Semiconductors and integrated circuits

Part 2 November 1977

Low-frequency and dual transistors

Low-frequency power transistors

SEMICONDUCTORS AND INTEGRATED CIRCUITS

Part 2 November 1977

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.

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ELECTRON TUBES (BLUE SERIES)

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Part 1b	August 1977	ET1b 08-77	**Transmitting tubes for communication, tubes for r.f. heating, amplifier circuit assemblies**
Part 2	May 1976	ET2 05-76	**Microwave products** Communication magnetrons, magnetrons for microwave heating, klystrons, travelling-wave tubes, isolators, circulators, diodes, triodes, T-R switches, microwave semiconductor devices
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Part 7b	March 1977	ET7b 03-77	**Gas-filled tubes** Segment indicator tubes, indicator tubes, switching diodes, dry reed contact units
Part 8	May 1977	ET8 05-77	**TV picture tubes**
Part 9	June 1976	ET9 06-76	**Photomultiplier tubes; phototubes**

SEMICONDUCTORS AND INTEGRATED CIRCUITS (RED SERIES)

Part 1a	**March 1976**	**SC1a 03-76**	**Rectifier diodes, thyristors, triacs** Rectifier diodes, voltage regulator diodes (> 1,5 W), transient suppressor diodes, rectifier stacks, thyristors, triacs
Part 1b	**May 1977**	**SC1b 05-77**	**Diodes** Small signal germanium diodes, small signal silicon diodes, special diodes, voltage regulator diodes (< 1,5 W), voltage reference diodes, tuner diodes
Part 2	**November 1977**	**SC2 11-77**	**Low-frequency and dual transistors**
Part 3	**April 1976**	**SC3 04-76**	**High-frequency and switching transistors**
Part 4a	**June 1976**	**SC4a 06-76**	**Special semiconductors** Transmitting transistors, field-effect transistors, dual transistors, microminiature devices for thick and thin-film circuits
Part 4b	**July 1976**	**SC4b 07-76**	**Devices for optoelectronics** Photosensitive diodes and transistors, light emitting diodes, displays, photocouplers, infrared sensitive devices, photoconductive devices
Part 5a	**November 1976**	**SC5a 11-76**	**Professional analogue integrated circuits**
Part 5b	**March 1977**	**SC5b 03-77**	**Consumer integrated circuits** Radio-audio, television
Part 6	**October 1977**	**SC6 10-77**	**Digital integrated circuits** LOCMOS HE4000B family
Signetics integrated circuits 1976			Logic, Memories, Interface, Analogue, Microprocessor, Milrel

COMPONENTS AND MATERIALS (GREEN SERIES)

Part 1	**June 1977**	**CM1 06-77**	**Assemblies for industrial use** High noise immunity logic FZ/30-series, counter modules 50-series, NORbits 60-series, 61-series, circuit blocks 90-series, circuit block CSA70(L), PLC modules, input/output devices, hybrid circuits, peripheral devices, ferrite core memory products
Part 2a	**October 1977**	**CM2a 10-77**	**Resistors** Fixed resistors, variable resistors, voltage dependent resistors (VDR), light dependent resistors (LDR), negative temperature coefficient thermistors (NTC), positive temperature coefficient thermistors (PTC), test switches
Part 2b	**April 1976**	**CM2b 04-76**	**Capacitors** Electrolytic and solid capacitors, paper capacitors and film capacitors, ceramic capacitors, variable capacitors
Part 3	**January 1977**	**CM3 01-77**	**Radio, audio, television** FM tuners, loudspeakers, television tuners and aerial input assemblies, components for black and white television, components for colour television
Part 4a	**October 1976**	**CM4a 10-76**	**Soft ferrites** Ferrites for radio, audio and television, beads and chokes, Ferroxcube potcores and square cores, Ferroxcube transformer cores
Part 4b	**December 1976**	**CM4b 12-76**	**Piezoelectric ceramics, permanent magnet materials**
Part 5	**July 1975**	**CM5 07-75**	**Ferrite core memory products** Ferroxcube memory cores, matrix planes and stacks, core memory systems
Part 6	**April 1977**	**CM6 04-77**	**Electric motors and accessories** Small synchronous motors, stepper motors, miniature direct current motors
Part 7	**September 1971**	**CM7 09-71**	**Circuit blocks** Circuit blocks 100 kHz-series, circuit blocks 1-series, circuit blocks 10-series, circuit blocks for ferrite core memory drive
Part 8	**February 1977**	**CM8 02-77**	**Variable mains transformers**
Part 9	**March 1976**	**CM9 03-76**	**Piezoelectric quartz devices**
Part 10	**November 1975**	**CM10 11-75**	**Connectors**

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 ($R_{th\ j\text{-}mb} > 15\ ^{o}C/W$)

D Power transistor for a.f. applications ($R_{th\ j\text{-}mb} \leq 15\ ^{o}C/W$)

E Tunnel diode

F Transistor for h.f. applications ($R_{th\ j\text{-}mb} > 15\ ^{o}C/W$)

G Multiple of dissimilar devices (see note on page 1); Miscellaneous

H Magnetic sensitive diode; Field probe

K Hall generator in an open magnetic circuit, e.g. magnetogram or signal probe

L Power transistor for h.f. applications ($R_{th\ j\text{-}mb} \leq 15\ ^{o}C/W$)

M Hall generator in a closed electrically energised magnetic circuit, e.g. Hall modulator or multiplier

N Photocoupler

P Radiation sensitive device [1)]

Q Radiation generating device

R Electrically triggered controlling and switching device having a breakdown characteristic ($R_{th\ j\text{-}mb} > 15\ ^{o}C/W$)

S Transistor for switching applications ($R_{th\ j\text{-}mb} > 15\ ^{o}C/W$)

T Electrically, or by means of light, triggered controlling and switching power device having a breakdown characteristic ($R_{th\ j\text{-}mb} \leq 15\ ^{o}C/W$)[1)]

U Power transistor for switching applications ($R_{th\ j\text{-}mb} \leq 15\ ^{o}C/W$)

X Multiplier diode, e.g. varactor, step recovery diode

Y Rectifying diode, booster diode, efficiency diode [1)]

Z Voltage reference or voltage regulator diode [1)]

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

The serial number consists of:

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

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

VERSION LETTER

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

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) rectifier 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 hyphen (-)

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 working voltage and where appropriate the letter R [1])
The first letter indicates the nominal tolerance of the working voltage in %.

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

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

b) **for rectifier 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.

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

RATING SYSTEMS

The rating systems described are those recommended by the International Electrotechnical Commission (IEC) in its Publication 134.

DEFINITIONS OF TERMS USED

Electronic device. An electronic tube or valve, transistor or other semiconductor device.

Note
This definition excludes inductors, capacitors, resistors and similar components.

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.

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.

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.

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.

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.

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.

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.

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.

LETTER SYMBOLS FOR TRANSISTORS AND SIGNAL DIODES

based on IEC Publication 148

LETTER SYMBOLS FOR CURRENTS, VOLTAGES AND POWERS

Basic letters

The basic letters to be used are:

I, i = current
V, v = voltage
P, p = power.

Lower-case basic letters shall be used for the representation of instantaneous values which vary with time.
In all other instances upper-case basic letters shall be used.

Subscripts

A, a	Anode terminal
(AV), (av)	Average value
B, b	Base terminal, for MOS devices: Substrate
(BR)	Breakdown
C, c	Collector terminal
D, d	Drain terminal
E, e	Emitter terminal
F, f	Forward
G, g	Gate terminal
K, k	Cathode terminal
M, m	Peak value
O, o	As third subscript: The terminal not mentioned is open circuited
R, r	As first subscript: Reverse. As second subscript: Repetitive. As third subscript: With a specified resistance between the terminal not mentioned and the reference terminal.
(RMS), (rms)	R.M.S. value
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
X, x	Specified circuit
Z, z	Replaces R to indicate the actual working voltage, current or power of voltage reference and voltage regulator diodes.

Note: No additional subscript is used for d.c. values.

Upper-case subscripts shall be used for the indication of:

a) continuous (d.c.) values (without signal)

Example I_B

b) instantaneous total values

Example i_B

c) average total values

Example $I_{B(AV)}$

d) peak total values

Example I_{BM}

e) root-mean-square total values

Example $I_{B(RMS)}$

Lower-case subscripts shall be used for the indication of values applying to the varying component alone:

a) instantaneous values

Example i_b

b) root-mean-square values

Example $I_{b(rms)}$

c) peak values

Example I_{bm}

d) average values

Example $I_{b(av)}$

Note: If more than one subscript is used, subscript for which both styles exist shall either be all upper-case or all lower-case.

Additional rules for subscripts

Subscripts for currents

Transistors: If it is necessary to indicate the terminal carrying the current, this should be done by the first subscript (conventional current flow from the external circuit into the terminal is positive).

Examples: I_B, i_B, i_b, I_{bm}

Diodes: To indicate a forward current (conventional current flow into the anode terminal) the subscript F or f should be used; for a reverse current (conventional current flow out of the anode terminal) the subscript R or r should be used.

Examples: I_F, I_R, i_F, $I_{f(rms)}$

Subscripts for voltages

Transistors: If it is necessary to indicate the points between which a voltage is measured, this should be done by the first two subscripts. The first subscript indicates the terminal at which the voltage is measured and the second the reference terminal or the circuit node. Where there is no possibility of confusion, the second subscript may be omitted.

Examples: V_{BE}, v_{BE}, v_{be}, V_{bem}

Diodes: To indicate a forward voltage (anode positive with respect to cathode), the subscript F or f should be used; for a reverse voltage (anode negative with respect to cathode) the subscript R or r should be used.

Examples: V_F, V_R, v_F, V_{rm}

Subscripts for supply voltages or supply currents

Supply voltages or supply currents shall be indicated by repeating the appropriate terminal subscript.

Examples: V_{CC}, I_{EE}

Note: If it is necessary to indicate a reference terminal, this should be done by a third subscript

Example : V_{CCE}

Subscripts for devices having more than one terminal of the same kind

If a device has more than one terminal of the same kind, the subscript is formed by the appropriate letter for the terminal followed by a number; in the case of multiple subscripts, hyphens may be necessary to avoid misunderstanding.

Examples: I_{B2} = continuous (d.c.) current flowing into the second base terminal

V_{B2-E} = continuous (d.c.) voltage between the terminals of second base and emitter

Subscripts for multiple devices

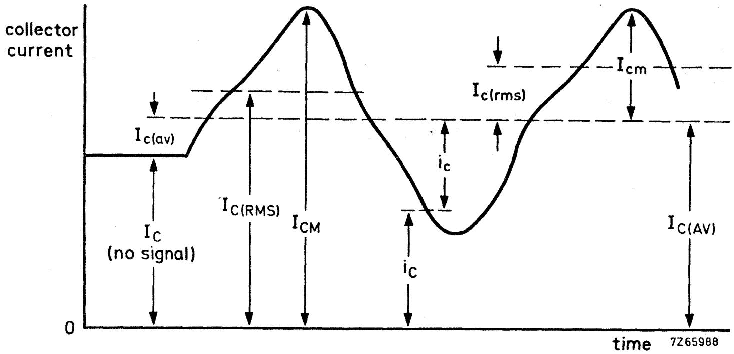
For multiple unit devices, the subscripts are modified by a number preceding the letter subscript; in the case of multiple subscripts, hyphens may be necessary to avoid misunderstanding.

Examples: I_{2C} = continuous (d.c.) current flowing into the collector terminal of the second unit

V_{1C-2C} = continuous (d.c.) voltage between the collector terminals of the first and the second unit.

Application of the rules

The figure below represents a transistor collector current as a function of time. It consists of a continuous (d.c.) current and a varying component.



LETTER SYMBOLS FOR ELECTRICAL PARAMETERS

Definition

For the purpose of this Publication, the term "electrical parameter" applies to four-pole matrix parameters, elements of electrical equivalent circuits, electrical impedances and admittances, inductances and capacitances.

Basic letters

The following is a list of the most important basic letters used for electrical parameters of semiconductor devices.

B, b = susceptance; imaginary part of an admittance

C = capacitance

G, g = conductance; real part of an admittance

H, h = hybrid parameter

L = inductance

R, r = resistance; real part of an impedance

X, x = reactance; imaginary part of an impedance

Y, y = admittance;

Z, z = impedance;

Upper-case letters shall be used for the representation of:

a) electrical parameters of external circuits and of circuits in which the device forms only a part;

b) all inductances and capacitances.

Lower-case letters shall be used for the representation of electrical parameters inherent in the device (with the exception of inductances and capacitances).

Subscripts

General subscripts

The following is a list of the most important general subscripts used for electrical parameters of semiconductor devices:

F, f = forward; forward transfer
I, i (or 1) = input
L, l = load
O, o (or 2) = output
R, r = reverse; reverse transfer
S, s = source

Examples: Z_S, h_f, h_F

The upper-case variant of a subscript shall be used for the designation of static (d.c.) values.

Examples : h_{FE} = static value of forward current transfer ratio in common-emitter configuration (d.c. current gain)

R_E = d.c. value of the external emitter resistance.

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.

The lower-case variant of a subscript shall be used for the designation of small-signal values.

Examples: h_{fe} = small-signal value of the short-circuit forward current transfer ratio in common-emitter configuration

$Z_e = R_e + jX_e$ = small-signal value of the external impedance

Note: If more than one subscript is used, subscripts for which both styles exist shall either be all upper-case or all lower-case

Examples: h_{FE}, y_{RE}, h_{fe}

Subscripts for four-pole matrix parameters

The first letter subscript (or double numeric subscript) indicates input, output, forward transfer or reverse transfer

Examples: h_i (or h_{11})
h_o (or h_{22})
h_f (or h_{21})
h_r (or h_{12})

A further subscript is used for the identification of the circuit configuration. When no confusion is possible, this further subscript may be omitted.

Examples: h_{fe} (or h_{21e}), h_{FE} (or h_{21E})

Distinction between real and imaginary parts

If it is necessary to distinguish between real and imaginary parts of electrical parameters, no additional subscripts should be used. If basic symbols for the real and imaginary parts exist, these may be used.

Examples: $Z_i = R_i + jX_i$
$y_{fe} = g_{fe} + jb_{fe}$

If such symbols do not exist or if they are not suitable, the following notation shall be used:

Examples: Re (h_{ib}) etc. for the real part of h_{ib}
Im (h_{ib}) etc. for the imaginary part of h_{ib}

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° to the axes.

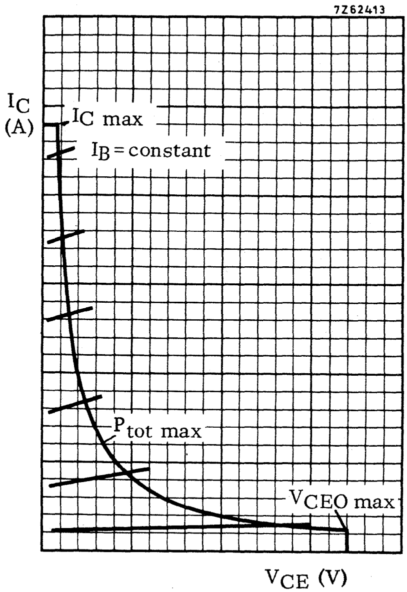


Fig. 1

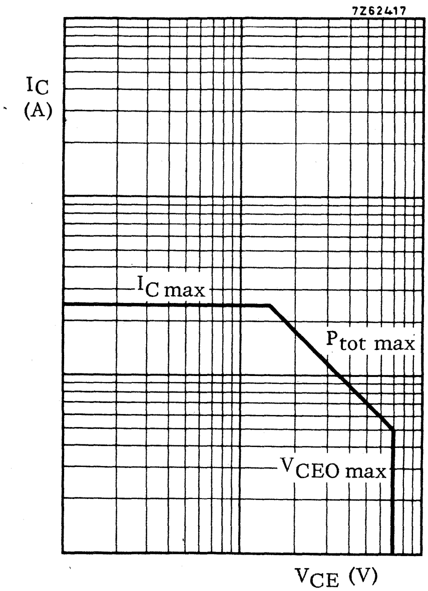


Fig. 2. D.C. SOAR curve

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.

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

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

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

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%.

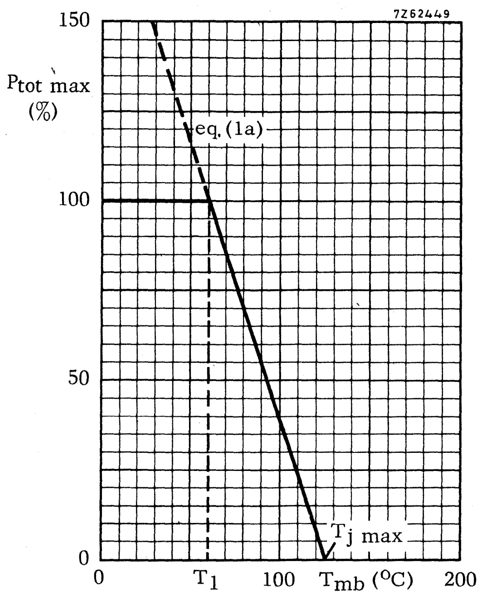


Fig. 3

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:

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

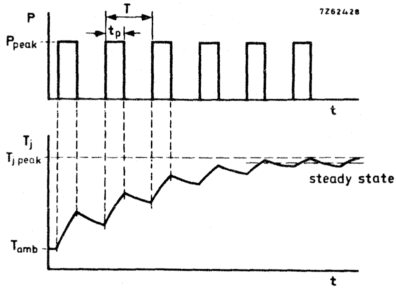


Fig. 4

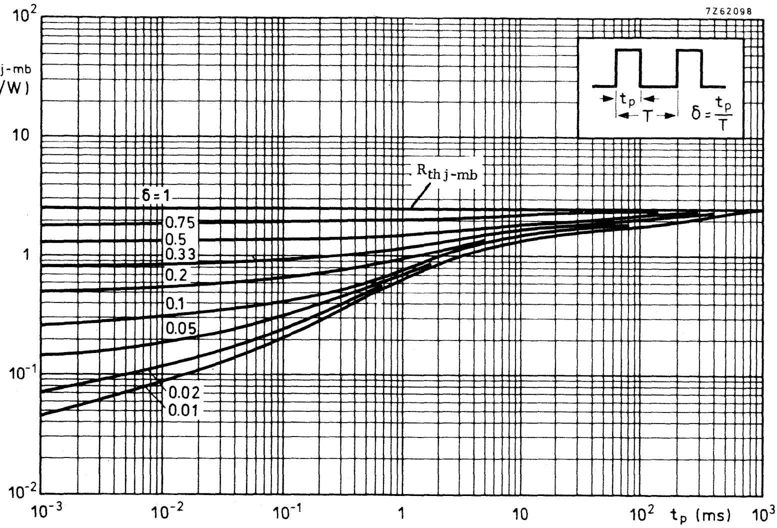


Fig. 5

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

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

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 not necessary when SOAR limits lower than the rated I_{CMmax} are indicated for different pulse durations.

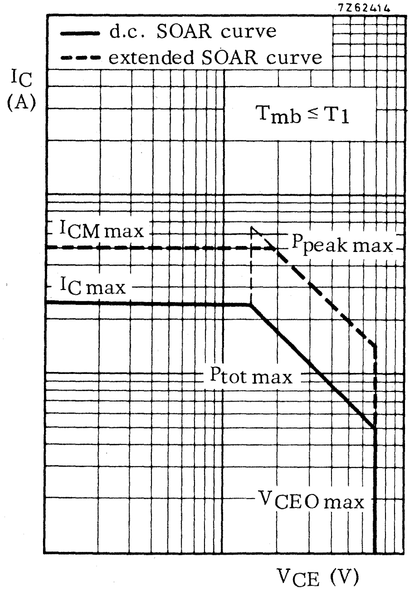


Fig. 6

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 concentration that leads to local heating within the crystal. The higher the voltage (before second breakdown) the lower the power at which the concentration occurs. If a single point on the crystal exceeds $T_{j\,max}$, the transistor characteristics may be permanently affected; further current concentration will lead to increased temperature and consequent second breakdown, which will destroy the transistor.

The SOAR curve must define an area that only precludes second breakdown but also the current concentration 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 concentration. With different combinations of I_C and V_{CE}, points are plotted at which current concentration is observed. A limit is then defined that precludes current concentration. 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.

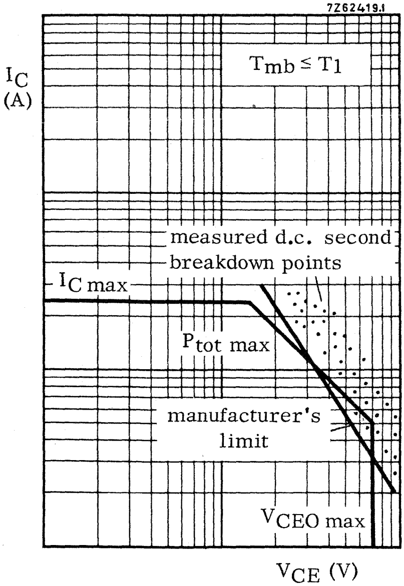


Fig. 7

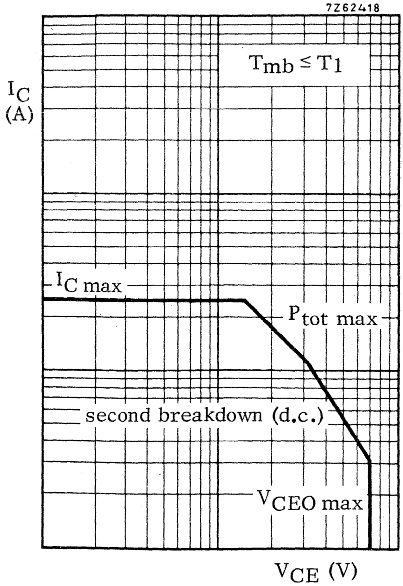


Fig. 8

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.

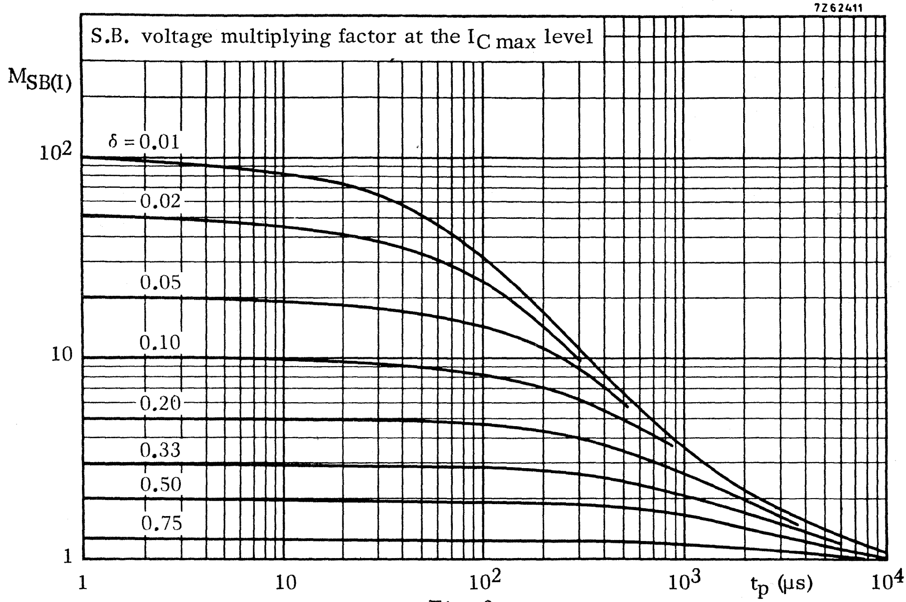

7Z62411
S.B. voltage multiplying factor at the I_C max level
M_SB(I)
δ = 0.01
0.02
0.05
0.10
0.20
0.33
0.50
0.75
10^2
10
1
1
10
10^2
10^3
t_p (μs)
10^4

Fig. 9a

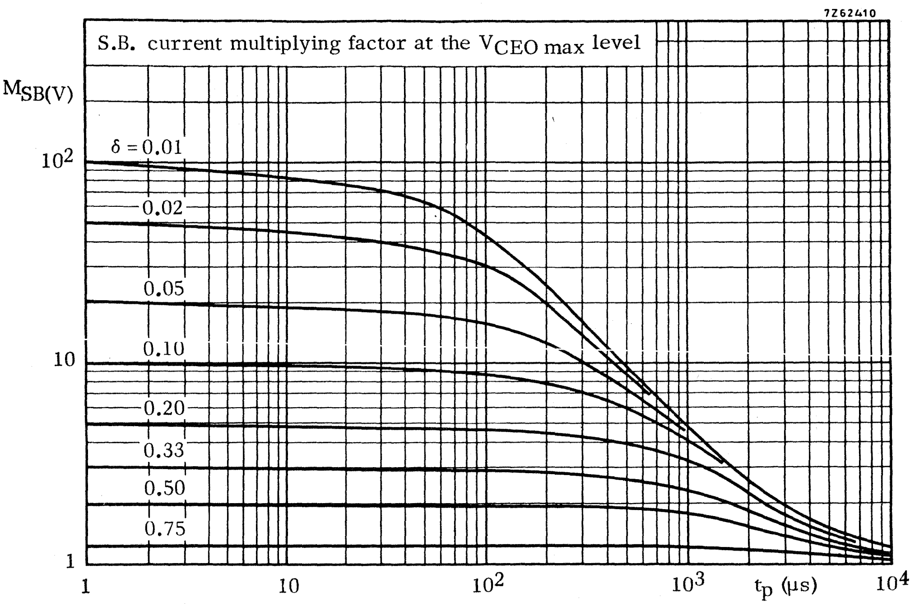

7Z62410
S.B. current multiplying factor at the V_CEO max level
M_SB(V)
δ = 0.01
0.02
0.05
0.10
0.20
0.33
0.50
0.75
10^2
10
1
1
10
10^2
10^3
t_p (μs)
10^4

Fig. 9b

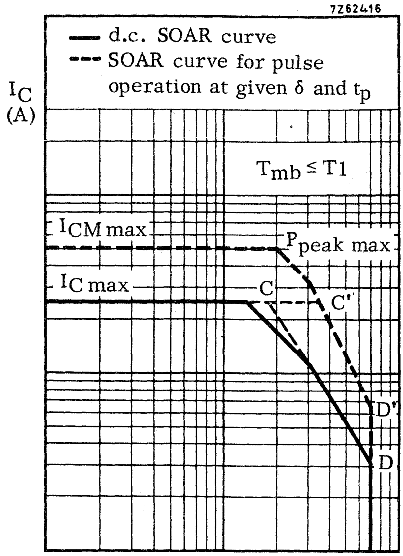


Fig. 10

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.

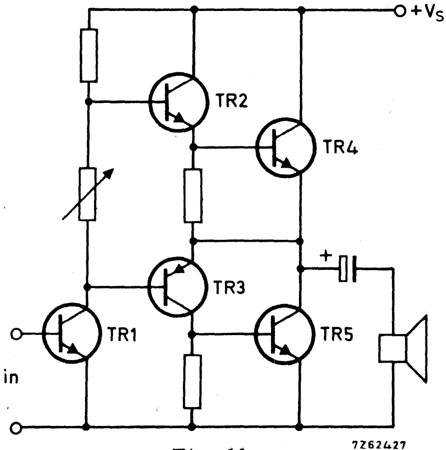


Fig. 11

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 ^oC.

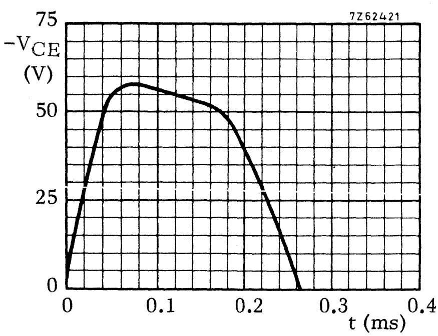


Fig. 12a

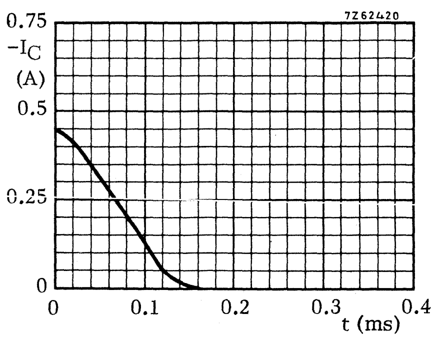


Fig. 12b

4.2 Information obtained from the published data of TR3

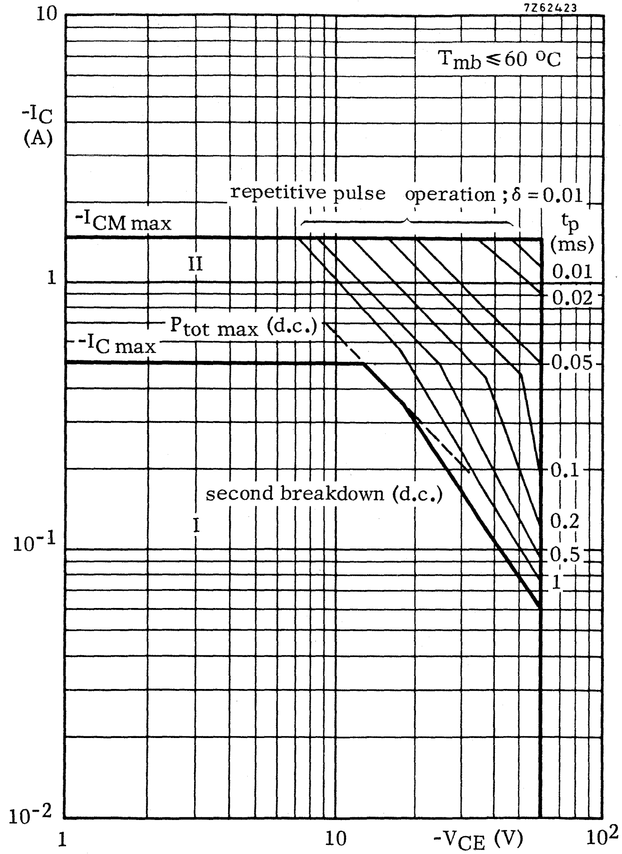


Fig. 13. Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation.

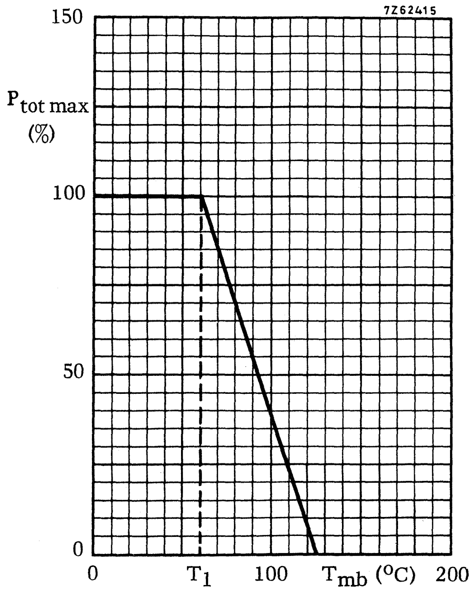


Fig. 14

$T_{j\,max}$ = 125 °C
$R_{th\,j\text{-}mb}$ = 10 °C/W

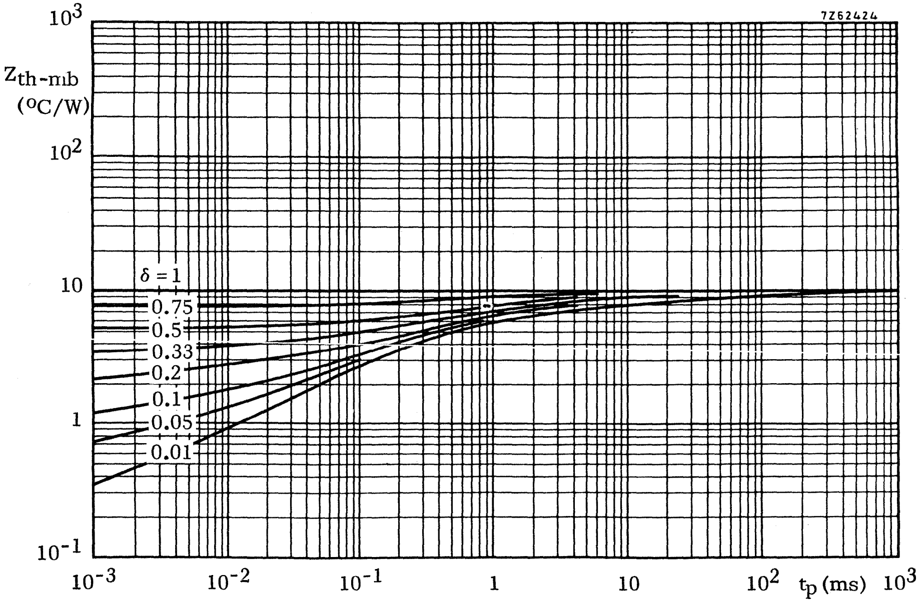


Fig. 15

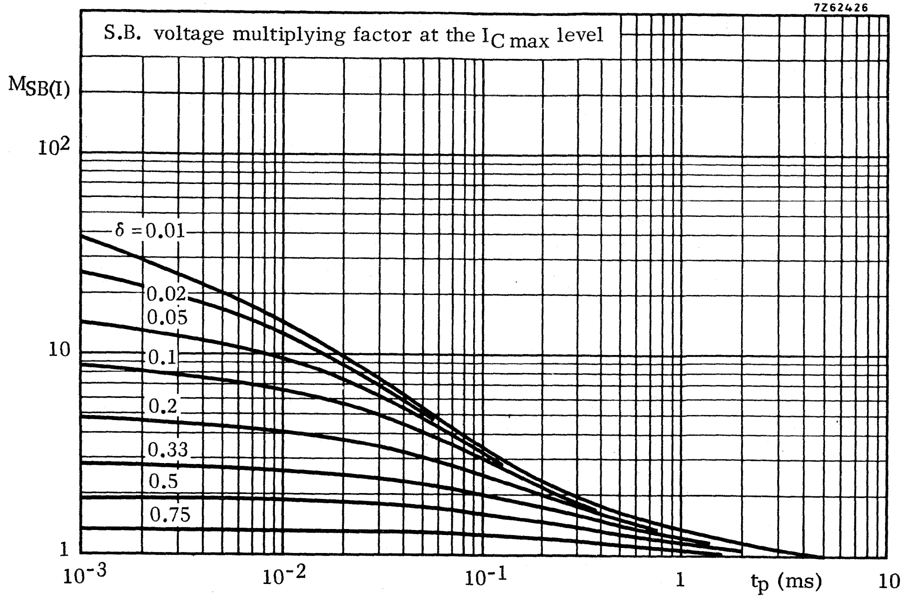

7Z62426
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
$\delta = 0.01$
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

Fig. 16

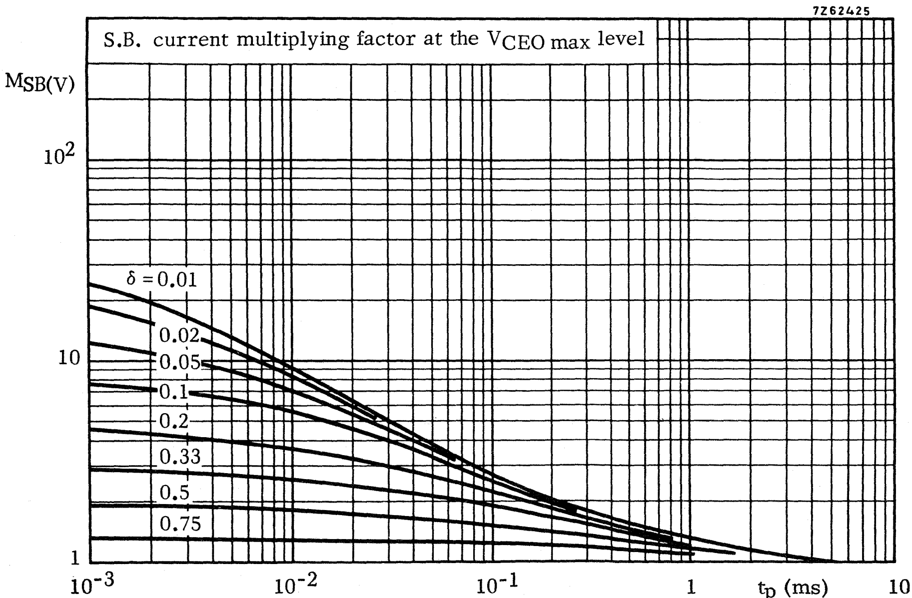

7Z62425
S.B. current multiplying factor at the $V_{CEO\,max}$ level
$M_{SB(V)}$
10^2
10
1
$\delta = 0.01$
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

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.

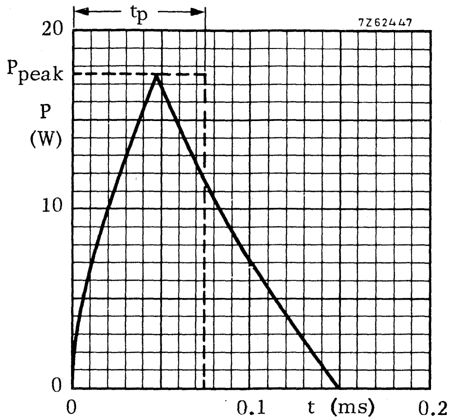


Fig. 18

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 ^{o}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 $\delta = 0.056$.

$R_{th\ j\text{-}mb} = 10\ ^{o}C/W$
$Z_{th\ j\text{-}mb} = 2.75\ ^{o}C/W$

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

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:

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

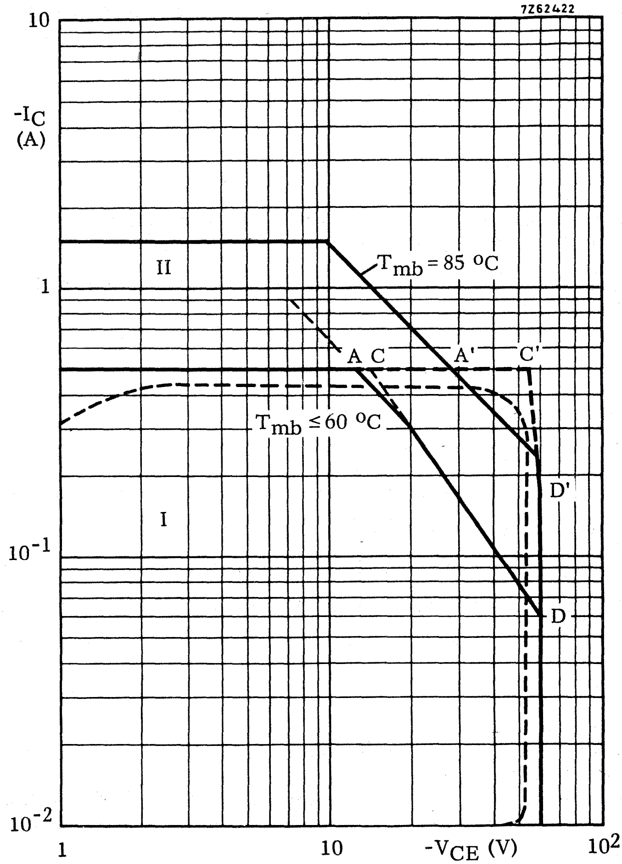


Fig. 19

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

II Permissible extension for t_p = 75 μs, δ = 0.056 and T_{mb} = 85 °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 $T_{mb} - T_{amb} = \delta . P_{peak} . R_{th\ mb-a}$.

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

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

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

Low-frequency and dual transistors

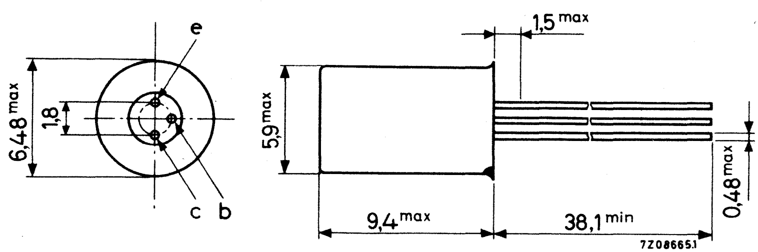
GERMANIUM ALLOY TRANSISTOR

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 56200 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: 56200 (cooling fin).

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

Currents

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

Power dissipation

Total power dissipation up to T_{amb} = 45 °C with cooling fin 56200 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	$R_{th\ j-a}$	=	0,3	°C/mW
From junction to ambient with cooling fin 56200 mounted on a heatsink of at least 12,5 cm^2	$R_{th\ j-a}$		0,09	°C/mW

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.	50 100	
$-I_C = 50$ 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 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.	1.3 1.7	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. 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	$\mu\Omega^{-1}$ $\mu\Omega^{-1}$

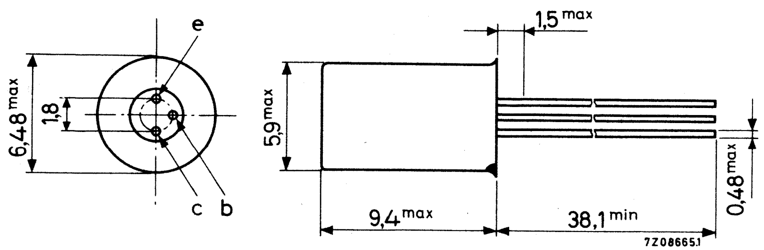
GERMANIUM ALLOY TRANSISTOR

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 56200 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: 56200 (cooling fin).

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

Currents

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

Power dissipation

Total power dissipation up to T_{amb} = 45 °C with cooling fin 56200 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	$R_{th\ j-a}$	=	0,3	°C/mW
From junction to ambient with cooling fin 56200 mounted on a heatsink of at least 12,5 cm^2	$R_{th\ j-a}$	=	0,09	°C/mW

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	$\lvert z_{rb} \rvert$	typ.	90	Ω
Transition frequency				
$-I_C = 10$ mA; $-V_{CE} = 2$ V	f_T	> typ.	1.7 2.3	MHz MHz
Cut-off frequency				
$-I_C = 10$ mA; $-V_{CE} = 2$ V	f_{hfe}	> typ.	10 17	kHz kHz
Noise figure at f = 1 kHz				
$-I_C = 0.5$ mA; $-V_{CE} = 5$ V; $R_S = 500$ Ω Bandwidth = 200 Hz	F	typ. <	4 10	dB dB

CHARACTERISTICS (continued) T_{amb} = 25 ^{o}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 1.7 to 3.8	kΩ kΩ
Reverse voltage transfer	h_{re}	typ. 8.0 < 13.0	10^{-4} 10^{-4}
Small signal current gain	h_{fe}	typ. 180 130 to 300	
Output admittance	h_{oe}	typ. 100 < 170	$\mu\Omega^{-1}$ $\mu\Omega^{-1}$

GERMANIUM ALLOY TRANSISTOR

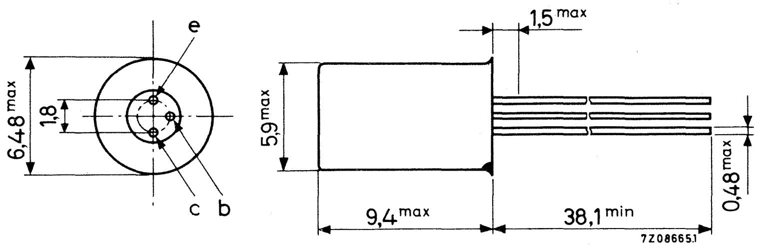
The AC127 is an n-p-n audio transistor in a TO-1 metal envelope. It is intended for use together with the p-n-p transistors AC128 or AC132 as matched pair in class-B output stages with complementary symmetry, or in driver stages.

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 56200 on a heatsink of at least 12,5 cm^2	P_{tot}	max.	340	mW
Junction temperature (incidental)	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

TO-1



The coloured dot indicates the collector.

Accessories: 56200 (cooling fin).

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.	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

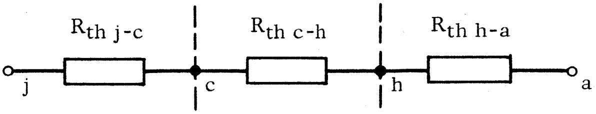
Total power dissipation up to T_{amb} = 45 °C with cooling fin 56200 mounted on a heatsink of of at least 12,5 cm^2	P_{tot}	max.	340	mW

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air				
without cooling fin	$R_{th\ j\text{-}a}$	=	370	°C/W
with cooling fin 56200 on 1,5 mm blackened Al heatsink of 12,5 cm^2	$R_{th\ j\text{-}a}$	=	160	°C/W
with cooling fin 56200 on infinite heatsink	$R_{th\ j\text{-}a}$	=	125	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	110	°C/W

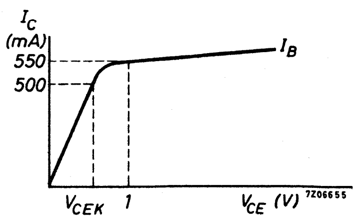


AC127 with fin 56200 110 | 15 | °C/W

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	

GERMANIUM ALLOY TRANSISTORS

The AC128 is a p-n-p audio transistor in a TO-1 metal envelope.
It 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 with an integral heat conducting block.
Type 2-AC128 and type 2-AC128/01 consist of 2 transistors AC128 and AC128/01 respectively selected for operation in a low distortion class-B amplifier.

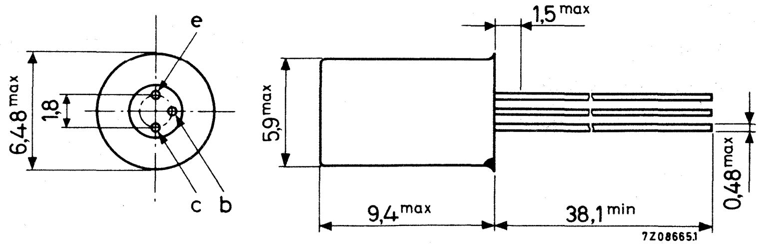
QUICK REFERENCE DATA

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 56200 on a blackened Al heatsink of at least 12,5 cm^2	P_{tot}	max.	1	W
Junction temperature (incidental)	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

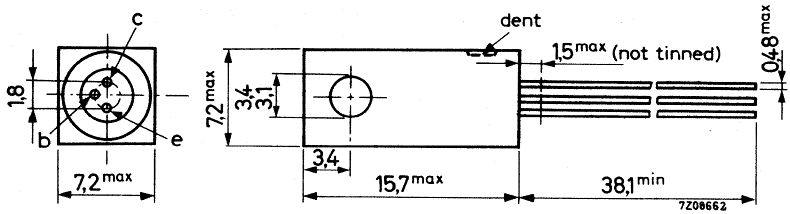


The coloured dot indicates the collector.

Accessories: 56200 (cooling fin).

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 Ω	$-V_{CER}$	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

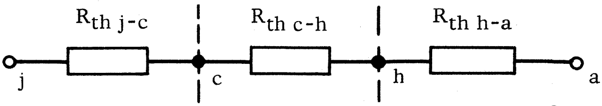
Total power dissipation up to T_{amb} = 20 °C with cooling fin 56200 on a 1,5 mm blackened Al heatsink of at least 12,5 cm^2	P_{tot}	max.	1000	mW

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air			AC128	AC128/01	
without cooling fin	$R_{th\ j-a}$	=	290	180	°C/W
with cooling fin 56200	$R_{th\ j-a}$	=	140		°C/W
with cooling fin 56200 on 1,5 mm blackened Al heatsink of 12,5 cm^2	$R_{th\ j-a}$	=	80	70,5	°C/W
with cooling fin 56200 on infinite heatsink	$R_{th\ j-a}$	=	55		°C/W
From junction to case	$R_{th\ j-c}$	=	40	45	°C/W



	$R_{th\ j-c}$	$R_{th\ c-h}$	$R_{th\ h-a}$	
AC128 with fin 56200	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

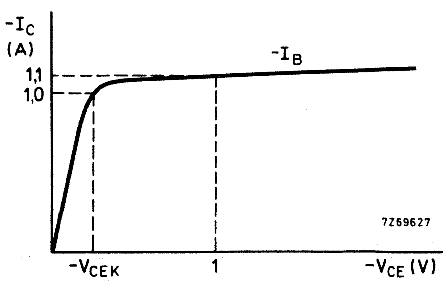
$I_C = 0$; $-V_{EB} = 10$ V	$-I_{EBO}$	<	200	µA
$I_C = 0$; $-V_{EB} = 5$ V; $T_j = 75$ °C	$-I_{EBO}$	<	500	µA

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		
$\lvert I_C \rvert$ = 300 mA; V_{CB} = 0	h_{FE1}/h_{FE2}	typ. 1.1
matched pair 2-AC128		
$\lvert I_C \rvert$ = 50 mA; V_{CB} = 0	h_{FE1}/h_{FE2}	typ. 1.1 < 1.25
$\lvert I_C \rvert$ = 300 mA; V_{CB} = 0	h_{FE1}/h_{FE2}	typ. 1.1 < 1.25

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

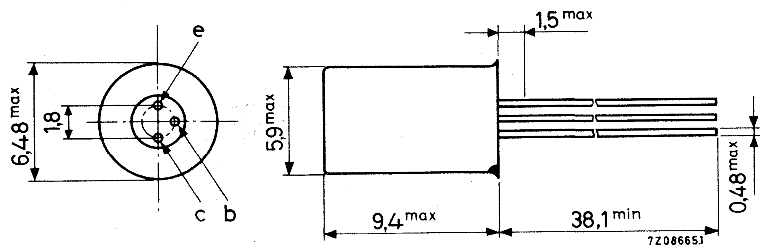
GERMANIUM ALLOY TRANSISTORS

The AC132 is a p-n-p audio transistor in a TO-1 metal envelope.
It 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.

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 56200 on a heatsink of at least 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	MHz

MECHANICAL DATA Dimensions in mm

TO-1



The coloured dot indicates the collector.

Accessories: 56200 (cooling fin).

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.	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 56200 mounted on a heatsink of at least 12,5 cm^2	P_{tot}	max.	500	mW

Temperatures

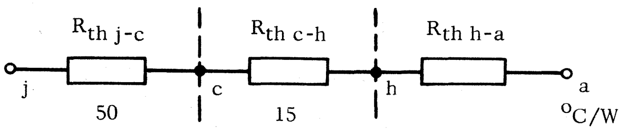
Storage temperature	T_{stg}		−55 to +90	°C
Junction temperature	T_j	max.	90	°C

THERMAL RESISTANCE

From junction to ambient in free air

without cooling fin	$R_{th\ j\text{-}a}$	=	300	$^{o}C/W$
with cooling fin 56200 on 1,5 mm blackened Al heatsink of 12,5 cm^2	$R_{th\ j\text{-}a}$	=	90	$^{o}C/W$
with cooling fin 56200 on infinite heatsink	$R_{th\ j\text{-}a}$	=	65	$^{o}C/W$
From junction to case	$R_{th\ j\text{-}c}$	=	50	$^{o}C/W$

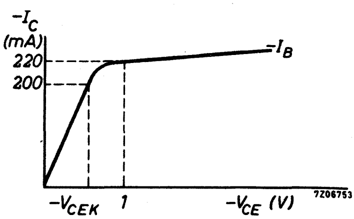
AC132 with fin 56200



CHARACTERISTICS

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

Collector cut-off current				
$I_E = 0;\ -V_{CB} = 0,5\ V$	$-I_{CBO}$	<	10	μA
$I_E = 0;\ -V_{CB} = 32\ V;\ T_j = 75\ ^{o}C$	$-I_{CBO}$	<	800	μA
Emitter cut-off current				
$I_C = 0;\ -V_{EB} = 5\ V;\ T_j = 75\ ^{o}C$	$-I_{EBO}$	<	550	μA
Emitter-base voltage				
$I_E = 2\ mA;\ -V_{CB} = 5\ V$	V_{EB}	typ.	105	mV
$I_E = 200\ mA;\ V_{CB} = 0$	V_{EB}	<	550	mV
Knee voltage				
$-I_C = 200$ mA; $-I_B$ = value for which $-I_C = 220$ mA at $-V_{CE} = 1$ V	$-V_{CEK}$	<	350	mV



CHARACTERISTICS (continued) T_{amb} = 25 ^{o}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	$\|z_{rb}\|$	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				
$\|I_C\|$ = 50 mA; V_{CB} = 0	h_{FE1}/h_{FE2}	typ.	1.1	
		<	1.25	
matched pair 2-AC132				
$\|I_C\|$ = 20 mA; V_{CB} = 0	h_{FE1}/h_{FE2}	typ.	1.1	
		<	1.25	
$\|I_C\|$ = 200 mA; V_{CB} = 0	h_{FE1}/h_{FE2}	typ.	1.1	
		<	1.25	

GERMANIUM ALLOY TRANSISTORS

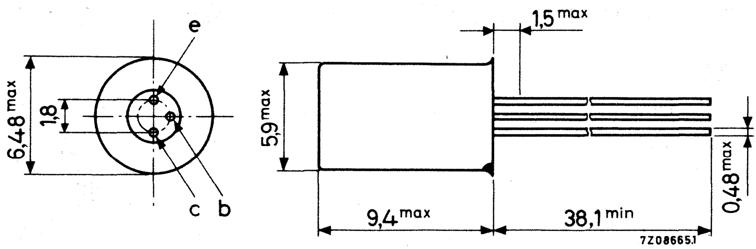
The AC187 is an n-p-n audio transistor in a TO-1 metal envelope.
It is primarily intended for use, together with its p-n-p complement AC188, as matched pair AC187/AC188 in class-B output stages with outputs up to about 3 W.
The AC187/01 is electrically equivalent to the AC187, constructed with an integral heat conducting block.
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	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

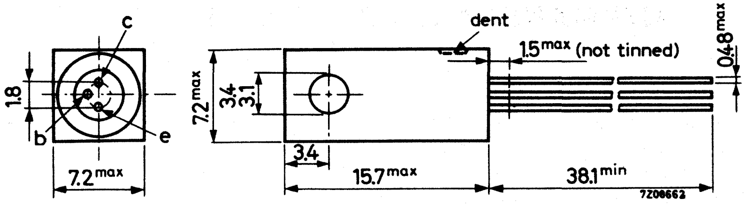


The coloured dot indicates the collector.

Accessories: 56200 (cooling fin).

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

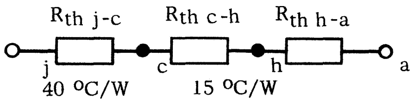
Storage temperature	T_{stg}	−55 to +75	°C
Junction temperature	T_j	max. 90	°C

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

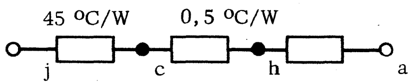
THERMAL RESISTANCE

			AC187	AC187/01	
From junction to ambient in free air					
without cooling fin	$R_{th\ j\text{-}a}$	=	290	180	°C/W
with cooling fin 56200	$R_{th\ j\text{-}a}$	=	140		°C/W
with cooling fin 56200 on 1,5 mm blackened Al heatsink of 12,5 cm^2	$R_{th\ j\text{-}a}$	=	80	70,5	°C/W
with cooling fin 56200 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 fin 56200



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
$-V_{BE} = 1$ 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

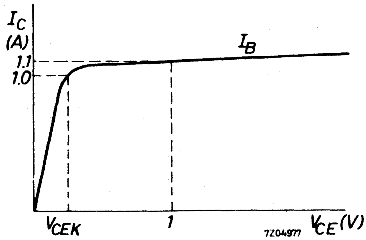
Emitter-base floating voltage

$I_E = 0$; $V_{CB} = 25$ 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

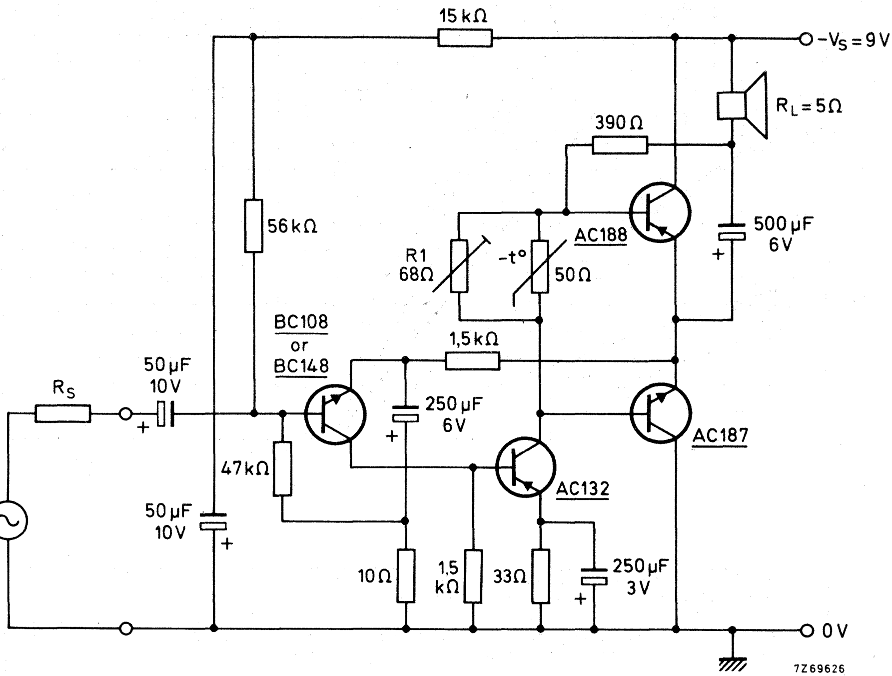
I_C = 10 mA; V_{CE} = 2 V	f_{hfe}	typ.	20	kHz

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

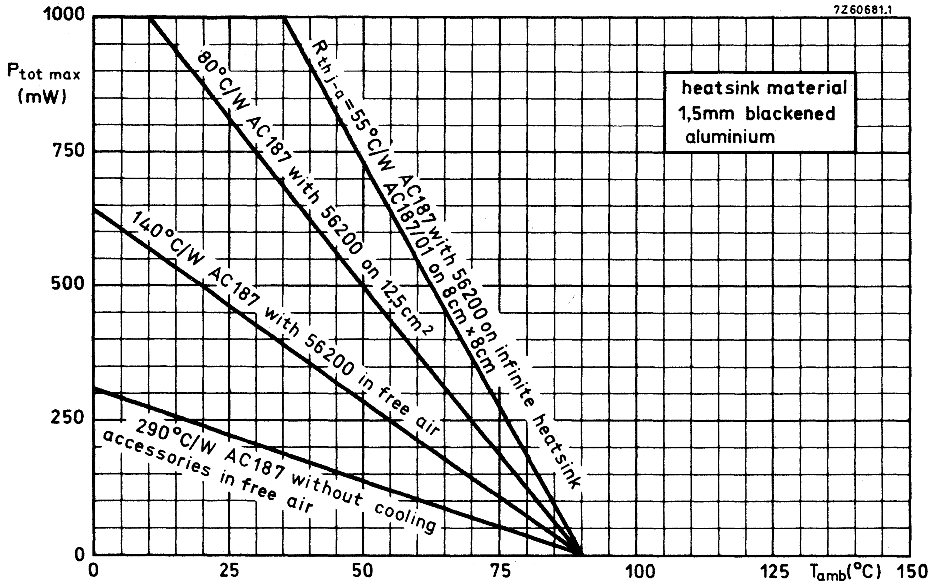
APPLICATION INFORMATION

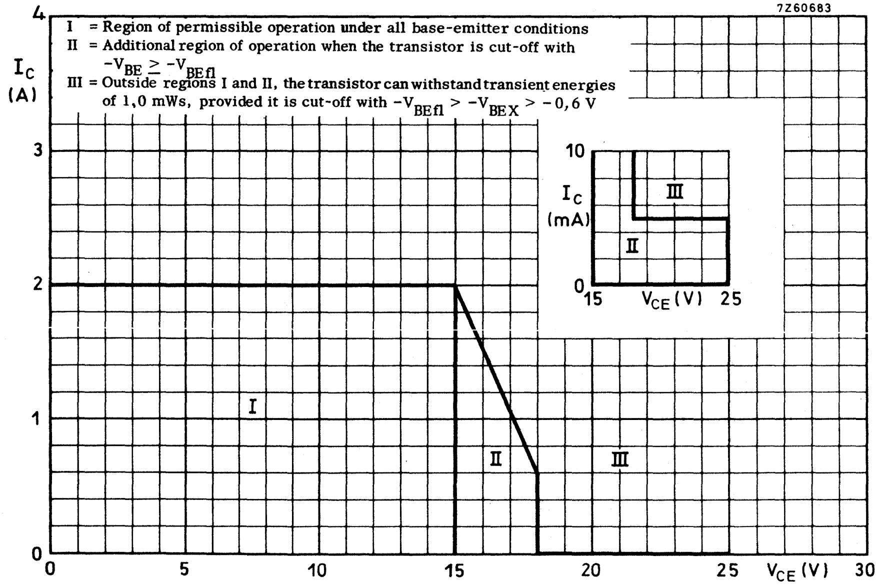
1,5 W audio frequency amplifier with matched pair AC187/AC188 in complementary symmetry class-B output stage up to T_{amb} = 45 °C.

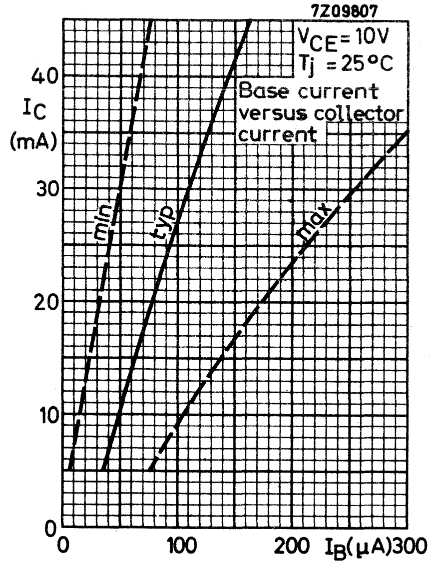


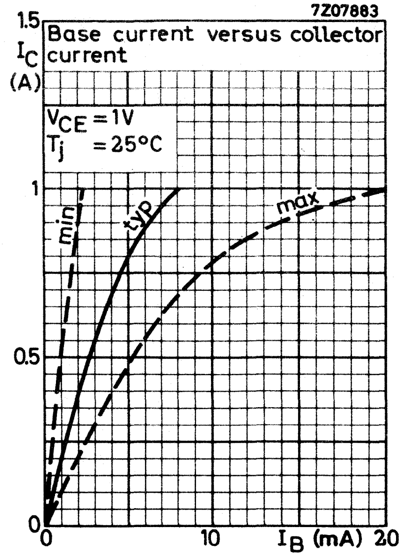
Typical input requirements for an output power of 50 mW	$V_{i(rms)}$ r_i	= 4 mV; $I_{i(rms)}$ = 0,12 μA; = 33 kΩ
Typical input requirements for an output power of 1,5 W	$V_{i(rms)}$ r_i	= 22 mV; $I_{i(rms)}$ = 0,66 μA; = 33 kΩ
Typical bandwidth (3 dB); R_S = 0	B	= 60 Hz to 65 kHz
Typical bandwidth (3 dB); R_S = 50 kΩ	B	= 65 Hz to 35 kHz
Quiescent current	$\lvert I_{CQ}\rvert$	= 5 mA, adjustable with R1

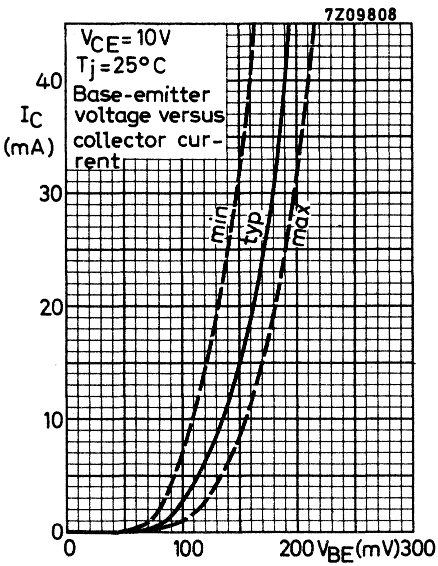
When using AC187 and AC188, each transistor should be mounted with cooling fin 56200 on 1,5 mm blackened Al heatsink of 3 cm x 3 cm.
When using AC187/01 and AC188/01, each transistor should be mounted on 1,5 mm blackened Al heatsink of 2,5 cm x 2,5 cm.

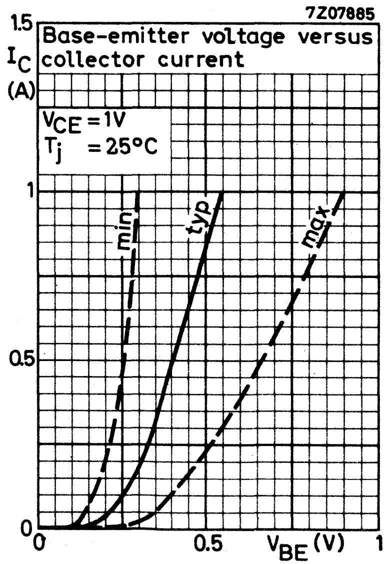

7Z60681.1
1000
750
500
250
0
Ptot max
(mW)
heatsink material
1,5mm blackened
aluminium
Rth j-a = 55°C/W AC187 with 56200 on infinite heatsink
AC187/01 on 8cm × 8cm
80°C/W AC187 with 56200 on 12,5cm2
140°C/W AC187 with 56200 in free air
290°C/W AC187 without cooling
accessories in free air
0
25
50
75
100
125
Tamb(°C)
150

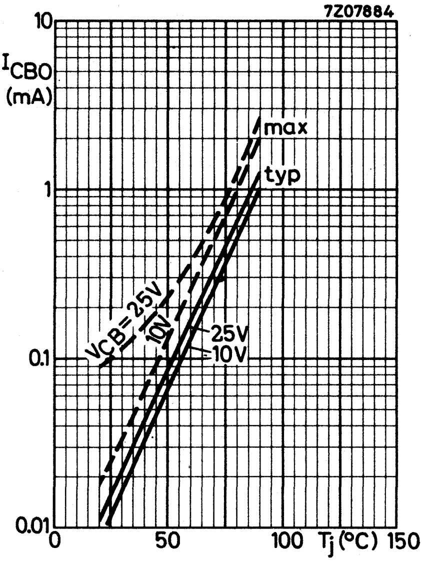

7Z60683
I = Region of permissible operation under all base-emitter conditions
II = Additional region of operation when the transistor is cut-off with
-VBE ≥ -VBEfl
III = Outside regions I and II, the transistor can withstand transient energies
of 1,0 mWs, provided it is cut-off with -VBEfl > -VBEX > -0,6 V
IC
(A)
4
3
2
1
0
I
II
III
0
5
10
15
20
25
VCE (V)
30
10
IC
(mA)
0
15
VCE (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
I_B (mA)
min
typ
max
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)
V_{BE} (mV)
min
typ
max
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
V_{BE} (V)
min
typ
max
0
0.5
1
1.5


7Z07884
10
1
0.1
0.01
ICBO
(mA)
max
typ
VCB=25V
10V
25V
10V
0
50
100
Tj (°C)
150

GERMANIUM ALLOY TRANSISTORS

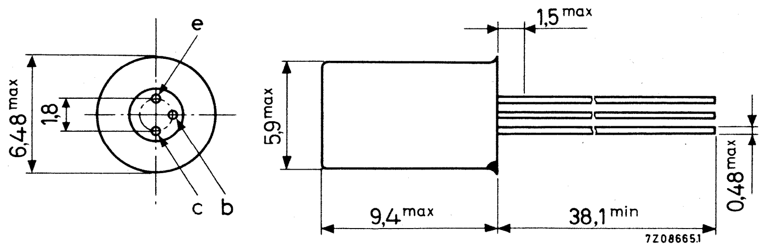
The AC188 is a p-n-p audio transistor in a TO-1 metal envelope.
It is primarily intended for use as matched pair 2-AC188 or, together with its n-p-n complement AC187, as matched pair AC187/AC188 in class-B output stages with outputs up to about 3 W.
The AC188/01 is electrically equivalent to the AC188, constructed with an integral heat conducting block.
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	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

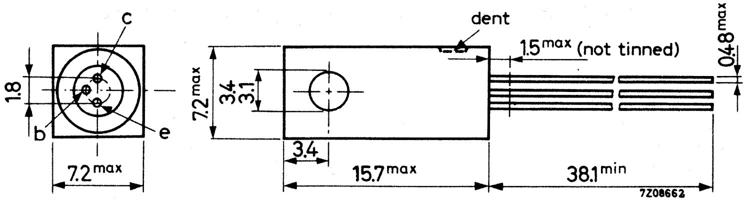


The coloured dot indicates the collector.

Accessories: 56200 (cooling fin).

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

Temperatures

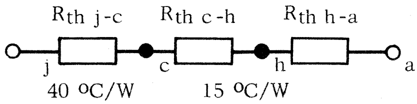
Storage temperature	T_{stg}		-55 to +75	^{o}C
Junction temperature	T_j	max.	90	^{o}C

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

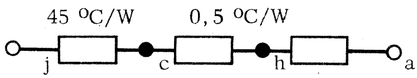
THERMAL RESISTANCE

From junction to ambient in free air			AC188	AC188/01	
without cooling fin	$R_{th\ j\text{-}a}$	=	290	180	°C/W
with cooling fin 56200	$R_{th\ j\text{-}a}$	=	140		°C/W
with cooling fin 56200 on 1,5 mm blackened Al heatsink of 12,5 cm^2	$R_{th\ j\text{-}a}$	=	80	70,5	°C/W
with cooling fin 56200 on infinite heatsink	$R_{th\ j\text{-}a}$	=	55	45	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	40	45	°C/W

AC188 with cooling fin 56200



AC188/01



CHARACTERISTICS

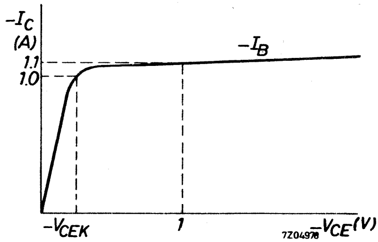
T_j = 25 °C unless otherwise specified

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
$+V_{BE} = 1$ 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

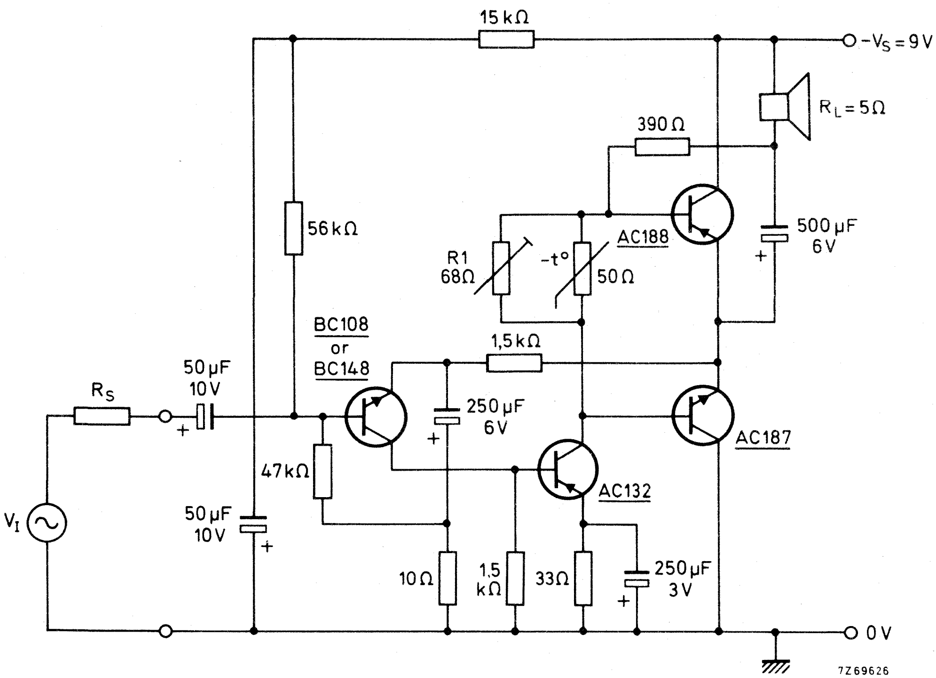
$\lvert I_C \rvert$ = 500 mA; $\lvert V_{CE} \rvert$ = 1 V	h_{FE1}/h_{FE2}	<	1.25

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

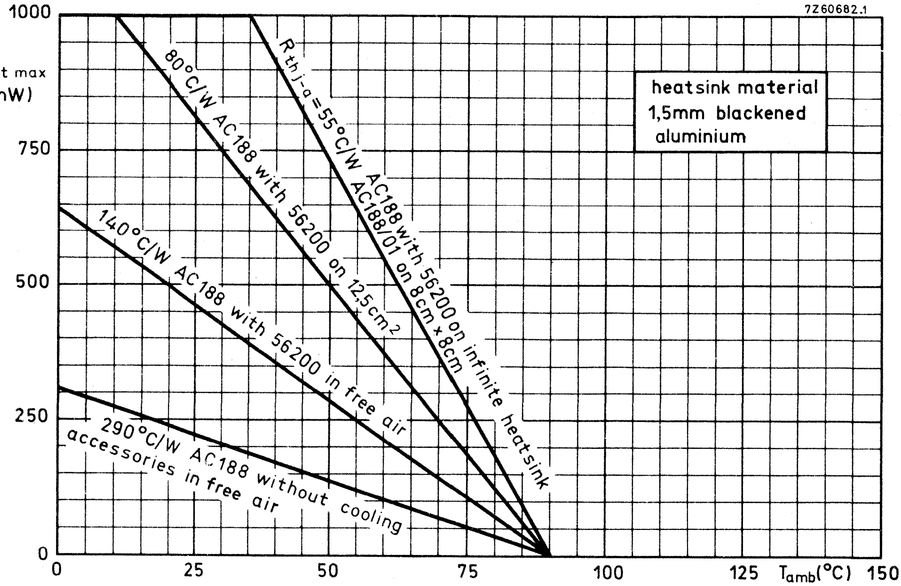
APPLICATION INFORMATION

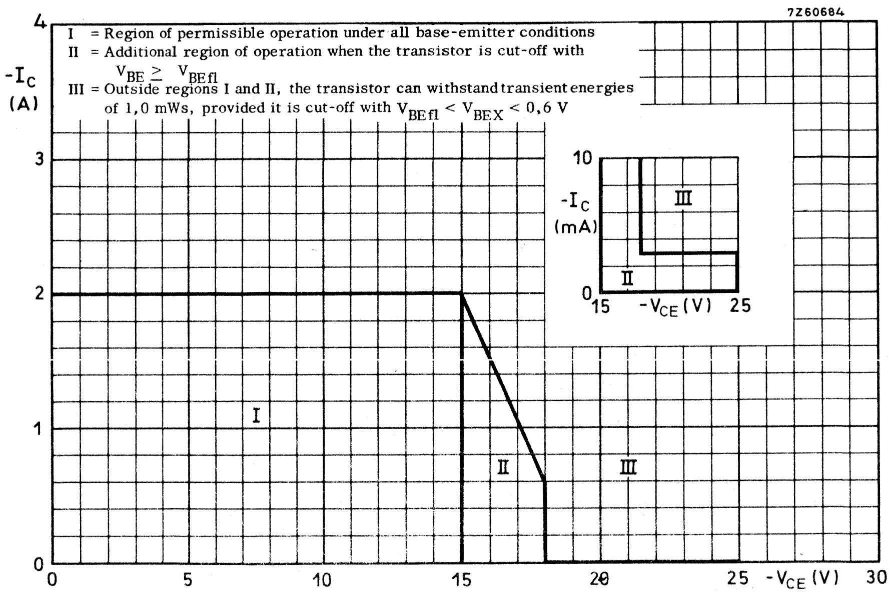
1,5 W audio frequency amplifier with matched pair AC187/AC188 in complementary symmetry class-B output stage up to T_{amb} = 45 °C.

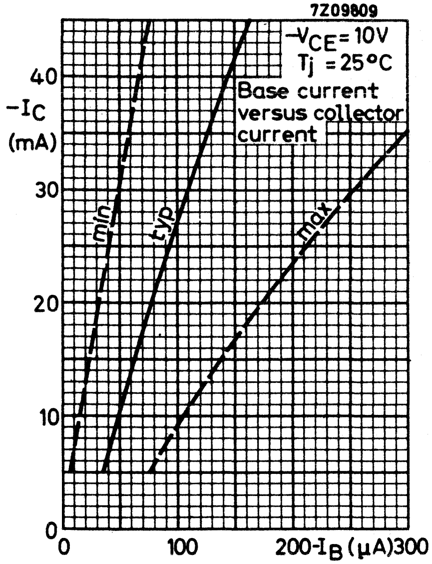


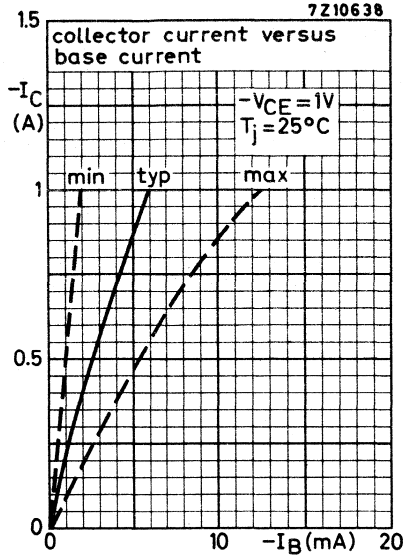
Typical input requirements for an output power of 50 mW	$V_{i(rms)}$ = 4 mV; $I_{i(rms)}$ = 0,12 µA; r_i = 33 kΩ
Typical input requirements for an output power of 1,5 W	$V_{i(rms)}$ = 22 mV; $I_{i(rms)}$ = 0,66 µA; r_i = 33 kΩ
Typical bandwidth (3 dB); R_S = 0	B = 60 Hz to 65 kHz
Typical bandwidth (3 dB); R_S = 50 kΩ	B = 65 Hz to 35 kHz
Quiescent current	$\lvert I_{CQ}\rvert$ = 5 mA, adjustable with R1

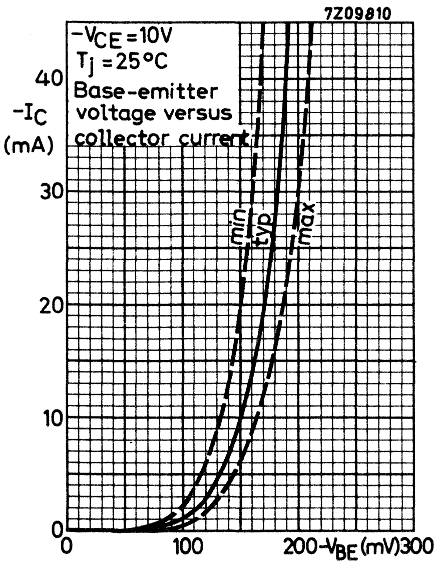
When using AC187 and AC188, each transistor should be mounted with cooling fin 56200 on 1,5 mm blackened Al heatsink of 3 cm x 3 cm.
When using AC187/01 and AC188/01, each transistor should be mounted on 1,5 mm blackened Al heatsink of 2,5 cm x 2,5 cm.

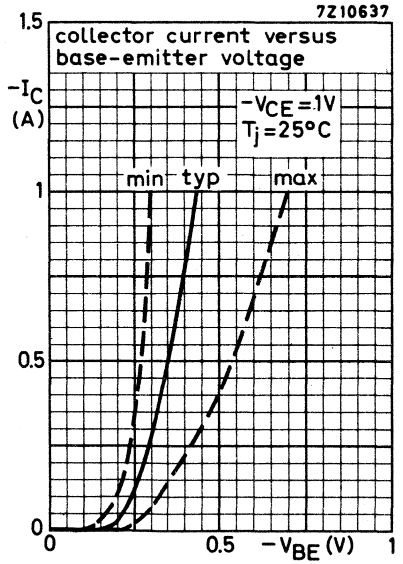

7Z60682.1
$P_{tot\,max}$ (mW)
1000
750
500
250
0
heatsink material
1,5mm blackened
aluminium
$R_{th\,j-a}$ = 55°C/W AC188 with 56200 on infinite heatsink
AC188/01 on 8cm × 8cm
80°C/W AC188 with 56200 on 12,5cm²
140°C/W AC188 with 56200 in free air
290°C/W AC188 without cooling
accessories in free air
0
25
50
75
100
125
T_{amb}(°C)
150

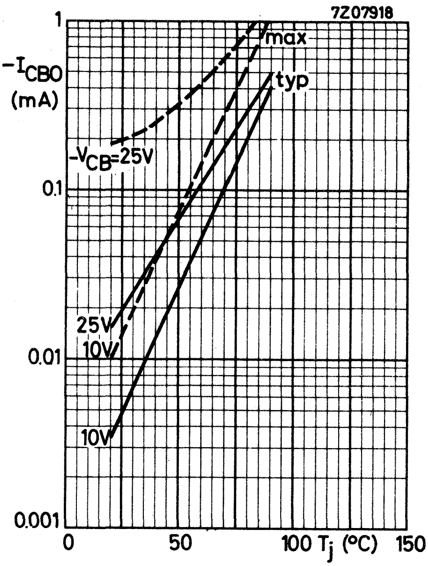

7Z60684
$-I_C$ (A)
4
3
2
1
0
I = Region of permissible operation under all base-emitter conditions
II = Additional region of operation when the transistor is cut-off with $V_{BE} \geq V_{BEfl}$
III = Outside regions I and II, the transistor can withstand transient energies of 1,0 mWs, provided it is cut-off with $V_{BEfl} < V_{BEX} < 0,6$ V
I
II
III
10
$-I_C$ (mA)
III
II
0
15
$-V_{CE}$ (V)
25
0
5
10
15
20
25
$-V_{CE}$ (V)
30


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


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


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


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


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 TO-18 metal envelopes 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 multitude of low-voltage applications e.g. driver stages or audio preamplifiers 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

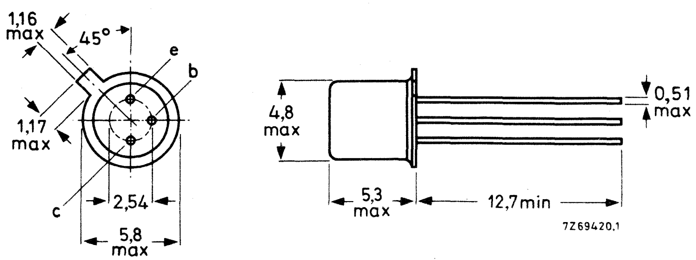
			BC107	BC108	BC109	
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max	50	30	30	V
Collector-emitter voltage (open base)	V_{CEO}	max	45	20	20	V
Collector current (peak value)	I_{CM}	max	200	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max	300	300	300	mW
Junction temperature	T_j	max	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 4,0	dB dB
f = 1 kHz; B = 200 Hz	F	typ	2	2	1,2	dB

MECHANICAL DATA

Dimensions in mm

TO-18

Collector connected to case



Accessories: 56246 (distance disc); 56263 (cooling fin).

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

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

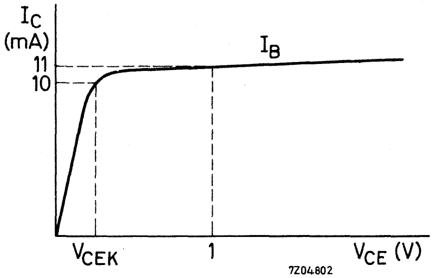
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Saturation voltages [1])

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

Knee voltage

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



Collector capacitance at f = 1 MHz

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

Emitter capacitance at f = 1 MHz

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

Transition frequency at f = 35 MHz

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

Small signal current gain at f = 1 kHz

Noise figure at R_S = 2 kΩ; I_C = 200 μA; V_{CE} = 5 V

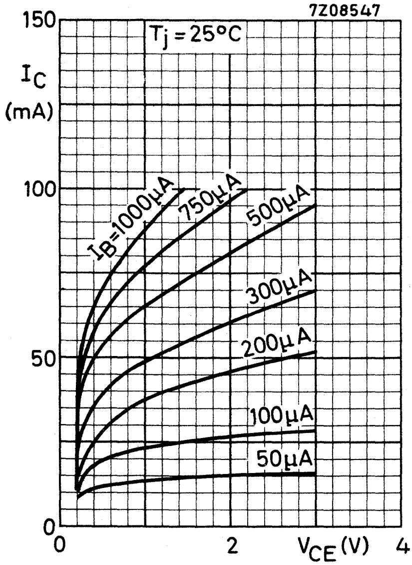
			BC107	BC108	BC109	
Small signal current gain: I_C = 2 mA; V_{CE} = 5 V	h_{fe}	>	125	125	240	
		<	500	900	900	
Noise figure: f = 30 Hz to 15 kHz	F	typ.			1.4	dB
		<			4	dB
Noise figure: f = 1 kHz; B = 200 Hz	F	typ.	2	2	1.2	dB
		<	10	10	4	dB

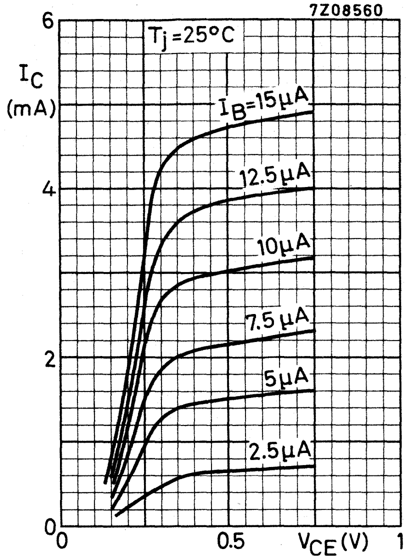
1) V_{BEsat} decreases by about 1.7 mV/°C with increasing temperature.

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

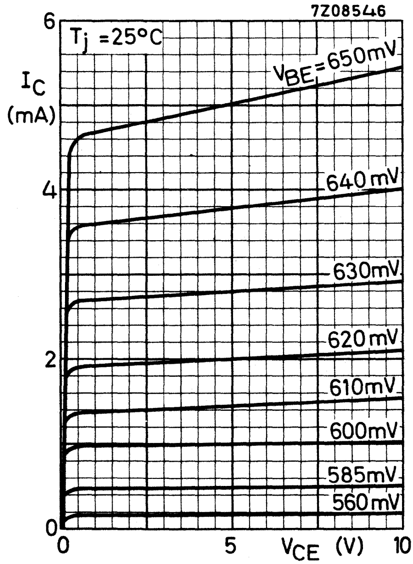
			BC107A BC108A	BC107B BC108B BC109B	BC108C BC109C	
D.C. current gain						
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	>		40	100	
		typ.	90	150	270	
I_C = 2 mA; V_{CE} = 5 V	h_{FE}	>	110	200	420	
		typ.	180	290	520	
		<	220	450	800	
h parameters at f = 1 kHz (common emitter)						
I_C = 2 mA; V_{CE} = 5 V						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

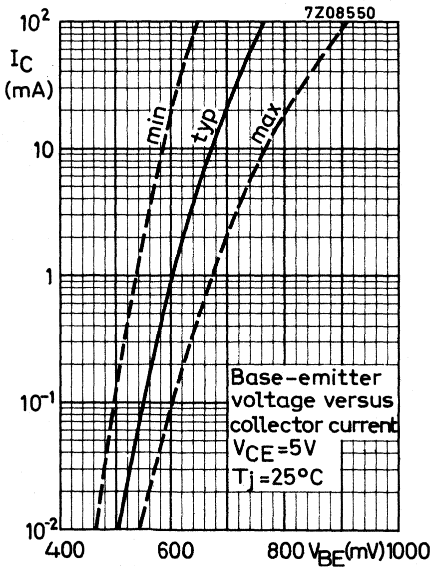
Typical behaviour of collector current versus collector-emitter voltage

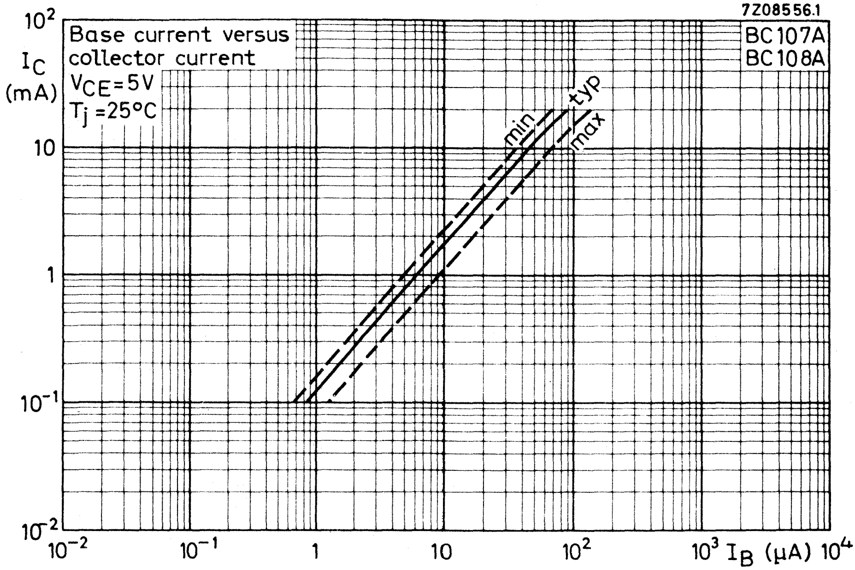


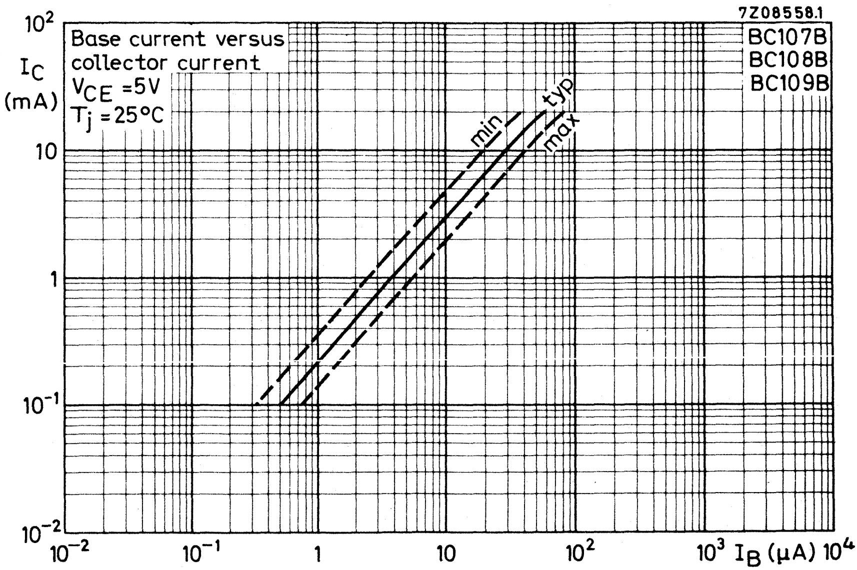


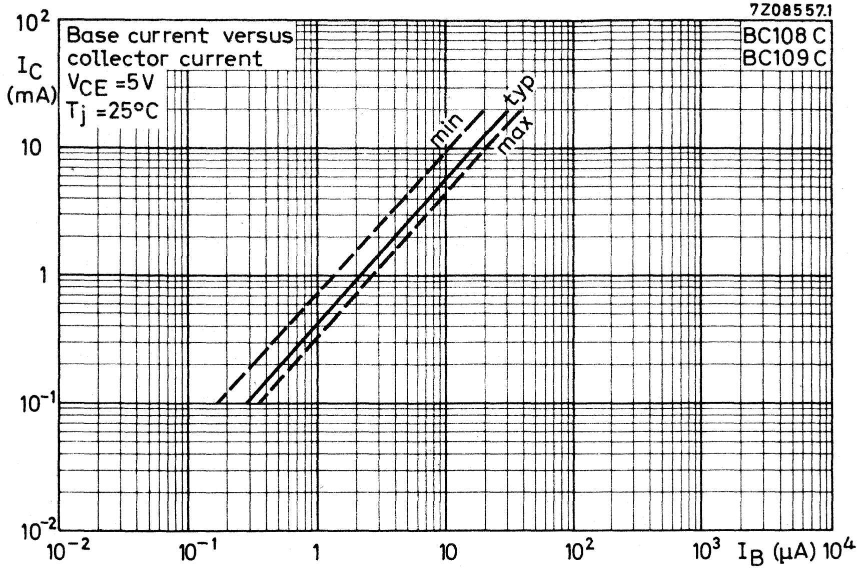
Typical behaviour of collector current versus collector-emitter voltage

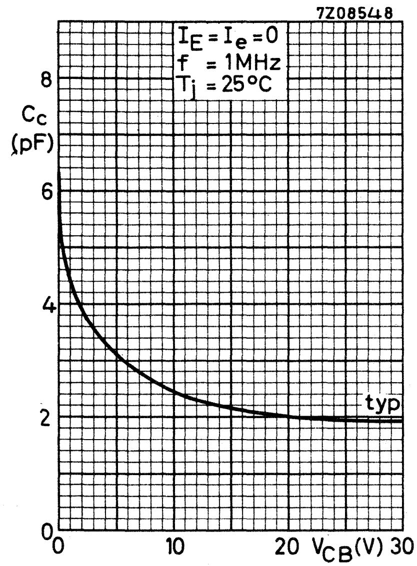


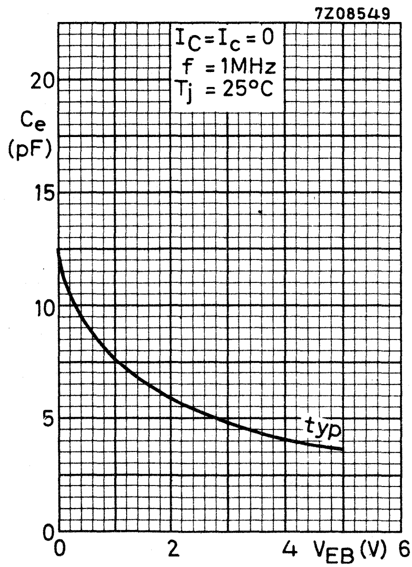


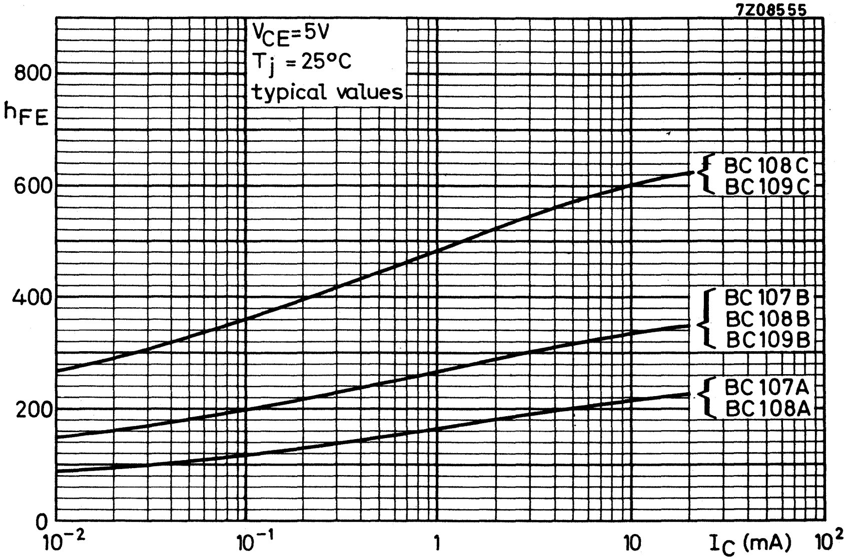

7Z08556.1
Base current versus
collector current
V_{CE} = 5V
T_j = 25°C
BC107A
BC108A
I_C (mA)
min
typ
max
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (µA)
10^4

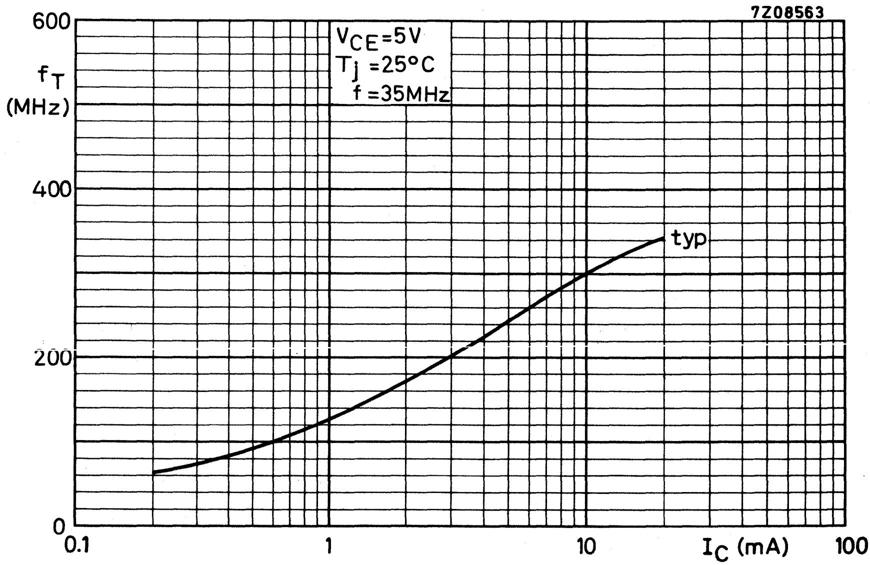

7Z08558.1
Base current versus
collector current
V_{CE} = 5V
T_j = 25°C
BC107B
BC108B
BC109B
I_C (mA)
min
typ
max
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (µA)
10^4


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

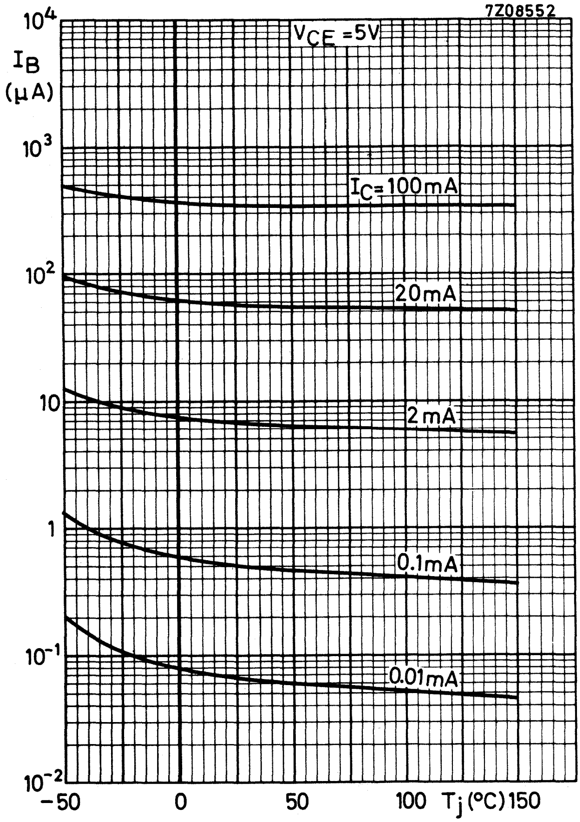

7Z08548
$I_E = I_e = 0$
f = 1 MHz
T_j = 25 °C
C_c (pF)
V_{CB} (V)
typ

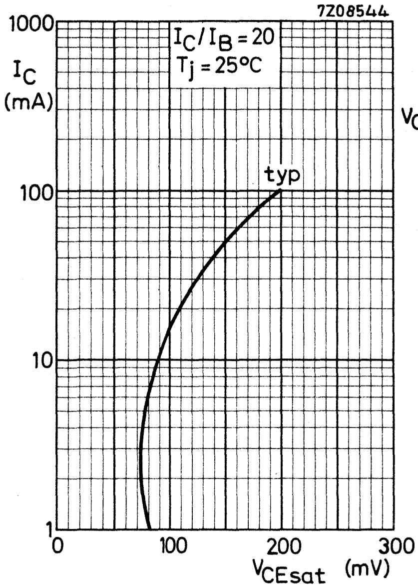

7Z08549
$I_C = I_c = 0$
f = 1 MHz
T_j = 25 °C
C_e (pF)
V_{EB} (V)
typ

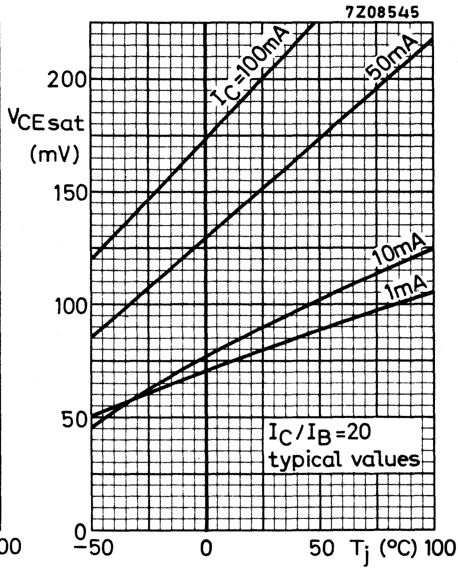

7Z08555
VCE=5V
Tj = 25°C
typical values
hFE
800
600
400
200
0
BC 108C
BC 109C
BC 107B
BC 108B
BC 109B
BC 107A
BC 108A
10−2
10−1
1
10
IC (mA)
102

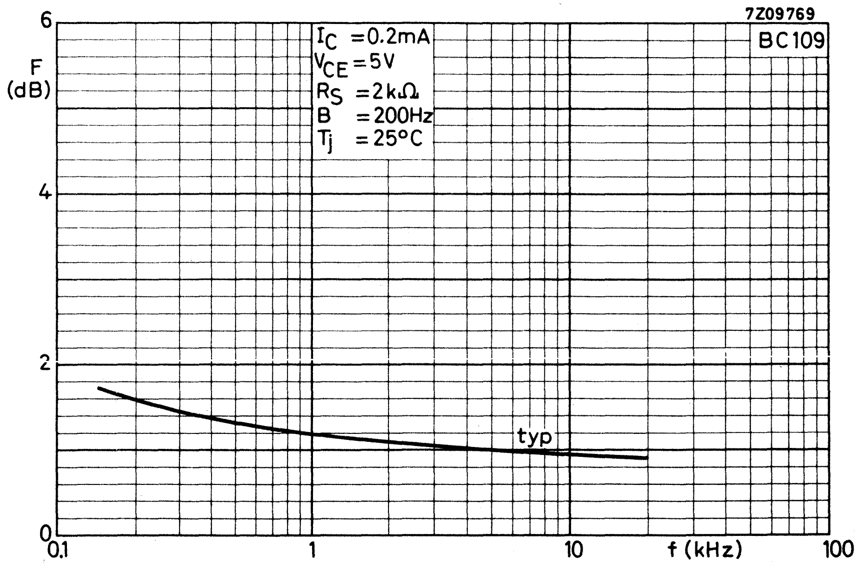

7Z08563
VCE=5V
Tj =25°C
f =35MHz
fT
(MHz)
600
400
200
0
typ
0.1
1
10
IC (mA)
100

Typical behaviour of base current
versus junction temperature

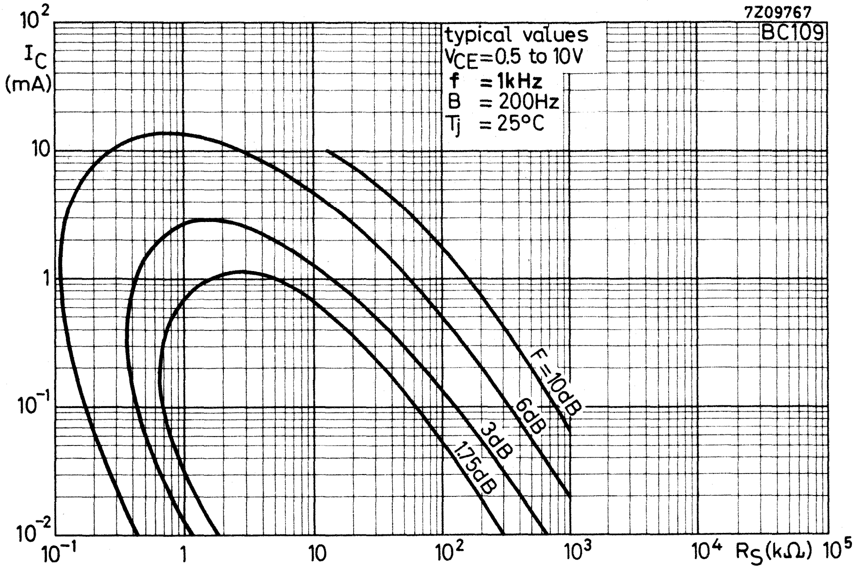


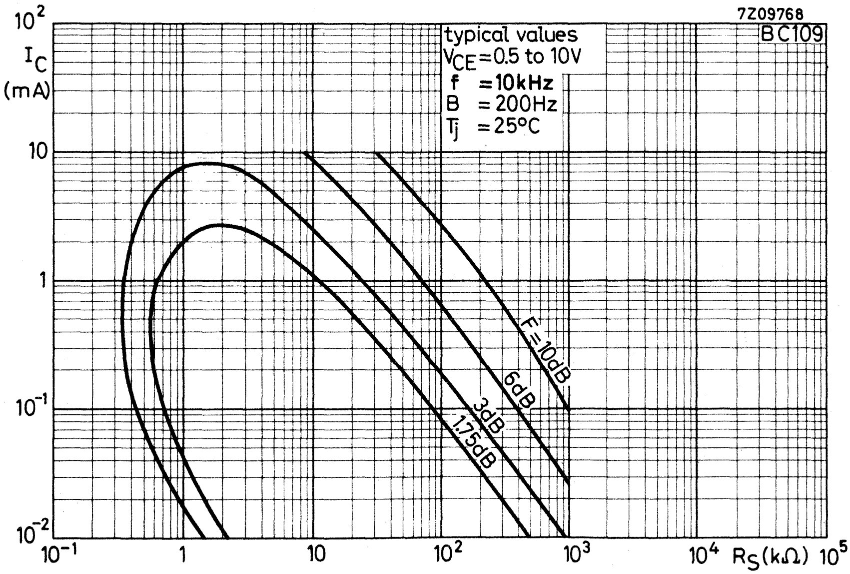

7Z08544
IC/IB = 20
Tj = 25°C
IC
(mA)
1000
100
10
1
typ
0
100
200
300
VCEsat (mV)

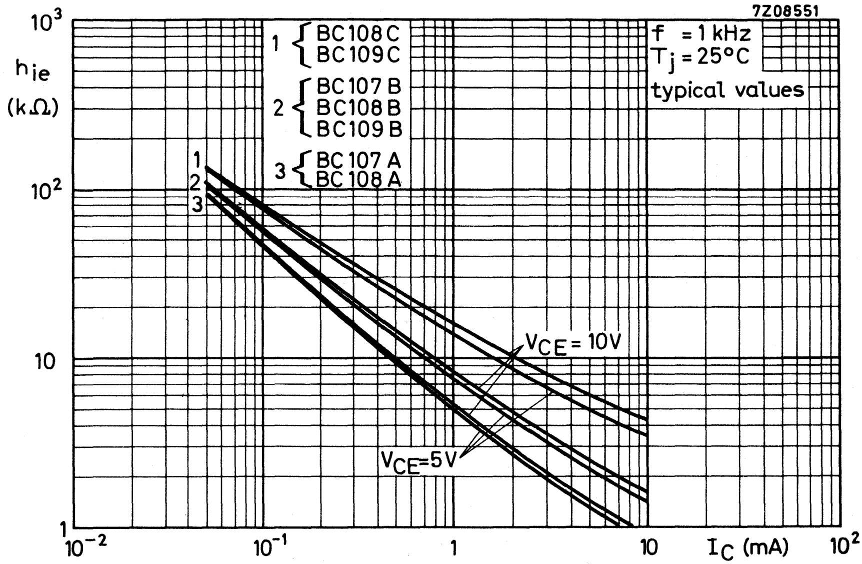

7Z08545
VCEsat
(mV)
200
150
100
50
0
IC=100mA
50mA
10mA
1mA
IC/IB=20
typical values
−50
0
50
Tj (°C) 100

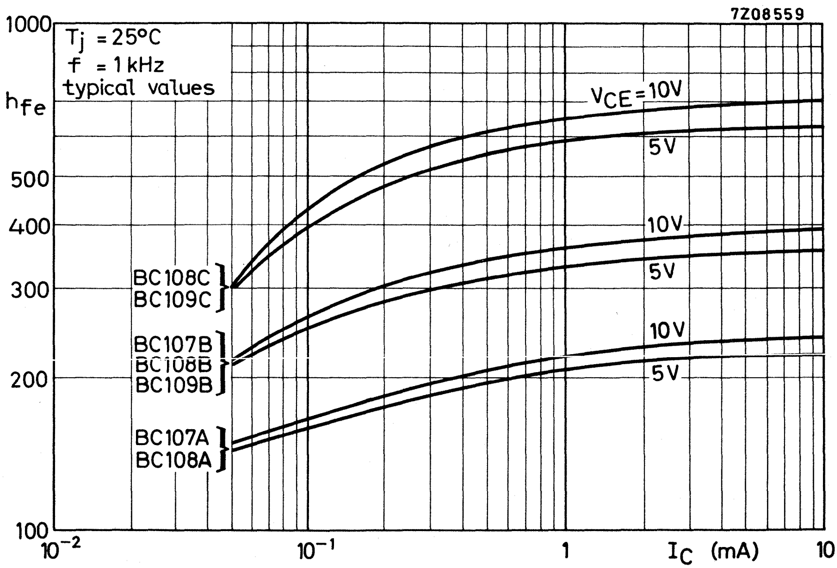

7Z09769
BC109
IC = 0.2mA
VCE = 5V
RS = 2kΩ
B = 200Hz
Tj = 25°C
F
(dB)
6
4
2
0
typ
0.1
1
10
f (kHz)
100

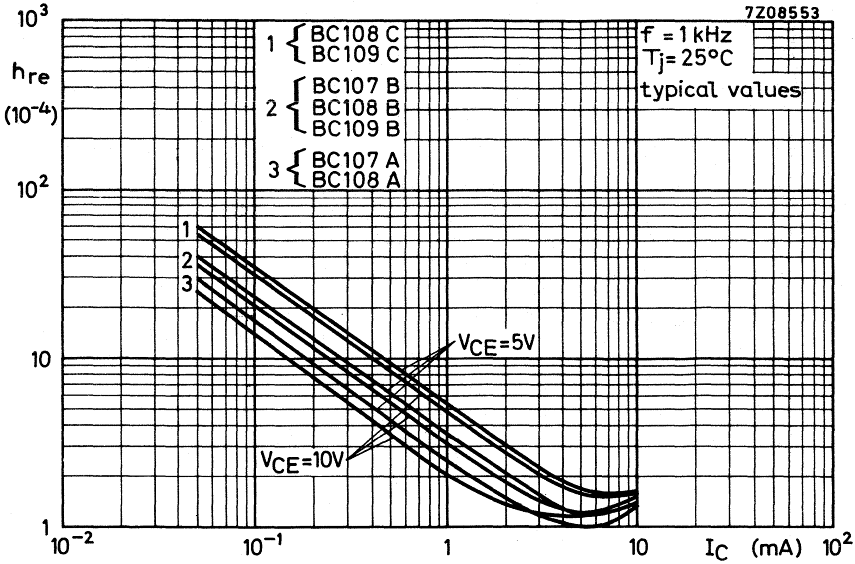
Curves of constant noise figure

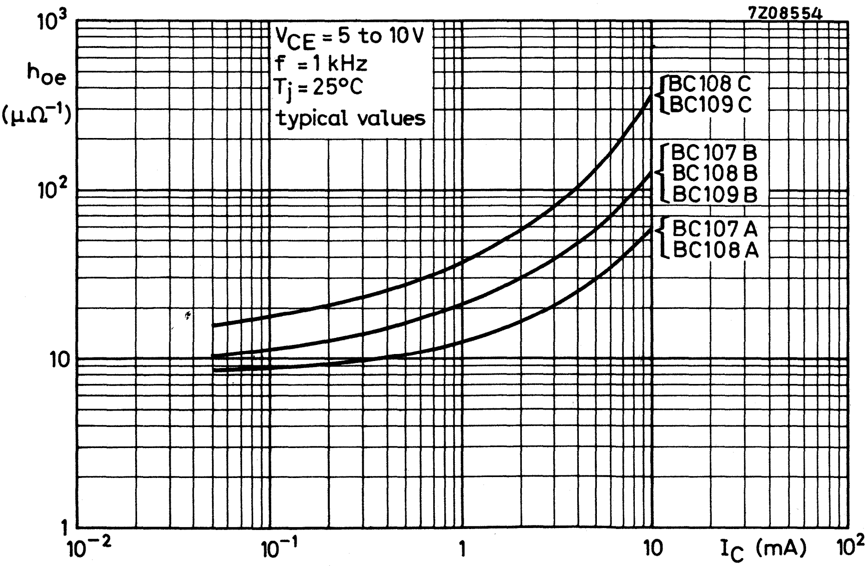


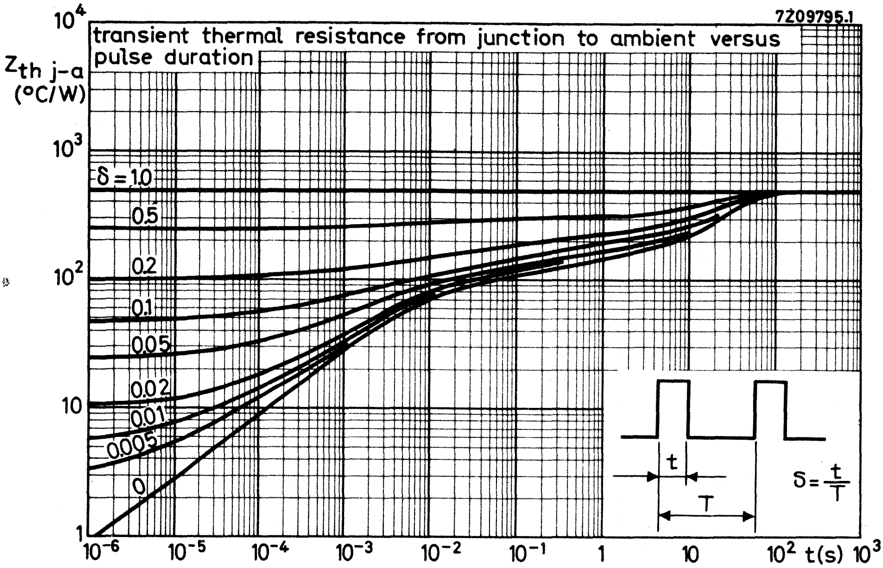



7Z08551
h_{ie} (kΩ)
1 { BC108C BC109C
2 { BC107B BC108B BC109B
3 { BC107A BC108A
f = 1 kHz
T_j = 25°C
typical values
V_{CE} = 10V
V_{CE} = 5V
I_C (mA)


7Z08559
T_j = 25°C
f = 1 kHz
typical values
h_{fe}
V_{CE} = 10V
5V
10V
5V
10V
5V
BC108C BC109C
BC107B BC108B BC109B
BC107A BC108A
I_C (mA)


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


7Z08554
10^3
h_{oe}
$(\mu\Omega^{-1})$
10^2
10
1
V_{CE} = 5 to 10 V
f = 1 kHz
Tj = 25°C
typical values
BC108 C BC109 C
BC107 B BC108 B BC109 B
BC107 A BC108 A
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2


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

SILICON PLANAR EPITAXIAL TRANSISTORS

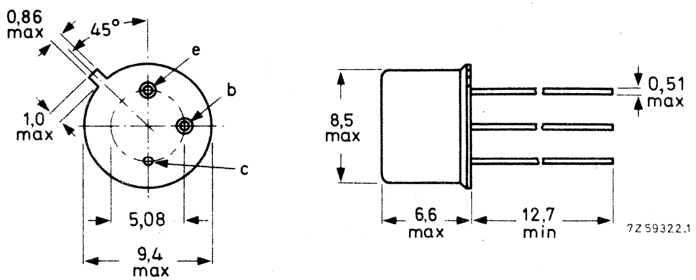
N-P-N transistors in TO-39 metal envelopes for general purpose applications. P-N-P complements are BC160 and BC161.

QUICK REFERENCE DATA						
			BC140		BC141	
Collector-emitter voltage (open base)	V_{CEO}	max.	40		60	V
Collector current (d.c.)	I_C	max.		1		A
Total power dissipation up to T_{case} = 45 °C	P_{tot}	max.		3,7		W
Junction temperature	T_j	max.		175		°C
Transition frequency I_C = 50 mA; V_{CE} = 10 V	f_T	>		50		MHz
			BC140-6 BC141-6	BC140-10 BC141-10	BC140-16 BC141-16	
D.C. current gain I_C = 100 mA; V_{CE} = 1 V	h_{FE}	>	40	63	100	
		<	100	160	250	

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-39



max. lead diameter is guaranteed only for 12,7 mm

Accessories: 56218 (package); 56245 (distance disc).

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

			BC 140	BC 141	
Voltages					
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	7	V
Currents					
Collector current (d.c.)	I_C	max.	1		A
Base current (d.c.)	I_B	max.	100		mA
Power dissipation					
Total power dissipation up to T_{case} = 45 °C	P_{tot}	max.	3,7		W
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	$R_{th\ j\text{-}a}$	=	200	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	35	°C/W

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

Characteristic	Symbol		Value	Unit
Collector cut-off current				
V_{BE} = 0; V_{CE} = 60 V	I_{CES}	typ.	10	nA
		<	100	nA
V_{BE} = 0; V_{CE} = 60 V; T_{amb} = 150 °C	I_{CES}	typ.	10	μA
		<	100	μA
Base-emitter voltage				
I_C = 1 A; V_{CE} = 1 V	V_{BE}	typ.	1,2	V
		<	1,8	V
Saturation voltage				
I_C = 1 A; I_B = 100 mA	V_{CEsat}	typ.	0,6	V
		<	1,0	V
Transition frequency at f = 20 MHz				
I_C = 50 mA; V_{CE} = 10 V	f_T	>	50	MHz
Collector capacitance at f = 1 MHz				
$I_E = I_e$ = 0; V_{CB} = 10 V	C_c	<	25	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c$ = 0; V_{EB} = 0,5 V	C_e	<	80	pF

D.C. current gain			BC140-6 BC141-6	BC140-10 BC141-10	BC140-16 BC141-16
I_C = 100 μA ; V_{CE} = 1 V	h_{FE}	typ.	28	40	90
		>	40	63	100
I_C = 100 mA; V_{CE} = 1 V	h_{FE}	typ.	63	100	160
		<	100	160	250
I_C = 1 A ; V_{CE} = 1 V	h_{FE}	typ.	15	20	30

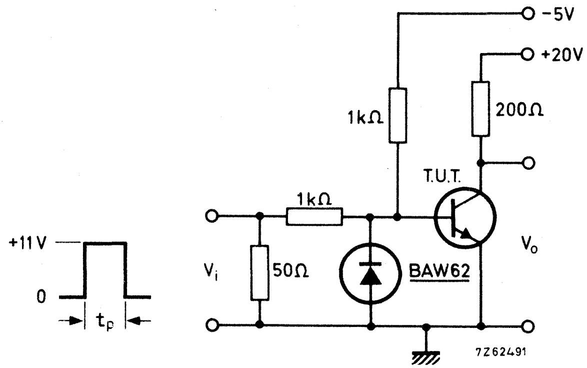
CHARACTERISTICS (continued) $T_{amb} = 25\ ^oC$

Switching times

$I_{Con} = 100$ mA; $I_{Bon} = -I_{Boff} = 5$ mA

Turn-on time	t_{on}	<	250	ns
Turn-off time	t_{off}	<	850	ns

Test circuit:



Pulse generator:

Pulse duration	t_p	= 10 μs
Rise time	t_r	≤ 15 ns
Fall time	t_f	≤ 15 ns
Source impedance	Z_s	= 50 Ω

Oscilloscope

Rise time	t_r	≤ 15 ns
Input impedance	Z_i	≥ 100 kΩ

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a microminiature plastic envelope designed for hearing aids, watches, etc.

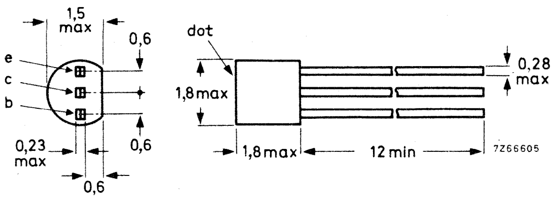
QUICK REFERENCE DATA

			BC146 /01	BC146 /02	BC146 /03	
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

SOT-42



Coloured dot on top of the black body indicates h_{FE} group:

BC146/01 red
BC146/02 yellow
BC146/03 green

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
Temperature				
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

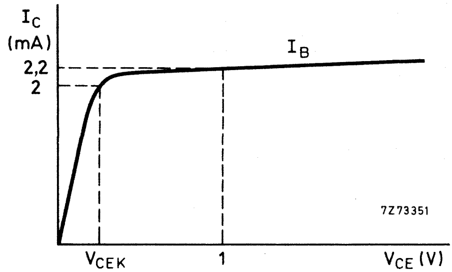
T_j = 25 °C unless otherwise specified

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



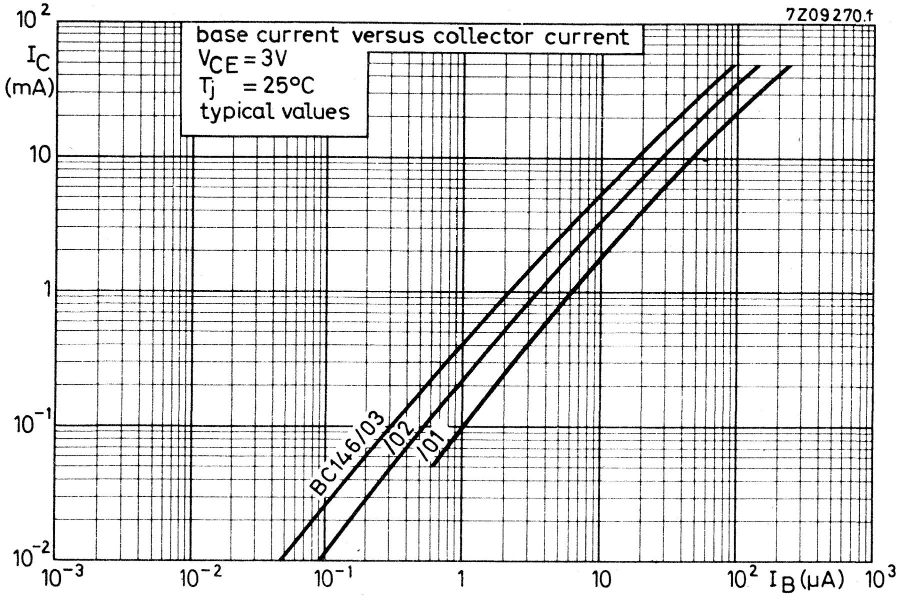
Collector capacitance at f = 1 MHz

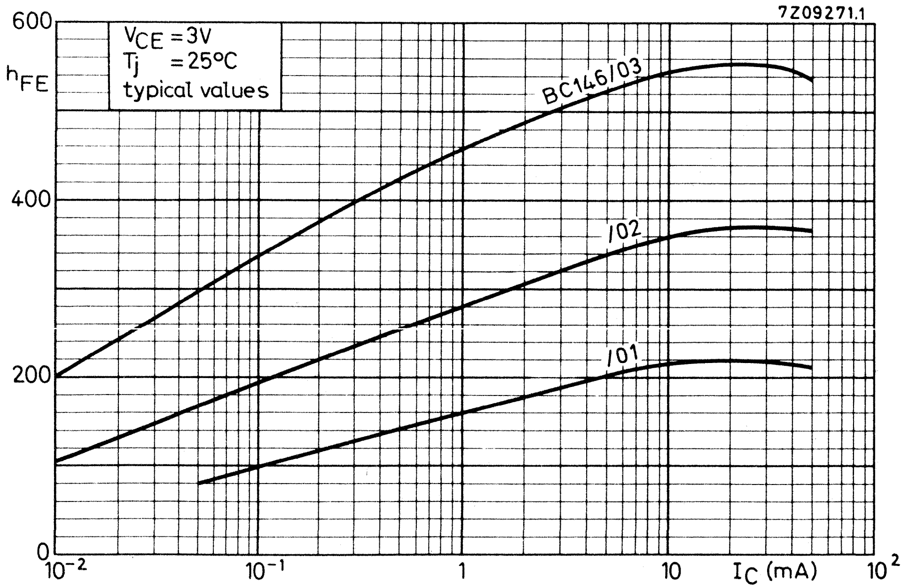
I_E = I_e = 0; V_{CB} = 5 V	C_c	typ.	4	pF

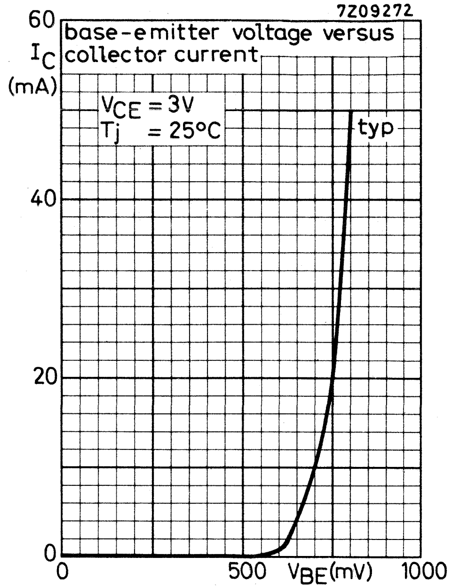
Transition frequency

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

D.C. current gain	BC146	/01	/02	/03
I_C = 0,2 mA; V_{CE} = 0,5 V	h_{FE}	typ. 115 80 to 200	220 140 to 350	380 280 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 4	2 dB - 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 μA/V


7Z09270.1
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}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
I_B (μA)
10^3
BC146/03
/02
/01


7Z09271.1
V_{CE} = 3V
T_j = 25°C
typical values
h_{FE}
600
400
200
0
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2
BC146/03
/02
/01


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

SILICON PLANAR EPITAXIAL TRANSISTORS

General-purpose n-p-n transistors in a plastic envelope with stiff, self-locking pins suitable for use with standard printed boards.
The BC149 is primarily intended for low noise input stages in tape recorders, hi-fi amplifiers and other audio frequency equipment.

QUICK REFERENCE DATA

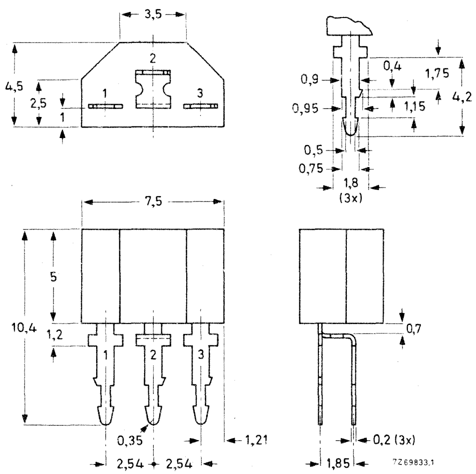
			BC147	BC148	BC149	
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	50	30	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	20	20	V
Collector current (peak value)	I_{CM}	max.	200	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	300	300	mW
Junction temperature	T_j	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 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

SOT-25

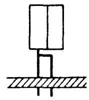
Connections

1. Emitter
2. Base
3. Collector

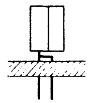


MOUNTING INSTRUCTIONS

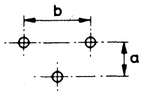
1. Thickness of printed board: max. 1.1 mm
   Hole diameter 0.77 to 0.83 mm



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]

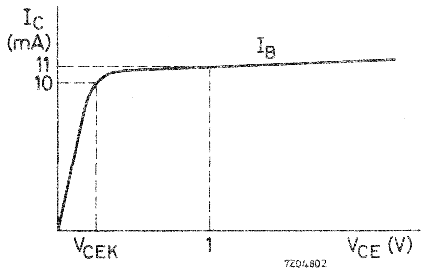
$I_C = 2$ mA; $V_{CE} = 5$ V	V_{BE}	typ.	620	mV
		550 to	700	mV
$I_C = 10$ mA; $V_{CE} = 5$ V	V_{BE}	<	770	mV

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

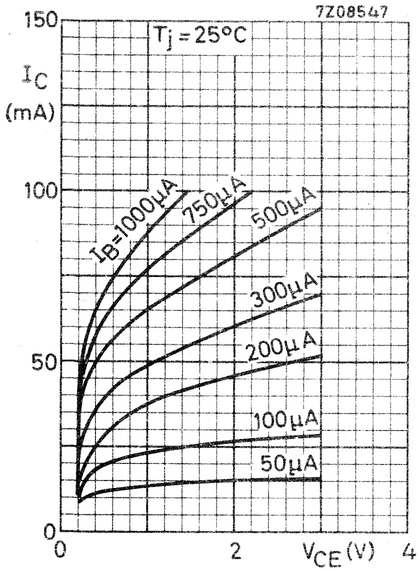
1) V_{BE} decreases by about 2 mV/°C with increasing temperature.
2) V_{BEsat} decreases by about 1.7 mV/°C with increasing temperature.

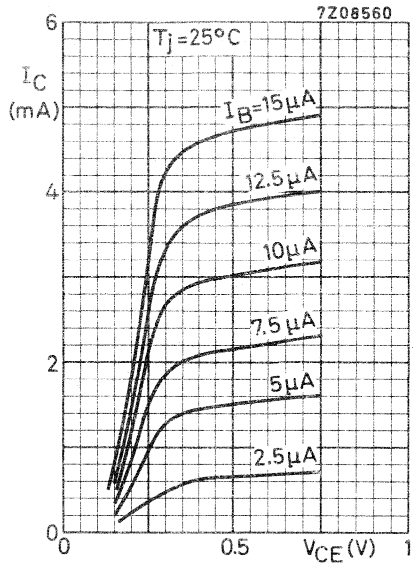
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

			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

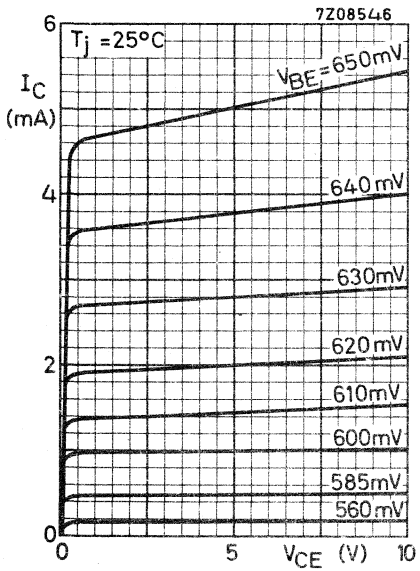
			BC147A BC148A	BC147B BC148B BC149B	BC148C BC149C	
D.C. current gain						
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	typ.	90	150	270	
I_C = 2 mA; V_{CE} = 5 V	h_{FE}	>	110	200	420	
		typ.	180	290	520	
		<	220	450	800	
h parameters at f = 1 kHz (common emitter)						
I_C = 2 mA; V_{CE} = 5 V						
Input impedance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

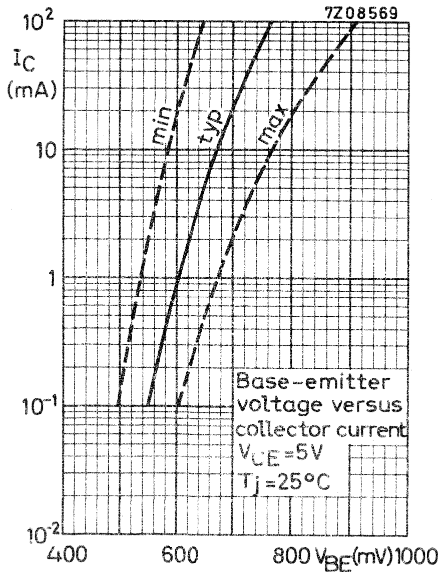
Typical behaviour of collector current versus collector-emitter voltage



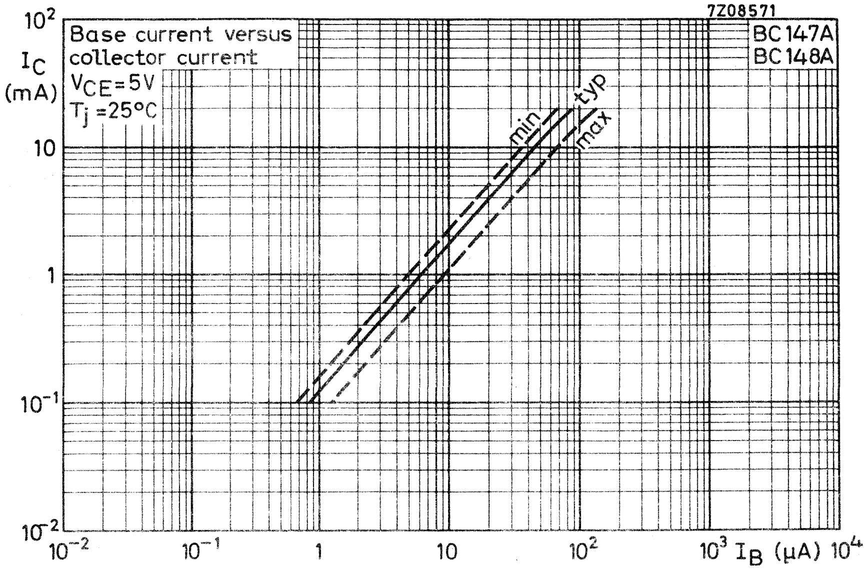


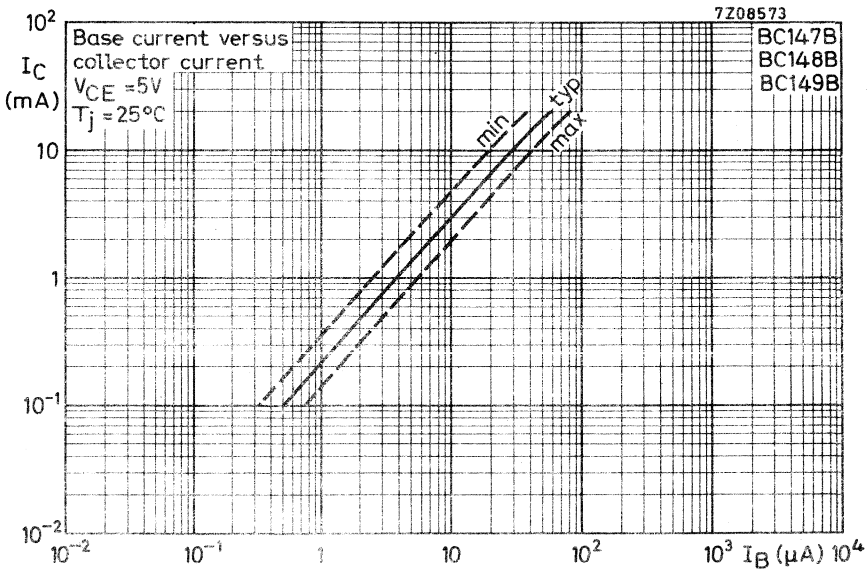
Typical behaviour of collector current versus collector-emitter voltage

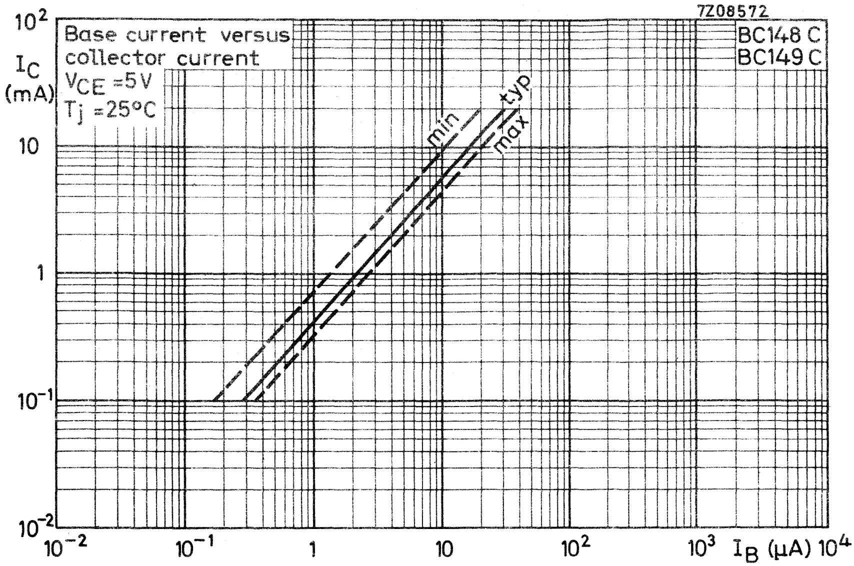


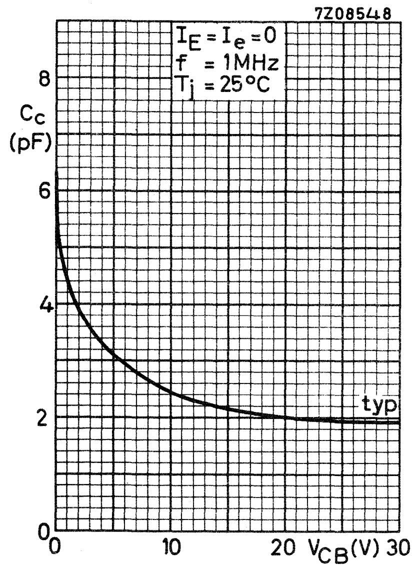


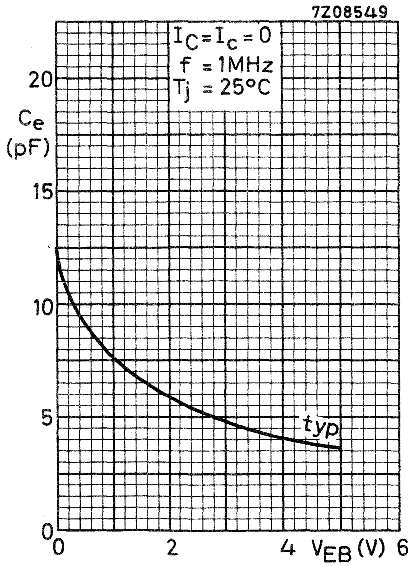
Base-emitter voltage versus collector current
V_{CE} = 5 V
$T_j = 25°C$

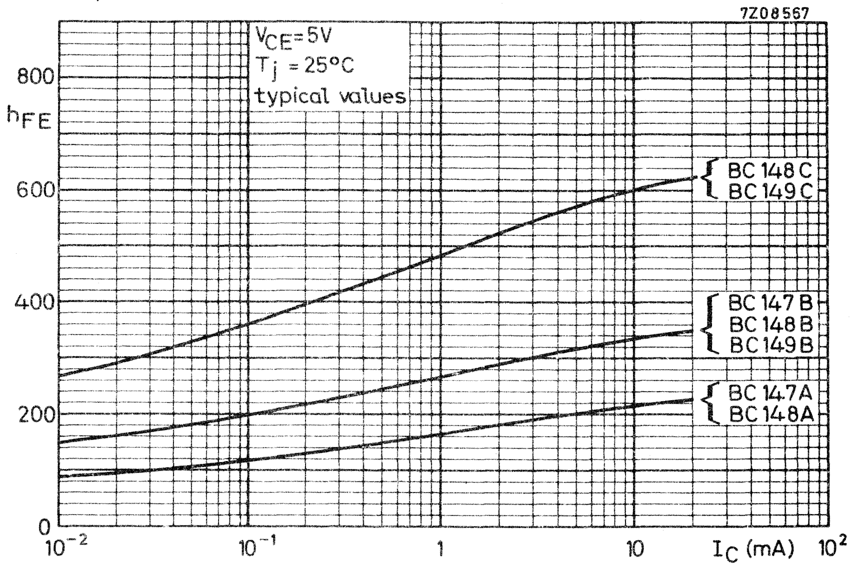

7Z08571
Base current versus
collector current
V_{CE} = 5V
T_j = 25°C
BC147A
BC148A
I_C
(mA)
10^2
10
1
10^{-1}
10^{-2}
min
typ
max
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (μA)
10^4

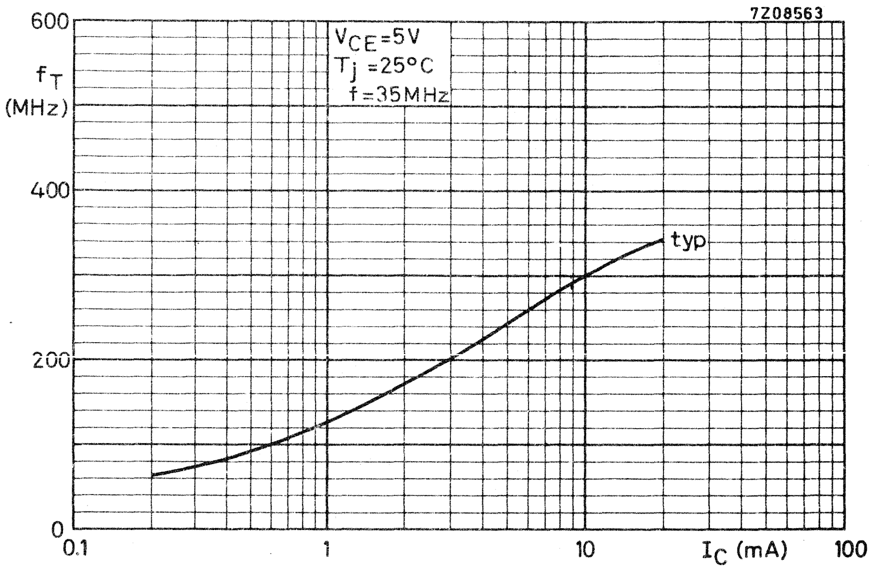

7Z08573
Base current versus
collector current
V_{CE} = 5V
T_j = 25°C
BC147B
BC148B
BC149B
I_C
(mA)
10^2
10
1
10^{-1}
10^{-2}
min
typ
max
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (μA)
10^4


7Z08572
Base current versus collector current
V_{CE} = 5 V
T_j = 25°C
BC148 C
BC149 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

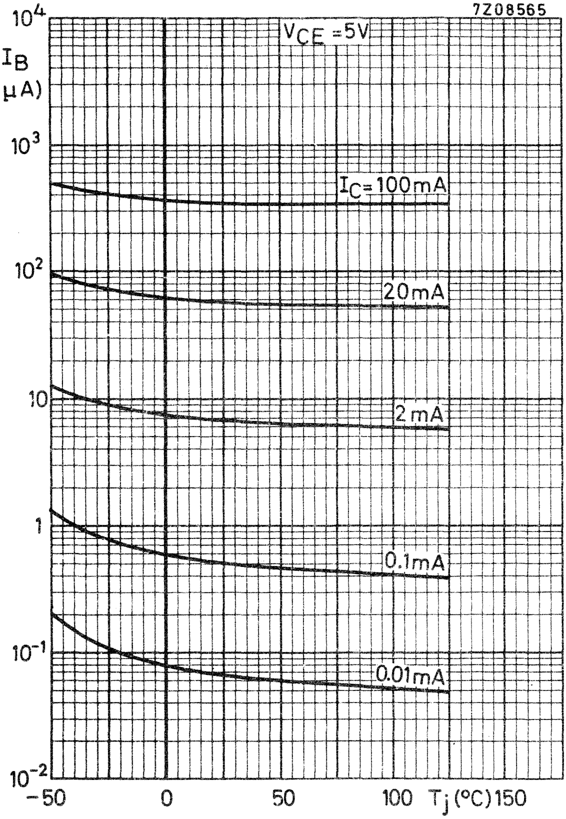

7Z08548
$I_E = I_e = 0$
f = 1 MHz
T_j = 25°C
C_c (pF)
8
6
4
2
0
typ
0
10
20
V_{CB} (V)
30

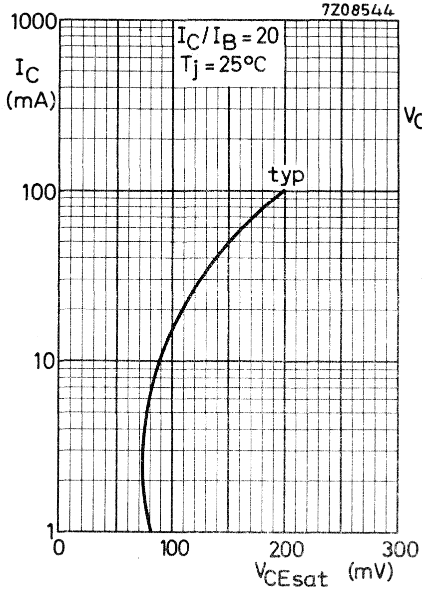

7Z08549
$I_C = I_c = 0$
f = 1 MHz
T_j = 25°C
C_e (pF)
20
15
10
5
0
typ
0
2
4
V_{EB} (V)
6

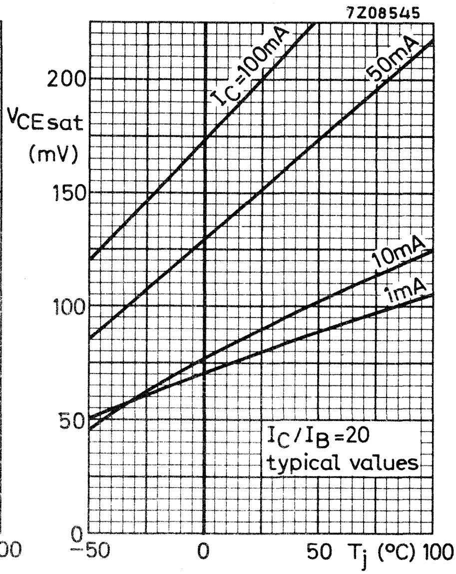

7Z08567
V_{CE}=5V
T_j = 25°C
typical values
h_{FE}
800
600
400
200
0
BC148C
BC149C
BC147B
BC148B
BC149B
BC147A
BC148A
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

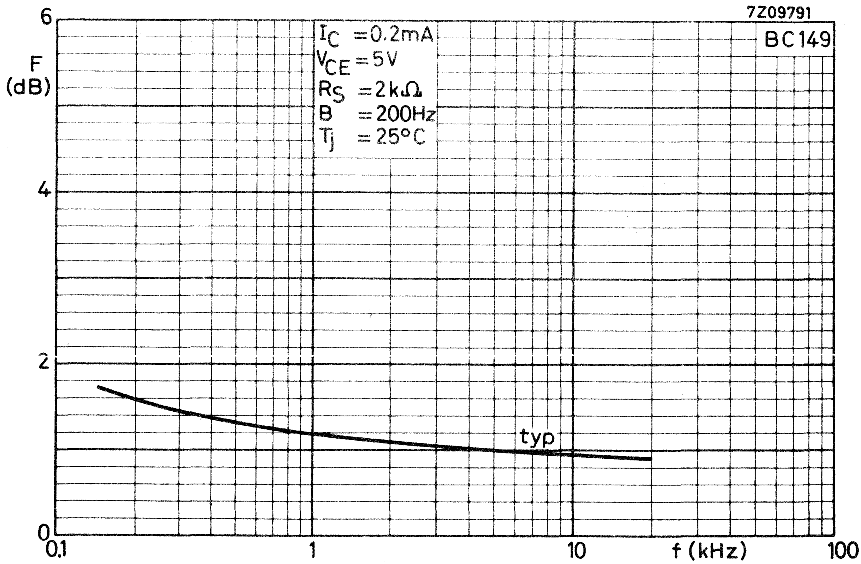

7Z08563
V_{CE}=5V
T_j =25°C
f=35MHz
f_T
(MHz)
600
400
200
0
typ
0.1
1
10
I_C (mA)
100

Typical behaviour of base current
versus junction temperature

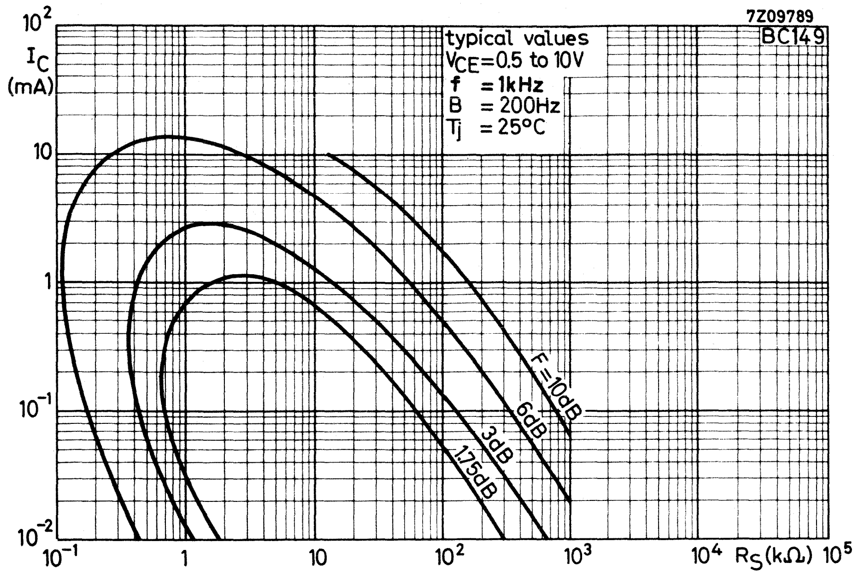


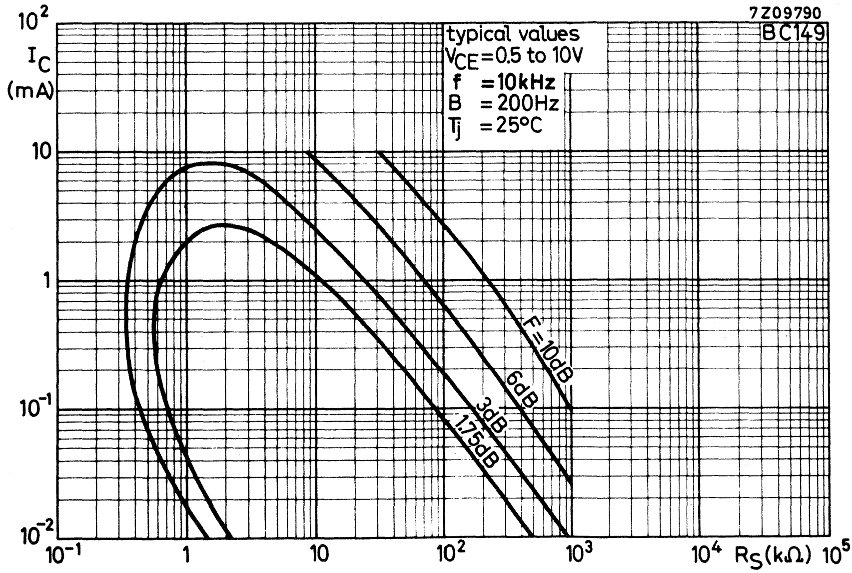

7Z08544
$I_C/I_B = 20$
$T_j = 25°C$
I_C
(mA)
1000
100
10
1
typ
0
100
200
300
V_{CEsat} (mV)

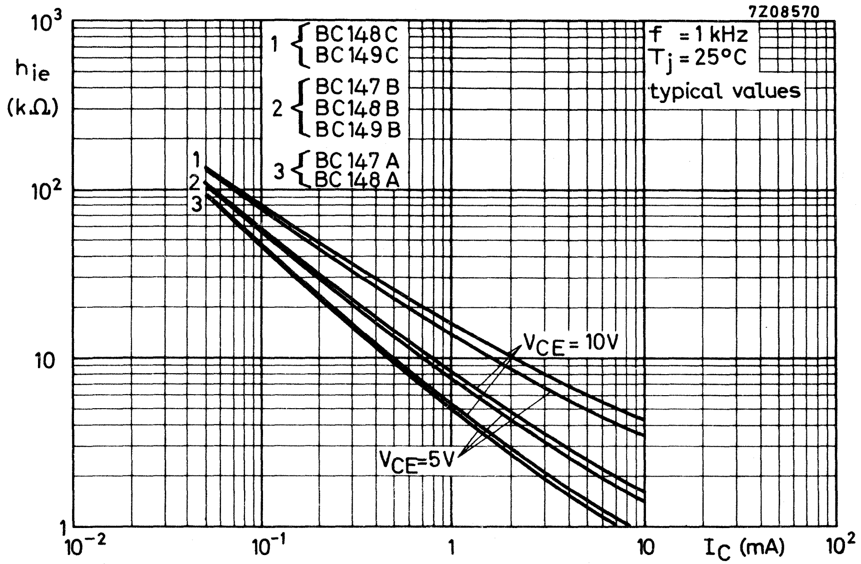

7Z08545
V_{CEsat}
(mV)
200
150
100
50
0
$I_C = 100mA$
50mA
10mA
1mA
$I_C/I_B = 20$
typical values
−50
0
50
T_j (°C)
100

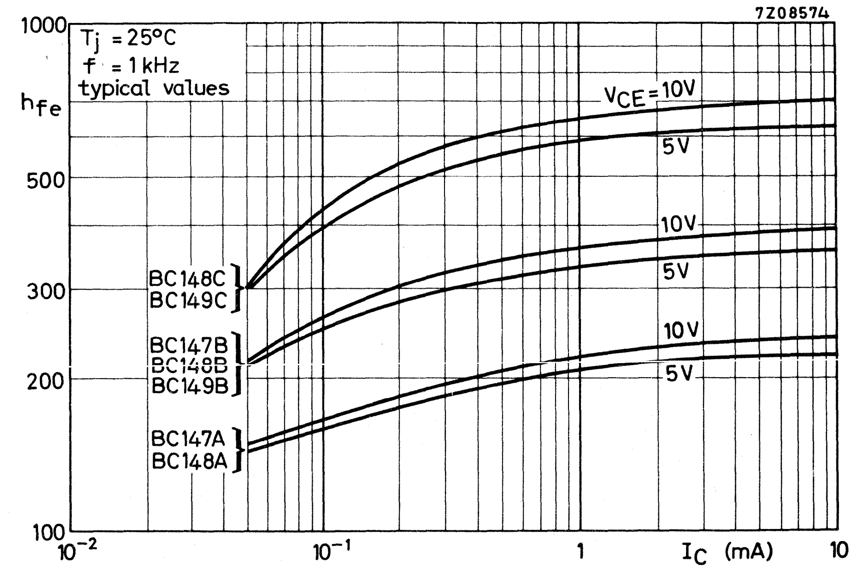

7Z09791
BC149
I_C = 0.2mA
V_{CE} = 5V
R_S = 2kΩ
B = 200Hz
T_j = 25°C
F
(dB)
6
4
2
0
typ
0.1
1
10
f (kHz)
100

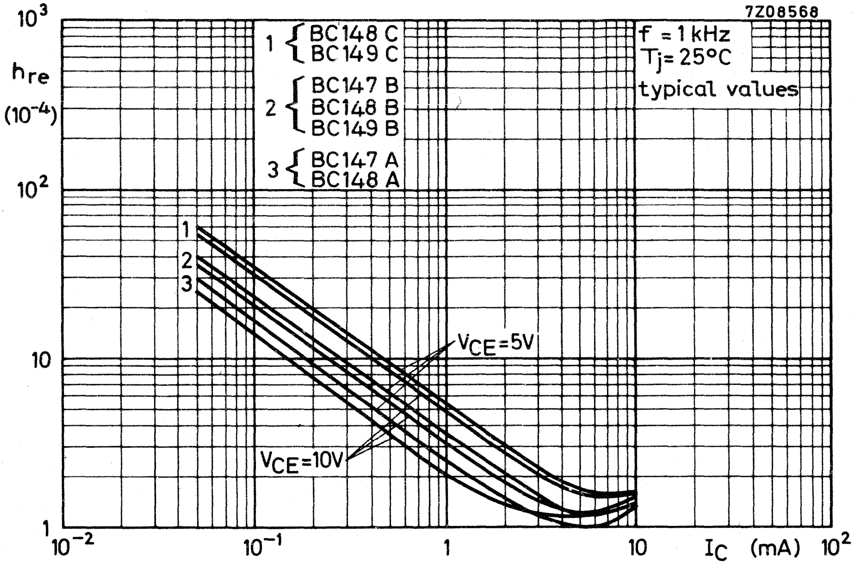
Curves of constant noise figure

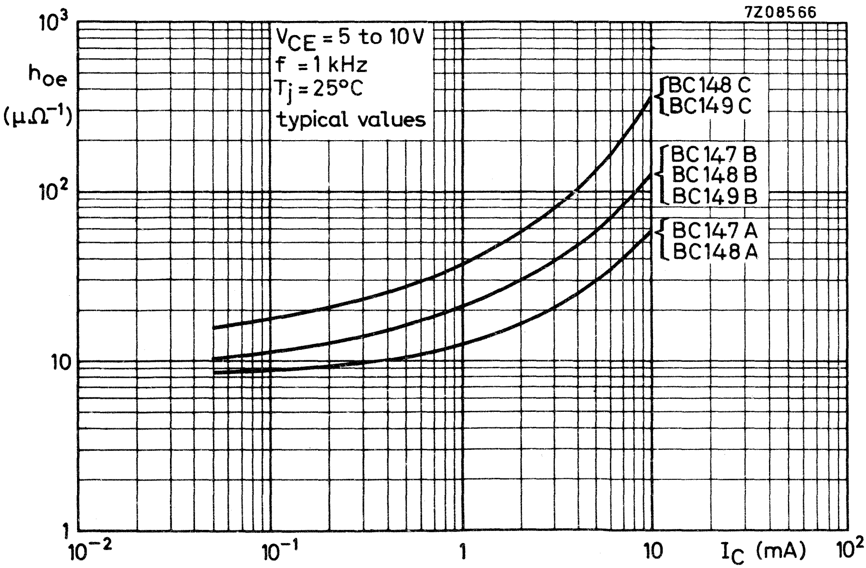


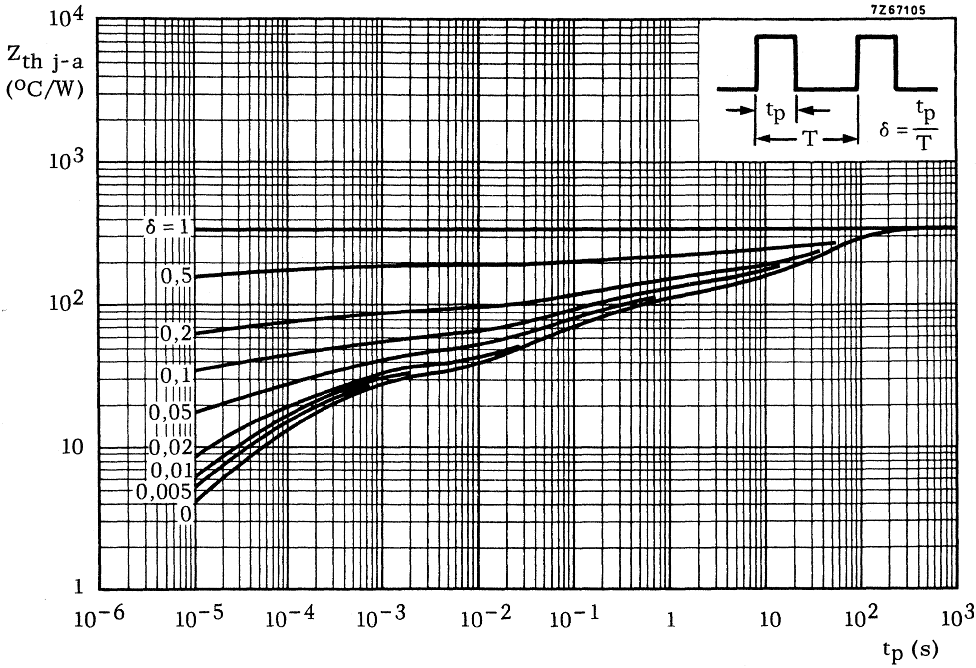



7Z08570
h_ie (kΩ)
1 { BC148C BC149C
2 { BC147B BC148B BC149B
3 { BC147A BC148A
f = 1 kHz
Tj = 25°C
typical values
VCE = 10V
VCE = 5V
IC (mA)


7Z08574
Tj = 25°C
f = 1 kHz
typical values
h_fe
VCE = 10V
5V
10V
5V
10V
5V
BC148C BC149C
BC147B BC148B BC149B
BC147A BC148A
IC (mA)


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


7Z08566
10^3
h_{oe}
$(\mu\Omega^{-1})$
10^2
10
1
V_{CE} = 5 to 10 V
f = 1 kHz
T_j = 25°C
typical values
{BC148 C / BC149 C
{BC147 B / BC148 B / BC149 B
{BC147 A / BC148 A
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2


7Z67105
$Z_{th\ j\text{-}a}$ (°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)

SILICON PLANAR EPITAXIAL TRANSISTORS

General-purpose p-n-p transistors in a plastic envelope with stiff self-locking pins suitable for use with standard printed boards.
The BC159 is primarily intended for low noise input stages in tape recorders, hi-fi amplifiers and other audio frequency equipment.

QUICK REFERENCE DATA

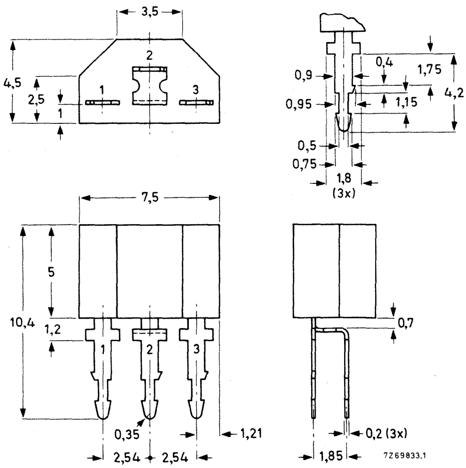
			BC157	BC158	BC159	
Collector-emitter voltage ($+V_{BE}$ = 1 V)	$-V_{CEX}$	max.	50	30	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	25	20	V
Collector current (peak value)	$-I_{CM}$	max.	200	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	300	300	mW
Junction temperature	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}	> <	75 260	75 500	125 500	
Transition frequency $-I_C$ = 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

SOT-25

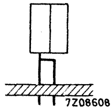
Connections

1. Emitter
2. Base
3. Collector

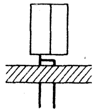


MOUNTING INSTRUCTIONS

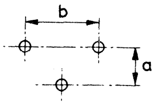
1. Thickness of printed board: max. 1.1 mm
   Hole diameter 0.77 to 0.83 mm



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])

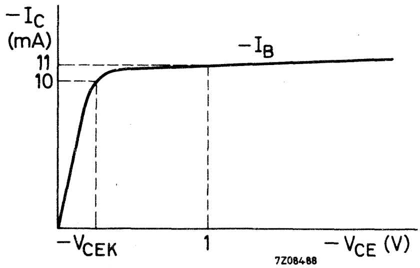
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	$-V_{BE}$	typ.	650	mV
		600 to 750		mV

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

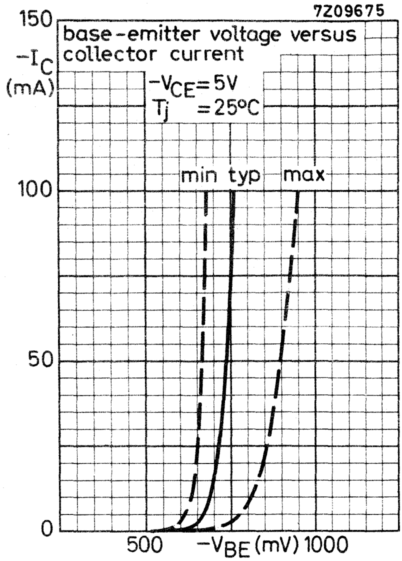
$-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.	150	MHz

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

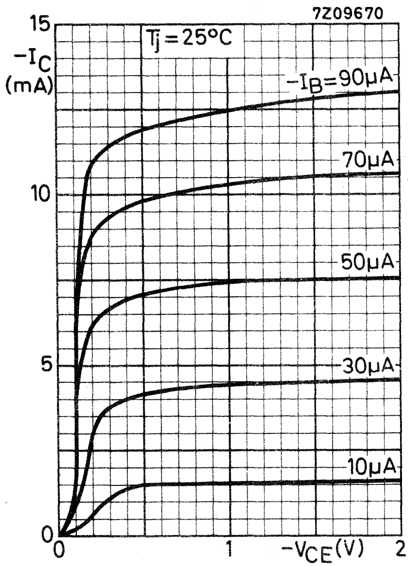
CHARACTERISTICS (continued) $T_j = 25\ ^oC$ unless otherwise specified

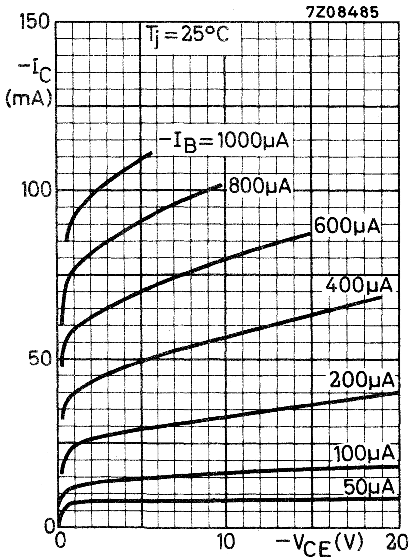
			BC157	BC158	BC159	
Small signal current gain at f = 1 kHz						
$-I_C = 2$ mA; $-V_{CE} = 5$ V	h_{fe}	>	75	75	125	
		<	260	500	500	
Noise figure at $R_S = 2\ k\Omega$						
$-I_C = 200\ \mu A$; $-V_{CE} = 5$ V						
f = 30 Hz to 15 kHz	F	typ.			1.2	dB
		<			4	dB
f = 1 kHz; B = 200 Hz	F	typ.	2	2	1	dB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

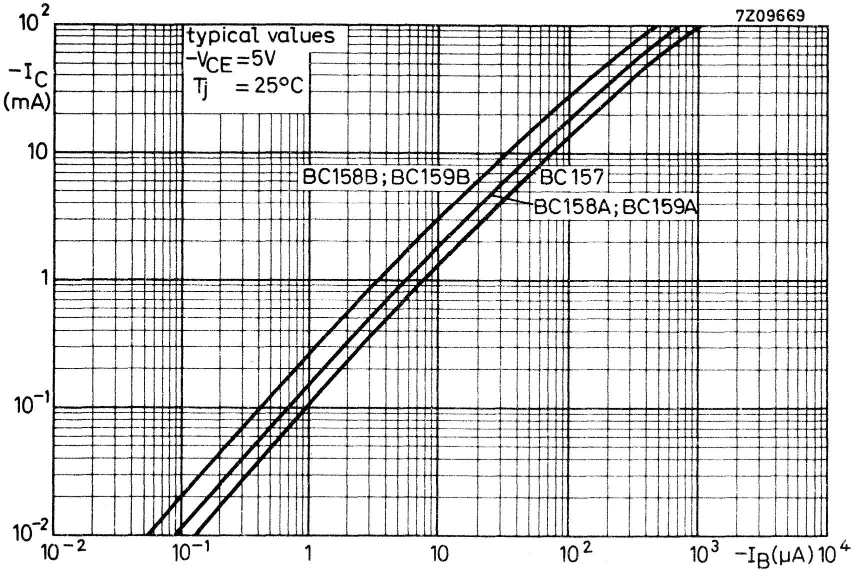
			BC157	BC158A BC159A	BC158B BC159B
D.C. current gain					
$-I_C = 2$ mA; $-V_{CE} = 5$ V	h_{FE}	typ.	140	180	290
Small signal current gain at f = 1 kHz					
$-I_C = 2$ mA; $-V_{CE} = 5$ V	h_{fe}	>	75	125	240
		<	260	260	500

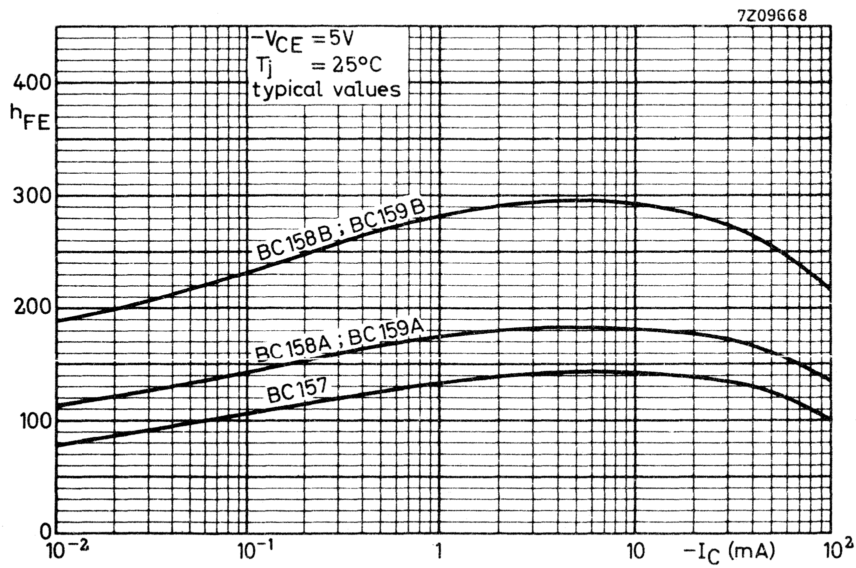


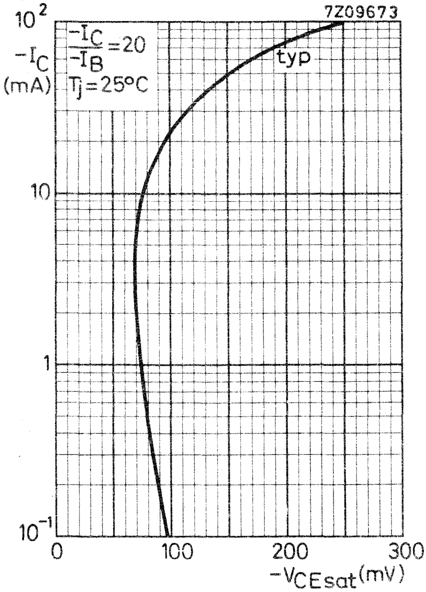
Typical behaviour of collector current versus collector-emitter voltage

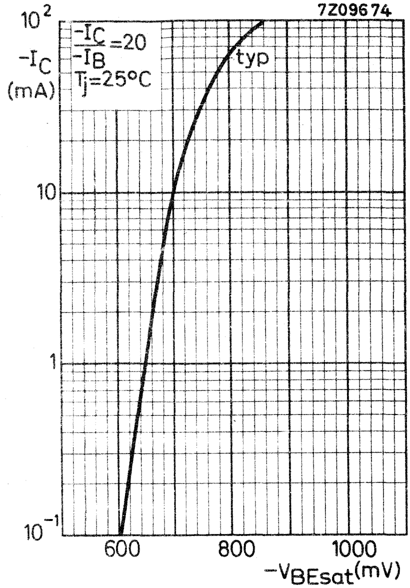


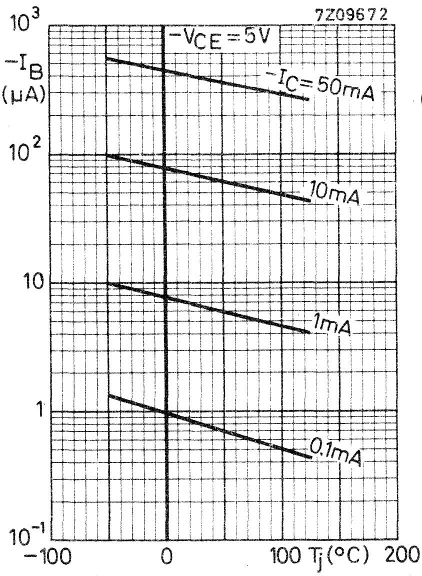



7Z09669
typical values
$-V_{CE} = 5V$
$T_j = 25°C$
$-I_C$ (mA)
10^2
10
1
10^{-1}
10^{-2}
BC158B; BC159B
BC157
BC158A; BC159A
10^{-2}
10^{-1}
1
10
10^2
10^3
$-I_B$ (μA)
10^4

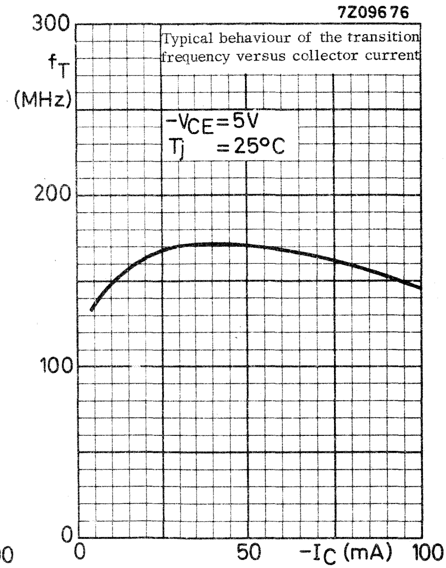

7Z09668
$-V_{CE} = 5V$
$T_j = 25°C$
typical values
h_{FE}
400
300
200
100
0
BC158B; BC159B
BC158A; BC159A
BC157
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2



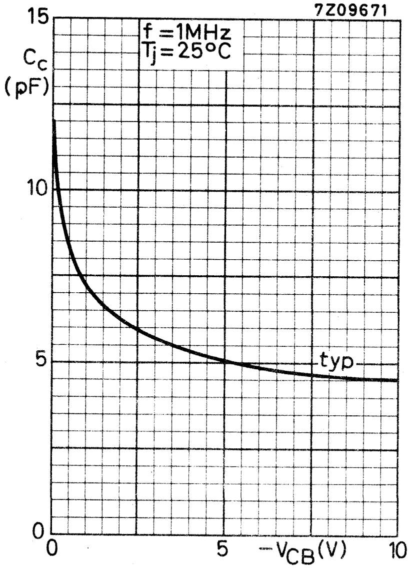


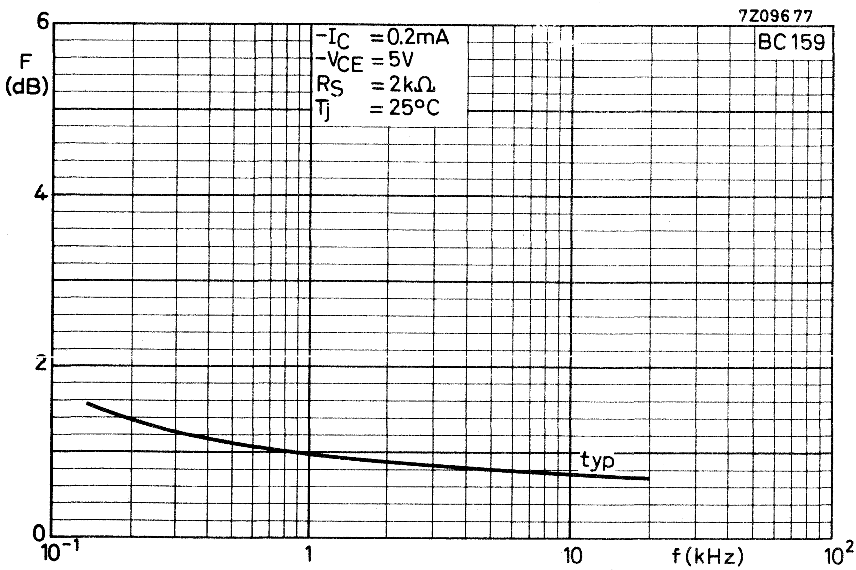


Typical behaviour of base current versus junction temperature

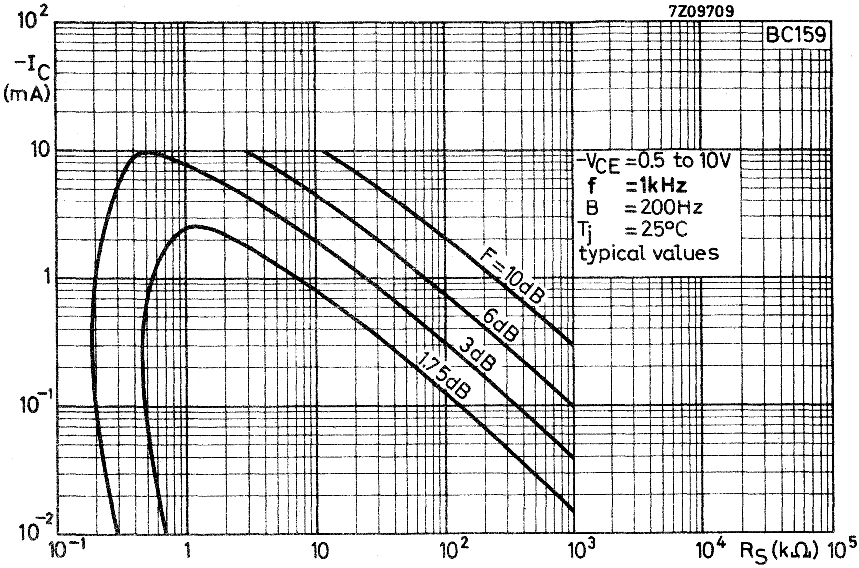


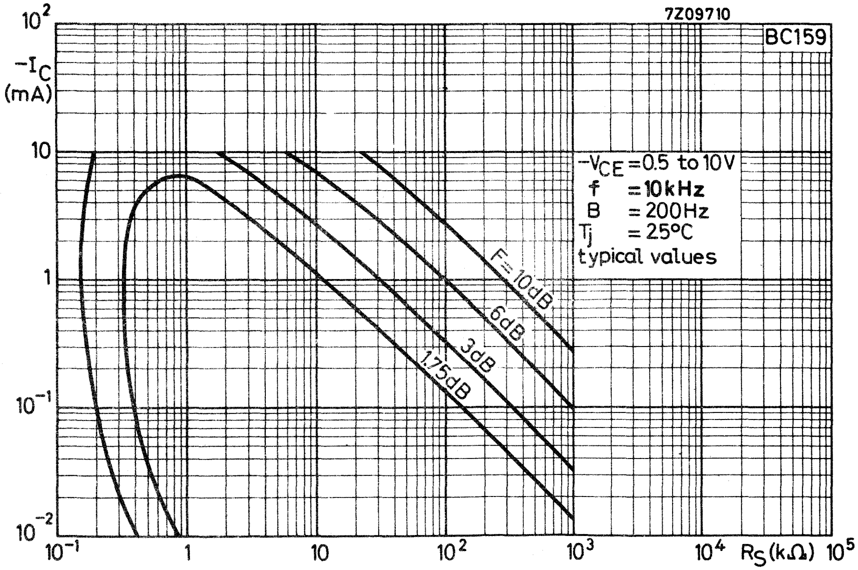
Typical behaviour of the transition frequency versus collector current

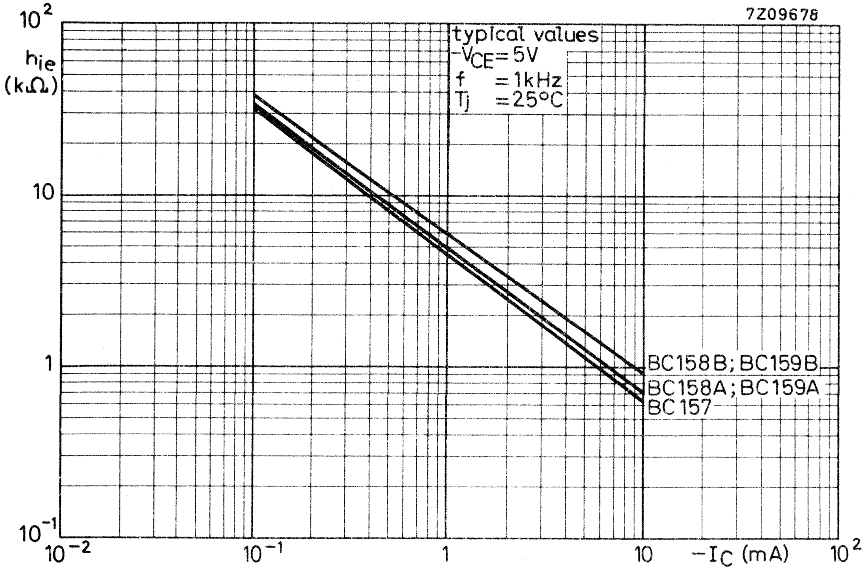

7Z09671
f = 1MHz
Tj = 25°C
Cc
(pF)
15
10
5
0
typ
0
5
−VCB (V)
10

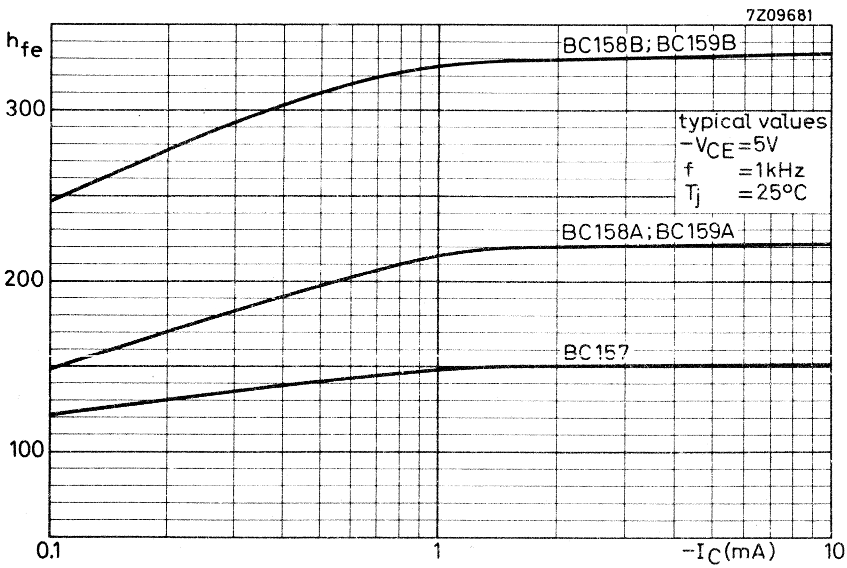

7Z09677
BC159
−IC = 0.2mA
−VCE = 5V
RS = 2kΩ
Tj = 25°C
F
(dB)
6
4
2
0
typ
10−1
1
10
f (kHz)
102

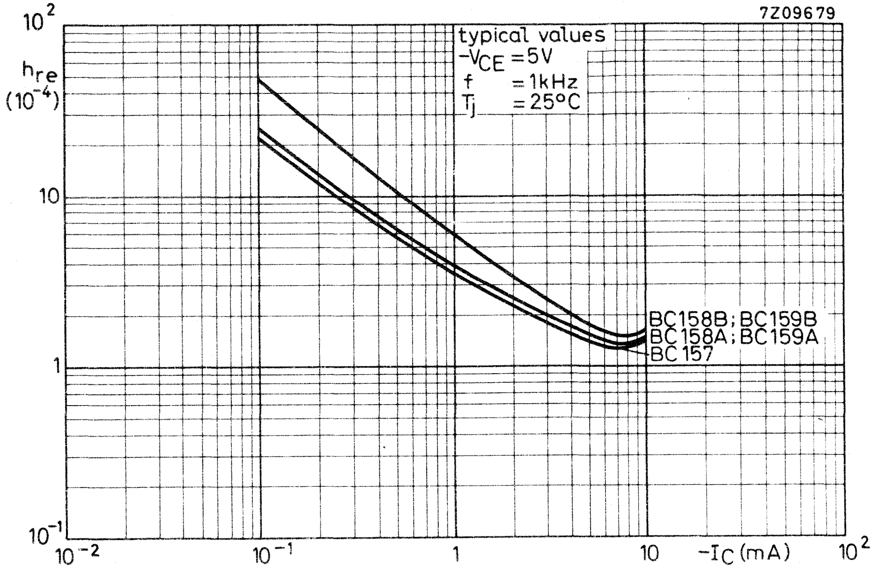
Curves of constant noise figure

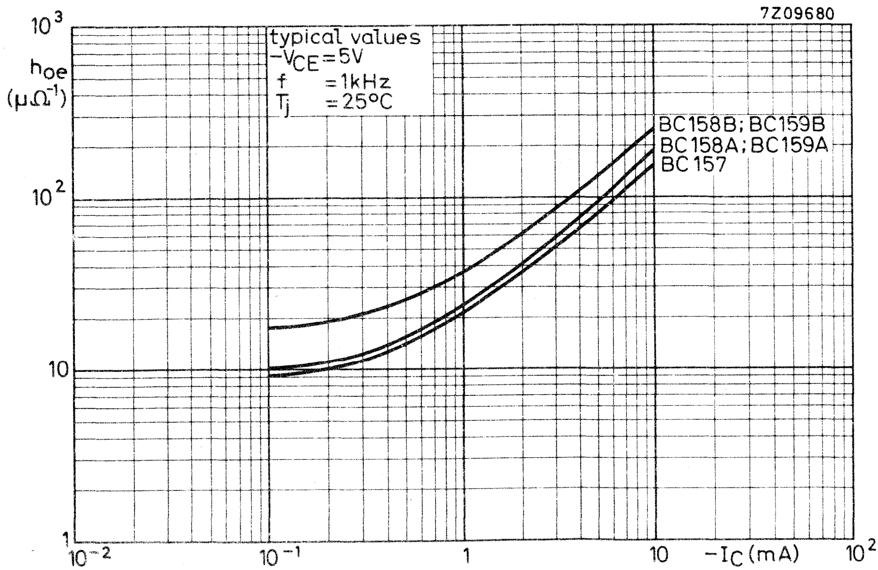


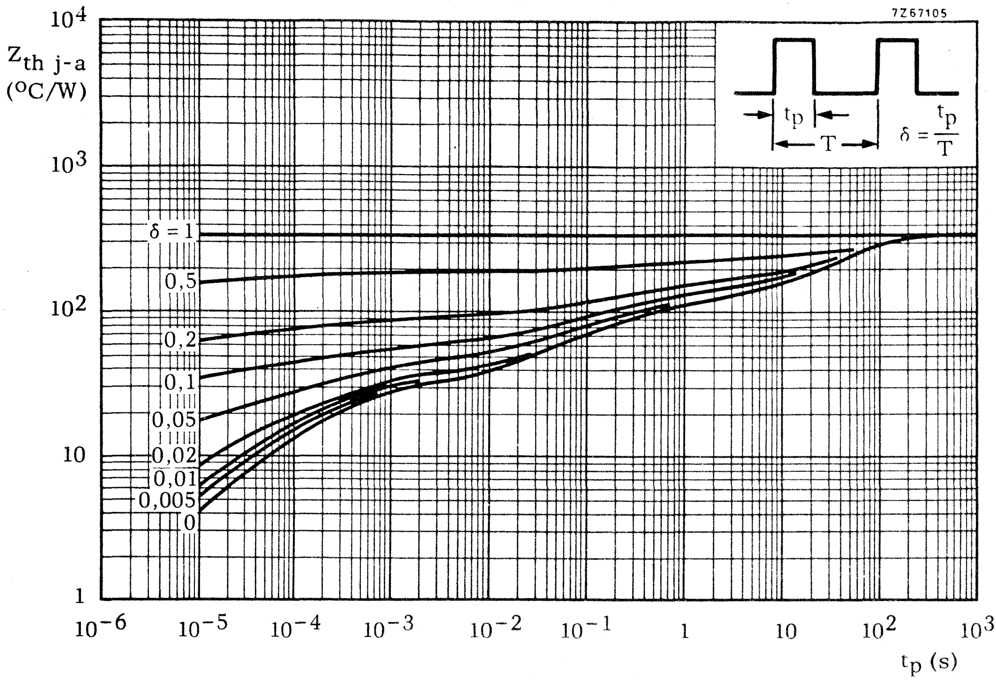



7Z09678
10^2
h_{ie}
(kΩ)
10
1
10^{-1}
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2
typical values
$-V_{CE}$ = 5V
f = 1kHz
T_j = 25°C
BC158B; BC159B
BC158A; BC159A
BC157


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


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


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


7Z67105
$Z_{th\ j\text{-}a}$ (°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)

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in TO-39 metal envelopes for general purpose applications. N-P-N complements are BC140 and BC141.

QUICK REFERENCE DATA

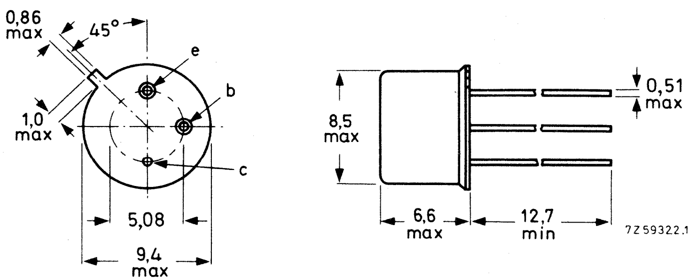
			BC160	BC161		
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60		V
Collector current (d.c.)	$-I_C$	max.	1			A
Total power dissipation up to T_{case} = 45 °C	P_{tot}	max.	3,7			W
Junction temperature	T_j	max.	175			°C
Transition frequency $-I_C$ = 50 mA; $-V_{CE}$ = 10 V	f_T	>	50			MHz

			BC160-6 BC161-6	BC160-10 BC161-10	BC160-16 BC161-16
D.C. current gain $-I_C$ = 100 mA; $-V_{CE}$ = 1 V	h_{FE}	>	40	63	100
		<	100	160	250

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-39



max. lead diameter is guaranteed only for 12,7 mm

Accessories: 56218 (package); 56245 (distance disc).

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

			BC 160	BC 161	
Voltages					
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40	60	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	V
Currents					
Collector current (d.c.)	$-I_C$	max.	1		A
Base current (d.c.)	$-I_B$	max.	100		mA
Power dissipation					
Total power dissipation up to T_{case} = 45 °C	P_{tot}	max.	3,7		W
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	$R_{th\ j\text{-}a}$	=	200	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	35	°C/W

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

Collector cut-off current				
$V_{BE} = 0$; $-V_{CE} = -V_{CEOmax}$	$-I_{CES}$	typ.	10	nA
		<	100	nA
$V_{BE} = 0$; $-V_{CE} = -V_{CEOmax}$; $T_{amb} = 150$ °C	$-I_{CES}$	typ.	10	µA
		<	100	µA
Base-emitter voltage				
$-I_C = 1$ A; $-V_{CE} = 1$ V	$-V_{BE}$	typ.	1,0	V
		<	1,7	V
Saturation voltage				
$-I_C = 1$ A; $-I_B = 100$ mA	$-V_{CEsat}$	typ.	0,6	V
		<	1,0	V
Transition frequency at f = 20 MHz				
$-I_C = 50$ mA; $-V_{CE} = 10$ V	f_T	>	50	MHz
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $-V_{CB} = 10$ V	C_c	<	30	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $-V_{EB} = 0,5$ V	C_e	<	180	pF

D.C. current gain			BC160-6 BC161-6	BC160-10 BC161-10	BC160-16 BC161-16
$-I_C = 100$ µA ; $-V_{CE} = 1$ V	h_{FE}	typ.	46	80	120
		>	40	63	100
$-I_C = 100$ mA; $-V_{CE} = 1$ V	h_{FE}	typ.	63	100	160
		<	100	160	250
$-I_C = 1$ A ; $-V_{CE} = 1$ V	h_{FE}	typ.	15	20	30

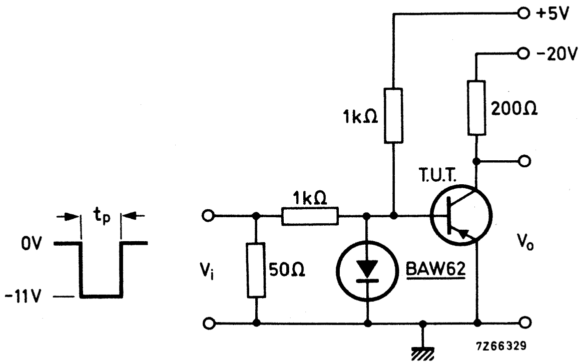
CHARACTERISTICS (continued) $T_{amb} = 25\ ^oC$

Switching times

$-I_{Con} = 100$ mA; $-I_{Bon} = I_{Boff} = 5$ mA

Turn-on time	t_{on}	<	500	ns
Turn-off time	t_{off}	<	650	ns

Test circuit



Pulse generator:

Pulse duration	$t_p = 10\ \mu s$
Rise time	$t_r \leq 15$ ns
Fall time	$t_f \leq 15$ ns
Source impedance	$Z_s = 50\ \Omega$

Oscilloscope:

Rise time	$t_r \leq 15$ ns
Input impedance	$Z_i \geq 100\ k\Omega$

A.F. SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in TO-18 metal envelopes 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 preamplifiers 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

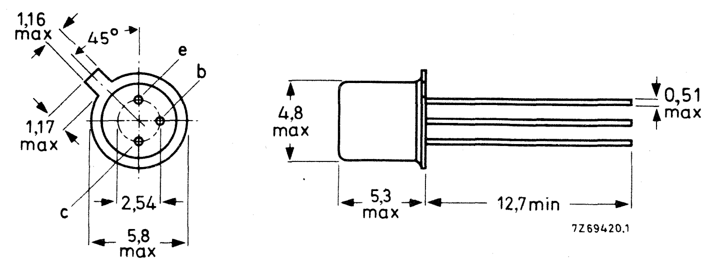
			BC177	BC178	BC179	
Collector-emitter voltage ($+V_{BE}$ = 1 V)	$-V_{CEX}$	max	50	30	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max	45	25	20	V
Collector current (peak value)	$-I_{CM}$	max	200	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max	300	300	300	mW
Junction temperature	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}	> <	75 260	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 4,0	dB dB
f = 1 kHz; B = 200 Hz	F	<	10	10	4,0	dB

MECHANICAL DATA

Dimensions in mm

TO-18

Collector connected to case



Accessories: 56246 (distance disc); 56263 (cooling fin).

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.

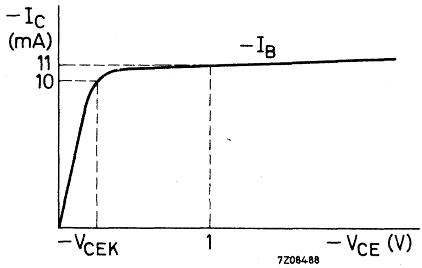
CHARACTERISTICS (continued) $T_j = 25\ ^oC$ unless otherwise specified

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

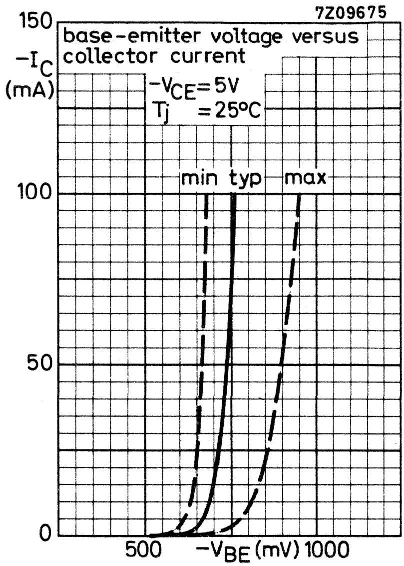
Transition frequency at f = 35 MHz

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

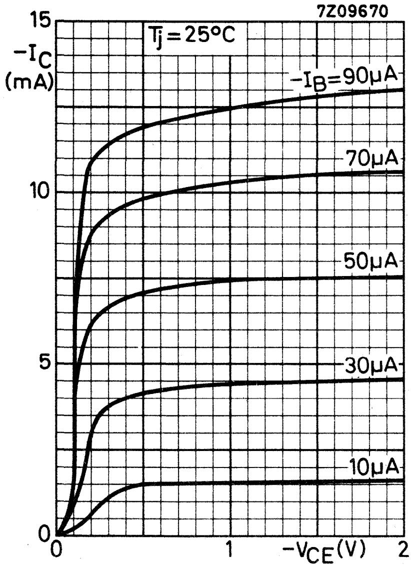
			BC177	BC178	BC179	
Small signal current gain at f = 1 kHz						
$-I_C = 2$ mA; $-V_{CE} = 5$ V	h_{fe}	>	75	75	125	
		<	260	500	500	
Noise figure at $R_S = 2$ kΩ						
$-I_C = 200\ \mu A$; $-V_{CE} = 5$ V						
f = 30 Hz to 15 kHz	F	typ.			1.2	dB
		<			4	dB
f = 1 kHz; B = 200 Hz	F	typ.	2	2	1	dB
		<	10	10	4	dB

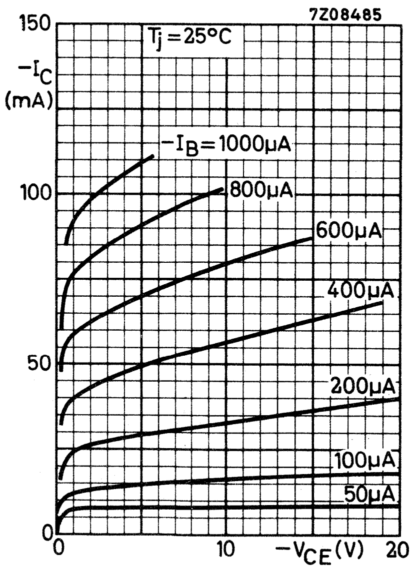
CHARACTERISTICS (continued)

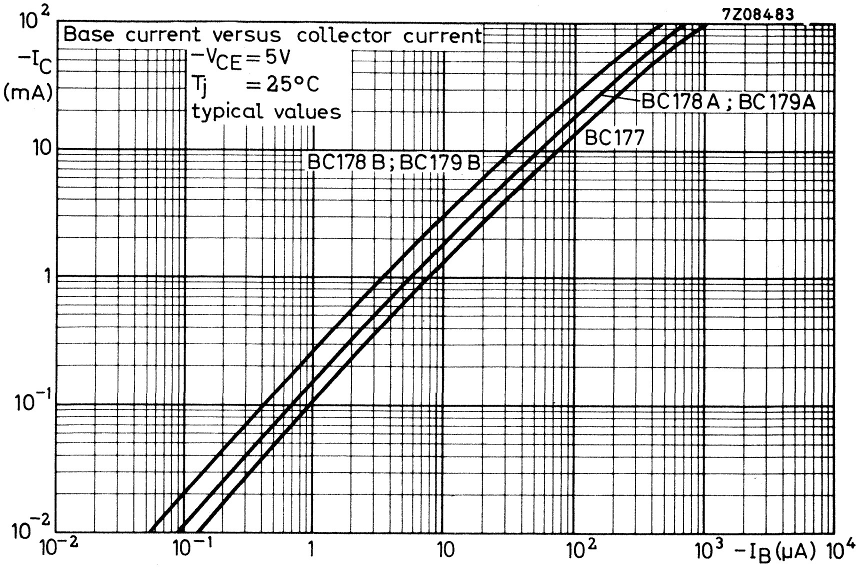
			BC177	BC178A BC179A	BC178B BC179B
D.C. current gain					
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{FE}	typ.	140	180	290
Small signal current gain at f = 1 kHz					
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{fe}	>	75	125	240
		<	260	260	500

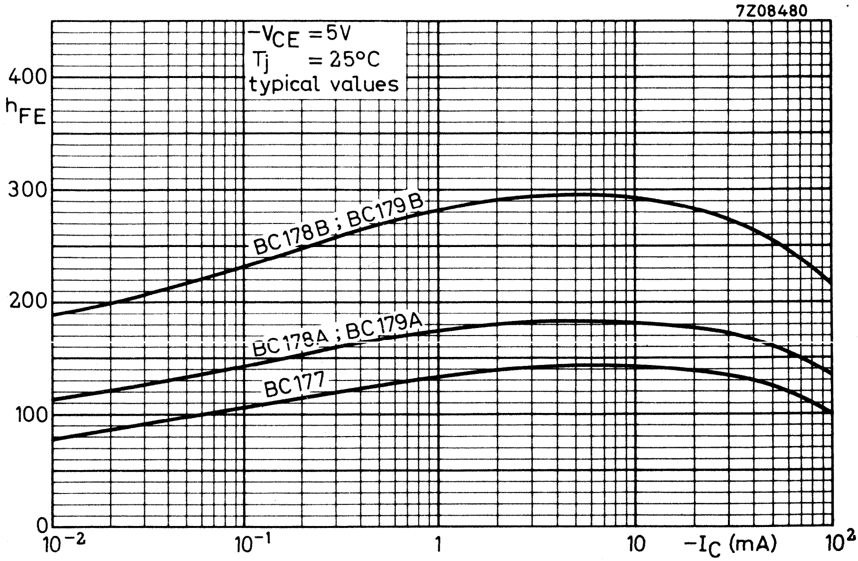


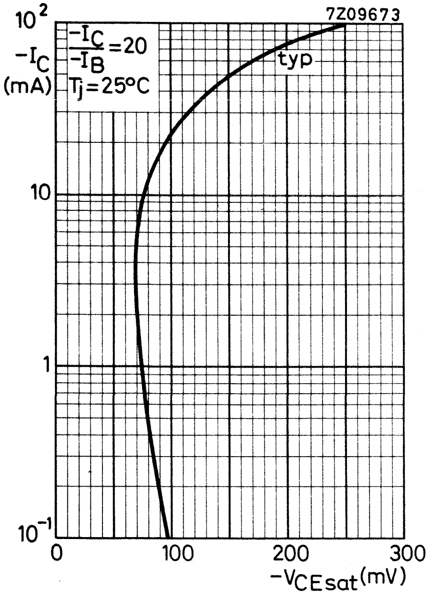
Typical behaviour of collector current versus collector-emitter voltage

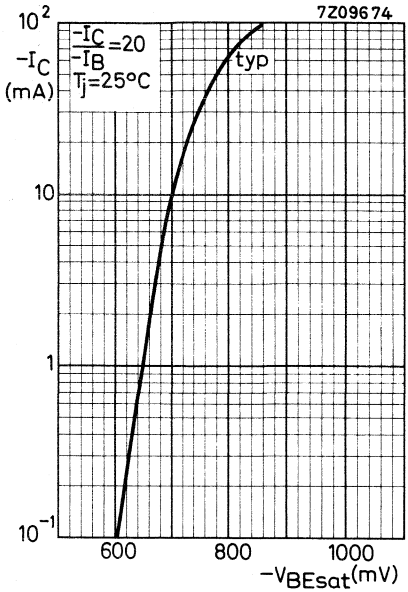


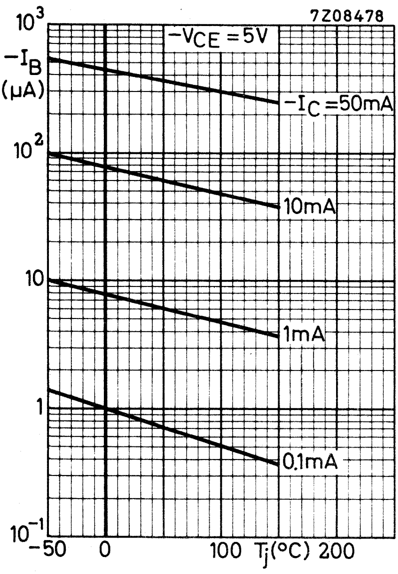



7Z08483
Base current versus collector current
$-V_{CE} = 5V$
$T_j = 25°C$
typical values
$-I_C$ (mA)
10^2
10
1
10^{-1}
10^{-2}
BC178 A ; BC179A
BC177
BC178 B ; BC179 B
10^{-2}
10^{-1}
1
10
10^2
10^3
$-I_B$ (μA)
10^4

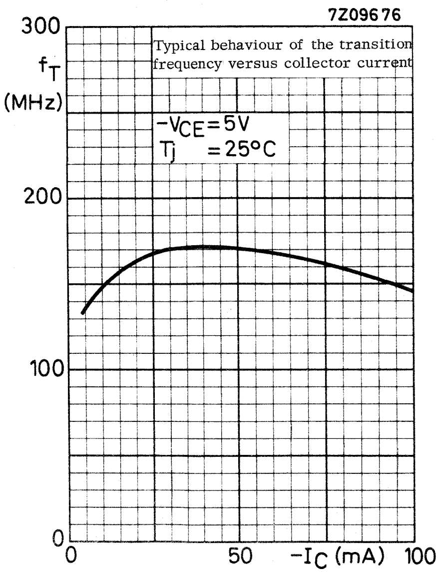

7Z08480
$-V_{CE} = 5V$
$T_j = 25°C$
typical values
h_{FE}
400
300
200
100
0
BC178 B ; BC179 B
BC178A ; BC179A
BC177
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2

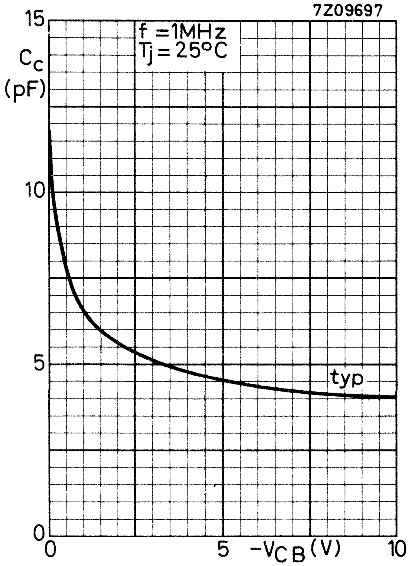


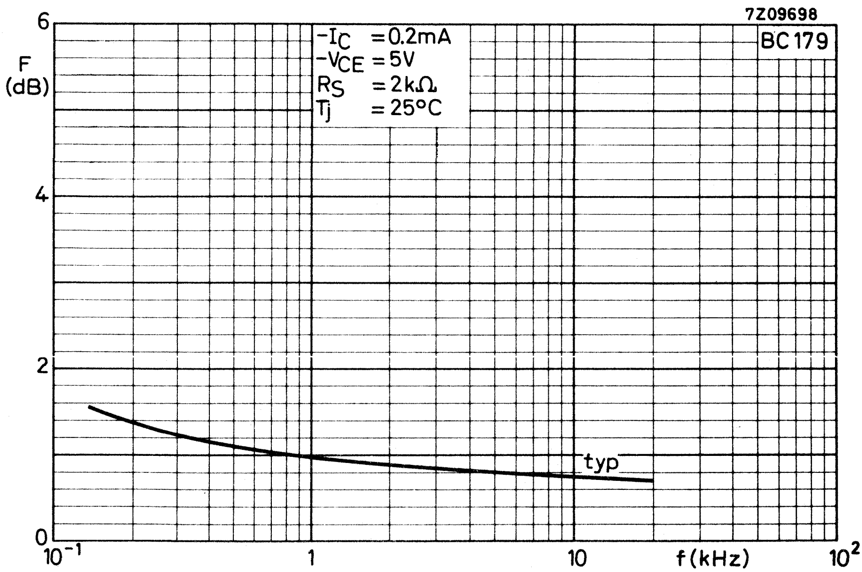




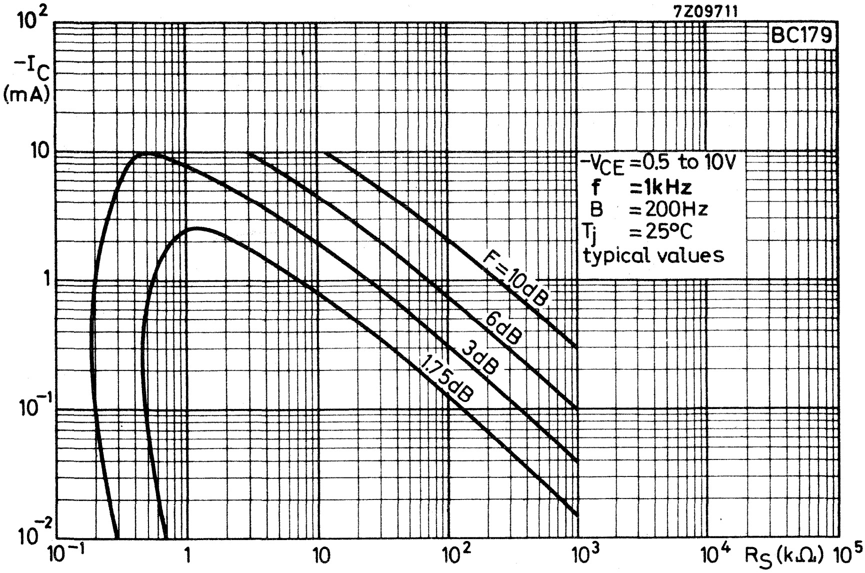
Typical behaviour of base current versus junction temperature

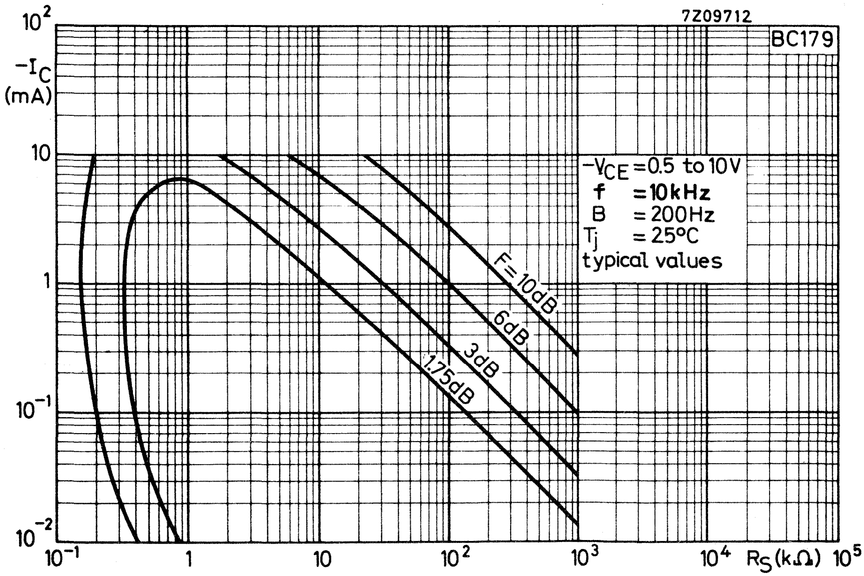


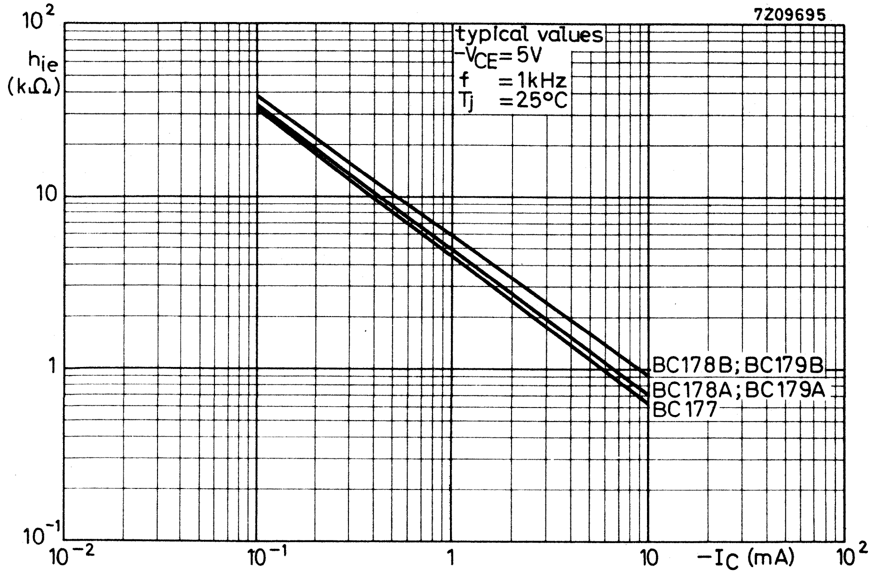

7Z09697
f = 1MHz
Tj = 25°C
Cc
(pF)
15
10
5
0
typ
0
5
-VCB (V)
10

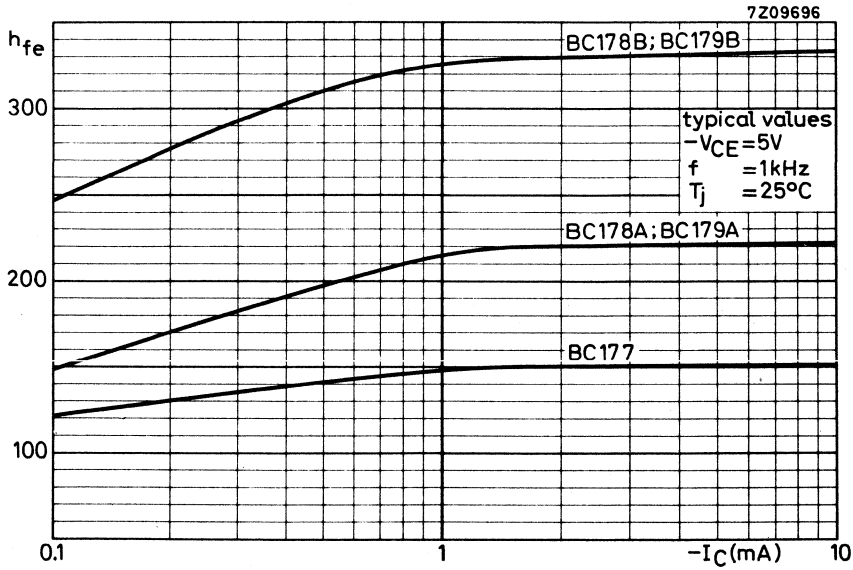

7Z09698
BC 179
-IC = 0.2mA
-VCE = 5V
RS = 2kΩ
Tj = 25°C
F
(dB)
6
4
2
0
typ
10⁻¹
1
10
f (kHz)
10²

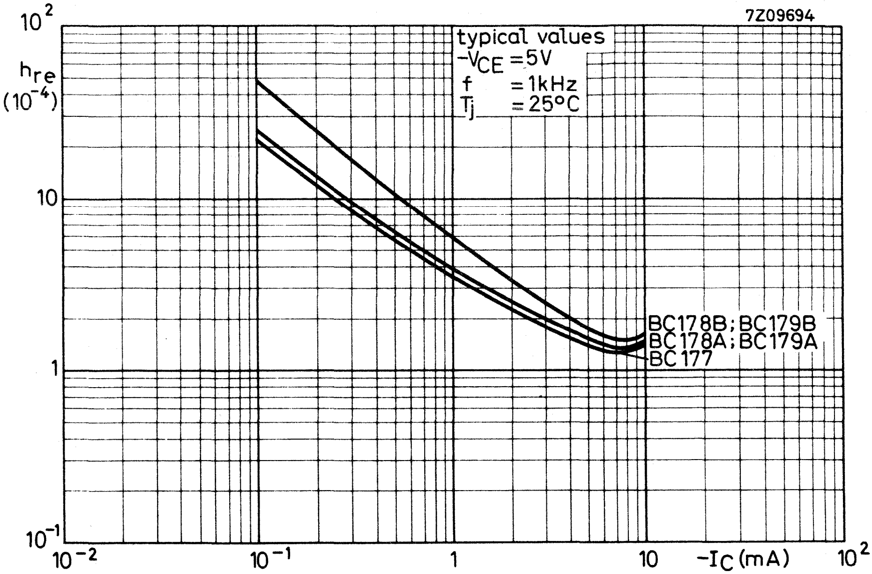
Curves of constant noise figure

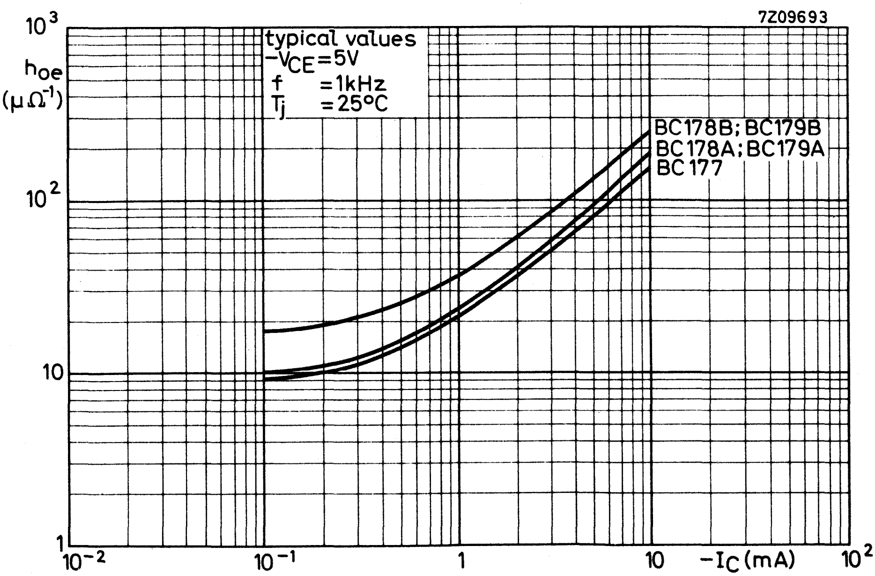


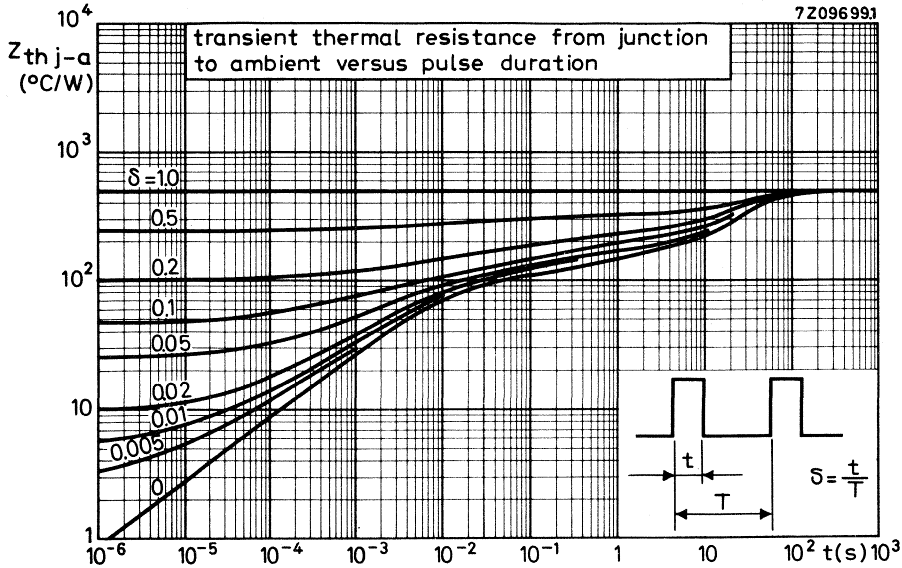



7Z09695
10^2
h_{ie}
(kΩ)
10
1
10^{-1}
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2
typical values
$-V_{CE} = 5V$
f = 1kHz
T_j = 25°C
BC178B; BC179B
BC178A; BC179A
BC177


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})
10^2
10
1
10^{-1}
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2
BC178B; BC179B
BC178A; BC179A
BC177


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


7Z09699.1
transient thermal resistance from junction to ambient versus pulse duration
Zth j-a (°C/W)
δ = 1.0
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0
t
T
δ = t/T
t(s)

SILICON PLANAR EPITAXIAL TRANSISTOR

P-N-P transistor in a microminiature plastic envelope designed for hearing aids, watches, etc.

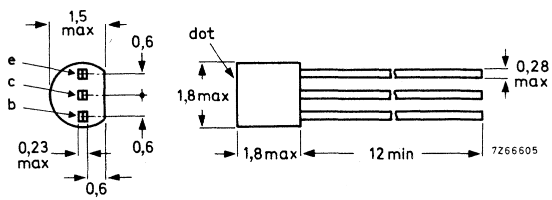
QUICK REFERENCE DATA

			BC200 /01	/02	/03	
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

SOT-42



Coloured dot on top of the body indicates h_{FE} group:

BC200/01 red
BC200/02 yellow
BC200/03 green

The flat side is blue to distinguish from BC146.

