Semiconductors and integrated circuits

Part 3 · April 1976

High-frequency transistors

Switching transistors

SEMICONDUCTORS AND INTEGRATED CIRCUITS

Part 3 **April 1976**

DATA HANDBOOK SYSTEM

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

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

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

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

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

December 1972

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

Part 1a	**Transmitting tubes for communication and Tubes for r.f. heating Types PE05/25 ÷ TBW15/125**	December 1975
Part 1b	**Transmitting tubes for communication** **Tubes for r.f. heating** **Amplifier circuit assemblies**	January 1976
Part 2	**Microwave products** Communication magnetrons Magnetrons for microwave heating Klystrons Travelling-wave tubes Diodes Triodes T-R Switches Microwave Semiconductor devices Isolators Circulators	October 1974
Part 3	**Special Quality tubes;** **Miscellaneous devices**	January 1975
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Part 5b	**Camera tubes; Image intensifier tubes**	May 1975
Part 6	**Products for nuclear technology** **Photodiodes** Channel electron multipliers Geiger-Mueller tubes Neutron tubes N.B. Photomultiplier tubes and Photo diodes will be issued in Part 9	July 1975
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SEMICONDUCTORS AND INTEGRATED CIRCUITS (RED SERIES)

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

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Rectifier diodes
Voltage regulator diodes (> 1,5 W)
Transient suppressor diodes
Rectifier stacks
Thyristors
Triacs

Part 1b Diodes — **October 1975**

Small signal germanium diodes
Small signal silicon diodes
Special diodes
Voltage regulator diodes (< 1,5 W)
Voltage reference diodes
Tuner diodes

Part 2 Low-frequency transistors — **December 1975**

Part 3 High-frequency and switching transistors — **April 1976**

Part 4a Special semiconductors — **November 1974**

Transmitting transistors
Microwave devices
Field-effect transistors
Dual transistors
Microminiature devices for thick- and thin-film circuits

Part 4b Devices for optoelectronics — **December 1974**

Photosensitive diodes and transistors
Light emitting diodes
Photocouplers
Infrared sensitive devices
Photoconductive devices

Part 5 Linear integrated circuits — **March 1975**

Part 6 Digital integrated circuits — **April 1974**

DTL (FC family)
CML (GX family)
MOS (FD family)
MOS (FE family)

COMPONENTS AND MATERIALS (GREEN SERIES)

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

Part 1 Functional units, Input/output devices, Peripheral devices — **November 1975**

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- Circuit blocks 40-Series and CSA70
- Counter modules 50-Series
- NORbits 60-Series, 61-Series
- Circuit blocks 90-Series
- Input/output devices
- Hybrid integrated circuits
- Peripheral devices

Part 2a Resistors — **February 1976**

- 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 Capacitors — **April 1976**

- Electrolytic and solid capacitors
- Paper capacitors and film capacitors
- Ceramic capacitors
- Variable capacitors

Part 3 Radio, Audio, Television — **February 1975**

- FM tuners
- Loudspeakers
- Television tuners and aerial input assemblies
- Components for black and white television
- Components for colour television

Part 4a Soft ferrites — **April 1975**

- Ferrites for radio, audio and television
- Beads and chokes
- Ferroxcube potcores and square cores
- Ferroxcube transformer cores

Part 4b Piezoelectric ceramics, Permanent magnet materials — **May 1975**

Part 5 Ferrite core memory products — **July 1975**

- Ferroxcube memory cores
- Matrix planes and stacks
- Core memory systems

Part 6 Electric motors and accessories — **September 1975**

- Small synchronous motors
- Stepper motors
- Miniature direct current motors

Part 7 Circuit blocks — **September 1971**

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

Part 8 Variable mains transformers — **July 1975**

Part 9 Piezoelectric quartz devices — **March 1976**

Part 10 Connectors — **November 1975**

General

Type designation
Rating systems
Letter symbols
SOAR curves

PRO ELECTRON TYPE DESIGNATION CODE

FOR SEMICONDUCTOR DEVICES

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

The type designation consists of:

TWO LETTERS FOLLOWED BY A SERIAL NUMBER

The first letter gives an indication of the material

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

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

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

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

R Compound material as employed in Hall generators and photoconductive cells

---

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

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

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

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

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

The serial number consists of:

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

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

VERSION LETTER

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

TYPE DESIGNATION FOR A RANGE OF SEMICONDUCTOR DEVICES

The type designation of a range of variants of:

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

b) 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

ACCORDING TO I.E.C. PUBLICATION 134

1. DEFINITIONS OF TERMS USED

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

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

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

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

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

Note: Limiting conditions may be either maxima or minima.

1.5 Rating system. The set of principles upon which ratings are established and which determine their interpretation.

Note: The rating system indicates the division of responsibility between the device manufacturer and the circuit designer, with the object of ensuring that the working conditions do not exceed the ratings.

2. ABSOLUTE MAXIMUM RATING SYSTEM

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

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

p.t.o.

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

3. DESIGN MAXIMUM RATING SYSTEM

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

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

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

4. DESIGN CENTRE RATING SYSTEM

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

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

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

NOTE

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

LETTER SYMBOLS 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

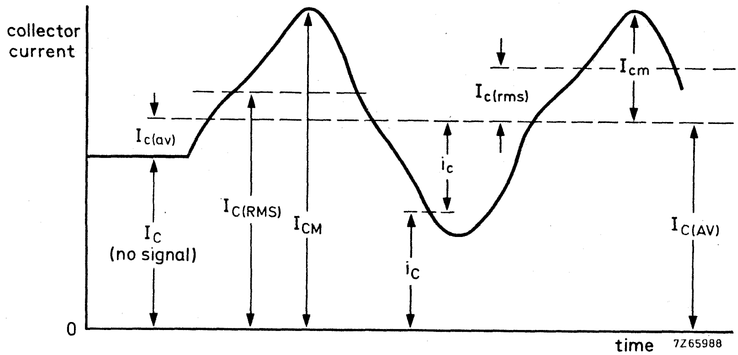
For multiple unit devices, the subscripts are modified by a number preceding the letter subscript; in the case of multiple subscripts, hyphens may be necessary to avoid misunderstanding.

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: $Z_i = R_i + jX_i$

$y_{fe} = g_{fe} + jb_{fe}$

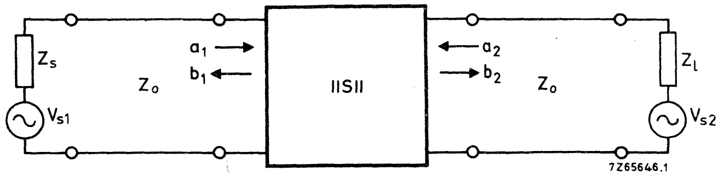
If such symbols do not exist or if they are not suitable, the following notation shall be used:

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

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

SCATTERING PARAMETERS

In distinction to the conventional h, y and z-parameters, s-parameters relate to travelling wave conditions. The figure below shows a two-port network with the incident and reflected waves a_1, b_1, a_2 and b_2.



$$a_1 = \frac{V_{i1}}{\sqrt{Z_o}} \qquad a_2 = \frac{V_{i2}}{\sqrt{Z_o}} \qquad [1]$$

$$b_1 = \frac{V_{r1}}{\sqrt{Z_o}} \qquad b_2 = \frac{V_{r2}}{\sqrt{Z_o}}$$

Z_o = characteristic impedance of the transmission line in which the two-port is connected.

V_i = incident voltage

V_r = reflected (generated) voltage

The four-pole equations for s-parameters are:

$$b_1 = s_{11}a_1 + s_{12}a_2$$

$$b_2 = s_{21}a_1 + s_{22}a_2$$

Using the subscripts i for 11, r for 12, f for 21 and o for 22, it follows that:

$$s_i = s_{11} = \left.\frac{b_1}{a_1}\right|_{a_2 = 0}$$

$$s_r = s_{12} = \left.\frac{b_1}{a_2}\right|_{a_1 = 0}$$

$$s_f = s_{21} = \left.\frac{b_2}{a_1}\right|_{a_2 = 0}$$

$$s_o = s_{22} = \left.\frac{b_2}{a_2}\right|_{a_1 = 0}$$

[1]) The squares of these quantities have the dimension of power.

The s-parameters can be named and expressed as follows:

$s_i = s_{11}$ = Input reflection coefficient.
The complex ratio of the reflected wave and the incident wave at the input, under the conditions $Z_l = Z_o$ and $V_{s2} = 0$.

$s_r = s_{12}$ = Reverse transmission coefficient.
The complex ratio of the generated wave at the input and the incident wave at the output, under the conditions $Z_s = Z_o$ and $V_{s1} = 0$.

$s_f = s_{21}$ = Forward transmission coefficient.
The complex ratio of the generated wave at the output and the incident wave at the input, under the conditions $Z_l = Z_o$ and $V_{s2} = 0$

$s_o = s_{22}$ = Output reflection coefficient.
The complex ratio of the reflected wave and the incident wave at the output, under the conditions $Z_s = Z_o$ and $V_{s1} = 0$.

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^o to the axes.

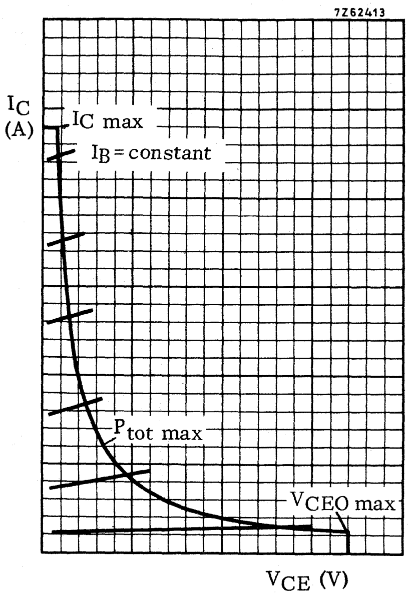


Fig. 1

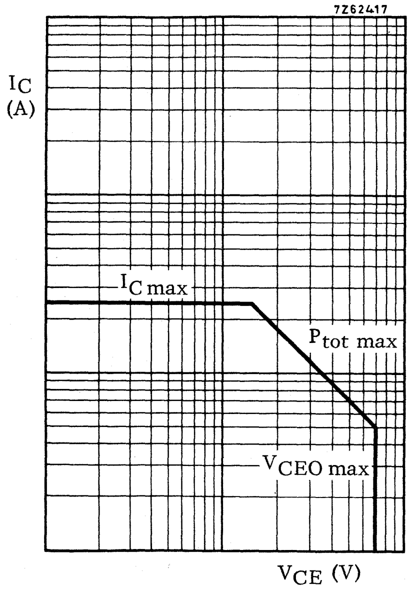


Fig. 2. D.C. SOAR curve

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%.

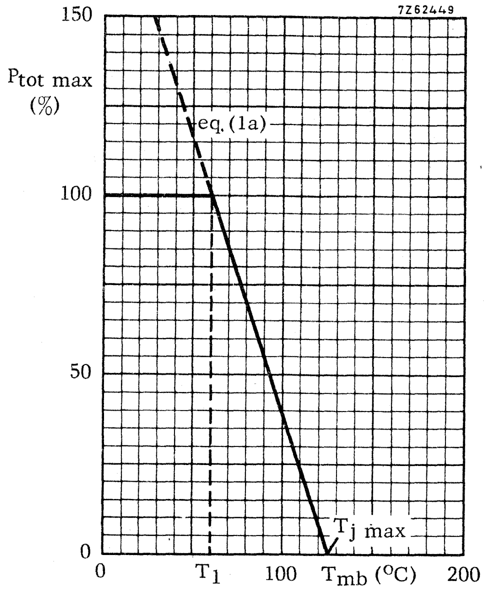


Fig. 3

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:

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

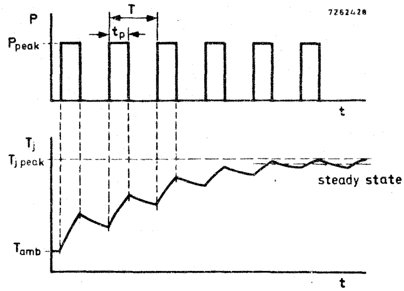


Fig. 4

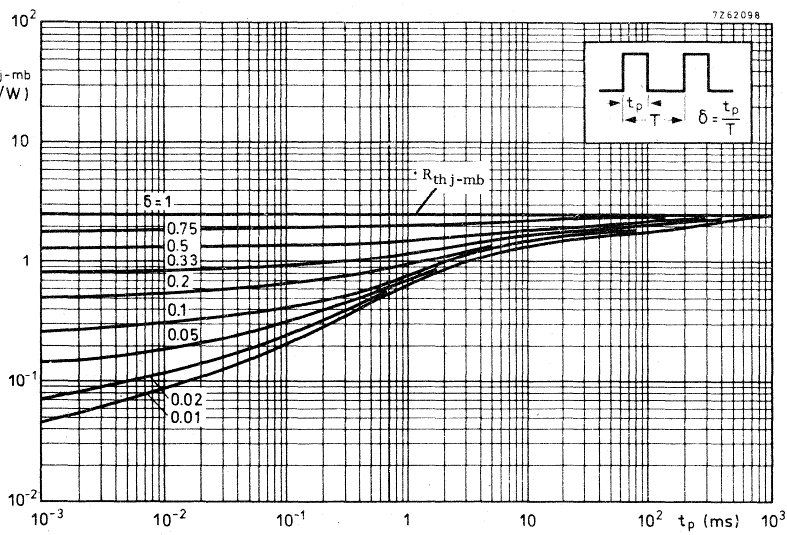


Fig. 5

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

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

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

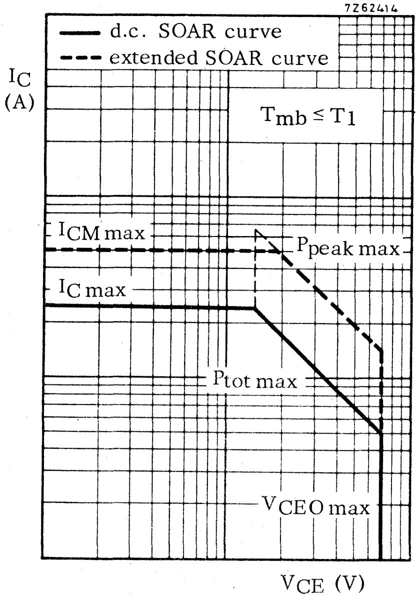


Fig. 6

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.

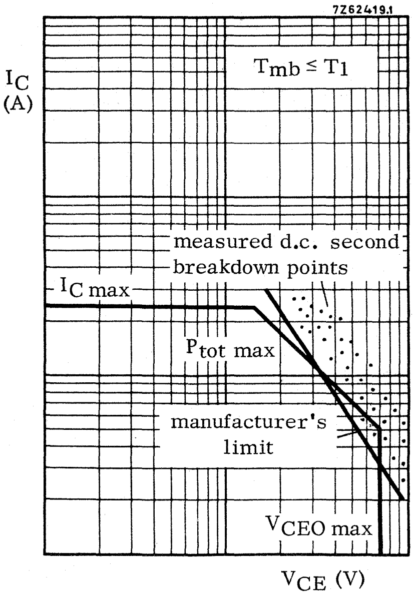


Fig. 7

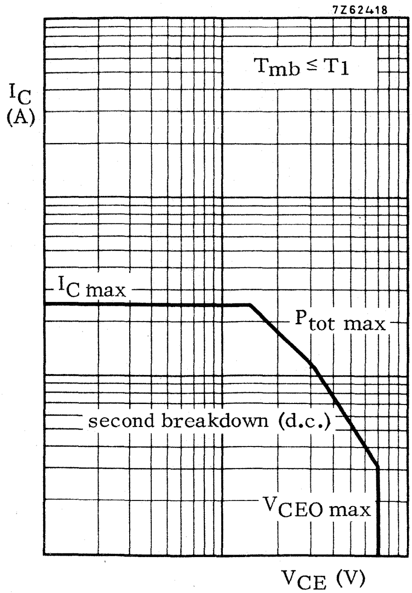


Fig. 8

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.

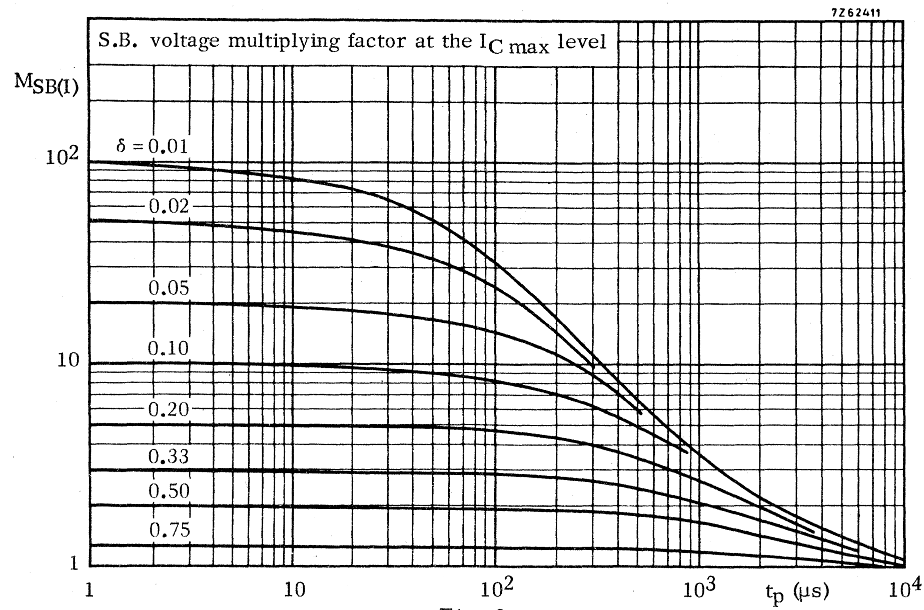

7Z62411
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
δ = 0.01
0.02
0.05
0.10
0.20
0.33
0.50
0.75
1
10
10^2
10^3
t_p (μs)
10^4

Fig. 9a

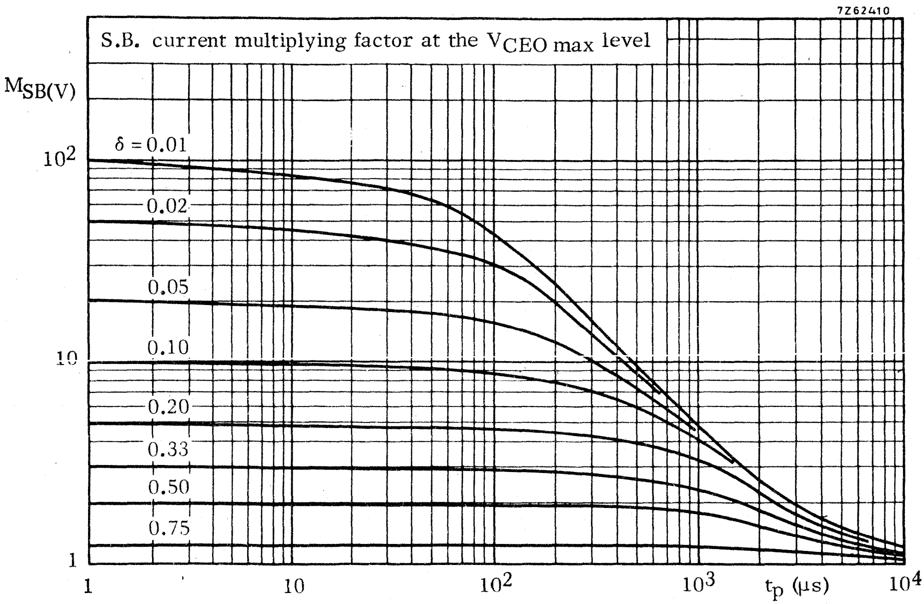

7Z62410
S.B. current multiplying factor at the $V_{CEO\,max}$ level
$M_{SB(V)}$
10^2
10
1
δ = 0.01
0.02
0.05
0.10
0.20
0.33
0.50
0.75
1
10
10^2
10^3
t_p (μs)
10^4

Fig. 9b

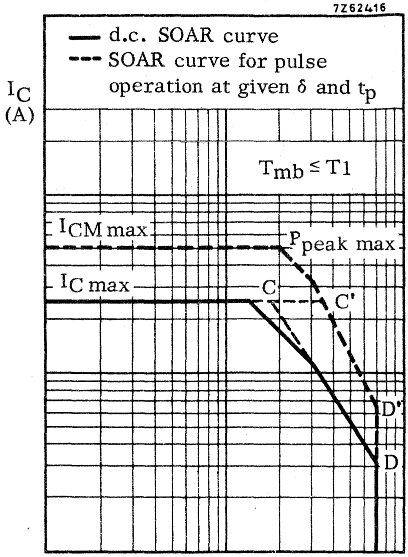


Fig. 10

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

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

4. Example of how to use the published SOAR information

4.1 Statement of the problem

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

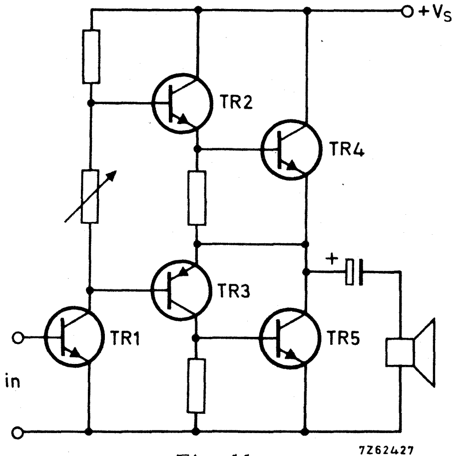


Fig. 11

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

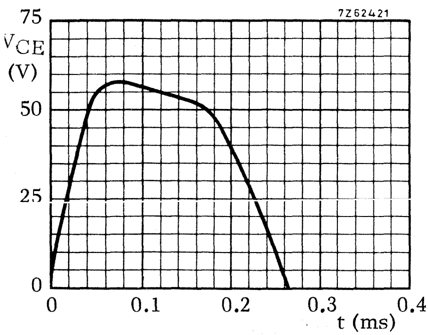


Fig. 12a

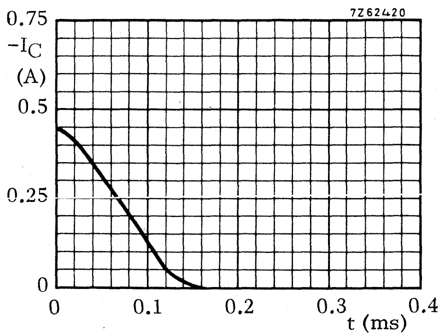


Fig. 12b

4.2 Information obtained from the published data of TR3

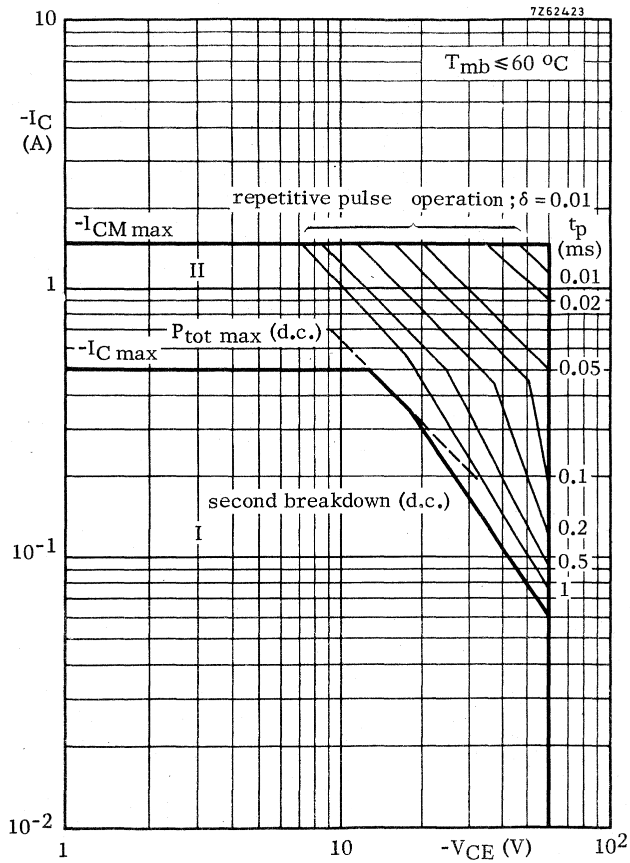
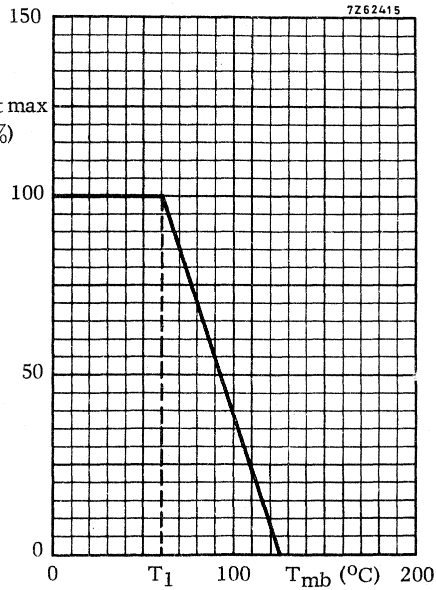


Fig. 13. Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation.



$T_{j\,max}$ = 125 °C

$R_{th\,j\text{-}mb}$ = 10 °C/W

Fig. 14

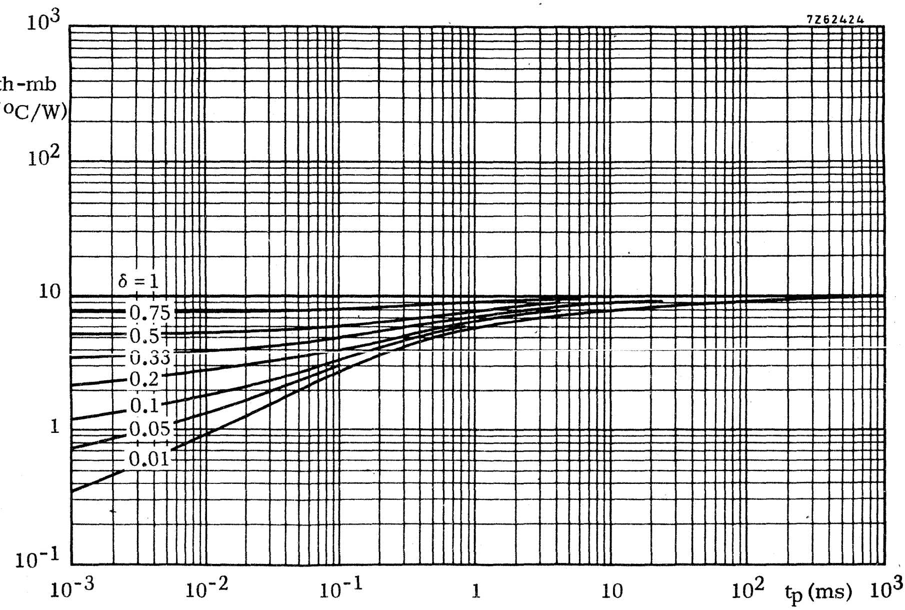


Fig. 15

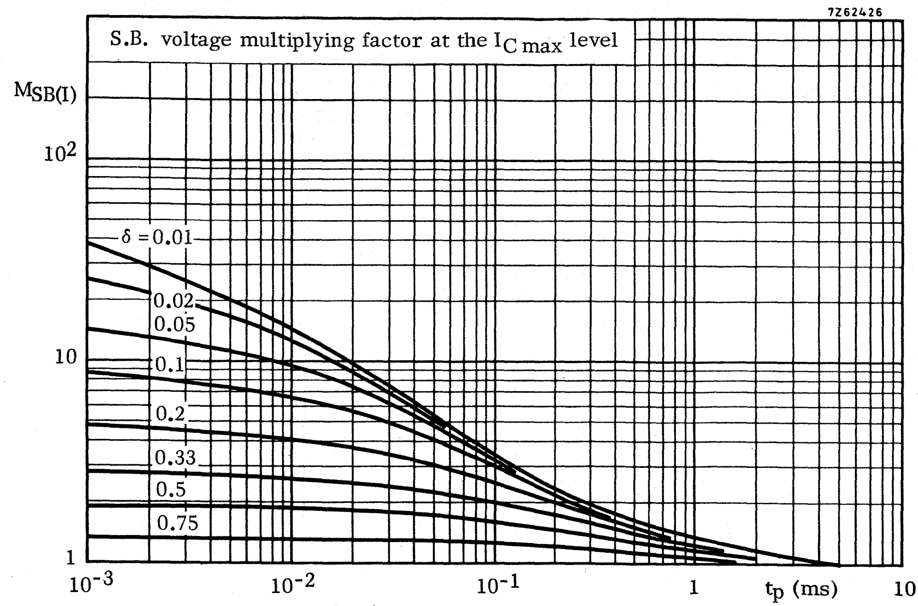

7Z62426
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
δ = 0.01
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

Fig. 16

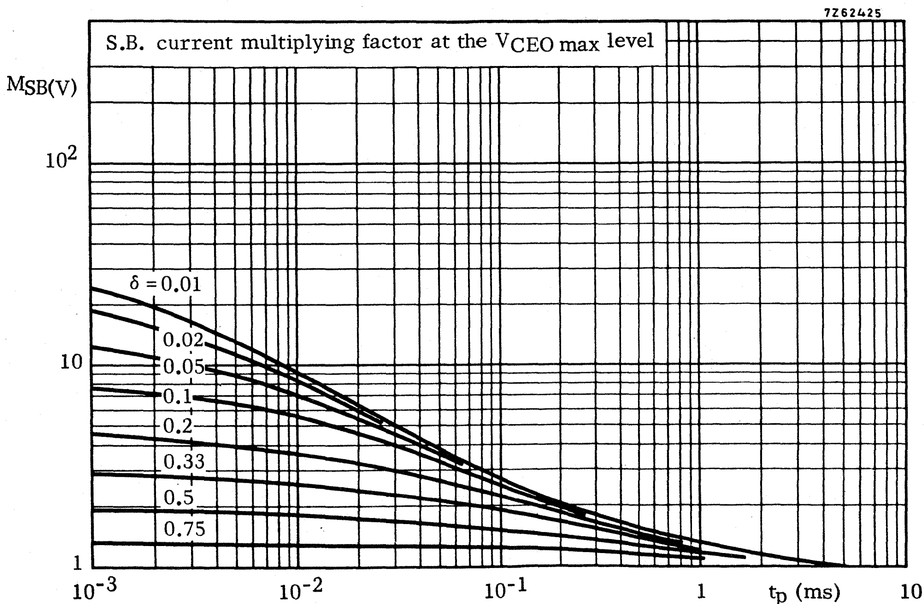

7Z62425
S.B. current multiplying factor at the $V_{CEO\,max}$ level
$M_{SB(V)}$
10^2
10
1
δ = 0.01
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

Fig. 17

4.3 Construction of the pulse SOAR of TR3 in this application

4.3.1

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

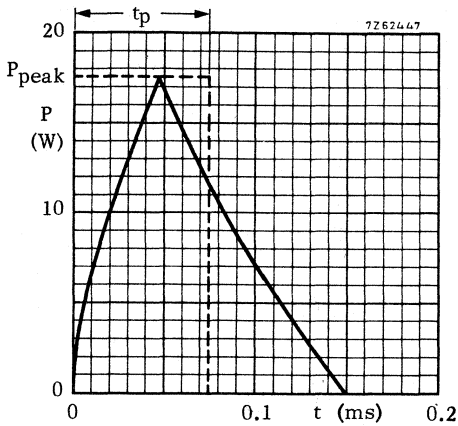


Fig. 18

4.3.2

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

$t_p = 75\ \mu s$

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

$\delta = 0.056$

$P_{peak} = 17.5$ W

4.3.3

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

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

$R_{th\ j\text{-}mb} = 10$ °C/W
$Z_{th\ j\text{-}mb} = 2.75$ °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°)
  $P_{peak\ max} = 28.4 \times I_{C\ max} = 14.2$ 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)

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

Therefore:

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

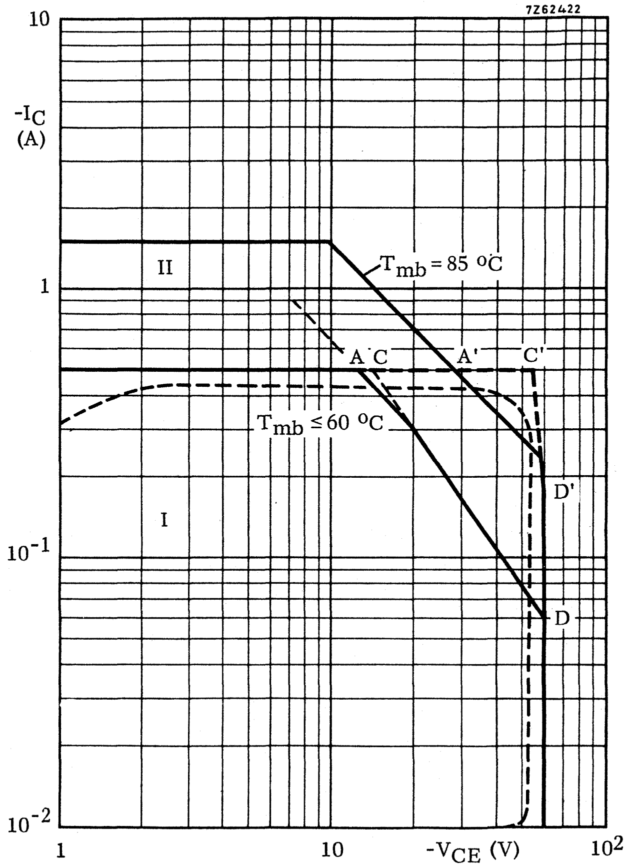


Fig. 19

I Region of permissible operation up to $T_{mb} = 60\ ^oC$

II Permissible extension for $t_p = 75\ \mu s$, $\delta = 0.056$ and $T_{mb} = 85\ ^oC$

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

High-frequency transistors

RULES FOR SOLDERING LEADS OF PLASTIC "T-PACK" ENVELOPE

Transistors in T-pack envelope may be mounted with leads flat (Fig. 1) or bent (Fig. 2). Different soldering procedures apply for the different styles of mounting.

Flat-lead mounting

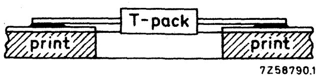


Fig. 1. Flat-lead mounting

Avoid putting any force on the leads during or just after soldering.
Solder the three leads one at a time, not simultaneously.
Proceed from one lead to the adjacent one, not to the opposite one.

Solder temperature, maximum:	300 °C
Solder time, maximum:	5 s
Solder-to-case distance, minimum:	2 mm

Bent-lead mounting

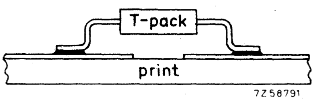


Fig. 2. Bent-lead mounting

If leads are bent, all three may be soldered simultaneously if desired.

Solder temperature, maximum:	300 °C
Soldering time, maximum:	10 s

RULES FOR MOUNTING QUARTER-INCH CAPSTAN HEADERS AS USED FOR R.F. POWER TRANSISTORS

A 5 mm thick brass nut is supplied with each transistor for securing it to a heatsink. To ensure optimum heat transfer and avoid damage to the threaded stud of the transistor the following recommendations should be observed:

- Diameter of mounting hole in heatsink: 4, 10 mm (+0, 05; −0, 00)
- Heatsink to be at least 3 mm thick.
  Attachment to a thinner heatsink may damage the mounting stud.
- Heatsink surfaces at the mounting hole to be flat, parallel, and free of burrs or oxidation.
- Mounting nut torque: 0, 80 Nm (+0, 05; −0, 00)
  8, 0 kg cm (+0, 5 ; −0, 0)
  If security against vibration is required, use a locking compound such as Lock-tite. Do not use washers; they impair the heat transfer.
- Recommended distance from the top surface of heatsink to surface of printed wiring board: 2, 9 mm (0, 0; −0, 2)
  Tension in the transistor leads sets the limit on spacing between heatsink and printed wiring board; in general, the leads can withstand more pull in the downward than in the upward direction.
- Solder the leads to the connection pads with resin-cored lead-tin solder, using an iron of normal temperature. Soldering iron temperatures as high as 350 °C are safely tolerable; the transistor can withstand an interior temperature of 250 °C for about ten minutes.
  The leads may be tinned, if required, by dipping them into a solder bath at about 230 °C; each lead may be dipped up to its full length. A flux of the quality of Super-Safe is recommended; after tinning, surplus flux should be rinsed away in tap water.

GERMANIUM ALLOY DIFFUSED TRANSISTOR

P-N-P transistor in a TO-72 metal envelope with a shield lead connected to the case. It has low noise and high power gain up to frequencies of 100 MHz and is intended for use as r.f. amplifier in f.m. receivers.

RATINGS (Limiting values) 1)

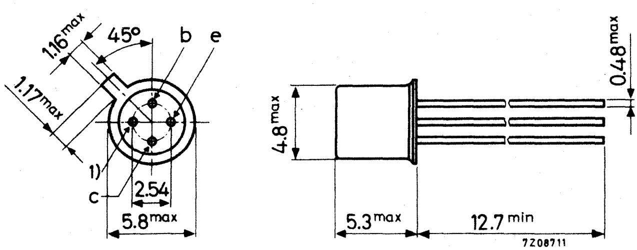
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	V
Collector-emitter voltage (Z_B/Z_E < 15)	$-V_{CER}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	15	V
Collector current (d.c.)	$-I_C$	max.	10	mA
Base current (d.c.)	$\|I_B\|$	max.	1	mA
Reverse emitter current	$-I_E$	max.	1	mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	60	mW
Storage temperature	T_{stg}	-55 to +75		°C
Junction temperature: continuous	T_j	max.	75	°C
incidentally	T_j	max.	90	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.75	°C/mW
From junction to case	$R_{th\ j-c}$	=	0.4	°C/mW

MECHANICAL DATA Dimensions in mm

TO-72



1) = shield lead (connected to case)

Accessories available: 56246, 56263

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

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

Collector cut-off current				
$I_E = 0$; $-V_{CB} = 6$ V	$-I_{CBO}$	typ.	1.2	μA
		<	8	μA
$I_E = 0$; $-V_{CB} = 6$ V; $T_j = 75$ °C	$-I_{CBO}$	typ.	90	μA
		<	180	μA
Base current				
$I_E = 1$ mA; $-V_{CB} = 6$ V	$-I_B$	typ.	7	μA
		<	25	μA
Base-emitter voltage				
$-I_C = 1$ mA; $-V_{CE} = 6$ V	$-V_{BE}$	typ.	270	mV
			210 to 330	mV
Small signal current gain at f = 1 kHz				
$-I_C = 1$ mA; $-V_{CE} = 6$ V	h_{fe}	typ.	150	
Feedback capacitance at f = 450 kHz				
$-I_C = 1$ mA; $-V_{CE} = 6$ V	C_{re}	typ.	1.5	pF
y parameters at f = 100 MHz (common base)				
$I_E = 1$ mA; $-V_{CB} = 6$ V [1]				
Input conductance	g_{ib}	typ.	15	$m\Omega^{-1}$
Input capacitance	$-C_{ib}$	typ.	5	pF
Feedback admittance	$\|y_{rb}\|$	typ.	0.45	$m\Omega^{-1}$
Phase angle of feedback admittance	φ_{rb}	typ.	250°	
Transfer admittance	$\|y_{fb}\|$	typ.	16	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fb}	typ.	95°	
Output conductance	g_{ob}	typ.	0.3	$m\Omega^{-1}$
Output capacitance	C_{ob}	typ.	2.5	pF
Feedback impedance at f = 2 MHz				
$I_E = 1$ mA; $-V_{CB} = 6$ V	$\|z_{rb}\|$	typ.	20	Ω

[1]) Length of leads between transistor bottom and measuring jig: 5 mm

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

Transition frequency

I_E = 1 mA; $-V_{CB}$ = 6 V	f_T	typ.	75	MHz

Noise figure at f = 100 MHz

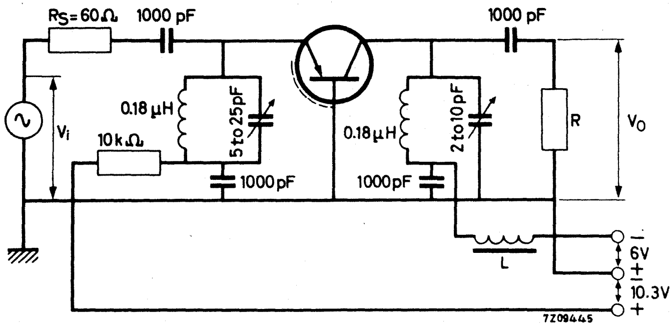
I_E = 1 mA; $-V_{CB}$ = 6 V; R_S = 60 Ω	F	typ.	8	dB
		<	9.5	dB

Power gain at f = 100 MHz

$$G_p = \frac{V_o2}{V_i2} \cdot \frac{4\,R_S}{R_\ell} = 0.073\,\frac{V_o2}{V_i2}$$

G_p	>	12.5	dB
	typ.	14	dB

Test circuit



R is chosen such that the total load impedance R_l consisting of R and the tuned circuit in parallel is 3.3 kΩ.

L = ferrite bead

GERMANIUM ALLOY DIFFUSED TRANSISTOR

P-N-P transistor in a TO-72 metal envelope with a shield lead connected to the case. It has a high conversion gain up to frequencies of 100 MHz and is intended for use as r.f. amplifiers and mixer-oscillator in short-wave receivers up to 27 MHz.

RATINGS (Limiting values) [1])

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	V
Collector-emitter voltage ($Z_B/Z_E < 15$)	$-V_{CER}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	15	V
Collector current (d.c.)	$-I_C$	max.	10	mA
Base current (d.c.)	$\lvert I_B \rvert$	max.	1	mA
Reverse emitter current	$-I_E$	max.	1	mA
Total power dissipation up to $T_{amb} = 45\,^oC$	P_{tot}	max.	60	mW
Storage temperature	T_{stg}		-55 to +75	^oC
Junction temperature: continuous	T_j	max.	75	^oC
incidentally	T_j	max.	90	^oC

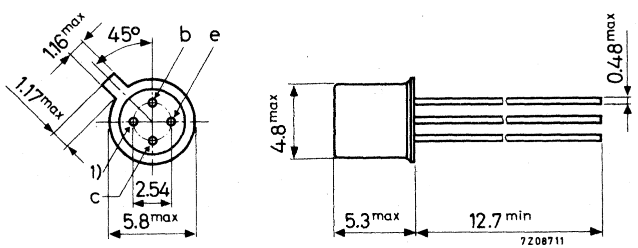
THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.75	$^oC/mW$
From junction to case	$R_{th\ j\text{-}c}$	=	0.4	$^oC/mW$

MECHANICAL DATA

Dimensions in mm

TO-72



1) = shield lead (connected to case)

Accessories available: 56246, 56263

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

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

Collector cut-off current				
I_E = 0; $-V_{CB}$ = 6 V	$-I_{CBO}$	typ.	1.2	μA
		<	8	μA
I_E = 0; $-V_{CB}$ = 6 V; T_j = 75 °C	$-I_{CBO}$	typ.	90	μA
		<	180	μA
Base current				
I_E = 1 mA; $-V_{CB}$ = 6 V	$-I_B$	typ.	7	μA
		<	25	μA
Base-emitter voltage				
$-I_C$ = 1 mA; $-V_{CE}$ = 6 V	$-V_{BE}$	typ.	270	mV
			210 to 330	mV
Small signal current gain at f = 1 kHz				
$-I_C$ = 1 mA; $-V_{CE}$ = 6 V	h_{fe}	typ.	150	
Feedback capacitance at f = 450 kHz				
$-I_C$ = 1 mA; $-V_{CE}$ = 6 V	C_{re}	typ.	1.5	pF

y parameters [1])

I_E = 1 mA; $-V_{CB}$ = 6 V at f = 100 MHz

Input conductance	g_{ib}	typ.	15	$m\Omega^{-1}$
Input capacitance	$-C_{ib}$	typ.	5	pF
Feedback admittance	$\|y_{rb}\|$	typ.	0.45	$m\Omega^{-1}$
Phase angle of feedback admittance	φ_{rb}	typ.	250°	
Transfer admittance	$\|y_{fb}\|$	typ.	15	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fb}	typ.	95°	
Output conductance	g_{ob}	typ.	0.35	$m\Omega^{-1}$
Output capacitance	C_{ob}	typ.	2.5	pF

$-I_C$ = 1 mA; $-V_{CE}$ = 6 V

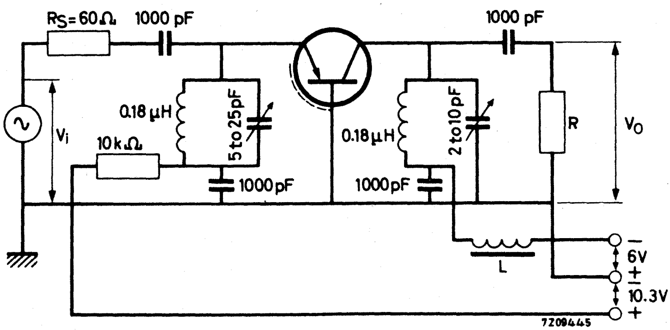
			f = 10.7	0.45	MHz
Input conductance	g_{ie}	typ.	1.3	0.25	$m\Omega^{-1}$
Input capacitance	C_{ie}	typ.	65	70	pF
Feedback admittance	$\|y_{re}\|$	typ.	80	4	$\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{re}	typ.	260°	270°	
Transfer admittance	$\|y_{fe}\|$	typ.	34	37	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fe}	typ.	335°	0	
Output conductance	g_{oe}	typ.	25	1.0	$\mu\Omega^{-1}$
Output capacitance	C_{oe}	typ.	3.0	4	pF

[1]) Length of leads between transistor bottom and measuring jig: 5 mm.

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

Feedback impedance at f = 2 MHz				
I_E = 1 mA; $-V_{CB}$ = 6 V	$\|z_{rb}\|$	typ.	25	Ω
Transition frequency				
I_E = 1 mA; $-V_{CB}$ = 6 V	f_T	typ.	75	MHz
Noise figure at I_E = 1 mA; $-V_{CB}$ = 6 V				
R_S = 60 Ω; f = 100 MHz	F	typ.	9.5	dB
R_S = 200 Ω; f = 10.7 MHz	F	typ.	3.0	dB
R_S = 500 Ω; f = 1 MHz	F	typ.	1.5	dB
		<	3	dB
Conversion noise figure at I_E = 1 mA; $-V_{CB}$ = 6 V				
R_S = 500 Ω; f = 1 MHz	F_c	typ.	3	dB
		<	5	dB
R_S = 2 kΩ; f = 200 kHz	F_c	typ.	4	dB
		<	7	dB
Power gain at f = 100 MHz				
$G_p = \frac{V_o^2}{V_i^2} \cdot \frac{4 R_S}{R_\ell} = 0.073 \frac{V_o^2}{V_i^2}$	G_p	>	10	dB
		typ.	13	dB

Test circuit:



R is chosen such that the total load impedance R_ℓ consisting of R and the tuned circuit in parallel is 3.3 kΩ.

L = ferrite bead

GERMANIUM ALLOY DIFFUSED TRANSISTOR

P-N-P transistor in a TO-72 metal envelope with a shield lead connected to the case. It has low output conductance and low collector capacitance at 10.7 MHz and low noise and good a.g.c. performance for use as i.f. amplifier in a.m. and f.m. receivers and as amplifier and mixer-oscillator in short-wave receivers up to 16 MHz.

RATINGS (Limiting values) [1])

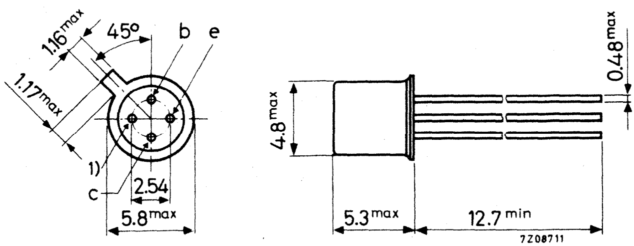
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	V
Collector-emitter voltage (Z_B/Z_E < 15)	$-V_{CER}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	15	V
Collector current (d.c.)	$-I_C$	max.	10	mA
Base current (d.c.)	$\|I_B\|$	max.	1	mA
Reverse emitter current	$-I_E$	max.	1	mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	60	mW
Storage temperature	T_{stg}		-55 to +75	°C
Junction temperature : continuous	T_j	max.	75	°C
incidentally	T_j	max.	90	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.75	°C/mW
From junction to case	$R_{th\ j-c}$	=	0.4	°C/mW

MECHANICAL DATA Dimensions in mm

TO-72



1) = shield lead (connected to case)

Accessories available: 56246, 56263

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

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

Collector cut-off current			
$I_E = 0$; $-V_{CB} = 6$ V	$-I_{CBO}$	typ. 1.2 μA < 8 μA	
$I_E = 0$; $-V_{CB} = 6$ V; $T_j = 75$ °C	$-I_{CBO}$	typ. 90 μA < 180 μA	
Base current			
$I_E = 1$ mA; $-V_{CB} = 6$ V	$-I_B$	typ. 7 μA < 25 μA	
Base-emitter voltage			
$-I_C = 1$ mA; $-V_{CE} = 6$ V	$-V_{BE}$	typ. 270 mV 210 to 330 mV	
Small signal current gain at f = 1 kHz			
$-I_C = 1$ mA; $-V_{CE} = 6$ V	h_{fe}	typ. 150	
Feedback capacitance at f = 450 kHz			
$-I_C = 1$ mA; $-V_{CE} = 6$ V	C_{re}	typ. 1.5 pF	

y parameters (common emitter)

$-I_C = 1$ mA; $-V_{CE} = 6$ V [1])

			f = 10.7	0.45	MHz
Input conductance	g_{ie}	typ.	1.7	0.25	$m\Omega^{-1}$
Input capacitance	C_{ie}	typ.	60	70	pF
Feedback admittance	$\|y_{re}\|$	typ.	100	4.0	$\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{re}	typ.	260°	270°	
Transfer admittance	$\|y_{fe}\|$	typ.	32	37	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fe}	typ.	335°	0	
Output conductance	g_{oe}	typ.	40	1.0	$\mu\Omega^{-1}$
Output capacitance	C_{oe}	typ.	3.5	4.0	pF

Feedback impedance at f = 2 MHz

$I_E = 1$ mA; $-V_{CB} = 6$ V	$\|z_{rb}\|$	typ.	27	Ω

[1]) Length of leads between transistor bottom and measuring jig : 5 mm

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

Transition frequency

I_E = 1 mA; $-V_{CB}$ = 6 V	f_T	typ.	75	MHz

Noise figure at I_E = 1 mA; $-V_{CB}$ = 6 V

R_S = 60 Ω; f = 10.7 MHz	F	typ.	3.0	dB
		<	4.5	dB
R_S = 500 Ω; f = 1 MHz	F	typ.	1.5	dB
		<	3.0	dB

Conversion noise figure

I_E = 1 mA; $-V_{CB}$ = 6 V

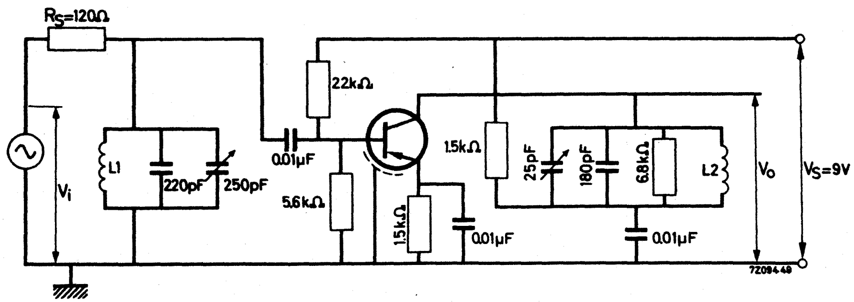
R_S = 500 Ω; f = 1 MHz	F_c	typ.	3	dB
		<	5	dB
R_S = 2 kΩ; f = 200 kHz	F_c	typ.	4	dB
		<	7	dB

Power gain at f = 10.7 MHz

$$G_p = \frac{V_o^2}{V_i^2} \cdot \frac{4 R_S}{R_l} = 0.1 \frac{V_o^2}{V_i^2}$$

	G_p	>	19	dB
		typ.	25	dB

Test circuit:



Total collector resistance R_l = 4.8 kΩ
L1 = 0.5 μH; unloaded Q-factor 100
L2 = 2.47 μH; unloaded Q-factor 100

GERMANIUM ALLOY DIFFUSED TRANSISTOR

P-N-P transistor in a TO-72 metal envelope with a shield lead connected to the case. It has a low collector capacitance, low noise and good a.g.c. performance and is intended for use as i.f. amplifier, r.f. amplifier and mixer-oscillator in a.m. receivers up to 6 MHz.

RATINGS (Limiting values) [1])

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	V
Collector-emitter voltage ($Z_B/Z_E < 15$)	$-V_{CER}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	15	V
Collector current (d.c.)	$-I_C$	max.	10	mA
Base current (d.c.)	$\lvert I_B \rvert$	max.	1	mA
Reverse emitter current	$-I_E$	max.	1	mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	60	mW
Storage temperature	T_{stg}		-55 to +75	°C
Junction temperature : continuous	T_j	max.	75	°C
incidentally	T_j	max.	90	°C

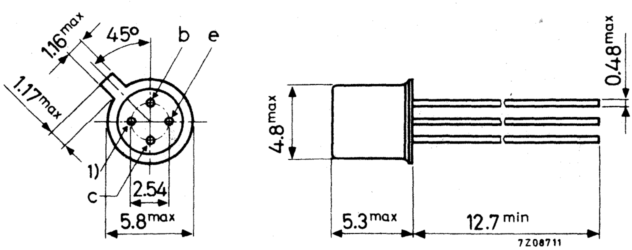
THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.75	°C/mW
From junction to case	$R_{th\ j-c}$	=	0.4	°C/mW

MECHANICAL DATA

Dimensions in mm

TO-72



1) = shield lead (connected to case)

Accessories available: 56246, 56263

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

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

Collector cut-off current

$I_E = 0$; $-V_{CB} = 6$ V	$-I_{CBO}$	typ.	1.2	μA
		<	8	μA
$I_E = 0$; $-V_{CB} = 6$ V; $T_j = 75$ °C	$-I_{CBO}$	typ.	90	μA
		<	180	μA

Base current

$I_E = 1$ mA; $-V_{CB} = 6$ V	$-I_B$	typ.	7	μA
		<	25	μA

Base-emitter voltage

$-I_C = 1$ mA; $-V_{CE} = 6$ V	$-V_{BE}$	typ.	270	mV
			210 to 330	mV

Small signal current gain at f = 1 kHz

$-I_C = 1$ mA; $-V_{CE} = 6$ V	h_{fe}	typ.	150	

Feedback capacitance at f = 450 kHz

$-I_C = 1$ mA; $-V_{CE} = 6$ V	C_{re}	typ.	1.5	pF

y parameters at f = 0.45 MHz (common emitter)

$-I_C = 1$ mA; $-V_{CE} = 6$ V [1])

Input conductance	g_{ie}	typ.	0.25	$m\Omega^{-1}$
Input capacitance	C_{ie}	typ.	70	pF
Feedback admittance	$\|y_{re}\|$	typ.	4.0	$\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{re}	typ.	270°	
Transfer admittance	$\|y_{fe}\|$	typ.	37	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fe}	typ.	0	
Output conductance	g_{oe}	typ.	1.0	$\mu\Omega^{-1}$
Output capacitance	C_{oe}	typ.	4.0	pF

Feedback impedance at f = 2 MHz

$I_E = 1$ mA; $-V_{CB} = 6$ V	$\|z_{rb}\|$	typ.	35	Ω

[1]) Length of leads between transistor bottom and measuring jig : 5 mm

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

Transition frequency

I_E = 1 mA; $-V_{CB}$ = 6 V	f_T	typ.	75	MHz

Noise figure at f = 1.0 MHz

I_E = 1 mA; $-V_{CB}$ = 6 V; R_S = 500 Ω	F	typ.	1.5	dB
		<	3	dB

Conversion noise figure

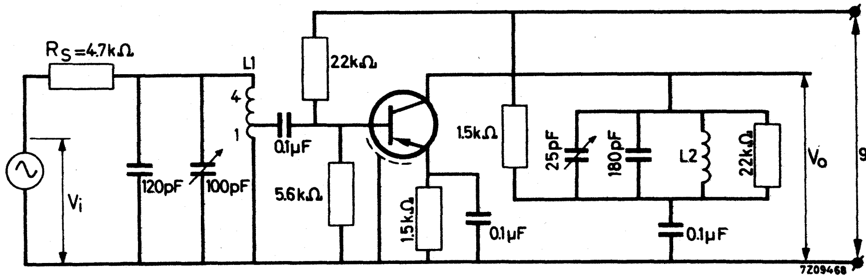
I_E = 1 mA; $-V_{CB}$ = 6 V

R_S = 500 Ω; f = 1 MHz	F_c	typ.	3	dB
		<	5	dB
R_S = 2 kΩ; f = 200 kHz	F_c	typ.	4	dB
		<	7	dB

Power gain at f = 0.45 MHz

$G_p = \frac{V_o 2}{V_i 2} \cdot \frac{4 R_S}{R_l} = 0.94 \frac{V_o^2}{V_i^2}$	G_p	>	40	dB
		typ.	42	dB

Test circuit :



Total collector resistance R_ℓ = 20 kΩ
L1 = 625 μH; unloaded Q-factor 140; tap at 0.2
L2 = 625 μH; unloaded Q-factor 140

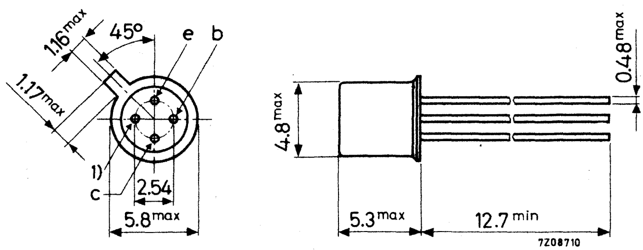
U.H.F. GERMANIUM MESA TRANSISTOR

P-N-P transistor in a TO-72 metal envelope, primarily intended for use in pre-amplifier, mixer or oscillator circuits up to frequencies of 860 MHz.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	20	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	15	V
Collector current (d.c.)	$-I_C$	max.	10	mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	60	mW
Junction temperature	T_j	max.	90	°C
Transition frequency				
$-I_C$ = 1.5 mA; $-V_{CE}$ = 12 V	f_T	typ.	550	MHz
Max. unilateralised power gain				
I_E = 1.5 mA; $-V_{CB}$ = 12 V; f = 800 MHz	G_{UM}	typ.	11.5	dB
Noise figure				
I_E = 1.5 mA; $-V_{CB}$ = 12 V;				
f = 800 MHz; R_S = 60 Ω	F	typ.	7	dB

MECHANICAL DATA Dimensions in mm

TO-72



1) = shield lead (connected to case)

Accessories available: 56246, 56263

RATINGS (Limiting values) [1]

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	20	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	15	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	0.3	V

Currents

Collector current (d.c.)	$-I_C$	max.	10	mA
Collector current (peak value)	$-I_{CM}$	max.	10	mA

Power dissipation

Total power dissipation up to T_{amb} = 45 ^oC	P_{tot}	max.	60	mW

Temperatures

Storage temperature	T_{stg}		-30 to +75	^oC
Junction temperature	T_j	max.	90	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.75	$^oC/mW$
From junction to case	$R_{th\ j-c}$	=	0.40	$^oC/mW$

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

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $-V_{CB} = 20$ V	$-I_{CBO}$	typ.	0.5	μA
		<	8	μA
$I_B = 0$; $-V_{CE} = 15$ V	$-I_{CEO}$	<	500	μA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 0.3$ V	$-I_{EBO}$	typ.	2	μA
		<	100	μA
Base current				
$I_E = 1.5$ mA; $-V_{CB} = 12$ V	$-I_B$	typ.	30	μA
		<	150	μA
$I_E = 2$ mA; $-V_{CB} = 6$ V	$-I_B$	typ.	36	μA
$I_E = 5$ mA; $-V_{CB} = 6$ V	$-I_B$	typ.	66	μA
Emitter-base voltage				
$I_E = 1.5$ mA; $-V_{CB} = 12$ V	V_{EB}	typ.	380	mV
			320 to 430	mV
$I_E = 2$ mA; $-V_{CB} = 6$ V	V_{EB}	typ.	380	mV
			320 to 430	mV
$I_E = 5$ mA; $-V_{CB} = 6$ V	V_{EB}	typ.	405	mV
			360 to 450	mV
Transition frequency				
$-I_C = 1.5$ mA; $-V_{CE} = 12$ V	f_T	typ.	550	MHz
Reverse transfer time constant				
$I_E = 1.5$ mA; $-V_{CB} = 12$ V; f = 2.5 MHz	$r_{bb'} \cdot C_{b'c}$	typ.	3	ps
Feedback capacitance at f = 450 kHz				
$-I_C = 1.5$ mA; $-V_{CE} = 12$ V	C_{re}	typ.	250	fF [1)]
Noise figure at $R_S = 60\ \Omega$				
$I_E = 1.5$ mA; $-V_{CB} = 12$ V; f = 800 MHz	F	typ.	7	dB
		<	8.2	dB
f = 860 MHz	F	typ.	7.5	dB
		<	8.8	dB

1) 1 fF = 1 femtofarad = 10^{-15} F

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

y parameters at f = 800 MHz [1]

I_E = 1.5 mA; $-V_{CB}$ = 12 V

Input conductance	g_{ib}	typ.	7	$m\Omega^{-1}$
Input capacitance	$-C_{ib}$	typ.	2.2	pF
Input susceptance	$-\omega C_{ib}$	typ.	11	$m\Omega^{-1}$
Feedback admittance	$\lvert y_{rb}\rvert$	typ.	0.4	$m\Omega^{-1}$
Phase angle of feedback admittance	φ_{rb}	typ.	240°	
Transfer admittance	$\lvert y_{fb}\rvert$	typ.	14	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fb}	typ.	35°	
Output conductance	g_{ob}	typ.	0.5	$m\Omega^{-1}$
Output capacitance	C_{ob}	typ.	1.5	pF

y parameters at f = 200 MHz [1]

I_E = 1.5 mA; $-V_{CB}$ = 12 V

Input conductance	g_{ib}	typ.	28	$m\Omega^{-1}$
Input capacitance	$-C_{ib}$	typ.	19	pF
Input susceptance	$-\omega C_{ib}$	typ.	24	$m\Omega^{-1}$
Feedback admittance	$\lvert y_{rb}\rvert$	typ.	0.17	$m\Omega^{-1}$
Phase angle of feedback admittance	φ_{rb}	typ.	250°	
Transfer admittance	$\lvert y_{fb}\rvert$	typ.	37	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fb}	typ.	126°	
Output conductance	g_{ob}	typ.	90	$\mu\Omega^{-1}$
Output capacitance	C_{ob}	typ.	1.5	pF

Maximum unilateralised power gain

$$G_{UM} = \frac{|y_{fb}|^2}{4\, g_{ib} g_{ob}}$$

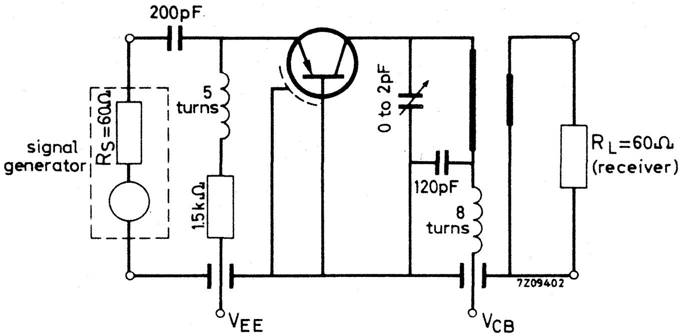
I_E = 1.5 mA; $-V_{CB}$ = 12 V; f = 800 MHz	G_{UM}	typ.	11.5	dB

[1]) Measured with a lead length of 5 mm.

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

Transducer gain

Basic circuit for measuring the transducer gain G_{tr}.



Total effective collector resistance R_C = 1.4 kΩ

$$G_{tr} = \frac{\text{output power in load } R_L}{\text{available power from source } R_S}$$

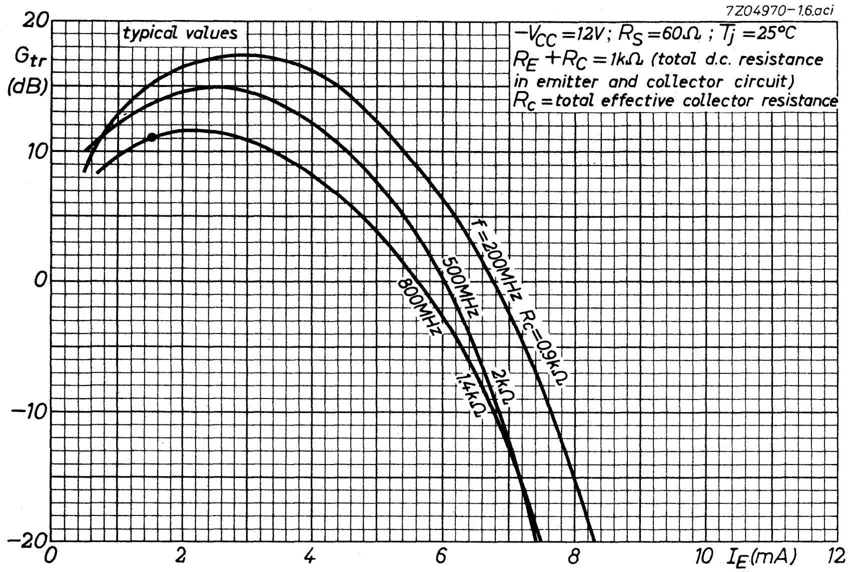
I_E = 1.5 mA; $-V_{CB}$ = 12 V

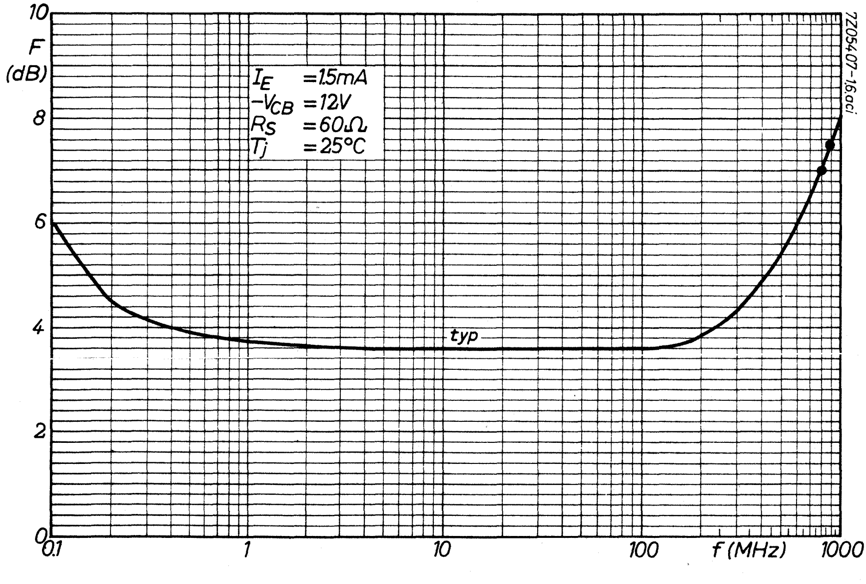
f = 800 MHz	G_{tr}	>	9	dB
		typ.	11	dB
f = 860 MHz	G_{tr}	>	7.5	dB
		typ.	10	dB

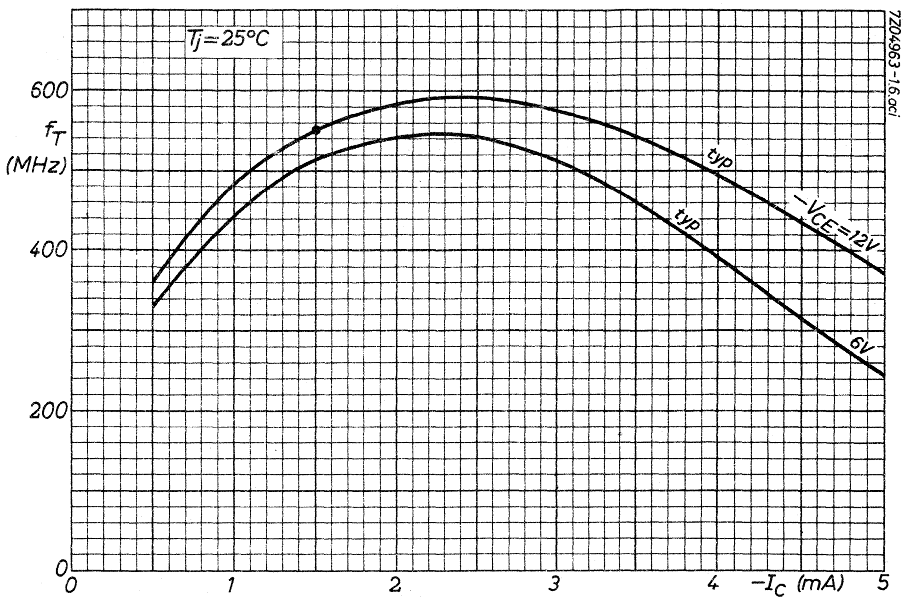
Reverse transducer gain

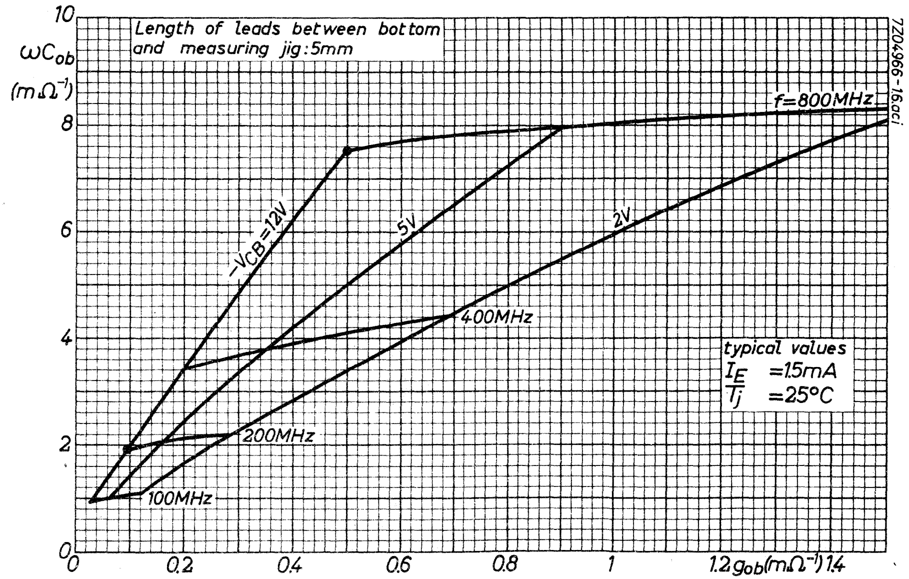
I_E = 1.5 mA; $-V_{CB}$ = 12 V; f = 800 MHz $G_{tr\ rev}$ typ. −23 dB

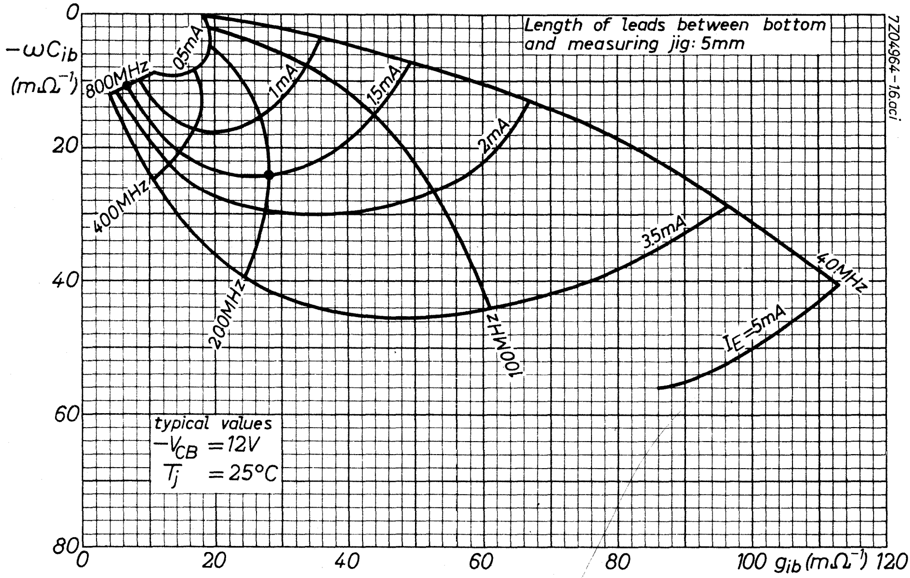
The reverse transducer gain is measured in the above circuit, with the signal generator and the load (receiver) interchanged.

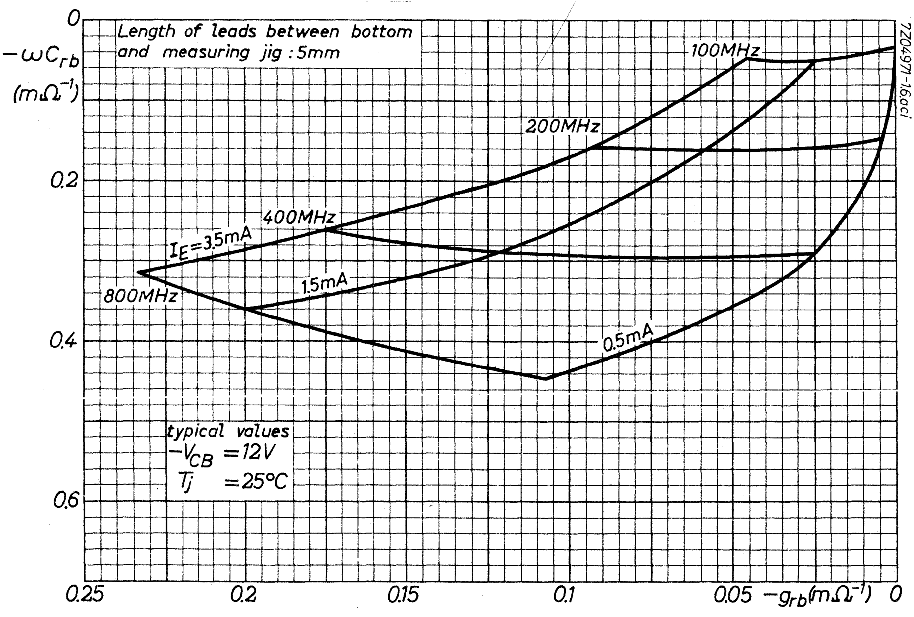

7Z04970-1.6.aci
20
G_{tr}
(dB)
10
0
−10
−20
typical values
$-V_{CC}$ = 12V; R_S = 60Ω ; T_j = 25°C
R_E + R_C = 1kΩ (total d.c. resistance in emitter and collector circuit)
R_c = total effective collector resistance
f = 200MHz
500MHz
800MHz
R_c = 0.9kΩ
2kΩ
1.4kΩ
0
2
4
6
8
10
I_E(mA)
12

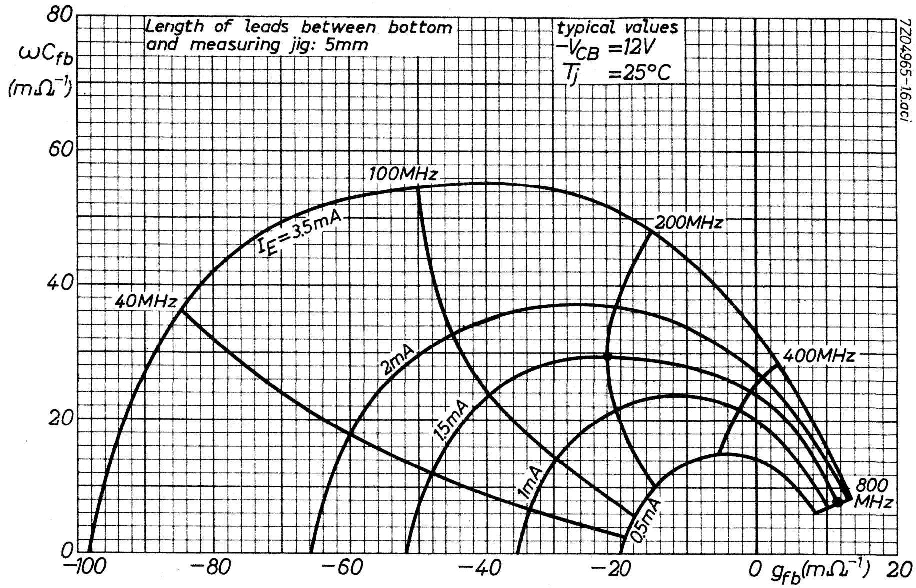

7Z05407-1.6.aci
10
F
(dB)
8
6
4
2
0
I_E = 1.5mA
$-V_{CB}$ = 12V
R_S = 60Ω
T_j = 25°C
typ
0.1
1
10
100
f (MHz)
1000

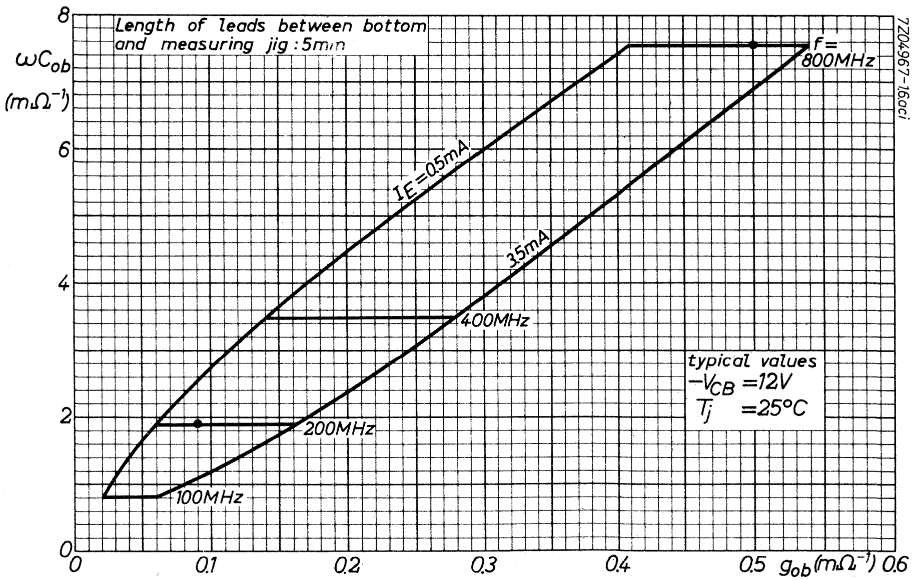

7Z04963-1.6.aci
$T_j = 25°C$
600
f_T
(MHz)
400
200
0
0
1
2
3
4
$-I_C$ (mA)
5
typ
typ
$-V_{CE}=12V$
6V

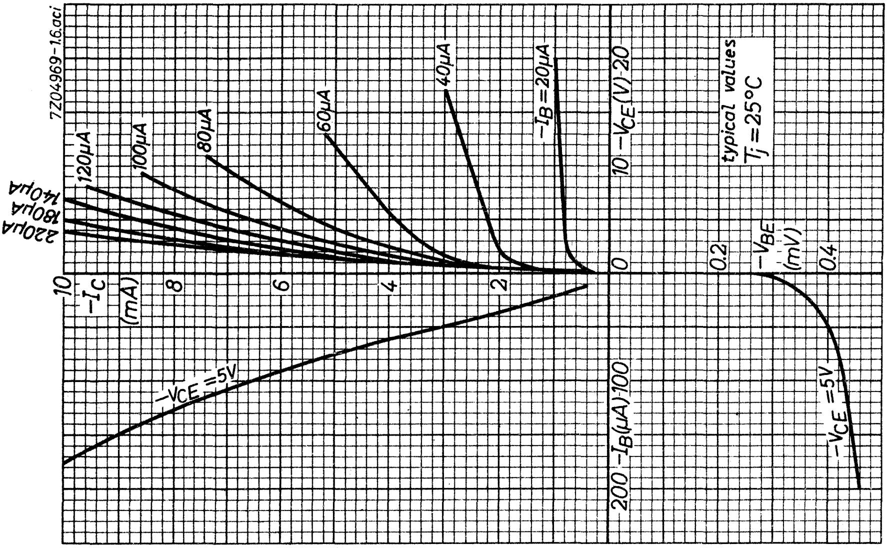

7Z04966-1.6.aci
Length of leads between bottom and measuring jig: 5mm
10
ωC_{ob}
$(m\Omega^{-1})$
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1
1.2
$g_{ob}(m\Omega^{-1})$
1.4
f=800MHz
$-V_{CB}=12V$
5V
2V
400MHz
200MHz
100MHz
typical values
I_E = 1.5mA
T_j = 25°C

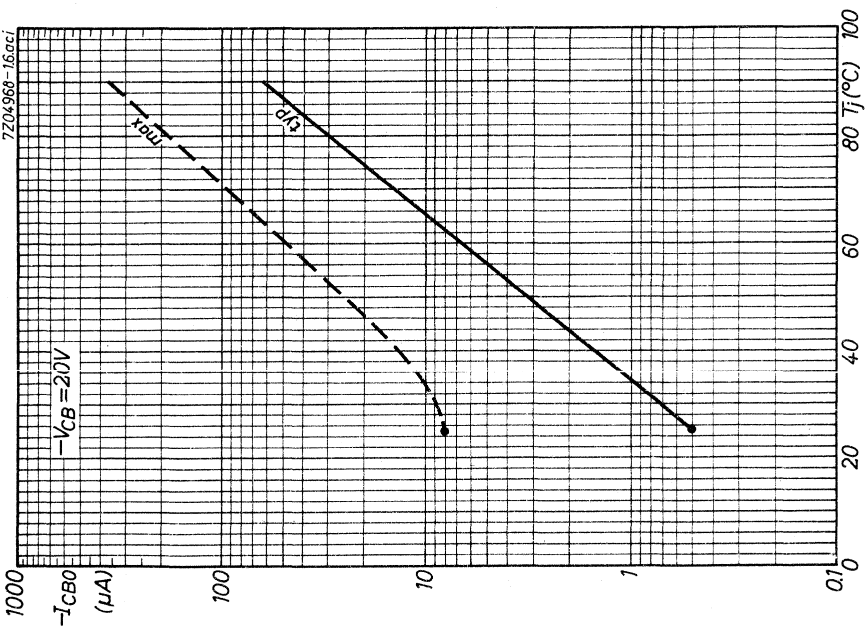

Length of leads between bottom and measuring jig: 5mm
7Z04964-1.6.aci
$-\omega C_{ib}$ ($m\Omega^{-1}$)
0
20
40
60
80
0.5mA
1mA
1.5mA
2mA
3.5mA
I_E=5mA
800MHz
400MHz
200MHz
100MHz
40MHz
typical values
$-V_{CB}$ = 12V
T_j = 25°C
0
20
40
60
80
100 g_{ib} ($m\Omega^{-1}$) 120


Length of leads between bottom and measuring jig: 5mm
7Z04971-1.6.aci
$-\omega C_{rb}$ ($m\Omega^{-1}$)
0
0.2
0.4
0.6
100MHz
200MHz
400MHz
800MHz
I_E=3.5mA
1.5mA
0.5mA
typical values
$-V_{CB}$ = 12V
T_j = 25°C
0.25
0.2
0.15
0.1
0.05 $-g_{rb}$ ($m\Omega^{-1}$) 0


80
ωC_{fb}
$(m\Omega^{-1})$
60
40
20
0
−100
−80
−60
−40
−20
0 $g_{fb}(m\Omega^{-1})$ 20
Length of leads between bottom and measuring jig: 5mm
typical values
$-V_{CB}$ =12V
T_j =25°C
100MHz
200MHz
40MHz
400MHz
800 MHz
I_E=3.5mA
2mA
1.5mA
1mA
0.5mA
7Z04965-16.aci


8
ωC_{ob}
$(m\Omega^{-1})$
6
4
2
0
0
0.1
0.2
0.3
0.4
0.5 $g_{ob}(m\Omega^{-1})$ 0.6
Length of leads between bottom and measuring jig : 5mm
f= 800MHz
I_E=0.5mA
3.5mA
400MHz
200MHz
100MHz
typical values
$-V_{CB}$ =12V
T_j =25°C
7Z04967-16.aci


7204969-1.6.aci
typical values
$T_j = 25°C$
$-I_B = 20\mu A$
40µA
60µA
80µA
100µA
120µA
140µA
180µA
220µA
$-I_C$ (mA)
$-V_{CE}$ (V)
$-I_B$ (µA)
$-V_{BE}$ (mV)
$-V_{CE} = 5V$
$-V_{CE} = 5V$


7204968-1.6.aci
$-V_{CB} = 20V$
max
typ
$-I_{CBO}$ (µA)
T_j (°C)

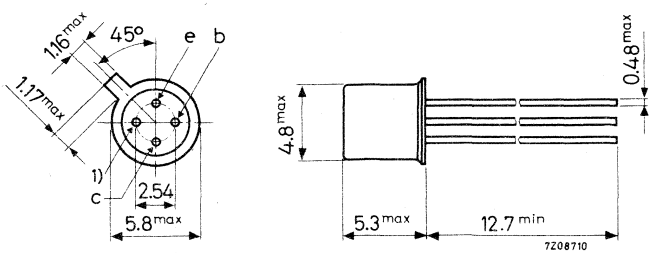
U.H.F GERMANIUM MESA TRANSISTOR

P-N-P transistor in a TO-72 metal envelope, primarily intended for use in pre-amplifier, mixer or oscillator circuits up to frequencies of 890 MHz.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	20	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	15	V
Collector current (d.c.)	$-I_C$	max.	15	mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	60	mW
Junction temperature	T_j	max.	90	°C
Transition frequency				
$-I_C$ = 2 mA; $-V_{CE}$ = 10 V	f_T	typ.	650	MHz
Max. unilateralised power gain				
I_E = 2 mA; $-V_{CB}$ = 10 V; f = 800 MHz	G_{UM}	typ.	17	dB
Noise figure				
I_E = 2 mA; $-V_{CB}$ = 10 V				
G_S = 16.7 mΩ^{-1}; B_S = 0				
f = 200 MHz	F	typ.	3	dB
f = 800 MHz	F	typ.	5	dB

MECHANICAL DATA Dimensions in mm

TO-72



1) = shield lead (connected to case)

Accessories available: 56246, 56263

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	20	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	15	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	0.3	V

Currents

Collector current (d.c.)	$-I_C$	max.	15	mA
Collector current (peak value)	$-I_{CM}$	max.	15	mA

Power dissipation

Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	60	mW

Temperatures

Storage temperature	T_{stg}		-30 to +75	°C
Junction temperature	T_j	max.	90	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.75	°C/mW
From junction to case	$R_{th\ j-c}$	=	0.40	°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

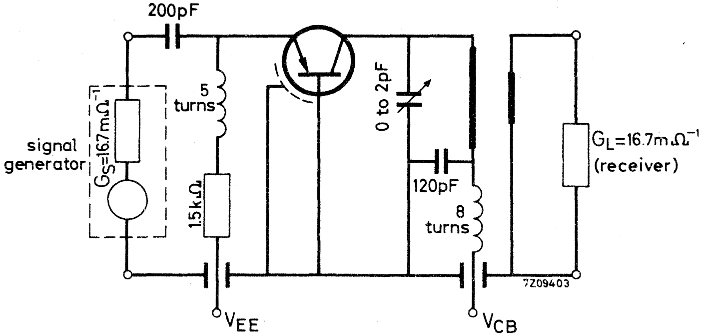
Collector cut-off current				
V_{EB} = 0; $-V_{CB}$ = 20 V	$-I_{CBS}$	typ. <	0.5 8	μA μA
I_B = 0; $-V_{CE}$ = 15 V	$-I_{CEO}$	<	500	μA
Emitter cut-off current				
I_C = 0; $-V_{EB}$ = 0.3 V	$-I_{EBO}$	<	100	μA
Base current				
I_E = 2 mA; $-V_{CB}$ = 10 V	$-I_B$	typ. <	60 200	μA μA
I_E = 5 mA; $-V_{CB}$ = 5 V	$-I_B$	typ.	167	μA
I_E = 10 mA; $-V_{CB}$ = 2 V	$-I_B$	<	1	mA
Emitter-base voltage				
I_E = 2 mA; $-V_{CB}$ = 10 V	V_{EB}	typ.	350	mV
I_E = 5 mA; $-V_{CB}$ = 5 V	V_{EB}	typ.	400	mV
Transition frequency				
$-I_C$ = 2 mA; $-V_{CE}$ = 10 V	f_T	typ.	650	MHz
Feeback capacitance at f = 1 MHz				
$-I_C$ = 2 mA; $-V_{CE}$ = 10 V	C_{re}	typ.	230	fF [1])
Noise figure				
I_E = 2 mA; $-V_{CB}$ = 10 V G_S = 16.7 mΩ^{-1}; B_S = 0				
f = 200 MHz	F	typ.	3	dB
f = 800 MHz	F	typ. <	5 6	dB dB
f = 900 MHz	F	typ. <	6 7	dB dB
Maximum unilateralised power gain				
$G_{UM} = \frac{\lvert y_{fb}\rvert^2}{4\, g_{ib} g_{ob}}$				
I_E = 2 mA; $-V_{CB}$ = 10 V; f = 800 MHz	G_{UM}	typ.	17	dB

[1]) 1 fF = 1 femtofarad = 10^{-15} F

CHARACTERISTICS (continued)

Transducer gain at T_{amb} = 25 °C

Basic circuit for measuring the transducer gain G_{tr} at f = 800 and 900 MHz.

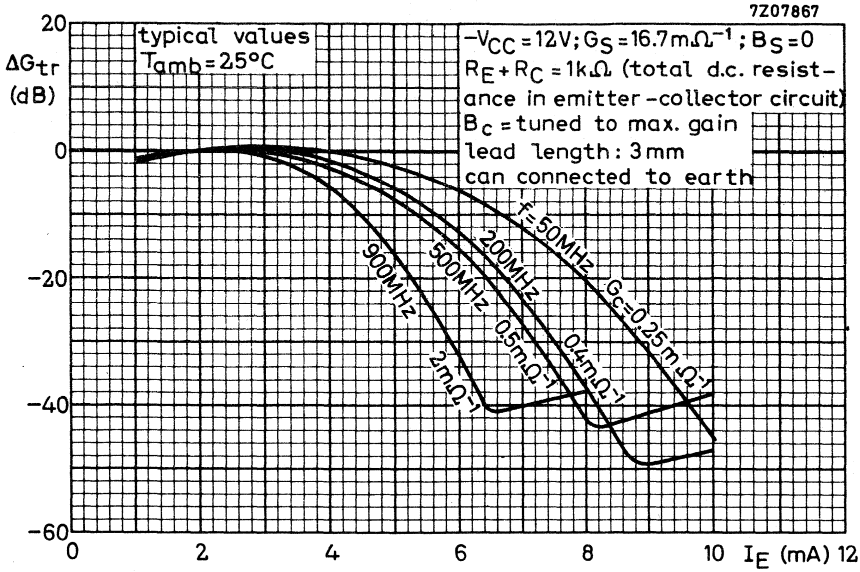


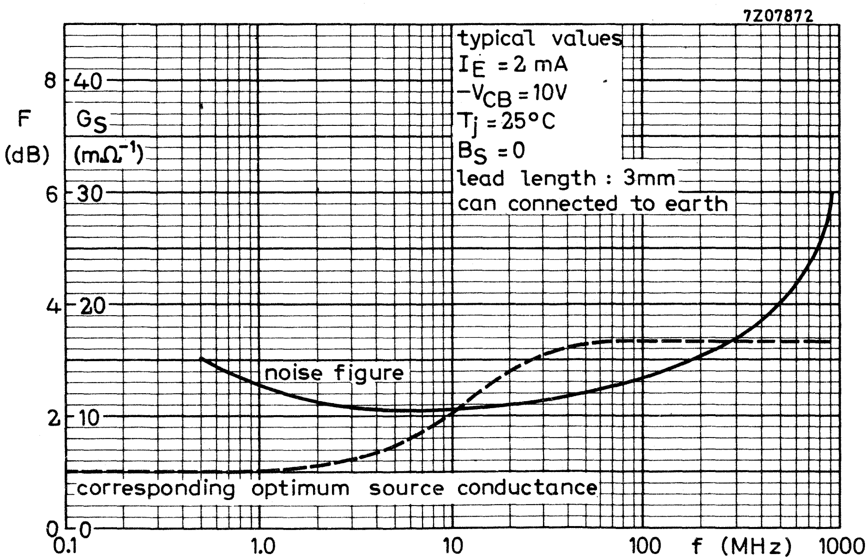
$$G_{tr} = \frac{\text{output power in load } G_L}{\text{available power from source } G_S}$$

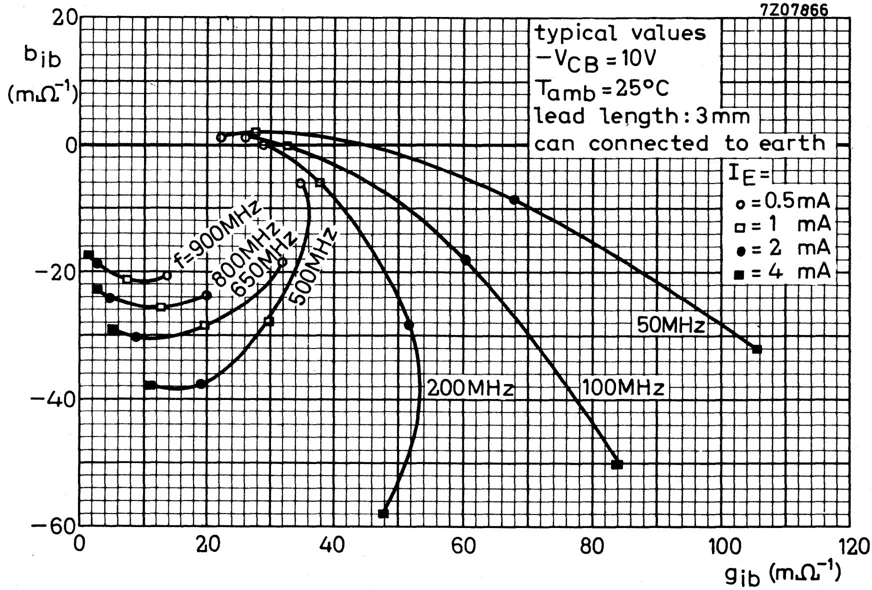
I_E = 2 mA; $-V_{CB}$ = 10 V; lead length: 3 mm; can connected to earth.

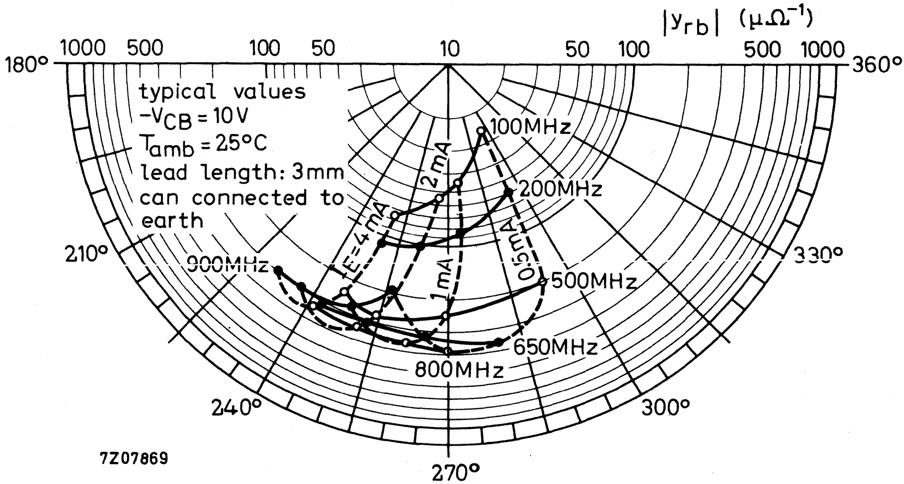
f = 50 MHz; G_c = 0.25 mΩ^{-1}	G_{tr}	typ.	22.5	dB
f = 200 MHz; G_c = 0.4 mΩ^{-1}	G_{tr}	typ.	21.5	dB
f = 500 MHz; G_c = 0.5 mΩ^{-1}	G_{tr}	typ.	18	dB
f = 800 MHz; G_c = 0.5 mΩ^{-1}	G_{tr}	>	11.5	dB
		typ.	14	dB
G_c = 2 mΩ^{-1}	G_{tr}	>	9	dB
		typ.	11.5	dB
f = 900 MHz; G_c = 0.5 mΩ^{-1}	G_{tr}	typ.	12.5	dB
G_c = 2 mΩ^{-1}	G_{tr}	typ.	10.5	dB

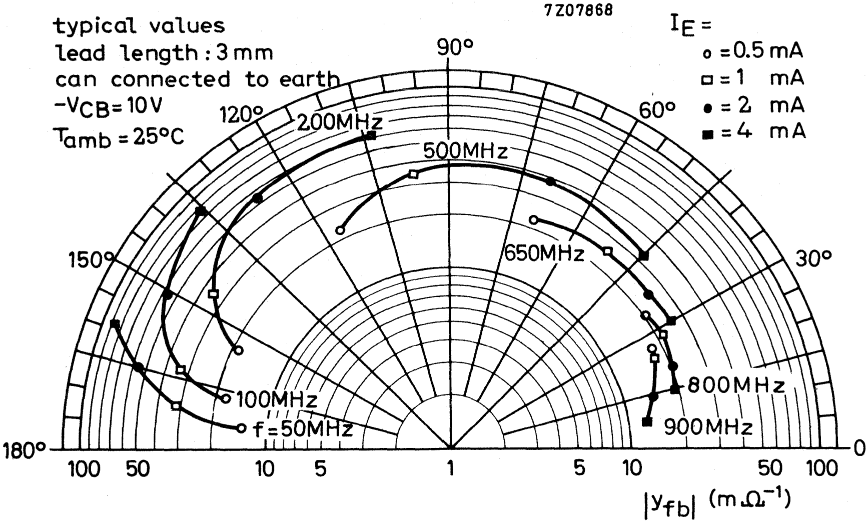
G_c = total effective collector conductance.

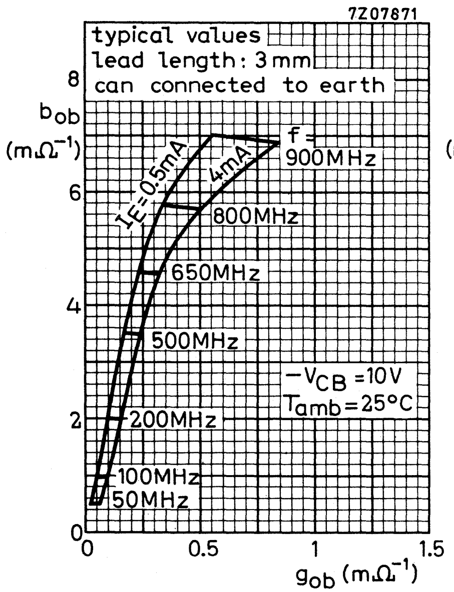

7Z07867
typical values
T_{amb} = 25°C
$-V_{CC}$ = 12V; G_S = 16.7mΩ^{-1}; B_S = 0
$R_E + R_C$ = 1kΩ (total d.c. resistance in emitter-collector circuit)
B_C = tuned to max. gain
lead length: 3mm
can connected to earth
ΔG_{tr} (dB)
20
0
−20
−40
−60
0
2
4
6
8
10
I_E (mA) 12
f = 50MHz
200MHz
500MHz
900MHz
G_C = 0.25mΩ^{-1}
0.4mΩ^{-1}
0.5mΩ^{-1}
2mΩ^{-1}

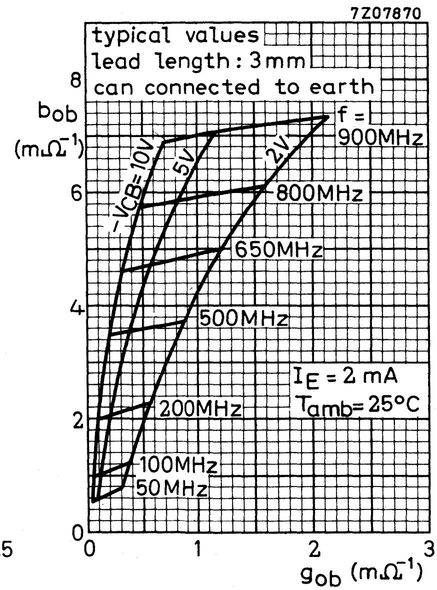

7Z07872
typical values
I_E = 2 mA
$-V_{CB}$ = 10V
T_j = 25°C
B_S = 0
lead length : 3mm
can connected to earth
F (dB)
G_S (mΩ^{-1})
8
6
4
2
0
40
30
20
10
0
noise figure
corresponding optimum source conductance
0.1
1.0
10
100
f (MHz)
1000

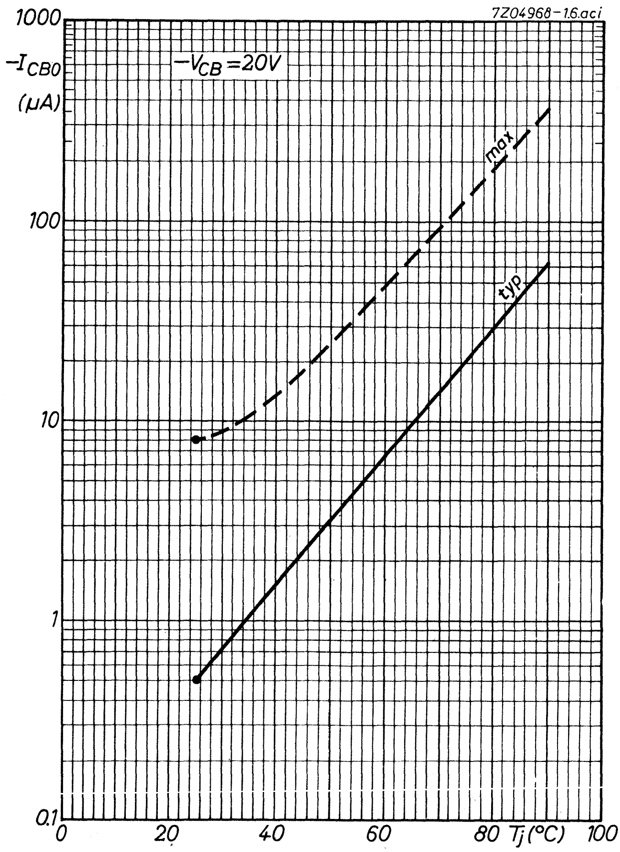

7Z07866
typical values
$-V_{CB} = 10V$
$T_{amb} = 25°C$
lead length: 3mm
can connected to earth
I_E =
o = 0.5mA
□ = 1 mA
● = 2 mA
■ = 4 mA
b_{ib} $(m\Omega^{-1})$
g_{ib} $(m\Omega^{-1})$
f=900MHz
800MHz
650MHz
500MHz
200MHz
100MHz
50MHz
20
0
−20
−40
−60
0
20
40
60
80
100
120


$|y_{rb}|$ $(\mu\Omega^{-1})$
1000
500
100
50
10
50
100
500
1000
180°
360°
210°
330°
240°
300°
270°
typical values
$-V_{CB} = 10V$
$T_{amb} = 25°C$
lead length: 3mm
can connected to earth
100MHz
200MHz
500MHz
650MHz
800MHz
900MHz
I_E = 4mA
2mA
1mA
0.5mA
7Z07869


7Z07868
typical values
lead length: 3 mm
can connected to earth
$-V_{CB}$ = 10 V
T_{amb} = 25 °C
I_E =
o = 0.5 mA
□ = 1 mA
• = 2 mA
■ = 4 mA
90°
120°
60°
150°
30°
180°
0
200MHz
500MHz
650MHz
800MHz
900MHz
100MHz
f = 50MHz
100 50 10 5 1 5 10 50 100
$|y_{fb}|$ (mΩ⁻¹)


7Z07871
typical values
lead length: 3 mm
can connected to earth
b_{ob} (mΩ⁻¹)
I_E = 0.5mA
4mA
f = 900MHz
800MHz
650MHz
500MHz
200MHz
100MHz
50MHz
$-V_{CB}$ = 10V
T_{amb} = 25°C
g_{ob} (mΩ⁻¹)


7Z07870
typical values
lead length: 3 mm
can connected to earth
b_{ob} (mΩ⁻¹)
$-V_{CB}$ = 10V
5V
2V
f = 900MHz
800MHz
650MHz
500MHz
200MHz
100MHz
50MHz
I_E = 2 mA
T_{amb} = 25°C
g_{ob} (mΩ⁻¹)


7Z04968-1.6.aci
1000
$-I_{CBO}$
(μA)
$-V_{CB}$=20V
max
100
typ
10
1
0.1
0
20
40
60
80
T_j(°C)
100

U.H.F. GERMANIUM MESA TRANSISTOR

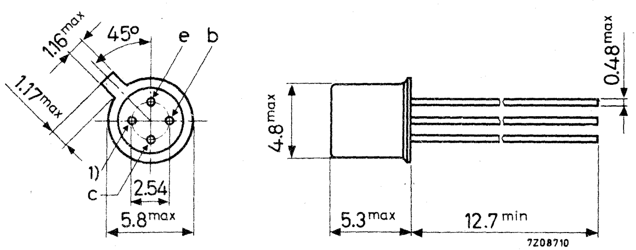
P-N-P transistor in a TO-72 metal envelope, primarily intended for use in pre-amplifier or mixer circuits up to frequencies of 890 MHz.

QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	20	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	15	V
Collector current (d.c.)	$-I_C$	max.	15	mA
Total power dissipation up to $T_{amb} = 45\ ^oC$	P_{tot}	max.	60	mW
Junction temperature	T_j	max.	90	^oC
Transition frequency $-I_C$ = 2 mA; $-V_{CE}$ = 10 V	f_T	typ.	780	MHz
Transducer gain at I_E = 2 mA; $-V_{CB}$ = 10 V f = 800 MHz; G_c = 0.5 $m\Omega^{-1}$	G_{tr}	typ.	15	dB
f = 900 MHz; G_c = 2 $m\Omega^{-1}$	G_{tr}	typ.	12	dB
Noise figure I_E = 2 mA; $-V_{CB}$ = 10 V G_S = 16.7 $m\Omega^{-1}$; B_S = 0 f = 800 MHz	F	<	5	dB
f = 900 MHz	F	<	6	dB

MECHANICAL DATA Dimensions in mm

TO-72



1) = shield lead (connected to case)

Accessories available: 56246, 56263

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

Voltages				
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	20	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	15	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	0.3	V
Currents				
Collector current (d.c.)	$-I_C$	max.	15	mA
Collector current (peak value)	$-I_{CM}$	max.	15	mA
Power dissipation				
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	60	mW
Temperatures				
Storage temperature	T_{stg}		-30 to +75	°C
Junction temperature	T_j	max.	90	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.75	°C/mW
From junction to case	$R_{th\ j-c}$	=	0.40	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
V_{EB} = 0; $-V_{CB}$ = 20 V	$-I_{CBS}$	typ.	0.5	µA
		<	8	µA
I_B = 0; $-V_{CE}$ = 15 V	$-I_{CEO}$	<	500	µA
Emitter cut-off current				
I_C = 0; $-V_{EB}$ = 0.3 V	$-I_{EBO}$	<	100	µA
Base current				
I_E = 2 mA; $-V_{CB}$ = 10 V	$-I_B$	typ.	60	µA
		<	200	µA
I_E = 5 mA; $-V_{CB}$ = 5 V	$-I_B$	typ.	167	µA
I_E = 10 mA; $-V_{CB}$ = 2 V	$-I_B$	<	1	mA

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

Emitter-base voltage

I_E = 2 mA; $-V_{CB}$ = 10 V	V_{EB}	typ.	350	mV
I_E = 5 mA; $-V_{CB}$ = 5 V	V_{EB}	typ.	400	mV

Transition frequency

$-I_C$ = 2 mA; $-V_{CE}$ = 10 V	f_T	typ.	780	MHz

Feedback capacitance at f = 1 MHz

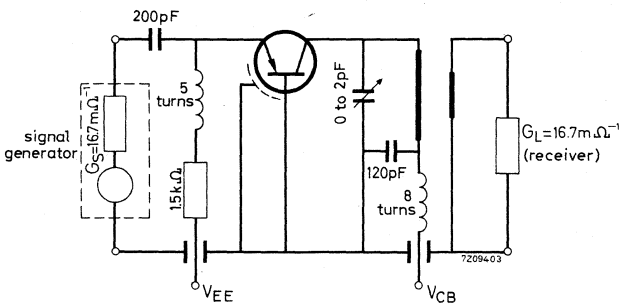
$-I_C$ = 2 mA; $-V_{CE}$ = 10 V	C_{re}	typ.	200	fF

Noise figure

I_E = 2 mA; $-V_{CB}$ = 10 V					
$G_S = 16.7\ m\Omega^{-1}$; B_S = 0	f = 800 MHz	F	<	5	dB
	f = 900 MHz	F	<	6	dB

Transducer gain at T_{amb} = 25 °C

Basic circuit for measuring the transducer gain G_{tr} at f = 800 and 900 MHz.

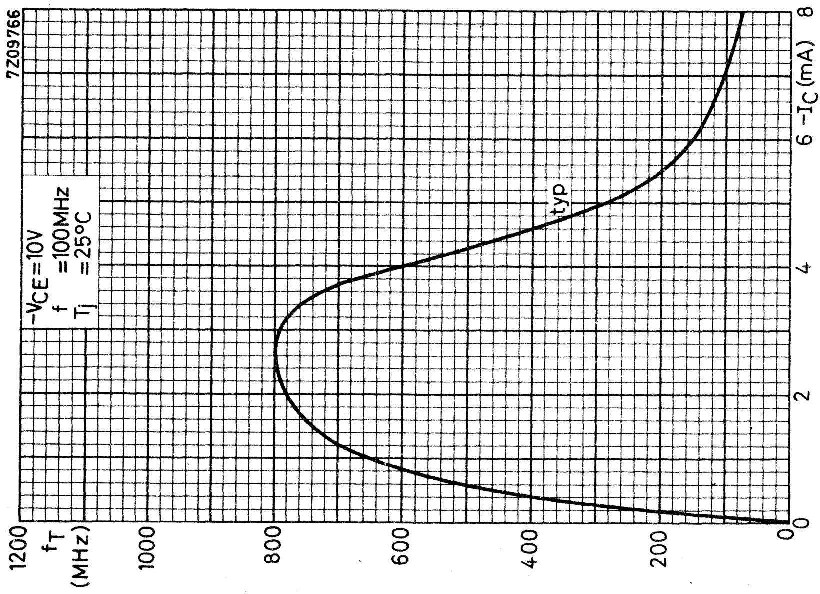


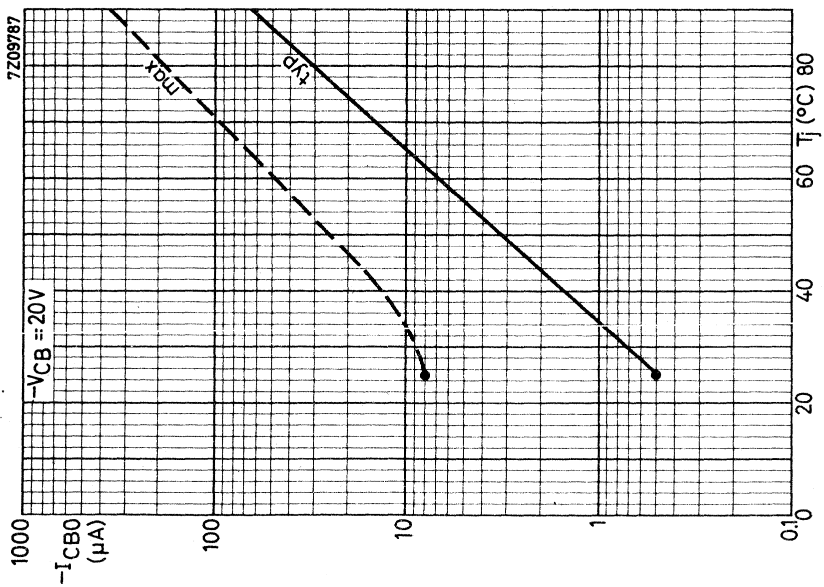
$$G_{tr} \text{ in dB} = 10 \log \frac{\text{output power in load } G_L}{\text{available power from source } G_S}$$

I_E = 2 mA; $-V_{CB}$ = 10 V; lead length: 3 mm; can connected to earth.

f = 800 MHz; $G_c = 0.5\ m\Omega^{-1}$	G_{tr}	typ.	15	dB
$G_c = 2\ m\Omega^{-1}$	G_{tr}	typ.	12.5	dB
f = 900 MHz; $G_c = 2\ m\Omega^{-1}$	G_{tr}	>	11	dB
		typ.	12	dB

G_c = total effective collector conductance.


7Z09766
$-V_{CE} = 10V$
$f = 100MHz$
$T_j = 25°C$
typ
f_T (MHz)
1200
1000
800
600
400
200
0
2
4
6
8
$-I_C$ (mA)


7Z09787
$-V_{CB} = 20V$
max
typ
$-I_{CBO}$ (μA)
1000
100
10
1
0.1
0
20
40
60
80
T_j (°C)

U.H.F. GERMANIUM PLANAR TRANSISTOR

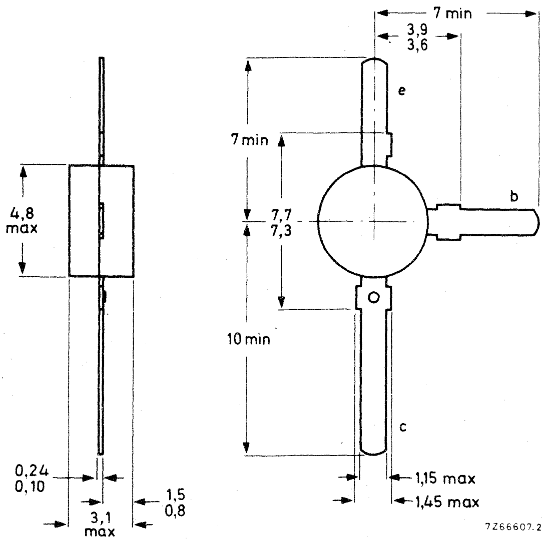
P-N-P transistors in a plastic T-pack, primarily intended for use in pre-amplifier circuits with frequencies up to 890 MHz.

QUICK REFERENCE DATA				
Collector-base voltage (V_{EB} = 0)	$-V_{CBS}$	max.	20	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	15	V
Collector current (d.c.)	$-I_C$	max.	10	mA
Total power dissipation up to T_{amb} = 54 ^oC	P_{tot}	max.	60	mW
Junction temperature	T_j	max.	90	^oC
Transition frequency				
I_E = 2 mA; $-V_{CB}$ = 10 V	f_T	typ.	800	MHz
Transducer gain				
I_E = 2 mA; $-V_{CB}$ = 10 V; f = 900 MHz	G_{tr}	typ.	12	dB
Noise figure				
I_E = 2 mA; $-V_{CB}$ = 10 V G_S = 16,7 mA/V; B_S = 0 f = 900 MHz	F	<	6	dB

MECHANICAL DATA

Dimensions in mm

SOT-37



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

Voltages

Collector-base voltage ($-V_{EB}$ = 0)	$-V_{CBS}$	max.	20	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	15	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	0,3	V

Currents

Collector current (d.c.)	$-I_C$	max.	10	mA
Base current	$-I_B$	max.	1	mA

Power dissipation

Total power dissipation up to T_{amb} = 54 °C	P_{tot}	max.	60	mW

Temperatures

Storage temperature	T_{stg}		−30 to +75	°C
Junction temperature	T_j	max.	90	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0,6	°C/mW

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

Collector cut-off current				
$V_{EB} = 0;\ -V_{CB} = 20$ V	$-I_{CBS}$	typ.	2	µA
		<	15	µA
$I_B = 0;\ -V_{CE} = 15$ V	$-I_{CEO}$	<	500	µA
Emitter cut-off current				
$I_C = 0;\ -V_{EB} = 0,3$ V	$-I_{EBO}$	<	100	µA
Base current				
$I_E = 2$ mA; $-V_{CB} = 10$ V	$-I_B$	<	200	µA
$I_E = 10$ mA; $-V_{CB} = 2$ V	$-I_B$	<	1	mA
Emitter-base voltage				
$I_E = 2$ mA; $-V_{CB} = 10$ V	V_{EB}	typ.	350	mV
Transition frequency at f = 100 MHz				
$I_E = 2$ mA; $-V_{CB} = 10$ V	f_T	typ.	800	MHz
Feedback capacitance at f = 0,45 MHz				
$I_E = 2$ mA; $-V_{CB} = 10$ V	C_{re}	typ.	0,4	pF
Noise figure at f = 900 MHz				
$I_E = 2$ mA; $-V_{CB} = 10$ V; $G_S = 16,7$ mA/V; $B_S = 0$	F	<	6	dB

Transducer gain at f = 900 MHz (common base)

$$G_{tr}\ (\text{in dB}) = 10 \log \frac{\text{output power in load } G_L}{\text{available power from source } G_S}$$

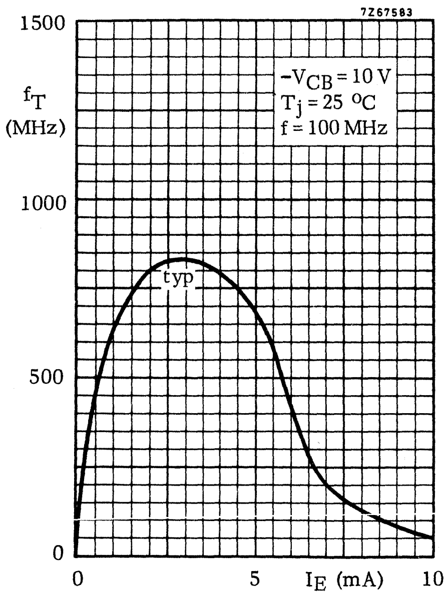
$I_E = 2$ mA; $-V_{CB} = 10$ V; $T_{amb} = 25\ ^oC$				
$G_S = 16,7$ mA/V; $G_L = 2$ mA/V	G_{tr}	>	10,5	dB
		typ.	12	dB

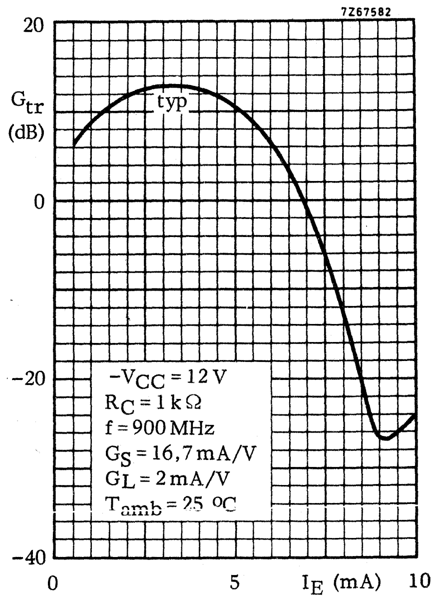
CHARACTERISTICS (continued)

y parameters (common base) at f = 900 MHz

I_E = 2 mA; $-V_{CB}$ = 10 V

Input admittance	y_{ib}	typ.	18 - j27	mA/V
Feedback admittance	$\lvert y_{rb} \rvert$	typ.	0, 6	mA/V
Phase angle of the feedback admittance	φ_{rb}	typ.	270°	
Transfer admittance	$\lvert y_{fb} \rvert$	typ.	26	mA/V
Phase angle of the transfer admittance	φ_{fb}	typ.	55°	
Output admittance	y_{ob}	typ.	0, 5 + j3, 5	mA/V





U.H.F. GERMANIUM PLANAR TRANSISTOR

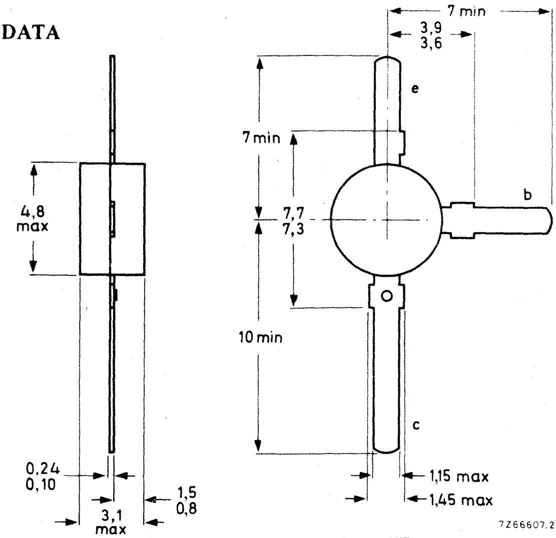
P-N-P transistors in a plastic T-pack, intended for use in mixer and oscillator circuits with frequencies up to 890 MHz.

QUICK REFERENCE DATA				
Collector-base voltage (V_{EB} = 0)	$-V_{CBS}$	max.	20	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	15	V
Collector current (d.c.)	$-I_C$	max.	10	mA
Total power dissipation up to T_{amb} = 54 °C	P_{tot}	max.	60	mW
Junction temperature	T_j	max.	90	°C
Transition frequency				
I_E = 2 mA; $-V_{CE}$ = 10 V	f_T	typ.	550	MHz
Transducer gain				
I_E = 2 mA; $-V_{CE}$ = 10 V; f = 900 MHz	G_{tr}	typ.	10,5	dB
Noise figure				
I_E = 2 mA; $-V_{CE}$ = 10 V G_S = 16,7 mA/V; B_S = 0 f = 900 MHz	F	typ.	6,5	dB

MECHANICAL DATA

SOT-37

Dimensions in mm



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

Voltages

Collector-base voltage (V_{BE} = 0)	$-V_{CBS}$	max.	20	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	15	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	0,3	V

Currents

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

Power dissipation

Total power dissipation up to T_{amb} = 54 °C	P_{tot}	max.	60	mW

Temperatures

Storage temperature	T_{stg}		−30 to +75	°C
Junction temperature	T_j	max.	90	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0,6	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

V_{EB} = 0; $-V_{CB}$ = 20 V	$-I_{CBS}$	typ.	0,8	μA
		<	15	μA
I_B = 0; $-V_{CE}$ = 15 V	$-I_{CEO}$	<	500	μA

Emitter cut-off current

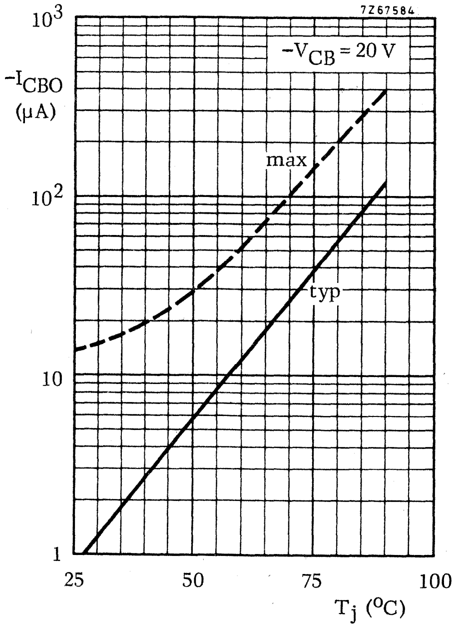
I_C = 0; $-V_{EB}$ = 0,3 V	$-I_{EBO}$	<	100	μA

D.C. current gain

$-I_C$ = 2 mA; $-V_{CE}$ = 10 V	h_{FE}	>	10	
$-I_C$ = 10 mA; $-V_{CE}$ = 1 V	h_{FE}	>	10	

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

Base-emitter voltage				
$-I_C$ = 2 mA; $-V_{CE}$ = 10 V	$-V_{BE}$	typ.	370	mV
Transition frequency at f = 100 MHz				
$-I_C$ = 2 mA; $-V_{CE}$ = 10 V	f_T	typ.	550	MHz
Feedback capacitance at f = 450 kHz				
$-I_C$ = 2 mA; $-V_{CE}$ = 10 V	C_{re}	typ.	400	fF
Output capacitance at f = 800 MHz				
$-I_C$ = 2 mA; $-V_{CE}$ = 10 V	C_{ob}	typ.	500	fF
Noise figure at f = 900 MHz				
$-I_C$ = 2 mA; $-V_{CE}$ = 10 V G_S = 16,7 mA/V; B_S = 0	F	typ.	6,5	dB
Transducer gain at f = 900 MHz (common base)				
G_{tr} (in dB) = $10\log\frac{\text{output power in load } G_L}{\text{available power from source } G_S}$				
$-I_C$ = 2 mA; $-V_{CE}$ = 10 V; T_{amb} = 25 °C G_L = 2 mA/V; G_S = 16,7 mA/V	G_{tr}	> typ.	9 10,5	dB dB


7Z67584
$-V_{CB} = 20$ V
$-I_{CBO}$
(μA)
10^3
10^2
10
1
max
typ
25
50
75
100
T_j (°C)

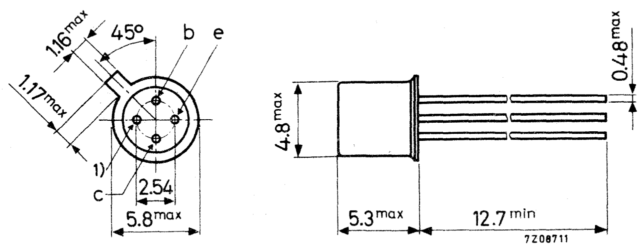
SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in TO-72 metal case with insulated electrodes and a shield lead connected to the case; the same transistor is available in lock-fit encapsulation under the type number BF194 or BF195. It is intended for general broadcast and television.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	50	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	V
Collector current (d.c.)	I_C	max.	30	mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	145	mW
Junction temperature	T_j	max.	175	°C
Transition frequency				
I_C = 1 mA; V_{CE} = 10 V	f_T	typ.	230	MHz
Noise figure				
I_C = 1 mA; V_{CE} = 10 V				
f = 1 MHz; G_S = 3.3 mΩ^{-1}	F	typ.	1.2	dB
f = 100 MHz; G_S = 10 mΩ^{-1}	F	typ.	4	dB

MECHANICAL DATA Dimensions in mm

TO-72



1) = shield lead (connected to case)

Accessories available: 56246, 56263.

FOR NEW DESIGN THE SUCCESSOR TYPES
BF494 OR BF495 ARE RECOMMENDED

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	50	V
Collector-emitter voltage (open base) (See also page 5)	V_{CEO}	max.	30	V
Collector-emitter voltage (see page 5)	V_{CER}	max.	50	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Currents

Collector current (d.c.)	I_C	max.	30	mA
Collector current (peak value)	I_{CM}	max.	30	mA

Power dissipation

Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	145	mW

Temperatures

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

THERMAL RESISTANCE

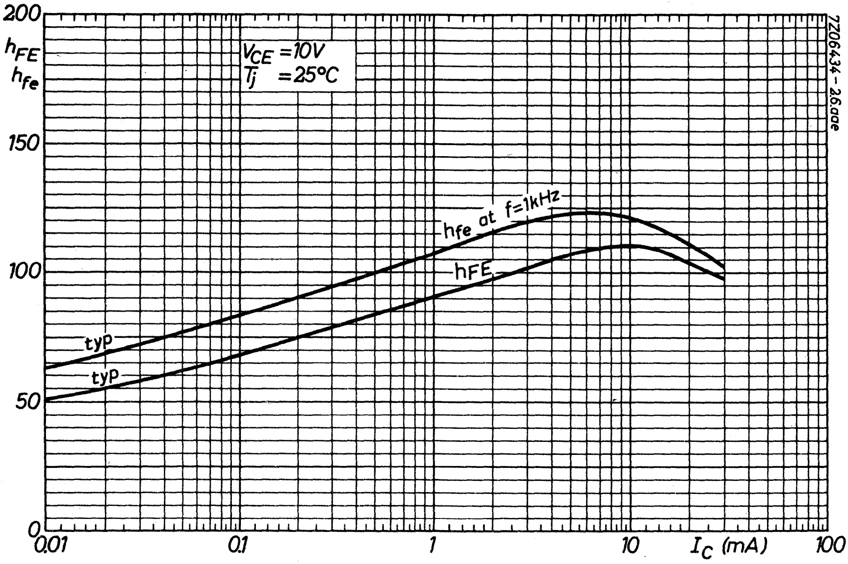
From junction to ambient in free air	$R_{th\ j-a}$	=	0.9	°C/mW

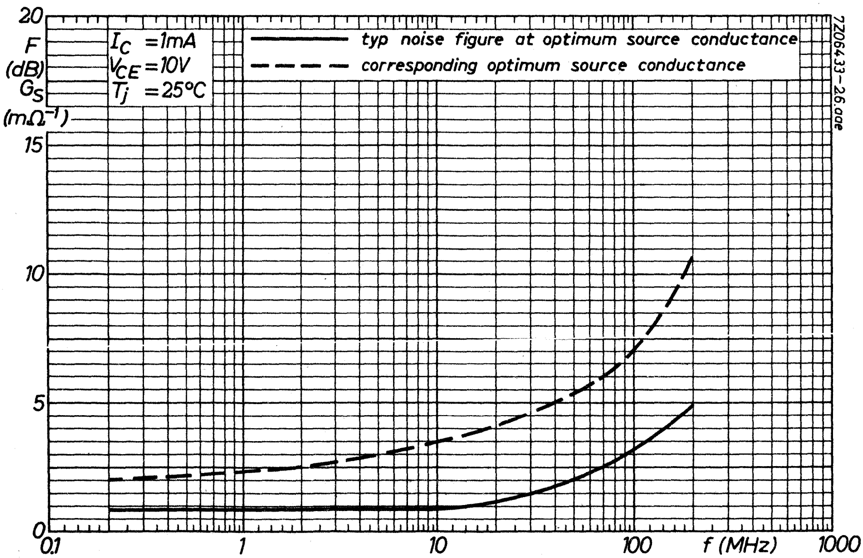
1) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

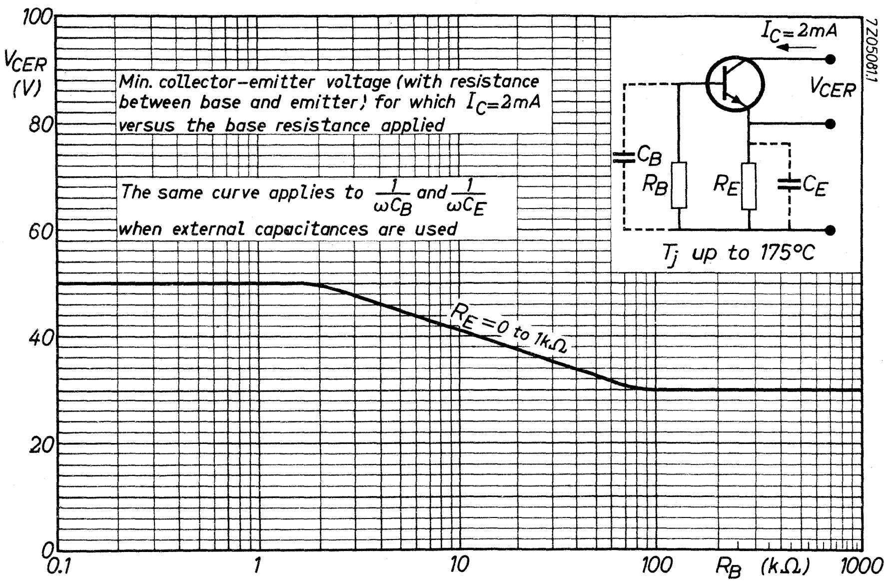
CHARACTERISTICS T_j = 25 °C unless otherwise specified

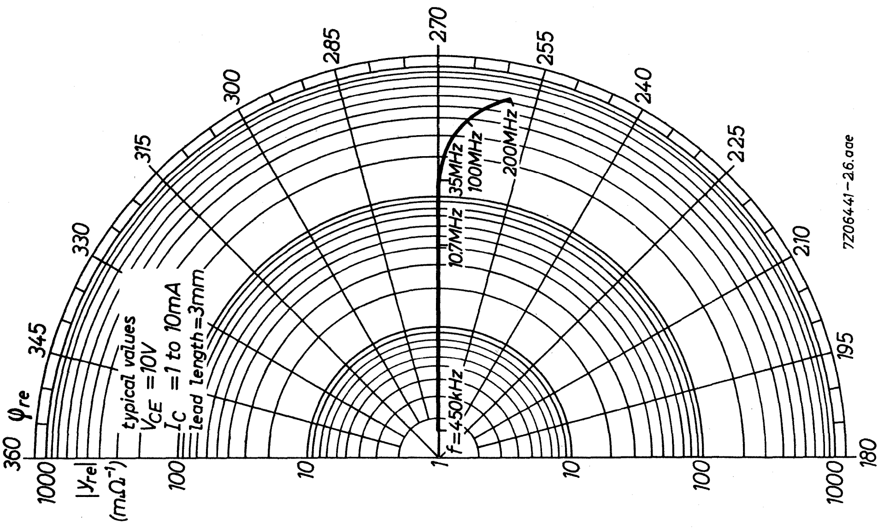
Emitter-base voltage [1]				
$-I_E$ = 1 mA; V_{CB} = 10 V	$-V_{EB}$		0.65 to 0.74	V
$-I_E$ = 20 mA; V_{CB} = 2 V; T_{amb} = 25 °C	$-V_{EB}$	<	1.0	V
Feedback capacitance at f = 0.45 MHz				
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	0.65	pF
D.C. current gain				
I_C = 1 mA; V_{CE} = 10 V	h_{FE}		45 to 165	
I_C = 20 mA; V_{CE} = 2 V	h_{FE}	>	40	
Transition frequency				
I_C = 1 mA; V_{CE} = 10 V	f_T	typ.	230	MHz
Noise figure at I_C = 1 mA; V_{CE} = 10 V				
f = 0.2 MHz; G_S = 3.3 mΩ^{-1}	F	typ.	1.5	dB
f = 1 MHz; G_S = 20 mΩ^{-1}	F	typ.	3.5	dB
f = 1 MHz; G_S = 3.3 mΩ^{-1}	F	typ.	1.2	dB
f = 100 MHz; G_S = 10 mΩ^{-1}	F	typ.	4	dB
Conversion noise figure at I_C = 1 mA; V_{CE} = 10 V				
f = 0.2 MHz; G_S = 1 mΩ^{-1}	F_c	typ.	3.5	dB
f = 1 MHz; G_S = 2 mΩ^{-1}	F_c	typ.	2.5	dB

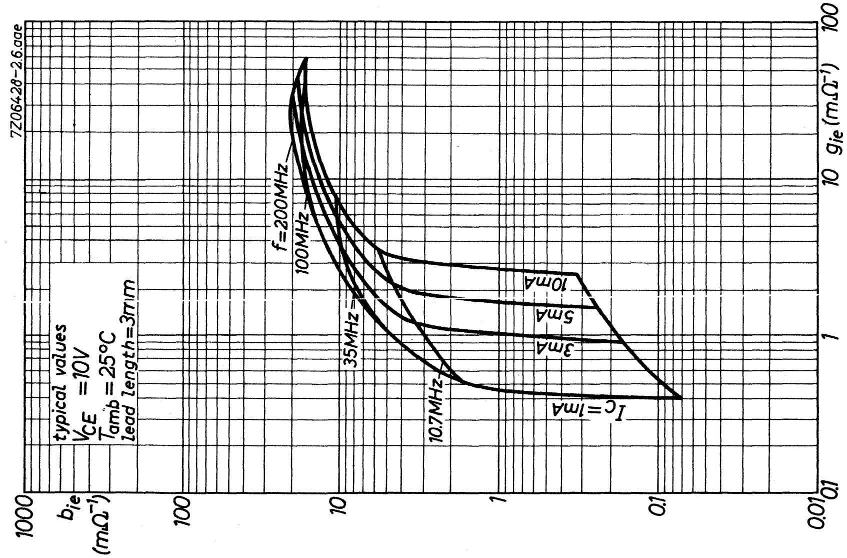
[1]) $-V_{EB}$ decreases by about 1.7 mV/°C with increasing temperature.

