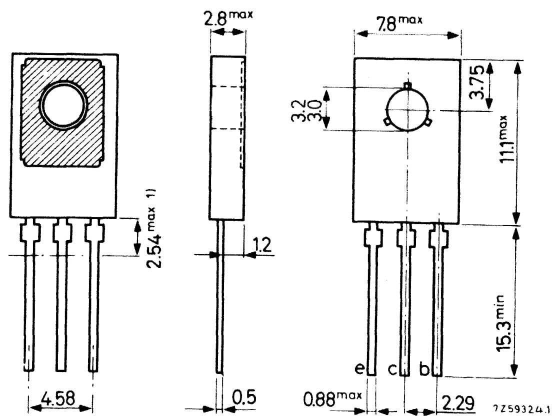
			BD233	BD235	BD237	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Collector current (peak value)	I_{CM}	max.		6		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		25		W
Junction temperature	T_j	max.		150		°C
D.C. current gain I_C = 1 A; V_{CE} = 2 V	h_{FE}	>		25		
Transition frequency at f = 1 MHz I_C = 250 mA; V_{CE} = 10 V	f_T	>		3		MHz

MECHANICAL DATA

Dimensions in mm

SOT-32 (TO-126)

Collector connected to metal part of mounting surface



For mounting instructions see section Accessories type 56326 for non-insulated mounting and type 56333 for insulated mounting.

1) Within this region the cross-section of the leads is uncontrolled.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltages

			BD233	BD235	BD237	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V

Currents

Collector current (d.c.)	I_C	max.	2	A
Collector current (peak value)	I_{CM}	max.	6	A

Power dissipation

Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	25	W

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	$R_{th\ j\text{-}a}$	=	100	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	5	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	100	μA
$I_E = 0$; $V_{CB} = V_{CBOmax}$; T_j = 150 °C	I_{CBO}	<	3	mA

Emitter cut-off current

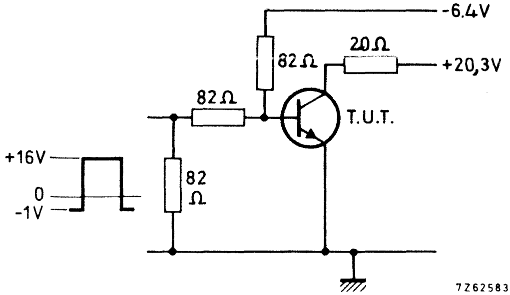
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	1	mA

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

Base-emitter voltage				
I_C = 1 A; V_{CE} = 2 V	V_{BE}	<	1,3	V
Saturation voltage				
I_C = 1 A; I_B = 0,1 A	V_{CEsat}	<	0,6	V

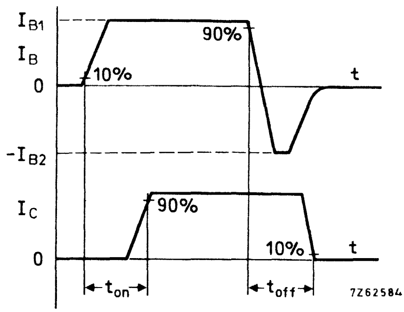
D.C. current gain			BD233;BD235	BD237
I_C = 150 mA; V_{CE} = 2 V	h_{FE}		40 to 250	40 to 160
I_C = 1 A; V_{CE} = 2 V	h_{FE}	>	25	25

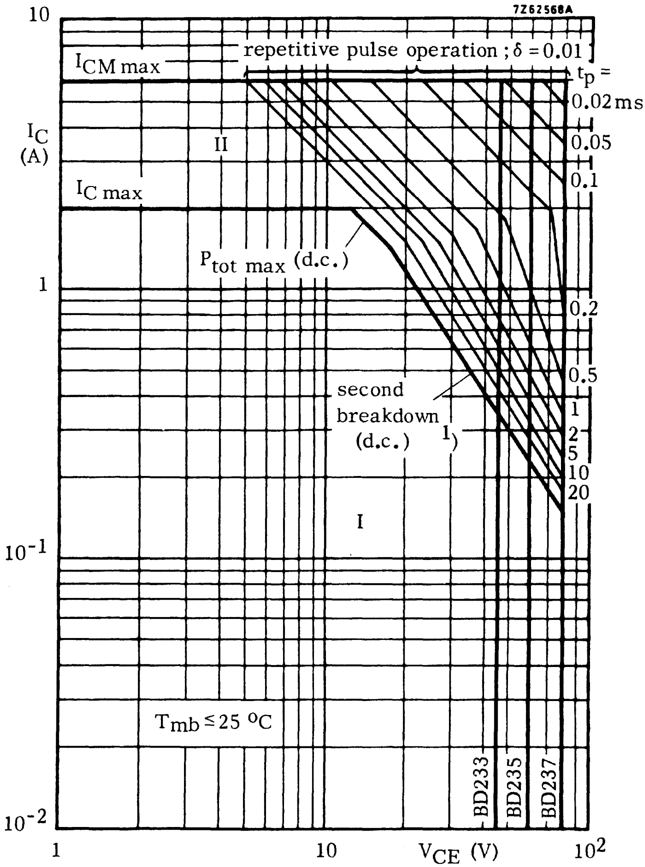
Transition frequency at f = 1 MHz				
I_C = 250 mA; V_{CE} = 10 V	f_T	>	3	MHz
Switching times				
I_C = 1 A; I_{B1} = $-I_{B2}$ = 0,1 A				
turn-on time	t_{on}	typ.	0,3	µs
turn-off time	t_{off}	typ.	1,1	µs



Test circuit

Input pulse:
$t_r = t_f$ = 15 ns
t_p = 10 µs
T = 500 µs



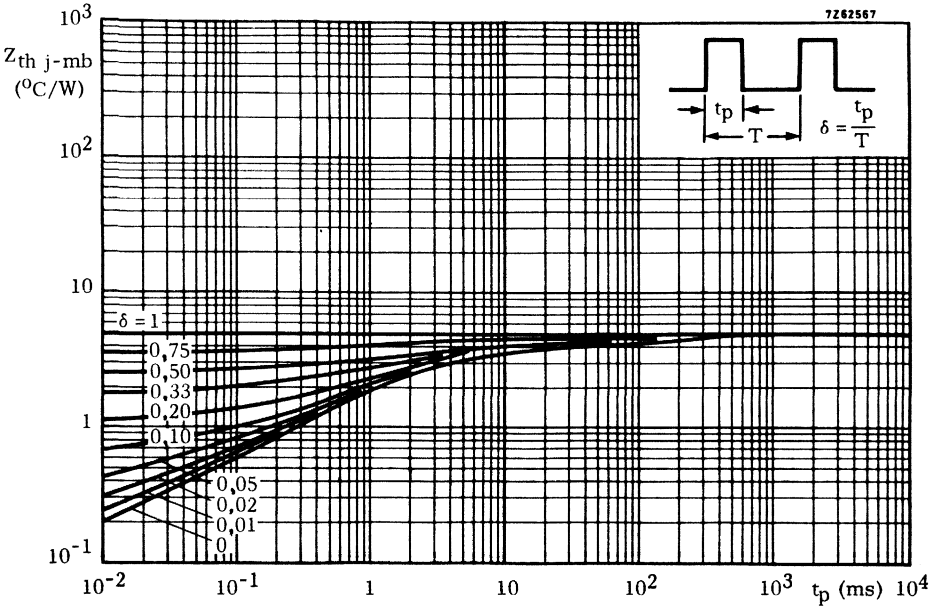


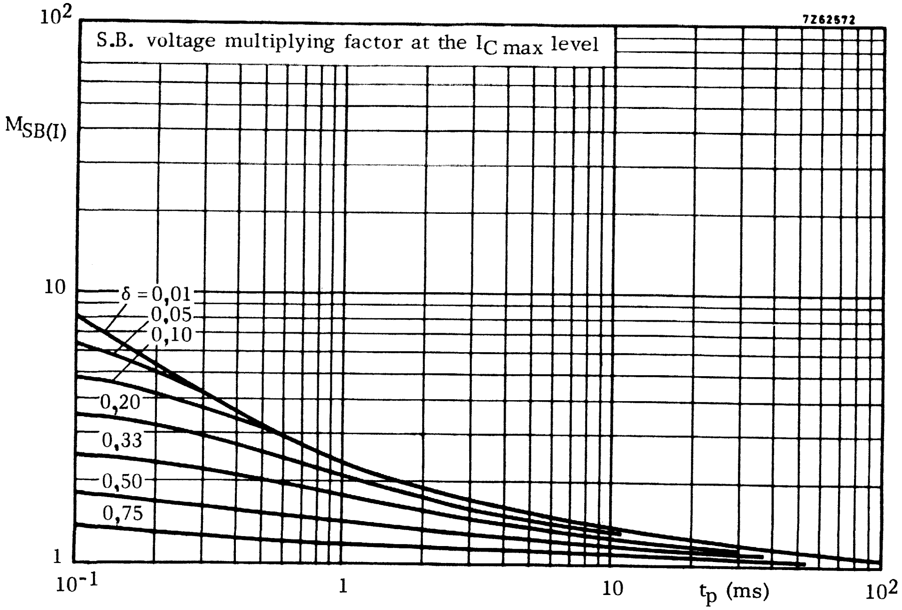
Safe Operating Area with the transistor forward biased

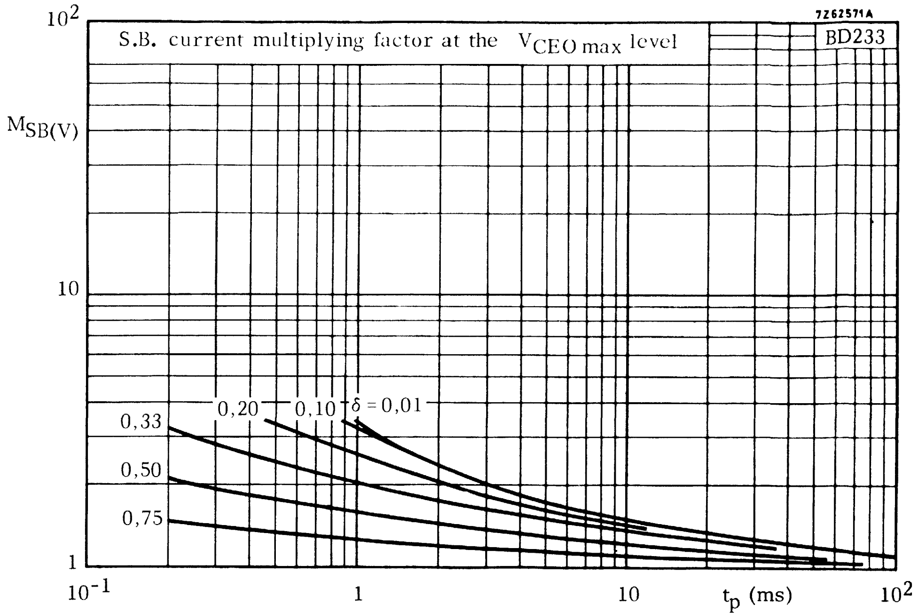
I   Region of permissible d.c. operation

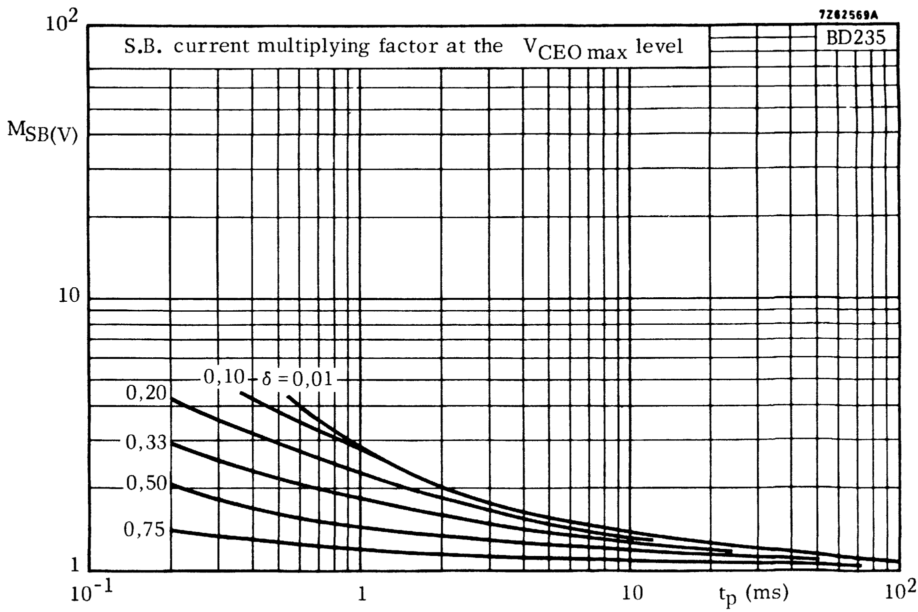
II Permissible extension for repetitive pulse operation

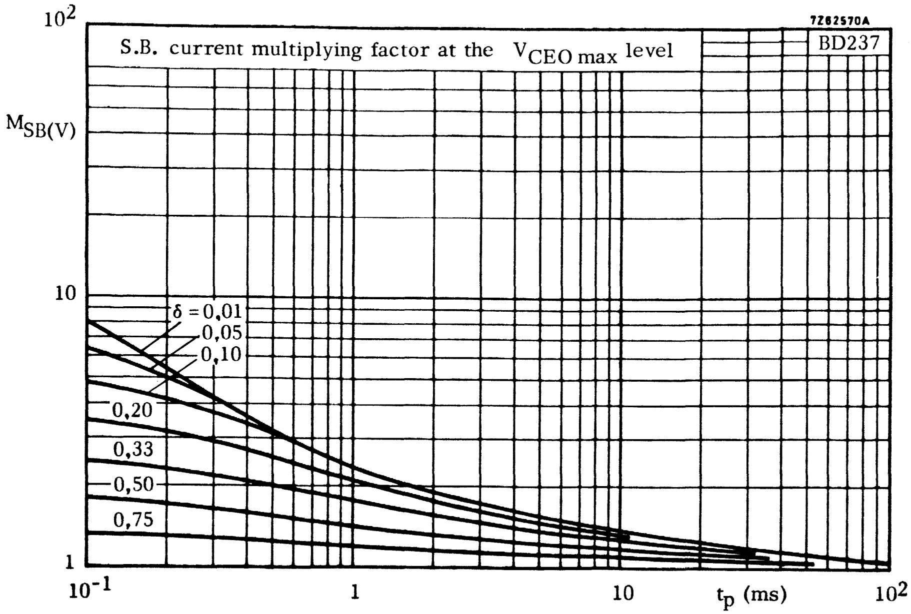
1) Independent of temperature

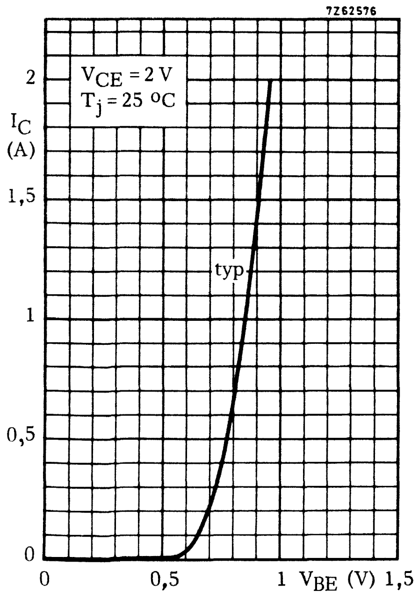

7Z62567
10^3
$Z_{th\ j-mb}$
($^oC/W$)
10^2
10
1
10^{-1}
$\delta = 1$
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
0
t_p
T
$\delta = \frac{t_p}{T}$
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (ms)
10^4

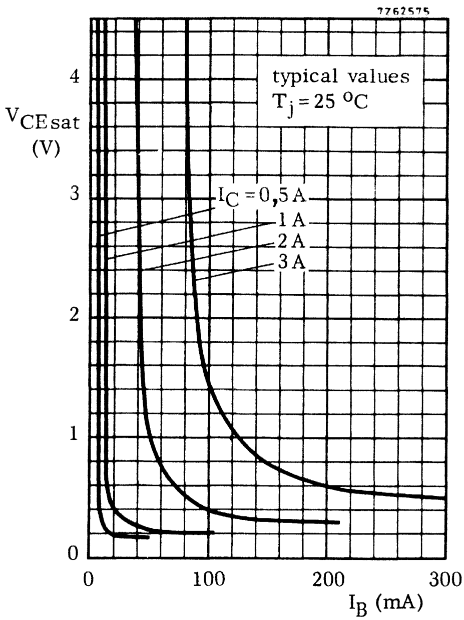

7Z62572
S.B. voltage multiplying factor at the $I_{C\ max}$ level
10^2
$M_{SB(I)}$
10
1
$\delta = 0,01$
0,05
0,10
0,20
0,33
0,50
0,75
10^{-1}
1
10
t_p (ms)
10^2

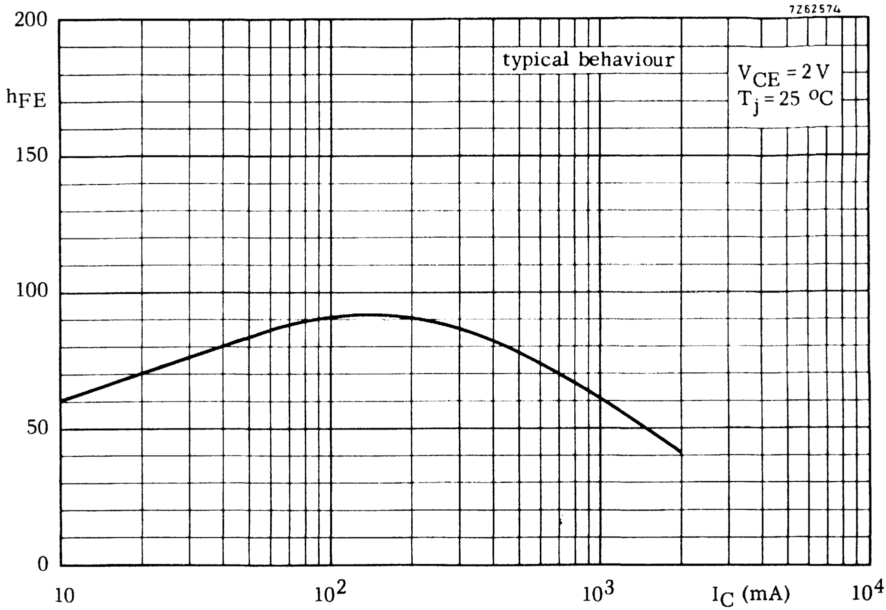

7Z62571A
S.B. current multiplying factor at the $V_{CEO\,max}$ level
BD233
10^2
$M_{SB(V)}$
10
1
0,33
0,50
0,75
0,20
0,10
δ = 0,01
10^{-1}
1
10
t_p (ms)
10^2


7Z62569A
S.B. current multiplying factor at the $V_{CEO\,max}$ level
BD235
10^2
$M_{SB(V)}$
10
1
0,20
0,33
0,50
0,75
0,10
δ = 0,01
10^{-1}
1
10
t_p (ms)
10^2


7Z62570A
S.B. current multiplying factor at the $V_{CEO\,max}$ level
BD237
$M_{SB(V)}$
10^2
10
1
δ = 0,01
0,05
0,10
0,20
0,33
0,50
0,75
10^{-1}
1
10
t_p (ms)
10^2


7Z62576
V_{CE} = 2 V
T_j = 25 °C
I_C
(A)
2
1,5
1
0,5
0
typ
0
0,5
1
V_{BE} (V)
1,5


7Z62575
typical values
T_j = 25 °C
V_{CEsat}
(V)
4
3
2
1
0
I_C = 0,5 A
1 A
2 A
3 A
0
100
200
300
I_B (mA)


7Z62574
200
150
100
50
0
hFE
typical behaviour
VCE = 2 V
Tj = 25 °C
10
10²
10³
10⁴
IC (mA)

SILICON EPITAXIAL-BASE TRANSISTORS

P-N-P transistor in a SOT-32 plastic envelope intended for use in television and audio amplifier circuits where high peak powers can occur.

QUICK REFERENCE DATA

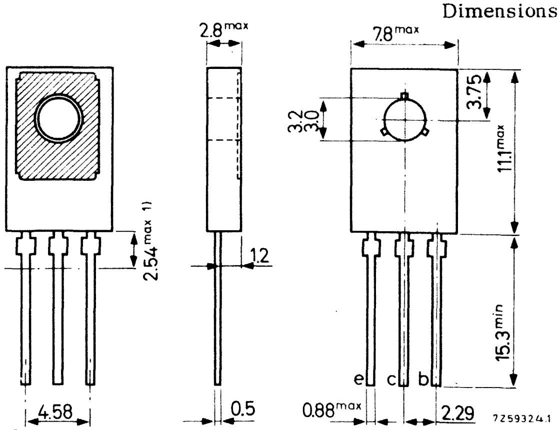
			BD234	BD236	BD238	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Collector current (peak value)	$-I_{CM}$	max.		6		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		25		W
Junction temperature	T_j	max.		150		°C
D.C. current gain $-I_C$ = 1 A; $-V_{CE}$ = 2 V	h_{FE}	>		25		
Transition frequency at f = 1 MHz $-I_C$ = 250 mA; $-V_{CE}$ = 10 V	f_T	>		3		MHz

MECHANICAL DATA

Dimensions in mm

SOT-32 (TO-126)

Collector connected to metal part of mounting surface



For mounting instructions see section Accessories type 56326 for non-insulated mounting and type 56333 for insulated mounting.

1) Within this region the cross-section of the leads is uncontrolled.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltages			BD234	BD236	BD238	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V

Currents

Collector current (d.c.)	$-I_C$	max.	2	A
Collector current (peak value)	$-I_{CM}$	max.	6	A

Power disspation

Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	25	W

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	$R_{th\ j-a}$	=	100	°C/W
From junction to mounting base	$R_{th\ j-mb}$	=	5	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $-V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	100	μA
$I_E = 0$; $-V_{CB} = -V_{CBOmax}$; T_j = 150 °C	$-I_{CBO}$	<	3	mA

Emitter cut-off current

$I_C = 0$; $-V_{EB}$ = 5 V	$-I_{EBO}$	<	1	mA

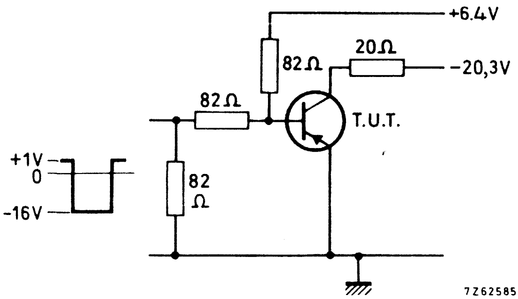
CHARACTERISTICS (continued) $T_j = 25\ ^oC$ unless otherwise specified

Base-emitter voltage				
$-I_C = 1$ A; $-V_{CE} = 2V$	$-V_{BE}$	<	1,3	V
Saturation voltage				
$-I_C = 1$ A; $-I_B = 0,1$ A	$-V_{CEsat}$	<	0,6	V

D.C. current gain

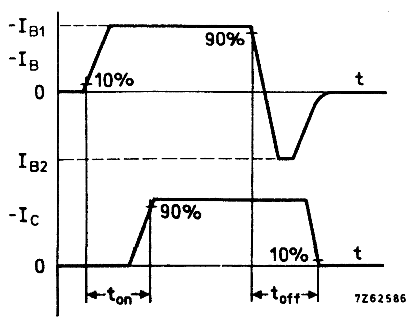
			BD234;BD236	BD238
$-I_C = 150$ mA; $-V_{CE} = 2$ V	h_{FE}		40 to 250	40 to 160
$-I_C = 1$ A; $-V_{CE} = 2$ V	h_{FE}	>	25	25

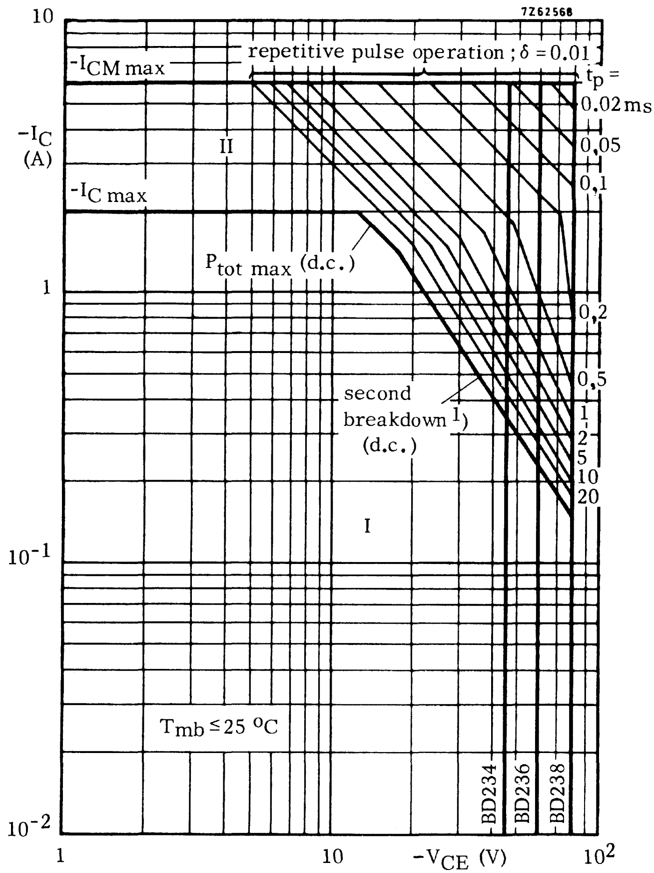
Transition frequency at f = 1 MHz				
$-I_C = 250$ mA; $-V_{CE} = 10$ V	f_T	>	3	MHz
Switching times				
$-I_C = 1$ A; $-I_{B1} = I_{B2} = 0,1$ A				
turn-on time	t_{on}	typ.	0,3	μs
turn-off time	t_{off}	typ.	0,7	μs



Test circuit

Input pulse:
$t_r = t_f =$ 15 ns
$t_p =$ 10 μs
T = 500 μs



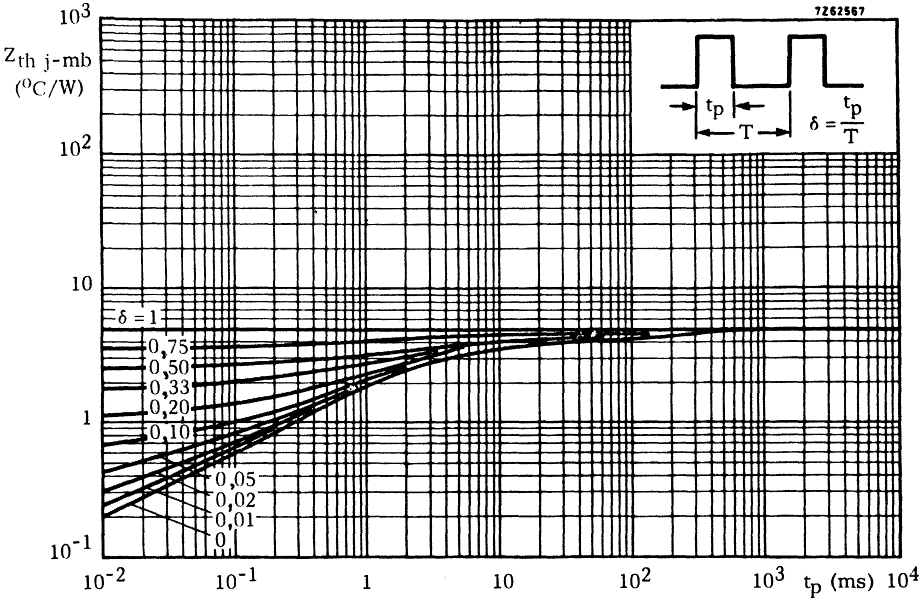


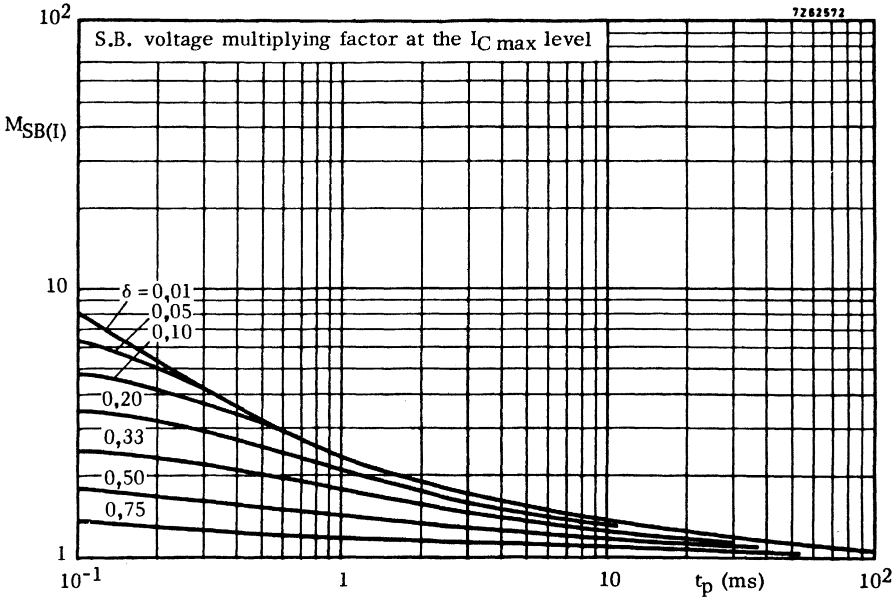
Safe Operating Area with the transistor forward biased

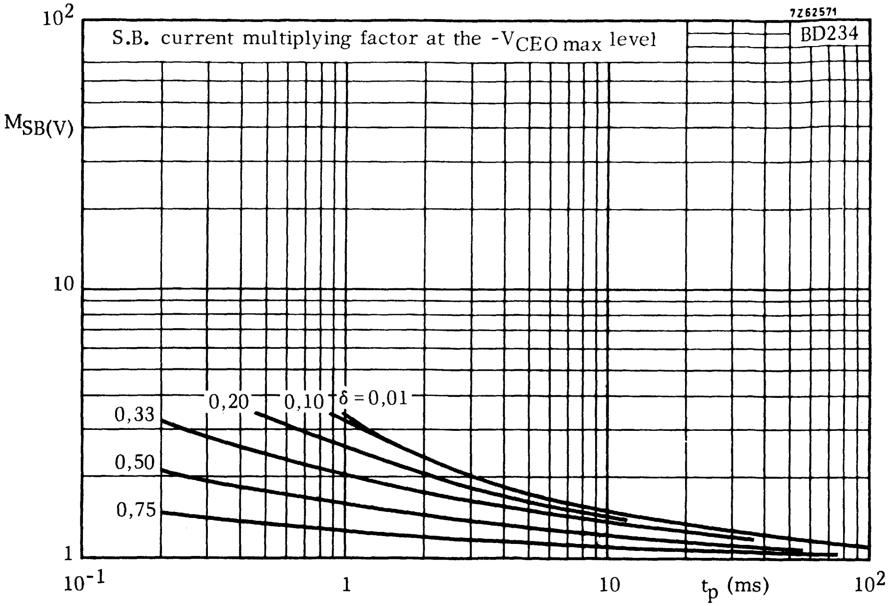
I Region of permissible d.c. operation

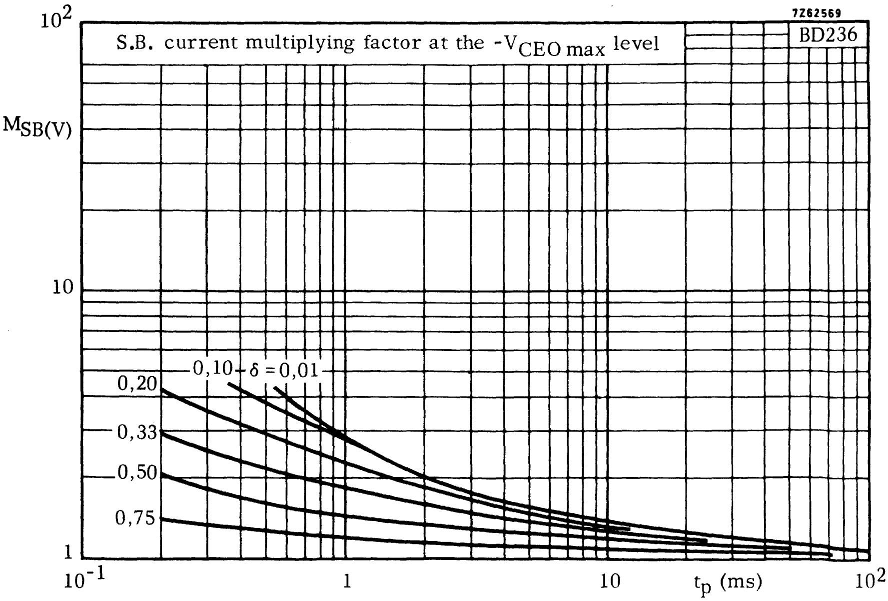
II Permissible extension for repetitive pulse operation

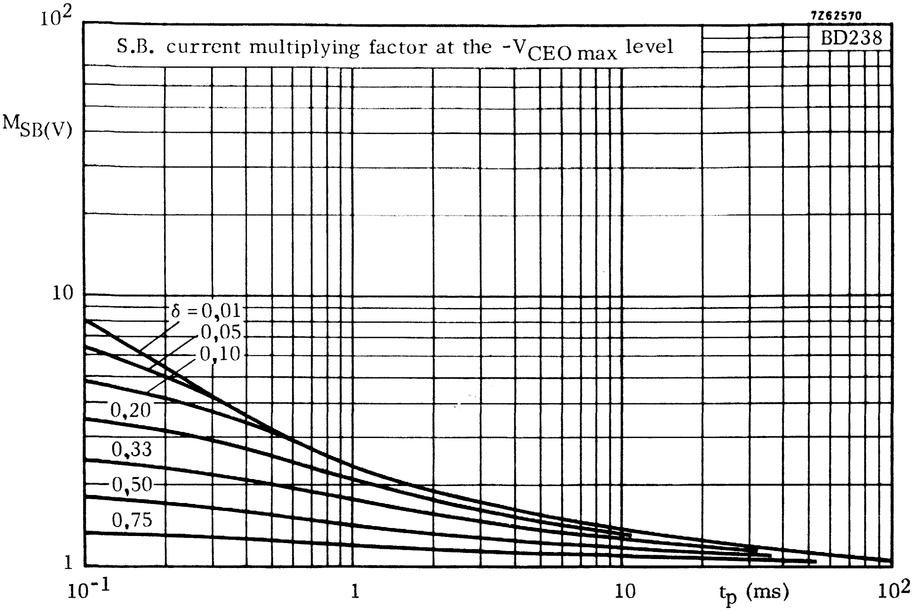
1) Independent of temperature.

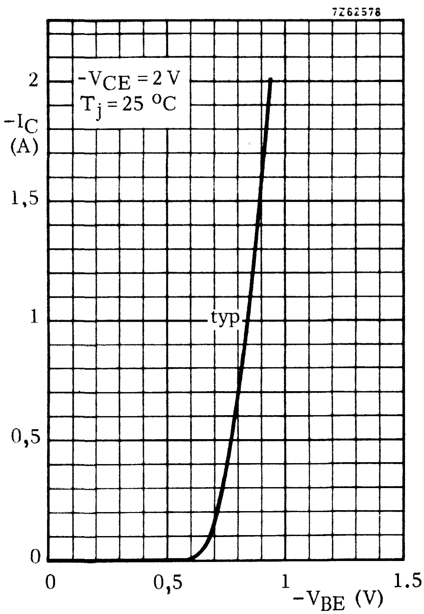

7Z62567
$Z_{th\ j\text{-}mb}$ (°C/W)
10^3
10^2
10
1
10^{-1}
$\delta = 1$
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
0
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (ms)
10^4
t_p
T
$\delta = \frac{t_p}{T}$

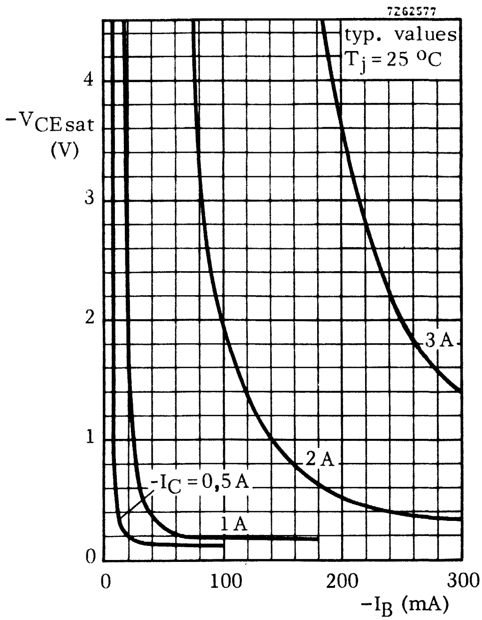

7Z62572
S.B. voltage multiplying factor at the $I_{C\ max}$ level
$M_{SB(I)}$
10^2
10
1
$\delta = 0,01$
0,05
0,10
0,20
0,33
0,50
0,75
10^{-1}
1
10
t_p (ms)
10^2

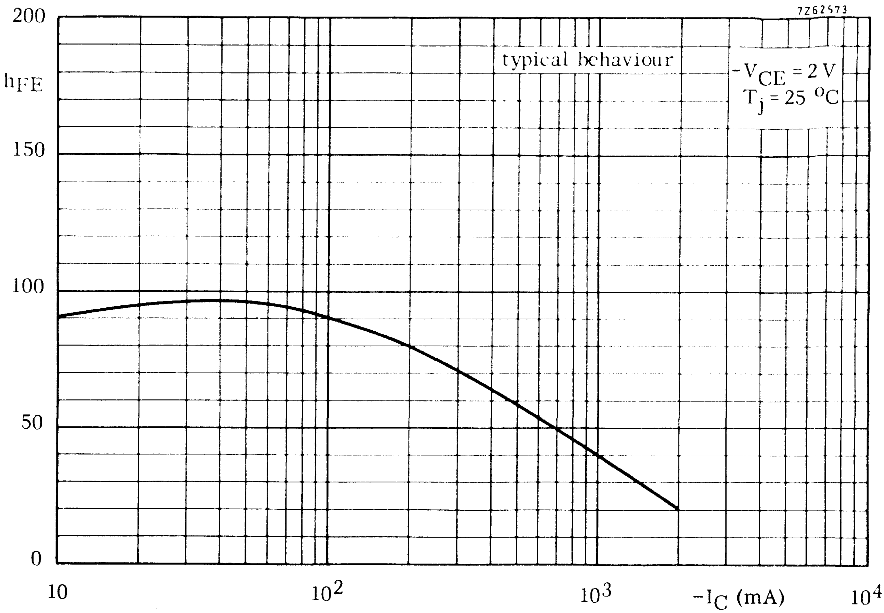

7Z62571
S.B. current multiplying factor at the -V CEO max level
BD234
$M_{SB(V)}$
10^2
10
1
10^{-1}
1
10
t_p (ms)
10^2
0,33
0,20
0,10
δ = 0,01
0,50
0,75


7Z62569
S.B. current multiplying factor at the -V CEO max level
BD236
$M_{SB(V)}$
10^2
10
1
10^{-1}
1
10
t_p (ms)
10^2
0,10
δ = 0,01
0,20
0,33
0,50
0,75


7Z62570
S.B. current multiplying factor at the -V CEO max level
BD238
10^2
M SB(V)
10
1
δ = 0,01
0,05
0,10
0,20
0,33
0,50
0,75
10^{-1}
1
10
10^2
t p (ms)


7Z62578
-V CE = 2 V
T j = 25 °C
-I C
(A)
2
1,5
1
0,5
0
typ
0
0,5
1
1.5
-V BE (V)


7Z62577
typ. values
T j = 25 °C
-V CEsat
(V)
4
3
2
1
0
3 A
2 A
-I C = 0,5 A
1 A
0
100
200
300
-I B (mA)


7Z62573
200
hFE
150
100
50
0
typical behaviour
-VCE = 2 V
Tj = 25 °C
10
10^2
10^3
-IC (mA)
10^4

SILICON EPITAXIAL-BASE POWER TRANSISTORS

N-P-N silicon power transistors in a SOT-32 plastic envelope, intended for use in l.f. applications.
The BD433 with its p-n-p complement BD434 is specially suitable for use in output stages of car radios.
The complementary pairs BD435/BD436 and BD437/BD438 are intended for use in mains operated amplifiers and radio receivers with output powers of up to 10 W and 15 W respectively.

QUICK REFERENCE DATA

			BD433	BD435	BD437	
Collector-base voltage (V_{BE} = 0)	V_{CES}	max.	22	32	45	V
Collector-emitter voltage (open base)	V_{CEO}	max.	22	32	45	V
Collector current (peak value)	I_{CM}	max.	7	7	7	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	36	36	36	W
Junction temperature	T_j	max.	150	150	150	°C
D.C. current gain						
I_C = 2 A; V_{CE} = 1 V	h_{FE}	>	50	50	40	
I_C = 3 A; V_{CE} = 1 V	h_{FE}	>	–	–	30	
Transition frequency at f = 1 MHz I_C = 250 mA; V_{CE} = 1 V	f_T	>	3	3	3	MHz

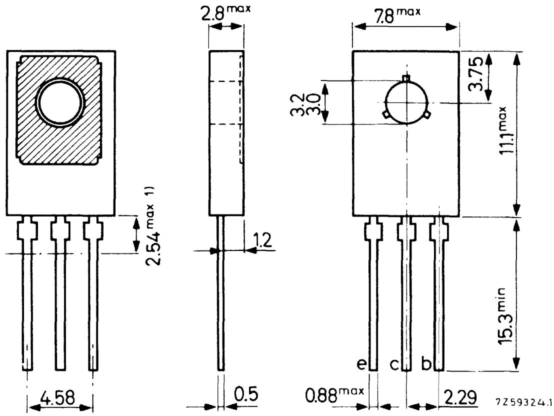
MECHANICAL DATA (See page 2)

MECHANICAL DATA

Dimensions in mm

SOT-32 (TO-126)

Collector connected to metal part of mounting surface



For mounting instructions see section Accessories type 56326 for non-insulated mounting and type 56333 for insulated mounting.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltage			BD433	BD435	BD437	
Collector-base voltage (open emitter)	V_{CBO}	max.	22	32	45	V
Collector-emitter voltage ($V_{BE} = 0$)	V_{CES}	max.	22	32	45	V
Collector-emitter (open base)	V_{CEO}	max.	22	32	45	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V

Current				
Collector current (d.c.)	I_C	max.	4	A
Collector current (peak value)	I_{CM}	max.	7	A
Base current (d.c.)	I_B	max.	1	A
Power dissipation				
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.	36	W
Temperature				
Storage temperature	T_{stg}	max.	−55 to +150	^oC
Junction temperature	T_j	max.	150	^oC

1) Within this region the cross-section of the leads is uncontrolled.

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	100	°C/W
From junction to mounting base	$R_{th\ j-mb}$	=	3,5	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current						
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	100			μA
$I_E = 0$; $V_{CB} = 10$ V; $T_j = 150$ °C	I_{CBO}	<	1			mA
$I_E = 0$; $V_{CB} = V_{CBOmax}$; $T_j = 150$ °C	I_{CBO}	<	3			mA
Emitter cut-off current						
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	1			mA
			BD433	**BD435**	**BD437**	
Knee voltage						
$I_C = 2$ A; I_B = value for which $I_C = 2,2$ A at $V_{CE} = 1$ V	V_{CEK}	<	0,8	–	–	V
Base-emitter voltage [1]						
$I_C = 10$ mA; $V_{CE} = 5$ V	V_{BE}	typ.	580	580	580	mV
$I_C = 2$ A; $V_{CE} = 1$ V	V_{BE}	<	1,1	1,1	–	V
$I_C = 3$ A; $V_{CE} = 1$ V	V_{BE}	<	–	–	1,3	V
Collector-emitter saturation voltage						
$I_C = 2$ A; $I_B = 0,2$ A	V_{CEsat}	<	0,5	0,5	–	V
$I_C = 3$ A; $I_B = 0,3$ A	V_{CEsat}	<	–	–	0,7	V
D.C. current gain						
$I_C = 10$ mA; $V_{CE} = 5$ V	h_{FE}	>	40	40	30	
$I_C = 500$ mA; $V_{CE} = 1$ V	h_{FE}	>	85	85	85	
		<	475	475	375	
$I_C = 2$ A; $V_{CE} = 1$ V	h_{FE}	>	50	50	40	
$I_C = 3$ A; $V_{CE} = 1$ V	h_{FE}	>	–	–	30	

1) V_{BE} decreases by typ. 2,3 mV/°C with increasing temperature.

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

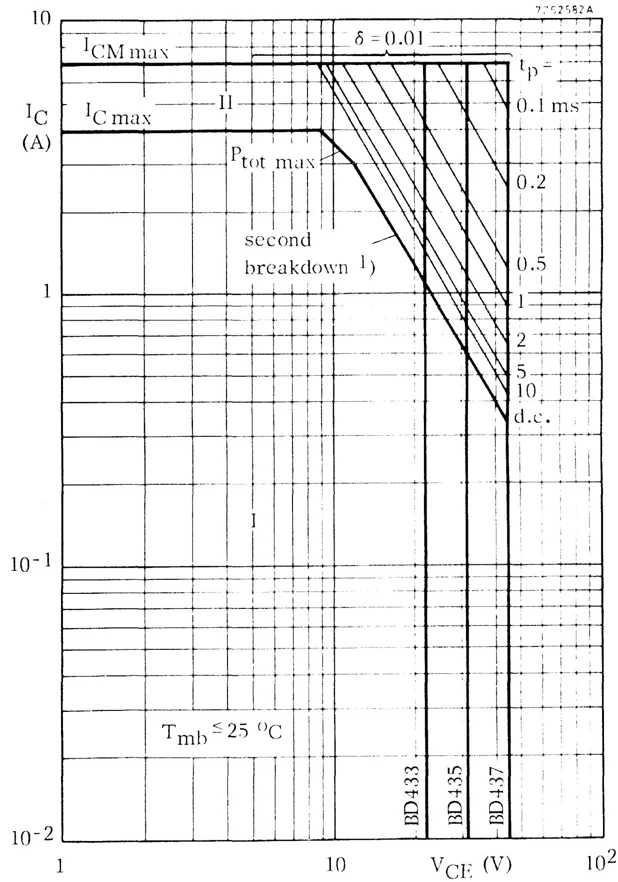
Transition frequency at f = 1 MHz

I_C = 250 mA; V_{CE} = 1 V	f_T	>	3	MHz

D.C. current gain ratio of the complementary pairs

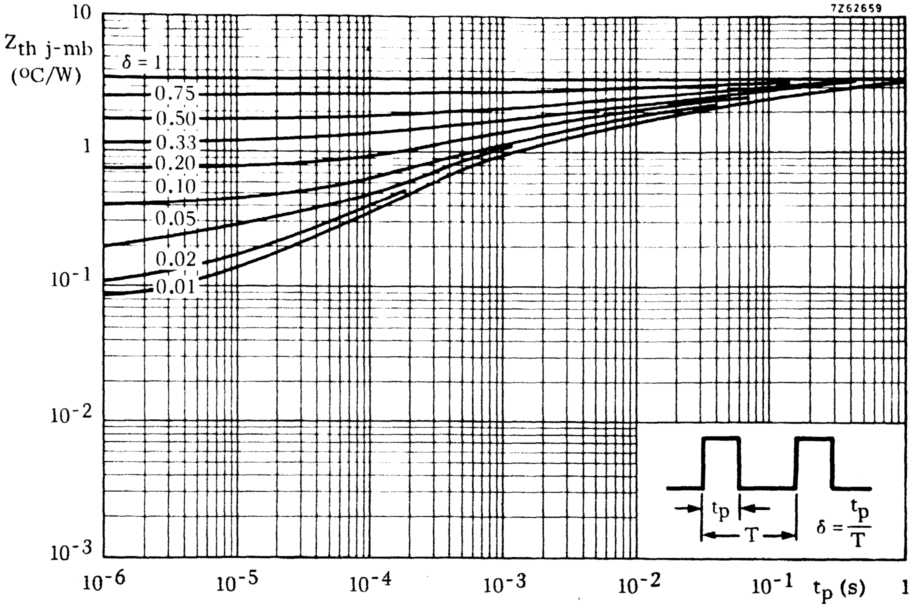
$|I_C|$ = 500 mA; $|V_{CE}|$ = 1 V

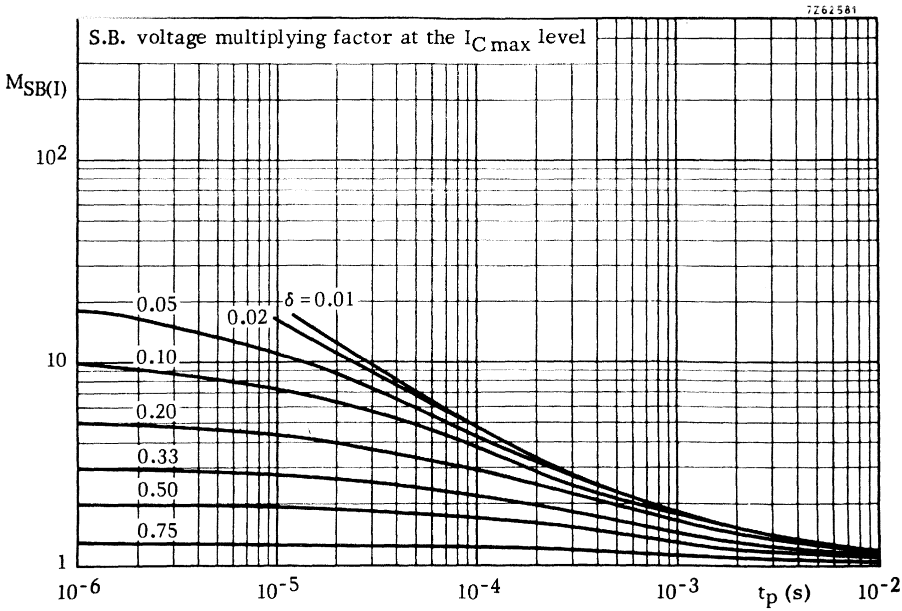
BD433/BD434 and BD435/BD436	h_{FE1}/h_{FE2}	<	1,4
BD437/BD438	h_{FE1}/h_{FE2}	<	1,8



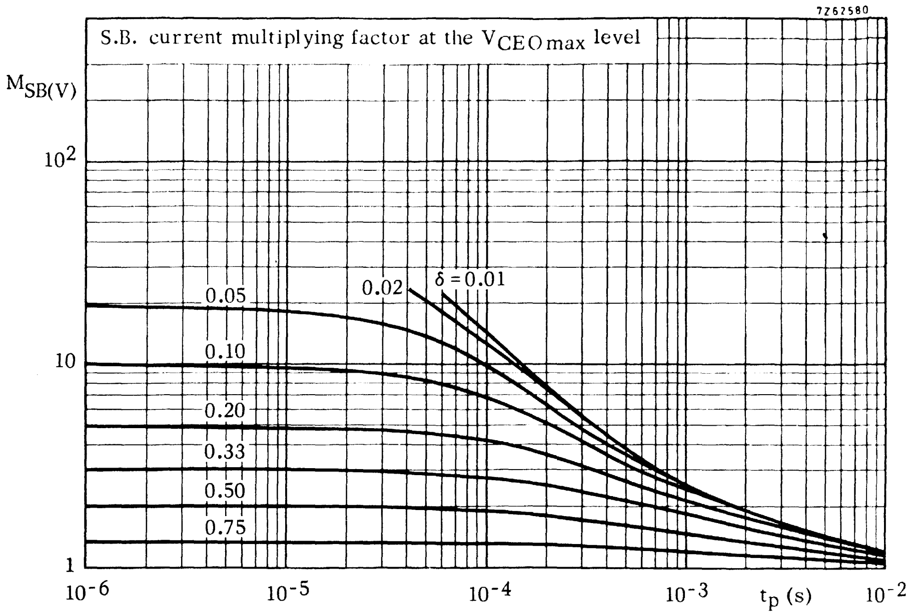
Safe Operating Area with the transistor forward biased
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation

1) Independent of temperature

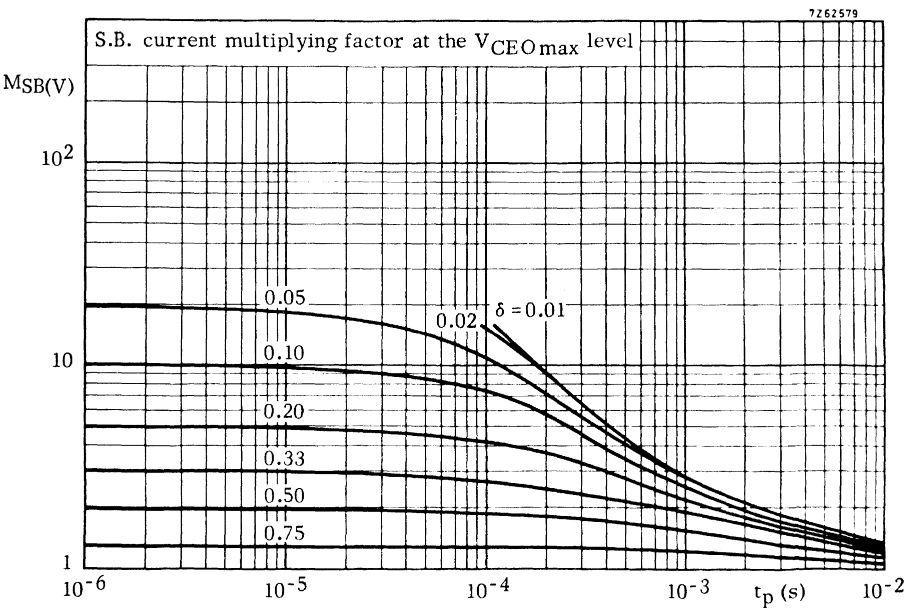

7Z62659
10
$Z_{th\ j\text{-}mb}$
(°C/W)
δ = 1
0.75
0.50
1
0.33
0.20
0.10
0.05
0.02
10^{-1}
0.01
10^{-2}
10^{-3}
tp
T
δ = tp/T
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
t_p (s)
1

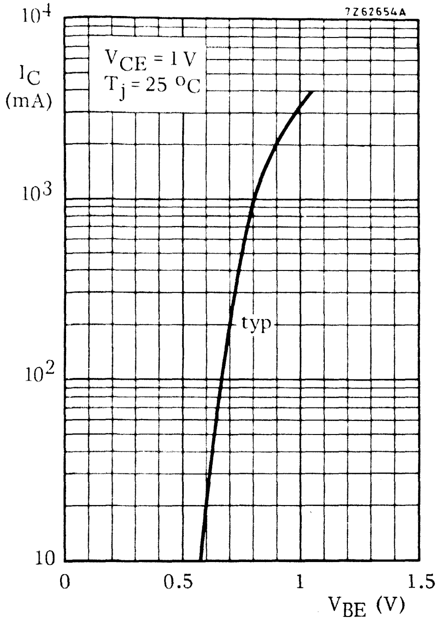

7Z62581
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
0.05
0.02
δ = 0.01
10
0.10
0.20
0.33
0.50
0.75
1
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

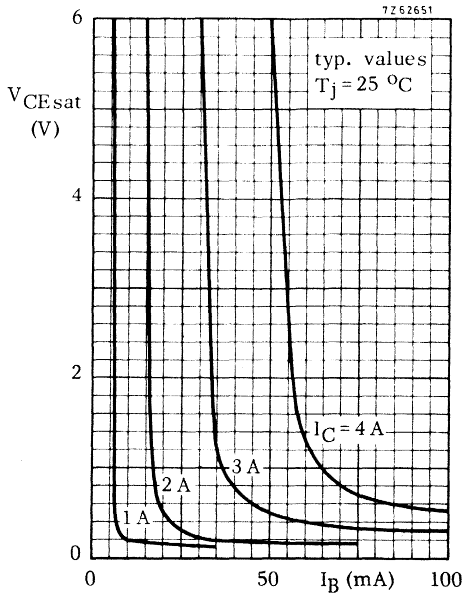
BD433; BD435

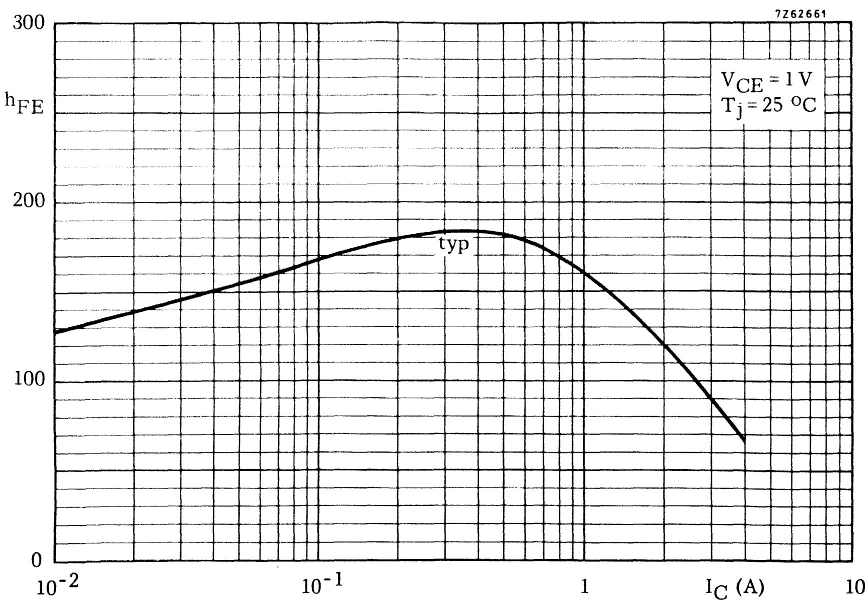


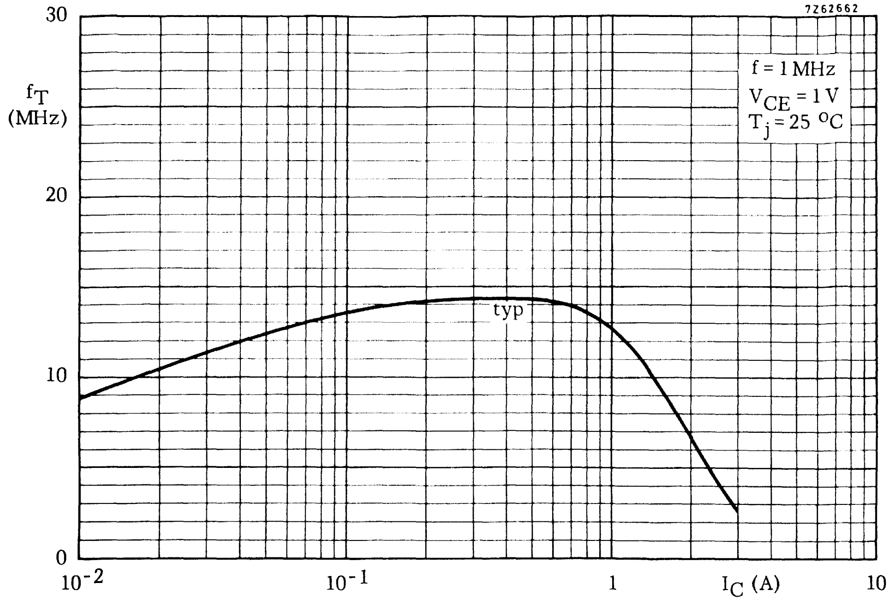
BD437

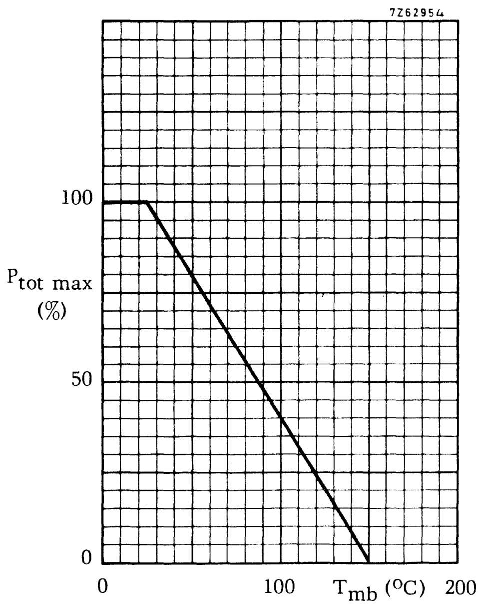



7Z62654A
I_C (mA)
V_{CE} = 1 V
T_j = 25 °C
typ
10
10^2
10^3
10^4
0
0.5
1
1.5
V_{BE} (V)


7Z62651
V_{CEsat} (V)
typ. values
T_j = 25 °C
I_C = 4 A
3 A
2 A
1 A
0
2
4
6
0
50
I_B (mA)
100

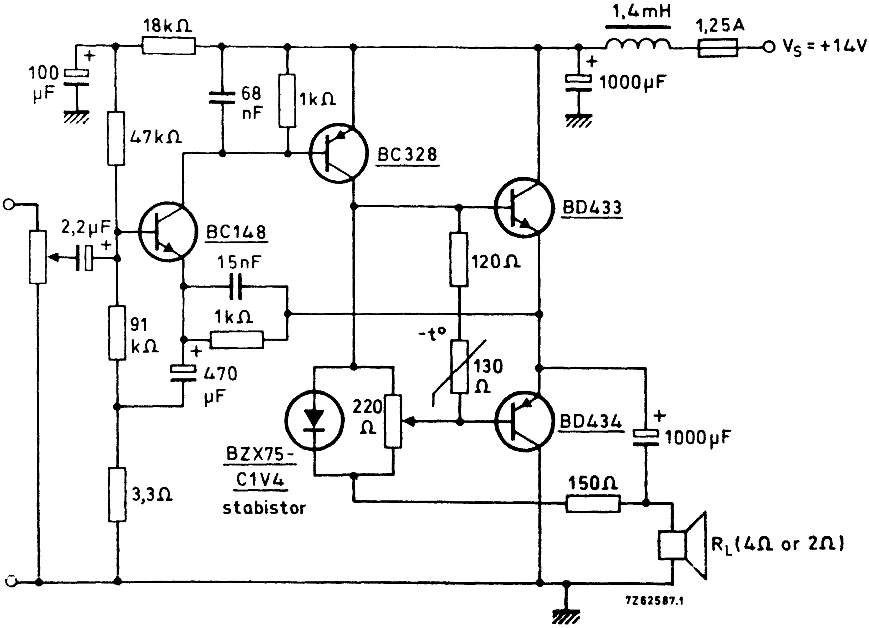

7Z62661
h_{FE}
V_{CE} = 1 V
T_j = 25 °C
typ
0
100
200
300
10^{-2}
10^{-1}
1
I_C (A)
10


7Z62662
30
20
10
0
f_T
(MHz)
f = 1 MHz
V_{CE} = 1 V
T_j = 25 °C
typ
10^{-2}
10^{-1}
1
I_C (A)
10


7Z62954
100
$P_{tot\ max}$
(%)
50
0
0
100
T_{mb} (°C)
200

APPLICATION INFORMATION

Basic circuit diagram of a 6 W car-radio audio amplifier.