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	$R_{th\ j-a}$	=	1,6	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

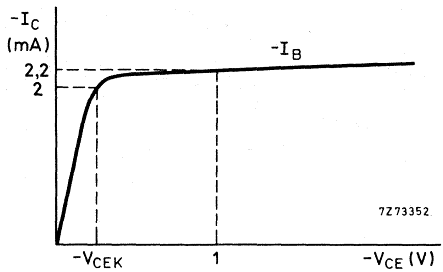
$I_E = 0$; $-V_{CB} = 20$ V	$-I_{CBO}$	<	100	nA
$I_E = 0$; $-V_{CB} = 20$ V; $T_j = 125$ °C	$-I_{CBO}$	<	1	μA

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



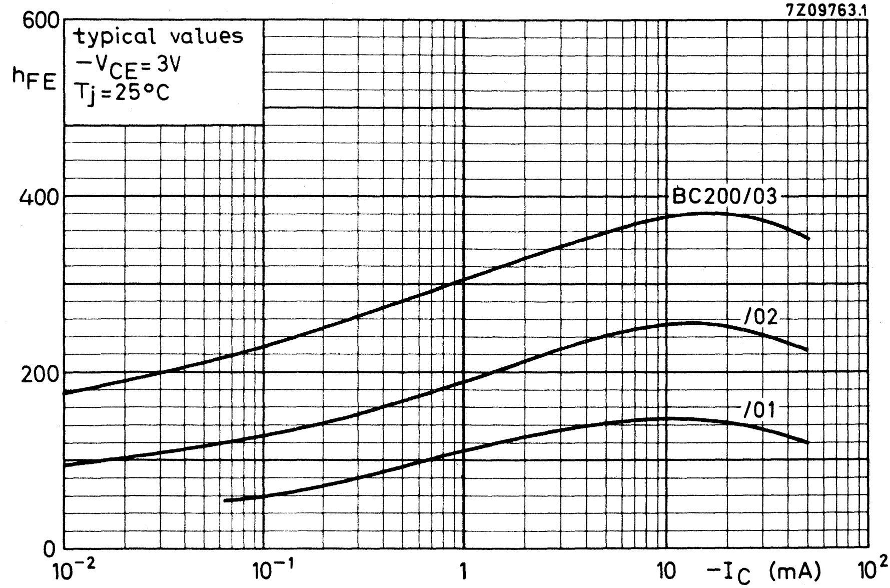
Collector capacitance at f = 1 MHz

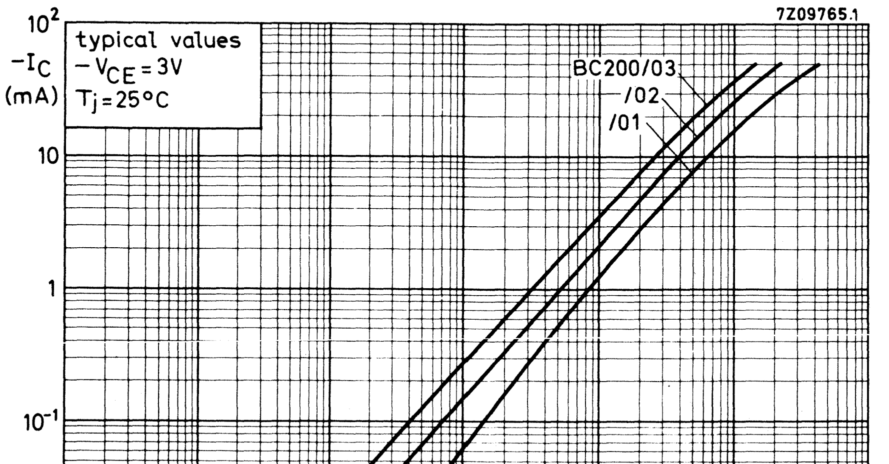
$I_E = I_e = 0$; $-V_{CB} = 5$ V	C_c	typ.	5	pF

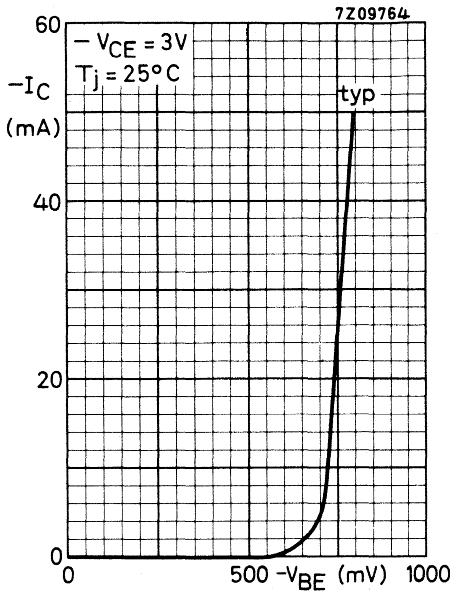
Transition frequency at f = 100 MHz

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

D.C. current gain	BC200	/01	/02	/03	
$-I_C = 0,2$ 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


7Z09763.1
typical values
$-V_{CE}=3V$
$T_j=25°C$
h_{FE}
600
400
200
0
BC200/03
/02
/01
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2


7Z09765.1
typical values
$-V_{CE}=3V$
$T_j=25°C$
$-I_C$ (mA)
10^2
10
1
10^{-1}
10^{-2}
BC200/03
/02
/01
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
$-I_B$ (μA)
10^3


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

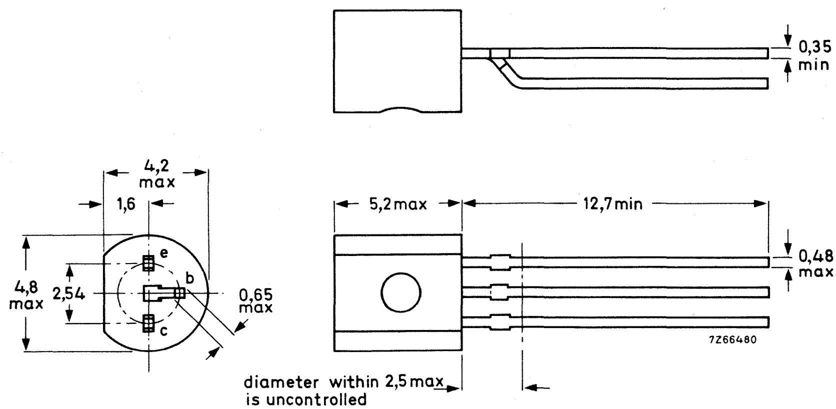
SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in a plastic TO-92 variant primarily intended for use in driver and output stages of audio amplifiers. N-P-N complements are BC337 and BC338.

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_{amb} = 25 °C	P_{tot}	max.	800		mW
Junction temperature	T_j	max.	150		°C
Transition frequency $-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.	100		MHz

MECHANICAL DATA Dimensions in mm

TO-92 variant



Accessories: 56356 (cooling clip).

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.	625	mW
up to T_{amb} = 25 °C	P_{tot}	max.	800	mW [1])

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	$R_{th\ j\text{-}a}$	=	0,2	°C/mW
From junction to ambient	$R_{th\ j\text{-}a}$	=	0,156	°C/mW [1])

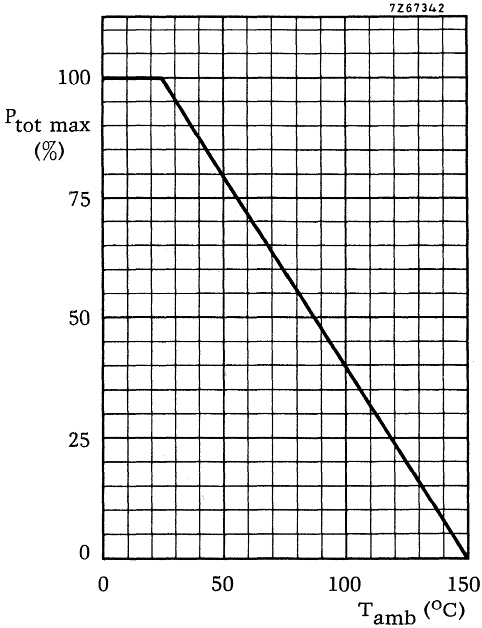
[1]) Transistor mounted on printed circuit board, max. lead length 4 mm, mounting pad for collector lead min. 10 mm x 10 mm.

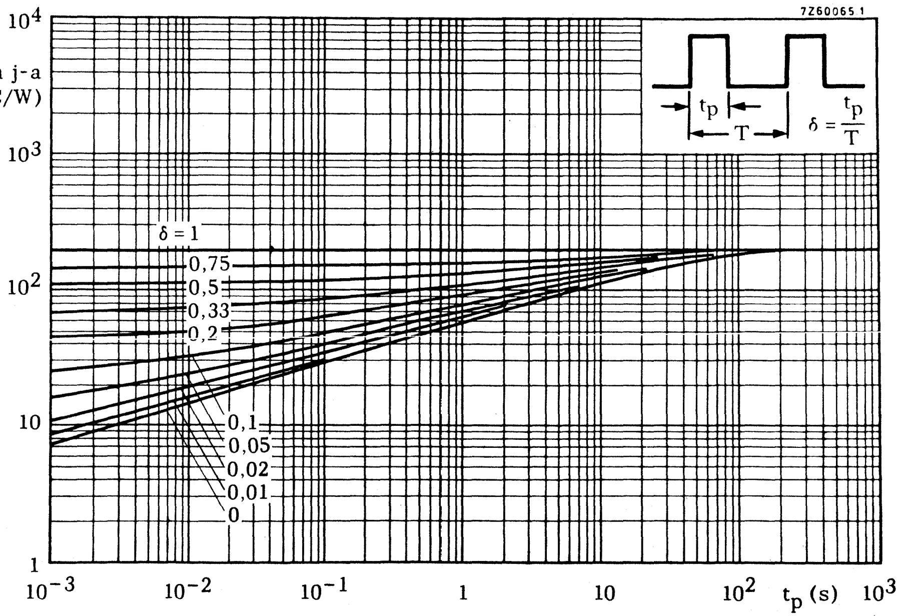
CHARACTERISTICS

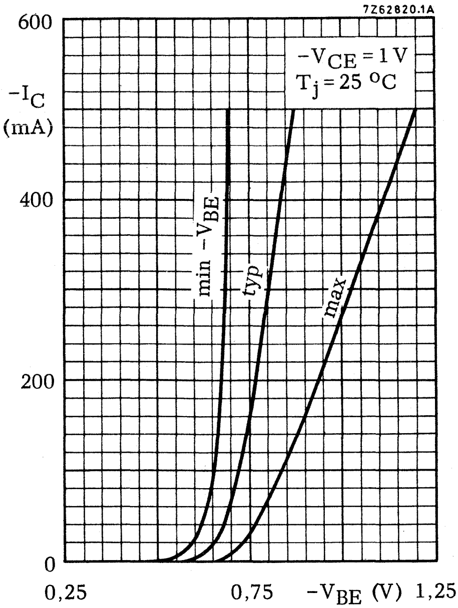
T_j = 25 °C unless otherwise specified

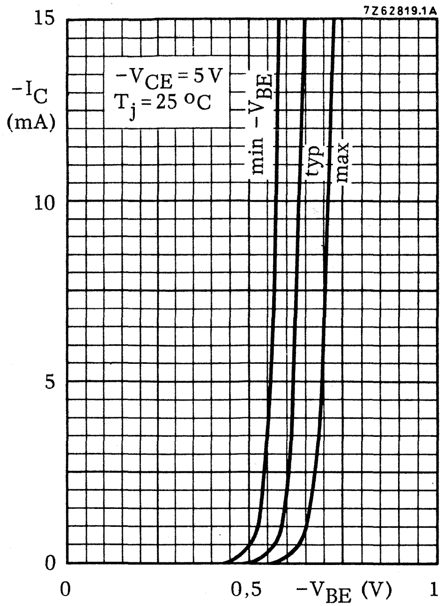
Collector cut-off current			
$I_E = 0$; $-V_{CB} = 20$ V; $T_j = 25$ °C	$-I_{CBO}$	<	100 nA
$I_E = 0$; $-V_{CB} = 20$ V; $T_j = 150$ °C	$-I_{CBO}$	<	5 μA
Emitter cut-off current			
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	10 μA
Base emitter voltage*			
$-I_C = 500$ mA; $-V_{CE} = 1$ V	$-V_{BE}$	<	1,2 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
BC327-40, BC328-40	h_{FE}		250 to 600 ←
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 pairs BC327/BC337; BC328/BC338			
$\|I_C\| = 100$ mA; $\|V_{CE}\| = 1$ V	h_{FE1}/h_{FE2}	typ <	1,25 1,40

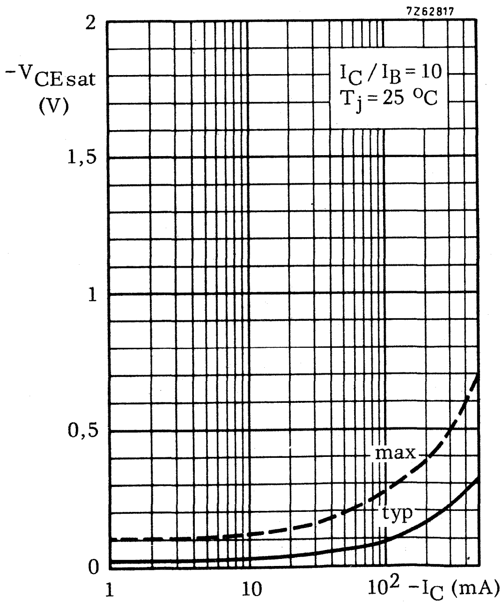
* $-V_{BE}$ decreases by about 2 mV/°C with increasing temperature.

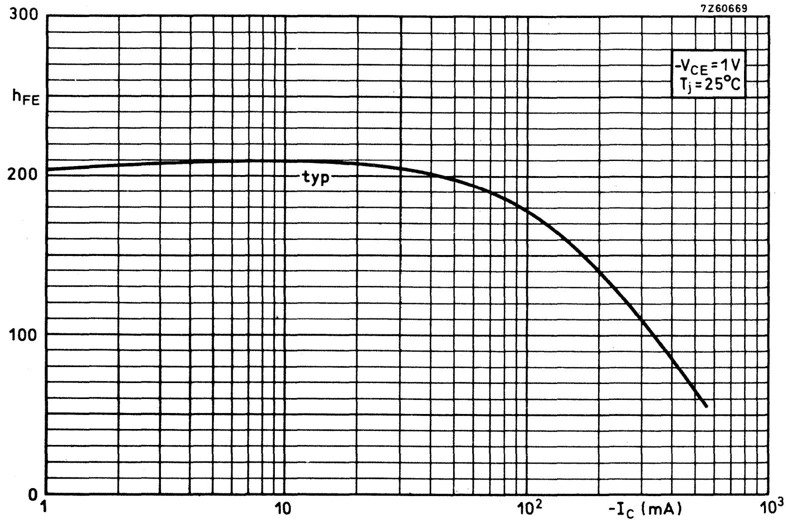

7Z67342
100
$P_{tot\ max}$
(%)
75
50
25
0
0
50
100
150
T_{amb} (°C)

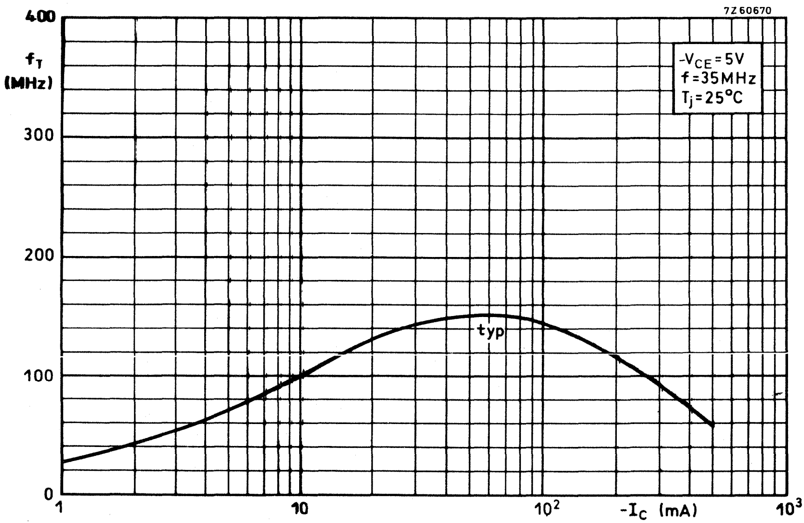

7Z60065.1
10^4
$Z_{th\ j\text{-}a}$
(°C/W)
10^3
10^2
10
1
t_p
T
$\delta = \frac{t_p}{T}$
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
0
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (s)
10^3


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


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

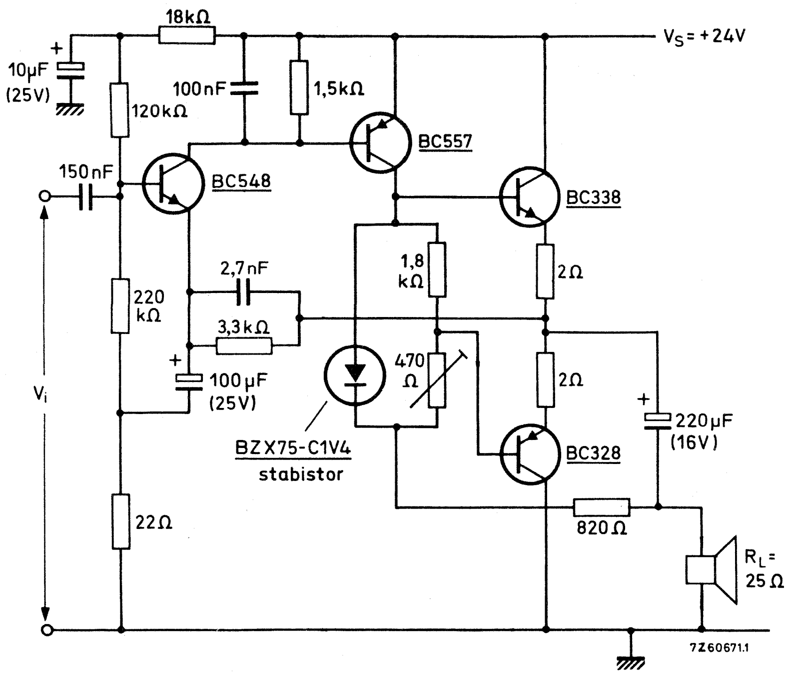

7Z62817
2
1,5
1
0,5
0
$-V_{CEsat}$ (V)
I_C / I_B = 10
T_j = 25 °C
max
typ
1
10
10^2
$-I_C$ (mA)


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, 8 W transformerless audio frequency amplifier with matched pair BC328/BC338 in complementary class B output stage up to T_{amb} = 45 °C.

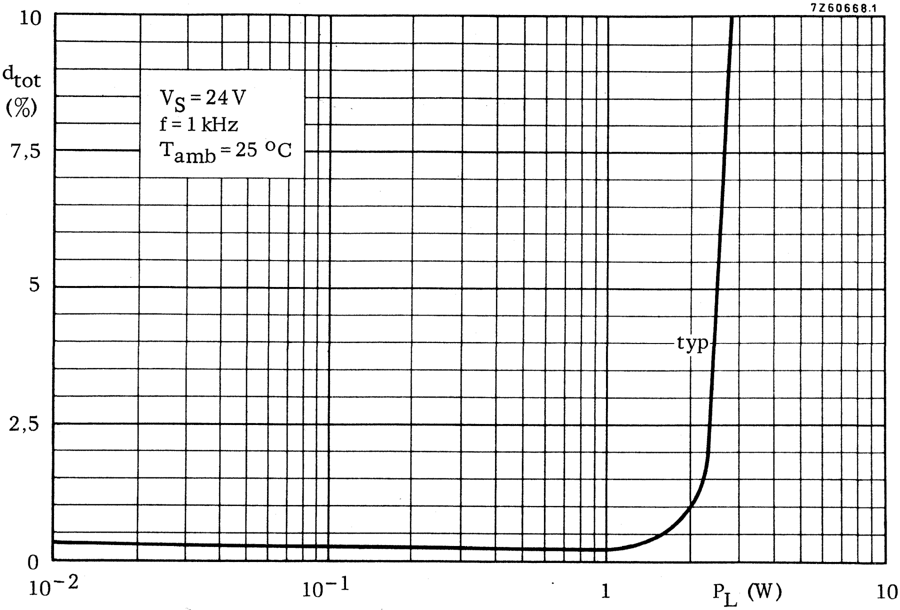


Performance at V_S = 24 V; R_L = 25 Ω

Collector quiescent current of BC338	I_{CQ}	typ.	1	mA
Input voltage for P_L = 50 mW	V_i	typ.	8	mV
Input voltage for P_L = 2, 8 W	Vi	typ.	67	mV
Output power at f = 1 kHz; d_{tot} = 10%	P_L	typ.	2, 8	W
Frequency response (3 dB)			70 to 16 000	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)



SILICON PLANAR EPITAXIAL TRANSISTORS

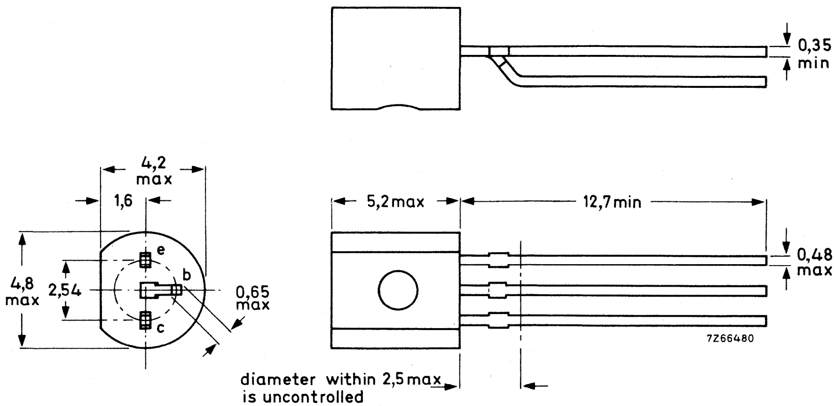
N-P-N transistors in a plastic TO-92 variant primarily intended for use in driver and output stages of audio amplifiers. P-N-P complements are BC327 and BC328.

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_{amb} = 25 °C	P_{tot}	max.	800		mW
Junction temperature	T_j	max.	150		°C
Transition frequency I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	200		MHz

MECHANICAL DATA

Dimensions in mm

TO-92 variant



Accessories: 56356 (cooling clip).

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 °C	P_{tot}	max.	625	mW
up to T_{amb} = 25 °C	P_{tot}	max.	800	mW [1])

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	$R_{th\ j\text{-}a}$	=	0,2	°C/mW
From junction to ambient	$R_{th\ j\text{-}a}$	=	0,156	°C/mW[1])

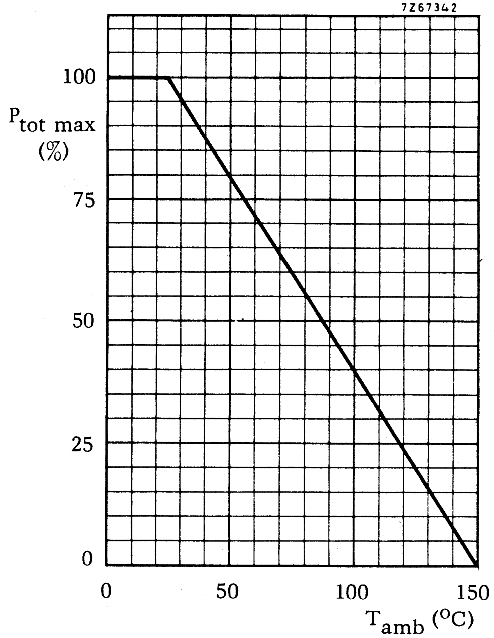
[1]) Transistor mounted on printed circuit board, max. lead length 4 mm, mounting pad for collector lead min. 10 mm x 10 mm.

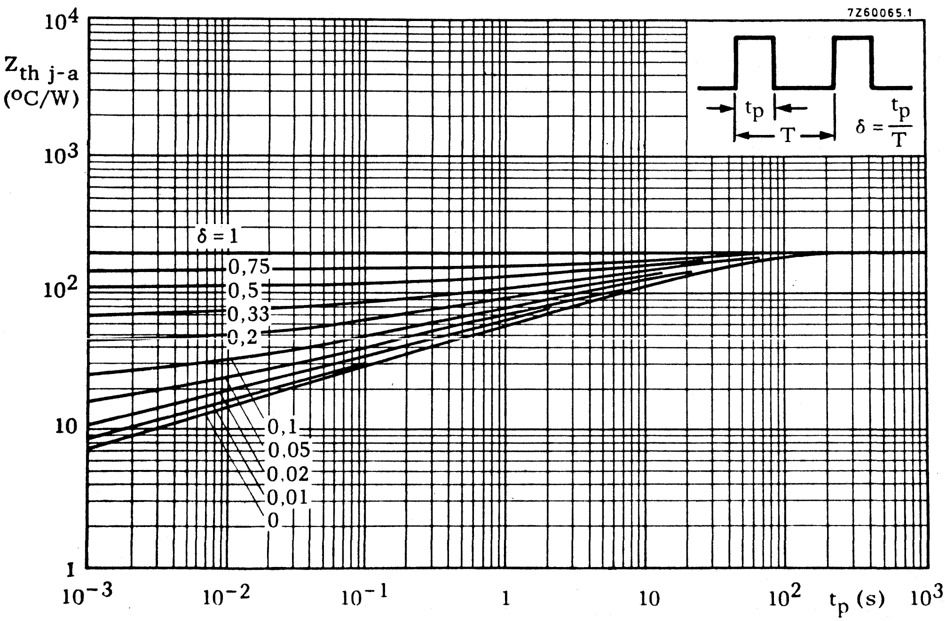
CHARACTERISTICS

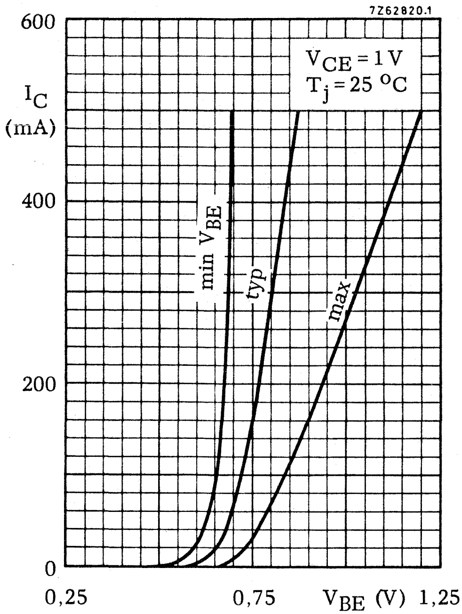
T_j = 25 °C unless otherwise specified

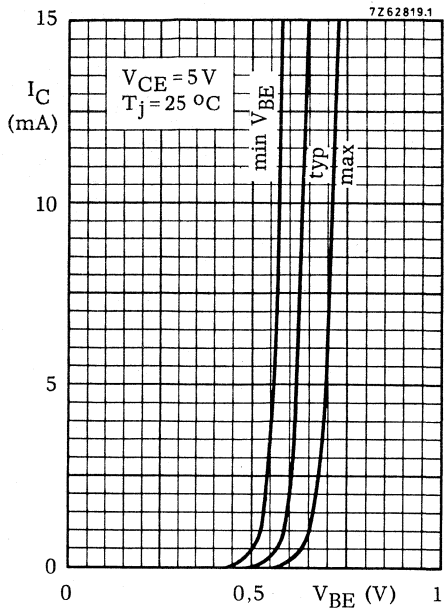
Collector cut-off current			
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 25$ °C	I_{CBO}	<	100 nA
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 150$ °C	I_{CBO}	<	5 μA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10 μA
Base emitter voltage*			
$I_C = 500$ mA; $V_{CE} = 1$ V	V_{BE}	<	1,2 V
Saturation voltage			
$I_C = 500$ 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
BC337-40, BC338-40	h_{FE}		250 to 600 ←
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 pairs BC327/BC337; BC328/BC338			
$\|I_C\| = 100$ mA; $\|V_{CE}\| = 1$ V	h_{FE1}/h_{FE2}	typ <</br>	1,25 1,40

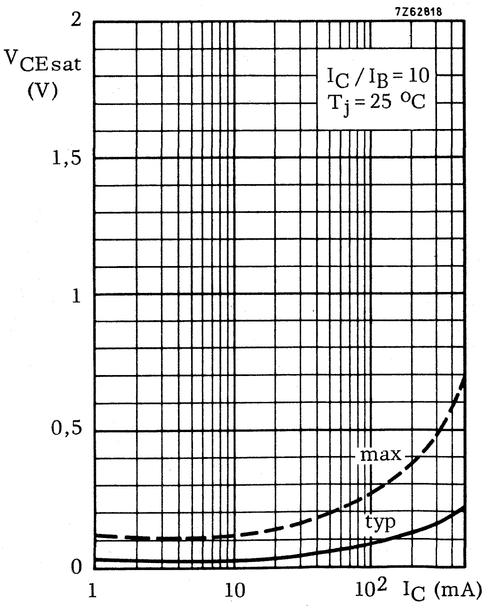
* V_{BE} decreases by about 2 mV/°C with increasing temperature.

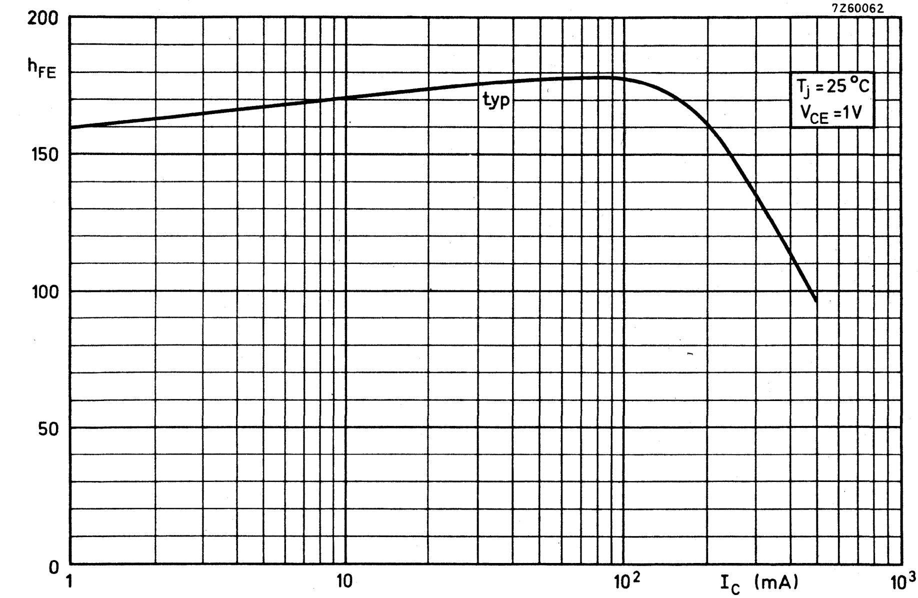

7Z67342
100
$P_{tot\ max}$
(%)
75
50
25
0
0
50
100
150
T_{amb} (°C)

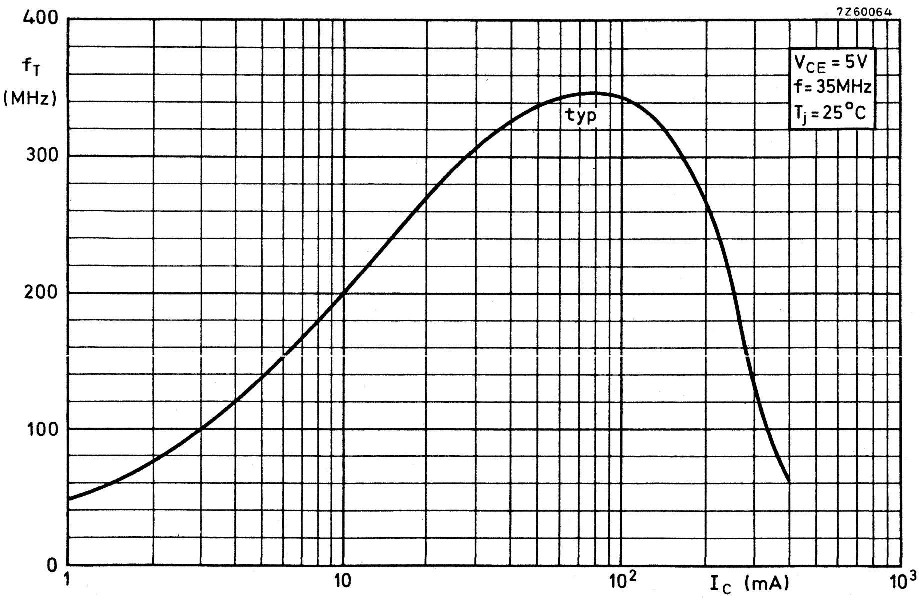

7Z60065.1
10^4
$Z_{th\ j\text{-}a}$
(°C/W)
10^3
$\delta = 1$
0,75
0,5
0,33
0,2
10^2
0,1
0,05
0,02
0,01
0
10
1
t_p
T
$\delta = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (s)
10^3


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


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


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)





APPLICATION INFORMATION SEE BC327; BC328

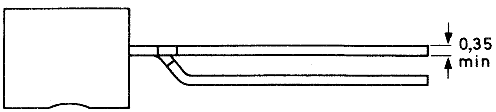
SILICON PLANAR EPITAXIAL TRANSISTOR

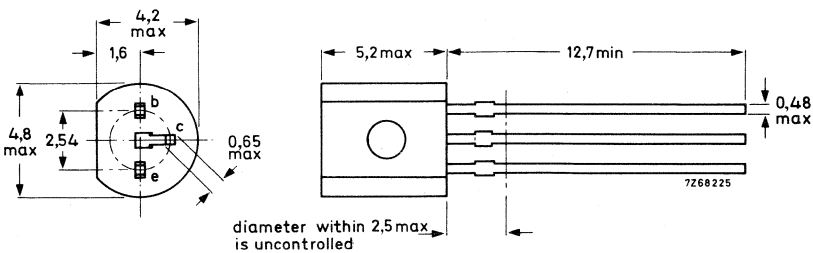
N-P-N transistor in a plastic TO-92 variant, intended for low-voltage, high-current l.f. applications. BC368/BC369 is the matched complementary pair suitable for class-B audio output stages up to 3 W.

QUICK REFERENCE DATA				
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector current (peak value)	I_{CM}	max.	2	A
Total power dissipation up to T_{amb} = 25 ^{o}C	P_{tot}	max.	1	W
Junction temperature	T_j	max.	150	^{o}C
D.C. current gain I_C = 500 mA; V_{CE} = 1 V	h_{FE}		85 to 375	
Transition frequency I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	60	MHz

MECHANICAL DATA Dimensions in mm

TO-92 variant





Accessory: 56356 (cooling clip).

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

Voltages

Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	25	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.	1	A
Collector current (peak value)	I_{CM}	max.	2	A
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 (in free air)	P_{tot}	max.	0,8	W
up to T_{amb} = 25 °C [1]	P_{tot}	max.	1	W

Temperatures

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

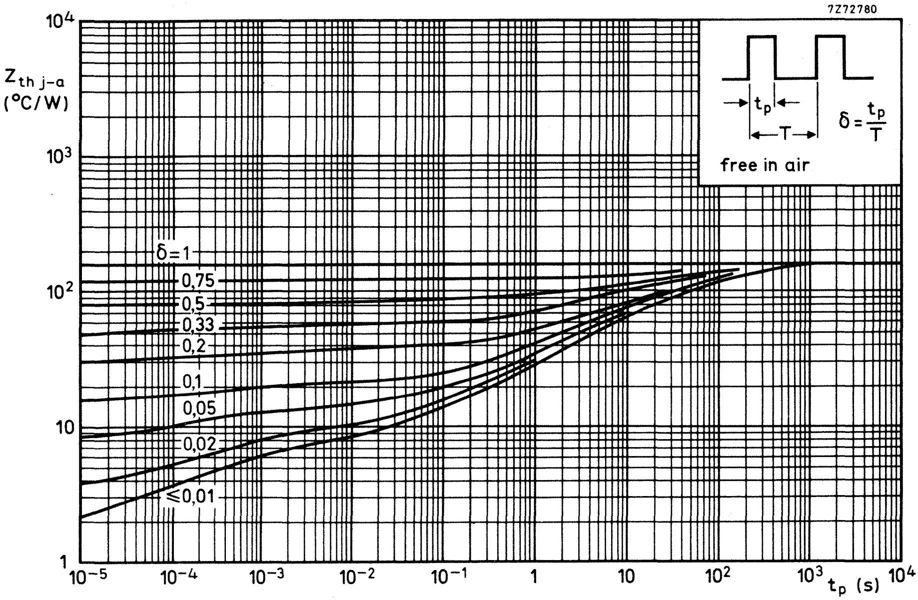
THERMAL RESISTANCE

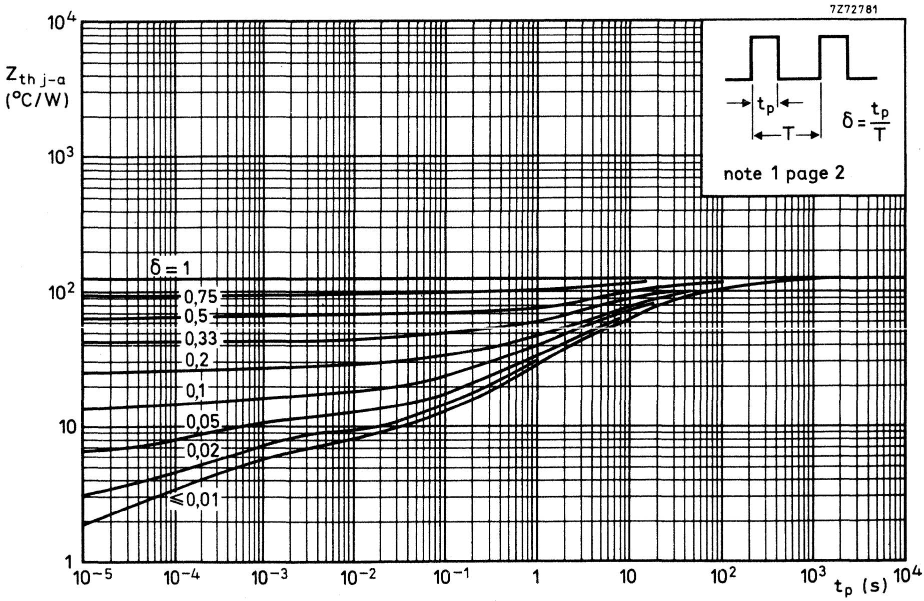
From junction to ambient in free air	$R_{th\ j-a}$	=	156	°C/W
From junction to ambient [1]	$R_{th\ j-a}$	=	125	°C/W
From junction to case	$R_{th\ j-c}$	=	60	°C/W

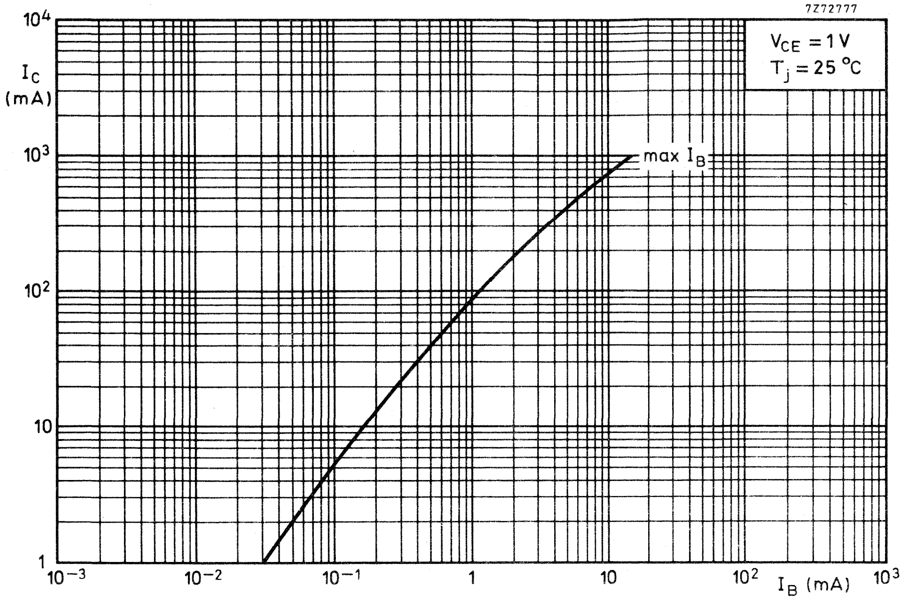
[1] Transistor mounted on printed-circuit board, max. lead length 4 mm, mounting pad for collector lead min. 10 mm x 10 mm.

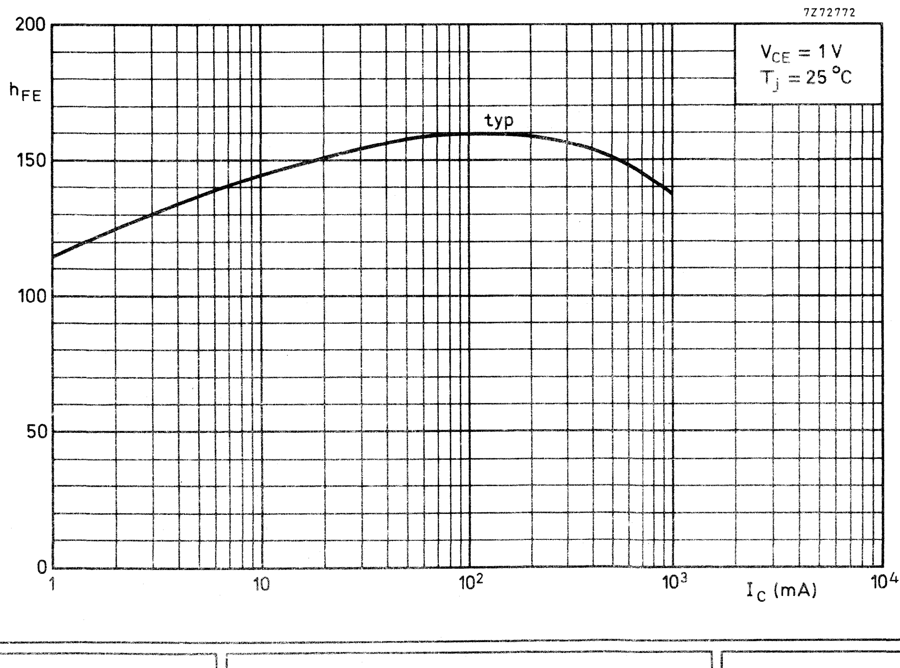
CHARACTERISTICS T_j = 25 °C unless otherwise specified

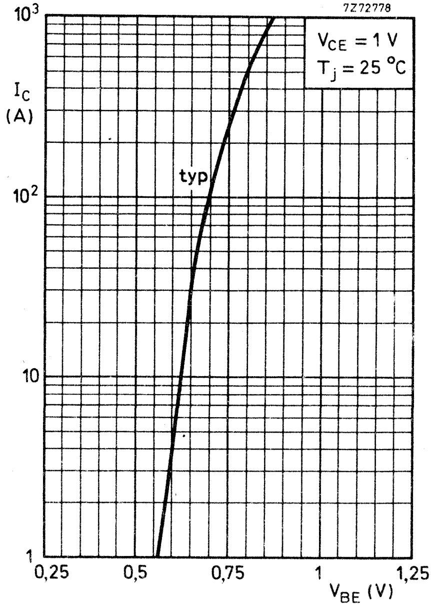
Parameter	Symbol		Value	Unit
Collector cut-off current				
I_E = 0; V_{CB} = 25 V	I_{CBO}	<	10	μA
I_E = 0; V_{CB} = 25 V; T_j = 150 °C	I_{CBO}	<	1	mA
Emitter cut-off current				
I_C = 0; V_{EB} = 5 V	I_{EBO}	<	10	μA
Base-emitter voltage				
I_C = 5 mA; V_{CE} = 10 V	V_{BE}	typ.	0,62	V
I_C = 1 A; V_{CE} = 1 V	V_{BE}	<	1	V
Collector-emitter saturation voltage				
I_C = 1 A; I_B = 100 mA	V_{CEsat}	<	0,5	V
D.C. current gain				
I_C = 5 mA; V_{CE} = 10 V	h_{FE}	>	50	
I_C = 500 mA; V_{CE} = 1 V	h_{FE}		85 to 375	
I_C = 1 A; V_{CE} = 1 V	h_{FE}	>	60	
Collector capacitance at f = 450 kHz				
$I_E = I_e$ = 0; V_{CB} = 5 V	C_c	typ.	27	pF ←
Cut-off frequency				
I_C = 10 mA; V_{CE} = 5 V	f_{hfe}	typ.	400	kHz ←
Transition frequency at f = 35 MHz				
I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	60	MHz ←
D.C. current gain ratio of matched pair BC368/BC369				
$\|I_C\|$ = 500 mA; $\|V_{CE}\|$ = 1 V	h_{FE1}/h_{FE2}	<	1,4	

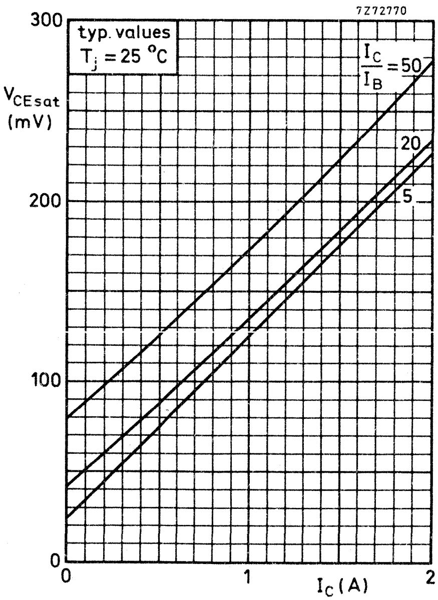

7Z72780
$Z_{th\ j-a}$ (°C/W)
free in air
$\delta = \frac{t_p}{T}$
δ=1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
≤0,01
t_p (s)

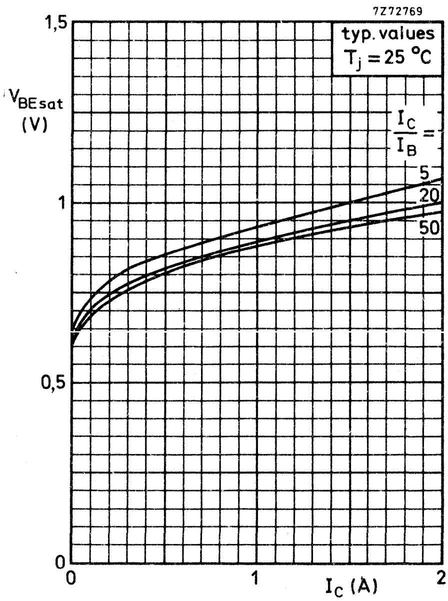

7Z72781
$Z_{th\ j-a}$ (°C/W)
note 1 page 2
$\delta = \frac{t_p}{T}$
δ=1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
≤0,01
t_p (s)

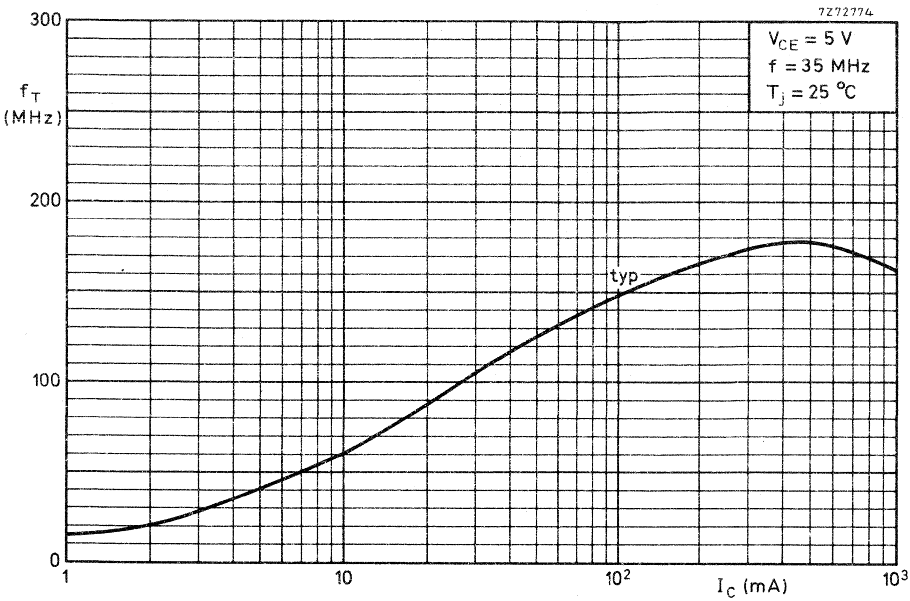

7Z72777
I_C (mA)
10^4
10^3
10^2
10
1
$V_{CE} = 1$ V
$T_j = 25$ °C
max I_B
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
I_B (mA)
10^3


7Z72772
h_{FE}
200
150
100
50
0
$V_{CE} = 1$ V
$T_j = 25$ °C
typ
1
10
10^2
10^3
I_C (mA)
10^4


7Z72778
V_{CE} = 1 V
T_j = 25 °C
I_C (A)
typ
10^3
10^2
10
1
0,25
0,5
0,75
1
1,25
V_{BE} (V)


7Z72770
typ. values
T_j = 25 °C
V_{CEsat} (mV)
$\frac{I_C}{I_B}$ = 50
20
5
300
200
100
0
0
1
2
I_C (A)


7Z72769
typ. values
T_j = 25 °C
V_{BEsat} (V)
$\frac{I_C}{I_B}$ =
5
20
50
1,5
1
0,5
0
0
1
2
I_C (A)


7Z72774
V_{CE} = 5 V
f = 35 MHz
T_j = 25 °C
f_T (MHz)
300
200
100
0
typ
1
10
10^2
I_C (mA)
10^3

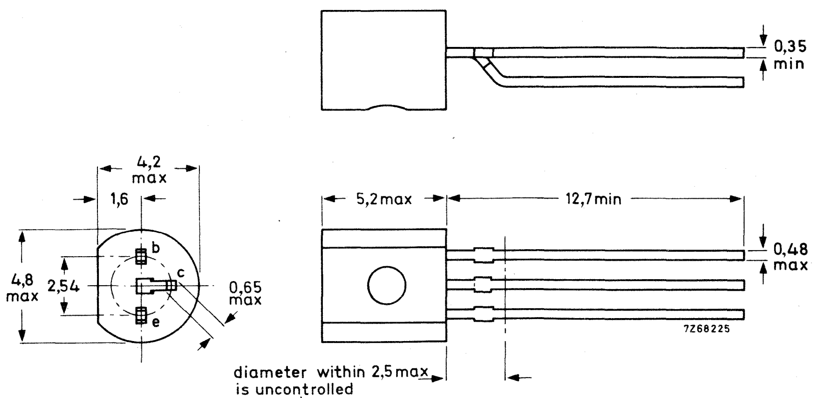
SILICON PLANAR EPITAXIAL TRANSISTOR

P-N-P transistor in a plastic TO-92 variant, intended for low-voltage, high-current l.f. applications. BC368/BC369 is the matched complementary pair suitable for class-B audio output stages up to 3 W.

QUICK REFERENCE DATA				
Collector-emitter voltage (V_{BE} = 0)	$-V_{CES}$	max.	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20	V
Collector current (peak value)	$-I_{CM}$	max.	2	A
Total power dissipation up to T_{amb} = 25 ^{o}C	P_{tot}	max.	1	W
Junction temperature	T_j	max.	150	^{o}C
D.C. current gain $-I_C$ = 500 mA; $-V_{CE}$ = 1 V	h_{FE}		85 to 375	
Transition frequency $-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.	60	MHz

MECHANICAL DATA Dimensions in mm

TO-92 variant



Accessory: 56356 (cooling clip).

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

Voltages

Collector-emitter voltage (V_{BE} = 0)	$-V_{CES}$	max.	25	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.	1	A
Collector current (peak value)	$-I_{CM}$	max.	2	A
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 (in free air)	P_{tot}	max.	0,8	W
up to T_{amb} = 25 °C [1]	P_{tot}	max.	1	W

Temperatures

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

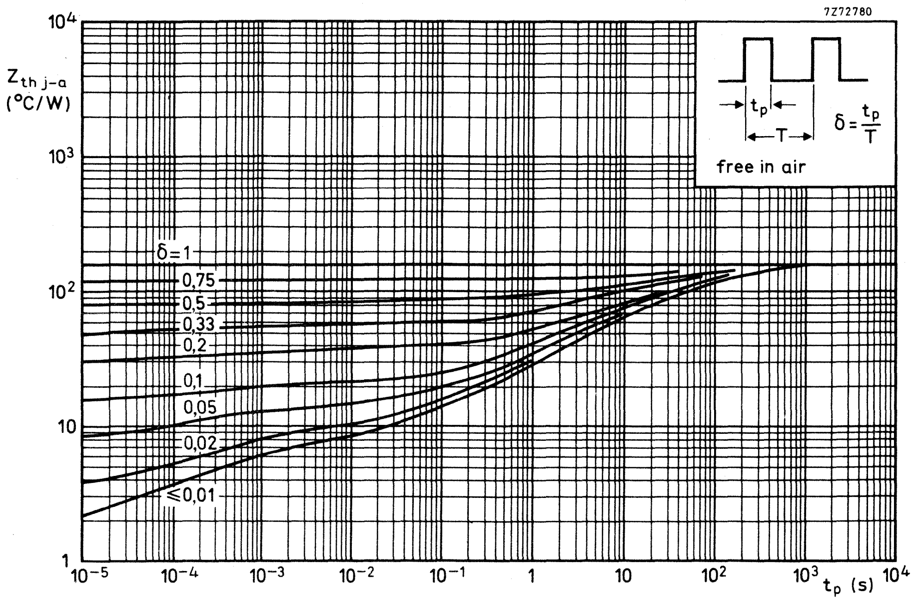
THERMAL RESISTANCE

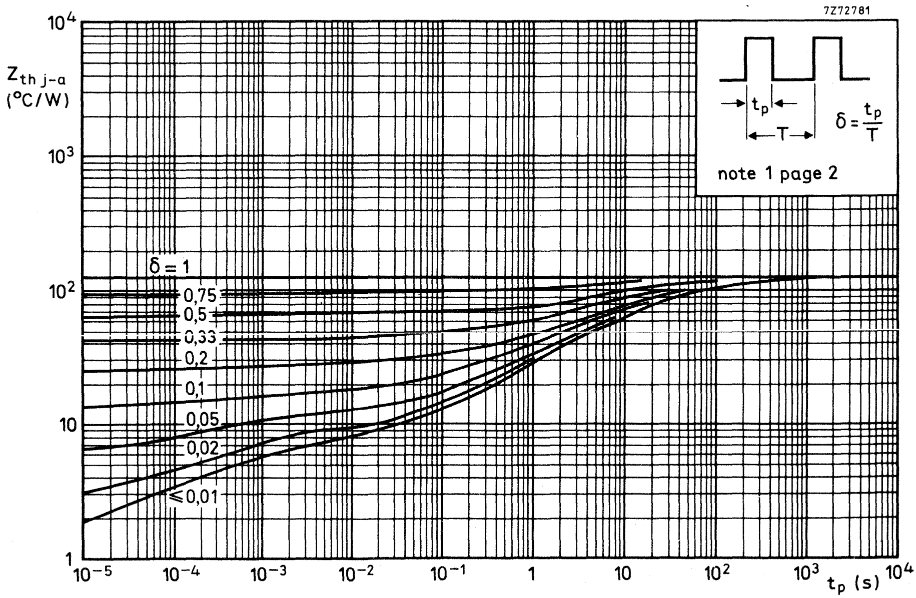
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	156	°C/W
From junction to ambient [1]	$R_{th\ j\text{-}a}$	=	125	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	60	°C/W

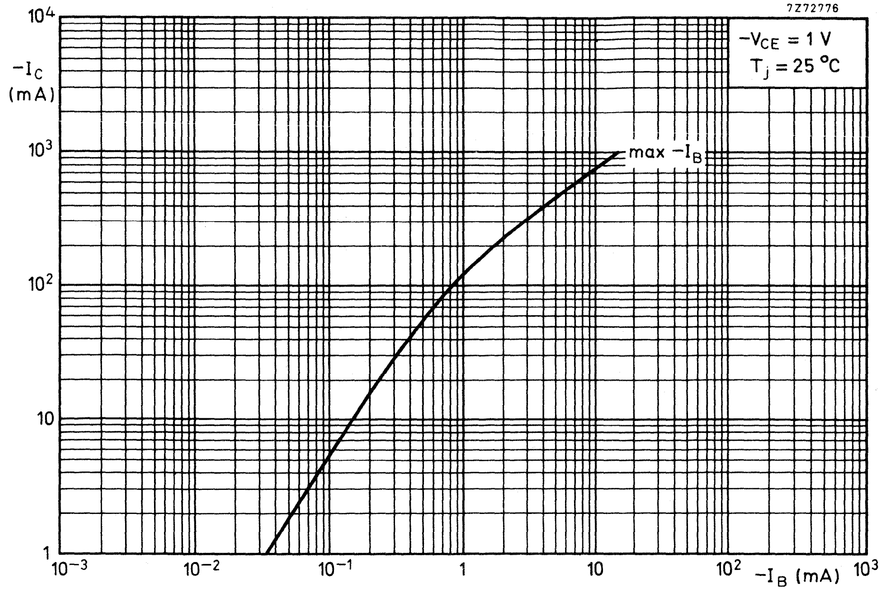
[1] Transistor mounted on printed-circuit board, max. lead length 4 mm, mounting pad for collector lead min. 10 mm x 10 mm.

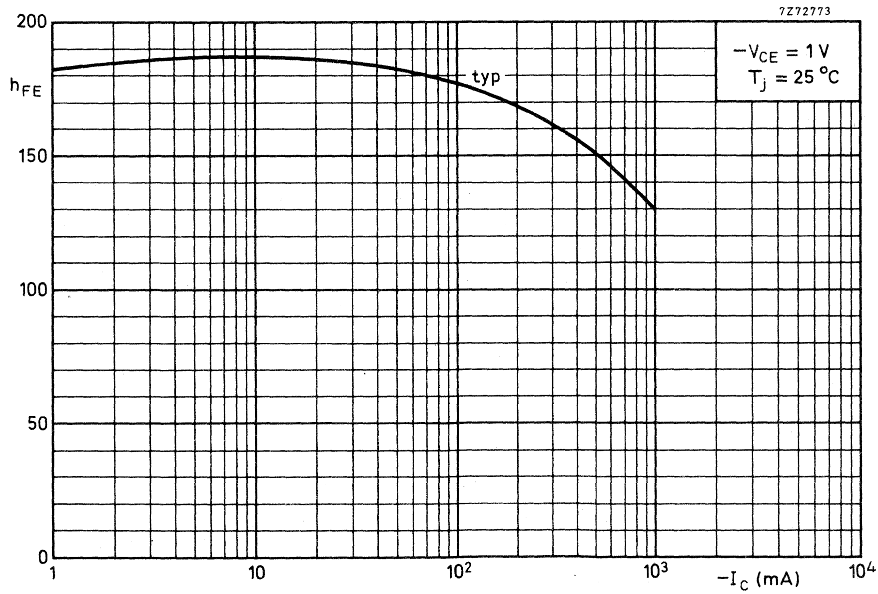
CHARACTERISTICS $T_j = 25\ ^oC$ unless otherwise specified

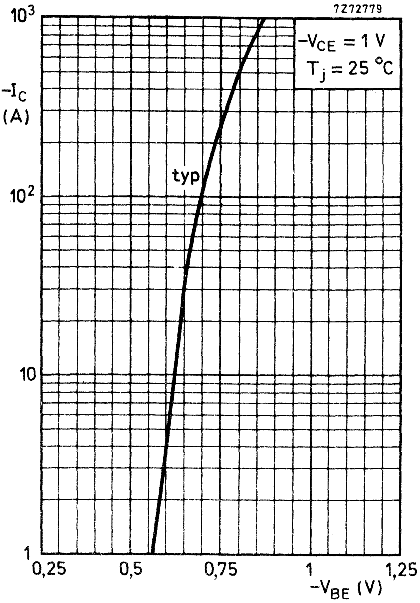
Collector cut-off current				
$I_E = 0$; $-V_{CB} = 25$ V	$-I_{CBO}$	<	10	µA
$I_E = 0$; $-V_{CB} = 25$ V; $T_j = 150\ ^oC$	$-I_{CBO}$	<	1	mA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	10	µA
Base-emitter voltage				
$-I_C = 5$ mA; $-V_{CE} = 10$ V	$-V_{BE}$	typ.	0,62	V
$-I_C = 1$ A; $-V_{CE} = 1$ V	$-V_{BE}$	<	1	V
Collector-emitter saturation voltage				
$-I_C = 1$ A; $-I_B = 100$ mA	$-V_{CEsat}$	<	0,5	V
D.C. current gain				
$-I_C = 5$ mA; $-V_{CE} = 10$ V	h_{FE}	>	50	
$-I_C = 500$ mA; $-V_{CE} = 1$ V	h_{FE}		85 to 375	
$-I_C = 1$ A; $-V_{CE} = 1$ V	h_{FE}	>	60	
Collector capacitance at f = 450 kHz				
$I_E = I_e = 0$; $-V_{CB} = 5$ V	C_c	typ.	45	pF ←
Cut-off frequency				
$-I_C = 10$ mA; $-V_{CE} = 5$ V	f_{hfe}	typ.	350	kHz ←
Transition frequency at f = 35 MHz				
$-I_C = 10$ mA; $-V_{CE} = 5$ V	f_T	typ.	60	MHz ←
D.C. current gain ratio of matched pair BC368/BC369				
$\|I_C\| = 500$ mA; $\|V_{CE}\| = 1$ V	h_{FE1}/h_{FE2}	<	1,4	

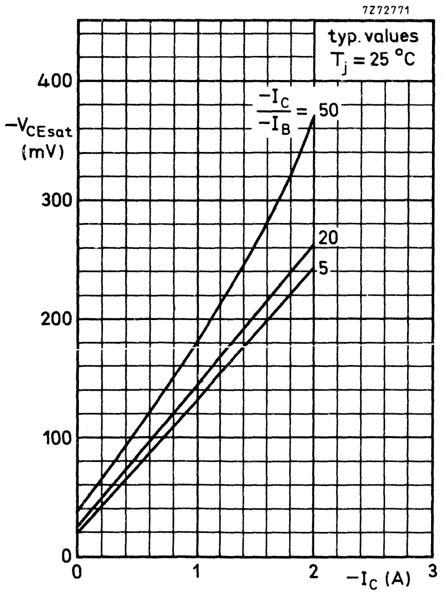

7Z72780
$Z_{th\ j-a}$ (°C/W)
free in air
$\delta = \frac{t_p}{T}$
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
≤0,01
t_p (s)

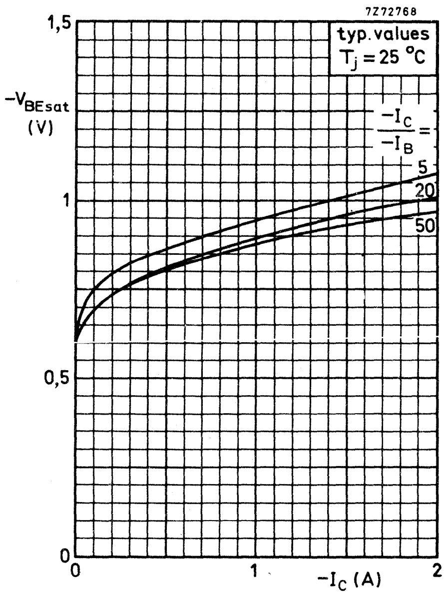

7Z72781
$Z_{th\ j-a}$ (°C/W)
note 1 page 2
$\delta = \frac{t_p}{T}$
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
≤0,01
t_p (s)

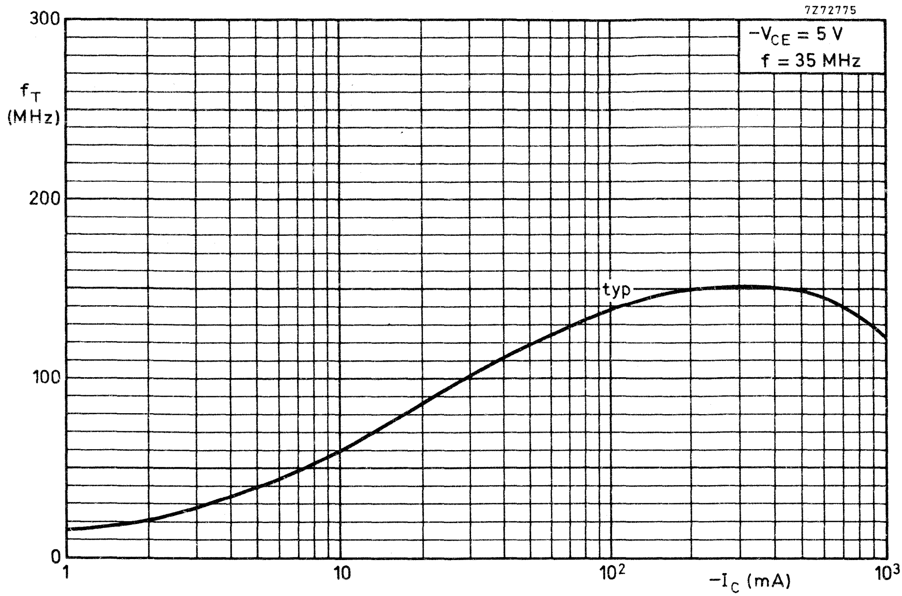

7Z72776
$-V_{CE}$ = 1 V
T_j = 25 °C
$-I_C$ (mA)
10^4
10^3
10^2
10
1
max $-I_B$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
$-I_B$ (mA)
10^3


7Z72773
$-V_{CE}$ = 1 V
T_j = 25 °C
h_{FE}
200
150
100
50
0
typ
1
10
10^2
10^3
$-I_C$ (mA)
10^4


7Z72779
$-V_{CE}$ = 1 V
T_j = 25 °C
$-I_C$ (A)
typ
10^3
10^2
10
1
0,25
0,5
0,75
1
1,25
$-V_{BE}$ (V)


7Z72771
typ. values
T_j = 25 °C
$-V_{CEsat}$ (mV)
$\frac{-I_C}{-I_B}$ = 50
20
5
400
300
200
100
0
0
1
2
3
$-I_C$ (A)


7Z72768
typ. values
T_j = 25 °C
$-V_{BEsat}$ (V)
$\frac{-I_C}{-I_B}$ =
5
20
50
1,5
1
0,5
0
0
1
2
$-I_C$ (A)


7Z72775
$-V_{CE}$ = 5 V
f = 35 MHz
f_T
(MHz)
300
200
100
0
typ
1
10
10^2
$-I_C$ (mA)
10^3

SILICON PLANAR EPITAXIAL TRANSISTORS

General purpose n-p-n transistors in a plastic TO-92 variant, especially suitable for use in driver stages of audio amplifiers.

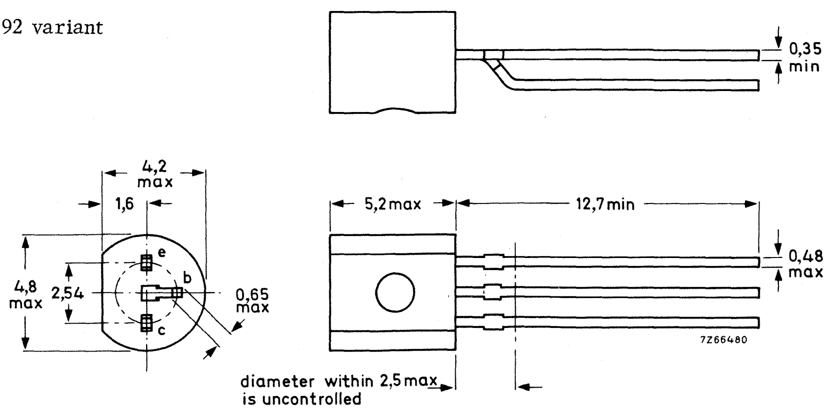
QUICK REFERENCE DATA

			BC546	BC547	BC548	
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	80	50	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	65	45	30	V
Collector current (peak value)	I_{CM}	max.	200	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	500	500	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}	> <	125 500	125 900	125 900	
Transition frequency 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 = 1 kHz; B = 200 Hz	F	typ.	2	2	2	dB

MECHANICAL DATA

Dimensions in mm

TO-92 variant



Accessories: 56356 (cooling clip).

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

			BC546	BC547	BC548	
Voltage						
Collector-base voltage (open emitter)	V_{CBO}	max.	80	50	30	V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	80	50	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	65	45	30	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	6	5	V

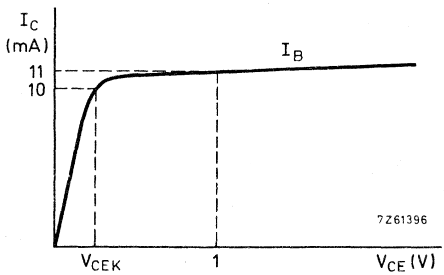
Current				
Collector current (d.c.)	I_C	max.	100	mA
Collector current (peak value)	I_{CM}	max.	200	mA
Emitter current (peak value)	$-I_{EM}$	max.	200	mA
Base current (peak value)	I_{BM}	max.	200	mA
Power dissipation				
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	mW
Temperature				
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	$R_{th\ j-c}$	=	0,15	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 30$ V	I_{CBO}	<	15	nA
$I_E = 0$; $V_{CB} = 30$ V; $T_j = 150$ °C	I_{CBO}	<	5	μA
Base-emitter voltage [1]				
I_C = 2 mA; V_{CE} = 5 V	V_{BE}	typ.	660	mV
			580 to 700	mV
I_C = 10 mA; V_{CE} = 5 V	V_{BE}	<	770	mV
Saturation voltage [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



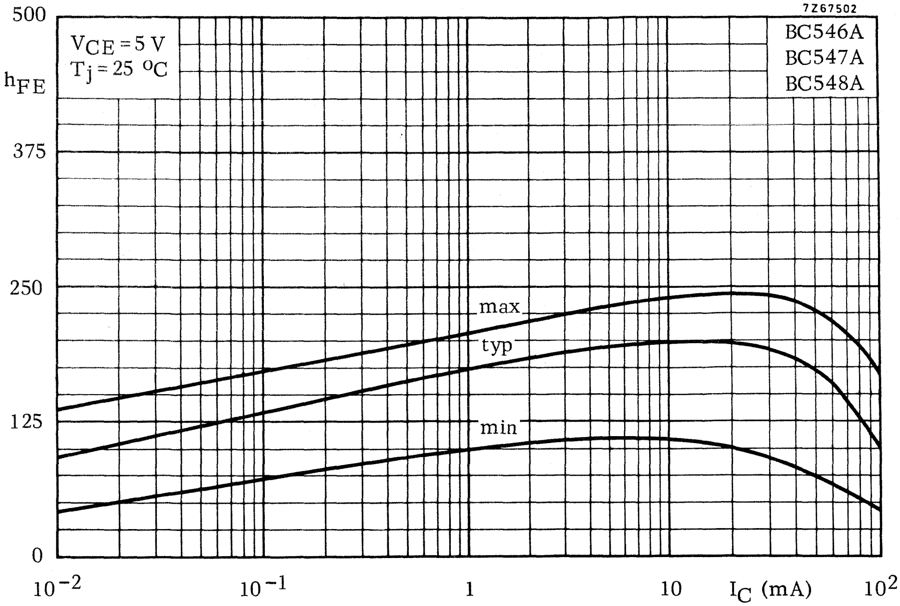
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; V_{CB} = 10 V	C_c	typ.	2,5	pF
		<	4,5	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; V_{EB} = 0,5 V	C_e	typ.	9	pF
Transition frequency at f = 35 MHz				
I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	300	MHz

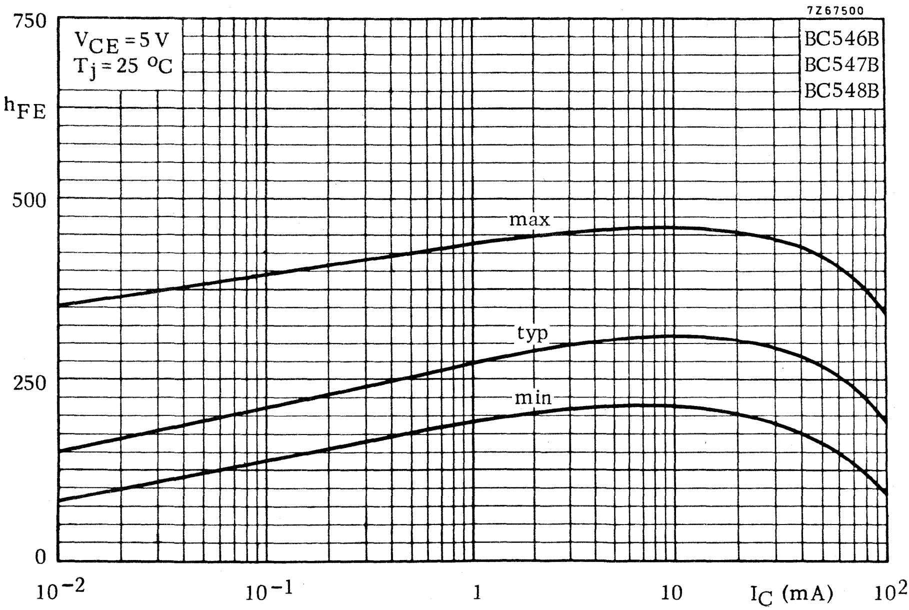
1) V_{BE} decreases by about 2 mV/°C with increasing temperature.
2) V_{BEsat} decreases by about 1,7 mV/°C with increasing temperature.

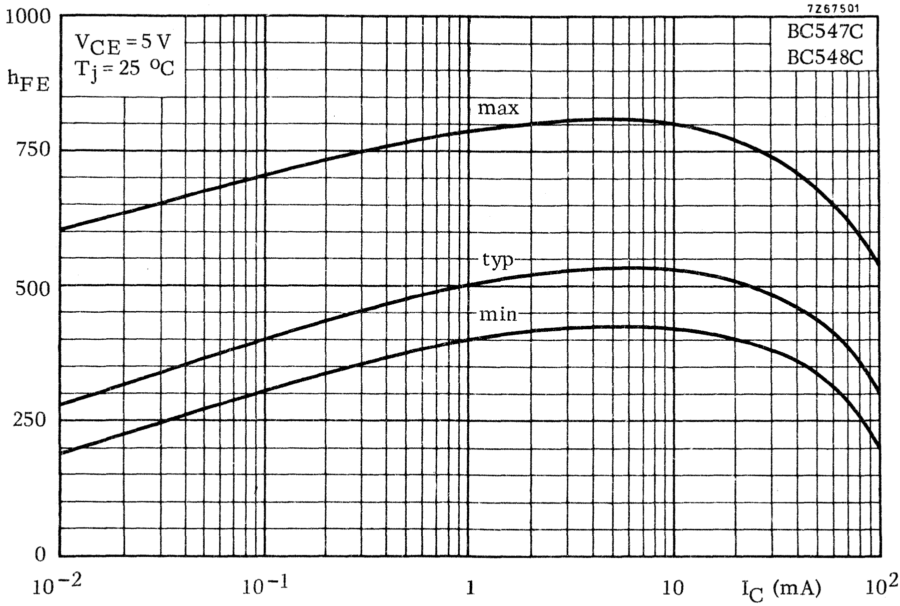
CHARACTERISTICS (continued) $T_j = 25\ ^oC$ unless otherwise specified

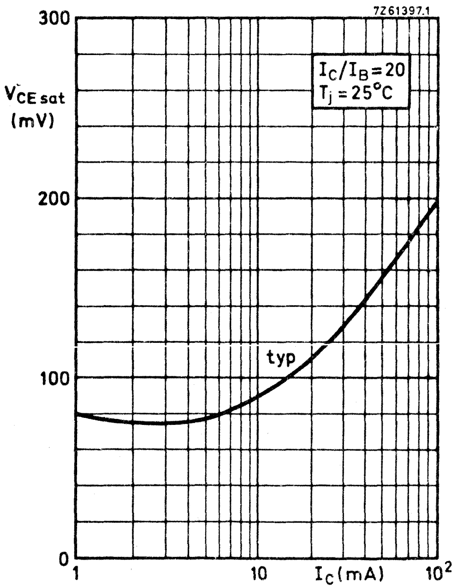
			BC546	BC547	BC548	
Small signal current gain at f = 1 kHz						
I_C = 2 mA; V_{CE} = 5 V	h_{fe}	>	125	125	125	
		<	500	900	900	
Noise figure at R_S = 2 kΩ						
I_C = 200 μA; V_{CE} = 5 V						
f = 1 kHz; B = 200 Hz	F	typ.	2	2	2	dB
		<	10	10	10	dB

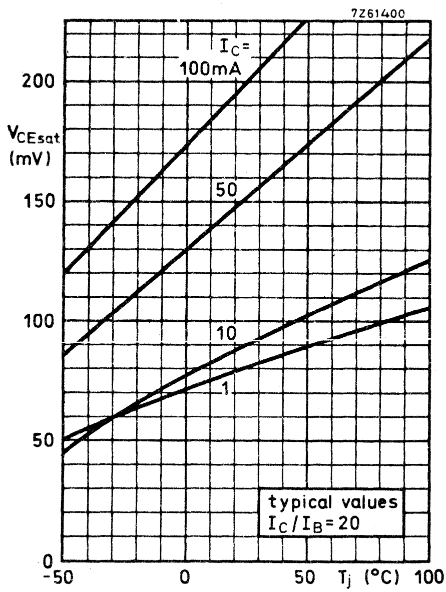
			BC546A BC547A BC548A	BC546B BC547B BC548B	BC547C BC548C	
D.C. current gain						
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	typ.	90	150	270	
		>	110	200	420	
I_C = 2 mA; V_{CE} = 5 V	h_{FE}	typ.	180	290	520	
		<	220	450	800	
h parameters at f = 1 kHz (common emitter)						
I_C = 2 mA; V_{CE} = 5 V						
		>	1,6	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	μA/V
		<	30	60	110	μA/V

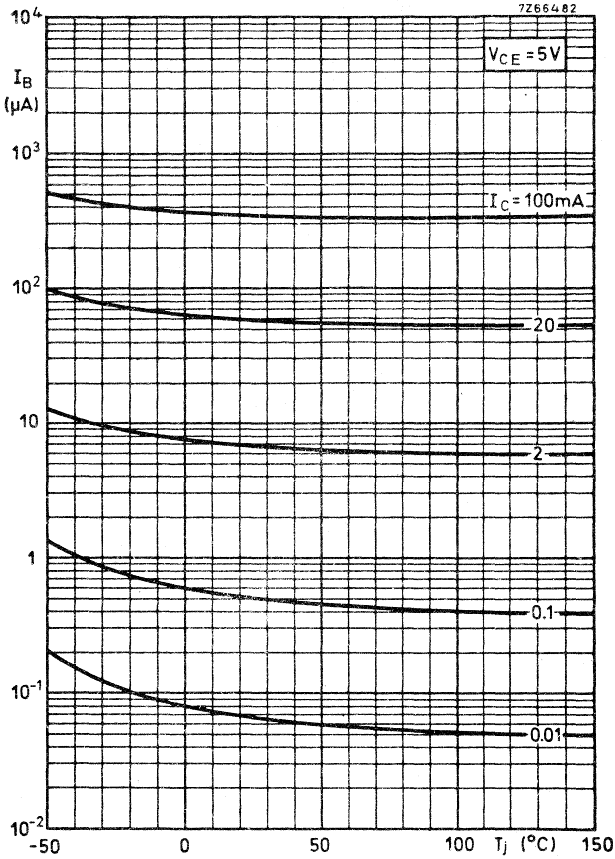

7Z67502
$V_{CE} = 5$ V
$T_j = 25$ °C
h_{FE}
BC546A
BC547A
BC548A
max
typ
min
500
375
250
125
0
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2


7Z67500
$V_{CE} = 5$ V
$T_j = 25$ °C
h_{FE}
BC546B
BC547B
BC548B
max
typ
min
750
500
250
0
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

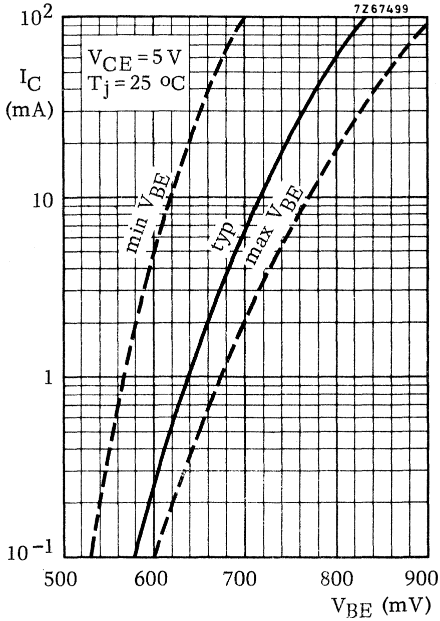

7Z67501
V_{CE} = 5 V
T_j = 25 °C
h_{FE}
BC547C
BC548C
max
typ
min
1000
750
500
250
0
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

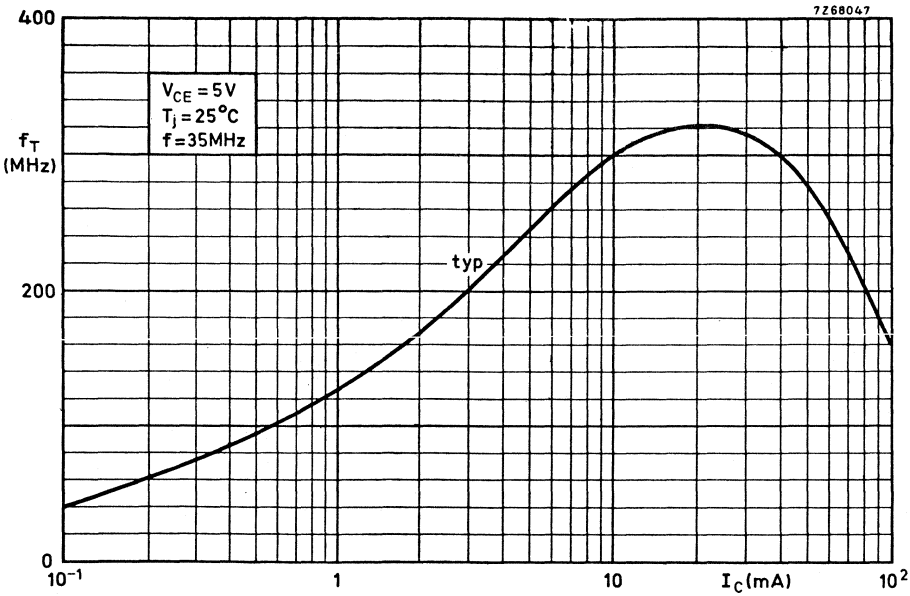

7Z61397.1
$V_{CE sat}$ (mV)
I_C/I_B = 20
T_j = 25 °C
typ
300
200
100
0
1
10
I_C (mA)
10^2

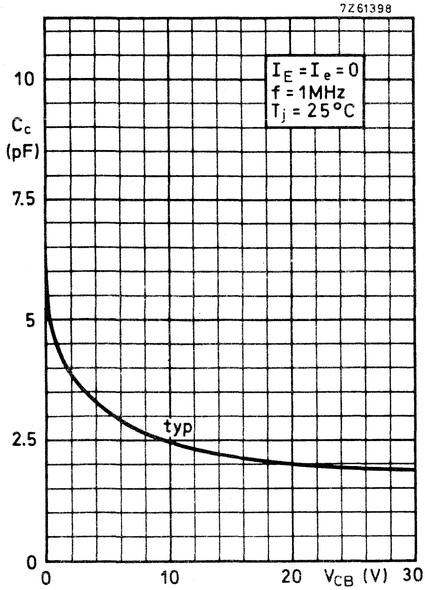

7Z61400
V_{CEsat} (mV)
I_C = 100mA
50
10
1
typical values
I_C/I_B = 20
200
150
100
50
0
-50
0
50
T_j (°C)
100

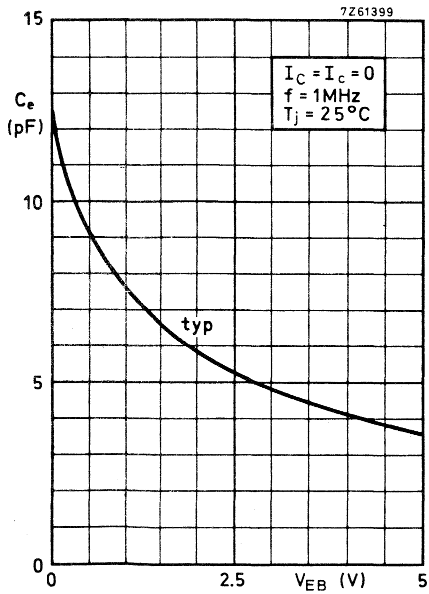


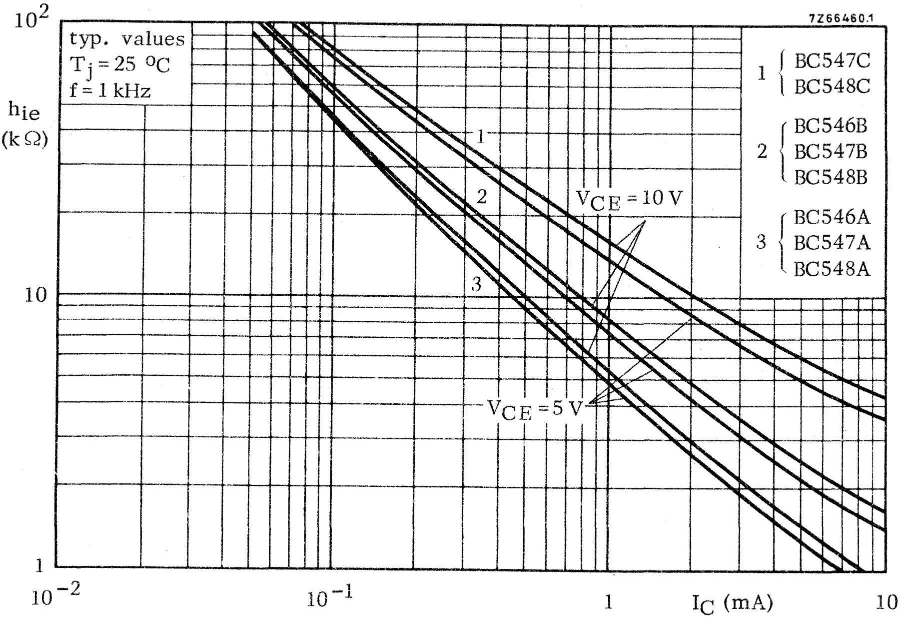
Typical behaviour of base current versus junction temperature

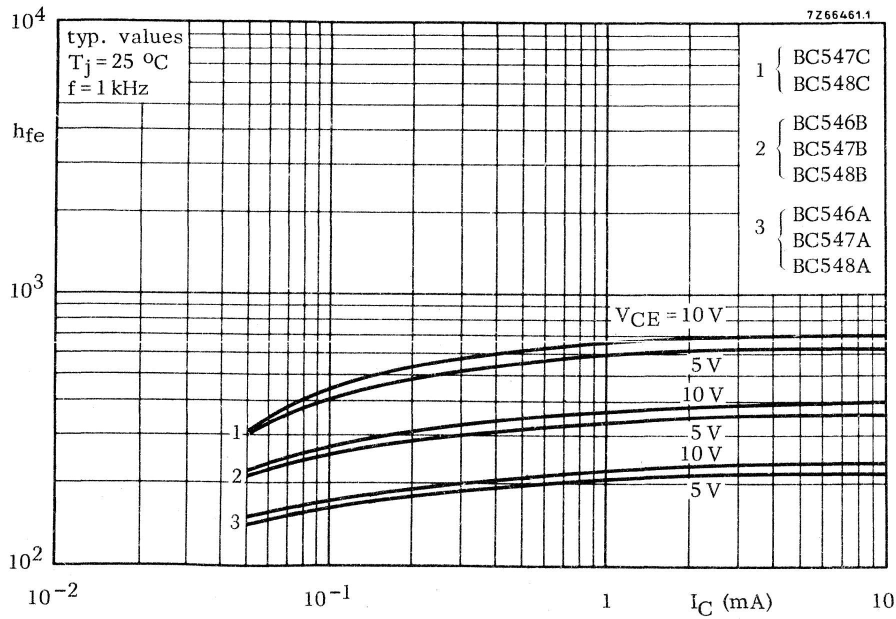

7Z67499
10^2
I_C (mA)
$V_{CE} = 5$ V
$T_j = 25$ °C
10
1
10^{-1}
min V_{BE}
typ
max V_{BE}
500
600
700
800
900
V_{BE} (mV)

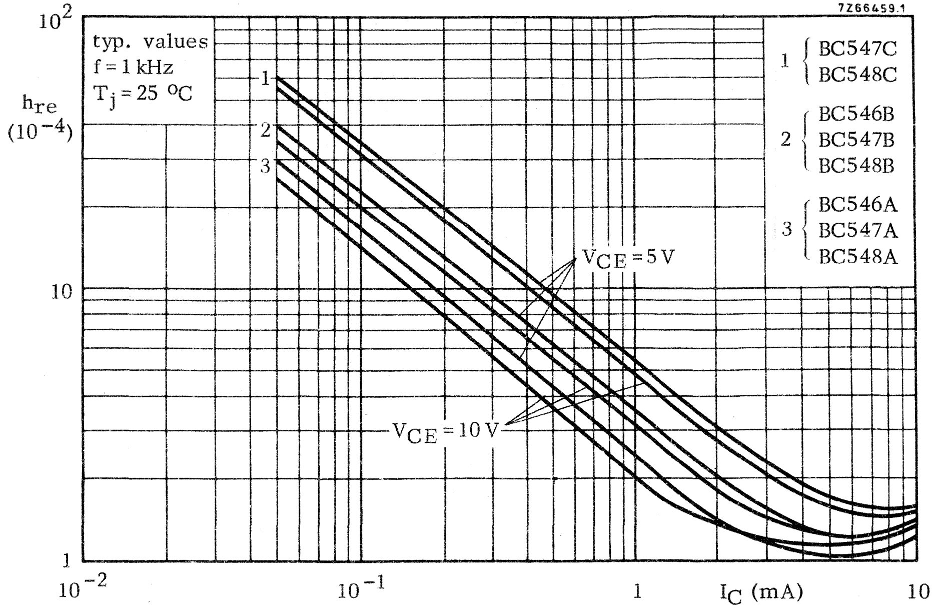

7Z68047
400
f_T (MHz)
200
0
$V_{CE} = 5$ V
$T_j = 25$ °C
f = 35 MHz
typ
10^{-1}
1
10
I_C (mA)
10^2

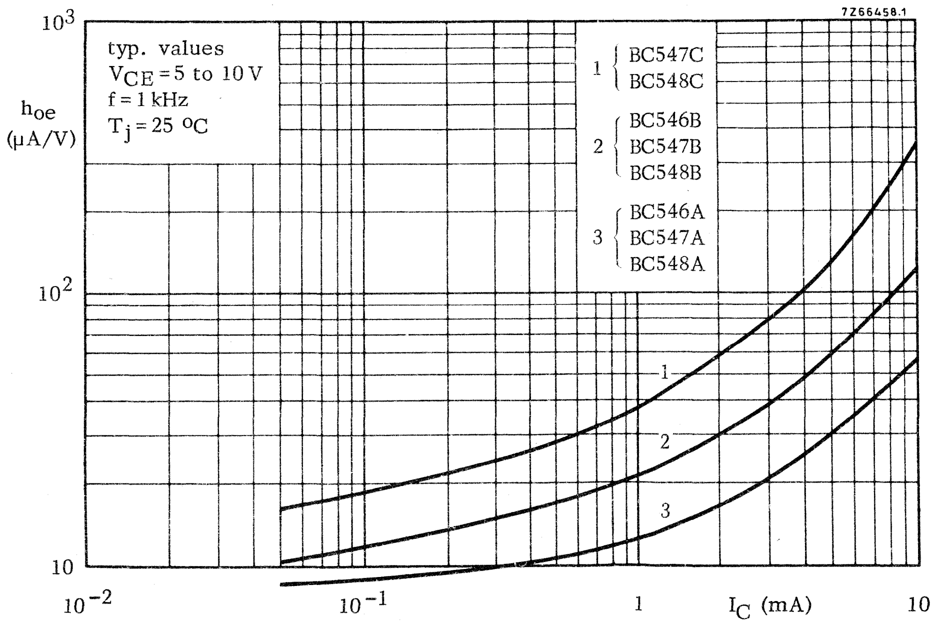

7Z61398
$I_E = I_e = 0$
f = 1MHz
$T_j = 25°C$
C_c (pF)
10
7.5
5
2.5
0
typ
0
10
20
V_{CB} (V)
30


7Z61399
$I_C = I_c = 0$
f = 1MHz
$T_j = 25°C$
C_e (pF)
15
10
5
0
typ
0
2.5
V_{EB} (V)
5


7Z66460.1
typ. values
Tj = 25 °C
f = 1 kHz
hie
(kΩ)
1 BC547C BC548C
2 BC546B BC547B BC548B
3 BC546A BC547A BC548A
VCE = 10 V
VCE = 5 V
IC (mA)


7Z66461.1
typ. values
Tj = 25 °C
f = 1 kHz
hfe
1 BC547C BC548C
2 BC546B BC547B BC548B
3 BC546A BC547A BC548A
VCE = 10 V
5 V
10 V
5 V
10 V
5 V
IC (mA)


7Z66459.1
typ. values
f = 1 kHz
Tj = 25 °C
hre
(10−4)
1 BC547C BC548C
2 BC546B BC547B BC548B
3 BC546A BC547A BC548A
VCE = 5 V
VCE = 10 V
IC (mA)


7Z66458.1
typ. values
VCE = 5 to 10 V
f = 1 kHz
Tj = 25 °C
hoe
(μA/V)
1 BC547C BC548C
2 BC546B BC547B BC548B
3 BC546A BC547A BC548A
IC (mA)

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in plastic TO-92 variants, primarily intended for low-noise input stages in tape recorders, hi-fi amplifiers and other audio-frequency equipment.

QUICK REFERENCE DATA

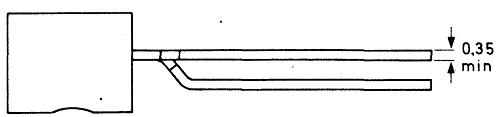
			BC549	BC550	
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max	30	50	V
Collector-emitter voltage (open base)	V_{CEO}	max	30	45	V
Collector current (peak value)	I_{CM}	max	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max	500	500	mW
Junction temperature	T_j	max	150	150	°C
Small-signal current gain I_C = 2 mA; V_{CE} = 5 V; f = 1 kHz	h_{fe}	> <	240 900	240 900	
Transition frequency I_C = 10 mA; V_{CE} = 5 V	f_T	typ	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	1,4 3	dB dB
f = 1 kHz; B = 200 Hz	F	typ	1,2	1	dB
f = 10 Hz to 50 Hz (equivalent noise voltage)	V_n	<	–	0,135	μV

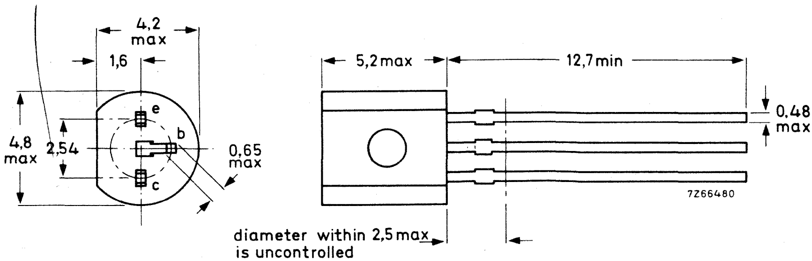
MECHANICAL DATA

Dimensions in mm

TO-92 variant

Accessories:
56356 (cooling clip)





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

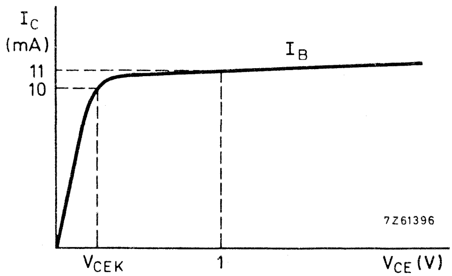
			BC549	BC550	
Voltage					
Collector-base voltage (open emitter)	V_{CBO}	max.	30	50	V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	30	50	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	45	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	V
Current					
Collector current (d. c.)	I_C	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} = 25 °C	P_{tot}	max.		500	mW
Temperature					
Storage temperature	T_{stg}			−65 to +150	°C
Junction temperature	T_j	max.		150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0,25	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0,15	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Parameter	Symbol		Value	Unit
Collector cut-off current				
I_E = 0; V_{CB} = 30 V	I_{CBO}	<	15	nA
I_E = 0; V_{CB} = 30 V; T_j = 150 °C	I_{CBO}	<	5	µA
Base emitter voltage				
I_C = 2 mA; V_{CE} = 5 V	V_{BE}	typ.	660	mV
			580 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



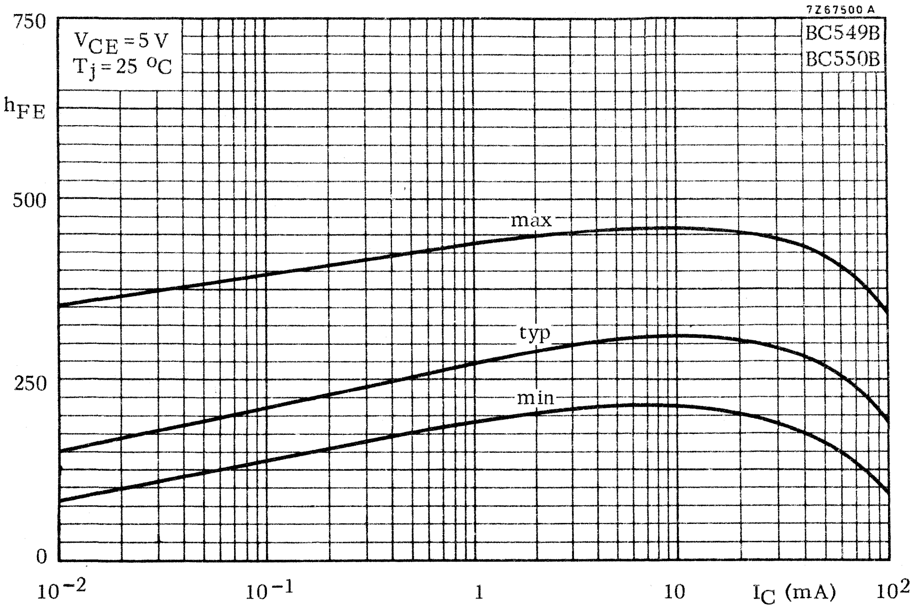
Parameter	Symbol		Value	Unit
Collector capacitance at f = 1 MHz				
I_E = I_e = 0; V_{CB} = 10 V	C_c	typ.	2,5	pF
		<	4,5	pF
Emitter capacitance at f = 1 MHz				
I_C = I_c = 0; V_{EB} = 0,5 V	C_e	typ.	9	pF
Transition frequency at f = 35 MHz				
I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	300	MHz

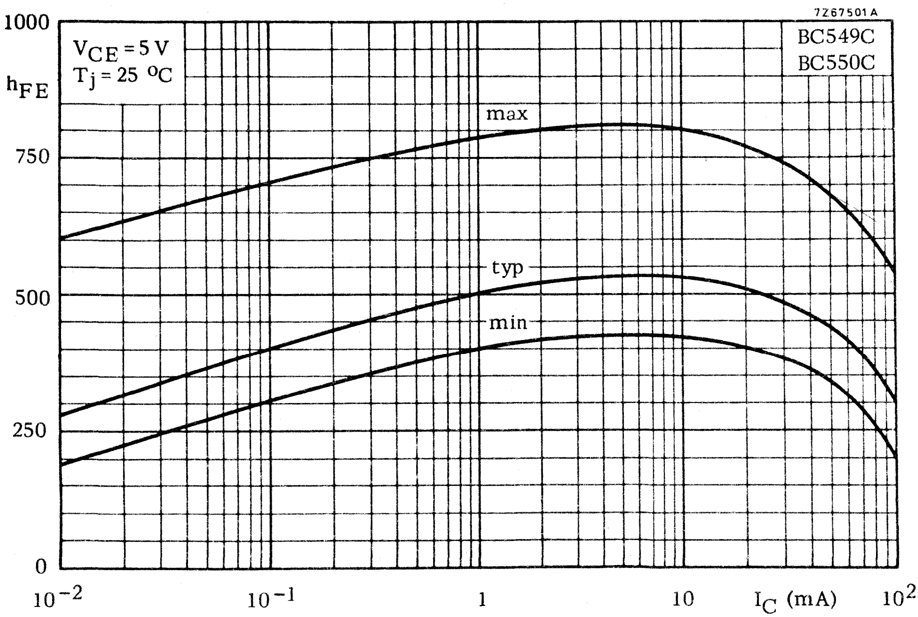
1) V_{BE} decreases by about 2 mV/°C with increasing temperature.
2) V_{BEsat} decreases by about 1,7 mV/°C with increasing temperature.

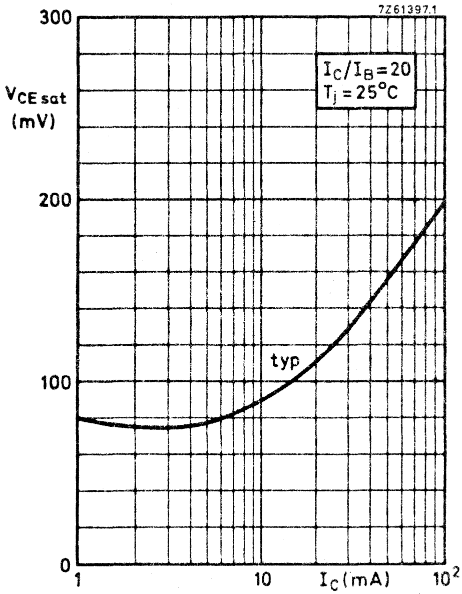
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

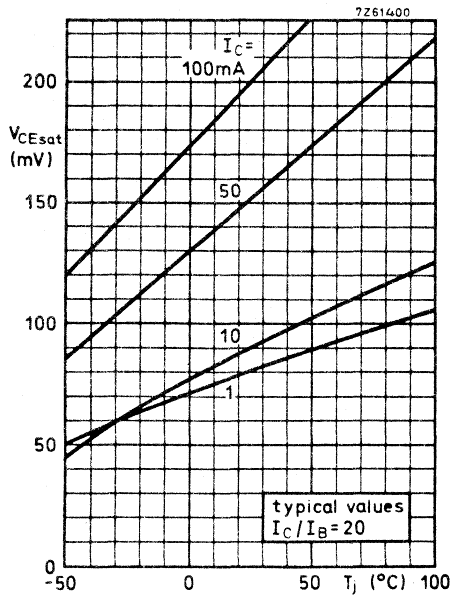
			BC549	BC550	
Small signal current gain at f = 1 kHz					
I_C = 2 mA; V_{CE} = 5 V	h_{fe}	>	240	240	
		<	900	900	
Noise figure at R_S = 2 kΩ					
I_C = 200 μA; V_{CE} = 5 V					
f = 30 Hz to 15 kHz	F	typ.	1,4	1,4	dB
		<	4	3	dB
f = 1 kHz; B = 200 Hz	F	typ.	1,2	1	dB
		<	4	4	dB
Equivalent noise voltage at R_S = 2 kΩ					
I_C = 200 μA; V_{CE} = 5 V					
f = 10 Hz to 50 Hz; T_{amb} = 25 °C	V_n	max.	–	0,135	μV

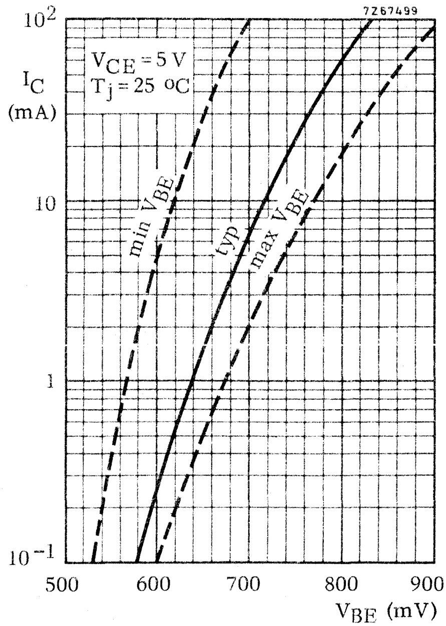
			BC549B BC550B	BC549C BC550C	
D.C. current gain					
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	typ.	150	270	
		>	200	420	
I_C = 2 mA; V_{CE} = 5 V	h_{FE}	typ.	290	520	
		<	450	800	
h parameters at f = 1 kHz (common emitter)					
I_C = 2 mA; V_{CE} = 5 V					
		>	3,2	6	kΩ
Input impedance	h_{ie}	typ.	4,5	8,7	kΩ
		<	8,5	15	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	2	3	10^{-4}
		>	240	450	
Small signal current gain	h_{fe}	typ.	330	600	
		<	500	900	
Output admittance	h_{oe}	typ.	30	60	μA/V
		<	60	110	μA/V

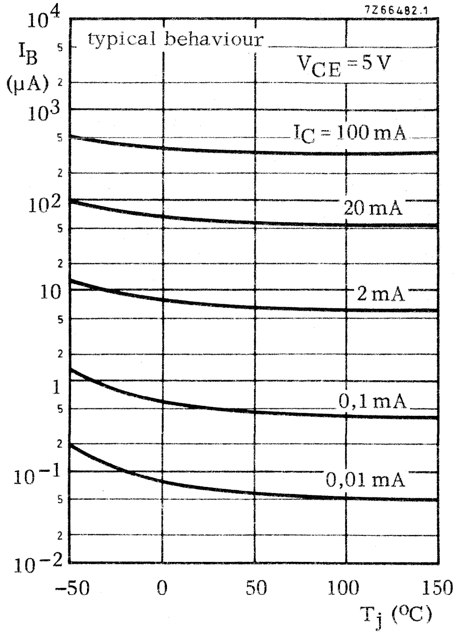

7Z67500 A
BC549B
BC550B
V_{CE} = 5 V
T_j = 25 °C
h_{FE}
750
500
250
0
max
typ
min
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

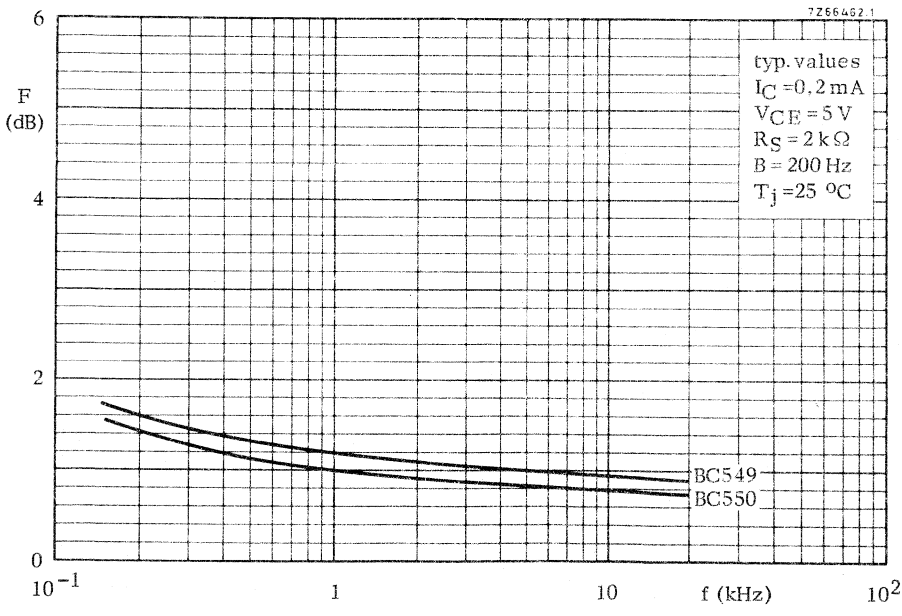

7Z67501 A
BC549C
BC550C
V_{CE} = 5 V
T_j = 25 °C
h_{FE}
1000
750
500
250
0
max
typ
min
10^{-2}
10^{-1}
1
10
I_C (mA)
10^2

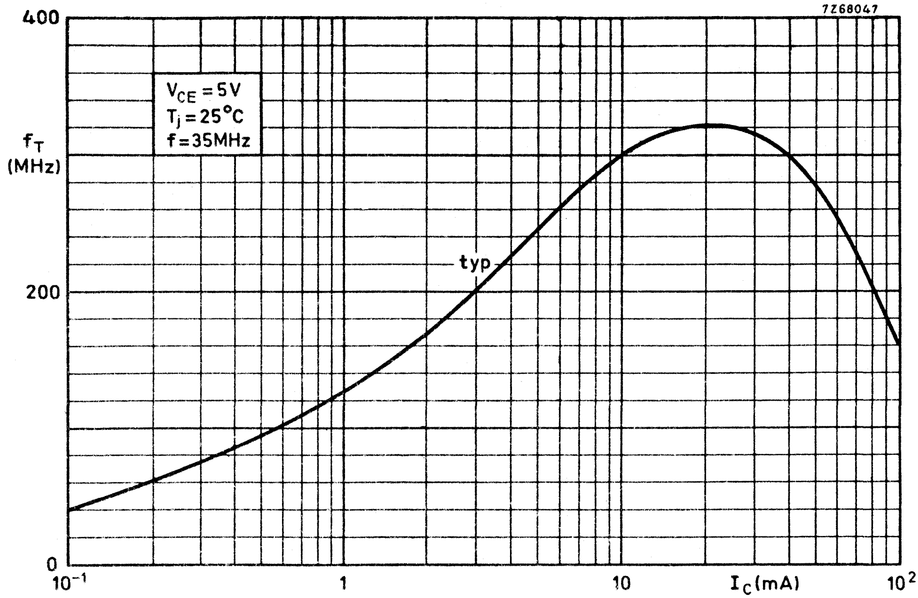

7Z61397.1
$V_{CE\,sat}$ (mV)
$I_C/I_B = 20$
$T_j = 25\,^{\circ}C$
typ
I_C (mA)
300
200
100
0
1
10
10^2

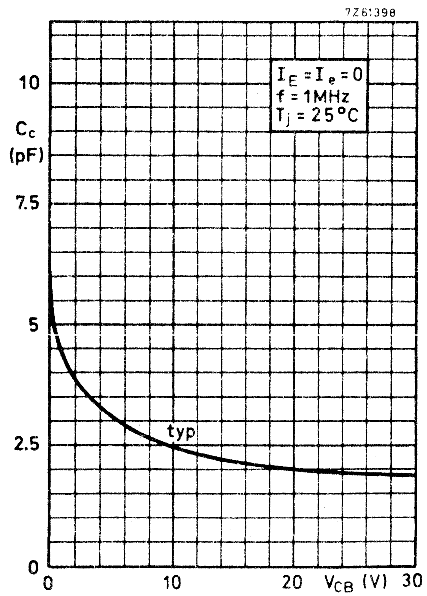

7Z61400
V_{CEsat} (mV)
I_C = 100mA
50
10
1
typical values
$I_C/I_B = 20$
T_j (°C)
200
150
100
50
0
-50
0
50
100

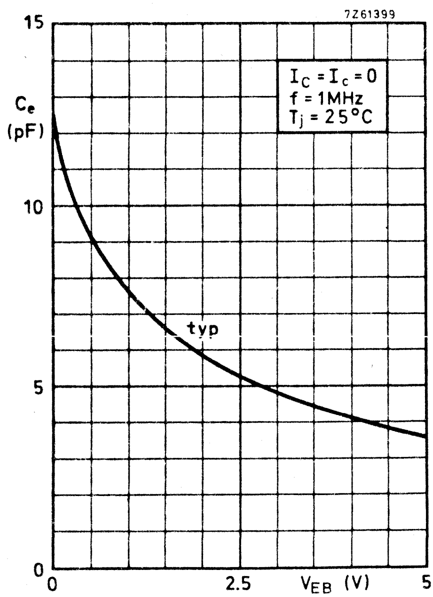

7Z67499
I_C (mA)
$V_{CE} = 5$ V
$T_j = 25$ °C
min V_{BE}
typ
max V_{BE}
V_{BE} (mV)
10^2
10
1
10^{-1}
500
600
700
800
900

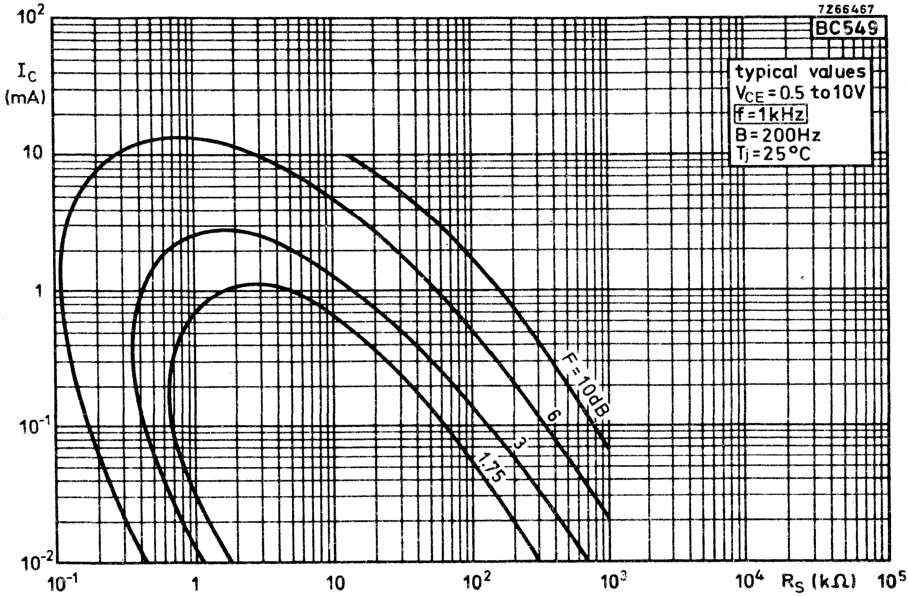

7Z66482.1
typical behaviour
$V_{CE} = 5$ V
I_B (μA)
$I_C = 100$ mA
20 mA
2 mA
0,1 mA
0,01 mA
T_j (°C)
−50
0
50
100
150


7Z66462.1
typ. values
$I_C = 0,2$ mA
$V_{CE} = 5$ V
$R_S = 2$ kΩ
B = 200 Hz
$T_j = 25$ °C
F (dB)
BC549
BC550
f (kHz)
10^{-1}
1
10
10^2

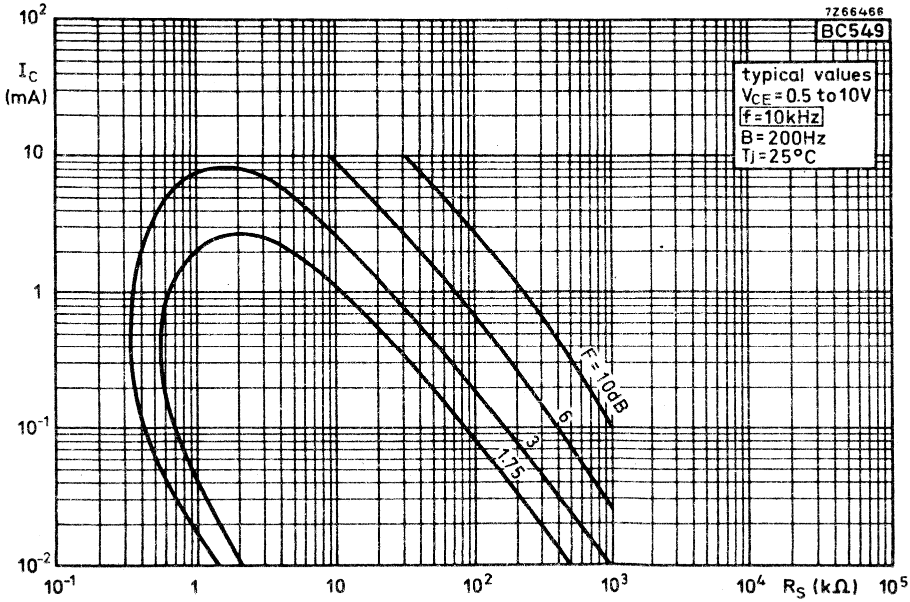

7Z68047
400
200
0
f_T (MHz)
V_{CE} = 5V
T_j = 25°C
f = 35MHz
typ
10^{-1}
1
10
I_C (mA)
10^2


7Z61398
10
7.5
5
2.5
0
C_c (pF)
$I_E = I_e = 0$
f = 1MHz
T_j = 25°C
typ
0
10
20
V_{CB} (V)
30

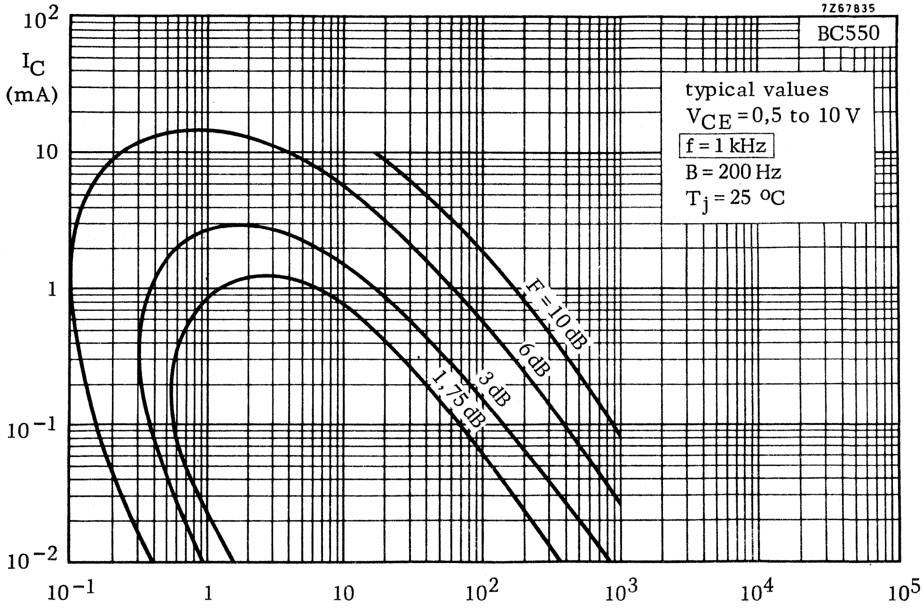

7Z61399
15
10
5
0
C_e (pF)
$I_C = I_c = 0$
f = 1MHz
T_j = 25°C
typ
0
2.5
V_{EB} (V)
5



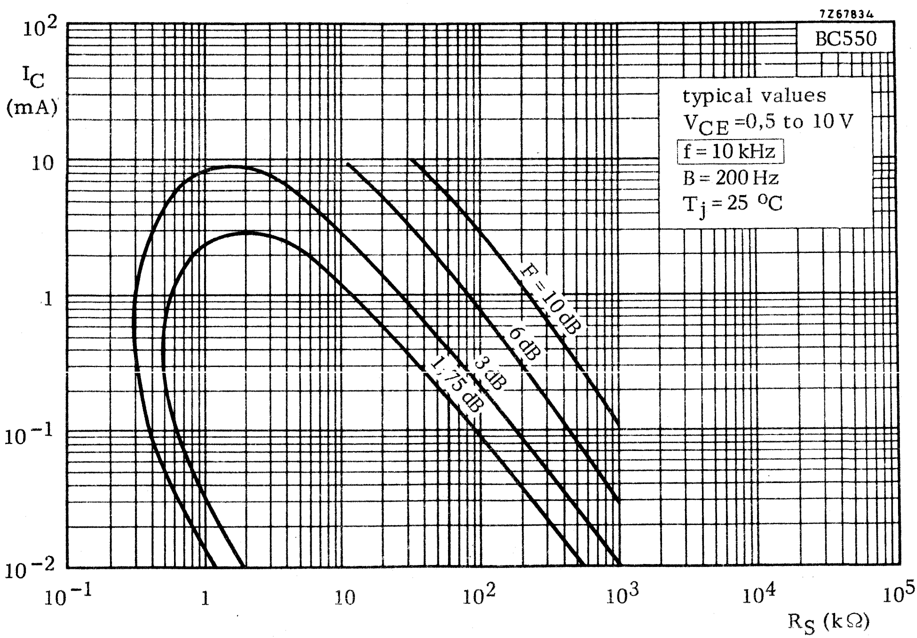
Curves of constant noise figure



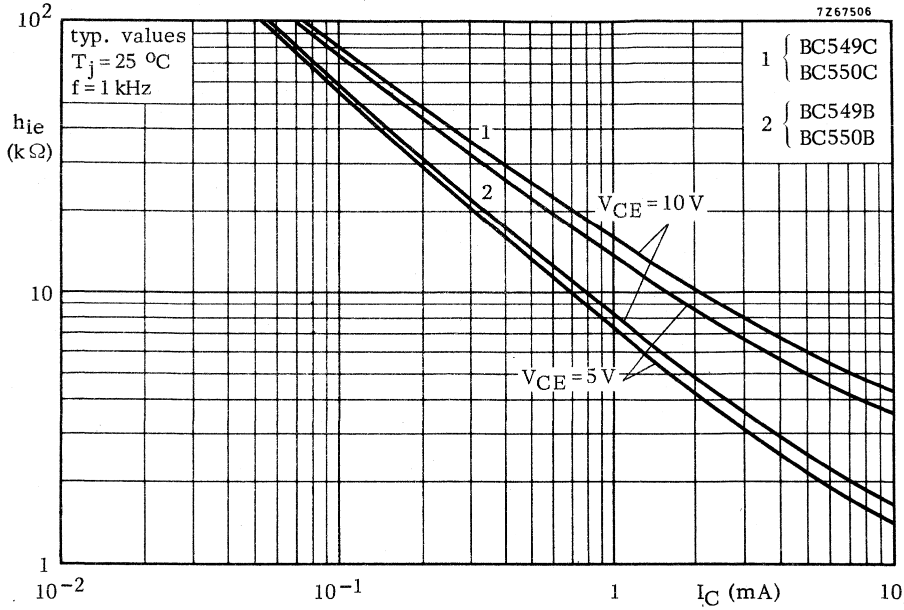
Curves of constant noise figure

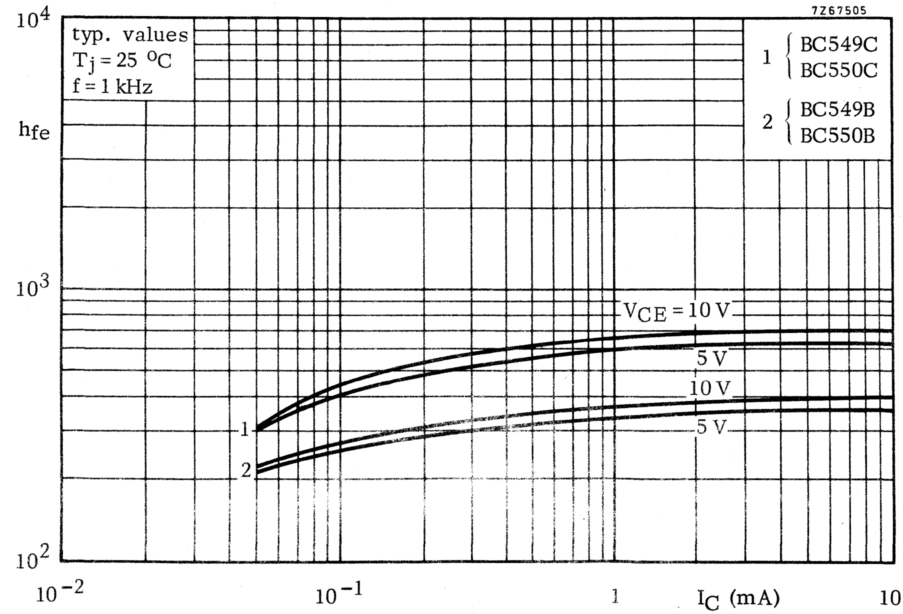


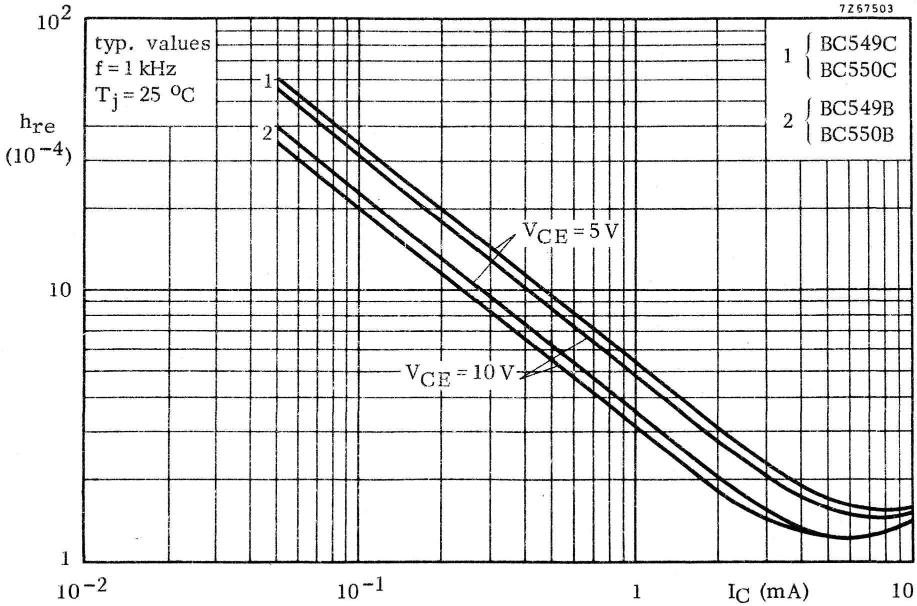
Curves of constant noise figure

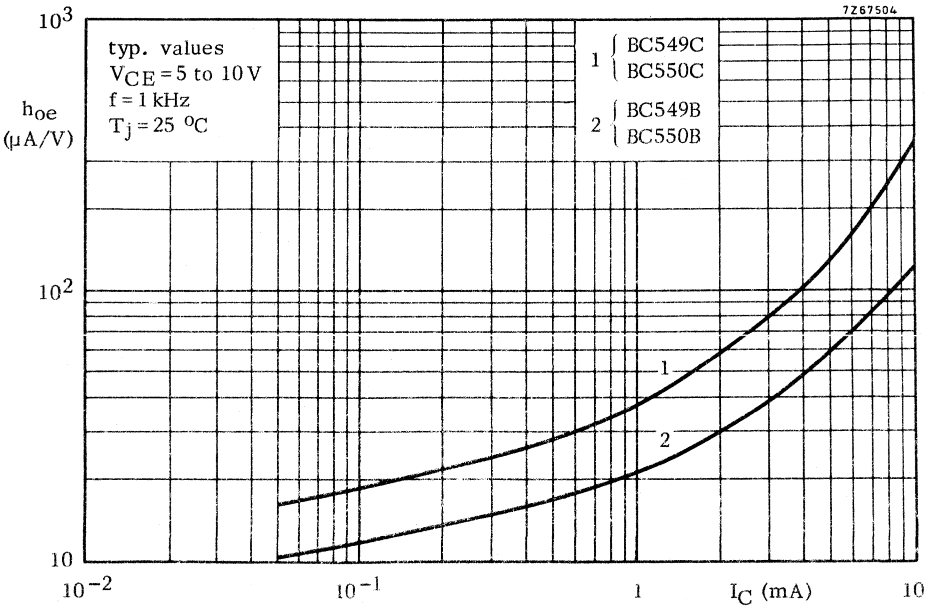


Curves of constant noise figure


7Z67506
typ. values
T_j = 25 °C
f = 1 kHz
h_{ie}
(kΩ)
10^2
10
1
1 { BC549C BC550C
2 { BC549B BC550B
1
2
V_{CE} = 10 V
V_{CE} = 5 V
10^{-2}
10^{-1}
1
I_C (mA)
10


7Z67505
typ. values
T_j = 25 °C
f = 1 kHz
h_{fe}
10^4
10^3
10^2
1 { BC549C BC550C
2 { BC549B BC550B
V_{CE} = 10 V
5 V
10 V
5 V
1
2
10^{-2}
10^{-1}
1
I_C (mA)
10


7Z67503
typ. values
f = 1 kHz
Tj = 25 °C
hre
(10^-4)
1 { BC549C BC550C
2 { BC549B BC550B
VCE = 5 V
VCE = 10 V
1
2
10^2
10
1
10^-2
10^-1
1
IC (mA)
10


7Z67504
typ. values
VCE = 5 to 10 V
f = 1 kHz
Tj = 25 °C
hoe
(μA/V)
1 { BC549C BC550C
2 { BC549B BC550B
1
2
10^3
10^2
10
10^-2
10^-1
1
IC (mA)
10

SILICON PLANAR EPITAXIAL TRANSISTORS

General purpose p-n-p transistors in a plastic TO-92 variant, especially suitable for use in driver stages of audio amplifiers.

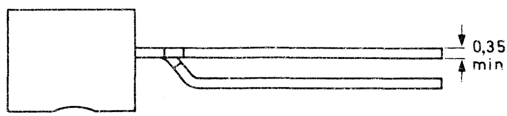
QUICK REFERENCE DATA

			BC556	BC557	BC558	
Collector-emitter voltage ($+V_{BE}$ = 1 V)	$-V_{CEX}$	max.	80	50	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	65	45	30	V
Collector current (peak value)	$-I_{CM}$	max.	200	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	500	500	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}	>	75	75	75	
		<	260	500	500	
Transition frequency $-I_C$ = 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 = 1 kHz; B = 200 Hz	F	<	10	10	10	dB

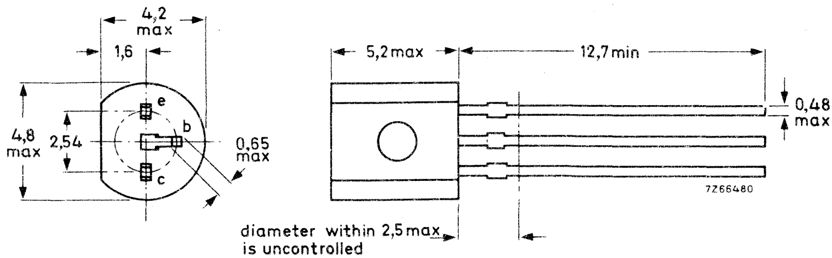
MECHANICAL DATA

Dimensions in mm

TO-92 variant



Accessories:
56356 (cooling clip)



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

Voltages

			BC 556	BC 557	BC 558	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80	50	30	V
Collector-emitter voltage ($+V_{BE}$ = 1 V)	$-V_{CEX}$	max.	80	50	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	65	45	30	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} = 25 °C	P_{tot}	max.	500	mW

Temperatures

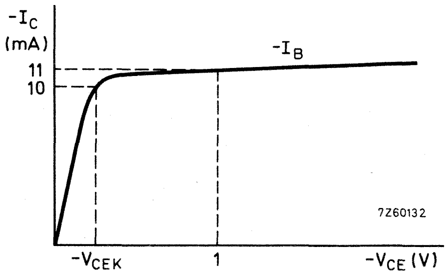
Storage temperature	T_{stg}		−65 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0,25	°C/mW
From junction to case	$R_{th\ j-c}$	=	0,15	°C/mW

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

Collector cut-off current			
$I_E = 0; -V_{CB} = 30\ V; T_j = 25\ ^oC$	$-I_{CBO}$	typ	1 nA ←
		<	15 nA
$T_j = 150\ ^oC$	$-I_{CBO}$	<	4 μA
Base-emitter voltage *			
$-I_C = 2\ mA; -V_{CE} = 5\ V$	$-V_{BE}$	typ	650 mV
		600 to	750 mV
$-I_C = 10\ mA; -V_{CE} = 5\ V$	$-V_{BE}$	<	820 mV
Saturation voltages **			
$-I_C = 10\ mA; -I_B = 0,5\ mA$	$-V_{CEsat}$	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 frequency at f = 35 MHz			
$-I_C = 10\ mA; -V_{CE} = 5\ V$	f_T	typ	150 MHz

* $-V_{BE}$ decreases by about 2 mV/^{o}C with increasing temperature.
** $-V_{BEsat}$ decreases by about 1,7 mV/^{o}C with increasing temperature.

CHARACTERISTICS (continued)

T_j = 25 °C unless otherwise specified

Small-signal current gain at f = 1 kHz

		BC556	BC557 BC558
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{fe}	75 to 260	75 to 500

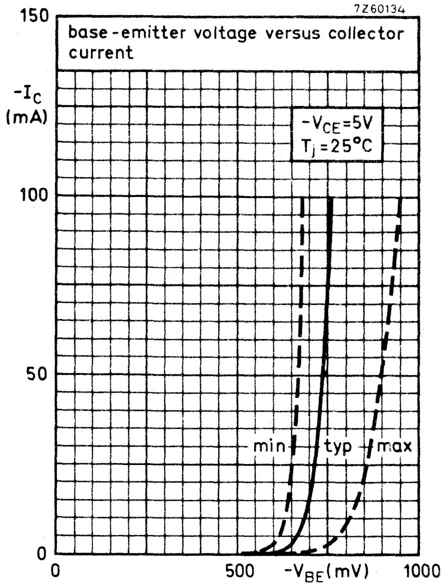
Noise figure at R_S = 2 kΩ

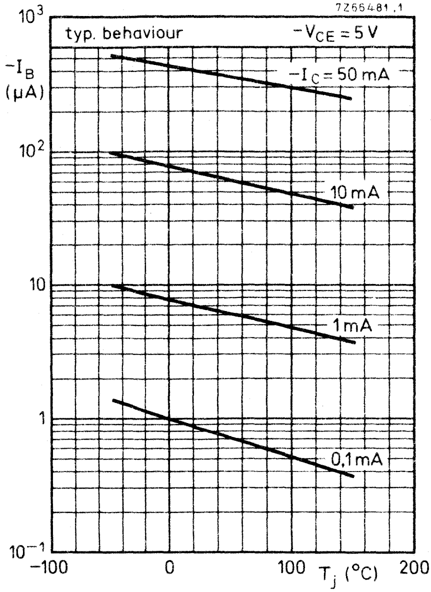
$-I_C$ = 200 μA; $-V_{CE}$ = 5 V; f = 1 kHz; B = 200 Hz	F	typ.	2	dB
		<	10	dB

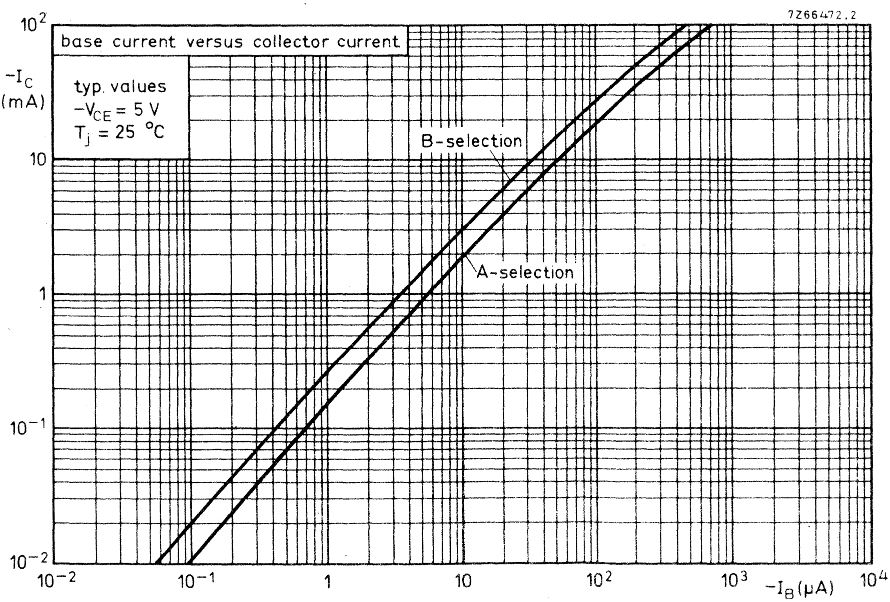
D.C. current gain

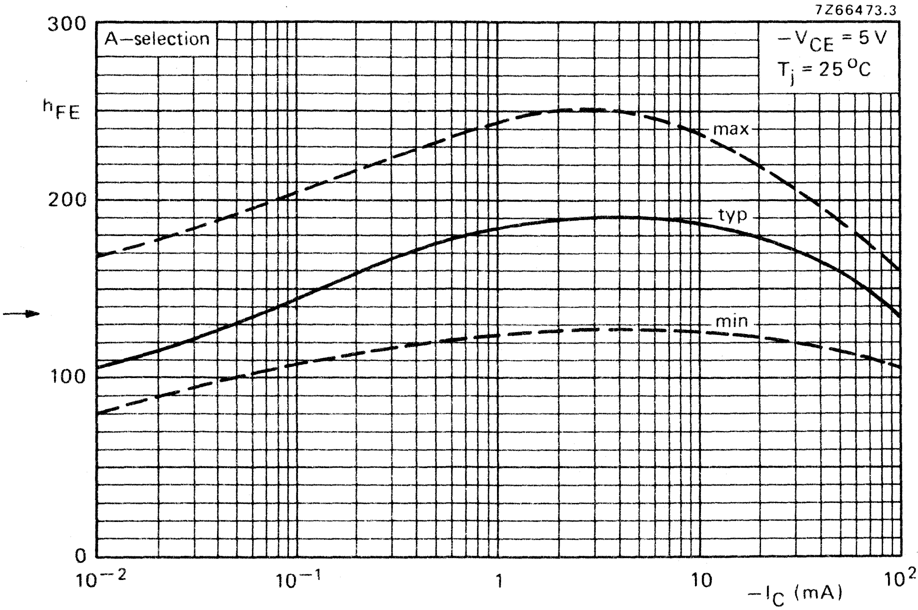
			BC556	BC556A
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{FE}	>	75	125
		<	250	250

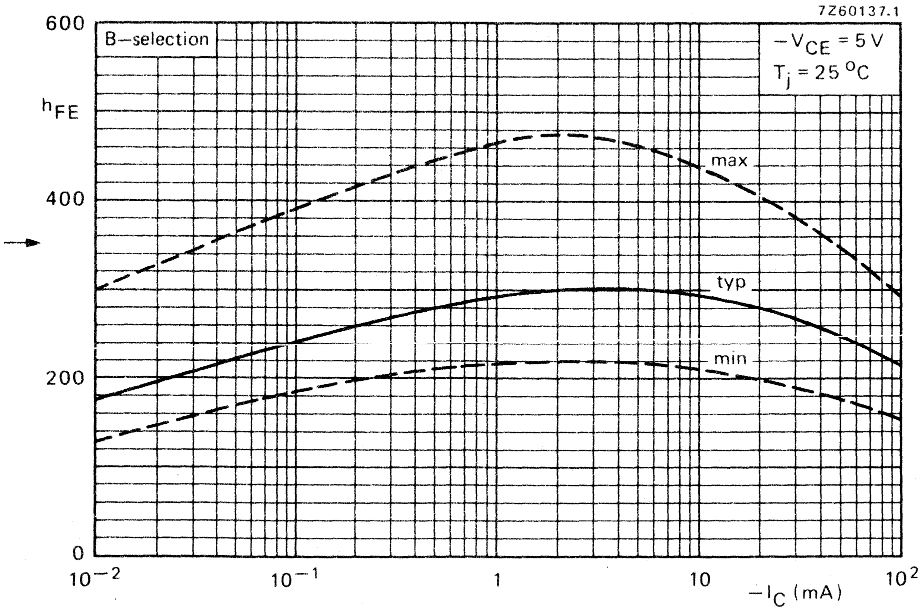
		BC557 BC558	BC557A BC558A	BC557B BC558B
h_{FE}	>	75	125	220
	<	475	250	475

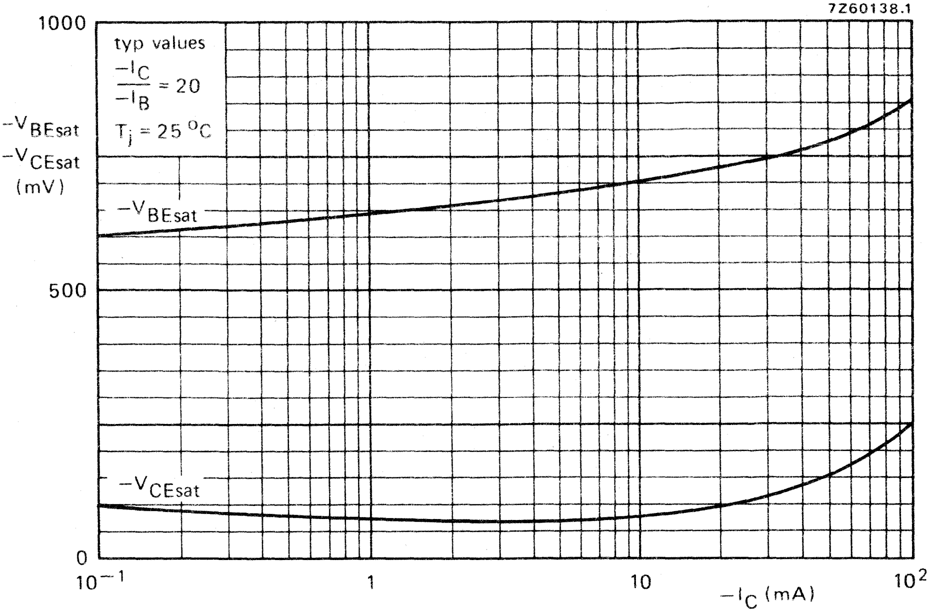

7Z60134
base-emitter voltage versus collector current
-I_C (mA)
-V_CE=5V
T_j=25°C
min
typ
max
-V_BE(mV)
0
500
1000
50
100
150

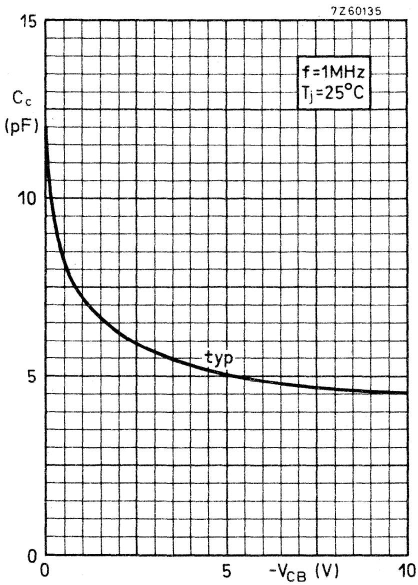

7Z66481.1
typ. behaviour
-V_CE = 5 V
-I_B (μA)
-I_C = 50 mA
10 mA
1 mA
0,1 mA
T_j (°C)
-100
0
100
200

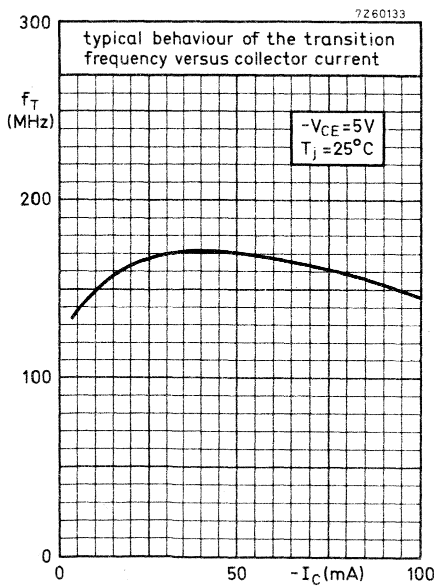

7Z66472.2
base current versus collector current
-I_C (mA)
typ. values
-V_CE = 5 V
T_j = 25 °C
B-selection
A-selection
-I_B (μA)

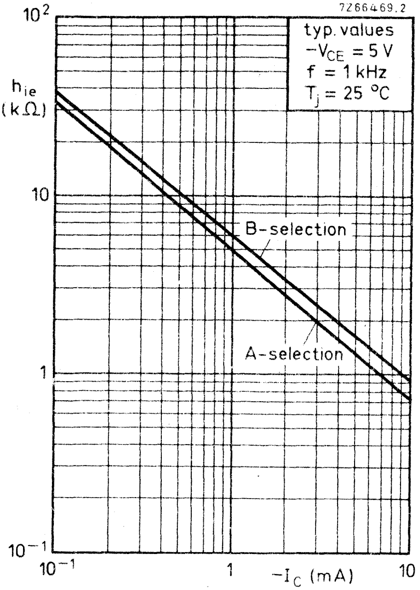

7Z66473.3
A–selection
$-V_{CE}$ = 5 V
T_j = 25 °C
h_{FE}
300
200
100
0
max
typ
min
10^{-2}
10^{-1}
1
10
10^2
$-I_C$ (mA)

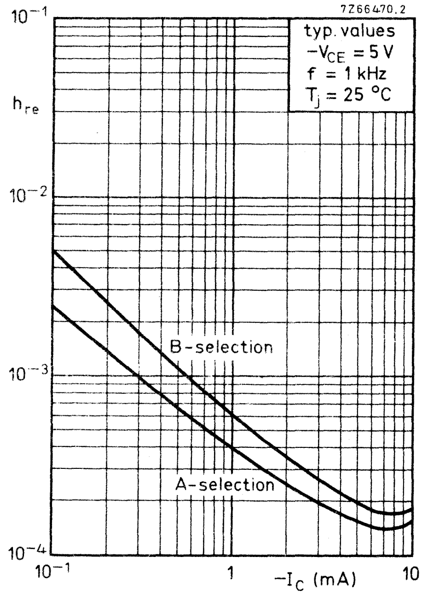

7Z60137.1
B–selection
$-V_{CE}$ = 5 V
T_j = 25 °C
h_{FE}
600
400
200
0
max
typ
min
10^{-2}
10^{-1}
1
10
10^2
$-I_C$ (mA)

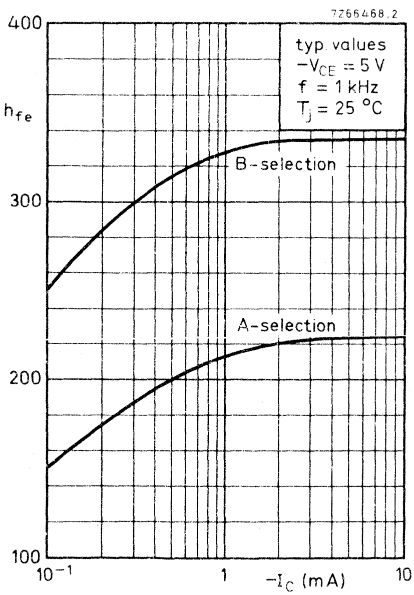

7Z60138.1
1000
typ values
$\frac{-I_C}{-I_B} = 20$
$T_j = 25\ ^oC$
$-V_{BEsat}$
$-V_{CEsat}$
(mV)
$-V_{BEsat}$
500
$-V_{CEsat}$
0
10^{-1}
1
10
10^2
$-I_C$ (mA)

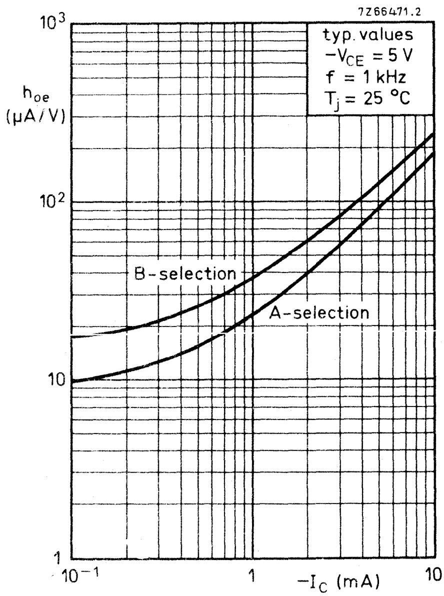

7Z60135
15
C_c
(pF)
f=1MHz
T_j=25°C
10
5
typ
0
0
5
$-V_{CB}$ (V)
10


7Z60133
300
typical behaviour of the transition frequency versus collector current
f_T
(MHz)
$-V_{CE}$=5V
T_j =25°C
200
100
0
0
50
$-I_C$(mA)
100


7Z66469.2
typ. values
$-V_{CE}$ = 5 V
f = 1 kHz
T_j = 25 °C
h_{ie}
(kΩ)
10^2
10
1
10^{-1}
B-selection
A-selection
10^{-1}
1
$-I_C$ (mA)
10


7Z66470.2
typ. values
$-V_{CE}$ = 5 V
f = 1 kHz
T_j = 25 °C
h_{re}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
B-selection
A-selection
10^{-1}
1
$-I_C$ (mA)
10


7Z66468.2
typ. values
$-V_{CE}$ = 5 V
f = 1 kHz
T_j = 25 °C
h_{fe}
400
300
200
100
B-selection
A-selection
10^{-1}
1
$-I_C$ (mA)
10


7Z66471.2
typ. values
$-V_{CE}$ = 5 V
f = 1 kHz
T_j = 25 °C
h_{oe}
(μA/V)
10^3
10^2
10
1
B-selection
A-selection
10^{-1}
1
$-I_C$ (mA)
10

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in a plastic TO-92 variant, primarily intended for low-noise input stages in tape recorders, hi-fi amplifiers and other audio frequency equipment.

QUICK REFERENCE DATA

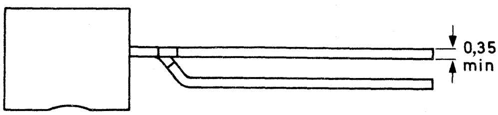
			BC559	BC560	
Collector-emitter voltage ($+V_{BE}$ = 1 V)	$-V_{CEX}$	max.	30	50	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30	45	V
Collector current (peak value)	$-I_{CM}$	max.	200	200	mA
Total power dissipation up to T_{amb} = 25 ^{o}C	P_{tot}	max.	500	500	mW
Junction temperature	T_j	max.	150	150	^{o}C
Small-signal current gain $-I_C$ = 2 mA; $-V_{CE}$ = 5 V; f = 1 kHz	h_{fe}	>	125	125	
		<	500	500	
Transition frequency $-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.	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	1	dB
		<	4	3	dB
f = 1 kHz; B = 200 Hz	F	<	4	4	dB

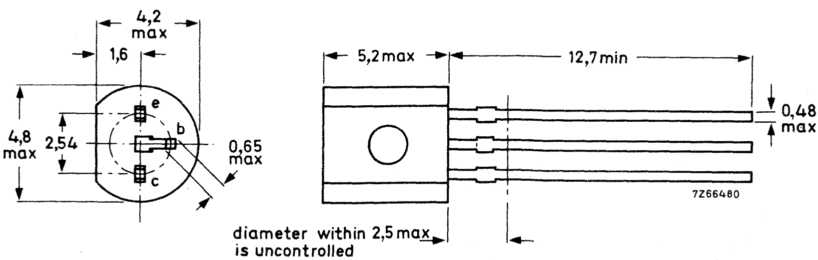
MECHANICAL DATA

Dimensions in mm

TO-92 variant

Accessories:
56356 (cooling clip)





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

Voltages			BC559	BC560	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30	50	V
Collector-emitter voltage ($+V_{BE}$ = 1 V)	$-V_{CEX}$	max.	30	50	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30	45	V
Emitter-base voltage (open collector)	$-V_{CBO}$	max.	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.	500	mW

Temperatures

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

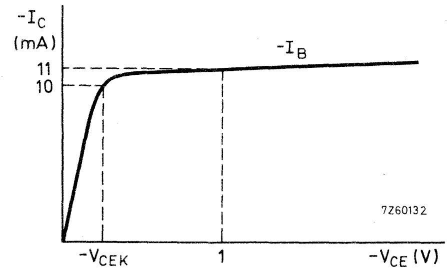
THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0,25	°C/mW
From junction to case	$R_{th\ j-c}$	=	0,15	°C/mW

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current			
$I_E = 0$; $-V_{CB} = 30$ V; T_j = 25 °C	$-I_{CBO}$	typ	1 nA
		$<$	15 nA
T_j = 150 °C	$-I_{CBO}$	$<$	4 μA
Base-emitter voltage *			
$-I_C = 2$ 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 **			
$-I_C = 10$ 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 frequency at f = 35 MHz			
$-I_C = 10$ mA; $-V_{CE} = 5$ V	f_T	typ	150 MHz

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

$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{fe}		125 to 500		

Noise figure at R_S = 2 kΩ

$-I_C$ = 200 μA; $-V_{CE}$ = 5 V

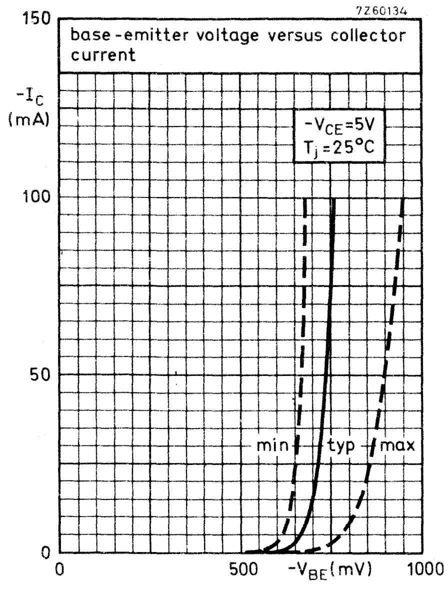
			BC559	BC560	
f = 30 Hz to 15 kHz	F	typ	1,2	1	dB
		<	4	3	dB
f = 1 kHz; B = 200 Hz	F	typ	1	1	dB
		<	4	4	dB

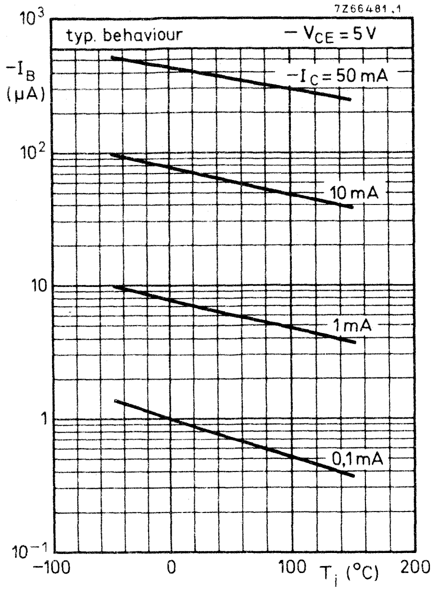
→ **Equivalent noise voltage** at R_S = 2 kΩ

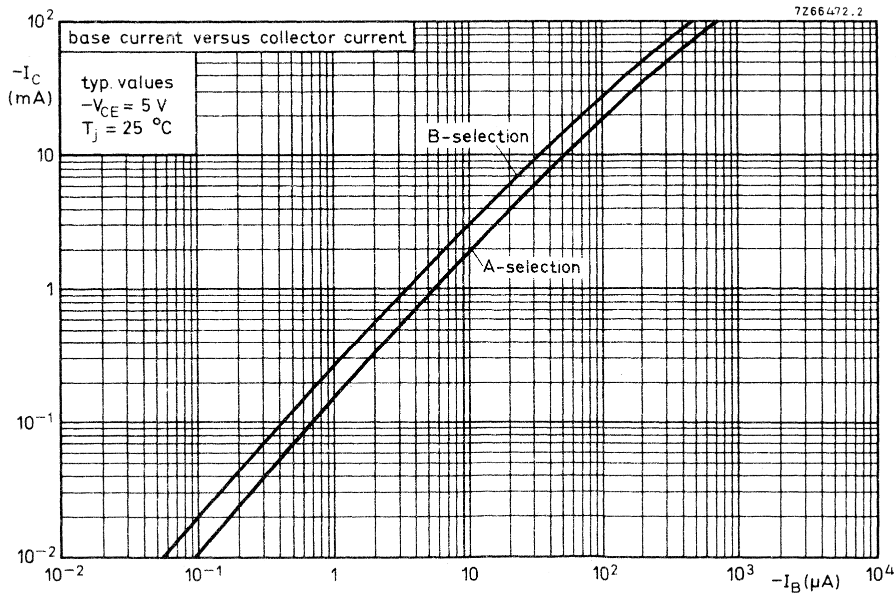
			BC559	BC560	
$-I_C$ = 200 μA; $-V_{CE}$ = 5 V f = 10 Hz to 50 Hz; T_{amb} = 25 °C	V_n	<	–	0,11	μV

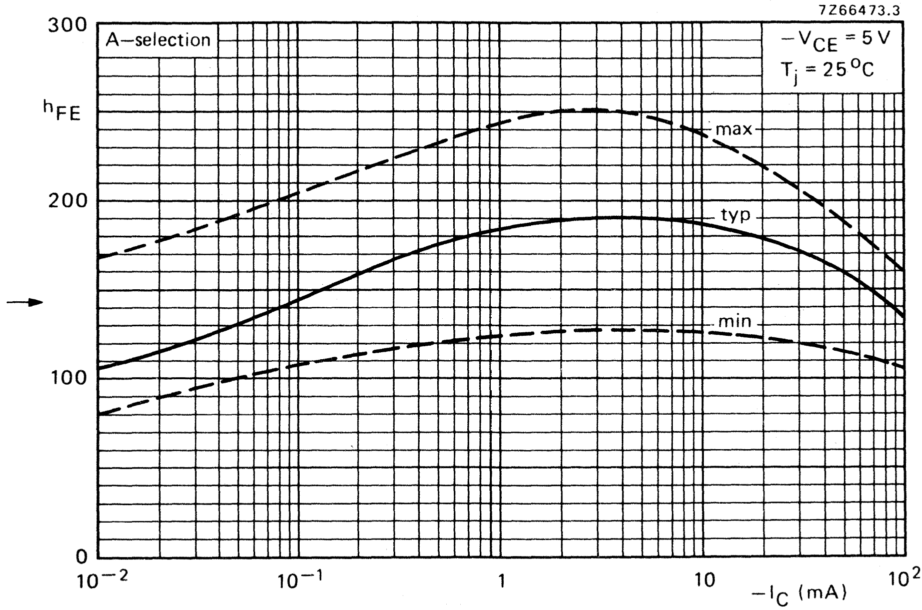
D.C. current gain

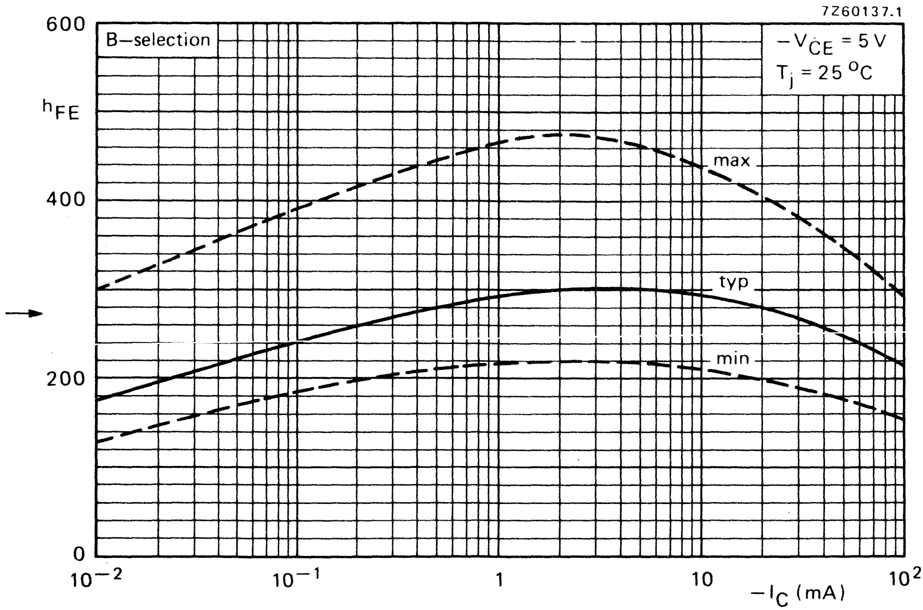
			BC559 BC560	BC559A BC560A	BC559B BC560B
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{FE}	>	125	125	220
		<	475	250	475

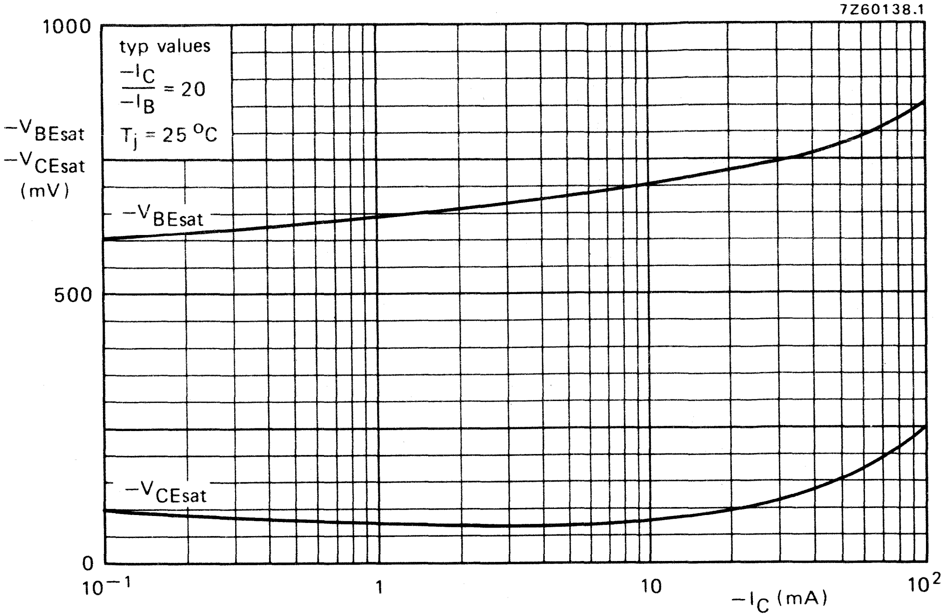

7Z60134
base-emitter voltage versus collector current
$-I_C$ (mA)
150
100
50
0
$-V_{CE}$=5V
T_j=25°C
min
typ
max
0
500
$-V_{BE}$(mV)
1000

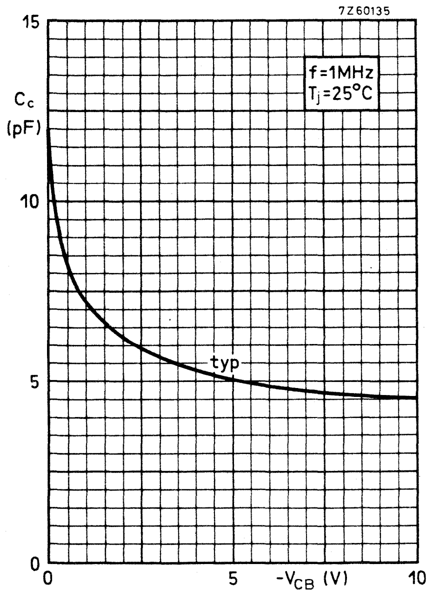

7Z66481.1
typ. behaviour
$-V_{CE}$ = 5 V
$-I_B$ (μA)
10^3
10^2
10
1
10^{-1}
$-I_C$ = 50 mA
10 mA
1 mA
0,1 mA
−100
0
100
200
T_j (°C)

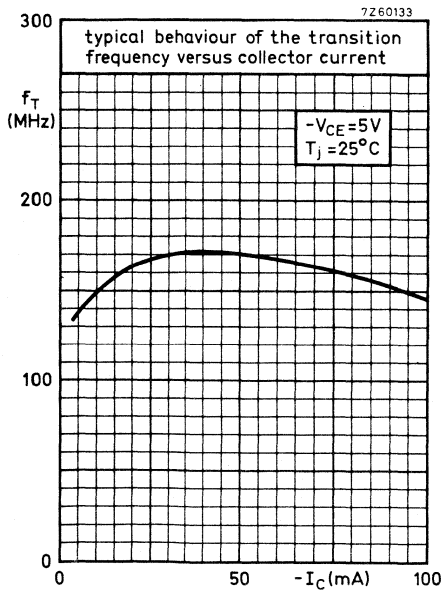

7Z66472.2
base current versus collector current
typ. values
$-V_{CE}$ = 5 V
T_j = 25 °C
$-I_C$ (mA)
10^2
10
1
10^{-1}
10^{-2}
B-selection
A-selection
10^{-2}
10^{-1}
1
10
10^2
10^3
$-I_B$(μA)
10^4

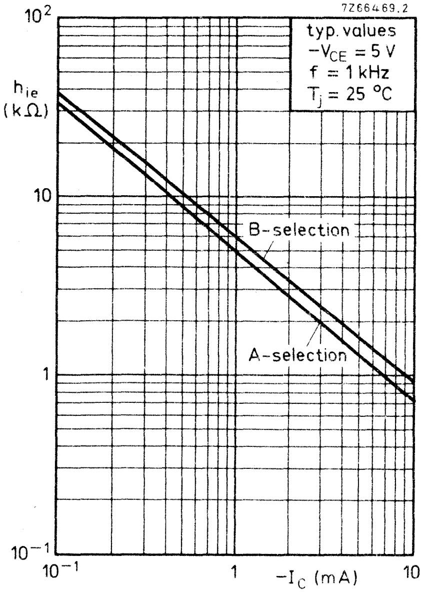

7Z66473.3
A—selection
$-V_{CE} = 5$ V
$T_j = 25\,^oC$
h_{FE}
300
200
100
0
max
typ
min
10^{-2}
10^{-1}
1
10
10^2
$-I_C$ (mA)

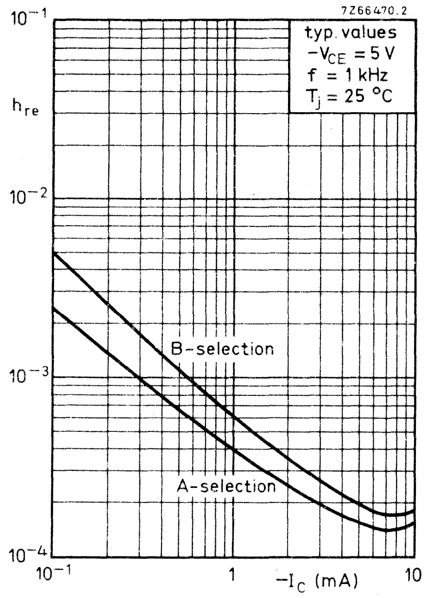

7Z60137.1
B—selection
$-V_{CE} = 5$ V
$T_j = 25\,^oC$
h_{FE}
600
400
200
0
max
typ
min
10^{-2}
10^{-1}
1
10
10^2
$-I_C$ (mA)

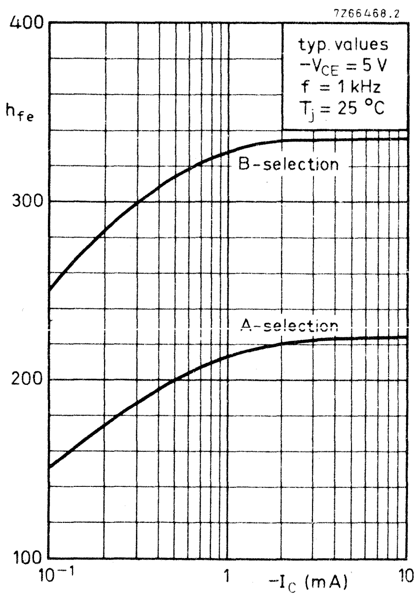

7Z60138.1
typ values
$\frac{-I_C}{-I_B} = 20$
$T_j = 25\ ^oC$
$-V_{BEsat}$
$-V_{CEsat}$
(mV)
1000
500
0
$-V_{BEsat}$
$-V_{CEsat}$
10^{-1}
1
10
10^2
$-I_C$ (mA)

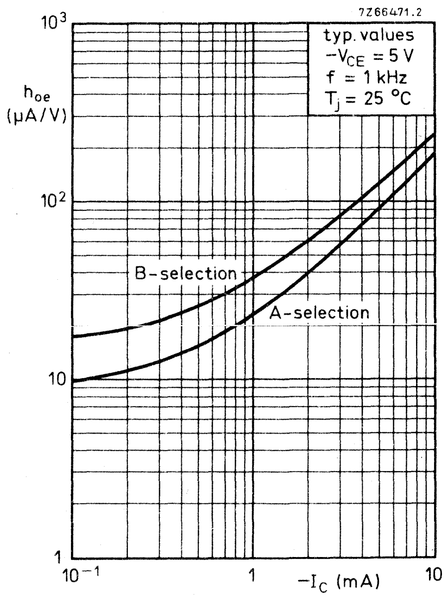

7Z60135
15
10
5
0
C_c
(pF)
f = 1MHz
T_j = 25°C
typ
0
5
$-V_{CB}$ (V)
10


7Z60133
typical behaviour of the transition frequency versus collector current
300
200
100
0
f_T
(MHz)
$-V_{CE}$ = 5V
T_j = 25°C
0
50
$-I_C$(mA)
100

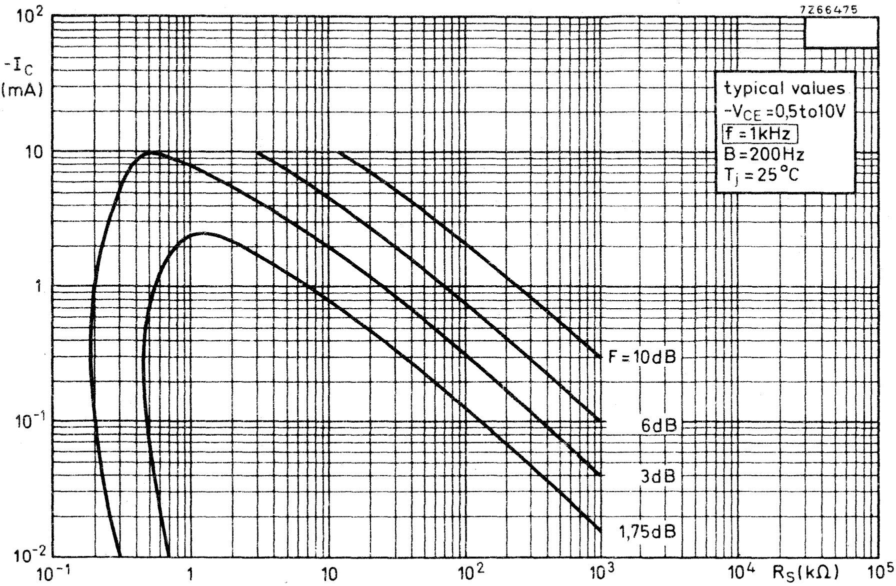

7Z66469.2
typ. values
$-V_{CE} = 5$ V
f = 1 kHz
$T_j = 25$ °C
h_{ie} (kΩ)
B-selection
A-selection
$-I_C$ (mA)
10^2
10
1
10^{-1}
1
10

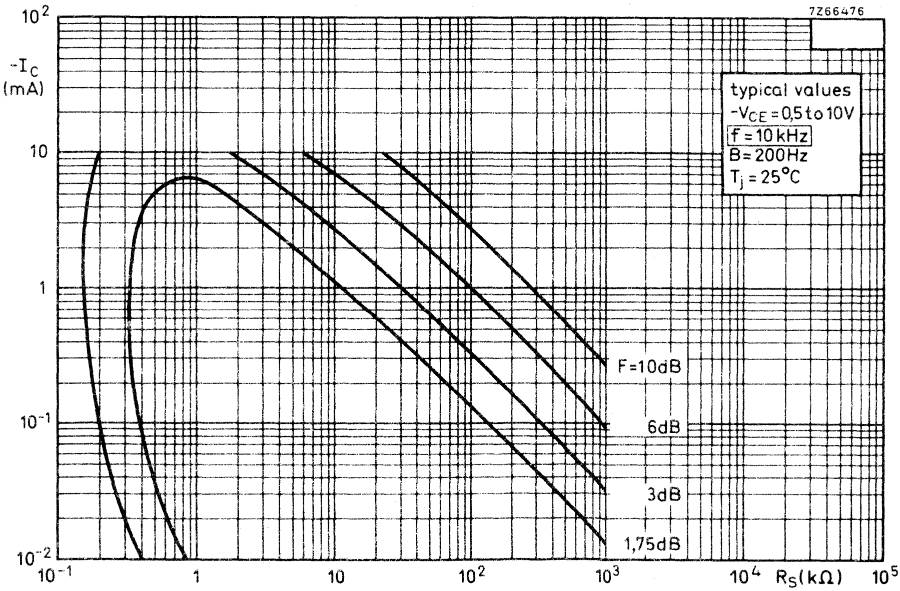

7Z66470.2
typ. values
$-V_{CE} = 5$ V
f = 1 kHz
$T_j = 25$ °C
h_{re}
B-selection
A-selection
$-I_C$ (mA)
10^{-1}
10^{-2}
10^{-3}
10^{-4}
1
10

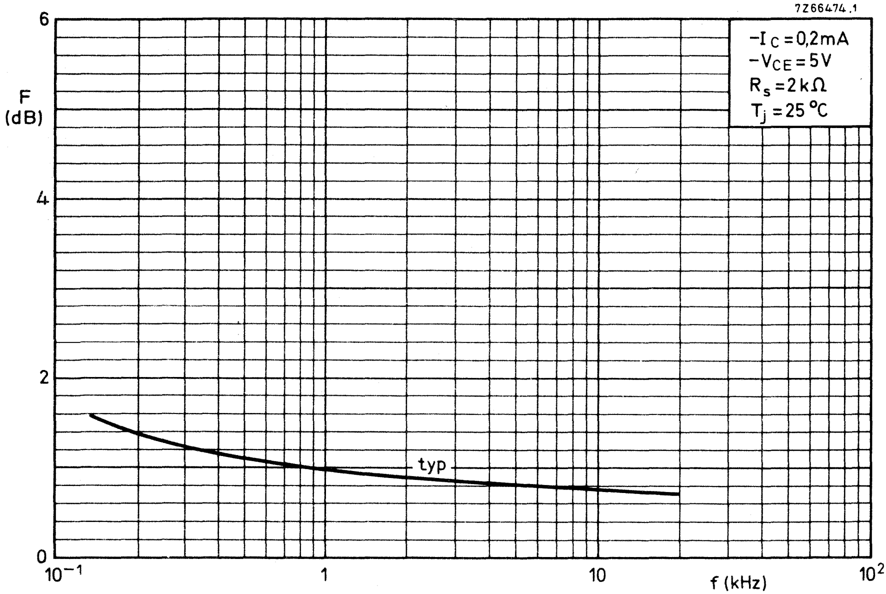

7Z66468.2
typ. values
$-V_{CE} = 5$ V
f = 1 kHz
$T_j = 25$ °C
h_{fe}
B-selection
A-selection
$-I_C$ (mA)
400
300
200
100
10^{-1}
1
10


7Z66471.2
typ. values
$-V_{CE} = 5$ V
f = 1 kHz
$T_j = 25$ °C
h_{oe} (μA/V)
B-selection
A-selection
$-I_C$ (mA)
10^3
10^2
10
1
10^{-1}
1
10

curves of constant noise figure






7Z66474.1
$-I_C = 0{,}2\,mA$
$-V_{CE} = 5\,V$
$R_s = 2\,k\Omega$
$T_j = 25\,^{\circ}C$
F
(dB)
6
4
2
0
typ
10^{-1}
1
10
10^2
f (kHz)

SILICON PLANAR EPITAXIAL TRANSISTORS

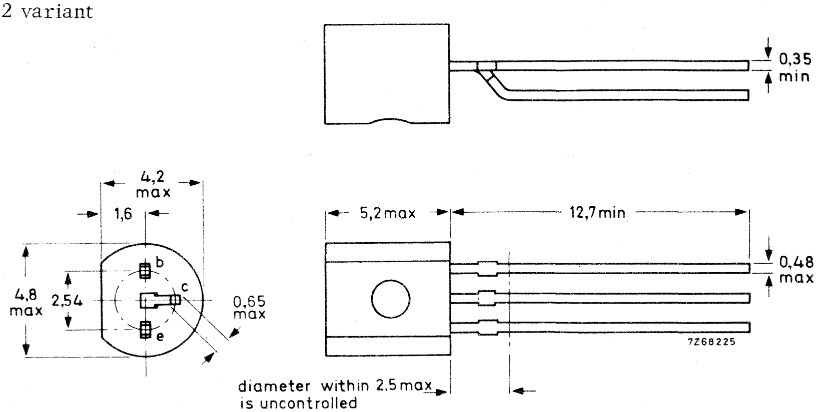
N-P-N transistors in a plastic TO-92 variant, primarily intended for use in driver stages of audio amplifiers. P-N-P complements are BC636, BC638 and BC640.

QUICK REFERENCE DATA

			BC635	BC637	BC639	
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_{amb} = 25 °C	P_{tot}	max.	1	1	1	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 I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	130	130	130	MHz

MECHANICAL DATA Dimensions in mm

TO-92 variant



Accessories: 56356 (cooling clip).

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

Voltages

			BC635	BC637	BC639	
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-emitter voltage (R_{BE} = 0)	V_{CES}	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	A
Collector current (peak value)	I_{CM}	max.	1,5	A
Emitter current (peak value)	$-I_{EM}$	max.	1,5	A
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.	0,8	W
up to T_{amb} = 25 °C	P_{tot}	max.	1	W [1]

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	$R_{th\ j\text{-}a}$	=	156	°C/W
From junction to ambient	$R_{th\ j\text{-}a}$	=	125	°C/W [1]
From junction to case	$R_{th\ j\text{-}c}$	=	60	°C/W

[1]) Transistor mounted on printed circuit board, max. lead length 4 mm, mounting pad for collector lead min. 10 mm x 10 mm.

CHARACTERISTICS

$T_j = 25\ ^{o}C$ 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; $T_j = 150\ ^{o}C$	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

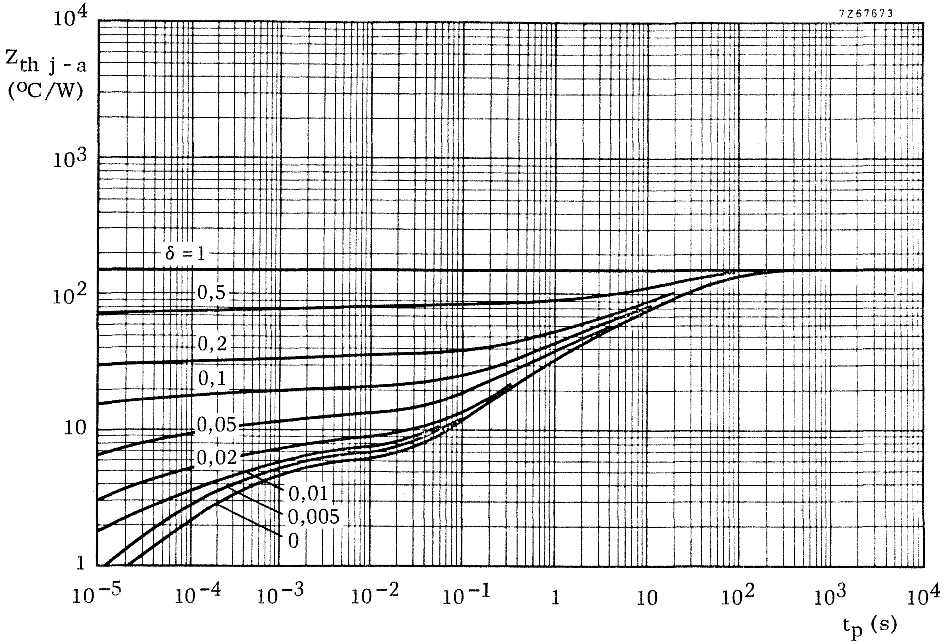
			BC635	BC637	BC639
$I_C = 5$ mA; $V_{CE} = 2$ V	h_{FE}	>	25	25	25
$I_C = 150$ mA; $V_{CE} = 2$ V	h_{FE}	>	40	40	40
		<	250	160	160
$I_C = 500$ mA; $V_{CE} = 2$ V	h_{FE}	>	25	25	25

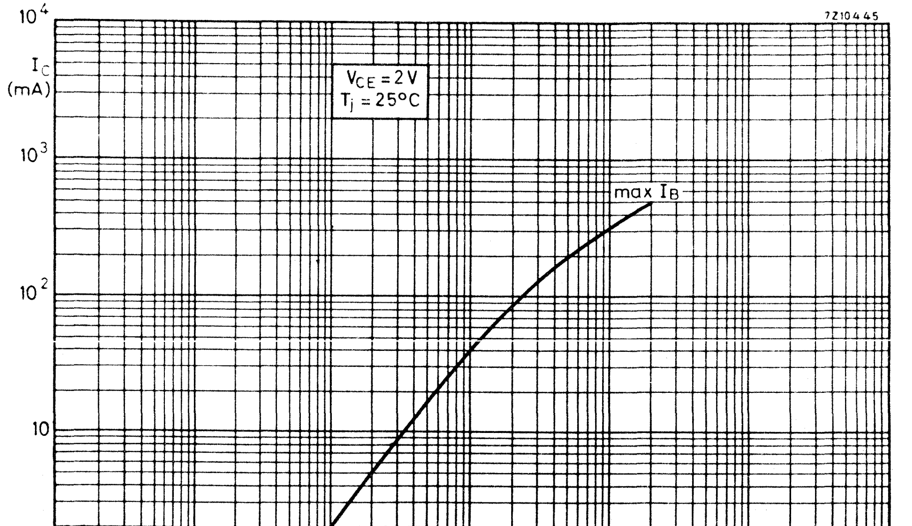
Transition frequency at f = 35 MHz				
$I_C = 10$ mA; $V_{CE} = 5$ V	f_T	typ.	130	MHz

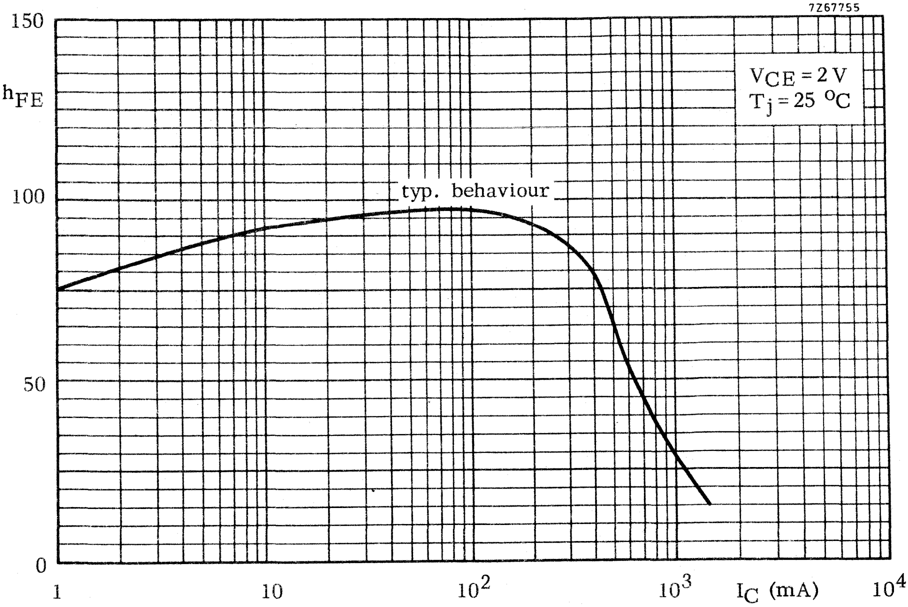
D.C. current gain ratio of matched pairs

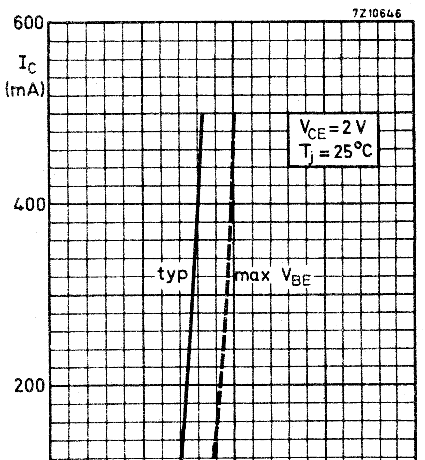
$|I_C| = 150$ mA; $|V_{CE}| = 2$ V

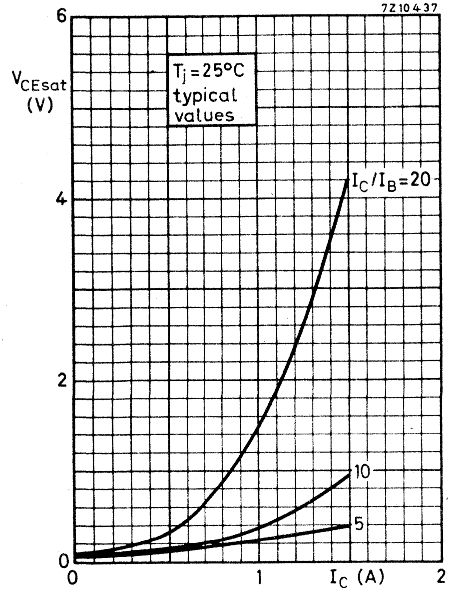
BC635/BC636, BC637/BC638 and BC639/BC640	h_{FE1}/h_{FE2}	typ.	1, 3
		<	1, 6

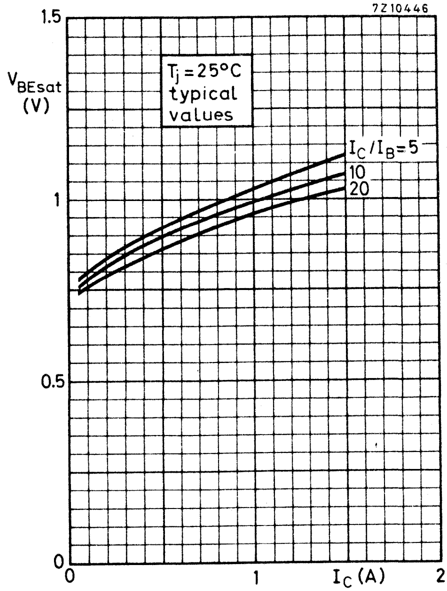

7Z67673
$Z_{th\ j-a}$ (°C/W)
10^4
10^3
10^2
10
1
δ = 1
0,5
0,2
0,1
0,05
0,02
0,01
0,005
0
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3
10^4
t_p (s)

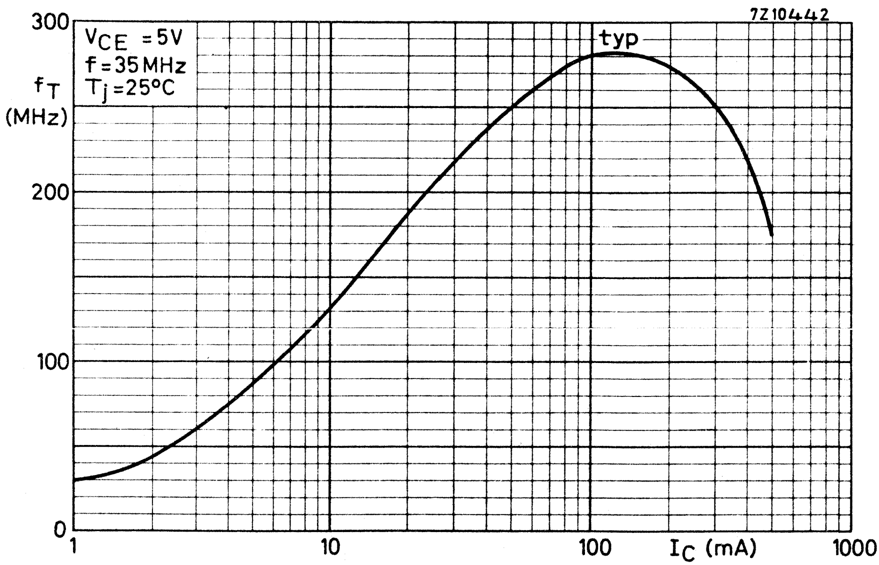

7Z10445
I_C (mA)
10^4
10^3
10^2
10
1
$V_{CE} = 2$ V
$T_j = 25$ °C
max I_B
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
I_B (mA)
10^3


7Z67755
150
h_{FE}
100
50
0
1
10
10^2
10^3
10^4
I_C (mA)
$V_{CE} = 2$ V
$T_j = 25$ °C
typ. behaviour


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


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


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


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

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in a plastic TO-92 variant, primarily intended for use in driver stages of audio amplifiers. N-P-N complements are BC635, BC637 and BC639.

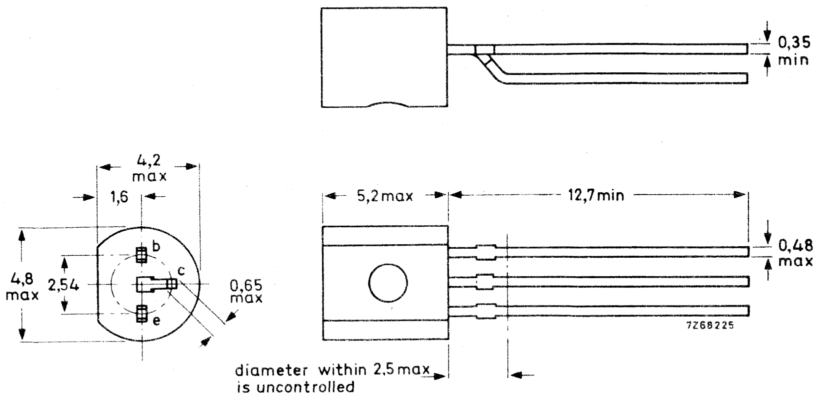
QUICK REFERENCE DATA

			BC636	BC638	BC640	
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_{amb} = 25 °C	P_{tot}	max.	1	1	1	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 $-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.	50	50	50	MHz

MECHANICAL DATA

Dimensions in mm

TO-92 variant



Accessories: 56356 (cooling clip).

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

Voltages			BC636	BC638	BC640	
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-emitter voltage ($-V_{BE}$ = 0)	$-V_{CES}$	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	A
Collector current (peak value)	$-I_{CM}$	max.	1,5	A
Emitter current (peak value)	I_{EM}	max.	1,5	A
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.	0,8	W
up to T_{amb} = 25 °C	P_{tot}	max.	1	W [1]

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	$R_{th\ j-a}$	=	156	°C/W
From junction to ambient	$R_{th\ j-a}$	=	125	°C/W [1]
From junction to case	$R_{th\ j-c}$	=	60	°C/W

[1]) Transistor mounted on printed circuit board, max. lead length 4 mm, mounting pad for collector lead min. 10 mm x 10 mm.

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

Collector cut-off current				
$I_E = 0;\ -V_{CB} = 30\ V$	$-I_{CBO}$	<	100	nA
$I_E = 0;\ -V_{CB} = 30\ V;\ T_j = 150\ ^oC$	$-I_{CBO}$	<	10	μA
Emitter cut-off current				
$I_C = 0;\ -V_{EB} = 5\ V$	$-I_{EBO}$	<	10	μA
Base-emitter voltage				
$-I_C = 500\ mA;\ -V_{CE} = 2\ V$	$-V_{BE}$	<	1	V
Saturation voltage				
$-I_C = 500\ mA;\ -I_B = 50\ mA$	$-V_{CEsat}$	<	0,5	V

D.C. current gain

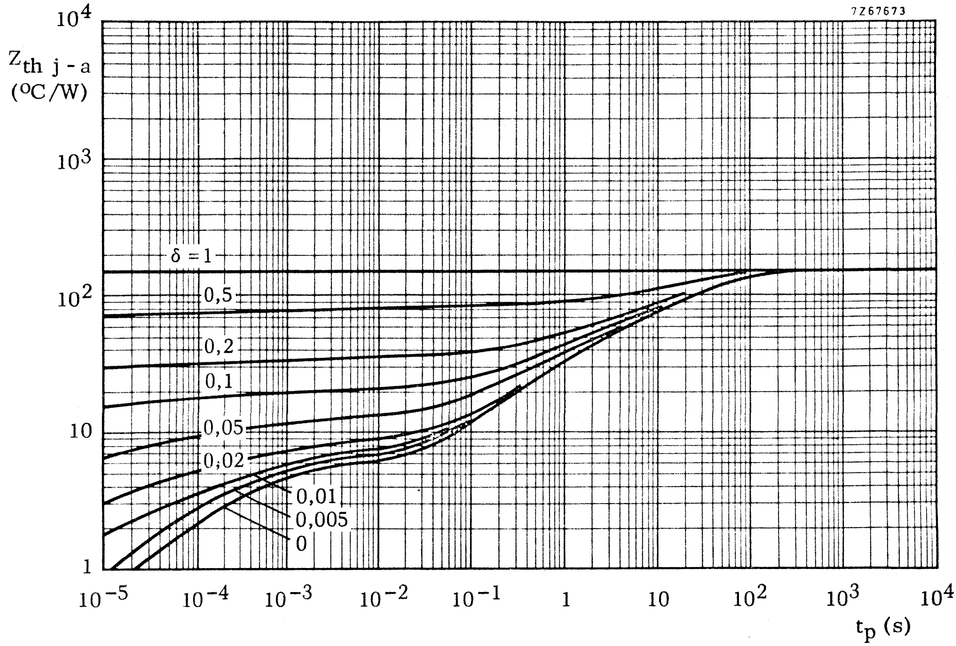
			BC636	BC638	BC640
$-I_C = 5\ mA;\ -V_{CE} = 2\ V$	h_{FE}	>	25	25	25
$-I_C = 150\ mA;\ -V_{CE} = 2\ V$	h_{FE}	>	40	40	40
		<	250	160	160
$-I_C = 500\ mA;\ -V_{CE} = 2\ V$	h_{FE}	>	25	25	25

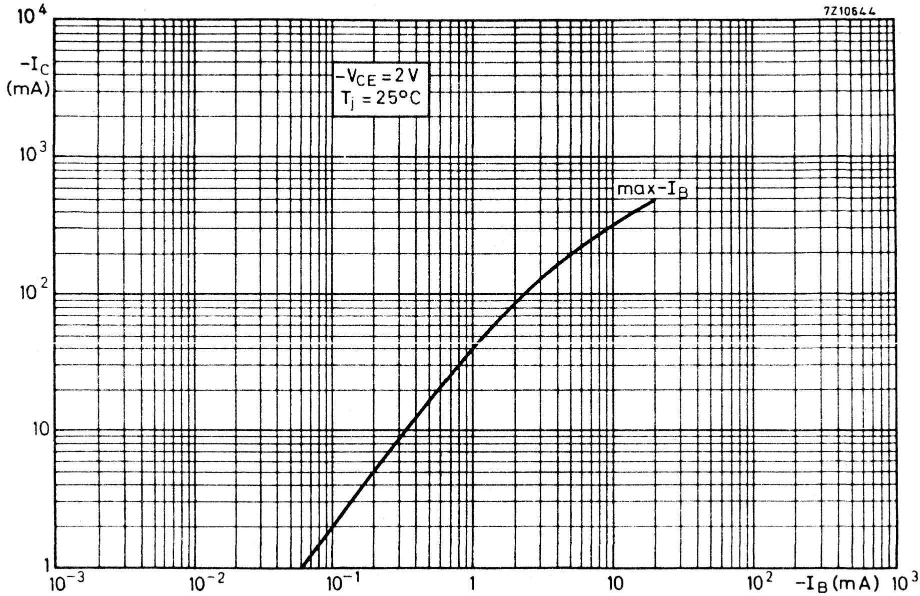
Transition frequency at f = 35 MHz				
$-I_C = 10\ mA;\ -V_{CE} = 5\ V$	f_T	typ.	50	MHz

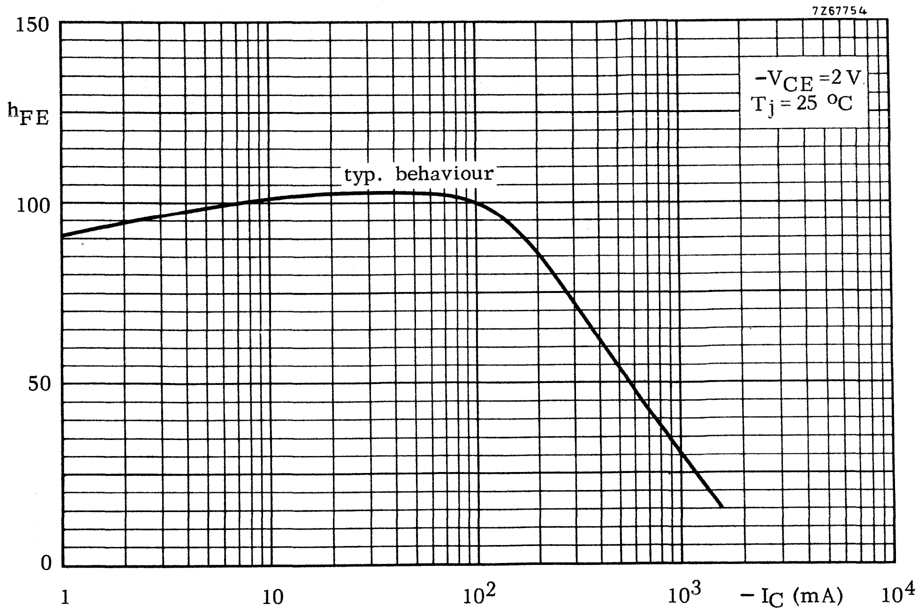
D.C. current gain ratio of matched pairs

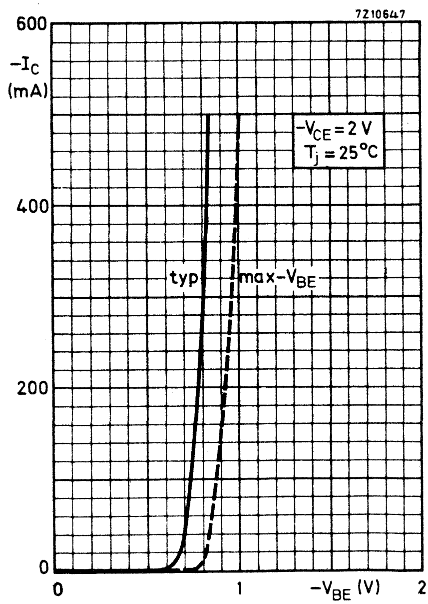
$|I_C| = 150\ mA;\ |V_{CE}| = 2\ V$

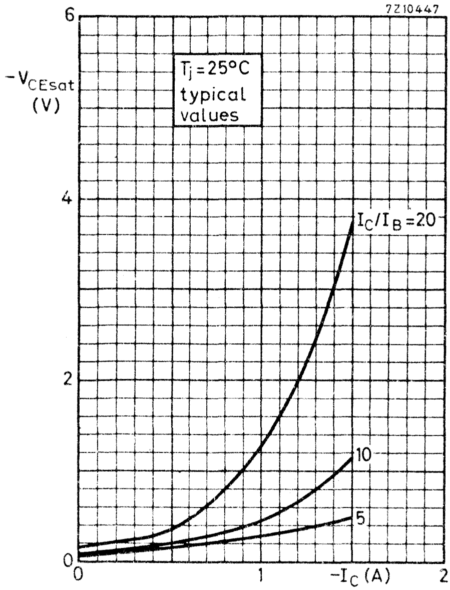
BC635/BC636,
BC637/BC638 and
BC639/BC640 — h_{FE1}/h_{FE2} typ. 1,3; < 1,6

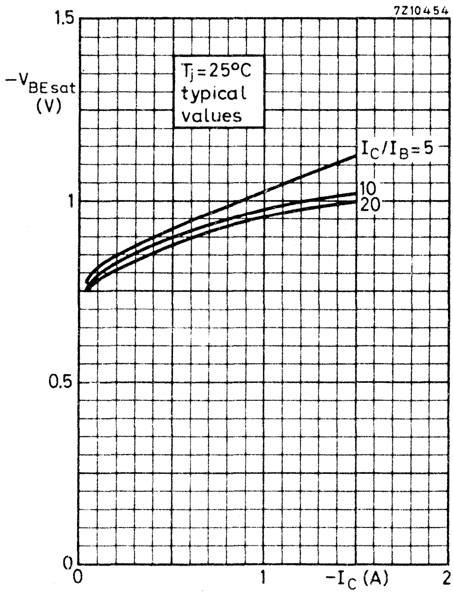

7Z67673
$Z_{th\ j-a}$ (°C/W)
10^4
10^3
10^2
10
1
δ = 1
0,5
0,2
0,1
0,05
0,02
0,01
0,005
0
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3
10^4
t_p (s)

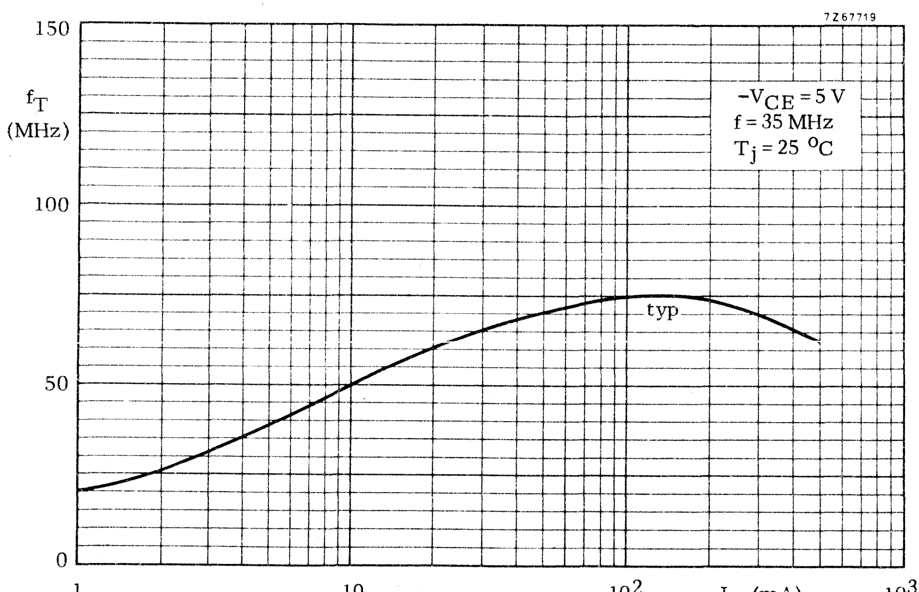

7Z10644
$-I_C$ (mA)
$-V_{CE} = 2$ V
$T_j = 25$ °C
max $-I_B$
10^4
10^3
10^2
10
1
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
$-I_B$ (mA)
10^3


7Z67754
150
100
50
0
hFE
typ. behaviour
−VCE =2 V
Tj = 25 °C
1
10
10²
10³
− IC (mA)
10⁴


7Z10647
600
400
200
0
−IC
(mA)
−VCE = 2 V
Tj = 25°C
typ
max−VBE
0
1
−VBE (V)
2


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


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


7Z67719
f_T (MHz)
$-V_{CE} = 5$ V
f = 35 MHz
$T_j = 25$ °C
typ
$-I_C$ (mA)
0
50
100
150
1
10
10^2
10^3

SILICON TRANSISTORS

P-N-P transistors featuring high emitter-base voltage ratings, intended for use in relay switching, resistor logic circuits and general industrial applications. TO-5 envelope.

QUICK REFERENCE DATA

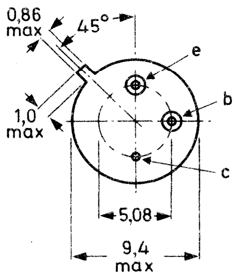
			BCY 30A	BCY 31A	BCY 32A	BCY 33A	BCY 34A	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	64	64	64	32	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	64	64	64	32	32	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	45	45	32	32	32	V
Collector current (peak)	$-I_{CM}$	max.	100	100	100	100	100	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	600	600	600	600	600	mW
Small-signal current gain $-I_C$ = 1 mA; f = 1 kHz	h_{fe}	typ.	25	35	55	25	35	
Transition frequency $-I_C$ = 1 mA; $-V_{CE}$ = 6 V	f_T	typ.	7	7	7	7	7	MHz

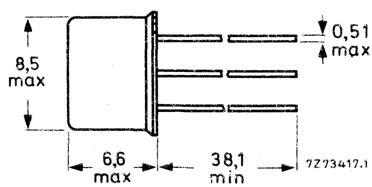
MECHANICAL DATA

Dimensions in mm

TO-5

Collector connected to case





Accessories: 56218 (package); 56245 (distance disc).

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

Voltages			BCY30A BCY31A	BCY32A	BCY33A BCY34A	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	64	64	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	64	64	32	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	45	32	32	V

Currents

Collector current [1]	$-I_{C(AV)}$	max.	50	mA
Collector current (peak value)	$-I_{CM}$	max.	100	mA
Base current [1]	$-I_{B(AV)}$	max.	15	mA
Base current (peak value)	$-I_{BM}$	max.	50	mA
Emitter current [1]	$I_{E(AV)}$	max.	65	mA
Emitter current (peak value)	I_{EM}	max.	100	mA

Power dissipation

Total power dissipation

up to T_{amb} = 25 °C	P_{tot}	max.	600	mW
up to T_{case} = 45 °C	P_{tot}	max.	3	W

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	$R_{th\ j\text{-}a}$	=	0,208	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0,035	°C/mW

[1]) Averaged over any 20 ms period.

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

Collector cut-off current				
$I_E = 0$; $-V_{CB} = 6$ V	$-I_{CBO}$	typ.	1	nA
		<	50	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
		<	50	nA
$I_C = 0$; $-V_{EB} = 6$ V; $T_j = 100$ °C	$-I_{EBO}$	typ.	0, 1	μA
		<	2, 5	μA

			BCY 30A	BCY 31A	BCY 32A	BCY 33A	BCY 34A	
Collector-emitter saturation voltage								
$-I_C = 250$ μA; $-I_B = 50$ μA	$-V_{CE\,sat}$	typ.	55	55	55	55	55	mV
		<	170	170	170	170	170	mV
$-I_C = 20$ mA; $-I_B = 3$ mA	$-V_{CE\,sat}$	typ.	–	130	120	160	130	mV
		<	550	550	550	550	550	mV
Base-emitter voltage								
$-I_C = 20$ mA; $-V_{CE} = 4,5$ V	$-V_{BE}$	typ.	0, 85	0, 80	0, 80	0, 85	0, 80	V
		<	1, 45	1, 45	1, 45	1, 45	1, 45	V
D.C. current gain								
		>	10	15	20	10	15	
$-I_C = 20$ mA; $-V_{CE} = 4,5$ V	h_{FE}	typ.	18	28	35	18	28	
		<	35	60	70	35	60	
Small-signal current gain								
		>	15	25	35	15	25	
$-I_C = 1$ mA; $-V_{CE} = 6$ V; $f = 1$ kHz	h_{fe}	typ.	25	35	55	25	35	
		<	35	60	80	35	60	
Transition frequency								
$-I_C = 1$ mA; $-V_{CE} = 6$ V	f_T	typ.	7	7	7	7	7	MHz
		<	10	15	20	10	15	MHz

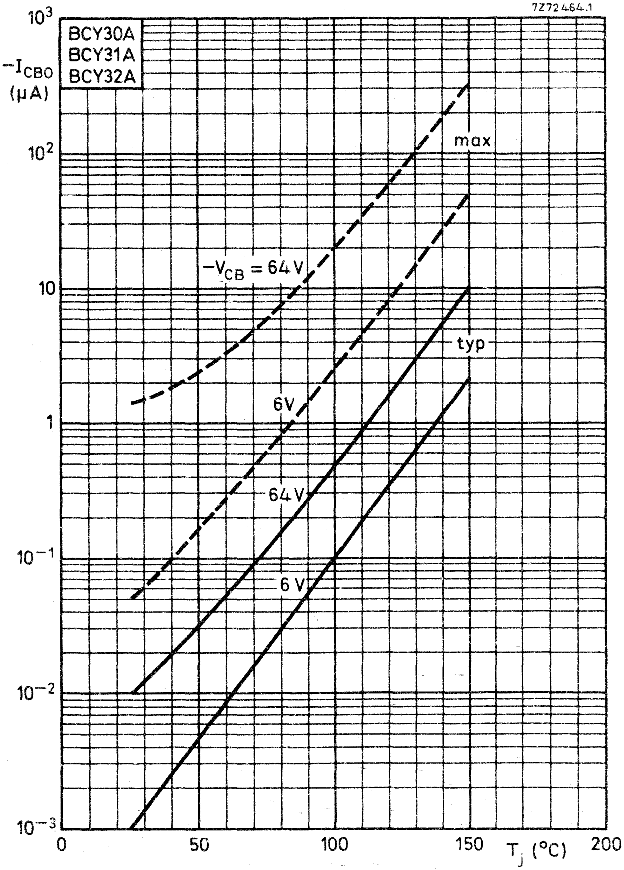
Noise figure at f = 1 kHz				
$I_E = 500$ μA; $-V_{CE} = 2$ V; $R_s = 500\ \Omega$	F	typ.	8	dB
		<	20	dB

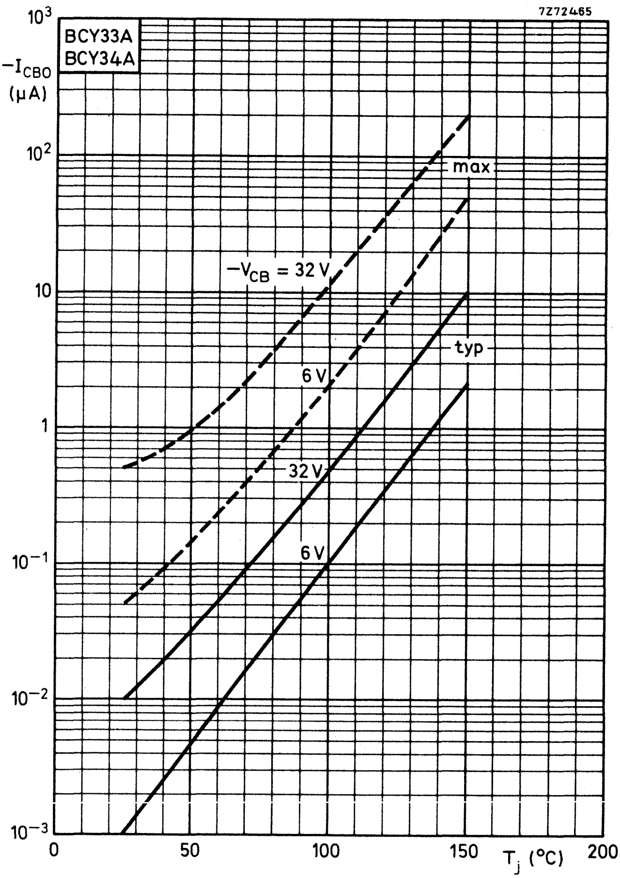
CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

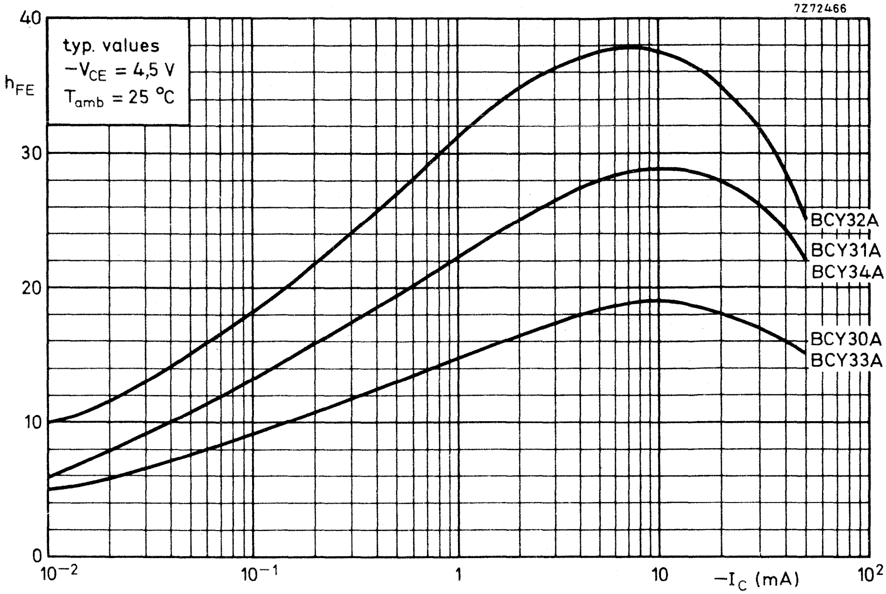
Collector capacitance at f = 500 kHz

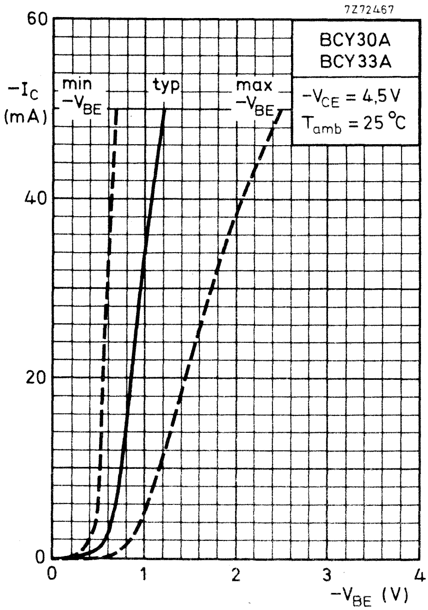
$I_E = I_e = 0$; $-V_{CB}$ = 6 V	C_c	>	15	pF
		typ.	20	pF
		<	60	pF

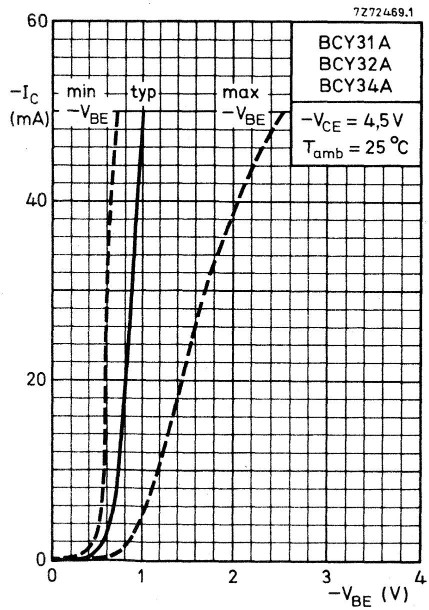
			BCY 30A	BCY 31A	BCY 32A	BCY 33A	BCY 34A	
Base resistance								
$-I_C$ = 1 mA; $-V_{CE}$ = 6 V; f = 500 kHz	$r_{bb'}$	>	80	100	110	60	50	Ω
		typ.	160	220	230	190	235	Ω
		<	500	500	500	500	500	Ω
h- parameters (common emitter)								
$-I_C$ = 1 mA; $-V_{CE}$ = 6 V; f = 1600 Hz								
Input impedance	h_{ie}	typ.	1,1	1,4	1,7	1,1	1,4	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	3	6	5	3	6	$x10^{-4}$
Output admittance	h_{oe}	typ.	17	25	30	17	25	μA/V

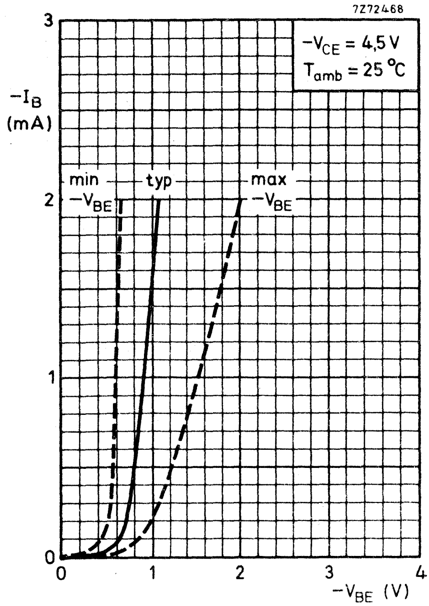

7Z72464.1
BCY30A
BCY31A
BCY32A
$-I_{CBO}$ (μA)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
max
typ
$-V_{CB}$ = 64 V
6V
64 V
6 V
0
50
100
150
200
T_j (°C)

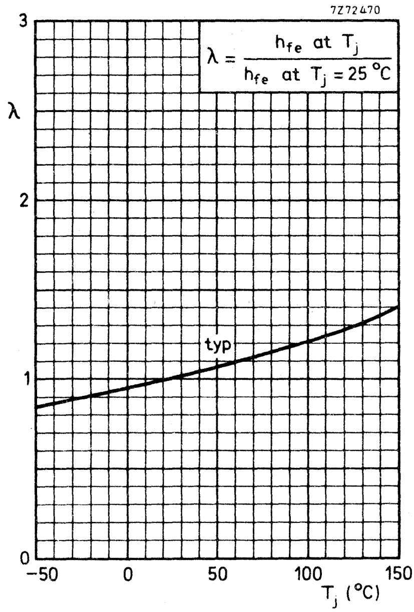

7Z72465
BCY33A
BCY34A
$-I_{CBO}$
(μA)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
max
$-V_{CB}$ = 32 V
6 V
typ
32 V
6 V
0
50
100
150
200
T_j (°C)


7Z72466
typ. values
$-V_{CE}$ = 4,5 V
T_{amb} = 25 °C
h_{FE}
BCY32A
BCY31A
BCY34A
BCY30A
BCY33A
$-I_C$ (mA)
40
30
20
10
0
10^{-2}
10^{-1}
1
10
10^2


7Z72467
BCY30A
BCY33A
$-V_{CE}$ = 4,5 V
T_{amb} = 25 °C
$-I_C$ (mA)
min $-V_{BE}$
typ
max $-V_{BE}$
60
40
20
0
0
1
2
3
4
$-V_{BE}$ (V)


7Z72469.1
BCY31A
BCY32A
BCY34A
$-V_{CE}$ = 4,5 V
T_{amb} = 25 °C
$-I_C$ (mA)
min $-V_{BE}$
typ
max $-V_{BE}$
60
40
20
0
0
1
2
3
4
$-V_{BE}$ (V)


7Z72468
$-V_{CE}$ = 4,5 V
T_{amb} = 25 °C
$-I_B$ (mA)
min $-V_{BE}$
typ
max $-V_{BE}$
$-V_{BE}$ (V)
0
1
2
3
4


7Z72470
$\lambda = \frac{h_{fe} \text{ at } T_j}{h_{fe} \text{ at } T_j = 25\,°C}$
λ
typ
−50
0
50
100
150
T_j (°C)

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

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

QUICK REFERENCE DATA

Equivalent differential voltage change referred to the input at T_{amb} = −20 °C to +90 °C

$|I_{1E} + I_{2E}| \leq 200\ \mu A$

$V_{1C-1E} = V_{2C-2E} \leq 20\ V$

$|V_{1B-1E} - V_{2B-2E}| \leq 100\ \mu V$

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

Equivalent differential current change referred to the input at T_{amb} = −20 °C to +90 °C

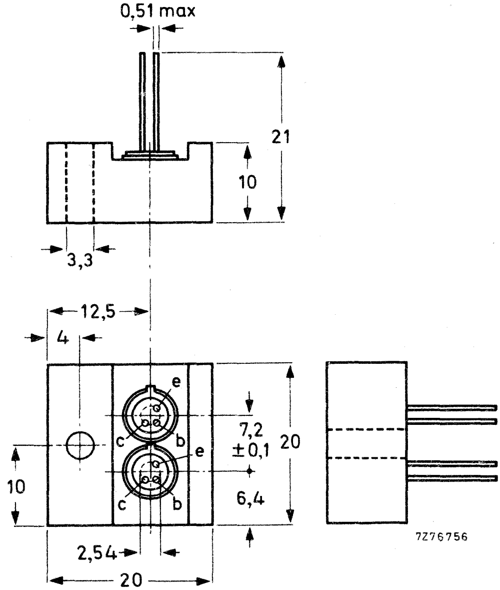
$I_{1C} + I_{2C} = 100\ \mu A$

$\left|\frac{\Delta I}{\Delta T}\right|$ typ 0,5 nA/°C; < 1,5 nA/°C

MECHANICAL DATA

Dimensions in mm

SOT-41



FOR NEW DESIGN THE SUCCESSOR TYPE BCY87 IS RECOMMENDED

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

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

CHARACTERISTICS of the complete device

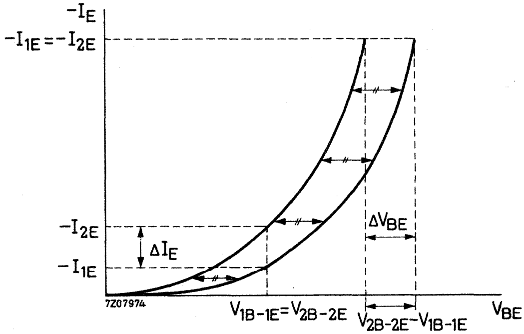
Ratio of collector currents

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

Difference of base-emitter voltages

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

Illustration of matching characteristics:



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

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

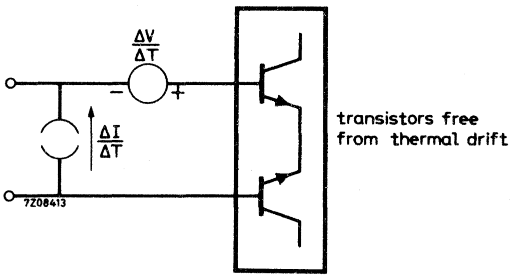
ΔV_{BE} measured at $\frac{I_{2E}}{I_{1E}} = 1$

CHARACTERISTICS of the complete device (continued)

Equivalent circuit for drift

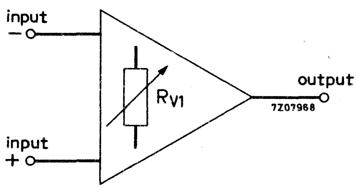
In the equivalent circuit the transistors are considered to be drift free.
All temperature coefficients are concentrated in the voltage source $\frac{\Delta V}{\Delta T}$ and in the current source $\frac{\Delta I}{\Delta T}$.