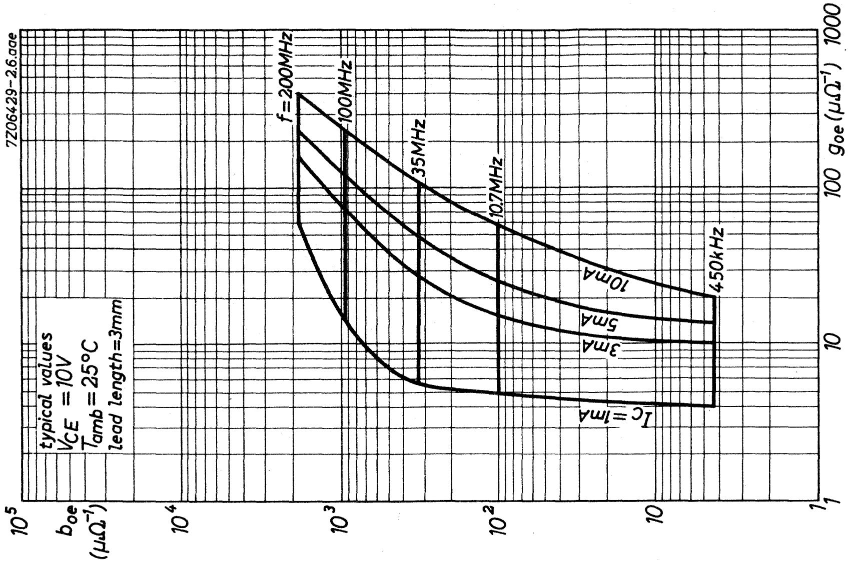

200
h_{FE}
h_{fe}
150
100
50
0
V_{CE} =10V
T_j =25°C
h_{fe} at f=1kHz
h_{FE}
typ
typ
0.01
0.1
1
10
I_C (mA)
100
7Z06434-26.aae

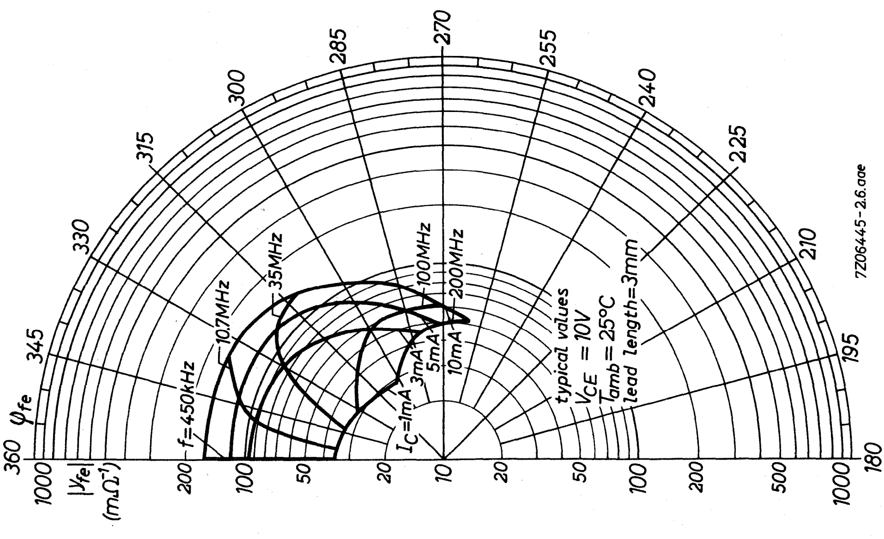

20
F
(dB)
G_S
$(m\Omega^{-1})$
15
10
5
0
I_C =1mA
V_{CE}=10V
T_j =25°C
typ noise figure at optimum source conductance
corresponding optimum source conductance
0.1
1
10
100
f (MHz)
1000
7Z06433-26.aae

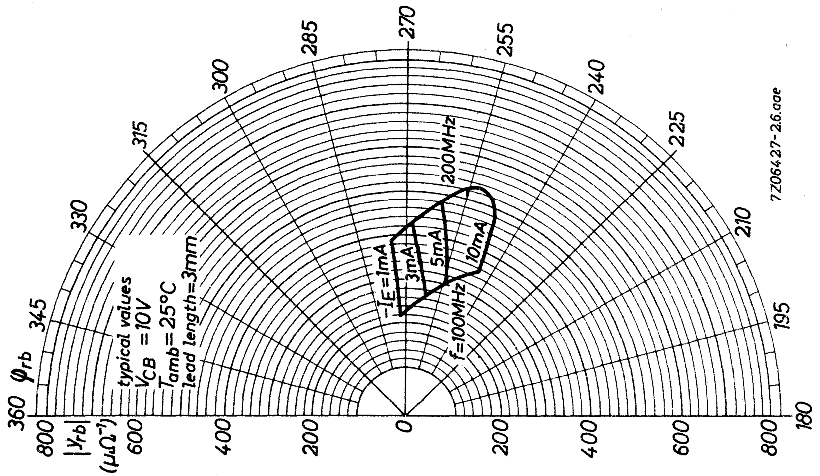

100
V_{CER}
(V)
80
60
40
20
0
0.1
1
10
100
R_B (kΩ)
1000
Min. collector-emitter voltage (with resistance between base and emitter) for which I_C=2mA versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$ when external capacitances are used
R_E = 0 to 1kΩ
I_C=2mA
V_{CER}
C_B
R_B
R_E
C_E
T_j up to 175°C
7Z05081.1

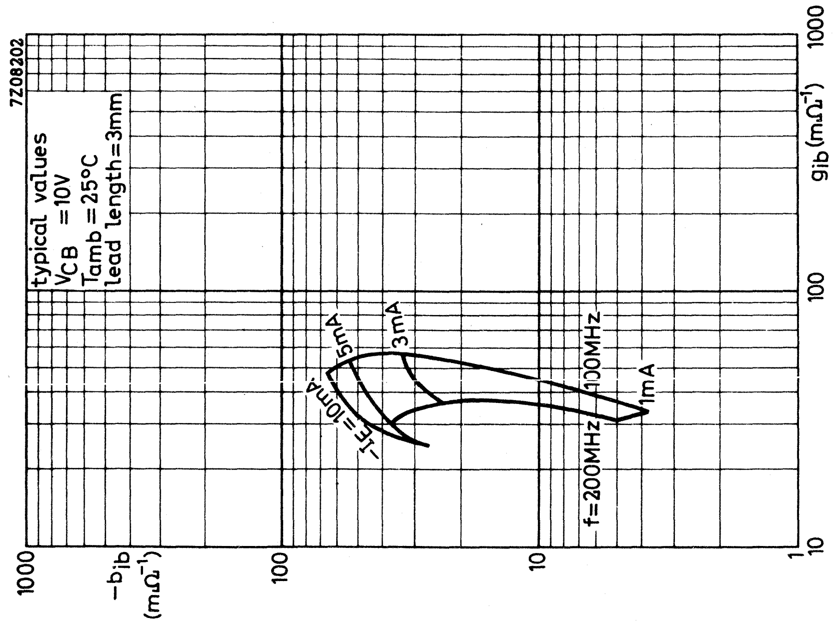

typical values
V_{CE} = 10V
I_C = 1 to 10mA
lead length = 3mm
φ_{re}
$|y_{re}|$ ($m\Omega^{-1}$)
f = 450kHz
10.7MHz
35MHz
100MHz
200MHz
7Z06441-2.6.aae

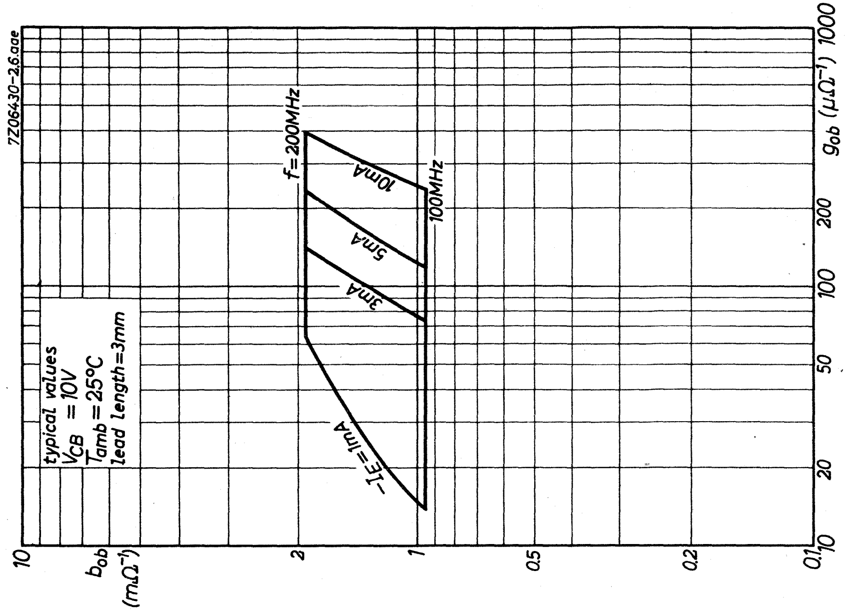

typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length = 3mm
b_{ie} ($m\Omega^{-1}$)
g_{ie} ($m\Omega^{-1}$)
f = 200MHz
100MHz
35MHz
10.7MHz
I_C = 1mA
3mA
5mA
10mA
7Z06428-2.6.aae

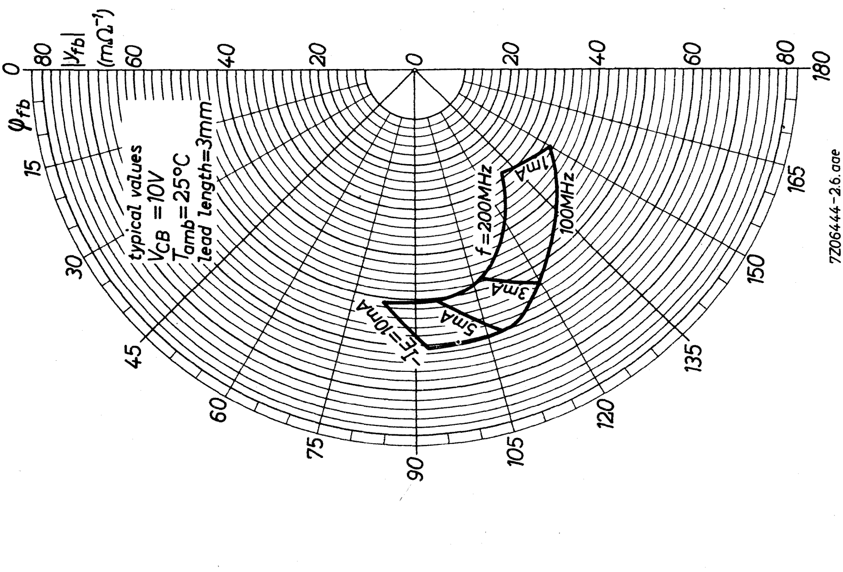

7Z06429-2.6.aae
typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length = 3mm
f = 200MHz
100MHz
35MHz
10.7MHz
450kHz
10mA
5mA
3mA
I_C = 1mA
b_{oe} ($\mu\Omega^{-1}$)
g_{oe} ($\mu\Omega^{-1}$)


7Z06445-2.6.aae
φ_{fe}
$|y_{fe}|$ ($m\Omega^{-1}$)
f = 450kHz
10.7MHz
35MHz
100MHz
200MHz
I_C = 1mA
3mA
5mA
10mA
typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length = 3mm


typical values
V_{CB} = 10V
T_{amb} = 25°C
lead length = 3mm
φ_{rb}
$|y_{rb}|$ ($\mu\Omega^{-1}$)
$-I_E$ = 1mA
3mA
5mA
10mA
f = 100MHz
200MHz
7Z06427-2.6.aae


7Z08202
typical values
V_{CB} = 10V
Tamb = 25°C
lead length = 3mm
$-b_{ib}$ ($m\Omega^{-1}$)
g_{ib} ($m\Omega^{-1}$)
$-I_E$ = 10mA
5mA
3mA
1mA
100MHz
f = 200MHz


7Z06430-2.6.aae
typical values
V_{CB} = 10V
T_{amb} = 25°C
lead length = 3mm
f = 200MHz
100MHz
10mA
5mA
3mA
$-I_E$ = 1mA
b_{ob}
($m\Omega^{-1}$)
g_{ob} ($\mu\Omega^{-1}$)
10
2
1
0.5
0.2
0.1
10
20
50
100
200
1000


7Z06444-2.6.aae
φ_{fb}
$|y_{fb}|$
($m\Omega^{-1}$)
typical values
V_{CB} = 10V
T_{amb} = 25°C
lead length = 3mm
f = 200MHz
100MHz
1mA
3mA
5mA
$-I_E$ = 10mA
0
15
30
45
60
75
90
105
120
135
150
165
180
80
60
40
20
0
20
40
60
80

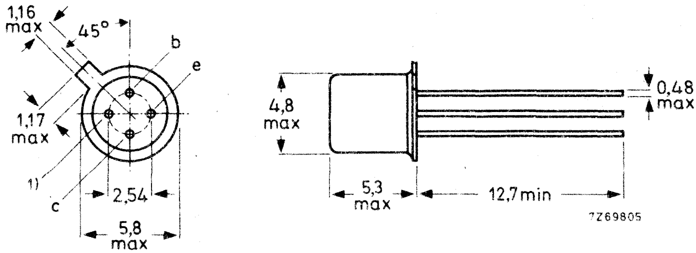
SILICON PLANAR TRANSISTOR

N-P-N transistor in a TO-72 metal envelope intended for use in forward gain control stages in video intermediate frequency amplifiers of television receivers.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	V
Collector current (d.c.)	I_C	max.	25	mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	130	mW
Junction temperature	T_j	max.	175	°C
Transition frequency I_C = 4 mA; V_{CE} = 10 V	f_T	typ.	350	MHz
Feedback capacitance at f = 10,7 MHz I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	0,15	pF
Max. unilateralized power gain I_C = 4 mA; V_{CE} = 10 V; f = 35 MHz	G_{UM}	typ.	42	dB
Gain control range	ΔG_{tr}	typ.	60	dB

MECHANICAL DATA Dimensions in mm

TO-72



1) = shield lead (connected to case)

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

FOR NEW DESIGN THE TYPE BF198 IS RECOMMENDED

RATINGS (Limiting values) [1]

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base) (See also page 5)	V_{CEO}	max.	30	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4	V

Currents

Collector current (d.c.)	I_C	max.	25	mA
Collector current (peak value)	I_{CM}	max.	25	mA

Power dissipation

Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	130	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	$R_{th\ j\text{-}a}$		1.0	°C/mW

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

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

Base current				
I_C = 4 mA; V_{CE} = 10 V	I_B	typ.	70	µA
		<	150	µA
Base-emitter voltage				
I_C = 4 mA; V_{CE} = 10 V	V_{BE}	typ.	700	mV [1]
Feedback capacitance at f = 10.7 MHz				
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	150	fF [2]
Transition frequency				
I_C = 4 mA; V_{CE} = 10 V	f_T	typ.	350	MHz
Noise figure at f = 35 MHz				
I_C = 4 mA; V_{CE} = 10 V; G_S = 10 mΩ^{-1}; B_S = 0	F	typ.	3	dB
y parameters at f = 35 MHz				
I_C = 4 mA; V_{CE} = 10 V				
Input conductance	g_{ie}	typ.	4.8	mΩ^{-1}
Input capacitance	C_{ie}	typ.	45	pF
Feedback admittance	$\|y_{re}\|$	typ.	37	µΩ^{-1}
Phase angle of feedback admittance	φ_{re}	typ.	268°	
Transfer admittance	$\|y_{fe}\|$	typ.	95	mΩ^{-1}
Phase angle of transfer admittance	φ_{fe}	typ.	337°	
Output conductance	g_{oe}	typ.	30	µΩ^{-1}
Output capacitance	C_{oe}	typ.	1.2	pF

Maximum unilateralised power gain

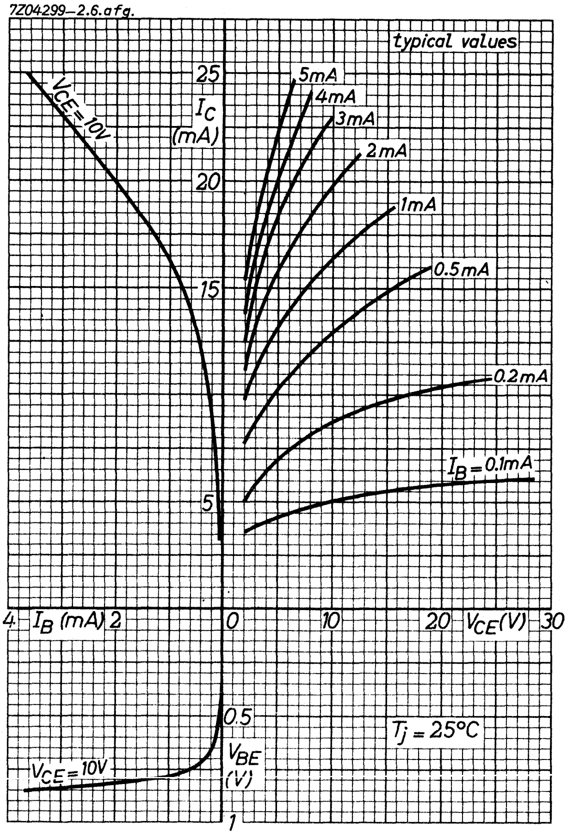
$$G_{UM} = \frac{|y_{fe}|^2}{4\ g_{ie}\ g_{oe}}$$

I_C = 4 mA; V_{CE} = 10 V; f = 35 MHz	G_{UM}	typ.	42	dB

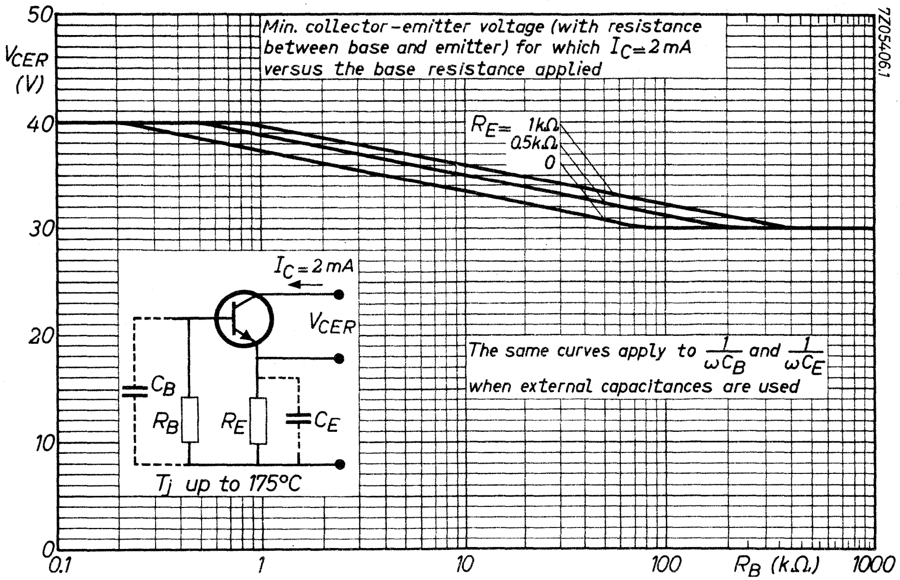
---

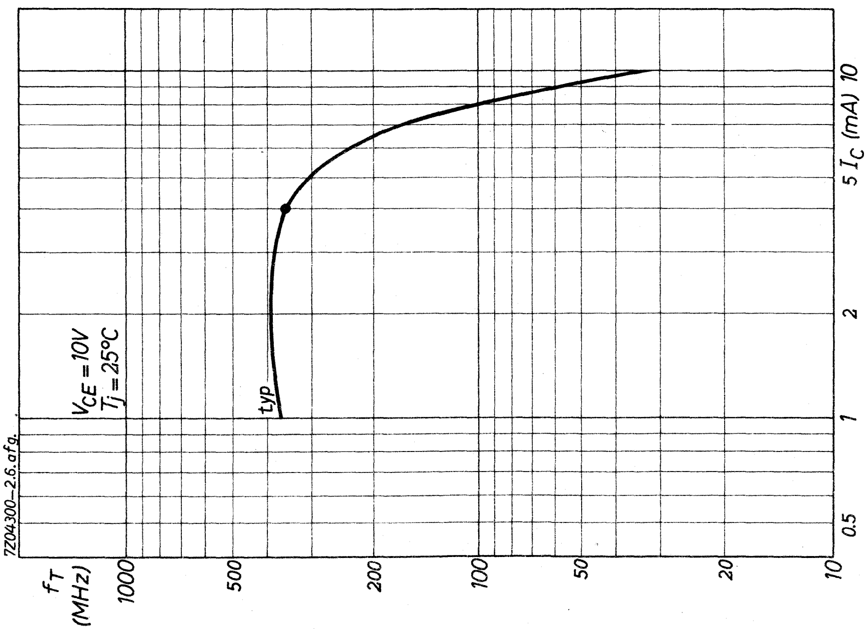
[1]) V_{BE} decreases with about 1.7 mV/°C at increasing temperature

[2]) 1 fF = 1 femtofarad = 10^{-15} F



7Z04299–2.6.afg.
typical values
V_{CE} = 10V
25
I_C (mA)
20
15
5
5mA
4mA
3mA
2mA
1mA
0.5mA
0.2mA
I_B = 0.1mA
4
I_B (mA)
2
0
10
20
V_{CE}(V)
30
0.5
V_{BE} (V)
1
T_j = 25°C
V_{CE} = 10V


Min. collector-emitter voltage (with resistance between base and emitter) for which $I_C = 2$ mA versus the base resistance applied
7Z054061
V_{CER} (V)
50
40
30
20
10
0
$R_E =$ 1kΩ
0.5kΩ
0
$I_C = 2$ mA
V_{CER}
C_B
R_B
R_E
C_E
T_j up to 175°C
The same curves apply to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$ when external capacitances are used
0.1
1
10
100
R_B (kΩ)
1000


$V_{CE} = 10$ V
$T_j = 25$°C
typ
7Z04300-2.6.afg.
I_C (mA)
10
5
2
1
0.5
f_T (MHz)
1000
500
200
100
50
20
10

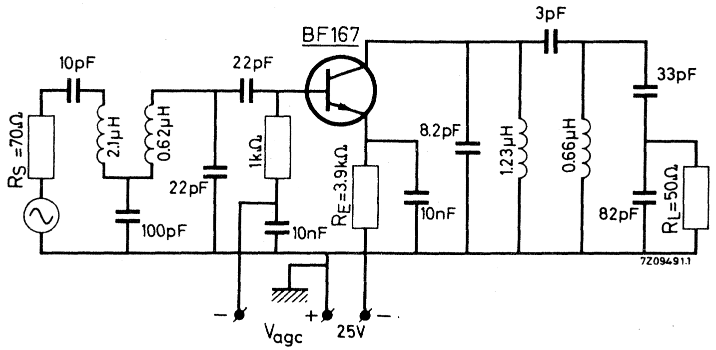
APPLICATION INFORMATION

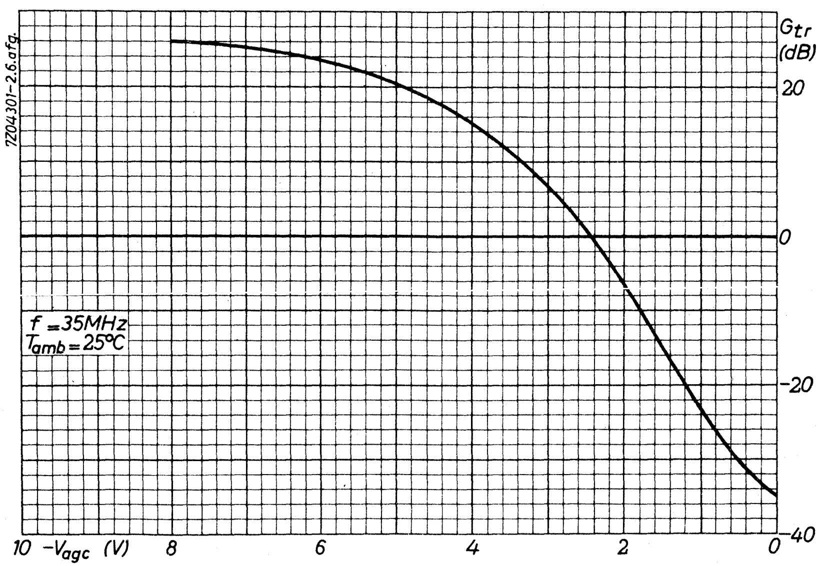
First stage of an intermediate frequency amplifier with a BF167 transistor. (Basic circuit with voltage gain control).

Transducer gain

$$G_{tr} = \frac{\text{output power in load } R_L}{\text{available power from source with } R_S}$$

I_C = 4 mA; f = 35 MHz	G_{tr}	typ.	26	dB
Gain control range	ΔG_{tr}	typ.	60	dB





SILICON PLANAR EPITAXIAL TRANSISTOR

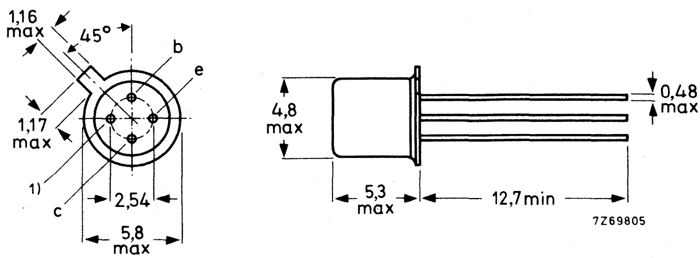
N-P-N transistor in a TO-72 metal envelope intended for use in video intermediate frequency amplifiers, in particular for the output stages.

QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Collector current (d.c.)	I_C	max.	25	mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	260	mW
Junction temperature	T_j	max.	175	°C
Transition frequency I_C = 5 mA; V_{CE} = 10 V	f_T	typ.	550	MHz
Feedback capacitance at f = 10,7 MHz I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	0,23	pF
Max. unilateralized power gain I_C = 7 mA; V_{CE} = 10 V; f = 35 MHz	G_{UM}	typ.	42,5	dB
Output voltage in the circuit of page 4	V_O	typ.	7,7	V

MECHANICAL DATA Dimensions in mm

TO-72



1) = shield lead (connected to case)

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

FOR NEW DESIGN THE TYPE BF199 IS RECOMMENDED

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base) (See also page A)	V_{CEO}	max.	25	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4	V

Currents

Collector current (d.c.)	I_C	max.	25	mA
Collector current (peak value)	I_{CM}	max.	25	mA

Power dissipation

Total power dissipation up to T_{amb} = 45 °C with cooling fin No. 56263 [2])	P_{tot}	max.	260	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	$R_{th\,j\text{-}a}$	=	0.65	°C/mW
From junction to ambient with cooling fin No. 56263	$R_{th\,j\text{-}a}$	=	0.5	°C/mW

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

[2]) Peak power dissipation see page 5.

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

Base current				
I_C = 7 mA; V_{CE} = 10 V	I_B	typ.	80	µA
		<	185	µA
Base-emitter voltage				
I_C = 7 mA; V_{CE} = 10 V	V_{BE}	typ.	740	mV [1])
		<	900	mV
Feedback capacitance at f = 10.7 MHz				
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	230	fF [2])
Transition frequency				
I_C = 5 mA; V_{CE} = 10 V	f_T	typ.	550	MHz
y parameters at f = 35 MHz				
I_C = 7 mA; V_{CE} = 10 V				
Input conductance	g_{ie}	typ.	4.5	$m\Omega^{-1}$
Input capacitance	C_{ie}	typ.	45	pF
Feedback admittance	$\|y_{re}\|$	typ.	55	$\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{re}	typ.	266°	
Transfer admittance	$\|y_{fe}\|$	typ.	145	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fe}	typ.	338°	
Output conductance	g_{oe}	typ.	65	$\mu\Omega^{-1}$
Output capacitance	C_{oe}	typ.	2.1	pF

Maximum unilateralised power gain

$$G_{UM} = \frac{|y_{fe}|^2}{4\, g_{ie}\, g_{oe}}$$

I_C = 7 mA; V_{CE} = 10 V; f = 35 MHz	G_{UM}	typ.	42.5	dB

---

1) V_{BE} decreases with about 1.7 mV/°C at increasing temperature

2) 1 fF = 1 femtofarad = 10^{-15} F

APPLICATION INFORMATION

Output stage of an intermediate frequency amplifier with a BF173 transistor.

Output voltage of the i.f. output stage

Voltage across the detector load R_L = 2.7 kΩ
for 30% synchronisation pulse compression

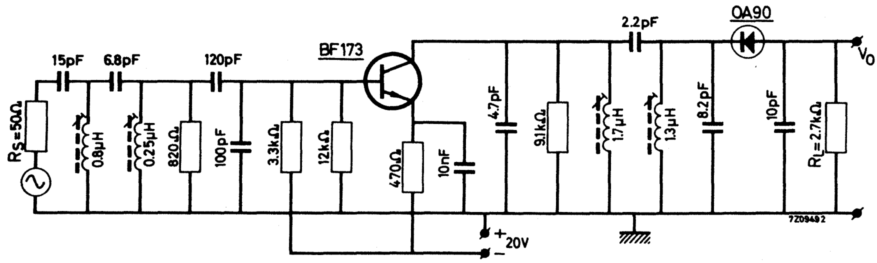
f = 38.9 MHz; I_C = 7.2 mA; V_{CE} = 16.6 V — V_O > 6 V; typ. 7.7 V

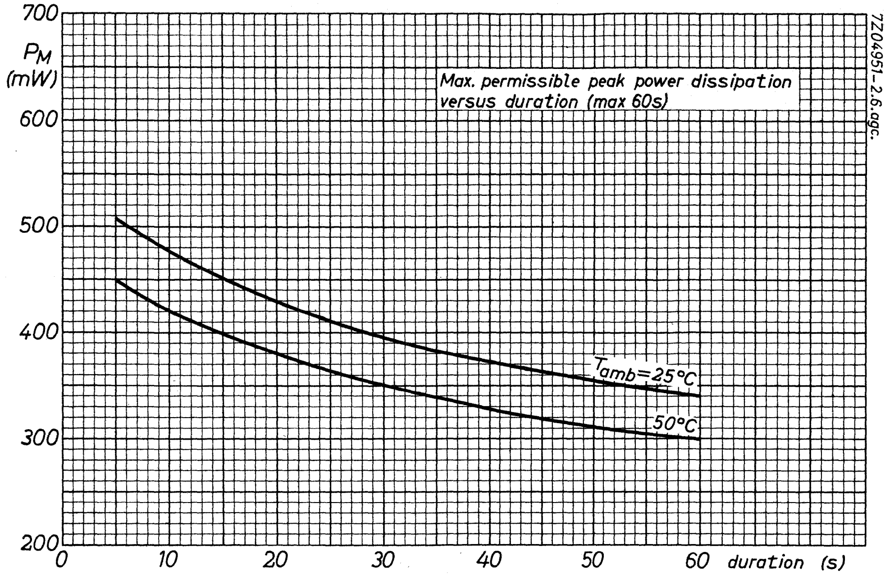
Transducer gain

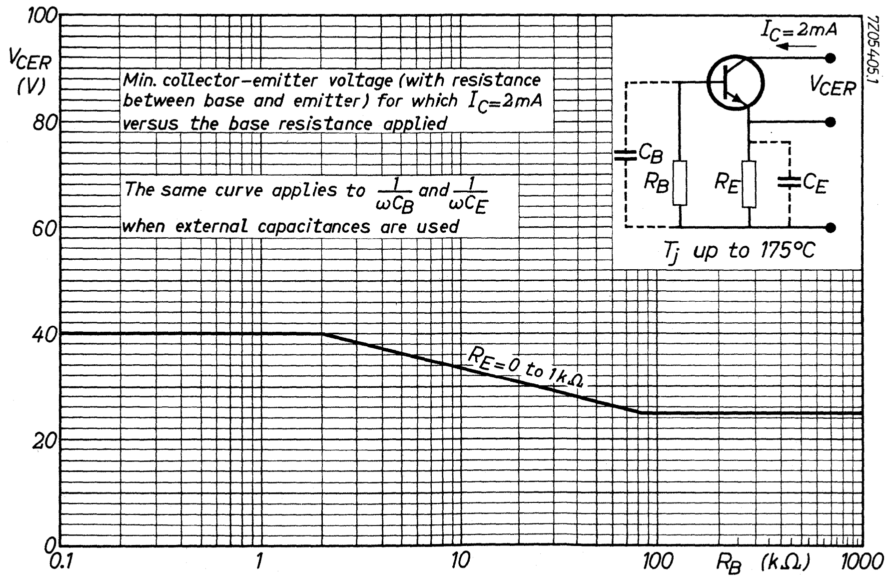
$$G_{tr} = \frac{\text{output power in load } R_L}{\text{available power from source with } R_S}$$

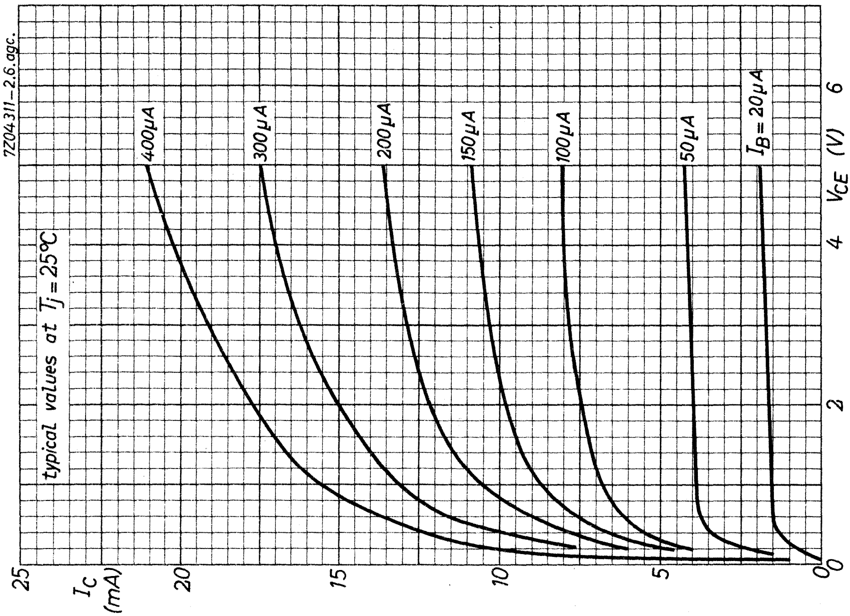
f = 36.4 MHz; I_C = 7.2 mA; V_{CE} = 16.6 V — G_{tr} typ. 26 dB

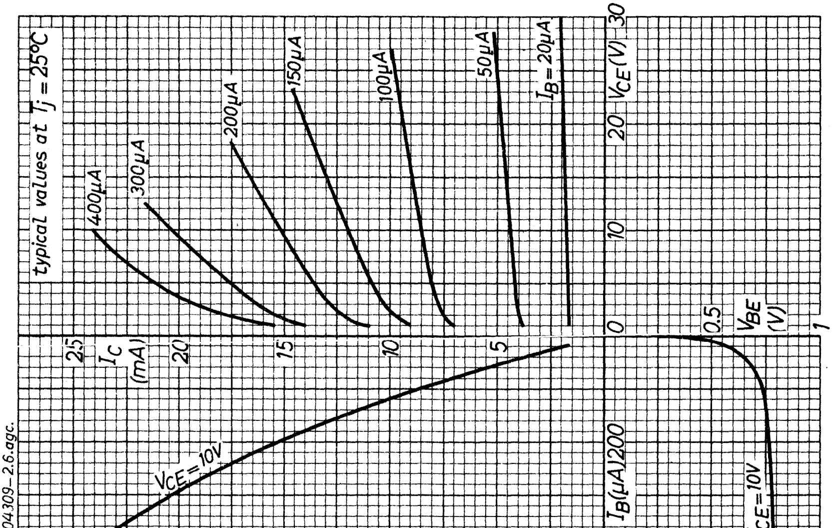
Tuning frequency for all tuned circuits is 37 MHz




7Z04951-2.6.agc.
Max. permissible peak power dissipation versus duration (max 60s)
P_M (mW)
700
600
500
400
300
200
T_{amb}=25°C
50°C
0
10
20
30
40
50
60
duration (s)


7Z05405.1
V_{CER} (V)
100
80
60
40
20
0
Min. collector-emitter voltage (with resistance between base and emitter) for which I_C=2mA versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$ when external capacitances are used
I_C=2mA
V_{CER}
C_B
R_B
R_E
C_E
T_j up to 175°C
R_E=0 to 1kΩ
0.1
1
10
100
R_B (kΩ)
1000


7Z04311–2.6.agc.
typical values at $T_j = 25°C$
400μA
300μA
200μA
150μA
100μA
50μA
$I_B = 20\,\mu A$
V_{CE} (V)
I_C (mA)
0
2
4
6
5
10
15
20
25


7Z04309–2.6.agc.
typical values at $T_j = 25°C$
400μA
300μA
200μA
150μA
100μA
50μA
$I_B = 20\,\mu A$
V_{CE}(V)
0
10
20
30
I_C (mA)
25
20
15
10
5
$V_{CE} = 10V$
I_B(μA)200
400
0.5
1
V_{BE} (V)
$V_{CE} = 10V$

VIDEO OUTPUT TRANSISTORS

N-P-N transistors in a TO-39 metal envelope with the collector connected to the case.
The BF177 is intended for tiny-vision black and white television receivers.
The BF178 and BF179 for application in large screen black and white television receivers.

QUICK REFERENCE DATA

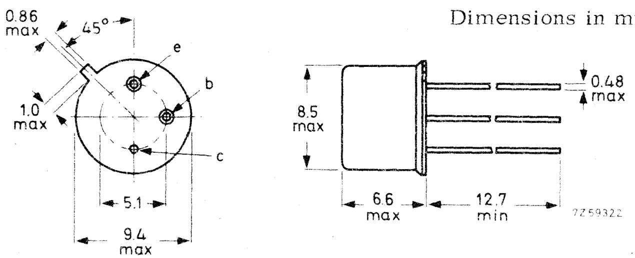
			BF177	BF178	BF179	
Collector-base voltage (open emitter)	V_{CBO}	max.	100	185	250	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	115	115	V
Collector current (peak value)	I_{CM}	max.	50	50	50	mA
Total power dissipation						
up to T_{amb} = 65 °C	P_{tot}	max.	0.6	0.6	0.6	W
up to T_{mb} = 130 °C	P_{tot}	max.		1.7	1.7	W
Junction temperature	T_j	max.	200	200	200	°C
D.C. current gain at T_j = 25 °C						
I_C = 15 mA; V_{CE} = 10 V	h_{FE}	>	20			
I_C = 20 mA; V_{CE} = 15 V	h_{FE}	>			20	
I_C = 30 mA; V_{CE} = 20 V	h_{FE}	>		20		
Transition frequency						
I_C = 10 mA; V_{CE} = 10 V	f_T	typ.	120	120	120	MHz
Feedback capacitance						
I_C = 10 mA; V_{CE} = 20 V	C_{re}	typ.	1.8	1.8	1.8	pF

MECHANICAL DATA

Dimensions in mm

TO-39

Collector connected to case



Accessories available: 56218; 56245

FOR NEW DESIGN THE SUCCESSOR TYPES BF336 to 338
ARE RECOMMENDED

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

Voltages			BF177	BF178	BF179	
Collector-base voltage (open emitter)	V_{CBO}	max.	100	185	250	V [1]
Collector-emitter voltage ($R_B \leq 1$ kΩ)	V_{CER}	max.	100	185	250	V [1]
Collector-emitter voltage (open base) I_C = 4 mA	V_{CEO}	max.	60	115	115	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V
Currents						
Collector current (d.c.)	I_C	max.	50	50	50	mA
Collector current (peak value)	I_{CM}	max.	50	50	50	mA
Power dissipation						
Total power dissipation up to T_{amb} = 65 °C in free air	P_{tot}	max.	0.6	0.6	0.6	W
up to T_{mb} = 130 °C	P_{tot}	max.		1.7	1.7	W

Temperatures

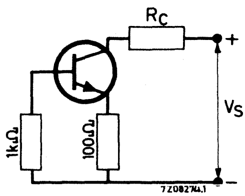
Storage temperature	T_{stg}	−55 to +175	°C
Junction temperature	T_j	max. 200	°C

THERMAL RESISTANCE

			BF177	BF178	BF179	
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	220	220	220	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=		40	40	°C/W

CHARACTERISTICS

			BF177	BF178	BF179	
Collector cut-off current at T_j = 200 °C	I_{CER}	typ.	0.03	0.05	0.10	mA
		<	4	4	4	mA



	V_S	R_C
BF177	100 V	3.9 kΩ
BF178	165 V	3.9 kΩ
BF179	260 V	10 kΩ

at V_{CERmax}; T_j = 25 °C I_{CER} < 1 mA

[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 (see page 6).

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

Base current

I_C = 15 mA; V_{CE} = 10 V	BF177	I_B	typ.	0.36	mA
			<	0.75	mA
I_C = 20 mA; V_{CE} = 15 V	BF179	I_B	typ.	0.45	mA
			<	1.0	mA
I_C = 30 mA; V_{CE} = 20 V	BF178	I_B	typ.	0.72	mA
			<	1.5	mA

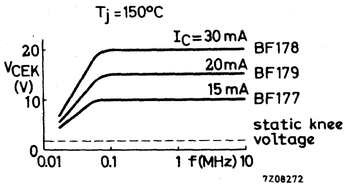
Base-emitter voltage [1])

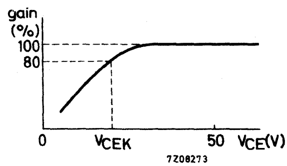
I_C = 15 mA; V_{CE} = 10 V for BF177				
I_C = 20 mA; V_{CE} = 15 V for BF179	V_{BE}	typ.	0.75	V
		<	1.2	V
I_C = 30 mA; V_{CE} = 20 V for BF178				

High frequency knee voltage at T_j = 150 °C

BF177:	I_C = 15 mA	V_{CEK}	typ.	10	V
BF179:	I_C = 20 mA	V_{CEK}	typ.	15	V
BF178:	I_C = 30 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.





Feedback capacitance at f = 0.5 MHz

I_C = 10 mA; V_{CE} = 20 V	C_{re}	typ.	1.8	pF
		<	3.5	pF

Feedback time constant at f = 10 MHz

$-I_E$ = 10 mA; V_{CB} = 10 V	$r_{bb'} \cdot C_{b'c}$	typ.	25	ps
		<	100	ps

Transition frequency

I_C = 10 mA; V_{CE} = 10 V	f_T	typ.	120	MHz

1) V_{BE} decreases by about 1.6 mV/°C with increasing temperature.

SILICON PLANAR TRANSISTOR

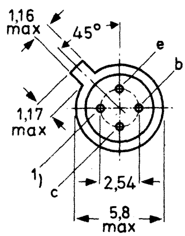
N-P-N transistor in a TO-72 metal envelope with insulated electrodes and a shield lead connected to the case. The BF180 is primarily intended for application in a forward gain controlled pre-amplifier in u.h.f. and integrated television tuners.

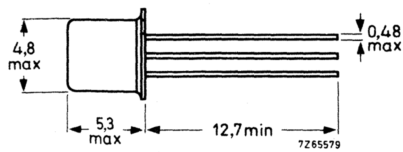
QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector current (d.c.)	I_C	max.	20	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	mW
Junction temperature	T_j	max.	175	°C
Transition frequency				
I_C = 2 mA; V_{CE} = 10 V	f_T	typ.	675	MHz
Feedback capacitance at f = 10.7 MHz				
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	280	fF
Max. unilateralised power gain				
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 200 MHz	G_{UM}	typ.	24	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 900 MHz	G_{UM}	typ.	12	dB
Noise figure at optimum source admittance				
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 200 MHz	F	typ.	2.5	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 800 MHz	F	typ.	5.7	dB

MECHANICAL DATA Dimensions in mm

TO-72

Accessories supplied on request: 56246, 56263.





1) Shield lead connected to case.

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	3	V

Currents

Collector current (d.c.)	I_C	max.	20	mA
Collector current (peak value)	I_{CM}	max.	20	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	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	$R_{th\ j\text{-}a}$	=	1	°C/mW

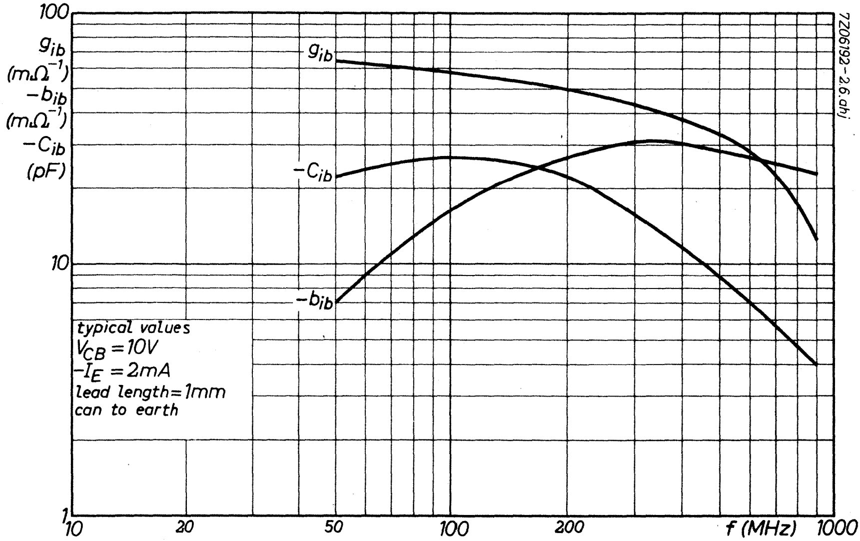
[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

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

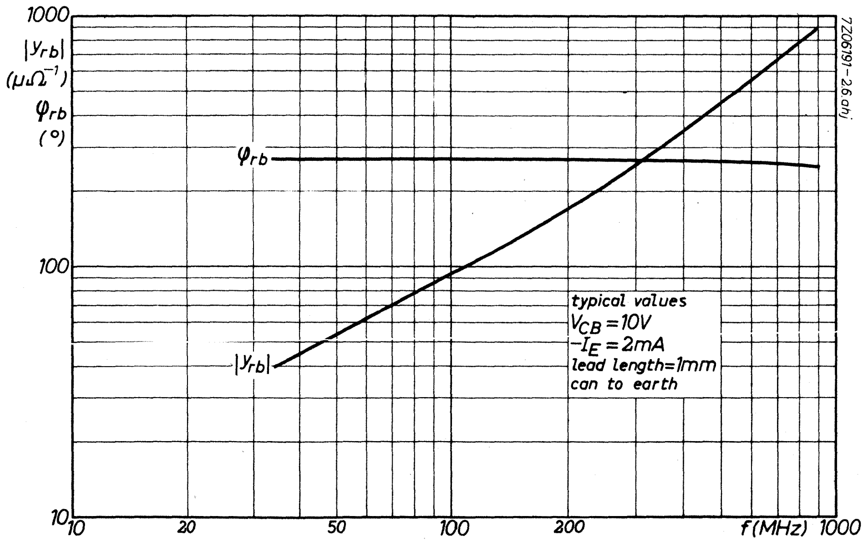
Base current				
$-I_E$ = 2 mA; V_{CB} = 10 V	I_B	typ. < 	45 150	μA μA
$-I_E$ = 12 mA; V_{CB} = 7 V	I_B	<	2.2	mA
Emitter-base voltage				
$-I_E$ = 2 mA; V_{CB} = 10 V	$-V_{EB}$	typ.	0.75	V
Feedback capacitance at f = 10.7 MHz				
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	280	fF [1]
Transition frequency				
I_C = 2 mA; V_{CE} = 10 V	f_T	typ.	675	MHz
Noise figure [2]				
$-I_E$ = 2 mA; V_{CB} = 10 V; G_S = 40 mΩ^{-1}; B_S = 0; f = 200 MHz	F	typ.	4.5	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; G_S = 10 mΩ^{-1}; B_S = 0; f = 800 MHz	F	typ. <	7.0 9.5	dB dB
Maximum unilateralised power gain [2]				
$G_{UM} = \frac{\lvert y_{fb}\rvert^2}{4\, g_{ib}\, g_{ob}}$				
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 50 MHz	G_{UM}	>	32	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 200 MHz	G_{UM}	typ.	24	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 500 MHz	G_{UM}	typ.	14	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 900 MHz	G_{UM}	typ.	12	dB
Transducer gain [2]				
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 200 MHz; G_S = 40 mΩ^{-1}; B_S = 0 G_L = 1 mΩ^{-1}; B_L : tuned	G_{tr}	typ.	16.5	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 900 MHz; G_S = 20 mΩ^{-1}; B_S = 0 G_L = 2 mΩ^{-1}; B_L : tuned	G_{tr}	> typ.	7.5 9	dB dB

[1]) 1 fF = 1 femtofarad = 10^{-15} F

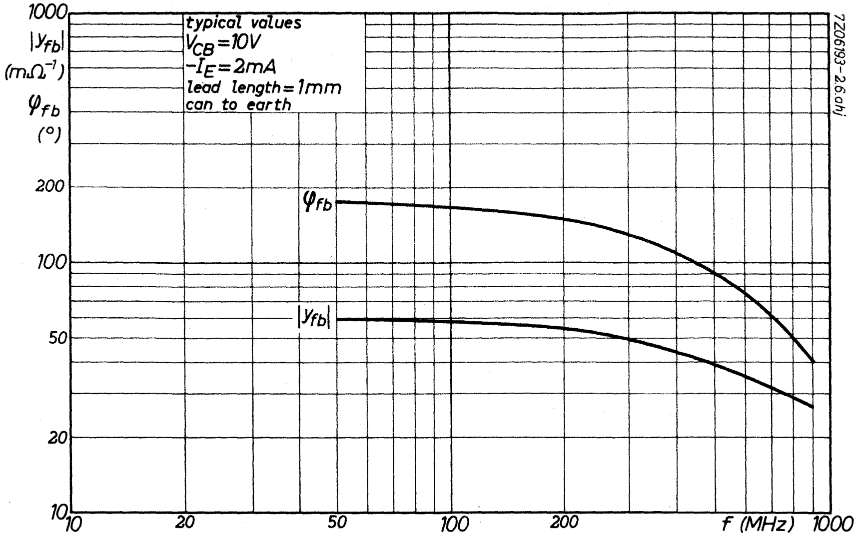
[2]) Common base configuration, metal envelope contacted to earth directly, external lead length: 1 mm.

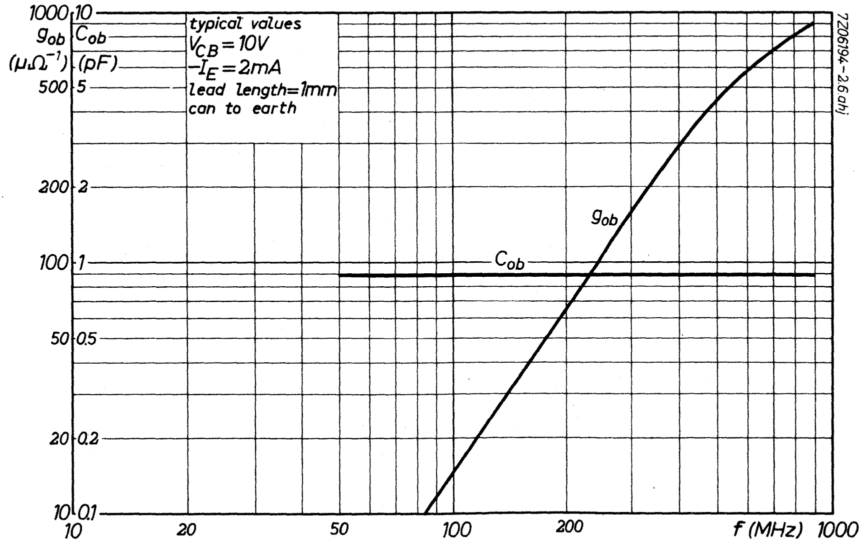


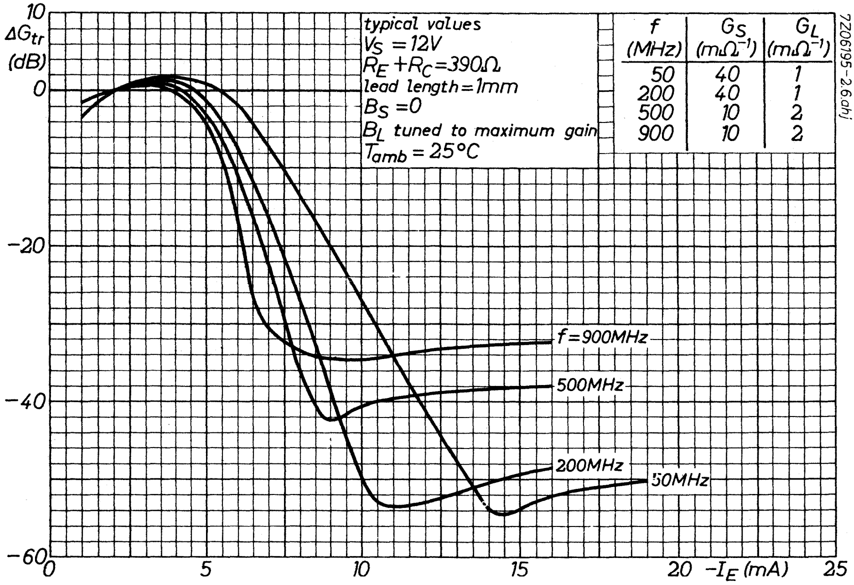
100
g_{ib}
$(m\Omega^{-1})$
$-b_{ib}$
$(m\Omega^{-1})$
$-C_{ib}$
(pF)
10
1
g_{ib}
$-C_{ib}$
$-b_{ib}$
typical values
$V_{CB}=10V$
$-I_E=2mA$
lead length=1mm
can to earth
10
20
50
100
200
f (MHz)
1000
7Z06192-2.6.ahj

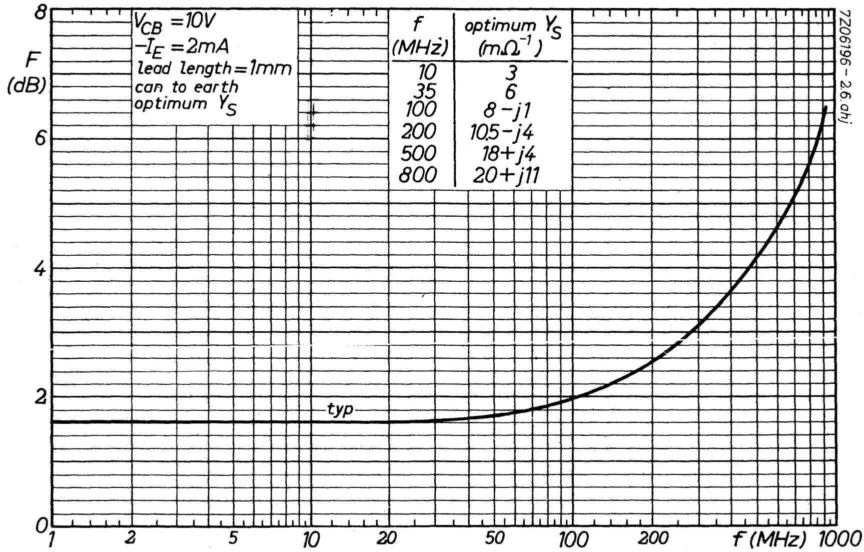


1000
$|y_{rb}|$
$(\mu\Omega^{-1})$
φ_{rb}
(°)
100
10
φ_{rb}
$|y_{rb}|$
typical values
$V_{CB}=10V$
$-I_E=2mA$
lead length=1mm
can to earth
10
20
50
100
200
f(MHz)
1000
7Z06191-2.6.ahj


typical values
V_{CB}=10V
$-I_E$=2mA
lead length=1mm
can to earth
$|y_{fb}|$ ($m\Omega^{-1}$)
φ_{fb} (°)
φ_{fb}
$|y_{fb}|$
f (MHz)
7Z06193-2.6.ahj
1000
200
100
50
20
10
10
20
50
100
200
1000


typical values
V_{CB}=10V
$-I_E$=2mA
lead length=1mm
can to earth
g_{ob} ($\mu\Omega^{-1}$)
C_{ob} (pF)
g_{ob}
C_{ob}
f (MHz)
7Z06194-2.6.ahj
1000
500
200
100
50
20
10
10
5
2
1
0.5
0.2
0.1
10
20
50
100
200
1000


10
ΔG_tr
(dB)
0
−20
−40
−60
typical values
V_S = 12V
R_E + R_C = 390Ω
lead length = 1mm
B_S = 0
B_L tuned to maximum gain
T_amb = 25°C
f (MHz) | G_S (mΩ⁻¹) | G_L (mΩ⁻¹)
50 | 40 | 1
200 | 40 | 1
500 | 10 | 2
900 | 10 | 2
f = 900MHz
500MHz
200MHz
50MHz
0
5
10
15
20 −I_E (mA) 25
7Z06195-2.6.ahj


8
F
(dB)
6
4
2
0
V_CB = 10V
−I_E = 2mA
lead length = 1mm
can to earth
optimum Y_S
f (MHz) | optimum Y_S (mΩ⁻¹)
10 | 3
35 | 6
100 | 8 − j1
200 | 10.5 − j4
500 | 18 + j4
800 | 20 + j11
typ
1
2
5
10
20
50
100
200
f (MHz) 1000
7Z06196 - 2.6.ahj

SILICON PLANAR TRANSISTOR

N-P-N transistor in a TO-72 metal envelope with insulated electrodes and a shield lead connected to the case. The BF181 is primarily intended for application as mixer-oscillator in the u.h.f. band.

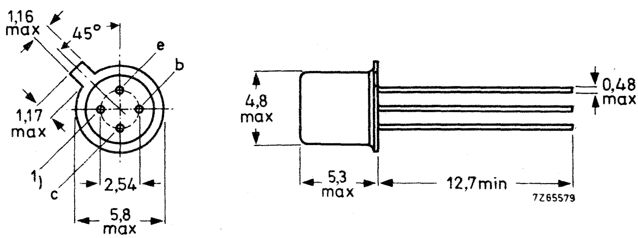
QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector current (d.c.)	I_C	max.	20	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	mW
Junction temperature	T_j	max.	175	°C
Transition frequency				
I_C = 2 mA; V_{CE} = 10 V	f_T	typ.	600	MHz
Feedback capacitance at f = 10.7 MHz				
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	280	fF
Max. unilateralised power gain				
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 900 MHz	G_{UM}	typ.	11	dB
Noise figure at optimum source admittance				
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 900 MHz	F	typ.	6.8	dB

MECHANICAL DATA

Dimensions in mm

TO-72

Accessories supplied on request: 56246, 56263.



[1]) Shield lead connected to case.

RATINGS (Limiting values) [1]

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	3	V

Currents

Collector current (d.c.)	I_C	max.	20	mA
Collector current (peak value)	I_{CM}	max.	20	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	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	$R_{th\ j\text{-}a}$	=	1	°C/mW

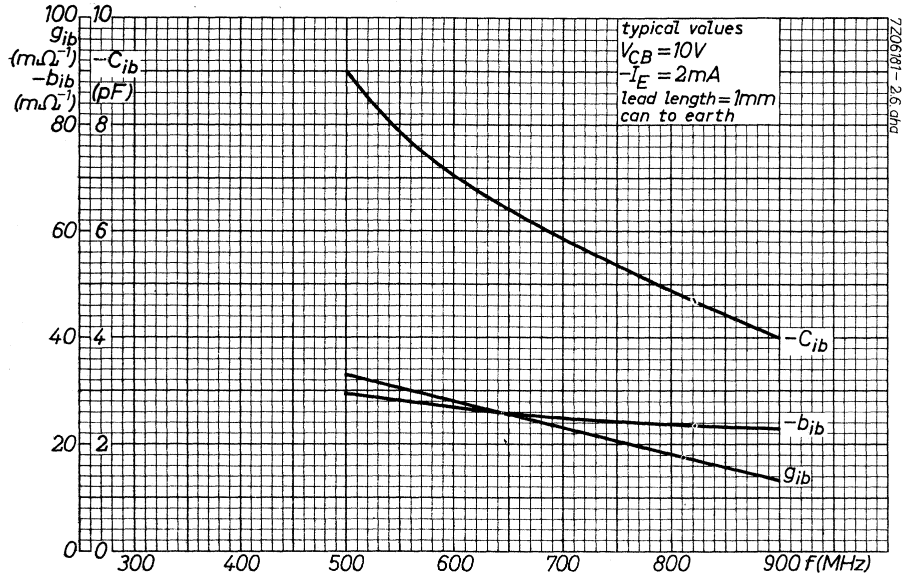
[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

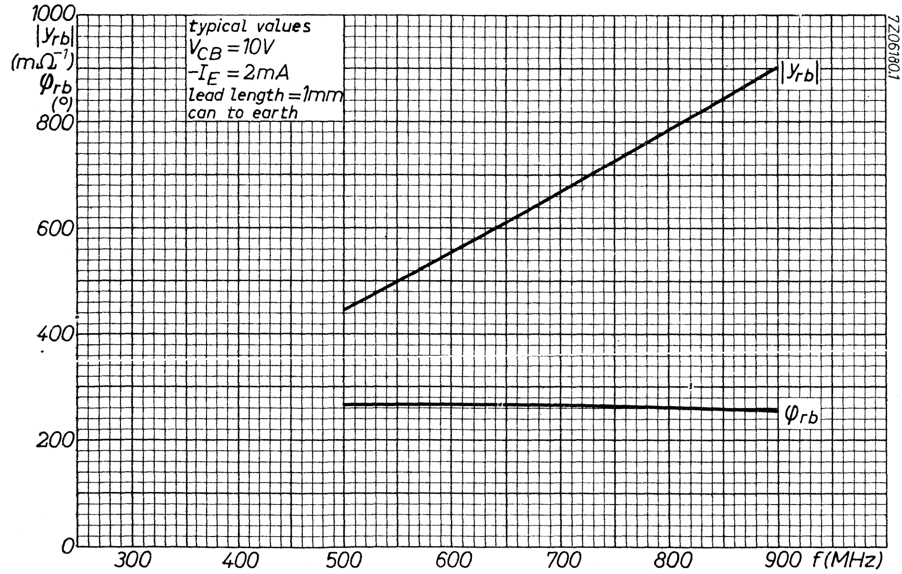
CHARACTERISTICS T_{amb} = 25 °C unless otherwise specified

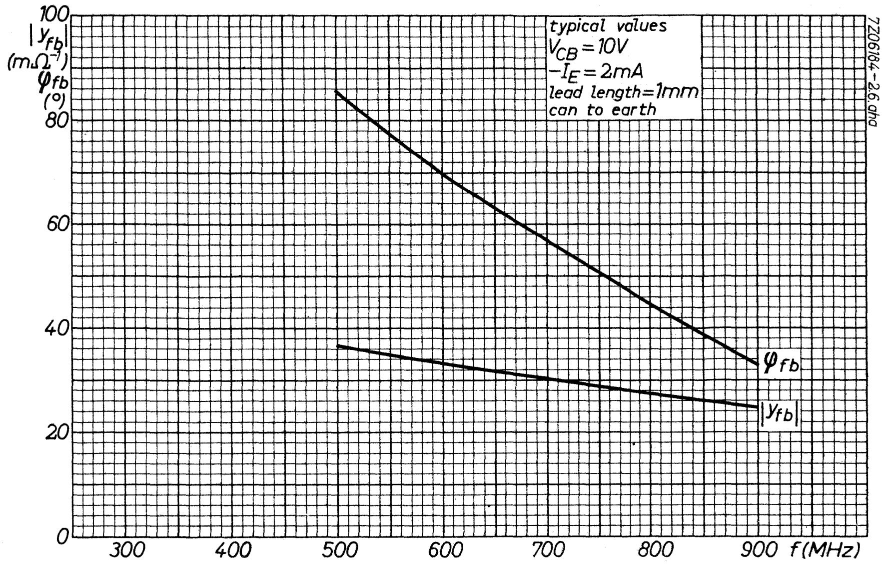
Base current				
$-I_E$ = 2 mA; V_{CB} = 10 V	I_B	typ.	70	μA
		<	150	μA
Emitter-base voltage				
$-I_E$ = 2 mA; V_{CB} = 10 V	$-V_{EB}$	typ.	0.75	V
Feedback capacitance at f = 10.7 MHz				
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	280	fF [1]
Transition frequency				
I_C = 2 mA; V_{CE} = 10 V	f_T	typ.	600	MHz
y parameters at f = 35 MHz [2]				
$-I_E$ = 2 mA; V_{CB} = 10 V				
Output conductance	g_{ob}	typ.	10	$\mu\Omega^{-1}$
Output capacitance	C_{ob}	typ.	0.9	pF
Maximum unilateralised power gain [2]				
$G_{UM} = \frac{\lvert y_{fb} \rvert^2}{4\, g_{ib}\, g_{ob}}$				
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 500 MHz	G_{UM}	typ.	13.5	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 900 MHz	G_{UM}	typ.	11	dB
Transducer gain [2]				
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 900 MHz;				
G_S = 20 $m\Omega^{-1}$; B_S = 0				
G_L = 2 $m\Omega^{-1}$; B_L : tuned	G_{tr}	typ.	8	dB

[1] 1 fF = 1 femtofarad = 10^{-15} F.

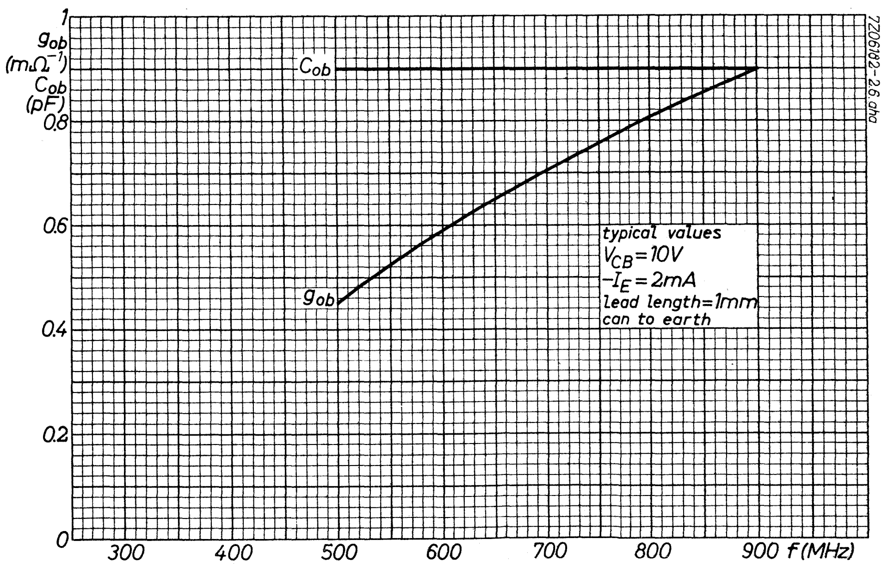
[2] Common base configuration, metal envelope contacted to earth directly, external lead length: 1 mm.


typical values
V_{CB} = 10V
$-I_E$ = 2mA
lead length = 1mm
can to earth
7Z06181 – 2.6.dhd
g_{ib} ($m\Omega^{-1}$)
$-b_{ib}$ ($m\Omega^{-1}$)
$-C_{ib}$ (pF)
$-C_{ib}$
$-b_{ib}$
g_{ib}
f (MHz)

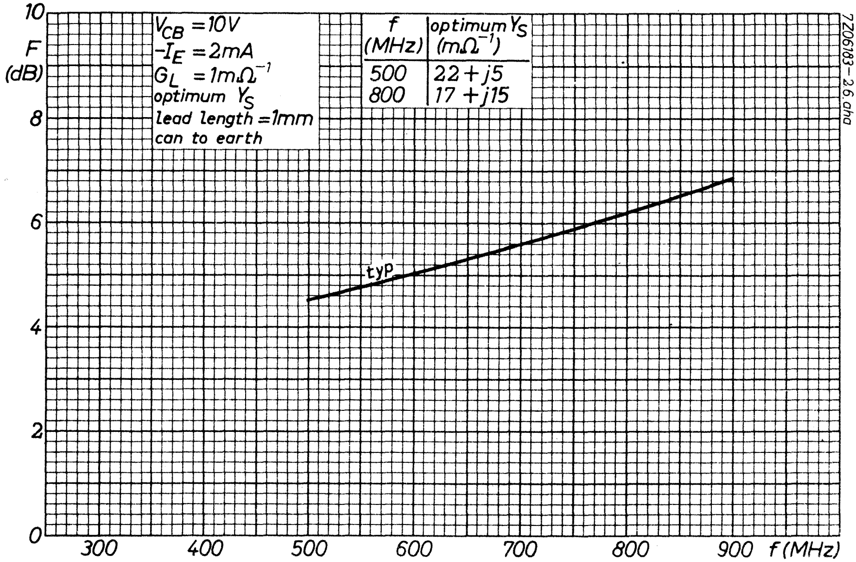

typical values
V_{CB} = 10V
$-I_E$ = 2mA
lead length = 1mm
can to earth
7Z06180.1
$|y_{rb}|$ ($m\Omega^{-1}$)
φ_{rb} (°)
$|y_{rb}|$
φ_{rb}
f (MHz)



100
$|y_{fb}|$
$(m\Omega^{-1})$
φ_{fb}
(°)
80
60
40
20
0
300
400
500
600
700
800
900
f(MHz)
typical values
$V_{CB} = 10V$
$-I_E = 2mA$
lead length=1mm
can to earth
φ_{fb}
$|y_{fb}|$
7Z06184-2.6.aha



1
g_{ob}
$(m\Omega^{-1})$
C_{ob}
(pF)
0.8
0.6
0.4
0.2
0
300
400
500
600
700
800
900
f(MHz)
C_{ob}
g_{ob}
typical values
$V_{CB} = 10V$
$-I_E = 2mA$
lead length=1mm
can to earth
7Z06182-2.6.aha



10
F
(dB)
8
6
4
2
0
V_{CB} = 10V
$-I_E$ = 2mA
G_L = 1mΩ^{-1}
optimum Y_S
lead length = 1mm
can to earth
f (MHz)
optimum Y_S (mΩ^{-1})
500 | 22 + j5
800 | 17 + j15
typ
300
400
500
600
700
800
900
f (MHz)
7Z06183-2.6.aha

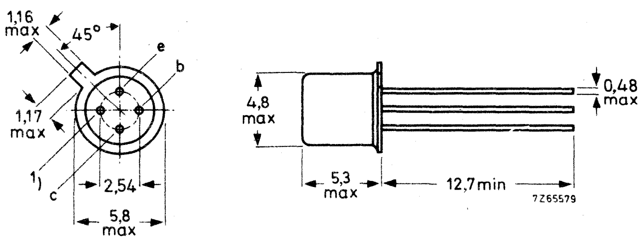
U.H.F. SILICON PLANAR TRANSISTOR

N-P-N transistor in a TO-72 metal envelope with insulated electrodes and a shield lead connected to the case. The BF182 is primarily intended for application as mixer in integrated television tuners.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector current (d.c.)	I_C	max.	15	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	mW
Junction temperature	T_j	max.	175	°C
Transition frequency				
I_C = 2 mA; V_{CE} = 10 V	f_T	typ.	650	MHz
Max. unilaterised power gain				
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 900 MHz	G_{UM}	typ.	11	dB
Noise figure at optimum source admittance				
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 800 MHz	F	typ.	7.4	dB

MECHANICAL DATA Dimensions in mm

TO-72



Accessories supplied on request: 56246, 56263.

1) Shield lead connected to case.

RATINGS (Limiting values) [1]

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	3	V

Currents

Collector current (d.c.)	I_C	max.	15	mA
Collector current (peak value)	I_{CM}	max.	15	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	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	$R_{th\ j\text{-}a}$	=	1	°C/mW

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

Base current

$-I_E$ = 2 mA; V_{CB} = 10 V	I_B	typ. <	100 200	μA μA

Emitter-base voltage [2]

$-I_E$ = 2 mA; V_{CB} = 10 V	$-V_{EB}$	typ.	770	mV

Transition frequency

I_C = 2 mA; V_{CE} = 10 V	f_T	typ.	650	MHz

Feedback capacitance at f = 10.7 MHz

I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	330	fF

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

2) $-V_{EB}$ decreases by about 1.6 mV/°C with increasing temperature.

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

Output conductance at f = 35 MHz

$-I_E$ = 2 mA; V_{CB} = 10 V	g_{ob}	typ.	8	$\mu\Omega^{-1}$

Transducer gain at f = 900 MHz (common base) [1]

$-I_E$ = 2 mA; V_{CB} = 10 V G_S = 20 mΩ^{-1}; G_L = 2 mΩ^{-1}	G_{tr}	> typ.	8 10	dB dB

Max. unilateralised power gain

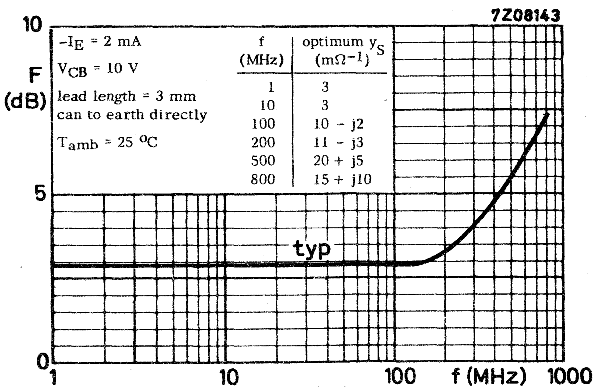
$$G_{UM} = \frac{|y_{fb}|^2}{4\, g_{ib} g_{ob}}$$

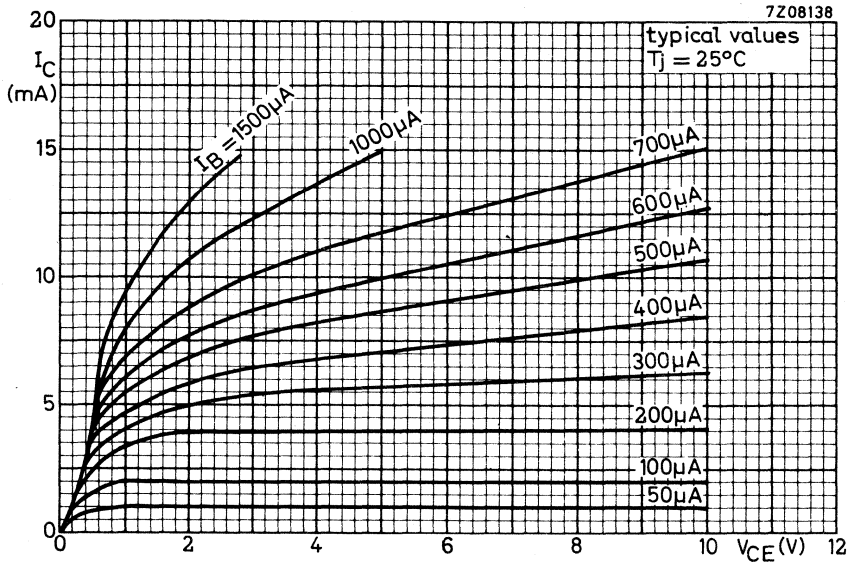
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 500 MHz	G_{UM}	typ.	15	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 900 MHz	G_{UM}	typ.	11	dB

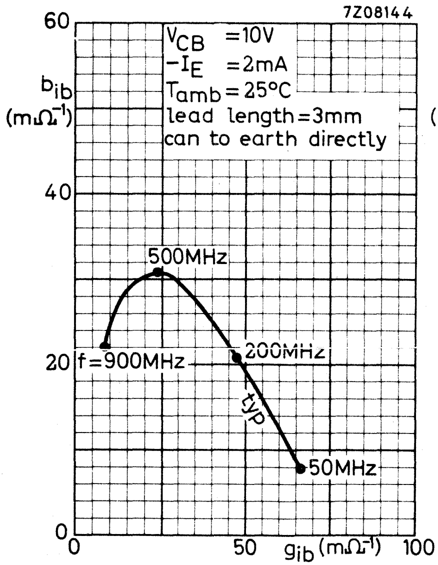
Noise figure at optimum source admittance

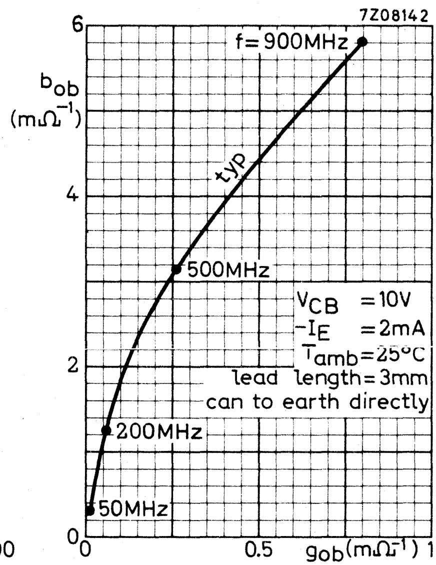
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 200 MHz	F	typ.	3.3	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 800 MHz	F	typ.	7.4	dB

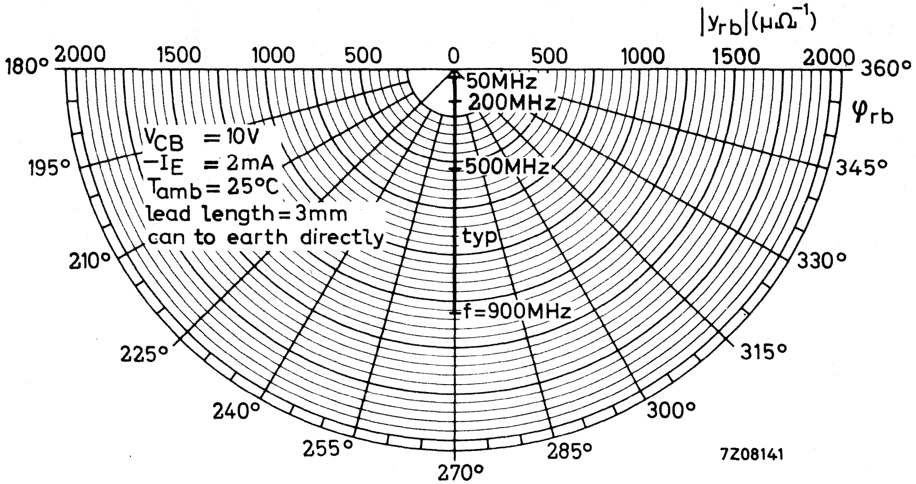
[1] Envelope connected to earth directly, lead length = 3 mm.



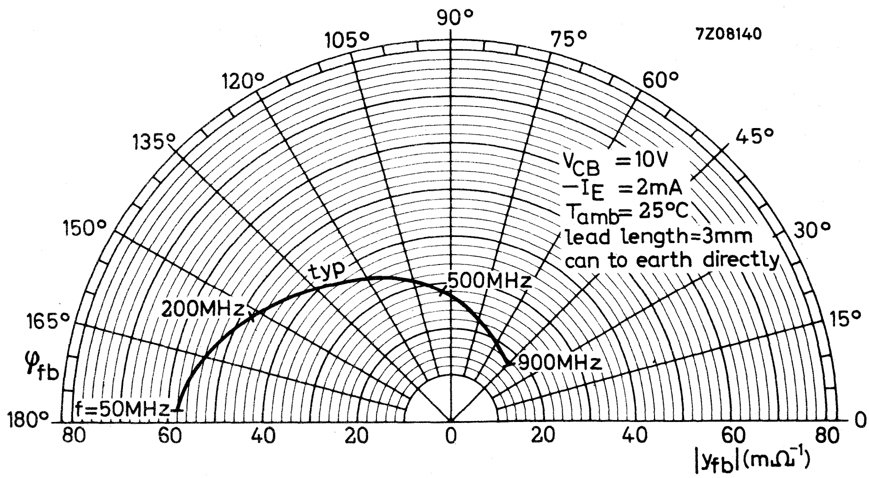

7Z08138
typical values
Tj = 25°C
I_C (mA)
I_B = 1500µA
1000µA
700µA
600µA
500µA
400µA
300µA
200µA
100µA
50µA
V_{CE} (V)
0
2
4
6
8
10
12
5
10
15
20


7Z08144
V_{CB} = 10V
$-I_E$ = 2mA
T_{amb} = 25°C
lead length = 3mm
can to earth directly
b_{ib} (mΩ^{-1})
500MHz
f = 900MHz
200MHz
typ
50MHz
g_{ib} (mΩ^{-1})
0
50
100
20
40
60

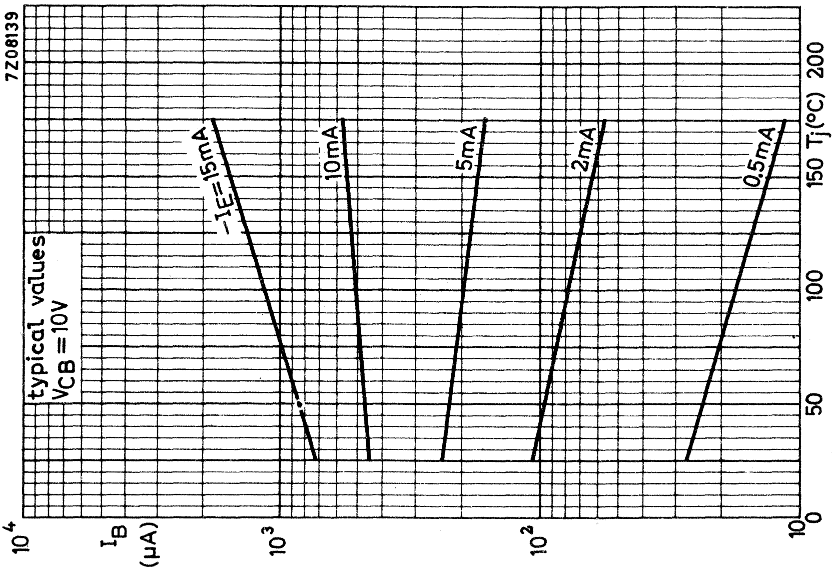

7Z08142
f = 900MHz
b_{ob} (mΩ^{-1})
typ
500MHz
V_{CB} = 10V
$-I_E$ = 2mA
T_{amb} = 25°C
lead length = 3mm
can to earth directly
200MHz
50MHz
g_{ob} (mΩ^{-1})
0
0.5
1
2
4
6

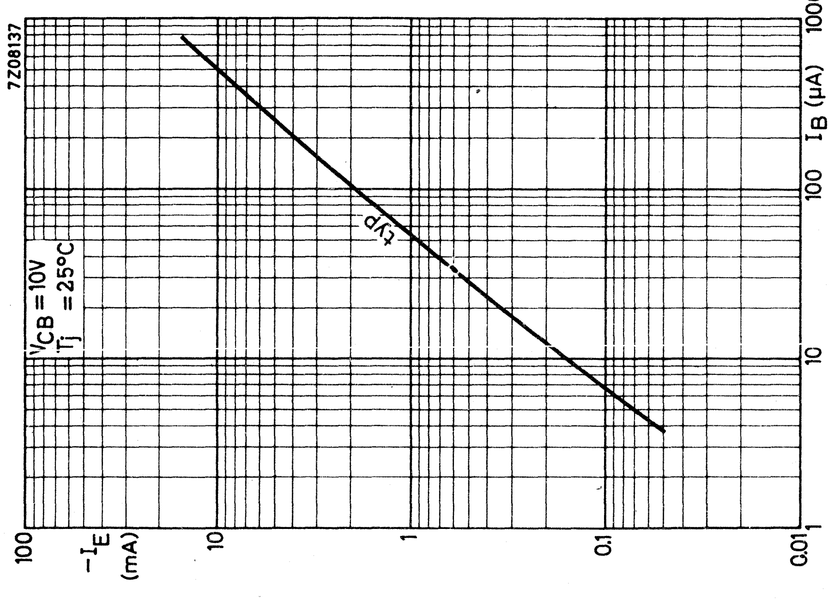


|yrb| (μΩ⁻¹)
180°
2000
1500
1000
500
0
500
1000
1500
2000
360°
φrb
50MHz
200MHz
500MHz
typ
f=900MHz
VCB = 10V
−IE = 2mA
Tamb = 25°C
lead length = 3mm
can to earth directly
195°
210°
225°
240°
255°
270°
285°
300°
315°
330°
345°
7Z08141



90°
105°
75°
120°
60°
135°
45°
150°
30°
165°
15°
φfb
180°
0
7Z08140
VCB = 10V
−IE = 2mA
Tamb = 25°C
lead length = 3mm
can to earth directly
typ
200MHz
500MHz
900MHz
f=50MHz
80
60
40
20
0
20
40
60
80
|yfb| (mΩ⁻¹)


7Z08139
typical values
$V_{CB} = 10V$
$-I_E = 15mA$
10mA
5mA
2mA
0.5mA
I_B (μA)
10^4
10^3
10^2
10
0
50
100
150
200
T_j(°C)


7Z08137
$V_{CB} = 10V$
$T_j = 25°C$
typ
$-I_E$ (mA)
100
10
1
0.1
0.01
1
10
100
1000
I_B (μA)

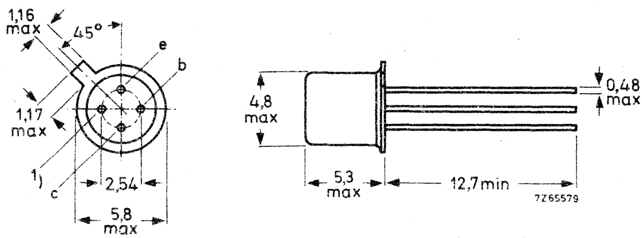
U.H.F. SILICON PLANAR TRANSISTOR

N-P-N transistor in a TO-72 metal envelope with insulated electrodes and a shield lead connected to the case. The BF183 is primarily intended for application in integrated television tuners as local oscillator with excellent frequency stability.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector current (d.c.)	I_C	max.	15	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	mW
Junction temperature	T_j	max.	175	°C
Transition frequency				
I_C = 3 mA; V_{CE} = 10 V	f_T	typ.	800	MHz
Max. unlilateralised power gain				
$-I_E$ = 3 mA; V_{CB} = 10 V; f = 900 MHz	G_{UM}	typ.	13	dB

MECHANICAL DATA Dimensions in mm

TO-72



Accessories on request: 56246, 56263.

1) Shield lead connected to case.

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	3	V

Currents

Collector current (d.c.)	I_C	max.	15	mA
Collector current (peak value)	I_{CM}	max.	15	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	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	$R_{th\ j\text{-}a}$	=	1	°C/mW

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

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

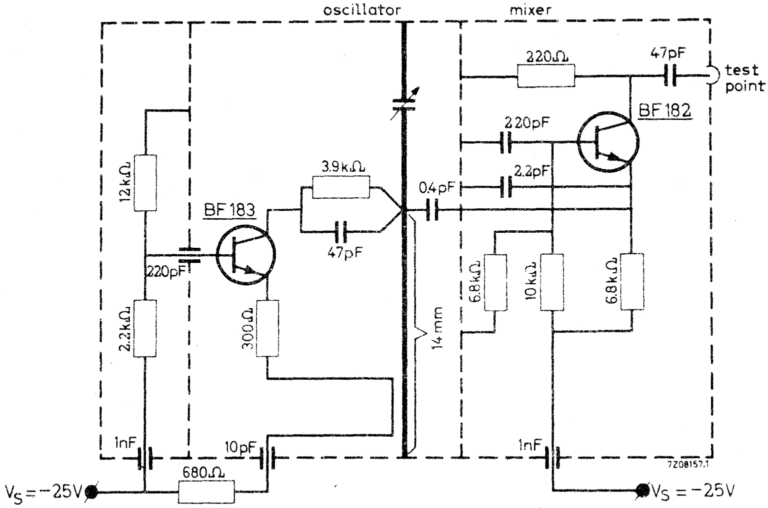
Base-current				
$-I_E$ = 3 mA; V_{CB} = 10 V	I_B	typ.	125	μA
		<	300	μA
Emitter-base voltage [1]				
$-I_E$ = 3 mA; V_{CB} = 10 V	$-V_{EB}$	typ.	770	mV
Transition frequency				
I_C = 3 mA; V_{CE} = 10 V	f_T	typ.	800	MHz
Feedback capacitance at f = 10.7 MHz				
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	330	fF
Transducer gain at f = 900 MHz (common base) [2]				
$-I_E$ = 3 mA; V_{CB} = 10 V; G_S = 20 mΩ^{-1}; G_L = 2 mΩ^{-1}	G_{tr}	>	8.5	dB
		typ.	12	dB
Max. unilateralised power gain				
$G_{UM} = \frac{\lvert y_{fb}\rvert^2}{4\, g_{ib} g_{ob}}$				
$-I_E$ = 3 mA; V_{CB} = 10 V; f = 500 MHz	G_{UM}	typ.	16	dB
$-I_E$ = 3 mA; V_{CB} = 10 V; f = 900 MHz	G_{UM}	typ.	13	dB

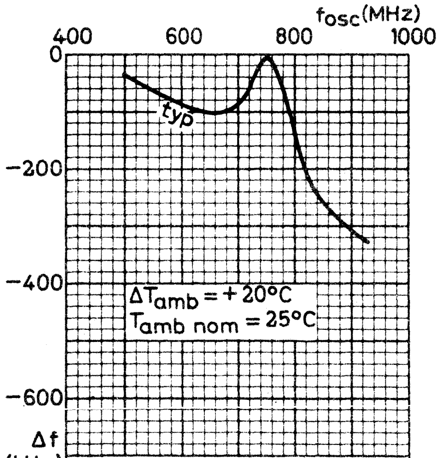
1) $-V_{EB}$ decreases by about 1.6 mV/°C with increasing temperature.

2) Envelope connected to earth directly, lead length = 3 mm.

APPLICATION INFORMATION

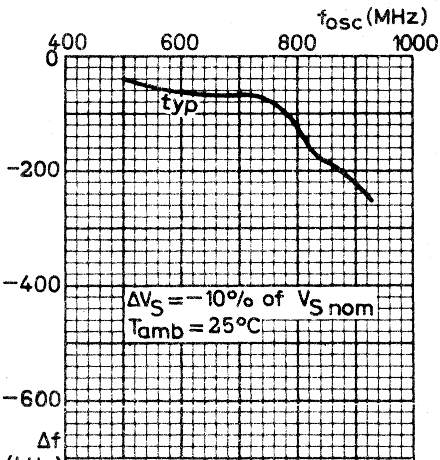
Oscillator circuit with simplified mixer stage





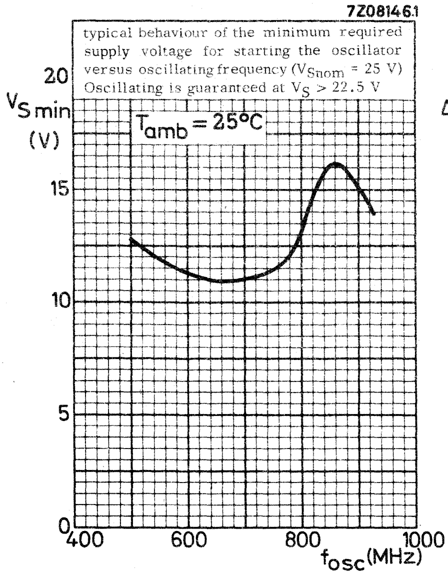
frequency change due to increase of the ambient temperature versus oscillator frequency

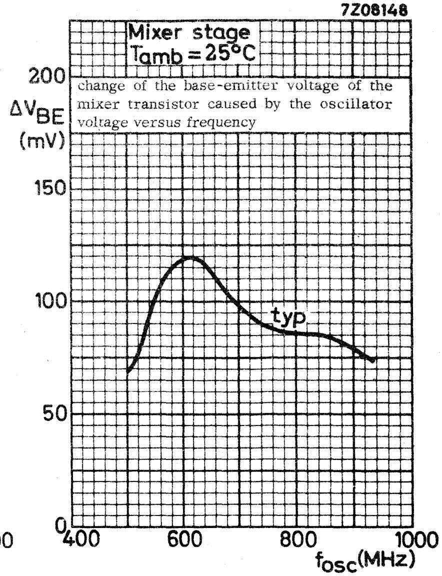
7Z08145

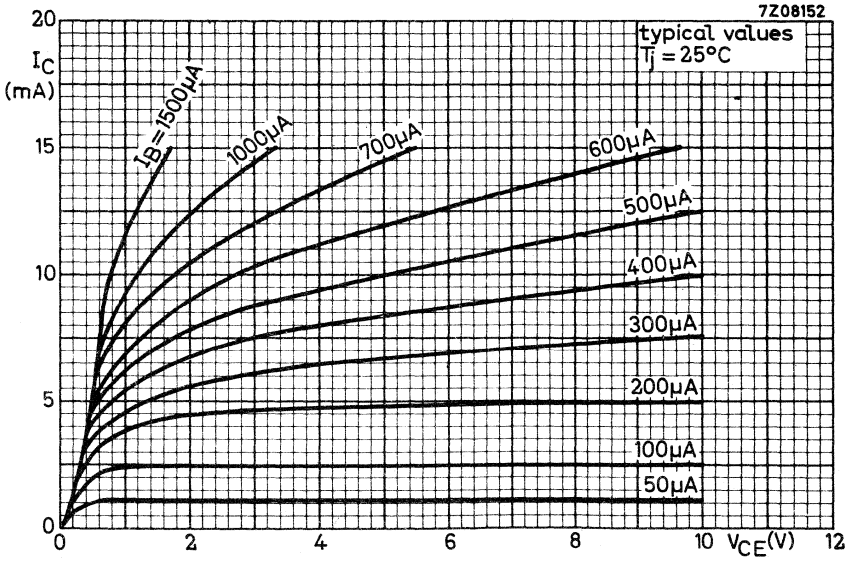


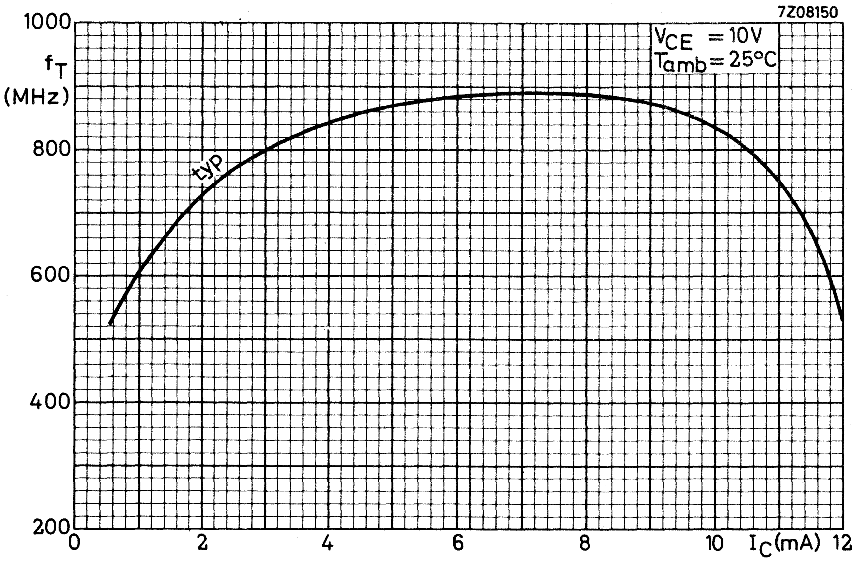
frequency change due to decrease of supply voltage versus oscillator frequency

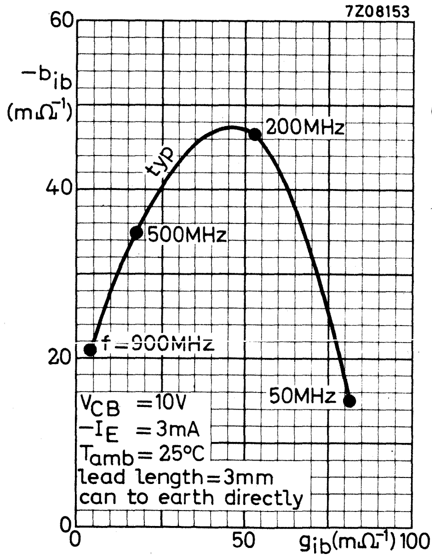
7Z08147

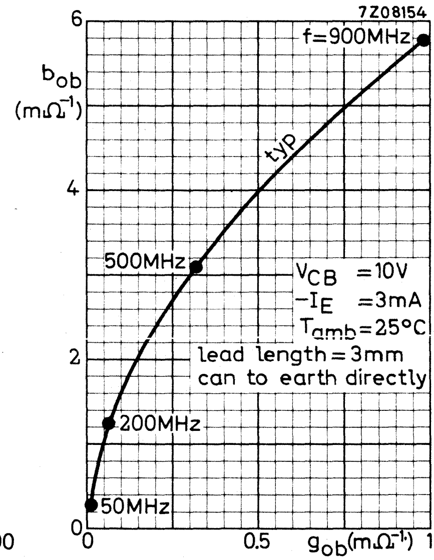

7Z08146.1
typical behaviour of the minimum required supply voltage for starting the oscillator versus oscillating frequency (V_{Snom} = 25 V)
Oscillating is guaranteed at V_S > 22.5 V
T_{amb} = 25°C
$V_{S\,min}$ (V)
f_{osc} (MHz)

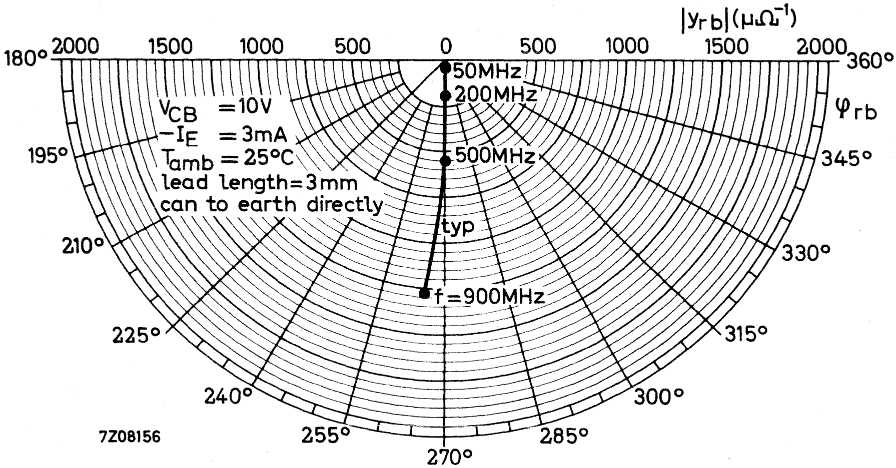

7Z08148
Mixer stage
T_{amb} = 25°C
change of the base-emitter voltage of the mixer transistor caused by the oscillator voltage versus frequency
ΔV_{BE} (mV)
typ
f_{osc} (MHz)

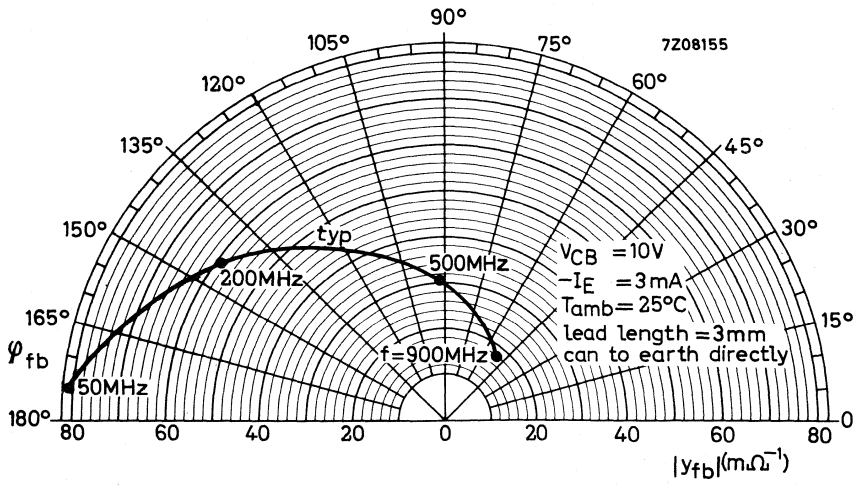

7Z08152
typical values
T_j = 25°C
I_C (mA)
I_B = 1500μA
1000μA
700μA
600μA
500μA
400μA
300μA
200μA
100μA
50μA
V_{CE} (V)

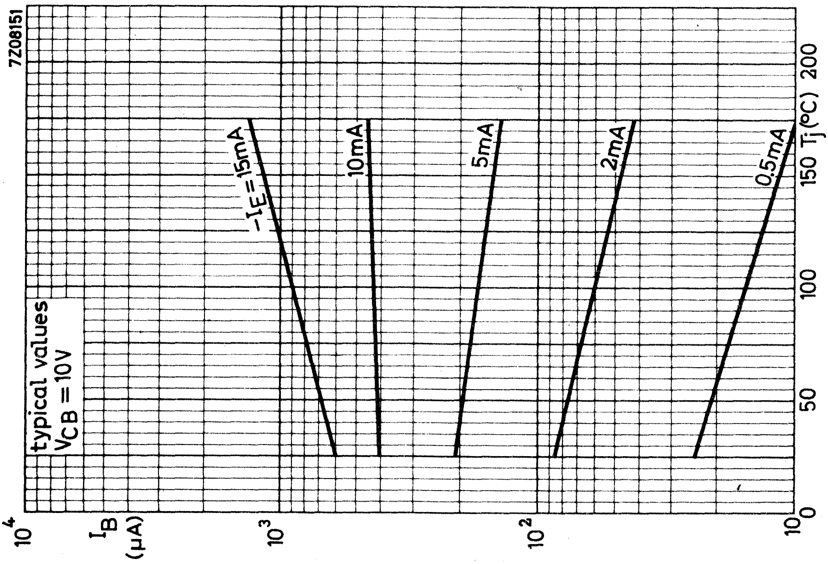

7Z08150
V_{CE} = 10V
T_{amb} = 25°C
f_T (MHz)
typ
I_C (mA)
1000
800
600
400
200
0
2
4
6
8
10
12

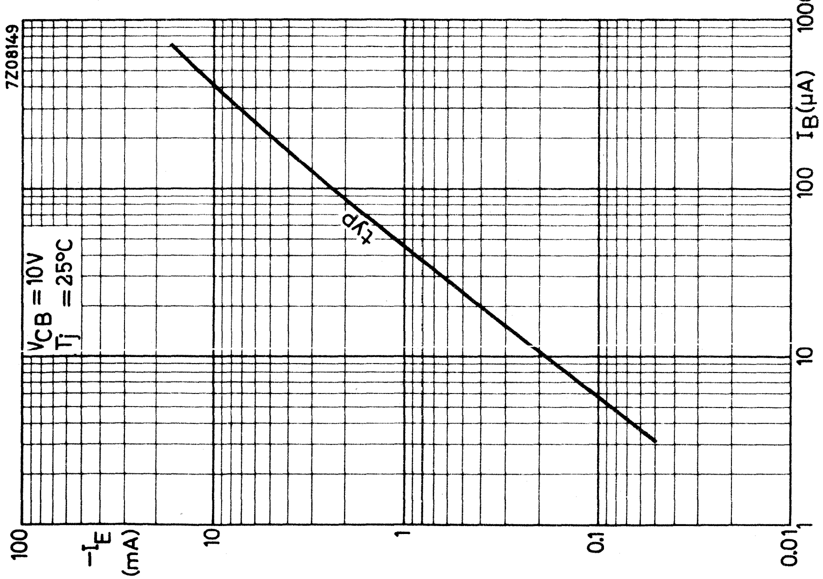

7Z08153
$-b_{ib}$ (mΩ^{-1})
typ
200MHz
500MHz
f = 900MHz
50MHz
V_{CB} = 10V
$-I_E$ = 3mA
T_{amb} = 25°C
lead length = 3mm
can to earth directly
g_{ib} (mΩ^{-1})
60
40
20
0
0
50
100


7Z08154
b_{ob} (mΩ^{-1})
f = 900MHz
typ
500MHz
200MHz
50MHz
V_{CB} = 10V
$-I_E$ = 3mA
T_{amb} = 25°C
lead length = 3mm
can to earth directly
g_{ob} (mΩ^{-1})
6
4
2
0
0
0.5
1


|yrb|(μΩ⁻¹)
2000 1500 1000 500 0 500 1000 1500 2000
180° 195° 210° 225° 240° 255° 270° 285° 300° 315° 330° 345° 360°
φrb
VCB = 10V
−IE = 3mA
Tamb = 25°C
lead length = 3mm
can to earth directly
50MHz
200MHz
500MHz
typ
f = 900MHz
7Z08156


90° 105° 120° 135° 150° 165° 180° 75° 60° 45° 30° 15° 0
7Z08155
φfb
typ
200MHz
500MHz
50MHz
f = 900MHz
VCB = 10V
−IE = 3mA
Tamb = 25°C
lead length = 3mm
can to earth directly
80 60 40 20 0 20 40 60 80
|yfb|(mΩ⁻¹)


7Z08151
typical values
$V_{CB} = 10V$
$-I_E = 15mA$
10mA
5mA
2mA
0.5mA
10^4
I_B (μA)
10^3
10^2
10
0
50
100
150
200
T_j (°C)


7Z08149
$V_{CB} = 10V$
$T_j = 25°C$
typ
100
$-I_E$ (mA)
10
1
0.1
0.01
10
100
1000
I_B (μA)

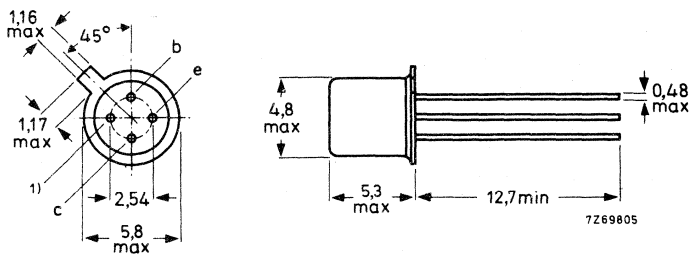
SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a TO-72 metal case intended for h.f. applications in radio and television receivers.
It is especially recommended for f.m. tuners, low noise a.m. mixer-oscillators with high source impedance and i.f. amplifiers in a.m./f.m. receivers where a high current gain is of importance.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector current (d.c.)	I_C	max.	30	mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	145	mW
Junction temperature	T_j	max.	175	°C
D.C. current gain at T_j = 25 °C I_C = 1 mA; V_{CE} = 10 V	h_{FE}	typ.	115	
Transition frequency I_C = 1 mA; V_{CE} = 10 V	f_T	typ.	300	MHz

MECHANICAL DATA Dimensions in mm

TO-72



1) = shield lead (connected to case)

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

FOR NEW DESIGN THE SUCCESSOR TYPE BF494 IS RECOMMENDED

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

Voltages				
Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base) (See also sheet 4)	V_{CEO}	max.	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V
Currents				
Collector current (d.c.)	I_C	max.	30	mA
Collector current (peak value)	I_{CM}	max.	30	mA
Power dissipation				
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	145	mW
Temperatures				
Storage temperature	T_{stg}	-65 to +175		°C
Junction temperature	T_j	max.	175	°C

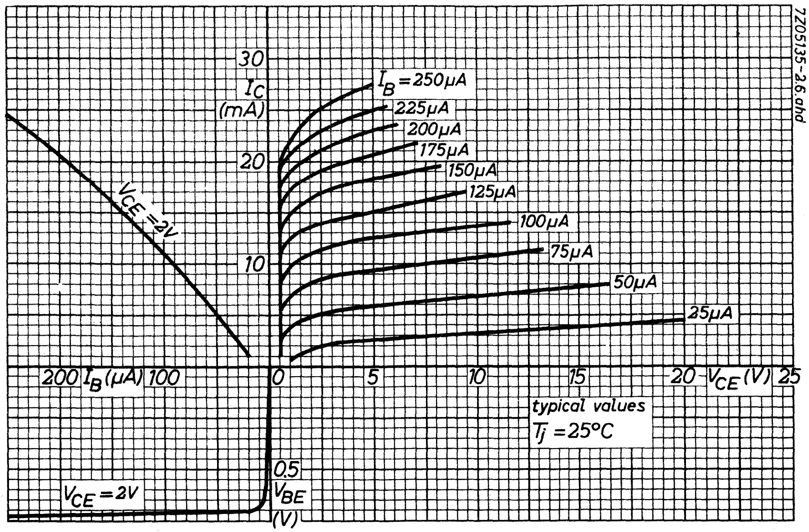
THERMAL RESISTANCE

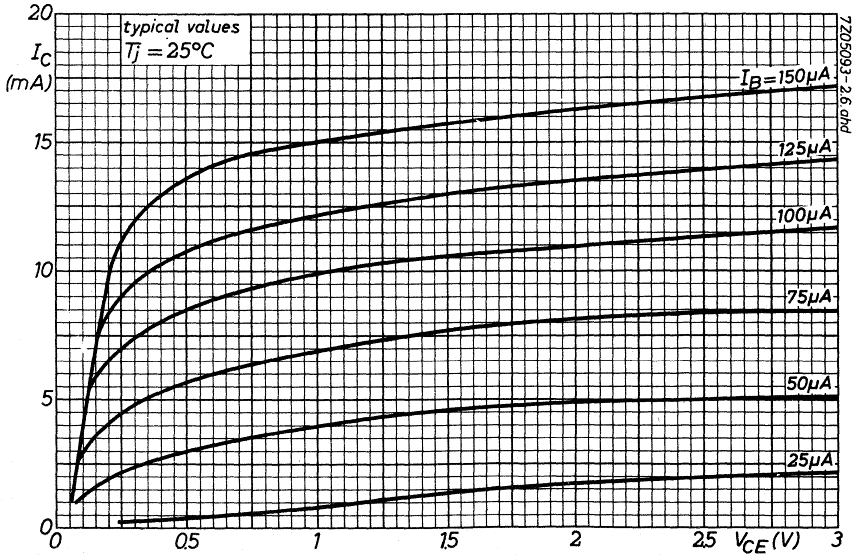
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.9	°C/mW

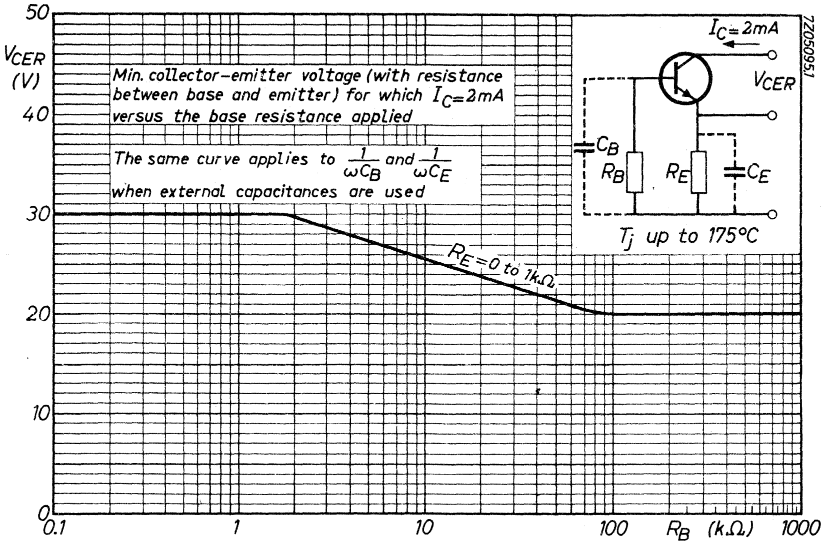
CHARACTERISTICS T_j = 25 °C unless otherwise specified

Base-emitter voltage [1]				
I_C = 1 mA; V_{CE} = 10 V	V_{BE}	0.65 to 0.74		V
I_C = 20 mA; V_{CE} = 2 V	V_{BE}	<	1.0	V
Feedback capacitance at f = 0.45 MHz				
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	0.65	pF
D.C. current gain				
I_C = 1 mA; V_{CE} = 10 V	h_{FE}	75 to	750	
		typ.	115	
Transition frequency				
I_C = 1 mA; V_{CE} = 10 V	f_T	typ.	300	MHz
Conversion noise figure				
I_C = 1 mA; V_{CE} = 10 V				
G_S = 0.6 mA/V ; f = 0.2 MHz	F_c	typ.	3	dB
G_S = 1.2 mA/V ; f = 1.0 MHz	F_c	typ.	2	dB

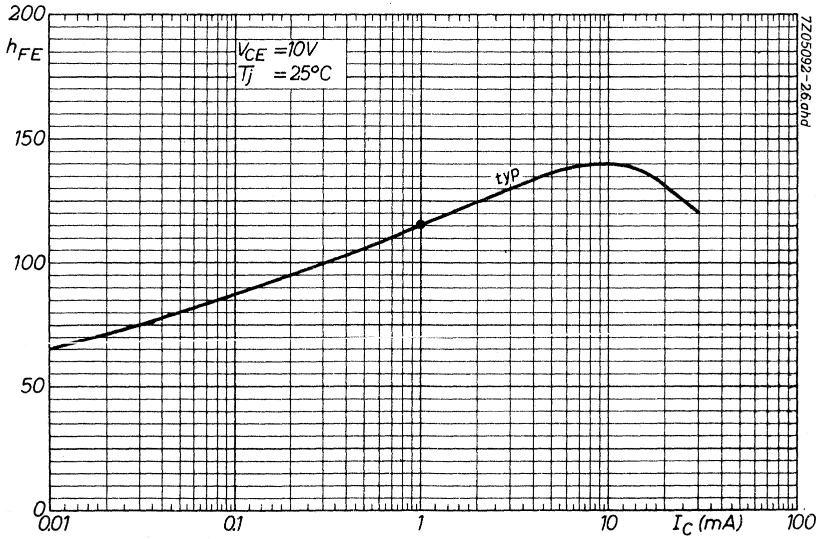
[1]) V_{BE} decreases with about 1.7 mV/°C at increasing temperature.


7Z05135-2.6.ahd
30
I_C
(mA)
20
10
I_B = 250μA
225μA
200μA
175μA
150μA
125μA
100μA
75μA
50μA
25μA
V_{CE} = 2V
200 I_B (μA) 100
0 5 10 15 20 V_{CE} (V) 25
typical values
T_j = 25°C
0.5
V_{BE}
(V)
V_{CE} = 2V

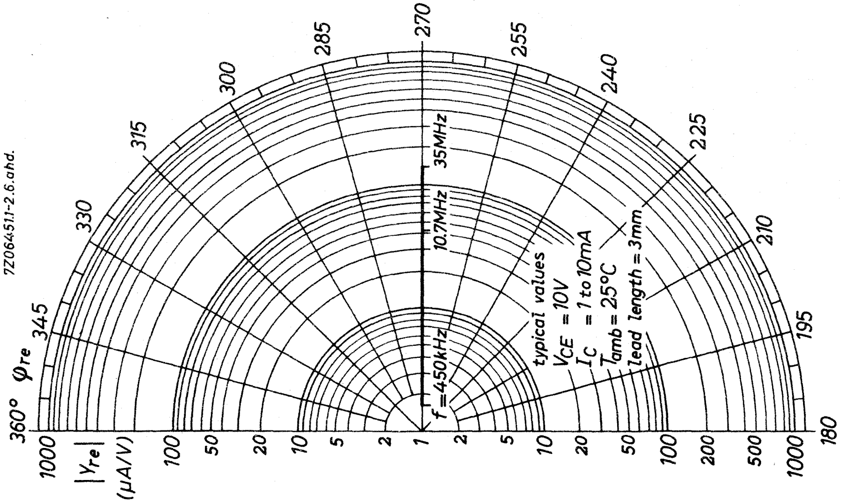

7Z05093-2.6.ahd
20
I_C
(mA)
15
10
5
0
typical values
T_j = 25°C
I_B = 150μA
125μA
100μA
75μA
50μA
25μA
0 0.5 1 1.5 2 2.5 V_{CE} (V) 3



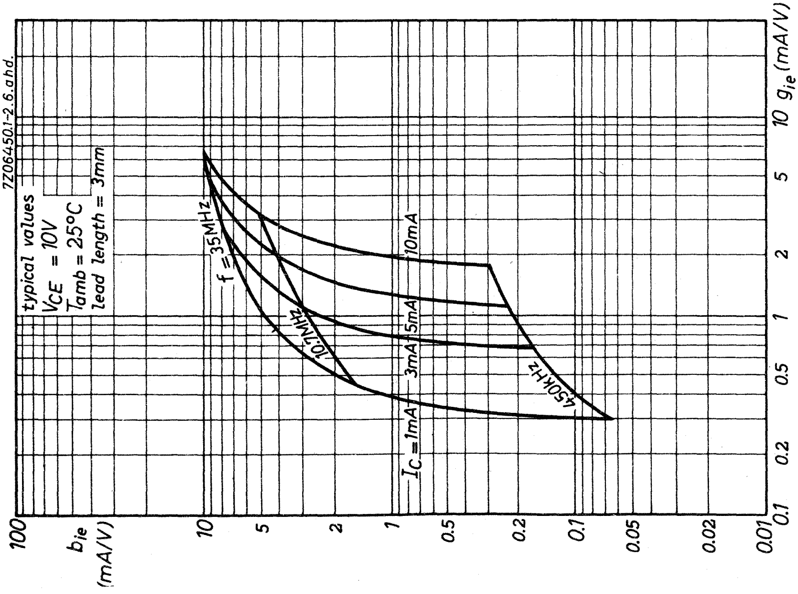
50
V_{CER} (V)
40
30
20
10
0
0.1
1
10
100
R_B (kΩ)
1000
7Z05095.1
Min. collector-emitter voltage (with resistance between base and emitter) for which I_C=2mA versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$ when external capacitances are used
R_E=0 to 1kΩ
I_C=2mA
V_{CER}
C_B
R_B
R_E
C_E
T_j up to 175°C



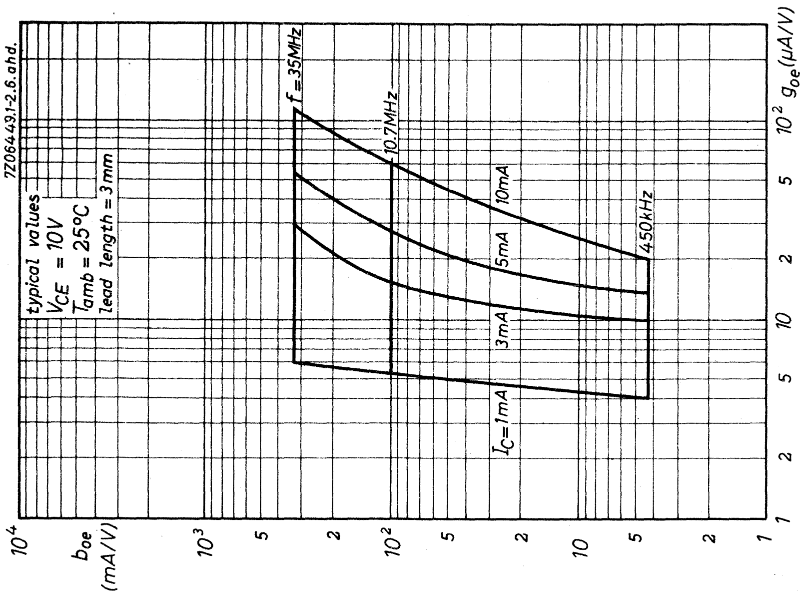
200
h_{FE}
150
100
50
0
0.01
0.1
1
10
I_C (mA)
100
7Z05092-2.6.ahd
V_{CE} =10V
T_j =25°C
typ

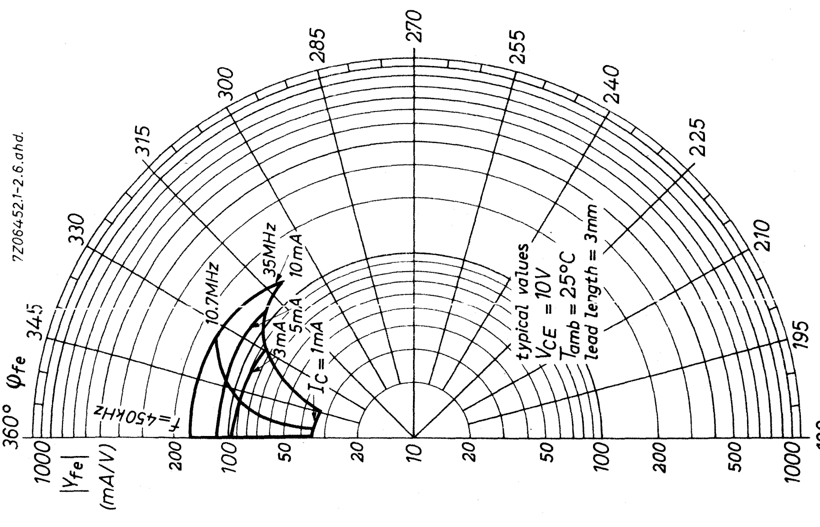


7Z06451.1-2.6.ahd.
φ_{re}
360°
345
330
315
300
285
270
255
240
225
210
195
180
$|y_{re}|$ (μA/V)
1000
100
50
20
10
5
2
1
2
5
10
20
50
100
200
500
1000
f = 450kHz
10.7MHz
35MHz
typical values
V_{CE} = 10V
I_C = 1 to 10mA
T_{amb} = 25°C
lead length = 3mm



7Z06450.1-2.6.ahd.
typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length = 3mm
f = 35MHz
10.7MHz
450kHz
I_C = 1mA
3mA
5mA
10mA
b_{ie} (mA/V)
100
10
5
2
1
0.5
0.2
0.1
0.05
0.02
0.01
g_{ie} (mA/V)
0.1
0.2
0.5
1
2
5
10


7Z06443.1-2.6.ahd.
typical values
VCE = 10V
Tamb = 25°C
lead length = 3mm
f = 35MHz
10.7MHz
450kHz
10mA
5mA
3mA
IC = 1mA
boe (mA/V)
10² goe (µA/V)


7Z06452.1-2.6.ahd.
360° φfe
|yfe| (mA/V)
typical values
VCE = 10V
Tamb = 25°C
lead length = 3mm
f = 450kHz
10.7MHz
35MHz
10mA
5mA
3mA
IC = 1mA

SILICON PLANAR EPITAXIAL TRANSISTOR

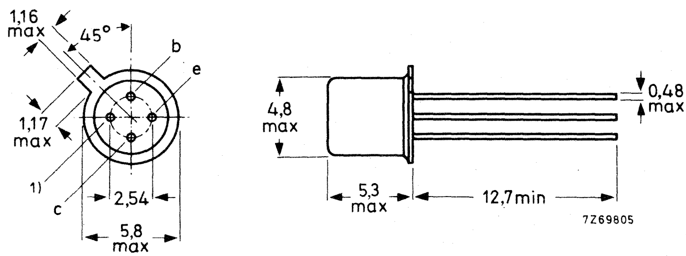
N-P-N transistor in a TO-72 metal case intended for h.f. applications in radio and television receivers.
It is especially recommended for f.m. tuners, i.f. amplifiers in a.m./f.m receivers where a low transistor output conductance is of importance, a.m. input stages of car-radios where a low noise figure at low source impedance is required.

QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector current (d.c.)	I_C	max.	30	mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	145	mW
Junction temperature	T_j	max.	175	°C
D.C. current gain at T_j = 25 °C I_C = 1 mA; V_{CE} = 10 V	h_{FE}	typ.	67	
Transition frequency I_C = 1 mA; V_{CE} = 10 V	f_T	typ.	220	MHz
Noise figure at f = 100 MHz I_C = 1 mA; V_{CE} = 10 V; G_S = 10 mA/V	F	typ.	4	dB

MECHANICAL DATA Dimensions in mm

TO-72



1) = shield lead (connected to case)

Accessories: 56246, 56263.

FOR NEW DESIGN THE SUCCESSOR TYPE BF495 IS RECOMMENDED

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

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base) (See also sheet 8)	V_{CEO}	max.	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Currents

Collector current (d.c.)	I_C	max.	30	mA
Collector current (peak value)	I_{CM}	max.	30	mA

Power dissipation

Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	145	mW

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.9	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Base-emitter voltage [1]

I_C = 1 mA; V_{CE} = 10 V	V_{BE}		0.65 to 0.74	V
I_C = 20 mA; V_{CE} = 2 V	V_{BE}	<	1.0	V

Feedback capacitance at f = 0.45 MHz

I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	0.65	pF

D.C. current gain

I_C = 1 mA; V_{CE} = 10 V	h_{FE}		34 to 140	
		typ.	67	

Transition frequency

I_C = 1 mA; V_{CE} = 10 V	f_T	typ.	220	MHz

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

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

Noise figure

I_C = 1 mA; V_{CE} = 10 V

f = 0, 2 MHz; G_S = 5 mA/V	F	typ.	2	dB
f = 1 MHz; G_S = 20 mA/V	F	typ.	3, 5	dB
f = 100 MHz; G_S = 10 mA/V	F	typ.	4	dB

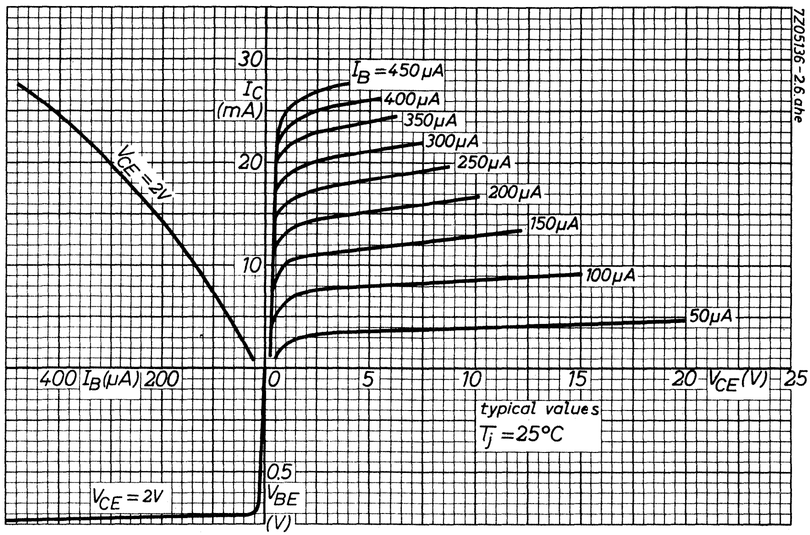
y parameters at f = 100 MHz (common base)

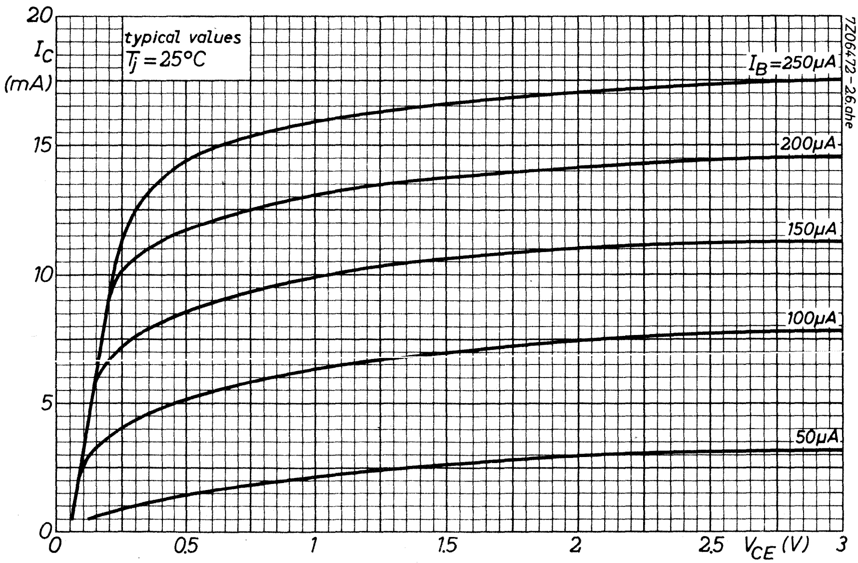
$-I_E$ = 1 mA; V_{CB} = 10 V

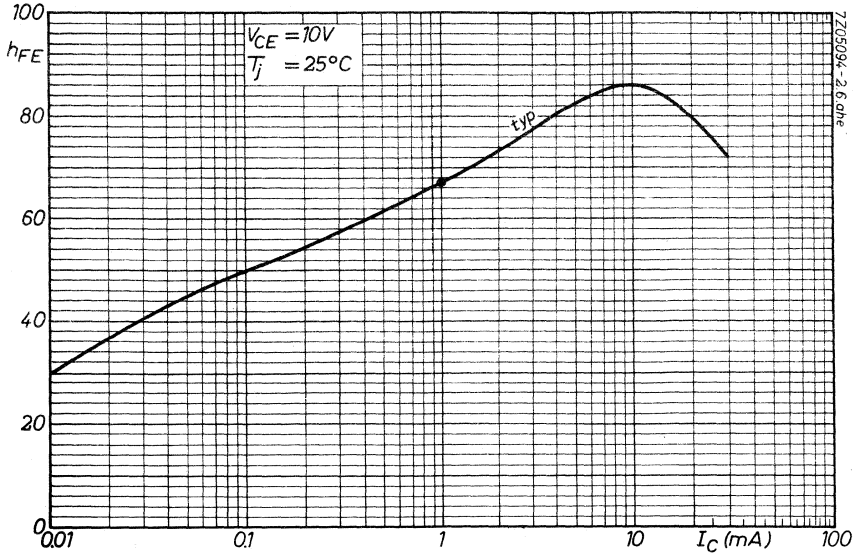
Input conductance	g_{ib}	typ.	33	mA/V
Input capacitance	$-C_{ib}$	typ.	5, 5	pF
Feedback admittance	$\|y_{rb}\|$	typ.	220	mA/V
Phase angle of feedback admittance	φ_{rb}	typ.	273°	
Transfer admittance	$\|y_{fb}\|$	typ.	33	mA/V
Phase angle of transfer admittance	φ_{fb}	typ.	150°	
Output conductance	g_{ob}	typ.	12	µA/V
Output capacitance	C_{ob}	typ.	1, 5	pF

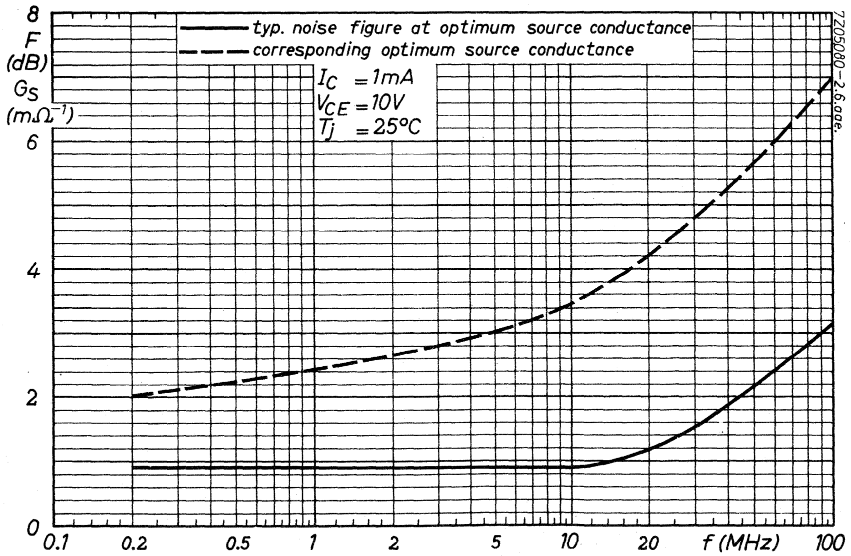
NOTE

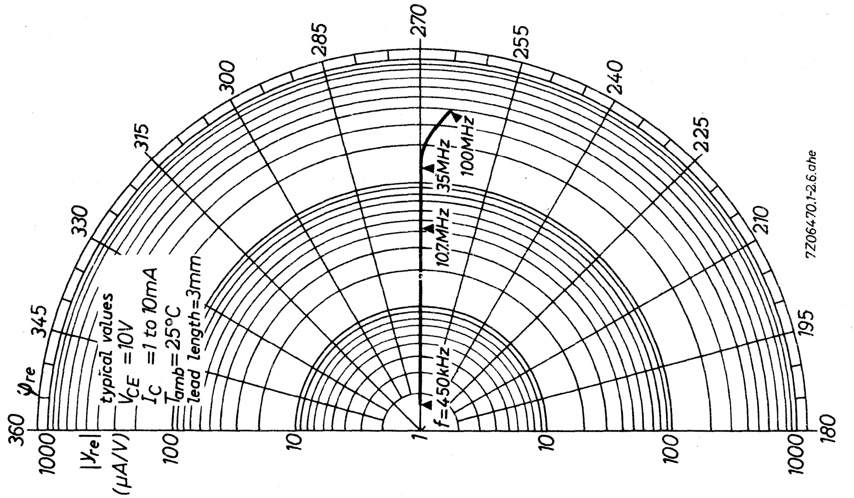
All small-signal quantities have been measured with a length of leads between the bottom of the transistor and measuring jig of 3 mm.


7Z05136-2.6.ahe
30
I_C
(mA)
20
10
I_B = 450 μA
400 μA
350 μA
300 μA
250 μA
200 μA
150 μA
100 μA
50 μA
V_{CE} = 2V
400 I_B (μA) 200
0 5 10 15 20 V_{CE} (V) 25
typical values
T_j = 25°C
0.5
V_{BE}
(V)
V_{CE} = 2V

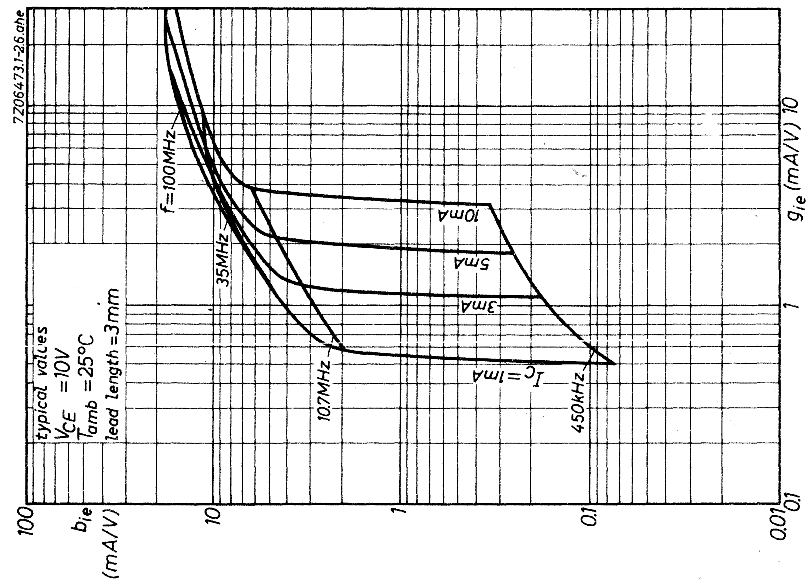

7Z06472-2.6.ahe
20
I_C
(mA)
15
10
5
0
typical values
T_j = 25°C
I_B = 250 μA
200 μA
150 μA
100 μA
50 μA
0 0.5 1 1.5 2 2.5 V_{CE} (V) 3


100
h_{FE}
80
60
40
20
0
V_{CE} = 10V
T_j = 25°C
typ
0.01
0.1
1
10
I_C (mA)
100
7Z05094-2.6.ahe

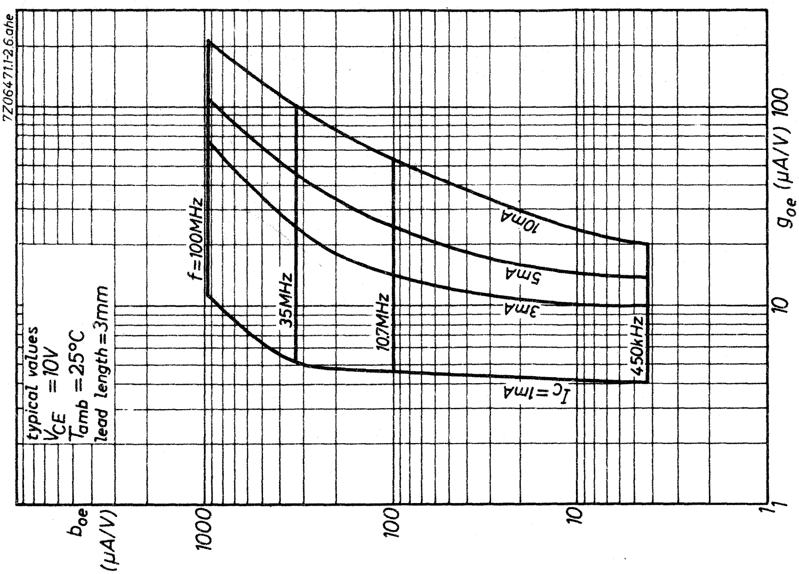

8
F
(dB)
G_S
(mΩ^{-1})
6
4
2
0
typ. noise figure at optimum source conductance
corresponding optimum source conductance
I_C = 1mA
V_{CE} = 10V
T_j = 25°C
0.1
0.2
0.5
1
2
5
10
20
f (MHz)
100
7Z05080-2.6.ahe.

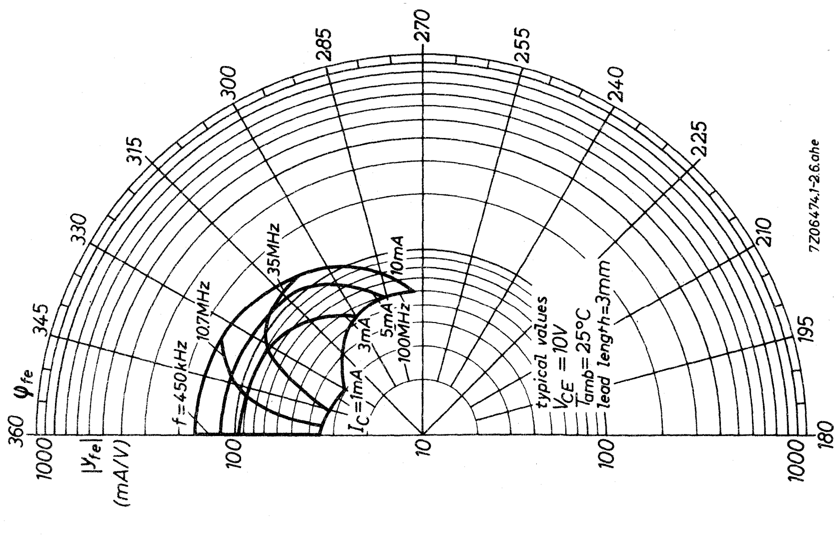


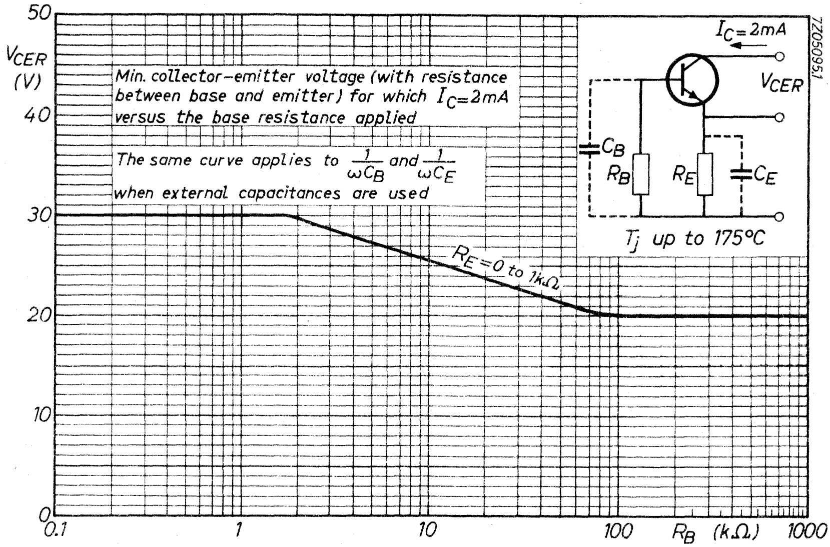
typical values
V_{CE} = 10V
I_C = 1 to 10mA
T_{amb} = 25°C
lead length = 3mm
φ_{re}
$|y_{re}|$ (μA/V)
f = 450kHz
10.7MHz
35MHz
100MHz
360
345
330
315
300
285
270
255
240
225
210
195
180
1000
100
10
1
10
100
1000
7Z06470.1-2.6.ahe



typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length = 3mm
b_{ie} (mA/V)
g_{ie} (mA/V)
f = 100MHz
35MHz
10.7MHz
450kHz
10mA
5mA
3mA
I_C = 1mA
100
10
1
0.1
0.01
0.1
1
10
7Z06473.1-2.6.ahe


7Z06471.1-2.6.ahe
typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length = 3mm
f = 100MHz
35MHz
10.7MHz
450kHz
I_C = 1mA
3mA
5mA
10mA
b_{oe} (μA/V)
g_{oe} (μA/V)
1000
100
10
1


7Z06474.1-2.6.ahe
φ_{fe}
$|y_{fe}|$ (mA/V)
360
345
330
315
300
285
270
255
240
225
210
195
180
1000
100
10
f = 450kHz
10.7MHz
35MHz
100MHz
I_C = 1mA
3mA
5mA
10mA
typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length = 3mm


50
V_{CER}
(V)
40
30
20
10
0
0.1
1
10
100
R_B (kΩ)
1000
Min. collector-emitter voltage (with resistance between base and emitter) for which I_C=2mA versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$ when external capacitances are used
R_E=0 to 1kΩ
I_C=2mA
V_{CER}
C_B
R_B
R_E
C_E
T_j up to 175°C
7Z05095.1

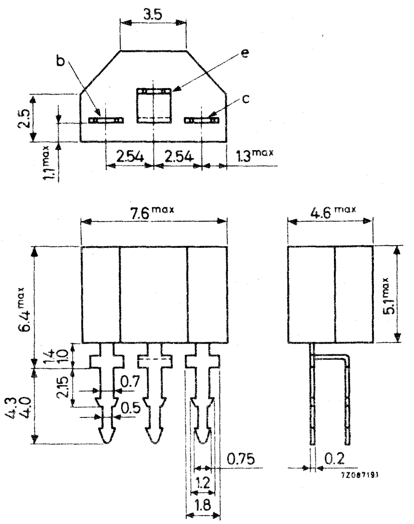
SILICON PLANAR EPITAXIAL TRANSISTOR

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

The BF194 is intended for h.f. applications in radio and television receivers; it is especially recommended for f.m. tuners, low noise a.m. mixer-oscillators with high source impedance and i.f. amplifiers in a.m./f.m. receivers where a high current gain is of importance.