Typical performance:

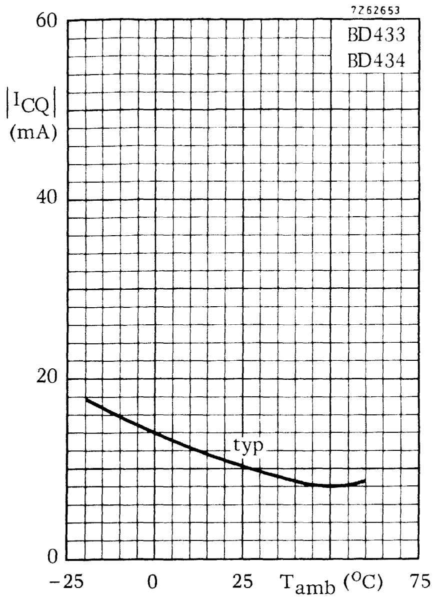
Output power at d_{tot} = 10% and R_L = 4 Ω	P_o	≥	6	W
Output power at d_{tot} = 10% and R_L = 2 Ω	P_o		8	W
Input voltage for P_o = 5 W; R_L = 4 Ω	V_i		20	mV
P_o = 5 W; R_L = 2 Ω	V_i		15	mV
Input impedance	Z_i		20	kΩ
Collector quiescent current of output transistors	$\lvert I_{CQ} \rvert$		10	mA
Collector current of BC328 [1])	I_C		39	mA
Total current consumption at P_o = 6 W	I_{tot}		580	mA
Frequency response (−3 dB)		0, 1 to	12	kHz
Total thermal resistance per output transistor	$R_{th\ j-a}$	max.	22	°C/W

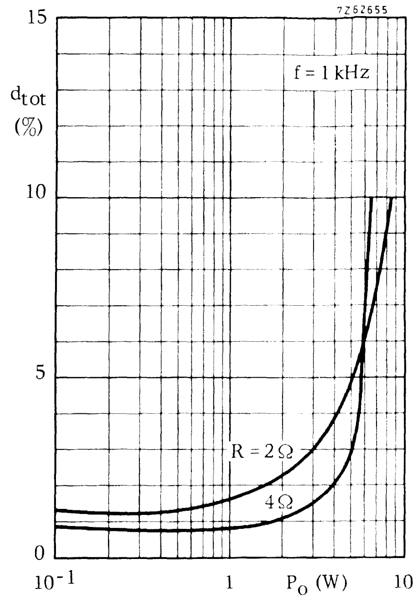
Stable continuous operation is ensured up to an ambient temperature of 60 °C

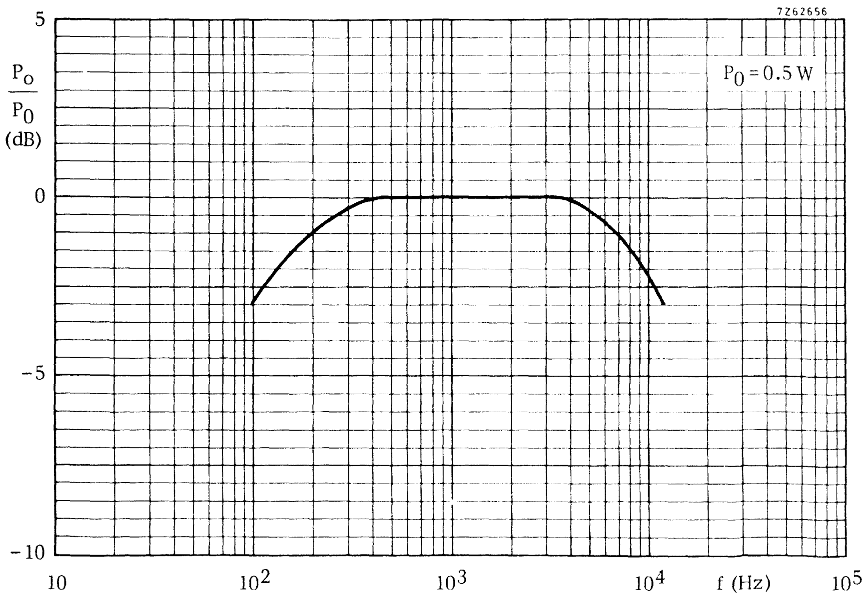
The amplifier is overdrive proof and short circuit proof.

1) Area of printed wiring copper around collector lead ≈ 1 cm^2.

APPLICATION INFORMATION (continued)

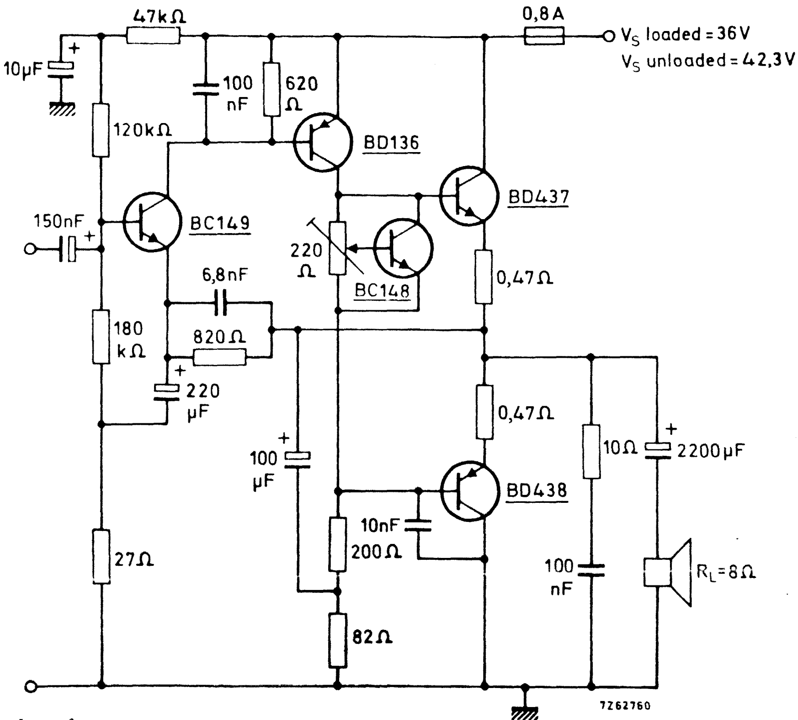






APPLICATION INFORMATION (continued)

Basic circuit diagram of a 15 W high quality amplifier.

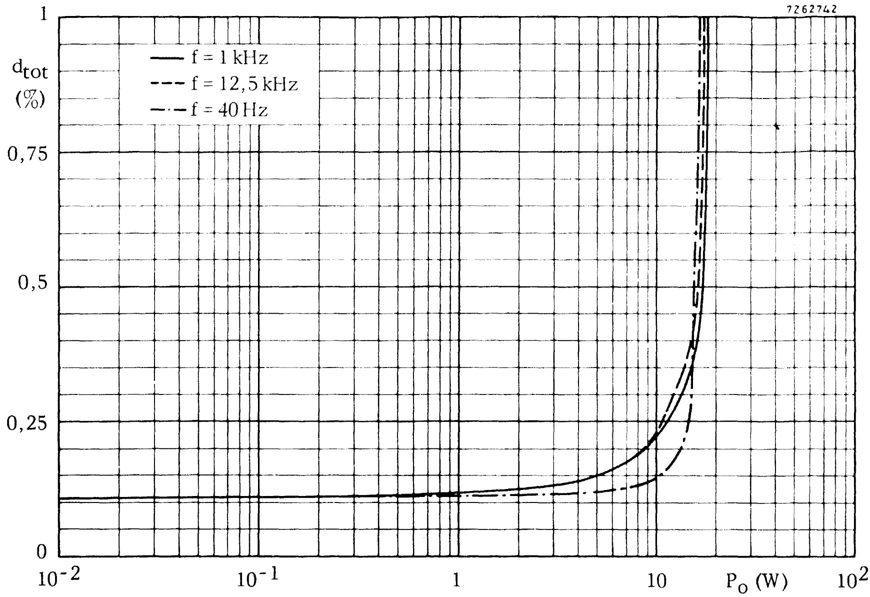


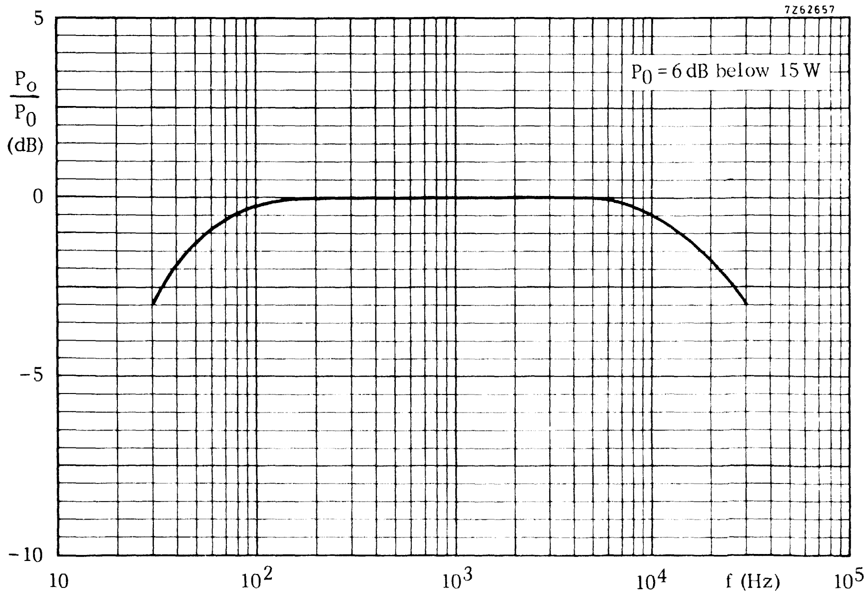
Typical performance:

Output power at d_{tot} = 1 %	P_o	≥	15	W
Input voltage for P_o = 10 W	V_i		360	mV
Input impedance	Z_i		100	kΩ
Output impedance	Z_o		0, 15	Ω
Collector quiescent current of output transistors	$\|I_{CQ}\|$		10	mA
Collector current of BD136	$-I_C$		72	mA
Collector current of BC149	I_C		1, 6	mA
Total current consumption at P_o = 15 W	I_{tot}		710	mA
Frequency response (−3 dB)			30 Hz to 30	kHz
Total thermal resistance per output transistor	$R_{th\ j-a}$	max.	18	°C/W
Total thermal resistance of the BD136	$R_{th\ j-a}$	max.	44	°C/W

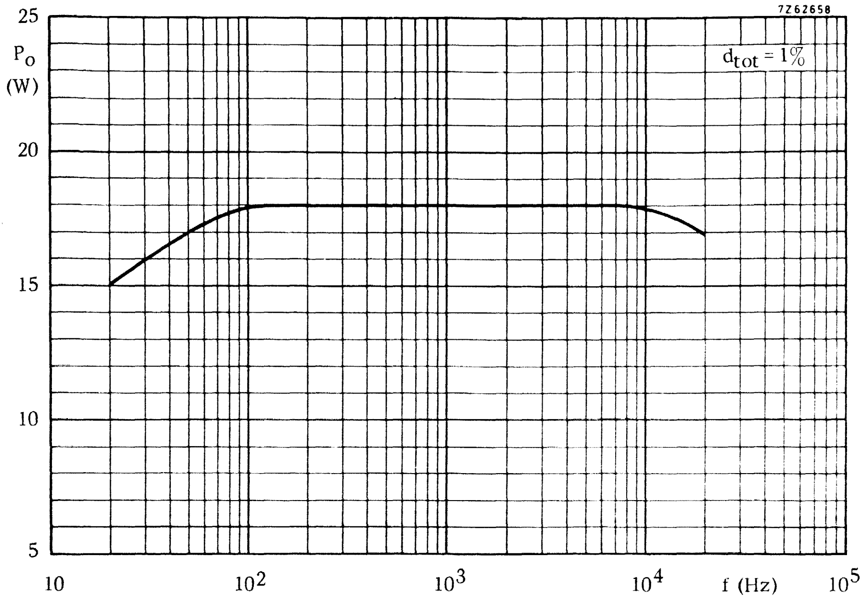
Stable continuous operation is ensured up to an ambient temperature of 45 °C.

APPLICATION INFORMATION (continued)





APPLICATION INFORMATION (continued)



SILICON EPITAXIAL-BASE POWER TRANSISTORS

P-N-P silicon power transistors in a SOT-32 plastic envelope, intended for use in l.f. applications.
The BD434 with its n-p-n complement BD433 is specially suitable for use in output stages of car radios.
The complementary pairs BD435/BD436 and BD437/BD438 are intended for use in mains operated amplifiers and radio receivers with output powers of up to 10 W and 15 W respectively.

QUICK REFERENCE DATA

			BD434	BD436	BD438	
Collector-base voltage ($-V_{BE} = 0$)	$-V_{CES}$	max.	22	32	45	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	22	32	45	V
Collector current (peak value)	$-I_{CM}$	max.	7	7	7	A
Total power dissipation up to $T_{mb} = 25\ ^{o}C$	P_{tot}	max.	36	36	36	W
Junction temperature	T_j	max.	150	150	150	^{o}C
D.C. current gain						
$-I_C = 2$ A; $-V_{CE} = 1$ V	h_{FE}	>	50	50	40	
$-I_C = 3$ A; $-V_{CE} = 1$ V	h_{FE}	>	–	–	30	
Transition frequency at f = 1 MHz						
$-I_C = 250$ mA; $-V_{CE} = 1$ V	f_T	>	3	3	3	MHz

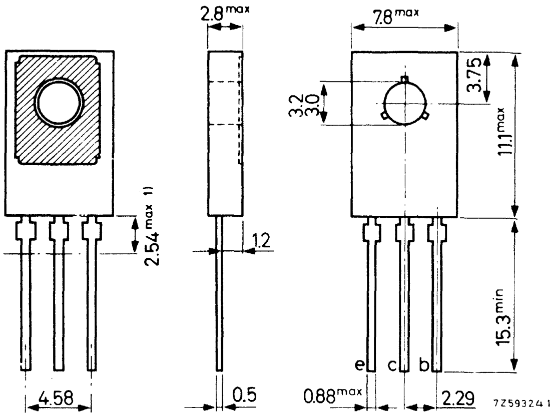
MECHANICAL DATA (See page 2)

MECHANICAL DATA

Dimensions in mm

SOT-32 (TO-126)

Collector connected to metal part of mounting surface



For mounting instructions see section Accessories type 56326 for non-insulated mounting and type 56333 for insulated mounting.

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltage			BD434	BD436	BD438	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	22	32	45	V
Collector-emitter voltage ($-V_{BE} = 0$)	$-V_{CES}$	max.	22	32	45	V
Collector-emitter (open base)	$-V_{CEO}$	max.	22	32	45	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V

Current

Collector current (d.c.)	$-I_C$	max.	4	A
Collector current (peak value)	$-I_{CM}$	max.	7	A
Base current (d.c.)	$-I_B$	max.	1	A

Power dissipation

Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.	36	W

Temperature

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

1) Within this region the cross-section of the leads is uncontrolled.

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	100	$^oC/W$
From junction to mounting base	$R_{th\ j-mb}$	=	3,5	$^oC/W$

CHARACTERISTICS T_j = 25 ^oC unless otherwise specified

Collector cut-off current

$I_E = 0$; $-V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	100	μA
$I_E = 0$; $-V_{CB} = 10$ V; $T_j = 150$ ^oC	$-I_{CBO}$	<	1	mA
$I_E = 0$; $-V_{CB} = -V_{CBOmax}$; $T_j = 150$ ^oC	$-I_{CBO}$	<	3	mA

Emitter cut-off current

$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	1	mA

			BD434	BD436	BD438	
Knee voltage						
$-I_C = 2$ A; $-I_B$ = value for which $-I_C = 2,2$ A at $-V_{CE} = 1$ V	$-V_{CEK}$	<	0,8	–	–	V
Base-emitter voltage [1]						
$-I_C = 10$ mA; $-V_{CE} = 5$ V	$-V_{BE}$	typ.	580	580	580	mV
$-I_C = 2$ A; $-V_{CE} = 1$ V	$-V_{BE}$	<	1,1	1,1	–	V
$-I_C = 3$ A; $-V_{CE} = 1$ V	$-V_{BE}$	<	–	–	1,3	V
Collector-emitter saturation voltage						
$-I_C = 2$ A; $-I_B = 0,2$ A	$-V_{CEsat}$	<	0,5	0,5	–	V
$-I_C = 3$ A; $-I_B = 0,3$ A	$-V_{CEsat}$	<	–	–	0,7	V
D.C. current gain						
$-I_C = 10$ mA; $-V_{CE} = 5$ V	h_{FE}	>	40	40	30	
$-I_C = 500$ mA; $-V_{CE} = 1$ V	h_{FE}	>	85	85	85	
		<	475	475	375	
$-I_C = 2$ A; $-V_{CE} = 1$ V	h_{FE}	>	50	50	40	
$-I_C = 3$ A; $-V_{CE} = 1$ V	h_{FE}	>	–	–	30	

1) $-V_{BE}$ decreases by typ. 2,3 mV/^oC with increasing temperature.

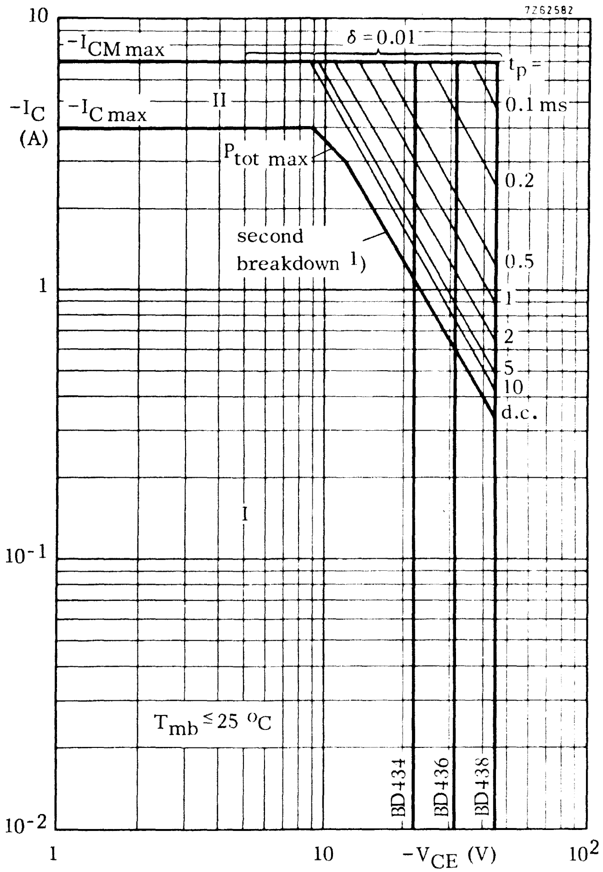
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Transition frequency at f = 1 MHz

$-I_C$ = 250 mA; $-V_{CE}$ = 1 V	f_T	>	3	MHz

D.C. current gain ratio of the complementary pairs

$\lvert I_C \rvert$ = 500 mA; $\lvert V_{CE} \rvert$ = 1 V			
BD433/BD434 and BD435/BD436	h_{FE1}/h_{FE2}	<	1,4
BD437/BD438	h_{FE1}/h_{FE2}	<	1,8

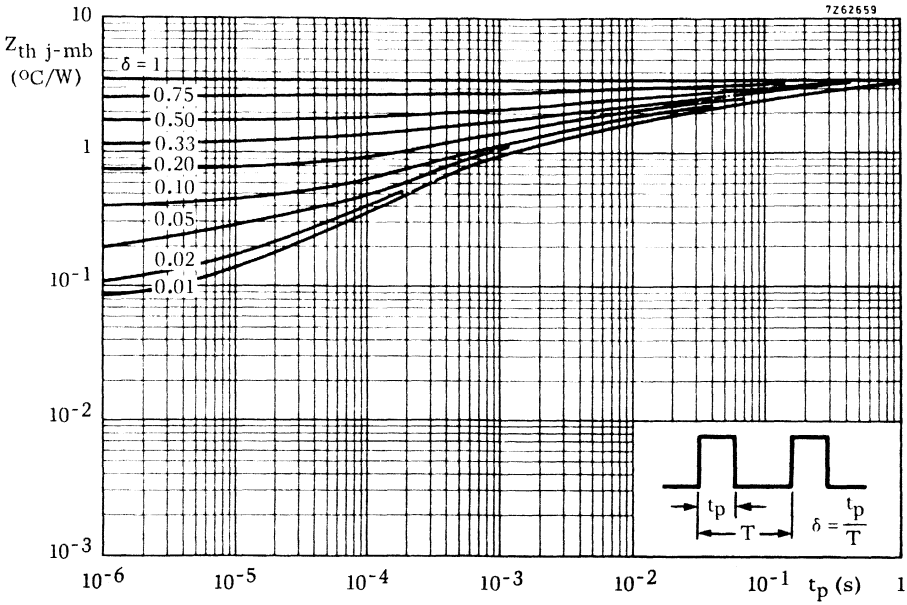


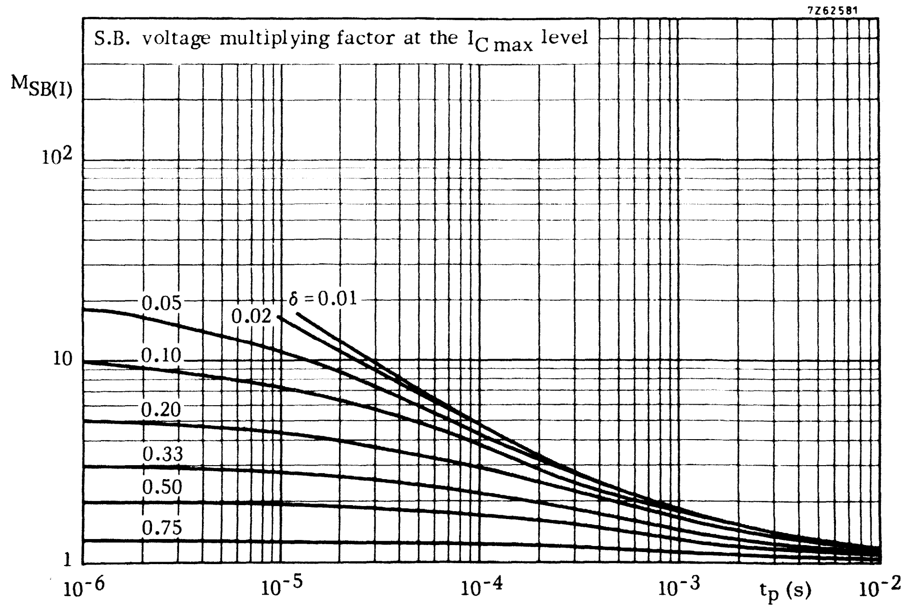
Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

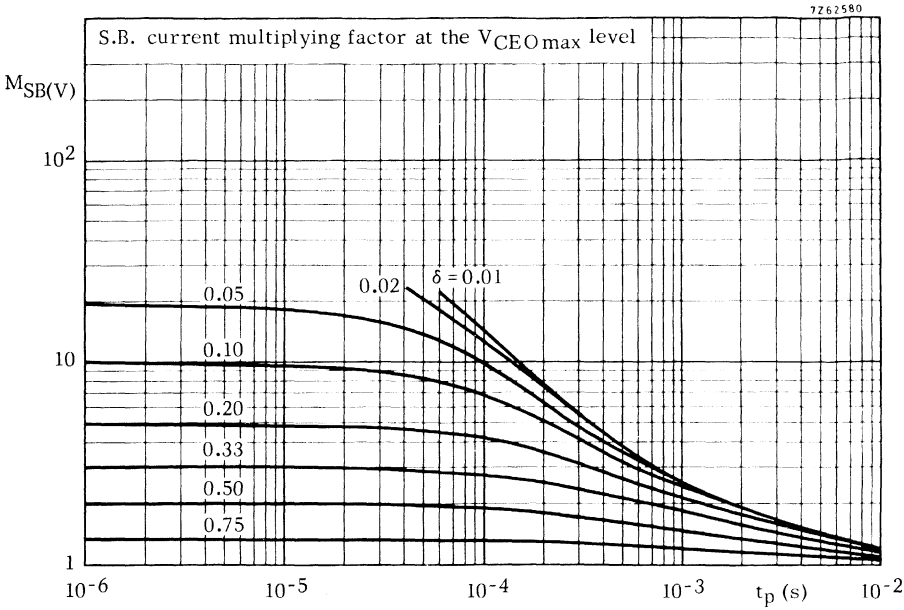
II Permissible extension for repetitive pulse operation

1) Independent of temperature

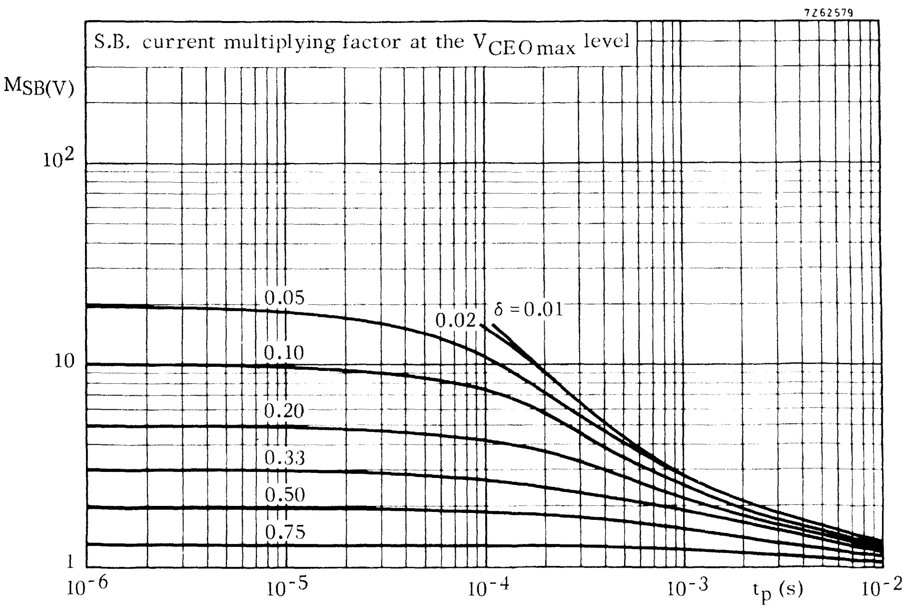

7Z62659
10
$Z_{th\ j-mb}$ (°C/W)
δ = 1
0.75
0.50
0.33
0.20
0.10
0.05
0.02
0.01
1
10^{-1}
10^{-2}
10^{-3}
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
t_p (s)
1
t_p
T
$\delta = \frac{t_p}{T}$

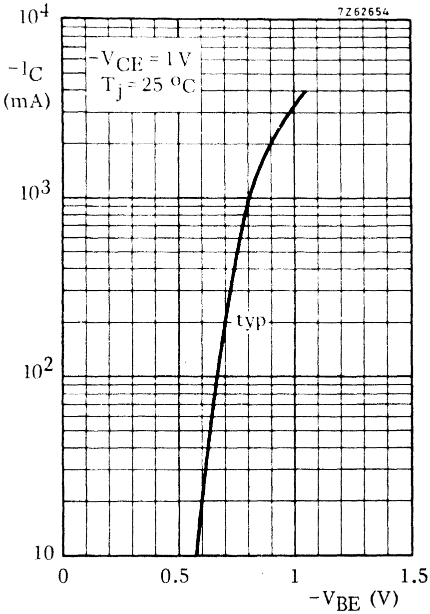

7Z62581
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
0.05
0.02
δ = 0.01
0.10
0.20
0.33
0.50
0.75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

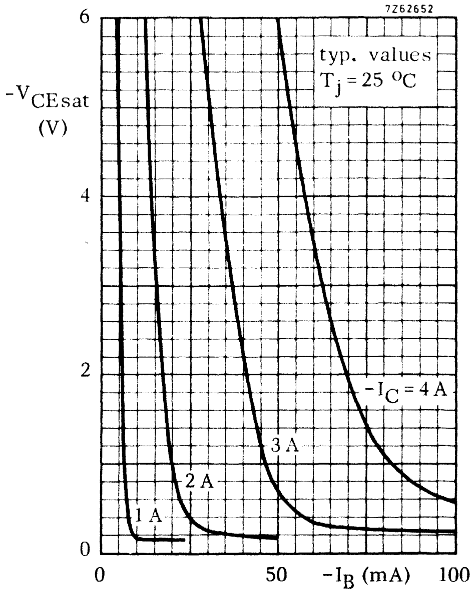
BD434; BD436

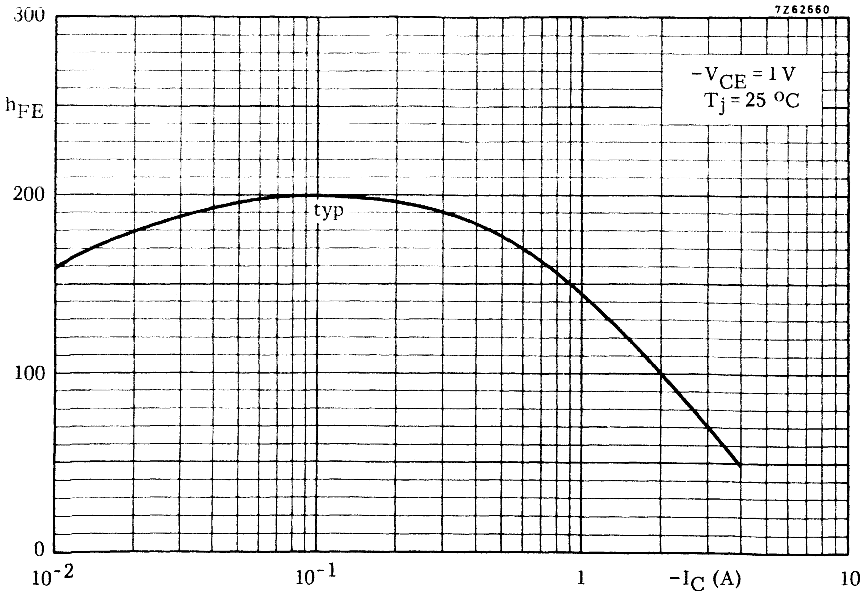


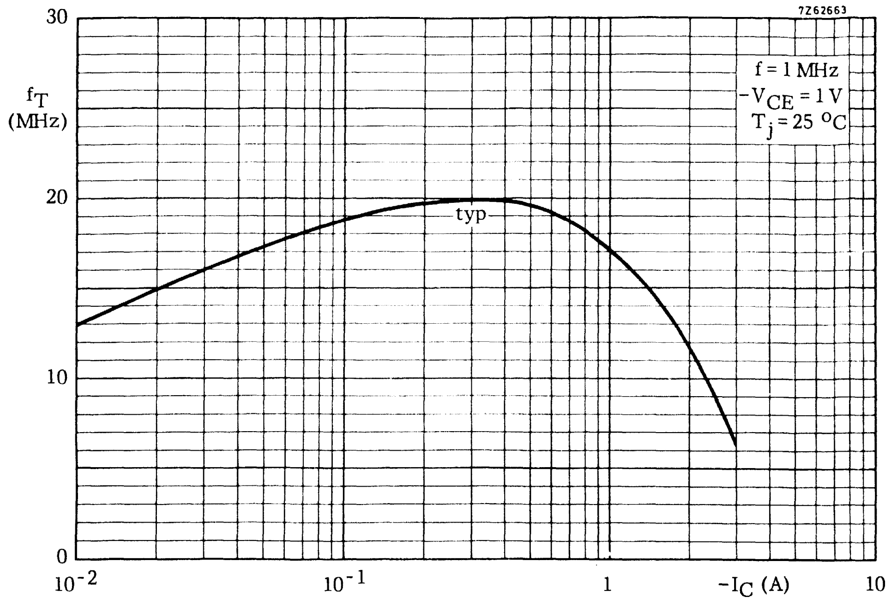
BD438

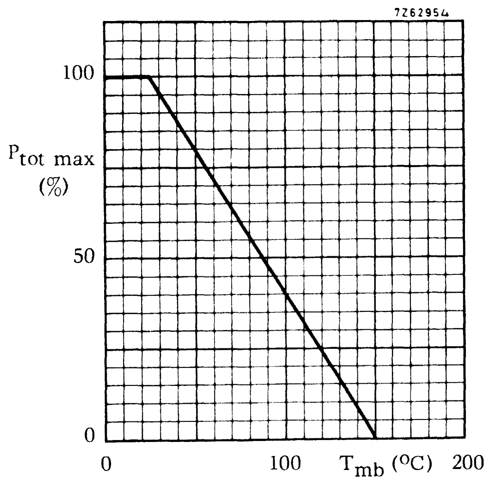



7Z62654
10^4
$-I_C$
(mA)
$-V_{CE} = 1$ V
$T_j = 25$ °C
10^3
typ
10^2
10
0
0.5
1
1.5
$-V_{BE}$ (V)


7Z62652
6
$-V_{CEsat}$
(V)
typ. values
$T_j = 25$ °C
4
2
$-I_C = 4$ A
3 A
2 A
1 A
0
0
50
$-I_B$ (mA)
100


7Z62660
300
h_{FE}
$-V_{CE} = 1$ V
$T_j = 25$ °C
200
typ
100
0
10^{-2}
10^{-1}
1
$-I_C$ (A)
10





APPLICATION INFORMATION

For information on a 6 W car-radio amplifier and on a 15 W high quality amplifier see BD433; BD435; BD437.

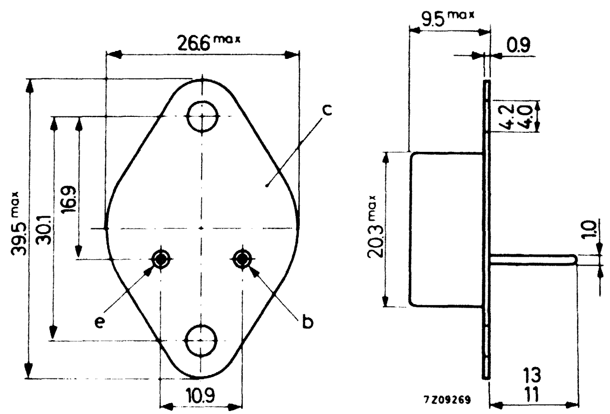
SILICON DIFFUSED POWER TRANSISTORS

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
$-V_{BE}$ = 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

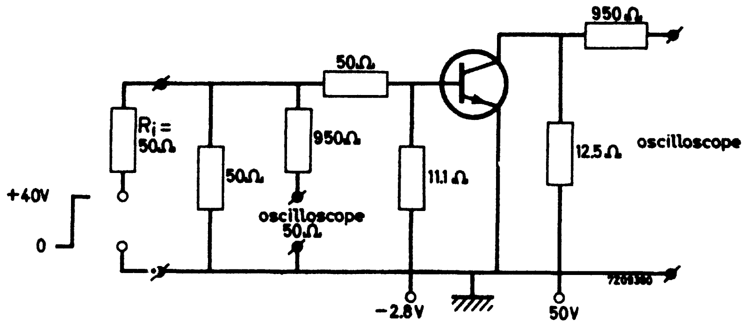
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

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:

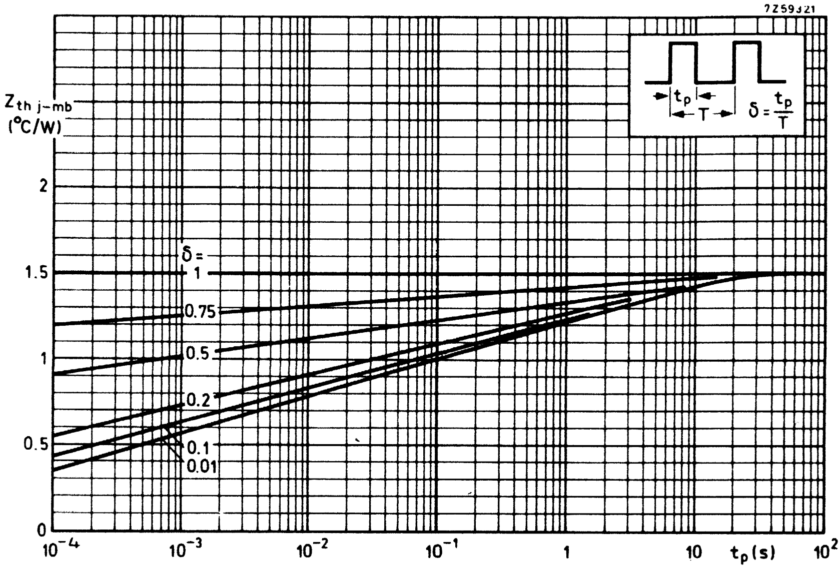


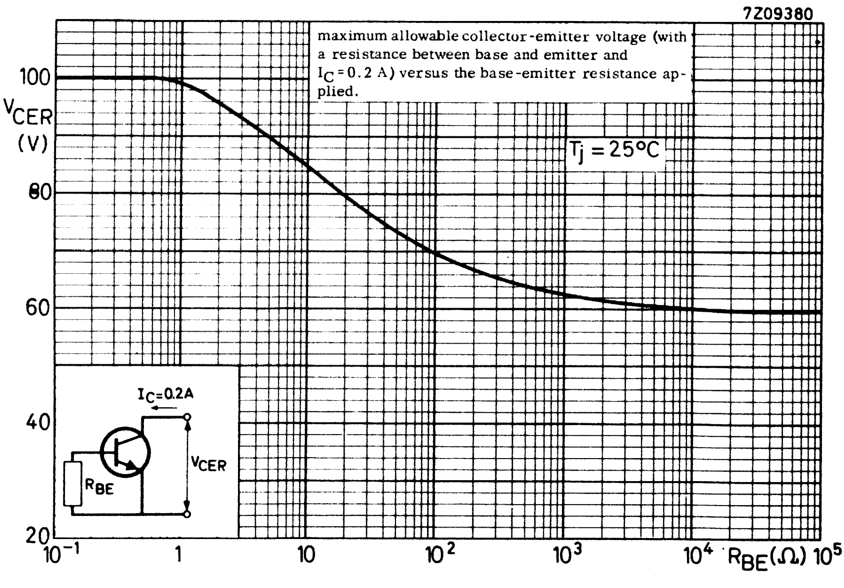
Pulse generator:

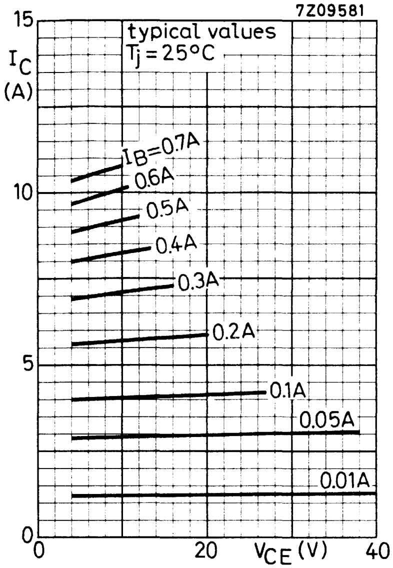
Pulse duration	t	>	10	μs
Rise time	t_r	≤	10	ns

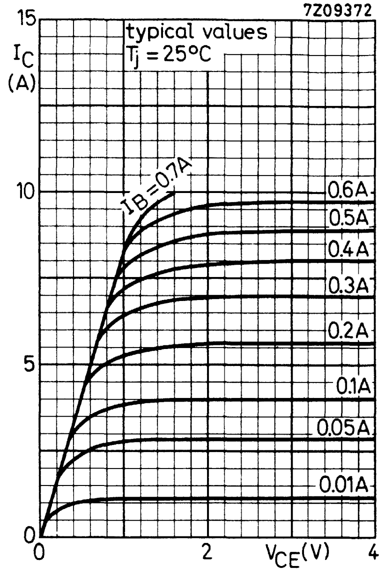
Oscilloscope:

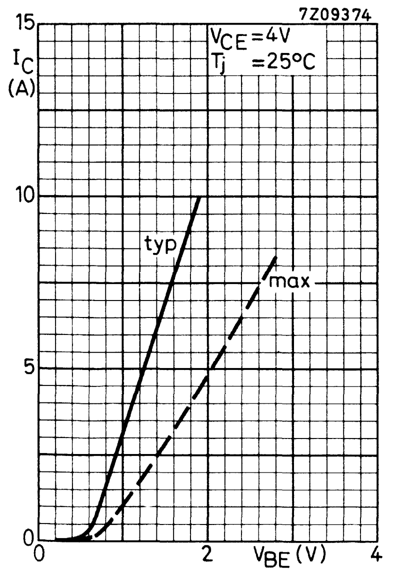
Rise time	t_r	≤	10	ns
Input resistance	R_i	=	50	Ω

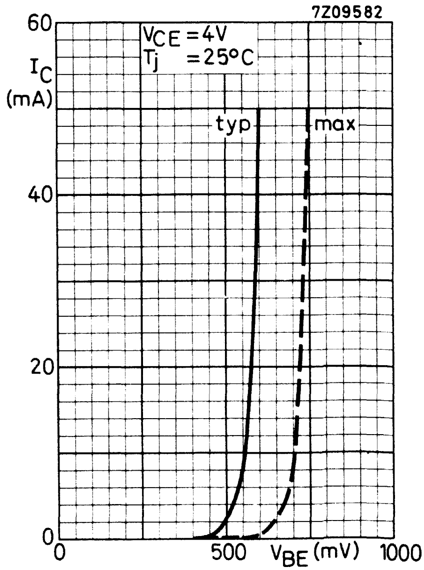

7Z59321
$Z_{th\ j-mb}$ (°C/W)
2
1.5
1
0.5
0
δ =
1
0.75
0.5
0.2
0.1
0.01
t_p
T
δ = $\frac{t_p}{T}$
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
t_p (s)
10^2

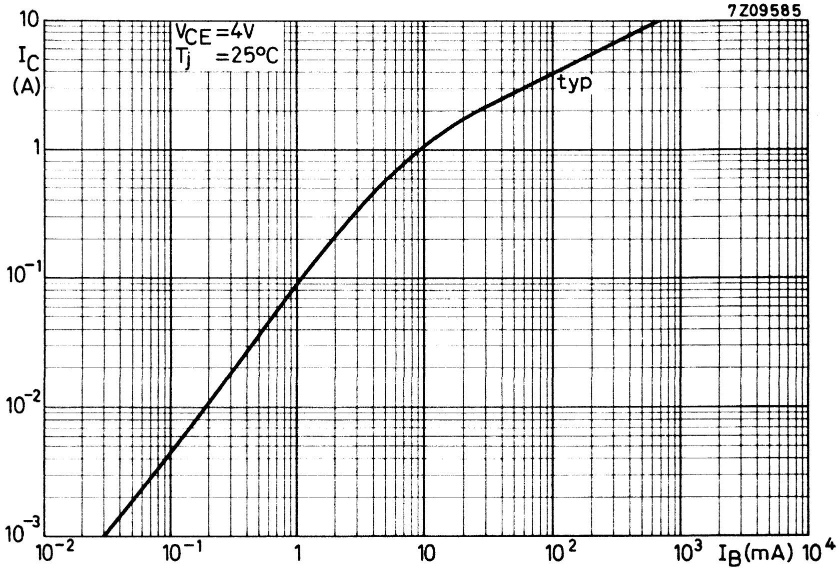

7Z09380
maximum allowable collector-emitter voltage (with a resistance between base and emitter and I_C = 0.2 A) versus the base-emitter resistance applied.
T_j = 25°C
100
V_{CER} (V)
80
60
40
20
I_C=0.2A
R_{BE}
V_{CER}
10^{-1}
1
10
10^2
10^3
10^4
R_{BE} (Ω)
10^5

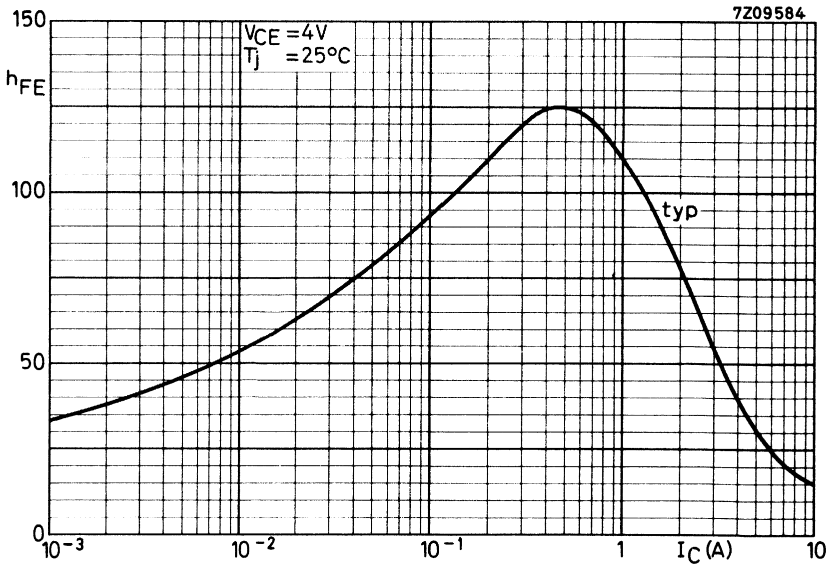

7Z09581
typical values
$T_j = 25°C$
I_C (A)
I_B=0.7A
0.6A
0.5A
0.4A
0.3A
0.2A
0.1A
0.05A
0.01A
V_{CE} (V)
0
5
10
15
20
40

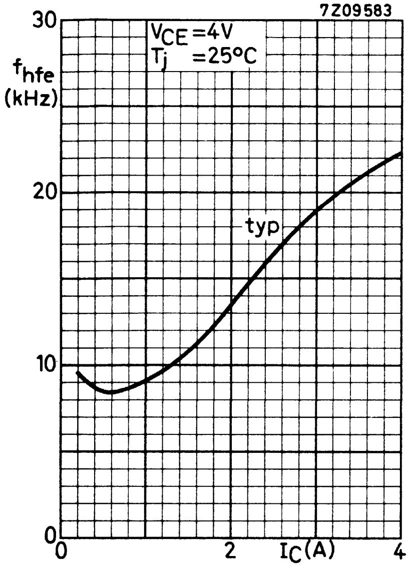

7Z09372
typical values
$T_j = 25°C$
I_C (A)
I_B=0.7A
0.6A
0.5A
0.4A
0.3A
0.2A
0.1A
0.05A
0.01A
V_{CE} (V)
0
2
4
5
10
15

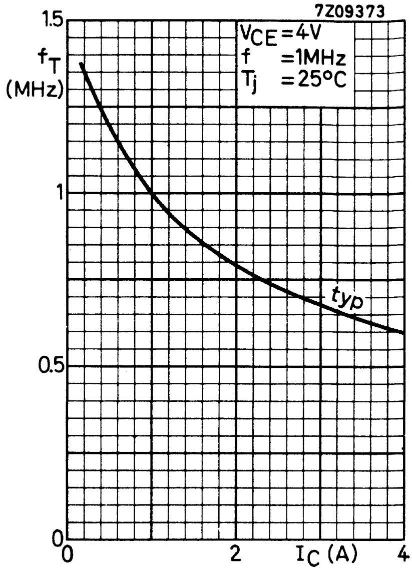

7Z09374
V_{CE} = 4V
T_j = 25°C
I_C (A)
typ
max
V_{BE} (V)
0
2
4
5
10
15

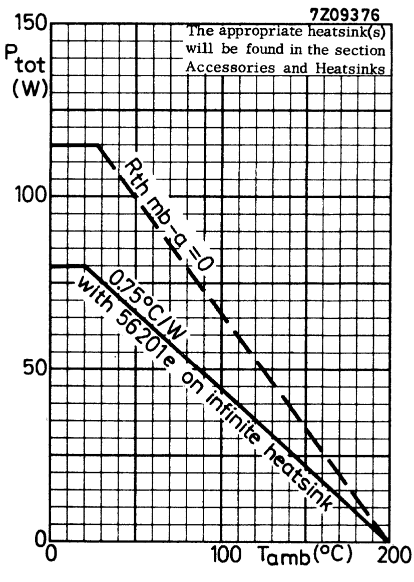

7Z09582
V_{CE} = 4V
T_j = 25°C
I_C (mA)
typ
max
V_{BE} (mV)
0
500
1000
20
40
60

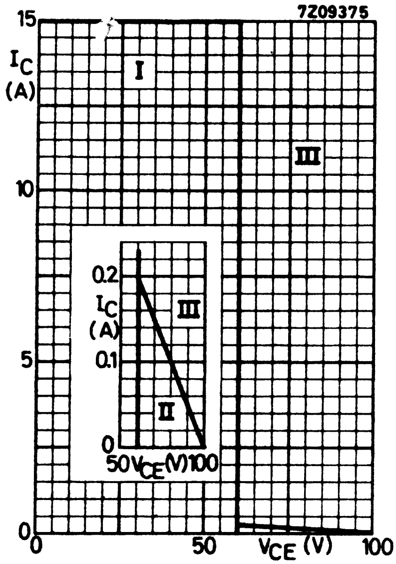

7Z09585
V_{CE} = 4V
T_j = 25°C
I_C (A)
10
1
10^{-1}
10^{-2}
10^{-3}
typ
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (mA)
10^4


7Z09584
V_{CE} = 4V
T_j = 25°C
h_{FE}
150
100
50
0
typ
10^{-3}
10^{-2}
10^{-1}
1
I_C (A)
10


7Z09583
V_{CE} = 4V
T_j = 25°C
f_{hfe} (kHz)
30
20
10
0
typ
0
2
I_C (A)
4


7Z09373
V_{CE} = 4V
f = 1MHz
T_j = 25°C
f_T (MHz)
1.5
1
0.5
0
typ
0
2
I_C (A)
4

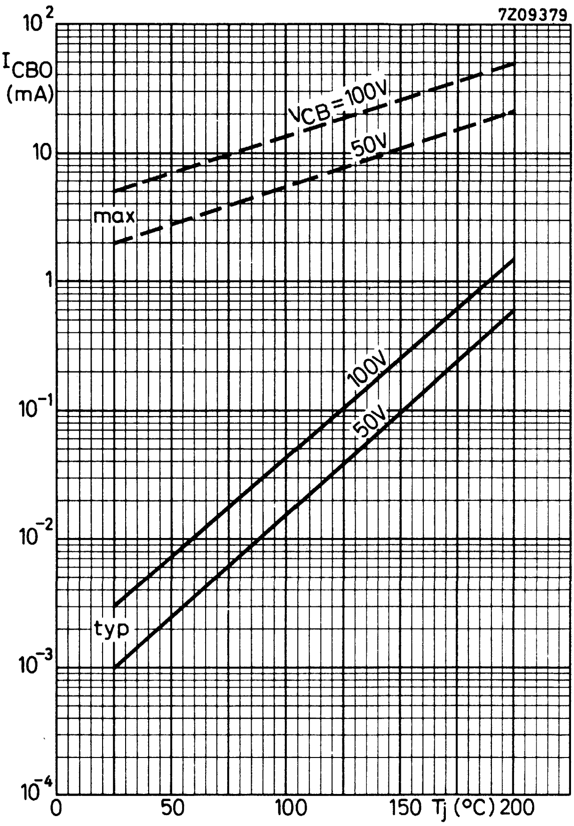

7Z09376
The appropriate heatsink(s) will be found in the section Accessories and Heatsinks
P_{tot} (W)
150
100
50
0
Rth mb-a = 0
0.75°C/W
with 56201e on infinite heatsink
0
100
T_{amb} (°C)
200



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

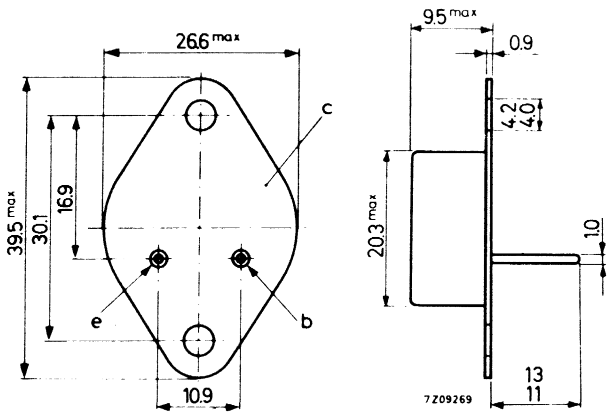
N-P-N transistor in a TO-3 metal envelope, intended for use in linear applications such as hi-fi amplifiers and signal processing circuits.

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

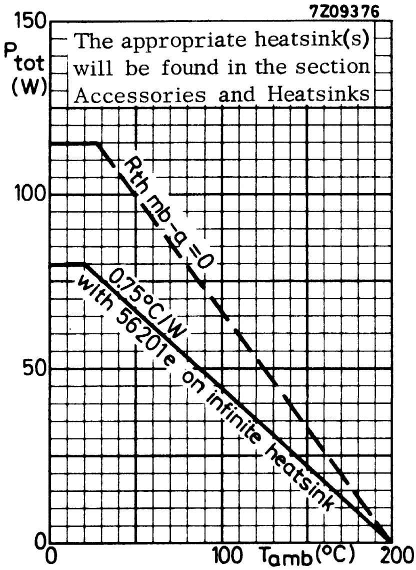
From junction to ambient in free air	$R_{th\ j-a}$	=	40	°C/W
From junction to mounting base	$R_{th\ j-mb}$	=	1.5	°C/W
From mounting base to heatsink	$R_{th\ mb-h}$	=	0.5	°C/W
From mounting base to heatsink with accessory 56201e	$R_{th\ mb-h}$	=	0.75	°C/W

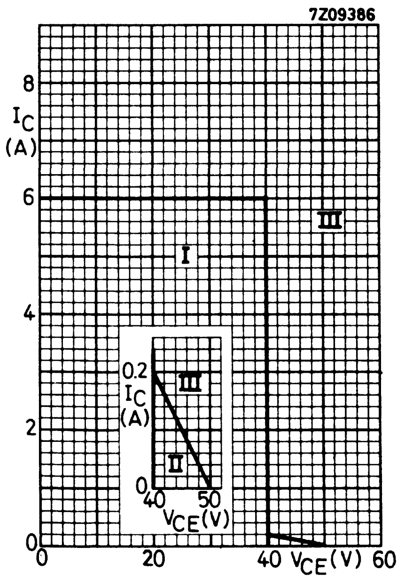
The appropriate heatsink(s) will be found in the Section HEATSINKS.

1) I_C = 0.2 A.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off 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	

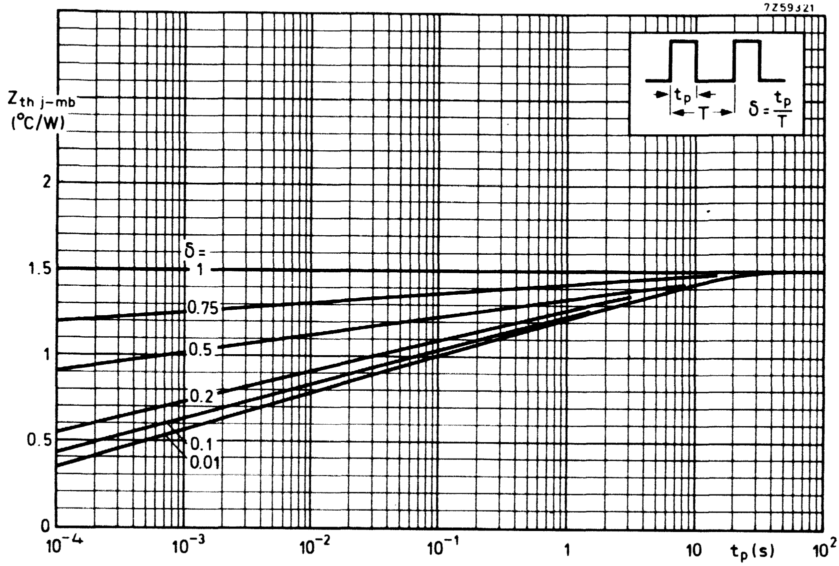


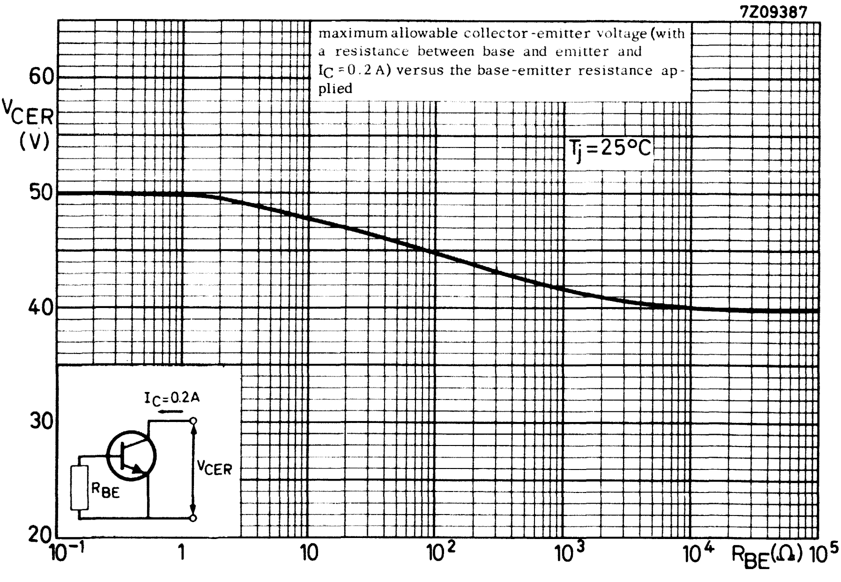


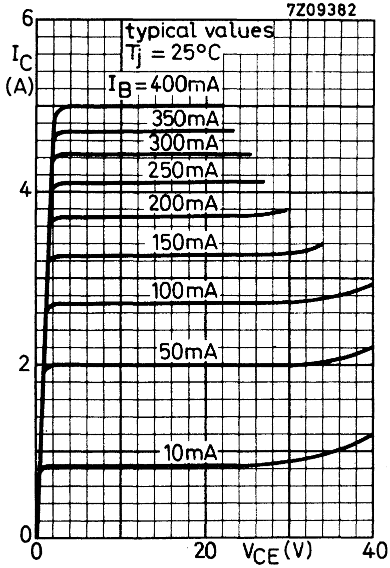
I Region of permissible operation under all base-emitter conditions provided no limiting values are exceeded.

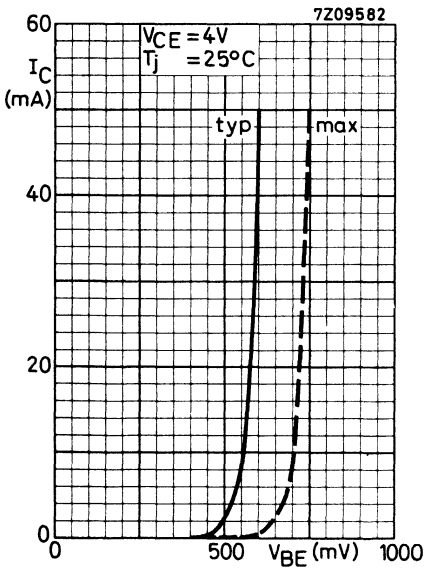
II Additional region of operation when the transistor is cut-off with $-V_{BE} \leq 1.5$ V.

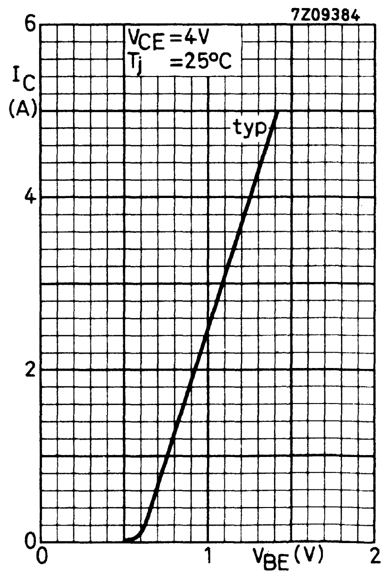
III Operation during switching-off is allowed, provided the transistor is cut-off with $-V_{BE} \leq 1.5$ V and the transient energy does not exceed 75 mWs.

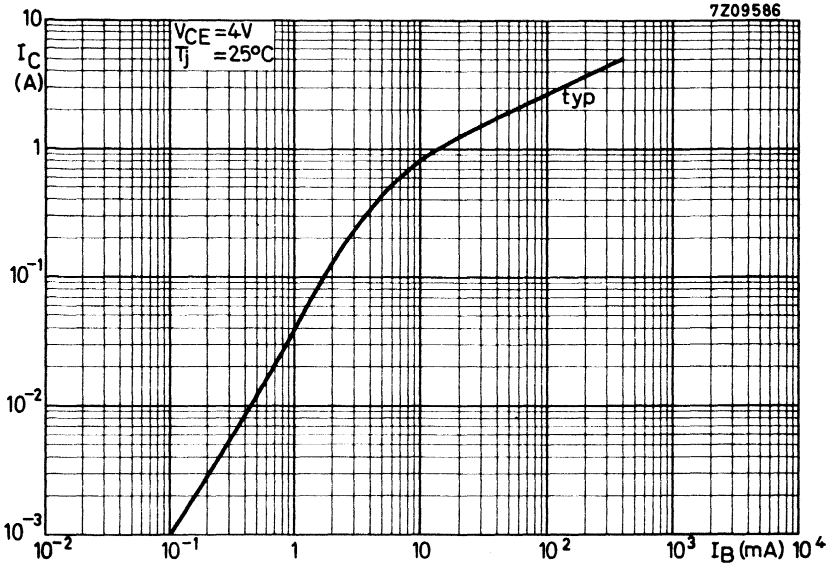

7Z59321
$Z_{th\ j-mb}$ (°C/W)
2
1.5
1
0.5
0
δ =
1
0.75
0.5
0.2
0.1
0.01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
t_p (s)
10^2

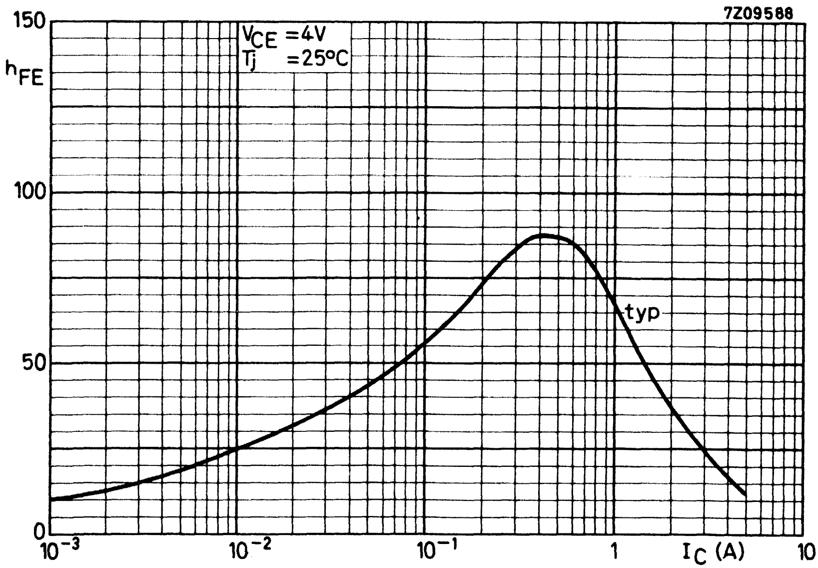

7Z09387
maximum allowable collector-emitter voltage (with a resistance between base and emitter and I_C = 0.2 A) versus the base-emitter resistance applied
V_{CER} (V)
60
50
40
30
20
$T_j = 25°C$
I_C=0.2A
R_{BE}
V_{CER}
10^{-1}
1
10
10^2
10^3
10^4
R_{BE} (Ω)
10^5

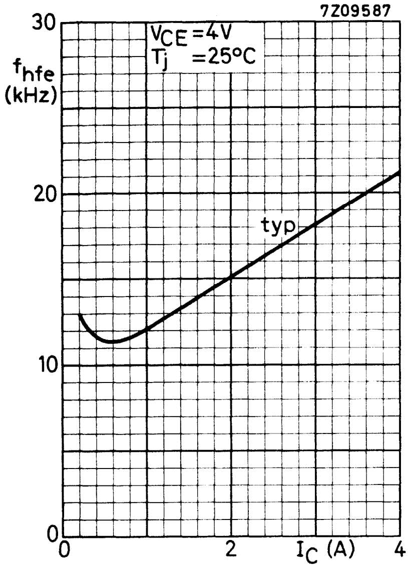

7Z09382
typical values
Tj = 25°C
IB = 400mA
350mA
300mA
250mA
200mA
150mA
100mA
50mA
10mA
IC
(A)
6
4
2
0
0
20
VCE (V)
40

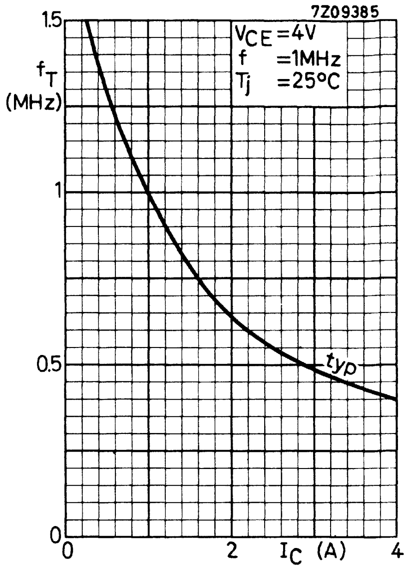

7Z09582
VCE = 4V
Tj = 25°C
typ
max
IC
(mA)
60
40
20
0
0
500
VBE (mV)
1000

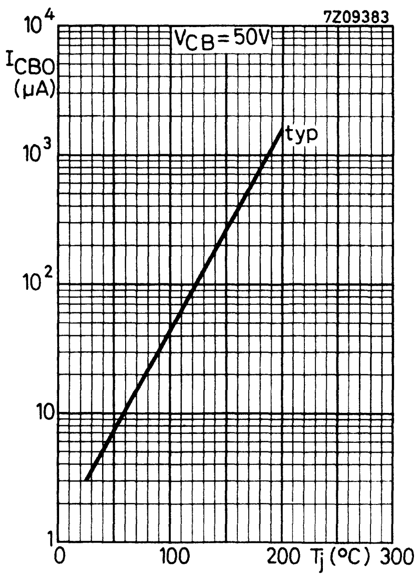

7Z09384
VCE = 4V
Tj = 25°C
typ
IC
(A)
6
4
2
0
0
1
VBE (V)
2


7Z09586
I_C (A)
10
1
10^{-1}
10^{-2}
10^{-3}
V_{CE} = 4V
T_j = 25°C
typ
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (mA)
10^4


7Z09588
h_{FE}
150
100
50
0
V_{CE} = 4V
T_j = 25°C
typ
10^{-3}
10^{-2}
10^{-1}
1
I_C (A)
10


7Z09587
30
f hfe
(kHz)
20
10
0
V_{CE} = 4V
T_j = 25°C
typ
0
2
I_C (A)
4


7Z09385
1.5
f_T
(MHz)
1
0.5
0
V_{CE} = 4V
f = 1MHz
T_j = 25°C
typ
0
2
I_C (A)
4


7Z09383
10^4
I_{CBO}
(μA)
10^3
10^2
10
1
V_{CB} = 50V
typ
0
100
200
T_j (°C)
300

SILICON PLANAR EPITAXIAL POWER TRANSISTORS

N-P-N transistors in a TO-3 metal envelope with the collector connected to the case. They are intended for high current switching applications, e.g. inverters, and switching regulator circuits.