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



Block symbol of test amplifier

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



CHARACTERISTICS of the complete device (continued)

Equivalent differential voltage change with temperature referred to the input.

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

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

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

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

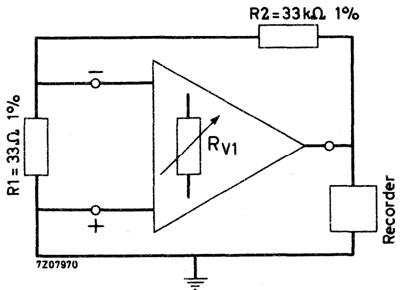
Equivalent differential current change with temperature referred to the input.

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

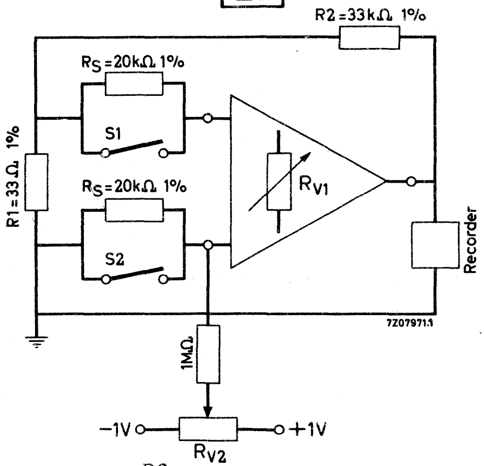
$\frac{\Delta I}{\Delta T}$	typ.	0.5	nA/°C
	<	1.5	nA/°C

Test methods

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



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



NOTE
To prevent contact potentials, connections should be soldered.

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

Output voltage against time is recorded.

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

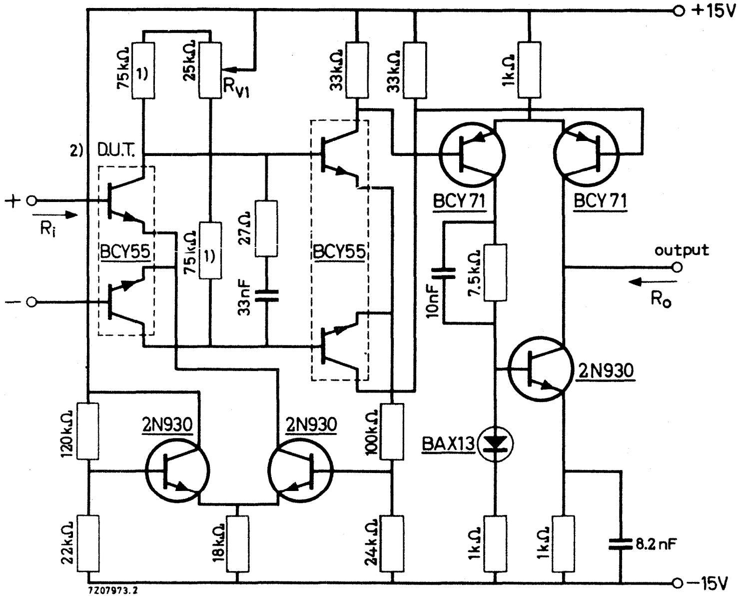
Then: $\frac{\Delta V}{\Delta T} = \frac{V_{T2} - V_{T1}}{T_2 - T_1} \cdot \frac{R1}{R2}$ or $\frac{\Delta I}{\Delta T} = \frac{V_{T2} - V_{T1}}{T_2 - T_1} \cdot \frac{R1}{R2} \cdot \frac{1}{2R_S}$

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

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

Differential test-amplifier

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

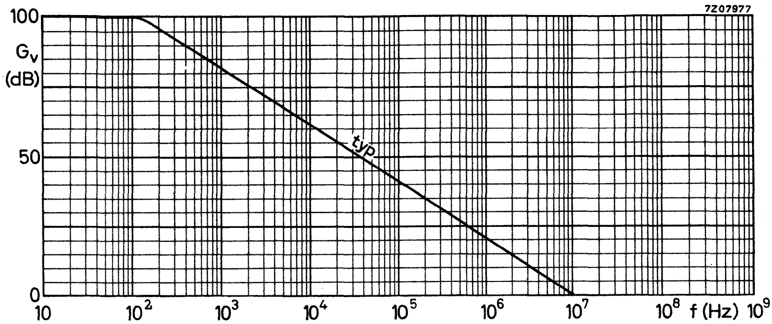


1) Relative temperature coefficient < $10^{-5}/^oC$

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

Performance of the test amplifier

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



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

Voltages				
Collector-base voltage (open emitter)	V_{CBO}	max.	45	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	V
Collector-emitter voltage with $V_{BE} = 0$	V_{CES}	max.	45	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V
Currents				
Collector currents (d.c. or average over any 50 ms period)	I_C	max.	30	mA
Collector current (peak value)	I_{CM}	max.	60	mA
Power dissipation				
Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	300	mW
Temperatures				
Storage temperature	T_{stg}	-50 to +125		^oC
Junction temperature	T_j	max.	125	^oC

THERMAL RESISTANCE

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

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

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

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in TO-18 metal envelopes 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

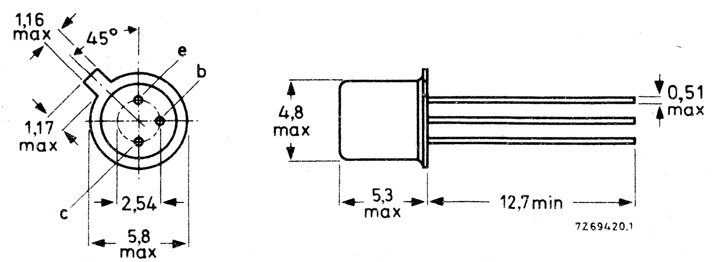
			BCY56	BCY57	
Collector-base voltage (open emitter)	V_{CBO}	max	45	25	V
Collector-emitter voltage (open base)	V_{CEO}	max	45	20	V
Collector current (d.c.)	I_C	max	100	100	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max	300	300	mW
Junction temperature	T_j	max	175	175	°C
D.C. current gain at 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	200	
		<	450	800	
Transition frequency					
I_C = 0,5 mA; V_{CE} = 5 V	f_T	typ	85	100	MHz
Noise figure at R_S = 2 kΩ					
I_C = 200 μA; V_{CE} = 5 V		typ	1,5	1,5	dB
f = 30 Hz to 15,7 kHz	F	<	5,0	5,0	dB

MECHANICAL DATA

Dimensions in mm

TO-18

Collector connected to case



Accessories: 56246 (distance disc); 56263 (cooling fin).

RATINGS (Limiting values) [1])

Voltages

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

Currents

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

Power dissipation

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

Temperatures

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

THERMAL RESISTANCE

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

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

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

Emitter cut-off current

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

Base-emitter voltage [2])

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

Collector-emitter saturation voltage

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

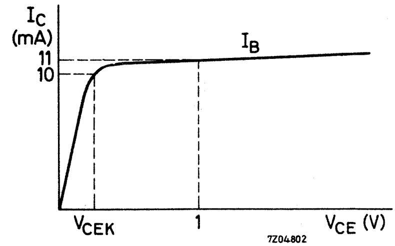
[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

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

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

Knee voltage

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



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

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in TO-18 metal envelopes 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 (d.c.)	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	VIII VIII	IX IX	X X
Small-signal current gain at T_j = 25 °C I_C = 2 mA; V_{CE} = 5 V; f = 1 kHz	h_{fe}	>	125	175	250	350
		<	250	350	500	700

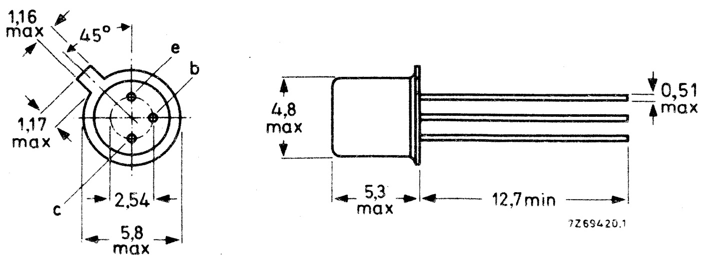
Transition frequency at f = 100 MHz I_C = 10 mA; V_{CE} = 5 V	f_T	typ	280	MHz
Noise figure at R_S = 2 kΩ I_C = 200 μA; V_{CE} = 5 V f = 1 kHz; B = 200 Hz	F	typ	2	dB

MECHANICAL DATA

Dimensions in mm

TO-18

Collector connected to case



Accessories: 56246 (distance disc); 56263 (cooling fin).

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

Voltages			BCY58	BCY59	
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 °C	P_{tot}	max.	1000	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	$R_{th\ j-a}$	=	0.45	°C/mW
From junction to case	$R_{th\ j-c}$	=	0.15	°C/mW

CHARACTERISTICS $T_j = 25\,^{\circ}C$ unless otherwise specified

	Symbol		BCY58	BCY59	Unit
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; $V_{BE} = 0$; $T_j = 150\,^{\circ}C$	I_{CES}	typ.	0.2		μA
		<	10		μA
$V_{CE} = 45$ V; $V_{BE} = 0$; $T_j = 150\,^{\circ}C$	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

	Symbol		Value	Unit
Base emitter voltage				
$I_C = 10\ \mu A$; $V_{CE} = 5$ V	V_{BE}	typ.	0.5	V
$I_C = 20\ \mu A$; $V_{CE} = V_{CEO\,max}$; $T_j = 100\,^{\circ}C$	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) $T_j = 25\,^{o}C$ 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

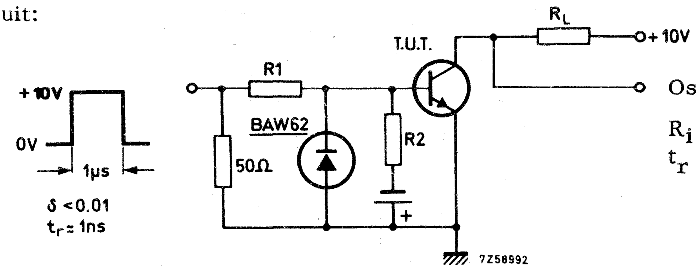
I_C = 10 mA; I_B = 1 mA; $-I_{BM}$ = 1 mA
R1 = 5 kΩ; R2 = 5 kΩ; R_L = 990 Ω
V_{BB} = 3.6 V

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

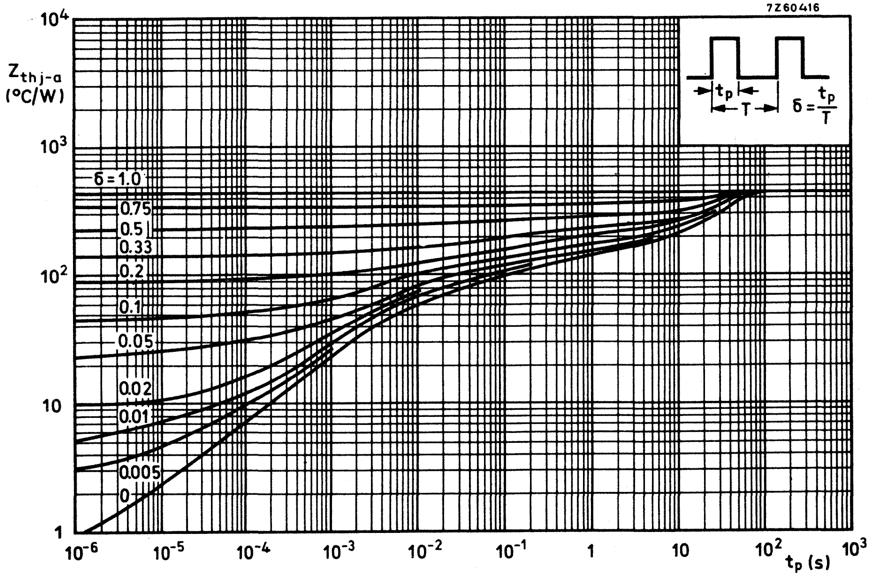
I_C = 100 mA; I_B = 10 mA; $-I_{BM}$ = 10 mA
R1 = 500 Ω; R2 = 700 Ω; R_L = 98 Ω
V_{BB} = 5 V

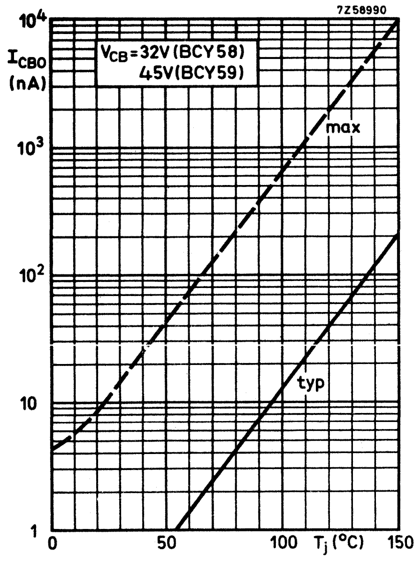
delay time	t_d	typ.	5	ns
rise time	t_r	typ.	50	ns
turn on time	t_{on}	typ.	55	ns
		<	150	ns
storage time	t_s	typ.	250	ns
fall time	t_f	typ.	200	ns
turn off time	t_{off}	typ.	450	ns
		<	800	ns

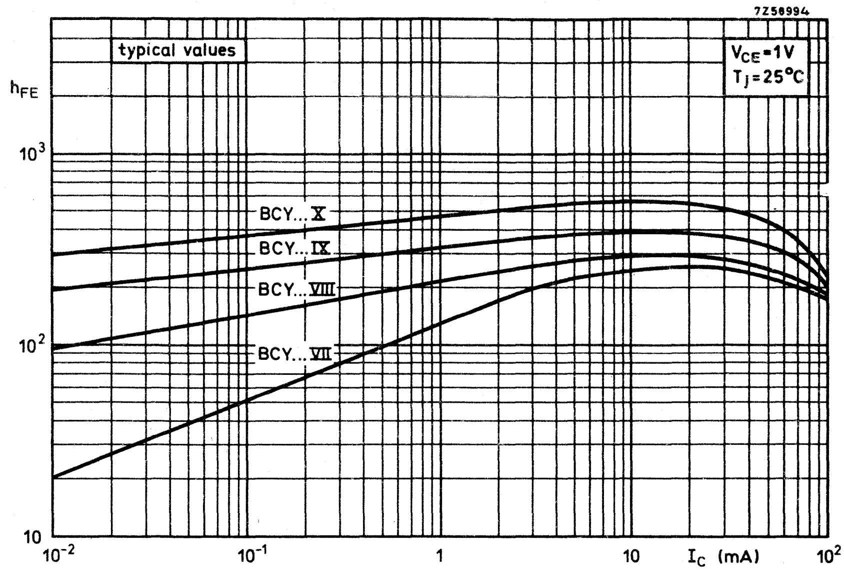
Test circuit:

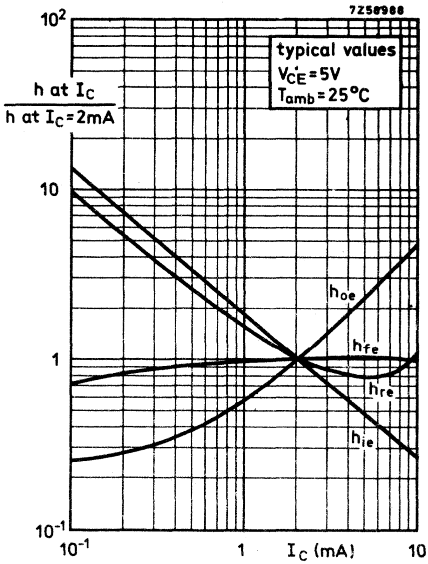


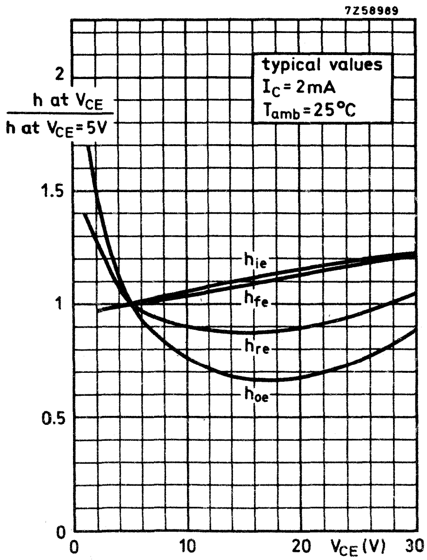
Oscilloscope:
R_i > 100 kΩ
t_r < 15 ns

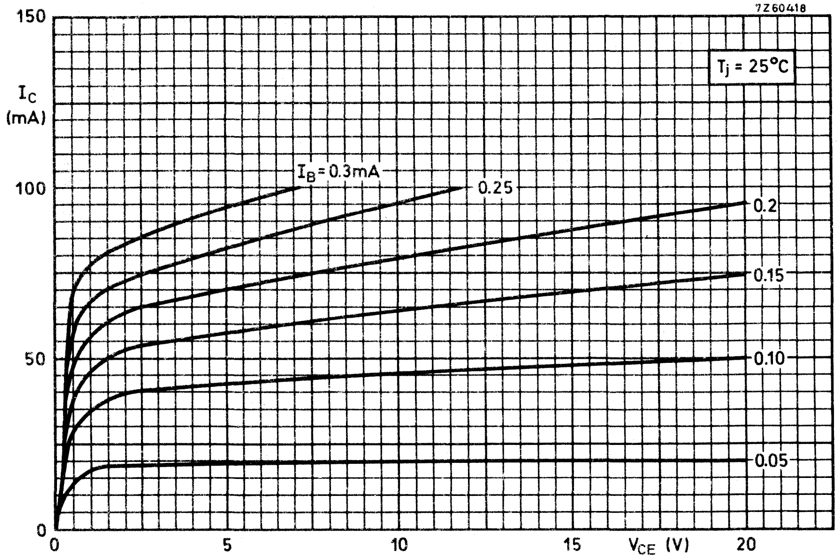

7Z60416
$Z_{th\,j-a}$ (°C/W)
δ = 1.0
0.75
0.5
0.33
0.2
0.1
0.05
0.02
0.01
0.005
0
t_p
T
$\delta = \frac{t_p}{T}$
t_p (s)
10^4
10^3
10^2
10
1
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3

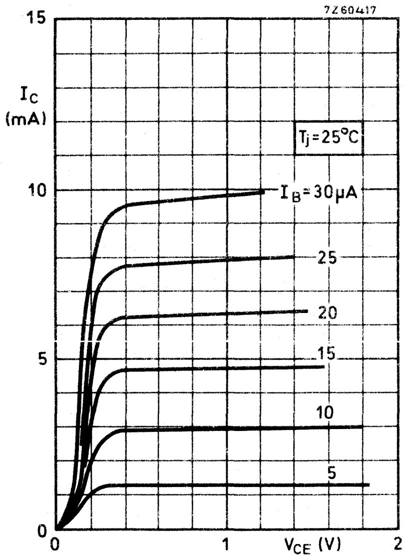

7Z58990
I_{CBO} (nA)
V_{CB} = 32V (BCY58)
45V (BCY59)
max
typ
10^4
10^3
10^2
10
1
0
50
100
T_j (°C)
150

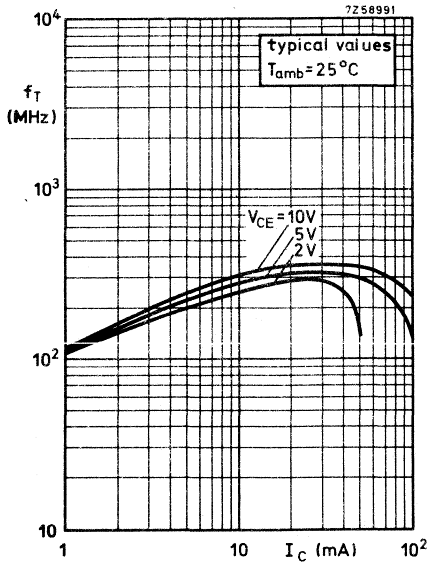

7Z58994
typical values
V_CE = 1V
T_j = 25°C
h_FE
10^3
10^2
10
BCY... X
BCY... IX
BCY... VIII
BCY... VII
10^-2
10^-1
1
10
I_C (mA)
10^2

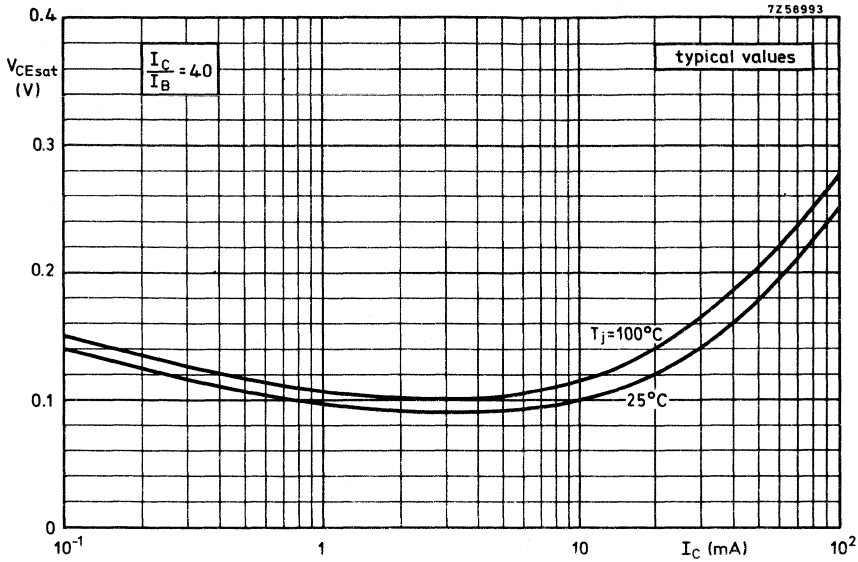

7Z58988
10^2
typical values
V_CE = 5V
T_amb = 25°C
h at I_C
h at I_C = 2mA
10
1
10^-1
h_oe
h_fe
h_re
h_ie
10^-1
1
I_C (mA)
10

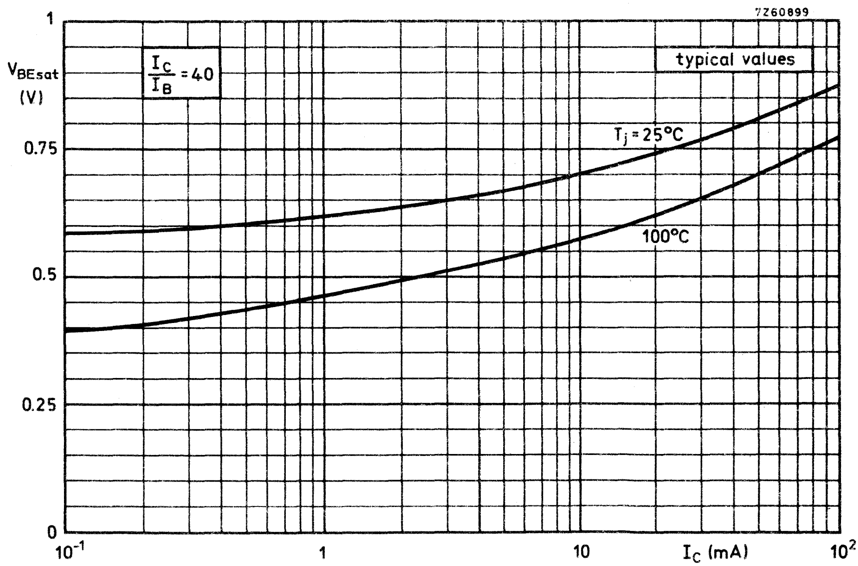

7Z58989
typical values
I_C = 2mA
T_amb = 25°C
h at V_CE
h at V_CE = 5V
2
1.5
1
0.5
0
h_ie
h_fe
h_re
h_oe
0
10
20
V_CE (V)
30


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


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


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


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


7Z60899
1
V_{BEsat}
(V)
$\frac{I_C}{I_B} = 40$
typical values
0.75
$T_j = 25°C$
100°C
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 TO-18 metal envelopes intended for general purpose industrial applications. The BCY71 is a low noise version.

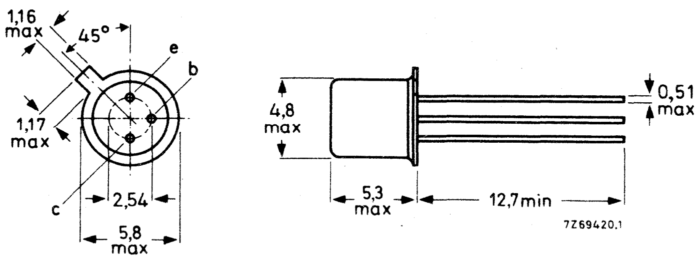
QUICK REFERENCE DATA

			BCY70	BCY71	BCY72	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	50	45	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	45	25	V
Collector current (peak value)	$-I_{CM}$	max.		200		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.		350		mW
Junction temperature	T_j	max.		200		°C
D.C. current gain $-I_C$ = 10 mA; $-V_{CE}$ = 1 V	h_{FE}	>		100		
Transition frequency at f = 100 MHz $-I_C$ = 10 mA; $-V_{CE}$ = 20 V	f_T	>		250		MHz

MECHANICAL DATA Dimensions in mm

TO-18

Collector connected to case



Accessories: 56246 (distance disc); 56263 (cooling fin).

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	30	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

Currents				
Collector current (d.c.)	$-I_C$	max.	200	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.	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	
$I_E = 0;\ -V_{CB} = -V_{CBO\,max}$	$-I_{CBO}$	typ.	10	10	10	nA
		<	500	500	500	nA
$I_E = 0;\ -V_{CB} = 40$ V	$-I_{CBO}$	typ.	0,5	0,5	−	nA
		<	10	50	−	nA
$I_E = 0;\ -V_{CB} = 40$ V; $T_j = 100$ °C	$-I_{CBO}$	typ.	0,1	0,1	−	μA
		<	0,5	2,0	−	μA
$I_E = 0;\ -V_{CB} = 25$ V	$-I_{CBO}$	typ.	−	−	0,5	nA
		<	−	−	50	nA
$I_E = 0;\ -V_{CB} = 25$ V; $T_j = 100$ °C	$-I_{CBO}$	typ.	−	−	0,1	μA
		<	−	−	2,0	μA
$-V_{CE} = 50$ V; $-V_{EB} = 3{,}0$ V	$-I_{CEX}$	typ.	1,0	−	−	nA
		<	20	−	−	nA

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

Emitter cut-off current

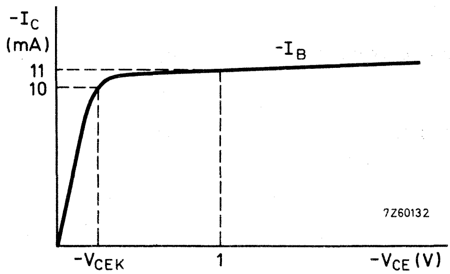
I_C = 0; $-V_{EB}$ = 4,0 V	$-I_{EBO}$	typ. <	0,3 10	nA nA
I_C = 0; $-V_{EB}$ = 4,0 V; T_j = 100 °C	$-I_{EBO}$	typ. <	20 2,0	nA μA
I_C = 0; $-V_{EB}$ = 5,0 V	$-I_{EBO}$	typ. <	5,0 500	nA nA

Saturation voltages

$-I_C$ = 10 mA; $-I_B$ = 1,0 mA	$-V_{CEsat}$	typ. <	95 250	mV mV
	$-V_{BEsat}$	typ. 600 to	750 900	mV mV
$-I_C$ = 50 mA; $-I_B$ = 5,0 mA	$-V_{CEsat}$	typ. <	190 500	mV mV
	$-V_{BEsat}$	typ. <	860 1200	mV mV

Knee voltage

$-I_C$ = 10 mA; $-I_B$ = value for which $-I_C$ = 11 mA at $-V_{CE}$ = 1 V	$-V_{CEK}$	typ. <	270 600	mV mV



D.C. current gain

$-I_C$ = 10 μA ; $-V_{CE}$ = 1,0 V		h_{FE}	> typ.	60 245
$-I_C$ = 0,1 mA; $-V_{CE}$ = 1,0 V		h_{FE}	> typ.	80 270
$-I_C$ = 1,0 mA; $-V_{CE}$ = 1,0 V		h_{FE}	> typ.	100 300
$-I_C$ = 10 mA; $-V_{CE}$ = 1,0 V		h_{FE}	> typ.	100 290
$-I_C$ = 10 mA; $-V_{CE}$ = 1,0 V	BCY71	h_{FE}	<	400
$-I_C$ = 50 mA; $-V_{CE}$ = 1,0 V		h_{FE}	> typ.	45 175

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

			BCY70	BCY71	BCY72	
Collector capacitance at f = 1 MHz						
$I_E = I_e = 0$; $-V_{CB}$ = 10 V	C_c	typ.		4,5		pF
		<		6,0		pF
Emitter capacitance at f = 1 MHz						
$I_C = I_e = 0$; $-V_{EB}$ = 1,0 V	C_e	typ.		6,0		pF
		<		8,0		pF
Transition frequency at T_{amb} = 25 °C						
$-I_C$ = 10 mA; $-V_{CE}$ = 20 V; f = 100 MHz	f_T	>	250	250	250	MHz
		typ.	450	450	450	MHz
$-I_C$ = 100 μA ; $-V_{CE}$ = 20 V; f = 10,7 MHz	f_T	>	-	15	-	MHz
		typ.	-	30	-	MHz
Noise figure						
$-I_C$ = 100 μA ; $-V_{CE}$ = 5,0 V f = 10 Hz to 10 kHz; R_S = 2,0 kΩ	F	typ.	2,0	0,8	2,0	dB
		<	6,0	2,0	6,0	dB
h parameters at f = 1 kHz (common emitter)						
$-I_C$ = 1,0 mA; $-V_{CE}$ = 10 V; T_{amb} = 25 °C						
Input impedance	h_{ie}	>	-	2,0	-	kΩ
		typ.	-	4,0	-	kΩ
		<	-	12,0	-	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	-	2,1	-	10^{-4}
		<	-	20,0	-	10^{-4}
Small signal current gain	h_{fe}	>	-	150	-	
		typ.	-	325	-	
		<	-	400	-	
Output admittance	h_{oe}	>	-	10	-	μA/V
		typ.	-	20	-	μA/V
		<	-	60	-	μA/V

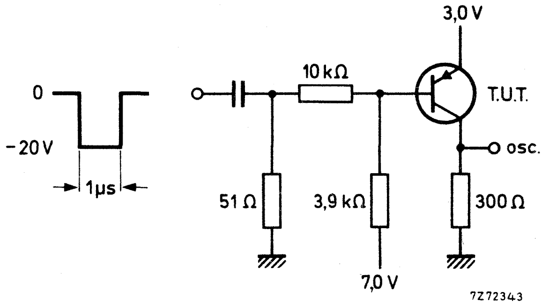
CHARACTERISTICS (continued)

Switching times of the BCY70 and BCY72.

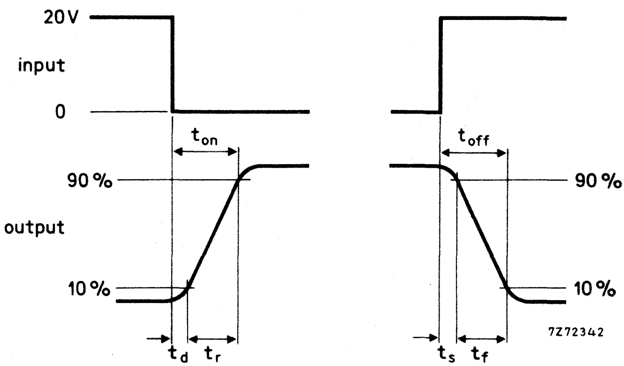
$-I_C = 10$ mA; $-I_{Bon} = +I_{Boff} = 1$ mA

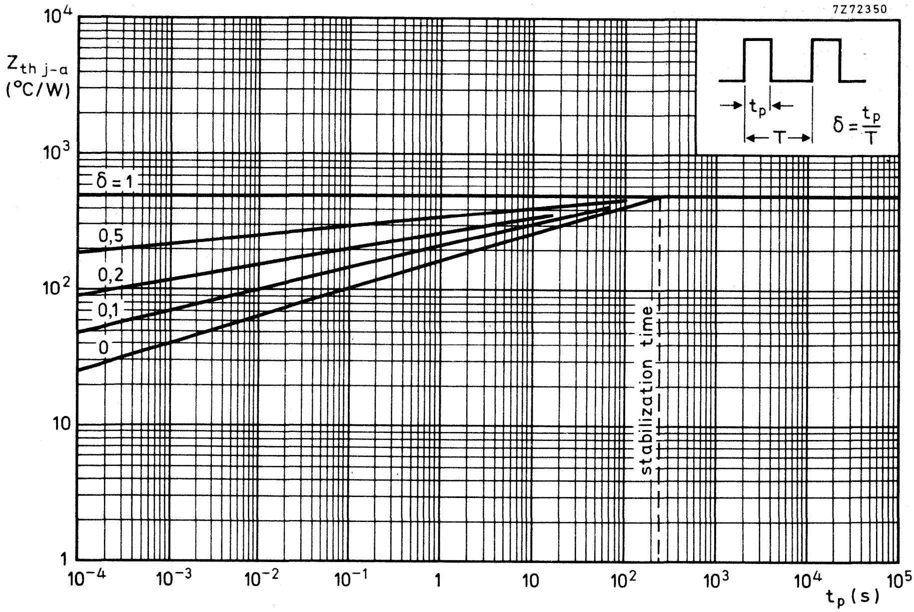
delay time	t_d	typ.	23	ns
		<	35	ns
rise time	t_r	typ.	25	ns
		<	35	ns
turn-on time	t_{on}	typ.	48	ns
		<	65	ns
storage time	t_s	typ.	270	ns
		<	350	ns
fall time	t_f	typ.	50	ns
		<	80	ns
turn-off time	t_{off}	typ.	320	ns
		<	420	ns

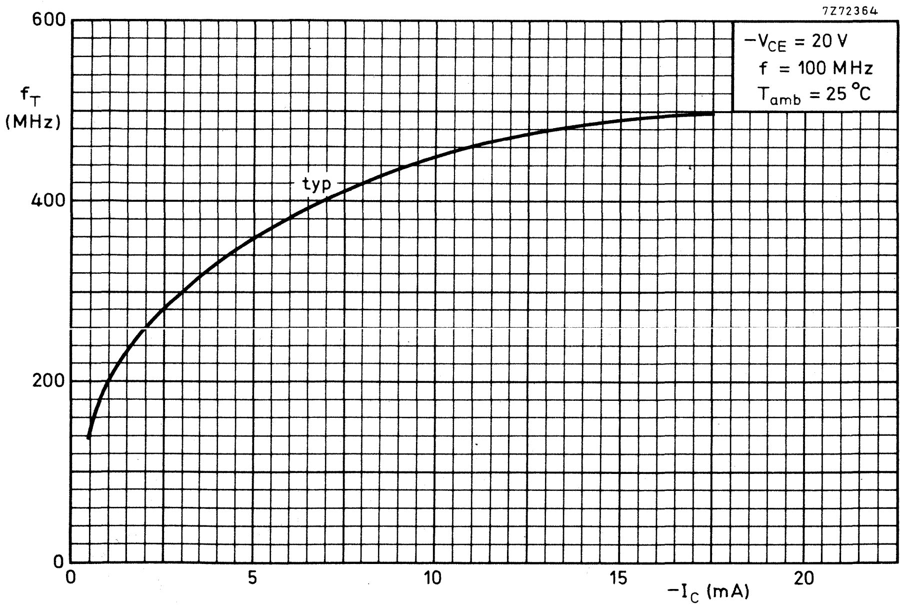
Test circuit:

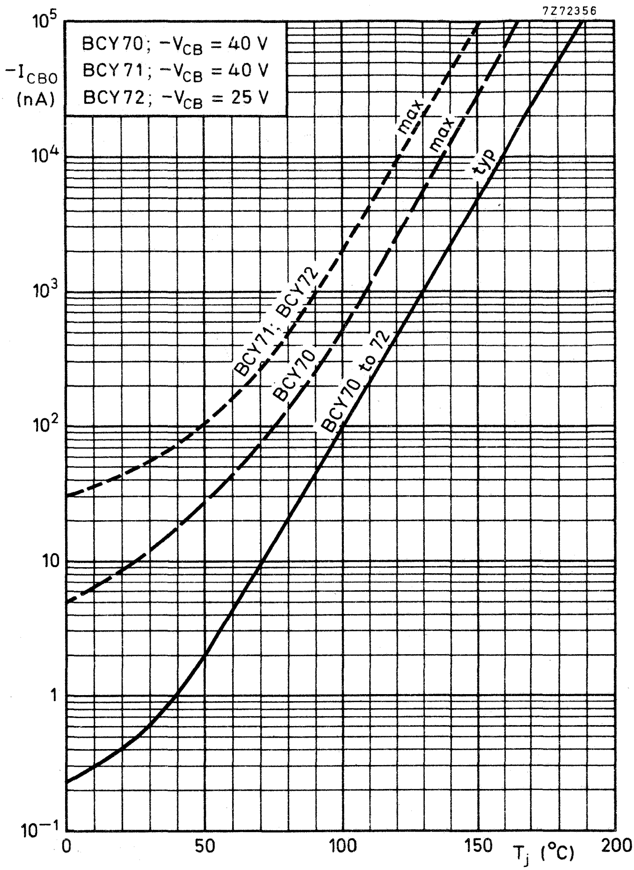


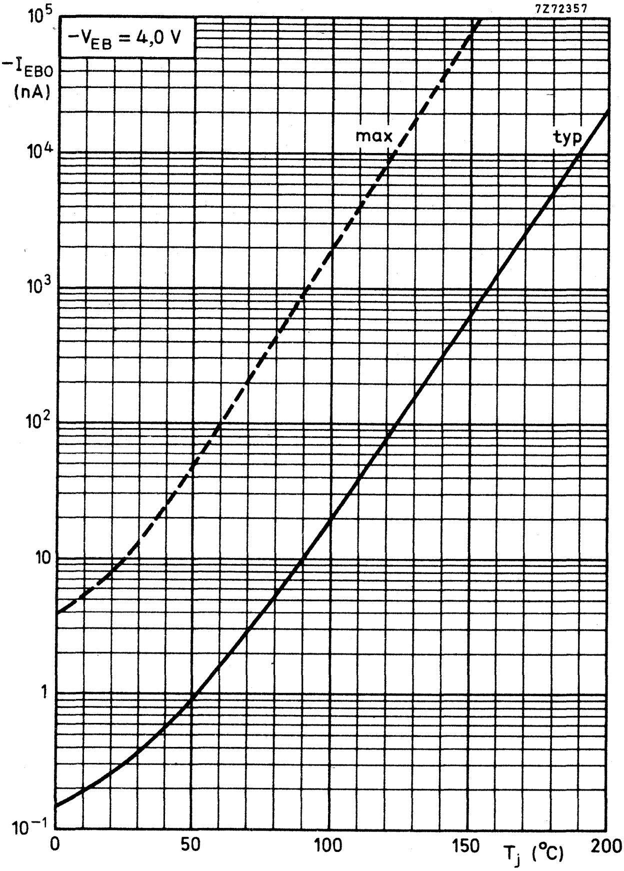
Switching waveforms:

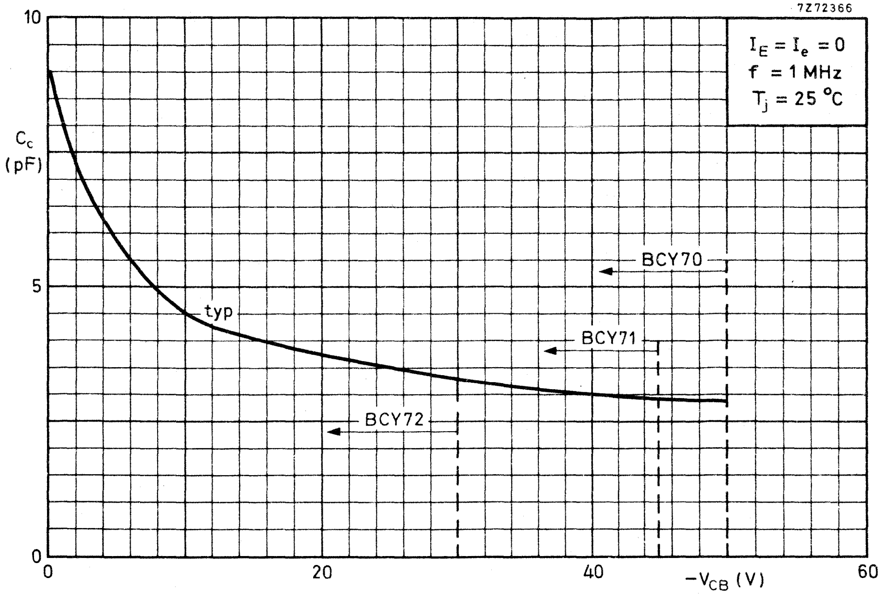


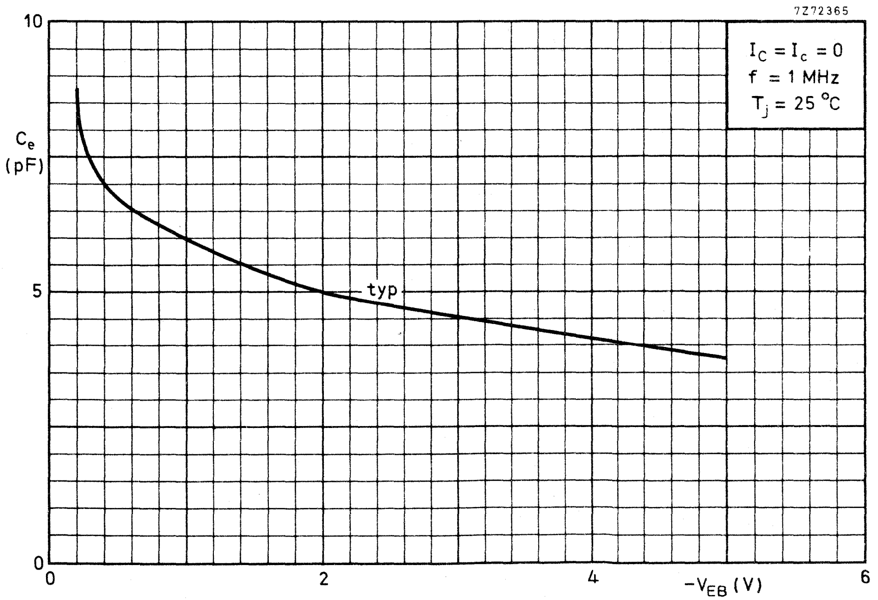

7Z72350
$Z_{th\ j\text{-}a}$ (°C/W)
10^4
10^3
10^2
10
1
δ = 1
0,5
0,2
0,1
0
stabilization time
t_p
T
$\delta = \frac{t_p}{T}$
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3
10^4
10^5
t_p (s)

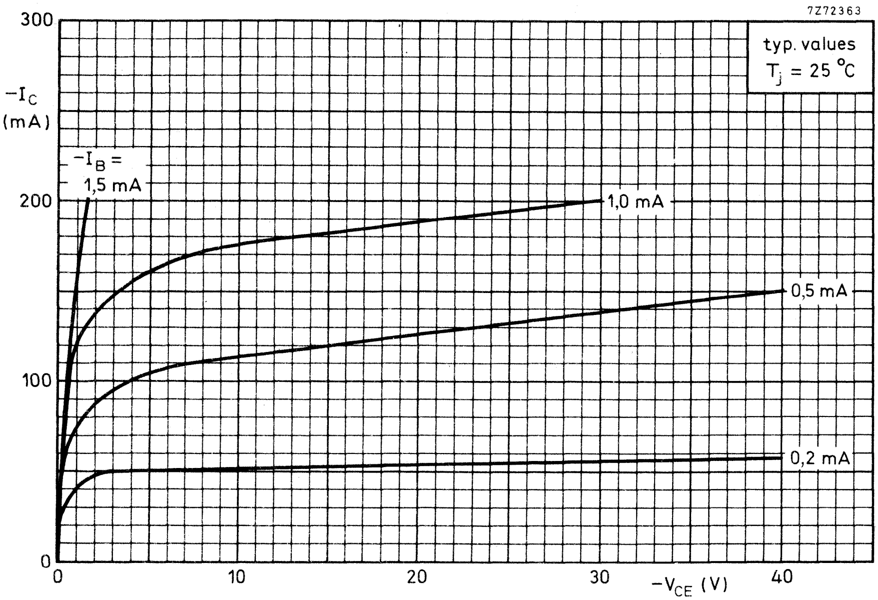

7Z72364
f_T (MHz)
600
400
200
0
typ
$-V_{CE}$ = 20 V
f = 100 MHz
T_{amb} = 25 °C
0
5
10
15
20
$-I_C$ (mA)

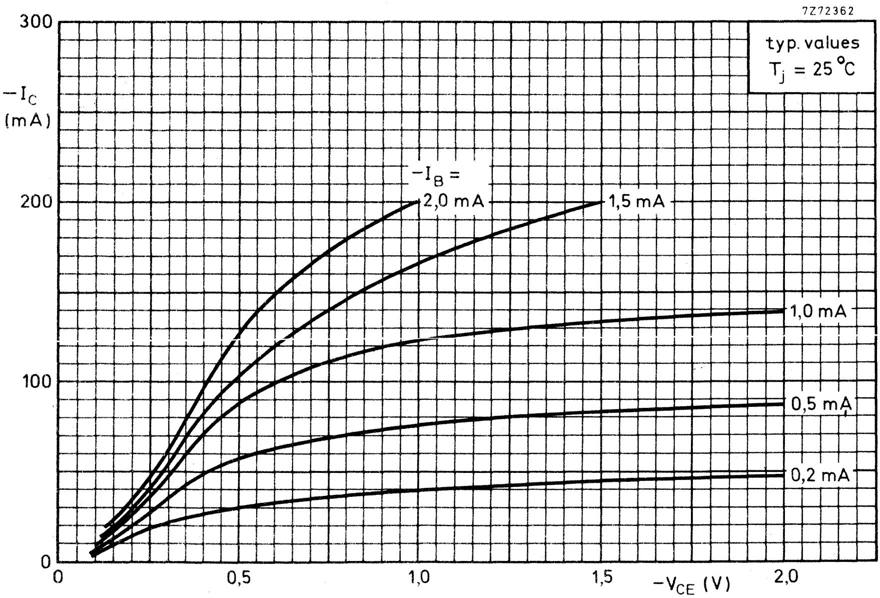

7Z72356
BCY70; $-V_{CB}$ = 40 V
BCY71; $-V_{CB}$ = 40 V
BCY72; $-V_{CB}$ = 25 V
$-I_{CBO}$
(nA)
10^5
10^4
10^3
10^2
10
1
10^{-1}
max
max
typ
BCY71; BCY72
BCY70
BCY70 to 72
0
50
100
150
200
T_j (°C)

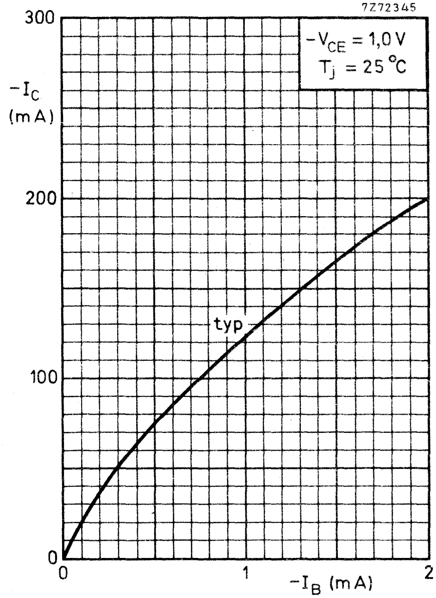

7Z72357
$-V_{EB} = 4,0$ V
$-I_{EBO}$ (nA)
10^5
10^4
10^3
10^2
10
1
10^{-1}
max
typ
0
50
100
150
200
T_j (°C)

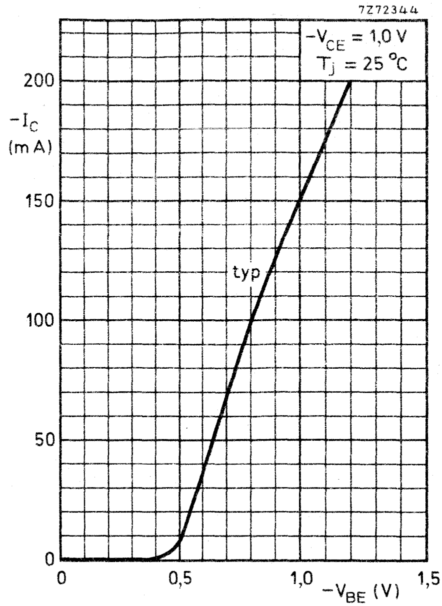

7Z72366
$I_E = I_e = 0$
f = 1 MHz
T_j = 25 °C
C_c
(pF)
10
5
0
0
20
40
60
$-V_{CB}$ (V)
typ
BCY70
BCY71
BCY72

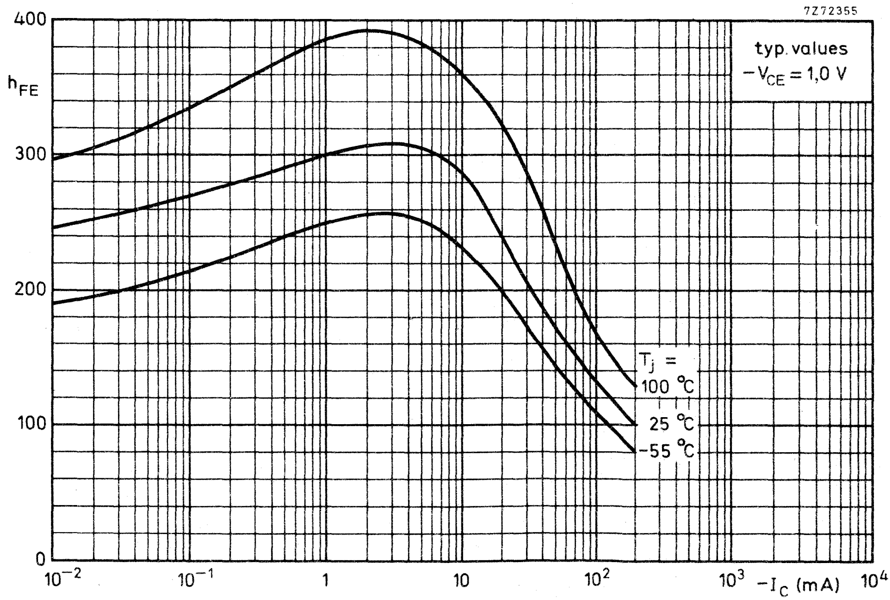

7Z72365
$I_C = I_c = 0$
f = 1 MHz
T_j = 25 °C
C_e
(pF)
10
5
0
0
2
4
6
$-V_{EB}$ (V)
typ

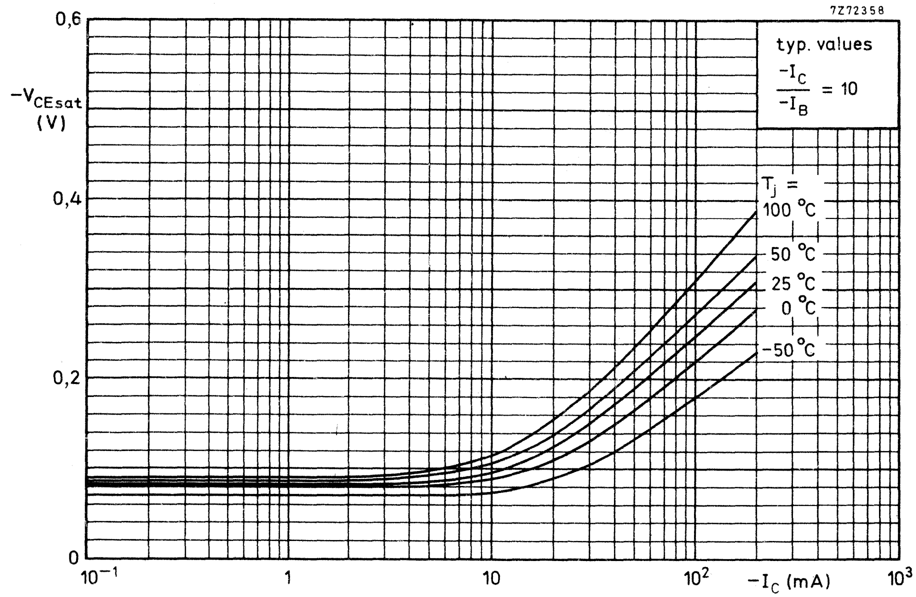

7Z72363
typ. values
T_j = 25 °C
$-I_C$ (mA)
$-I_B$ = 1,5 mA
1,0 mA
0,5 mA
0,2 mA
300
200
100
0
0
10
20
30
40
$-V_{CE}$ (V)

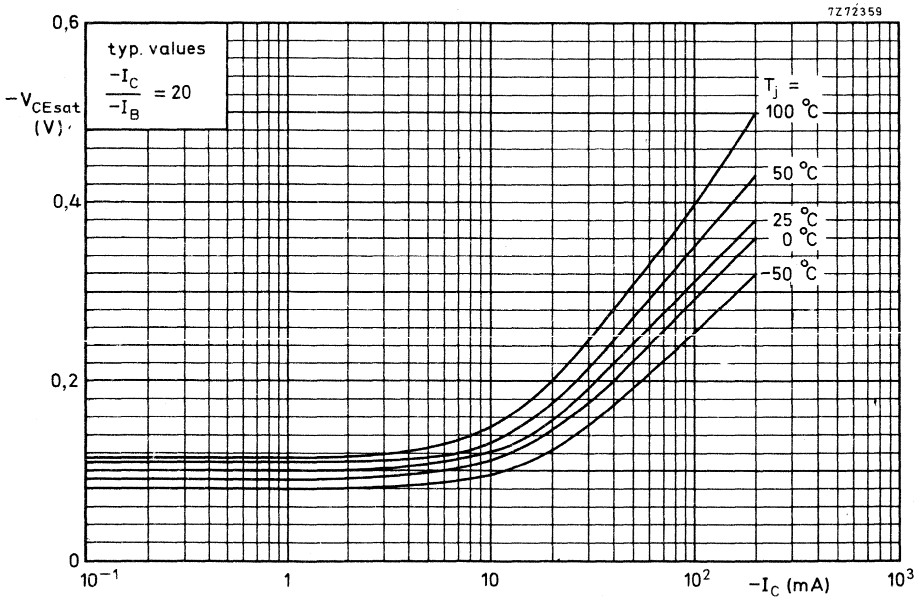

7Z72362
typ. values
T_j = 25 °C
$-I_C$ (mA)
$-I_B$ = 2,0 mA
1,5 mA
1,0 mA
0,5 mA
0,2 mA
300
200
100
0
0
0,5
1,0
1,5
2,0
$-V_{CE}$ (V)

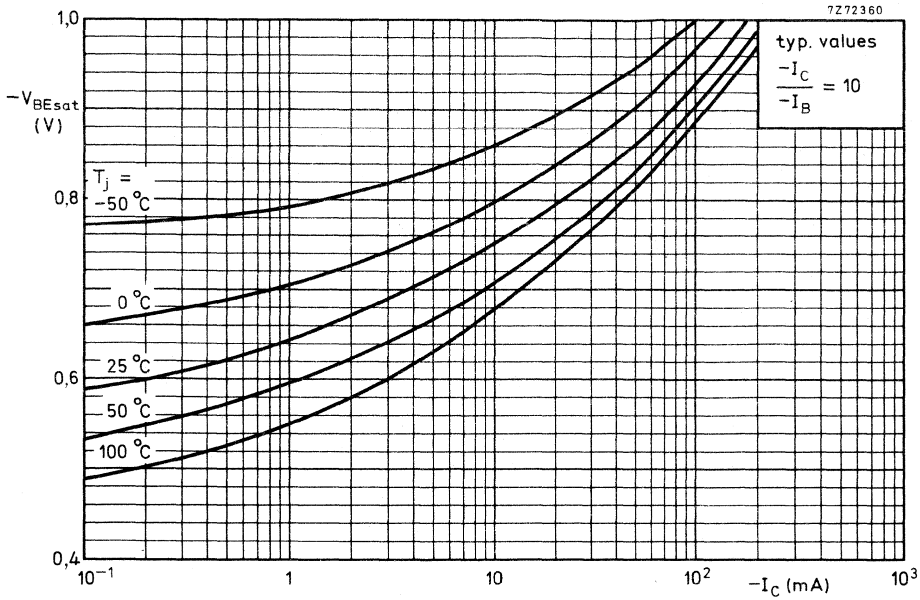

7Z72345
$-V_{CE}$ = 1,0 V
T_j = 25 °C
$-I_C$ (mA)
300
200
100
0
typ
0
1
2
$-I_B$ (mA)

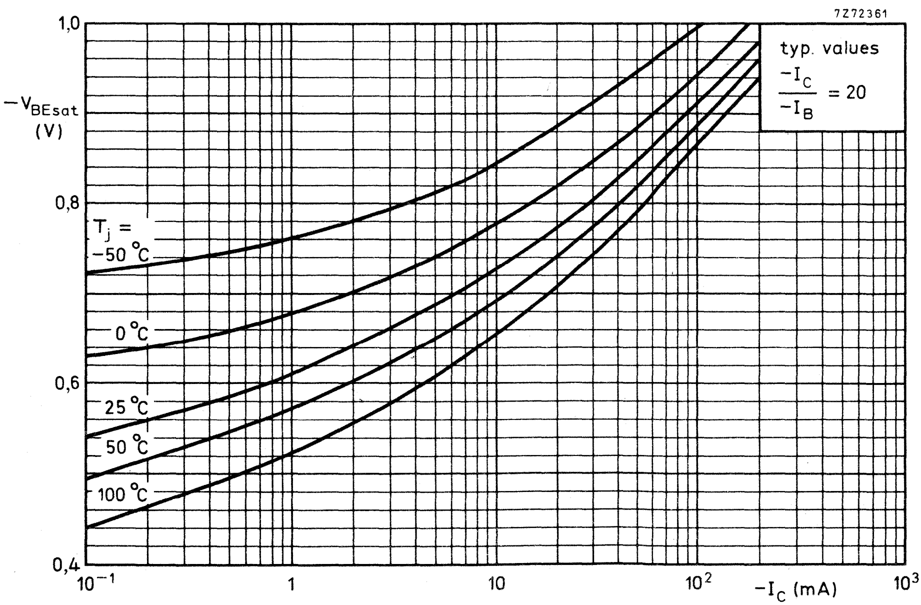

7Z72344
$-V_{CE}$ = 1,0 V
T_j = 25 °C
$-I_C$ (mA)
200
150
100
50
0
typ
0
0,5
1,0
1,5
$-V_{BE}$ (V)

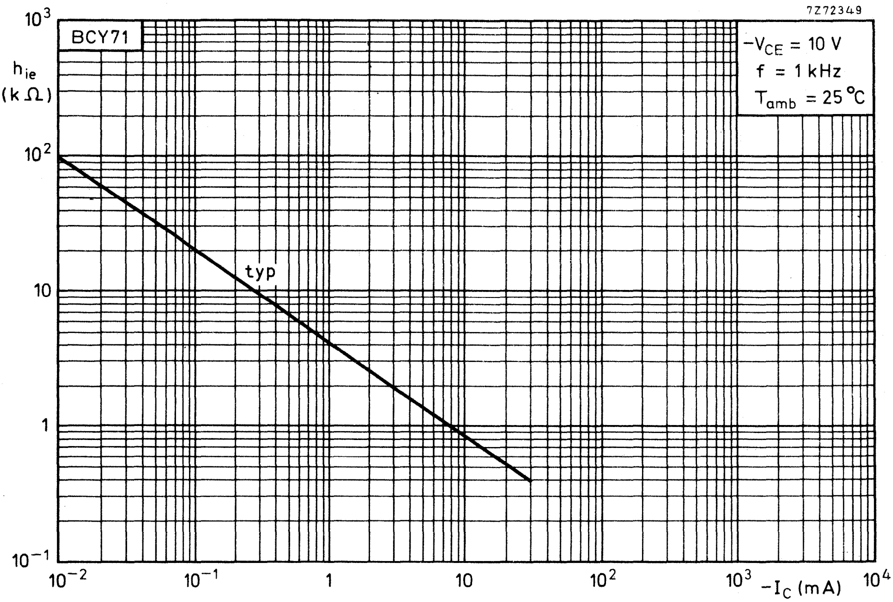

7Z72355
typ. values
$-V_{CE}$ = 1,0 V
h_{FE}
400
300
200
100
0
T_j =
100 °C
25 °C
-55 °C
10^{-2}
10^{-1}
1
10
10^2
10^3
10^4
$-I_C$ (mA)

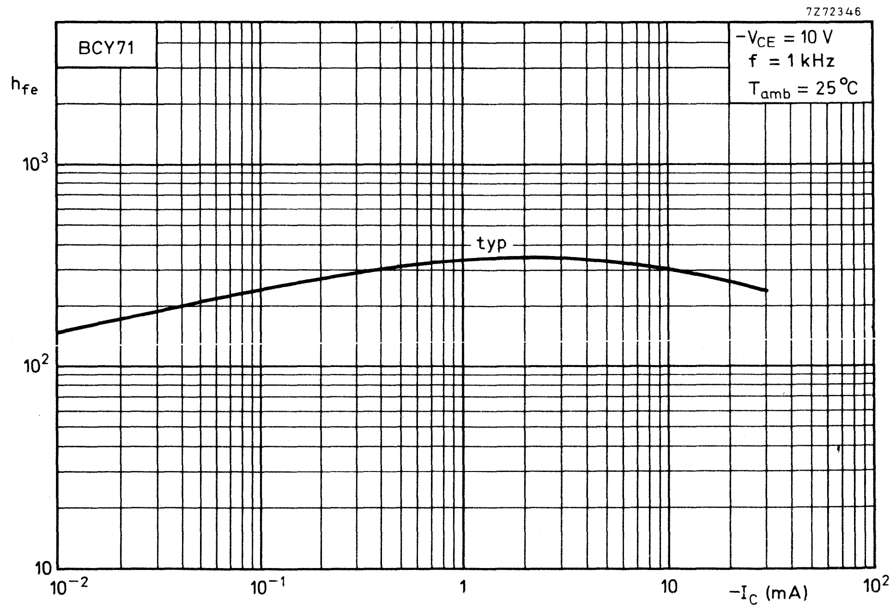

7Z72358
typ. values
$\frac{-I_C}{-I_B}$ = 10
$-V_{CEsat}$ (V)
0,6
0,4
0,2
0
T_j =
100 °C
50 °C
25 °C
0 °C
−50 °C
10^{-1}
1
10
10^2
10^3
$-I_C$ (mA)

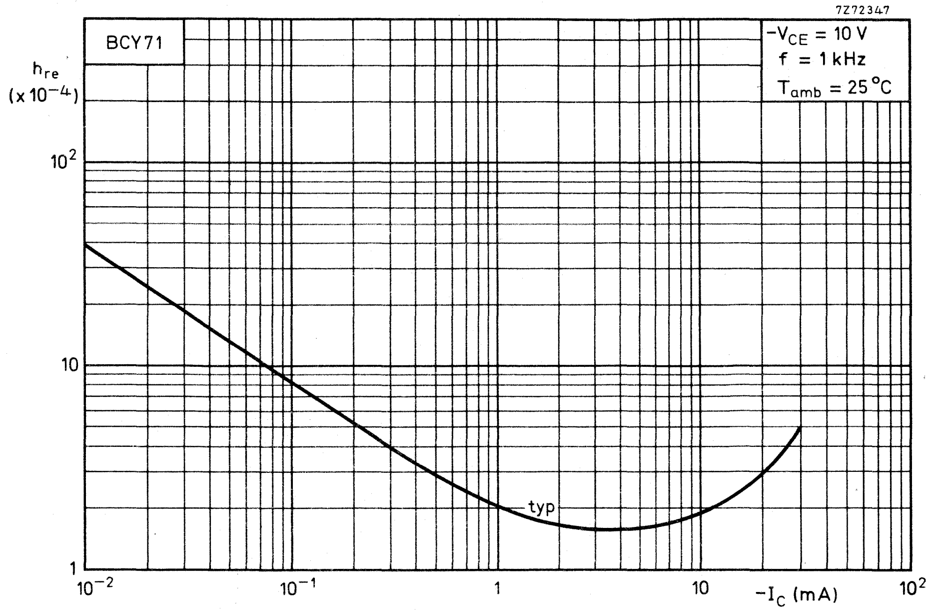

7Z72359
typ. values
$\frac{-I_C}{-I_B}$ = 20
$-V_{CEsat}$ (V)
0,6
0,4
0,2
0
T_j =
100 °C
50 °C
25 °C
0 °C
−50 °C
10^{-1}
1
10
10^2
10^3
$-I_C$ (mA)

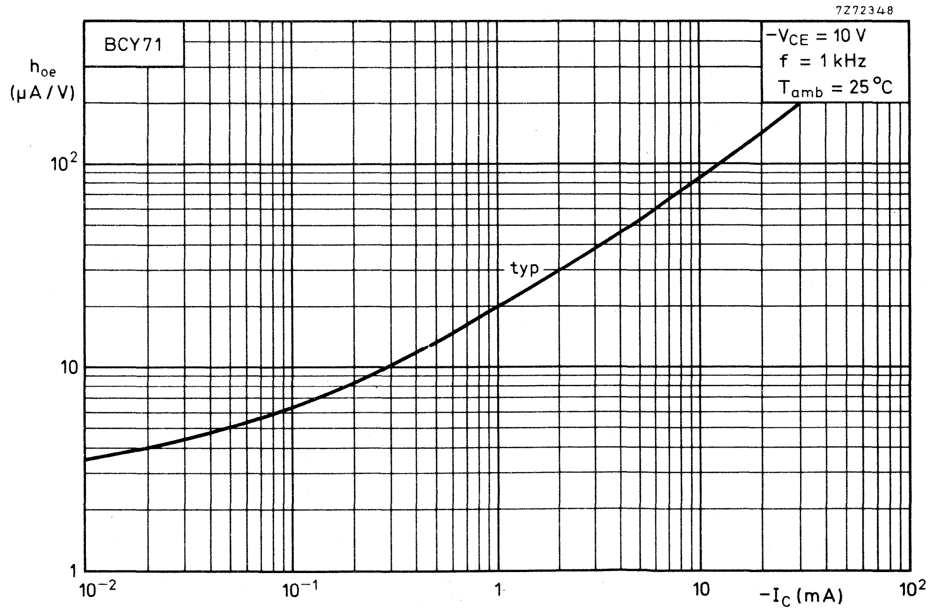

7Z72360
typ. values
$\frac{-I_C}{-I_B}$ = 10
$-V_{BEsat}$
(V)
1,0
0,8
0,6
0,4
T_j =
−50 °C
0 °C
25 °C
50 °C
100 °C
10^{-1}
1
10
10^2
$-I_C$ (mA)
10^3

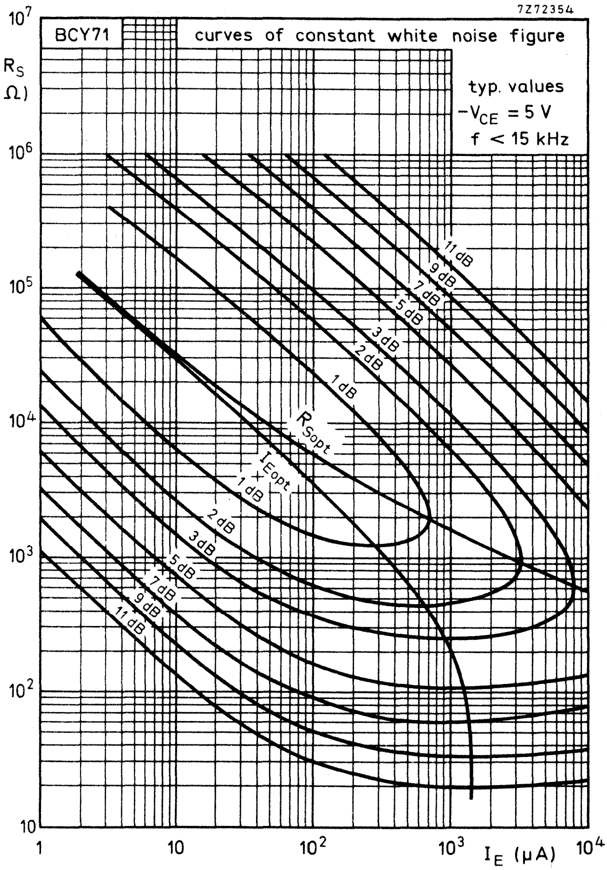

7Z72361
typ. values
$\frac{-I_C}{-I_B}$ = 20
$-V_{BEsat}$
(V)
1,0
0,8
0,6
0,4
T_j =
−50 °C
0 °C
25 °C
50 °C
100 °C
10^{-1}
1
10
10^2
$-I_C$ (mA)
10^3


7Z72349
BCY71
h_{ie}
(k Ω)
$-V_{CE}$ = 10 V
f = 1 kHz
T_{amb} = 25 °C
typ
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-1}
1
10
10^2
10^3
$-I_C$ (mA)
10^4

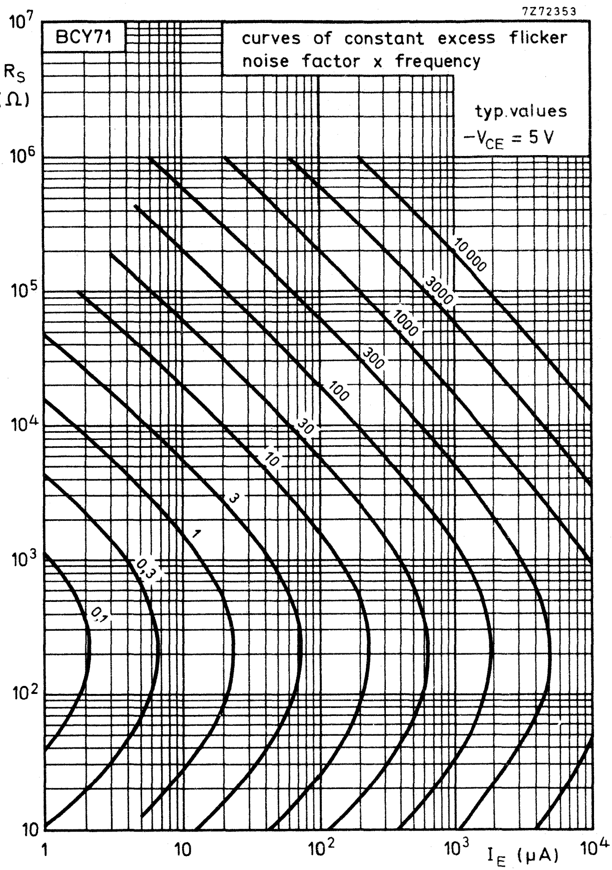

7Z72346
BCY71
h_{fe}
$-V_{CE}$ = 10 V
f = 1 kHz
T_{amb} = 25 °C
typ
10^3
10^2
10
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2


7Z72347
BCY71
h_{re} $(\times 10^{-4})$
$-V_{CE}$ = 10 V
f = 1 kHz
T_{amb} = 25 °C
typ
10^2
10
1
10^{-2}
10^{-1}
1
10
10^2
$-I_C$ (mA)


7Z72348
BCY71
h_{oe} (μA / V)
$-V_{CE}$ = 10 V
f = 1 kHz
T_{amb} = 25 °C
typ
10^2
10
1
10^{-2}
10^{-1}
1
10
10^2
$-I_C$ (mA)



See also the graph and text on next page.



Determination of total noise figure

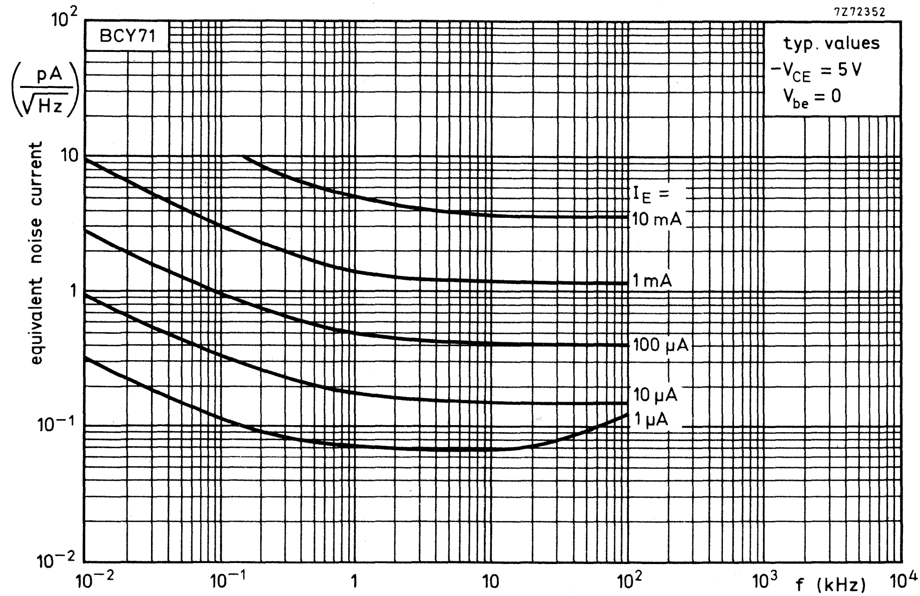
Total noise at f < 15 kHz includes flicker noise and white noise.

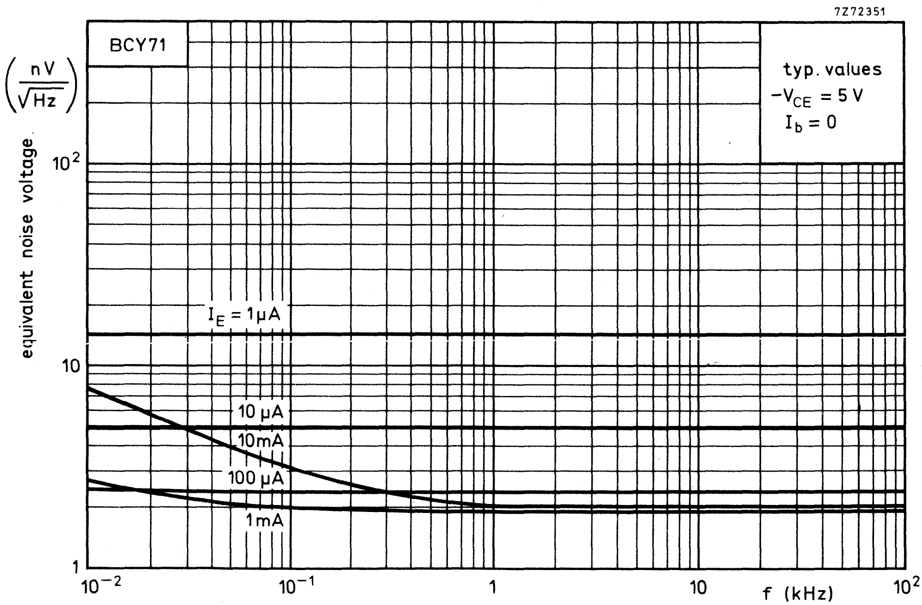
The relationship is as follows: noise factor = 1 + flicker noise factor + white noise factor.

The flicker noise factor can be derived from the curves of the graph above, the white noise factor from the curves of the graph on page 16.

Example:

Assume a BCY71 operating at f = 200 Hz; I_E = 200 μA with a source resistance R_S = 10 kΩ. From the graph on this page it follows that at I_E = 200 μA with R_S = 10 kΩ the product of frequency and flicker noise factor is 110. Since the frequency is 200 Hz, the flicker noise factor is 110/200 = 0, 55.
From page 16 it follows that at I_E = 200 μA with R_S = 10 kΩ the white noise figure is 0,9 dB, representing a factor of 1,23. Thus the total noise factor = 0, 55 + 1, 23 = 1,78 or 2,5 dB.


7Z72352
BCY71
typ. values
$-V_{CE} = 5\,V$
$V_{be} = 0$
equivalent noise current
$\left(\frac{pA}{\sqrt{Hz}}\right)$
10^2
10
1
10^{-1}
10^{-2}
$I_E =$
10 mA
1 mA
100 μA
10 μA
1 μA
10^{-2}
10^{-1}
1
10
10^2
10^3
f (kHz)
10^4


7Z72351
BCY71
typ. values
$-V_{CE} = 5\,V$
$I_b = 0$
equivalent noise voltage
$\left(\frac{nV}{\sqrt{Hz}}\right)$
10^2
10
1
$I_E = 1\,\mu A$
10 μA
10mA
100 μA
1mA
10^{-2}
10^{-1}
1
10
f (kHz)
10^2

SILICON PLANAR EPITAXIAL TRANSISTORS

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

QUICK REFERENCE DATA

			BCY78	BCY79	
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	32	45	V
Collector current	$-I_C$	max.	200		mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	345		mW
up to T_{case} = 45 °C	P_{tot}	max.	1000		mW
Junction temperature	T_j	max.	200		°C

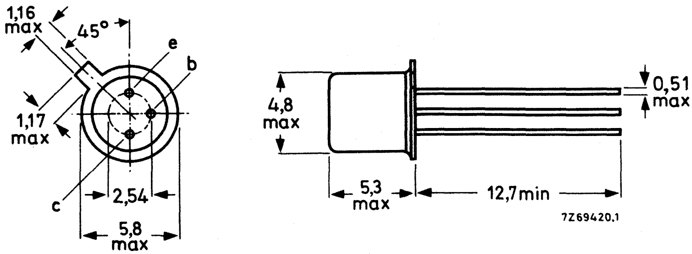
			BCY78-VII	VIII	IX	X
			BCY79-VII	VIII	IX	
Small-signal current gain $-I_C$ = 2 mA; $-V_{CE}$ = 5 V	h_{fe}	>	125	175	250	350
		<	250	350	500	700

Transition frequency $-I_C$ = 10 mA; $-V_{CE}$ = 5 V	f_T	typ.	180	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 : 56246 (distance disc); 56263 (cooling fin).

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

			BCY78	BCY79	
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.	5	5	V
Currents					
Collector current (d.c.)	$-I_C$	max.	200		mA
Base current (d.c.)	$-I_B$	max.	20		mA
Power dissipation					
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	345		mW
up to T_{case} = 45 °C	P_{tot}	max.	1000		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	$R_{th\ j-a}$	=	0,45	°C/mW
From junction to case	$R_{th\ j-c}$	=	0,15	°C/mW

CHARACTERISTICS

$T_{amb} = 25\ ^oC$ unless otherwise specified

			BCY78	BCY79	
Collector cut-off currents					
$V_{BE} = 0$; $-V_{CE} = 25$ V	$-I_{CES}$	typ.	2	–	nA
		<	20	–	nA
$V_{BE} = 0$; $-V_{CE} = 35$ V	$-I_{CES}$	typ.	–	2	nA
		<	–	20	nA
$V_{BE} = 0$; $-V_{CE} = 25$ V; $T_{amb} = 150\ ^oC$	$-I_{CES}$	<	10	–	μA
$V_{BE} = 0$; $-V_{CE} = 35$ V; $T_{amb} = 150\ ^oC$	$-I_{CES}$	<	–	10	μA
$V_{BE} = 0$; $-V_{CE} = -V_{CEOmax}$	$-I_{CES}$	<	100	100	nA
$-V_{EB} = 0,2$ V; $-V_{CE} = -V_{CEOmax}$; $T_{amb} = 100\ ^oC$	$-I_{CEX}$	<	20	20	μA
Emitter cut-off current					
$I_C = 0$; $-V_{EB} = 4$ V	$-I_{EBO}$	<	20	20	nA
Collector-emitter breakdown voltage					
$V_{BE} = 0$; $-I_C = 10$ μA	$-V_{(BR)CES}$	>	32	45	V
$I_B = 0$; $-I_C = 2$ mA	$-V_{(BR)CEO}$	>	32	45	V
Emitter-base breakdown voltage					
$I_C = 0$; $-I_E = 1$ μA	$-V_{(BR)EBO}$	>	5		V
Base-emitter voltage					
$-I_C = 10$ μA; $-V_{CE} = 5$ V	$-V_{BE}$	typ.	550		mV
$-I_C = 2$ mA; $-V_{CE} = 5$ V	$-V_{BE}$	typ.	650		mV
		600 to	750		mV
$-I_C = 10$ mA; $-V_{CE} = 1$ V	$-V_{BE}$	typ.	680		mV
$-I_C = 100$ mA; $-V_{CE} = 1$ V	$-V_{BE}$	typ.	750		mV
Saturation voltages					
$-I_C = 10$ mA; $-I_B = 250$ μA	$-V_{CEsat}$	typ.	120		mV
		<	250		mV
	$-V_{BEsat}$	typ.	700		mV
		600 to	850		mV
$-I_C = 100$ mA; $-I_B = 2,5$ mA	$-V_{CEsat}$	typ.	400		mV
		<	800		mV
	$-V_{BEsat}$	typ.	850		mV
		700 to	1200		mV
Transition frequency at f = 35 MHz					
$-I_C = 10$ mA; $-V_{CE} = 5$ V	f_T	typ.	180		MHz

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

Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $-V_{CB}$ = 10 V	C_c	typ.	4,5	pF
		<	7,0	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $-V_{EB}$ = 0,5 V	C_e	typ.	11	pF
		<	15	pF
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

			BCY78-VII / BCY79-VII	VIII / VIII	IX / IX	X	
D.C. current gain							
$-I_C$ = 10 µA ; $-V_{CE}$ = 5 V	h_{FE}	>	–	30	40	100	
		typ.	140	200	270	340	
$-I_C$ = 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.	180	260	360	500	
		<	–	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}	typ.	2,7	3,6	4,5	7,5	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	1,5	2	2	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

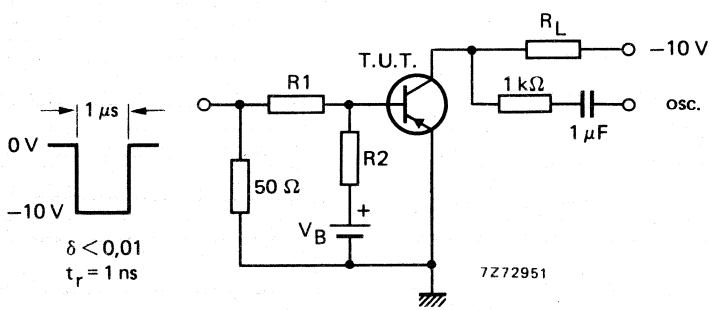
$-I_{Con}$ = 10 mA; $-I_{Bon} = I_{Boff}$ = 1 mA
R1 = R2 = 5 kΩ; R_L = 990 Ω
V_B = 3,6 V

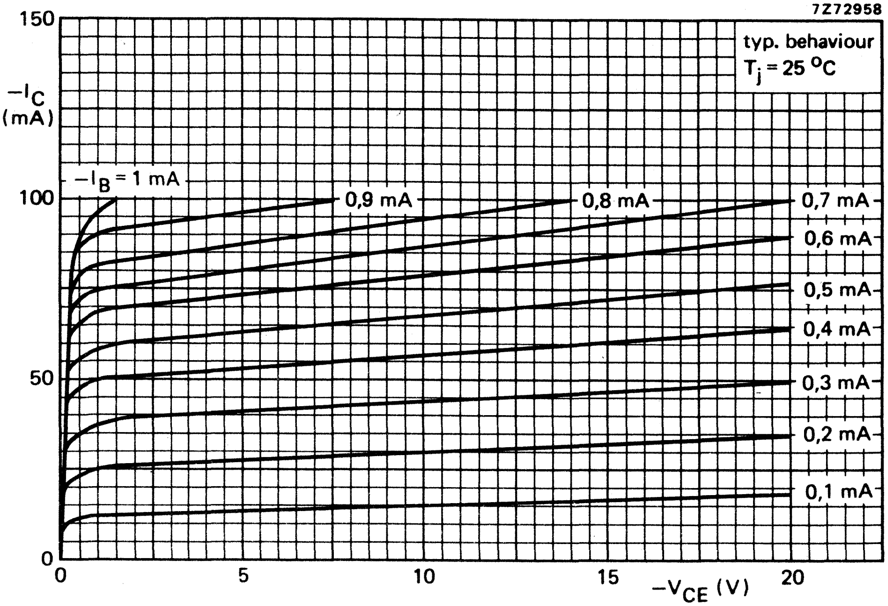
delay time	t_d	typ.	35	ns
rise time	t_r	typ.	50	ns
turn-on time ($t_d + t_r$)	t_{on}	typ.	85	ns
		<	150	ns
storage time	t_s	typ.	400	ns
fall time	t_f	typ.	80	ns
turn-off time ($t_s + t_f$)	t_{off}	typ.	480	ns
		<	800	ns

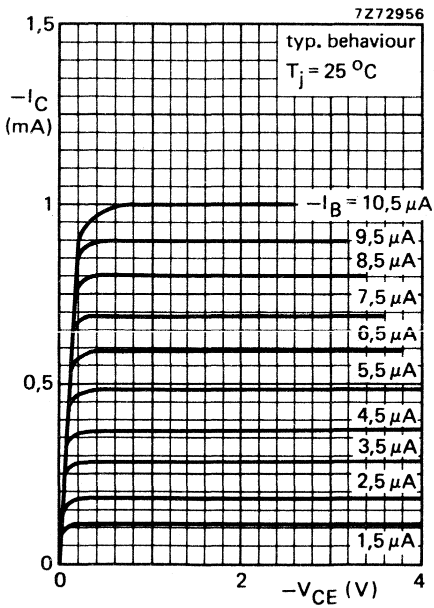
$-I_{Con}$ = 100 mA; $-I_{Bon} = I_{Boff}$ = 10 mA
R1 = 500 Ω; R2 = 700 Ω; R_L = 98 Ω
V_B = 5 V

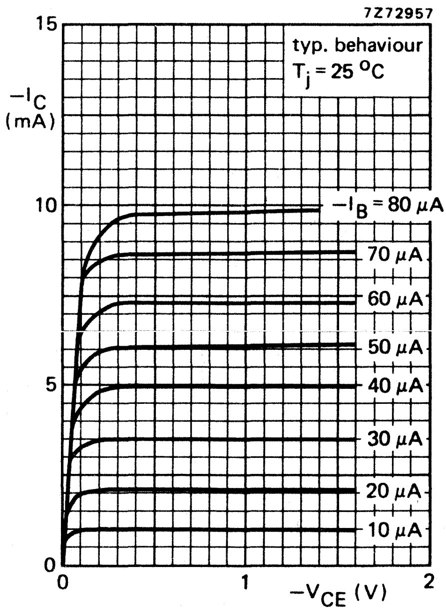
delay time	t_d	typ.	5	ns
rise time	t_r	typ.	50	ns
turn-on time ($t_d + t_r$)	t_{on}	typ.	55	ns
		<	150	ns
storage time	t_s	typ.	250	ns
fall time	t_f	typ.	200	ns
turn-off time ($t_s + t_f$)	t_{off}	typ.	450	ns
		<	800	ns

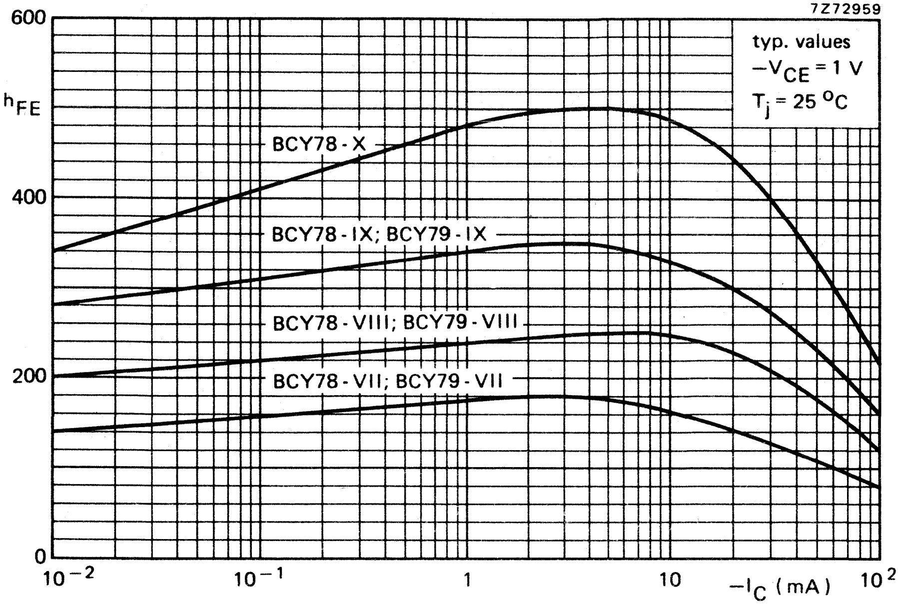
Test circuit:

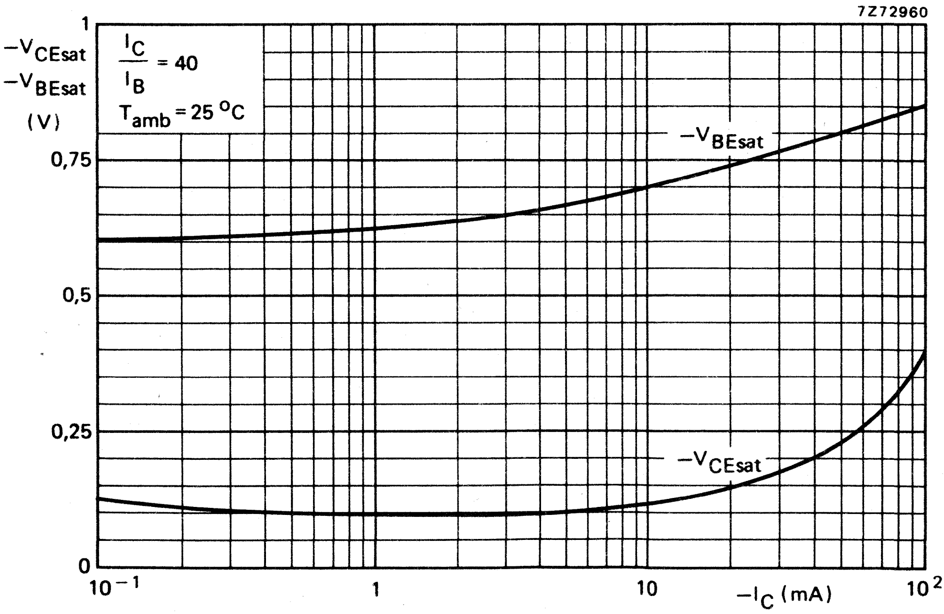


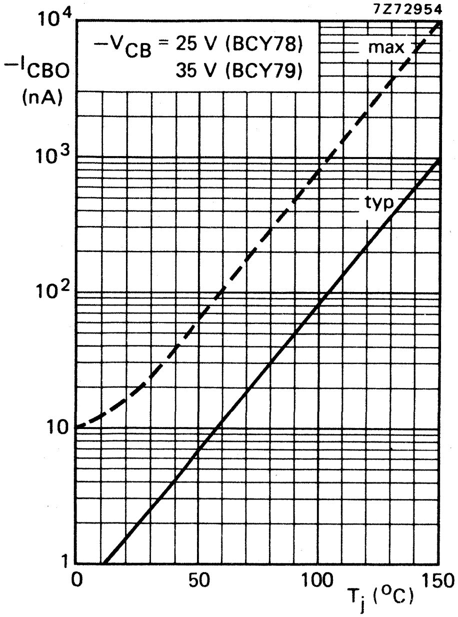

7Z72958
typ. behaviour
T_j = 25 °C
$-I_C$ (mA)
150
100
50
0
$-I_B$ = 1 mA
0,9 mA
0,8 mA
0,7 mA
0,6 mA
0,5 mA
0,4 mA
0,3 mA
0,2 mA
0,1 mA
0
5
10
15
20
$-V_{CE}$ (V)

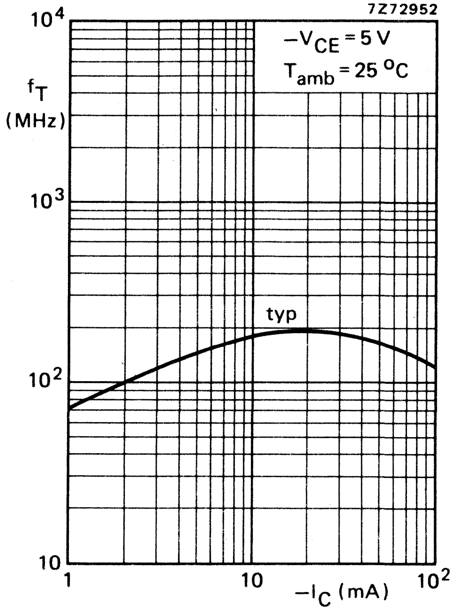

7Z72956
typ. behaviour
T_j = 25 °C
$-I_C$ (mA)
1,5
1
0,5
0
$-I_B$ = 10,5 μA
9,5 μA
8,5 μA
7,5 μA
6,5 μA
5,5 μA
4,5 μA
3,5 μA
2,5 μA
1,5 μA
0
2
4
$-V_{CE}$ (V)

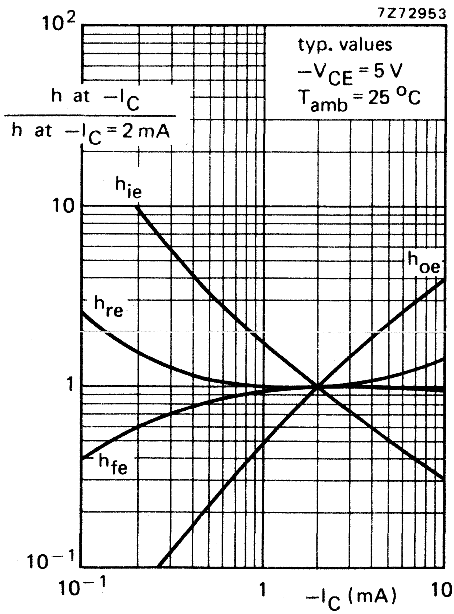

7Z72957
typ. behaviour
T_j = 25 °C
$-I_C$ (mA)
15
10
5
0
$-I_B$ = 80 μA
70 μA
60 μA
50 μA
40 μA
30 μA
20 μA
10 μA
0
1
2
$-V_{CE}$ (V)

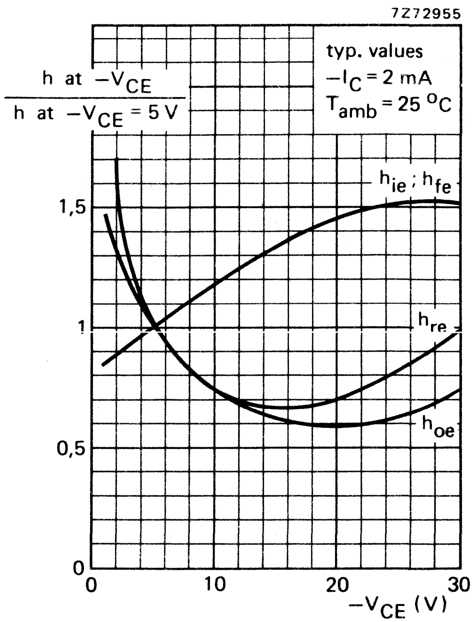

7Z72959
typ. values
$-V_{CE} = 1$ V
$T_j = 25$ °C
h_{FE}
600
400
200
0
BCY78 - X
BCY78 - IX; BCY79 - IX
BCY78 - VIII; BCY79 - VIII
BCY78 - VII; BCY79 - VII
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2


7Z72960
$\frac{I_C}{I_B} = 40$
$T_{amb} = 25$ °C
$-V_{CEsat}$
$-V_{BEsat}$
(V)
1
0,75
0,5
0,25
0
$-V_{BEsat}$
$-V_{CEsat}$
10^{-1}
1
10
$-I_C$ (mA)
10^2


7Z72954
$-V_{CB}$ = 25 V (BCY78)
35 V (BCY79)
$-I_{CBO}$ (nA)
max
typ
T_j (°C)


7Z72952
$-V_{CE}$ = 5 V
T_{amb} = 25 °C
f_T (MHz)
typ
$-I_C$ (mA)


7Z72953
typ. values
$-V_{CE}$ = 5 V
T_{amb} = 25 °C
h at $-I_C$ / h at $-I_C$ = 2 mA
h_{ie}
h_{oe}
h_{re}
h_{fe}
$-I_C$ (mA)


7Z72955
typ. values
$-I_C$ = 2 mA
T_{amb} = 25 °C
h at $-V_{CE}$ / h at $-V_{CE}$ = 5 V
h_{ie} ; h_{fe}
h_{re}
h_{oe}
$-V_{CE}$ (V)

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

Matched dual n-p-n transistors in a TO-71 metal envelope with all leads insulated from the case. They are primarily intended for differential amplifier applications in general industrial service; e.g. instrumentation and control.

Products are divided into three types according to their matching accuracy.
The BCY87 and BCY88 are intended for applications in pre-stages of differential amplifiers where low offset, drift and noise are of prime importance. The BCY89 is for second stages, long-tailed pairs and more general purposes.

QUICK REFERENCE DATA

Ratings

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

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

			BCY87	BCY88	BCY89	
Ratio of collector currents at $V_{1B-1E} = V_{2B-2E}$	I_{1C}/I_{2C}		0,9–1,11	0,8–1,25	0,67–1,5	
Base current difference at $V_{1B-1E} = V_{2B-2E}$	$\lvert I_{1B}-I_{2B} \rvert$	<	25	80	300	nA
Equivalent differential voltage change with temperature *	$\left\lvert \frac{\Delta V}{\Delta T} \right\rvert$	<	3	6	10	μV/°C
Equivalent differential current change with temperature *	$\left\lvert \frac{\Delta I}{\Delta T} \right\rvert$	<	0,5	2	10	nA/°C

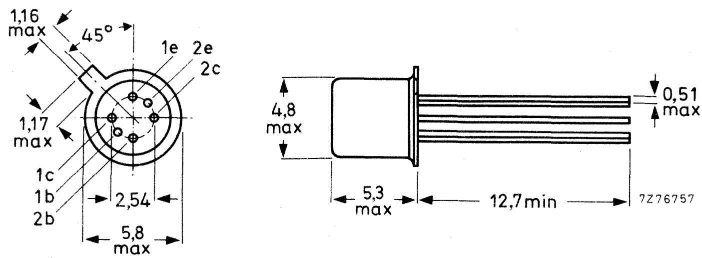
MECHANICAL DATA

Dimensions in mm

TO-71

All leads insulated from the case

Accessories: 56263 (cooling fin).



* T_{amb} = −20 °C to +90 °C.

RATINGS see page 7

CHARACTERISTICS of the individual transistors

T_{amb} = 25 °C unless otherwise specified

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

CHARACTERISTICS of the complete device.

These characteristics are valid under the following conditions:

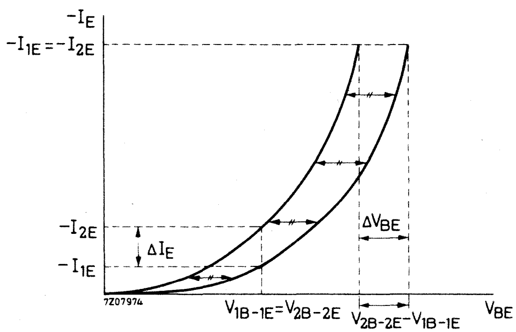
a. Collector-base voltage of both transistors not exceeding 10 V ($V_{1C-1B} = V_{2C-2B} \leq 10$ V)

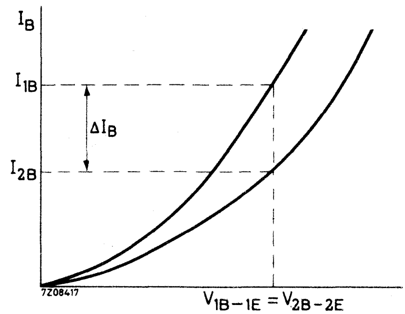
b. Sum of the emitter currents from 10 to 100 μA
$-(I_{1E} + I_{2E}) = 10$ to 100 μA

MATCHING CHARACTERISTICS

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

Illustration of matching characteristics:





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

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

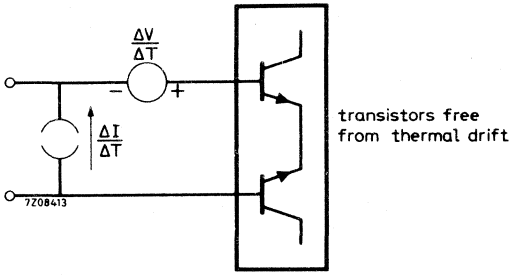
ΔV_{BE} measured at $\frac{I_{2E}}{I_{1E}} = 1$

CHARACTERISTICS of the complete device (continued)

Equivalent circuit for drift

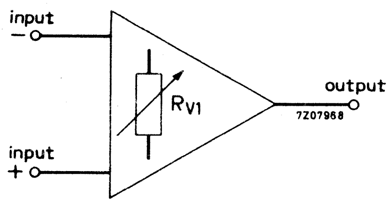
In the equivalent circuit the transistors are considered to be drift free. All temperature coefficients are concentrated in the voltage source $\frac{\Delta V}{\Delta T}$ and in the current source $\frac{\Delta I}{\Delta T}$.

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



Block symbol of test amplifier

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



CHARACTERISTICS of the complete device (continued)

Equivalent differential voltage change with temperature

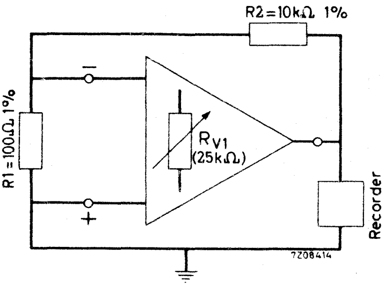
			BCY87	BCY88	BCY89	
T_{amb} = −20 to +90 °C	$\left\|\frac{\Delta V}{\Delta T}\right\|$	typ.	1	2	4	µV/°C
		<	3	6	10	µV/°C

Equivalent differential current change with temperature

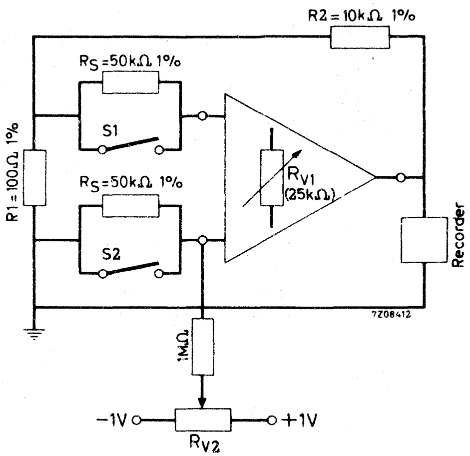
			BCY87	BCY88	BCY89	
T_{amb} = −20 to +90 °C	$\left\|\frac{\Delta I}{\Delta T}\right\|$	<	0.5	2	10	nA/°C

Test methods

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



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



NOTE

To prevent contact potentials, connections should be soldered.

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

Output voltage against time is recorded.

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

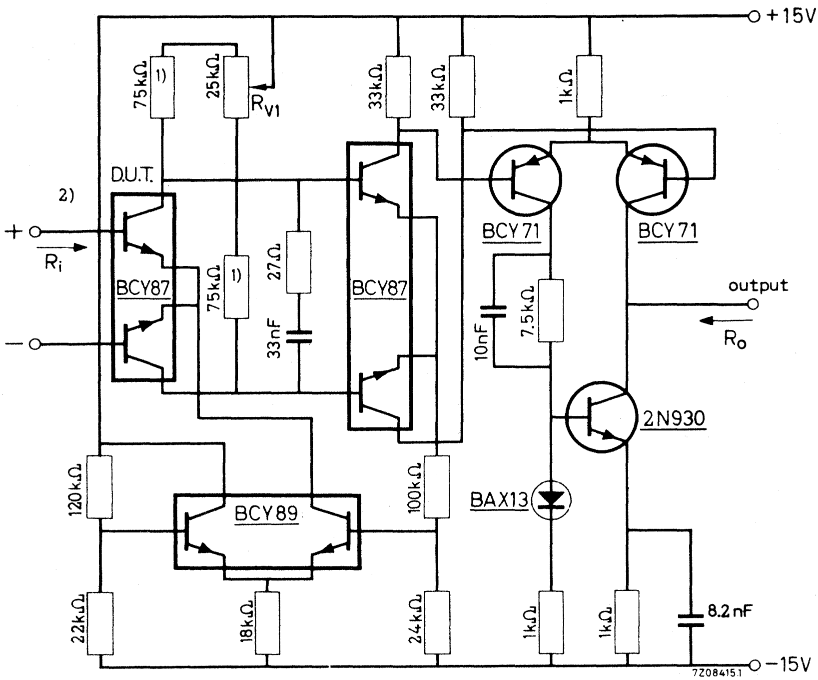
Then: $\frac{\Delta V}{\Delta T} = \frac{V_{T2} - V_{T1}}{T_2 - T_1} \cdot \frac{R1}{R2}$ or $\frac{\Delta I}{\Delta T} = \frac{V_{T2} - V_{T1}}{T_2 - T_1} \cdot \frac{R1}{R2} \cdot \frac{1}{2R_S}$

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

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

Differential test-amplifier

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

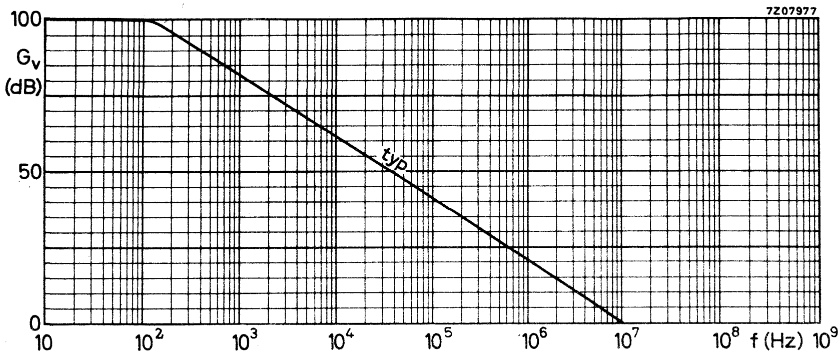


[1]) Relative temperature coefficient < $10^{-5}/^{o}C$

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

Performance of the test amplifier

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



RATINGS (Limiting values) 1)

Voltages (each transistor)

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

Currents (each transistor)

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

Temperatures

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

THERMAL RESISTANCE

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

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

N-P-N SILICON PLANAR TRANSISTORS

N-P-N transistors in TO-18 metal envelopes 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

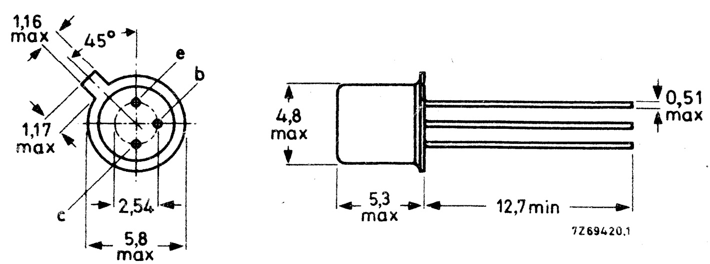
			2N929	2N930	
Collector-base voltage (open emitter)	V_{CBO}	max	45	45	V
Collector-emitter voltage (open base)	V_{CEO}	max	45	45	V
Collector current (peak value)	I_{CM}	max	60	60	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max	300	300	mW
Junction temperature	T_j	max	175	175	°C
D.C. current gain at T_j = 25 °C					
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	>	40	100	
		<	120	300	
I_C = 10 mA; V_{CE} = 5 V	h_{FE}	>	100	150	
		<	350	600	
Transition frequency					
I_C = 0,5 mA; V_{CE} = 5 V	f_T	typ	80	80	MHz
Noise figure at R_S = 10 kΩ					
I_C = 10 μA; V_{CE} = 5 V		typ	2,5	2	dB
f = 10 Hz to 15 kHz	F	<	4	3	dB

MECHANICAL DATA

Dimensions in mm

TO-18

Collector connected to case



Accessories: 56246 (distance disc); 56263 (cooling fin).

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	$R_{th\ j\text{-}a}$	=	0.5	$^oC/mW$
From junction to case	$R_{th\ j\text{-}c}$	=	0.25	$^oC/mW$

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

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

		2N929	2N930	
<u>D.C. current gain</u>				
$I_C = 10\ \mu A$; $V_{CE} = 5$ V	h_{FE}	40 to 120	100 to 300	
$I_C = 10\ \mu A$; $V_{CE} = 5$ V; $T_j = -55\ ^{o}C$	h_{FE}	> 10	> 20	
$I_C = 500\ \mu A$; $V_{CE} = 5$ V	h_{FE}	> 60	> 150	
$I_C = 10$ mA; $V_{CE} = 5$ V	h_{FE}	100 to 350	150 to 600	
<u>Collector capacitance</u> at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	< 8	< 8	pF
<u>Transition frequency</u>				
$I_C = 0.5$ mA; $V_{CE} = 5$ V	f_T	> 50	> 50	MHz
<u>Cut-off frequency</u>				
$I_C = 0.5$ 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	$\mu\Omega^{-1}$

SILICON PLANAR TRANSISTORS

N-P-N transistors in TO-18 metal envelopes with the collector connected to the case.

These transistors are primarily intended for use in high performance, low-level, low-noise amplifier applications both for direct current and frequencies of up to 100 MHz.

QUICK REFERENCE DATA

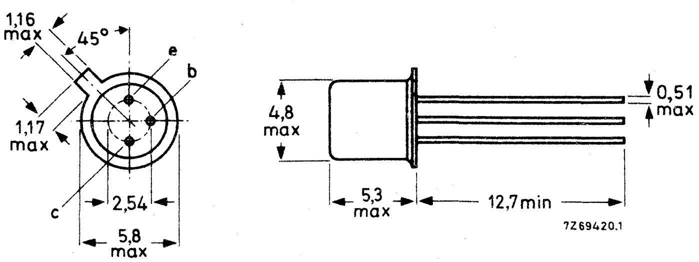
			2N2483	2N2484	
Collector-base voltage (open emitter)	V_{CBO}	max	60	60	V
Collector-emitter voltage (open base)	V_{CEO}	max	60	60	V
Collector current (peak value)	I_{CM}	max	50	50	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max	360	360	mW
Junction temperature	T_j	max	200	200	°C
D.C. current gain at T_j = 25 °C					
I_C = 10 μA; V_{CE} = 5 V	h_{FE}	>	40	100	
		<	120	500	
I_C = 1 mA; V_{CE} = 5 V	h_{FE}	>	175	250	
I_C = 10 mA; V_{CE} = 5 V	h_{FE}	<	500	800	
Transition frequency					
I_C = 0,5 mA; V_{CE} = 5 V	f_T	typ	80	80	MHz
Noise figure at R_S = 10 kΩ					
I_C = 10 μA; V_{CE} = 5 V; B = 15,7 kHz	F	<	4	3	dB

MECHANICAL DATA

Dimensions in mm

TO-18

Collector connected to case



Accessories: 56246 (distance disc); 56263 (cooling fin).

RATINGS (Limiting values) [1])

Voltages

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

Currents

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

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360	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	$R_{th\ j-a}$	=	0.48	°C/mW
From junction to case	$R_{th\ j-c}$	=	0.15	°C/mW

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

CHARACTERISTICS — T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 45$ V	I_{CBO}	<	10	nA
$I_E = 0$; $V_{CB} = 45$ V; $T_j = 150$ °C	I_{CBO}	<	10	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	nA
Base-emitter voltage				
$I_C = 0.1$ mA; $V_{CE} = 5$ V	V_{BE}		0.5 to 0.7	V
Collector-emitter saturation voltage				
$I_C = 1$ mA; $I_B = 0.1$ mA	V_{CEsat}	<	350	mV

D.C. current gain			2N2483	2N2484	
$I_C = 1$ μA; $V_{CE} = 5$ V	h_{FE}	>		30	
$I_C = 10$ μA; $V_{CE} = 5$ V	h_{FE}		40 to 120	100 to 500	
$I_C = 10$ μA; $V_{CE} = 5$ V; $T_j = 55$ °C	h_{FE}	>	10	20	
$I_C = 100$ μA; $V_{CE} = 5$ V	h_{FE}	>	75	175	
$I_C = 500$ μA; $V_{CE} = 5$ V	h_{FE}	>	100	200	
$I_C = 1$ mA; $V_{CE} = 5$ V	h_{FE}	>	175	250	
$I_C = 10$ mA; $V_{CE} = 5$ V [1]	h_{FE}	<	500	800	
Collector capacitance at f = 1 MHz					
$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	<	6	6	pF
Emitter capacitance at f = 1 MHz					
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	<	6	6	pF
Transition frequency					
$I_C = 50$ μA; $V_{CE} = 5$ V	f_T	>	12	15	MHz
$I_C = 500$ μA; $V_{CE} = 5$ V	f_T	>	60	60	MHz
		typ.	80	80	MHz

[1]) Measured under pulsed conditions to prevent excessive dissipation.
Pulse duration t < 300 μs; duty cycle $\delta < 0.01$

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

Noise figure

I_C = 10 μA; V_{CE} = 5 V; R_S = 10 kΩ

		2N2483	2N2484	
f = 100 Hz; bandwidth 20 Hz	F	< 15	10	dB
f = 1 kHz; bandwidth 200 Hz	F	< 4	3	dB
f = 10 kHz; bandwidth 2 kHz	F	< 3	2	dB
Wide band: bandwidth 15.7 kHz	F	< 4	3	dB

h parameters at f = 1 kHz

I_C = 1 mA; V_{CE} = 5 V

		2N2483	2N2484	
Input impedance	h_{ie}	1.5 to 13	3.5 to 24	kΩ
Reverse voltage transfer	h_{re}	< 8	8	10^{-4}
Small signal current gain	h_{fe}	80 to 450	150 to 900	
Output admittance	h_{oe}	< 30	40	$\mu\Omega^{-1}$

Low-frequency power transistors

GERMANIUM ALLOYED POWER TRANSISTORS

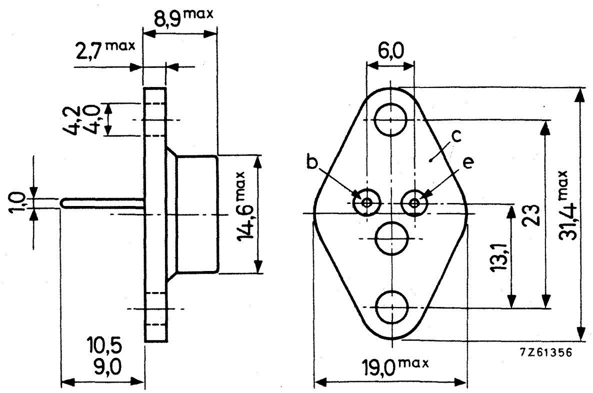
N-P-N power transistor in a metal envelope with the collector connected to the mounting base.
The AD161 is primarily intended for use together with the p-n-p power transistor AD162 as matched pair AD161/AD162 in 10 W complementary symmetry class-B output stages of mains operated amplifiers and radio 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 °C	P_{tot}	max.	4	W
Junction temperature (incidental)	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.	35	kHz

MECHANICAL DATA — Dimensions in mm

Collector connected to mounting base

SOT-9



Accessories: 56203 (mica washer and 2 insulating bushes).

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

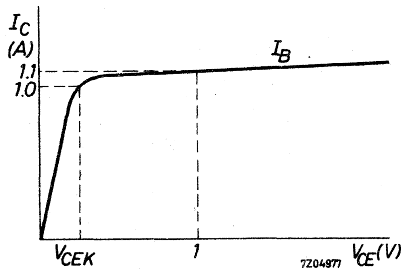
I_C = 0; V_{EB} = 10 V	I_{EBO}	typ.	20	μA
		<	200	μA
I_C = 0; V_{EB} = 10 V; T_j = 90 °C	I_{EBO}	<	2	mA

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

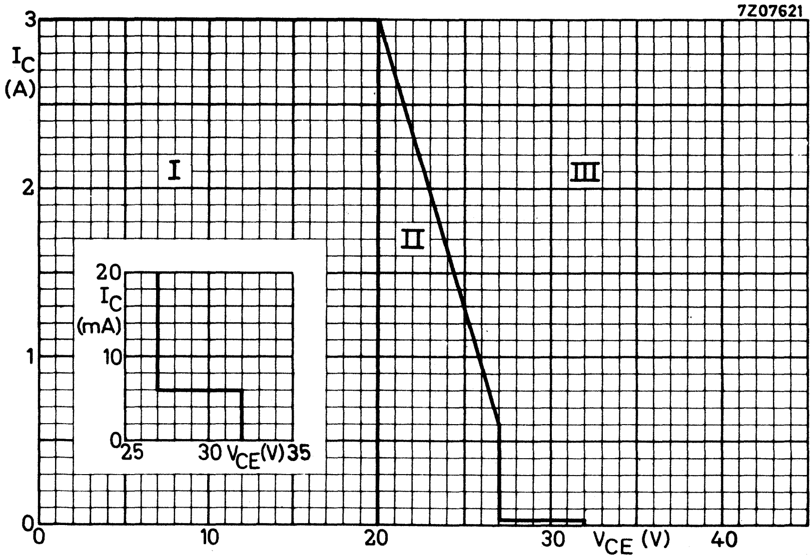
I_C = 10 mA; V_{CE} = 2 V	f_T	typ.	3	MHz

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

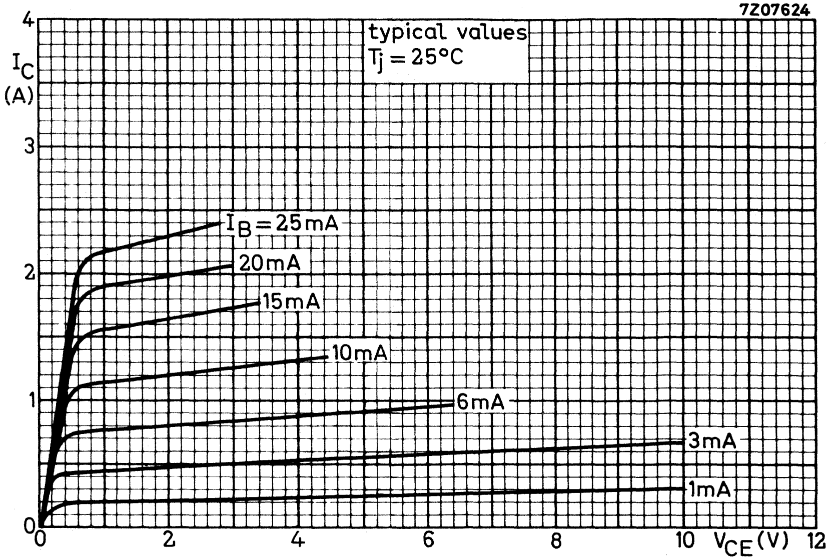
$\lvert I_C \rvert$ = 500 mA; $\lvert V_{CE} \rvert$ = 1 V	h_{FE1}/h_{FE2}	typ.	1.1
		<	1.25

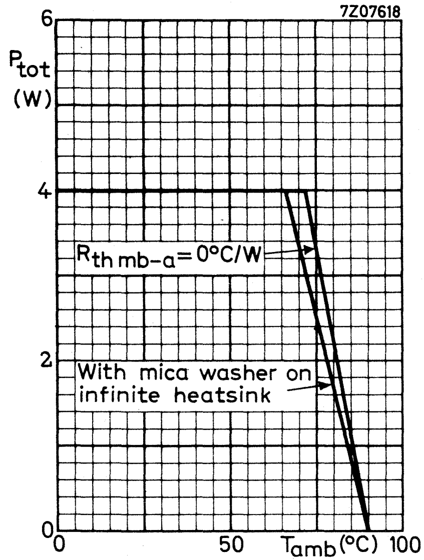


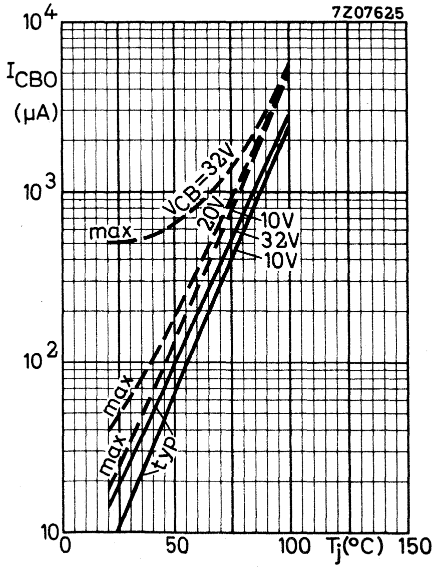
I = Region of permissible operation under all base-emitter conditions.

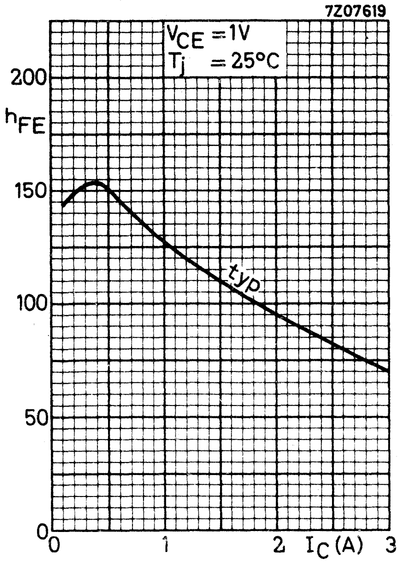
II = Additional region of operation when the transistor is cut-off with $-V_{BE} \geq -V_{BEfl}$.

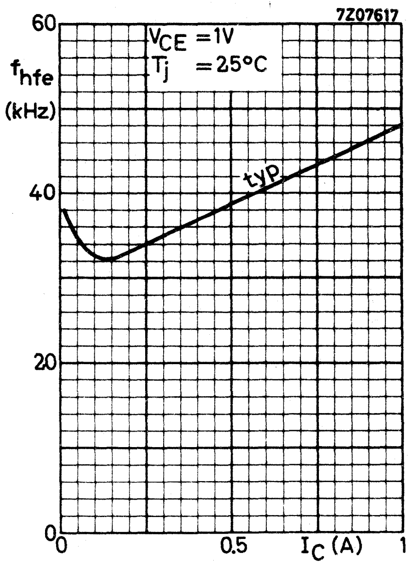
III = Outside regions I and II, the transistor can withstand transient energies of 1 mWs, provided it is cut-off with $-V_{BB} \leq 0.6$ V; R_i = 18 Ω.

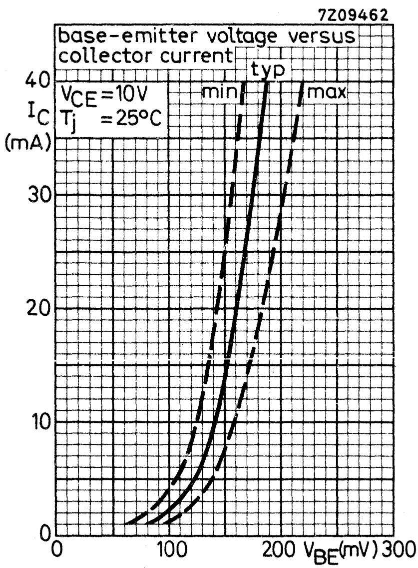

7Z07624
typical values
$T_j = 25°C$
I_C (A)
$I_B = 25 mA$
20mA
15mA
10mA
6mA
3mA
1mA
V_{CE} (V)
0
1
2
3
4
0
2
4
6
8
10
12

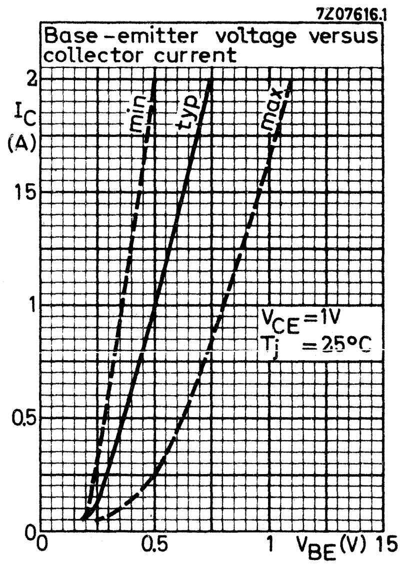

7Z07618
P_{tot} (W)
$R_{th\,mb-a} = 0°C/W$
With mica washer on
infinite heatsink
T_{amb} (°C)
0
2
4
6
0
50
100


7Z07625
I_{CBO} (μA)
max
VCB=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
h_{FE}
200
150
100
50
0
typ
0
1
2
I_C (A)
3


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


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


7Z07616.1
Base-emitter voltage versus
collector current
min
typ
max
2
I_C
(A)
15
1
0.5
0
V_{CE} = 1V
T_j = 25°C
0
0.5
1
V_{BE} (V) 15

GERMANIUM ALLOYED POWER TRANSISTORS

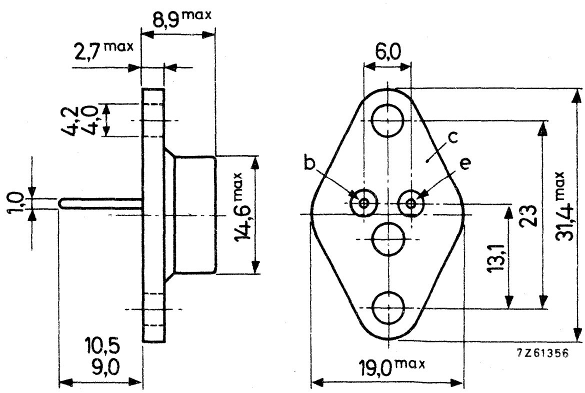
P-N-P power transistor in a metal envelope with the collector connected to the mounting base.
It is primarily intended for use as matched pair 2-AD162 in class-B push-pull output stages, and together with the n-p-n power transistor AD161 as matched pair AD161/ AD162 in 10 W complementary symmetry class-B 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 (incidental)	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

SOT-9



Accessories: 56203 (mica washer and 2 insulating bushes).

RATINGS (Limiting values) [1]

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20	V
Collector-emitter voltage with $+V_{BE}$ = 0.6 V (See also page 4)	$-V_{CEX}$	max.	32	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	10	V

Currents

Collector current (d.c. or average over any 50 ms period)	$-I_C$	max.	1	A
Collector current (peak value)	$-I_{CM}$	max.	3	A

Power dissipation

Total power dissipation up to T_{mb} = 63 °C	P_{tot}	max.	6	W

Temperatures

Storage temperature	T_{stg}		-65 to +90	°C
Junction temperature: continuous	T_j	max.	90	°C
incidentally	T_j	max.	100	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	4.5	°C/W
From mounting base to heatsink with mica washer	$R_{th\ mb-h}$	=	1.5	°C/W
without mica washer	$R_{th\ mb-h}$	=	0.5	°C/W

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

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $-V_{CB} = 32$ V	$-I_{CBO}$	typ.	15	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

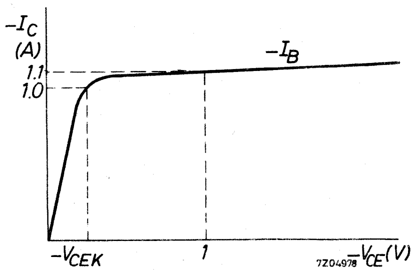
$I_C = 0$; $-V_{EB} = 10$ V	$-I_{EBO}$	typ.	15	μA
		<	200	μA
$I_C = 0$; $-V_{EB} = 10$ V; $T_j = 90$ °C	$-I_{EBO}$	<	2	mA

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

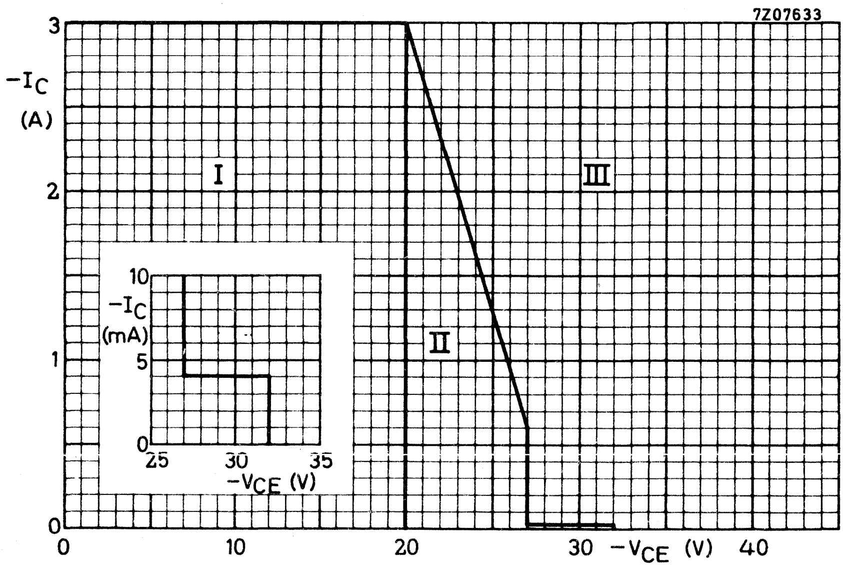
Collector capacitance at f = 450 kHz

$I_E = I_e = 0$; $-V_{CB} = 5$ V	C_c	typ.	115	pF

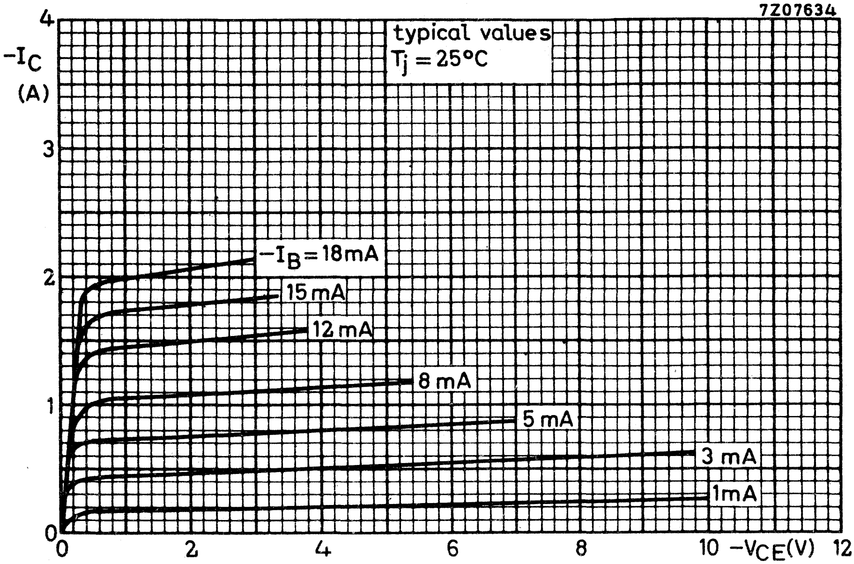
[1]) $-V_{BE}$ decreases by about 2 mV/°C with increasing temperature.

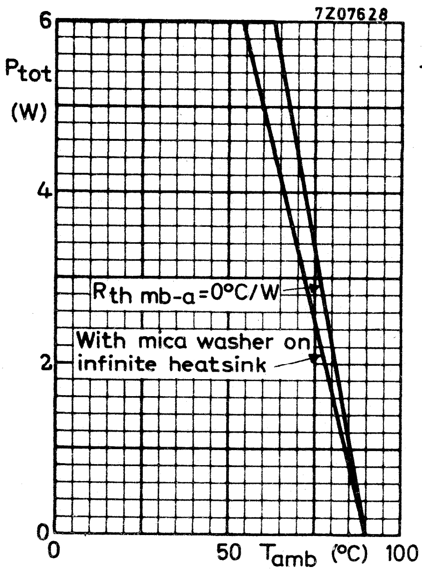
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

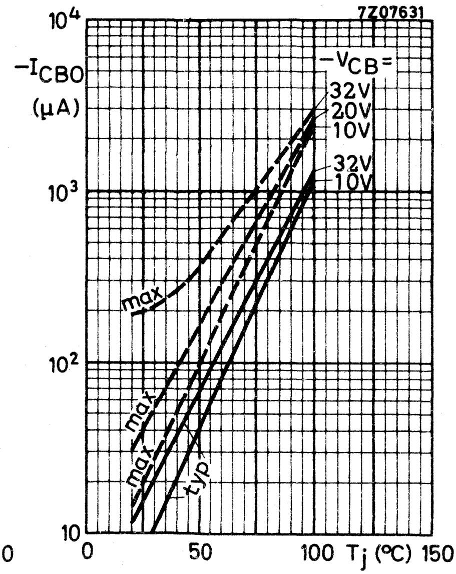
D.C. current gain		
$-I_C$ = 5 mA; $-V_{CE}$ = 10 V	h_{FE}	> 60
$-I_C$ = 50 mA; $-V_{CE}$ = 1 V	h_{FE}	74 to 300
$-I_C$ = 500 mA; $-V_{CE}$ = 1 V	h_{FE}	typ. 150 80 to 320
$-I_C$ = 2 A ; $-V_{CE}$ = 1 V	h_{FE}	> 60
Transition frequency		
$-I_C$ = 10 mA; $-V_{CE}$ = 2 V	f_T	typ. 1.5 MHz
Cut-off frequency		
$-I_C$ = 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

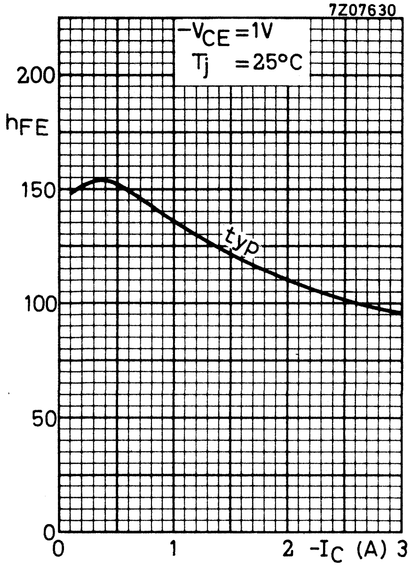


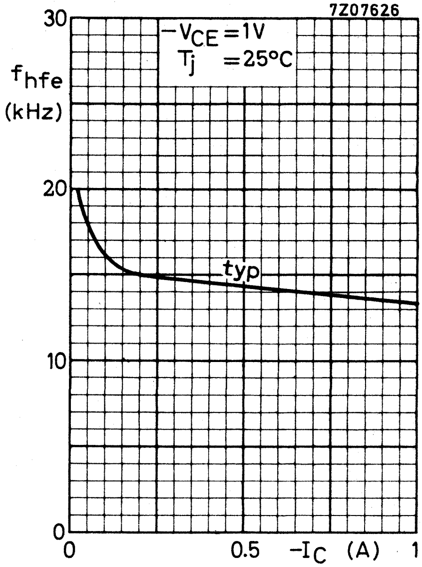
I Region of permissible operation under all base-emitter conditions.
II Additional region of operation when the transistor is cut-off with $V_{BE} \geq V_{BEfl}$.
III Outside regions I and II, the transistor can withstand transient energies of 4.5 mWs, provided it is cut-off with $+V_{BB} < 0.6$ V; R_i = 18 Ω.

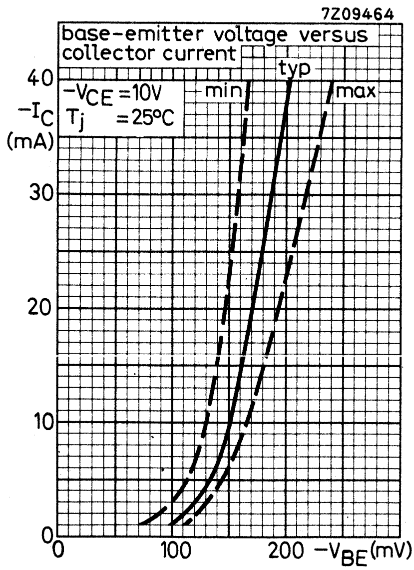

7Z07634
typical values
$T_j = 25°C$
$-I_C$ (A)
$-I_B = 18mA$
15 mA
12 mA
8 mA
5 mA
3 mA
1mA
$-V_{CE}$ (V)

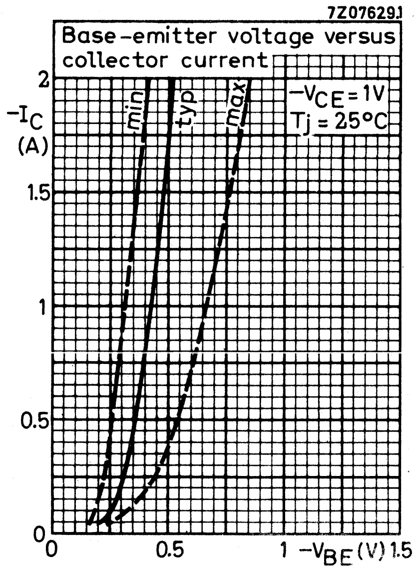

7Z07628
P_{tot} (W)
$R_{th\ mb-a} = 0°C/W$
With mica washer on infinite heatsink
T_{amb} (°C)


7Z07631
$-I_{CBO}$ (μA)
$-V_{CB}=$
32V
20V
10V
32V
10V
max
max
max
typ
T_j (°C)


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

GERMANIUM ALLOYED POWER TRANSISTORS

P-N-P low-spread medium-gain power transistors in TO-3 metal envelopes intended for power switching at high currents.

QUICK REFERENCE DATA

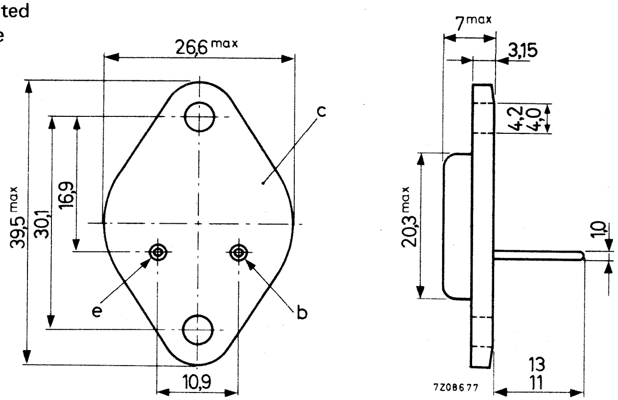
			ASZ15	ASZ16	ASZ17	ASZ18	
Collector-base voltage (open emitter)	$-V_{CBO}$	max	100	60	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max	60	32	32	32	V
Total power dissipation up to T_{mb} = 45 °C	P_{tot}	max	30	30	30	30	W
Junction temperature	T_j	max	90	90	90	90	°C
D.C. current gain at T_j = 25 °C $-I_C$ = 1 A; $-V_{CE}$ = 1 V	h_{FE}	> <	20 55	45 130	25 75	30 110	
$-I_C$ = 6 A; $-V_{CE}$ = 1 V	h_{FE}	> <	15 30	35 80	20 45	20 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



For mounting instructions and accessories see Accessories.

FOR NEW DESIGN THE BDX92 FAMILY IS RECOMMENDED

SILICON PLANAR POWER TRANSISTOR

N-P-N 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.

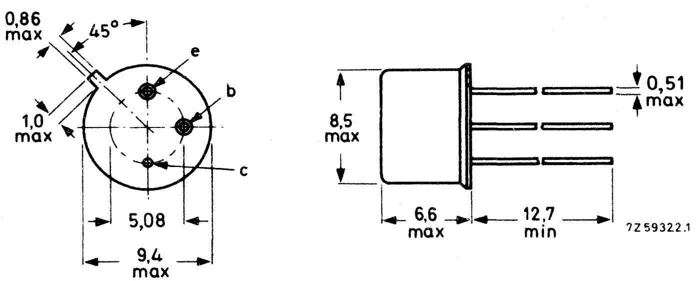
QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	245	V
Collector-emitter voltage (open base)	V_{CEO}	max.	180	V
Collector current (peak value)	I_{CM}	max.	200	mA
Total power dissipation up to T_{amb} = 50 °C (device mounted on a heatsink)	P_{tot}	max.	6	W
D.C. current gain 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



Maximum lead diameter is guaranteed only for 12,7 mm.

Accessories :56218 (package); 56245 (distance disc).

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 blackened Al heatsink of at least 30 cm^2 (See also page 5)	P_{tot}	max.	6	W

Temperatures

Storage temperature	T_{stg}		-65 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

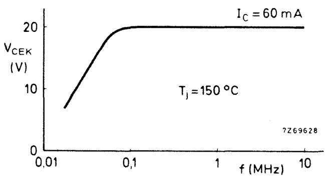
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	200	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	12,5	°C/W
From junction to ambient mounted on a 1,5 mm blackened aluminium heatsink of at least 30 cm^2	$R_{th\ j\text{-}a}$	=	25	°C/W

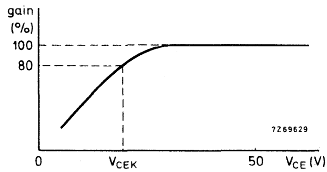
[1]) During switching on, a supply voltage of 1,2 times the rated V_{CER} value is permitted. The current must be limited so that maximum dissipation and maximum junction temperature are not exceeded.

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

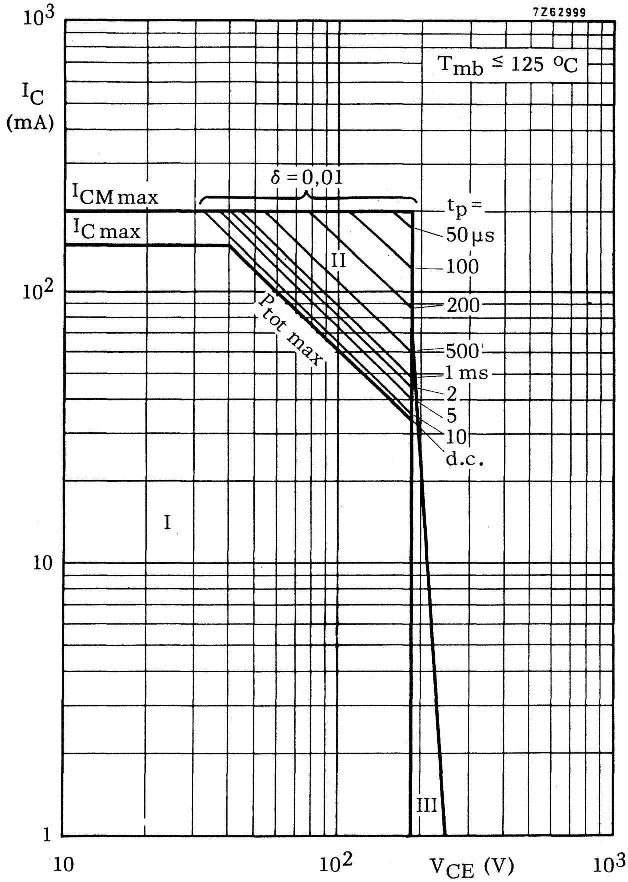
The high frequency knee voltage of a transistor is that value of the collector-emitter voltage at which the small signal gain, measured in a practical circuit, has dropped to 80% of the gain at V_{CE} = 50 V. A further decrease of the collector-emitter voltage results in a rapid increase of the distortion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





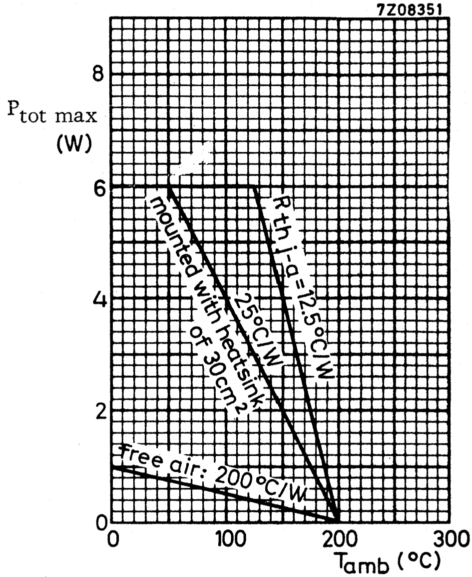
D.C. current gain				
I_C = 50 mA; V_{CE} = 100 V	h_{FE}	> typ.	22 60	
Ratio of h_{FE} at I_C = 100 mA; V_{CE} = 15 V and at I_C = 10 mA; V_{CE} = 165 V		typ.	1,1	
Feedback capacitance				
I_C = 10 mA; V_{CE} = 20 V; f = 1,0 MHz	C_{re}	<	3,5	pF
Feedback time constant				
$-I_E$ = 10 mA; V_{CB} = 10 V; 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

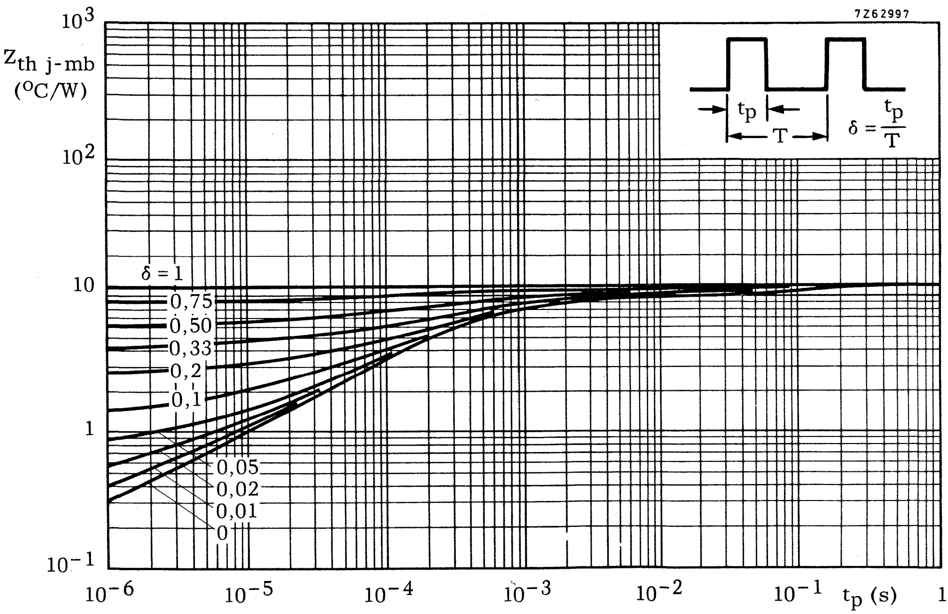
[1] V_{BE} decreases by about 2 mV/°C with increasing temperature.

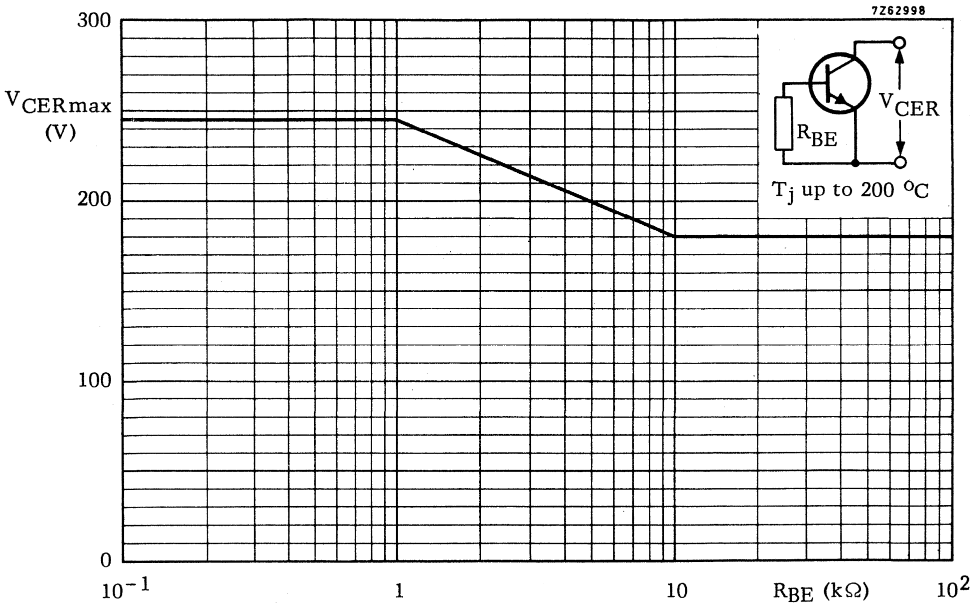


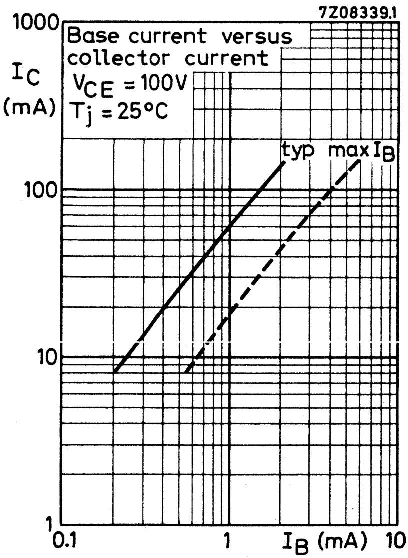
Safe Operating Area with the transistor forward biased

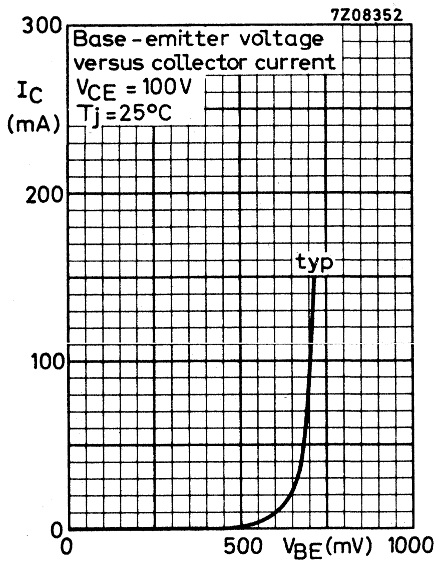
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation
III Operation in this region is allowable, provided $R_{BE} \leq 1\ k\Omega$. (See also note [1]) page 2.)

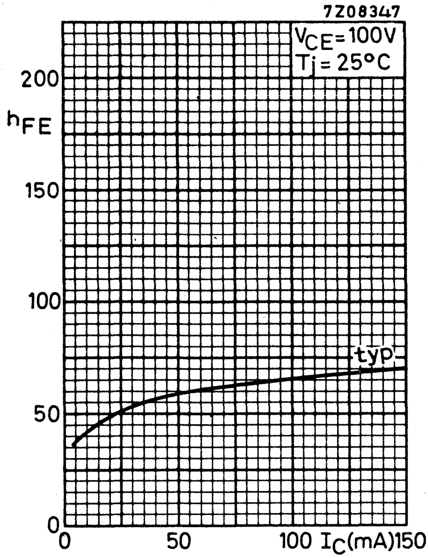

7Z08351
$P_{tot\ max}$ (W)
free air: 200 °C/W
mounted with heatsink of 30cm²
25°C/W
R th j-a = 12.5 °C/W
T_{amb} (°C)
0
100
200
300
0
2
4
6
8

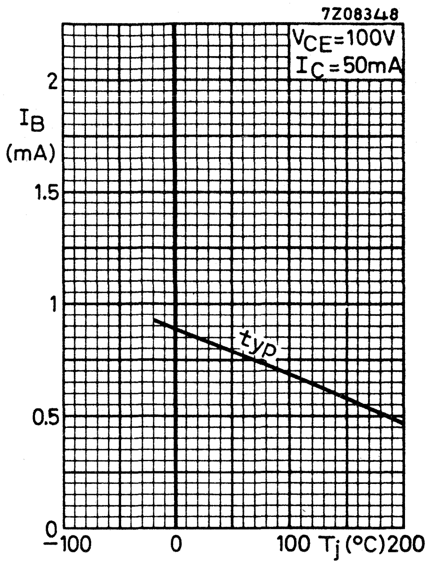

7Z62997
$Z_{th\ j-mb}$ (°C/W)
t_p (s)
δ = 1
0,75
0,50
0,33
0,2
0,1
0,05
0,02
0,01
0
t_p
T
$\delta = \frac{t_p}{T}$
10^3
10^2
10
1
10^{-1}
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1

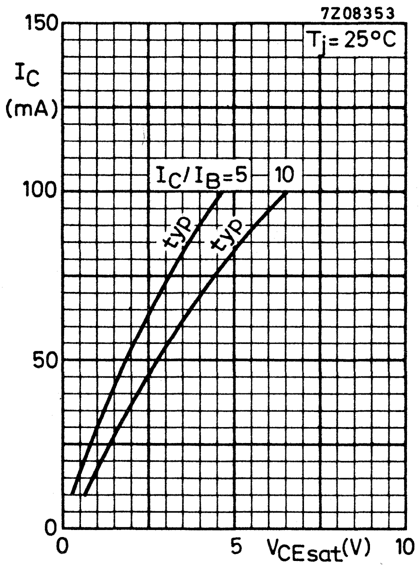

7Z62998
300
200
100
0
VCERmax
(V)
RBE
VCER
Tj up to 200 °C
10−1
1
10
RBE (kΩ)
10²

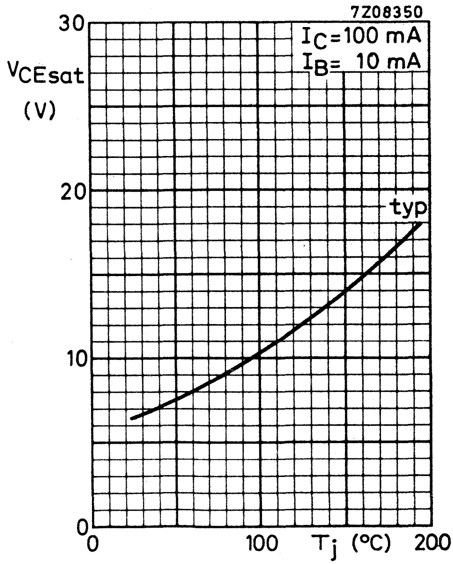

7Z08339.1
Base current versus
collector current
VCE = 100V
Tj = 25°C
IC
(mA)
1000
100
10
1
typ
max IB
0.1
1
IB (mA)
10

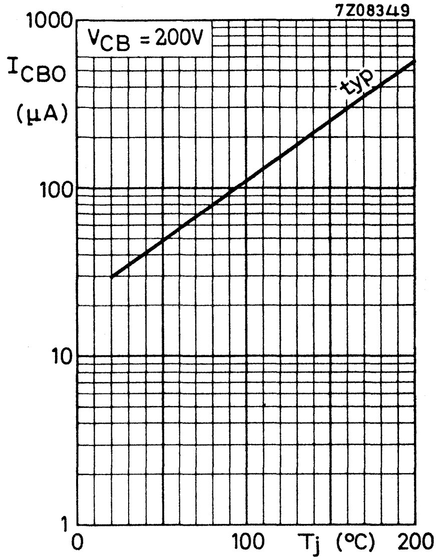

7Z08352
Base-emitter voltage
versus collector current
VCE = 100V
Tj = 25°C
IC
(mA)
300
200
100
0
typ
0
500
VBE (mV)
1000

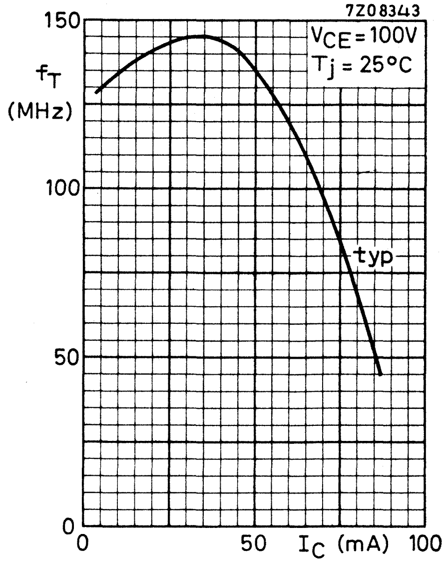

7Z08347
VCE=100V
Tj=25°C
hFE
200
150
100
50
0
typ
0
50
100
IC(mA)150

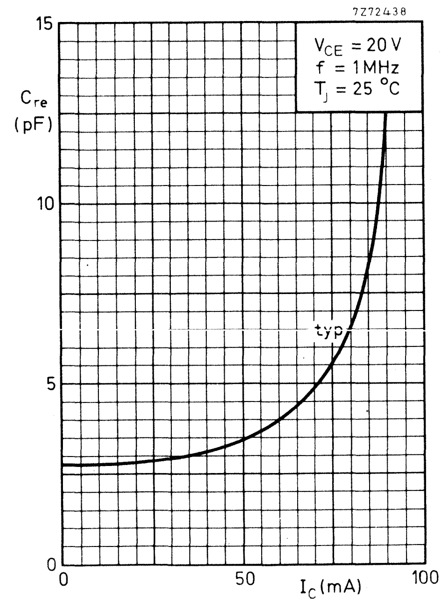

7Z08348
VCE=100V
IC=50mA
IB
(mA)
2
1.5
1
0.5
0
typ
−100
0
100
Tj(°C)200

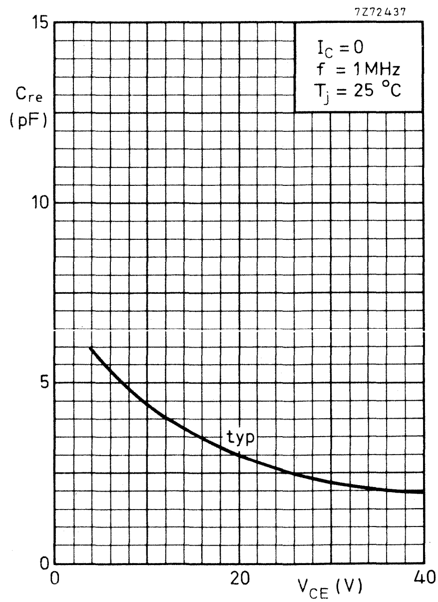

7Z08353
Tj=25°C
IC
(mA)
150
100
50
0
IC/IB=5
10
typ
typ
0
5
VCEsat(V)
10


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

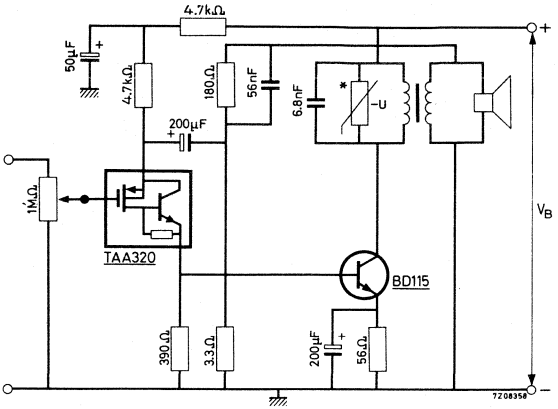

7Z08349
1000
I_{CBO}
(µA)
V_{CB} = 200V
typ
100
10
1
0
100
T_j (°C)
200


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


7Z72438
15
C_{re}
(pF)
V_{CE} = 20 V
f = 1 MHz
T_j = 25 °C
10
typ
5
0
0
50
I_C (mA)
100


7Z72437
15
C_{re}
(pF)
I_C = 0
f = 1 MHz
T_j = 25 °C
10
5
typ
0
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

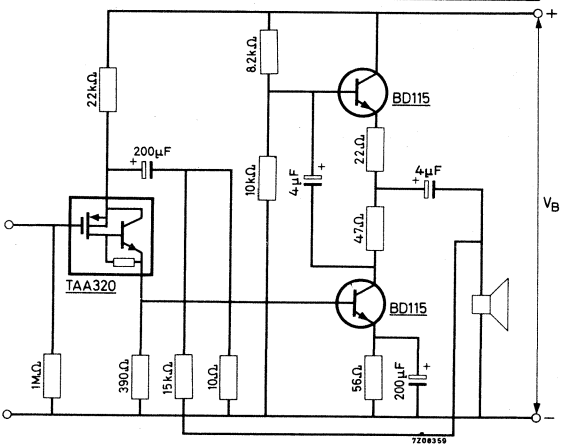
Output power at d_{tot} = 10% (on primary of the output transformer)	P_o	typ.	2.6	W
Input voltage for P_o = 50 mW	$V_{i(rms)}$	typ.	13.5	mV
Input voltage for P_o = 2 W	$V_{i(rms)}$	typ.	86	mV
Total distortion at P_o = 2 W	d_{tot}	typ.	3.6	%
Frequency response (−3 dB)		60 Hz to 20		kHz
Signal-noise ratio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

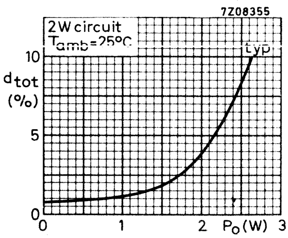


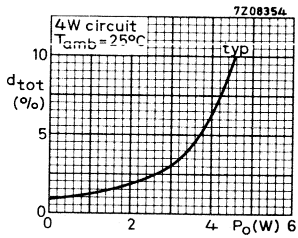
Supply voltage	V_B		200	V
Collector current of a BD115	I_C	typ.	52	mA
Drain current of TAA320	$-I_D$	typ.	8.6	mA

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

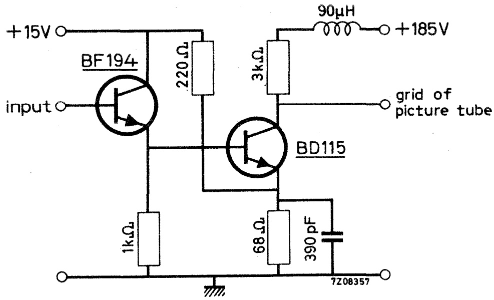




APPLICATION INFORMATION (continued)

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: $R_{th\ j-a}$ < 45 °C/W.
   To ensure the above mentioned performance for bandwidth and transient response, the contribution of the heatsink to the total output capacitance of the device should not exceed 4 pF.
2. For grid drive of the picture tube, the sync pulses must be negative going.
   To avoid driving the output transistor into the high frequency knee voltage, the sync pulses must be clipped before the output stage.

SILICON PLANAR EPITAXIAL POWER TRANSISTOR

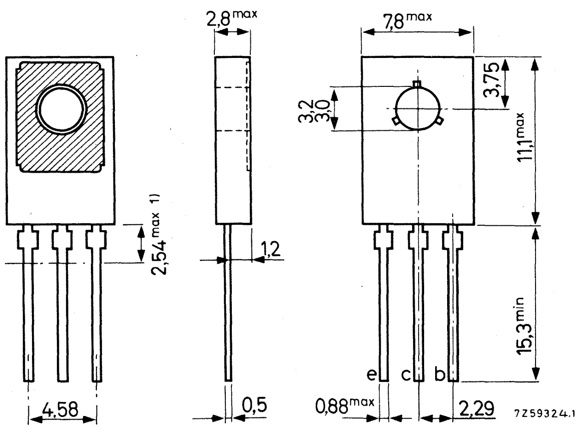
N-P-N transistor in a SOT-32 plastic envelope for general purpose, medium power applications. P-N-P complement is BD132.

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.	15	W
Junction temperature	T_j	max.	150	°C
D.C. current gain I_C = 0,5 A; V_{CE} = 12 V	h_{FE}	>	40	
Transition frequency I_C = 0,25 A; V_{CE} = 5 V	f_T	>	60	MHz

MECHANICAL DATA Dimensions in mm

TO-126 (SOT-32)

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)

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.	15	W

Temperatures

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

THERMAL RESISTANCE

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

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 50$ V	I_{CBO}	<	5	μA
$I_E = 0$; $V_{CB} = 50$ V; $T_j = 150$ °C	I_{CBO}	<	500	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	5	μA
Saturation voltages				
$I_C = 0,5$ A; $I_B = 50$ mA	V_{CEsat}	<	0,3	V
	V_{BEsat}	<	1,2	V
$I_C = 2$ A; $I_B = 200$ mA	V_{CEsat}	<	0,7	V
	V_{BEsat}	<	1,5	V
D.C. current gain				
$I_C = 0,5$ A; $V_{CE} = 12$ V	h_{FE}	>	40	
$I_C = 2$ A; $V_{CE} = 1$ 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; $T_{amb} = 25$ °C	f_T	>	60	MHz

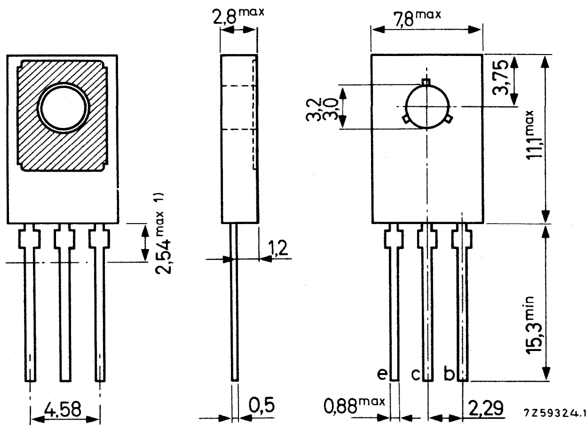
SILICON PLANAR EPITAXIAL POWER TRANSISTOR

P-N-P transistor in a SOT-32 plastic envelope for general purpose, medium power applications. N-P-N complement is BD131.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	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.	15	W
Junction temperature	T_j	max.	150	°C
D.C. current gain $-I_C$ = 0,5 A; $-V_{CE}$ = 12 V	h_{FE}	>	40	
Transition frequency $-I_C$ = 0,25 A; $-V_{CE}$ = 5 V	f_T	>	60	MHz

MECHANICAL DATA Dimensions in mm

TO-126 (SOT-32)
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)

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	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.	15	W
→ Temperatures				
Storage temperature	T_{stg}	-65 to +150		°C
Junction temperature	T_j	max.	150	°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				
$I_E = 0$; $-V_{CB} = 40$ V	$-I_{CBO}$	<	5	μA
$I_E = 0$; $-V_{CB} = 40$ V; $T_j = 150$ °C	$-I_{CBO}$	<	500	μA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 3$ V	$-I_{EBO}$	<	5	μA
Saturation voltages				
$-I_C = 0,5$ A; $-I_B = 50$ mA	$-V_{CEsat}$	<	0,3	V
	$-V_{BEsat}$	<	1,2	V
$-I_C = 2$ A; $-I_B = 200$ mA	$-V_{CEsat}$	<	0,7	V
	$-V_{BEsat}$	<	1,5	V
D.C. current gain				
$-I_C = 0,5$ A; $-V_{CE} = 12$ V	h_{FE}	>	40	
$-I_C = 2$ A; $-V_{CE} = 1$ V	h_{FE}	>	20	
Transition frequency at f = 35 MHz				
$-I_C = 0,25$ A; $-V_{CE} = 5$ V; $T_{amb} = 25$ °C	f_T	>	60	MHz

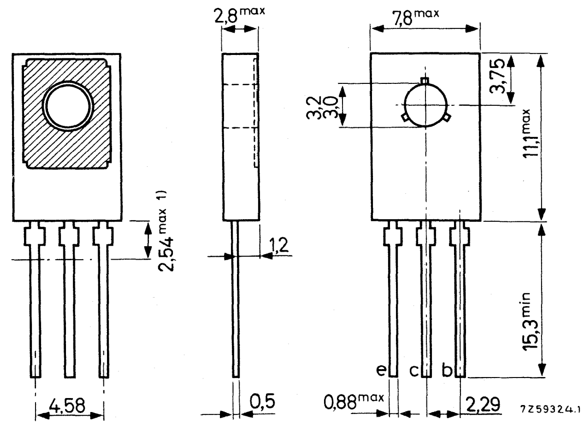
SILICON PLANAR EPITAXIAL POWER TRANSISTOR

N-P-N transistor in a SOT-32 plastic envelope 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.	15	W
Junction temperature	T_j	max.	150	°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

TO-126 (SOT-32)
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)

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 ^oC	P_{tot}	max.	15	W
Temperatures				
Storage temperature	T_{stg}		−65 to +150	^oC
Junction temperature	T_j	max.	150	^oC

THERMAL RESISTANCE

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

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	<	5	μA
$I_E = 0$; $V_{CB} = 60$ V; $T_j = 150$ °C	I_{CBO}	<	500	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	5	μA
Saturation voltages				
$I_C = 0,5$ A; $I_B = 50$ mA	V_{CEsat}	<	0,3	V
	V_{BEsat}	<	1,2	V
$I_C = 2,0$ A; $I_B = 200$ mA	V_{CEsat}	<	0,7	V
	V_{BEsat}	<	1,5	V
D.C. current gain				
$I_C = 0,5$ A; $V_{CE} = 12$ V	h_{FE}	>	40	
$I_C = 2$ A; $V_{CE} = 1$ 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; $T_{amb} = 25$ °C	f_T	>	60	MHz

SILICON PLANAR EPITAXIAL POWER 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.

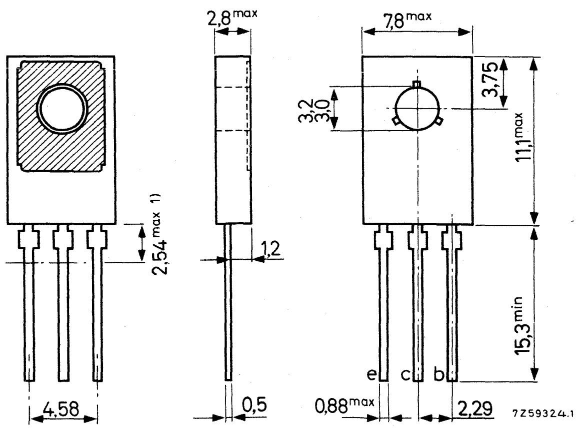
QUICK REFERENCE DATA

			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	250	250	
Transition frequency						
I_C = 50 mA; V_{CE} = 5 V	f_T	typ.	250	250	250	MHz

MECHANICAL DATA Dimensions in mm

TO-126 (SOT-32)

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)

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						
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}		−65 to +150	°C
Junction temperature	T_j	max.	150	°C

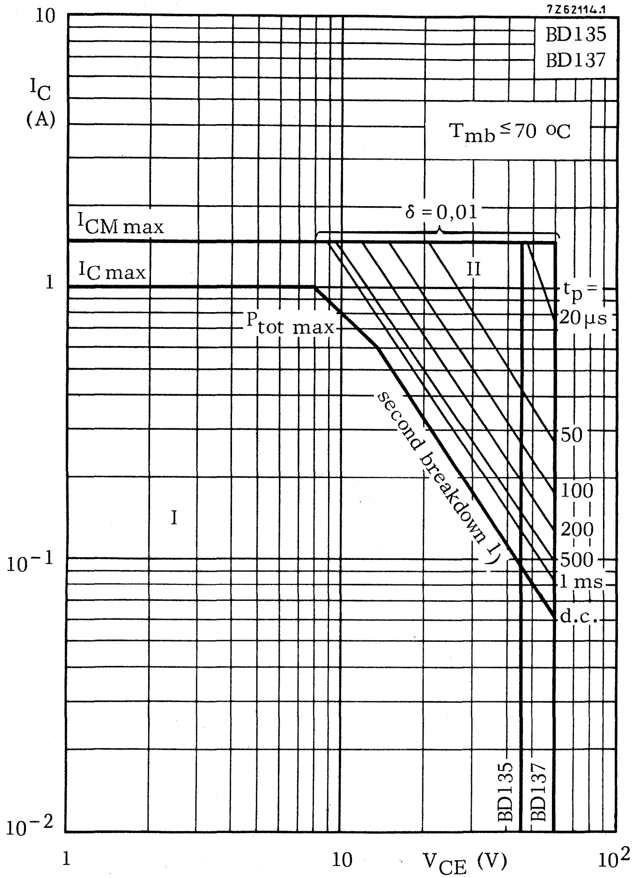
THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	100	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	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				
$I_C = 5$ mA; $V_{CE} = 2$ V	h_{FE}	>	25	
$I_C = 150$ mA; $V_{CE} = 2$ V	h_{FE}		40 to 250 ←	
$I_C = 500$ mA; $V_{CE} = 2$ V	h_{FE}	>	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				
$\|I_C\| = 150$ mA; $\|V_{CE}\| = 2$ V	h_{FE1}/h_{FE2}	typ	1,3	
		<	1,6	

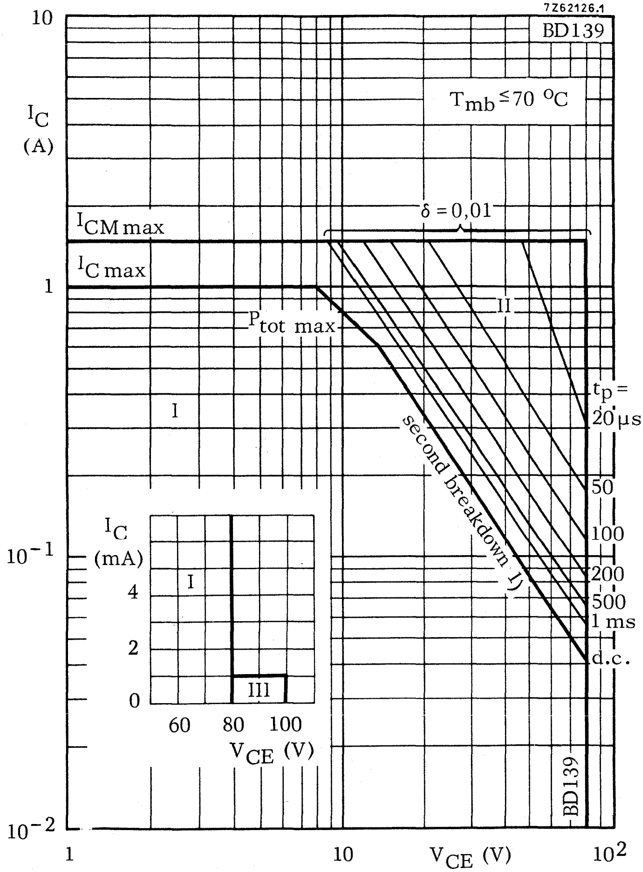


Safe Operating Area with the transistor forward biased

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

---

1) Independent of temperature

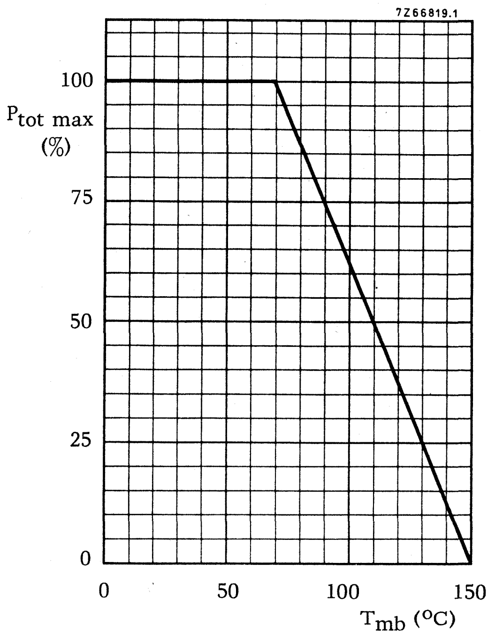


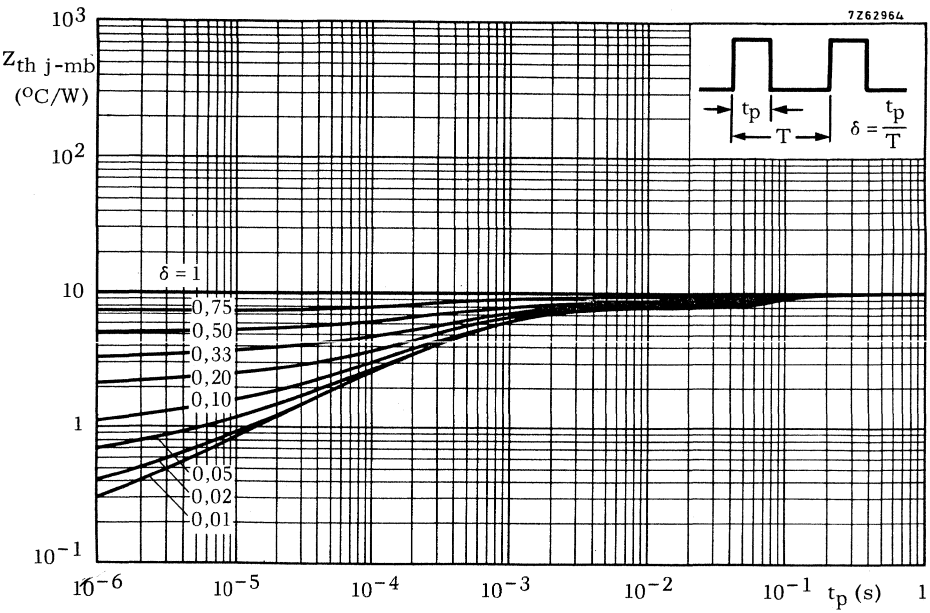
Safe Operating Area with the transistor forward biased

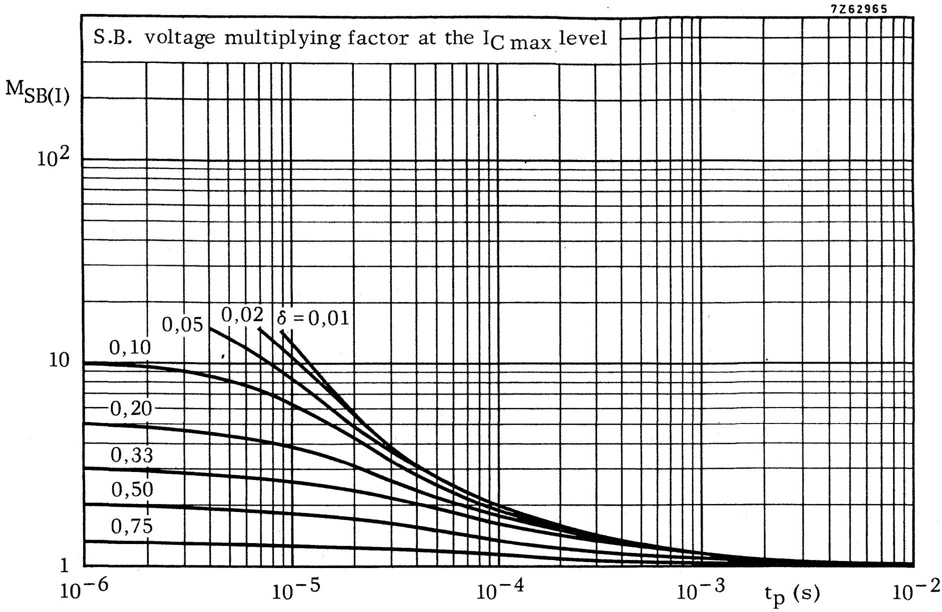
I Region of permissible d.c. operation
II Permissible extension for repetitive pulsed operation
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 1$ kΩ

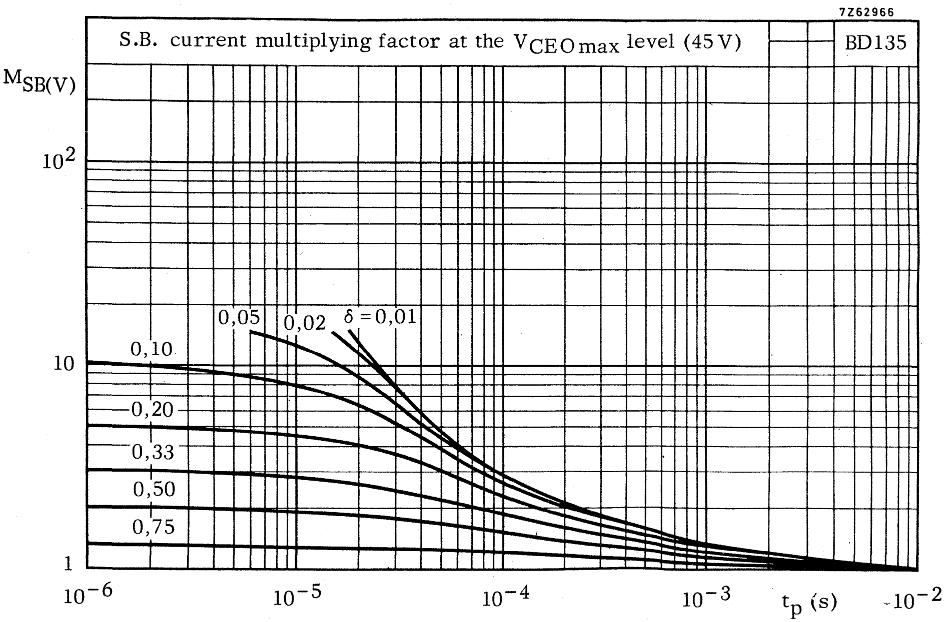
---

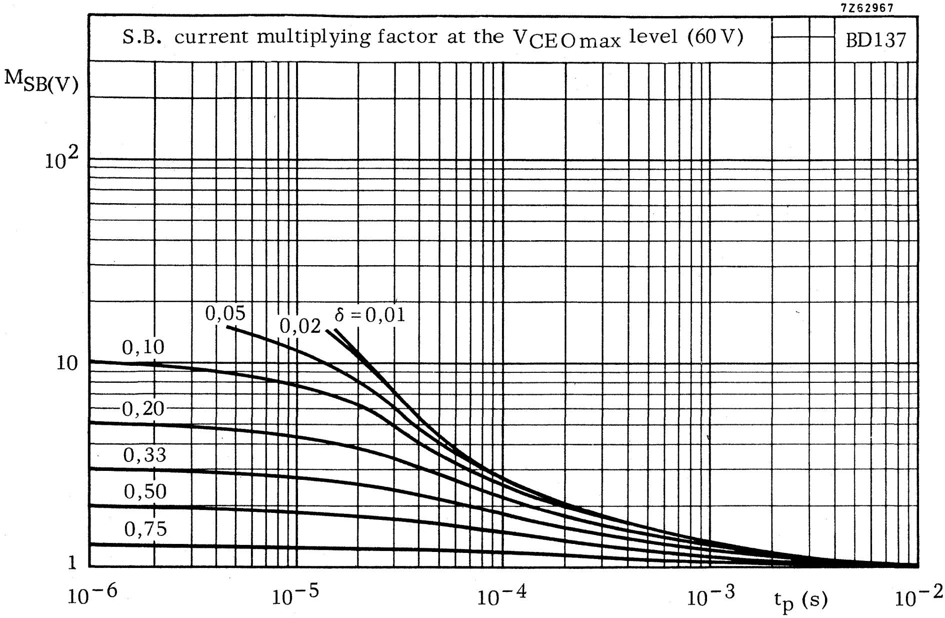
1) Independent of temperature

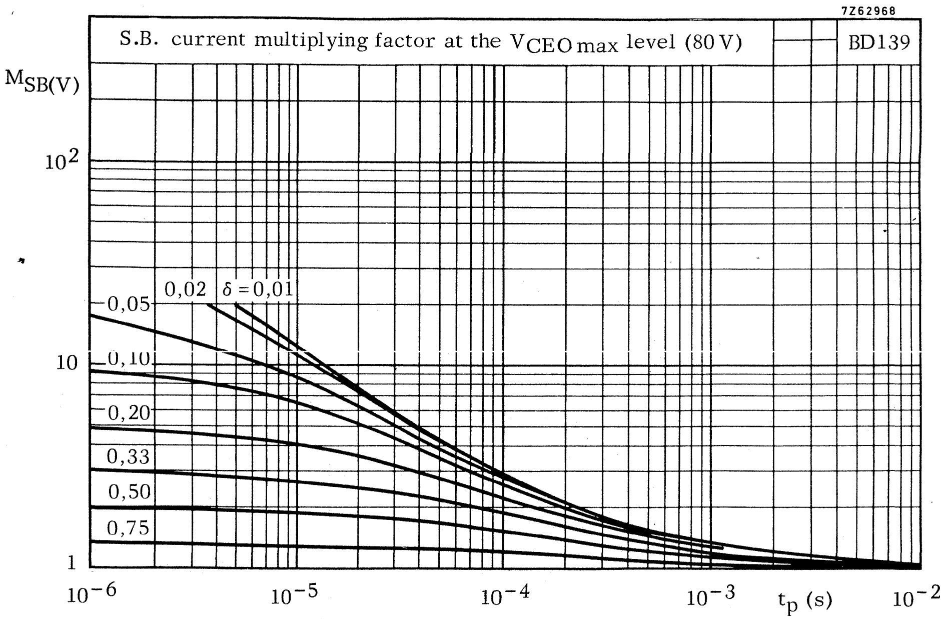

7Z66819.1
100
Ptot max
(%)
75
50
25
0
0
50
100
150
Tmb (°C)

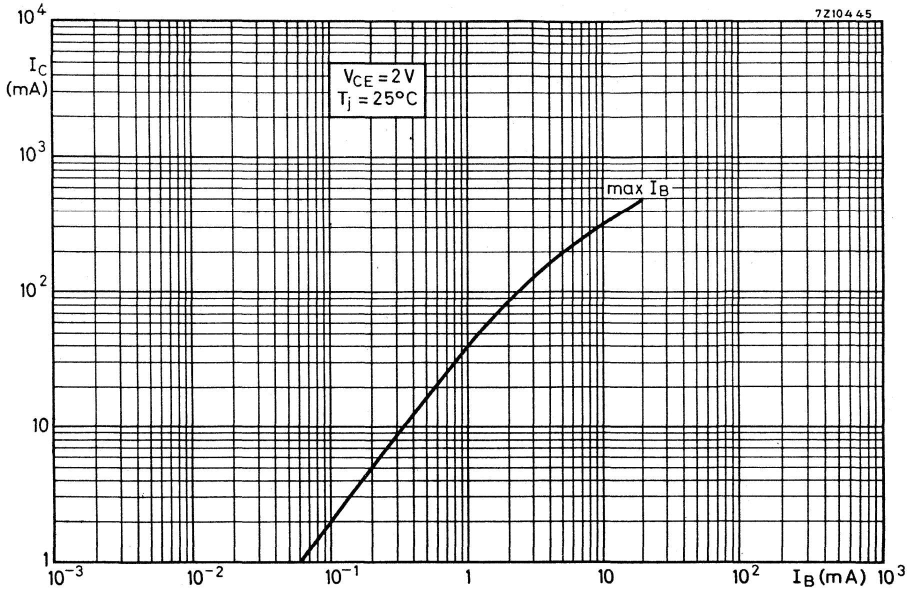

7Z62964
10^3
Zth j-mb
(°C/W)
10^2
10
1
10^-1
δ = 1
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
tp
T
δ = tp/T
10^-6
10^-5
10^-4
10^-3
10^-2
10^-1
tp (s)
1

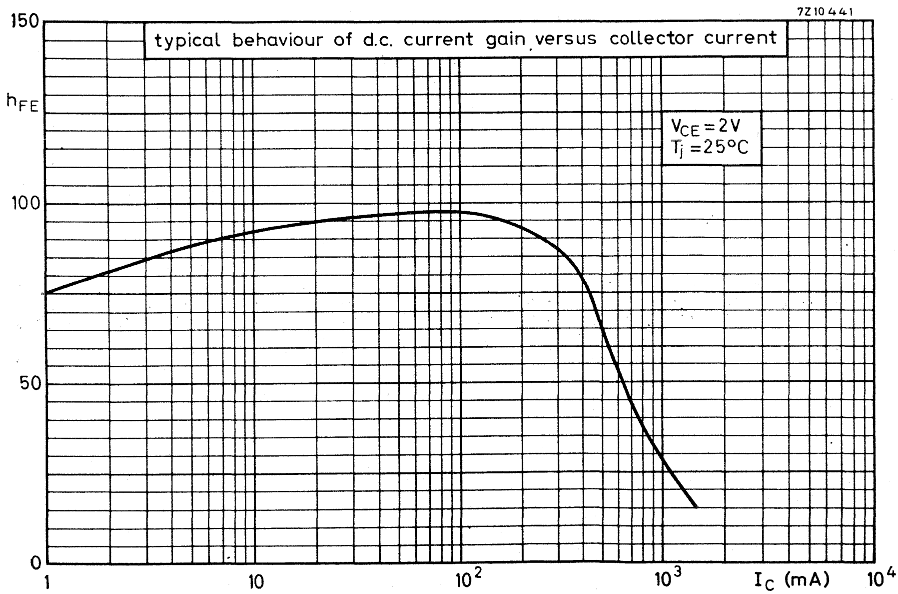

7Z62965
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

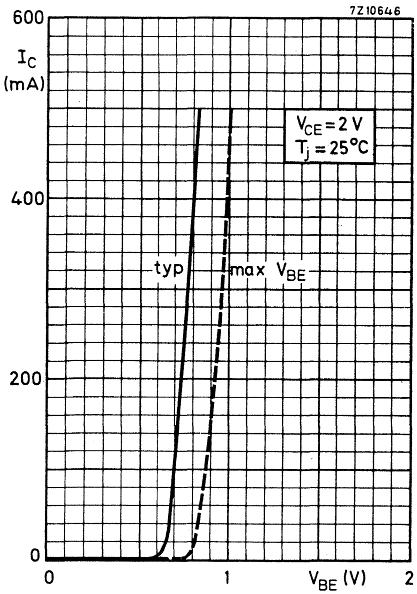

7Z62966
S.B. current multiplying factor at the $V_{CEO\,max}$ level (45 V)
BD135
$M_{SB(V)}$
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

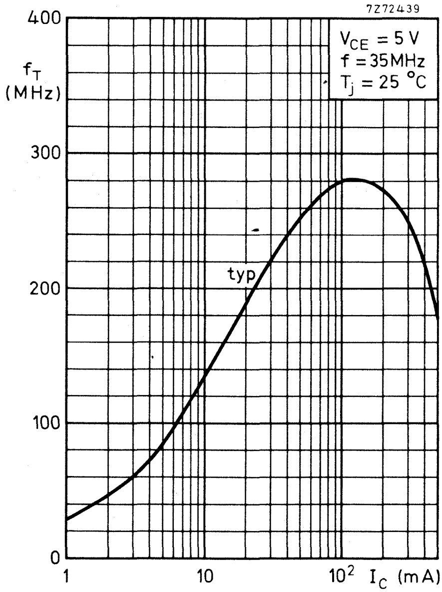

7Z62967
S.B. current multiplying factor at the $V_{CEO\,max}$ level (60 V)
BD137
$M_{SB(V)}$
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

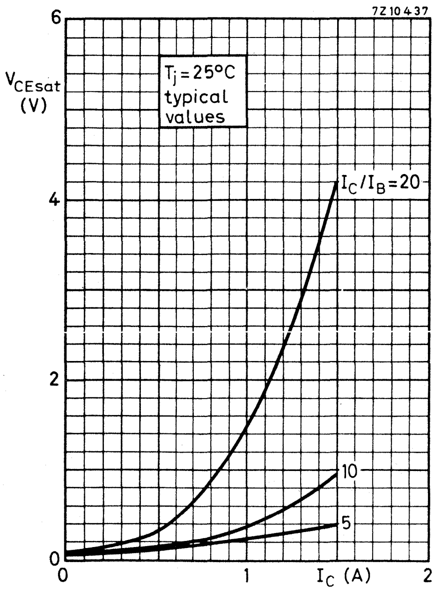

7Z62968
S.B. current multiplying factor at the $V_{CEO\,max}$ level (80 V)
BD139
$M_{SB(V)}$
10^2
10
1
0,02
δ = 0,01
0,05
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

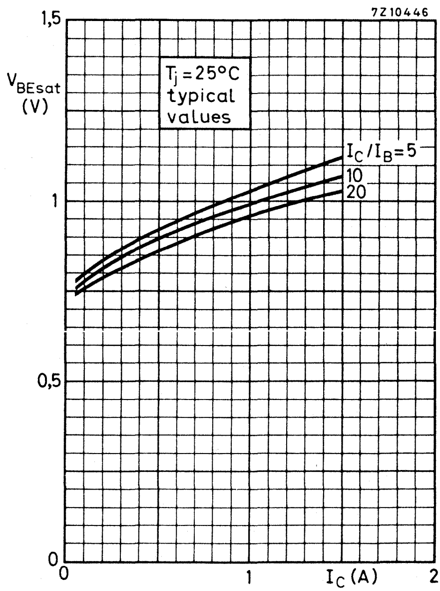

7Z10445
10^4
I_C
(mA)
$V_{CE} = 2 V$
$T_j = 25°C$
10^3
max I_B
10^2
10
1
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
I_B (mA)
10^3


7Z10441
150
typical behaviour of d.c. current gain versus collector current
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
I_C (mA)
600
400
200
0
$V_{CE} = 2$ V
$T_j = 25$ °C
typ
max V_{BE}
0
1
V_{BE} (V)
2


7Z72439
f_T (MHz)
400
300
200
100
0
$V_{CE} = 5$ V
f = 35 MHz
$T_j = 25$ °C
typ
1
10
10^2
I_C (mA)


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


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

SILICON PLANAR EPITAXIAL POWER 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

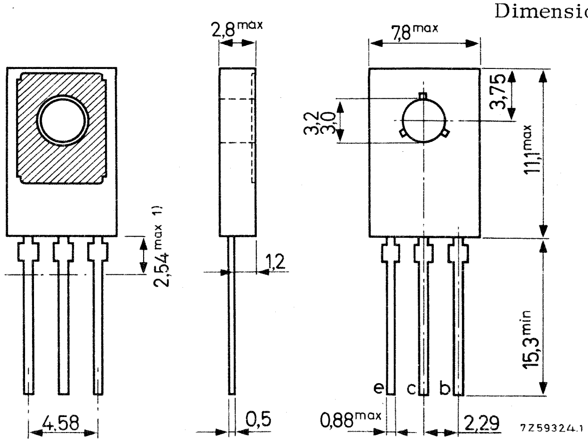
			BD136	BD138	BD140	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Collector current (peak value)	$-I_{CM}$	max.	1,5	1,5	1,5	A
Total power dissipation 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	250	250	
Transition frequency $-I_C$ = 50 mA; $-V_{CE}$ = 5 V	f_T	typ.	75	75	75	MHz

MECHANICAL DATA

Dimensions in mm

TO-126 (SOT-32)

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}		−65 to +150	°C
Junction temperature	T_j	max.	150	°C

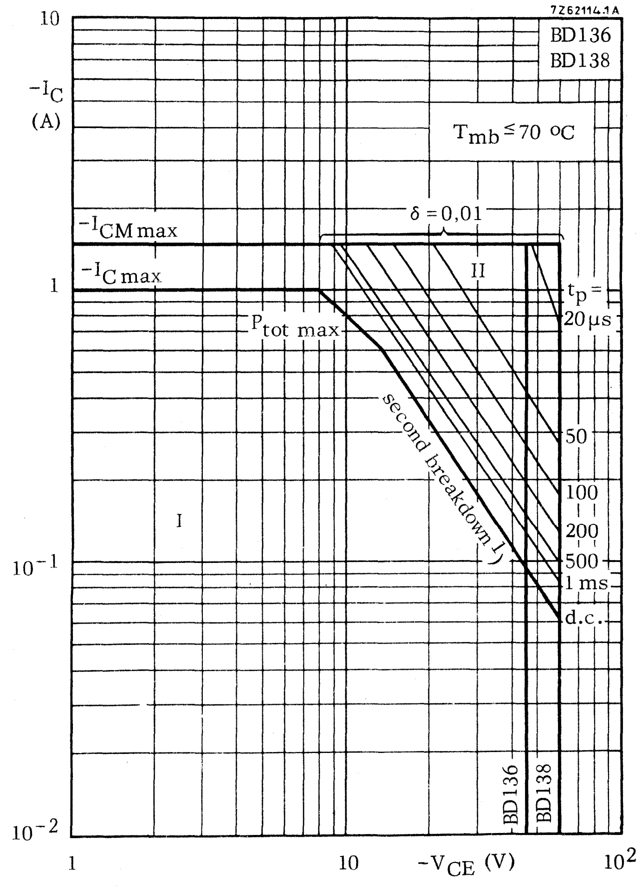
THERMAL RESISTANCE

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

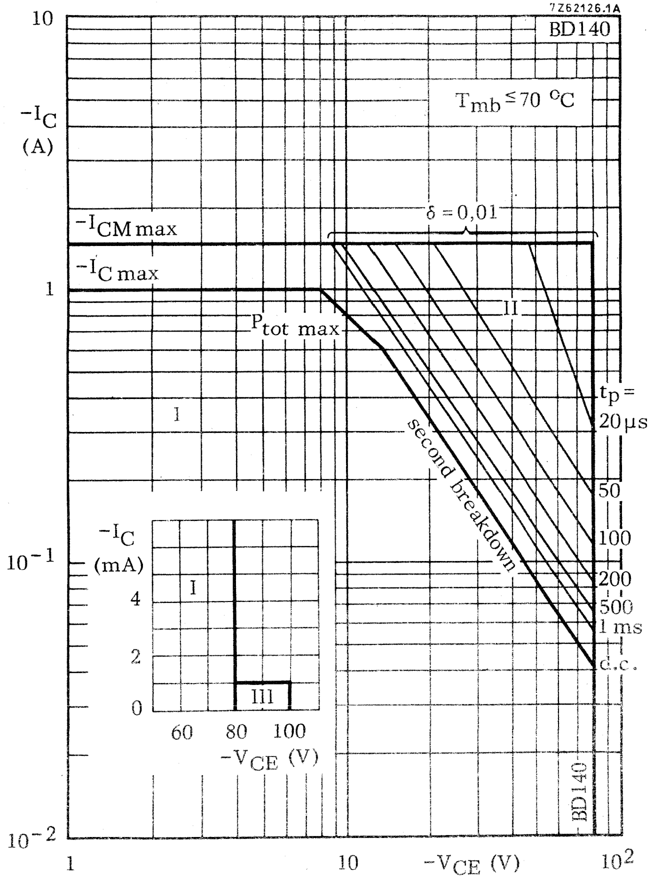
Collector cut-off current				
I_E = 0; $-V_{CB}$ = 30 V	$-I_{CBO}$	<	100	nA
I_E = 0; $-V_{CB}$ = 30 V; T_j = 125 °C	$-I_{CBO}$	<	10	μA
Emitter cut-off current				
I_C = 0; $-V_{EB}$ = 5 V	$-I_{EBO}$	<	10	μA
Base-emitter voltage				
$-I_C$ = 500 mA; $-V_{CE}$ = 2 V	$-V_{EB}$	<	1	V
Saturation voltage				
$-I_C$ = 500 mA; $-I_B$ = 50 mA	$-V_{CEsat}$	<	0,5	V
D.C. current gain				
$-I_C$ = 5 mA; $-V_{CE}$ = 2 V	h_{FE}	>	25	
$-I_C$ = 150 mA; $-V_{CE}$ = 2 V	h_{FE}		40 to 250	←
$-I_C$ = 500 mA; $-V_{CE}$ = 2 V	h_{FE}	>	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

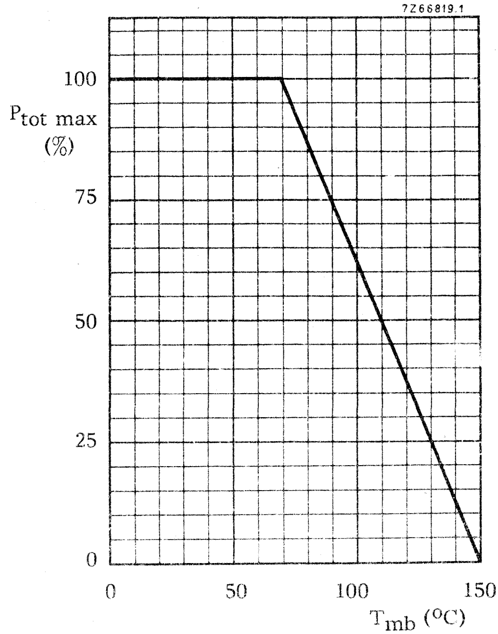
1) Independent of temperature

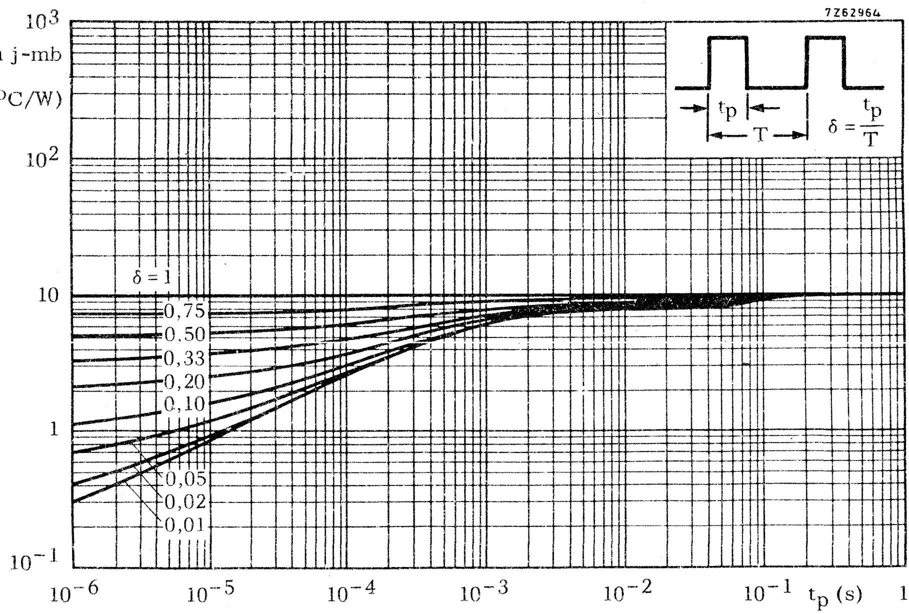


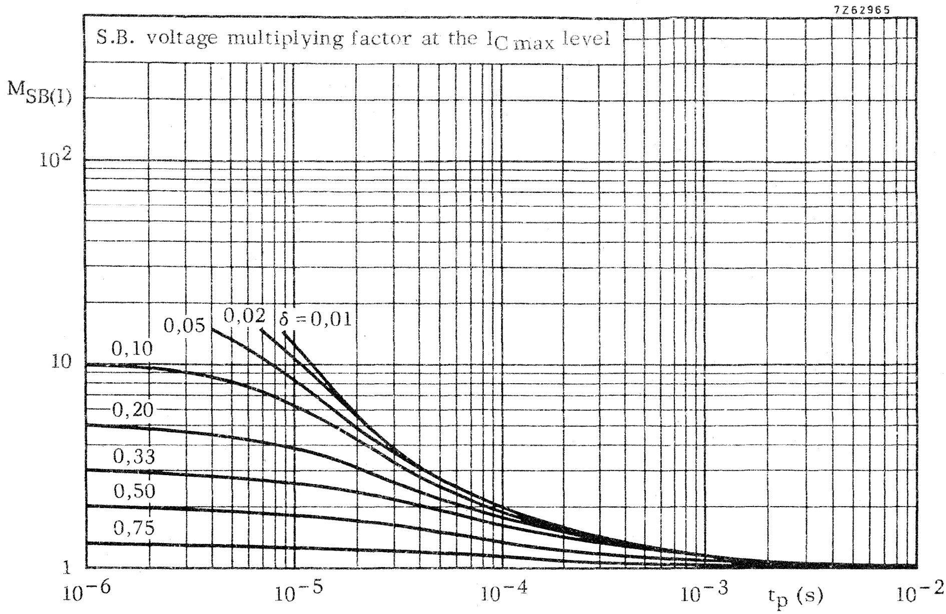
Safe Operating Area with the transistor forward biased

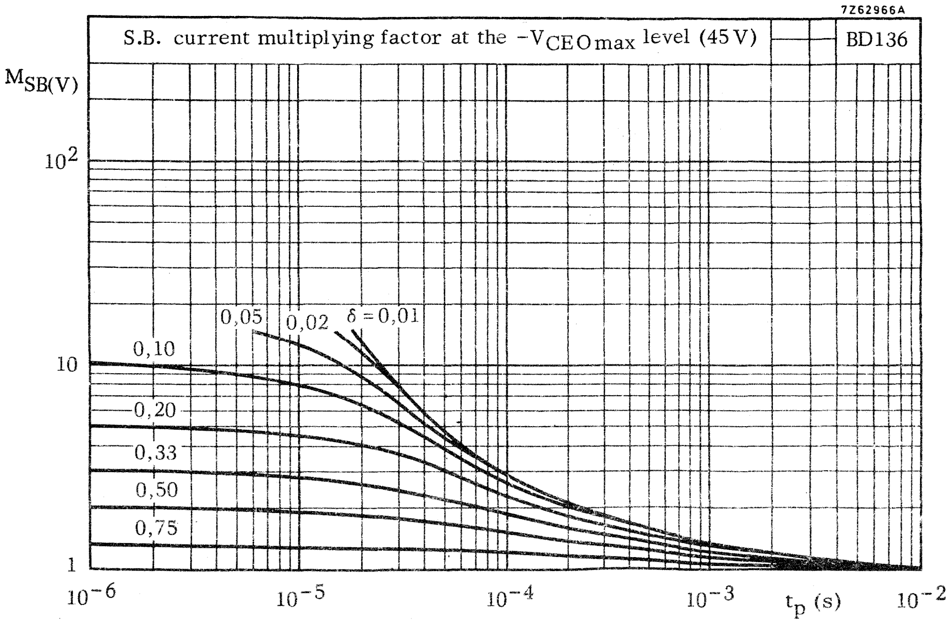
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse[1] operation
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 1\ k\Omega$.

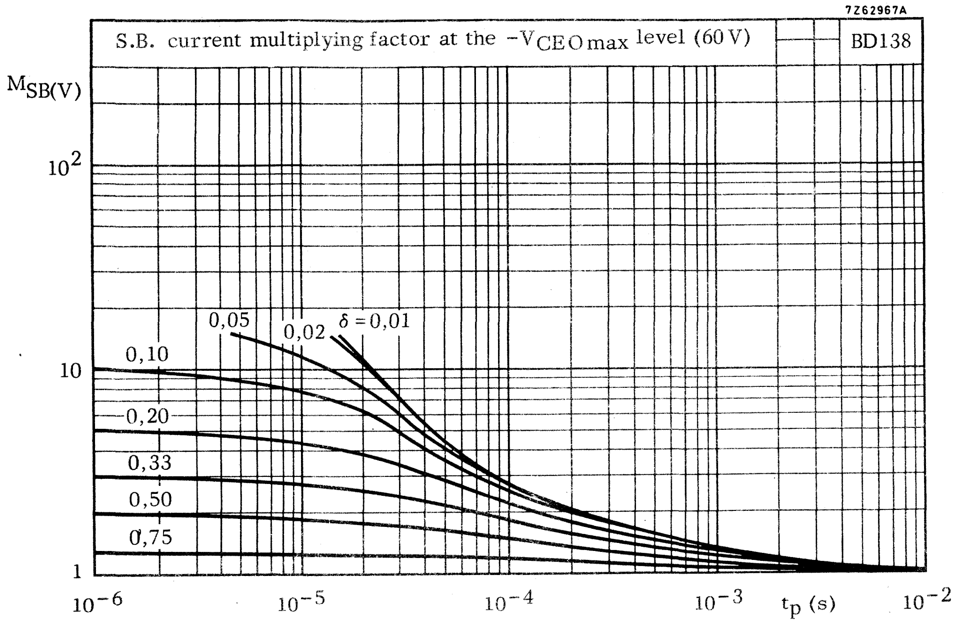
[1]) Independent of temperature

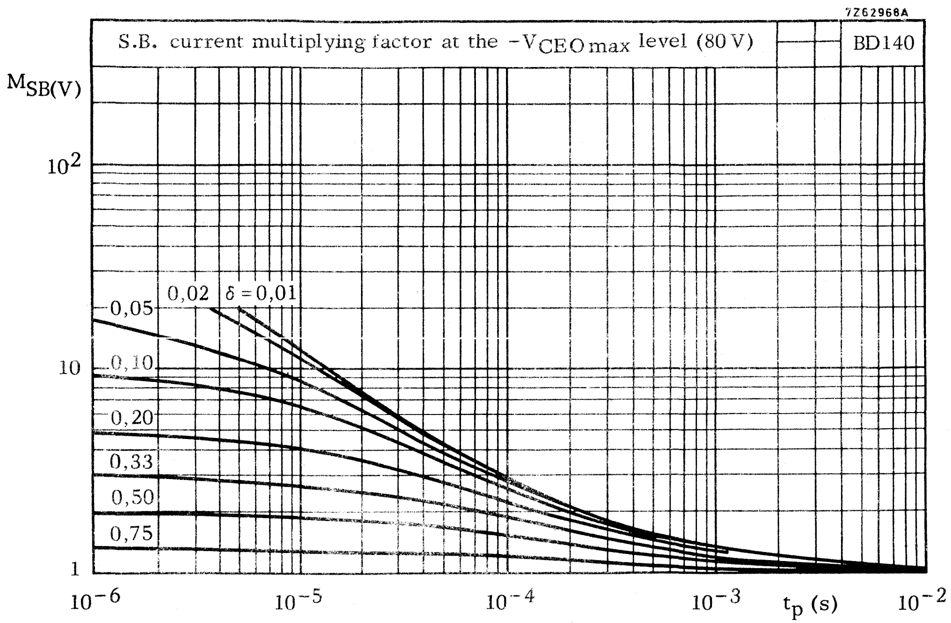

7Z66819.1
100
$P_{tot\ max}$
(%)
75
50
25
0
0
50
100
150
T_{mb} (°C)

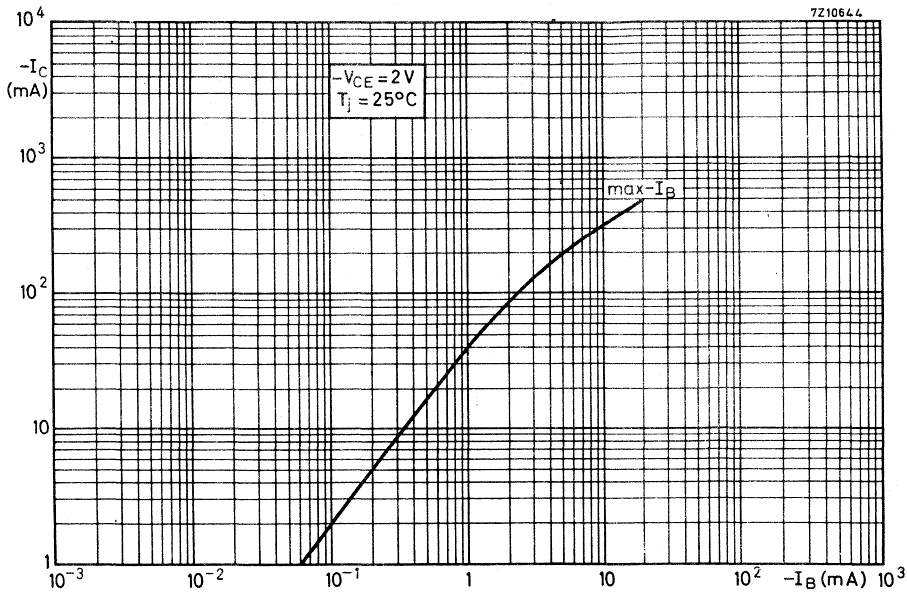

7Z62964
10^3
$Z_{th\ j-mb}$
(°C/W)
10^2
10
1
10^{-1}
δ = 1
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
t_p (s)
1

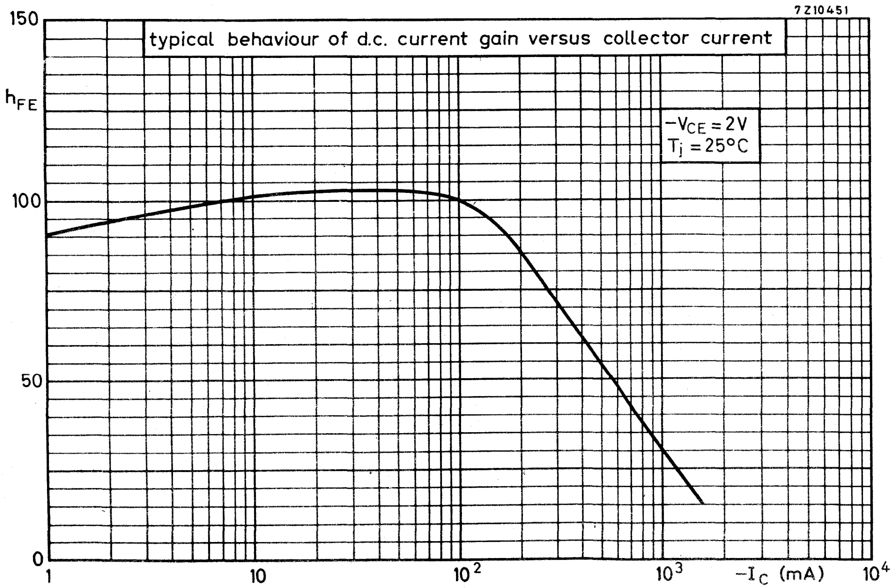

7Z62965
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

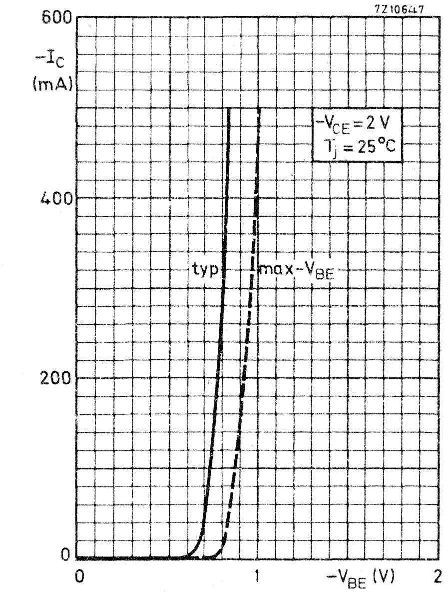

7Z62966A
S.B. current multiplying factor at the $-V_{CEO\,max}$ level (45 V)
BD136
$M_{SB(V)}$
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

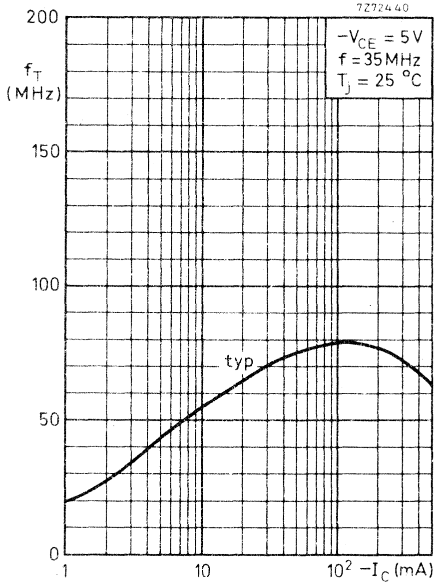

7Z62967A
S.B. current multiplying factor at the $-V_{CEO max}$ level (60 V)
BD138
$M_{SB(V)}$
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

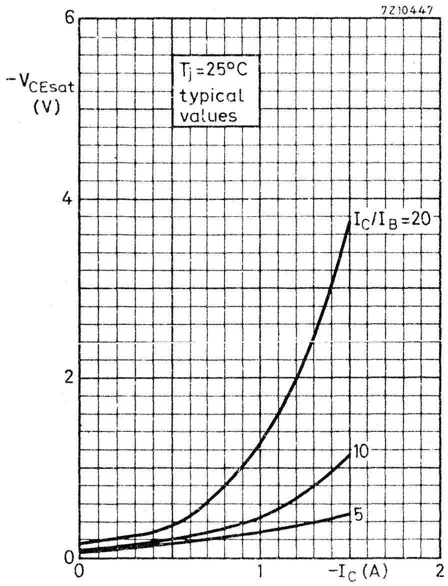

7Z62968A
S.B. current multiplying factor at the $-V_{CEO max}$ level (80 V)
BD140
$M_{SB(V)}$
10^2
10
1
0,02
δ = 0,01
0,05
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

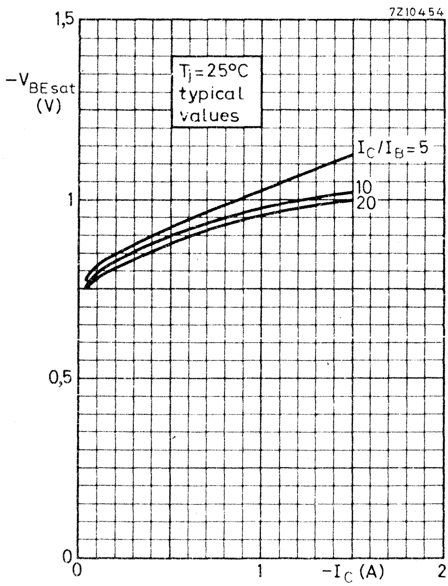

7Z10644
10^4
$-I_C$ (mA)
$-V_{CE} = 2$ V
$T_j = 25$ °C
10^3
max-I_B
10^2
10
1
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
$-I_B$ (mA)
10^3


7Z10451
150
typical behaviour of d.c. current gain versus collector current
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
400
200
0
$-I_C$
(mA)
$-V_{CE} = 2$ V
$T_j = 25$ °C
typ
max $-V_{BE}$
0
1
2
$-V_{BE}$ (V)


7Z72440
200
150
100
50
0
f_T
(MHz)
$-V_{CE} = 5$ V
f = 35 MHz
$T_j = 25$ °C
typ
1
10
10^2
$-I_C$ (mA)


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


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

SILICON DIFFUSED POWER TRANSISTORS

N-P-N 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 type numbers 2-BD181, 2-BD182 and 2-BD183.

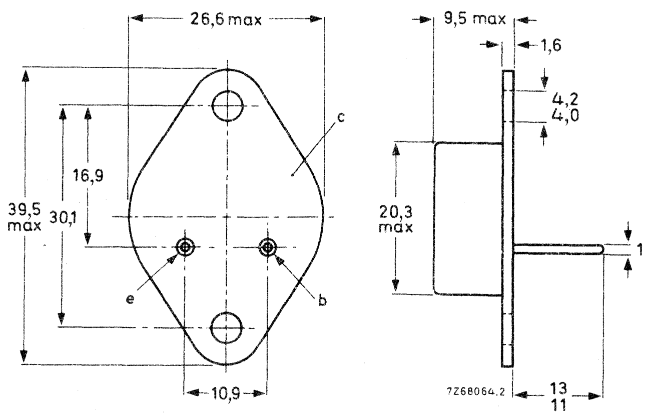
QUICK REFERENCE DATA

			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



For mounting instructions and accessories, see section Accessories.