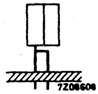
QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector current (d.c.)	I_C	max.	30	mA
Total power dissipation up to $T_{amb} = 25\,^oC$	P_{tot}	max.	250	mW
Junction temperature	T_j	max.	125	^oC
D.C. current gain at $T_j = 25\,^oC$				
$I_C = 1$ mA; $V_{CE} = 10$ V	h_{FE}	typ.	115	
Transition frequency				
$I_C = 1$ mA; $V_{CE} = 10$ V	f_T	typ.	260	MHz
Noise figure at f = 100 MHz				
$I_C = 1$ mA; $V_{CE} = 10$ V; $G_S = 10\,m\Omega^{-1}$	F	typ.	4	dB
Conversion noise figure at f = 1 MHz				
$I_C = 1$ mA; $V_{CE} = 10$ V; $G_S = 1.2\,m\Omega^{-1}$	F_c	typ.	2	dB

MECHANICAL DATA Dimensions in mm

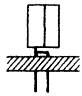


MOUNTING INSTRUCTIONS

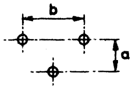
1. Thickness of printed board: max. 1.1 mm
   Hole diameter 0.77 to 0.83 mm



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

Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base) (See also page 4)	V_{CEO}	max.	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Currents

Collector current (d.c.)	I_C	max.	30	mA
Collector current (peak value)	I_{CM}	max.	30	mA

Power dissipation

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

Temperatures

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

THERMAL RESISTANCE

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

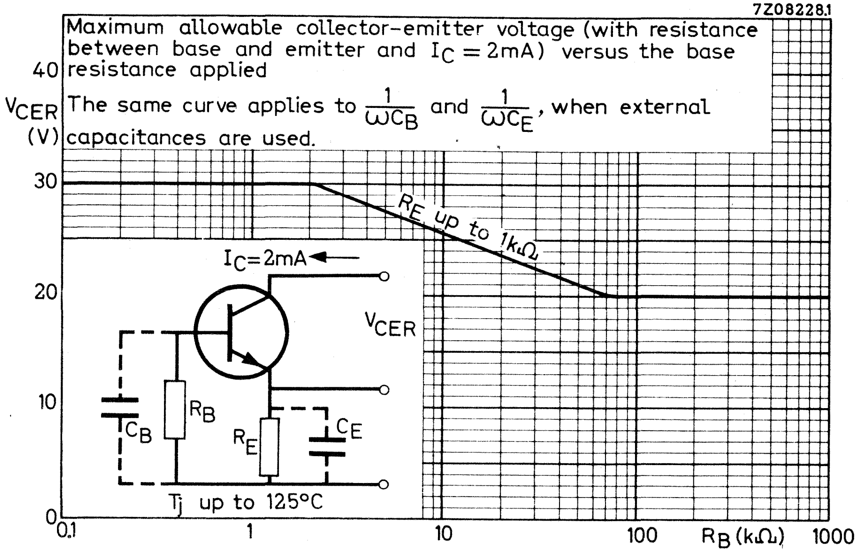
CHARACTERISTICS $T_j = 25\ ^oC$

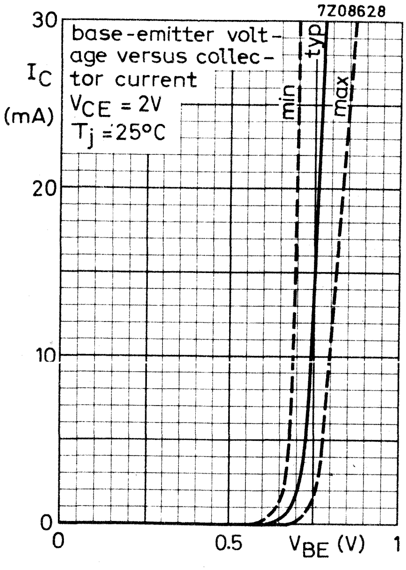
Base-emitter voltage [1]				
$I_C = 1$ mA; $V_{CE} = 10$ V	V_{BE}		0.65 to 0.74	V
Base current				
$I_C = 1$ mA; $V_{CE} = 10$ V	I_B	4.5 to	15	µA
		typ.	8.7	µA
Feedback capacitance at f = 0.45 MHz				
$I_C = 1$ mA; $V_{CE} = 10$ V	C_{re}	typ.	0.95	pF
Transition frequency				
$I_C = 1$ mA; $V_{CE} = 10$ V	f_T	typ.	260	MHz
Noise figure				
$I_C = 1$ mA; $V_{CE} = 10$ V				
$G_S = 2\ m\Omega^{-1}$; f = 0.2 MHz	F	typ.	1.5	dB
$G_S = 1.5\ m\Omega^{-1}$; f = 1.0 MHz	F	typ.	1.2	dB
$G_S = 10\ m\Omega^{-1}$; f = 100 MHz	F	typ.	4	dB
Conversion noise figure				
$I_C = 1$ mA; $V_{CE} = 10$ V				
$G_S = 0.6\ m\Omega^{-1}$; f = 0.2 MHz	F_c	typ.	3	dB
$G_S = 1.2\ m\Omega^{-1}$; f = 1.0 MHz	F_c	typ.	2	dB
y parameters at f = 100 MHz (common base)				
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)				
Input conductance	g_{ib}	typ.	36	$m\Omega^{-1}$
Input susceptance	$-b_{ib}$	typ.	3	$m\Omega^{-1}$
Feedback admittance	$\|y_{rb}\|$	typ.	450	$\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{rb}	typ.	272°	
Tranfer admittance	$\|y_{fb}\|$	typ.	33	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fb}	typ.	146°	
Output conductance	g_{ob}	typ.	22	$\mu\Omega^{-1}$
Output susceptance	b_{ob}	typ.	1.1	$m\Omega^{-1}$

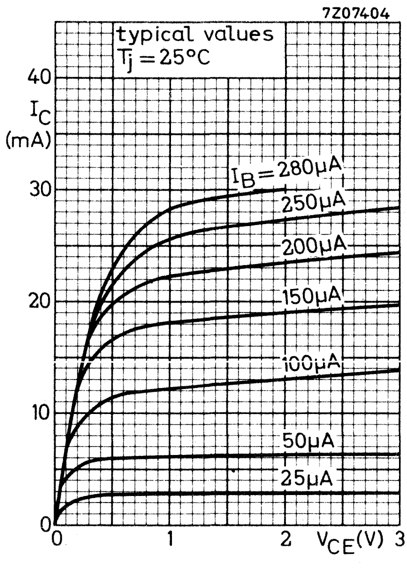
y parameters (common emitter)

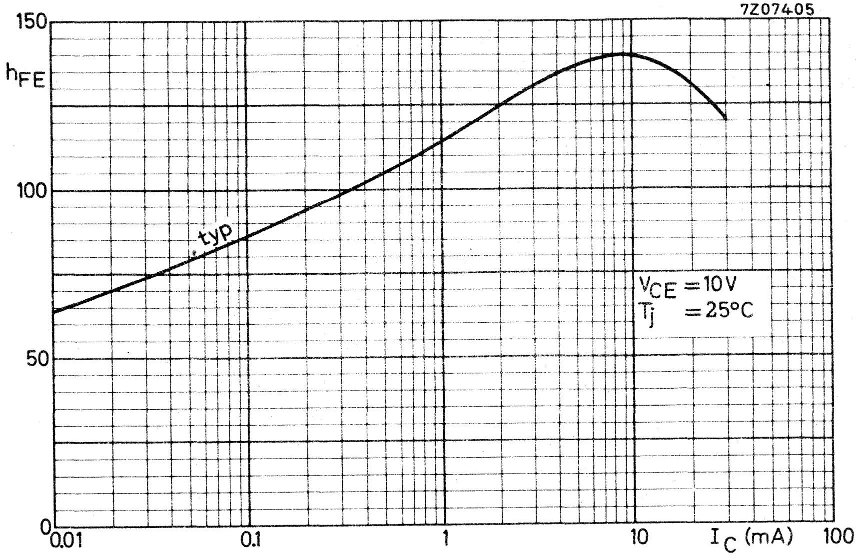
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)			f = 10.7 MHz	f = 0.45 MHz	
Input conductance	g_{ie}	<	0.64	0.54	$m\Omega^{-1}$
Output conductance	g_{oe}	<	13.5	11.5	$\mu\Omega^{-1}$

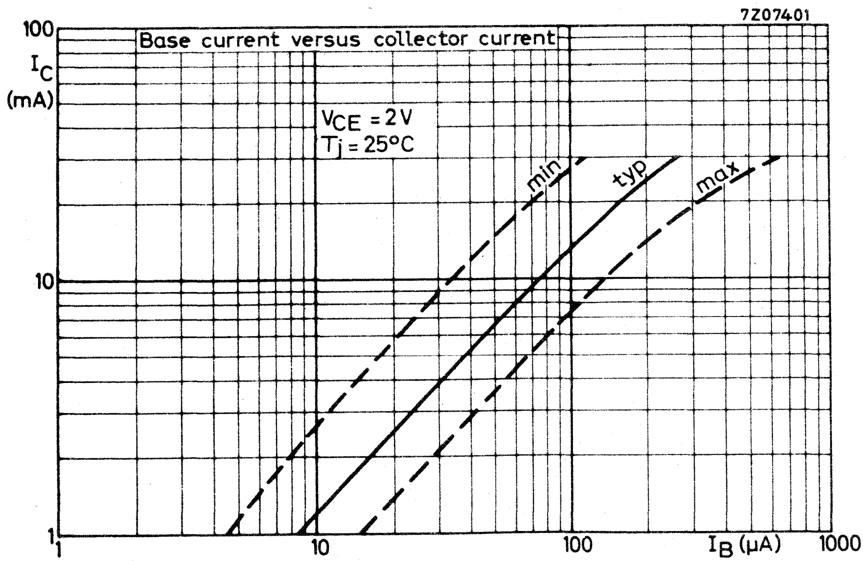
1) V_{BE} decreases by about 1.7 mV/°C with increasing temperature.

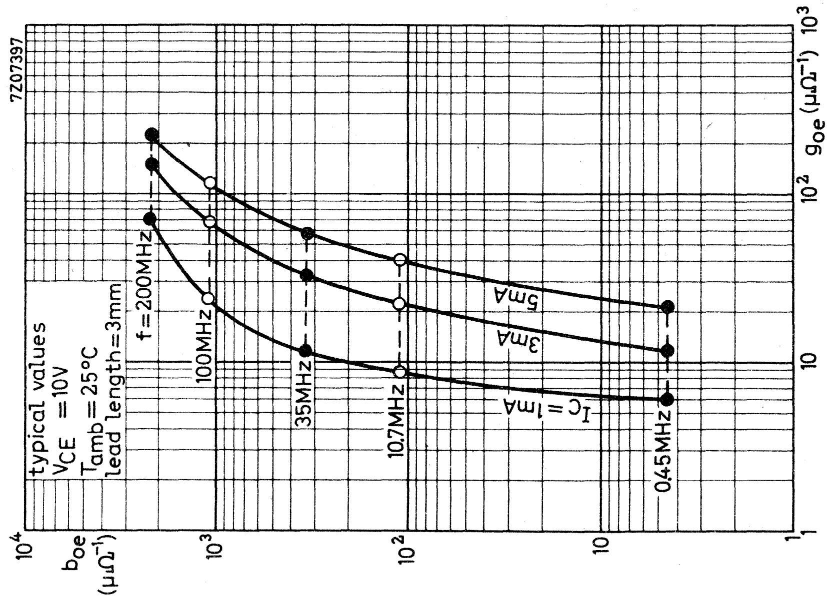

7Z08228.1
Maximum allowable collector-emitter voltage (with resistance between base and emitter and IC = 2mA) versus the base resistance applied
The same curve applies to 1/ωCB and 1/ωCE, when external capacitances are used.
VCER (V)
40
30
20
10
0
RE up to 1kΩ
IC=2mA
VCER
CB
RB
RE
CE
Tj up to 125°C
0.1
1
10
100
RB (kΩ)
1000

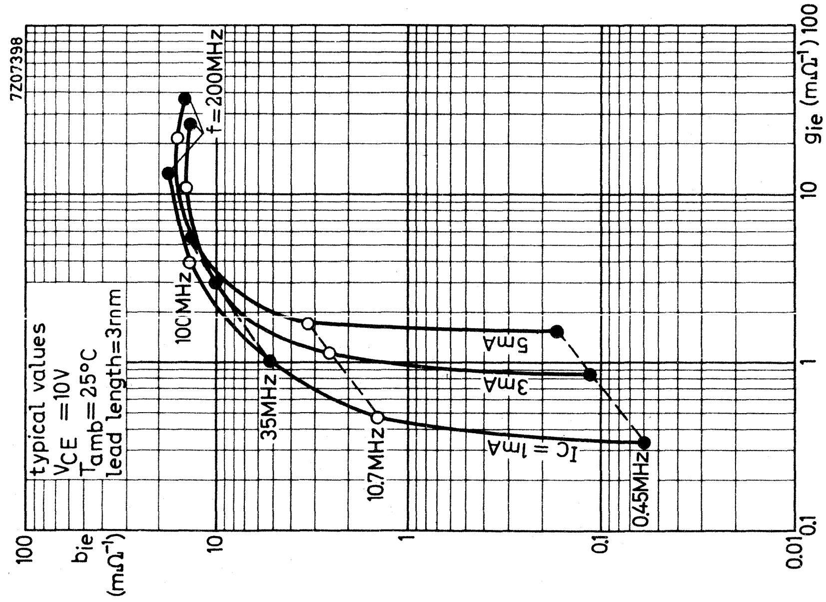

7Z08628
base-emitter voltage versus collector current
VCE = 2V
Tj = 25°C
IC (mA)
30
20
10
0
min
typ
max
0
0.5
VBE (V)
1

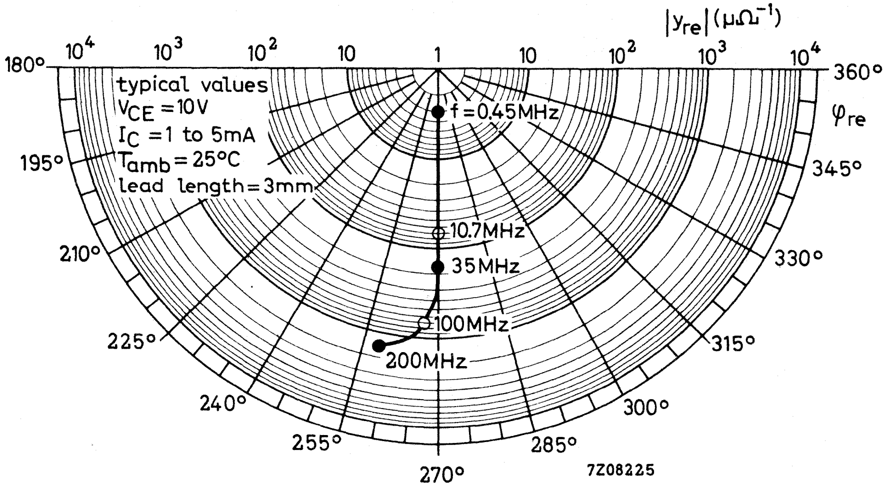

7Z07404
typical values
Tj = 25°C
IC (mA)
40
30
20
10
0
IB = 280μA
250μA
200μA
150μA
100μA
50μA
25μA
0
1
2
VCE (V)
3

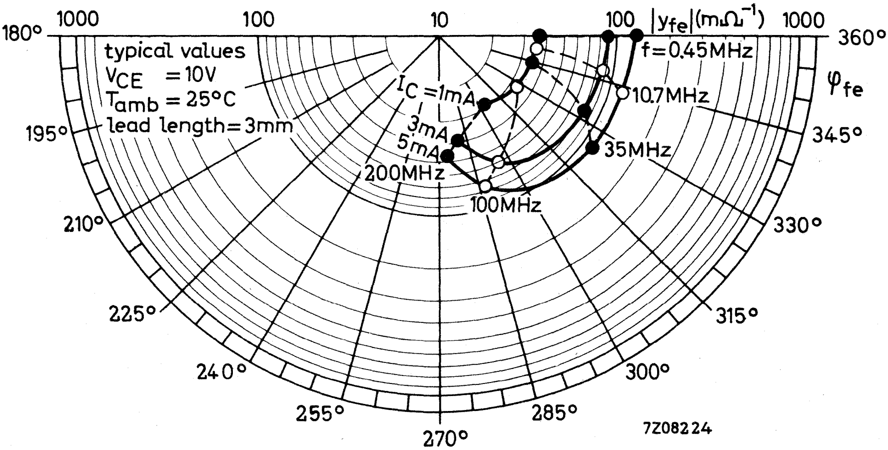

7Z07405
150
h_{FE}
100
50
0
0.01
0.1
1
10
I_C (mA)
100
typ
V_{CE} = 10 V
T_j = 25°C

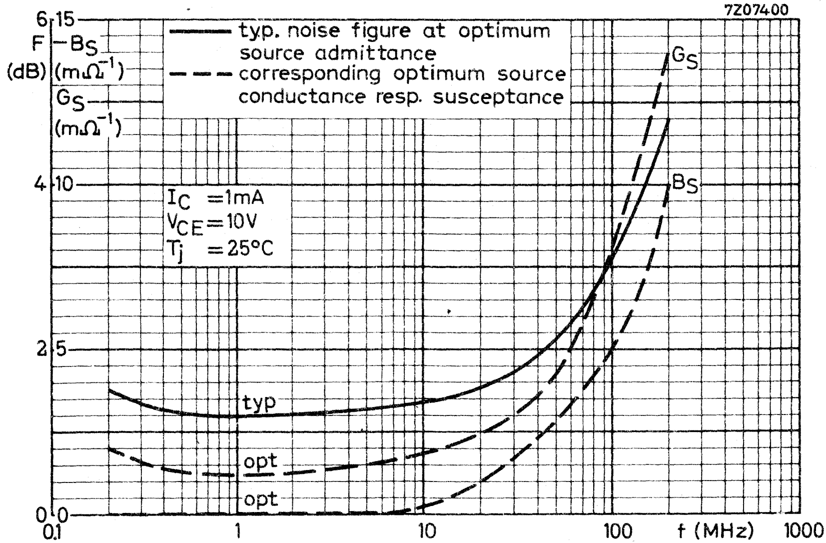

7Z07401
Base current versus collector current
100
I_C
(mA)
10
1
1
10
100
I_B (μA)
1000
V_{CE} = 2 V
T_j = 25°C
min
typ
max

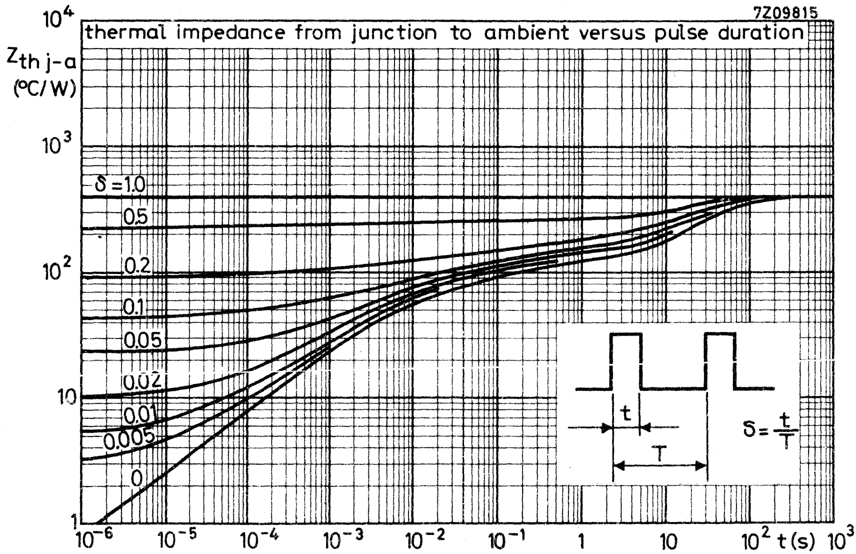

7Z07397
typical values
VCE = 10V
Tamb = 25°C
lead length = 3mm
f = 200MHz
100MHz
35MHz
10.7MHz
0.45MHz
5mA
3mA
IC = 1mA
boe (μΩ⁻¹)
10⁴
10³
10²
10
1
goe (μΩ⁻¹)
10³
10²
10
1


7Z07398
typical values
VCE = 10V
Tamb = 25°C
lead length = 3mm
f = 200MHz
100MHz
35MHz
10.7MHz
0.45MHz
5mA
3mA
IC = 1mA
bie (mΩ⁻¹)
100
10
1
0.1
0.01
gie (mΩ⁻¹)
100
10
1
0.1


|y_re| (μΩ⁻¹)
10^4 10^3 10^2 10 1 10 10^2 10^3 10^4
180° 195° 210° 225° 240° 255° 270° 285° 300° 315° 330° 345° 360°
φ_re
typical values
V_CE = 10V
I_C = 1 to 5mA
T_amb = 25°C
lead length = 3mm
f = 0.45MHz
10.7MHz
35MHz
100MHz
200MHz
7Z08225


1000 100 10 100 |y_fe| (mΩ⁻¹) 1000
180° 195° 210° 225° 240° 255° 270° 285° 300° 315° 330° 345° 360°
φ_fe
typical values
V_CE = 10V
T_amb = 25°C
lead length = 3mm
I_C = 1mA
3mA
5mA
f = 0.45MHz
10.7MHz
35MHz
100MHz
200MHz
7Z08224


7Z07400
typ. noise figure at optimum source admittance
corresponding optimum source conductance resp. susceptance
F (dB)
$-B_S$ (mΩ^{-1})
G_S (mΩ^{-1})
I_C = 1mA
V_{CE} = 10V
T_j = 25°C
typ
opt
opt
G_S
B_S
f (MHz)


7Z09815
thermal impedance 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 TRANSISTOR

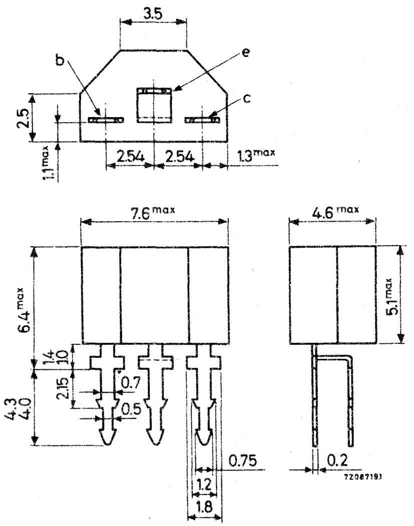
N-P-N transistor in a plastic envelope with stiff self-locking pins suitable for use with standard printed boards.

The BF195 is intended for h.f. applications in radio and television receivers; it is especially recommended for f.m. tuners, i.f. amplifiers in a.m./f.m. receivers where a low transistor output conductance is of importance, a.m. input stages of carradios where a low noise figure at low source impedance is required.

QUICK REFERENCE DATA

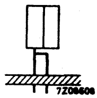
Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector current (d.c.)	I_C	max.	30	mA
Total power dissipation up to $T_{amb} = 25\,^oC$	P_{tot}	max.	250	mW
Junction temperature	T_j	max.	125	^oC
D.C. current gain at $T_j = 25\,^oC$				
$I_C = 1$ mA; $V_{CE} = 10$ V	h_{FE}	typ.	67	
Transition frequency				
$I_C = 1$ mA; $V_{CE} = 10$ V	f_T	typ.	200	MHz
Noise figure				
$I_C = 1$ mA; $V_{CE} = 10$ V				
$G_S = 20\ m\Omega^{-1}$; f = 1 MHz	F	typ.	3.5	dB
$G_S = 10\ m\Omega^{-1}$; f = 100 MHz	F	typ.	4	dB

MECHANICAL DATA Dimensions in mm

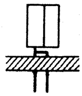


MOUNTING INSTRUCTIONS

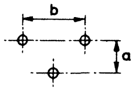
1. Thickness of printed board: max. 1.1 mm
   Hole diameter 0.77 to 0.83 mm



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

Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base) (See also page 4)	V_{CEO}	max.	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Currents

Collector current (d.c.)	I_C	max.	30	mA
Collector current (peak value)	I_{CM}	max.	30	mA

Power dissipation

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

Temperatures

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

THERMAL RESISTANCE

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

CHARACTERISTICS $T_j = 25\ ^oC$

Base-emitter voltage [1])

$I_C = 1$ mA; $V_{CE} = 10$ V	V_{BE}	0.65 to 0.74		V

Base current

$I_C = 1$ mA; $V_{CE} = 10$ V	I_B	8 to	28	μA
		typ.	15	μA

Feedback capacitance at f = 0.45 MHz

$I_C = 1$ mA; $V_{CE} = 10$ V	C_{re}	typ.	0.95	pF

Transition frequency

$I_C = 1$ mA; $V_{CE} = 10$ V	f_T	typ.	200	MHz

Noise figure

$I_C = 1$ mA; $V_{CE} = 10$ V

$G_S = 20\ m\Omega^{-1}$; f = 1 MHz	F	typ.	3.5	dB
$G_S = 10\ m\Omega^{-1}$; f = 100 MHz	F	typ.	4	dB

Conversion noise figure

$I_C = 1$ mA; $V_{CE} = 10$ V

$G_S = 1.2\ m\Omega^{-1}$; f = 0.2 MHz	F_c	typ.	4	dB
$G_S = 1.5\ m\Omega^{-1}$; f = 1 MHz	F_c	typ.	2.5	dB

y parameters at f = 100 MHz (common base)

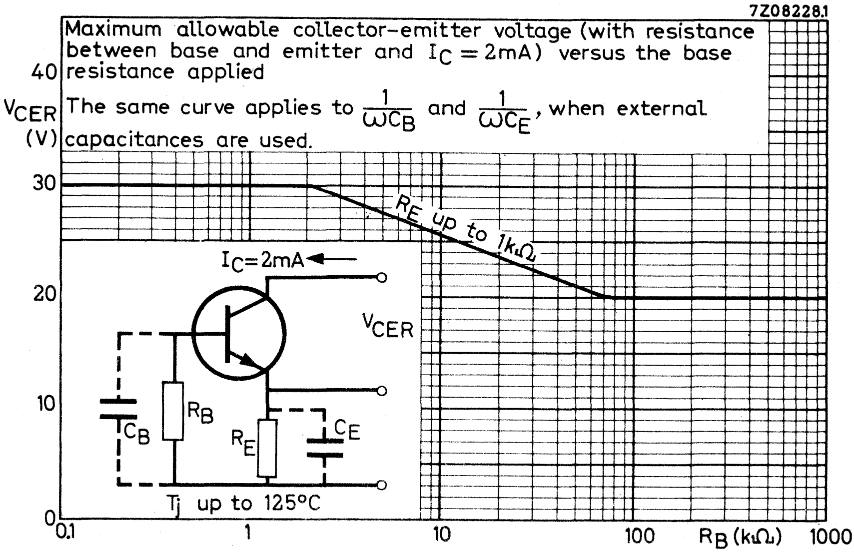
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)

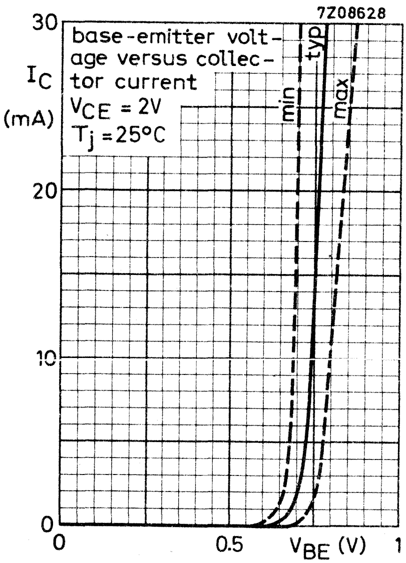
Input conductance	g_{ib}	typ.	38	$m\Omega^{-1}$
Input susceptance	$-b_{ib}$	typ.	1	$m\Omega^{-1}$
Feedback admittance	$\lvert y_{rb}\rvert$	typ.	440	$\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{rb}	typ.	275^o	
Transfer admittance	$\lvert y_{fb}\rvert$	typ.	34	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fb}	typ.	140^o	
Output conductance	g_{ob}	typ.	12	$\mu\Omega^{-1}$
Output susceptance	b_{ob}	typ.	1.1	$m\Omega^{-1}$

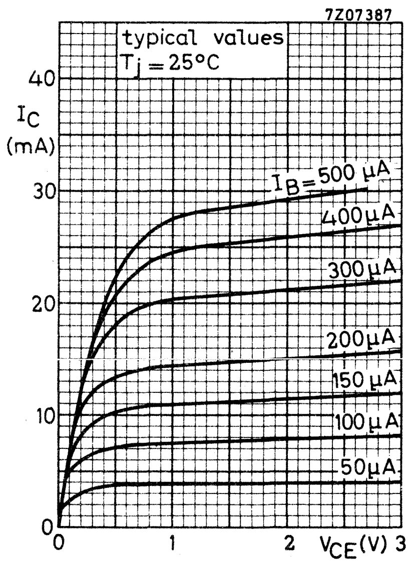
y parameters (common emitter)

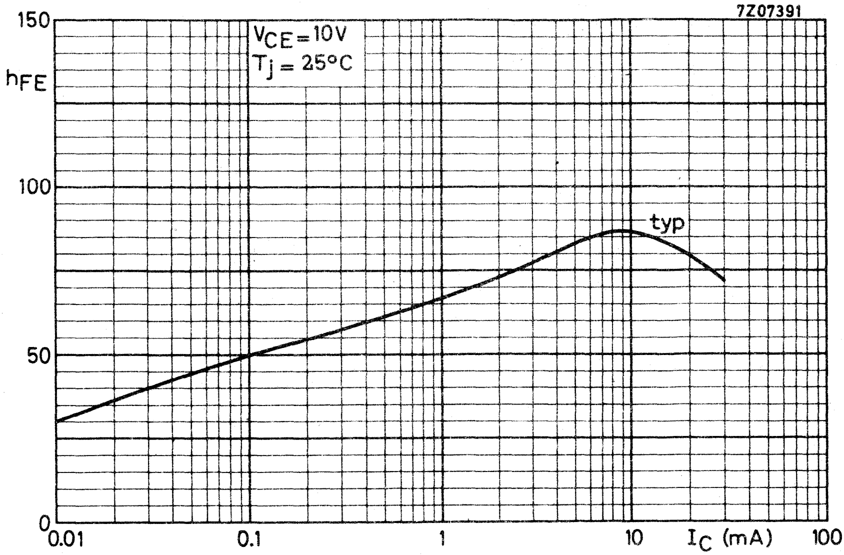
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)			f = 10.7 MHz	f = 0.45 MHz	
Input conductance	g_{ie}	<	0.96	0.86	$m\Omega^{-1}$
Output conductance	g_{oe}	<	9.5	7.0	$\mu\Omega^{-1}$

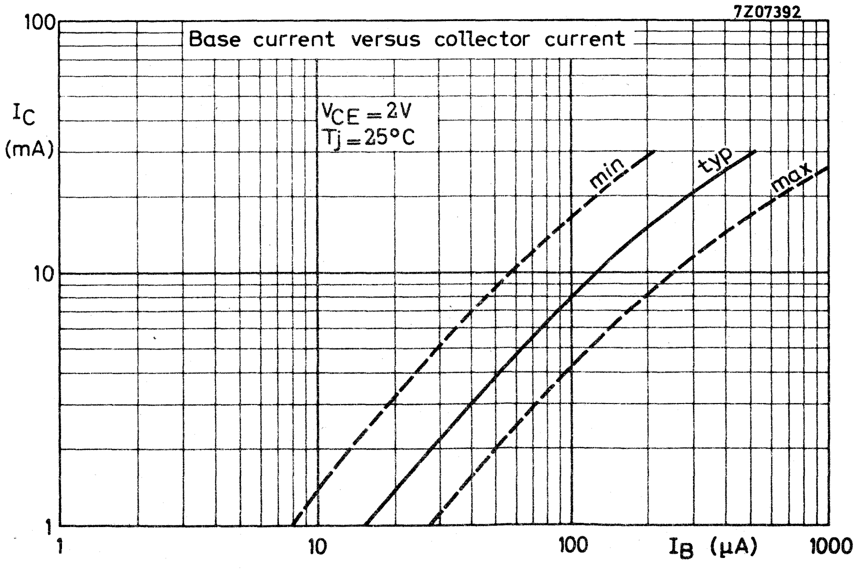
[1]) V_{BE} decreases by about 1.7 mV/^{o}C with increasing temperature.

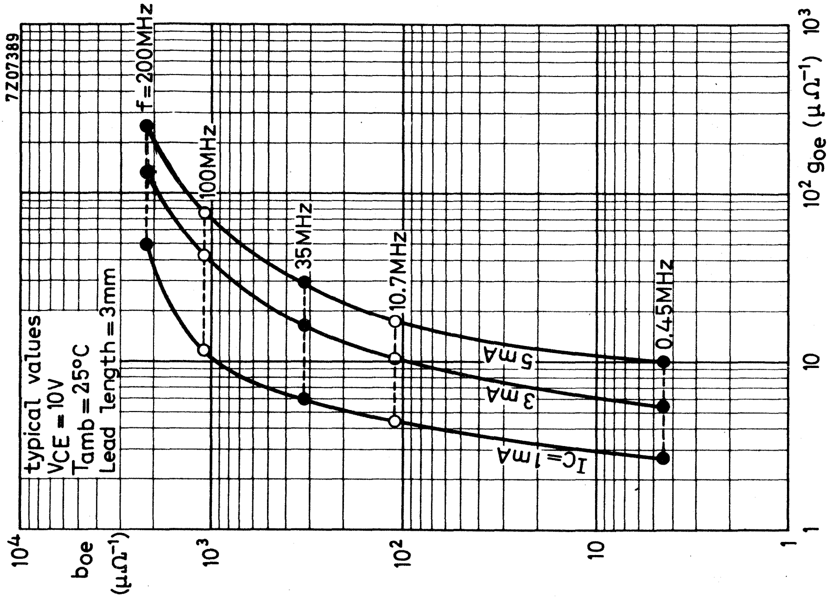

7Z08228.1
Maximum allowable collector-emitter voltage (with resistance between base and emitter and $I_C = 2mA$) versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$, when external capacitances are used.
V_{CER} (V)
40
30
20
10
0
0.1
1
10
100
R_B (kΩ)
1000
R_E up to 1kΩ
$I_C = 2mA$
V_{CER}
R_B
C_B
R_E
C_E
T_j up to 125°C

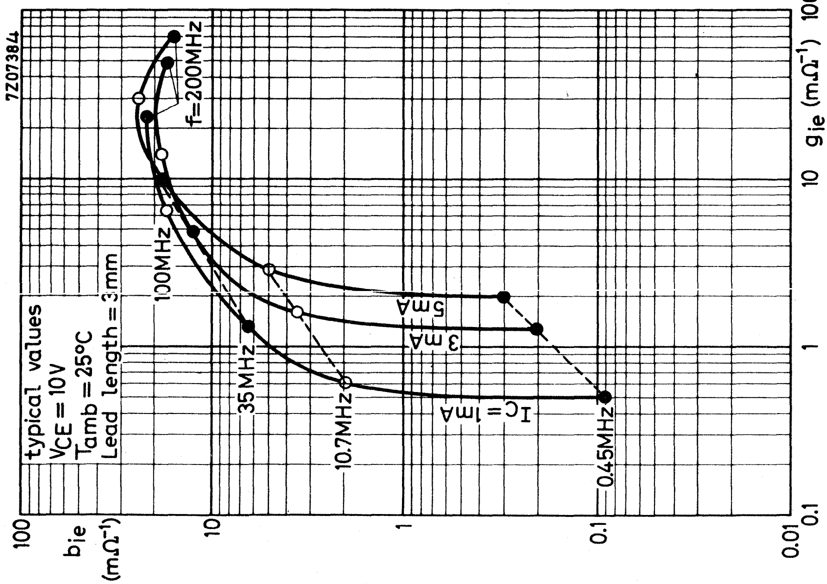

7Z08628
base-emitter voltage versus collector current
$V_{CE} = 2V$
$T_j = 25°C$
I_C (mA)
30
20
10
0
0
0.5
V_{BE} (V)
1
min
typ
max

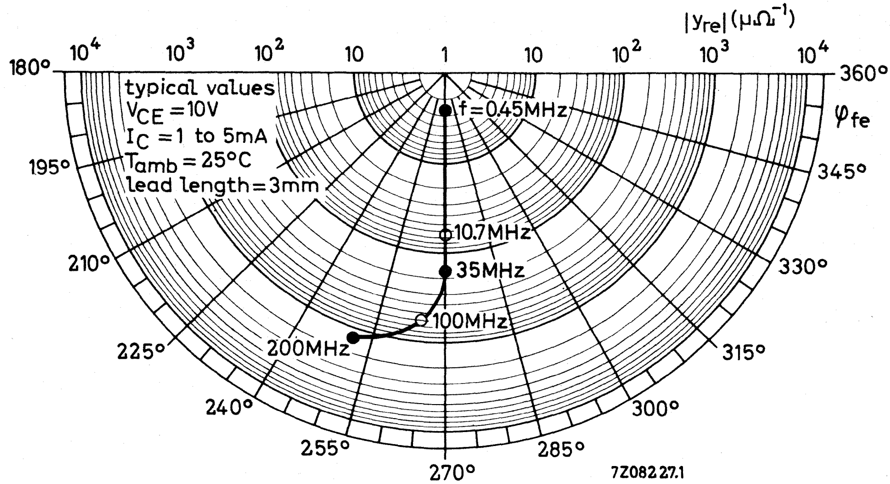

7Z07387
typical values
$T_j = 25°C$
I_C (mA)
40
30
20
10
0
0
1
2
V_{CE} (V)
3
$I_B = 500\ \mu A$
400 µA
300 µA
200 µA
150 µA
100 µA
50 µA

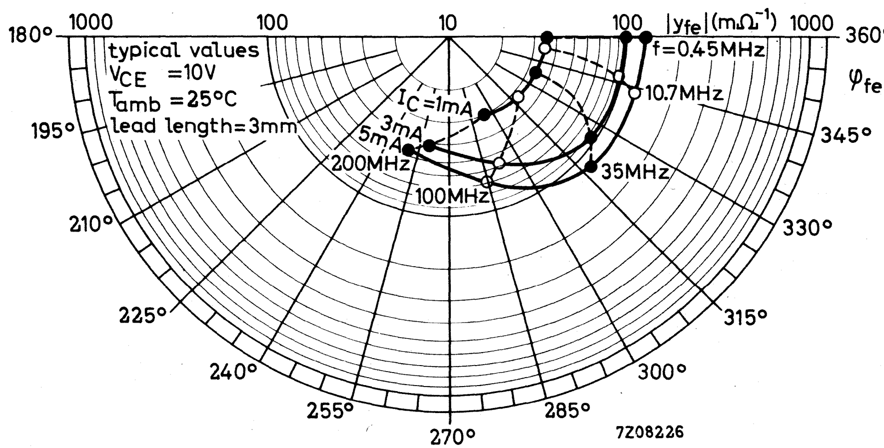

7Z07391
150
h_{FE}
100
50
0
$V_{CE} = 10V$
$T_j = 25°C$
typ
0.01
0.1
1
10
I_C (mA)
100

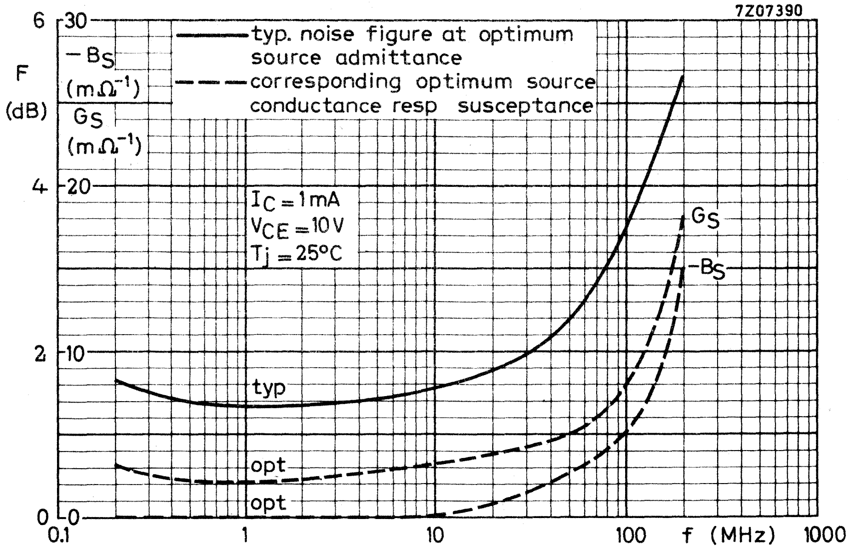

7Z07392
Base current versus collector current
100
I_C
(mA)
10
1
$V_{CE} = 2V$
$T_j = 25°C$
min
typ
max
1
10
100
I_B (μA)
1000

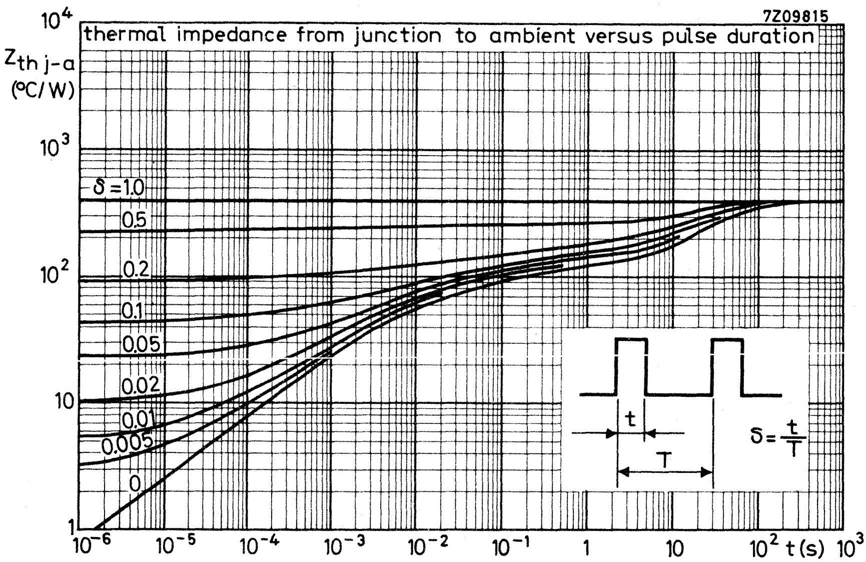

7Z07389
typical values
V_{CE} = 10V
T_{amb} = 25°C
Lead length = 3mm
f = 200MHz
100MHz
35MHz
10.7MHz
0.45MHz
5 mA
3 mA
I_C = 1 mA
b_{oe} ($\mu\Omega^{-1}$)
10^4
10^3
10^2
10
1
g_{oe} ($\mu\Omega^{-1}$)
1
10
10^2
10^3


7Z07384
typical values
V_{CE} = 10V
T_{amb} = 25°C
Lead length = 3mm
f=200MHz
100MHz
35MHz
10.7MHz
0.45MHz
5 mA
3 mA
I_C = 1 mA
b_{ie} ($m\Omega^{-1}$)
100
10
1
0.1
0.01
g_{ie} ($m\Omega^{-1}$)
0.1
1
10
100


|yre| (μΩ⁻¹)
10⁴
10³
10²
10
1
10
10²
10³
10⁴
180°
360°
φfe
typical values
VCE =10V
IC =1 to 5mA
Tamb = 25°C
lead length = 3mm
f = 0.45MHz
10.7MHz
35MHz
100MHz
200MHz
195°
210°
225°
240°
255°
270°
285°
300°
315°
330°
345°
7Z082 27.1


1000
100
10
100
|yfe| (mΩ⁻¹)
1000
180°
360°
φfe
typical values
VCE =10V
Tamb =25°C
lead length=3mm
f=0.45MHz
10.7MHz
IC=1mA
3mA
5mA
200MHz
100MHz
35MHz
195°
210°
225°
240°
255°
270°
285°
300°
315°
330°
345°
7Z08226


7Z07390
typ. noise figure at optimum source admittance
corresponding optimum source conductance resp susceptance
F (dB)
−BS (mΩ⁻¹)
GS (mΩ⁻¹)
IC = 1 mA
VCE = 10 V
Tj = 25°C
typ
opt
opt
GS
−BS
f (MHz)
0.1
1
10
100
1000


7Z09815
thermal impedance 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 TRANSISTOR

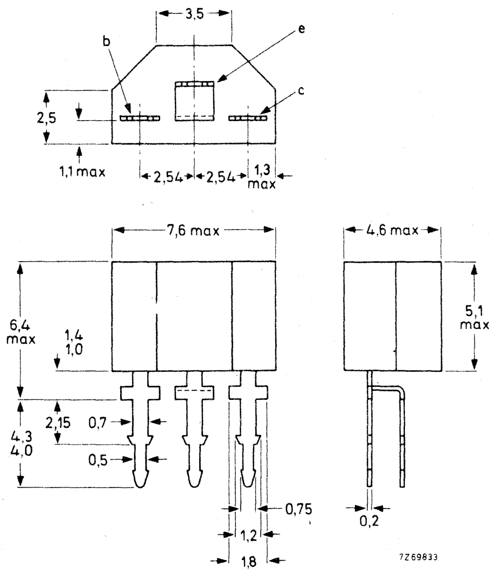
N-P-N transistor in a plastic envelope with stiff self-locking pins suitable for use with standard printed-circuit boards. The transistor has a very low feedback capacitance and is intended for use in the forward gain control stage of the television i.f. amplifier.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	V
Collector current (d.c.)	I_C	max.	25	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	250	mW
Junction temperature	T_j	max.	125	°C
Transition frequency I_C = 4 mA; V_{CE} = 10 V	f_T	typ.	400	MHz
Feedback capacitance at f = 10,7 MHz I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	200	fF
Max. unilateralized power gain I_C = 4 mA; V_{CE} = 10 V; f = 35 MHz	G_{UM}	typ.	42	dB
f = 45 MHz	G_{UM}	typ.	39	dB
Gain control range	ΔG_{tr}	typ.	60	dB

MECHANICAL DATA

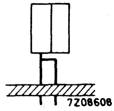
Dimensions in mm

SOT-25

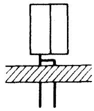


MOUNTING INSTRUCTIONS

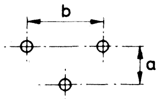
1. Thickness of printed board: max. 1.1 mm
   Hole diameter 0.77 to 0.83 mm



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) [1]

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	V [2]
Emitter-base voltage (open collector)	V_{EBO}	max.	4	V

Currents

Collector current (d.c.)	I_C	max.	25	mA
Collector current (peak value)	I_{CM}	max.	25	mA

Power dissipation

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

Temperatures

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

THERMAL RESISTANCE

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

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

2) See also page 6 .

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

Base current at about 50 dB gain control				
I_C = 6 mA; V_{CE} = 2 V	I_B	<	270	μA
I_C = 15 mA; V_{CE} = 5 V	I_B	<	1.5	mA
Base current				
I_C = 4 mA; V_{CE} = 10 V	I_B	typ.	60	μA
		<	150	μA
Base-emitter voltage [1]				
I_C = 4 mA; V_{CE} = 10 V	V_{BE}	typ.	750	mV
		<	840	mV
Feedback capacitance at f = 10.7 MHz				
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	200	fF
Transition frequency at f = 100 MHz				
I_C = 4 mA; V_{CE} = 10 V	f_T	typ.	400	MHz
Noise figure				
I_C = 4 mA; V_{CE} = 10 V; G_S = 10 mΩ^{-1}; f = 35 MHz; B_S = 0	F	typ.	3	dB

y parameters (common emitter)

I_C = 4 mA; V_{CE} = 10 V (mounted according to instruction 2, see page 2)

			f = 35	45	MHz
Input conductance	g_{ie}	typ.	3.2	4.8	mΩ^{-1}
Input capacitance	C_{ie}	typ.	37	35	pF
Feedback admittance	$\|y_{re}\|$	typ.	47	60	μΩ^{-1}
Phase angle of feedback admittance	φ_{re}	typ.	268°	268°	
Transfer admittance	$\|y_{fe}\|$	typ.	105	100	mΩ^{-1}
Phase angle of transfer admittance	φ_{fe}	typ.	340°	340°	
Output conductance	g_{oe}	typ.	50	60	μΩ^{-1}
Output capacitance	C_{oe}	typ.	1.3	1.3	pF

Maximum unilateralised power gain

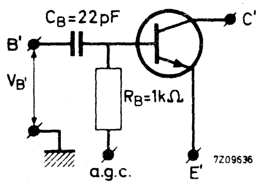
$$G_{UM} \text{ (in dB)} = 10 \log \frac{|y_{fe}|^2}{4 g_{ie} g_{oe}}$$

I_C = 4 mA; V_{CE} = 10 V	G_{UM}	typ.	42	39	dB

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

Equivalent gain control transistor

To ensure an almost constant input admittance and an output conductance that varies little with gain control, we recommend that where a BF196 is used in a gain controlled i.f. stage, a series base capacitor of 22 pF and a bias resistor of 1 kΩ be used.



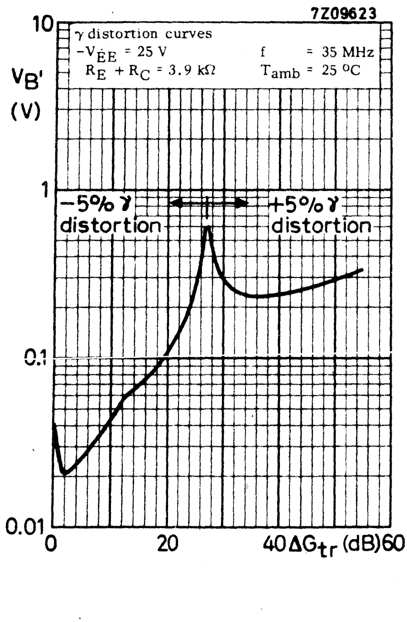
The transistor with these additional components is effectively an "equivalent transistor" for gain control purposes, the signal handling capability of which may be expressed in terms of voltage. (Without these components the varying input admittance means that the signal handling capability can only be expressed in terms of power).

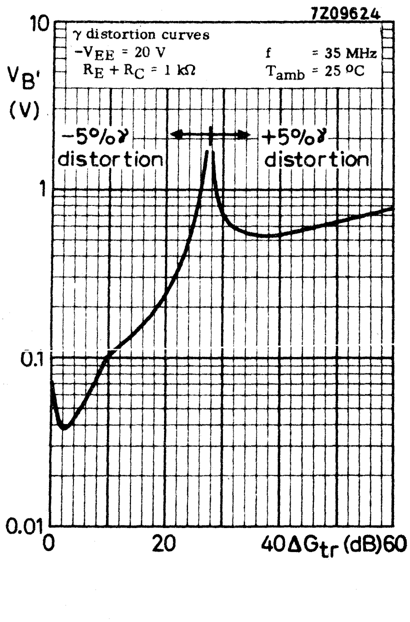
The signal handling capability of the equivalent transistor as a function of ΔG_{tr} (the reduction in transducer gain with gain control) will be found on pages 4 and 5.

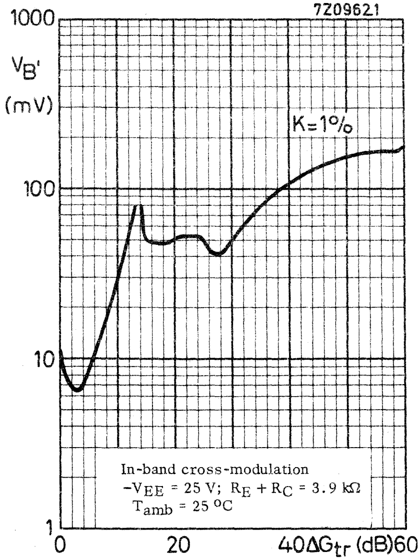
a. Voltage versus ΔG_{tr} curves for a γ distortion of 5% are below.

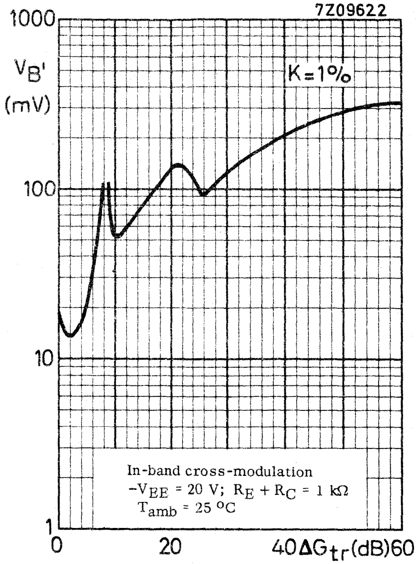
b. Voltage versus ΔG_{tr} curves for an in-band cross modulation factor of 1% are on page 5.

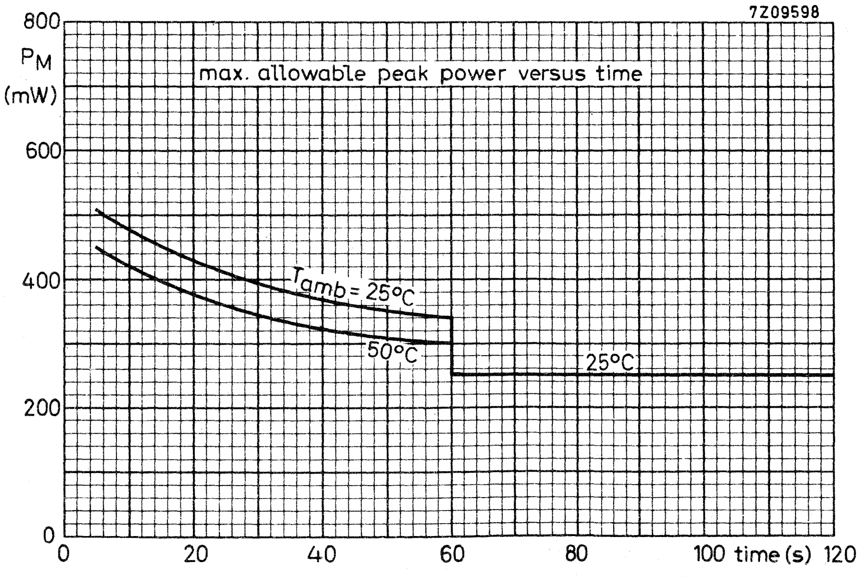
Graphs of the y-parameters are on pages 8 to 11.

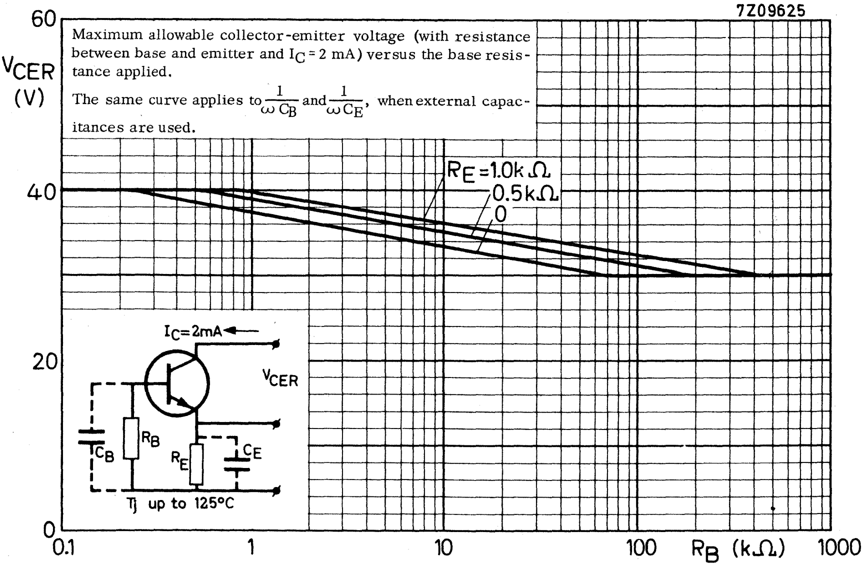


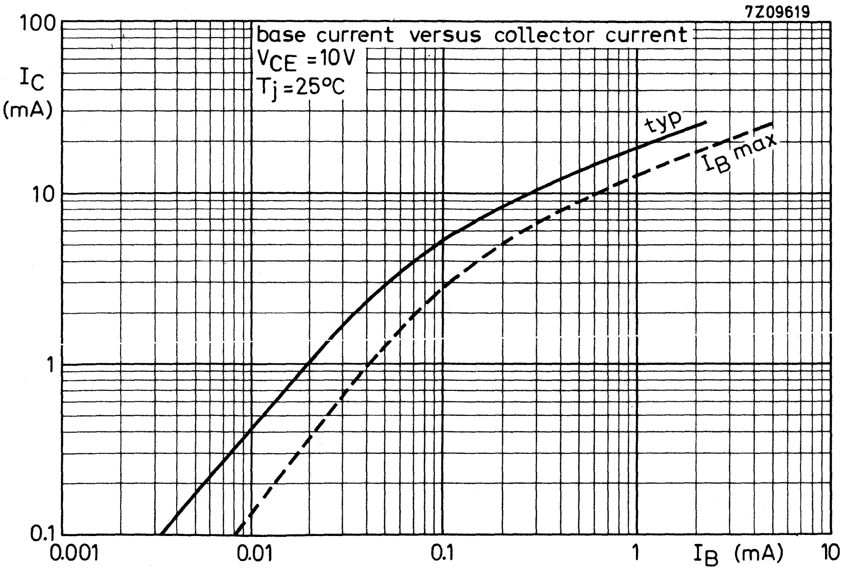


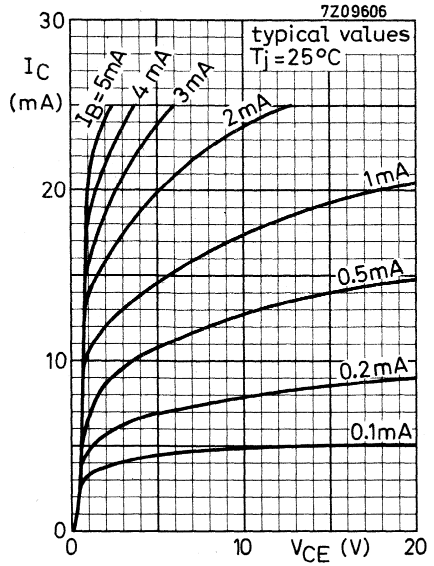

7Z09621
1000
$V_{B'}$
(mV)
100
10
1
K=1%
In-band cross-modulation
$-V_{EE}$ = 25 V; $R_E + R_C$ = 3.9 kΩ
T_{amb} = 25 °C
0
20
40 ΔG_{tr} (dB) 60

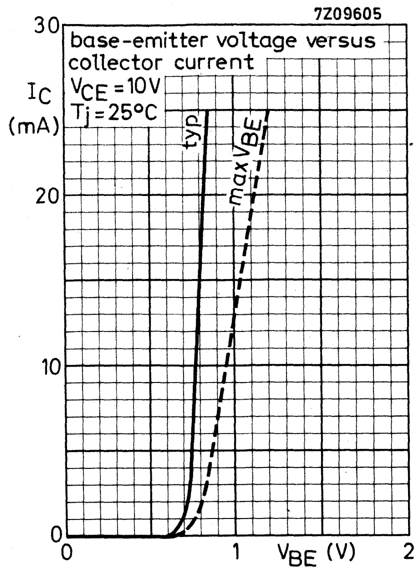

7Z09622
1000
$V_{B'}$
(mV)
100
10
1
K=1%
In-band cross-modulation
$-V_{EE}$ = 20 V; $R_E + R_C$ = 1 kΩ
T_{amb} = 25 °C
0
20
40 ΔG_{tr} (dB) 60

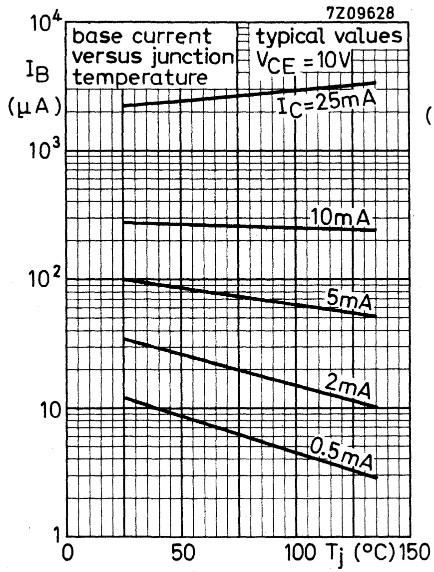

7Z09598
800
P_M
(mW)
600
400
200
0
max. allowable peak power versus time
T_{amb} = 25 °C
50 °C
25 °C
0
20
40
60
80
100 time (s) 120

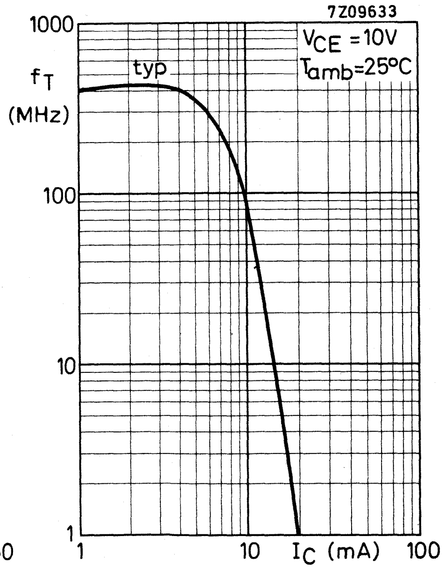

7Z09625
Maximum allowable collector-emitter voltage (with resistance between base and emitter and I_C = 2 mA) versus the base resistance applied.
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$, when external capacitances are used.
V_{CER} (V)
R_E = 1.0 kΩ
0.5 kΩ
0
I_C = 2mA
V_{CER}
C_B
R_B
R_E
C_E
Tj up to 125°C
R_B (kΩ)


7Z09619
base current versus collector current
V_{CE} = 10 V
T_j = 25°C
I_C (mA)
typ
I_B max
I_B (mA)

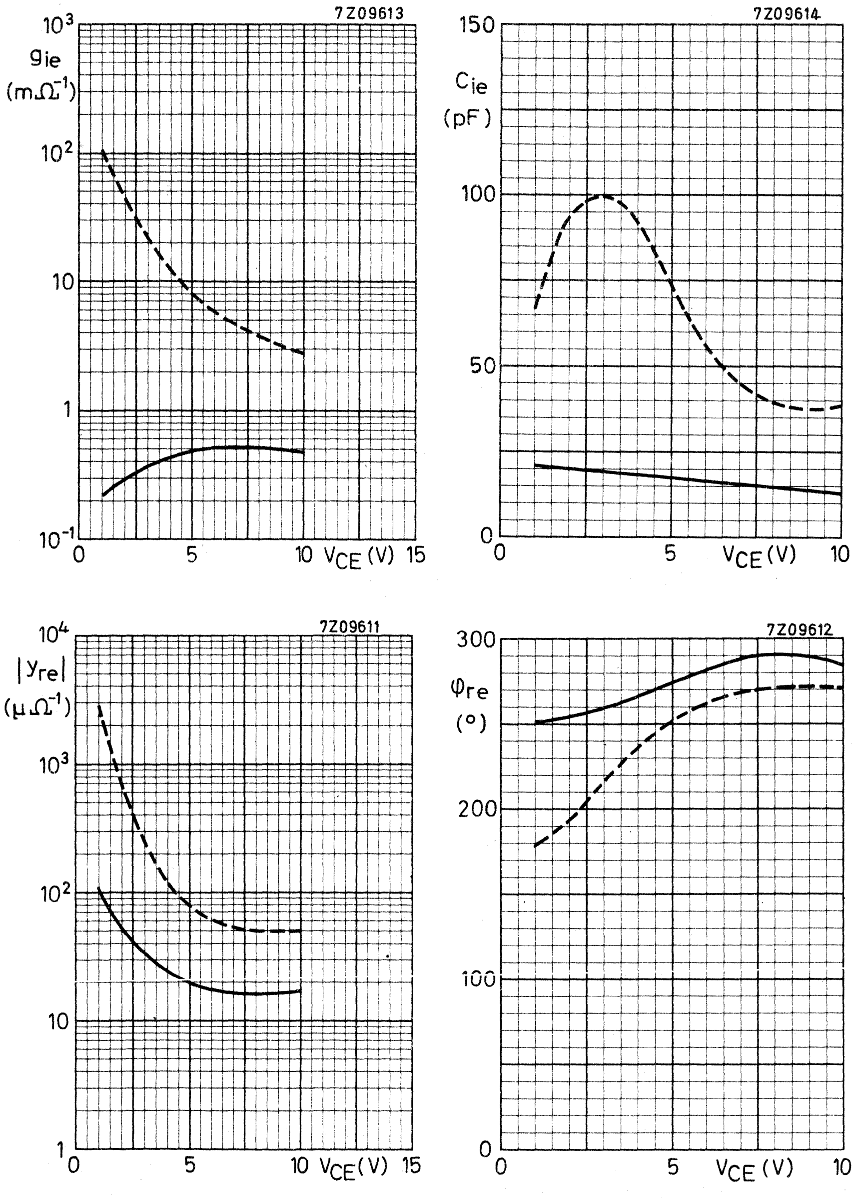

7Z09606
typical values
Tj = 25 °C
IC
(mA)
IB = 5 mA
4 mA
3 mA
2 mA
1 mA
0.5 mA
0.2 mA
0.1 mA
VCE (V)


7Z09605
base-emitter voltage versus collector current
VCE = 10 V
Tj = 25 °C
IC
(mA)
typ
max VBE
VBE (V)


7Z09628
base current versus junction temperature
typical values
VCE = 10 V
IB
(μA)
IC = 25 mA
10 mA
5 mA
2 mA
0.5 mA
Tj (°C)

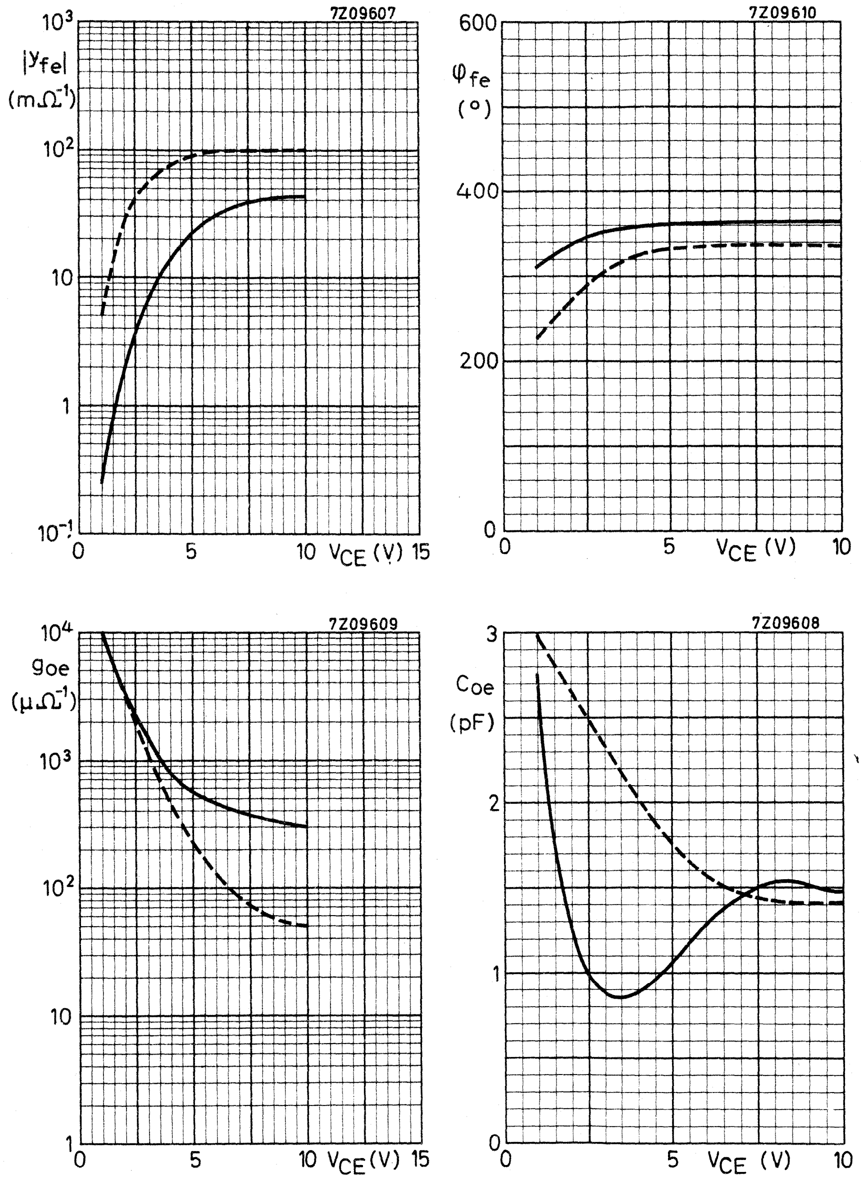

7Z09633
VCE = 10 V
Tamb = 25 °C
fT
(MHz)
typ
IC (mA)

Voltage control; $-V_{EE}$ = 25 V; $R_E + R_C$ = 3.9 kΩ; f = 35 MHz



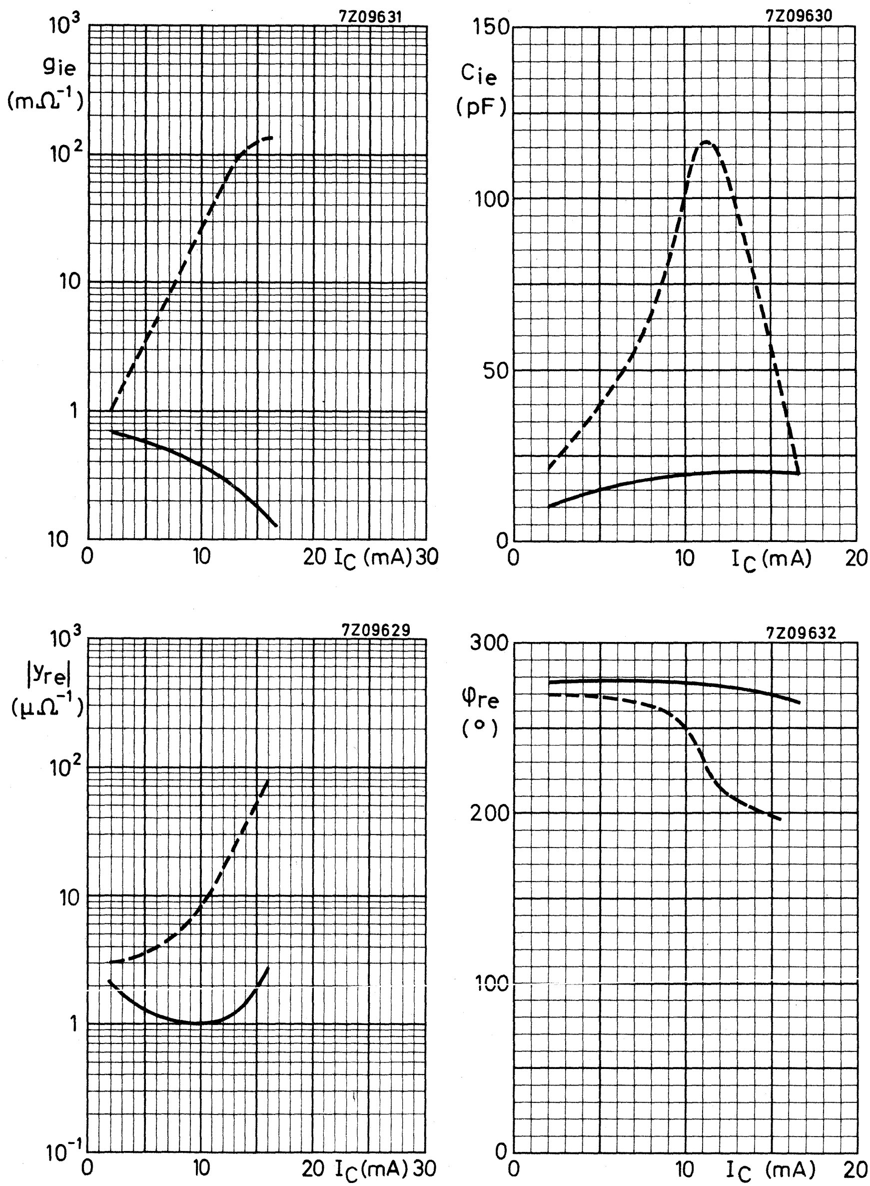
y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

Voltage control; $-V_{EE} = 25$ V; $R_E + R_C = 3.9$ kΩ; f = 35 MHz



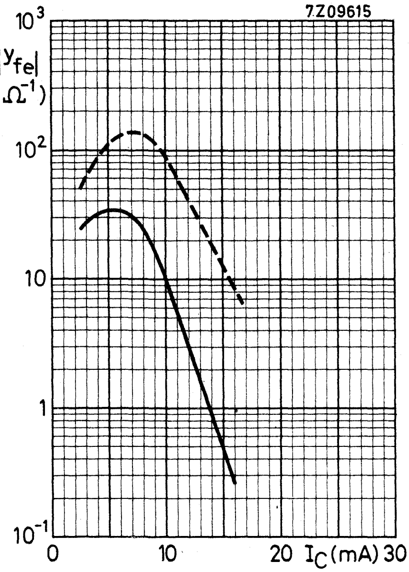
y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

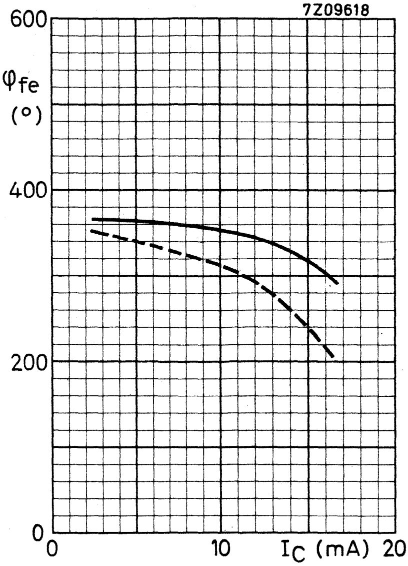
Current control; $-V_{EE}$ = 20 V; $R_E + R_C$ = 1 kΩ; f = 35 MHz

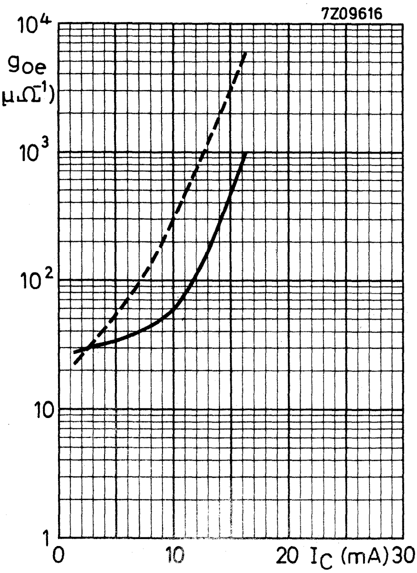


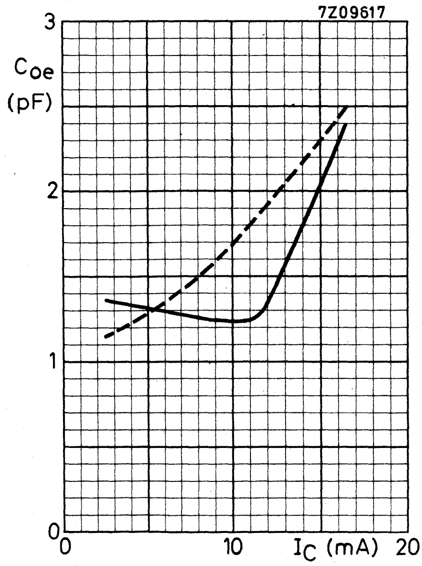
y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

Current control; $-V_{EE}$ = 20 V; $R_E + R_C$ = 1 kΩ; f = 35 MHz









y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

APPLICATION INFORMATION

For application information see BF198.

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic envelope with stiff self-locking pins suitable for use with standard printed-circuit boards.
The BF197 has a very low feedback capacitance and is intended for use in the output stage of a vision i.f. amplifier.

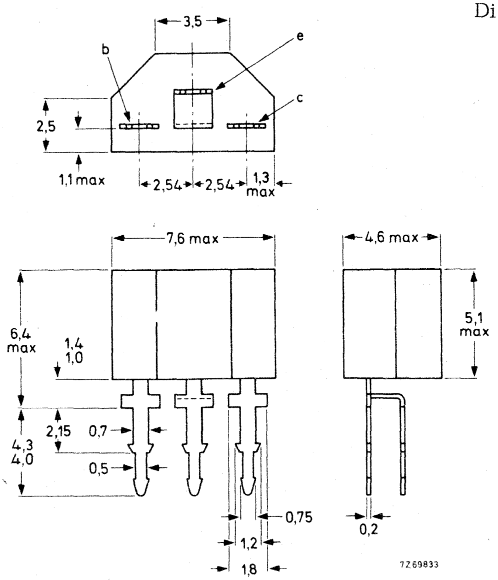
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Collector current (d.c.)	I_C	max.	25	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	250	mW
Junction temperature	T_j	max.	125	°C
Transition frequency I_C = 5 mA; V_{CE} = 10 V	f_T	typ.	550	MHz
Feedback capacitance at f = 10,7 MHz I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	300	fF
Max. unilateralized power gain I_C = 7 mA; V_{CE} = 10 V; f = 35 MHz	G_{UM}	typ.	43	dB
f = 45 MHz	G_{UM}	typ.	41	dB
Video detector output voltage	V_O	typ.	7,7	V

MECHANICAL DATA

Dimensions in mm

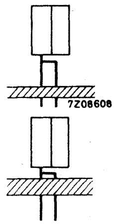
SOT-25



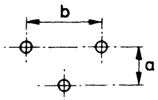
MOUNTING INSTRUCTIONS

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) [1]

Voltages				
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V [2]
Emitter-base voltage (open collector)	V_{EBO}	max.	4	V
Currents				
Collector current (d.c.)	I_C	max.	25	mA
Collector current (peak value)	I_{CM}	max.	25	mA
Power dissipation				
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	250	mW
Temperatures				
Storage temperature	T_{stg}	-65 to +125		°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

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

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

[2] See also page 4.

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

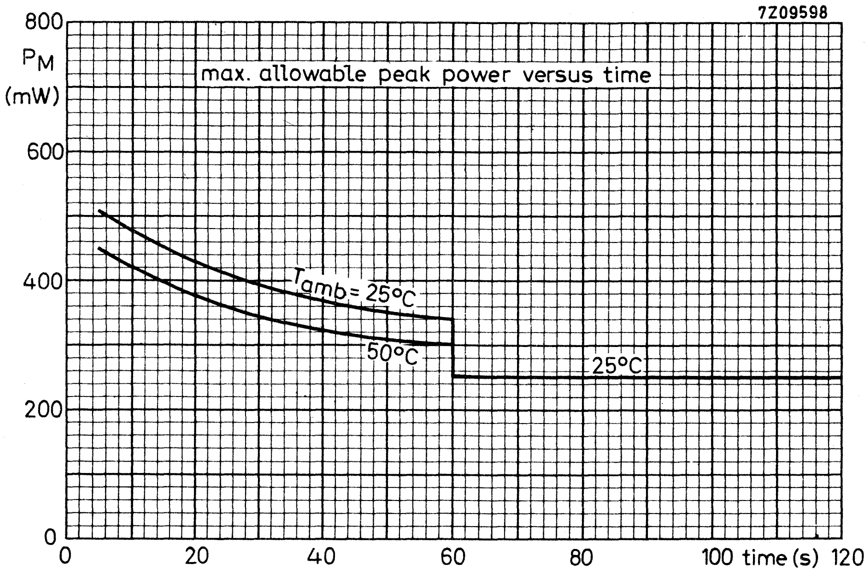
Base current				
I_C = 7 mA; V_{CE} = 10 V	I_B	typ.	60	μA
		<	185	μA
Base-emitter voltage [1]				
I_C = 7 mA; V_{CE} = 10 V	V_{BE}	typ.	750	mV
		<	900	mV
Feedback capacitance at f = 10,7 MHz				
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	300	fF
Transition frequency at f = 100 MHz				
I_C = 5 mA; V_{CE} = 10 V	f_T	typ.	550	MHz

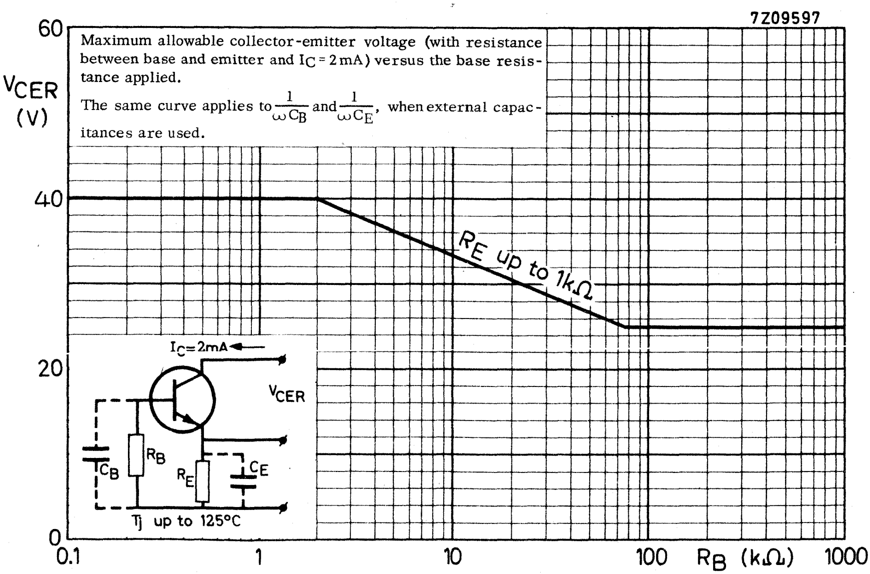
y parameters (common emitter)

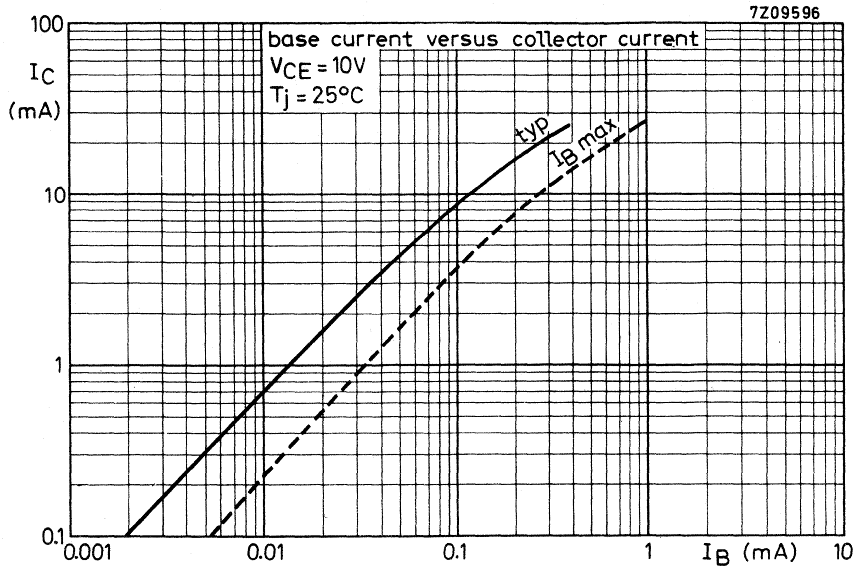
I_C = 7 mA; V_{CE} = 10 V (mounted according to instruction 2, see page 2)

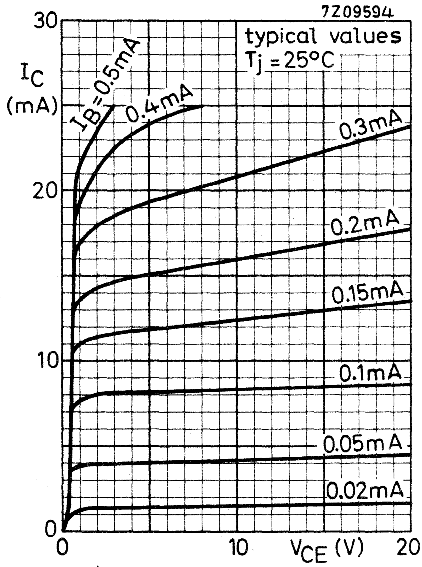
			f = 35	45	MHz
Input conductance	g_{ie}	typ.	4,5	5,5	mA/V
Input capacitance	C_{ie}	typ.	45	45	pF
Feedback admittance	$\lvert y_{re} \rvert$	typ.	67	86	μA/V
Phase angle of feedback admittance	φ_{re}	typ.	268°	268°	
Transfer admittance	$\lvert y_{fe} \rvert$	typ.	170	155	mA/V
Phase angle of transfer admittance	φ_{fe}	typ.	338°	335°	
Output conductance	g_{oe}	typ.	85	95	μA/V
Output capacitance	C_{oe}	typ.	1,8	1,8	pF
Maximum unilateralized power gain					
G_{UM} (in dB) $= 10 \log \frac{\lvert y_{fe} \rvert^2}{4 g_{ie} g_{oe}}$					
I_C = 7 mA; V_{CE} = 10 V	G_{UM}	typ.	43	41	dB

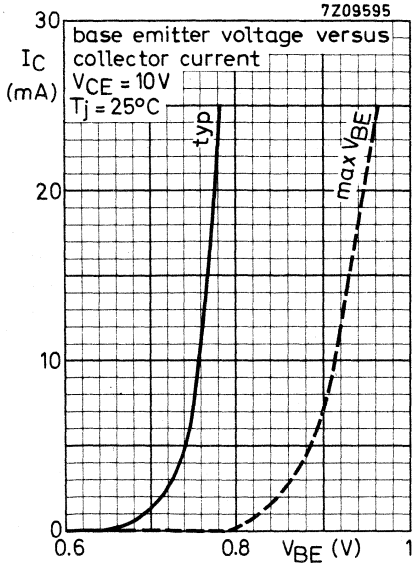
[1] V_{BE} decreases by about 1,7 mV/°C with increasing temperature.

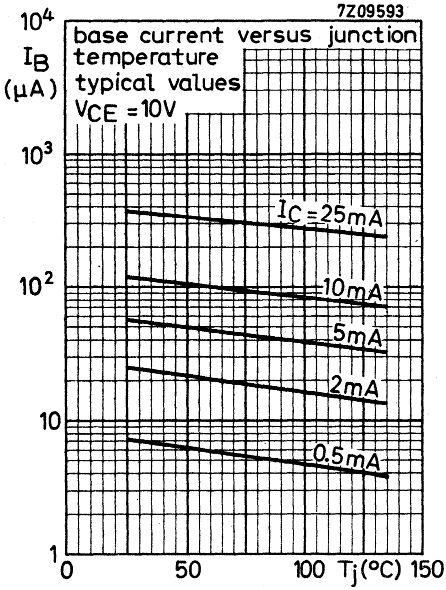

7Z09598
800
P_M
(mW)
max. allowable peak power versus time
600
400
T_{amb} = 25°C
50°C
25°C
200
0
0
20
40
60
80
100 time (s) 120

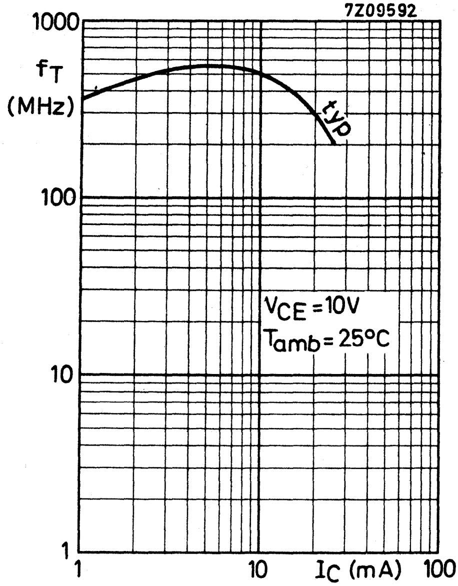

7Z09597
60
V_{CER}
(V)
Maximum allowable collector-emitter voltage (with resistance between base and emitter and $I_C = 2\,mA$) versus the base resistance applied.
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$, when external capacitances are used.
40
R_E up to 1kΩ
20
I_C=2mA
V_{CER}
C_B
R_B
R_E
C_E
Tj up to 125°C
0
0.1
1
10
100
R_B (kΩ)
1000


7Z09596
base current versus collector current
V_{CE} = 10V
T_j = 25°C
I_C
(mA)
100
10
1
0.1
typ
I_B max
0.001
0.01
0.1
1
10
I_B (mA)


7Z09594
typical values
T_j = 25°C
I_C
(mA)
30
20
10
0
I_B = 0.5mA
0.4mA
0.3mA
0.2mA
0.15mA
0.1mA
0.05mA
0.02mA
0
10
20
V_{CE} (V)


7Z09595
base emitter voltage versus collector current
V_{CE} = 10V
T_j = 25°C
I_C
(mA)
30
20
10
0
typ
max V_{BE}
0.6
0.8
1
V_{BE} (V)





APPLICATION INFORMATION

For application information see BF199.

SILICON PLANAR TRANSISTOR

N-P-N transistor in a plastic TO-92 variant.
The BF198 has a very low feedback capacitance and is intended for use in the forward gain control stage of the television i.f. amplifier.

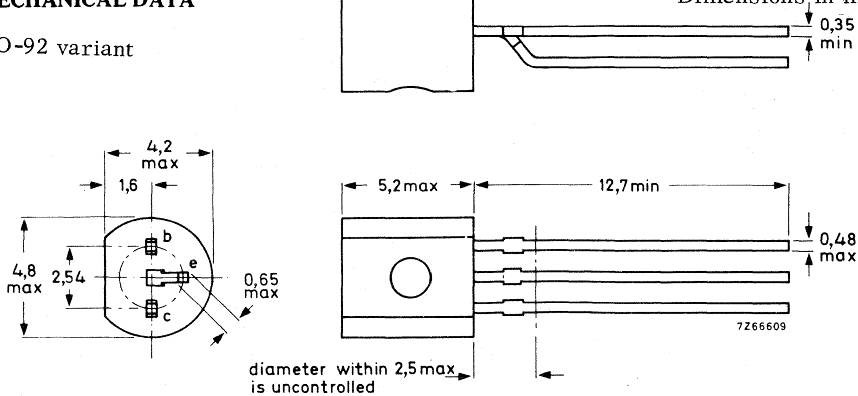
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	V
Collector current (d.c.)	I_C	max.	25	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	mW
Junction temperature	T_j	max.	150	°C
Transition frequency at f = 100 MHz I_C = 4 mA; V_{CE} = 10 V	f_T	typ.	400	MHz
Feedback capacitance at f = 10.7 MHz I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	200	fF
Max. unilateralized power gain I_C = 4 mA; V_{CE} = 10 V; f = 35 MHz	G_{UM}	typ.	42	dB
f = 45 MHz	G_{UM}	typ.	39	dB
Gain control range	ΔG_{tr}	typ.	60	dB

MECHANICAL DATA

TO-92 variant

Dimensions in mm



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

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	V [1]
Emitter-base voltage (open collector)	V_{EBO}	max.	4	V

Currents

Collector current (d.c.)	I_C	max.	25	mA
Collector current (peak value)	I_{CM}	max.	25	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	$R_{th\ j\text{-}a}$	=	0.25	°C/mW

[1]) See also page 6.

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

Base current at about 50 dB gain control				
I_C = 6 mA; V_{CE} = 2 V	I_B	<	270	µA
I_C = 15 mA; V_{CE} = 5 V	I_B	<	1.5	mA
Base current				
I_C = 4 mA; V_{CE} = 10 V	I_B	typ.	60	µA
		<	150	µA
Base-emitter voltage [1]				
I_C = 4 mA; V_{CE} = 10 V	V_{BE}	typ.	760	mV
		<	850	mV
Feedback capacitance at f = 10.7 MHz				
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	200	fF
Transition frequency at f = 100 MHz				
I_C = 4 mA; V_{CE} = 10 V	f_T	typ.	400	MHz
Noise figure				
I_C = 4 mA; V_{CE} = 10 V; G_S = 10 mA/V; f = 35 MHz; B_S = 0	F	typ.	3	dB

y parameters (common emitter)

I_C = 4 mA; V_{CE} = 10 V

			f = 35	45	MHz
Input conductance	g_{ie}	typ.	3.2	4.8	mA/V
Input capacitance	C_{ie}	typ.	37	35	pF
Feedback admittance	$\|y_{re}\|$	typ.	47	60	µA/V
Phase angle of feedback admittance	φ_{re}	typ.	268°	268°	
Transfer admittance	$\|y_{fe}\|$	typ.	105	100	mA/V
Phase angle of transfer admittance	φ_{fe}	typ.	340°	340°	
Output conductance	g_{oe}	typ.	50	60	µA/V
Output capacitance	C_{oe}	typ.	1.3	1.3	pF

Maximum unilateralized power gain

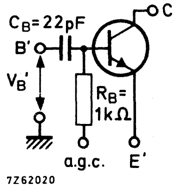
$$G_{UM} \text{ (in dB)} = 10 \log \frac{|y_{fe}|^2}{4 g_{ie} g_{oe}}$$

I_C = 4 mA; V_{CE} = 10 V	G_{UM}	typ.	42	39	dB

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

Equivalent gain control transistor

To ensure an almost constant input admittance and an output conductance that varies little with gain control, we recommend that where a BF198 is used in a gain controlled i.f. stage, a series base capacitor of 22 pF and a bias resistor of 1 kΩ be used.



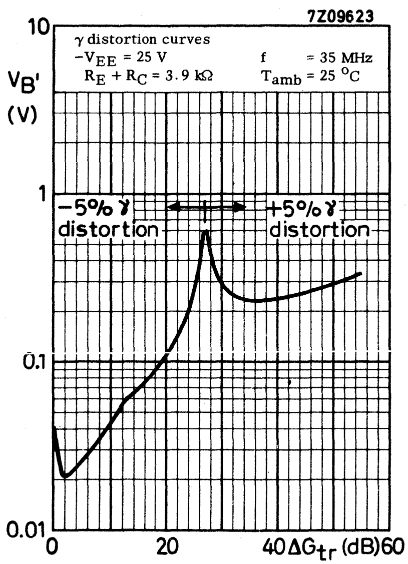
The transistor with these additional components is effectively an "equivalent transistor" for gain control purposes, the signal handling capability of which may be expressed in terms of voltage. (Without these components the varying input admittance means that the signal handling capability can only be expressed in terms of power).

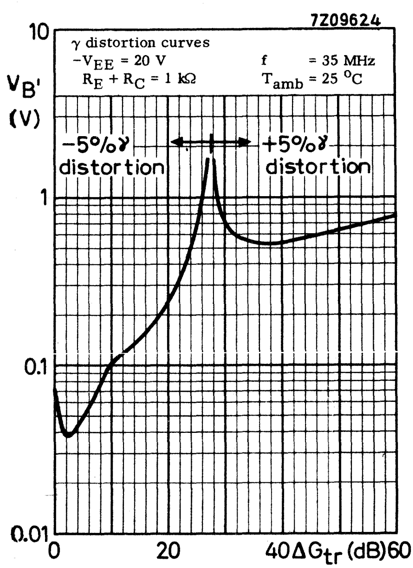
The signal handling capability of the equivalent transistor as a function of ΔG_{tr} (the reduction in transducer gain with gain control) will be found on pages 4 and 5.

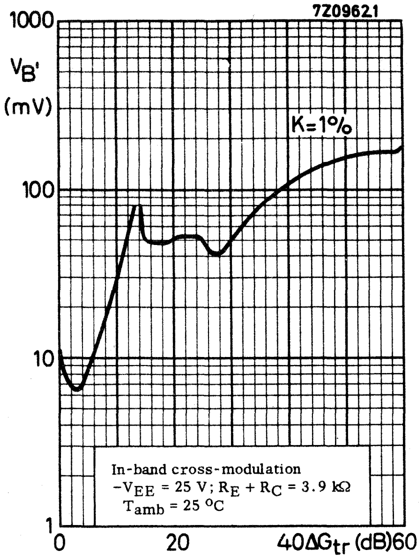
a. Voltage versus ΔG_{tr} curves for a γ distortion of 5% are below.

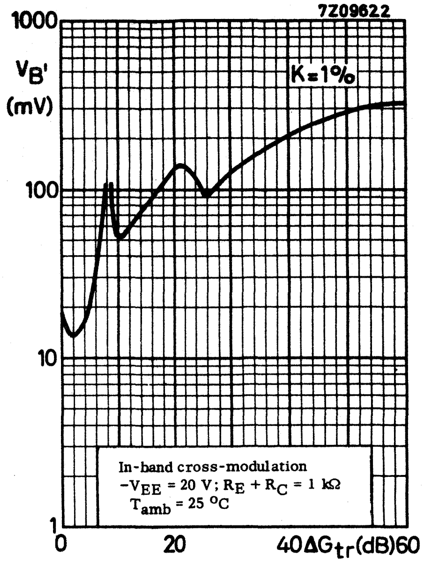
b. Voltage versus ΔG_{tr} curves for an in-band cross modulation factor of 1% are on page 5.

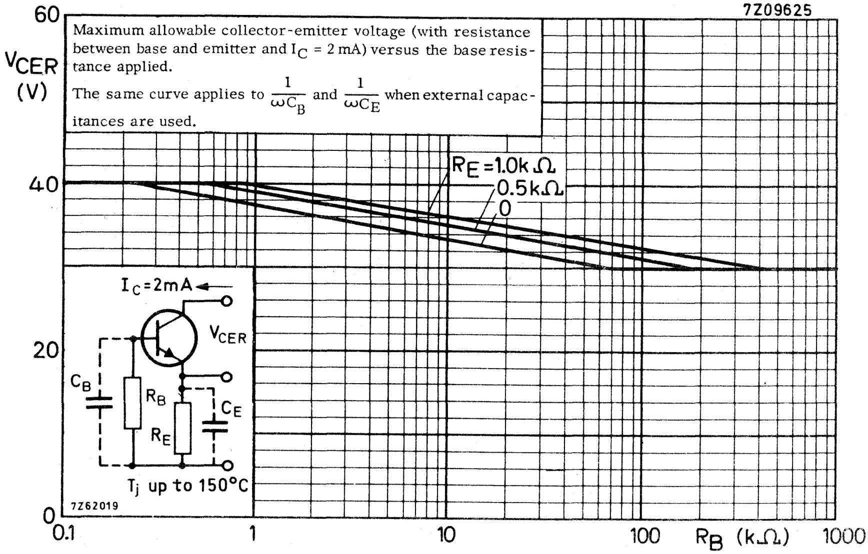
Graphs of the y-parameters are on pages 8 to 11.

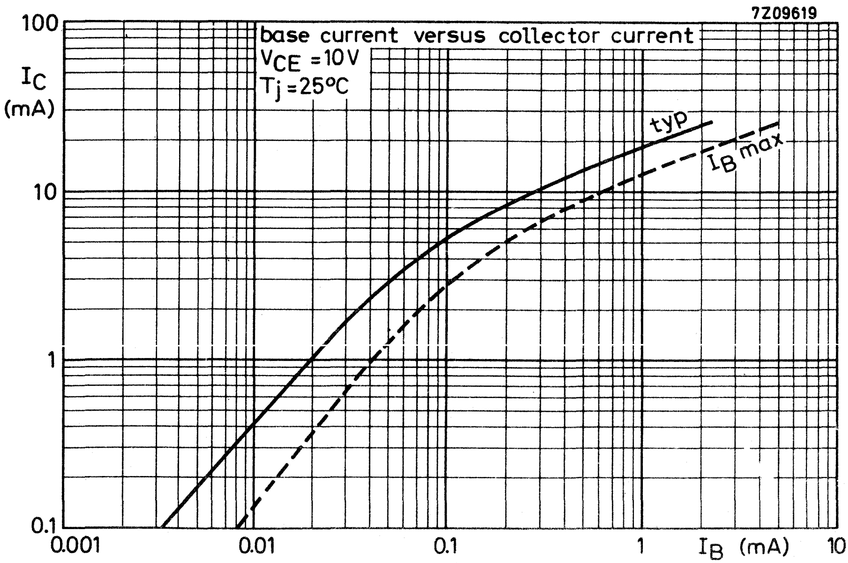


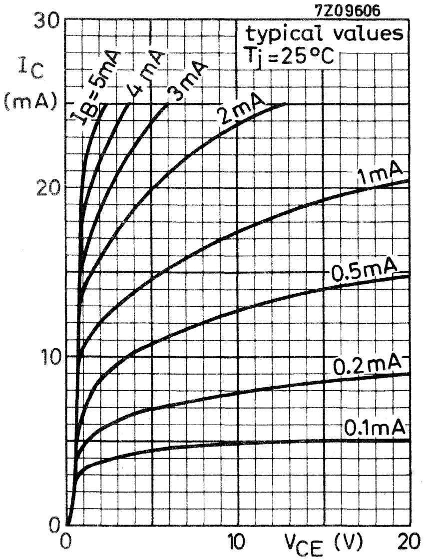


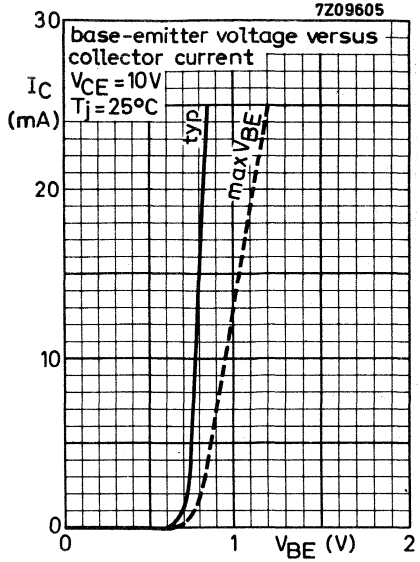

7Z09621
1000
$V_{B'}$
(mV)
K=1%
100
10
1
In-band cross-modulation
$-V_{EE}$ = 25 V; $R_E + R_C$ = 3.9 kΩ
T_{amb} = 25 °C
0
20
40 ΔG_{tr} (dB) 60

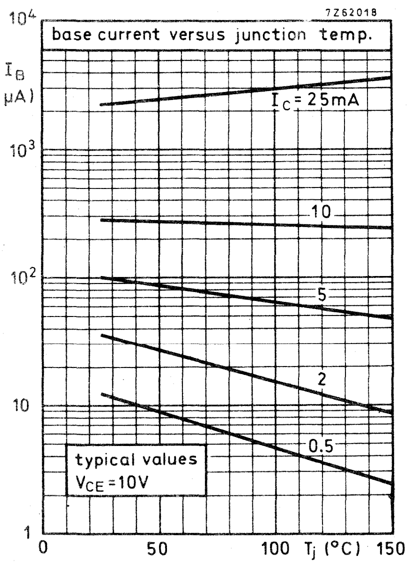

7Z09622
1000
$V_{B'}$
(mV)
K=1%
100
10
1
In-band cross-modulation
$-V_{EE}$ = 20 V; $R_E + R_C$ = 1 kΩ
T_{amb} = 25 °C
0
20
40 ΔG_{tr} (dB) 60

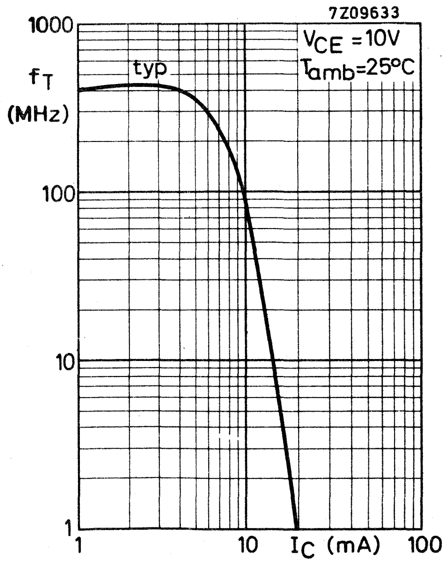

7Z09625
Maximum allowable collector-emitter voltage (with resistance between base and emitter and I_C = 2 mA) versus the base resistance applied.
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$ when external capacitances are used.
V_{CER} (V)
60
40
20
0
R_E = 1.0 kΩ
0.5 kΩ
0
I_C = 2 mA
V_{CER}
C_B
R_B
R_E
C_E
T_j up to 150°C
7Z62019
0.1
1
10
100
R_B (kΩ)
1000


7Z09619
base current versus collector current
V_{CE} = 10 V
T_j = 25°C
I_C (mA)
100
10
1
0.1
typ
I_B max
0.001
0.01
0.1
1
I_B (mA)
10

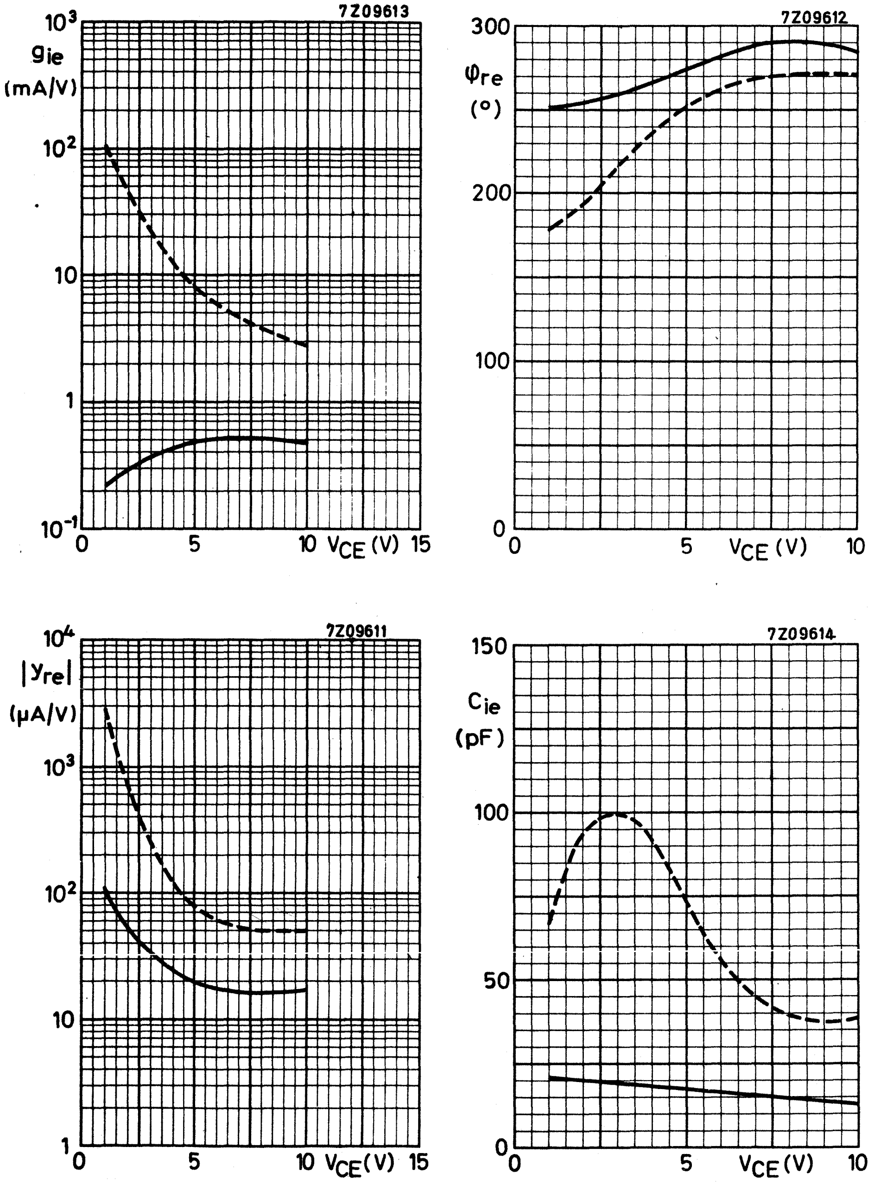

7Z09606
typical values
Tj = 25°C
IC
(mA)
IB=5mA
4mA
3mA
2mA
1mA
0.5mA
0.2mA
0.1mA
30
20
10
0
0
10
VCE (V)
20


7Z09605
base-emitter voltage versus collector current
VCE = 10V
Tj = 25°C
IC
(mA)
typ
max VBE
30
20
10
0
0
1
VBE (V)
2


7Z62018
base current versus junction temp.
IB
(μA)
IC = 25mA
10
5
2
0.5
typical values
VCE = 10V
10^4
10^3
10^2
10
1
0
50
100
Tj (°C)
150

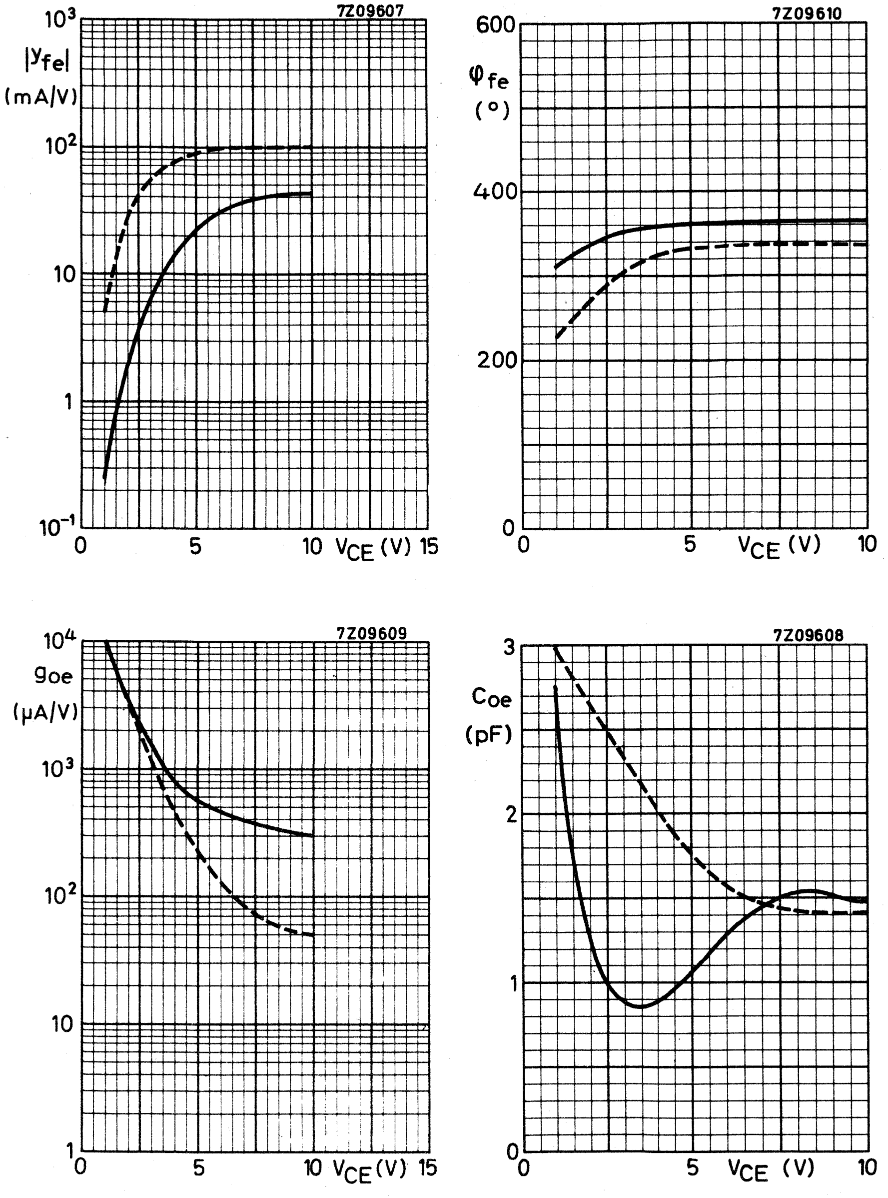

7Z09633
VCE = 10V
Tamb = 25°C
fT
(MHz)
typ
1000
100
10
1
1
10
IC (mA)
100

Voltage control; $-V_{EE}$ = 25 V; $R_E + R_C$ = 3.9 kΩ; f = 35 MHz



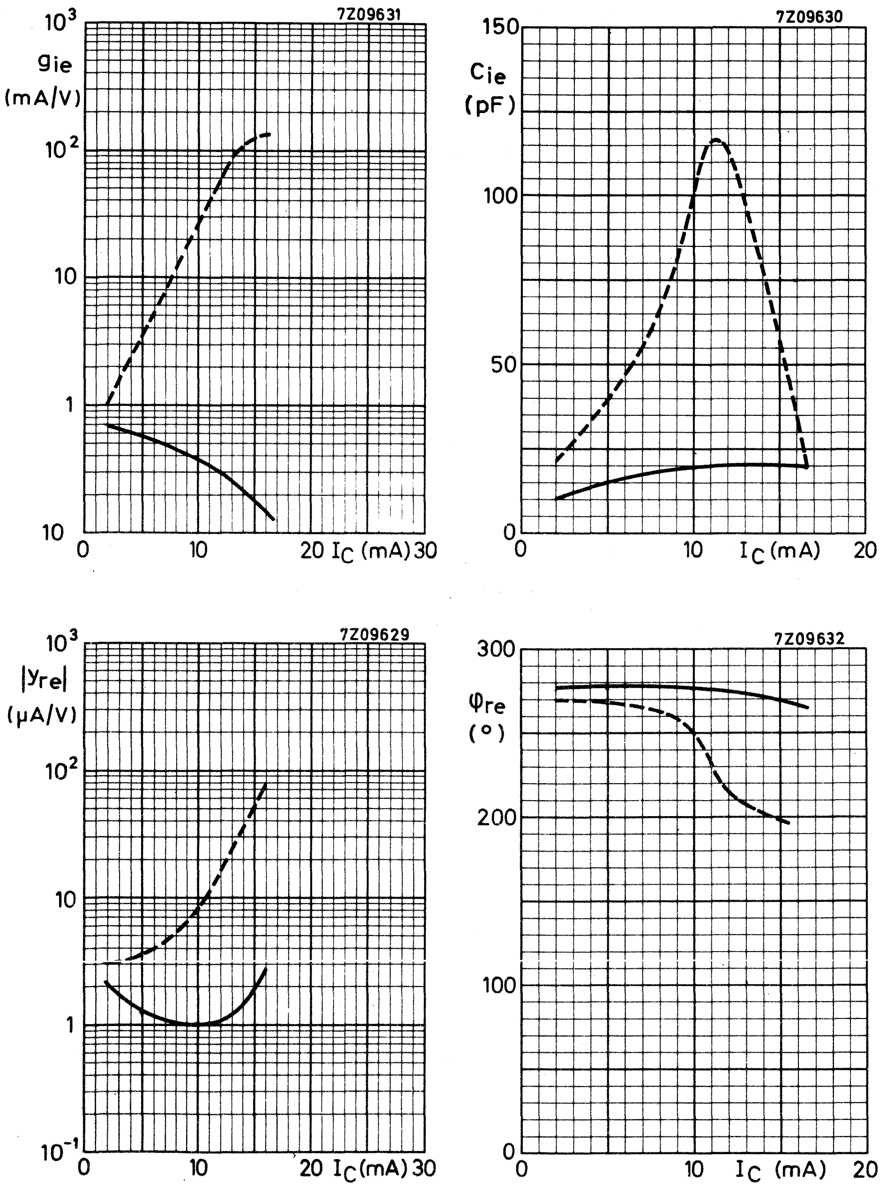
y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

Voltage control; $-V_{EE} = 25$ V; $R_E + R_C = 3.9$ kΩ; f = 35 MHz



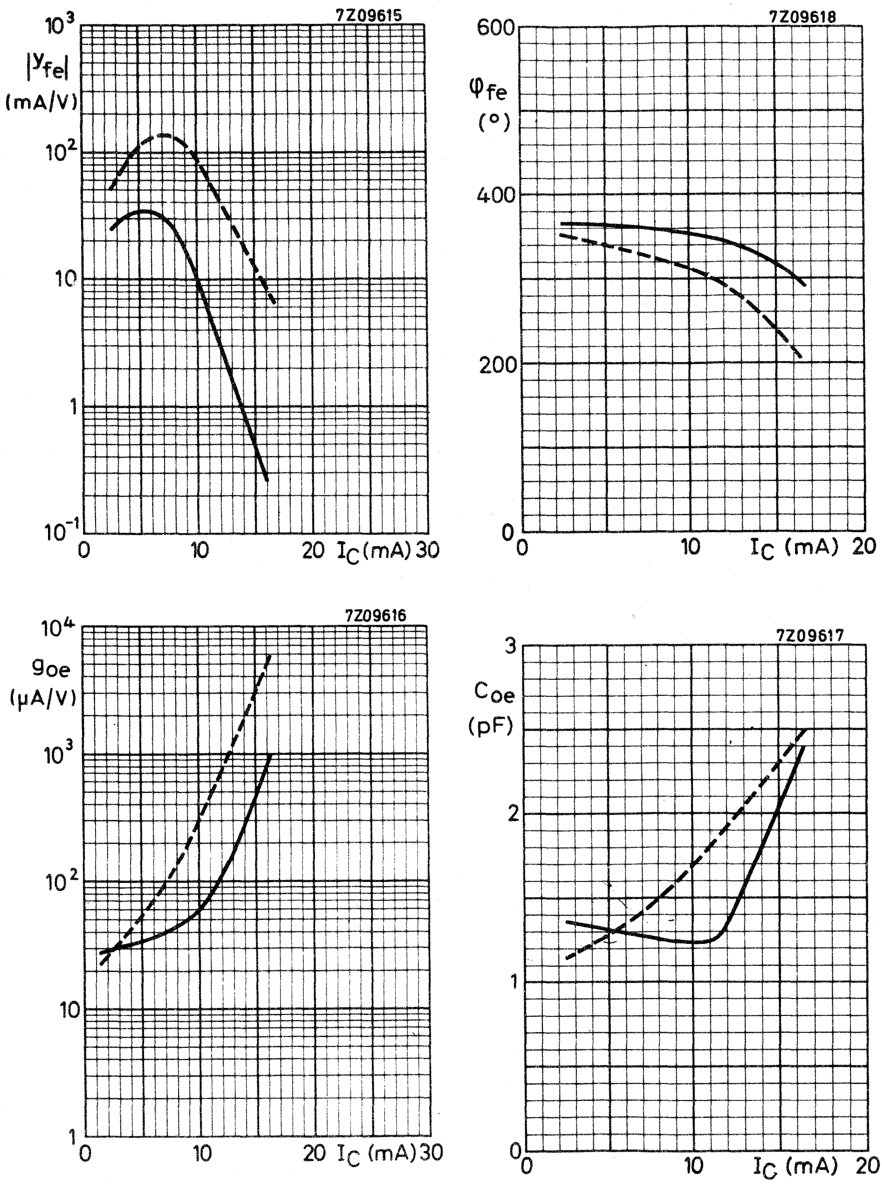
y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

Current control; $-V_{EE}$ = 20 V; $R_E + R_C$ = 1 kΩ; f = 35 MHz



y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

Current control; $-V_{EE} = 20$ V; $R_E + R_C = 1$ kΩ; f = 35 MHz



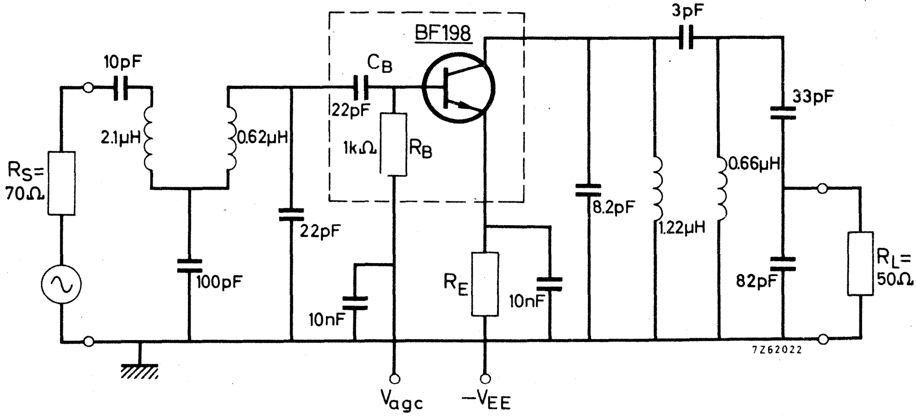
y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

APPLICATION INFORMATION

First stage of an i.f. amplifier

Basic circuit with voltage gain control: $R_E + R_C = 3.9\ k\Omega$; $-V_{EE} = 25\ V$

current gain control: $R_E + R_C = 1\ k\Omega$; $-V_{EE} = 20\ V$

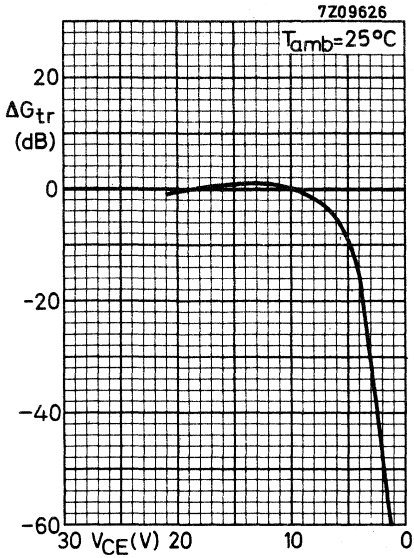


Transducer gain

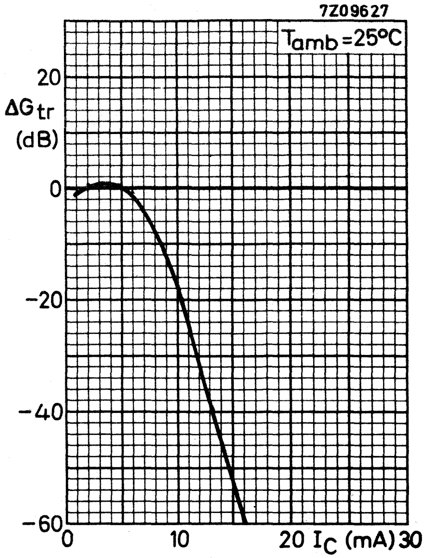
$$G_{tr} \text{ (in dB)} = 10 \log \frac{\text{output power in load } R_L}{\text{available power from source } R_S}$$

f = 36.4 MHz; I_C = 4 mA; $R_E + R_C = 3.9\ k\Omega$; $-V_{EE} = 25\ V$	G_{tr}	typ.	25.5	dB
Gain control range (see also upper graphs next page)	ΔG_{tr}	typ.	60	dB

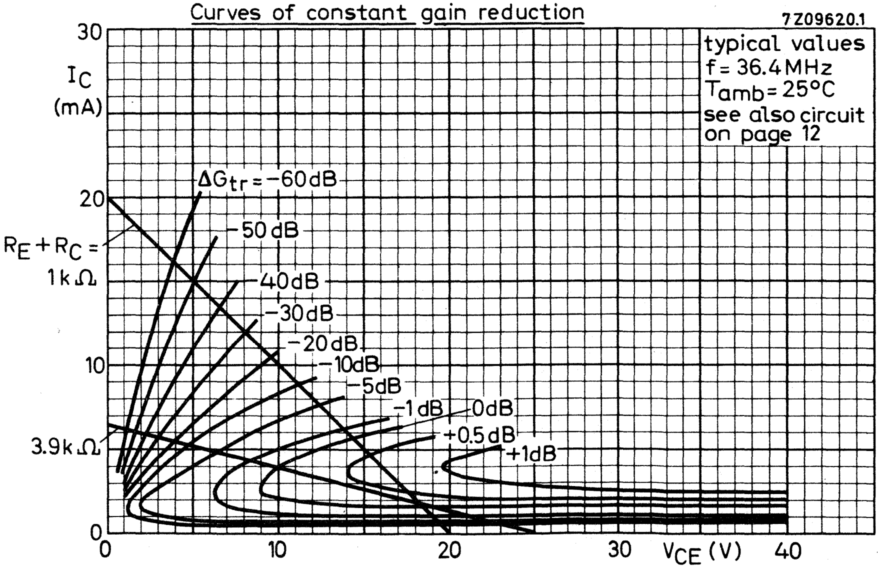
Voltage gain control



Current gain control



Curves of constant gain reduction



SILICON PLANAR EPITAXIAL TRANSISTOR

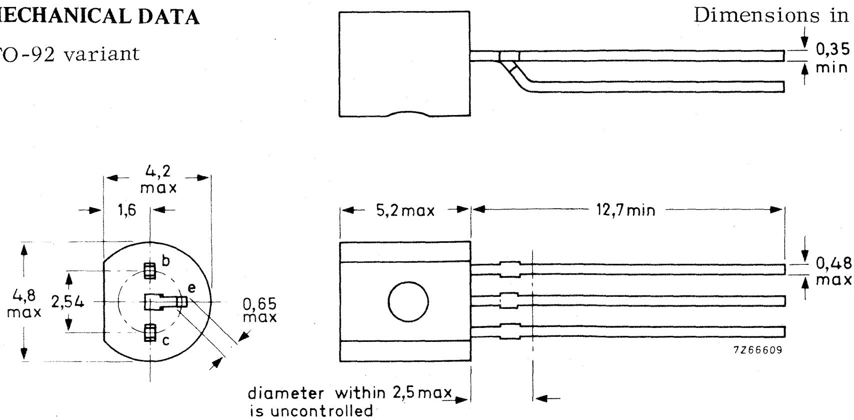
N-P-N transistor in a plastic TO-92 variant.
The BF199 has a very low feedback capacitance and is intended for use in the output stage of a vision i.f. amplifier.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Collector current (d.c.)	I_C	max.	25	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	mW
Junction temperature	T_j	max.	150	°C
Transition frequency at f = 100 MHz I_C = 5 mA; V_{CE} = 10 V	f_T	typ.	550	MHz
Feedback capacitance at f = 10.7 MHz I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	300	fF
Max. unilateralized power gain I_C = 7 mA; V_{CE} = 10 V; f = 35 MHz	G_{UM}	typ.	43	dB
f = 45 MHz	G_{UM}	typ.	41	dB
Video detector output voltage	V_O	typ.	7.7	V

MECHANICAL DATA

TO-92 variant

Dimensions in mm



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

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V [1]
Emitter-base voltage (open collector)	V_{EBO}	max.	4	V

Currents

Collector current (d.c.)	I_C	max.	25	mA
Collector current (peak value)	I_{CM}	max.	25	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	$R_{th\ j\text{-}a}$	=	0.25	°C/mW

[1]) See also page 4

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

Base current

I_C = 7 mA; V_{CE} = 10 V	I_B	typ.	60	μA
		<	185	μA

Base-emitter voltage [1]

I_C = 7 mA; V_{CE} = 10 V	V_{BE}	typ.	775	mV
		<	925	mV

Feedback capacitance at f = 10.7 MHz

I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	300	fF

Transition frequency at f = 100 MHz

I_C = 5 mA; V_{CE} = 10 V	f_T	typ.	550	MHz

y parameters (common emitter)

I_C = 7 mA; V_{CE} = 10 V

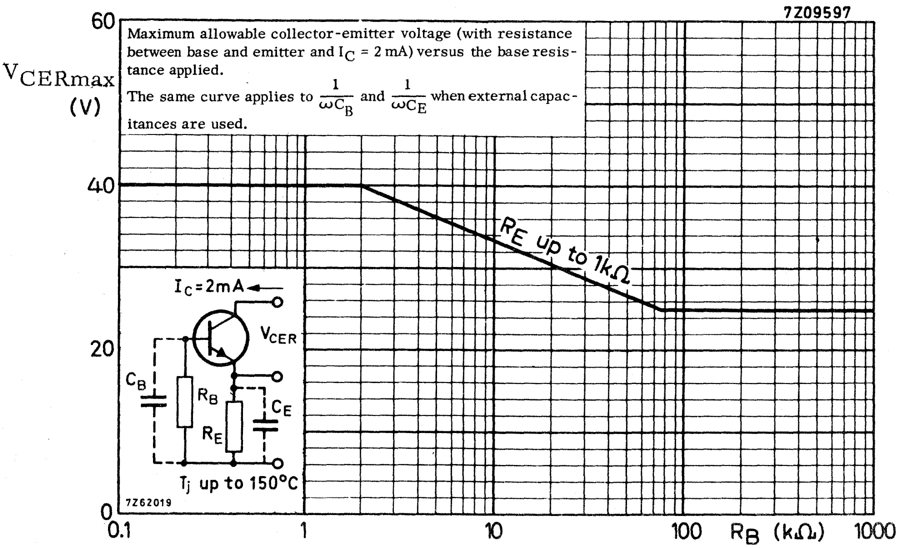
			f = 35	45	MHz
Input conductance	g_{ie}	typ.	4.5	5.5	mA/V
Input capacitance	C_{ie}	typ.	45	45	pF
Feedback admitance	$\|y_{re}\|$	typ.	67	86	μA/V
Phase angle of feedback admittance	φ_{re}	typ.	268°	268°	
Transfer admitance	$\|y_{fe}\|$	typ.	170	155	mA/V
Phase angle of transfer admittance	φ_{fe}	typ.	338°	335°	
Output conductance	g_{oe}	typ.	85	95	μA/V
Output capacitance	C_{oe}	typ.	1.8	1.8	pF

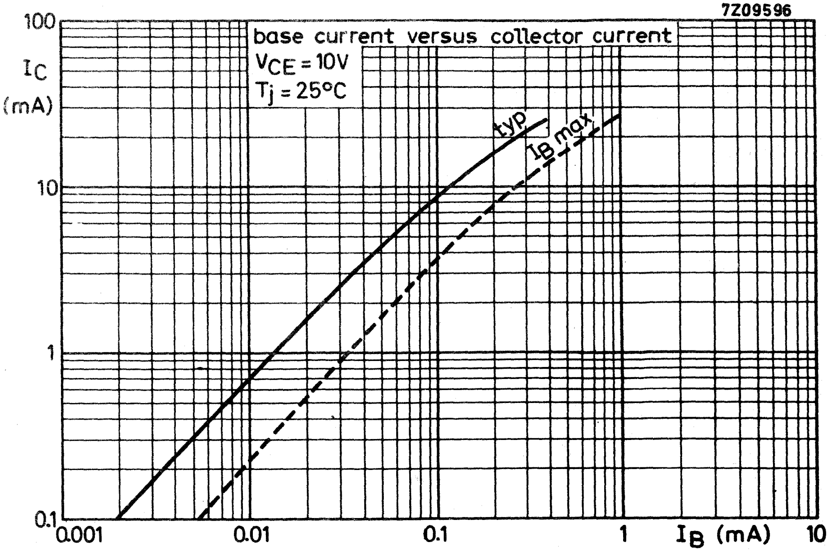
Maximum unilateralized power gain

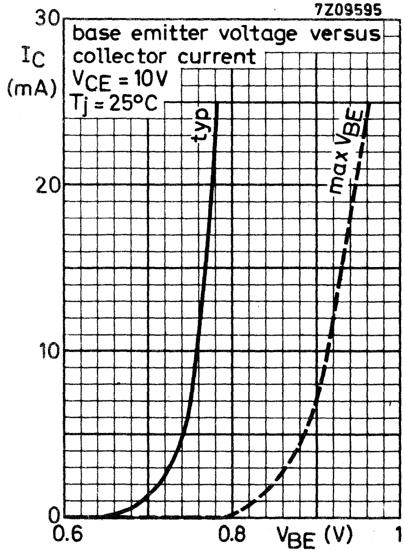
$$G_{UM} \text{ (in dB)} = 10 \log \frac{|y_{fe}|^2}{4 g_{ie} g_{oe}}$$

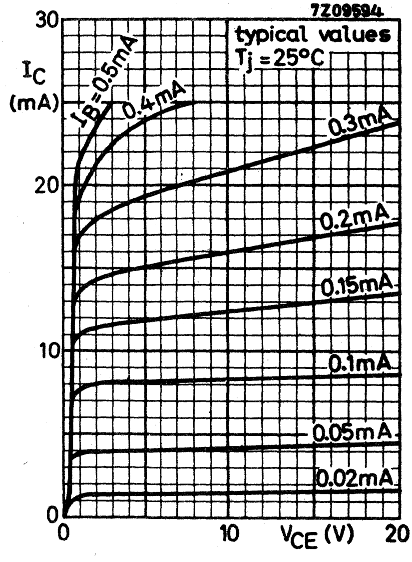
I_C = 7 mA; V_{CE} = 10 V	G_{UM}	typ.	43	41	dB

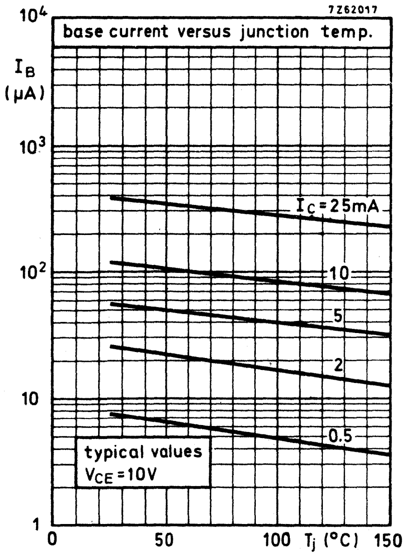
[1] V_{BE} decreases by about 1.7 mV/°C with increasing temperature.

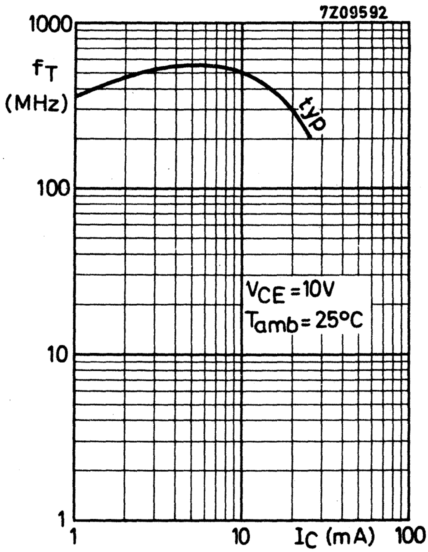

7Z09597
60
40
20
0
V_{CERmax} (V)
Maximum allowable collector-emitter voltage (with resistance between base and emitter and I_C = 2 mA) versus the base resistance applied.
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$ when external capacitances are used.
R_E up to 1kΩ
I_C=2mA
V_{CER}
C_B
R_B
R_E
C_E
T_j up to 150°C
7Z62019
0.1
1
10
100
R_B (kΩ)
1000


7Z09596
base current versus collector current
V_{CE} = 10V
T_j = 25°C
I_C (mA)
typ
I_B max
I_B (mA)
100
10
1
0.1
0.001
0.01
0.1
1
10


7Z09595
base emitter voltage versus collector current
V_{CE} = 10V
T_j = 25°C
I_C (mA)
typ
max V_{BE}
V_{BE} (V)
30
20
10
0
0.6
0.8
1

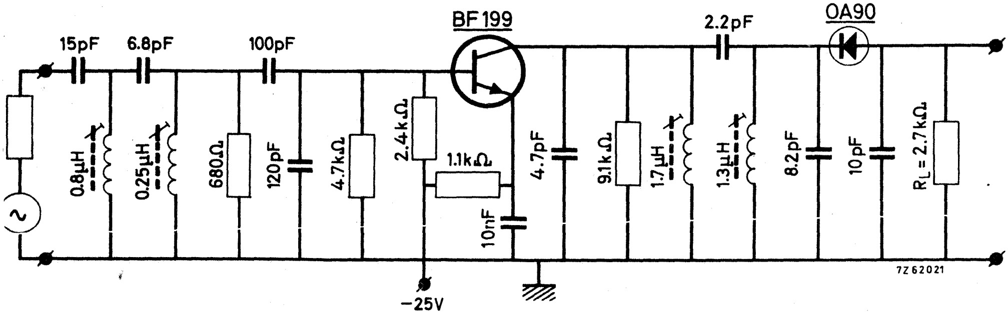

7Z09594
typical values
T_j = 25°C
I_C (mA)
I_B = 0.5mA
0.4mA
0.3mA
0.2mA
0.15mA
0.1mA
0.05mA
0.02mA
V_{CE} (V)
30
20
10
0
10
20





APPLICATION INFORMATION

Output stage of television video i.f. amplifier with the BF199 transistor, followed by a video detector circuit.



APPLICATION INFORMATION (continued)

Video detector output voltage at f = 38.9 MHz [1]

I_C = 7.2 mA; V_{CE} = 16.6 V	V_O	>	6	V
		typ.	7.7	V

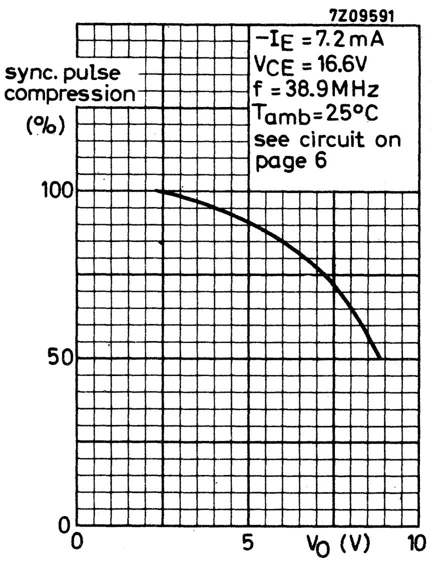
Transducer gain at f = 36.4 MHz

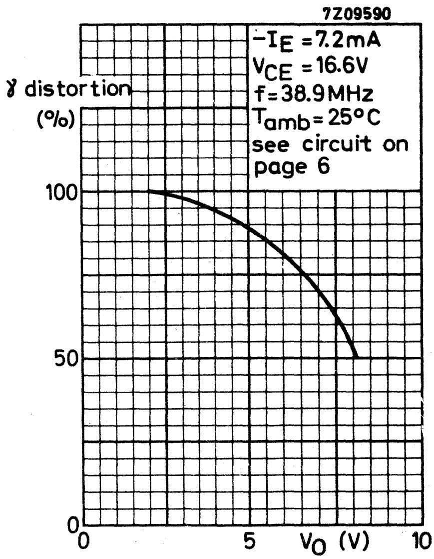
$$G_{tr} \text{ (in dB)} = 10 \log \frac{\text{output power in load } R_L}{\text{available power from source with } R_S}$$

I_C = 7.2 mA; V_{CE} = 16.6 V	G_{tr}	typ.	25.5	dB

Tuning frequency for all tuned circuits is 37 MHz

[1]) The output voltage V_O is difined as the voltage across the 2.7 kΩ detector load R_L for 30% synchronisation pulse compression.





SILICON PLANAR TRANSISTOR

N-P-N transistor in a TO-72 metal envelope with insulated electrodes and a shield lead connected to the case. The BF200 is primarily intended for application in a forward gain controlled pre-amplifier in v.h.f. television tuners and f.m. tuners.

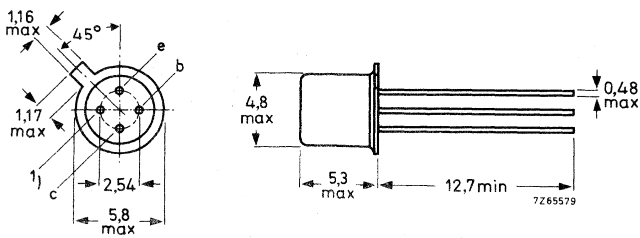
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector current (d.c.)	I_C	max.	20	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	mW
Junction temperature	T_j	max.	175	°C
Transition frequency				
$-I_E$ = 3 mA; V_{CB} = 10 V	f_T	typ.	650	MHz
Max. unilateralised power gain				
$-I_E$ = 3 mA; V_{CB} = 10 V; f = 50 MHz	G_{UM}	typ.	30	dB
f = 200 MHz	G_{UM}	typ.	22	dB
Noise figure at optimum source admittance				
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 100 MHz	F	typ.	2	dB
$-I_E$ = 3 mA; V_{CB} = 10 V; f = 200 MHz	F	typ.	2.7	dB

MECHANICAL DATA Dimensions in mm

TO-72

Accessories supplied on request: 56246, 56263.



1) Shield lead connected to case.

RATINGS (Limiting values) [1]

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector-emitter voltage ($R_{BE} \leq 1$ kΩ)	V_{CER}	max.	30	V
Emitter-base voltage (open collector)	V_{EBO}	max.	3	V

Currents

Collector current (d.c.)	I_C	max.	20	mA
Collector current (peak value)	I_{CM}	max.	20	mA

Power dissipation

Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	150	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	$R_{th\ j\text{-}a}$	=	1	^oC/mW

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

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

Base current				
$-I_E$ = 3 mA; V_{CB} = 10 V	I_B	typ.	100	μA
		<	200	μA
$-I_E$ = 12 mA; V_{CB} = 7 V	I_B	<	2.2	mA
Emitter-base voltage				
$-I_E$ = 3 mA; V_{CB} = 10 V	$-V_{EB}$	typ.	0.75	V
$-I_E$ = 12 mA; V_{CB} = 7 V	$-V_{EB}$	<	1.0	V
Transition frequency				
$-I_E$ = 3 mA; V_{CB} = 10 V	f_T	typ.	650	MHz
Feedback capacitance at f = 10.7 MHz				
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	280	fF [1]
Noise figure at optimum source admittance				
$-I_E$ = 3 mA; V_{CB} = 10 V; f = 50 MHz	F	typ.	1.9	dB
f = 200 MHz	F	typ.	2.7	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 100 MHz	F	typ.	2.0	dB
Maximum unilateralised power gain [2]				
$G_{UM} = \frac{\lvert y_{fb} \rvert^2}{4\, g_{ib} g_{ob}}$				
$-I_E$ = 3 mA; V_{CB} = 10 V; f = 50 MHz	G_{UM}	typ.	30	dB
f = 200 MHz	G_{UM}	typ.	22	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 100 MHz	G_{UM}	typ.	28	dB

1) 1 fF = 1 femtofarad = 10^{-15} F.

2) Common base configuration, metal envelope connected to earth directly, external lead length = 3 mm.