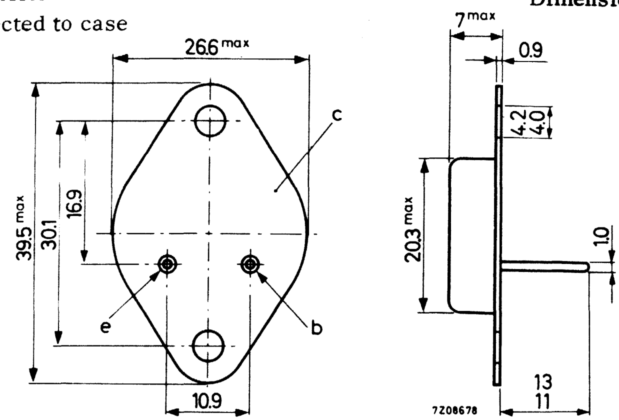
QUICK REFERENCE DATA

			BDY60	BDY61	
Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	120	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60		V
Collector current (peak value)	I_{CM}	max.	10		A
Total power dissipation up to T_{mb} = 100 °C	P_{tot}	max.	15		W
Junction temperature	T_j	max.	175		°C
D.C. current gain I_C = 0.5 A; V_{CE} = 10 V	h_{FE}	>	45		
Transition frequency at f = 35 MHz I_C = 0.5 A; V_{CE} = 5.0 V	f_T	typ.	100		MHz
Turn off time when switched from I_C = 5.0 A; I_B = $-I_{BM}$ = 0.5 A	t_{off}	typ.	350		ns

MECHANICAL DATA

Dimensions in mm

Collector connected to case
TO-3



Accessories supplied on request: 56201e (for insulated mounting on a 2 mm heatsink).

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

			BDY60	BDY61	
Voltages					
Collector-base voltage (open emitter)	V_{CBO}	max.	60	60	V
(open emitter; peak value)	V_{CBOM}	max.	120	100	V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	60	60	V
(V_{BE} = 0; peak value)	V_{CESM}	max.	120	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60		V
Emitter-base voltage (open collector)	V_{EBO}	max.	5		V
Currents					
Collector current (d.c.)	I_C	max.	5		A
Collector current (peak value)	I_{CM}	max.	10		A
Base current (d.c.)	I_B	max.	1		A
Base current (peak value)	I_{BM}	max.	2		A
Reverse base current (peak value)	$-I_{BM}$	max.	2		A
Power dissipation					
Total power dissipation up to T_{mb} = 100 °C	P_{tot}	max.	15		W
Temperatures					
Storage temperature	T_{stg}	−55 to	+175		°C
Junction temperature	T_j	max.	175		°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	5	°C/W

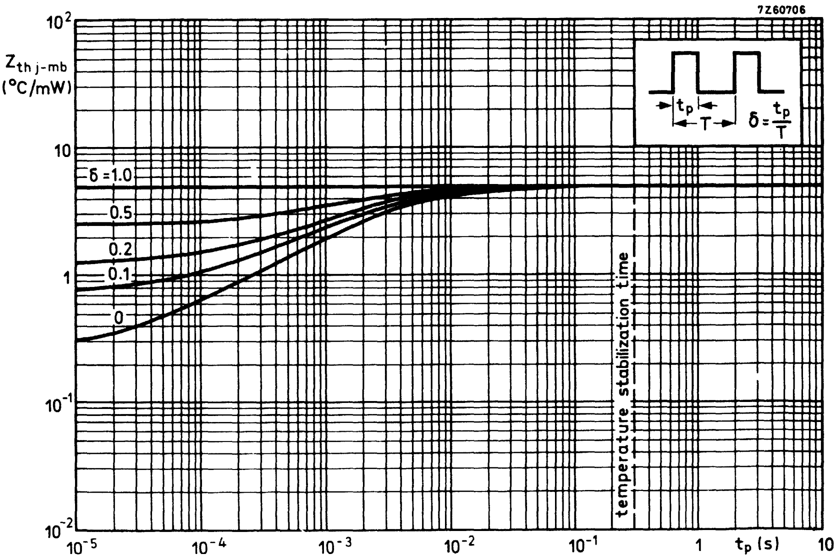
CHARACTERISTICS T_j = 25 °C unless otherwise specified

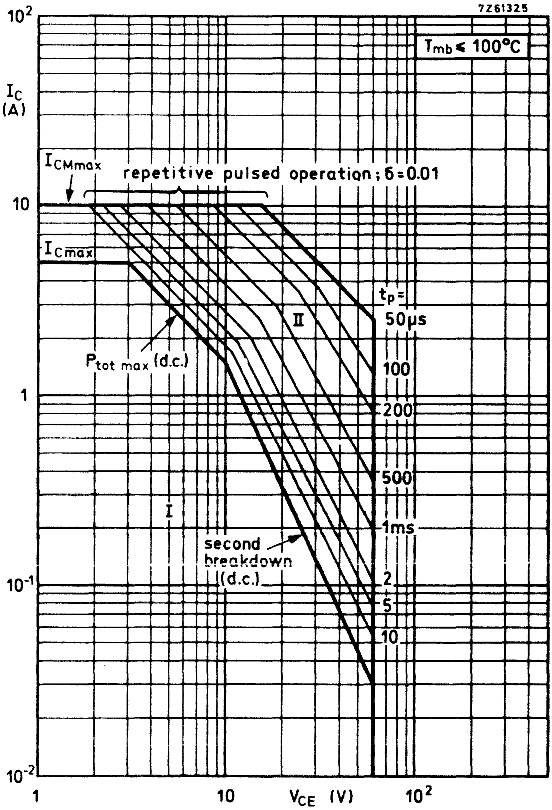
			BDY60	BDY61	
Collector cut-off current					
I_E = 0; V_{CB} = 100 V	I_{CBO}	<	10	–	µA
I_E = 0; V_{CB} = 100 V; T_j = 100 °C	I_{CBO}	<	300	–	µA
I_E = 0; V_{CB} = 80 V	I_{CBO}	<	–	10	µA
I_E = 0; V_{CB} = 80 V; T_j = 100 °C	I_{CBO}	<	–	300	µA
V_{BE} = 0; V_{CE} = 120 V	I_{CES}	<	1	–	mA
V_{BE} = 0; V_{CE} = 100 V	I_{CES}	<	–	1	mA
Emitter cut-off current					
I_C = 0; V_{EB} = 4 V	I_{EBO}	typ.	5.0	5.0	nA
		<	10	10	µA
I_C = 0; V_{EB} = 5 V	I_{EBO}	<	1.0	1.0	mA
Saturation voltages					
I_C = 5 A; I_B = 0.5 A	V_{CEsat}	typ.	0.46	0.54	V
		<	0.7	0.9	V
	V_{BEsat}	typ.	1.2	1.2	V
		<	1.7	1.7	V
I_C = 7 A; I_B = 0.7 A	V_{CEsat}	typ.	–	0.8	V
		<	–	1.5	V
	V_{BEsat}	typ.	1.4	1.4	V
		<	1.8	1.8	V
I_C = 10 A; I_B = 1 A	V_{CEsat}	typ.	1.0	–	V
		<	1.5	–	V
	V_{BEsat}	typ.	1.75	–	V
		<	2.2	–	V
D.C. current gain					
I_C = 0.5 A; V_{CE} = 10 V	h_{FE}	>	45	45	
I_C = 1 A; V_{CE} = 2 V	h_{FE}	>	40	38	
I_C = 5 A; V_{CE} = 2 V	h_{FE}	>	18	15	
Collector capacitance at f = 1 MHz					
$I_E = I_e$ = 0; V_{CB} = 10 V	C_c	typ.	42	42	pF
		<	80	80	pF
Transition frequency at f = 35 MHz					
I_C = 0.5 A; V_{CE} = 5 V; T_{amb} = 25 °C	f_T	typ.	100	100	MHz

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

Switching times (see page 8)

			BDY60	BDY61	
I_C = 5 A; $I_B = -I_{BM}$ = 0.5 A					
turn-on time	t_{on}	typ.	120	120	ns
turn-off time	t_{off}	typ.	350	350	ns
I_C = 10 A; $I_B = -I_{BM}$ = 1 A					
turn-on time	t_{on}	typ.	150	–	ns
turn-off time	t_{off}	typ.	270	–	ns
		<	1	–	μs

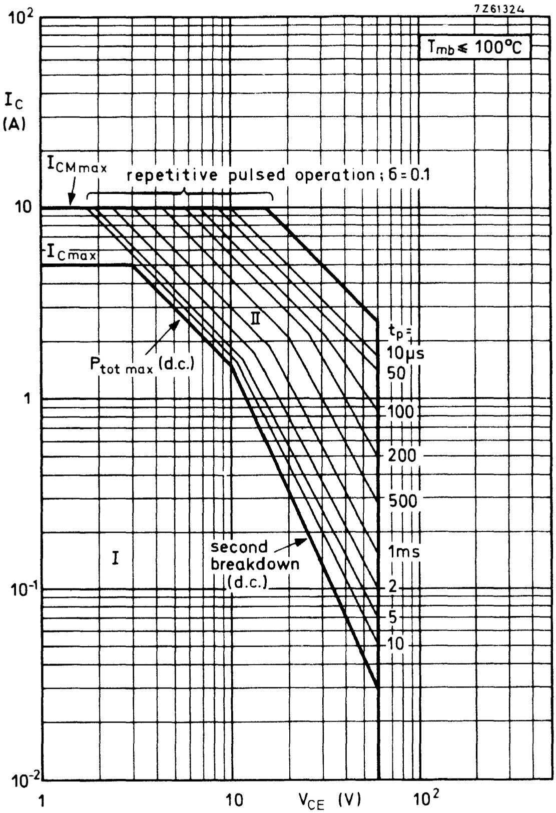




Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

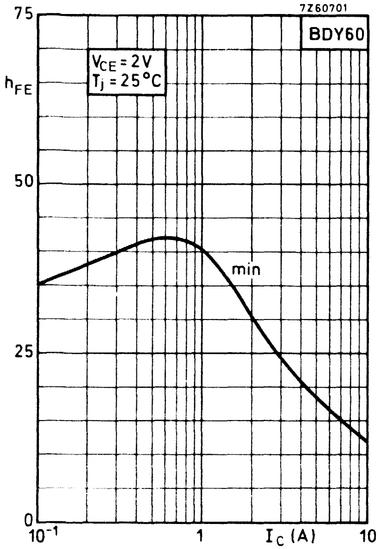
II Permissible extension for repetitive pulsed operation

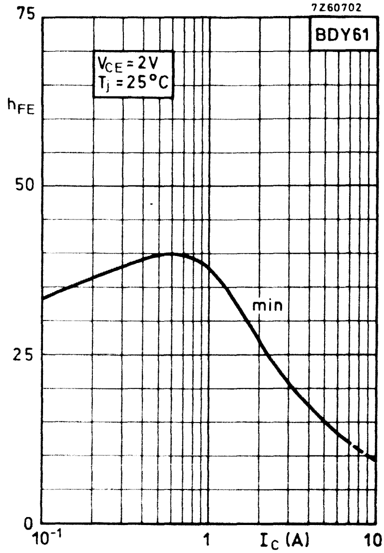


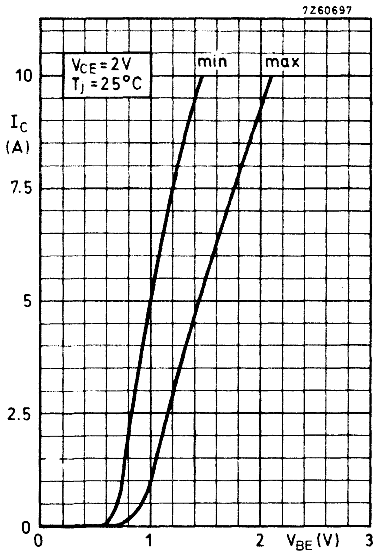
Safe Operating Area with the transistor forward biased

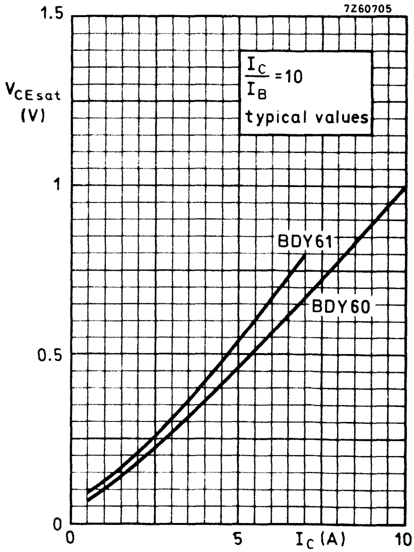
I Region of permissible d.c. operation

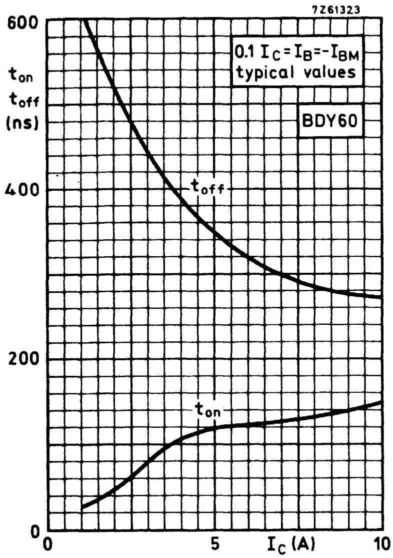
II Permissible extension for repetitive pulsed operation

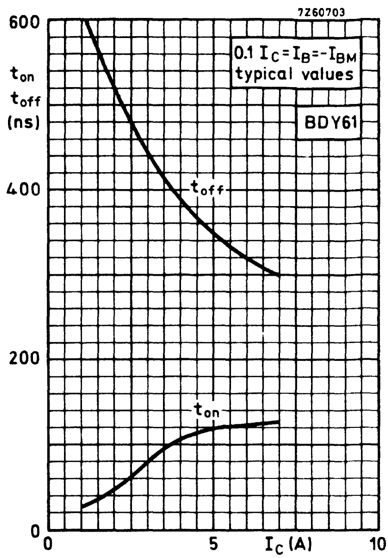

7Z60701
BDY60
V_{CE} = 2V
T_j = 25°C
h_{FE}
75
50
25
0
min
10^{-1}
1
I_C (A)
10


7Z60702
BDY61
V_{CE} = 2V
T_j = 25°C
h_{FE}
75
50
25
0
min
10^{-1}
1
I_C (A)
10


7Z60697
V_{CE} = 2V
T_j = 25°C
min
max
I_C (A)
10
7.5
5
2.5
0
0
1
2
V_{BE} (V)
3


7Z60705
1.5
V_{CEsat} (V)
$\frac{I_C}{I_B}$ = 10
typical values
1
0.5
0
BDY61
BDY60
0
5
I_C (A)
10


7Z61323
600
400
200
0
t_on
t_off
(ns)
0.1 I_C = I_B = -I_BM
typical values
BDY60
t_off
t_on
0
5
I_C (A)
10


7Z60703
600
400
200
0
t_on
t_off
(ns)
0.1 I_C = I_B = -I_BM
typical values
BDY61
t_off
t_on
0
5
I_C (A)
10

SILICON HIGH SPEED SWITCHING POWER TRANSISTORS

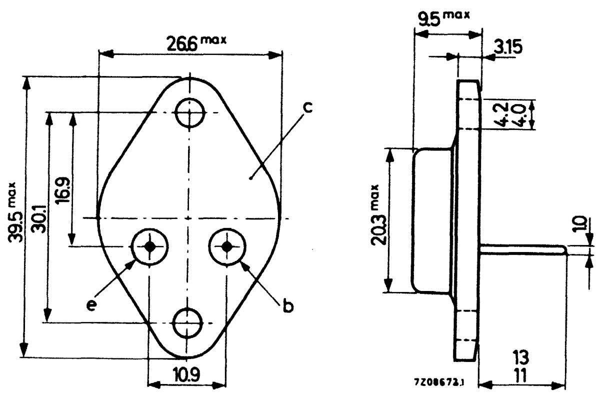
N-P-N transistors in a metal envelope intended for use in convertors, invertors, switching regulators and switching control amplifiers.

QUICK REFERENCE DATA

			BDY90	BDY91	BDY92	
Collector-base voltage (open emitter)	V_{CBO}	max.	120	100	80	V
Collector-emitter voltage (open base)	V_{CEO}	max.	100	80	60	V
Collector current (peak value)	I_{CM}	max.	15	15	15	A
Total power dissipation up to T_{mb}=75°C	P_{tot}	max.	40	40	40	W
Collector-emitter saturation voltage I_C = 10 A; I_B = 1 A	V_{CEsat}	<	1.5	1.5	1.0	V
Fall time I_C = 5.0 A; I_B = $-I_{BM}$ = 0.5A; V_{CC} = 30 V	t_f	<	0.2	0.2	0.2	μs
Transition frequency at f = 5 MHz I_C = 0.5 A; V_{CE} = 5 V	f_T	typ.	70	70	70	MHz

MECHANICAL DATA

Collector connected to case | Dimensions in mm



Accessories supplied on request : 56201e

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

Voltages (See also pages 4, 5 and 6)			BDY90	BDY91	BDY92
Collector-base voltage (open emitter)	V_{CBO}	max.	120	100	80 V
Collector-emitter voltage (V_{EB} = 1.5 V)	V_{CEX}	max.	120	100	80 V
Collector-emitter voltage (open base)	V_{CEO}	max.	100	80	60 V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	6	6 V

Currents

Collector current (d.c.)	I_C	max.	10 A
Collector current (peak value)	I_{CM}	max.	15 A
Base current (d.c.)	I_B	max.	2 A
Base current (peak value)	I_{BM}	max.	3 A
Emitter current (d.c.)	$-I_E$	max.	11 A
Emitter current (peak value)	$-I_{EM}$	max.	15 A

Power dissipation

Total power dissipation up to T_{mb}=75°C	P_{tot}	max.	40 W

Temperatures

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

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2.5 °C/W

CHARACTERISTICS Tj = 25°C unless otherwise specified

Collector cut-off current

V_{EB} = 1.5 V; V_{CE} = V_{CEXmax}; T_{mb} = 150°C		I_{CEX}	<	3 mA

Saturation voltages

I_C = 5 A; I_B = 0.5 A		V_{CEsat}	<	0.5 V
		V_{BEsat}	<	1.2 V
I_C = 10 A; I_B = 1 A	BDY90 BDY91	V_{CEsat}	<	1.5 V
	BDY92	V_{CEsat}	<	1.0 V
	BDY90 to 92	V_{BEsat}	<	1.5 V

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

D.C. current gain

$I_C = 1\ A$; $V_{CE} = 2\ V$	h_{FE}	>	35
$I_C = 5\ A$; $V_{CE} = 5\ V$	h_{FE}	30 to 120	
$I_C = 10\ A$; $V_{CE} = 5\ V$	h_{FE}	>	20

Transition frequency at f = 5 MHz

$I_C = 0.5\ A$; $V_{CE} = 5\ V$	f_T	typ.	70	MHz

Switching times

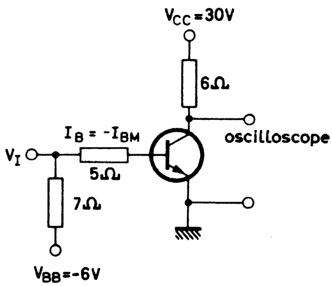
Turn on time

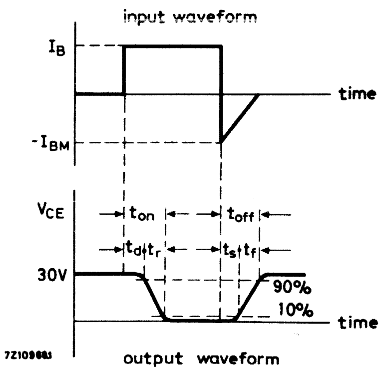
$I_C = 5\ A$; $I_B = -I_{BM} = 0.5\ A$				
$V_{CC} = 30\ V$	t_{on}	<	0.35	µs

Turn off time

$I_C = 5\ A$; $I_B = -I_{BM} = 0.5\ A$				
$V_{CC} = 30\ V$ storage time	t_s	<	1.3	µs
fall time	t_f	<	0.2	µs

Test circuit

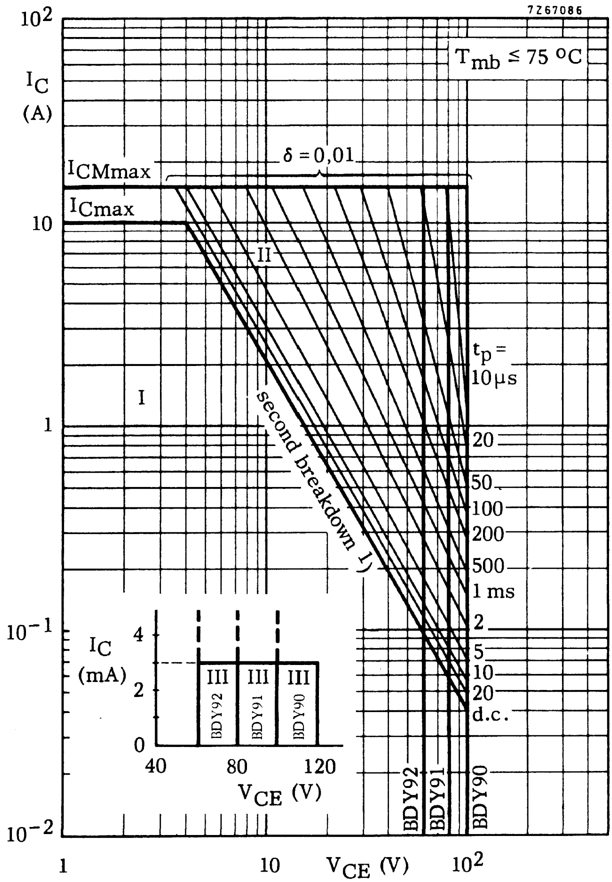




Pulse generator:

Rise time	t_r	<	50	ns
Fall time	t_f	<	50	ns

Pulse duration	t_p	=	20	µs
Duty cycle	δ	=	0.02	



Safe Operating Area (Regions I and II forward biased)

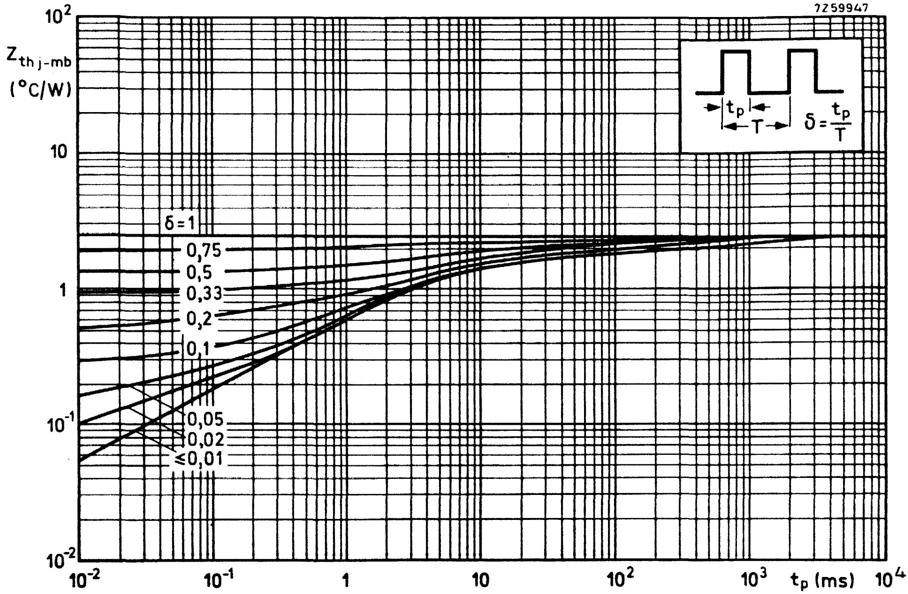
I Region of permissible d.c. operation

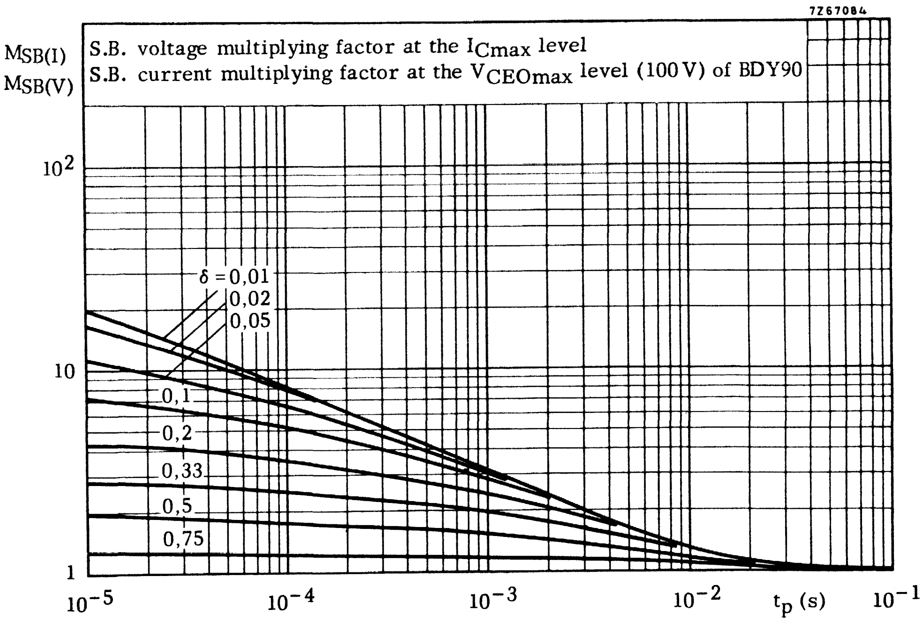
II Permissible extension for repetitive pulse operation

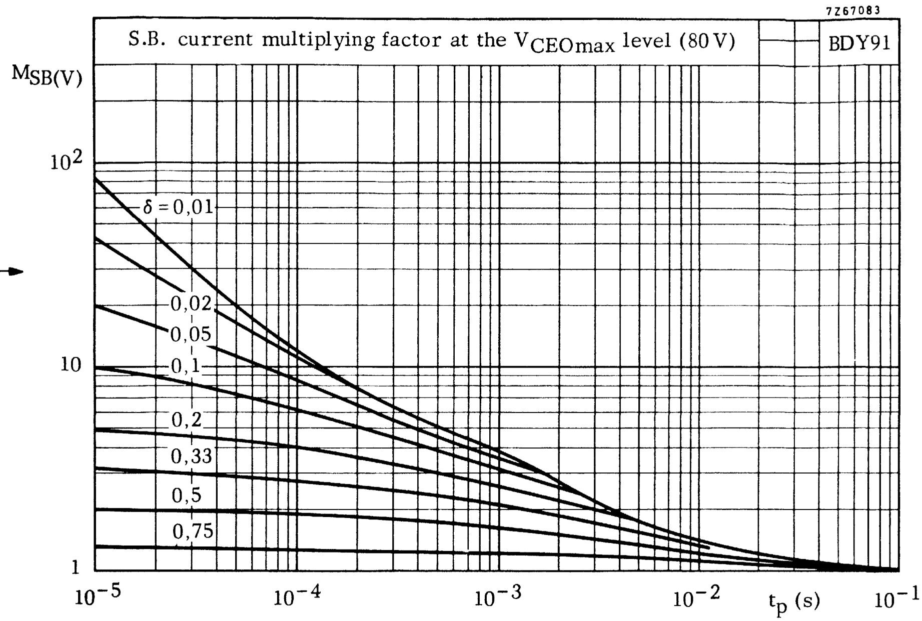
III Repetitive pulse operation in this region is allowable, provided $-V_{BE} \geq 1{,}5$ V

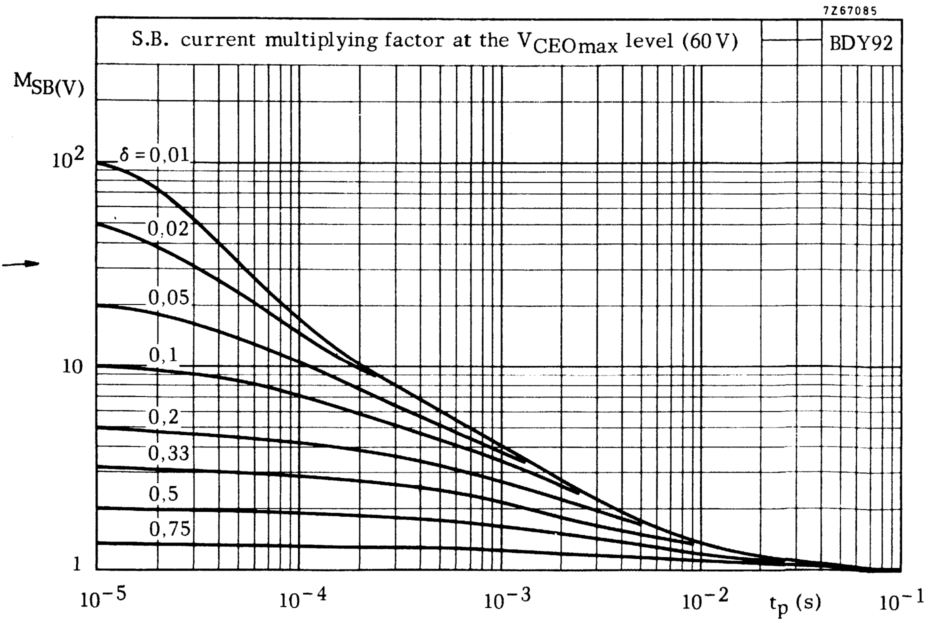
For $P_{tot\ max}$ versus T_{mb} see page 10.

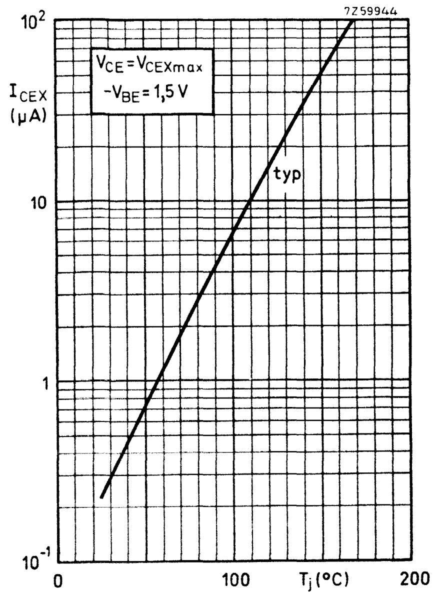
1) Independent of temperature

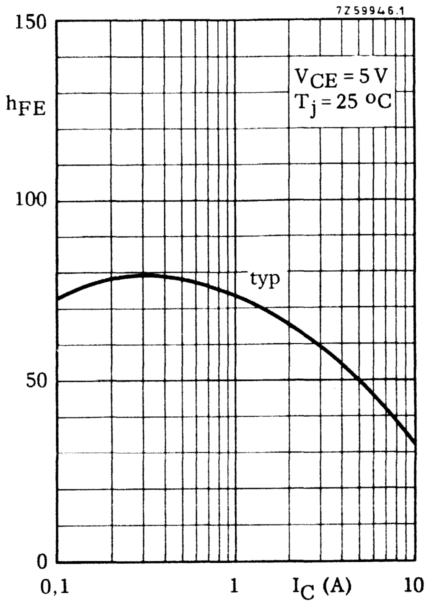

7Z59947
10^2
$Z_{th\,j\text{-}mb}$ (°C/W)
10
1
10^{-1}
10^{-2}
$\delta = 1$
0,75
0,5
0,33
0,2
0,1
0,05
0,02
≤0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (ms)
10^4

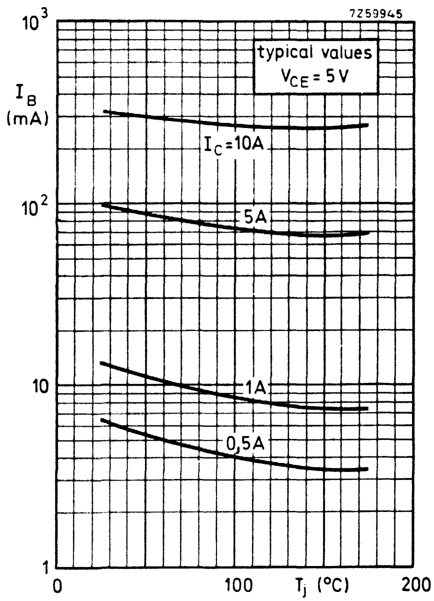

7Z67084
$M_{SB(I)}$
$M_{SB(V)}$
S.B. voltage multiplying factor at the I_{Cmax} level
S.B. current multiplying factor at the V_{CEOmax} level (100 V) of BDY90
10^2
10
1
$\delta = 0,01$
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-5}
10^{-4}
10^{-3}
10^{-2}
t_p (s)
10^{-1}

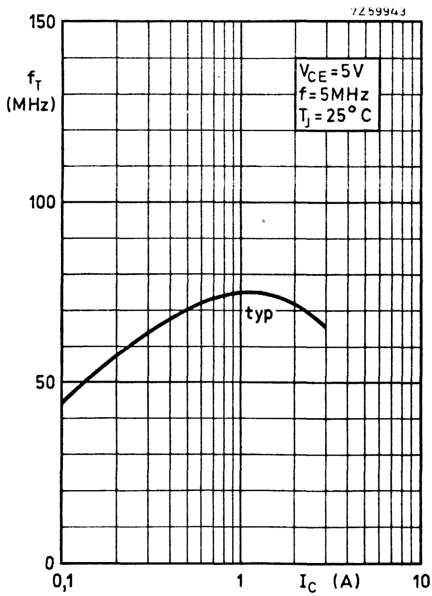

7Z67083
S.B. current multiplying factor at the V_{CEOmax} level (80 V)
BDY91
$M_{SB(V)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-5}
10^{-4}
10^{-3}
10^{-2}
t_p (s)
10^{-1}

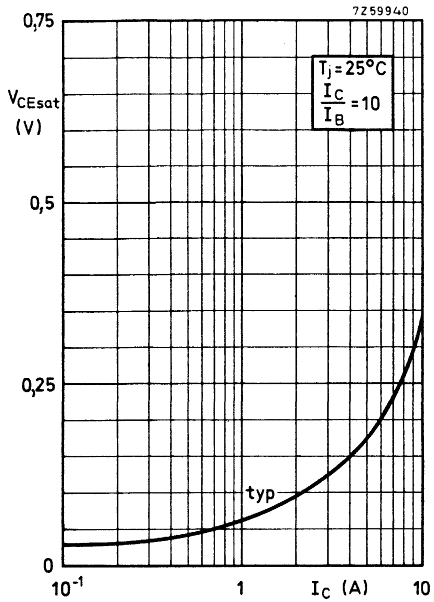

7Z67085
S.B. current multiplying factor at the V_{CEOmax} level (60 V)
BDY92
$M_{SB(V)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-5}
10^{-4}
10^{-3}
10^{-2}
t_p (s)
10^{-1}

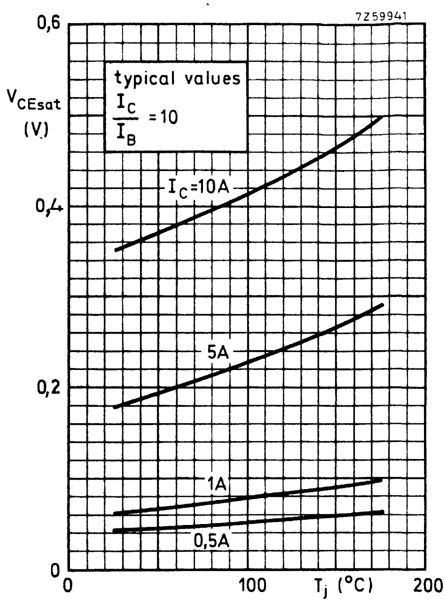

7Z59944
10^2
I_{CEX} (μA)
$V_{CE} = V_{CEXmax}$
$-V_{BE} = 1,5$ V
typ
10
1
10^{-1}
0
100
T_j (°C)
200

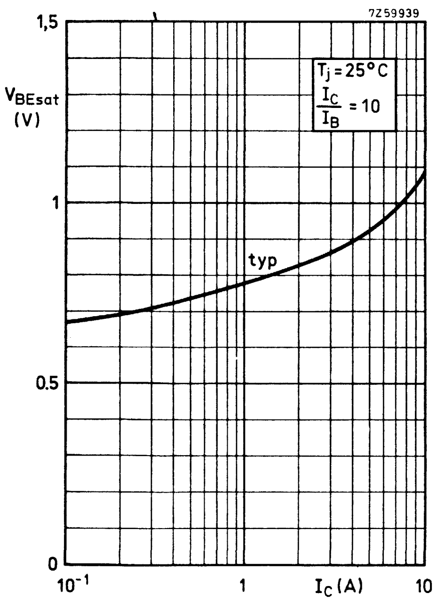

7Z59946.1
150
h_{FE}
$V_{CE} = 5$ V
$T_j = 25$ °C
100
typ
50
0
0,1
1
I_C (A)
10

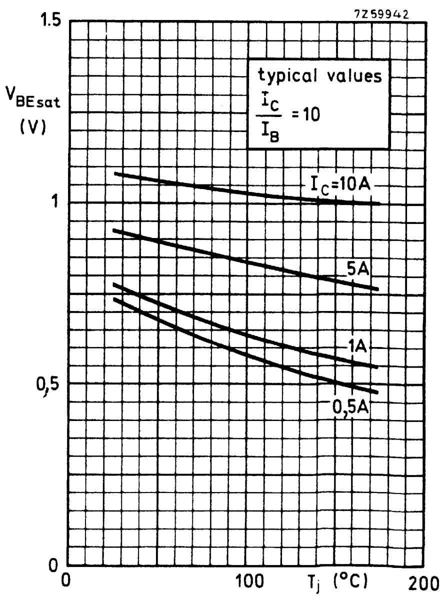

7Z59945
10^3
I_B (mA)
typical values
$V_{CE} = 5$ V
$I_C = 10$A
10^2
5A
10
1A
0,5A
1
0
100
T_j (°C)
200


7Z59943
150
f_T (MHz)
$V_{CE} = 5$ V
f = 5MHz
$T_j = 25$° C
100
typ
50
0
0,1
1
I_C (A)
10


7Z59940
0,75
V_{CEsat}
(V)
0,5
0,25
0
10^{-1}
1
I_C (A)
10
T_j = 25°C
$\frac{I_C}{I_B}$ = 10
typ

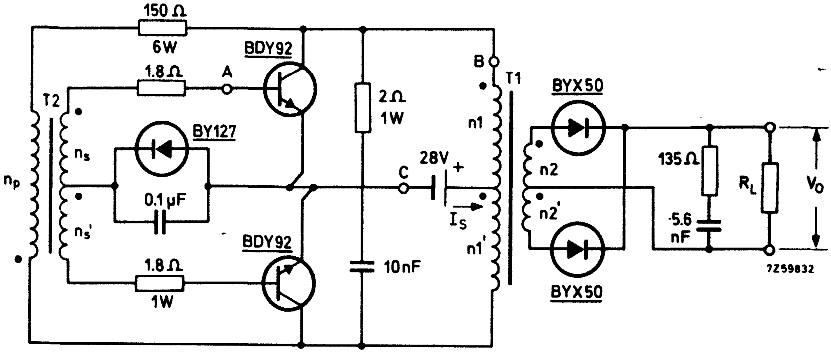

7Z59941
0,6
V_{CEsat}
(V)
0,4
0,2
0
0
100
T_j (°C)
200
typical values
$\frac{I_C}{I_B}$ = 10
I_C=10A
5A
1A
0,5A


7Z59939
1,5
V_{BEsat}
(V)
1
0.5
0
10^{-1}
1
I_C (A)
10
T_j = 25°C
$\frac{I_C}{I_B}$ = 10
typ


7Z59942
1.5
V_{BEsat}
(V)
1
0,5
0
0
100
T_j (°C)
200
typical values
$\frac{I_C}{I_B}$ = 10
I_C=10A
5A
1A
0,5A

APPLICATION INFORMATION

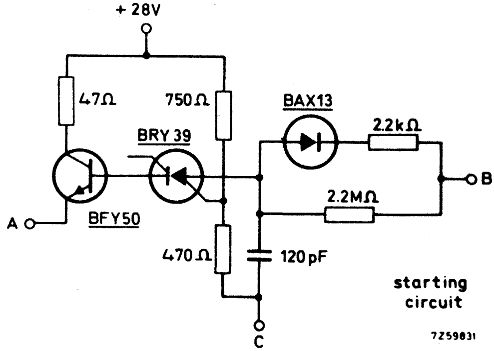
Typical operation in a 250 W d.c. to d.c. converter with two BDY92 transistors



Each transistor is mounted on a heatsink of $R_{th\ h\text{-}a} = 15\ ^{o}C/W$

Performance at $T_{amb} = 55\ ^{o}C$

I_S = 10.5 A
V_O = 240 V
P_O = 250 W
η = 84 %
f = 28.5 kHz



Losses at P_O = 250 W

In transistors	2 x 6 W
In diodes	2 x 2 W
In transformers	8 W
Circuit losses	14 W

Transformer data

T_1 = Ferroxcube core E55 material 3E1
Cat. No. 4332 020 34780

$n_1 + n_1'$ is bifilarly wound

$n_1 = n_1'$ = 9 turns, ϕ 1.4 mm

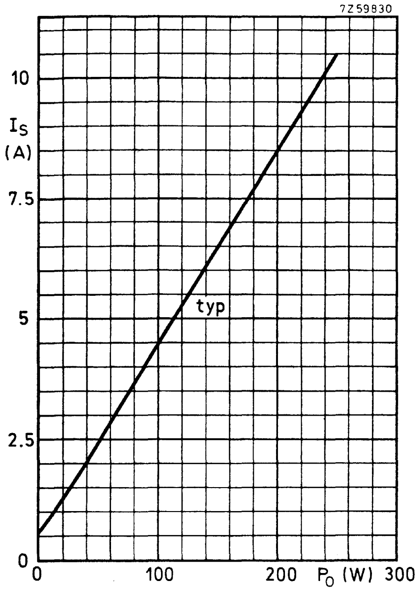
$n_2 = n_2'$ = 85 turns, ϕ 0.5 mm

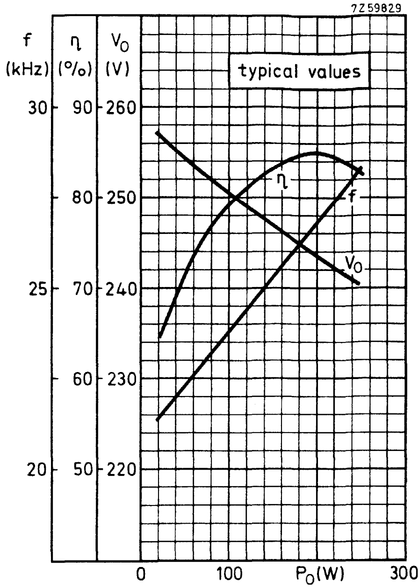
T_2 = Ferroxcube core H16 material 3E2
Cat. No. 4322 020 33030

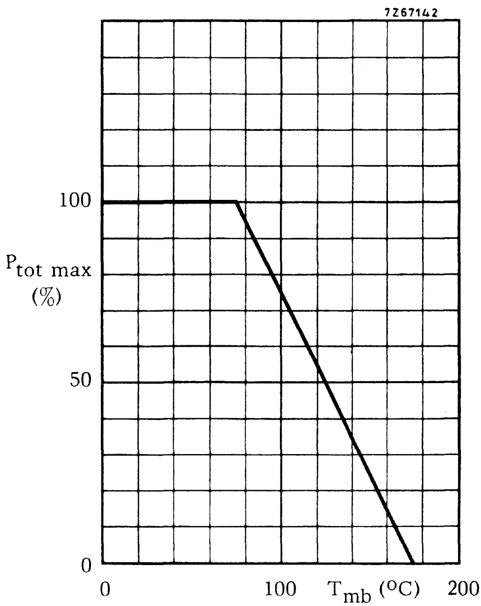
$n_s + n_s'$ is bifilarly wound

$n_s = n_s'$ = 4 turns, ϕ 0.7 mm

n_p = 24 turns, ϕ 0.3 mm


7Z59830
10
I_S
(A)
7.5
5
2.5
0
typ
0
100
200
P_O (W)
300


7Z59829
f
(kHz)
η
(%)
V_O
(V)
typical values
30
25
20
90
80
70
60
50
260
250
240
230
220
η
f
V_O
0
100
P_O(W)
300


7Z67142
100
$P_{tot\ max}$
(%)
50
0
0
100
T_{mb} (°C)
200

HIGH VOLTAGE SILICON POWER TRANSISTORS

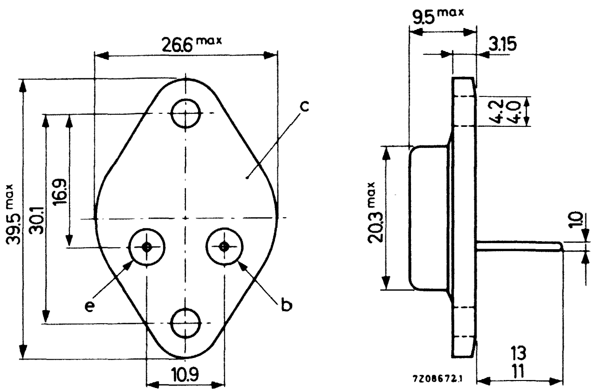
High voltage n-p-n power transistors intended for use in converters, inverters, switching regulators and motor control systems.

QUICK REFERENCE DATA						
			BDY93	BDY94	BDY95	
Collector-emitter voltage (V_{BE} = 0) (peak value)	V_{CESM}	max.	750	750	600	V
Collector-emitter voltage (open base)	V_{CEO}	max.	350	300	250	V
Collector current (peak value)	I_{CM}	max.	6	6	6	A
Total power dissipation up to T_{mb} = 50 °C	P_{tot}	max.	30	30	30	W
Collector-emitter saturation voltage I_C = 2.5 A; I_B = 0.5 A	$V_{CE\,sat}$	<	1.5	1.5	1.5	V
Fall time I_C = 2.5 A; $I_{B1} = -I_{B2}$ = 0.5 A; V_{CC} = 125 V	t_f	typ.	0.4	0.5	0.5	μs

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)

			BDY93	BDY94	BDY95	
Voltages						
Collector-emitter voltage (V_{BE} = 0) (peak value)	V_{CESM}	max.	750	750	600	V
Collector-emitter voltage ($-V_{BE}$ = 1.5 V) (peak value)	V_{CEXM}	max.	750	750	600	V
Collector-emitter voltage (open base)	V_{CEO}	max.	350	300	250	V

Currents

Collector current (d.c.)	I_C	max.	3	A
Collector current (peak value)	I_{CM}	max.	6	A
Reverse collector current (peak value)	$-I_{CM}$	max.	3	A
Base current (d.c.)	I_B	max.	2	A
Base current (peak value)	I_{BM}	max.	2	A
Reverse base current (d.c. or average over any 20 ms period)	$-I_{B(AV)}$	max.	100	mA
Reverse base current (peak value)	$-I_{BM}$	max.	1.5	A [1]

Power dissipation

Total power dissipation up to T_{mb} = 50 °C	P_{tot}	max.	30	W

Temperatures

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

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2.5	°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.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current [1])

V_{CESM} = max; (V_{BE} = 0;)	I_{CES}	<	0.5	mA
V_{CESM} = max; (V_{BE} = 0;) T_{mb} = 125 °C	I_{CES}	<	2	mA

Emitter cut-off current

I_C = 0; V_{EB} = 6 V	I_{EBO}	<	5	mA

D.C. current gain

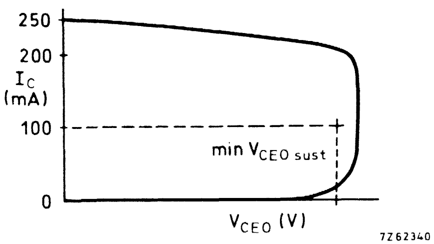
I_C = 1 A; V_{CE} = 5 V, BDY93	h_{FE}		15 to 60	
BDY94	h_{FE}		25 to 80	
BDY95	h_{FE}		25 to 80	
I_C = 3 A; V_{CE} = 5 V	h_{FE}	>	5	

Saturation voltages

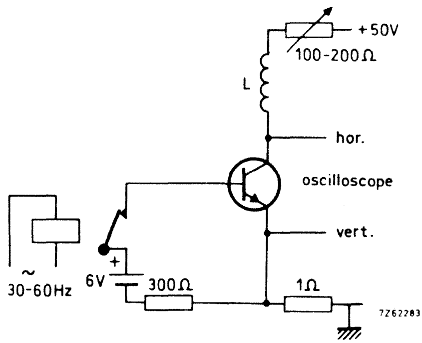
I_C = 1 A; I_B = 0.1 A	$V_{CE\,sat}$	<	1.0	V
I_C = 2.5 A; I_B = 0.5 A	$V_{CE\,sat}$	<	1.5	V
	$V_{BE\,sat}$	<	1.5	V

Collector-emitter sustaining voltage

I_B = 0; I_C = 100 mA; L = 25 mH; BDY93	$V_{CEO\,sust}$	>	350	V
BDY94	$V_{CEO\,sust}$	>	300	V
BDY95	$V_{CEO\,sust}$	>	250	V



Oscilloscope display for $V_{CEO\,sust}$



Test circuit for $V_{CEO\,sust}$

1) Measured with a half sine wave voltage (curve tracer).

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

Collector capacitance at f = 1 MHz

$I_E = I_e = 0$; V_{CB} = 10 V	C_c	typ.	85	pF

Emitter capacitance at f = 1 MHz

$I_C = I_c = 0$; V_{EB} = 2 V	C_e	typ.	1.4	nF

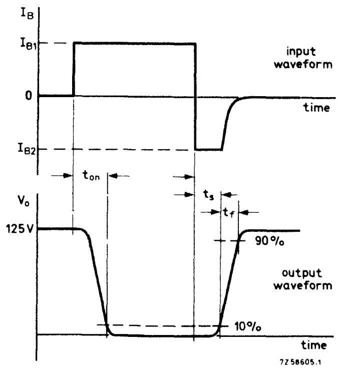
Transition frequency at f = 1 MHz

I_C = 0.2 A; V_{CE} = 10 V	f_T	typ.	8	MHz

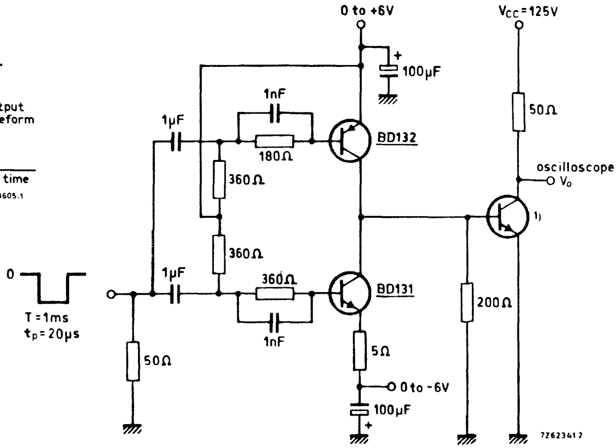
Switching times

I_C = 2.5 A; I_{B1} = $-I_{B2}$ = 0.5 A; V_{CC} = 125 V

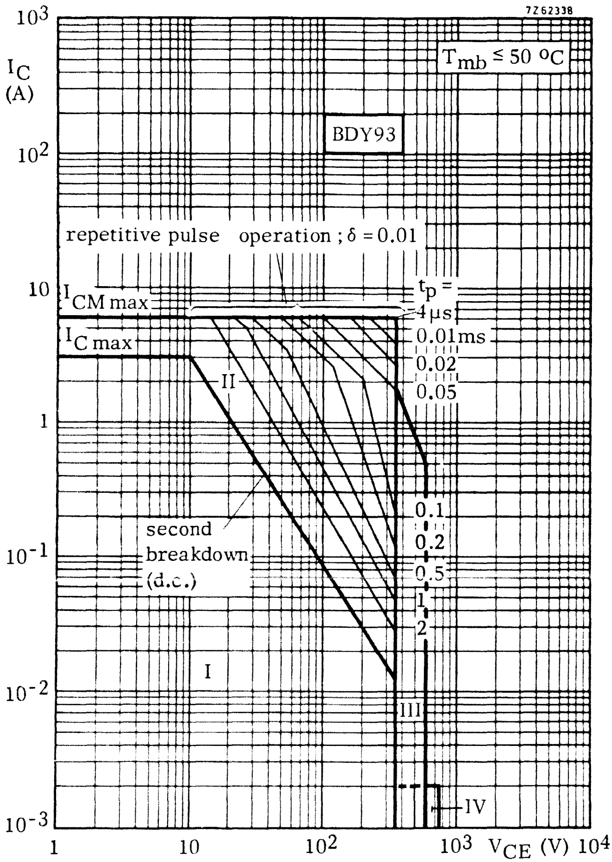
			BDY93	BDY94	BDY95	
turn-on time	t_{on}	typ.	0.25	0.25	0.25	μs
	t_{on}	<	0.5	0.5	0.5	μs
turn-off storage time	t_s	typ.	2	2	2	μs
	t_s	<	3	3.5	3.5	μs
turn-off fall time	t_f	typ.	0.4	0.5	0.5	μs
	t_f	<	0.6	1.0	1.0	μs
turn-off fall time, T_{mb} = 95 °C	t_f	<	1.2	2.0	2.0	μs



Test circuit



1) Transistor under test



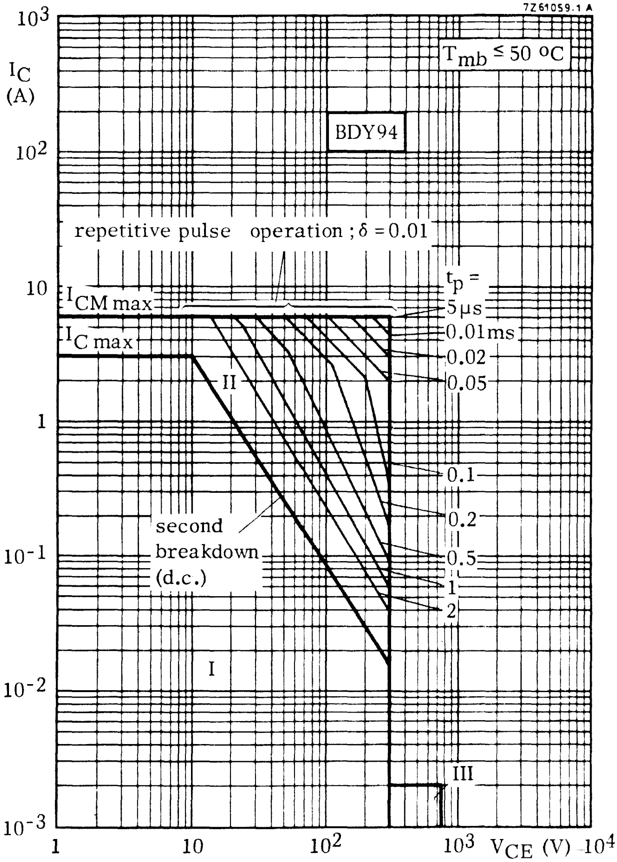
Safe Operating Area (Regions I, II, and III forward biased)

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

III Area of permissible operation during turn-on in single-transistor converters, provided $t_p \leq 0.6$ μs and $R_{BE} \leq 100\,\Omega$

IV Repetitive pulse operation in this region is allowable, provided $V_{BE} \leq 0$ and $t_p \leq 2$ ms.