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	$R_{th\ j-mb}$	=	1,5	°C/W
From junction to ambient	$R_{th\ j-a}$	=	45	°C/W

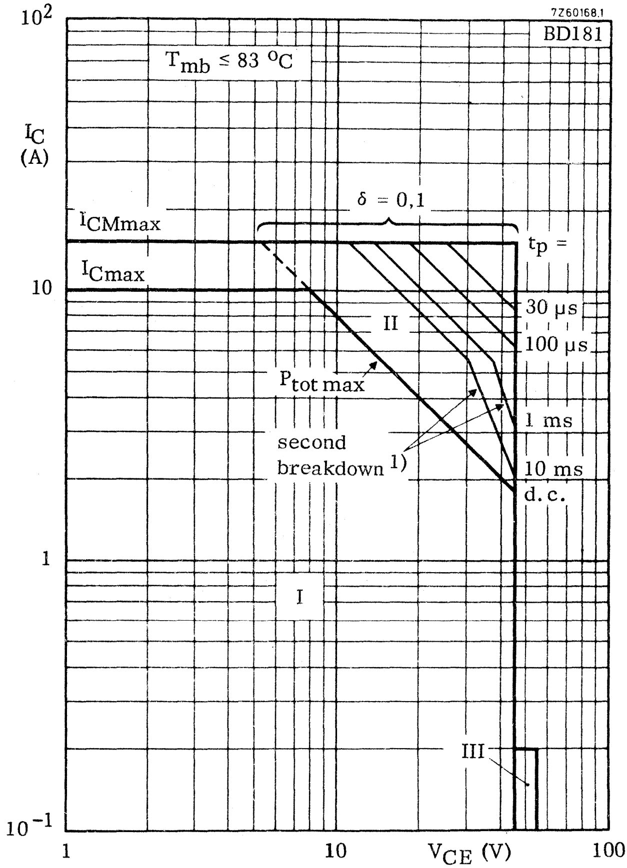
CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current			BD181	BD182	BD183	
I_E = 0; V_{CB} = 45 V; Tj = 200 °C	I_{CBO}	typ.	1			mA
		<	2			mA
I_E = 0; V_{CB} = 60 V; T_j = 200 °C	I_{CBO}	typ.		1		mA
		<		5		mA
I_E = 0; V_{CB} = 80 V; T_j = 200 °C	I_{CBO}	typ.			1	mA
		<			5	mA

CHARACTERISTICS (continued) T_j = 25 °C 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/°C with increasing temperature.



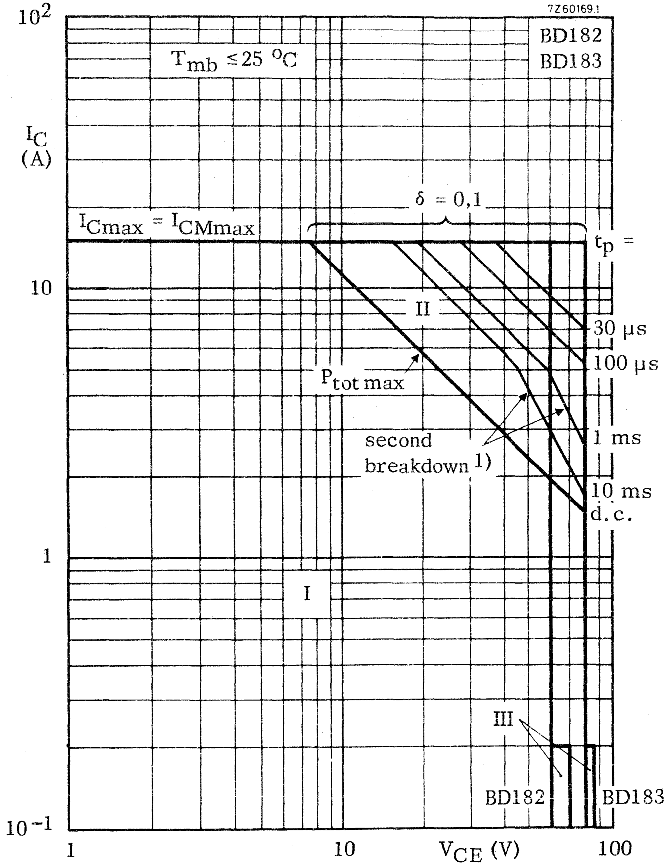
Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

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

1) Independent of temperature



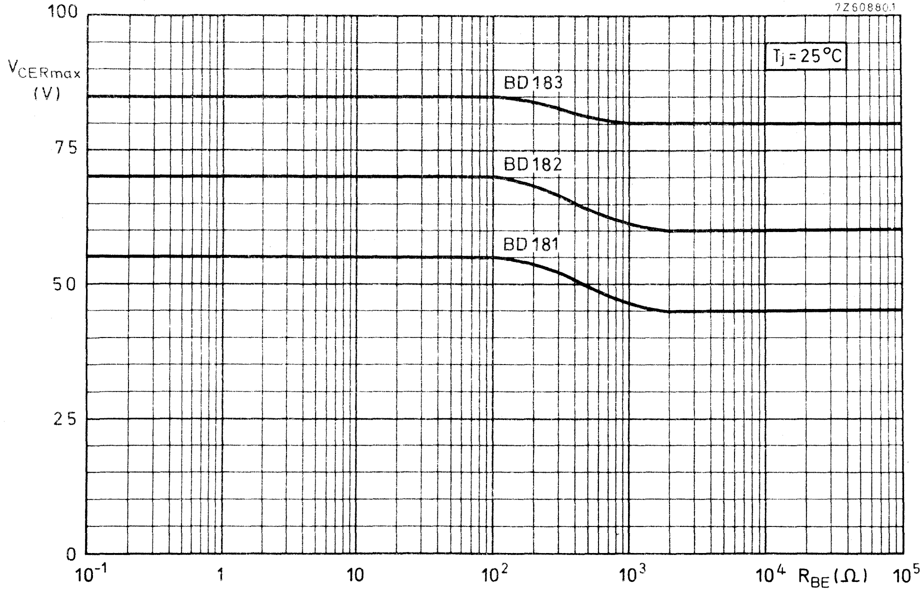
Safe Operating Area with the transistor forward biased

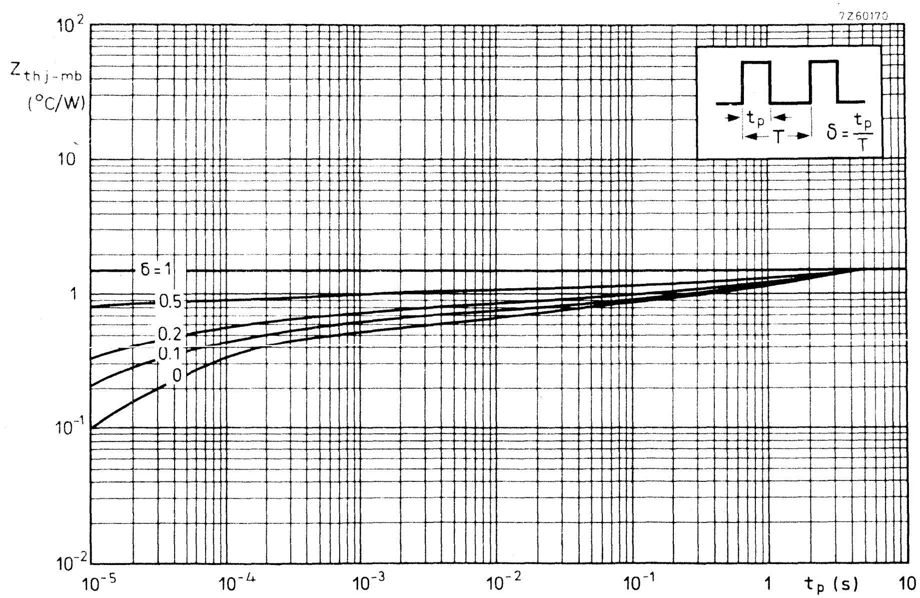
I Region of permissible d.c. operation

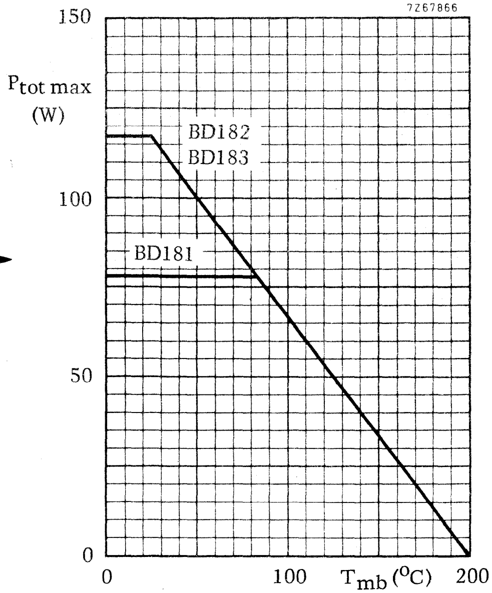
II Permissible extension for repetitive pulse operation

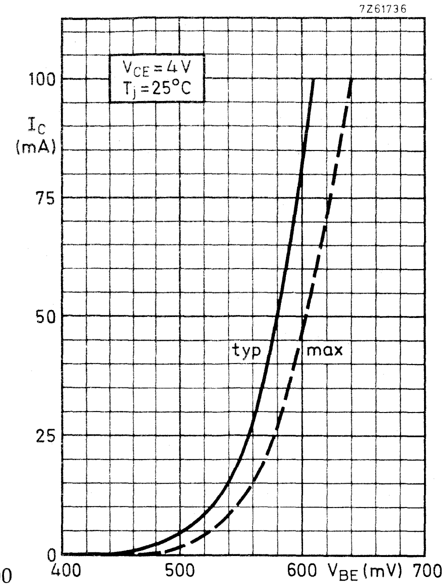
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 100\ \Omega$

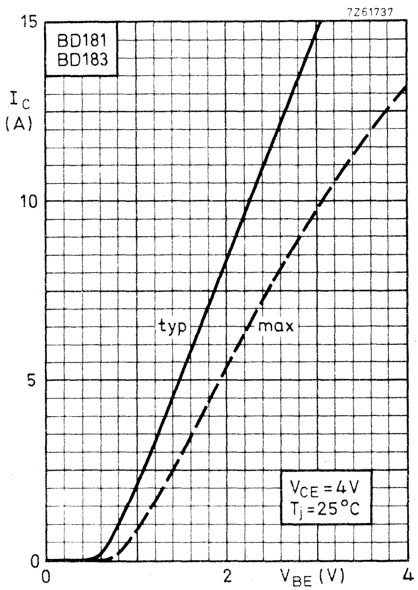
1) Independent of temperature

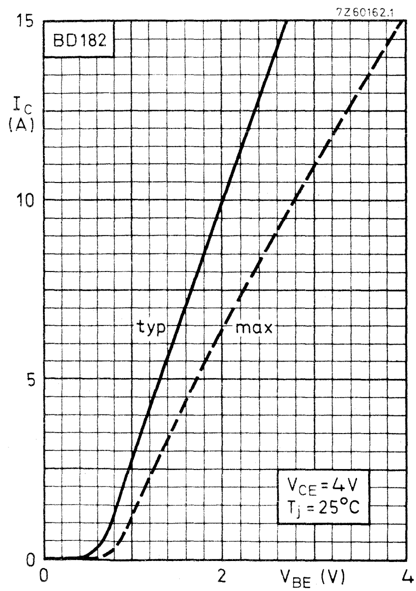

7Z60880.1
100
75
50
25
0
V_{CERmax}
(V)
$T_j = 25°C$
BD183
BD182
BD181
10^{-1}
1
10
10^2
10^3
10^4
R_{BE} (Ω)
10^5

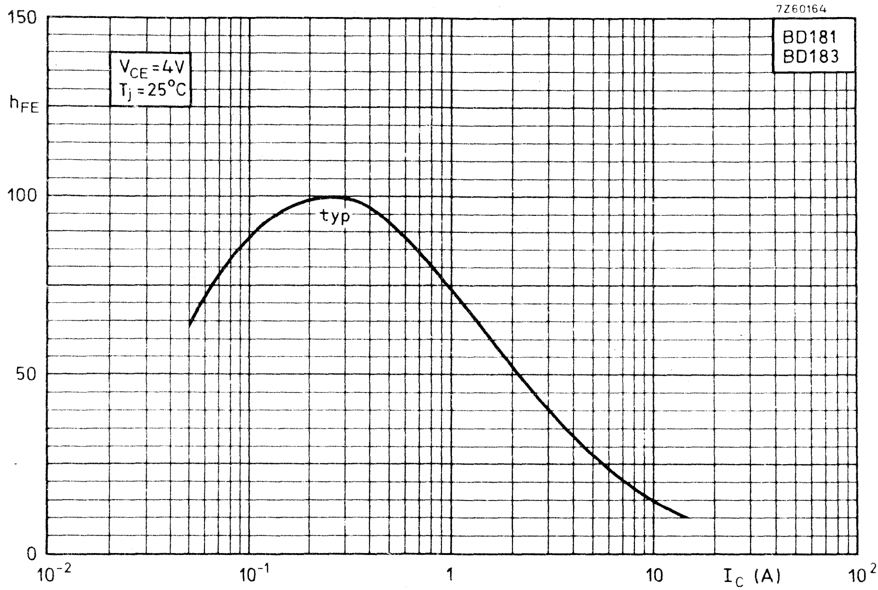

7Z60170
10^2
10
1
10^{-1}
10^{-2}
$Z_{th\,j\text{-}mb}$
(°C/W)
t_p
T
$\delta = \frac{t_p}{T}$
δ = 1
0.5
0.2
0.1
0
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t_p (s)
10

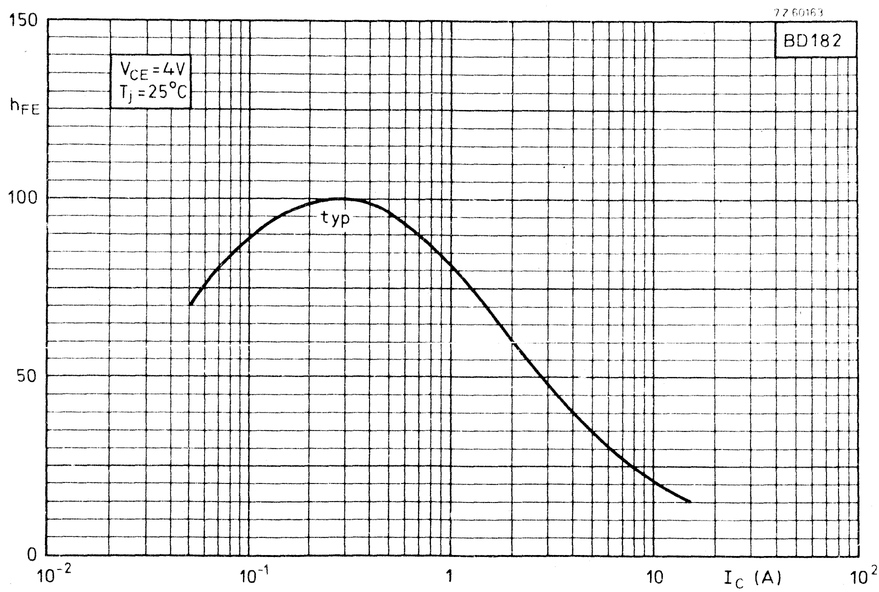

7Z67866
150
Ptot max
(W)
100
50
0
BD182
BD183
BD181
0
100
Tmb (°C)
200


7Z61736
VCE = 4 V
Tj = 25°C
100
IC
(mA)
75
50
25
0
typ
max
400
500
600
VBE (mV)
700


7Z61737
15
BD181
BD183
IC
(A)
10
5
0
typ
max
VCE = 4 V
Tj = 25°C
0
2
VBE (V)
4


7Z60162.1
15
BD182
IC
(A)
10
5
0
typ
max
VCE = 4 V
Tj = 25°C
0
2
VBE (V)
4


7Z60164
BD181
BD183
$V_{CE} = 4V$
$T_j = 25°C$
h_{FE}
150
100
50
0
typ
10^{-2}
10^{-1}
1
10
10^2
I_C (A)


7Z60163
BD182
$V_{CE} = 4V$
$T_j = 25°C$
h_{FE}
150
100
50
0
typ
10^{-2}
10^{-1}
1
10
10^2
I_C (A)

SILICON EPITAXIAL-BASE POWER TRANSISTORS

N-P-N 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 to 25 W into a 4 Ω or 8 Ω load.

QUICK REFERENCE DATA

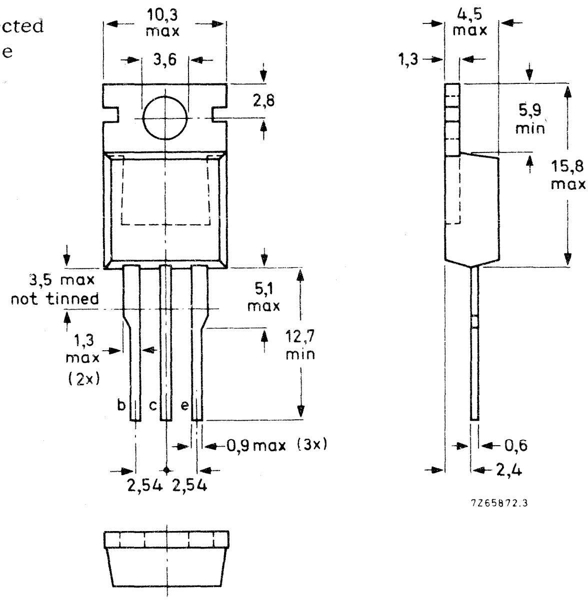
			BD201	BD203	
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	V
Collector current (d.c.)	I_C	max.	8	8	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60	60	W
Cut-off frequency I_C = 0,3 A; V_{CE} = 3 V	f_{hfe}	>	25	25	kHz

MECHANICAL DATA

Dimensions in mm

TO-220

Collector connected to mounting base



For mounting instructions and accessories see section Accessories.

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

			BD201	BD203	
Voltages					
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

Currents

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

Power dissipation

Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60	W

Temperatures

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

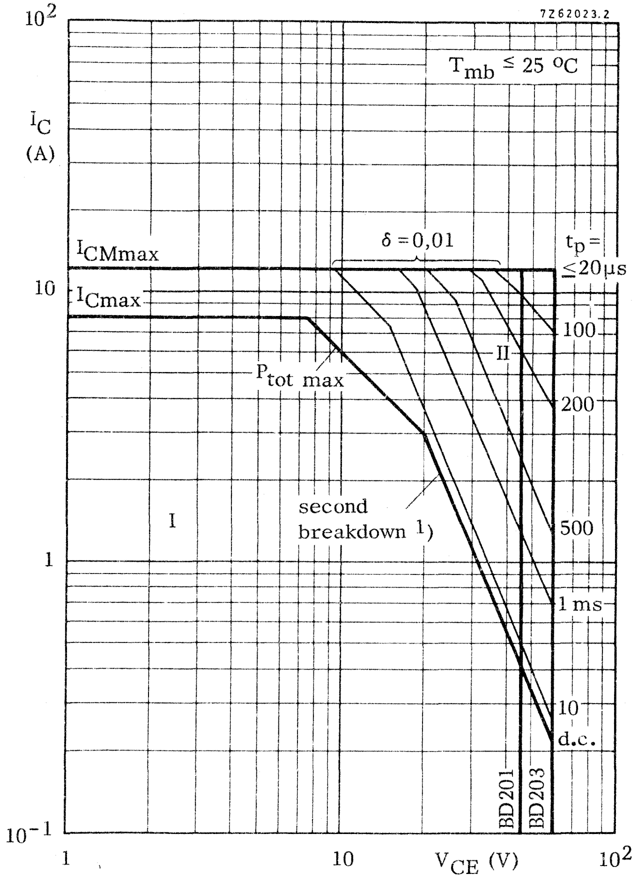
THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,08	°C/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	°C/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 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)				
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 under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.



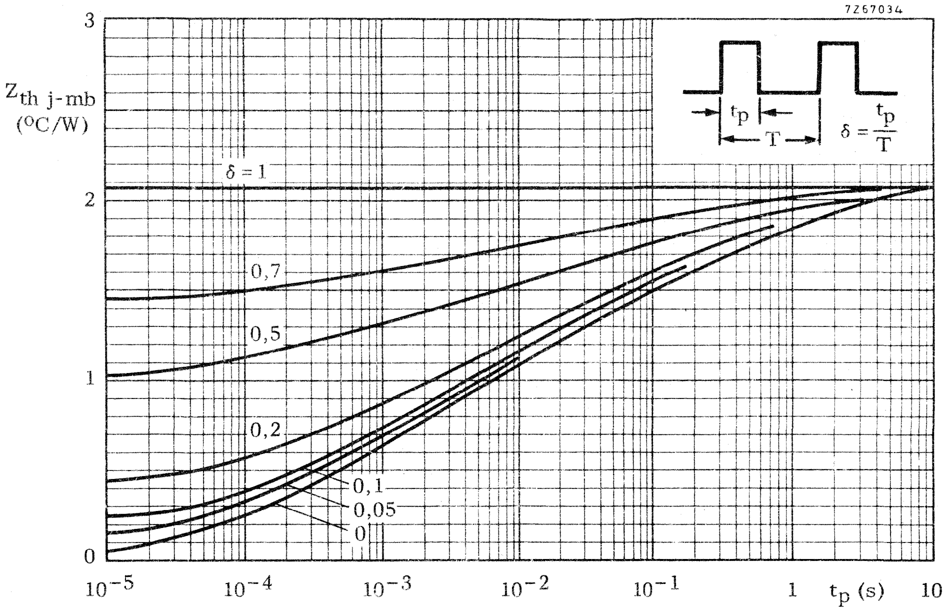
Safe Operating Area with the transistor forward biased

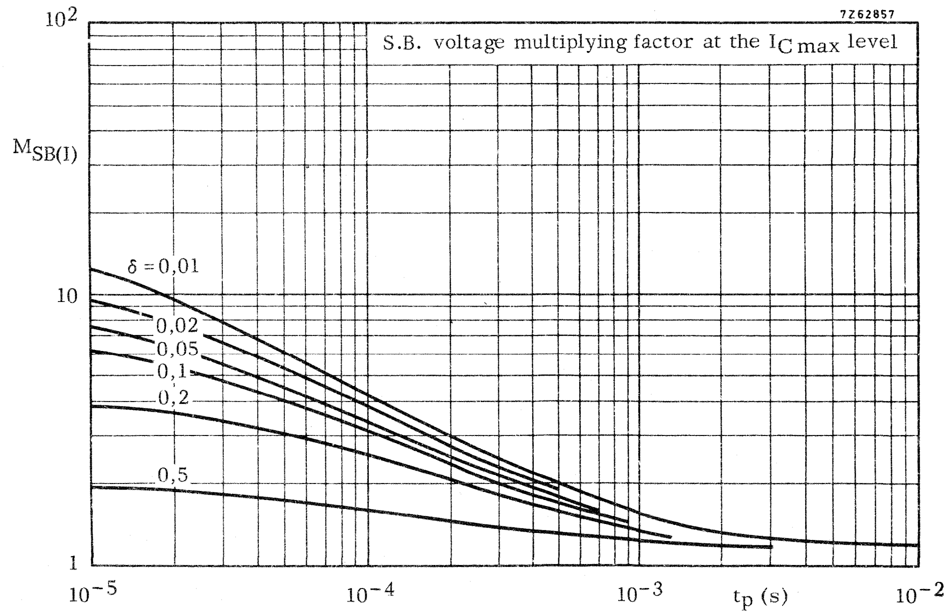
I Region of permissible d.c. operation

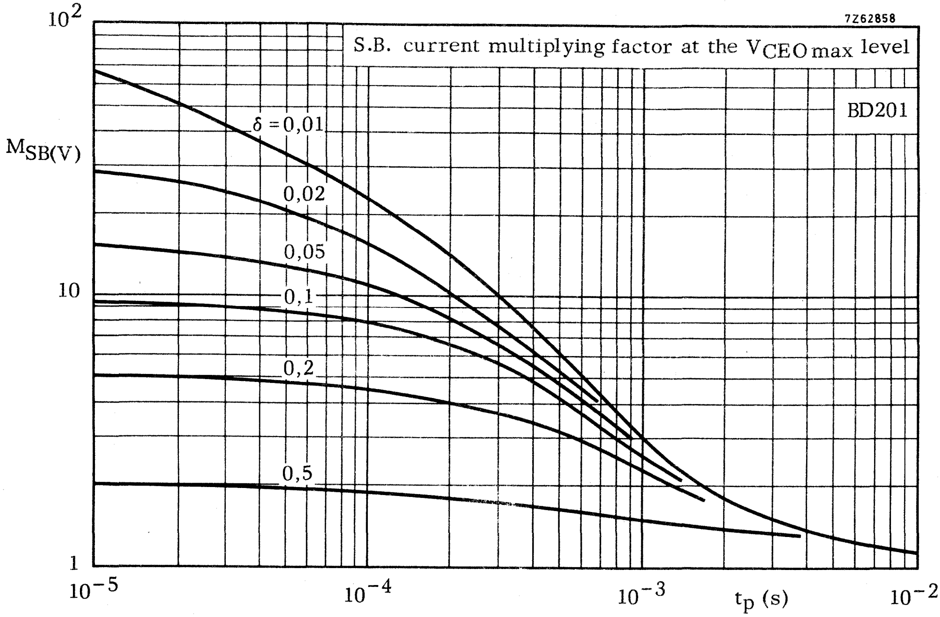
II Permissible extension for repetitive pulse operation

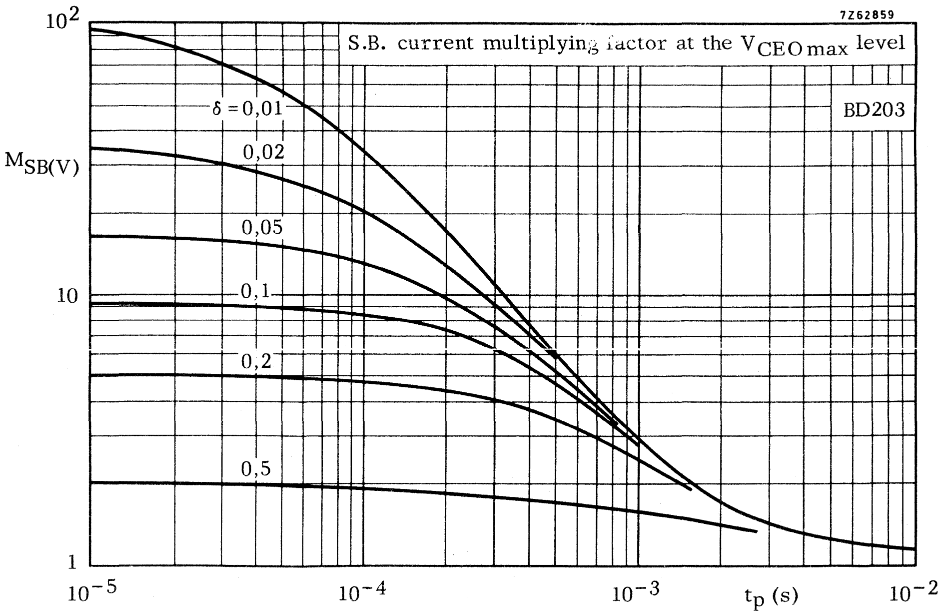
For $P_{tot\ max}$ versus T_{mb} see page 8.

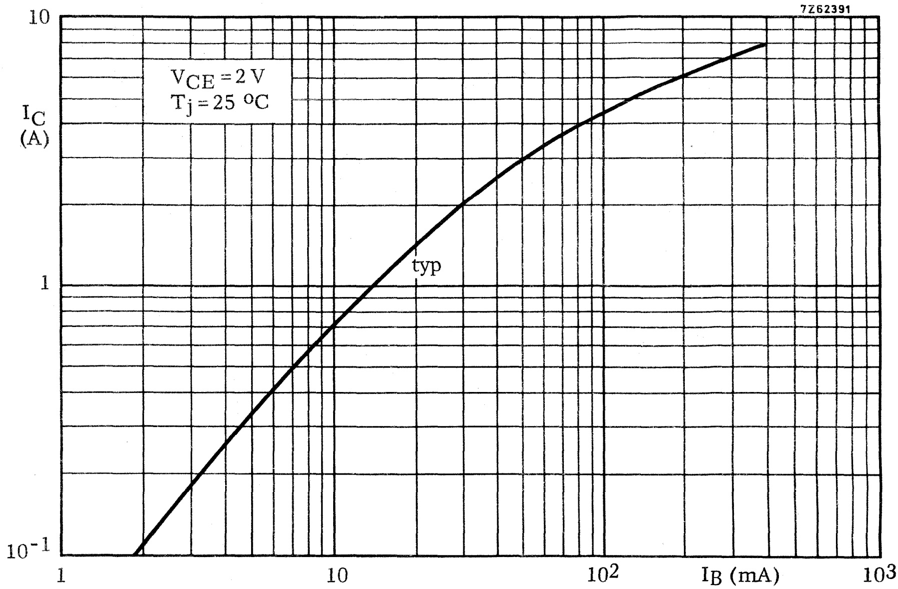
1) Independent of temperature.

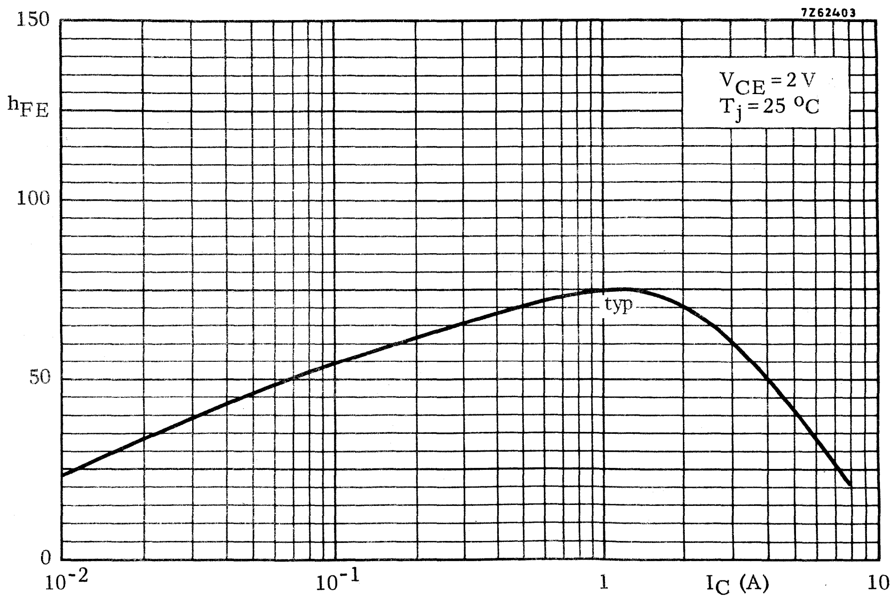

7Z67034
$Z_{th\ j\text{-}mb}$ (°C/W)
δ = 1
0,7
0,5
0,2
0,1
0,05
0
$\delta = \frac{t_p}{T}$
t_p
T
t_p (s)

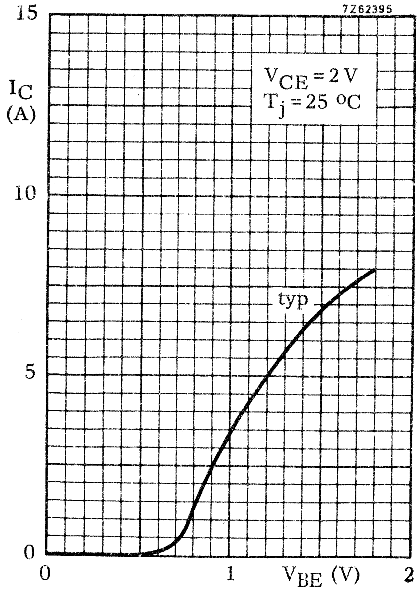

7Z62857
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
δ = 0,01
0,02
0,05
0,1
0,2
0,5
t_p (s)

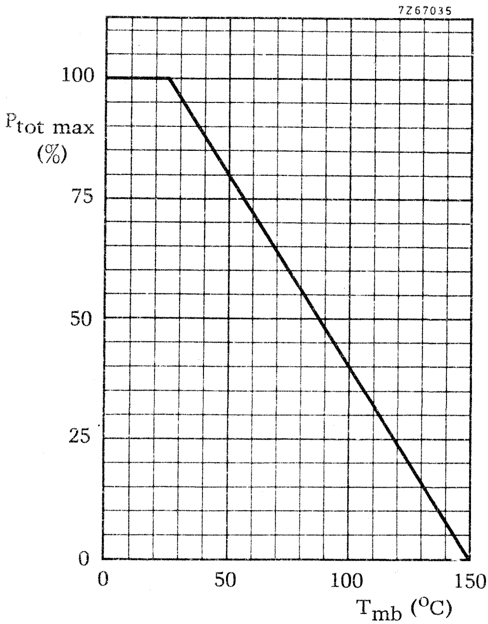

7Z62858
S.B. current multiplying factor at the $V_{CEO\,max}$ level
BD201
$M_{SB(V)}$
$\delta = 0,01$
0,02
0,05
0,1
0,2
0,5
10^2
10
1
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

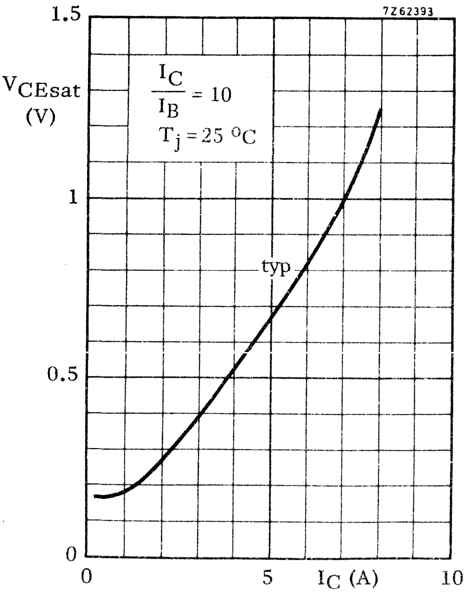

7Z62859
S.B. current multiplying factor at the $V_{CEO\,max}$ level
BD203
$M_{SB(V)}$
$\delta = 0,01$
0,02
0,05
0,1
0,2
0,5
10^2
10
1
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

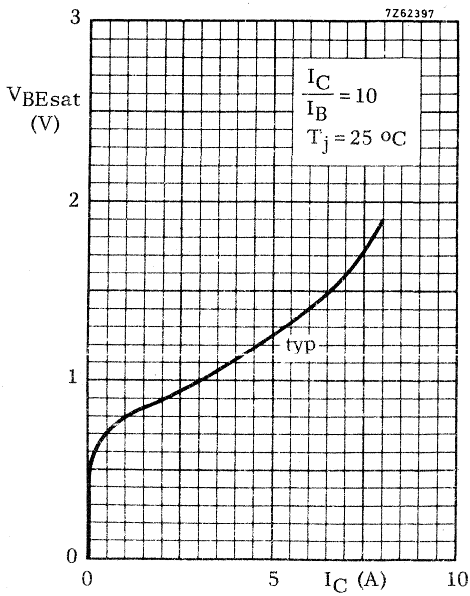

7Z62391
$V_{CE} = 2$ V
$T_j = 25$ °C
I_C (A)
10
1
10^{-1}
typ
1
10
10^2
I_B (mA)
10^3

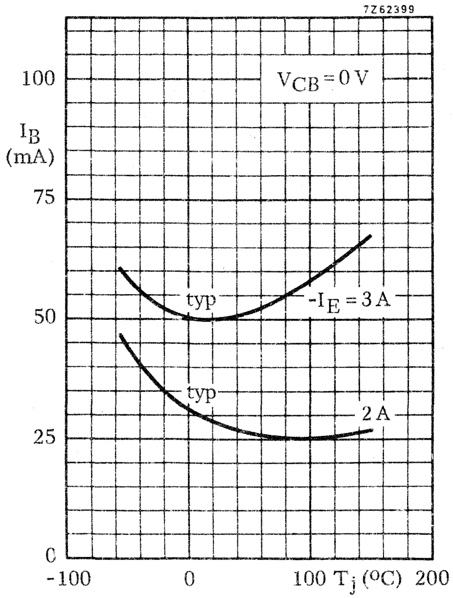

7Z62403
$V_{CE} = 2$ V
$T_j = 25$ °C
h_{FE}
150
100
50
0
typ
10^{-2}
10^{-1}
1
I_C (A)
10

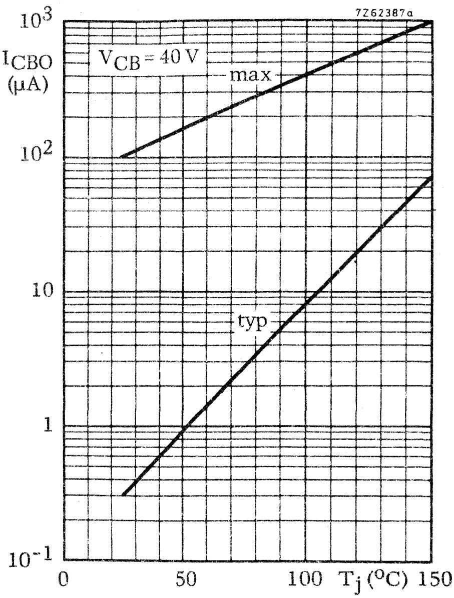

7Z62395
$V_{CE} = 2$ V
$T_j = 25$ °C
I_C
(A)
15
10
5
0
typ
0
1
V_{BE} (V)
2

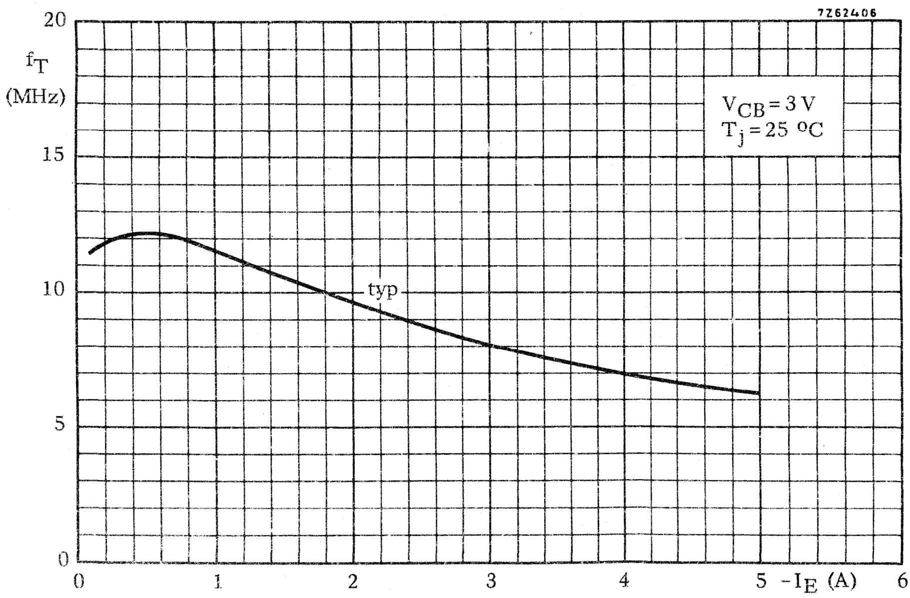

7Z67035
$P_{tot\ max}$
(%)
100
75
50
25
0
0
50
100
150
T_{mb} (°C)


7Z62393
V_{CEsat}
(V)
$\frac{I_C}{I_B} = 10$
$T_j = 25$ °C
1.5
1
0.5
0
typ
0
5
I_C (A)
10


7Z62397
V_{BEsat}
(V)
$\frac{I_C}{I_B} = 10$
$T_j = 25$ °C
3
2
1
0
typ
0
5
I_C (A)
10


7Z62399
100
75
50
25
0
I_B
(mA)
V_CB = 0 V
typ
-I_E = 3 A
typ
2 A
-100
0
100 T_j (°C) 200


7Z62387a
10^3
I_CBO
(μA)
V_CB = 40 V
max
10^2
10
typ
1
10^-1
0
50
100 T_j (°C) 150


7Z62406
20
f_T
(MHz)
15
V_CB = 3 V
T_j = 25 °C
10
typ
5
0
0
1
2
3
4
5 -I_E (A) 6

SILICON EPITAXIAL-BASE POWER TRANSISTORS

P-N-P 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 of 15 to 25 W into a 4 Ω or 8 Ω load.

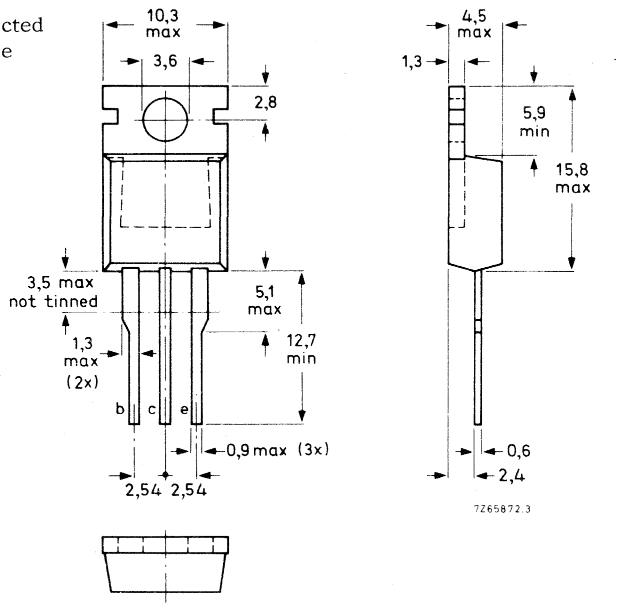
QUICK REFERENCE DATA

			BD202	BD204	
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
Cut-off frequency					
$-I_C$ = 0,3 A; $-V_{CE}$ = 3 V	f_{hfe}	>	25	25	kHz

MECHANICAL DATA Dimensions in mm

TO-220

Collector connected to mounting base



For mounting instructions and accessories see section Accessories.

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

Voltages

			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

Currents

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

Power dissipation

Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.	60	W

Temperatures

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

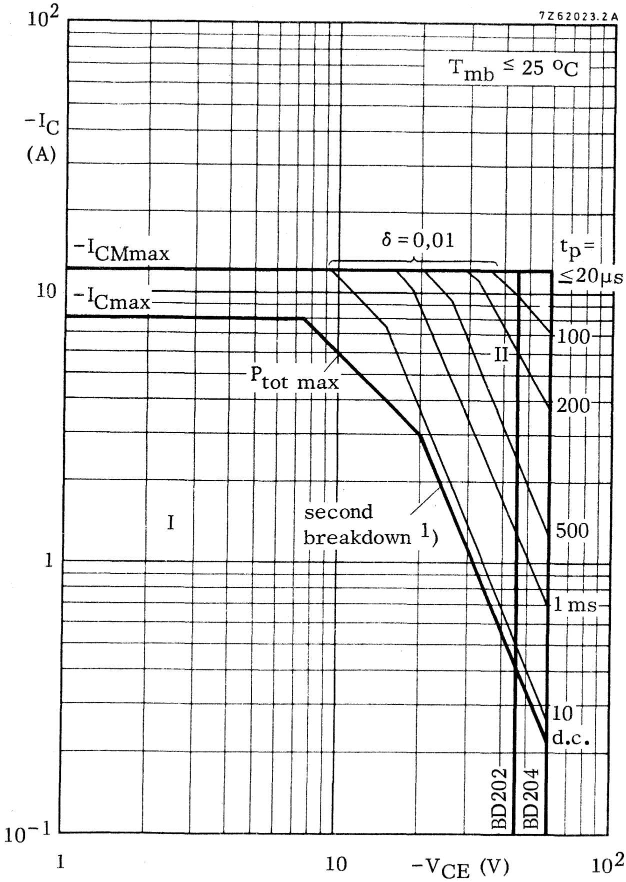
THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	2,08	°C/W
From junction to ambient in free air	$R_{th\ j-a}$	=	70	°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 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]				
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 under pulse conditions: $t_p < 300$ µs, $\delta < 2\%$.

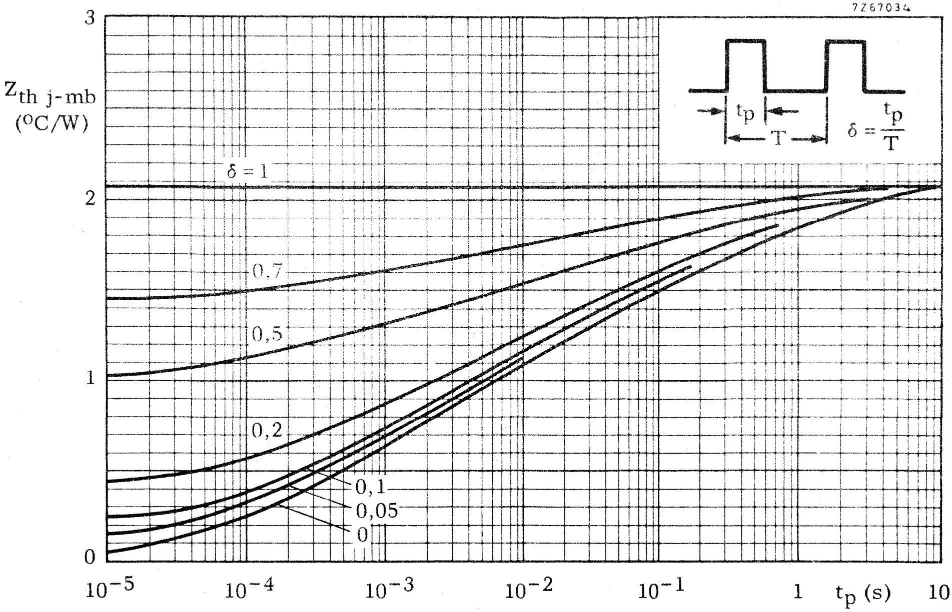


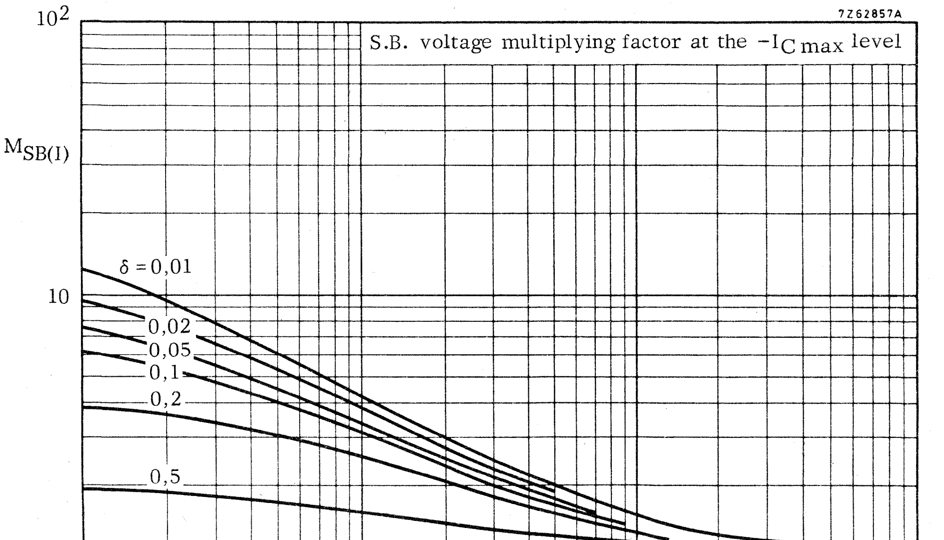
Safe Operating Area with the transistor forward biased

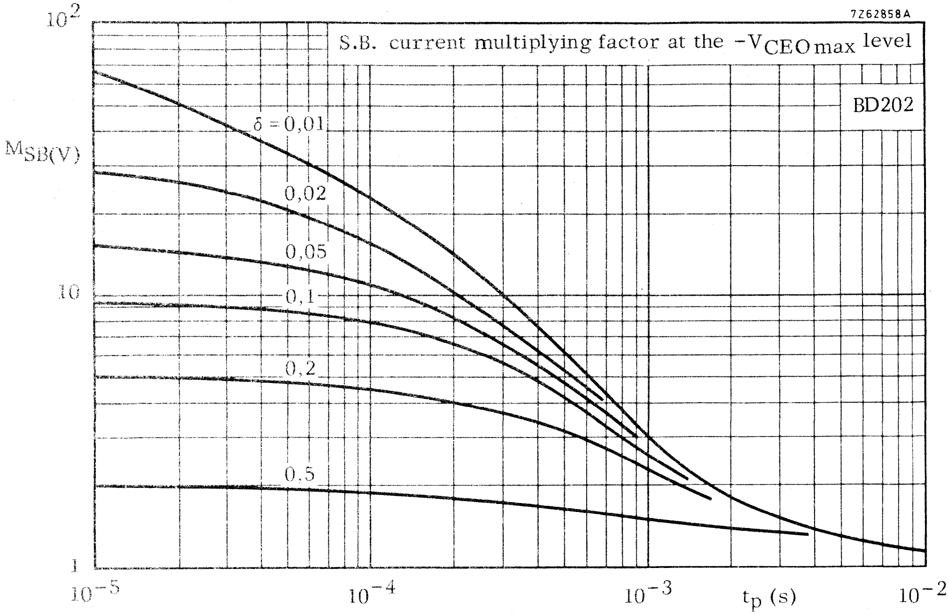
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation

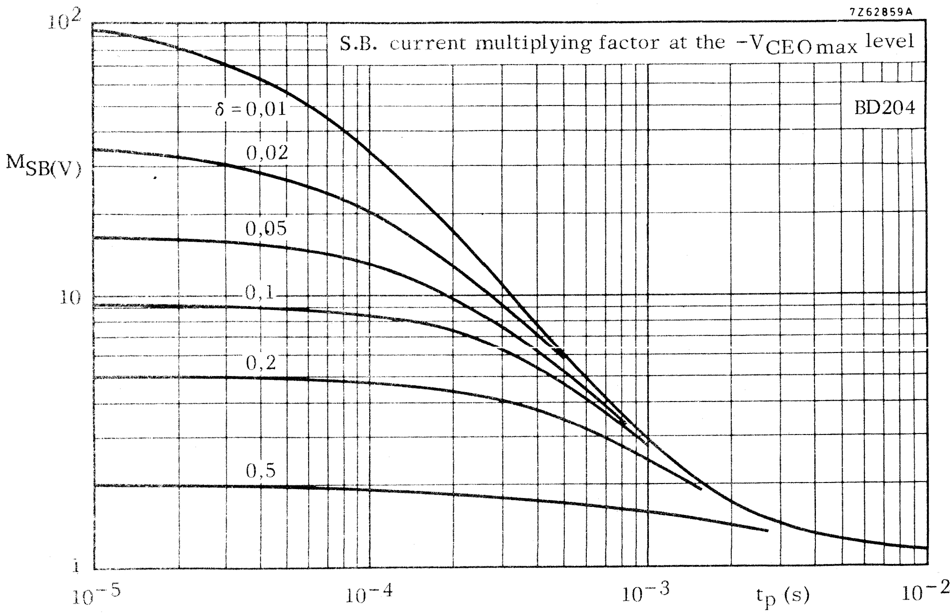
For $P_{tot\ max}$ versus T_{mb} see page 8.

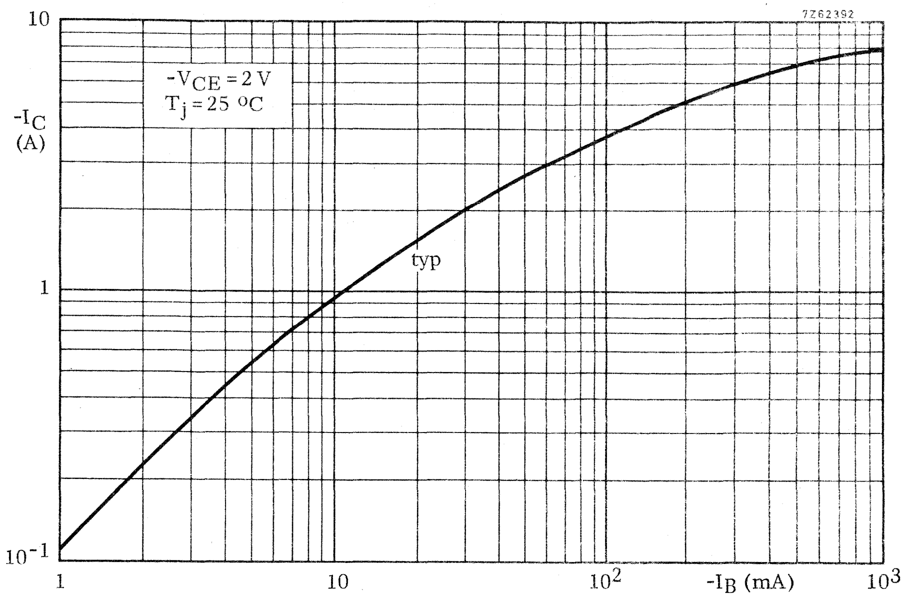
1) Independent of temperature.

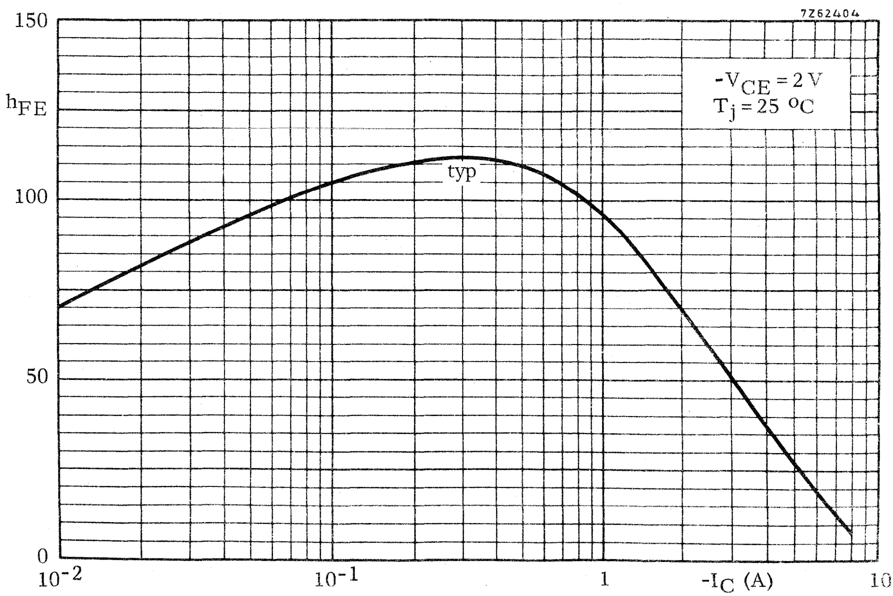

7Z67034
$Z_{th\ j\text{-}mb}$ (°C/W)
3
2
1
0
δ = 1
0,7
0,5
0,2
0,1
0,05
0
t_p
T
$\delta = \frac{t_p}{T}$
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t_p (s)
10

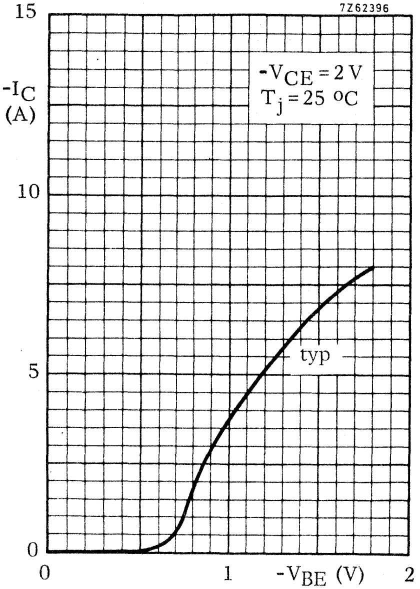

7Z62857A
S.B. voltage multiplying factor at the $-I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,5
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

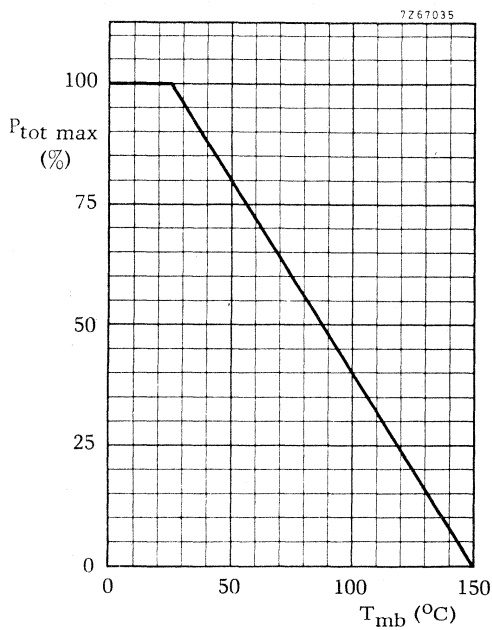

7Z62858A
S.B. current multiplying factor at the $-V_{CEO\,max}$ level
BD202
10^2
$M_{SB(V)}$
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,5
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

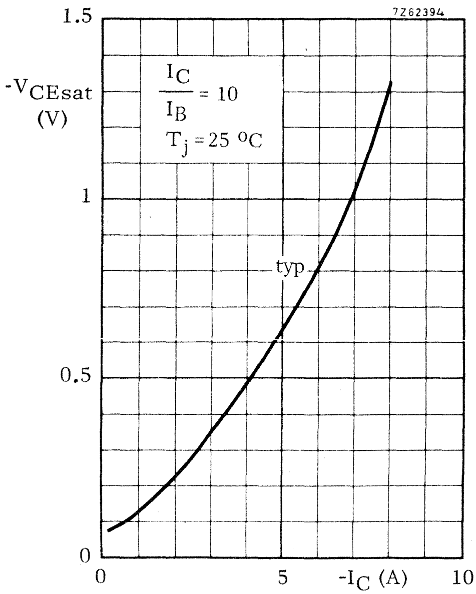

7Z62859A
S.B. current multiplying factor at the $-V_{CEO\,max}$ level
BD204
10^2
$M_{SB(V)}$
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,5
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

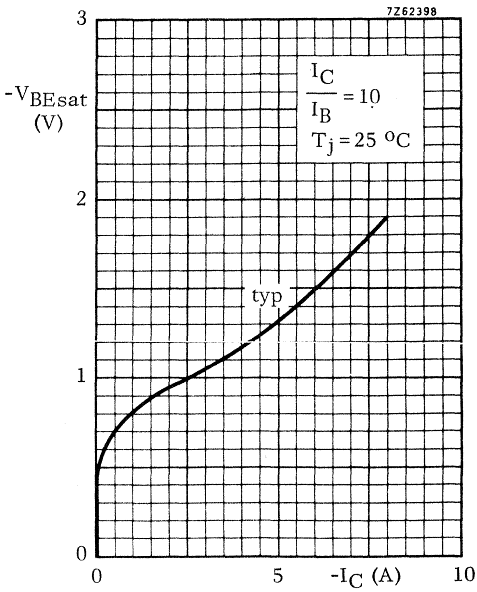

7Z62392
$-V_{CE} = 2$ V
$T_j = 25$ °C
$-I_C$ (A)
10
1
10^{-1}
typ
1
10
10^2
$-I_B$ (mA)
10^3

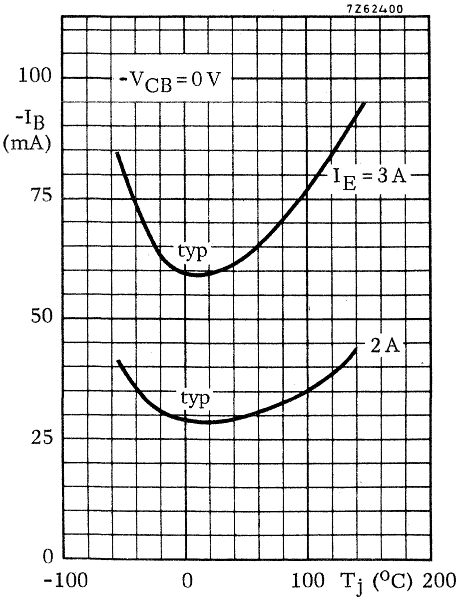

7Z62404
$-V_{CE} = 2$ V
$T_j = 25$ °C
h_{FE}
150
100
50
0
typ
10^{-2}
10^{-1}
1
$-I_C$ (A)
10

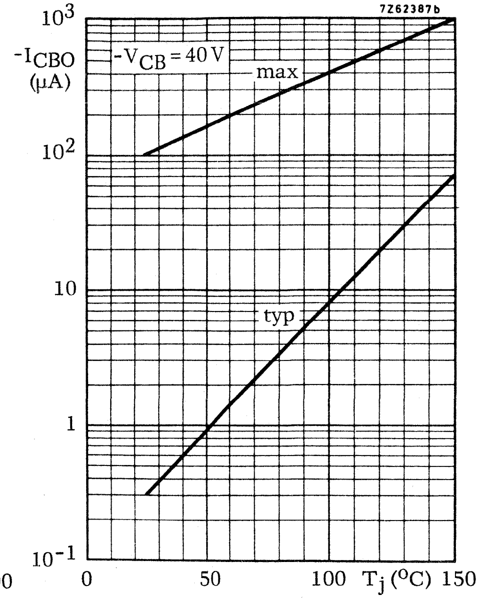

7Z62396
15
-I_C
(A)
10
5
0
0
1
-V_{BE} (V)
2
-V_{CE} = 2 V
T_j = 25 °C
typ

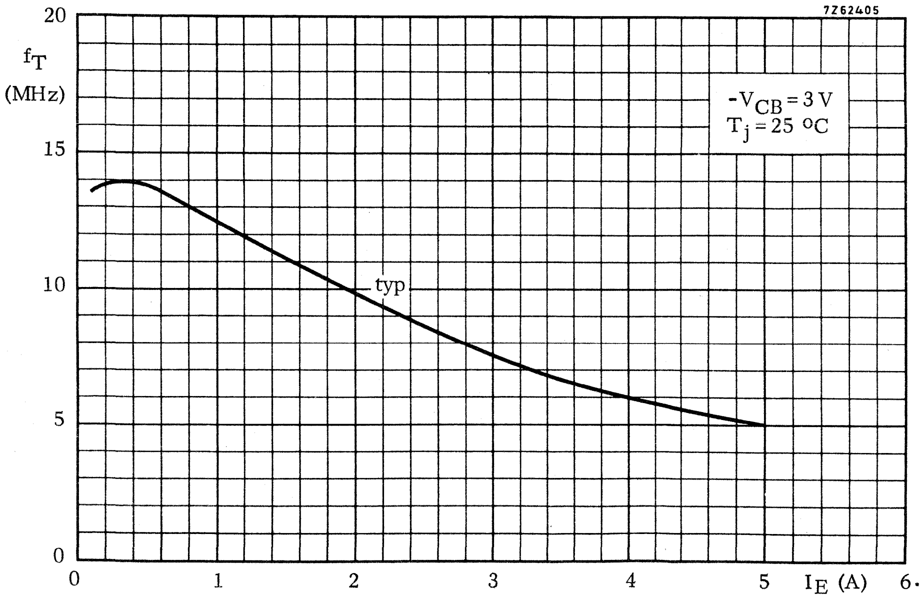

7Z67035
100
$P_{tot\ max}$
(%)
75
50
25
0
0
50
100
150
T_{mb} (°C)


7Z62394
1.5
-V_{CEsat}
(V)
1
0.5
0
0
5
-I_C (A)
10
$\frac{I_C}{I_B}$ = 10
T_j = 25 °C
typ


7Z62398
3
-V_{BEsat}
(V)
2
1
0
0
5
-I_C (A)
10
$\frac{I_C}{I_B}$ = 10
T_j = 25 °C
typ


7Z62400
-VCB = 0 V
-IB
(mA)
100
75
50
25
0
IE = 3 A
typ
2 A
typ
-100
0
100
Tj (°C)
200


7Z62387b
-ICBO
(μA)
-VCB = 40 V
max
typ
10³
10²
10
1
10⁻¹
0
50
100
Tj (°C)
150


7Z62405
fT
(MHz)
20
15
10
5
0
-VCB = 3 V
Tj = 25 °C
typ
0
1
2
3
4
5
IE (A)
6

SILICON PLANAR EPITAXIAL POWER 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

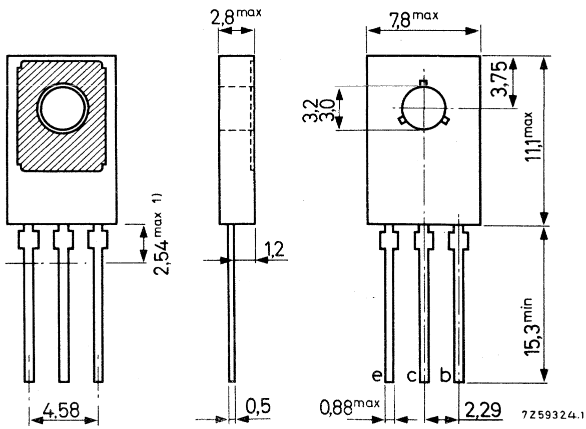
			BD226	BD228	BD230	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Collector current (peak value)	I_{CM}	max.	3	3	3	A
Total power dissipation up to T_{mb} = 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						
I_C = 50 mA; V_{CE} = 5 V	f_T	typ.	125	125	125	MHz

MECHANICAL DATA

Dimensions in mm

TO-126 (SOT-32)

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)

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	A
Collector current (peak value)	I_{CM}	max.	3	A

Power dissipation				
Total power dissipation up to T_{mb} = 62 °C	P_{tot}	max.	12,5	W

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	$R_{th\ j-a}$	=	100	°C/W
From junction to mounting base	$R_{th\ j-mb}$	=	7	°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 [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

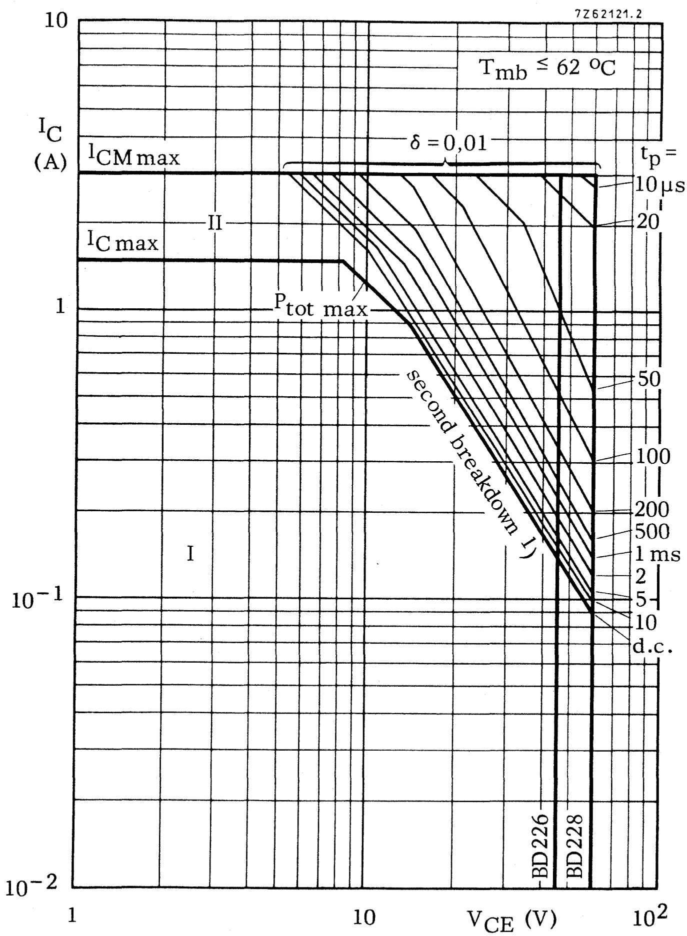
D.C. current gain ratio of matched pairs

BD226/BD227; BD228/BD229;

BD230/BD231

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

[1] V_{BE} decreases by about 2,3 mV/°C with increasing temperature.

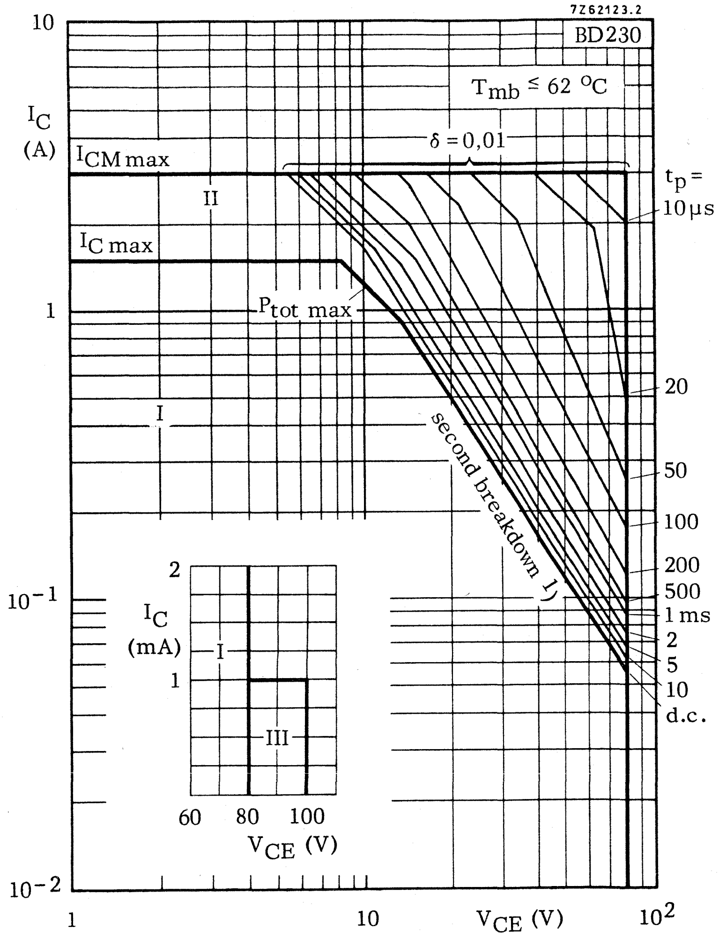


Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

1) Independent of temperature



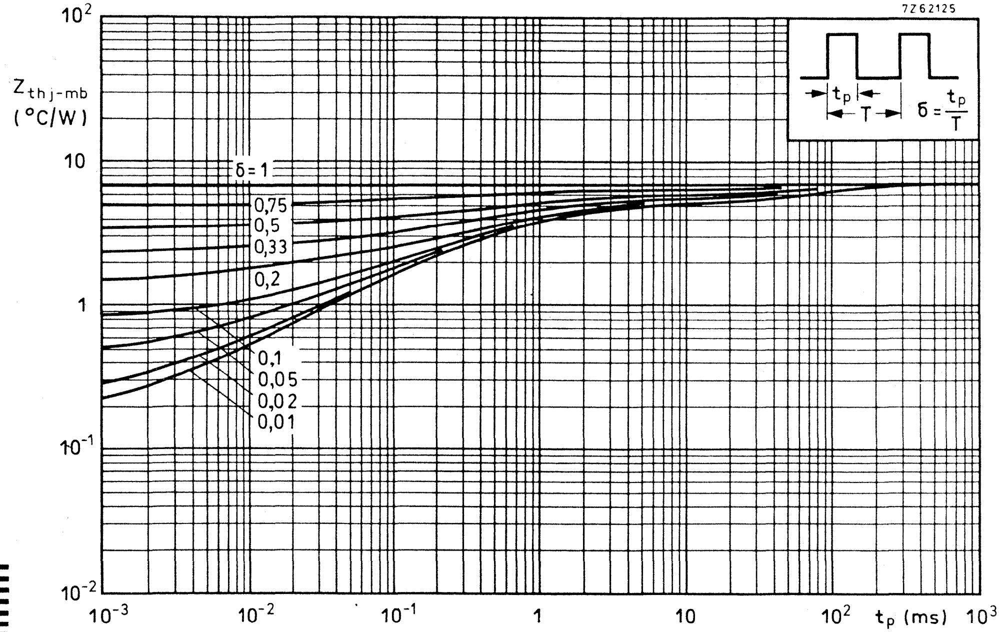
Safe Operating Area with the transistor forward biased

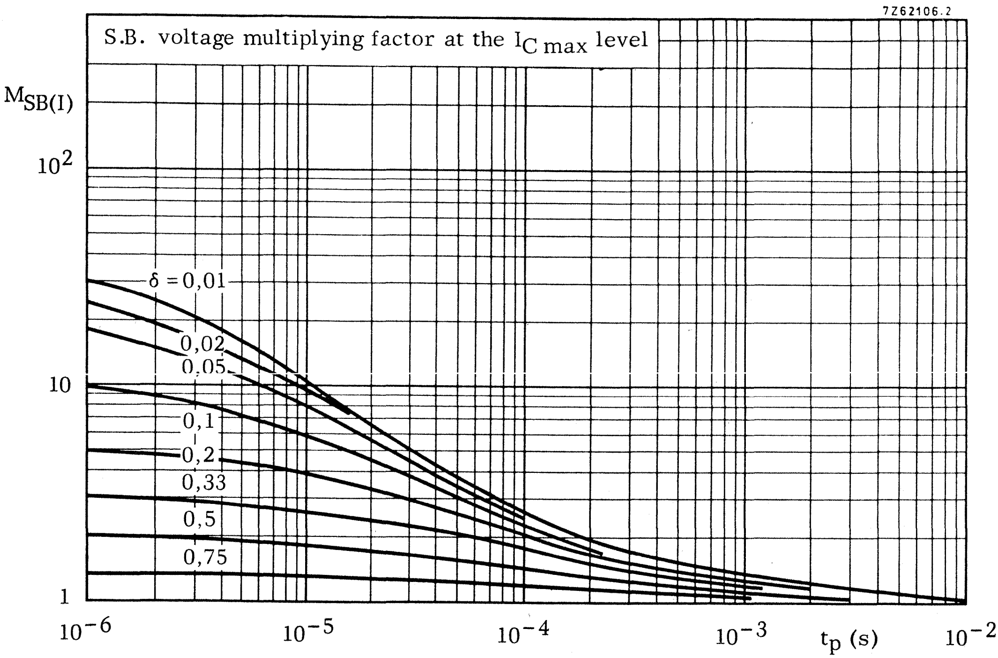
I Region of permissible d.c. operation

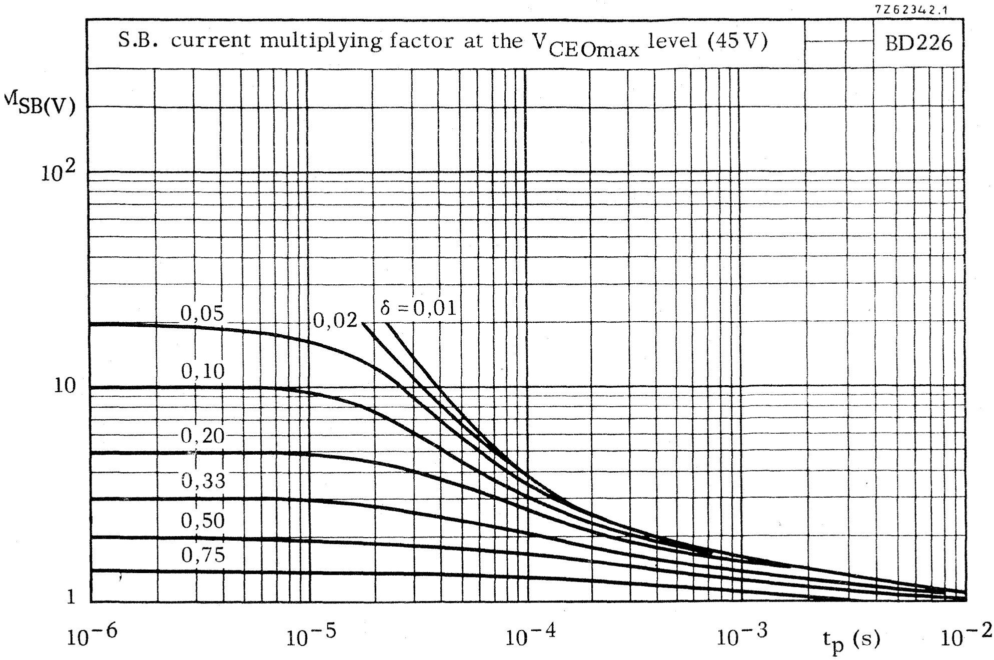
II Permissible extension for repetitive pulse. operation

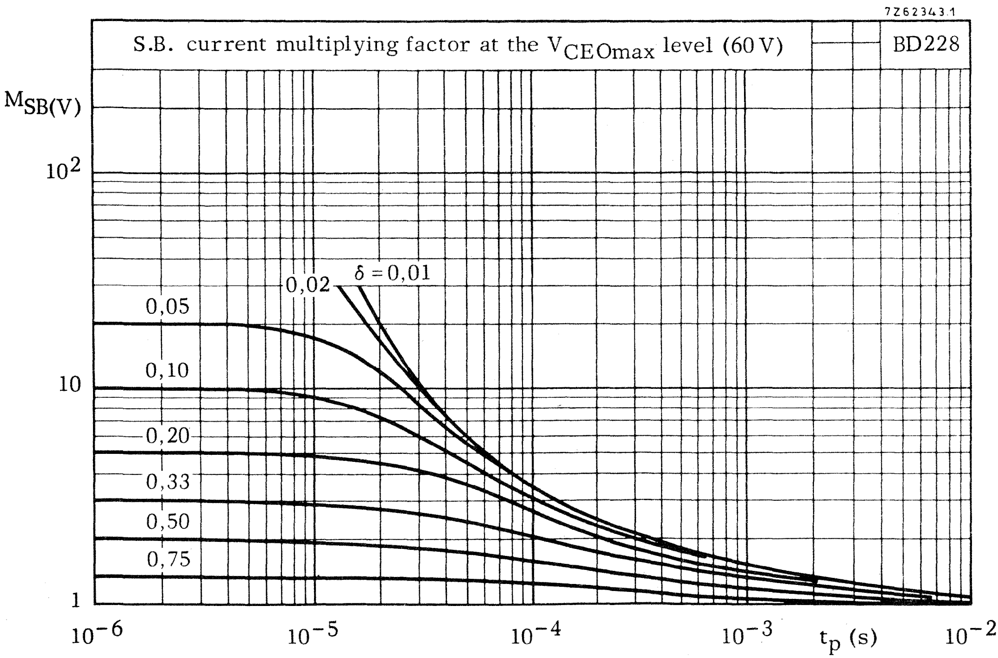
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 1$ kΩ

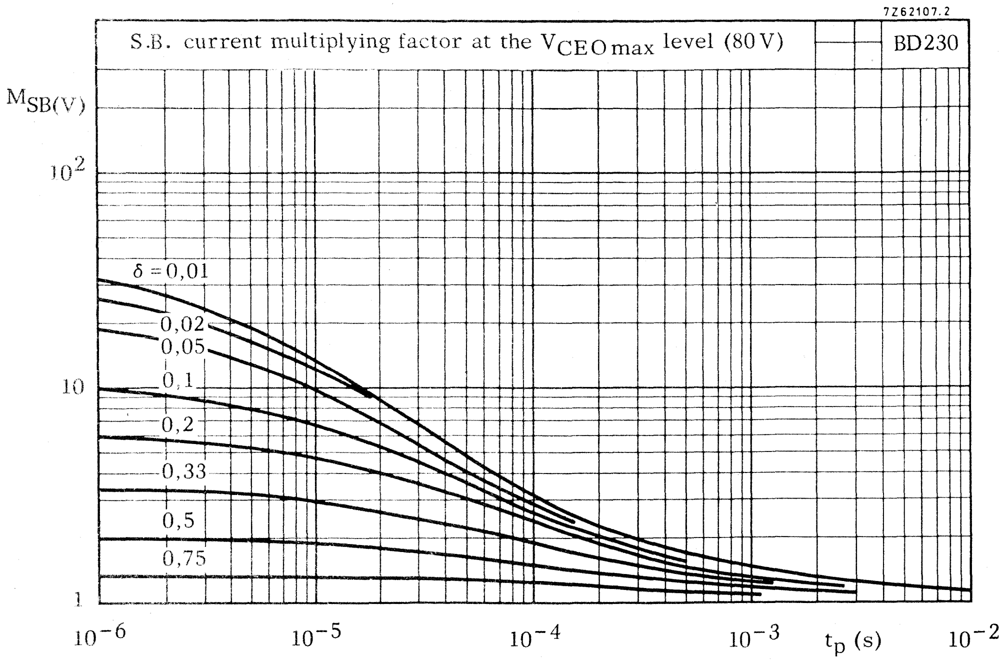
1) Independent of temperature

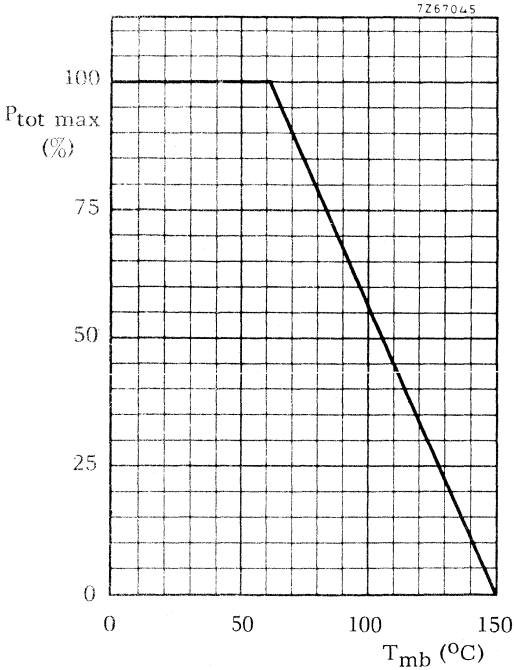

7Z62125
$Z_{th\,j\text{-}mb}$
(°C/W)
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
t_p
T
$\delta = \frac{t_p}{T}$
t_p (ms)

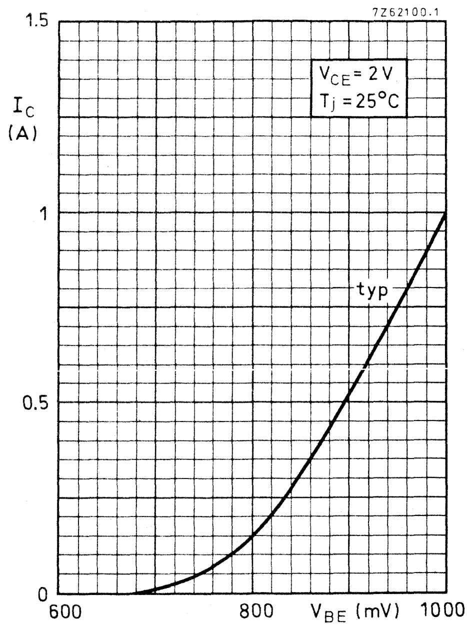

7Z62106.2
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
t_p (s)

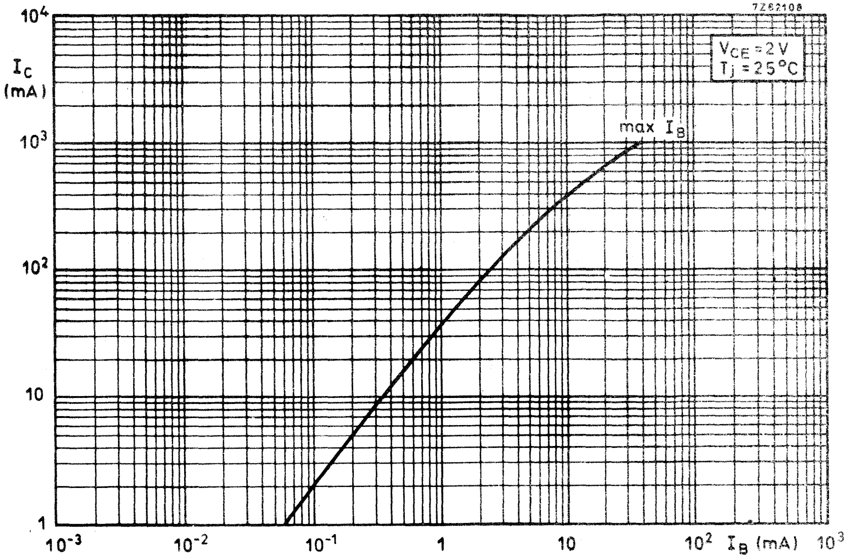

7Z62342.1
S.B. current multiplying factor at the V_{CEOmax} level (45 V)
BD226
$M_{SB(V)}$
10^2
10
1
0,05
0,02
$\delta = 0,01$
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

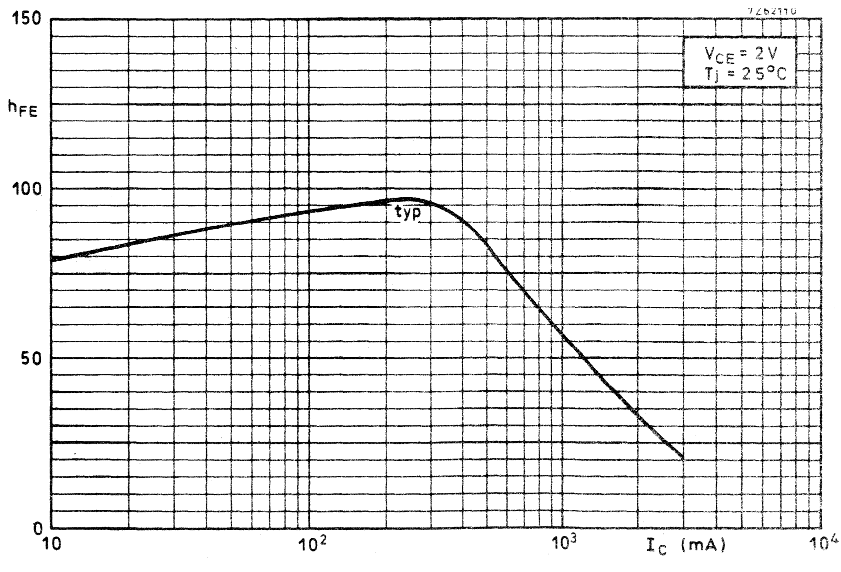

7Z62343.1
S.B. current multiplying factor at the V_{CEOmax} level (60 V)
BD228
$M_{SB(V)}$
10^2
10
1
0,05
0,02
$\delta = 0,01$
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

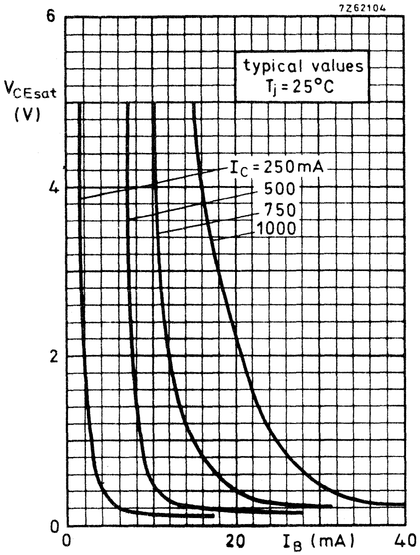

7Z62107.2
S.B. current multiplying factor at the VCEOmax level (80 V)
BD230
MSB(V)
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^-6
10^-5
10^-4
10^-3
tp (s)
10^-2

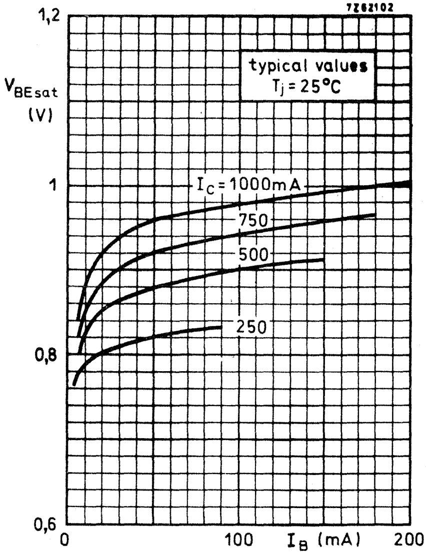

7Z67045
Ptot max
(%)
100
75
50
25
0
0
50
100
150
Tmb (°C)

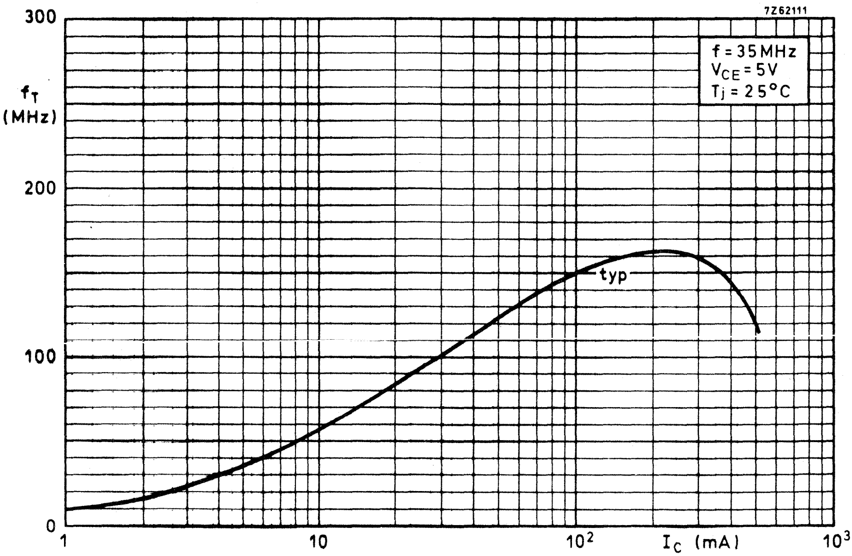

7Z62100.1
IC
(A)
1.5
1
0.5
0
VCE = 2 V
Tj = 25°C
typ
600
800
VBE (mV)
1000


7Z62108
I_C
(mA)
10^4
10^3
10^2
10
1
V_{CE} = 2 V
T_j = 25 °C
max I_B
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
I_B (mA)
10^3


7Z62110
150
h_{FE}
100
50
0
V_{CE} = 2 V
T_j = 25 °C
typ
10
10^2
10^3
I_C (mA)
10^4


7Z62104
typical values
$T_j = 25°C$
V_{CEsat}
(V)
$I_C = 250 mA$
500
750
1000
6
4
2
0
0
20
I_B (mA)
40


7Z62102
typical values
$T_j = 25°C$
V_{BEsat}
(V)
$I_C = 1000 mA$
750
500
250
1,2
1
0,8
0,6
0
100
I_B (mA)
200


7Z62111
f = 35 MHz
$V_{CE} = 5 V$
$T_j = 25°C$
f_T
(MHz)
typ
300
200
100
0
1
10
10^2
I_C (mA)
10^3

SILICON PLANAR EPITAXIAL POWER 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.

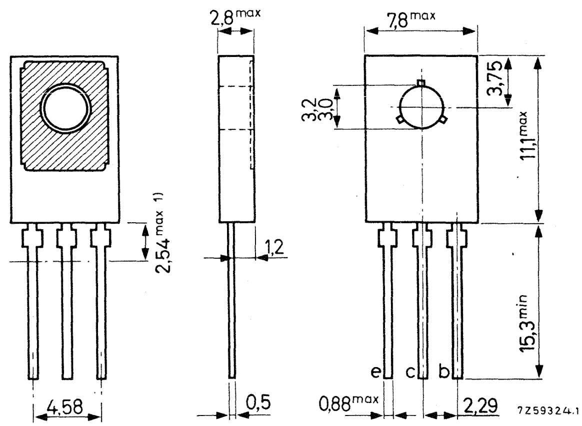
QUICK REFERENCE DATA

			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						
$-I_C$ = 50 mA; $-V_{CE}$ = 5 V	f_T	typ.	50	50	50	MHz

MECHANICAL DATA Dimensions in mm

TO-126 (SOT-32)

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)

Voltages

			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
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V

Currents

Collector current (d.c.)	$-I_C$	max.	1,5	A
Collector current (peak value)	$-I_{CM}$	max.	3	A

Power dissipation

Total power dissipation up to T_{mb} = 62 °C	P_{tot}	max.	12,5	W

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	$R_{th\ j-a}$	=	100	°C/W
From junction to mounting base	$R_{th\ j-mb}$	=	7	°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 [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

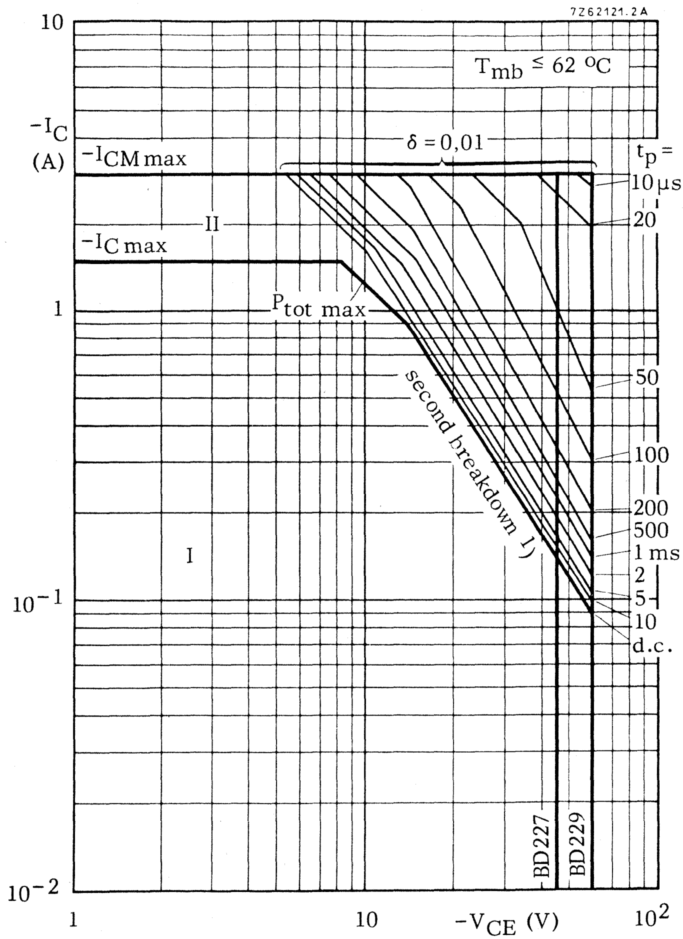
D.C. current gain ratio of matched pairs

BD226/BD227; BD228/BD229;

BD230/BD231

$\lvert I_C \rvert$ = 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/°C with increasing temperature.

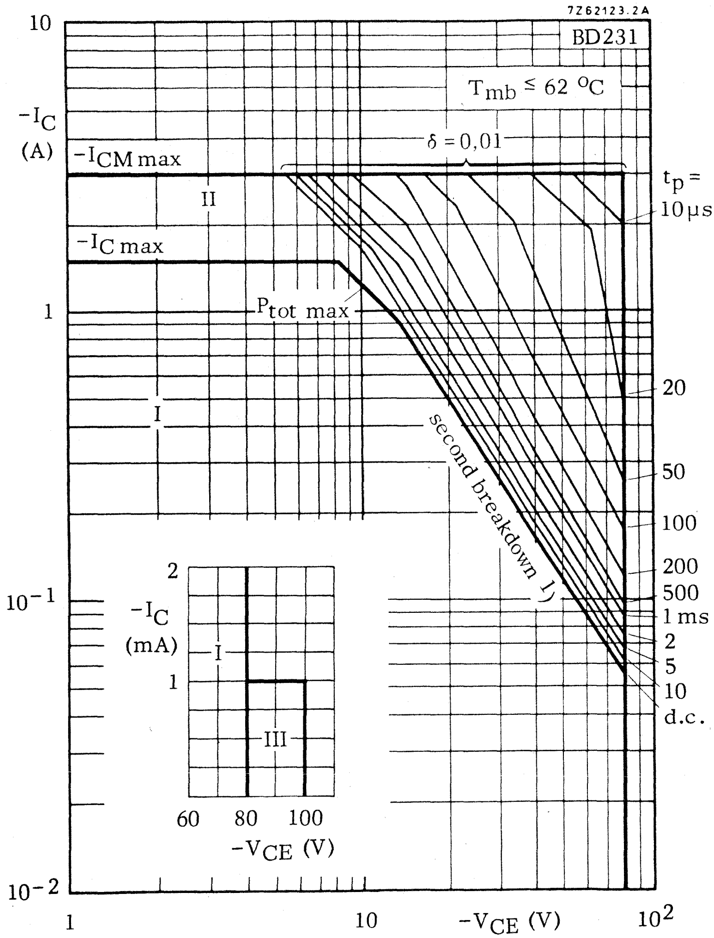


Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

1) Independent of temperature



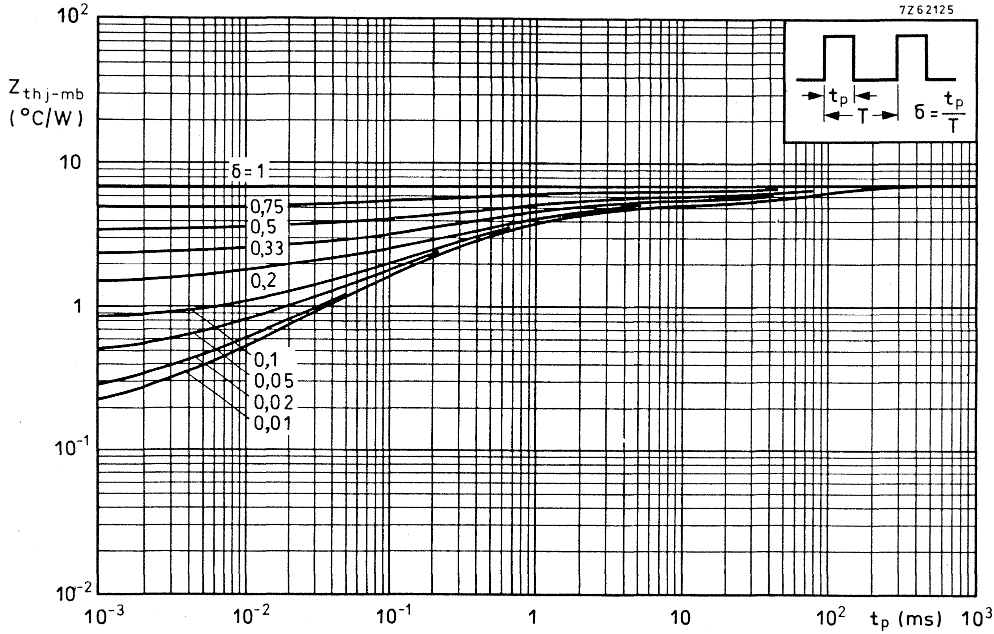
Safe Operating Area with the transistor forward biased

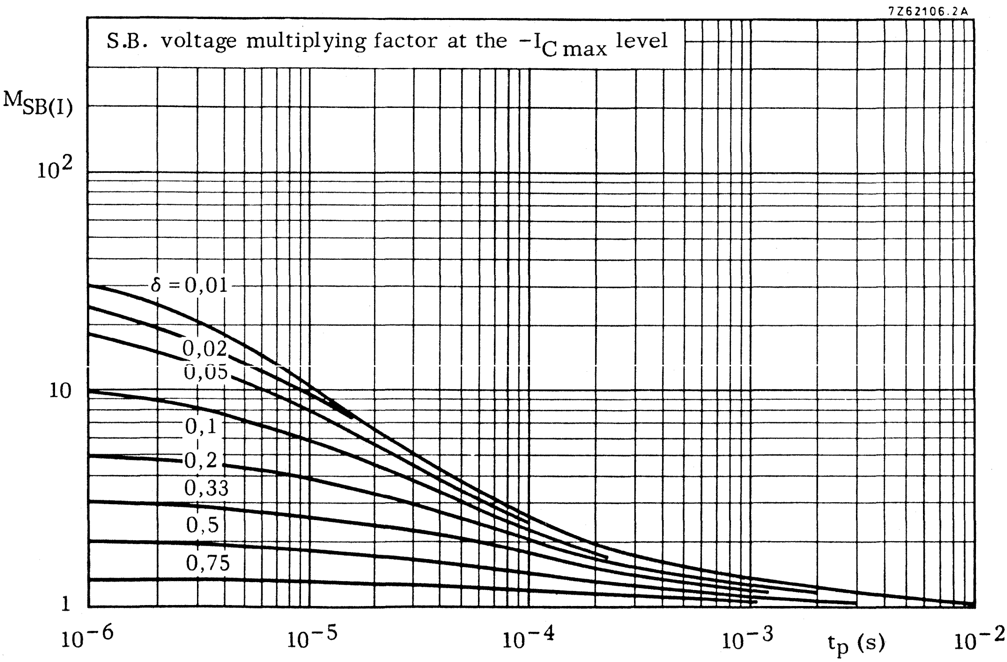
I Region of permissible d.c. operation

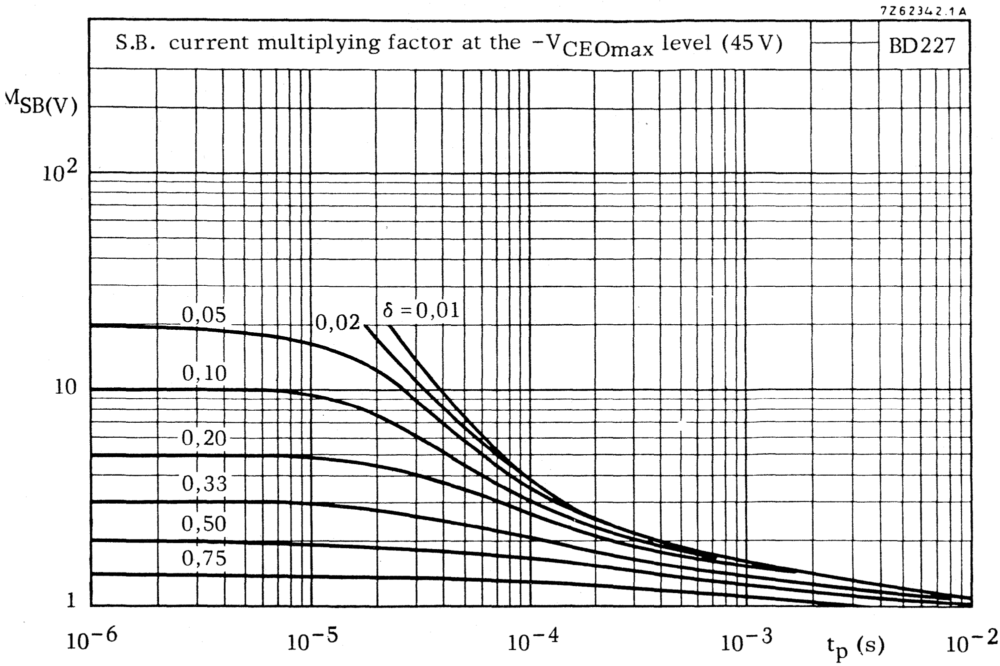
II Permissible extension for repetitive pulse operation

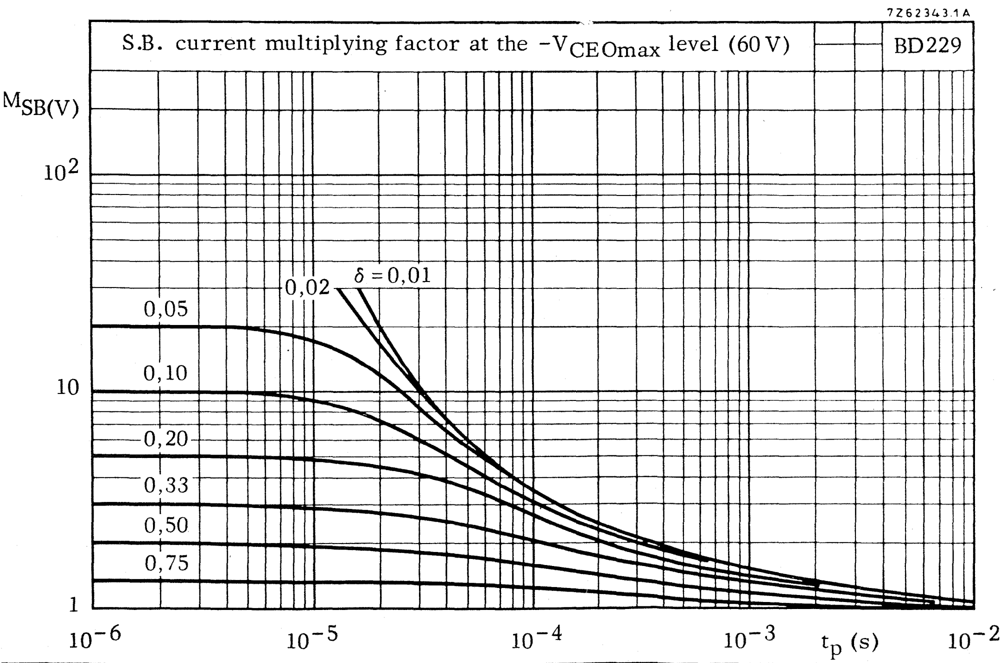
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 1$ kΩ

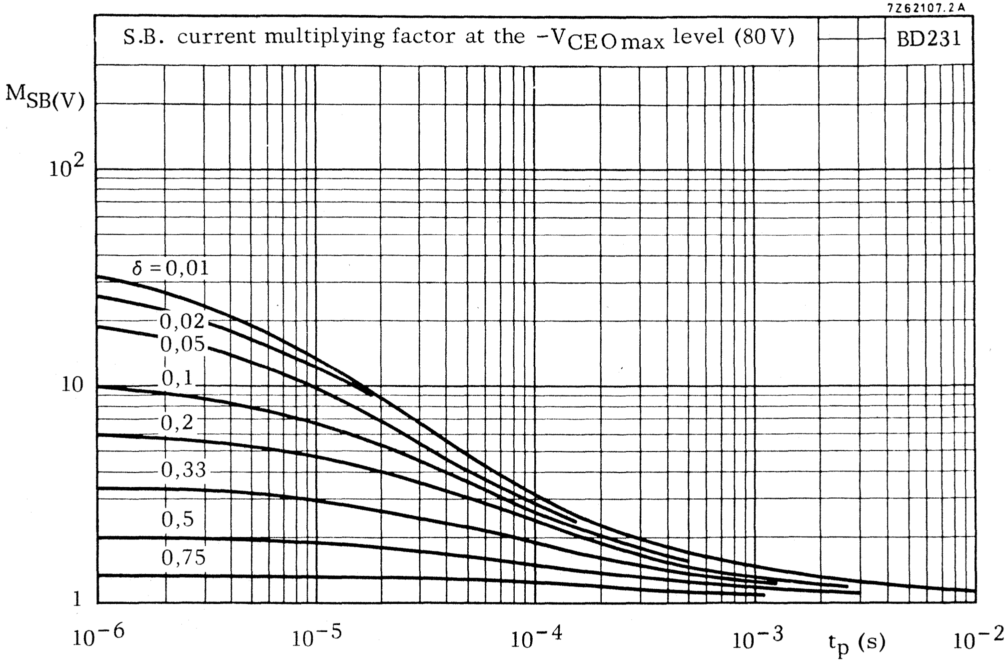
1) Independent of temperature

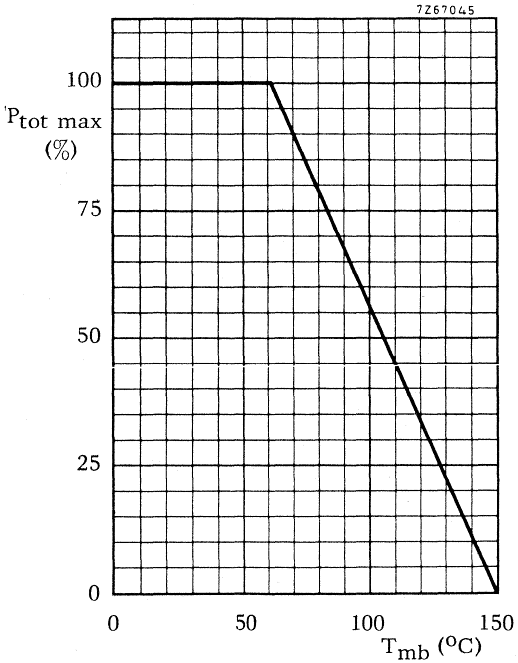

7Z62125
$Z_{th\,j-mb}$ (°C/W)
10^2
10
1
10^{-1}
10^{-2}
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3

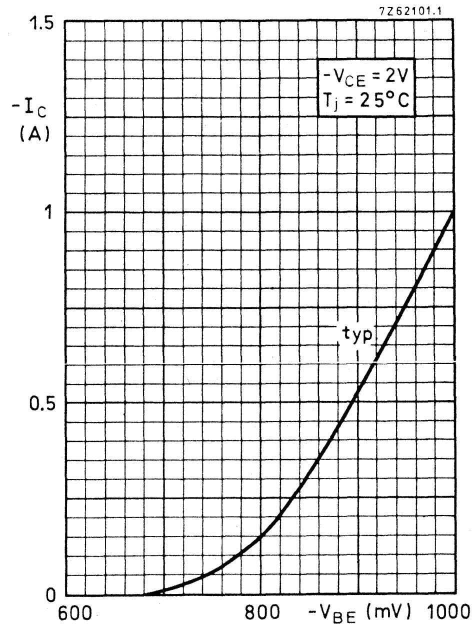

7Z62106.2A
S.B. voltage multiplying factor at the $-I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

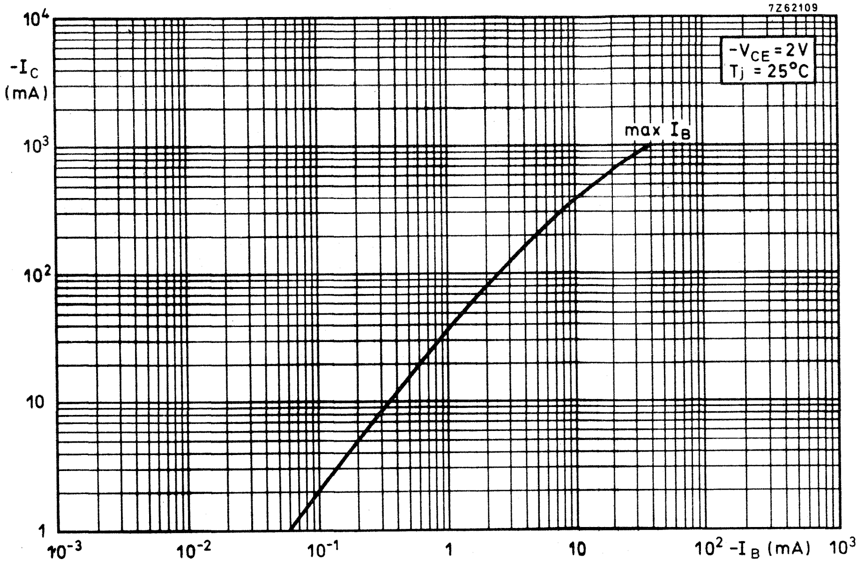

7Z62342.1A
S.B. current multiplying factor at the $-V_{CEOmax}$ level (45 V)
BD227
$M_{SB(V)}$
10^2
10
1
0,05
0,02
δ = 0,01
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

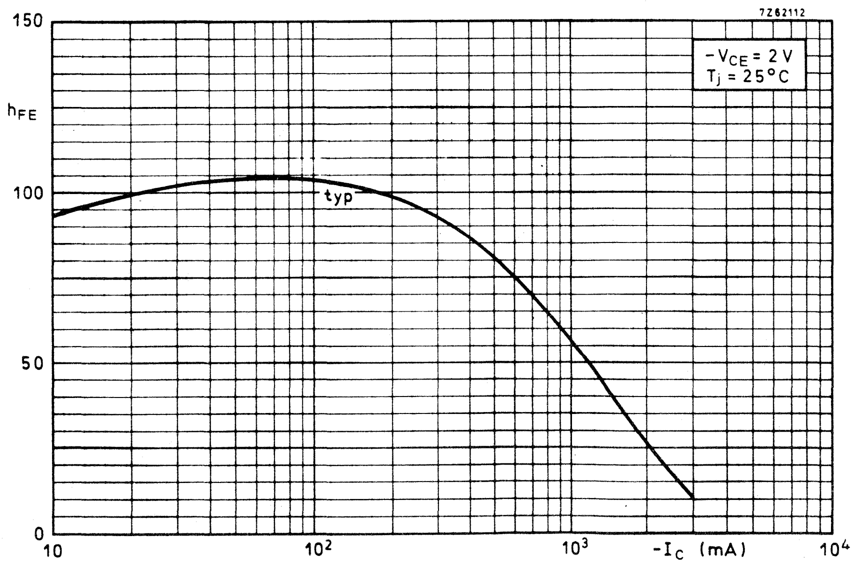

7Z62343.1A
S.B. current multiplying factor at the $-V_{CEOmax}$ level (60 V)
BD229
$M_{SB(V)}$
10^2
10
1
0,02
δ = 0,01
0,05
0,10
0,20
0,33
0,50
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

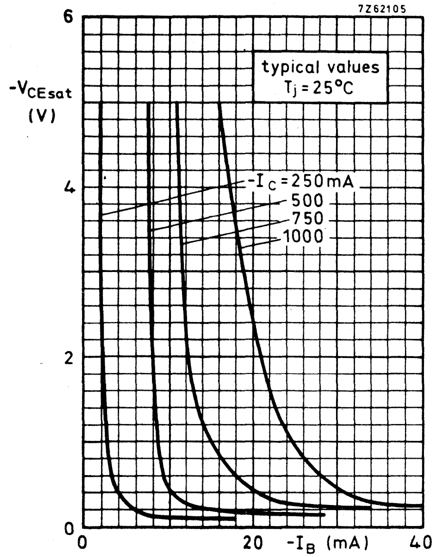

7Z62107.2A
S.B. current multiplying factor at the $-V_{CEO\,max}$ level (80 V)
BD231
$M_{SB(V)}$
10^2
10
1
$\delta = 0{,}01$
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

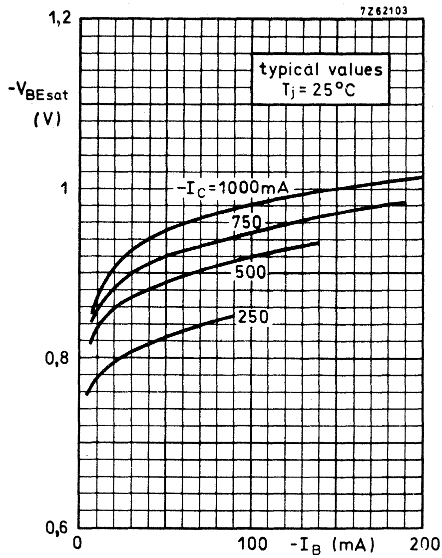

7Z67045
$P_{tot\,max}$ (%)
100
75
50
25
0
0
50
100
150
T_{mb} (°C)

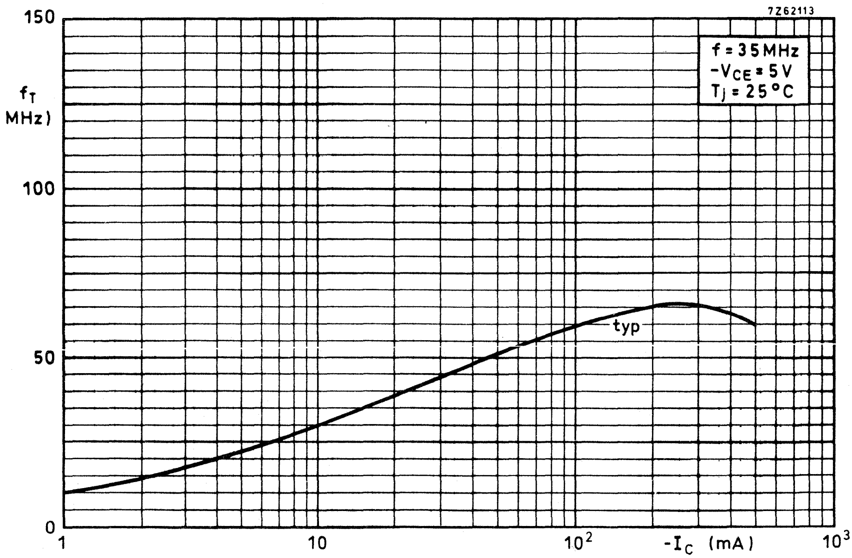

7Z62101.1
$-I_C$ (A)
1.5
1
0.5
0
$-V_{CE} = 2V$
$T_j = 25°C$
typ
600
800
$-V_{BE}$ (mV)
1000


7Z62109
10^4
$-I_C$ (mA)
10^3
10^2
10
1
$-V_{CE} = 2$ V
$T_j = 25$°C
max I_B
10^{-3}
10^{-2}
10^{-1}
1
10
10^2 $-I_B$ (mA)
10^3


7Z62112
150
h_{FE}
100
50
0
$-V_{CE} = 2$ V
$T_j = 25$°C
typ
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)

SILICON DIFFUSED POWER TRANSISTOR

High-voltage n-p-n transistor in a SOT-32 plastic envelope intended for use as line driver in television receivers.

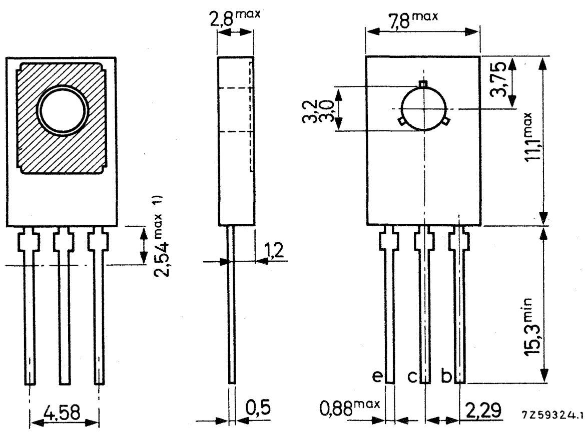
QUICK REFERENCE DATA				
Collector-emitter voltage ($R_{BE} \leq 1$ kΩ) peak value	V_{CERM}	max.	500	V
Collector-emitter voltage (open base)	V_{CEO}	max.	300	V
Collector current (d.c.)	I_C	max.	0,25	A
Collector current (peak value, $t_p \leq 1$ ms)	I_{CM}	max.	1	A
Total power dissipation up to T_{mb} = 57,5 °C	P_{tot}	max.	15	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 I_C = 50 mA; V_{CE} = 10 V	f_T	typ.	20	MHz

MECHANICAL DATA

Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface



For mounting instructions see section Accessories in handbook SC2, type 56333 for insulated mounting and type 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 (IEC 134)

Voltages

Collector-emitter voltage ($R_{BE} \leq 1\ k\Omega$, 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} = 57,5 °C	P_{tot}	max.	15	W

Temperatures

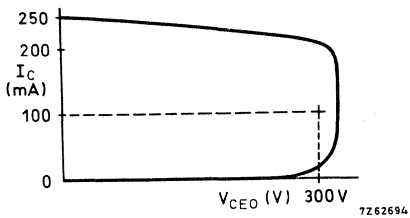
Storage temperature	T_{stg}		−65 to +125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

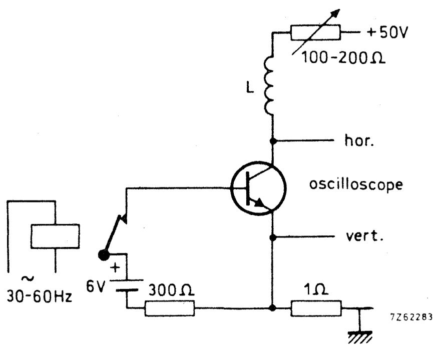
→ From junction to mounting base	$R_{th\ j-mb}$	=	4,5	°C/W
From junction to ambient in free air	$R_{th\ j-a}$	=	100	°C/W

CHARACTERISTICS $T_j = 25\ ^oC$ 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; $T_j = 125\ ^oC$	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



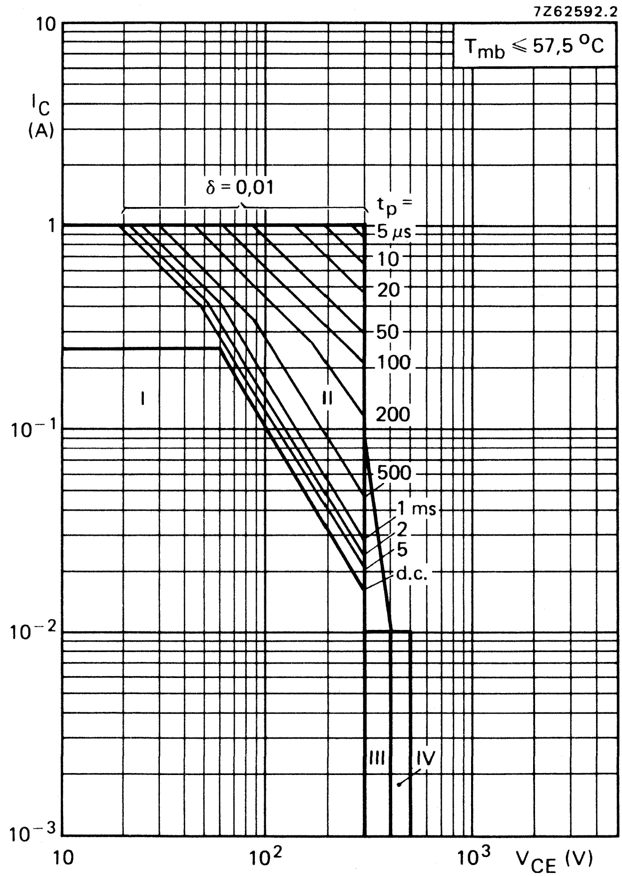
Oscilloscope display for $V_{CEOsust}$



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).



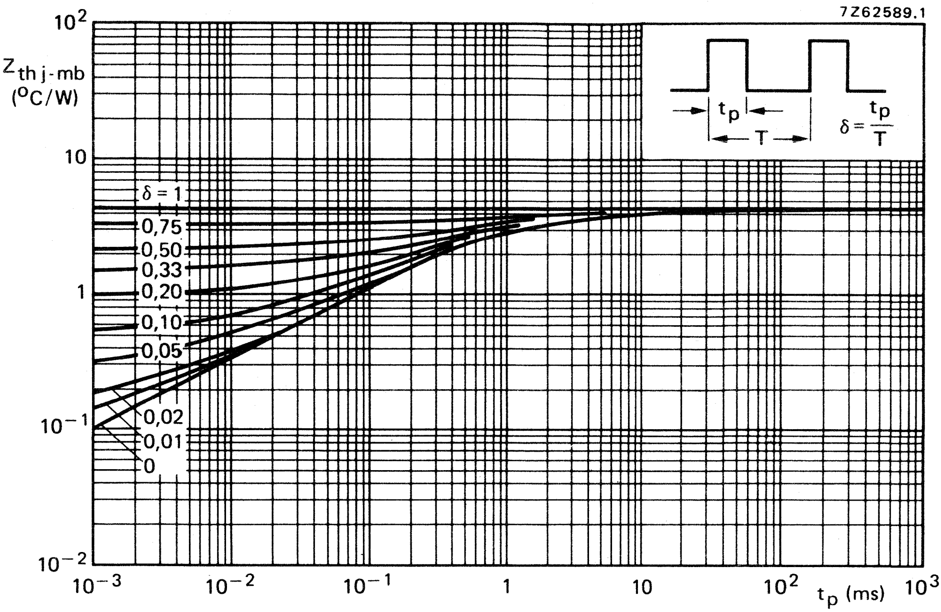
Safe Operating ARea

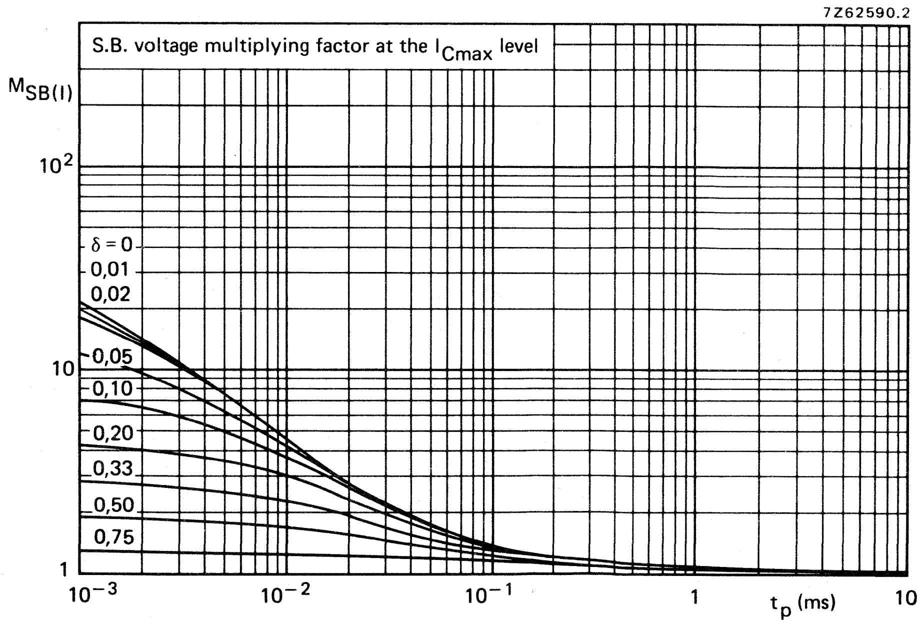
I Region of permissible d.c. operation

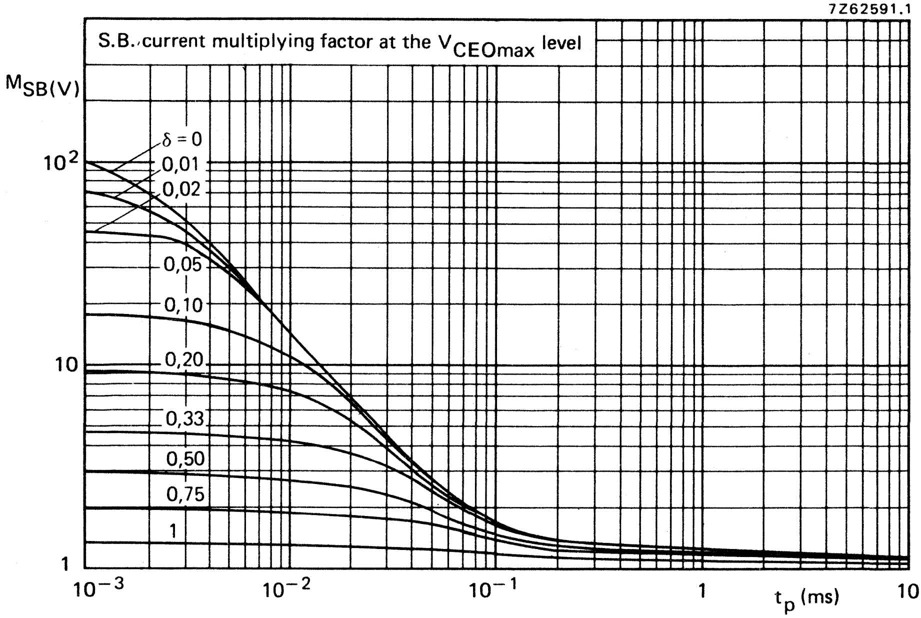
II Permissible extension for repetitive pulse operation

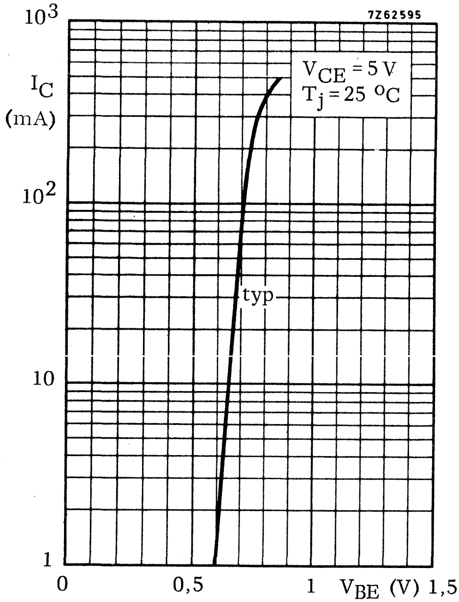
III Area of permissible operation during turn-on, provided $R_{BE} \leq 1\ k\Omega$ and $t_p \leq 0,3\ \mu s$

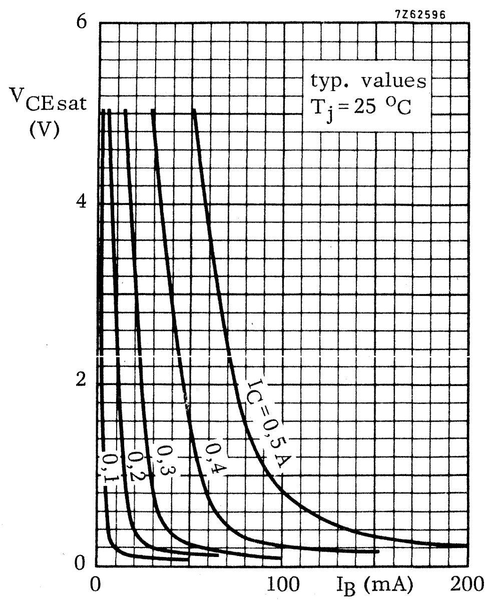
IV Repetitive pulse operation in this region is permissible, provided $R_{BE} \leq 1\ k\Omega$

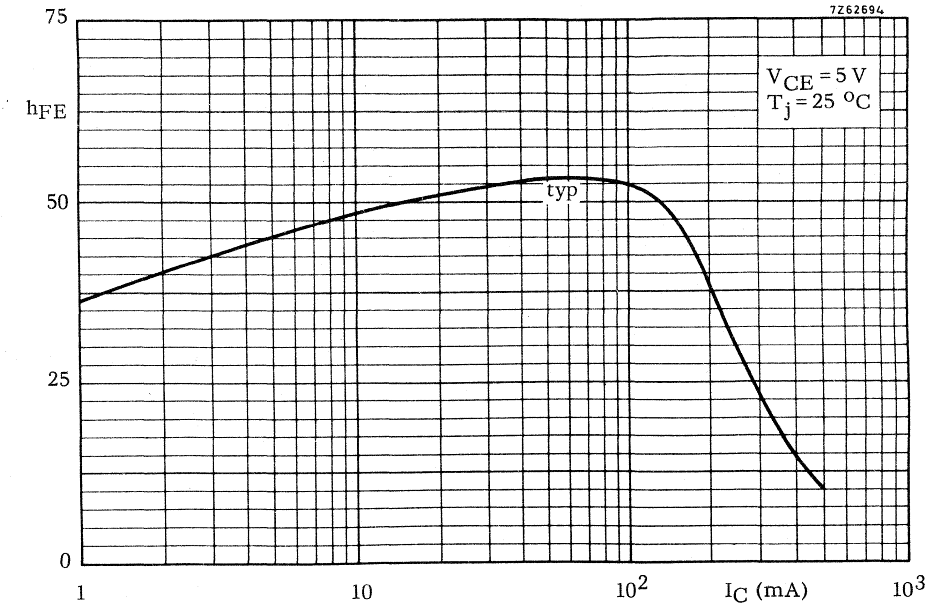

7Z62589.1
10^2
$Z_{th\,j\text{-}mb}$ ($^oC/W$)
10
1
10^{-1}
10^{-2}
δ = 1
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
0
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3
t_p
T
$\delta = \frac{t_p}{T}$

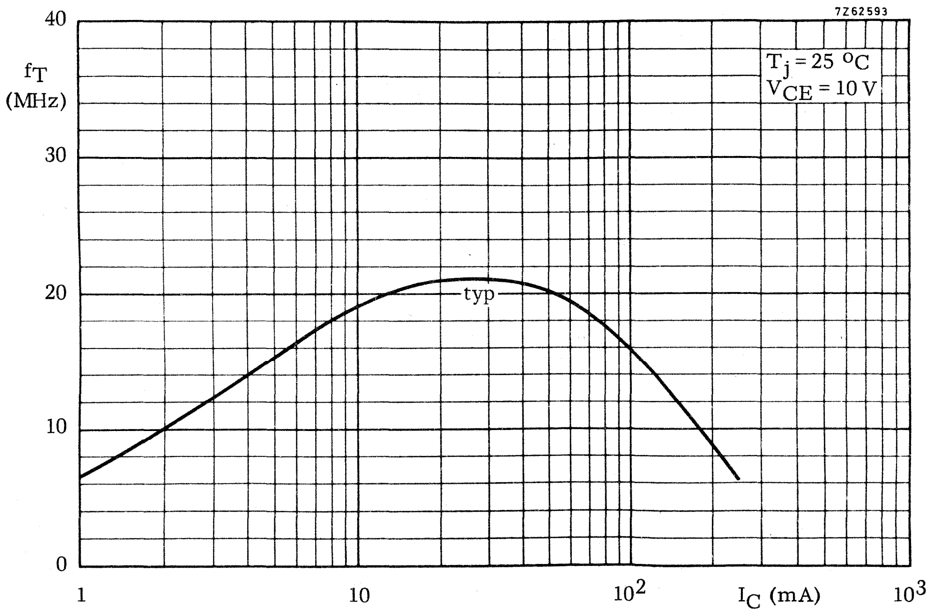

7Z62590.2
S.B. voltage multiplying factor at the I_{Cmax} level
$M_{SB(I)}$
10^2
10
1
δ = 0
0,01
0,02
0,05
0,10
0,20
0,33
0,50
0,75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10


7Z62591.1
S.B. current multiplying factor at the V_{CEOmax} level
$M_{SB(V)}$
$\delta = 0$
0,01
0,02
0,05
0,10
0,20
0,33
0,50
0,75
1
10^2
10
1
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
50
25
0
h_{FE}
$V_{CE} = 5$ V
$T_j = 25$ °C
typ
1
10
10^2
I_C (mA)
10^3


7Z62593
40
30
20
10
0
f_T
(MHz)
$T_j = 25$ °C
$V_{CE} = 10$ V
typ
1
10
10^2
I_C (mA)
10^3

SILICON EPITAXIAL-BASE POWER 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. P-N-P complements are BD234, BD236 and BD238. Matched pairs can be supplied. ←

QUICK REFERENCE DATA

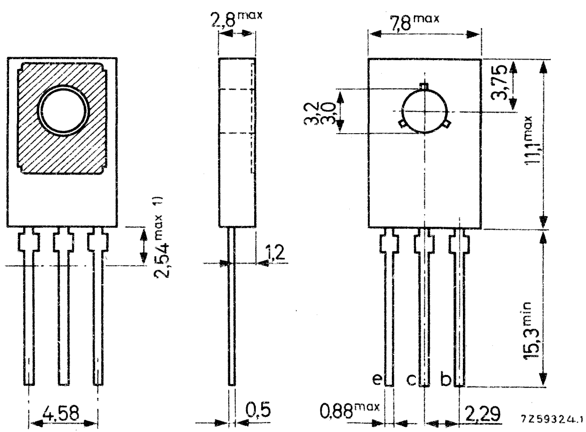
			BD233	BD235	BD237	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	V_{CER}	max.	45	60	100	V
Collector current (peak value)	I_{CM}	max.		6		A
Total power dissipation up to T_{mb} = 25 °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 I_C = 250 mA; V_{CE} = 10 V	f_T	>		3		MHz

MECHANICAL DATA

Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface



For mounting instructions see section Accessories, type 56326 for direct 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)

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}		−65 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	5	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

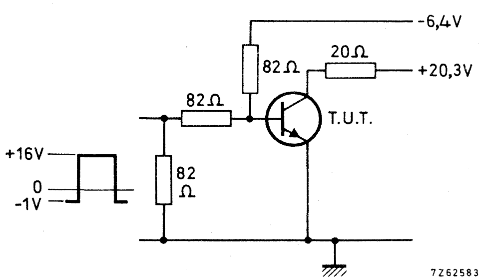
Collector cut-off current				
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	100	µA
$I_E = 0$; $V_{CB} = V_{CBOmax}$; T_j = 150 °C	I_{CBO}	<	3	mA
Emitter cut-off current				
$I_C = 0$; V_{EB} = 5 V	I_{EBO}	<	1	mA

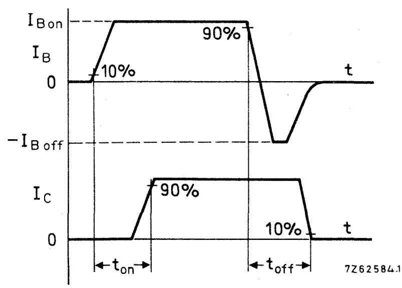
CHARACTERISTICS (continued)

T_j = 25 °C

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			
I_C = 150 mA; V_{CE} = 2 V	h_{FE}		40 to 250
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
D.C. current gain ratio of matched pairs BD233/BD234; BD235/BD236; BD237/BD238			
$\|I_C\|$ = 150 mA; $\|V_{CE}\|$ = 2 V	h_{FE1}/h_{FE2}	<	1,6
Switching times			
I_{Con} = 1 A; I_{Bon} = $-I_{Boff}$ = 0,1 A			
turn-on time	t_{on}	typ	0,3 μs
turn-off time	t_{off}	typ	1,1 μs

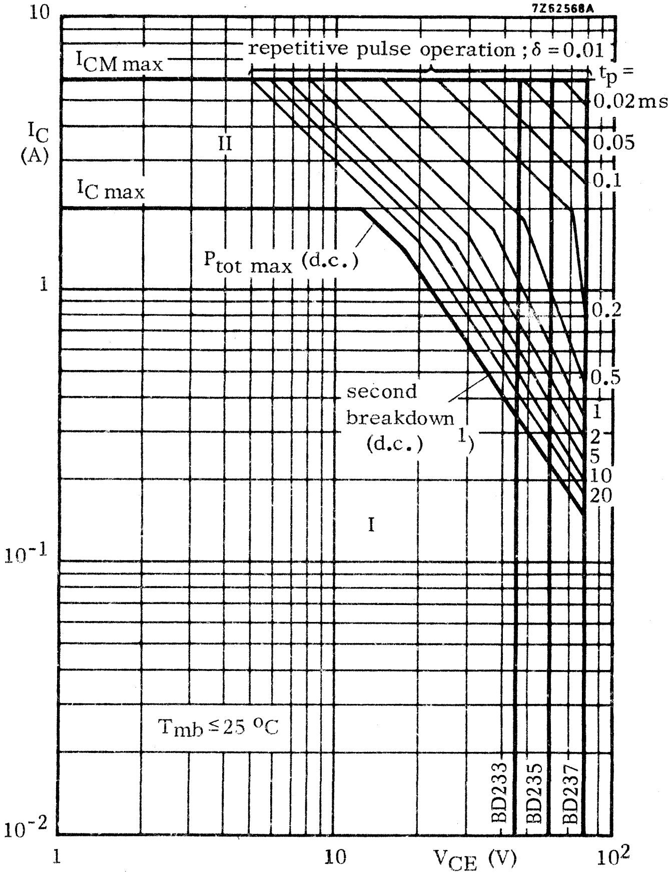
Test circuit





Input pulse:

$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

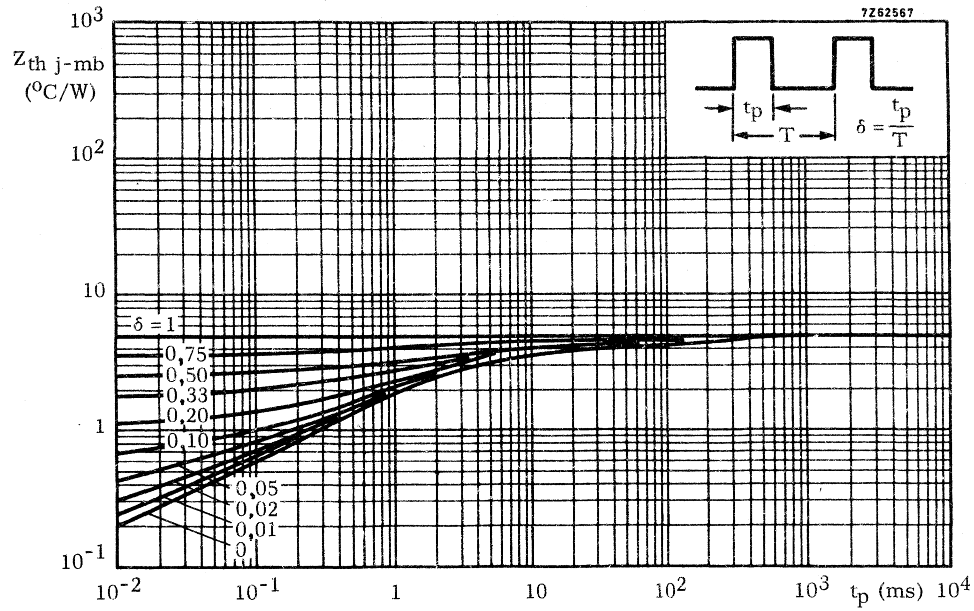


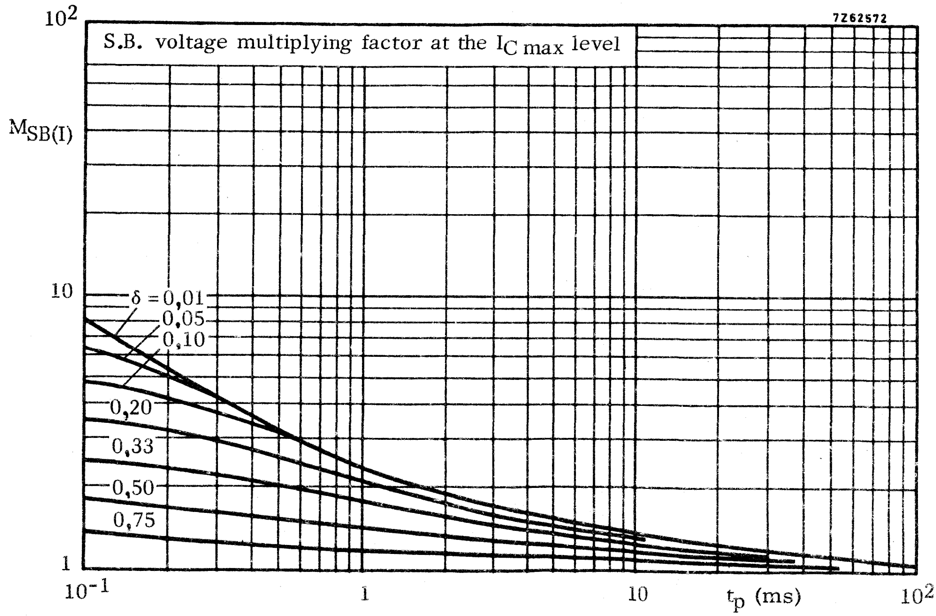
Safe Operating Area with the transistor forward biased

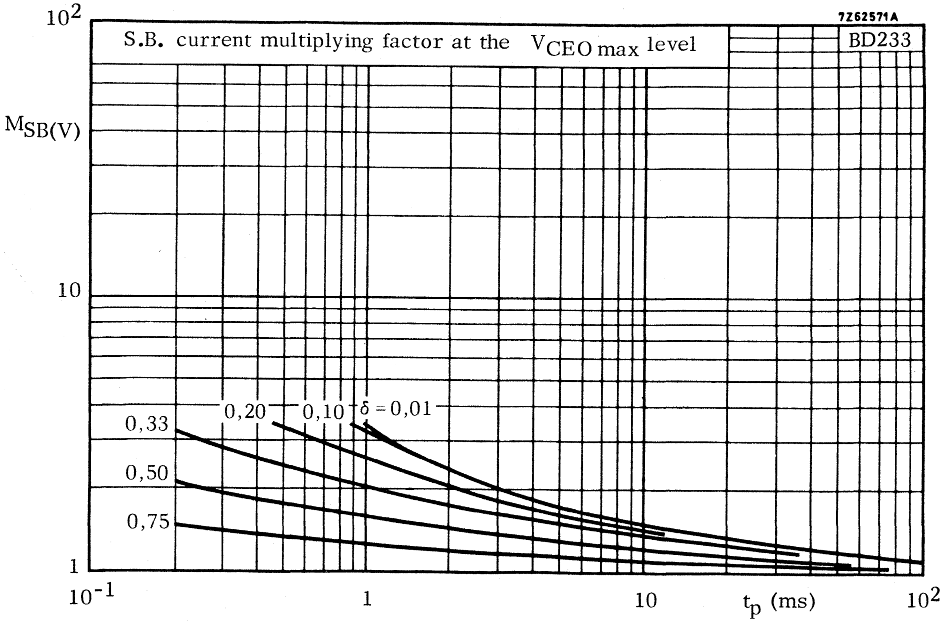
I Region of permissible d.c. operation

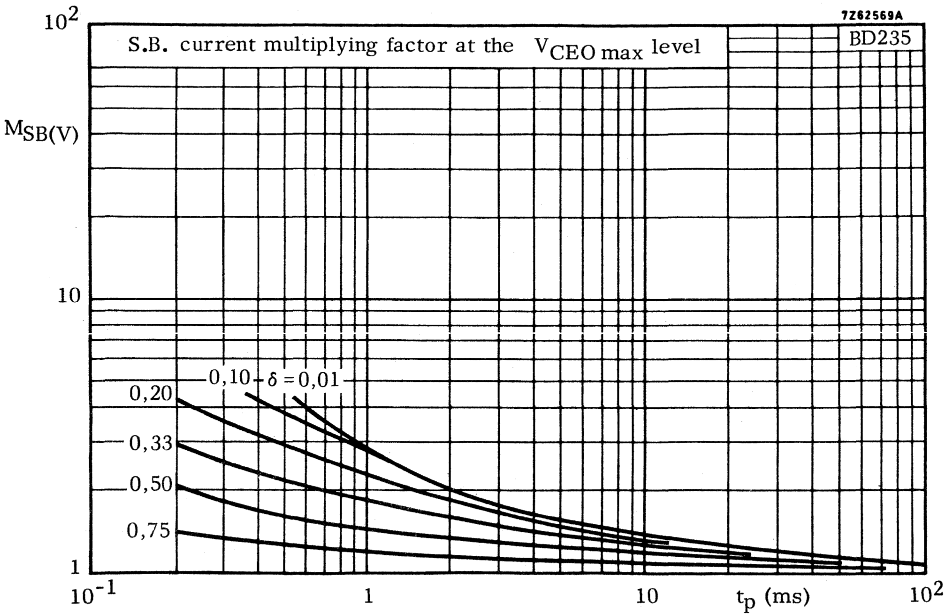
II Permissible extension for repetitive pulse operation

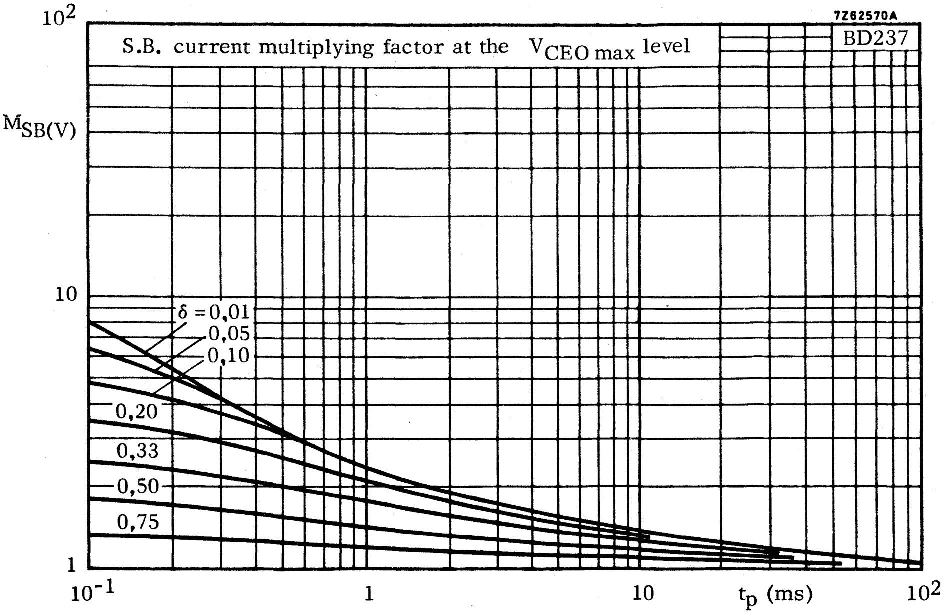
1) Independent of temperature

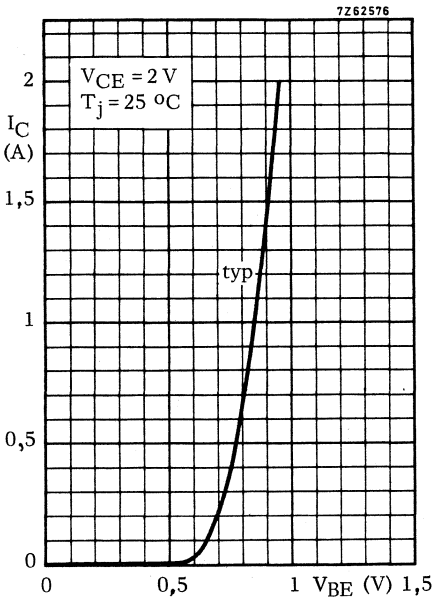

7Z62567
Zth j-mb
(°C/W)
δ = 1
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
0
tp
T
δ = tp/T
tp (ms)

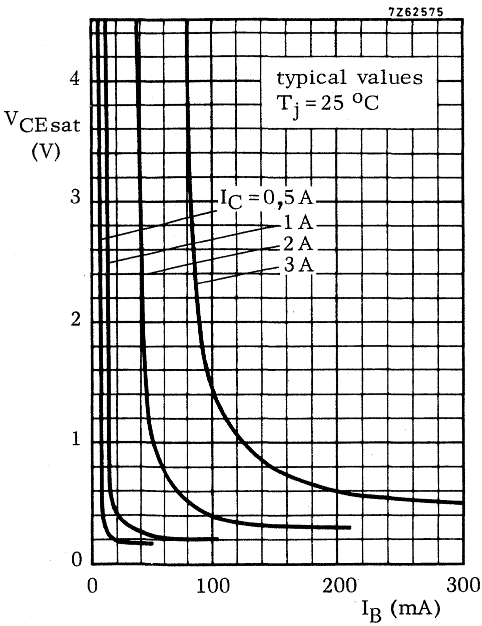

7Z62572
S.B. voltage multiplying factor at the IC max level
MSB(I)
δ = 0,01
0,05
0,10
0,20
0,33
0,50
0,75
tp (ms)

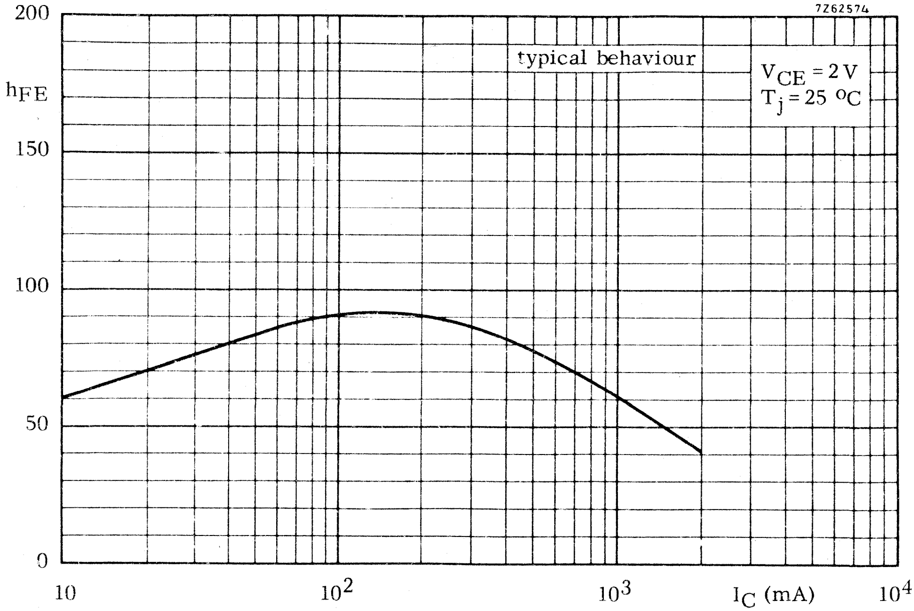

7Z62571A
S.B. current multiplying factor at the $V_{CEO\,max}$ level
BD233
10^2
$M_{SB(V)}$
10
1
0,33
0,20
0,10
δ = 0,01
0,50
0,75
10^{-1}
1
10
t_p (ms)
10^2


7Z62569A
S.B. current multiplying factor at the $V_{CEO\,max}$ level
BD235
10^2
$M_{SB(V)}$
10
1
0,20
0,10
δ = 0,01
0,33
0,50
0,75
10^{-1}
1
10
t_p (ms)
10^2


7Z62570A
BD237
S.B. current multiplying factor at the VCEO max level
MSB(V)
10²
10
1
δ = 0,01
0,05
0,10
0,20
0,33
0,50
0,75
10⁻¹
1
10
10²
tp (ms)


7Z62576
VCE = 2 V
Tj = 25 °C
IC
(A)
2
1,5
1
0,5
0
typ
0
0,5
1
VBE (V)
1,5


7Z62575
typical values
Tj = 25 °C
VCEsat
(V)
4
3
2
1
0
IC = 0,5 A
1 A
2 A
3 A
0
100
200
300
IB (mA)


7Z62574
200
150
100
50
0
h_{FE}
typical behaviour
$V_{CE} = 2\ V$
$T_j = 25\ ^oC$
10
10^2
10^3
I_C (mA)
10^4

SILICON EPITAXIAL-BASE POWER TRANSISTORS

P-N-P transistors in a SOT-32 plastic envelope intended for use in television and audio amplifier circuits where high peak powers can occur. N-P-N complements are BD233, BD235 and BD237. Matched pairs can be supplied.

QUICK REFERENCE DATA

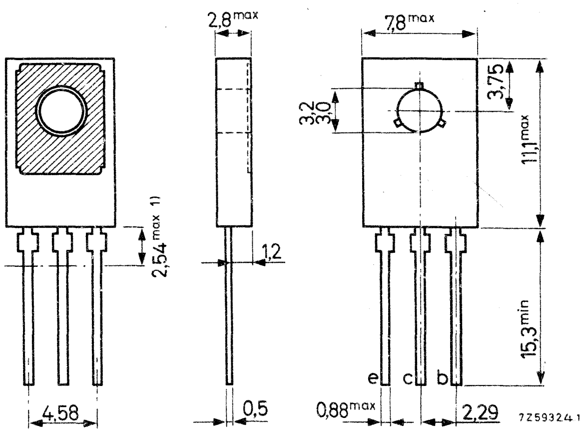
			BD234	BD236	BD238	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	V
Collector-emitter voltage (R_{BE} = 1 kΩ)	$-V_{CER}$	max.	45	60	100	V
Collector current (peak value)	$-I_{CM}$	max.		6		A
Total power dissipation up to 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 $-I_C$ = 250 mA; $-V_{CE}$ = 10 V	f_T	>		3		MHz

MECHANICAL DATA

Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface



For mounting instructions see section Accessories, type 56326 for direct 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)

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 dissipation

Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	25	W

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	$R_{th\ j\text{-}a}$	=	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

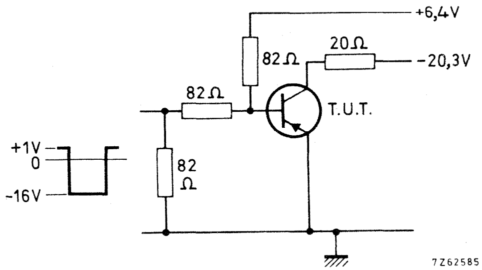
$I_C = 0$; $-V_{EB}$ = 5 V	$-I_{EBO}$	<	1	mA

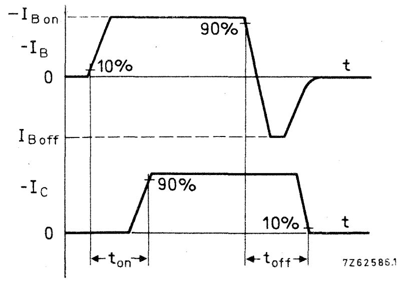
CHARACTERISTICS (continued)

T_j = 25 °C

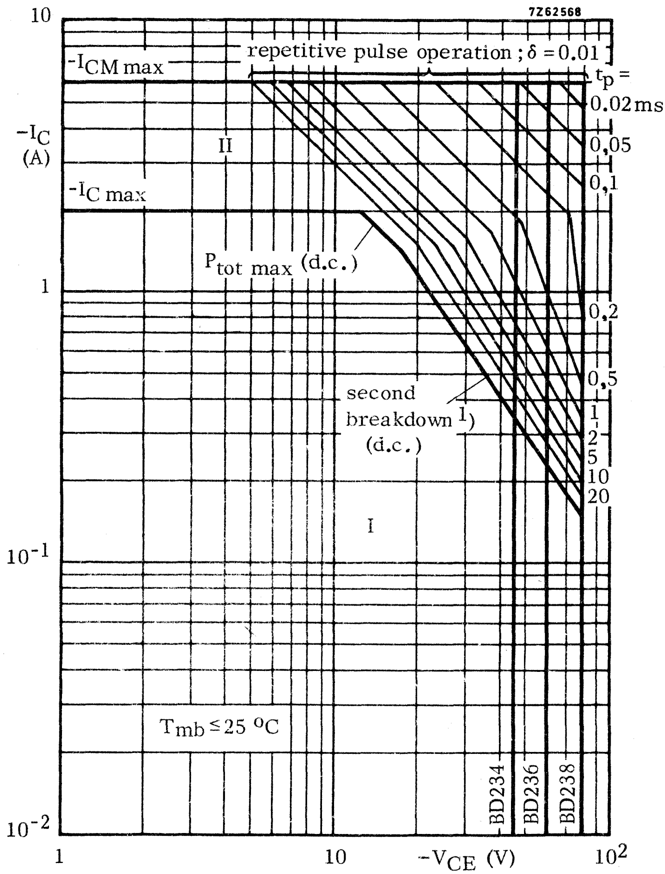
Base-emitter voltage			
$-I_C$ = 1 A; $-V_{CE}$ = 2 V	$-V_{BE}$	<	1,3 V
Saturation voltage			
$-I_C$ = 1 A; $-I_B$ = 0,1 A	$-V_{CEsat}$	<	0,6 V
D.C. current gain			
$-I_C$ = 150 mA; $-V_{CE}$ = 2 V	h_{FE}		40 to 250
$-I_C$ = 1 A; $-V_{CE}$ = 2 V	h_{FE}	>	25
Transition frequency at f = 1 MHz			
$-I_C$ = 250 mA; $-V_{CE}$ = 10 V	f_T	>	3 MHz
D.C. current gain ratio of matched pairs BD233/BD234; BD235/BD236; BD237/BD238			
$\|I_C\|$ = 150 mA; $\|V_{CE}\|$ = 2 V	h_{FE1}/h_{FE2}	<	1,6
Switching times			
$-I_{Con}$ = 1 A; $-I_{Bon}$ = I_{Boff} = 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

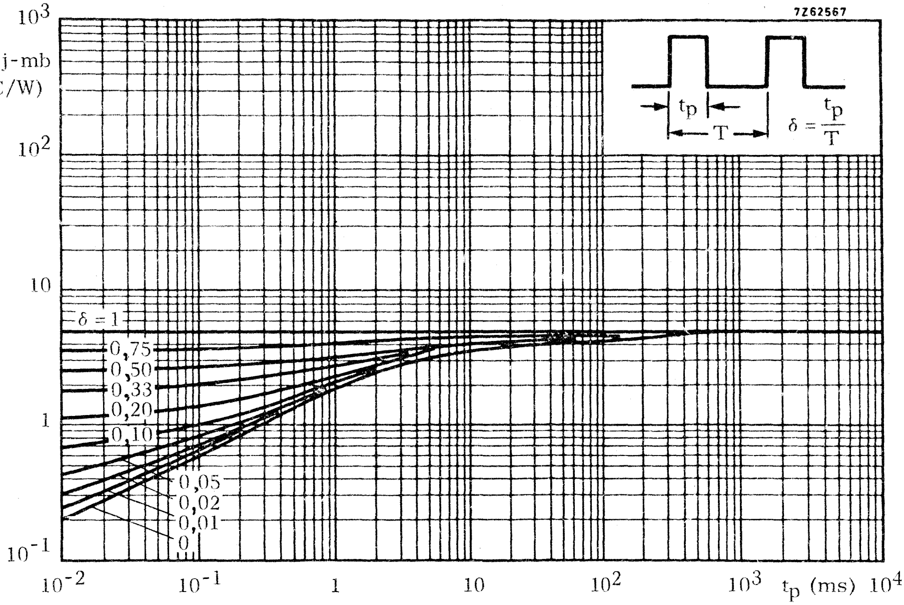


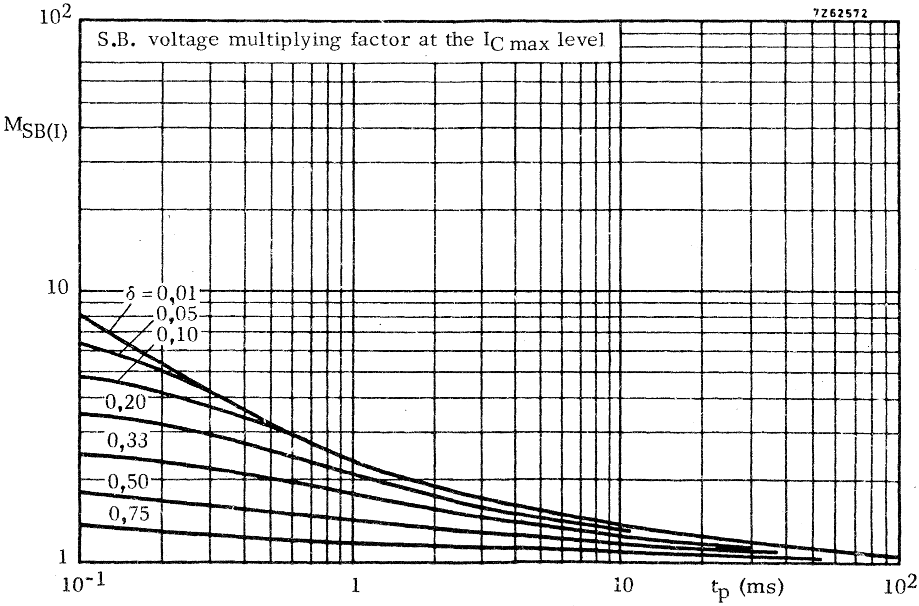
Safe Operating Area with the transistor forward biased

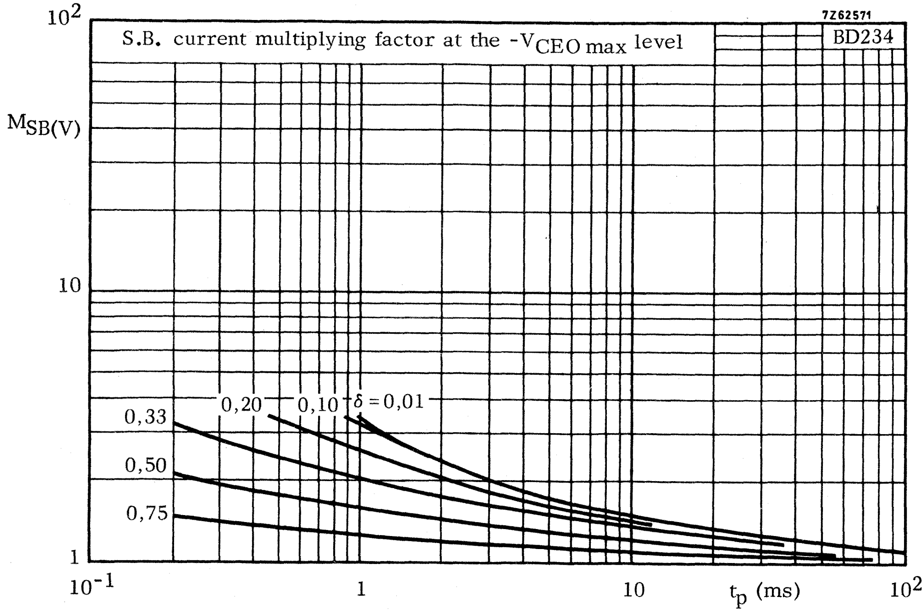
I Region of permissible d.c. operation

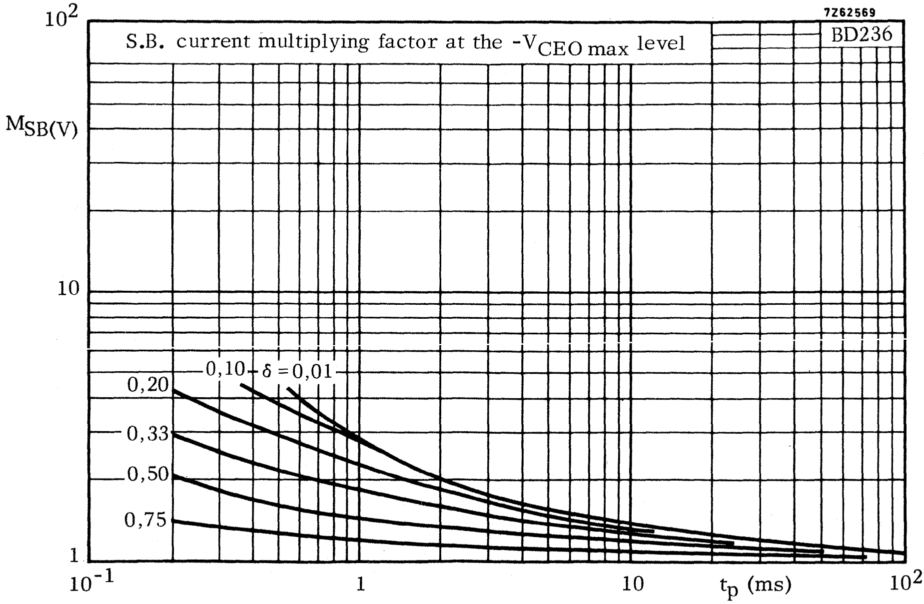
II Permissible extension for repetitive pulse operation

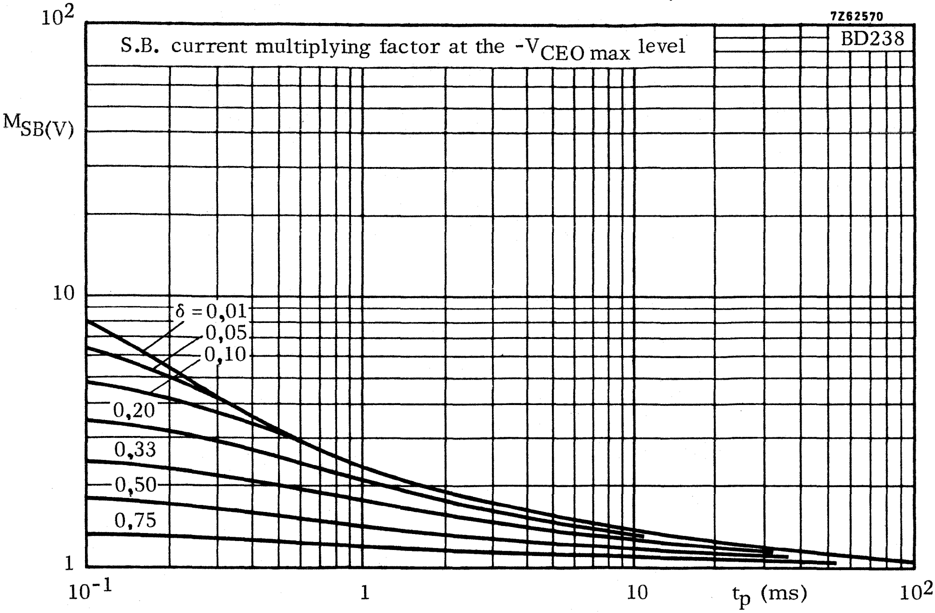
1) Independent of temperature.

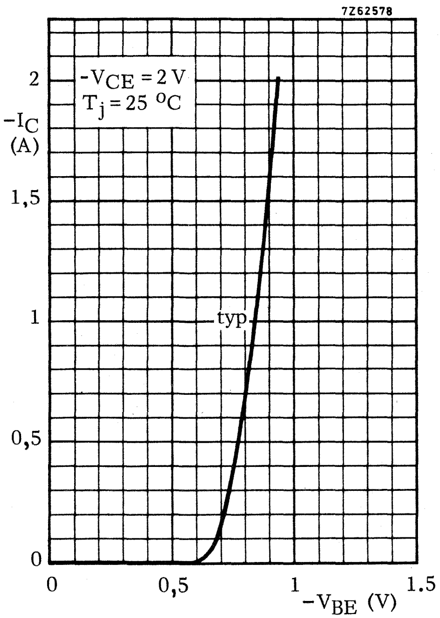

7Z62567
10^3
$Z_{th\ j\text{-}mb}$
($^oC/W$)
10^2
10
1
10^{-1}
$\delta = 1$
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
0
t_p
T
$\delta = \frac{t_p}{T}$
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (ms)
10^4

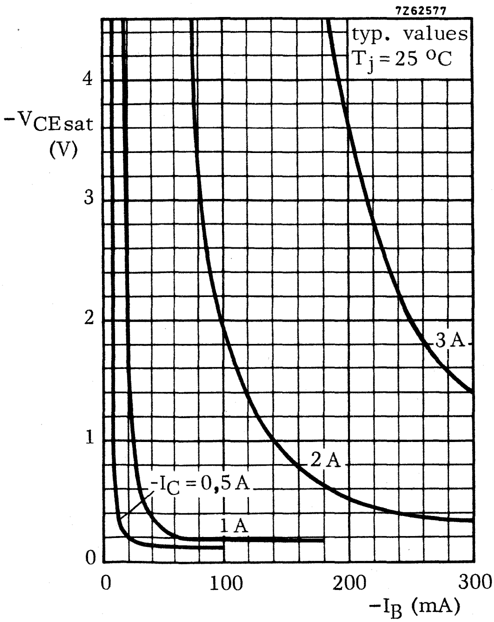

7Z62572
10^2
S.B. voltage multiplying factor at the $I_{C\ max}$ level
$M_{SB(I)}$
10
$\delta = 0,01$
0,05
0,10
0,20
0,33
0,50
0,75
1
10^{-1}
1
10
t_p (ms)
10^2

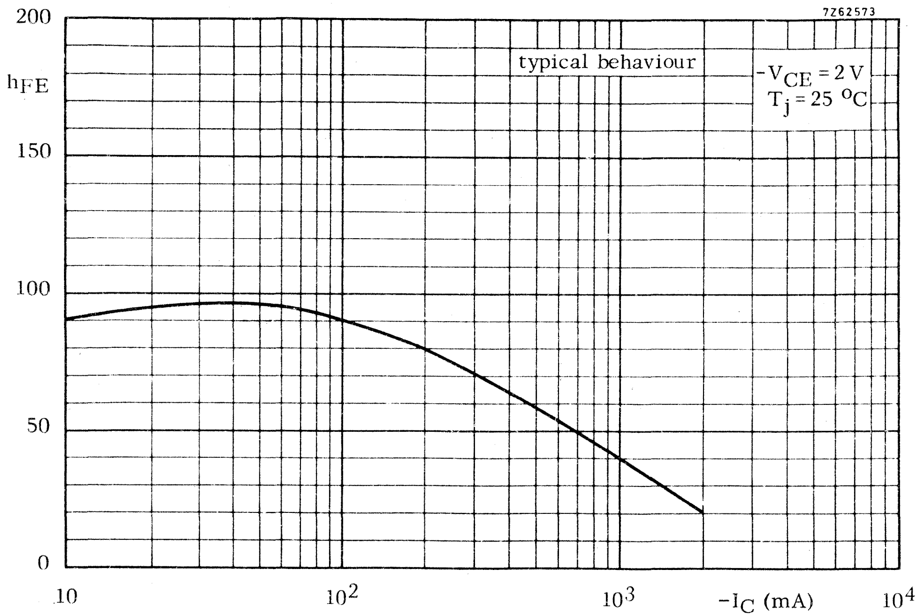

7Z62571
S.B. current multiplying factor at the -VCEO max level
BD234
MSB(V)
10²
10
1
0,33
0,20
0,10
δ = 0,01
0,50
0,75
10⁻¹
1
10
tp (ms)
10²


7Z62569
S.B. current multiplying factor at the -VCEO max level
BD236
MSB(V)
10²
10
1
0,10
δ = 0,01
0,20
0,33
0,50
0,75
10⁻¹
1
10
tp (ms)
10²


7Z62570
S.B. current multiplying factor at the $-V_{CEO\,max}$ level
BD238
$M_{SB(V)}$
10^2
10
1
$\delta = 0,01$
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
h_{FE}
150
100
50
0
typical behaviour
$-V_{CE}$ = 2 V
T_j = 25 °C
10
10^2
10^3
$-I_C$ (mA)
10^4

SILICON DARLINGTON POWER TRANSISTORS

P-N-P epitaxial-base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; SOT-32 plastic envelope. N-P-N complements are BD263, BD263A and BD263B.

QUICK REFERENCE DATA

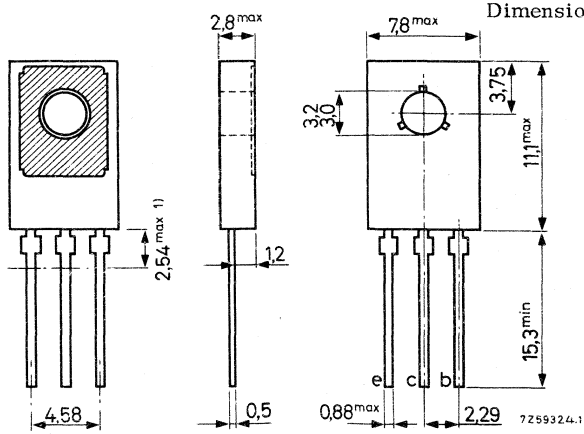
			BD262	BD262A	BD262B	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Collector current (peak value)	$-I_{CM}$	max.		6		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		36		W
Junction temperature	T_j	max.		150		°C
D.C. current gain						
$-I_C$ = 0,5 A; $-V_{CE}$ = 3 V	h_{FE}	typ.		1000		
$-I_C$ = 1,5 A; $-V_{CE}$ = 3 V	h_{FE}	>		750		
Transition frequency						
$-I_C$ = 1,5 A; $-V_{CE}$ = 3 V	f_T	typ.		7		MHz

MECHANICAL DATA

Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface



SUCCESSOR TYPES : BD676, BD678, BD680 and BD682.

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

SILICON DARLINGTON POWER TRANSISTORS

N-P-N epitaxial-base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; SOT-32 plastic envelope. P-N-P complements are BD262, BD262A and BD262B.

QUICK REFERENCE DATA

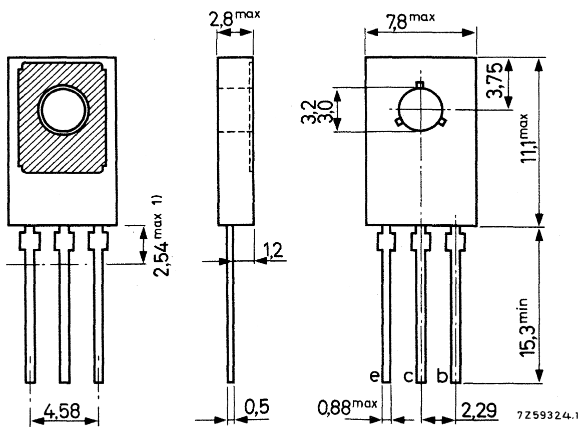
			BD263	BD263A	BD263B	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Collector current (peak value)	I_{CM}	max.		6		A
Total power dissipation up to $T_{mb} = 25\,^{o}C$	P_{tot}	max.		36		W
Junction temperature	T_j	max.		150		^{o}C
D.C. current gain						
$I_C = 0,5$ A; $V_{CE} = 3$ V	h_{FE}	typ.		1000		
$I_C = 1,5$ A; $V_{CE} = 3$ V	h_{FE}	>		750		
Transition frequency						
$I_C = 1,5$ A; $V_{CE} = 3$ V	f_T	typ.		7		MHz

MECHANICAL DATA

Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface



SUCCESSOR TYPES : BD675, BD677, BD679 and BD681.

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

SILICON DARLINGTON POWER TRANSISTORS

P-N-P epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; plastic envelope. N-P-N complements are BD267, BD267A and BD267B. Matched complementary pairs can be supplied.

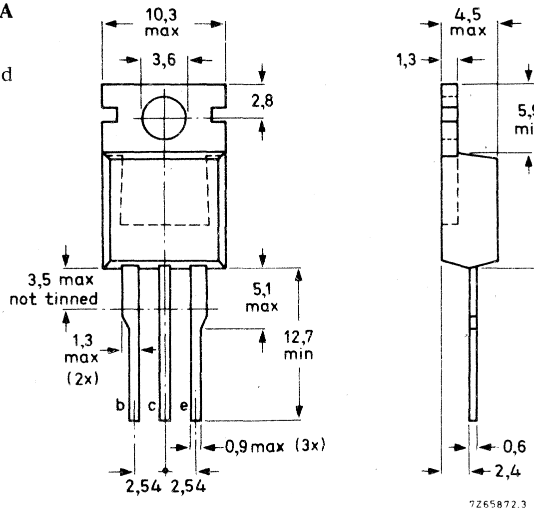
QUICK REFERENCE DATA

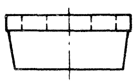
			BD266	BD266A	BD266B	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Collector current (peak value)	$-I_{CM}$	max.		12		A
Total power dissipation up to T_{mb} = 25 ^oC	P_{tot}	max.		60		W
Junction temperature	T_j	max.		150		^oC
D.C. current gain $-I_C$ = 0,5 A; $-V_{CE}$ = 3 V	h_{FE}	typ.		1500		
$-I_C$ = 3,0 A; $-V_{CE}$ = 3 V	h_{FE}	>		750		
Cut-off frequency $-I_C$ = 3 A; $-V_{CE}$ = 3 V	f_{hfe}	typ.		100		kHz

MECHANICAL DATA

Dimensions in mm

TO-220
Collector connected to mounting base





For mounting instructions and accessories see section Accessories

FOR NEW DESIGN THE SUCCESSOR TYPES BD646; BD648 AND BD650 ARE RECOMMENDED

SILICON DARLINGTON POWER TRANSISTORS

N-P-N epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; plastic envelope. P-N-P complements are BD266, BD266A and BD266B. Matched complementary pairs can be supplied.

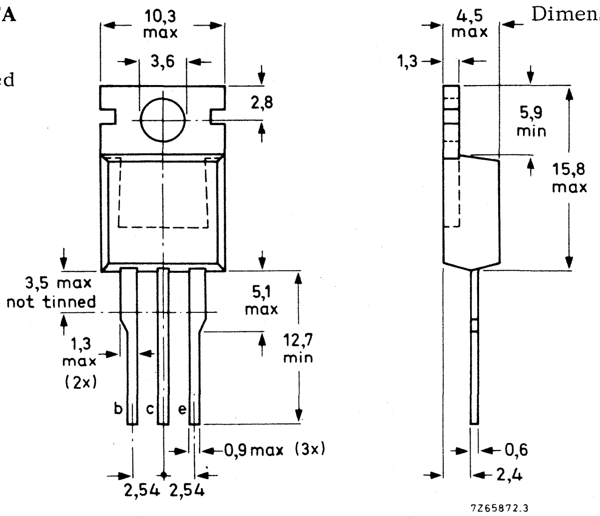
QUICK REFERENCE DATA

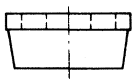
			BD267	BD267A	BD267B	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Collector current (peak value)	I_{CM}	max.		12		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		60		W
Junction temperature	T_j	max.		150		°C
D.C. current gain						
I_C = 0,5 A; V_{CE} = 3 V	h_{FE}	typ.		1500		
I_C = 3,0 A; V_{CE} = 3 V	h_{FE}	>		750		
Cut-off frequency						
I_C = 3 A; V_{CE} = 3 V	f_{hfe}	typ.		100		kHz

MECHANICAL DATA

TO-220
Collector connected to mounting base

Dimensions in mm





For mounting instructions and accessories see section Accessories

FOR NEW DESIGN THE SUCCESSOR TYPES BD645; BD647 AND BD649 ARE RECOMMENDED

SILICON EPITAXIAL-BASE POWER TRANSISTORS

General purpose n-p-n transistors in plastic SOT-82 envelopes for clip mounting; can also be soldered or adhesive mounted into a hybrid circuit. Recommended for use with p-n-p complements BD292 and BD294 in class-B output stages. In a hi-fi circuit the combinations can deliver 20 W into 4 Ω or 8 Ω load. Matched pairs can be supplied.

QUICK REFERENCE DATA

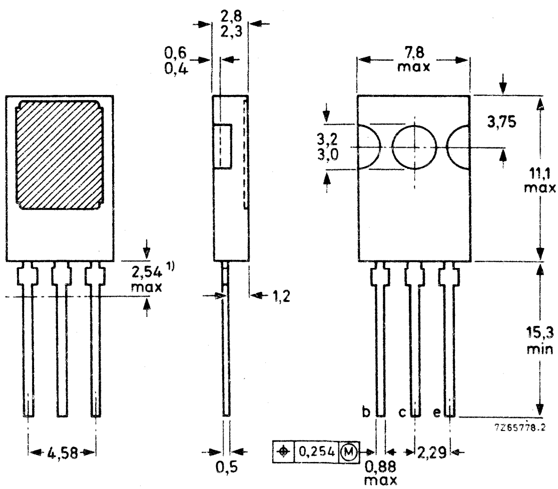
			BD291	BD293	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	V
Collector-current (d.c.)	I_C	max.	6		A
Collector-current (peak) $t_p < 10$ ms; $\delta < 0,1$	I_{CM}	max.	10		A
Base current (d.c.)	I_B	max.	2,5		A
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.	60		W
D.C. current gain $I_C = 1$ A; $V_{CE} = 2$ V	h_{FE}	>	30		
Transition frequency $I_C = 300$ mA; $V_{CE} = 3$ V	f_T	>	3		MHz

MECHANICAL DATA

Dimensions in mm

SOT-82

Collector connected to metal part of mounting surface



Accessories supplied on request: 56353 and 56354.

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

MOUNTING

Soldering to a substrate or heatsink

Maximum permissible mounting surface temperature: 250 °C for 10 seconds.

Clip mounting

For mounting instructions see clip type 56353.

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

Voltages			BD291	BD293	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	
Emitter-base voltage	V_{EBO}	max.	5	5	

Currents				
Collector current (d.c.)	I_C	max.	6	A
Collector current (peak value) $t_p < 10$ ms; $\delta < 0,1$	I_{CM}	max.	10	A
Base current (d.c.)	I_B	max.	2,5	A
Emitter current (d.c.)	$-I_E$	max.	6	A

Power dissipation				
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60	W

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

THERMAL RESISTANCE

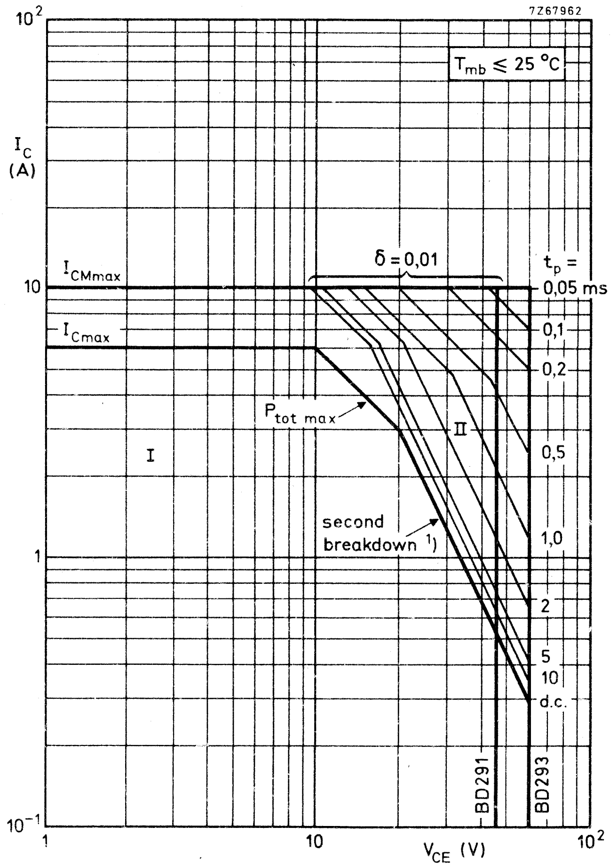
From junction to ambient in free air	$R_{th\ j-a}$	=	100	°C/W
From junction to mounting base	$R_{th\ j-mb}$	=	2,08	°C/W

From mounting base to heatsink			direct mounting	insulated mounting	
→ with heatsink compound	$R_{th\ mb-h}$	=	0,4	2,0	°C/W
→ without heatsink compound	$R_{th\ mb-h}$	=	2,0	5,0	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
I_E = 0; V_{CB} = 40 V; T_j = 150 °C	I_{CBO}	<	1	mA
I_B = 0; V_{CE} = 30 V	I_{CEO}	<	1	mA
Emitter cut-off current				
I_C = 0; V_{EB} = 5 V	I_{EBO}	<	5	mA
Collector-emitter saturation voltage				
I_C = 3 A; I_B = 0,3 A	V_{CEsat}	<	1	V
Base-emitter voltage				
I_C = 3 A; V_{CE} = 2 V	V_{BE}	<	1,5	V
D.C. current gain				
I_C = 1 A; V_{CE} = 2 V	h_{FE}	>	30	
I_C = 2 A; V_{CE} = 2 V : BD293 I_C = 3 A; V_{CE} = 2 V : BD291	h_{FE}	>	30	
Transition frequency at f = 1 MHz				
I_C = 300 mA; V_{CE} = 3 V	f_T	>	3	MHz

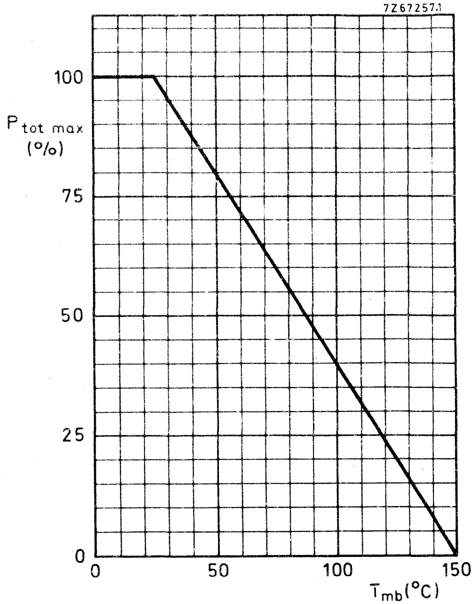


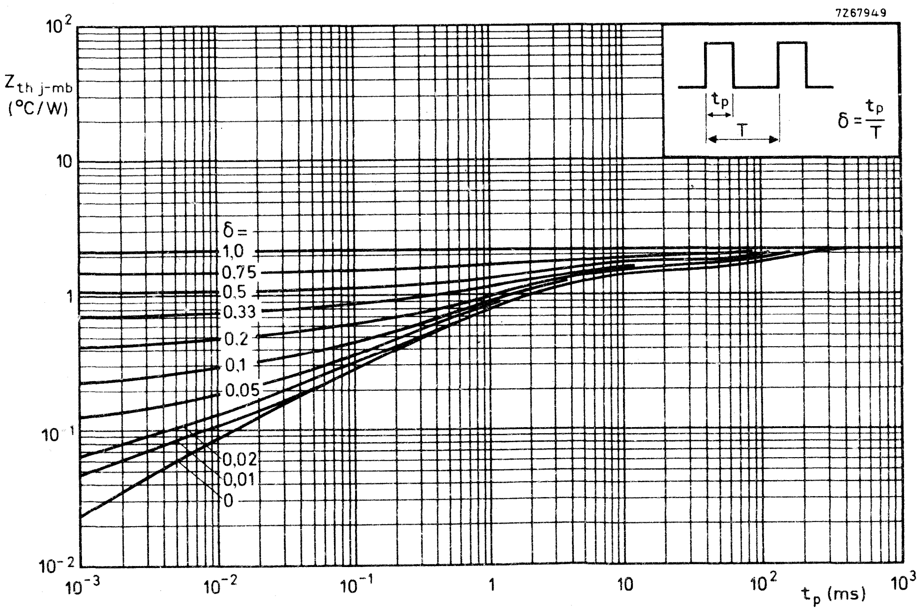
Safe Operating Area with the transistor forward biased

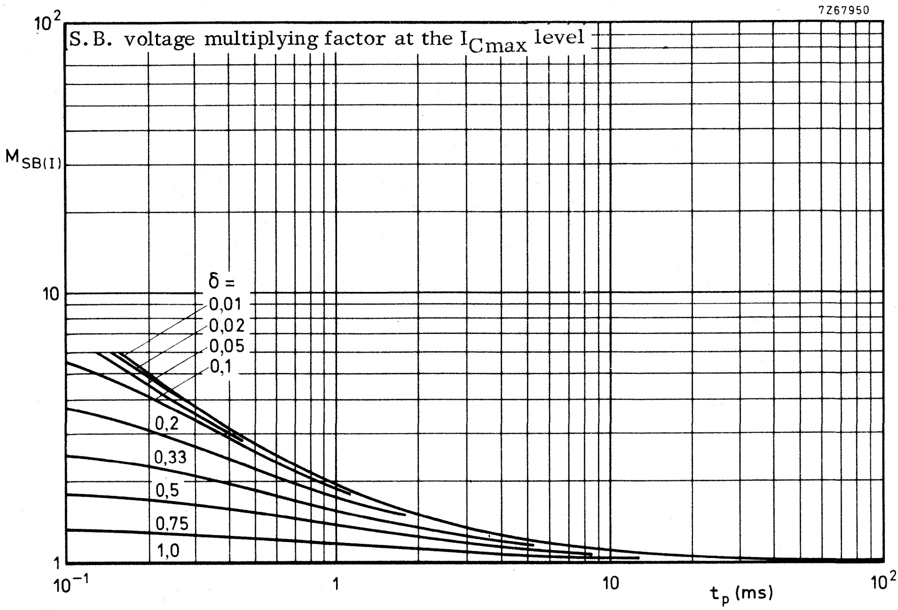
I Region of permissible d.c. operation

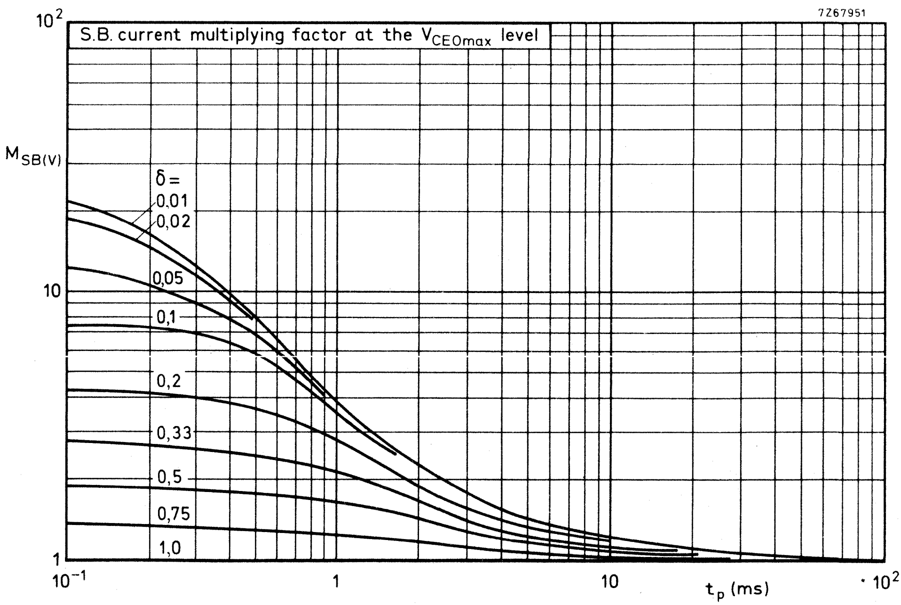
II Permissible extension for repetitive pulse operation

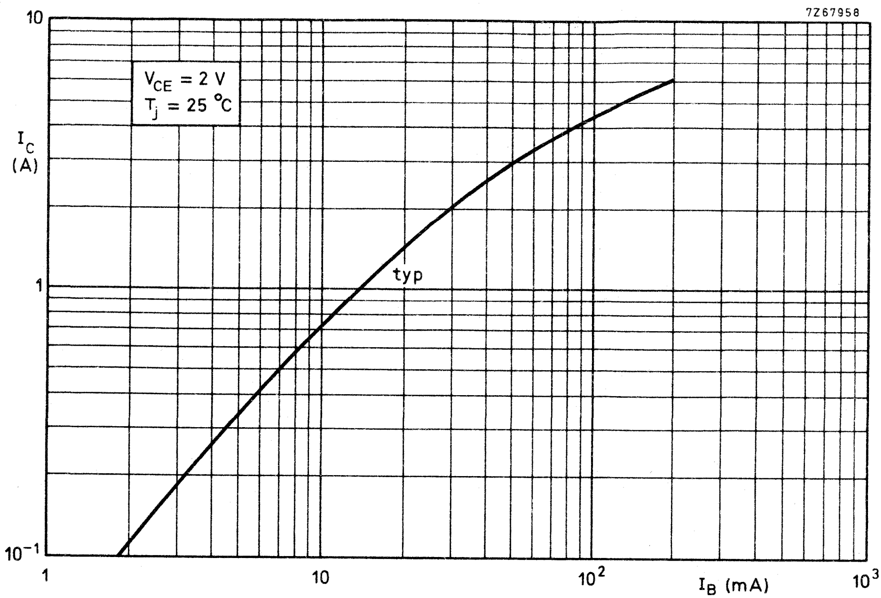
1) Independent of temperature

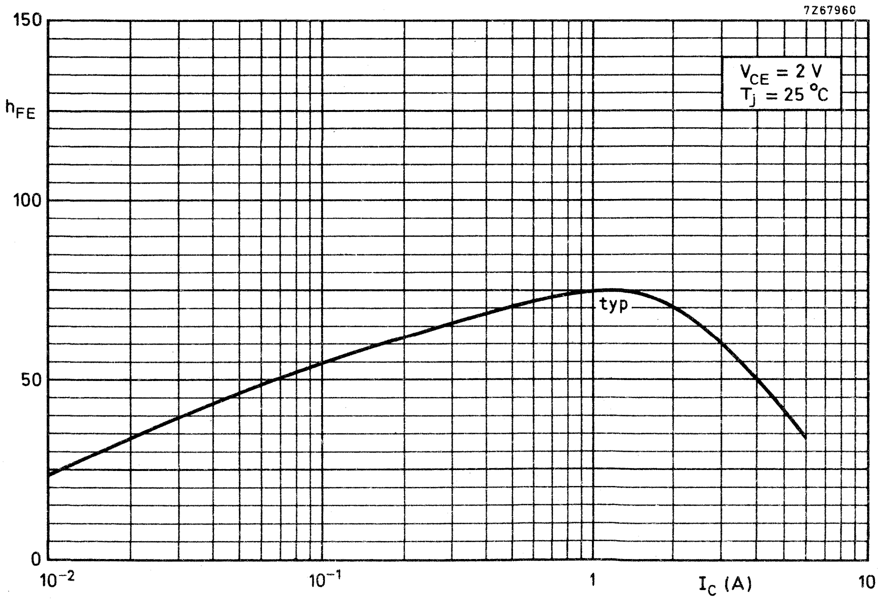

7Z67257.1
100
$P_{tot\ max}$
(%)
75
50
25
0
0
50
100
150
T_{mb}(°C)

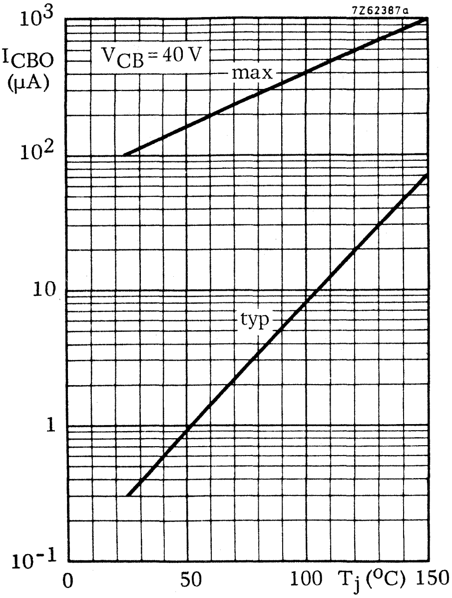

7Z67949
10^2
$Z_{th\ j\text{-}mb}$
(°C/W)
10
1
10^{-1}
10^{-2}
t_p
T
$\delta = \frac{t_p}{T}$
δ =
1,0
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
0
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (ms)

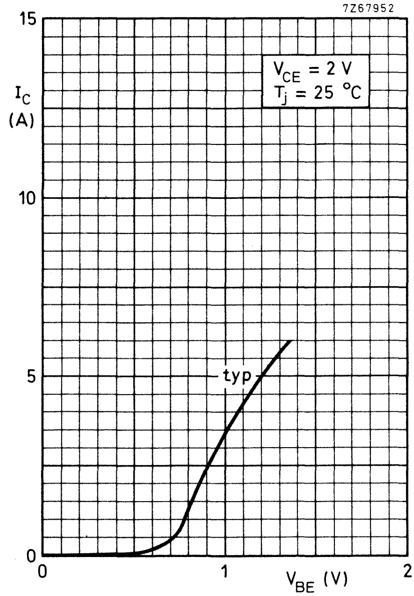

7Z67950
S.B. voltage multiplying factor at the I$_{Cmax}$ level
$M_{SB(I)}$
10^2
10
1
δ =
0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
1,0
10^{-1}
1
10
10^2
t_p (ms)

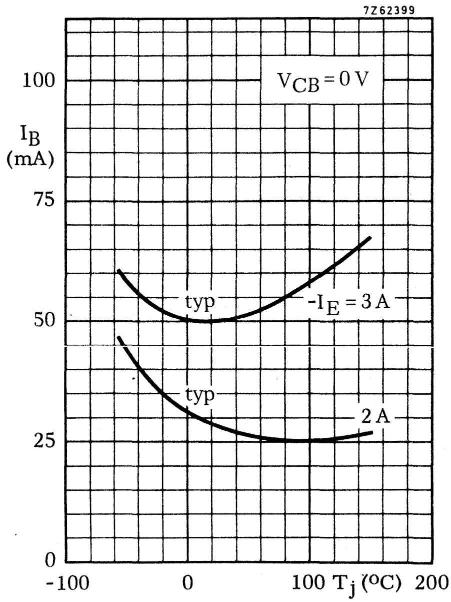

7Z67951
S.B. current multiplying factor at the V$_{CEOmax}$ level
$M_{SB(V)}$
10^2
10
1
δ =
0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
1,0
10^{-1}
1
10
10^2
t_p (ms)

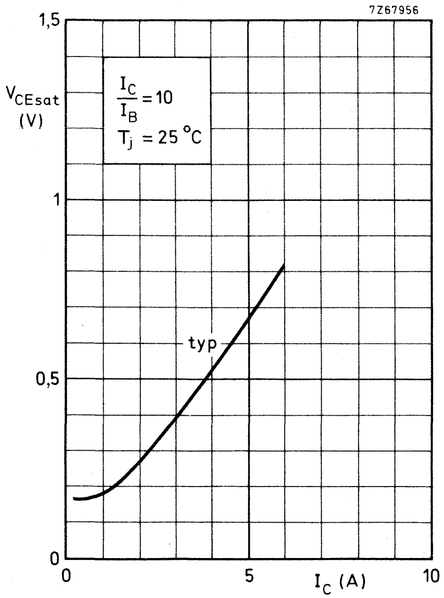

7Z67958
V_{CE} = 2 V
T_j = 25 °C
I_C (A)
10
1
10^{-1}
typ
1
10
10^2
I_B (mA)
10^3

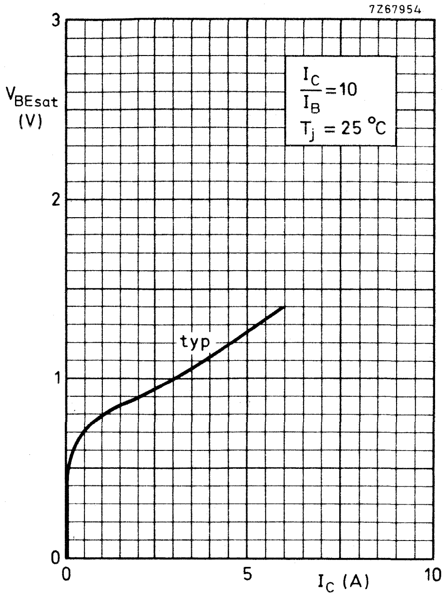

7Z67960
V_{CE} = 2 V
T_j = 25 °C
h_{FE}
150
100
50
0
typ
10^{-2}
10^{-1}
1
I_C (A)
10

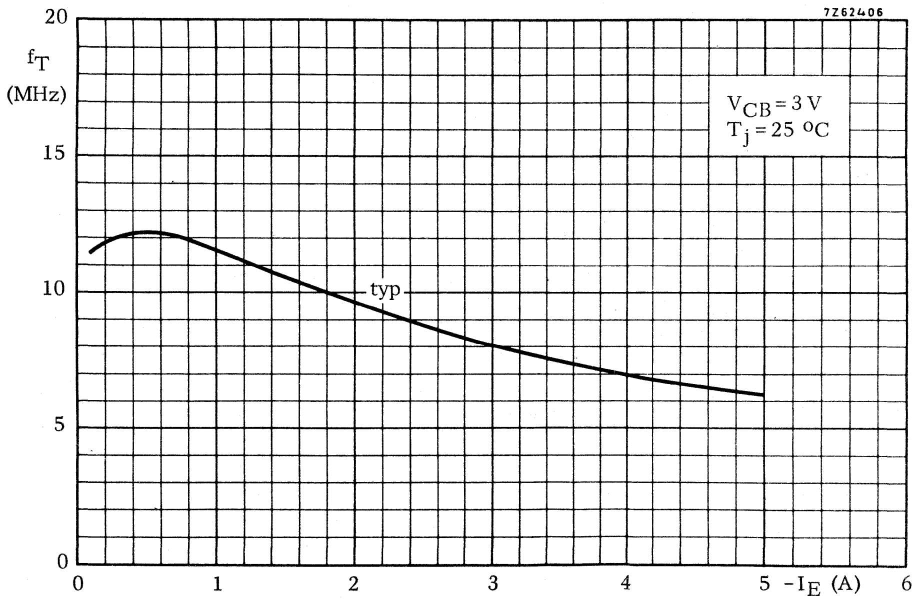

7Z62387a
10^3
I_{CBO} (μA)
V_{CB} = 40 V
max
10^2
10
typ
1
10^{-1}
0
50
100
T_j (°C)
150


7Z67952
15
I_C (A)
V_{CE} = 2 V
T_j = 25 °C
10
5
typ
0
0
1
V_{BE} (V)
2


7Z62399
100
I_B (mA)
V_{CB} = 0 V
75
typ
$-I_E$ = 3 A
50
typ
2 A
25
0
-100
0
100
T_j (°C)
200

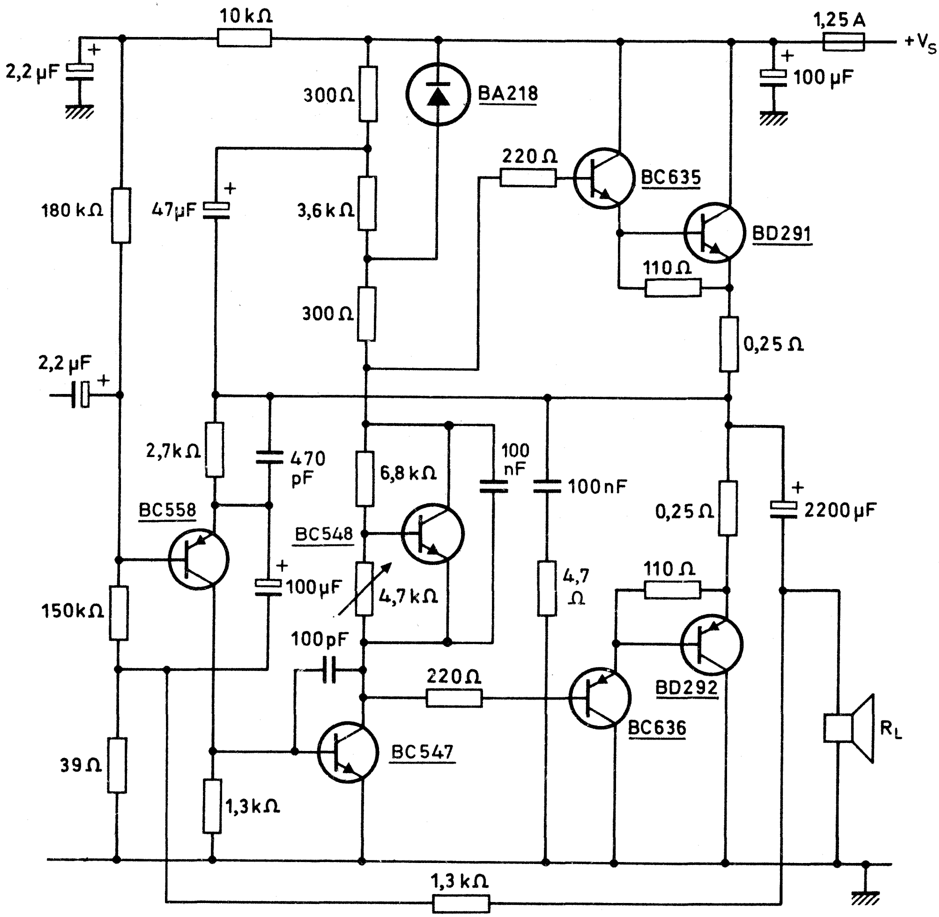

7Z67956
1,5
V_{CEsat}
(V)
$\frac{I_C}{I_B}$ = 10
T_j = 25 °C
1
typ
0,5
0
0
5
I_C (A)
10


7Z67954
3
V_{BEsat}
(V)
$\frac{I_C}{I_B}$ = 10
T_j = 25 °C
2
typ
1
0
0
5
I_C (A)
10


7Z62406
20
f_T
(MHz)
V_{CB} = 3 V
T_j = 25 °C
15
10
typ
5
0
0
1
2
3
4
5
$-I_E$ (A)
6

APPLICATION INFORMATION

Basic circuit diagram of a 20W hi-fi amplifier.



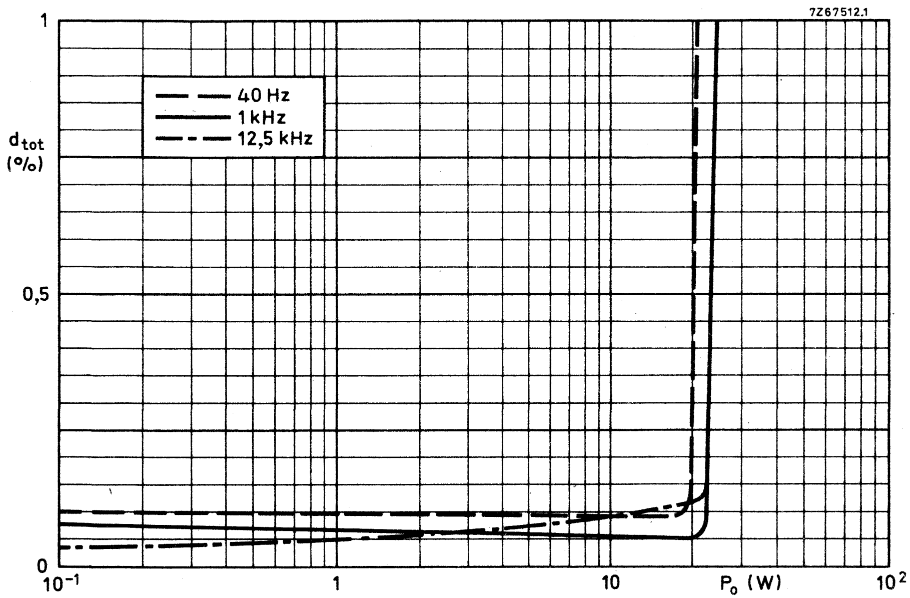
7Z67513.2

Performance at V_S = 32, 4 V; R_L = 4 Ω (unloaded supply voltage = 38 V):

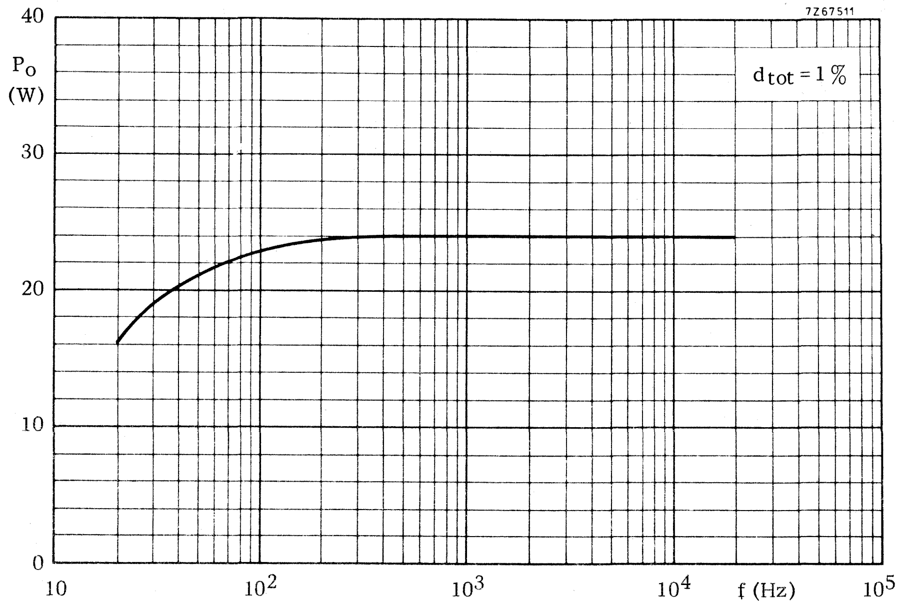
Collector quiescent current of BD291 and BD292	$\|I_{CQ}\|$	typ.	20	mA
Total current drain at P_o = 20 W; f = 1 kHz	I_S	typ.	1	A
Input impedance	z_i	typ.	175	kΩ
Output impedance	z_o	typ.	50	mΩ
Output power at f = 1 kHz; d_{tot} = 1%	P_o	typ.	24	W
Input voltage for P_o = 20 W; f = 1 kHz	$V_{i(rms)}$	typ.	375	mV

Total harmonic distortion at P_o = 20 W	d_{tot}	typ.	0,06	%
Intermodulation distortion at P_o = 20 W	d_{im}	typ.	0,5	%
Voltage feedback factor		typ.	52	dB
Unweighted signal to noise ratio, (ref. to P_o = 50 mW)		typ.	75	dB
Frequency response (−1 dB)		typ. 20 Hz to 75		kHz
Thermal resistance required per output transistor	R_{thj-a}	≤	8,65	$^oC/W$

Stable continuous operation is ensured up to an ambient temperature of 50 ^oC.



APPLICATION INFORMATION (continued)



SILICON EPITAXIAL-BASE POWER TRANSISTORS

General purpose p-n-p transistors in plastic SOT-82 envelopes for clip mounting; can also be soldered or adhesive mounted into a hybrid circuit. Recommended for use with n-p-n complements BD291 and BD293 in class-B output stages. In a hi-fi circuit the combinations can deliver 20 W into 4 Ω or 8 Ω load. Matched pairs can be supplied.

QUICK REFERENCE DATA

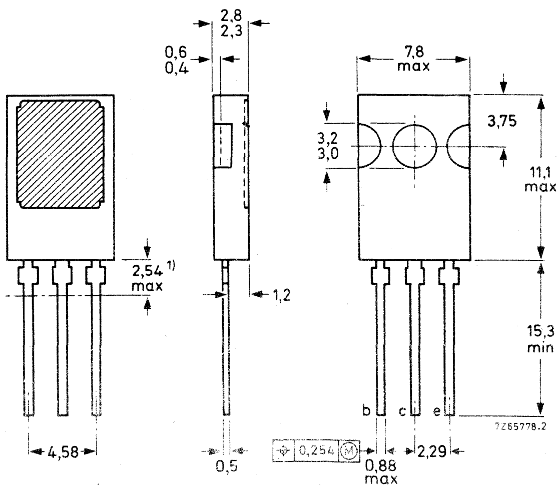
			BD292	BD294	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	V
Collector-current (d.c.)	$-I_C$	max.	6		A
Collector-current (peak) $t_p < 10$ ms; $\delta < 0,1$	$-I_{CM}$	max.	10		A
Base current (d.c.)	$-I_B$	max.	2,5		A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max.	60		W
D.C. current gain $-I_C = 1$ A; $-V_{CE} = 2$ V	h_{FE}	>	30		
Transition frequency $-I_C = 300$ mA; $-V_{CE} = 3$ V	f_T	>	3		MHz

MECHANICAL DATA

Dimensions in mm

SOT-82

Collector connected to metal part of mounting surface



Accessories supplied on request: 56353 and 56354.

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

MOUNTING

Soldering to a substrate or heatsink

Maximum permissible mounting surface temperature: 250 °C for 10 seconds.

Clip mounting

For mounting instructions see clip type 56353.