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

y parameters at f = 100 MHz (common emitter)

I_C = 2 mA; V_{CE} = 10 V

Input conductance	g_{ie}	typ.	5	$m\Omega^{-1}$
Input capacitance	C_{ie}	typ.	16	pF
Feedback admittance	$\|y_{re}\|$	typ.	0.16	$m\Omega^{-1}$
Phase angle of feedback admittance	φ_{re}	typ.	270°	
Transfer admittance	$\|y_{fe}\|$	typ.	56	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fe}	typ.	340°	
Output conductance	g_{oe}	typ.	15	$\mu\Omega^{-1}$
Output capacitance	C_{oe}	typ.	0.9	pF

y parameters at f = 50 MHz (common base)

$-I_E$ = 3 mA; V_{CB} = 10 V

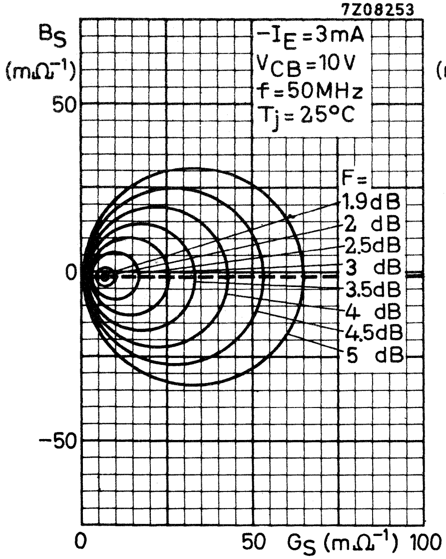
Input conductance	g_{ib}	typ.	85	$m\Omega^{-1}$
Input susceptance	$-b_{ib}$	typ.	15	$m\Omega^{-1}$
Feedback admittance	$\|y_{rb}\|$	typ.	55	$\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{rb}	typ.	270°	
Transfer admittance	$\|y_{fb}\|$	typ.	85	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fb}	typ.	165°	
Output conductance	g_{ob}	typ.	15	$\mu\Omega^{-1}$
Output susceptance	b_{ob}	typ.	280	$\mu\Omega^{-1}$

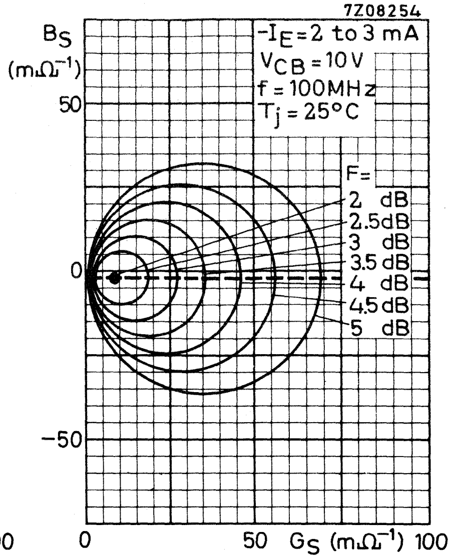
y parameters at f = 200 MHz (common base)

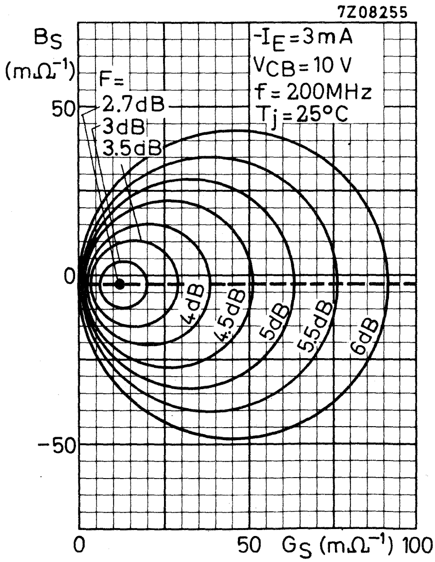
$-I_E$ = 3 mA; V_{CB} = 10 V

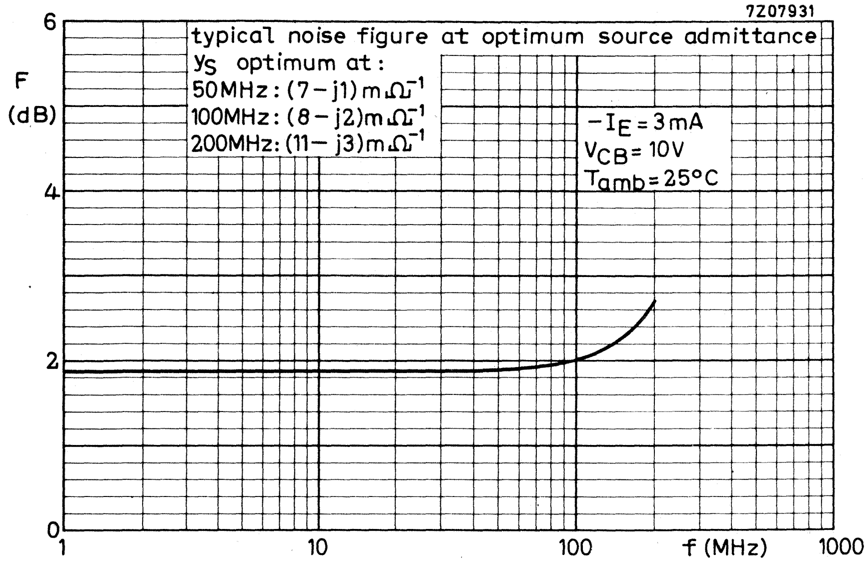
Input conductance	g_{ib}	typ.	62	$m\Omega^{-1}$
Input susceptance	$-b_{ib}$	typ.	38	$m\Omega^{-1}$
Feedback admittance	$\|y_{rb}\|$	typ.	180	$\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{rb}	typ.	270°	
Transfer admittance	$\|y_{fb}\|$	typ.	70	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fb}	typ.	145°	
Output conductance	g_{ob}	typ.	150	$\mu\Omega^{-1}$
Output susceptance	b_{ob}	typ.	1.1	$m\Omega^{-1}$

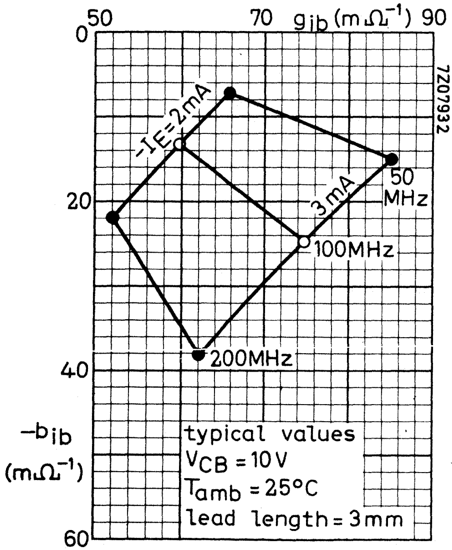
circles of constant noise figure

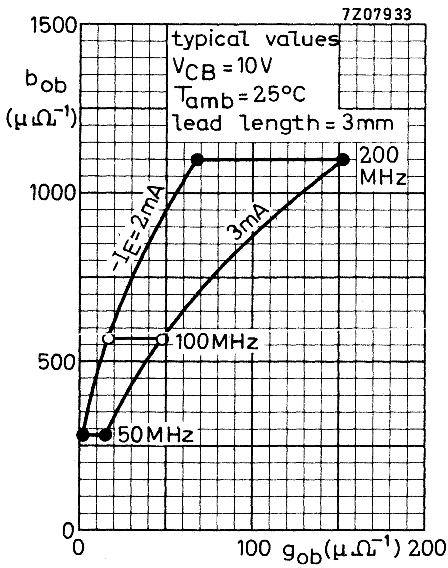


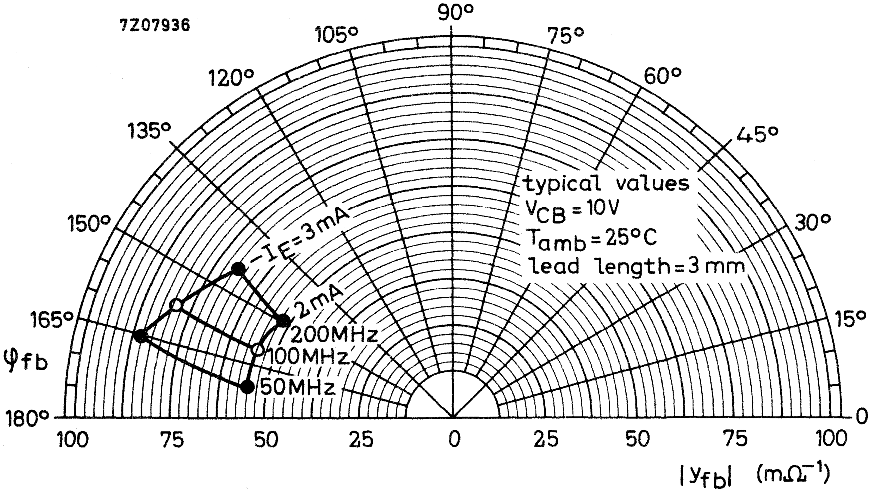


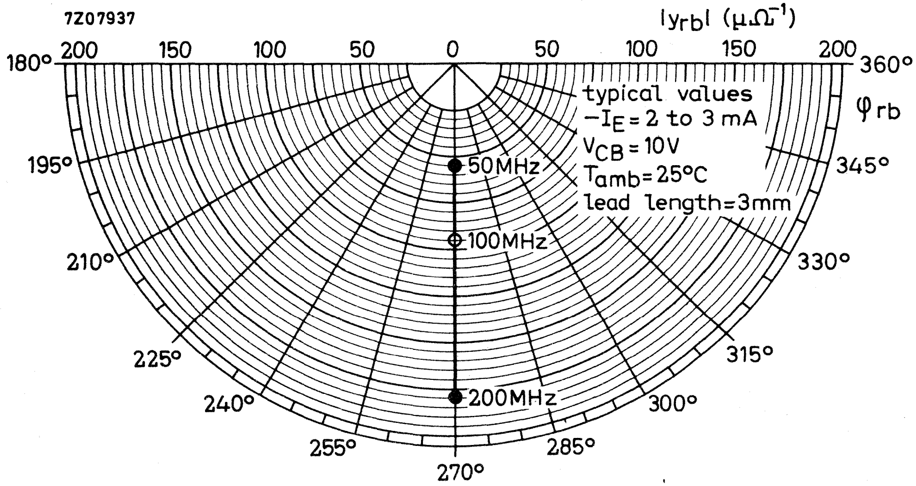



7Z07931
typical noise figure at optimum source admittance
y_S optimum at:
50MHz: (7 − j1) mΩ⁻¹
100MHz: (8 − j2) mΩ⁻¹
200MHz: (11 − j3) mΩ⁻¹
−I_E = 3 mA
V_{CB} = 10 V
T_{amb} = 25°C
F (dB)
6
4
2
0
1
10
100
f (MHz)
1000


7Z07932
50
70
g_{ib} (mΩ⁻¹)
90
0
20
40
60
−b_{ib} (mΩ⁻¹)
−I_E = 2mA
3mA
50 MHz
100MHz
200MHz
typical values
V_{CB} = 10 V
T_{amb} = 25°C
lead length = 3mm


7Z07933
1500
1000
500
0
b_{ob} (μΩ⁻¹)
typical values
V_{CB} = 10V
T_{amb} = 25°C
lead length = 3mm
200 MHz
−I_E = 2mA
3mA
100MHz
50MHz
0
100
g_{ob} (μΩ⁻¹)
200

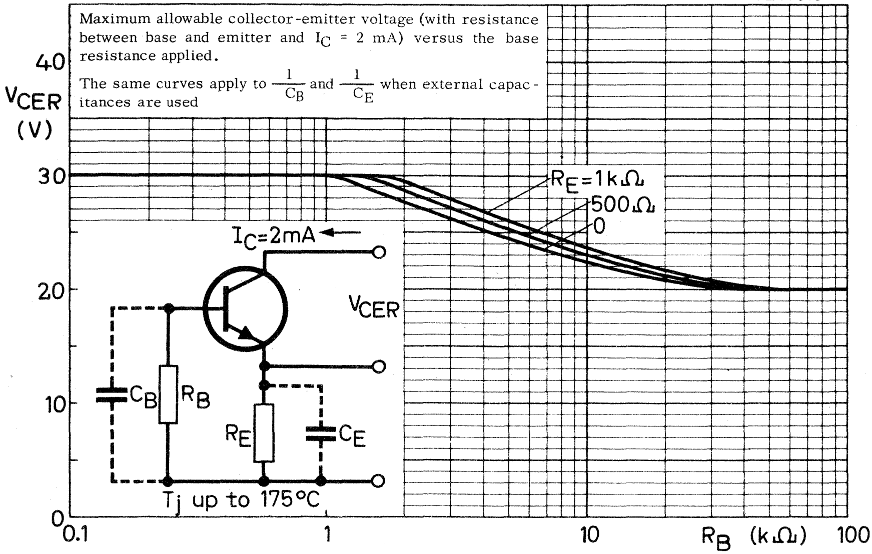

7Z07936
90°
105°
75°
120°
60°
135°
45°
150°
30°
165°
15°
180°
0
φfb
typical values
VCB = 10V
Tamb = 25°C
lead length = 3 mm
−IE = 3 mA
2 mA
200MHz
100MHz
50MHz
100
75
50
25
0
25
50
75
100
|yfb| (mΩ⁻¹)


7Z07937
|yrb| (μΩ⁻¹)
180°
200
150
100
50
0
50
100
150
200
360°
φrb
typical values
−IE = 2 to 3 mA
VCB = 10V
Tamb = 25°C
lead length = 3mm
50MHz
100MHz
200MHz
195°
345°
210°
330°
225°
315°
240°
300°
255°
285°
270°

7Z07919

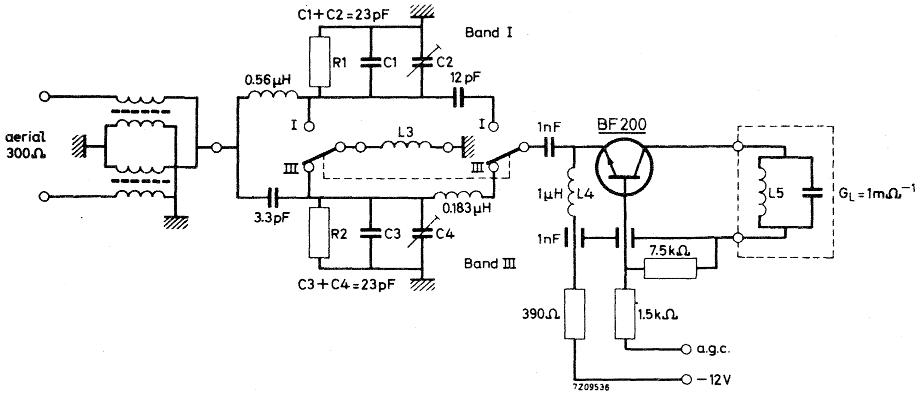
Maximum allowable collector-emitter voltage (with resistance between base and emitter and I_C = 2 mA) versus the base resistance applied.

The same curves apply to $\frac{1}{C_B}$ and $\frac{1}{C_E}$ when external capacitances are used



APPLICATION INFORMATION

1. R.F. stage for v.h.f. television tuner



Resistors R_1 and R_2 should be chosen so that the 3 dB bandwidth of the unloaded input circuit is 3.0 MHz with the aerial and transistor input terminals short-circuited.

Inductors L_3 and L_5 to be selected for each channel.

PERFORMANCE at T_{amb} = 25 °C (see circuit above)

Transducer gain

$$G_{tr} = \frac{\text{output power in load } G_L}{\text{available power from aerial}}$$

$-I_E$ = 3 mA; f = 50 MHz	G_{tr}	typ.	13	dB
$-I_E$ = 3 mA; f = 200 MHz	G_{tr}	typ.	13	dB

Noise figure

f = 50 MHz	F	typ.	4.9	dB
f = 200 MHz	F	typ.	5.2	dB

Voltage standing wave ratio over the entired gain control range, measured at the vision carrier frequency — V.S.W.R. < 4

APPLICATION INFORMATION (continued)

Signal-handling capability (see next page)

In-channel cross-modulation curves of the tuner (see upper graphs); showing the interfering signal e.m.f. (in a 300 Ω aerial) that will cause a cross-modulation factor of 1% (K), plotted against ΔG_{tr}, the reduction in transducer gain caused by gain control. The broken lines indicate the signal level, assuming that gain control starts when desired aerial signal reaches 2 mV.

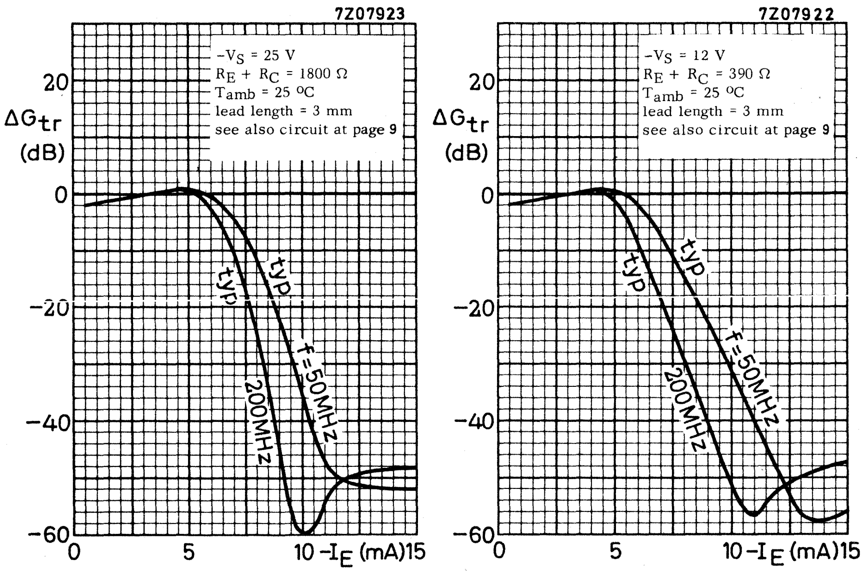
Measuring conditions

Desired signal at vision carrier frequency and interference signal at sound carrier frequency. Interference signal modulated with 4 kHz (modulation depth 100%).

In-band cross-modulation curves of the tuner; showing the interfering signal e.m.f. (in a 300 Ω aerial) that will cause a cross-modulation factor of 1% (K), plotted against ΔG_{tr}, the reduction in transducer gain caused by gain control.

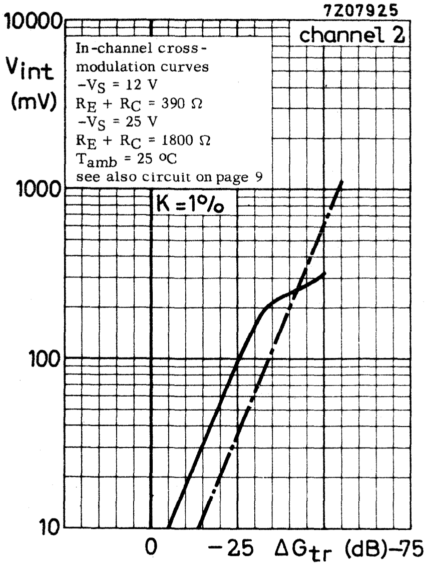
Measuring conditions

Desired signal at the vision carrier frequency and interference signal, 14 MHz above the desired signal. Interference signal modulated with 4 kHz (modulation depth 100%).

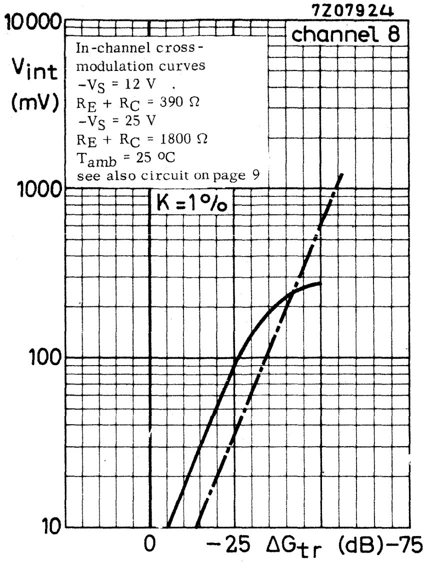


APPLICATION INFORMATION (continued)

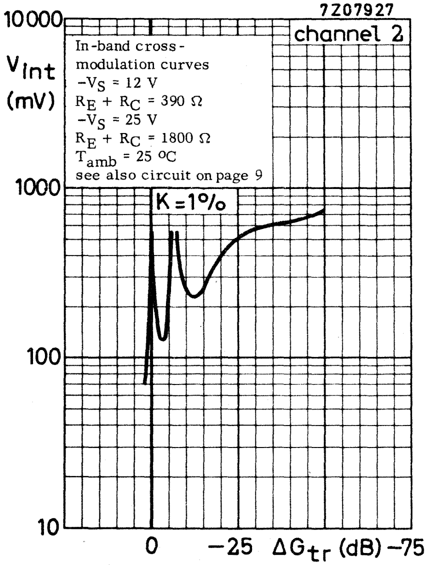
7Z07925



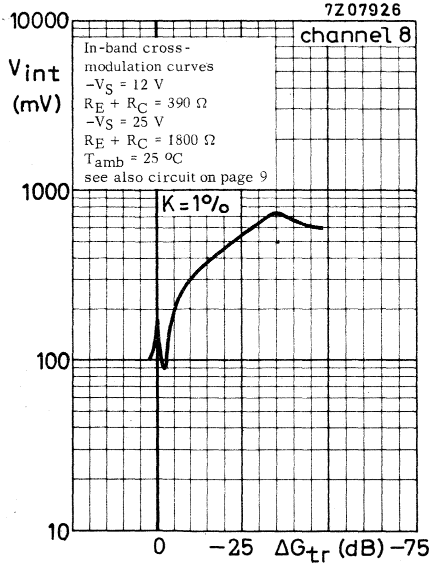
7Z07924



7Z07927

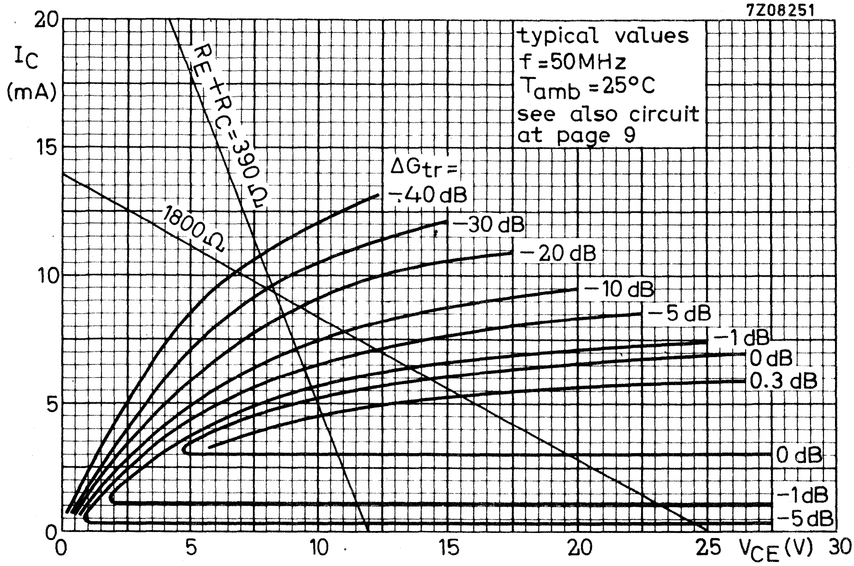


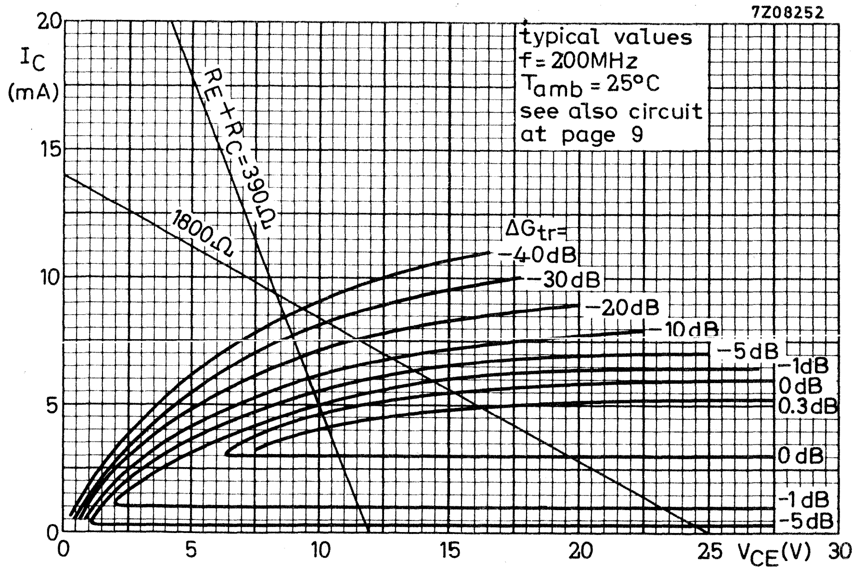
7Z07926



APPLICATION INFORMATION (continued)

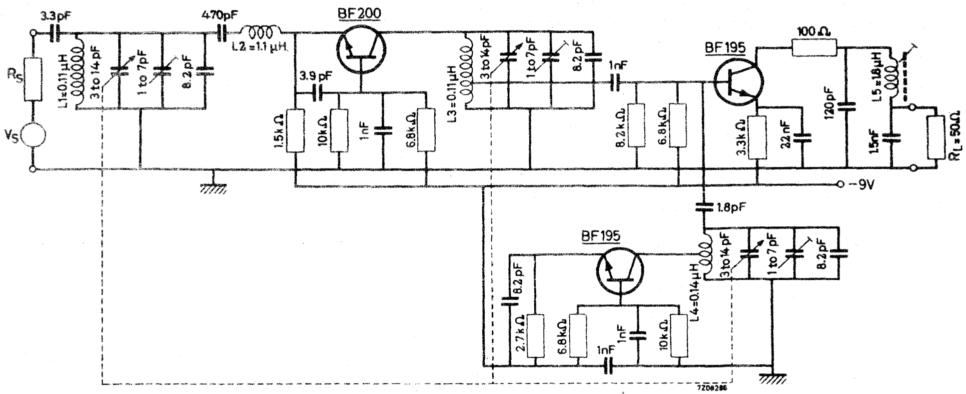
curves of constant gain reduction





APPLICATION INFORMATION (continued)

2. F.M. tuner with a BF200 in the pre-amplifier stage.



Coil data:

L1 = 4 turns enamelled Cu wire (1 mm); int. diam. 8 mm; winding pitch 2 mm; air; Q_0 = 200; Q_L = 50

L2 = 22 turns closely wound enamelled Cu wire (0.2 mm); int. diam. 4 mm; Q_0 = 150

L3 = 4 turns enamelled Cu wire (1 mm); int. diam. 8 mm; winding pitch 2 mm; air; mixer base tap 3/4 turns from earth-side; Q_0 = 200; Q_L = 100

L4 = 4.5 turns enamelled Cu wire (1 mm); int. diam. 8 mm; winding pitch 2 mm; air; oscillator collector tap 3.5 turns from earth-side; Q_0 = 200

L5 = 11 turns enamelled Cu wire (0.2 mm); winding pitch 0.4 mm; Q_0 = 150

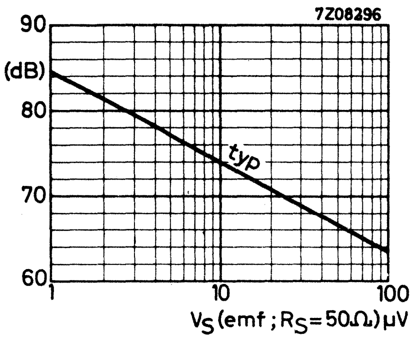
Coil former	AP3016/02	Ferroxcube core	3122 104 93041
Can	AP3015/02	Ferroxcube frame	AP3014/02

APPLICATION INFORMATION (continued)

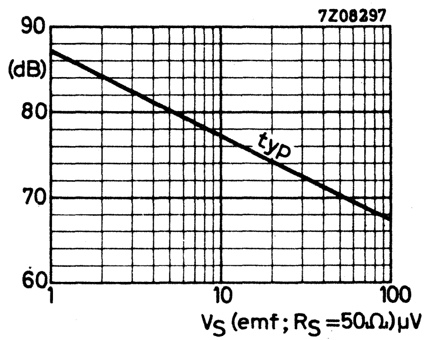
Typical performance of the f.m.tuner at T_{amb} = 25 °C; f = 98 MHz (oscillator frequency lower than tuning frequency)

Noise figure	F	4.5	dB
Transducer gain $G_{tr} = \frac{\text{output power in load}}{\text{available power from source}}$	G_{tr}	33	dB
Image rejection		65	dB
Double beat suppression (V_S = 1 μV; emf; R_S = 50 Ω)		85	dB
Repeat spot suppression (V_S = 1 μV; emf; R_S = 50 Ω)		87	dB
Oscillator frequency variation at ΔV_B = 2 V	Δf_{osc}	< 20	kHz
Signal handling for Δf_{osc} = 20 kHz (emf; R_S = 50 Ω)		> 1	V

Double beat suppression

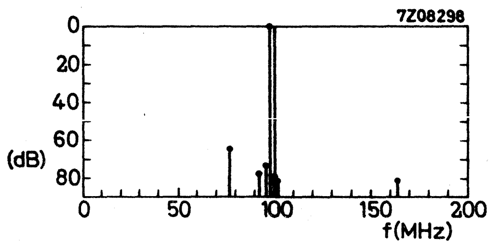


Repeat spot suppression



Spurious response suppression

Tuner adjusted to f = 98 MHz.
Reference level of wanted source signal: 8 μV (emf; R_S = 50 Ω) = 0 dB.



H.F. SILICON PLANAR EPITAXIAL TRANSISTORS

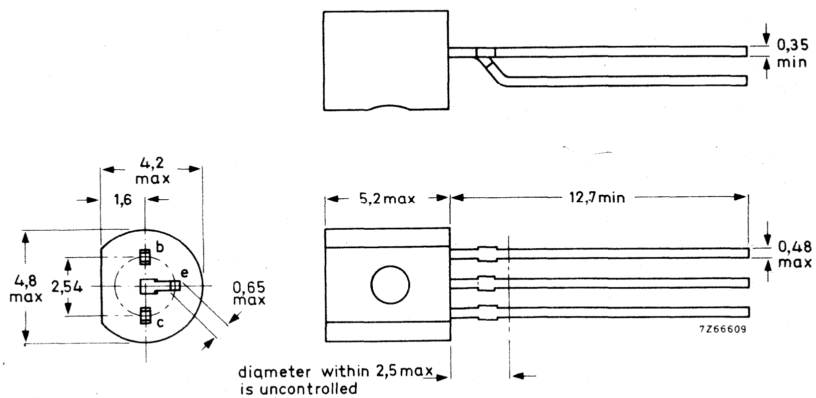
N-P-N transistors in a plastic envelope, recommended for a.m. mixers and i.f. amplifiers in a.m./f.m. receivers.

QUICK REFERENCE DATA

			BF240	BF241	
Collector-base voltage (open emitter)	V_{CBO}	max.	40		V
Collector-emitter voltage (open base)	V_{CEO}	max.	40		V
Collector current (d.c.)	I_C	max.	25		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	250		mW
Junction temperature	T_j	max.	125		°C
Base current I_C = 1 mA; V_{CE} = 10 V	I_B		4,5-15	8-28	μA
Transition frequency I_C = 1 mA; V_{CE} = 10 V	f_T	typ.	380	350	MHz
Feedback capacitance at f = 1 MHz I_C = 1 mA; V_{CE} = 10 V	C_{re}	<	0,34		pF
Noise figure I_C = 1 mA; V_{CE} = 10 V R_S = 200 Ω; f = 0,2 MHz	F	<	3,5		dB

MECHANICAL DATA Dimensions in mm

TO-92 variant



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

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4	V

Current

Collector current (d.c.)	I_C	max.	25	mA

Power dissipation

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

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0, 4	°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

Base-emitter voltage

$I_C = 1$ mA; $V_{CE} = 10$ V	V_{BE}	typ.	700	mV
			650 to 740	mV

			BF240	BF241	
Base current					
$I_C = 1$ mA; $V_{CE} = 10$ V	I_B		4, 5-15	8-28	μA
Transition frequency at f = 100 MHz					
$I_C = 1$ mA; $V_{CE} = 10$ V	f_T	typ.	380	350	MHz
Feedback capacitance at f = 1 MHz					
$I_C = 1$ mA; $V_{CE} = 10$ V	C_{re}	typ.	0, 27	0, 27	pF
		<	0, 34	0, 34	pF
Noise figure					
$I_C = 1$ mA; $V_{CE} = 10$ V					
$R_S = 200\ \Omega$; f = 0, 2 MHz	F	typ.	1, 5	2, 0	dB
		<	3, 5	3, 5	dB

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

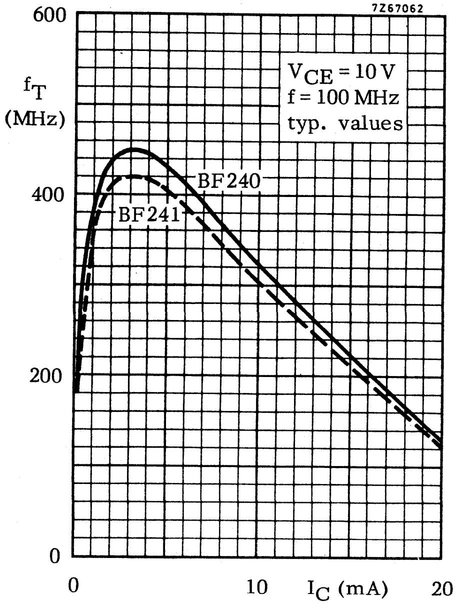
y parameters (common emitter) Lead length = 3 mm

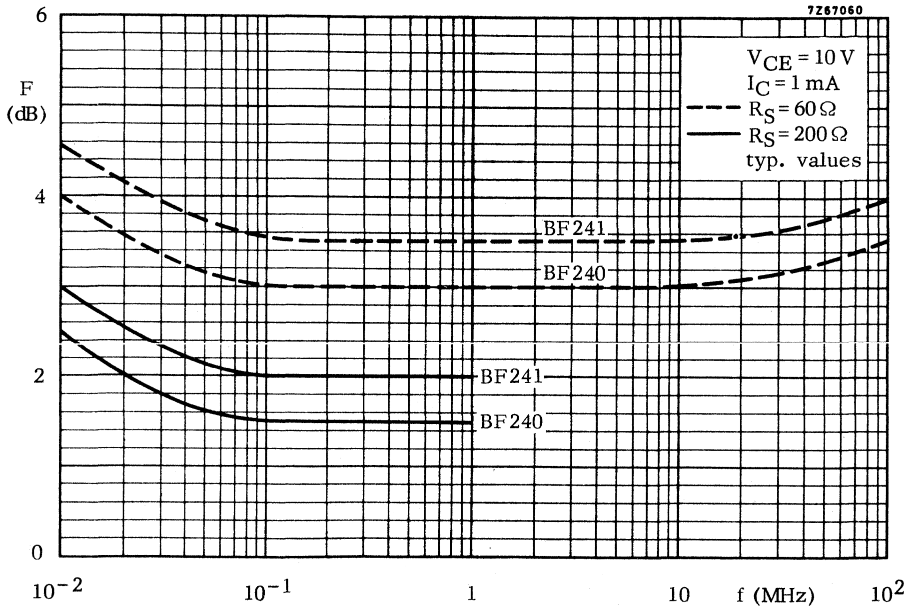
$I_C = 1$ mA; $V_{CE} = 10$ V

			BF240		BF241		
	f	=	0, 45	10, 7	0, 45	10, 7	MHz
Input conductance	g_{ie}	typ.	0, 2	0, 3	0, 4	0, 5	mA/V
Input capacitance	C_{ie}	typ.	17	14	23	19	pF
Transfer admittance	$\|y_{fe}\|$	typ.	37	37	37	37	mA/V
Phase angle of transfer admittance	φ_{fe}	typ.	0^o	0^o	0^o	0^o	
Output conductance	g_{oe}	<	8, 3	10, 5	8, 3	10, 5	µA/V
Output capacitance	C_{oe}	typ.	1	1	1	1	pF
Feedback admittance	$\|y_{re}\|$	typ.	0, 75	18	0, 75	18	µA/V
Phase angle of feedback admittance	φ_{re}	typ.	270^o	270^o	270^o	270^o	

$I_C = 4$ mA; $V_{CE} = 10$ V; f = 35 MHz (BF240, BF241)

Input conductance	g_{ie}	typ.	4	mA/V
Input capacitance	C_{ie}	typ.	25	pF
Transfer admittance	$\|y_{fe}\|$	typ.	125	mA/V
Output conductance	g_{oe}	typ.	62	µA/V
Output capacitance	C_{oe}	typ.	1	pF


7Z67062
600
400
200
0
fT
(MHz)
VCE = 10 V
f = 100 MHz
typ. values
BF240
BF241
0
10
IC (mA)
20


7Z67060
6
4
2
0
F
(dB)
VCE = 10 V
IC = 1 mA
RS = 60 Ω
RS = 200 Ω
typ. values
BF241
BF240
BF241
BF240
10−2
10−1
1
10
f (MHz)
102

H.F. SILICON PLANAR EPITAXIAL TRANSISTOR

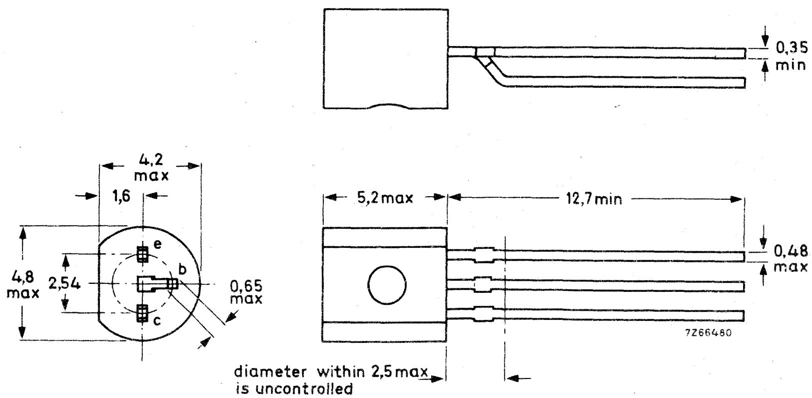
P-N-P transistor in a plastic envelope especially intended for r.f. stages in f.m. front-ends in common base configuration.

QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30	V
Collector current (d.c.)	$-I_C$	max.	25	mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	250	mW
Junction temperature	T_j	max.	150	°C
Base current $-I_C$ = 4 mA; $-V_{CE}$ = 10 V	$-I_B$	typ. <	80 160	µA µA
Transition frequency $-I_C$ = 4 mA; $-V_{CE}$ = 10 V	f_T	typ.	450	MHz
Noise figure at f = 100 MHz $-I_C$ = 2 mA; $-V_{CE}$ = 10 V; G_s = 16,7 mA/V	F	typ.	3	dB
Feedback capacitance at f = 1 MHz V_{EB} = 0; $-V_{CB}$ = 10 V	C_{rb}	typ.	0,1	pF

MECHANICAL DATA Dimensions in mm

TO-92 variant



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

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	4	V

Current

Collector current (d.c.)	$-I_C$	max.	25	mA

Power dissipation

Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	250	mW

Temperatures

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

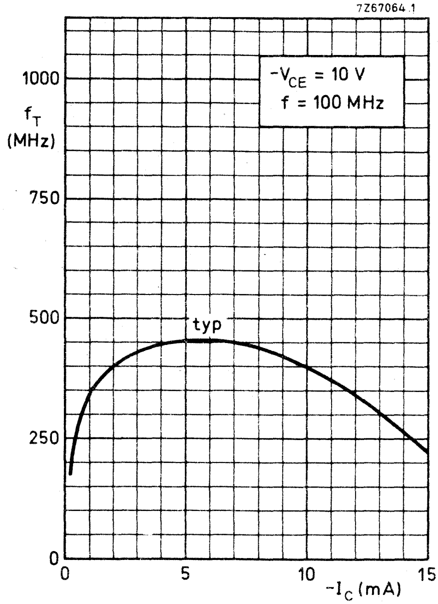
THERMAL RESISTANCE

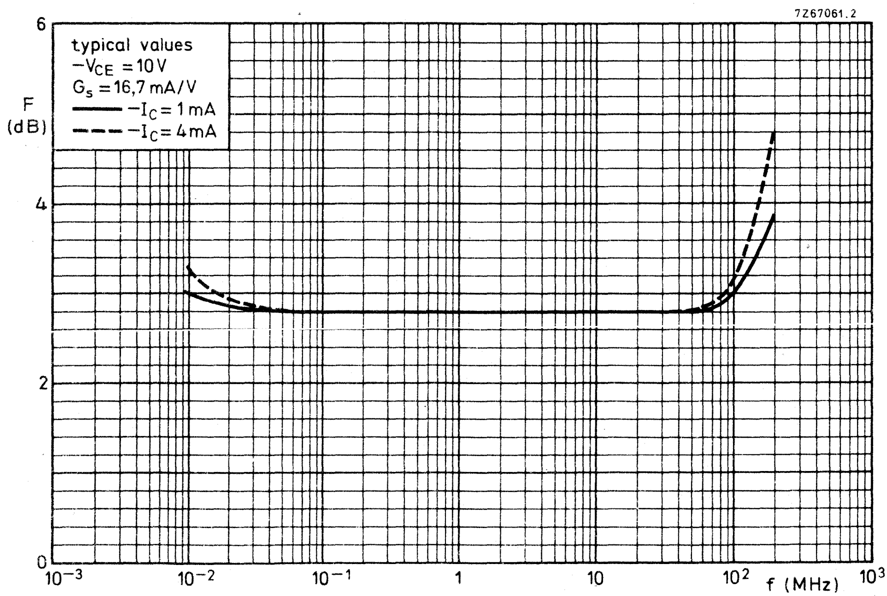
From junction to ambient in free air	$R_{th\ j-a}$	=	0, 42	°C/mW

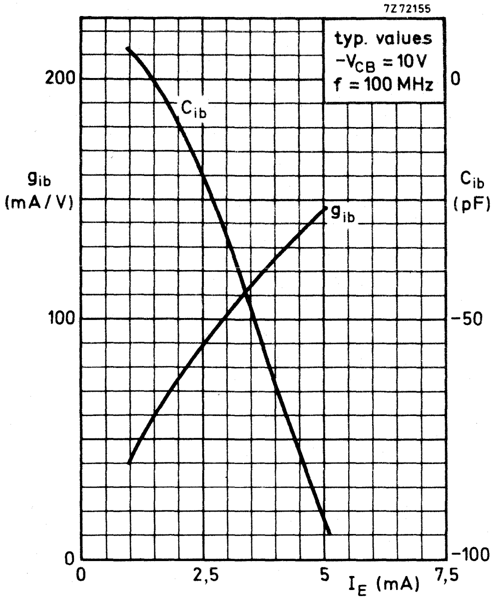
CHARACTERISTICS

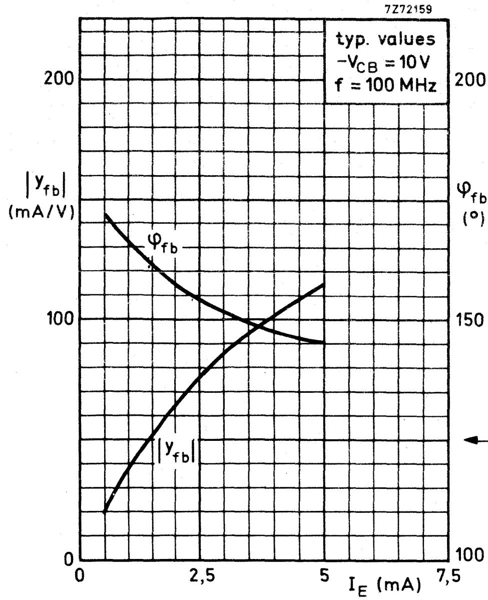
$T_j = 25\ ^oC$

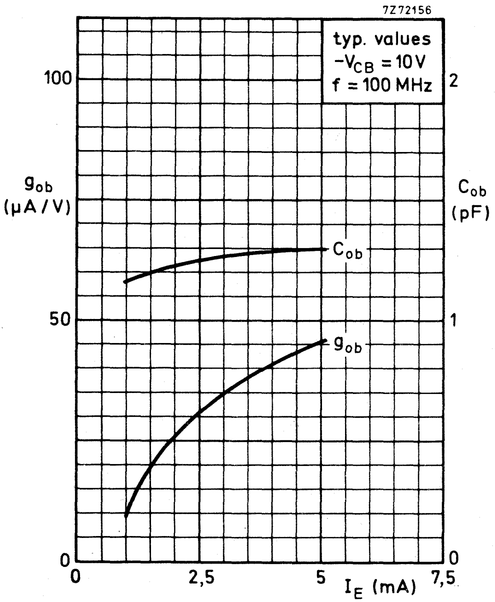
Collector cut-off current				
$I_E = 0; -V_{CB} = 30$ V	$-I_{CBO}$	<	50	nA
Emitter cut-off current				
$I_C = 0; -V_{EB} = 4$ V	$-I_{EBO}$	<	10	μA
Base current				
$-I_C = 4$ mA; $-V_{CE} = 10$ V	$-I_B$	typ.	80	μA
		<	160	μA
$-I_C = 1$ mA; $-V_{CE} = 10$ V	$-I_B$	typ.	22	μA
Base-emitter voltage ←				
$-I_C = 4$ mA; $-V_{CE} = 10$ V	$-V_{BE}$	typ.	0,76	V
Transition frequency at f = 100 MHz ←				
$-I_C = 1$ mA; $-V_{CE} = 10$ V	f_T	typ.	350	MHz
$-I_C = 4$ mA; $-V_{CE} = 10$ V	f_T	typ.	450	MHz
$-I_C = 8$ mA; $-V_{CE} = 10$ V	f_T	typ.	440	MHz
Feedback capacitance at f = 1 MHz				
$V_{EB} = 0; -V_{CB} = 10$ V	C_{rb}	typ.	0,1	pF
Noise factor at f = 100 MHz				
$-I_C = 2$ mA; $-V_{CE} = 10$ V; $G_s = 16,7$ mA/V	F	typ.	3	dB
$-I_C = 5$ mA; $-V_{CE} = 10$ V; $G_s = 6,7$ mA/V; $-jB_s = 5$ mA/V	F	typ.	3,5	dB
y-parameters (common base) at f = 100 MHz ←				
$-I_C = 4$ mA; $-V_{CB} = 10$ V				
Input conductance	g_{ib}	typ.	125	mA/V
Input capacitance	$-C_{ib}$	typ.	64	pF
Transfer admittance	$\lvert y_{fb} \rvert$	typ.	100	mA/V
Phase angle of transfer admittance	φ_{fb}	typ.	147^o	
Output conductance	g_{ob}	typ.	40	μA/V
Output capacitance	C_{ob}	typ.	1,25	pF
Feedback admittance	$\lvert y_{rb} \rvert$	typ.	220	μA/V
Phase angle of feedback admittance	$-\varphi_{rb}$	typ.	85^o	

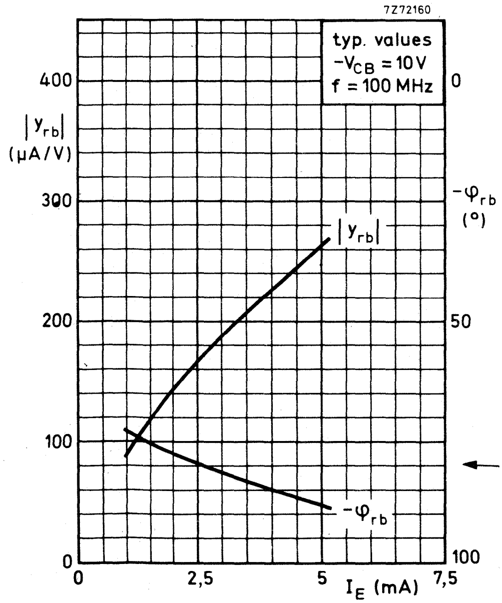

7Z67064.1
$-V_{CE}$ = 10 V
f = 100 MHz
f_T
(MHz)
1000
750
500
250
0
typ
0
5
10
15
$-I_C$ (mA)

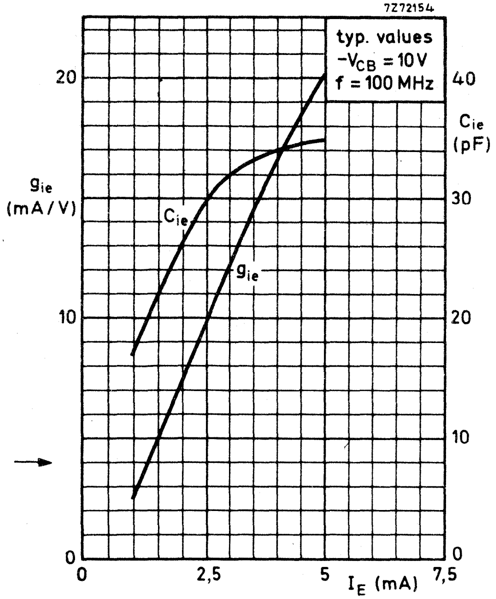

7Z67061.2
typical values
$-V_{CE}$ = 10 V
G_s = 16,7 mA/V
$-I_C$ = 1 mA
$-I_C$ = 4 mA
F
(dB)
6
4
2
0
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3
f (MHz)

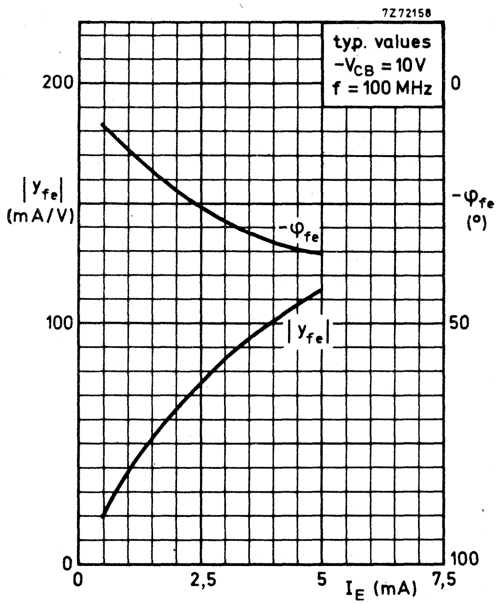

7Z72155
typ. values
$-V_{CB}$ = 10 V
f = 100 MHz
g_{ib}
(mA / V)
C_{ib}
(pF)
200
100
0
0
-50
-100
0
2,5
5
7,5
I_E (mA)

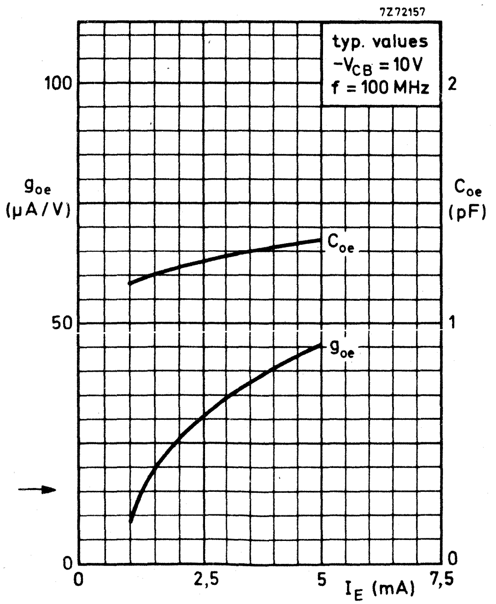

7Z72159
typ. values
$-V_{CB}$ = 10 V
f = 100 MHz
$|y_{fb}|$
(mA/V)
φ_{fb}
(°)
200
100
0
200
150
100
0
2,5
5
7,5
I_E (mA)

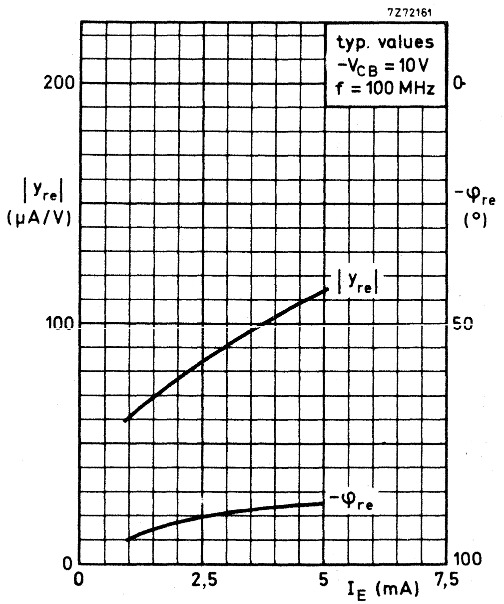

7Z72156
typ. values
$-V_{CB}$ = 10 V
f = 100 MHz
g_{ob}
(μA / V)
C_{ob}
(pF)
100
50
0
2
1
0
0
2,5
5
7,5
I_E (mA)


7Z72160
typ. values
$-V_{CB}$ = 10 V
f = 100 MHz
$|y_{rb}|$
(μA/V)
$-\varphi_{rb}$
(°)
400
300
200
100
0
0
50
100
0
2,5
5
7,5
I_E (mA)


7Z72154
typ. values
$-V_{CB}$ = 10 V
f = 100 MHz
g_{ie}
(mA/V)
C_{ie}
(pF)
C_{ie}
g_{ie}
20
10
0
40
30
20
10
0
0
2,5
5
7,5
I_E (mA)


7Z72158
typ. values
$-V_{CB}$ = 10 V
f = 100 MHz
$|y_{fe}|$
(mA/V)
$-\varphi_{fe}$
(°)
$-\varphi_{fe}$
$|y_{fe}|$
200
100
0
0
50
100
0
2,5
5
7,5
I_E (mA)


7Z72157
typ. values
$-V_{CB}$ = 10 V
f = 100 MHz
g_{oe}
(μA/V)
C_{oe}
(pF)
C_{oe}
g_{oe}
100
50
0
2
1
0
0
2,5
5
7,5
I_E (mA)


7Z72161
typ. values
$-V_{CB}$ = 10 V
f = 100 MHz
$|y_{re}|$
(μA/V)
$-\varphi_{re}$
(°)
$|y_{re}|$
$-\varphi_{re}$
200
100
0
0
50
100
0
2,5
5
7,5
I_E (mA)

N-P-N SILICON PLANAR TRANSISTORS FOR VIDEO OUTPUT STAGES

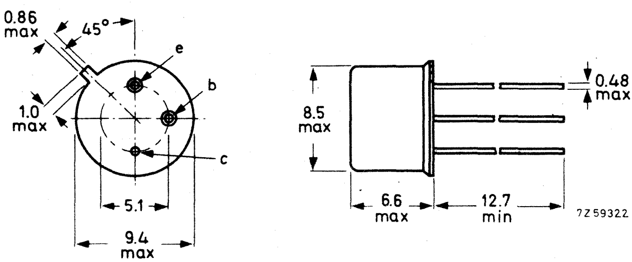
N-P-N transistors in a TO-39 metal envelope intended for the video amplifier and the line driver in black-and-white and colour television receivers.

QUICK REFERENCE DATA

			BF336	BF337	BF338	
Collector-base voltage (open emitter)	V_{CBO}	max.	185	250	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	180	200	225	V
Collector current (peak value)	I_{CM}	max.		200	mA	
Total power dissipation up to T_{mb} = 140 °C	P_{tot}	max.		3,0	W	
Junction temperature	T_j	max.		200	°C	
D.C. current gain at T_j = 25 °C; I_C = 30 mA; V_{CE} = 10 V	h_{FE}	>		20		
Transition frequency; I_C = 30 mA; V_{CE} = 20 V	f_T	>		80	MHz	
Feedback capacitance at f = 0,5 MHz; I_C = 10 mA; V_{CE} = 20 V	C_{re}	<		3,5	pF	

MECHANICAL DATA Dimensions in mm

TO-39
Collector connected to case



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

Accessories supplied on request: 56218; 56245

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

Voltages			BF336	BF337	BF338	
Collector-base voltage (open emitter)	V_{CBO}	max.	185	250	300	V
Collector-emitter voltage ($R_{BE} \leq 1$ kΩ) I_C = 1 mA; up to T_j = 150 °C	V_{CER}	max.	185	250	300	V
Collector-emitter voltage (open base) I_C = 4 mA	V_{CEO}	max.	180	200	225	V
Emitter-base voltage (open collector) I_E = 0.1 mA	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
Base current (peak value)	I_{BM}	max.	20	mA

Power dissipation

Total power dissipation up to T_{mb} = 140 °C	P_{tot}	max.	3.0	W

Temperatures

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

THERMAL RESISTANCE

From junction to ambient	$R_{th\ j-a}$	=	220	°C/W
From junction to mounting base	$R_{th\ j-mb}$	=	20	°C/W
From junction to case	$R_{th\ j-c}$	=	25	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current at R_{BE} = 1 kΩ

V_{CE} = 150 V for BF336; V_{CE} = 200 V for BF337; V_{CE} = 250 V for BF338	I_{CER}	typ.	10	nA
		<	100	µA

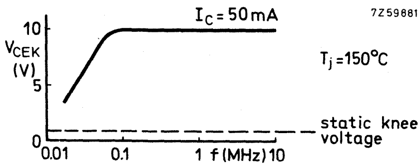
Base-emitter voltage

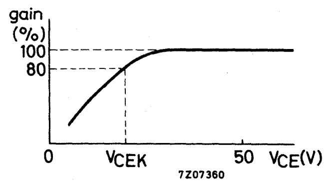
I_C = 30 mA; V_{CE} = 10 V	V_{BE}	typ.	0,7	V
		<	1,2	V

High frequency knee voltage at T_j = 150 °C

I_C = 50 mA	V_{CEK}	typ.	10	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 reduction of the collector-emitter voltage results in a rapid increase of the distortion of the signal.





D.C. current gain

I_C = 30 mA; V_{CE} = 10 V	h_{FE}	>	20	
		typ.	60	

Feedback capacitance at f = 0.5 MHz

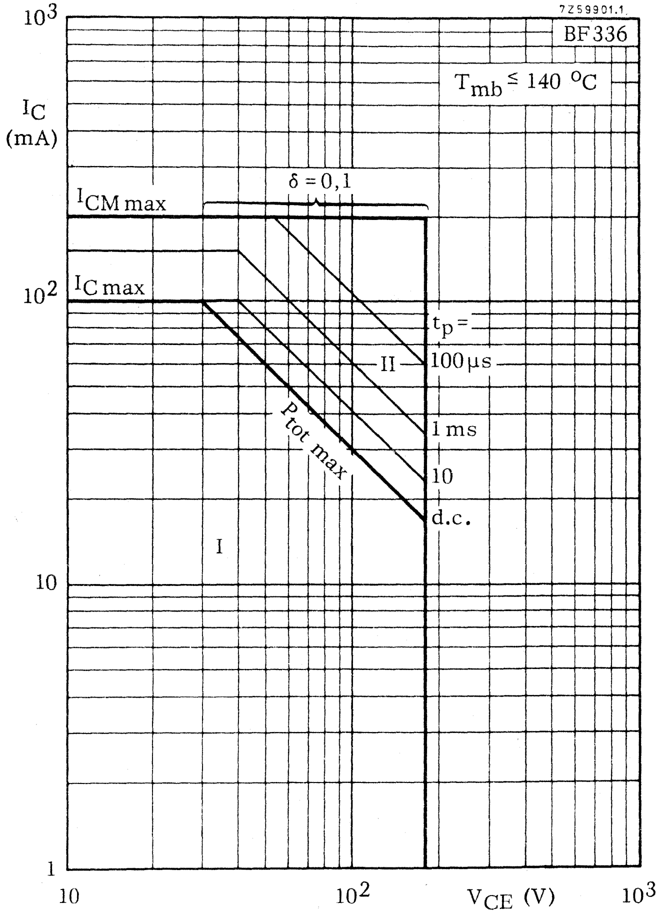
I_C = 10 mA; V_{CE} = 20 V	C_{re}	typ.	3,0	pF
		<	3,5	pF

Feedback time constant at f = 10 MHz

$-I_E$ = 30 mA; V_{CB} = 20 V	$r_{bb'}C_{b'c}$	typ.	30	ps
		<	100	ps

Transition frequency at f = 100 MHz

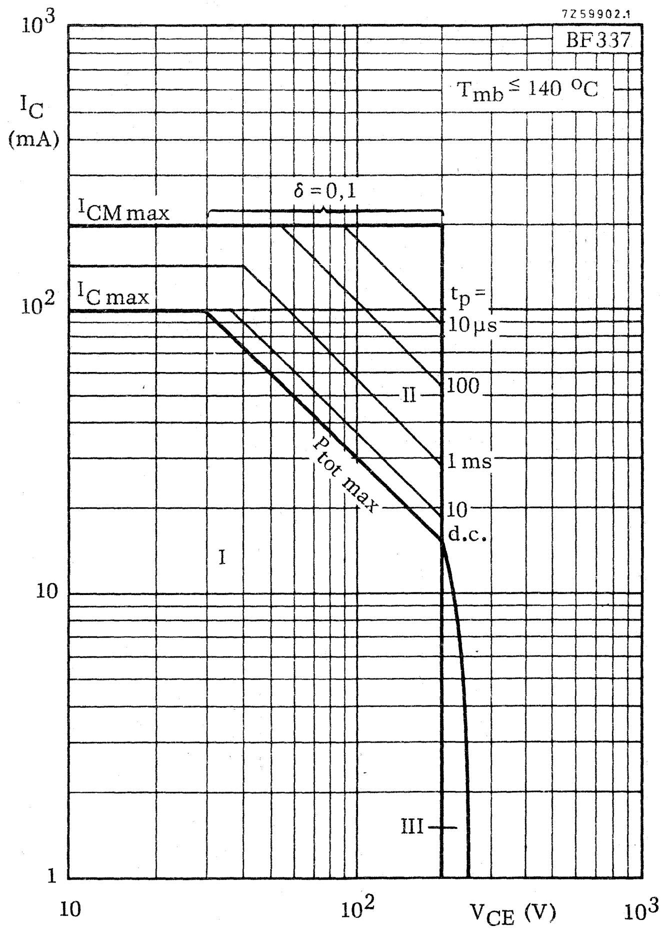
I_C = 30 mA; V_{CE} = 20 V	f_T	>	80	MHz
		typ.	130	MHz



Safe Operating Area with the transistor forward biased

I Region of permissible d. c. operation

II Permissible extension for repetitive pulse operation

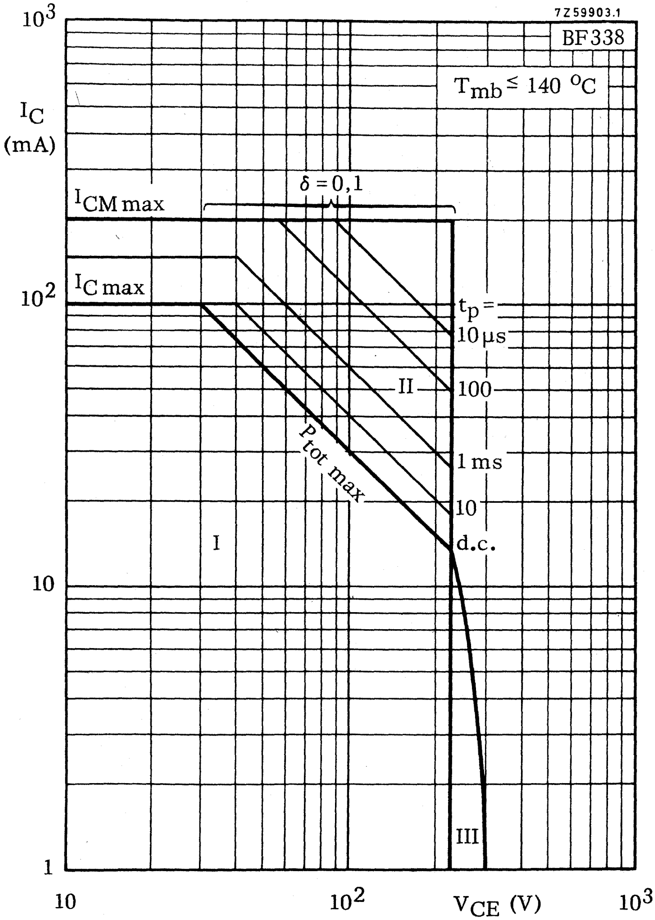


Safe Operating Area with the transistor forward biased

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

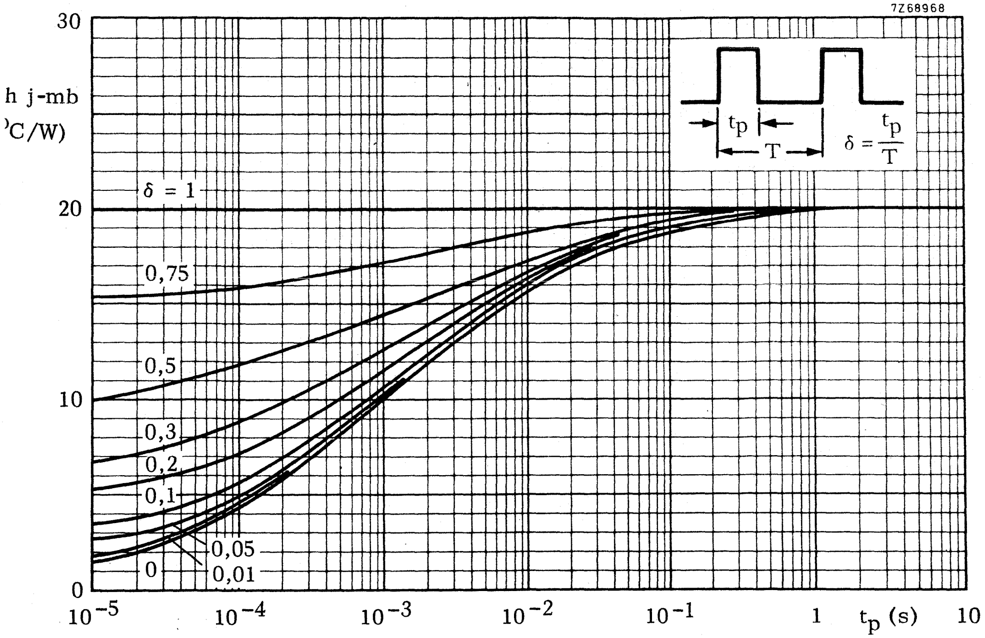


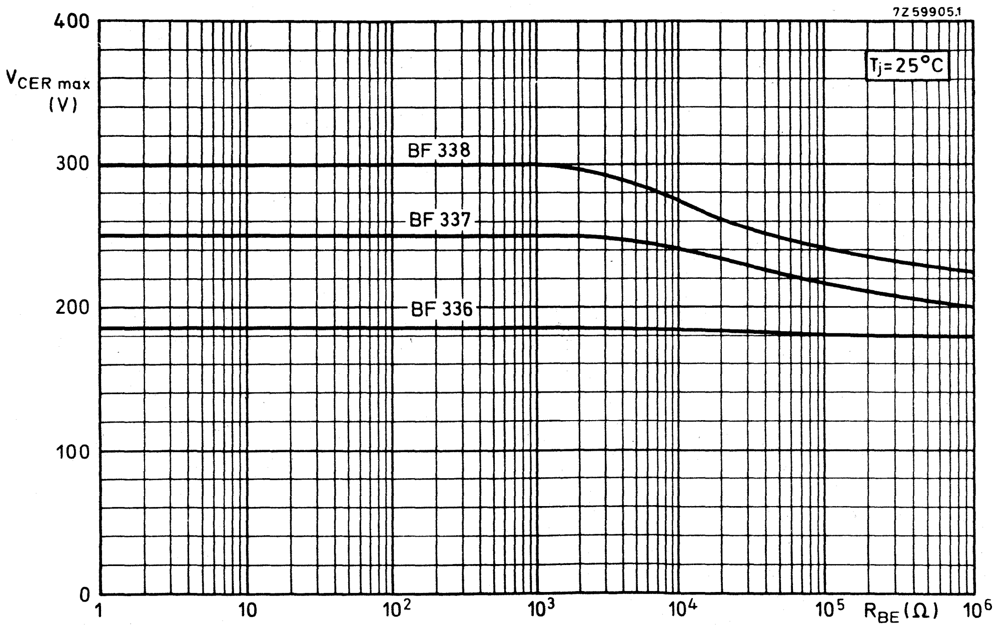
Safe Operating Area with the transistor forward biased

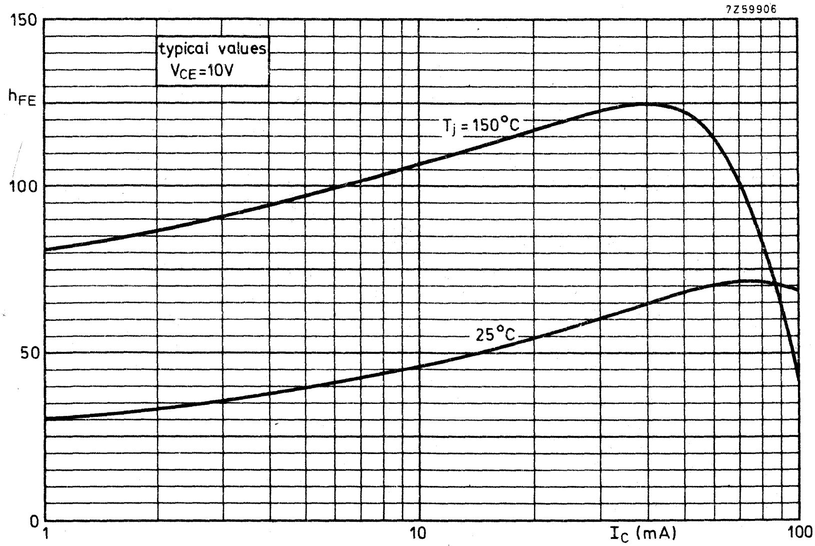
I Region of permissible d.c. operation

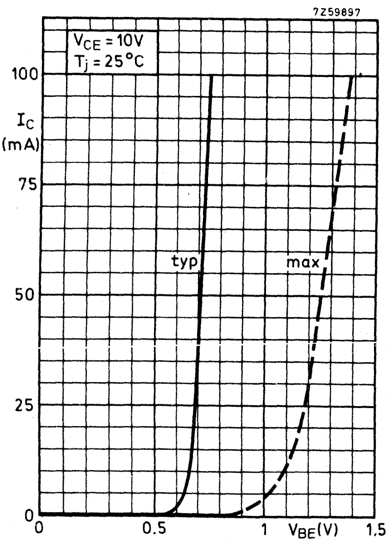
II Permissible extension for repetitive pulse operation

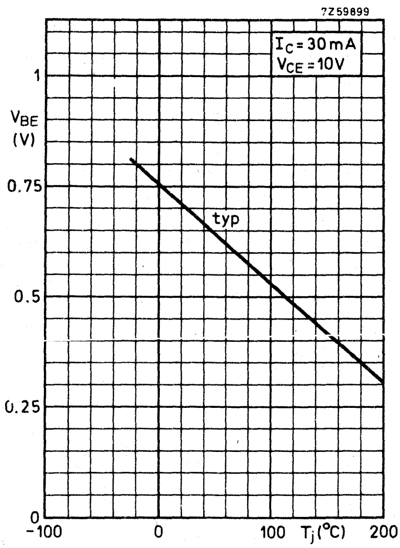
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 1\ k\Omega$

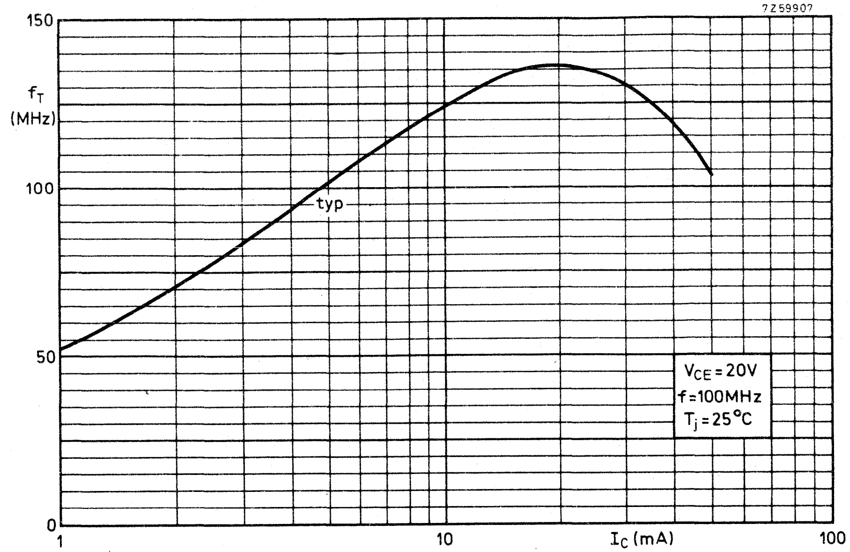

7Z68968
h j-mb
°C/W)
δ = 1
0,75
0,5
0,3
0,2
0,1
0,05
0
0,01
tp
T
δ = tp/T
30
20
10
0
10−5
10−4
10−3
10−2
10−1
1
tp (s)
10

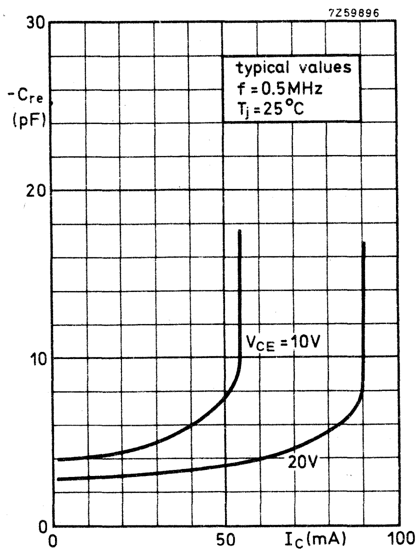

7Z59905.1
VCER max
(V)
Tj=25°C
BF 338
BF 337
BF 336
400
300
200
100
0
1
10
10²
10³
10⁴
10⁵
RBE (Ω)
10⁶

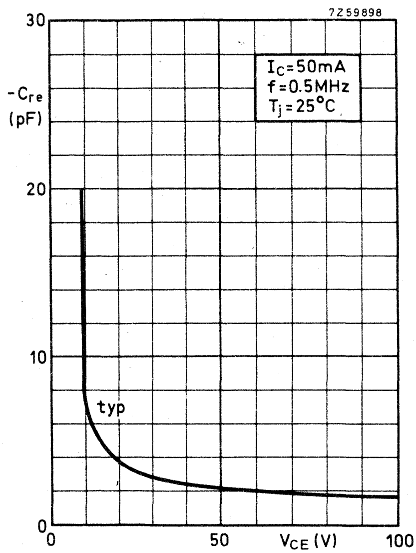

7Z59906
typical values
V_{CE} = 10V
h_{FE}
150
100
50
0
T_j = 150°C
25°C
1
10
100
I_C (mA)

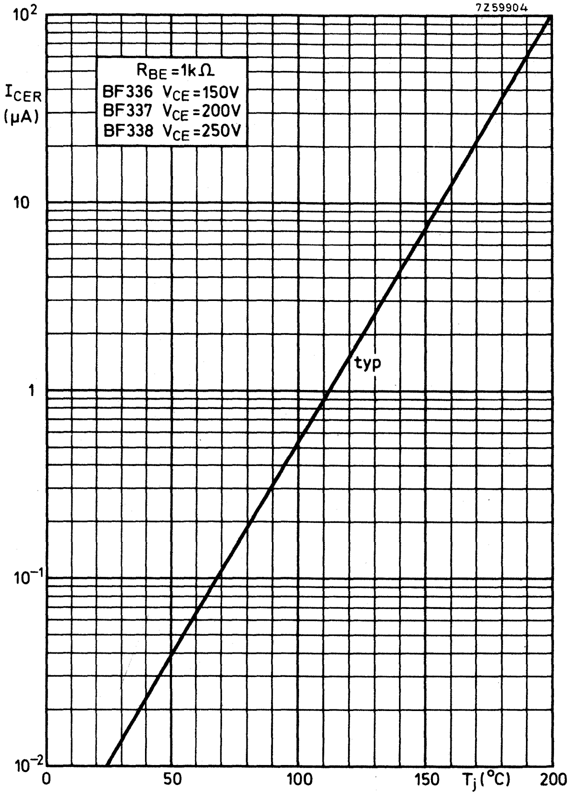

7Z59897
V_{CE} = 10V
T_j = 25°C
I_C
(mA)
100
75
50
25
0
typ
max
0
0.5
1
V_{BE}(V)
1.5


7Z59899
I_C = 30 mA
V_{CE} = 10V
V_{BE}
(V)
1
0.75
0.5
0.25
0
typ
−100
0
100
T_j(°C)
200


7Z59907
150
f_T
(MHz)
100
50
0
1
10
I_C (mA)
100
typ
V_{CE} = 20V
f = 100MHz
T_j = 25 °C


7Z59896
30
$-C_{re}$
(pF)
20
10
0
0
50
I_C (mA)
100
typical values
f = 0.5MHz
T_j = 25 °C
V_{CE} = 10V
20V


7Z59898
30
$-C_{re}$
(pF)
20
10
0
0
50
V_{CE} (V)
100
I_C = 50mA
f = 0.5MHz
T_j = 25 °C
typ


7Z59904
R_{BE} = 1 kΩ
BF336 V_{CE} = 150V
BF337 V_{CE} = 200V
BF338 V_{CE} = 250V
I_{CER} (μA)
10^2
10
1
10^{-1}
10^{-2}
typ
0
50
100
150
T_j (°C)
200

U.H.F. SILICON PLANAR TRANSISTORS

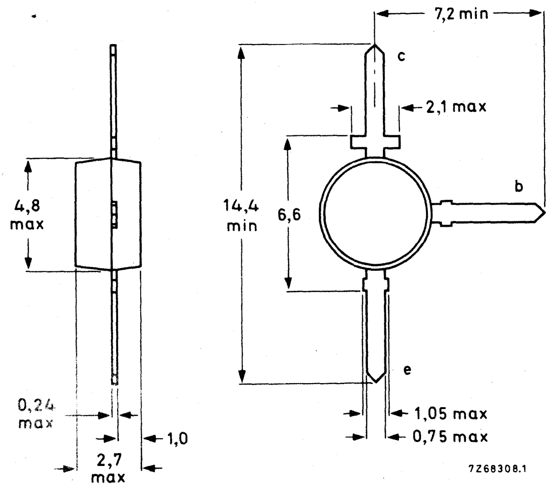
High gain n-p-n transistors in plastic T-package. The BF362 is intended for use in the r.f. stage of television tuners and the BF363 is an oscillator-mixer. The combination of low self-capacitance and low lead inductance due to the T-package makes these devices especially suitable for use in television tuners with diode tuning.

QUICK REFERENCE DATA

Collector-base voltage (open emitter)		V_{CBO}	max.	30	V
Collector-emitter voltage (open base)		V_{CEO}	max.	20	V
Collector current (d.c.)		I_C	max.	20	mA
Total power dissipation up to T_{amb} = 55 °C		P_{tot}	max.	120	mW
Transition frequency I_C = 3 mA; V_{CE} = 10 V	BF362	f_T	typ.	800	MHz
	BF363	f_T	600 to	820	MHz
Transducer gain at f = 900 MHz $-I_E$ = 3 mA; V_{CC} = 12 V		G_{tr}	>	11	dB
Noise figure at f = 800 MHz $-I_E$ = 3 mA; V_{CC} = 12 V		F	typ.	5	dB
Feedback capacitance at f = 10, 7 MHz I_C = 1 mA; V_{CE} = 10 V		C_{re}	typ.	0, 25	pF

MECHANICAL DATA Dimensions in mm

SOT 37



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

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	3	V

Currents

Collector current (d.c.)	I_C	max.	20	mA
Collector current (peak value)	I_{CM}	max.	20	mA

Power dissipation

Total power dissipation up to T_{amb} = 55 ^oC	P_{tot}	max.	120	mW

Temperature

Junction temperature	T_j	max.	125	^oC
Storage temperature	T_{stg}	−55 ^oC to 125 ^oC		

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0,58	^oC/mW

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

Base current

$-I_E$ = 3 mA; V_{CB} = 10 V		I_B	typ.	60	μA
			<	150	μA
$-I_E$ = 12 mA; V_{CB} = 7 V		I_B	typ.	0,3	mA
			<	1,0	mA

Emitter-base voltage

$-I_E$ = 3 mA; V_{CB} = 10 V		$-V_{EB}$	typ.	0,75	V
$-I_E$ = 12 mA; V_{CB} = 7 V		$-V_{EB}$	typ.	0,80	V

Transition frequency at f = 100 MHz

I_C = 3 mA; V_{CE} = 10 V	BF362	f_T	typ.	800	MHz
	BF363	f_T	600 to 820		MHz

Feedback capacitance at f = 10,7 MHz

I_C = 1 mA; V_{CE} = 10 V		C_{re}	typ.	0,25	pF

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

Noise figure

$-I_E$ = 3 mA; V_{CC} = 12 V; f = 800 MHz				
G_S = 27 mA/V; B_S = 9 mA/V; R_C = 390 Ω	F	typ.	5,0	dB
$-I_E$ = 3 mA; V_{CC} = 12 V; f = 500 MHz				
G_S = 32 mA/V; $-B_S$ = 11 mA/V; R_C = 390 Ω	F	typ.	4,5	dB

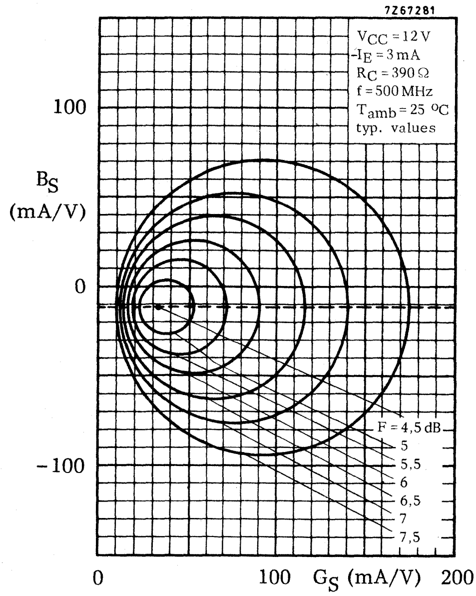
Transducer gain at f = 900 MHz

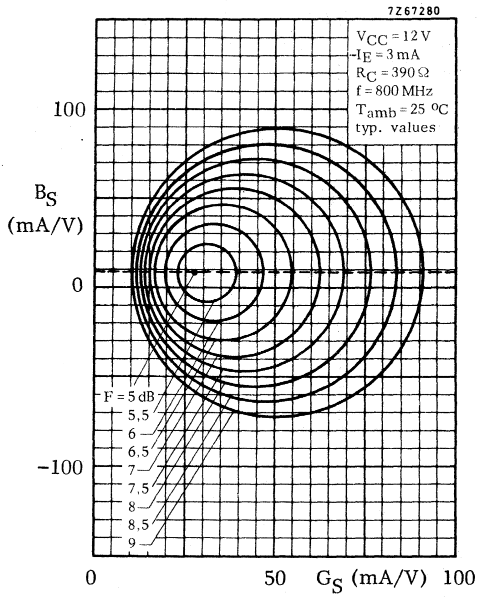
$-I_E$ = 3 mA; V_{CC} = 12 V				
G_S = 20 mA/V; B_S = 0				
G_L = 2 mA/V; B_L tuned; R_C = 390 Ω	G_{tr}	>	11	dB
		typ.	12	dB

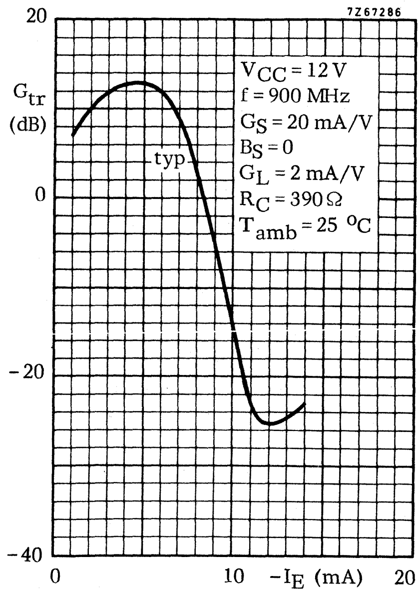
y-parameters (common base)

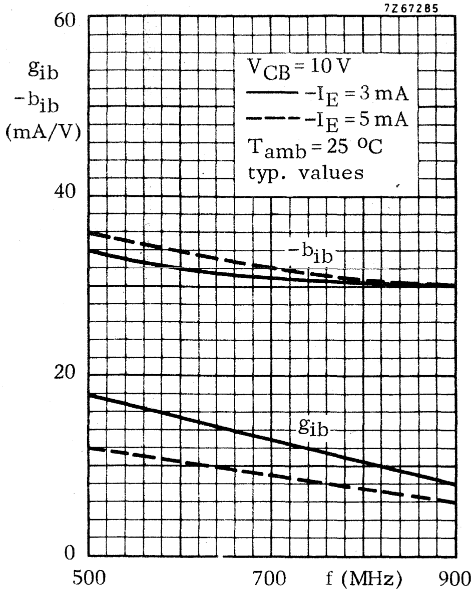
$-I_E$ = 3 mA; V_{CB} = 10 V

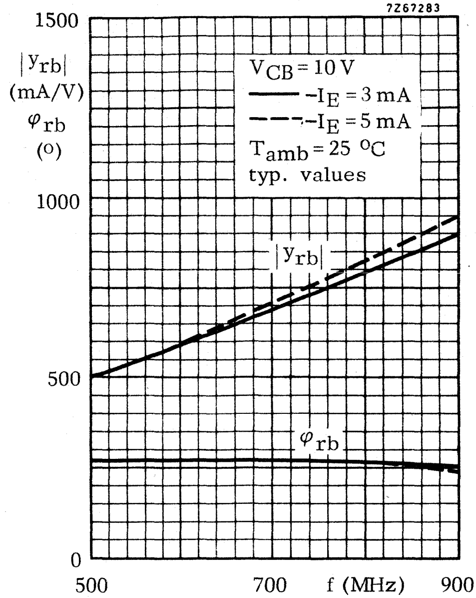
	f	=	500	900	MHz
Input conductance	g_{ib}	typ.	18	8	mA/V
Input susceptance	$-b_{ib}$	typ.	34	30	mA/V
Feedback admittance	$\|y_{rb}\|$	typ.	500	900	µA/V
Phase angle of feedback admittance	φ_{rb}	typ.	270°	250°	
Transfer admittance	$\|y_{fb}\|$	typ.	45	25	mA/V
Phase angle of transfer admittance	φ_{fb}	typ.	80°	40°	
Output conductance	g_{ob}	typ.	0,6	1,8	µA/V
Output capacitance	C_{ob}	typ.	0,5	0,6	pF

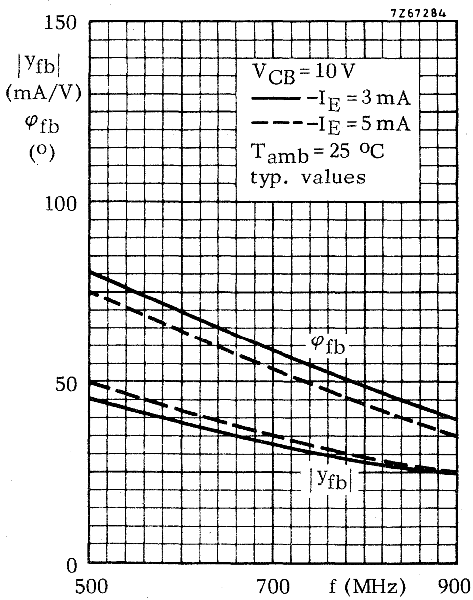

7Z67281
V_{CC} = 12 V
$-I_E$ = 3 mA
R_C = 390 Ω
f = 500 MHz
T_{amb} = 25 °C
typ. values
100
B_S (mA/V)
0
−100
F = 4,5 dB
5
5,5
6
6,5
7
7,5
0
100
G_S (mA/V)
200

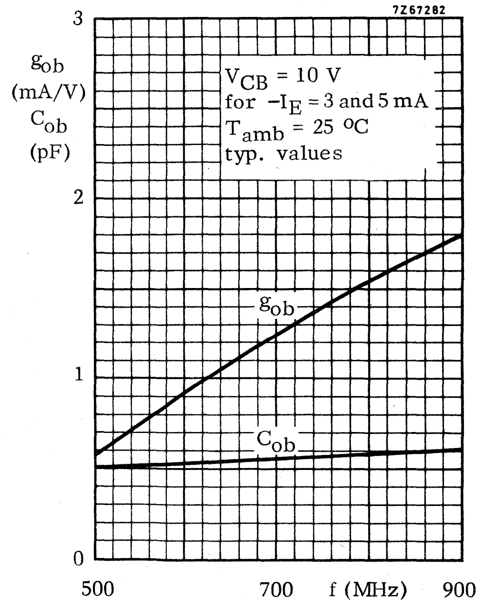

7Z67280
V_{CC} = 12 V
$-I_E$ = 3 mA
R_C = 390 Ω
f = 800 MHz
T_{amb} = 25 °C
typ. values
100
B_S (mA/V)
0
−100
F = 5 dB
5,5
6
6,5
7
7,5
8
8,5
9
0
50
G_S (mA/V)
100


7Z67286
20
G_{tr} (dB)
0
−20
−40
V_{CC} = 12 V
f = 900 MHz
G_S = 20 mA/V
B_S = 0
G_L = 2 mA/V
R_C = 390 Ω
T_{amb} = 25 °C
typ
0
10
$-I_E$ (mA)
20


7Z67285
60
g_{ib}
$-b_{ib}$
(mA/V)
40
20
0
$V_{CB} = 10$ V
$-I_E = 3$ mA
$-I_E = 5$ mA
$T_{amb} = 25$ °C
typ. values
$-b_{ib}$
g_{ib}
500
700
f (MHz)
900


7Z67283
1500
$|y_{rb}|$
(mA/V)
φ_{rb}
(°)
1000
500
0
$V_{CB} = 10$ V
$-I_E = 3$ mA
$-I_E = 5$ mA
$T_{amb} = 25$ °C
typ. values
$|y_{rb}|$
φ_{rb}
500
700
f (MHz)
900


7Z67284
150
$|y_{fb}|$
(mA/V)
φ_{fb}
(°)
100
50
0
$V_{CB} = 10$ V
$-I_E = 3$ mA
$-I_E = 5$ mA
$T_{amb} = 25$ °C
typ. values
φ_{fb}
$|y_{fb}|$
500
700
f (MHz)
900


7Z67282
3
g_{ob}
(mA/V)
C_{ob}
(pF)
2
1
0
$V_{CB} = 10$ V
for $-I_E = 3$ and 5 mA
$T_{amb} = 25$ °C
typ. values
g_{ob}
C_{ob}
500
700
f (MHz)
900

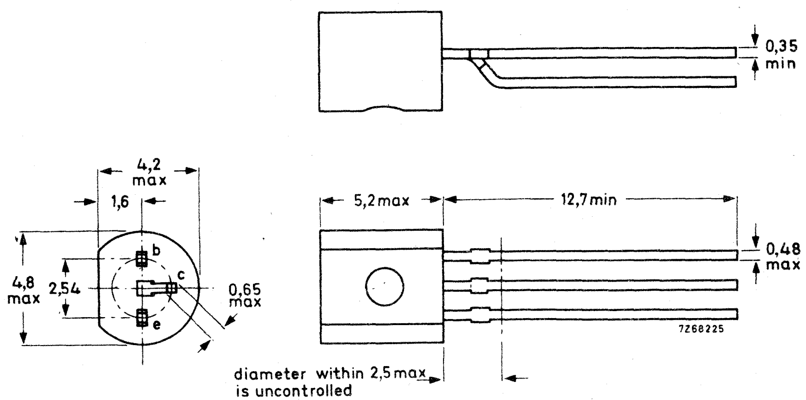
SILICON EPITAXIAL TRANSISTOR FOR VIDEO OUTPUT STAGES

N-P-N transistor in plastic TO-92 variant intended for class-B video output stages in colour television receivers. P-N-P complement is BF423.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	250	V
Collector-emitter voltage (open base)	V_{CEO}	max.	250	V
Collector current (peak value)	I_{CM}	max.	100	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	830	mW
Junction temperature	T_j	max.	150	°C
D.C. current gain at T_j = 25 °C I_C = 25 mA; V_{CE} = 20 V	h_{FE}	>	50	
Transition frequency $-I_E$ = 10 mA; V_{CB} = 10 V	f_T	>	60	MHz
Feedback capacitance at f = 0,5 MHz I_E = 0; V_{CB} = 30 V	C_{re}	<	1,6	pF

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-base voltage (open emitter)	V_{CBO}	max.	250	V
Collector-emitter voltage (open base)	V_{CEO}	max.	250	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V
Currents				
Collector current (d.c.)	I_C	max.	20	mA
Collector current (peak value)	I_{CM}	max.	100	mA
Power dissipation				
Total power dissipation up to T_{amb} = 25 °C [1]	P_{tot}	max.	830	mW
Temperatures				
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient [1]	$R_{th\ j\text{-}a}$	=	0,15	°C/mW

[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 currents				
$I_E = 0$; $V_{CE} = 200$ V	I_{CBO}	<	10	nA
$R_{BE} = 10$ kΩ; $V_{CE} = 200$ V; $T_j = 150$ °C	I_{CER}	<	10	µA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	µA
D.C. current gain				
$I_C = 25$ mA; $V_{CE} = 20$ V	h_{FE}	>	50	
High-frequency knee voltage at $T_j = 150$ °C				
$I_C = 25$ 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 reduction of the collector-emitter voltage results in a rapid increase of the distortion of the signal.

Transition frequency				
$-I_E = 10$ mA; $V_{CB} = 10$ V	f_T	>	60	MHz
Feedback capacitance at f = 0,5 MHz				
$I_E = 0$; $V_{CB} = 30$ V	C_{re}	<	1,6	pF
Feedback time constant at f = 10,7 MHz				
$-I_E = 30$ mA; $V_{CB} = 20$ V	$r_{bb'} C_{b'c}$	<	70	ps [1]

[1] $r_{bb'} C_{b'c} = \frac{|h_{rb}|}{\omega}$.

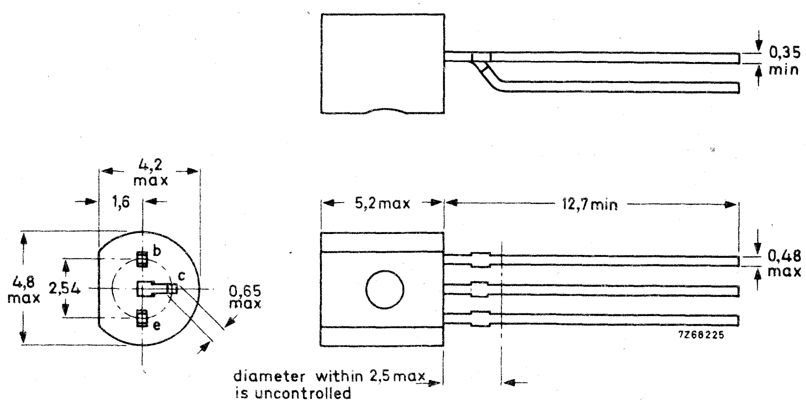
SILICON EPITAXIAL TRANSISTOR FOR VIDEO OUTPUT STAGES

P-N-P transistor in a plastic TO-92 variant intended for class-B video output stages in colour television receivers. N-P-N complement is BF422.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	250	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	250	V
Collector current (peak value)	$-I_{CM}$	max.	100	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	830	mW
Junction temperature	T_j	max.	150	°C
D.C. current gain at T_j = 25 °C $-I_C$ = 25 mA; $-V_{CE}$ = 20 V	h_{FE}	>	50	
Transition frequency I_E = 10 mA; $-V_{CB}$ = 10 V	f_T	>	60	MHz
Feedback capacitance at f = 0,5 MHz I_E = 0; $-V_{CB}$ = 30 V	C_{re}	<	1,6	pF

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-base voltage (open emitter)	$-V_{CBO}$	max.	250	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	250	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	V
Currents				
Collector current (d.c.)	$-I_C$	max.	20	mA
Collector current (peak value)	$-I_{CM}$	max.	100	mA
Power dissipation				
Total power dissipation up to T_{amb} = 25 °C [1]	P_{tot}	max.	830	mW
Temperatures				
Storage temperature	T_{stg}		−65 to + 150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient [1]	$R_{th\ j-a}$	=	0,15	°C/mW

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 currents				
$I_E = 0$; $-V_{CB} = 200$ V	$-I_{CBO}$	<	10	nA
$R_{BE} = 10$ kΩ; $-V_{CE} = 200$ V; $T_j = 150$ °C	$-I_{CER}$	<	10	μA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	10	μA
D.C. current gain				
$-I_C = 25$ mA; $-V_{CE} = 20$ V	h_{FE}	>	50	
High-frequency knee voltage at $T_j = 150$ °C				
$-I_C = 25$ 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 reduction of the collector-emitter voltage results in a rapid increase of the distortion of the signal.

Transition frequency				
$I_E = 10$ mA; $-V_{CB} = 10$ V	f_T	>	60	MHz
Feedback capacitance at f = 0,5 MHz				
$I_E = 0$; $-V_{CB} = 30$ V	C_{re}	<	1,6	pF
Feedback time constant at f = 10,7 MHz				
$I_E = 30$ mA; $-V_{CB} = 20$ V	$r_{bb'} C_{b'c}$	<	70	ps [1]

[1] $r_{bb'} C_{b'c} = \frac{|h_{rb}|}{\omega}$.

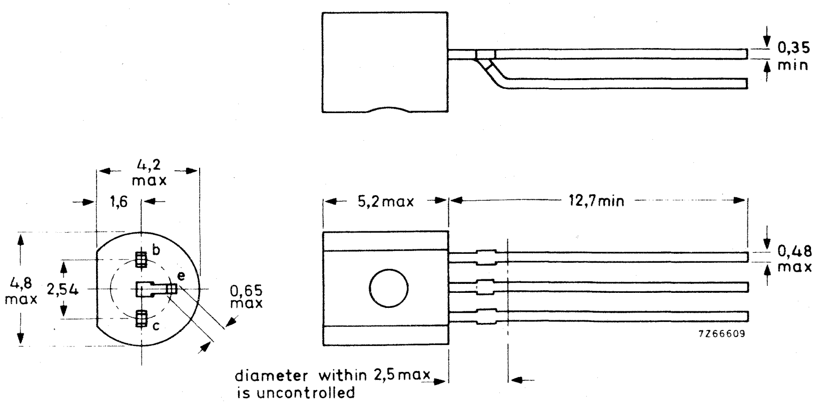
H.F. SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in a plastic envelope intended for h.f. and i.f. applications in radio receivers, especially for mixer stages in a.m. receivers and i.f. stages in a.m./f.m. receivers with negative earth.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	V
Collector current (d.c.)	$-I_C$	max.	25	mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	250	mW
Junction temperature	T_j	max.	150	°C
Base current $-I_C$ = 1 mA; $-V_{CE}$ = 10 V BF450:	$-I_B$		5 to 16	μA
BF451:	$-I_B$		11 to 33	μA
Transition frequency $-I_C$ = 1 mA; $-V_{CE}$ = 10 V	f_T	typ.	325	MHz
Noise figure at f = 100 kHz $-I_C$ = 1 mA; $-V_{CE}$ = 10 V; R_S = 300 Ω	F	typ.	2	dB

MECHANICAL DATA Dimensions in mm

TO-92 variant



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

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	4	V

Current

Collector current (d.c.)	$-I_C$	max.	25	mA

Power dissipation

Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	250	mW

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0,42	°C/mW

CHARACTERISTICS T_j = 25 °C

Collector cut-off current

$I_E = 0$; $-V_{CB} = 30$ V	$-I_{CBO}$	<	50	nA
$I_E = 0$; $-V_{CB} = 40$ V	$-I_{CBO}$	<	10	μA

Emitter cut-off current

$I_C = 0$; $-V_{EB} = 4$ V	$-I_{EBO}$	<	10	μA

Base current

→ $-I_C = 1$ mA; $-V_{CE} = 10$ V	BF450:	$-I_B$	<	5 to 16	μA
	BF451:	$-I_B$	<	11 to 33	μA

Base-emitter voltage

$-I_C = 1$ mA; $-V_{CE} = 10$ V	$-V_{BE}$	typ.	700	mV

CHARACTERISTICS (continued) $T_j = 25\ ^oC$

Transition frequency at f = 100 MHz

$-I_C = 1$ mA; $-V_{CE} = 10$ V	f_T	typ.	325	MHz

Feedback capacitance at f = 1 MHz

$-I_C = 1$ mA; $-V_{CE} = 10$ V	C_{re}	typ.	0,35	pF

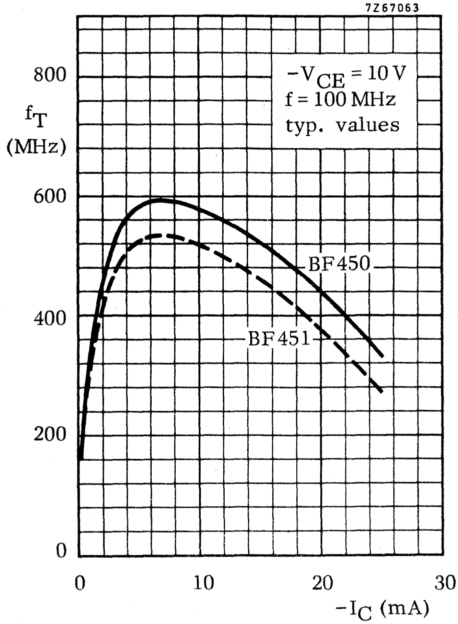
Noise figure at f = 100 kHz

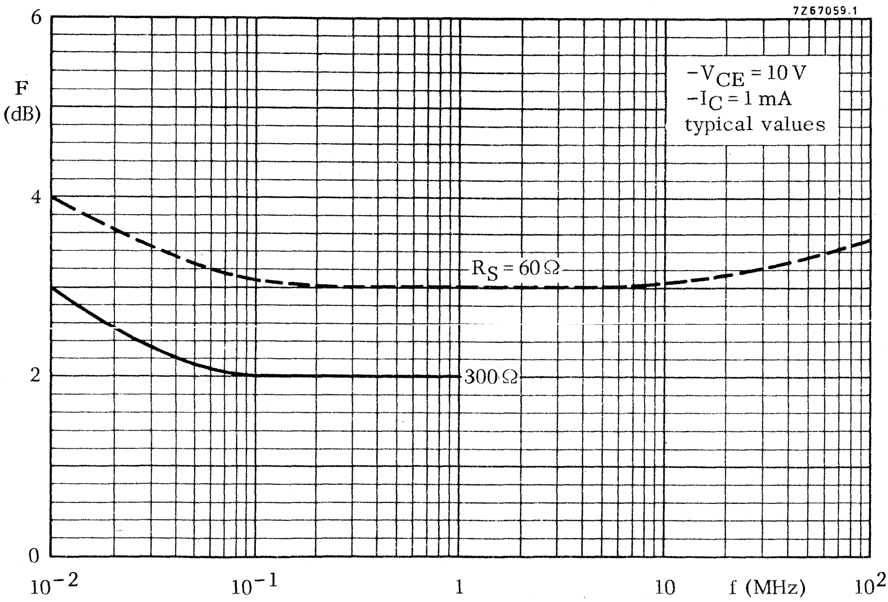
$-I_C = 1$ mA; $-V_{CE} = 10$ V; $R_S = 300\ \Omega$	F	typ.	2	dB

y-parameters (common emitter)

$-I_C = 1$ mA; $-V_{CE} = 10$ V

			BF450		BF451		
	f	=	0,45	10,7	0,45	10,7	MHz
Input conductance	g_{ie}	typ.	0,3	0,4	0,7	0,8	mA/V
Input capacitance	C_{ie}	typ.	20	13	30	20	pF
Transfer admittance	$\|y_{fe}\|$	typ.	37	37	37	37	mA/V
Phase angle of transfer admittance	φ_{fe}	typ.	0^o	0^o	0^o	0^o	
Output conductance	g_{oe}	typ.	8	10	8	10	µA/V
Output capacitance	C_{oe}	typ.	1	1	1	1	pF
Feedback admittance	$\|y_{re}\|$	typ.	1	24	1	24	µA/V
Phase angle of feedback admittance	φ_{re}	typ.	270^o	270^o	270^o	270^o	


7Z67063
f_T (MHz)
800
600
400
200
0
$-V_{CE} = 10$ V
f = 100 MHz
typ. values
BF450
BF451
0
10
20
30
$-I_C$ (mA)


7Z67059.1
F (dB)
6
4
2
0
$-V_{CE} = 10$ V
$-I_C = 1$ mA
typical values
$R_S = 60\,\Omega$
300 Ω
10^{-2}
10^{-1}
1
10
f (MHz)
10^2

SILICON PLANAR TRANSISTORS
FOR VIDEO OUTPUT STAGES

N-P-N transistors in a SOT-32 plastic envelope intended for video output stages in black-and-white and in colour television receivers.

QUICK REFERENCE DATA

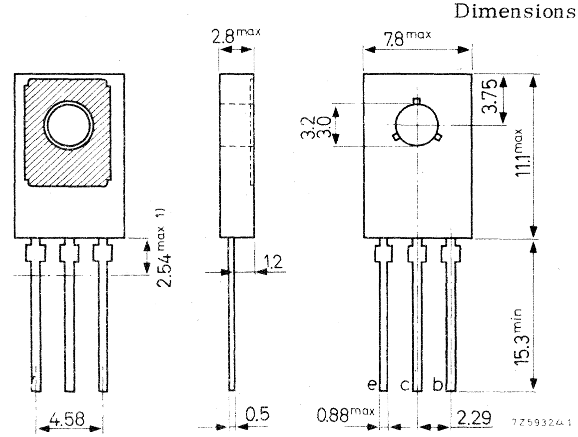
			BF457	BF458	BF459	
Collector-base voltage (open emitter)	V_{CBO}	max.	160	250	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	160	250	300	V

Collector current (peak value)	I_{CM}	max.	300	mA
Total power dissipation up to T_{mb} = 90 °C	P_{tot}	max.	6	W
Junction temperature	T_j	max.	150	°C
D.C. current gain at T_j = 25 °C I_C = 30 mA; V_{CE} = 10 V	h_{FE}	>	26	
Transition frequency I_C = 15 mA; V_{CE} = 10 V	f_T	typ.	90	MHz
Feedback capacitance at f = 1 MHz I_E = 0; V_{CB} = 30 V	C_{re}	<	3,5	pF

MECHANICAL DATA Dimensions in mm

TO-126 (SOT-32)

Collector connected to metal part of mounting surface



Accessories supplied on request: 56326, 56333

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

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

Voltage

			BF457	BF458	BF459	
Collector-base voltage (open emitter)	V_{CBO}	max.	160	250	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	160	250	300	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V

Current

Collector current (d.c.)	I_C	max.	100	mA
Collector current (peak value)	I_{CM}	max.	300	mA
Base current (d.c.)	I_B	max.	50	mA

Power dissipation

Total power dissipation up to T_{mb} = 90 °C	P_{tot}	max.	6	W

Temperature

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

THERMAL RESISTANCE

From junction to ambient	$R_{th\ j-a}$	=	104	°C/W
From junction to mounting base	$R_{th\ j-mb}$	=	10	°C/W

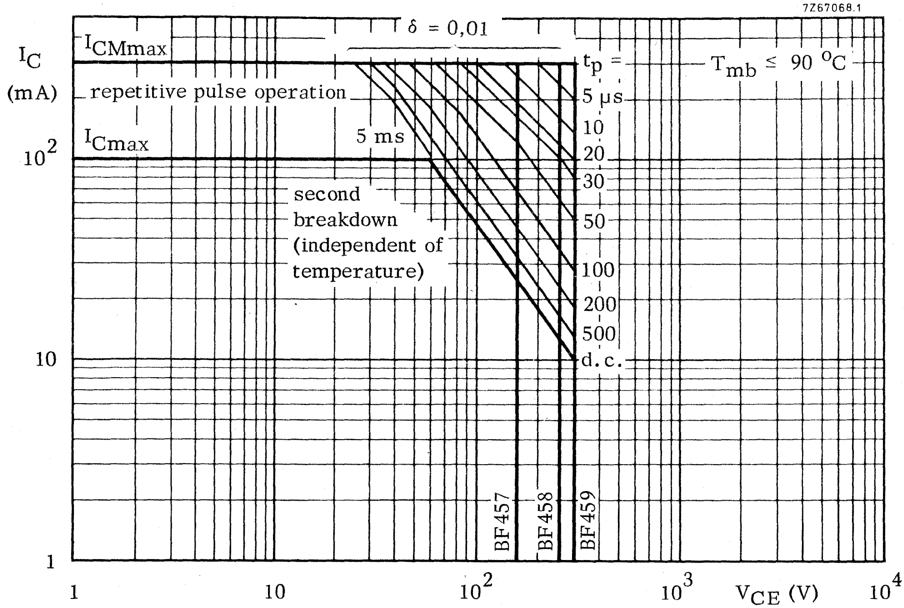
CHARACTERISTICS

T_j = 25 °C unless otherwise specified

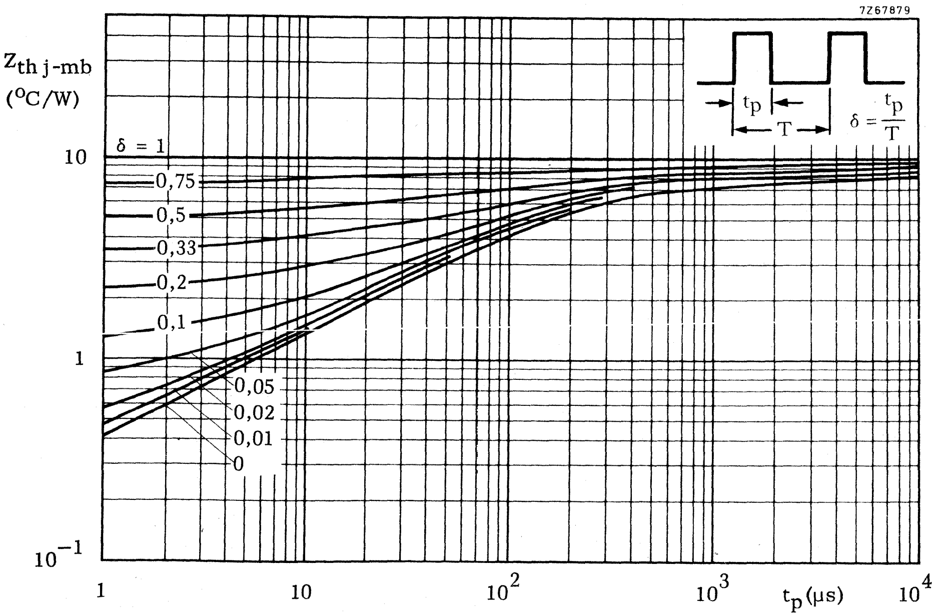
Collector cut-off current				
I_E = 0; V_{CB} = 100 V for BF457				
I_E = 0; V_{CB} = 200 V for BF458	I_{CBO}	<	50	nA
I_E = 0; V_{CB} = 250 V for BF459				
Emitter cut-off current				
I_C = 0; V_{EB} = 3 V	I_{EBO}	<	50	nA
D.C. current gain				
I_C = 30 mA; V_{CE} = 10 V	h_{FE}	>	26	
Collector-emitter saturation voltage				
I_C = 30 mA; I_B = 6 mA	V_{CEsat}	<	1	V
High frequency knee voltage at T_j = 150 °C				
I_C = 50 mA	V_{CEK}	typ.	15	V

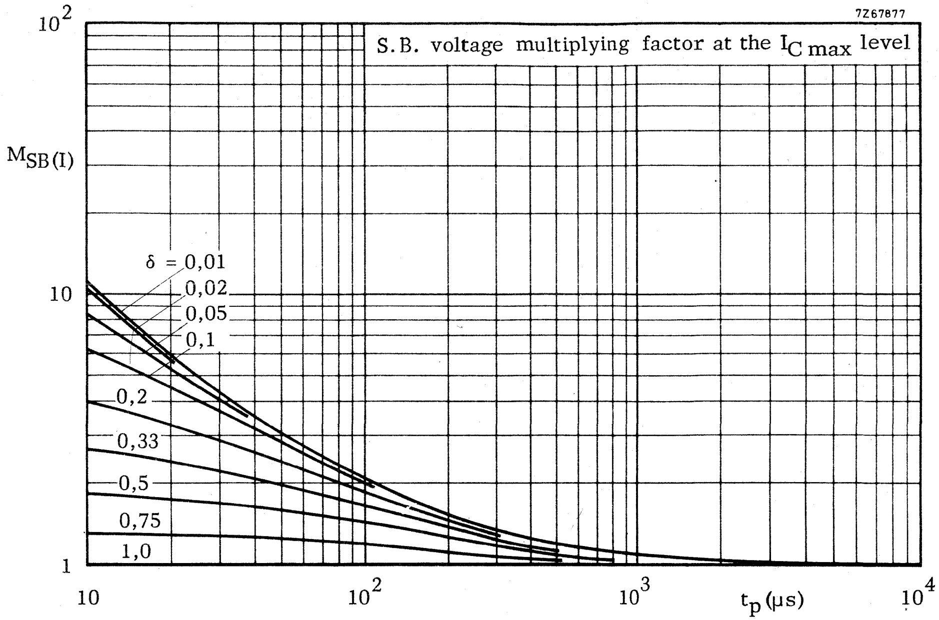
The high frequency knee voltage of a transistor is that value of the collector-emitter voltage at which the small signal gain, measured in a practical circuit, has dropped to 80% of the gain at V_{CE} = 50 V. A further reduction of the collector-emitter voltage results in a rapid increase of the distortion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

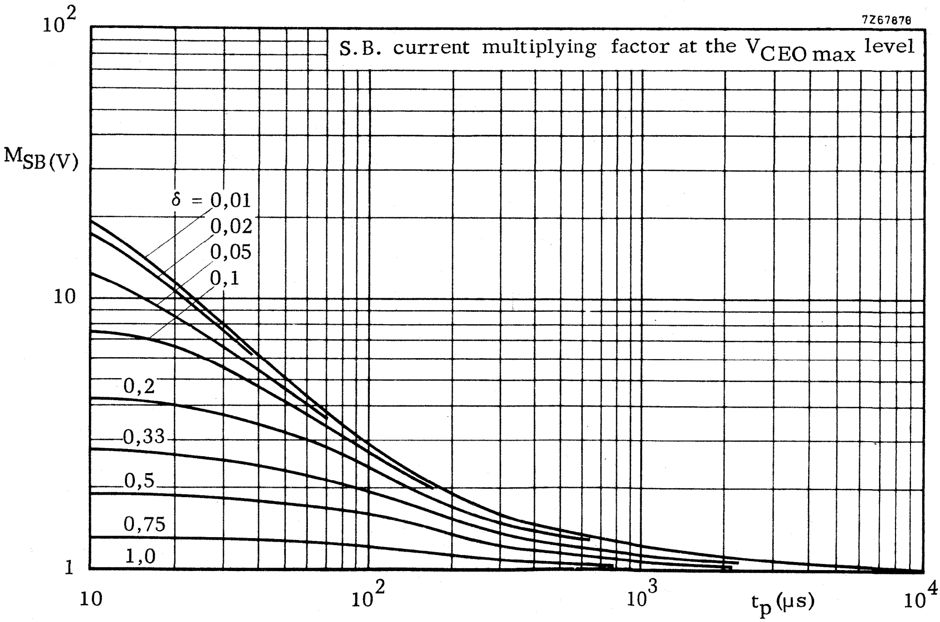
Transition frequency at f = 100 MHz				
I_C = 15 mA; V_{CE} = 10 V	f_T	typ.	90	MHz
Feedback capacitance at f = 1 MHz				
I_E = 0; V_{CB} = 30 V	C_{re}	<	3,5	pF
Output capacitance at f = 1 MHz				
I_E = 0; V_{CB} = 30 V	C_{oe}	<	4,5	pF

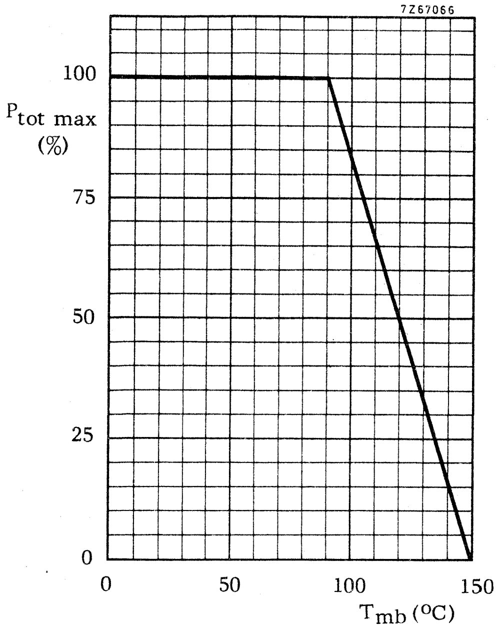


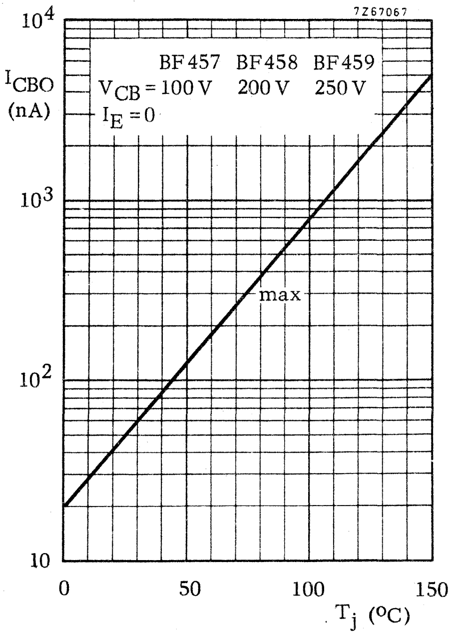
Safe Operating Area with the transistor forward biased




7Z67877
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
0,33
0,5
0,75
1,0
10
10^2
10^3
t_p (μs)
10^4


7Z67878
S.B. current multiplying factor at the $V_{CEO\,max}$ 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
1,0
10
10^2
10^3
t_p (μs)
10^4


7Z67066
100
$P_{tot\ max}$
(%)
75
50
25
0
0
50
100
150
T_{mb} (°C)


7Z67067
10^4
I_{CBO}
(nA)
BF457 BF458 BF459
V_{CB} = 100 V 200 V 250 V
I_E = 0
10^3
max
10^2
10
0
50
100
150
T_j (°C)

SILICON PLANAR TRANSISTOR

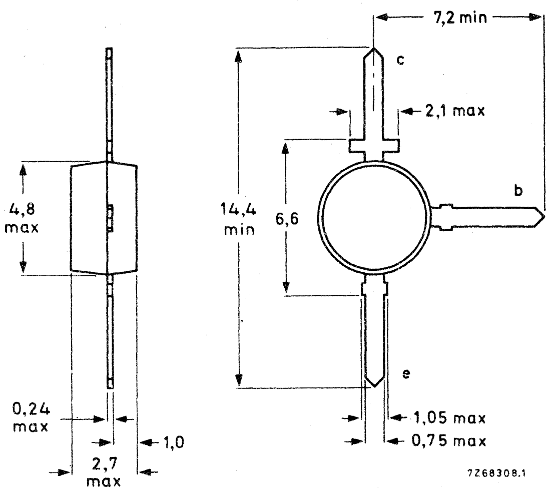
N-P-N transistor in a subminiature plastic T-package, primarily intended for application in non-controlled r.f. stages of television tuners using p-i-n diode attenuators.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	20	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector current (d.c.)	I_C	max.	20	mA
Total power dissipation up to T_{amb} = 55 °C	P_{tot}	max.	140	mW
Junction temperature	T_j	max.	125	°C
Transition frequency $-I_E$ = 10 mA; V_{CB} = 10 V	f_T	typ.	1600	MHz
Noise figure at G_S = 20 mA/V; B_S = 0, I_C = 10 mA, V_{CB} = 10 V, f = 800 MHz	F	typ.	3,3	dB
Cross modulation (K = 1%) e.m.f. in 75 Ω	$V_{(int)rms}$	typ.	330	mV

MECHANICAL DATA

Dimensions in mm

SOT-37



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

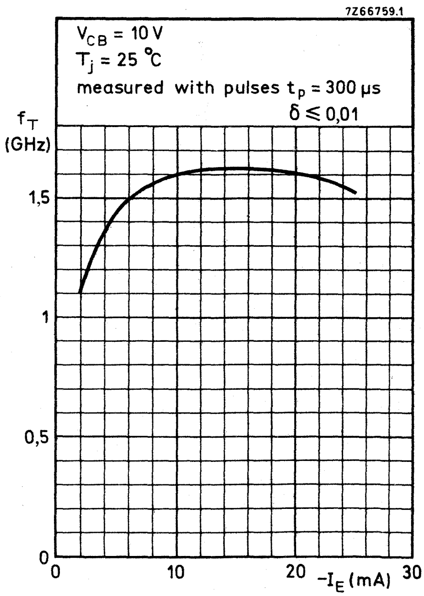
Voltage				
Collector-base voltage (open emitter)	V_{CBO}	max.	20	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Emitter-base voltage (open collector)	V_{EBO}	max.	2	V
Current				
Collector current (d.c.)	I_C	max.	20	mA
Collector current (peak value)	I_{CM}	max.	30	mA
Power dissipation				
Total power dissipation up to T_{amb} = 55 ^oC	P_{tot}	max.	140	mW
Temperature				
Storage temperature	T_s		−55 to +125	^oC
Junction temperature	T_j	max.	125	^oC

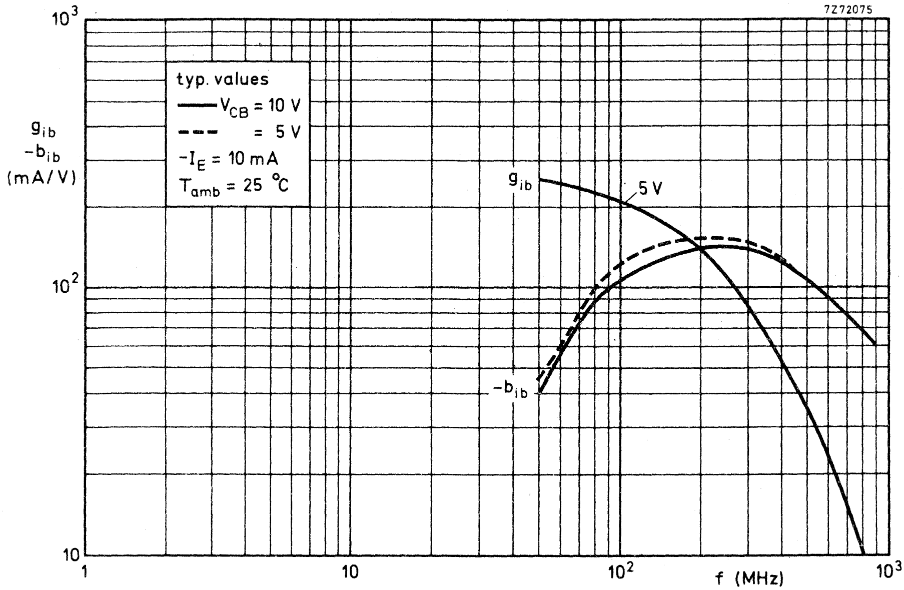
THERMAL RESISTANCE

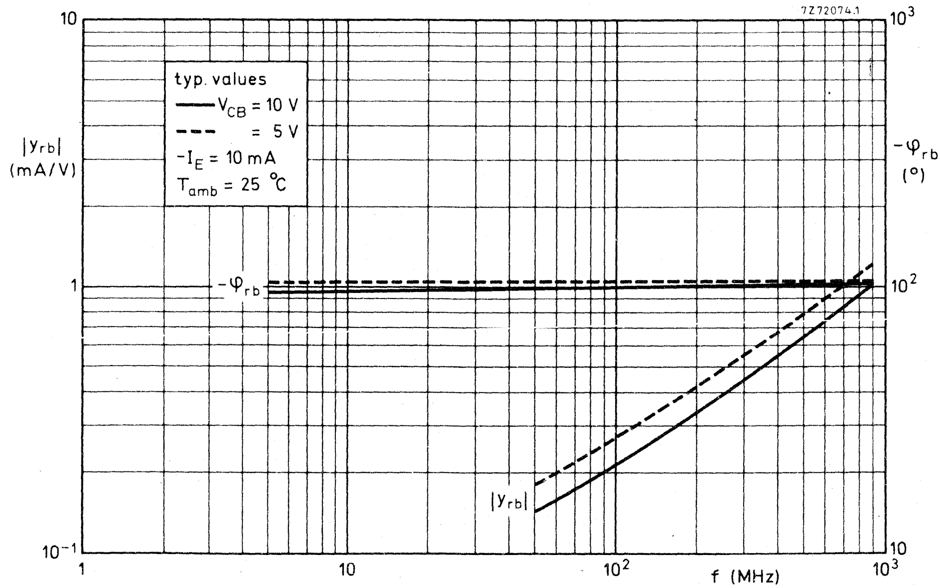
From junction to ambient in free air mounted on a printed wiring board	$R_{th\ j\text{-}a}$	=	0,5	$^oC/mW$

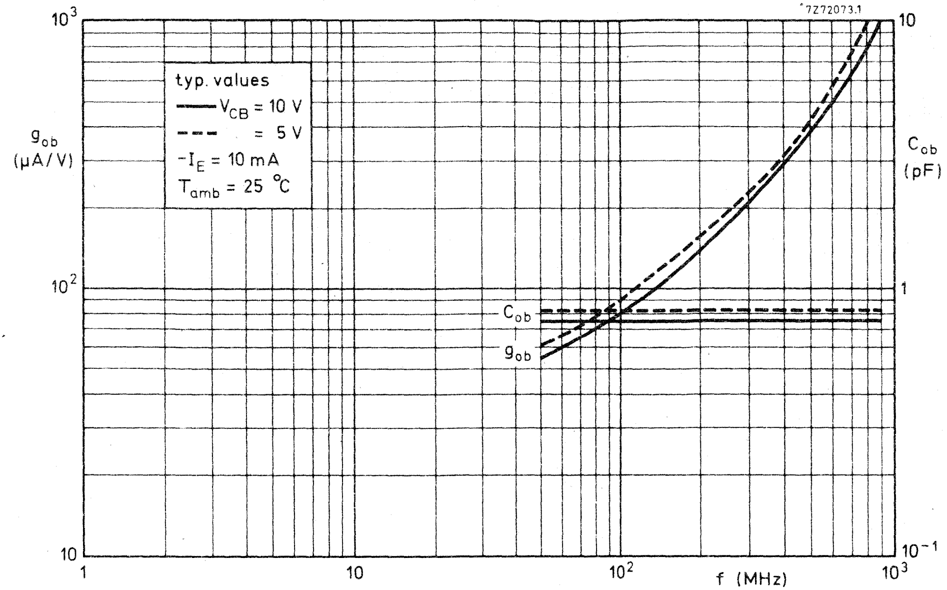
CHARACTERISTICS T_{amb} = 25 °C unless otherwise specified

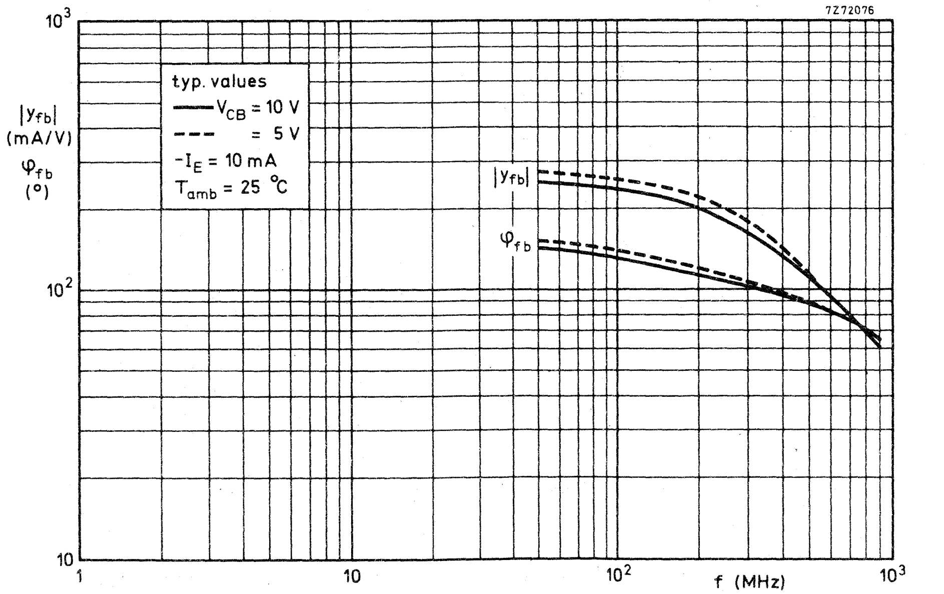
Base current				
$-I_E$ = 10 mA; V_{CB} = 10 V	I_B	<	1	mA
Emitter-base voltage				
$-I_E$ = 10 mA; V_{CB} = 10 V	$-V_{EB}$	typ.	0,75	V
Transition frequency				
$-I_E$ = 10 mA; V_{CB} = 10 V	f_T	typ.	1600	MHz
Noise figure (common base)				
$-I_E$ = 10 mA; V_{CB} = 10 V G_s = 20 mA/V; B_s = 0; f = 800 MHz	F	typ.	3,3	dB
$-I_E$ = 10 mA; V_{CB} = 10 V G_s = 20 mA/V; B_s = 0; f = 200 MHz	F	typ.	2,7	dB
Transducer gain (common base)				
$-I_E$ = 10 mA; V_{CB} = 10 V; f = 900 MHz G_s = 20 mA/V; B_s = 0 G_l = 2 mA/V; B_l = tuned	G_{tr}	typ.	15	dB



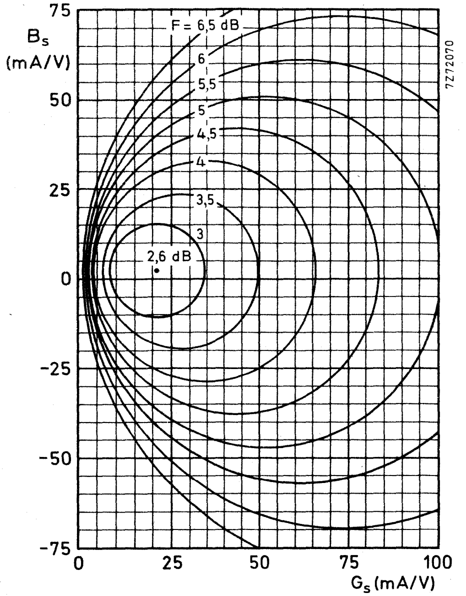

7Z72075
typ. values
—— V_{CB} = 10 V
- - - = 5 V
$-I_E$ = 10 mA
T_{amb} = 25 °C
g_{ib}
$-b_{ib}$
(mA/V)
5 V
f (MHz)


7Z72074.1
typ. values
—— V_{CB} = 10 V
- - - = 5 V
$-I_E$ = 10 mA
T_{amb} = 25 °C
$|y_{rb}|$
(mA/V)
$-\varphi_{rb}$
(°)
f (MHz)

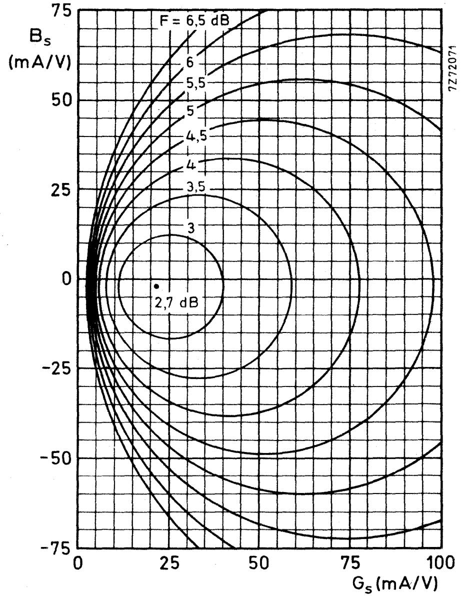

7Z72073.1
typ. values
V_{CB} = 10 V
= 5 V
$-I_E$ = 10 mA
T_{amb} = 25 °C
g_{ob} (μA/V)
C_{ob} (pF)
C_{ob}
g_{ob}
10^3
10^2
10
1
10
10^{-1}
1
10
10^2
10^3
f (MHz)


7Z72076
typ. values
V_{CB} = 10 V
= 5 V
$-I_E$ = 10 mA
T_{amb} = 25 °C
$|y_{fb}|$ (mA/V)
φ_{fb} (°)
$|y_{fb}|$
φ_{fb}
10^3
10^2
10
1
10
10^2
10^3
f (MHz)

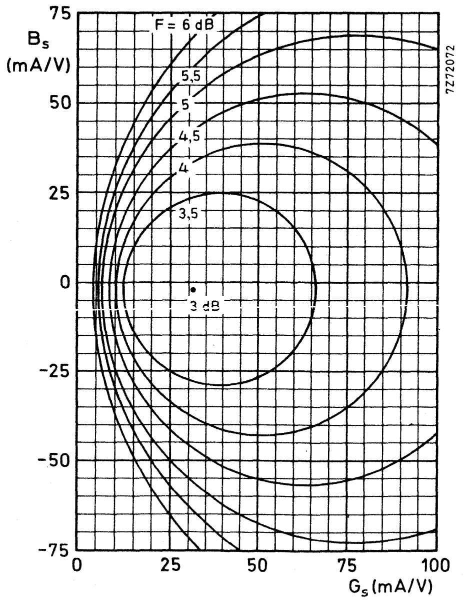
$-I_E = 10$ mA; $V_{CB} = 10$ V; f = 100 MHz; $T_{amb} = 25\,^{\circ}C$



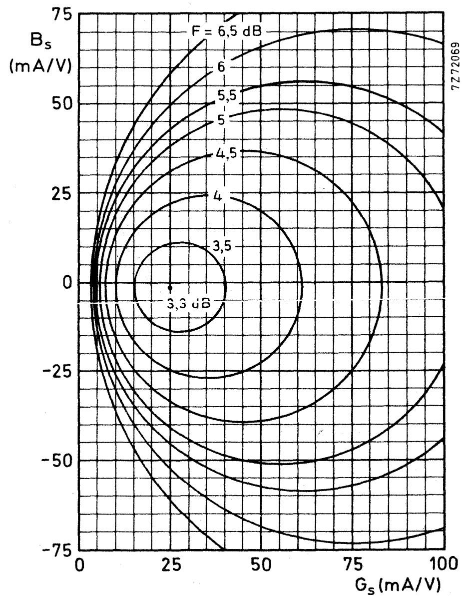
$-I_E = 10$ mA; $V_{CB} = 10$ V; f = 200 MHz; $T_{amb} = 25\,^{\circ}C$



$-I_E = 10$ mA; $V_{CB} = 10$ V; f = 500 MHz; $T_{amb} = 25\,^{\circ}C$

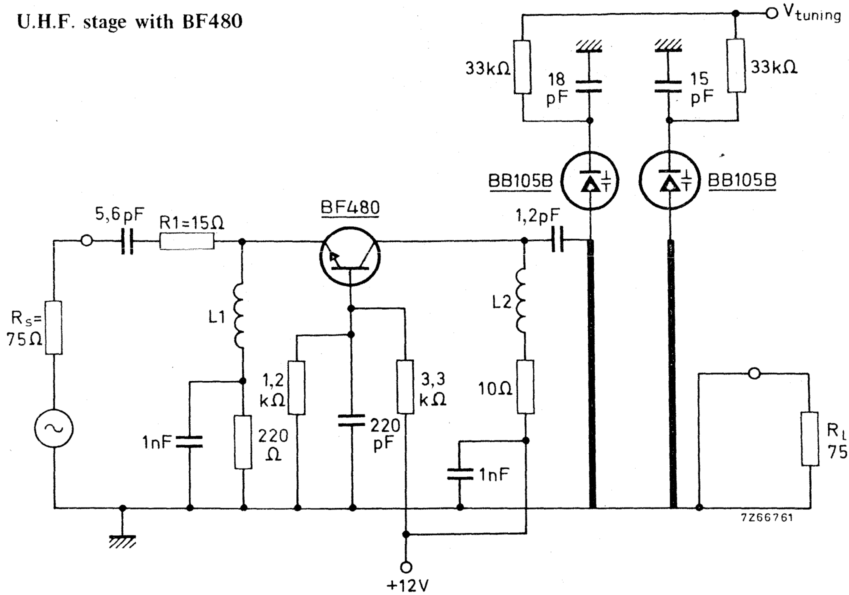


$-I_E = 10$ mA; $V_{CB} = 10$ V; f = 800 MHz; $T_{amb} = 25\,^{\circ}C$



APPLICATION INFORMATION

1. U.H.F. stage with BF480



L_1 = 6 turns, Ø 3 mm
L_2 = 4,5 turns, Ø 3 mm

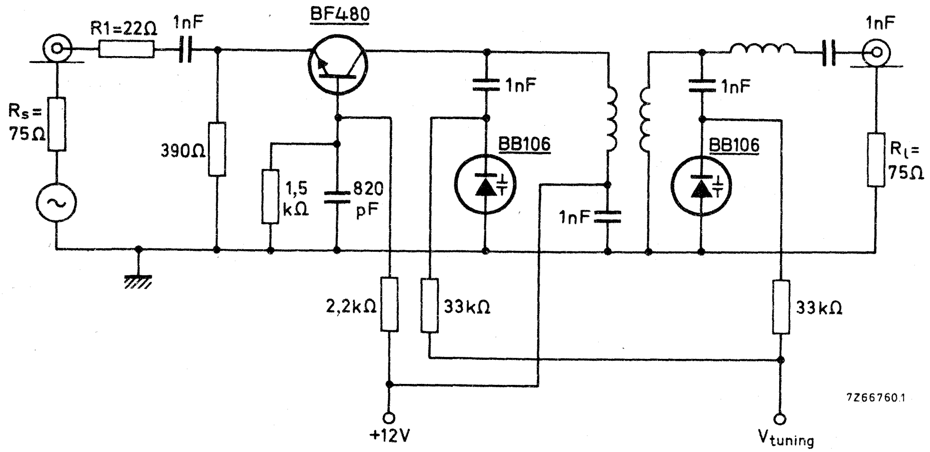
PERFORMANCE at T_{amb} = 25 °C

Measuring frequency	f_i	=	800	MHz
3 dB bandwidth	B_{3dB}	typ.	25	MHz
Emitter current	$-I_E$	typ.	10, 3	mA
Collector-emitter voltage	V_{CE}	typ.	9, 7	V
Transducer gain	G_{tr}	typ.	8, 5	dB
Noise figure including influence of a. mixer stage with a noise figure of 10 dB b. R_1 = 15 Ω	F	typ.	6, 5	dB
Voltage standing wave ratio (incl. R_1 = 15 Ω)	VSWR	<	4	
Cross modulation [1]				
Interference voltage for K = 1 %	$V_{(int)rms}$	typ.	300	mV

[1]) See definition next page.

APPLICATION INFORMATION (continued)

2. V.H.F. stage with BF480



PERFORMANCE at T_{amb} = 25 °C

Measuring frequency	f_i	=	200	MHz
3 dB bandwidth	B_{3dB}	typ.	13	MHz
Emitter current	$-I_E$	typ.	10	mA
Collector-emitter voltage	V_{CE}	typ.	8, 1	V
Transducer gain	G_{tr}	typ.	8, 5	dB
Noise figure including influence of a. mixer stage with a noise figure of 10 dB b. R_1 = 22 Ω	F	typ.	6, 5	dB
Voltage standing wave ratio (incl. R_1 = 22 Ω)	VSWR	<	3	
Cross modulation [1]				
Interference voltage for K = 1 %	$V_{(int)rms}$	typ.	330	mV

[1]) Cross modulation is defined here as the e.m.f. in 75 Ω of an unwanted signal with 80 % modulation depth, giving 0, 8 % modulation depth on the wanted signal.

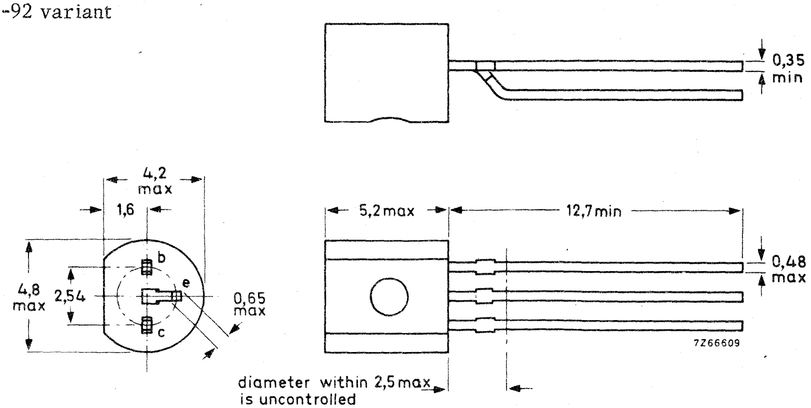
SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic TO-92 variant intended for h.f. applications in radio and television receivers; it is especially recommended for f.m. tuners, low noise a.m. mixer-oscillators with high source impedance and i.f. amplifiers in a.m./f.m. receivers where a high current gain is of importance.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector current (d.c.)	I_C	max.	30	mA
Total power dissipation up to T_{amb} = 75 °C	P_{tot}	max.	300	mW
Junction temperature	T_j	max.	150	°C
D.C. current gain at T_j = 25 °C I_C = 1 mA; V_{CE} = 10 V	h_{FE}	typ.	115	
Transition frequency I_C = 1 mA; V_{CE} = 10 V	f_T	typ.	260	MHz
Noise figure at f = 100 MHz I_C = 1 mA; V_{CE} = 10 V; G_S = 10 mA/V	F	typ.	4	dB
Conversion noise figure at f = 1 MHz I_C = 1 mA; V_{CE} = 10 V; G_S = 1,2 mA/V	F_c	typ.	2	dB

MECHANICAL DATA Dimensions in mm

TO-92 variant



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

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base) (See also page 4)	V_{CEO}	max.	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Currents

Collector current (d.c.)	I_C	max.	30	mA
Collector current (peak value)	I_{CM}	max.	30	mA

Power dissipation

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

Temperatures

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

THERMAL RESISTANCE

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

CHARACTERISTICS T_j = 25 °C

Base-emitter voltage [2])

I_C = 1 mA; V_{CE} = 10 V	V_{BE}		0,65 to 0,74	V

Base current

I_C = 1 mA; V_{CE} = 10 V	I_B		4,5 to 15	µA
		typ.	8,7	µA

Feedback capacitance at f = 0,45 MHz

I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	0,85	pF

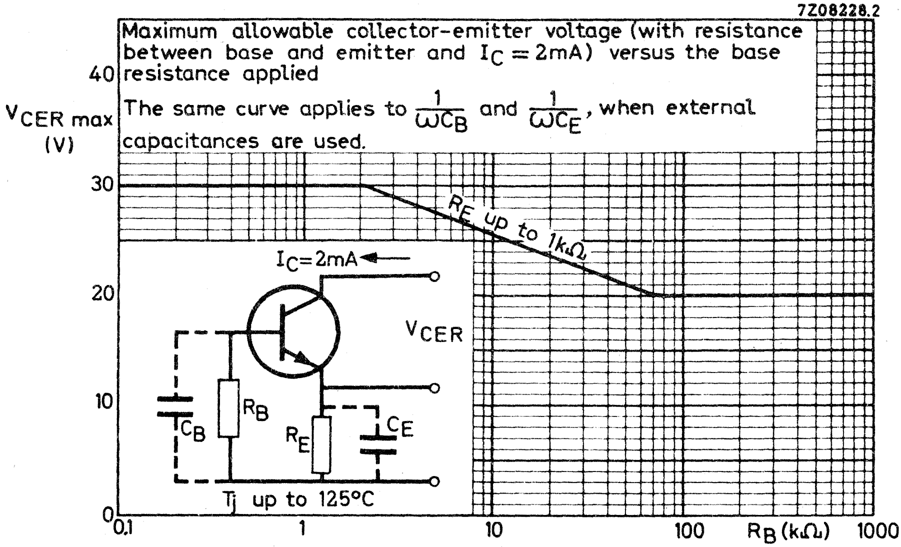
[1]) V_{BE} decreases by about 1,7 mV/°C with increasing temperature.