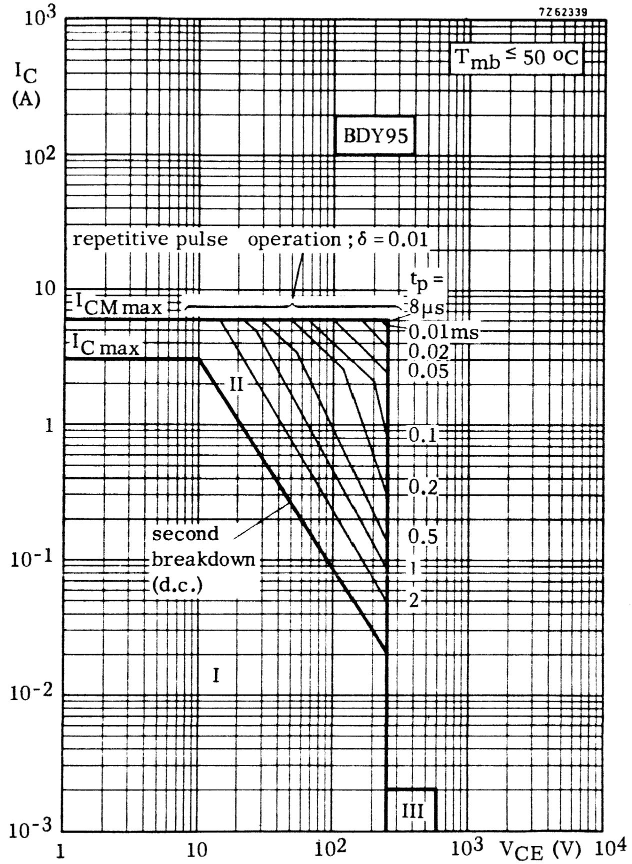


Safe Operating Area (Regions I and II forward biased)

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

III Repetitive pulse operation in this region is allowable, provided $V_{BE} \leq 0$ V and $t_p \leq 2$ ms

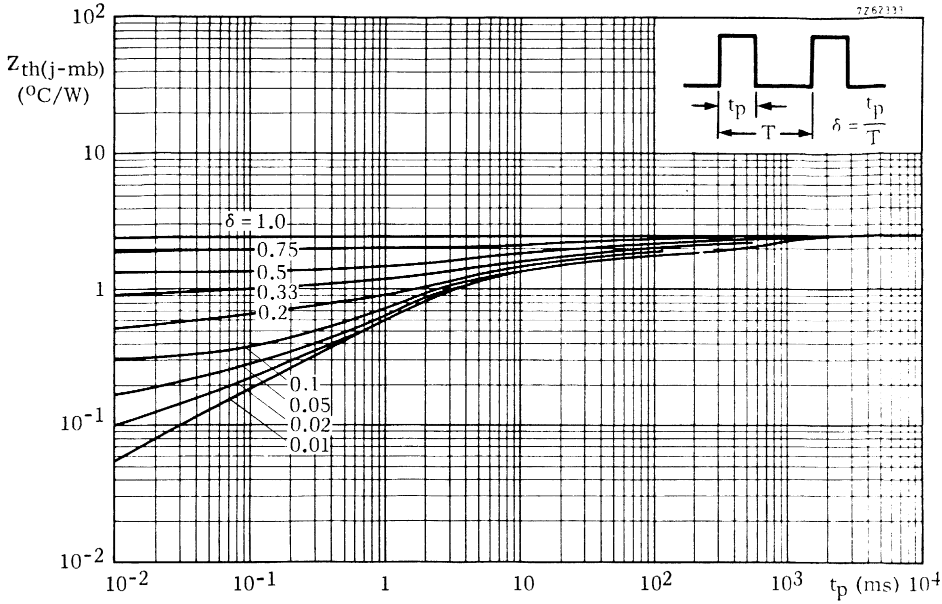


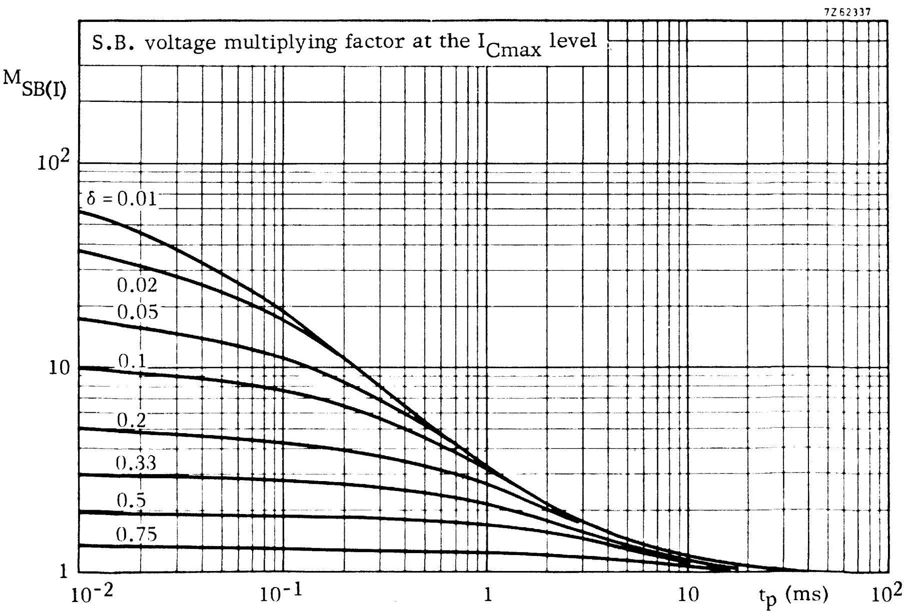
Safe Operating Area (Regions I and II forward biased)

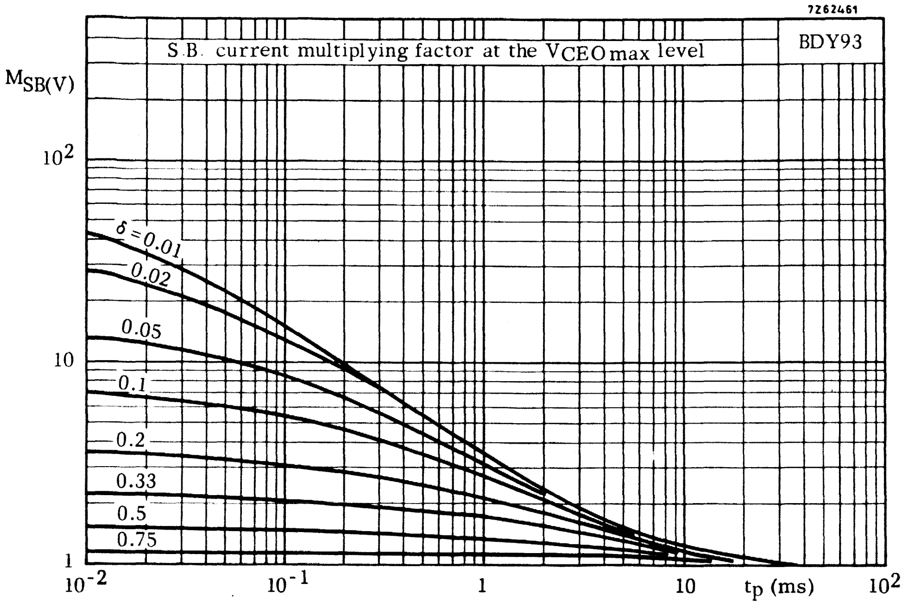
I Region of permissible d.c. operation

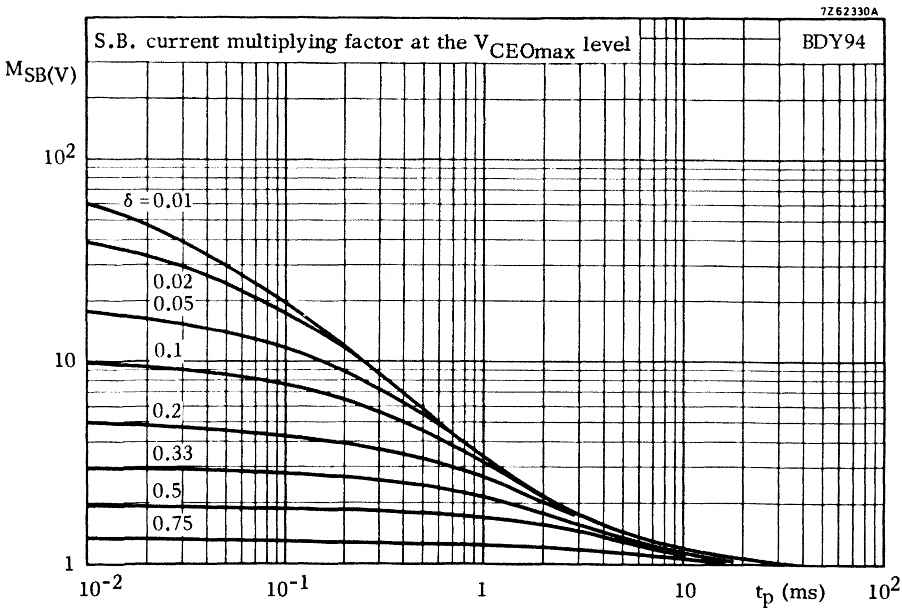
II Permissible extension for repetitive pulse operation

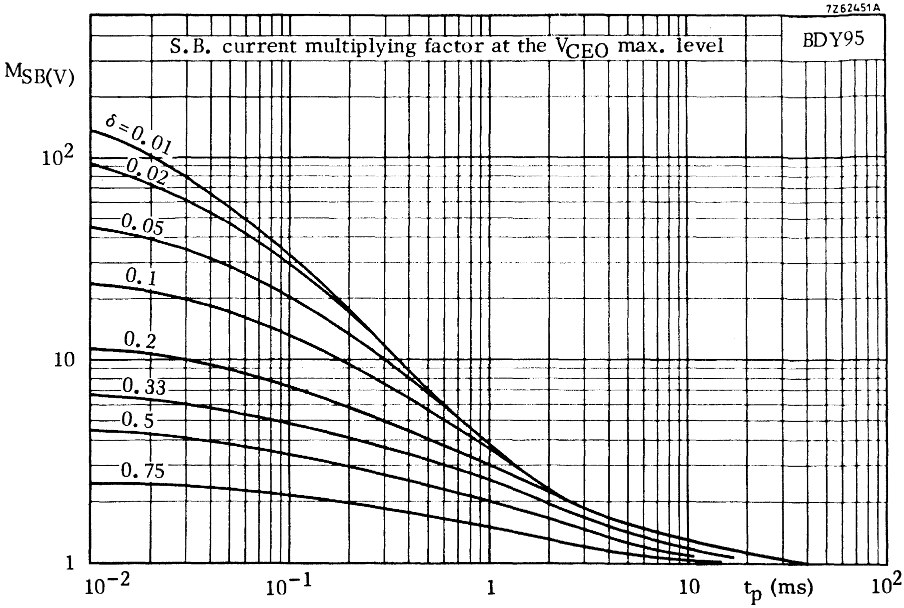
III Repetitive pulse operation in this region is allowable, provided $V_{BE} \leq 0$ V and $t_p \leq 2$ ms

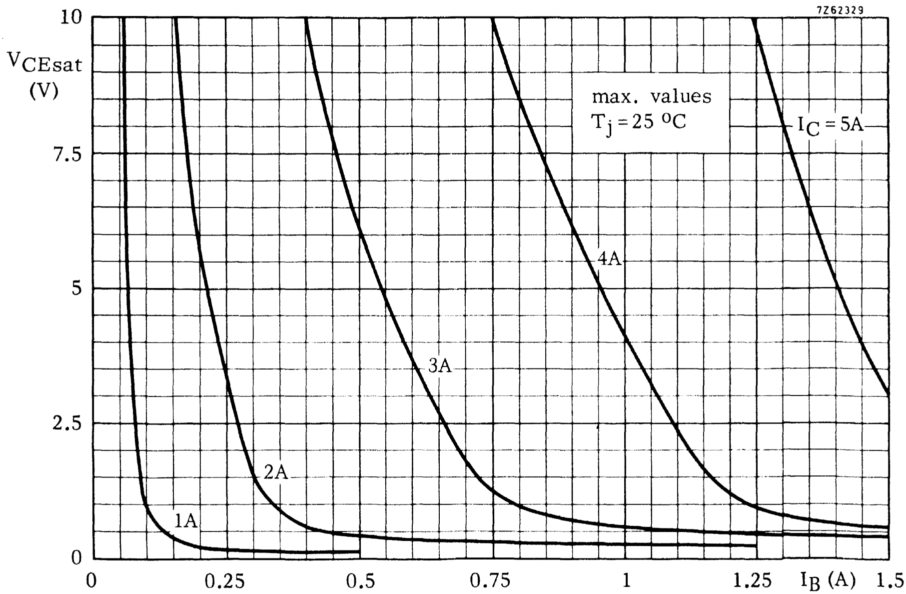

7Z62333
$Z_{th(j-mb)}$
(°C/W)
10^2
10
1
10^{-1}
10^{-2}
δ = 1.0
0.75
0.5
0.33
0.2
0.1
0.05
0.02
0.01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (ms)
10^4

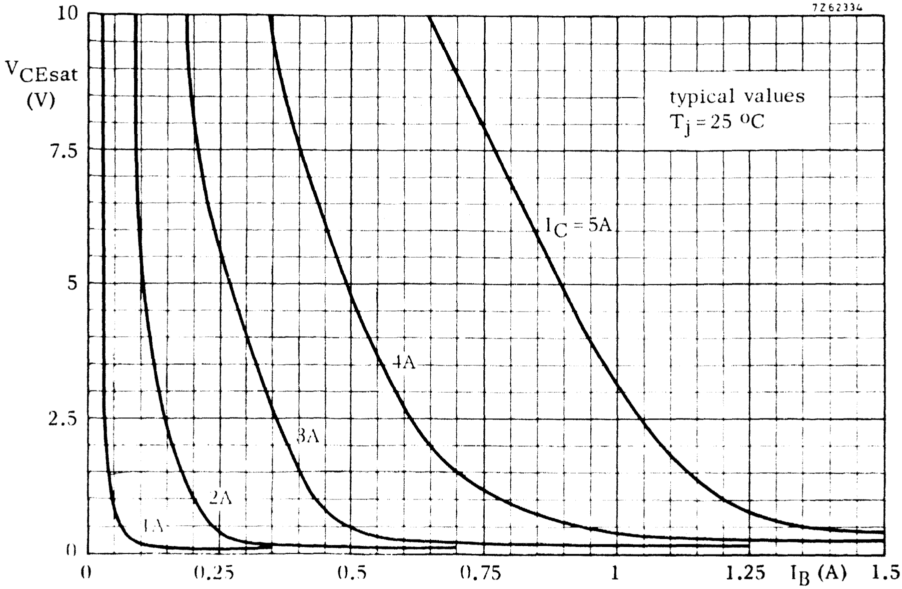

7Z62337
S.B. voltage multiplying factor at the I_{Cmax} level
$M_{SB(I)}$
10^2
10
1
δ = 0.01
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^{-2}
10^{-1}
1
10
t_p (ms)
10^2

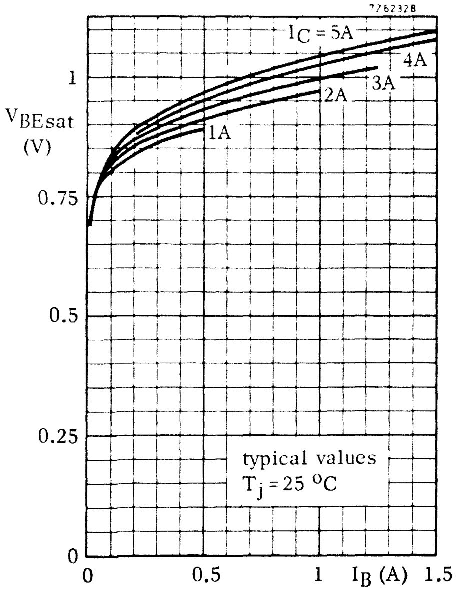

7Z62461
S.B. current multiplying factor at the VCEO max level
BDY93
MSB(V)
10^2
10
1
δ = 0.01
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^-2
10^-1
1
10
tp (ms)
10^2

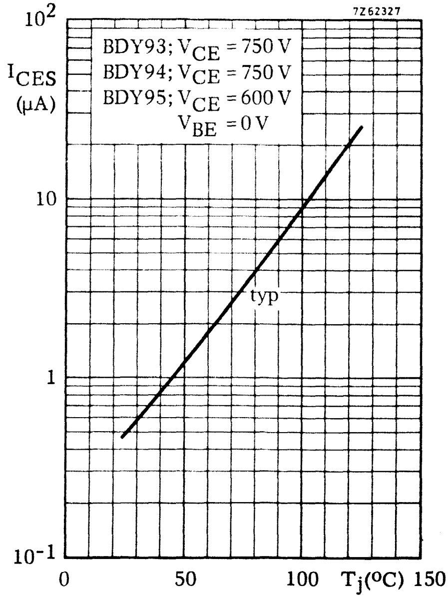

7Z62330A
S.B. current multiplying factor at the VCEOmax level
BDY94
MSB(V)
10^2
10
1
δ = 0.01
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^-2
10^-1
1
10
tp (ms)
10^2

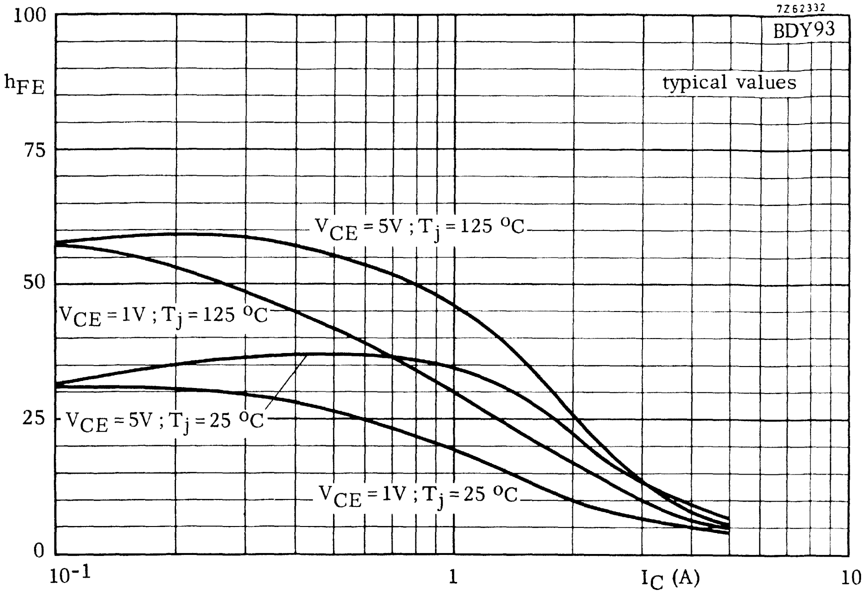

7Z62451A
S.B. current multiplying factor at the V_{CEO} max. level
BDY95
$M_{SB(V)}$
$\delta = 0.01$
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^2
10
1
10^{-2}
10^{-1}
1
10
t_p (ms)
10^2

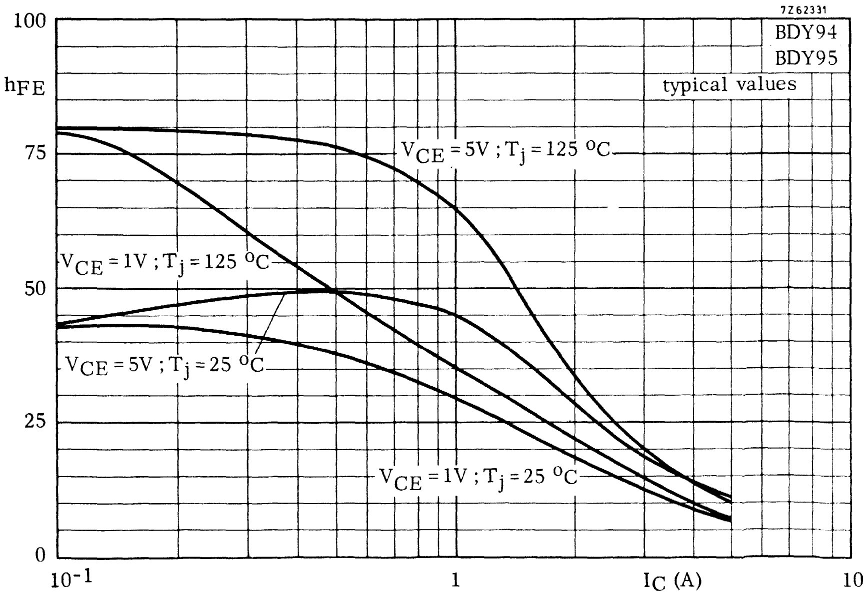

7Z62329
V_{CEsat} (V)
10
7.5
5
2.5
0
max. values
$T_j = 25\ ^oC$
$I_C = 5A$
4A
3A
2A
1A
0
0.25
0.5
0.75
1
1.25
I_B (A)
1.5

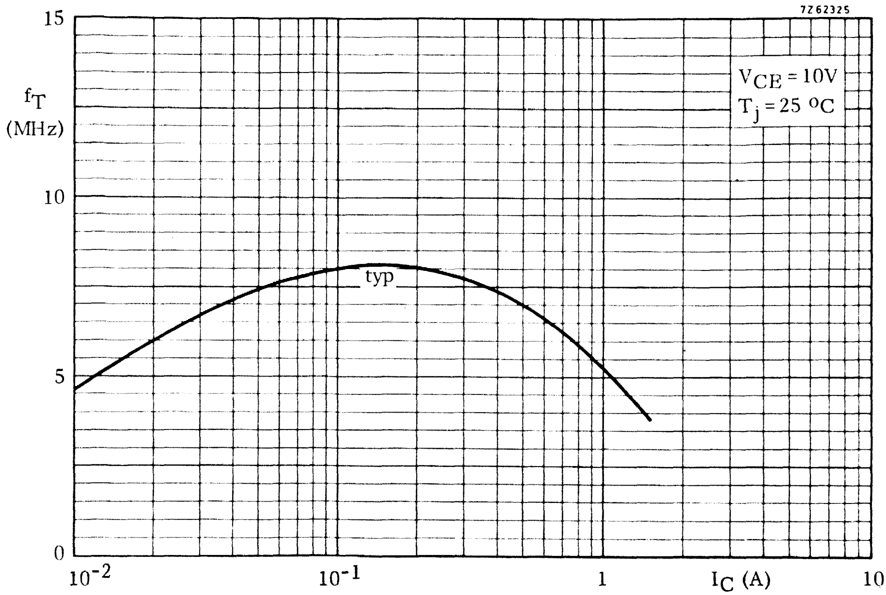

7Z62334
10
7.5
5
2.5
0
V_{CEsat} (V)
typical values
$T_j = 25\ ^oC$
$I_C = 5A$
4A
3A
2A
1A
0
0.25
0.5
0.75
1
1.25
I_B (A)
1.5

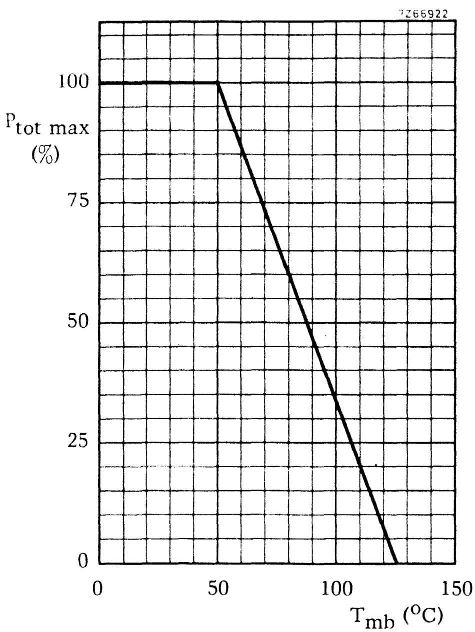

7Z62328
V_{BEsat} (V)
1
0.75
0.5
0.25
0
$I_C = 5A$
4A
3A
2A
1A
typical values
$T_j = 25\ ^oC$
0
0.5
1
I_B (A)
1.5


7Z62327
10^2
10
1
10^{-1}
I_{CES} (μA)
BDY93; $V_{CE} = 750$ V
BDY94; $V_{CE} = 750$ V
BDY95; $V_{CE} = 600$ V
$V_{BE} = 0$ V
typ
0
50
100
T_j (^oC)
150


7Z62332
BDY93
typical values
100
hFE
75
50
25
0
V_{CE} = 5V ; T_j = 125 °C
V_{CE} = 1V ; T_j = 125 °C
V_{CE} = 5V ; T_j = 25 °C
V_{CE} = 1V ; T_j = 25 °C
10^{-1}
1
I_C (A)
10


7Z62331
BDY94
BDY95
typical values
100
hFE
75
50
25
0
V_{CE} = 5V ; T_j = 125 °C
V_{CE} = 1V ; T_j = 125 °C
V_{CE} = 5V ; T_j = 25 °C
V_{CE} = 1V ; T_j = 25 °C
10^{-1}
1
I_C (A)
10


7Z62325
15
10
5
0
f_T
(MHz)
V_{CE} = 10V
T_j = 25 °C
typ
10^{-2}
10^{-1}
1
10
I_C (A)


7Z66922
100
75
50
25
0
$P_{tot\ max}$
(%)
0
50
100
150
T_{mb} (°C)

APPLICATION INFORMATION BDY93 [1])

High frequency power converters

High voltage switching transistors such as the BDY93 are well suited for use in high voltage d.c. converters and switching regulators fed directly from the rectified mains at operating frequencies above the audible limit.

Two widely used converter principles, the single-transistors and the two-transistor converter are given in Figs. 1 and 2 together with their basic waveforms in Figs. 3 and 4. Such converters equipped with the BDY93 can deliver output powers up to 250 W and 450 W respecitively.

Important factors in the design of such high frequency converters are the base drive conditions during the turn-off, the power losses of the power transistors and their heatsink requirements. The base drive is essential to the design, especially for operation at high output powers; it determines the switching speed of the power transistor and, hence, a fair part of the dissipation. In practical designs the ratio between maximum peak collector current I_{CMmax} and the forward base current at the end of the conduction period I_{Bend} is normally 5. For a fast turn-off transient the base current has to be sufficiently negative, preferably $-I_B > I_{Bend}$, for a period longer than the fall-time of the collector current. Such a waveform is given in Fig. 5. The base-emitter junction of the output transistor is driven into breakdown to meet these conditions.

Besides the switching dissipation, further transistor losses are the saturation and base drive disspation during the conduction period of the transistor. These losses depend on the duty factor δ of the system. For the single-transistor converter δ can be chosen according to the desired output; for the two-transistor converter δ has to be smaller than 0,5 under all circumstances to prevent simultaneous conduction of both transistors.

For a typical application in 20 kHz converters the dissipation P_{tot} in the BDY93 is given in Figs. 6 to 9 as a function of the maximum peak collector current, with the rate of the collector voltage dv_{CE}/dt as a parameter, and for two values of δ.

The max. permissible thermal resistance $R_{th\ mb\text{-}a}$ for the heatsink can be calculated from:

$$R_{th\ (mb\text{-}a)max}\ ^{2)} = \frac{T_{j\ max} - T_{amb}}{P_{tot}} - R_{th\ j\text{-}mb}$$

where for the BDY93: $T_{j\ max} = 125\ ^oC$ and $R_{th\ j\text{-}mb} = 2,5\ ^oC/W$.

To ensure thermal stability, the thermal resistance of the heatsink used must not exceed the value plotted in Figs. 10 and 11.

1) Detailed application information available on request.
2) Including additional thermal resistance resulting from mounting hardware.

APPLICATION INFORMATION BDY93 (continued)

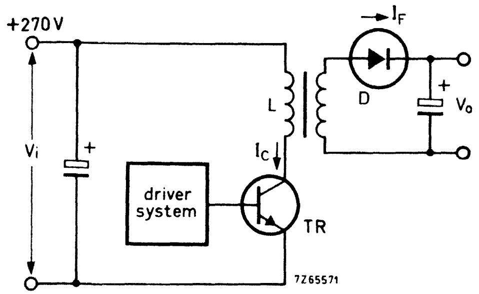


Fig. 1 Single-transistor converter, basic circuit arrangement

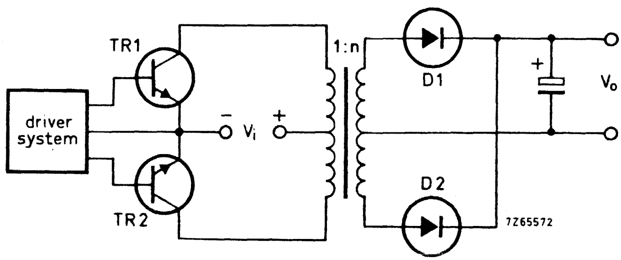


Fig. 2 Two-transistor converter, basic circuit arrangement.

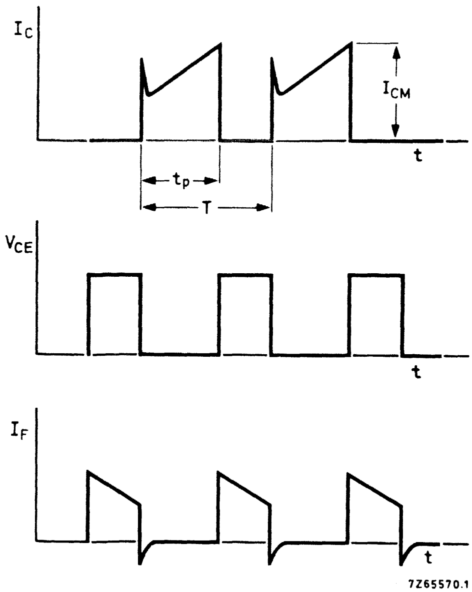


Fig. 3 Waveforms of single-transistor converter.

APPLICATION INFORMATION BDY93 (continued)

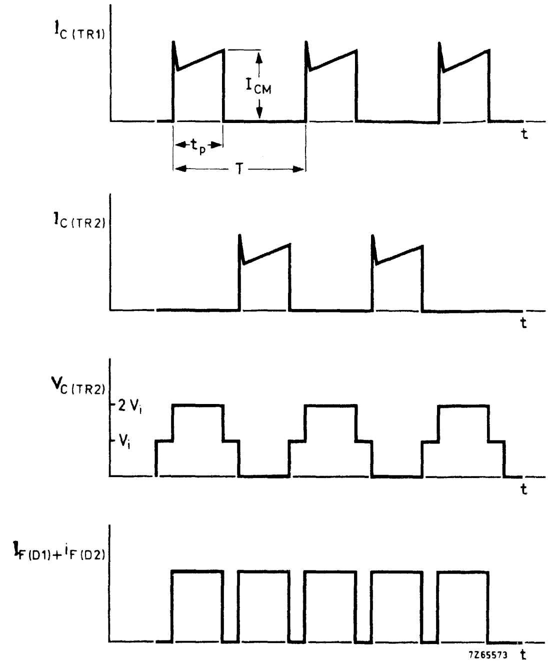


Fig. 4 Waveforms of two-transistor converter.

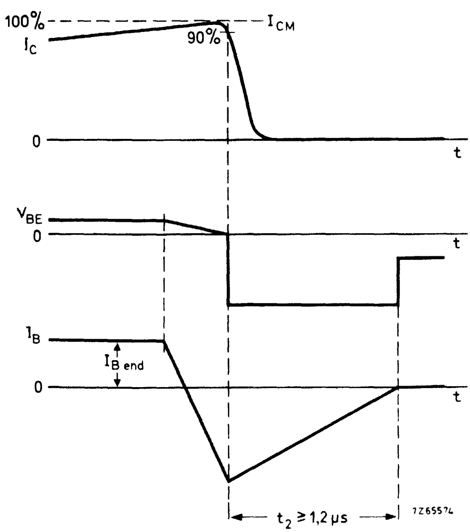


Fig. 5 Transistor waveforms during turn-off (for both single and two-transistor converter).

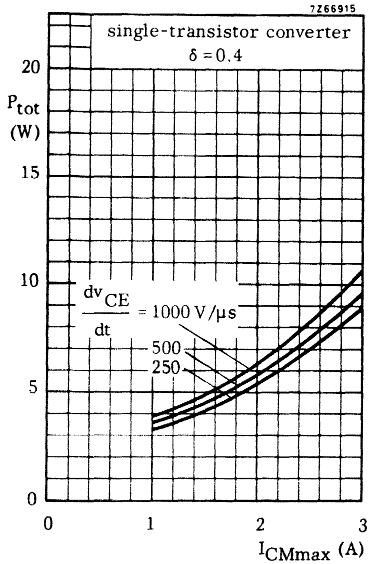


Fig. 6

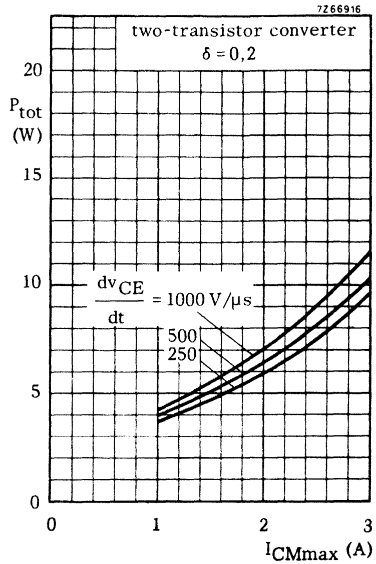


Fig. 7

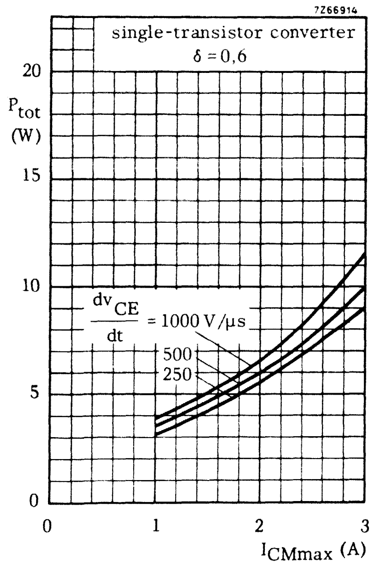


Fig. 8

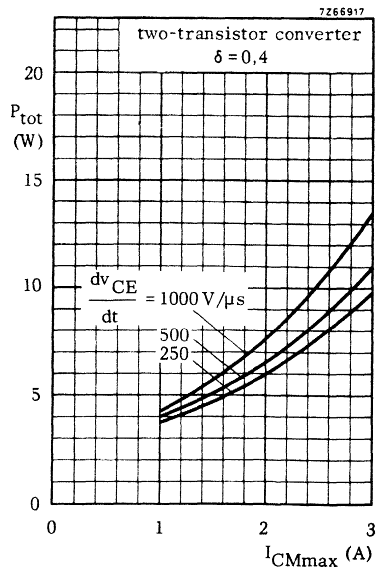


Fig. 9

Figs 6 to 9 Total transistor power dissipation versus maximum peak collector current

APPLICATION INFORMATION BDY93 (continued)

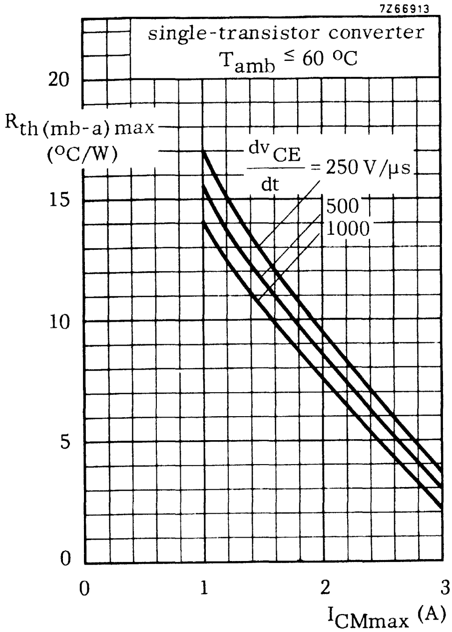


Fig. 10

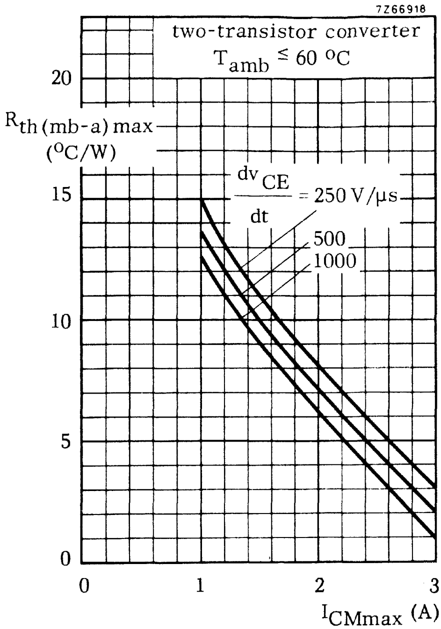


Fig. 11

Fig. 10, Fig. 11 Maximum allowable value of $R_{th\ mb-a}$ versus maximum peak collector current to ensure thermal stability.

HIGH VOLTAGE SILICON POWER TRANSISTORS

High voltage n-p-n power transistors in a TO-3 envelope, intended for use in converters, inverters, switching regulators and motor control systems.

QUICK REFERENCE DATA

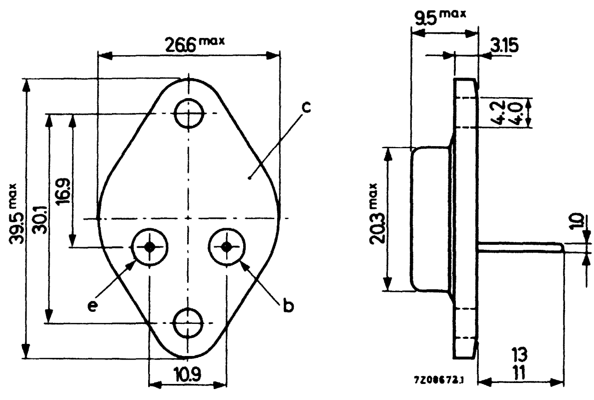
			BDY 96	BDY 97	BDY 98	
Collector-emitter voltage (V_{BE} = 0)	V_{CESM}	max.	750	750	600	V
Collector-emitter voltage (open base)	V_{CEO}	max.	350	300	250	V
Collector current (d.c.)	I_C	max.	10	10	10	A
Collector current (peak value)	I_{CM}	max.	15	15	15	A
Total power dissipation up to T_{mb} = 65 °C	P_{tot}	max.	40	40	40	W
Collector-emitter saturation voltage I_C = 5 A; I_B = 1 A	V_{CEsat}	<	1	1,5	1,5	V
Fall time I_C = 5 A; I_{B1} = $-I_{B2}$ = 1 A; V_{CC} = 250 V	t_f	typ.	0,3	0,5	0,5	μs

MECHANICAL DATA

Dimensions in mm

TO-3

Collector connected to case



Accessories available: 56201e

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltage

			BDY 96	BDY 97	BDY 98	
Collector-emitter voltage (V_{BE} = 0) peak value	V_{CESM}	max.	750	750	600	V
Collector-emitter voltage (open base)	V_{CEO}	max.	350	300	250	V

Current

Collector current (d.c.)	I_C	max.	10	A
Collector current (peak value; $t_p \leq$ 1 ms)	I_{CM}	max.	15	A
Base current (d.c.)	I_B	max.	4	A
Base current (peak value; $t_p \leq$ 1 ms)	I_{BM}	max.	6	A
Reverse base current (d.c. or average over any 20 ms period)	$-I_{B(AV)}$	max.	100	mA
Reverse base current(peak value) [1]	$-I_{BM}$	max.	4	A

Power dissipation

Total power dissipation up to T_{mb} = 65 °C	P_{tot}	max.	40	W

Temperature

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

THERMAL RESISTANCE

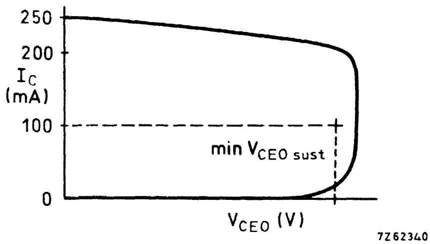
From junction to mounting base	$R_{th\,j-mb}$	=	1,5	°C/W
From mounting base to heatsink: with mica washer and lead washer	$R_{th\,mb-h}$	=	0,75	°C/W
with lead washer only	$R_{th\,mb-h}$	=	0,5	°C/W

1) Turn-off current

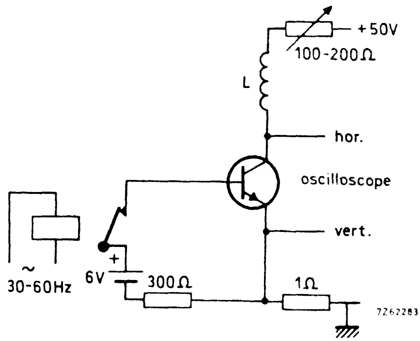
CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BDY 96	BDY 97	BDY 98	
Collector cut-off current [1]						
V_{CE} = 600 V; V_{BE} = 0	I_{CES}	<	–	–	0,5	mA
V_{CE} = 750 V; V_{BE} = 0	I_{CES}	<	0,5	0,5	–	mA
V_{CE} = 600 V; V_{BE} = 0; T_j = 125 °C	I_{CES}	<	–	–	2	mA
V_{CE} = 750 V; V_{BE} = 0; T_j = 125 °C	I_{CES}	<	2	2	–	mA
Emitter cut-off current						
I_C = 0; V_{EB} = 6 V	I_{EBO}	<	5	5	5	mA
D.C. current gain						
I_C = 2 A; V_{CE} = 5 V	h_{FE}		15 to 60	25 to 80	25 to 80	
Saturation voltage						
I_C = 5 A; I_B = 1 A	V_{CEsat}	<	1	1,5	1,5	V
	V_{BEsat}	<	1,4	1,4	1,4	V
I_C = 10 A; I_B = 3.3 A	V_{CEsat}	<	3	5	5	V
	V_{BEsat}	<	2	2	2	V
Collector-emitter sustaining voltage						
I_C = 100 mA; I_B = 0; L = 25 mH	$V_{CEOsust}$	>	350	300	250	V



Oscilloscope display for $V_{CEOsust}$



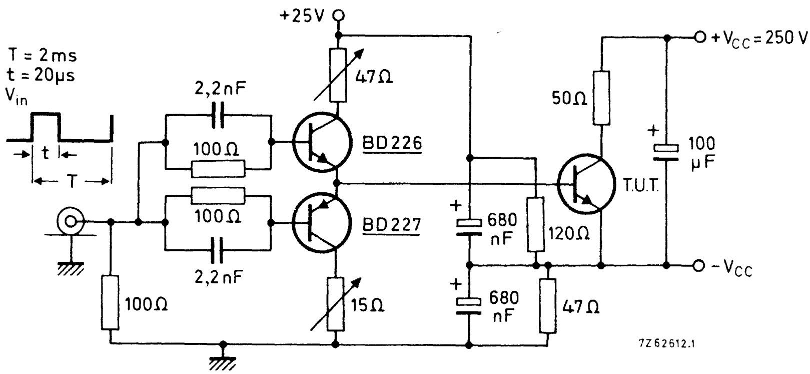
Test circuit for $V_{CEOsust}$

1) Measured with a half sine wave voltage (curve tracer).

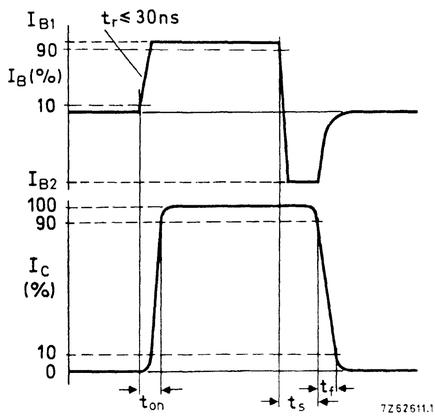
CHARACTERISTICS (continued)

T_j = 25 °C unless otherwise specified

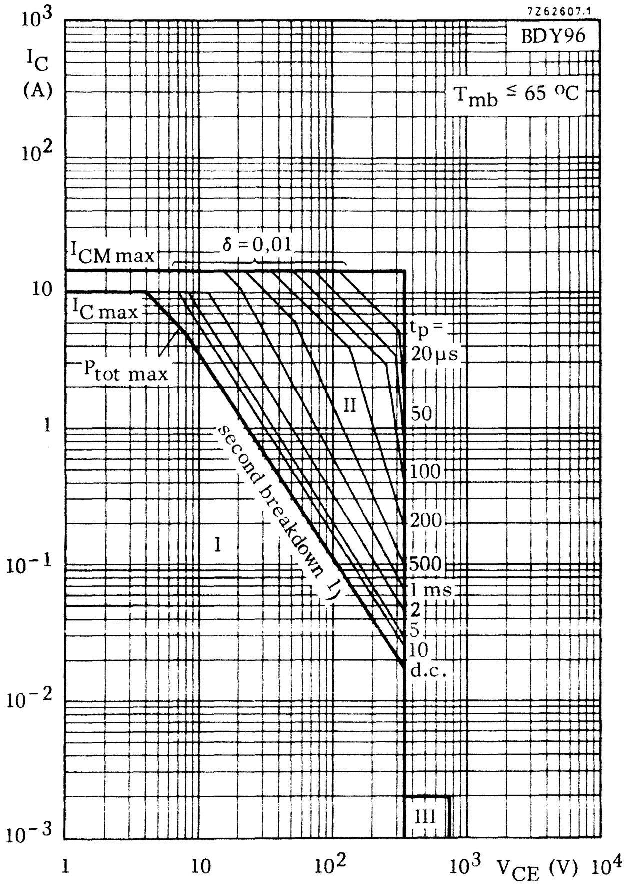
			BDY 96	BDY 97	BDY 98	
Transition frequency at f = 1 MHz						
I_C = 0,2 A; V_{CE} = 10 V	f_T	typ.	10	10	10	MHz
Switching times						
I_C = 5 A; I_{B1} = $-I_{B2}$ = 1 A, V_{CC} = 250 V						
Turn-on time	t_{on}	typ.	0,35	0,35	0,35	μs
		<	0,5	0,5	0,5	μs
Turn-off storage time	t_s	typ.	2,5	3,0	3,0	μs
		<	3,0	4,0	4,0	μs
Turn-off fall time	t_f	typ.	0,3	0,5	0,5	μs
		<	0,4	0,9	0,9	μs
Turn-off fall time, T_{mb} = 95 °C	t_f	<	1	2	2	μs



Test circuit



Waveform



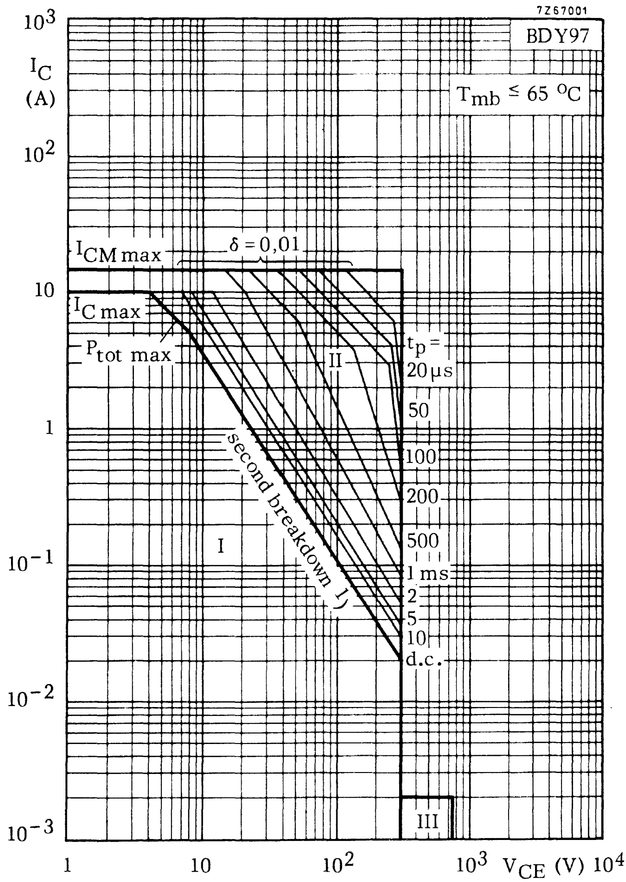
Safe Operating Area with the transistor forward biased (region I + II)

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

III Repetitive pulse operation in this region is allowable provided $V_{BE} \leq 0$ and $t_p \leq 2$ ms

1) Independent of temperature



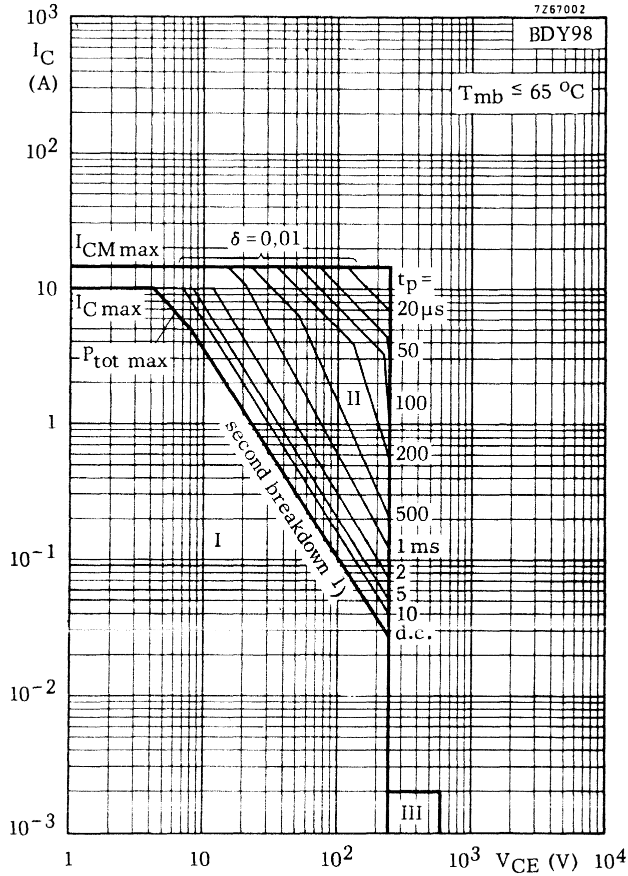
Safe Operating Area with the transistor forward biased (region I + II)

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

III Repetitive pulse operation in this region is allowable provided $V_{BE} \leq 0$ and $t_p \leq 2$ ms

1) Independent of temperature



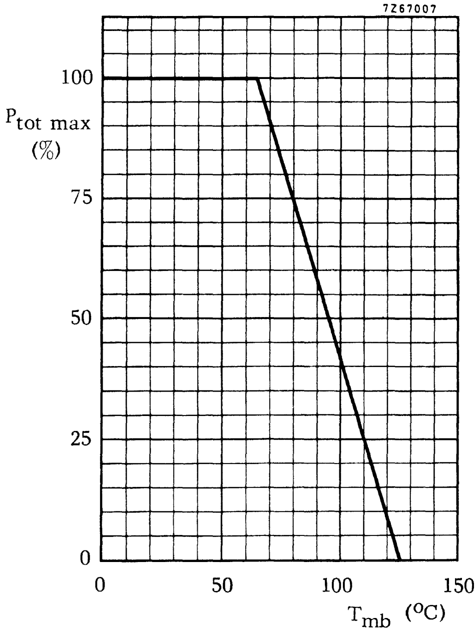
Safe Operating Area with the transistor forward biased (region I + II)

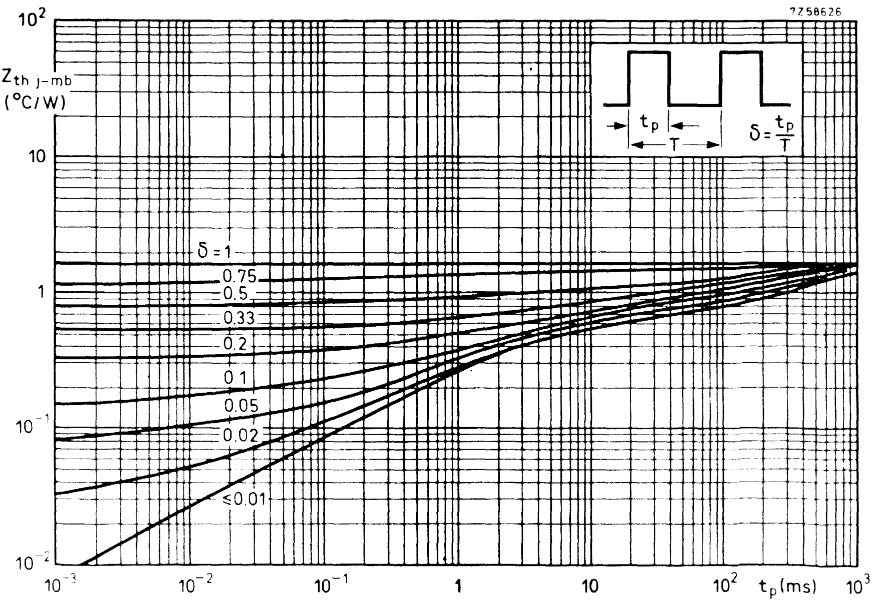
I Region of permissible d.c. operation

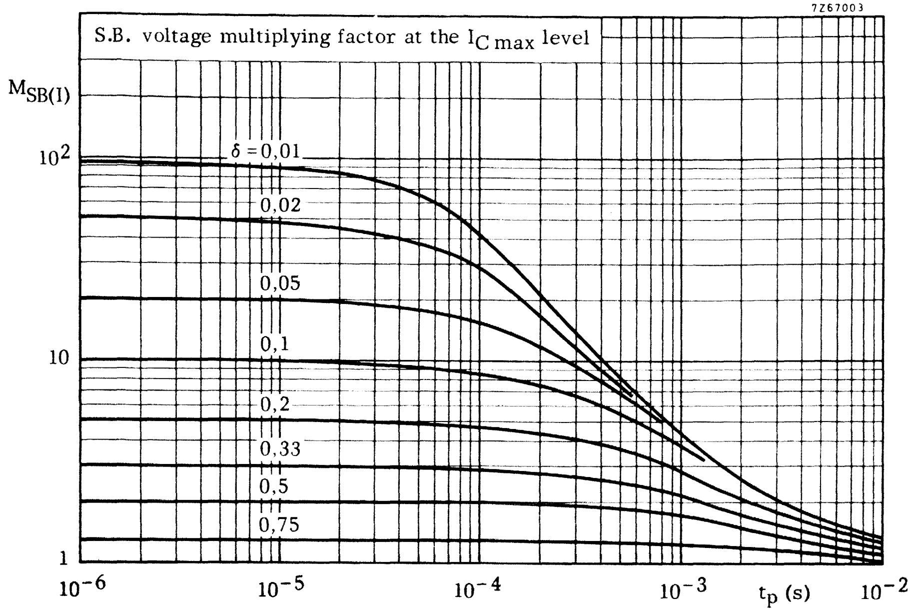
II Permissible extension for repetitive pulse operation

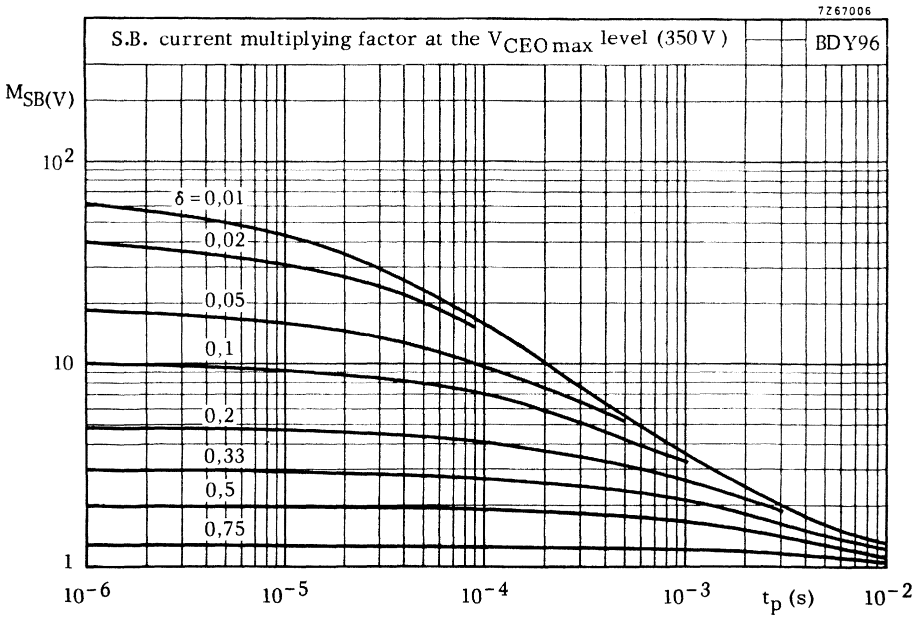
III Repetitive pulse operation in this region is allowable provided $V_{BE} \leq 0$ and $t_p \leq 2$ ms

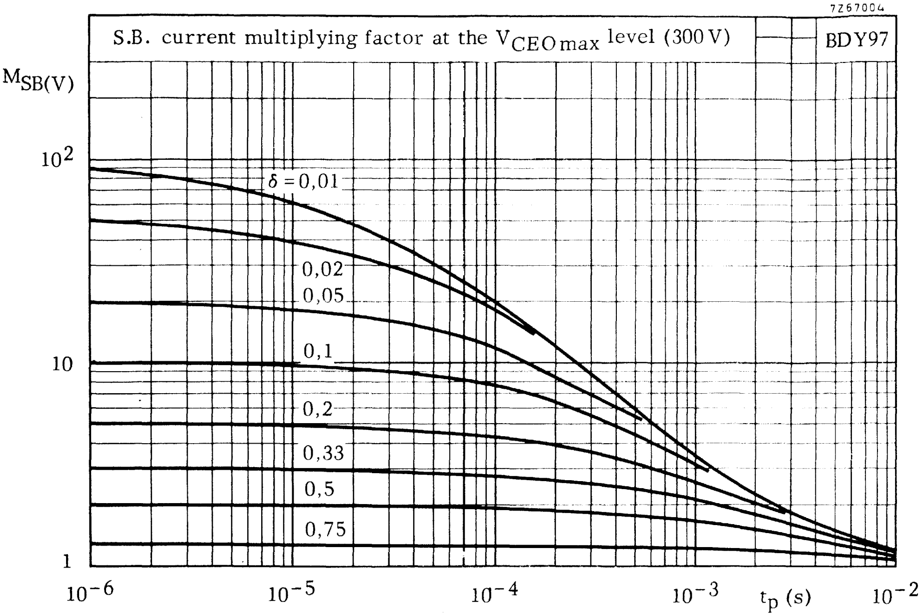
1) Independent of temperature

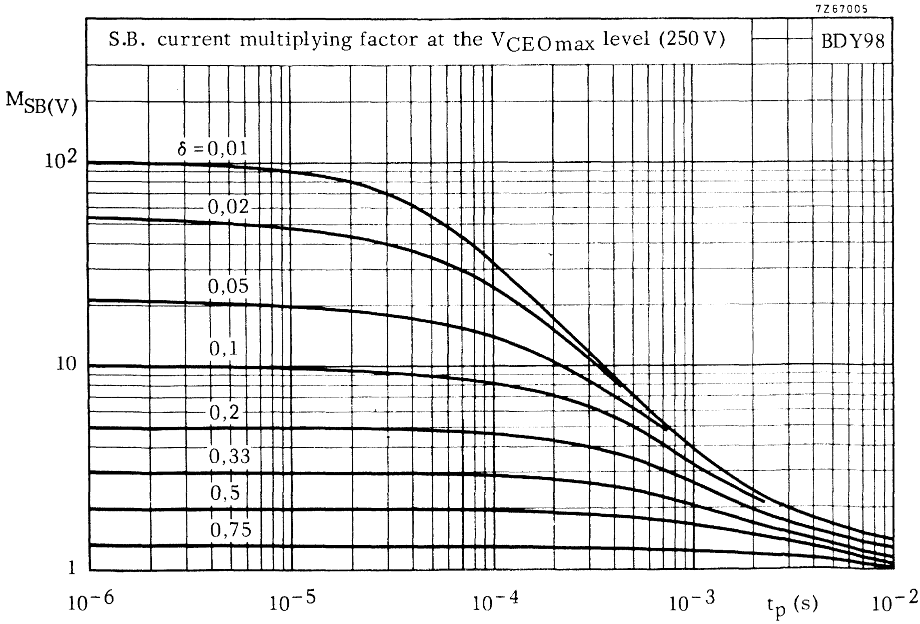

7Z67007
100
$P_{tot\ max}$
(%)
75
50
25
0
0
50
100
150
T_{mb} (°C)

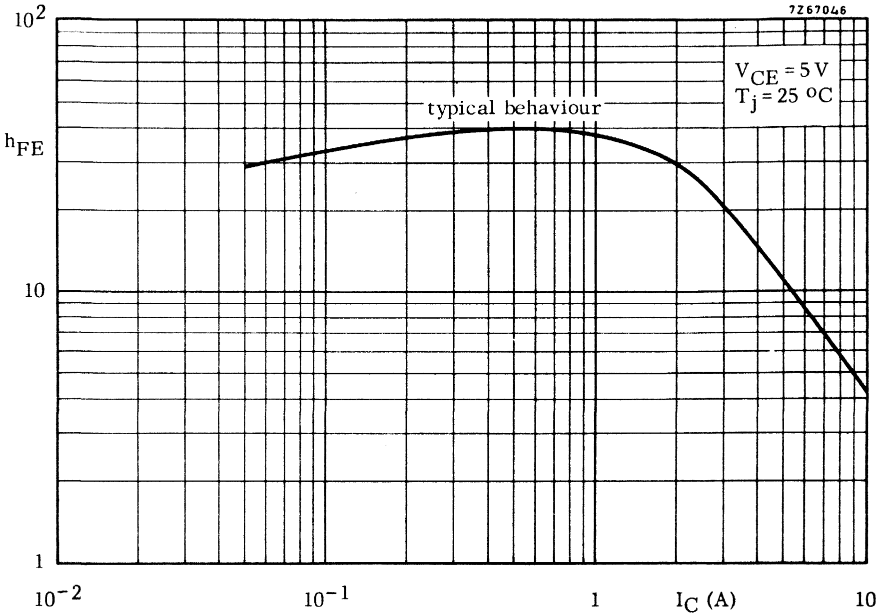

7Z58626
10^2
$Z_{th\ j-mb}$
(°C/W)
10
1
10^{-1}
10^{-2}
t_p
T
$\delta = \frac{t_p}{T}$
δ = 1
0.75
0.5
0.33
0.2
0.1
0.05
0.02
≤0.01
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p(ms)
10^3

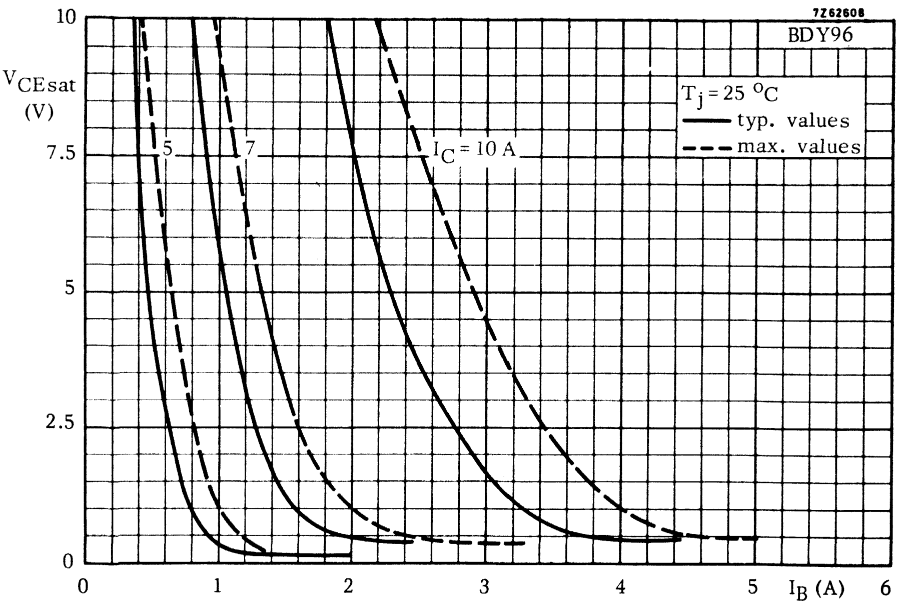

7Z67003
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

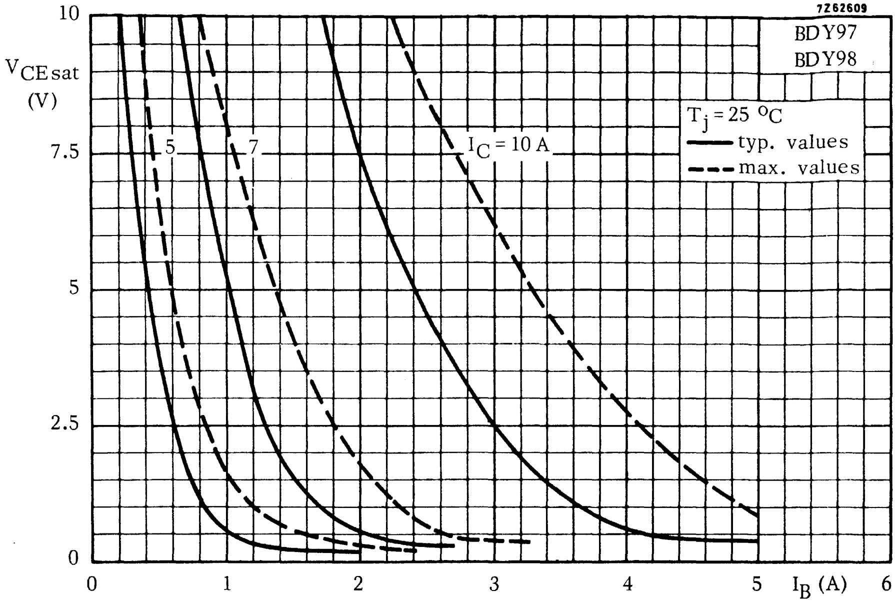

7Z67006
S.B. current multiplying factor at the $V_{CEO\,max}$ level (350 V)
BDY96
$M_{SB(V)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

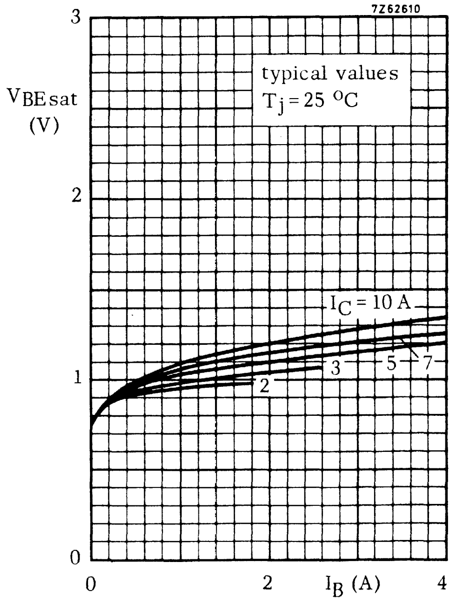

7Z67004
S.B. current multiplying factor at the V_{CEOmax} level (300 V)
BDY97
$M_{SB(V)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}


7Z67005
S.B. current multiplying factor at the V_{CEOmax} level (250 V)
BDY98
$M_{SB(V)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}


7Z67046
10^2
h_{FE}
10
1
10^{-2}
10^{-1}
1
I_C (A)
10
typical behaviour
$V_{CE} = 5$ V
$T_j = 25$ °C


7Z62608
BDY96
V_{CEsat}
(V)
10
7.5
5
2.5
0
1
2
3
4
5
6
I_B (A)
5
7
$I_C = 10$ A
$T_j = 25$ °C
typ. values
max. values


7Z62609
BDY97
BDY98
$T_j = 25\ ^oC$
typ. values
max. values
V_{CEsat}
(V)
10
7.5
5
2.5
0
5
7
$I_C = 10\ A$
0
1
2
3
4
5
I_B (A)
6


7Z62610
typical values
$T_j = 25\ ^oC$
V_{BEsat}
(V)
3
2
1
0
$I_C = 10\ A$
2
3
5
7
0
2
I_B (A)
4

HIGH VOLTAGE SILICON POWER TRANSISTOR

High voltage n-p-n power transistor intended for general purpose consumer applications.

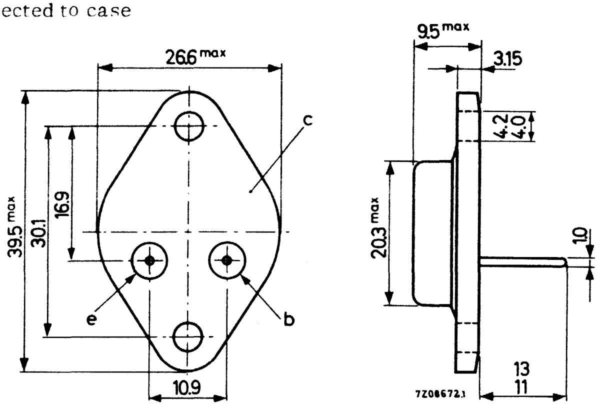
QUICK REFERENCE DATA				
Collector-emitter voltage (V_{BE} = 0) (peak value)	V_{CESM}	max.	750	V
Collector current (peak value)	I_{CM}	max.	6	A
Total power dissipation up to T_{mb} = 50 °C	P_{tot}	max.	30	W
Collector-emitter saturation voltage I_C = 2.5 A; I_B = 0.25 A	$V_{CE\,sat}$	<	10	V
Fall time I_{CM} = 2.5 A; I_{B1} = $-I_{B2}$ = 0.5 A; V_{CC} = 125 V	t_f	typ.	0.5	μs

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-emitter voltage (V_{BE} = 0) (peak value)	V_{CESM}	max.	750	V
Collector-emitter voltage ($-V_{BE}$ = 1.5 V) (peak value)	V_{CEXM}	max.	750	V
Collector-emitter voltage (open base)	V_{CEO}	max.	250	V
Currents				
Collector current (d.c.)	I_C	max.	3	A
Collector current (peak value)	I_{CM}	max.	6	A
Reverse collector current (peak value)	$-I_{CM}$	max.	3	A
Base current (d.c.)	I_B	max.	2	A
Base current (peak value)	I_{BM}	max.	2	A
Reverse base current (d.c. or average over any 20 ms period)	$-I_{B(AV)}$	max.	100	mA
Reverse base current (peak value)	$-I_{BM}$	max.	1.5	A [1]
Power dissipation				
Total power dissipation up to T_{mb} = 50 °C	P_{tot}	max.	30	W
Temperatures				
Storage temperature	T_{stg}		-65 to +125	°C
Junction temperature	T_j	max.	125	°C

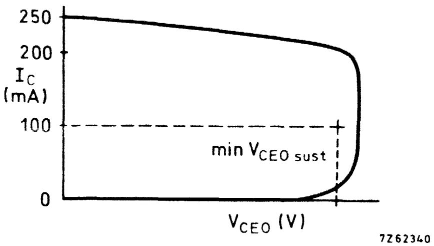
THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2.5	°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

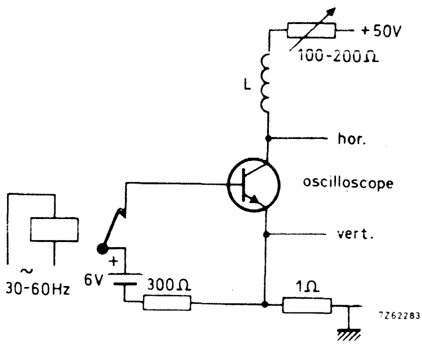
1) Turn-off current.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current [1]				
V_{CEM} = 750 V; V_{BE} = 0	I_{CES}	<	0.5	mA
V_{CEM} = 750 V; V_{BE} = 0; T_j = 125 °C	I_{CES}	<	2	mA
Emitter cut-off current				
I_C = 0; V_{EB} = 6 V	I_{EBO}	<	5	mA
D.C. current gain				
I_C = 1 A; V_{CE} = 5 V	h_{FE}		15 to 80	
Saturation voltages				
I_C = 2.5 A; I_B = 0.25 A	$V_{CE\,sat}$	<	10	V
	$V_{BE\,sat}$	<	1.5	V
Collector-emitter sustaining voltage				
I_B = 0; I_C = 100 mA; L = 25 mH	$V_{CEO\,sust}$	>	250	V



Oscilloscope display for $V_{CEO\,sust}$

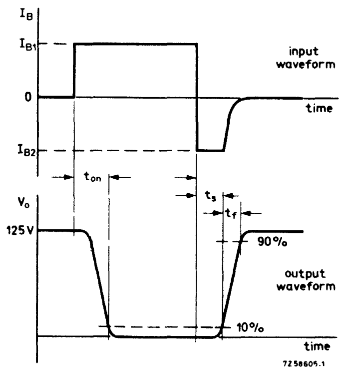


Test circuit for $V_{CEO\,sust}$

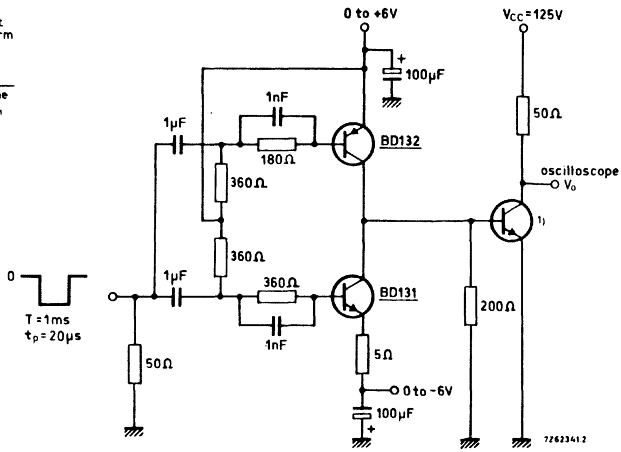
1) Measured with a half sine wave voltage (curve tracer).