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

Voltages			BD292	BD294	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	V
Emitter-base voltage	$-V_{EBO}$	max.	5	5	V

Currents				
Collector current (d.c.)	$-I_C$	max.	6	A
Collector current (peak value) $t_p < 10$ ms; $\delta < 0,1$	$-I_{CM}$	max.	10	A
Base current (d.c.)	$-I_B$	max.	2,5	A
Emitter current (d.c.)	I_E	max.	6	A

Power dissipation

Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max.	60	W

Temperatures

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

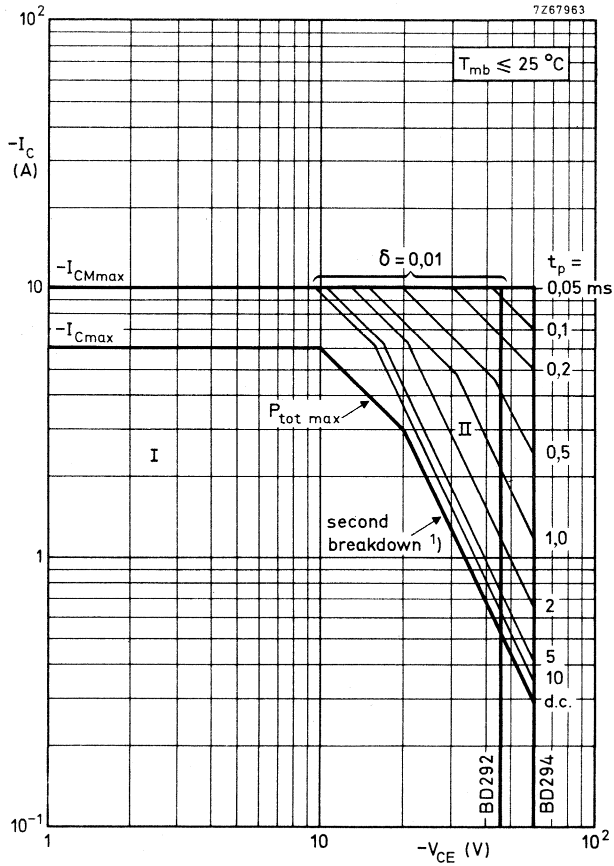
THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	100	°C/W
From junction to mounting base	$R_{th\ j-mb}$	=	2,08	°C/W

From mounting base to heatsink			direct mounting	insulated mounting	
→ with heatsink compound	$R_{th\ mb-h}$	=	0,4	2,0	°C/W
→ without heatsink compound	$R_{th\ mb-h}$	=	2,0	5,0	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $-V_{CB} = 40$ V; $T_j = 150$ °C	$-I_{CBO}$	<	1	mA
$I_B = 0$; $-V_{CE} = 30$ V	$-I_{CEO}$	<	1	mA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	5	mA
Collector-emitter saturation voltage				
$-I_C = 3$ A; $-I_B = 0,3$ A	$-V_{CEsat}$	<	1	V
Base-emitter voltage				
$-I_C = 3$ A; $-V_{CE} = 2$ V	$-V_{BE}$	<	1,5	V
D.C. current gain				
$-I_C = 1$ A; $-V_{CE} = 2$ V	h_{FE}	>	30	
$-I_C = 2$ A; $-V_{CE} = 2$ V : BD294 $-I_C = 3$ A; $-V_{CE} = 2$ V : BD292	h_{FE}	>	30	
Transition frequency at f = 1 MHz				
$-I_C = 300$ mA; $-V_{CE} = 3$ V	f_T	>	3	MHz

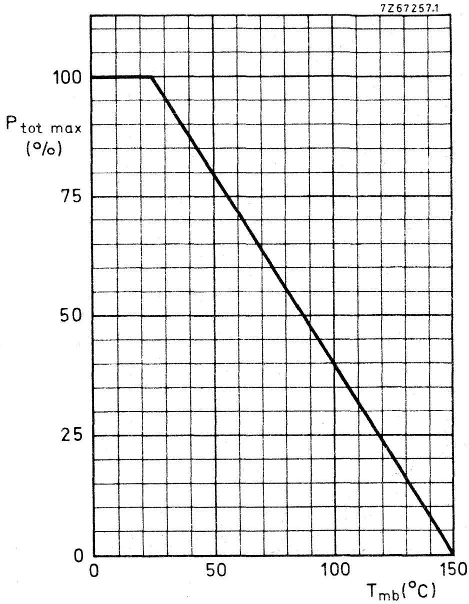


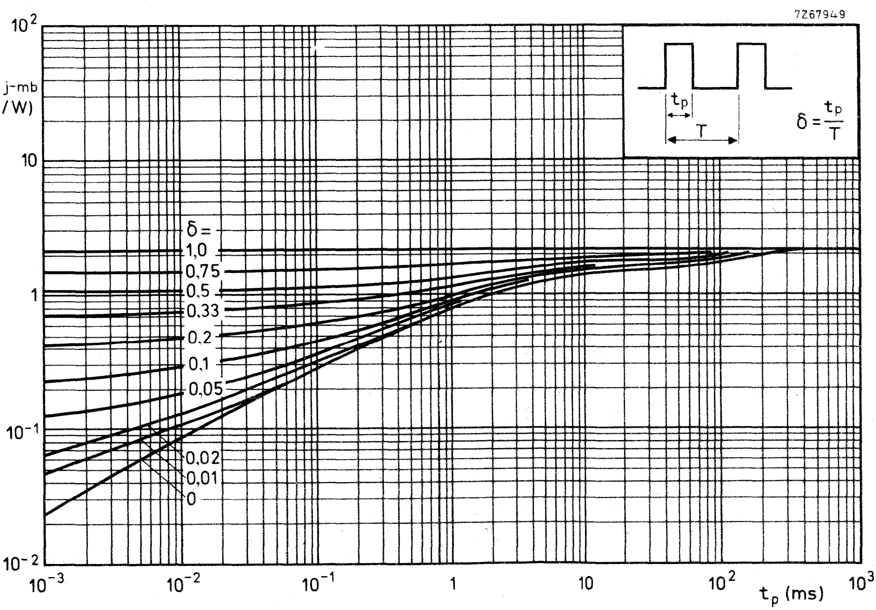
Safe Operating Area with the transistor forward biased

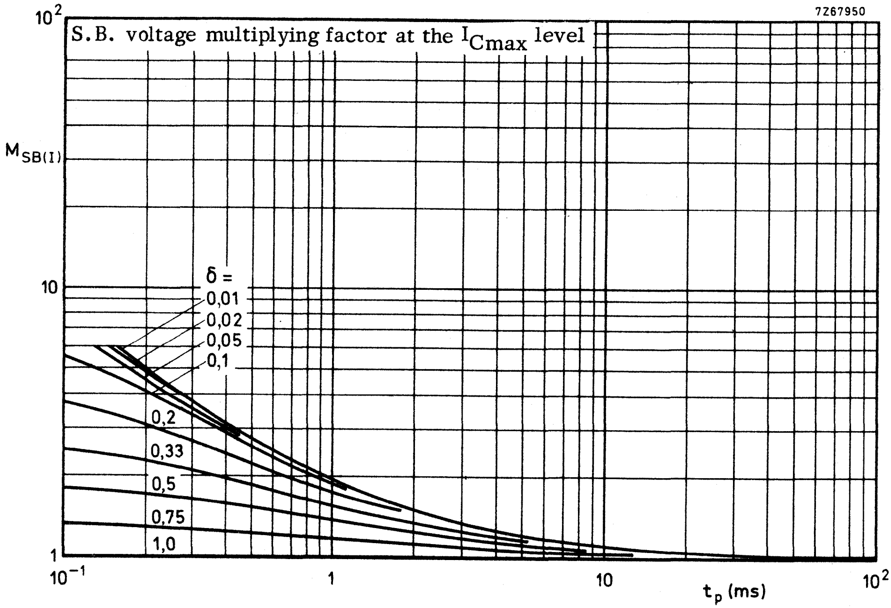
I Region of permissible d.c. operation

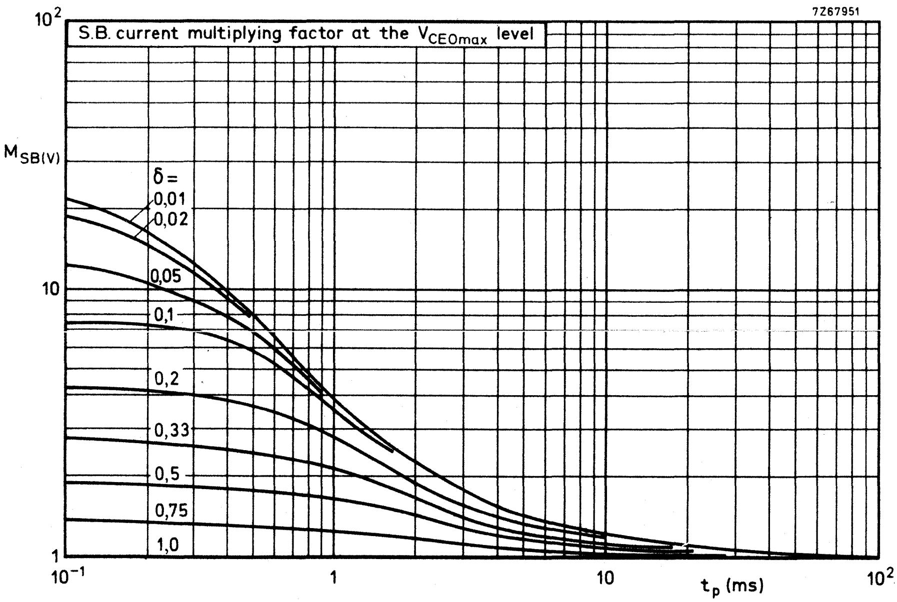
II Permissible extension for repetitive pulse operation

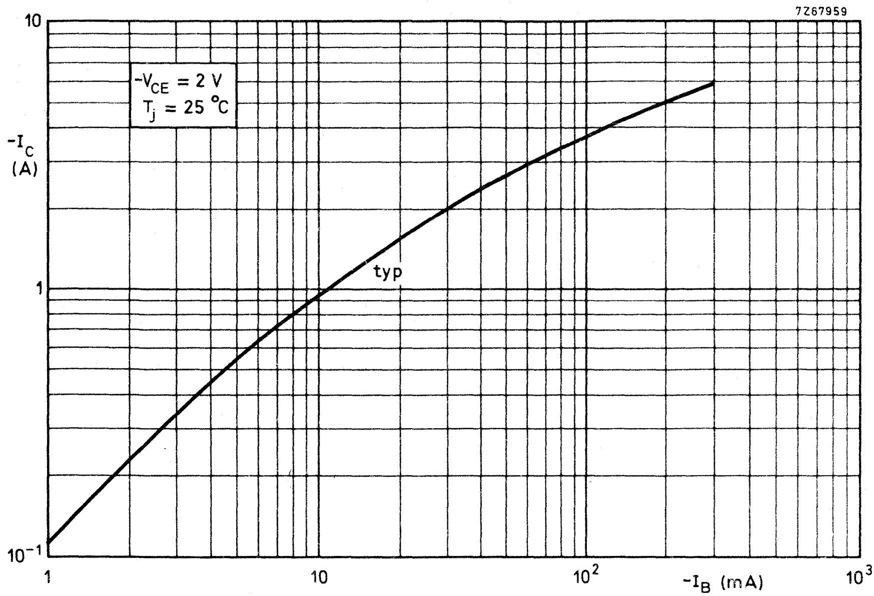
1) Independent of temperature

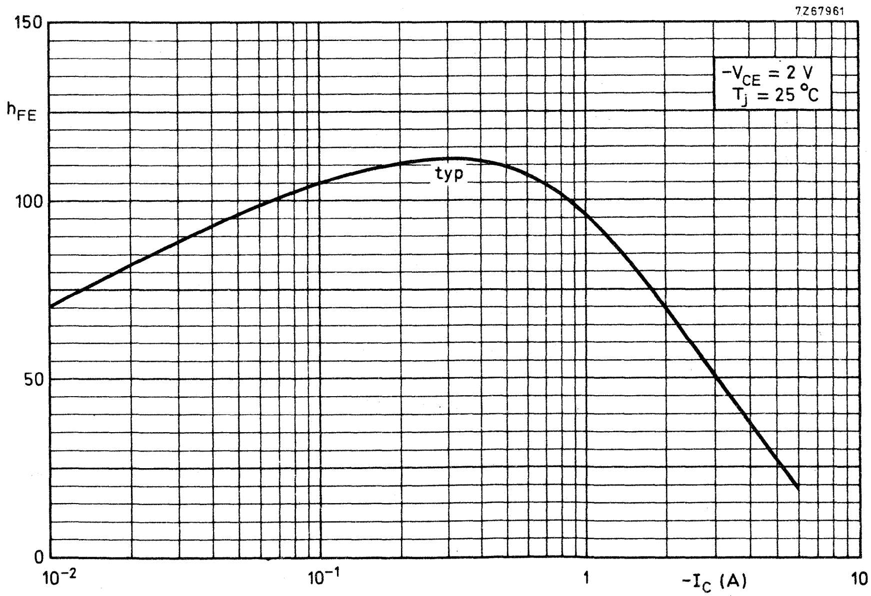

7Z67257.1
100
$P_{tot\ max}$ (%)
75
50
25
0
0
50
100
150
T_{mb} (°C)

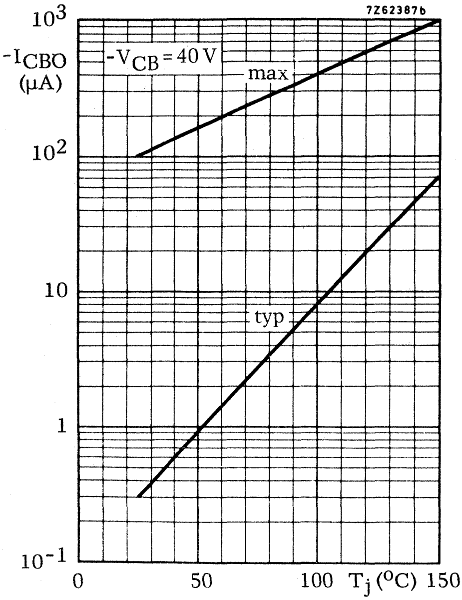

7Z67949
10^2
$Z_{th\ j\text{-}mb}$ (°C/W)
10
1
10^{-1}
10^{-2}
t_p
T
$\delta = \frac{t_p}{T}$
δ =
1,0
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
0
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3

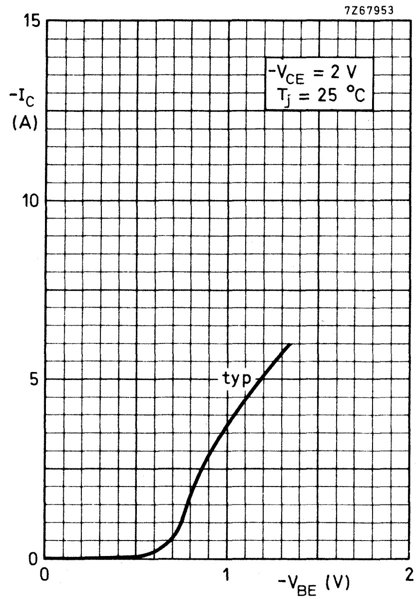

7Z67950
S.B. voltage multiplying factor at the ICmax level
MSB(I)
δ =
0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
1,0
10²
10
1
10⁻¹
1
10
10²
tp (ms)

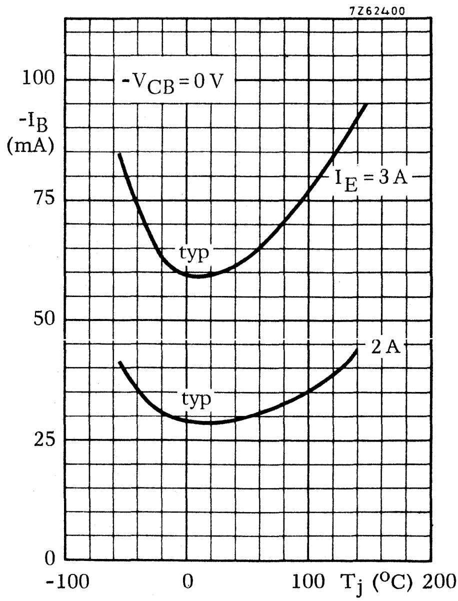

7Z67951
S.B. current multiplying factor at the VCEOmax level
MSB(V)
δ =
0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
1,0
10²
10
1
10⁻¹
1
10
10²
tp (ms)

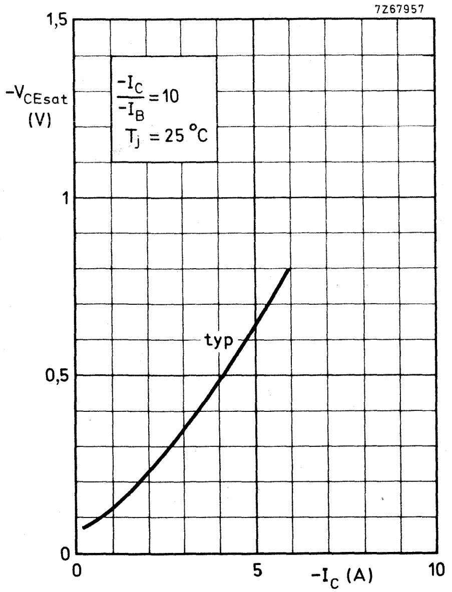

7Z67959
10
$-V_{CE}$ = 2 V
T_j = 25 °C
$-I_C$
(A)
typ
1
10^{-1}
1
10
10^2
$-I_B$ (mA)
10^3

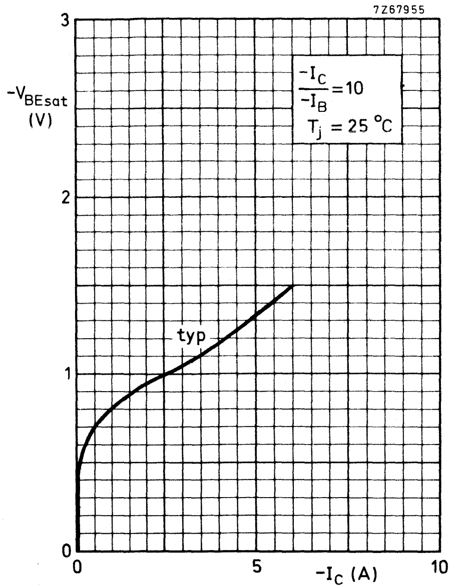

7Z67961
150
$-V_{CE}$ = 2 V
T_j = 25 °C
h_{FE}
typ
100
50
0
10^{-2}
10^{-1}
1
$-I_C$ (A)
10

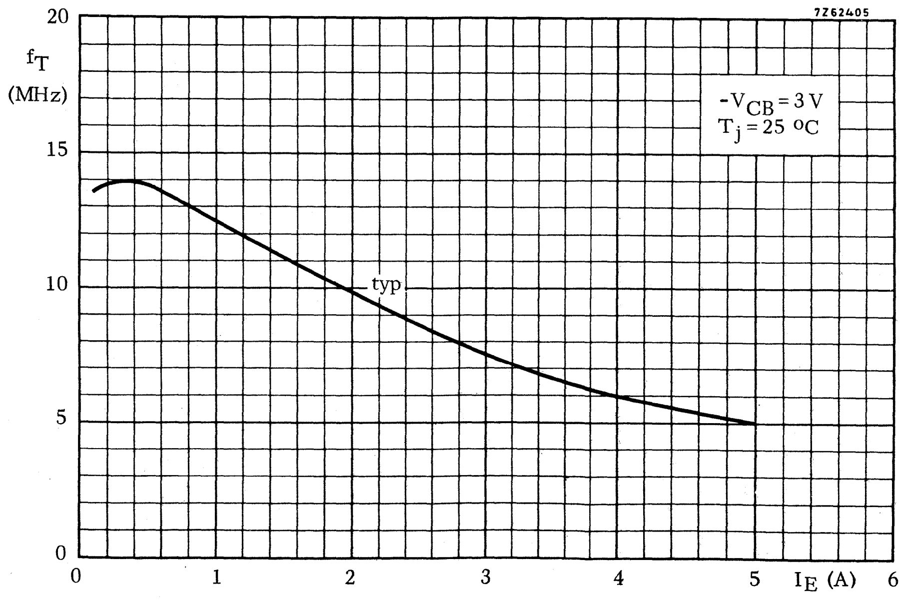

7Z62387b
10^3
$-I_{CBO}$ (μA)
$-V_{CB} = 40$ V
max
10^2
10
typ
1
10^{-1}
0
50
100
T_j (°C)
150


7Z67953
15
$-I_C$ (A)
$-V_{CE} = 2$ V
$T_j = 25$ °C
10
5
typ
0
0
1
$-V_{BE}$ (V)
2


7Z62400
100
$-V_{CB} = 0$ V
$-I_B$ (mA)
$I_E = 3$ A
75
typ
50
2 A
typ
25
0
-100
0
100
T_j (°C)
200







FOR APPLICATION INFORMATION SEE BD291; BD293

SILICON PLANAR EPITAXIAL POWER TRANSISTOR

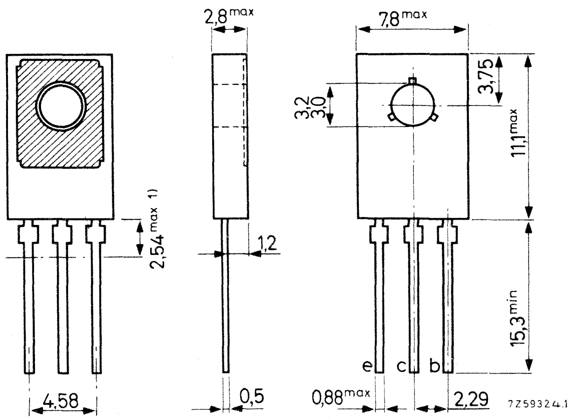
N-P-N transistor in a SOT-32 plastic envelope intended for car-radio output stages. P-N-P complement is BD330. Matched pairs can be supplied.

QUICK REFERENCE DATA				
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	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} = 45 °C	P_{tot}	max.	15	W
Junction temperature	T_j	max.	150	°C
D.C. current gain I_C = 0,5 A; V_{CE} = 1 V	h_{FE}		85 to 375	
Transition frequency I_C = 50 mA; V_{CE} = 5 V	f_T	typ.	130	MHz

MECHANICAL DATA Dimensions in mm

TO-126 (SOT-32)

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)

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	32	V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	32	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.	3	A
Collector current (peak value)	I_{CM}	max.	3	A
Base current (d.c.)	I_B	max.	1	A
Emitter current (d.c.)	$-I_E$	max.	3	A

Power dissipation

Total power dissipation up to T_{mb} = 45 ^oC	P_{tot}	max.	15	W

Temperatures

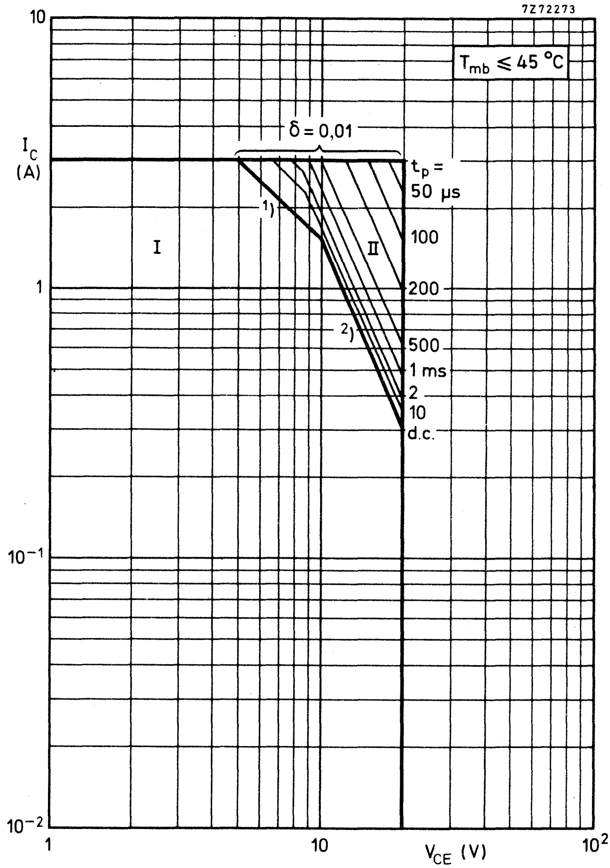
Storage temperature	T_{stg}		− 65 to +150	^oC
Junction temperature	T_j	max.	150	^oC

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	7	$^oC/W$
From junction to ambient in free air	$R_{th\ j-a}$	=	100	$^oC/W$

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 32$ V	I_{CBO}	<	10	μA
$I_E = 0$; $V_{CB} = 32$ V; $T_j = 150$ °C	I_{CBO}	<	1	mA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	μA
Base-emitter voltage				
$I_C = 5$ mA; $V_{CE} = 10$ V	V_{BE}	typ.	0,6	V
$I_C = 2$ A; $V_{CE} = 1$ V	V_{BE}	<	1,2	V
Collector-emitter saturation voltage				
$I_C = 2$ A; $I_B = 0,2$ A	V_{CEsat}	<	0,5	V
D.C. current gain				
$I_C = 5$ mA; $V_{CE} = 10$ V	h_{FE}	>	50	
$I_C = 0,5$ A; $V_{CE} = 1$ V	h_{FE}		85 to 375	
$I_C = 2$ A; $V_{CE} = 1$ V	h_{FE}	>	40	
Transition frequency at f = 35 MHz				
$I_C = 50$ mA; $V_{CE} = 5$ V	f_T	typ.	130	MHz
D.C. current gain ratio of matched pairs				
BD329/BD330				
$\lvert I_C \rvert = 0,5$ A; $\lvert V_{CE} \rvert = 1$ V	h_{FE1}/h_{FE2}	<	1,6	←



Safe Operating ARea with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetive pulse operation

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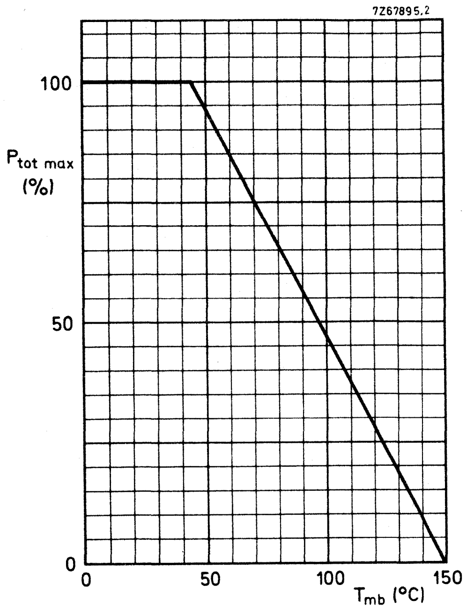
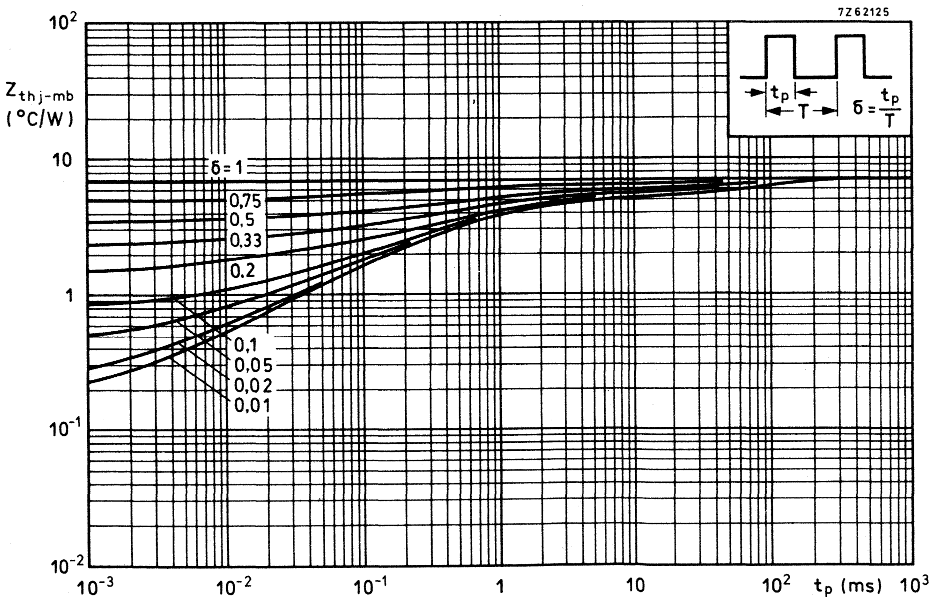
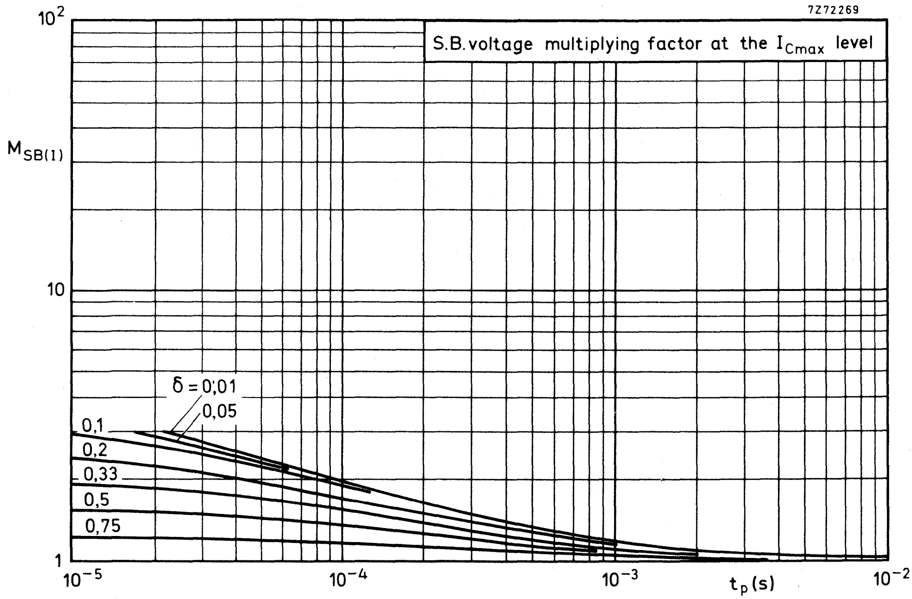
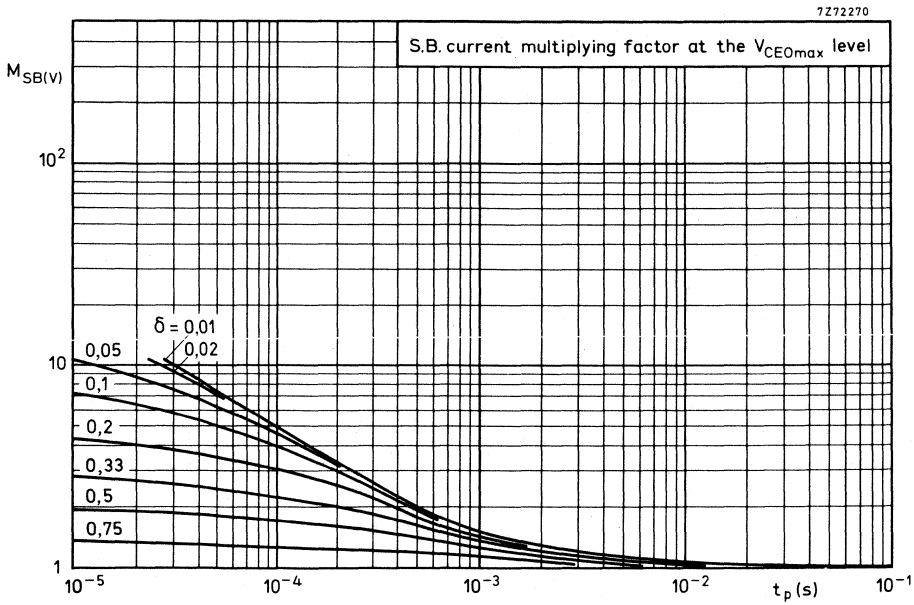
[1]) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

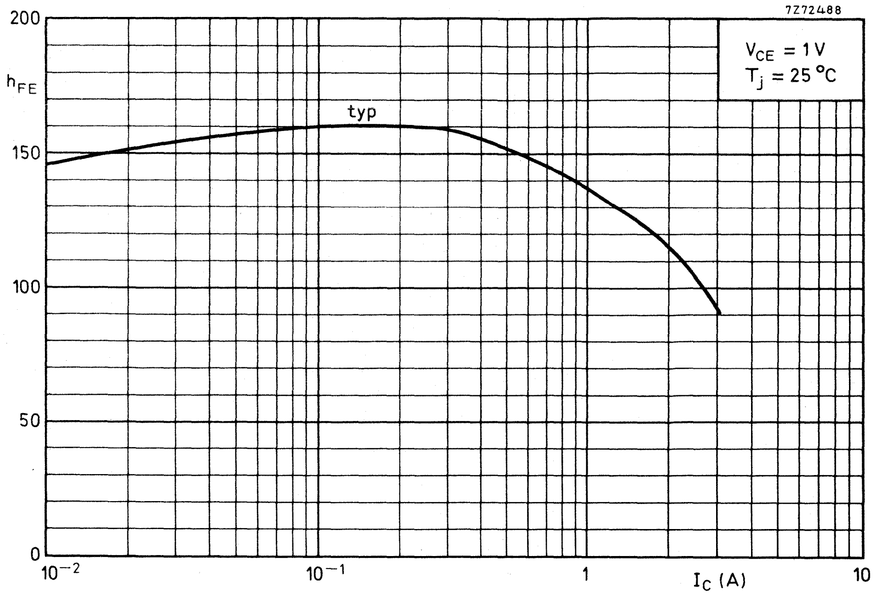
[2]) Second-breakdown limits (independent of temperature).

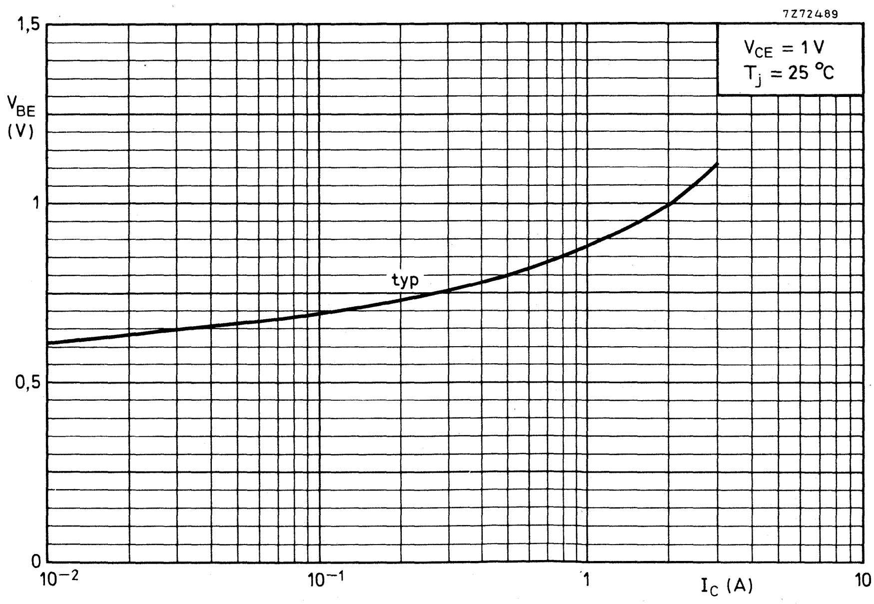

7Z67895.2
100
$P_{tot\ max}$
(%)
50
0
0
50
100
150
T_{mb} (°C)

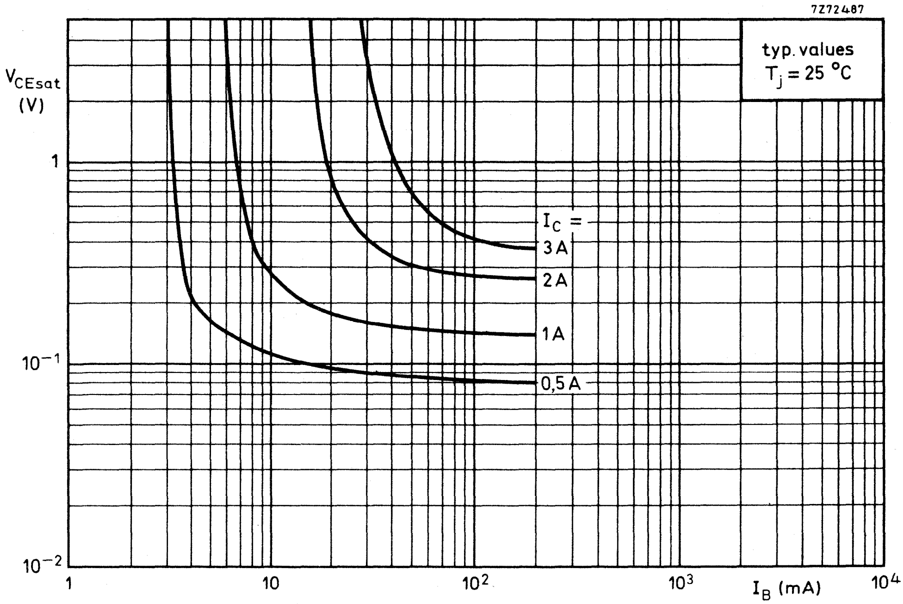

7Z62125
10^2
$Z_{th\ j-mb}$
(°C/W)
10
1
10^{-1}
10^{-2}
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3


7Z72269
S.B. voltage multiplying factor at the I_{Cmax} level
10^2
$M_{SB(I)}$
10
1
δ = 0,01
0,05
0,1
0,2
0,33
0,5
0,75
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}


7Z72270
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^{-5}
10^{-4}
10^{-3}
10^{-2}
t_p (s)
10^{-1}


7Z72488
200
150
100
50
0
h_{FE}
typ
V_{CE} = 1 V
T_j = 25 °C
10^{-2}
10^{-1}
1
I_C (A)
10

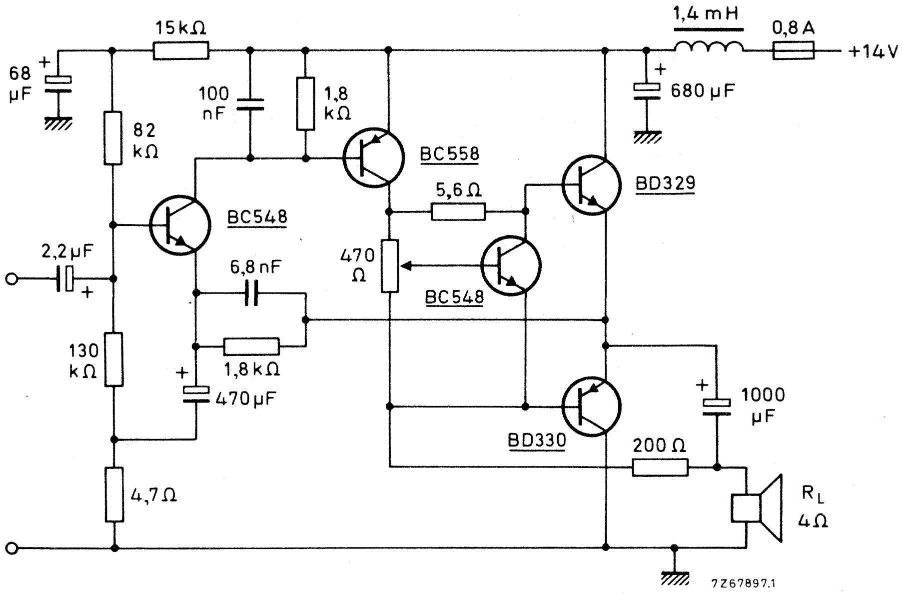

7Z72489
1,5
1
0,5
0
V_{BE}
(V)
typ
V_{CE} = 1 V
T_j = 25 °C
10^{-2}
10^{-1}
1
I_C (A)
10



APPLICATION INFORMATION See next page.

APPLICATION INFORMATION

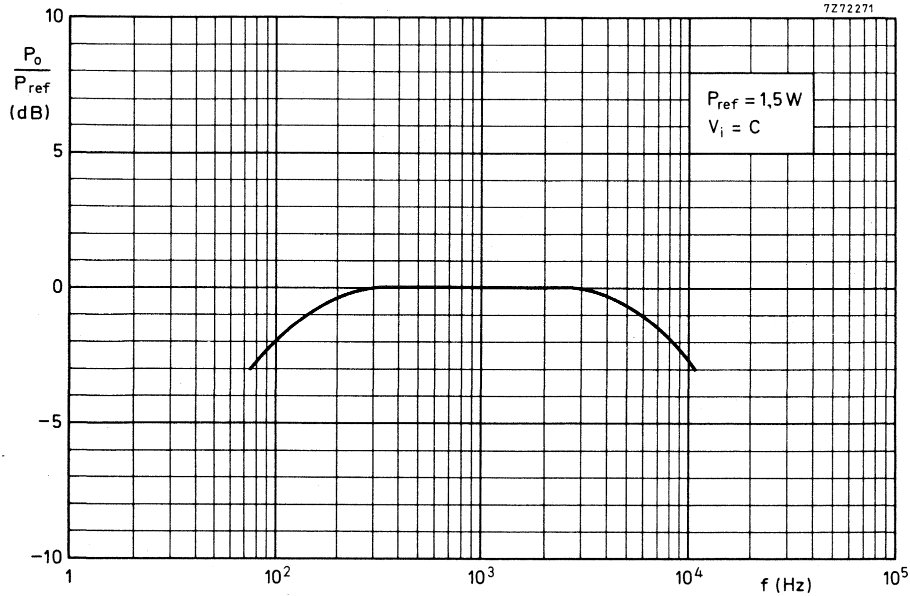
Basic circuit diagram of a 5,5 W car-radio audio amplifier.

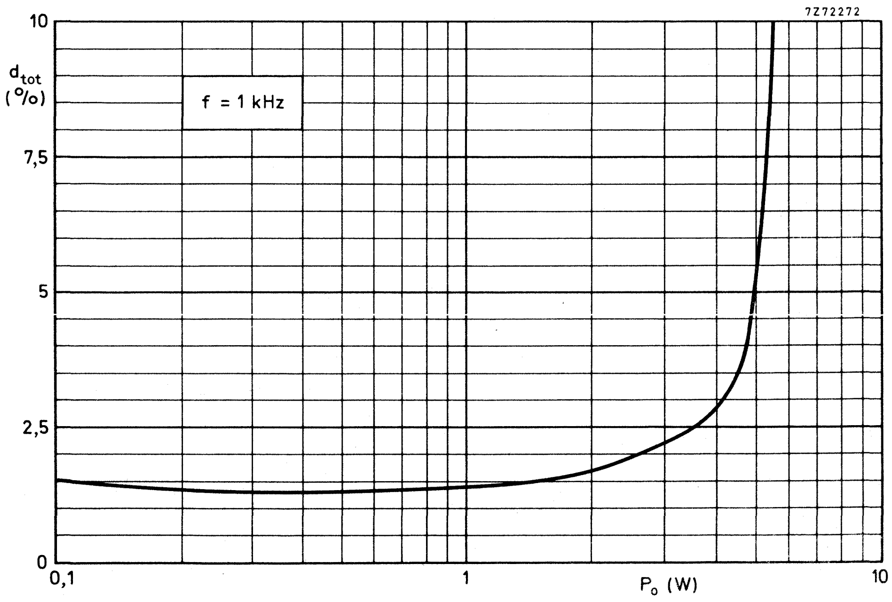


Performance at f = 1 kHz unless otherwise specified

Output power at d_{tot} = 10%	P_o	typ.	5,5	W
Input voltage for P_o = 5,5 W	$V_{i(rms)}$	typ.	20	mV
Input impedance	z_i	typ.	20	kΩ
Collector quiescent current of output transistors	$\|I_{CQ}\|$	typ.	10	mA
Collector current of BC558	$-I_C$	typ.	28	mA
Collector current of BC548 (pre-amplifier)	I_C	typ.	0,5	mA
Total current drain at P_o = 5,5 W	I_B	typ.	540	mA
Frequency range (−3 dB)	f		75 Hz to 11	kHz

With a heatsink thermal resistance for each output transistor of 40 °C/W the maximum permissible ambient temperature is 60 °C.


7Z72271
10
$\frac{P_o}{P_{ref}}$ (dB)
5
0
−5
−10
1
10^2
10^3
10^4
f (Hz)
10^5
P_{ref} = 1,5 W
V_i = C


7Z72272
10
d_{tot} (%)
7,5
5
2,5
0
0,1
1
10
P_o (W)
f = 1 kHz

SILICON PLANAR EPITAXIAL POWER TRANSISTOR

P-N-P transistor in a SOT-32 plastic envelope intended for car-radio output stages. N-P-N complement is BD329. Matched pairs can be supplied.

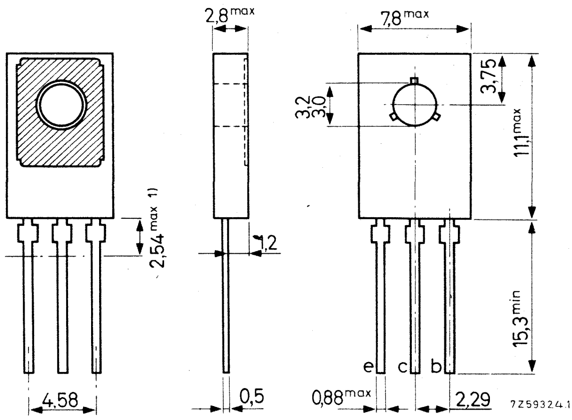
QUICK REFERENCE DATA				
Collector-emitter voltage (V_{BE} = 0)	$-V_{CES}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	20	V
Collector current (peak value)	$-I_{CM}$	max.	3	A
Total power dissipation up to T_{mb} = 45 °C	P_{tot}	max.	15	W
Junction temperature	T_j	max.	150	°C
D.C. current gain $-I_C$ = 0,5 A; $-V_{CE}$ = 1 V	h_{FE}		85 to 375	
Transition frequency $-I_C$ = 50 mA; $-V_{CE}$ = 5 V	f_T	typ.	100	MHz

MECHANICAL DATA

Dimensions in mm

TO-126 (SOT-32)

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)

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	V
Collector-emitter voltage (V_{BE} = 0)	$-V_{CES}$	max.	32	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.	3	A
Collector current (peak value)	$-I_{CM}$	max.	3	A
Base current (d.c.)	$-I_B$	max.	1	A
Emitter current (d.c.)	I_E	max.	3	A

Power dissipation

Total power dissipation up to T_{mb} = 45 °C	P_{tot}	max.	15	W

Temperatures

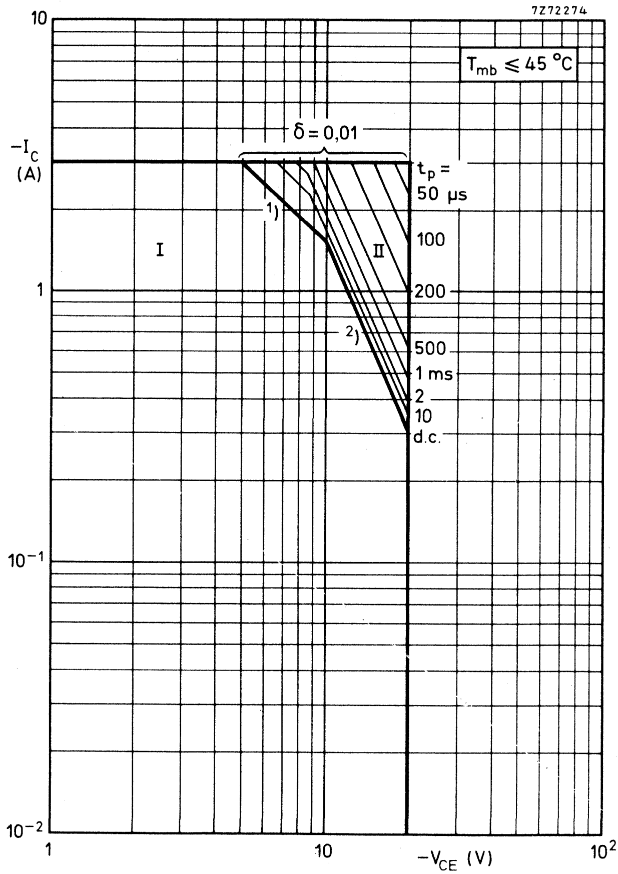
Storage temperature	T_{stg}		− 65 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	7	°C/W
From junction to ambient in free air	$R_{th\ j-a}$	=	100	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $-V_{CB} = 32$ V	$-I_{CBO}$	<	10	μA
$I_E = 0$; $-V_{CB} = 32$ V; $T_j = 150$ °C	$-I_{CBO}$	<	1	mA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	10	μA
Base-emitter voltage				
$-I_C = 5$ mA; $-V_{CE} = 10$ V	$-V_{BE}$	typ.	0,6	V
$-I_C = 2$ A; $-V_{CE} = 1$ V	$-V_{BE}$	<	1,2	V
Collector-emitter saturation voltage				
$-I_C = 2$ A; $-I_B = 0,2$ A	$-V_{CEsat}$	<	0,5	V
D.C. current gain				
$-I_C = 5$ mA; $-V_{CE} = 10$ V	h_{FE}	>	50	
$-I_C = 0,5$ A; $-V_{CE} = 1$ V	h_{FE}		85 to 375	
$-I_C = 2$ A; $-V_{CE} = 1$ V	h_{FE}	>	40	
Transition frequency at f = 35 MHz				
$-I_C = 50$ mA; $-V_{CE} = 5$ V	f_T	typ.	100	MHz
D.C. current gain ratio of matched pairs				
BD329/BD330				
$\|I_C\| = 0,5$ A; $\|V_{CE}\| = 1$ V	h_{FE1}/h_{FE2}	<	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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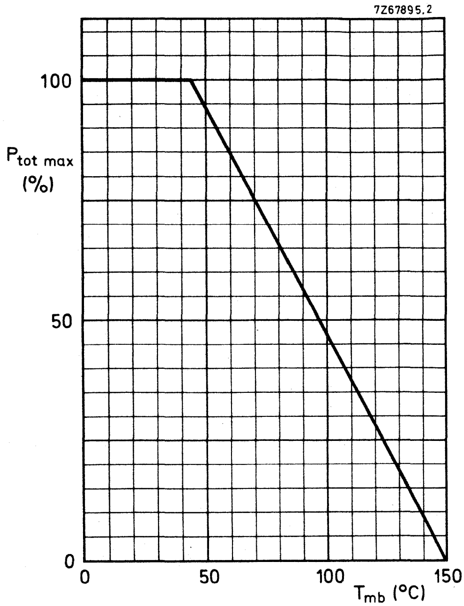
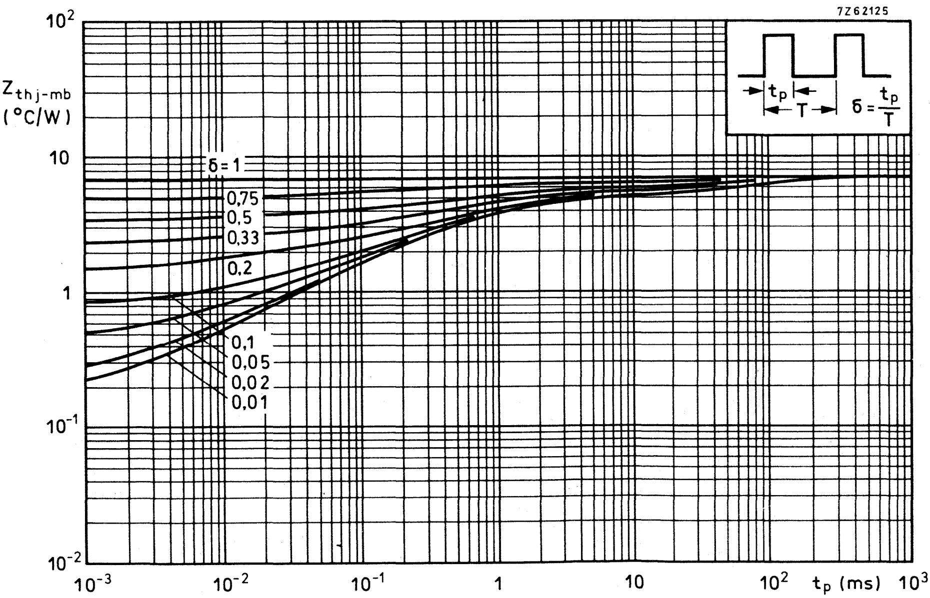
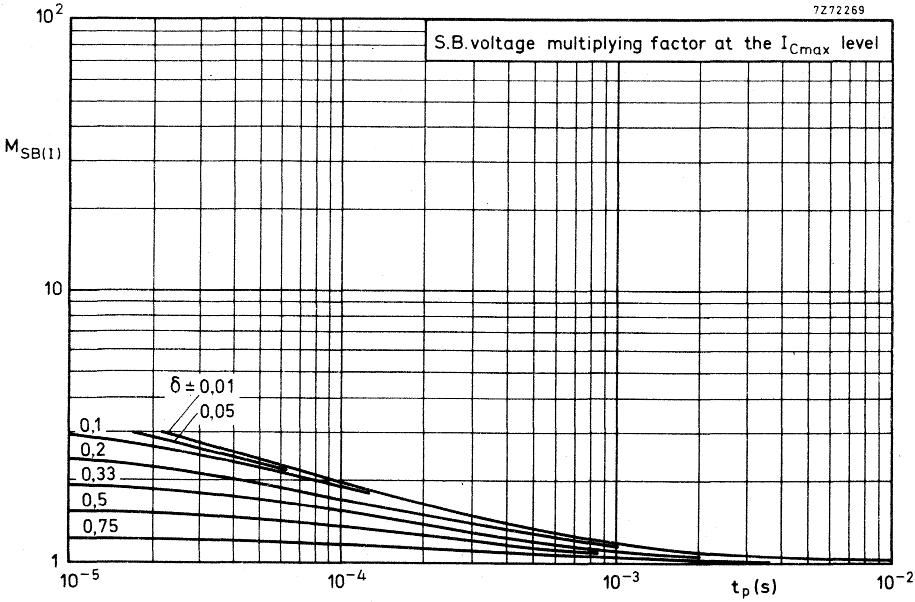
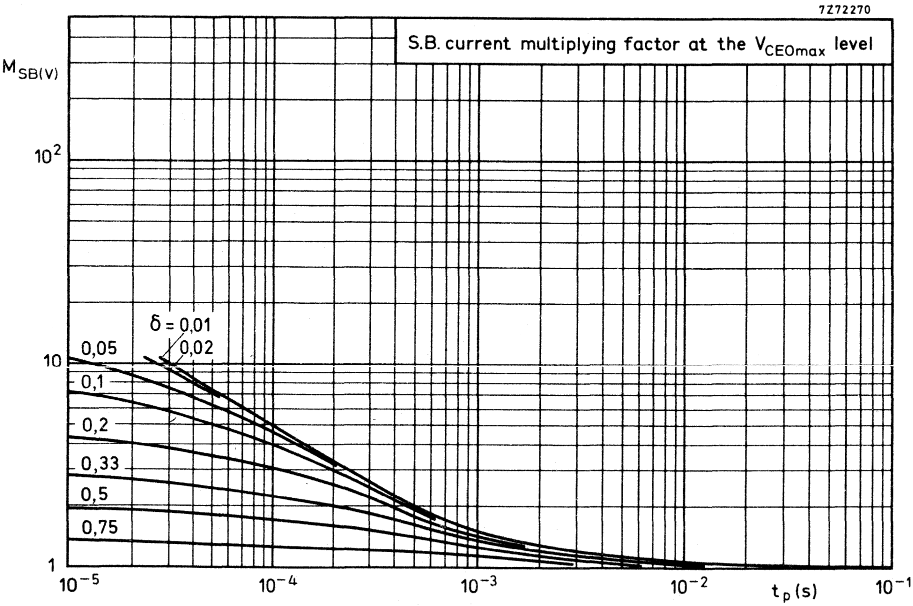
1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

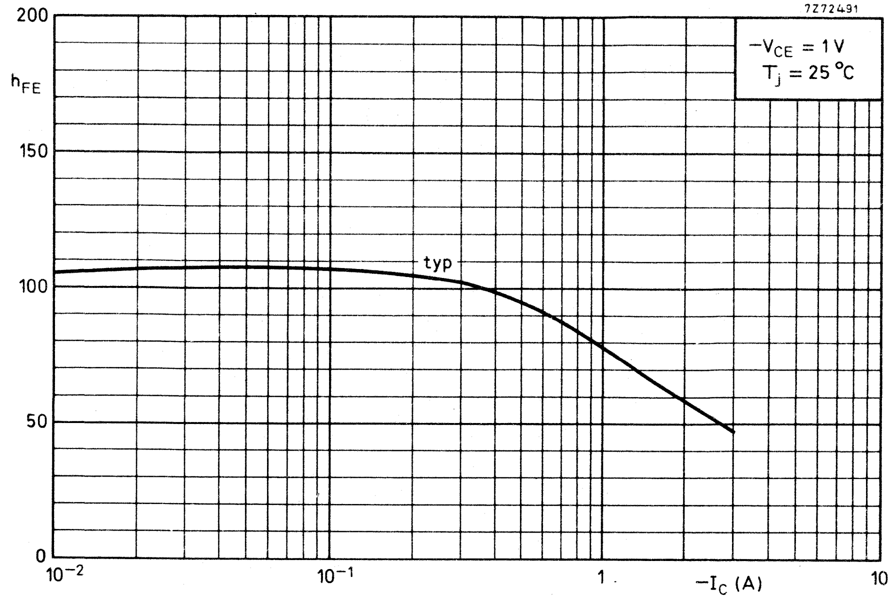
2) Second-breakdown limits (independent of temperature).

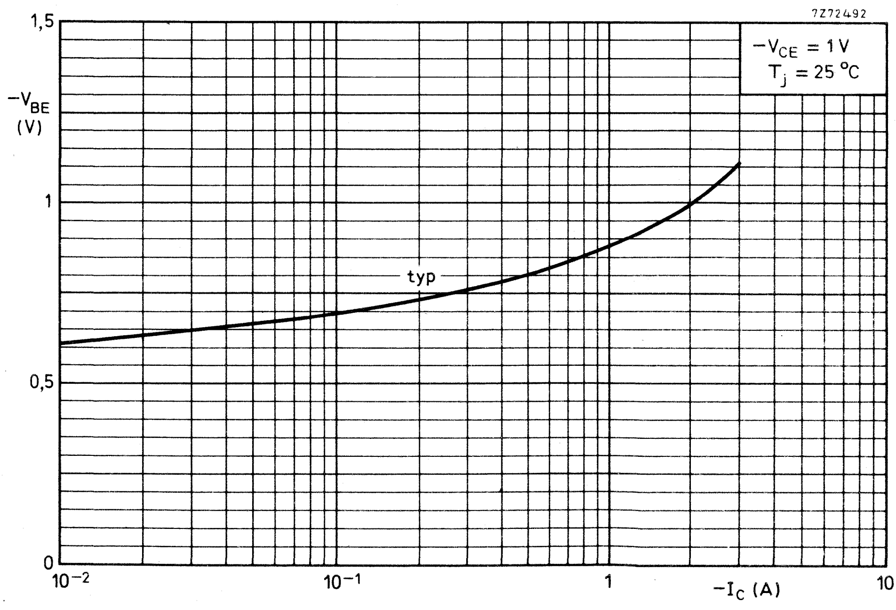

7Z67895.2
100
$P_{tot\ max}$
(%)
50
0
0
50
100
150
T_{mb} (°C)

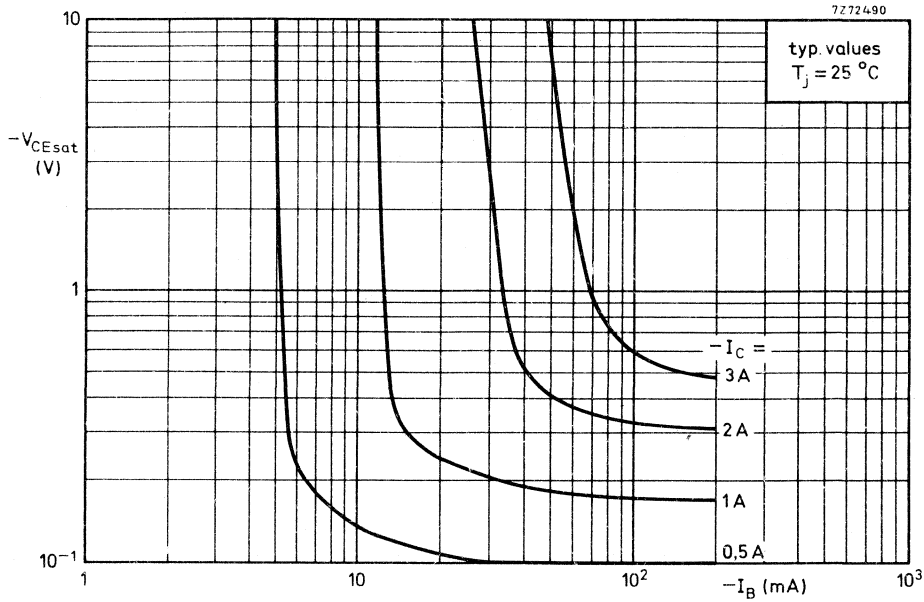

7Z62125
10^2
$Z_{th\ j-mb}$
(°C/W)
10
1
10^{-1}
10^{-2}
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
t_p
T
$δ = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3


7Z72269
S.B. voltage multiplying factor at the I_{Cmax} level
$M_{SB(I)}$
10^2
10
1
$\delta = 0,01$
0,05
0,1
0,2
0,33
0,5
0,75
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}


7Z72270
S.B. current multiplying factor at the V_{CEOmax} level
$M_{SB(V)}$
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}


7Z72491
$-V_{CE}$ = 1 V
T_j = 25 °C
h_{FE}
200
150
100
50
0
typ
10^{-2}
10^{-1}
1
10
$-I_C$ (A)


7Z72492
$-V_{CE}$ = 1 V
T_j = 25 °C
$-V_{BE}$
(V)
1,5
1
0,5
0
typ
10^{-2}
10^{-1}
1
10
$-I_C$ (A)



FOR APPLICATION INFORMATION SEE BD329.

SILICON DARLINGTON POWER TRANSISTORS

N-P-N epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; plastic SOT-82 envelope for clip mounting; can also be soldered or adhesive mounted into a hybrid circuit. P-N-P complements are BD332, BD334 and BD336.

QUICK REFERENCE DATA

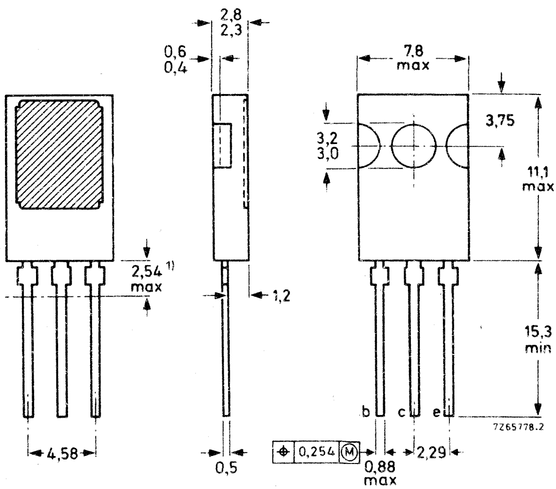
			BD331	BD333	BD335	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Collector-current (d.c.)	I_C	max.		6		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		60		W
Junction temperature	T_j	max.		150		°C
D.C. current gain I_C = 0,5 A; V_{CE} = 3 V	h_{FE}	typ.		1500		
I_C = 3,0 A; V_{CE} = 3 V	h_{FE}	>		750		
Transition frequency I_C = 3 A; V_{CE} = 3 V	f_T	typ.		7		MHz

MECHANICAL DATA

Dimensions in mm

SOT-82

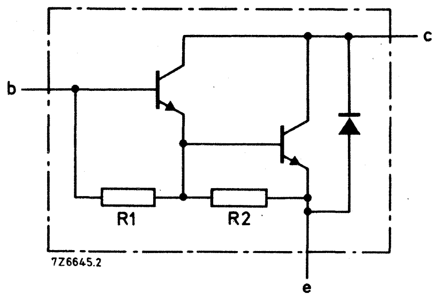
Collector connected to metal part of mounting surface



Accessories supplied on request: 56353 and 56354

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

CIRCUIT DIAGRAM



R_1 typ. 10 kΩ
R_2 typ. 150 Ω

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

Voltages			BD331	BD333	BD335	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V

Currents				
Collector current (d.c.)	I_C	max.	6	A
Collector current (peak value) $t_p \leq 10$ ms; $\delta \leq 0,1$	I_{CM}	max.	10	A
Base current (d.c.)	I_B	max.	150	mA
Power dissipation				
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.	60	W
Temperatures				
Storage temperature	T_{stg}		−65 to +150	^oC
Junction temperature*	T_j		150	^oC

THERMAL RESISTANCE *

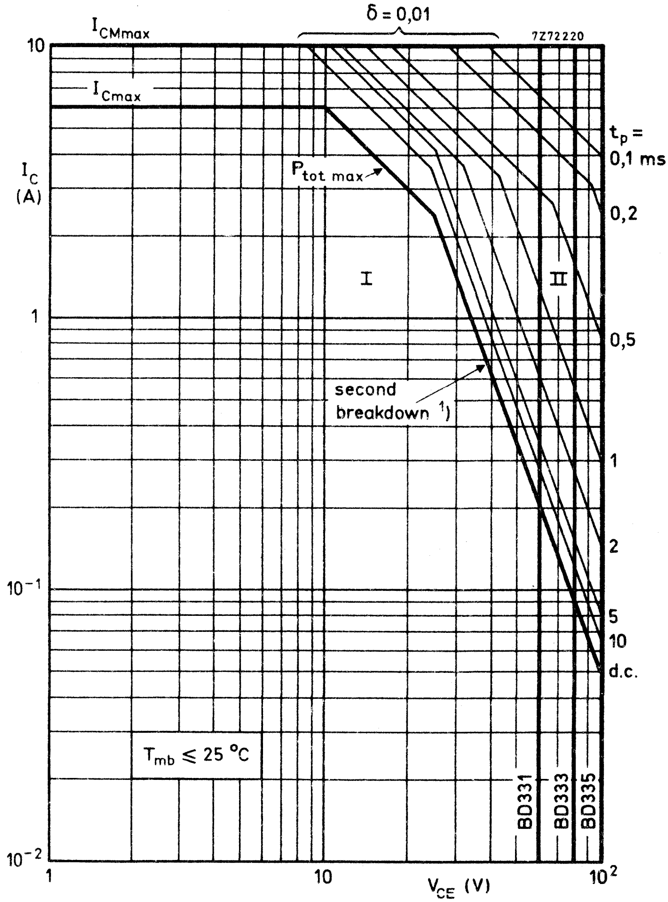
From junction to mounting base	$R_{th\ j-mb}$	=	2,08	$^oC/W$
From junction to ambient in free air	$R_{th\ j-a}$	=	100	$^oC/W$

→ * Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

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

Collector cut-off current				
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	0,2	mA
$I_E = 0$; $V_{CB} = V_{CBOmax}$; $T_j = 150\ ^oC$	I_{CBO}	<	2	mA
$I_B = 0$; $V_{CE} = 30$ V: BD331 $I_B = 0$; $V_{CE} = 40$ V: BD333 $I_B = 0$; $V_{CE} = 50$ V: BD335	I_{CEO}	<	0,5	mA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	5	mA
D.C. current gain [1]				
$I_C = 0,5$ A; $V_{CE} = 3$ V	h_{FE}	typ.	1500	
$I_C = 3$ A; $V_{CE} = 3$ V	h_{FE}	>	750	
$I_C = 6$ A; $V_{CE} = 3$ V	h_{FE}	typ.	1500	
Base-emitter voltage				
$I_C = 3$ A; $V_{CE} = 3$ V	V_{BE}	<	2,5	V
Collector-emitter saturation voltage				
$I_C = 3$ A; $I_B = 12$ mA	V_{CEsat}	<	2	V
Transition frequency				
$I_C = 3$ A; $V_{CE} = 3$ V	f_T	typ.	7	MHz
Cut-off frequency				
$I_C = 3$ A; $V_{CE} = 3$ V	f_{hfe}	typ.	60	kHz
Turn-off breakdown energy with inductive load				
$-I_{Boff} = 0$; $I_{Con} = 4,5$ A; $t_p = 1$ ms; T = 100 ms; see circuit on page 8	$E_{(BR)}$	>	50	mJ
Diode, forward voltage				
$I_F = 3$ A	V_F	typ.	1,8	V

[1]) Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.

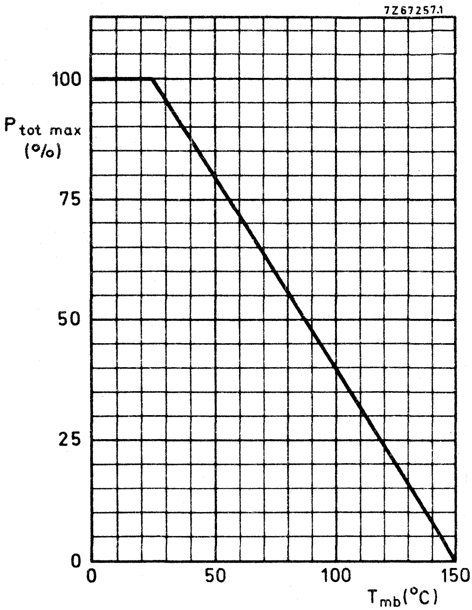


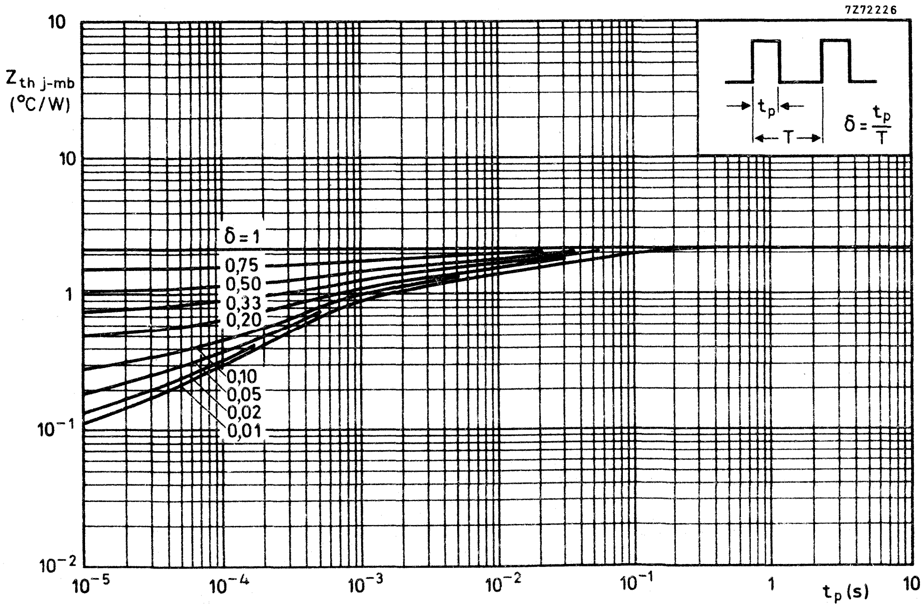
Safe Operating Area with the transistor forward biased

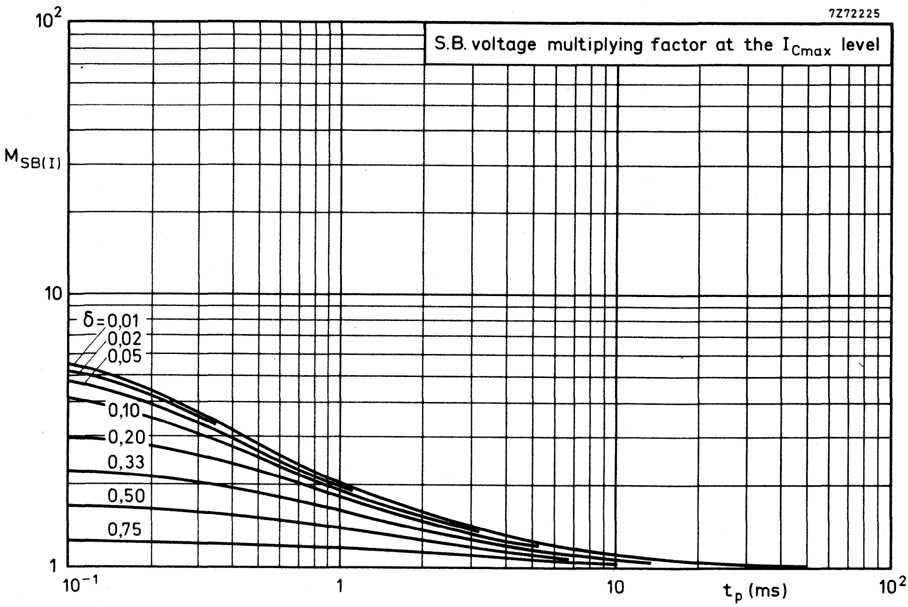
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation

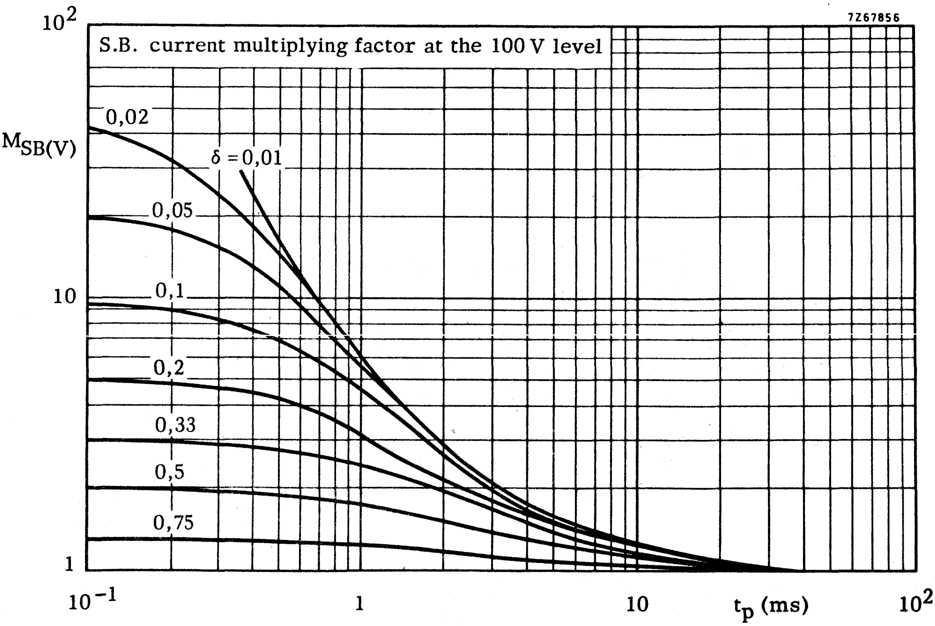
---

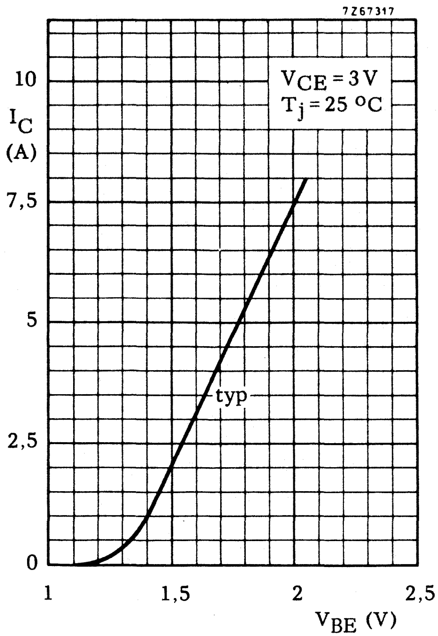
1) Independent of temperature

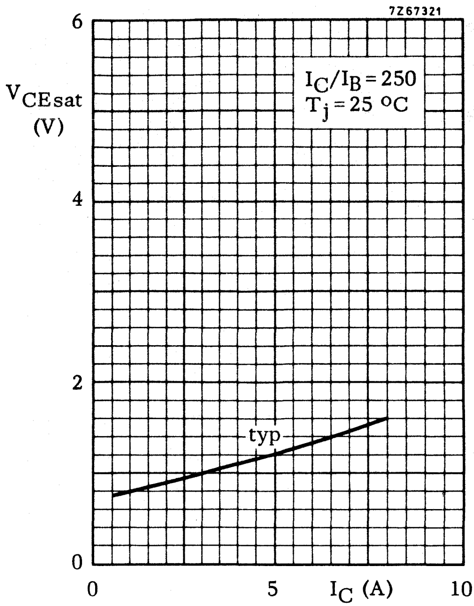

7Z67257.1
100
P tot max
(%)
75
50
25
0
0
50
100
150
Tmb(°C)

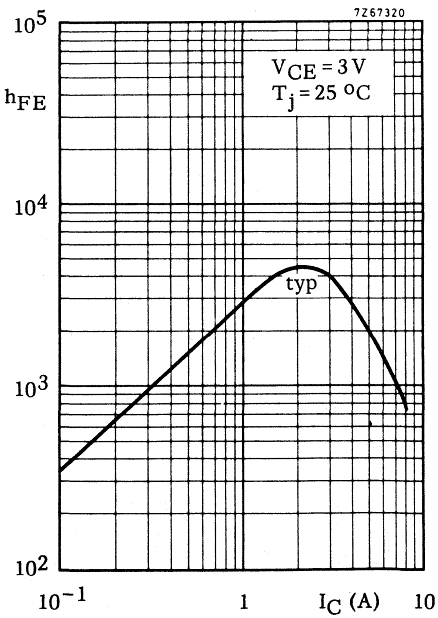

7Z72226
Zth j-mb
(°C/W)
10
1
10^{-1}
10^{-2}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
tp (s)
δ = 1
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
tp
T
δ = tp/T

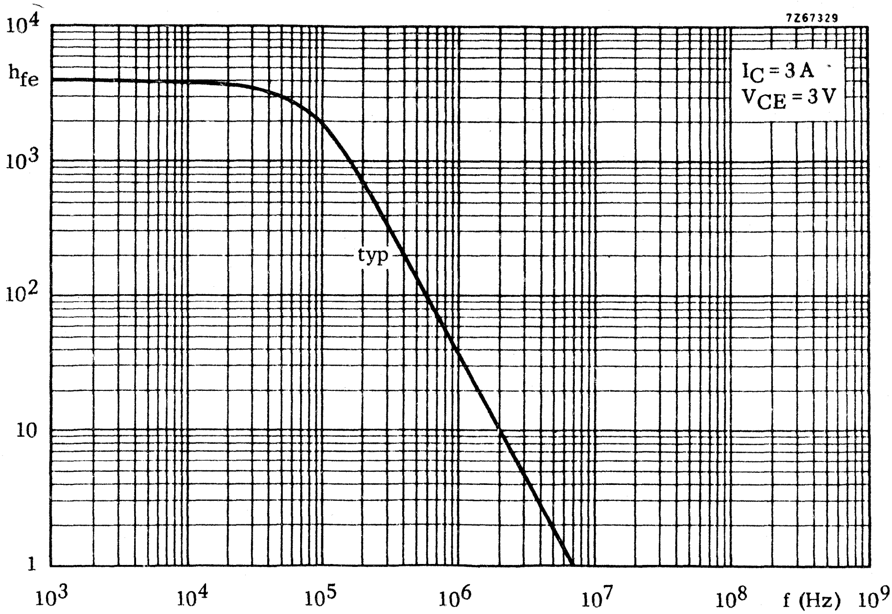

7Z72225
S.B. voltage multiplying factor at the I_{Cmax} level
$M_{SB(I)}$
10^2
10
1
δ=0,01
0,02
0,05
0,10
0,20
0,33
0,50
0,75
10^{-1}
1
10
t_p (ms)
10^2

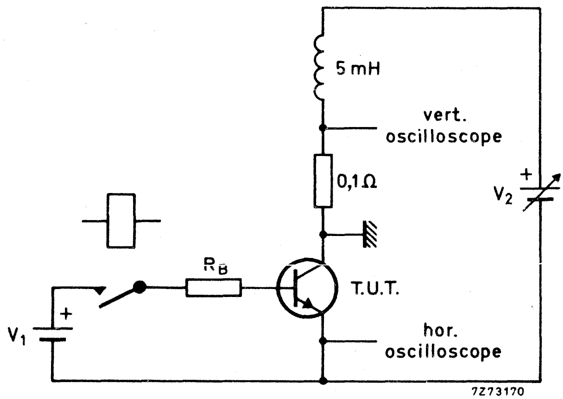

7Z67856
S.B. current multiplying factor at the 100 V level
$M_{SB(V)}$
10^2
10
1
0,02
δ = 0,01
0,05
0,1
0,2
0,33
0,5
0,75
10^{-1}
1
10
t_p (ms)
10^2


7Z67317
V_{CE} = 3 V
T_j = 25 °C
I_C
(A)
10
7,5
5
2,5
0
typ
1
1,5
2
2,5
V_{BE} (V)


7Z67321
I_C/I_B = 250
T_j = 25 °C
V_{CEsat}
(V)
6
4
2
0
typ
0
5
I_C (A)
10


7Z67320
V_{CE} = 3 V
T_j = 25 °C
h_{FE}
10^5
10^4
10^3
10^2
typ
10^{-1}
1
I_C (A)
10

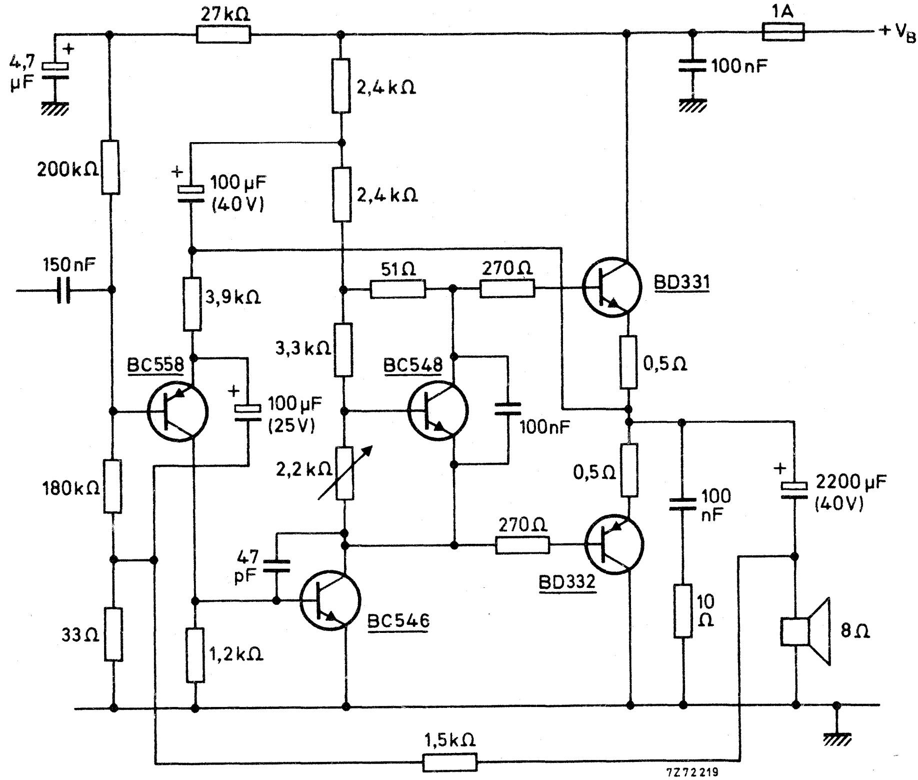




Test circuit for turn-off breakdown energy (page 3)
$V_1 = 12$ V; $R_B = 270\ \Omega$

APPLICATION INFORMATION

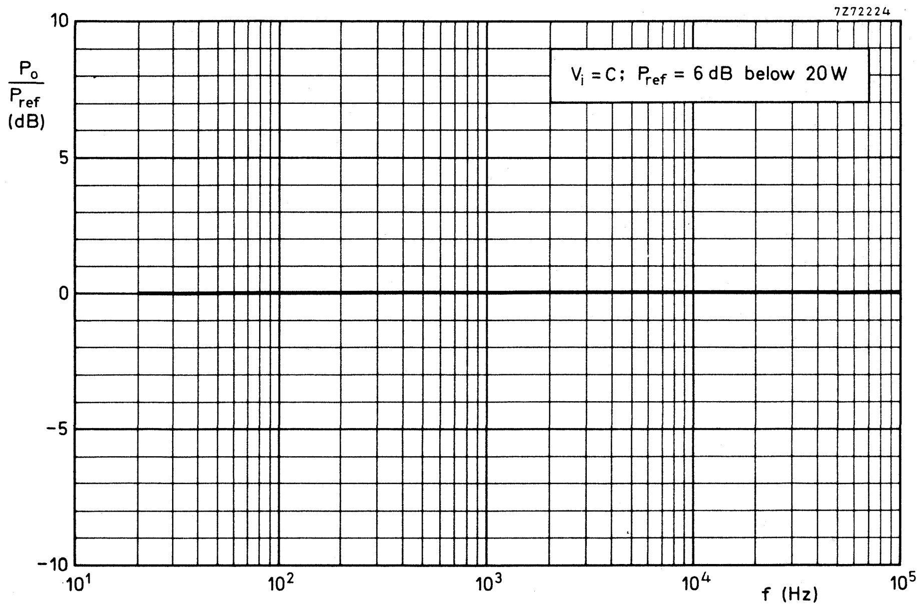
Basic circuit diagram of a 20 W hi-fi amplifier.

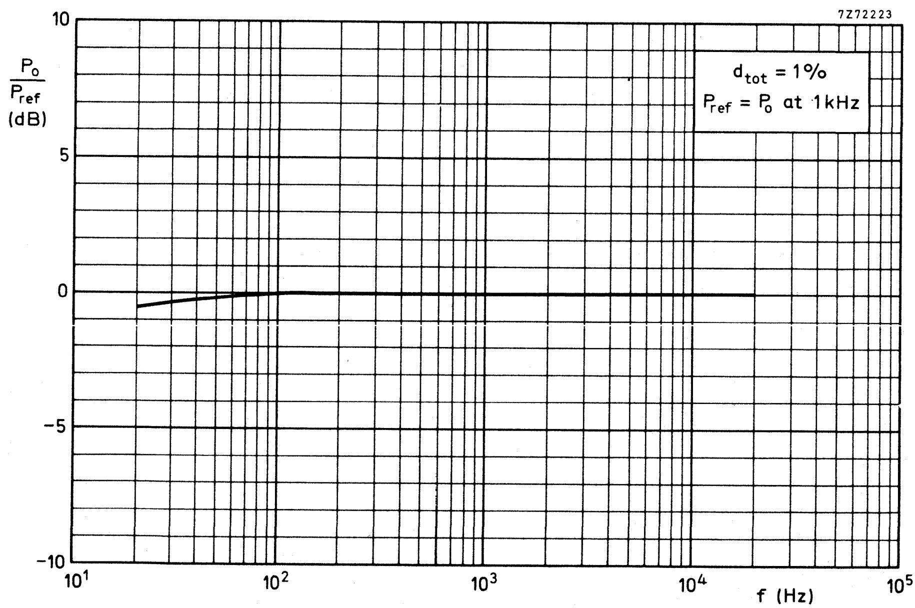


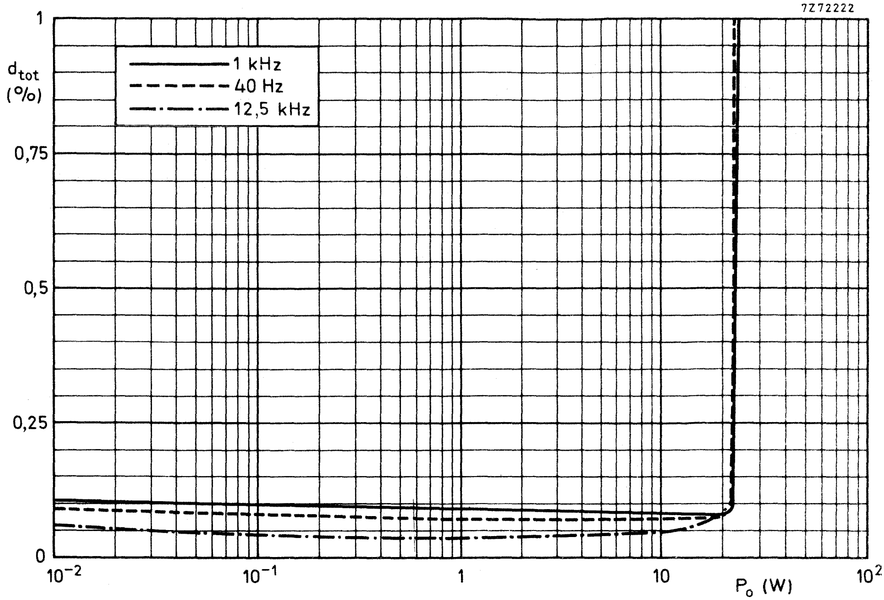
Performance at V_B = 43 V (unloaded supply voltage = 51 V):

Collector quiescent current of BD331 and BD332	$\lvert I_{CQ} \rvert$	typ.	20	mA
Total current drain at P_o = 20 W; f = 1 kHz	I_B	typ.	710	mA
Input impedance	z_i	typ.	180	kΩ
Output impedance	z_o	typ.	80	mΩ
Output power at f = 1 kHz; d_{tot} = 1 %	P_o	typ.	24	W
Input voltage for P_o = 20 W; f = 1 kHz	$V_{i(rms)}$	typ.	375	mV
Total harmonic distortion at P_o = 20 W	d_{tot}	typ.	0,08	%
Intermodulation distortion at P_o = 20 W	d_{im}	typ.	0,2	%
Heatsink thermal resistance per output transistor	$R_{th\ h-a}$	≤	6,4	°C/W

Stable continuous operation is ensured up to an ambient temperature of 50 °C.


7Z72224
$V_i = C$; P_{ref} = 6 dB below 20 W
$\frac{P_o}{P_{ref}}$ (dB)
10
5
0
−5
−10
10^1
10^2
10^3
10^4
10^5
f (Hz)


7Z72223
d_{tot} = 1%
$P_{ref} = P_o$ at 1 kHz
$\frac{P_o}{P_{ref}}$ (dB)
10
5
0
−5
−10
10^1
10^2
10^3
10^4
10^5
f (Hz)


7Z72222
d_tot
(%)
1
0,75
0,5
0,25
0
1 kHz
40 Hz
12,5 kHz
10^-2
10^-1
1
10
10^2
P_o (W)

SILICON DARLINGTON POWER TRANSISTORS

P-N-P epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; plastic SOT-82 envelope for clip mounting; can also be soldered or adhesive mounted into a hybrid circuit. N-P-N complements are BD331, BD333 and BD335.

QUICK REFERENCE DATA

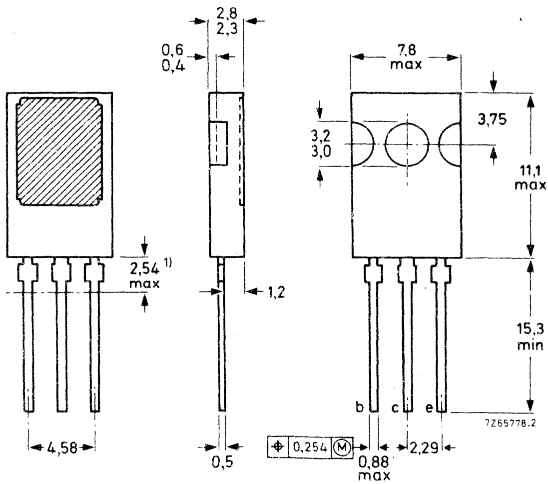
			BD332	BD334	BD336	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Collector-current (d.c.)	$-I_C$	max.		6		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		60		W
Junction temperature	T_j	max.		150		°C
D.C. current gain $-I_C$ = 0,5 A; $-V_{CE}$ = 3 V	h_{FE}	typ.		1500		
$-I_C$ = 3,0 A; $-V_{CE}$ = 3 V	h_{FE}	>		750		
Transition frequency $-I_C$ = 3 A; $-V_{CE}$ = 3 V	f_T	typ.		7		MHz

MECHANICAL DATA

Dimensions in mm

SOT-82

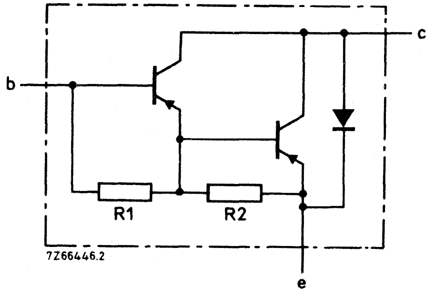
Collector connected to metal part of mounting surface



Accessories supplied on request: 56353 and 56354

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

CIRCUIT DIAGRAM



R_1 typ. 10 kΩ
R_2 typ. 150 Ω

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

Voltages			BD332	BD334	BD336	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V

Currents				
Collector current (d.c.)	$-I_C$	max.	6	A
Collector current (peak value) $t_p \leq 10$ ms; $\delta \leq 0,1$	$-I_{CM}$	max.	10	A
Base current (d.c.)	$-I_B$	max.	150	mA
Power dissipation				
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.	60	W
Temperatures				
Storage temperature	T_{stg}		−65 to +150	^oC
Junction temperature*	T_j		150	^oC

THERMAL RESISTANCE*

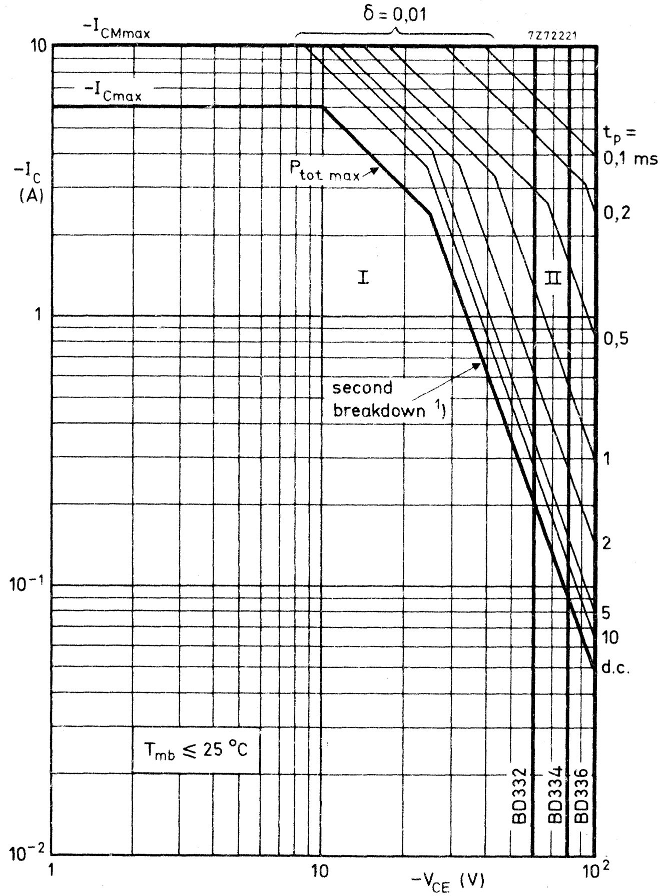
From junction to mounting base	$R_{th\ j-mb}$	=	2,08	$^oC/W$
From junction to ambient in free air	$R_{th\ j-a}$	=	100	$^oC/W$

* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

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

Collector cut-off current				
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	0, 2	mA
$I_E = 0; -V_{CB} = -V_{CBOmax}; T_j = 150\ ^oC$	$-I_{CBO}$	<	2	mA
$I_B = 0; -V_{CE} = 30$ V: BD332 $I_B = 0; -V_{CE} = 40$ V: BD334 $I_B = 0; -V_{CE} = 50$ V: BD336	$-I_{CEO}$	<	0, 5	mA
Emitter cut-off current				
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	5	mA
D.C. current gain [1]				
$-I_C = 0,5$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	1500	
$-I_C = 3$ A; $-V_{CE} = 3$ V	h_{FE}	>	750	
$-I_C = 6$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	1500	
Base-emitter voltage				
$-I_C = 3$ A; $-V_{CE} = 3$ V	$-V_{BE}$	<	2, 5	V
Collector-emitter saturation voltage				
$-I_C = 3$ A; $-I_B = 12$ mA	$-V_{CEsat}$	<	2	V
Transition frequency				
$-I_C = 3$ A; $-V_{CE} = 3$ V	f_T	typ.	7	MHz
Cut-off frequency				
$-I_C = 3$ A; $-V_{CE} = 3$ V	f_{hfe}	typ.	60	kHz
Diode, forward voltage				
$I_F = 3$ A	V_F	typ.	1, 8	V

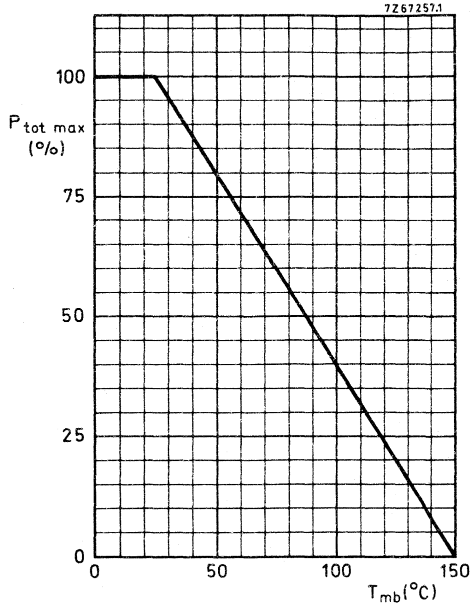
[1]) Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.

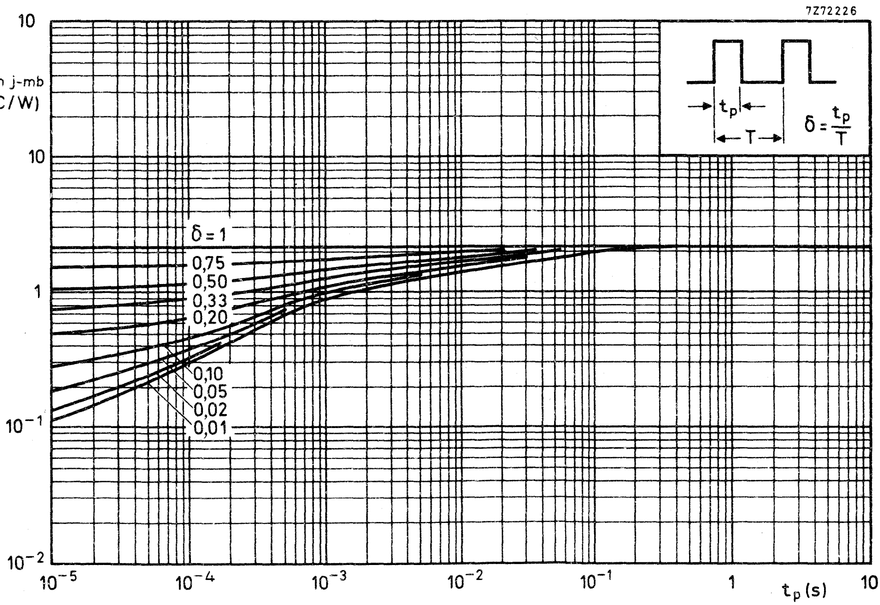


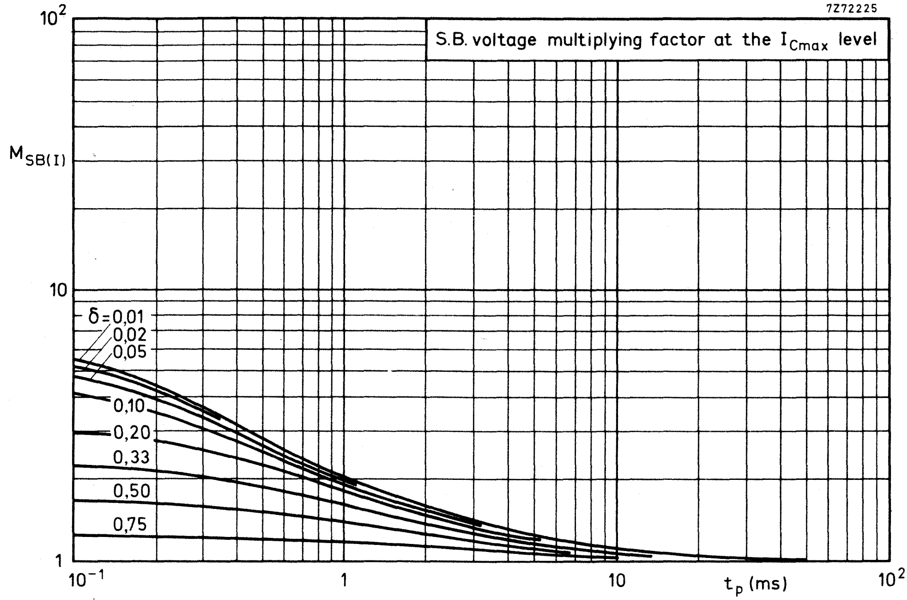
Safe Operating Area with the transistor forward biased

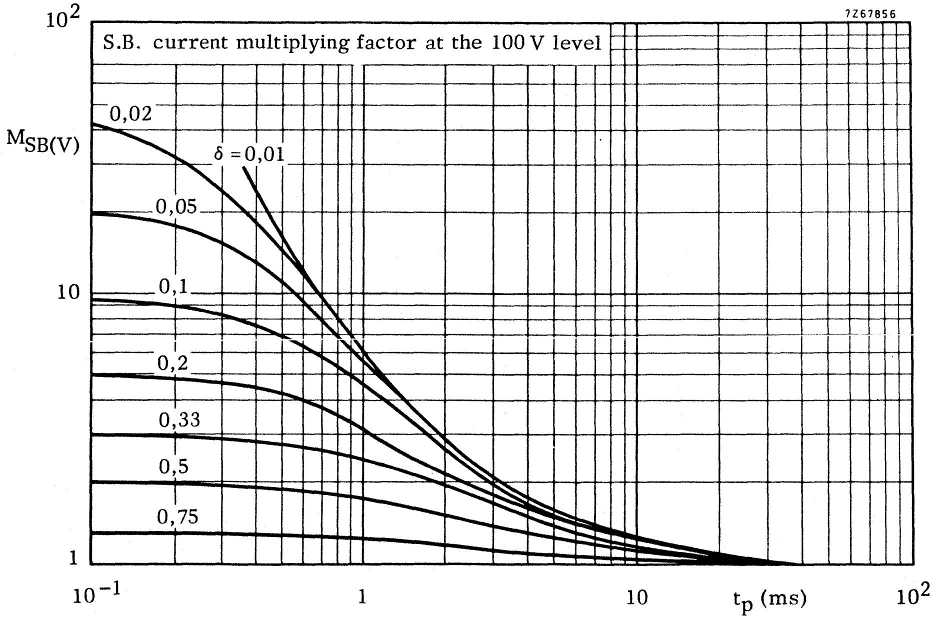
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation

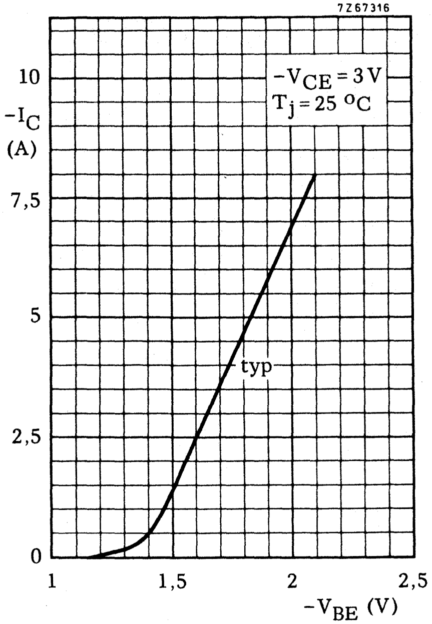
1) Independent of temperature

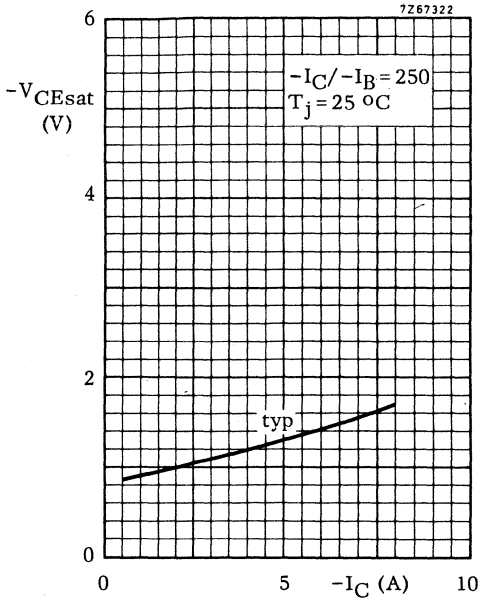

7Z67257.1
100
$P_{tot\ max}$
(%)
75
50
25
0
0
50
100
150
T_{mb} (°C)

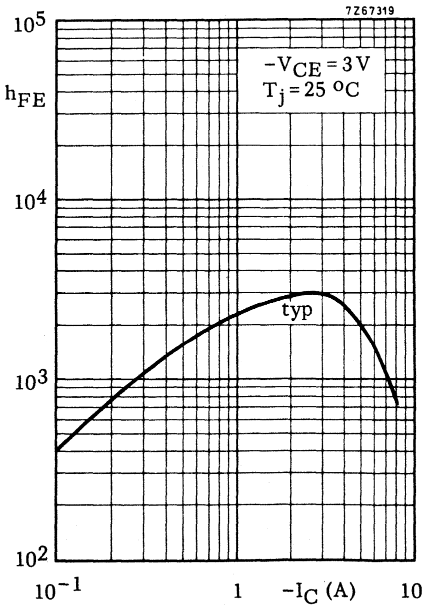

7Z72226
10
$Z_{th\ j\text{-}mb}$
(°C/W)
10
1
10^{-1}
10^{-2}
$\delta = 1$
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
t_p (s)

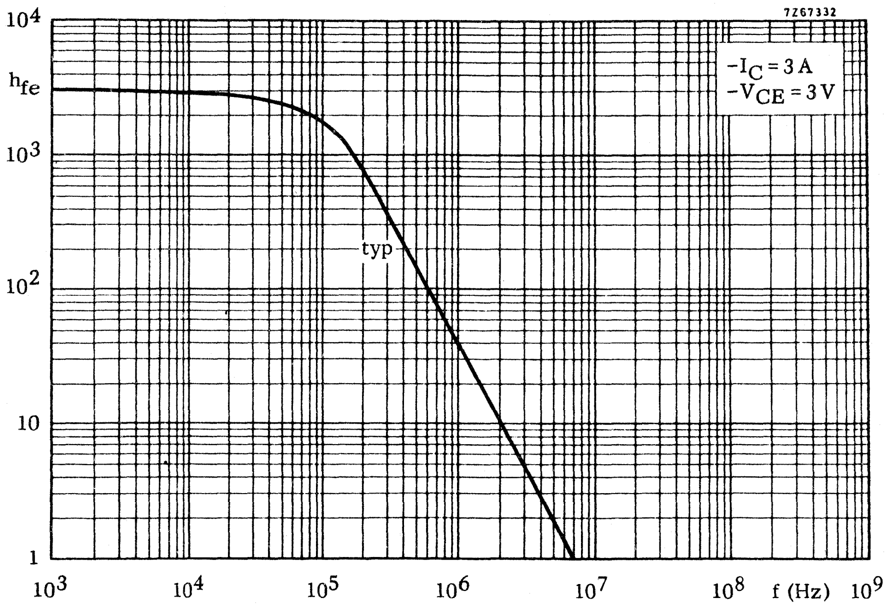

7Z72225
S.B. voltage multiplying factor at the I_{Cmax} level
$M_{SB(I)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,10
0,20
0,33
0,50
0,75
10^{-1}
1
10
t_p (ms)
10^2


7Z67856
S.B. current multiplying factor at the 100 V level
$M_{SB(V)}$
10^2
10
1
0,02
δ = 0,01
0,05
0,1
0,2
0,33
0,5
0,75
10^{-1}
1
10
t_p (ms)
10^2


7Z67316
$-V_{CE} = 3$ V
$T_j = 25$ °C
$-I_C$
(A)
10
7,5
5
2,5
0
typ
1
1,5
2
2,5
$-V_{BE}$ (V)


7Z67322
$-I_C/-I_B = 250$
$T_j = 25$ °C
$-V_{CEsat}$
(V)
6
4
2
0
typ
0
5
$-I_C$ (A)
10


7Z67319
$-V_{CE} = 3$ V
$T_j = 25$ °C
h_{FE}
10^5
10^4
10^3
10^2
typ
10^{-1}
1
$-I_C$ (A)
10



FOR APPLICATION INFORMATION SEE BD331 etc.

SILICON EPITAXIAL-BASE POWER TRANSISTORS

N-P-N transistors in a SOT-32 plastic envelope, intended for use in complementary output stages of audio amplifiers up to 15 W.
The complementary pairs are BD433/BD434, BD435/BD436 and BD437/BD438.

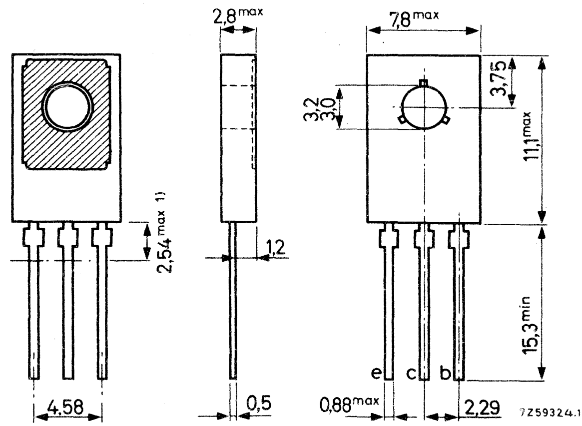
QUICK REFERENCE DATA

			BD433	BD435	BD437	
Collector-emitter 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
D.C. current gain I_C = 2 A; V_{CE} = 1 V	h_{FE}	>	50	50	40	
Transition frequency I_C = 250 mA; V_{CE} = 1 V	f_T	>	3	3	3	MHz

MECHANICAL DATA Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface



For mounting instructions see section Accessories, type 56333 for insulated mounting and type 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 (IEC 134)

Voltages

			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 voltage (open base)	V_{CEO}	max.	22	32	45	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V

Currents

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 °C	P_{tot}	max.	36	W

Temperatures

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

THERMAL RESISTANCE

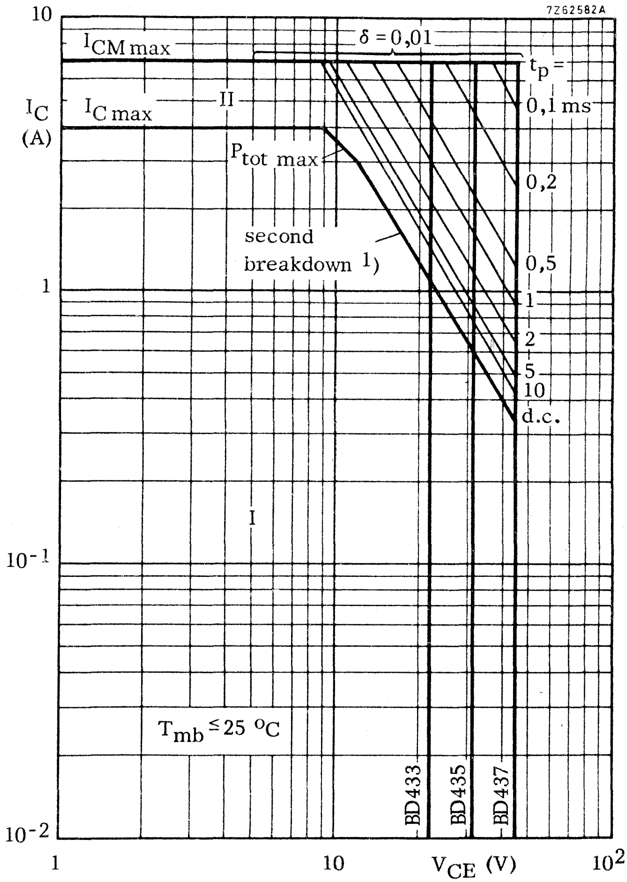
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	3,5	°C/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BD433	BD435	BD437	
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
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}	>	25	25	25	
$I_C = 500$ 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	
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		

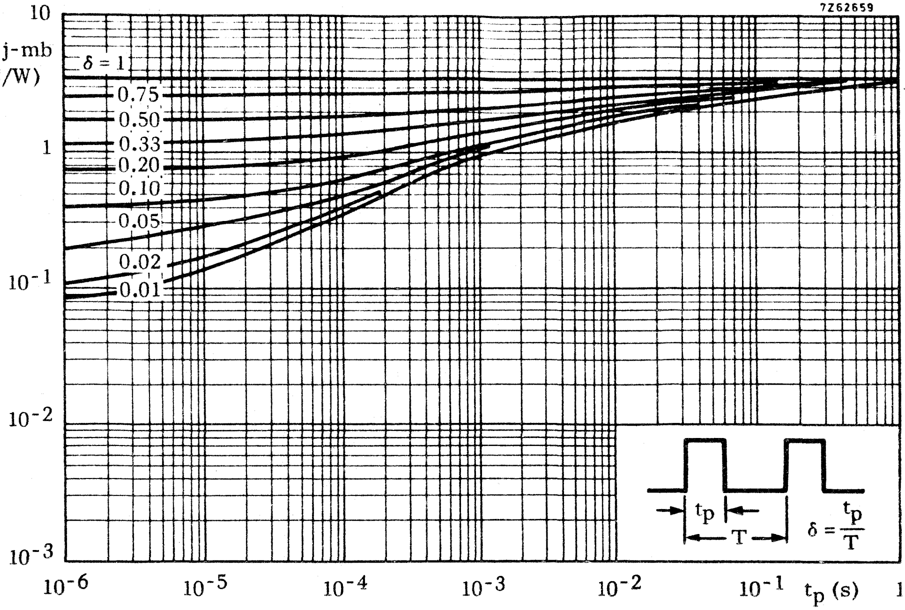
[1] V_{BE} decreases by typ. 2,3 mV/°C with increasing temperature.

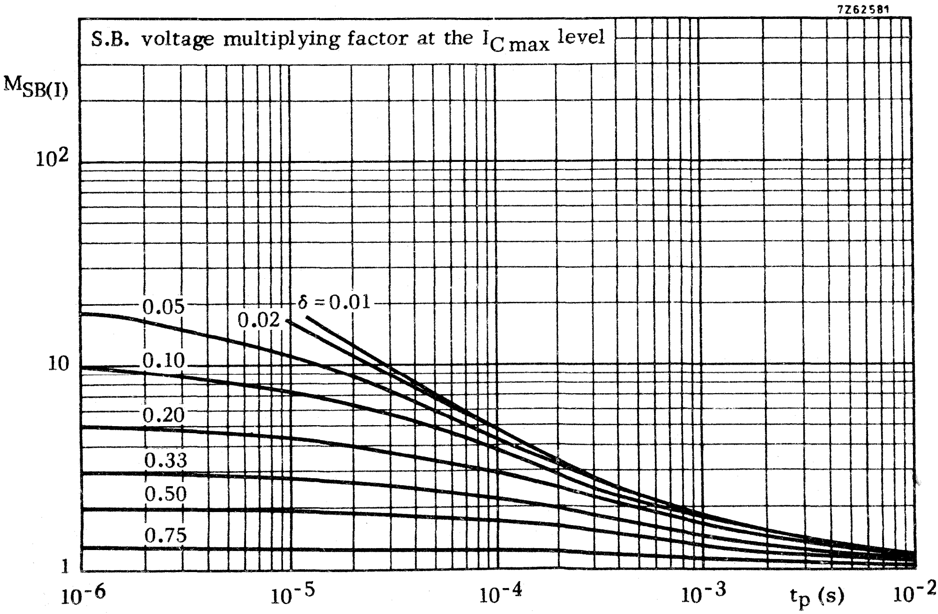


Safe Operating ARea with the transistor forward biased

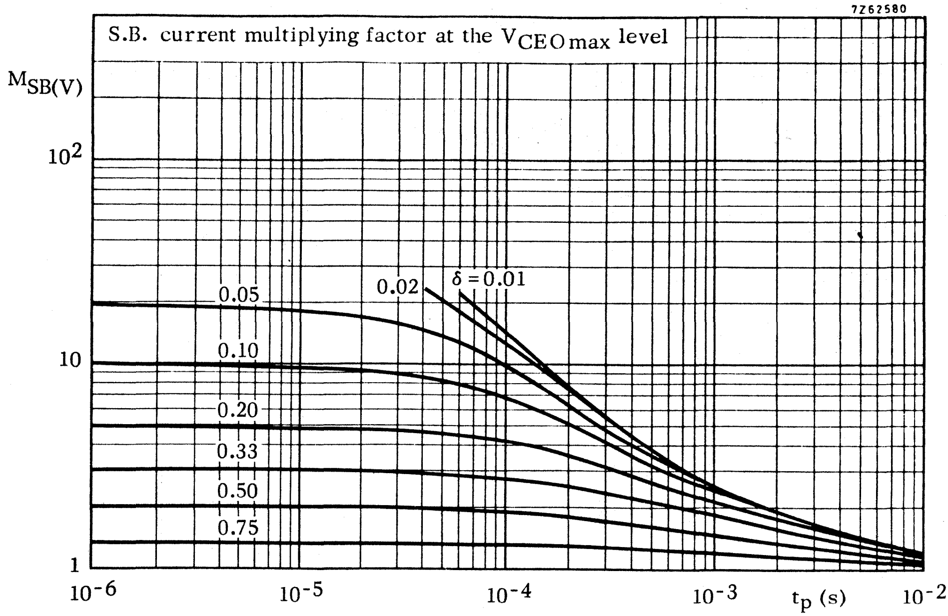
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation

1) Independent of temperature.

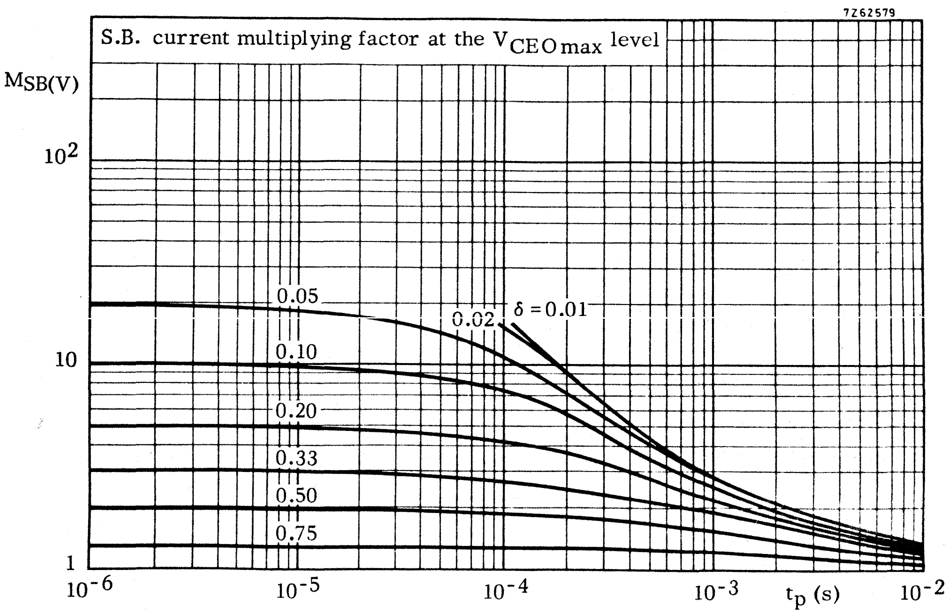

7Z62659
10
$Z_{th\ j\text{-}mb}$
($^oC/W$)
δ = 1
0.75
0.50
0.33
1
0.20
0.10
0.05
0.02
10^{-1}
0.01
10^{-2}
10^{-3}
t_p
T
$\delta = \frac{t_p}{T}$
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
t_p (s)
1

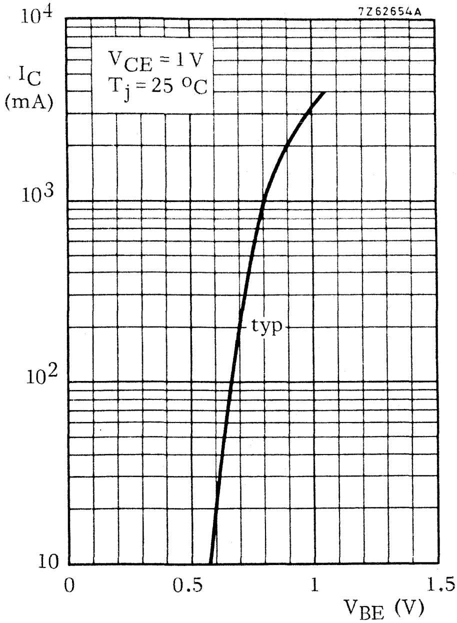

7Z62581
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
0.05
0.02
δ = 0.01
10
0.10
0.20
0.33
0.50
0.75
1
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

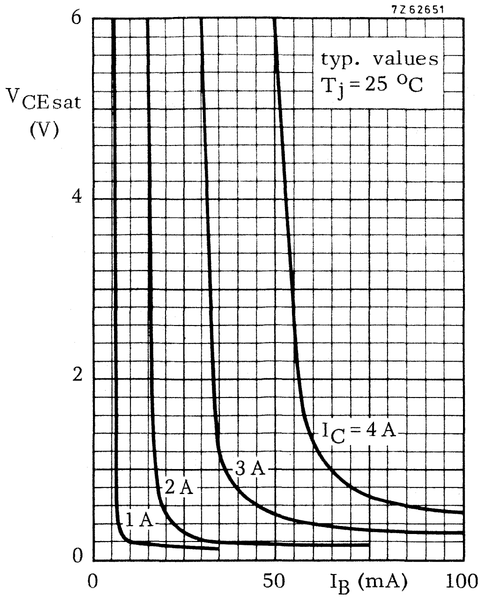
BD433; BD435

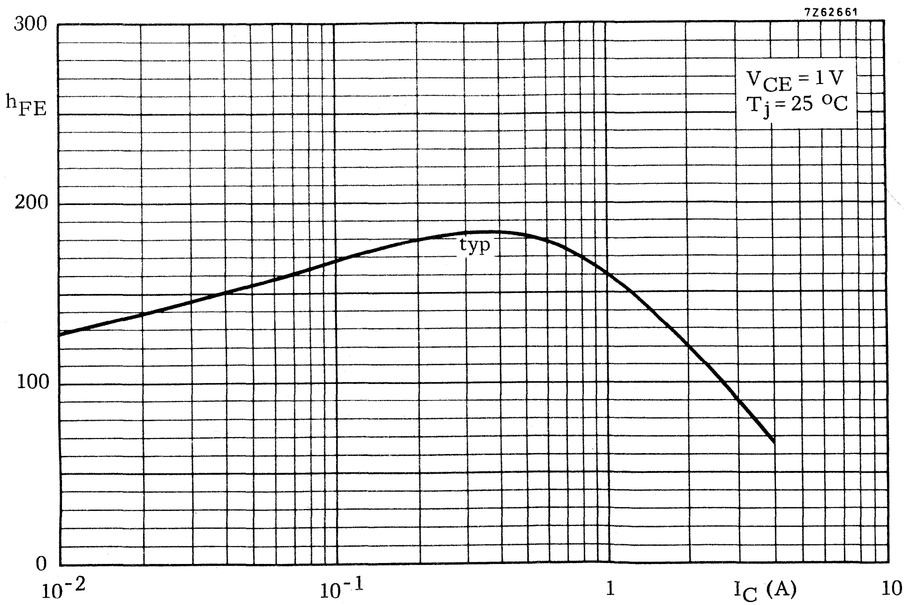


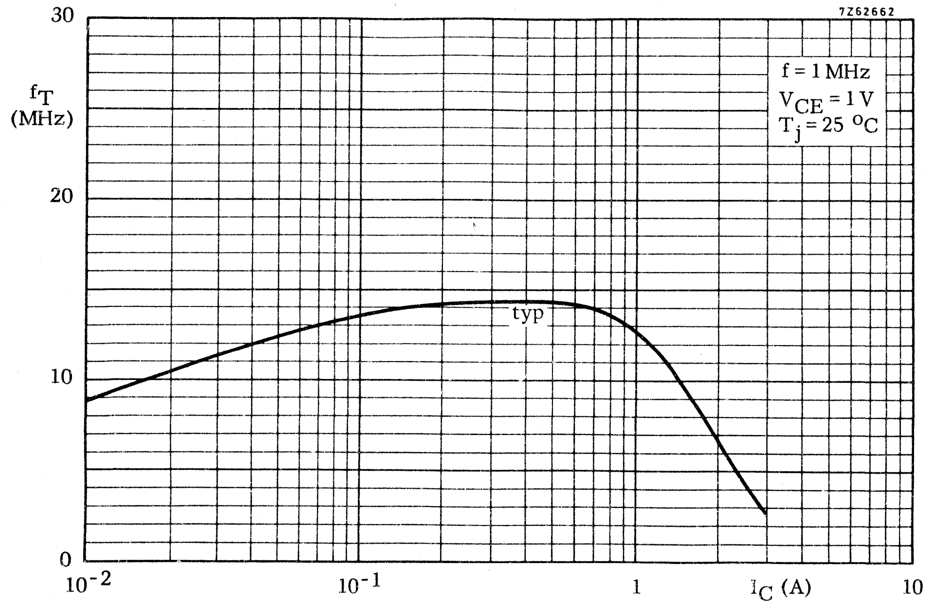
BD437

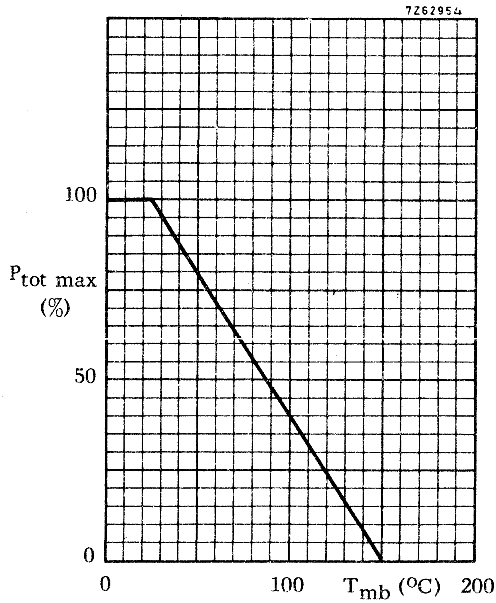



7Z62654A
10^4
I_C
(mA)
$V_{CE} = 1$ V
$T_j = 25$ °C
10^3
typ
10^2
10
0
0.5
1
1.5
V_{BE} (V)


7Z62651
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

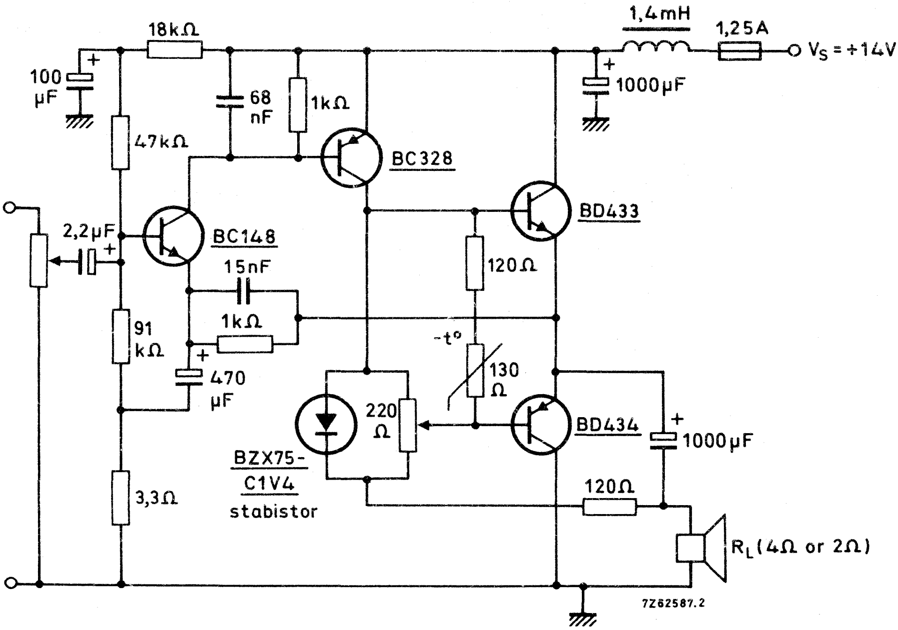

7Z62661
300
h_{FE}
$V_{CE} = 1$ V
$T_j = 25$ °C
200
typ
100
0
10^{-2}
10^{-1}
1
I_C (A)
10


7Z62662
f = 1 MHz
V_{CE} = 1 V
T_j = 25 °C
f_T
(MHz)
typ
30
20
10
0
10^{-2}
10^{-1}
1
I_C (A)
10


7Z62954
$P_{tot\ max}$
(%)
100
50
0
0
100
T_{mb} (°C)
200

APPLICATION INFORMATION

Basic circuit diagram of a 6 W car-radio audio amplifier.



Typical performance:

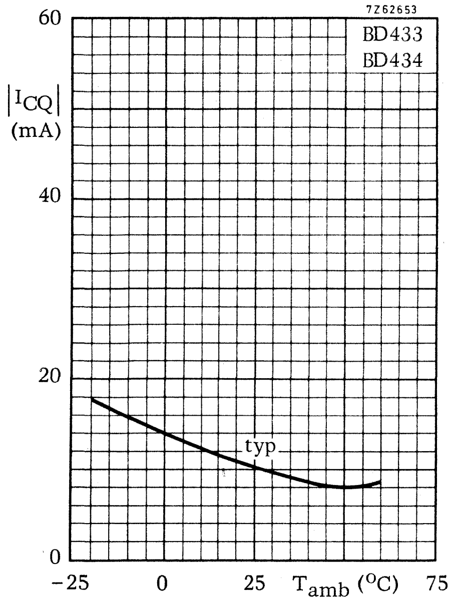
Output power at d_{tot} = 10% and R_L = 4 Ω	P_o	≥	6	W
Output power at d_{tot} = 10% and R_L = 2 Ω	P_o		8	W
Input voltage for P_o = 5 W; R_L = 4 Ω	$V_{i(rms)}$		20	mV
P_o = 5 W; R_L = 2 Ω	$V_{i(rms)}$		15	mV
Input impedance	z_i		20	kΩ
Collector quiescent current of output transistors	$\lvert I_{CQ} \rvert$		10	mA
Collector current of BC328 [1]	$-I_C$		50	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. 26,5	°C/W

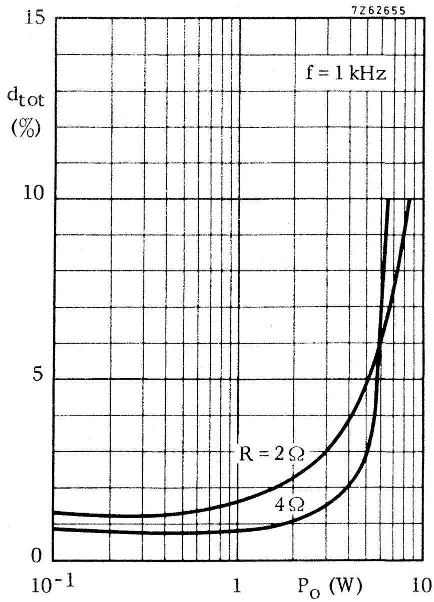
Stable continuous operation is ensured up to an ambient temperature of 60 °C

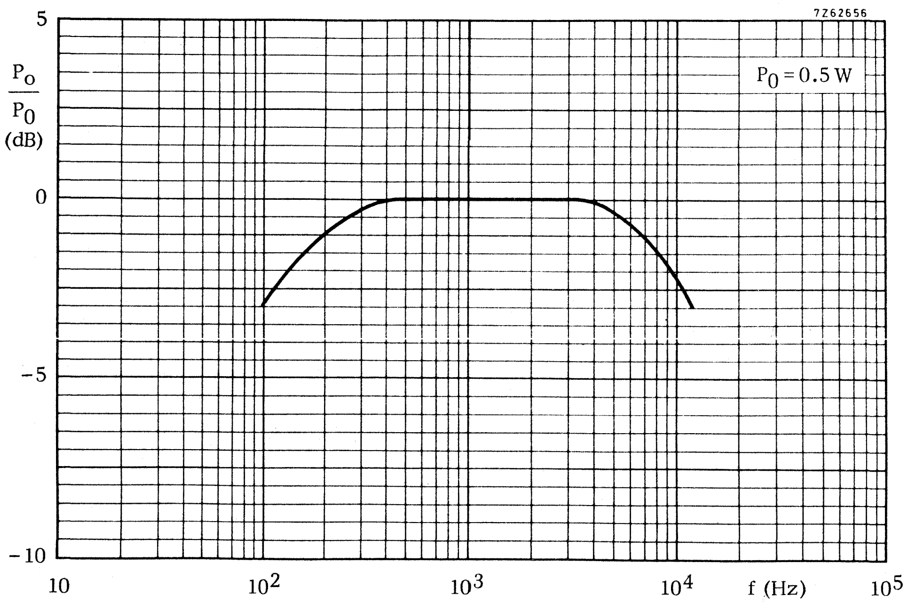
The amplifier is overdrive proof and short circuit proof.

1) Area of printed wiring copper around collector lead ≈ 1 cm^2.

APPLICATION INFORMATION (continued)

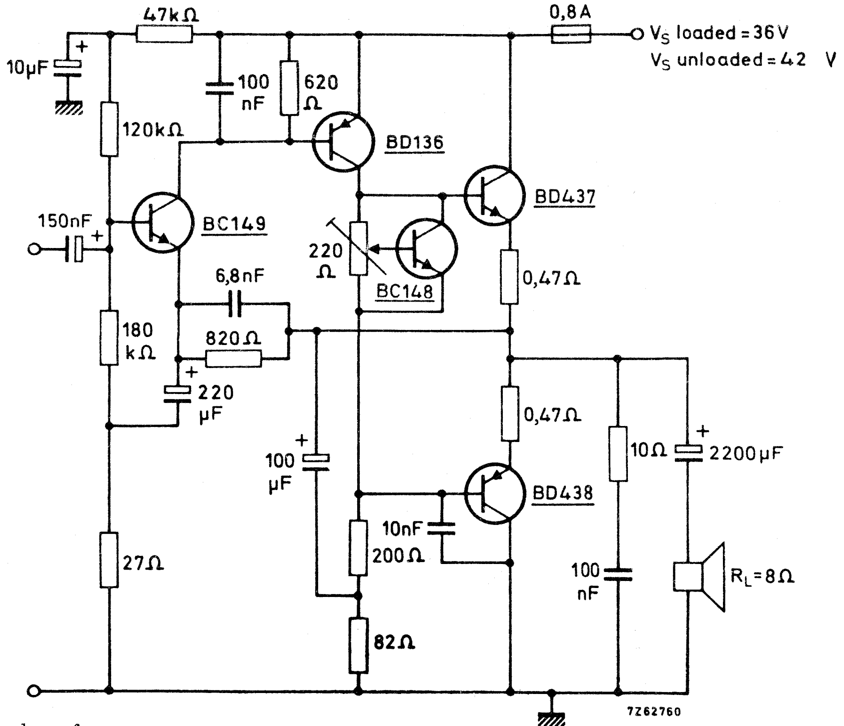






APPLICATION INFORMATION (continued)

Basic circuit diagram of a 15 W high quality amplifier.

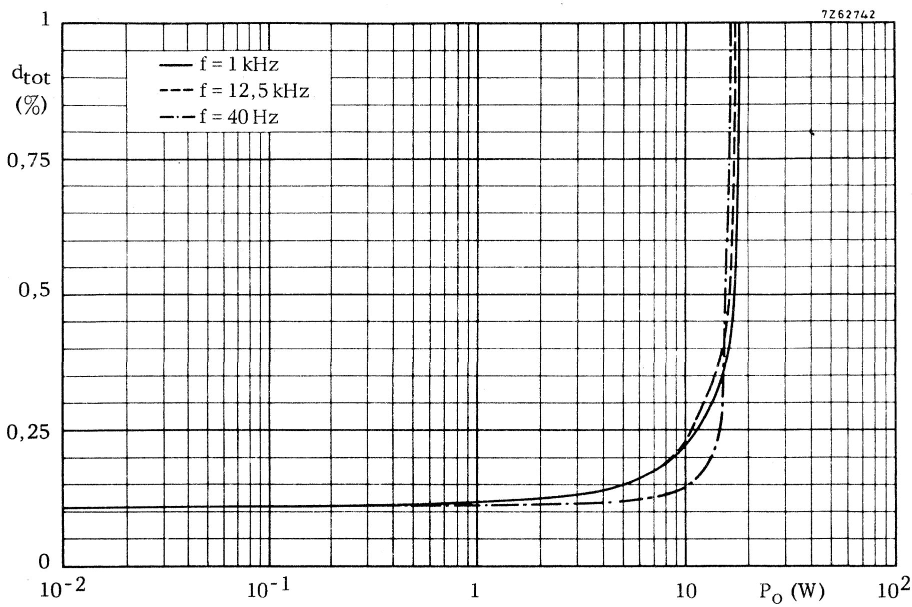


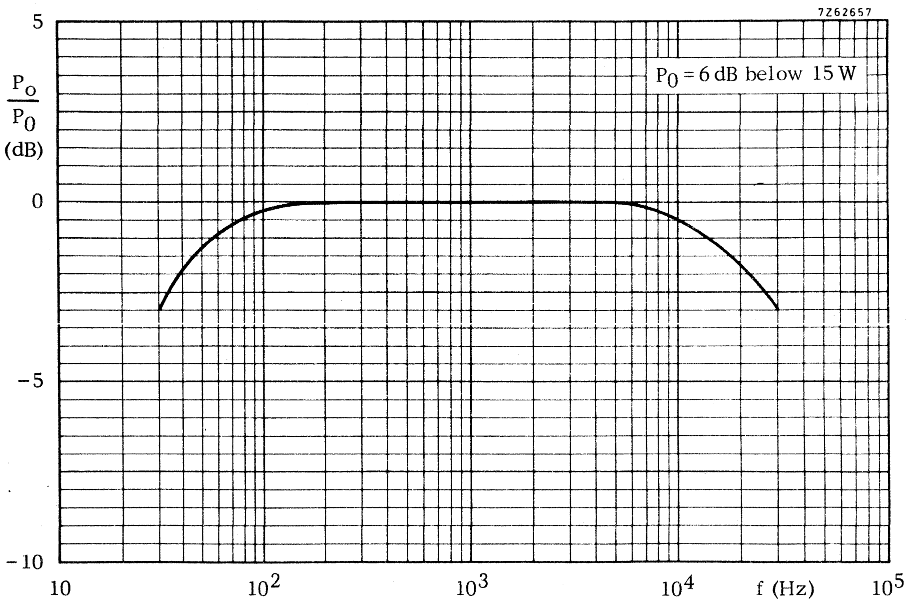
Typical performance:

Output power at d_{tot} = 1 %	P_o	≥	15	W
Input voltage for P_o = 10 W	$V_{i(rms)}$		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	$R_{th\ j\text{-}a}$	max.	18	°C/W
Total thermal resistance of the BD136	$R_{th\ j\text{-}a}$	max.	44	°C/W

Stable continuous operation is ensured up to an ambient temperature of 45 °C.

APPLICATION INFORMATION (continued)





SILICON EPITAXIAL-BASE POWER TRANSISTORS

P-N-P transistors in a SOT-32 plastic envelope, intended for use in complementary output stages of audio amplifiers up to 15 W.
The complementary pairs are BD433/BD434, BD435/BD436 and BD437/BD438.

QUICK REFERENCE DATA

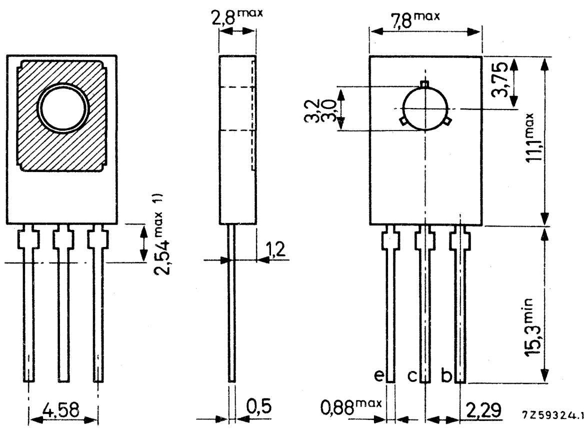
			BD434	BD436	BD438	
Collector-emitter voltage ($-V_{BE} = 0$)	$-V_{CES}$	max.	22	32	45	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	22	32	45	V
Collector current (peak value)	$-I_{CM}$	max.	7	7	7	A
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.	36	36	36	W
D.C. current gain $-I_C = 2$ A; $-V_{CE} = 1$ V	h_{FE}	>	50	50	40	
Transition frequency $-I_C = 250$ mA; $-V_{CE} = 1$ V	f_T	>	3	3	3	MHz

MECHANICAL DATA

Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface



For mounting instructions see section Accessories, type 56333 for insulated mounting and 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 (IEC 134)

Voltages			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 voltage (open base)	$-V_{CEO}$	max.	22	32	45	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V

Currents				
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 °C	P_{tot}	max.	36	W

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

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	3,5	°C/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	°C/W

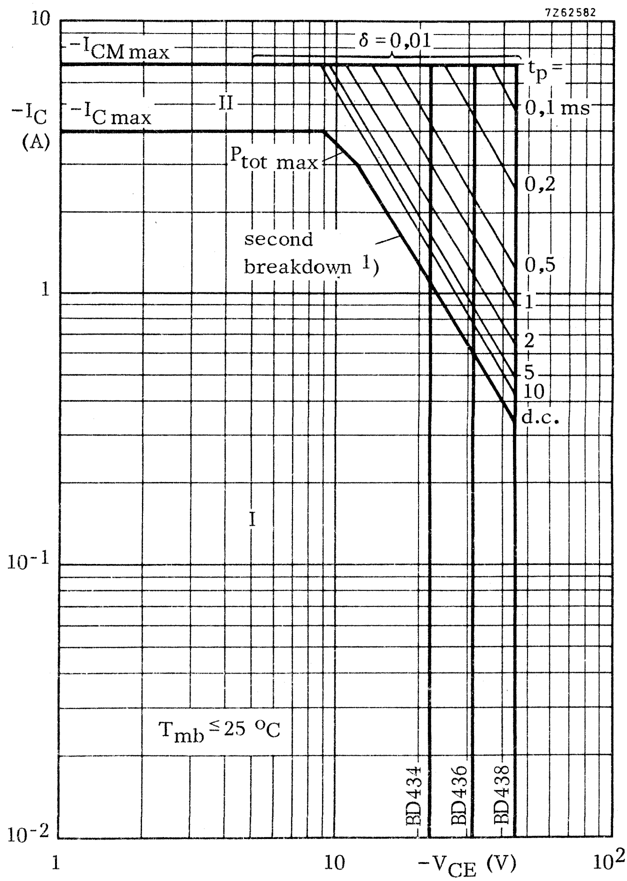
CHARACTERISTICS T_j = 25 °C unless otherwise specified

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

			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}	>	25	25	25	
$-I_C = 500$ 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	

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	

[1] $-V_{BE}$ decreases by typ. 2,3 mV/°C with increasing temperature.

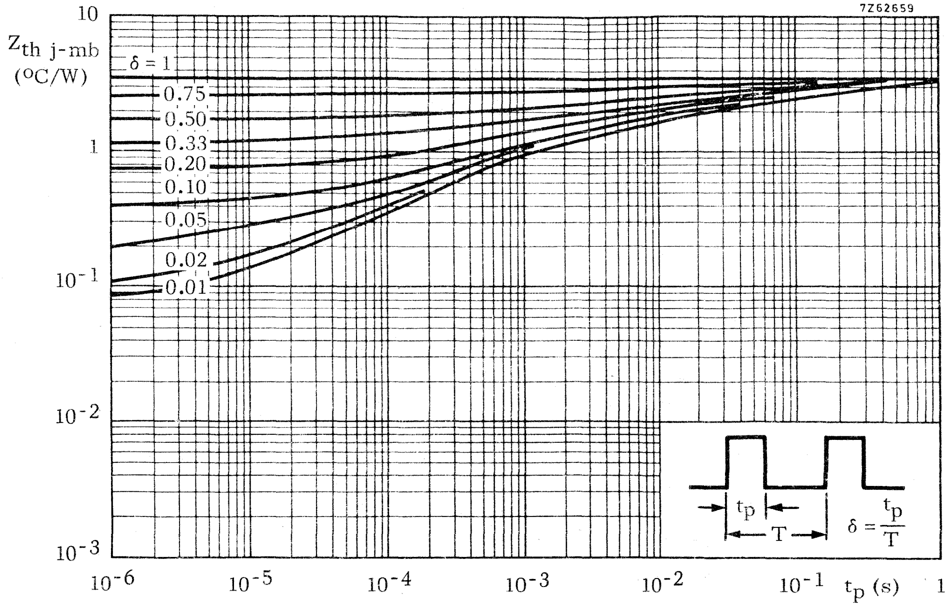


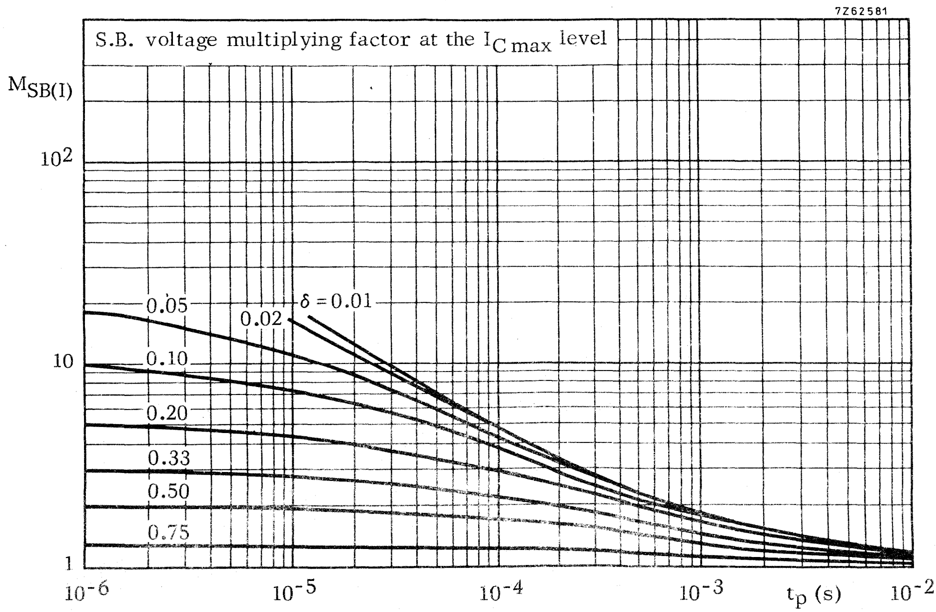
Safe Operating ARea with the transistor forward biased

I Region of permissible d.c. operation

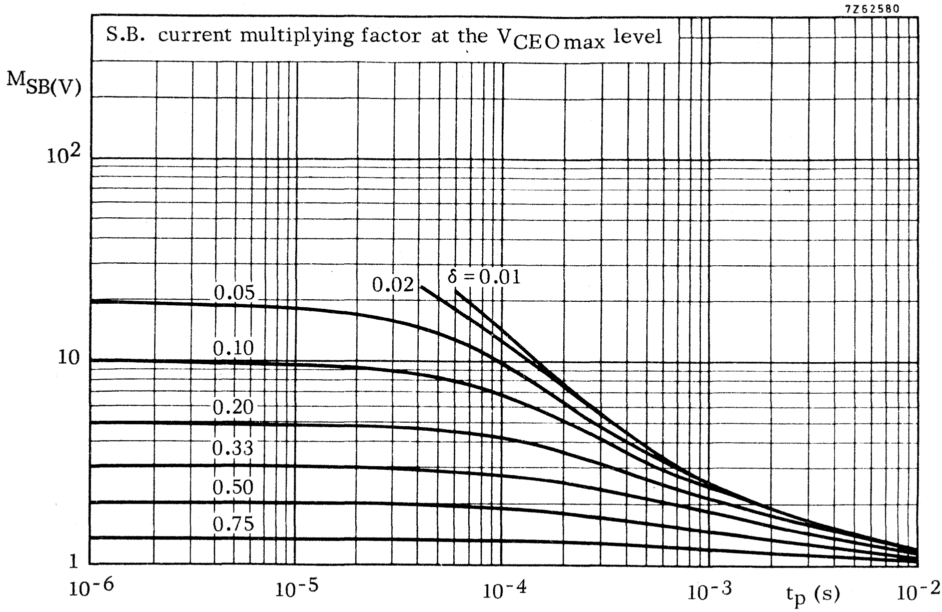
II Permissible extension for repetitive pulse operation

1) Independent of temperature.

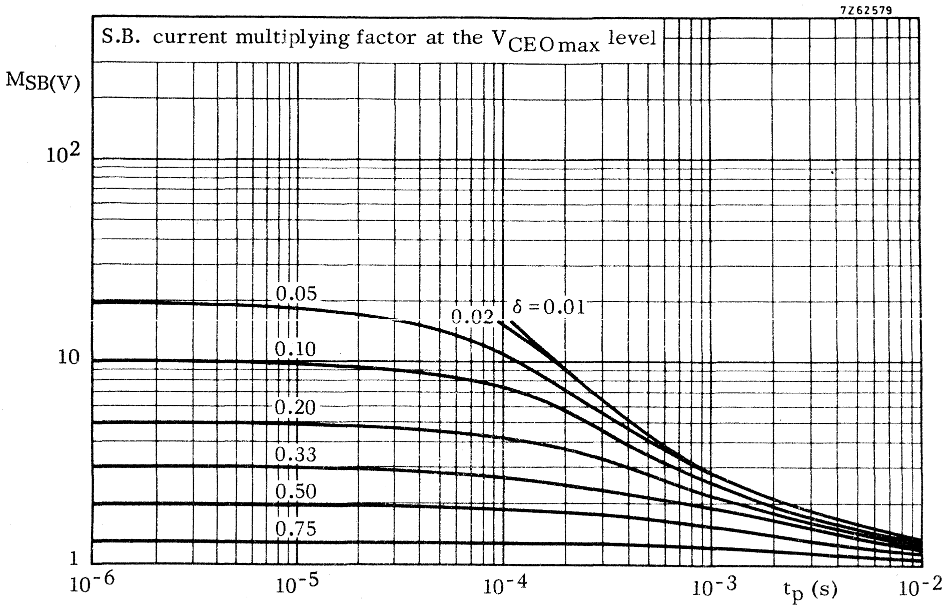

7Z62659
$Z_{th\ j\text{-}mb}$ (°C/W)
10
1
10^{-1}
10^{-2}
10^{-3}
δ = 1
0.75
0.50
0.33
0.20
0.10
0.05
0.02
0.01
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
t_p (s)
1
t_p
T
$\delta = \frac{t_p}{T}$

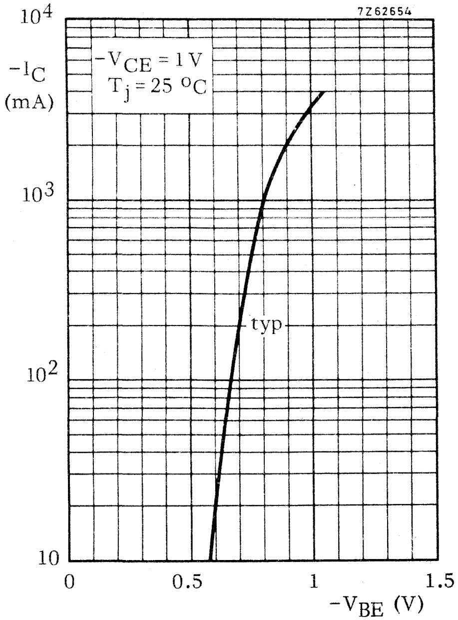

7Z62581
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
0.05
0.02
δ = 0.01
0.10
0.20
0.33
0.50
0.75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

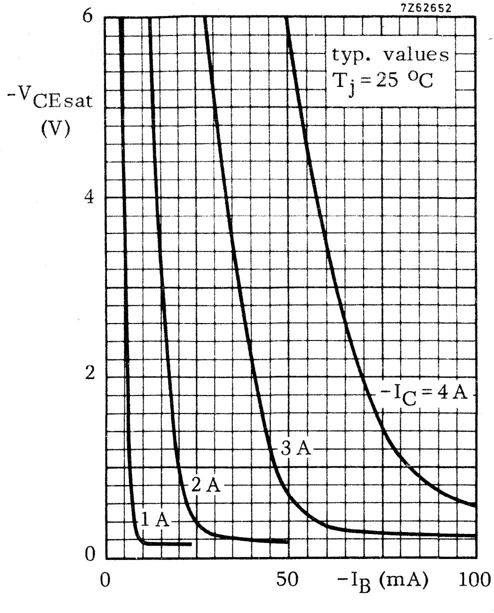
BD434; BD436

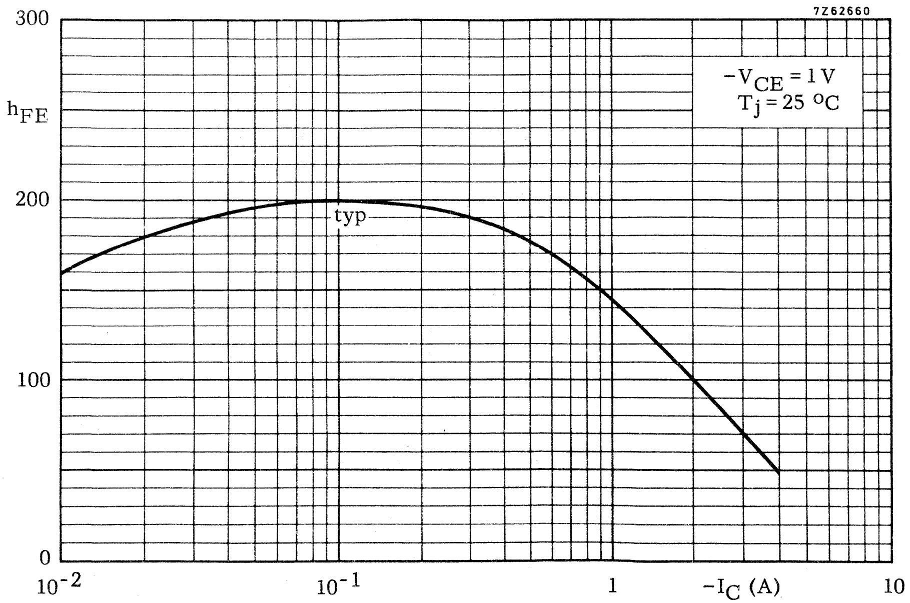


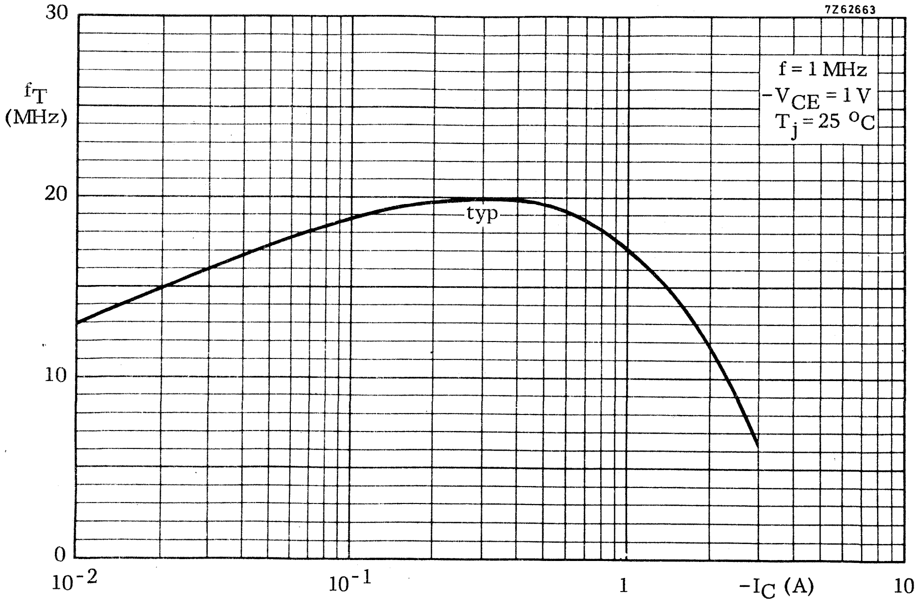
BD438

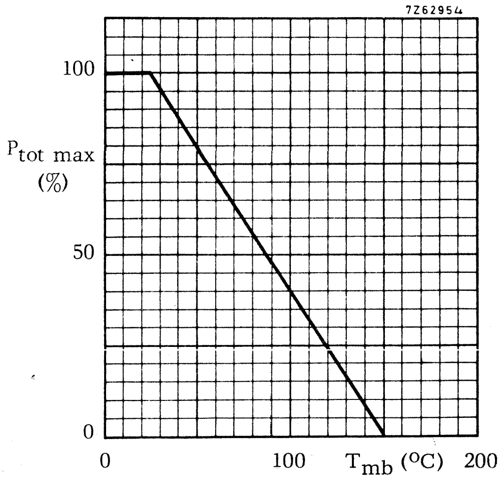



7Z62654
10^4
$-I_C$ (mA)
$-V_{CE} = 1$ V
$T_j = 25$ °C
10^3
typ
10^2
10
0
0.5
1
1.5
$-V_{BE}$ (V)


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 DARLINGTON POWER TRANSISTORS

N-P-N epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; TO-220 plastic envelope. P-N-P complements are BD646, BD648 and BD650. Matched complementary pairs can be supplied.

QUICK REFERENCE DATA

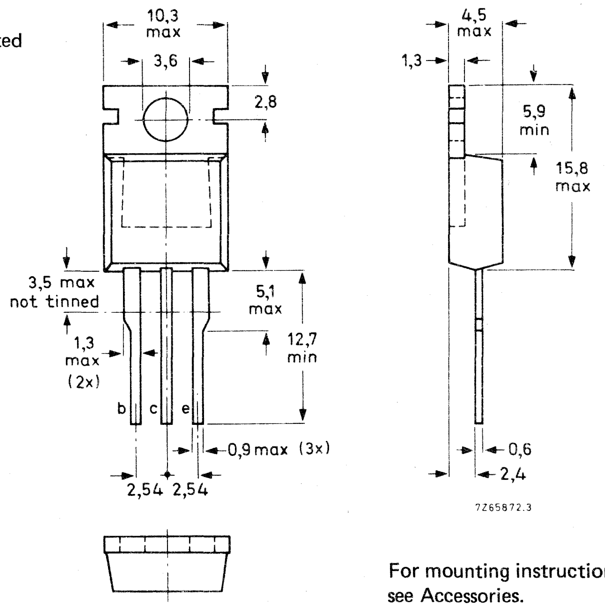
			BD645	BD647	BD649	
Collector-base voltage (open emitter)	V_{CBO}	max	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max	60	80	100	V
Collector current (peak value)	I_{CM}	max		12		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max		62,5		W
Junction temperature	T_j	max		150		°C
D.C. current gain:						
I_C = 0,5 A; V_{CE} = 3 V	h_{FE}	typ		1500		
I_C = 3,0 A; V_{CE} = 3 V	h_{FE}	>		750		
Cut-off frequency: I_C = 3 A; V_{CE} = 3 V	f_{hfe}	typ		50		kHz

MECHANICAL DATA

Dimensions in mm

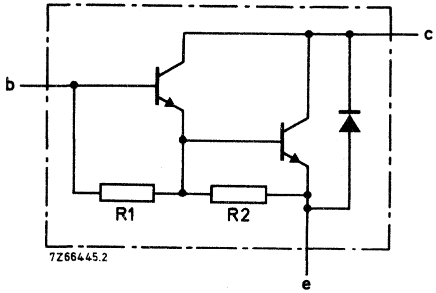
TO-220

Collector connected to mounting base



For mounting instructions and accessories see Accessories.

CIRCUIT DIAGRAM



R_1 typ 4 kΩ ←
R_2 typ 100 Ω

RATINGS

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

Voltages			BD645	BD647	BD649	
Collector-base voltage (open emitter)	V_{CBO}	max	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max	60	80	100	V
Emitter-base voltage (open collector)	V_{EBO}	max	5	5	5	V

Currents				
Collector current (d.c.)	I_C	max	8	A
Collector current (peak value)	I_{CM}	max	12	A
Base current (d.c.)	I_B	max	150	mA
Power dissipation				
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max	62,5	W
Temperatures				
Storage temperature	T_{stg}		−65 to +150	°C
Junction temperature *	T_j	max	150	°C

THERMAL RESISTANCE *

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2	°C/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	°C/W

→ * Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current			
$I_E = 0$; $V_{CBO} = 60$ V: BD645 $I_E = 0$; $V_{CBO} = 80$ V: BD647 $I_E = 0$; $V_{CBO} = 100$ V; BD649	I_{CBO}	<	0,2 mA
$I_E = 0$; $V_{CB} = 40$ V; $T_j = 150\ ^oC$: BD645 $I_E = 0$; $V_{CB} = 50$ V; $T_j = 150\ ^oC$: BD647 $I_E = 0$; $V_{CB} = 60$ V; $T_j = 150\ ^oC$: BD649	I_{CBO}	<	2 mA
$I_B = 0$; $V_{CE} = 30$ V: BD645 $I_B = 0$; $V_{CE} = 40$ V: BD647 $I_B = 0$; $V_{CE} = 50$ V: BD649	I_{CEO}	<	0,5 mA
Emitter cut-off current			
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	5 mA
D.C. current gain (Note 1)			
$I_C = 0{,}5$ A; $V_{CE} = 3$ V	h_{FE}	typ	1500
$I_C = 3$ A; $V_{CE} = 3$ V	h_{FE}	>	750
$I_C = 8$ A; $V_{CE} = 3$ V	h_{FE}	typ	500 ←
Base-emitter voltage (Notes 1 and 2)			
$I_C = 3$ A; $V_{CE} = 3$ V	V_{BE}	<	2,5 V
Collector-emitter saturation voltage (Note 1)			
$I_C = 3$ A; $I_B = 12$ mA	V_{CEsat}	<	2 V
Collector capacitance at f = 1 MHz			
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ	75 pF ←
Cut-off frequency			
$I_C = 3$ A; $V_{CE} = 3$ V	f_{hfe}	typ	50 kHz ←
Turn-off breakdown energy with inductive load			
$-I_{Boff} = 0$; $I_{CM} = 4{,}5$ A; $t_p = 1$ ms; T = 100 ms; see circuit on page 4	$E_{(BR)}$	>	50 mJ

Notes
1. Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.
2. V_{BE} decreases by about 3,6 mV/^oC with increasing temperature.

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

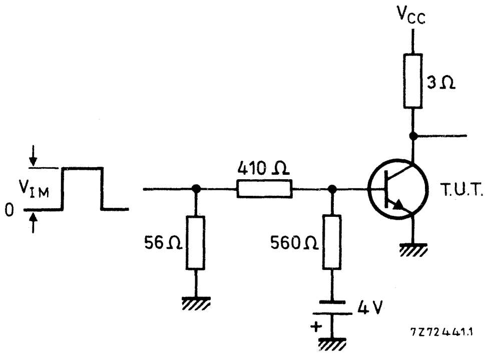
Switching times (between 10% and 90% levels)

I_{Con} = 3 A; I_{Bon} = $-I_{Boff}$ = 12 mA; V_{CC} = 10 V

Turn-on time	t_{on}	typ	0,5 μs
Turn-off time	t_{off}	typ	2,5 μs

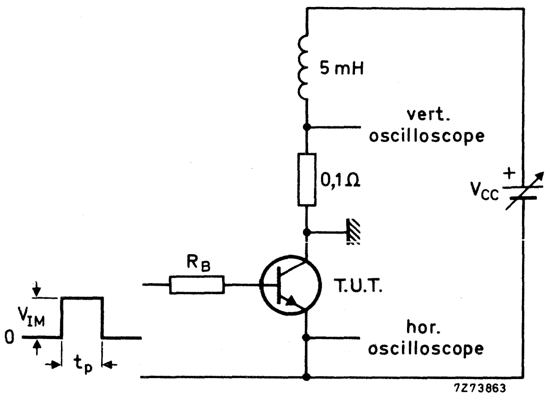
Test circuit

V_{IM} = 10 V
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

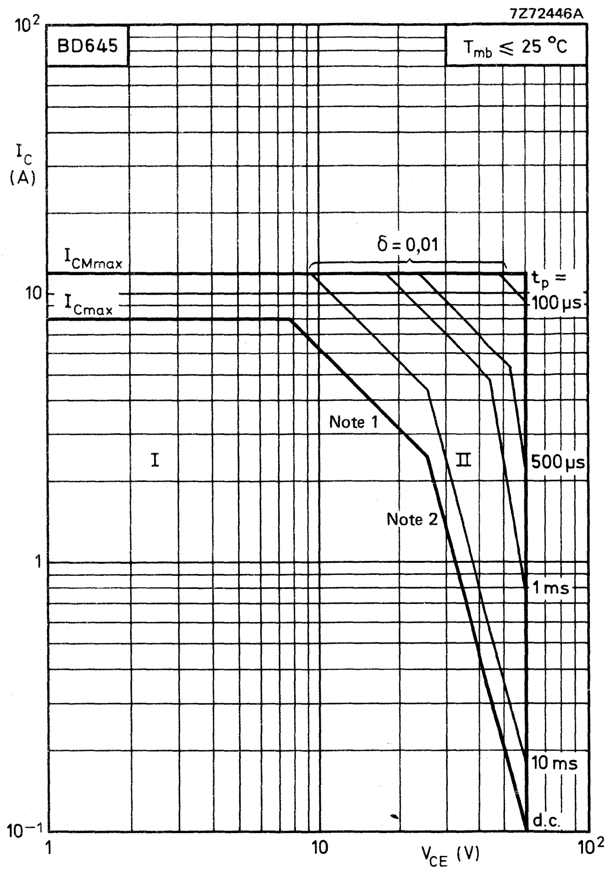


Diode, forward voltage

I_F = 3 A	V_F	typ	1,2 V



Test circuit for turn-off breakdown energy (page 3)
V_{IM} = 12 V; R_B = 270 Ω.



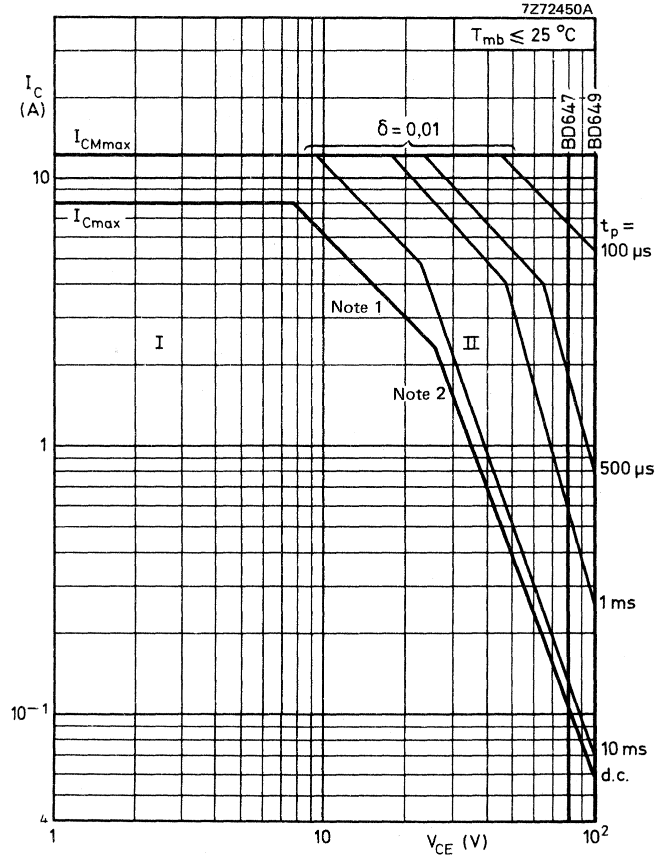
Safe Operating ARea.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

Notes

1. $P_{tot\ max}$ and $P_{peak\ max}$ lines.
2. Second-breakdown limits (independent of temperature).



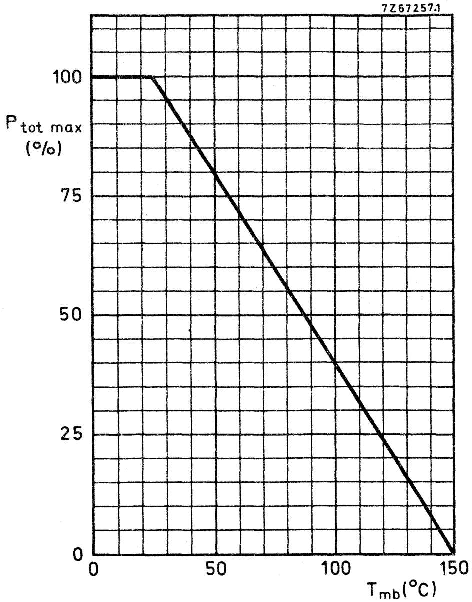
Safe Operating ARea.

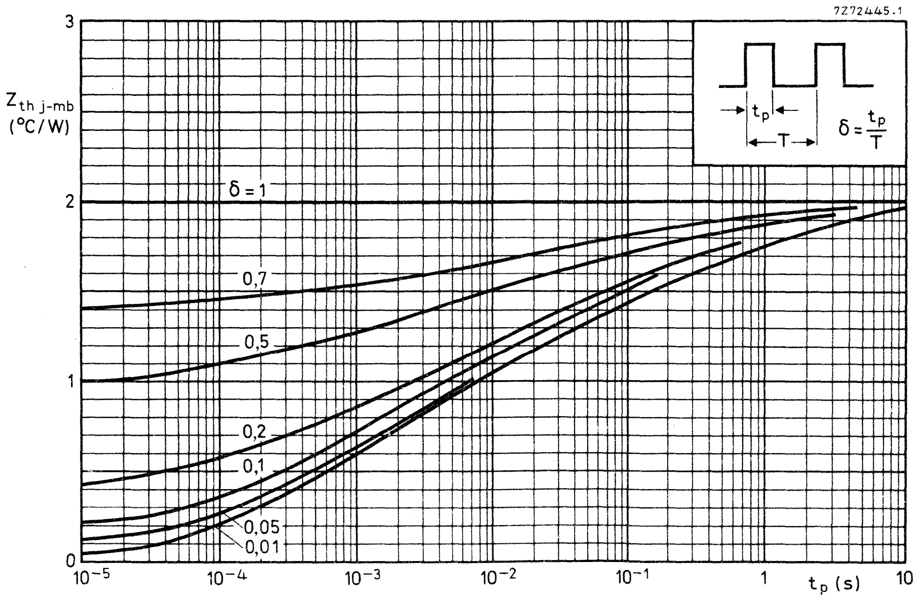
I Region of permissible d.c. operation.

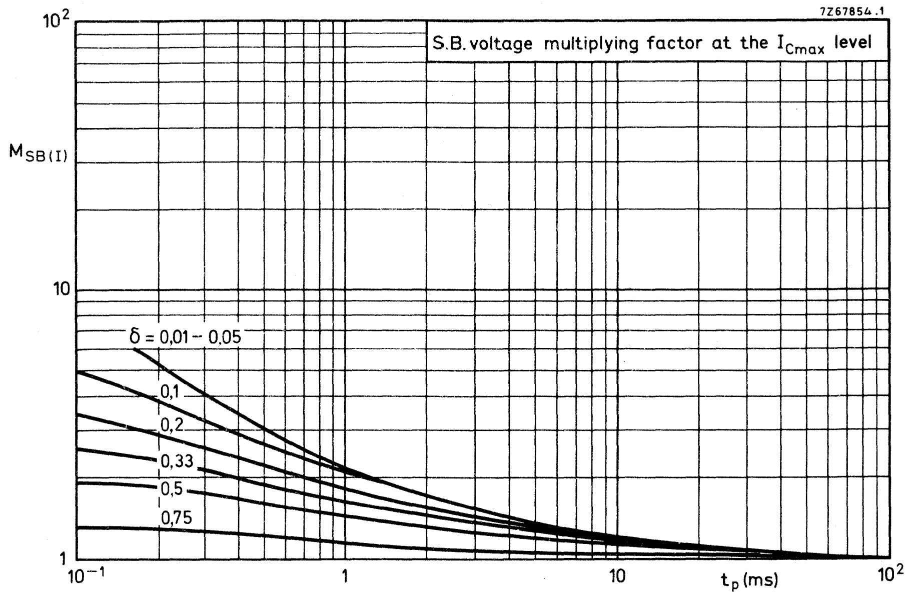
II Permissible extension for repetitive pulse operation.

Notes

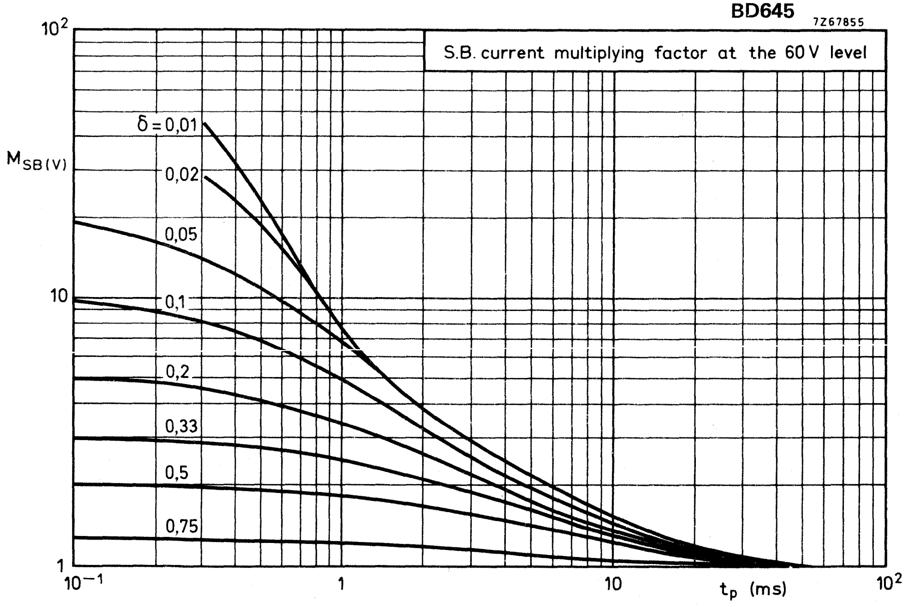
1. $P_{tot\ max}$ and P_{peak} lines.
2. Second-breakdown limits (independent of temperature).


7Z67257.1
P tot max (%)
100
75
50
25
0
0
50
100
150
Tmb(°C)

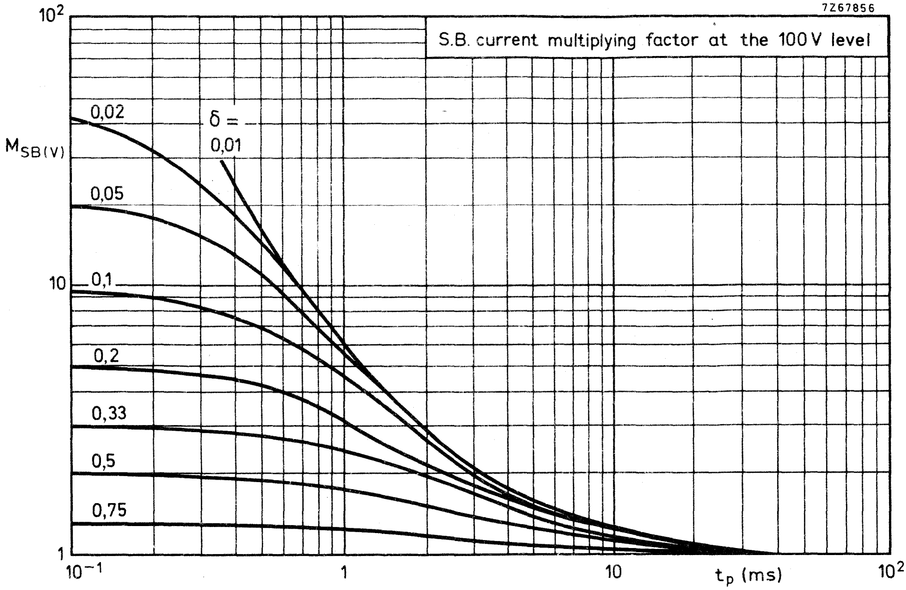

7Z72445.1
Zth j-mb (°C/W)
3
2
1
0
δ = 1
0,7
0,5
0,2
0,1
0,05
0,01
tp
T
δ = tp/T
10−5
10−4
10−3
10−2
10−1
1
tp (s)
10

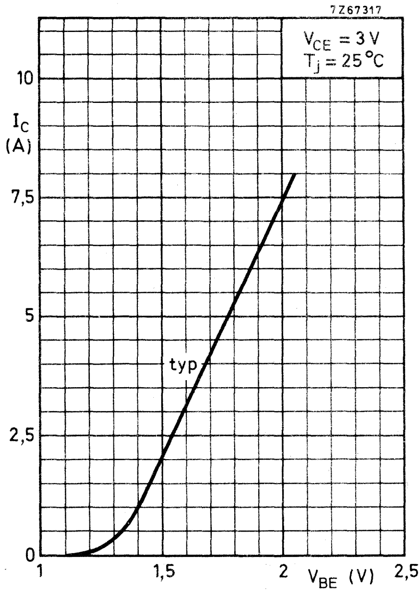

7Z67854.1
S.B. voltage multiplying factor at the I_{Cmax} level
$M_{SB(I)}$
10^2
10
1
δ = 0,01 – 0,05
0,1
0,2
0,33
0,5
0,75
10^{-1}
1
10
t_p (ms)
10^2

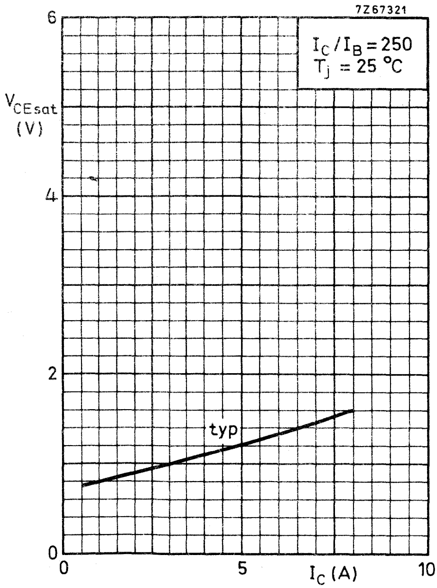
BD645

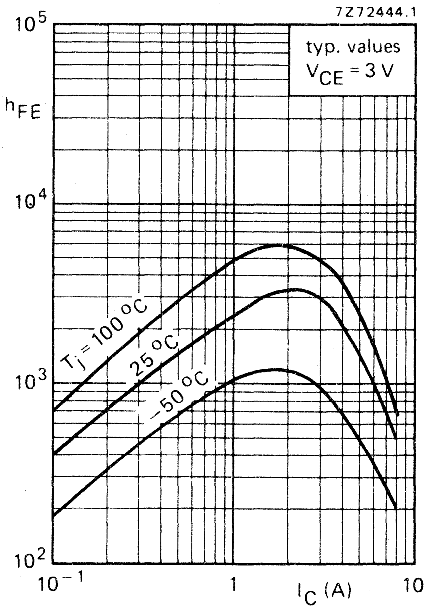

7Z67855
S.B. current multiplying factor at the 60 V level
$M_{SB(V)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-1}
1
10
t_p (ms)
10^2

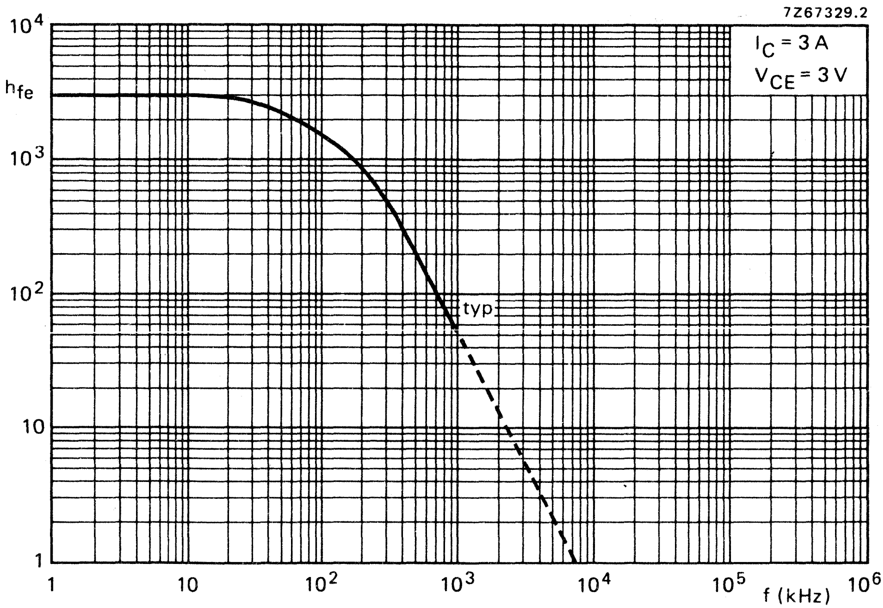
BD647; BD649


7Z67856
S.B. current multiplying factor at the 100 V 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^{-1}
1
10
10^2
t_p (ms)


7Z67317
V_{CE} = 3 V
T_j = 25 °C
I_C
(A)
10
7,5
5
2,5
0
typ
1
1,5
2
2,5
V_{BE} (V)


7Z67321
I_C/I_B = 250
T_j = 25 °C
V_{CEsat}
(V)
6
4
2
0
typ
0
5
10
I_C (A)


7Z72444.1
typ. values
V_{CE} = 3 V
h_{FE}
10^5
10^4
10^3
10^2
T_j = 100 °C
25 °C
−50 °C
10^{-1}
1
10
I_C (A)


7Z67329.2
I_C = 3 A
V_{CE} = 3 V
h_{fe}
10^4
10^3
10^2
10
1
typ
1
10
10^2
10^3
10^4
10^5
10^6
f (kHz)

SILICON DARLINGTON POWER TRANSISTORS

P-N-P epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; TO-220 plastic envelope. N-P-N complements are BD645, BD647 and BD649. Matched complementary pairs can be supplied.

QUICK REFERENCE DATA

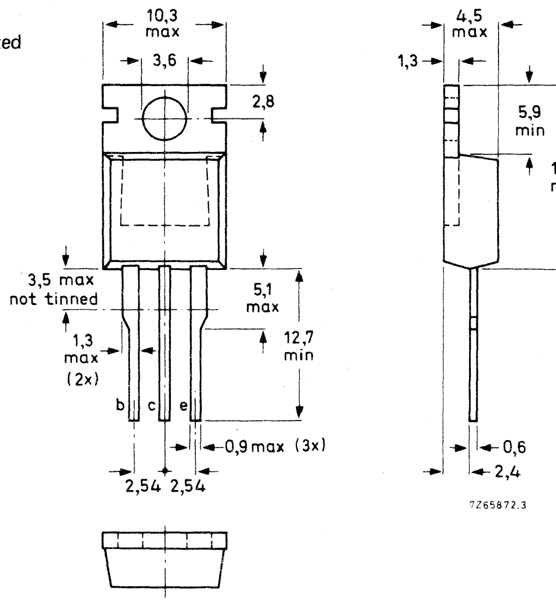
			BD646	BD648	BD650	
Collector-base voltage (open emitter)	$-V_{CBO}$	max	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max	60	80	100	V
Collector current (peak value)	$-I_{CM}$	max		12		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max		62,5		W
Junction temperature	T_j	max		150		°C
D.C. current gain:						
$-I_C$ = 0,5 A; $-V_{CE}$ = 3 V	h_{FE}	typ		1500		
$-I_C$ = 3,0 A; $-V_{CE}$ = 3 V	h_{FE}	>		750		
Cut-off frequency:						
$-I_C$ = 3 A; $-V_{CE}$ = 3 V	f_{hfe}	typ		100		kHz

MECHANICAL DATA

Dimensions in mm

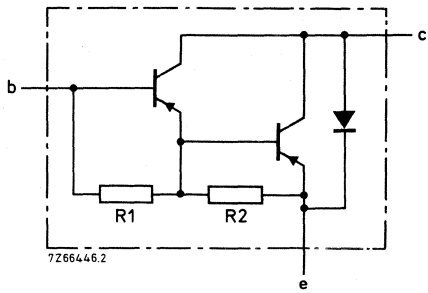
TO-220

Collector connected to mounting base



For mounting instructions and accessories see Accessories.

CIRCUIT DIAGRAM



R_1 typ 4 kΩ
R_2 typ 80 Ω

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

			BD646	BD648	BD650	
Voltages						
Collector-base voltage (open emitter)	$-V_{CBO}$	max	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max	60	80	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max	5	5	5	V
Currents						
Collector current (d.c.)	$-I_C$	max		8		A
Collector current (peak value)	$-I_{CM}$	max		12		A
Base current (d.c.)	$-I_B$	max		150		mA
Power dissipation						
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max		62,5		W
Temperatures						
Storage temperature	T_{stg}			−65 to +150		°C
Junction temperature*	T_j			150		°C

THERMAL RESISTANCE*

From junction to mounting base	$R_{th\,j\text{-}mb}$	=	2	°C/W
From junction to ambient in free air	$R_{th\,j\text{-}a}$	=	70	°C/W

* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current			
$I_E = 0; -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	0,2 mA
$I_E = 0; -V_{CB} = 40\ V; T_j = 150\ ^oC$: BD646 $I_E = 0; -V_{CB} = 50\ V; T_j = 150\ ^oC$: BD648 $I_E = 0; -V_{CB} = 60\ V; T_j = 150\ ^oC$: BD650	$-I_{CBO}$	<	2 mA
$I_B = 0; -V_{CE} = 30\ V$: BD646 $I_B = 0; -V_{CE} = 40\ V$: BD648 $I_B = 0; -V_{CE} = 50\ V$: BD650	$-I_{CEO}$	<	0,5 mA
Emitter cut-off current			
$I_C = 0; -V_{EB} = 5\ V$	$-I_{EBO}$	<	5 mA
D.C. current gain (Note 1)			
$-I_C = 0,5\ A; -V_{CE} = 3\ V$	h_{FE}	typ	1500
$-I_C = 3\ A; -V_{CE} = 3\ V$	h_{FE}	>	750
$-I_C = 8\ A; -V_{CE} = 3\ V$	h_{FE}	typ	500 ←
Base-emitter voltage (Notes 1 and 2)			
$-I_C = 3\ A; -V_{CE} = 3\ V$	$-V_{BE}$	<	2,5 V
Collector-emitter saturation voltage (Note 1)			
$-I_C = 3\ A; -I_B = 12\ mA$	$-V_{CEsat}$	<	2 V
Collector capacitance at f = 1 MHz			
$I_E = I_e = 0; -V_{CB} = 10\ V$	C_c	typ	75 pF ←
Cut-off frequency			
$-I_C = 3\ A; -V_{CE} = 3\ V$	f_{hfe}	typ	100 kHz

Notes
1. Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.
2. $-V_{BE}$ decreases by about 3,6 mV/^{o}C with increasing temperature.

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

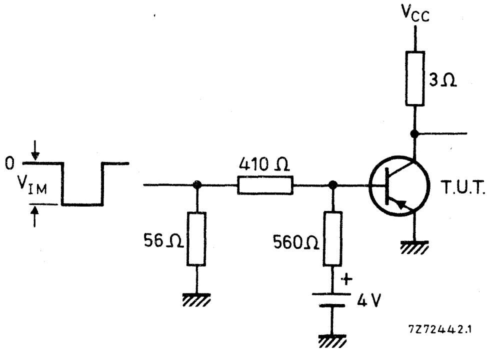
Switching times (between 10% and 90% levels)

$-I_{Con}$ = 3 A; $-I_{Bon}$ = I_{Boff} = 12 mA; V_{CC} = −10 V

→ Turn-on time	t_{on}	typ	0,2 μs
→ Turn-off time	t_{off}	typ	1,5 μs

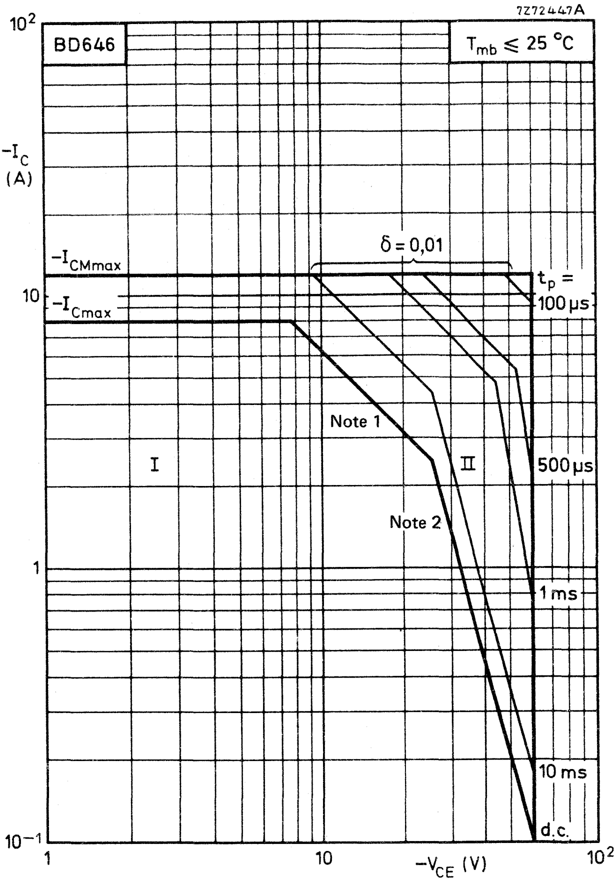
Test circuit

V_{IM} = 10 V
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs



Diode, forward voltage

I_F = 3 A	V_F	typ	1,8 V



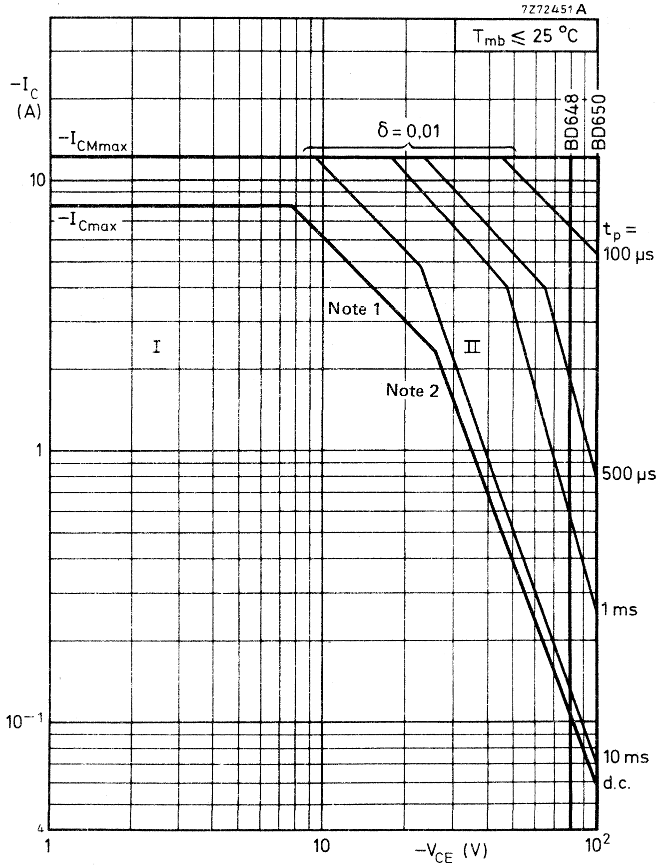
Safe Operating ARea.

I Region of permissible d.c. operation.

II Permissible extension for repetitive pulse operation.

Notes

1. $P_{tot\ max}$ and $P_{peak\ max}$ lines.
2. Second-breakdown limits (independent of temperature).



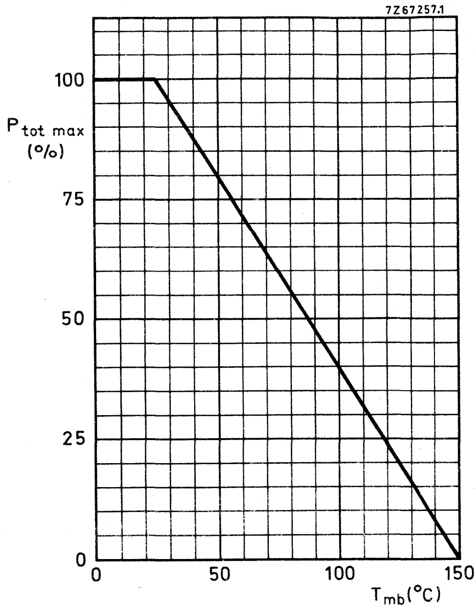
Safe Operating ARea.

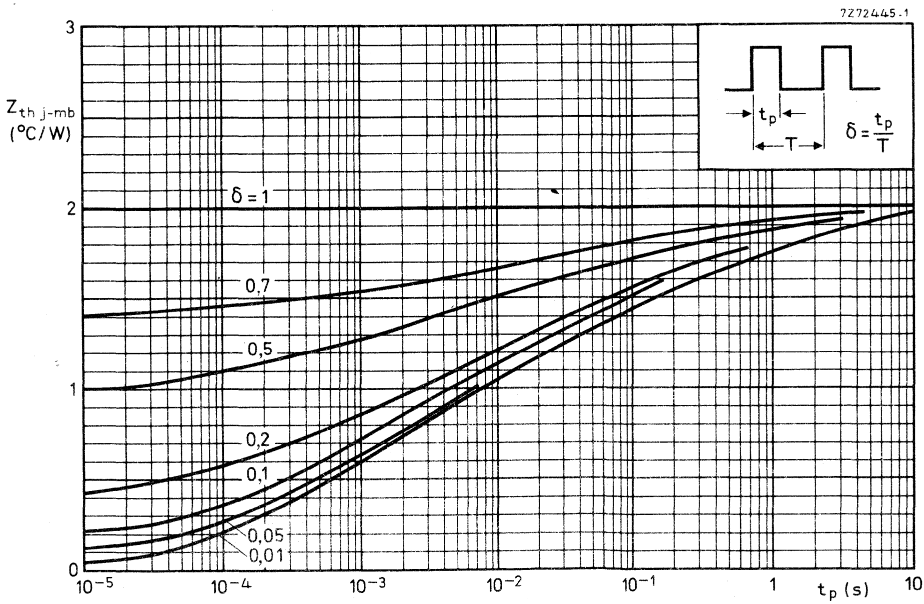
I Region of permissible d.c. operation.

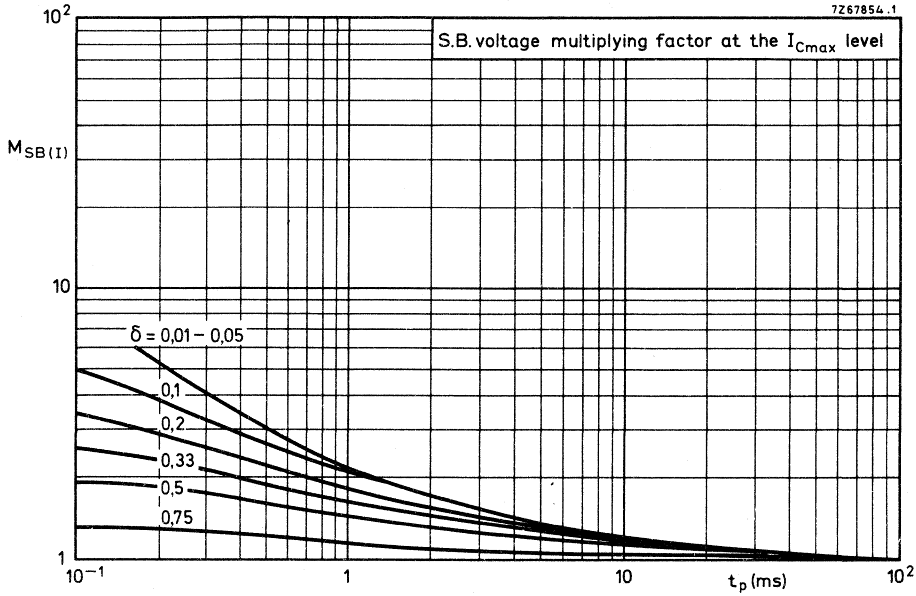
II Permissible extension for repetitive pulse operation.

Notes

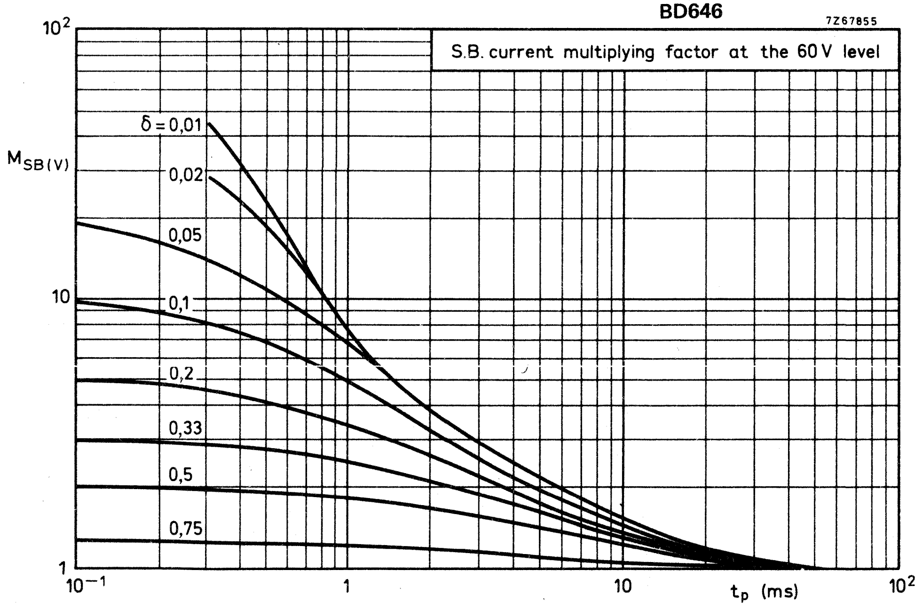
1. $P_{tot\ max}$ and $P_{peak\ max}$ lines.
2. Second-breakdown limits (independent of temperature).


7Z67257.1
100
P tot max
(%)
75
50
25
0
0
50
100
150
T mb (°C)

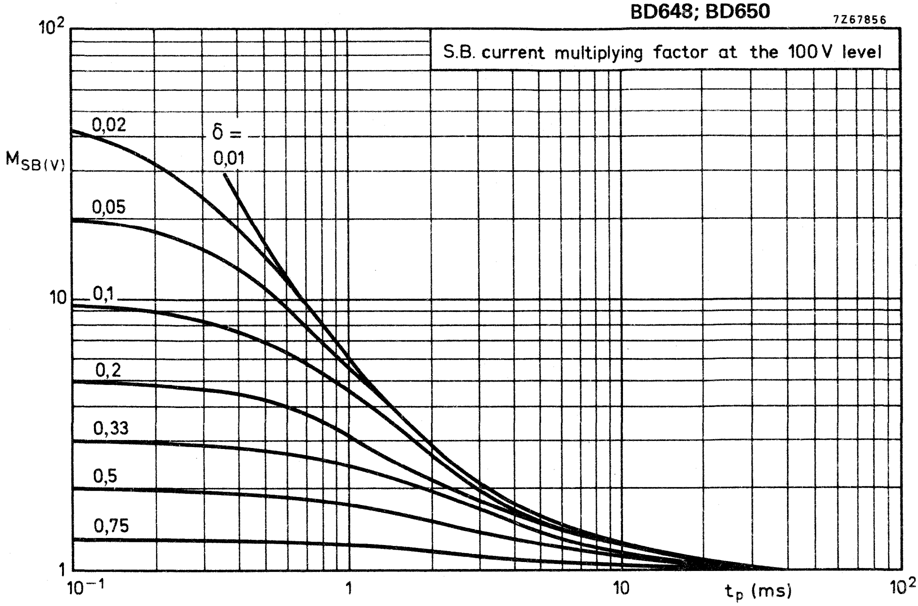

7Z72445.1
3
Z th j-mb
(°C/W)
2
1
0
δ = 1
0,7
0,5
0,2
0,1
0,05
0,01
t p
T
δ = t p / T
10^−5
10^−4
10^−3
10^−2
10^−1
1
t p (s)
10

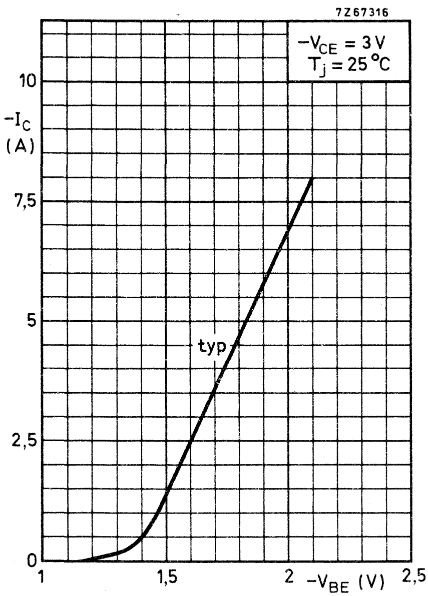

7Z67854.1
S.B. voltage multiplying factor at the I_{Cmax} level
10^2
$M_{SB(I)}$
10
1
δ = 0,01 – 0,05
0,1
0,2
0,33
0,5
0,75
10^{-1}
1
10
t_p (ms)
10^2

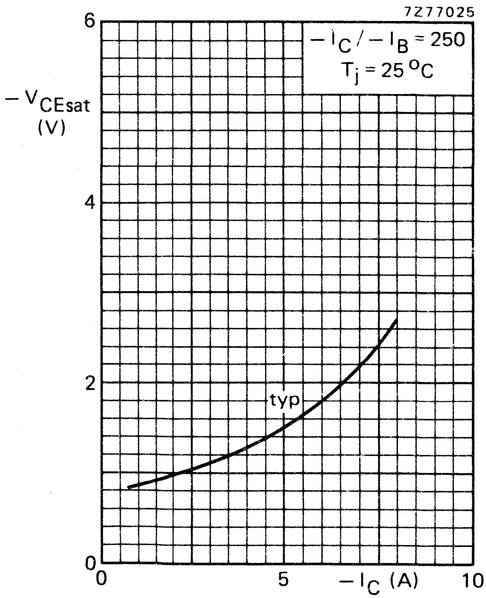
BD646

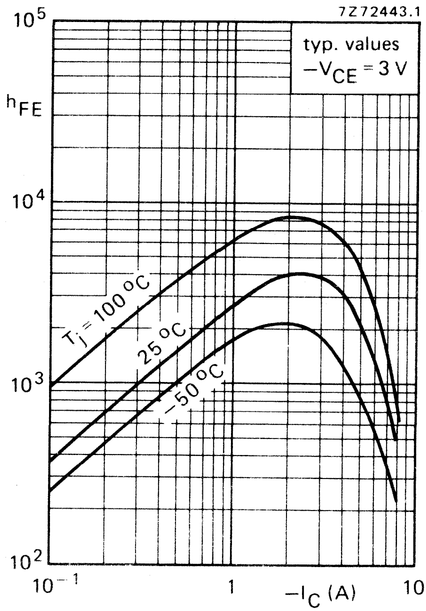

7Z67855
S.B. current multiplying factor at the 60 V level
10^2
$M_{SB(V)}$
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-1}
1
10
t_p (ms)
10^2

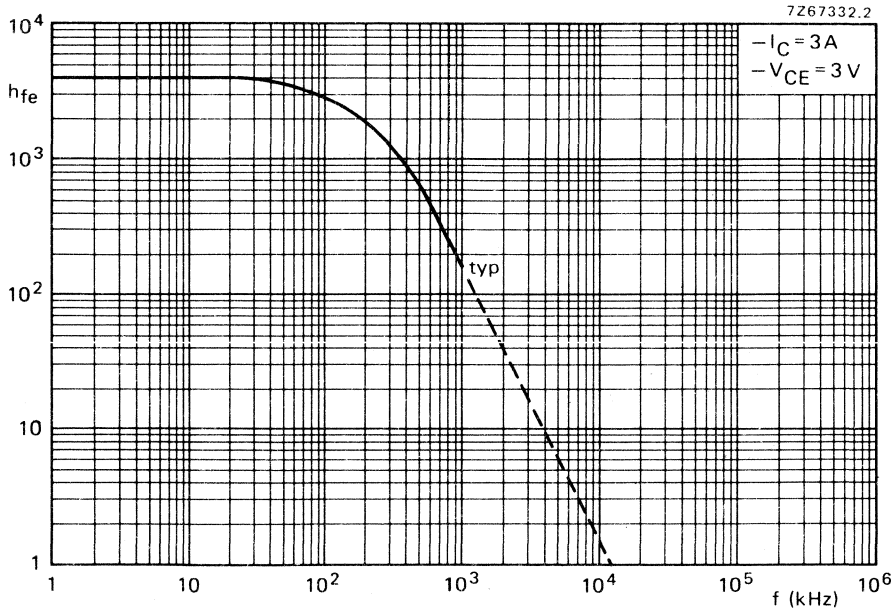
BD648; BD650


7Z67856
S.B. current multiplying factor at the 100 V level
10^2
$M_{SB(V)}$
10
1
δ =
0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-1}
1
10
t_p (ms)
10^2


7Z67316
$-V_{CE}$ = 3 V
T_j = 25 °C
$-I_C$
(A)
10
7,5
5
2,5
0
typ
1
1,5
2
$-V_{BE}$ (V)
2,5


7Z77025
$-I_C/-I_B$ = 250
T_j = 25 °C
$-V_{CEsat}$
(V)
6
4
2
0
typ
0
5
$-I_C$ (A)
10


7Z72443.1
typ. values
$-V_{CE} = 3$ V
h_{FE}
10^5
10^4
10^3
10^2
$T_j = 100\ ^oC$
$25\ ^oC$
$-50\ ^oC$
10^{-1}
1
$-I_C$ (A)
10


7Z67332.2
$-I_C = 3$ A
$-V_{CE} = 3$ V
h_{fe}
10^4
10^3
10^2
10
1
typ
1
10
10^2
10^3
10^4
10^5
10^6
f (kHz)

SILICON DARLINGTON POWER TRANSISTORS

N-P-N epitaxial-base transistors in monolithic Darlington circuit for audio and video applications; SOT-32 plastic envelope. P-N-P complements are BD676, BD678, BD680 and BD682.

QUICK REFERENCE DATA

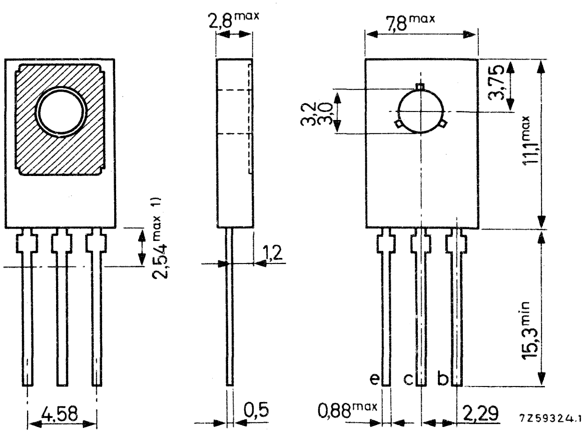
			BD675	BD677	BD679	BD681	
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	100	V
Collector current (peak value)	I_{CM}	max.	6				A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	40				W
Junction temperature	T_j	max.	150				°C
D.C. current gain I_C = 0,5 A; V_{CE} = 3 V	h_{FE}	typ.	1000				
I_C = 1,5 A; V_{CE} = 3 V	h_{FE}	>	750				
Transition frequency I_C = 1,5 A; V_{CE} = 3 V	f_T	>	1				MHz
		typ.	7				MHz

MECHANICAL DATA

Dimensions in mm

TO-126 (SOT-32)

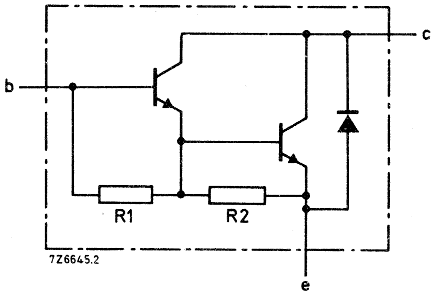
Collector connected to metal part of mounting surface



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

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

CIRCUIT DIAGRAM



R_1 typ. 30 kΩ
R_2 typ. 150 Ω

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

			BD675	BD677	BD679	BD681	
Voltages							
Collector-base voltage (open emitter)	V_{CBO}	max.	45	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	60	80	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	5	V

Currents				
Collector current (d.c.)	I_C	max.	4	A
Collector current (peak value)	I_{CM}	max.	6	A
Base current (d.c.)	I_B	max.	100	mA
Power dissipation				
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	40	W
Temperatures				
Storage temperature	T_{stg}		−65 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

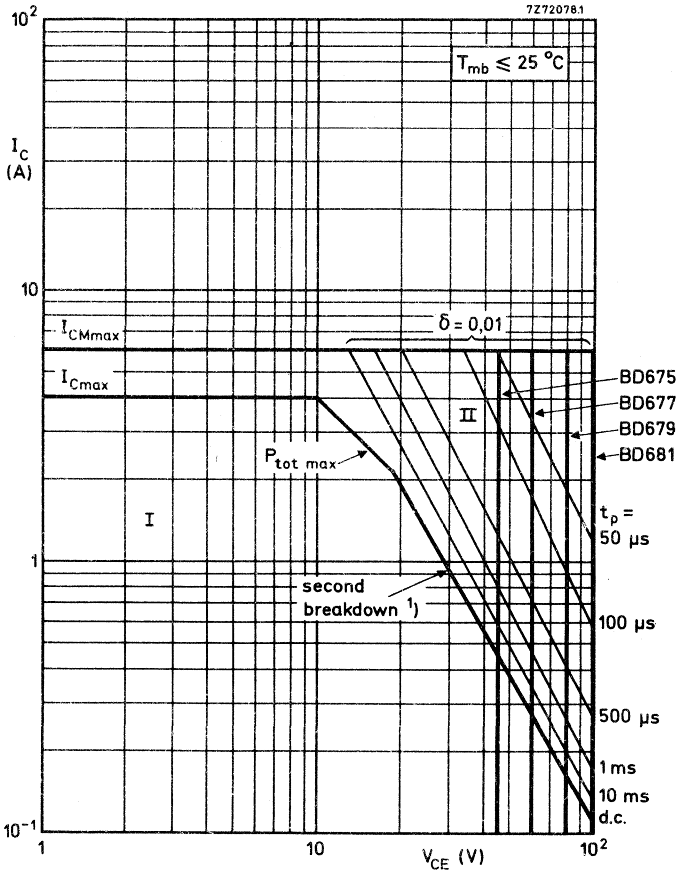
From junction to mounting base	$R_{th\ j-mb}$	=	3, 12	°C/W
From junction to ambient in free air	$R_{th\ j-a}$	=	100	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	0,2	mA
$I_E = 0$; $T_{mb} = 150$ °C [1]	I_{CBO}	<	2	mA
$I_B = 0$; $V_{CE} = 25$ V: BD675 $I_B = 0$; $V_{CE} = 30$ V: BD677 $I_B = 0$; $V_{CE} = 40$ V: BD679 $I_B = 0$; $V_{CE} = 50$ V: BD681	I_{CEO}	<	0,5	mA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	5	mA
D.C. current gain [2]				
$I_C = 0,5$ A; $V_{CE} = 3$ V	h_{FE}	typ.	1000	
$I_C = 1,5$ A; $V_{CE} = 3$ V	h_{FE}	>	750	
$I_C = 4$ A; $V_{CE} = 3$ V	h_{FE}	typ.	500	
Base-emitter voltage				
$I_C = 1,5$ A; $V_{CE} = 3$ V	V_{BE}	<	2,5	V
Collector-emitter saturation voltage				
$I_C = 1,5$ A; $I_B = 6$ mA	V_{CEsat}	<	2,5	V
Transition frequency				
$I_C = 1,5$ A; $V_{CE} = 3$ V	f_T	> typ.	1 7	MHz MHz

[1] And V_{CBO} = 30 V for BD675, 40 V for BD677, 50 V for BD679, 60 V for BD681.

[2] Measured under pulse conditions: $t_p < 300$ µs, $\delta < 2\%$.

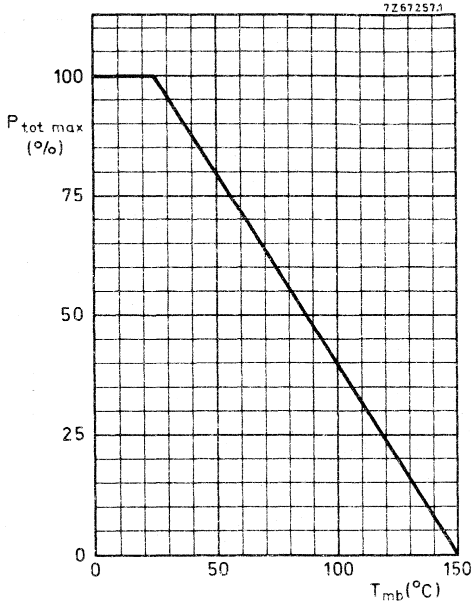


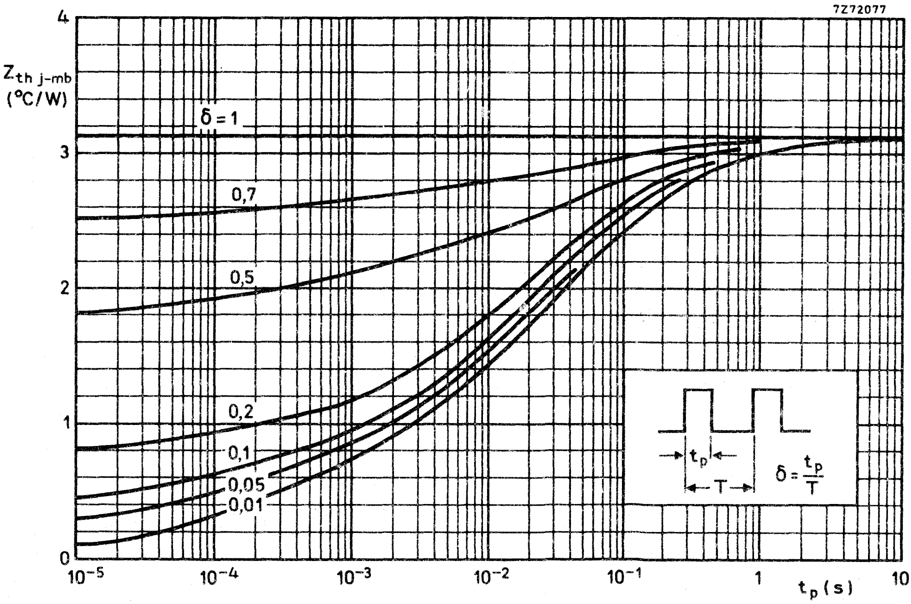
Safe Operating Area with the transistor forward biased

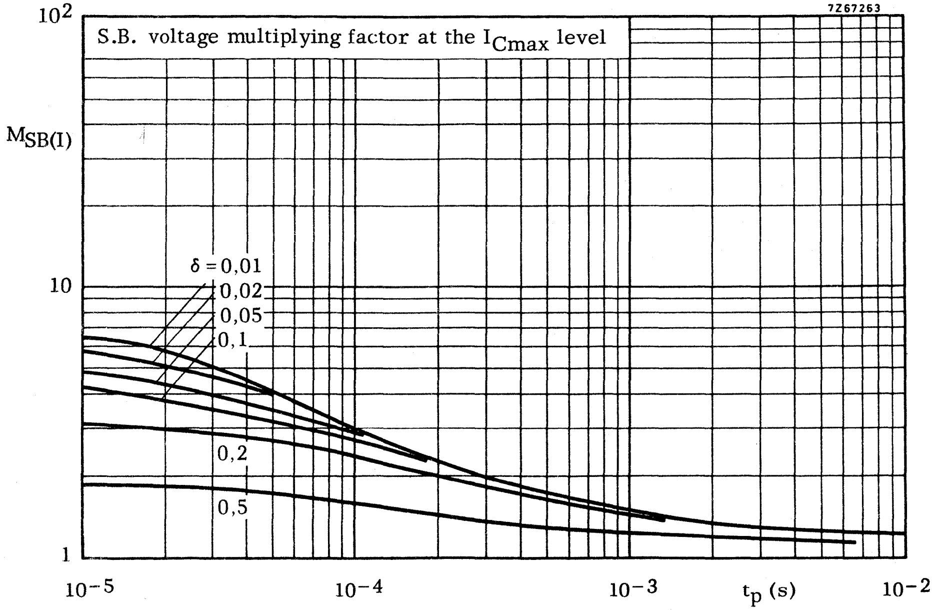
I Region of permissible d.c. operation

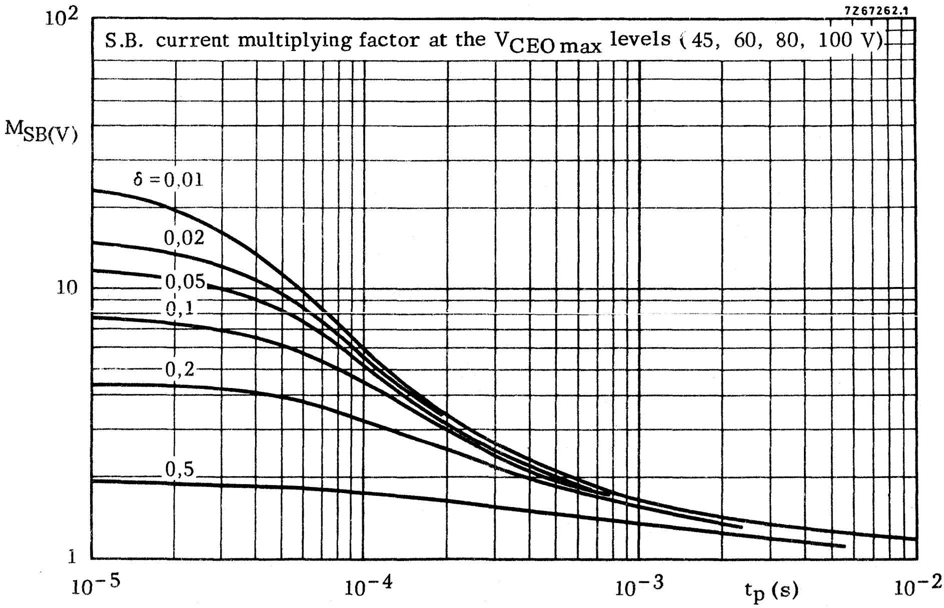
II Permissible extension for repetitive pulse operation

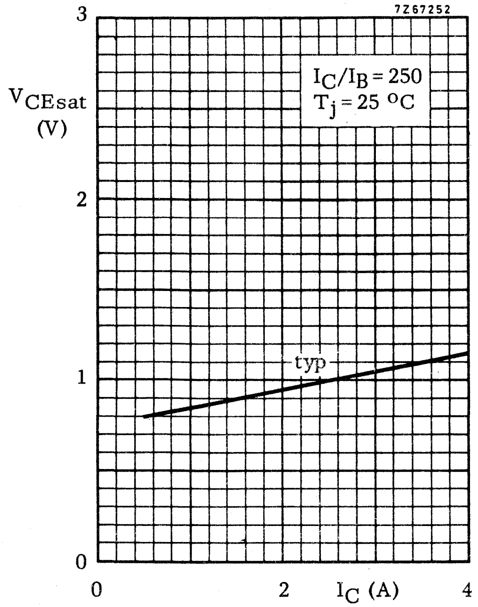
1) Independent of temperature

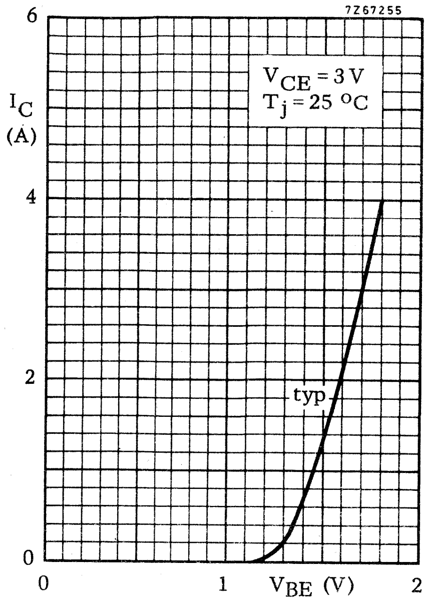

7Z67257.1
100
P tot max
(%)
75
50
25
0
0
50
100
150
Tmb(°C)

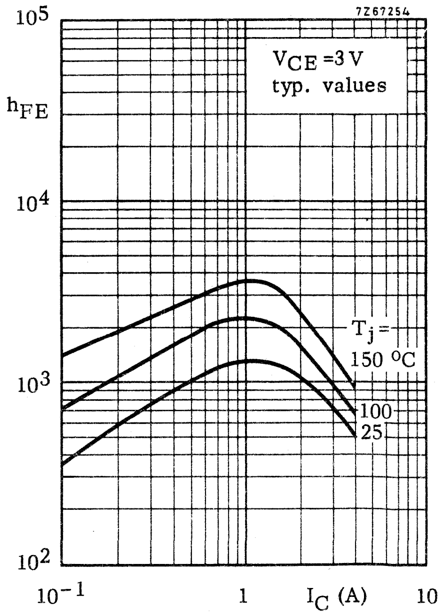

7Z72077
4
Zth j-mb
(°C/W)
δ = 1
3
0,7
0,5
2
0,2
1
0,1
0,05
0,01
0
10^-5
10^-4
10^-3
10^-2
10^-1
1
10
tp (s)
tp
T
δ = tp/T


7Z67263
S.B. voltage multiplying factor at the I$_{Cmax}$ 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}


7Z67262.1
S.B. current multiplying factor at the V$_{CEO max}$ levels (45, 60, 80, 100 V)
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}


7Z67252
$I_C/I_B = 250$
$T_j = 25$ °C
V_{CEsat} (V)
typ
I_C (A)
3
2
1
0
0
2
4


7Z67255
$V_{CE} = 3$ V
$T_j = 25$ °C
I_C (A)
typ
V_{BE} (V)
6
4
2
0
0
1
2


7Z67254
$V_{CE} = 3$ V
typ. values
h_{FE}
$T_j =$
150 °C
100
25
I_C (A)
10^5
10^4
10^3
10^2
10^{-1}
1
10

SILICON DARLINGTON POWER TRANSISTORS

P-N-P epitaxial-base transistors in monolithic Darlington circuit for audio and video applications; SOT-32 plastic envelope. N-P-N complements are BD675, BD677, BD679 and BD681.