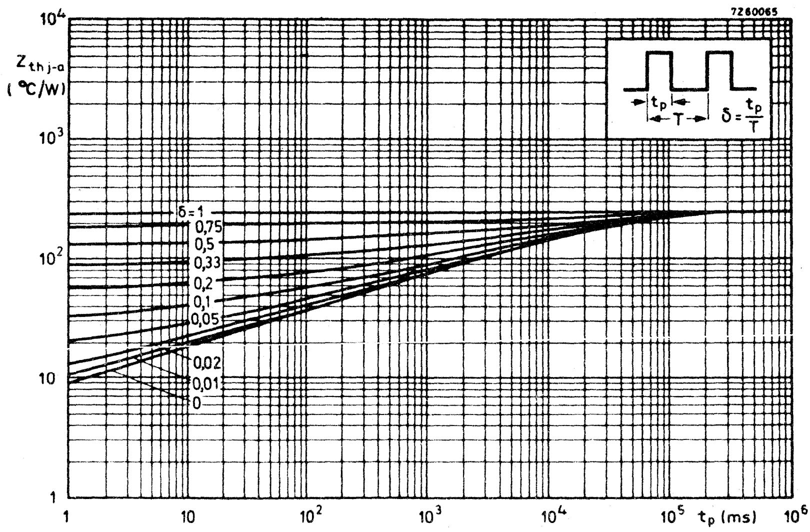
CHARACTERISTICS (continued) T_j = 25 °C

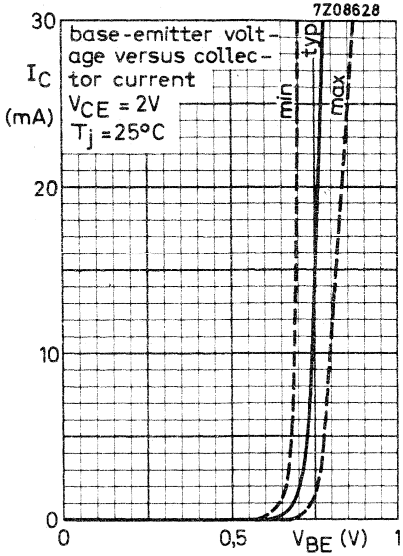
Transition frequency				
I_C = 1 mA; V_{CE} = 10 V	f_T	typ.	260	MHz
Noise figure				
I_C = 1 mA; V_{CE} = 10 V				
G_S = 2 mA/V; f = 0, 2 MHz	F	typ.	1, 5	dB
G_S = 1, 5 mA/V; f = 1, 0 MHz	F	typ.	1, 2	dB
G_S = 10 mA/V; f = 100 MHz	F	typ.	4	dB
Conversion noise figure				
I_C = 1 mA; V_{CE} = 10 V				
G_S = 0, 6 mA/V; f = 0, 2 MHz	F_c	typ.	3	dB
G_S = 1, 2 mA/V; f = 1, 0 MHz	F_c	typ.	2	dB
y parameters at f = 100 MHz (common base)				
I_C = 1 mA; V_{CE} = 10 V (lead length = 3 mm)				
Input conductance	g_{ib}	typ.	32	mA/V
Input susceptance	$-b_{ib}$	typ.	3	mA/V
Feedback admittance	$\|y_{rb}\|$	typ.	500	μA/V
Phase angle of feedback admittance	φ_{rb}	typ.	272°	
Transfer admittance	$\|y_{fb}\|$	typ.	33	mA/V
Phase angle of transfer admittance	φ_{fb}	typ.	150°	
Output conductance	g_{ob}	typ.	22	μA/V
Output susceptance	b_{ob}	typ.	1, 1	mA/V

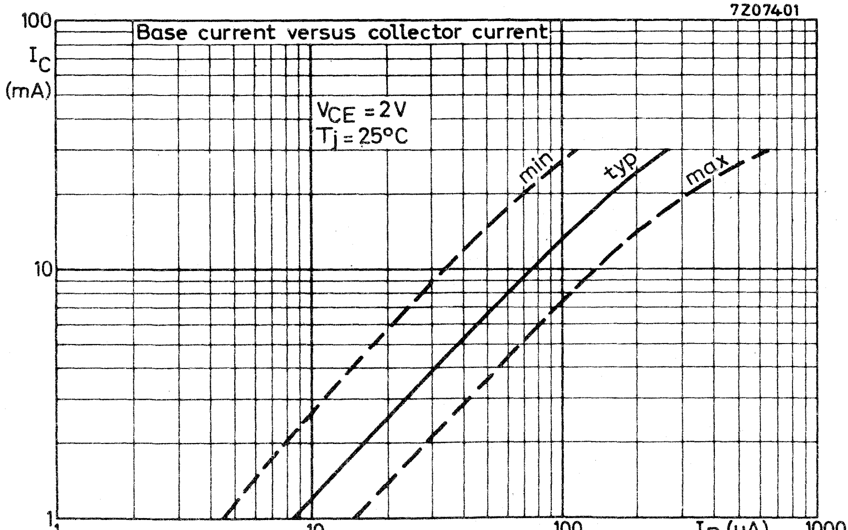
y parameters (common emitter)

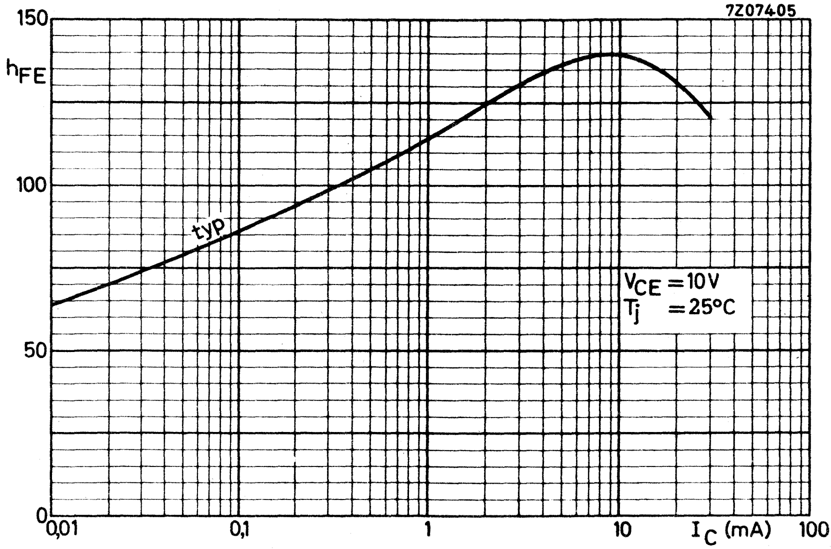
I_C = 1 mA; V_{CE} = 10 V (lead length = 3 mm)			f = 10, 7 MHz	f = 0, 45 MHz	
Input conductance	g_{ie}	<	0, 64	0, 54	mA/V
Output conductance	g_{oe}	<	13, 5	11, 5	μA/V

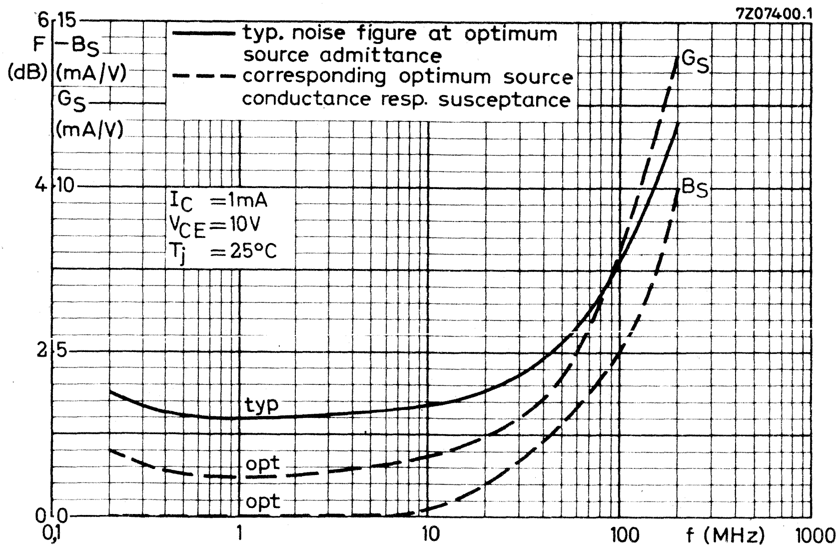

7Z08228.2
Maximum allowable collector-emitter voltage (with resistance between base and emitter and $I_C = 2mA$) versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$, when external capacitances are used.
$V_{CER\,max}$ (V)
R_E up to 1kΩ
$I_C = 2mA$
V_{CER}
R_B
C_B
R_E
C_E
T_j up to 125°C
R_B (kΩ)
0
10
20
30
40
0,1
1
10
100
1000

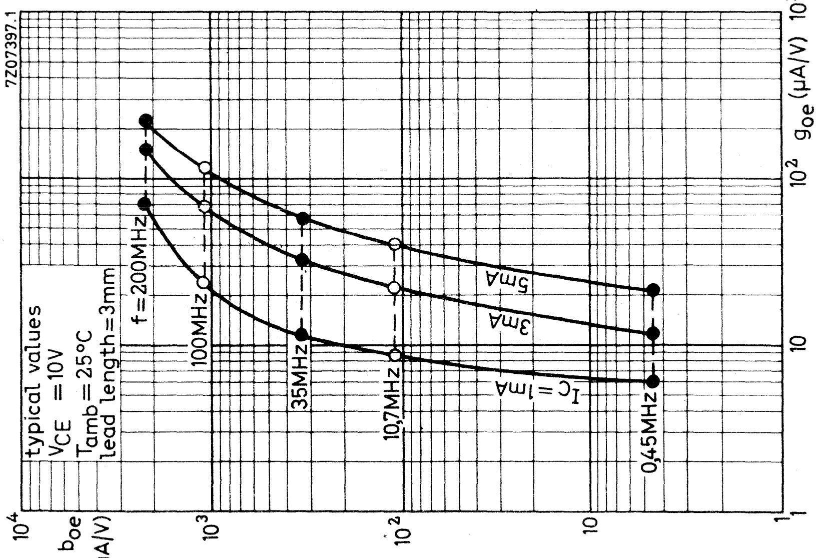

7Z60065
$Z_{th\,j\text{-}a}$ (°C/W)
t_p
T
$\delta = \frac{t_p}{T}$
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
0
t_p (ms)
1
10
10^2
10^3
10^4
10^5
10^6

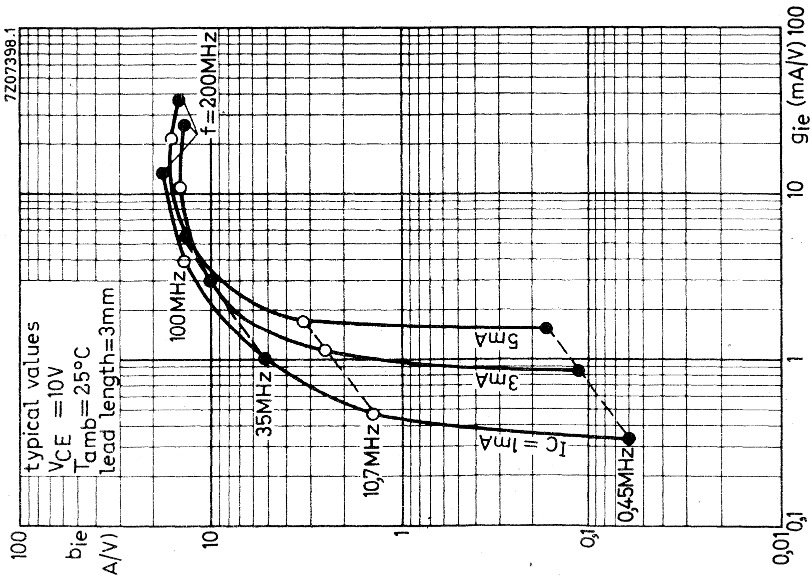

7Z08628
base-emitter voltage versus collector current
V_{CE} = 2V
T_j = 25°C
I_C (mA)
30
20
10
0
min
typ
max
0
0,5
V_{BE} (V)
1

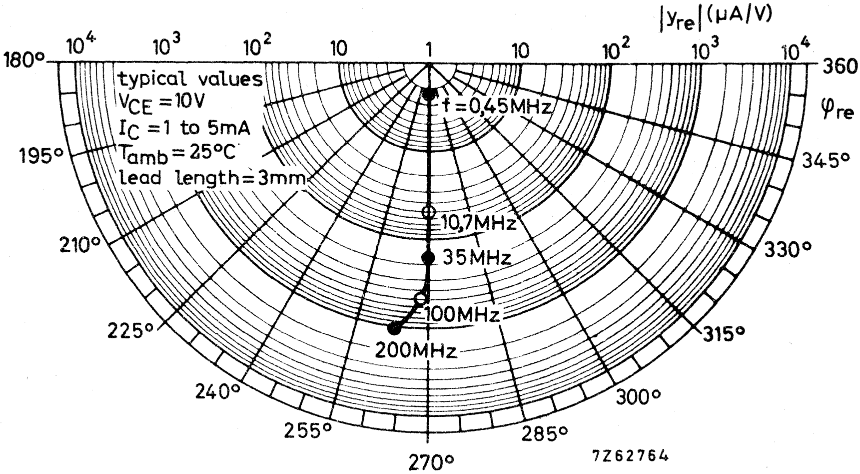

7Z07401
Base current versus collector current
V_{CE} = 2V
T_j = 25°C
I_C (mA)
100
10
1
min
typ
max
1
10
100
I_B (μA)
1000


7Z07405
150
h_{FE}
100
50
0
typ
V_{CE} = 10 V
T_j = 25 °C
0,01
0,1
1
10
I_C (mA)
100

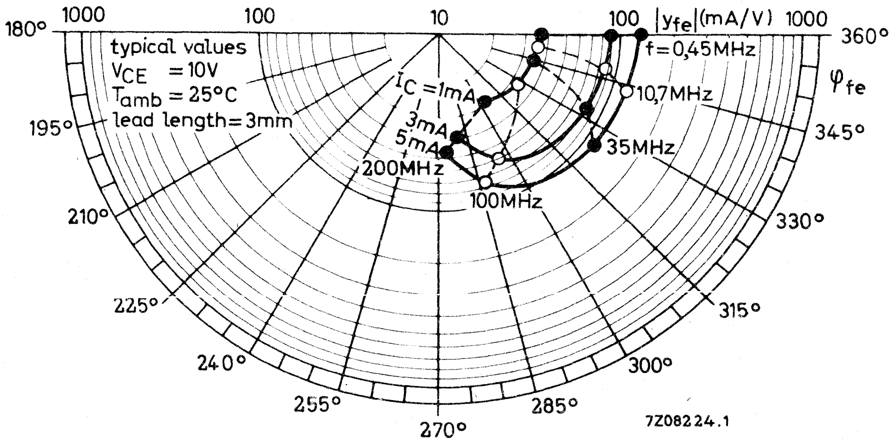

7Z07400.1
6
15
F
$-B_S$
(dB)
(mA/V)
G_S
(mA/V)
4
10
2
5
0
0
typ. noise figure at optimum source admittance
corresponding optimum source conductance resp. susceptance
I_C = 1 mA
V_{CE} = 10 V
T_j = 25 °C
typ
opt
opt
G_S
B_S
0,1
1
10
100
f (MHz)
1000


7Z07397.1
typical values
VCE = 10V
Tamb = 25°C
lead length = 3mm
f = 200MHz
100MHz
35MHz
10,7MHz
0,45MHz
5mA
3mA
IC = 1mA
boe (μA/V)
goe (μA/V)
10^4
10^3
10^2
10
1
10
10^2
10^3


7Z07398.1
typical values
VCE = 10V
Tamb = 25°C
lead length = 3mm
f = 200MHz
100MHz
35MHz
10,7MHz
0,45MHz
5mA
3mA
IC = 1mA
bie (mA/V)
gie (mA/V)
100
10
1
0,1
0,01
0,1
1
10
100



|yre| (μA/V)
10^4 10^3 10^2 10 1 10 10^2 10^3 10^4
180°
360°
φre
typical values
VCE = 10V
IC = 1 to 5mA
Tamb = 25°C
lead length = 3mm
f = 0,45MHz
10,7MHz
35MHz
100MHz
200MHz
195°
210°
225°
240°
255°
270°
285°
300°
315°
330°
345°
7Z62764



1000 100 10 100 |yfe| (mA/V) 1000
180°
360°
φfe
typical values
VCE = 10V
Tamb = 25°C
lead length = 3mm
IC = 1mA
3mA
5mA
f = 0,45MHz
10,7MHz
35MHz
100MHz
200MHz
195°
210°
225°
240°
255°
270°
285°
300°
315°
330°
345°
7Z08224.1

SILICON PLANAR EPITAXIAL TRANSISTOR

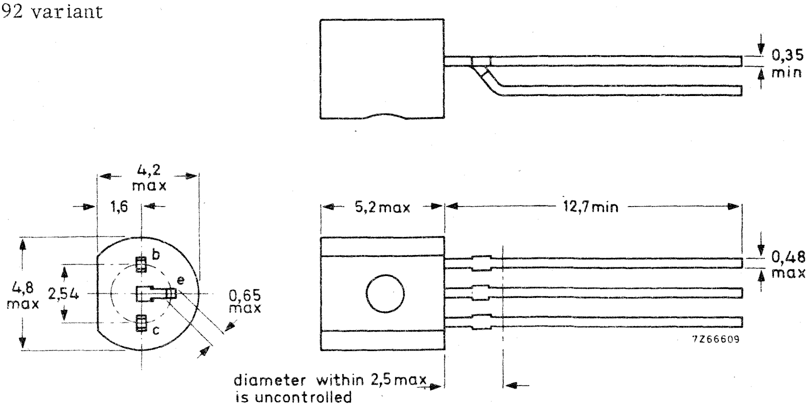
N-P-N transistor in a plastic TO-92 variant intended for h.f. applications in radio and television receivers; it is especially recommended for f.m. tuners, i.f. amplifiers in a.m./f.m. receivers where a low transistor output conductance is of importance, a.m. input stages of car radios where a low noise figure at low source impedance is required.

QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector current (d.c.)	I_C	max.	30	mA
Total power dissipation up to T_{amb} = 75 °C	P_{tot}	max.	300	mW
Junction temperature	T_j	max.	150	°C
D.C. current gain at T_j = 25 °C				
I_C = 1 mA; V_{CE} = 10 V	h_{FE}	typ.	67	
Transition frequency				
I_C = 1 mA; V_{CE} = 10 V	f_T	typ.	200	MHz
Noise figure				
I_C = 1 mA; V_{CE} = 10 V				
G_S = 20 mA/V; f = 1 MHz	F	typ.	3,5	dB
G_S = 10 mA/V; f = 100 MHz	F	typ.	4	dB

MECHANICAL DATA Dimensions in mm

TO-92 variant



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

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base) (See also page 4)	V_{CEO}	max.	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Currents

Collector current (d.c.)	I_C	max.	30	mA
Collector current (peak value)	I_{CM}	max.	30	mA

Power dissipation

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

Temperatures

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

THERMAL RESISTANCE

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

CHARACTERISTICS T_j = 25 °C

Base-emitter voltage [2])

I_C = 1 mA; V_{CE} = 10 V	V_{BE}		0,65 to 0,74	V

Base current

I_C = 1 mA; V_{CE} = 10 V	I_B		8 to 28	μA
		typ.	15	μA

Feedback capacitance at f = 0,45 MHz

I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	0,85	pF

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

CHARACTERISTICS (continued) $T_j = 25\ ^oC$

Transition frequency

$I_C = 1$ mA; $V_{CE} = 10$ V	f_T	typ.	200	MHz

Noise figure

$I_C = 1$ mA; $V_{CE} = 10$ V				
$G_S = 20$ mA/V; f = 1 MHz	F	typ.	3,5	dB
$G_S = 10$ mA/V; f = 100 MHz	F	typ.	4	dB

Conversion noise figure

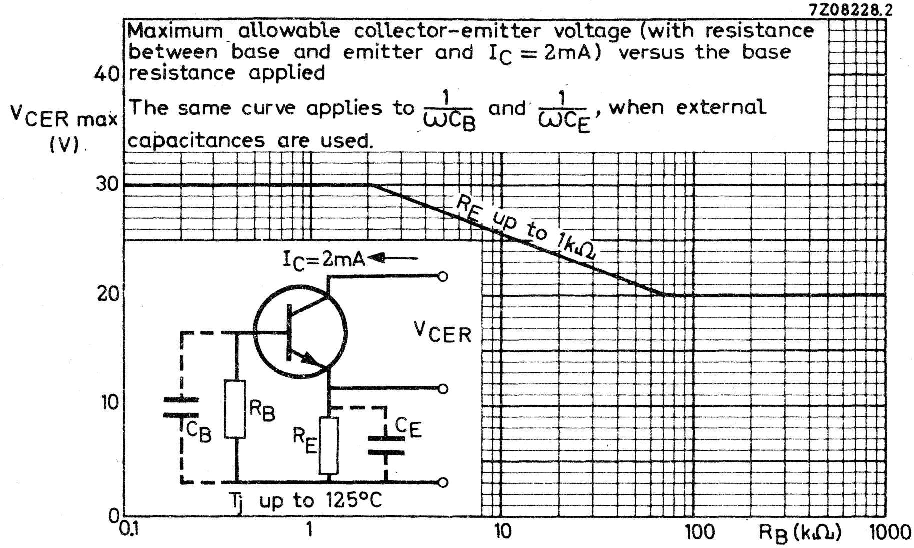
$I_C = 1$ mA; $V_{CE} = 10$ V				
$G_S = 1,2$ mA/V; f = 0,2 MHz	F_c	typ.	4	dB
$G_S = 1,5$ mA/V; f = 1 MHz	F_c	typ.	2,5	dB

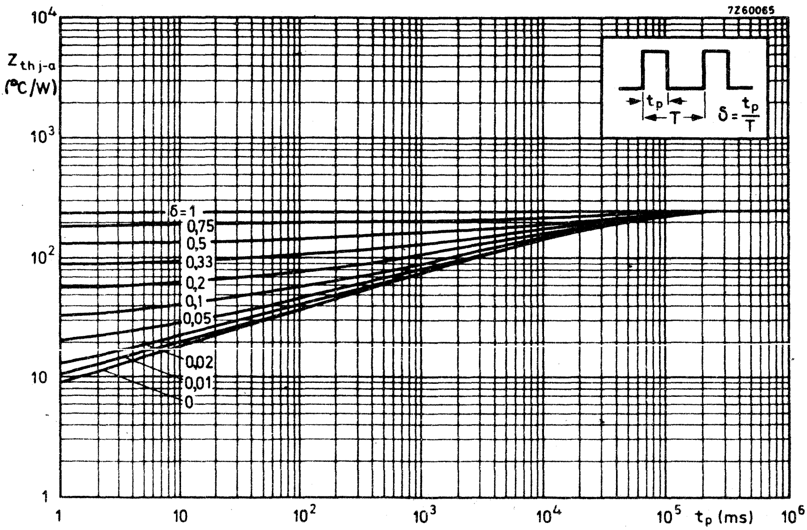
y parameters at f = 100 MHz (common base)

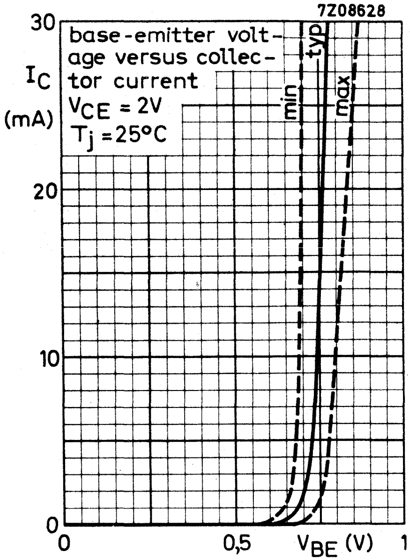
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)				
Input conductance	g_{ib}	typ.	34	mA/V
Input susceptance	$-b_{ib}$	typ.	1	mA/V
Feedback admittance	$\|y_{rb}\|$	typ.	490	µA/V
Phase angle of feedback admittance	φ_{rb}	typ.	272^o	
Transfer admittance	$\|y_{fb}\|$	typ.	34	mA/V
Phase angle of transfer admittance	φ_{fb}	typ.	144^o	
Output conductance	g_{ob}	typ.	12	µA/V
Output susceptance	b_{ob}	typ.	1,1	mA/V

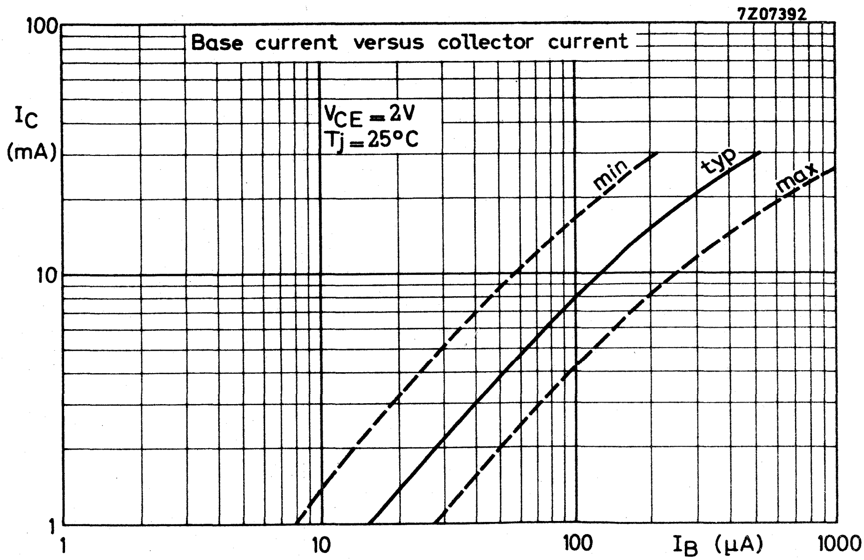
y parameters (common emitter)

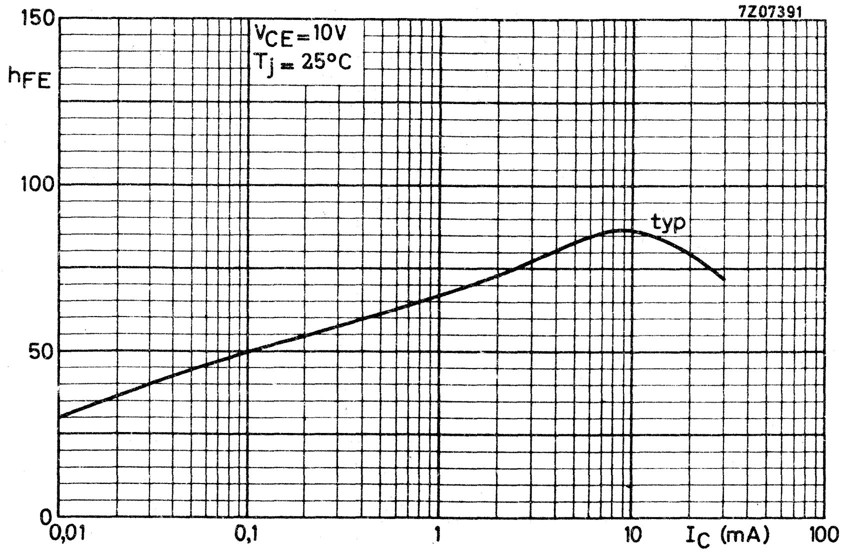
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)		f = 10,7 MHz	f = 0,45 MHz	
Input conductance	g_{ie}	< 0,96	0,86	mA/V
Output conductance	g_{oe}	< 9,5	7,0	µA/V

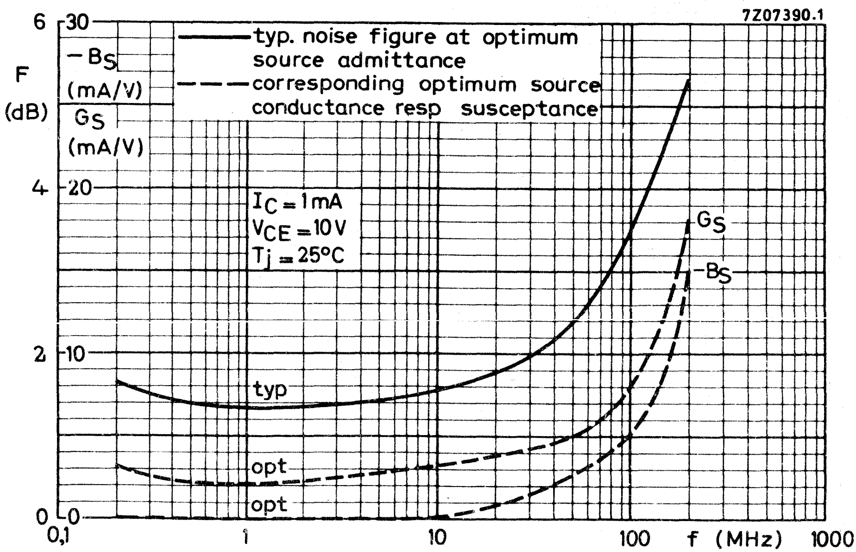

7Z08228.2
Maximum allowable collector-emitter voltage (with resistance between base and emitter and $I_C = 2mA$) versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$, when external capacitances are used.
$V_{CER\,max}$ (V)
R_E up to 1kΩ
I_C=2mA
V_{CER}
C_B
R_B
R_E
C_E
T_j up to 125°C
R_B (kΩ)

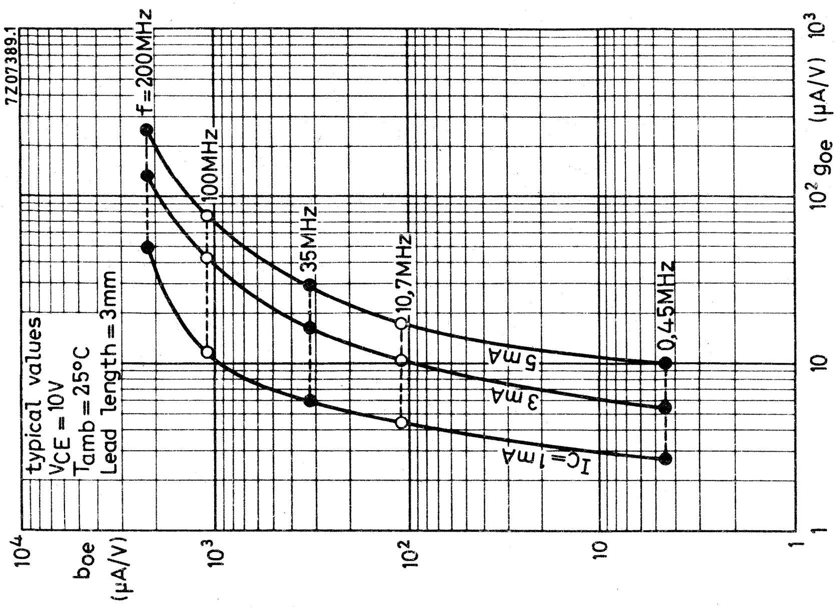

7Z60065
$Z_{th\,j\text{-}a}$ (°C/W)
δ=1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
0
t_p
T
$\delta = \frac{t_p}{T}$
t_p (ms)

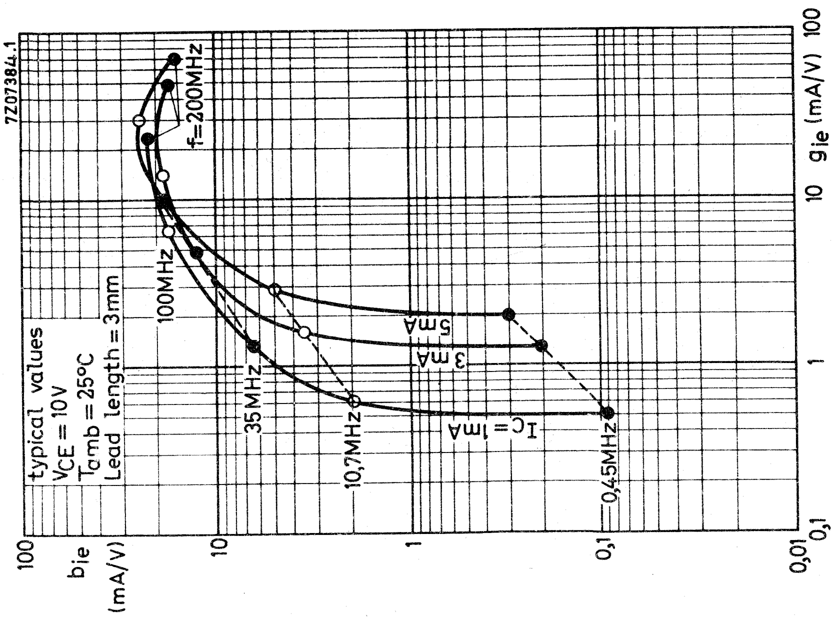

7Z08628
base-emitter voltage versus collector current
V_{CE} = 2V
T_j = 25°C
I_C (mA)
30
20
10
0
0
0,5
1
V_{BE} (V)
min
typ
max

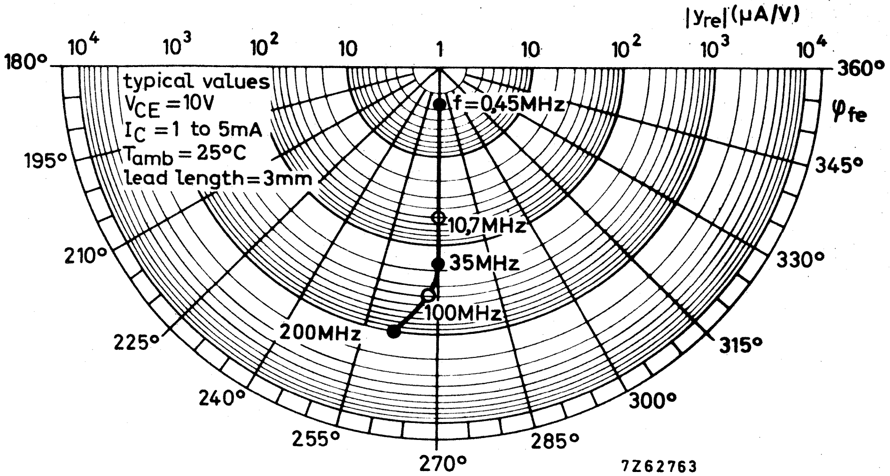

7Z07392
Base current versus collector current
V_{CE} = 2V
T_j = 25°C
I_C (mA)
100
10
1
1
10
100
1000
I_B (μA)
min
typ
max


7Z07391
150
hFE
100
50
0
VCE = 10V
Tj = 25°C
typ
0,01
0,1
1
10
IC (mA)
100

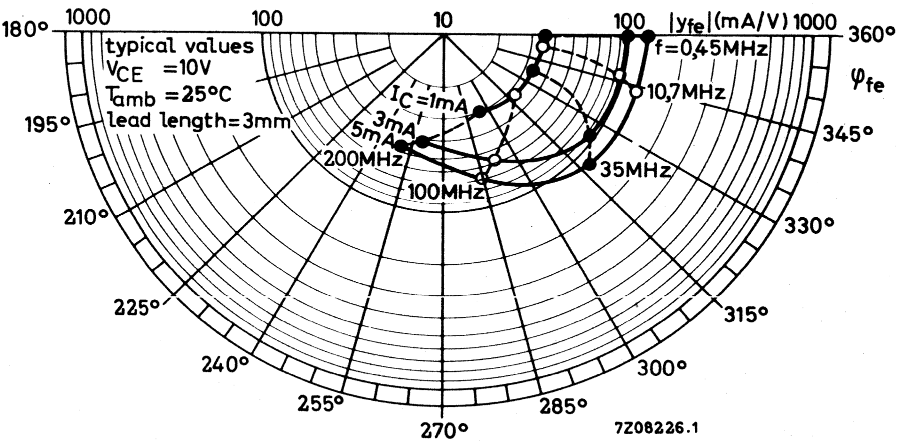

7Z07390.1
6
F
(dB)
4
2
0
30
−BS
(mA/V)
GS
(mA/V)
20
10
0
typ. noise figure at optimum source admittance
corresponding optimum source conductance resp susceptance
IC = 1mA
VCE = 10V
Tj = 25°C
typ
opt
opt
GS
−BS
0,1
1
10
100
f (MHz)
1000


7Z07389.1
typical values
V_{CE} = 10V
T_{amb} = 25°C
Lead length = 3mm
f = 200MHz
100MHz
35MHz
10,7MHz
0,45MHz
5 mA
3 mA
I_C = 1 mA
b_{oe} (μA/V)
g_{oe} (μA/V)
10^4
10^3
10^2
10
1
1
10
10^2
10^3


7Z07384.1
typical values
V_{CE} = 10V
T_{amb} = 25°C
Lead length = 3mm
f = 200MHz
100MHz
35MHz
10,7MHz
0,45MHz
5 mA
3 mA
I_C = 1mA
b_{ie} (mA/V)
g_{ie} (mA/V)
100
10
1
0,1
0,01
0,1
1
10
100



|yre| (μA/V)
10^4
10^3
10^2
10
1
10
10^2
10^3
10^4
180°
360°
φfe
typical values
VCE = 10V
IC = 1 to 5mA
Tamb = 25°C
lead length = 3mm
f = 0,45MHz
10,7MHz
35MHz
100MHz
200MHz
195°
210°
225°
240°
255°
270°
285°
300°
315°
330°
345°
7Z62763



1000
100
10
100
|yfe| (mA/V)
1000
180°
360°
φfe
typical values
VCE = 10V
Tamb = 25°C
lead length = 3mm
IC = 1mA
3mA
5mA
f = 0,45MHz
10,7MHz
35MHz
100MHz
200MHz
195°
210°
225°
240°
255°
270°
285°
300°
315°
330°
345°
7Z08226.1

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N multi-emitter transistor in a capstan envelope. The transistor has extremely good intermodulation properties and high power gain.

The device is primarily intended for:

a Final and driver stages of channel and band aerial amplifiers with high output power for band I, II, III and IV/V (40-860 MHz).

b Final and driver stages of wideband amplifiers (40-230 MHz).

c Final stages of the wideband vertical amplifier in high-speed oscilloscopes.

d Frequency multiplier and oscillator circuits.

QUICK REFERENCE DATA

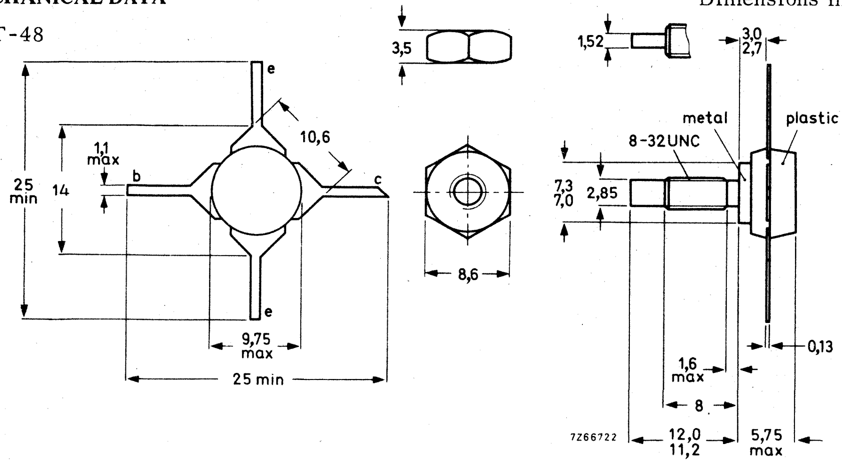
Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Collector current (peak value)	I_{CM}	max.	500	mA
Total power dissipation up to T_{mb} = 60 °C; f ≥ 1 MHz	P_{tot}	max.	3,5	W
Junction temperature	T_j	max.	150	°C
Transition frequency at f = 500 MHz				
I_C = 75 mA; V_{CE} = 20 V	f_T	>	1200	MHz
Output power at f = 200 MHz				
I_C = 70 mA; V_{CE} = 20 V; d_{im} = −30 dB	P_o	typ.	150	mW
Power gain at f = 200 MHz				
I_C = 70 mA; V_{CE} = 20 V	G_p	typ.	16	dB

MECHANICAL DATA See page 2.

MECHANICAL DATA

Dimensions in mm

SOT-48



When locking is required an adhesive instead of a lock washer is preferred.

Torque on nut: min. 0,75 Nm (7,5 kg cm)
max. 0,85 Nm (8,5 kg cm)

Diameter of clearance hole in heatsink: max. 4,17 mm.
Mounting hole to have no burrs at either end. De-burring must leave surface flat; do not chamfer or countersink either end of hole.

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

Voltages

Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	40	V	1)
Collector-emitter voltage (R_{BE} = 10 Ω; peak value)	V_{CERM}	max.	40	V	2)
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V	2)
Emitter-base voltage (open collector)	V_{EBO}	max.	3,5	V	3)

Currents

Collector current (d.c.)	I_C	max.	200	mA
Collector current (peak value) f > 1 MHz	I_{CM}	max.	500	mA

Power dissipation (f > 1 MHz; see SOAR)

Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max.	3,5	W

Temperatures

Storage temperature	T_{stg}	−40 to +150	°C
Junction temperature	T_j	max. 150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	25	°C/W
From mounting base to heatsink	$R_{th\ mb\text{-}h}$	=	0,5	°C/W

1) at I_C = 100 μA. 2) at I_C = 10 mA. 3) at I_E = 100 μA.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
I_E = 0; V_{CB} = 20 V	I_{CBO}	<	10	µA
Saturation voltage				
I_C = 100 mA; I_B = 10 mA	V_{CEsat}	<	0,75	V
D.C. current gain				
I_C = 50 mA; V_{CE} = 5 V	h_{FE}	>	25	
I_C = 150 mA; V_{CE} = 5 V	h_{FE}	>	25	
Collector capacitance at f = 1 MHz				
I_E = I_e = 0; V_{CB} = 20 V	C_c	<	4,5	pF
Feedback capacitance at f = 1 MHz				
I_C = 10 mA; V_{CE} = 20 V; T_{mb} = 25 °C	C_{re}	typ.	1,7	pF
Noise figure at f = 200 MHz				
I_C = 40 mA; V_{CE} = 20 V; R_S = 75 Ω; T_{mb} = 25 °C	F	typ.	6	dB
Transition frequency at f = 500 MHz				
I_C = 15 mA; V_{CE} = 20 V	f_T	typ.	1000	MHz
I_C = 75 mA; V_{CE} = 20 V	f_T	>	1200	MHz
I_C = 150 mA; V_{CE} = 20 V	f_T	typ.	1200	MHz
Output power at f = 200 MHz; T_{mb} = 25 °C				
I_C = 70 mA; V_{CE} = 20 V; VSWR at output < 2 f_p = 202 MHz; f_q = 205 MHz; d_{im} = −30 dB measured at $f_{(2q-p)}$ = 208 MHz (channel 9)	P_o	> typ.	130 150	mW mW
Output power at f = 800 MHz; T_{mb} = 25 °C				
I_C = 70 mA; V_{CE} = 20 V; VSWR at output < 2 f_p = 798 MHz; f_q = 802 MHz; d_{im} = −30 dB measured at $f_{(2q-p)}$ = 806 MHz (channel 62)	P_o	> typ.	70 90	mW mW
Power gain (not neutralized) T_{mb} = 25 °C				
I_C = 70 mA; V_{CE} = 20 V; f = 200 MHz	G_p	> typ.	15 16	dB dB
I_C = 70 mA; V_{CE} = 20 V; f = 800 MHz	G_p	typ.	6,5	dB

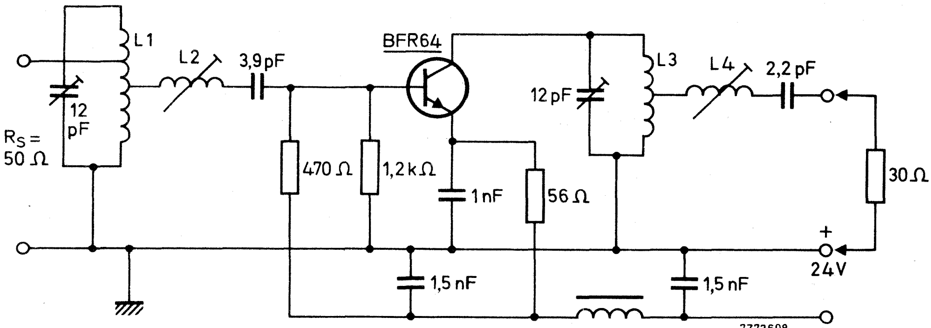
CHARACTERISTICS (continued)

Intermodulation characteristics

1. Output power at f = 200 MHz; T_{mb} = 25 °C

   I_C = 70 mA; V_{CE} = 20 V; VSWR at output < 2
   f_p = 202 MHz; f_q = 205 MHz; d_{im} = −30 dB
   measured at $f_{(2q-p)}$ = 208 MHz (channel 9)

Test circuit:



Coil data:

L1 = 3 turns silver-plated Cu wire (1, 4 mm); winding pitch 2, 7 mm; int. dia. 8 mm; taps at 0, 5 turn and 1, 5 turns from earth.
L2 = 5, 5 turns silver-plated Cu wire (1, 4 mm); winding pitch 2, 2 mm; int. dia. 8 mm
L3 = 3 turns silver-plated Cu wire (1, 4 mm); winding pitch 3, 3 mm; int. dia. 8 mm
L4 = 5, 5 turns silver-plated Cu wire (1, 4 mm); winding pitch 2, 2 mm; int. dia. 11 mm

CHARACTERISTICS (continued)

Basis of adjustment

The intermodulation at an intermodulation distortion of −30 dB is caused by h.f. output current-voltage clipping.
The maximum undistorted output power is realized, if

a. Current and voltage clipping take place concurrently.
   This occurs if

$$R_L = \frac{V_{CE} - V_{CEK}}{I_C},$$

   in which V_{CEK} is the high-frequency knee voltage.

b. The h.f. collector current is as small as possible.
   This is so if $-C_L = +C_{oe}$,
   in which C_{oe} is the output capacitance of the transistor at short-circuited input.

For maximum output power at an intermodulation distortion of −30 dB, the (experimentally found) values of R_L and C_L are:
$R_L = 220\ \Omega$; $C_L = -4$ pF.

Adjustment procedure

1. Remove the transistor and connect a dummy consisting of a 220 Ω resistor in parallel with a 4 pF capacitor between the collector and emitter connections of the output circuit.

2. Tune and match the output circuit for zero reflection at 205 MHz (VSWR = 1).
   After this adjustment, no further change may be made in the output circuit.

3. Replace the dummy by the transistor. Tune and match the input circuit for maximum power gain and good band-pass curve.
   The VSWR of the output will then, in most cases, be ≤ 2 over the whole channel.
   Corrections can be made by tuning L2; this will not disturb the band-pass curve.

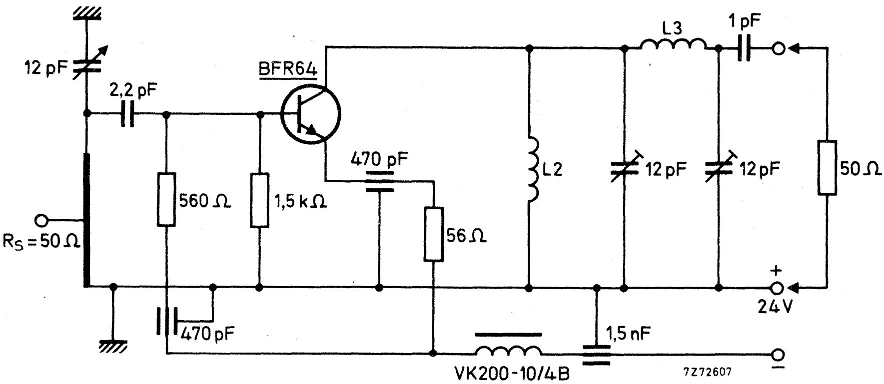
CHARACTERISTICS (continued)

Intermodulation characteristics

2. Output power at f = 800 MHz; T_{mb} = 25 °C

I_C = 70 mA; V_{CE} = 20 V; VSWR at output < 2
f_p = 798 MHz; f_q = 802 MHz; d_{im} = −30 dB
measured at $f_{(2q-p)}$ = 806 MHz (channel 62)

Test circuit:



Coil data:

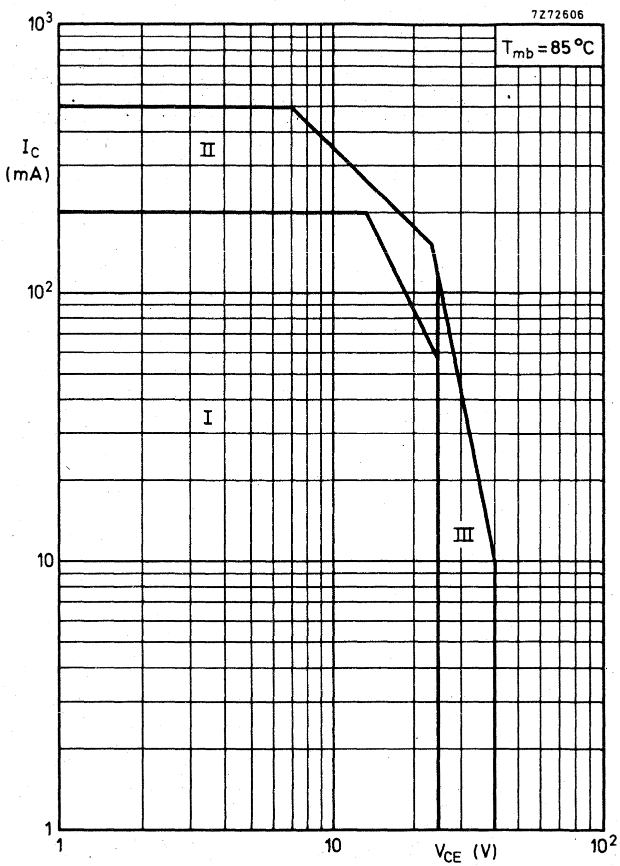
L1 = 25 mm x 7 mm x 0,85 mm silver-plated Cu strip
Tap of the input at 5 mm from earth.
L2 = 13 turns enamelled Cu wire (0,6 mm); int. dia. 8 mm
L3 = 1,5 turns Cu wire (1,3 mm); int. dia. 8 mm

Basis of adjustment

At 800 MHz no dummy can be used to adjust for optimum collector load because at these frequencies the impedance transformations of a dummy are too high. A small signal at the mid-channel frequency of 802 MHz is fed to the input and increased until clipping occurs; that is, until the output power no longer increases linearily with the input signal. This clipping can be eliminated by tuning the output circuit, thereby making the output power equal to

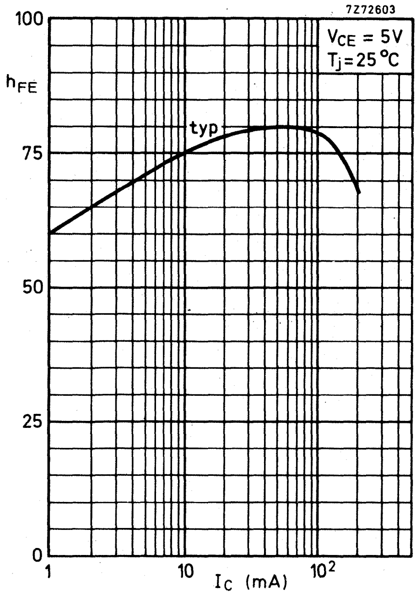
$$P_o = \frac{I_C(V_{CE} - V_{CEK})}{2} = 480 \text{ mW}.$$

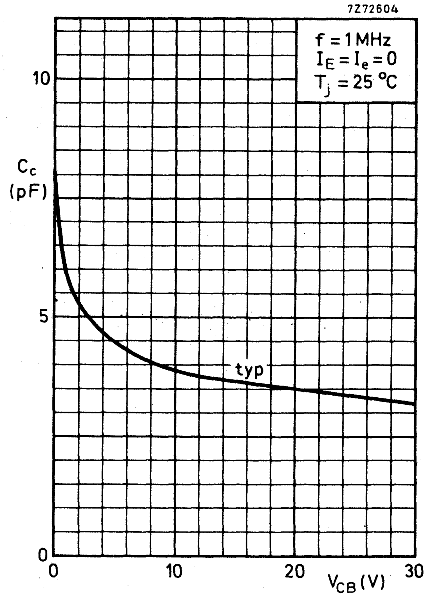
The output circuit is adjusted for minimum intermodulation if the input signal is as small as possible at P_o = 480 mW. With this adjusting method, care must be taken that the transistor is not damaged by second breakdown (the voltage swing may not exceed the rated V_{CER} value). Therefore as soon as clipping occurs, the increase of the input signal should be stopped until the clipping has been eliminated. After this adjustment has been made no further change may be made in the output circuit. Adjust the input circuit for maximum power gain and good band-pass curve. The VSWR of the output is then ≤ 2 over the whole channel.

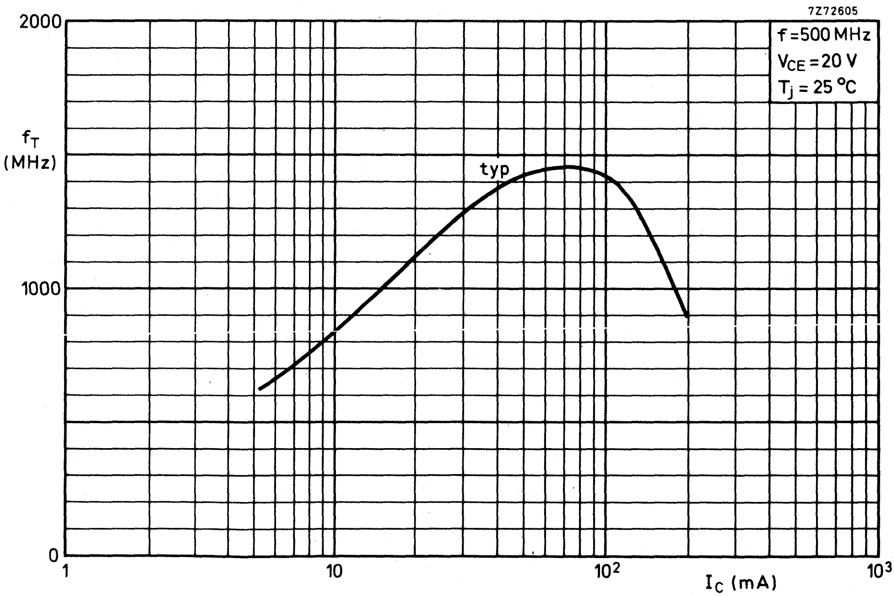


Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation
II Permissible extension for repetitive pulsed operation; f > 1 MHz
III Repetitive pulse operation in this region is allowable, provided $R_{BE} < 10\ \Omega$ and f > 1 MHz


7Z72603
V_{CE} = 5V
T_j = 25 °C
h_{FE}
typ
100
75
50
25
0
1
10
10^2
I_C (mA)


7Z72604
f = 1 MHz
$I_E = I_e = 0$
T_j = 25 °C
C_c (pF)
typ
10
5
0
0
10
20
30
V_{CB} (V)


7Z72605
f = 500 MHz
V_{CE} = 20 V
T_j = 25 °C
f_T (MHz)
typ
2000
1000
0
1
10
10^2
10^3
I_C (mA)

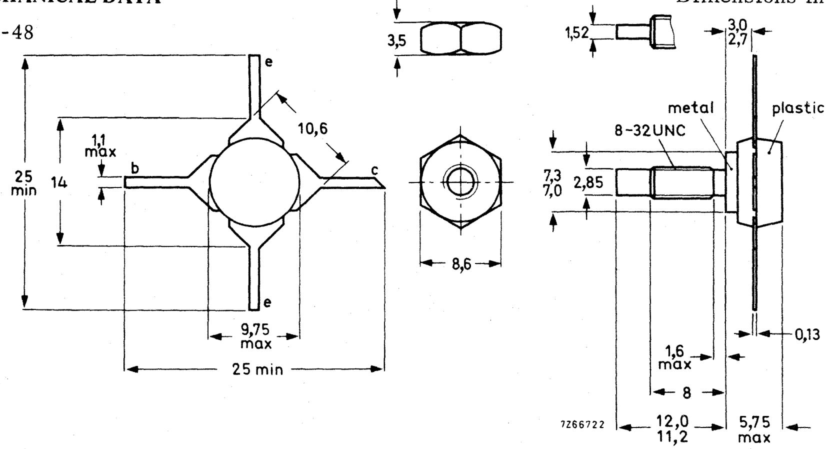
SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N multi-emitter silicon transistor in a capstan envelope. The transistor has extremely good intermodulation properties and high power gain.
The device is primarily intended for channel amplifiers in aerial amplifier systems as well as other applications where an excellent f_T linearity and higher signal handling capabilities than available in existing devices are required.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Collector current (peak value)	I_{CM}	max.	1000	mA
Junction temperature	T_j	max.	200	^oC
Thermal resistance from junction to mounting base	$R_{th\ j\text{-}mb}$	=	15	$^oC/W$
Transition frequency at f = 500 MHz I_C = 200 mA; V_{CE} = 20 V	f_T	>	1200	MHz
Output power at f = 200 MHz I_C = 200 mA; V_{CE} = 20 V; d_{im} = −30 dB	P_o	typ.	450	mW
Power gain at f = 200 MHz I_C = 200 mA; V_{CE} = 20 V	G_p	typ.	19	dB

MECHANICAL DATA Dimensions in mm

SOT-48



When locking is required an adhesive instead of a lock washer is preferred.

Torque on nut: min. 0,75 Nm
(7,5 kg cm)
0,85 Nm
(8,5 kg cm)

Diameter of clearance hole in heatsink: max. 4,17 mm.
Mounting hole to have no burrs at either end.
De-burring must leave surface flat; do not chamfer or countersink either end of hole.

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

Voltages				
Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	40	V
Collector-emitter voltage (R_{BE} = 10 Ω; peak value)	V_{CERM}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Emitter-base voltage (open collector)	V_{EBO}	max.	3.5	V
Currents				
Collector current (d.c.)	I_C	max.	400	mA
Collector current (peak value) f > 1 MHz	I_{CM}	max.	1000	mA
Power dissipation				
Total power dissipation up to T_{mb} = 125 °C See also page 6	P_{tot}	max.	5	W
Temperatures				
Storage temperature	T_{stg}		−65 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	15	°C/W
From mounting base to heatsink	$R_{th\ mb\text{-}h}$	=	0.5	°C/W

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

Breakdown voltages				
Collector-base voltage				
open emitter, $I_C = 1$ mA	$V_{(BR)CBO}$	>	40	V
Collector-emitter voltage				
$R_{BE} = 10\ \Omega$, $I_C = 5$ mA	$V_{(BR)CER}$	>	40	V
open base, $I_C = 5$ mA	$V_{(BR)CEO}$	>	25	V
Emitter-base voltage				
open collector; $I_E = 1$ mA	$V_{(BR)EBO}$	>	3.5	V
Collector cut-off current				
$I_E = 0$; $V_{CB} = 20$ V	I_{CBO}	<	100	μA
Saturation voltage				
$I_C = 200$ mA; $I_B = 20$ mA	V_{CEsat}	<	0.75	V
D.C. current gain				
$I_C = 200$ mA; $V_{CE} = 20$ V	h_{FE}	>	30	
$I_C = 400$ mA; $V_{CE} = 20$ V	h_{FE}	>	20	
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 20$ V	C_c	<	10	pF
Feedback capacitance at f = 1 MHz				
$I_C = 10$ mA; $V_{CE} = 20$ V; $T_{mb} = 25\ ^oC$	C_{re}	typ.	3.5	pF
Collector-stud capacitance	C_{cs}	typ.	2	pF
Transition frequency at f = 500 MHz				
$I_C = 200$ mA; $V_{CE} = 20$ V	f_T	>	1200	MHz
$I_C = 400$ mA; $V_{CE} = 20$ V	f_T	>	1000	MHz
Output power at f = 200 MHz; $T_{mb} = 25\ ^oC$				
$I_C = 200$ mA; $V_{CE} = 20$ V; V.S.W.R. at output < 2 $f_p = 202$ MHz; $f_q = 205$ MHz; $d_{im} = -30$ dB measured at $f_{(2q-p)} = 208$ MHz (channel 9)	P_o	typ.	450	mW
Power gain (not neutralized) $T_{mb} = 25\ ^oC$				
$I_C = 200$ mA; $V_{CE} = 20$ V; f = 200 MHz	G_p	> typ.	15 19	dB dB
$I_C = 200$ mA; $V_{CE} = 20$ V; f = 800 MHz	G_p	typ.	4.5	dB

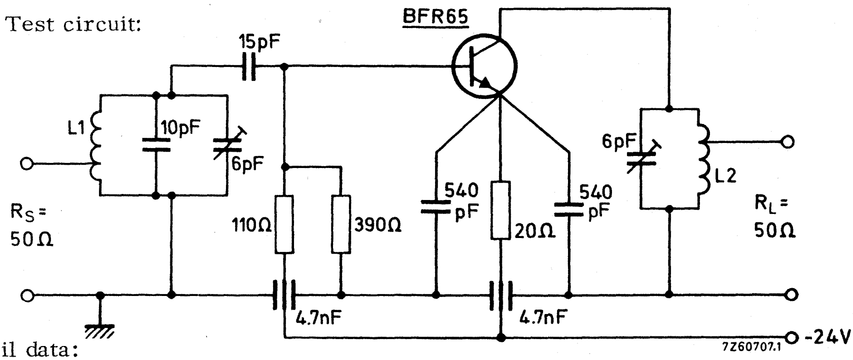
CHARACTERISTICS (continued)

Intermodulation characteristics

1. Output power at f = 200 MHz; T_{mb} = 25 °C

   I_C = 200 mA; V_{CE} = 20 V; V.S.W.R. at output < 2
   f_p = 202 MHz; f_q = 205 MHz; d_{im} = −30 dB
   measured at $f_{(2q-p)}$ = 208 MHz (channel 9)

   Test circuit:



Coil data:

L1 = 1 turn silver plated Cu wire (1.4 mm); int. diam. 8 mm; tap at 0.75 turn from earth.
L2 = 3 turns silver plated Cu wire (1.4 mm); int. diam. 8 mm; winding pitch 2.7 mm; tap at 2.5 turns from earth.

CHARACTERISTICS (continued)

Basis of adjustment

The intermodulation at an intermodulation distortion of −30 dB is caused by h.f. output current − voltage clipping.
The maximum undistorted output power is realised, if

a. Current and voltage clipping take place concurrently.
   This occurs if

$$R_L = \frac{V_{CE} - V_{CEK}}{I_C},$$

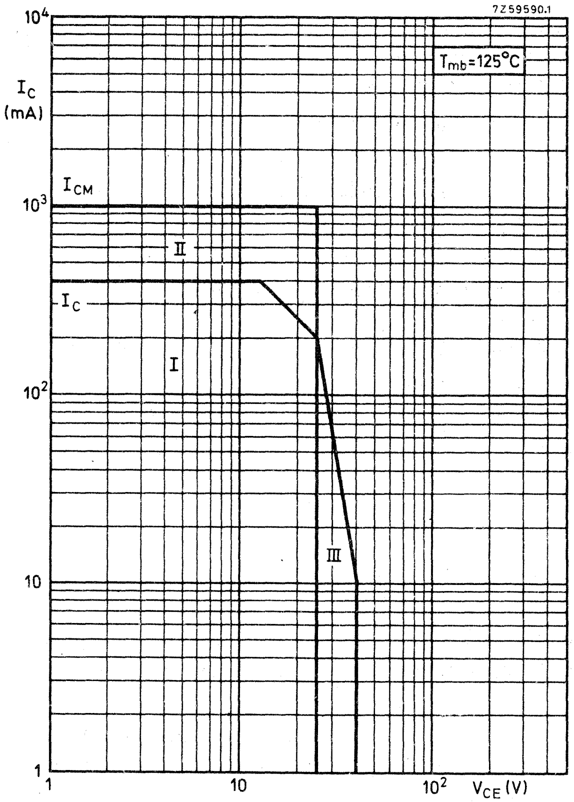
   in which V_{CEK} is the high frequency knee voltage.

b. The h.f. collector current is as small as possible.
   This is so if $-C_L = +C_{oe}$,
   in which C_{oe} is the output capacitance of the transistor at short circuited input.

For maximum output power at an intermodulation distortion of −30 dB, the (experimentally found) values of R_L and C_L are:
$R_L = 91\ \Omega$; $C_L = -6.8$ pF.

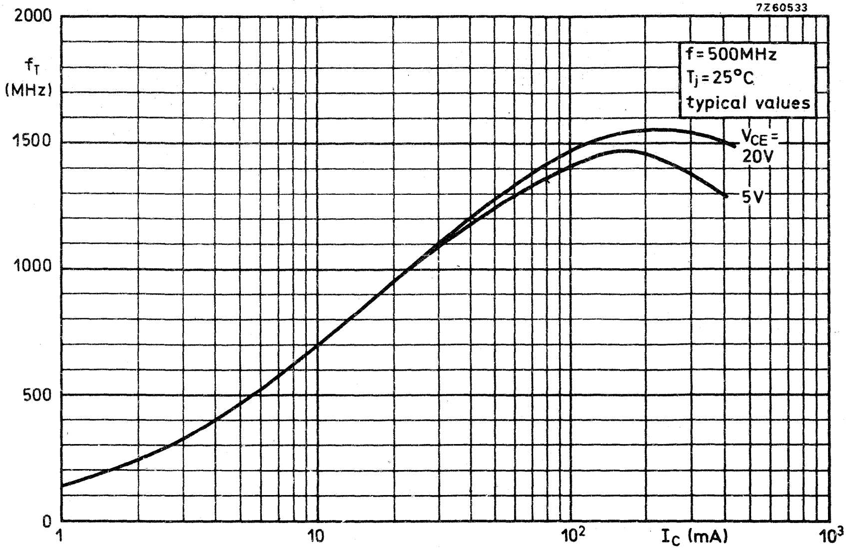
Adjustment procedure

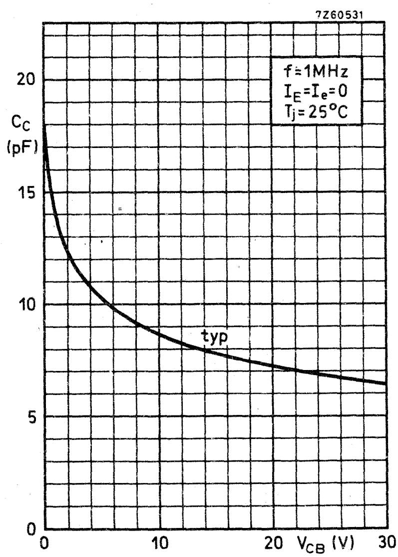
1. Remove the transistor and connect a dummy consisting of a 91 Ω resistor in parallel with a 6.8 pF capacitor between the collector and emitter connections of the output circuit.
2. Tune and match the output circuit for zero reflection at 205 MHz (V.S.W.R. = 1)
   After this adjustment, no further change may be made in the output circuit.
3. Replace the dummy by the transistor. Tune and match the input circuit for maximum power gain and good band pass curve.
   The V.S.W.R. of the output will then, in most cases, be ≤ 2 over the whole channel.

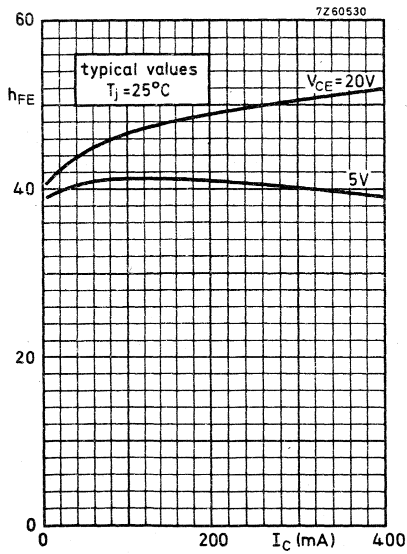


Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation
II Permissible extension for repetitive pulsed operation; f > 1 MHz
III Repetitive pulsed operation in this region is allowable, provided f > 1 MHz; R_{BE} < 10 Ω


7Z60533
2000
f_T
(MHz)
1500
1000
500
0
1
10
10^2
I_C (mA)
10^3
f = 500MHz
T_j = 25°C
typical values
V_{CE} = 20V
5V


7Z60531
20
C_c
(pF)
15
10
5
0
0
10
20
V_{CB} (V)
30
f = 1MHz
$I_E = I_e = 0$
T_j = 25°C
typ


7Z60530
60
h_{FE}
40
20
0
0
200
I_C (mA)
400
typical values
T_j = 25°C
V_{CE} = 20V
5V

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a subminiature plastic transfer-moulded T-package.
It is primarily intended for use in u.h.f. and microwave amplifiers such as in aerial amplifiers, radar systems, oscilloscopes, spectrum analysers etc.
The transistor features low intermodulation distortion and high power gain; thanks to its very high transition frequency, it also has excellent wideband properties and low noise up to high frequencies.

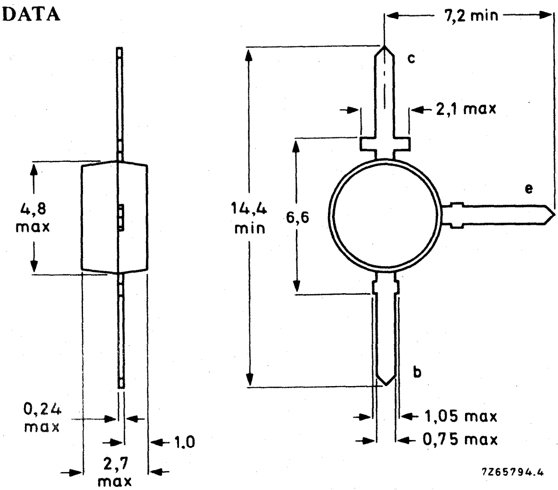
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	20	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector current (d.c.)	I_C	max.	25	mA
Total power dissipation up to T_{amb} = 60 °C	P_{tot}	max.	180	mW
Junction temperature	T_j	max.	150	°C
Transition frequency at f = 500 MHz I_C = 14 mA; V_{CE} = 10 V	f_T	typ.	5	GHz
Feedback capacitance at f = 1 MHz I_C = 2 mA; V_{CE} = 10 V; T_{amb} = 25 °C	C_{re}	typ.	0,4	pF
Noise figure at optimum source impedance I_C = 2 mA; V_{CE} = 10 V; f = 500 MHz; T_{amb} = 25 °C	F	typ.	2,4	dB
Max. unilateral power gain (see page 3) I_C = 14 mA; V_{CE} = 10 V; f = 500 MHz; T_{amb} = 25 °C	G_{UM}	typ.	19,5	dB
Intermodulation distortion at T_{amb} = 25 °C I_C = 14 mA; V_{CE} = 10 V; R_L = 75 Ω; V_o = 150 mV $f_{(p+q-r)}$ = 493,25 MHz (see page 4)	d_{im}	typ.	−60	dB

MECHANICAL DATA

Dimensions in mm

SOT-37



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

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	20	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Emitter-base voltage (open collector)	V_{EBO}	max.	2,0	V

Current

Collector current (d.c.)	I_C	max.	25	mA

Power dissipation

Total power dissipation up to T_{amb} = 60 °C	P_{tot}	max.	180	mW

Temperatures

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

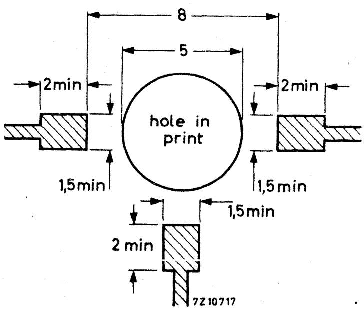
THERMAL RESISTANCE

From junction to ambient in free air

mounted on a glass-fibre print *) of 40 mm x 25 mm x 1 mm	$R_{th\ j-a}$	=	0,5	°C/mW

*) Requirements for glas-fibre print

(dimensions in mm)



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

Collector cut-off current				
$I_E = 0$; $V_{CB} = 10\,V$	I_{CBO}	<	50	nA
D.C. current gain [1]				
$I_C = 14\,mA$; $V_{CE} = 10\,V$	h_{FE}	>	25	
		typ.	50	
Transition frequency at f = 500 MHz [1]				
$I_C = 14\,mA$; $V_{CE} = 10\,V$	f_T	typ.	5	GHz
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10\,V$	C_c	typ.	0,5	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 0{,}5\,V$	C_e	typ.	0,8	pF
Feedback capacitance at f = 1 MHz				
$I_C = 2\,mA$; $V_{CE} = 10\,V$; $T_{amb} = 25\,^oC$	C_{re}	typ.	0,4	pF
Noise figure at optimum source impedance				
$I_C = 2\,mA$; $V_{CE} = 10\,V$; f = 500 MHz; $T_{amb} = 25\,^oC$	F	typ.	2,4	dB

Max. unilateral power gain (s_{re} assumed to be zero)

$$G_{UM}\ \text{(in dB)} = 10 \log \frac{|s_{fe}|^2}{(1 - |s_{ie}|^2)(1 - |s_{oe}|^2)}$$

$I_C = 14\,mA$; $V_{CE} = 10\,V$; f = 500 MHz; $T_{amb} = 25\,^oC$	G_{UM}	typ.	19,5	dB

[1]) Measured under pulse conditions.

CHARACTERISTICS (continued)

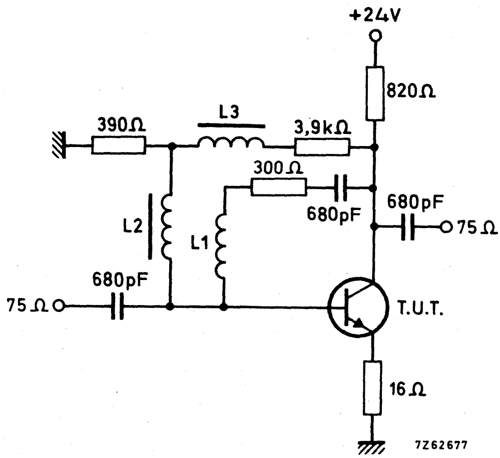
Intermodulation distortion at $T_{amb} = 25\,^{o}C$

I_C = 14 mA; V_{CE} = 10 V; R_L = 75 Ω; V.S.W.R. < 2

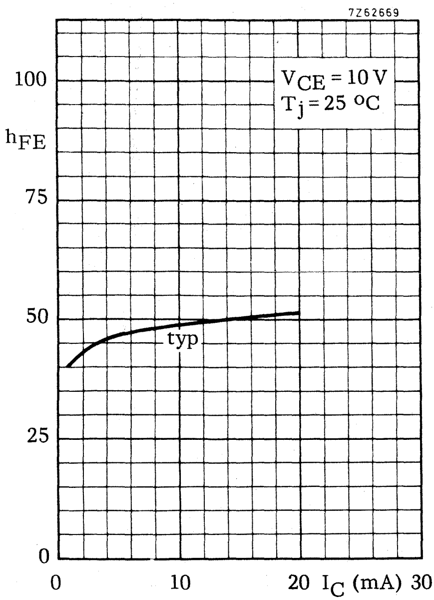
$V_p = V_o$ = 150 mV at f_p = 495,25 MHz
$V_q = V_o$ − 6 dB at f_q = 503,25 MHz
$V_r = V_o$ − 6 dB at f_r = 505,25 MHz

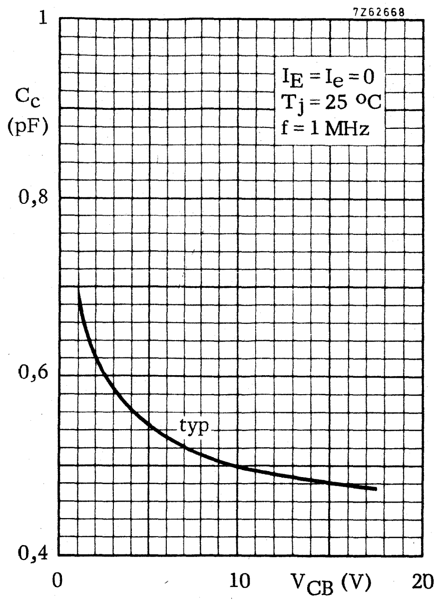
Measured at $f_{(p+q-r)}$ = 493,25 MHz — d_{im} typ. −60 dB

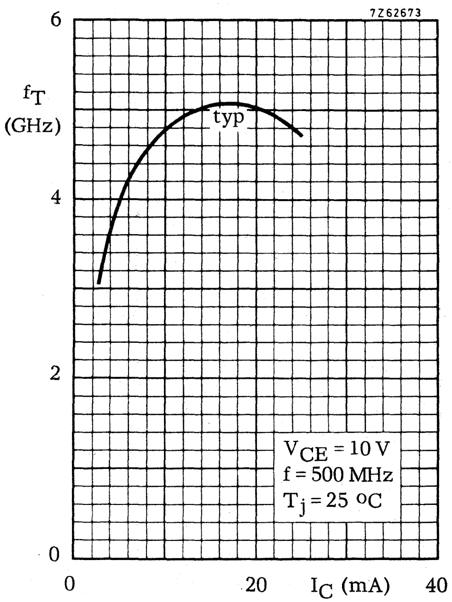
Intermodulation test circuit:

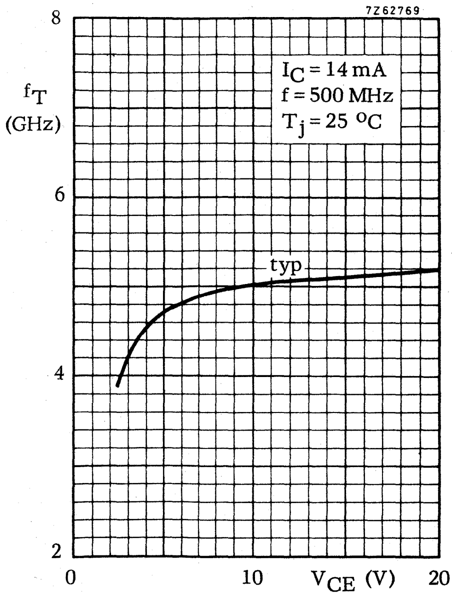


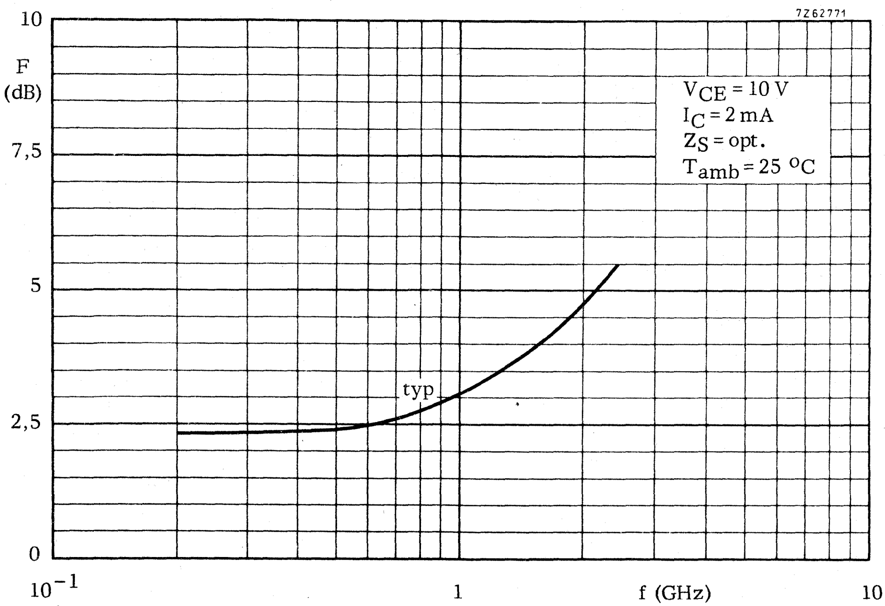
L1 = 4 turns Cu wire (0,35 mm); winding pitch 1 mm; int. diam. 4 mm
L2 and L3 5 μH (code number: 3122 108 20150)

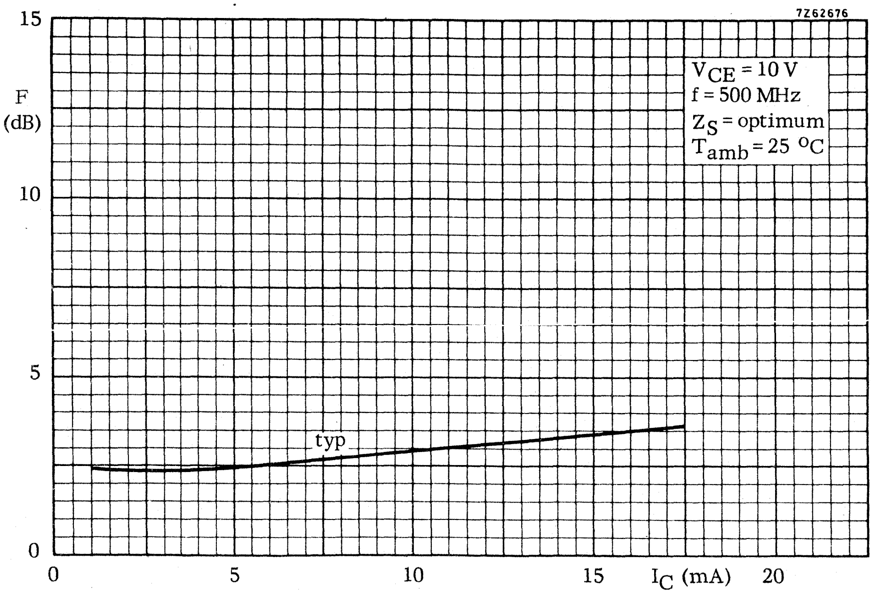

7Z62669
V_{CE} = 10 V
T_j = 25 °C
h_{FE}
typ
100
75
50
25
0
0
10
20
I_C (mA)
30

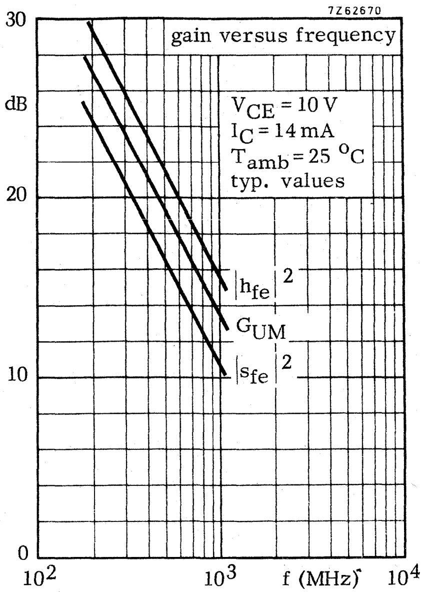

7Z62668
$I_E = I_e = 0$
T_j = 25 °C
f = 1 MHz
C_c
(pF)
typ
1
0,8
0,6
0,4
0
10
V_{CB} (V)
20


7Z62673
f_T
(GHz)
typ
V_{CE} = 10 V
f = 500 MHz
T_j = 25 °C
6
4
2
0
0
20
I_C (mA)
40

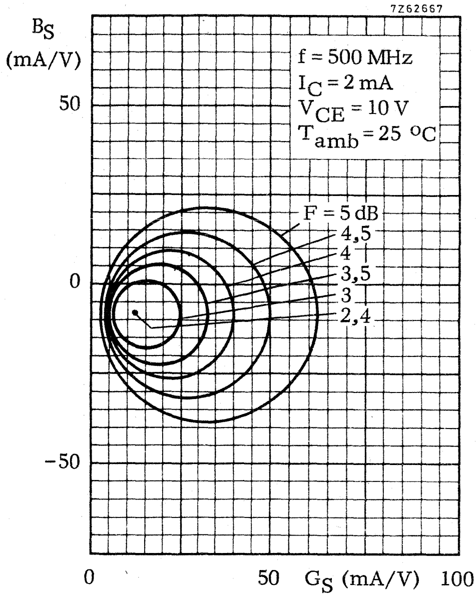

7Z62769
I_C = 14 mA
f = 500 MHz
T_j = 25 °C
f_T
(GHz)
typ
8
6
4
2
0
10
V_{CE} (V)
20


7Z62771
10
F
(dB)
7,5
5
2,5
0
VCE = 10 V
IC = 2 mA
ZS = opt.
Tamb = 25 °C
typ
10−1
1
f (GHz)
10


7Z62676
15
F
(dB)
10
5
0
VCE = 10 V
f = 500 MHz
ZS = optimum
Tamb = 25 °C
typ
0
5
10
15
IC (mA)
20



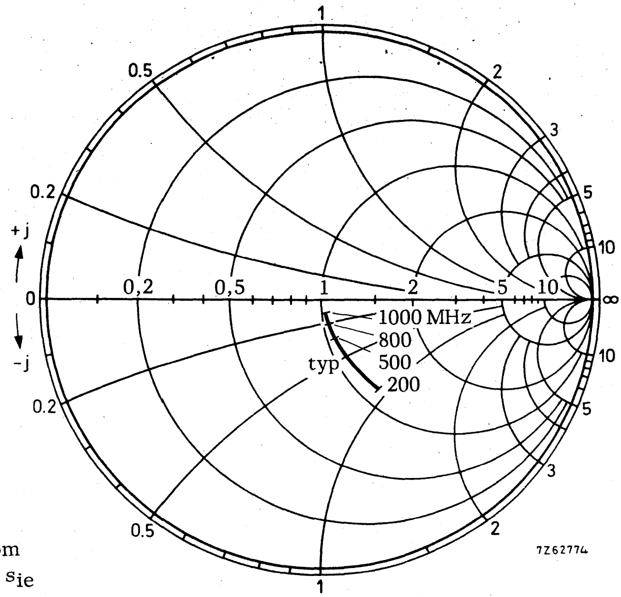
circles of constant noise figure



V_{CE} = 10 V

I_C = 14 mA

T_{amb} = 25 °C

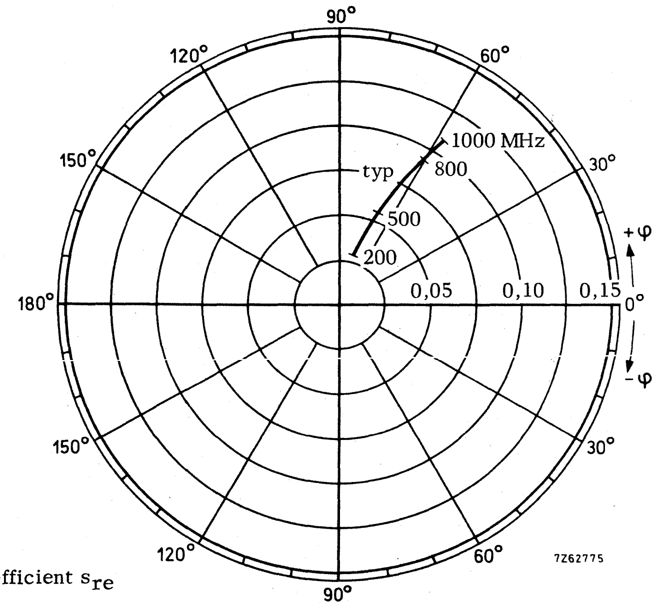


Input impedance derived from input reflection coefficient s_{ie} coordinates in ohm x 50

V_{CE} = 10 V

I_C = 14 mA

T_{amb} = 25 °C

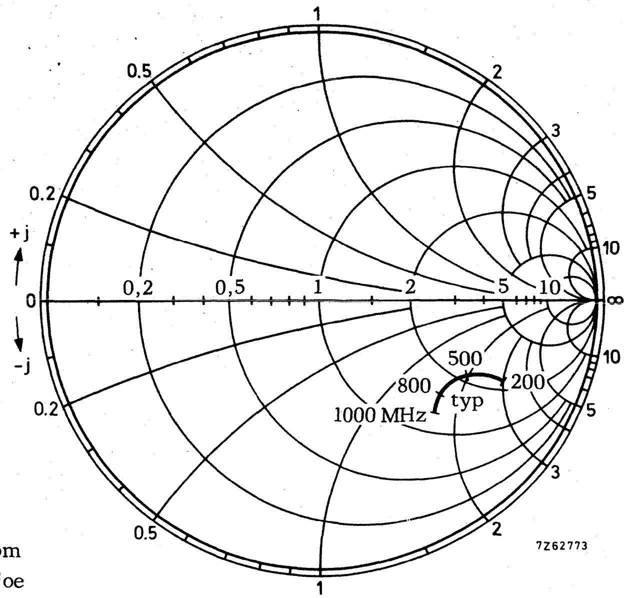


Reverse transmission coefficient s_{re}

V_{CE} = 10 V

I_C = 14 mA

T_{amb} = 25 °C

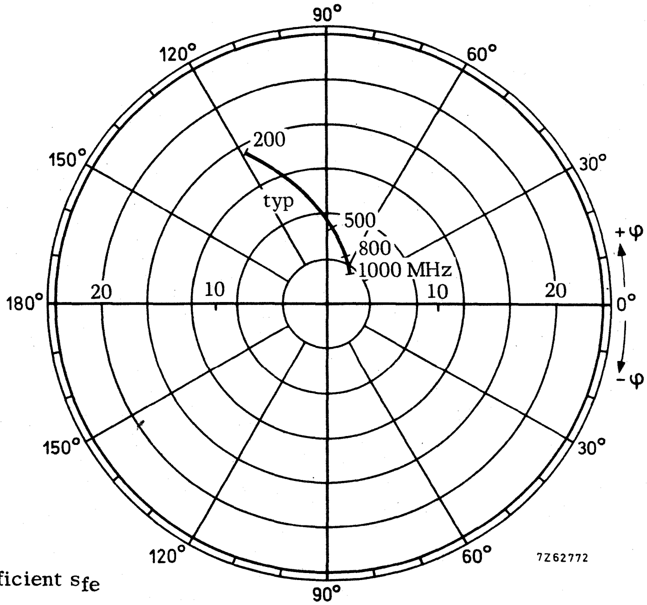


Output impedance derived from output reflection coefficient s_{oe} coordinates in ohm x 50

V_{CE} = 10 V

I_C = 14 mA

T_{amb} = 25 °C



Forward transmission coefficient s_{fe}

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a subminiature plastic transfer-moulded T-package.
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The transistor features very low intermodulation distortion and high power gain; thanks to its very high transition frequency, it also has excellent wideband properties and low noise up to high frequencies.

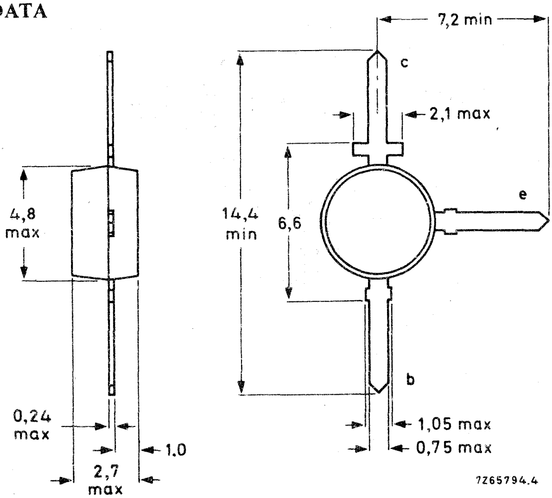
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	15	V
Collector-emitter voltage (open base)	V_{CEO}	max.	12	V
Collector current (d.c.)	I_C	max.	35	mA
Total power dissipation up to T_{amb} = 60 °C	P_{tot}	max.	180	mW
Junction temperature	T_j	max.	150	°C
Transition frequency at f = 500 MHz				
I_C = 30 mA; V_{CE} = 5 V	f_T	typ.	5	GHz
Feedback capacitance at f = 1 MHz				
I_C = 2 mA; V_{CE} = 5 V; T_{amb} = 25 °C	C_{re}	typ.	0,8	pF
Noise figure at optimum source impedance				
I_C = 2 mA; V_{CE} = 5 V; f = 500 MHz; T_{amb} = 25 °C	F	typ.	1,9	dB
Max. unilateral power gain (see page 3)				
I_C = 30 mA; V_{CE} = 5 V; f = 500 MHz; T_{amb} = 25 °C	G_{UM}	typ.	16,5	dB
Intermodulation distortion at T_{amb} = 25 °C				
I_C = 30 mA; V_{CE} = 5 V; R_L = 75 Ω; V_o = 300 mV				
$f_{(p+q-r)}$ = 493,25 MHz (see page 4)	d_{im}	typ.	−60	dB

MECHANICAL DATA

Dimensions in mm

SOT-37



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

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	15	V
Collector-emitter voltage (open base)	V_{CEO}	max.	12	V
Emitter-base voltage (open collector)	V_{EBO}	max.	2,0	V

Current

Collector current (d.c.)	I_C	max.	35	mA

Power dissipation

Total power dissipation up to T_{amb} = 60 °C	P_{tot}	max.	180	mW

Temperatures

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

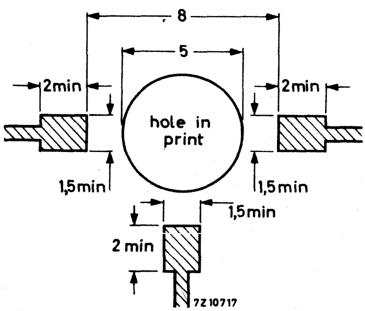
THERMAL RESISTANCE

From junction to ambient in free air

mounted on a glass-fibre print *) of 40 mm x 25 mm x 1 mm	$R_{th\ j-a}$	=	0,5	°C/mW

*) Requirements for glass-fibre print

(dimensions in mm)



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

Collector cut-off current				
$I_E = 0$; $V_{CB} = 5$ V	I_{CBO}	<	50	nA
D.C. current gain [1]				
$I_C = 30$ mA; $V_{CE} = 5$ V	h_{FE}	> typ.	25 50	
Transition frequency at f = 500 MHz [1]				
$I_C = 30$ mA; $V_{CE} = 5$ V	f_T	typ.	5	GHz
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	0,7	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 0{,}5$ V	C_e	typ.	1,8	pF
Feedback capacitance at f = 1 MHz				
$I_C = 2$ mA; $V_{CE} = 5$ V; $T_{amb} = 25\ ^oC$	C_{re}	typ.	0,8	pF
Noise figure at optimum source impedance				
$I_C = 2$ mA; $V_{CE} = 5$ V; f = 500 MHz; $T_{amb} = 25\ ^oC$	F	typ.	1,9	dB

Max. unilateral power gain (s_{re} **assumed to be zero)**

$$G_{UM}\ (\text{in dB}) = 10 \log \frac{|s_{fe}|^2}{(1-|s_{ie}|^2)(1-|s_{oe}|^2)}$$

$I_C = 30$ mA; $V_{CE} = 5$ V; f = 500 MHz ; $T_{amb} = 25\ ^oC$	G_{UM}	typ.	16,5	dB

[1]) Measured under pulse conditions.

CHARACTERISTICS (continued)

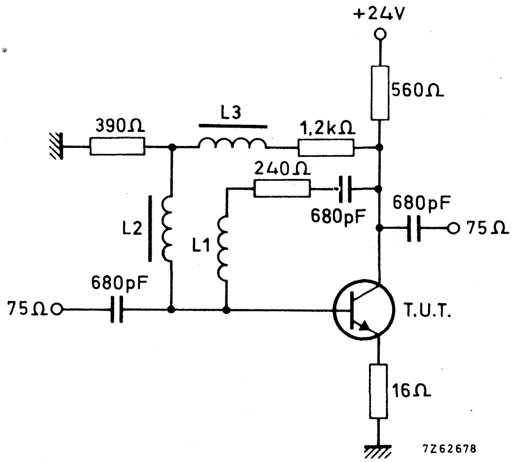
Intermodulation distortion at T_{amb} = 25 °C

I_C = 30 mA; V_{CE} = 5 V; R_L = 75 Ω; V.S.W.R. < 2

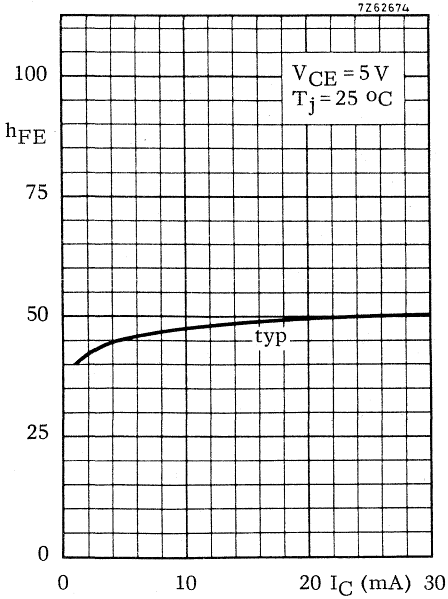
$V_p = V_o$ = 300 mV at f_p = 495,25 MHz
$V_q = V_o$ −6 dB at f_q = 503,25 MHz
$V_r = V_o$ −6 dB at f_r = 505,25 MHz

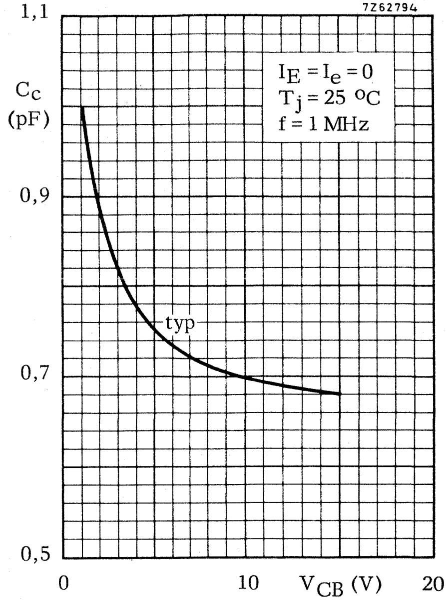
Measured at $f_{(p+q-r)}$ = 493,25 MHz — d_{im} typ. −60 dB

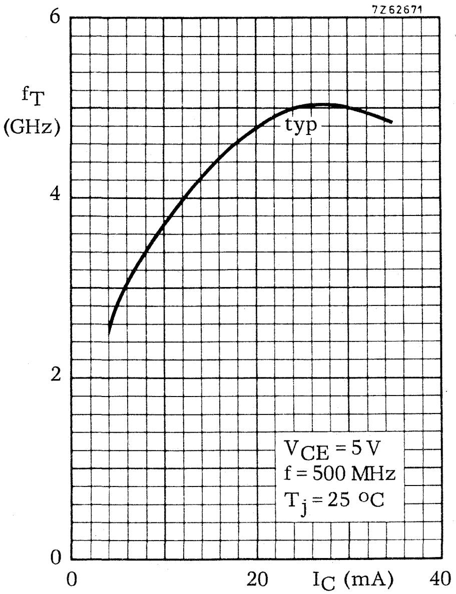
Intermodulation test circuit:

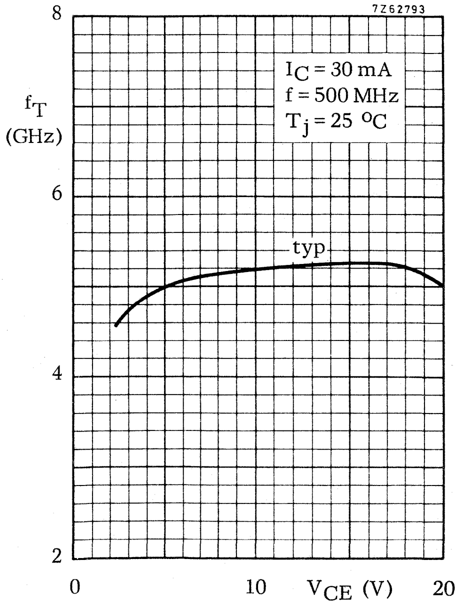


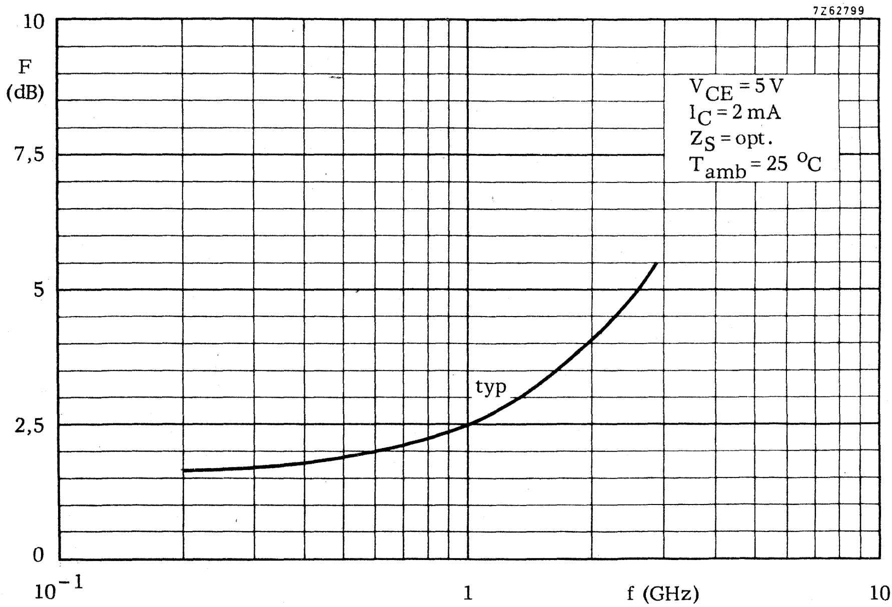
L1 = 4 turns Cu wire (0,35); winding pitch 1 mm; int. diam. 4 mm
L2 and L3 5 μH (code number: 3122 108 20150)

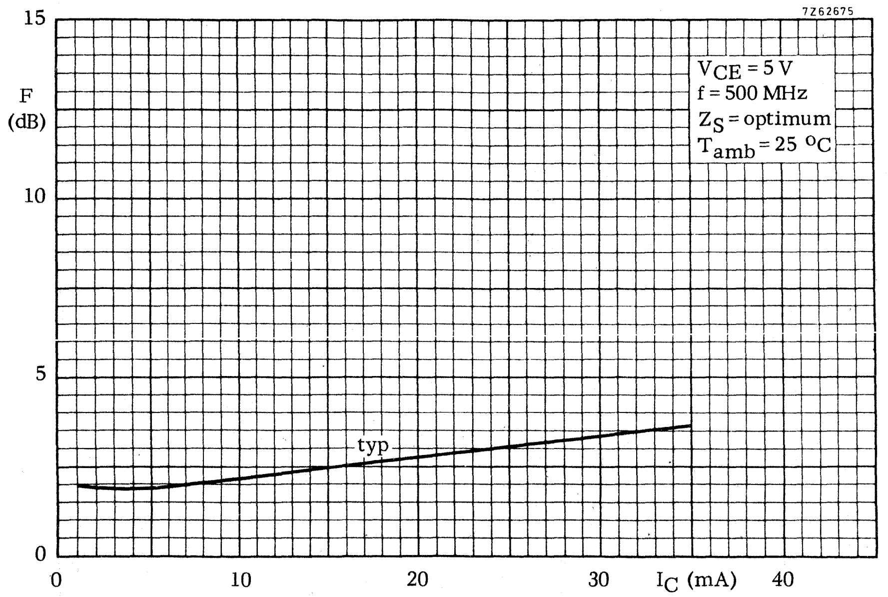

7Z62674
100
75
50
25
0
h_{FE}
V_{CE} = 5 V
T_j = 25 °C
typ
0
10
20
I_C (mA)
30


7Z62794
1,1
0,9
0,7
0,5
C_c
(pF)
I_E = I_e = 0
T_j = 25 °C
f = 1 MHz
typ
0
10
V_{CB} (V)
20

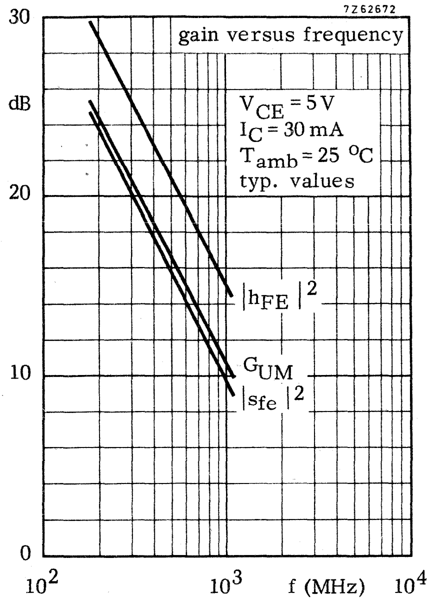

7Z62671
6
4
2
0
f_T
(GHz)
typ
V_{CE} = 5 V
f = 500 MHz
T_j = 25 °C
0
20
I_C (mA)
40

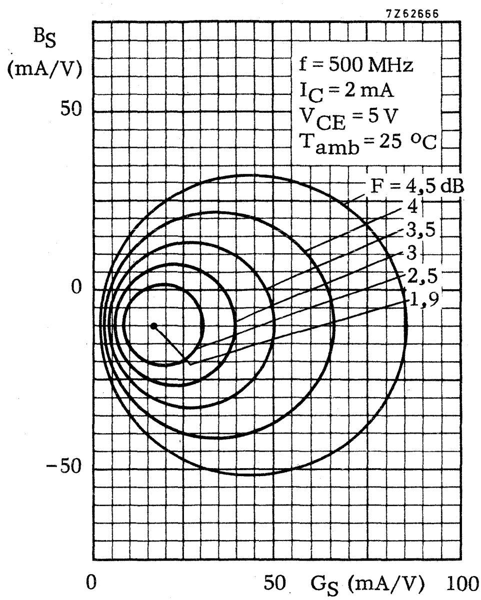

7Z62793
8
6
4
2
f_T
(GHz)
I_C = 30 mA
f = 500 MHz
T_j = 25 °C
typ
0
10
V_{CE} (V)
20


7Z62799
10
F
(dB)
7,5
5
2,5
0
$V_{CE} = 5$ V
$I_C = 2$ mA
Z_S = opt.
$T_{amb} = 25$ °C
typ
10^{-1}
1
f (GHz)
10

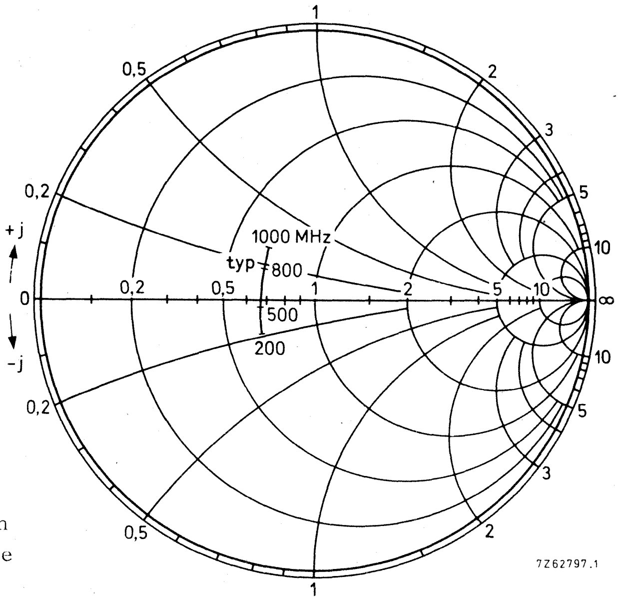

7Z62675
15
F
(dB)
10
5
0
$V_{CE} = 5$ V
f = 500 MHz
Z_S = optimum
$T_{amb} = 25$ °C
typ
0
10
20
30
I_C (mA)
40

circles of constant noise figure



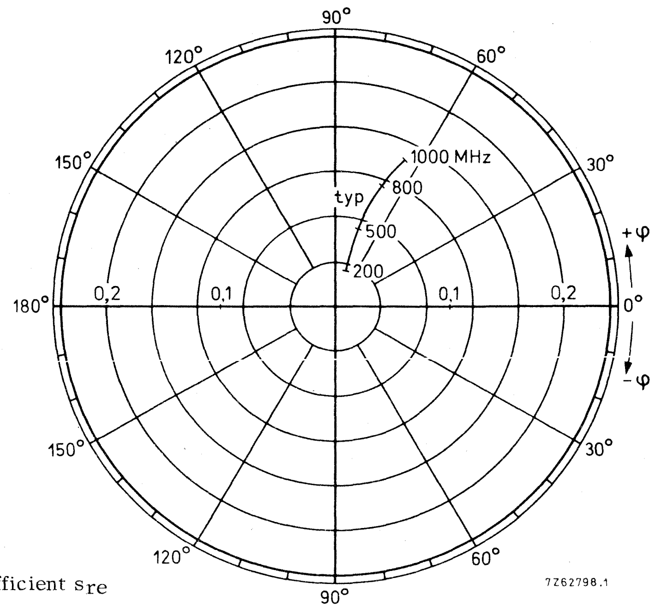


$V_{CE} = 5\ V$
$I_C = 30\ mA$
$T_{amb} = 25\ ^oC$



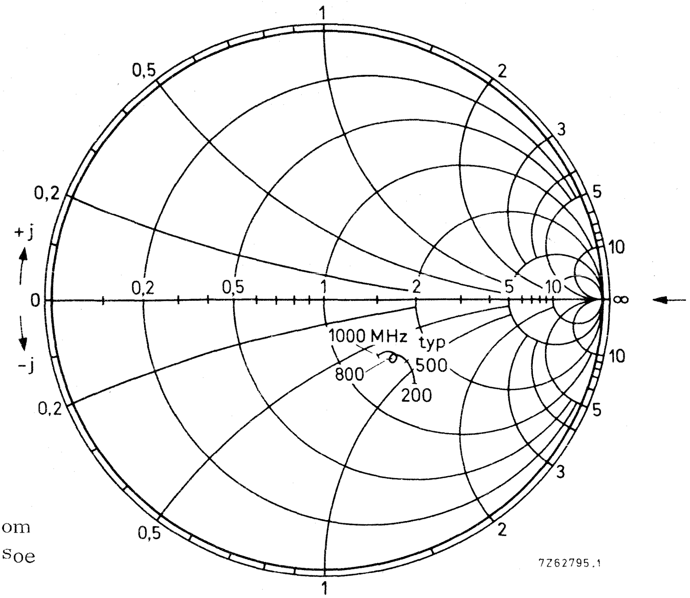
Input impedance derived from input reflection coefficient s_{ie} coordinates in ohm x 50

$V_{CE} = 5\ V$
$I_C = 30\ mA$
$T_{amb} = 25\ ^oC$



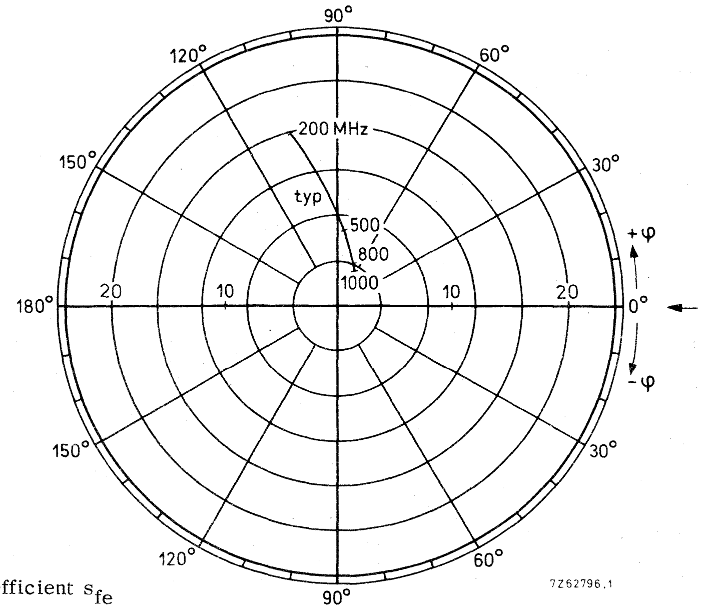
Reverse transmission coefficient s_{re}

V_{CE} = 5 V
I_C = 30 mA
T_{amb} = 25 °C



Output impedance derived from output reflection coefficient s_{oe} coordinates in ohm x 50

V_{CE} = 5 V
I_C = 30 mA
Tamb = 25 °C



Forward transmission coefficient s_{fe}

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N resistance-stabilized transistor in a SOT-48 capstan envelope featuring extremely low cross modulation, intermodulation and second harmonic distortion. Thanks to its high transition frequency it has a high power gain in conjunction with good wideband properties and low noise up to high frequencies.
It is primarily intended for CATV and MATV applications.

QUICK REFERENCE DATA

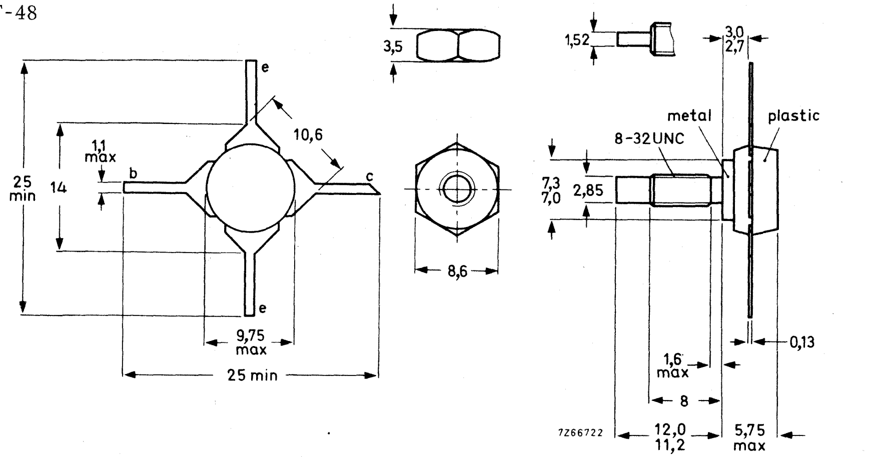
Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Collector current (d.c.)	I_C	max.	150	mA
Total power dissipation up to T_h = 145 °C; f > 1 MHz	P_{tot}	max.	3,5	W
Junction temperature	T_j	max.	200	°C
Transition frequency at f = 500 MHz I_C = 90 mA; V_{CE} = 20 V	f_T	typ.	3,5	GHz
Cross modulation distortion (channel 13) I_C = 90 mA; V_{CE} = 20 V; V_o = 48 dBmV	d_{cm}	typ. <	−61 −57	dB dB
I_C = 90 mA; V_{CE} = 20 V; V_o = 32 dBmV	d_{cm}	typ. <	−93 −89	dB dB
Intermodulation distortion at $f_{(p+q-r)}$ = 194, 25 MHz I_C = 90 mA; V_{CE} = 20 V; V_o = 60 dBmV	d_{im}	typ.	−63	dB
Broadband power gain I_C = 90 mA; V_{CE} = 20 V	G_p	> typ.	10 11	dB dB
Noise figure at f = 200 MHz I_C = 90 mA; V_{CE} = 20 V	F	typ. <	8 10	dB dB
2nd harmonic distortion at $f_p + f_q$ = 210 MHz I_C = 90 mA; V_{CE} = 20 V; V_o = 48 dBmV	d_2	<	−56	dB

MECHANICAL DATA (see page 2)

MECHANICAL DATA

Dimensions in mm

SOT-48



When locking is required an adhesive instead of a lock washer is preferred.

Torque on nut: min. 0, 75 Nm (7, 5 kg cm)
max. 0, 85 Nm (8, 5 kg cm)

Diameter of clearance hole in heatsink: max. 4, 17 mm.
Mountinghole to have no burrs at either end. De-burring must leave surface flat; do not chamfer or countersink either end of hole.

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

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (R_{BE} = 10 Ω)	V_{CER}	max.	35	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Emitter-base voltage (open collector)	V_{EBO}	max.	3	V

Currents

Collector current (d.c.)	I_C	max.	150	mA
Collector current (peak value); f > 1 MHz	I_{CM}	max.	300	mA

Power dissipation

Total power dissipation (d.c.) up to T_h = 160 °C	P_{tot}	max.	2, 5	W
Total power dissipation up to T_h = 145 °C; f > 1 MHz	P_{tot}	max.	3, 5	W

Temperatures

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

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j-mb}$	=	15	°C/W
From mounting base to heatsink	$R_{th\ mb-h}$	=	0, 6	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current					
$I_E = 0$; $V_{CB} = 20$ V	I_{CBO}	<	50	μA	
D.C. current gain					
$I_C = 50$ mA; $V_{CE} = 20$ V	h_{FE}	>	30		1)
$I_C = 150$ mA; $V_{CE} = 20$ V	h_{FE}	>	30		1)
Transition frequency at f = 500 MHz					
$I_C = 90$ mA; $V_{CE} = 20$ V	f_T	typ.	3,5	GHz	1)
$I_C = 150$ mA; $V_{CE} = 20$ V	f_T	typ.	3,5	GHz	1)
Collector capacitance at f = 1 MHz					
$I_E = I_e = 0$; $V_{CB} = 20$ V	C_c	typ.	3,5	pF	
Emitter capacitance at f = 1 MHz					
$I_C = I_c = 0$; $V_{EB} = 0,5$ V	C_e	typ.	12	pF	
Feedback capacitance at f = 1 MHz					
$I_C = 10$ mA; $V_{CE} = 20$ V	C_{re}	typ.	1,3	pF	
Collector-stud capacitance at f = 1 MHz	C_{cs}	typ.	2	pF	
Noise figure at optimum source impedance					
$I_C = 90$ mA; $V_{CE} = 20$ V; f = 500 MHz; $T_{amb} = 25$ °C	F	typ.	5	dB	1)

Max. unilateral power gain (s_{re} assumed to be zero)

$$G_{UM} \text{ (in dB)} = 10 \log \frac{|s_{fe}|^2}{(1 - |s_{ie}|^2)(1 - |s_{oe}|^2)}$$

$I_C = 90$ mA; $V_{CE} = 20$ V; f = 500 MHz; $T_{amb} = 25$ °C	G_{UM}	typ.	13,5	dB	

1) Measured under pulse conditions.

CHARACTERISTICS (continued)

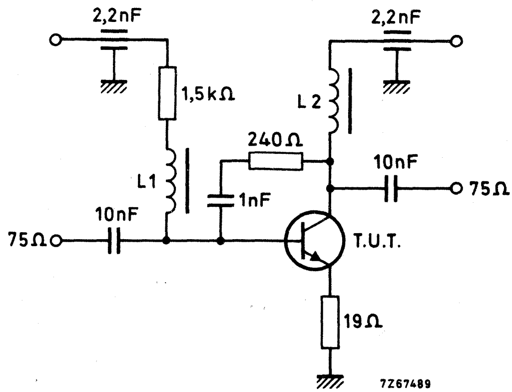
Intermodulation distortion at T_{amb} = 25 °C

I_C = 90 mA; V_{CE} = 20 V; R_L = 75 Ω

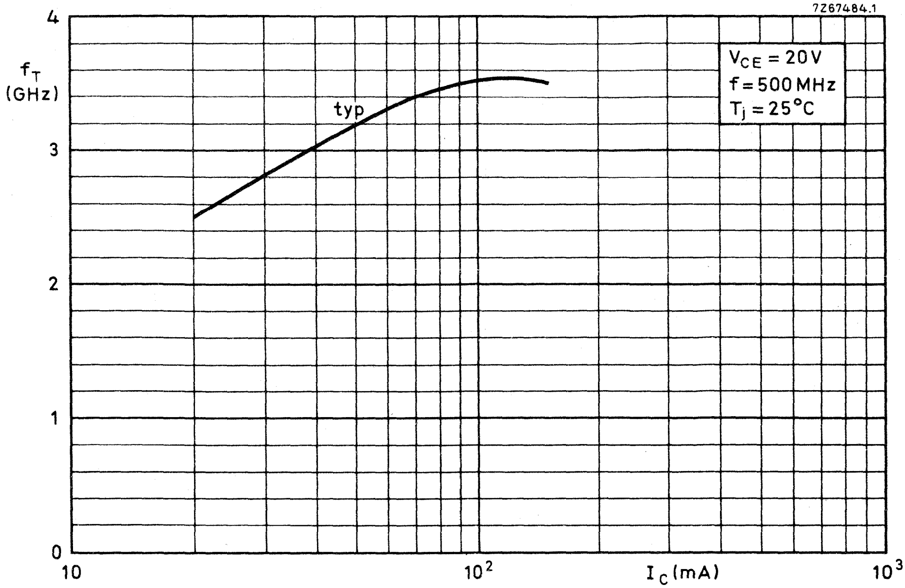
$V_p = V_o$ = 700 mV at f_p = 495, 25 MHz
$V_q = V_o$ −6 dB at f_q = 503, 25 MHz
$V_r = V_o$ −6 dB at f_r = 505, 25 MHz

Measured at $f_{(p+q-r)}$ = 493, 25 MHz | d_{im} typ. −60 dB

MATV test circuit



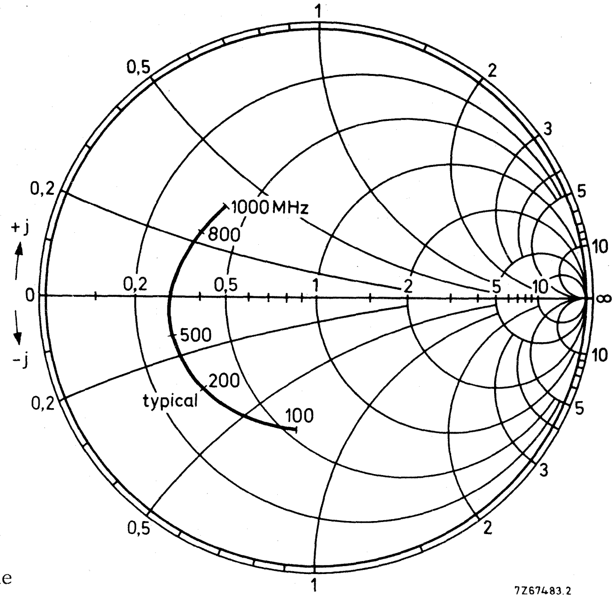
L1 = L2 = 5 μH ferroxcube coil (code number: 3122 108 20153)


7Z67484.1
f_T
(GHz)
4
3
2
1
0
typ
$V_{CE} = 20 V$
$f = 500 MHz$
$T_j = 25 °C$
10
10^2
I_C (mA)
10^3

V_{CE} = 20 V

I_C = 90 mA

T_{amb} = 25 °C

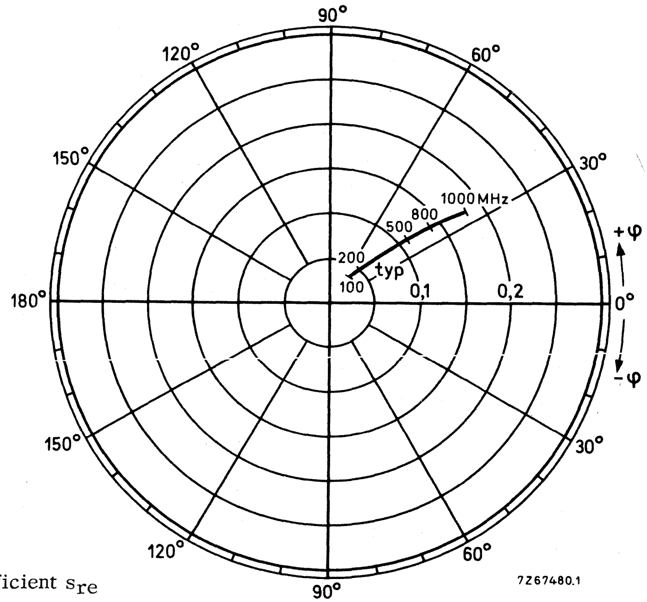


Input reflection coefficient s_{ie}

V_{CE} = 20 V

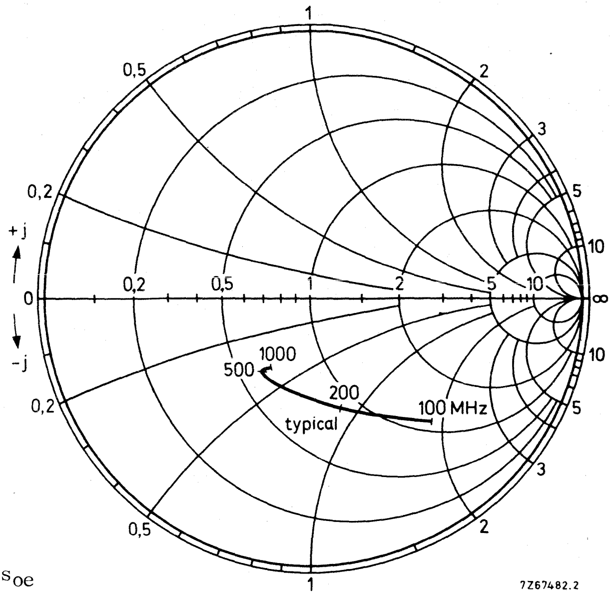
I_C = 90 mA

T_{amb} = 25 °C



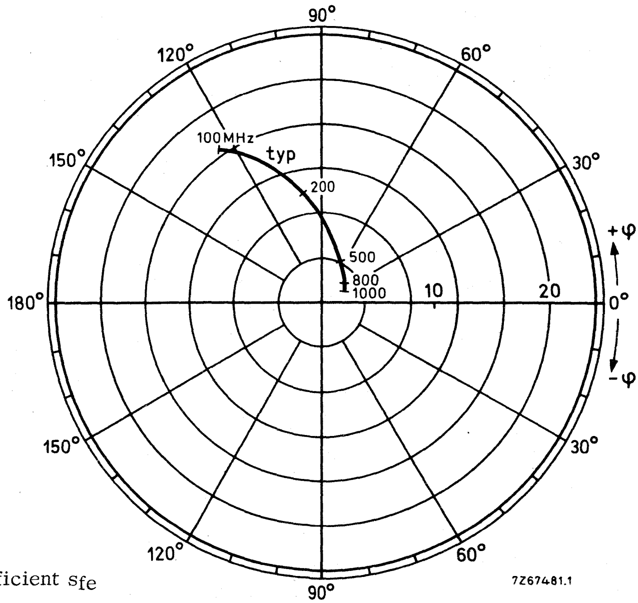
Reverse transmission coefficient s_{re}

V_{CE} = 20 V
I_C = 90 mA
T_{amb} = 25 °C



Output reflection coefficient s_{oe}

V_{CE} = 20 V
I_C = 90 mA
T_{amb} = 25 °C



Forward transmission coefficient s_{fe}

APPLICATION INFORMATION (see page 9) T_{amb} = 25 °C unless otherwise specified

Cross modulation distortion (channel 13) [1])

I_C = 90 mA; V_{CE} = 20 V; V_o = 48 dBmV	d_{cm}	typ.	−61	dB
		<	−57	dB
I_C = 90 mA; V_{CE} = 20 V; V_o = 32 dBmV	d_{cm}	typ.	−93	dB
		<	−89	dB

Intermodulation distortion

I_C = 90 mA; V_{CE} = 20 V; R_L = 75 Ω

$V_p = V_o$ = 60 dBmV at f_p = 196,25 MHz
$V_q = V_o$ −6 dB at f_q = 203,25 MHz
$V_r = V_o$ −6 dB at f_r = 205,25 MHz

Measured at $f_{(p+q-r)}$ = 194,25 MHz	d_{im}	typ.	−63	dB

Broadband power gain

I_C = 90 mA; V_{CE} = 20 V	G_p	>	10	dB
		typ.	11	dB

Noise figure

I_C = 90 mA; V_{CE} = 20 V; f = 200 MHz	F	typ.	8	dB
		<	10	dB

2nd harmonic distortion

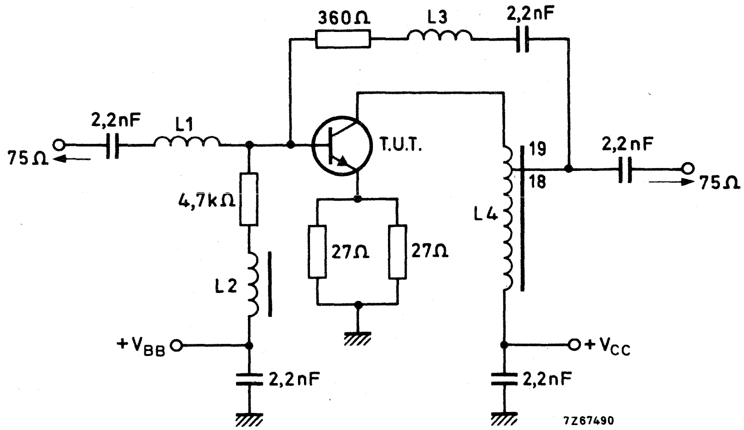
I_C = 90 mA; V_{CE} = 20 V

f_p = 66 MHz; f_q = 144 MHz; $f_p + f_q$ = 210 MHz; V_o = 48 dBmV	d_2	<	−56	dB

1) In 12-channel measuring equipment; channel 13 unmodulated.
V_o = output level/signal, according to NCTA measuring standard.

APPLICATION INFORMATION (continued)

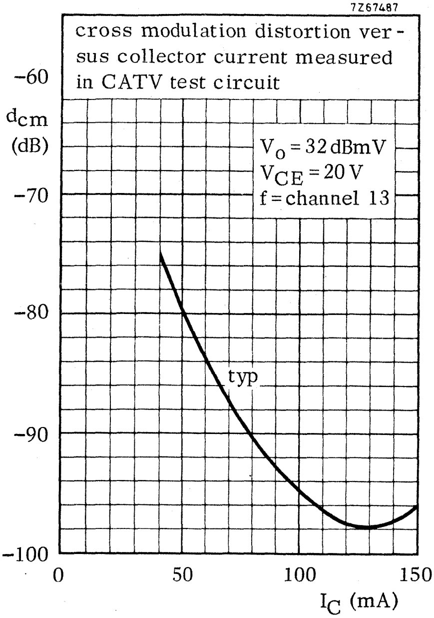
CATV test circuit

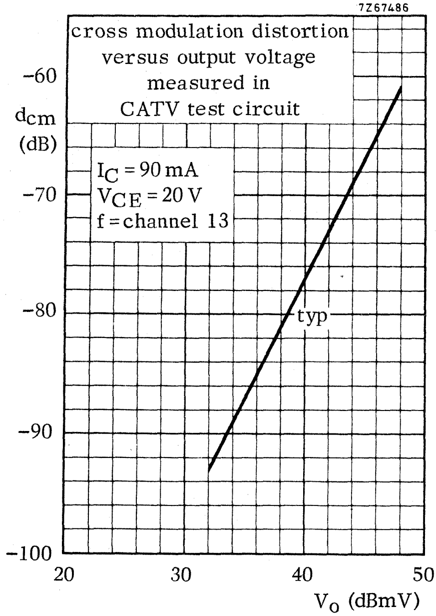


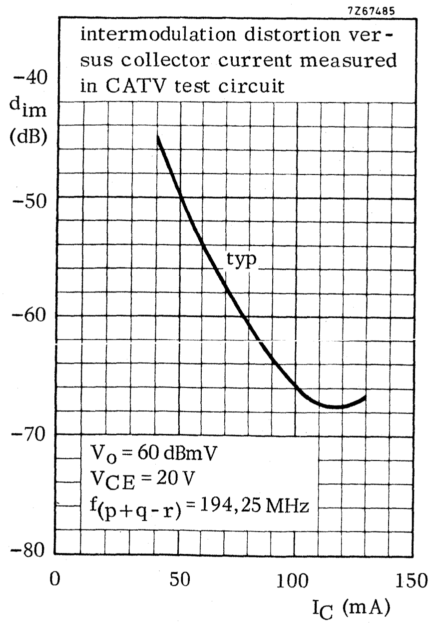
Frequency range 40 to 300 MHz (flatness gain ±0, 2 dB)			
Return losses input and output		<	−16 dB
Power gain	G_p	typ.	11 dB

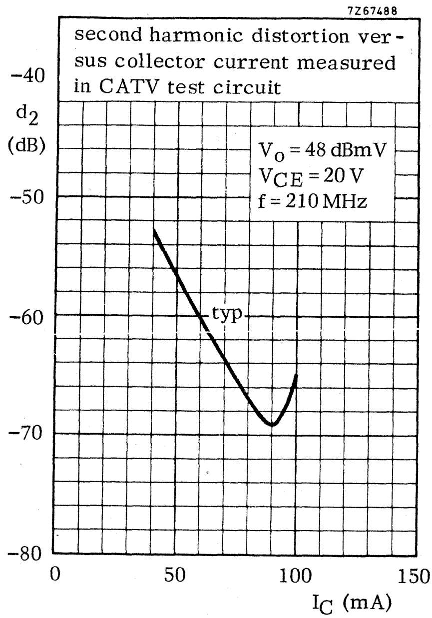
L1 = 2 turns closely wound enamelled Cu wire (0, 7 mm); int. diam. 3 mm
L2 = 5 μH ferroxcube coil (code number 3122 108 20153)
L3 = 5 turns closely wound enamelled Cu wire (0, 7 mm); int. diam. 4, 7 mm
L4 = 19 turns enamelled Cu wire (0, 3 mm) on ferroxcube core (code no. 4322 020 91001)

APPLICATION INFORMATION (continued)









SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in a TO-39 metal envelope with the collector connected to the case. These transistors are intended for general industrial applications.

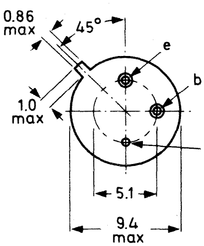
QUICK REFERENCE DATA

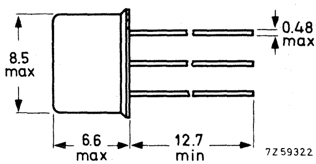
			BFS 92	BFS 93	BFS 94	BFS 95	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	100	100	80	40	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	60	40	35	V
Collector current (d.c.)	$-I_C$	max.	1,0	1,0	1,0	1,0	A
Total power dissipation up to T_{mb} = 50 °C	P_{tot}	max.	5	5	5	5	W
Junction temperature	T_j	max.	200	200	200	200	°C
Collector-emitter saturation voltage $-I_C$ = 500 mA; $-I_B$ = 50 mA	$-V_{CEsat}$	<	1,0	1,0	0,7	0,7	V
D.C. current gain $-I_C$ = 150 mA; $-V_{CE}$ = 10 V	h_{FE}	>	30	70	40	70	
Transition frequency at f = 35 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 10 V	f_T	typ.	70	70	70	70	MHz

MECHANICAL DATA

Dimensions in mm

TO-39
Collector connected to case





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

Accessories supplied on request: 56218; 56245

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

Voltages

			BFS 92	BFS 93	BFS 94	BFS 95	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	100	100	80	40	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	60	40	35	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	6	6	6	6	V

Currents

Collector current (d.c.)	$-I_C$	max.	1.0	A
Collector current (peak value)	$-I_{CM}$	max.	1.0	A
Emitter current (d.c.)	I_E	max.	1.0	A
Emitter current (peak value)	I_{EM}	max.	1.0	A
Reverse base current (peak value)	$+I_{BM}$	max.	100	mA

Power dissipation

Total power dissipation up to T_{mb} = 50 °C See page 6	P_{tot}	max.	5	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	$R_{th\ j\text{-}a}$	=	220	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	35	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	30	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

I_E = 0; $-V_{CB}$ = 80 V; T_j = 25 °C	BFS92; BFS93	$-I_{CBO}$	<	50	nA
T_j = 100 °C		$-I_{CBO}$	<	2.5	μA
I_E = 0; $-V_{CB}$ = 60 V; T_j = 25 °C	BFS94	$-I_{CBO}$	<	50	nA
T_j = 100 °C		$-I_{CBO}$	<	2.5	μA
I_E = 0; $-V_{CB}$ = 30 V; T_j = 25 °C	BFS95	$-I_{CBO}$	<	50	nA
T_j = 100 °C		$-I_{CBO}$	<	2.5	μA

Emitter cut-off current

I_C = 0; $-V_{EB}$ = 5 V; T_j = 25 °C	$-I_{EBO}$	<	50	nA
T_j = 100 °C	$-I_{EBO}$	<	2.5	μA

Saturation voltages

			BFS92	BFS93	BFS94	BFS95	
$-I_C$ = 10 mA; $-I_B$ = 1 mA	$-V_{CEsat}$	<	0.15	0.15	0.10	0.10	V
	$-V_{BEsat}$	<	1.2	1.2	1.2	1.2	V
$-I_C$ = 150 mA; $-I_B$ = 15 mA	$-V_{CEsat}$	<	0.35	0.35	0.20	0.20	V
	$-V_{BEsat}$	<	1.3	1.3	1.3	1.3	V
$-I_C$ = 500 mA; $-I_B$ = 50 mA	$-V_{CEsat}$	<	1.00	1.00	0.70	0.70	V
	$-V_{BEsat}$	<	1.5	1.5	1.5	1.5	V
$-I_C$ = 1 A; $-I_B$ = 100 mA	$-V_{CEsat}$	<	2.00	1.60	1.00	1.00	V
	$-V_{BEsat}$	<	2.0	2.0	2.0	2.0	V

D.C. current gain

			BFS92	BFS93	BFS94	BFS95
$-I_C$ = 10 mA; $-V_{CE}$ = 10 V	h_{FE}	>	20	50	30	50
$-I_C$ = 150 mA; $-V_{CE}$ = 10 V	h_{FE}	>	30	70	40	70
$-I_C$ = 500 mA; $-V_{CE}$ = 10 V	h_{FE}	>	20	30	25	30
$-I_C$ = 1 A; $-V_{CE}$ = 10 V	h_{FE}	>	15	15	15	15

Collector capacitance at f = 1 MHz

$I_E = I_e = 0$; $-V_{CB}$ = 10 V — C_c < 20 pF

Transition frequency at f = 35 MHz

$-I_C$ = 50 mA; $-V_{CE}$ = 10 V — f_T > 40 MHz; typ. 70 MHz

CHARACTERISTICS (continued)

h parameters at f = 1 kHz

$-I_C$ = 10 mA; $-V_{CE}$ = 5 V				
Input impedance	h_{ie}	typ.	300	Ω
Reverse voltage transfer ratio	h_{re}	typ.	70	10^{-6}
Small signal current gain	h_{fe}	typ.	100	
Output admittance	h_{oe}	typ.	• 60	$\mu\Omega^{-1}$
$-I_C$ = 1 mA; $-V_{CE}$ = 5 V				
Small signal current gain	h_{fe}	typ.	90	

Switching times (see also page 5)

Turn on time				
$-I_C$ = 150 mA; $-I_B$ = + I_{BM} = 15 mA				
delay time	t_d	typ.	20	ns
rise time	t_r	typ.	35	ns
Turn off time				
$-I_C$ = 150 mA; $-I_B$ = + I_{BM} = 15 mA				
storage time	t_s	typ.	500	ns
fall time	t_f	typ.	65	ns

MEASUREMENT OF SWITCHING TIMES

Fig. 1: Circuit diagram

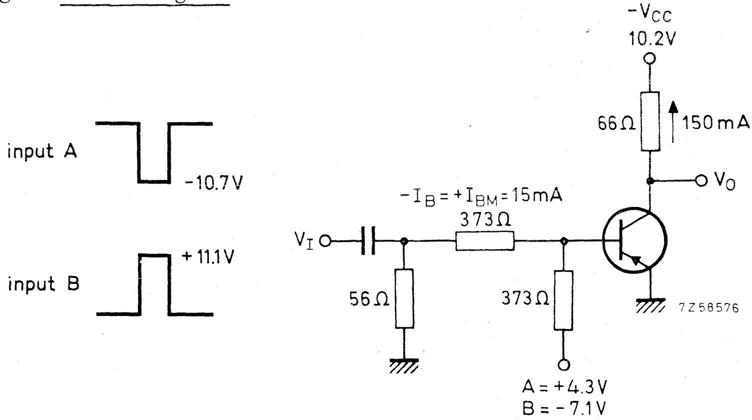
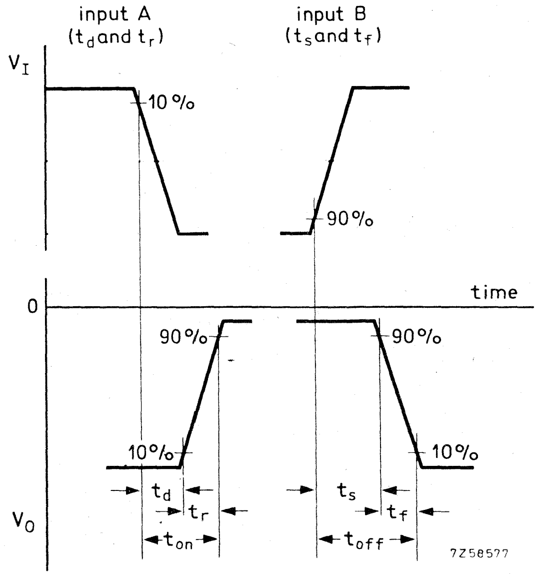
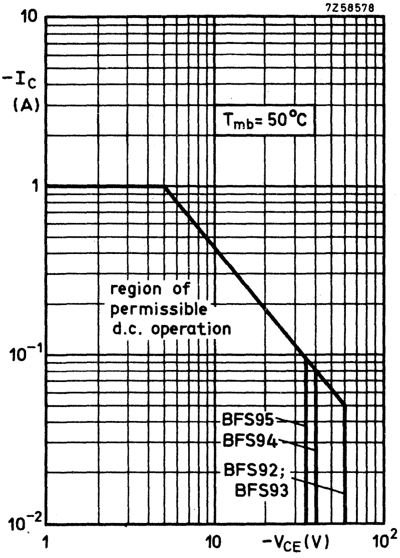


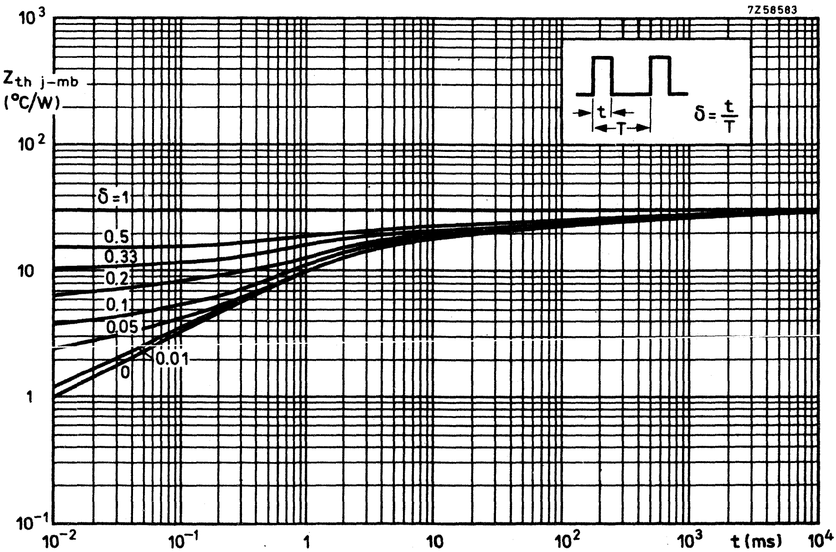
Fig. 2: Waveforms

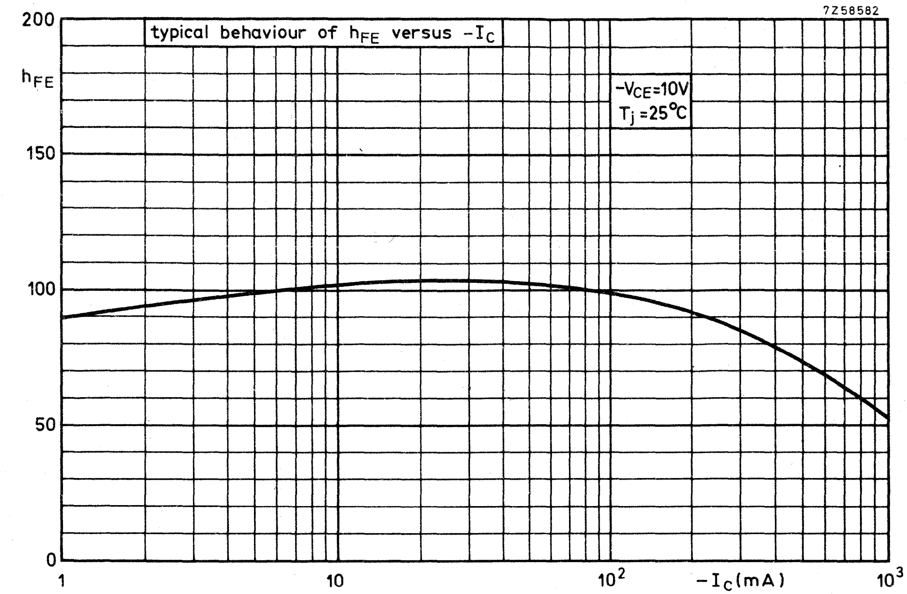


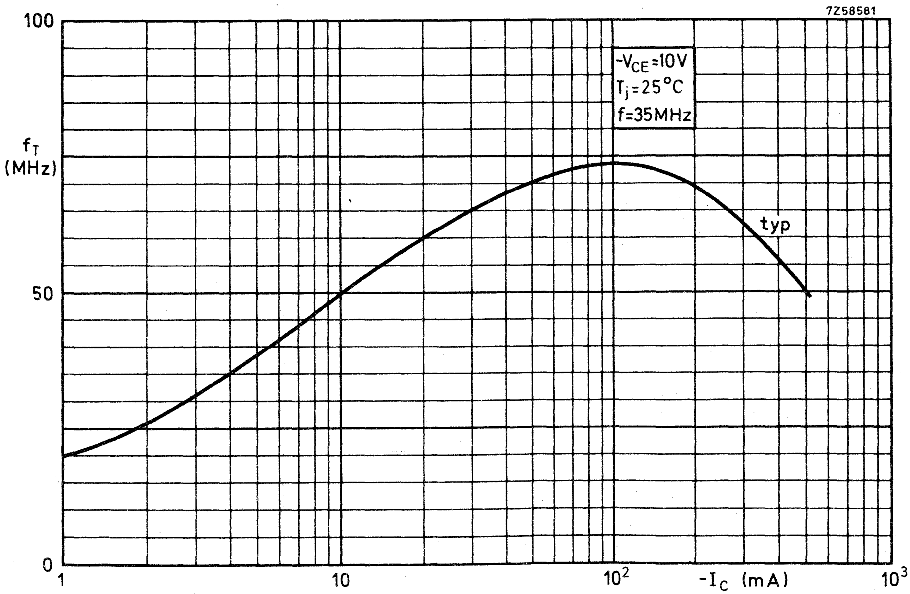
Equipment: Pulse generator (rise time = 1 ns)
Double beam or dual trace oscilloscope (rise time < 5 ns)

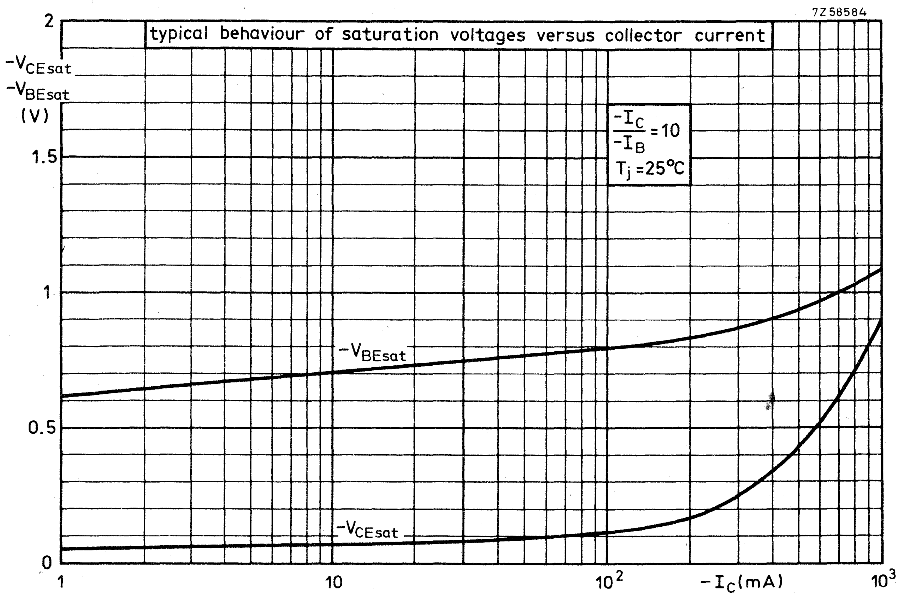


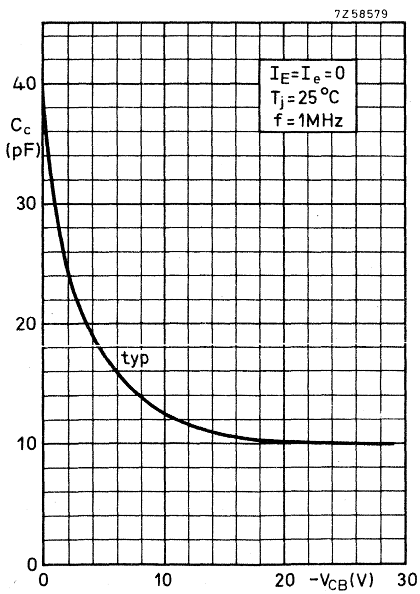
Safe Operating Area
with the transistor forward biased

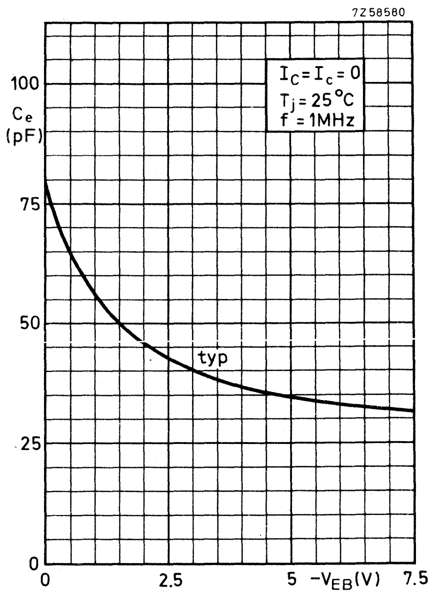



7Z58582
typical behaviour of hFE versus -IC
hFE
200
150
100
50
0
-VCE=10V
Tj =25°C
1
10
10²
-IC(mA)
10³


7Z58581
fT
(MHz)
100
50
0
-VCE=10V
Tj=25°C
f=35MHz
typ
1
10
10²
-IC (mA)
10³


7Z58584
typical behaviour of saturation voltages versus collector current
2
$-V_{CEsat}$
$-V_{BEsat}$
(V)
1.5
1
0.5
0
$\frac{-I_C}{-I_B} = 10$
$T_j = 25^\circ C$
$-V_{BEsat}$
$-V_{CEsat}$
1
10
10^2
$-I_C$ (mA)
10^3


7Z58579
40
C_c
(pF)
30
20
10
0
$I_E = I_e = 0$
$T_j = 25\,^\circ C$
f = 1MHz
typ
0
10
20
$-V_{CB}$ (V)
30


7Z58580
100
C_e
(pF)
75
50
25
0
$I_C = I_c = 0$
$T_j = 25\,^\circ C$
f = 1MHz
typ
0
2.5
5
$-V_{EB}$ (V)
7.5

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a subminiature plastic transfer-moulded T-package.
It is primarily intended for use in u.h.f. low power amplifiers such as in pocket phones, paging systems, etc.
The transistor features low current consumption (100 μA - 1 mA); thanks to its high transition frequency, it also has excellent wideband properties and low noise up to high frequencies.