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

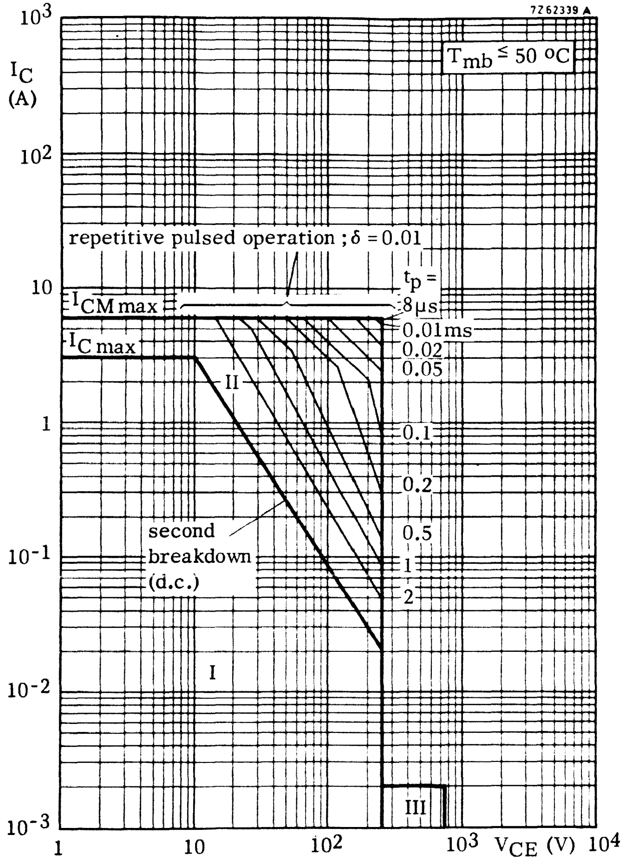
Transition frequency at f = 1MHz				
I_C = 0.2 A; V_{CE} = 10 V	f_T	typ.	8	MHz
Collector capacitance at f = 1 MHz				
I_E = I_e = 0; V_{CB} = 10 V	C_c	typ.	85	pF
Emitter capacitance at f = 1 kHz				
I_C = I_c = 0; V_{EB} = 2 V	C_e	typ.	1.4	nF
Switching times				
I_C = 2.5 A; I_{B1} = $-I_{B2}$ = 0.5 A; V_{CC} = 125 V				
turn-off storage time	t_s	typ.	2	μs
turn-off fall time	t_f	typ.	0.5	μs
turn-off fall time, T_{mb} = 95 °C	t_f	<	2	μs



Test circuit



1) Transistor BU133 under test.

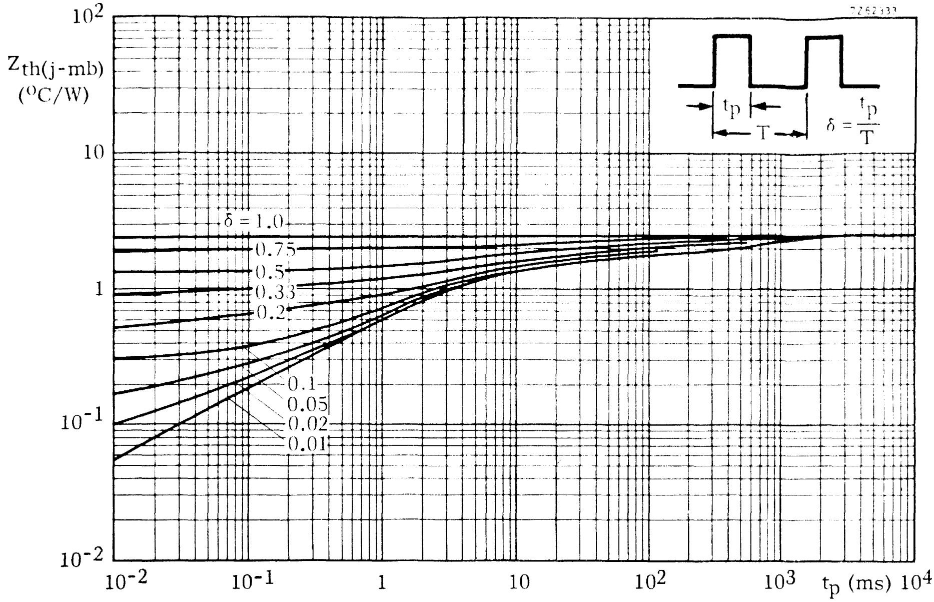


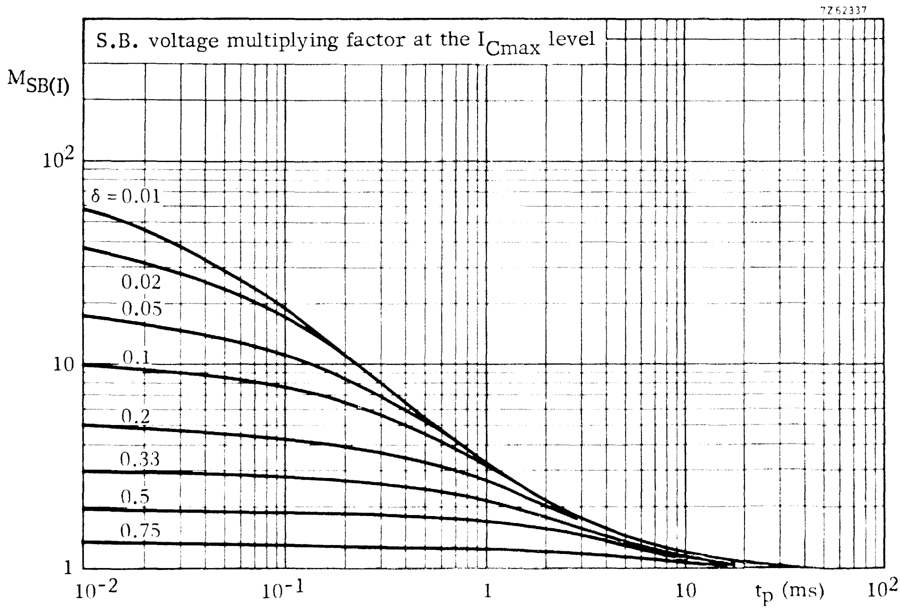
Safe Operating Area (Regions I and II forward biased)

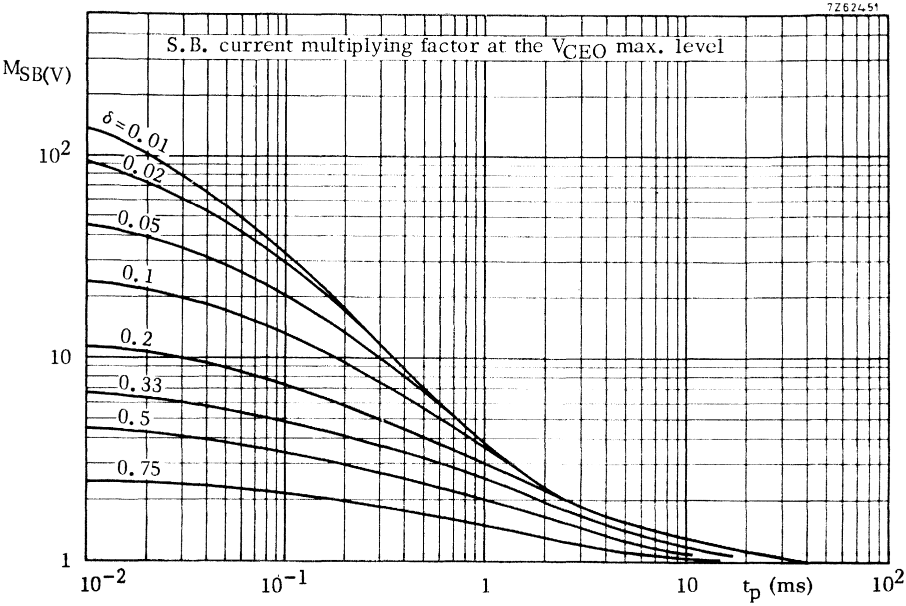
I Region of permissible d.c. operation

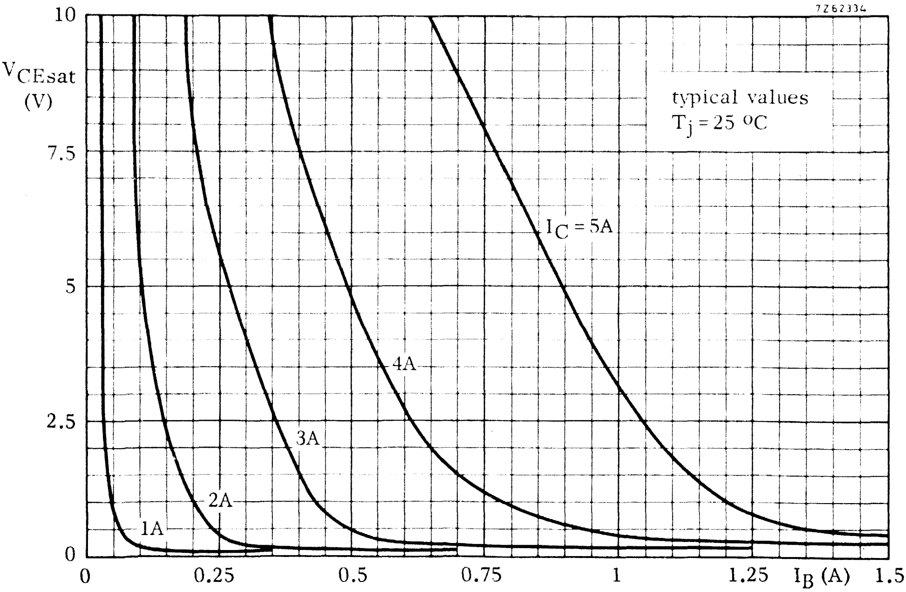
II Permissible extension for repetiive pulsed operation

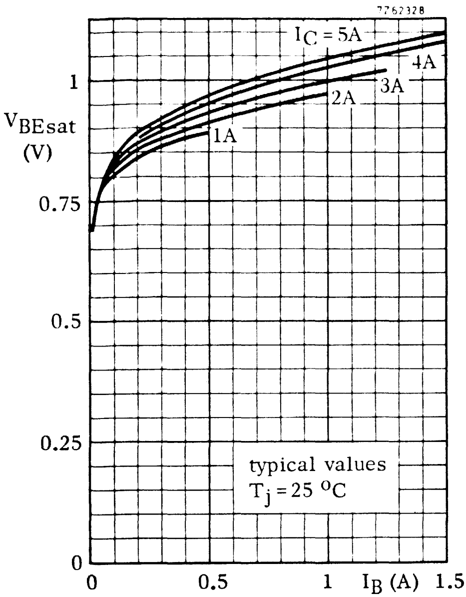
III Repetitive pulsed operation in this region is allowable, provided $V_{BE} \leq 0$ V and $t_p \leq 2$ ms

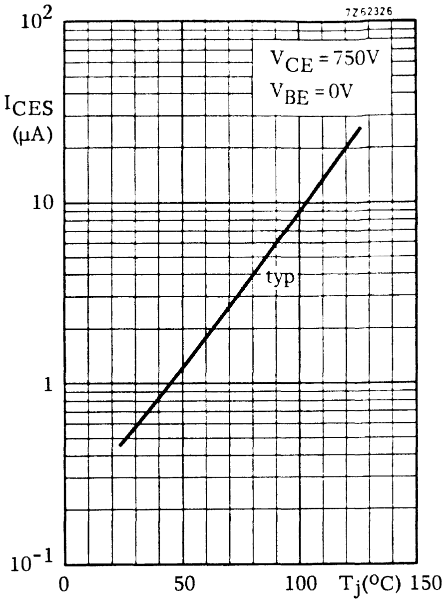

7Z62333
$Z_{th(j-mb)}$ ($^oC/W$)
10^2
10
1
10^{-1}
10^{-2}
t_p
T
$\delta = \frac{t_p}{T}$
δ = 1.0
0.75
0.5
0.33
0.2
0.1
0.05
0.02
0.01
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (ms) 10^4

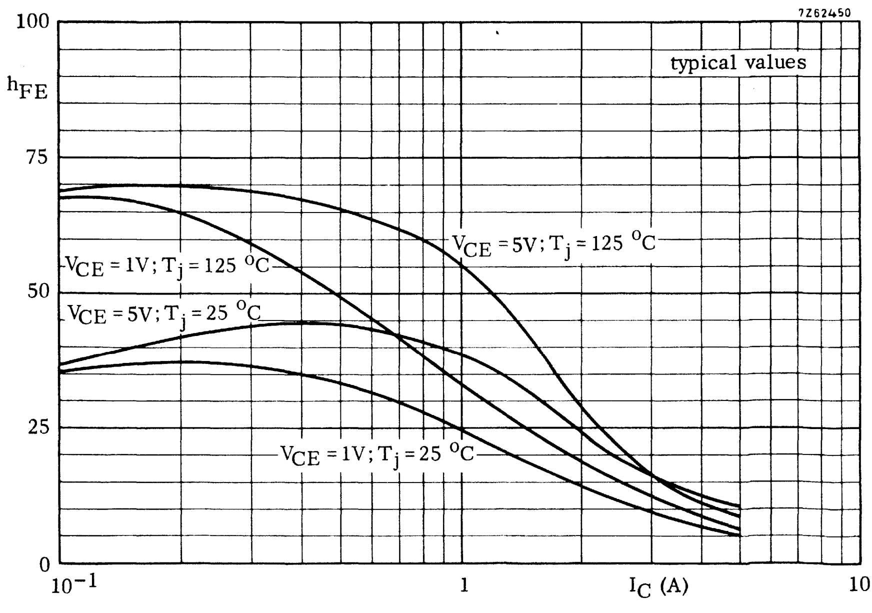

7Z62337
S.B. voltage multiplying factor at the I_{Cmax} level
$M_{SB(I)}$
10^2
10
1
δ = 0.01
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^{-2}
10^{-1}
1
10
t_p (ms)
10^2

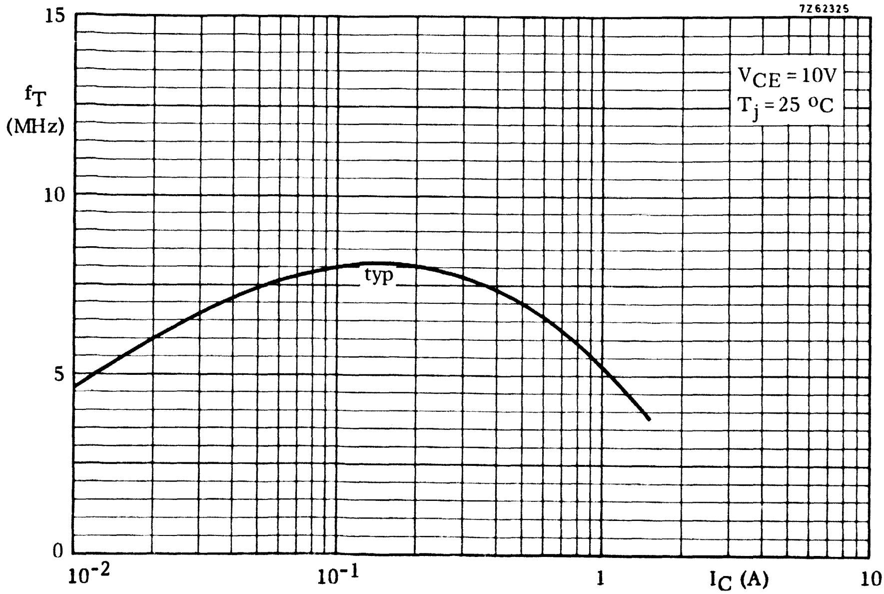

7Z62451
S.B. current multiplying factor at the VCEO max. level
MSB(V)
10^2
10
1
δ = 0.01
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^-2
10^-1
1
10
tp (ms)
10^2


7Z62334
10
VCEsat
(V)
7.5
5
2.5
0
typical values
Tj = 25 °C
IC = 5A
4A
3A
2A
1A
0
0.25
0.5
0.75
1
1.25
IB (A)
1.5


7Z62328
$I_C = 5A$
4A
3A
2A
1A
V_{BEsat}
(V)
1
0.75
0.5
0.25
0
typical values
$T_j = 25\ ^oC$
0
0.5
1
I_B (A)
1.5


7Z62326
10^2
$V_{CE} = 750V$
$V_{BE} = 0V$
I_{CES}
(μA)
10
typ
1
10^{-1}
0
50
100
$T_j (^oC)$
150


7Z62450
100
typical values
h_{FE}
75
$V_{CE} = 5V; T_j = 125\ ^oC$
$V_{CE} = 1V; T_j = 125\ ^oC$
50
$V_{CE} = 5V; T_j = 25\ ^oC$
25
$V_{CE} = 1V; T_j = 25\ ^oC$
0
10^{-1}
1
I_C (A)
10


7Z62325
15
10
5
0
f_T
(MHz)
V_{CE} = 10V
T_j = 25 °C
typ
10^{-2}
10^{-1}
1
I_C (A)
10

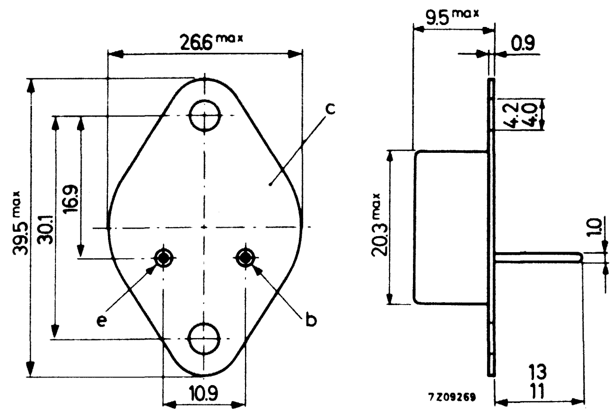
SILICON DIFFUSED POWER TRANSISTOR

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}	<	0.7	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	

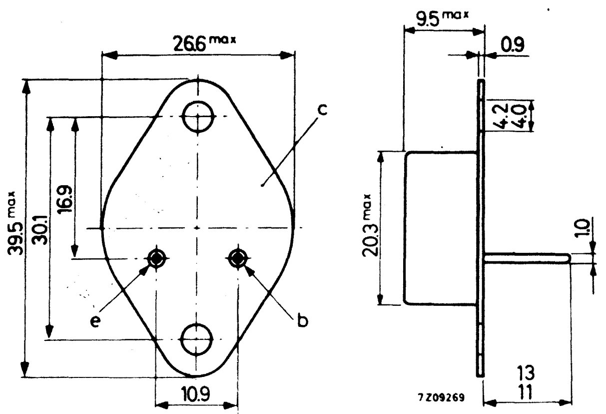
SILICON DIFFUSED POWER TRANSISTORS

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

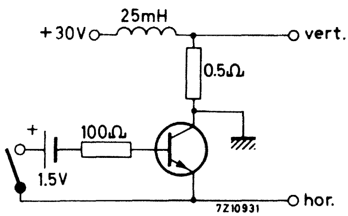
THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	1.5	1.75	°C/W
From mounting base to heatsink	$R_{th\ mb-h}$	=	0.5	0.5	°C/W
From mounting base to heatsink with accessory 56201e	$R_{th\ mb-h}$	=	0.75	0.75	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off currents			2N3442	2N4347	
$I_E = 0$; $V_{CB} = 140$ 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; $R_{BE} = 100\ \Omega$	$V_{(BR)CER}$	>	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



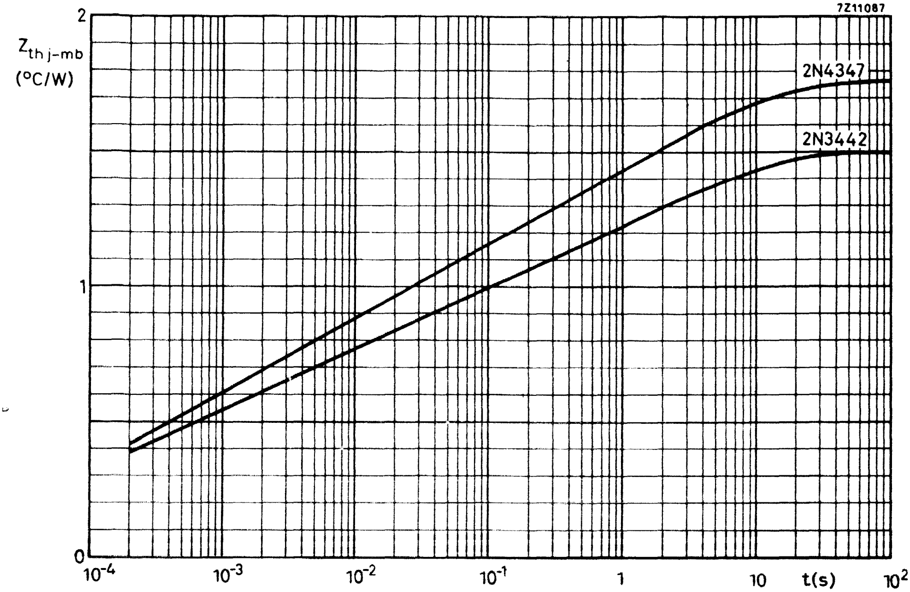
Base-emitter voltage [1]			2N3442	2N4347	
$I_C = 2$ A; $V_{CE} = 4$ V	V_{BE}	typ.		0.95	V
		<		2.0	V
$I_C = 3$ A; $V_{CE} = 4$ V	V_{BE}	typ.	1.15		V
		<	1.7		V
$I_C = 5$ A; $V_{CE} = 4$ V	V_{BE}	typ.		1.55	V
		<		4.0	V
$I_C = 10$ A; $V_{CE} = 4$ V	V_{BE}	typ.	2.8		V
		<	5.7		V

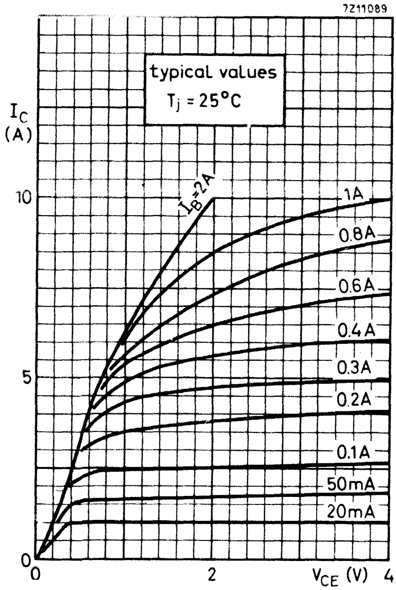
[1] $t_p = 10$ ms

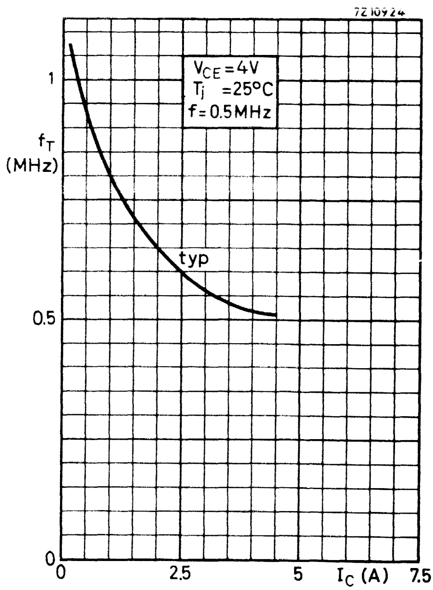
CHARACTERISTICS (continued) — $T_j = 25\,^{o}C$ unless otherwise specified

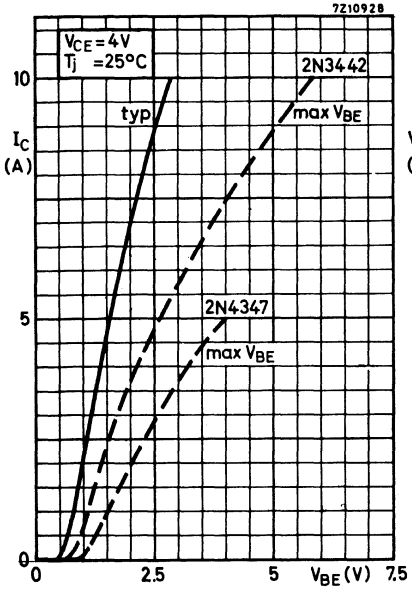
			2N3442	2N4347	
Saturation voltages [1]					
I_C = 2 A; I_B = 0.2 A	V_{CEsat}	<		1	V
I_C = 3 A; I_B = 0.3 A	V_{CEsat}	<	1		V
I_C = 5 A; I_B = 1.0 A	V_{CEsat}	<		5	V
I_C = 10 A; I_B = 2.0 A	V_{CEsat}	<	5		V
D.C. current gain [1]					
I_C = 2 A; V_{CE} = 4 V	h_{FE}	typ.		35	
				20 to 70	
I_C = 3 A; V_{CE} = 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		

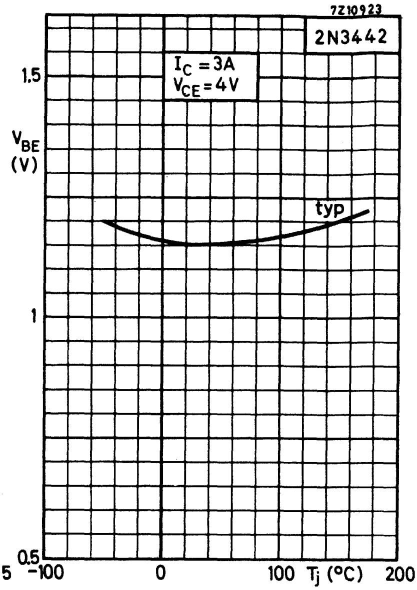
[1]) t_p = 10 ms

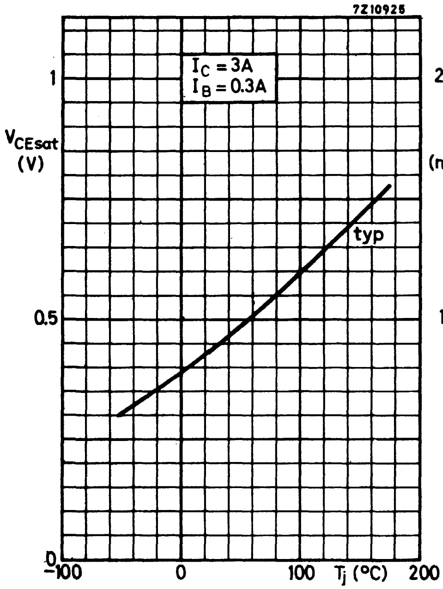

7Z11087
$Z_{th\,j-mb}$ (°C/W)
2
1
0
2N4347
2N3442
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
t(s)
10^{2}

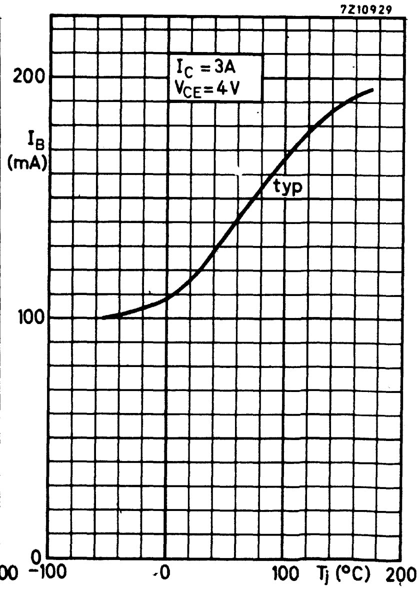

7Z11089
typical values
T_j = 25°C
I_C (A)
10
5
0
I_B=2A
1A
0.8A
0.6A
0.4A
0.3A
0.2A
0.1A
50mA
20mA
0
2
V_{CE} (V)
4

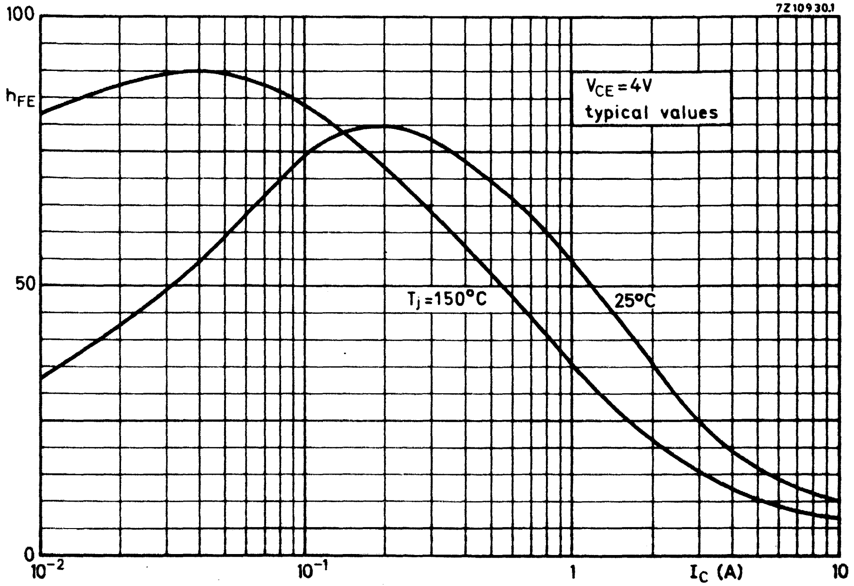

7Z10924
V_{CE} = 4V
T_j = 25°C
f = 0.5MHz
f_T (MHz)
1
0.5
0
typ
0
2.5
5
I_C (A)
7.5

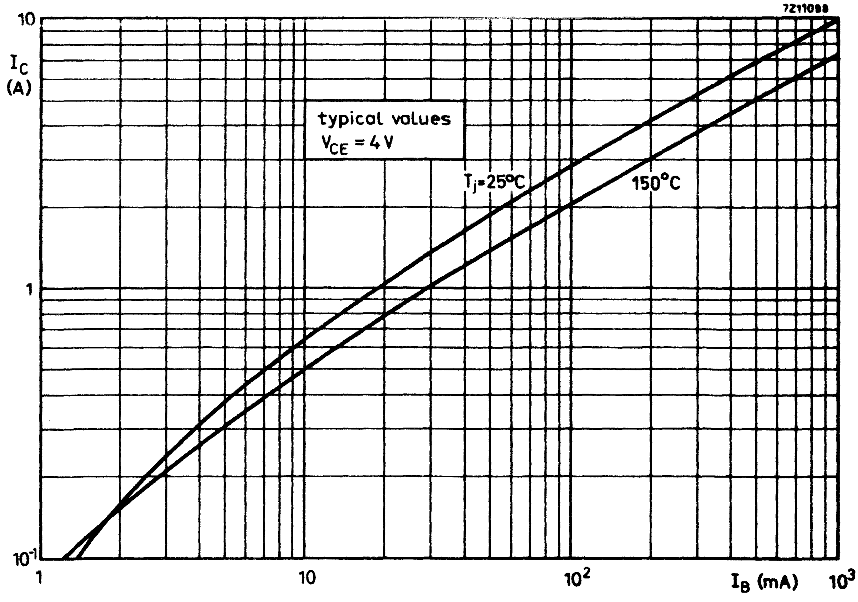

7Z10928
VCE = 4V
Tj = 25°C
IC (A)
typ
2N3442
max VBE
2N4347
max VBE
VBE (V)
0
2.5
5
7.5
10

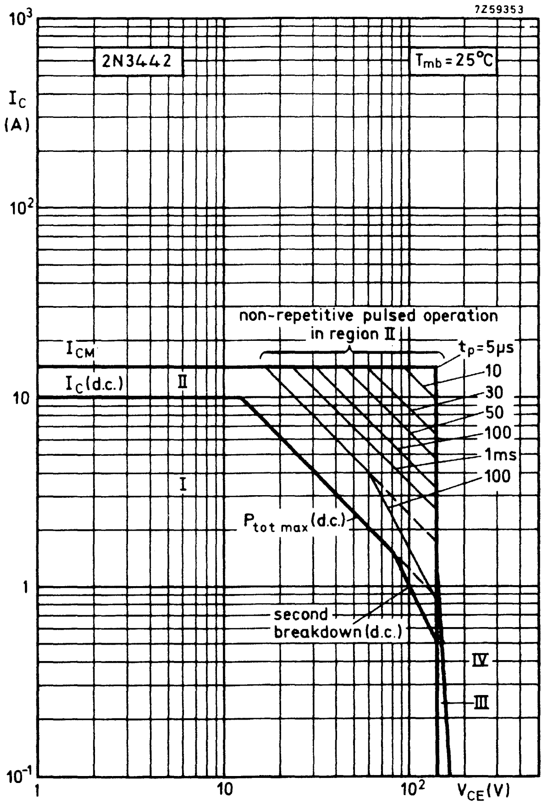

7Z10923
2N3442
IC = 3A
VCE = 4V
VBE (V)
typ
1.5
1
0.5
−100
0
100
Tj (°C)
200


7Z10925
IC = 3A
IB = 0.3A
VCEsat (V)
typ
1
0.5
0
−100
0
100
Tj (°C)
200


7Z10929
IC = 3A
VCE = 4V
IB (mA)
typ
200
100
0
−100
0
100
Tj (°C)
200


7Z10930.1
100
h_{FE}
50
0
10^{-2}
10^{-1}
1
I_C (A)
10
V_{CE} = 4V
typical values
T_j = 150°C
25°C


7Z11088
10
I_C
(A)
1
10^{-1}
1
10
10^2
I_B (mA)
10^3
typical values
V_{CE} = 4 V
T_j = 25°C
150°C

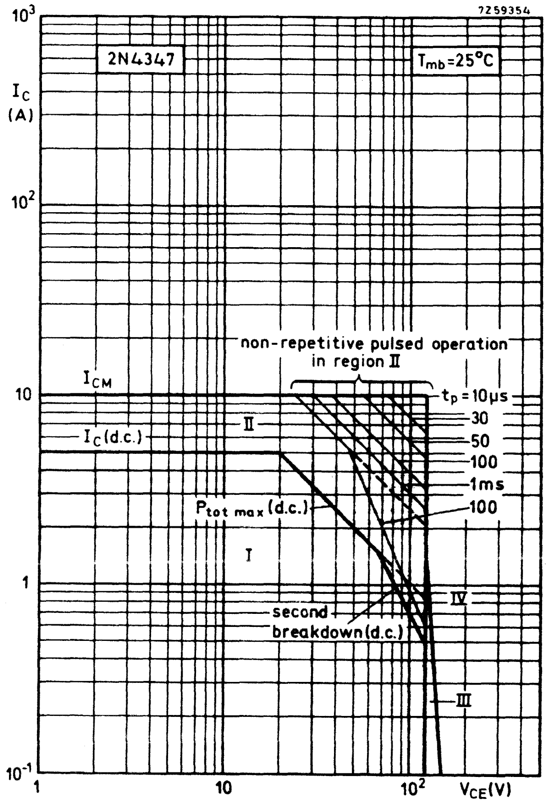


I Region of permissible operation under all base-emitter conditions and at all frequencies, including d.c.

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.

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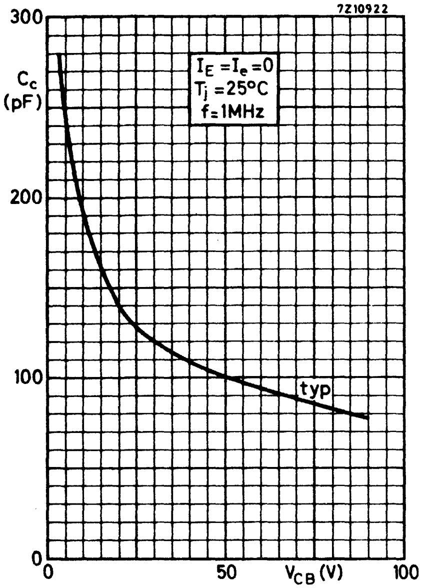
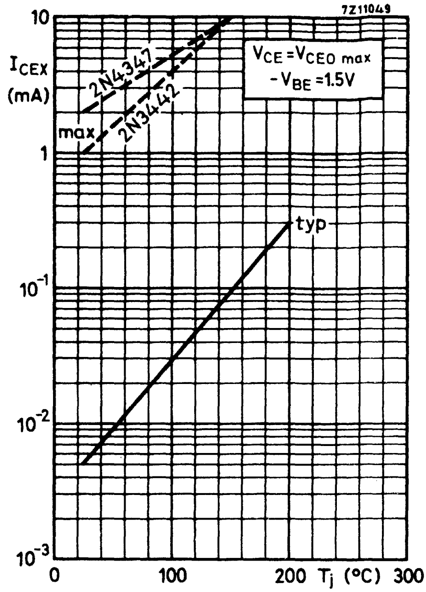
III Operation during switching off in this region is allowed, provided the transistor is cut-off with $-V_{BE} \leq 1.5$ V; $I_{CM} < 1.5$ A.

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.


7Z10922
$I_E = I_e = 0$
$T_j = 25^\circ C$
f = 1MHz
C_c (pF)
300
200
100
0
typ
0
50
V_{CB} (V)
100


7Z11049
$V_{CE} = V_{CEO\,max}$
$-V_{BE} = 1.5V$
I_{CEX} (mA)
10
1
10^{-1}
10^{-2}
10^{-3}
max
2N4347
2N3442
typ
0
100
200
T_j (°C)
300

SILICON POWER TRANSISTORS

N-P-N transistors in a TO-3 metal envelope, intended for untuned amplifier applications.

QUICK REFERENCE DATA

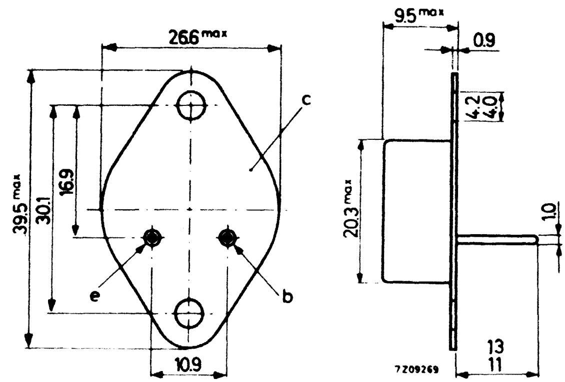
			2N3771	2N3772	
Collector-base voltage (open emitter)	V_{CBO}	max.	50	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	V
Collector current (d.c.)	I_C	max.	30	20	A
Total power dissipation up to T_{mb} = 25 ^oC	P_{tot}	max.	150	150	W
Junction temperature	T_j	max.	200	200	^oC
D.C. current gain					
I_C = 15 A; V_{CE} = 4 V	h_{FE}		15 to 60	-	
I_C = 10 A; V_{CE} = 4 V	h_{FE}		-	15 to 60	

MECHANICAL DATA

Dimensions in mm

Collector connected to envelope

TO-3



Accessories available : 56201e

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

			2N3771	2N3772	
Voltages					
Collector-base voltage (open emitter)	V_{CBO}	max.	50	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	V
Collector-emitter voltage ($-V_{BE} = 1.5$ V)	V_{CEX}	max.	50	90	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	7	V
Currents					
Collector current (d.c.)	I_C	max.	30	20	A
Collector current (peak value)	I_{CM}	max.	30	30	A
Base current (d.c.)	I_B	max.	7.5	5	A
Base current (peak value)	I_{BM}	max.	15	15	A
Power dissipation					
Total power dissipation up to $T_{mb} = 25\,^oC$	P_{tot}	max.	150	150	W
Temperatures					
Storage temperature	T_{stg}		−65 to +200	−65 to +200	^oC
Junction temperature	T_j	max.	200	200	^oC

THERMAL RESISTANCE

			2N3771	2N3772	
From junction to mounting base	$R_{th\ j-mb}$	=	1.17	1.17	$^oC/W$
From mounting base to heatsink with mica washer and lead washer (56201e)	$R_{th\ j-mb}$		0.75	0.75	$^oC/W$
with lead washer only	$R_{th\ mb-h}$		0.5	0.5	$^oC/W$

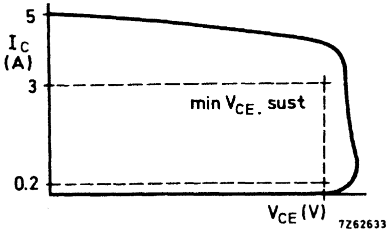
CHARACTERISTICS T_j = 25 °C unless otherwise specified

			2N3771	2N3772	
Collector cut-off current					
$I_E = 0$; $V_{CB} = 50$ V	I_{CBO}	<	2	–	mA
$I_E = 0$; $V_{CB} = 100$ V	I_{CBO}	<	–	5	mA
$I_E = 0$; $V_{CB} = 30$ V; $T_{mb} = 150$ °C	I_{CBO}	<	10	10	mA
$I_B = 0$; $V_{CE} = 30$ V	I_{CEO}	<	10	–	mA
$I_B = 0$; $V_{CE} = 50$ V	I_{CEO}	<	–	10	mA
$-V_{BE} = 1.5$ V; $V_{CE} = 50$ V	I_{CEX}	<	2	–	mA
$-V_{BE} = 1.5$ V; $V_{CE} = 30$ V; $T_{mb} = 150$ °C	I_{CEX}	<	10	–	mA
$-V_{BE} = 1.5$ V; $V_{CE} = 90$ V	I_{CEX}	<	–	5	mA
$-V_{BE} = 1.5$ V; $V_{CE} = 30$ V; $T_{mb} = 150$ °C	I_{CEX}	<	–	10	mA
Emitter cut-off current					
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	5	–	mA
$I_C = 0$; $V_{EB} = 7$ V	I_{EBO}	<	–	5	mA
D.C. current gain 1)					
$I_C = 15$ A; $V_{CE} = 4$ V	h_{FE}		15 to 60		
$I_C = 10$ A; $V_{CE} = 4$ V	h_{FE}			15 to 60	←
Base-emitter voltage 1)					
$I_C = 15$ A; $V_{CE} = 4$ V	V_{BE}	<	2.7	–	V
$I_C = 10$ A; $V_{CE} = 4$ V	V_{BE}	<	–	2.2	V
Saturation voltage 1)					
$I_C = 15$ A; $I_B = 1.5$ A	V_{CEsat}	<	2.0	–	V
$I_C = 10$ A; $I_B = 1.0$ A	V_{CEsat}	<	–	1.4	V
Collector-emitter sustaining voltage					
$I_C = 0.2$ A; $I_B = 0$	$V_{CEOsust}$	>	40	60	V
$I_C = 0.2$ A; $-V_{BE} = 1.5$ V	$V_{CEXsust}$	>	50	80	V
$I_C = 3$ A; $-V_{BE} = 1.5$ V	$V_{CEXsust}$	>	50	90	V ←
$I_C = 0.2$ A; $R_{BE} = 100\ \Omega$	$V_{CERsust}$	>	45	70	V

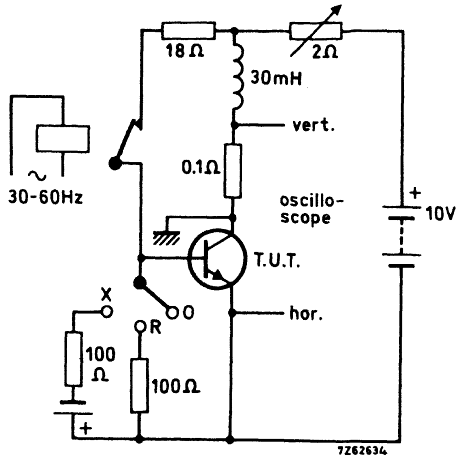
For test circuit and oscilloscope display see next page.

1) Measured with pulses of 300 μs at 60 Hz.

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



Oscilloscope display for sustaining voltages.



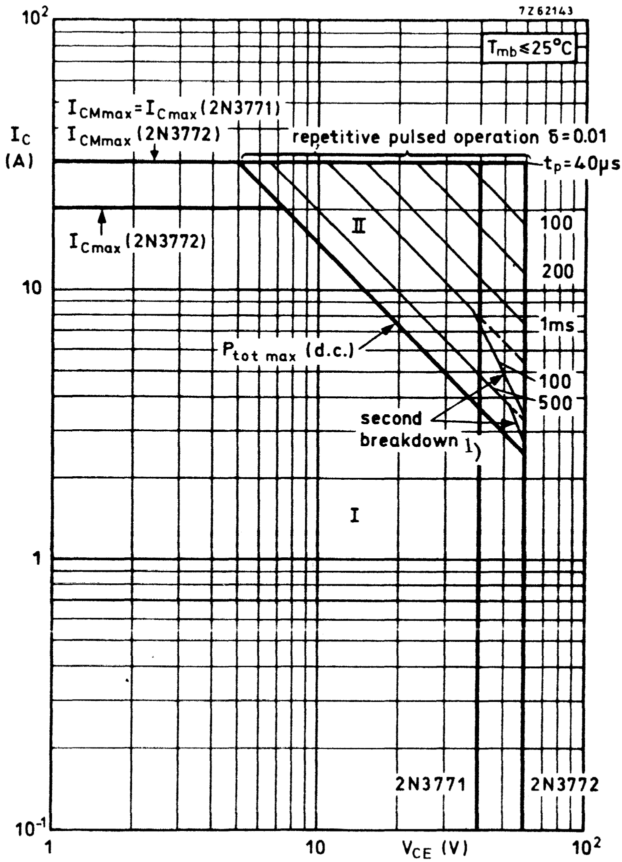
Test circuit for sustaining voltages.

→ Transition frequency at f = 500 kHz

I_C = 1 A; V_{CE} = 4 V	f_T	>	800	kHz
		typ.	1250	kHz

Small signal current gain at f = 1 kHz

I_C = 1 A; V_{CE} = 4 V	h_{fe}	typ.	110

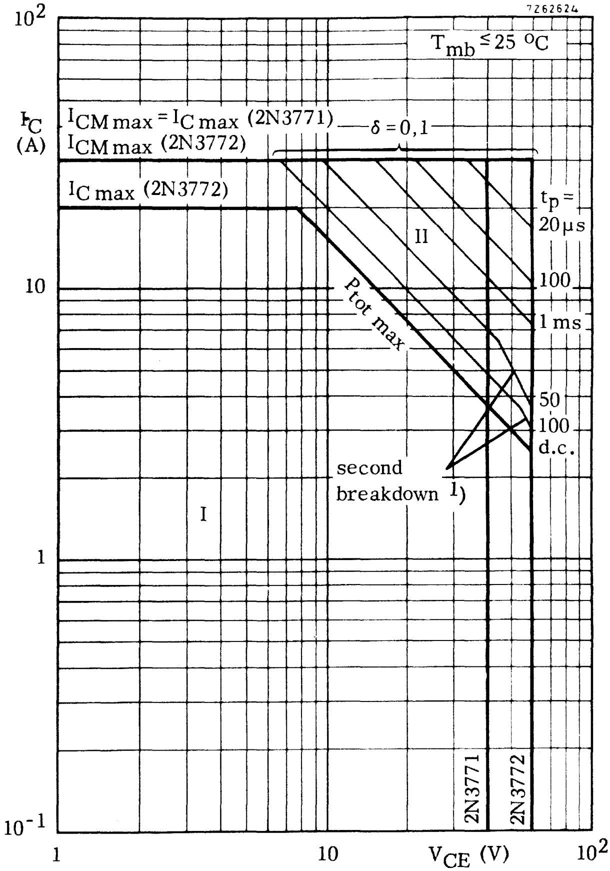


Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

1) Independent of temperature

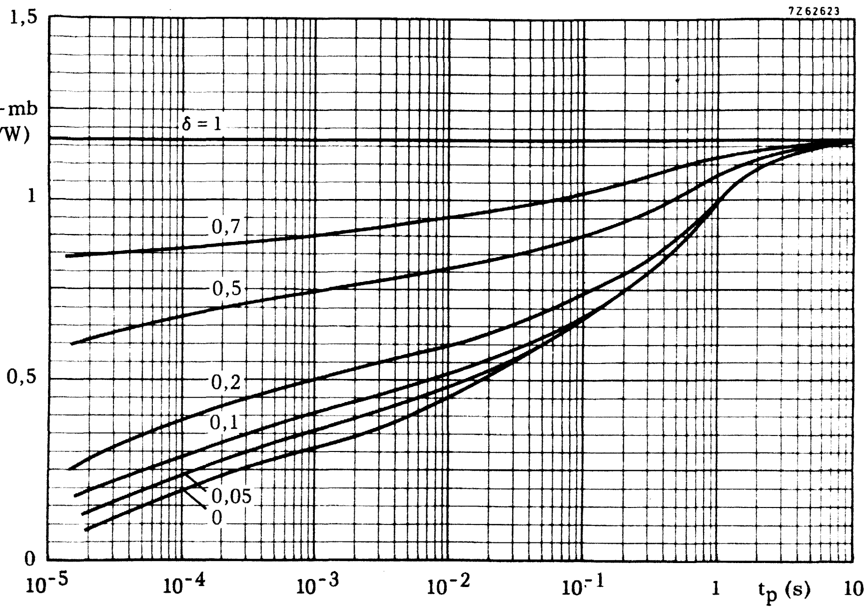


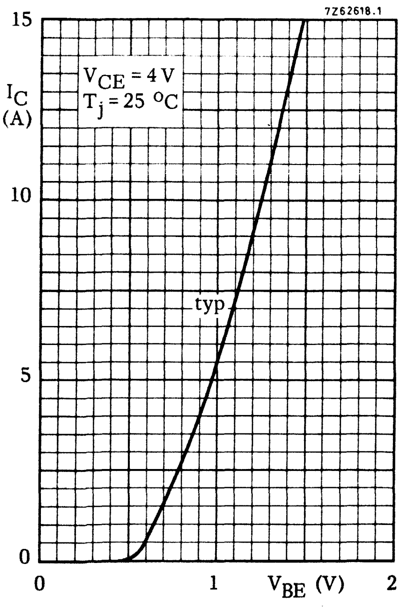
Safe Operation Area with the transistor forward biased

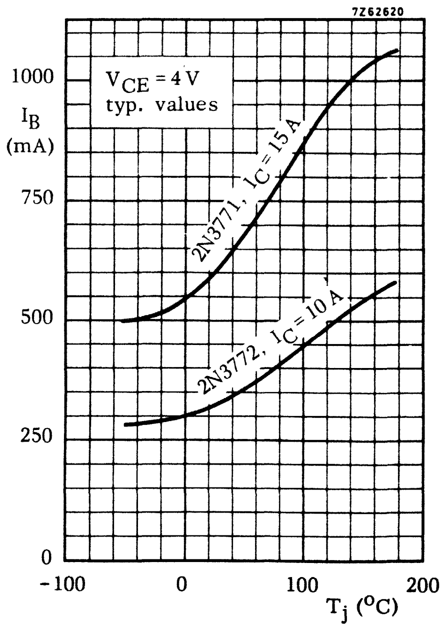
I Region of permissible d.c. operation

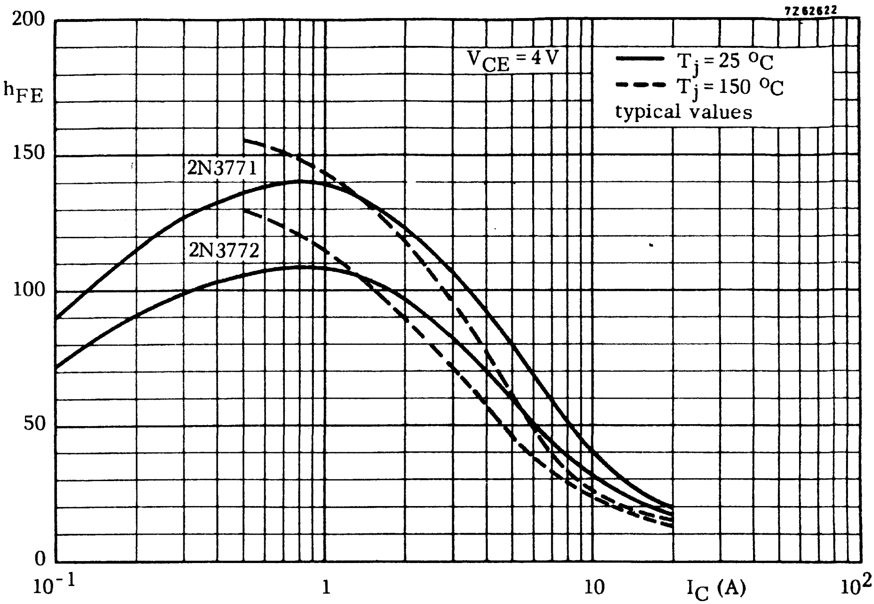
II Permissible extension for repetitive pulse operation

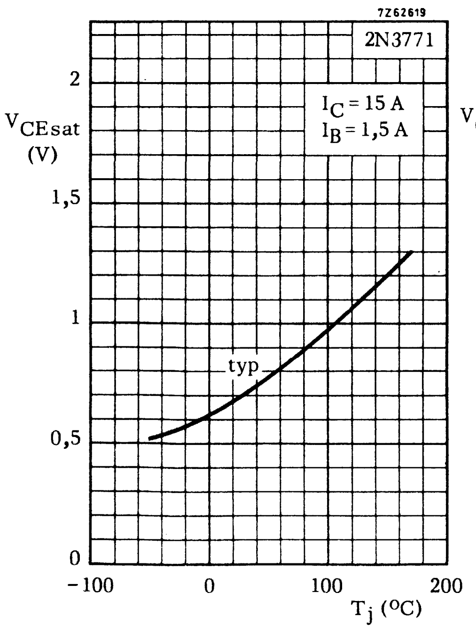
1) Independent of temperature

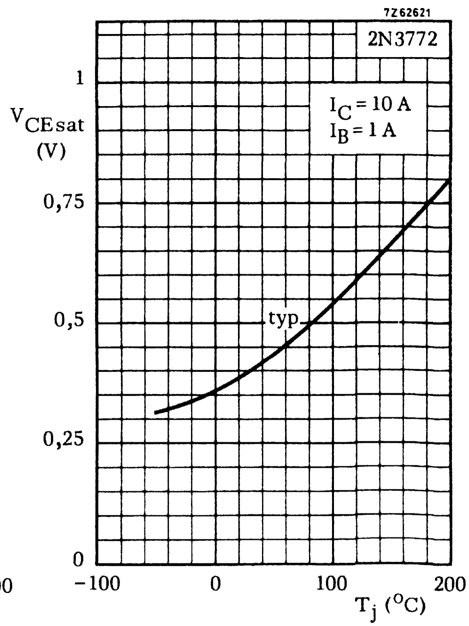

7Z62623
1,5
Zth j-mb
(°C/W)
δ = 1
1
0,7
0,5
0,5
0,2
0,1
0,05
0
0
10-5
10-4
10-3
10-2
10-1
1
tp (s)
10


7Z62618.1
15
IC
(A)
VCE = 4 V
Tj = 25 °C
10
typ
5
0
0
1
VBE (V)
2


7Z62620
1000
IB
(mA)
VCE = 4 V
typ. values
750
2N3771, IC = 15 A
500
2N3772, IC = 10 A
250
0
-100
0
100
200
Tj (°C)


7Z62622
200
150
100
50
0
h_{FE}
$V_{CE} = 4\,V$
$T_j = 25\ ^oC$
$T_j = 150\ ^oC$
typical values
2N3771
2N3772
10^{-1}
1
10
I_C (A)
10^2


7Z62619
2N3771
$I_C = 15\,A$
$I_B = 1,5\,A$
V_{CEsat}
(V)
2
1,5
1
0,5
0
typ
−100
0
100
200
T_j (^oC)


7Z62621
2N3772
$I_C = 10\,A$
$I_B = 1\,A$
V_{CEsat}
(V)
1
0,75
0,5
0,25
0
typ
−100
0
100
200
T_j (^oC)

Deflection transistors

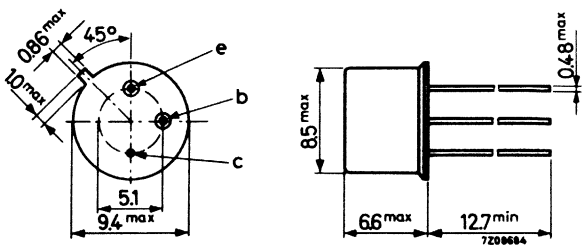
SILICON PLANAR TRANSISTOR

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	$R_{th\ j\text{-}a}$	=	200	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	20	°C/W [2])
From junction to case	$R_{th\ j\text{-}c}$	=	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

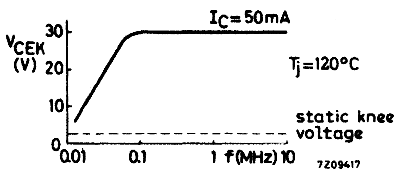
Base-emitter voltage [1])

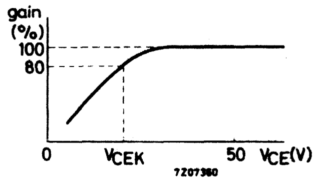
$I_C = 50$ mA; $V_{CE} = 20$ V	V_{BE}	<	1.3	V

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

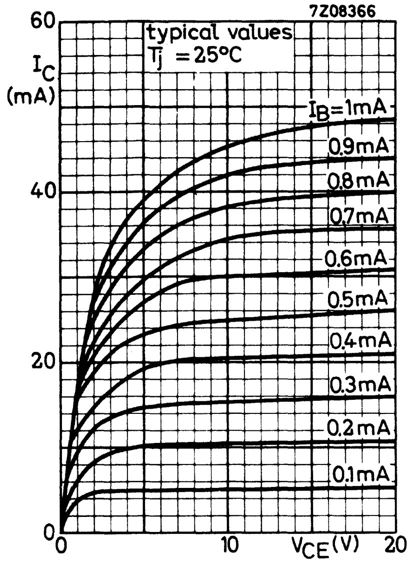
Collector capacitance at f = 1 MHz

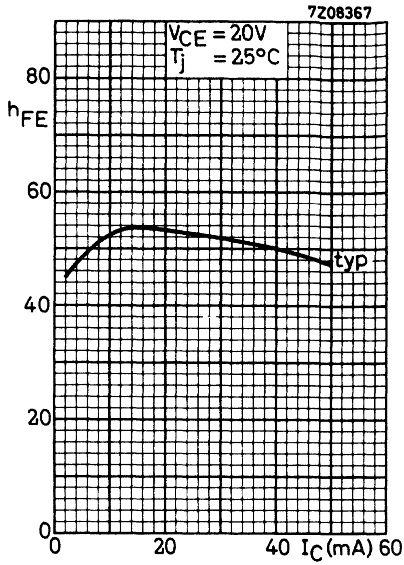
$I_E = I_e = 0$; $V_{CB} = 20$ V	C_c	<	6	pF

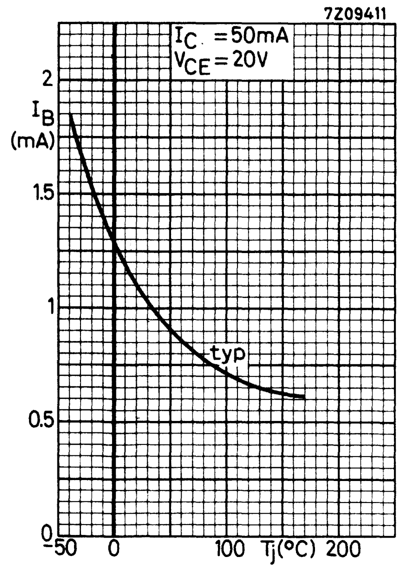
Transition frequency at f = 100 MHz

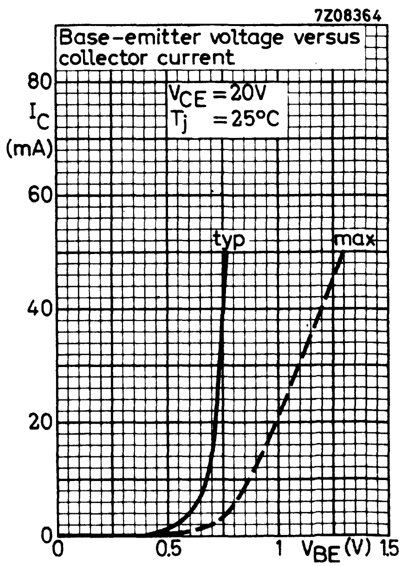
$I_C = 10$ mA; $V_{CE} = 10$ V	f_T	>	80	MHz
		typ.	120	MHz

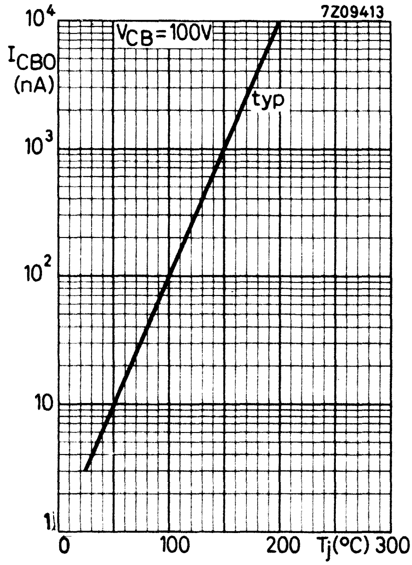
[1]) V_{BE} decreases by about 1.6 mV/°C with increasing temperature.