QUICK REFERENCE DATA

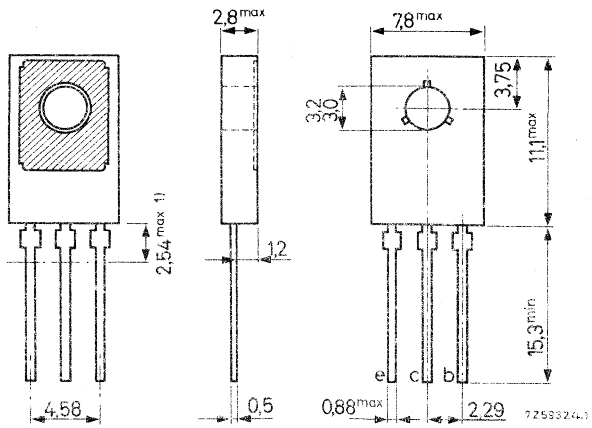
			BD676	BD678	BD680	BD682	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	100	V
Collector current (peak value)	$-I_{CM}$	max.		6			A
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.		40			W
Junction temperature	T_j	max.		150			^oC
D.C. current gain $-I_C = 0,5$ A $-V_{CE} = 3$ V	h_{FE}	typ.		1000			
$-I_C = 1,5$ A; $-V_{CE} = 3$ V	h_{FE}	>		750			
Transition frequency $-I_C = 1,5$ A; $-V_{CE} = 3$ V	f_T	>		1			MHz
		typ.		7			MHz

MECHANICAL DATA

Dimensions in mm

TO-126 (SOT-32)

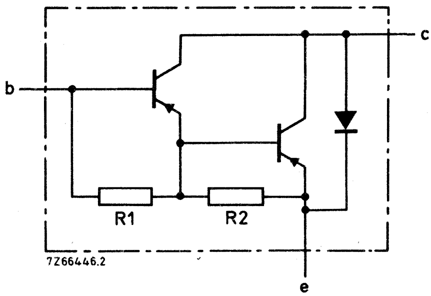
Collector connected to metal part of mounting surface



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

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

CIRCUIT DIAGRAM



R_1 typ. 30 kΩ
R_2 typ. 150 Ω

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

Voltages			BD676	BD678	BD680	BD682	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	45	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	45	60	80	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	5	V

Currents				
Collector current (d.c.)	$-I_C$	max.	4	A
Collector current (peak value)	$-I_{CM}$	max.	6	A
Base current (d.c.)	$-I_B$	max.	100	mA

Power dissipation				
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	40	W

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

THERMAL RESISTANCE

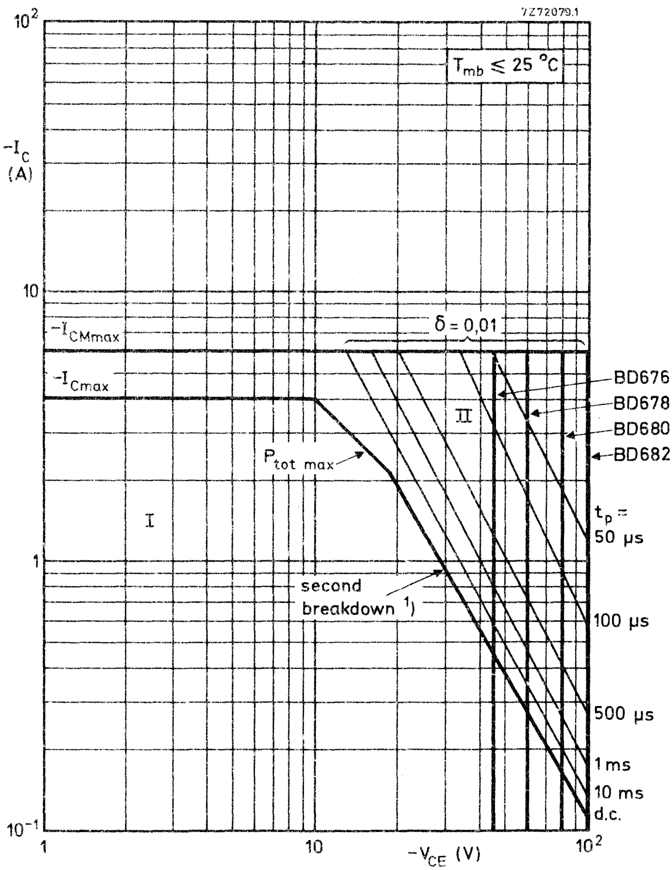
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	3, 12	°C/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $-V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	0,2	mA
$I_E = 0$; $T_{mb} = 150$ °C [1]	$-I_{CBO}$	<	2	mA
$I_B = 0$; $-V_{CE} = 25$ V: BD676 $I_B = 0$; $-V_{CE} = 30$ V: BD678 $I_B = 0$; $-V_{CE} = 40$ V: BD680 $I_B = 0$; $-V_{CE} = 50$ V: BD682	$-I_{CEO}$	<	0,5	mA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	5	mA
D.C. current gain [2]				
$-I_C = 0,5$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	1000	
$-I_C = 1,5$ A; $-V_{CE} = 3$ V	h_{FE}	>	750	
$-I_C = 4$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	500	
Base-emitter voltage				
$-I_C = 1,5$ A; $-V_{CE} = 3$ V	$-V_{BE}$	<	2,5	V
Collector-emitter saturation voltage				
$-I_C = 1,5$ A; $-I_B = 6$ mA	$-V_{CEsat}$	<	2,5	V
Transition frequency				
$-I_C = 1,5$ A; $-V_{CE} = 3$ V	f_T	> typ.	1 7	MHz MHz

[1] And $-V_{CBO}$ = 30 V for BD676, 40 V for BD678, 50 V for BD680, 60 V for BD682

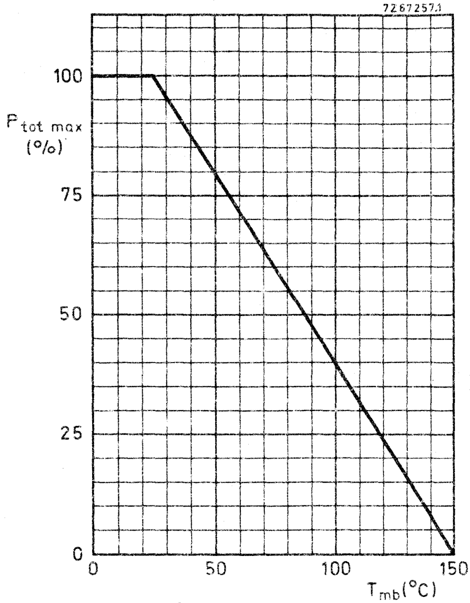
[2] Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$

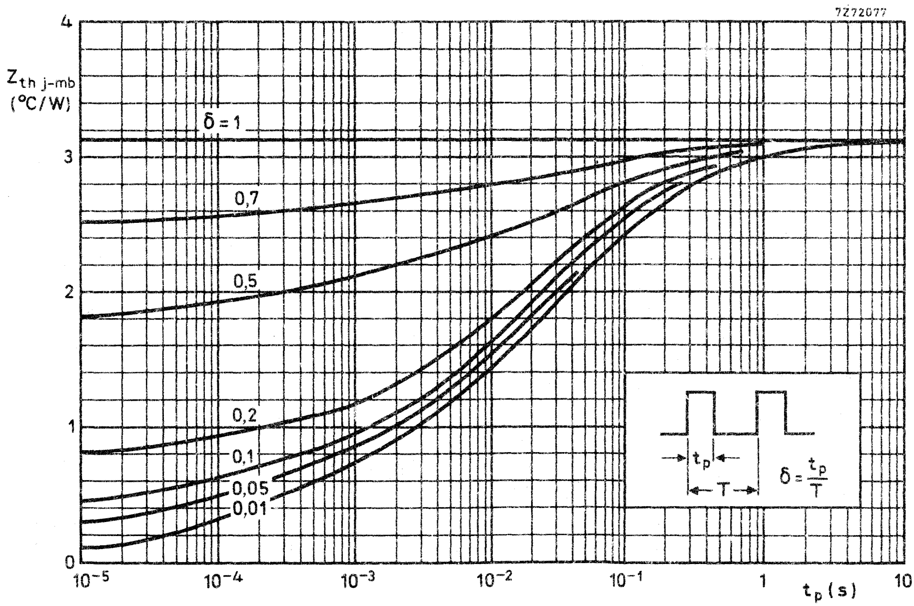


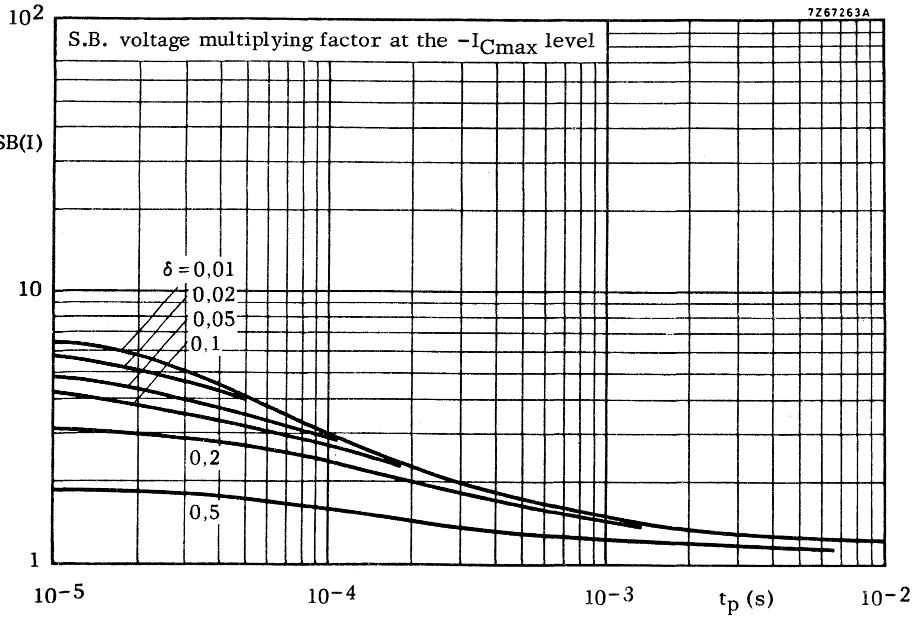
Safe Operating Area with the transistor forward biased

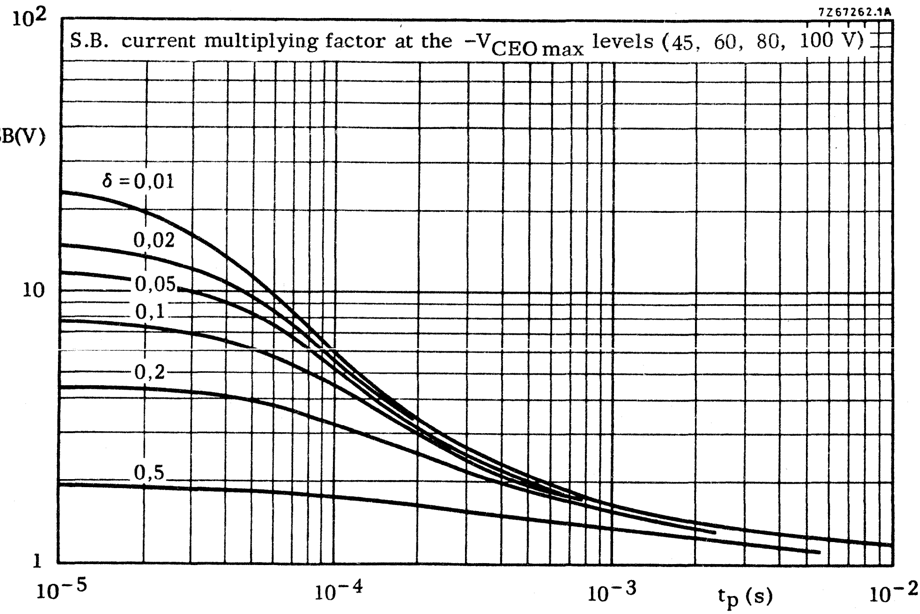
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation

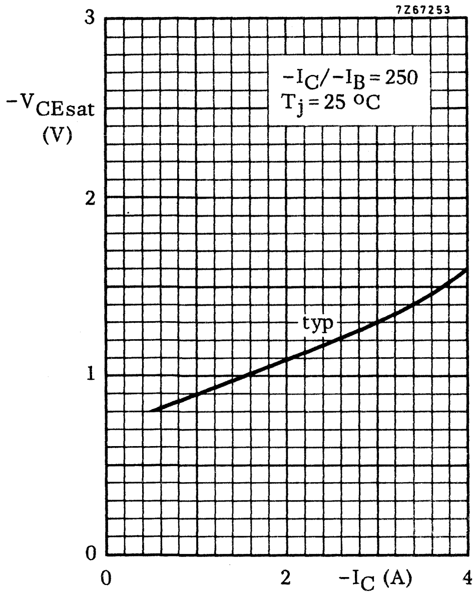
[1]) Independent of temperature

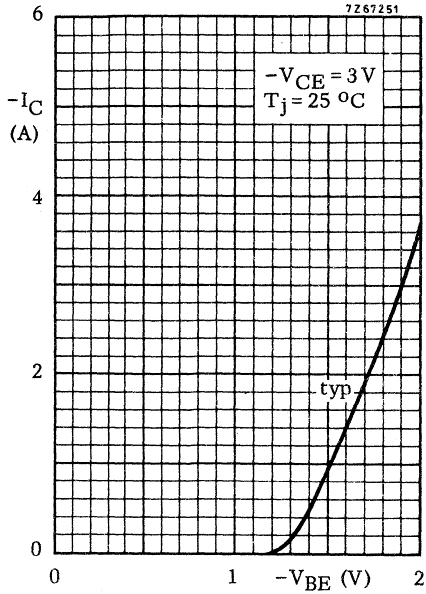

7Z67257.1
100
$P_{tot\ max}$
(%)
75
50
25
0
0
50
100
150
T_{mb}(°C)

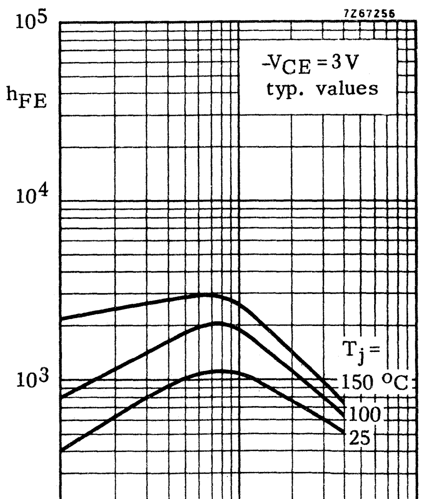

7Z72077
4
$Z_{th\ j\text{-}mb}$
(°C/W)
δ = 1
3
0,7
0,5
2
0,2
1
0,1
0,05
0,01
0
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t_p (s)
10
t_p
T
$\delta = \frac{t_p}{T}$


7Z67263A
S.B. voltage multiplying factor at the $-I_{Cmax}$ level
10^2
$M_{SB(I)}$
$\delta = 0,01$
0,02
0,05
0,1
0,2
0,5
10
1
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}


7Z67262.1A
S.B. current multiplying factor at the $-V_{CEO\,max}$ levels (45, 60, 80, 100 V)
10^2
$M_{SB(V)}$
$\delta = 0,01$
0,02
0,05
0,1
0,2
0,5
10
1
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}


7Z67253
$-I_C/-I_B = 250$
$T_j = 25$ °C
$-V_{CEsat}$ (V)
3
2
1
0
typ
0
2
$-I_C$ (A)
4


7Z67251
$-V_{CE} = 3$ V
$T_j = 25$ °C
$-I_C$ (A)
6
4
2
0
typ
0
1
$-V_{BE}$ (V)
2


7Z67256
$-V_{CE} = 3$ V
typ. values
h_{FE}
10^5
10^4
10^3
10^2
T_j =
150 °C
100
25
10^{-1}
1
$-I_C$ (A)
10

SILICON PLANAR EPITAXIAL POWER TRANSISTORS

N-P-N transistors in a SOT-32 plastic envelope intended for high current switching applications, e.g. inverters, and switching regulator circuits.

QUICK REFERENCE DATA

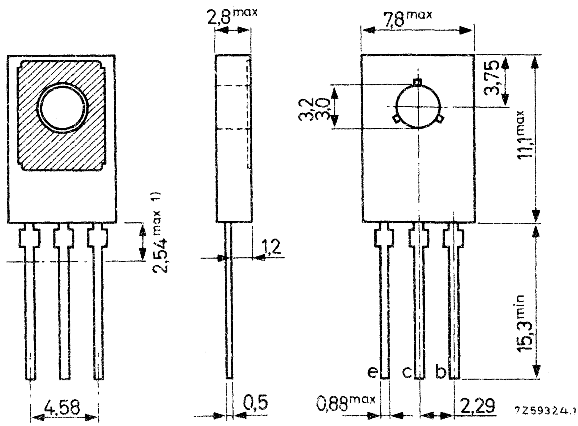
			BDX35	BDX36	BDX37	
Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	100	120	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	60	80	V
Collector current (peak value)	I_{CM}	max.	10	10	10	A
Total power dissipation up to T_{mb} = 75 °C	P_{tot}	max.	15	15	15	W
D.C. current gain I_C = 0,5 A; V_{CE} = 10 V	h_{FE}	>	45	45	45	
Collector-emitter saturation voltage I_C = 5 A; I_B = 0,5 A	V_{CEsat}	<	0,9	0,7	0,9	V
Turn off time I_{Con} = 5 A; I_{Bon} = $-I_{Boff}$ = 0,5 A	t_{off}	typ.	350	350	350	ns

MECHANICAL DATA

Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface



For mounting instructions see section Accessories, type 56326 for direct mounting and type 56333 for insulated mounting.

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

SILICON DARLINGTON POWER TRANSISTORS

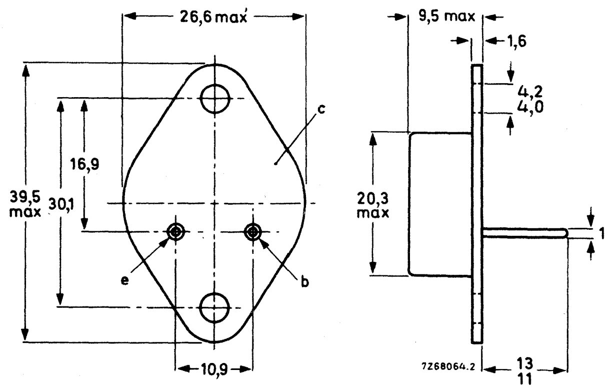
P-N-P epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications: TO-3 envelope. N-P-N complements are BDX63, BDX63A and BDX63B. Matched complementary pairs can be supplied.

QUICK REFERENCE DATA

			BDX62	BDX62A	BDX62B	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Collector current (peak value)	$-I_{CM}$	max.		12		A
Total power dissipation up to $T_{mb} = 25\ ^oC$	P_{tot}	max.		90		W
Junction temperature	T_j	max.		200		^oC
D.C. current gain						
$-I_C = 0,5$ A; $-V_{CE} = 3$ V	h_{FE}	typ.		1500		
$-I_C = 3,0$ A; $-V_{CE} = 3$ V	h_{FE}	>		1000		
Cut-off frequency						
$-I_C = 3$ A; $-V_{CE} = 3$ V	f_{hfe}	typ.		100		kHz

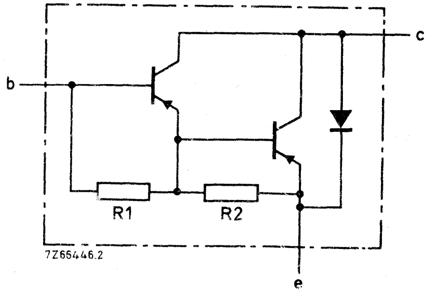
MECHANICAL DATA Dimensions in mm

TO-3
Collector connected to envelope



For mounting instructions and accessories see section Accessories.

CIRCUIT DIAGRAM



R_1 typ. 6 kΩ
R_2 typ. 80 Ω

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

Voltages			BDX62	BDX62A	BDX62B	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V

Currents				
Collector current (d.c.)	$-I_C$	max.	8	A
Collector current (peak value)	$-I_{CM}$	max.	12	A
Base current (d.c.)	$-I_B$	max.	150	mA
Power dissipation				
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	90	W
Temperatures				
Storage temperature	T_{stg}		−65 to +200	°C
Junction temperature*	T_j	max.	200	°C

THERMAL RESISTANCE*

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,94	°C/W

→ * Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

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

Collector cut-off current				
$I_E = 0$; $-V_{CB} = -V_{CBO\,max}$	$-I_{CBO}$	<	0,2	mA
$I_E = 0$; $-V_{CB} = 40$ V; $T_j = 200\ ^oC$: BDX62				
$I_E = 0$; $-V_{CB} = 50$ V; $T_j = 200\ ^oC$: BDX62A	$-I_{CBO}$	<	2	mA
$I_E = 0$; $-V_{CB} = 60$ V; $T_j = 200\ ^oC$: BDX62B				
$I_B = 0$; $-V_{CE} = 30$ V : BDX62				
$I_B = 0$; $-V_{CE} = 40$ V : BDX62A	$-I_{CEO}$	<	0,5	mA
$I_B = 0$; $-V_{CE} = 50$ V : BDX62B				
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	5	mA
D.C. current gain [1]				
$-I_C = 0,5$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	1500	
$-I_C = 3$ A; $-V_{CE} = 3$ V	h_{FE}	>	1000	
$-I_C = 8$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	750	
Base-emitter voltage [1] [2]				
$-I_C = 3$ A; $-V_{CE} = 3$ V	$-V_{BE}$	<	2,5	V
Collector-emitter saturation voltage [1]				
$-I_C = 3$ A; $-I_B = 12$ mA	$-V_{CEsat}$	<	2	V
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $-V_{CB} = 10$ V	C_c	typ.	100	pF
Cut-off frequency				
$-I_C = 3$ A; $-V_{CE} = 3$ V	f_{hfe}	typ.	100	kHz

[1] Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.

[2] $-V_{BE}$ decreases by about 3,6 mV/^oC with increasing temperature.

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

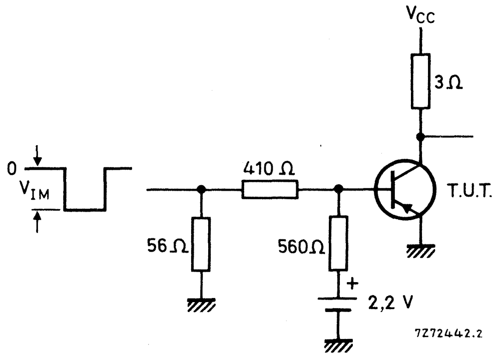
Switching times (between 10% and 90% levels)

$-I_{Con}$ = 3 A; $-I_{Bon}$ = I_{Boff} = 12 mA; V_{CC} = −10 V

Turn-on time	t_{on}	typ.	0,5	μs
Turn-off time	t_{off}	typ.	2,5	μs

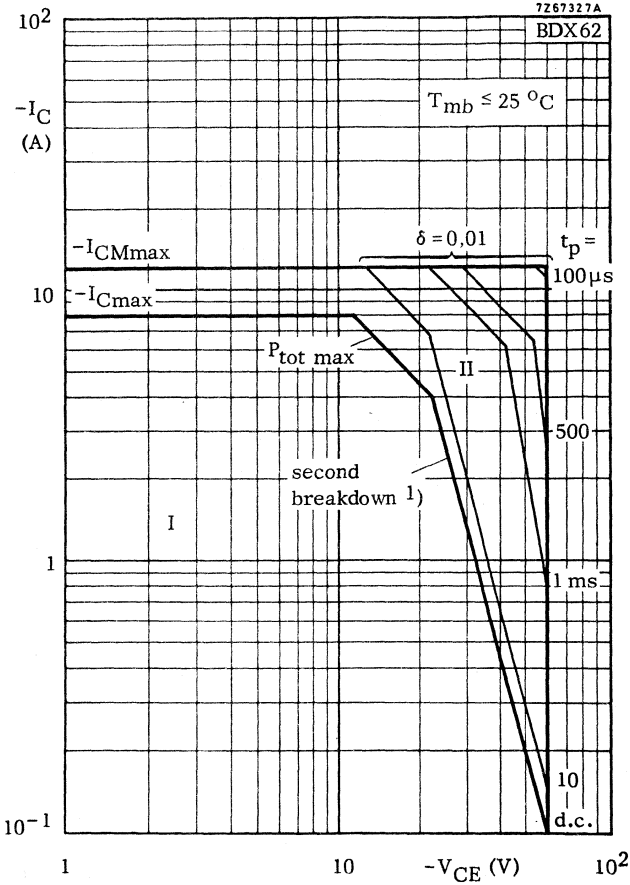
Test circuit

V_{IM} = 10 V
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs



Diode, forward voltage

I_F = 3 A	V_F	typ.	1,8	V

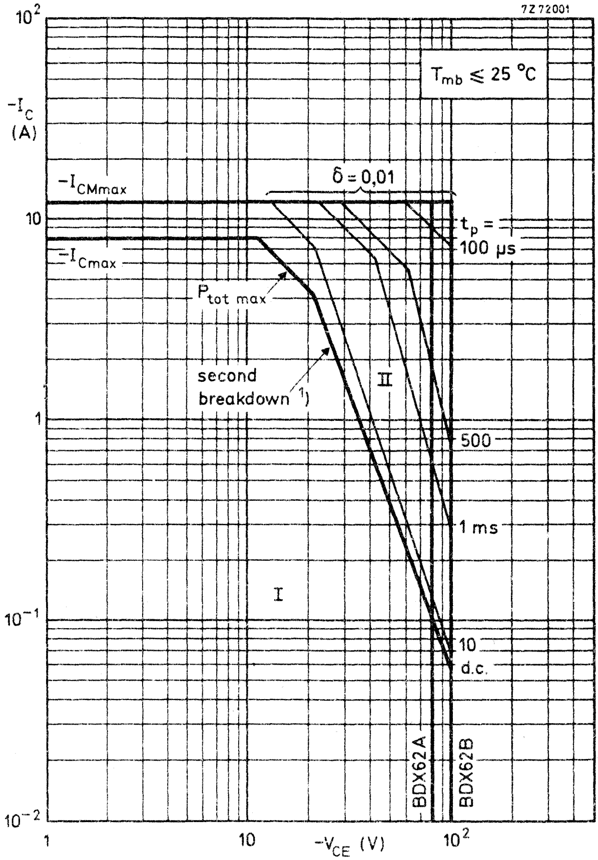


Safe Operating ARea with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

1) Independent of temperature.

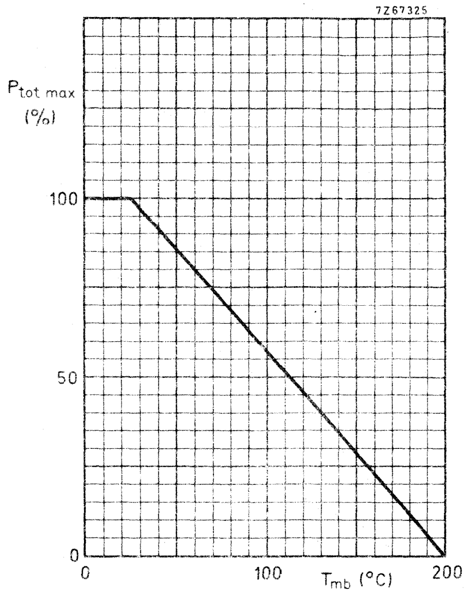


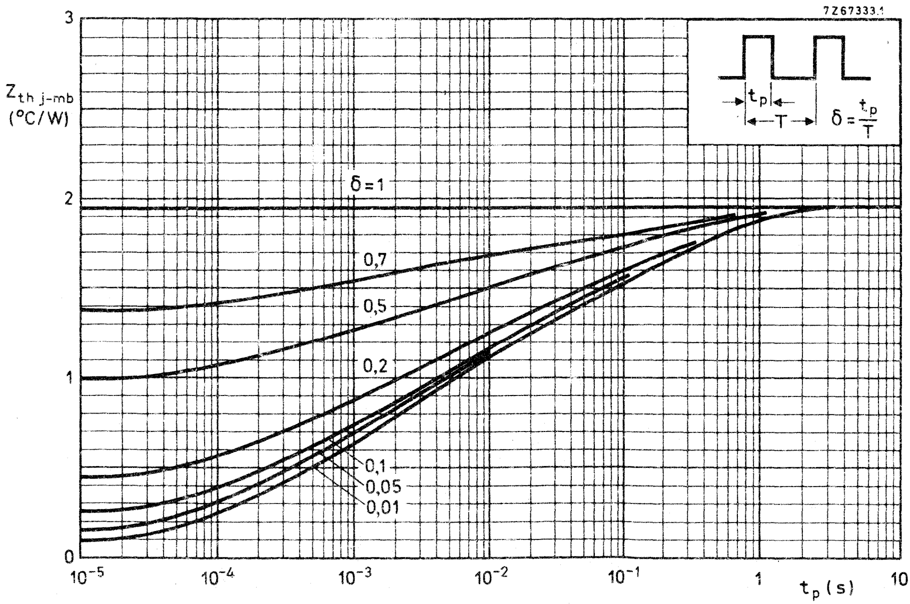
Safe Operating ARea with the transistor forward biased

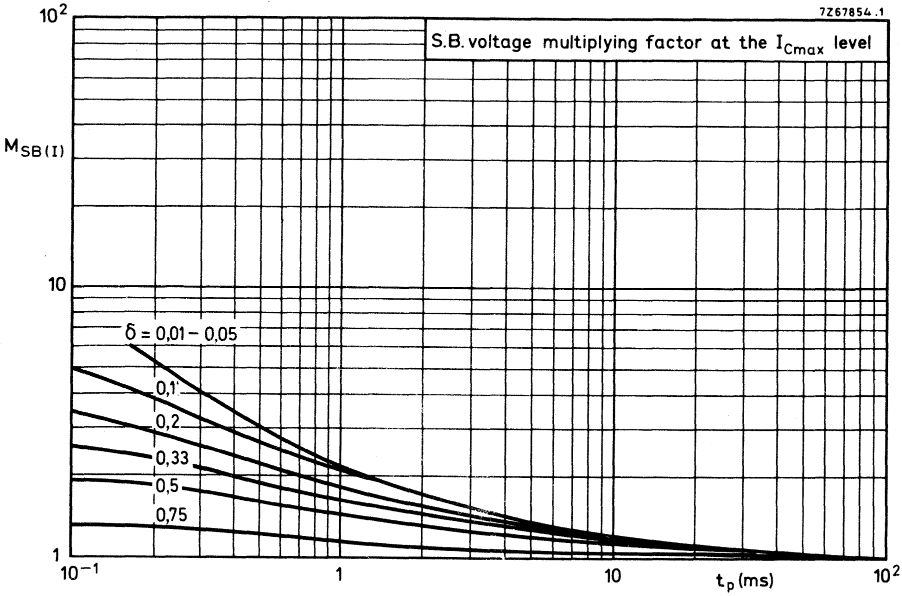
I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

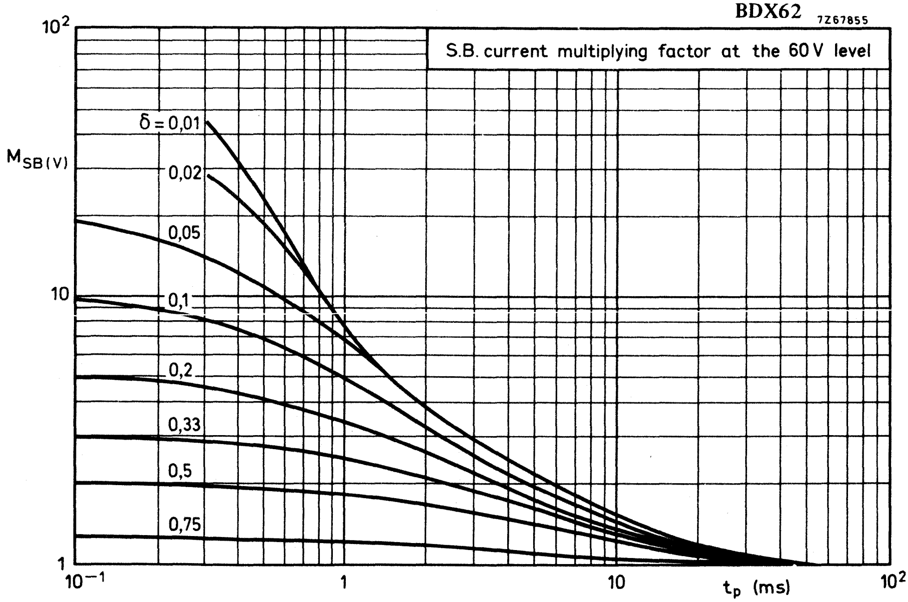
1) Independent of temperature.


7Z67325
$P_{tot\ max}$ (%)
100
50
0
0
100
T_{mb} (°C)
200

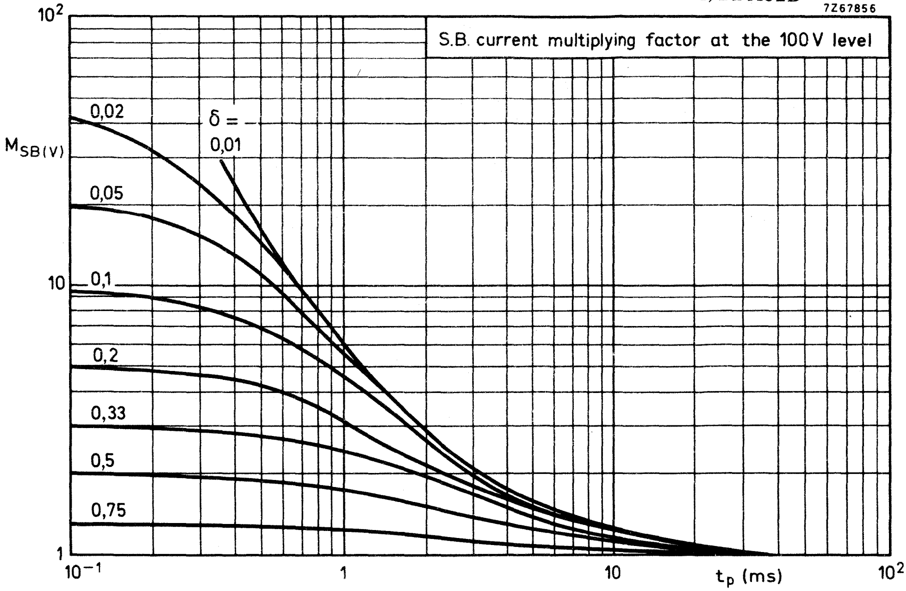

7Z67333.1
$Z_{th\ j\text{-}mb}$ (°C/W)
3
2
1
0
t_p
T
$\delta = \frac{t_p}{T}$
δ = 1
0,7
0,5
0,2
0,1
0,05
0,01
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t_p (s)
10

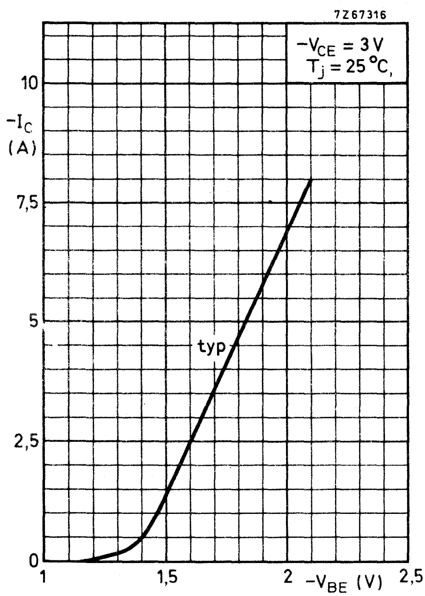

7Z67854.1
S.B. voltage multiplying factor at the I_{Cmax} level
$M_{SB(I)}$
10^2
10
1
δ = 0,01 – 0,05
0,1
0,2
0,33
0,5
0,75
10^{-1}
1
10
t_p (ms)
10^2

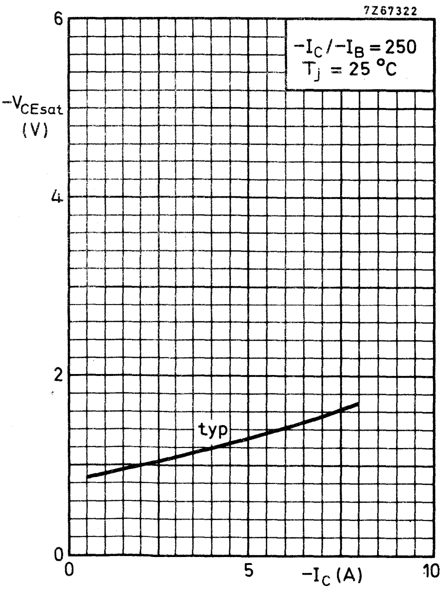
BDX62

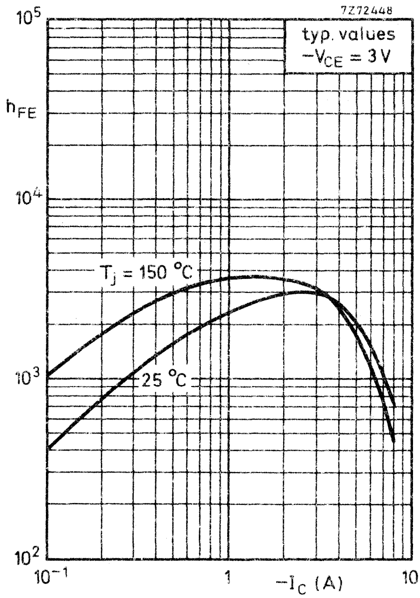

7Z67855
S.B. current multiplying factor at the 60 V level
$M_{SB(V)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-1}
1
10
t_p (ms)
10^2

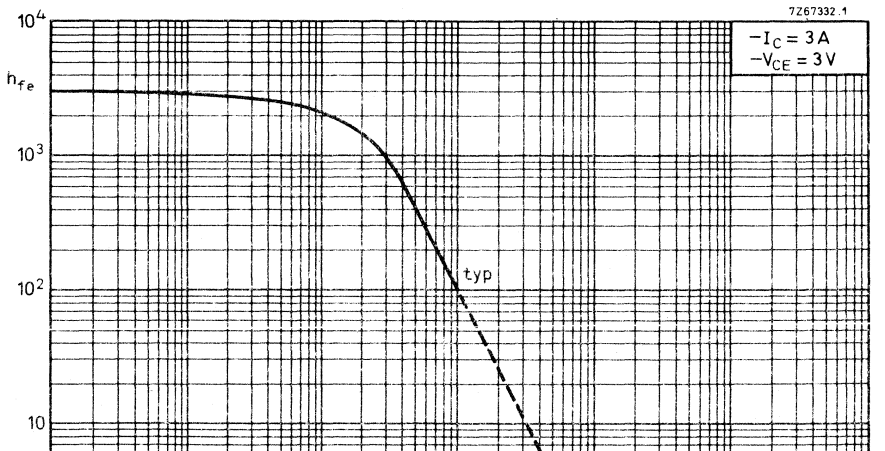
BDX62A; BDX62B








7Z72448
typ. values
$-V_{CE} = 3\ V$
h_{FE}
10^5
10^4
10^3
10^2
$T_j = 150\ °C$
25 °C
10^{-1}
1
$-I_C$ (A)
10


7Z67332.1
$-I_C = 3\ A$
$-V_{CE} = 3\ V$
h_{fe}
10^4
10^3
10^2
10
1
typ
10^3
10^4
10^5
10^6
10^7
10^8
f (Hz)
10^9

SILICON DARLINGTON POWER TRANSISTORS

N-P-N epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; TO-3 envelope. P-N-P complements are BDX62, BDX62A and BDX62B. Matched complementary pairs can be supplied.

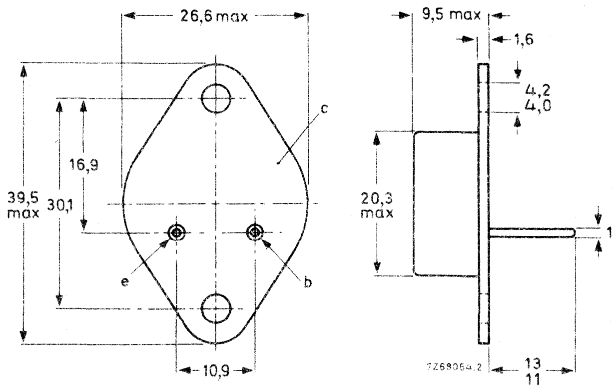
QUICK REFERENCE DATA

			BDX63	BDX63A	BDX63B	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Collector current (peak value)	I_{CM}	max.		12		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		90		W
Junction temperature	T_j	max.		200		°C
D.C. current gain I_C = 0,5 A; V_{CE} = 3 V	h_{FE}	typ.		1500		
I_C = 3,0 A; V_{CE} = 3 V	h_{FE}	>		1000		
Cut-off frequency I_C = 3 A; V_{CE} = 3 V	f_{hfe}	typ.		100		kHz

MECHANICAL DATA

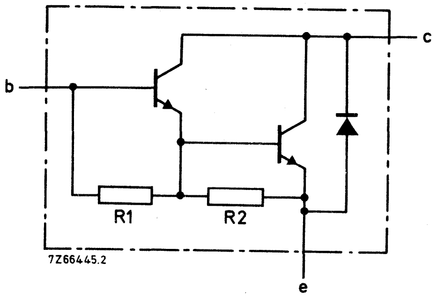
Dimensions in mm

TO-3
Collector connected to envelope



For mounting instructions and accessories see section Accessories.

CIRCUIT DIAGRAM



R_1 typ. 8 kΩ
R_2 typ. 100 Ω

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

Voltages			BDX63	BDX63A	BDX63B	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V

Currents				
Collector current (d.c.)	I_C	max.	8	A
Collector current (peak value)	I_{CM}	max.	12	A
Base current (d.c.)	I_B	max.	150	mA

Power dissipation				
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	90	W

Temperatures				
Storage temperature	T_{stg}		−65 to +200	°C
Junction temperature*	T_j	max.	200	°C

THERMAL RESISTANCE *

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,94	°C/W

→ * Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

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

Collector cut-off current				
$I_E = 0$ [1]	I_{CBO}	<	0,2	mA
$I_E = 0$; $V_{CB} = 40$ V; $T_j = 200\ ^oC$: BDX63 $I_E = 0$; $V_{CB} = 50$ V; $T_j = 200\ ^oC$: BDX63A $I_E = 0$; $V_{CB} = 60$ V; $T_j = 200\ ^oC$: BDX63B	I_{CBO}	<	2	mA
$I_B = 0$; $V_{CE} = 30$ V: BDX63 $I_B = 0$; $V_{CE} = 40$ V: BDX63A $I_B = 0$; $V_{CE} = 50$ V: BDX63B	I_{CEO}	<	0,5	mA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	5	mA
D.C. current gain [2]				
$I_C = 0,5$ A; $V_{CE} = 3$ V	h_{FE}	typ.	1500	
$I_C =$ 3 A; $V_{CE} = 3$ V	h_{FE}	>	1000	
$I_C =$ 8 A; $V_{CE} = 3$ V	h_{FE}	typ.	2000	
Base-emitter voltage [2] [3]				
$I_C = 3$ A; $V_{CE} = 3$ V	V_{BE}	<	2,5	V
Collector-emitter saturation voltage [2]				
$I_C = 3$ A; $I_B = 12$ mA	V_{CEsat}	<	2	V
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	100	pF
Cut-off frequency				
$I_C = 3$ A; $V_{CE} = 3$ V	f_{hfe}	typ.	100	kHz
Turn-off breakdown energy with inductive load				
$-I_{Boff} = 0$; $I_{Con} = 4,5$ A; $t_p = 1$ ms; T = 100 ms; see circuit on page 4	$E_{(BR)}$	>	50	mJ

1) $V_{CBO} = 60$ V for BDX63, 80 V for BDX63A, 100 V for BDX63B.

2) Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.

3) V_{BE} decreases by about 3,6 mV/^oC with increasing temperature.

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

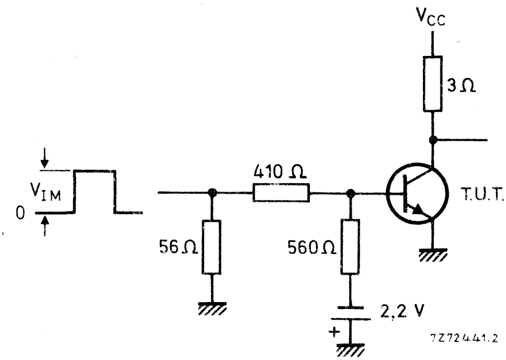
Switching times (between 10% and 90% levels)

I_{Con} = 3 A; I_{Bon} = $-I_{Boff}$ = 12 mA; V_{CC} = 10 V

Turn-on time	t_{on}	typ.	0,5	μs
Turn-off time	t_{off}	typ.	2,5	μs

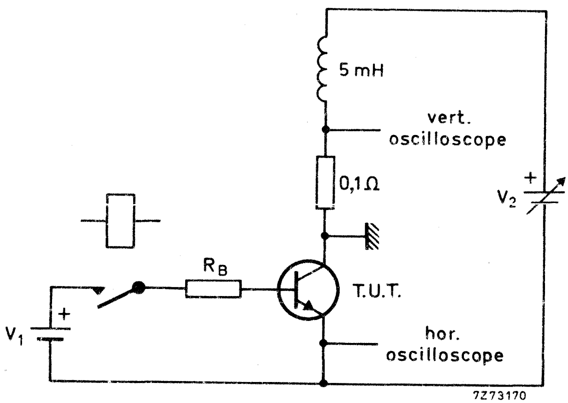
Test circuit

V_{IM} = 10 V
t_r = tf = 15 ns
t_p = 10 μs
T = 500 μs

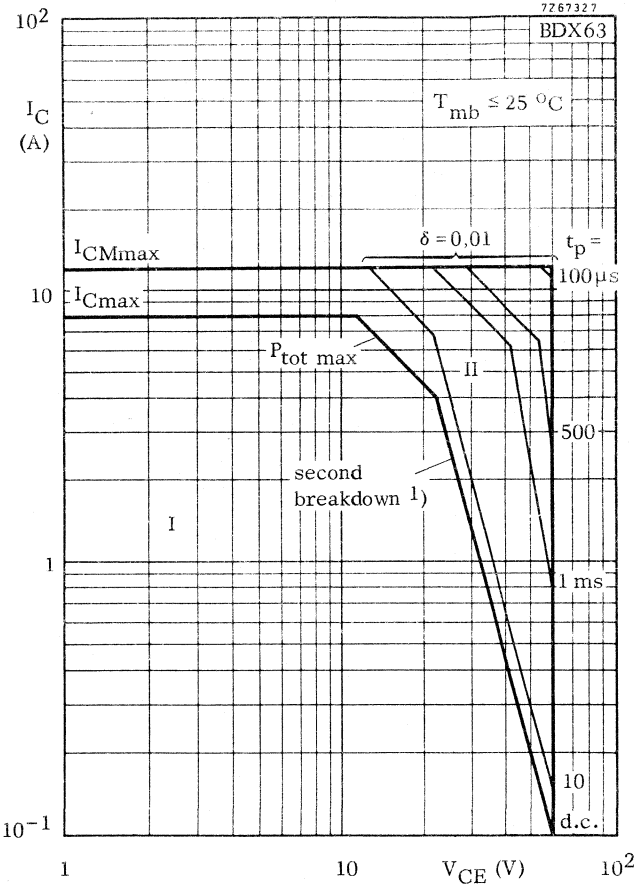


Diode, forward voltage

I_F = 3 A	V_F	typ.	1,2	V



Test circuit for turn-off breakdown energy (page 3)
V_1 = 12 V; R_B = 270 Ω

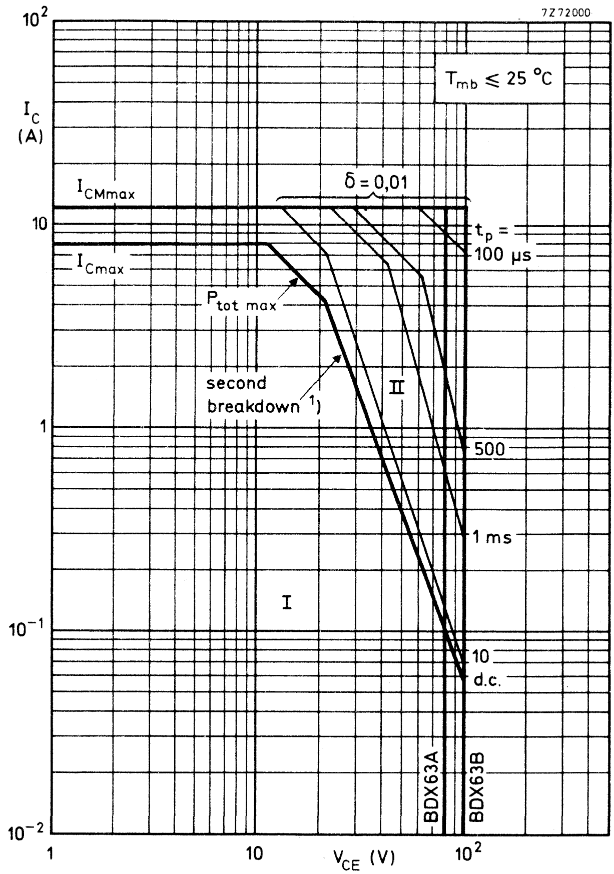


Safe Operating ARea with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

1) Independent of temperature.

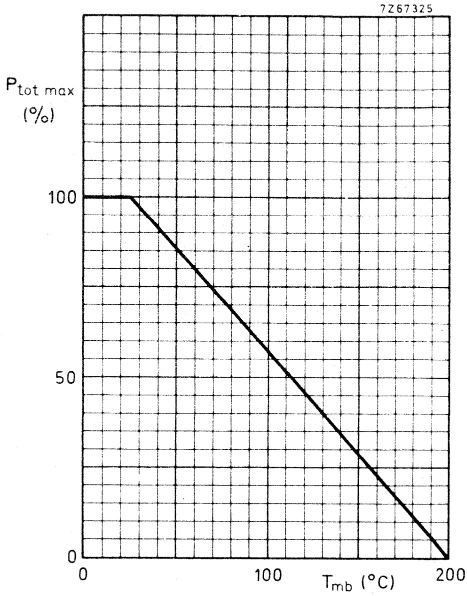


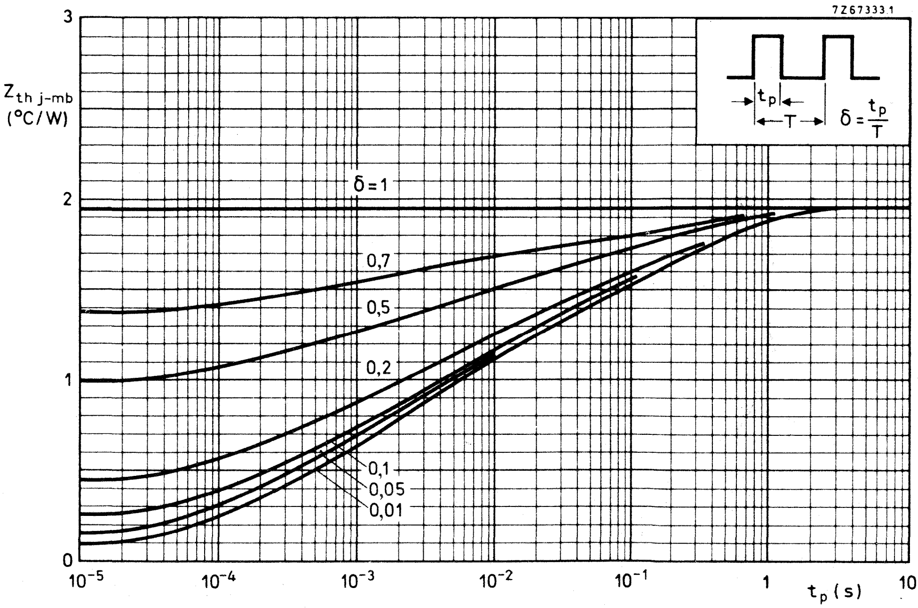
Safe Operating ARea with the transistor forward biased

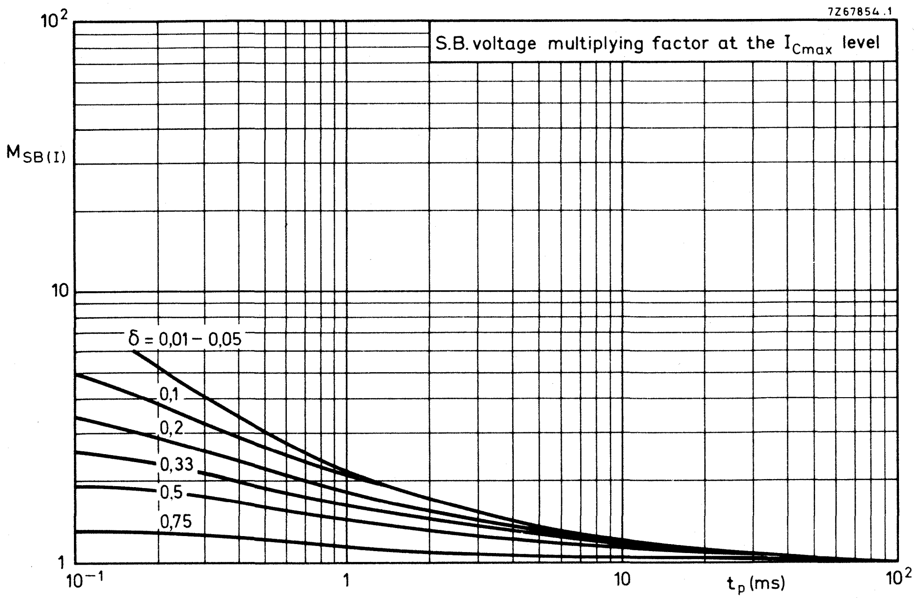
I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

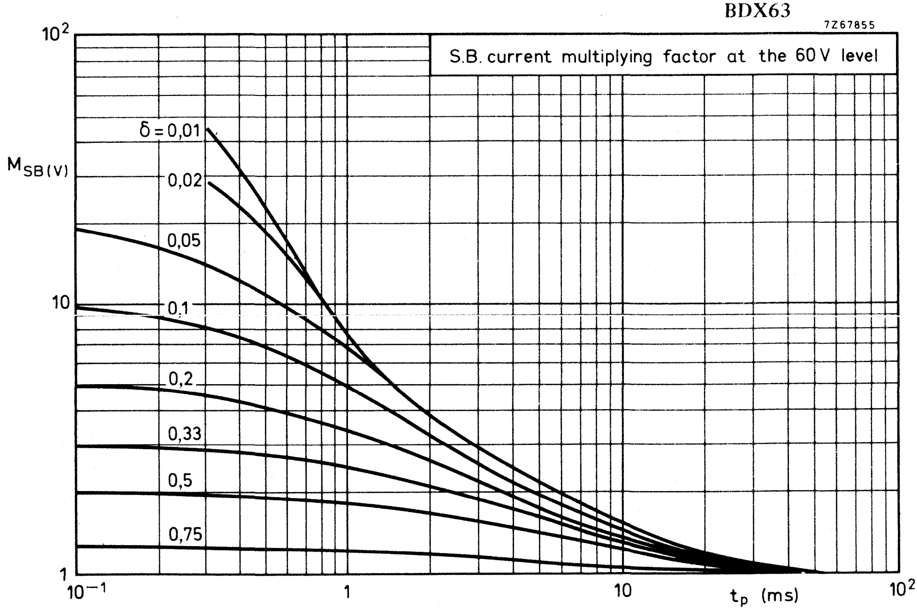
[1]) Independent of temperature.


7Z67325
$P_{tot\ max}$ (%)
100
50
0
0
100
200
T_{mb} (°C)

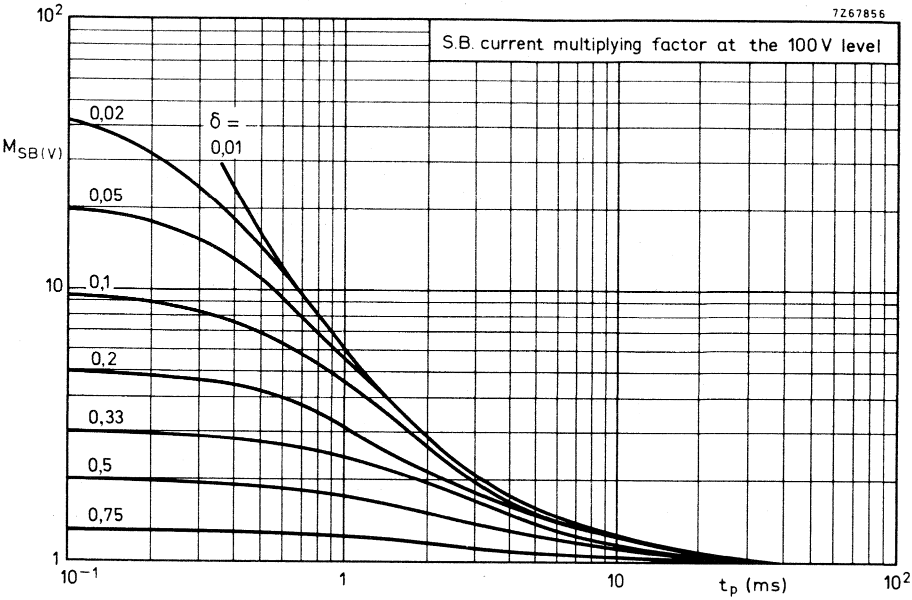

7Z67333.1
$Z_{th\ j\text{-}mb}$ (°C/W)
3
2
1
0
t_p
T
$\delta = \frac{t_p}{T}$
δ = 1
0,7
0,5
0,2
0,1
0,05
0,01
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
t_p (s)

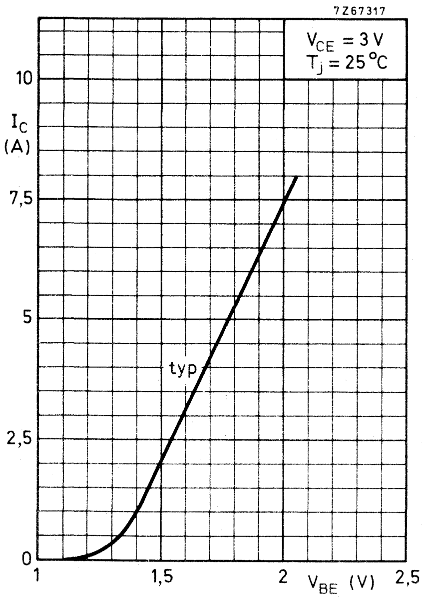

7Z67854.1
S.B. voltage multiplying factor at the I_{Cmax} level
$M_{SB(I)}$
10^2
10
1
δ = 0,01 − 0,05
0,1
0,2
0,33
0,5
0,75
10^{-1}
1
10
t_p (ms)
10^2

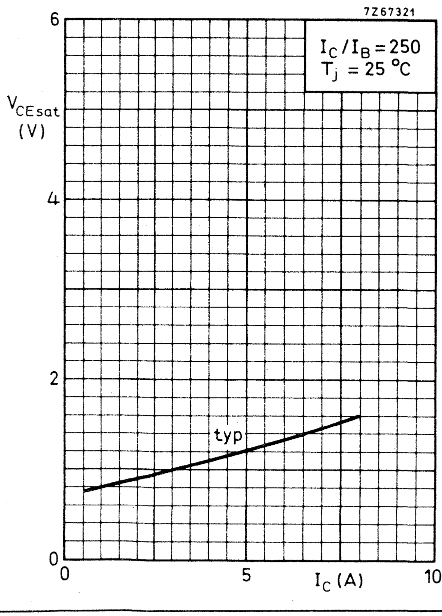
BDX63

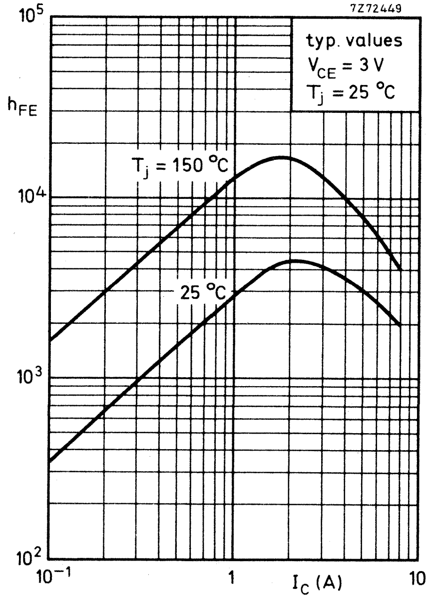

7Z67855
S.B. current multiplying factor at the 60 V level
$M_{SB(V)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-1}
1
10
t_p (ms)
10^2

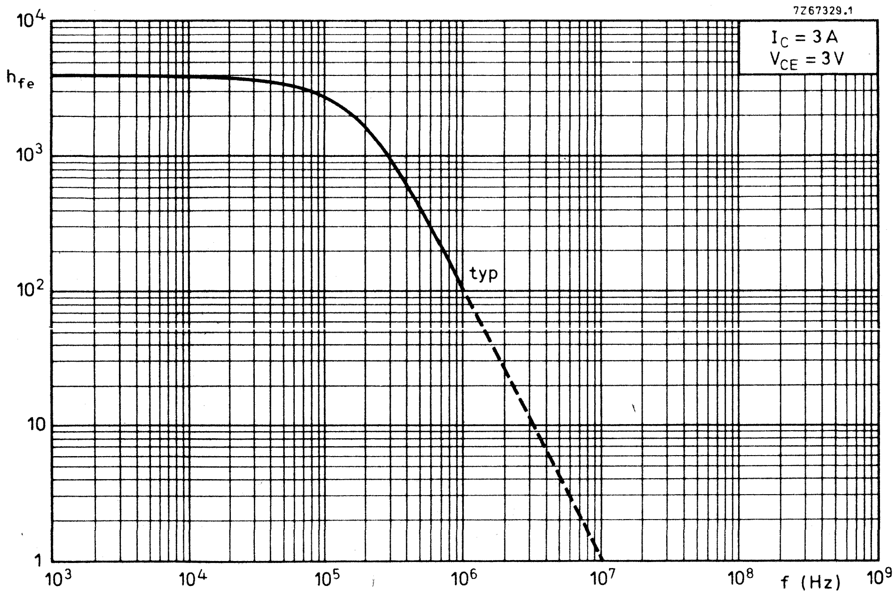
BDX63A; BDX63B








7Z72449
typ. values
V_{CE} = 3 V
T_j = 25 °C
h_{FE}
T_j = 150 °C
25 °C
10^5
10^4
10^3
10^2
10^{-1}
1
10
I_C (A)


7Z67329.1
I_C = 3 A
V_{CE} = 3 V
h_{fe}
typ
10^4
10^3
10^2
10
1
10^3
10^4
10^5
10^6
10^7
10^8
10^9
f (Hz)

SILICON DARLINGTON POWER TRANSISTORS

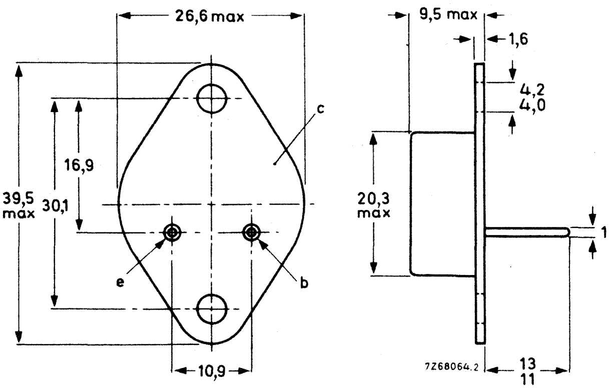
P-N-P epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; TO-3 envelope. N-P-N complements are BDX65, BDX65A and BDX65B. Matched complementary pairs can be supplied.

QUICK REFERENCE DATA

			BDX64	BDX64A	BDX64B	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Collector current (peak value)	$-I_{CM}$	max.		16		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		117		W
Junction temperature	T_j	max.		200		°C
D.C. current gain $-I_C$ = 1 A; $-V_{CE}$ = 3 V	h_{FE}	typ.		1500		
$-I_C$ = 5 A; $-V_{CE}$ = 3 V	h_{FE}	>		1000		
Cut-off frequency $-I_C$ = 5 A; $-V_{CE}$ = 3 V	f_{hfe}	typ.		80		kHz

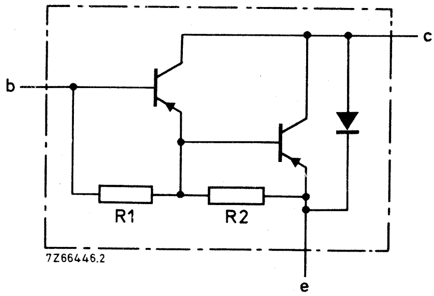
MECHANICAL DATA Dimensions in mm

TO-3
Collector connected to envelope



For mounting instructions and accessories see section Accessories.

CIRCUIT DIAGRAM



R_1 typ. 5 kΩ
R_2 typ. 80 Ω

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

Voltages			BDX64	BDX64A	BDX64B	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V

Currents				
Collector current (d.c.)	$-I_C$	max.	12	A
Collector current (peak value)	$-I_{CM}$	max.	16	A
Base current (d.c.)	$-I_B$	max.	200	mA

Power dissipation				
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	117	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

→ * Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

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

Collector cut-off current				
$I_E = 0;\ -V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	0,4	mA
$I_E = 0;\ -V_{CB} = 40$ V; $T_j = 200\ ^oC$: BDX64 $I_E = 0;\ -V_{CB} = 50$ V; $T_j = 200\ ^oC$: BDX64A $I_E = 0;\ -V_{CB} = 60$ V; $T_j = 200\ ^oC$: BDX64B	$-I_{CBO}$	<	3	mA
$I_B = 0;\ -V_{CE} = 30$ V: BDX64 $I_B = 0;\ -V_{CE} = 40$ V: BDX64A $I_B = 0;\ -V_{CE} = 50$ V: BDX64B	$-I_{CEO}$	<	1	mA
Emitter cut-off current				
$I_C = 0;\ -V_{EB} = 5$ V	$-I_{EBO}$	<	5	mA
D.C. current gain [1]				
$-I_C = 1$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	1500	
$-I_C = 5$ A; $-V_{CE} = 3$ V	h_{FE}	>	1000	
$-I_C = 12$A; $-V_{CE} = 3$ V	h_{FE}	typ.	750	
Base-emitter voltage [1] [2]				
$-I_C = 5$ A; $-V_{CE} = 3$ V	$-V_{BE}$	<	2,5	V
Collector-emitter saturation voltage [1]				
$-I_C = 5$ A; $-I_B = 20$ mA	$-V_{CEsat}$	<	2	V
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0;\ -V_{CB} = 10$ V	C_c	typ.	200	pF
Cut-off frequency				
$-I_C = 5$ A; $-V_{CE} = 3$ V	f_{hfe}	typ.	80	kHz

1) Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.

2) $-V_{BE}$ decreases by about 3,6 mV/^oC with increasing temperature.

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

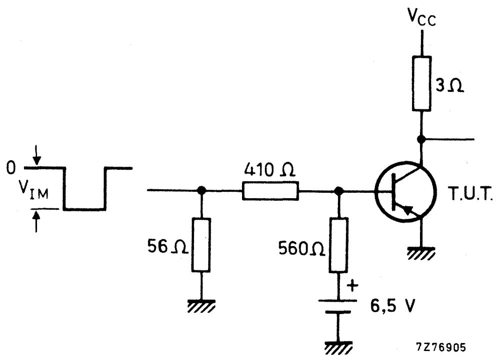
Switching times (between 10% and 90% levels)

$-I_{Con}$ = 5 A; $-I_{Bon}$ = I_{Boff} = 20 mA; V_{CC} = −16 V

Turn-on time	t_{on}	typ.	1	μs
Turn-off time	t_{off}	typ.	2,5	μs

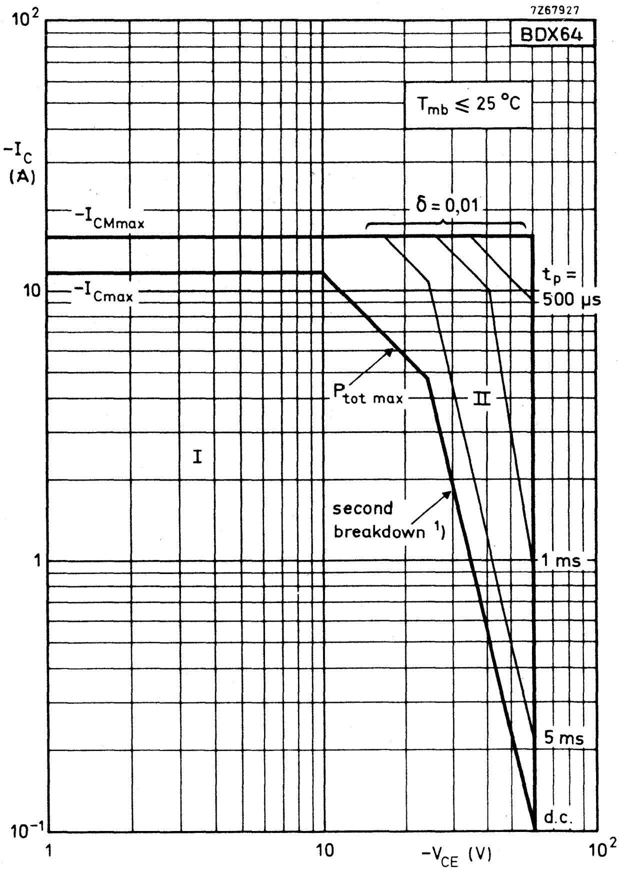
Test circuit

V_{IM} = 16,5 V
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs



Diode, forward voltage

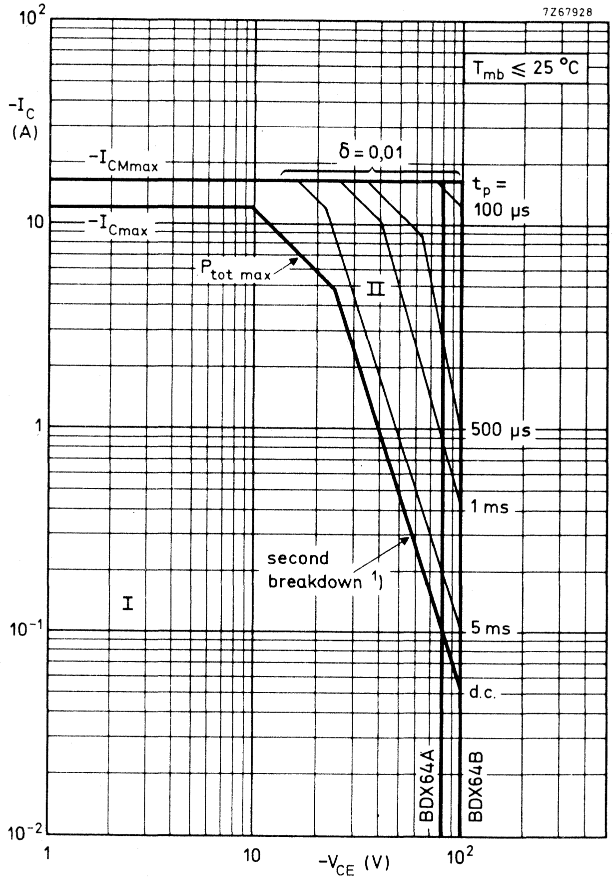
I_F = 5 A	V_F	typ.	1,8	V



Safe Operating ARea with the transistor forward biased

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

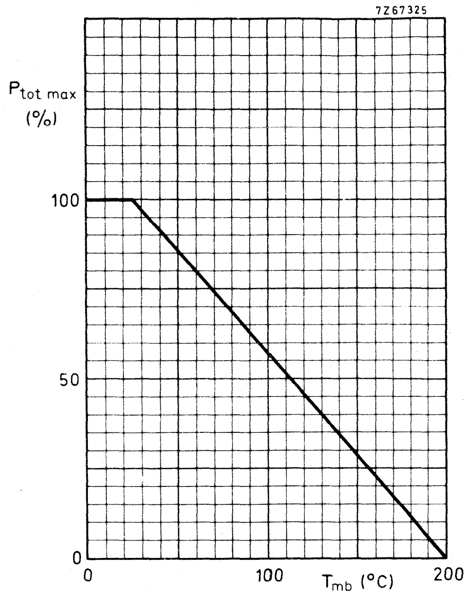
[1]) Independent of temperature.

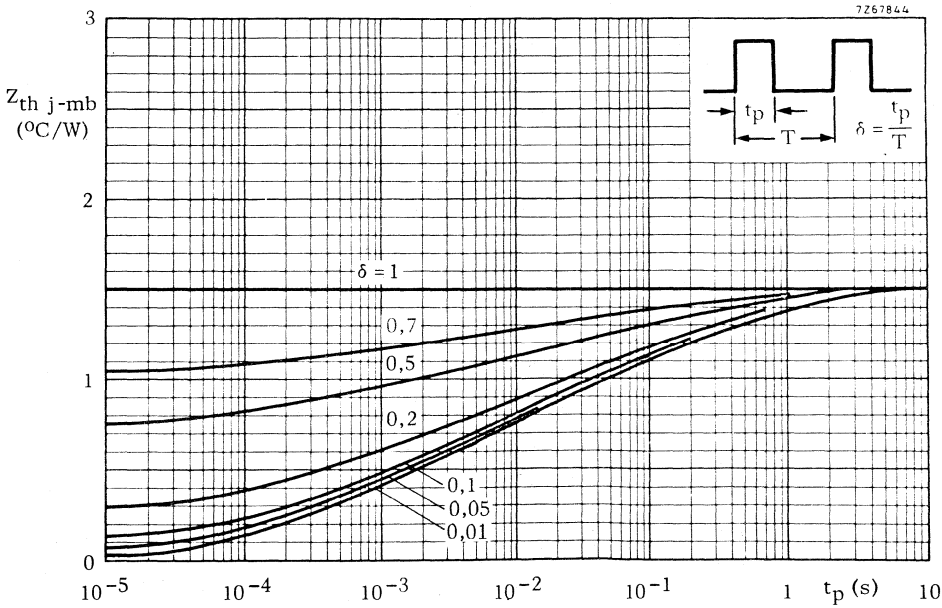


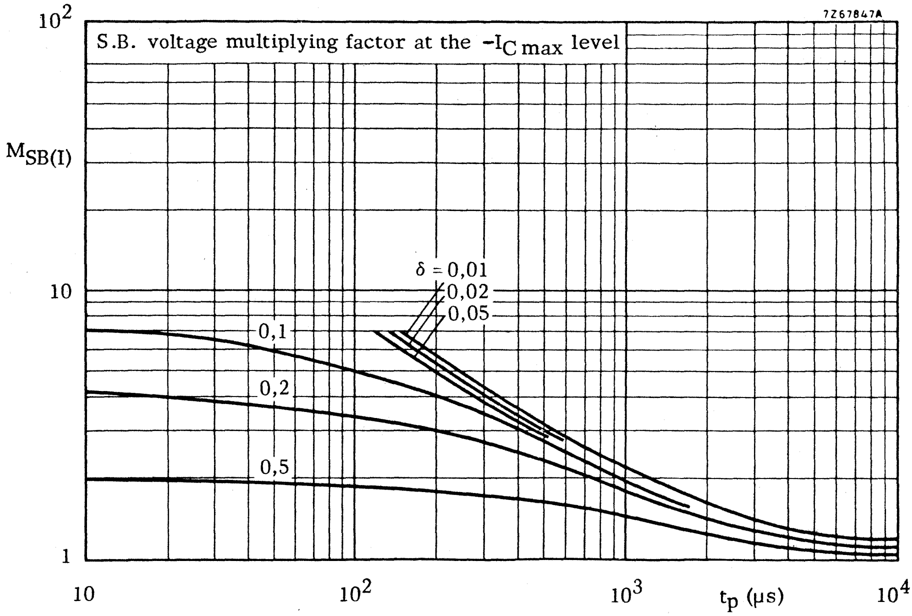
Safe Operating ARea with the transistor forward biased

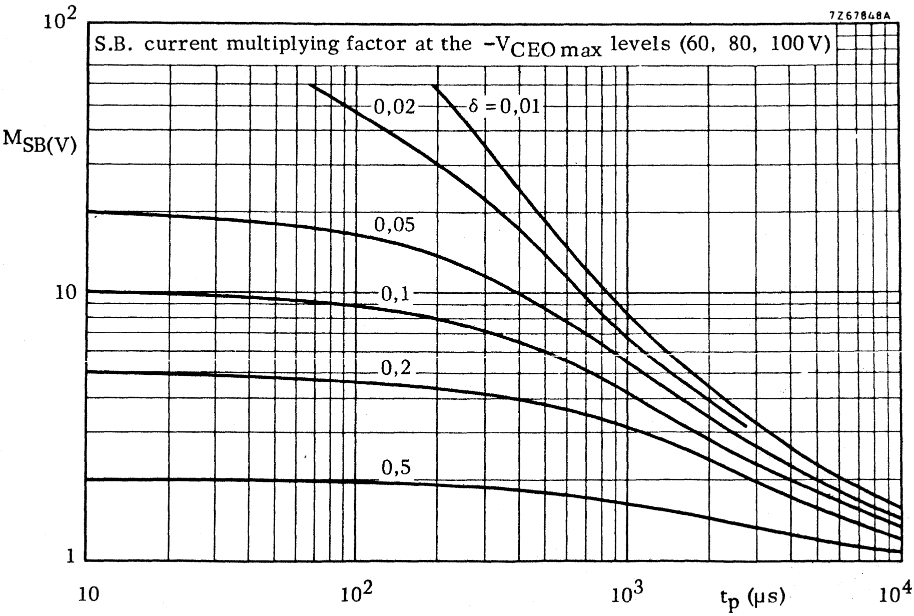
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation

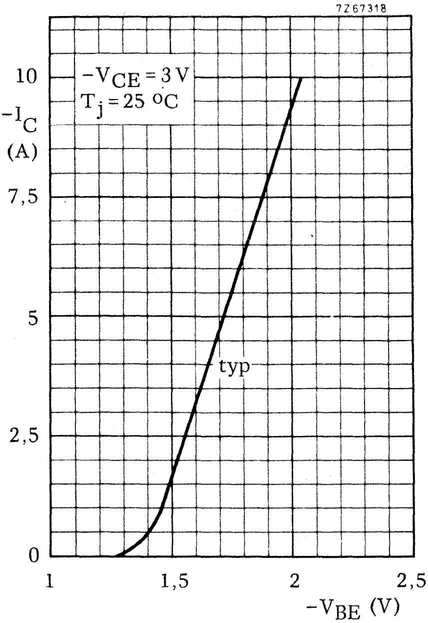
1) Independent of temperature.

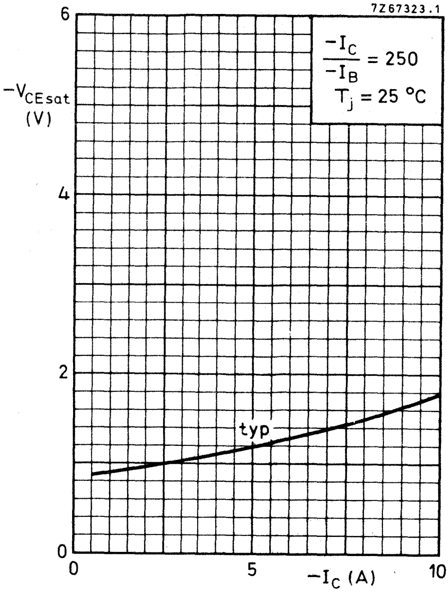

7Z67325
$P_{tot\ max}$ (%)
100
50
0
0
100
T_{mb} (°C)
200

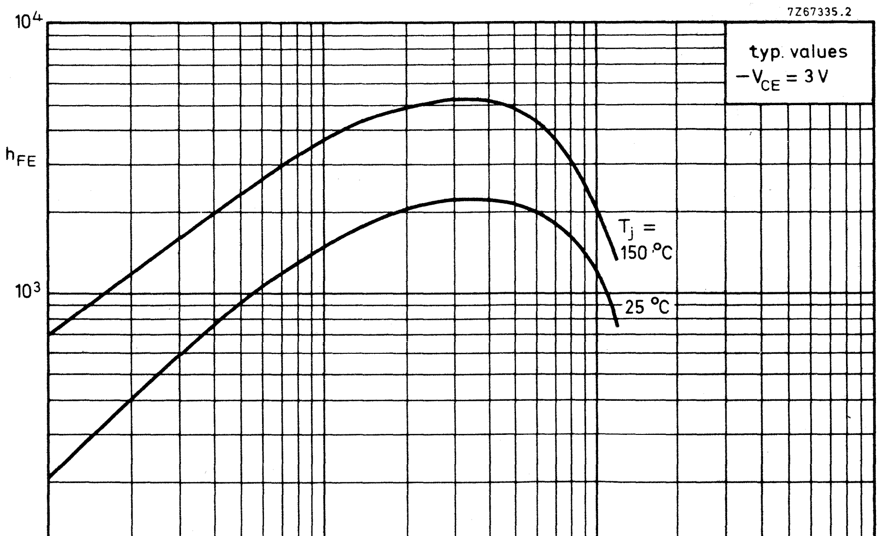

7Z67844
3
$Z_{th\ j\text{-}mb}$ (°C/W)
2
1
0
t_p
T
$\delta = \frac{t_p}{T}$
δ = 1
0,7
0,5
0,2
0,1
0,05
0,01
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t_p (s)
10

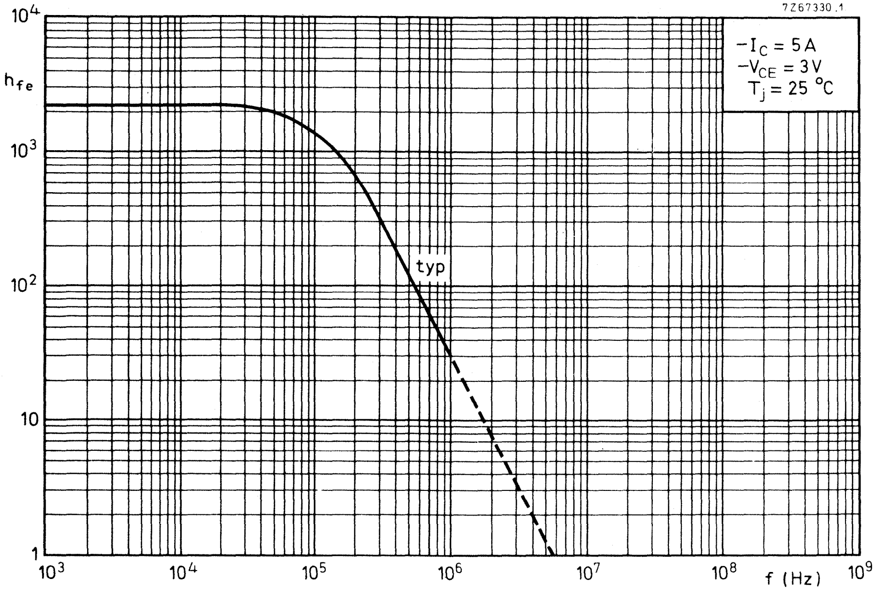

7Z67847A
S.B. voltage multiplying factor at the $-I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,5
10
10^2
10^3
t_p (μs)
10^4


7Z67848A
S.B. current multiplying factor at the $-V_{CEO\,max}$ levels (60, 80, 100 V)
$M_{SB(V)}$
10^2
10
1
0,02
δ = 0,01
0,05
0,1
0,2
0,5
10
10^2
10^3
t_p (μs)
10^4


7Z67318
$-V_{CE}$ = 3 V
T_j = 25 °C
$-I_C$ (A)
10
7,5
5
2,5
0
typ
1
1,5
2
2,5
$-V_{BE}$ (V)


7Z67323.1
$\frac{-I_C}{-I_B}$ = 250
T_j = 25 °C
$-V_{CEsat}$ (V)
6
4
2
0
typ
0
5
$-I_C$ (A)
10


7Z67335.2
typ. values
$-V_{CE}$ = 3 V
h_{FE}
10^4
10^3
10^2
T_j =
150 °C
25 °C
10^{-1}
1
10
$-I_C$ (A)
10^2


7Z67330.1
$-I_C = 5\,A$
$-V_{CE} = 3\,V$
$T_j = 25\,^oC$
h_{fe}
10^4
10^3
10^2
10
1
typ
10^3
10^4
10^5
10^6
10^7
10^8
10^9
f (Hz)

SILICON DARLINGTON POWER TRANSISTORS

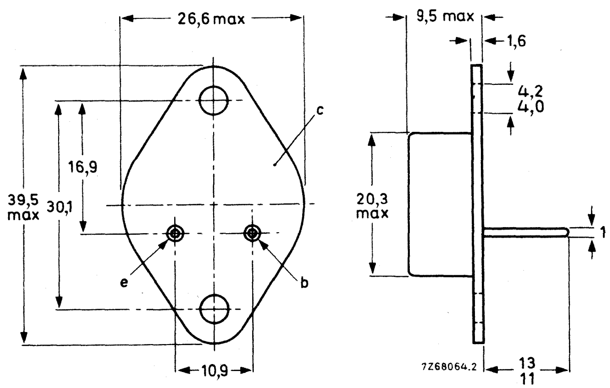
N-P-N epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; TO-3 envelope. P-N-P complements are BDX64, BDX64A and BDX64B. Matched complementary pairs can be supplied.

QUICK REFERENCE DATA

			BDX65	BDX65A	BDX65B	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Collector current (peak value)	I_{CM}	max.		16		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		117		W
Junction temperature	T_j	max.		200		V
D.C. current gain I_C = 1 A; V_{CE} = 3 V	h_{FE}	typ.		1500		
I_C = 5 A; V_{CE} = 3 V	h_{FE}	>		1000		
Cut-off frequency I_C = 5 A; V_{CE} = 3 V	f_{hfe}	typ.		50		kHz

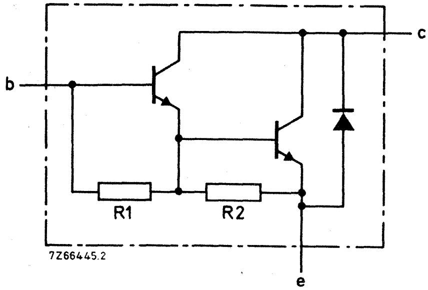
MECHANICAL DATA Dimensions in mm

TO-3
Collector connected to envelope



For mounting instructions and accessories see section Accessories.

CIRCUIT DIAGRAM



R_1 typ. 5 kΩ
R_2 typ. 80 Ω

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

Voltages			BDX65	BDX65A	BDX65B	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V

Currents

Collector current (d.c.)	I_C	max.	12	A
Collector current (peak value)	I_{CM}	max.	16	A
Base current (d.c.)	I_B	max.	200	mA

Power dissipation

Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	117	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

* Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS — T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$ [1]	I_{CBO}	<	0,4	mA
$I_E = 0$; $V_{CB} = 40$ V; $T_j = 200$ °C: BDX65 $I_E = 0$; $V_{CB} = 50$ V; $T_j = 200$ °C: BDX65A $I_E = 0$; $V_{CB} = 60$ V; $T_j = 200$ °C: BDX65B	I_{CBO}	<	3	mA
$I_B = 0$; $V_{CE} = 30$ V: BDX65 $I_B = 0$; $V_{CE} = 40$ V: BDX65A $I_B = 0$; $V_{CE} = 50$ V: BDX65B	I_{CEO}	<	1	mA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	5	mA
D.C. current gain [2]				
$I_C = 1$ A; $V_{CE} = 3$ V	h_{FE}	typ.	1500	
$I_C = 5$ A; $V_{CE} = 3$ V	h_{FE}	>	1000	
$I_C = 12$ A; $V_{CE} = 3$ V	h_{FE}	typ.	1250	
Base-emitter voltage [2] [3]				
$I_C = 5$ A; $V_{CE} = 3$ V	V_{BE}	<	2,5	V
Collector-emitter saturation voltage [2]				
$I_C = 5$ A; $I_B = 20$ mA	V_{CEsat}	<	2	V
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	200	pF
Cut-off frequency				
$I_C = 5$ A; $V_{CE} = 3$ V	f_{hfe}	typ.	50	kHz
Turn-off breakdown energy with inductive load				
$-I_{Boff} = 0$; $I_{Con} = 6,3$ A; $t_p = 1$ ms; T = 100 ms; see circuit on page 4	$E_{(BR)}$	>	100	mJ

[1] V_{CBO} = 60 V for BDX65, 80 V for BDX65A, 100 V for BDX65B.

[2] Measured under pulse conditions: $t_p < 300$ µs, $\delta < 2\%$.

[3] V_{BE} decreases by about 3,6 mV/°C with increasing temperature.

CHARACTERISTICS (continued)

T_j = 25 °C unless otherwise specified

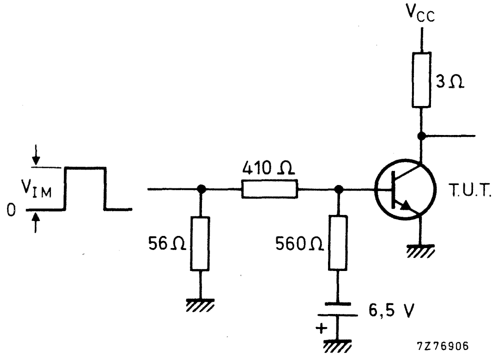
Switching times (between 10% and 90% levels)

I_{Con} = 5 A; I_{Bon} = $-I_{Boff}$ = 20 mA; V_{CC} = 16 V

Turn-on time	t_{on}	typ.	1	μs
Turn-off time	t_{off}	typ.	2,5	μs

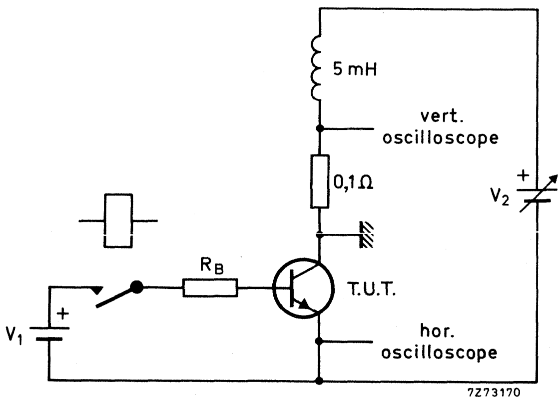
Test circuit

V_{IM} = 16,5 V
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

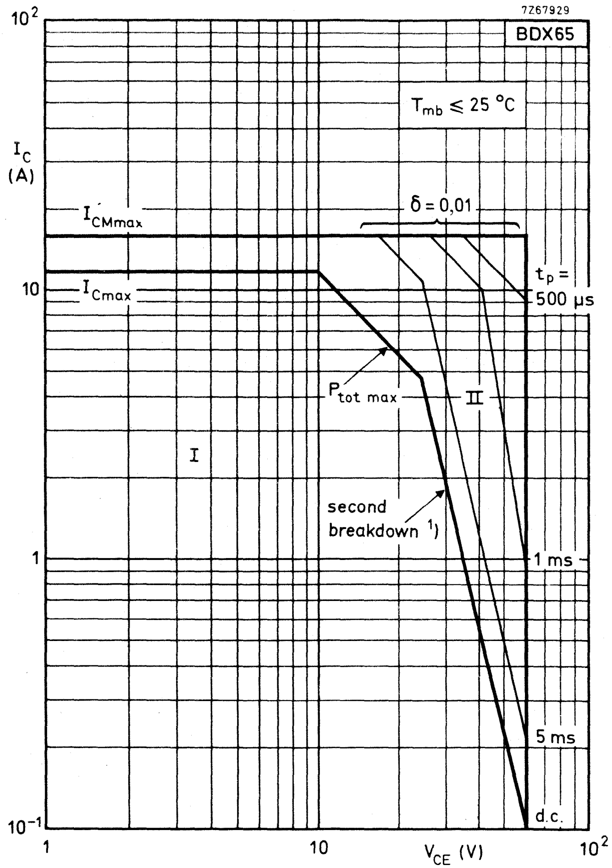


Diode, forward voltage

I_F = 5 A	V_F	typ.	1,2	V



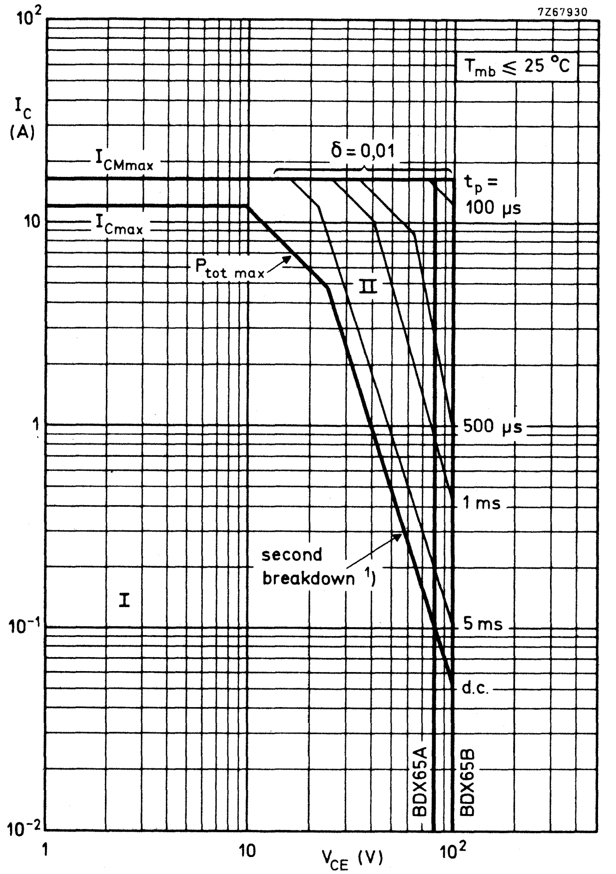
Test circuit for turn-off breakdown energy (page 3)
V_1 = 12 V; R_B = 270 Ω



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.

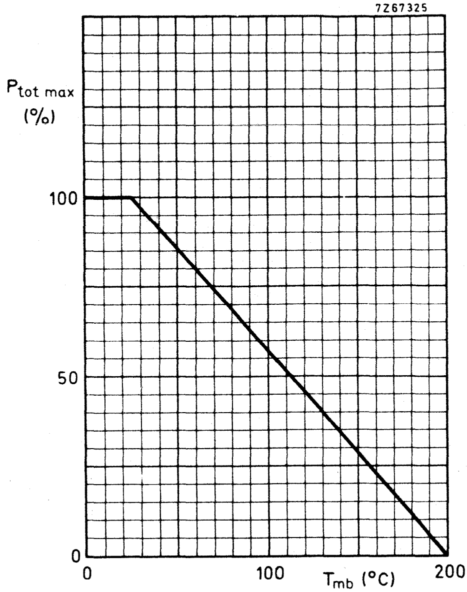


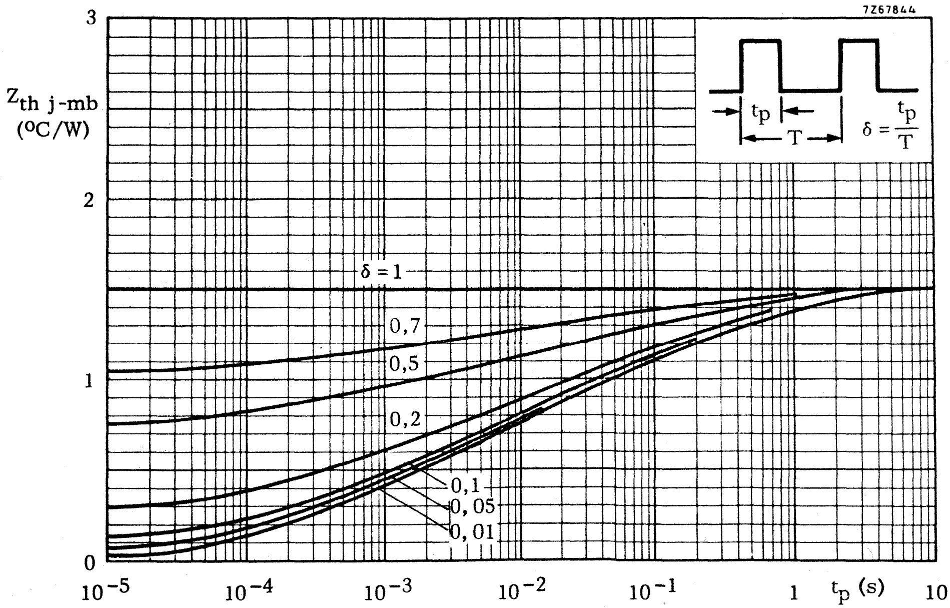
Safe Operating ARea with the transistor forward biased

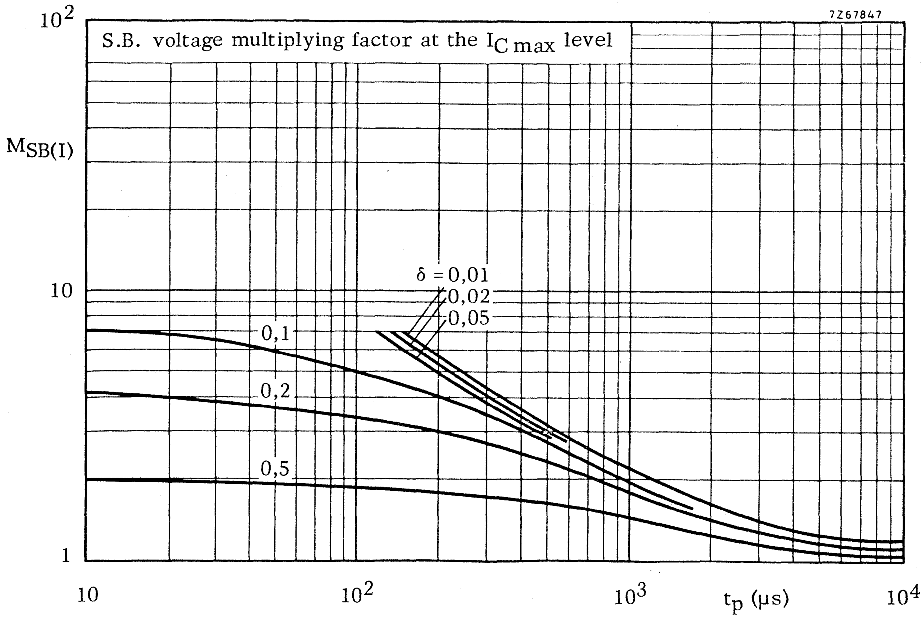
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation

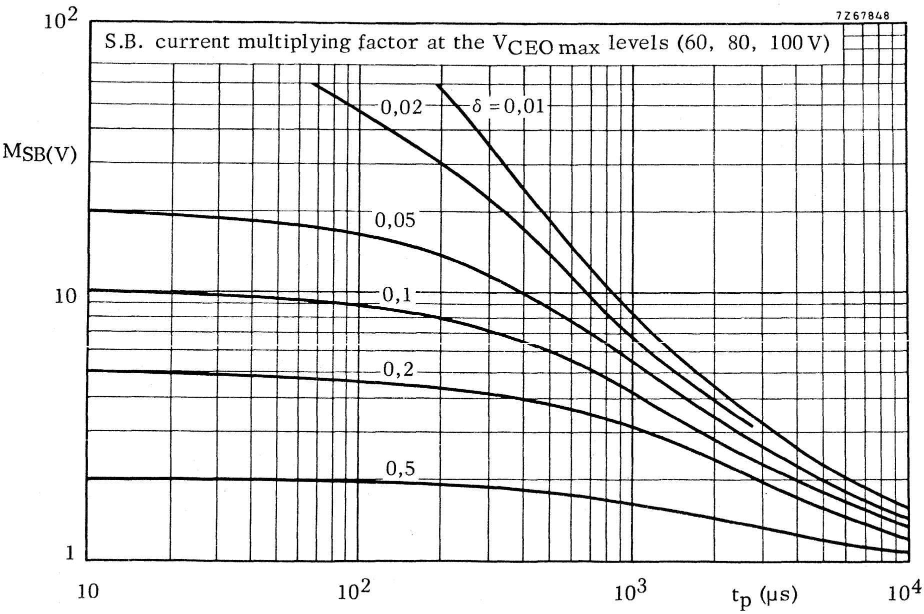
---

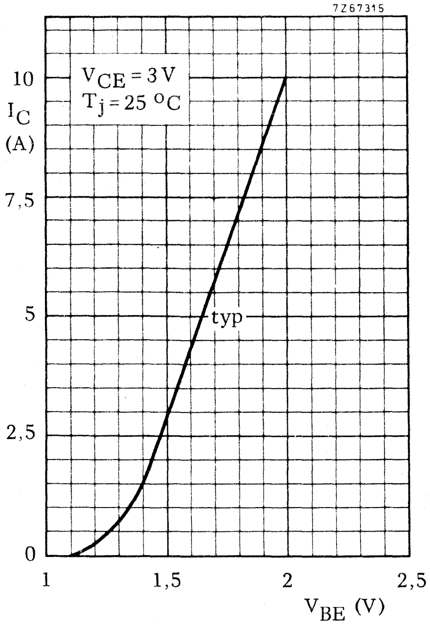
[1]) Independent of temperature.

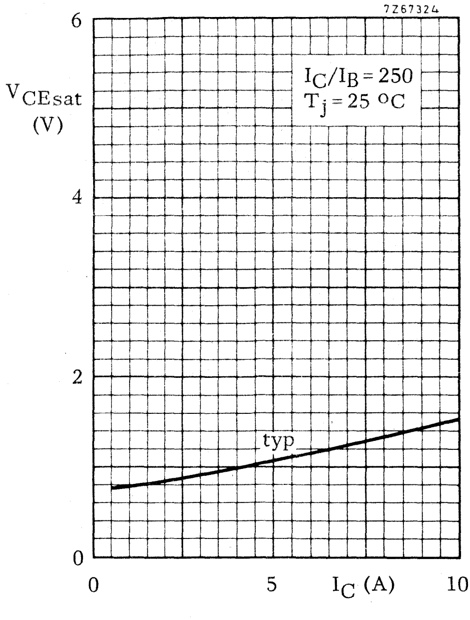

7Z67325
$P_{tot\,max}$
(%)
100
50
0
0
100
200
T_{mb} (°C)

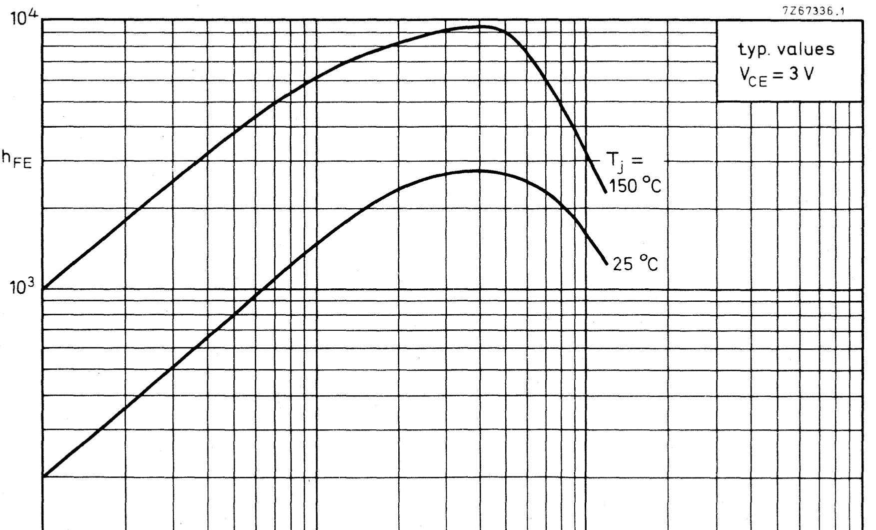

7Z67844
3
2
1
0
$Z_{th\,j\text{-}mb}$
(°C/W)
δ = 1
0,7
0,5
0,2
0,1
0, 05
0, 01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t_p (s)
10

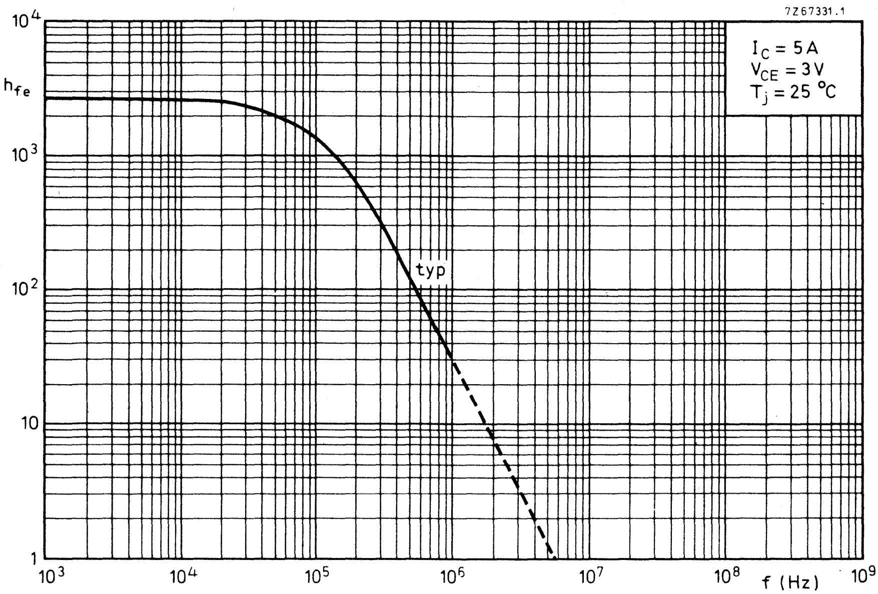

7Z67847
S.B. voltage multiplying factor at the $I_{C max}$ level
10^2
$M_{SB(I)}$
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,5
10
10^2
10^3
t_p (μs)
10^4


7Z67848
S.B. current multiplying factor at the $V_{CEO max}$ levels (60, 80, 100 V)
10^2
$M_{SB(V)}$
10
1
0,02
δ = 0,01
0,05
0,1
0,2
0,5
10
10^2
10^3
t_p (μs)
10^4


7Z67315
V_{CE} = 3 V
T_j = 25 °C
I_C
(A)
10
7,5
5
2,5
0
typ
1
1,5
2
2,5
V_{BE} (V)


7Z67324
I_C/I_B = 250
T_j = 25 °C
V_{CEsat}
(V)
6
4
2
0
typ
0
5
I_C (A)
10


7Z67336.1
typ. values
V_{CE} = 3 V
h_{FE}
10^4
10^3
10^2
T_j =
150 °C
25 °C
10^{-1}
1
10
10^2
I_C (A)


7Z67331.1
I_C = 5 A
V_{CE} = 3 V
T_j = 25 °C
h_{fe}
10^4
10^3
10^2
10
1
typ
10^3
10^4
10^5
10^6
10^7
10^8
10^9
f (Hz)

SILICON DARLINGTON POWER TRANSISTORS

P-N-P epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; TO-3 envelope. N-P-N complements are BDX67, BDX67A and BDX67B. Matched complementary pairs can be supplied.

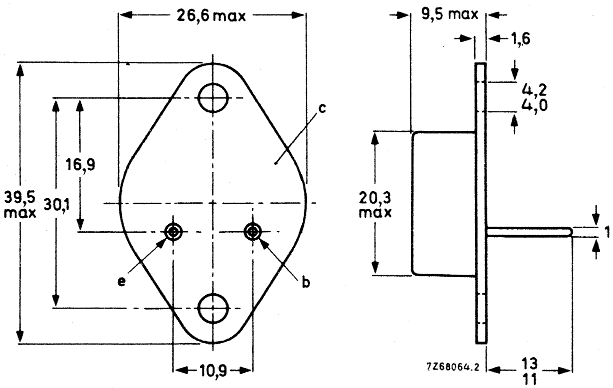
QUICK REFERENCE DATA

			BDX66	BDX66A	BDX66B	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Collector current (peak value)	$-I_{CM}$	max.		20		A
Total power dissipation up to $T_{mb} = 25\ ^{o}C$	P_{tot}	max.		150		W
Junction temperature	T_j	max.		200		^{o}C
D.C. current gain						
$-I_C = 1$ A; $-V_{CE} = 3$ V	h_{FE}	typ.		2000		
$-I_C = 10$ A; $-V_{CE} = 3$ V	h_{FE}	>		1000		
Cut-off frequency						
$-I_C = 5$ A; $-V_{CE} = 3$ V	f_{hfe}	typ.		60		kHz

MECHANICAL DATA Dimensions in mm

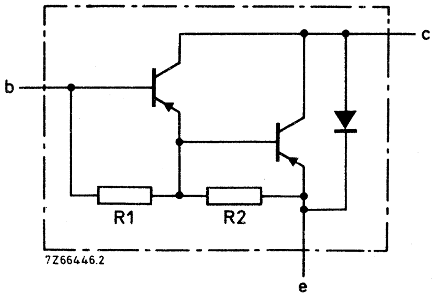
TO-3

Collector connected to envelope



For mounting instructions and accessories see section Accessories.

CIRCUIT DIAGRAM



R_1 typ. 3 kΩ
R_2 typ. 80 Ω

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

Voltage			BDX66	BDX66A	BDX66B	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V

Current				
Collector current (d.c.)	$-I_C$	max.	16	A
Collector current (peak value)	$-I_{CM}$	max.	20	A
Base current	$-I_B$	max.	250	mA

Power dissipation				
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	150	W

Temperature				
Storage temperature	T_{stg}		−55 to + 200	°C
Junction temperature*	T_j	max.	200	°C

THERMAL RESISTANCE *

From junction to mounting base	$R_{th\ j\text{-}mb}$ =	1,17	°C/W

→ * Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0; -V_{CB} = -V_{CBO\,max}$	$-I_{CBO}$	<	1	mA
$I_E = 0; -V_{CB} = 40$ V; $T_j = 200$ °C: BDX66 $I_E = 0; -V_{CB} = 50$ V; $T_j = 200$ °C: BDX66A $I_E = 0; -V_{CB} = 60$ V; $T_j = 200$ °C: BDX66B	$-I_{CBO}$	<	5	mA
$I_B = 0; -V_{CE} = 30$ V: BDX66 $I_B = 0; -V_{CE} = 40$ V: BDX66A $I_B = 0; -V_{CE} = 50$ V: BDX66B	$-I_{CEO}$	<	3	mA
Emitter cut-off current				
$I_C = 0; -V_{EB} = 5$ V	$-I_{EBO}$	<	5	mA
D.C. current gain [1]				
$-I_C = 1$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	2000	
$-I_C = 10$ A; $-V_{CE} = 3$ V	h_{FE}	>	1000	
$-I_C = 16$ A; $-V_{CE} = 3$ V	h_{FE}	typ.	1000	
Base-emitter voltage [1]				
$-I_C = 10$ A; $-V_{CE} = 3$ V	$-V_{BE}$	<	2,5	V
Collector-emitter saturation voltage [1]				
$-I_C = 10$ A; $-I_B = 40$ mA	$-V_{CEsat}$	<	2	V
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $-V_{CB} = 10$ V	C_c	typ.	300	pF
Cut-off frequency				
$-I_C = 5$ A; $-V_{CE} = 3$ V	f_{hfe}	typ.	60	kHz

[1] Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.

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

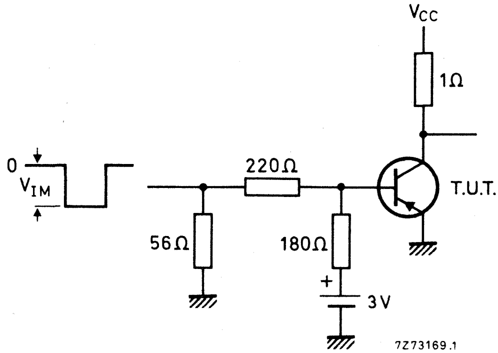
Switching times (between 10% and 90% levels)

$-I_{Con}$ = 10 A; $-I_{Bon}$ = I_{Boff} = 40 mA; V_{CC} = −12 V

Turn-on time	t_{on}	typ.	1	µs
Turn-off time	t_{off}	typ.	3,5	µs

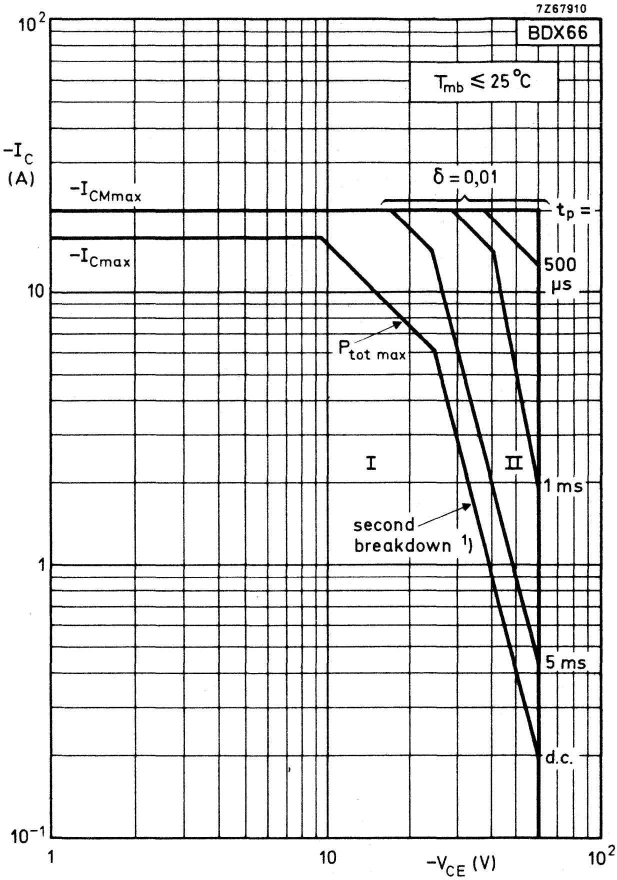
Test circuit

V_{IM} = 18 V
$t_r = t_f$ = 15 ns
t_p = 10 µs
T = 500 µs



Diode, forward voltage

I_F = 10 A	V_F	typ.	2	V

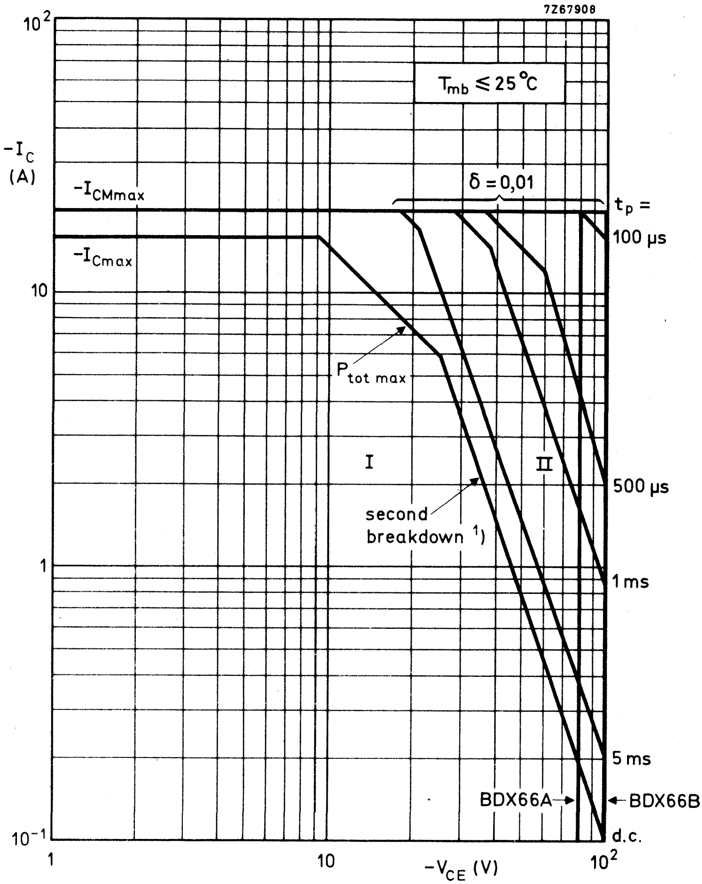


Safe Operating ARea with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

1) Independent of temperature.

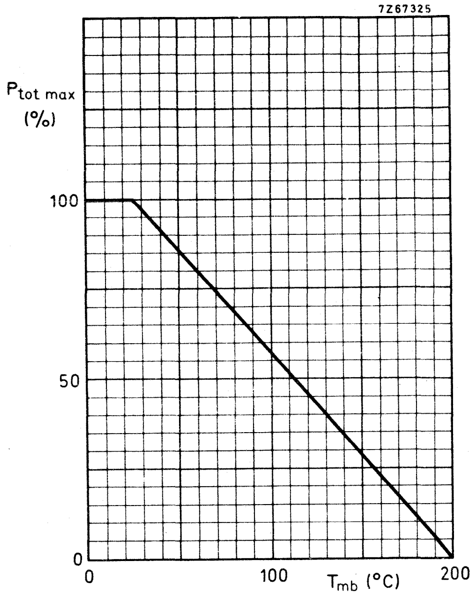


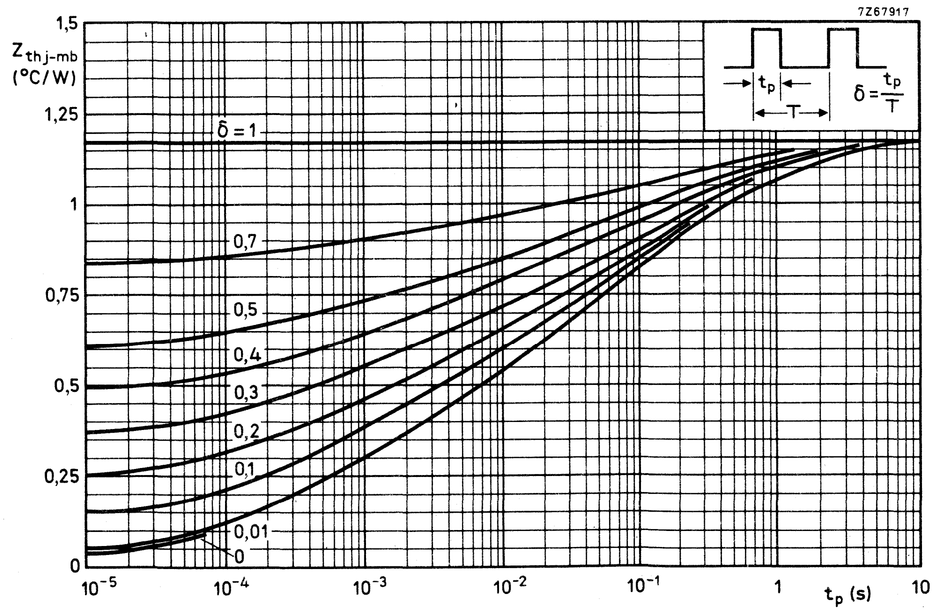
Safe Operating ARea with the transistor forward biased

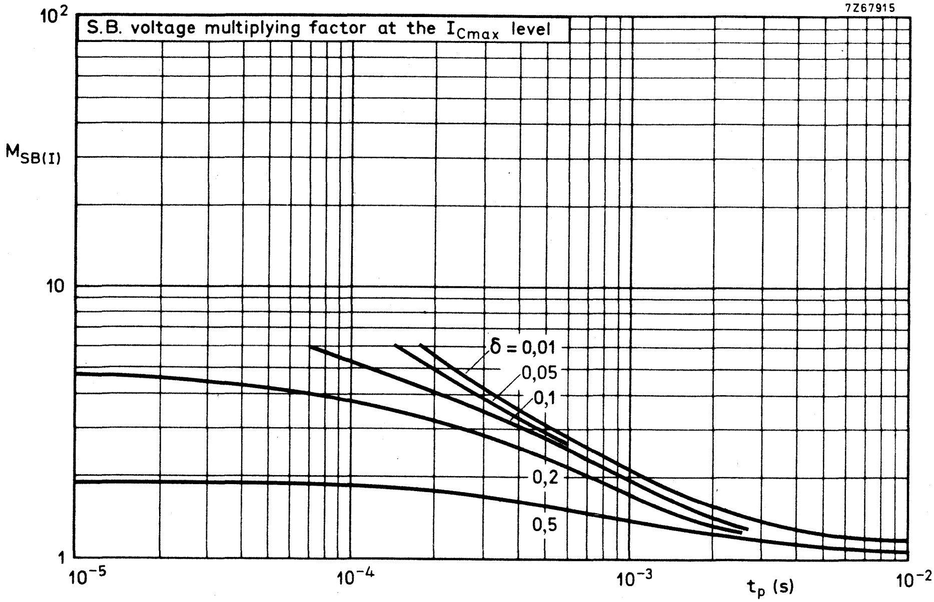
I Region of permissible d. c. operation

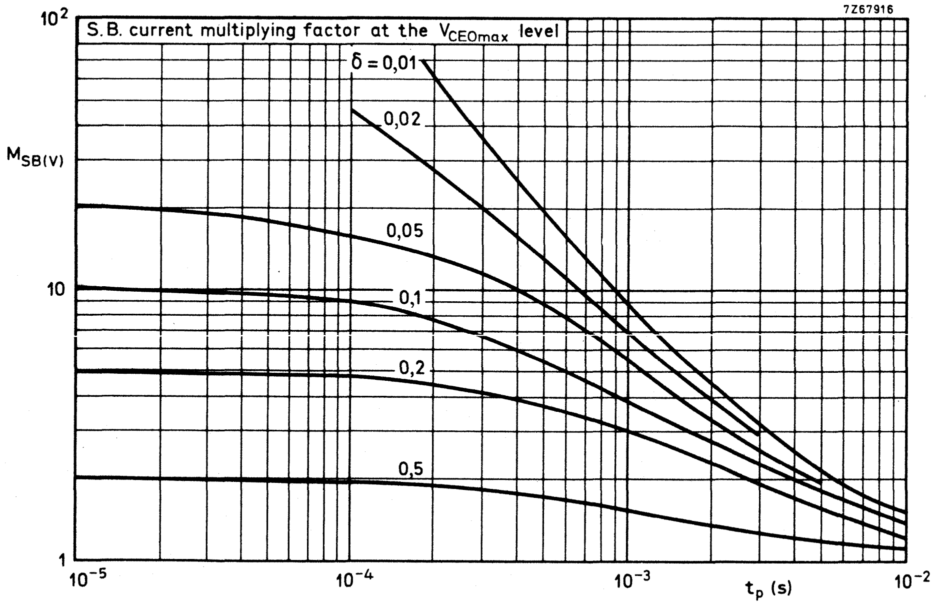
II Permissible extension for repetitive pulse operation

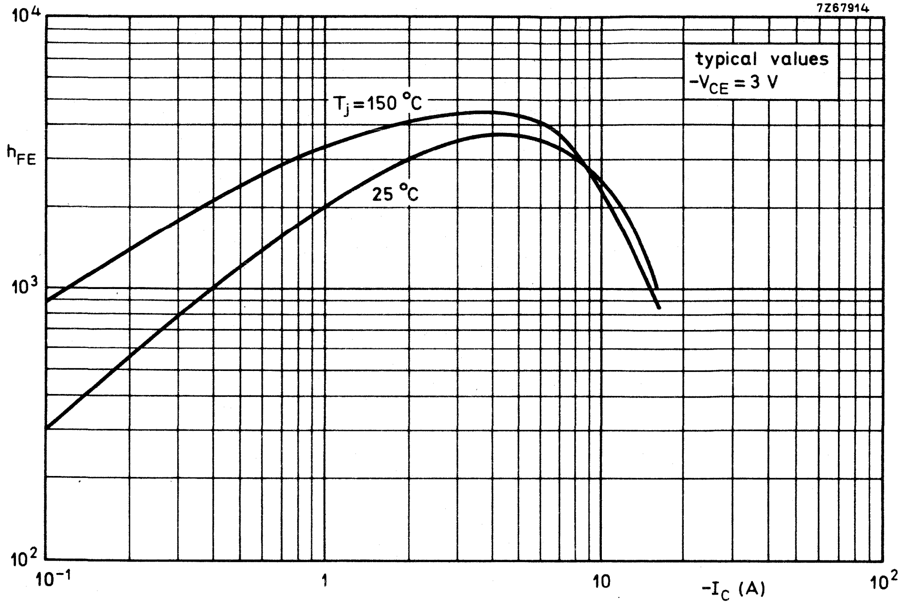
1) Independent of temperature.

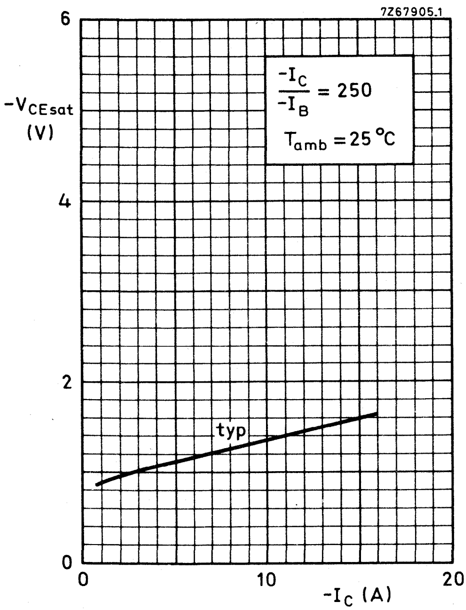

7Z67325
$P_{tot\ max}$ (%)
100
50
0
0
100
T_{mb} (°C)
200

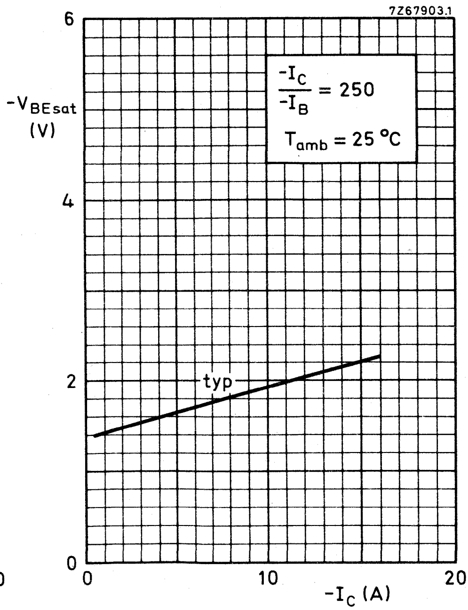

7Z67917
$Z_{th\ j\text{-}mb}$ (°C/W)
1,5
1,25
1
0,75
0,5
0,25
0
δ = 1
0,7
0,5
0,4
0,3
0,2
0,1
0,01
0
t_p
T
$\delta = \frac{t_p}{T}$
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t_p (s)
10

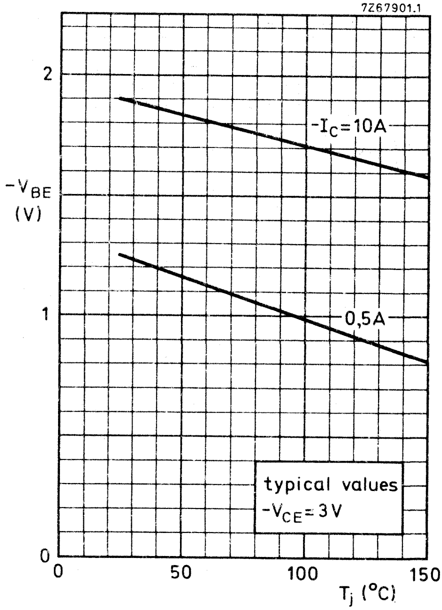

7Z67915
S.B. voltage multiplying factor at the I_{Cmax} level
10^2
$M_{SB(I)}$
10
1
δ = 0,01
0,05
0,1
0,2
0,5
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

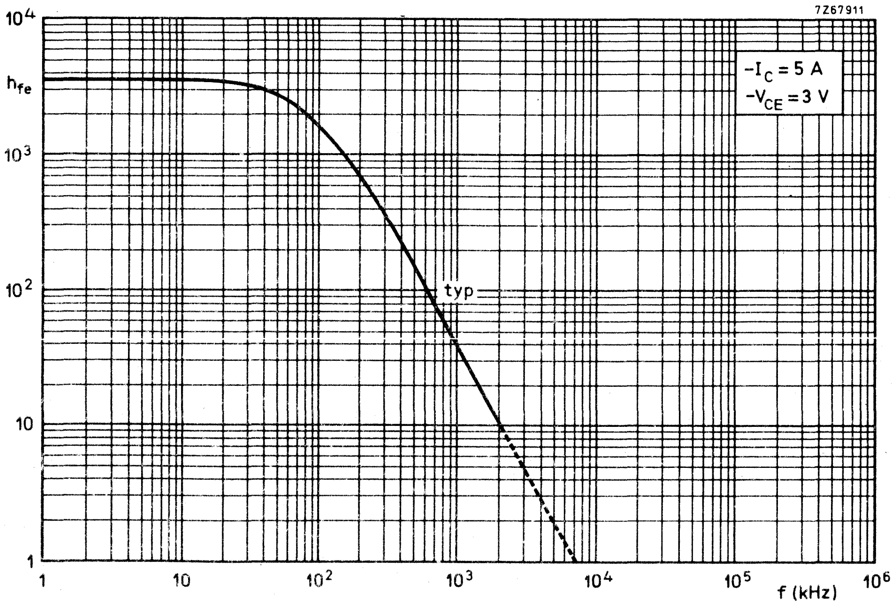

7Z67916
S.B. current multiplying factor at the V_{CEOmax} level
10^2
$M_{SB(V)}$
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,5
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}


7Z67914
typical values
$-V_{CE} = 3$ V
$T_j = 150$ °C
25 °C
h_{FE}
10^4
10^3
10^2
10^{-1}
1
10
10^2
$-I_C$ (A)


7Z67905.1
$\frac{-I_C}{-I_B} = 250$
$T_{amb} = 25$ °C
$-V_{CEsat}$ (V)
typ
6
4
2
0
10
20
$-I_C$ (A)


7Z67903.1
$\frac{-I_C}{-I_B} = 250$
$T_{amb} = 25$ °C
$-V_{BEsat}$ (V)
typ
6
4
2
0
10
20
$-I_C$ (A)


7Z67901.1
2
1
0
−V_BE
(V)
−I_C = 10A
0,5A
typical values
−V_CE = 3 V
0
50
100
150
T_j (°C)


7Z67911
10^4
h_fe
10^3
10^2
10
1
−I_C = 5 A
−V_CE = 3 V
typ
1
10
10^2
10^3
10^4
10^5
10^6
f (kHz)

SILICON DARLINGTON POWER TRANSISTORS

N-P-N epitaxial base transistors in monolithic Darlington circuit for audio output stages and general amplifier and switching applications; TO-3 envelope. P-N-P complements are BDX66, BDX66A and BDX66B. Matched complementary pairs can be supplied.

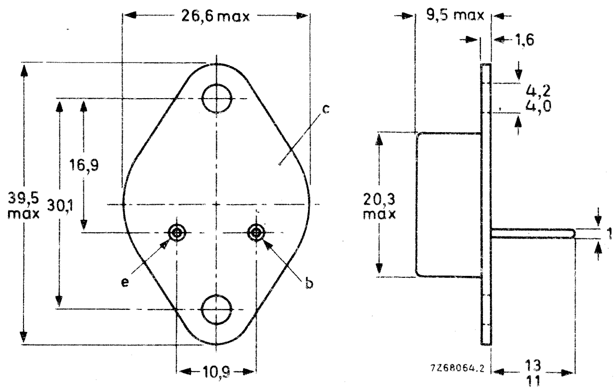
QUICK REFERENCE DATA

			BDX67	BDX67A	BDX67B	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Collector current (peak value)	I_{CM}	max.		20		A
Total power dissipation up to $T_{mb} = 25\,^{o}C$	P_{tot}	max.		150		W
Junction temperature	T_j	max.		200		^{o}C
D.C. current gain						
$I_C = 1$ A; $V_{CE} = 3$ V	h_{FE}	typ.		1350		
$I_C = 10$ A; $V_{CE} = 3$ V	h_{FE}	>		1000		
Cut-off frequency						
$I_C = 5$ A; $V_{CE} = 3$ V	f_{hfe}	typ.		50		kHz

MECHANICAL DATA Dimensions in mm

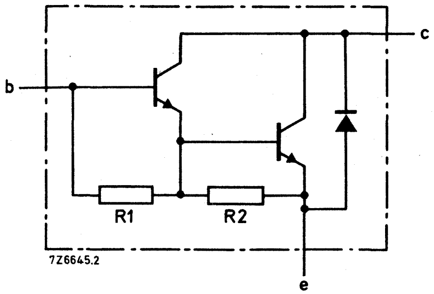
TO-3

Collector connected to envelope



For mounting accessories and instructions see section Accessories.

CIRCUIT DIAGRAM



R_1 typ. 3 kΩ
R_2 typ. 80 Ω

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

			BDX67	BDX67A	BDX67B	
Voltages						
Collector-base voltage (open emitter)	V_{CBO}	max.	80	100	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V
Currents						
Collector current (d.c.)	I_C	max.		16		A
Collector current (peak value)	I_{CM}	max.		20		A
Base current (d.c.)	I_B	max.		250		mA
Power dissipation						
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		150		W
Temperatures						
Storage temperature	T_{stg}			−55 to +200		°C
Junction temperature*	T_j	max.		200		°C

THERMAL RESISTANCE*

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1, 17	°C/W

→ * Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

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

Collector cut-off current				
$I_E = 0$ [1]	I_{CBO}	<	1	mA
$I_E = 0$; $V_{CB} = 40$ V; $T_j = 200\ ^oC$: BDX67 $I_E = 0$; $V_{CB} = 50$ V; $T_j = 200\ ^oC$: BDX67A $I_E = 0$; $V_{CB} = 60$ V; $T_j = 200\ ^oC$: BDX67B	I_{CBO}	<	5	mA
$I_B = 0$; $V_{CE} = 30$ V : BDX67 $I_B = 0$; $V_{CE} = 40$ V : BDX67A $I_B = 0$; $V_{CE} = 50$ V : BDX67B	I_{CEO}	<	3	mA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	5	mA
D.C. current gain [2]				
$I_C = 1$ A; $V_{CE} = 3$ V	h_{FE}	typ.	1350	
$I_C = 10$ A; $V_{CE} = 3$ V	h_{FE}	>	1000	
$I_C = 16$ A; $V_{CE} = 3$ V	h_{FE}	typ.	850	
Base-emitter voltage [2]				
$I_C = 10$ A; $V_{CE} = 3$ V	V_{BE}	<	2,5	V
Collector-emitter saturation voltage [2]				
$I_C = 10$ A; $I_B = 40$ mA	V_{CEsat}	<	2	V
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	300	pF
Cut-off frequency				
$I_C = 5$ A; $V_{CE} = 3$ V	f_{hfe}	typ.	50	kHz
Turn-off breakdown energy with inductive load				
$-I_{Boff} = 0$; $I_{Con} = 7,8$ A; $t_p = 1$ ms; T = 100 ms; see circuit on page 4	$E_{(BR)}$	>	150	mJ

1) $V_{CBO} = 60$ V for BDX67, 80 V for BDX67A, 100 V for BDX67B.

2) Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.

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

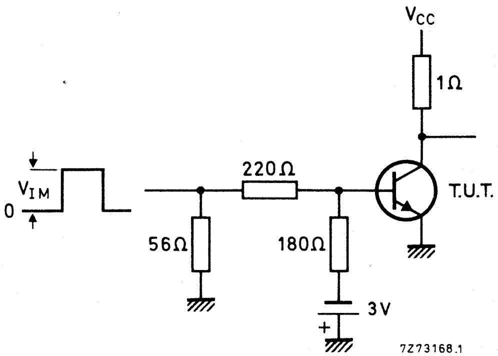
Switching times (between 10% and 90% levels)

I_{Con} = 10 A; I_{Bon} = $-I_{Boff}$ = 40 mA; V_{CC} = 12 V

Turn-on time	t_{on}	typ.	1	μs
Turn-off time	t_{off}	typ.	3,5	μs

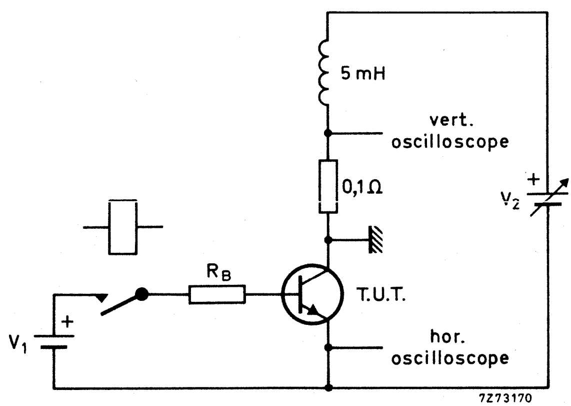
Test circuit

V_{IM} = 18 V
$t_r = t_f$ = 15 ns
t_p = 10 μs
T = 500 μs

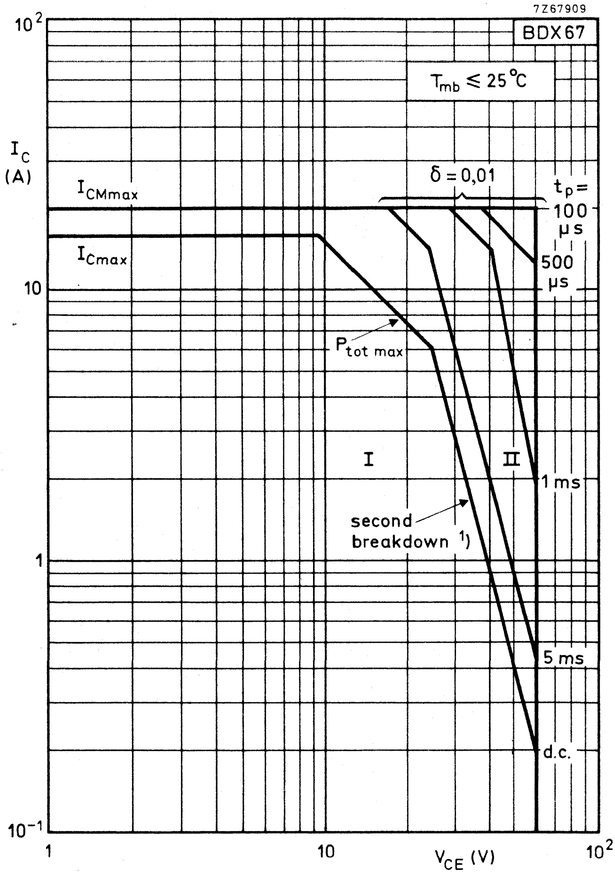


Diode, forward voltage

I_F = 10 A	V_F	typ.	2	V



Test circuit for turn-off breakdown energy (page 3)
V_1 = 12 V; R_B = 270 Ω



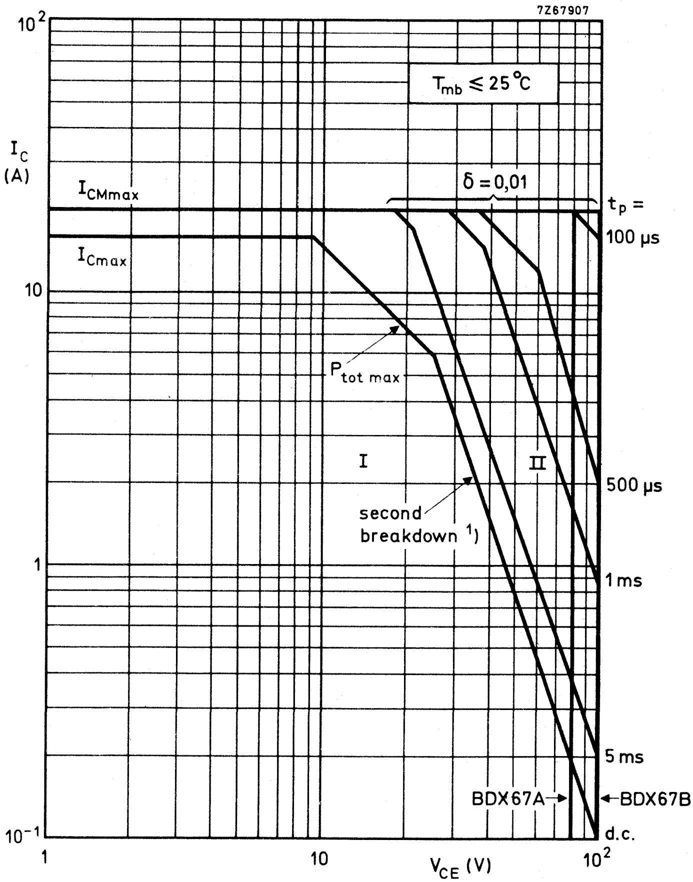
Safe Operating ARea with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

---

1) Independent of temperature.



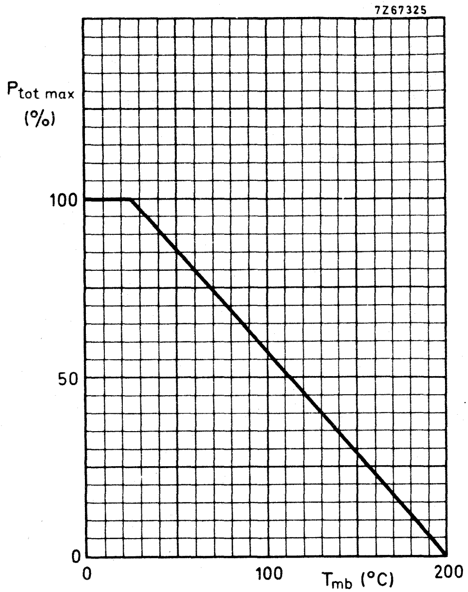
Safe Operating ARea with the transistor forward biased

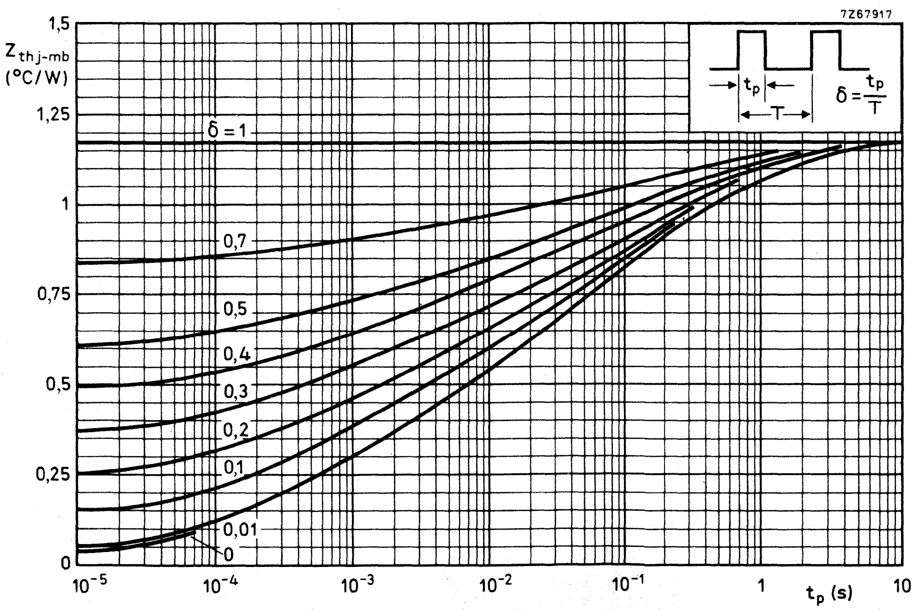
I Region of permissible d.c. operation

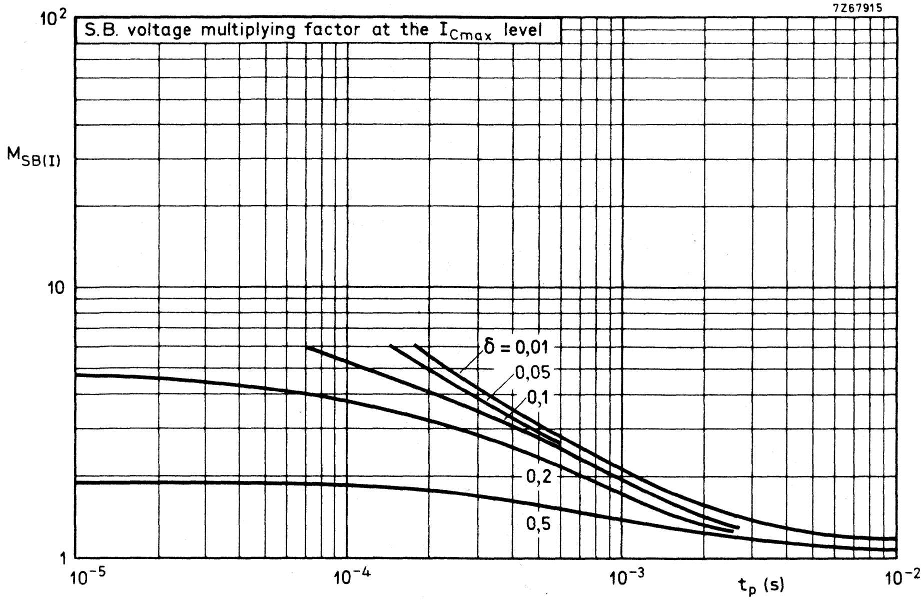
II Permissible extension for repetitive pulse operation

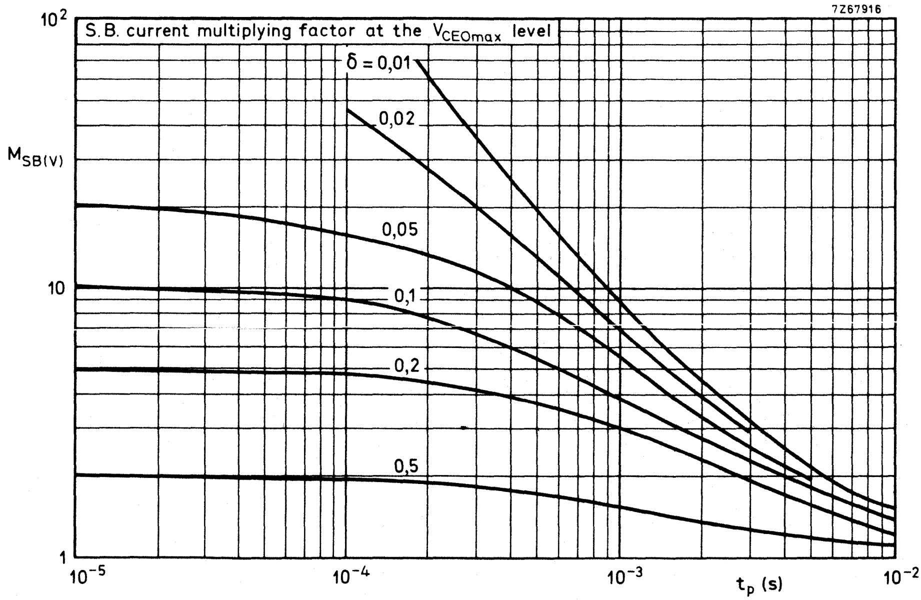
---

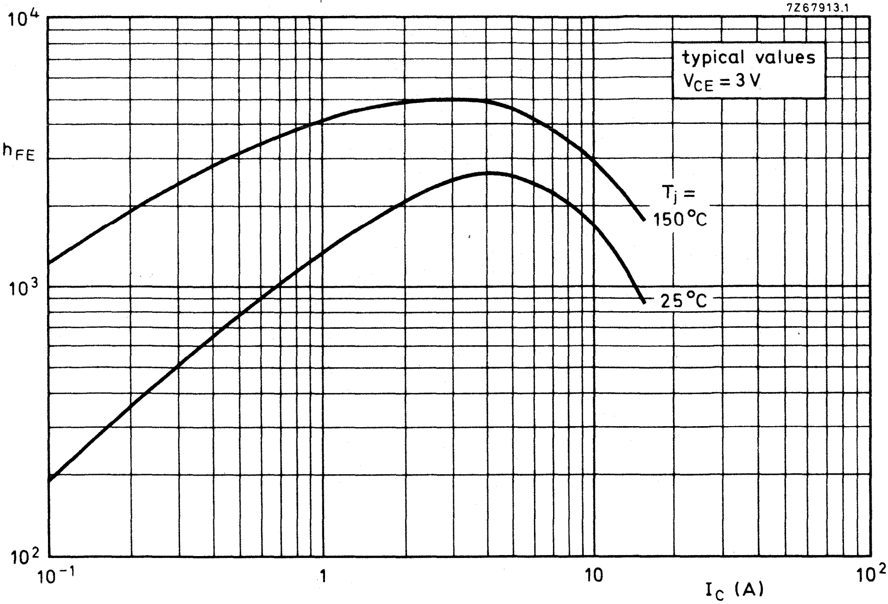
[1]) Independent of temperature.

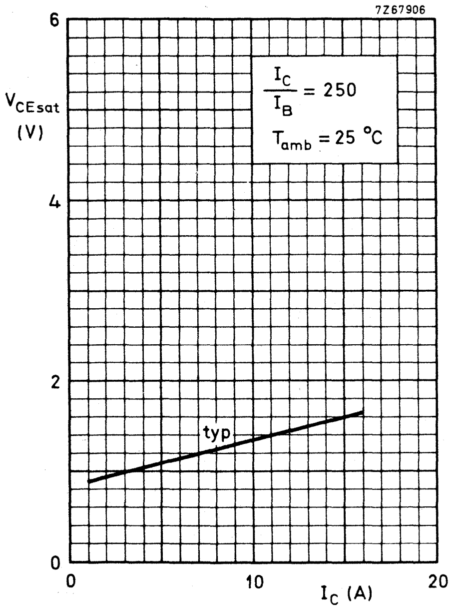

7Z67325
$P_{tot\ max}$
(%)
100
50
0
0
100
T_{mb} (°C)
200

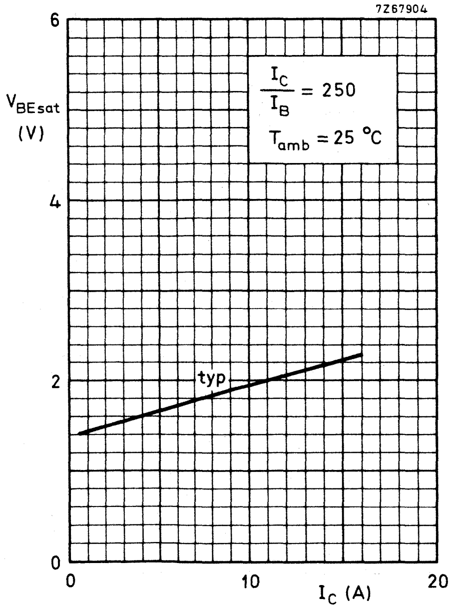

7Z67917
1,5
$Z_{th\ j\text{-}mb}$
(°C/W)
1,25
1
0,75
0,5
0,25
0
δ = 1
0,7
0,5
0,4
0,3
0,2
0,1
0,01
0
t_p
T
$\delta = \frac{t_p}{T}$
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t_p (s)
10

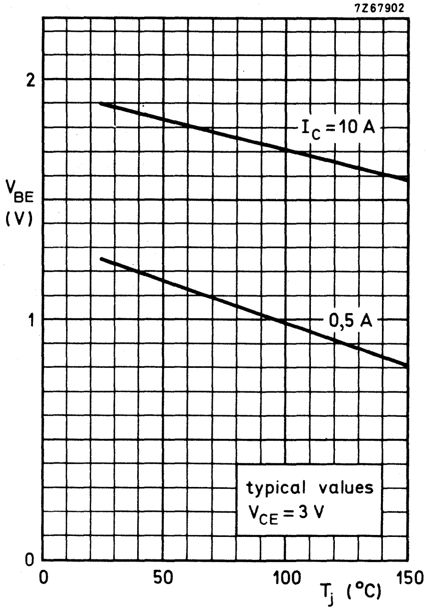

7Z67915
S.B. voltage multiplying factor at the I_{Cmax} level
10^2
$M_{SB(I)}$
10
1
δ = 0,01
0,05
0,1
0,2
0,5
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

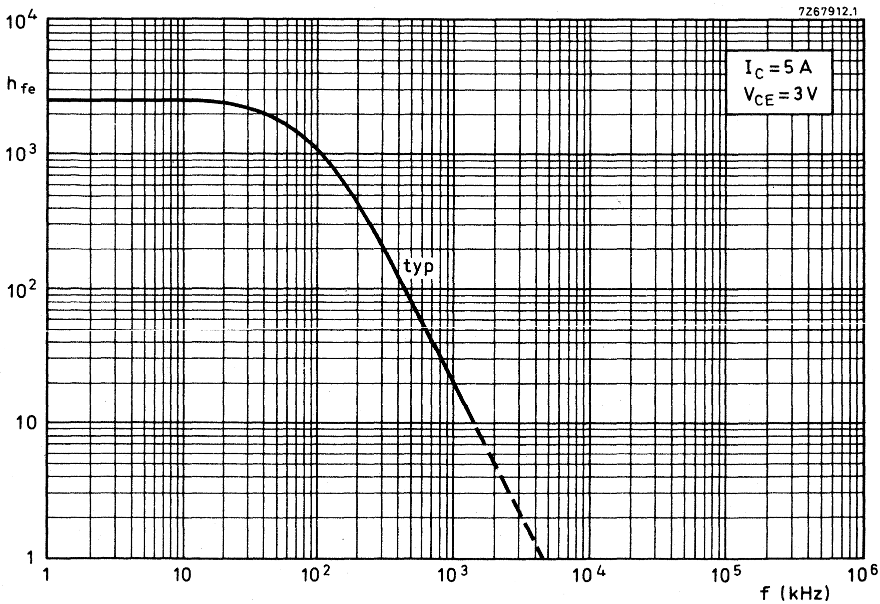

7Z67916
S.B. current multiplying factor at the V_{CEOmax} level
10^2
$M_{SB(V)}$
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,5
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}


7Z67913.1
typical values
$V_{CE} = 3$ V
h_{FE}
$T_j =$ 150 °C
25 °C
10^4
10^3
10^2
10^{-1}
1
10
10^2
I_C (A)


7Z67906
$\frac{I_C}{I_B} = 250$
$T_{amb} = 25$ °C
V_{CEsat} (V)
typ
6
4
2
0
0
10
20
I_C (A)


7Z67904
$\frac{I_C}{I_B} = 250$
$T_{amb} = 25$ °C
V_{BEsat} (V)
typ
6
4
2
0
0
10
20
I_C (A)


7Z67902
2
1
0
V_{BE}
(V)
$I_C = 10$ A
0,5 A
typical values
$V_{CE} = 3$ V
0
50
100
150
T_j (°C)


7Z67912.1
10^4
h_{fe}
10^3
10^2
10
1
$I_C = 5$ A
$V_{CE} = 3$ V
typ
1
10
10^2
10^3
10^4
10^5
10^6
f (kHz)

SILICON EPITAXIAL-BASE POWER TRANSISTOR

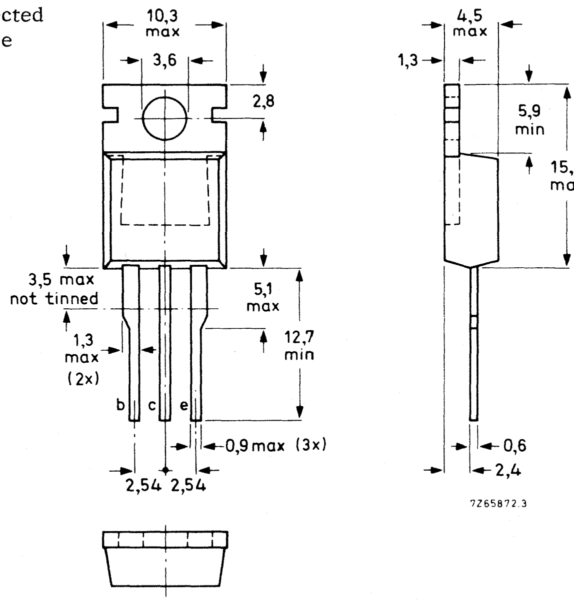
N-P-N transistor in a plastic envelope, intended for industrial amplifier and switching applications. P-N-P complement is BDX78.

QUICK REFERENCE DATA				
Collector-emitter voltage (open base)	V_{CEO}	max.	80	V
Collector current (d.c.)	I_C	max.	8	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60	W
D.C. current gain 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	kHz

MECHANICAL DATA Dimensions in mm

TO-220

Collector connected to mounting base



For mounting instructions and accessories see section Accessories.

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

Voltage

Collector-base voltage (open emitter)	V_{CBO}	max.	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	80	V
Emitter-base voltage (open collector)	V_{EBO}	max.	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

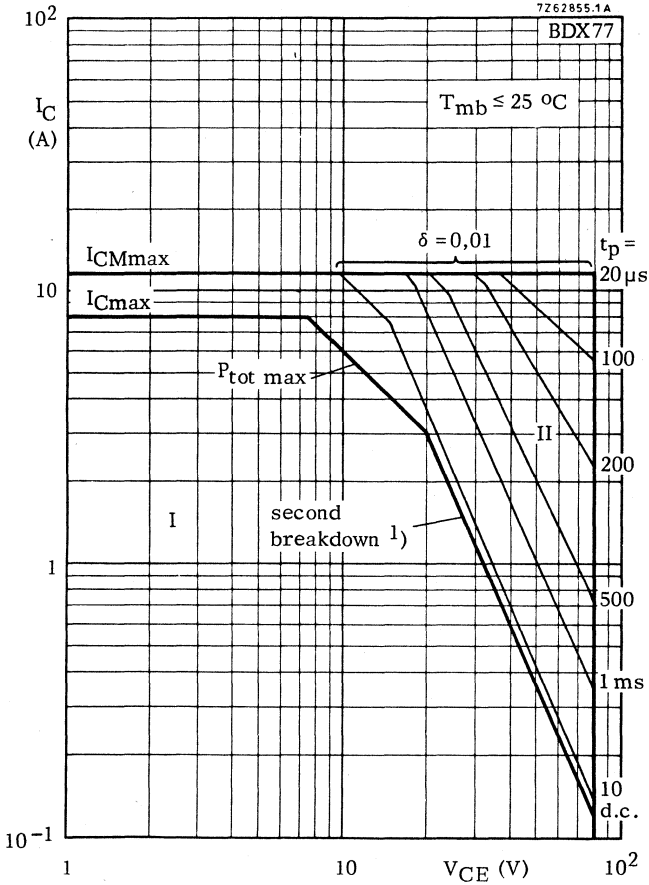
THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,08	$^oC/W$
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	$^oC/W$

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]				
$I_C = 2$ A; $V_{CE} = 2$ V	h_{FE}	>	30	
Cut-off frequency				
$I_C = 0,3$ A; $V_{CE} = 3$ V	f_{hfe}	>	25	kHz
Transition frequency at f = 1 MHz				
$-I_E = 0,3$ A; $V_{CB} = 3$ V	f_T	>	3	MHz

[1]) Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.



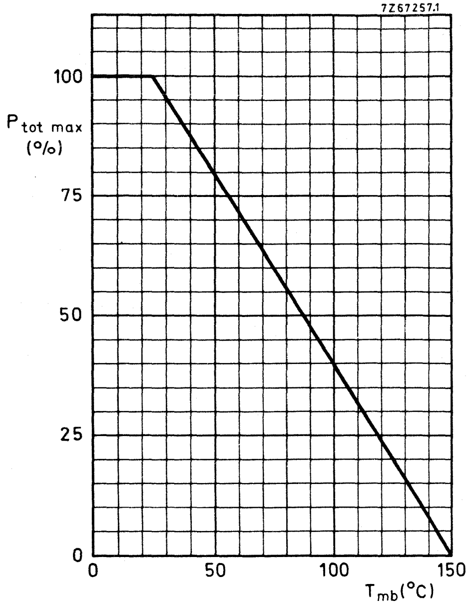
Safe Operating Area with the transistor forward biased

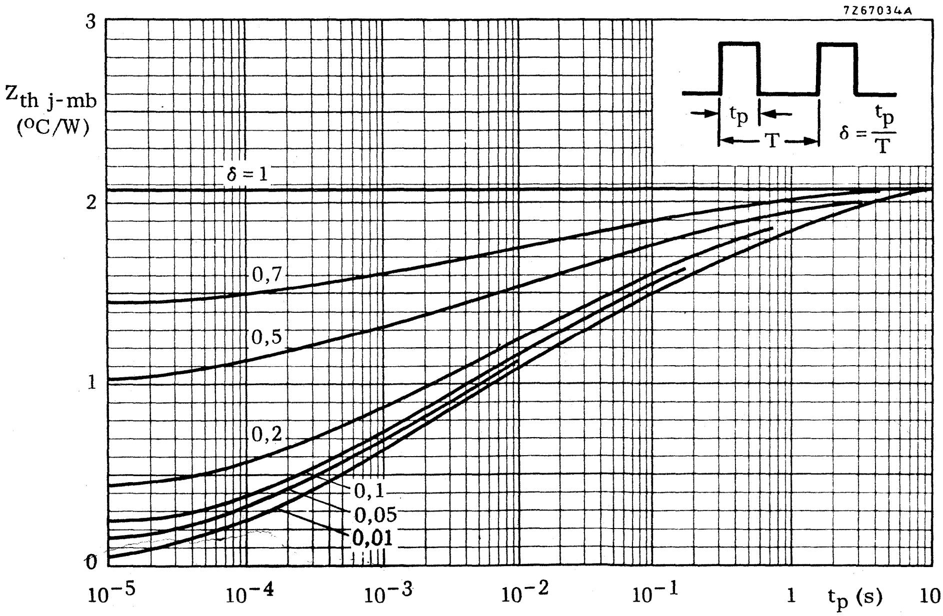
I Region of permissible d.c. operation

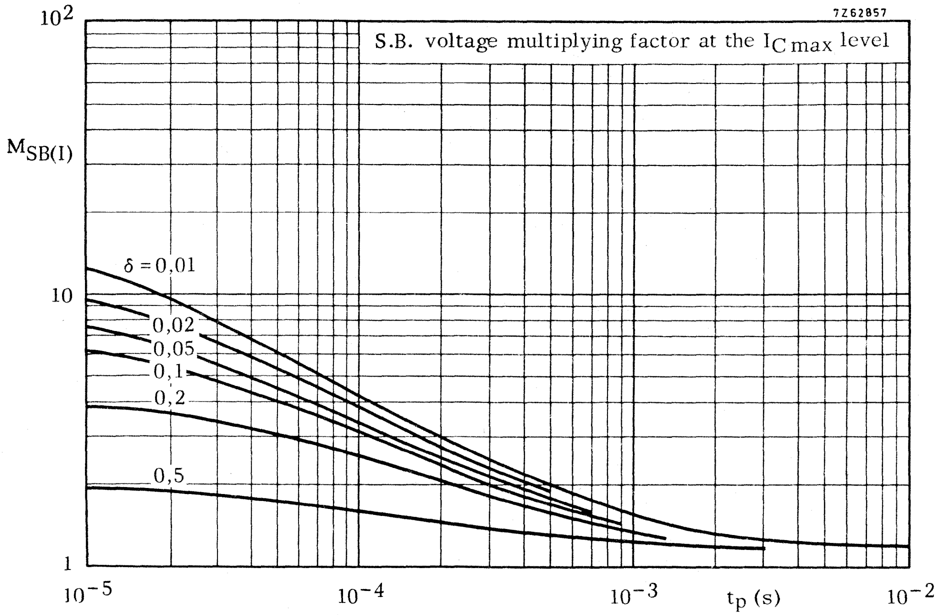
II Permissible extension for repetitive pulse operation

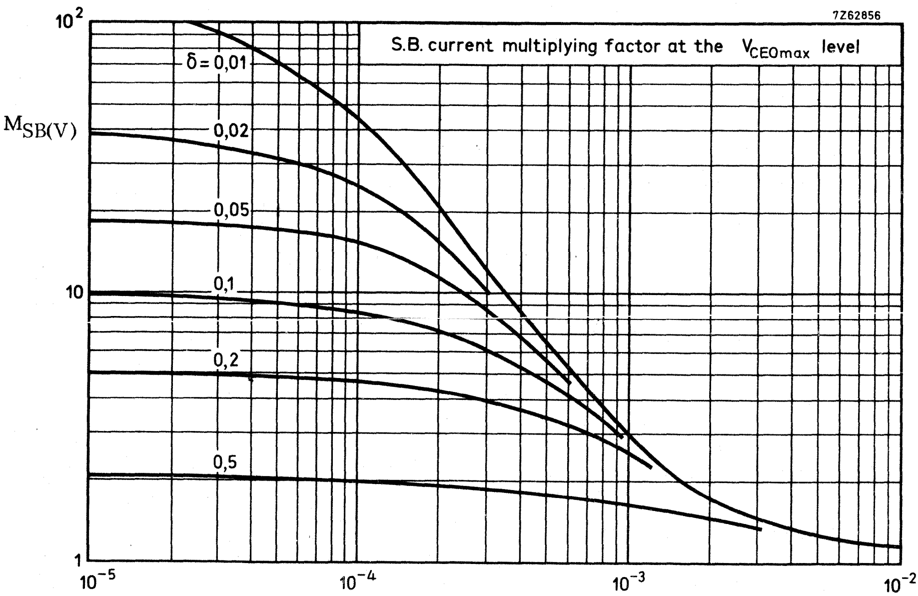
---

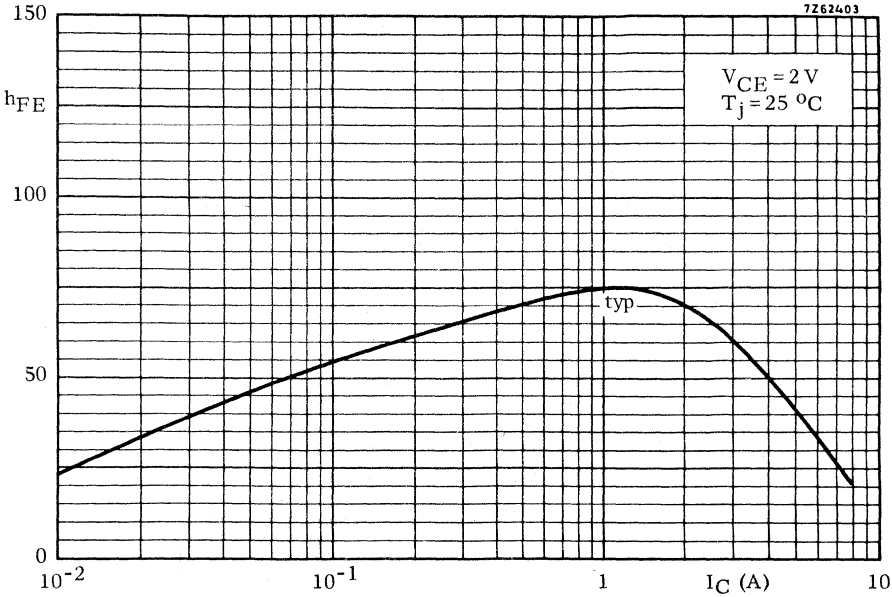
1) Independent of temperature.

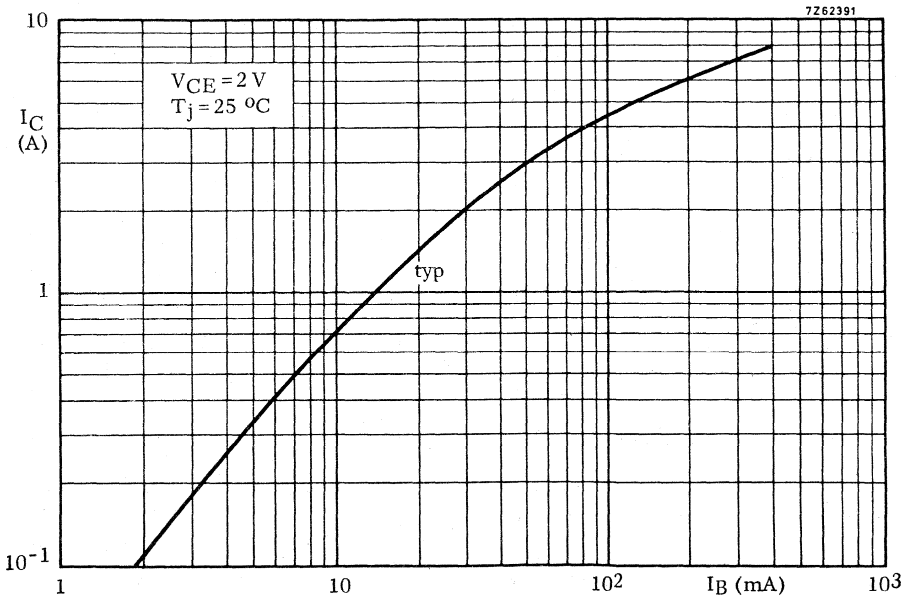

7Z67257.1
100
$P_{tot\ max}$
(%)
75
50
25
0
0
50
100
150
T_{mb}(°C)

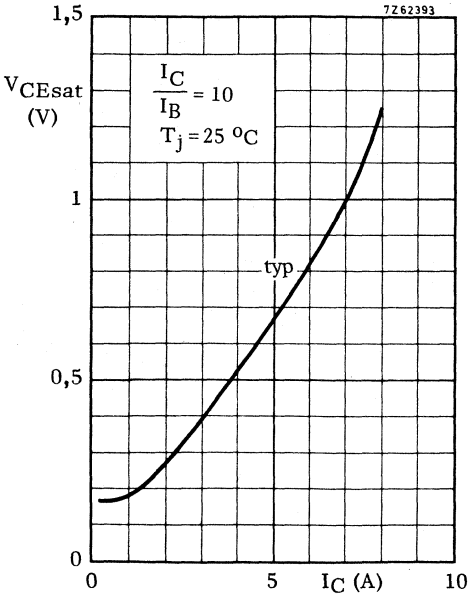

7Z67034A
3
$Z_{th\ j\text{-}mb}$
(°C/W)
2
1
0
δ = 1
0,7
0,5
0,2
0,1
0,05
0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t_p (s)
10

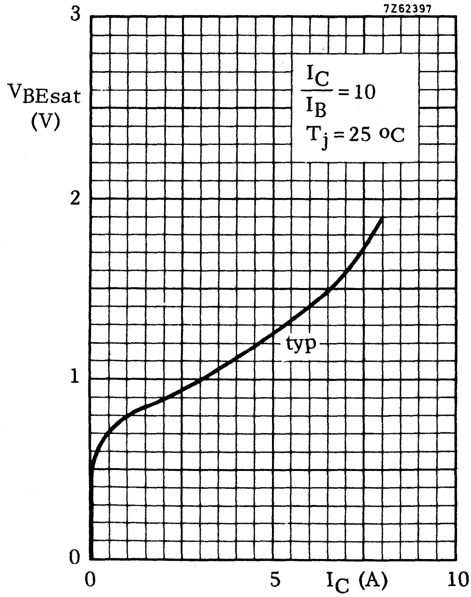

7Z62857
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,5
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

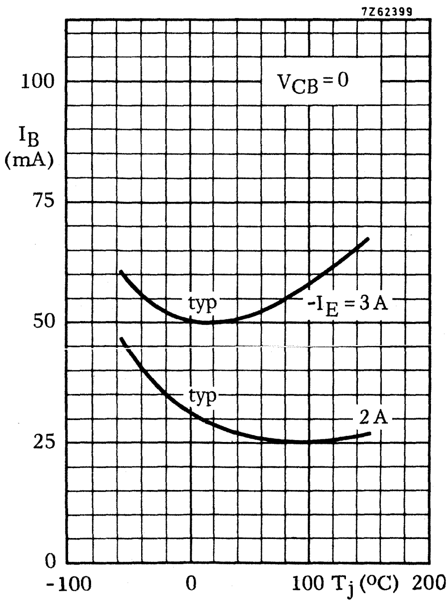

7Z62856
S.B. current multiplying factor at the V_{CEOmax} level
$M_{SB(V)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,5
10^{-5}
10^{-4}
10^{-3}
10^{-2}

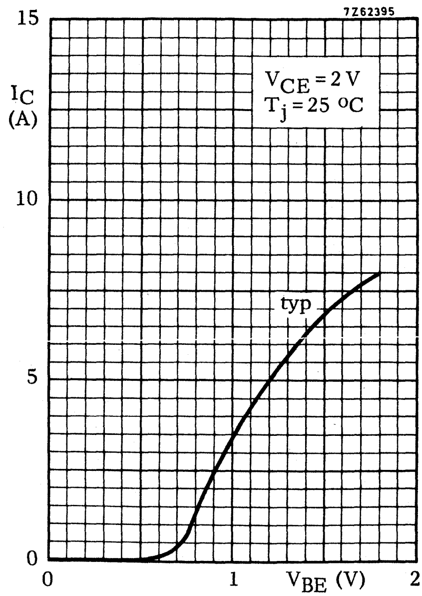

7Z62403
150
100
50
0
h_{FE}
$V_{CE} = 2\ V$
$T_j = 25\ ^oC$
typ
10^{-2}
10^{-1}
1
I_C (A)
10

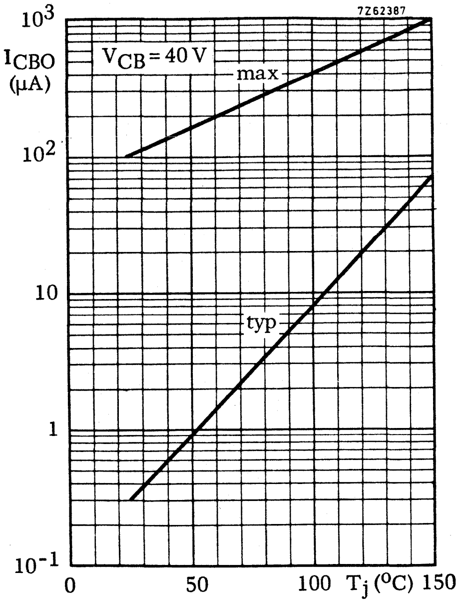

7Z62391
10
1
10^{-1}
I_C
(A)
$V_{CE} = 2\ V$
$T_j = 25\ ^oC$
typ
1
10
10^2
I_B (mA)
10^3

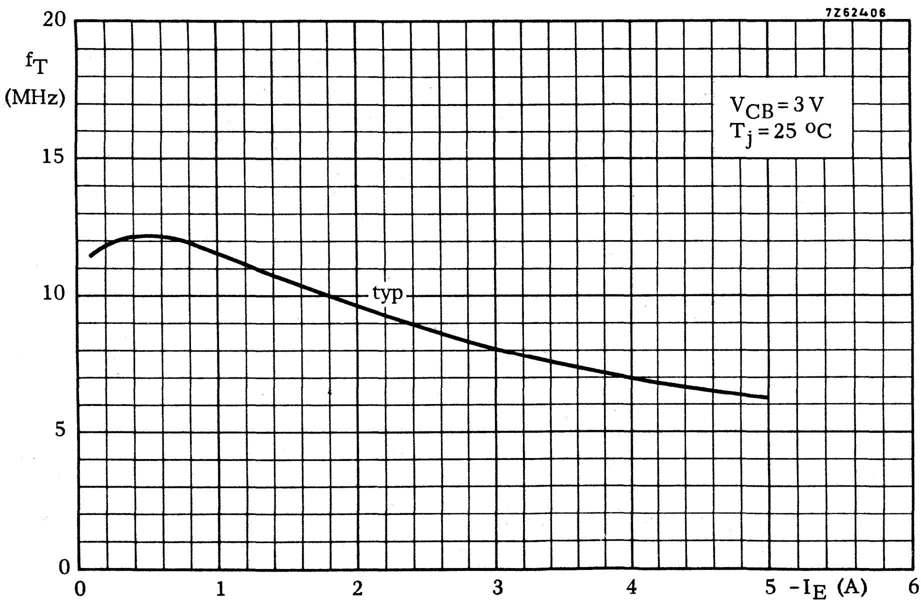

7Z62393
1,5
1
0,5
0
V_{CEsat} (V)
$\frac{I_C}{I_B} = 10$
$T_j = 25\ ^oC$
typ
0
5
I_C (A)
10


7Z62397
3
2
1
0
V_{BEsat} (V)
$\frac{I_C}{I_B} = 10$
$T_j = 25\ ^oC$
typ
0
5
I_C (A)
10


7Z62399
100
75
50
25
0
I_B (mA)
$V_{CB} = 0$
typ
$-I_E = 3$ A
typ
2 A
-100
0
100
T_j (^oC)
200


7Z62395
15
10
5
0
I_C (A)
$V_{CE} = 2$ V
$T_j = 25\ ^oC$
typ
0
1
V_{BE} (V)
2


7Z62387
I_{CBO} (μA)
V_{CB} = 40 V
max
typ
10^3
10^2
10
1
10^{-1}
0
50
100
T_j (°C)
150


7Z62406
f_T (MHz)
V_{CB} = 3 V
T_j = 25 °C
typ
20
15
10
5
0
0
1
2
3
4
5
$-I_E$ (A)
6

SILICON EPITAXIAL-BASE POWER TRANSISTOR

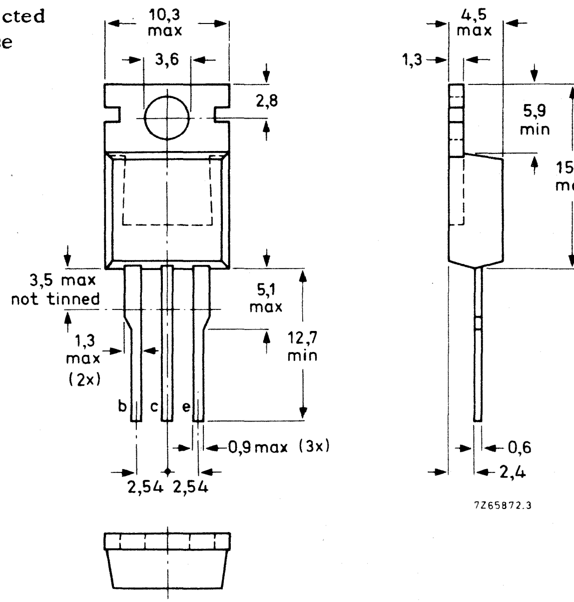
P-N-P transistor in a plastic envelope, intended for industrial amplifier and switching applications. N-P-N complement BDX77.

QUICK REFERENCE DATA				
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	80	V
Collector current (d.c.)	$-I_C$	max.	8	A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	60	W
D.C. current gain $-I_C$ = 2 A; $-V_{CE}$ = 2 V	h_{FE}	>	30	
Cut-off frequency $-I_C$ = 0,3 A; $-V_{CE}$ = 3 V	f_{hfe}	>	25	kHz

MECHANICAL DATA Dimensions in mm

TO-220

Collector connected to mounting base



For mounting instructions and accessories see section Accessories.

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

Voltage

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	80	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	80	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	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

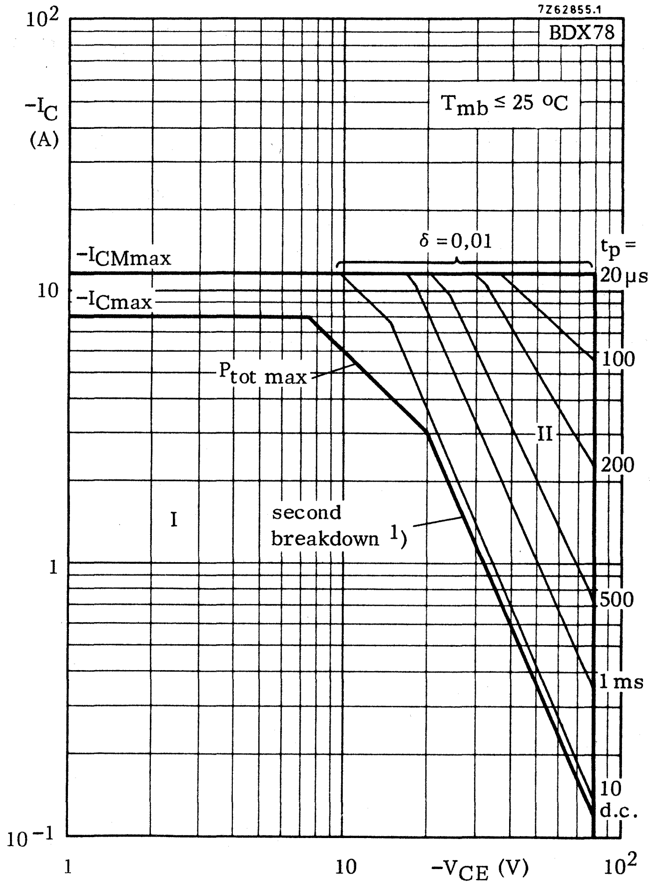
THERMAL RESISTANCE

From junction to mounting base	$R_{th\,j\text{-}mb}$	=	2,08	°C/W
From junction to mounting base in free air	$R_{th\,j\text{-}a}$	=	70	°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]				
$-I_C = 2$ A; $-V_{CE} = 2$ V	h_{FE}	>	30	
Cut-off frequency				
$-I_C = 0,3$ A; $-V_{CE} = 3$ V	f_{hfe}	>	25	kHz
Transition frequency at f = 1 MHz				
$I_E = 0,3$ A; $-V_{CB} = 3$ V	f_T	>	3	MHz

[1]) Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.



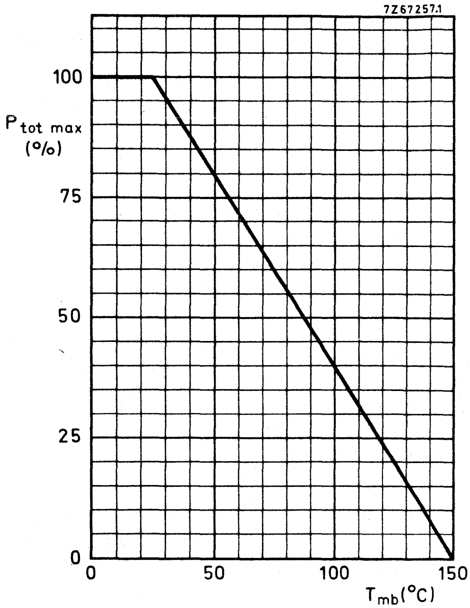
Safe Operating Area with the transistor forward biased

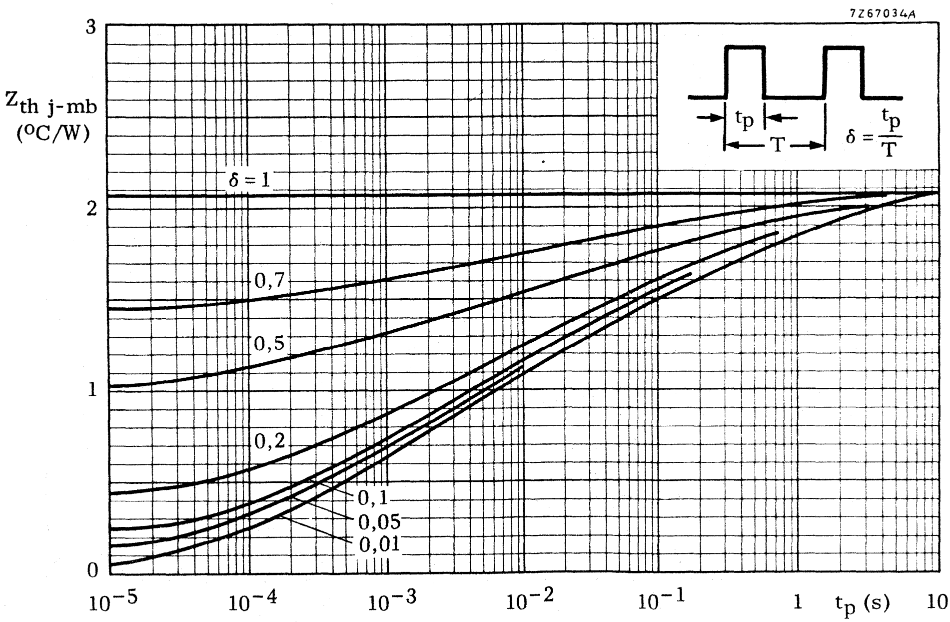
I Region of permissible d.c. operation

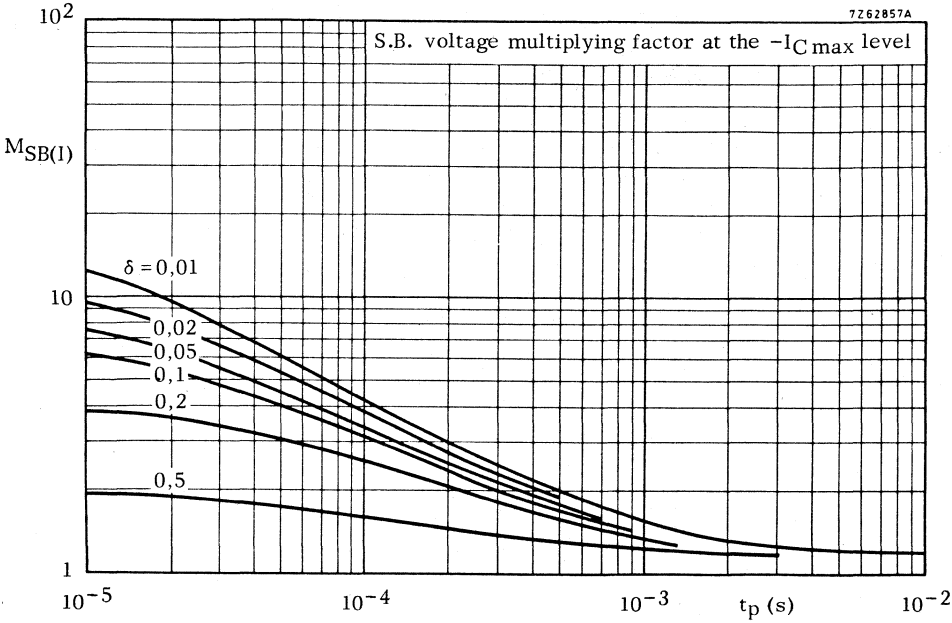
II Permissible extension for repetitive pulse operation

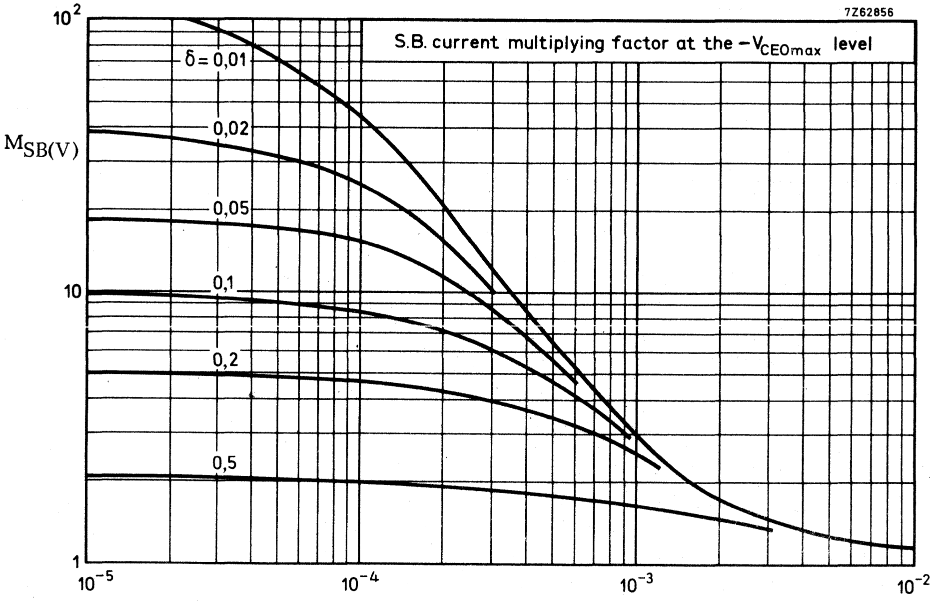
---

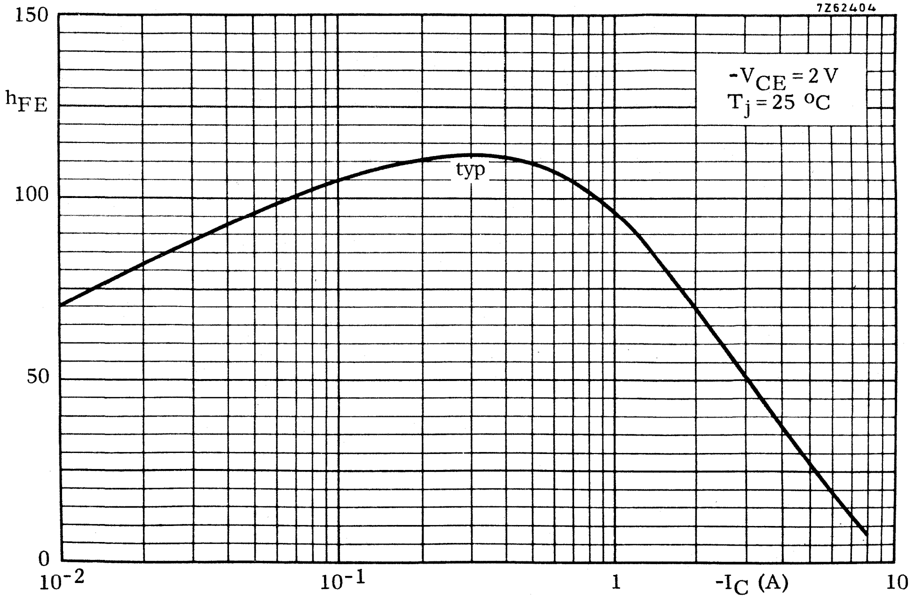
[1]) Independent of temperature.

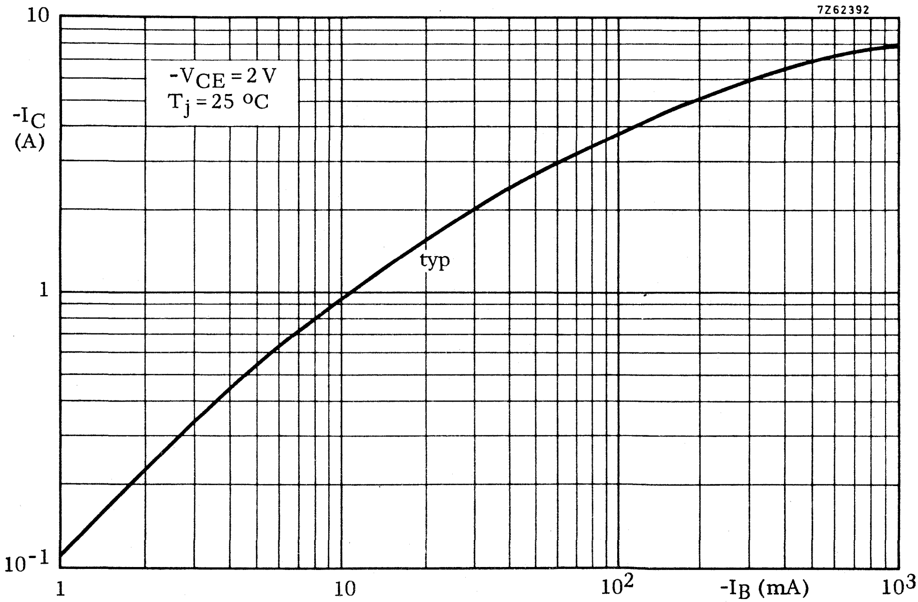

7Z67257.1
100
P tot max
(%)
75
50
25
0
0
50
100
150
Tmb(°C)

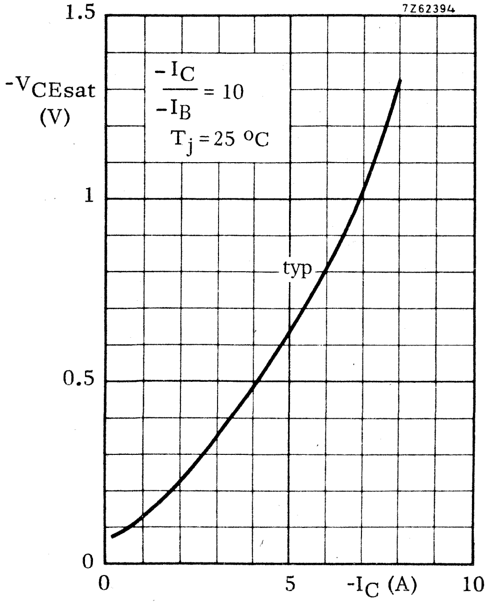

7Z67034A
3
Zth j-mb
(°C/W)
2
1
0
δ = 1
0,7
0,5
0,2
0,1
0,05
0,01
tp
T
δ = tp/T
10−5
10−4
10−3
10−2
10−1
1
tp (s)
10

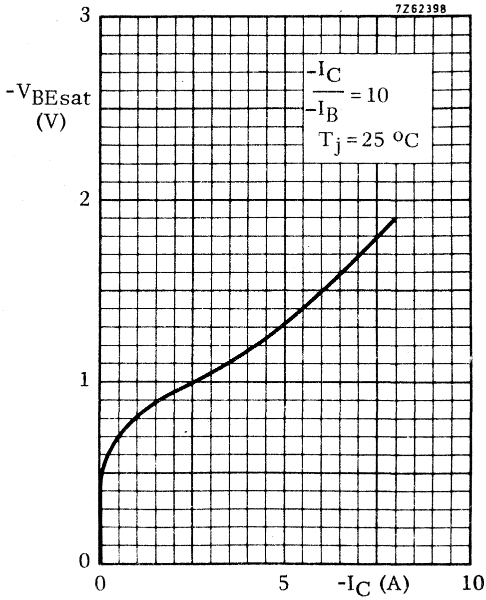

7Z62857A
S.B. voltage multiplying factor at the $-I_{C\,max}$ level
10^2
$M_{SB(I)}$
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,5
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}

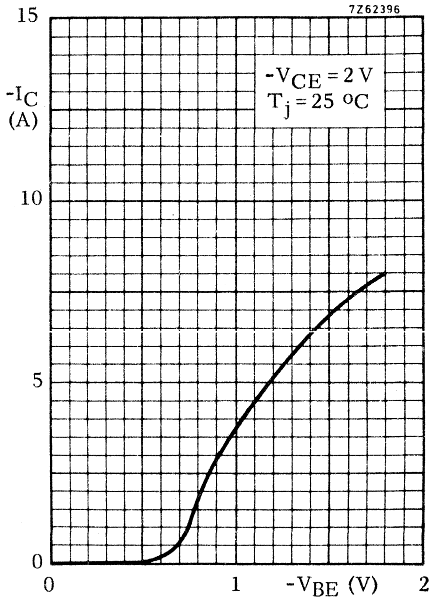

7Z62856
S.B. current multiplying factor at the $-V_{CEOmax}$ level
10^2
$M_{SB(V)}$
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,5
10^{-5}
10^{-4}
10^{-3}
10^{-2}

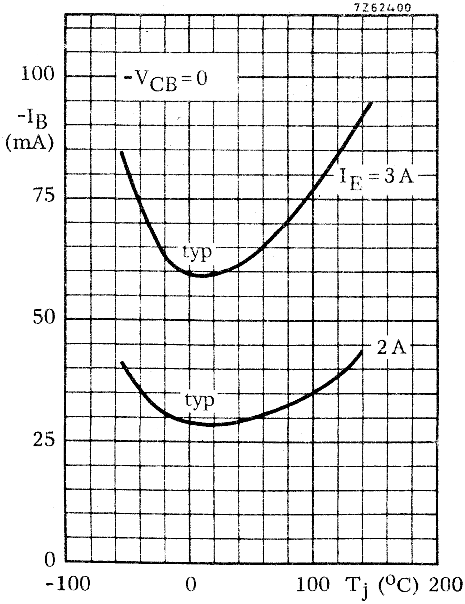

7Z62404
150
h_{FE}
100
50
0
$-V_{CE} = 2$ V
$T_j = 25$ °C
typ
10^{-2}
10^{-1}
1
$-I_C$ (A)
10

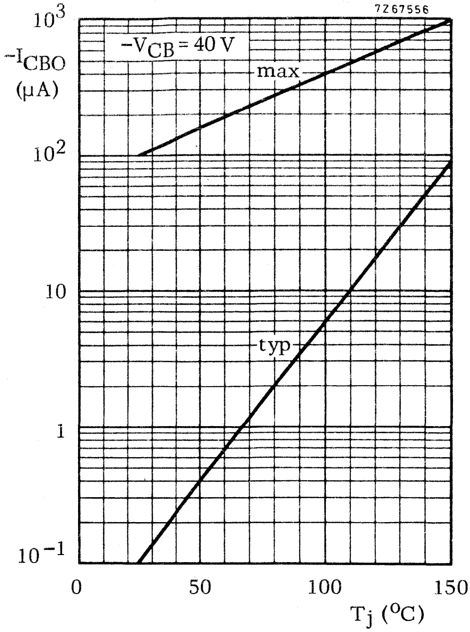

7Z62392
10
$-I_C$
(A)
1
10^{-1}
$-V_{CE} = 2$ V
$T_j = 25$ °C
typ
1
10
10^2
$-I_B$ (mA)
10^3

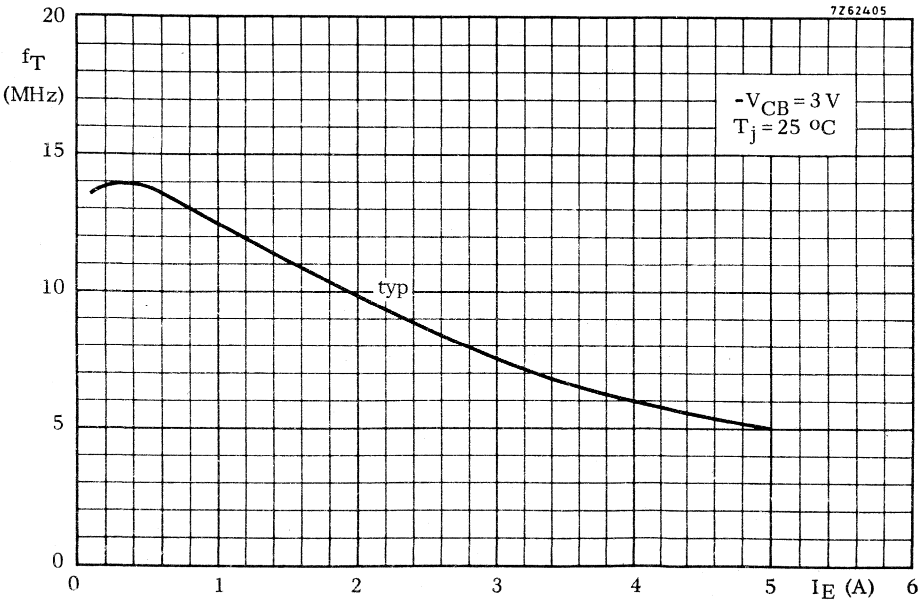

7Z62394
1.5
-V_CEsat
(V)
-I_C / -I_B = 10
T_j = 25 °C
1
typ
0.5
0
0
5
-I_C (A)
10


7Z62398
3
-V_BEsat
(V)
-I_C / -I_B = 10
T_j = 25 °C
2
1
0
0
5
-I_C (A)
10


7Z62396
15
-I_C
(A)
-V_CE = 2 V
T_j = 25 °C
10
5
0
0
1
-V_BE (V)
2


7Z62400
100
75
50
25
0
-IB
(mA)
-VCB = 0
IE = 3 A
typ
2 A
typ
-100
0
100
Tj (°C)
200


7Z67556
10^3
-ICBO
(μA)
-VCB = 40 V
max
10^2
10
typ
1
10^-1
0
50
100
150
Tj (°C)


7Z62405
20
fT
(MHz)
15
10
5
0
-VCB = 3 V
Tj = 25 °C
typ
0
1
2
3
4
5
IE (A)
6

SILICON POWER TRANSISTORS

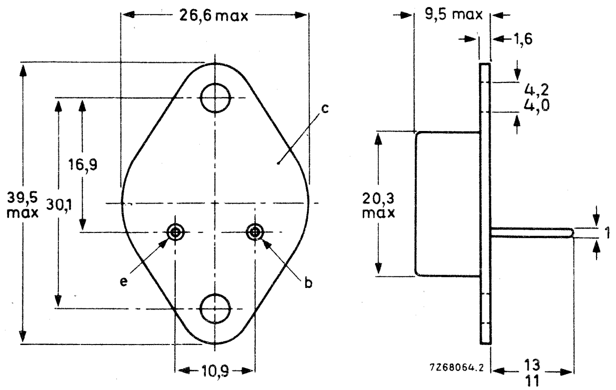
N-P-N transistors in TO-3 envelope for audio output stages and general amplifier and switching applications. P-N-P complements are BDX92, BDX94 and BDX96.

QUICK REFERENCE DATA

			BDX91	BDX93	BDX95	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Collector current (peak value)	I_{CM}	max.		12		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		90		W
Junction temperature	T_j	max.		200		°C
D.C. current gain I_C = 3 A; V_{CE} = 2 V	h_{FE}	>		20		
Transition frequency I_C = 1 A; V_{CE} = 10 V	f_T	>		4		MHz

MECHANICAL DATA Dimensions in mm

TO-3
Collector connected to envelope



For mounting instructions and accessories see section Accessories.

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

			BDX91	BDX93	BDX95	
Voltages						
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	80	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V
Currents						
Collector current (d.c.)	I_C	max.		8		A
Collector current (peak value)	I_{CM}	max.		12		A
Power dissipation						
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		90		W
Temperatures						
Storage temperature	T_{stg}			−65 to +200		°C
Junction temperature	T_j	max.		200		°C

THERMAL RESISTANCE

From junction to mounting base $R_{th\ j\text{-}mb}$ = 1,94 °C/W

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

Collector cut-off current				
$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	0,1	mA
$I_E = 0$; $V_{CB} = 30$ V; $T_j = 200\ ^oC$: BDX91 $I_E = 0$; $V_{CB} = 40$ V; $T_j = 200\ ^oC$: BDX93 $I_E = 0$; $V_{CB} = 50$ V; $T_j = 200\ ^oC$: BDX95	I_{CBO}	<	2	mA
$I_B = 0$; $V_{CE} = V_{CEOmax}$	I_{CEO}	<	1	mA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	1	mA
D.C. current gain [1]				
$I_C = 3$ A; $V_{CE} = 2$ V	h_{FE}	>	20	
$I_C = 5$ A; $V_{CE} = 2$ V	h_{FE}	>	10	
Base-emitter voltage [1]				
$I_C = 3$ A; $V_{CE} = 2$ V	V_{BE}	<	1,4	V
Collector-emitter saturation voltage [1]				
$I_C = 3$ A; $I_B = 0,3$ A	V_{CEsat}	<	0,8	V
$I_C = 5$ A; $I_B = 1$ A	V_{CEsat}	<	1	V
Base-emitter saturation voltage [1]				
$I_C = 3$ A; $I_B = 0,3$ A	V_{BEsat}	<	1,5	V
$I_C = 5$ A; $I_B = 1$ A	V_{BEsat}	<	2	V
Small-signal current gain at f = 1 kHz				
$I_C = 0,5$ A; $V_{CE} = 10$ V	h_{fe}	>	40	
Transition frequency				
$I_C = 1$ A; $V_{CE} = 10$ V	f_T	>	4	MHz

[1]) Measured under pulse conditions: $t_p < 300\ \mu s$, $\delta < 2\%$.

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

Switching times (between 10% and 90% levels)

$I_{Con} = 3$ A; $I_{Bon} = -I_{Boff} = 0,3$ A; $V_{CC} = 30$ V

Turn-on time	t_{on}	<	1 µs
Turn-off-time	t_{off}	<	2 µs

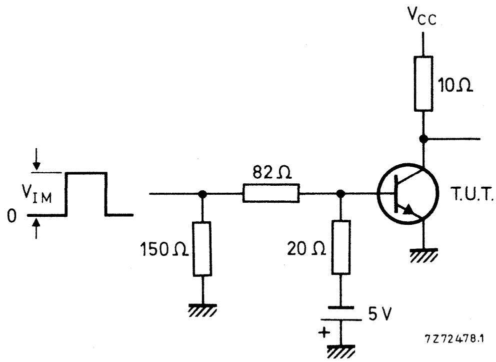
Test circuit

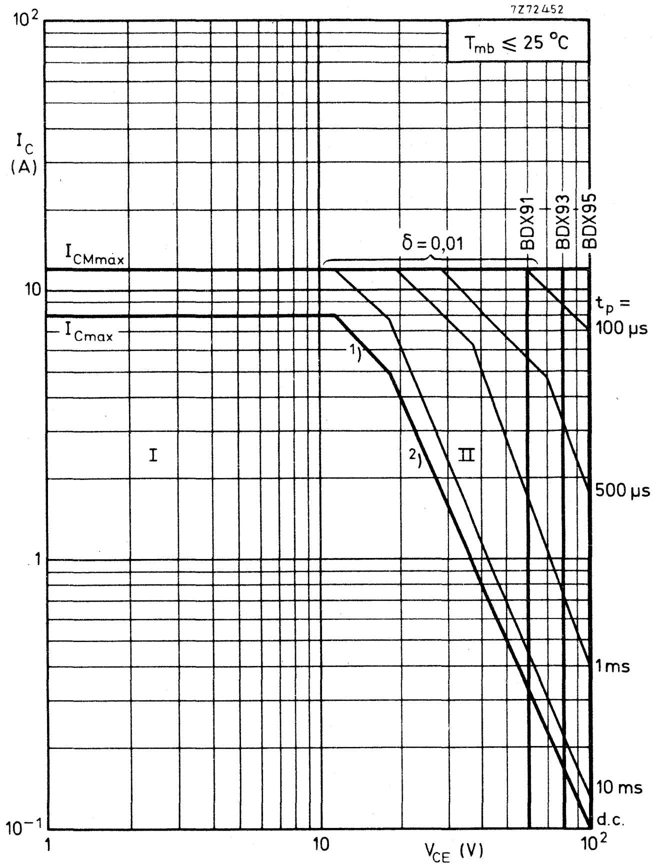
$V_{IM} = 55$ V

$t_r = t_f = 15$ ns

$t_p = 10$ µs

$T = 500$ µs





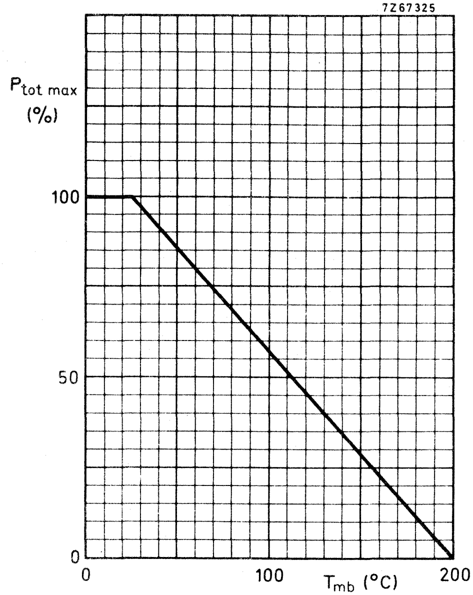
Safe Operating ARea with the transistor forward biased

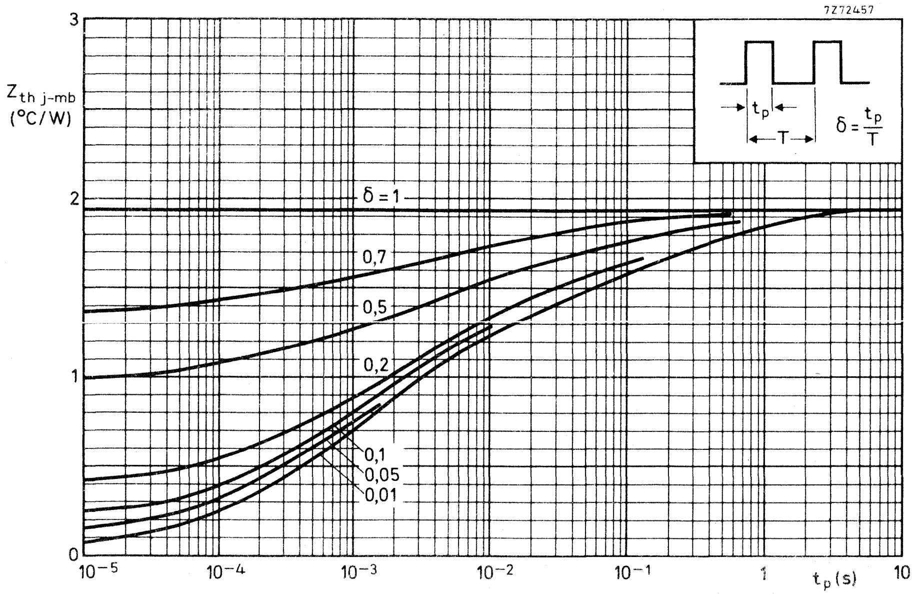
I Region of permissible d.c. operation

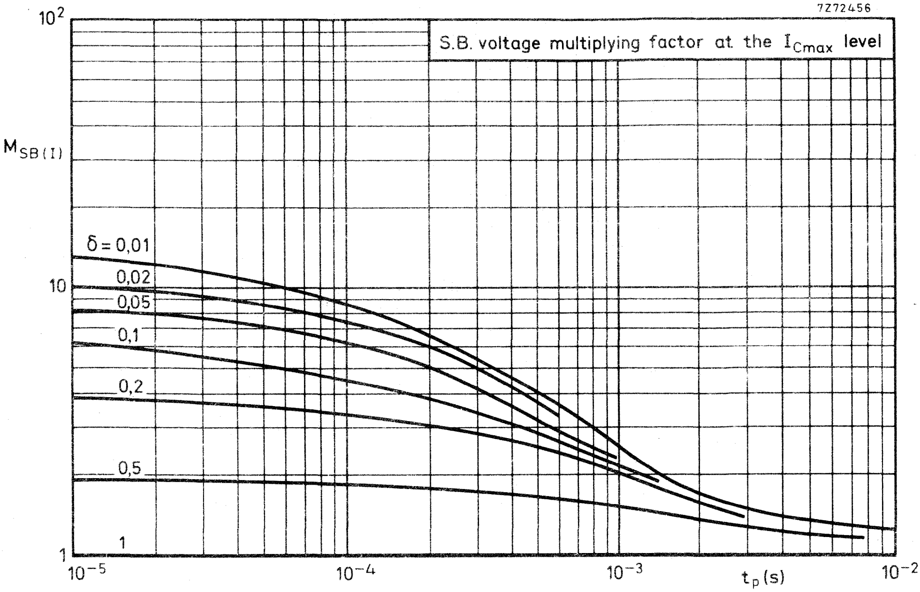
II Permissible extension for repetitive pulse operation

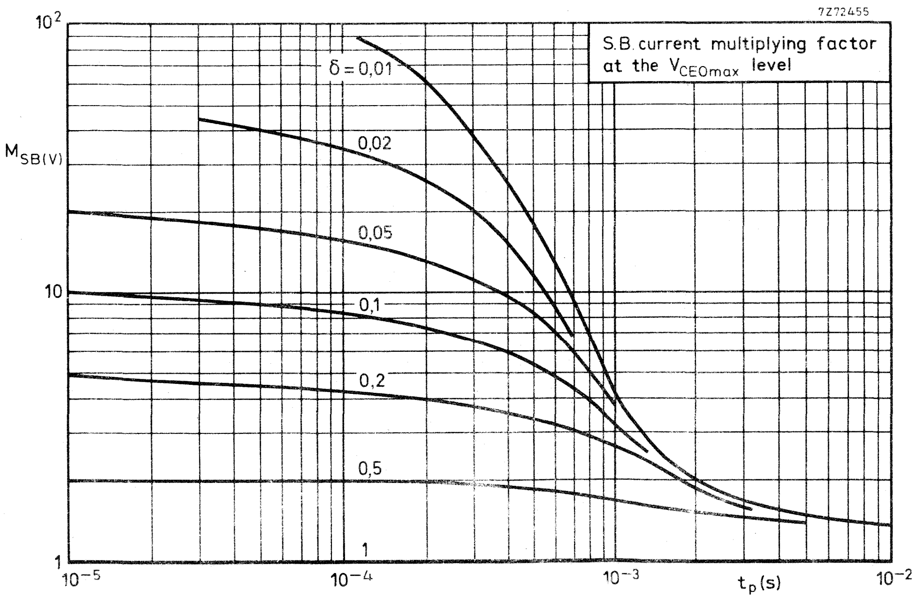
1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

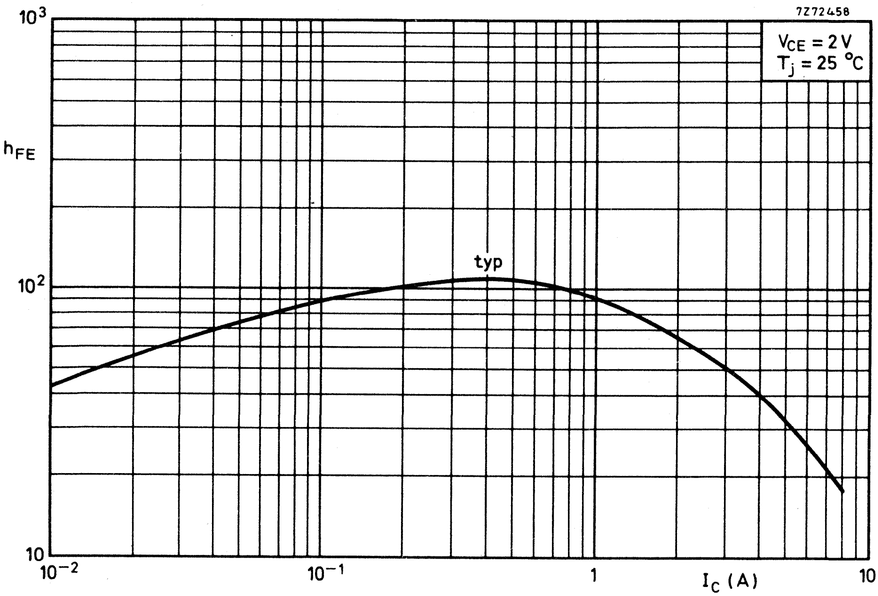
2) Second-breakdown limits (independent of temperature).

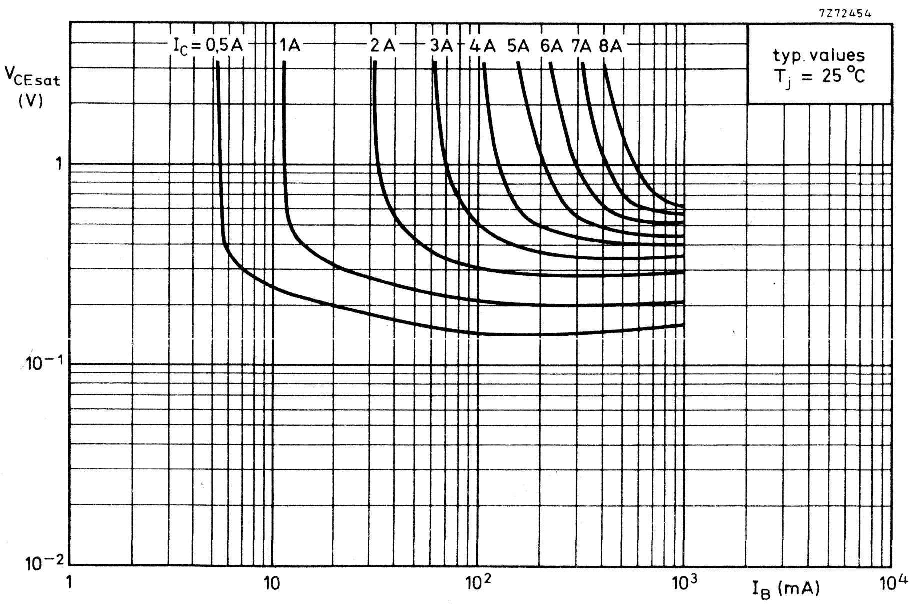

7Z67325
$P_{tot\ max}$ (%)
100
50
0
0
100
T_{mb} (°C)
200


7Z72457
$Z_{th\ j\text{-}mb}$ (°C/W)
3
2
1
0
δ = 1
0,7
0,5
0,2
0,1
0,05
0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t_p (s)
10


7Z72456
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
0,5
1
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}


7Z72455
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
0,5
1
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}


7Z72458
V_{CE} = 2 V
T_j = 25 °C
h_{FE}
typ
10^3
10^2
10
10^{-2}
10^{-1}
1
I_C (A)
10


7Z72454
typ. values
T_j = 25 °C
V_{CEsat}
(V)
I_C = 0,5 A
1 A
2 A
3 A
4 A
5 A
6 A
7 A
8 A
1
10^{-1}
10^{-2}
1
10
10^2
10^3
I_B (mA)
10^4

SILICON POWER TRANSISTORS

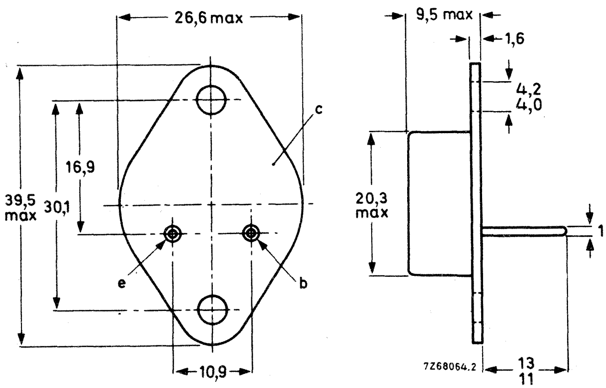
P-N-P transistors in TO-3 envelope for audio output stages and general amplifier and switching applications. N-P-N complements are BDX91, BDX93 and BDX95.

QUICK REFERENCE DATA

			BDX92	BDX94	BDX96	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Collector current (peak value)	$-I_{CM}$	max.		12		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.		90		W
Junction temperature	T_j	max.		200		°C
D.C. current gain $-I_C$ = 3 A; $-V_{CE}$ = 2 V	h_{FE}	>		20		
Transition frequency $-I_C$ = 1 A; $-V_{CE}$ = 10 V	f_T	>		4		MHz

MECHANICAL DATA Dimensions in mm

TO-3
Collector connected to envelope



For mounting instructions and accessories see section Accessories.

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

			BDX92	BDX94	BDX96	
Voltages						
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	100	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V

Currents

Collector current (d.c.)	$-I_C$	max.	8	A
Collector current (peak value)	$-I_{CM}$	max.	12	A

Power dissipation

Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	90	W

Temperatures

Storage temperature	T_{stg}		−65 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	1,94	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $-V_{CB} = -V_{CBOmax}$	$-I_{CBO}$	<	0,1	mA
$I_E = 0$; $-V_{CB} = 30$ V; $T_j = 200$ °C: BDX92				
$I_E = 0$; $-V_{CB} = 40$ V; $T_j = 200$ °C: BDX94	$-I_{CBO}$	<	2	mA
$I_E = 0$; $-V_{CB} = 50$ V; $T_j = 200$ °C: BDX96				
$I_B = 0$; $-V_{CE} = -V_{CEOmax}$	$-I_{CEO}$	<	1	mA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	1	mA
D.C. current gain [1]				
$-I_C = 3$ A; $-V_{CE} = 2$ V	h_{FE}	>	20	
$-I_C = 5$ A; $-V_{CE} = 2$ V	h_{FE}	>	10	
Base-emitter voltage [1]				
$-I_C = 3$ A; $-V_{CE} = 2$ V	$-V_{BE}$	<	1,4	V
Collector-emitter saturation voltage [1]				
$-I_C = 3$ A; $-I_B = 0,3$ A	$-V_{CEsat}$	<	0,8	V
$-I_C = 5$ A; $-I_B = 1$ A	$-V_{CEsat}$	<	1	V
Base-emitter saturation voltage [1]				
$-I_C = 3$ A; $-I_B = 0,3$ A	$-V_{BEsat}$	<	1,5	V
$-I_C = 5$ A; $-I_B = 1$ A	$-V_{BEsat}$	<	2	V
Small-signal current gain at f = 1 kHz				
$-I_C = 0,5$ A; $-V_{CE} = 10$ V	h_{fe}	>	40	
Transition frequency				
$-I_C = 1$ A; $-V_{CE} = 10$ V	f_T	>	4	MHz

[1]) Measured under pulse conditions: $t_p < 300$ µs, $\delta < 2\%$.