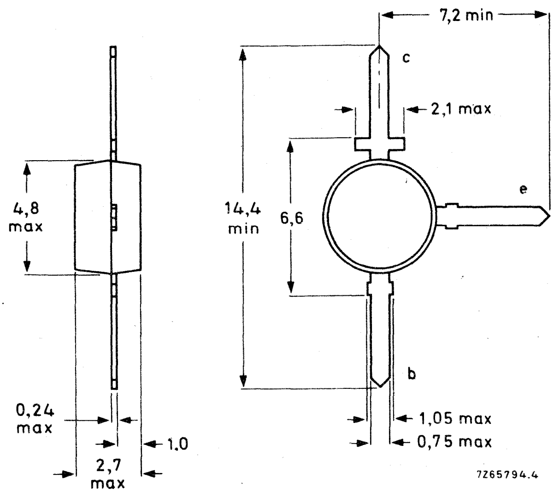
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	8	V
Collector-emitter voltage (open base)	V_{CEO}	max.	5	V
Collector current (d.c.)	I_C	max.	2,5	mA
Total power dissipation up to T_{amb} = 135 °C	P_{tot}	max.	30	mW
Junction temperature	T_j	max.	150	°C
Transition frequency at f = 500 MHz I_C = 1 mA; V_{CE} = 1 V	f_T	typ.	2,3	GHz
Feedback capacitance at f = 1 MHz I_C = 1 mA; V_{CE} = 1 V; T_{amb} = 25 °C	C_{re}	<	0,4	pF
Noise figure at optimum source impedance I_C = 1 mA; V_{CE} = 1 V; f = 500 MHz; T_{amb} = 25 °C	F	typ.	3,8	dB
Max. unilateral power gain (see page 3) I_C = 1 mA; V_{CE} = 1 V; f = 500 MHz; T_{amb} = 25 °C	G_{UM}	typ.	17	dB

MECHANICAL DATA

Dimensions in mm

SOT-37



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

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	8	V
Collector-emitter voltage (open base)	V_{CEO}	max.	5	V
Emitter-base voltage (open collector)	V_{EBO}	max.	2	V

Current

Collector current (d.c.)	I_C	max.	2,5	mA
Collector current (peak value; f > 1 MHz)	I_{CM}	max.	5,0	mA

Power dissipation

Total power dissipation up to T_{amb} = 135 °C	P_{tot}	max.	30	mW

Temperatures

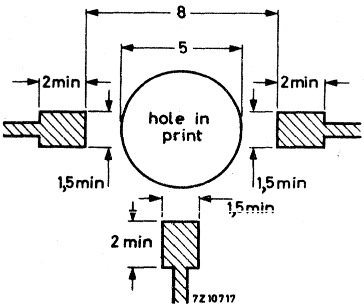
Storage temperature	T_{stg}	-65 to +150		°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air mounted on a glass-fibre print *) of 40 mm x 25 mm x 1 mm	$R_{th\ j-a}$	=	0,5	°C/mW

*) Requirements for glass-fibre print

(dimensions in mm)



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

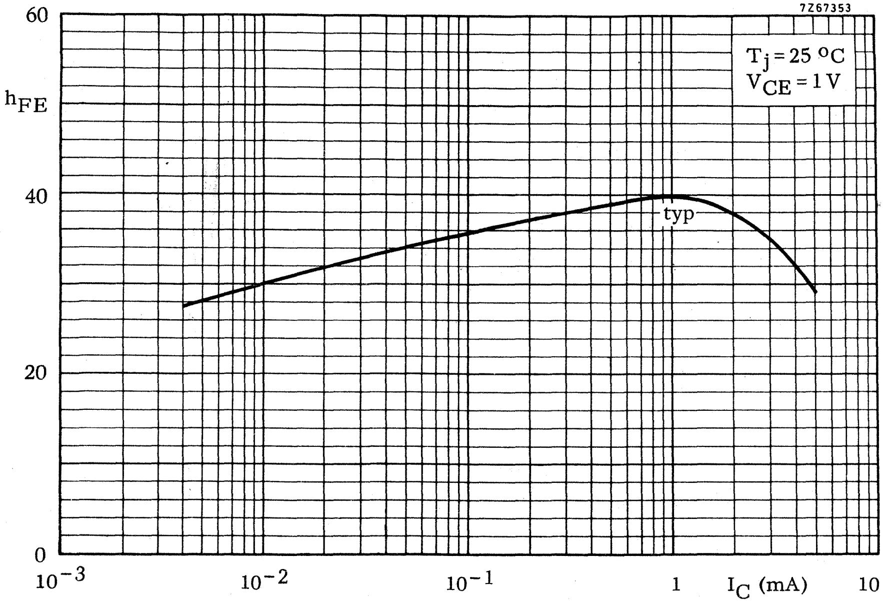
Collector cut-off current				
$I_E = 0$; $V_{CB} = 5$ V	I_{CBO}	<	50	nA
D.C. current gain [1]				
$I_C = 10\ \mu A$; $V_{CE} = 1$ V	h_{FE}	>	20	
		typ.	30	
$I_C = 1$ mA; $V_{CE} = 1$ V	h_{FE}	>	20	
		typ.	40	
Saturation voltages				
$I_C = 10\ \mu A$; $I_B = 1\ \mu A$	V_{CEsat}	<	100	mV
	V_{BEsat}	<	700	mV
$I_C = 1$ mA; $I_B = 0{,}1$ mA	V_{CEsat}	<	125	mV
	V_{BEsat}	<	850	mV
Transition frequency at f = 500 MHz [1]				
$I_C = 1$ mA; $V_{CE} = 1$ V	f_T	>	1,2	GHz
		typ.	2,3	GHz
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 0{,}5$ V	C_c	<	0,55	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 0$	C_e	<	0,45	pF
Feedback capacitance at f = 1 MHz				
$I_C = 1$ mA; $V_{CE} = 1$ V; $T_{amb} = 25\ ^oC$	C_{re}	<	0,4	pF
Noise figure at optimum source impedance				
$I_C = 0{,}1$ mA; $V_{CE} = 1$ V; f = 500 MHz; $T_{amb} = 25\ ^oC$	F	typ.	5,5	dB
$I_C = 1$ mA; $V_{CE} = 1$ V; f = 500 MHz; $T_{amb} = 25\ ^oC$	F	typ.	3,8	dB

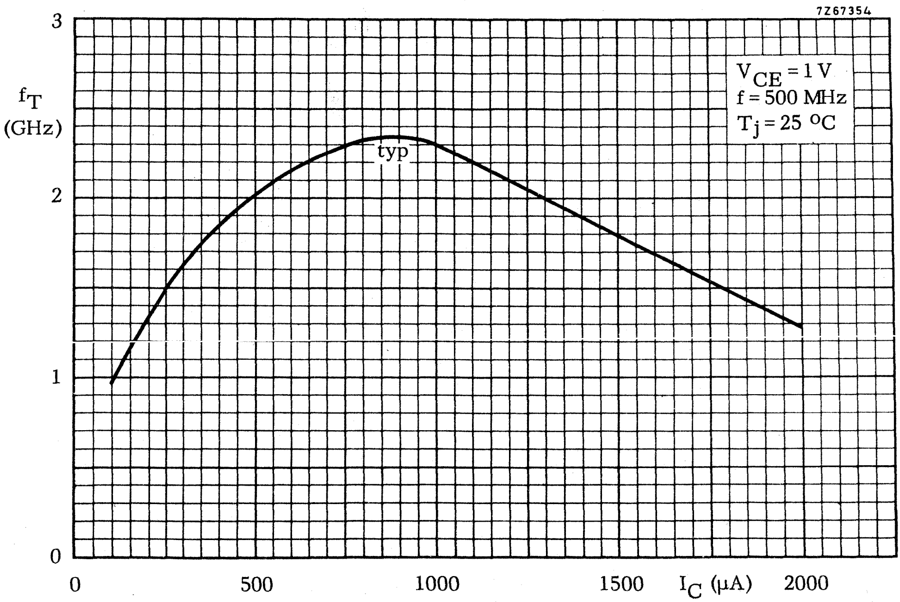
Max. unilateral power gain (s_{re} assumed to be zero)

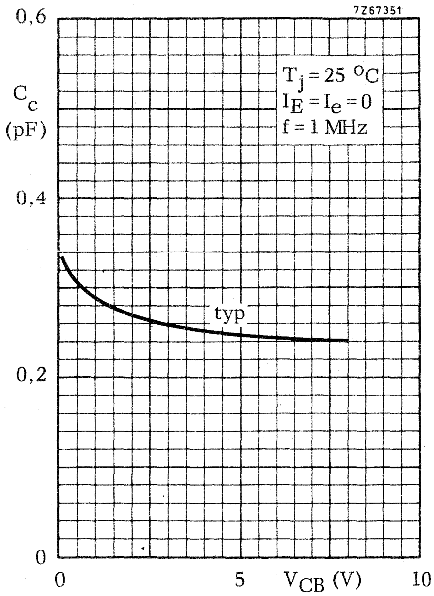
$$G_{UM}\ (\text{in dB}) = 10 \log \frac{|s_{fe}|^2}{(1 - |s_{ie}|^2)(1 - |s_{oe}|^2)}$$

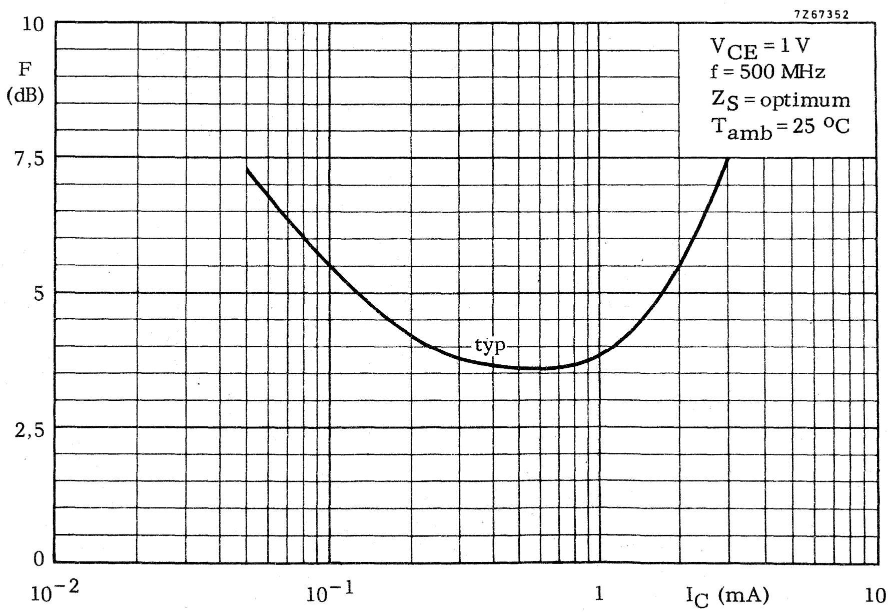
$I_C = 1$ mA; $V_{CE} = 1$ V; f = 200 MHz; $T_{amb} = 25\ ^oC$	G_{UM}	typ.	24	dB
$I_C = 1$ mA; $V_{CE} = 1$ V; f = 500 MHz; $T_{amb} = 25\ ^oC$	G_{UM}	typ.	17	dB
$I_C = 1$ mA; $V_{CE} = 1$ V; f = 800 MHz; $T_{amb} = 25\ ^oC$	G_{UM}	typ.	11	dB

1) Measured under pulse conditions.

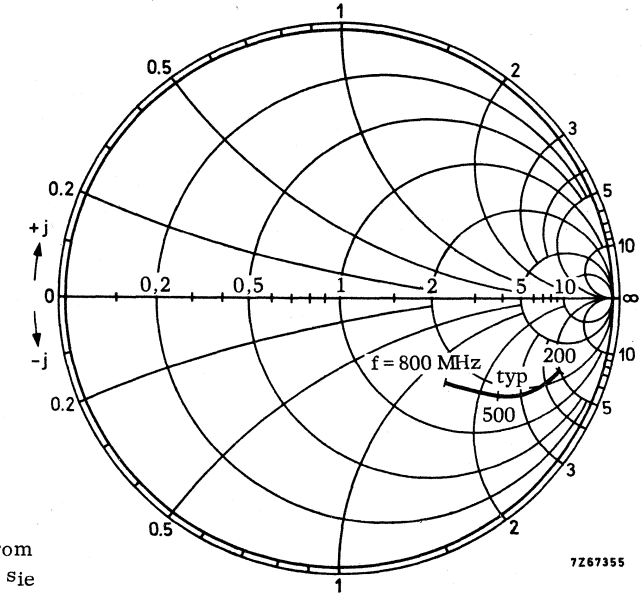

7Z67353
60
40
20
0
h_{FE}
$T_j = 25\ ^oC$
$V_{CE} = 1\ V$
typ
10^{-3}
10^{-2}
10^{-1}
1
I_C (mA)
10


7Z67354
3
2
1
0
f_T
(GHz)
$V_{CE} = 1\ V$
f = 500 MHz
$T_j = 25\ ^oC$
typ
0
500
1000
1500
I_C (μA)
2000


7Z67351
0,6
0,4
0,2
0
C_c
(pF)
$T_j = 25\ ^oC$
$I_E = I_e = 0$
f = 1 MHz
typ
0
5
V_{CB} (V)
10

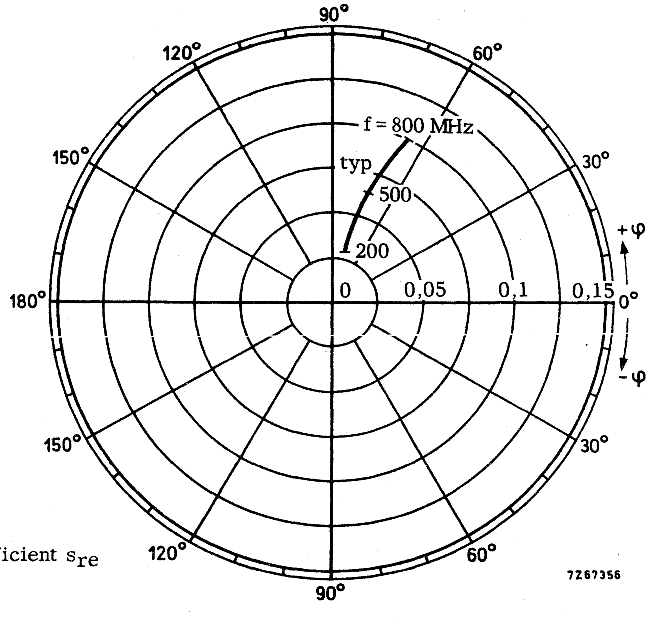

7Z67352
10
7,5
5
2,5
0
F
(dB)
$V_{CE} = 1\ V$
f = 500 MHz
Z_S = optimum
$T_{amb} = 25\ ^oC$
typ
10^{-2}
10^{-1}
1
I_C (mA)
10

V_{CE} = 1 V
I_C = 1 mA
T_{amb} = 25 °C



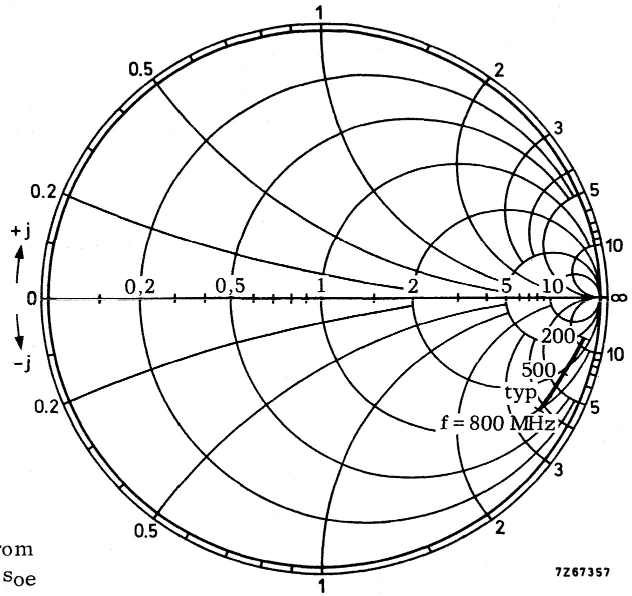
Input impedance derived from input reflection coefficient s_{ie} coordinates in ohm x 50

V_{CE} = 1 V
I_C = 1 mA
T_{amb} = 25 °C



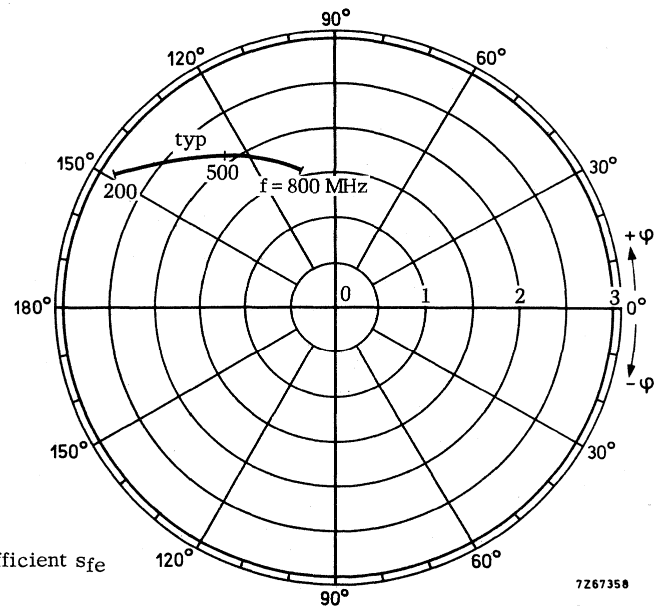
Reverse transmission coefficient s_{re}

V_{CE} = 1 V
I_C = 1 mA
T_{amb} = 25 °C



Output impedance derived from output reflection coefficient s_{oe} coordinates in ohm x 50

V_{CE} = 1 V
I_C = 1 mA
T_{amb} = 25 °C



Forward transmission coefficient s_{fe}

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N multi-emitter transistor in a TO-39 metal envelope, with the collector connected to the case. The transistor has extreme good intermodulation properties and a high power gain. It is a ruggedized version of the BFW16, which it succeeds. It is primarily intended for:

- Final and driver stages of channel- and band aerial amplifiers with high output power for band I, II, III and IV/V (40-860 MHz).
- Final stage of the wide band vertical amplifier in high speed oscilloscopes.

QUICK REFERENCE DATA

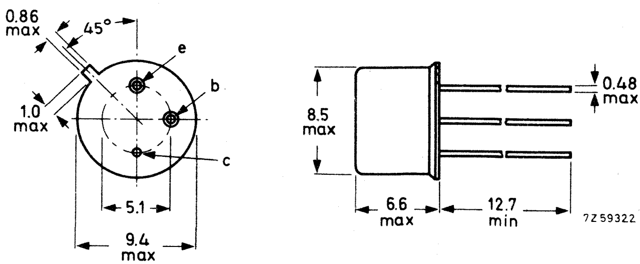
Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.		40	V
Collector-emitter voltage (open base)	V_{CEO}	max.		25	V
Collector current (peak value; f > 1 MHz)	I_{CM}	max.		300	mA
Total power dissipation up to T_{mb} = 125 °C	P_{tot}	max.		1.5	W
Junction temperature	T_j	max.		200	°C
Feedback capacitance at f = 1 MHz; I_C = 10 mA; V_{CE} = 15 V	C_{re}	typ.		1.7	pF
Transition frequency; I_C = 150 mA; V_{CE} = 15 V; f = 500 MHz	f_T	typ.		1.2	GHz
		f =	200	800	MHz
Power gain (not neutralized); I_C = 70 mA; V_{CE} = 18 V	G_p	typ.	16	6.5	dB
Output power; d_{im} = −30 dB; V.S.W.R. at output <2; I_C = 70 mA; V_{CE} = 18 V	P_o	typ.	150	90	mW

MECHANICAL DATA

Dimensions in mm

Collector connected to case

TO-39



Accessories available: 56218; 56245.

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

Voltages

Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	40	V
Collector-emitter voltage ($R_{BE} \leq 50\ \Omega$) peak value	V_{CERM}	max.	40	V [1]
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V [1]
Emitter-base voltage (open collector)	V_{EBO}	max.	2	V

Currents

Collector current (d.c.)	I_C	max.	150	mA
Collector current (peak value; f > 1 MHz)	I_{CM}	max.	300	mA

Power dissipation

Total power dissipation up to T_{mb} = 125 °C	P_{tot}	max.	1.5	W

Temperatures

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

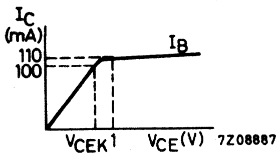
THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	250	°C/W
From junction to mounting base	$R_{th\ j-mb}$	=	50	°C/W
From mounting base to heatsink mounted with top clamping washer of 56218 and a boron nitride washer for electrical insulation	$R_{th\ mb-h}$	=	1.2	°C/W

[1] I_C = 10 mA.

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}	<	20	μA
Knee voltage				
I_C = 100 mA; I_B = value for which I_C = 110 mA at V_{CE} = 1 V	V_{CEK}	<	0.75	V



D.C. current gain					
I_C = 50 mA; V_{CE} = 5 V	h_{FE}	>	25		
I_C = 150 mA; V_{CE} = 5 V	h_{FE}	>	25		
Transition frequency					
I_C = 150 mA; V_{CE} = 15 V; f = 500 MHz	f_T	typ.	1.2	GHz	
Collector capacitance at f = 1 MHz					
$I_E = I_e$ = 0; V_{CB} = 15 V	C_c	<	4	pF	
Feedback capacitance at f = 1 MHz					
I_C = 10 mA; V_{CE} = 15 V; T_{amb} = 25 °C	C_{re}	typ.	1.7	pF	
Noise figure at f = 200 MHz					
I_C = 30 mA; V_{CE} = 15 V; R_S = 75 Ω; T_{amb} =25 °C	F	<	6	dB	
Power gain (not neutralized)		f = 200		800	MHz
I_C = 70 mA; V_{CE} = 18 V; T_{amb} = 25 °C	G_p	typ. 16		6.5	dB

CHARACTERISTICS (continued)

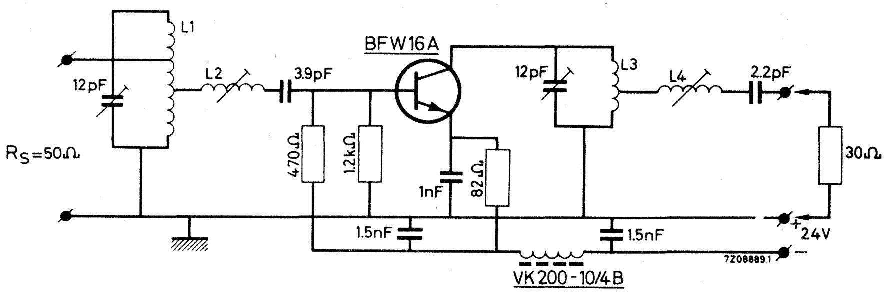
Intermodulation characteristics

1. Output power at f = 200 MHz; T_{amb} = 25 °C

I_C = 70 mA; V_{CE} = 18 V; V.S.W.R. at output < 2
f_p = 202 MHz; f_q = 205 MHz; d_{im} = −30 dB
measured at $f_{(2q-p)}$ = 208 MHz (Channel 9)

P_o	>	130	mW
	typ.	150	mW

Test circuit:



Coil data:

L1 = 3 turns silver plated Cu wire (1.4 mm); winding pitch 2.7 mm; int. diam. 8 mm; taps at 0.5 turn and 1.5 turns from earth.
L2 = 5.5 turns silver plated Cu wire (1.4 mm); winding pitch 2.2 mm; int. diam. 8 mm.
L3 = 3 turns silver plated Cu wire (1.4 mm); winding pitch 3.3 mm; int. diam. 8 mm.
L4 = 5.5 turns silver plated Cu wire (1.4 mm); winding pitch 2.2 mm; int. diam. 11 mm.

CHARACTERISTICS (continued)

Basis of adjustment

The intermodulation at an intermodulation distortion of −30 dB is caused by h.f. output current - voltage clipping.
The maximum undistorted output power is realised, if

a. Current and voltage clipping take place concurrently.
This occurs if

$$R_L = \frac{V_{CE} - V_{CEK}}{I_C},$$

in which V_{CEK} is the high frequency knee voltage.

b. The h.f. collector current is as small as possible.
This is so if $-C_L = +C_{oe}$,
in which C_{oe} is the output capacitance of the transistor at short circuited input.

For maximum output power at an intermodulation distortion of −30 dB, the (experimentally found) values of R_L and C_L are:
$R_L = 220\ \Omega$; $C_L = -5.6$ pF.

C_{oe} is found by 4 pF of the transistor and 1.6 pF by the mounting system concerning of a borium nitride washer between the envelope of the transistor and the chassis. See also page 10, note 1.

Adjustment procedure

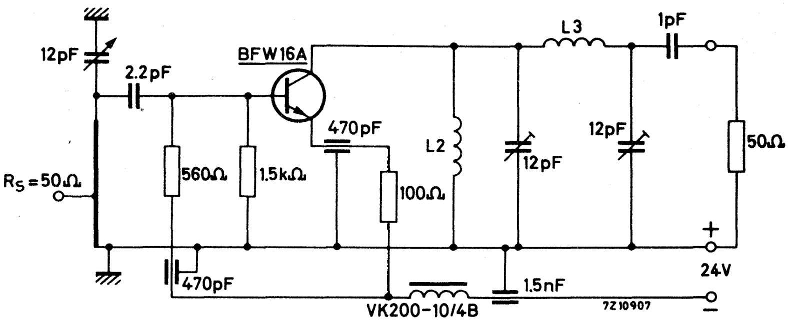
1. Remove the transistor and connect a dummy consisting of a 220 Ω resistor in parallel with a 5.6 pF capacitor between the collector and emitter connections of the output circuit.
2. Tune and match the output circuit for zero reflection at 205 MHz (V.S.W.R. = 1). After this adjustment, no further change may be made in the output circuit.
3. Replace the dummy by the transistor. Tune and match the input circuit for maximum power gain and good band pass curve.
The V.S.W.R. of the output will then, in most cases, be ≤ 2 over the whole channel.
Corrections can be made by tuning L2; this will not disturb the band pass curve.

CHARACTERISTICS (continued)

Intermodulation characteristics

2. Output power at f = 800 MHz; T_{amb} = 25 °C
I_C = 70 mA; V_{CE} = 18 V; V.S.W.R. at output < 2
f_p = 798 MHz; f_q = 802 MHz; d_{im} = −30 dB
measured at $f_{(2q-p)}$ = 806 MHz (Channel 62) — P_o > 70 mW, typ. 90 mW

Test circuit:



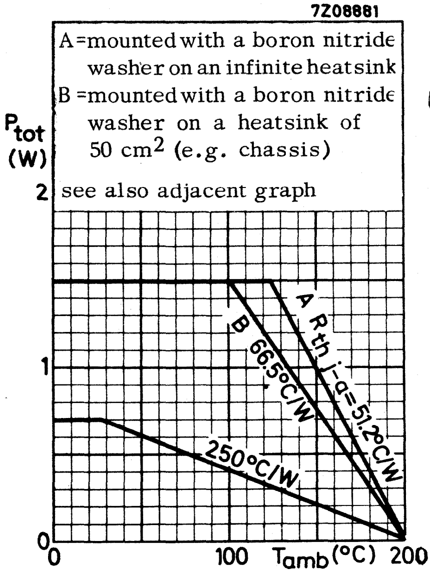
Coil data:
L1 = 25 mm x 7 mm x 0.85 mm silver plated Cu strip
Tap of the input at 5 mm from earth.
L2 = 13 turns enamelled Cu wire (0.6 mm); int. diam. 8 mm
L3 = 1.5 turns Cu wire (1.3 mm); int. diam. 8 mm

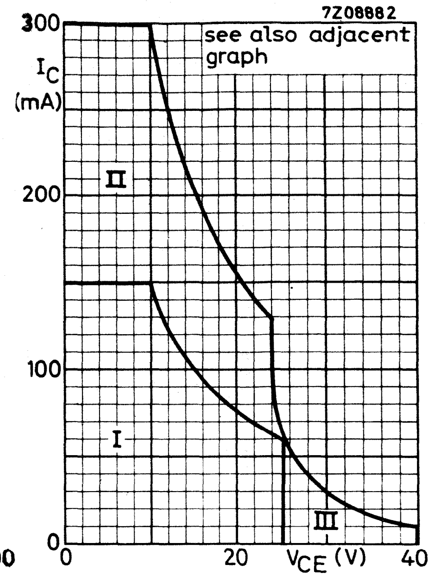
Basis of adjustment

At 800 MHz no dummy can be used to adjust for optimum collector load because at these frequencies the impedance transformations of a dummy are too high. A small signal at the mid-channel frequency of 802 MHz is fed to the input and increased until clipping occurs; that is, until the output power no longer increases linearly with the input signal. This clipping can be eliminated by tuning the output circuit, thereby making the output power equal to

$$P_o = \frac{I_C(V_{CE} - V_{CEK})}{2} = 480 \text{ mW}.$$

The output circuit is adjusted for minimum intermodulation if the input signal is as small as possible at P_o = 480 mW.
With this adjusting method care must be taken, that the transistor is not destructed by second breakdown (the voltage swing may not exceed the rated V_{CER} value). Therefore as soon as clipping occurs, the increase of the input signal should be stopped until the clipping has been eliminated. After this adjustment has been made no further change may be made in the output circuit.
Adjust the input circuit for maximum power gain and good band pass curve. The V.S.W.R. of the output is then ≤ 2 over the whole channel.

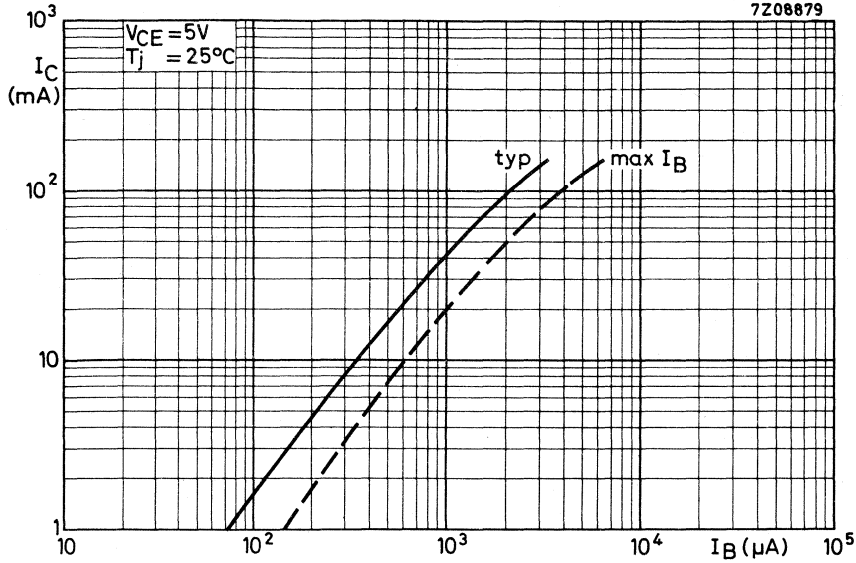


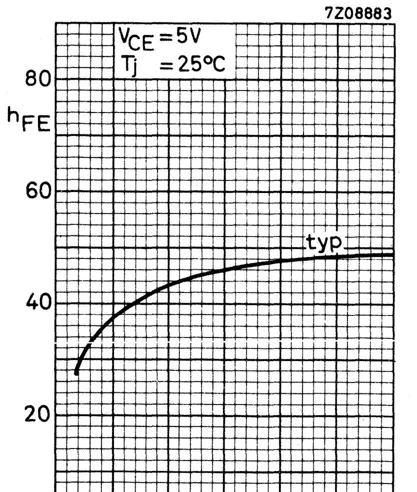


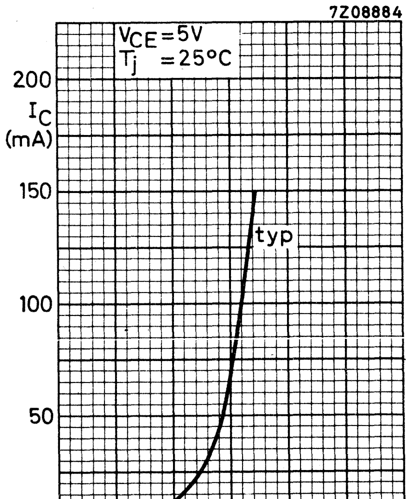
I = Region of permissible operation under all base-emitter conditions and at all frequencies, including d.c.

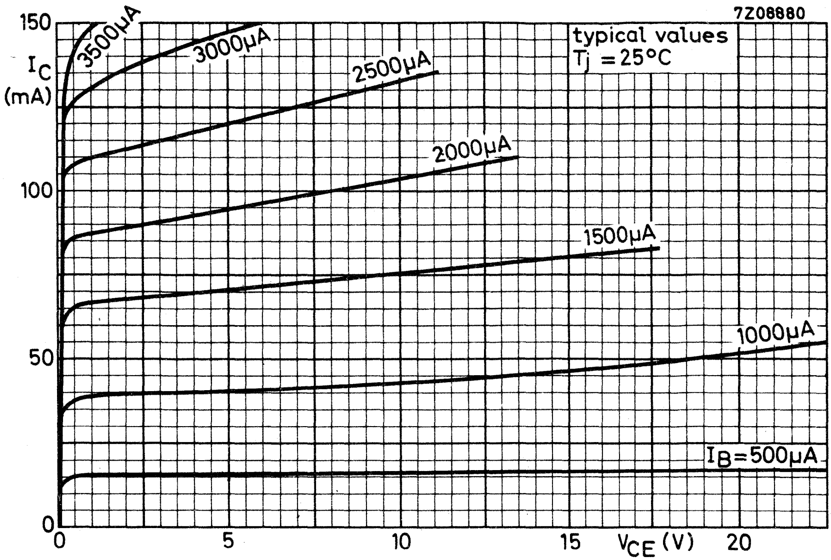
II = Additional region of operation at f $\geq$ 1 MHz.

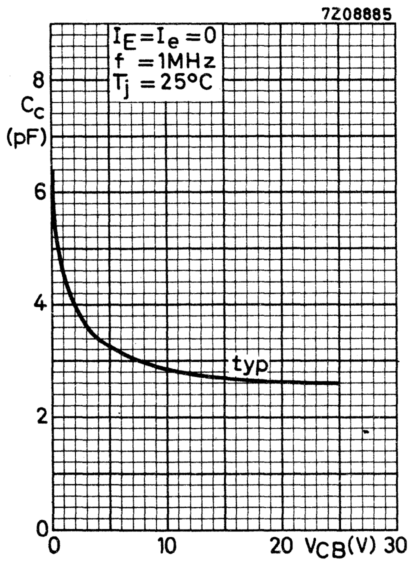
III = Operating under pulsed conditions is allowed, provided the transistor is cut-off with $R_{BE} \leq 50\ \Omega$ and f $\geq$ 1 MHz.

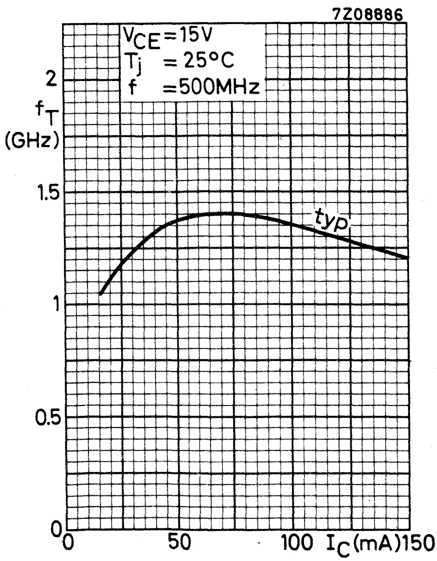

7Z08879
$V_{CE} = 5V$
$T_j = 25°C$
I_C (mA)
typ
max I_B
I_B (μA)
10
10^2
10^3
10^4
10^5
1
10
10^2
10^3


7Z08883
$V_{CE} = 5V$
$T_j = 25°C$
h_{FE}
typ
I_C(mA)
0
50
100
150
0
20
40
60
80


7Z08884
$V_{CE} = 5V$
$T_j = 25°C$
I_C (mA)
typ
V_{BE}(mV)
700
800
900
0
50
100
150
200


7Z08880
typical values
Tj = 25°C
IC (mA)
150
100
50
0
3500μA
3000μA
2500μA
2000μA
1500μA
1000μA
IB=500μA
0
5
10
15
VCE (V)
20


7Z08885
IE = Ie = 0
f = 1MHz
Tj = 25°C
Cc (pF)
8
6
4
2
0
typ
0
10
20
VCB(V)
30


7Z08886
VCE = 15V
Tj = 25°C
f = 500MHz
fT (GHz)
2
1.5
1
0.5
0
typ
0
50
100
IC (mA)
150

APPLICATION INFORMATION

Performance of channel- and band amplifiers [1])

Frequency range	channel 4 61-68	channel 9 202-209	channel 55 742-750	band I 47-68	band II 87.5-108	band III 174-230	MHz
Transistor used in							
final stage	BFW16A	BFW16A	BFW16A	BFW16A	BFW16A	BFW16A	
driver stage		BFW16A	BFW16A			BFW16A	
second stage			BFY90				
first stage	BFY90	BFY90	BFY90	BFY90	BFY90	BFY90	
Output power at							
d_{im} = −30 dB	150 [2])	150 [2])	100				mW
d_{im} = −50 dB					30		mW
d_{im} = −60 dB				10		10	mW
Power gain	50	44	26.5	51	43	39	dB
Noise figure	7	6	8	6.0-6.5	6.5	6.5	dB
V.S.W.R. over the whole channel or band							
for the input	< 2	< 2	< 2	< 2	< 2	< 2	
for the output	< 2	< 2	< 2	< 2	< 2	< 2	
Load impedance	30	30	50	30	30	30	Ω
Source impedance	60	60	50	60	60	60	Ω

1) Application information bulletins of all these amplifiers and a study of intermodulation are available on request.

2) V_o = 2.2 V over R_L = 30 Ω or
V_o = 3 V over R_L = 60 Ω.

SILICON PLANAR EPITAXIAL TRANSISTOR

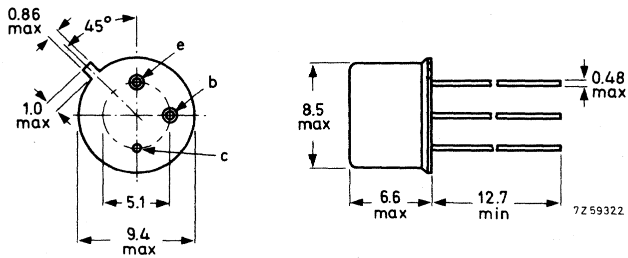
N-P-N multi-emitter transistor in a TO-39 metal envelope, with the collector connected to the case. The transistor has extreme good intermodulation properties and a high power gain. It is a ruggedized version of the BFW17, which it succeeds.
It is primarily intended for final and driver stages of channel- and band aerial amplifiers with high output power for band I; II and III (40 - 230 MHz).

QUICK REFERENCE DATA				
Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Collector current (peak value; f > 1 MHz)	I_{CM}	max.	300	mA
Total power dissipation up to T_{mb} = 125 °C	P_{tot}	max.	1.5	W
Junction temperature	T_j	max.	200	°C
Feedback capacitance at f = 1 MHz I_C = 10 mA; V_{CE} = 15 V	C_{re}	typ.	1.7	pF
Transition frequency I_C = 150 mA; V_{CE} = 15 V; f = 500 MHz	f_T	typ.	1.1	GHz
Power gain (not neutralized) I_C = 70 mA; V_{CE} = 18 V; f = 200 MHz	G_p	typ.	16	dB
Output power d_{im} = −30 dB; V.S.W.R. at output < 2 I_C = 70 mA; V_{CE} = 18 V	P_o	typ.	150	mW

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-39



Accessories available: 56218; 56245.

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

Voltages

Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	40	V	
Collector-emitter voltage ($R_{BE} \leq 50\ \Omega$) peak value	V_{CERM}	max.	40	V	1)
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V	1)
Emitter-base voltage (open collector)	V_{EBO}	max.	2	V	

Currents

Collector current (d.c.)	I_C	max.	150	mA
Collector current (peak value; f > 1 MHz)	I_{CM}	max.	300	mA

Power dissipation

Total power dissipation up to T_{mb} = 125 °C	P_{tot}	max.	1.5	W

Temperatures

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

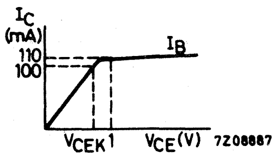
THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	250	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	50	°C/W
From mounting base to heatsink mounted with top clamping washer of 56218 and a boron nitride washer for electrical insulation	$R_{th\ mb\text{-}h}$	=	1.2	°C/W

1) I_C = 10 mA.

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}	<	20	μA
Knee voltage				
$I_C = 100$ mA; I_B = value for which				
$I_C = 110$ mA at $V_{CE} = 1$ V	V_{CEK}	<	0.75	V



D.C. current gain				
$I_C = 50$ mA; $V_{CE} = 5$ V	h_{FE}	>	25	
$I_C = 150$ mA; $V_{CE} = 5$ V	h_{FE}	>	25	
Transition frequency				
$I_C = 150$ mA; $V_{CE} = 15$ V; f = 500 MHz	f_T	typ.	1.1	GHz
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 15$ V	C_c	<	4	pF
Feedback capacitance at f = 1 MHz				
$I_C = 10$ mA; $V_{CE} = 15$ V; $T_{amb} = 25$ °C	C_{re}	typ.	1.7	pF
Power gain (not neutralized)				
$I_C = 70$ mA; $V_{CE} = 18$ V f = 200 MHz; $T_{amb} = 25$ °C	G_p	typ.	16	dB

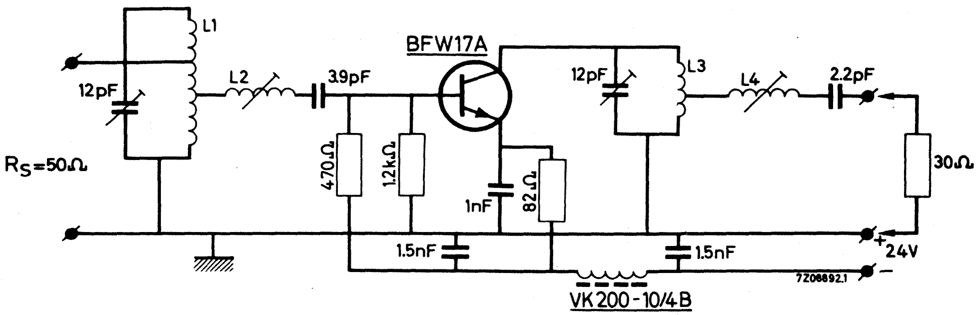
CHARACTERISTICS (continued)

Intermodulation characteristics

1. Output power at f = 200 MHz; T_{amb} = 25 °C

   I_C = 70 mA; V_{CE} = 18 V; V.S.W.R. at output < 2
   f_p = 202 MHz; f_q = 205 MHz; d_{im} = −30 dB
   measured at $f_{(2q-p)}$ = 208 MHz (Channel 9) | P_o | typ. 150 | mW

   Test circuit:



Coil data:

L1 = 3 turns silver plated Cu wire (1.4 mm); winding pitch 2.7 mm; int. diam. 8 mm; taps at 0.5 turn and 1.5 turns from earth.
L2 = 5.5 turns silver plated Cu wire (1.4 mm); winding pitch 2.2 mm; int. diam. 8 mm.
L3 = 3 turns silver plated Cu wire (1.4 mm); winding pitch 3.3 mm; int. diam. 8 mm.
L4 = 5.5 turns silver plated Cu wire (1.4 mm); winding pitch 2.2 mm; int. diam. 11 mm.

CHARACTERISTICS (continued)

Basis of adjustment

The intermodulation at an intermodulation distortion of −30 dB is caused by h.f. output current - voltage clipping.
The maximum undistorted output power is realised, if

a. Current and voltage clipping take place concurrently.
   This occurs if

$$R_L = \frac{V_{CE} - V_{CEK}}{I_C}$$

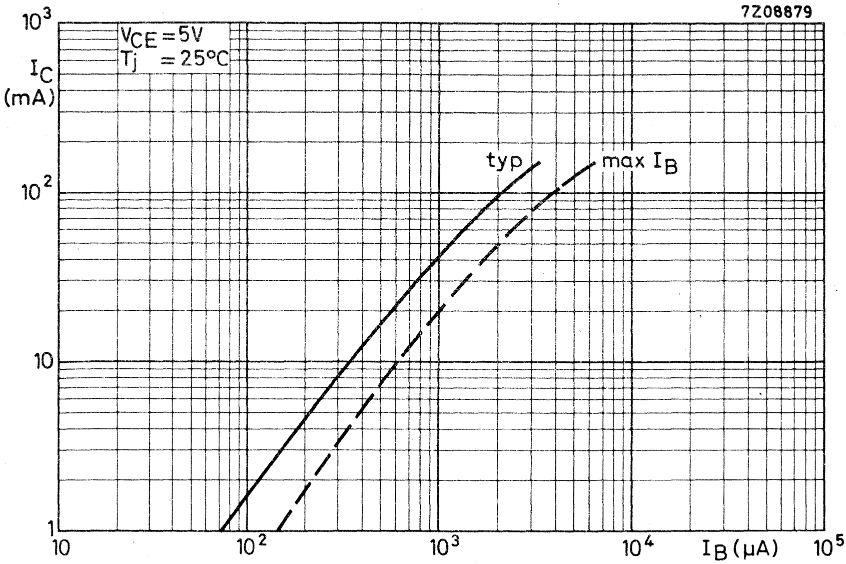
   in which V_{CEK} is the high frequency knee voltage.

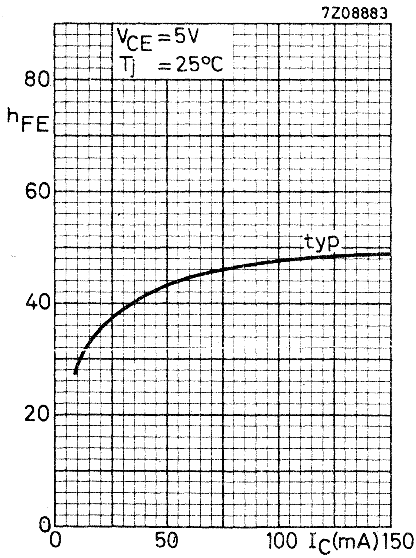
b. The h.f. collector current is as small as possible.
   This is so if $-C_L = +C_{oe}$,
   in which C_{oe} is the output capacitance of the transistor at short circuited input.

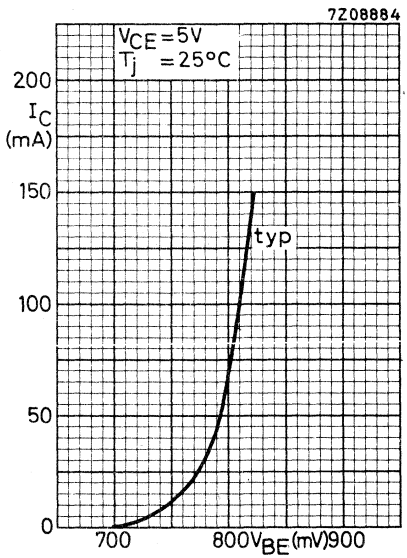
For maximum output power at an intermodulation distortion of −30 dB, the (experimentally found) values of R_L and C_L are:
$R_L = 220\ \Omega$; $C_L = -5.6$ pF.
C_{oe} is found by 4 pF of the transistor and 1.6 pF by the mounting system concerning of a borium nitride washer between the envelope of the transistor and the chassis.

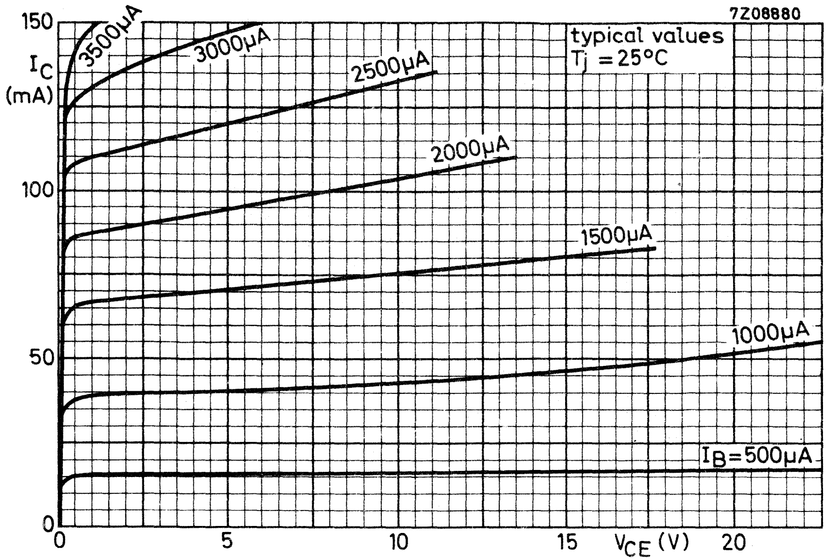
Adjustment procedure

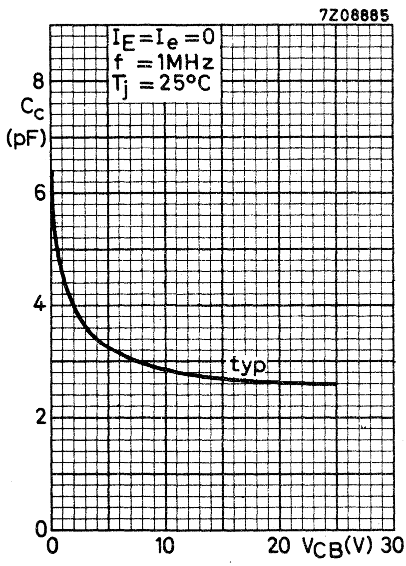
1. Remove the transistor and connect a dummy consisting of a 220 Ω resistor in parallel with a 5.6 pF capacitor between the collector and emitter connections of the output circuit.
2. Tune and match the output circuit for zero reflection at 205 MHz (V.S.W.R. = 1). After this adjustment, no further change may be made in the output circuit.
3. Replace the dummy by the transistor. Tune and match the input circuit for maximum power gain and good band pass curve.
   The V.S.W.R. of the output will then, in most cases, be ≤ 2 over the whole channel.
   Corrections can be made by tuning L2; this will not disturb the band pass curve.

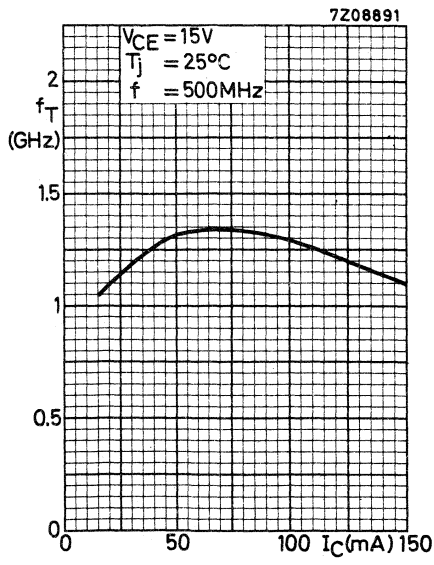

7Z08879
$V_{CE} = 5V$
$T_j = 25°C$
I_C (mA)
10^3
10^2
10
1
typ
max I_B
10
10^2
10^3
10^4
I_B (μA)
10^5

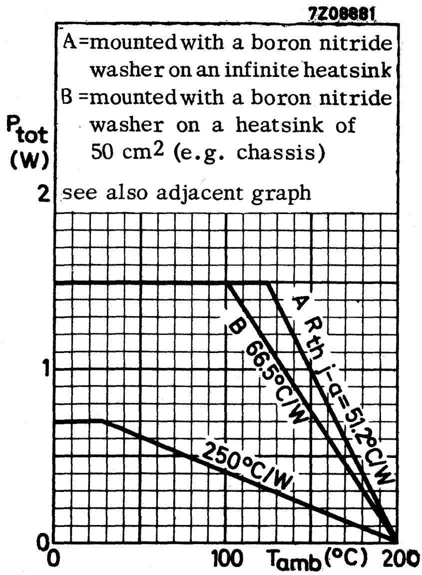

7Z08883
$V_{CE} = 5V$
$T_j = 25°C$
h_{FE}
80
60
40
20
0
typ
0
50
100
I_C (mA)
150

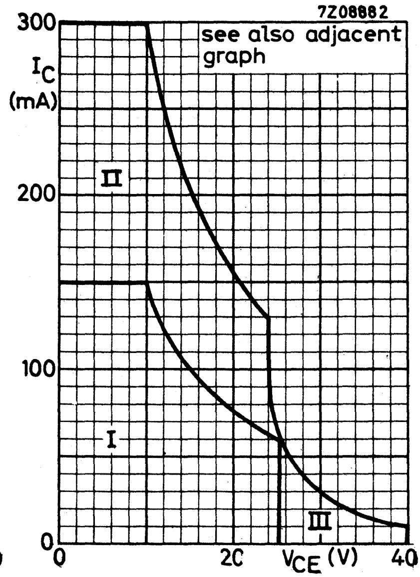

7Z08884
$V_{CE} = 5V$
$T_j = 25°C$
I_C (mA)
200
150
100
50
0
typ
700
800
V_{BE} (mV)
900


7Z08880
typical values
Tj = 25°C
IC
(mA)
150
100
50
0
3500µA
3000µA
2500µA
2000µA
1500µA
1000µA
IB = 500µA
0
5
10
15
VCE (V)
20


7Z08885
IE = Ie = 0
f = 1MHz
Tj = 25°C
Cc
(pF)
8
6
4
2
0
typ
0
10
20
VCB (V)
30


7Z08891
VCE = 15V
Tj = 25°C
f = 500MHz
fT
(GHz)
2
1.5
1
0.5
0
0
50
100
IC (mA)
150





I = Region of permissible operation under all base-emitter conditions and at all frequencies, including d.c.

II = Additional region of operation at f ≥ 1 MHz

III = Operating under pulsed conditions is allowed, provided the transistor is cut-off with $R_{BE} \leq 50\ \Omega$ and f ≥ 1 MHz.

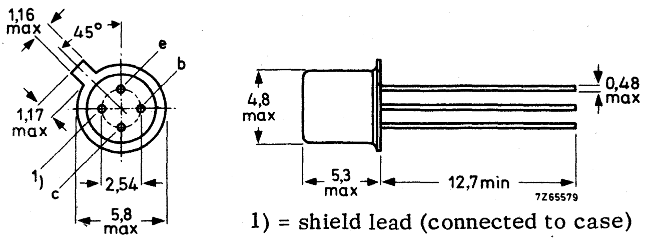
SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N multi-emitter transistor in a TO-72 metal envelope, with insulated electrodes and a shield lead connected to the case. The transistor has very low intermodulation distortion and very high power gain.
It is primarily intended for:
- Wideband vertical amplifiers in high speed oscilloscopes.
- Wideband aerial amplifiers (40-860 MHz)
- Television distribution amplifiers

QUICK REFERENCE DATA				
Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	20	V
Collector-emitter voltage (open base)	V_{CEO}	max.	10	V
Collector current (peak value; f > 1 MHz)	I_{CM}	max.	100	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	250	mW
Junction temperature	T_j	max.	200	°C
Feedback capacitance at f = 1 MHz I_C = 2 mA; V_{CE} = 5 V	C_{re}	typ.	0.8	pF
Transition frequency I_C = 50 mA; V_{CE} = 5 V; f = 500 MHz	f_T	typ.	1.6	GHz
Power gain (not neutralized)		f = 200	800	MHz
I_C = 30 mA; V_{CE} = 5 V	G_p	typ. 21	7.5	dB
Intermodulation distortion I_C = 30 mA; V_{CE} = 6 V; R_L = 37.5 Ω V_o = 100 mV at f_p = 183 MHz V_o = 100 mV at f_q = 200 MHz measured at $f_{(2q-p)}$ = 217 MHz	d_{im}	typ.	-60	dB

MECHANICAL DATA Dimensions in mm

TO-72
insulated electrodes



1) = shield lead (connected to case)

Accessories available: 56246; 56263

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

<u>Voltages</u>				
Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	20	V
Collector-emitter voltage (open base)				
I_C = 10 mA	V_{CEO}	max.	10	V
Emitter-base voltage (open collector)	V_{EBO}	max.	2.5	V
<u>Currents</u>				
Collector current (d.c.)	I_C	max.	50	mA
Collector current (peak value; f > 1 MHz)	I_{CM}	max.	100	mA
<u>Power dissipation</u>				
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	250	mW
<u>Temperatures</u>				
Storage temperature	T_{stg}		-65 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.7	°C/mW
From junction to case	$R_{th\ j-c}$	=	0.5	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

I_E = 0; V_{CB} = 10 V	I_{CBO}	<	50	nA

D.C. current gain

I_C = 25 mA; V_{CE} = 5 V	h_{FE}	>	25	
I_C = 50 mA; V_{CE} = 5 V	h_{FE}	>	25	

Transition frequency [1])

I_C = 50 mA; V_{CE} = 5 V; f = 500 MHz	f_T	typ.	1.6	GHz

Collector capacitance at f = 1 MHz [2])

I_E = I_e = 0; V_{CB} = 5 V	C_c	<	1.5	pF

Feedback capacitance at f = 1 MHz [1])

I_C = 2 mA; V_{CE} = 5 V	C_{re}	typ.	0.8	pF

Noise figure [1])

I_C = 2 mA; V_{CE} = 5 V f = 500 MHz; R_S = 50 Ω	F	<	5	dB

Power gain (not neutralized) [1])

I_C = 30 mA; V_{CE} = 5 V; T_{amb} = 25 °C

		f = 200	800	MHz
G_p	>	19		dB
	typ.	21	7.5	dB

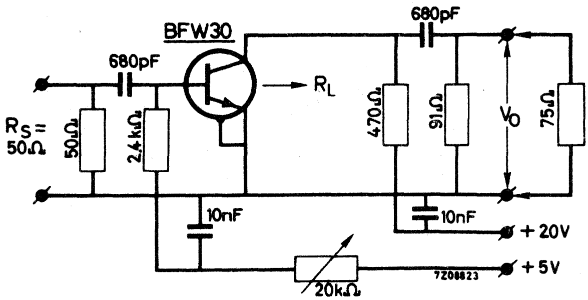
Intermodulation distortion [1])

I_C = 30 mA; V_{CE} = 6 V; R_L = 37.5 Ω; T_{amb} = 25 °C

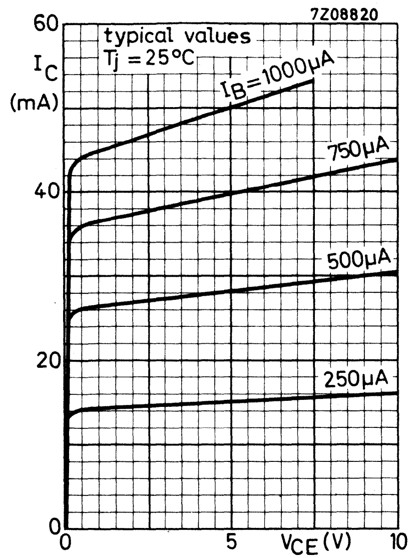
V_o = 100 mV at f_p = 183 MHz

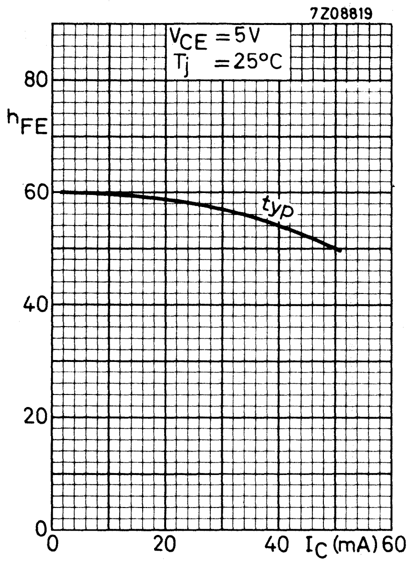
V_o = 100 mV at f_q = 200 MHz
measured at $f_{(2q-p)}$ = 217 MHz — d_{im} typ. −60 dB

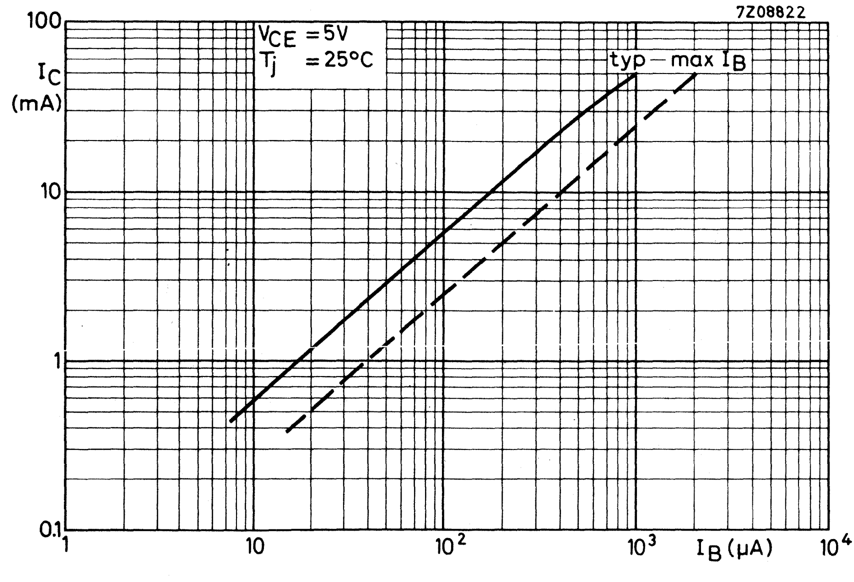
Test circuit

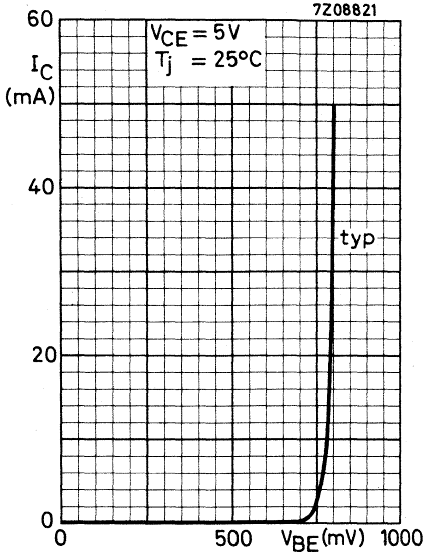


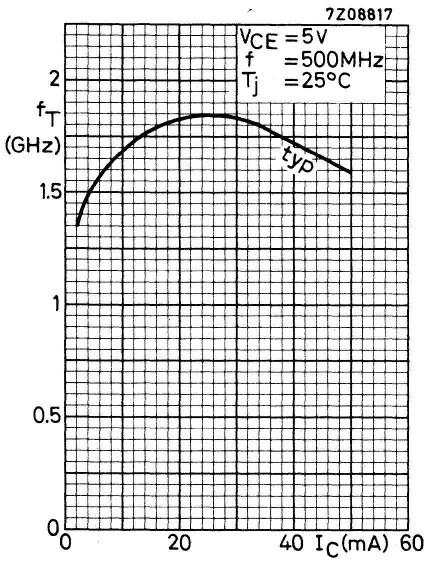
1) Shield lead grounded.
2) Shield lead not connected.

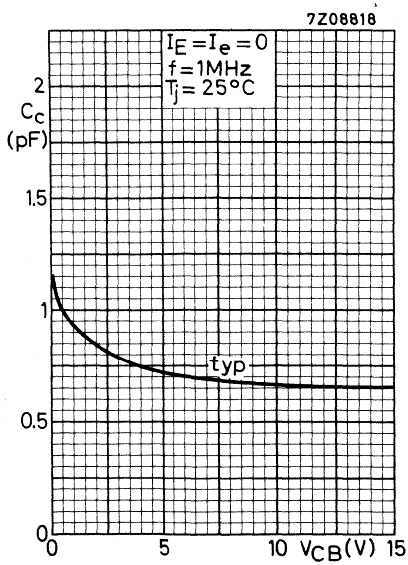

7Z08820
typical values
Tj = 25°C
IC (mA)
IB = 1000μA
750μA
500μA
250μA
VCE (V)
0
5
10
20
40
60


7Z08819
VCE = 5V
Tj = 25°C
hFE
typ
IC (mA)
0
20
40
60
80


7Z08822
VCE = 5V
Tj = 25°C
IC (mA)
typ — max IB
IB (μA)
0.1
1
10
100
10^2
10^3
10^4


7Z08821
60
I_C
(mA)
40
20
0
0
500
1000
V_{BE} (mV)
$V_{CE} = 5 V$
$T_j = 25 °C$
typ


7Z08817
2
f_T
(GHz)
1.5
1
0.5
0
0
20
40
60
I_C (mA)
$V_{CE} = 5 V$
$f = 500 MHz$
$T_j = 25 °C$
typ


7Z08818
2
C_c
(pF)
1.5
1
0.5
0
0
5
10
15
V_{CB} (V)
$I_E = I_e = 0$
$f = 1 MHz$
$T_j = 25 °C$
typ

SILICON PLANAR TRANSISTOR

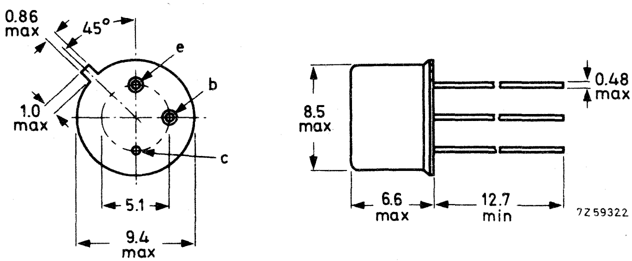
N-P-N transistor in a TO-39 metal envelope with the collector connected to the case. The BFW45 is primarily intended for the output stage of the horizontal deflection amplifier in wide band oscilloscopes.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	165	V
Collector-emitter voltage (open base)	V_{CEO}	max.	130	V
Collector current (peak value)	I_{CM}	max.	100	mA
Total power dissipation up to T_{mb} = 150 °C	P_{tot}	max.	2.5	W
Junction temperature	T_j	max.	200	°C
D.C. current gain I_C = 50 mA; V_{CE} = 20 V	h_{FE}		20 to 120	
Transition frequency at f = 100 MHz I_C = 10 mA; V_{CE} = 10 V	f_T	> typ.	80 120	MHz MHz
Feedback capacitance at f = 1 MHz I_C = 10 mA; V_{CE} = 20 V	C_{re}	<	3.5	pF

MECHANICAL DATA

Dimensions in mm

TO-39
Collector connected to case



Accessories available: 56218, 56245

RATINGS (Limiting values) [1]

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	165	V
Collector-emitter voltage (open base)	V_{CEO}	max.	130	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Currents

Collector current (d.c.)	I_C	max.	50	mA
Collector current (peak value)	I_{CM}	max.	100	mA

Power dissipation

Total power dissipation up to T_{amb} = 40 °C	P_{tot}	max.	0.8	W
T_{mb} = 150 °C	P_{tot}	max.	2.5	W

Temperatures

Storage temperature	T_{stg}		−55 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	200	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	20	°C/W [2]
From junction to case	$R_{th\ j\text{-}c}$	=	25	°C/W [2]

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

[2] See also page 8.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

I_E = 0; V_{CB} = 100 V	I_{CBO}	<	100	nA
I_E = 0; V_{CB} = 100 V; T_j = 150 °C	I_{CBO}	<	10	μA

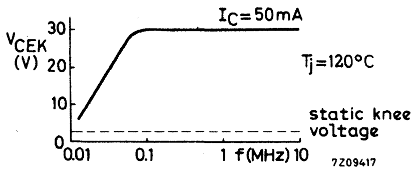
Base-emitter voltage [1])

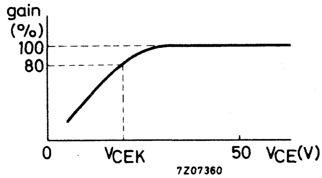
I_C = 50 mA; V_{CE} = 20 V	V_{BE}	<	1.3	V

High frequency knee voltage at T_j = 120 °C

I_C = 50 mA	V_{CEK}	<	27	V

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





Collector-emitter saturation voltage

I_C = 10 mA; I_B = 1 mA	V_{CEsat}	<	3	V
I_C = 50 mA; I_B = 5 mA	V_{CEsat}	<	10	V

D.C. current gain

I_C = 50 mA; V_{CE} = 20 V	h_{FE}		20 to 120	

Feedback capacitance at f = 1 MHz

I_C = 10 mA; V_{CE} = 20 V	C_{re}	<	3.5	pF

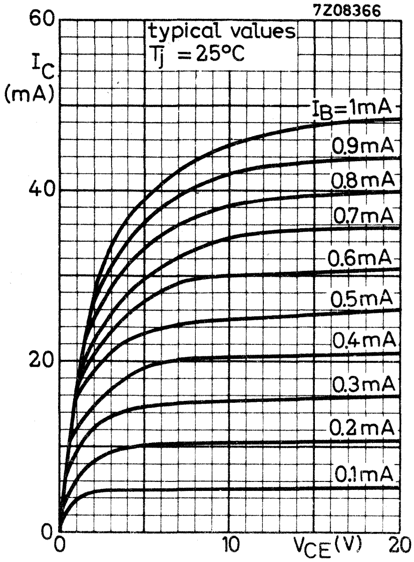
Collector capacitance at f = 1 MHz

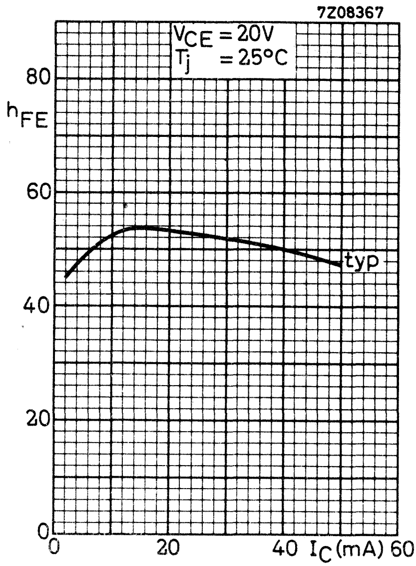
I_E = I_e = 0; V_{CB} = 20 V	C_c	<	6	pF

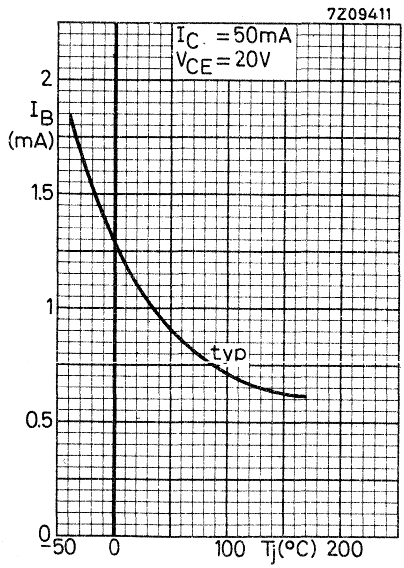
Transition frequency at f = 100 MHz

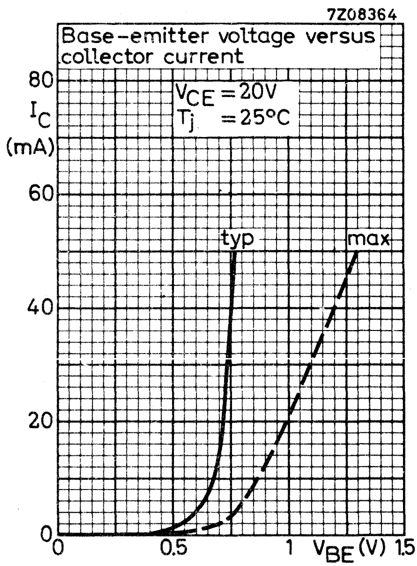
I_C = 10 mA; V_{CE} = 10 V	f_T	>	80	MHz
		typ.	120	MHz

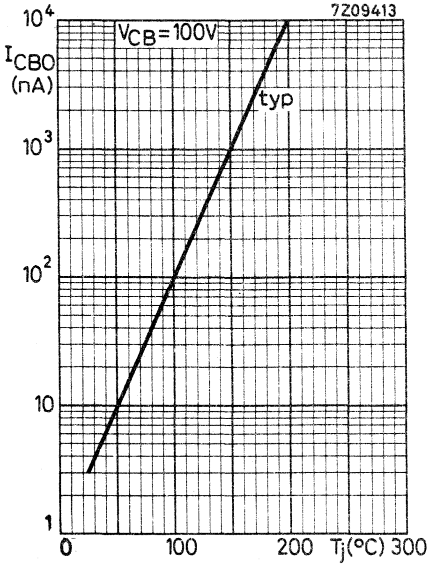
[1]) V_{BE} decreases by about 1.6 mV/°C with increasing temperature.

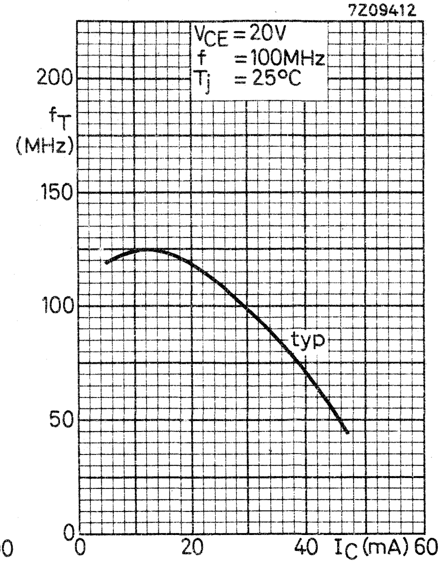

7Z08366
typical values
Tj = 25°C
IC (mA)
IB=1mA
0.9mA
0.8mA
0.7mA
0.6mA
0.5mA
0.4mA
0.3mA
0.2mA
0.1mA
VCE (V)
60
40
20
0
0
10
20

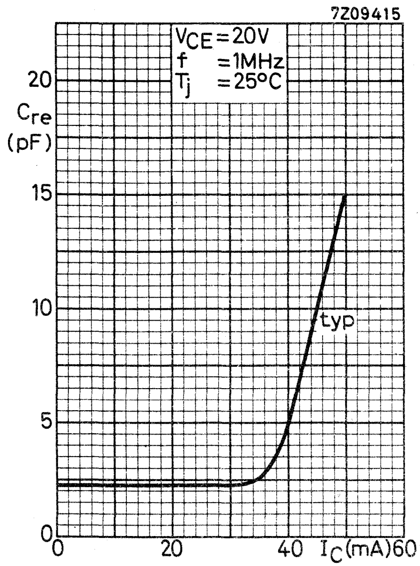

7Z08367
VCE = 20V
Tj = 25°C
hFE
typ
IC (mA)
80
60
40
20
0
0
20
40
60

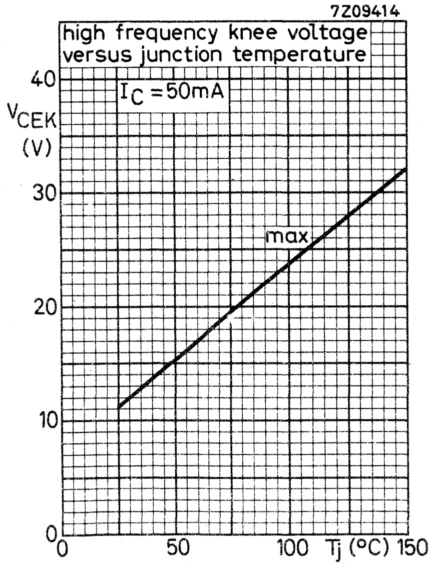

7Z09411
IC = 50mA
VCE = 20V
IB (mA)
typ
Tj (°C)
2
1.5
1
0.5
0
-50
0
100
200

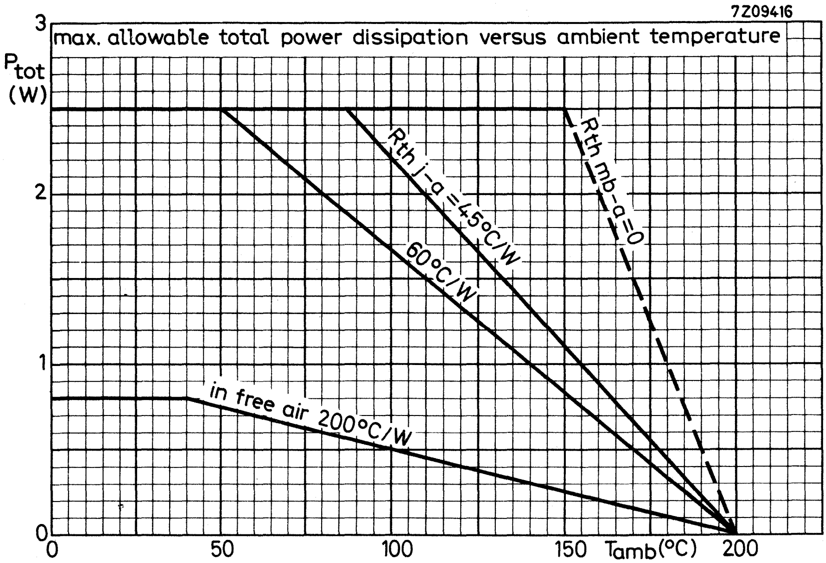

7Z08364
Base-emitter voltage versus collector current
VCE = 20V
Tj = 25°C
IC (mA)
typ
max
VBE (V)
80
60
40
20
0
0
0.5
1
1.5

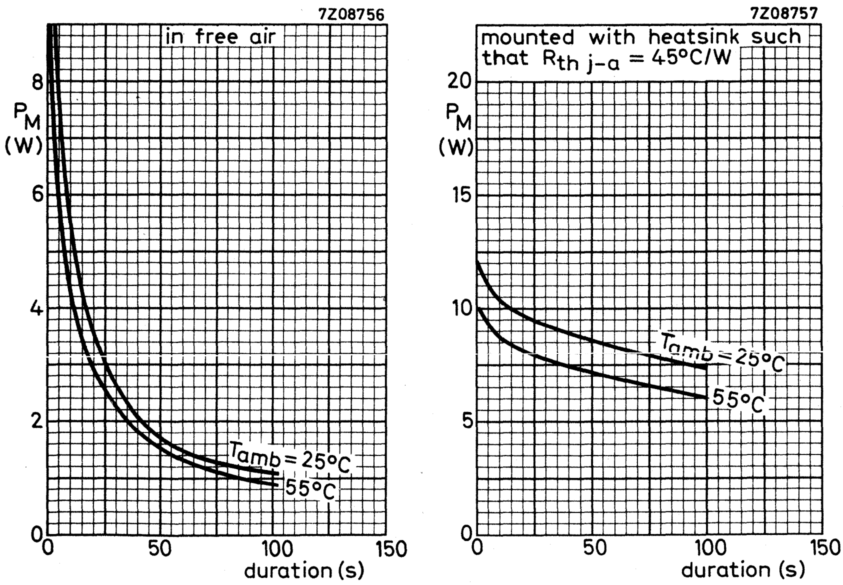

7Z09413
V_{CB} = 100V
I_{CBO} (nA)
typ
10^4
10^3
10^2
10
1
0
100
200
T_j (°C) 300


7Z09412
V_{CE} = 20V
f = 100MHz
T_j = 25°C
f_T (MHz)
typ
200
150
100
50
0
20
40
I_C (mA) 60


7Z09415
V_{CE} = 20V
f = 1MHz
T_j = 25°C
C_{re} (pF)
typ
20
15
10
5
0
20
40
I_C (mA) 60


7Z09414
high frequency knee voltage versus junction temperature
I_C = 50mA
V_{CEK} (V)
max
40
30
20
10
0
50
100
T_j (°C) 150





maximum allowable peak power dissipation versus duration

SILICON PLANAR EPITAXIAL TRANSISTOR

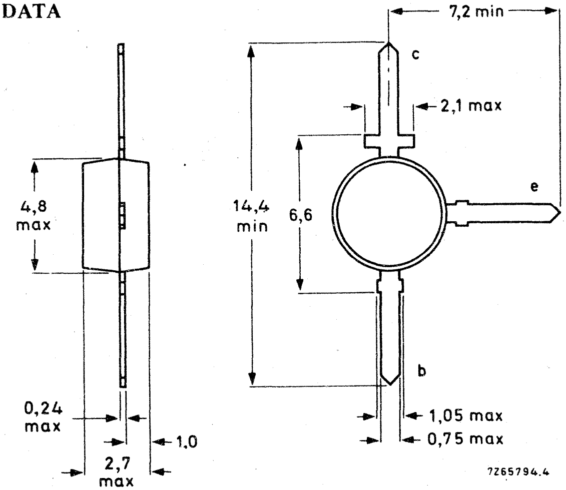
N-P-N transistor in a subminiature plastic T-package. It has a low noise over a wide current range, a very high power gain and good intermodulation properties.
It is primarily intended for:
- Wideband aerial amplifiers (40 - 860 MHz)
- Channel and band aerial amplifiers for band I, II, III and IV/V (40 - 860 MHz)
- Television distribution amplifiers
- Low noise wideband vertical amplifier in high speed oscilloscopes

QUICK REFERENCE DATA

Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	25		V
Collector-emitter voltage (open base)	V_{CEO}	max.	15		V
Collector current (peak value; f > 1 MHz)	I_{CM}	max.	50		mA
Total power dissipation up to T_{amb} = 73 °C	P_{tot}	max.	190		mW
Junction temperature	T_j	max.	150		°C
Transition frequency at f = 500 MHz; I_C = 25 mA; V_{CE} = 5 V	f_T	typ.	1,6		GHz
Feedback capacitance at f = 1 MHz; I_C = 2 mA; V_{CE} = 5 V	C_{re}	typ.	0,6		pF
Noise figure at f = 500 MHz; I_C = 2 mA; V_{CE} = 5 V	F	typ.	4		dB
		f =	200	800	MHz
Power gain (not neutralized); I_C = 10 mA; V_{CE} = 10 V; T_{amb} = 25 °C	G_p	typ.	23	11	dB
Output power at d_{im} = −30 dB; VSWR at output < 2; I_C = 10 mA; V_{CE} = 10 V	P_o	typ.	8	8	mW

MECHANICAL DATA Dimensions in mm

SOT-37



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

Voltages

Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V 1)
Emitter-base voltage (open collector)	V_{EBO}	max.	2.5	V

Currents

Collector current (d.c.)	I_C	max.	25	mA
Collector current (peak value; f > 1 MHz)	I_{CM}	max.	50	mA

Power dissipation

Total power dissipation up to T_{amb} = 73 °C	P_{tot}	max.	190	mW

Temperatures

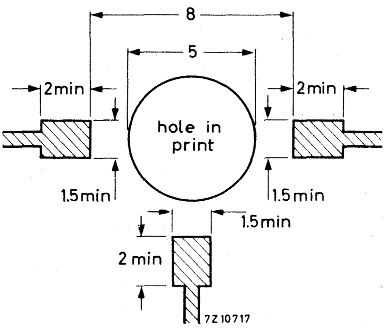
Storage temperature	T_{stg}		-65 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air mounted on a glass-fibre print *) of 40 mm x 25 mm x 1 mm — $R_{th\ j-a}$ = 0.4 °C/mW

*) Requirements for glass-fibre print

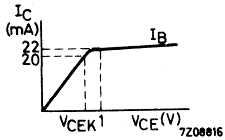
(dimensions in mm)



1) At I_C = 10 mA

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 10$ V	I_{CBO}	<	50	nA
Knee voltage [1]				
$I_C = 20$ mA; I_B = value for which $I_C = 22$ mA at $V_{CE} = 1$ V	V_{CEK}	<	0.75	V



D.C. current gain				
$I_C = 2$ mA; $V_{CE} = 1$ V	h_{FE}	> <</br>	20 150	
$I_C = 25$ mA; $V_{CE} = 1$ V [1]	h_{FE}	>	20	
Transition frequency at f = 500 MHz				
$I_C = 2$ mA; $V_{CE} = 5$ V	f_T	typ.	1.0	GHz
$I_C = 25$ mA; $V_{CE} = 5$ V [1]	f_T	typ.	1.6	GHz
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	0.7	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	typ.	1.5	pF
Feedback capacitance at f = 1 MHz				
$I_C = 2$ mA; $V_{CE} = 5$ V; $T_{amb} = 25$ °C	C_{re}	typ.	0.6	pF
Noise figure at f = 500 MHz				
$I_C = 2$ mA; $V_{CE} = 5$ V; $R_S = 50\,\Omega$; $T_{amb} = 25$ °C	F	typ.	4.0	dB

			f =	200	800	MHz
Power gain (not neutralized)						
$I_C = 10$ mA; $V_{CE} = 10$ V; $T_{amb} = 25$ °C	G_p	typ.		23	11	dB

[1]) Measured under pulsed conditions.

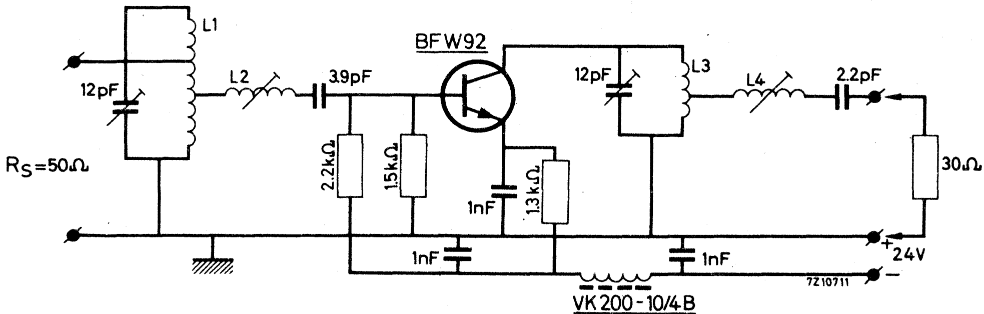
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Intermodulation characteristics

1. Output power at f = 200 MHz; T_{amb} = 25 °C

   I_C = 10 mA; V_{CE} = 10 V; V.S.W.R. at output < 2
   f_p = 202 MHz; f_q = 205 MHz; d_{im} = −30 dB
   measured at $f_{(2q-p)}$ = 208 MHz (Channel 9) P_o typ. 8 mW

   Test circuit:



Coil data:

L1 = 3 turns silver plated Cu wire (1.4 mm); winding pitch 2.7 mm; int. diam. 8 mm; taps at 0.5 turn and 1.5 turns from earth.
L2 = 5.5 turns silver plated Cu wire (1.4 mm); winding pitch 2.2 mm; int. diam. 8 mm.
L3 = 3 turns silver plated Cu wire (1.4 mm); winding pitch 3.3 mm; int. diam. 8 mm.
L4 = 5.5 turns silver plated Cu wire (1.4 mm); winding pitch 2.2 mm; int. diam. 11 mm.

CHARACTERISTICS (continued)

Basis of adjustment

The intermodulation at an intermodulation distortion of −30 dB is caused by h.f. output current - voltage clipping.
The maximum undistorted output power is realised, if

a. Current and voltage clipping take place concurrently.
   This occurs if

$$R_L = \frac{V_{CE} - V_{CEK}}{I_C},$$

   in which V_{CEK} is the high frequency knee voltage.

b. The h.f. collector current is as small as possible.
   This is so if $-C_L = +C_{oe}$,
   in which C_{oe} is the output capacitance of the transistor at short circuited input.

For maximum output power at an intermodulation distortion of −30 dB, the (experimentally found) values of R_L and C_L are:
R_L = 820 Ω; C_L = −1.0 pF

Adjustment procedure

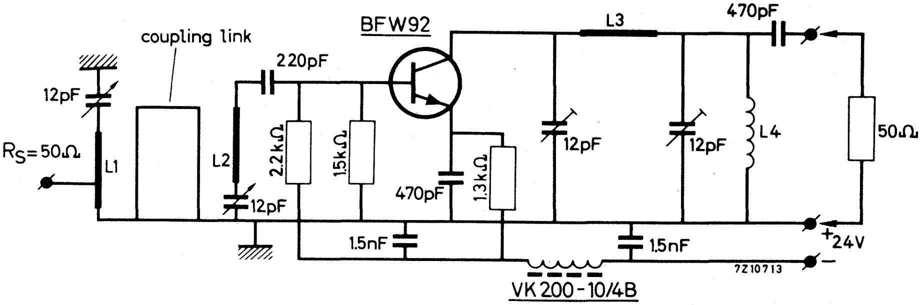
1. Remove the transistor and connect a dummy consisting of a 820 Ω resistor in parallel with a 1.0 pF capacitor between the collector and emitter connections of the output circuit.
2. Tune and match the output circuit for zero reflection at 205 MHz (V.S.W.R. = 1). After this adjustment, no further change may be made in the output circuit.
3. Replace the dummy by the transistor. Tune and match the input circuit for maximum power gain and good band pass curve.
   The V.S.W.R. of the output will then, in most cases, be ≤ 2 over the whole channel.
   Corrections can be made by tuning L2; this will not disturb the band pass curve.

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

Intermodulation characteristics

2. Output power at f = 800 MHz; T_{amb} = 25 °C

I_C = 10 mA; V_{CE} = 10 V; V.S.W.R. at output < 2
f_p = 798 MHz; f_q = 802 MHz; d_{im} = −30 dB
measured at $f_{(2q-p)}$ = 806 MHz (Channel 62) P_o typ. 8 mW



Coil data:
L1 = 24 mm x 6 mm x 0.5 mm silver plated Cu strip.
Tap of the input at 5 mm from earth.
L2 = 15 mm x 6 mm x 0.5 mm silver plated Cu strip.
L3 = 20 mm x 8 mm x 0.5 mm silver plated Cu strip.
L4 = 4 turns enamelled Cu wire (0.5 mm); winding pitch 1.5 mm; int. diam. 4 mm
Coupling link: 42 mm silver plated Cu wire (1 mm).

Basis of adjustment.

At 800 MHz no dummy can be used to adjust for optimum collector load because at these frequencies the impedance transformations of a dummy are too high. A small signal at the mid-channel frequency of 802 MHz is fed to the input and increased until clipping occurs; that is, until the output power no longer increases linearily with the input signal. This clipping can be eliminated by tuning the output circuit, thereby making the output power equal to

$$P_o = \frac{I_C (V_{CE} - V_{CEK})}{2} = 40 \text{ mW}$$

The output circuit is adjusted for minimum intermodulation if the input signal is as small as possible at P_o = 40 mW.
After this adjustment has been made no further change may be made in the output circuit.
Adjust the input circuit for maximum power gain and good band pass curve.
The V.S.W.R. of the output is then ≤ 2 over the whole channel.

CHARACTERISTICS (continued)

Intermodulation characteristics

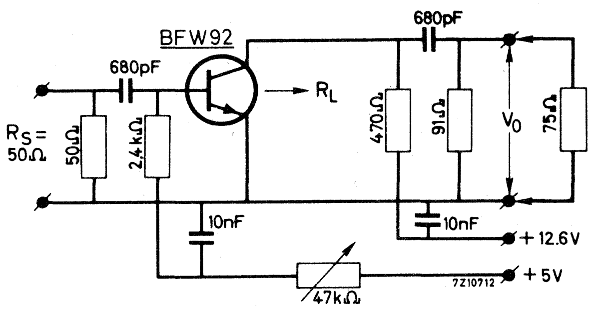
3. Intermodulation distortion

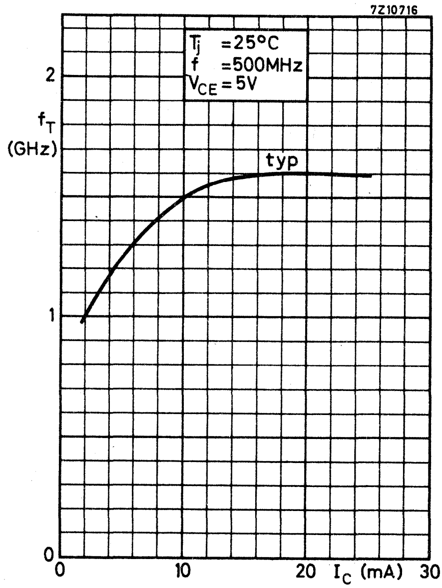
I_C = 10 mA; V_{CE} = 6 V; R_L = 37.5 Ω; T_{amb} = 25 °C

V_0 = 100 mV at f_p = 183 MHz

V_0 = 100 mV at f_q = 200 MHz
measured at $f_{(2q-p)}$ = 217 MHz — d_{im} typ. −45 dB

Test circuit:




7Z10716
T_j = 25°C
f = 500MHz
V_{CE} = 5V
f_T
(GHz)
typ
2
1
0
0
10
20
I_C (mA)
30

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a subminiature plastic transfer-moulded T-package.
The device is intended for use in v.h.f. - u.h.f. applications, primarily wideband aerial amplifiers 40 - 800 MHz.
It is intended for mounting on miniature printed-circuit boards.

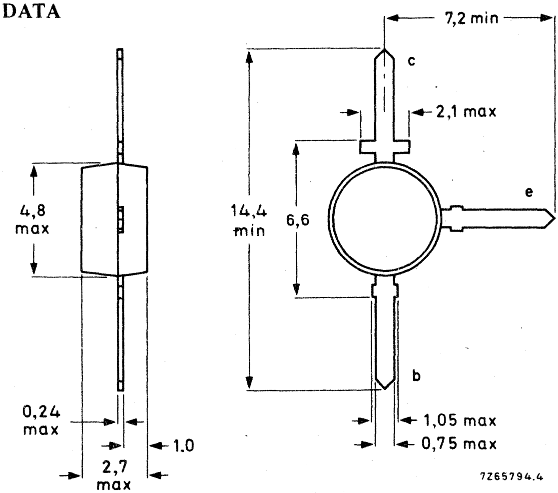
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	18	V
Collector-emitter voltage (open base)	V_{CEO}	max.	10	V
Collector current (peak value; f > 1 MHz)	I_{CM}	max.	100	mA
Total power dissipation up to T_{amb} = 73 °C	P_{tot}	max.	190	mW
Junction temperature	T_j	max.	150	°C
Feedback capacitance at f = 1 MHz				
I_C = 2 mA; V_{CE} = 5 V; T_{amb} = 25 °C	C_{re}	typ.	0,6	pF
Transition frequency at f = 500 MHz				
I_C = 50 mA; V_{CE} = 5 V	f_T	typ.	1,7	GHz
Max. unilateral power gain (see page 3)				
I_C = 30 mA; V_{CE} = 5 V; f = 200 MHz; T_{amb} = 25 °C	G_{UM}	typ.	22	dB
I_C = 30 mA; V_{CE} = 5 V; f = 800 MHz; T_{amb} = 25 °C	G_{UM}	typ.	10,5	dB
Intermodulation distortion at T_{amb} = 25 °C				
I_C = 30 mA; V_{CE} = 5 V; R_L = 37,5 Ω				
V_O = 100 mV at f_p = 183 MHz				
V_O = 100 mV at f_q = 200 MHz				
measured at $f_{(2q-p)}$ = 217 MHz	d_{im}	typ.	−60	dB

MECHANICAL DATA

Dimensions in mm

SOT-37



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

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	18	V
Collector-emitter voltage (open base)	V_{CEO}	max.	10	V
Emitter-base voltage (open collector)	V_{EBO}	max.	2.5	V

Currents

Collector current (d.c.)	I_C	max.	50	mA
Collector current (peak value; f > 1 MHz)	I_{CM}	max.	100	mA

Power dissipation

Total power dissipation up to T_{amb} = 73 °C	P_{tot}	max.	190	mW

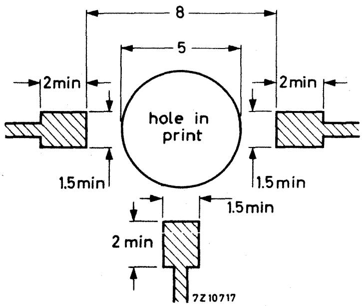
Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air mounted on a glass-fibre print of 40 mm x 25 mm x 1 mm	$R_{th\ j-a}$	=	0.4	°C/mW

Requirements for glass-fibre print (dimensions in mm)



CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 10$ V	I_{CBO}	<	50	nA
D.C. current gain [1]				
$I_C = 25$ mA; $V_{CE} = 5$ V	h_{FE}	>	25	
$I_C = 50$ mA; $V_{CE} = 5$ V	h_{FE}	>	25	
Transition frequency at f = 500 MHz [1]				
$I_C = 50$ mA; $V_{CE} = 5$ V	f_T	typ.	1.7	GHz
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	typ.	0.7	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	typ.	1.5	pF
Feedback capacitance at f = 1 MHz				
$I_C = 2$ mA; $V_{CE} = 5$ V; $T_{amb} = 25$ °C	C_{re}	typ.	0.6	pF
Noise figure at f = 500 MHz				
$I_C = 2$ mA; $V_{CE} = 5$ V; $G_S = 20$ mA/V; B_S is tuned; $T_{amb} = 25$ °C	F	<	5	dB

Max. unilateral power gain (s_{re} assumed to be zero)

$$G_{UM} \text{ (in dB)} = 10 \log \frac{|s_{fe}|^2}{(1 - |s_{ie}|^2)(1 - |s_{oe}|^2)}$$

$I_C = 30$ mA; $V_{CE} = 5$ V; f = 200 MHz; $T_{amb} = 25$ °C	G_{UM}	typ.	22	dB
$I_C = 30$ mA; $V_{CE} = 5$ V; f = 800 MHz; $T_{amb} = 25$ °C	G_{UM}	typ.	10.5	dB

[1] Measured under pulse conditions.

CHARACTERISTICS (continued)

Intermodulation distortion at T_{amb} = 25 °C

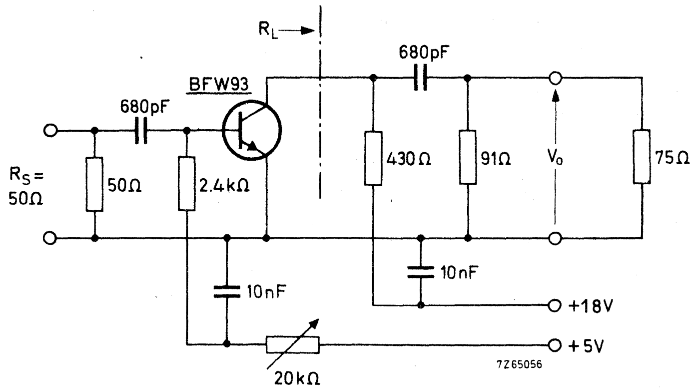
I_C = 30 mA; V_{CE} = 5 V; R_L = 37.5 Ω

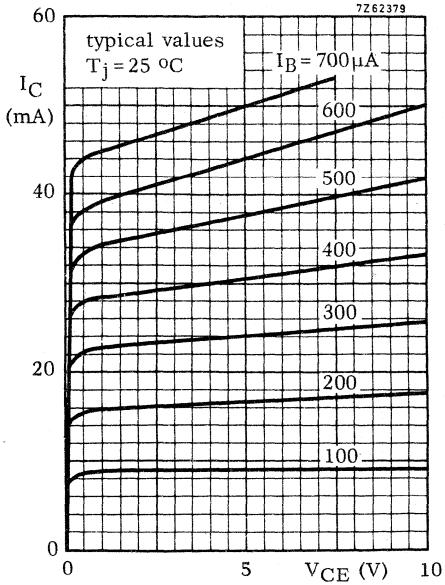
V_o = 100 mV at f_p = 183 MHz

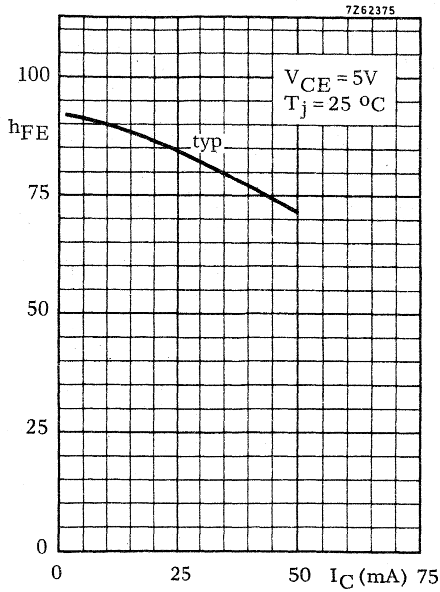
V_o = 100 mV at f_q = 200 MHz

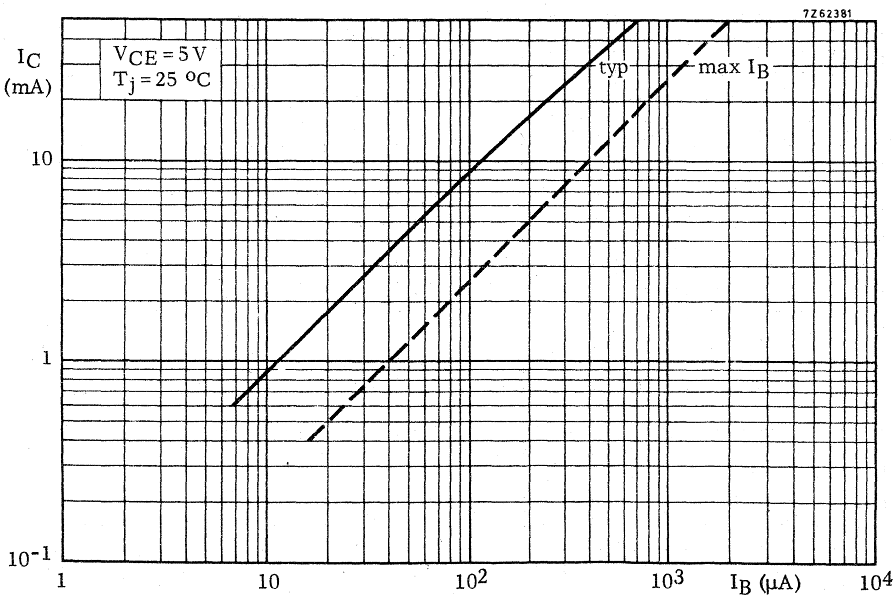
measured at $f_{(2q-p)}$ = 217 MHz — d_{im} typ. −60 dB

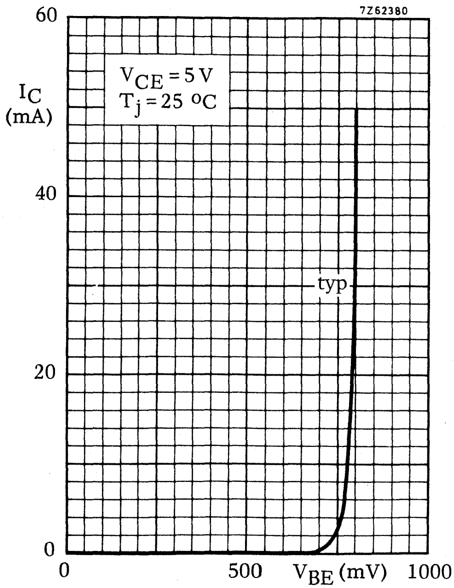
Test circuit:

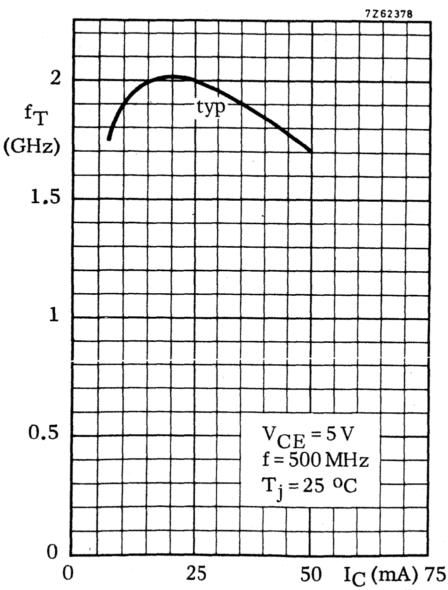


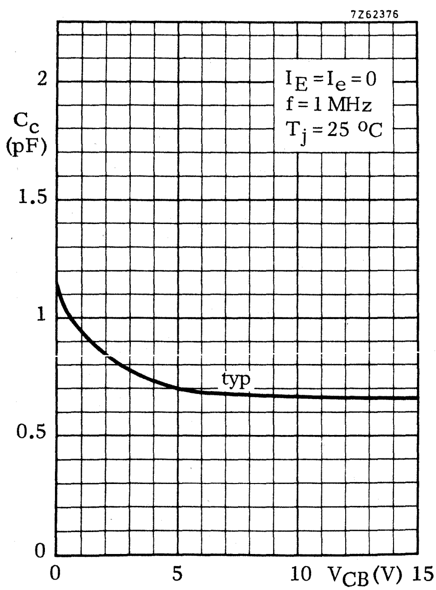

7Z62379
typical values
$T_j = 25\ ^oC$
$I_B = 700\,\mu A$
600
500
400
300
200
100
I_C (mA)
60
40
20
0
0
5
V_{CE} (V)
10


7Z62375
$V_{CE} = 5V$
$T_j = 25\ ^oC$
typ
h_{FE}
100
75
50
25
0
0
25
50
I_C (mA)
75

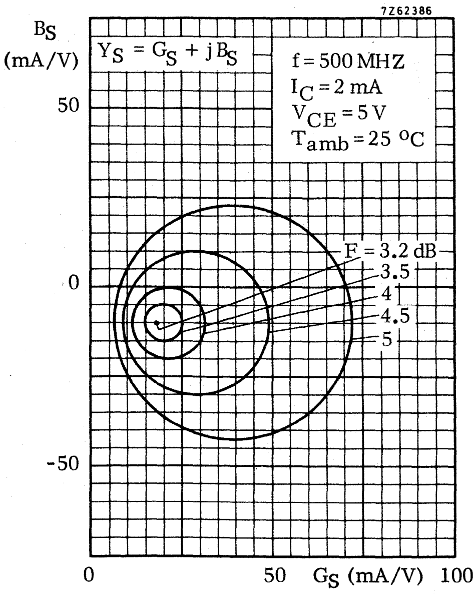

7Z62381
$V_{CE} = 5\,V$
$T_j = 25\ ^oC$
typ
max I_B
I_C (mA)
10
1
10^{-1}
1
10
10^2
10^3
I_B (μA)
10^4

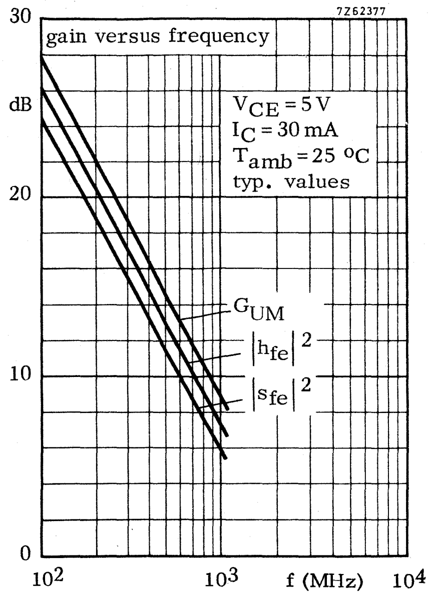

7Z62380
60
40
20
0
I_C (mA)
$V_{CE} = 5$ V
$T_j = 25$ °C
typ
0
500
V_{BE} (mV)
1000

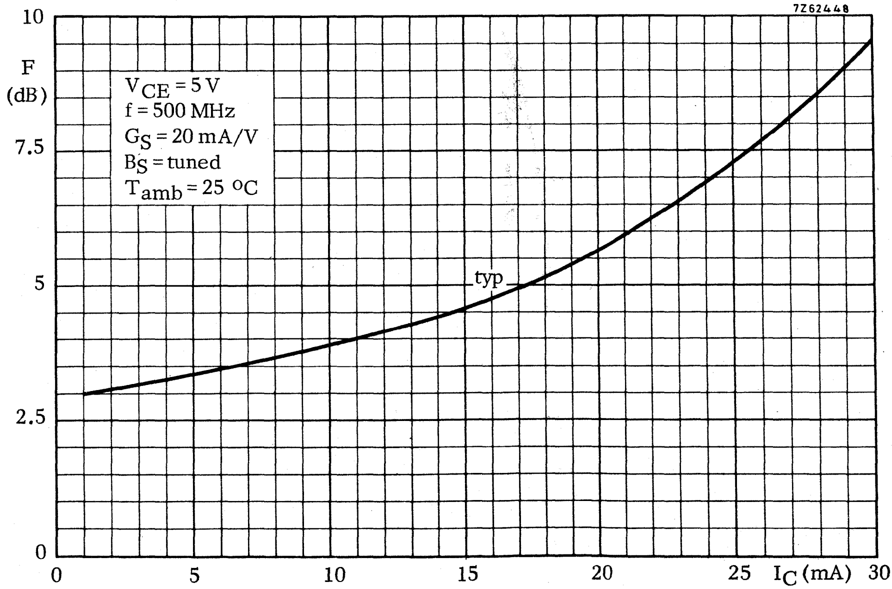

7Z62378
2
1.5
1
0.5
0
f_T (GHz)
typ
$V_{CE} = 5$ V
f = 500 MHz
$T_j = 25$ °C
0
25
50
I_C (mA) 75


7Z62376
2
1.5
1
0.5
0
C_c (pF)
$I_E = I_e = 0$
f = 1 MHz
$T_j = 25$ °C
typ
0
5
10
V_{CB} (V) 15

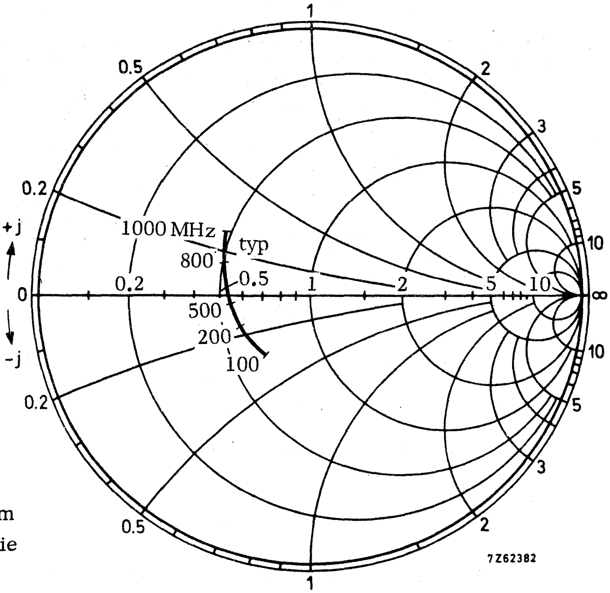
circles of constant noise figure





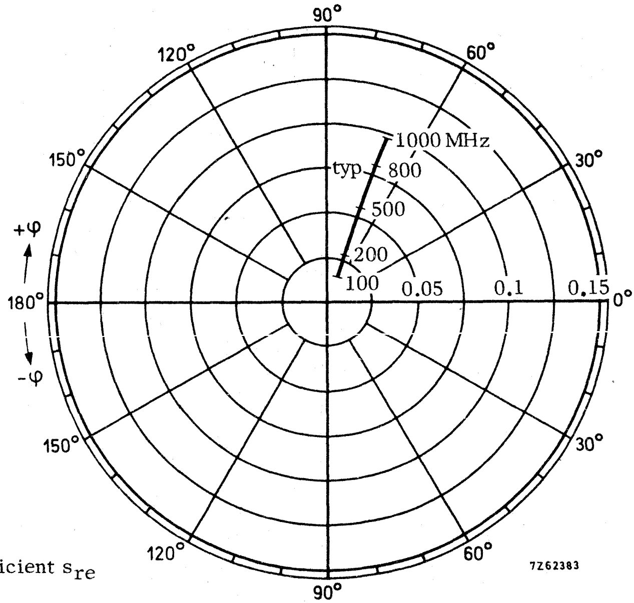


V_{CE} = 5 V
I_C = 30 mA
T_{amb} = 25 °C



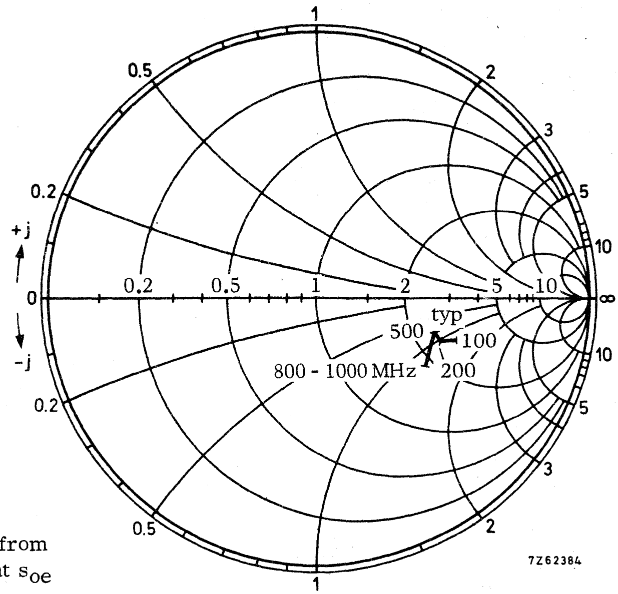
Input impedance derived from input reflection coefficient s_{ie} coordinates in ohm x 50

V_{CE} = 5 V
I_C = 30 mA
T_{amb} = 25 °C



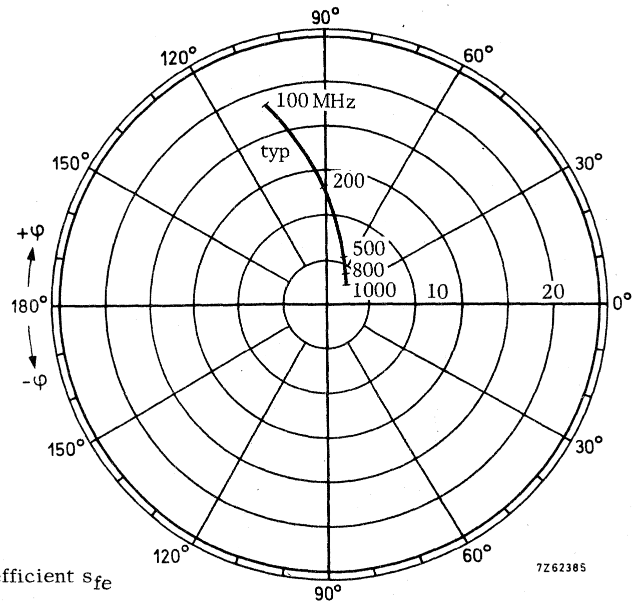
Reverse transmission coefficient s_{re}

V_{CE} = 5 V
I_C = 30 mA
T_{amb} = 25 °C



Output impedance derived from output reflection coefficient s_{oe} coordinates in ohm x 50

V_{CE} = 5 V
I_C = 30 mA
T_{amb} = 25 °C



Forward transmission coefficient s_{fe}

SILICON PLANAR EPITAXIAL TRANSISTOR

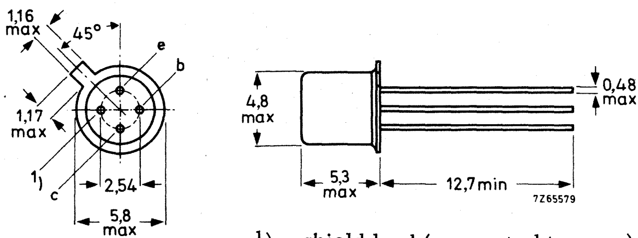
N-P-N transistor in a TO-72 metal envelope, with insulated electrodes and a shield lead connected to the case.
The transistor has a low noise, a very high power gain and good intermodulation properties.
It is primarily intended for:
- Channel aerial amplifiers for band I, II, III and IV/V (40-860 MHz)
- Wide band aerial amplifiers (40-860 MHz).

QUICK REFERENCE DATA

Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	30		V
Collector-emitter voltage (open base)	V_{CEO}	max.	15		V
Collector current (peak value; f > 1 MHz)	I_{CM}	max.	50		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	200		mW
Junction temperature	T_j	max.	200		°C
Transition frequency I_C = 25 mA; V_{CE} = 5 V; f = 500 MHz	f_T	typ.	1.2		GHz
Feedback capacitance I_C = 2 mA; V_{CE} = 5 V; f = 1 MHz	C_{re}	typ.	0.6		pF
			f = 200	800	MHz
Noise figure at optimum source impedance I_C = 2 mA; V_{CE} = 5 V	F	typ.	3.3	7	dB
Power gain (not neutralized) I_C = 8 mA; V_{CE} = 10 V	G_p	typ.	22	7	dB
Output power d_{im} = −30 dB; V.S.W.R. at output <2 I_C = 8 mA; V_{CE} = 10 V	P_o	typ.	6	6	mW

MECHANICAL DATA Dimensions in mm

TO-72
insulated electrodes



1) = shield lead (connected to case)

Accessories available: 56246, 56263

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

Voltages

Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	30	V
Collector-emitter voltage (peak value) $R_{BE} \leq 50\ \Omega$	V_{CERM}	max.	30	V [1]
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V [1]
Emitter-base voltage (open collector)	V_{EBO}	max.	2.5	V

Currents

Collector current (d.c.)	I_C	max.	25	mA
Collector current (peak value; f > 1 MHz)	I_{CM}	max.	50	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	200	mW

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.88	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0.58	°C/mW

[1] I_C = 10 mA.

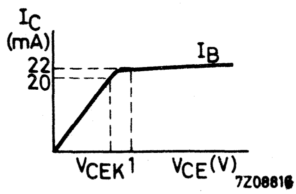
CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $V_{CB} = 15$ V	I_{CBO}	<	10	nA

Knee voltage

$I_C = 20$ mA; I_B = value for which $I_C = 22$ mA at $V_{CE} = 1$ V	V_{CEK}	<	0.75	V



D.C. current gain

$I_C = 2$ mA; $V_{CE} = 1$ V	h_{FE}	20 to 150		
$I_C = 25$ mA; $V_{CE} = 1$ V	h_{FE}	20 to 125		

Transition frequency [1]

$I_C = 2$ mA; $V_{CE} = 5$ V; f = 500 MHz	f_T	typ.	1.0	GHz
$I_C = 25$ mA; $V_{CE} = 5$ V; f = 500 MHz	f_T	typ.	1.2	GHz

Collector capacitance at f = 1 MHz [2]

$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	1.7	pF

Feedback capacitance at f = 1 MHz [1]

$I_C = 2$ mA; $V_{CE} = 5$ V	C_{re}	typ.	0.6	pF

Noise figure [1]

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

f = 200 MHz; optimum source impedance	F	<	4	dB
f = 500 MHz; $R_S = 50\ \Omega$	F	<	6.5	dB
f = 800 MHz; optimum source impedance	F	typ.	7.0	dB

Power gain (not neutralized) [1]

			f = 200	800	MHz
$I_C = 8$ mA; $V_{CE} = 10$ V; $T_{amb} = 25$ °C	G_p	>	19	-	dB
		typ.	22	7	dB

[1] Shield lead grounded.
[2] Shield lead not connected.

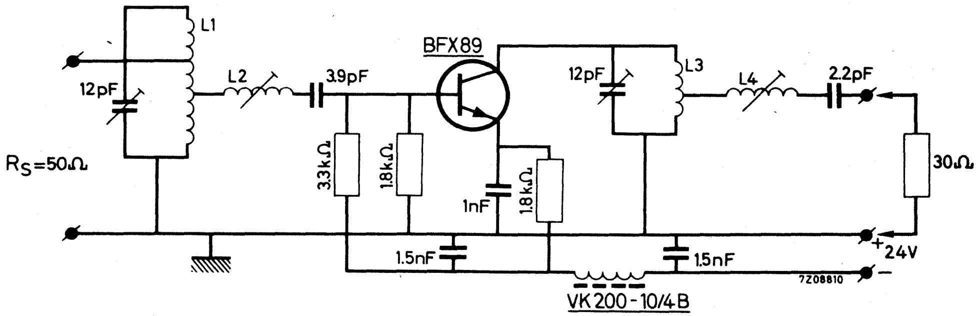
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Intermodulation characteristics [1])

1. Output power at f = 200 MHz; T_{amb} = 25 °C

I_C = 8 mA; V_{CE} = 10 V; V.S.W.R. at output < 2
f_p = 202 MHz; f_q = 205 MHz; d_{im} = −30 dB
measured at $f_{(2q-p)}$ = 208 MHz (Channel 9) P_o typ. 6 mW

Test circuit:



Coil data:

L1 = 3 turns silver plated Cu wire (1.4 mm); winding pitch 2.7 mm; int. diam. 8 mm; taps at 0.5 turn and 1.5 turns from earth.
L2 = 5.5 turns silver plated Cu wire (1.4 mm); winding pitch 2.2 mm; int. diam. 8 mm.
L3 = 3 turns silver plated Cu wire (1.4 mm) winding pitch 3.3 mm; int. diam. 8 mm.
L4 = 5.5 turns silver plated Cu wire (1.4 mm) winding pitch 2.2 mm; int. diam. 11 mm.

[1]) Shield lead grounded.

CHARACTERISTICS (continued)

Basis of adjustment

The intermodulation at an intermodulation distortion of −30 dB is caused by h.f. output current - voltage clipping.
The maximum undistorted output power is realised, if

a. Current and voltage clipping take place concurrently.
This occurs if

$$R_L = \frac{V_{CE} - V_{CEK}}{I_C},$$

in which V_{CEK} is the high frequency knee voltage.

b. The h.f. collector current is as small as possible.
This is so if $-C_L = +C_{oe}$,
in which C_{oe} is the output capacitance of the transistor at short circuited input.

For maximum output power at an intermodulation distortion of −30 dB, the (experimentally found) values of R_L and C_L are:
R_L = 1 kΩ; C_L = −1.8 pF

Adjustment procedure

1. Remove the transistor and connect a dummy consisting of a 1 kΩ resistor in parallel with a 1.8 pF capacitor between the collector and emitter connections of the output circuit.
2. Tune and match the output circuit for zero reflection at 205 MHz (V.S.W.R. = 1). After this adjustment, no further change may be made in the output circuit.
3. Replace the dummy by the transistor. Tune and match the input circuit for maximum power gain and good band pass curve.
The V.S.W.R. of the output will then, in most cases, be ≤ 2 over the whole channel.
Corrections can be made by tuning L2; this will not disturb the band pass curve.

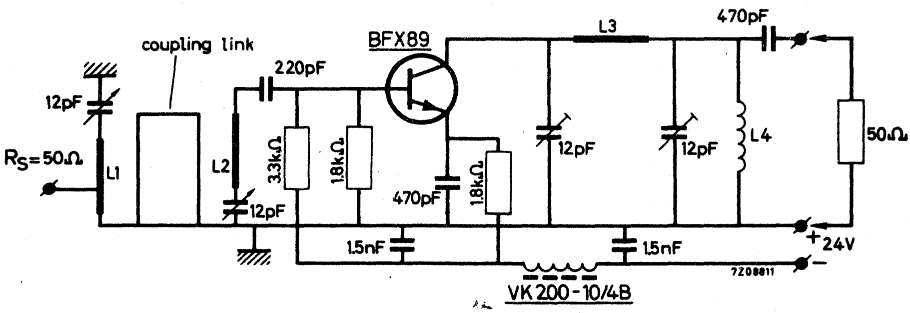
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Intermodulation characteristics [1])

2. Output power at f = 800 MHz; T_{amb} = 25 °C

I_C = 8 mA; V_{CE} = 10 V; V.S.W.R. at output < 2
f_p = 798 MHz; f_q = 802 MHz; d_{im} = −30 dB
measured at $f_{(2q-p)}$ = 806 MHz (Channel 62) P_o typ. 6 mW

Test circuit:



Coil data:

L1 = 24 mm x 6 mm x 0.5 mm silver plated Cu strip.
Tap of the input at 5 mm from earth.
L2 = 15 mm x 6 mm x 0.5 mm silver plated Cu strip.
L3 = 20 mm x 8 mm x 0.5 mm silver plated Cu strip.
L4 = 4 turns enamelled Cu wire (0.5 mm); winding pitch 1.5 mm; int. diam. 4 mm.
Coupling link: 42 mm silver plated Cu wire (1 mm).

Basis of adjustment

At 800 MHz no dummy can be used to adjust for optimum collector load because at these frequencies the impedance transformations of a dummy are too high. A small signal at the mid-channel frequency of 802 MHz is fed to the input and increased until clipping occurs; that is, until the output power no longer increases linearily with the input signal. This clipping can be eliminated by tuning the output circuit, thereby making the output power equal to

$$P_o = \frac{I_C\,(V_{CE} - V_{CEK})}{2} = 35 \text{ mW}$$

The output circuit is adjusted for minimum intermodulation if the input signal is as small as possible at P_o = 35 mW.
After this adjustment has been made no further change may be made in the output circuit.
Adjust the input circuit for maximum power gain and good band pass curve.
The V.S.W.R. of the output is then ≤ 2 over the whole channel.

[1]) Shield lead grounded

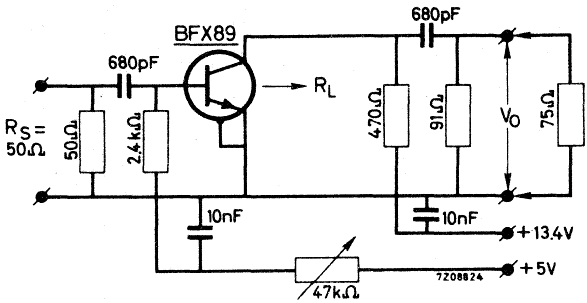
CHARACTERISTICS (continued) $T_j = 25\ ^oC$ unless otherwise specified

Intermodulation characteristics [1])

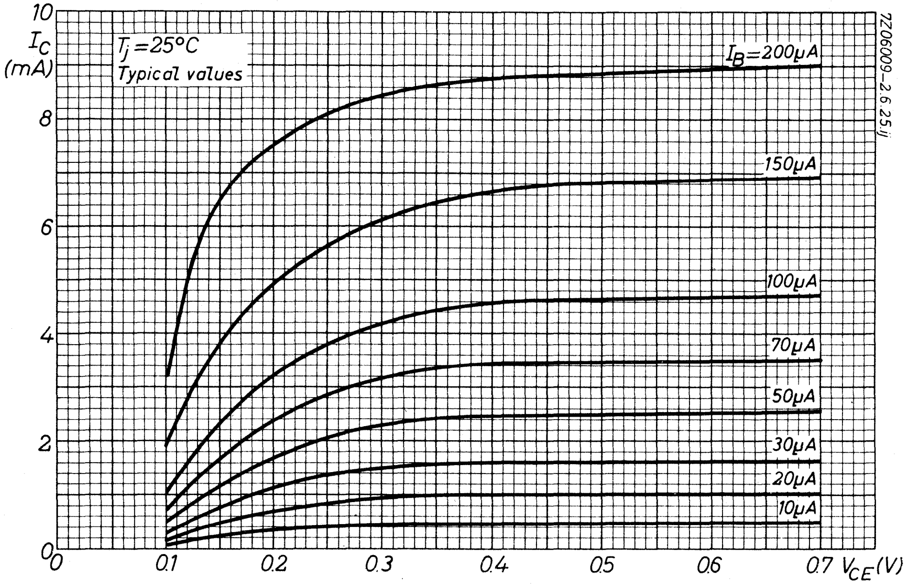
3. Intermodulation distortion

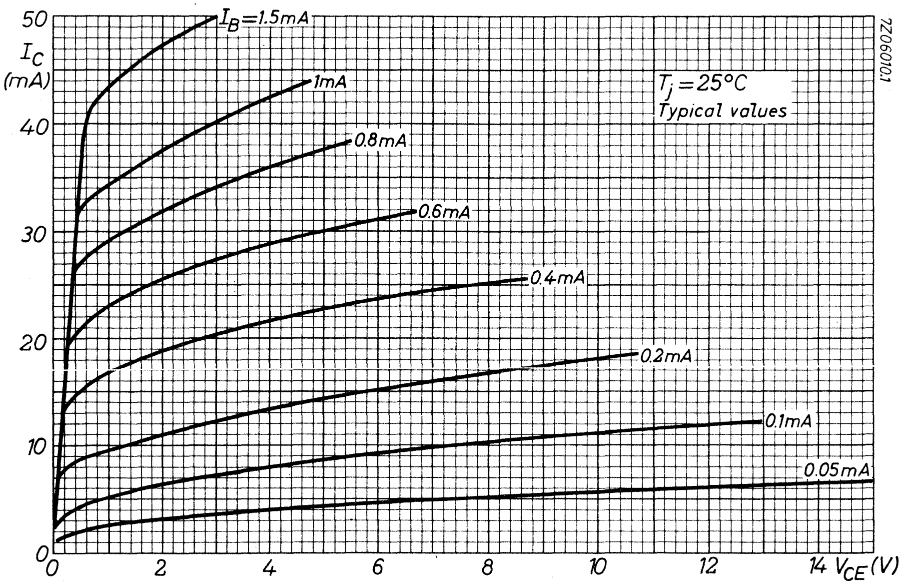
$I_C = 8$ mA; $V_{CE} = 6$ V; $R_L = 37.5\ \Omega$; $T_{amb} = 25\ ^oC$
$V_o = 100$ mV at $f_p = 183$ MHz
$V_o = 100$ mV at $f_q = 200$ MHz
measured at $f_{(2q-p)} = 217$ MHz — d_{im} typ. −40 dB

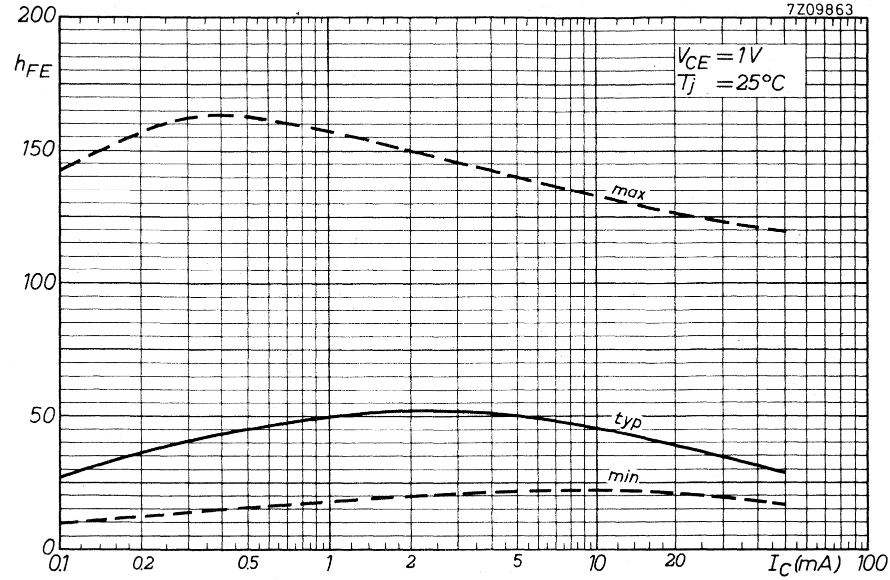
Test circuit:

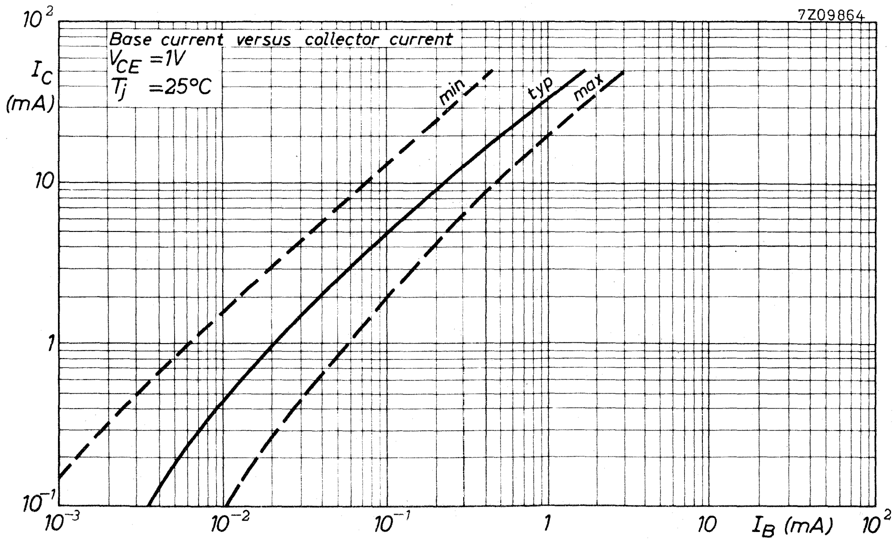


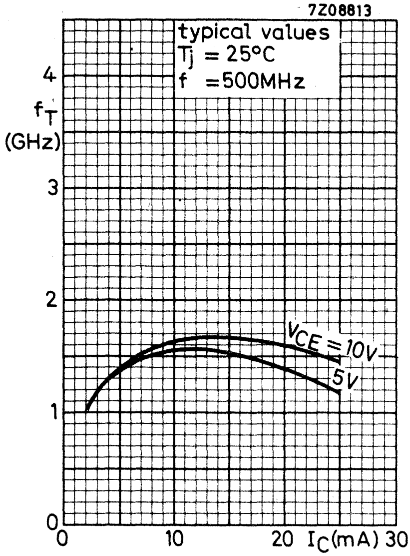
1) Shield lead grounded.