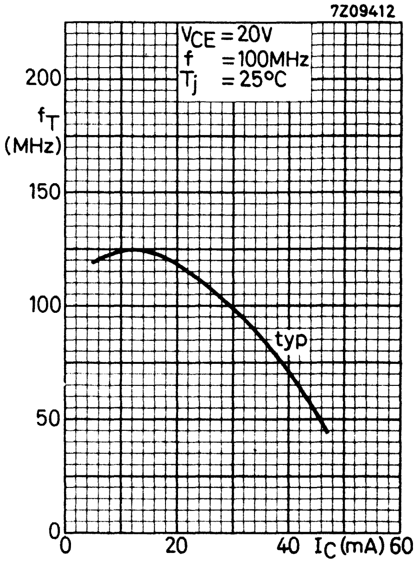

7Z08366
typical values
Tj = 25°C
IC (mA)
IB=1mA
0.9mA
0.8mA
0.7mA
0.6mA
0.5mA
0.4mA
0.3mA
0.2mA
0.1mA
60
40
20
0
0
10
VCE (V)
20

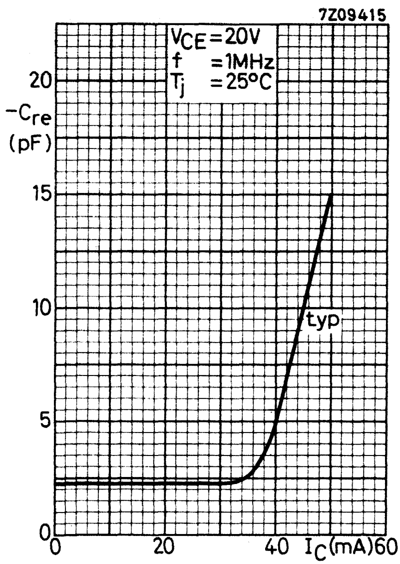

7Z08367
VCE = 20V
Tj = 25°C
hFE
typ
80
60
40
20
0
0
20
40
IC (mA)
60

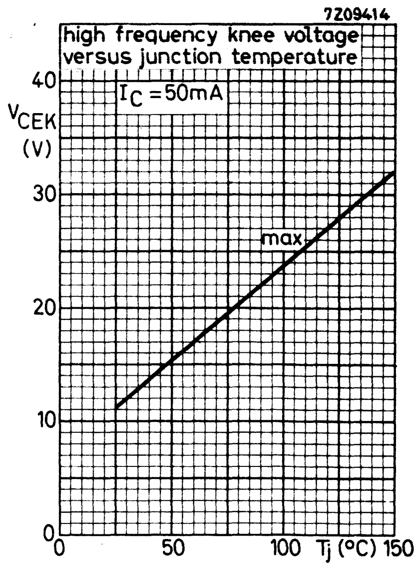

7Z09411
IC = 50mA
VCE = 20V
IB (mA)
typ
2
1.5
1
0.5
0
-50
0
100
Tj (°C)
200

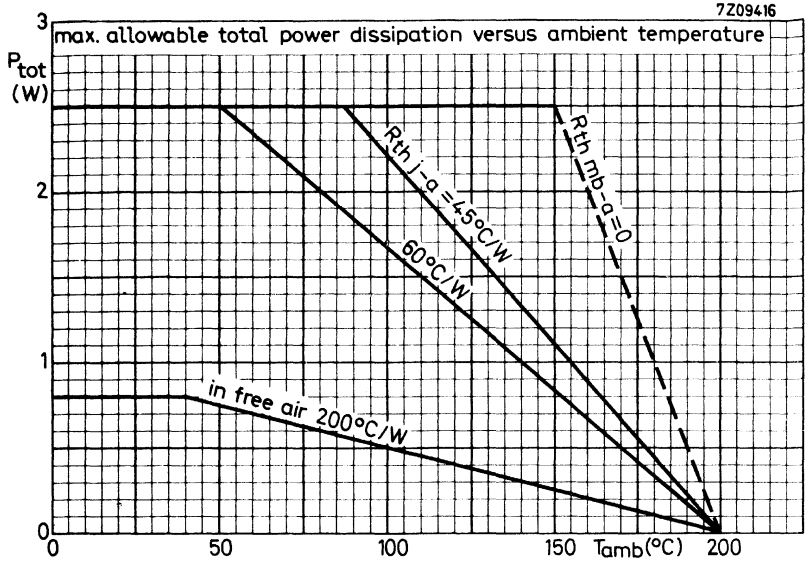

7Z08364
Base-emitter voltage versus
collector current
VCE = 20V
Tj = 25°C
IC (mA)
typ
max
80
60
40
20
0
0
0.5
1
VBE (V)
1.5

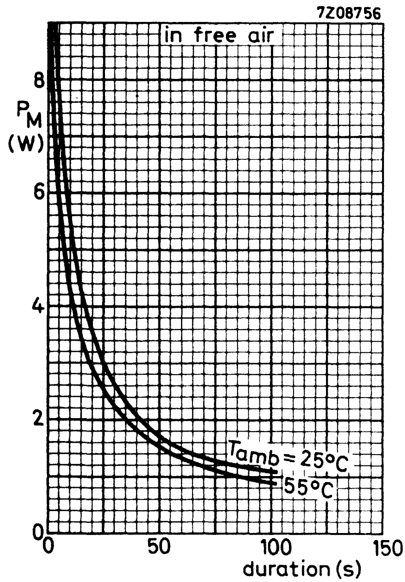

7Z09413
V_{CB} = 100V
I_{CBO} (nA)
10^4
10^3
10^2
10
1
typ
0
100
200
T_j(°C) 300

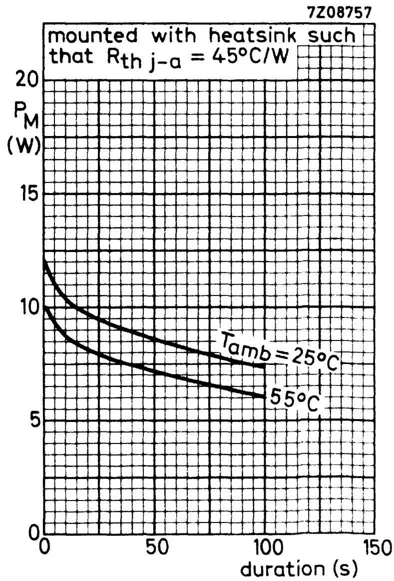

7Z09412
V_{CE} = 20V
f = 100MHz
T_j = 25°C
f_T (MHz)
200
150
100
50
0
typ
0
20
40
I_C (mA) 60


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



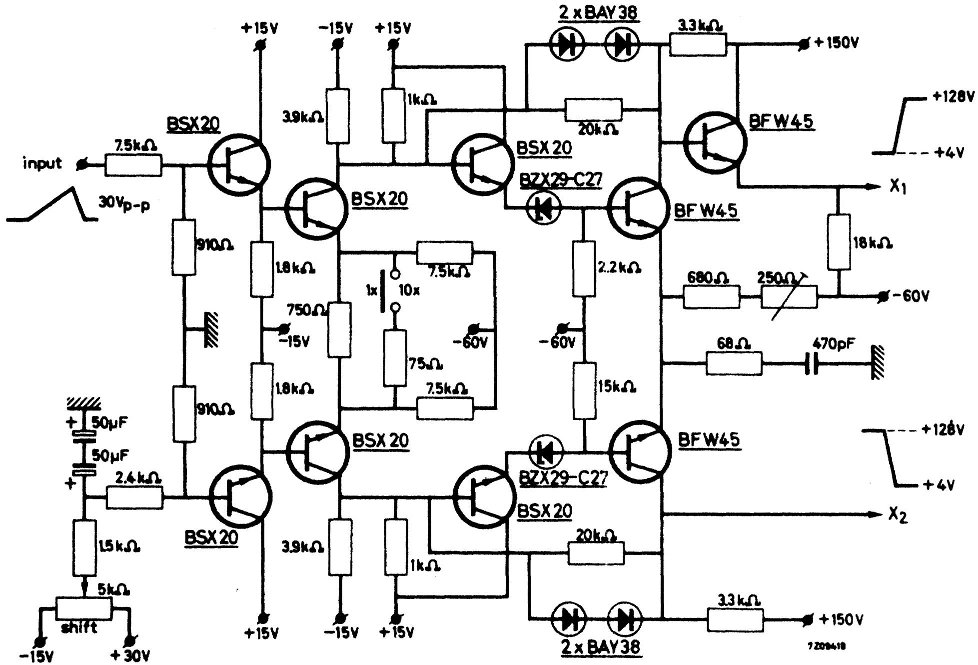




maximum allowable peak power dissipation versus duration

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

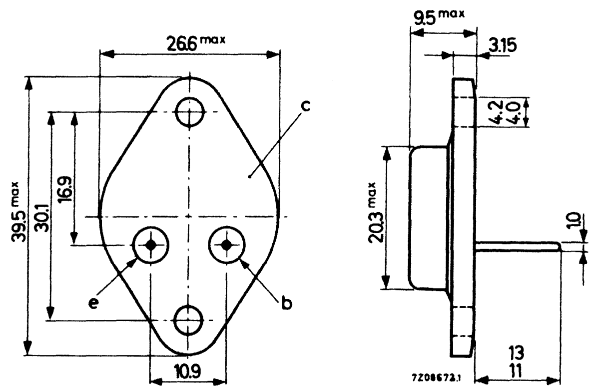
HIGH VOLTAGE SILICON POWER TRANSISTOR

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

FOR NEW DESIGN THE SUCCESSOR TYPES BU204 TO BU206 ARE RECOMMENDED

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 $T_{mb} = 90\ ^oC$	P_{tot}	max.	10	W

Temperatures

Storage temperature	T_{stg}		-65 to +115	^oC
Junction temperature	T_j	max.	115	^oC

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	2.5	$^oC/W$
From mounting base to heatsink with mica washer and lead washer (56201e)	$R_{th\ mb\text{-}h}$	0.75	$^oC/W$
with lead washer only	$R_{th\ mb\text{-}h}$	0.5	$^oC/W$

[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

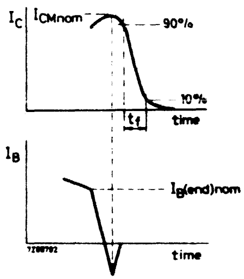
$I_C = 0.1$ A; $V_{CE} = 5$ V	f_T	typ.	7.5	MHz

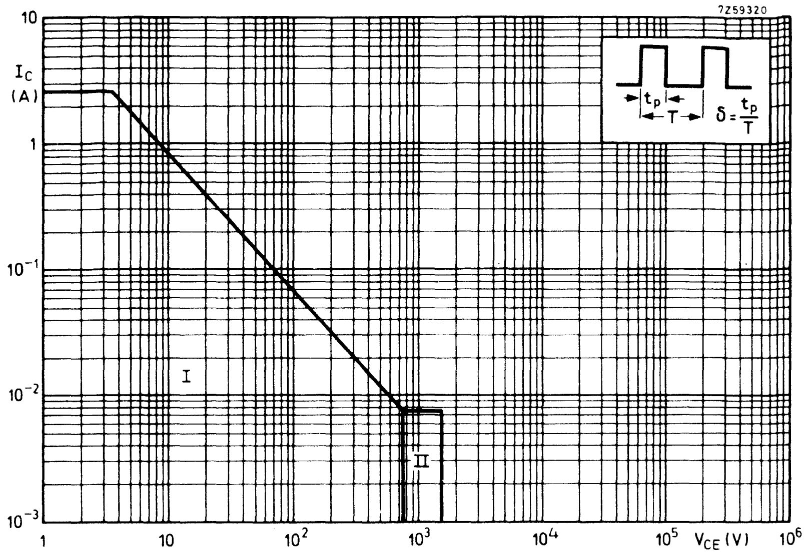
Collector capacitance at f = 1 MHz

$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	65	pF

Fall time (with stabilized power supply)

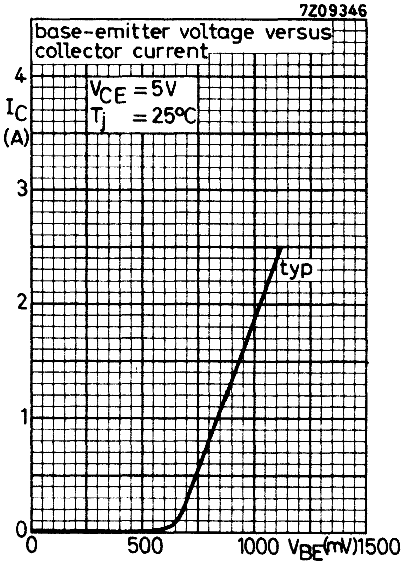
$I_{CMnom} = 2.0$ A; $I_{B(end)nom} = 1.5$ A; $L_B = 10$ μH	t_f	typ.	0.75	μs

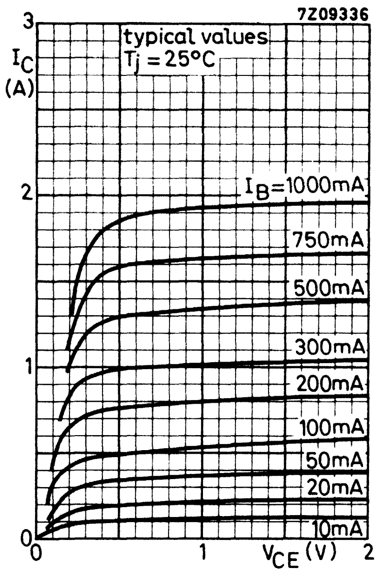


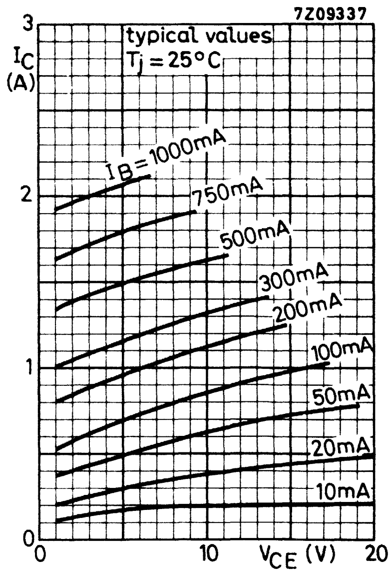


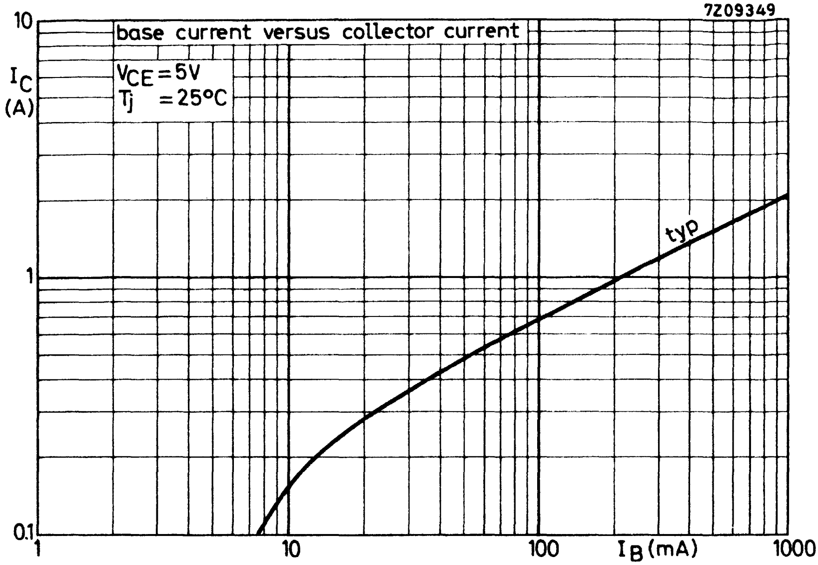
I Region of permissible operation under all base-emitter conditions.

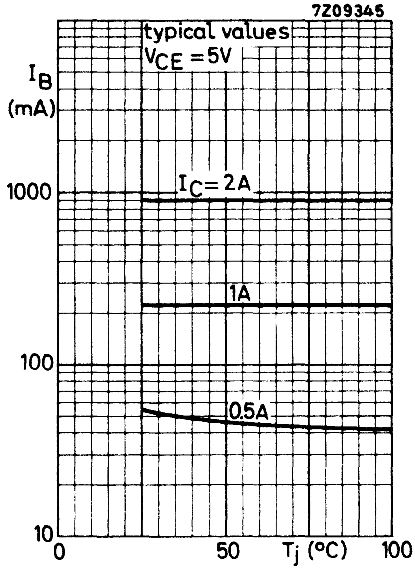
II Additional region of permissible operation for repetitive pulse conditions, provided $R_{BE} \leq 100\ \Omega$; $t_p \leq 20\ \mu s$; $\delta \leq 0.25$.

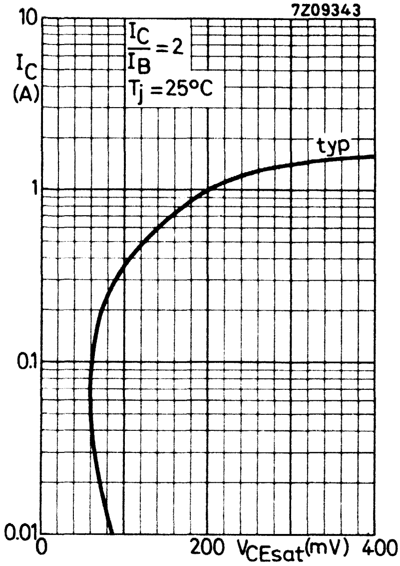

7Z09346
base-emitter voltage versus collector current
V_{CE} = 5V
T_j = 25°C
I_C (A)
typ
0
1
2
3
4
0
500
1000
V_{BE} (mV)
1500

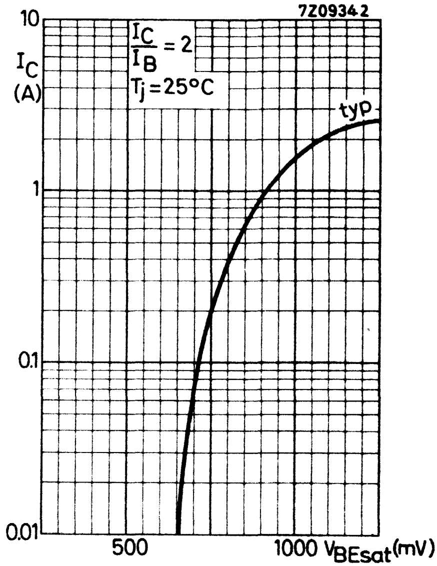

7Z09336
typical values
T_j = 25°C
I_C (A)
I_B=1000mA
750mA
500mA
300mA
200mA
100mA
50mA
20mA
10mA
0
1
2
3
0
1
V_{CE} (V)
2

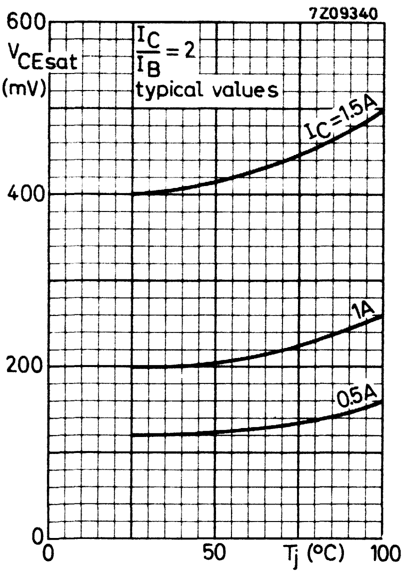

7Z09337
typical values
T_j = 25°C
I_C (A)
I_B=1000mA
750mA
500mA
300mA
200mA
100mA
50mA
20mA
10mA
0
1
2
3
0
10
V_{CE} (V)
20

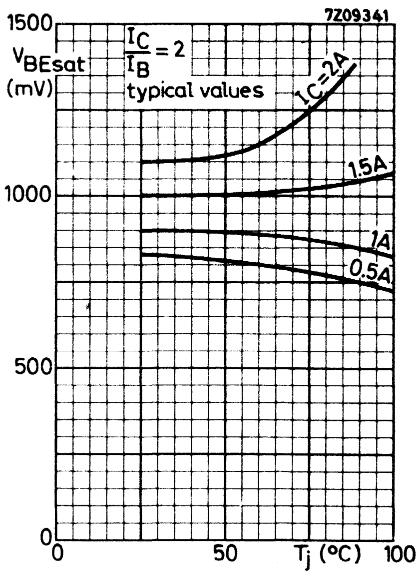

7Z09349
base current versus collector current
V_{CE} = 5V
T_j = 25°C
I_C
(A)
10
1
0.1
typ
1
10
100
I_B (mA)
1000

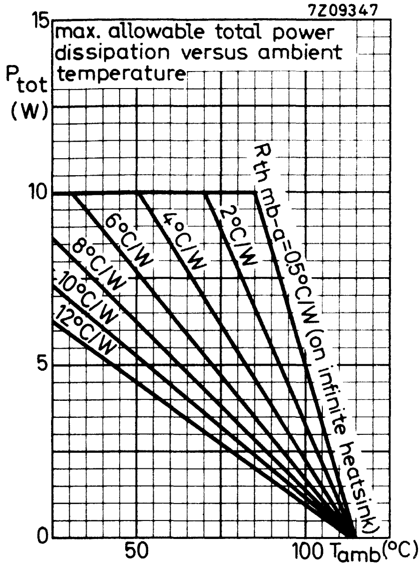

7Z09345
typical values
V_{CE} = 5V
I_B
(mA)
1000
100
10
I_C = 2A
1A
0.5A
0
50
T_j (°C)
100

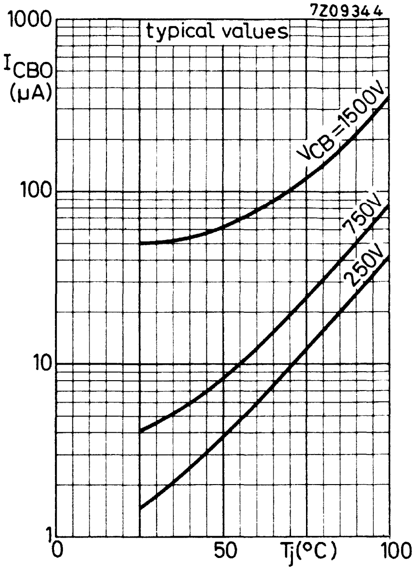

7Z09343
$\frac{I_C}{I_B} = 2$
$T_j = 25°C$
I_C (A)
typ
V_{CEsat} (mV)
10
1
0.1
0.01
0
200
400


7Z09342
$\frac{I_C}{I_B} = 2$
$T_j = 25°C$
I_C (A)
typ
V_{BEsat} (mV)
10
1
0.1
0.01
500
1000


7Z09340
$\frac{I_C}{I_B} = 2$
typical values
V_{CEsat} (mV)
$I_C = 1.5A$
1A
0.5A
T_j (°C)
600
400
200
0
0
50
100


7Z09341
$\frac{I_C}{I_B} = 2$
typical values
V_{BEsat} (mV)
$I_C = 2A$
1.5A
1A
0.5A
T_j (°C)
1500
1000
500
0
0
50
100


7Z09347
max. allowable total power dissipation versus ambient temperature
P tot (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

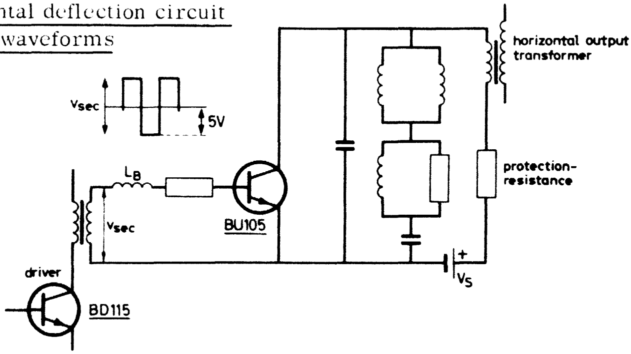

7Z09344
typical values
ICBO (μA)
1000
100
10
1
0
50
100
Tj(°C)
VCB=1500V
750V
250V

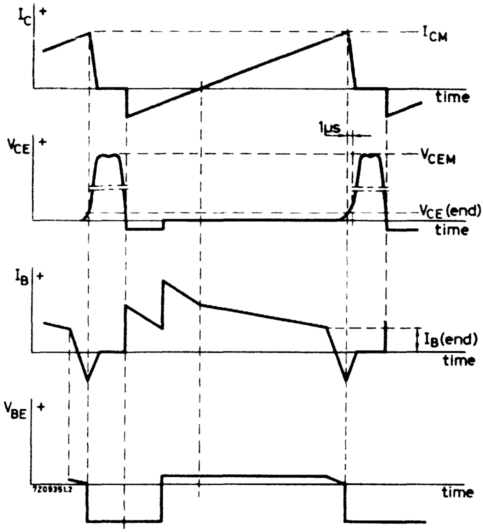
APPLICATION INFORMATION

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

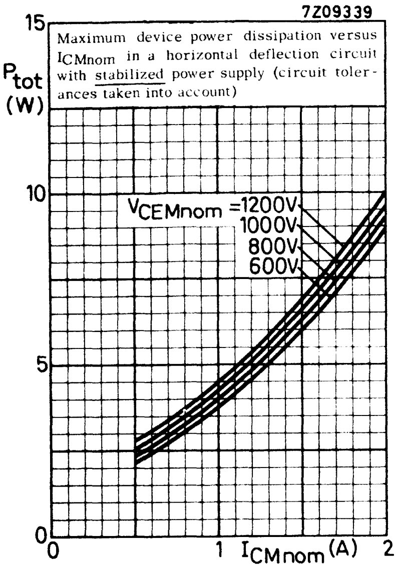


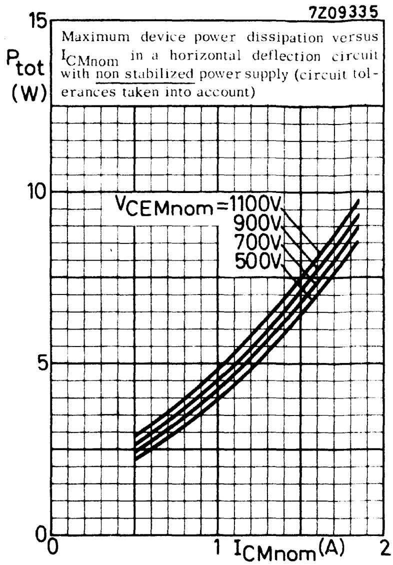


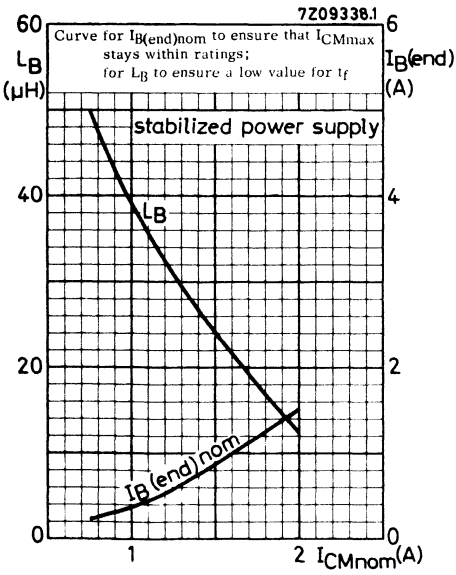
Remark:

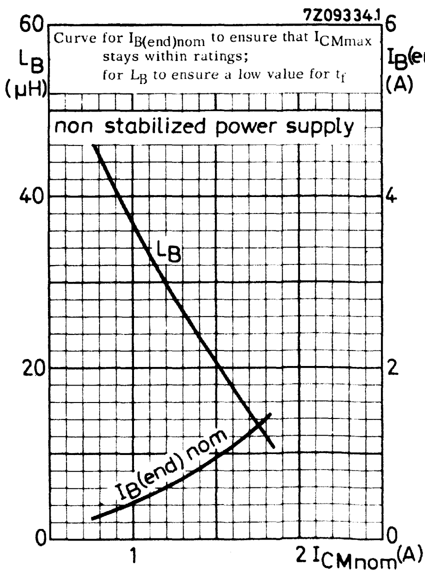
1. The driver and output stage should operate in a non-simultaneous mode i.e. the driver transistor should be conductive during flyback and the first part of scan.
2. The reverse bias voltage for the output transistor should be in the order of 5 V with a duty cycle $\delta \approx 0.5$.

APPLICATION INFORMATION (continued)

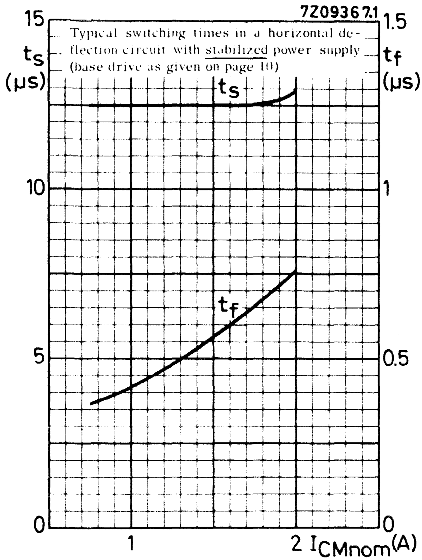


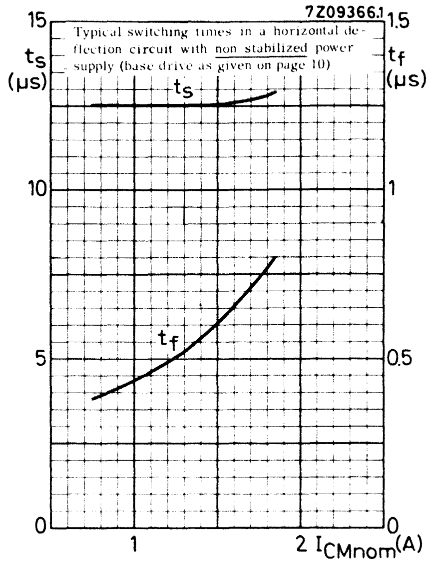






APPLICATION INFORMATION (continued)





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:

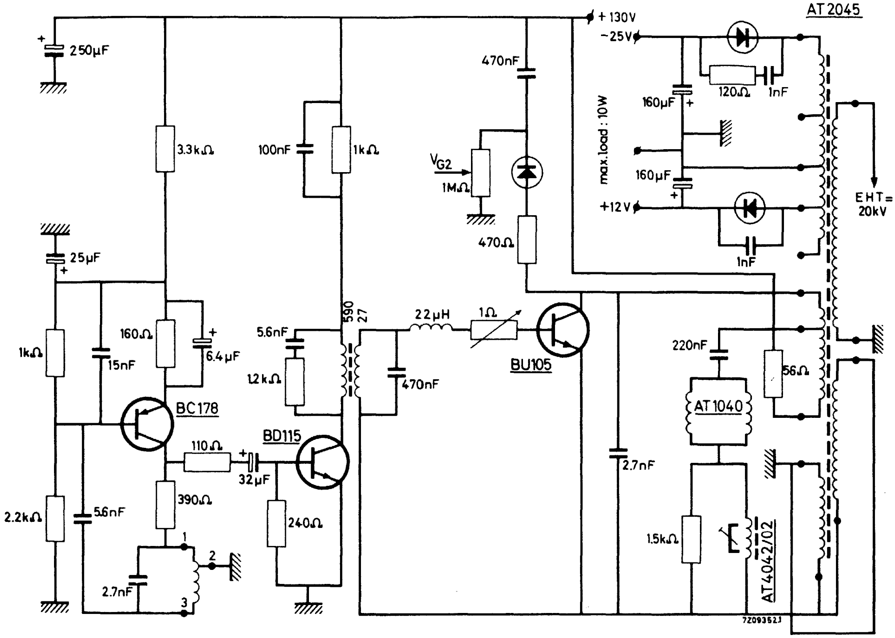
with stabilized power supply : $I_{B(end)nom}$ = 1.2 A; L_B = 17 μH
non stabilized power supply : $I_{B(end)nom}$ = 1.4 A; L_B = 12 μH

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)

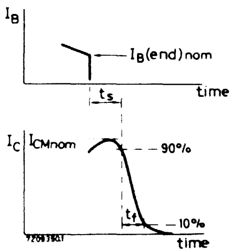
Horizontal deflection circuit with BC178, BD115 and BU105 (stabilized power supply)



The BU105 in the circuit above has been designed for $I_{CMnom} = 1.6$ A with recommended inductance $L_B = 22\ \mu H$ 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

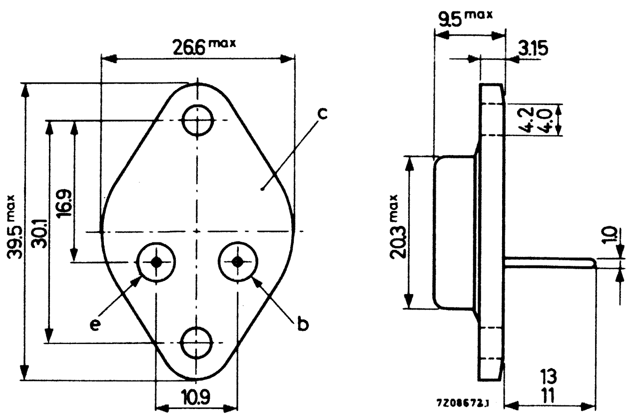
HIGH VOLTAGE SILICON POWER TRANSISTOR

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 (d.c.)	I_C	max.	5.0	A
Total power dissipation up to T_{mb} = 95 °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_C = 4.5 A; $I_{B(end)}$ = 1.8 A; L_B = 10 µH	t_f	typ.	0.7	µs

MECHANICAL DATA Dimensions in mm

Collector connected to case



FOR NEW DESIGN THE SUCCESSOR TYPES BU207 TO BU209 ARE RECOMMENDED

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

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 ($R_{BE} \leq 100\Omega$; $t_p \leq 20\ \mu s$; $\delta \leq 0.25$; peak value)	V_{CERM}	max.	1500 V

Currents

Collector current (d. c.)	I_C	max.	5.0 A
Collector current (peak value)	I_{CM}	max.	7.5 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)	$-I_{B(AV)}$	max.	0.1 A
Reverse base current (peak value)	$-I_{BM}$	max.	2.5 A [1]
Emitter current (d. c.)	$-I_E$	max.	7.0 A
Emitter current (peak value)	$-I_{EM}$	max.	7.5 A

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

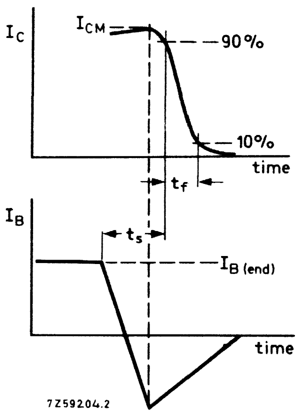
THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1.6 °C/W
From mounting base to heatsink	$R_{th\ mb\text{-}h}$	=	0.5 °C/W

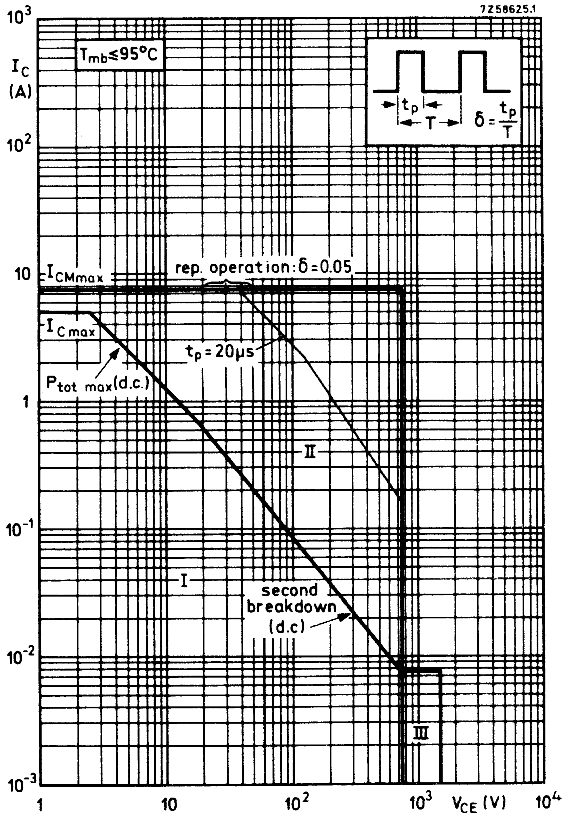
[1]) Turn off current; e.g. in horizontal deflection circuits.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current ($t_p \leq 20 \mu s; \delta \leq 0.25$)				
$V_{BE} = 0; V_{CE} = 1500$ V	I_{CES}	<	1	mA
Emitter-base voltage (open collector)				
$I_C = 0; I_E = 5$ mA	$+V_{EBO}$	>	5	V
Saturation voltages ($t_p = 0.3$ ms; $\delta = 0.01$)				
$I_C = 4.5$ 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
Switching times [1]				
$I_{CM} = 4.5$ A; $I_{B(end)} = 1.8$ A; $L_B = 10$ µH				
Fall time	t_f	typ.	0.7	µs
		<	1.0	µs
Storage time	t_s	typ.	9.5	µs



[1] See circuit on page 7.



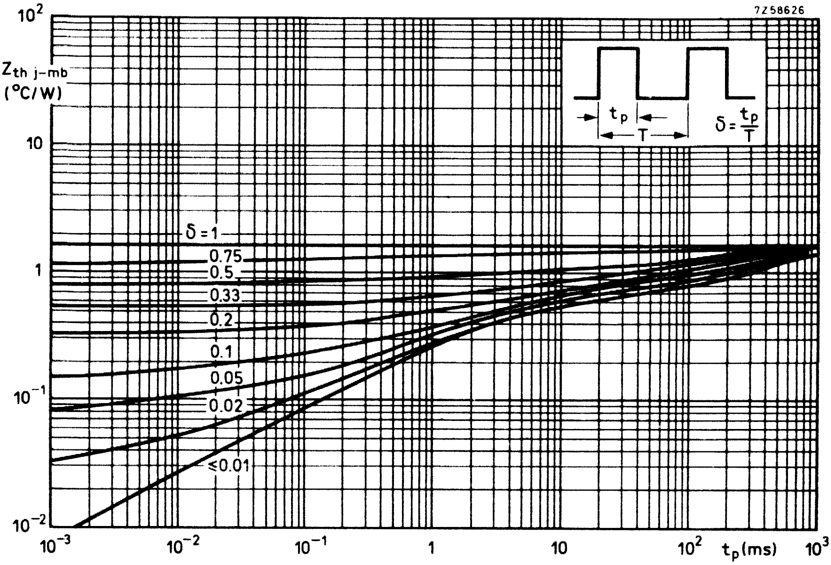
Safe Operating Area with the transistor forward biased

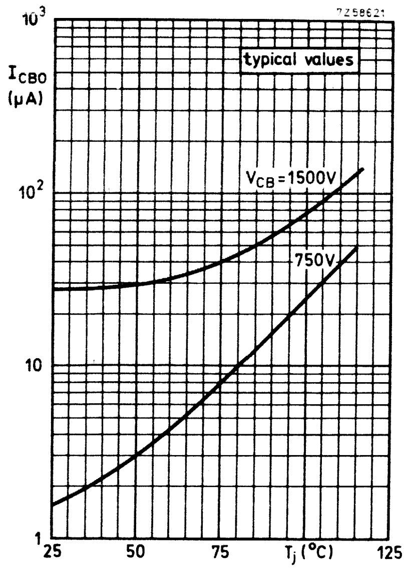
A I Region of permissible d. c. operation

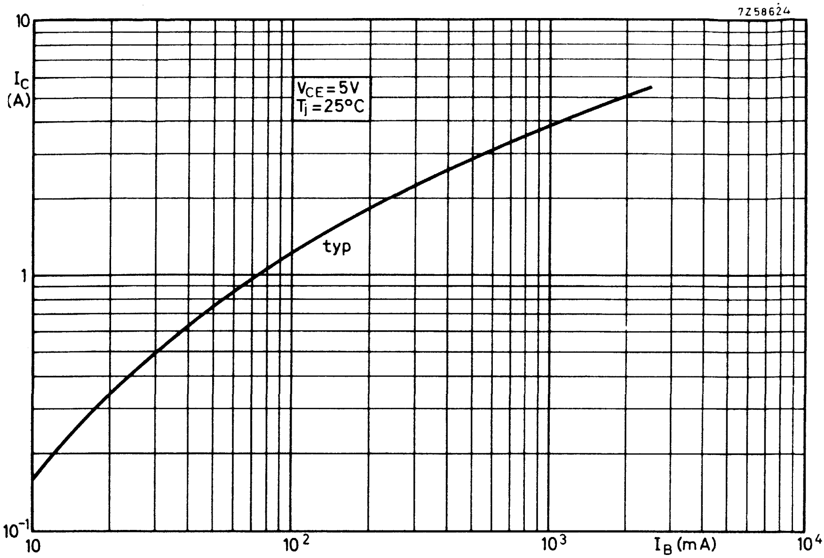
II Permissible extension for repetitive pulsed operation

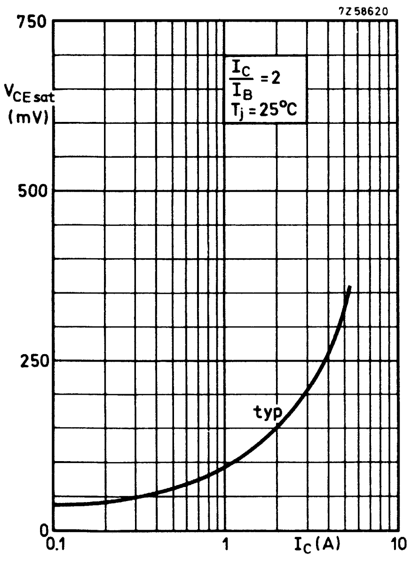
III Repetitive pulsed operation in this region is allowed, provided $R_{BE} \leq 100\Omega$, $t_p \leq 20\ \mu s$, $\delta \leq 0.25$

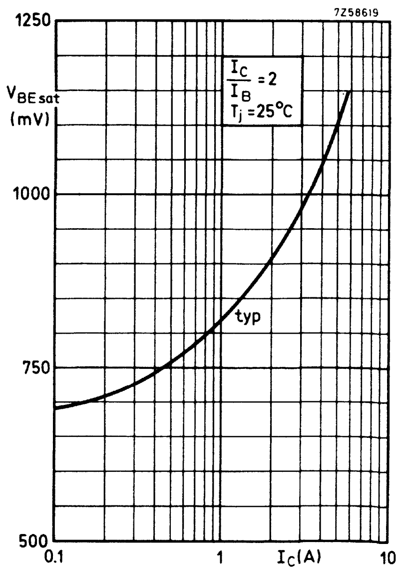
B Excursions outside indicated area due to picture tube arcing in practical horizontal deflection circuits are allowed, provided a protection resistor of suitable value is used. (See page 7) For proper values see relevant application information bulletins.


7Z58626
$Z_{th\ j-mb}$ (°C/W)
10^2
10
1
10^{-1}
10^{-2}
δ = 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
V_{CB} = 1500V
750V
10^2
10
1
25
50
75
T_j (°C)
125


7Z58624
I_C (A)
$V_{CE} = 5V$
$T_j = 25°C$
typ
I_B (mA)
10
1
10^{-1}
10
10^2
10^3
10^4


7Z58620
V_{CEsat} (mV)
$\frac{I_C}{I_B} = 2$
$T_j = 25°C$
typ
750
500
250
0
0.1
1
I_C (A)
10

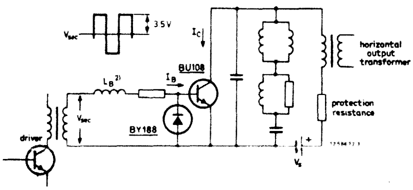

7Z58619
V_{BEsat} (mV)
$\frac{I_C}{I_B} = 2$
$T_j = 25°C$
typ
1250
1000
750
500
0.1
1
I_C(A)
10

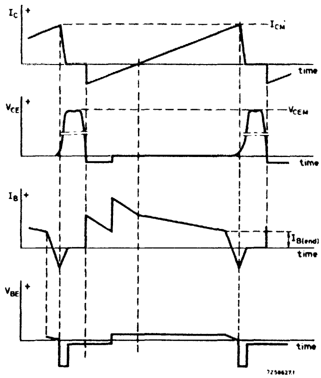
APPLICATION INFORMATION

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 ± 5% with respect to the nominal value and EHT loading current up to an average of 1.5 mA.
The design graphs on the following pages refer to the nominal conditions. This implies that normal circuit tolerances and normal operational variations are taken into account when establishing the recommended base drive and heatsink parameters.
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.

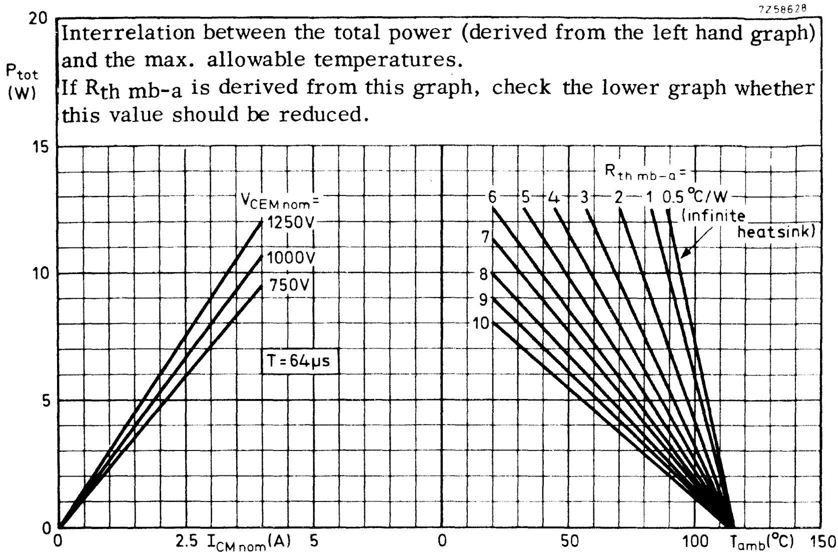


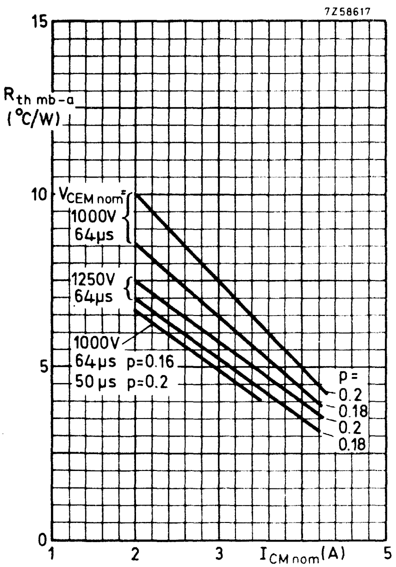


Remarks:

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. Including leakage conductance of driver transformer.

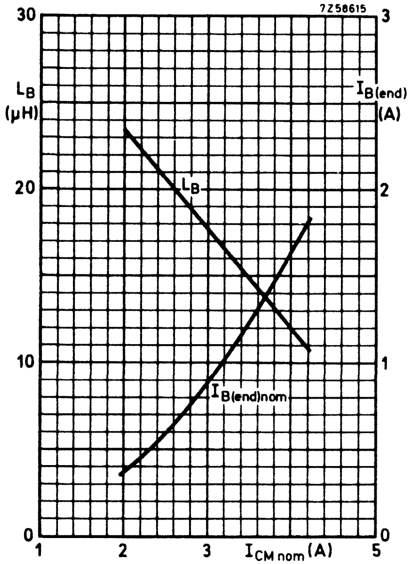
APPLICATION INFORMATION (continued)

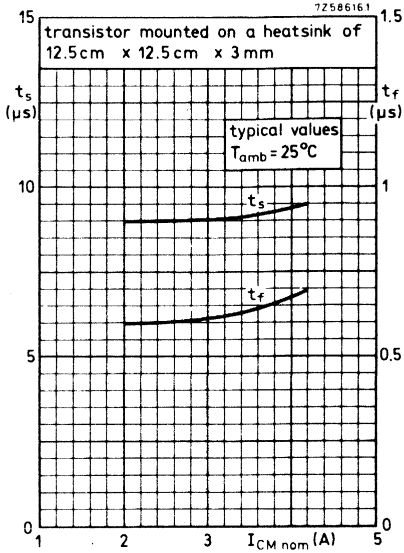


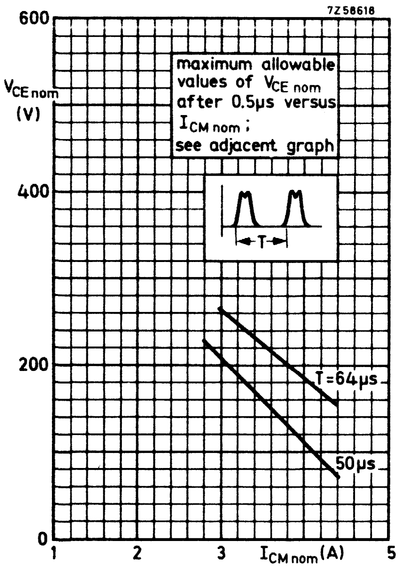


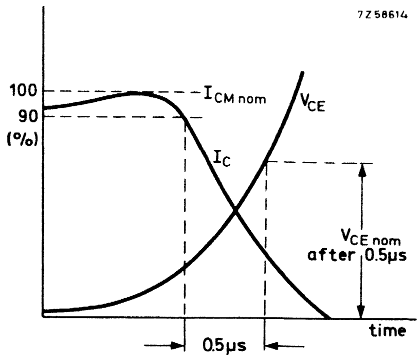
Maximum allowable $R_{th\ mb-a}$ for various operating conditions.
The values for V_{CEMnom} and I_{CMnom} referred to are normal operating conditions, the quantity 'p' denotes the ratio of the flyback pulse (t_p) over the period time T.

APPLICATION INFORMATION (continued)









HIGH VOLTAGE SILICON POWER TRANSISTOR

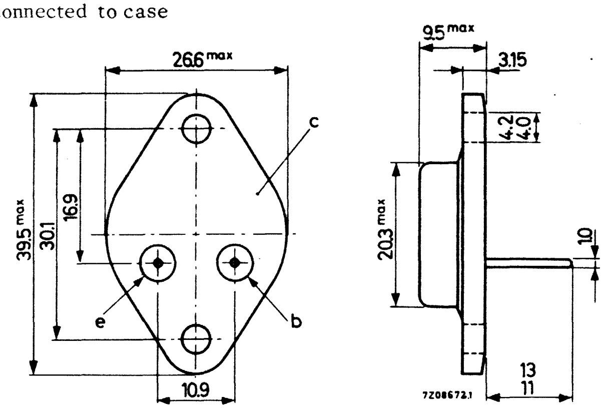
High voltage n-p-n power transistor intended for use in the switched mode power supply of 90° and 110° colour television receivers.

QUICK REFERENCE DATA				
Collector-emitter voltage (V_{BE} = 0)(peak value)	V_{CESM}	max.	750	V
Collector current (peak value)	I_{CM}	max.	6	A
Total power dissipation up to T_{mb} = 50 °C	P_{tot}	max.	30	W
Collector-emitter saturation voltage I_C = 2.5 A; I_B = 0.25 A	V_{CEsat}	<	10	V
Fall time I_{CM} = 2.5 A; $I_{B(end)}$ = 0.25 A	t_f	typ.	0.15	μs

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-emitter voltage (V_{BE} = 0) (peak value)	V_{CESM}	max.	750	V
Collector-emitter voltage ($-V_{BE}$ = 1.5 V)(peak v.)	V_{CEXM}	max.	750	V
Collector-emitter voltage (open base)	V_{CEO}	max.	300	V
Currents				
Collector current (d.c.)	I_C	max.	3	A
Collector current (peak value)	I_{CM}	max.	6	A
Reverse collector current (peak value)	$-I_{CM}$	max.	3	A
Base current (d.c.)	I_B	max.	2	A
Base current (peak value)	I_{BM}	max.	2	A
Reverse base current (d.c. or average over any 20 ms period)	$-I_{B(AV)}$	max.	100	mA
Reverse base current (peak value)	$-I_{BM}$	max.	1.5	A[1])
Power dissipation				
Total power dissipation up to T_{mb} = 50 °C	P_{tot}	max.	30	W
Temperatures				
Storage temperature	T_{stg}		-65 to +125	°C
Junction temperature	T_j	max.	125	°C

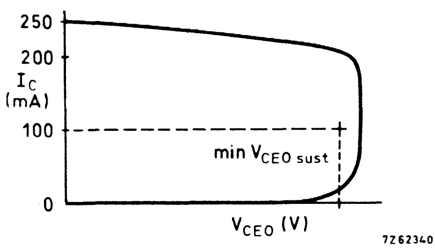
THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2.5	°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

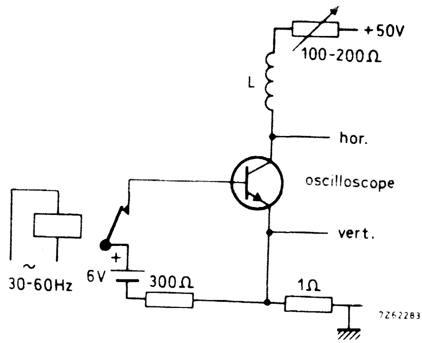
1) Turn-off current.

CHARACTERISTICS $T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current [1]				
$V_{CEM} = 750$ V; $V_{BE} = 0$	I_{CES}	<	0.5	mA
$V_{CEM} = 750$ V; $V_{BE} = 0$; $T_j = 125\ ^oC$	I_{CES}	<	2	mA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 6$ V	I_{EBO}	<	5	mA
D.C. current gain				
$I_C = 1$ A, $V_{CE} = 5$ V	h_{FE}		15 to 60	
Saturation voltages				
$I_C = 2.5$ A; $I_B = 0.25$ A	$V_{CE\,sat}$	<	10	V
$I_C = 4$ A; $I_B = 1$ A	$V_{CE\,sat}$	<	5	V
	$V_{BE\,sat}$	<	1.5	V
Collector-emitter sustaining voltage				
$I_B = 0$; $I_C = 100$ mA; $L = 25$ mH	$V_{CEO\,sust}$	>	300	V



Oscilloscope display for $V_{CEO\,sust}$



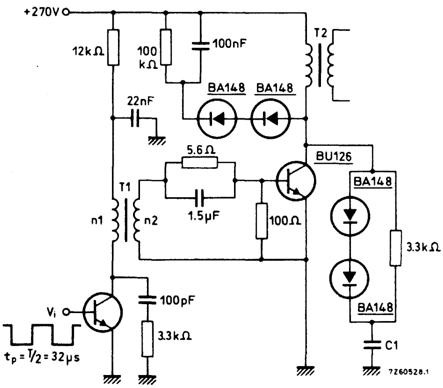
Test circuit for $V_{CEO\,sust}$

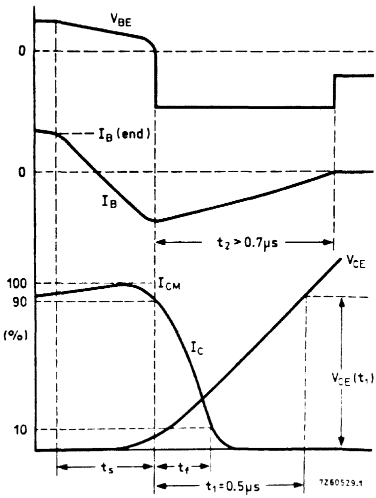
[1]) Measured with a half sine wave voltage (curve tracer).

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

Transition frequency at f = 1 MHz				
$I_C = 0.2\ A$; $V_{CE} = 10\ V$	f_T	typ.	8	MHz
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10\ V$	C_c	typ.	85	pF
Emitter capacitance at f = 1 kHz				
$I_C = I_c = 0$; $V_{EB} = 2\ V$	C_e	typ.	1.4	nF
Turn off time				
$I_{CM} = 2.5\ A$; $I_{B(end)} = 0.25\ A$				
storage time	t_s	typ.	1.2	μs
fall time	t_f	typ.	0.15	μs

Practical turn off circuit

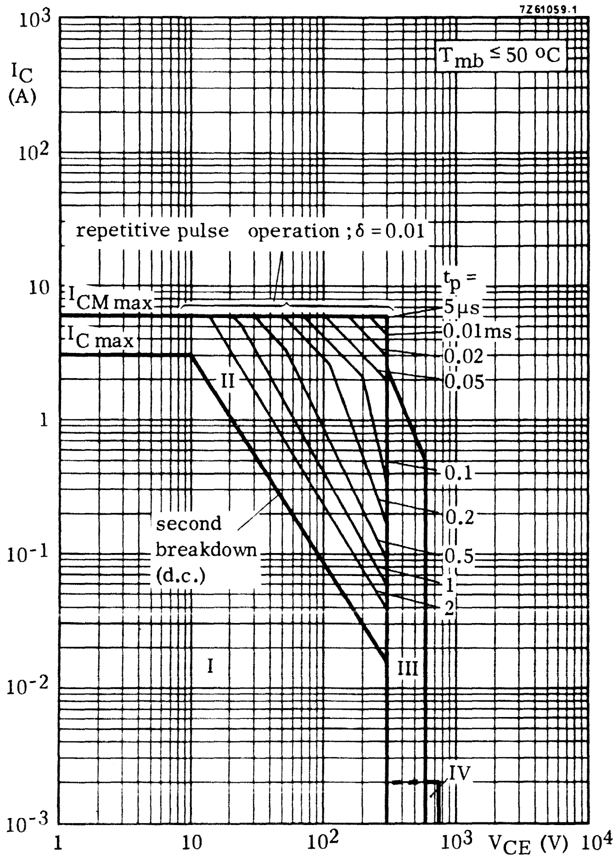




Max. allowable value of V_{CE} after $t_1 = 0.5\ \mu s$ and when $t_2 > 0.7\ \mu s$	$V_{CE(t_1)}$	<	500	V

T_1: Core EI25; n_1 = 350 turns, 100 mH; n_2 = 32 turns
Leakage inductance at secondary = 3 μH

The value of C_1 depends on the stray capacitance of T_2 and on the capacitive loading of the secondary (typical value for C_1 is 1.5 nF).