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

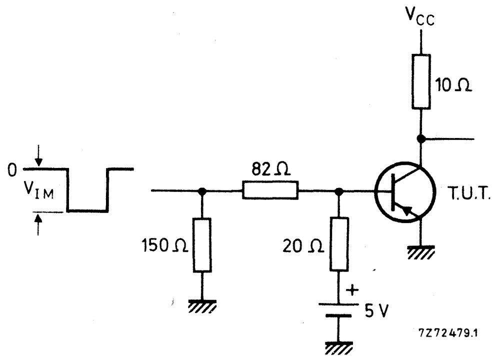
Switching times (between 10% and 90% levels)

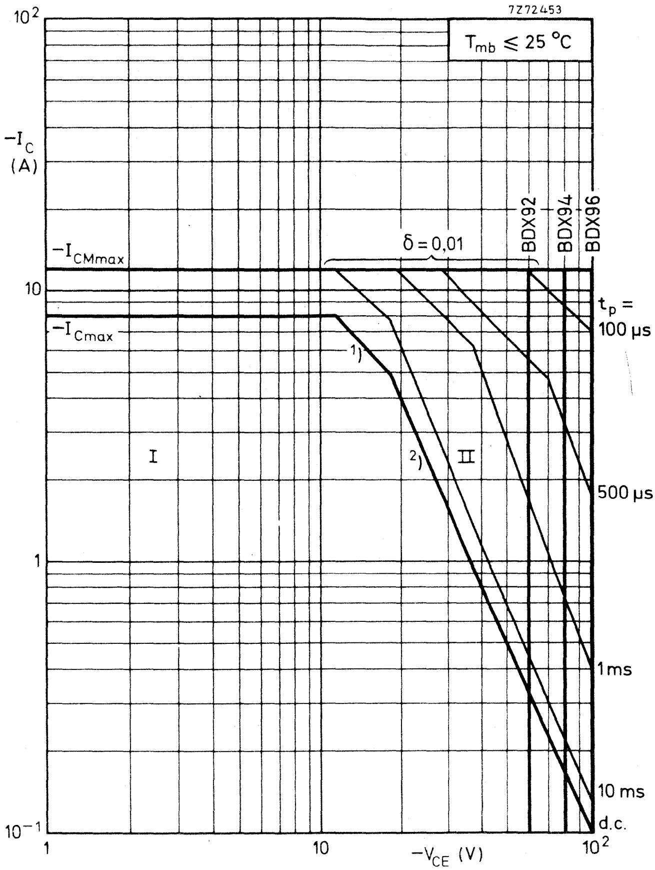
$-I_{Con} = 3$ A; $-I_{Bon} = I_{Boff} = 0,3$ A; $V_{CC} = -30$ V

Turn-on time	t_{on}	<	1	μs
Turn-off time	t_{off}	<	2	μs

Test circuit

$V_{IM} = 55$ V
$t_r = t_f = 15$ 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

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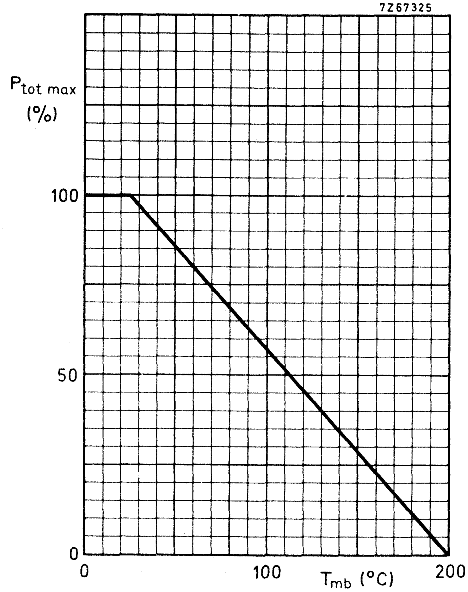
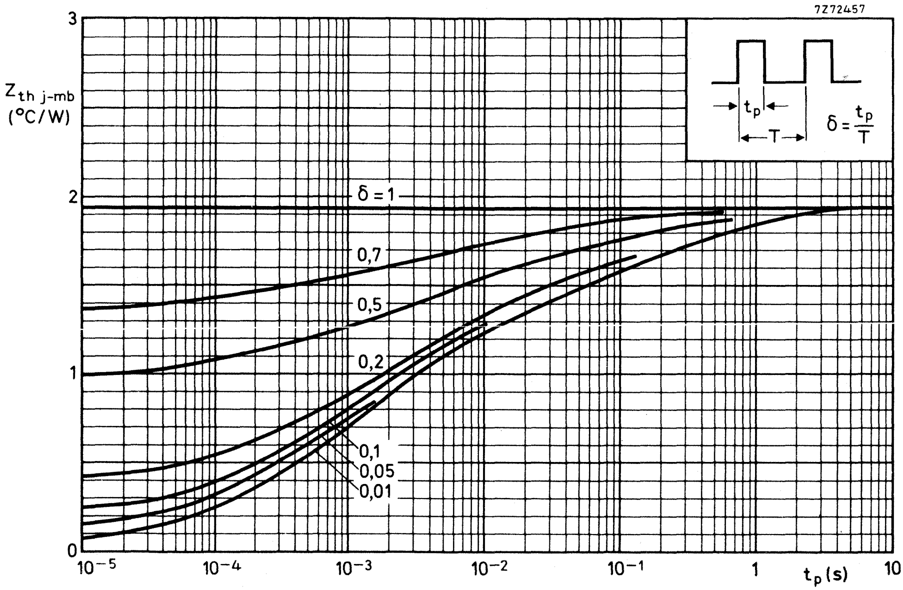
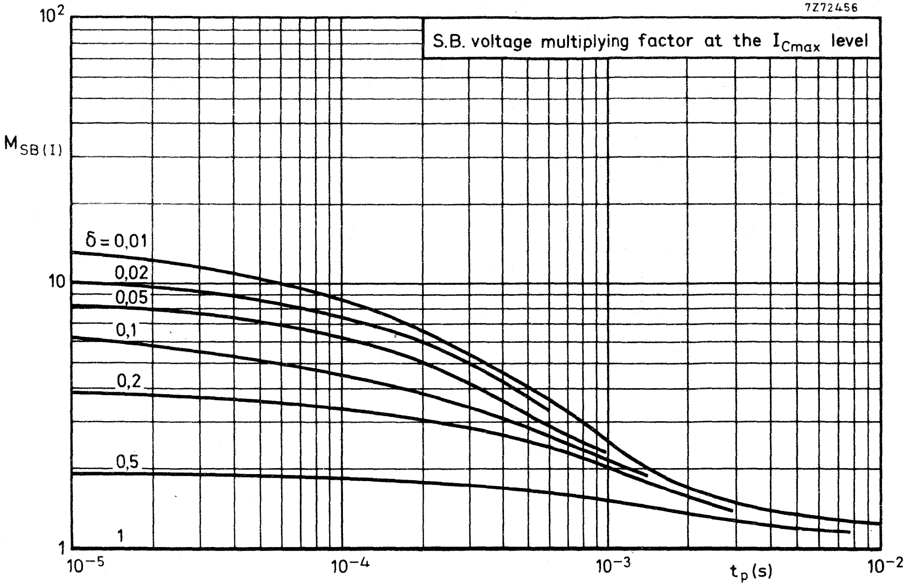
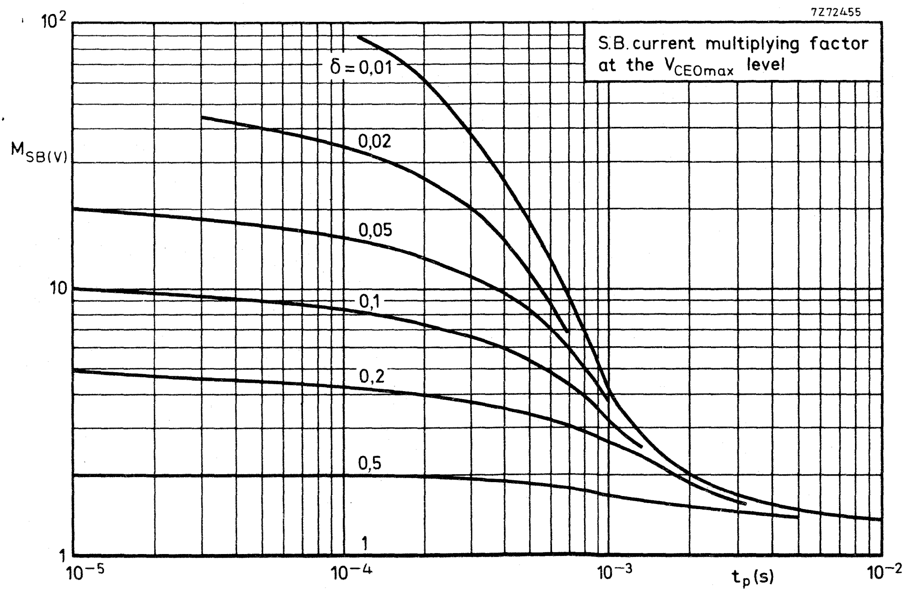
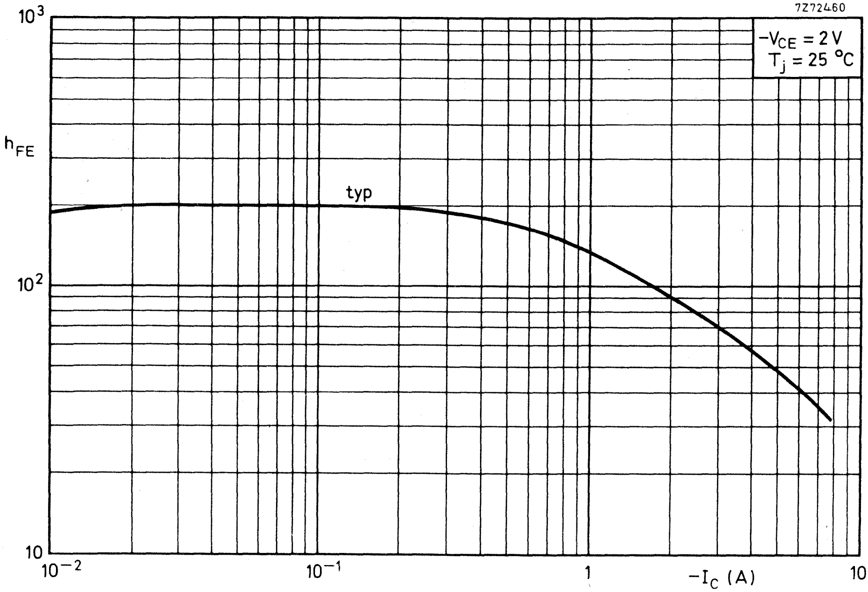
1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.
2) Second-breakdown limits (independent of temperature).

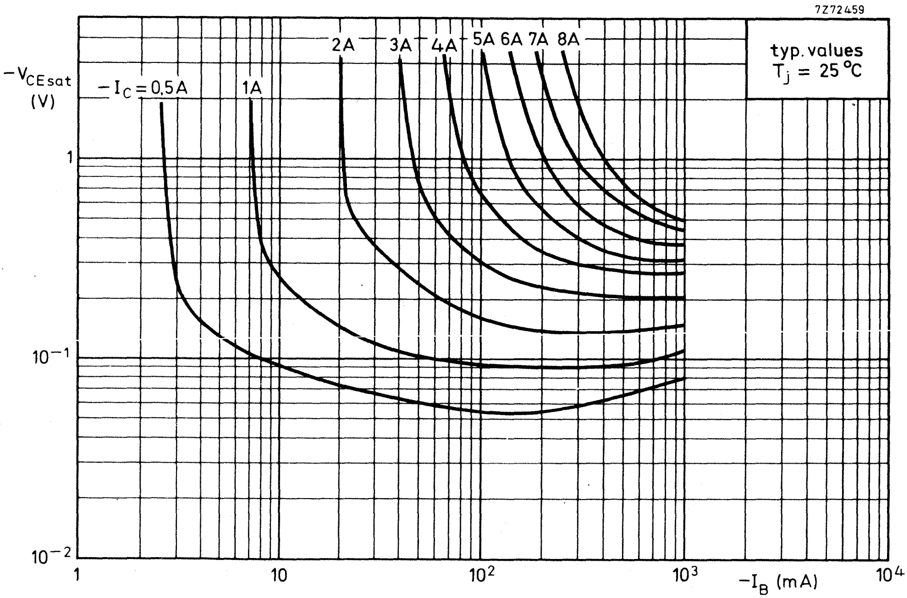

7Z67325
$P_{tot\ max}$
(%)
100
50
0
0
100
T_{mb} (°C)
200


7Z72457
3
$Z_{th\ j-mb}$
(°C/W)
2
1
0
δ = 1
0,7
0,5
0,2
0,1
0,05
0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t_p (s)
10


7Z72456
S.B. voltage multiplying factor at the I_{Cmax} level
10^2
$M_{SB(I)}$
10
1
$\delta = 0,01$
0,02
0,05
0,1
0,2
0,5
1
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}


7Z72455
S.B. current multiplying factor at the V_{CEOmax} level
10^2
$M_{SB(V)}$
10
1
$\delta = 0,01$
0,02
0,05
0,1
0,2
0,5
1
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}


7Z72460
$-V_{CE} = 2$ V
$T_j = 25$ °C
h_{FE}
typ
10^3
10^2
10
10^{-2}
10^{-1}
1
10
$-I_C$ (A)


7Z72459
typ. values
$T_j = 25$ °C
$-V_{CEsat}$ (V)
$-I_C = 0,5$A
1A
2A
3A
4A
5A
6A
7A
8A
1
10^{-1}
10^{-2}
1
10
10^2
10^3
10^4
$-I_B$ (mA)

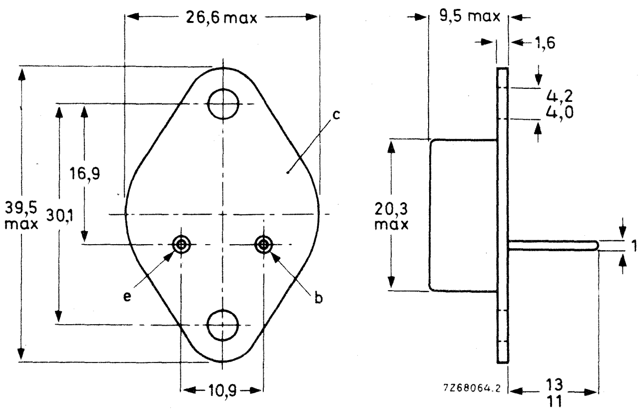
SILICON DIFFUSED POWER TRANSISTORS

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



For mounting instructions and accessories, see section Accessories.

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	$R_{th\ j\text{-}a}$	=	40	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1.5	°C/W

[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

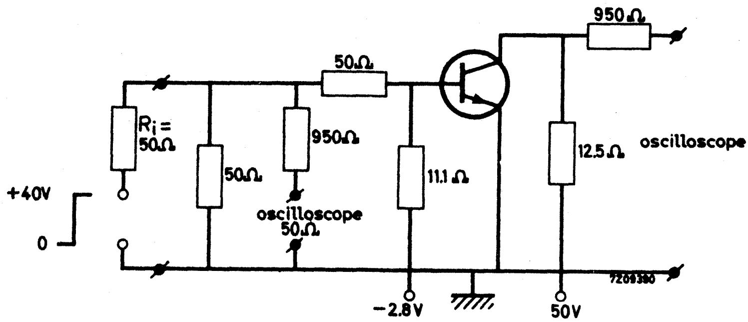
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

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:

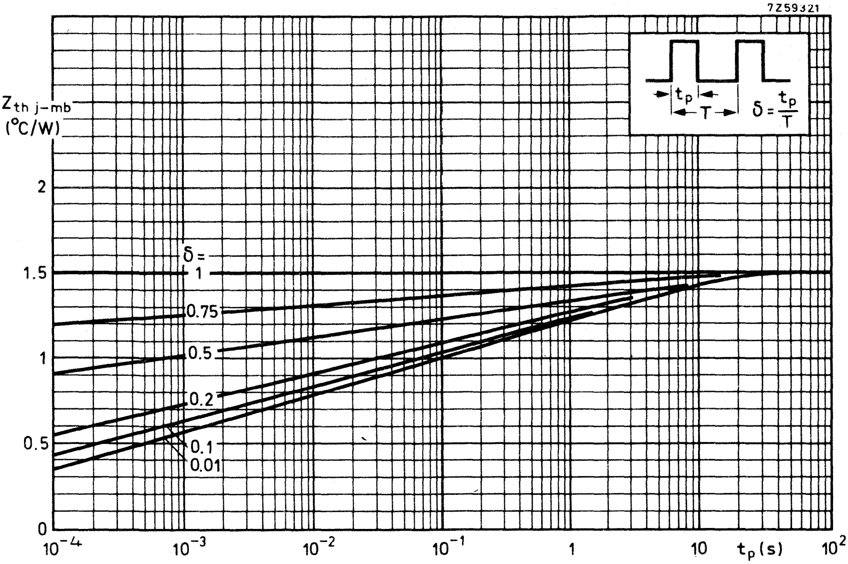


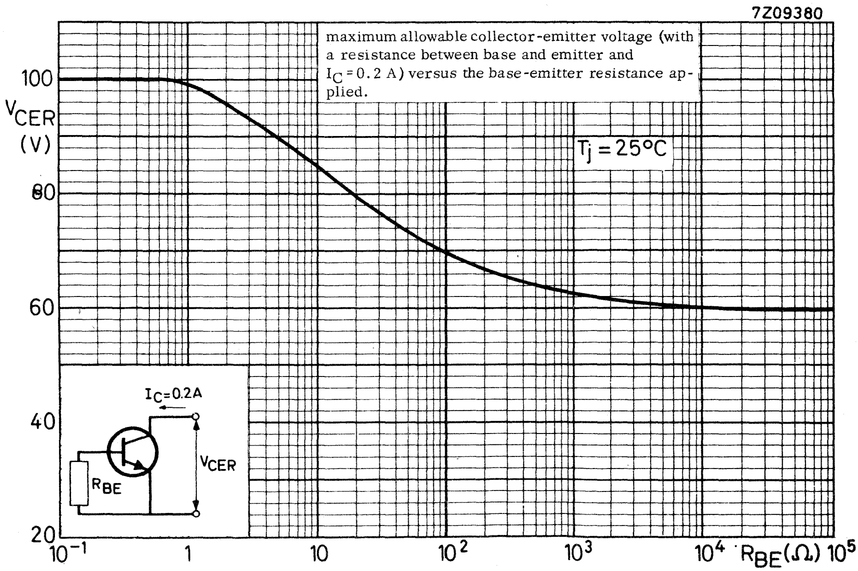
Pulse generator:

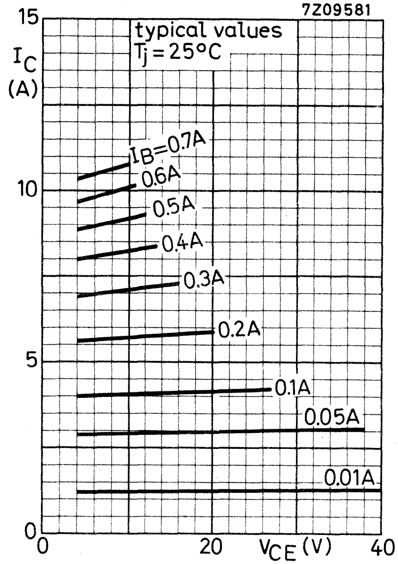
Pulse duration	t	>	10	µs
Rise time	t_r	≤	10	ns

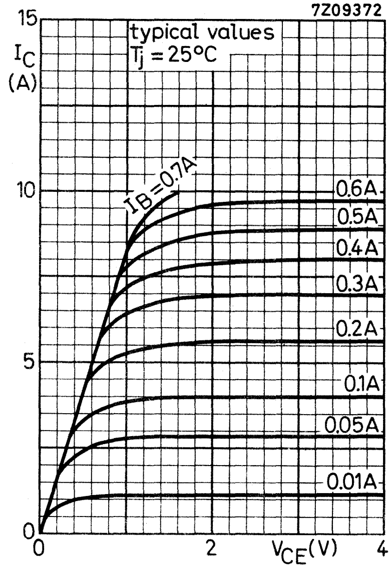
Oscilloscope:

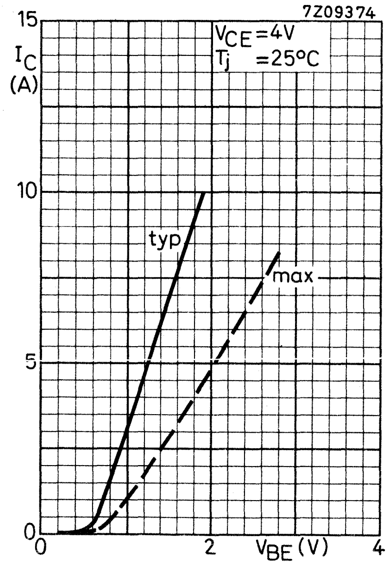
Rise time	t_r	≤	10	ns
Input resistance	R_i	=	50	Ω

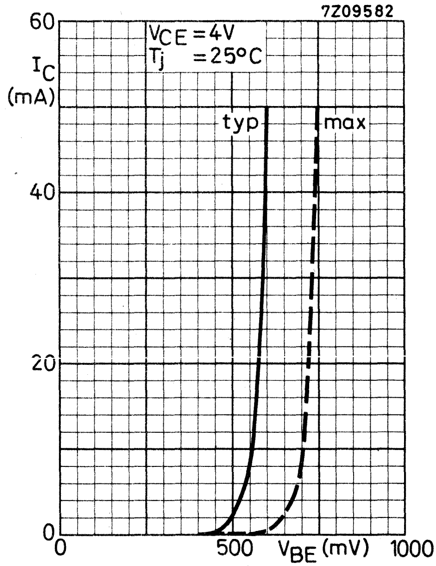

7Z59321
$Z_{th\ j-mb}$ (°C/W)
δ =
1
0.75
0.5
0.2
0.1
0.01
t_p
T
$\delta = \frac{t_p}{T}$
t_p (s)
0
0.5
1
1.5
2
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^{2}

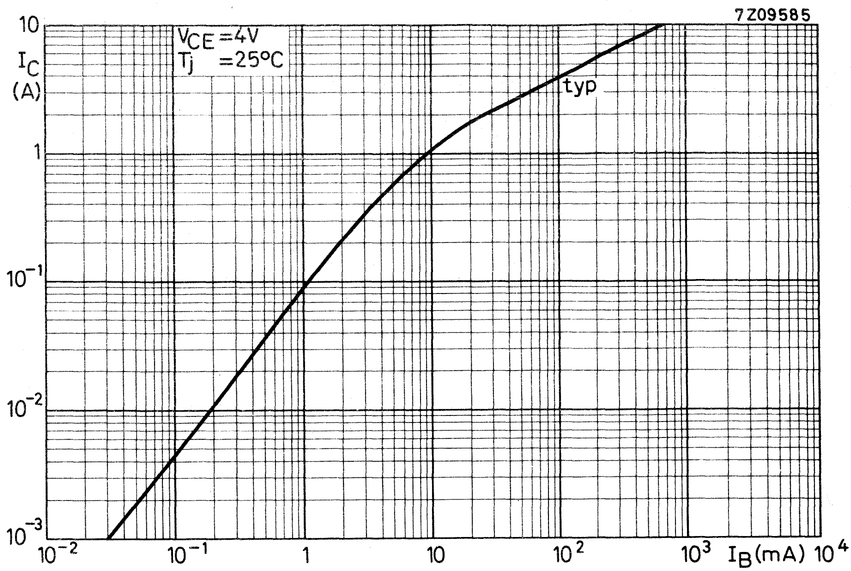

7Z09380
maximum allowable collector-emitter voltage (with a resistance between base and emitter and $I_C = 0.2$ A) versus the base-emitter resistance applied.
$T_j = 25°C$
V_{CER} (V)
I_C=0.2A
V_{CER}
R_{BE}
20
40
60
80
100
10^{-1}
1
10
10^{2}
10^{3}
10^{4}
R_{BE} (Ω)
10^{5}

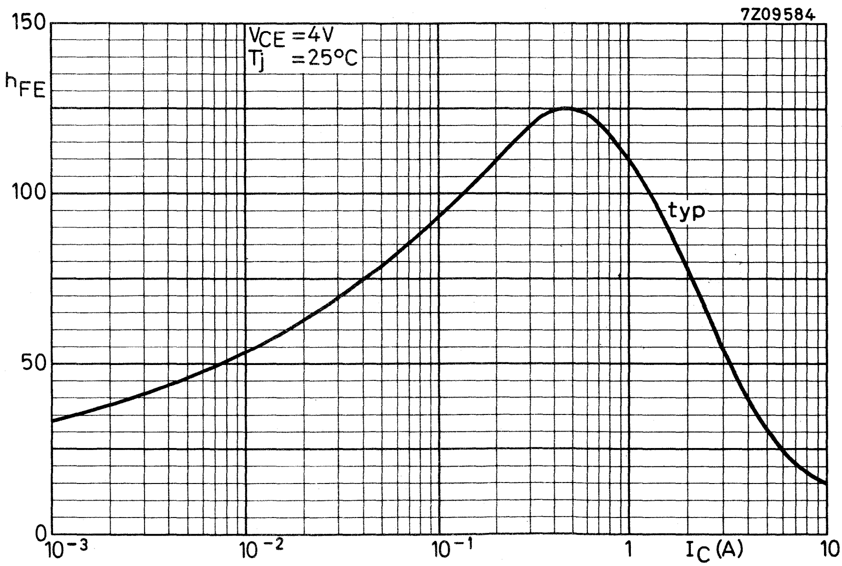

7Z09581
typical values
$T_j = 25^oC$
I_C (A)
I_B=0.7A
0.6A
0.5A
0.4A
0.3A
0.2A
0.1A
0.05A
0.01A
V_{CE} (V)
0
5
10
15
20
40

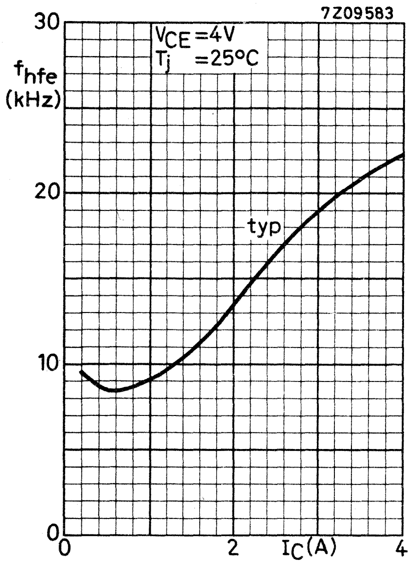

7Z09372
typical values
$T_j = 25^oC$
I_C (A)
I_B=0.7A
0.6A
0.5A
0.4A
0.3A
0.2A
0.1A
0.05A
0.01A
V_{CE} (V)
0
2
4
5
10
15

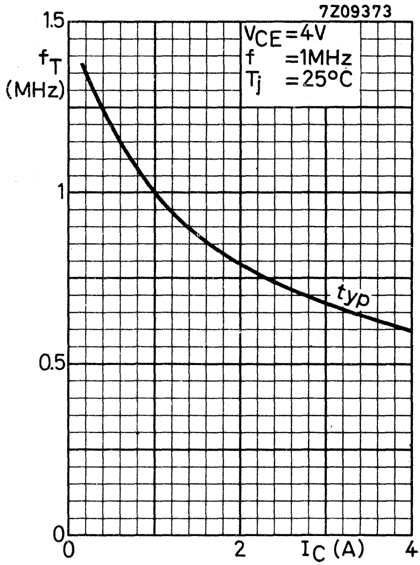

7Z09374
V_{CE} = 4V
T_j = 25°C
I_C (A)
typ
max
V_{BE} (V)
0
2
4
5
10
15

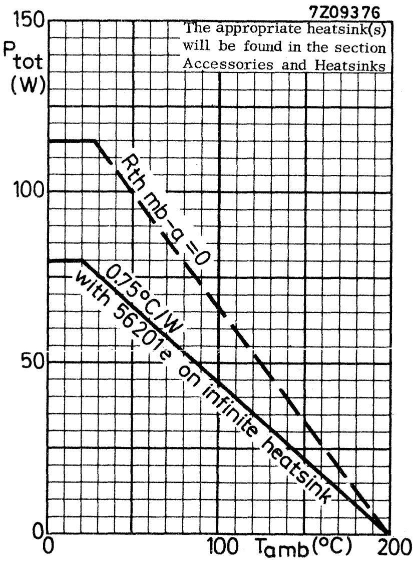

7Z09582
V_{CE} = 4V
T_j = 25°C
I_C (mA)
typ
max
V_{BE} (mV)
0
500
1000
20
40
60

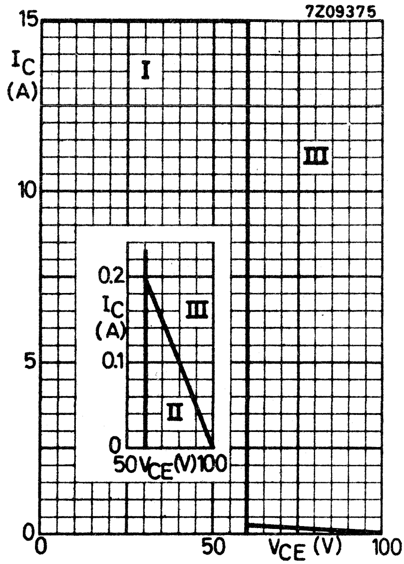

7Z09585
10
I_C
(A)
1
10^{-1}
10^{-2}
10^{-3}
V_{CE} = 4V
T_j = 25°C
typ
10^{-2}
10^{-1}
1
10
10^2
10^3
I_B (mA)
10^4


7Z09584
150
h_{FE}
100
50
0
V_{CE} = 4V
T_j = 25°C
typ
10^{-3}
10^{-2}
10^{-1}
1
I_C (A)
10


7Z09583
V_{CE} = 4V
T_j = 25°C
f_{hfe}
(kHz)
typ
30
20
10
0
0
2
I_C (A)
4


7Z09373
V_{CE} = 4V
f = 1MHz
T_j = 25°C
f_T
(MHz)
typ
1.5
1
0.5
0
0
2
I_C (A)
4

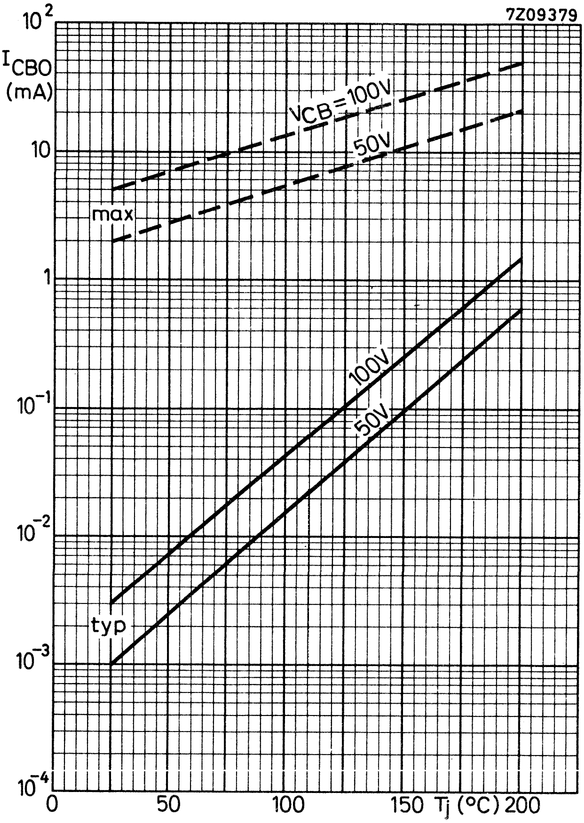

7Z09376
The appropriate heatsink(s) will be found in the section Accessories and Heatsinks
P_{tot}
(W)
Rth mb-a = 0
0.75°C/W
with 56201e on infinite heatsink
150
100
50
0
0
100
T_{amb} (°C)
200



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
10²
I_CBO
(mA)
V_CB = 100V
50V
10
max
1
100V
50V
10⁻¹
10⁻²
typ
10⁻³
10⁻⁴
0
50
100
150
T_j (°C)
200

SILICON DIFFUSED POWER TRANSISTORS

High-speed switching n-p-n transistors in a metal envelope intended for use in converters, inverters, switching regulators and switching control amplifiers.

QUICK REFERENCE DATA

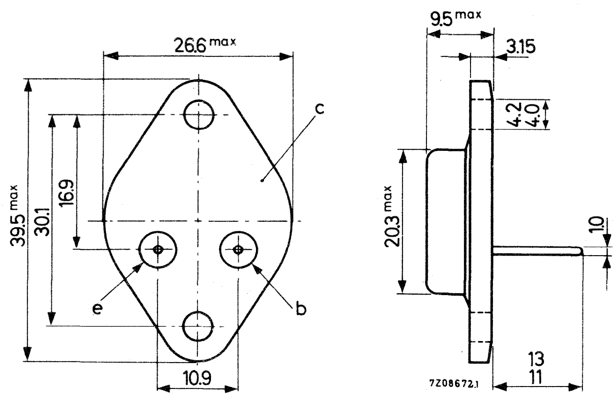
			BDY90	BDY91	BDY92	
Collector-base voltage (open emitter)	V_{CBO}	max.	120	100	80	V
Collector-emitter voltage (open base)	V_{CEO}	max.	100	80	60	V
Collector current (peak value)	I_{CM}	max.	15	15	15	A
Total power dissipation up to T_{mb}=75°C	P_{tot}	max.	40	40	40	W
Collector-emitter saturation voltage 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

TO-3



For mounting instructions and accessories, see section Accessories

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 — T_j = 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) $T_j = 25\ ^{o}C$ 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

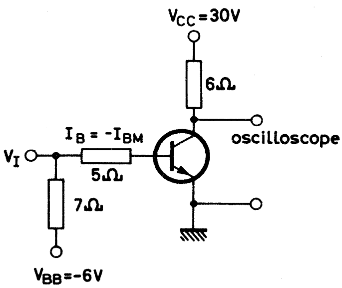
Turn on time

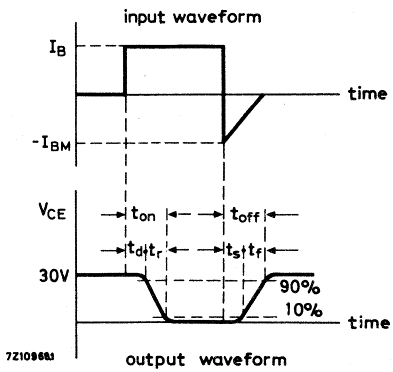
$I_C = 5$ A; $I_B = -I_{BM} = 0.5$ A				
$V_{CC} = 30$ V	t_{on}	<	0.35	μs

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

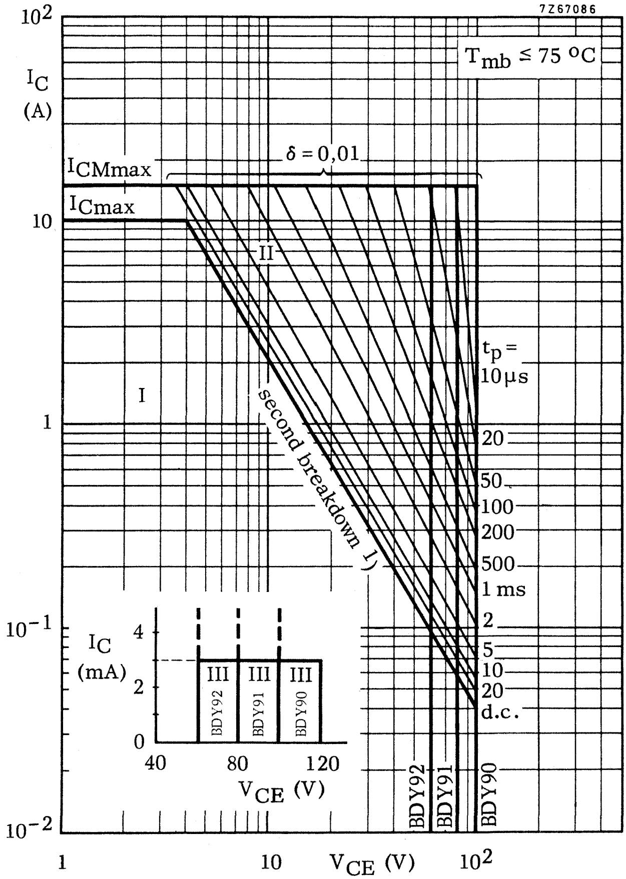




Pulse generator:

Rise time	t_r	<	50	ns
Fall time	t_f	<	50	ns

Pulse duration	t_p	=	20	μs
Duty cycle	δ	=	0.02	

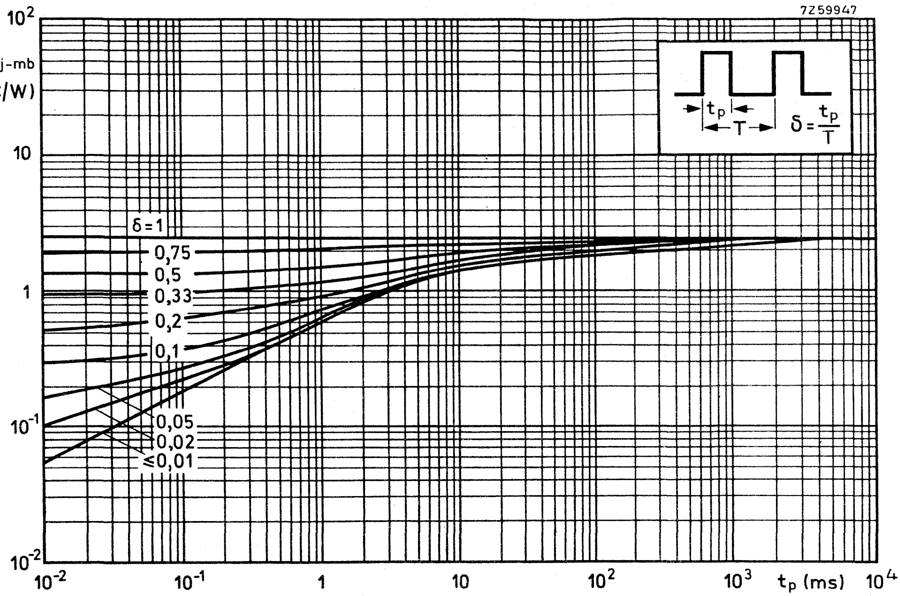


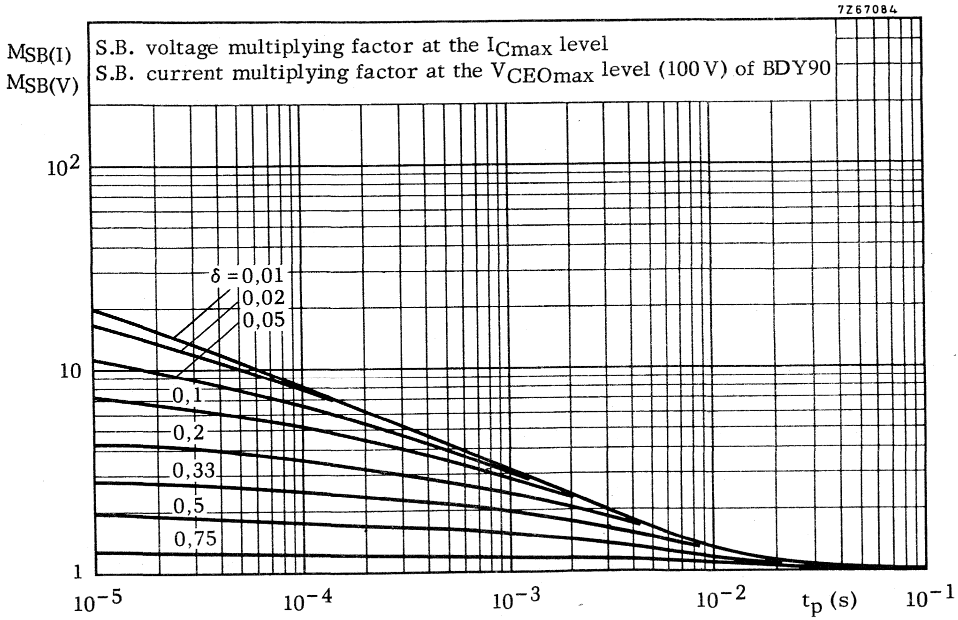
Safe Operating Area (Regions I and II forward biased)

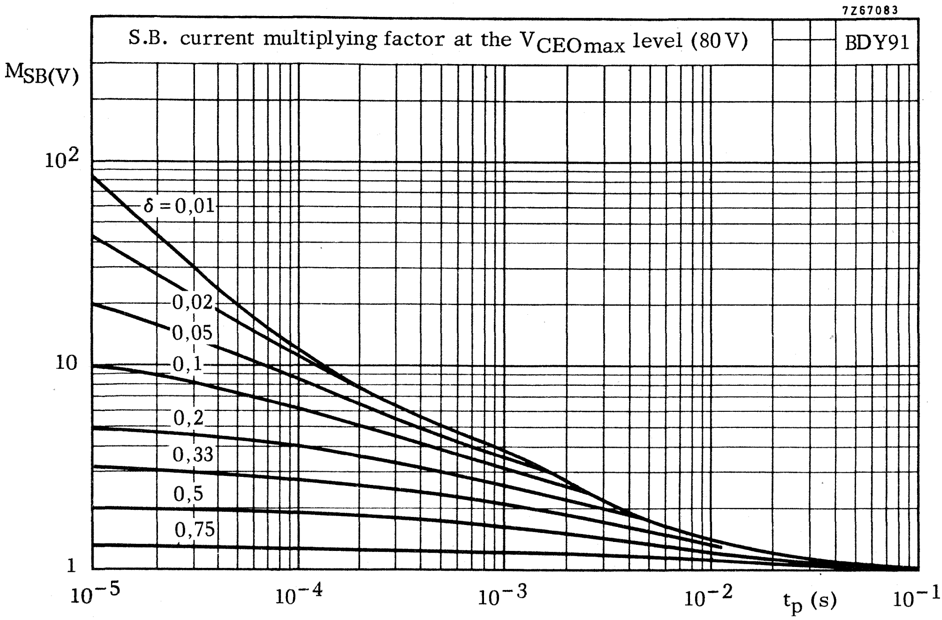
I Region of permissible d.c. operation
II Permissible extension for repetitive pulse operation
III Repetitive pulse operation in this region is allowable, provided $-V_{BE} \geq 1,5$ V

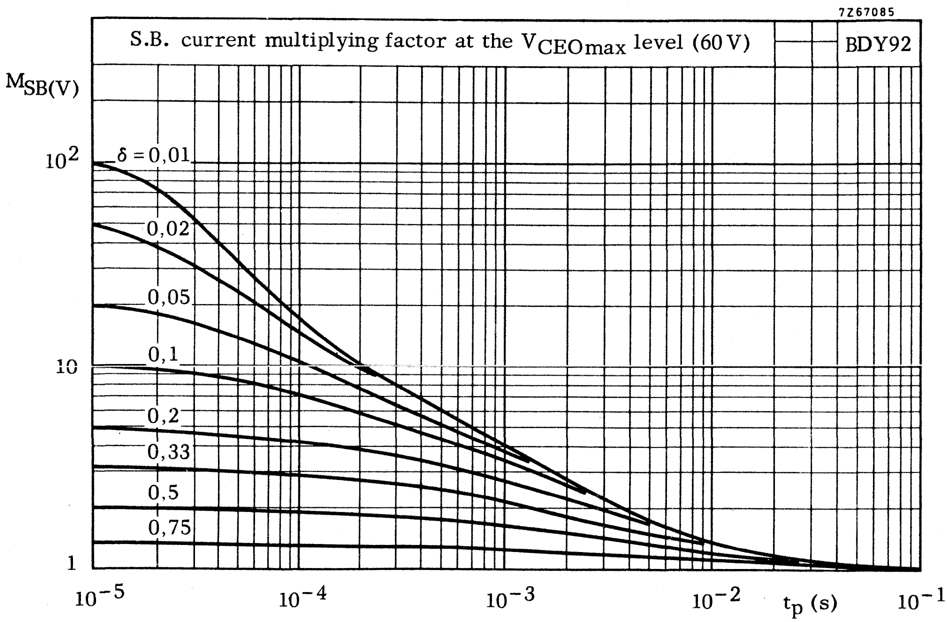
For $P_{tot\ max}$ versus T_{mb} see page 10.

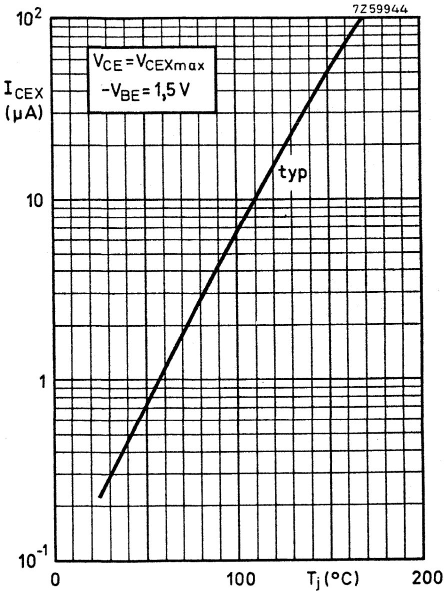
1) Independent of temperature

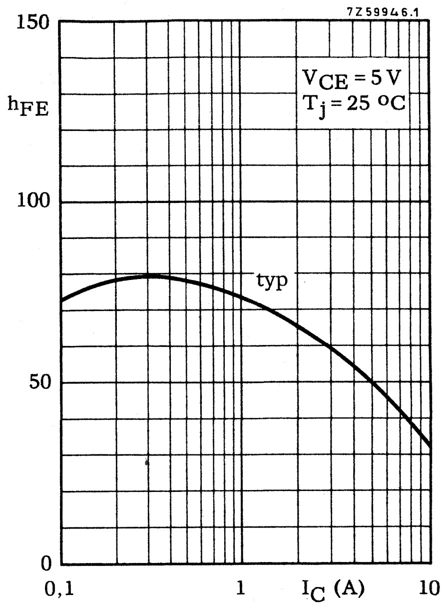

7Z59947
10^2
$Z_{th\ j-mb}$ (°C/W)
10
1
10^{-1}
10^{-2}
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
≤0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (ms)
10^4

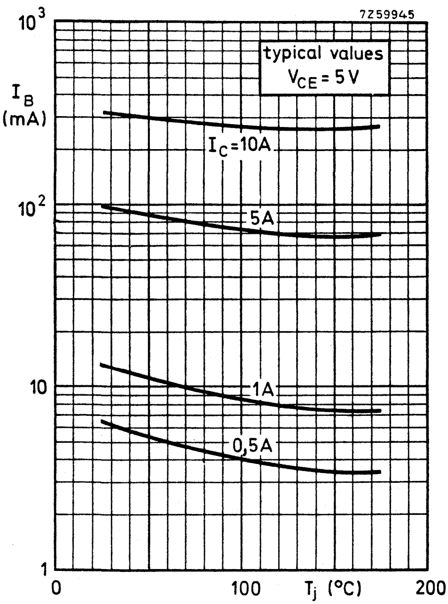

7Z67084
$M_{SB(I)}$
$M_{SB(V)}$
S.B. voltage multiplying factor at the I_{Cmax} level
S.B. current multiplying factor at the V_{CEOmax} level (100 V) of BDY90
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-5}
10^{-4}
10^{-3}
10^{-2}
t_p (s)
10^{-1}

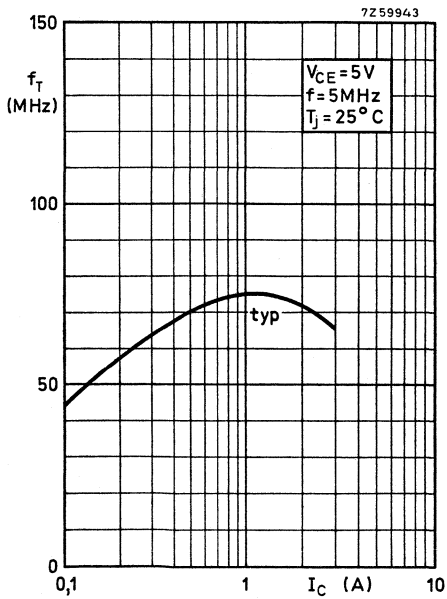

7Z67083
S.B. current multiplying factor at the V_{CEOmax} level (80 V)
BDY91
$M_{SB(V)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-5}
10^{-4}
10^{-3}
10^{-2}
t_p (s)
10^{-1}

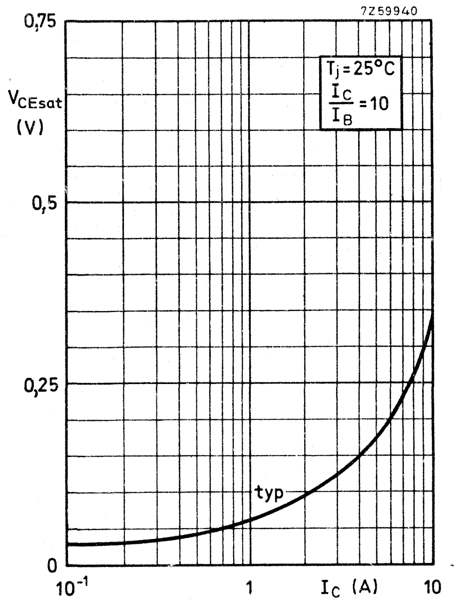

7Z67085
S.B. current multiplying factor at the V_{CEOmax} level (60 V)
BDY92
$M_{SB(V)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-5}
10^{-4}
10^{-3}
10^{-2}
t_p (s)
10^{-1}

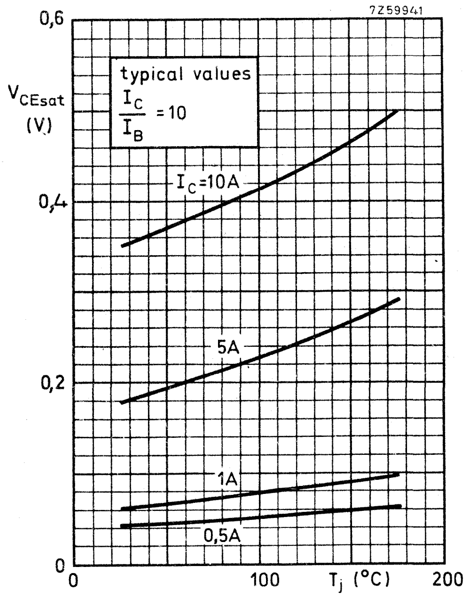

7Z59944
$V_{CE} = V_{CEXmax}$
$-V_{BE} = 1,5$ V
I_{CEX} (μA)
10^2
10
1
10^{-1}
typ
0
100
T_j (°C)
200

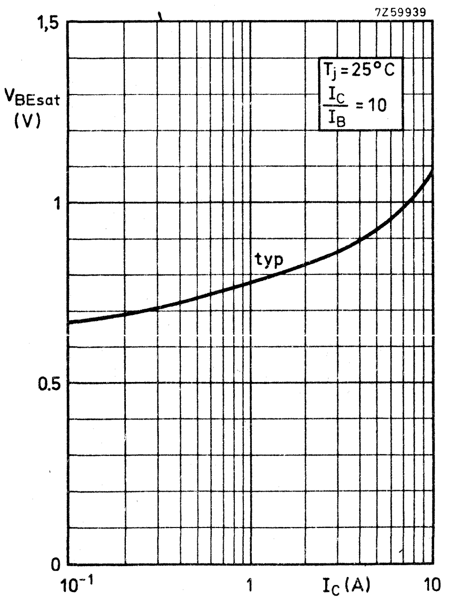

7Z59946.1
$V_{CE} = 5$ V
$T_j = 25$ °C
h_{FE}
150
100
50
0
typ
0,1
1
I_C (A)
10

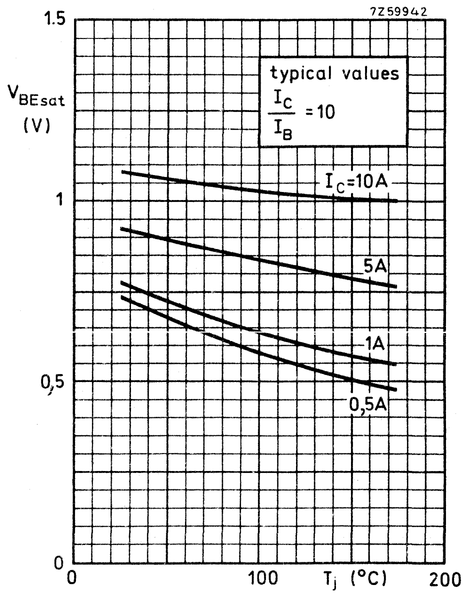

7Z59945
typical values
$V_{CE} = 5$ V
I_B (mA)
10^3
10^2
10
1
I_C=10A
5A
1A
0,5A
0
100
T_j (°C)
200


7Z59943
$V_{CE} = 5$ V
f = 5MHz
$T_j = 25$° C
f_T (MHz)
150
100
50
0
typ
0,1
1
I_C (A)
10


7Z59940
0,75
V_{CEsat}
(V)
0,5
0,25
0
$T_j = 25°C$
$\frac{I_C}{I_B} = 10$
typ
10^{-1}
1
I_C (A)
10

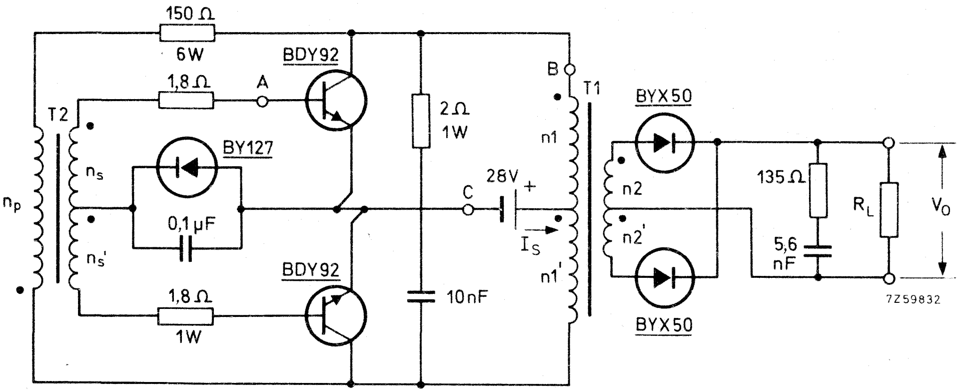

7Z59941
0,6
V_{CEsat}
(V)
0,4
0,2
0
typical values
$\frac{I_C}{I_B} = 10$
I_C=10A
5A
1A
0,5A
0
100
T_j (°C)
200


7Z59939
1,5
V_{BEsat}
(V)
1
0.5
0
$T_j = 25°C$
$\frac{I_C}{I_B} = 10$
typ
10^{-1}
1
I_C (A)
10


7Z59942
1.5
V_{BEsat}
(V)
1
0,5
0
typical values
$\frac{I_C}{I_B} = 10$
I_C=10A
5A
1A
0,5A
0
100
T_j (°C)
200

APPLICATION INFORMATION

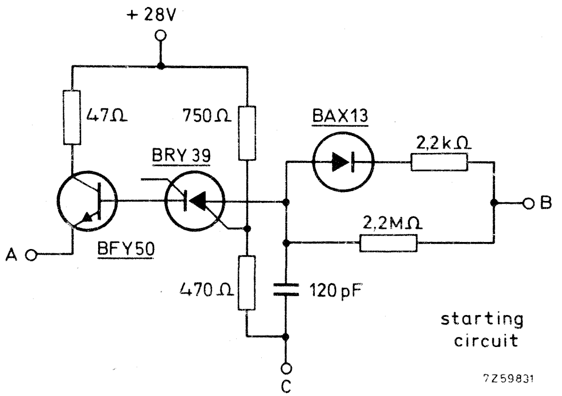
Typical operation in a 250 W d.c. to d.c. converter with two BDY92 transistors



Each transistor is mounted on a heatsink of $R_{th\ h\text{-}a}$ = 15 °C/W

Performance at T_{amb} = 55 °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 34900

$n_1 + n_1'$ is bifilarly wound

$n_1 = n_1'$ = 9 turns, ϕ 1,4 mm

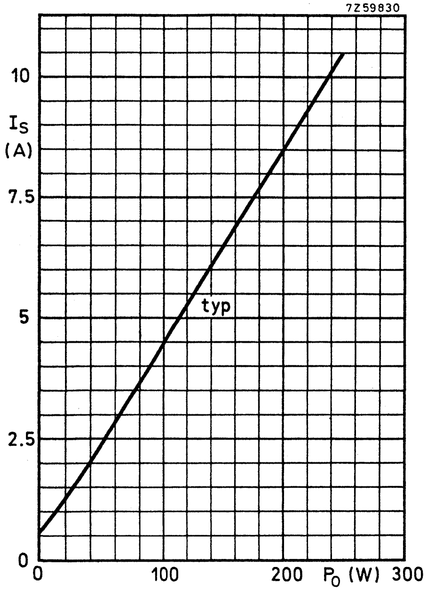
$n_2 = n_2'$ = 85 turns, ϕ 0,5 mm

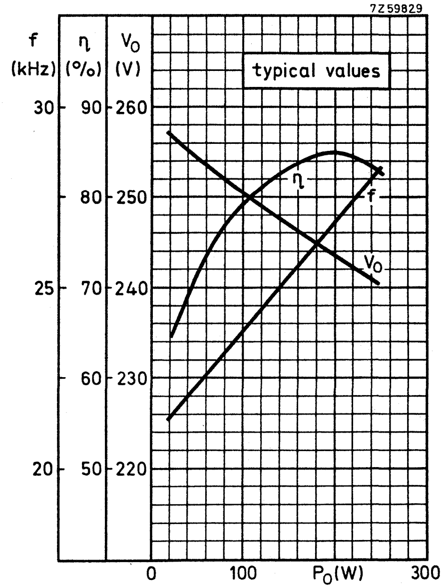
T_2 = Ferroxcube core H16 material 3E2
Cat. No. 4322 020 33030

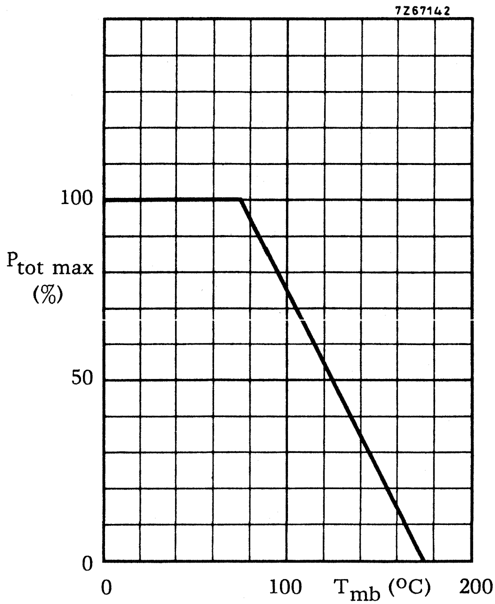
$n_s + n_s'$ is bifilarly wound

$n_s = n_s'$ = 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
90
260
80
250
25
70
240
60
230
20
50
220
η
f
V_o
0
100
P_o(W)
300


7Z67142
100
$P_{tot\ max}$
(%)
50
0
0
100
T_{mb} (°C)
200

SILICON DIFFUSED POWER TRANSISTORS

High voltage, high speed switching n-p-n power transistors in a TO-3 envelope, intended for use in converters, inverters, switching regulators and motor control systems.

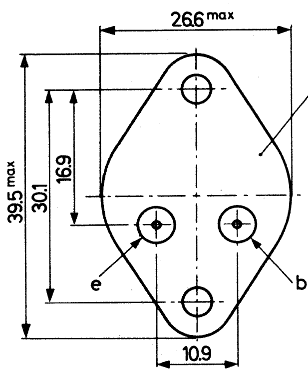
QUICK REFERENCE DATA

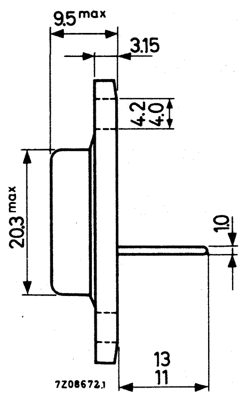
			BDY93	BDY94	
Collector-emitter peak voltage (V_{BE} = 0)	V_{CESM}	max.	750	750	V
Collector-emitter voltage (R_{BE} = 100 Ω)	V_{CER}	max.	450	400	V
Collector-emitter voltage (open base)	V_{CEO}	max.	350	300	V
Collector current (d.c.)	I_C	max.	4	4	A
Collector current (peak value)	I_{CM}	max.	7	7	A
Total power dissipation up to T_{mb} = 75 °C	P_{tot}	max.	30	30	W
Collector-emitter saturation voltage I_C = 2,5 A; I_B = 0,5 A	V_{CEsat}	<	1,5	1,5	V
Fall time I_C = 2,5 A; I_{B1} = 0,5 A; $-I_{B2}$ = 1 A	t_f	typ.	0,4	0,5	μs

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-3





For mounting instructions and accessories, see section Accessories.

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

Voltage

			BDY93	BDY94	
Collector-emitter voltage (V_{BE} = 0) (peak value)	V_{CESM}	max.	750	750	V
Collector-emitter voltage (R_{BE} = 100 Ω)	V_{CER}	max.	450	400	V
Collector-emitter voltage (open base)	V_{CEO}	max.	350	300	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.	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) [1]	$-I_{BM}$	max.	3	A

Power dissipation

Total power dissipation up to T_{mb} = 75 °C	P_{tot}	max.	30	W

Temperature

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

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,5	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current [2]

V_{CE} = 750 V; V_{BE} = 0	I_{CES}	<	0,5	mA
V_{CE} = 750 V; V_{BE} = 0; T_j = 125 °C	I_{CES}	<	2	mA

D.C. current gain

I_C = 1 A; V_{CE} = 5 V	h_{FE}	typ.	30

[1]) Turn-off current.

[2]) Measured with a half sine wave voltage (curve tracer).

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

Emitter-base breakdown voltage

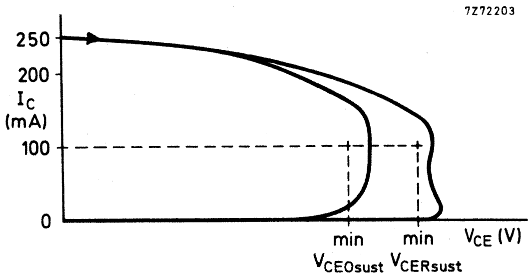
$I_C = 0$; $I_E = 5$ mA	$V_{(BR)EBO}$	>	6	V

Saturation voltage

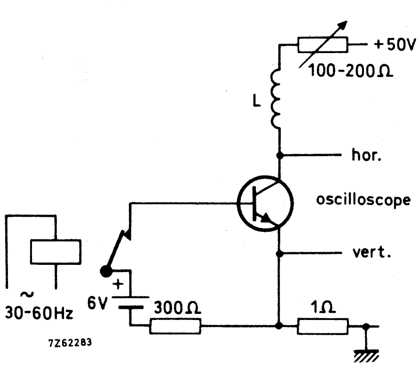
$I_C = 2,5$ A; $I_B = 0,5$ A	V_{CEsat}	<	1,5	V
	V_{BEsat}	<	1,4	V
$I_C = 4$ A; $I_B = 1,25$ A	V_{CEsat}	<	3	V
	V_{BEsat}	<	2	V

Collector-emitter sustaining voltage

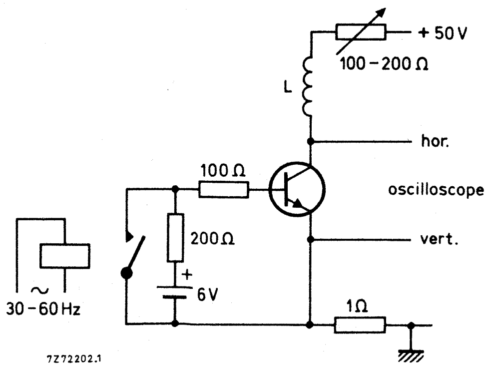
$I_C = 100$ mA; $I_B = 0$; L = 25 mH; BDY93	$V_{CEOsust}$	>	350	V
BDY94	$V_{CEOsust}$	>	300	V
$I_C = 100$ mA; $R_{BE} = 100\ \Omega$; L = 5 mH; BDY93	$V_{CERsust}$	>	450	V
BDY94	$V_{CERsust}$	>	400	V



Oscilloscope display for sustaining voltages



Test circuit for $V_{CEOsust}$



Test circuit for $V_{CERsust}$

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

Transition frequency at f = 1 MHz

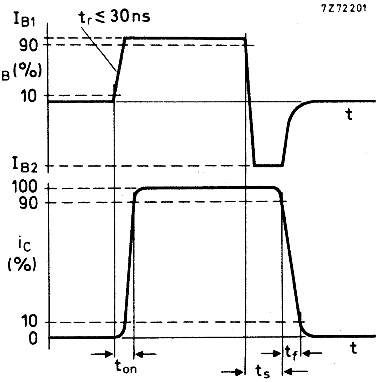
$I_C = 0,2\ A;\ V_{CE} = 10\ V$	f_T	typ.	10	MHz

Switching times

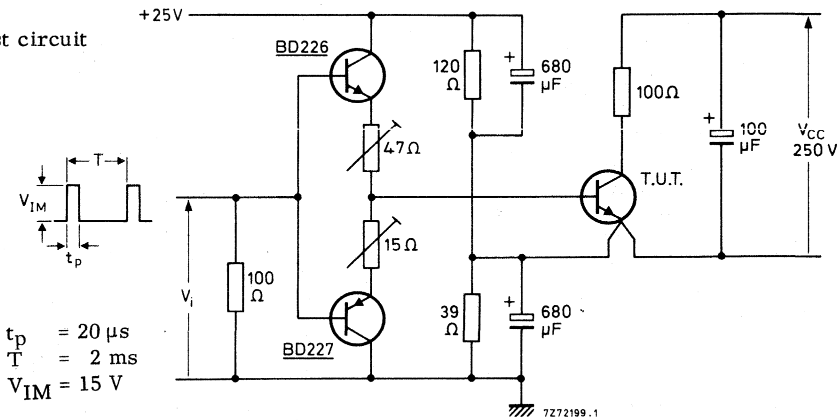
$I_{Con} = 2,5\ A;\ I_{B1} = 0,5\ A;\ -I_{B2} = 1\ A;\ V_{CC} = 250\ V$

			BDY93	BDY94	
Turn-on time	t_{on}	typ.	0,25	0,25	µs
	t_{on}	<	0,5	0,5	µs
Turn-off: Storage time	t_s	typ.	2	2	µs
	t_s	<	3	3,5	µs
Fall time	t_f	typ.	0,4	0,5	µs
Fall time, $T_{mb} = 95\ ^oC$	t_f	<	1,2	1,6	µs

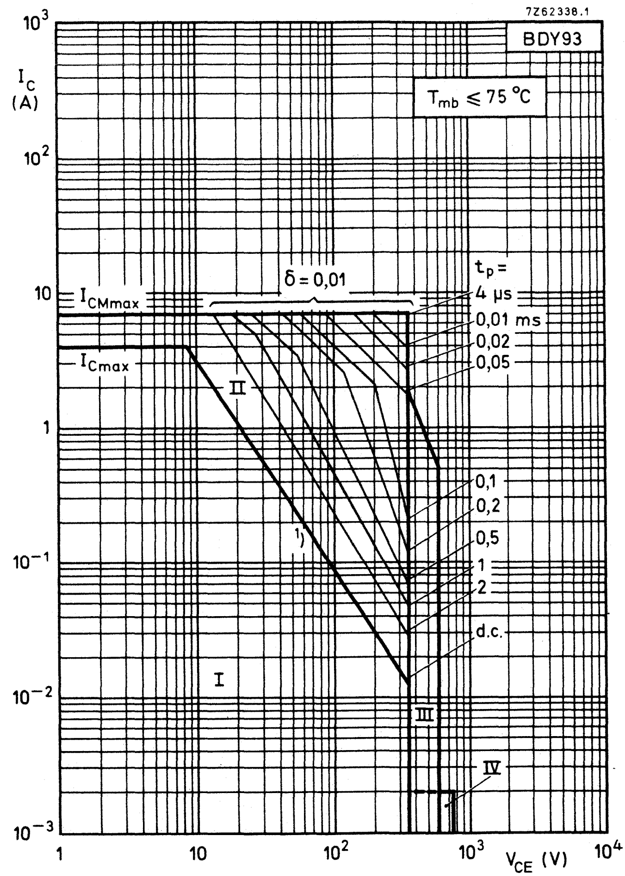
Waveform



Test circuit



t_p = 20 µs
T = 2 ms
V_{IM} = 15 V



Safe Operating Area (Regions I, II, and III forward biased)

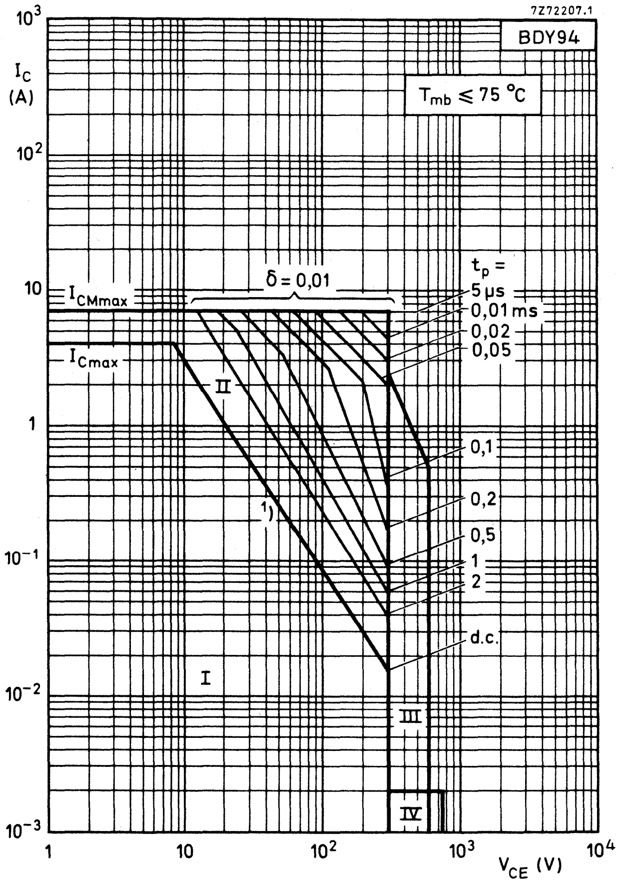
I Region of permissible d.c. operation

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.

1) Second breakdown (independent of temperature)



Safe Operating Area (Regions I, II, and III forward biased)

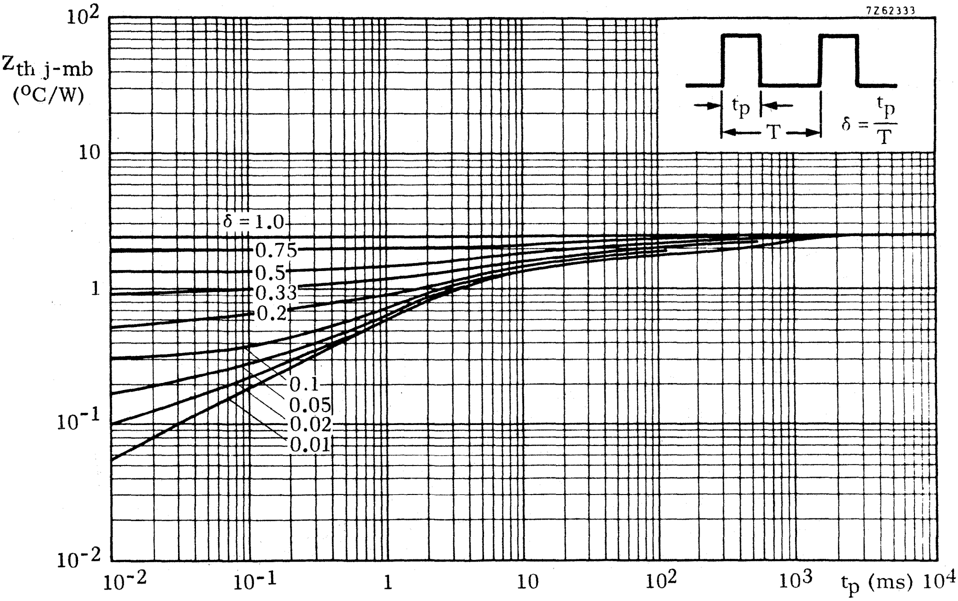
I Region of permissible d.c. operation

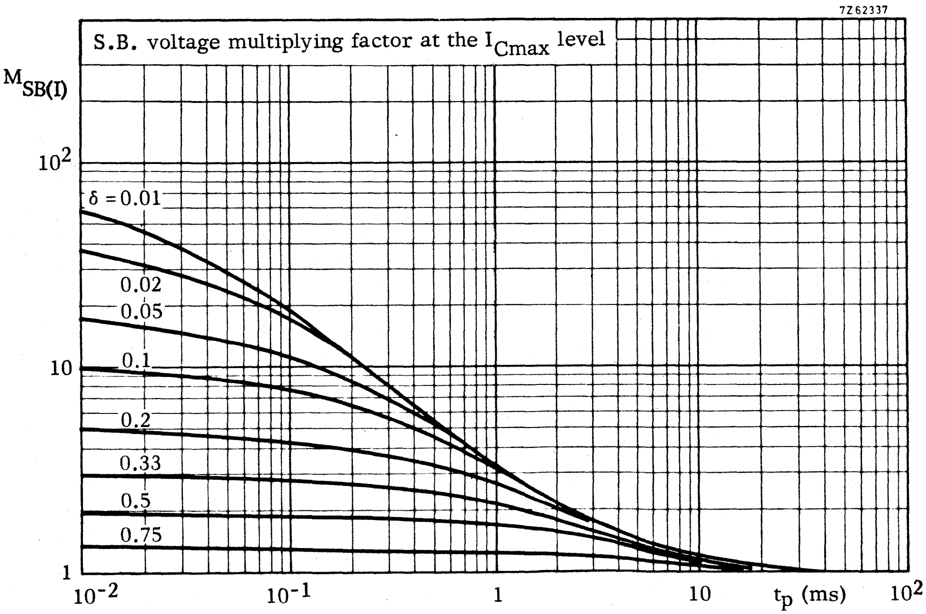
II Permissible extension for repetitive pulse operation

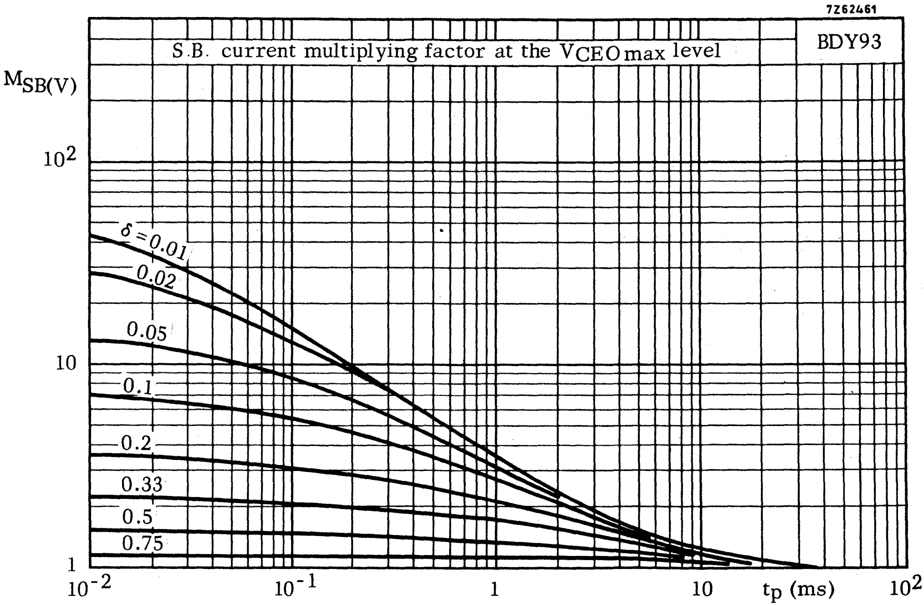
III Area of permissible operation during turn-on in single-transistor converters, provided $t_p \leq 0,6$ μs and $R_{BE} \leq 100\ \Omega$

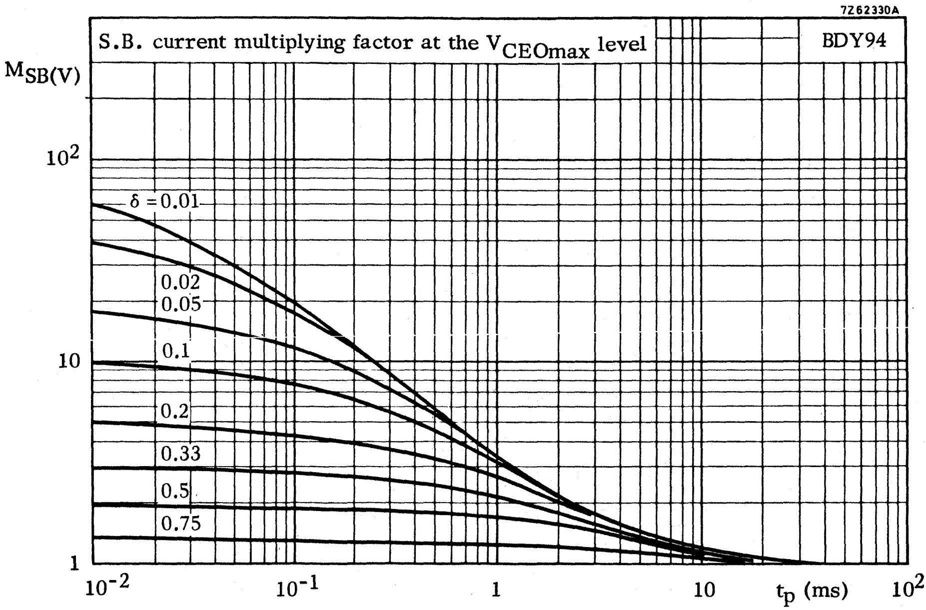
IV Repetitive pulse operation in this region is allowable, provided $V_{BE} \leq 0$ and $t_p \leq 2$ ms.

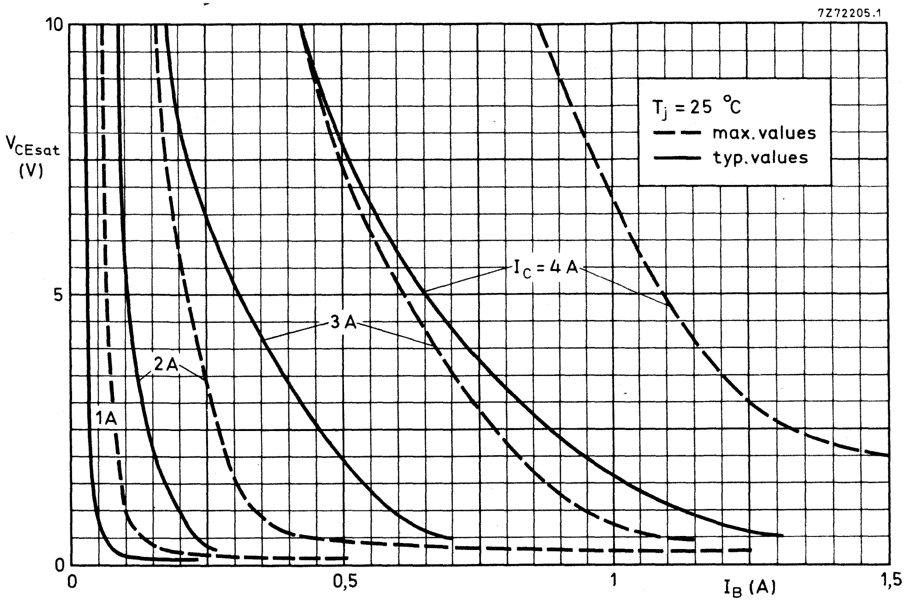
[1]) Second breakdown (independent of temperature)

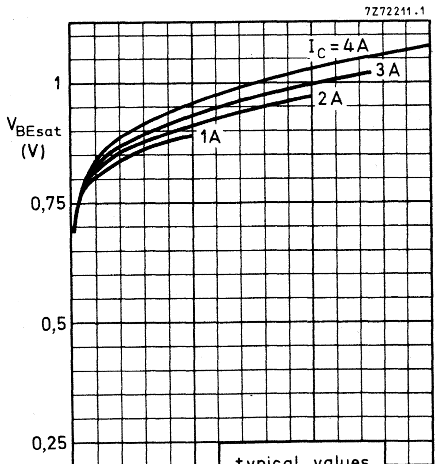

7Z62333
$Z_{th\ j-mb}$ (°C/W)
10^2
10
1
10^{-1}
10^{-2}
$\delta = 1.0$
0.75
0.5
0.33
0.2
0.1
0.05
0.02
0.01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (ms) 10^4

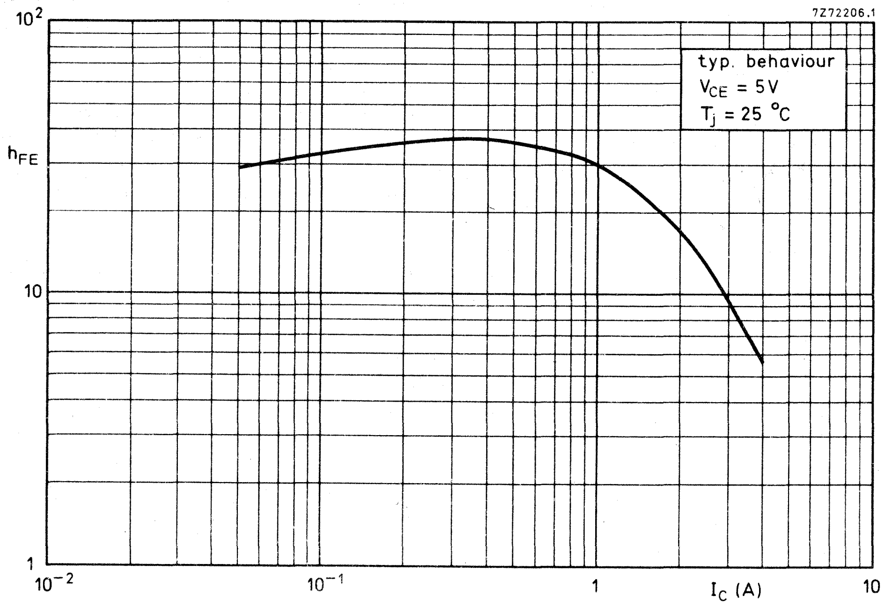

7Z62337
S.B. voltage multiplying factor at the I_{Cmax} level
$M_{SB(I)}$
10^2
10
1
$\delta = 0.01$
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^{-2}
10^{-1}
1
10
t_p (ms)
10^2

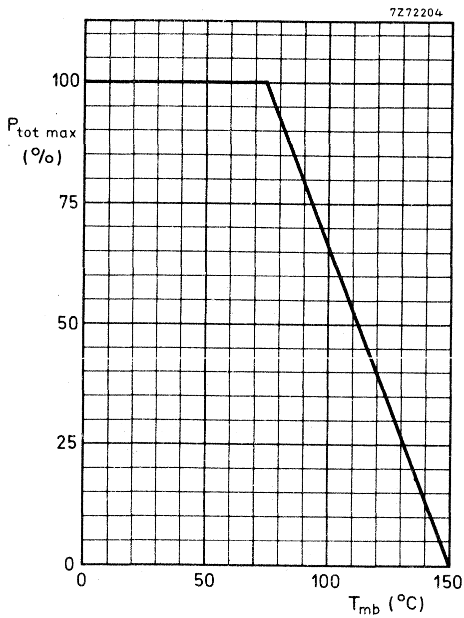

7Z62461
S.B. current multiplying factor at the $V_{CEO\,max}$ level
BDY93
$M_{SB(V)}$
10^2
10
1
$\delta = 0.01$
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^{-2}
10^{-1}
1
10
t_p (ms)
10^2


7Z62330A
S.B. current multiplying factor at the V_{CEOmax} level
BDY94
$M_{SB(V)}$
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


7Z72205.1
10
5
0
VCEsat
(V)
Tj = 25 °C
max. values
typ. values
IC = 4 A
3 A
2 A
1A
0
0,5
1
1,5
IB (A)


7Z72211.1
1
0,75
0,5
0,25
0
VBEsat
(V)
IC = 4 A
3 A
2 A
1A
typical values
Tj = 25 °C
0
0,5
1
1,5
IB (A)


7Z72206.1
typ. behaviour
V_{CE} = 5 V
T_j = 25 °C
10^2
h_{FE}
10
1
10^{-2}
10^{-1}
1
I_C (A)
10


7Z72204
100
$P_{tot\ max}$
(%)
75
50
25
0
0
50
100
150
T_{mb} (°C)

SILICON DIFFUSED POWER TRANSISTORS

High voltage, high speed switching n-p-n power transistors in a TO-3 envelope, intended for use in converters, inverters, switching regulators and motor control systems.

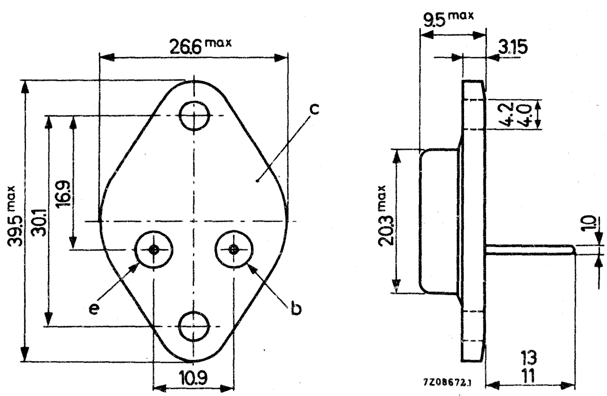
QUICK REFERENCE DATA

			BDY96	BDY97	
Collector-emitter peak voltage ($V_{BE} = 0$)	V_{CESM}	max.	750	750	V
Collector-emitter voltage ($R_{BE} = 100\ \Omega$)	V_{CER}	max.	450	400	V
Collector-emitter voltage (open base)	V_{CEO}	max.	350	300	V
Collector current (d.c.)	I_C	max.	10	10	A
Collector current (peak value)	I_{CM}	max.	15	15	A
Total power dissipation up to $T_{mb} = 90\ ^oC$	P_{tot}	max.	40	40	W
Collector-emitter saturation voltage $I_C = 5$ A; $I_B = 1$ A	V_{CEsat}	<	1,5	1,5	V
Fall time $I_C = 5$ A; $I_{B1} = 1$ A; $-I_{B2} = 2$ A	t_f	typ.	0,3	0,4	µs

MECHANICAL DATA Dimensions in mm

TO-3

Collector connected to case



For mounting instructions and accessories, see section Accessories

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

Voltage

			BDY96	BDY97	
Collector-emitter voltage (V_{BE} = 0), peak value	V_{CESM}	max.	750	750	V
Collector-emitter voltage (R_{BE} = 100 Ω)	V_{CER}	max.	450	400	V
Collector-emitter voltage (open base)	V_{CEO}	max.	350	300	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.	6	A

Power dissipation

Total power dissipation up to T_{mb} = 90 °C	P_{tot}	max.	40	W

Temperature

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

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,5	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current [2]

V_{CE} = 750 V; V_{BE} = 0	I_{CES}	<	0,5	mA
V_{CE} = 750 V; V_{BE} = 0; T_j = 125 °C	I_{CES}	<	2	mA

D.C. current gain

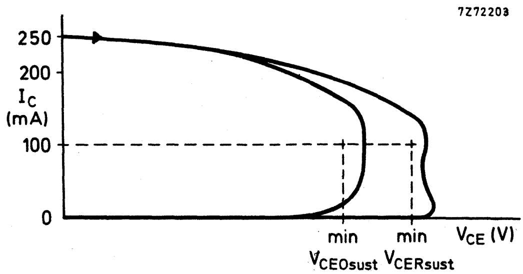
I_C = 2 A; V_{CE} = 5 V	h_{FE}	typ.	30

[1]) Turn-off current.

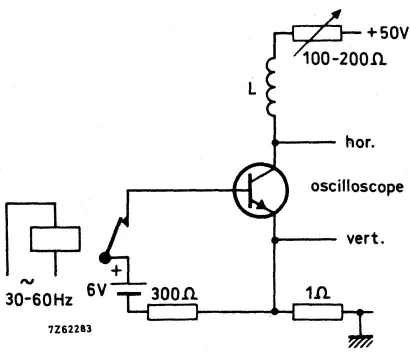
[2]) Measured with a half sine wave voltage (curve tracer).

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

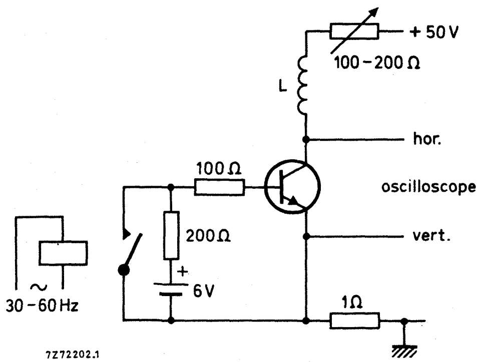
			BDY96	BDY97	
Emitter-base breakdown voltage					
$I_C = 0$; $I_E = 5$ mA	$V_{(BR)EBO}$	>	6	6	V
Saturation voltage					
$I_C = 5$ A; $I_B = 1$ A	V_{CEsat}	<	1,5	1,5	V
	V_{BEsat}	<	1,4	1,4	V
$I_C = 8$ A; $I_B = 2,5$ A	V_{CEsat}	<	3	3	V
	V_{BEsat}	<	2	2	V
Collector-emitter sustaining voltage					
$I_C = 100$ mA; $I_B = 0$; $L = 25$ mH	$V_{CEOsust}$	>	350	300	V
$I_C = 100$ mA; $R_{BE} = 100\ \Omega$; $L = 5$ mH	$V_{CERsust}$	>	450	400	V



Oscilloscope display for sustaining voltages



Test circuit for $V_{CEOsust}$



Test circuit for $V_{CERsust}$

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

Transition frequency at f = 1 MHz

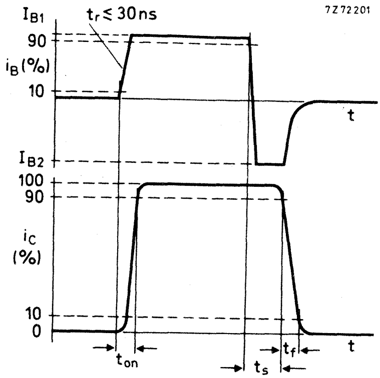
$I_C = 0,2$ A; $V_{CE} = 10$ V	f_T	typ.	10	MHz

Switching times

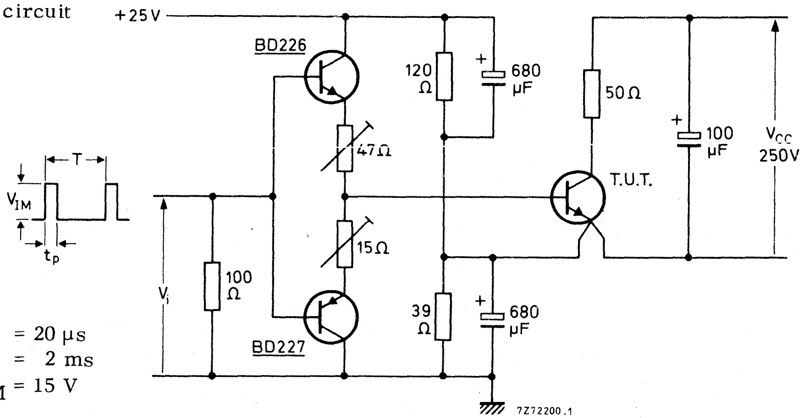
$I_{Con} = 5$ A; $I_{B1} = 1$ A; $-I_{B2} = 2$ A; $V_{CC} = 250$ V

			BDY96	BDY97	
Turn-on time	t_{on}	typ.	0,35	0,35	µs
		<	0,5	0,5	µs
Turn-off:					
Storage time	t_s	typ.	2,5	3,0	µs
		<	3,0	3,5	µs
Fall time	t_f	typ.	0,3	0,4	µs
Fall time, $T_{mb} = 95\ ^oC$	t_f	<	1,0	1,3	µs

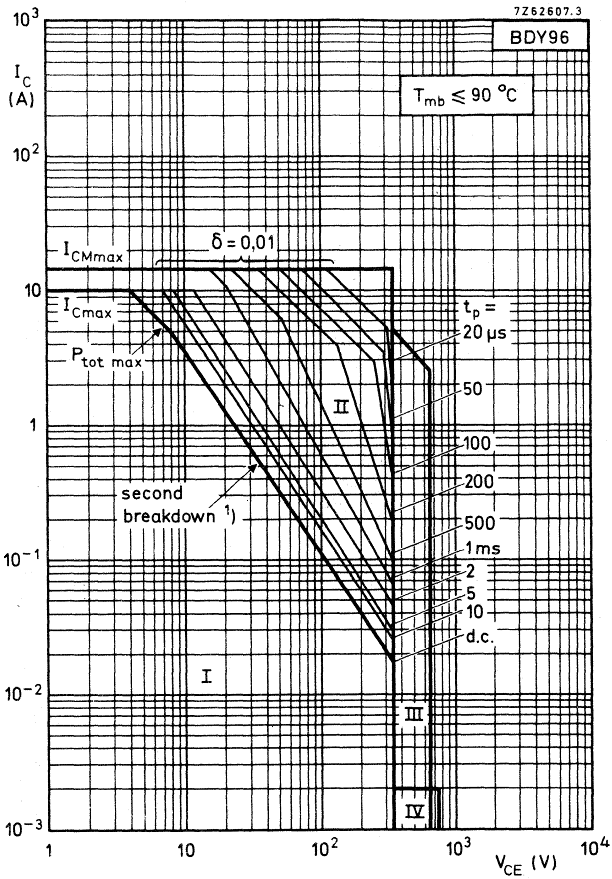
Waveform



Test circuit



t_p = 20 µs
T = 2 ms
V_{IM} = 15 V



Safe Operating Area with the transistor forward biased (region I + II)

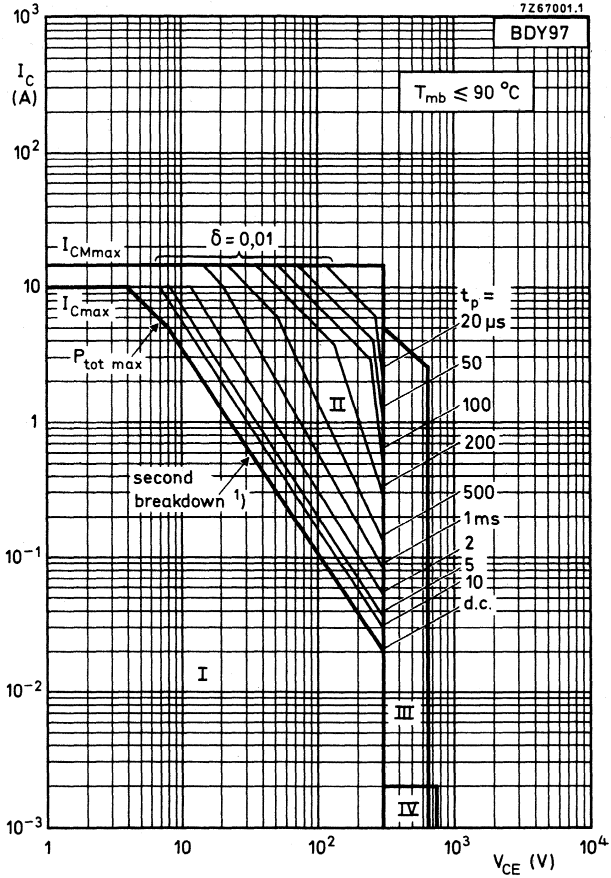
I Region of permissible d. c. operation

II Permissible extension for repetitive pulse operation

III Area of permissible operation during turn-on, provided $t_p \leq 0,3$ 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

[1]) Independent of temperature



Safe Operating Area with the transistor forward biased (region I + II)

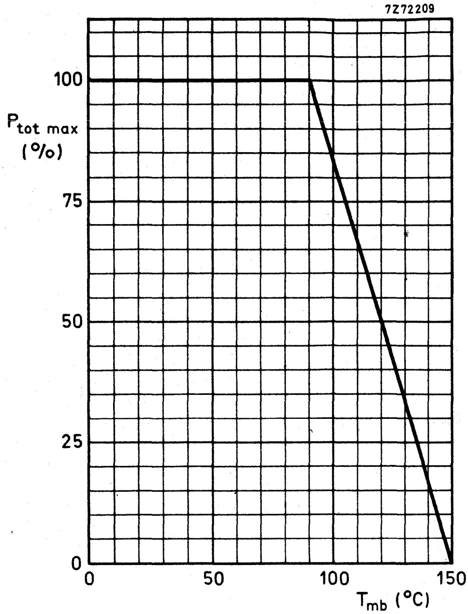
I Region of permissible d.c. operation

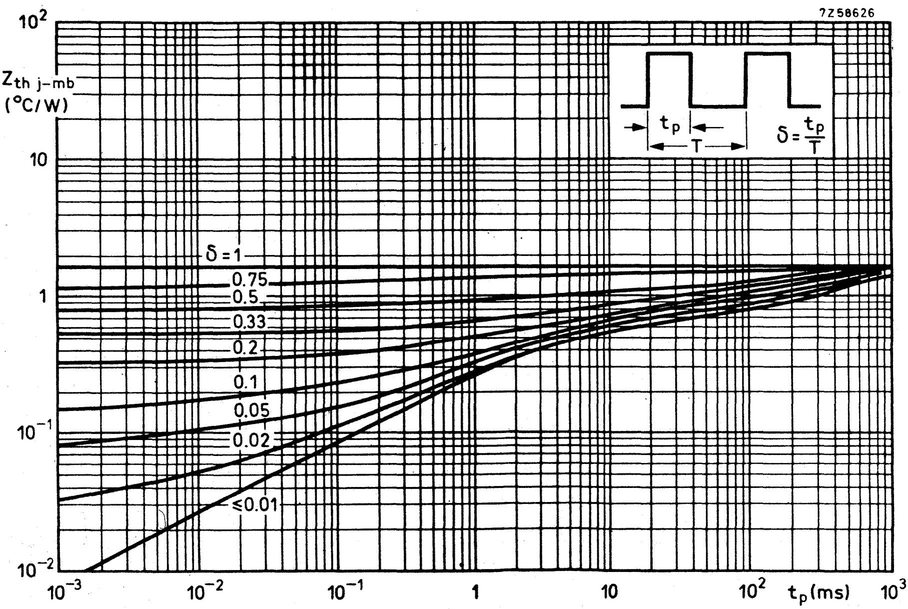
II Permissible extension for repetitive pulse operation

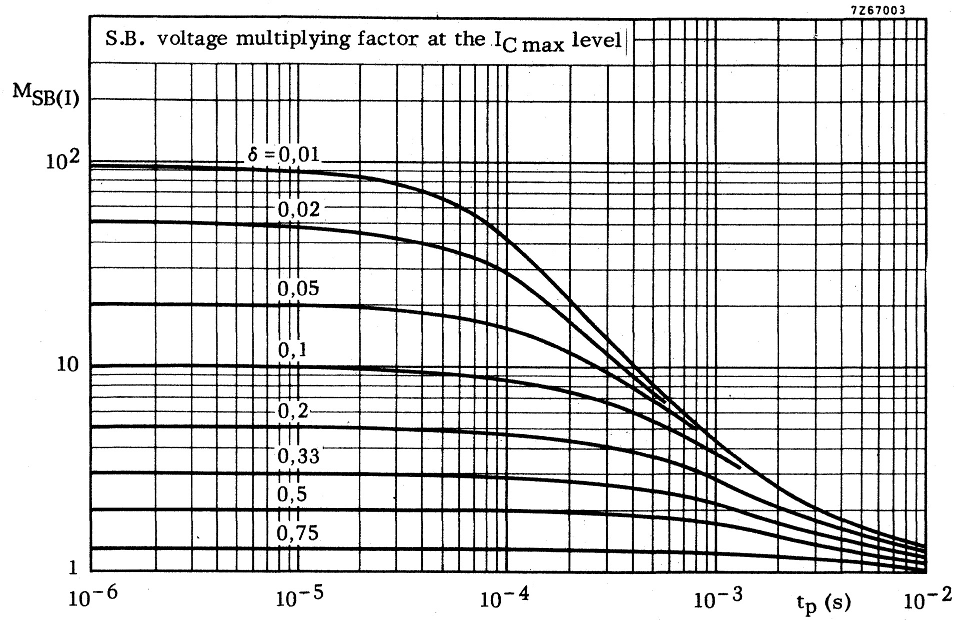
III Area of permissible operation during turn-on, provided $t_p \leq 0,3\ \mu s$ and $R_{BE} \leq 100\ \Omega$

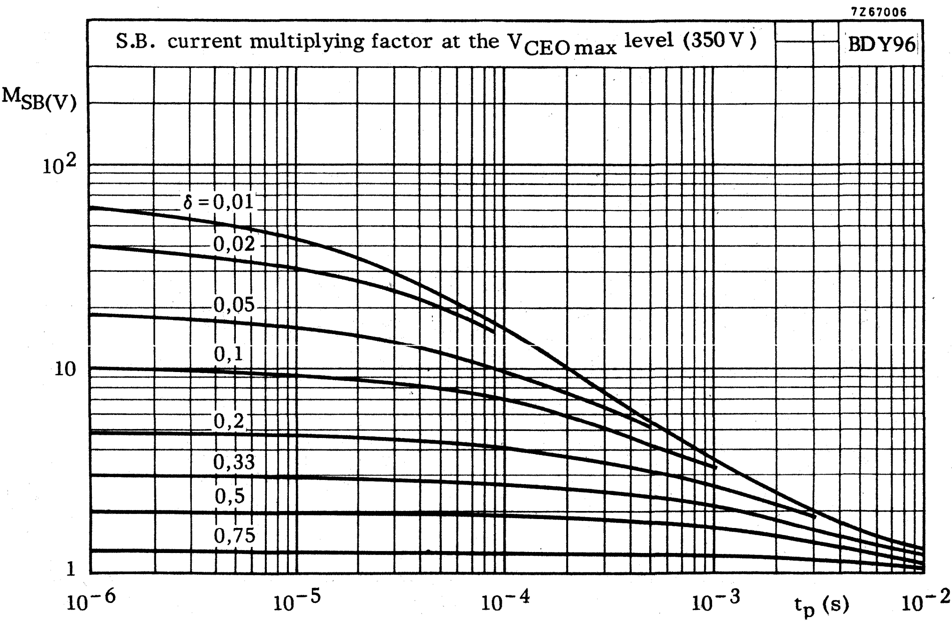
IV Repetitive pulse operation in this region is allowable provided $V_{BE} \leq 0$ and $t_p \leq 2$ ms

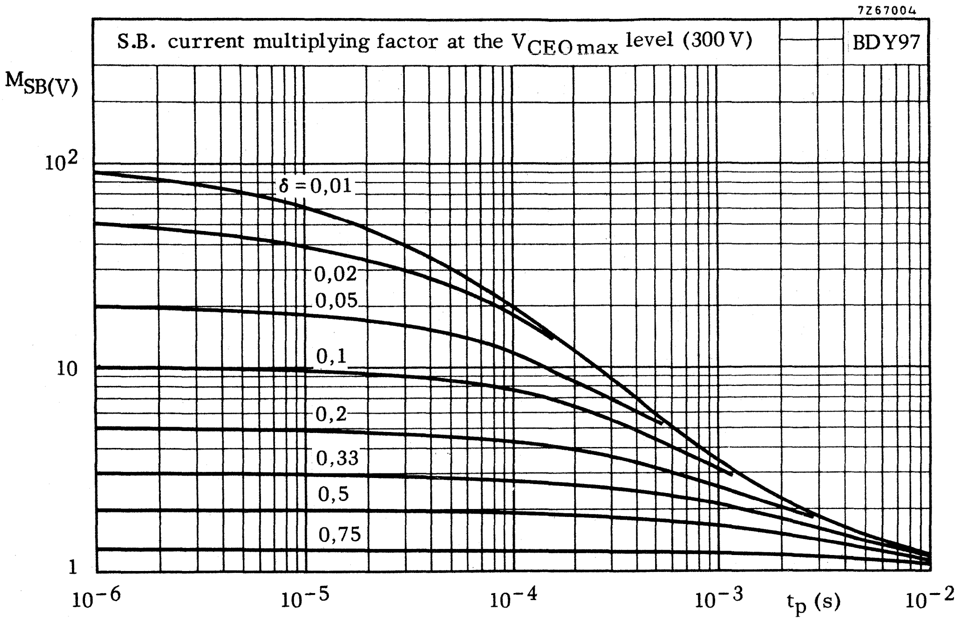
1) Independent of temperature

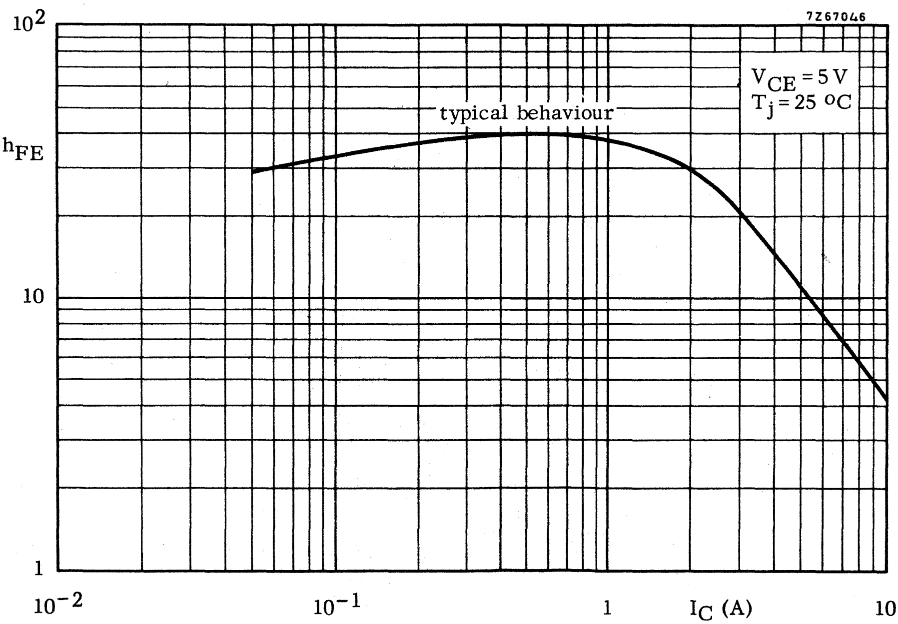

7Z72209
100
$P_{tot\ max}$ (%)
75
50
25
0
0
50
100
150
T_{mb} (°C)

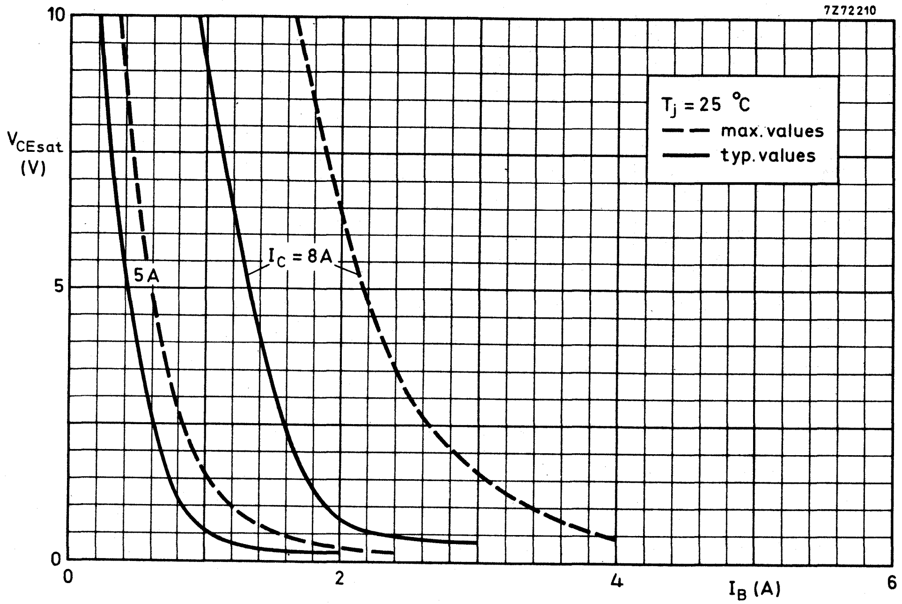

7Z58626
10^2
$Z_{th\ j-mb}$ (°C/W)
10
1
10^{-1}
10^{-2}
t_p
T
$\delta = \frac{t_p}{T}$
δ = 1
0.75
0.5
0.33
0.2
0.1
0.05
0.02
≤0.01
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3

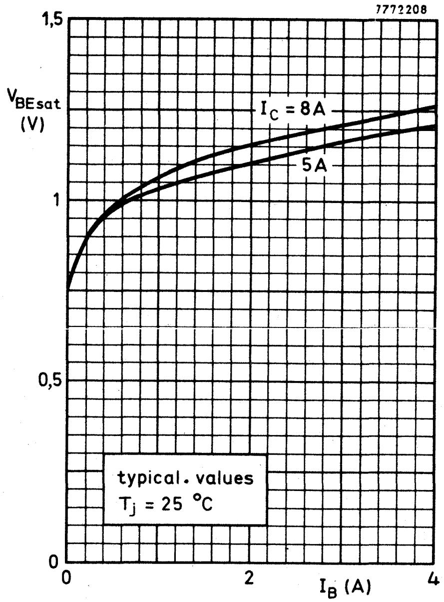

7Z67003
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^{-6}
10^{-5}
10^{-4}
10^{-3}
t_p (s)
10^{-2}


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 VCEO max level (300 V)
BDY97
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


7Z67046
10²
hFE
10
1
typical behaviour
VCE = 5 V
Tj = 25 °C
10⁻²
10⁻¹
1
IC (A)
10


7Z72210
10
5
0
0
2
4
6
V_{CEsat}
(V)
I_B (A)
T_j = 25 °C
max. values
typ. values
I_C = 8 A
5 A


7Z72208
1,5
1
0,5
0
0
2
4
V_{BEsat}
(V)
I_B (A)
I_C = 8 A
5 A
typical. values
T_j = 25 °C

SILICON DIFFUSED POWER TRANSISTOR

High voltage n-p-n transistor in a metal envelope intended for use in horizontal deflection circuits of television receivers.

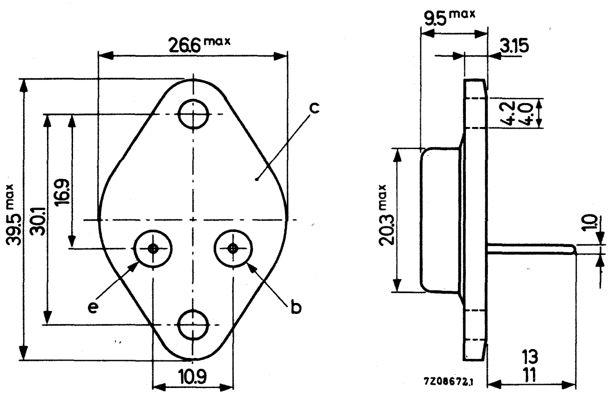
QUICK REFERENCE DATA				
Collector-base voltage (peak value)	V_{CBOM}	max.	1500	V
Collector-emitter voltage (peak value) $R_{BE} \leq 100\ \Omega$	V_{CERM}	max.	1500	V
Collector current (peak value)	I_{CM}	max.	2.5	A
Total power dissipation up to $T_{mb} = 90\ ^{o}C$	P_{tot}	max.	10	W
Collector-emitter 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

TO-3



For mounting instructions and accessories, see section Accessories

FOR NEW DESIGN THE SUCCESSOR TYPES BU204 TO BU206 ARE RECOMMENDED

SILICON DIFFUSED POWER TRANSISTOR

High-voltage n-p-n transistor in metal envelope intended for use in horizontal deflection circuits of colour television receivers.

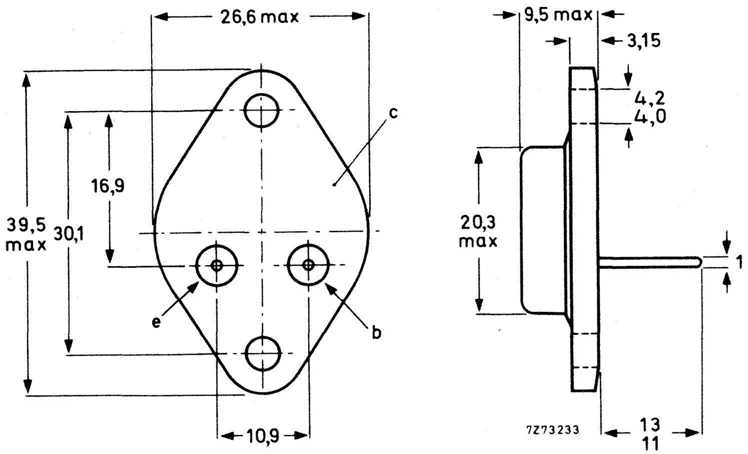
QUICK REFERENCE DATA				
Collector-base voltage (peak value)	V_{CBOM}	max.	1500	V
Collector-emitter voltage (peak value: $R_{BE} \leq 100\ \Omega$)	V_{CERM}	max.	1500	V
Collector current (d.c.)	I_C	max.	5	A
Total power dissipation up to $T_{mb} = 95\ ^oC$	P_{tot}	max.	12,5	W
Collector-emitter saturation voltage $I_C = 4,5$ A; $I_B = 2$ A	V_{CEsat}	<	5	V
Fall time when switched from $I_C = 4,5$ A; $I_{B(end)} = 1,8$ A; $L_B = 10\ \mu H$	t_f	typ.	0,7	μs

MECHANICAL DATA

TO-3

Collector connected to case

Dimensions in mm



SUCCESSOR TYPES: BU207A TO BU209A

SILICON DIFFUSED POWER TRANSISTOR

High voltage, high speed switching n-p-n power transistor intended for use in the switched mode power supply of 90° and 110° colour television receivers.

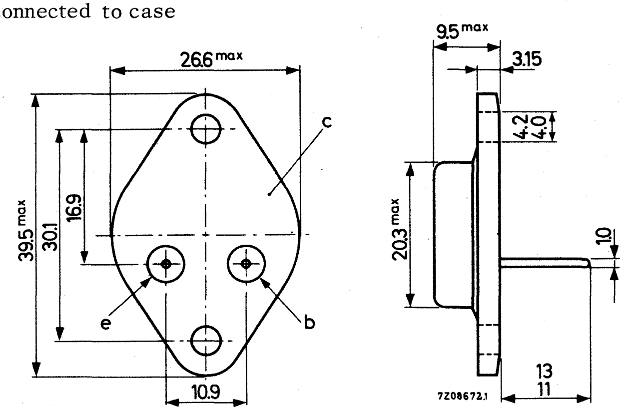
QUICK REFERENCE DATA				
Collector-emitter voltage (V_{BE} = 0)(peak value)	V_{CESM}	max.	750	V
Collector current (peak value)	I_{CM}	max.	6	A
Total power dissipation up to T_{mb} = 50 °C	P_{tot}	max.	30	W
Collector-emitter saturation voltage I_C = 2.5 A; I_B = 0.25 A	V_{CEsat}	<	10	V
Fall time I_{CM} = 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



For mounting instructions and accessories, see section Accessories

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

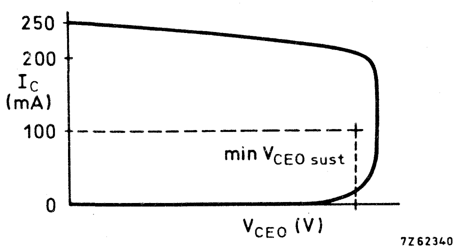
THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	2.5	°C/W

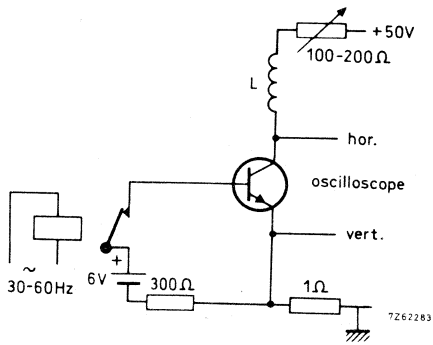
[1]) Turn-off current.

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 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 $V_{CEO sust}$



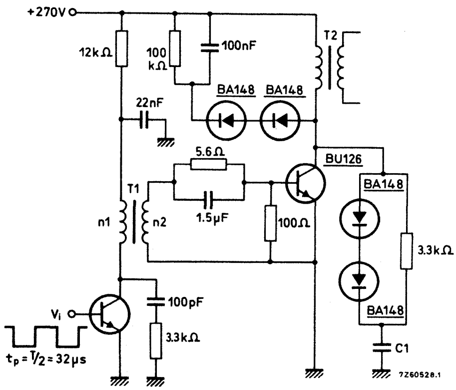
Test circuit for $V_{CEO sust}$

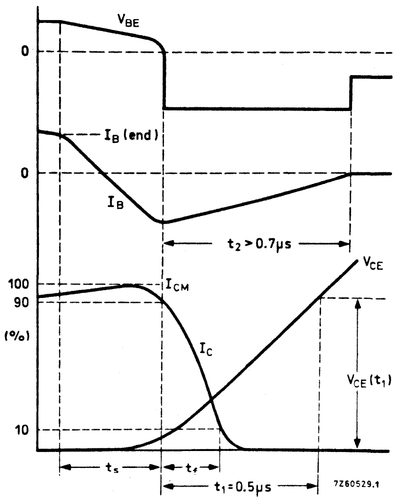
1) Measured with a half sine wave voltage (curve tracer).

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

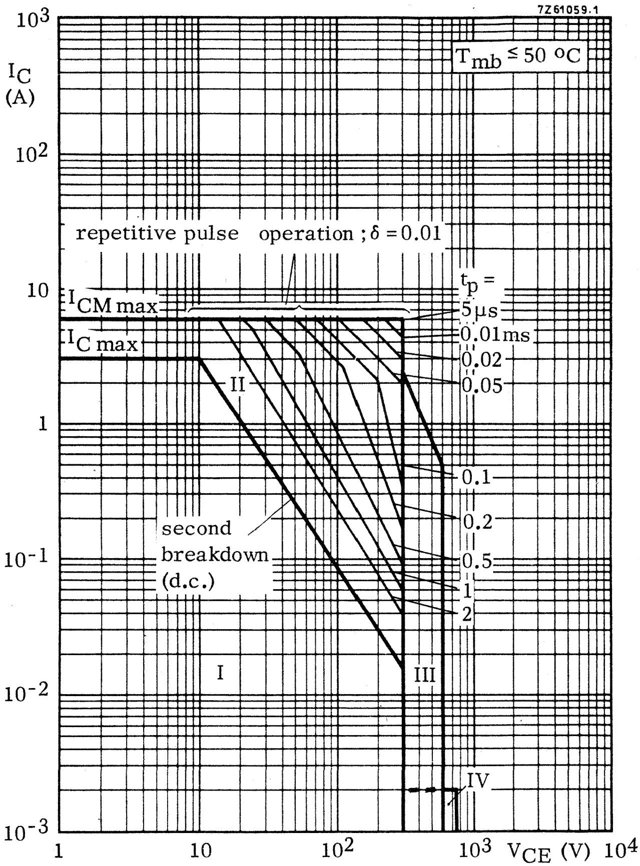




Max. allowable value of V_{CE} after $t_1 = 0.5$ μs and when $t_2 > 0.7$ μs	$V_{CE(t_1)}$	<	500	V

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).



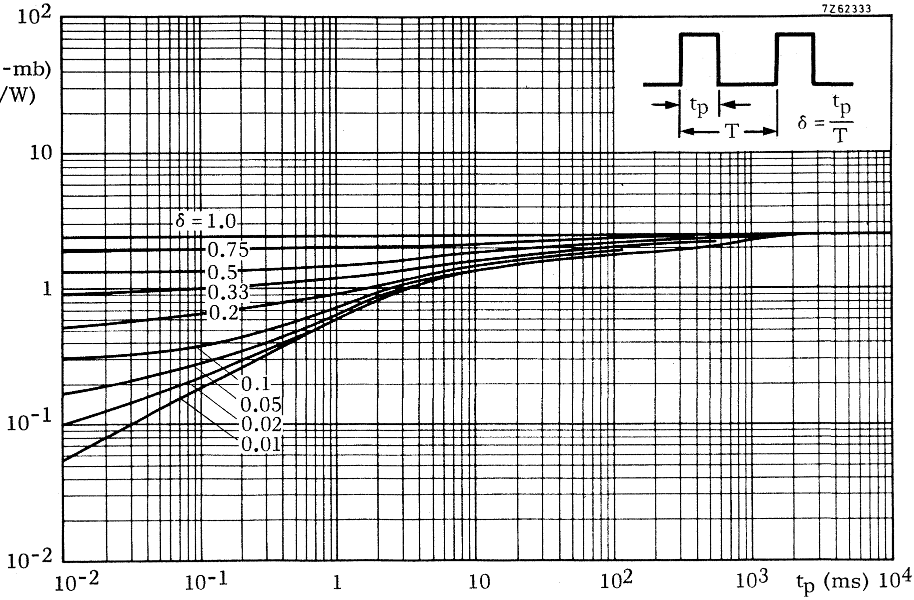
Safe Operating Area (Regions I, II and III forward biased)

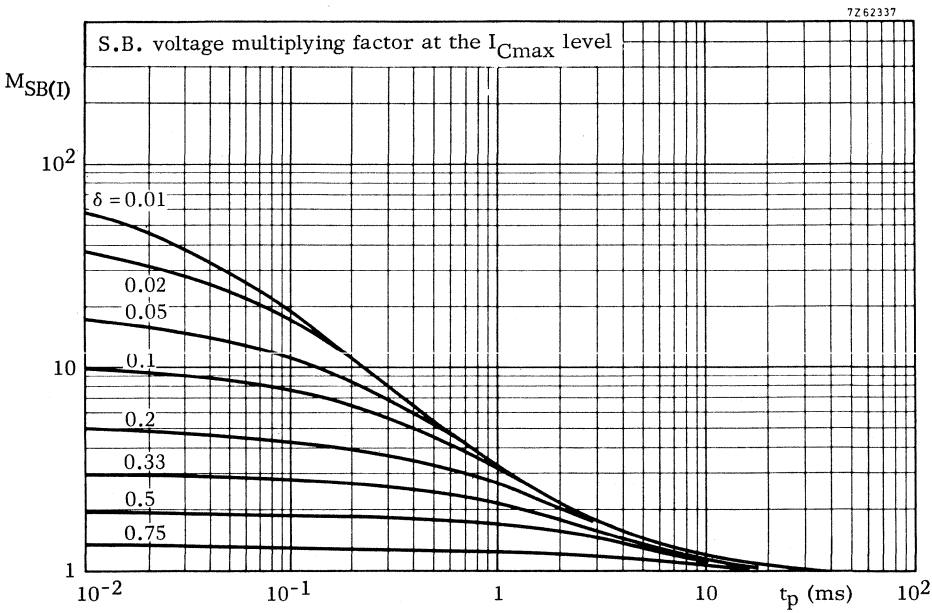
I Region of permissible d.c. operation

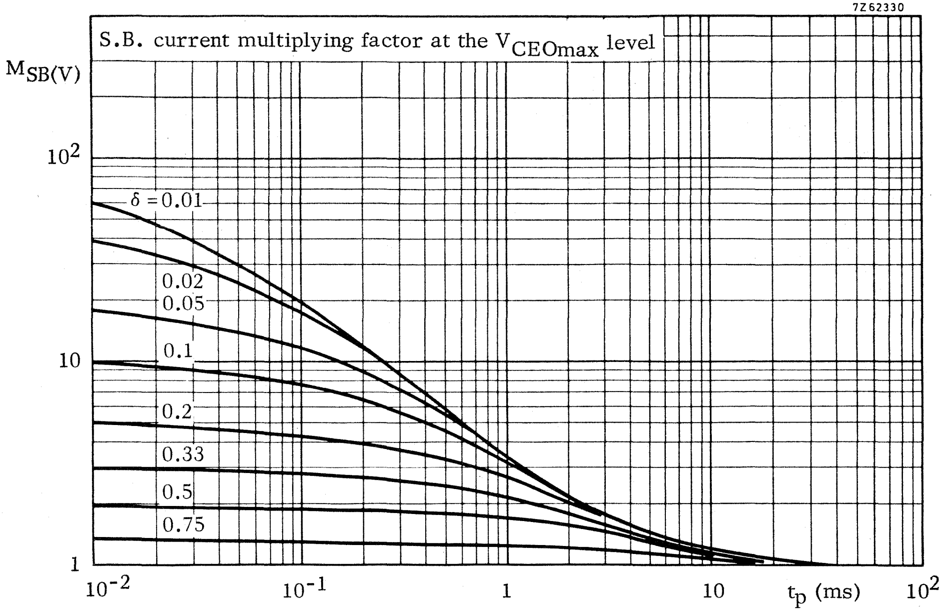
II Permissible extension for repetitive pulse operation

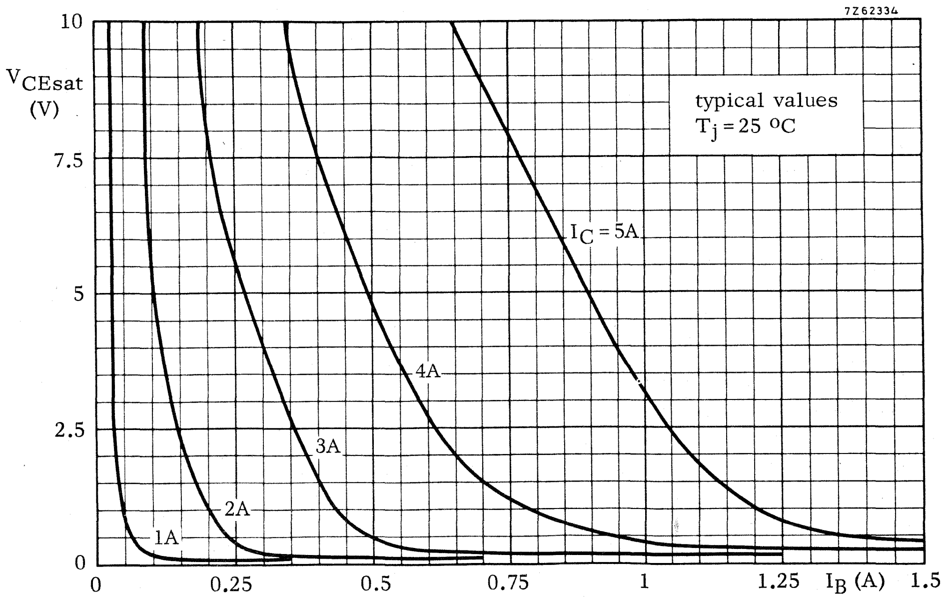
III Area of permissible operation during turn-on in switched mode power supply circuits, provided $t_p \leq 0.6\ \mu s$ and $R_{BE} \leq 100\ \Omega$

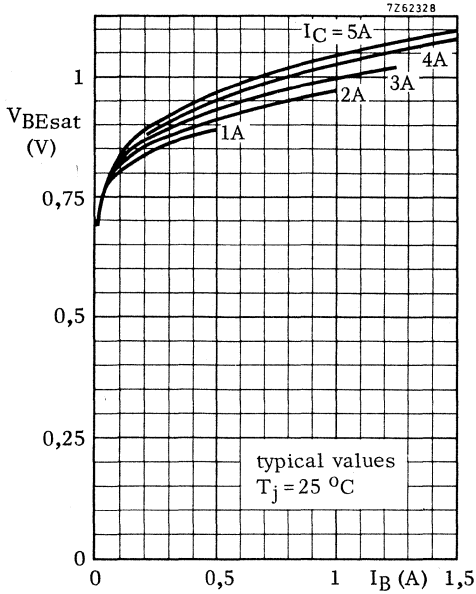
IV Repetitive pulse operation in this region is allowable, provided $V_{BE} \leq 0$ and $t_p \leq 2$ ms

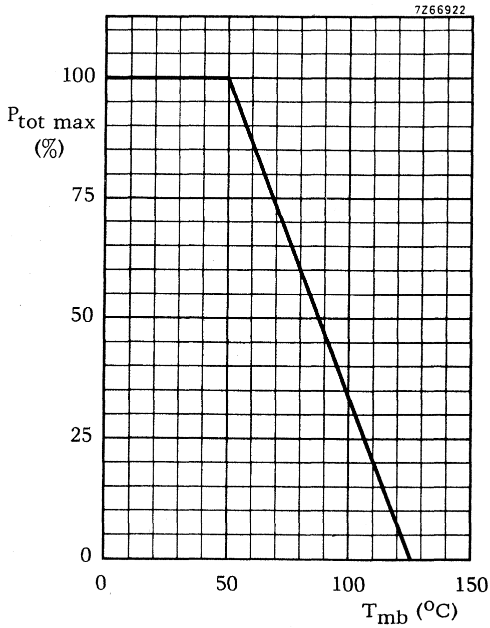

7Z62333
$Z_{th(j-mb)}$ (°C/W)
$\delta = 1.0$
0.75
0.5
0.33
0.2
0.1
0.05
0.02
0.01
t_p
T
$\delta = \frac{t_p}{T}$
t_p (ms)

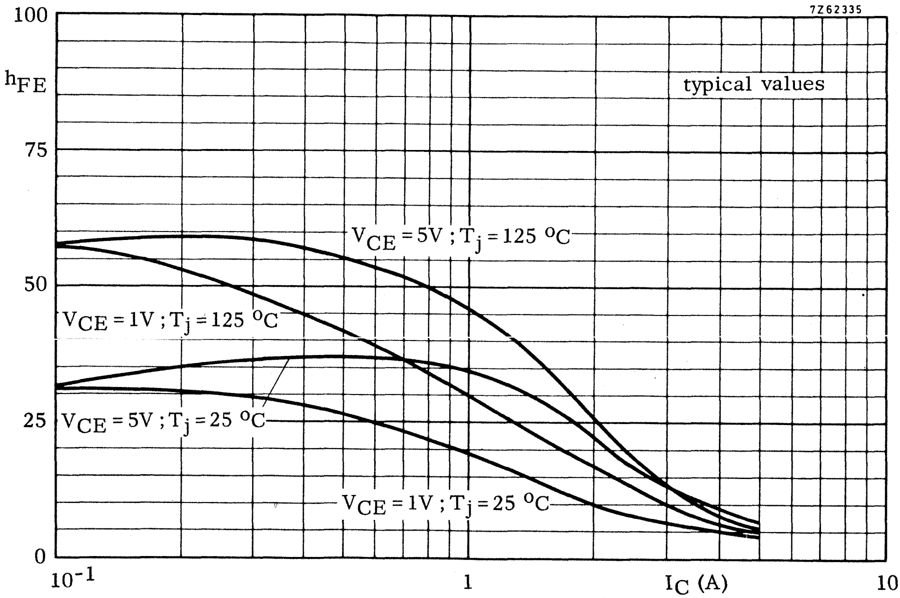

7Z62337
S.B. voltage multiplying factor at the I_{Cmax} level
$M_{SB(I)}$
$\delta = 0.01$
0.02
0.05
0.1
0.2
0.33
0.5
0.75
t_p (ms)


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
$T_j = 25\ ^oC$
$I_C = 5A$
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
$T_j = 25\ ^oC$
0
0,5
1
I_B (A)
1,5


7Z66922
$P_{tot\ max}$ (%)
100
75
50
25
0
0
50
100
150
T_{mb} (^oC)


7Z62335
100
h_{FE}
75
50
25
0
typical values
$V_{CE} = 5V ; T_j = 125\ ^oC$
$V_{CE} = 1V ; T_j = 125\ ^oC$
$V_{CE} = 5V ; T_j = 25\ ^oC$
$V_{CE} = 1V ; T_j = 25\ ^oC$
10^{-1}
1
I_C (A)
10

APPLICATION INFORMATION ON BU126 (detailed information on request)

Important factors in the design of SMPS circuits are the power losses and heatsink requirements of the supply output transistor and the base drive conditions during turn-off.

The basic arrangements for parallel and series-type SMPS circuits are shown in Figs 1, 2 and 3 together with the relevant waveforms. In power supply circuits for CTV receivers the duty factor of the collector current generally varies between 0,4 and 0,6.

The maximum permissible thermal resistance for the heatsink can be calculated from

$$R_{th\ mb\text{-}a\ max}{}^{*} = \frac{T_{j\ max} - T_{amb\ max}}{P_{tot}} - R_{th\ j\text{-}mb}.$$

* Including additional thermal resistances resulting from mounting hardware.

For the BU126: $T_{mb\ max} \leqslant 100\ ^oC$ see Fig. 5.

To ensure thermal stability the thermal resistance of the heatsink used must not exceed the values plotted in Fig. 6.

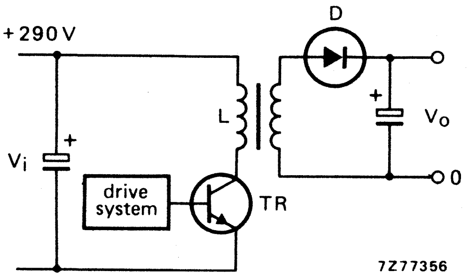


Fig. 1.

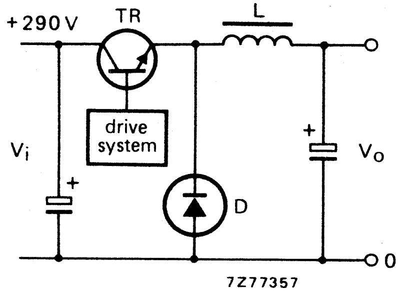


Fig. 2.

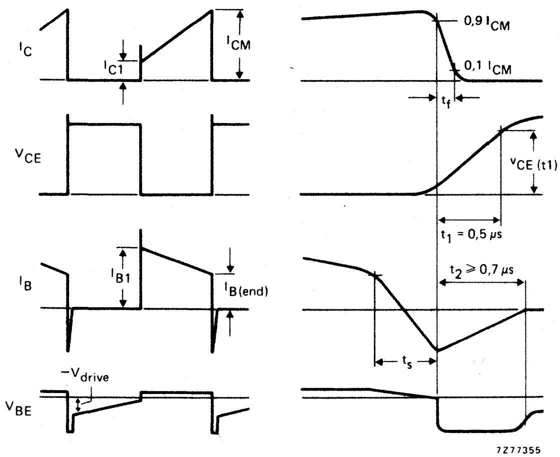


Fig. 3 $v_{CE(t1)} < 500$ V.

Fig. 1 Basic circuit arrangement of parallel-type SMPS power supply (flyback converter).

Fig. 2 Basic circuit arrangement of series-type SMPS power supply (forward converter).

Fig. 3 Relevant waveforms of switching transistor.

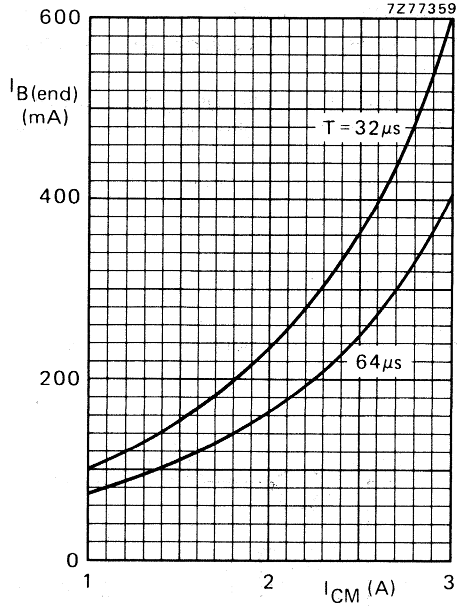


Fig. 4.

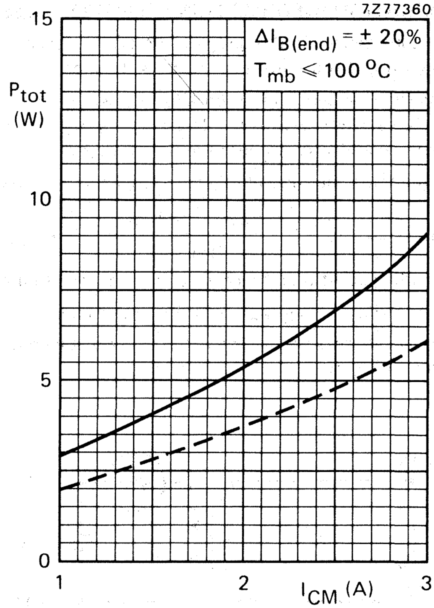


Fig. 5.

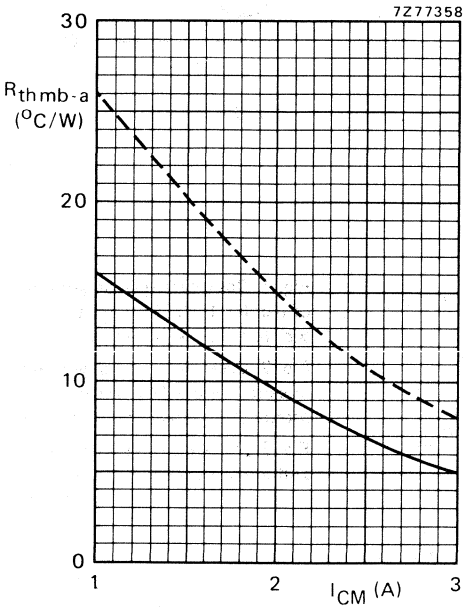


Fig. 6.

Fig. 4 Recommended nominal "end" value of the base current versus maximum peak collector current.

Fig. 5 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 4. Solid line for I_{C1}/I_{CM} = 0,4 and dotted line for I_{C1}/I_{CM} = 0.

Fig. 6 Maximum permissible thermal resistance of the heatsink versus maximum peak collector current to ensure thermal stability. Solid line for I_{C1}/I_{CM} = 0,4 and dotted line for I_{C1}/I_{CM} = 0.

SILICON DIFFUSED POWER TRANSISTOR

High voltage 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.

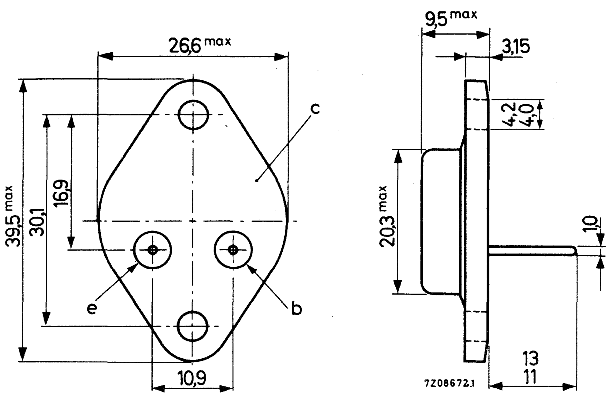
QUICK REFERENCE DATA				
Collector-emitter voltage (V_{BE} = 0) peak value	V_{CESM}	max.	800	V
Collector-emitter voltage (R_{BE} = 220 Ω) peak v.	V_{CERM}	max.	700	V
Collector current (peak value)	I_{CM}	max.	2	A
Total power dissipation up to T_{mb} = 97 °C	P_{tot}	max.	15	W
Junction temperature	T_j	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



For mounting instructions and accessories, see section Accessories

SILICON DIFFUSED POWER TRANSISTOR

High voltage n-p-n power transistor intended for general purpose applications.

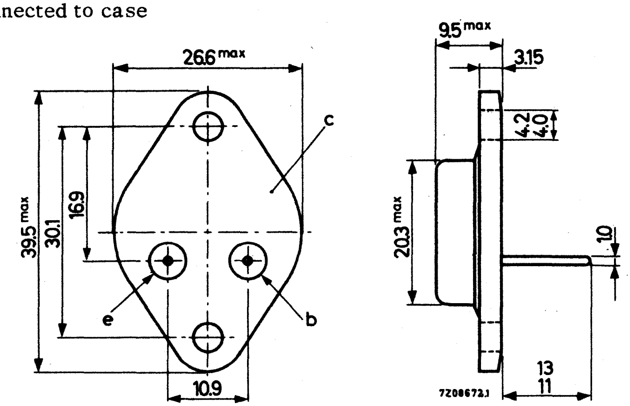
QUICK REFERENCE DATA

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



For mounting instructions and accessories, see section Accessories

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

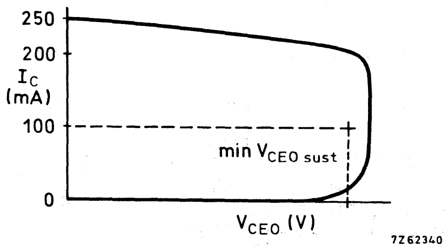
THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2.5	°C/W

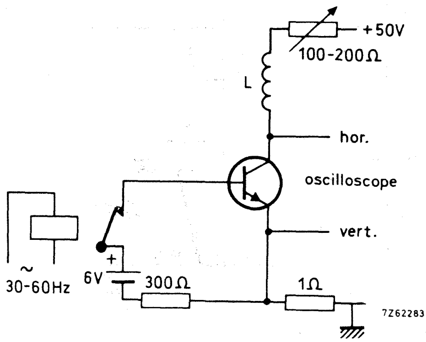
1) Turn-off current.

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
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	$V_{CEO\,sust}$	>	250	V



Oscilloscope display for $V_{CEO\,sust}$

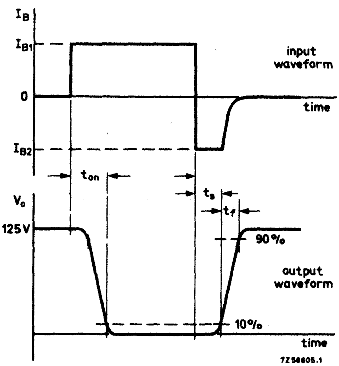


Test circuit for $V_{CEO\,sust}$

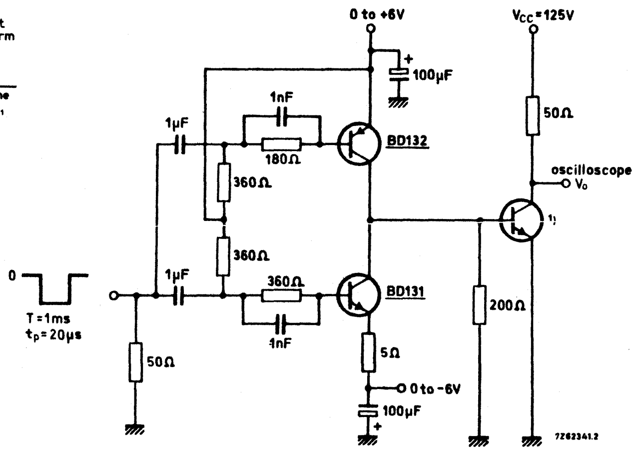
1) Measured with a half sine wave voltage (curve tracer).

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

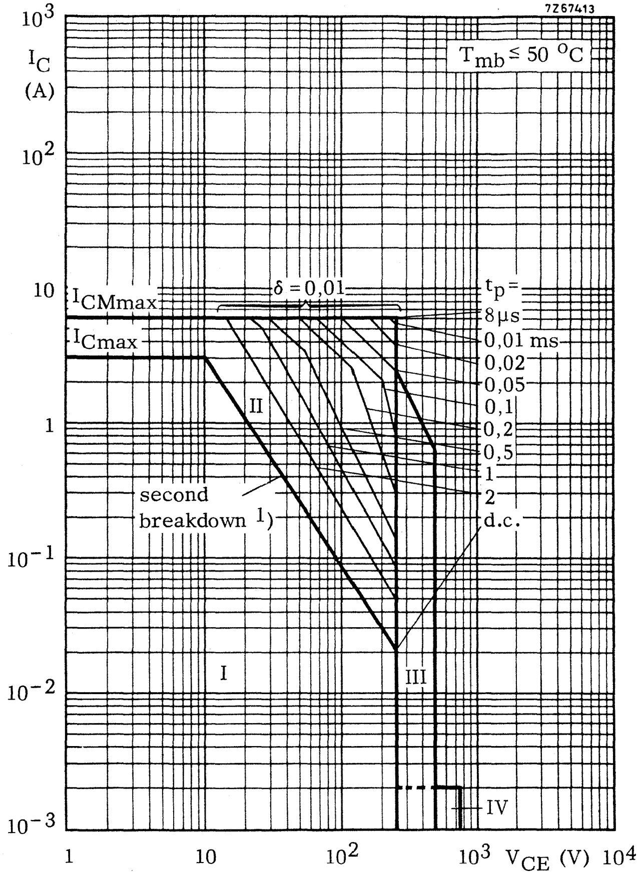
Transition frequency at f = 1MHz				
I_C = 0.2 A; V_{CE} = 10 V	f_T	typ.	8	MHz
Collector capacitance at f = 1 MHz				
$I_E = I_e$ = 0; V_{CB} = 10 V	C_c	typ.	85	pF
Emitter capacitance at f = 1 kHz				
$I_C = I_c$ = 0; V_{EB} = 2 V	C_e	typ.	1.4	nF
Switching times				
I_C = 2.5 A; $I_{B1} = -I_{B2}$ = 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)

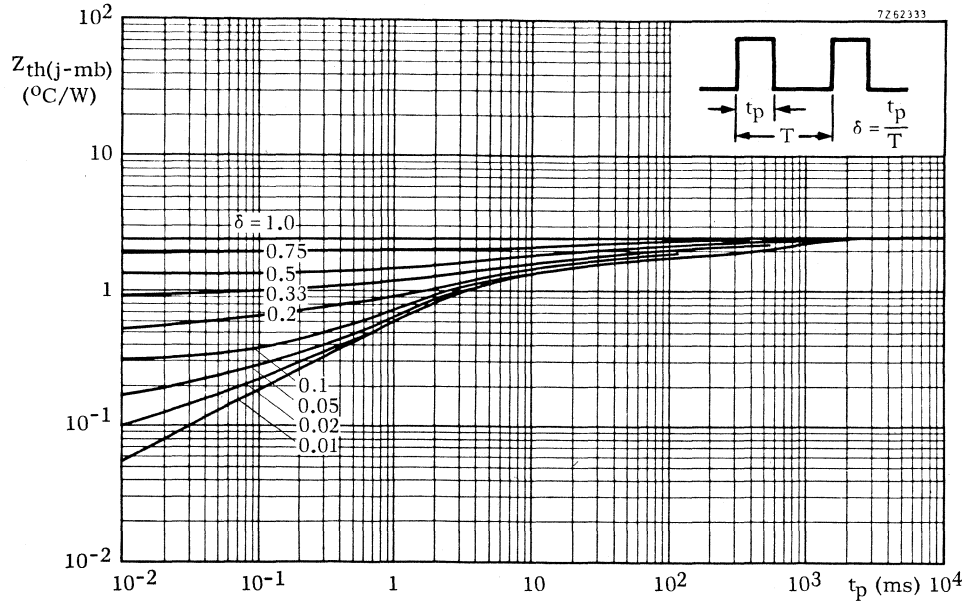
I Region of permissible d.c. operation

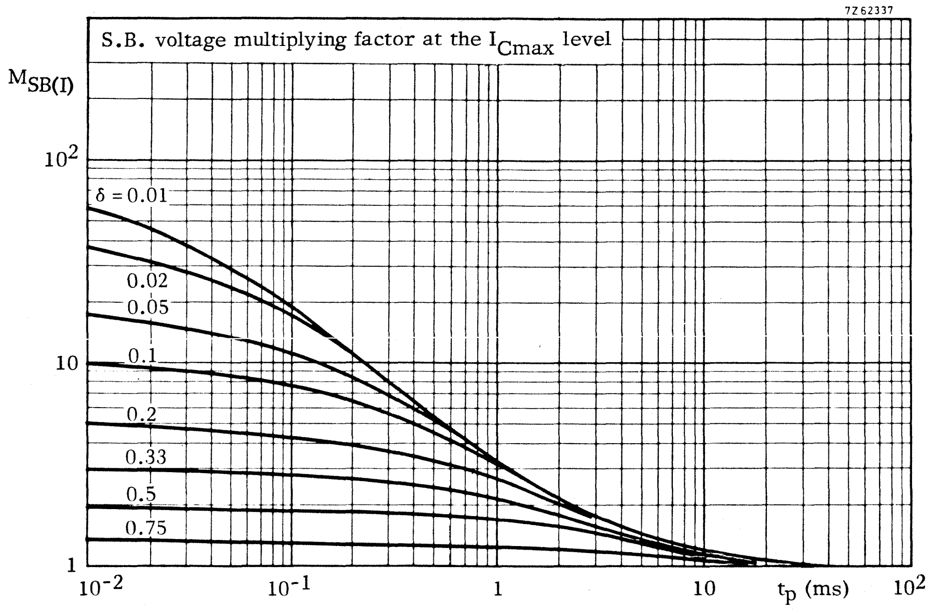
II Permissible extension for repetitive pulse operation

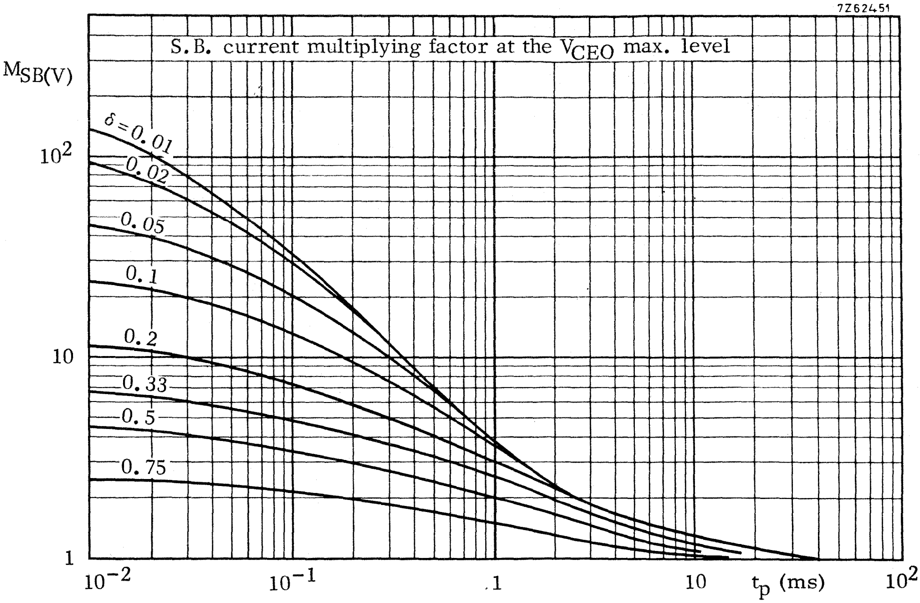
III Area of permissible operation during turn-on, provided pulse duration ≤ 0, 6 µsec and R_{BE} ≤ 100 Ω, e.g. for use in switched mode power supply circuits.

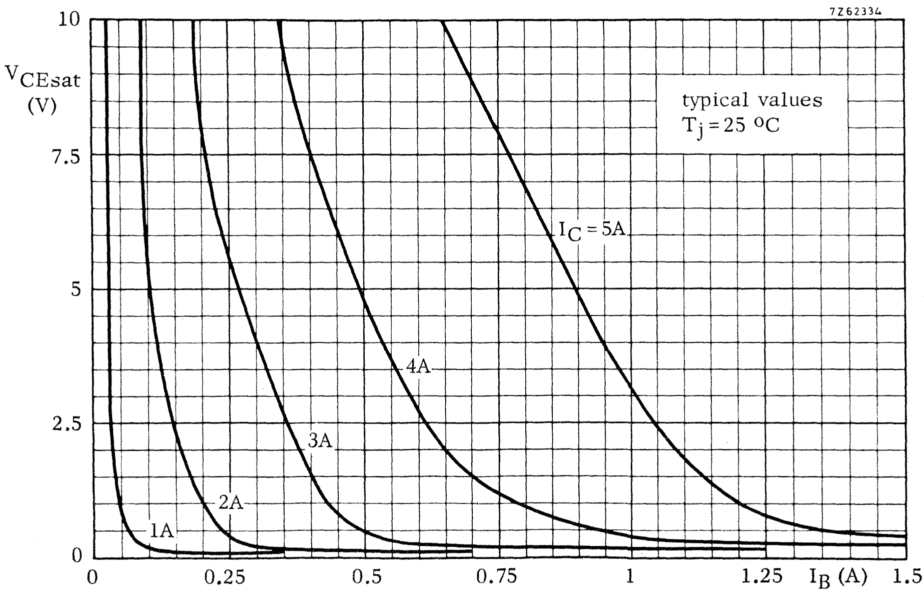
IV Repetitive pulse operation in this region is allowable, provided V_{BE} ≤ 0 V and t_p ≤ 2 ms.

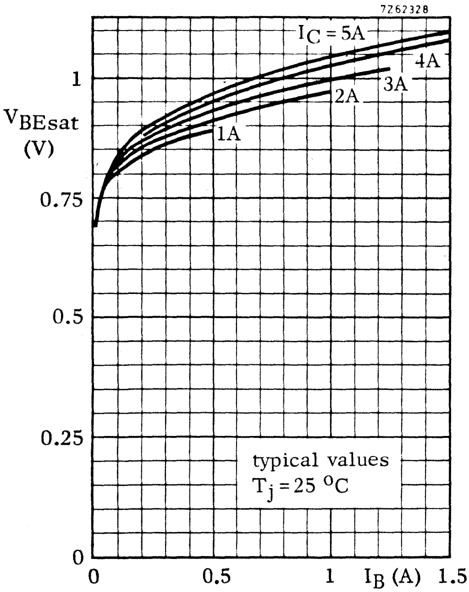
1) Independent of temperature.

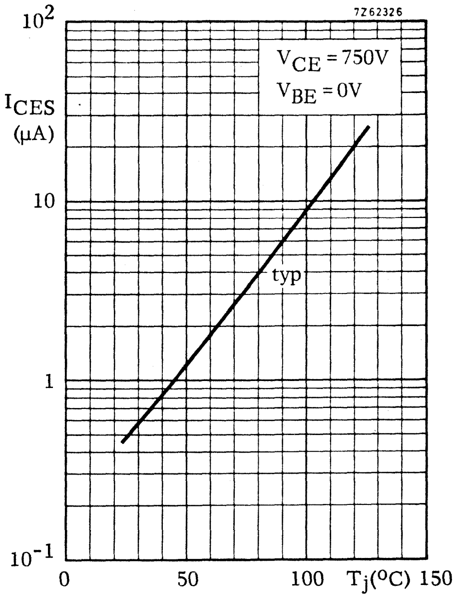

7Z62333
$Z_{th(j-mb)}$ ($^oC/W$)
10^2
10
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (ms) 10^4
t_p
T
$\delta = \frac{t_p}{T}$
$\delta = 1.0$
0.75
0.5
0.33
0.2
0.1
0.05
0.02
0.01

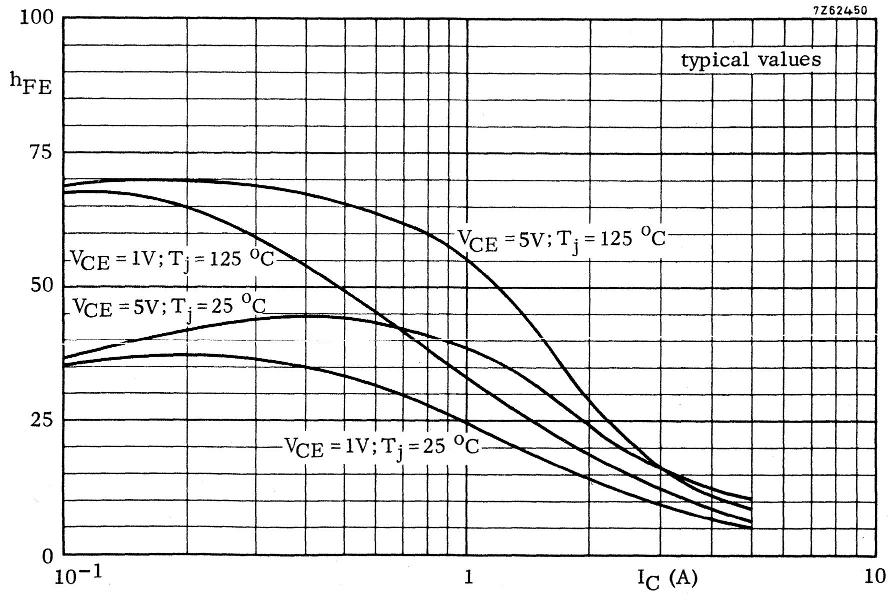

7Z62337
S.B. voltage multiplying factor at the I_{Cmax} level
$M_{SB(I)}$
10^2
10
1
$\delta = 0.01$
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^{-2}
10^{-1}
1
10
t_p (ms)
10^2


7Z62451
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^-2
10^-1
1
10
t_p (ms)
10^2


7Z62334
V_CEsat (V)
10
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
V_{CE} = 750V
V_{BE} = 0V
I_{CES}
(μA)
10
typ
1
10^{-1}
0
50
100
T_j(°C)
150


7Z62450
100
typical values
h_{FE}
75
V_{CE} = 5V; T_j = 125 °C
V_{CE} = 1V; T_j = 125 °C
50
V_{CE} = 5V; T_j = 25 °C
25
V_{CE} = 1V; T_j = 25 °C
0
10^{-1}
1
I_C (A)
10

SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed switching n-p-n transistors in a metal envelope intended for use in horizontal deflection circuits of television receivers.

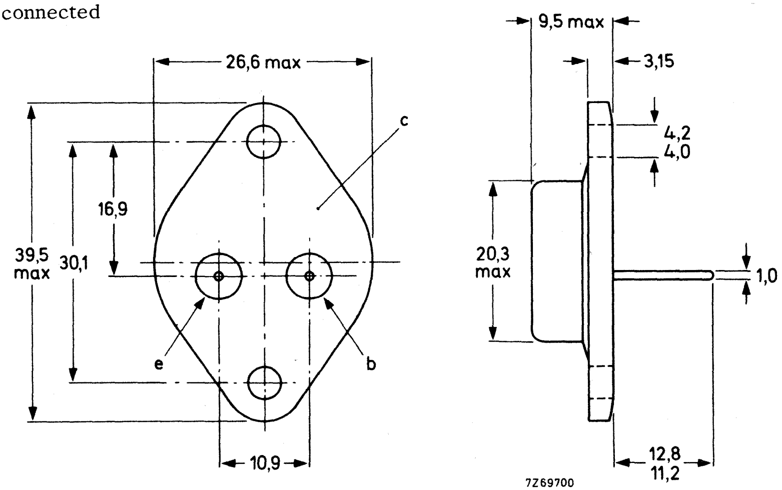
QUICK REFERENCE DATA

			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 °C	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_{CM} = 2 A; $I_{B(end)}$ = 1 A	t_f	typ.	0,75	0,75	0,75	µs

MECHANICAL DATA

TO-3

Collector connected to case



For mounting instructions and accessories see section Accessories.

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

			BU204	BU205	BU206	
Voltage						
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

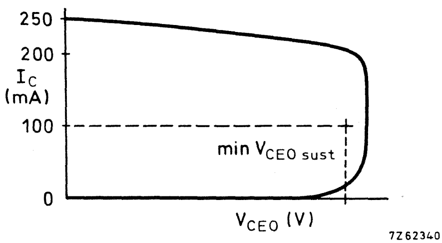
THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	max.	2,5	°C/W

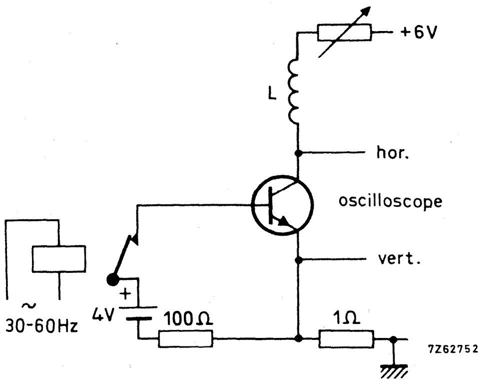
1) Turn-off current.

CHARACTERISTICS $T_j = 25\ ^{o}C$ 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						
$I_C = 2$ 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

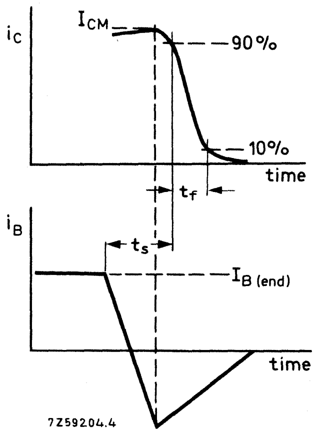
Collector capacitance at f = 1 MHz

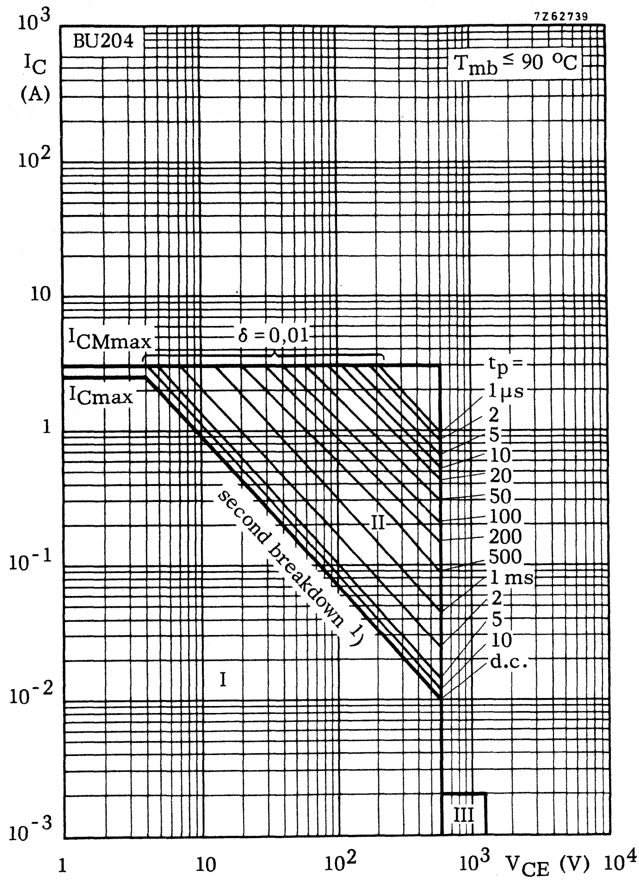
$I_E = I_e = 0$; V_{CB} = 10 V	C_c	typ.	65	pF

Switching times (in horizontal deflection circuit)

I_{CM} = 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





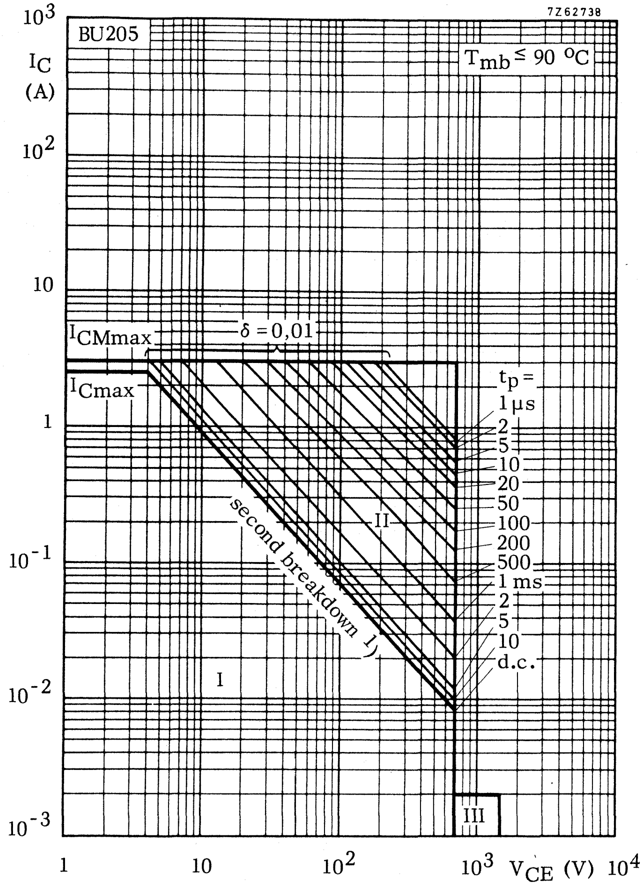
Safe Operation Area with the transistor forward biased.

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.



Safe Operation Area with the transistor forward biased.

I Region of permissible d.c. operation.
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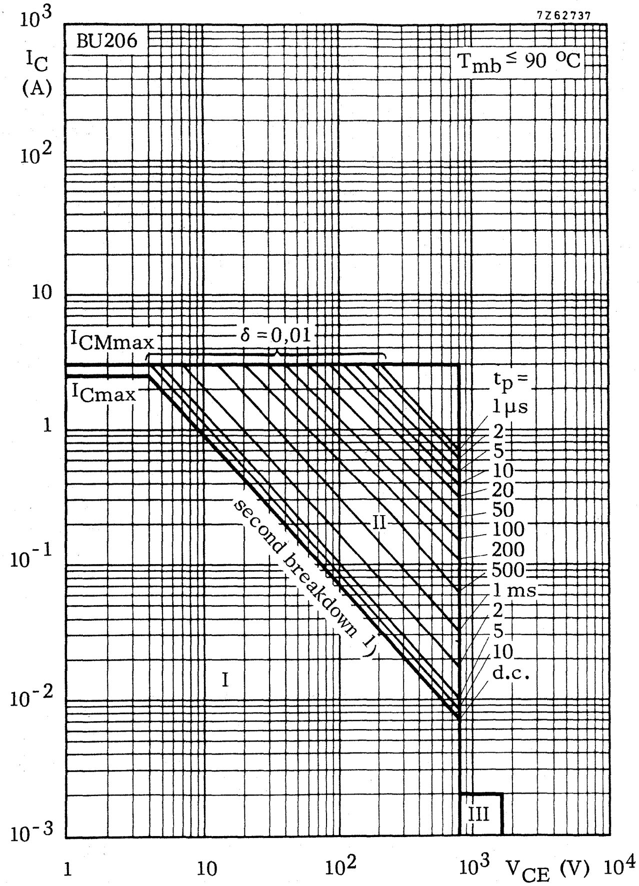


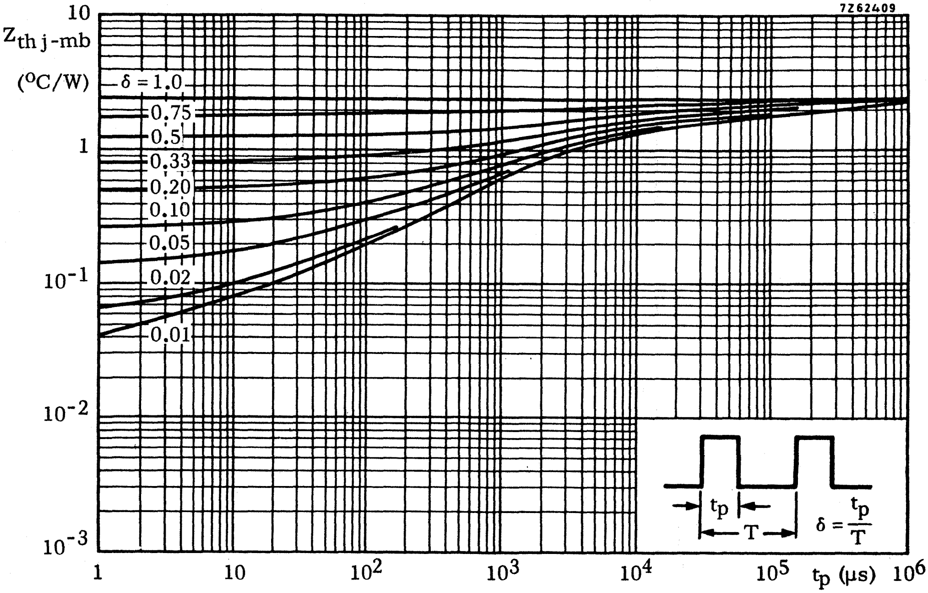
Safe Operating Area with the transistor forward biased.

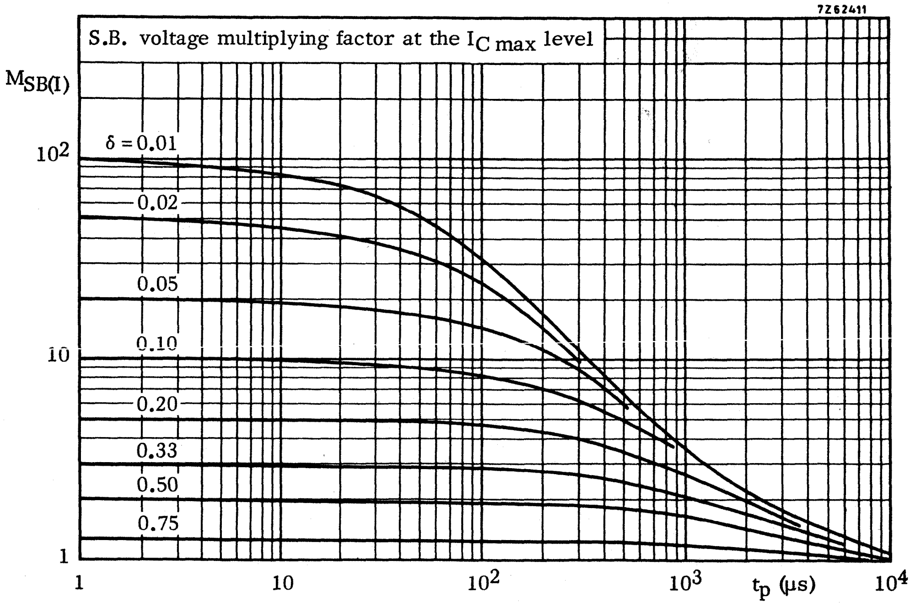
I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 100\ \Omega$; $t_p \leq 20\ \mu s$; $\delta \leq 0,25$.

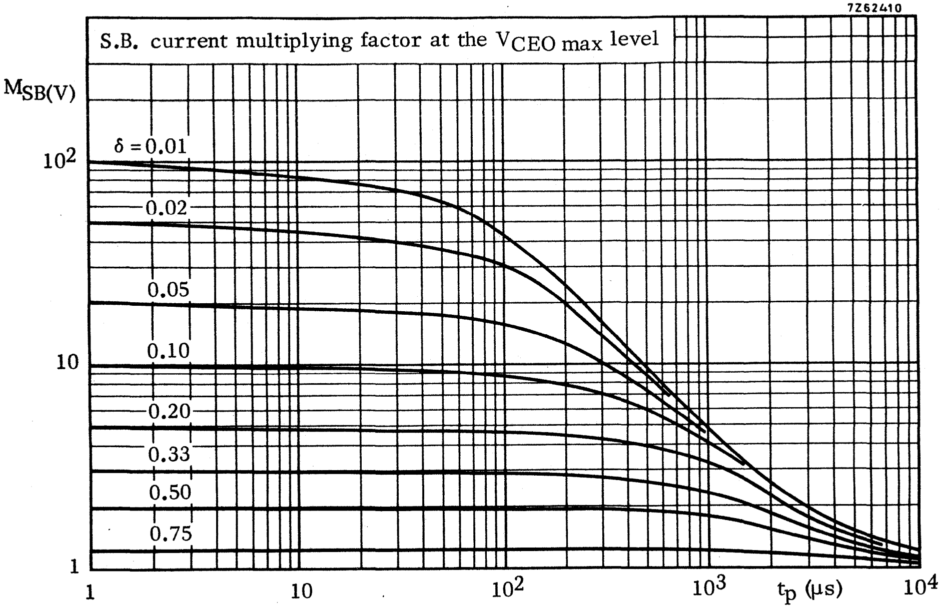
Note

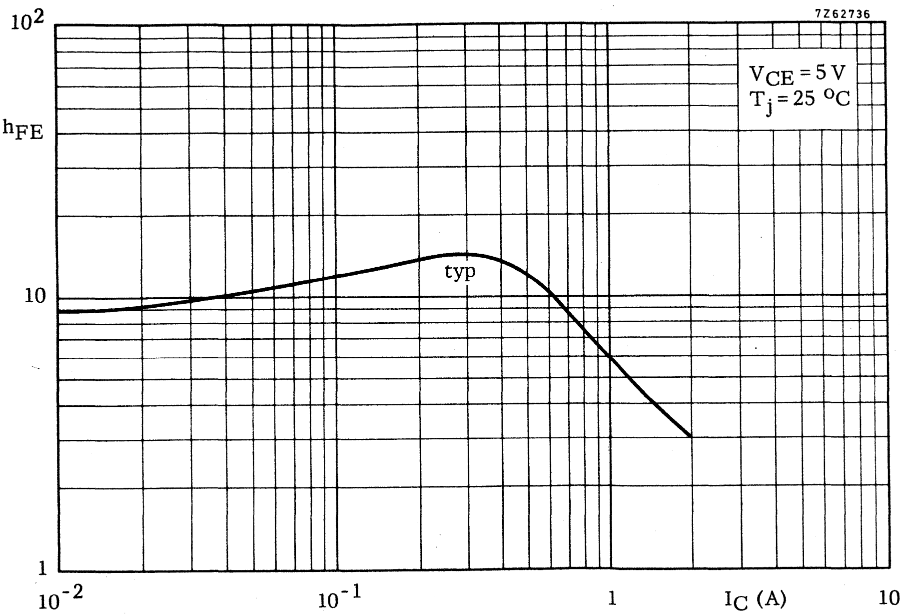
Information on picture tube arcing is available.

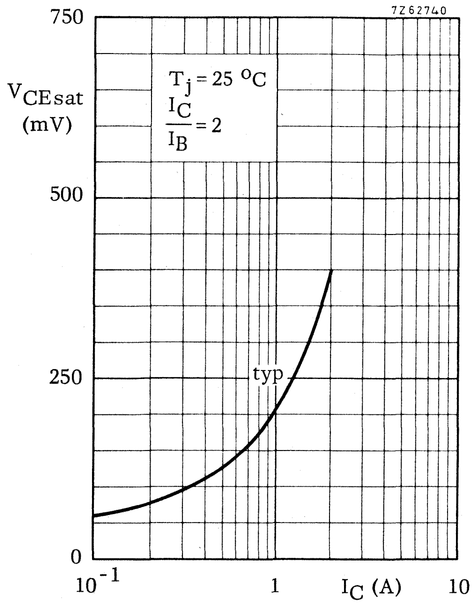
1) Independent of temperature.

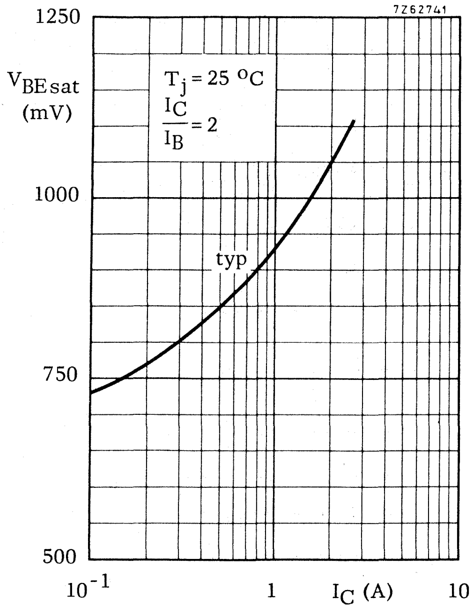

7Z62409
10
$Z_{th\,j\text{-}mb}$
(°C/W)
δ = 1.0
0.75
0.5
1
0.33
0.20
0.10
0.05
10^{-1}
0.02
0.01
10^{-2}
10^{-3}
tp
T
$\delta = \frac{t_p}{T}$
1
10
10^2
10^3
10^4
10^5
t_p (μs)
10^6


7Z62411
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
δ = 0.01
10^2
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
$M_{SB(V)}$
δ = 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
10^2
h_{FE}
V_{CE} = 5 V
T_j = 25 °C
typ
10
1
10^{-2}
10^{-1}
1
I_C (A)
10


7Z62740
750
500
250
0
V_{CEsat} (mV)
$T_j = 25\ ^oC$
$\frac{I_C}{I_B} = 2$
typ
10^{-1}
1
I_C (A)
10


7Z62741
1250
1000
750
500
V_{BEsat} (mV)
$T_j = 25\ ^oC$
$\frac{I_C}{I_B} = 2$
typ
10^{-1}
1
I_C (A)
10

SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed switching n-p-n transistors in a metal envelope intended for use in horizontal deflection circuits of colour television receivers.

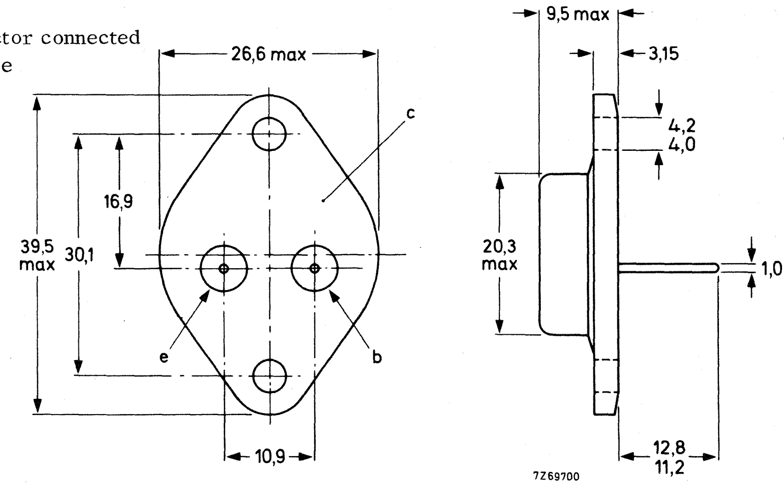
QUICK REFERENCE DATA

			BU207A	BU208A	BU209A	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	1500	1500	1700	V
Collector current (d.c.)	I_C	max.	5	5	4	A
Total power dissipation up to T_{mb} = 95 °C	P_{tot}	max.	12,5	12,5	12,5	W
Collector-emitter saturation voltage						
I_C = 4,5 A; I_B = 2 A	V_{CEsat}	<	5	1	–	V
I_C = 3 A; I_B = 1,3 A	V_{CEsat}	<	–	–	5	V
Fall time						
I_{CM} = 4,5 A; $I_{B(end)}$ = 1,8 A	t_f	typ.	0,9	0,7	–	µs
I_{CM} = 3 A; $I_{B(end)}$ = 1,3 A	t_f	typ.	–	–	0,7	µs

MECHANICAL DATA

TO-3

Collector connected to case



For mounting instructions and accessories see section Accessories.

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

			BU207A	BU208A	BU209A	
<u>Voltages</u>						
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	1500	1500	1700	V
Collector-emitter voltage ($R_{BE} \leq 100\ \Omega$, peak value)	V_{CERM}	max.	1500	1500	1700	V
Collector-emitter voltage (open base)	V_{CEO}	max.	600	700	800	V
<u>Currents</u>						
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.		3,5		A
<u>Power dissipation</u>						
Total power dissipation up to T_{mb} = 95 °C	P_{tot}	max.		12,5		W
<u>Temperatures</u>						
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

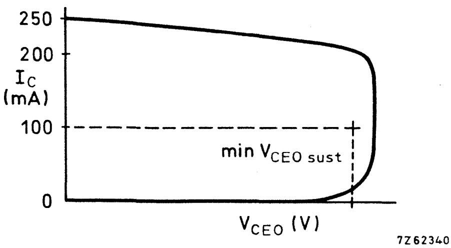
1) Turn-off current.

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

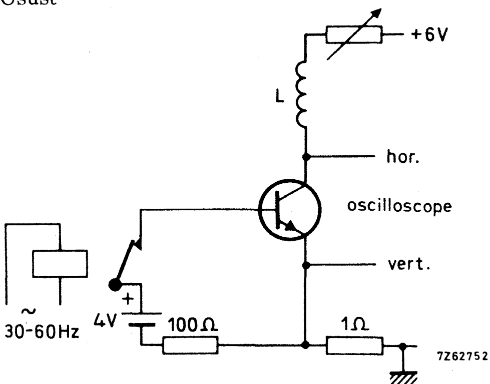
Collector cut-off current

$V_{BE} = 0$; $V_{CE} = V_{CESMmax}$	I_{CES}	<		1,0		mA

			BU207A	BU208A	BU209A	
D.C. current gain						
$I_C = 4,5$ A; $V_{CE} = 5$ V	h_{FE}	>	2,25	2,5	–	
$I_C = 3,0$ 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	1	–	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) $T_j = 25\ ^oC$ unless otherwise specified

Transition frequency at f = 5 MHz

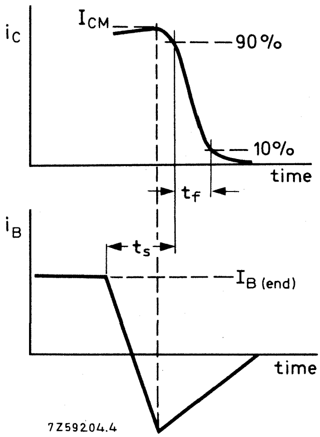
$I_C = 0,1\ A$; $V_{CE} = 5\ V$	f_T	typ.	7	MHz

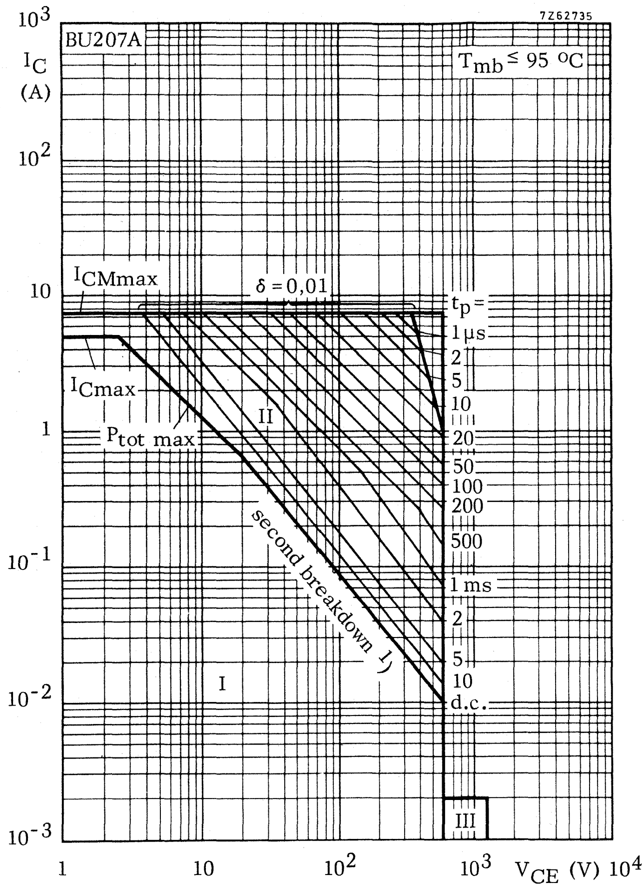
Collector capacitance at f = 1 MHz

$I_E = I_e = 0$; $V_{CB} = 10\ V$	C_c	typ.	125	pF

Switching times (in line deflection circuit)

			BU207A	BU208A	BU209A	
$L_B = 10\ \mu H$						
$I_{CM} = 4,5\ A$; $I_{B(end)} = 1,8\ A$	t_f	typ.	0,9	0,7	–	μs
$I_{CM} = 3,0\ A$; $I_{B(end)} = 1,3\ A$	t_f	typ.	–	–	0,7	μs
$I_{CM} = 4,5\ A$; $I_{B(end)} = 1,8\ A$	t_s	typ.	10	10	–	μs
$I_{CM} = 3,0\ A$; $I_{B(end)} = 1,3\ A$	t_s	typ.	–	–	10	μs





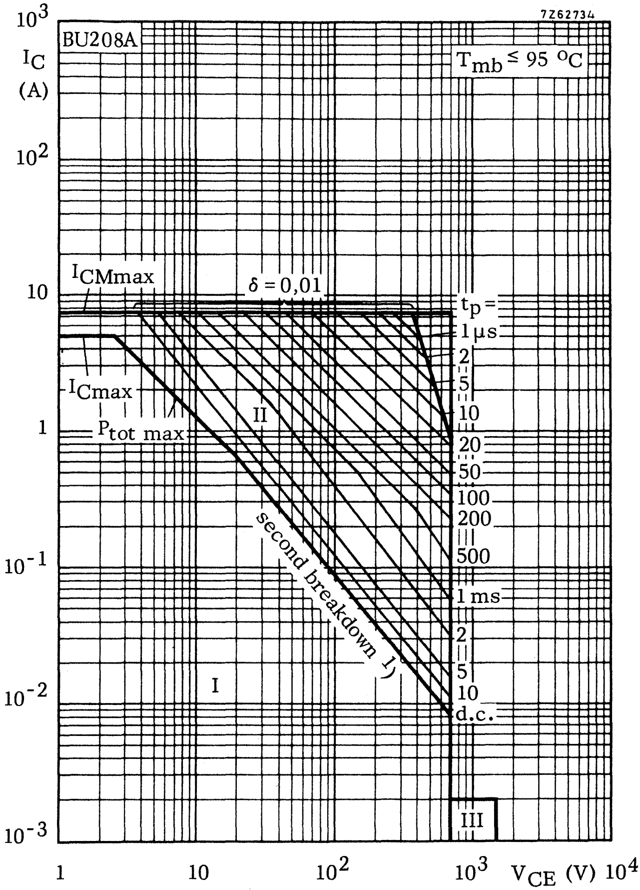
Safe Operating ARea with the transistor forward biased.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
III Repetitive pulse operation in this region is permissible, provided $R_{BE} \leq 100\ \Omega$; $t_p \leq 20$ μs; $\delta \leq 0,25$.

Note

Information on picture tube arcing is available.

1) Independent of temperature.



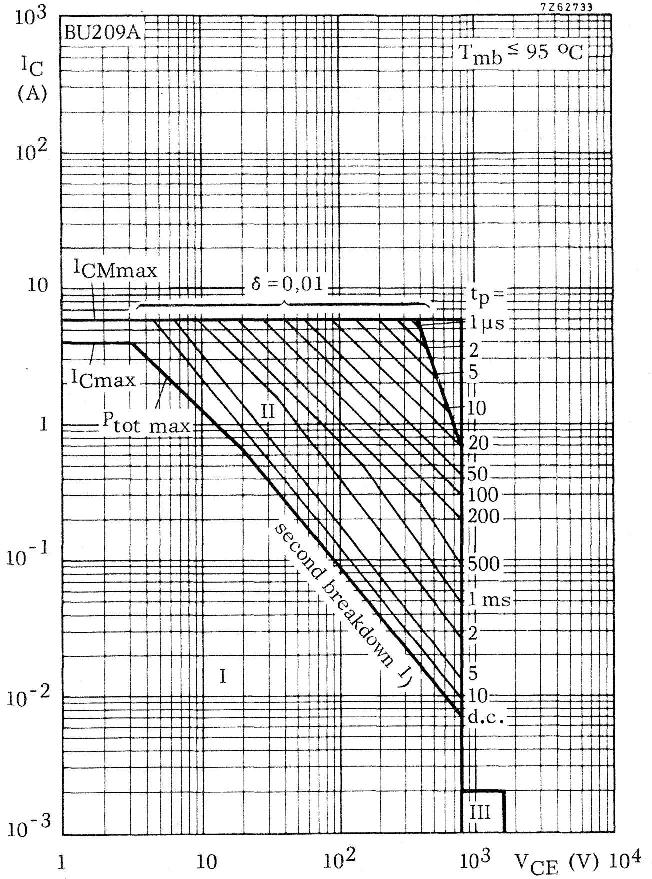
Safe Operating ARea with the transistor forward biased.

I Region of permissible d.c. operation.
II Permissible extension for repetitive pulse operation.
III Repetitive pulse operation in this region is permissible, provided $R_{BE} \leq 100\ \Omega$; $t_p < 20\ \mu s$; $\delta \leq 0{,}25$.

Note

Information on picture tube arcing is available.

1) Independent of temperature.



Safe Operating ARea with the transistor forward biased.

I Region of permissible d.c. operation.

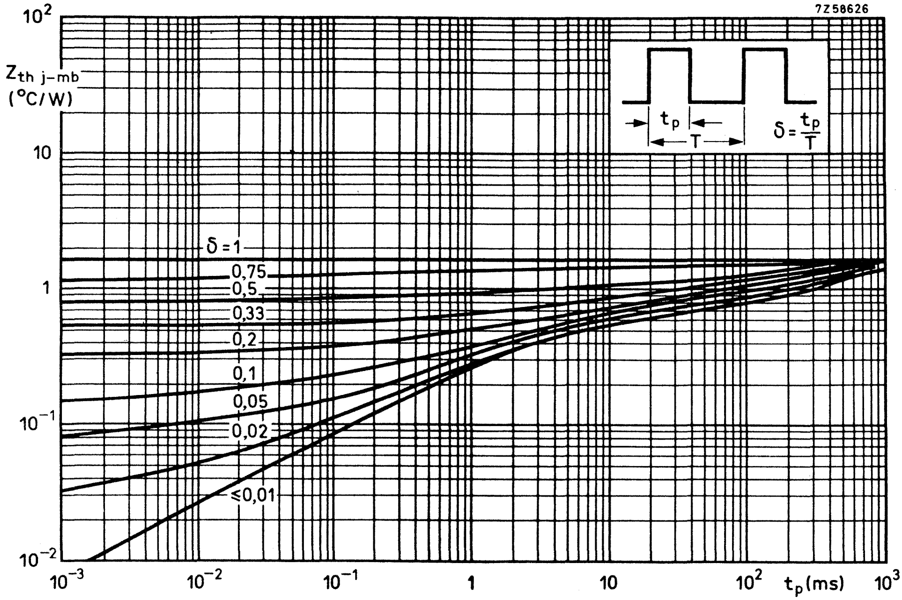
II Permissible extension for repetitive pulse operation.

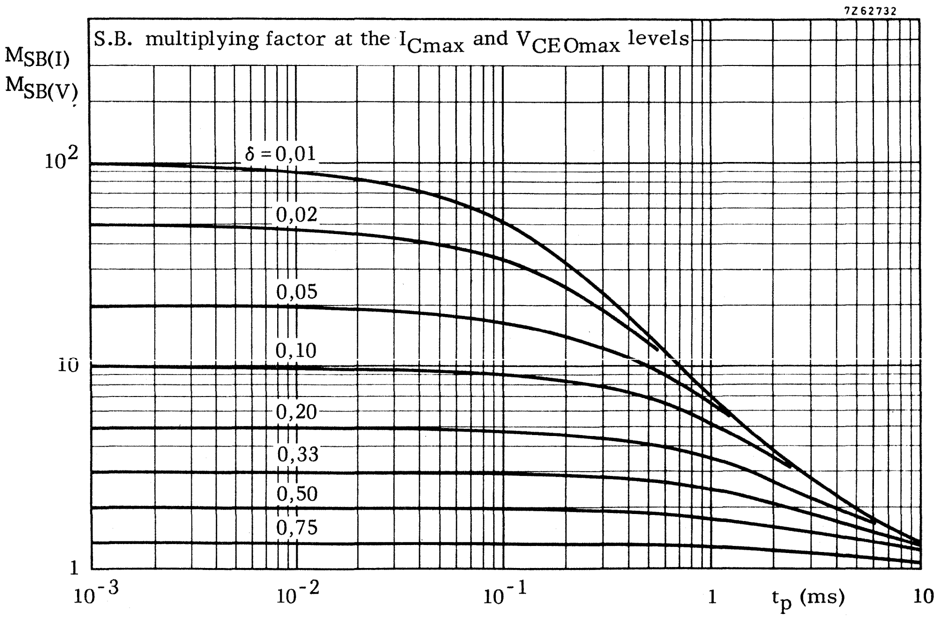
III Repetitive pulse operation in this region is permissible, provided $R_{BE} \leq 100\ \Omega$; $t_p \leq 20\ \mu s$; $\delta \leq 0{,}25$.

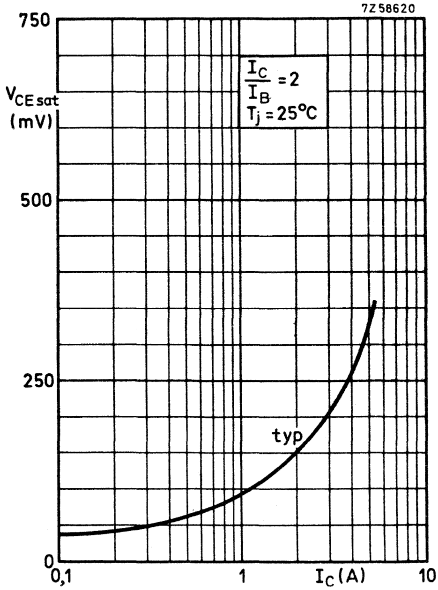
Note

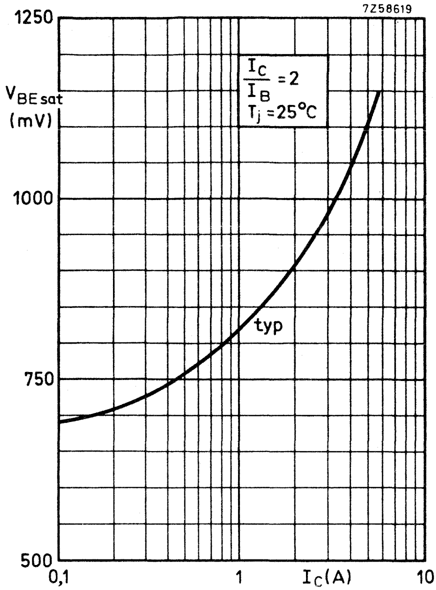
Information on picture tube arcing is available.

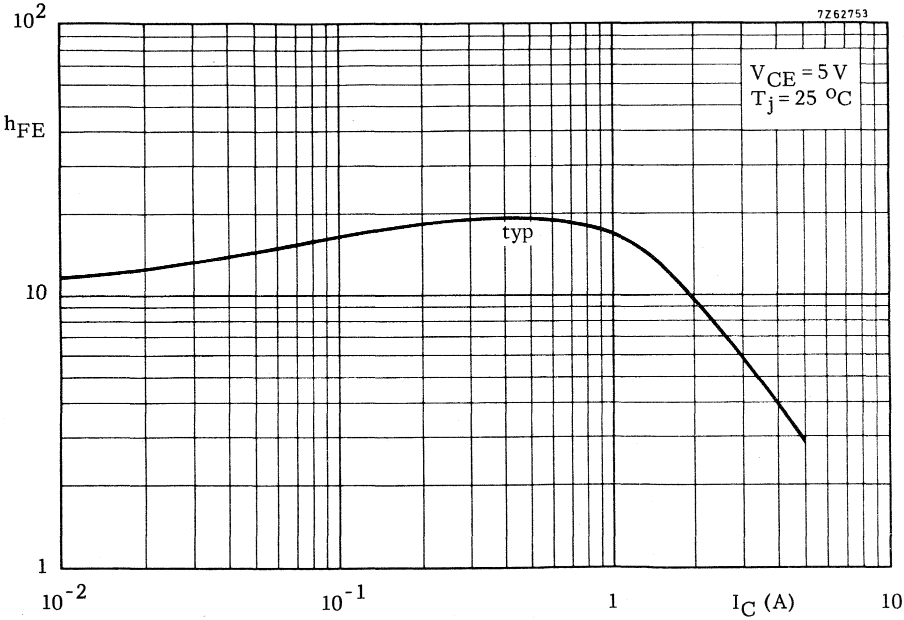
1) Independent of temperature.


7Z58626
$Z_{th\ j-mb}$ (°C/W)
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p(ms)
10^3
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


7Z62732
S.B. multiplying factor at the I_{Cmax} and V_{CEOmax} levels
$M_{SB(I)}$
$M_{SB(V)}$
10^2
10
1
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10
δ = 0,01
0,02
0,05
0,10
0,20
0,33
0,50
0,75


7Z58620
750
500
250
0
VCE sat
(mV)
IC/IB = 2
Tj = 25°C
typ
0,1
1
IC (A)
10


7Z58619
1250
1000
750
500
VBE sat
(mV)
IC/IB = 2
Tj = 25°C
typ
0,1
1
IC (A)
10


7Z62753
10^2
hFE
10
1
VCE = 5 V
Tj = 25 °C
typ
10^-2
10^-1
1
IC (A)
10

APPLICATION INFORMATION - HORIZONTAL DEFLECTION CIRCUIT WITH BU208A [1]

In designing horizontal deflection circuits, allowance has to be made for component and operating spreads in order not to exceed any Absolute Maximum Rating. Extensive analysis has shown that, for the peak collector current and the collector-emitter voltage of the output transistor, the total allowance need not be higher than 25%, and the following recommended base-drive and heatsink conditions are based on this figure.

To simplify the presentation, the design curves given refer to nominal conditions. Where the collector current will be modulated by the E-W correction circuit, the average value of the peak collector current applies, provided the modulation is less than ±10%.

To obtain a short fall time with a high-voltage transistor, the storage time has to be sufficiently long and, during turn-off, the negative base-emitter voltage must be sufficiently high. Both requirements can be simply realized by including a coil in series with the base of the output transistor. However, to reduce base current variations, a base resistor is added to most designs, with the disadvantage of reduced - and perhaps even insufficient - energy in the base inductance during turn-off. This can be improved by shunting the base resistor by a diode and/or a capacitor. Instead of giving various detailed base circuits based on these considerations, it is a more direct approach to specify the recommended $-di_B/dt$, see Fig. 3.

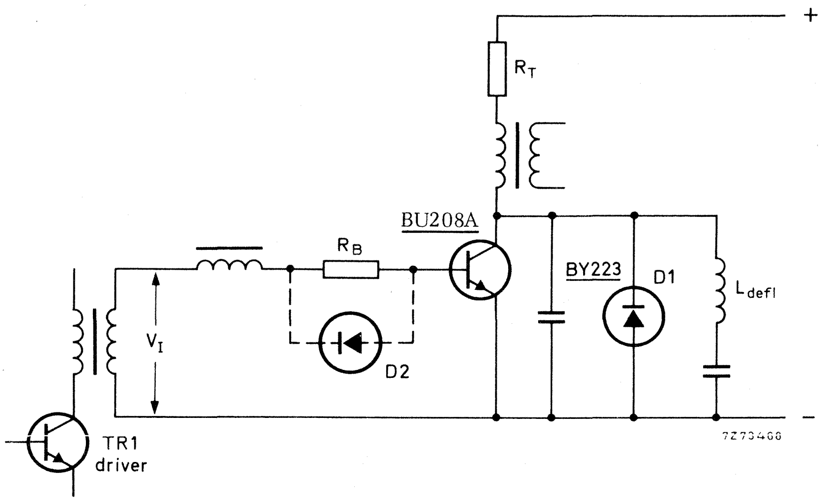


Fig. 1. Simplified horizontal deflection circuit

[1]) Detailed Application Information is available.

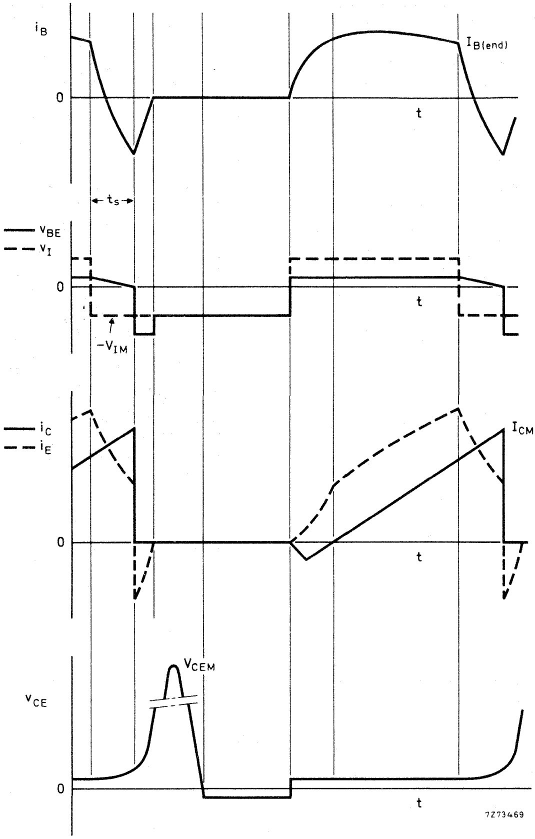


Fig. 2. Fundamental waveforms

Next page:

Fig. 3. "End" value of the base current and its rate of fall during turn-off as a function of the peak collector current to obtain, for a typical transistor, a recommended storage time of 6,5 μs. (During the storage time and the decay time of the collector current the negative turn-off drive voltage ($-V_{IM}$) must be > 4 V.)

Fig. 4. Total dissipation of a limit-case transistor under maximum operating conditions for 625 and 819 lines (T_{mb} = 100 °C). The dashed line gives the total dissipation of a typical transistor under nominal conditions (T_{mb} = 50 °C).

Fig. 5. Maximum permissible thermal resistance of the heatsink for thermal stability of the output transistor (Design Centre Rating System).

Fig. 6. Maximum permissible collector-emitter voltage at the time t_1 during turn-off; t_1 = 0,5 μs from the 90% value of the collector current peak (Design Centre Rating System).

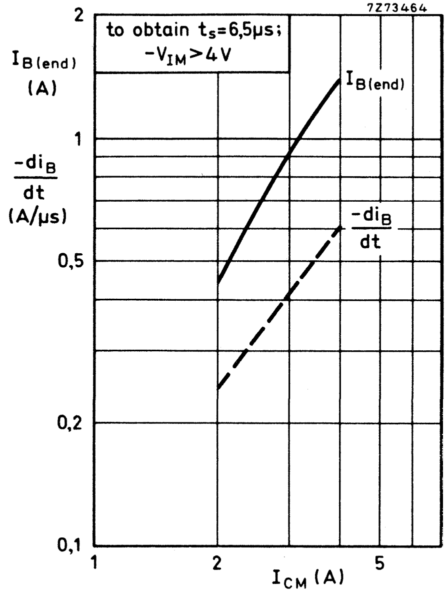


Fig. 3

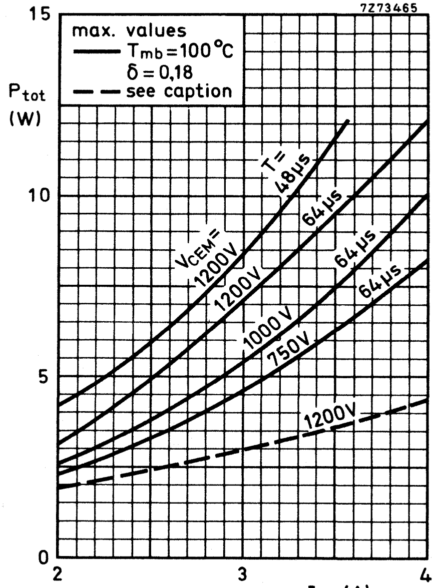


Fig. 4

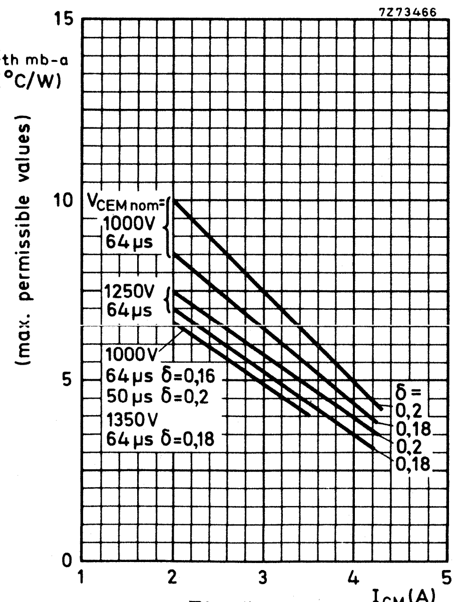


Fig. 5

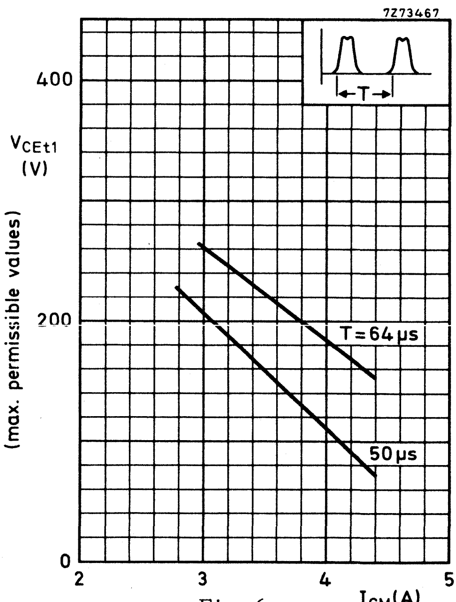


Fig. 6

SILICON DIFFUSED POWER TRANSISTOR

High-voltage, high-speed switching n-p-n power transistors in TO-3 envelopes, intended for use in the switched-mode power supply of 90° and 110° colour television receivers.

QUICK REFERENCE DATA

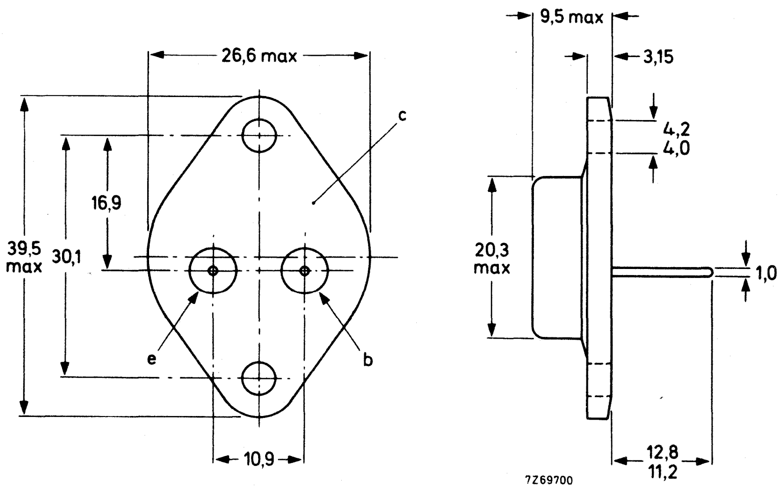
Collector-emitter voltage (V_{BE} = 0; peak value)	V_{CESM}	max	900	V
Collector-emitter voltage (open base)	V_{CEO}	max	400	V
Collector current (d.c.)	I_C	max	6	A
Collector current (peak value; t_p < 2 ms)	I_{CM}	max	8	A
Total power dissipation up to T_{mb} = 50 °C	P_{tot}	max	60	W
Collector-emitter saturation voltage I_C = 2,5 A; I_B = 0,5 A	V_{CEsat}	<	1,5	V
Fall time I_{Con} = 2,5 A; I_{Bon} = 0,5 A; $-I_{Boff}$ = 1 A	t_f	typ	0,3	μs

MECHANICAL DATA

Dimensions in mm

TO-3

Collector connected to case



For mounting instructions and accessories see Accessories.

RATINGS

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

Collector-emitter voltage (V_{BE} = 0; peak value)	V_{CESM}	max	900	V
Collector-emitter voltage (open base)	V_{CEO}	max	400	V
Collector current (d.c.)	I_C	max	6	A
Collector current (peak value; $t_p < 2$ ms)	I_{CM}	max	8	A
Base current (d.c.)	I_B	max	2	A
Base current (peak value)	I_{BM}	max	3	A
Reverse base current (d.c. or average over any 20 ms period)	$-I_{B(AV)}$	max	0,1	A
Reverse base current (peak value; turn-off current)	$-I_{BM}$	max	3	A
Total power dissipation up to T_{mb} = 50 °C	P_{tot}	max	60	W
Storage temperature	T_{stg}	−65 to + 150		°C
Junction temperature	T_j	max	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,65	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current *				
$V_{BE} = 0$; $V_{CEM} = V_{CESMmax}$	I_{CES}	<	1	mA
$V_{BE} = 0$; $V_{CEM} = V_{CESMmax}$; T_j = 125 °C	I_{CES}	<	2	mA
Emitter cut-off current				
$I_C = 0$; V_{EB} = 10 V	I_{EBO}	<	10	mA
Saturation voltages				
I_C = 2,5 A; I_B = 0,5 A	V_{CEsat}	<	1,5	V
	V_{BEsat}	<	1,4	V
I_C = 4 A; I_B = 1,25 A	V_{CEsat}	<	3	V
	V_{BEsat}	<	1,6	V
Collector-emitter sustaining voltage (see Figs 1 and 2)				
$I_{Boff} = 0$; I_C = 0,1 A; L = 25 mH	$V_{CEOsust}$	>	400	V
D.C. current gain				
I_C = 0,6 A; V_{CE} = 5 V	h_{FE}	typ	30	
Transition frequency at f = 1 MHz				
I_C = 0,2 A; V_{CE} = 10 V	f_T	typ	6	MHz
Switching times (see Figs 3 and 4)				
I_{Con} = 2,5 A; V_{CC} = 250 V; I_{Bon} = 0,5 A; $-I_{Boff}$ = 1 A				
Turn-on time	t_{on}	typ	0,3	μs
		<	0,5	μs
Turn-off time ($t_{off} = t_s + t_f$): Storage time	t_s	typ	2	μs
		<	3,5	μs
Turn-off time ($t_{off} = t_s + t_f$): Fall time	t_f	typ	0,3	μs
Turn-off time ($t_{off} = t_s + t_f$): Fall time at T_{mb} = 95 °C	t_f	<	1	μs

* Measured with a half sine-wave voltage (curve tracer).

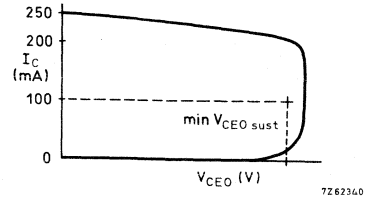


Fig. 1 Oscilloscope display for $V_{CEOsust}$.

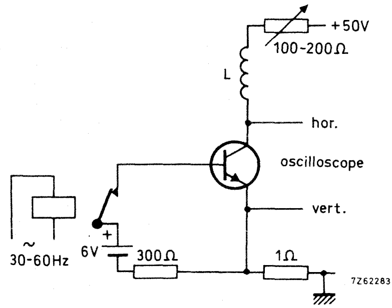


Fig. 2 Test circuit for $V_{CEOsust}$.

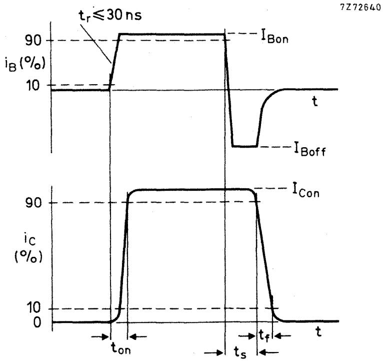


Fig. 3 Waveforms.

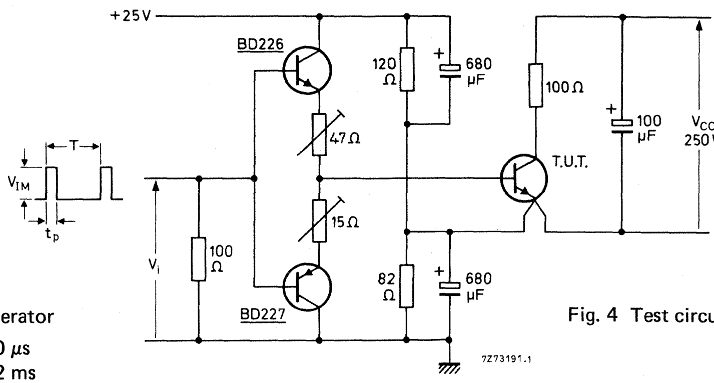
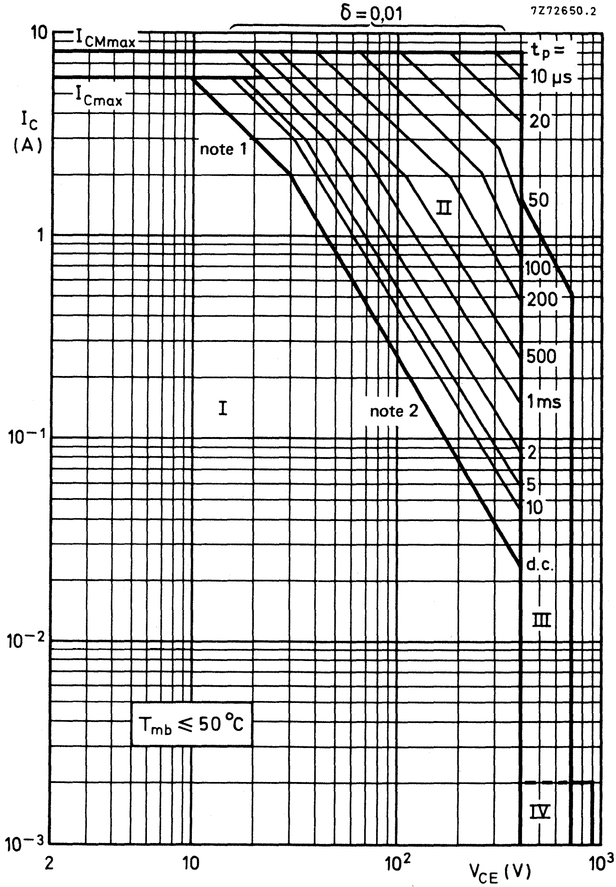


Fig. 4 Test circuit.

Pulse generator

t_p = 20 μs
T = 2 ms
V_{IM} = 15 V



Safe Operating ARea

I Region of permissible d.c. operation

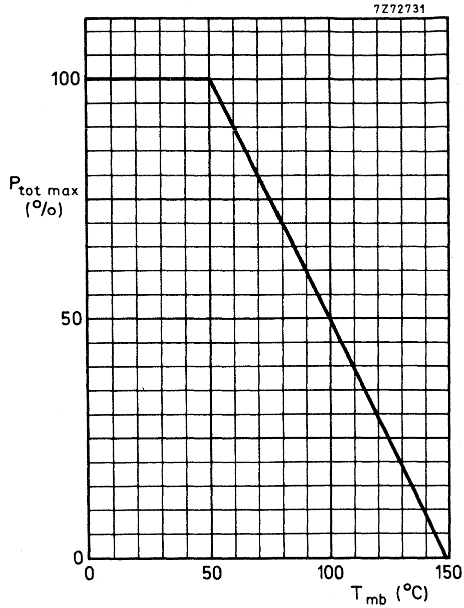
II Permissible extension for repetitive pulse operation

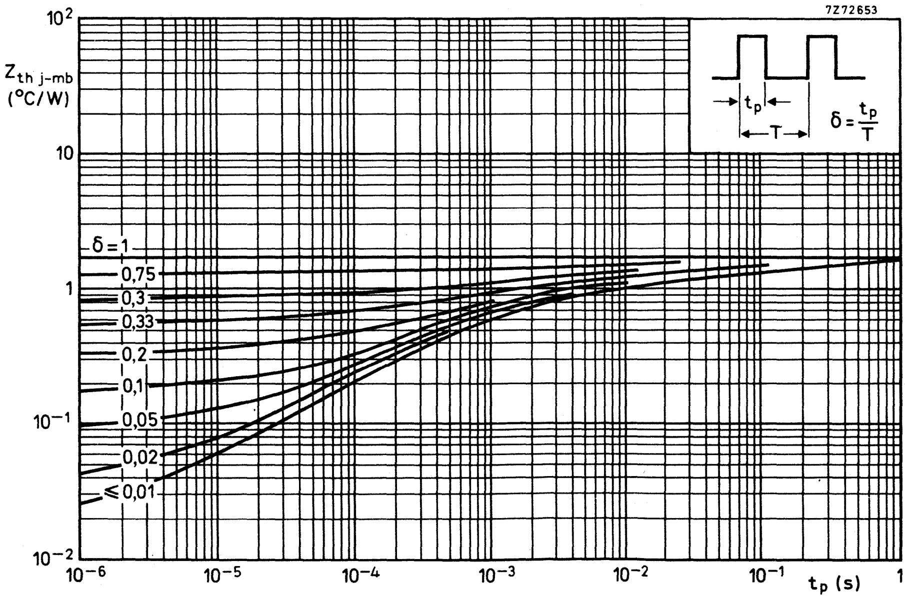
III Area of permissible operation during turn-on in single-transistor converters, provided $R_{BE} \leq 100\ \Omega$ and $t_p \leq 0,6\ \mu s$

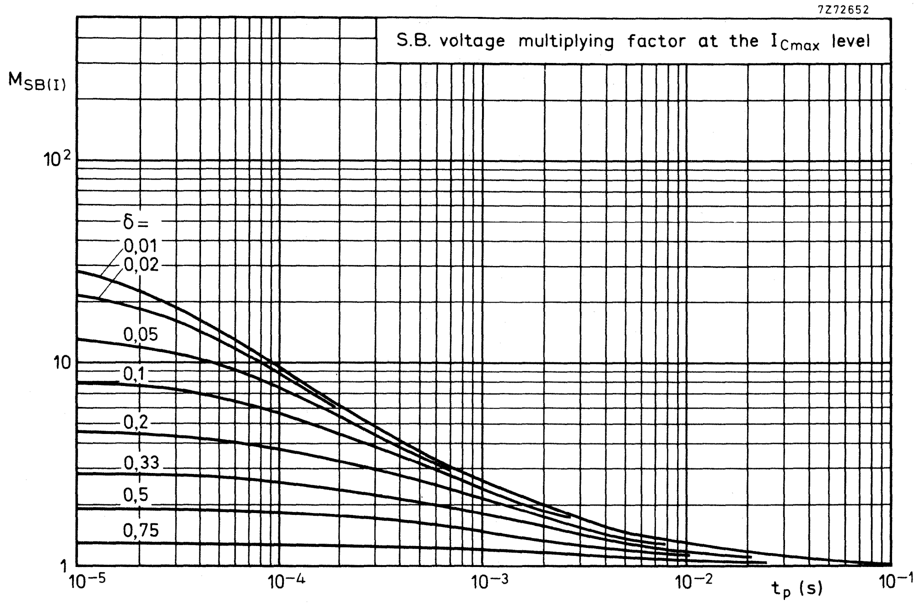
IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leq 0$ and $t_p \leq 2$ ms

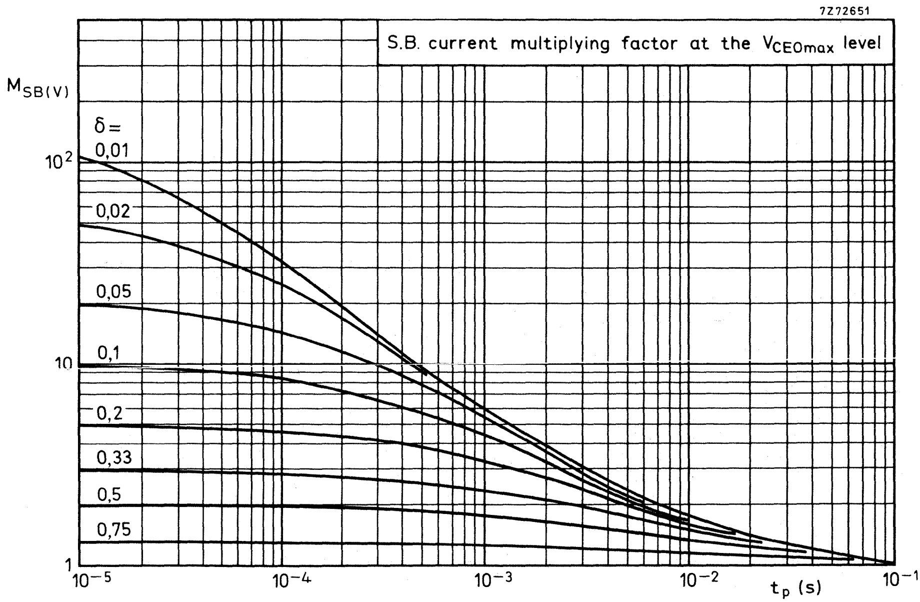
Notes

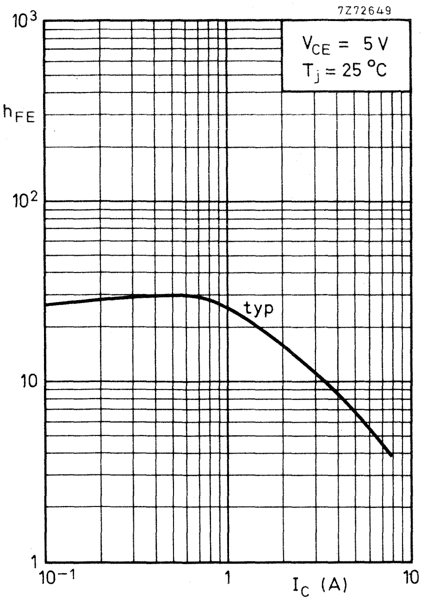
1. $P_{tot\ max}$ and $P_{peak\ max}$ lines.
2. Second-breakdown limits (independent of temperature).