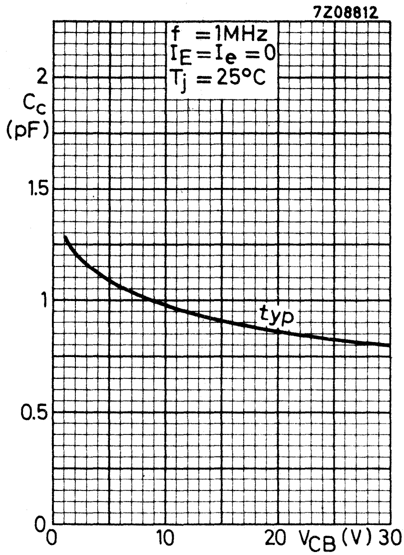

10
I_C (mA)
8
6
4
2
0
$T_j = 25°C$
Typical values
$I_B = 200 \mu A$
150µA
100µA
70µA
50µA
30µA
20µA
10µA
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7 V_{CE} (V)
7Z06009-2.6.25.ij

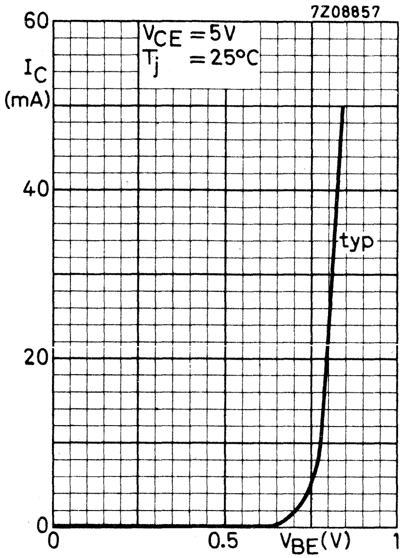

50
I_C (mA)
40
30
20
10
0
$I_B = 1.5mA$
1mA
0.8mA
0.6mA
0.4mA
0.2mA
0.1mA
0.05mA
$T_j = 25°C$
Typical values
0
2
4
6
8
10
12
14 V_{CE} (V)
7Z06010.1

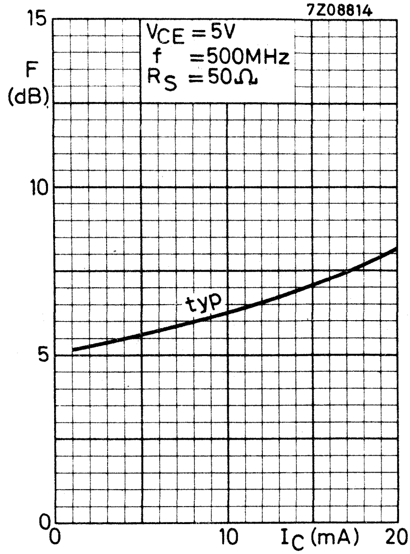

7Z09863
h_{FE}
V_{CE} = 1V
T_j = 25°C
max
typ
min
200
150
100
50
0
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100

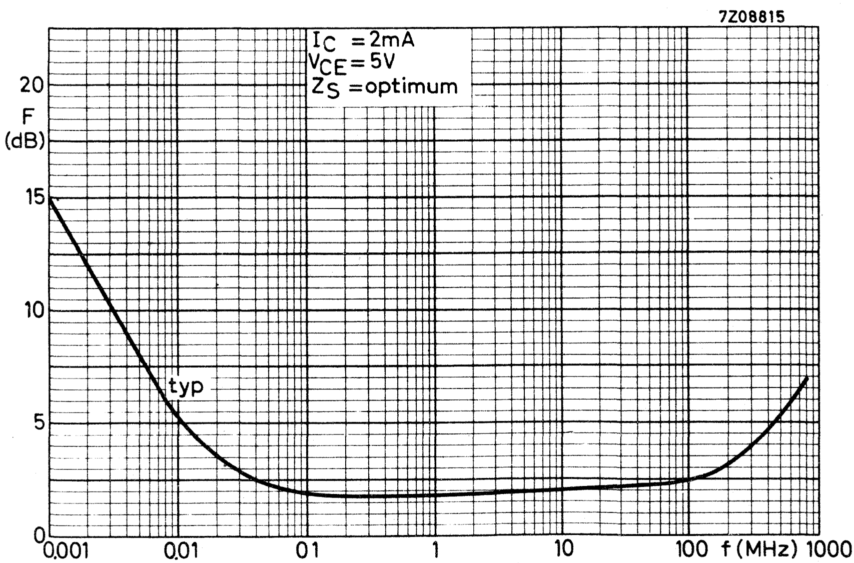

7Z09864
Base current versus collector current
V_{CE} = 1V
T_j = 25°C
I_C (mA)
min
typ
max
10^2
10
1
10^{-1}
10^{-3}
10^{-2}
10^{-1}
1
10
I_B (mA)
10^2


7Z08813
typical values
Tj = 25°C
f = 500MHz
fT
(GHz)
VCE = 10V
5V
IC (mA)


7Z08812
f = 1MHz
IE = Ie = 0
Tj = 25°C
Cc
(pF)
typ
VCB (V)


7Z08857
VCE = 5V
Tj = 25°C
IC
(mA)
typ
VBE (V)


7Z08814
V_{CE} = 5V
f = 500MHz
R_S = 50 Ω
F
(dB)
15
10
5
0
typ
0
10
I_C (mA)
20


7Z08815
I_C = 2mA
V_{CE} = 5V
Z_S = optimum
F
(dB)
20
15
10
5
0
typ
0,001
0,01
0,1
1
10
100
f (MHz)
1000

SILICON EPITAXIAL PLANAR TRANSISTORS

N-P-N transistors in a TO-39 metal envelope with the collector connected to the case. These transistors are intended for general purpose industrial applications.

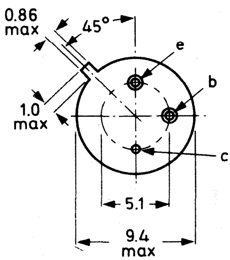
QUICK REFERENCE DATA

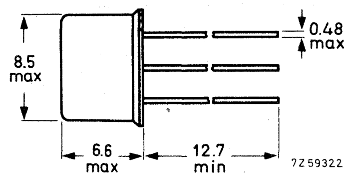
			BFY50	BFY51	BFY52	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	60	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	35	30	20	V
Collector current (peak value)	I_{CM}	max.	1	1	1	A
Total dissipation up to T_{mb} = 50 °C	P_{tot}	max.	5	5	5	W
Junction temperature	T_j	max.	200	200	200	°C
D.C. current gain at T_j = 25 °C						
I_C = 150 mA; V_{CE} = 10 V	h_{FE}	typ.	112	123	142	
Transition frequency						
I_C = 50 mA; V_{CE} = 10 V	f_T	typ.	140	160	185	MHz
Saturation voltage						
I_C = 500 mA; I_B = 50 mA	V_{CEsat}	<	0.7	1.0	1.0	V

MECHANICAL DATA

Dimensions in mm

TO-39
Collector connected to case





max. lead diameter is guaranteed only for 12.7 mm.
Accessories supplied on request: 56218, 56245

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

			BFY50	BFY51	BFY52	
Voltages						
Collector-base voltage (open emitter)	V_{CBO}	max.	80	60	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	35	30	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	6	6	V

Currents

Collector current (d.c.)	I_C	max.	1	A
Collector current (peak value)	I_{CM}	max.	1	A
Emitter current (d.c.)	$-I_E$	max.	1	A
Emitter current (peak value)	$-I_{EM}$	max.	1	A
Reverse base current (peak value)	$-I_{BM}$	max.	0.1	A

Power dissipation (See also page 8)

Total power dissipation up to T_{mb} = 50 °C	P_{tot}	max.	5	W

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	220	°C/W
From junction to case	$R_{th\ j-c}$	=	35	°C/W
From junction to mounting base	$R_{th\ j-mb}$	=	30	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BFY50	BFY51	BFY52	
Collector cut-off current						
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	typ.	2			nA
		<	50			nA
$I_E = 0$; $V_{CB} = 40$ V	I_{CBO}	typ.		2		nA
		<		50		nA
$I_E = 0$; $V_{CB} = 30$ V	I_{CBO}	typ.			2	nA
		<			50	nA
$I_E = 0$; $V_{CB} = 60$ V; $T_j = 100$ °C	I_{CBO}	typ.	100			nA
		<	2.5			μA
$I_E = 0$; $V_{CB} = 40$ V; $T_j = 100$ °C	I_{CBO}	typ.		100		nA
		<		2.5		μA
$I_E = 0$; $V_{CB} = 30$ V; $T_j = 100$ °C	I_{CBO}	typ.			100	nA
		<			2.5	μA
Emitter cut-off current						
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	typ.	2	2	2	nA
		<	50	50	50	nA
$I_C = 0$; $V_{EB} = 5$ V; $T_j = 100$ °C	I_{EBO}	typ.	0.1	0.1	0.1	μA
		<	2.5	2.5	2.5	μA
Saturation voltages						
$I_C = 10$ mA; $I_B = 1.0$ mA	V_{CEsat}	typ.	0.06	0.06	0.06	V
		<	0.10	0.15	0.15	V
	V_{BEsat}	typ.	0.69	0.69	0.69	V
		<	1.2	1.2	1.2	V
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	typ.	0.15	0.15	0.15	V
		<	0.20	0.35	0.35	V
	V_{BEsat}	typ.	0.92	0.92	0.92	V
		<	1.3	1.3	1.3	V
$I_C = 500$ mA; $I_B = 50$ mA [1]	V_{CEsat}	typ.	0.35	0.35	0.35	V
		<	0.70	1.00	1.00	V
	V_{BEsat}	typ.	1.15	1.15	1.15	V
		<	1.5	1.5	1.5	V
$I_C = 1$ A; $I_B = 100$ mA [1]	V_{CEsat}	typ.	0.66	0.66	0.66	V
		<	1.00	1.60	1.60	V
	V_{BEsat}	typ.	1.40	1.40	1.40	V
		<	2.0	2.0	2.0	V

[1] Measured under pulsed conditions to avoid excessive dissipation.

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

			BFY50	BFY51	BFY52	
D.C. current gain						
I_C = 10 mA; V_{CE} = 10 V	h_{FE}	>	20	30	30	
		typ.	80	85	90	
I_C = 150 mA; V_{CE} = 10 V [1)]	h_{FE}	>	30	40	60	
		typ.	112	123	142	
I_C = 500 mA; V_{CE} = 10 V [1)]	h_{FE}	>	20	25	30	
		typ.	70	79	90	
I_C = 1 A ; V_{CE} = 10 V [1)]	h_{FE}	>	15	15	15	
		typ.	35	40	50	
Switching times (See also page 5)						
I_C = 150 mA; $+I_B = -I_{BM}$ = 15 mA						
delay time	t_d	typ.	15	15	15	ns
rise time	t_r	typ.	40	40	40	ns
storage time	t_s	typ.	300	300	300	ns
fall time	t_f	typ.	60	60	60	ns
Collector capacitance at f = 1 MHz						
$I_E = I_e$ = 0; V_{CB} = 10 V	C_c	<	12	12	12	pF
Transition frequency at f = 35 MHz						
I_C = 50 mA; V_{CE} = 10 V	f_T	>	60	50	50	MHz
		typ.	140	160	185	MHz
h parameters at f = 1 kHz						
I_C = 10 mA; V_{CE} = 5 V						
Input impedance	h_{ie}	<	750	750	750	Ω
Reverse voltage transfer ratio	h_{re}	<	5.0	5.0	5.0	10^{-4}
Small signal current gain	h_{fe}	>	15	45	45	
		typ.	90	100	110	
Output admittance	h_{oe}	<	80	80	80	$\mu\Omega^{-1}$
I_C = 1 mA; V_{CE} = 5 V						
Small signal current gain	h_{fe}	>	10	30	30	
		typ.	60	65	70	

1) Measured under pulsed conditions to avoid excessive dissipation.

MEASUREMENT OF SWITCHING TIMES

Fig. 1 : Circuit diagram

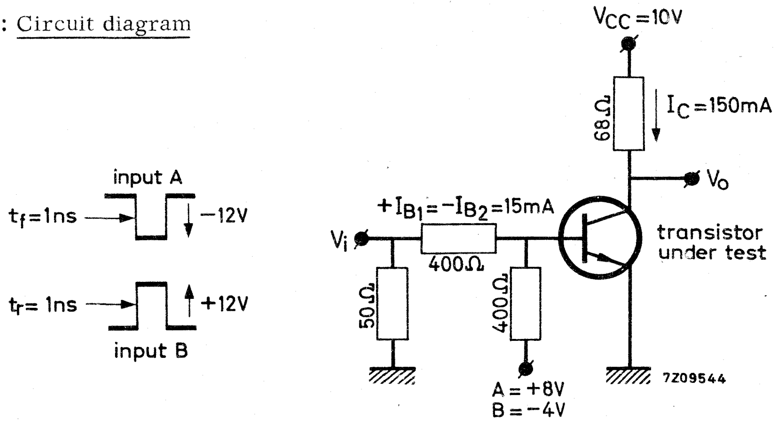
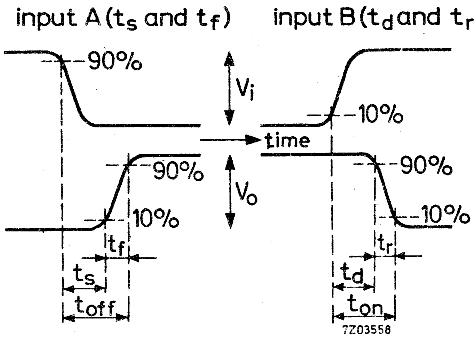


Fig. 2 : Waveforms



Equipment			
	Pulse generator:	rise time	t_r = 1 ns
		pulse duration	t_p = 1 μs
	Double beam or dual trace oscilloscope:	rise time	t_r < 5 ns

OPERATING NOTES (Dissipation and heatsink considerations)

1. Steady-state conditions

The max. allowable steady-state dissipation P_S is given by the relationship

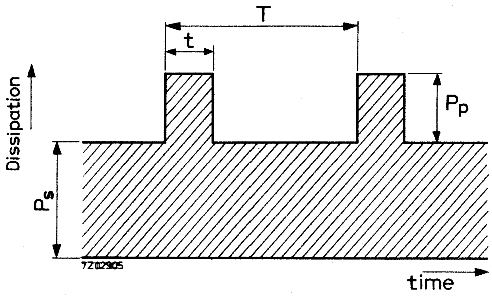
$$P_{s\,max.} = \frac{T_{j\,max.} - T_{amb}}{R_{th\,j\text{-}a}}$$

where $T_{j\,max.}$ is the maximum permissible operating junction temperature,

T_{amb} is the ambient temperature,

$R_{th\,j\text{-}a}$ is the total thermal resistance between junction and ambient.

2. Pulse conditions (rectangular pulses)



The maximum allowable pulse power P_p is given by the formula

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

where Z_{th} is the thermal impedance of the device between junction and mounting base and is a function of the pulse duration t and duty cycle δ (see page 9),

δ is the duty cycle and is equal to the pulse duration t divided by the periodic time T,

$R_{th\,mb\text{-}a}$ is the total thermal resistance between mounting base and ambient.

Example

The following example shows how to calculate the maximum permissible peak dissipation of a BFY50 mounted in free air at a temperature not exceeding 65 ^{o}C. The steady-state dissipation under the bottomed condition is 350 mW, the pulse width is 1 ms and the duty cycle is 0.2.

The thermal impedance Z_{th} = 13 ^{o}C/W (from page 9)

OPERATING NOTES (continued)

$$P_{p\,max} = \frac{(200-65) - (0.35 \times 220)}{13 + 0.2\,(220-30)}$$

$$= \frac{135 - 77}{13 + 38} = 1.14\,W$$

The peak pulse dissipation of 1.14 W is therefore allowed provided that the voltage and current ratings of the device are not exceeded.

3. Pulse conditions (other than rectangular)

For sinusoidal and irregular shaped waveforms, the power pulse is converted to an equivalent rectangular pulse of the same average and peak values, and treated as in the previous section.

Example

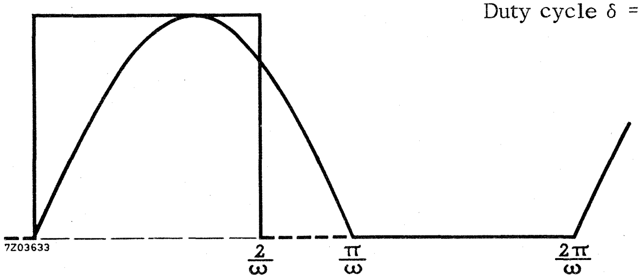
The following example illustrates how to find the maximum permissible peak dissipation of a BFY52 operating in a class "B" circuit at 1 kHz. The device is mounted on a heatsink of thermal resistance equal to 50 °C/W and at an ambient temperature not exceeding 100 °C. Assuming that the waveform is sinusoidal for half period and zero for the other half,

$$\text{Average of sinewave over half cycle} = \frac{2\,P_p}{\pi}$$

Therefore equivalent rectangular pulse width of same amplitude and average value,

$$t = \frac{2}{\omega} = \frac{2}{2\pi \times 10^3} = 0.318\ \text{ms}$$

$$\text{Duty cycle } \delta = \frac{2/\omega}{2\pi/\omega} = \frac{1}{\pi}$$

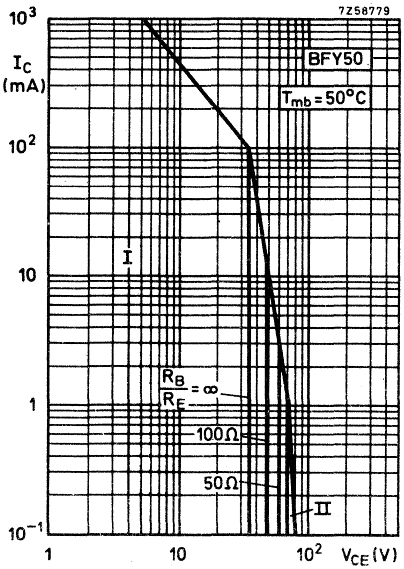


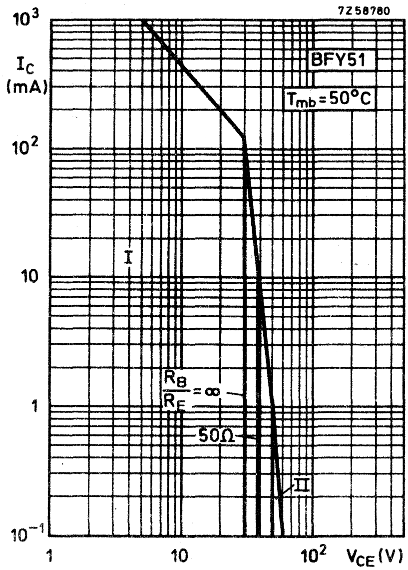
From page 9: $Z_{th\,0} = 6.0\ ^{o}C/W$ $R_{th\,j\text{-}mb} = 30\ ^{o}C/W$

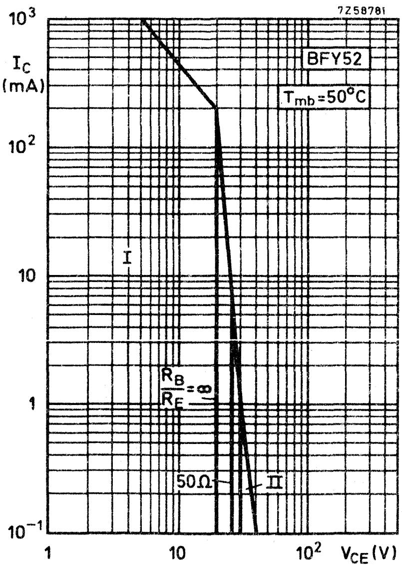
$$Z_{th}\ (\text{at } \delta = 0.318) = 6.0 + 0.318\,(30-6.0) = 13.6\ ^{o}C/W$$

$$P_{p\,max} = \frac{(200-100) - 0}{13.6 + 0.318 \times 50} = 3.39\,W$$

A peak power of 3.39 W is therefore permissible provided that the voltage and current ratings of the device are not exceeded.



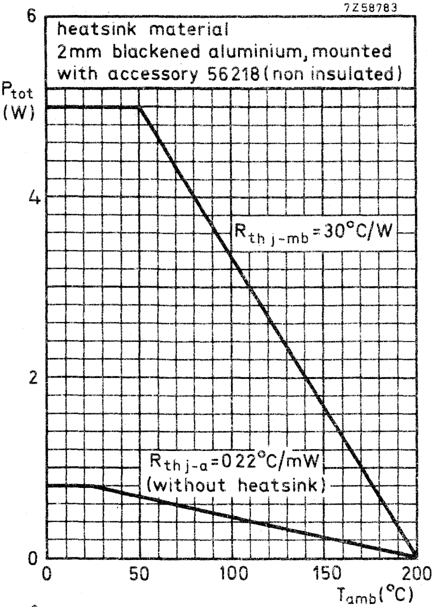


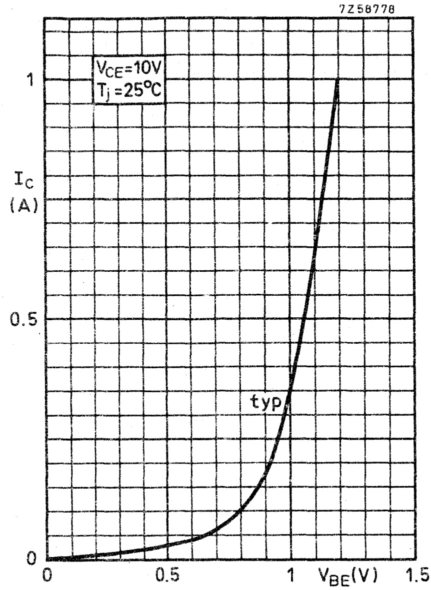


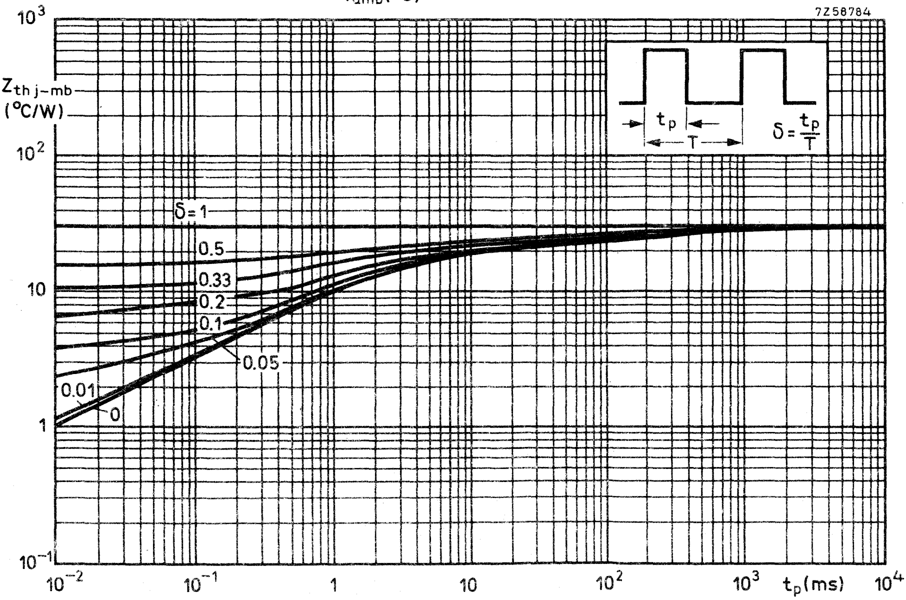
Safe Operating Area with the transistor forward biased

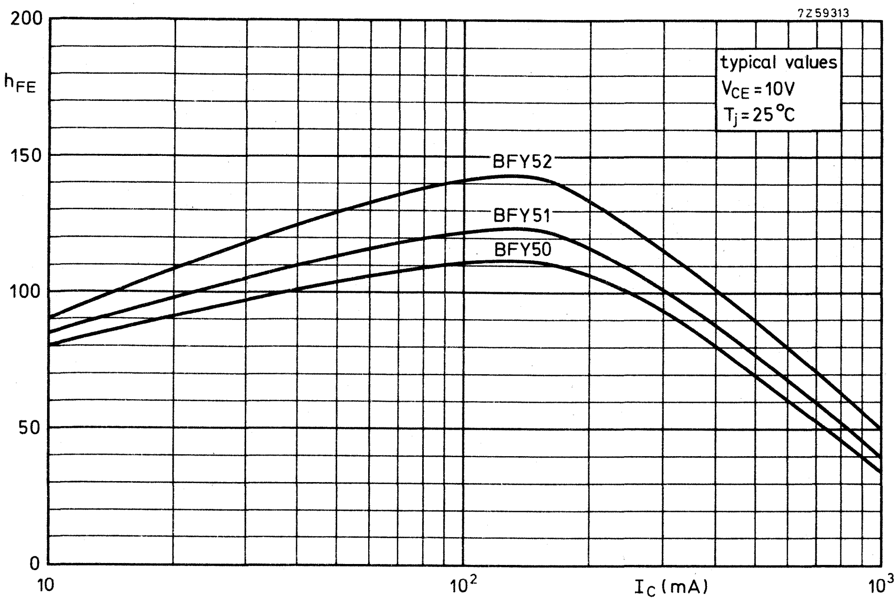
I. Region of permissible d.c. operation

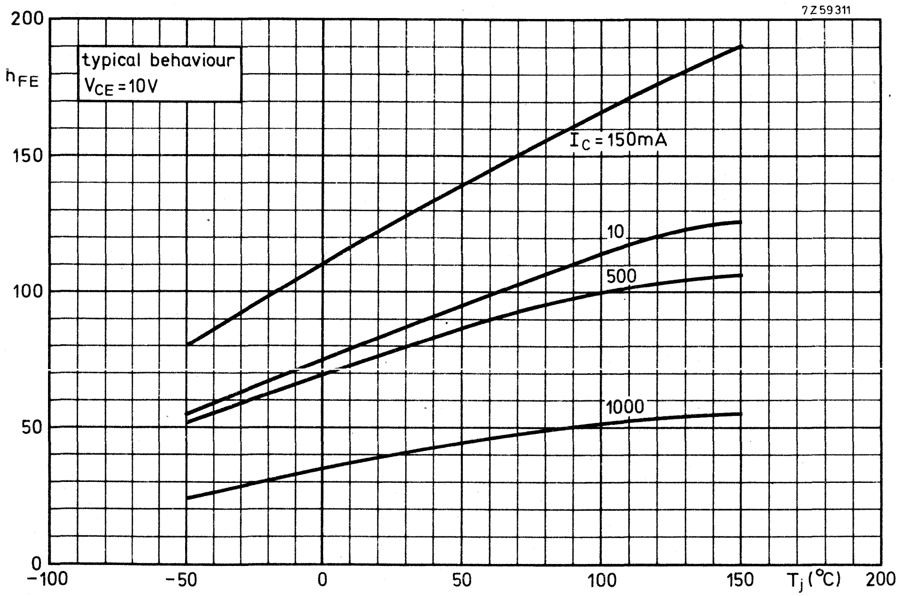
II. Additional area for d.c. operation when $R_B / R_E < 10\ \Omega$

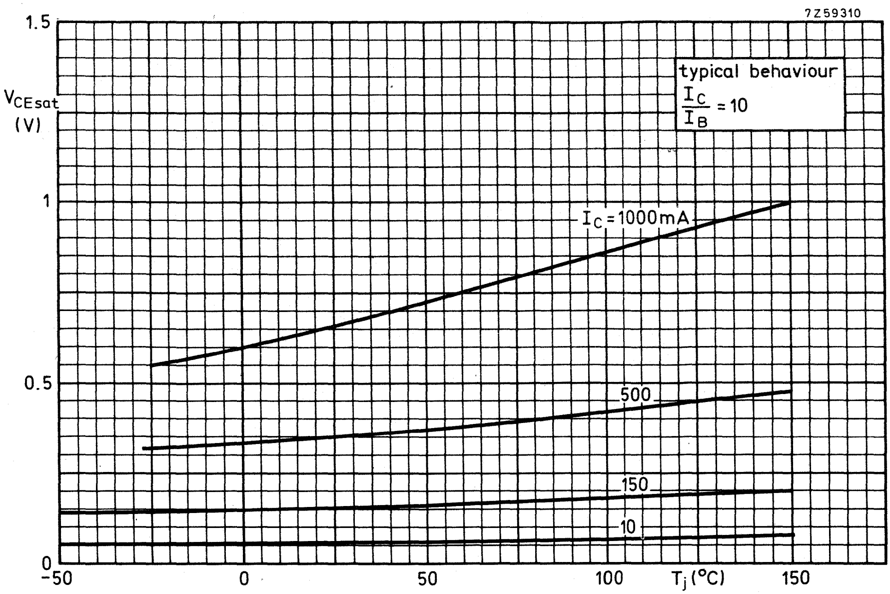

7Z58783
heatsink material
2mm blackened aluminium, mounted
with accessory 56218 (non insulated)
P_{tot} (W)
$R_{th\,j-mb}$ = 30°C/W
$R_{th\,j-a}$ = 0.22°C/mW
(without heatsink)
T_{amb} (°C)
0
2
4
6
50
100
150
200

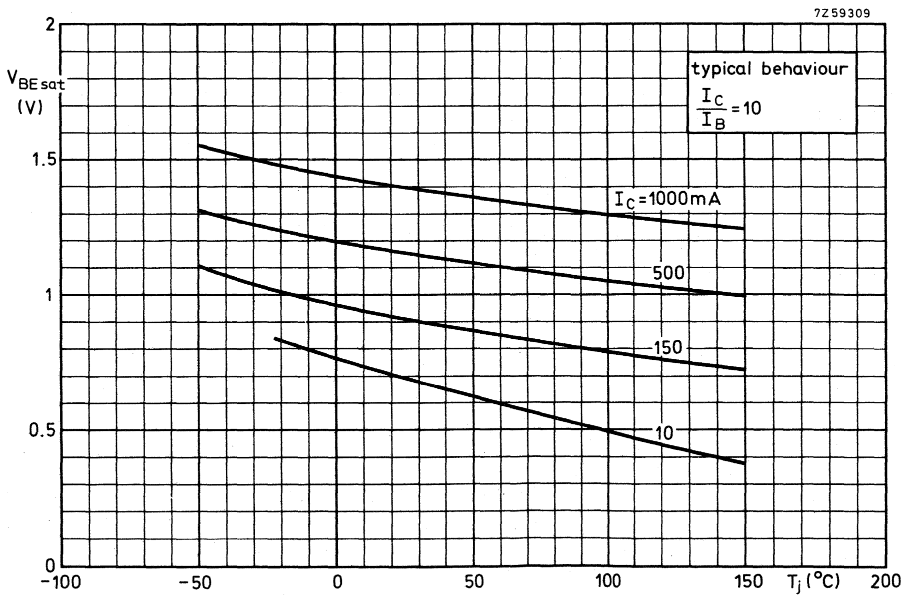

7Z58778
V_{CE} = 10V
T_j = 25°C
I_C (A)
typ
V_{BE} (V)
0
0.5
1
1.5

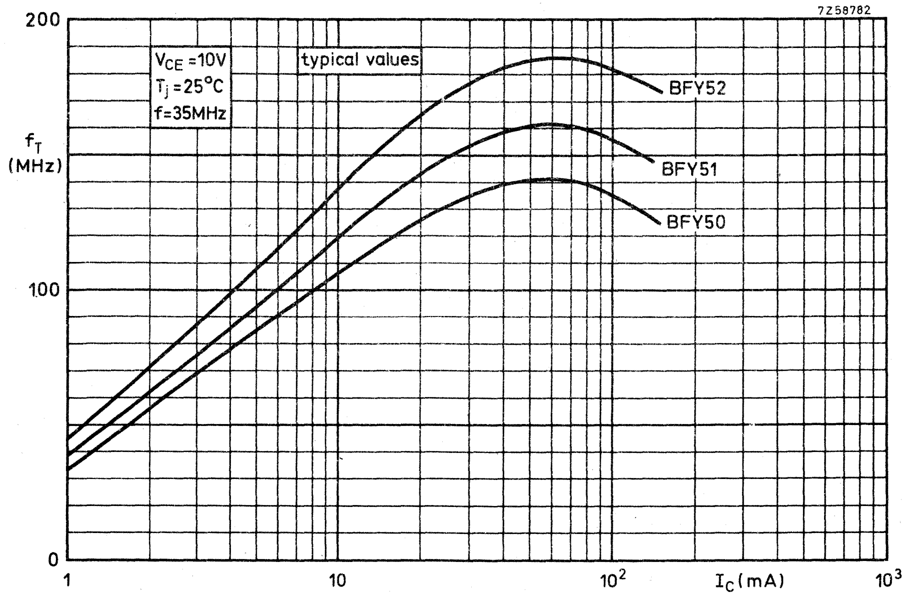

7Z58784
$Z_{th\,j-mb}$ (°C/W)
t_p
T
$\delta = \frac{t_p}{T}$
δ = 1
0.5
0.33
0.2
0.1
0.05
0.01
0
t_p (ms)
10^{-1}
1
10
10^2
10^3
10^{-2}
10^4

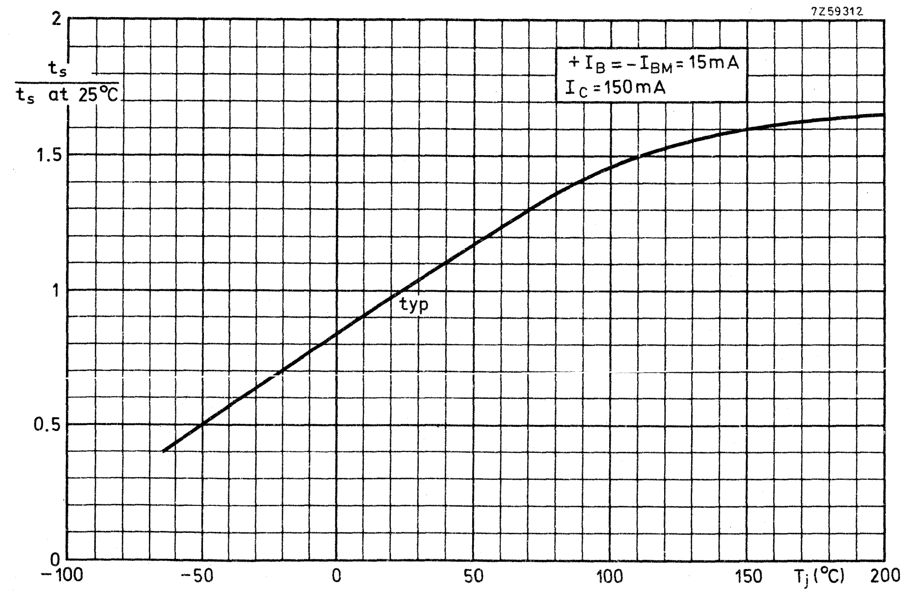

7Z59313
typical values
V_{CE} = 10V
T_j = 25 °C
BFY52
BFY51
BFY50
h_{FE}
200
150
100
50
0
10
10^2
I_C (mA)
10^3

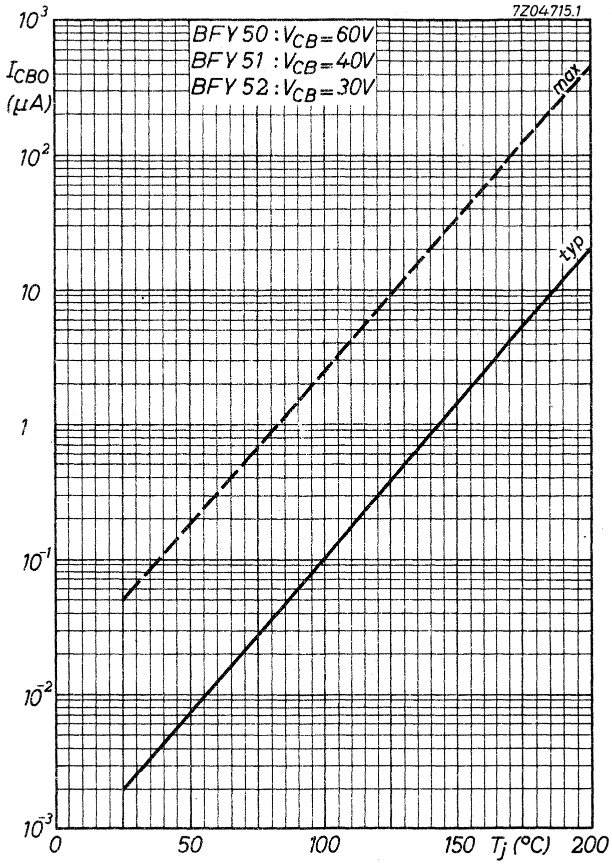

7Z59311
typical behaviour
V_{CE} = 10V
I_C = 150mA
10
500
1000
h_{FE}
200
150
100
50
0
−100
−50
0
50
100
150
T_j (°C)
200

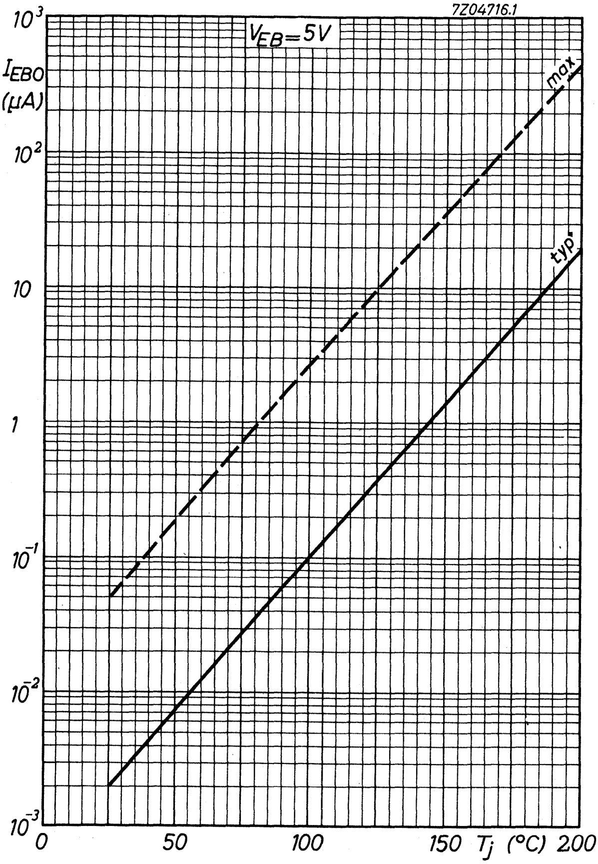

7Z59310
1.5
V_{CEsat} (V)
typical behaviour
$\frac{I_C}{I_B} = 10$
1
I_C = 1000mA
0.5
500
150
10
0
−50
0
50
100
T_j (°C)
150


7Z59309
2
V_{BEsat} (V)
typical behaviour
$\frac{I_C}{I_B} = 10$
1.5
I_C = 1000mA
500
1
150
0.5
10
0
−100
−50
0
50
100
150
T_j (°C)
200


7Z58782
VCE = 10V
Tj = 25°C
f = 35MHz
typical values
fT (MHz)
200
100
0
BFY52
BFY51
BFY50
1
10
10^2
IC (mA)
10^3


7Z59312
ts / ts at 25°C
+IB = −IBM = 15mA
IC = 150mA
typ
2
1.5
1
0.5
0
−100
−50
0
50
100
150
Tj (°C)
200


7Z04715.1
BFY 50 : V_{CB} = 60V
BFY 51 : V_{CB} = 40V
BFY 52 : V_{CB} = 30V
I_{CBO}
(μA)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
max
typ
0
50
100
150
T_j (°C)
200


7Z04716.1
$V_{EB} = 5V$
I_{EBO} (µA)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
max
typ
0
50
100
150
T_j (°C)
200

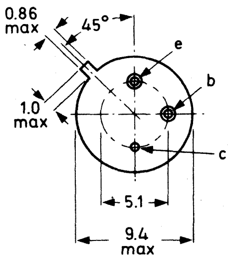
SILICON PLANAR EPITAXIAL TRANSISTOR

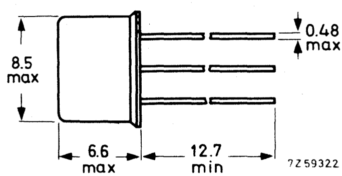
N-P-N transistor in TO-39 metal case with the collector connected to the case. It is primarily intended for use in high frequency and very high frequency oscillators and amplifiers as well as for output stages of servo amplifiers.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	80	V
Collector-emitter voltage (open base)	V_{CEO}	max.	35	V
Collector current (d.c.)	I_C	max.	1	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	800	mW
Junction temperature	T_j	max.	200	°C
D.C. current gain at T_j = 25 °C				
I_C = 150 mA; V_{CE} = 10 V	h_{FE}	>	40	
Transition frequency				
I_C = 50 mA; V_{CE} = 10 V	f_T	>	60	MHz
Collector-emitter saturation voltage				
I_C = 1 A; I_B = 100 mA	V_{CEsat}	<	1	V

MECHANICAL DATA Dimensions in mm

Collecter connected to case
TO-39





max.lead diameter is guaranteed only for 12.7 mm

Accessories available: 56218, 56245.

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	80	V
Collector-emitter voltage (open base)	V_{CEO}	max.	35	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	V

Currents

Collector current (d.c.)	I_C	max.	1	A
Collector current (peak value)	I_{CM}	max.	1	A
Emitter current (d.c.)	$-I_E$	max.	1	A
Emitter current (peak value)	$-I_{EM}$	max.	1	A

Power dissipation (See also page 4)

Total power dissipation up to T_{amb} = 40 °C	P_{tot}	max.	4	W
Total power dissipation without cooling fin up to T_{amb} = 25 °C	P_{tot}	max.	0.8	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	$R_{th\ j\text{-}a}$	=	0.22	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0.035	°C/mW

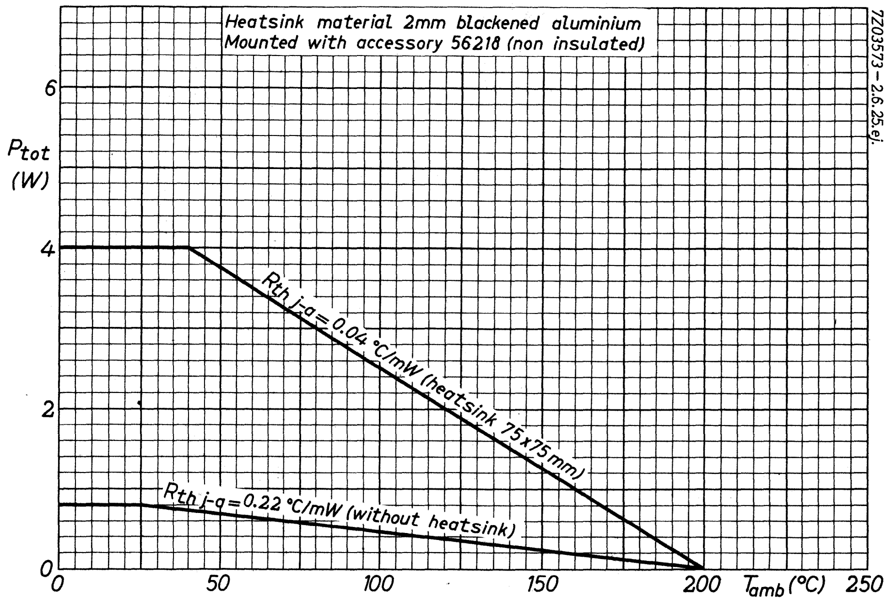
1) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

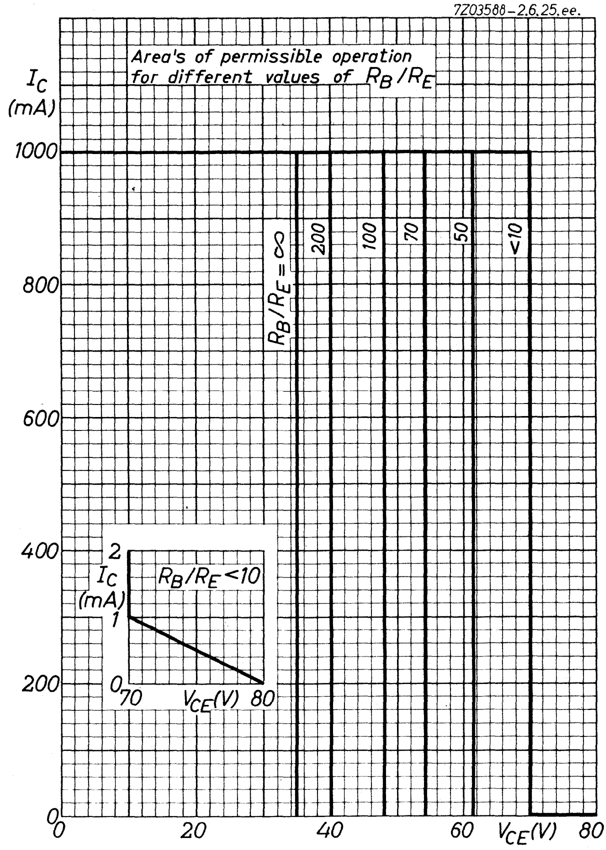
CHARACTERISTICS — T_j = 25 °C unless otherwise specified

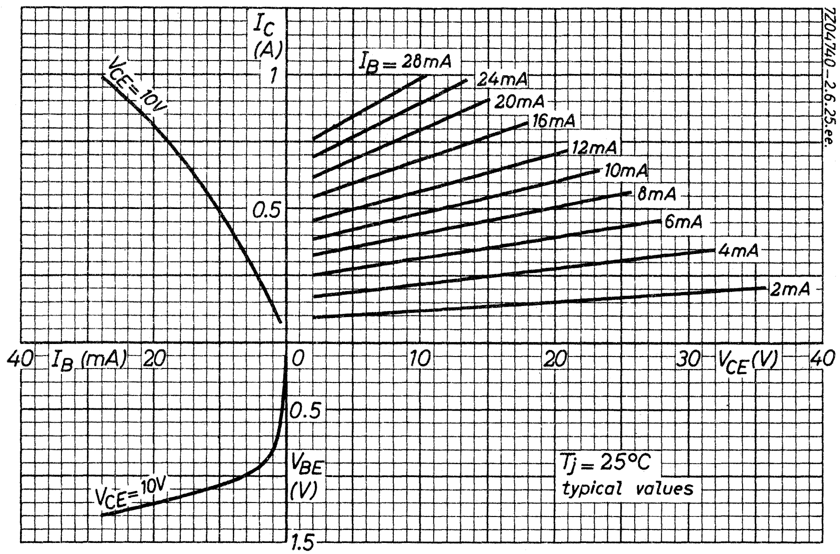
Collector cut-off current				
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	<	10	nA
$I_E = 0$; $V_{CB} = 60$ V; $T_j = 150$ °C	I_{CBO}	<	10	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	nA
Saturation voltages				
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0.2	V
$I_C = 1$ A; $I_B = 100$ mA [1][2]	V_{CEsat}	<	1.0	V
	V_{BEsat}	<	1.6	V
Sustaining voltage				
$I_C = 30$ mA; $I_B = 0$ [2]	$V_{CEOsust}$	>	35	V
D.C. current gain [2]				
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	30	
$I_C = 150$ mA; $V_{CE} = 10$ V	h_{FE}		40 to 120	
$I_C = 1$ A; $V_{CE} = 10$ V	h_{FE}	>	15	
Feedback time constant				
$I_C = 10$ mA; $V_{CB} = 10$ V; f = 4 MHz	$r_{b'}C_c$	<	800	ps
Collector capacitance at f = 500 kHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	12	pF
Emitter capacitance at f = 500 kHz				
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	<	80	pF
Transition frequency				
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	>	60	MHz

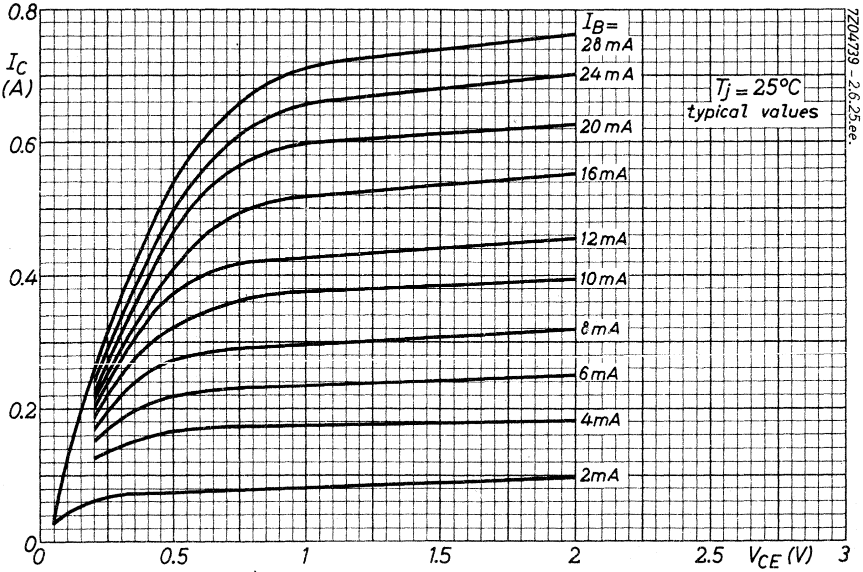
[1]) Measured with a lead length of 1 cm.

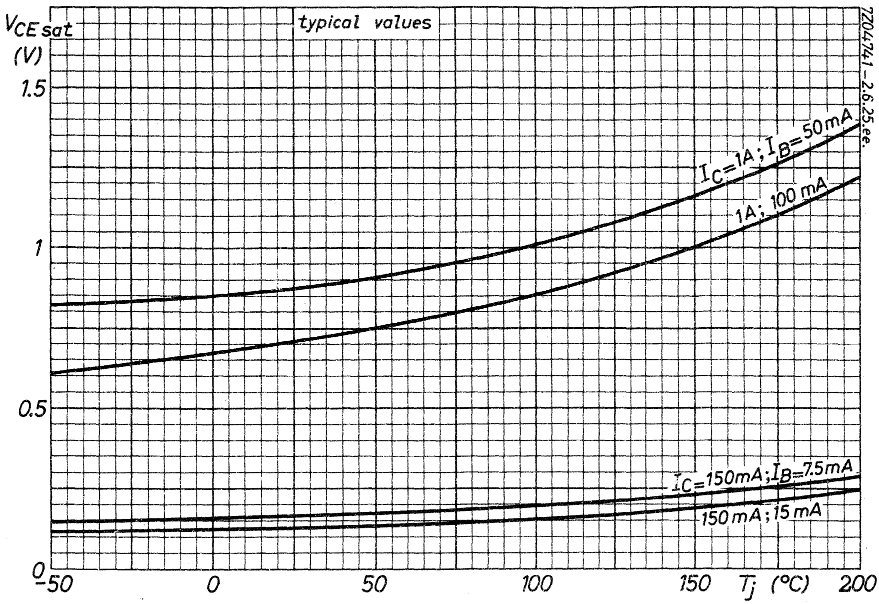
[2]) Measured under pulsed conditions to avoid excessive dissipation.
Pulse duration = 300 μs; duty cycle $\delta < 0.01$

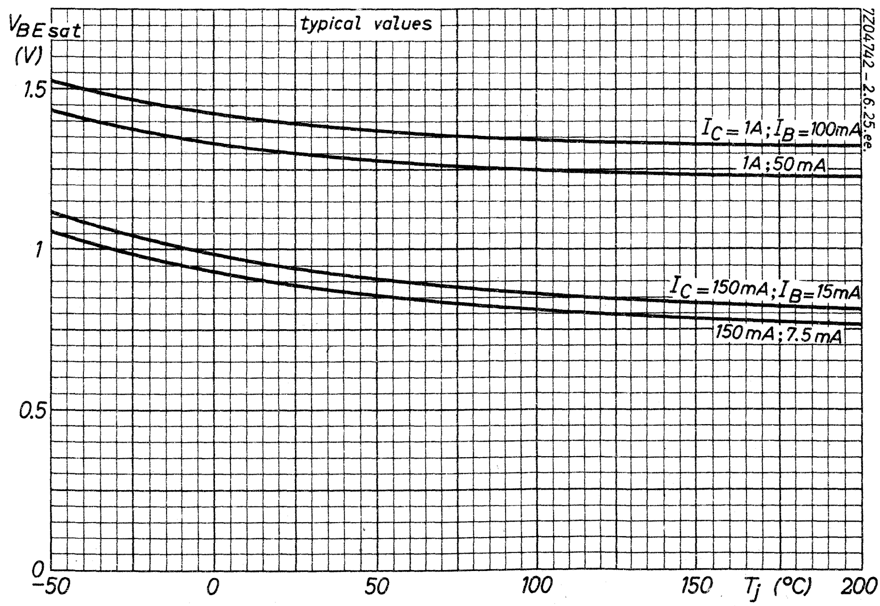

Heatsink material 2mm blackened aluminium
Mounted with accessory 56218 (non insulated)
7Z03573 - 2.6.25.ej.
P_{tot} (W)
6
4
2
0
$R_{th\ j\text{-}a}$ = 0.04 °C/mW (heatsink 75x75mm)
$R_{th\ j\text{-}a}$ = 0.22 °C/mW (without heatsink)
0
50
100
150
200
T_{amb} (°C)
250

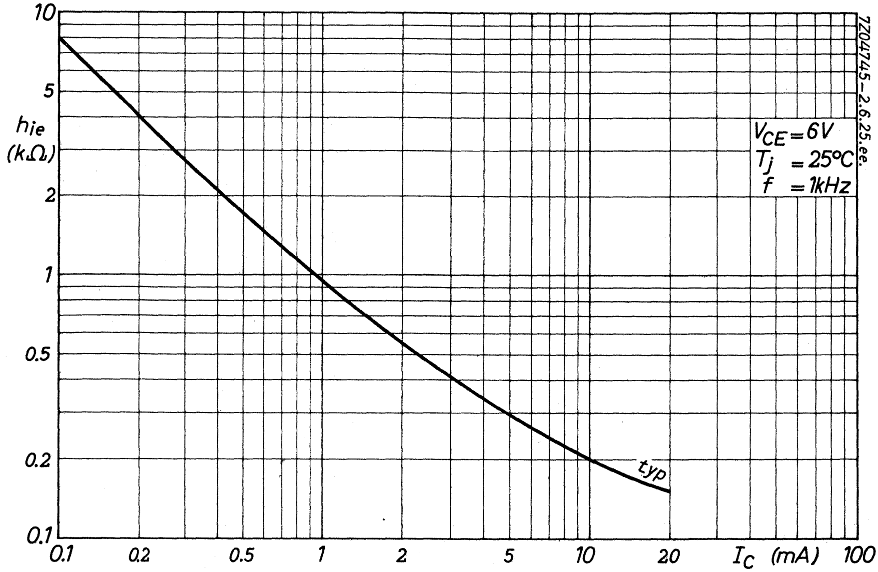

7Z03588-2.6.25.ee.
Area's of permissible operation for different values of R_B/R_E
I_C (mA)
1000
800
600
400
200
0
0
20
40
60
V_{CE}(V)
80
$R_B/R_E=\infty$
200
100
70
50
<10
2
I_C (mA)
1
0
70
V_{CE}(V)
80
$R_B/R_E<10$

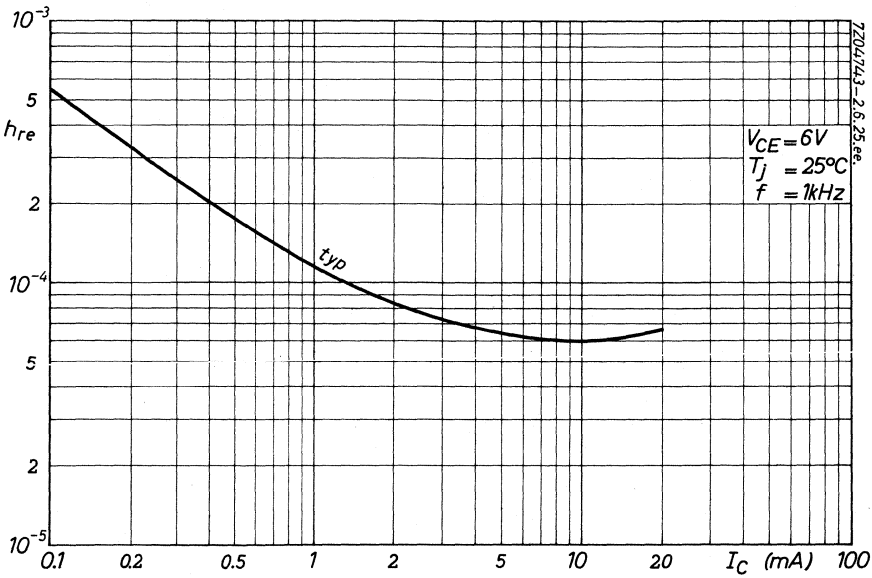

7Z04740 – 2.6.25.ee.
I_C (A)
1
0.5
I_B = 28mA
24mA
20mA
16mA
12mA
10mA
8mA
6mA
4mA
2mA
V_{CE} = 10V
40
I_B (mA)
20
0
10
20
30
V_{CE} (V)
40
0.5
V_{BE} (V)
1.5
V_{CE} = 10V
T_j = 25°C
typical values

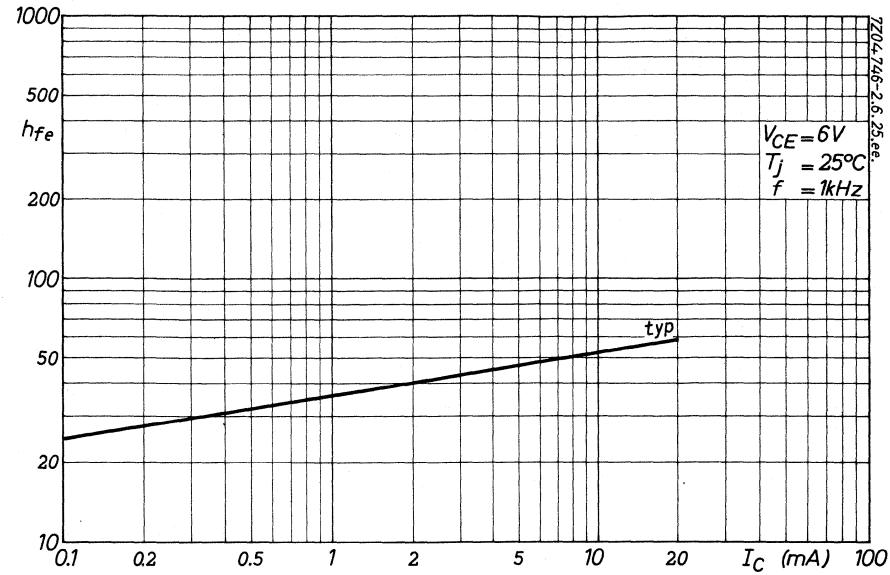

7Z04739 – 2.6.25.ee.
0.8
I_C (A)
0.6
0.4
0.2
0
I_B = 28 mA
24 mA
20 mA
16 mA
12 mA
10 mA
8 mA
6 mA
4mA
2mA
T_j = 25°C
typical values
0
0.5
1
1.5
2
2.5
V_{CE} (V)
3

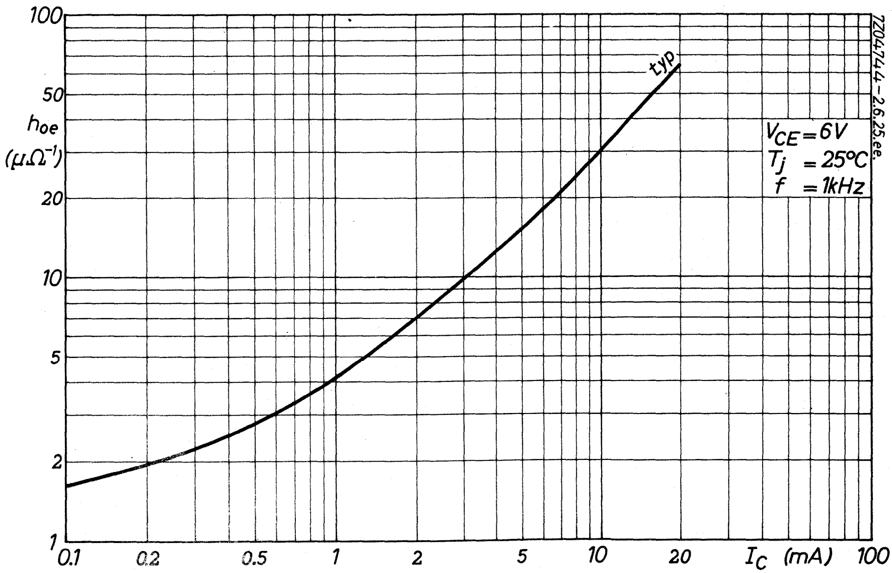

typical values
$V_{CE sat}$ (V)
1.5
1
0.5
0
-50
0
50
100
150
T_j (°C)
200
I_C=1A; I_B=50mA
1A; 100 mA
I_C=150mA; I_B=7.5mA
150 mA; 15 mA
7Z04741 - 2.6.25.ee.

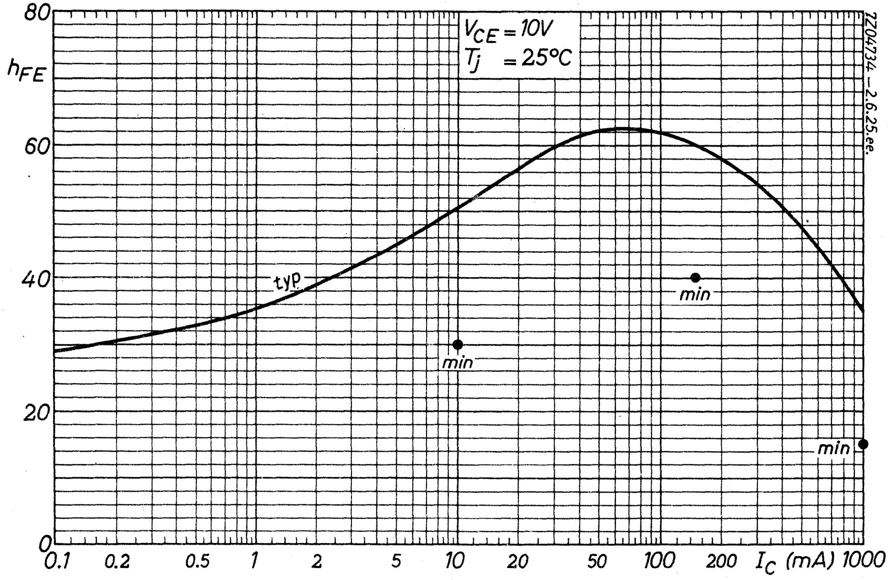

typical values
$V_{BE sat}$ (V)
1.5
1
0.5
0
-50
0
50
100
150
T_j (°C)
200
I_C = 1A; I_B =100mA
1A; 50 mA
I_C =150mA; I_B=15mA
150 mA; 7.5 mA
7Z04742 - 2.6.25.ee.

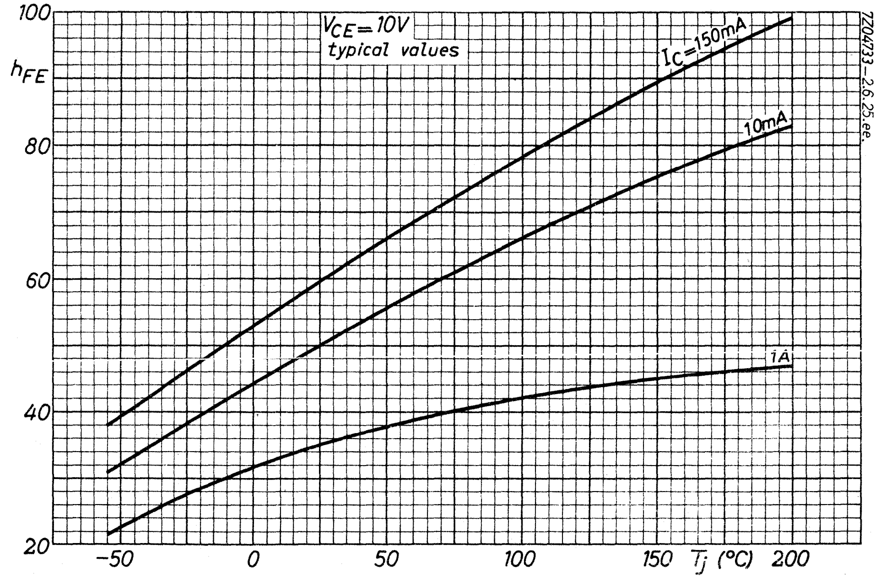

10
5
h_{ie} (kΩ)
2
1
0.5
0.2
0.1
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100
typ
V_{CE} = 6V
T_j = 25°C
f = 1kHz
7Z04745-2.6.25.ee.

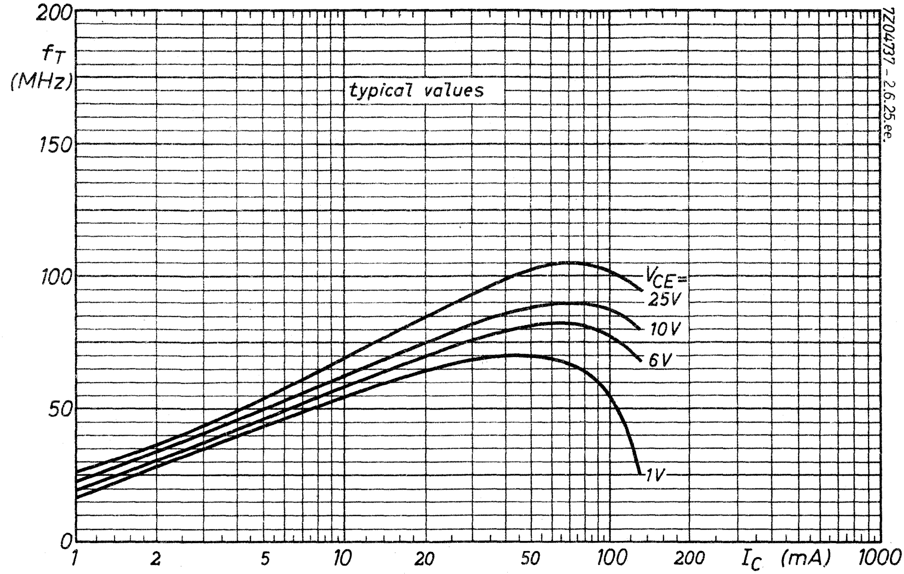

10^{-3}
5
h_{re}
2
10^{-4}
5
2
10^{-5}
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100
typ
V_{CE} = 6V
T_j = 25°C
f = 1kHz
7Z04743-2.6.25.ee.


1000
500
h_{fe}
200
100
50
20
10
typ
7Z04746-2.6.25.ee.
V_{CE} = 6V
T_j = 25°C
f = 1kHz
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100

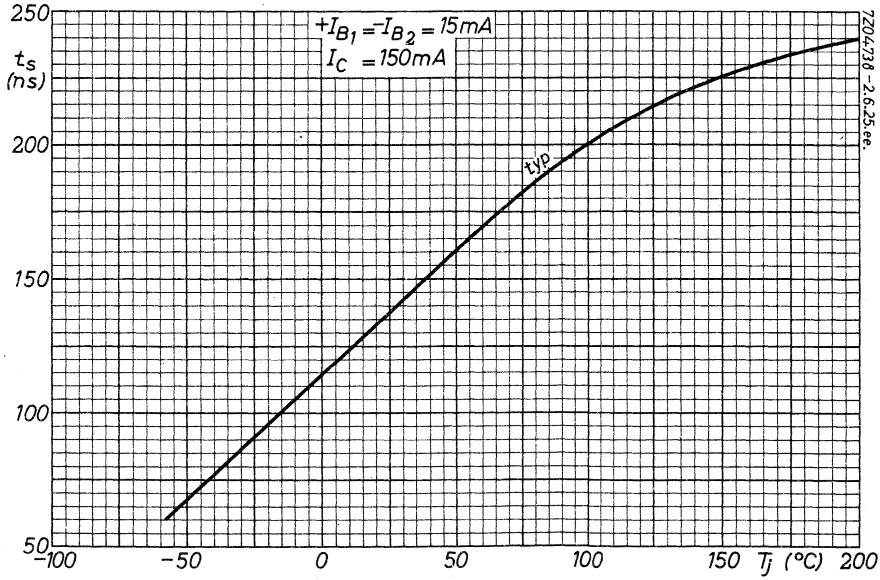

100
50
h_{oe}
($\mu\Omega^{-1}$)
20
10
5
2
1
typ
7Z04744-2.6.25.ee.
V_{CE} = 6V
T_j = 25°C
f = 1kHz
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100


80
60
40
20
0
h_{FE}
$V_{CE} = 10V$
$T_j = 25°C$
7Z04734-2.6.25.ee.
typ
min
min
min
0.1
0.2
0.5
1
2
5
10
20
50
100
200
I_C (mA)
1000

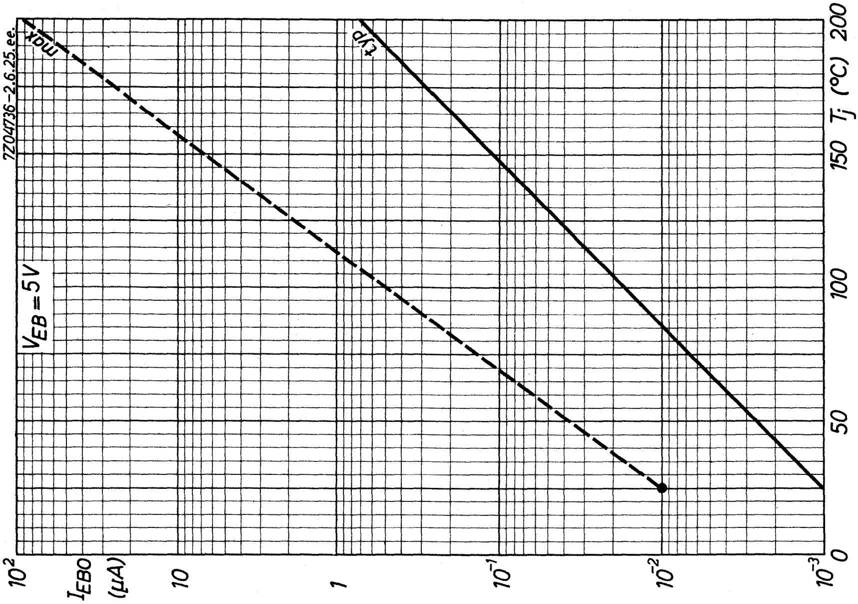

100
80
60
40
20
h_{FE}
$V_{CE} = 10V$
typical values
7Z04733-2.6.25.ee.
I_C=150mA
10mA
1A
−50
0
50
100
150
T_j (°C)
200

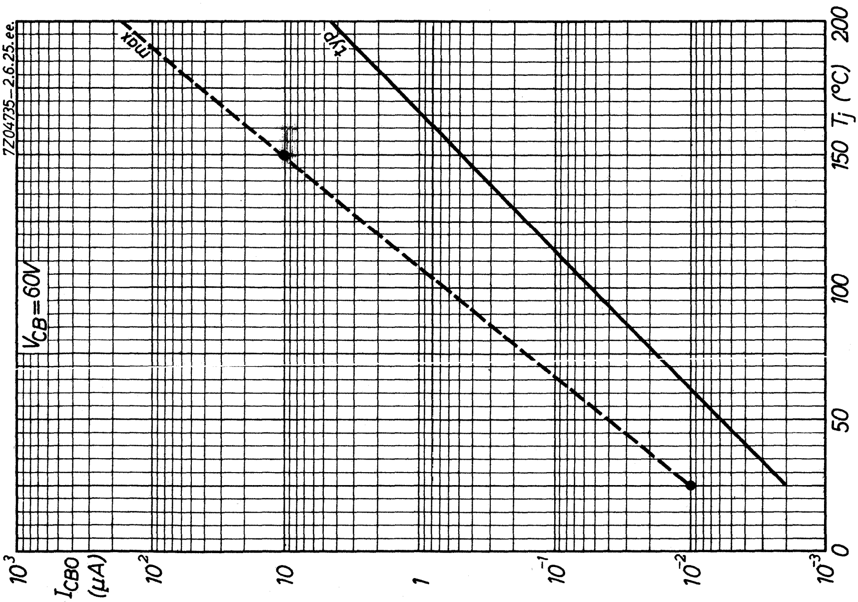


7Z04737 - 2.6.25.ee.
typical values
f_T (MHz)
200
150
100
50
0
V_{CE} = 25V
10V
6V
1V
1
2
5
10
20
50
100
200
I_C (mA)
1000



7Z04738 - 2.6.25.ee.
$+I_{B1} = -I_{B2} = 15mA$
$I_C = 150mA$
t_s (ns)
250
200
150
100
50
typ
−100
−50
0
50
100
150
T_j (°C)
200


7Z04736-2.6.25.ee.
max
typ
$V_{EB} = 5V$
I_{EBO} (μA)
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
T_j (°C)
0
50
100
150
200


7Z04735-2.6.25.ee.
max
typ
$V_{CB} = 60V$
I_{CBO} (μA)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
T_j (°C)
0
50
100
150
200

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a TO-72 metal envelope with insulated electrodes and a shield lead connected to the case.
The transistor has very low noise over a wide current range, a very high power gain and excellent intermodulation properties.
It is primarily intended for:
- Channel- and band aerial amplifiers for band I, II, III and IV/V (40-860 MHz)
- Wide band aerial amplifiers (40-860 MHz)
- Television distribution amplifiers
- Low noise wide band vertical amplifier in high speed oscilloscopes

It is also suitable for military- and industrial applications, such as:
- R.F. amplifiers and mixers for communication equipment
- **Microwave telephony link systems, wide band i.f. amplifiers**
- Large bandwidth radar i.f. amplifiers

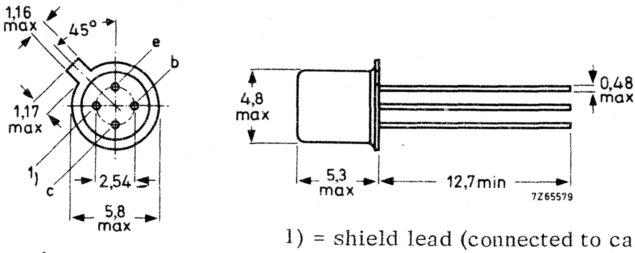
QUICK REFERENCE DATA

Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	30		V
Collector-emitter voltage (open base)	V_{CEO}	max.	15		V
Collector current (peak value; f > 1 MHz)	I_{CM}	max.	50		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	200		mW
Junction temperature	T_j	max.	200		°C
Transition frequency I_C = 25 mA; V_{CE} = 5 V; f = 500 MHz	f_T	typ.	1.4		GHz
Feedback capacitance at f = 1 MHz I_C = 2 mA; V_{CE} = 5 V	C_{re}	typ.	0.6		pF
Noise figure at optimum source impedance		f =	200	800	MHz
I_C = 2 mA; V_{CE} = 5 V	F	typ.	2.5	5.5	dB
Power gain (not neutralized) I_C = 14 mA; V_{CE} = 10 V	G_p	typ.	23	8	dB
Output power d_{im} = −30 dB; V.S.W.R. at output < 2 I_C = 14 mA; V_{CE} = 10 V	P_o	typ.	12	12	mW

MECHANICAL DATA see page 2.

MECHANICAL DATA Dimensions in mm

TO-72
insulated electrodes



1) = shield lead (connected to case)

Accessories available: 56246; 56263

RATINGS (Limiting values) [1]

Voltages

Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	30	V	
Collector-emitter voltage (peak value) $R_{BE} \leq 50\ \Omega$	V_{CERM}	max.	30	V	[2]
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V	[2]
Emitter-base voltage (open collector)	V_{EBO}	max.	2.5	V	

Currents

Collector current (d.c.)	I_C	max.	25	mA
Collector current (peak value; f > 1 MHz)	I_{CM}	max.	50	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	200	mW

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.88	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0.58	°C/mW

---

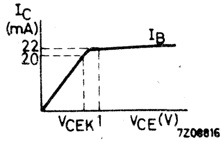
[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

[2]) I_C = 10 mA

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
I_E = 0; V_{CB} = 15 V	I_{CBO}	<	10	nA
Knee voltage				
I_C = 20 mA; I_B = value for which I_C = 22 mA at V_{CE} = 1 V	V_{CEK}	<	0.75	V



D.C. current gain				
I_C = 2 mA; V_{CE} = 1 V	h_{FE}		25 to 150	
I_C = 25 mA; V_{CE} = 1 V	h_{FE}		20 to 125	
Transition frequency [1]				
I_C = 2 mA; V_{CE} = 5 V; f = 500 MHz	f_T	>	1.0	GHz
		typ.	1.1	GHz
I_C = 25 mA; V_{CE} = 5 V; f = 500 MHz	f_T	>	1.3	GHz
		typ.	1.4	GHz
Collector capacitance at f = 1 MHz [2]				
I_E = I_e = 0; V_{CB} = 10 V	C_c	<	1.5	pF
Feedback capacitance at f = 1 MHz [1]				
I_C = 2 mA; V_{CE} = 5 V	C_{re}	typ.	0.6	pF
		<	0.8	pF
Noise figure [1]				
I_C = 2 mA; V_{CE} = 5 V				
f = 100 kHz; optimum source resistance	F	<	4	dB
f = 200 MHz; optimum source impedance	F	<	3.5	dB
f = 500 MHz; R_S = 50 Ω	F	<	5	dB
f = 800 MHz; optimum source impedance	F	typ.	5.5	dB

Power gain (not neutralized) [1]
I_C = 14 mA; V_{CE} = 10 V; T_{amb} = 25 °C

		f = 200	800	MHz
G_p	>	21		dB
	typ.	23	8	dB

1) Shield lead grounded.

2) Shield lead not connected.

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

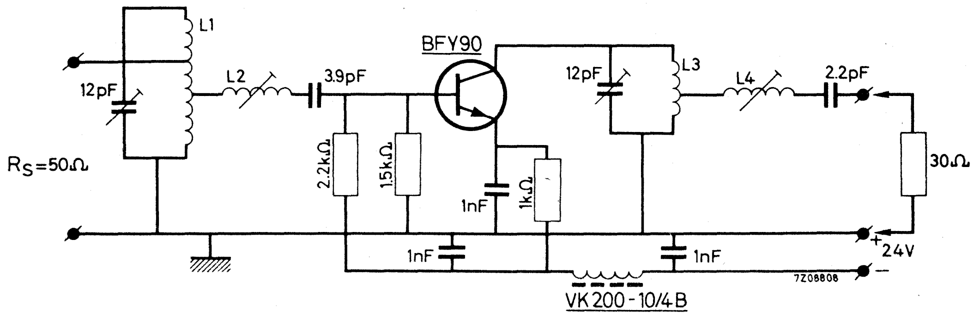
Intermodulation characteristics [1])

1. Output power at f = 200 MHz; T_{amb} = 25 °C

I_C = 14 mA; V_{CE} = 10 V; V.S.W.R. at output < 2
f_p = 202 MHz; f_q = 205 MHz; d_{im} = −30 dB
measured at $f_{(2q-p)}$ = 208 MHz (Channel 9)

P_o	>	10	mW
	typ.	12	mW

Test circuit:



Coil data:

L1 = 3 turns silver plated Cu wire (1.4 mm); winding pitch 2.7 mm; int. diam. 8 mm; taps at 0.5 turn and 1.5 turns from earth.
L2 = 5.5 turns silver plated Cu wire (1.4 mm); winding pitch 2.2 mm; int. diam. 8 mm.
L3 = 3 turns silver plated Cu wire (1.4 mm); winding pitch 3.3 mm; int. diam. 8 mm.
L4 = 5.5 turns silver plated Cu wire (1.4 mm); winding pitch 2.2 mm; int. diam. 11 mm.

1) Shield lead grounded

CHARACTERISTICS (continued)

Basis of adjustment

The intermodulation at an intermodulation distortion of −30 dB is caused by h.f. output current - voltage clipping.
The maximum undistorted output power is realised, if

a. Current and voltage clipping take place concurrently.
   This occurs if

$$R_L = \frac{V_{CE} - V_{CEK}}{I_C},$$

   in which V_{CEK} is the high frequency knee voltage.

b. The h.f. collector current is as small as possible.
   This is so if $-C_L = +C_{oe}$,
   in which C_{oe} is the output capacitance of the transistor at short circuited input.

For maximum output power at an intermodulation distortion of −30 dB, the (experimentally found) values of R_L and C_L are:
$R_L = 560\ \Omega$; $C_L = -1.8$ pF

Adjustment procedure

1. Remove the transistor and connect a dummy consisting of a 560 Ω resistor in parallel with a 1.8 pF capacitor between the collector and emitter connections of the output circuit.
2. Tune and match the output circuit for zero reflection at 205 MHz (V.S.W.R. = 1). After this adjustment, no further change may be made in the output circuit.
3. Replace the dummy by the transistor. Tune and match the input circuit for maximum power gain and good band pass curve.
   The V.S.W.R. of the output will then, in most cases, be ≤ 2 over the whole channel.
   Corrections can be made by tuning L2; this will not disturb the band pass curve.

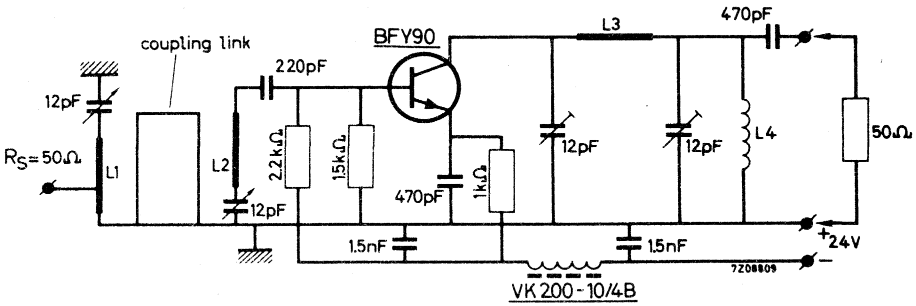
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Intermodulation characteristics [1]

2. Output power at f = 800 MHz; T_{amb} = 25 °C

I_C = 14 mA; V_{CE} = 10 V; V.S.W.R. at output < 2
f_p = 798 MHz; f_q = 802 MHz; d_{im} = −30 dB
measured at $f_{(2q-p)}$ = 806 MHz (Channel 62) P_o typ. 12 mW

Test circuit:



Coil data:

L1 = 24 mm x 6 mm x 0.5 mm silver plated Cu strip.
Tap of the input at 5 mm from earth.
L2 = 15 mm x 6 mm x 0.5 mm silver plated Cu strip.
L3 = 20 mm x 8 mm x 0.5 mm silver plated Cu strip.
L4 = 4 turns enamelled Cu wire (0.5 mm); winding pitch 1.5 mm; int. diam. 4 mm
Coupling link: 42 mm silver plated Cu wire (1 mm).

Basis of adjustment.

At 800 MHz no dummy can be used to adjust for optimum collector load because at these frequencies the impedance transformations of a dummy are too high. A small signal at the mid-channel frequency of 802 MHz is fed to the input and increased until clipping occurs; that is, until the output power no longer increases linearily with the input signal. This clipping can be eliminated by tuning the output circuit, thereby making the output power equal to

$$P_o = \frac{I_C (V_{CE} - V_{CEK})}{2} = 60 \text{ mW}$$

The output circuit is adjusted for minimum intermodulation if the input signal is as small as possible at P_o = 60 mW.
After this adjustment has been made no further change may be made in the output circuit.
Adjust the input circuit for maximum power gain and good band pass curve.
The V.S.W.R. of the output is then ≤ 2 over the whole channel.

[1]) Shield lead grounded

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

Intermodulation characteristics [1]

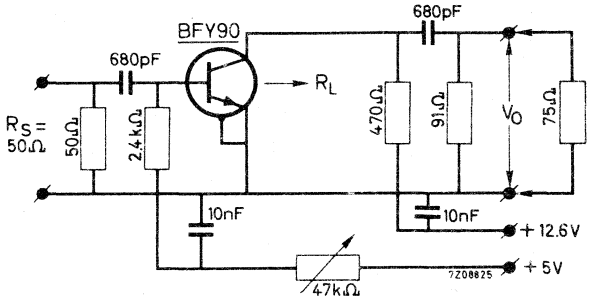
3. Intermodulation distortion

I_C = 14 mA; V_{CE} = 6 V; R_L = 37.5 Ω; T_{amb} = 25 °C

V_o = 100 mV at f_p = 183 MHz

V_o = 100 mV at f_q = 200 MHz
measured at $f_{(2q-p)}$ = 217 MHz d_{im} typ. −50 dB

Test circuit:



y parameters at f = 500 MHz (common emitter) [1]

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

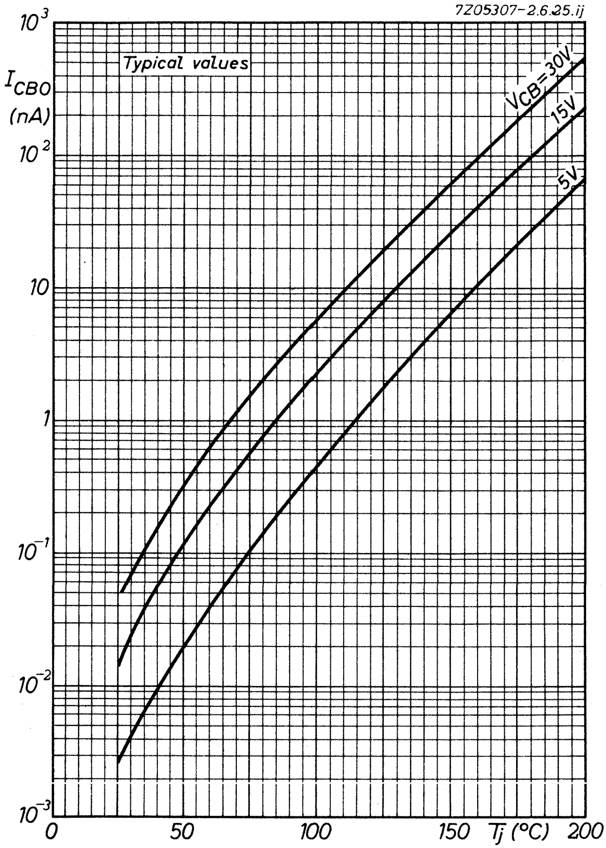
Input conductance	g_{ie}	typ.	16	mΩ^{-1}
Input capacitance	C_{ie}	typ.	3.75	pF
Feedback admittance	$\|y_{re}\|$	typ.	1.55	mΩ^{-1}
Phase angle of feedback admittance	φ_{re}	typ.	258°	
Transfer admittance	$\|y_{fe}\|$	typ.	45	mΩ^{-1}
Phase angle of transfer admittance	φ_{fe}	typ.	285°	
Output conductance	g_{oe}	typ.	0.19	mΩ^{-1}
Output capacitance	C_{oe}	typ.	1.9	pF

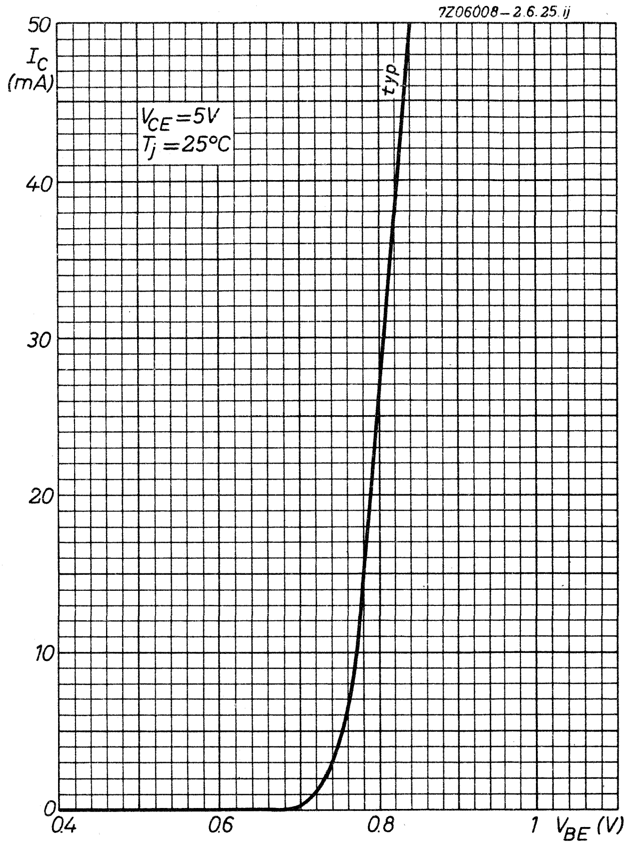
Maximum unilateralised power gain

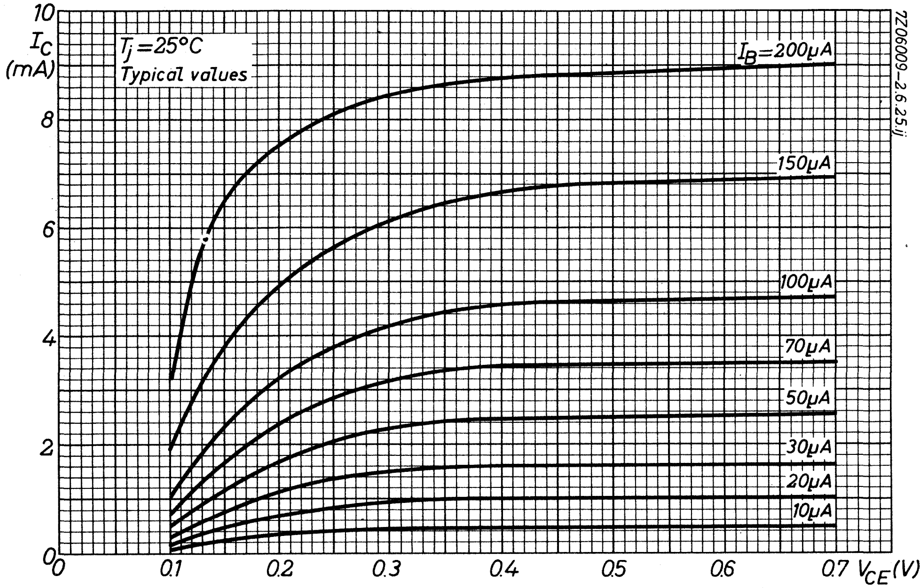
$$G_{UM} = \frac{|y_{fe}|^2}{4 g_{ie} g_{oe}}$$

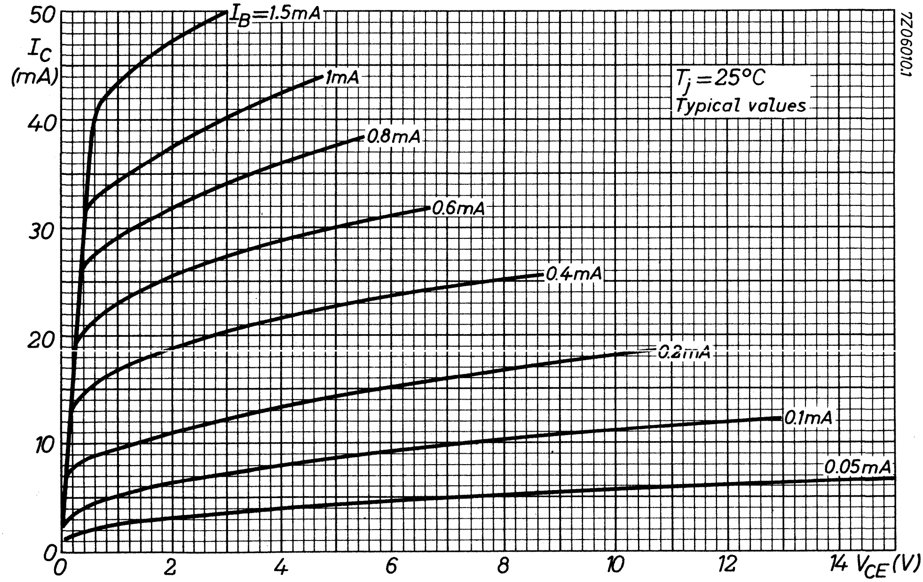
I_C = 2 mA; V_{CE} = 5 V; f = 500 MHz G_{UM} typ. 22 dB

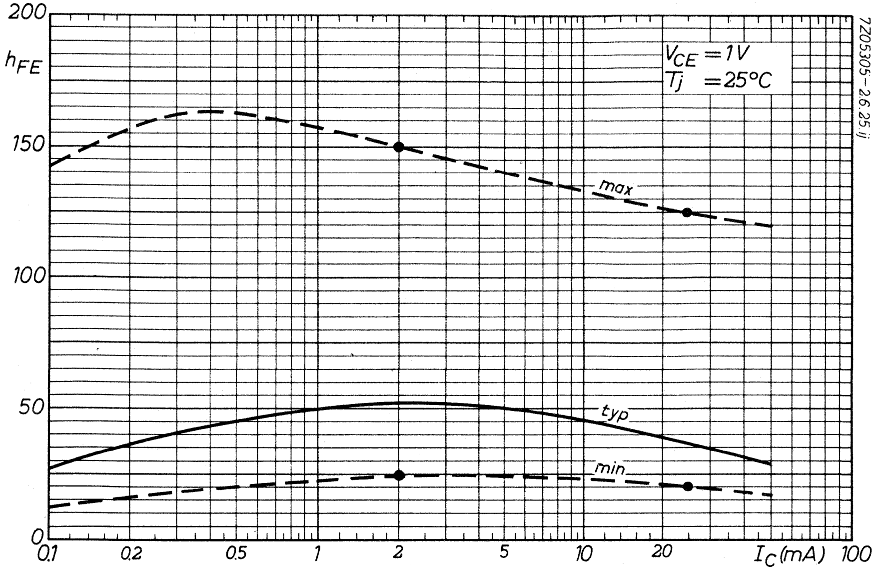
1) Shield lead grounded

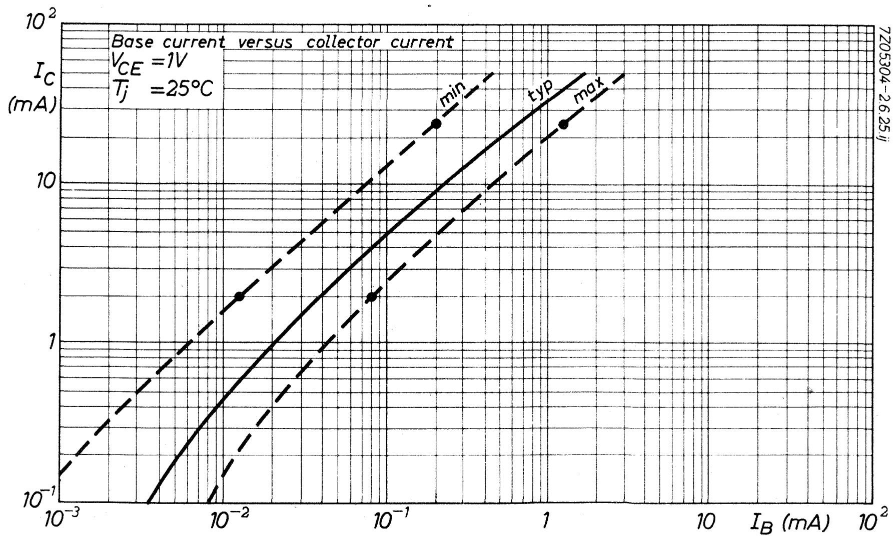

7Z05307-2.6.25.ij
Typical values
I_{CBO} (nA)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
0
50
100
150
T_j (°C)
200
V_{CB}=30V
15V
5V

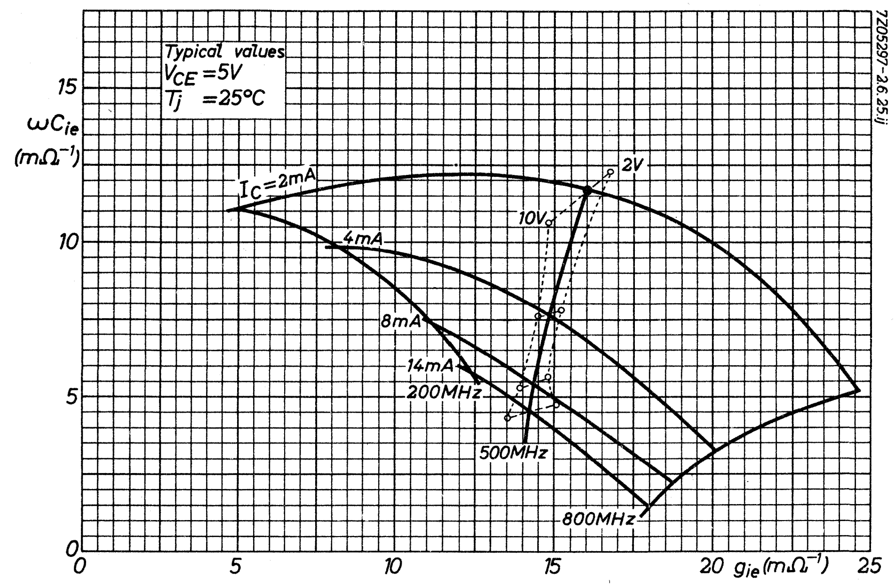

7Z06008 – 2.6.25. ij
50
I_C
(mA)
V_{CE} = 5V
T_j = 25°C
typ
40
30
20
10
0
0.4
0.6
0.8
1
V_{BE} (V)


10
I_C
(mA)
8
6
4
2
0
$T_j = 25°C$
Typical values
$I_B = 200\mu A$
150μA
100μA
70μA
50μA
30μA
20μA
10μA
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7 V_{CE}(V)
7Z06009–2.6.25.ij

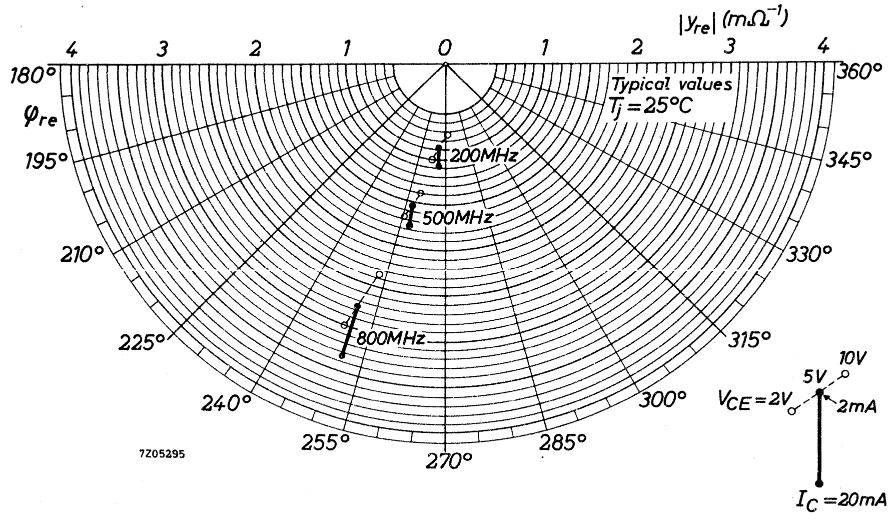

50
I_C
(mA)
40
30
20
10
0
$I_B = 1.5mA$
1mA
0.8mA
0.6mA
0.4mA
0.2mA
0.1mA
0.05mA
$T_j = 25°C$
Typical values
0
2
4
6
8
10
12
14 V_{CE}(V)
7Z06010.1


200
h_{FE}
150
100
50
0
0.1
0.2
0.5
1
2
5
10
20
I_C(mA)
100
V_{CE} = 1V
T_j = 25°C
max
typ
min
7Z05305–26.25.ij

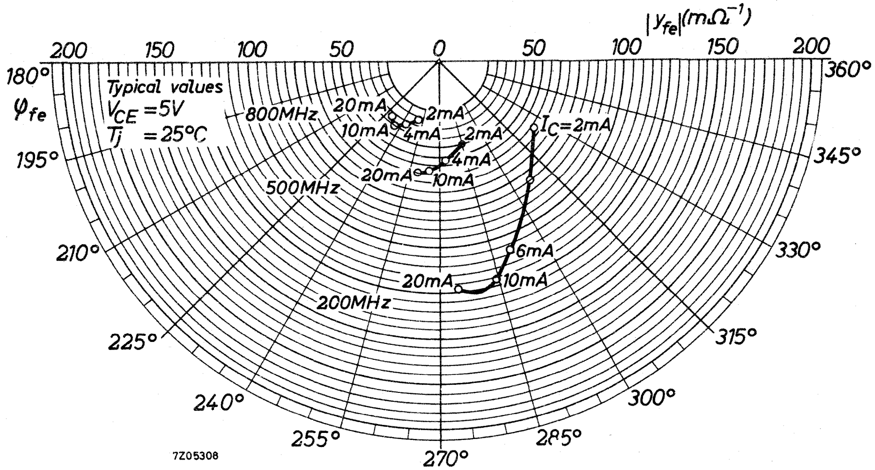

Base current versus collector current
V_{CE} = 1V
T_j = 25°C
10^2
I_C
(mA)
10
1
10^{-1}
10^{-3}
10^{-2}
10^{-1}
1
10
I_B (mA)
10^2
min
typ
max
7Z05304–26.25.ij



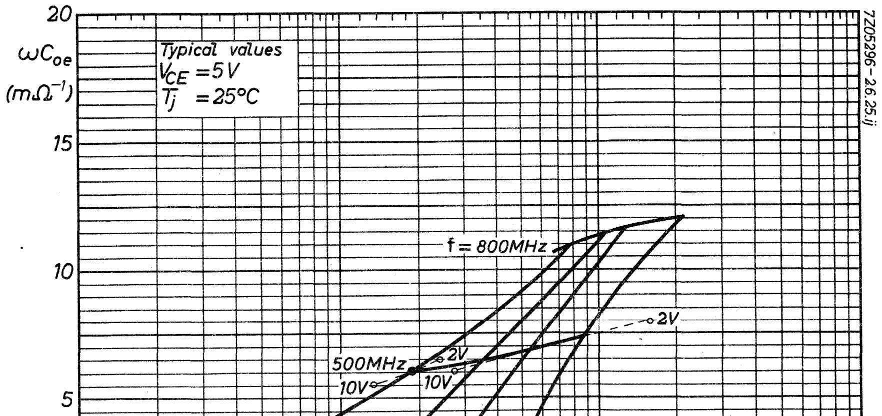
7Z05297-2.6.25.ii
Typical values
V_{CE} =5V
T_j =25°C
ωC_{ie} ($m\Omega^{-1}$)
I_C=2mA
4mA
8mA
14mA
200MHz
500MHz
800MHz
2V
10V
g_{ie} ($m\Omega^{-1}$)



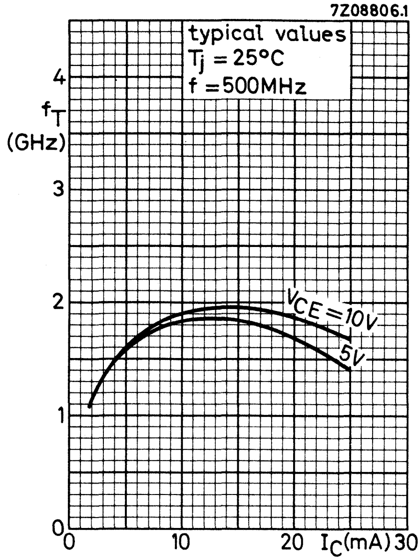
$|y_{re}|$ ($m\Omega^{-1}$)
φ_{re}
Typical values
T_j=25°C
200MHz
500MHz
800MHz
V_{CE}=2V
5V
10V
2mA
I_C =20mA
7Z05295

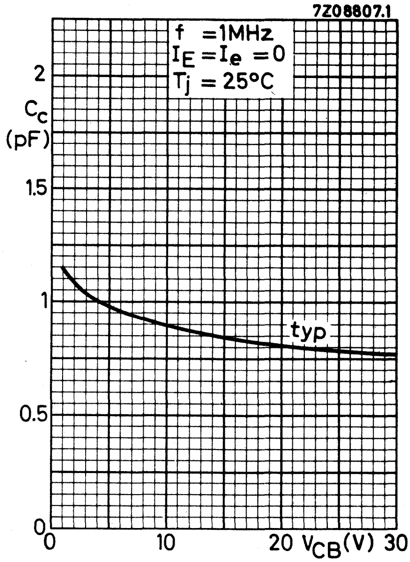


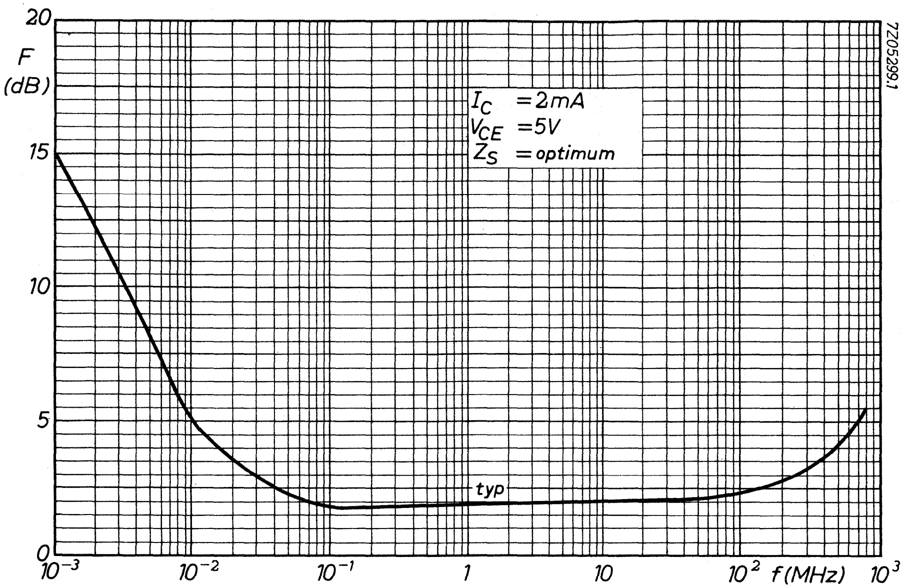
|y_fe| (mΩ⁻¹)
200 150 100 50 0 50 100 150 200
180° 195° 210° 225° 240° 255° 270° 285° 300° 315° 330° 345° 360°
φ_fe
Typical values
V_CE = 5V
T_j = 25°C
800MHz
500MHz
200MHz
20mA
10mA
2mA
4mA
2mA
4mA
20mA
10mA
I_C = 2mA
6mA
20mA
10mA
7Z05308

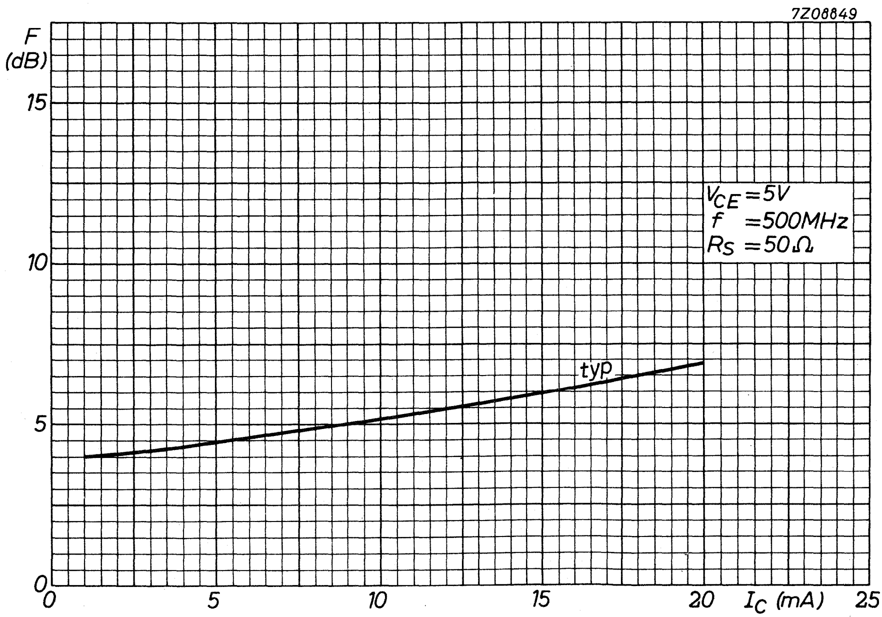


ωC_oe (mΩ⁻¹)
20 15 10 5 0
Typical values
V_CE = 5V
T_j = 25°C
f = 800MHz
2V
500MHz
2V
10V
10V
200MHz
I_C = 2mA
10mA
15mA
20mA
0.01 0.02 0.05 0.1 0.2 0.5 1 2 10
g_oe (mΩ⁻¹)
7Z05296-2.6.25.ij


7Z08806.1
typical values
Tj = 25°C
f = 500MHz
fT
(GHz)
VCE = 10V
5V
IC (mA)
0
1
2
3
4
10
20
30


7Z08807.1
f = 1MHz
IE = Ie = 0
Tj = 25°C
Cc
(pF)
typ
VCB (V)
0
0.5
1
1.5
2
10
20
30


7Z05299.1
F
(dB)
20
15
10
5
0
I_C =2mA
V_{CE} =5V
Z_S =optimum
typ
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
f (MHz)
10^3


7Z08849
F
(dB)
15
10
5
0
V_{CE} =5V
f =500MHz
R_S =50Ω
typ
0
5
10
15
20
I_C (mA)
25

APPLICATION INFORMATION

Performance of channel- and band amplifiers [1]

Frequency range	Channel 9 202-209			Channel 55 742-750	Band II 87.5-108	Band III 174-230	MHz
Transistor used in							
final stage	BFW16	BFW16	BFY90	BFW16	BFW16	BFW16	
driver stage	BFW16	BFY90	BF183	BFW16		BFW16	
second stage				BFY90			
first stage	BFY90	BF200	BF200	BFY90	BFY90	BFY90	
Output power at							
d_{im} = −30 dB	150[2]	60	10	80			mW
d_{im} = −50 dB					25		mW
d_{im} = −60 dB						10	mW
Power gain	44	48	49	30	42.5	39	dB
Noise figure	6.3	5.7	5.5	7	6.0-6.5	6.2-6.7	dB
V.S.W.R. over the whole channel or band							
for the input	< 2	< 2	< 2	< 2	< 2	< 2	
for the output	< 2	< 2	< 2	< 2	< 2	< 2	
Load impedance	30	30	30	50	30	30	Ω
Source impedance	60	60	60	50	60	60	Ω

1) Application information bulletins with detailed informations of all these amplifiers and a study of intermodulation are available on request.

2) V_o = 2.2 V over R_L = 30 Ω or
V_o = 3 V over R_L = 60 Ω.

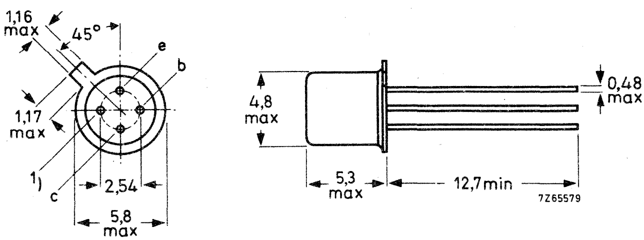
SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in TO-72 metal envelope with insulated electrodes and a shield lead connected to the case. The 2N918 is primarily intended for low power amplifiers and oscillators in the v.h.f. and u.h.f. ranges for industrial service.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector current (d.c.)	I_C	max.	50	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	200	mW
Junction temperature	T_j	max.	200	°C
Transition frequency I_C = 6 mA; V_{CE} = 10 V	f_T	>	900	MHz
Maximum unilaterised power gain I_C = 6 mA; V_{CE} = 12 V; f = 200 MHz	G_{UM}	typ.	36	dB
Noise figure at f = 60 MHz I_C = 1 mA; V_{CE} = 6 V; R_S = 400 Ω	F	<	6	dB

MECHANICAL DATA Dimensions in mm

TO-72
Insulated electrodes



1) = shield lead (connected to case)

Accessories available: 56246, 56263

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

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base) I_C = 3 mA	V_{CEO}	max.	15	V
Emitter-base voltage (open collector)	V_{EBO}	max.	3	V

Currents

Collector current (d.c.)	I_C	max.	50	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	200	mW

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.88	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0.58	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified
All measurements taken with ungrounded shield lead

Collector cut-off current				
$I_E = 0$; $V_{CB} = 15$ V	I_{CBO}	<	10	nA
$I_E = 0$; $V_{CB} = 15$ V; $T_j = 150$ °C	I_{CBO}	<	1	µA
Saturation voltages				
$I_C = 10$ mA; $I_B = 1$ mA	V_{CEsat}	<	0.4	V
	V_{BEsat}	<	1	V
D.C. current gain				
$I_C = 3$ mA; $V_{CE} = 1$ V	h_{FE}	>	20	
Collector capacitance at f = 140 kHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	1.7	pF
$I_E = I_e = 0$; $V_{CB} = 0$	C_c	<	3.0	pF
Emitter capacitance at f = 140 kHz				
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	<	2.0	pF
Transition frequency				
$I_C = 6$ mA; $V_{CE} = 10$ V [1]	f_T	>	900	MHz
Noise figure at f = 60 MHz				
$I_C = 1$ mA; $V_{CE} = 6$ V; $R_S = 400\ \Omega$	F	<	6	dB
Oscillator power output at f = 500 MHz				
$-I_E = 8$ mA; $V_{CB} = 15$ V	P_o	>	30	mW
Maximum unilateralised power gain				
$G_{UM} = \frac{\lvert y_{fe}\rvert^2}{4 g_{ie} g_{oe}}$				
$I_C = 6$ mA; $V_{CE} = 12$ V; f = 200 MHz	G_{UM}	typ.	36	dB

[1]) JEDEC registration: $I_C = 4$ mA; $V_{CE} = 10$ V, $f_T > 600$ MHz.

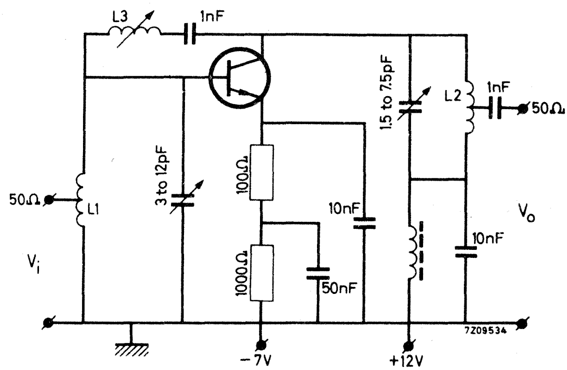
CHARACTERISTICS (continued) $T_j = 25\ ^oC$

Available power gain at f = 200 MHz

I_C = 6 mA	G_p	> 15	dB

Basic circuit for measuring the available neutralised power gain

Grounded shield lead



L1 = 3.5 turns tinned Cu wire, 1.3 mm
d = 8 mm; length = 11 mm

Tap at ≈ 2 turns from earth side

L2 = 8 turns tinned Cu wire, 1.3 mm
d = 3 mm; length = 22 mm

Tap at 1 turn from earth side

L3 = 0.4 to 0.65 μH

SILICON PLANAR TRANSISTOR

N-P-N double diffused transistor in a TO-39 metal envelope with the collector connected to the case. The 2N1613 is intended for use in a wide variety of applications, such as d.c. and high frequency amplifiers and switching applications.

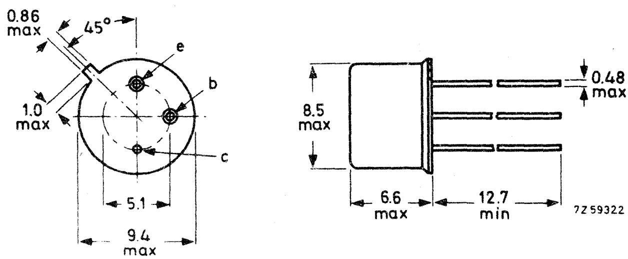
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	75	V
Collector-emitter voltage ($R_{BE} < 10\,\Omega$)	V_{CER}	max.	50	V
Collector current (peak value)	I_{CM}	max.	1	A
Total power dissipation up to $T_{amb} = 25\,^{o}C$	P_{tot}	max.	0.8	W
Junction temperature	T_j	max.	200	^{o}C
D.C. current gain				
$I_C = 0.1$ mA; $V_{CE} = 10$ V	h_{FE}	>	20	
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	35	
$I_C = 150$ mA; $V_{CE} = 10$ V	h_{FE}		40 to 120	
Transition frequency				
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	>	60	MHz

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-39



max. lead diameter is guaranteed only for 12.7 mm

Accessories available: 56218, 56245

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	75	V
Collector-emitter voltage ($R_{BE} < 10\,\Omega$)	V_{CER}	max.	50	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	V

Current

Collector current (peak value)	I_{CM}	max.	1	A

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.8	W
up to T_{case} = 100 °C	P_{tot}	max.	1.7	W
up to T_{case} = 25 °C	P_{tot}	max.	3.0	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	$R_{th\,j\text{-}a}$	=	220	°C/W
From junction to case	$R_{th\,j\text{-}c}$	=	58	°C/W

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

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	<	10	nA
$I_E = 0$; $V_{CB} = 60$ V; $T_{amb} = 150$ °C	I_{CBO}	<	10	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	nA
Collector-emitter sustaining voltage				
$I_C = 100$ mA; $R_{BE} < 10\ \Omega$	$V_{CERsust}$	>	50	V [1]
Saturation voltages				
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	1.5	V [1]
	V_{BEsat}	<	1.3	V [1]
D.C. current gain				
$I_C = 0.1$ mA; $V_{CE} = 10$ V	h_{FE}	>	20	
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	35	[1]
$I_C = 150$ mA; $V_{CE} = 10$ V	h_{FE}		40 to 120	[1]
$I_C = 500$ mA; $V_{CE} = 10$ V	h_{FE}	>	20	[1]
$I_C = 10$ mA; $V_{CE} = 10$ V; $T_{amb} = -55$ °C	h_{FE}	>	20	
h parameters at f = 1 kHz				
$-I_E = 1$ mA; $V_{CB} = 5$ V				
Input impedance	h_{ib}		24 to 34	Ω
Reverse voltage transfer	h_{rb}	<	3	10^{-4}
Output admittance	h_{ob}		0.1 to 0.5	$\mu\Omega^{-1}$
$-I_E = 5$ mA; $V_{CB} = 10$ V				
Input impedance	h_{ib}		4 to 8	Ω
Reverse voltage transfer	h_{rb}	<	3	10^{-4}
Output admittance	h_{ob}		0.1 to 1.0	$\mu\Omega^{-1}$
Small signal current gain				
$I_C = 1$ mA; $V_{CE} = 5$ V	h_{fe}		30 to 100	
$I_C = 5$ mA; $V_{CE} = 10$ V	h_{fe}		35 to 150	

[1] Measured under pulse conditions to avoid excessive dissipation. Pulse duration $t < 300\ \mu s$, duty cycle $\delta < 0.01$

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

Transition frequency				
I_C = 50 mA; V_{CE} = 10 V	f_T	>	60	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
Noise figure at f = 1 kHz				
I_C = 0.3 mA; V_{CE} = 10 V R_S = 510 Ω; Bandwidth: 200 Hz	F	<	12	dB

SILICON PLANAR TRANSISTOR

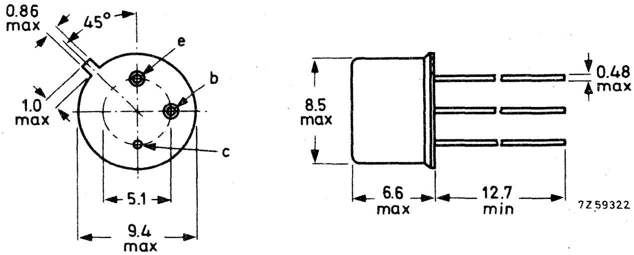
N-P-N double diffused transistor in a TO-39 metal envelope with the collector connected to the case. The 2N1711 is intended for use in a wide variety of applications, such as d.c. and high frequency amplifiers and switching applications.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	75	V
Collector-emitter voltage ($R_{BE} < 10\,\Omega$)	V_{CER}	max.	50	V
Collector current (peak value)	I_{CM}	max.	1	A
Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	0.8	W
Junction temperature	T_j	max.	200	^oC
D.C. current gain				
I_C = 0.1 mA; V_{CE} = 10 V	h_{FE}	>	35	
I_C = 10 mA; V_{CE} = 10 V	h_{FE}	>	75	
I_C = 150 mA; V_{CE} = 10 V	h_{FE}		100 to 300	
Transition frequency				
I_C = 50 mA; V_{CE} = 10 V	f_T	>	70	MHz

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-39



max.lead diameter is guaranteed only for 12.7 mm

Accessories available: 56218, 56245

RATINGS (Limiting values) [1]

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	75	V
Collector-emitter voltage ($R_{BE} < 10\ \Omega$)	V_{CER}	max.	50	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	V

Current

Collector current (peak value)	I_{CM}	max.	1	A

Power dissipation

Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	0.8	W
up to $T_{case} = 100\ ^oC$	P_{tot}	max.	1.7	W
up to $T_{case} = 25\ ^oC$	P_{tot}	max.	3.0	W

Temperatures

Storage temperature	T_{stg}	-65 to +200		^oC
Junction temperature	T_j	max.	200	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	220	$^oC/W$
From junction to case	$R_{th\ j-c}$	=	58	$^oC/W$

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

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

Collector cut-off current				
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	<	10	nA
$I_E = 0$; $V_{CB} = 60$ V; $T_{amb} = 150$ °C	I_{CBO}	<	10	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	5	nA
Collector-emitter sustaining voltage				
$I_C = 100$ mA; $R_{BE} < 10\ \Omega$	$V_{CERsust}$	>	50	V [1]
Saturation voltages				
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	1.5	V [1]
	V_{BEsat}	<	1.3	V [1]
D.C. current gain				
$I_C = 10\ \mu A$; $V_{CE} = 10$ V	h_{FE}	>	20	
$I_C = 0.1$ mA; $V_{CE} = 10$ V	h_{FE}	>	35	
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	75	[1]
$I_C = 150$ mA; $V_{CE} = 10$ V	h_{FE}		100 to 300	[1]
$I_C = 500$ mA; $V_{CE} = 10$ V	h_{FE}	>	40	[1]
$I_C = 10$ mA; $V_{CE} = 10$ V; $T_{amb} = -55$ °C	h_{FE}	>	35	
h parameters at f = 1 kHz				
$-I_E = 1$ mA; $V_{CB} = 5$ V				
Input impedance	h_{ib}		24 to 34	Ω
Reverse voltage transfer	h_{rb}	<	5	10^{-4}
Output admittance	h_{ob}		0.1 to 0.5	$\mu\Omega^{-1}$
$-I_E = 5$ mA; $V_{CB} = 10$ V				
Input impedance	h_{ib}		4 to 8	Ω
Reverse voltage transfer	h_{rb}	<	5	10^{-4}
Output admittance	h_{ob}		0.1 to 1.0	$\mu\Omega^{-1}$
Small signal current gain				
$I_C = 1$ mA; $V_{CE} = 5$ V	h_{fe}		50 to 200	
$I_C = 5$ mA; $V_{CE} = 10$ V	h_{fe}		70 to 300	

[1] Measured under pulse conditions to avoid excessive dissipation.
Pulse duration $t < 300\ \mu s$, duty cycle $\delta < 0.01$

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

Transition frequency				
I_C = 50 mA; V_{CE} = 10 V	f_T	>	70	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
Noise figure at f = 1 kHz				
I_C = 0.3 mA; V_{CE} = 10 V R_S = 510 Ω; Bandwidth: 200 Hz	F	<	8	dB

SILICON TRANSISTOR

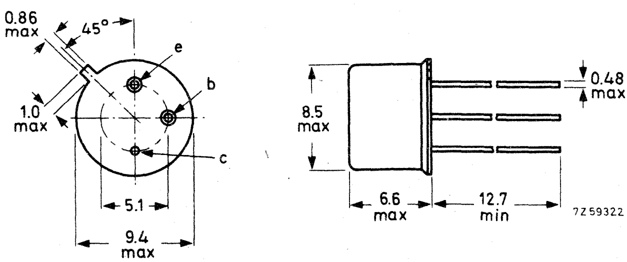
High voltage n-p-n transistor in a TO-39 metal envelope with the collector connected to the case.
It is intended for use in high performance amplifier, oscillator and switching applications.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	120	V
Collector-emitter voltage ($R_{BE} \leq 10\ \Omega$)	V_{CER}	max.	100	V
Collector current (d.c.)	I_C	max.	500	mA
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	3.0	W
Junction temperature	T_j	max.	200	°C
D.C. current gain				
I_C = 0.1 mA; V_{CE} = 10 V	h_{FE}	>	20	
I_C = 10 mA; V_{CE} = 10 V; T = −55 °C	h_{FE}	>	20	
I_C = 10 mA; V_{CE} = 10 V	h_{FE}	>	35	
I_C = 150 mA; V_{CE} = 10 V	h_{FE}	40 to	120	

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-39



Accessories supplied on request: 56218; 56245

RATINGS (Limiting values) [1]

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	80	V
Collector-emitter voltage ($R_{BE} \leq 10\ \Omega$)	V_{CER}	max.	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7.0	V

Current

Collector current (d.c.)	I_C	max.	500	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.8	W
up to T_{case} = 100 °C	P_{tot}	max.	1.7	W
up to T_{case} = 25 °C	P_{tot}	max.	3.0	W

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	219	°C/W
From junction to case	$R_{th\ j-c}$	=	58.3	°C/W

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

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

Collector cut-off current				
$I_E = 0$; $V_{CB} = 90$ V	I_{CBO}	<	10	nA
$I_E = 0$; $V_{CB} = 90$ V; $T_{amb} = 150$ °C	I_{CBO}	<	15	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	nA
Collector-emitter sustaining voltage [1]				
$I_C = 100$ mA; $R_{BE} \geq 10\ \Omega$	$V_{CER\ sust}$	>	100	V
$I_C = 30$ mA; $I_B = 0$	$V_{CEO\ sust}$	>	80	V
Saturation voltages [1]				
$I_C = 150$ mA; $I_B = 15$ mA	$V_{CE\ sat}$	<	5.0	V
	$V_{BE\ sat}$	<	1.3	V
$I_C = 50$ mA; $I_B = 5$ mA	$V_{CE\ sat}$	<	1.2	V
	$V_{BE\ sat}$	<	0.9	V
Breakdown voltages				
$I_E = 0$; $I_C = 100$ μA	$V_{(BR)\ CBO}$	>	120	V
$I_C = 0$; $I_E = 100$ μA	$V_{(BR)\ EBO}$	>	7.0	V
D.C. current gain				
$I_C = 0.1$ mA; $V_{CE} = 10$ V	h_{FE}	>	20	
$I_C = 10$ mA; $V_{CE} = 10$ V; $T = -55$ °C	h_{FE}	>	20	
$I_C = 10$ mA; $V_{CE} = 10$ V [1]	h_{FE}	>	35	
$I_C = 150$ mA; $V_{CE} = 10$ V [1]	h_{FE}	40 to	120	

[1]) Measured under pulsed conditions to avoid excessive dissipation.
Pulse duration $t \leq 300$ μs, duty cycle $\delta < 0.02$

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

h parameters at f = 1 kHz (common base)			
I_C = 1 mA; V_{CE} = 5 V			
Input impedance	h_{ib}	20 to 30	Ω
Reverse voltage transfer ratio	h_{rb}	1.25	10^{-4}
Output conductance	h_{ob}	0.5	$\mu\Omega^{-1}$
I_C = 5 mA; V_{CE} = 10 V			
Input impedance	h_{ib}	4 to 8	Ω
Reverse voltage transfer ratio	h_{rb}	1.50	10^{-4}
Output conductance	h_{ob}	0.5	$\mu\Omega^{-1}$
Small signal current gain (common emitter)			
I_C = 1 mA; V_{CE} = 5 V; f = 1 kHz	h_{fe}	30 to 100	
I_C = 5 mA; V_{CE} = 10 V; f = 1 kHz	h_{fe}	> 45	
I_C = 50 mA; V_{CE} = 10 V; f = 20 MHz	h_{fe}	> 2.5	
Collector capacitance			
$I_E = I_e = 0$; V_{CB} = 10 V	C_c	< 15	pF
Emitter capacitance			
$I_C = I_c = 0$; V_{EB} = 0.5 V	C_e	< 85	pF

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a TO-39 metal envelope with the collector connected to the case. It is primarily intended for use in high frequency and very high frequency oscillators and amplifiers as well as for output stages of servo amplifiers.

RATINGS (Limiting values)

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	80	V
Collector-emitter voltage (open base)	V_{CEO}	max.	35	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	V

Current

Collector current (d.c. or average over any 20 ms period)	I_C	max.	1	A

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.8	W
up to T_{case} = 100 °C	P_{tot}	max.	2.8	W
up to T_{case} = 25 °C	P_{tot}	max.	5.0	W

Temperatures

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

THERMAL RESISTANCE

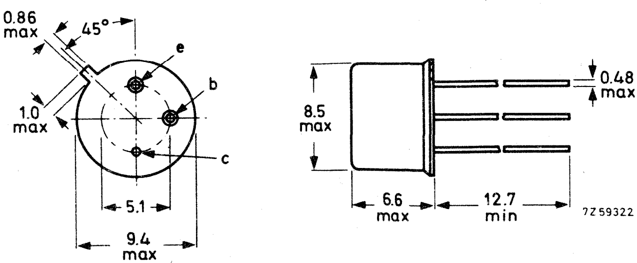
From junction to ambient in free air	$R_{th\,j-a}$	=	0.22	°C/mW
From junction to case	$R_{th\,j-c}$	=	0.035	°C/mW

MECHANICAL DATA

Dimensions in mm

Collecter connected to case

TO-39



max. lead diameter is guaranteed only for 12.7 mm

Accessories available: 56218, 56245.

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

Collector cut-off current				
I_E = 0; V_{CB} = 60 V	I_{CBO}	<	10	nA
I_E = 0; V_{CB} = 60 V; T_{amb} = 150 °C	I_{CBO}	<	10	μA
Emitter cut-off current				
I_C = 0; V_{EB} = 5 V	I_{EBO}	<	10	nA
Sustaining voltage				
I_C = 30 mA; I_B = 0 2)	$V_{CEOsust}$	>	35	V
Saturation voltages				
I_C = 150 mA; I_B = 15 mA	V_{CEsat}	<	0.2	V
I_C = 1 A; I_B = 100 mA 1)2)	V_{CEsat}	<	1.0	V
	V_{BEsat}	<	1.6	V
D.C. current gain 2)				
I_C = 10 mA; V_{CE} = 10 V	h_{FE}	>	30	
I_C = 150 mA; V_{CE} = 10 V	h_{FE}	40 to	120	
I_C = 1 A; V_{CE} = 10 V	h_{FE}	>	15	
Feedback time constant				
I_C = 10 mA; V_{CB} = 10 V; f = 4 MHz	$r_{b'}C_c$	<	800	ps
Collector capacitance at f = 500 kHz				
I_E = I_e = 0; V_{CB} = 10 V	C_c	<	12	pF
Emitter capacitance at f = 500 kHz				
I_C = I_c = 0; V_{EB} = 0.5 V	C_e	<	80	pF
Transition frequency				
I_C = 50 mA; V_{CE} = 10 V	f_T	>	60	MHz

1) Measured with a lead length of 1 cm.

2) Measured under pulsed conditions to avoid excessive dissipation. Pulse duration t = 300 μs; duty cycle $\delta < 0.01$

SILICON PLANAR TRANSISTORS

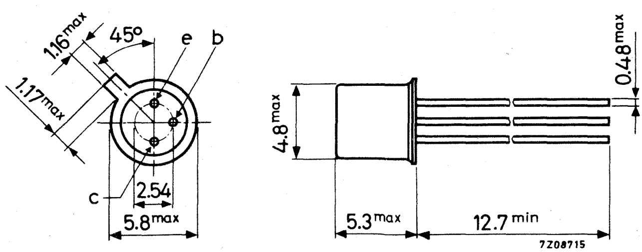
N-P-N transistors in a TO-18 metal envelope with the collector connected to the case.
These transistors are primarily intended for use in high performance, low level, low noise amplifier applications both for d.c. and frequencies up to 100 MHz.

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 to 120	100 to 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					
I_C = 10 μA; V_{CE} = 5 V; R_S = 10 kΩ					
Bandwidth: 15.7 kHz	F	<	4	3	dB

MECHANICAL DATA Dimensions in mm

Collector connected
to case
TO-18



Accessories available: 56246, 56263

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 $T_{amb} = 25\ ^oC$	P_{tot}	max.	360	mW

Temperatures

Storage temperature	T_{stg}		-65 to +200	^oC
Junction temperature	T_j	max.	200	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.48	^oC/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0.15	^oC/mW

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

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $V_{CB} = 45$ 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

			2N2483	2N2484	
Noise figure					
I_C = 10 μA; V_{CE} = 5 V; R_S = 10 kΩ					
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					
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	$\mu\Omega^{-1}$

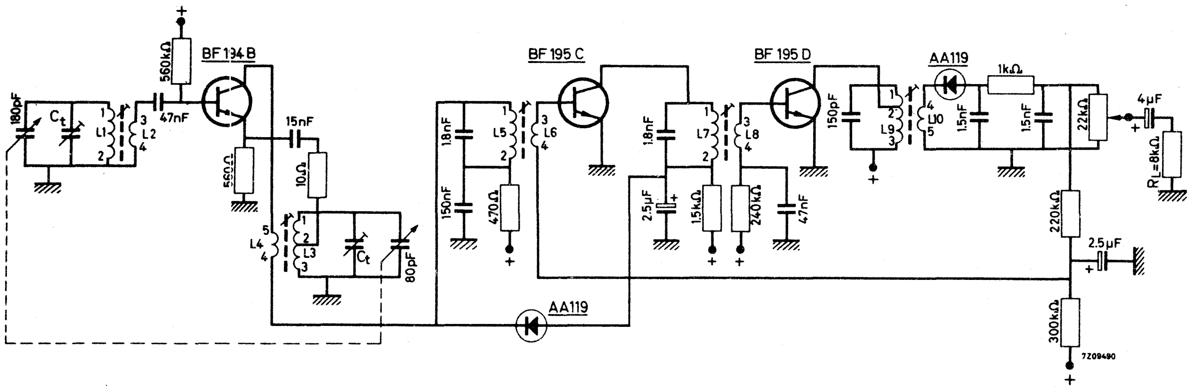
HIGH FREQUENCY PACKAGE

The high frequency package 40820 contains three silicon transistors selected from the BF194 and BF195 products.
The BF194B is intended for use as mixer-oscillator transistor,
the BF195C for controlled first i.f. transistor,
the BF195D for second i.f. transistor.
The low h_{FE} spread of the transistors makes it possible to apply current biasing (one base resistor) and achieve a gain with small spread and low dependence on supply voltage, even at low battery voltages.
The transistors have a plastic envelope with stiff, self-locking pins suitable for use with standard printed wiring-boards.

QUICK REFERENCE DATA				
Base current				
I_C = 1 mA; V_{CE} = 10 V	BF194B	I_B	5 to 9	µA
	BF195C	I_B	9 to 14	µA
	BF195D	I_B	14 to 26	µA
Conversion noise figure of mixer BF194B				
I_C = 1 mA; V_{CE} = 10 V				
G_S = 1.0 mΩ^{-1}; f = 1 MHz		F_c	typ. 2	dB

APPLICATION INFORMATION

H.F. section of a 6 V medium wave portable radio receiver



COIL DATA

L1 = 450 μH; Q_0 at f = 1 MHz : 120

Voltage ratio $\frac{n_{3-4}}{n_{1-2}}$: 5.7×10^{-2}

L3 = 260 μH; Q_0 at f = 1.2 MHz : 120

Voltage ratio $\frac{n_{2-3}}{n_{1-3}}$: 3×10^{-2}

Voltage ratio $\frac{n_{4-5}}{n_{1-3}}$: 5.4×10^{-2}

L5 = L7 = 69 μH; Q_0 at f = 0.45 MHz : 80

Voltage ratio $\frac{n_{3-4}}{n_{1-2}}$: 7.35×10^{-2}

L9 = 800 μH; Q_0 at f = 0.45 MHz : 110

Voltage ratio $\frac{n_{2-3}}{n_{1-3}}$: 41.5×10^{-2}

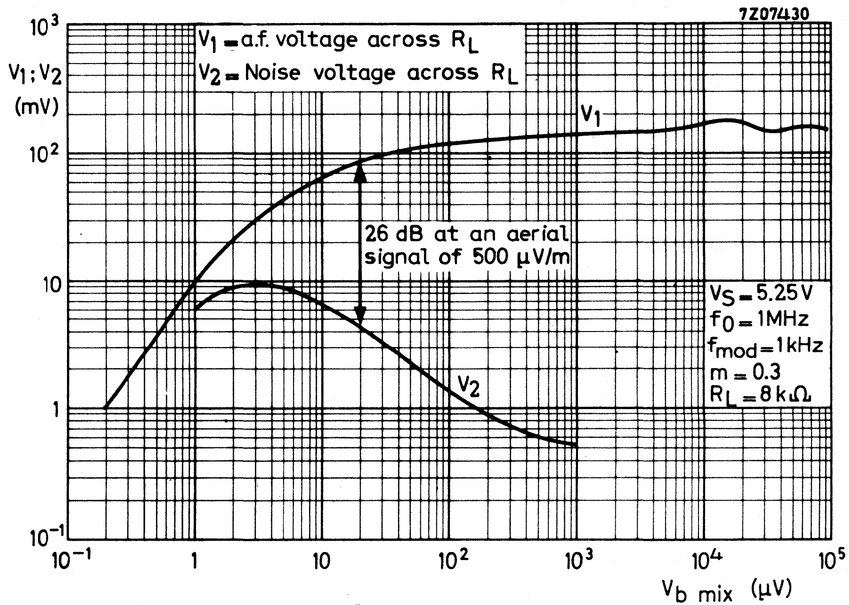
Voltage ratio $\frac{n_{4-5}}{n_{1-3}}$: 59.2×10^{-2}

PERFORMANCE at f = 1 MHz; T_{amb} = 25 °C

Supply voltage (from 6 V, via a RC-smoothing filter)	V_S	=	5.25	V
Total current drain	I_{tot}	=	3	mA
Gain spread of the h.f. part	ΔG	=	±3.6	dB
Signal handling capability d_{tot} = 10%; m = 0.8		≥	2	V/m

Sensitivity

Signal to obtain V_o = 10 mV across R_L = 8 kΩ	25	µV/m
Signal to obtain 26 dB signal/noise ratio	500	µV/m
Decrease of sensitivity at $V_S \approx 3.2$ V	15	dB



CHARACTERISTICS T_j = 25 °C unless otherwise specified

Base current

I_C = 1 mA; V_{CE} = 10 V

BF194B	I_B	5 to 9	µA
BF195C	I_B	9 to 14	µA
BF195D	I_B	14 to 26	µA

Conversion noise figure of mixer BF194B

I_C = 1 mA; V_{CE} = 10 V

G_S = 1.0 mΩ^{-1}; f = 1 MHz F_c typ. 2 dB

y parameters (common emitter)

I_C = 1 mA; V_{CE} = 10 V (lead length = 3 mm)

				f = 10.7 MHz	f = 0.45 MHz	
Input conductance	BF194B:	g_{ie}	<	0.5	0.4	mΩ^{-1}
	BF195C:	g_{ie}	<	0.64	0.54	mΩ^{-1}
	BF195D:	g_{ie}	<	0.95	0.85	mΩ^{-1}
Output conductance	BF194B:	g_{oe}	typ.	10	6.5	µΩ^{-1}
			<	13.5	11.5	µΩ^{-1}
	BF195C:	g_{oe}	typ.	6.5	4	µΩ^{-1}
			<	9.5	7	µΩ^{-1}
	BF195D:	g_{oe}	typ.	4	2	µΩ^{-1}
			<	9.5	7	µΩ^{-1}

FOR THE REMAINING DATA OF THE INDIVIDUAL TRANSISTORS PLEASE REFER TO THE DATA SHEETS OF THE BF194 AND THE BF195

HIGH FREQUENCY PACKAGE

The high frequency package 40835 contains three silicon transistors selected from the BF494 and BF495 products.
The BF494B is intended for use as mixer-oscillator transistor,
the BF495C for controlled first i.f. transistor,
the BF495D for second i.f. transistor.
The low h_{FE} spread of the transistors makes it possible to apply current biasing (one base resistor) and achieve a gain with small spread and low dependence on supply voltage, even at low battery voltages.

QUICK REFERENCE DATA				
Base current				
I_C = 1 mA; V_{CE} = 10 V	BF494B	I_B	5 to 9	μA
	BF495C	I_B	9 to 14	μA
	BF495D	I_B	14 to 26	μA
Conversion noise figure of mixer BF494B				
I_C = 1 mA; V_{CE} = 10 V				
G_S = 1 mA/V; f = 1 MHz		F_c	typ. 2	dB

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

Base current

$I_C = 1$ mA; $V_{CE} = 10$ V	BF494B	I_B	5 to 9	μA
	BF495C	I_B	9 to 14	μA
	BF495D	I_B	14 to 26	μA

Conversion noise figure of mixer BF494B

$I_C = 1$ mA; $V_{CE} = 10$ V

$G_S = 1$ mA/V; f = 1 MHz F_c typ. 2 dB

y parameters (common emitter)

$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)

				f = 10,7 MHz	f = 0,45	MHz
Input conductance	BF494B:	g_{ie}	<	0,5	0,4	mA/V
	BF495C:	g_{ie}	<	0,64	0,54	mA/V
	BF495D:	g_{ie}	<	0,95	0,85	mA/V
Output conductance	BF494B:	g_{oe}	typ.	10	6,5	μA/V
			<	13,5	11,5	μA/V
	BF495C:	g_{oe}	typ.	6,5	4	μA/V
			<	9,5	7	μA/V
	BF495D:	g_{oe}	typ.	4	2	μA/V
			<	9,5	7	μA/V

FOR THE REMAINING DATA OF THE INDIVIDUAL TRANSISTORS PLEASE REFER TO THE DATA SHEETS OF THE BF494 AND THE BF495

FOR APPLICATION INFORMATION SEE 40820

in which BF194B must be replaced by BF494B,
BF195C by BF495C,
BF195D by BF495D.