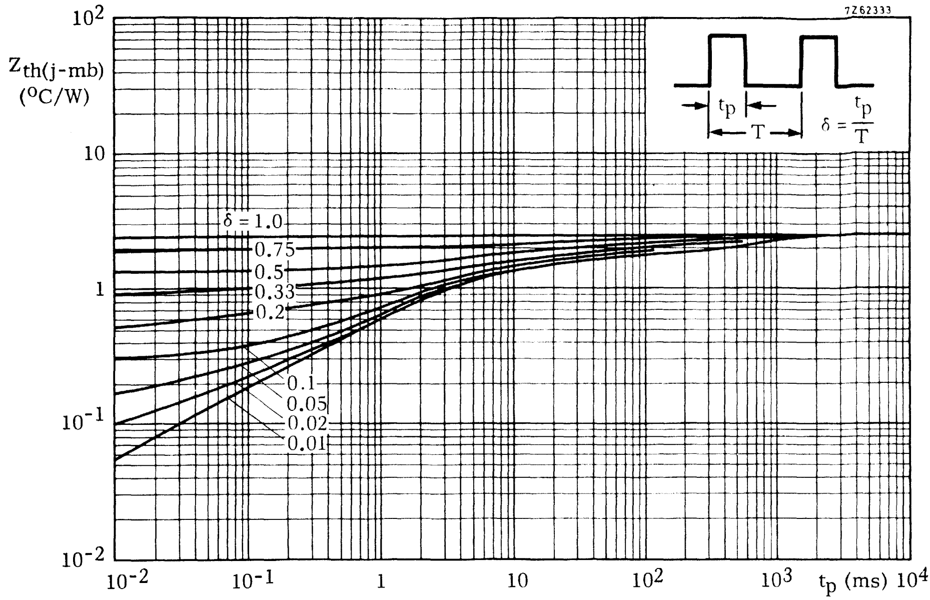
Safe Operating Area (Regions I, II and III forward biased)

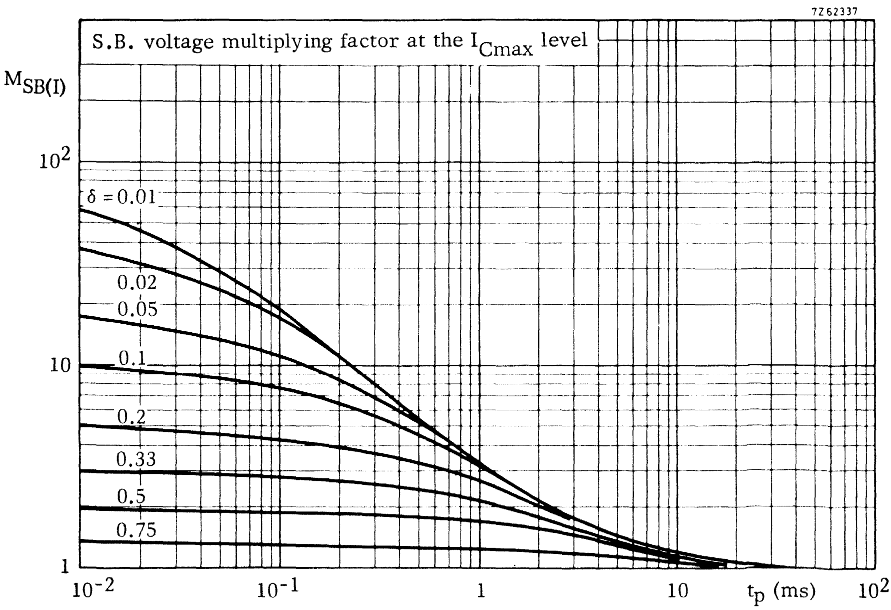
I Region of permissible d.c. operation

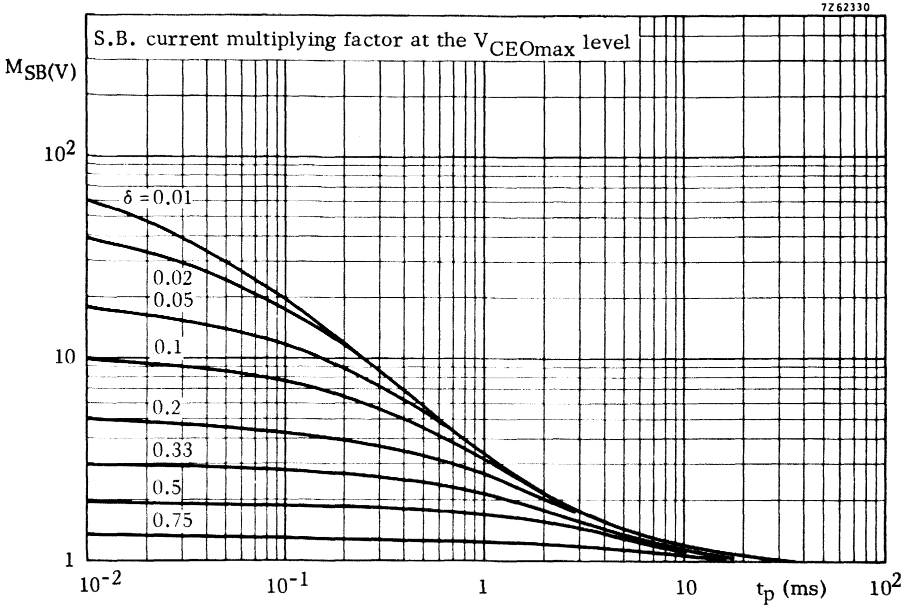
II Permissible extension for repetitive pulse operation

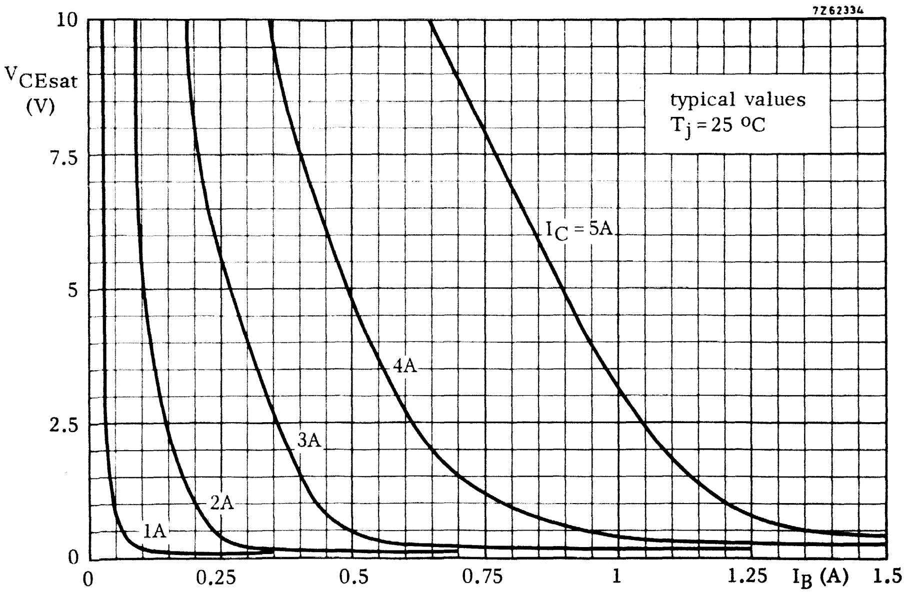
III Area of permissible operation during turn-on in switched mode power supply circuits, provided $t_p \leq 0.6\ \mu s$ and $R_{BE} \leq 100\ \Omega$

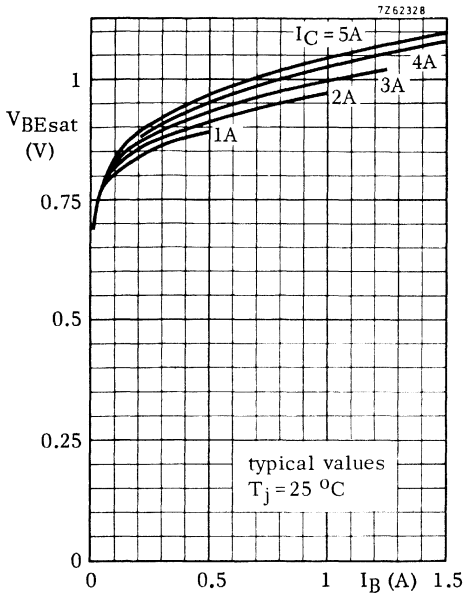
IV Repetitive pulse operation in this region is allowable, provided $V_{BE} \leq 0$ and $t_p \leq 2$ ms

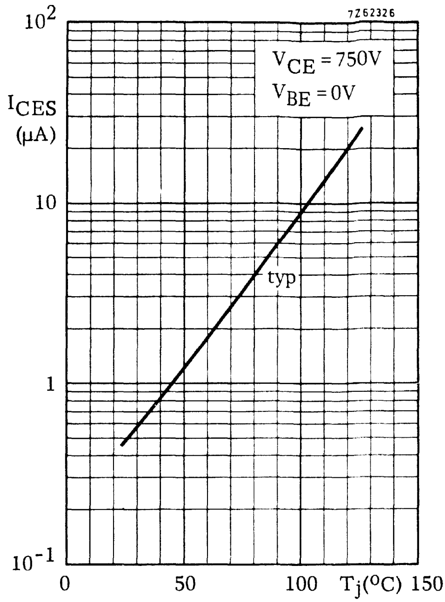

7Z62333
$Z_{th(j-mb)}$ (°C/W)
10^2
10
1
10^{-1}
10^{-2}
$\delta = 1.0$
0.75
0.5
0.33
0.2
0.1
0.05
0.02
0.01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (ms) 10^4

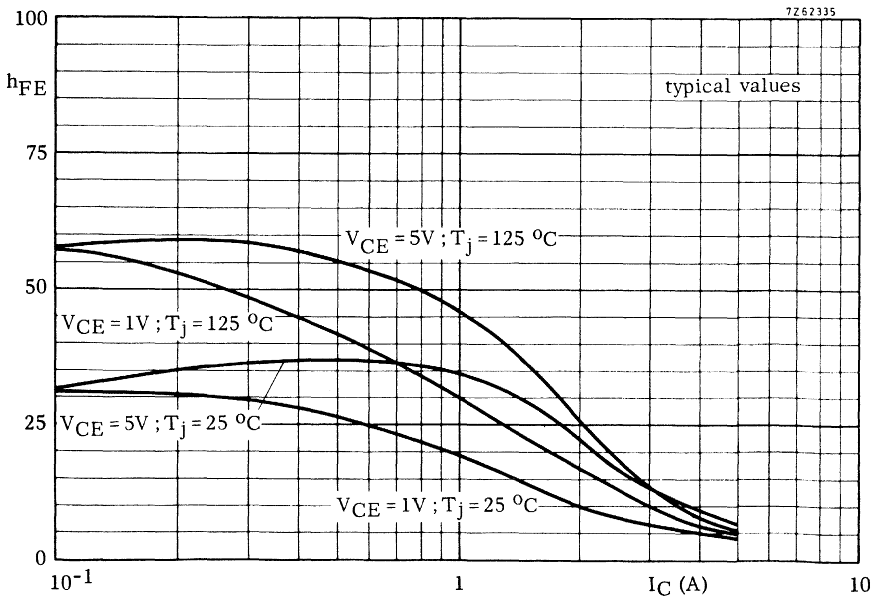

7Z62337
S.B. voltage multiplying factor at the I_{Cmax} level
$M_{SB(I)}$
10^2
10
1
$\delta = 0.01$
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^{-2}
10^{-1}
1
10
t_p (ms)
10^2

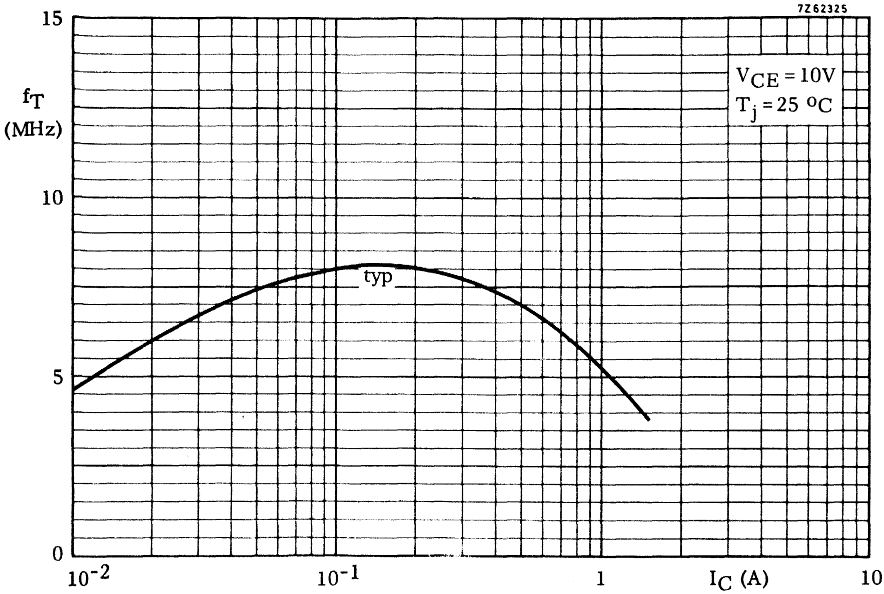

7Z62330
S.B. current multiplying factor at the V_{CEOmax} level
$M_{SB(V)}$
10^2
10
1
δ = 0.01
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^{-2}
10^{-1}
1
10
t_p (ms)
10^2

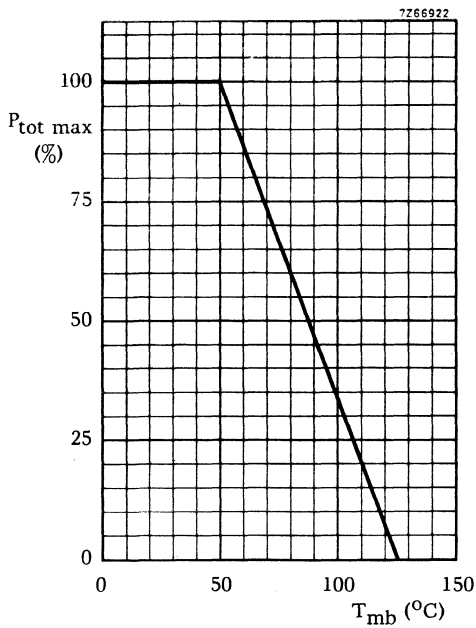

7Z62334
10
V_{CEsat}
(V)
7.5
5
2.5
0
typical values
T_j = 25 °C
I_C = 5A
4A
3A
2A
1A
0
0.25
0.5
0.75
1
1.25
I_B (A)
1.5


7Z62328
I_C = 5A
4A
3A
2A
1A
V_{BEsat} (V)
1
0.75
0.5
0.25
0
typical values
T_j = 25 °C
0
0.5
1
I_B (A)
1.5


7Z62326
10^2
I_{CES} (μA)
10
1
10^{-1}
V_{CE} = 750V
V_{BE} = 0V
typ
0
50
100
T_j(°C)
150


7Z62335
100
h_{FE}
75
50
25
0
typical values
V_{CE} = 5V ; T_j = 125 °C
V_{CE} = 1V ; T_j = 125 °C
V_{CE} = 5V ; T_j = 25 °C
V_{CE} = 1V ; T_j = 25 °C
10^{-1}
1
I_C (A)
10


7Z62325
f_T
(MHz)
15
10
5
0
$V_{CE} = 10V$
$T_j = 25\ ^oC$
typ
10^{-2}
10^{-1}
1
I_C (A)
10


7Z66922
$P_{tot\ max}$
(%)
100
75
50
25
0
0
50
100
150
T_{mb} (^oC)

APPLICATION INFORMATION [1)]

Switched-mode power supply circuits

Important factors in the design of switched-mode power supply circuits are the power losses and heatsink requirements of the output transistor and the base drive condition during turn-off. The basic arrangements for parallel and series-type switched-mode circuits are shown in Figs. 1, 2 and 3, together with the basic waveforms.
In power supply circuits for colour receivers the duty cycle δ varies between 0,4 and 0,6.
Fig. 4 gives the nominal value of the recommended base current I_{Bend} versus the maximum peak collector current (which occurs at maximum load and minimum input voltage).
Fig. 5 shows the base current waveform during turn-off.
Fig. 6 gives the total device dissipation P_{tot} versus the maximum peak collector current.
The max. permissible thermal resistance for the heatsink can be calculated from:

$$R_{th(mb\text{-}a)max}\ ^{2)} = \frac{T_{j\,max} - T_{amb}}{P_{tot}} - R_{th\ j\text{-}mb}$$

For the BU126: $T_{j\ max} = 125\ ^{o}C$ and $R_{th\ j\text{-}mb} = 2,5\ ^{o}C/W$

To ensure thermal stability, the thermal resistance of the heatsink used must not exceed the value plotted in Fig. 7.

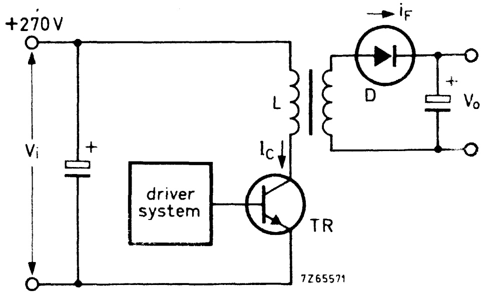


Fig. 1 Parallel type switched-mode power supply, basic circuit arrangement.

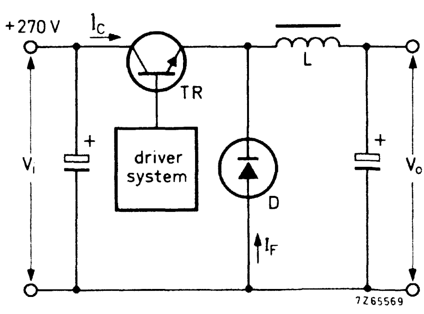


Fig. 2 Series type switched-mode power supply, basic circuit arrangement.

1) Detailed application information available on request.
2) Including additional thermal resistances resulting from mounting hardware.

APPLICATION INFORMATION
(continued)

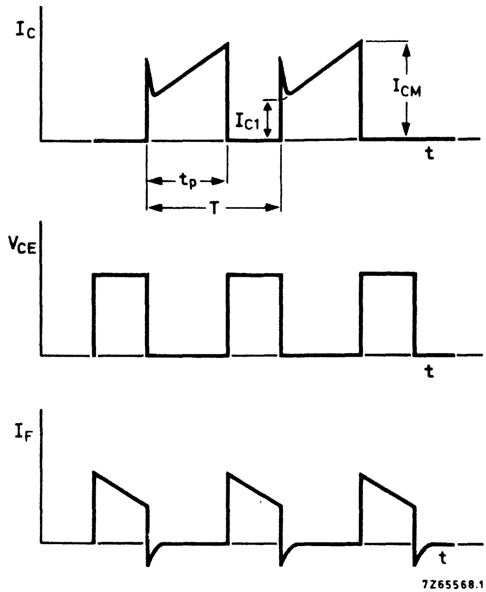


Fig. 3 Waveforms applying to switched-mode power supplies.

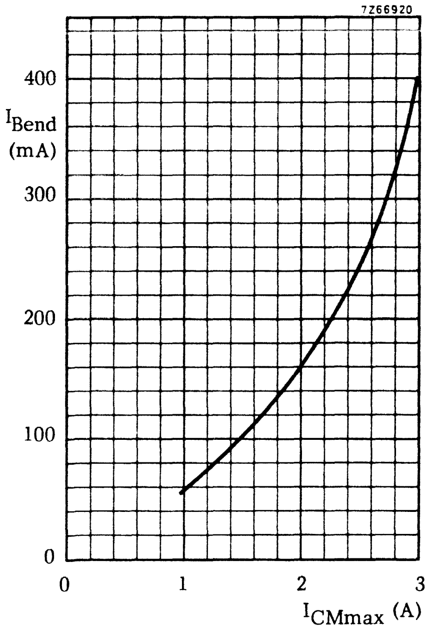


Fig. 4 Recommended nominal value of base current versus max. peak collector current.
Applies for ratio $I_{CM}/I_{C1} \geq 2$ (Fig. 3).

APPLICATION INFORMATION
(continued)

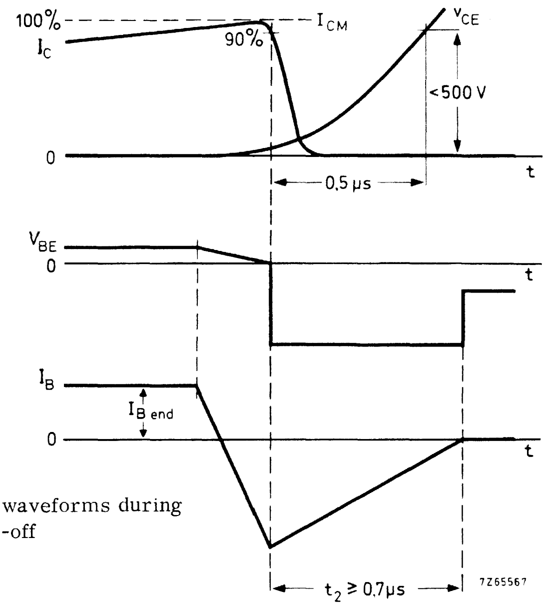


Fig.5 Basic waveforms during current turn-off

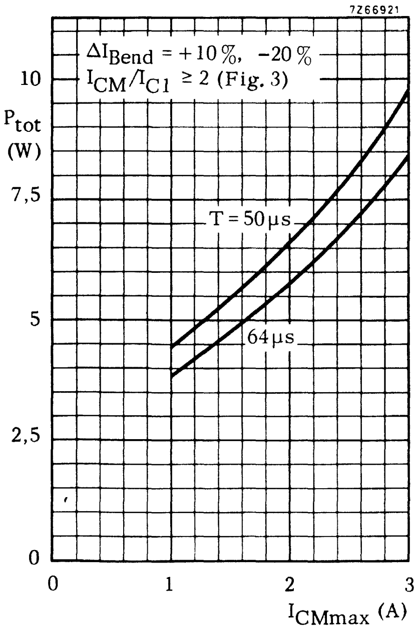


Fig. 6 Total transistor dissipation versus max. peak collector current.

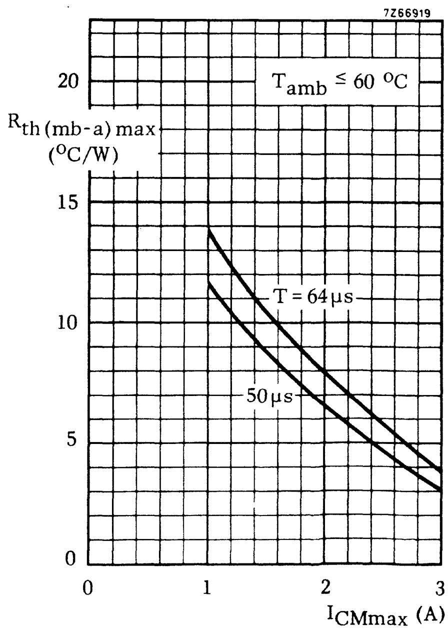


Fig. 7 Max. allowable value of $R_{th\ mb-a}$ to ensure thermal stability.

HIGH VOLTAGE SILICON POWER TRANSISTOR

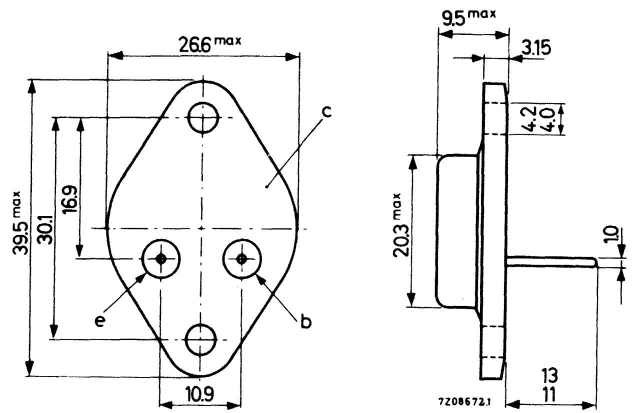
N-P-N transistor in a metal envelope intended for use in the vertical deflection output stage of black-and-white and colour television receivers.

QUICK REFERENCE DATA				
Collector-emitter voltage (V_{BE} = 0) peak value	V_{CESM}	max.	800	V
Collector-emitter voltage (R_{BE} = 220 Ω) peak v.	V_{CERM}	max.	700	V
Collector current (peak value)	I_{CM}	max.	2	A
Total power dissipation up to T_{mb} = 97 °C	P_{tot}	max.	15	W
Junction temperature	T_j	max.	135	°C
D.C. current gain I_C = 250 mA; V_{CE} = 10 V	h_{FE}	> <	25 80	

MECHANICAL DATA Dimensions in mm

Collector connected to mounting base

TO-3



Accessories supplied on request: 56201e

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltages

Collector-emitter voltage (V_{BE} = 0) peak value	V_{CESM}	max.	800	V
Collector-emitter voltage (open base)	V_{CEO}	max.	600	V
Collector-emitter voltage (R_{BE} = 220 Ω) peak v.	V_{CERM}	max.	700	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Currents

Collector current (d.c.)	I_C	max.	1	A
→ Collector current (peak value)	I_{CM}	max.	2	A
Base current (d.c.)	I_B	max.	250	mA

Power dissipation

Total power dissipation up to T_{mb} = 97 °C	P_{tot}	max.	15	W

Temperatures

Storage temperature	T_{stg}		−65 to +135	°C
Junction temperature	T_j	max.	135	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	2,5	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

V_{CE} = 800 V; V_{BE} = 0	I_{CES}	<	250	μA
V_{CE} = 800 V; V_{BE} = 0; T_j = 125 °C	I_{CES}	<	2	mA

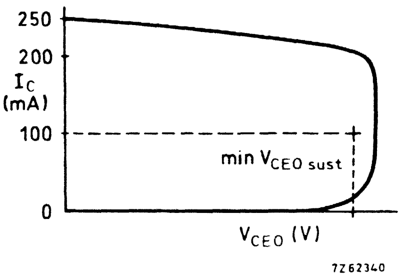
Saturation voltages

I_C = 250 mA; I_B = 25 mA	V_{CEsat}	<	5	V
	V_{BEsat}	<	1,2	V

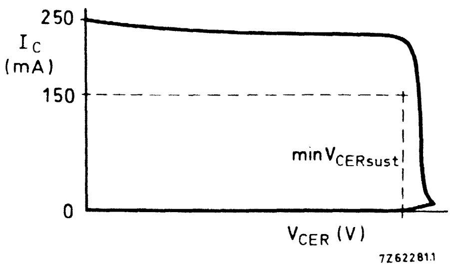
Collector-emitter sustaining voltages

$I_B = 0$; $I_C = 100$ mA; L = 100 mH	$V_{CEOsust}$	>	600	V
$I_C = 150$ mA; L = 100 mH; $R_{BE} = 220\ \Omega$	$V_{CERsust}$	>	700	V

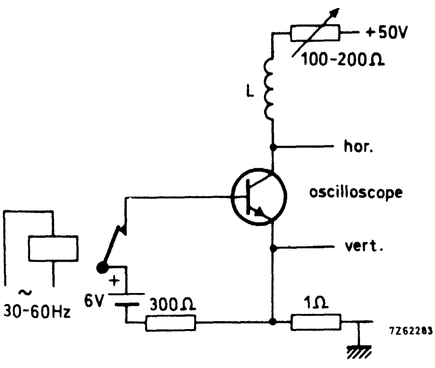
Oscilloscope display for $V_{CEOsust}$



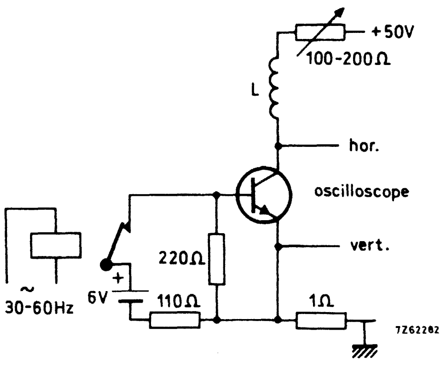
Oscilloscope display for $V_{CERsust}$



Test circuit for $V_{CEOsust}$



Test circuit for $V_{CERsust}$

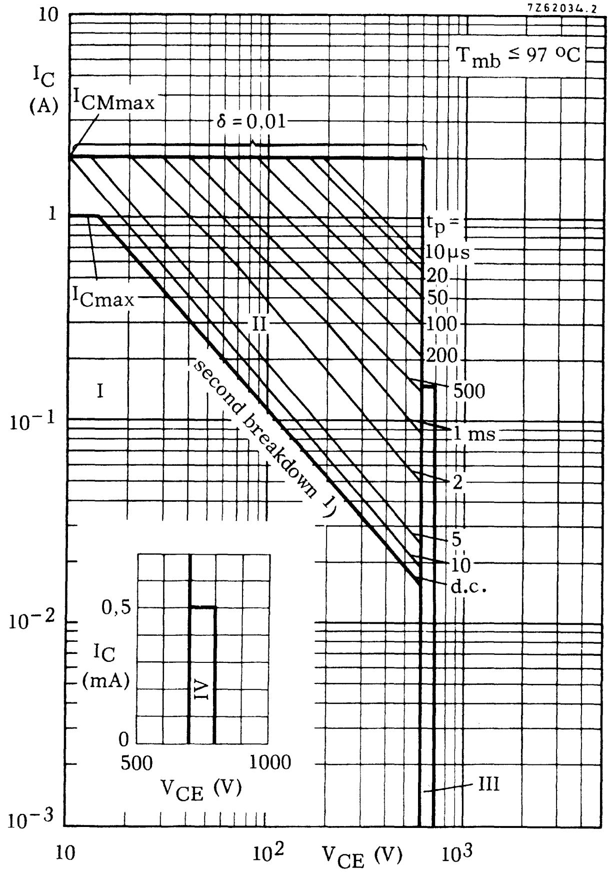


D.C. current gain

$I_C = 250$ mA; $V_{CE} = 10$ V	h_{FE}	> <	25 80	

Transition frequency at f = 1 MHz

$I_C = 100$ mA; $V_{CE} = 10$ V	f_T	typ.	8	MHz



Safe Operating Area (regions I and II with the transistor forward biased).

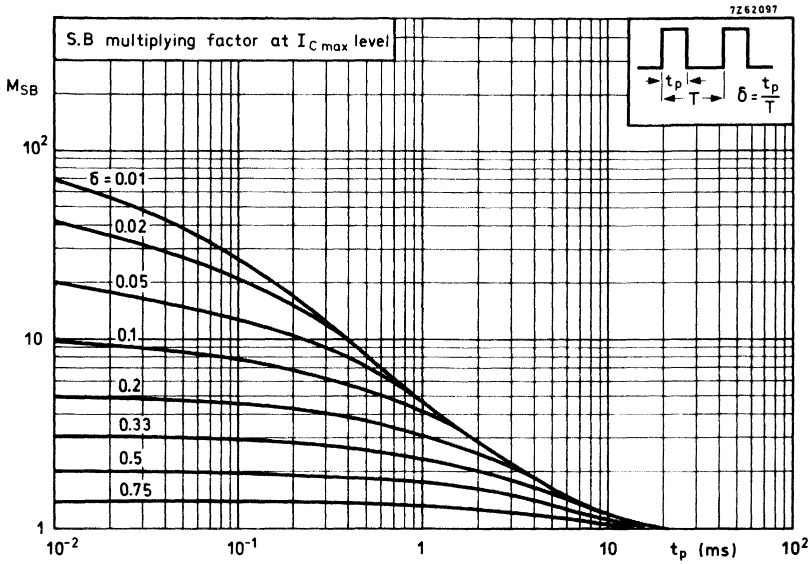
I Region of permissible d.c. operation.

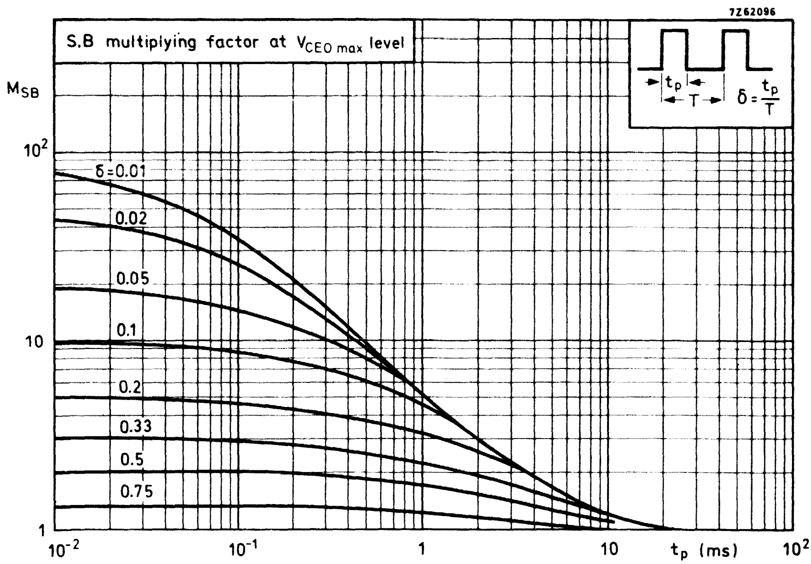
II Permissible extension for repetitive pulse operation.

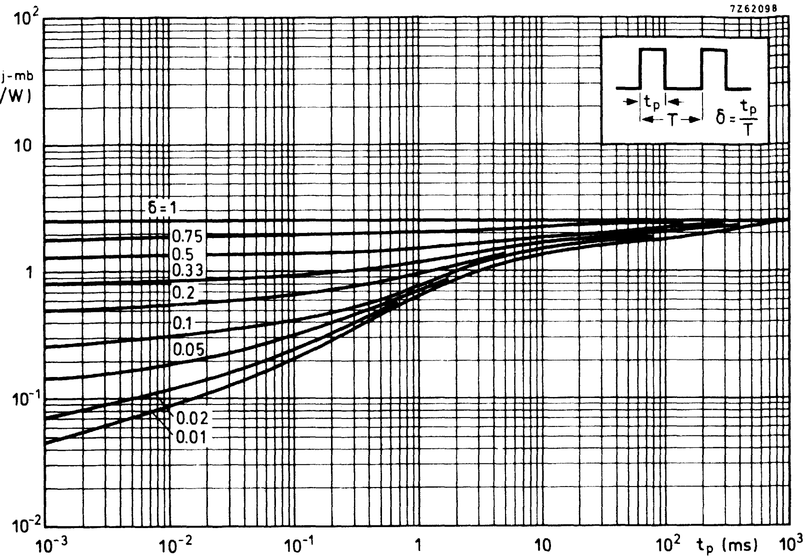
III In this region repetitive pulse operation is allowed during retrace period in vertical deflection circuits.

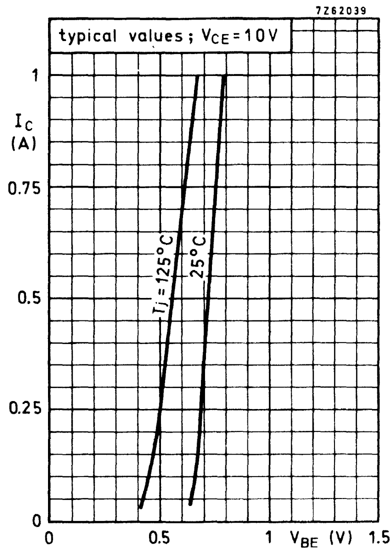
IV In this region repetitive pulse operation is allowed, provided $V_{BE} < 0$ V.

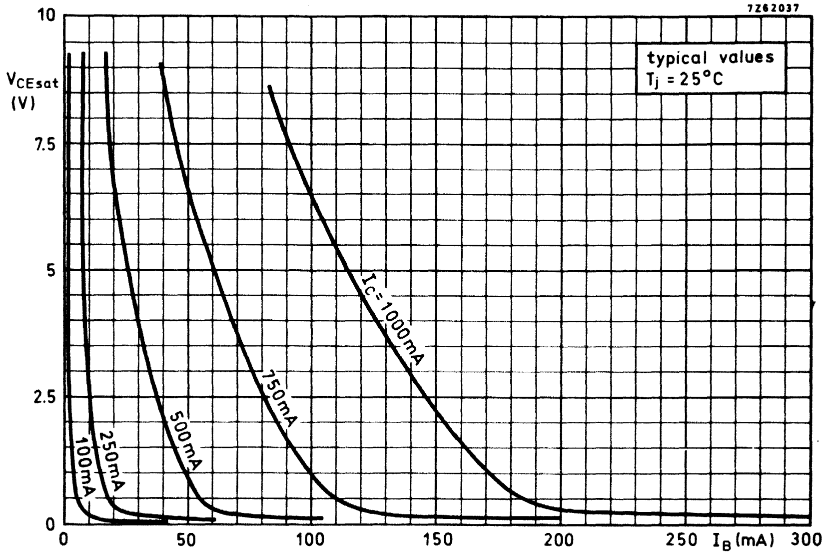
1) Independent of temperature

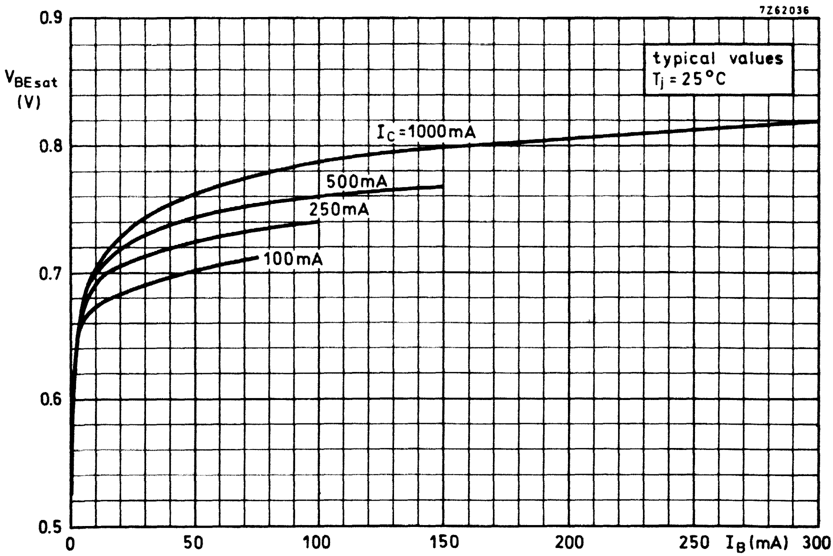

7Z62097
S.B multiplying factor at $I_{C\,max}$ level
M_{SB}
10^2
10
1
δ = 0.01
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^{-2}
10^{-1}
1
10
t_p (ms)
10^2
t_p
T
$\delta = \frac{t_p}{T}$

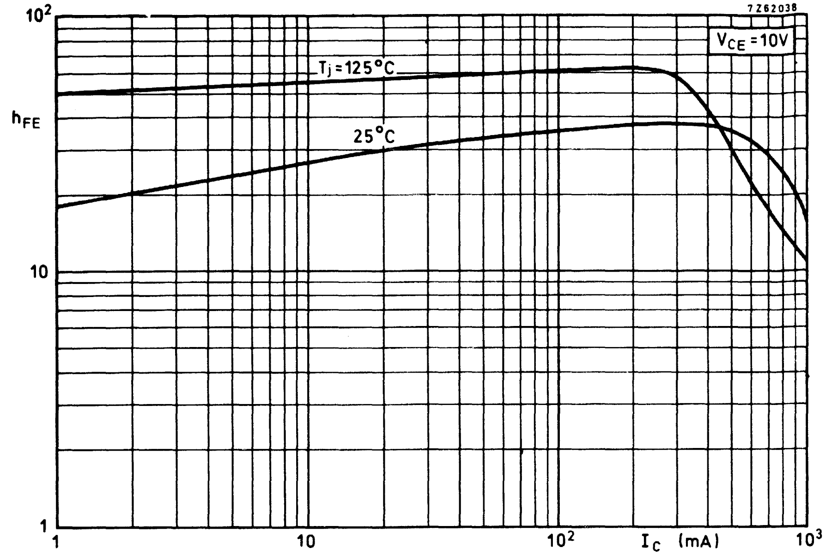

7Z62096
S.B multiplying factor at $V_{CEO\,max}$ level
M_{SB}
10^2
10
1
δ = 0.01
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^{-2}
10^{-1}
1
10
t_p (ms)
10^2
t_p
T
$\delta = \frac{t_p}{T}$

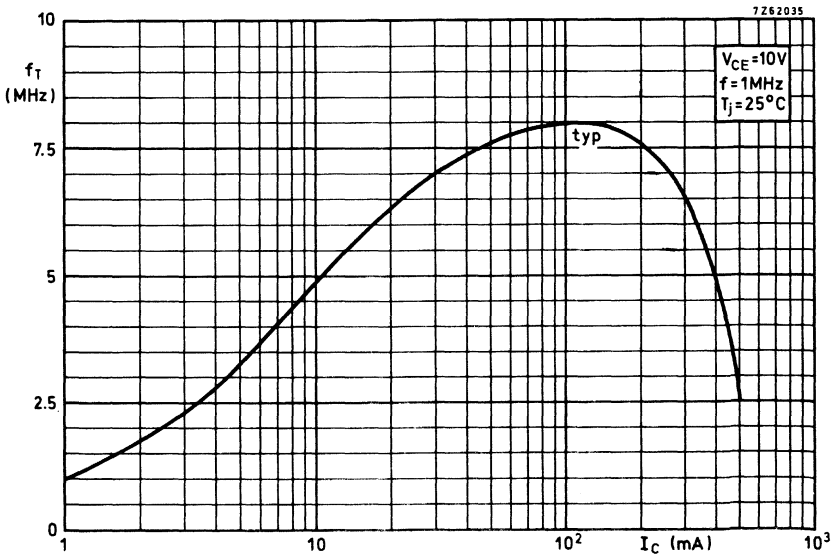

7Z62098
$Z_{th\,j\text{-}mb}$ (°C/W)
10^2
10
1
10^{-1}
10^{-2}
δ = 1
0.75
0.5
0.33
0.2
0.1
0.05
0.02
0.01
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3
t_p
T
$\delta = \frac{t_p}{T}$


7Z62039
typical values; V_{CE} = 10 V
I_C (A)
1
0.75
0.5
0.25
0
T_j = 125 °C
25 °C
0
0.5
1
V_{BE} (V)
1.5


7Z62037
10
7.5
5
2.5
0
V_{CEsat} (V)
typical values
T_j = 25°C
100mA
250mA
500mA
750mA
I_C = 1000mA
0
50
100
150
200
250
300
I_B (mA)


7Z62036
0.9
0.8
0.7
0.6
0.5
V_{BEsat} (V)
typical values
T_j = 25°C
I_C = 1000mA
500mA
250mA
100mA
0
50
100
150
200
250
300
I_B (mA)


7Z62038
10^2
V_{CE} = 10V
T_j = 125°C
h_{FE}
25°C
10
1
1
10
10^2
I_C (mA)
10^3


7Z62035
10
f_T (MHz)
V_{CE} = 10V
f = 1MHz
T_j = 25°C
typ
7.5
5
2.5
0
1
10
10^2
I_C (mA)
10^3

HIGH VOLTAGE SILICON POWER TRANSISTORS

N-P-N transistors in a metal envelope intended for use in horizontal deflection circuits of television receivers.

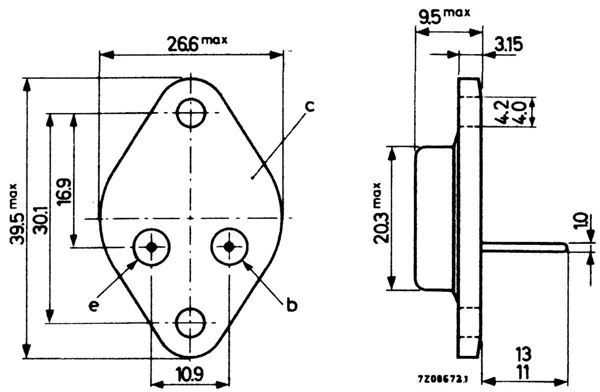
QUICK REFERENCE DATA

			BU204	BU205	BU206	
Collector-emitter voltage ($V_{BE} = 0$, peak value)	V_{CESM}	max.	1300	1500	1700	V
Collector current (d.c.)	I_C	max.	2, 5	2, 5	2, 5	A
Total power dissipation up to $T_{mb} = 90\ ^oC$	P_{tot}	max.	10	10	10	W
D.C. current gain $I_C = 2$ A; $V_{CE} = 5$ V	h_{FE}	>	2	2	1, 8	
Fall time $I_C = 2$ A; $I_B = 1$ A	t_f	typ.	0, 75	0, 75	0, 75	μs

MECHANICAL DATA

TO-3

Collector connected to case



RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltage			BU204	BU205	BU206	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	1300	1500	1700	V
Collector-emitter voltage (R_{BE} ≤ 100 Ω, peak value)	V_{CERM}	max.	1300	1500	1700	V
Collector-emitter voltage (open base)	V_{CEO}	max.	600	700	800	V

Current				
Collector current (d.c.)	I_C	max.	2,5	A
Collector current (peak value)	I_{CM}	max.	3	A
Base current (peak value)	I_{BM}	max.	2,5	A
Reverse base current (d.c. or average over any 20 ms period)	$-I_{B(AV)}$	max.	100	mA
Reverse base current (peak value)[1]	$-I_{BM}$	max.	1,5	A

Power dissipation				
Total power dissipation up to T_{mb} = 90 °C	P_{tot}	max.	10	W

Temperature				
Storage temperature	T_{stg}		−65 to +115	°C
Junction temperature	T_j	max.	115	°C

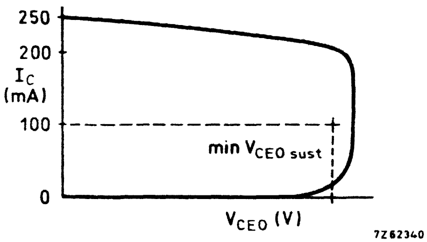
THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	max.	2,5	°C/W

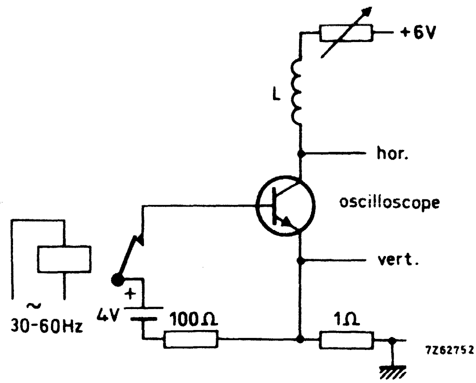
1) Turn-off current.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

			BU204	BU205	BU206	
Collector cut-off current						
V_{BE} = 0; V_{CE} = $V_{CESMmax}$	I_{CES}	<		1		mA
D.C. current gain			BU204	BU205	BU206	
I_C = 2 A; V_{CE} = 5 V	h_{FE}	>	2	2	1,8	
Emitter-base voltage						
I_C = 0; I_E = 10 mA	$+V_{EBO}$	>	5	5	5	V
I_C = 0; I_E = 100 mA	$+V_{EBO}$	typ.	7	7	7	V
Saturation voltage						
I_C = 2 A; I_B = 1 A	V_{CEsat}	<	5	5	-	V
I_C = 2 A; I_B = 1,1 A	V_{CEsat}	<	-	-	5	V
I_C = 2 A; I_B = 1 A	V_{BEsat}	<	1,5	1,5	-	
I_C = 2 A; I_B = 1,1 A	V_{BEsat}	<	-	-	1,5	V
Collector-emitter sustaining voltage						
I_B = 0; I_C = 100 mA; L = 25 mH	$V_{CEOsust}$	>	600	700	800	V



Oscilloscope display for $V_{CEOsust}$



Test circuit for $V_{CEOsust}$

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

Transition frequency at f = 5 MHz

I_C = 0,1 A; V_{CE} = 5 V	f_T	typ.	7,5	MHz

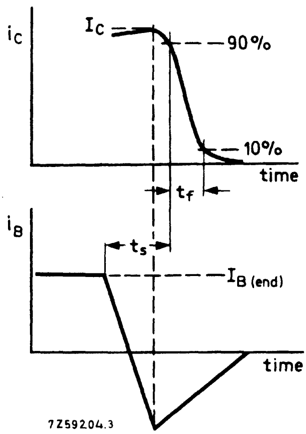
Collector capacitance at f = 1 MHz

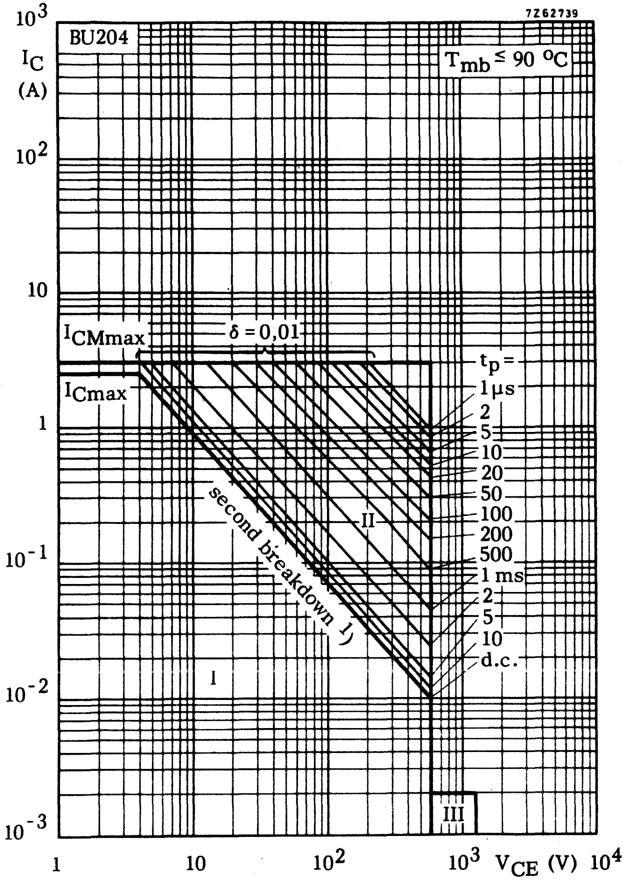
$I_E = I_e = 0$; V_{CB} = 10 V	C_c	typ.	65	pF

Switching times (in line deflection circuit)

I_C = 2 A; $I_{B(end)}$ = 1 A; L_B = 25 μH

Fall time	t_f	typ.	0,75	μs
Storage time	t_s	typ.	10	μs





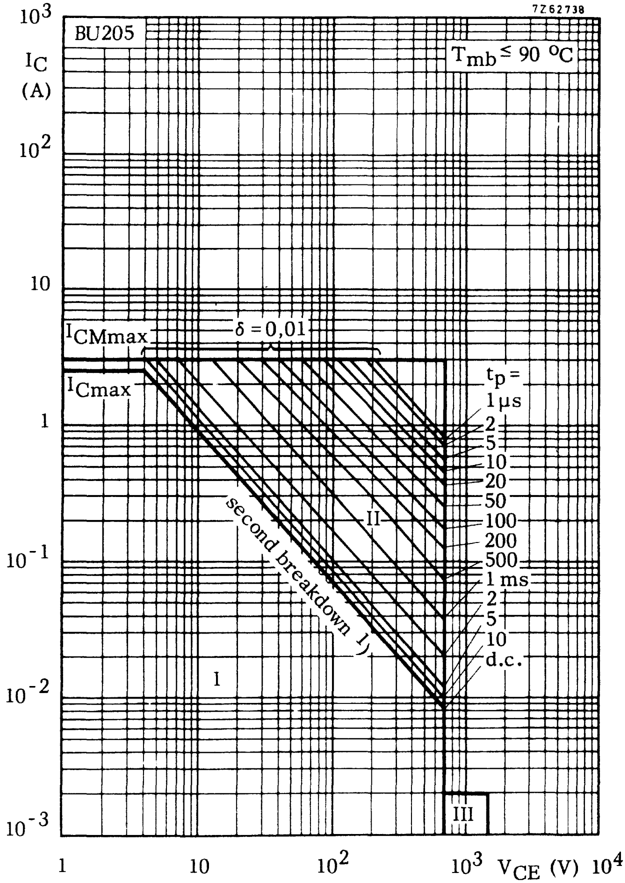
Safe Operation Area with the transistor forward biased.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 100\ \Omega$; $t_p \leq 20\ \mu s$; $\delta \leq 0,25$.

Note

Information on picture tube arcing is available.

1) Independent of temperature.



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Note

Information on picure tube arcing is available.

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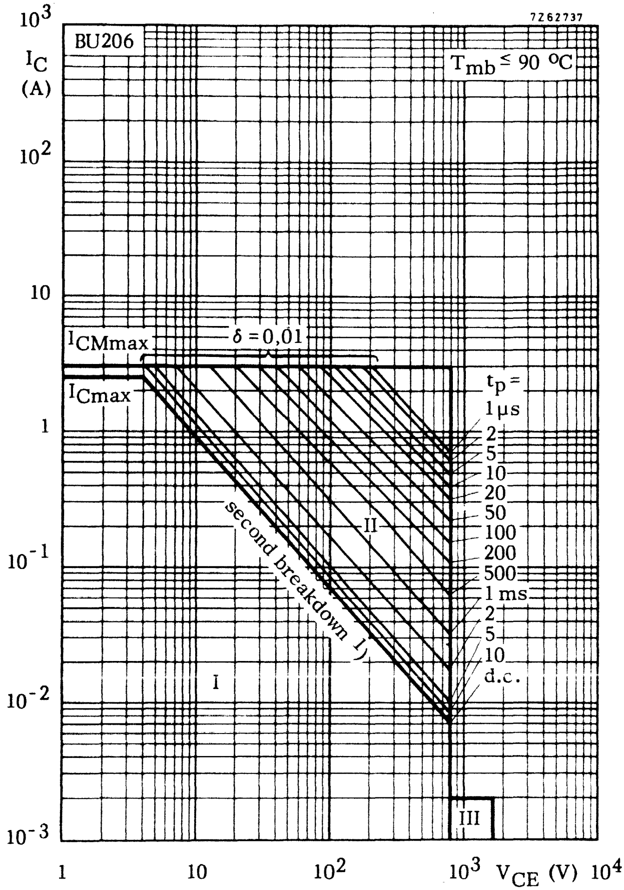


Safe Operating Area with the transistor forward biased.

I Region of permissible d.c. operation.

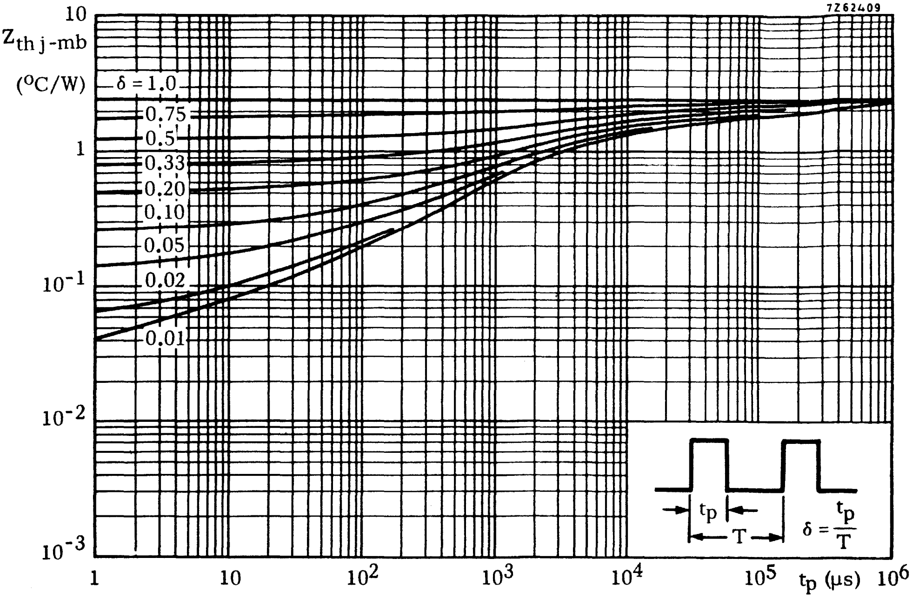
II Permissible extension for repetitive pulse operation.

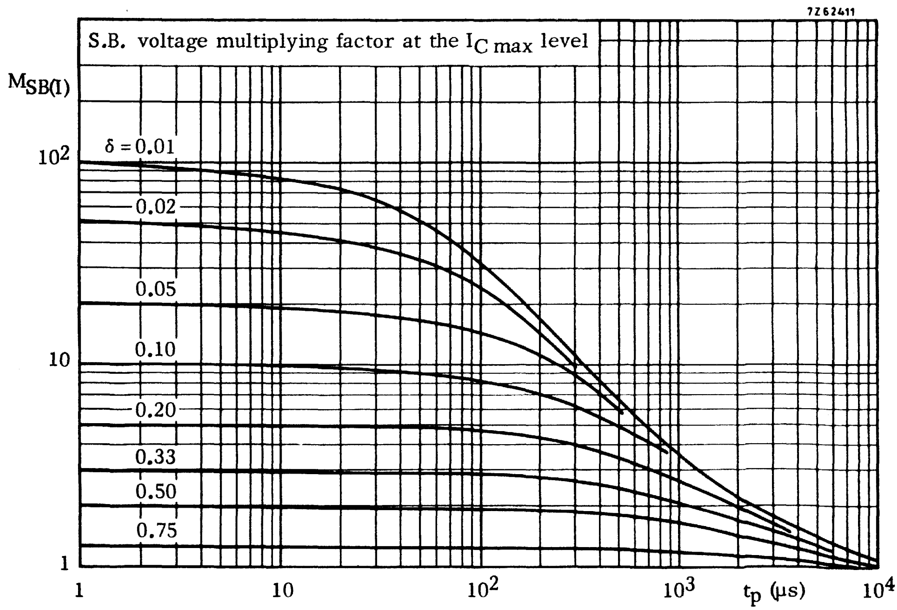
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 100\ \Omega$; $t_p \leq 20\ \mu s$; $\delta \leq 0,25$.

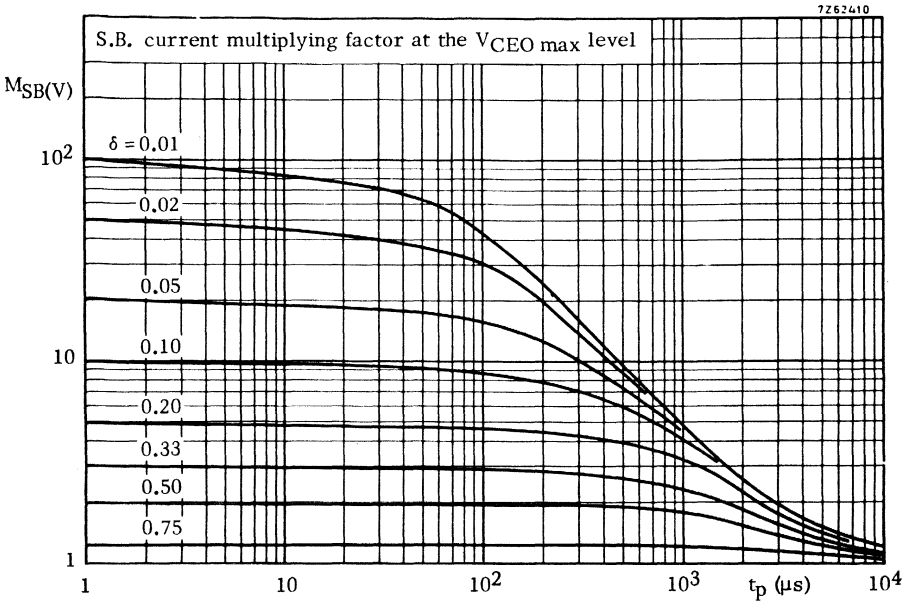
Note

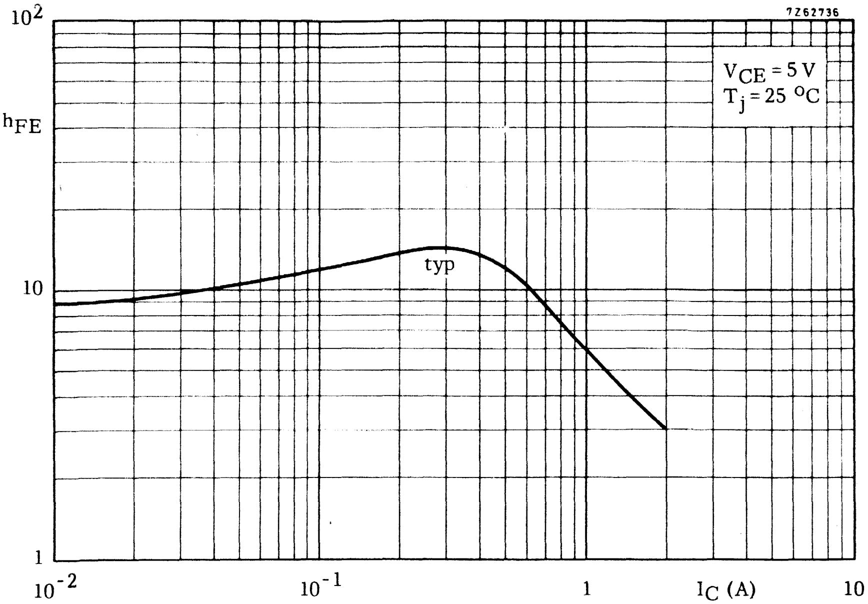
Information on picture tube arcing is available.

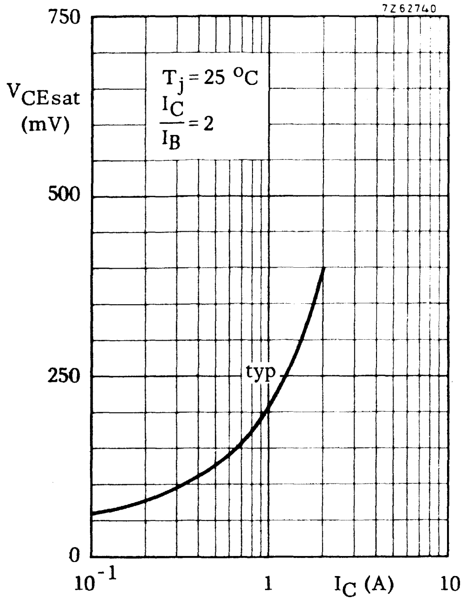
1) Independent of temperature.

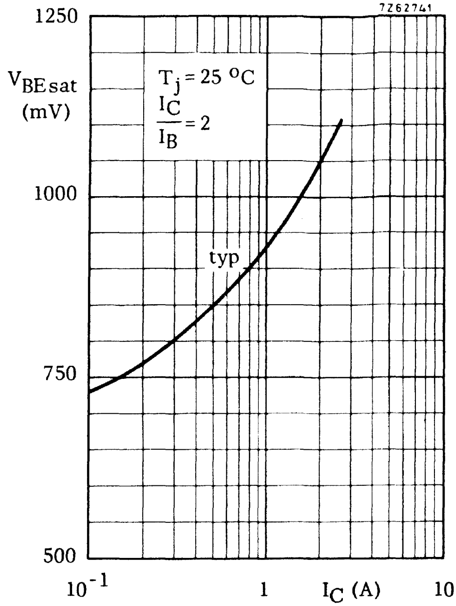

7Z62409
10
$Z_{th\,j\text{-}mb}$
(°C/W)
δ = 1.0
0.75
0.5
1
0.33
0.20
0.10
0.05
10^{-1}
0.02
0.01
10^{-2}
10^{-3}
1
10
10^2
10^3
10^4
10^5
t_p (μs)
10^6
t_p
T
δ = $\frac{t_p}{T}$


7Z62411
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
δ = 0.01
0.02
0.05
0.10
10
0.20
0.33
0.50
0.75
1
1
10
10^2
10^3
t_p (μs)
10^4


7Z62410
S.B. current multiplying factor at the $V_{CEO\,max}$ level
$M_{SB(V)}$
$\delta = 0.01$
0.02
0.05
0.10
0.20
0.33
0.50
0.75
10^2
10
1
1
10
10^2
10^3
t_p (μs)
10^4


7Z62736
h_{FE}
$V_{CE} = 5$ V
$T_j = 25$ °C
typ
10^2
10
1
10^{-2}
10^{-1}
1
I_C (A)
10


7Z62740
750
500
250
0
V_CEsat
(mV)
T_j = 25 °C
I_C / I_B = 2
typ
10^-1
1
I_C (A)
10


7Z62741
1250
1000
750
500
V_BEsat
(mV)
T_j = 25 °C
I_C / I_B = 2
typ
10^-1
1
I_C (A)
10

HIGH VOLTAGE SILICON POWER TRANSISTORS

N-P-N transistors in a metal envelope intended for use in horizontal deflection circuits of colour television receivers.

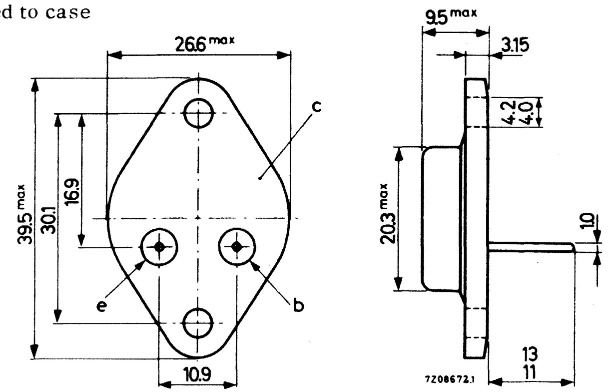
QUICK REFERENCE DATA

			BU207	BU208	BU209	
Collector-emitter voltage ($V_{BE}=0$, peak value)	V_{CESM}	max.	1300	1500	1700	V
Collector current (d.c.)	I_C	max.	5	5	4	A
Total power dissipation up to $T_{mb}=95\ ^oC$	P_{tot}	max.	12, 5	12, 5	12, 5	W
D.C. current gain						
$I_C = 4,5$ A; $V_{CE} = 5$ V	h_{FE}	>	2, 25	2, 25	-	
$I_C = 3$ A; $V_{CE} = 5$ V	h_{FE}	>	-	-	2,25	
Fall time						
$I_C = 4,5$ A; $I_B = 1,8$ A	t_f	typ.	0, 9	0, 7	-	µs
$I_C = 3$ A; $I_B = 1,3$ A	t_f	typ.	-	-	0, 7	µs

MECHANICAL DATA

TO-3

Collector connected to case



RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltage			BU207	BU208	BU209	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	1300	1500	1700	V
Collector-emitter voltage (R_{BE} ≤ 100 Ω, peak value)	V_{CERM}	max.	1300	1500	1700	V
Collector-emitter voltage (open base)	V_{CEO}	max.	600	700	800	V
Current						
Collector current (d.c.)	I_C	max.	5	5	4	A
Collector current (peak value)	I_{CM}	max.	7,5	7,5	6	A
Base current (peak value)	I_{BM}	max.	4	4	4	A
Reverse base current (d.c. or average over any 20 ms period)	$-I_{B(AV)}$	max.		100		mA
Reverse base current (peak value) [1]	$-I_{BM}$	max.		2,5		A
Power dissipation						
Total power dissipation up to T_{mb} = 95 °C	P_{tot}	max.		12,5		W
Temperature						
Storage temperature	T_{stg}			−65 to +115		°C
Junction temperature	T_j	max.		115		°C

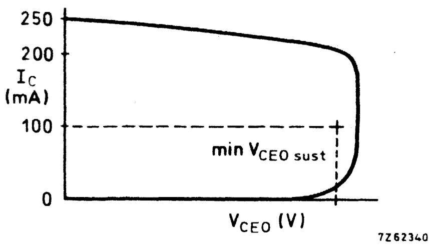
THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	max.	1,6	°C/W

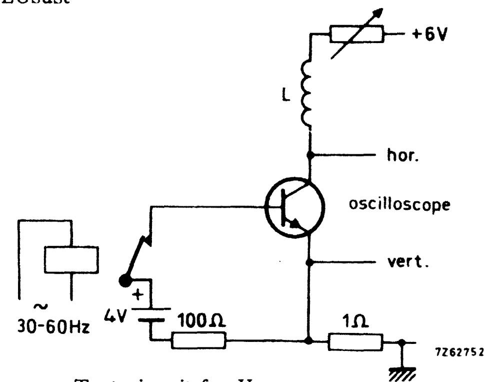
1) Turn-off current.

CHARACTERISTICS $T_j = 25\ ^oC$ unless otherwise specified

			BU207	BU208	BU209	
Collector cut-off current						
$V_{BE} = 0$; $V_{CE} = V_{CESMmax}$	I_{CES}	<		1,0		mA
D.C. current gain						
$I_C = 4,5$ A; $V_{CE} = 5$ V	h_{FE}	>	2,25	2,25	–	
$I_C = 3,0$ A; $V_{CE} = 5$ V	h_{FE}	>	–	–	2,25	
Emitter-base voltage						
$I_C = 0$; $I_E = 10$ mA	$+V_{EBO}$	>	5	5	5	V
$I_C = 0$; $I_E = 100$ mA	$+V_{EBO}$	typ.	7	7	7	V
Saturation voltage						
$I_C = 4,5$ A; $I_B = 2$ A	V_{CEsat}	<	5	5	–	V
$I_C = 3,0$ A; $I_B = 1,3$ A	V_{CEsat}	<	–	–	5	V
$I_C = 4,5$ A; $I_B = 2$ A	V_{BEsat}	<	1,5	1,5	–	
$I_C = 3,0$ A; $I_B = 1,3$ A	V_{BEsat}	<	–	–	1,5	V
Collector-emitter sustaining voltage						
$I_B = 0$; $I_C = 100$ mA; L = 25 mH	$V_{CEOsust}$	>	600	700	800	V



Oscilloscope display for $V_{CEOsust}$



Test circuit for $V_{CEOsust}$

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

Transition frequency at f = 5 MHz

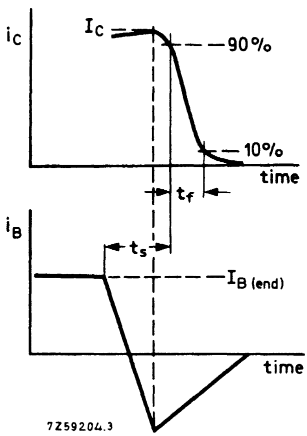
I_C = 0,1 A; V_{CE} = 5 V	f_T	typ.	7	MHz

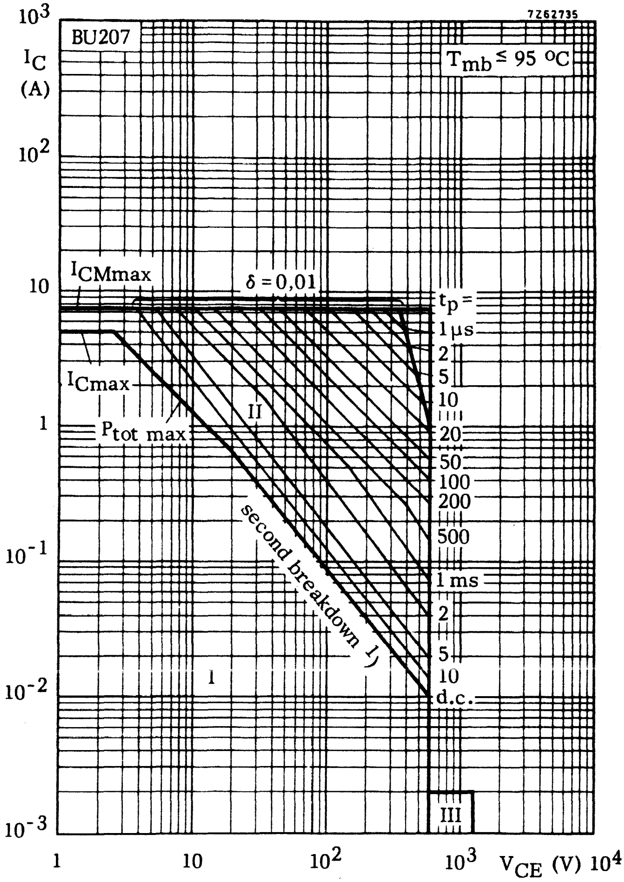
Collector capacitance at f = 1 MHz

$I_E = I_e$ = 0; V_{CB} = 10 V	C_c	typ.	125	pF

Switching times (in line deflection circuit)

			BU207	BU208	BU209	
L_B = 10 μH						
I_C = 4,5 A; $I_{B(end)}$ = 1,8 A	t_f	typ.	0,9	0,7	-	μs
I_C = 3,0 A; $I_{B(end)}$ = 1,3 A	t_f	typ.	-	-	0,7	μs
I_C = 4,5 A; $I_{B(end)}$ = 1,8 A	t_s	typ.	10	10	-	μs
I_C = 3,0 A; $I_{B(end)}$ = 1,3 A	t_s	typ.	-	-	10	μs





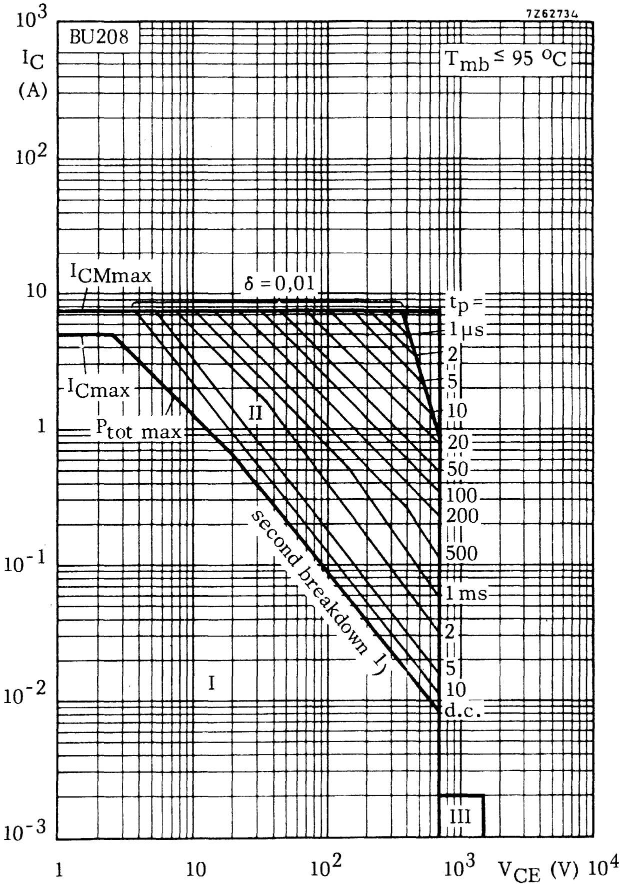
Safe Operating Area with the transistor forward biased.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 100\ \Omega$; $t_p \leq 20\ \mu s$; $\delta \leq 0,25$.