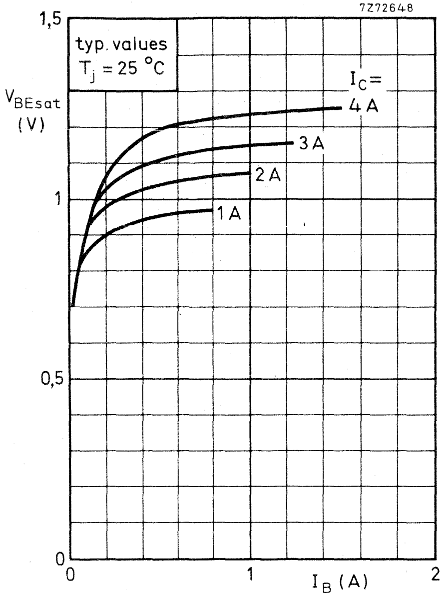

7Z72731
100
50
0
$P_{tot\ max}$ (%)
0
50
100
150
T_{mb} (°C)

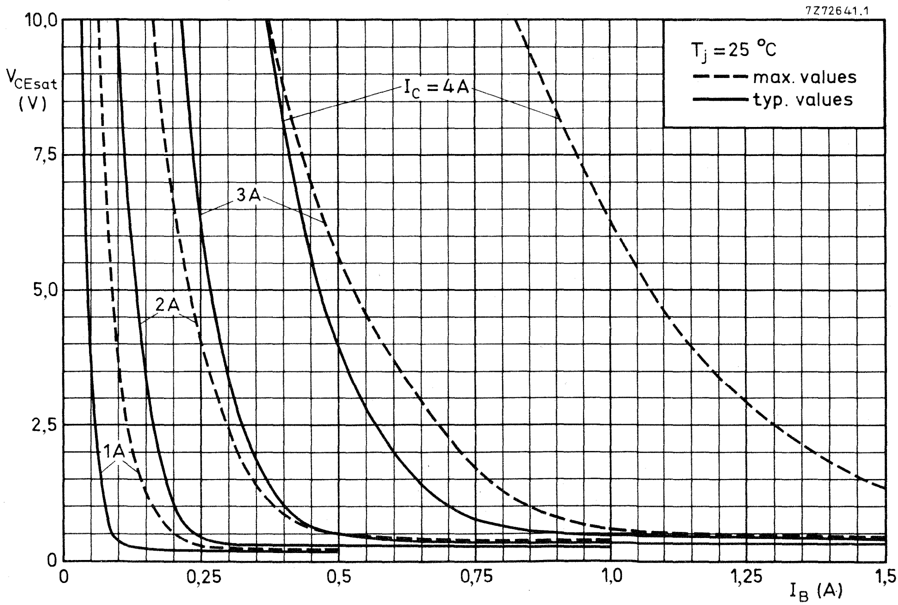

7Z72653
10^2
$Z_{th\ j\text{-}mb}$ (°C/W)
10
1
10^{-1}
10^{-2}
δ = 1
0,75
0,3
0,33
0,2
0,1
0,05
0,02
≤ 0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
t_p (s)
1


7Z72652
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^{-5}
10^{-4}
10^{-3}
10^{-2}
t_p (s)
10^{-1}


7Z72651
S.B. current multiplying factor at the V_{CEOmax} level
$M_{SB(V)}$
δ =
0,01
10^2
0,02
0,05
0,1
10
0,2
0,33
0,5
0,75
1
10^{-5}
10^{-4}
10^{-3}
10^{-2}
t_p (s)
10^{-1}


7Z72649
V_{CE} = 5 V
T_j = 25 °C
h_{FE}
typ
I_C (A)
10^3
10^2
10
1
10^{-1}
1
10


7Z72648
typ. values
T_j = 25 °C
V_{BEsat}
(V)
I_C =
4 A
3 A
2 A
1 A
I_B (A)
1,5
1
0,5
0
0
1
2


7Z72641.1
T_j = 25 °C
max. values
typ. values
V_{CEsat}
(V)
I_C = 4 A
3 A
2 A
1 A
I_B (A)
10,0
7,5
5,0
2,5
0
0
0,25
0,5
0,75
1,0
1,25
1,5

APPLICATION INFORMATION (detailed information on request)

Important factors in the design of SMPS circuits are the power losses and heatsink requirements of the supply output transistor and the base drive conditions during turn-off. In SMPS circuits for CTV receivers the duty factor of the collector current generally varies between 0,35 and 0,6.

The operating frequency lies between 15 kHz and 35 kHz and the shape of the collector current varies from rectangular in a forward converter to a sawtooth in a flyback circuit.

As the BU326A will mainly be used in flyback converters the information on optimum base drive and device dissipation given in the graphs on page 10 is concentrated on this application. In these figures I_{CM} represents the highest repetitive peak collector current that can occur in the given circuit, e.g. during overload.

The total power dissipation for a limit-case transistor is given in Fig. 9 which applies for a mounting base temperature of 100 °C. The required thermal resistance for the heatsink can be calculated from

$$R_{th\ mb\text{-}a\ max}{}^{*} = \frac{T_{mb\ max} - T_{amb\ max}}{P_{tot}}.$$

* Including additional thermal resistances resulting from mounting hardware.

To ensure thermal stability the thermal resistance of the heatsink used must not exceed the values plotted in Fig. 10.

A practical SMPS output circuit for an output power in the order of 180 W is given in Fig. 6.

At a collector current of 2,5 A and a base current of 0,25 A in this circuit the following turn-off times can be expected.

			T_{mb} = 25 °C	= 100 °C	
Storage time	t_s	typ	1,4	< 2,0	μs
Fall time	t_f	typ	0,15	< 0,5	μs

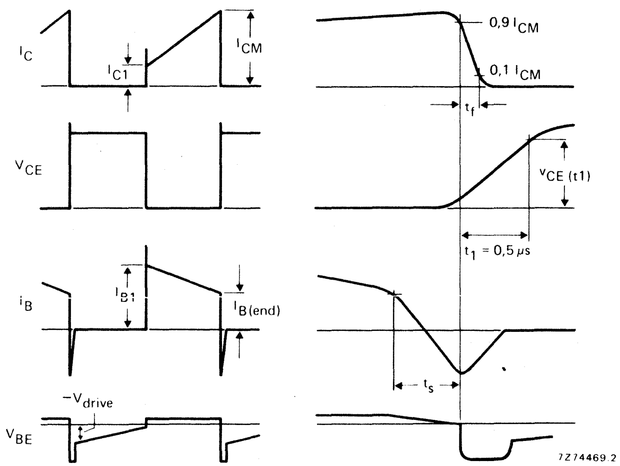


Fig. 5 Relevant waveforms of switching transistor.

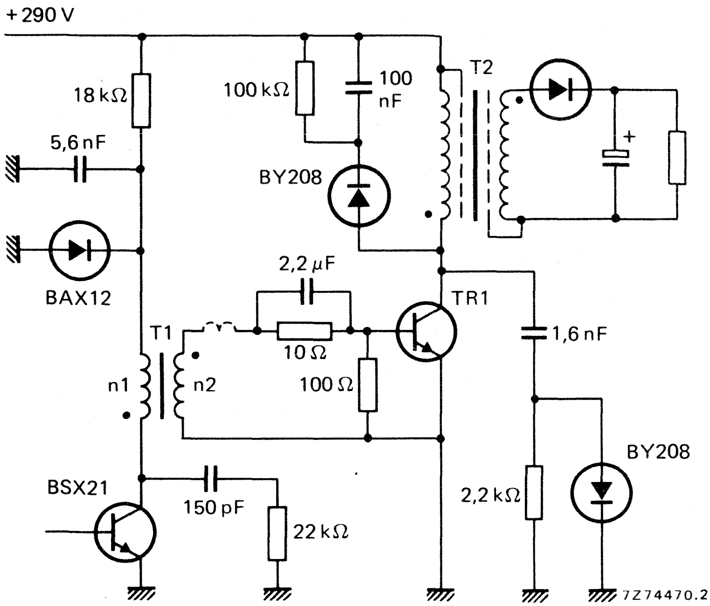


Fig. 6 Practical SMPS output circuit.

TR1 = BU326A
T1 (driver transformer): Core U20; n1 = 400 turns; n2 = 25 turns
total inductance in base circuit ≈ 4,5 μH
T2 (output transformer): L_p = 6 mH
$v_{CE(t1)} < 500$ V (see Fig. 5)

Next page:

Fig. 7 Recommended nominal "end" value of the base current versus maximum peak collector current.

Fig. 8 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

Fig. 9 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 7.

Fig. 10 Maximum permissible thermal resistance of the heatsink versus maximum peak collector current to ensure thermal stability.

Note: For all curves the duty factor δ = 0,5, as shown in Fig. 5.

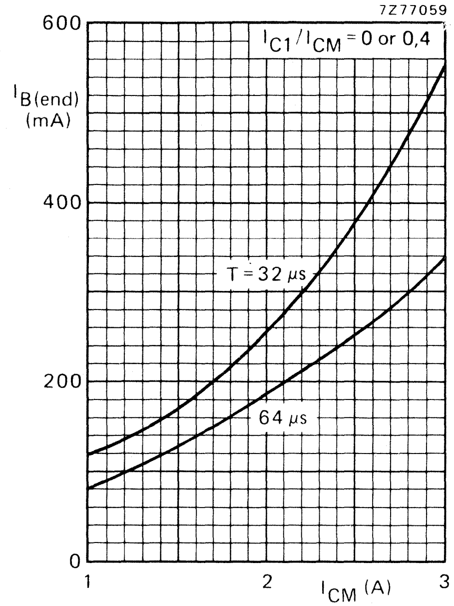


Fig. 7.

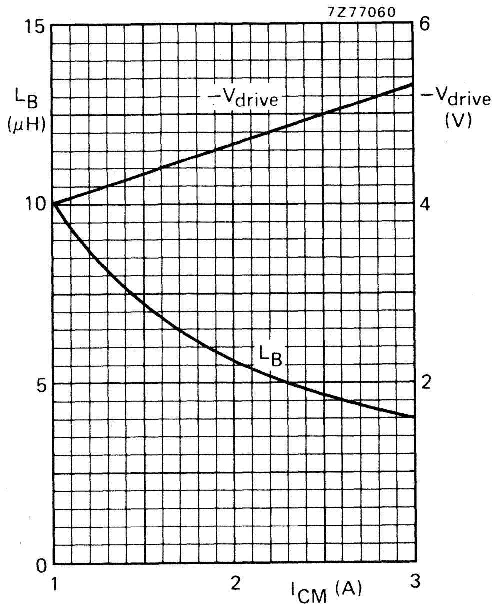


Fig. 8.

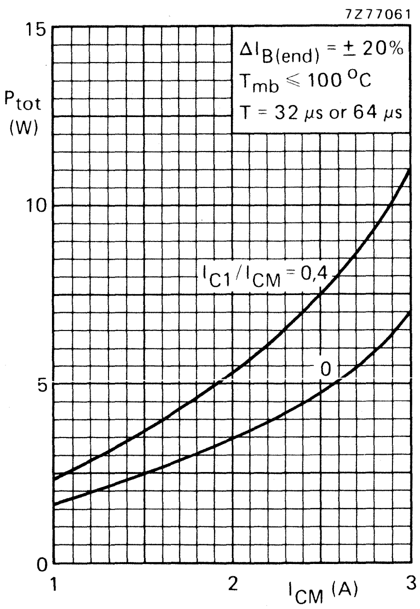


Fig. 9.

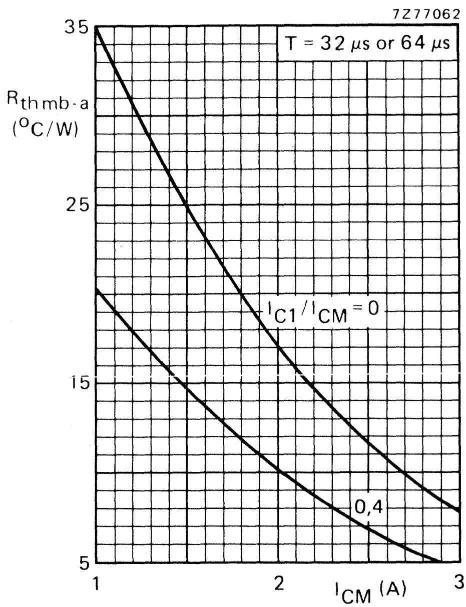


Fig. 10.

SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed switching n-p-n power transistors in TO-3 envelopes, intended for use in converters, inverters, switching regulators and motor control systems.

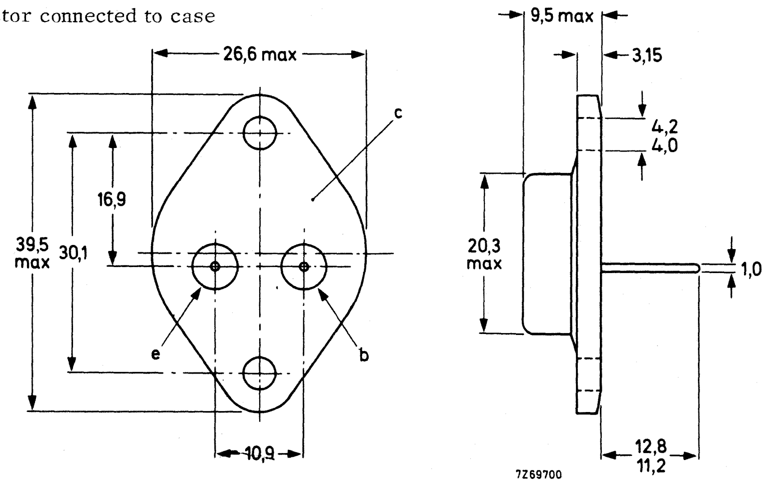
QUICK REFERENCE DATA

			BUX80	BUX81	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	800	1000	V
Collector-emitter voltage (R_{BE} = 50 Ω)	V_{CER}	max.	500	500	V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450	V
Collector current (d.c.)	I_C	max.	10		A
Collector current (peak value) t_p = 2 ms	I_{CM}	max.	15		A
Total power dissipation up to T_{mb} = 40 °C	P_{tot}	max.	100		W
Collector-emitter saturation voltage I_C = 5 A; I_B = 1 A	V_{CEsat}	<	1,5		V
Fall time I_{Con} = 5 A; I_{Bon} = 1 A; $-I_{Boff}$ = 2 A	t_f	typ.	0,3		μs

MECHANICAL DATA Dimensions in mm

TO-3

Collector connected to case



For mounting instructions and accessories see section Accessories in handbook SC2.

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

Voltages

			BUX80	BUX81	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	800	1000	V
Collector-emitter voltage (R_{BE} = 50 Ω)	V_{CER}	max.	500	500	V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450	V

Currents

Collector current (d.c.)	I_C	max.	10	A
Collector current (peak value) t_p = 2 ms	I_{CM}	max.	15	A
Base current (d.c.)	I_B	max.	4	A
Base current (peak value)	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.	6	A

Power dissipation

Total power dissipation up to T_{mb} = 40 °C	P_{tot}	max.	100	W

Temperatures

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

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,1	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current [2]

$V_{CEM} = V_{CESMmax}$; V_{BE} = 0	I_{CES}	<	1	mA
$V_{CEM} = V_{CESMmax}$; V_{BE} = 0; T_j = 125 °C	I_{CES}	<	3	mA

D.C. current gain

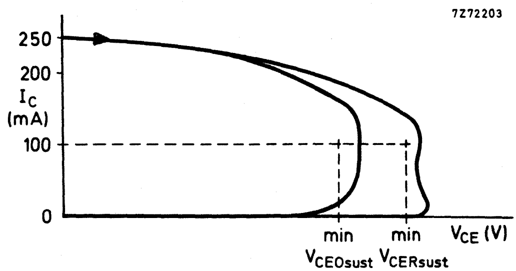
I_C = 1,2 A; V_{CE} = 5 V	h_{FE}	typ.	30	

[1]) Turn-off current.

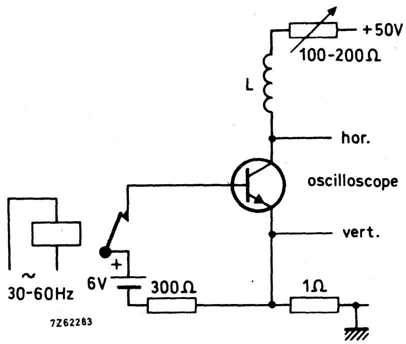
[2]) Measured with a half sine wave voltage (curve tracer).

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

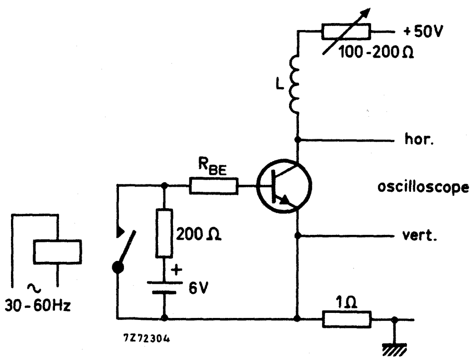
Emitter cut-off current					
I_C = 0; V_{EB} = 10 V	I_{EBO}	<	10		mA
Saturation voltages					
I_C = 5 A; I_B = 1 A	V_{CEsat}	<	1,5		V
	$V_{BE\,sat}$	<	1,4		V
I_C = 8 A; I_B = 2,5 A	V_{CEsat}	<	3		V
	$V_{BE\,sat}$	<	1,8		V
Collector-emitter sustaining voltages			BUX80	BUX81	
I_C = 100 mA; I_{Boff} = 0; L = 25 mH	$V_{CEOsust}$	>	400	450	V
I_C = 100 mA; R_{BE} = 50 Ω; L = 15 mH	$V_{CERsust}$	>	500	500	V



Oscilloscope display for sustaining voltages



Test circuit for $V_{CEOsust}$



Test circuit for $V_{CERsust}$

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

Transition frequency at f = 1 MHz

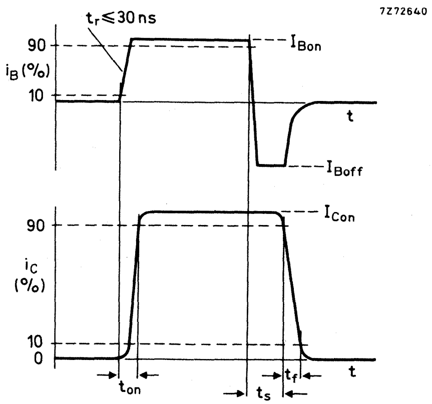
$I_C = 0,2$ A; $V_{CE} = 10$ V	f_T	typ.	6	MHz

Switching times

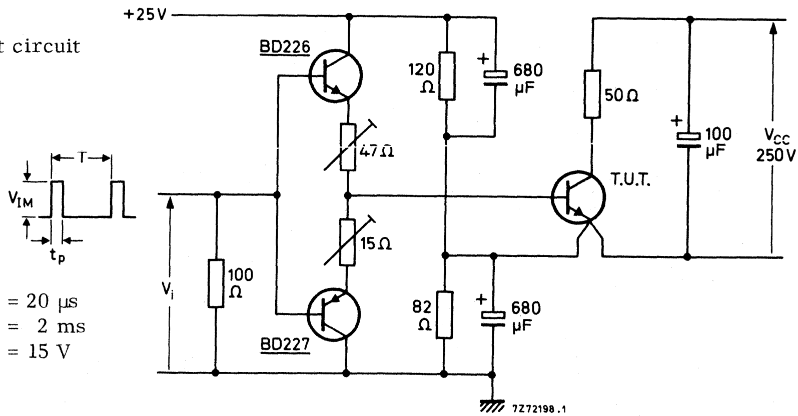
$I_{Con} = 5$ A; $V_{CC} = 250$ V
$I_{Bon} = 1$ A; $-I_{Boff} = 2$ A

Turn-on time	t_{on}	typ.	0,35	μs
		<	0,5	μs
Turn-off: Storage time	t_s	typ.	2,5	μs
		<	3,5	μs
Fall time	t_f	typ.	0,3	μs
Fall time, $T_{mb} = 95\ ^oC$	t_f	<	0,8	μs

Waveform

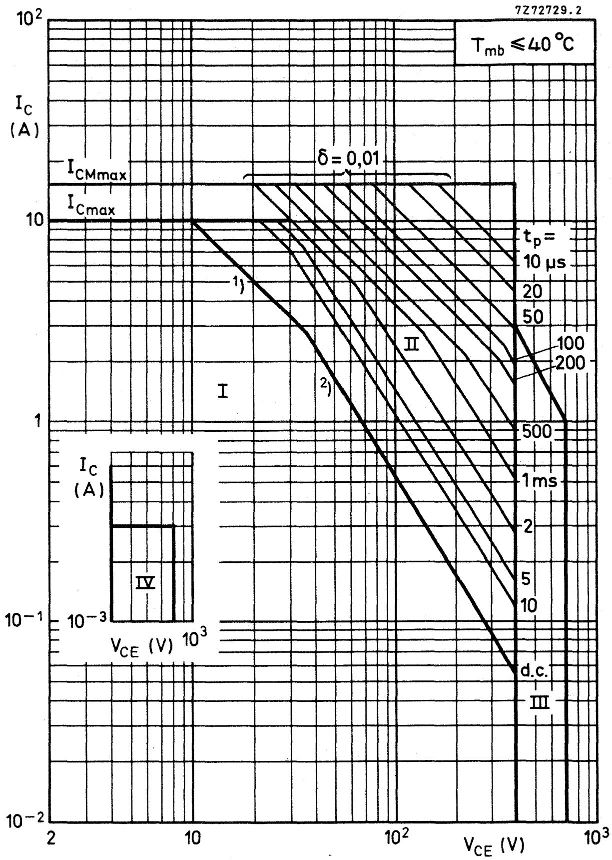


Test circuit



$t_p = 20$ μs
$T = 2$ ms
$V_{IM} = 15$ V

BUX80



Safe Operating ARea

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

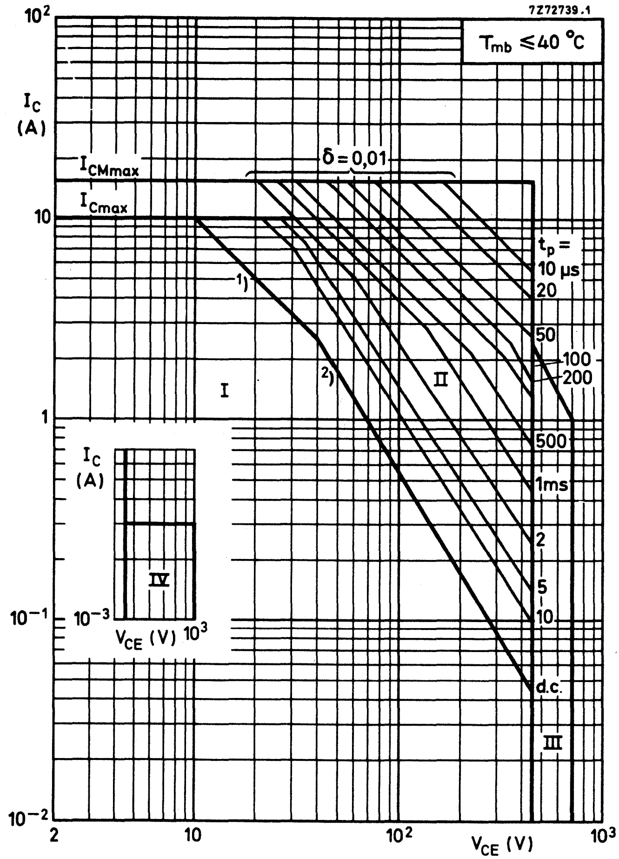
III Area of permissible operation during turn-on in single-transistor converters, provided $R_{BE} \leq 100\ \Omega$ and $t_p \leq 0,6\ \mu s$

IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leq 0$ and $t_p \leq 2$ ms

1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

2) Second-breakdown limits (independent of temperature).

BUX81



Safe Operating ARea

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 $R_{BE} \leq 100\ \Omega$ and $t_p \leq 0,6\ \mu s$

IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leq 0$ and $t_p \leq 2$ ms

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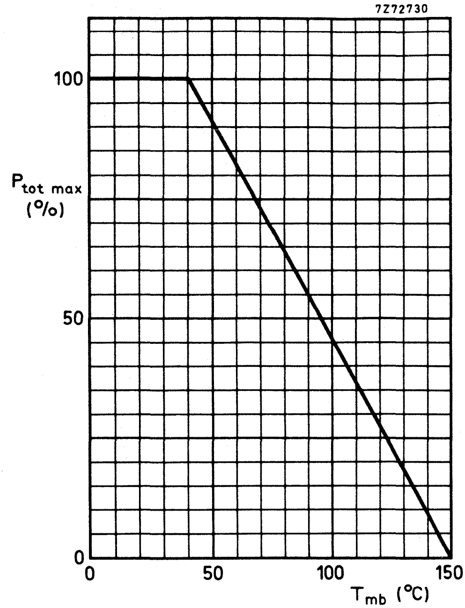
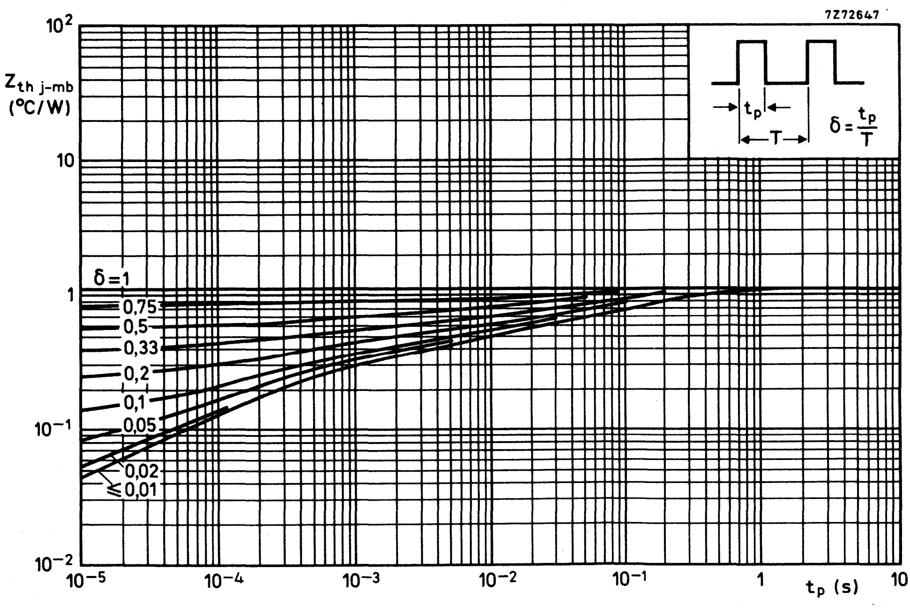
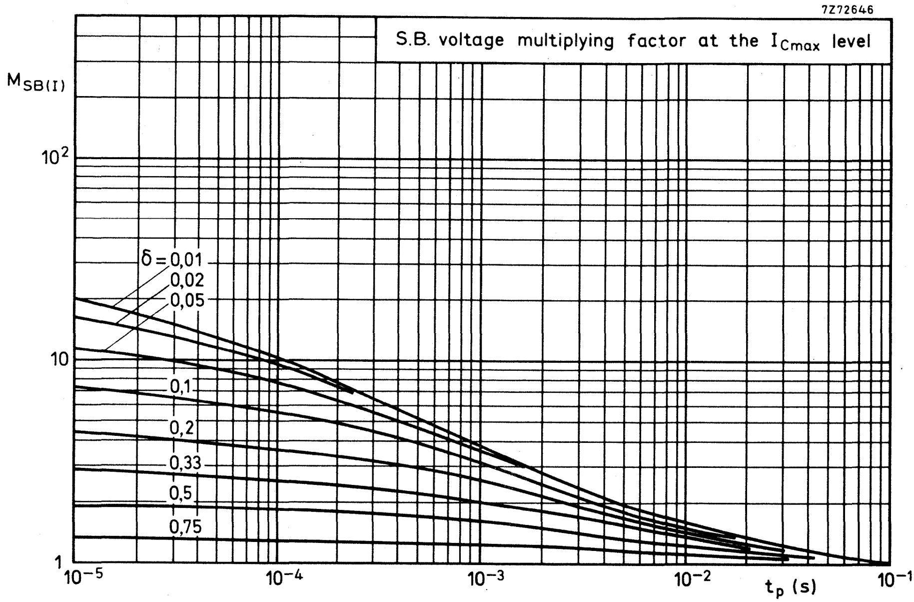
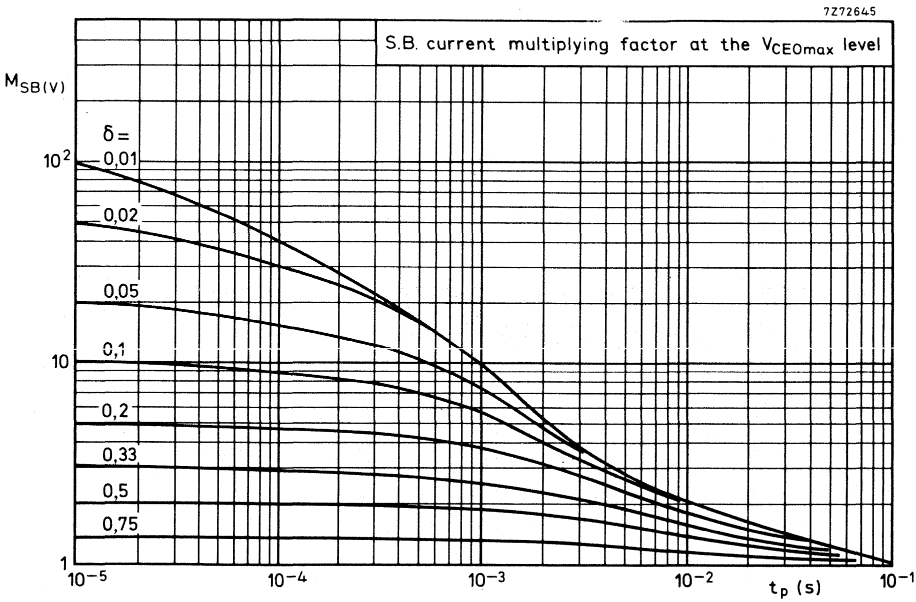
1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

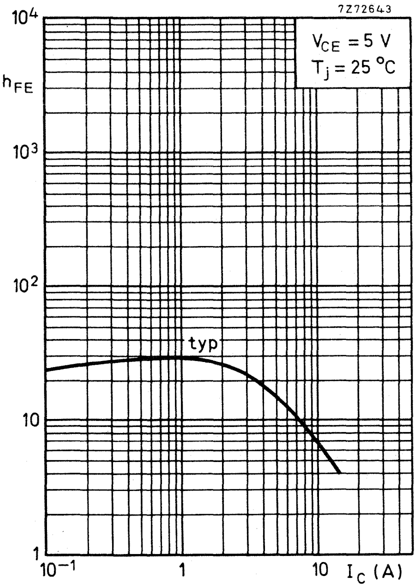
2) Second-breakdown limits (independent of temperature).

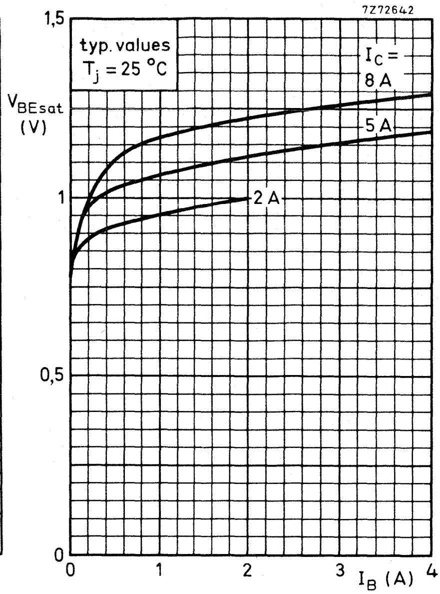

7Z72730
100
$P_{tot\ max}$ (%)
50
0
0
50
100
150
T_{mb} (°C)

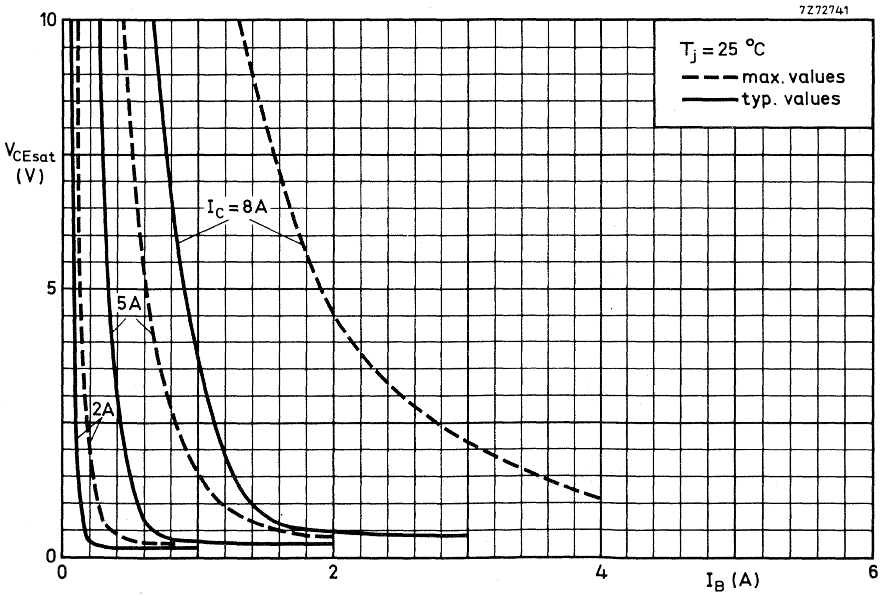

7Z72647
10^2
$Z_{th\ j\text{-}mb}$ (°C/W)
10
1
10^{-1}
10^{-2}
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
≤ 0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t_p (s)
10


7Z72646
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^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
t_p (s)


7Z72645
S.B. current multiplying factor at the V_{CEOmax} level
$M_{SB(V)}$
δ =
0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
10^2
10
1
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
t_p (s)


7Z72643
V_{CE} = 5 V
T_j = 25 °C
h_{FE}
10^4
10^3
10^2
10
1
typ
10^{-1}
1
10
I_C (A)


7Z72642
typ. values
T_j = 25 °C
I_C =
8 A
5 A
2 A
V_{BEsat}
(V)
1,5
1
0,5
0
0
1
2
3
4
I_B (A)


7Z72741
T_j = 25 °C
max. values
typ. values
V_{CEsat}
(V)
10
5
0
I_C = 8A
5A
2A
0
2
4
6
I_B (A)

APPLICATION INFORMATION ON BUX80 (detailed information on request)

Important factors in the design of SMPS circuits are the power losses and heatsink requirements of the supply output transistor and the base drive conditions during turn-off. In SMPS circuits with mains isolation the duty factor of the collector current generally varies between 0,25 and 0,5.

The operating frequency lies between 15 kHz and 50 kHz and the shape of the collector current varies from rectangular in a forward converter to a sawtooth in a flyback circuit.

As the BUX80 will mainly be used in forward or push-pull converters the information on optimum base drive and device dissipation given in the graphs on page 12 is concentrated on this application. In these figures I_{CM} represents the highest repetitive peak collector current that can occur in the given circuit, e.g. during overload.

The total power dissipation for a limit-case transistor is given in Fig. 5 which applies for a mounting base temperature of 100 °C. The required thermal resistance for the heatsink can be calculated from

$$R_{th\ mb\text{-}a} = \frac{100 - T_{amb\ max}}{P_{tot}}$$

To ensure thermal stability the minimum value of T_{amb} in the above equation is 40 °C.

A practical SMPS output circuit for an output power in the order of 400 W is given in Fig. 2.

At a collector current of 5 A and a base current of 1 A in this circuit the following turn-off times can be expected.

			T_{mb} = 25 °C	100 °C	
Storage time	t_s	typ	2	2,7	µs
Fall time	t_f	typ	0,18	0,5	µs

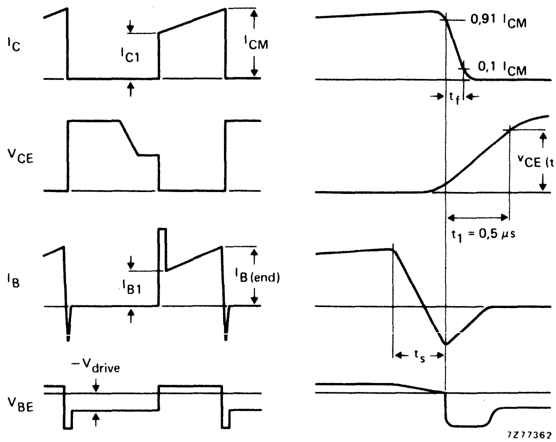


Fig. 1 Relevant waveforms of switching transistor.

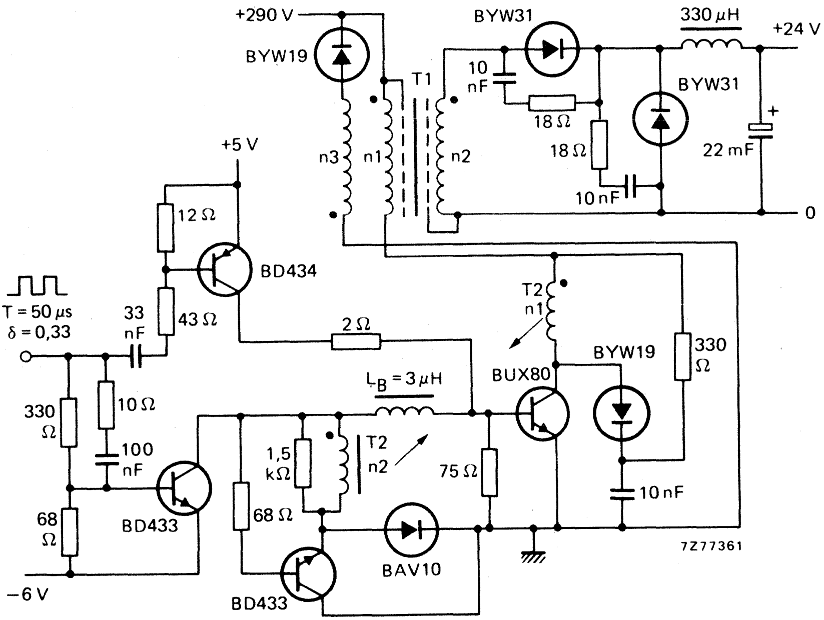


Fig. 2 Practical SMPS output circuit.

T1 (output transformer): Core U64; n1 = n3 = 56 turns; n2 = 17 turns

T2 (base current transformer): Core U20; n1 = 5 turns; n2 = 25 turns

$v_{CE(t1)} < 300$ V (see Fig. 1)

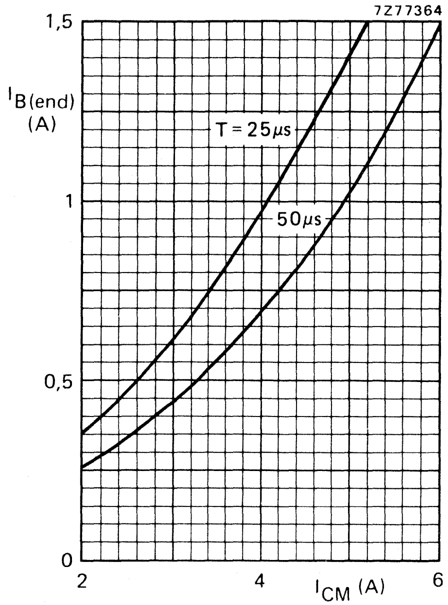


Fig. 3.

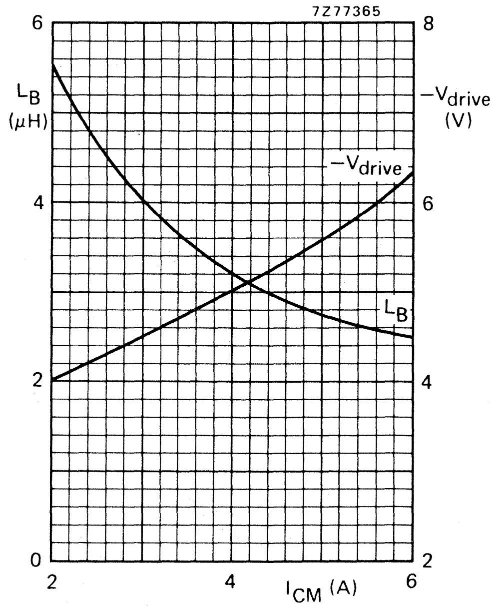


Fig. 4.

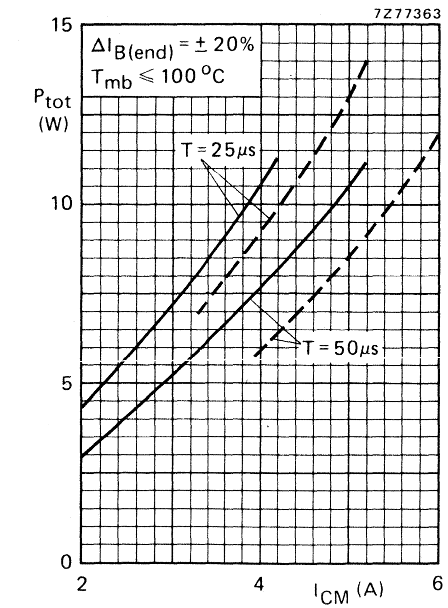


Fig. 5.

Fig. 3 Recommended nominal "end" value of the base current versus maximum peak collector current.

Fig. 4 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

Fig. 5 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 3. Solid lines for transformer drive and dotted lines for collector-coupled current drive.

SILICON DIFFUSED POWER TRANSISTORS

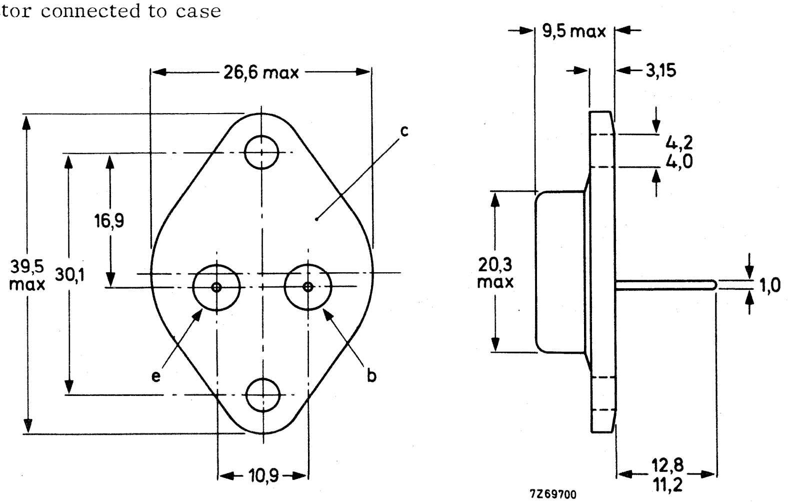
High-voltage, high-speed switching n-p-n power transistors in TO-3 envelopes, intended for use in converters, inverters, switching regulators and motor control systems.

QUICK REFERENCE DATA

			BUX82	BUX83	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	800	1000	V
Collector-emitter voltage (R_{BE} = 100 Ω)	V_{CER}	max.	500	500	V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450	V
Collector current (d.c.)	I_C	max.	6		A
Collector current (peak value) t_p = 2 ms	I_{CM}	max.	8		A
Total power dissipation up to T_{mb} = 50 °C	P_{tot}	max.	60		W
Collector-emitter saturation voltage I_C = 2,5 A; I_B = 0,5 A	V_{CEsat}	<	1,5		V
Fall time I_{Con} = 2,5 A; I_{Bon} = 0,5 A; $-I_{Boff}$ = 1 A	t_f	typ.	0,3		μs

MECHANICAL DATA Dimensions in mm

TO-3
Collector connected to case



For mounting instructions and accessories see section Accessories in handbook SC2.

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

Voltages

			BUX82	BUX83	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max.	800	1000	V
Collector-emitter voltage (R_{BE} = 100 Ω)	V_{CER}	max.	500	500	V
Collector-emitter voltage (open base)	V_{CEO}	max.	400	450	V

Currents

Collector current (d.c.)	I_C	max.	6	A
Collector current (peak value) t_p = 2 ms	I_{CM}	max.	8	A
Base current (d.c.)	I_B	max.	2	A
Base current (peak value)	I_{BM}	max.	3	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.	3	A

Power dissipation

Total power dissipation up to T_{mb} = 50 °C	P_{tot}	max.	60	W

Temperatures

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

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	1,65	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current [2]

$V_{CEM} = V_{CESMmax}$; $V_{BE} = 0$	I_{CES}	<	1	mA
$V_{CEM} = V_{CESMmax}$; $V_{BE} = 0$; T_j = 125 °C	I_{CES}	<	2	mA

D.C. current gain

I_C = 0,6 A; V_{CE} = 5 V	h_{FE}	typ.	30	

1) Turn-off current.

2) Measured with a half sine wave voltage (curve tracer).

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

Emitter cut-off current

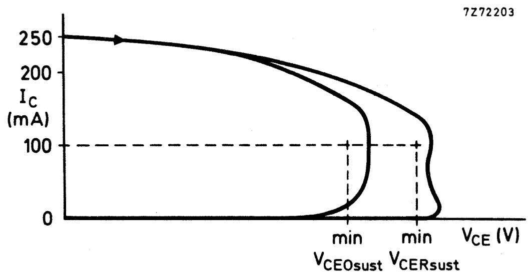
$I_C = 0$; $V_{EB} = 10$ V	I_{EBO}	<	10	mA

Saturation voltages

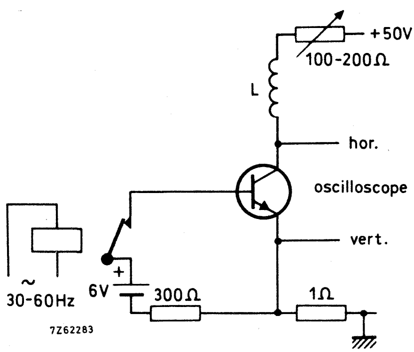
$I_C = 2,5$ A; $I_B = 0,5$ A	V_{CEsat}	<	1,5	V
	$V_{BE\,sat}$	<	1,4	V
$I_C = 4$ A; $I_B = 1,25$ A	V_{CEsat}	<	3	V
	$V_{BE\,sat}$	<	1,6	V

Collector-emitter sustaining voltages

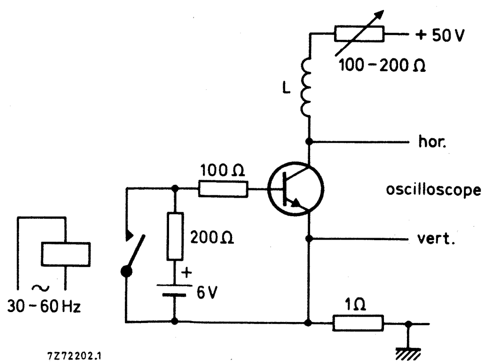
			BUX82	BUX83	
$I_C = 100$ mA; $I_{Boff} = 0$; $L = 25$ mH	$V_{CEOsust}$	>	400	450	V
$I_C = 100$ mA; $R_{BE} = 100\,\Omega$; $L = 15$ mH	$V_{CERsust}$	>	500	500	V



Oscilloscope display for sustaining voltages



Test circuit for $V_{CEOsust}$



Test circuit for V_{ERsust}

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

Transition frequency at f = 1 MHz

I_C = 0,2 A; V_{CE} = 10 V	f_T	typ.	6	MHz

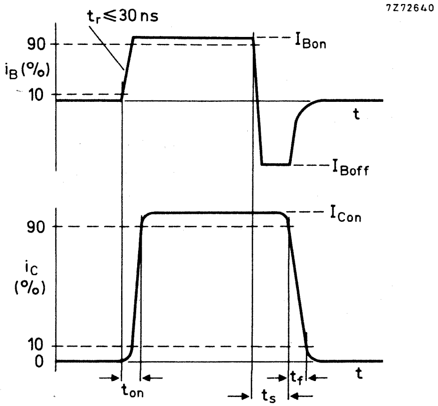
Switching times

I_{Con} = 2,5 A; V_{CC} = 250 V

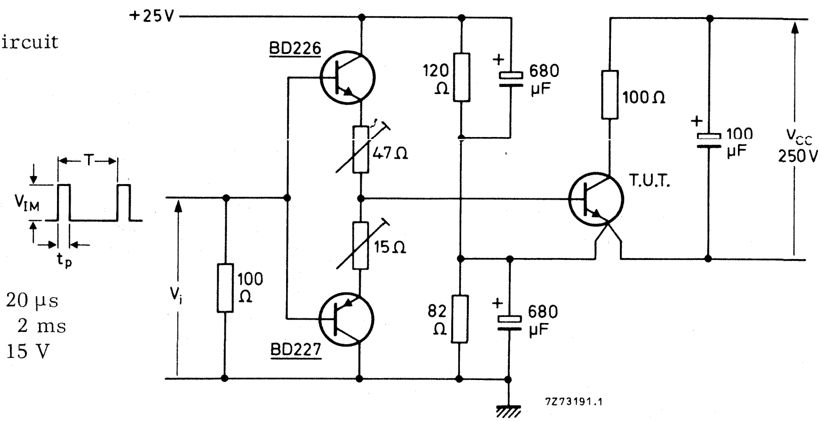
I_{Bon} = 0,5 A; $-I_{Boff}$ = 1 A

Turn-on time	t_{on}	typ.	0,3	µs
		<	0,5	µs
Turn-off: Storage time	t_s	typ.	2	µs
		<	3,5	µs
Fall time	t_f	typ.	0,3	µs
Fall time, T_{mb} = 95 °C	t_f	<	1	µs

Waveform

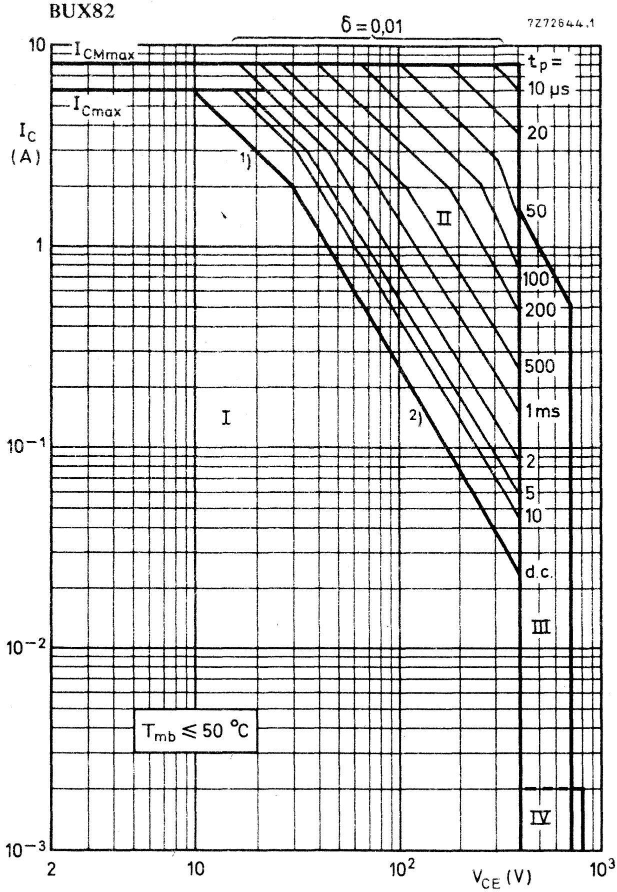


Test circuit



t_p = 20 µs
T = 2 ms
V_{IM} = 15 V

BUX82



Safe Operating ARea

I Region of permissible d.c. operation

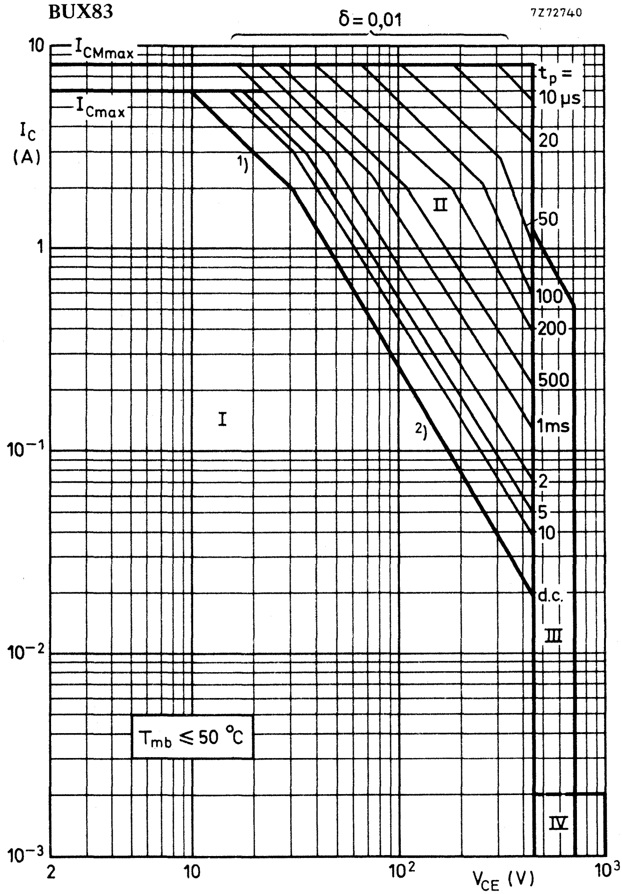
II Permissible extension for repetitive pulse operation

III Area of permissible operation during turn-on in single-transistor converters, provided $R_{BE} \leq 100\ \Omega$ and $t_p \leq 0,6\ \mu s$

IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leq 0$ and $t_p \leq 2$ ms

1) $P_{tot\,max}$ and $P_{peak\,max}$ lines.

2) Second-breakdown limits (independent of temperature).



Safe Operating ARea

I Region of permissible d.c. operation

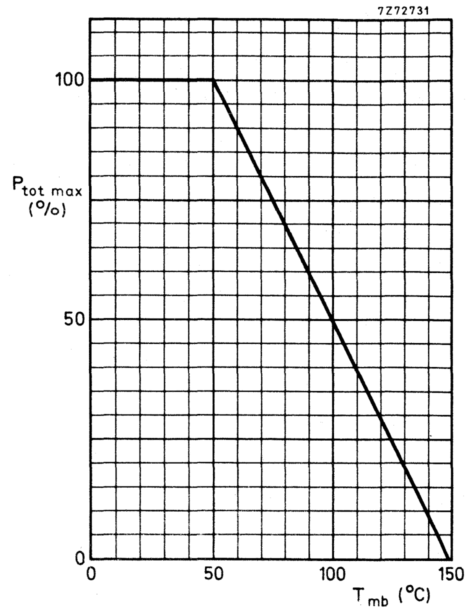
II Permissible extension for repetitive pulse operation

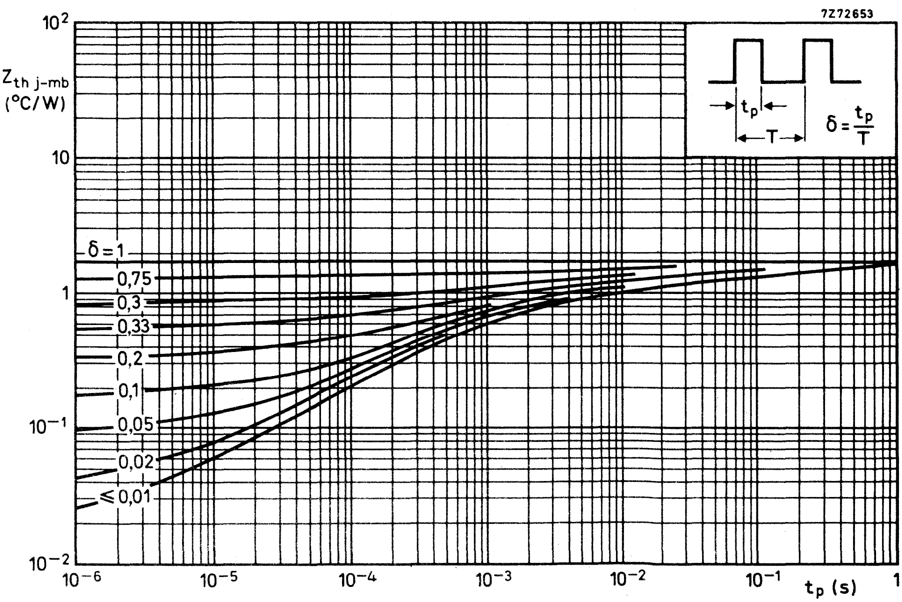
III Area of permissible operation during turn-on in single-transistor converters, provided $R_{BE} \leq 100\ \Omega$ and $t_p \leq 0,6\ \mu s$

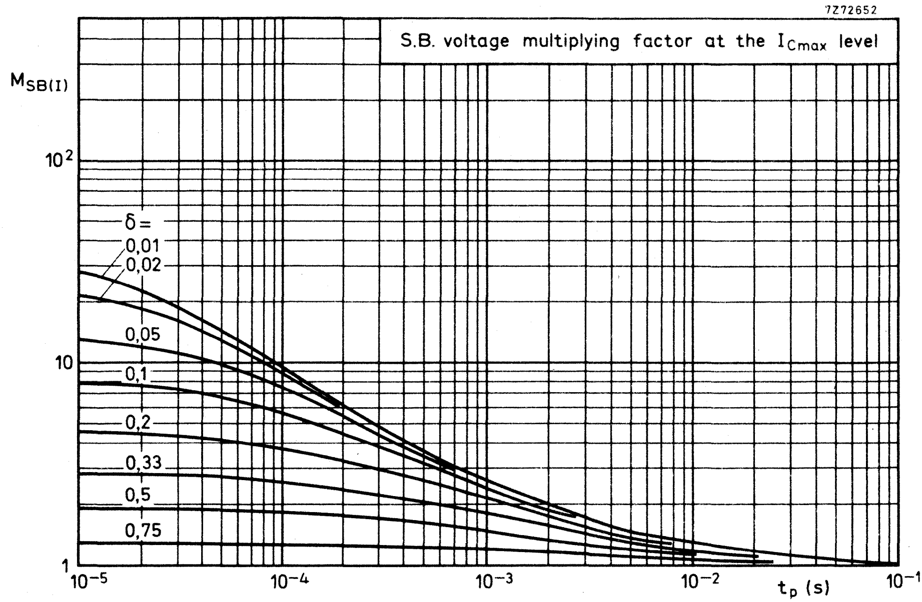
IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leq 0$ and $t_p \leq 2$ ms

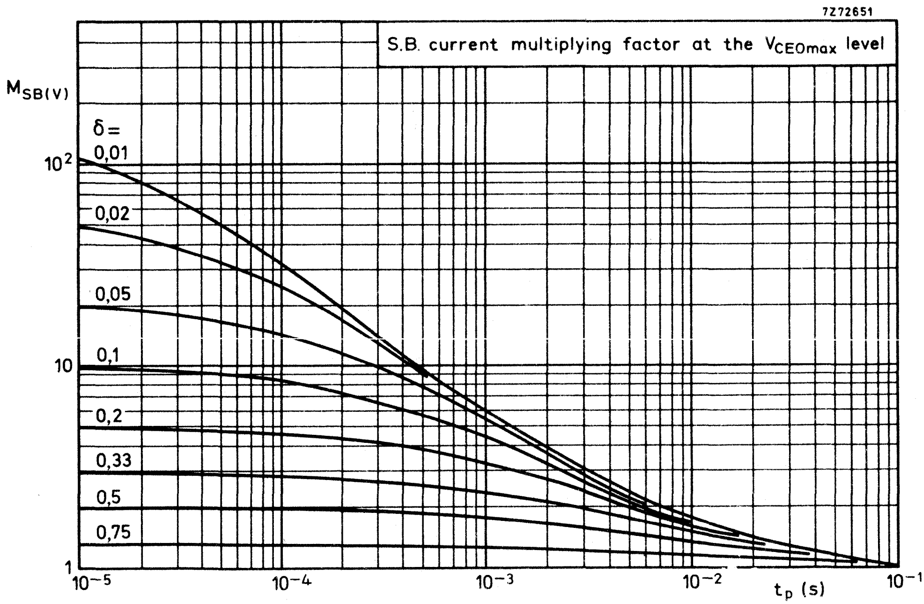
1) $P_{tot\ max}$ and $P_{peak\ max}$ lines.

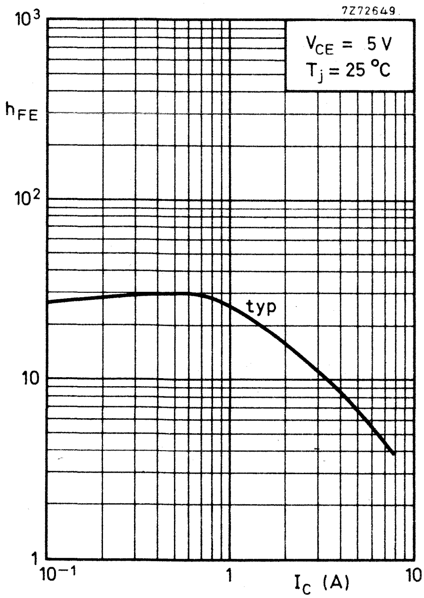
2) Second-breakdown limits (independent of temperature).

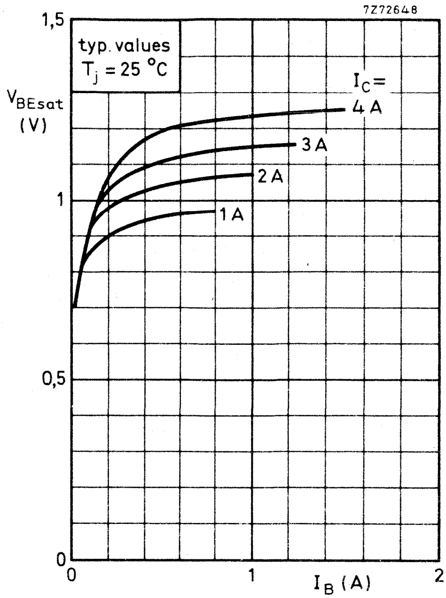

7Z72731
100
50
0
$P_{tot\ max}$ (%)
0
50
100
150
T_{mb} (°C)

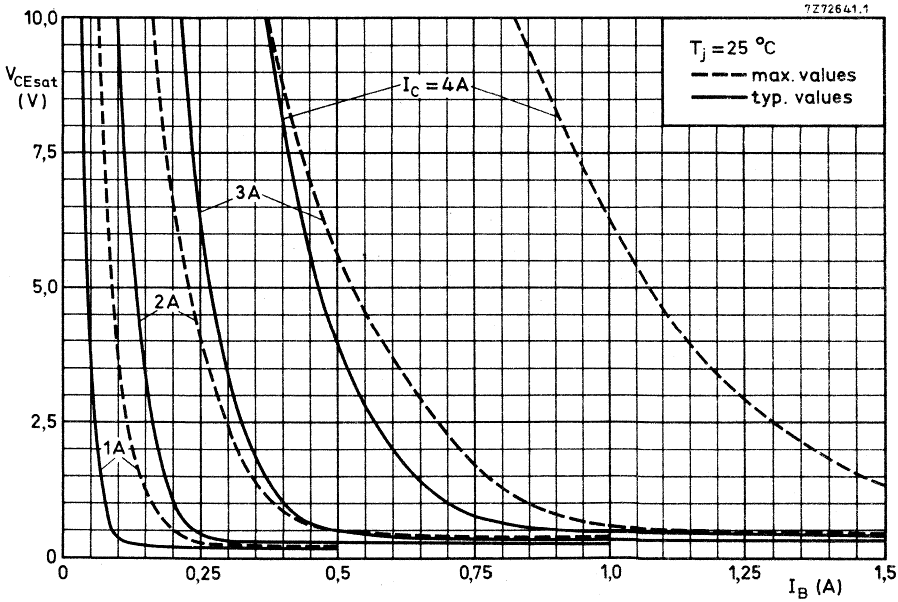

7Z72653
10^2
$Z_{th\ j\text{-}mb}$ (°C/W)
10
1
10^{-1}
10^{-2}
$\delta = 1$
0,75
0,3
0,33
0,2
0,1
0,05
0,02
≤ 0,01
t_p
T
$\delta = \frac{t_p}{T}$
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
t_p (s)
1


7Z72652
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^{-5}
10^{-4}
10^{-3}
10^{-2}
t_p (s)
10^{-1}


7Z72651
S.B. current multiplying factor at the V_{CEOmax} level
$M_{SB(V)}$
δ =
0,01
10^2
0,02
0,05
10
0,1
0,2
0,33
0,5
0,75
1
10^{-5}
10^{-4}
10^{-3}
10^{-2}
t_p (s)
10^{-1}


7Z72649
V_{CE} = 5 V
T_j = 25 °C
h_{FE}
10^3
10^2
10
1
typ
10^{-1}
1
10
I_C (A)


7Z72648
typ. values
T_j = 25 °C
V_{BEsat}
(V)
I_C =
4 A
3 A
2 A
1 A
1,5
1
0,5
0
0
1
2
I_B (A)


7Z72641.1
T_j = 25 °C
max. values
typ. values
V_{CEsat}
(V)
I_C = 4A
3A
2A
1A
10,0
7,5
5,0
2,5
0
0
0,25
0,5
0,75
1,0
1,25
1,5
I_B (A)

APPLICATION INFORMATION ON BUX82 (detailed information on request)

Important factors in the design of SMPS circuits are the power losses and heatsink requirements of the supply output transistor and the base drive conditions during turn-off. In SMPS circuits with mains isolation the duty factor of the collector current generally varies between 0,25 and 0,5.

The operating frequency lies between 15 kHz and 50 kHz and the shape of the collector current varies from rectangular in a forward converter to a sawtooth in a flyback circuit.

Information on optimum base drive and device dissipation of the BUX82 in a flyback converter is given in Figs 3 to 5. Figs 6 to 8 apply to a forward converter. In these figures I_{CM} represents the highest repetitive peak collector current that can occur in the given circuit, e.g. during overload.

The total power dissipation for a limit-case transistor is given in Figs 5 and 8 which applies for a mounting base temperature of 100 °C. The required thermal resistance for the heatsink can be calculated from

$$R_{th\ mb\text{-}a} = \frac{100 - T_{amb\ max}}{P_{tot}}.$$

To ensure thermal stability the minimum value of T_{amb} in the above equation is 40 °C.

A practical forward converter output circuit for an output power in the order of 200 W is given in Fig. 2.

At a collector current of 2,5 A and a base current of 0,5 A in this circuit the following turn-off times can be expected.

			T_{mb} = 25 °C	100 °C	
Storage time	t_s	typ	1,9	2,7	µs
Fall time	t_f	typ	0,17	0,7	µs

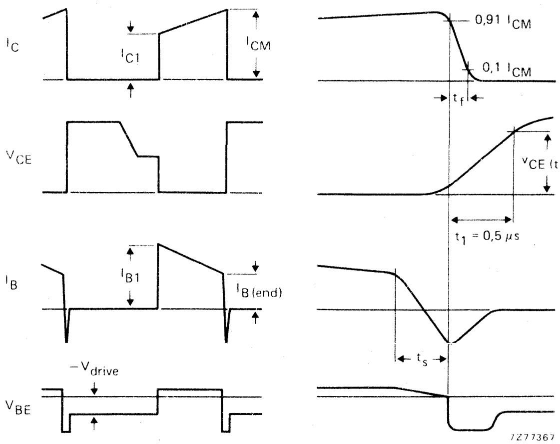


Fig. 1 Relevant waveforms of switching transistor.

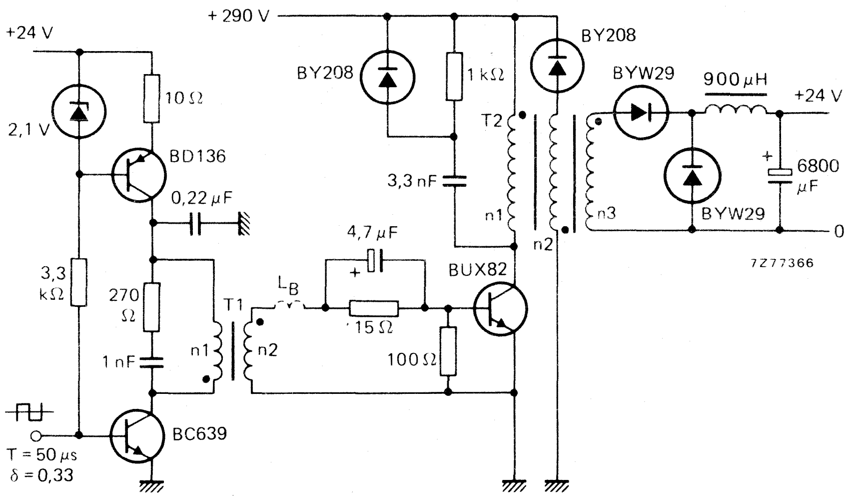


Fig. 2 Practical forward converter SMPS output circuit.

T1 (driver transformer): Core U20; n1 = 75 turns; n2 = 20 turns
T2 (output transformer): Core E55; n1 = n2 = 72 turns; n3 = 19 turns

$v_{CE(t1)} < 300$ V (see Fig. 1)

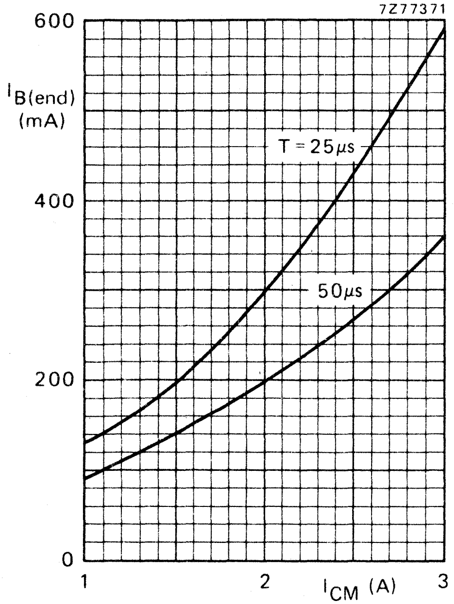


Fig. 3.

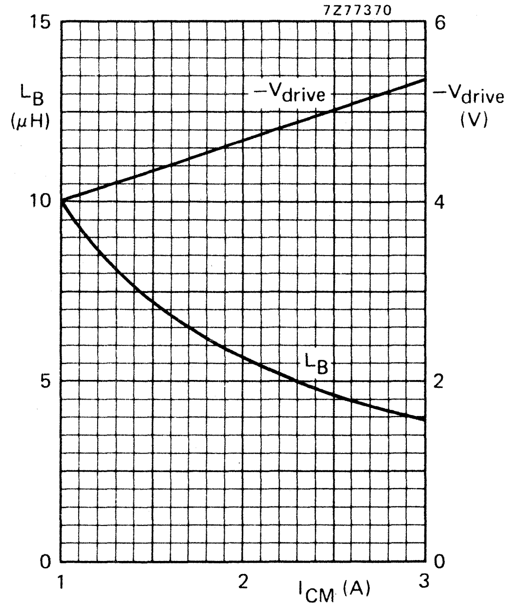


Fig. 4.

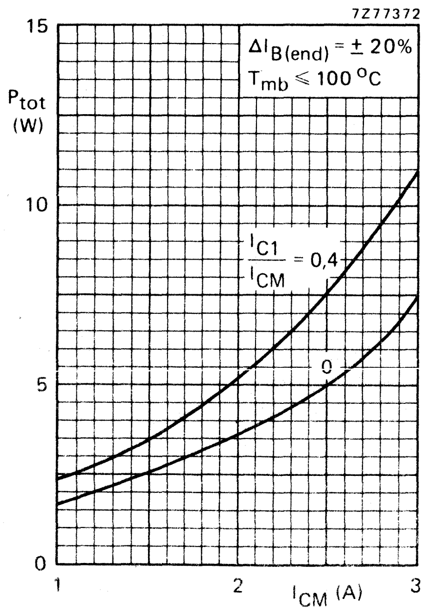


Fig. 5.

Fig. 3 Recommended nominal "end" value of the base current versus maximum peak collector current in a **flyback** converter.

Fig. 4 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

Fig. 5 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 3.

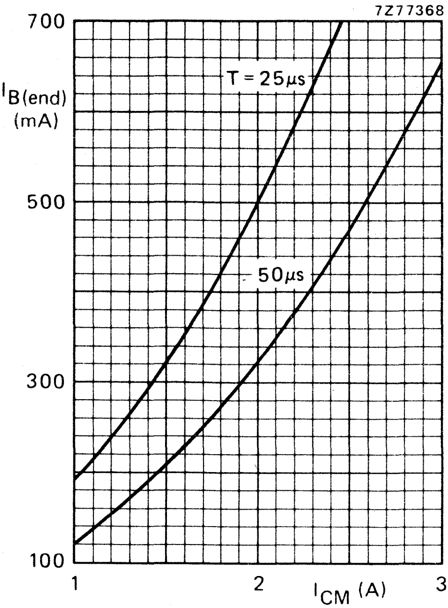


Fig. 6.

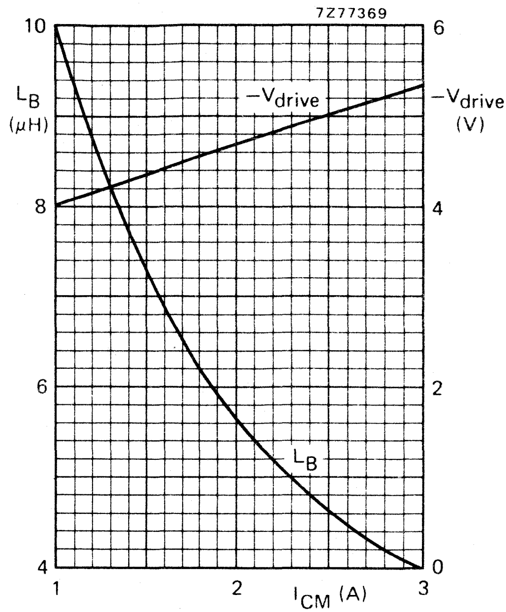


Fig. 7.

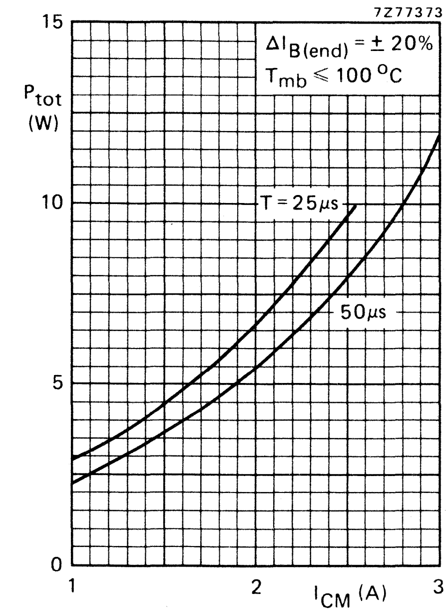


Fig. 8.

Fig. 6 Recommended nominal "end" value of the base current versus maximum peak collector current in a **forward** converter.

Fig. 7 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

Fig. 8 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 6.

SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed, glass-passivated n-p-n power transistors in TO-220 envelopes, intended for use in converters, inverters, switching regulators, motor control systems and switching applications.

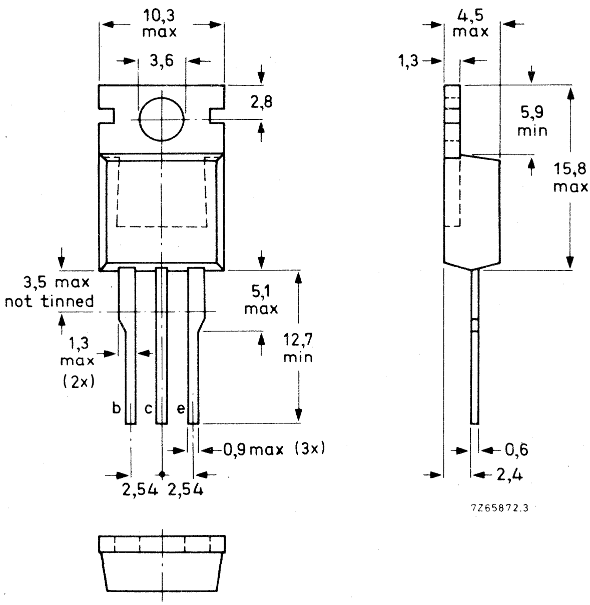
QUICK REFERENCE DATA

			BUX84	BUX85	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max	800	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max	400	450	V
Collector current (d.c.)	I_C	max	2		A
Collector current (peak value) t_p = 2 ms	I_{CM}	max	3		A
Total power dissipation up to T_{mb} = 50 °C	P_{tot}	max	40		W
Collector-emitter saturation voltage I_C = 1 A; I_B = 0,2 A	V_{CEsat}	<	3		V
Fall time I_{Con} = 1 A; I_{Bon} = 0,2 A; $-I_{Boff}$ = 0,4 A	t_f	typ	0,4		µs

MECHANICAL DATA

Dimensions in mm

TO-220
Collector connected to mounting base



For mounting instructions and accessories see section Accessories (Handbook SC2).

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

Voltages

			BUX84	BUX85	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max	800	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max	400	450	V

Currents

Collector current (d.c.)	I_C	max	2	A
Collector current (peak value) t_p = 2 ms	I_{CM}	max	3	A
Base current (d.c.)	I_B	max	0,75	A
Base current (peak value)	I_{BM}	max	1	A
Reverse base current (peak value) *	$-I_{BM}$	max	1	A

Power dissipation

Total power dissipation up to T_{mb} = 50 °C	P_{tot}	max	40	W

Temperatures

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

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	2,5	°C/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	70	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current **

$V_{CEM} = V_{CESMmax}$; $V_{BE} = 0$	I_{CES}	<	200	µA
$V_{CEM} = V_{CESMmax}$; $V_{BE} = 0$; T_j = 125 °C	I_{CES}	<	1,5	mA

D.C. current gain

I_C = 0,1 A; V_{CE} = 5 V	h_{FE}	typ	50	

* Turn-off current.
** Measured with a half sine-wave voltage (curve tracer).

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

Emitter cut-off current

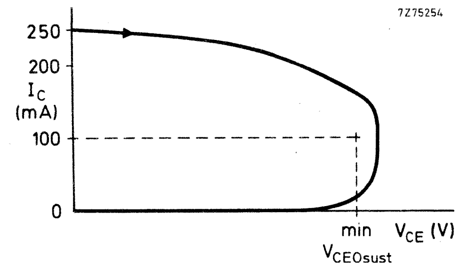
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	1		mA

Saturation voltages

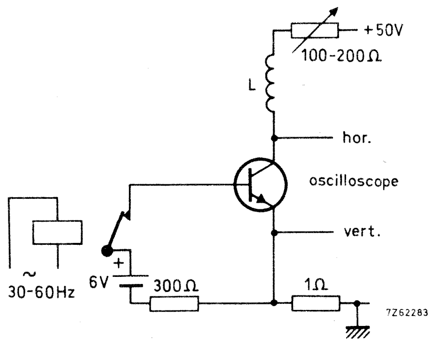
$I_C = 0{,}3$ A; $I_B = 30$ mA	V_{CEsat}	<	1,5		V
$I_C = 1$ A; $I_B = 0{,}2$ A	V_{CEsat}	<	3		V
$I_C = 1$ A; $I_B = 0{,}2$ A	V_{BEsat}	<	1,1		V

Collector-emitter sustaining voltage

			BUX84	BUX85	
$I_C = 100$ mA; $I_{Boff} = 0$; $L = 25$ mH	$V_{CEOsust}$	>	400	450	V



Oscilloscope display for sustaining voltage.



Test circuit for $V_{CEOsust}$.

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

Transition frequency at f = 1 MHz

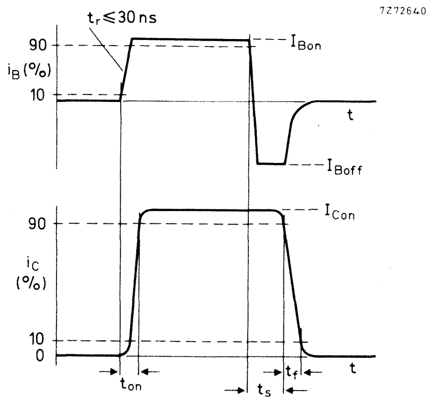
I_C = 0,2 A; V_{CE} = 10 V	f_T	typ	20	MHz

Switching times

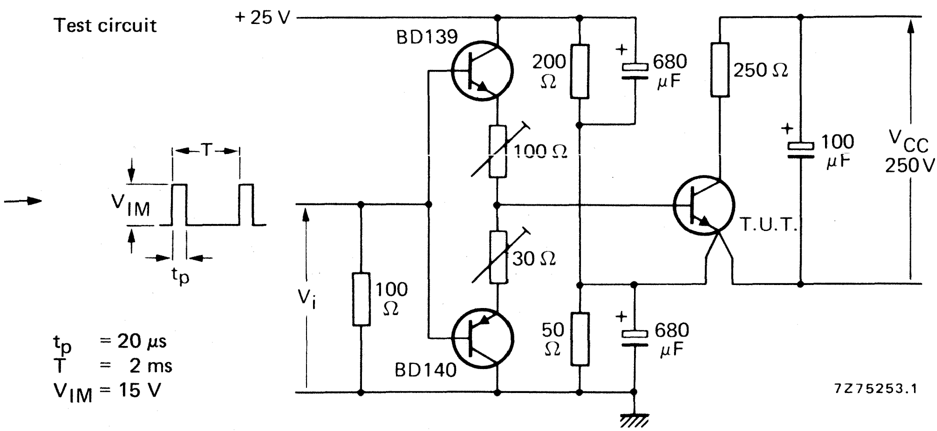
I_{Con} = 1 A; V_{CC} = 250 V
I_{Bon} = 0,2 A; $-I_{Boff}$ = 0,4 A

Turn-on time	t_{on}	typ	0,2	μs
		<	0,5	μs
Turn-off: Storage time	t_s	typ	2	μs
		<	3,5	μs
Fall time	t_f	typ	0,4	μs
Fall time, T_{mb} = 95 °C	t_f	<	1,4	μs

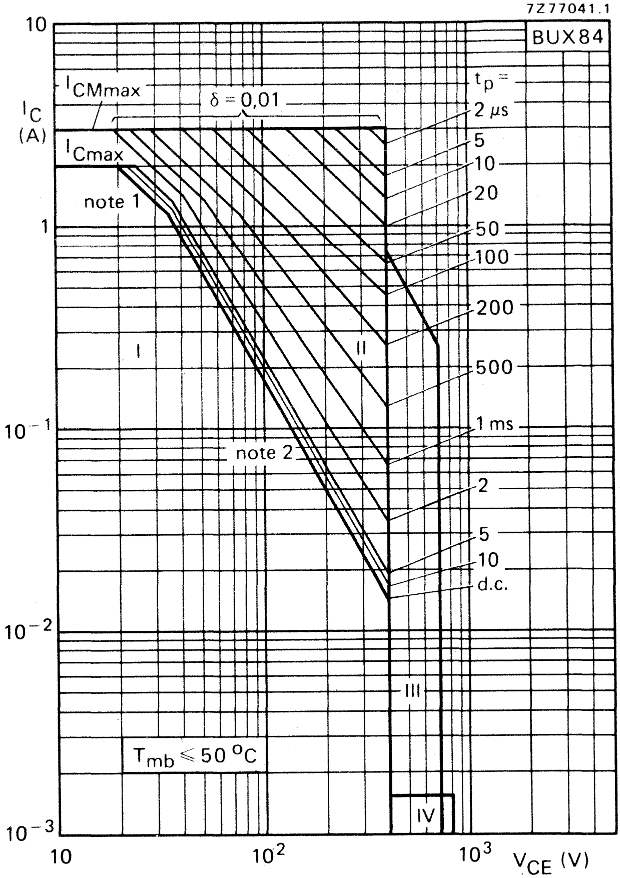
Waveform



Test circuit



t_p = 20 μs
T = 2 ms
V_{IM} = 15 V



Safe Operating ARea

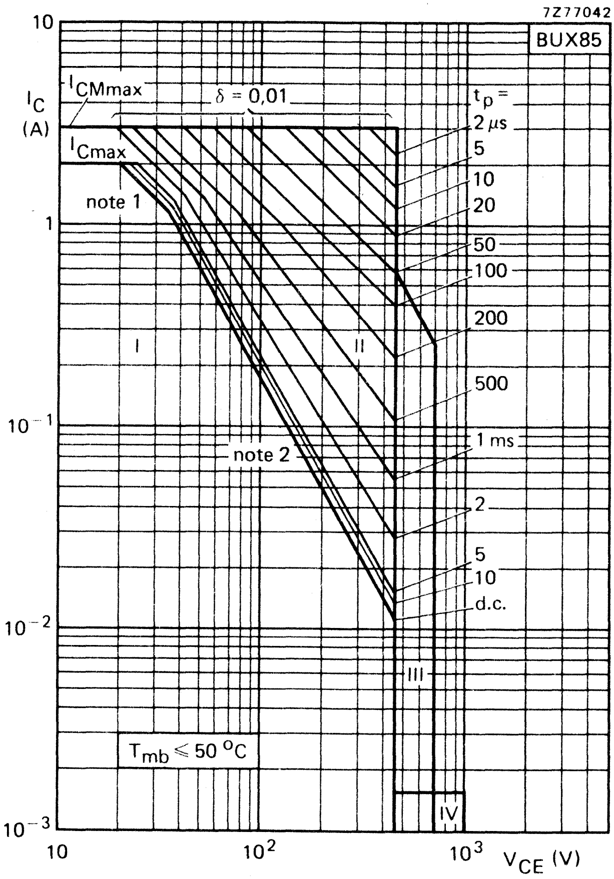
I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

III Area of permissible operation during turn-on in single transistor converters, provided $R_{BE} \leqslant 100\ \Omega$ and $t_p \leqslant 0{,}6\ \mu s$

IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leqslant 0$ and $t_p \leqslant 2$ ms

Notes
1. $P_{tot\ max}$ and $P_{peak\ max}$ lines.
2. Second-breakdown limits (independent of temperature).



Safe Operating ARea

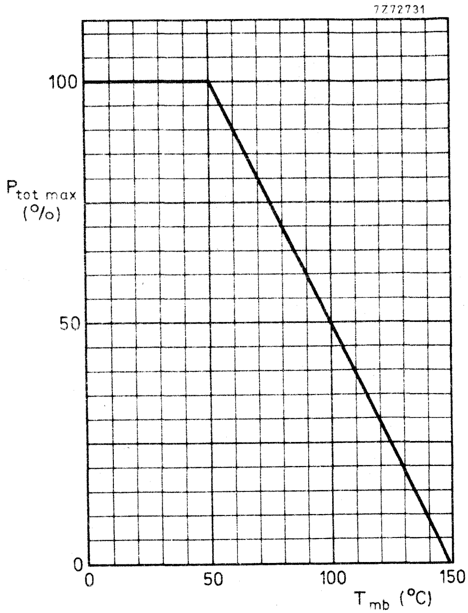
I Region of permissible d.c. operation

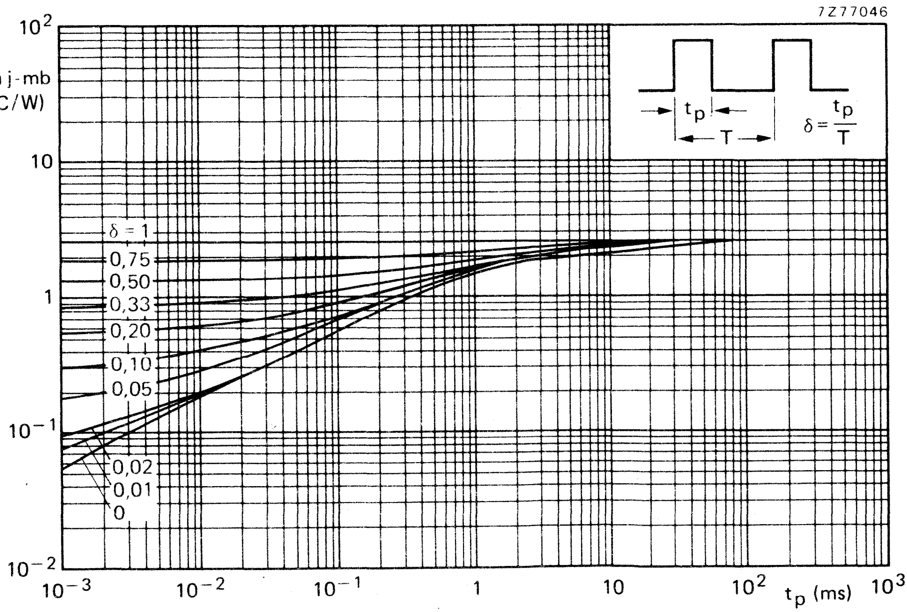
II Permissible extension for repetitive pulse operation

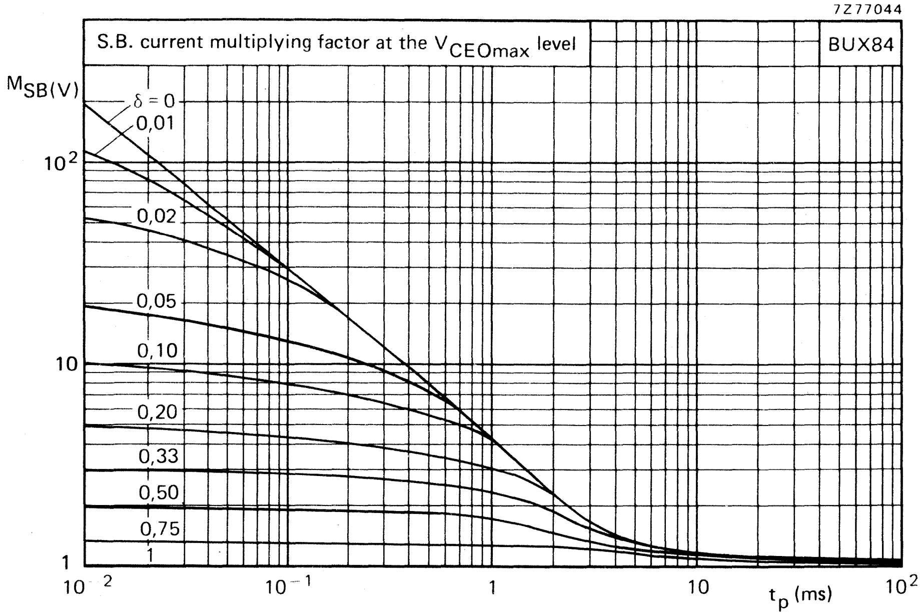
III Area of permissible operation during turn-on in single transistor converters, provided $R_{BE} \leqslant 100\ \Omega$ and $t_p \leqslant 0{,}6\ \mu s$

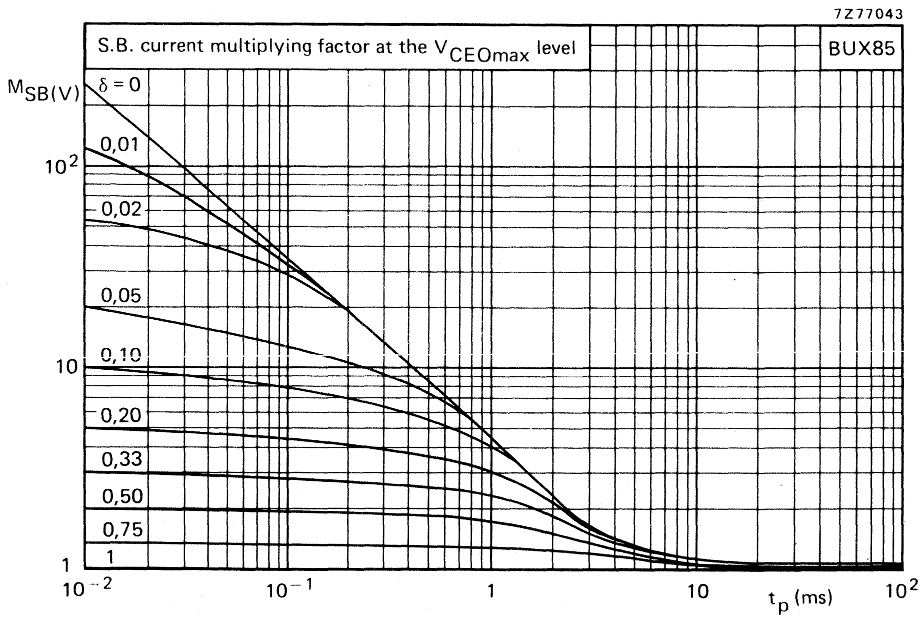
IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leqslant 0$ and $t_p \leqslant 2$ ms

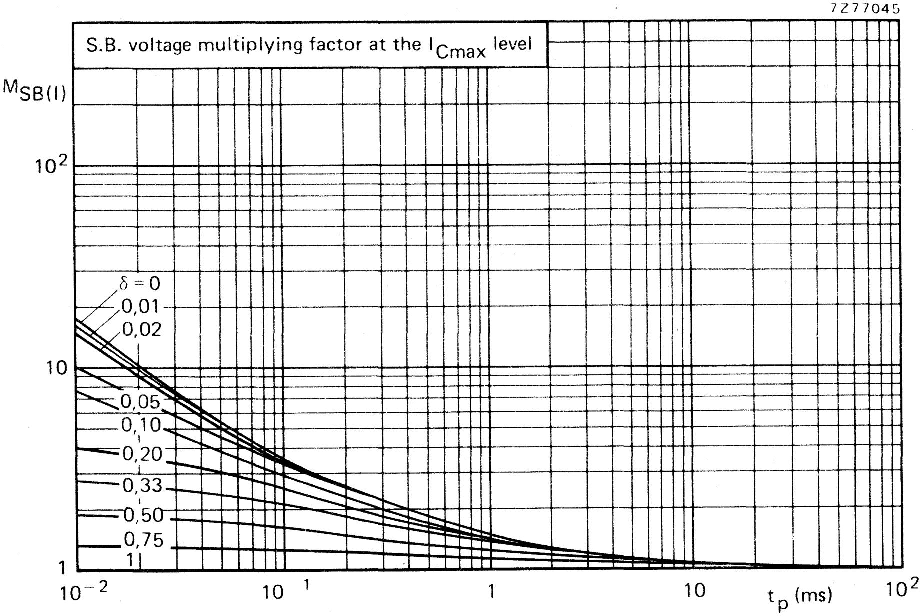
Notes
1. $P_{tot\,max}$ and $P_{peak\,max}$ lines.
2. Second-breakdown limits (independent of temperature).

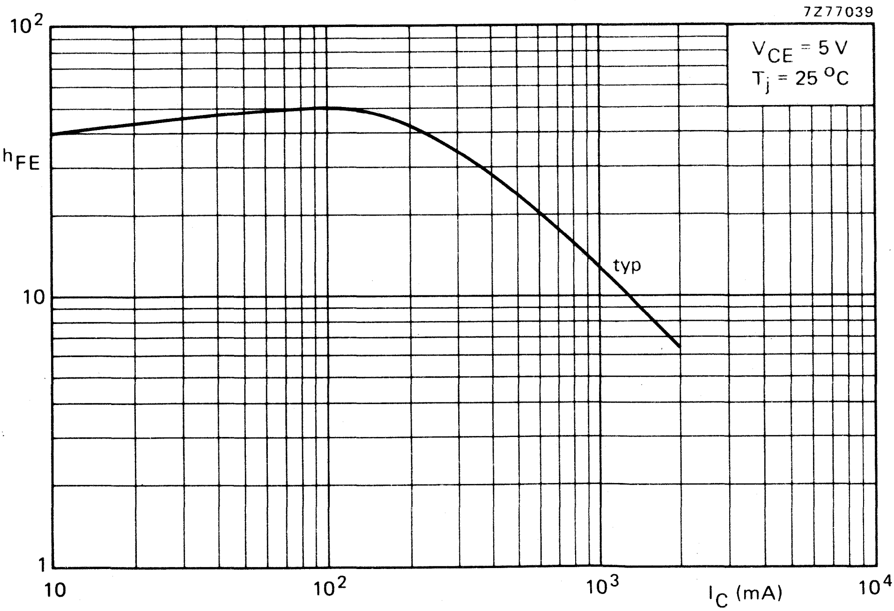

7Z72731
$P_{tot\ max}$ (%)
100
50
0
0
50
100
150
T_{mb} (°C)

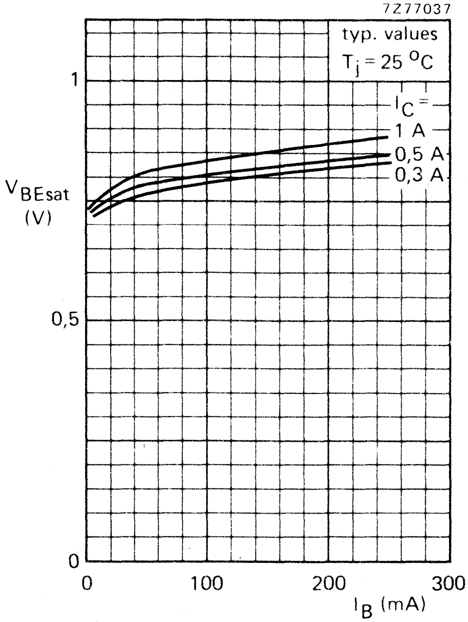

7Z77046
$Z_{th\ j\text{-}mb}$ (°C/W)
10^2
10
1
10^{-1}
10^{-2}
$\delta = 1$
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
0
t_p
T
$\delta = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3

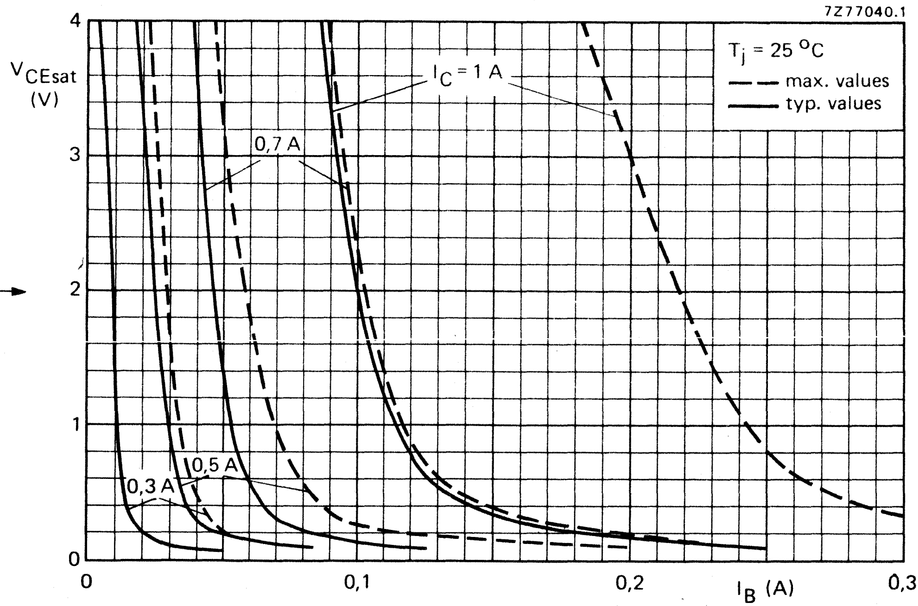

7Z77044
S.B. current multiplying factor at the V$_{CEOmax}$ level
BUX84
M$_{SB(V)}$
δ = 0
0,01
0,02
0,05
0,10
0,20
0,33
0,50
0,75
1
10^2
10
1
10^{-2}
10^{-1}
1
10
10^2
t$_p$ (ms)


7Z77043
S.B. current multiplying factor at the V$_{CEOmax}$ level
BUX85
M$_{SB(V)}$
δ = 0
0,01
0,02
0,05
0,10
0,20
0,33
0,50
0,75
1
10^2
10
1
10^{-2}
10^{-1}
1
10
10^2
t$_p$ (ms)


7Z77045
S.B. voltage multiplying factor at the I_{Cmax} level
$M_{SB(I)}$
10^2
10
1
δ = 0
0,01
0,02
0,05
0,10
0,20
0,33
0,50
0,75
1
10^{-2}
10^{-1}
1
10
t_p (ms)
10^2


7Z77039
V_{CE} = 5 V
T_j = 25 °C
h_{FE}
10^2
10
1
typ
10
10^2
10^3
I_C (mA)
10^4


7Z77037
typ. values
$T_j = 25\ ^oC$
$I_C =$
1 A
0,5 A
0,3 A
V_{BEsat} (V)
1
0,5
0
0
100
200
300
I_B (mA)


7Z77040.1
$T_j = 25\ ^oC$
max. values
typ. values
$I_C = 1$ A
0,7 A
0,5 A
0,3 A
V_{CEsat} (V)
4
3
2
1
0
0
0,1
0,2
0,3
I_B (A)

APPLICATION INFORMATION ON BUX84 (detailed information on request)

Important factors in the design of SMPS circuits are the power losses and heatsink requirements of the supply output transistor and the base drive conditions during turn-off. In most SMPS circuits with mains isolation the duty factor of the collector current generally varies between 0,25 and 0,5.

The operating frequency lies between 15 kHz and 50 kHz and the shape of the collector current varies from rectangular in a forward converter to a sawtooth in a flyback circuit.

Information on optimum base drive and device dissipation of the BUX84 in a flyback converter is given in Figs 3 to 5. Figs 6 to 8 apply to a forward converter. In these figures I_{CM} represents the highest repetitive peak collector current that can occur in the given circuit, e.g. during overload.

The total power dissipation for a limit-case transistor is given in Figs 5 and 8 which apply for a mounting base temperature of 100 °C. The required thermal resistance for the heatsink can be calculated from

$$R_{th\ mb\text{-}a} = \frac{100 - T_{amb\ max}}{P_{tot}}.$$

To ensure thermal stability the minimum value of T_{amb} in the above equation is 40 °C.

A practical SMPS output circuit for an output power in the order of 50 W is given in Fig. 2.

At a collector current of 0,7 A and a base current of 70 mA in this circuit the following turn-off times can be expected.

			T_{mb} = 25 °C	100 °C	
Storage time	t_s	typ	2,2	2,8	μs
Fall time	t_f	typ	0,25	0,85	μs

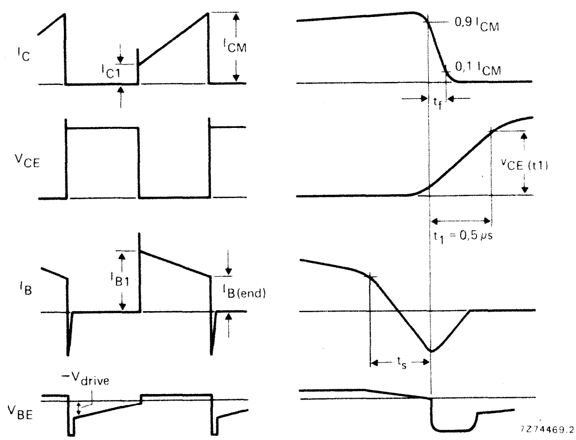


Fig. 1 Relevant waveforms of switching transistor.

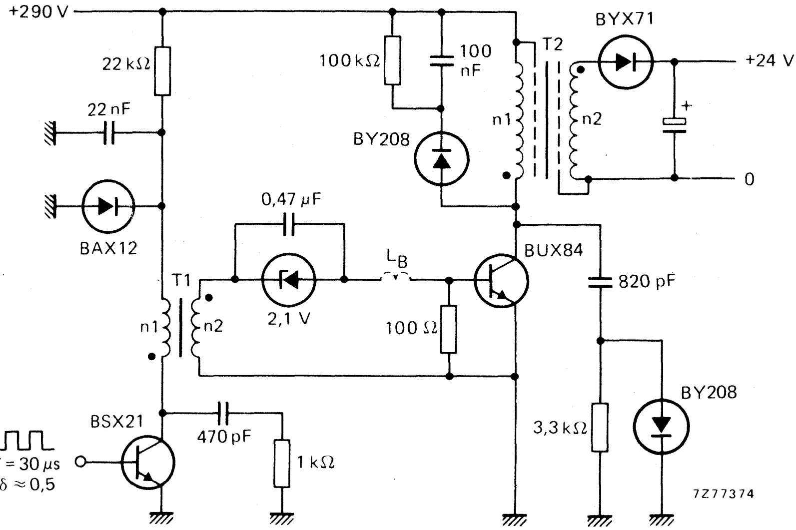


Fig. 2 Practical SMPS output circuit.

T1 (driver transformer): Core U15; n1 = 360 turns; n2 = 60 turns
total inductance in base circuit ≈ 15 μH

T2 (output transformer): Core E55; primary inductance L_p = 16 mH
n1 = 116 turns; n2 = 12 turns

$v_{CE(t1)} < 300$ V (see Fig. 1)

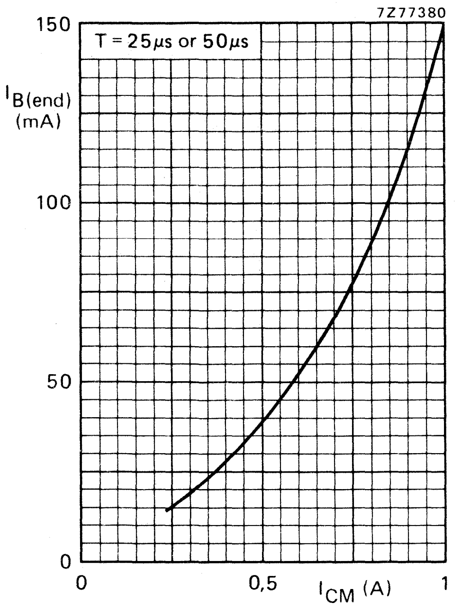


Fig. 3.

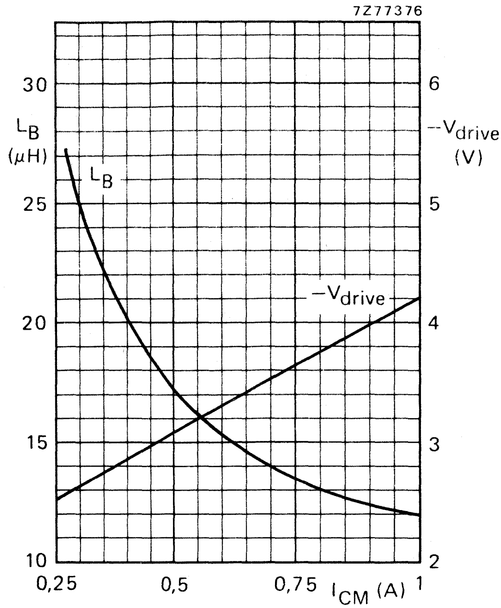


Fig. 4.

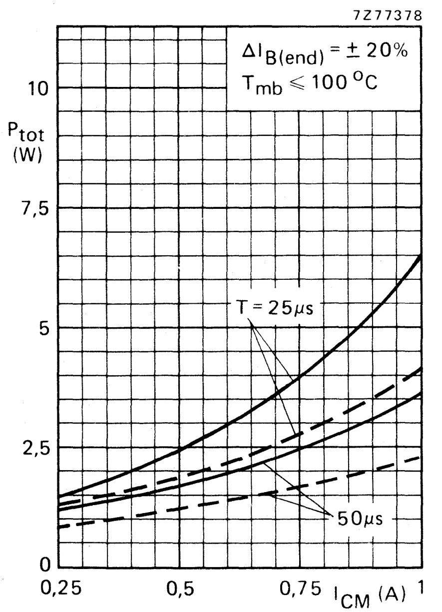


Fig. 5.

Fig. 3 Recommended nominal "end" value of the base current versus maximum peak collector current in a **flyback** converter.

Fig. 4 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

Fig. 5 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 3. Solid lines for I_{C1}/I_{CM} = 0,4 and dotted lines for I_{C1}/I_{CM} = 0.

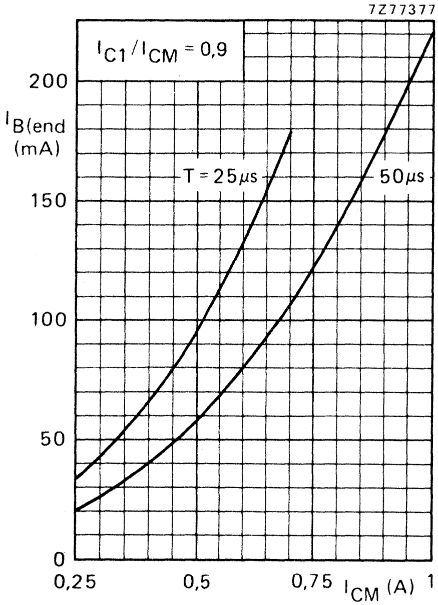


Fig. 6.

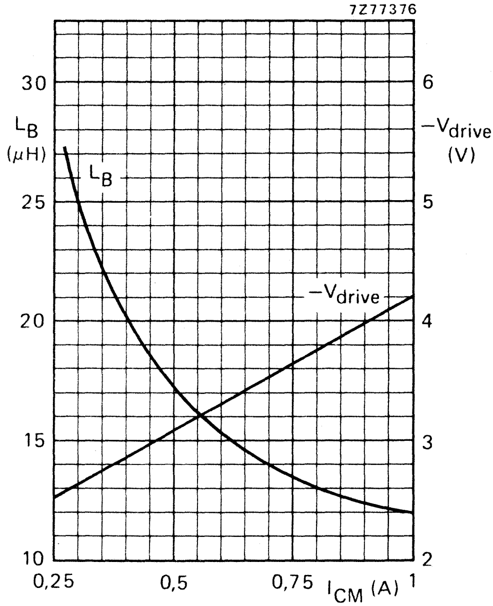


Fig. 7.

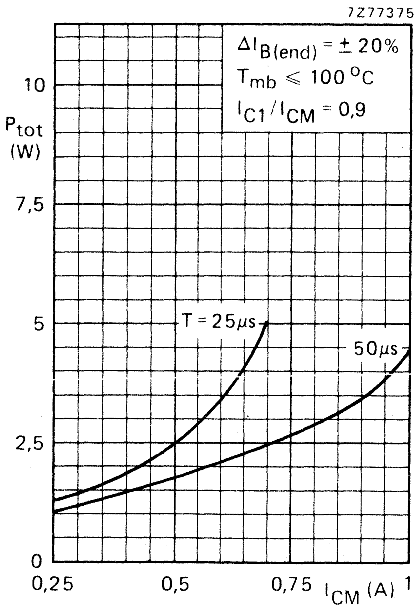


Fig. 8.

Fig. 6 Recommended nominal "end" value of the base current versus maximum peak collector current in a **forward** converter.

Fig. 7 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

Fig. 8 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 6.

SILICON DIFFUSED POWER TRANSISTORS

High-voltage, high-speed, glass-passivated n-p-n power transistors in SOT-32 envelopes, for use in converters, inverters, switching regulators, motor control systems and switching applications.

QUICK REFERENCE DATA

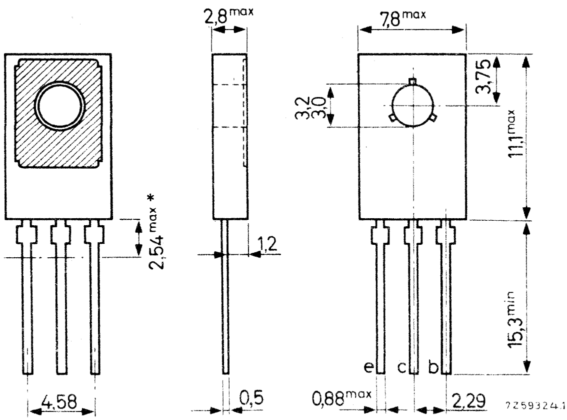
			BUX86	BUX87	
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max	800	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max	400	450	V
Collector current (d.c.)	I_C	max	0,5		A
Collector current (peak value): t_p = 2 ms	I_{CM}	max	1		A
Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max	20		W
Collector-emitter saturation voltage: I_C = 0,2 A; I_B = 20 mA	V_{CEsat}	<	3		V
Fall time: I_{Con} = 0,2 A; I_{Bon} = 20 mA; $-I_{Boff}$ = 40 mA	t_f	typ	0,4		μs

MECHANICAL DATA

Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface



Accessories: 56326 (washer) or 56353 (clip) for direct mounting and 56353 + 56354 (package) for insulated mounting. See Handbook SC2.

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

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

			BUX86	BUX87	
Voltages					
Collector-emitter voltage (V_{BE} = 0, peak value)	V_{CESM}	max	800	1000	V
Collector-emitter voltage (open base)	V_{CEO}	max	400	450	V

Currents				
Collector current (d.c.)	I_C	max	0,5	A
Collector current (peak value): t_p = 2 ms	I_{CM}	max	1	A
Base current (d.c.)	I_B	max	0,2	A
Base current (peak value)	I_{BM}	max	0,3	A
Reverse base current (peak value) (note 1)	$-I_{BM}$	max	0,3	A
Power dissipation				
Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max	20	W
Temperatures				
Storage temperature	T_{stg}		−65 to +150	°C
Junction temperature	T_j	max	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	4,5	°C/W
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	100	°C/W

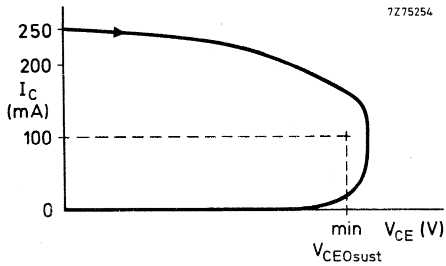
CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current (note 2)				
$V_{CEM} = V_{CESMmax}$; $V_{BE} = 0$	I_{CES}	<	100	μA
$V_{CEM} = V_{CESMmax}$; $V_{BE} = 0$; T_j = 125 °C	I_{CES}	<	1	mA
D.C. current gain				
I_C = 50 mA; V_{CE} = 5 V	h_{FE}	typ	50	

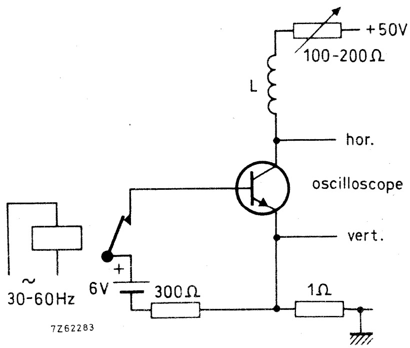
Notes
1. Turn-off current
2. Measured with a half sine-wave voltage (curve tracer).

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

			BUX86	BUX87	
Emitter cut-off current					
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	1		mA
Saturation voltage					
$I_C = 0{,}1$ A; $I_B = 10$ mA	V_{CEsat}	<	1,5		V
$I_C = 0{,}2$ A; $I_B = 20$ mA	V_{CEsat}	<	3		V
$I_C = 0{,}2$ A; $I_B = 20$ mA	V_{BEsat}	<	1,0		V
Collector-emitter sustaining voltages					
$I_C = 100$ mA; $I_{Boff} = 0$; $L = 25$ mH	$V_{CEOsust}$		400	450	V



Oscilloscope display for sustaining voltage



Test circuit for $V_{CEOsust}$

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

Transition frequency at f = 1 MHz

$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	typ	20	MHz

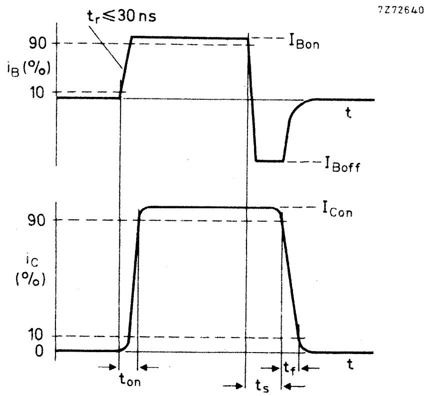
Switching times

$I_{Con} = 0{,}2$ A; $V_{CC} = 250$ V

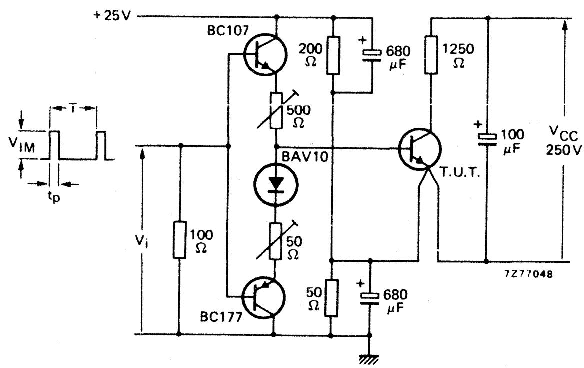
$I_{Bon} = 20$ mA; $-I_{Boff} = 40$ mA

Turn-on time	t_{on}	typ	0,25	µs
		<	0,5	µs
Turn-off: Storage time	t_s	typ	2	µs
		<	3,5	µs
Fall time	t_f	typ	0,4	µs
Fall time, $T_{mb} = 95\ ^oC$	t_f	<	1,3	µs

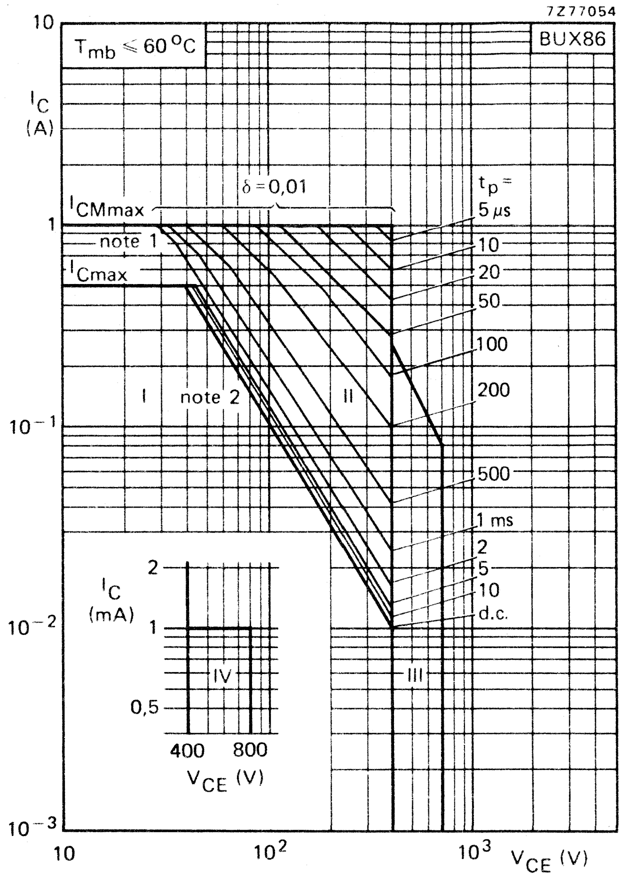
Waveform



Test circuit



t_p = 20 µs
T = 2 ms
V_{IM} = 15 V



Safe Operating ARea

I Region of permissible d.c. operation

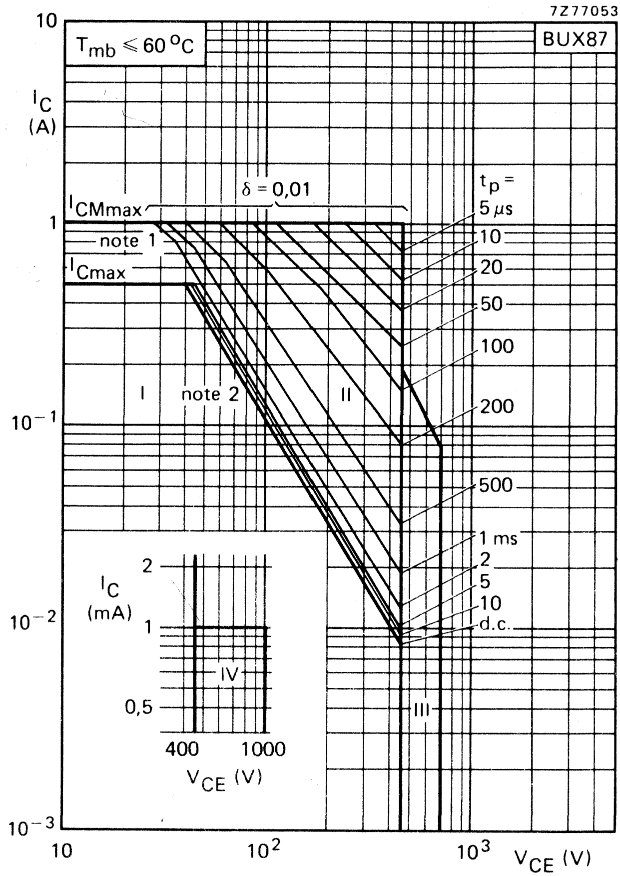
II Permissible extension for repetitive pulse operation

III Area of permissible operation during turn-on in single-transistor converters, provided $R_{BE} \leqslant 100\ \Omega$ and $t_p \leqslant 0{,}6\ \mu s$

IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leqslant 0$ and $t_p \leqslant 2$ ms

Notes

1. $P_{peak\ max}$ lines.
2. Second-breakdown limits (independent of temperature).



Safe Operating ARea

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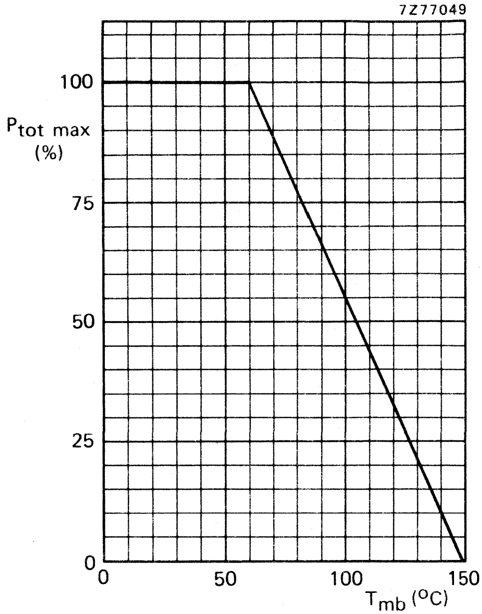
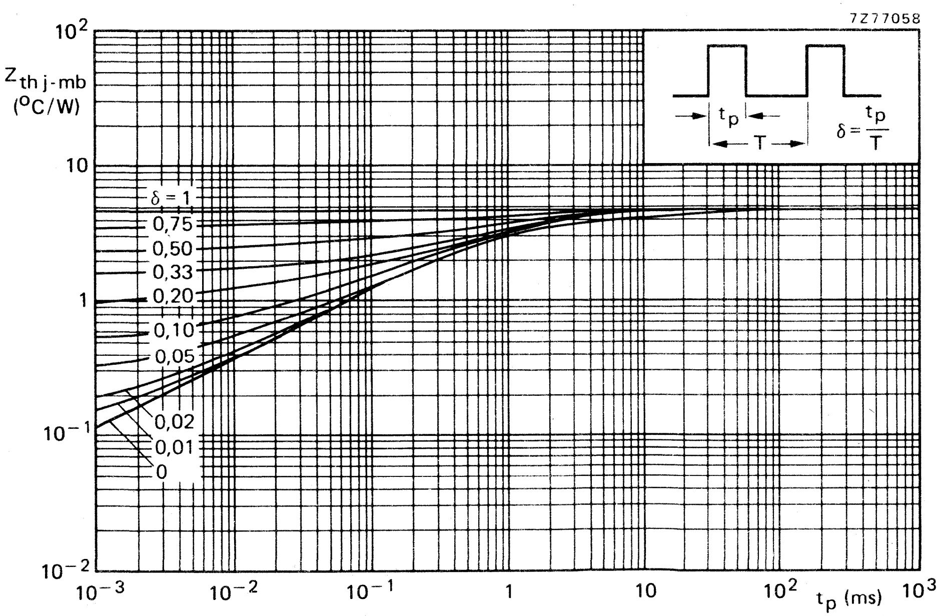
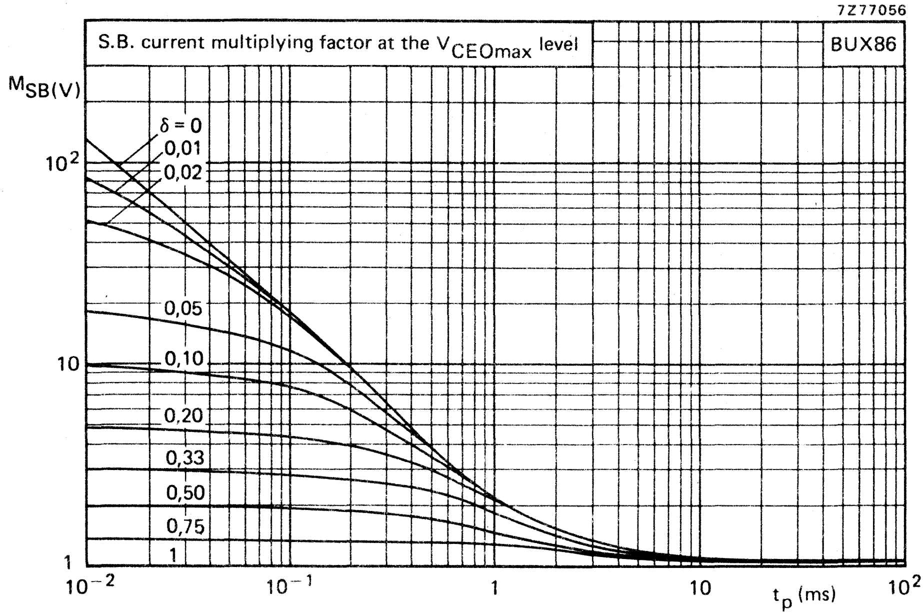
III Area of permissible operation during turn-on in single-transistor converters, provided $R_{BE} \leqslant 100\ \Omega$ an $t_p \leqslant 0,6\ \mu s$

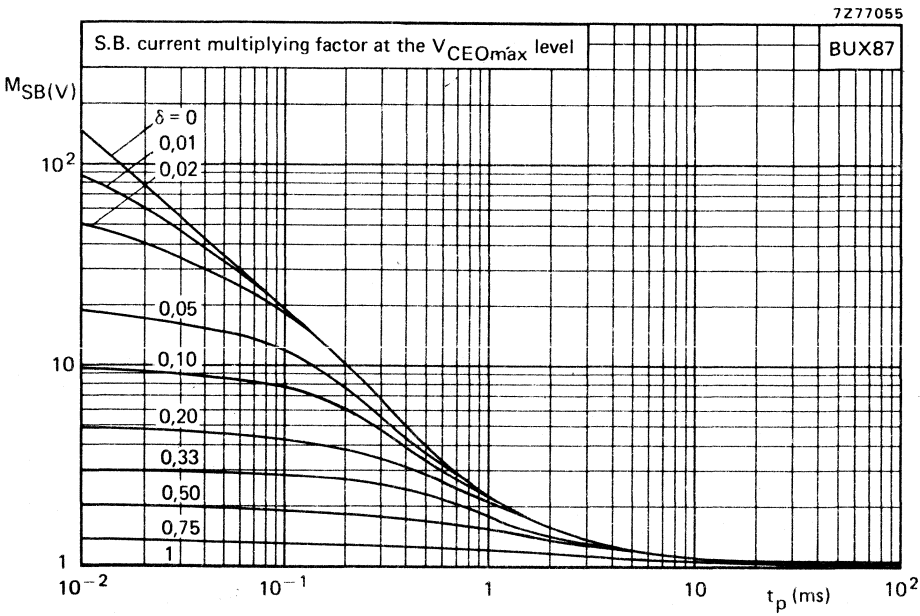
IV Repetitive pulse operation in this region is permissible, provided $V_{BE} \leqslant 0$ and $t_p \leqslant 2$ ms

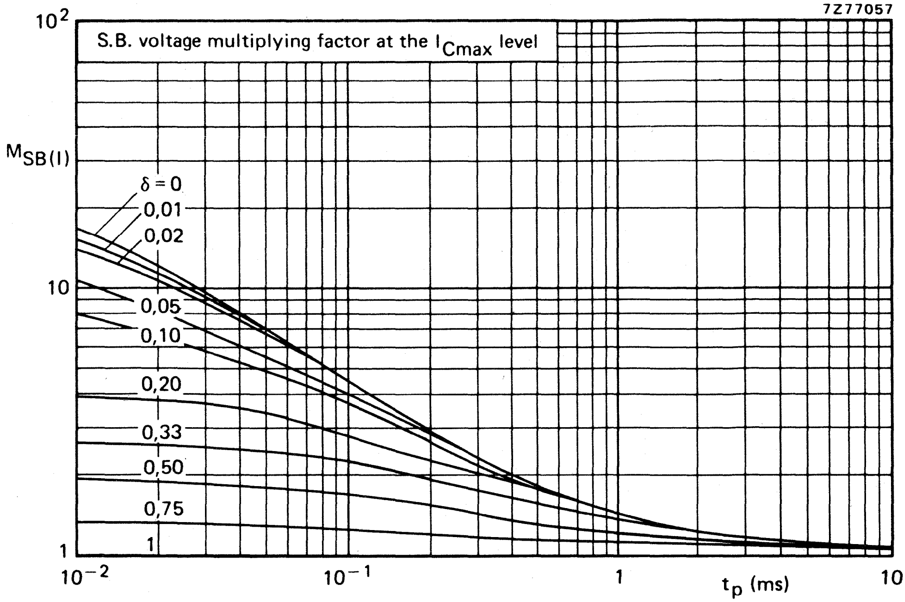
Notes
1. $P_{peak\ max}$ lines.
2. Second-breakdown limits (independent of temperature).

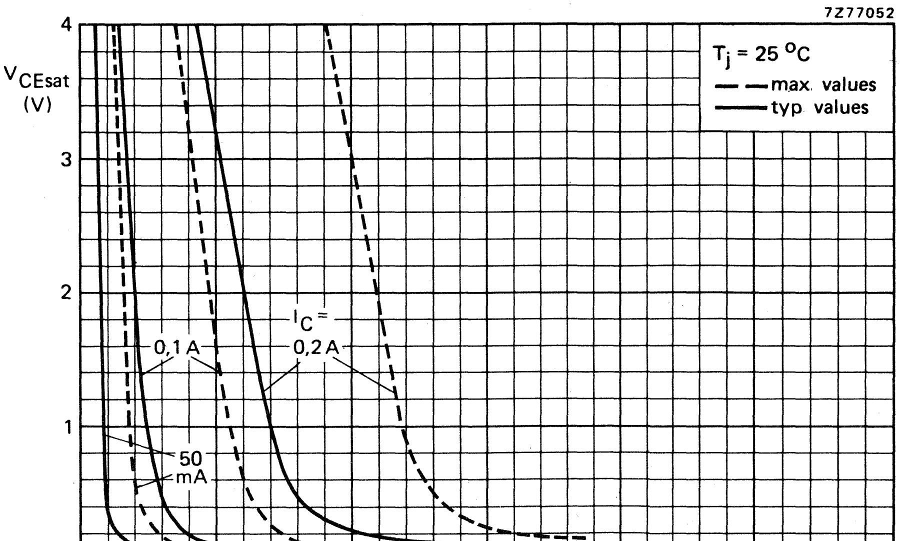

7Z77049
100
$P_{tot\ max}$ (%)
75
50
25
0
0
50
100
150
T_{mb} (°C)

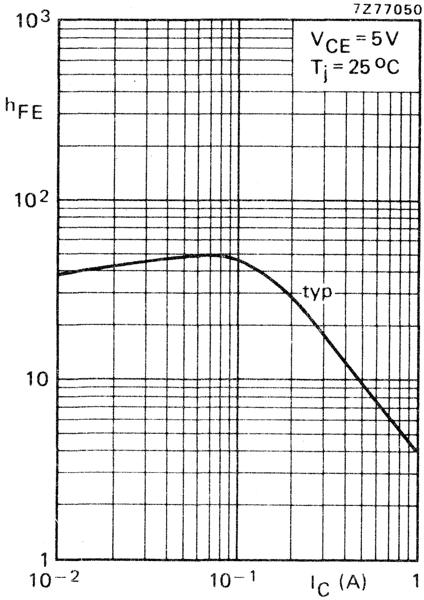

7Z77058
10^2
$Z_{th\ j\text{-}mb}$ (°C/W)
10
1
10^{-1}
10^{-2}
$\delta = 1$
0,75
0,50
0,33
0,20
0,10
0,05
0,02
0,01
0
t_p
T
$\delta = \frac{t_p}{T}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3

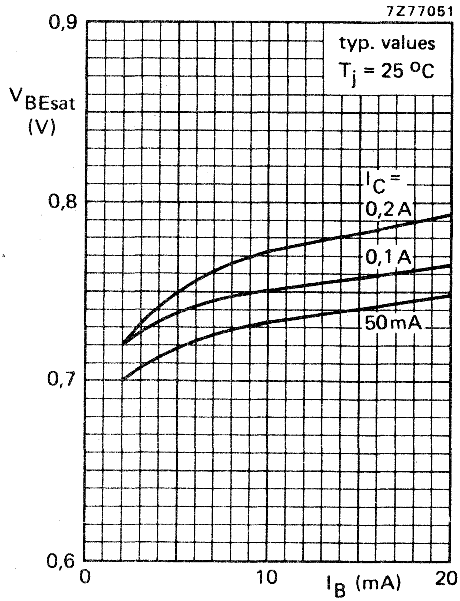

7Z77056
S.B. current multiplying factor at the V_{CEOmax} level
BUX86
$M_{SB(V)}$
δ = 0
0,01
0,02
0,05
0,10
0,20
0,33
0,50
0,75
1
10^2
10
1
10^{-2}
10^{-1}
1
10
t_p (ms)
10^2


7Z77055
S.B. current multiplying factor at the V_{CEOmax} level
BUX87
$M_{SB(V)}$
δ = 0
0,01
0,02
0,05
0,10
0,20
0,33
0,50
0,75
1
10^2
10
1
10^{-2}
10^{-1}
1
10
t_p (ms)
10^2


7Z77057
S.B. voltage multiplying factor at the I_Cmax level
10^2
M_SB(I)
δ = 0
0,01
0,02
10
0,05
0,10
0,20
0,33
0,50
0,75
1
1
10^-2
10^-1
1
t_p (ms)
10


7Z77052
T_j = 25 °C
max. values
typ. values
V_CEsat
(V)
4
3
2
1
0
I_C =
0,1 A
0,2 A
50
mA
0
20
40
I_B (mA)
60


7Z77050
V_{CE} = 5 V
T_j = 25 °C
h_{FE}
10^3
10^2
10
1
typ
10^{-2}
10^{-1}
I_C (A)
1


7Z77051
typ. values
T_j = 25 °C
V_{BEsat} (V)
0,9
0,8
0,7
0,6
I_C =
0,2 A
0,1 A
50 mA
0
10
I_B (mA)
20

APPLICATION INFORMATION ON BUX86 (detailed information on request)

Important factors in the design of SMPS circuits are the power losses and heatsink requirements of the supply output transistor and the base drive conditions during turn-off. In SMPS circuits with mains isolation the duty factor of the collector current generally varies between 0,25 to 0,5.

The operating frequency lies between 15 kHz and 50 kHz and the shape of the collector current varies from rectangular in a forward converter to a sawtooth in a flyback circuit.

As the BUX86 will mainly be used in low-power flyback converters the information on optimum base drive and device dissipation given in the graphs on page 13 is concentrated on this application. In these figures I_{CM} represents the highest repetitive peak collector current that can occur in the given circuit, e.g. during overload.

The total power dissipation for a limit-case transistor is given in Fig. 5 which applies for a mounting base temperature of 100 °C. The required thermal resistance for the heatsink can be calculated from

$$R_{th\ mb\text{-}a} = \frac{100 - T_{amb\ max}}{P_{tot}}.$$

To ensure thermal stability the minimum value of T_{amb} in the above equation is 40 °C.

A practical SMPS output circuit for an output of power in the order of 15 W is given in Fig. 2.

At a collector current of 200 mA and a base current of 20 mA in this circuit the following turn-off times can be expected.

			T_{mb} = 25 °C	100 °C	
Storage time	t_s	typ	1,3	1,8	µs
Fall time	t_f	typ	0,2	0,8	µs

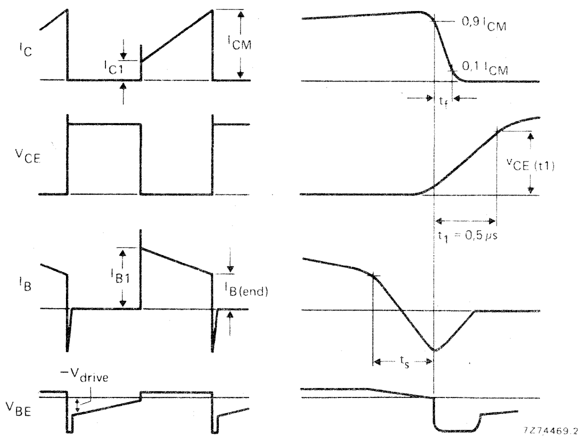


Fig. 1 Relevant waveforms of switching transistor.

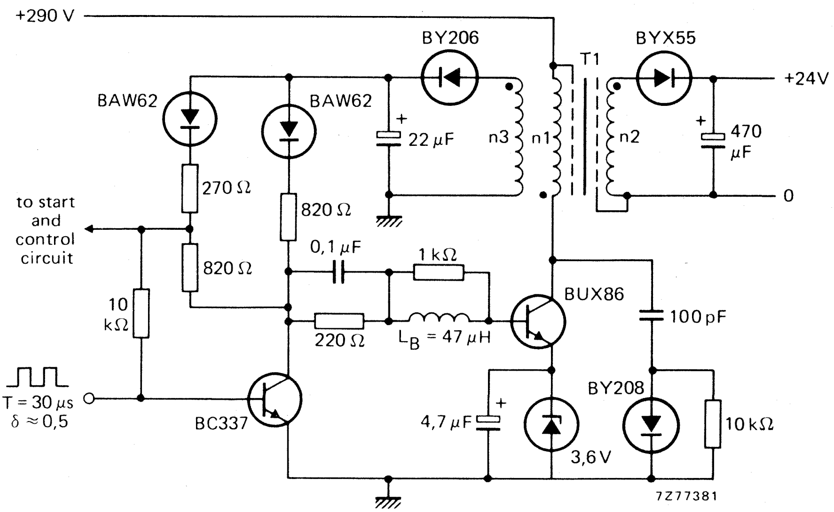


Fig. 2 Practical SMPS output circuit.

T1 (output transformer): Core U20; primary inductance L_p = 23 mH
n1 = 252 turns; n2 = 27 turns; n3 = 22 turns

$v_{CE(t1)} < 300$ V (see Fig. 1)

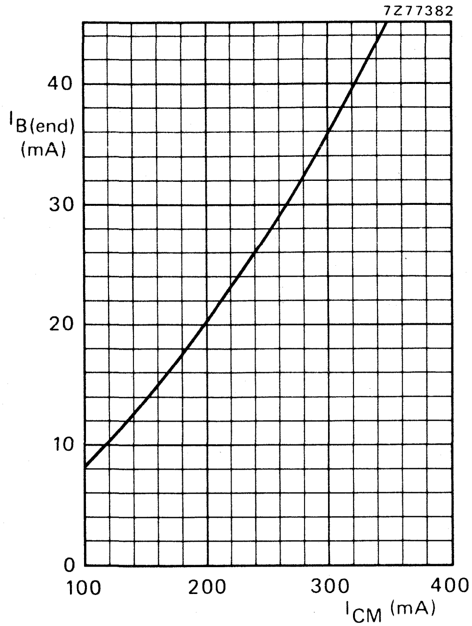


Fig. 3.

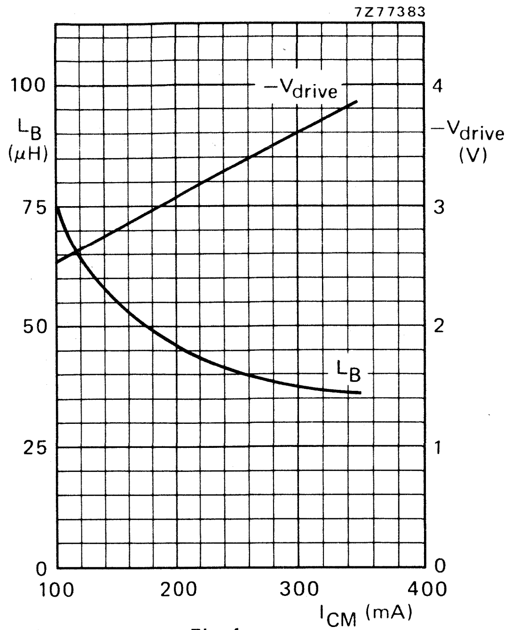


Fig. 4.

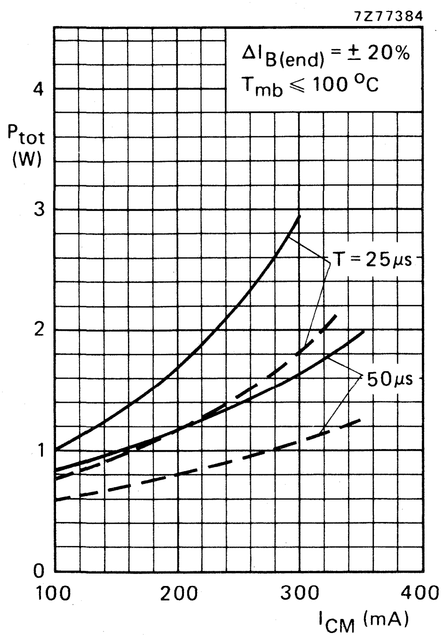


Fig. 5.

Fig. 3 Recommended nominal "end" value of the base current versus maximum peak collector current.

Fig. 4 Minimum required base inductance and recommended negative drive voltage versus maximum peak collector current.

Fig. 5 Maximum total power dissipation of a limit-case transistor if the base current is chosen in accordance with Fig. 3. Solid lines for $I_{C1}/I_{CM} = 0,4$ and dotted lines for $I_{C1}/I_{CM} = 0$.

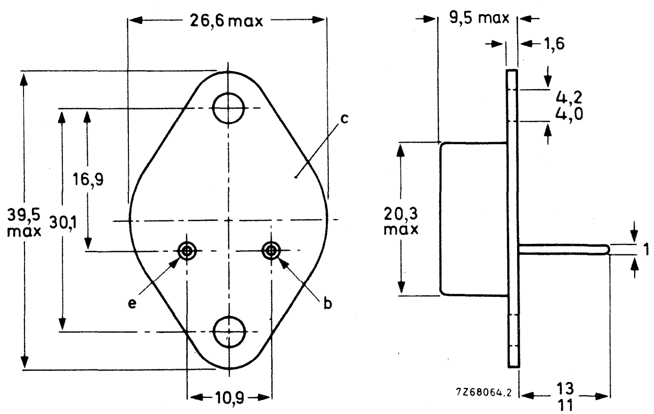
SILICON DIFFUSED POWER TRANSISTOR

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



For mounting instructions and accessories, see section Accessories.

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.

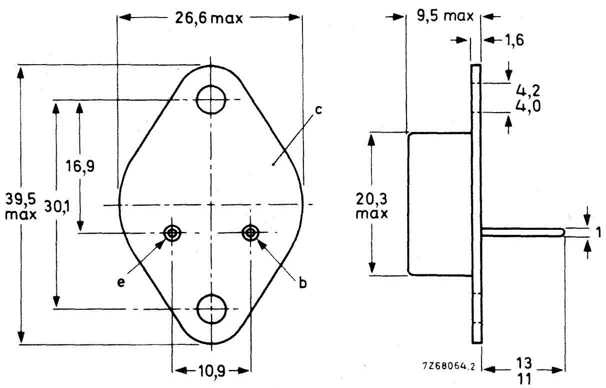
QUICK REFERENCE DATA

			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		A
Total power dissipation up to T_{mb} = 25 °C	P_{tot}	max.	117		W
Junction temperature	T_j	max.	200		°C
D.C. current gain I_C = 3 A; V_{CE} = 4 V: 2N3442 I_C = 2 A; V_{CE} = 4 V: 2N4347	h_{FE}		20 to 70		

MECHANICAL DATA — Dimensions in mm

Collector connected to envelope

TO-3



For mounting instructions and accessories, see section Accessories.

Accessories

GENERAL NOTE ON FLAT HEATSINKS

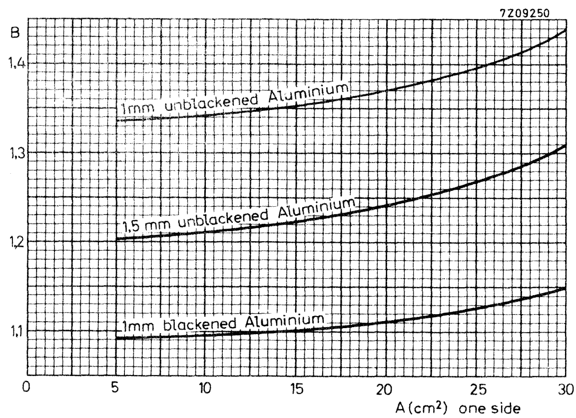
All information on thermal resistances of the accessories combined with flat heatsinks is valid for square heatsinks of 1,5 mm blackened aluminium.
For a few variations the thermal resistance may be derived as follows:

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.



MOUNTING INSTRUCTIONS FOR TO-3 ENVELOPES

GENERAL DATA AND INSTRUCTIONS

Instructions for direct mounting.

Mounting instructions for up to 500 V insulation.
- Using package 56201.
- Using insulating bushes 56261 or 56261a and mica washer 56201d.
- Using insulating bushes 56201c or 56201j and mica washer 56201d.

Mounting instructions for 500 to 2000 V insulation.
- Using package 56351.
- Using mounting support 56352 and mica washer 56339.

Heatsink requirements

Flatness in the mounting area: 0,05 mm per 40 mm

Mounting holes must be deburred.

Mounting torques

Minimum torque (for good heat transfer)	0,4 Nm (4 kgcm)
Maximum torque (to avoid damaging the transistor)	0,6 Nm (6 kgcm)

N.B.: When the driven nut or screw is in direct contact with a toothed lock washer (e.g. Fig. 10), the torques are as follows:

Minimum torque	0,55 Nm (5,5 kgcm)
Maximum torque	0,8 Nm (8 kgcm)

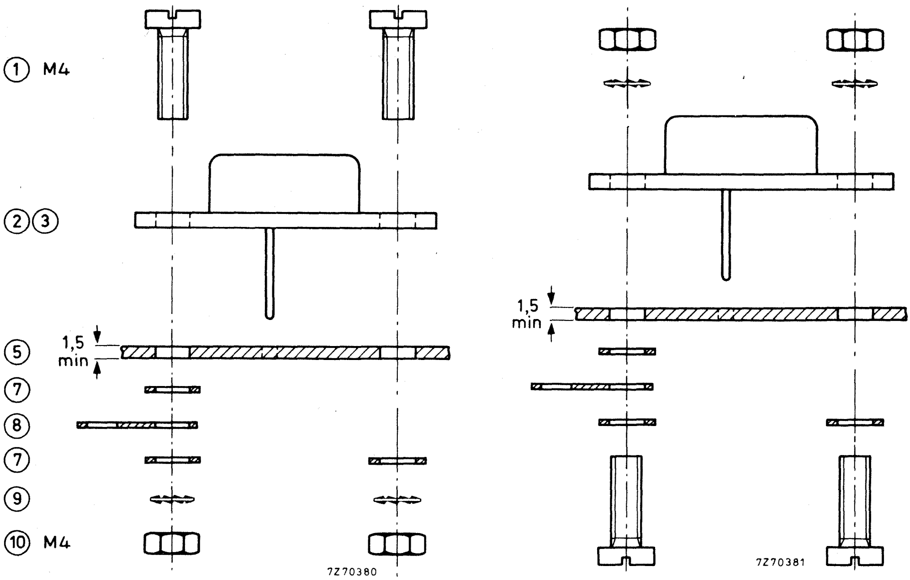
Thermal data

The thermal resistance from mounting base to heatsink ($R_{th\ mb-h}$) can be reduced by applying a heat conducting compound between transistor and heatsink. For insulated mounting the compound should be applied to the bottom of both device and insulator.

		Direct mounting	Insulated mounting		
			500 V mica	2000 V mica	
From mounting base to heatsink					
without heatsink compound	$R_{th\ mb-h}$	0,6	1,0	1,25	$^{o}C/W$
with heatsink compound	$R_{th\ mb-h}$	0,1	0,3	0,5	$^{o}C/W$

INSTRUCTIONS FOR DIRECT MOUNTING

The transistors should be mounted with M4 screws, see Figs 1 and 2. Minimum heatsink thickness (for good heat transfer) 1,5 mm. Hole pattern: Fig. 3.
A heatsink with tapped holes or insert nuts can also be used, but a torque washer is necessary between metal washer and transistor. See Fig. 4.



Figs 1 and 2. Direct mounting with nuts

Legend for all figures:

(1) = screw
(2) = TO-3 thick base (3, 15 mm)
(2)(3) = TO-3 thick or thin base
(3) = TO-3 thin base (1, 6 mm)
(4) = mica
(5) = heatsink
(6) = insulating bush
(7) = metal washer
(8) = soldering tag
(9) = lock washer
(10) = nut
(11) = tapped hole
(12) = insert nut
Dimensions in mm

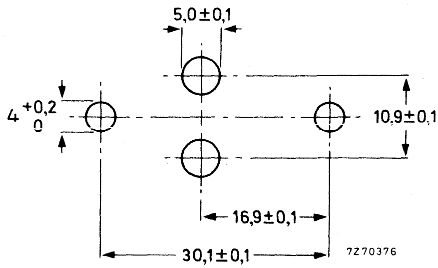


Fig. 3. Hole pattern for direct mounting with nuts

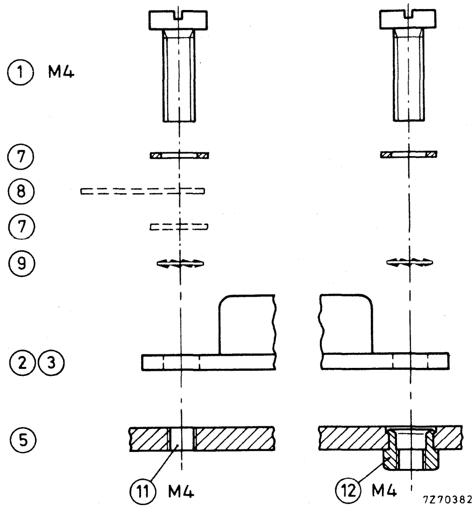


Fig. 4 Direct mounting with tapped holes or insert nuts.

MOUNTING INSTRUCTIONS FOR UP TO 500 V INSULATION

Using package 56201

For the component arrangement with minimum heatsink thickness see Figs 5 and 6. For hole pattern and shape of holes see Figs 7 and 8.

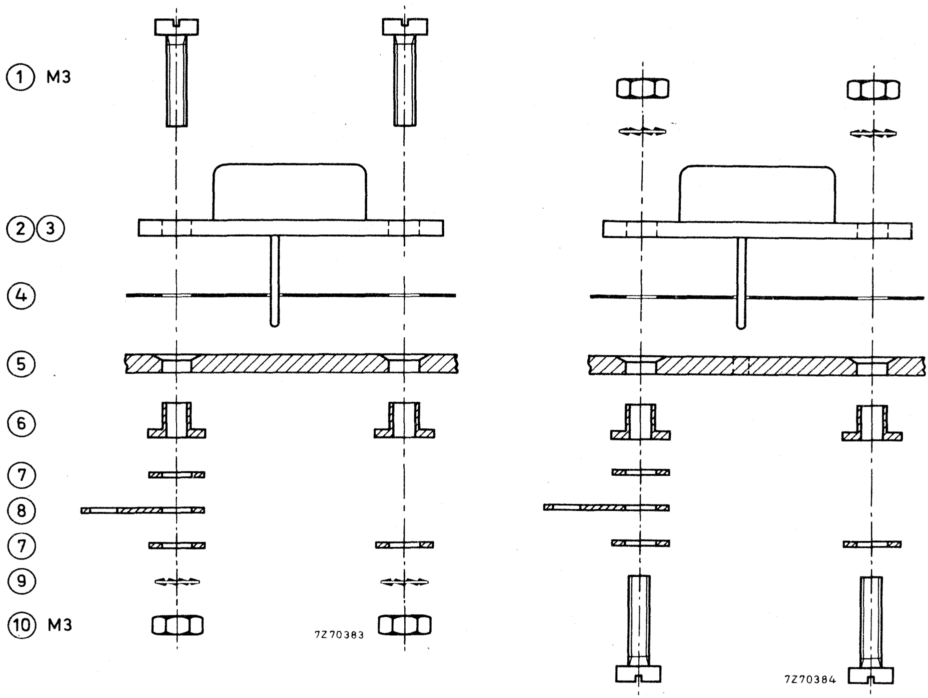
Using insulating bushes 56261 and mica washer 56201d

For an arrangement with M3 screws and nuts see Fig. 9, mounting holes are given in Figs 7 and 8. The accessories can also be used in combination with M3 screws and heatsinks provided with tapped holes or insert nuts. Lock washers are necessary between screw-head and metal washer, see Fig. 10. For an assembly drawing with tapped holes see Fig. 11, with insert nuts see Fig. 12.

Using insulating bushes 56201c and mica washer 56201d

They are suitable for the same arrangement with M3 nuts as package 56201; can also be used for thin-base transistors on a 2,5 mm heatsink provided with M3 insert nuts in an arrangement like Figs 10 and 12.

MOUNTING INSTRUCTIONS FOR UP TO 500 V INSULATION (continued)



Figs 5 and 6. Insulated mounting (500 V) with package 56201

Heatsink thickness: 1,5 to 2,5 mm for thick-base TO-3
2 to 2,5 mm for thin-base TO-3

For legend see page 2.

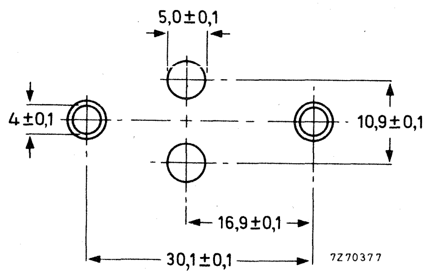


Fig. 7. Hole pattern for 500 V insulation, nut fastening

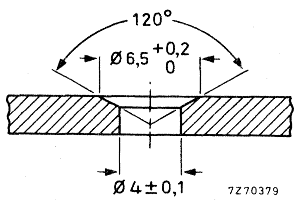


Fig. 8. Shape of hole for 500 V insulation, nut fastening

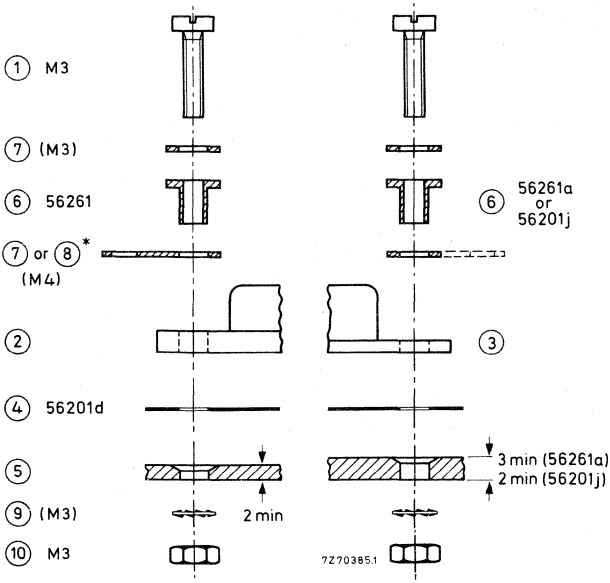


Fig. 9 Insulated mounting (500 V) with nuts.

For legend see page 2.

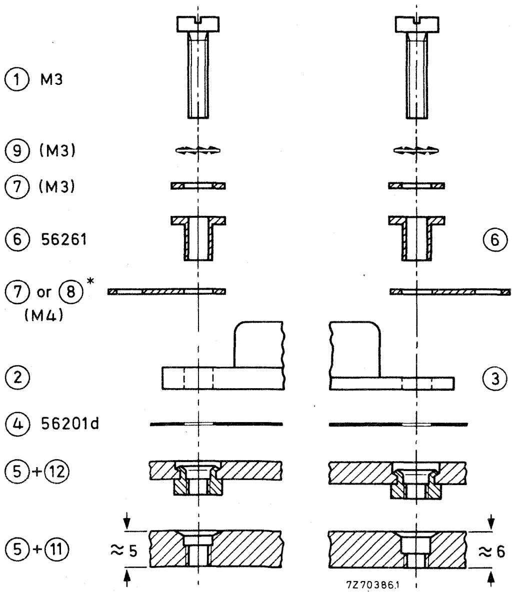


Fig. 10 Insulated mounting (500 V) with tapped holes or insert nuts.

* Thickness approximately 0,6 mm, outer diameter 7,5 mm.

MOUNTING INSTRUCTIONS FOR UP TO 500 V INSULATION (continued)

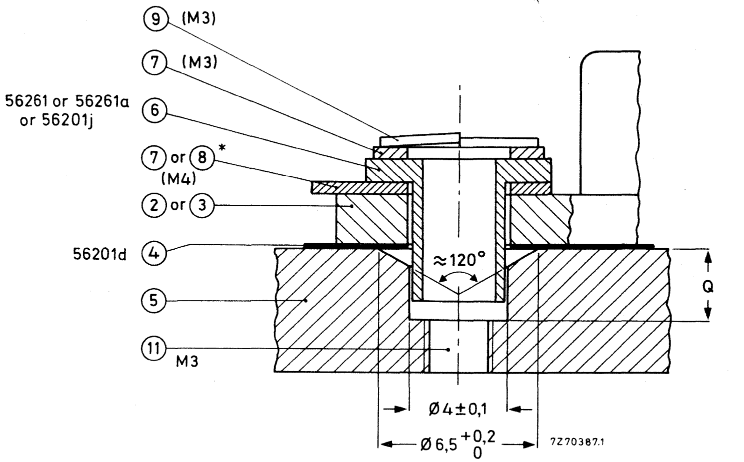


Fig. 11 Assembly (partial) for Fig. 10 – tapped holes.
Q minimum 2 mm for thick-base TO-3 (with 56261).
Q minimum 3 mm for thin-base TO-3 (with 56261a).
Q minimum 2 mm for thin-base TO-3 (with 56261j).

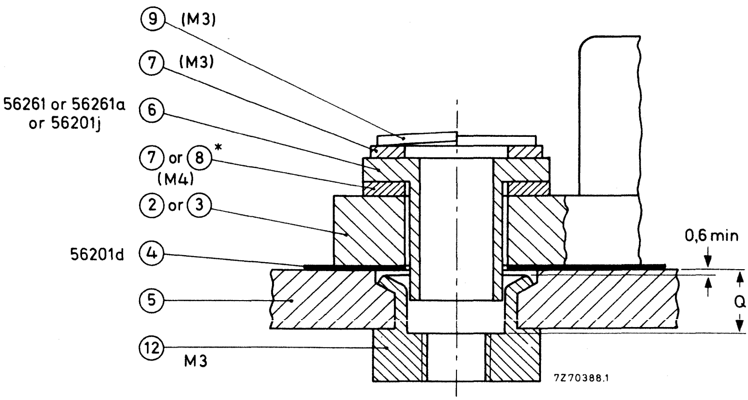


Fig. 12 Assembly (partial) for Fig. 10 – insert nuts and thick-base TO-3.
Q minimum 2 mm for thick-base TO-3 (with 56261).
Q minimum 3 mm for thin-base TO-3 (with 56261a).
Q minimum 2 mm for thin-base TO-3 (with 56261j).

* Thickness approximately 0,6 mm, outer diameter 7,5 mm.

Legend for all figures:

(1)	screw.
(2)	TO-3 thick base (3,15 mm).
(2) (3)	TO-3 thick or thin base.
(3)	TO-3 thin base (1,6 mm).
(4)	mica.
(5)	heatsink.
(6)	insulating bush.
(7)	metal washer.
(8)	soldering tag.
(9)	lock washer.
(10)	nut.
(11)	tapped hole.
(12)	insert nut.

Dimensions in mm

MOUNTING INSTRUCTIONS FOR 500 V TO 2000 V INSULATION (Thick-base TO-3 only)

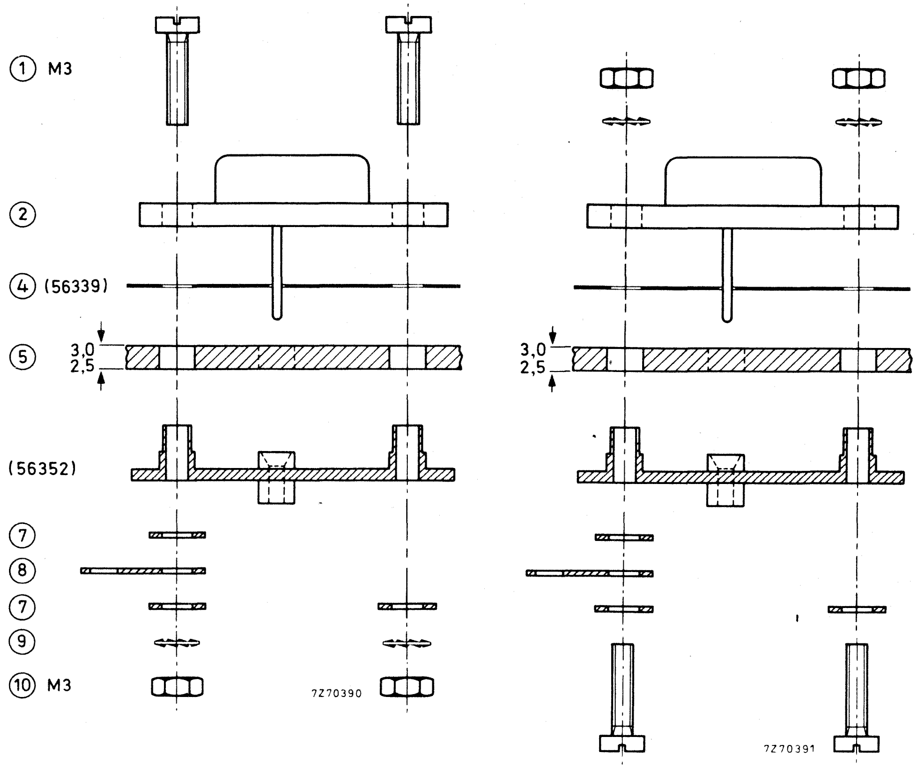
Using package 56351

The transistor should be mounted with M3 screws. For component arrangement see Figs 13 and 14. For hole pattern see Fig. 15. Thickness of heatsink 2,5 mm to 3 mm.

Using mounting support 56352 and mica washer 56339

The same figures apply as for package **56351.**

MOUNTING INSTRUCTIONS FOR 500 V TO 2000 V INSULATION (continued)



Figs 13 and 14 Insulated mounting (500 V – 2000 V, thick-base TO-3) with package **56351** or separate mica **56339** and mounting support **56352.**

For legend see page 2 or 7.

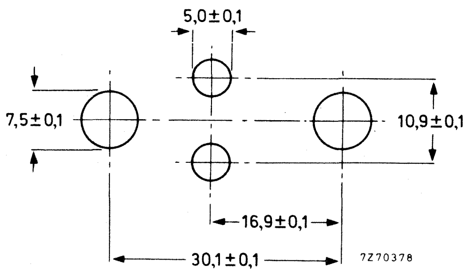


Fig. 15 Hole pattern for Figs 13 and 14.

MOUNTING INSTRUCTIONS FOR TO-220 ENVELOPES

GENERAL DATA AND INSTRUCTIONS

General rules

1. First fasten the devices to the heatsink before soldering the leads.
2. Avoid axial stress to the leads.
3. Keep mounting tool (e.g. screwdriver) clear of the plastic body.
4. The rectangular washer may only touch the plastic part of the body; it should not exert any force on that part (screw mounting).

Heatsink requirements

Flatness in the mounting area: 0,02 mm maximum per 10 mm.
Mounting holes must be deburred, see further mounting instructions.

Heatsink compound

Values of the thermal resistance from mounting base to heatsink ($R_{th\ mb\text{-}h}$) given for mounting with heatsink compound refer to the use of a metallic oxide-loaded compound. Ordinary silicone grease is not recommended.

For insulated mounting, the compound should be applied to the bottom of both device and insulator.

Mounting methods for power transistors

1. Clip mounting

   Mounting by means of spring clip offers:

   a. A good thermal contact under the crystal area, and slightly lower $R_{th\ mb\text{-}h}$ values than screw mounting.
   b. Safe insulation for mains operation.

2. M3 screw mounting

   It is recommended that the rectangular spacing washer is inserted between screw head and mounting tab.

   Mounting torque for screw mounting:

   (For thread-forming screws these are final values. Do not use self-tapping screws.)

Minimum torque (for good heat transfer)	0,55 Nm (5,5 kgcm)
Maximum torque (to avoid damaging the device)	0,80 Nm (8,0 kgcm)

N.B.: When a nut or screw is not driven direct against a curved spring washer or lock washer (not for thread-forming screw), the torques are as follows:

Minimum torque (for good heat transfer)	0,4 Nm (4 kgcm)
Maximum torque (to avoid damaging the device)	0,6 Nm (6 kgcm)

N.B.: Data on accessories are given in separate data sheets.

3. Rivet mounting non-insulated

The device should not be pop-rivetted to the heatsink. However, it is permissible to press-rivet providing that eyelet rivets of soft material are used, and the press forces are slowly and carefully controlled so as to avoid shock and deformation of either heatsink or mounting tab.

Thermal data

			clip mounting	screw mounting	
From mounting base to heatsink					
with heatsink compound, direct mounting	$R_{th\ mb\text{-}h}$	=	0,3	0,5	°C/W
without heatsink compound, direct mounting	$R_{th\ mb\text{-}h}$	=	1,4	1,4	°C/W
with heatsink compound and 0,1 mm maximum mica washer	$R_{th\ mb\text{-}h}$	=	2,2	–	°C/W
with heatsink compound and 0,25 mm maximum alumina insulator	$R_{th\ mb\text{-}h}$	=	0,8	–	°C/W
with heatsink compound and 0,05 mm mica washer					
insulated up to 500 V	$R_{th\ mb\text{-}h}$	=	–	1,4	°C/W
insulated up to 800 V/1000 V	$R_{th\ mb\text{-}h}$	=	–	1,6	°C/W
without heatsink compound and 0,05 mm mica washer					
insulated up to 500 V	$R_{th\ mb\text{-}h}$	=	–	3,0	°C/W
insulated up to 800 V/1000 V	$R_{th\ mb\text{-}h}$	=	–	4,5	°C/W

Lead bending

Maximum permissible tensile force on the body, for 5 seconds is 20 N (2 kgf).

The leads can be bent through 90° maximum, twisted or straightened. To keep forces within the above-mentioned limits, the leads are generally clamped near the body, using pliers. The leads should neither be bent nor twisted less than 2,4 mm from the body.

Soldering

Lead soldering temperature at > 3 mm from the body; $t_{sld} < 5$ s:

Devices with $T_{j\ max} \leq 175$ °C, soldering temperature $T_{sld\ max} = 275$ °C.
Devices with $T_{j\ max} \leq 110$ °C, soldering temperature $T_{sld\ max} = 240$ °C.

Avoid any force on body and leads during or after soldering: do not correct the position of the device or of its leads after soldering.

It is not permitted to solder the metal tab of the device to a heatsink, otherwise its junction temperature rating will be exceeded.

INSTRUCTIONS FOR CLIP MOUNTING

Direct mounting with clip 56363

1. Place the device on the heatsink, applying heatsink compound to the mounting base.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10^{o} to 30^{o} to the vertical (see Figs 1 and 2).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab (see Fig. 2a).

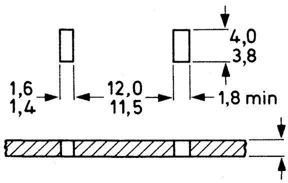


Fig. 1 Heatsink requirements.

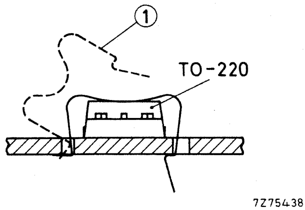


Fig. 2 Mounting.
(1) spring clip.

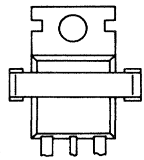


Fig. 2a Position of transistor (top view).

Insulated mounting with clip 56364

With the insulators 56367 or 56369 insulation up to 2 kV is obtained.

1. Place the device with the insulator on the heatsink, applying heatsink compound to the bottom of both device and insulator.
2. Push the short end of the clip into the narrow slot in the heatsink with the clip at an angle of 10^{o} to 30^{o} to the vertical (see Figs 3 and 4).
3. Push down the clip over the device until the long end of the clip snaps into the wide slot in the heatsink. The clip should bear on the plastic body, not on the tab. There should be minimum 3 mm distance between the device and the edge of the insulator for adequate creepage.

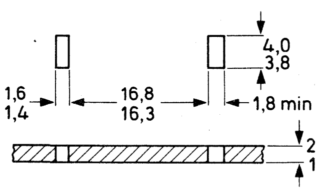


Fig. 3 Heatsink requirements.

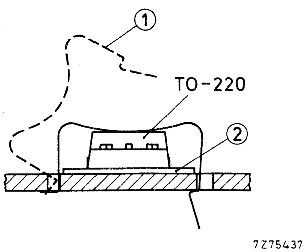


Fig. 4 Mounting.
(1) spring clip.
(2) insulator 56369 or 56367.

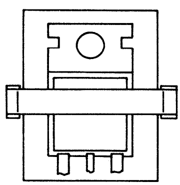


Fig. 4a Position of transistor (top view).

INSTRUCTIONS FOR SCREW MOUNTING

Dimensions in mm

Direct mounting with screw and spacing washer

- *through heatsink with nut*

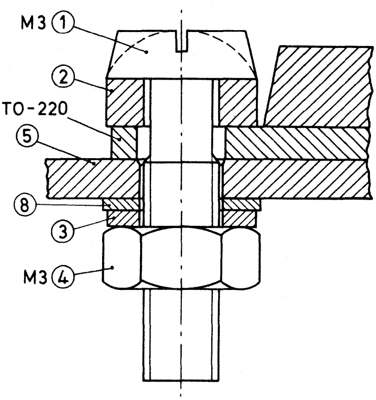


Fig. 5 Assembly.

(1) M3 screw.
(2) rectangular washer.
(3) toothed lock washer.
(4) M3 nut.
(5) heatsink.
(6) plain washer.

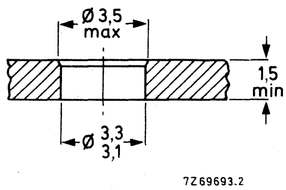


Fig. 6 Heatsink requirements.

(1) to (4) + (8) = **package 56360.**
(2) alone = **56360a.**

- *into tapped heatsink*

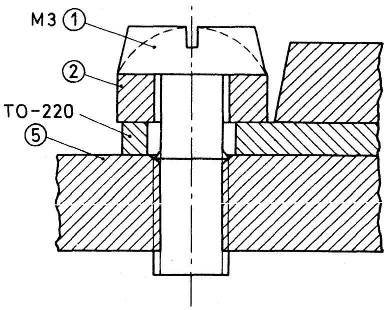


Fig. 7 Assembly.

(1) M3 screw.
(2) rectangular washer 56360a.
(5) heatsink.

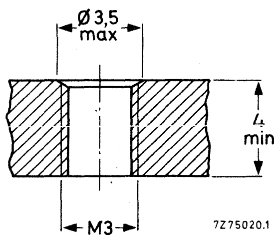


Fig. 8 Heatsink requirements.

Insulated mounting with screw and spacing washer (not recommended where mounting tab is on mains voltage)

- *through heatsink with nut*

Dimensions in mm

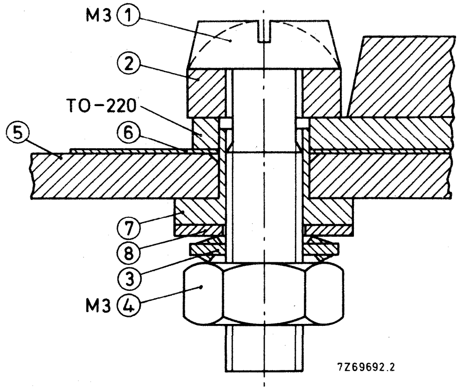


Fig. 9 Assembly.

(1) M3 screw.
(2) rectangular washer.
(3) toothed lock washer.
(4) M3 nut.
(5) heatsink.
(6) mica insulator.
(7) insulating bush.
(8) plain washer.

(1) to (4) + (8) = **package 56360.**
(6) + (7) = **package 56359.**

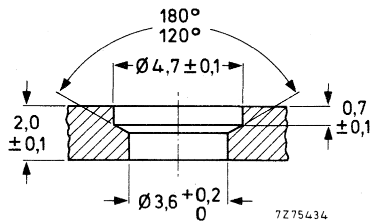


Fig. 10 Heatsink requirements for 500 V insulation.

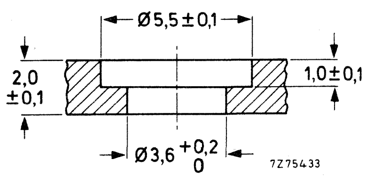


Fig. 11 Heatsink requirements for 800 V insulation.

- *into tapped heatsink*

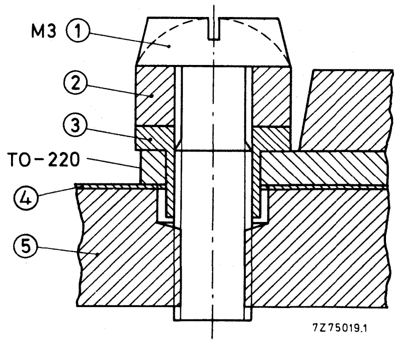


Fig. 12 Assembly.

(1) M3 screw.
(2) rectangular washer.
(3) rectangular insulation bush.
(4) mica insulator.
(5) heatsink.

(2) to (4) = **package 56359a.**

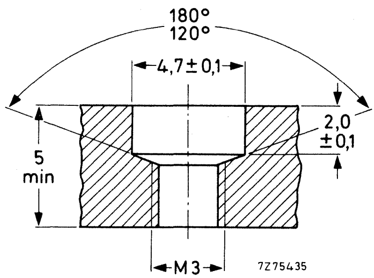


Fig. 13 Heatsink requirements for 500 V insulation.

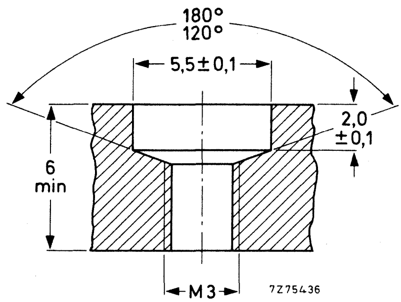
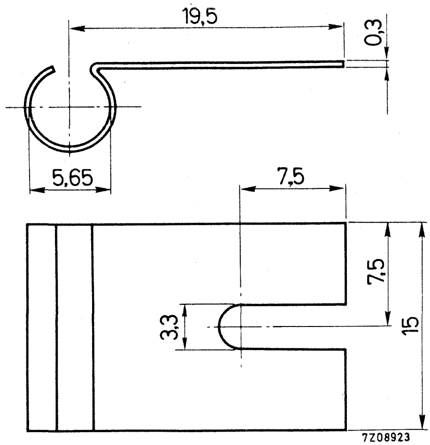


Fig. 14 Heatsink requirements for 1000 V insulation.

COOLING FIN

MECHANICAL DATA

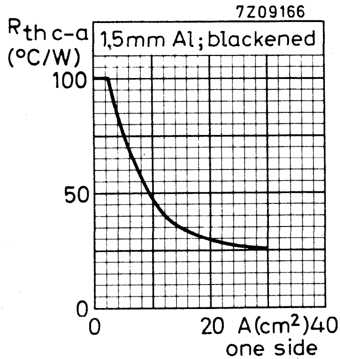
Dimensions in mm



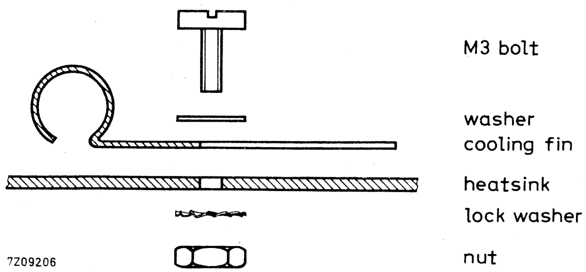
Material:
brass, nickel plated

THERMAL RESISTANCE

From case to ambient with cooling fin only	$R_{th\ c-a}$	=	100	°C/W
with heatsink	see graph			



MOUNTING INSTRUCTIONS



Torque on nut for good heat transfer: 0,5 Nm (5 kgcm)

MOUNTING ACCESSORIES

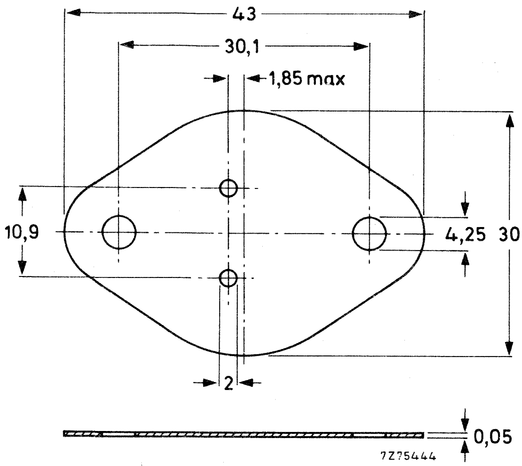
Mounting accessories for insulated mounting (up to 500 V) of **TO-3** envelopes; the package consists of:

- 1 mica washer
- 2 insulating bushes
- 2 cheese-head screws (M3)
- 3 plain metal washers
- 1 soldering tag
- 2 lock washers
- 2 hexagon nuts (M3)

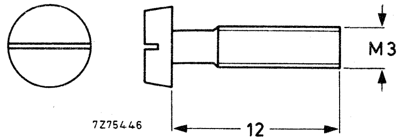
Mounting instructions with R_{th} values are given separately.

MECHANICAL DATA

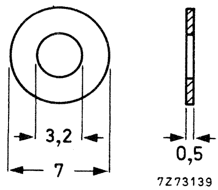
Dimensions in mm



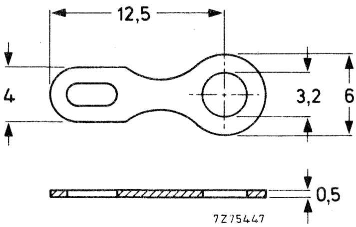
1 mica washer.



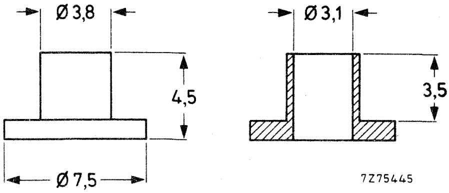
2 cheese-head screws, slotted;
material: brass, nickel plated.



3 plain washers;
material: brass, nickel plated.



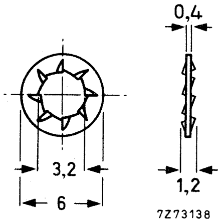
1 soldering tag.



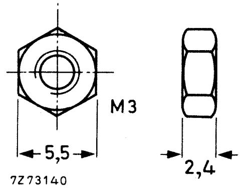
2 insulating bushes.

MECHANICAL DATA of package **56201** (continued)

Dimensions in mm



2 lock washers, internal teeth;
material: steel, nickel plated.



2 hexagon nuts;
material: brass, nickel plated.

TEMPERATURE

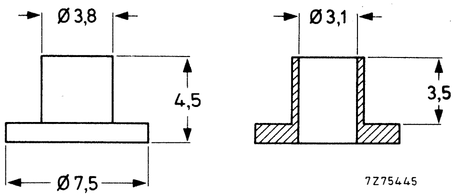
Maximum permissible temperature T_{max} 150 °C

56201c 2 INSULATING BUSHES

Two insulating bushes for up to 500 V insulation of **TO-3** envelopes.

MECHANICAL DATA

Dimensions in mm



TEMPERATURE

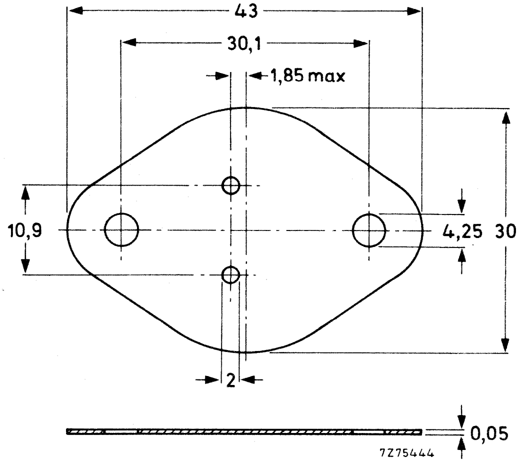
Maximum permissible temperature T_{max} 150 °C

56201d MICA WASHER

Mica washer for up to 500 V insulation of **TO-3** envelopes.

MECHANICAL DATA

Dimensions in mm



TEMPERATURE

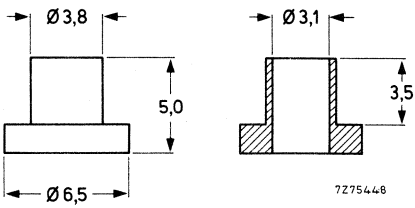
Maximum permissible temperature T_{max} 150 °C

56201j 2 INSULATING BUSHES ←

Two insulating bushes for up to 500 V insulation of **TO-3** envelopes.

MECHANICAL DATA

Dimensions in mm



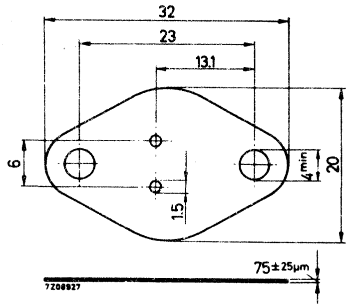
TEMPERATURE

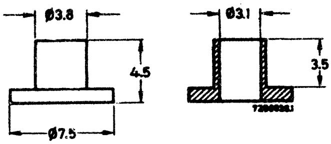
Maximum permissible temperature T_{max} 150 °C

MICA WASHER AND 2 INSULATING BUSHES

MECHANICAL DATA

Dimensions in mm





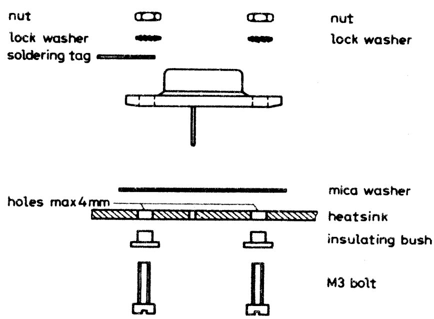
THERMAL RESISTANCE

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.

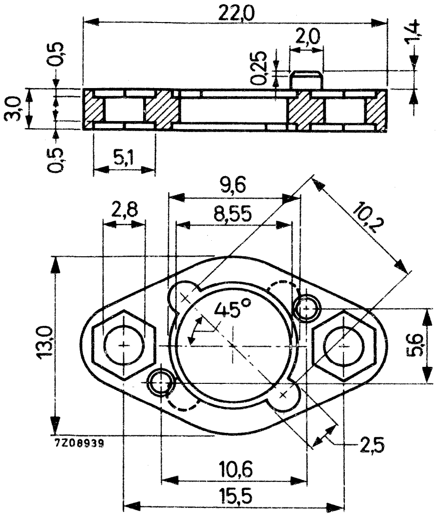
MOUNTING ACCESSORIES

Mounting accessories for TO-5 envelopes. The package consists of:

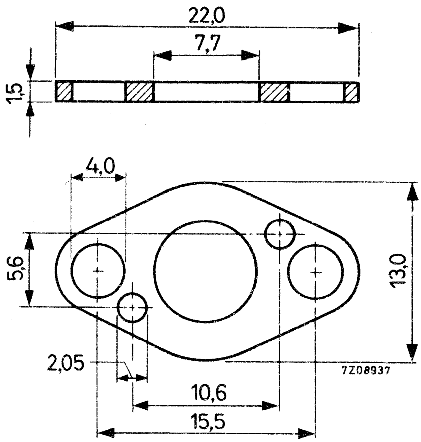
1 top clamping piece
1 bottom clamping piece
1 mylar insulator

MECHANICAL DATA

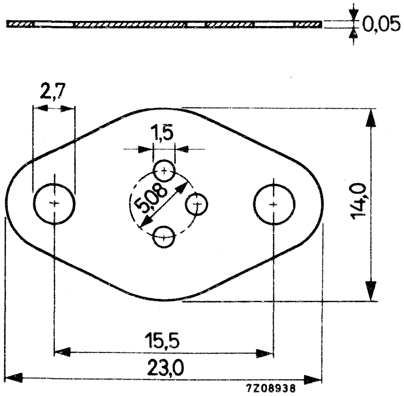
Dimensions in mm



top clamping piece
of insulating material



bottom clamping piece
material: brass, tin-plated



mylar insulator

THERMAL RESISTANCE

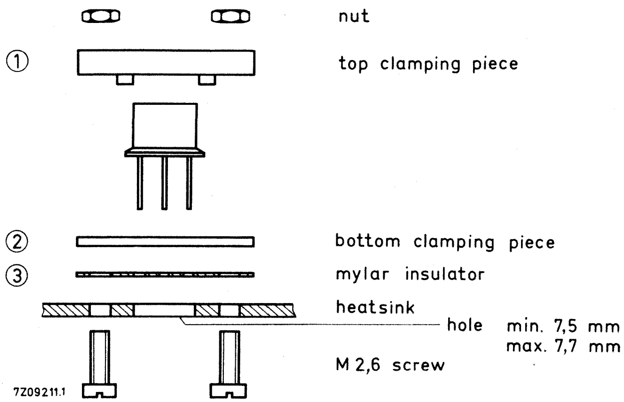
From mounting base to heatsink direct mounting	$R_{th\ mb\text{-}h}$	=	3	$^oC/W$
insulated mounting	$R_{th\ mb\text{-}h}$	=	6	$^oC/W$

TEMPERATURE

Maximum permissible temperature	T_{max}	=	100	^oC

MOUNTING INSTRUCTIONS

Insulated mounting:



Direct mounting: without items 2 and 3; item 1 to be mounted upside-down.

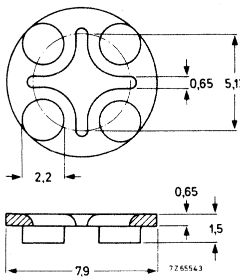
DISTANCE DISCS

MECHANICAL DATA

Dimensions in mm

56245

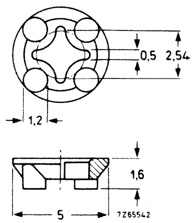
TO-5 or **TO-39**



Insulating material.

56246

TO-18 or **TO-72**



Insulating material.

TEMPERATURE

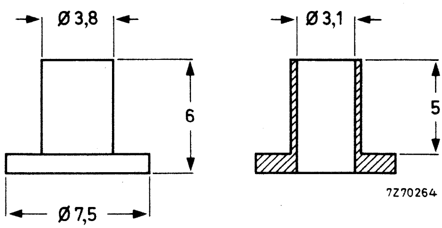
Maximum permissible temperature T_{max} 100 °C

56261 2 INSULATING BUSHES

Two insulating bushes for up to 500 V insulation of **TO-3** envelopes.

MECHANICAL DATA

Dimensions in mm



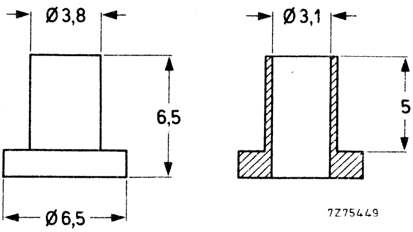
TEMPERATURE

Maximum permissible temperature T_{max} 150 °C

→ 56261a 2 INSULATING BUSHES

Two insulating bushes for up to 500 V insulation of **TO-3** envelopes.

MECHANICAL DATA Dimensions in mm



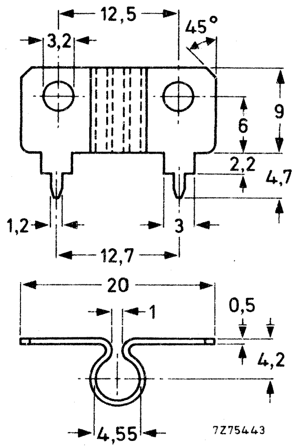
TEMPERATURE

Maximum permissible temperature T_{max} 150 °C

56263 COOLING FIN

→ Cooling fin for **TO-18** or **TO-72** envelopes.

MECHANICAL DATA Dimensions in mm



Material: copper, tin plated.

THERMAL RESISTANCE

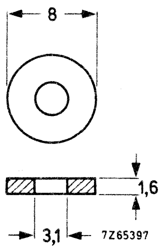
From case to ambient $R_{th\ c\text{-}a}$ = 100 °C/W

WASHER

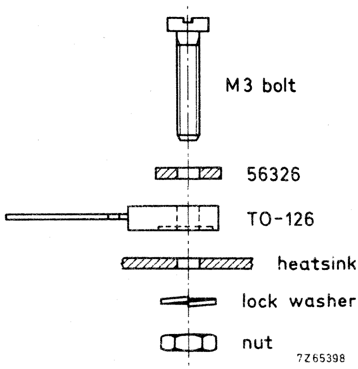
Flat metal washer for direct mounting of envelope SOT-32 (TO-126).

MECHANICAL DATA

Dimensions in mm



MOUNTING INSTRUCTIONS



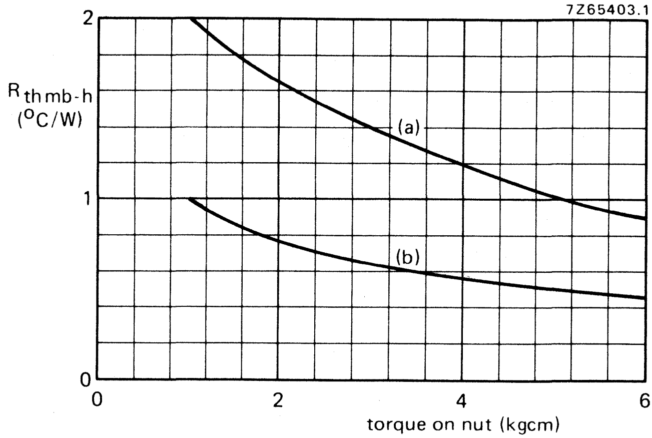
Minimum torque on nut for good heat transfer	(0,4 Nm) 4 kgcm
Maximum torque on nut	(0,6 Nm) 6 kgcm
Minimum thickness of heatsink	2 mm

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° tolerance (for M3 thread).
For mounting on a heatsink the use of a heatsink compound is recommended.

→ **THERMAL RESISTANCE** (see also the graph)

From mounting base to heatsink

without heatsink compound (a)	$R_{th\ mb\text{-}h}$	=	1,0 °C/W
with heatsink compound (b)	$R_{th\ mb\text{-}h}$	=	0,5 °C/W

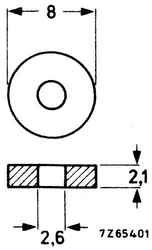


MOUNTING ACCESSORIES

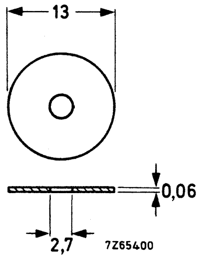
Mounting accessories for insulated mounting of envelope SOT-32 (TO-126); the set consists of a metal washer, a mica washer and an insulating bush.

MECHANICAL DATA

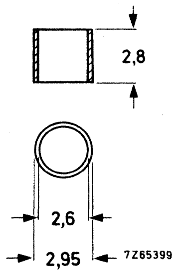
Dimensions in mm



Metal washer

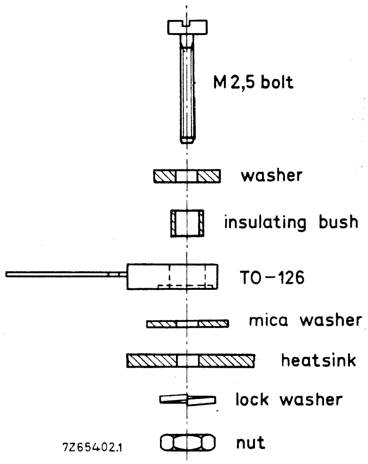


Mica washer



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

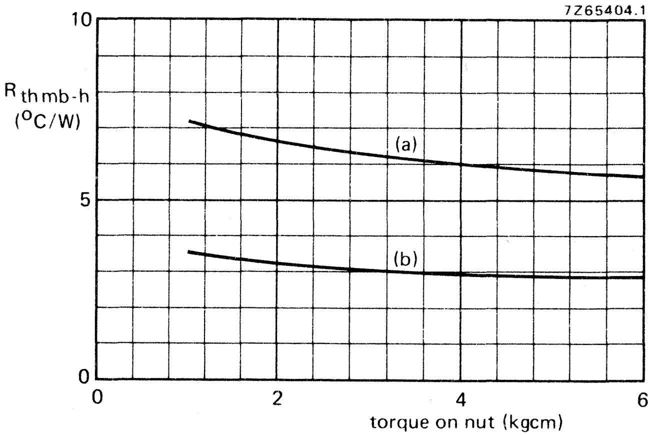
MOUNTING INSTRUCTIONS (continued)

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° tolerance (for M2, 5 thread). For good heat transfer the use of a metallic heatsink compound is recommended and should be applied to the bottom of both device and insulator.

THERMAL RESISTANCE (see also the graph)

From mounting base to heatsink

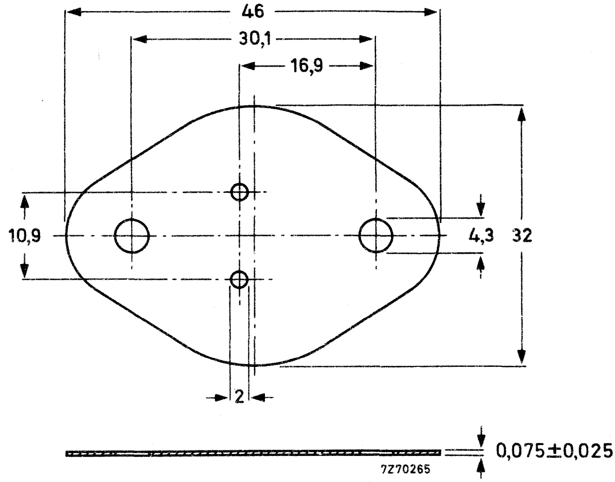
without heatsink compound (a)	$R_{th\ mb\text{-}h}$	= 6 °C/W
with heatsink compound (b)	$R_{th\ mb\text{-}h}$	= 3 °C/W



MICA WASHER

Mica washer for 500 to 2000 V insulation of TO-3 envelopes, for which it should be combined with mounting support 56352.
Mounting instructions are given in a previous section.

MECHANICAL DATA Dimensions in mm



TEMPERATURE

Maximum allowable temperature	T_{max}	150	^{o}C

THERMAL RESISTANCE

From mounting base to heatsink			
without heat conducting compound	$R_{th\ mb-h}$	1,25	$^{o}C/W$
with heat conducting compound	$R_{th\ mb-h}$	0,5	$^{o}C/W$

MOUNTING ACCESSORIES

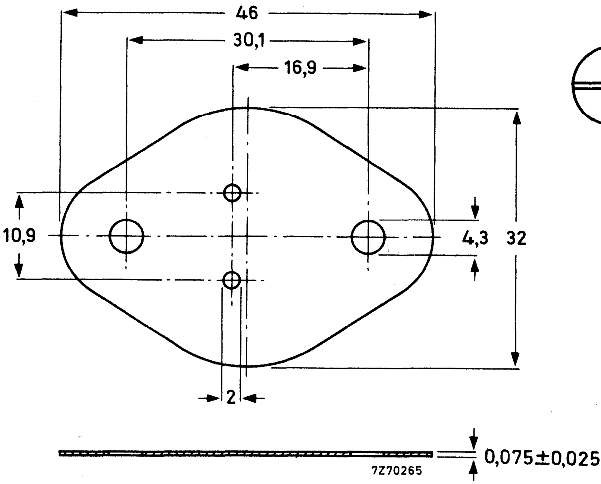
Mounting accessories for insulated mounting - 500 to 2000 V - of TO-3 thick-base envelopes; the package consists of

1 mica washer
1 mounting support
2 cheese head screws (M3)
3 plain metal washers
1 soldering tag
2 lock washers
2 hexagon nuts (M3)

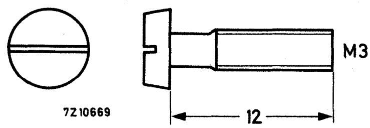
Mounting instructions are given in a previous section.

MECHANICAL DATA

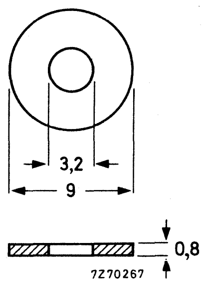
Dimensions in mm



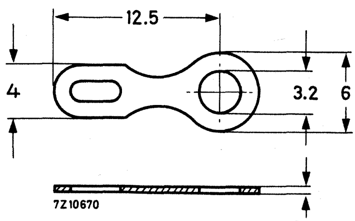
1 mica washer



2 cheese head screws, slotted;
material: brass, nickel plated

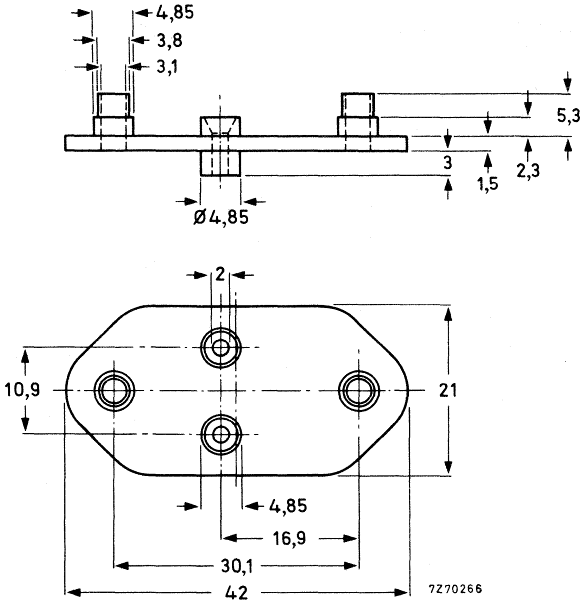


3 plain washers;
material; brass, nickel plated

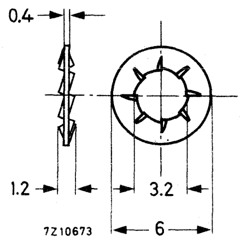


1 soldering tag

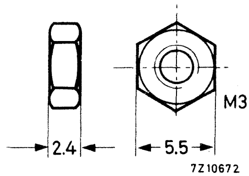
MECHANICAL DATA (continued)



1 mounting support, insulating material



2 lock washers, internal teeth;
material: steel, nickel plated



2 hexagon nuts;
material: brass, nickel plated

TEMPERATURE

Maximum allowable temperature	T_{max}	125	^oC

THERMAL RESISTANCE

From mounting base to heatsink

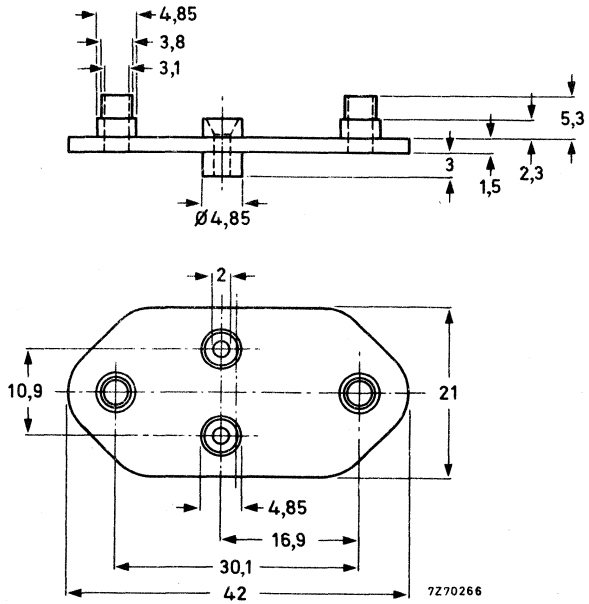
without heat conducting compound	$R_{th\ mb\text{-}h}$ =	1,25	$^oC/W$
with heat conducting compound	$R_{th\ mb\text{-}h}$ =	0,5	$^oC/W$

MOUNTING SUPPORT

Mounting support for 500 to 2000 V insulation of thick-base TO-3 envelopes, for which it should be combined with mica washer 56339.
Mounting instructions are given in a previous section.

MECHANICAL DATA

Dimensions in mm



TEMPERATURE

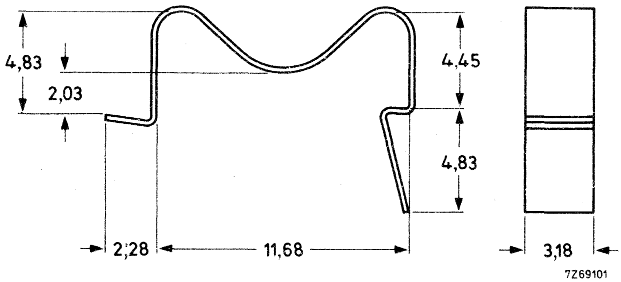
Maximum allowable temperature	T_{max}	125	^{0}C

CLIP AND MICA INSULATOR
FOR SOT-32 AND SOT-82 ENVELOPES

MECHANICAL DATA

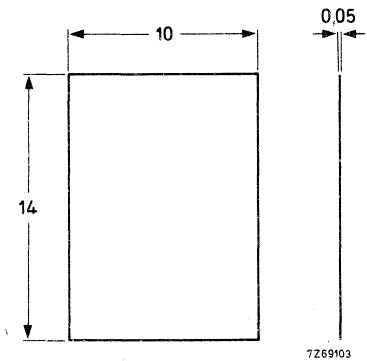
Dimensions in mm

56353



Spring clip suitable for heatsinks of 1,5 to 2 mm.

56354

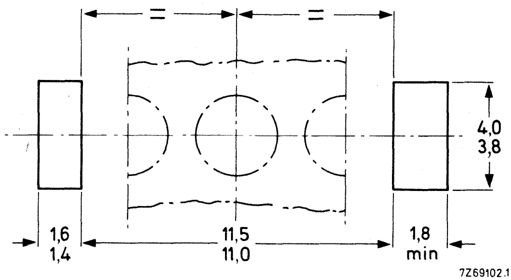


mica insulator.

MOUNTING INSTRUCTIONS

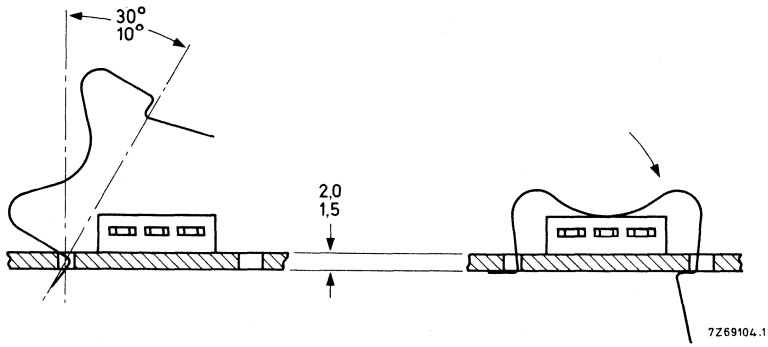
Dimensions in mm

Hole pattern for clip and position of transistor



Mounting

1. Place the transistor (with the mica, if necessary) on the heatsink, applying metallic heatsink compound to the bottom of both device and insulator.
2. Push the short end of the clip into the narrow slot of the heatsink with the clip at an angle of 10° to 30° to the vertical (left figure).
3. Push down the clip over the transistor until the long end of the clip snaps into the wide slot (right figure).



THERMAL RESISTANCE

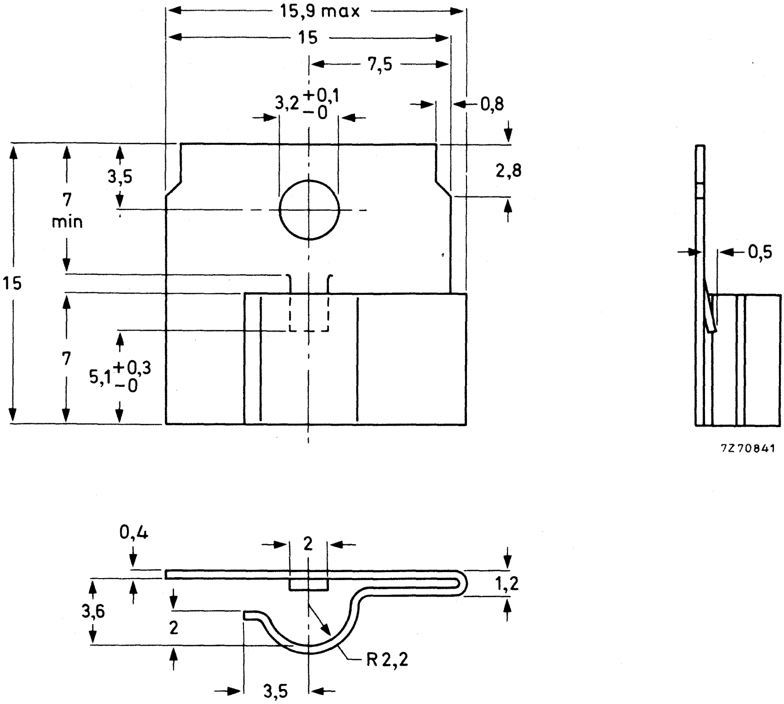
From mounting base to heatsink

			SOT-32	SOT-82	
with heatsink compound, direct mounting	$R_{th\ mb\text{-}h}$	=	1,0	0,4	°C/W
without heatsink compound, direct mounting	$R_{th\ mb\text{-}h}$	=	3,0	2,0	°C/W
with heatsink compound and mica insulator	$R_{th\ mb\text{-}h}$	=	3,0	2,0	°C/W
without heatsink compound and mica insulator	$R_{th\ mb\text{-}h}$	=	6,0	5,0	°C/W

COOLING CLIP FOR TO-92 VARIANT

MECHANICAL DATA

Dimensions in mm



Material: steel, aluminium plated.

THERMAL RESISTANCE

		BC546-BC550 BC556-BC560	BC327, BC328 BC337, BC338	BC368, BC369 BC635 -BC640	
From junction to ambient, with clip					
- in free air	$R_{th\,j-a}$ =	210	150	120	°C/W
- mounted on p.c. board with 1 cm^2 collector pad; lead length 4 mm	$R_{th\,j-a}$ =	195	135	105	°C/W

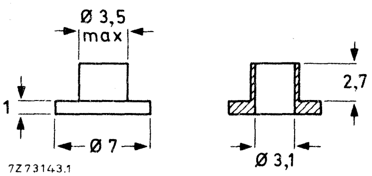
MOUNTING ACCESSORIES

→ Mounting accessories for insulated screw mounting (up to 800 V) of **TO-220** envelopes; the package consists of:

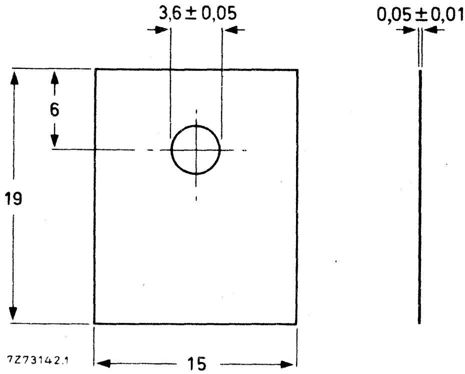
1 insulating bush
1 mica insulator

They should be used in conjunction with package **56360.** Mounting instructions with R_{th} values are given separately.

MECHANICAL DATA Dimensions in mm



insulating bush.



mica insulator.

TEMPERATURE

Maximum permissible temperature of insulating bush T_{max} 150 °C

MOUNTING ACCESSORIES

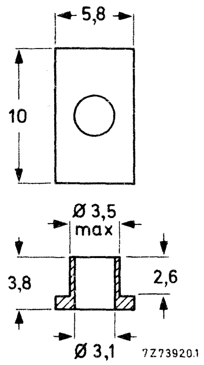
Mounting accessories for insulated screw mounting (up to 1000 V) of **TO-220** envelopes; the package consists of:

1 rectangular insulating bush
1 mica insulator
1 rectangular metal washer

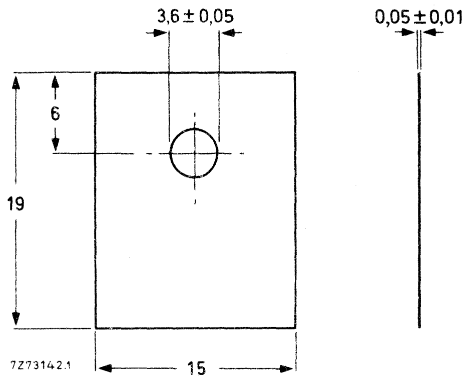
Mounting instructions with R_{th} values are given separately.

MECHANICAL DATA

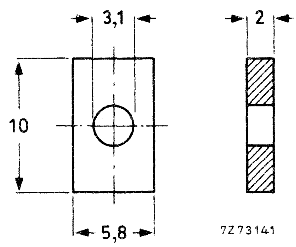
Dimensions in mm



rectangular insulating bush.



mica insulator.



rectangular washer:
material: brass, nickel plated.

TEMPERATURE

Maximum permissible temperature of insulating bush T_{max} 150 °C

56360 MOUNTING ACCESSORIES

Mounting accessories for direct mounting of **TO-220** envelopes; the package consists of:

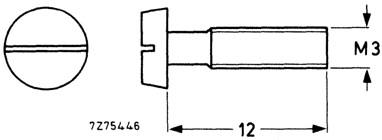
1 cheese-head screw (M3)
1 hexagonal nut (M3)
1 rectangular washer
1 plain washer
1 lock washer

→ Mounting instructions with R_{th} values are given separately.

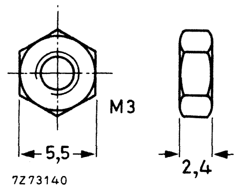
MECHANICAL DATA

Dimensions in mm

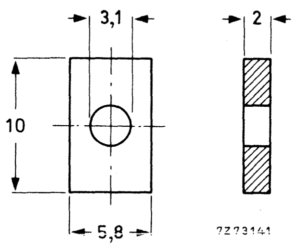
All accessories are nickel plated.



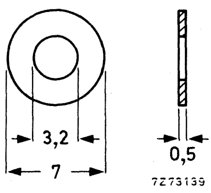
cheese-head screw, slotted;
material: brass.



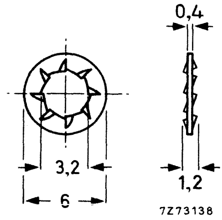
hexagonal nut;
material: brass.



rectangular washer;
material: brass.



plain washer;
material: brass.



lock washer, internal teeth;
material: steel.

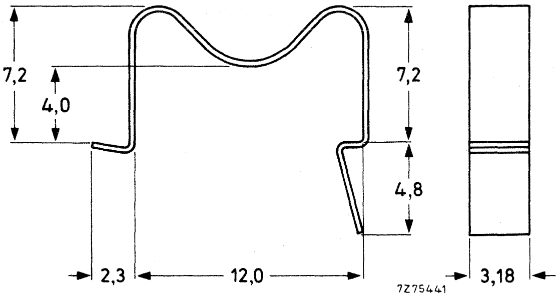
→ 56360a RECTANGULAR WASHER

Rectangular washer from the **56360** package (for separate ordering).

CLIPS AND INSULATOR FOR TO-220 ENVELOPES

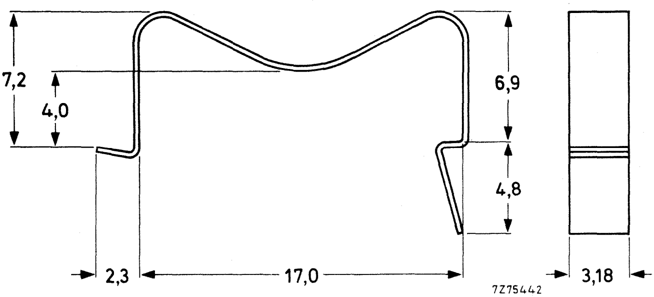
MECHANICAL DATA Dimensions in mm

56363



spring clip for direct mounting on heatsink of 1,0 to 2,0 mm;
material: steel, zinc-chromate passivated.

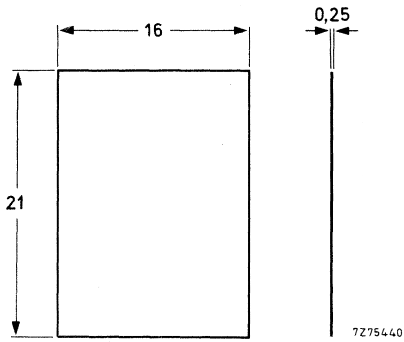
56364



To be used in conjunction with **56367** or **56369.**

spring clip for insulated mounting on heatsink of 1,0 to 2,0 mm;
material: steel, zinc-chromate passivated.

56367



alumina insulator (up to 2 kV) to be used in conjunction with spring clip **56364.**
material: 96-alumina.*

Mounting instructions with R_{th} values are given separately.

* Because alumina is brittle, extreme care must be taken, when mounting devices, not to crack the alumina, particularly when used without heatsink compound.

56368 MOUNTING ACCESSORIES

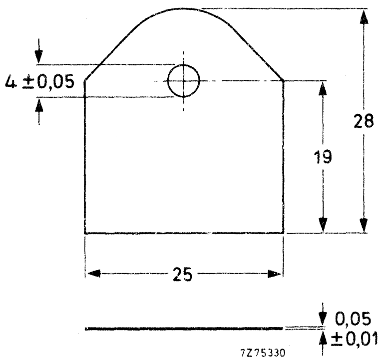
Mounting accessories for insulated mounting (up to 800 V) of the **SOT-93** envelopes; the package consists of:

1 mica insulator
1 insulating bush

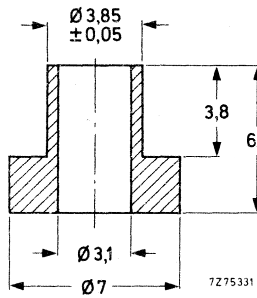
Mounting instructions with R_{th} values are given separately.

MECHANICAL DATA

Dimensions in mm



mica insulator.



insulating bush.

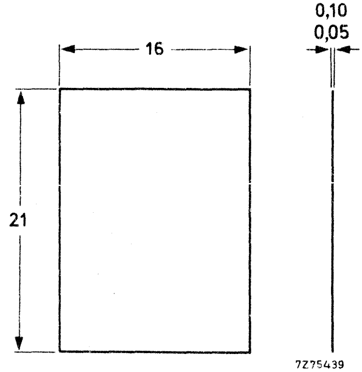
TEMPERATURE

Maximum permissible temperature of insulating bush T_{max} 150 °C

56369 INSULATOR FOR TO-220 ENVELOPES

MECHANICAL DATA

Dimensions in mm



mica insulator (up to 2 kV) to be used in conjunction with spring clip **56364.**

Mounting instructions with R_{th} values are given separately.

INDEX OF TYPE NUMBERS

The inclusion of a type number in this publication does not necessarily imply its availability.

AD = Silicon alloyed diodes
GB = Germanium gold bonded diodes
HF = High-frequency transistors
LF = Low frequency transistors
Mm = Microminiature devices for thick and thin-film circuits
P = Low-frequency power transistors
PC = Germanium point contact diodes
R = Rectifier diodes
Sp = Special diodes
Sw = Switching transistors
T = Tuner diodes
Vrg = Voltage regulator diodes
WD = Silicon whiskerless diodes

INDEX

DT = Dual transistors
FET = Field-effect transistors
LF = Low-frequency transistors
Mm = Microminiature devices for thick and thin-film circuits
P = Low-frequency power transistors
T = Tuner diodes

FET = Field-effect transistors
HF = High-frequency transistors
P = Low-frequency power transistors

FET = Field-effect transistors
HF = High-frequency transistors
Mm = Microminiature devices for thick and thin-film circuits
PDT = Photodiodes or transistors
R = Rectifier diodes
Sw = Switching transistors
Th = Thyristors, diacs
Tra = Transmitting transistors

type no.	part	section	type no.	part	section	type no.	part	section
BT129 series	1a	Th	BUX87	2	P	BYX98 series	1a	R
BTW23 series	1a	Th	BY126	1a	R	BYX99 series	1a	R
BTW24 series	1a	Th	BY127	1a	R	BZV10	1b	Vrf
BTW30 series	1a	Th	BY164	1a	R	BZV11	1b	Vrf
BTW31 series	1a	Th	BY176	1a	R	BZV12	1b	Vrf
BTW32 series	1a	Th	BY179	1a	R	BZV13	1b	Vrf
BTW33 series	1a	Th	BY184	1a	R	BZV14	1b	Vrf
BTW34 series	1a	Tri	BY187	1a	R	BZV15 series	1a	Vrg
BTW38 series	1a	Th	BY188 series	1a	R	BZV38	1b	Vrf
BTW40 series	1a	Th	BY206	1a	R	BZW70 series	1a	TS
BTW42 series	1a	Th	BY207	1a	R	BZW86 series	1a	TS
BTW43 series	1a	Tri	BY208 series	1a	R	BZW91 series	1a	TS
BTW45 series	1a	Th	BY209	1a	R	BZW93 series	1a	TS
BTW47 series	1a	Th	BY223	1a	R	BZX55 series	1b	Vrg
BTW92 series	1a	Th	BY409	1a	R	BZX61 series	1b	Vrg
BTX18 series	1a	Th	BY476	1a	R	BZX70 series	1a	Vrg
BTX94 series	1a	Tri	BYX10	1a	R	BZX75 series	1b	Vrg
BTX95 series	1a	Th	BYX22 series	1a	R	BZX79 series	1b	Vrg
BTY79 series	1a	Th	BYX25 series	1a	R	BZX84 series	4a	Mm
BTY87 series	1a	Th	BYX29 series	1a	R	BZX87 series	1b	Vrg
BTY91 series	1a	Th	BYX30 series	1a	R	BZX90	1b	Vrf
BU105	2	P	BYX32 series	1a	R	BZX91	1b	Vrf
BU108	2	P	BYX35	1a	R	BZX92	1b	Vrf
BU126	2	P	BYX36 series	1a	R	BZX93	1b	Vrf
BU132	2	P	BYX38 series	1a	R	BZY78	1b	Vrf
BU133	2	P	BYX39 series	1a	R	BZY88 series	1b	Vrg
BU204	2	P	BYX42 series	1a	R	BZY91 series	1a	Vrg
BU205	2	P	BYX45 series	1a	R	BZY93 series	1a	Vrg
BU206	2	P	BYX46 series	1a	R	BZY95 series	1a	Vrg
BU207A	2	P	BYX48 series	1a	R	BZY96 series	1a	Vrg
BU208A	2	P	BYX49 series	1a	R	BZZ14	1a	Vrg
BU209A	2	P	BYX50 series	1a	R	BZZ15	1a	Vrg
BU326A	2	P	BYX52 series	1a	R	BZZ16	1a	Vrg
BUX80	2	P	BYX55 series	1a	R	BZZ17	1a	Vrg
BUX81	2	P	BYX56 series	1a	R	BZZ18	1a	Vrg
BUX82	2	P	BYX71 series	1a	R	BZZ19	1a	Vrg
BUX83	2	P	BYX90	1a	R	BZZ20	1a	Vrg
BUX84	2	P	BYX91 series	1a	R	BZZ21	1a	Vrg
BUX85	2	P	BYX96 series	1a	R	BZZ22	1a	Vrg
BUX86	2	P	BYX97 series	1a	R	BZZ23	1a	Vrg

Mm = Microminiature devices for thick and thin-film circuits
P = Low-frequency power transistors
R = Rectifier diodes
Th = Thyristors, diacs
Tri = Triacs
TS = Transient suppressor diodes
Vrf = Voltage reference diodes
Vrg = Voltage regulator diodes

AD = Silicon alloyed diodes
D = Display
GB = Germanium gold bonded diodes
HF = High-frequency transistors
I = Infrared devices
LED = Light emitting diodes
LF = Low-frequency transistors
PC = Germanium point contact diodes
Ph = Photoconductive devices
PhC = Photocouplers
St = Rectifier stacks
Vrf = Voltage reference diodes
Vrg = Voltage regulator diodes
WD = Silicon whiskerless diodes

A = Accessories
DH = Diecast heatsinks
FET = Field-effect transistors
HE = Heatsink extrusions
HF = High-frequency transistors
I = Infrared devices
P = Low-frequency power transistors
Sw = Switching transistors
Tra = Transmitting transistors

MAINTENANCE TYPE LIST

The types listed below are not included in this handbook except for those marked with an asterisk. Detailed information will be supplied on request.

AC127/01	BC308	BCY38	BD266A
AC132/01	BC309	BCY39	BD266B
AD149	BC407	BCY40	BD267
AD161*	BC408	BCY54	BD267A
AD162*	BC409	BCY55*	BD267B
ASZ15*	BC417	BD160	BDX35*
ASZ16*	BC418	BD262	BDX36*
ASZ17*	BC419	BD262A	BDX37*
ASZ18*	BCY30	BD262B	BDY38
BC237	BCY31	BD263	BDY60
BC238	BCY32	BD263A	BDY61
BC239	BCY33	BD263B	BU105
BC307	BCY34	BD266	BU108*
			BU132*

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