Note

Information on picture tube arcing is available.

1) Independent of temperature.



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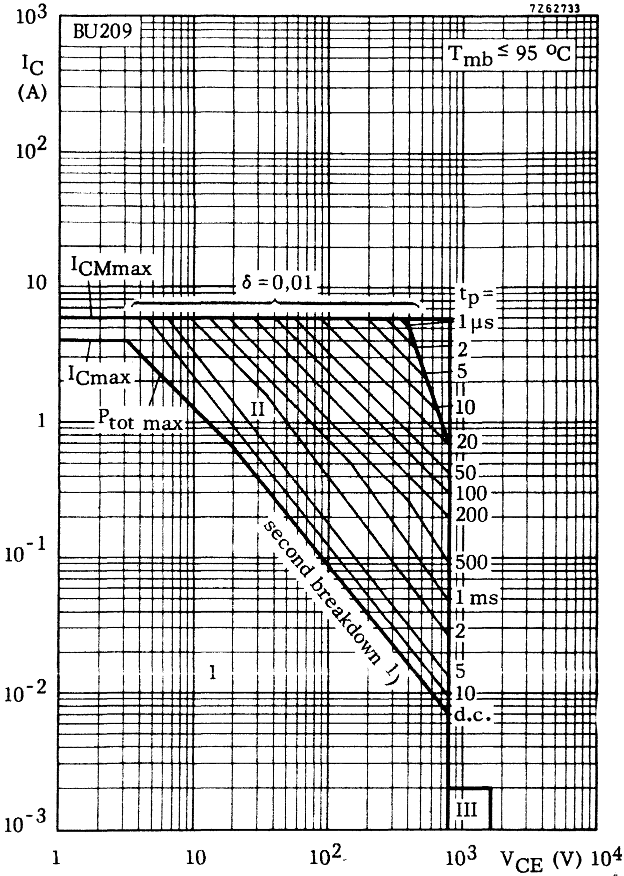

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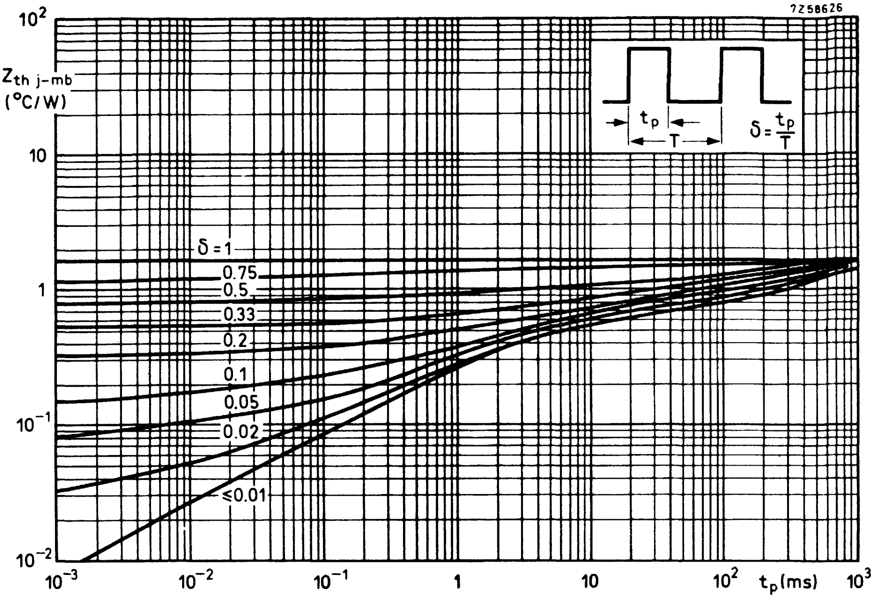
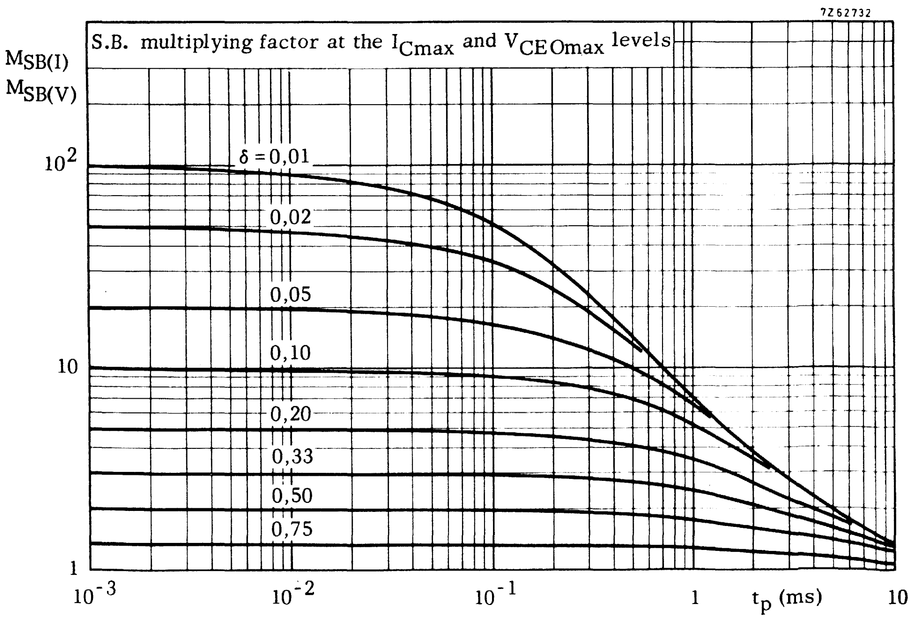
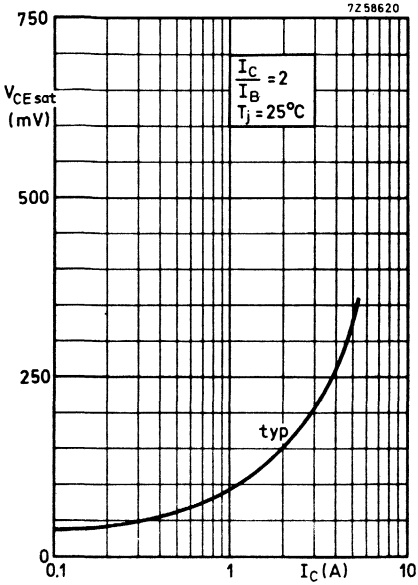
Note

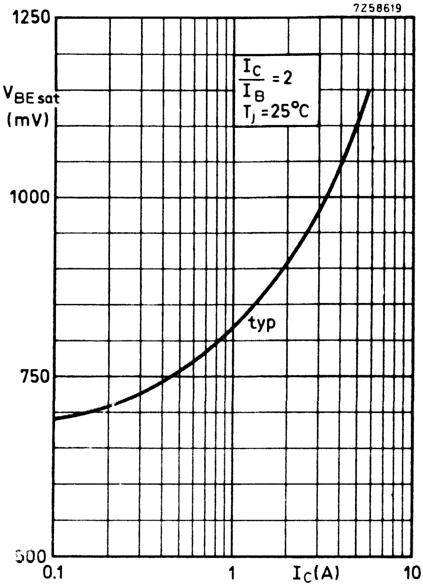
Information on picture tube arcing is available.

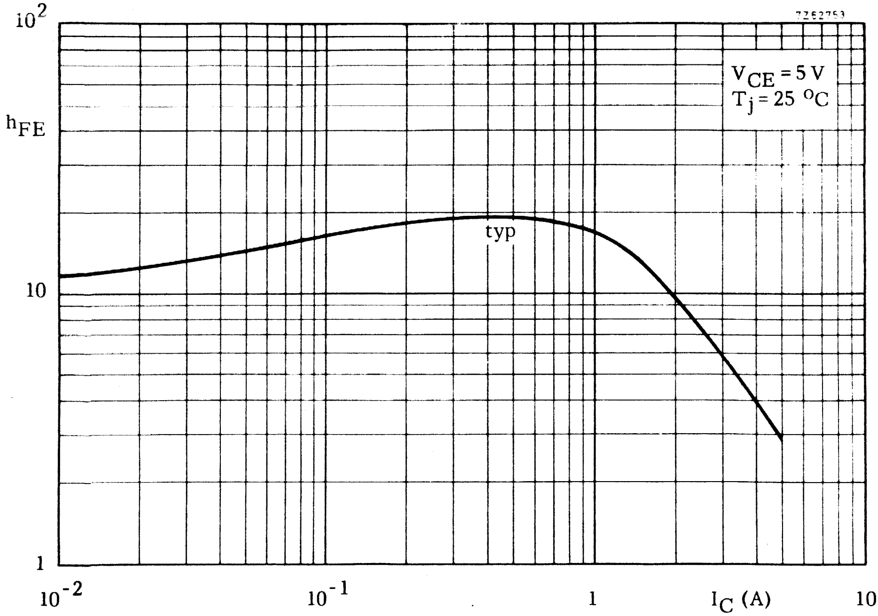
1) Independent of temperature.


7Z58626
10^2
$Z_{th\ j-mb}$ (°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


7Z62732
S.B. multiplying factor at the I_{Cmax} and V_{CEOmax} levels
$M_{SB(I)}$
$M_{SB(V)}$
10^2
10
1
$\delta = 0,01$
0,02
0,05
0,10
0,20
0,33
0,50
0,75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10


7Z58620
750
500
250
0
$V_{CE\,sat}$
(mV)
$\frac{I_C}{I_B} = 2$
$T_j = 25\,^{\circ}C$
typ
0.1
1
I_C (A)
10


7Z58619
1250
1000
750
500
$V_{BE\,sat}$
(mV)
$\frac{I_C}{I_B} = 2$
$T_j = 25\,^{\circ}C$
typ
0.1
1
I_C (A)
10


10^2
h_{FE}
10
1
$V_{CE} = 5$ V
$T_j = 25\,^{\circ}C$
typ
10^{-2}
10^{-1}
1
I_C (A)
10

Accessories

Introduction

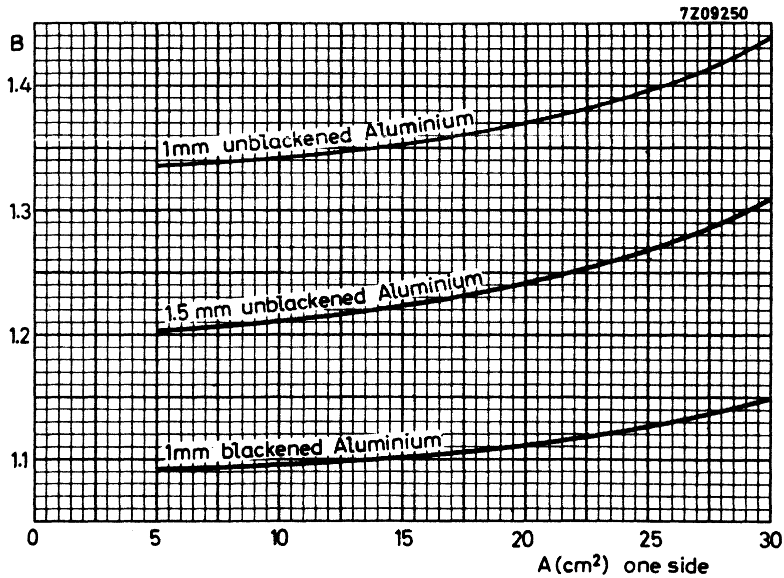
All information on thermal resistances of the accessories combined with flat heatsinks is valid for square heatsinks of 1.5 mm blackened aluminium.
For a few variations the thermal resistance may be derived as follows:

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 thinner heatsinks

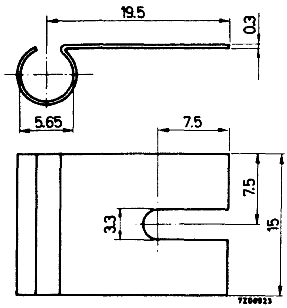
Multiply by the factor B given below as a function of the heatsink size A.



COOLING FIN

MECHANICAL DATA

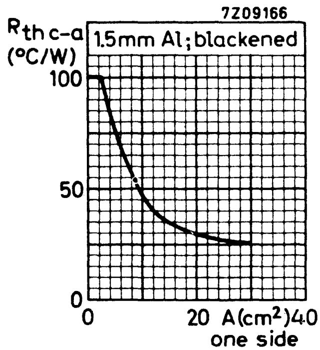
Dimensions in mm



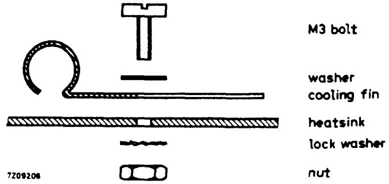
Fin material: brass, nickel plated

THERMAL RESISTANCE

From case to ambient with cooling fin only	$R_{th\ c\text{-}a}$	= 100 °C/W
with heatsink		see graph



MOUNTING INSTRUCTIONS

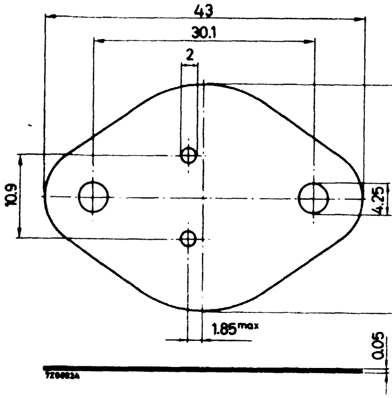


Torque on nut for good heat transfer: 5 cm kg

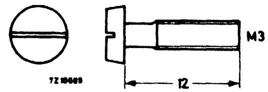
MOUNTING ACCESSORIES

MECHANICAL DATA

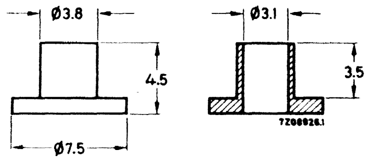
Dimensions in mm



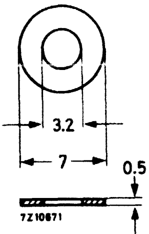
mica washer



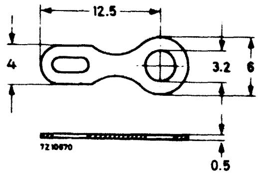
2 cheese head screws, slotted
material: brass, nickel plated



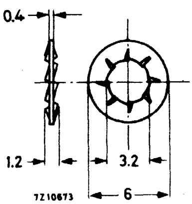
2 insulating bushes



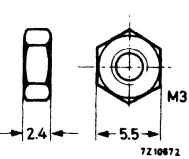
3 plain washers
material: brass, nickel plated



soldering tag



2 lock washers, internal teeth
material: steel, nickel plated



2 hexagon nuts
material: brass, nickel plated

THERMAL RESISTANCE

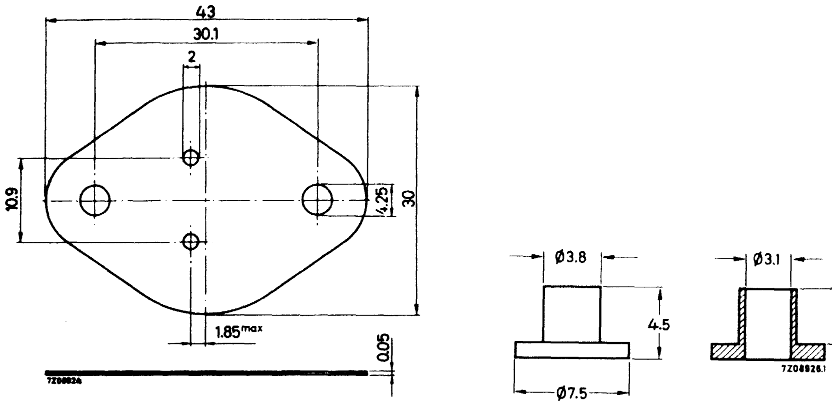
From mounting base to heatsink with mica washer $R_{th\ mb\text{-}h}$ = 1.0 °C/W

TEMPERATURES

Maximum allowable temperature T_{max} = 150 °C

56201a MICA WASHER AND 2 INSULATING BUSHES

MECHANICAL DATA Dimensions in mm

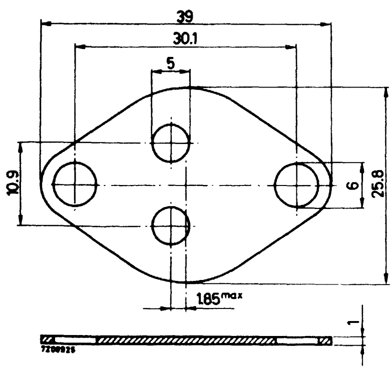


THERMAL RESISTANCE

From mounting base to heatsink $R_{th\ mb\text{-}h}$ = 1.0 $^{o}C/W$

56201b LEAD WASHER

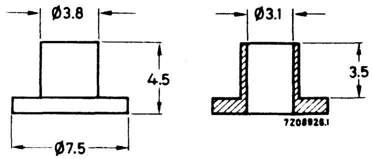
MECHANICAL DATA Dimensions in mm



56201c INSULATING BUSH

MECHANICAL DATA

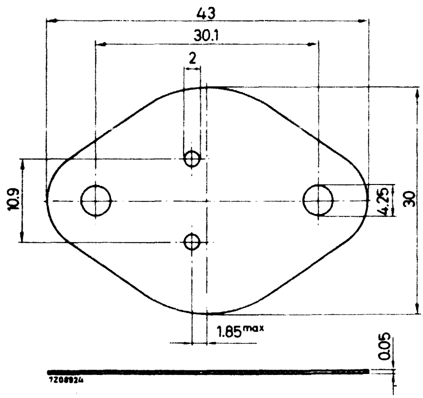
Dimensions in mm



56201d MICA WASHER

MECHANICAL DATA

Dimensions in mm

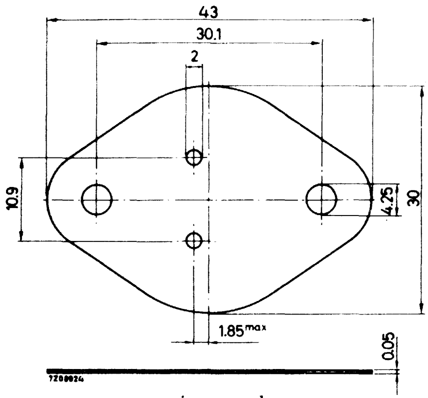


THERMAL RESISTANCE

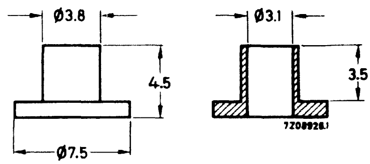
From mounting base to heatsink $R_{th\ mb\text{-}h}$ = 1.0 °C/W

MOUNTING ACCESSORIES

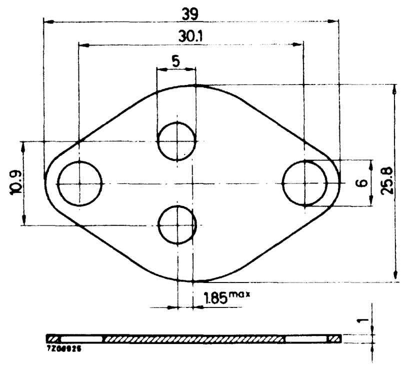
MECHANICAL DATA Dimensions in mm



mica washer



2 insulating bushes



lead washer

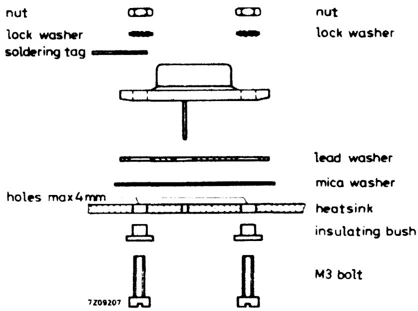
THERMAL RESISTANCE

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



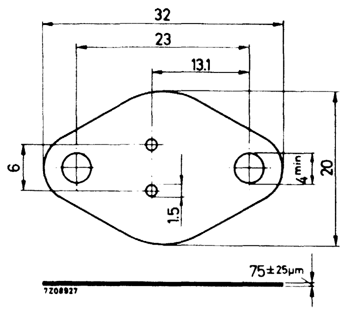
Torque on nut for good heat transfer : 5 cm kg

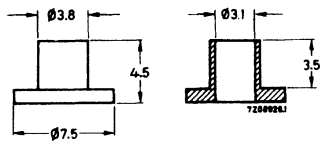
Warning: A plain washer shall be inserted between M3 bolt and insulating bush to prevent this insulating bush from being damaged.

MICA WASHER AND 2 INSULATING BUSHES

MECHANICAL DATA

Dimensions in mm





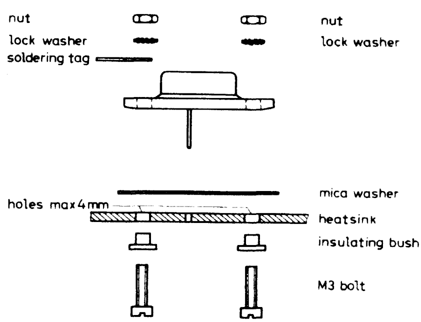
THERMAL RESISTANCE

From mounting base to heatsink $R_{th\ mb\text{-}h}$ = 1.5 °C/W

TEMPERATURE

Maximum allowable temperature T_{max} = 150 °C

MOUNTING INSTRUCTIONS



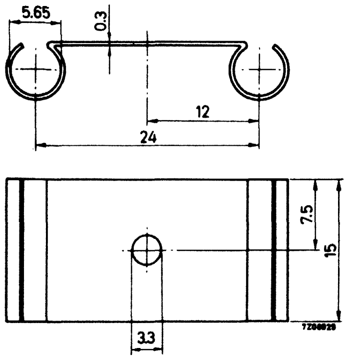
Torque on nut for good heat transfer: 5 cm kg

Warning: A plain washer shall be inserted between M3 bolt and insulating bush to prevent this insulating bush from being damaged.

COOLING FIN

MECHANICAL DATA

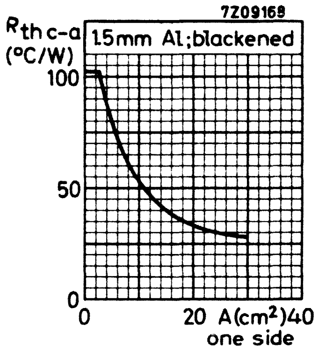
Dimensions in mm



Fin material: brass, nickel plated

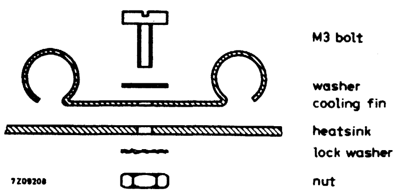
THERMAL RESISTANCE

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

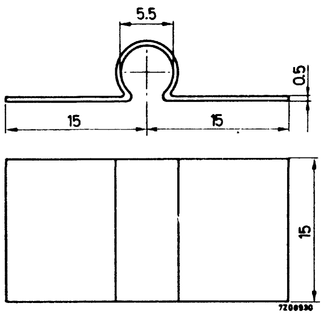


Torque on nut for good heat transfer: 5 cm kg

COOLING FIN

MECHANICAL DATA

Dimensions in mm



Fin material: brass, nickel plated

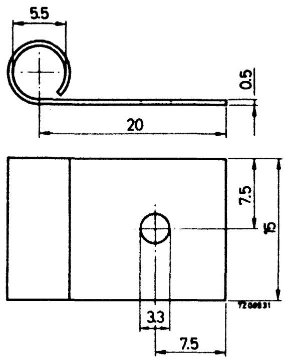
THERMAL RESISTANCE

From case to ambient with cooling fin only $R_{th\ c\text{-}a}$ = 75 $^{o}C/W$

COOLING FIN

MECHANICAL DATA

Dimensions in mm

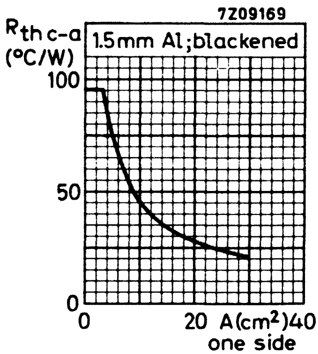


Fin material: brass, nickel plated

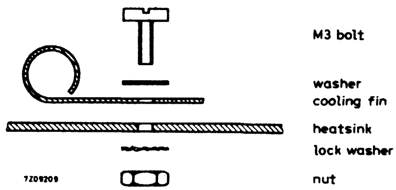
THERMAL RESISTANCE

From case to ambient with cooling fin only $R_{th\ c\text{-}a}$ = 95 °C/W

with heatsink see graph



MOUNTING INSTRUCTIONS

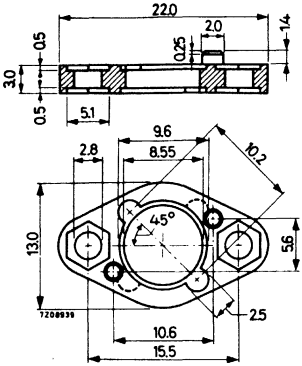


Torque on nut for good heat transfer: 5 cm kg

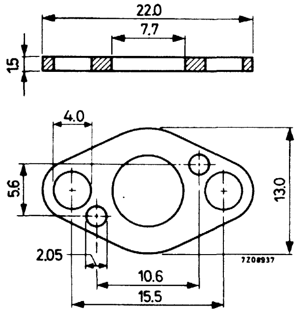
MOUNTING ACCESSORIES

MECHANICAL DATA

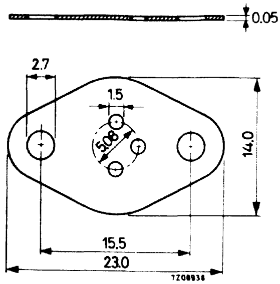
Dimensions in mm



top clamping washer
of insulating material



bottom clamping washer
material: brass, tin plated



mylar washer

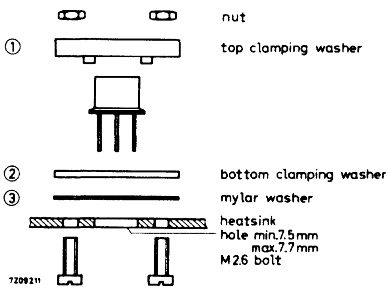
THERMAL RESISTANCE

From mounting base to heatsink	non insulated mounting	$R_{th\ mb-h}$	= 3	$^oC/W$
	insulated mounting	$R_{th\ mb-h}$	= 6	$^oC/W$

TEMPERATURE

Maximum allowable temperature T_{max} = 100 ^oC

MOUNTING INSTRUCTIONS

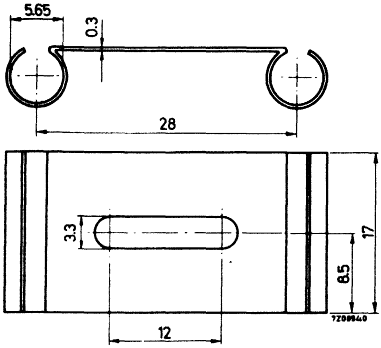


Non insulated mounting; without items 2 and 3. (Note: item 1 must than be mounted up-side down)

COOLING FIN

MECHANICAL DATA

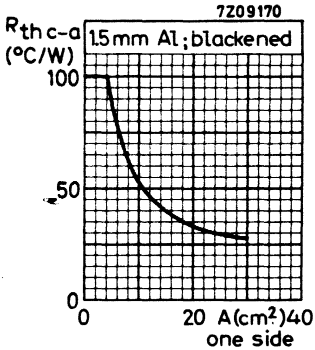
Dimensions in mm



Fin material: brass, nickel plated

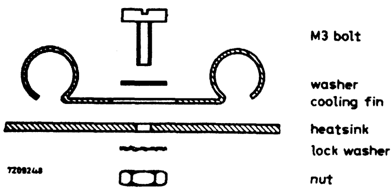
THERMAL RESISTANCE

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

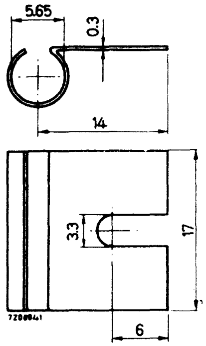


Torque on nut for good heat transfer: 5 cmkg

COOLING FIN

MECHANICAL DATA

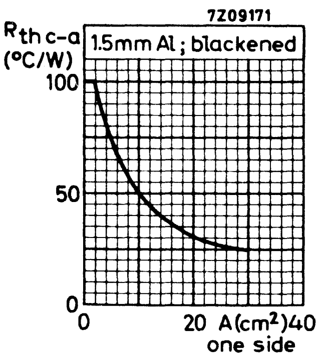
Dimensions in mm



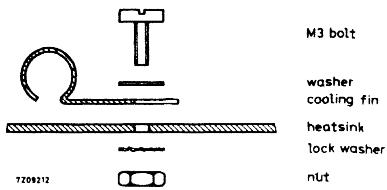
Fin material: brass, nickel plated

THERMAL RESISTANCE

From case to ambient with cooling fin only — $R_{th\ c\text{-}a}$ = 100 °C/W
with heatsink — see graph



MOUNTING INSTRUCTIONS

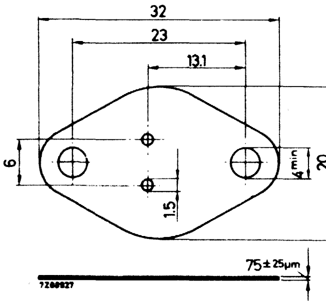


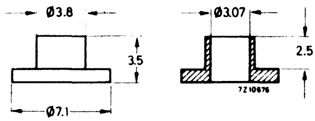
Torque on nut for good heat transfer: 5 cm kg

MICA WASHER AND 2 INSULATING BUSHES

56239

MECHANICAL DATA Dimensions in mm





THERMAL RESISTANCE

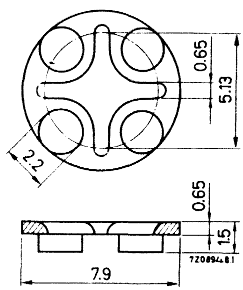
From mounting base to heatsink $R_{th\ mb-h}$ = 1.5 $^{o}C/W$

TEMPERATURE

Maximum allowable temperature T_{max} = 150 ^{o}C

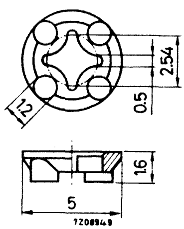
DISTANCE DISCS

56245



Insulating material

56246



Insulating material

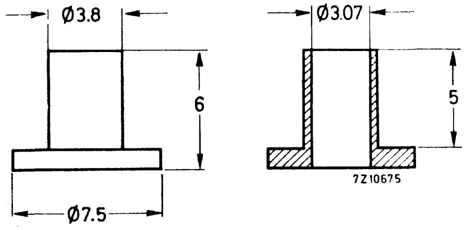
TEMPERATURE

Maximum allowable temperature T_{max} = 100 ^{o}C

2 INSULATING BUSHES

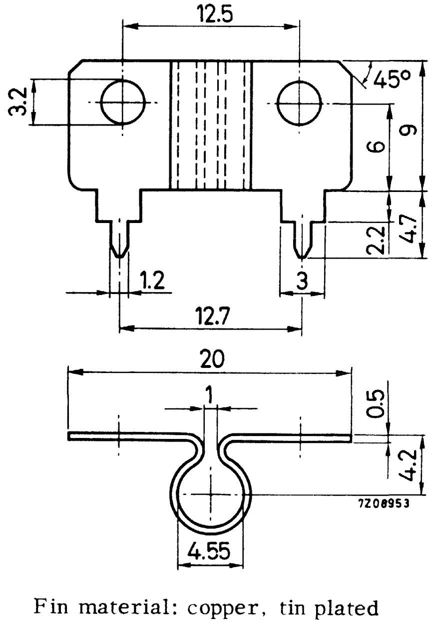
56261

MECHANICAL DATA Dimensions in mm



56263 COOLING FIN

MECHANICAL DATA Dimensions in mm



Fin material: copper, tin plated

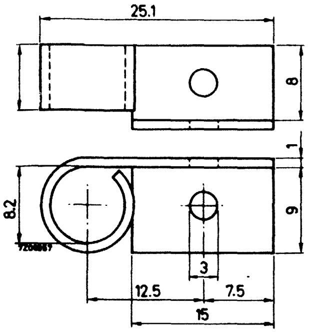
THERMAL RESISTANCE

From case to ambient $R_{th\ c-a}$ = 100 °C/W

COOLING FIN

MECHANICAL DATA

Dimensions in mm

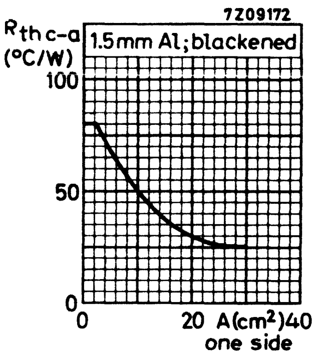


Fin material: aluminium, blackened

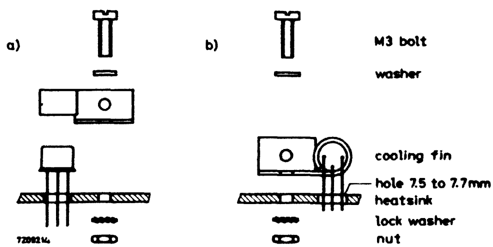
THERMAL RESISTANCE

From case to ambient with cooling fin only — $R_{th\ c-a}$ = 80 °C/W

with heatsink — see graph



MOUNTING INSTRUCTIONS

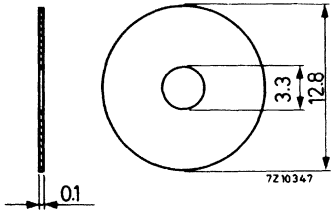


Torque on nut for good heat transfer: 5 cm kg

56302 MICA WASHER

MECHANICAL DATA

Dimensions in mm



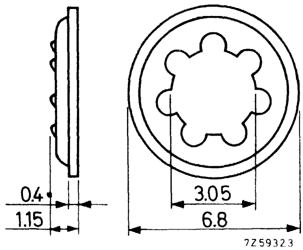
THERMAL RESISTANCE

From mounting base to heatsink $R_{th\ mb\text{-}h}$ = 6 °C/W

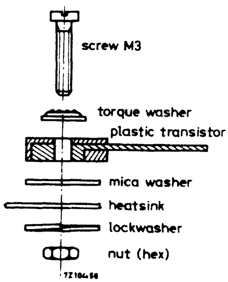
56303 TORQUE WASHER

MECHANICAL DATA

Dimensions in mm



MOUNTING INSTRUCTIONS



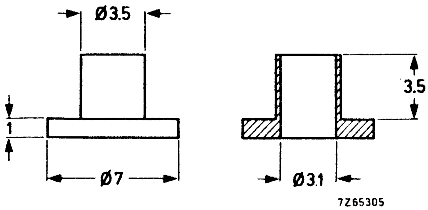
Torque on nut: see data of relevant transistor.

INSULATING BUSH

56324

MECHANICAL DATA

Dimensions in mm

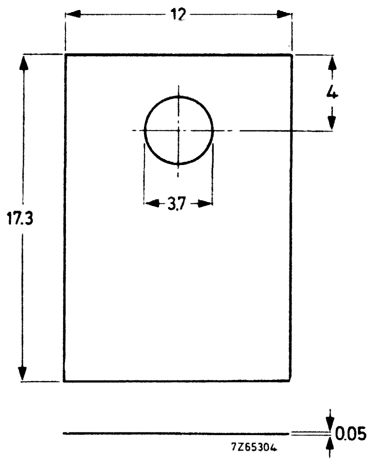


MICA INSULATOR

56325

MECHANICAL DATA

Dimensions in mm



THERMAL RESISTANCE

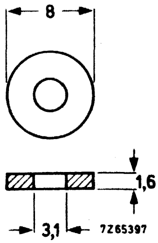
From mounting base to heatsink $R_{th\ mb\text{-}h}$ = 2.5 °C/W

WASHER

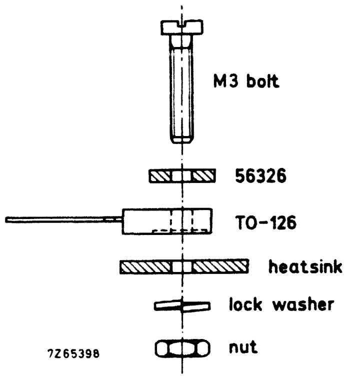
Flat metal washer for non-insulated mounting of envelope SOT-32 (TO-126).

MECHANICAL DATA

Dimensions in mm



MOUNTING INSTRUCTIONS



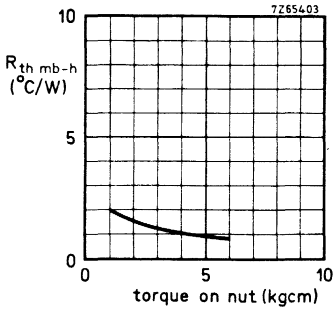
Minimum torque on nut for good heat transfer	4 kgcm (0, 4 Nm)
Maximum torque on nut	6 kgcm (0, 6 Nm)
Minimum thickness of heatsink	2 mm

The heatsink surface must appear flat and smooth, without burrs or scratches. If the hole in the heatsink is threaded, it should be countersunk and free of burrs; the hole should also be perpendicular to the plane of the heatsink, within 2^o tolerance (for M3 thread).
For mounting on a heatsink the use of a heat conducting compound is recommended.

THERMAL RESISTANCE

From mounting base to heatsink $R_{th\ mb\text{-}h}$ = 1 $^{o}C/W$

See also the graph.

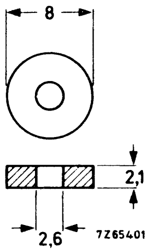


MOUNTING ACCESSORIES

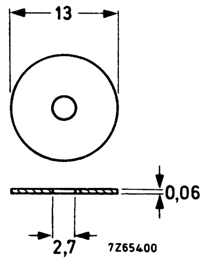
Mounting accessories for insulated mounting of envelope SOT-32 (TO-126); the set con-consists of a metal washer, a mica washer and an insulating bush.

MECHANICAL DATA

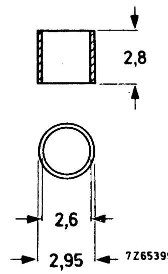
Dimensions in mm



Metal washer

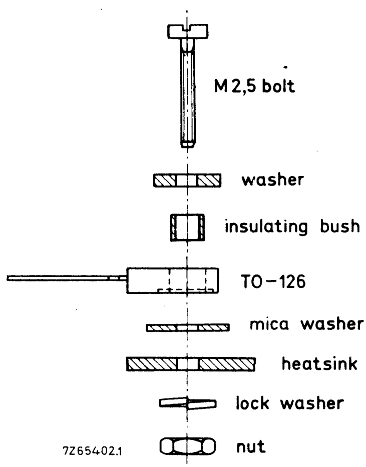


Mica washer



Insulating bush

MOUNTING INSTRUCTIONS



Minimum torque on nut for good heat transfer	4 kgcm (0, 4 Nm)
Maximum torque on nut	6 kgcm (0, 6 Nm)
Minimum thickness of heatsink	2 mm

MOUNTING INSTRUCTIONS (continued)

The heatsink surface must appear flat and smooth, without burrs or scratches. If the hole in the heatsink is threaded, it should be countersunk and free of burrs; the hole should also be perpendicular to the plane of the heatsink, within 10^{o} tolerance (for M2,5 thread). For good heat transfer the use of a heat conducting compound is recommended.

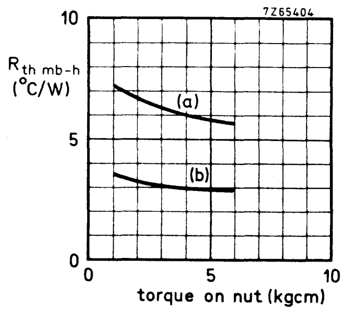
THERMAL RESISTANCE

From mounting base to heatsink

(a) without heat conducting compound — $R_{th\ mb-h}$ = 6 °C/W

(b) with heat conducting compound — $R_{th\ mb-h}$ = 3 °C/W

See also the graph.



INDEX OF TYPE NUMBERS

The inclusion of a type number in this publication does not necessarily imply its availability.

Type No.	Part	Section	Type No.	Part	Section	Type No.	Part	Section
AA119	1b	GePC	AF114	3	HF	ASZ15	2	P
AAY21	1b	GePC	AF115	3	HF	ASZ16	2	P
AAY30	1b	GeGB	AF116	3	HF	ASZ17	2	P
AAY32	1b	GeGB	AF117	3	HF	ASZ18	2	P
AAY39	4	Mw	AF118	3	HF	ASZ20	3	Sw
AAY39A	4	Mw	AF121	3	HF	ASZ21	3	Sw
AAY59	4	Mw	AF124	3	HF	BA100	1b	SiA
AAZ13	1b	GeGB	AF125	3	HF	BA102	1b	T
AAZ15	1b	GeGB	AF126	3	HF	BA114	1b	SiA
AAZ17	1b	GeGB	AF127	3	HF	BA145	1a	R
AAZ18	1b	GeGB	AF139	3	HF	BA148	1a	R
AC125	2	LF	AF178	3	HF	BA182	1b	T
AC126	2	LF	AF239	3	HF	BA216	1b	SiW
AC127	2	LF	AF239S	3	HF	BA217	1b	SiW
AC127/01	2	LF	AF240	3	HF	BA218	1b	SiW
AC128	2	LF	AF267	3	HF	BA219	1b	SiW
AC128/01	2	LF	AFY16	3	HF	BA220	1b	SiW
AC132	2	LF	AFY19	4	Tr	BA221	1b	SiW
AC132/01	2	LF	AFY40	3	HF	BA222	1b	SiW
			AFZ12	3	HF	BA314	1b	SiW
AC187	2	LF	ASY26	3	Sw	BA315	1b	SiW
AC187/01	2	LF	ASY27	3	Sw	BA316	1b	SiW
AC188	2	LF	ASY28	3	Sw	BA317	1b	SiW
AC188/01	2	LF	ASY29	3	Sw	BA318	1b	SiW
			ASY73	3	Sw	BAV10	1b	SiW
AD161	2	P	ASY74	3	Sw	BAV18	1b	SiW
AD162	2	P	ASY75	3	Sw	BAV19	1b	SiW
AEY13	4	Mw	ASY76	3	Sw	BAV20	1b	SiW
AEY15	4	Mw	ASY77	3	Sw	BAV21	1b	SiW
AEY16	4	Mw	ASY80	3	Sw	BAV40	1b	Sp

GeGB = Germanium gold bonded diodes
GePC = Germanium point contact diodes
HF = High frequency transistors
LF = Low frequency transistors
Mw = Microwave devices
P = Low frequency power transistors
R = Rectifier diodes
SiA = Silicon alloyed diodes
SiW = Silicon whiskerless diodes
Sp = Special diodes
Sw = Switching transistors
T = Tuner diodes
Tr = Transmitting transistors

Type No.	Part	Section	Type No.	Part	Section	Type No.	Part	Section
BAV41	1b	Sp	BC149	2	LF	BCW58	2	LF
BAV42	1b	Sp	BC157	2	LF	BCW59	2	LF
BAV43	1b	Sp	BC158	2	LF	BCW69	4	Mm
BAV45	1b	Sp	BC159	2	LF	BCW70	4	Mm
BAW56	4	Mm	BC177	2	LF	BCW71	4	Mm
BAW62	1b	SiW	BC178	2	LF	BCW72	4	Mm
BAW95D	4	Mw	BC179	2	LF	BCY10	2	LF
BAW95E	4	Mw	BC200	2	LF	BCY11	2	LF
BAW95F	4	Mw	BC237	2	LF	BCY12	2	LF
BAX12	1b	SiW	BC238	2	LF	BCY30	2	LF
BAX13	1b	SiW	BC239	2	LF	BCY31	2	LF
BAX14	1b	SiW	BC307	2	LF	BCY32	2	LF
BAX15	1b	SiW	BC308	2	LF	BCY33	2	LF
BAX16	1b	SiW	BC309	2	LF	BCY34	2	LF
BAX17	1b	SiW	BC327	2	LF	BCY38	2	LF
BAX18	1	SiW	BC328	2	LF	BCY39	2	LF
BAY66	4	Mw	BC337	2	LF	BCY40	2	LF
BAY96	4	Mw	BC338	2	LF	BCY54	2	LF
BB104B	1b	T	BC547	2	LF	BCY55	4	Dual
BB104C	1b	T	BC548	2	LF	BCY56	2	LF
12-BB105A	1b	T	BC549	2	LF	BCY57	2	LF
12-BB105B	1b	T	BC557	2	LF	BCY58	2	LF
12-BB105G	1b	T	BC558	2	LF	BCY59	2	LF
3-BB106	1b	T	BC559	2	LF	BCY70	2	LF
4-BB106	1b	T	BCW29	4	Mm	BCY71	2	LF
BB110B	1b	T	BCW30	4	Mm	BCY72	2	LF
BB110G	1b	T	BCW31	4	Mm	BCY87	4	Dual
BB113	1b	T	BCW32	4	Mm	BCY88	4	Dual
BB117	1b	T	BCW33	4	Mm	BCY89	4	Dual
BC107	2	LF	BCW46	2	LF	BCZ10	2	LF
BC108	2	LF	BCW47	2	LF	BCZ11	2	LF
BC109	2	LF	BCW48	2	LF	BCZ12	2	LF
BC146	2	LF	BCW49	2	LF	BD115	2	P
BC147	2	LF	BCW56	2	LF	BD131	2	P
BC148	2	LF	BCW57	2	LF	BD132	2	P

Dual = Dual transistors
LF = Low frequency transistors
Mm = Microminiature devices for thick-and thin-film circuits
Mw = Microwave devices
P = Low frequency power transistors
SiW = Silicon whiskerless diodes
Sp = Special diodes
T = Tuner diodes

Type No.	Part	Section	Type No.	Part	Section	Type No.	Part	Section
BD133	2	P	BDY61	2	P	BF336	3	HF
BD135	2	P	BDY90	2	P	BF337	3	HF
BD136	2	P	BDY91	2	P	BF338	3	HF
BD137	2	P	BDY92	2	P	BFR29	4	FET
BD138	2	P	BDY93	2	P	BFR30	4	Mm
BD139	2	P	BDY94	2	P	BFR31	4	Mm
BD140	2	P	BDY95	2	P	BFR63	3	HF
BD181	2	P	BDY96	2	P	BFR64	3	HF
BD182	2	P	BDY97	2	P	BFR65	3	HF
BD183	2	P	BDY98	2	P	BFS17	4	Mm
BD201	2	P	BF115	3	HF	BFS18	4	Mm
BD202	2	P	BF167	3	HF	BFS19	4	Mm
BD203	2	P	BF173	3	HF	BFS20	4	Mm
BD204	2	P	BF179	3	HF	BFS21	4	FET
BD226	2	P	–	-	–	BFS21A	4	FET
BD227	2	P	BF180	3	HF	BFS22A	4	Tr
BD228	2	P	BF181	3	HF	BFS23A	4	Tr
BD229	2	P	BF177	3	HF	BFS28	4	FET
BD230	2	P	BF178	3	HF	BFS92	3	HF
BD231	2	P	–	–	–	BFS93	3	HF
BD233	2	P	BF182	3	HF	BFS94	3	HF
BD234	2	P	BF183	3	HF	BFS95	3	HF
BD235	2	P	BF184	3	HF	BFW10	4	FET
BD236	2	P	BF185	3	HF	BFW11	4	FET
BD237	2	P	BF194	3	HF	BFW12	4	FET
BD238	2	P	BF195	3	HF	BFW13	4	FET
BD433	2	P	BF196	3	HF	BFW16A	3	HF
BD434	2	P	BF197	3	HF	BFW17A	3	HF
BD435	2	P	BF198	3	HF	BFW30	3	HF
BD436	2	P	BF199	3	HF	BFW45	2	Defl
BD437	2	P	BF200	3	HF	BFW61	4	FET
BD438	2	P	BF254	3	HF	BFW92	3	HF
BDY20	2	P	BF255	3	HF	BFX34	3	Sw
BDY38	2	P	BF334	3	HF	BFX44	3	HF
BDY60	2	P	BF335	3	HF	BFX89	3	HF

Defl = Deflection transistors
FET = Field effect transistors
HF = High frequency transistors
Mm = Microminiature devices for thick-and thin-film circuits
P = Low frequency power transistors
Sw = Switching transistors
Tr = Transmitting transistors

Type No.	Part	Section	Type No.	Part	Section	Type No.	Part	Section
BFY44	4	Tr	BRY39(SCS)	3	Sw	BT102series	1a	Thyr
BFY50	3	HF	BRY39(PUT)	3	Sw	BTW23series	1a	Thyr
BFY51	3	HF	BSS27	3	Sw	BTW24series	1a	Thyr
BFY52	3	HF	BSS28	3	Sw	BTW30series	1a	Thyr
BFY55	3	HF	BSS29	3	Sw	BTW31series	1a	Thyr
BFY70	4	Tr	BSV52	4	Mm	BTW32series	1a	Thyr
BFY90	3	HF	BSV64	3	Sw	BTW33series	1a	Thyr
BLX13	4	Tr	BSV68	3	Sw	BTW34series	1a	Thyr
BLX14	4	Tr	BSV78	4	FET	BTW47series	1a	Thyr
BLX69	4	Tr	BSV79	4	FET	BTW92series	1a	Thyr
BLY14	4	Tr	BSV80	4	FET	BTX18series	1a	Thyr
BLY17	4	Tr	BSV81	4	FET	BTX41series	1a	Thyr
BLY83	4	Tr	BSV86	3	Sw	BTX94series	1a	Thyr
BLY84	4	Tr	BSV87	3	Sw	BTX95series	1a	Thyr
BLY87A	4	Tr	BSV88	3	Sw	BTY79series	1a	Thyr
BLY88A	4	Tr	BSV96	3	Sw	BTY87series	1a	Thyr
BLY89A	4	Tr	BSV97	3	Sw	BTY91series	1a	Thyr
BLY90	4	Tr	BSV98	3	Sw	BU105	2	Defl
BLY91A	4	Tr	BSW41	3	Sw	BU108	2	Defl
BLY92A	4	Tr	BSW66	3	Sw	BU126	2	Defl
BLY93A	4	Tr	BSW67	3	Sw			
BLY94	4	Tr	BSW68	3	Sw	BU132	2	Defl
BPX25; 29	4	PhDT	BSW69	3	Sw	BU133	2	P
BPX40	4	PhDT	BSX12	3	Sw	BU204	2	Defl
BPX41	4	PhDT	BSX12A	3	Sw	BU205	2	Defl
BPX42	4	PhDT	BSX19	3	Sw	BU206	2	Defl
BPX66P	4	PhDT	BSX20	3	Sw	BU207	2	Defl
BPX71	4	PhDT	BSX21	3	Sw	BU208	2	Defl
BPY10	4	PhDT	BSX59	3	Sw	BU209	2	Defl
BPY68	4	PhDT	BSX60	3	Sw	BXY27	4	Mw
BPY69	4	PhDT	BSX61	3	Sw	BXY28	4	Mw
BPY76	4	PhDT	BSY38	3	Sw	BXY29	4	Mw
BPY77	4	PhDT	BSY39	3	Sw	BXY32	4	Mw
BR100	1a	Thyr	BT100Aseries	1a	Thyr	BY126	1a	R
BRY39	1a	Thyr	BT101series	1a	Thyr	BY127	1a	R

Defl = Deflection transistors
FET = Field effect transistors
HF = High frequency transistors
PhDT = Photodiodes and transistors
Mm = Microminiature devices for thick-and thin-film circuits
Mw = Microwave devices
R = Rectifier diodes
Sw = Switching transistors
Thyr = Thyristors, diacs, triacs
Tr = Transmitting transistors

Type No.	Part	Section	Type No.	Part	Section	Type No.	Part	Section
BY164	1a	R	BZX49	1b	Vref	CXY10	4	Mw
BY176	1a	R	BZX50	1b	Vref	CXY11A	4	Mw
BY179	1a	R	BZX61series	1b	Vreg	CXY11B	4	Mw
BY184	1a	R	BZX70series	1a	Vreg	CXY11C	4	Mw
BY185	1a	R	BZX75series	1b	Vreg	CXY12	4	Mw
BY187	1a	R	BZX79series	1b	Vreg	OA47	1b	GeGB
BY188	1a	R	BZX84series	4	Mm	OA90	1b	GePC
BY206	1a	R	BZX90	1b	Vref	OA91	1b	GePC
BYX10	1a	R	BZX91	1b	Vref	OA95	1b	GePC
BYX13series	1a	R	BZX92	1b	Vref	OA200	1b	SiA
BYX22series	1a	R	BZX93	1b	Vref	OA202	1b	SiA
BYX25series	1a	R	BZY78	1b	Vref	OAP12	4	PhDT
BYX29series	1a	R	BZY88series	1b	Vref	OC122	3	Sw
BYX30series	1a	R	BZY91series	1a	Vreg	OC123	3	Sw
BYX32series	1a	R	BZY93series	1a	Vreg	OC139	3	Sw
BYX35	1a	R	BZY95series	1a	Vreg	OC140	3	Sw
BYX36series	1a	R	BZY96series	1a	Vreg	OC141	3	Sw
BYX38series	1a	R	BZZ14	1a	Vreg	OCP70	4	PhDT
BYX39series	1a	R	BZZ15	1a	Vreg	ORP10	4	I
BYX40series	1a	R	BZZ16	1a	Vreg	ORP13	4	I
BYX42series	1a	R	BZZ17	1a	Vreg	ORP30N	4	PhC
BYX45series	1a	R	BZZ18	1a	Vreg	ORP50	4	PhC
BYX46series	1a	R	BZZ19	1a	Vreg	ORP52	4	PhC
BYX48series	1a	R	BZZ20	1a	Vreg	ORP60	4	PhC
BYX49series	1a	R	BZZ21	1a	Vreg	ORP61	4	PhC
BYX50series	1a	R	BZZ22	1a	Vreg	ORP62	4	PhC
BYX52series	1a	R	BZZ23	1a	Vreg	ORP63	4	PhC
BYX55series	1a	R	BZZ24	1a	Vreg	ORP69	4	PhC
BYX56series	1a	R	BZZ25	1a	Vreg	ORP90	4	PhC
BYX59series	1a	R	BZZ26	1a	Vreg	OSB9110	1a	St
BYX71series	1a	R	BZZ27	1a	Vreg	OSB9210	1a	St
BZW86series	1a	TS	BZZ28	1a	Vreg	OSB9310	1a	St
BZW91series	1a	TS	BZZ29	1a	Vreg	OSB9410	1a	St
BZW93series	1a	TS	CAY10	4	Mw	OSM9110	1a	St
BZX48	1b	Vref	CQY11B	4	L	OSM9210	1a	St

GeGB = Germanium gold bonded diodes
GePC = Germanium point contact diodes
I = Infrared devices
L = Light emitting devices
Mm = Microminiature devices for thick-and thin-film circuits
Mw = Microwave devices
PhC = Photoconductive devices
PhDT = Photodiodes and phototransistors
SiA = Silicon alloyed diodes
SiW = Silicon whiskerless diodes
St = Rectifier stacks
Sw = Switching transistors
TS = Transient suppressor diodes
Vref = Voltage reference diodes
Vreg = Voltage regulator diodes

Type No.	Part	Section	Type No.	Part	Section	Type No.	Part	Section
OSM9310	1a	St	1N829	1b	Vref	1N5747B	1b	Vreg
OSM9410	1a	St	1N914	1b	SiW	1N5748B	1b	Vreg
OSS9110	1a	St	1N914A	1b	SiW	1N5749B	1b	Vreg
OSS9210	1a	St	1N916	1b	SiW	1N5750B	1b	Vreg
OSS9310	1a	St	1N916A	1b	SiW	1N5751B	1b	Vreg
OSS9410	1a	St	1N916B	1b	SiW	1N5752B	1b	Vreg
OTH1200	1a	Ign	1N4009	1b	SiW	1N5753B	1b	Vreg
RPY13	4	PhC	1N4148	1b	SiW	1N5754B	1b	Vreg
RPY18	4	PhC	1N4150	1b	SiW	1N5755B	1b	Vreg
RPY19	4	PhC	1N4151	1b	SiW	1N5756B	1b	Vreg
RPY20	4	PhC	1N4154	1b	SiW	1N5757B	1b	Vreg
RPY27	4	PhC	1N4446	1b	SiW	2N706A	3	Sw
RPY33	4	PhC	1N4448	1b	SiW	2N708	3	Sw
RPY41	4	PhC	1N5152	4	Mw	2N743	3	Sw
RPY43	4	PhC	1N5153	4	Mw	2N744	3	Sw
RPY55	4	PhC	1N5155	4	Mw	2N753	3	Sw
RPY58	4	PhC	1N5157	4	Mw	2N914	3	Sw
RPY71	4	PhC	1N5729B	1b	Vreg	2N918	3	HF
RPY76A	4	I	1N5730B	1b	Vreg	2N929	2	LF
1N748A	1b	Vreg	1N5731B	1b	Vreg	2N930	2	LF
1N749A	1b	Vreg	1N5732B	1b	Vreg	2N1131	3	Sw
1N750A	1b	Vreg	1N5733B	1b	Vreg	2N1132	3	Sw
1N751A	1b	Vreg	1N5734B	1b	Vreg	2N1302	3	Sw
1N752A	1b	Vreg	1N5735B	1b	Vreg	2N1303	3	Sw
1N753A	1b	Vreg	1N5736B	1b	Vreg	2N1304	3	Sw
1N754A	1b	Vreg	1N5737B	1b	Vreg	2N1305	3	Sw
1N755A	1b	Vreg	1N5738B	1b	Vreg	2N1306	3	Sw
1N756A	1b	Vreg	1N5739B	1b	Vreg	2N1307	3	Sw
1N757A	1b	Vreg	1N5740B	1b	Vreg	2N1308	3	Sw
1N758A	1b	Vreg	1N5741B	1b	Vreg	2N1309	3	Sw
1N759A	1b	Vreg	1N5742B	1b	Vreg	2N1613	3	HF
1N821	1b	Vref	1N5743B	1b	Vreg	2N1711	3	HF
1N823	1b	Vref	1N5744B	1b	Vreg	2N1893	3	HF
1N825	1b	Vref	1N5745B	1b	Vreg	2N2218	3	Sw
1N827	1b	Vref	1N5746B	1b	Vreg	2N2218A	3	Sw

HF = High frequency transistors
I = Infrared devices
Ign = Ignistors
LF = Low frequency transistors
Mw = Microwave devices
PhC = Photoconductive devices
SiW = Silicon whiskerless diodes
St = Rectifier stacks
Sw = Switching transistors
Tr = Transmitting transistors
Vref = Voltage reference diodes
Vreg = Voltage regulator diodes

Type No.	Part	Section	Type No.	Part	Section	Type No.	Part	Section
2N2483	3	HF	2N3772	2	P	56203	2.3.4	A
2N2484	3	HF	2N3823	4	FET	56208	2.3.4	A
2N2894	3	Sw	2N3866	4	Tr	56209	2.3.4	A
2N2894A	3	Sw	2N3924	4	Tr	56210	2.3.4	A
2N2904	3	Sw	2N3926	4	Tr	56218	2.3.4	A
2N2904A	3	Sw	2N3927	4	Tr	56226	2.3.4	A
2N2905	3	Sw	2N3966	4	FET	56227	2.3.4	A
2N2905A	3	Sw	2N4036	3	Sw	56230	1a	HE
2N2906	3	Sw	2N4091	4	FET	56231	1a	HE
2N2906A	3	Sw	2N4092	4	FET	56233	1a	A
2N2219	3	Sw	2N4093	4	FET	56234	1a	A
2N2219A	3	Sw	2N4347	2	P	56239	2.3.4	A
2N2221	3	Sw	2N4391	4	FET	56245	2.3.4	A
2N2221A	3	Sw	2N4392	4	FET	56246	1a to 4	A
2N2222	3	Sw	2N4393	4	FET	56253	1a	DH
2N2222A	3	Sw	2N4427	4	Tr	56256	1a	DH
2N2297	3	HF	2N4856	4	FET	56261	2.3.4	A
2N2368	3	Sw	2N4857	4	FET	56262A	1a	A
2N2369	3	Sw	2N4858	4	FET	56263	1a to 4	A
2N2369A	3	Sw	2N4859	4	FET	56264A	1a	A
2N2907	3	Sw	2N4860	4	FET	56265	2.3.4	A
2N2907A	3	Sw	2N4861	4	FET	56268	1a	DH
2N3055	2	P	61SV	4	I	56271	1a	DH
2N3133	3	Sw	40809	2	LF	56278	1a	DH
2N3134	3	Sw	40819	2	LF	56280	1a	DH
2N3303	3	Sw	40820	3	HF	56284	1a	DH
2N3375	4	Tr	40822	3	HF	56290	1a	HE
2N3426	3	Sw	40829	3	HF	56293	1a	HE
2N3442	2	P	56200	2.3.4	A	56295	1a	A
2N3553	4	Tr	56201	2.3.4	A	56299	1a	A
2N3570	3	HF	56201a	2.3.4	A	56302	2.3.4	A
2N3571	3	HF	56201b	2.3.4	A	56303	2.3.4	A
2N3572	3	HF	56201c	2.3.4	A	56309B	1a	A
2N3632	4	Tr	56201d	2.3.4	A	56309R	1a	A
2N3771	2	P	56201e	2.3.4	A	56311	1a	WH

A = Accessories
DH = Diecast heatsinks
FET = Field effect transistors
HE = Heatsink extrusions
HF = High frequency transistors
I = Infrared devices
LF = Low frequency transistors
P = Low frequency power transistors
Sw = Switching transistors
Tr = Transmitting transistors
WH = Water cooled heatsinks

Type No.	Part	Section
56312	1a	DH
56313	1a	DH
56314	1a	DH
56315	1a	DH
56316	1a	A
56318	1a	DH
56319	1a	DH
56324	2	A
56325	2	A
56326	2	A
56333	2	A
56334	1a	DH

A = Accessories
DH = Diecast heatsinks

MAINTENANCE TYPE LIST

The type numbers listed below are not included in this handbook except for those types marked with an asterisk.

Detailed information will be supplied on request.

AD149	BCY10*
BC237*	BCY11*
BC238*	BCY12*
BC239*	BCZ10*
BC307*	BCZ11*
BC308*	BCZ12*
BC309*	

General

Low frequency transistors

Low frequency power transistors

Deflection transistors

Accessories