HIGH-FREQUENCY PACKAGE

The high-frequency package 40838 contains three transistors selected from the BF240 and BF241 products.
The BF240B is intended for use as mixer-oscillator transistor,
the BF241C for controlled first i.f. transistor,
the BF241D for second i.f. transistor.
The low h_{FE} spread of the transistors makes it possible to apply current biasing (one base resistor) and achieve a gain with small spread and low dependence on supply voltage, even at low battery voltages.

QUICK REFERENCE DATA

Base current				
	BF240B	I_B	5 to 9	μA
I_C = 1 mA; V_{CE} = 10 V	BF241C	I_B	9 to 14	μA
	BF241D	I_B	14 to 26	μA
Conversion noise figure of mixer BF240B				
I_C = 1 mA; V_{CE} = 10 V		F_c	typ. 2	dB
G_S = 1 mA/V; f = 1 MHz				

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Base current

I_C = 1 mA; V_{CE} = 10 V	BF240B	I_B	5 to 9	μA
	BF241C	I_B	9 to 14	μA
	BF241D	I_B	14 to 26	μA

Conversion noise figure of mixer BF240B

I_C = 1 mA; V_{CE} = 10 V
G_S = 1 mA/V; f = 1 MHz — F_c typ. 2 dB

y parameters (common emitter)

I_C = 1 mA; V_{CE} = 10 V (lead length = 3 mm)

				f = 10,7	0,45	MHz
Input conductance	BF240B :	g_{ie}	typ.	0,3	0,2	mA/V
	BF241C :	g_{ie}	typ.	0,5	0,4	mA/V
	BF241D :	g_{ie}	typ.	0,7	0,6	mA/V
Output conductance	BF240B :	g_{oe}	typ.	7	5	μA/V
			<	10	8	μA/V
	BF241C :	g_{oe}	typ.	5	3	μA/V
			<	7	5	μA/V
	BF241D :	g_{oe}	typ.	5	3	μA/V
			<	6	4	μA/V

FOR THE REMAINING DATA OF THE INDIVIDUAL TRANSISTORS PLEASE REFER TO THE DATA SHEETS OF THE BF240 AND THE BF241

FOR APPLICATION INFORMATION SEE 40820

in which BF194B must be replaced by BF240B,
BF195C by BF241C,
BF195D by BF241D.

Switching transistors

GERMANIUM ALLOYED TRANSISTORS

P-N-P transistors in a TO-5 metal envelope with the base connected to the case. These general purpose transistors are primarily intended for medium current medium speed computer logic applications.

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

Voltages			ASY26	ASY27	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	15	15	V
Collector-emitter voltage at $+V_{BE}=0.2$ V	$-V_{CEX}$	max.	25	20	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	20	20	V

Currents

Collector current (d.c. or average over any 20 ms period)	$-I_C$	max.	200	mA
Collector current (peak value)	$-I_{CM}$	max.	300	mA

Power dissipation

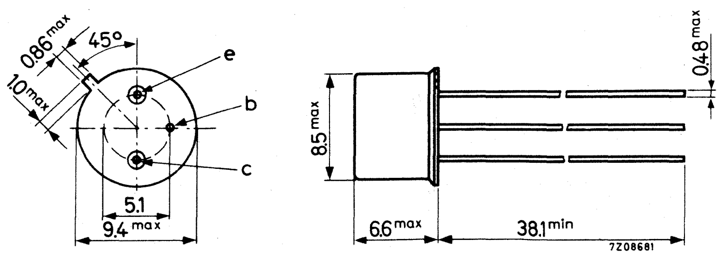
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	mW

Temperatures

Storage temperature	T_{stg}		−65 to +100	°C
Junction temperature	T_j	max.	85	°C

MECHANICAL DATA Dimensions in mm

TO-5
Base connected to case



Accessories available: 56218, 56245.

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.4	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0.2	°C/mW

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			ASY26	ASY27	
<u>Collector cut-off current</u>					
$I_E = 0$; $-V_{CB} = 30$ V	$-I_{CBO}$	<	7		μA
$I_E = 0$; $-V_{CB} = 25$ V	$-I_{CBO}$	<		7	μA
$I_E = 0$; $-V_{CB} = 30$ V; $T_j = 60$ °C	$-I_{CBO}$	<	35		μA
$I_E = 0$; $-V_{CB} = 25$ V; $T_j = 60$ °C	$-I_{CBO}$	<		35	μA
<u>Emitter cut-off current</u>					
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	3	3	μA
<u>Currents at reverse biased emitter junction</u>					
$-V_{CE} = 25$ V; $+V_{BE} = 0.2$ V; $T_j = 60$ °C	$-I_{CEX}$	<	35		μA
$-V_{CE} = 20$ V; $+V_{BE} = 0.2$ V; $T_j = 60$ °C	$-I_{CEX}$	<		35	μA
$-V_{CE} = 20$ V; $+V_{BE} = 5$ V; $T_j = 60$ °C	$+I_{BEX}$	<	35	35	μA
<u>Base-emitter voltage</u>					
$-I_C = 100$ mA; $-V_{CE} = 1$ V	$-V_{BE}$	<	0.65	0.55	V
$-I_C = 300$ mA; $-V_{CE} = 1$ V	$-V_{BE}$	<	1.5	1.4	V
<u>Collector-emitter saturation voltage</u>					
$-I_C = 10$ mA; $-I_B = 0.33$ mA	$-V_{CE\,sat}$	<	0.20		V
$-I_C = 10$ mA; $-I_B = 0.2$ mA	$-V_{CE\,sat}$	<		0.20	V
$-I_C = 50$ mA; $-I_B = 2$ mA	$-V_{CE\,sat}$	<	0.25		V
$-I_C = 50$ mA; $-I_B = 1.25$ mA	$-V_{CE\,sat}$	<		0.25	V
<u>Base-emitter saturation voltage</u>					
$-I_C = 10$ mA; $-I_B = 0.4$ mA	$-V_{BE\,sat}$	>	0.20		V
		<	0.37		V
$-I_C = 10$ mA; $-I_B = 0.25$ mA	$-V_{BE\,sat}$	>		0.15	V
		<		0.32	V
$-I_C = 50$ mA; $-I_B = 2.4$ mA	$-V_{BE\,sat}$	<	0.55		V
$-I_C = 50$ mA; $-I_B = 1.55$ mA	$-V_{BE\,sat}$	<		0.45	V

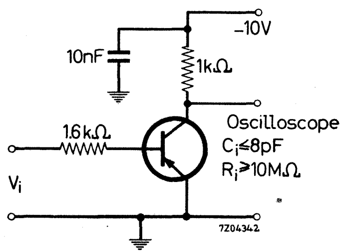
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

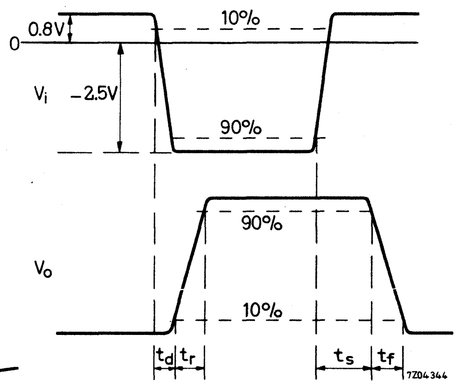
			ASY26	ASY27	
Collector-emitter sustaining voltage					
$-I_C$ = 5 mA; I_B = 0	$-V_{CEO\,sust}$	>	15	15	V
Punch through voltage	V_{pt}	>	25	20	V
Base-emitter floating voltage					
I_B = 0; $-V_{CE}$ = 25 V; T_j = 60 °C	$-V_{BE\,fl}$	<	0.20		V
I_B = 0; $-V_{CE}$ = 20 V; T_j = 60 °C	$-V_{BE\,fl}$	<		0.20	V
D.C. current gain					
$-I_C$ = 10 mA; $-V_{CE}$ = 1 V	h_{FE}	>	30	50	
		typ.	45	80	
$-I_C$ = 20 mA; $-V_{CE}$ = 1 V	h_{FE}	>	30	50	
		typ.	47	78	
		<	80	150	
$-I_C$ = 100 mA; $-V_{CE}$ = 1 V	h_{FE}	>	20	30	
		typ.	39	58	
$-I_C$ = 200 mA; $-V_{CE}$ = 1 V	h_{FE}	>	15	20	
		typ.	27	40	
Collector capacitance at f = 1 MHz					
$I_E = I_e$ = 0; $-V_{CB}$ = 5 V	C_c	typ.	11	11	pF
		<	16	16	pF
Emitter capacitance at f = 1 MHz					
$I_C = I_c$ = 0; $-V_{EB}$ = 5 V	C_e	typ.	7	6	pF
		<	13	13	pF
Transition frequency					
$-I_C$ = 3 mA; $-V_{CE}$ = 5 V	f_T	>	4	6	MHz
		typ.	8	14	MHz
h parameters at f = 1 kHz					
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V					
Input impedance	h_{ie}	typ.	0.75	1.4	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	5.0	7.5	10^{-4}
Small signal current gain	h_{fe}	typ.	50	90	
Output admittance	h_{oe}	typ.	65	100	$\mu\Omega^{-1}$

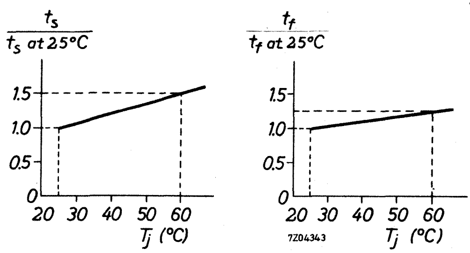
CHARACTERISTICS (continued) $T_j = 25\ ^oC$

Switching characteristics			ASY26	ASY27	
Desaturation time constant $I_C = 0$; $-I_B = 1$ mA	τ_s	<	1.25	1.25	μs
Current feed time constant $-I_{CM} = 50$ mA; $-V_{CE} = 0.75$ V	τ_c	<	2.2	2.2	μs
Voltage feed time constant $-I_{CM} = 1$ mA; $-V_{CE} = 0.75$ V	τ_v	<	0.2	0.2	μs
Switching times (See test circuit)					
delay time	t_d	typ.	65	50	ns
		<	90	75	ns
rise time	t_r	typ.	275	200	ns
		<	490	350	ns
storage time	t_s	typ.	500	600	ns
		<	1350	1500	ns
fall time	t_f	typ.	475	400	ns
		<	730	620	ns

Test circuit:







GERMANIUM ALLOYED TRANSISTORS

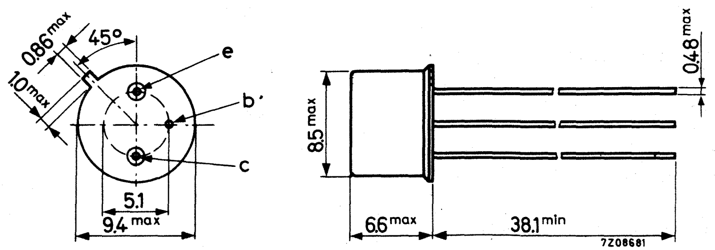
N-P-N transistors in a TO-5 metal envelope with the base connected to the case. These general purpose transistors are primarily intended for medium current medium speed computor logic applications.

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

			ASY28	ASY29	
Voltages					
Collector-base voltage (open emitter)	V_{CBO}	max.	30	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	15	V
Collector-emitter voltage at $-V_{BE}$ = 0.2 V	V_{CEX}	max.	25	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	20	20	V
Currents					
Collector current (d.c. or average over any 20 ms period)	I_C	max.	200		mA
Collector current (peak value)	I_{CM}	max.	300		mA
Power dissipation					
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150		mW
Temperatures					
Storage temperature	T_{stg}		-65 to +100		°C
Junction temperature	T_j	max.	85		°C

MECHANICAL DATA Dimensions in mm

TO-5
Base connected to case



Accessories available: 56218, 56245.

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.4	°C/mW
From junction to case	$R_{th\ j-c}$	=	0.2	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

			ASY28	ASY29	
Collector cut-off current					
I_E = 0; V_{CB} = 30 V	I_{CBO}	<	7		μA
I_E = 0; V_{CB} = 25 V	I_{CBO}	<		7	μA
I_E = 0; V_{CB} = 30 V; T_j = 60 °C	I_{CBO}	<	35		μA
I_E = 0; V_{CB} = 25 V; T_j = 60 °C	I_{CBO}	<		35	μA
Emitter cut-off current					
I_C = 0; V_{EB} = 5 V	I_{EBO}	<	3	3	μA
Currents at reverse biased emitter junction					
V_{CE} = 25 V; $-V_{BE}$ = 0.2 V; T_j = 60 °C	I_{CEX}	<	35		μA
V_{CE} = 20 V; $-V_{BE}$ = 0.2 V; T_j = 60 °C	I_{CEX}	<		35	μA
V_{CE} = 20 V; $-V_{BE}$ = 5 V; T_j = 60 °C	$-I_{BEX}$	<	35	35	μA
Base-emitter voltage					
I_C = 100 mA; V_{CE} = 1 V	V_{BE}	<	0.65	0.55	V
I_C = 300 mA; V_{CE} = 1 V	V_{BE}	<	1.5	1.4	V
Collector-emitter saturation voltage					
I_C = 10 mA; I_B = 0.33 mA	$V_{CE\ sat}$	<	0.20		V
I_C = 10 mA; I_B = 0.2 mA	$V_{CE\ sat}$	<		0.20	V
I_C = 50 mA; I_B = 2 mA	$V_{CE\ sat}$	<	0.25		V
I_C = 50 mA; I_B = 1.25 mA	$V_{CE\ sat}$	<		0.25	V
Base-emitter saturation voltage					
I_C = 10 mA; I_B = 0.4 mA	$V_{BE\ sat}$	> <	0.20 0.37		V V
I_C = 10 mA; I_B = 0.25 mA	$V_{BE\ sat}$	> <		0.15 0.32	V V
I_C = 50 mA; I_B = 2.4 mA	$V_{BE\ sat}$	<	0.55		V
I_C = 50 mA; I_B = 1.55 mA	$V_{BE\ sat}$	<		0.45	V

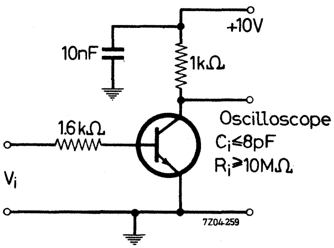
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

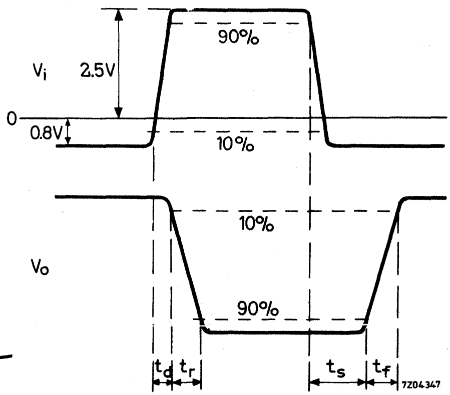
			ASY28	ASY29	
Collector-emitter sustaining voltage					
I_C = 5 mA; I_B = 0	$V_{CEO\,sust}$	>	15	15	V
Punch through voltage	V_{pt}	>	25	20	V
Base-emitter floating voltage					
I_B = 0; V_{CE} = 25 V; T_j = 60 °C	$V_{BE\,fl}$	<	0.20		V
I_B = 0; V_{CE} = 20 V; T_j = 60 °C	$V_{BE\,fl}$	<		0.20	V
D.C. current gain					
I_C = 10 mA; V_{CE} = 1 V	h_{FE}	>	30	50	
		typ.	43	113	
I_C = 20 mA; V_{CE} = 1 V	h_{FE}	>	30	50	
		typ.	46	113	
		<	80	150	
I_C = 100 mA; V_{CE} = 1 V	h_{FE}	>	20	30	
		typ.	43	102	
I_C = 200 mA; V_{CE} = 1 V	h_{FE}	>	15	20	
		typ.	32	84	
Collector capacitance at f = 1 MHz					
$I_E = I_e$ = 0; V_{CB} = 5 V	C_c	typ.	11	11	pF
		<	16	16	pF
Emitter capacitance at f = 1 MHz					
$I_C = I_c$ = 0; V_{EB} = 5 V	C_e	typ.	7	6	pF
		<	13	13	pF
Transition frequency					
I_C = 3 mA; V_{CE} = 5 V	f_T	>	4	10	MHz
		typ.	14	20	MHz
h parameters at f = 1 kHz					
I_C = 2 mA; V_{CE} = 5 V					
Input impedance	h_{ie}	typ.	0.75	1.4	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	3.5	5.0	10^{-4}
Small signal current gain	h_{fe}	typ.	50	90	
Output admittance	h_{oe}	typ.	45	70	$\mu\Omega^{-1}$

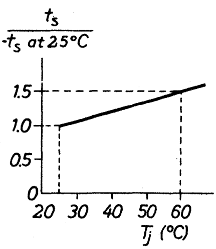
CHARACTERISTICS (continued) $T_j = 25\ ^oC$

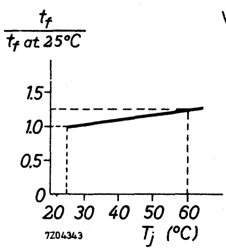
			ASY28	ASY29	
Switching characteristics					
Desaturation time constant $I_C = 0;\ I_B = 1$ mA	τ_s	<	1.4	1.4	μs
Current feed time constant $I_{CM} = 50$ mA; $V_{CE} = 0.75$ V	τ_c	<	2.2	2.2	μs
Voltage feed time constant $I_{CM} = 1$ mA; $V_{CE} = 5$ V	τ_v	<	0.2	0.2	μs
Switching times (See test circuit)					
delay time	t_d	typ.	50	45	ns
		<	90	75	ns
rise time	t_r	typ.	175	140	ns
		<	400	300	ns
storage time	t_s	typ.	450	500	ns
		<	700	800	ns
fall time	t_f	typ.	325	300	ns
		<	620	520	ns

Test circuit:









SYMMETRICAL N-P-N SWITCHING TRANSISTORS

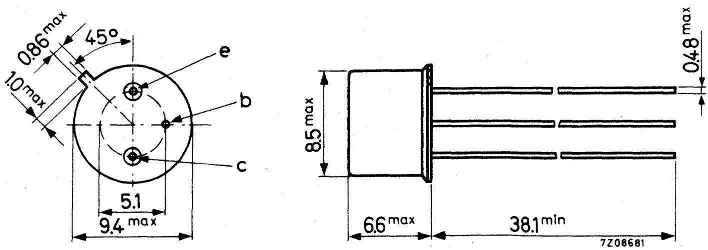
Symmetrical N-P-N germanium alloy transistors in a TO-5 metal envelope with the base connected to the case intended for high current medium speed switching applications.

QUICK REFERENCE DATA

			ASY73	ASY74	ASY75	
Collector-base voltage (open emitter)	V_{CBO}	max.	30	30	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	15	15	V
Collector-current (d.c. or average)	I_C	max.	400	400	400	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	140	140	140	mW
Junction temperature	T_j	max.	75	75	75	°C
D.C. current gain at T_j = 25 °C						
$-I_E$ = 200 mA; V_{CB} = 0	h_{FE}	>	20	35	50	
$-I_C$ = 200 mA; V_{EB} = 0	h_{FC}	>	12	20	20	
Transition frequency						
$-I_E$ = 3 mA; V_{CB} = 5 V	f_T	>	4	6	10	MHz
Desaturation time constant						
I_B = 1 mA; I_C = 0	τ_s		<1.75	1.75	1.75	µs

MECHANICAL DATA Dimensions in mm

TO-5
Base connected to case



Accessories available: 56218, 56245

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open-emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V [2])
Collector-emitter voltage with $-V_{BE} = 0.2$ V	V_{CEX}	max.	20	V [2])
Emitter-base voltage (open collector)	V_{EBO}	max.	30	V

Currents

Collector current (d.c. or average over any 20 ms period)	I_C	max.	400	mA
Emitter current (d.c. or average over any 20 ms period)	$-I_E$	max.	400	mA
Base current (d.c. or average over any 20 ms period)	I_B	max.	40	mA
Base current (peak value)	I_{BM}	max.	400	mA

Power dissipation

Total steady state power dissipation up to $T_{amb} = 25$ °C	P_{tot}	max.	140	mW

Temperatures

Storage temperature	T_{stg}		−55 to 85	°C
Operating junction temperature	T_j	max.	75	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.35	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0.2	°C/mW

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

[2]) For switch-off transients with inductive load see page 12

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $V_{CB} = 5$ V	I_{CBO}	<	3	μA
$V_{CB} = 30$ V; $T_j = 55$ °C	I_{CBO}	<	100	μA

Emitter cut-off current

$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	3	μA
$V_{EB} = 30$ V; $T_j = 55$ °C	I_{EBO}	<	100	μA

Currents at reverse biased emitter junction

$V_{CE} = 20$ V; $-V_{BE} = 0.2$ V; $T_j = 55$ °C	I_{CEX}	<	50	μA
$-V_{BE} = 20$ V; $V_{CB} = 20$ V; $T_j = 55$ °C	$-I_{BEX}$	<	50	μA

Saturation voltages

ASY73.	$I_C = 50$ mA; $I_B = 2.5$ mA	V_{CEsat}	<	0.22	V
	$I_C = 200$ mA; $I_B = 10$ mA	V_{CEsat}	<	0.30	V
	$I_E = 200$ mA; $I_B = 16.5$ mA	V_{ECsat}	<	0.30	V
	$I_C = 50$ mA; $I_B = 3$ mA	$V_{BE\,sat}$	<	0.50	V
	$I_C = 200$ mA; $I_B = 12$ mA	$V_{BE\,sat}$	<	0.90	V
ASY74.	$I_C = 50$ mA; $I_B = 1.25$ mA	V_{CEsat}	<	0.22	V
	$I_C = 200$ mA; $I_B = 5.7$ mA	V_{CEsat}	<	0.30	V
	$I_C = 400$ mA; $I_B = 20$ mA	V_{CEsat}	<	0.37	V
	$I_E = 200$ mA; $I_B = 10$ mA	V_{ECsat}	<	0.30	V
	$I_C = 50$ mA; $I_B = 1.5$ mA	$V_{BE\,sat}$	<	0.38	V
	$I_C = 200$ mA; $I_B = 7$ mA	$V_{BE\,sat}$	<	0.70	V
	$I_C = 400$ mA; $V_{CB} = 0$	$V_{BE\,sat}$	<	0.90	V
ASY75.	$I_C = 50$ mA; $I_B = 0.75$ mA	V_{CEsat}	<	0.22	V
	$I_C = 200$ mA; $I_B = 4$ mA	V_{CEsat}	<	0.30	V
	$I_C = 400$ mA; $I_B = 13.5$ mA	V_{CEsat}	<	0.37	V
	$I_E = 200$ mA; $I_B = 10$ mA	V_{ECsat}	<	0.30	V
	$I_C = 50$ mA; $I_B = 0.95$ mA	$V_{BE\,sat}$	<	0.34	V
	$I_C = 200$ mA; $I_B = 5$ mA	$V_{BE\,sat}$	<	0.60	V
	$I_C = 400$ mA; $V_{CB} = 0$	$V_{BE\,sat}$	<	0.70	V

Sustaining voltage

$I_C = 10$ mA; $I_B = 0$	$V_{CEOsust}$	>	15	V

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

Punch-through voltage	V_{pt}	>	20	V
Floating potential				
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 55$ °C	V_{EBfl}	<	180	mV
$I_C = 0$; $V_{CB} = 20$ V; $T_j = 55$ °C	V_{CBfl}	<	180	mV
D.C. current gain				
ASY73 $V_{CB} = 0$; $-I_E = 50$ mA	h_{FE}	>	25	
$V_{CB} = 0$; $-I_E = 200$ mA	h_{FE}	>	20	
$V_{EB} = 0$; $-I_C = 200$ mA	h_{FC}	>	12	
ASY74 $V_{CB} = 0$; $-I_E = 50$ mA	h_{FE}	>	40	
$V_{CB} = 0$; $-I_E = 200$ mA	h_{FE}	>	35	
$V_{CB} = 0$; $-I_E = 400$ mA	h_{FE}	>	20	
$V_{EB} = 0$; $-I_C = 200$ mA	h_{FC}	>	20	
ASY75 $V_{CB} = 0$; $-I_E = 50$ mA	h_{FE}	>	65	
$V_{CB} = 0$; $-I_E = 200$ mA	h_{FE}	>	50	
$V_{CB} = 0$; $-I_E = 400$ mA	h_{FE}	>	30	
$V_{EB} = 0$; $-I_C = 200$ mA	h_{FC}	>	20	
Switching parameters				
Desaturation time constant $I_B = 1$ mA; $I_C = 0$	τ_s	<	1.75	µs
Current-feed time constant $I_{CM} = 200$ mA; $V_{CE} = 0.75$ V	τ_c	<	1.75	µs
Voltage-feed time constant $I_{CM} = 1$ mA; $V_{CE} = 5$ V	τ_v	<	0.20	µs
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	<	30	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 5$ V	C_e	<	30	pF
Transition frequency				
$-I_E = 3$ mA; $V_{CB} = 5$ V — ASY73	f_T	>	4	MHz
$-I_E = 3$ mA; $V_{CB} = 5$ V — ASY74	f_T	>	6	MHz
$-I_E = 3$ mA; $V_{CB} = 5$ V — ASY75	f_T	>	10	MHz

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a TO-39 metal envelope primarily intended for use as high current switching device, e.g. inverters and switching regulators.

QUICK REFERENCE DATA

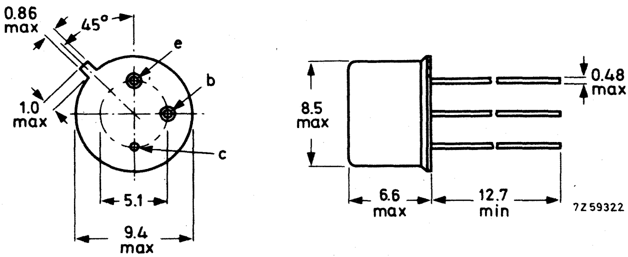
Collector-base voltage (open emitter)	V_{CBO}	max.	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	V
Collector-current (peak value)	I_{CM}	max.	5.0	A
Total power dissipation				
up to $T_{case} = 25\,^{o}C$	P_{tot}	max.	5.0	W
Junction temperature	T_j	max.	200	^{o}C
D.C. current gain				
$I_C = 2$ A; $V_{CE} = 2$ V	h_{FE}		40 to 150	
Transition frequency at f = 35 MHz				
$I_C = 0.5$ A; $V_{CE} = 5$ V	f_T	>	70	MHz
Turn off time when switched from				
$I_C = 5$ A; $I_B = 0.5$ A to cut-off				
with $-I_{BM} = 0.5$ A	t_{off}	<	1.2	μs

MECHANICAL DATA

Dimensions in mm

Collector connected to case

TO-39



max. lead diameter is guaranteed only for 12.7 mm

Accessories supplied on request: 56218, 56254

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

Voltages				
Collector-base voltage (open emitter)	V_{CBO}	max.	120	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.	2.0	A
Collector current (peak value)	I_{CM}	max.	5.0	A
Base current (d.c.)	I_B	max.	1.0	A
Power dissipation				
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	5.0	W
up to T_{amb} = 25 °C	P_{tot}	max.	0.87	W
Temperatures				
Storage temperature	T_{stg}		−55 to +200	°C
Junction temperature	T_j	max.	200	°C

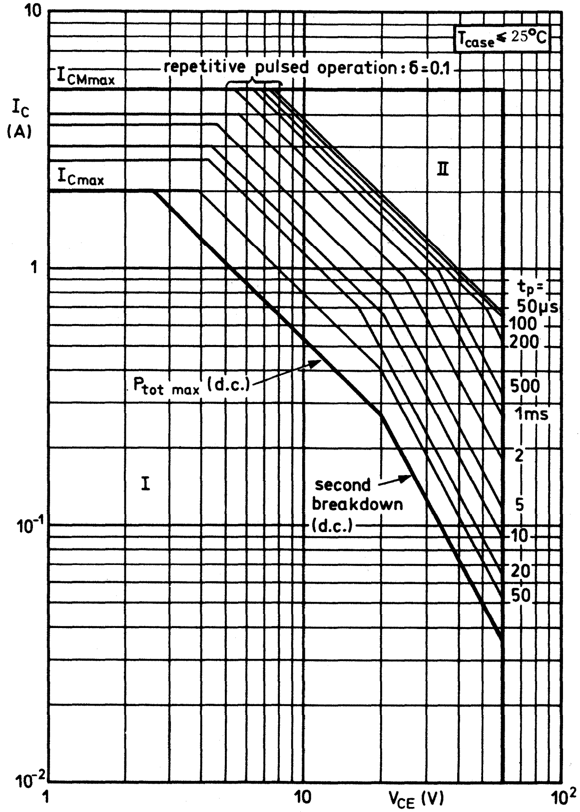
THERMAL RESISTANCE

Frm 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

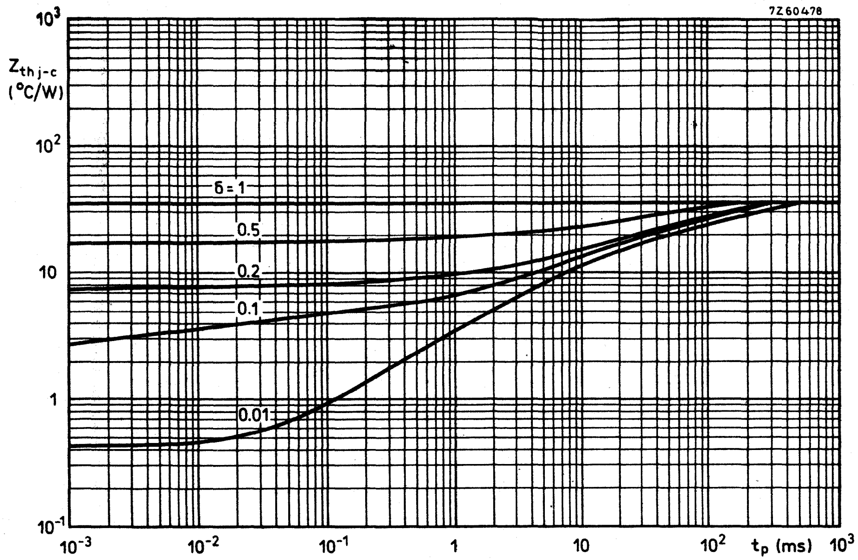
$T_j = 25\ ^oC$ unless otherwise specified

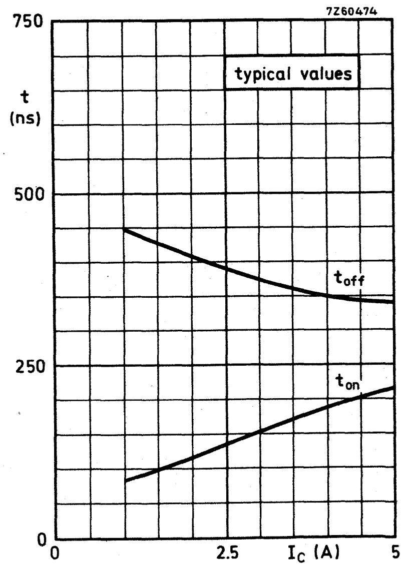
Parameter / Conditions	Symbol		Value	Unit
Collector cut-off current				
$V_{EB} = 0$; $V_{CE} = 60$ V	I_{CES}	<	10	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 4$ V	I_{EBO}	typ.	0.01	μA
		<	10	μA
Saturation voltages				
$I_C = 5$ A; $I_B = 0.5$ A	V_{CEsat}	typ.	0.77	V
		<	1.0	V
	V_{BEsat}	typ.	1.43	V
		<	1.8	V
D.C. current gain				
$I_C = 1.0$ A; $V_{CE} = 2.0$ V	h_{FE}	typ.	130	
$I_C = 1.5$ A; $V_{CE} = 0.6$ V	h_{FE}	typ.	60	
$I_C = 2.0$ A; $V_{CE} = 2.0$ V	h_{FE}	typ.	110	
			40 to 150	
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	36	pF
		<	100	pF
Emitter-capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	typ.	345	pF
Transition frequency at f = 35 MHz				
$I_C = 0.5$ A; $V_{CE} = 5$ V	f_T	>	70	MHz
		typ.	100	MHz
Turn on time when switched from				
$-V_{BE} = 2.0$ V to $I_C = 5$ A; $I_B = 0.5$ A with $I_{BM} = 0.5$ A	t_{on}	typ.	0.2	μs
		<	0.6	μs
Turn off time when switched from				
$I_C = 5$ A; $I_B = 0.5$ A to $-V_{BE} = 2.0$ V with $-I_{BM} = 0.5$ A	t_{off}	typ.	0.34	μs
		<	1.2	μs

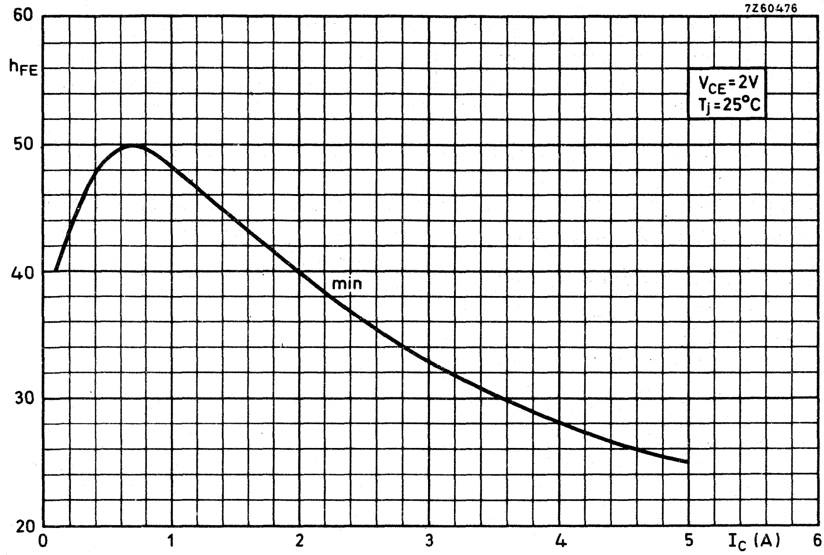


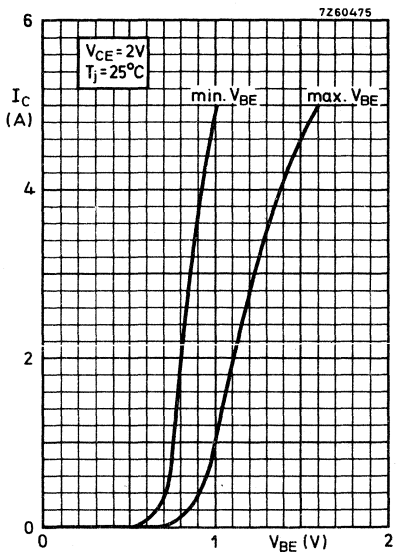
Safe Operation Area with the transistor forward biased

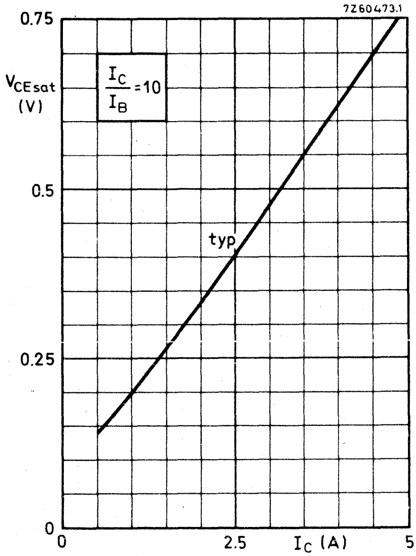
I Region of permissible d. c. operation
II Permissible extension for repetitive pulsed operation


7Z60478
10^3
$Z_{th\,j-c}$ (°C/W)
10^2
10
1
10^{-1}
δ = 1
0.5
0.2
0.1
0.01
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3


7Z60474
750
t (ns)
500
250
0
typical values
t_{off}
t_{on}
0
2.5
I_C (A)
5


7Z60476
60
50
40
30
20
h_{FE}
$V_{CE} = 2V$
$T_j = 25^oC$
min
0
1
2
3
4
5
I_C (A)
6


7Z60475
6
4
2
0
I_C
(A)
$V_{CE} = 2V$
$T_j = 25^oC$
min. V_{BE}
max. V_{BE}
0
1
V_{BE} (V)
2


7Z60473.1
0.75
0.5
0.25
0
V_{CEsat}
(V)
$\frac{I_C}{I_B} = 10$
typ
0
2.5
I_C (A)
5

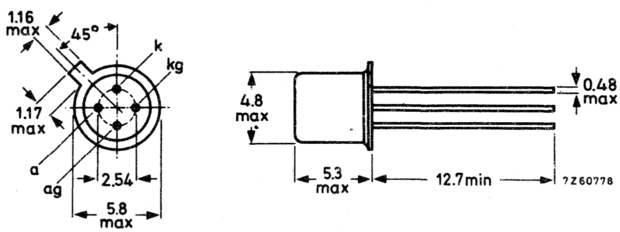
SILICON CONTROLLED SWITCH

The BR101 is a planar p-n-p-n switch in a TO-72 metal envelope, intended for time base circuits and other television applications. It is also suitable as trigger device for thyristors. It is an integrated pnp-npn transistor pair of which all electrodes are accessible.
The collector of the n-p-n transistor is connected to the case.

QUICK REFERENCE DATA				
P-N-P transistor				
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	50	V
N-P-N transistor				
Collector-base voltage (open emitter)	V_{CBO}	max.	50	V
Repetitive peak emitter current	$-I_{ERM}$	max.	2,5	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	275	mW
Junction temperature	T_j	max.	150	°C
Forward on-state voltage				
I_A = 50 mA; I_{AG} = 0; R_{KG-K} = 10 kΩ	V_{AK}	<	1,4	V
Holding current				
I_{AG} = 10 mA; $-V_{BB}$ = 2 V; R_{KG-K} = 10 kΩ	I_H	<	1,0	mA

MECHANICAL DATA Dimensions in mm

Collector of the n-p-n transistor (anode gate) connected to the case.
TO-72



Accessories supplied on request: 56246; 56263.

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

			p-n-p	n-p-n	
Voltages					
Collector-base voltage (open emitter)	V_{CBO}	max.	−50	50	V
Collector-emitter voltage (R_{BE} = 10 kΩ)	V_{CER}	max.	−	50	V
Collector-emitter voltage (open base)	V_{CEO}	max.	−50	−	V
Emitter-base voltage (open collector)	V_{EBO}	max.	−50	5 1)	V
Currents					
Emitter current (d.c.)	I_E	max.	175	−175	mA
Repetitive peak emitter current t_p = 10 µs; δ = 0,01	I_{ERM}	max.	2,5	− 2,5	A
Collector current (d.c.)	I_C	max.	−	175 2)	mA
Collector current (peak value)	I_{CM}	max.	−	175	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	275	mW

Temperatures

Storage temperature	T_{stg}		−65 to +200	°C
Operating junction temperature	T_j	max.	150	°C

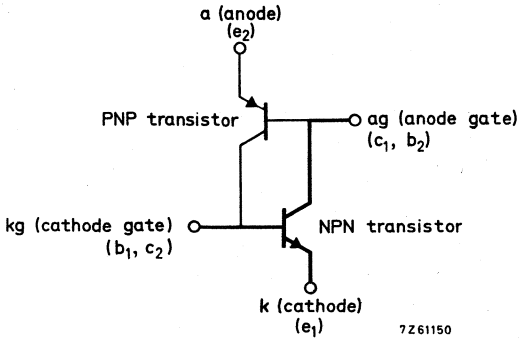
THERMAL RESISTANCE

From junction to ambient	$R_{th\ j\text{-}a}$	=	0,45	°C/mW

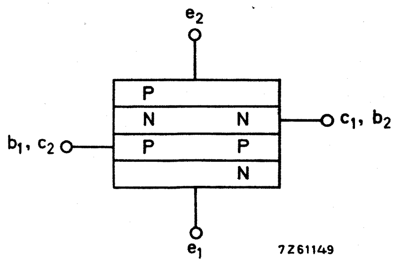
1) Exceeding of this voltage is allowed during the discharge of a capacitor of max. 390 pF, provided the charge does not exceed 50 nC.
2) Provided the I_E rating will not be exceeded.

MEANING OF SYMBOLS , used in the schematic presentation of the S.C.S.

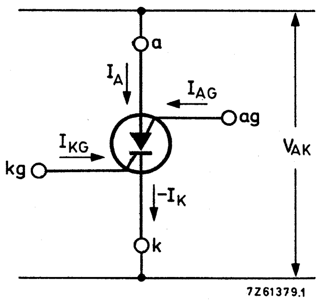
2 transistors equivalent circuit
n-p-n transistor + p-n-p transistor



p-n-p-n S.C.S. equivalent circuit



S.C.S. symbol



CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Individual N-P-N transistor

Collector cut-off current

V_{CE} = 50 V; R_{BE} = 10 kΩ	I_{CER}	<	0,5	μA
V_{CE} = 50 V; R_{BE} = 10 kΩ; T_j = 150 °C	I_{CER}	<	50	μA

Emitter cut-off current

I_C = 0; V_{EB} = 5 V; T_j = 150 °C	I_{EBO}	<	50	μA

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

Individual N-P-N transistor

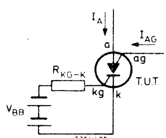
Saturation voltages				
$I_C = 10$ mA; $I_B = 1$ mA	V_{CEsat}	<	500	mV
	V_{BEsat}	<	900	mV
D.C. current gain				
$I_C = 10$ mA; $V_{CE} = 2$ V	h_{FE}	>	50	
Transition frequency				
$I_C = 10$ mA; $V_{CE} = 2$ V	f_T	typ.	300	MHz
Collector capacitance				
$I_E = I_e = 0$; $V_{CB} = 20$ V	C_c	<	5	pF
Emitter capacitance				
$I_C = I_c = 0$; $V_{EB} = 1$ V	C_e	<	25	pF

Individual P-N-P transistor

Collector cut-off current				
$I_B = 0$; $-V_{CE} = 50$ V; $T_j = 150\ ^oC$	$-I_{CEO}$	<	50	μA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 50$ V; $T_j = 150\ ^oC$	$-I_{EBO}$	<	50	μA
D.C. current gain				
$I_E = 1$ mA; $V_{CB} = 0$	h_{FE}	0,25 to 2,5		

Combined device

Forward on-state voltage at $R_{KG-K} = 10\ k\Omega$				
$I_A = 50$ mA; $I_{AG} = 0$	V_{AK}	<	1,4	V
$I_A = 1$ mA; $I_{AG} = 10$ mA	V_{AK}	<	1,2	V
Holding current at $R_{KG-K} = 10\ k\Omega$				
$I_{AG} = 10$ mA; $-V_{BB} = 2$ V	I_H	<	1,0	mA



SILICON CONTROLLED SWITCH

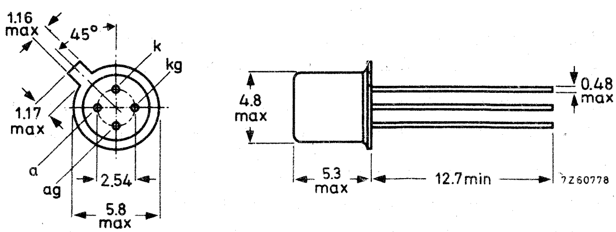
The BRY39 is a planar p-n-p-n switch in a TO-72 metal envelope, intended as driver for numerical indicator tubes and other switching applications.
It is an integrated pnp-npn transistor pair of which all electrodes are accessible.
The collector of the n-p-n transistor is connected to the case.
For the applications of the BRY39 as THYRISTOR TETRODE see Handbook Part 1a, section THYRISTORS, DIACS, TRIACS and as PROGRAMMABLE UNIJUNCTION TRANSISTOR see Handbook Part 3, section SWITCHING TRANSISTORS.

QUICK REFERENCE DATA				
P-N-P transistor				
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	70	V
N-P-N transistor				
Collector-base voltage (open emitter)	V_{CBO}	max.	70	V
Repetitive peak emitter current	$-I_{ERM}$	max.	2,5	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	275	mW
Junction temperature	T_j	max.	150	°C
Forward on-state voltage I_A = 50 mA; I_{AG} = 0; R_{KG-K} = 10 kΩ	V_{AK}	<	1,4	V
Holding current I_{AG} = 10 mA; $-V_{BB}$ = 2 V; R_{KG-K} = 10 kΩ	I_H	<	1,0	mA
Turn-on time	t_{on}	<	0,25	µs
Turn-off time	t_q	<	5,0	µs

MECHANICAL DATA

Dimensions in mm

Collector of the n-p-n transistor (anode gate) connected to the case.
TO-72



Accessories supplied on request: 56246; 56263.

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

			p-n-p	n-p-n	
Voltages					
Collector-base voltage (open emitter)	V_{CBO}	max.	−70	70 1)	V
Collector-emitter voltage (R_{BE} = 10 kΩ)	V_{CER}	max.	–	70 1)	V
Collector-emitter voltage (open base)	V_{CEO}	max.	−70	–	V
Emitter-base voltage (open collector)	V_{EBO}	max.	−70 1)	5 2)	V
Currents					
Emitter current (d.c.)	I_E	max.	175	−175	mA
Repetitive peak emitter current t_p = 10 µs: δ = 0,01	I_{ERM}	max.	2,5	−2,5	A
Collector current (d.c.)	I_C	max.	–	175 3)	mA
Collector current (peak value)	I_{CM}	max.	–	175 4)	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	275	mW

Temperatures

Storage temperature	T_{stg}		−65 to +200	°C
Operating junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient	$R_{th\ j-a}$	=	0,45	°C/mW

1) In numerical indicator tube driver circuits higher voltages are allowed, provided the collector current does not exceed a d.c. current of 1 mA.

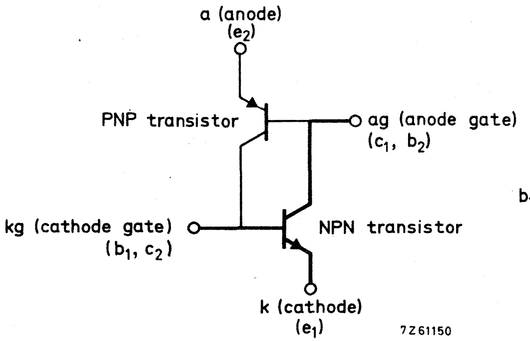
2) In numerical indicator tube driver circuits higher voltages are allowed during the discharge of a capacitor of max. 390 pF, provided the charge does not exceed 50 nC.

3) Provided the I_E rating will not be exceeded.

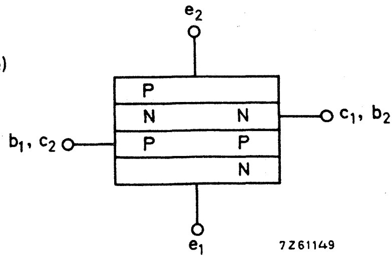
4) During switching on, the device can withstand a discharge of a capacitor of max. 500 pF. This capacitor is charged, when the transistor is in cut-off condition, with a collector supply voltage of 160 V with a series resistance of 100 kΩ.

MEANING OF SYMBOLS, used in the schematic presentation of the S.C.S.

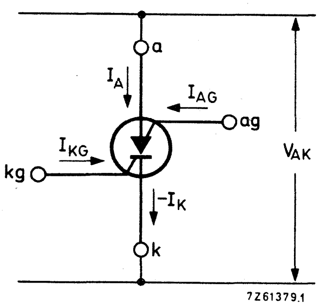
2 transistor equivalent circuit



p-n-p-n S.C.S. equivalent circuit



S.C.S. symbol



CHARACTERISTICS T_j = 25 °C unless otherwise specified

Individual N-P-N transistor

Collector cut-off current

V_{CE} = 70 V; R_{BE} = 10 kΩ	I_{CER}	<	100	nA
V_{CE} = 70 V; R_{BE} = 10 kΩ; T_j = 150 °C	I_{CER}	<	10	µA

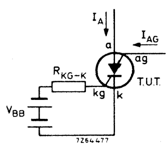
Emitter cut-off current

I_C = 0; V_{EB} = 5 V; T_j = 150 °C	I_{EBO}	<	10	µA

CHARACTERISTICS (continued)

$T_j = 25\ ^oC$ unless otherwise specified

Individual N-P-N transistor				
Saturation voltages				
$I_C = 10$ mA; $I_B = 1$ mA	V_{CEsat}	<	500	mV
	V_{BEsat}	<	900	mV
D.C. current gain				
$I_C = 10$ mA; $V_{CE} = 2$ V	h_{FE}	>	50	
Transition frequency				
$I_C = 10$ mA; $V_{CE} = 2$ V	f_T	typ.	300	MHz
Collector capacitance				
$I_E = I_e = 0$; $V_{CB} = 20$ V	C_c	<	5	pF
Emitter capacitance				
$I_C = I_c = 0$; $V_{EB} = 1$ V	C_e	<	25	pF
Individual P-N-P transistor				
Collector cut-off current				
$I_B = 0$; $-V_{CE} = 70$ V; $T_j = 150\ ^oC$	$-I_{CEO}$	<	10	μA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 70$ V; $T_j = 150\ ^oC$	$-I_{EBO}$	<	10	μA
D.C. current gain				
$I_E = 1$ mA; $V_{CB} = 0$	h_{FE}	0,25 to 2,5		
Combined device				
Forward on-state voltage at $R_{KG-K} = 10$ kΩ				
$I_A = 50$ mA; $I_{AG} = 0$	V_{AK}	<	1,4	V
$I_A = 50$ mA; $I_{AG} = 0$; $T_j = -55\ ^oC$	V_{AK}	<	1,9	V
$I_A = 1$ mA; $I_{AG} = 10$ mA	V_{AK}	<	1,2	V
Holding current at $R_{KG-K} = 10$ kΩ				
$I_{AG} = 10$ mA; $-V_{BB} = 2$ V	I_H	<	1,0	mA

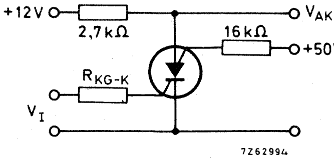


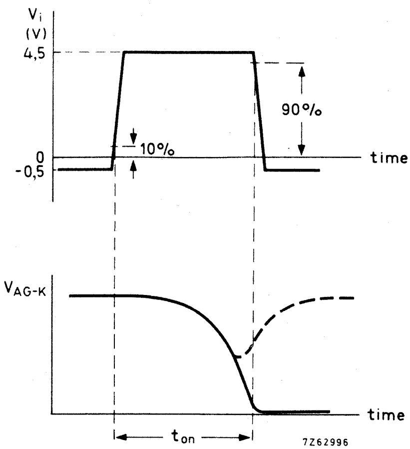
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Switching times see also page 6

Turn-on time when switched from

$-V_{KG\text{-}K}$ = 0,5 V to $+V_{KG\text{-}K}$ = 4,5 V; $R_{KG\text{-}K}$ = 1 kΩ	t_{on}	<	0,25 μs
$R_{KG\text{-}K}$ = 10 kΩ	t_{on}	<	1,5 μs

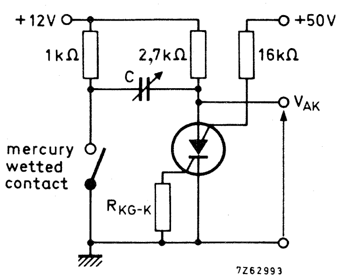


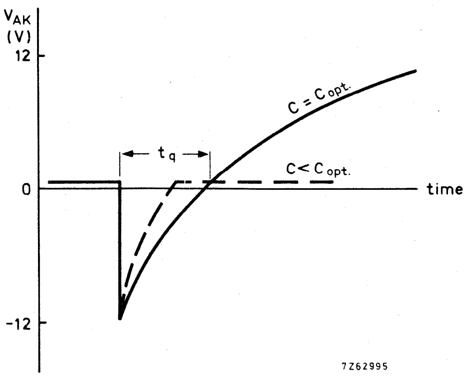


Pulse duration increased until dashed curve disappears

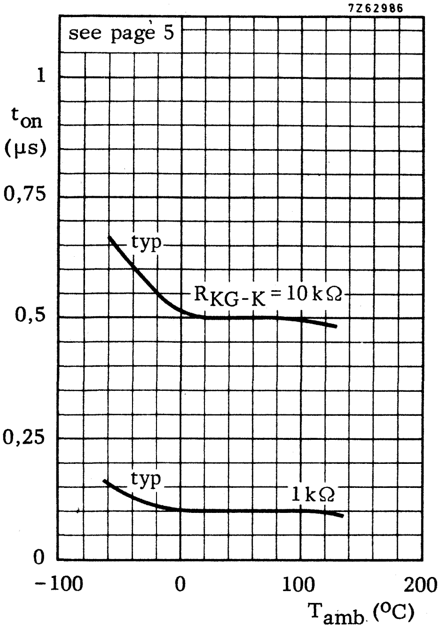
Turn-off time

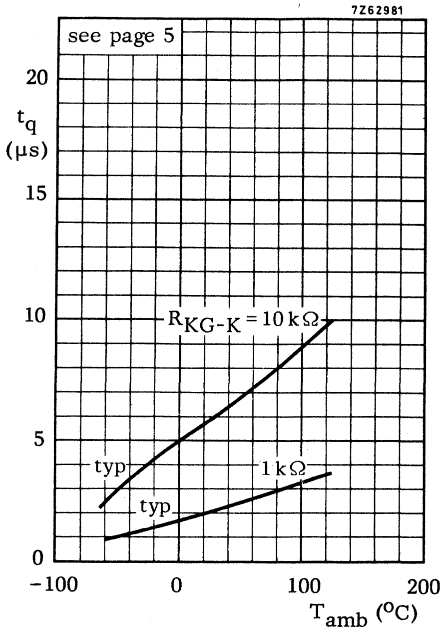
$R_{KG\text{-}K}$ = 1 kΩ	t_q	<	5 μs
$R_{KG\text{-}K}$ = 10 kΩ	t_q	<	8 μs
T_j = 125 °C; $R_{KG\text{-}K}$ = 10 kΩ	t_q	<	15 μs

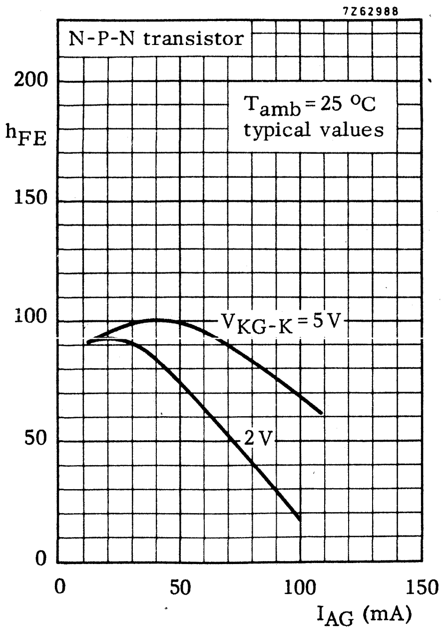


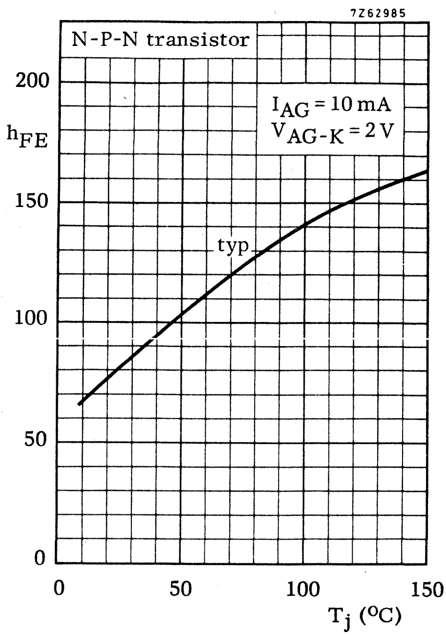


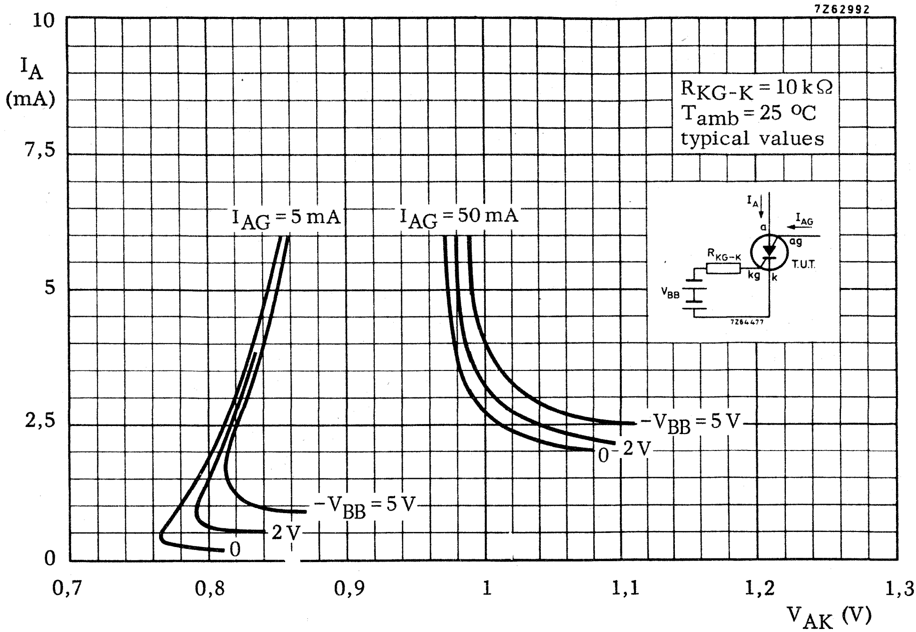
Capacitance increased until dashed curve disappears at C = C_{opt}

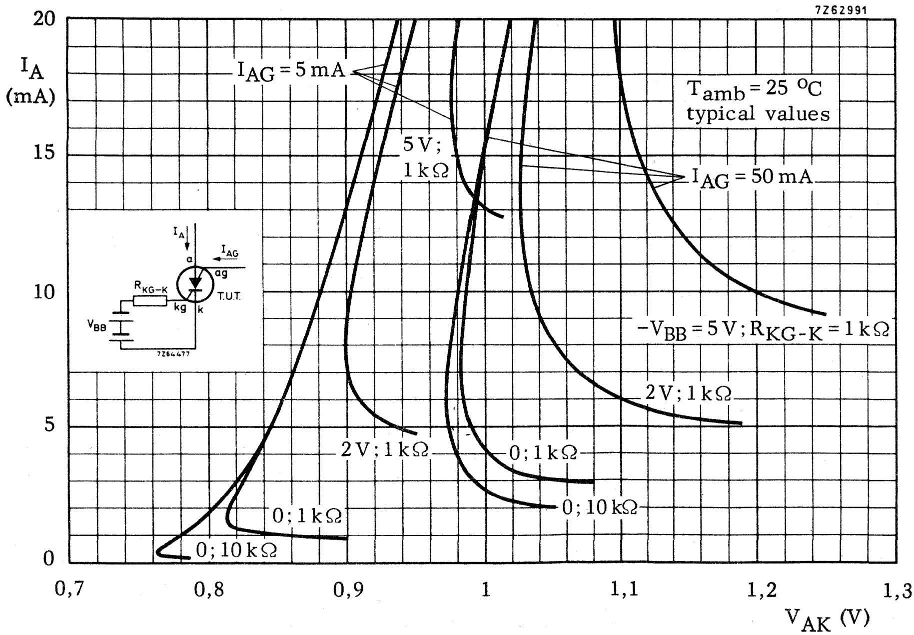

7Z62986
see page 5
1
t_{on}
(μs)
0,75
0,5
0,25
0
typ
R_{KG-K} = 10 kΩ
typ
1 kΩ
−100
0
100
200
T_{amb} (°C)

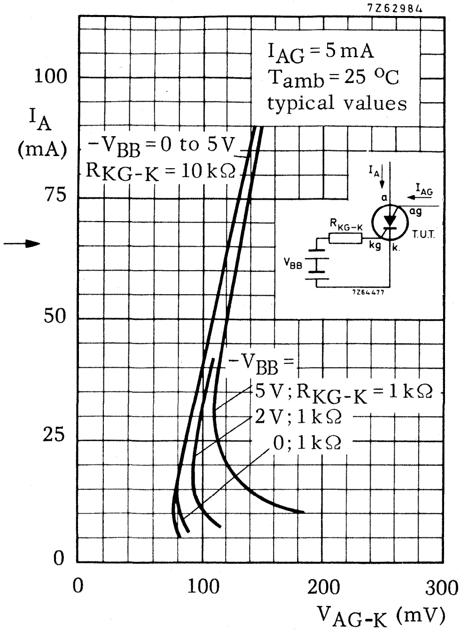

7Z62981
see page 5
20
t_q
(μs)
15
10
5
0
R_{KG-K} = 10 kΩ
typ
1 kΩ
typ
−100
0
100
200
T_{amb} (°C)

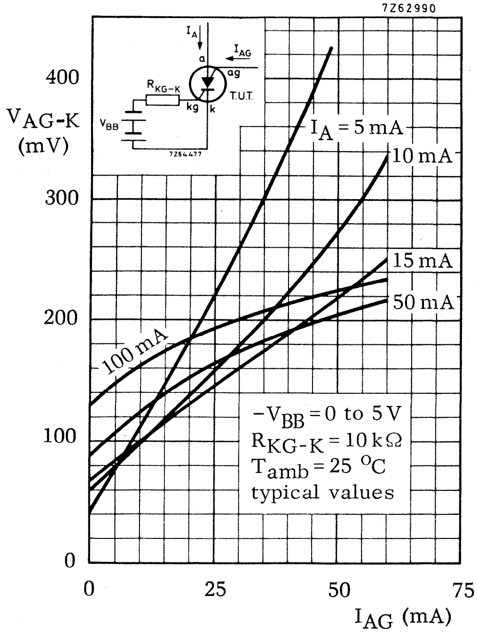

7Z62988
N-P-N transistor
T_{amb} = 25 °C
typical values
200
h_{FE}
150
100
50
0
V_{KG-K} = 5 V
2 V
0
50
100
150
I_{AG} (mA)

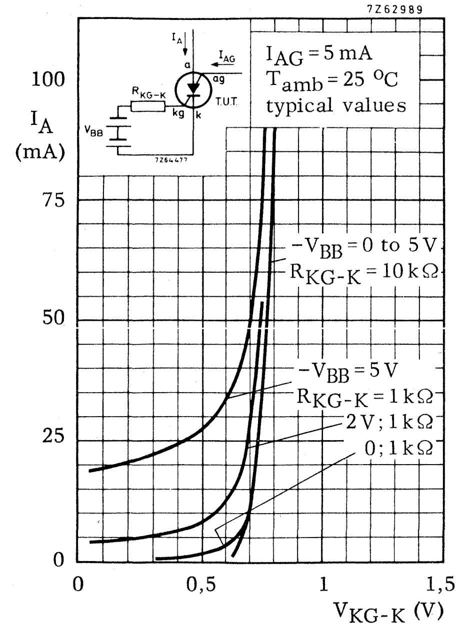

7Z62985
N-P-N transistor
I_{AG} = 10 mA
V_{AG-K} = 2 V
200
h_{FE}
150
100
50
0
typ
0
50
100
150
T_j (°C)

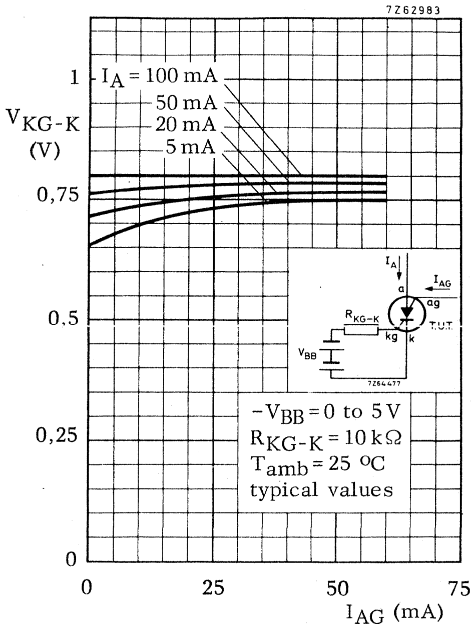

7Z62992
10
I_A
(mA)
7,5
5
2,5
0
0,7
0,8
0,9
1
1,1
1,2
1,3
V_{AK} (V)
$R_{KG-K} = 10\,k\Omega$
$T_{amb} = 25\ ^oC$
typical values
$I_{AG} = 5\ mA$
$I_{AG} = 50\ mA$
$-V_{BB} = 5\ V$
2 V
0
T.U.T.

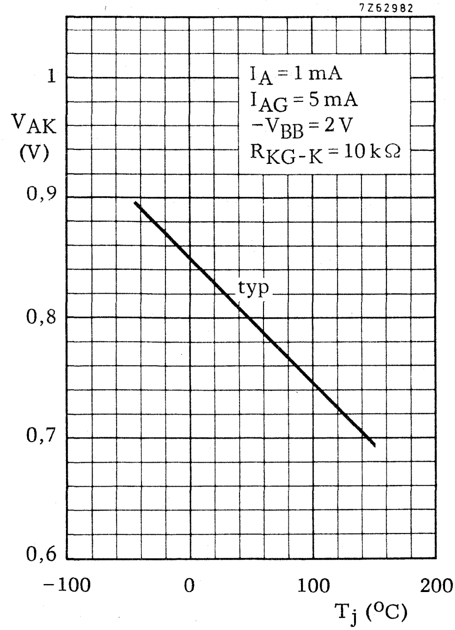

7Z62991
20
I_A
(mA)
15
10
5
0
0,7
0,8
0,9
1
1,1
1,2
1,3
V_{AK} (V)
$T_{amb} = 25\ ^oC$
typical values
$I_{AG} = 5\ mA$
$I_{AG} = 50\ mA$
5 V; 1 kΩ
$-V_{BB} = 5\ V; R_{KG-K} = 1\ k\Omega$
2 V; 1 kΩ
0; 1 kΩ
0; 10 kΩ
T.U.T.

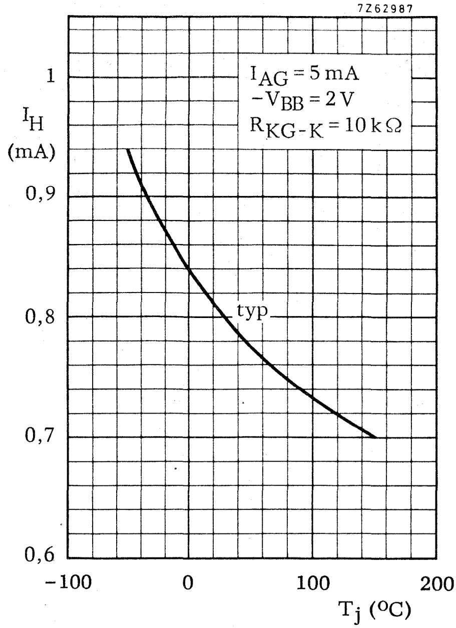

7Z62984
I_{AG} = 5 mA
T_{amb} = 25 °C
typical values
$-V_{BB}$ = 0 to 5 V
R_{KG-K} = 10 kΩ
$-V_{BB}$ =
5 V; R_{KG-K} = 1 kΩ
2 V; 1 kΩ
0; 1 kΩ
I_A
(mA)
100
75
50
25
0
0
100
200
300
V_{AG-K} (mV)
I_A
I_{AG}
a
ag
R_{KG-K}
kg
k
T.U.T.
V_{BB}
7Z64477

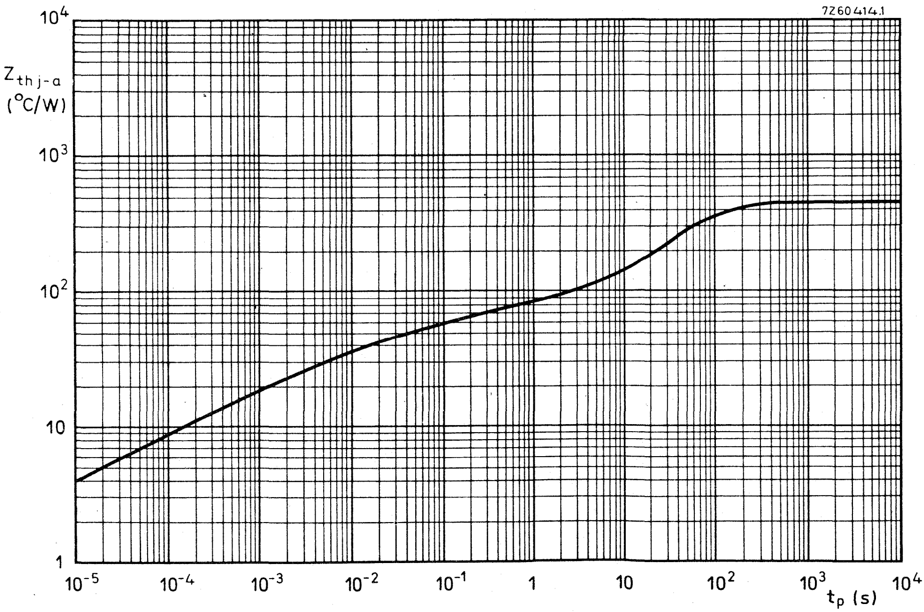

7Z62990
I_A = 5 mA
10 mA
15 mA
50 mA
100 mA
$-V_{BB}$ = 0 to 5 V
R_{KG-K} = 10 kΩ
T_{amb} = 25 °C
typical values
V_{AG-K}
(mV)
400
300
200
100
0
0
25
50
75
I_{AG} (mA)
I_A
I_{AG}
a
ag
R_{KG-K}
kg
k
T.U.T.
V_{BB}
7Z64477

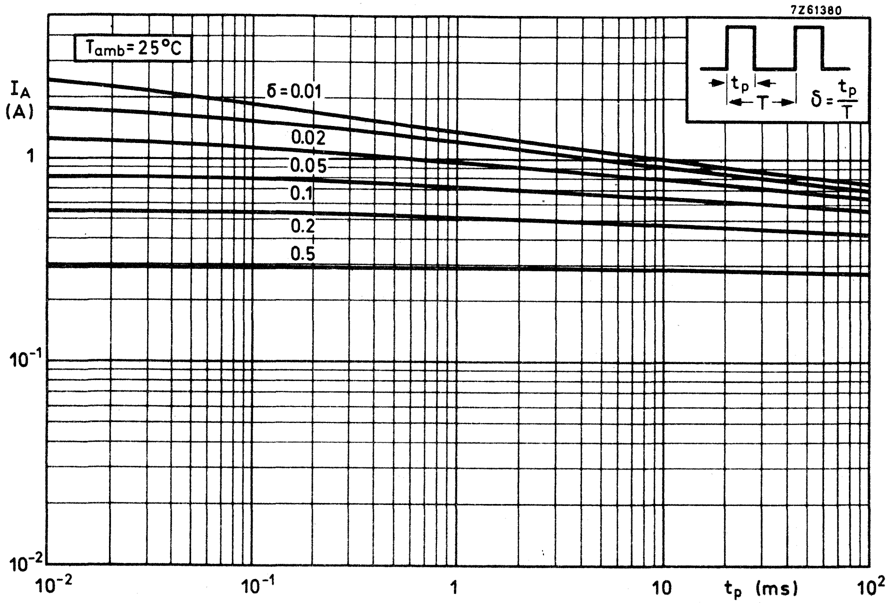

7Z62989
I_{AG} = 5 mA
T_{amb} = 25 °C
typical values
$-V_{BB}$ = 0 to 5 V
R_{KG-K} = 10 kΩ
$-V_{BB}$ = 5 V
R_{KG-K} = 1 kΩ
2 V; 1 kΩ
0; 1 kΩ
I_A
(mA)
100
75
50
25
0
0
0,5
1
1,5
V_{KG-K} (V)
I_A
I_{AG}
a
ag
R_{KG-K}
kg
k
T.U.T.
V_{BB}
7Z64477

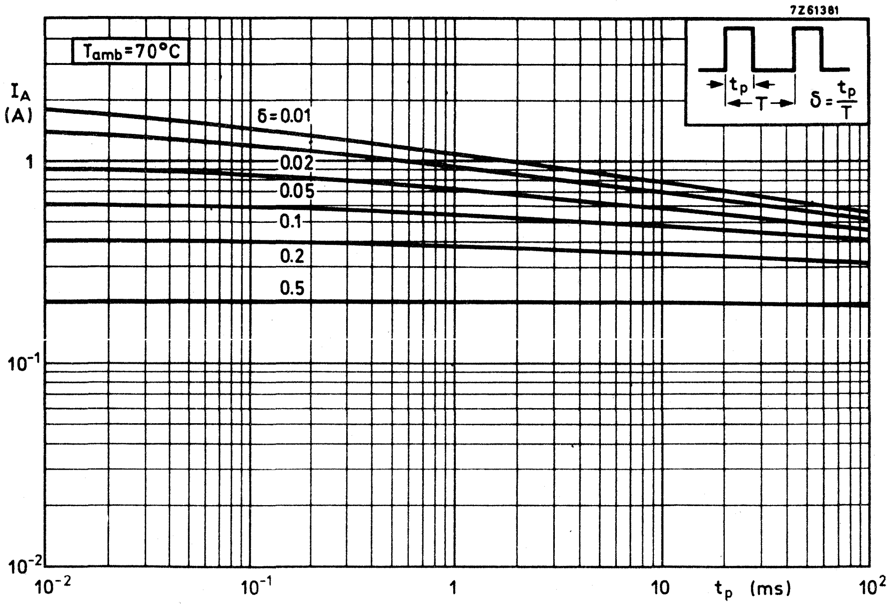

7Z62983
I_A = 100 mA
50 mA
20 mA
5 mA
$-V_{BB}$ = 0 to 5 V
R_{KG-K} = 10 kΩ
T_{amb} = 25 °C
typical values
V_{KG-K}
(V)
1
0,75
0,5
0,25
0
0
25
50
75
I_{AG} (mA)
I_A
I_{AG}
a
ag
R_{KG-K}
kg
k
T.U.T.
V_{BB}
7Z64477


7Z62982
$I_A = 1$ mA
$I_{AG} = 5$ mA
$-V_{BB} = 2$ V
$R_{KG-K} = 10$ kΩ
V_{AK} (V)
typ
1
0,9
0,8
0,7
0,6
−100
0
100
200
T_j (°C)


7Z62987
$I_{AG} = 5$ mA
$-V_{BB} = 2$ V
$R_{KG-K} = 10$ kΩ
I_H (mA)
typ
1
0,9
0,8
0,7
0,6
−100
0
100
200
T_j (°C)


7Z60414.1
$Z_{th\,j-a}$ (°C/W)
10^4
10^3
10^2
10
1
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3
10^4
t_p (s)

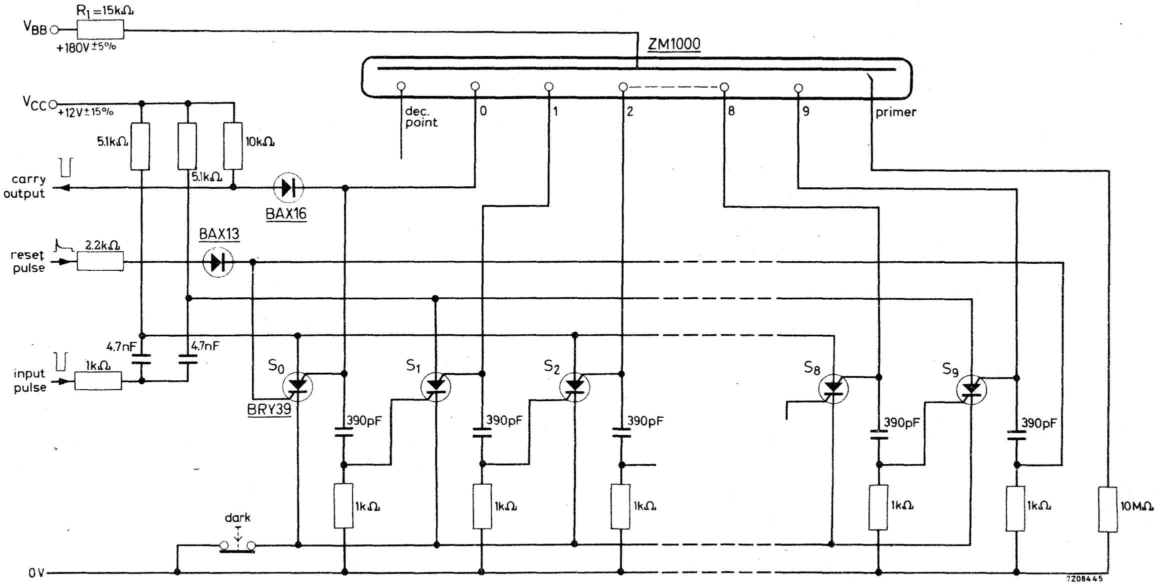

7Z61380
T_{amb} = 25 °C
I_A (A)
δ = 0.01
0.02
0.05
0.1
0.2
0.5
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
t_p
T
$\delta = \frac{t_p}{T}$


7Z61381
T_{amb} = 70 °C
I_A (A)
δ = 0.01
0.02
0.05
0.1
0.2
0.5
1
10^{-1}
10^{-2}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
t_p
T
$\delta = \frac{t_p}{T}$

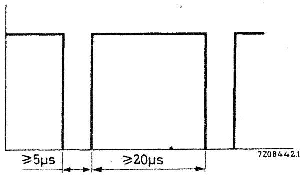
APPLICATION INFORMATION

Decade ring-counter circuit with display (f ≤ 40 kHz)

Operating ambient temperature T_{amb} 0 to 70 ^{o}C



Input pulse:



All resistors 1/8 W; ±5%; except R_1: 3%

PROGRAMMABLE UNIJUNCTION TRANSISTOR

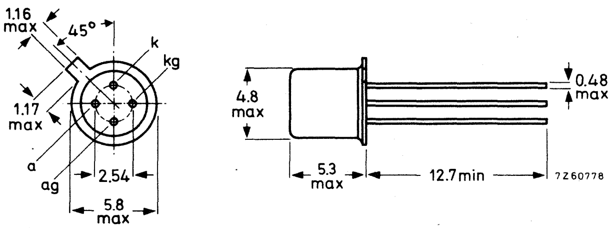
The BRY39 is a planar p-n-p-n trigger device in a TO-72 metal envelope, intended for use in switching applications such as motor control, oscillators, relay replacement, timers, pulse shaper, trigger device etc.
For the application of the BRY39 as SCS see Handbook Part 3, section SWITCHING TRANSISTORS and as THYRISTOR TETRODE see Handbook Part 1a, section THYRISTORS, DIACS, TRIACS. (For explanation of symbols see page 2).

QUICK REFERENCE DATA				
Gate-anode voltage	V_{GA}	max.	70	V
Anode current (d.c.) up to T_{case} = 85 °C	I_A	max.	250	mA
Junction temperature	T_j	max.	150	°C
Peak point current V_S = 10 V; R_G = 10 kΩ	I_P	<	5	μA
Valley point current V_S = 10 V; R_G = 10 kΩ	I_V	>	50	μA

MECHANICAL DATA Dimensions in mm

Anode gate connected to case

TO-72



Accessories supplied on request: 56246; 56263.

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

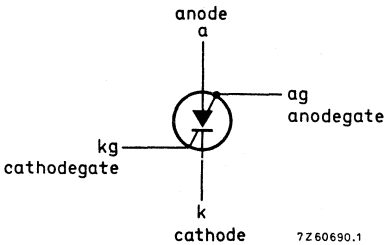
Voltage				
Gate-anode voltage	V_{GA}	max.	70	V
Currents				
Anode current (d.c.) up to T_{amb} = 25 °C	I_A	max.	175	mA
Anode current (d.c.) up to T_{case} = 85 °C	I_A	max.	250	mA
Repetitive peak anode current t = 10 µs; δ = 0.01	I_{ARM}	max.	2.5	A
Non-repetitive peak anode current t = 10 µs; T_j = 150 °C	I_{ASM}	max.	3	A
Rate of rise of anode current up to I_A = 2.5 A	$\frac{dI_A}{dt}$	max.	20	A/µs
Temperatures				
Storage temperature	T_{stg}	-65 to +200		°C
Operating junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

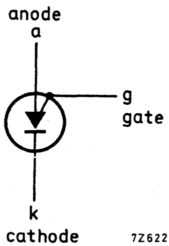
From junction to ambient in free air	$R_{th\ j-a}$	=	0.45	°C/mW
From junction to case	$R_{th\ j-c}$	=	0.15	°C/mW

EXPLANATION OF SYMBOLS

For application of the BRY39 as programmable unijunction transistor only the anode gate is used. To simplify the symbols the term gate instead of anode gate will be applied.



7Z60690.1



7Z62253

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

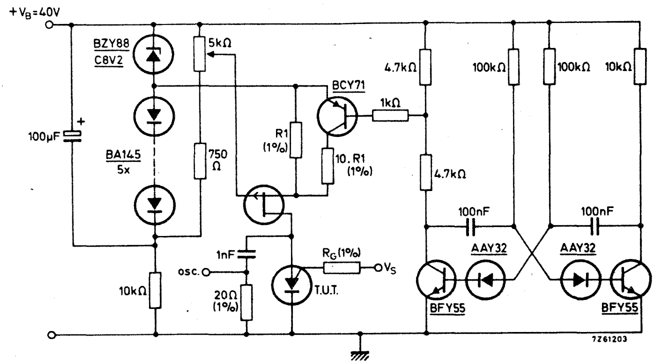
Peak point current

V_S = 10 V; R_G = 10 kΩ	I_P	<	5	µA
V_S = 10 V; R_G = 1 MΩ	I_P	<	1	µA

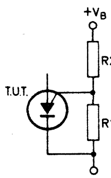
Valley point current

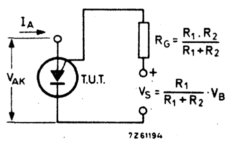
V_S = 10 V; R_G = 10 kΩ	I_V	>	50	µA
V_S = 10 V; R_G = 1 MΩ	I_V	<	50	µA

Practical test circuit: 1 Remove BCY71 during measurement of I_P
2 Value of R_1 depends on the voltage range of voltmeter



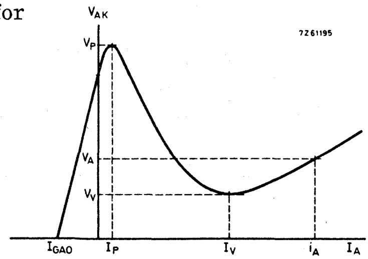
Equivalent test circuit





BRY39 with "program" resistors R_1 and R_2

Equivalent test circuit for characteristics testing



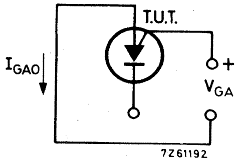
Offset voltage $V_{offset} = V_P - V_S\ (I_A = 0)$

See graph on page 6.

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

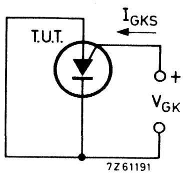
Gate-anode leakage current

$I_K = 0$; $V_{GA} = 70$ V	I_{GAO}	<	10	nA

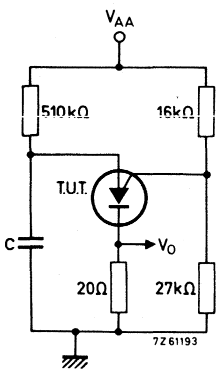


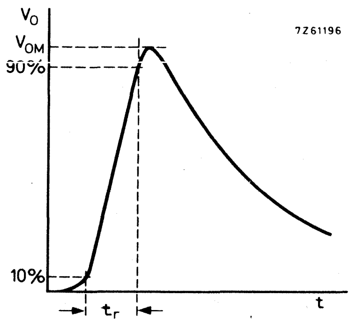
Gate-cathode leakage current

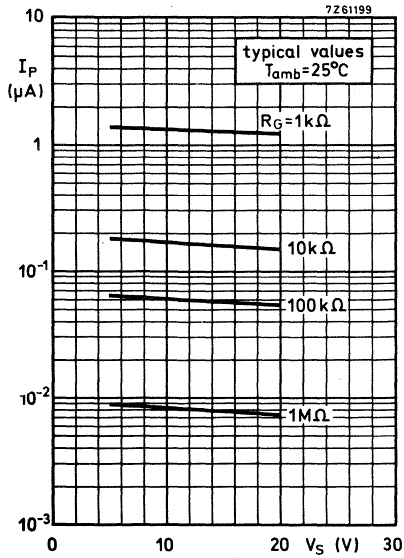
$V_{AK} = 0$; $V_{GK} = 70$ V	I_{GKS}	<	100	nA

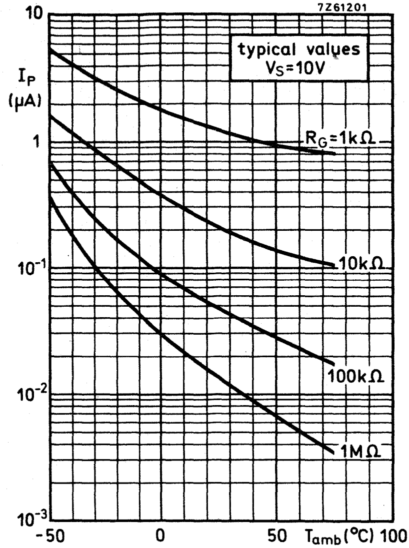


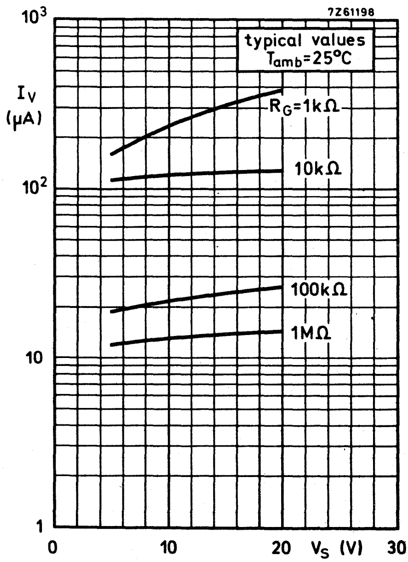
Anode voltage at I_A = 100 mA	V_A	<	1.4	V
Peak output voltage				
V_{AA} = 20 V; C = 0.2 μF	V_{OM}	>	6	V
Rise time				
V_{AA} = 20 V; C = 10 nF	t_r	<	80	ns

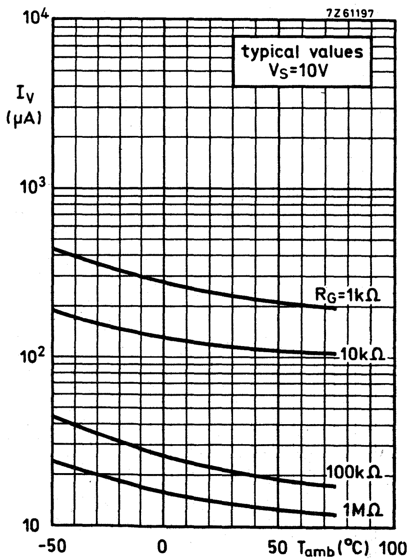


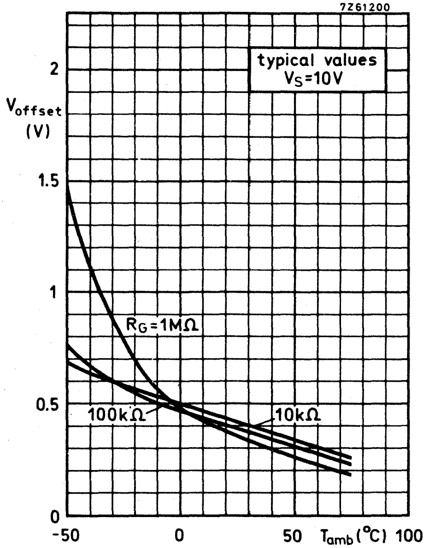


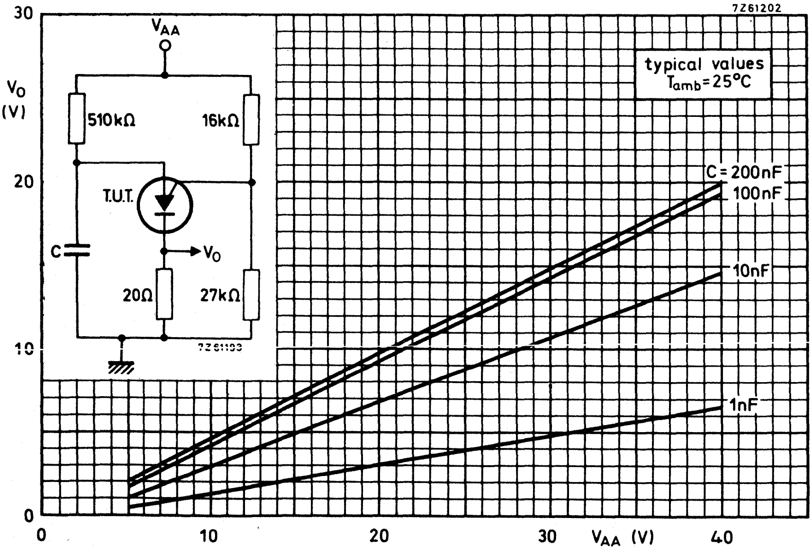

7Z61199
typical values
T_{amb}=25°C
I_P
(μA)
10
1
10^{-1}
10^{-2}
10^{-3}
R_G=1kΩ
10kΩ
100kΩ
1MΩ
0
10
20
V_S (V)
30


7Z61201
typical values
V_S=10V
I_P
(μA)
10
1
10^{-1}
10^{-2}
10^{-3}
R_G=1kΩ
10kΩ
100kΩ
1MΩ
-50
0
50
T_{amb}(°C)
100


7Z61198
typical values
T_{amb}=25°C
I_V
(μA)
10^3
10^2
10
1
R_G=1kΩ
10kΩ
100kΩ
1MΩ
0
10
20
V_S (V)
30


7Z61197
typical values
V_S=10V
I_V
(μA)
10^4
10^3
10^2
10
R_G=1kΩ
10kΩ
100kΩ
1MΩ
-50
0
50
T_{amb}(°C)
100


7Z61200
typical values
V_S=10V
V_{offset}
(V)
2
1.5
1
0.5
0
R_G=1MΩ
100kΩ
10kΩ
-50
0
50
T_{amb} (°C)
100


7Z61202
typical values
T_{amb}=25°C
V_O
(V)
30
20
10
0
V_{AA}
510kΩ
16kΩ
T.U.T.
C
V_O
20Ω
27kΩ
C=200nF
100nF
10nF
1nF
0
10
20
30
V_{AA} (V)
40

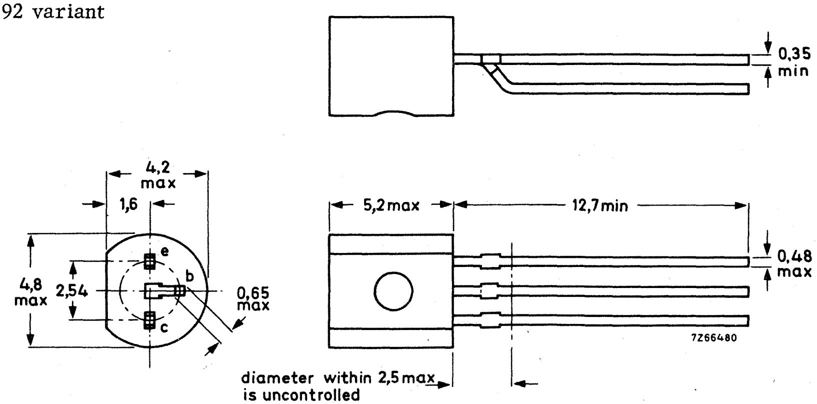
SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic TO-92 variant.
It is primarily intended for general purpose switching and as driver for numerical indicator tubes.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	100	V
Collector current (peak value)	I_{CM}	max.	250	mA
Total power dissipation up to T_{amb} = 25 ^oC	P_{tot}	max.	500	mW
Junction temperature	T_j	max.	150	^oC
D.C. current gain I_C = 4 mA; V_{CE} = 1 V	h_{FE}	> typ.	20 80	
Transition frequency at f = 35 MHz I_C = 4 mA; V_{CE} = 10 V	f_T	>	60	MHz
Turn-off time I_{Con} = 15 mA; I_{Bon} = 1 mA; $-I_{Boff}$ = 1 mA	t_{off}	<	1	µs

MECHANICAL DATA Dimensions in mm

TO-92 variant



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

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Currents

Collector current (d.c. or averaged over any 20 ms period)	$I_{C(AV)}$	max.	100	mA
Collector current (peak value)	I_{CM}	max.	250	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	$R_{th\ j\text{-}a}$	=	0,25	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $V_{CB} = 90$ V	I_{CBO}	<	200	nA
$I_E = 0$; $V_{CB} = 90$ V; $T_j = 150$ °C	I_{CBO}	<	50	μA
$V_{BE} = 0$; $V_{CE} = 80$ V; $T_j = 85$ °C	I_{CES}	<	20	μA

Emitter cut-off current

$I_C = 0$; $V_{EB} = 4$ V	I_{EBO}	<	200	nA
$I_C = 0$; $V_{EB} = 4$ V; $T_j = 150$ °C	I_{EBO}	<	50	μA

Saturation voltages

$I_C = 4$ mA; $I_B = 0,4$ mA	V_{CEsat}	<	0,7	V
	V_{BEsat}	<	1,2	V
$I_C = 50$ mA; $I_B = 15$ mA	V_{CEsat}	<	3,0	V

D.C. current gain

$I_C = 4$ mA; $V_{CE} = 1$ V	h_{FE}	>	20
		typ.	80
$I_C = 10$ mA; $V_{CE} = 1$ V	h_{FE}	typ.	80

CHARACTERISTICS (continued) $T_j = 25\ ^oC$

Transition frequency at f = 35 MHz

$I_C = 4$ mA ; $V_{CE} = 10$ V	f_T	>	60	MHz

Collector capacitance at f = 1 MHz

$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	4, 5	pF

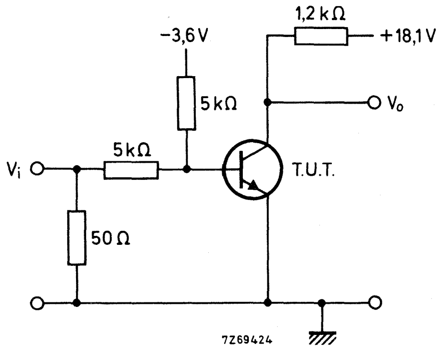
Emitter capacitance at f = 1 MHz

$I_C = I_c = 0$; $V_{EB} = 0,5$ V	C_e	<	17	pF

Switching time

Turn-off time when switched from $I_{Con} = 15$ mA; $I_{Bon} = 1$ mA to cut-off with $-I_{Boff} = 1$ mA	t_{off}	<	1	μs

Test circuit for measuring turn-off time:



Pulse generator:

Input voltage	V_i	=	+10 V
Pulse duration	t_p	=	1 μs
Duty factor	δ	=	0, 01
Source impedance	Z_S	=	50 Ω

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in TO-18 metal envelopes with the collector connected to the case. They are primarily intended for very high-speed core-driving purposes.

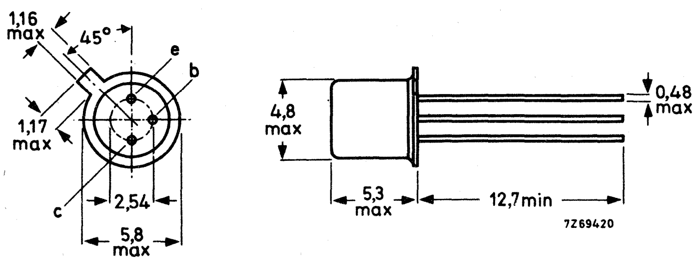
QUICK REFERENCE DATA

			BSS40	BSS41	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	60	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	30	V
Collector current (peak value)	I_{CM}	max.	1		A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360		mW
Junction temperature	T_j	max.	200		°C
D.C. current gain I_C = 500 mA; V_{CE} = 5 V	h_{FE}	>	25		
Saturation voltage I_C = 500 mA; I_B = 50 mA	V_{CEsat}	<	0,5		V
Turn-off time I_C = 500 mA; I_B = 50 mA; $-I_{BM}$ = 50 mA	t_{off}	<	45		ns

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 (IEC134)

			BSS40	BSS41	
Voltages					
Collector-base voltage (open emitter)	V_{CBO}	max.	60	60	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	30	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	V

Currents				
Collector current (peak value)	I_{CM}	max.	1	A
Base current (peak value)	I_{BM}	max.	0.2	A
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	$R_{th\ j-a}$	=	480	°C/W
From junction to case	$R_{th\ j-c}$	=	150	°C/W

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

			BSS40	BSS41	
Collector cut-off current					
$V_{CE} = 40$ V; $R_{BE} = 50\ \Omega$	I_{CER}	<	1		μA
$V_{CE} = 40$ V; $R_{BE} = 50\ \Omega$; $T_j = 150\ ^oC$	I_{CER}	<	1000		μA
Current at reverse biased emitter junction			BSS40	BSS41	
$-V_{BE} = 4$ V; $V_{CE} = 40$ V	$-I_{BEX}$	<	1	–	μA
$-V_{BE} = 4$ V; $V_{CE} = 30$ V	$-I_{BEX}$	<	–	1	μA
Breakdown voltages					
Collector-base voltage; $I_E = 0$; $I_C = 100$ μA	$V_{(BR)CBO}$	>	60	60	V
Collector-emitter voltage; $I_C = 1$ mA; $R_{BE} = 50\ \Omega$	$V_{(BR)CER}$	>	60	50	V
Collector-emitter voltage; $I_B = 0$; $I_C = 10$ mA	$V_{(BR)CEO}$	>	40	30	V
Emitter-base voltage; $I_C = 0$; $I_E = 100$ μA	$V_{(BR)EBO}$	>	5	5	V
Saturation voltages [1]					
$I_C = 150$ mA; $I_B = 10$ mA	V_{CEsat}	<	0,4		V
	V_{BEsat}	<	1,0		V
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	0,5		V
	V_{BEsat}	<	1,2		V
D.C. current gain					
$I_C = 150$ mA; $V_{CE} = 5$ V	h_{FE}	>	30		
$I_C = 500$ mA; $V_{CE} = 5$ V	h_{FE}	>	25		
Transition frequency at f = 100 MHz					
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	>	200		MHz
Collector capacitance at f = 1 MHz					
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	10		pF
Emitter capacitance at f = 1 MHz					
$I_C = I_c = 0$; $V_{EB} = 0,5$ V	C_e	<	50		pF

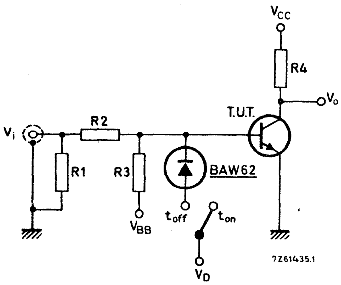
[1]) Measured under pulse conditions: $t_p = 300$ μs; $\delta = 0,01$.

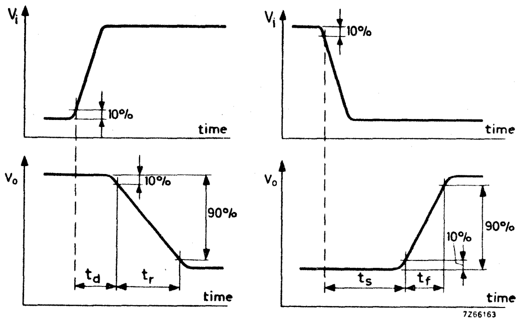
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Switching times

Turn-on time when switched from $-V_{BE}$ = 2 V to I_C = 500 mA; I_B = 50 mA	t_{on}	<	35	ns
Turn-off time when switched from I_C = 500 mA; I_B = 50 mA to cut-off with $-I_{BM}$ = 1 mA	t_{off}	<	250	ns
Turn-off time when switched from I_C = 500 mA; I_B = 50 mA to cut-off with $-I_{BM}$ = 50 mA	t_{off}	<	45	ns
Storage time when switched from I_C = 500 mA; I_B = 50 mA to cut-off with $-I_{BM}$ = 50 mA	t_s	>	10	ns

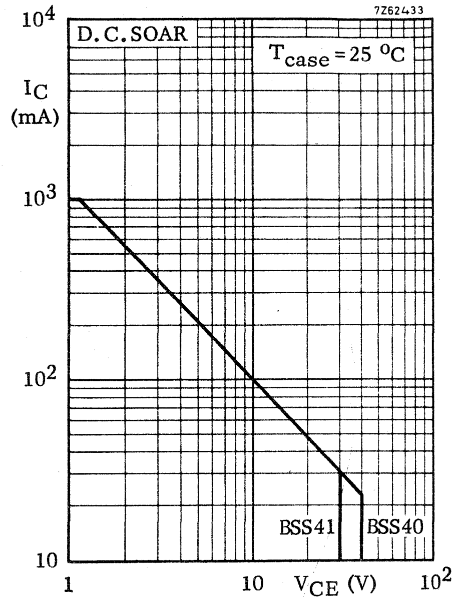
Test circuit:

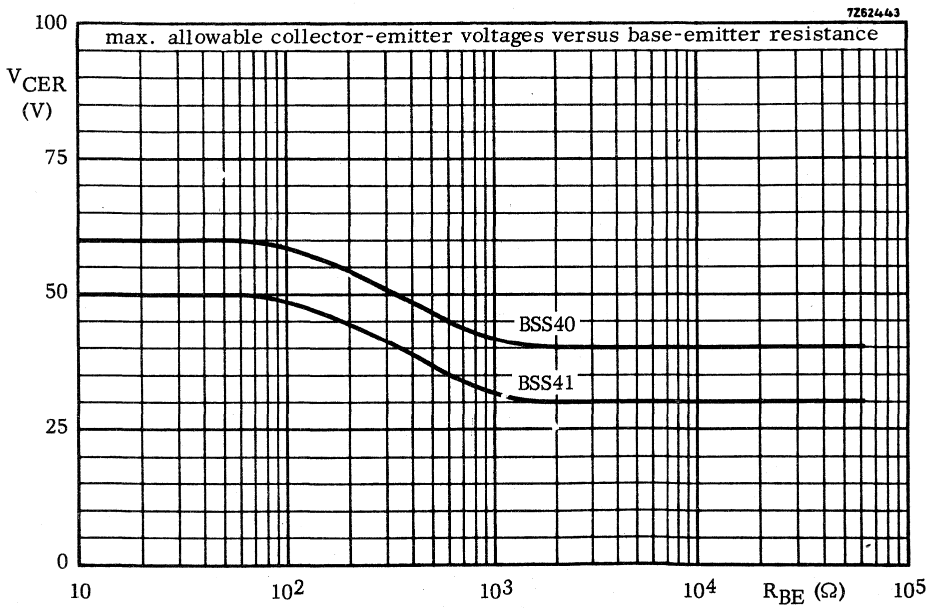


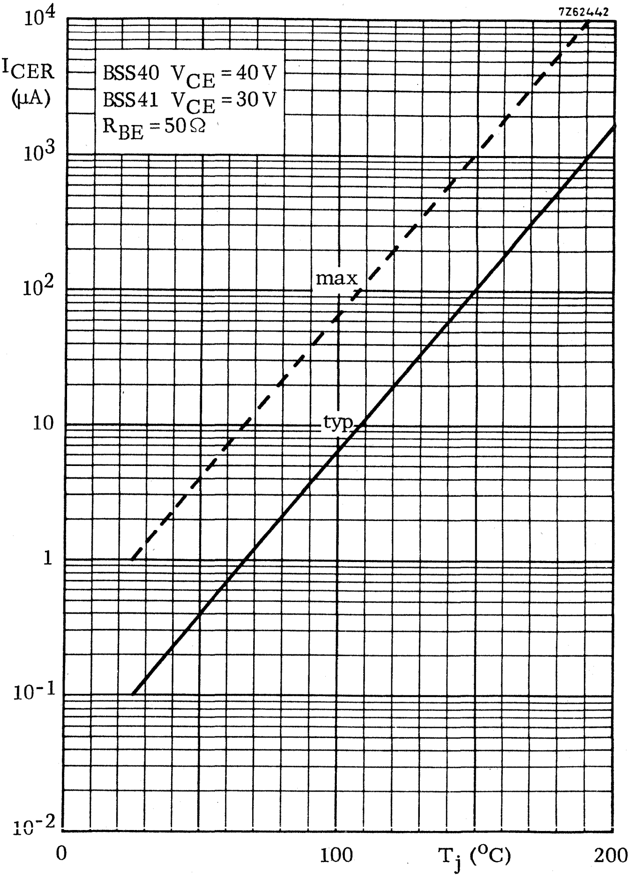


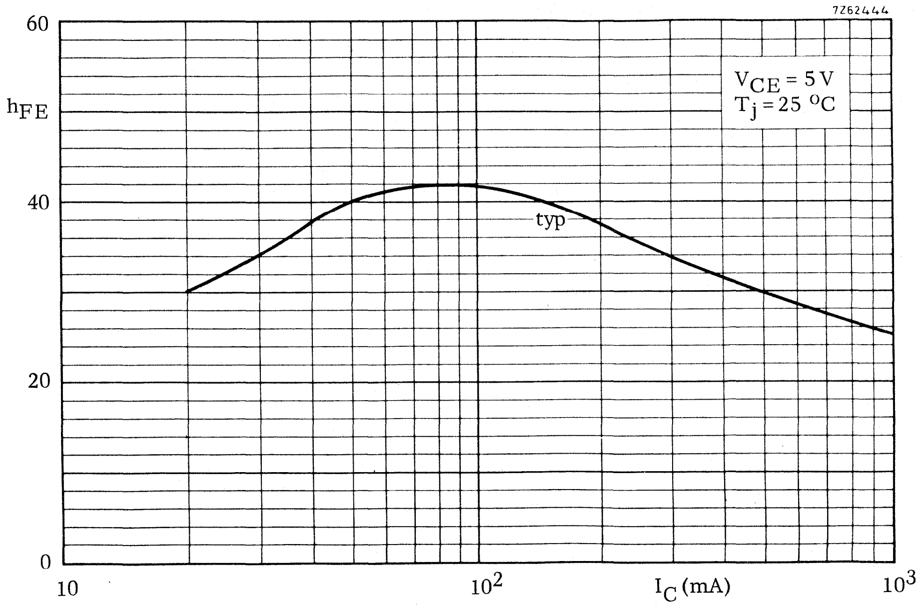
Pulse generator: Pulse duration $t_p \geq$ 500 ns
Rise time $t_r \leq$ 5 ns
Fall time $t_f \leq$ 5 ns
Source impedance R_S = 50 Ω

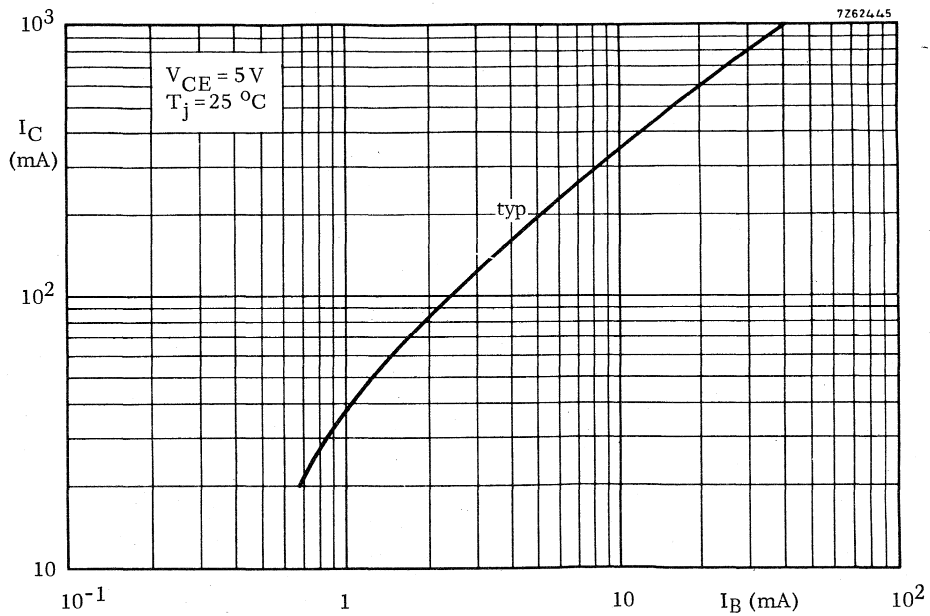
								turn-on time		turn-off time		
I_C (mA)	I_B (mA)	$-I_{BM}$ (mA)	V_{CC} (V)	R1 (Ω)	R2 (Ω)	R3 (Ω)	R4 (Ω)	$-V_{BB}$ (V)	V_i (V)	$+V_{BB}$ (V)	V_i (V)	$-V_D$ (V)
500	50	50	45	56	375	400	90	4	24.75	16.7	37.5	3
500	50	1	45	56	750	∞	90	–	–	–	37.5	–

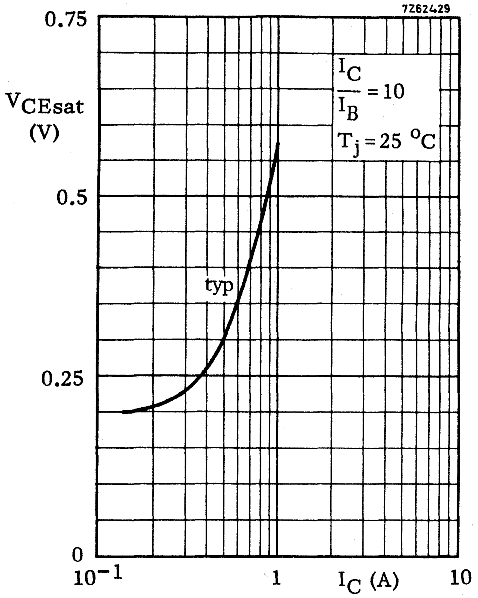

7Z62433
D.C.SOAR
$T_{case} = 25\ ^oC$
I_C (mA)
10^4
10^3
10^2
10
1
10
V_{CE} (V)
10^2
BSS41
BSS40

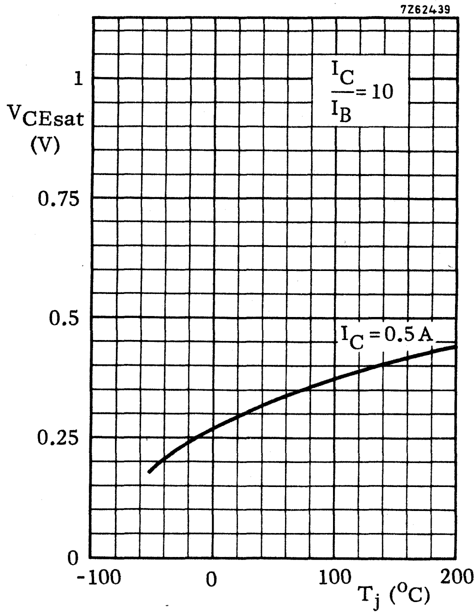

7Z62443
max. allowable collector-emitter voltages versus base-emitter resistance
V_{CER} (V)
100
75
50
25
0
10
10^2
10^3
10^4
R_{BE} (Ω)
10^5
BSS40
BSS41

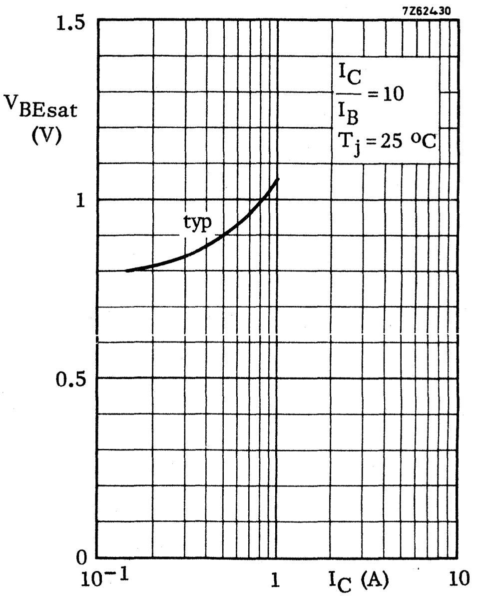

7Z62442
10^4
I_{CER}
(μA)
BSS40 $V_{CE} = 40$ V
BSS41 $V_{CE} = 30$ V
$R_{BE} = 50\,\Omega$
10^3
10^2
max
10
typ
1
10^{-1}
10^{-2}
0
100
T_j (°C)
200

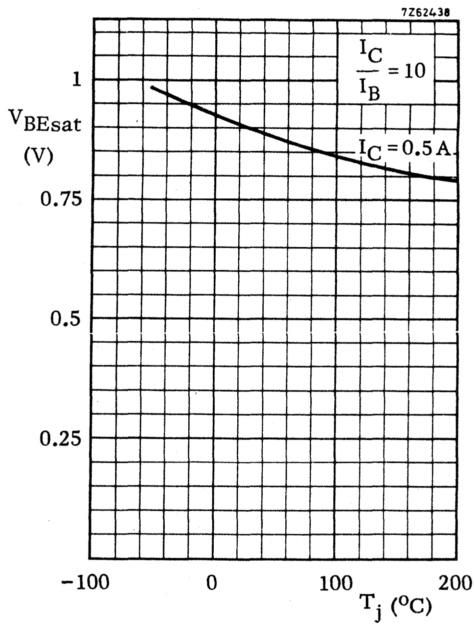

7Z62444
60
40
20
0
h_{FE}
V_{CE} = 5 V
T_j = 25 °C
typ
10
10^2
I_C (mA)
10^3

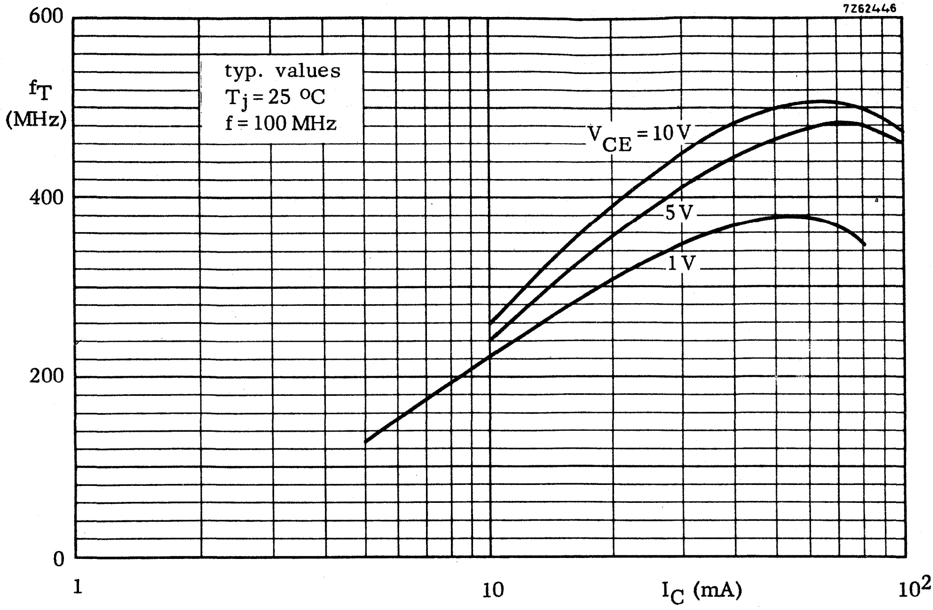

7Z62445
10^3
10^2
10
I_C
(mA)
V_{CE} = 5 V
T_j = 25 °C
typ
10^{-1}
1
10
I_B (mA)
10^2

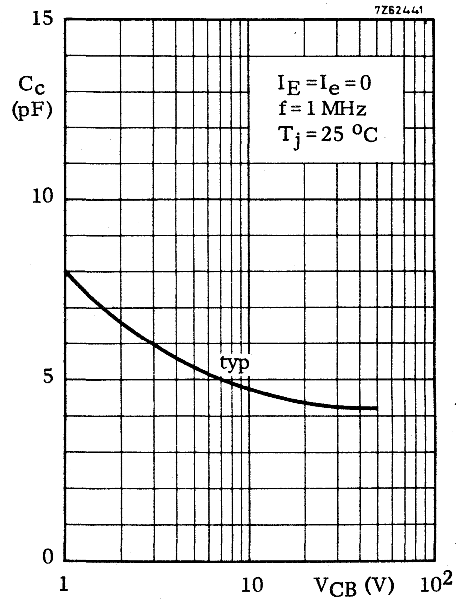

7Z62429
0.75
0.5
0.25
0
V_{CEsat}
(V)
$\frac{I_C}{I_B} = 10$
$T_j = 25\ ^oC$
typ
10^{-1}
1
I_C (A)
10

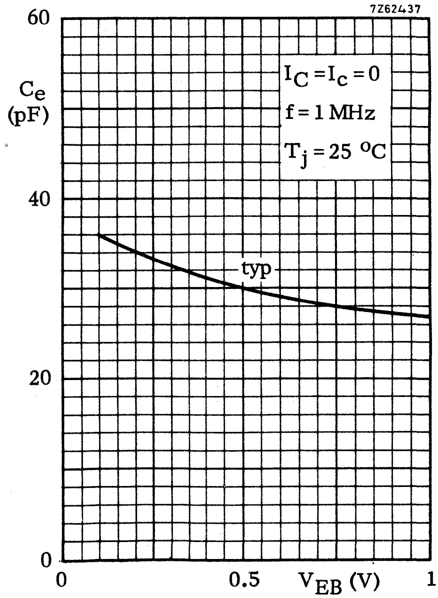

7Z62439
1
0.75
0.5
0.25
0
V_{CEsat}
(V)
$\frac{I_C}{I_B} = 10$
$I_C = 0.5$ A
-100
0
100
200
T_j (^oC)

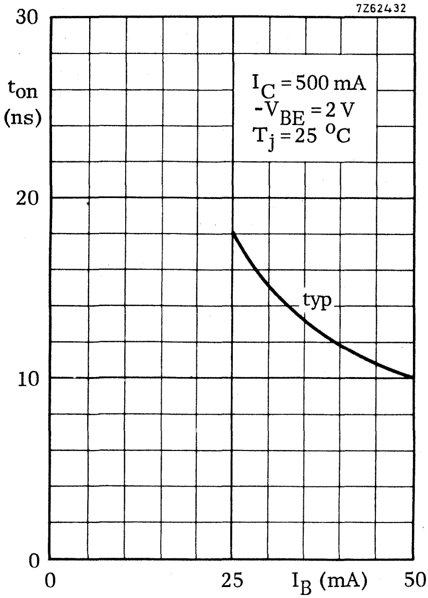

7Z62430
1.5
1
0.5
0
V_{BEsat}
(V)
$\frac{I_C}{I_B} = 10$
$T_j = 25\ ^oC$
typ
10^{-1}
1
I_C (A)
10

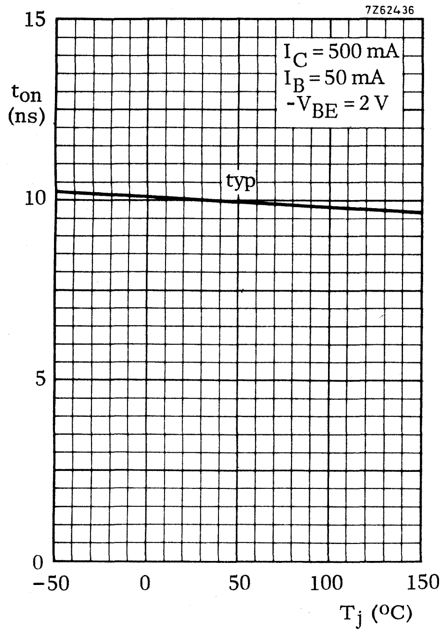

7Z62438
1
0.75
0.5
0.25
V_{BEsat}
(V)
$\frac{I_C}{I_B} = 10$
$I_C = 0.5$ A
-100
0
100
200
T_j (^oC)

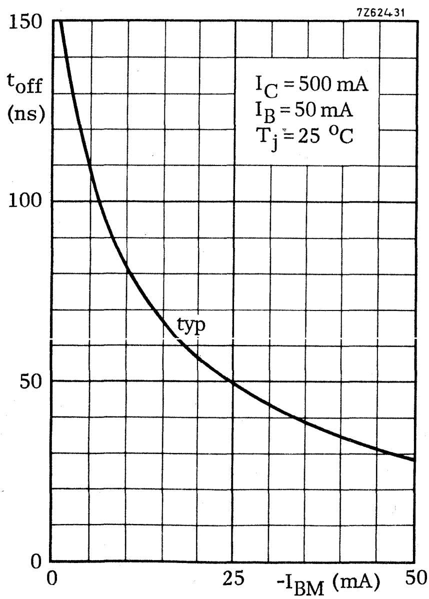

7Z62446
600
400
200
0
fT
(MHz)
typ. values
Tj = 25 °C
f = 100 MHz
VCE = 10 V
5 V
1 V
1
10
IC (mA)
10^2

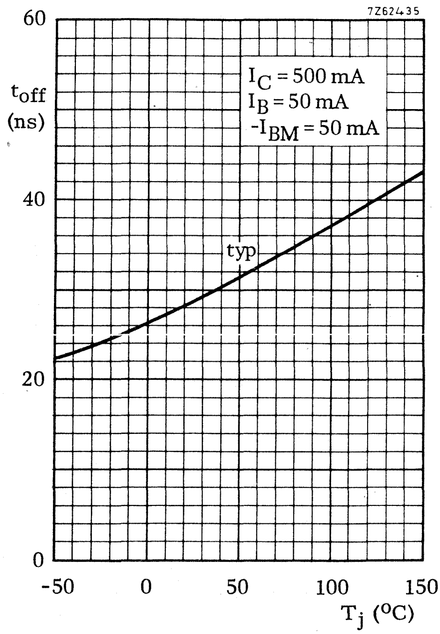

7Z62441
15
10
5
0
Cc
(pF)
IE = Ie = 0
f = 1 MHz
Tj = 25 °C
typ
1
10
VCB (V)
10^2

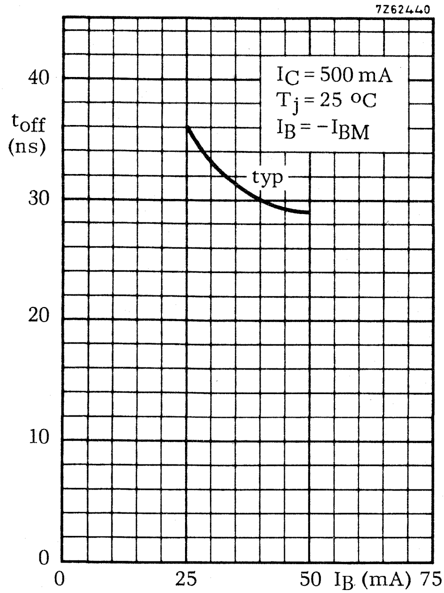

7Z62437
60
40
20
0
Ce
(pF)
IC = Ic = 0
f = 1 MHz
Tj = 25 °C
typ
0
0.5
VEB (V)
1

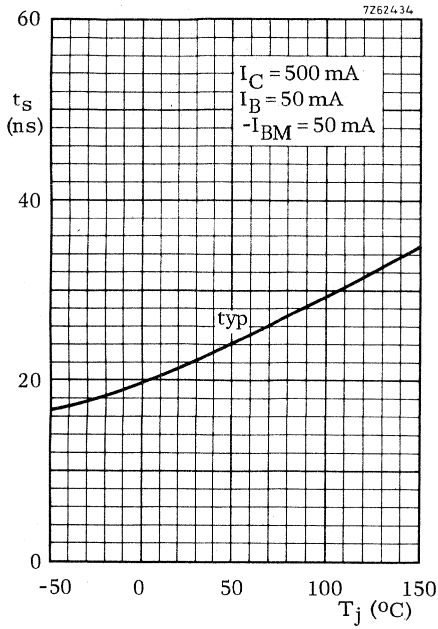

7Z62432
30
20
10
0
ton
(ns)
IC = 500 mA
-VBE = 2 V
Tj = 25 °C
typ
0
25
IB (mA)
50


7Z62436
15
10
5
0
ton
(ns)
IC = 500 mA
IB = 50 mA
-VBE = 2 V
typ
−50
0
50
100
150
Tj (°C)


7Z62431
150
100
50
0
toff
(ns)
IC = 500 mA
IB = 50 mA
Tj = 25 °C
typ
0
25
-IBM (mA)
50


7Z62435
60
40
20
0
toff
(ns)
IC = 500 mA
IB = 50 mA
-IBM = 50 mA
typ
-50
0
50
100
150
Tj (°C)


7Z62440
I_C = 500 mA
T_j = 25 °C
$I_B = -I_{BM}$
t_{off} (ns)
typ
0
10
20
30
40
0
25
50
I_B (mA)
75


7Z62434
I_C = 500 mA
I_B = 50 mA
$-I_{BM}$ = 50 mA
t_s (ns)
typ
0
20
40
60
-50
0
50
100
150
T_j (°C)

N-P-N DARLINGTON TRANSISTORS

Silicon planar transistors in a TO-39 metal envelope with the collector connected to the case, intended for industrial switching applications e.g. print hammer, solenoid, relay and lamp driving.

QUICK REFERENCE DATA

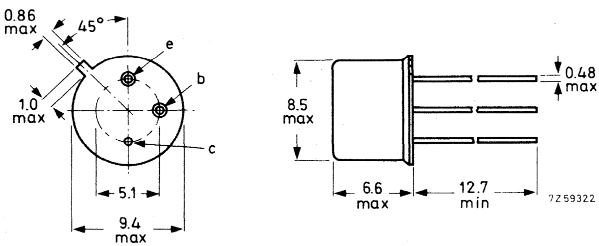
			BSS50	BSS51	BSS52	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (see page 5)	V_{CER}	max.	45	60	80	V
Collector current (d.c.)	I_C	max.			1,0	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.			0,8	W
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.			5,0	W
D.C. current gain I_C = 500 mA; V_{CE} = 10 V	h_{FE}	>			2000	
Collector-emitter saturation voltages I_C = 1,0 A; I_B = 1,0 mA — BSS51	V_{CEsat}	<			1,6	V
I_C = 1,0 A; I_B = 4,0 mA — BSS50; BSS52	V_{CEsat}	<			1,6	V
Turn-off time when switched from I_C = 500 mA; I_B = 0,5 mA to cut-off with $-I_{BM}$ = 0,5 mA	t_{off}	typ.			1,0	μs

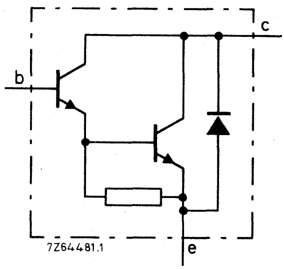
MECHANICAL DATA

Dimensions in mm

Collector connected to case

TO-39





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

Accessories supplied on request: 56218; 56245

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

Voltages

			BSS50	BSS51	BSS52	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (see page 5)	V_{CER}	max.	45	60	80	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5,0	5,0	5,0	V

Currents

Collector current (d.c.)	I_C	max.	1,0	A
Collector current (peak value)	I_{CM}	max.	2,0	A
Base current (d.c.)	I_B	max.	0,1	A

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8	W
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	5,0	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	$R_{th\ j\text{-}a}$	=	220	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	35	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Conditions	Type	Symbol		Value	Unit
Collector cut-off current					
$I_E = 0$; $V_{CB} = 45$ V	BSS50	I_{CBO}	<	50	nA
$I_E = 0$; $V_{CB} = 60$ V	BSS51	I_{CBO}	<	50	nA
$I_E = 0$; $V_{CB} = 80$ V	BSS52	I_{CBO}	<	50	nA
Emitter cut-off current					
$I_C = 0$; $V_{EB} = 4,0$ V		I_{EBO}	<	50	nA
Base-emitter voltage 1)					
$I_C = 150$ mA; $V_{CE} = 10$ V		V_{BE}	typ.	1,45	V
				1,4 to 1,55	V
$I_C = 500$ mA; $V_{CE} = 10$ V		V_{BE}	typ.	1,55	V
				1,5 to 1,65	V
Saturation voltages 2)					
$I_C = 0,5$ A; $I_B = 0,5$ mA		V_{CEsat}	<	1,3	V
		V_{BEsat}	<	1,9	V
$I_C = 0,5$ A; $I_B = 0,5$ mA; $T_j = 200$ °C		V_{CEsat}	<	1,3	V
$I_C = 1,0$ A; $I_B = 1,0$ mA	BSS51	V_{CEsat}	<	1,6	V
		V_{BEsat}	<	2,2	V
$I_C = 1,0$ A; $I_B = 1,0$ mA; $T_j = 200$ °C	BSS51	V_{CEsat}	<	2,3	V
$I_C = 1,0$ A; $I_B = 4,0$ mA	BSS50	V_{CEsat}	<	1,6	V
		V_{BEsat}	<	2,2	V
$I_C = 1,0$ A; $I_B = 4,0$ mA; $T_j = 200$ °C	BSS50	V_{CEsat}	<	1,6	V
$I_C = 1,0$ A; $I_B = 4,0$ mA	BSS52	V_{CEsat}	<	1,6	V
		V_{BEsat}	<	2,2	V
$I_C = 1,0$ A; $I_B = 4,0$ mA; $T_j = 200$ °C	BSS52	V_{CEsat}	<	1,6	V
D.C. current gain					
$I_C = 150$ mA; $V_{CE} = 10$ V		h_{FE}	>	1000	←
$I_C = 500$ mA; $V_{CE} = 10$ V		h_{FE}	>	2000	
Small signal current gain at f = 35 MHz					
$I_C = 500$ mA; $V_{CE} = 5,0$ V		h_{fe}	>	7,5	
			typ.	10	

1) V_{BE} decreases by about 3,5 mV/°C with increasing temperature.

2) V_{BEsat} decreases by about 2,5 mV/°C with increasing temperature.

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

Switching times

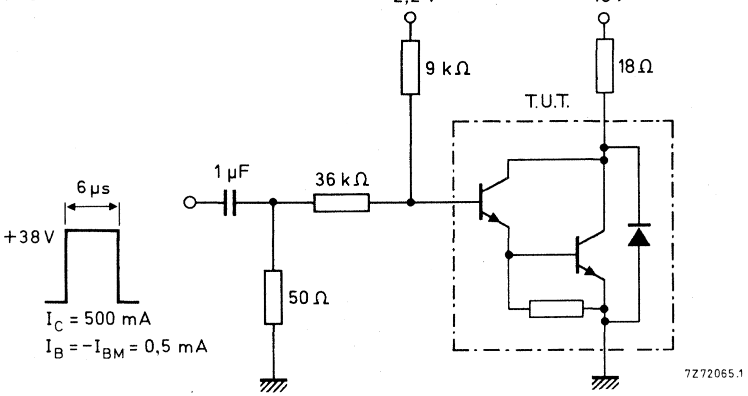
I_C = 0,5 A; I_B = $-I_{BM}$ = 0,5 mA

Turn-on time	t_{on}	<	400	ns
Turn-off time	t_{off}	typ.	1,0	µs
		<	2,0	µs

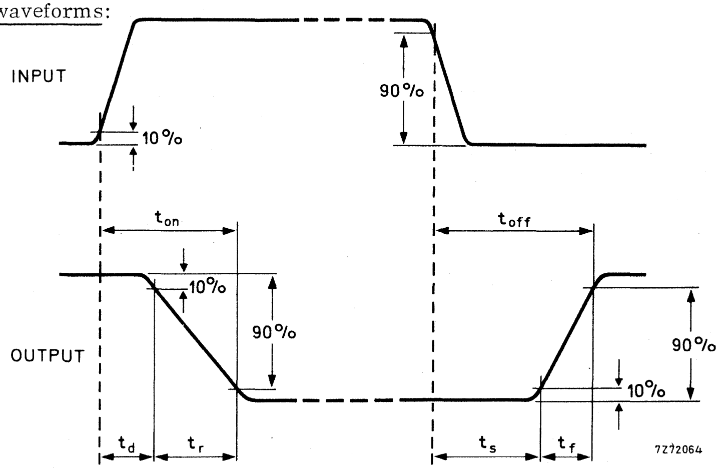
I_C = 1,0 A; I_B = $-I_{BM}$ = 1,0 mA

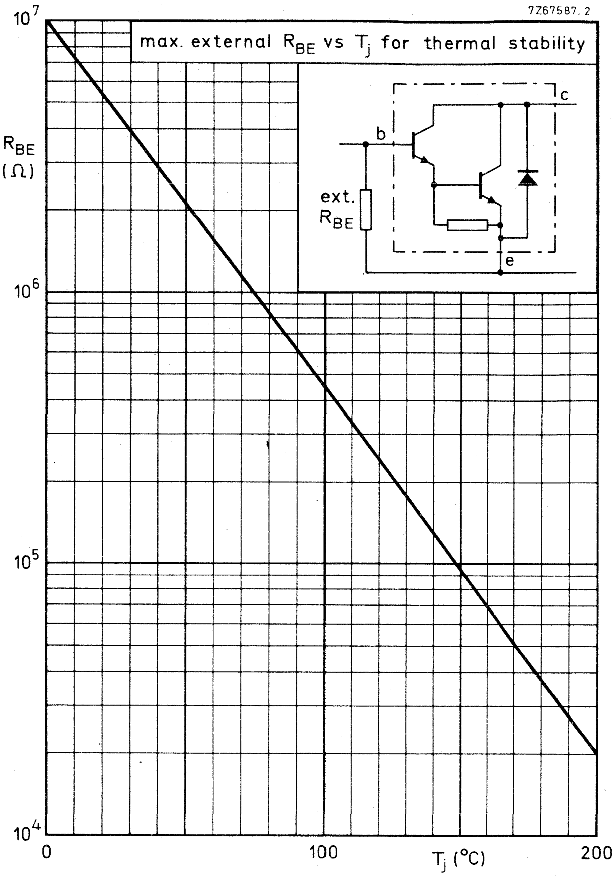
Turn-on time	t_{on}	<	400	ns
Turn-off time	t_{off}	typ.	1,0	µs
		<	2,0	µs

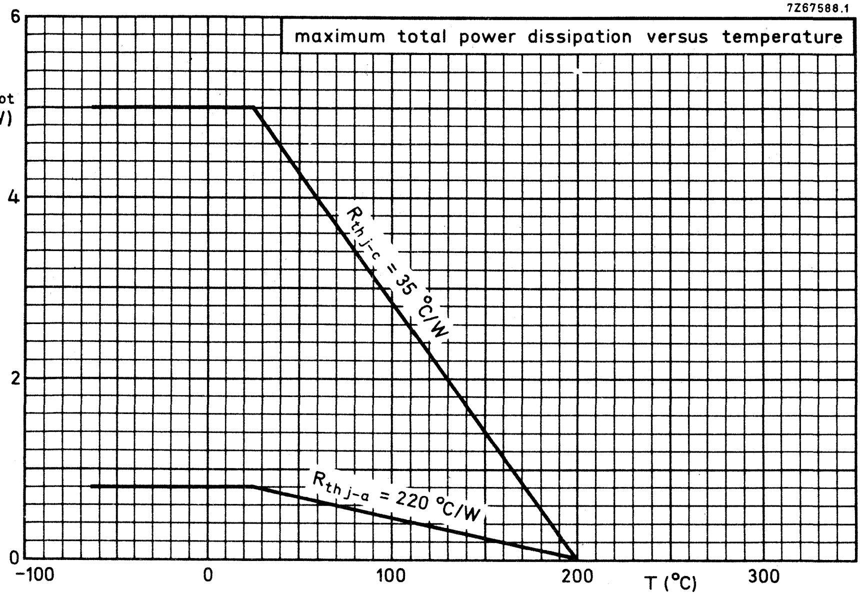
Test circuit for 500 mA switching:

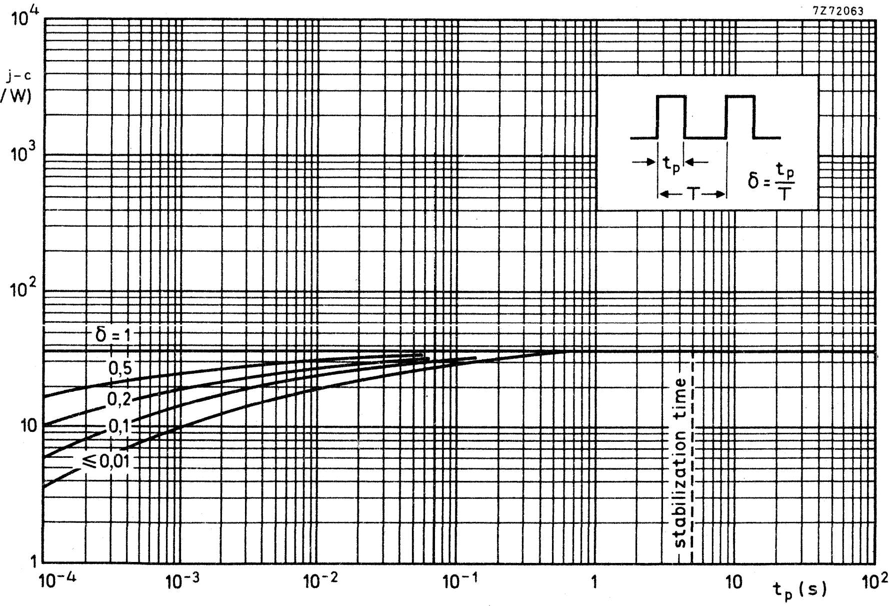


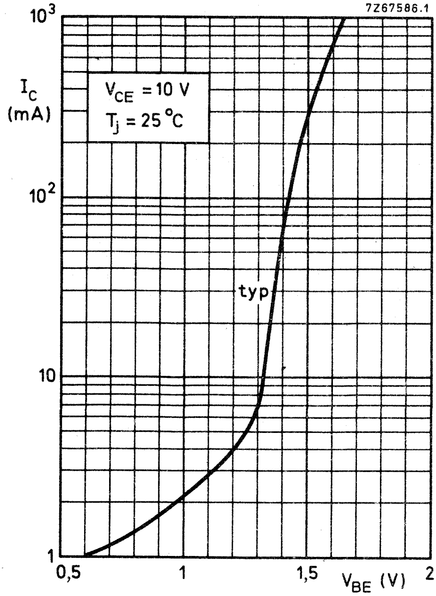
Switching waveforms:

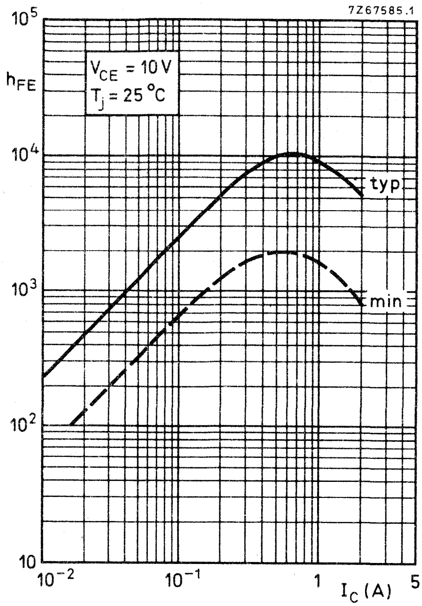


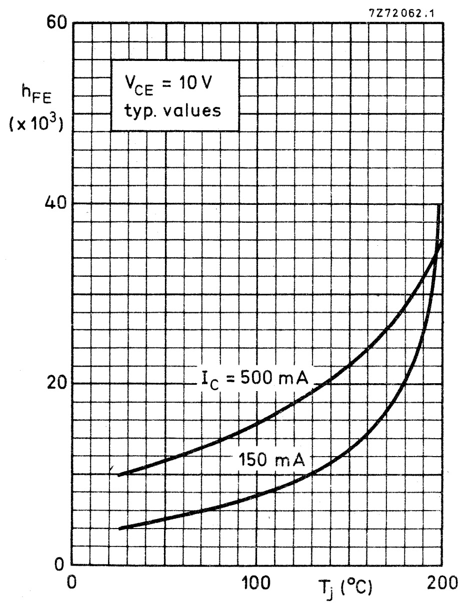

7Z67587.2
max. external R_{BE} vs T_j for thermal stability
R_{BE} (Ω)
10^7
10^6
10^5
10^4
0
100
200
T_j (°C)
b
c
e
ext. R_{BE}

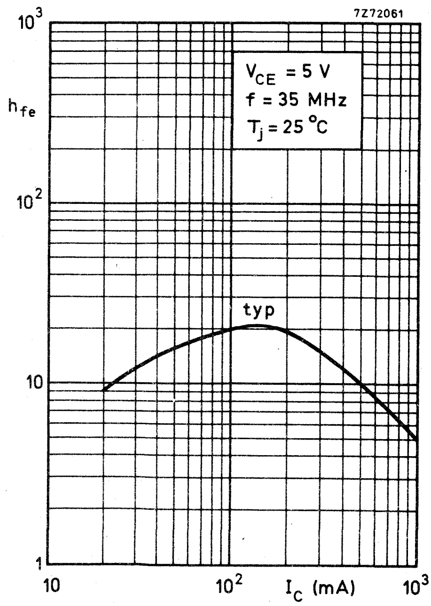

7Z67588.1
maximum total power dissipation versus temperature
P_tot (W)
6
4
2
0
R_th j-c = 35 °C/W
R_th j-a = 220 °C/W
−100
0
100
200
300
T (°C)

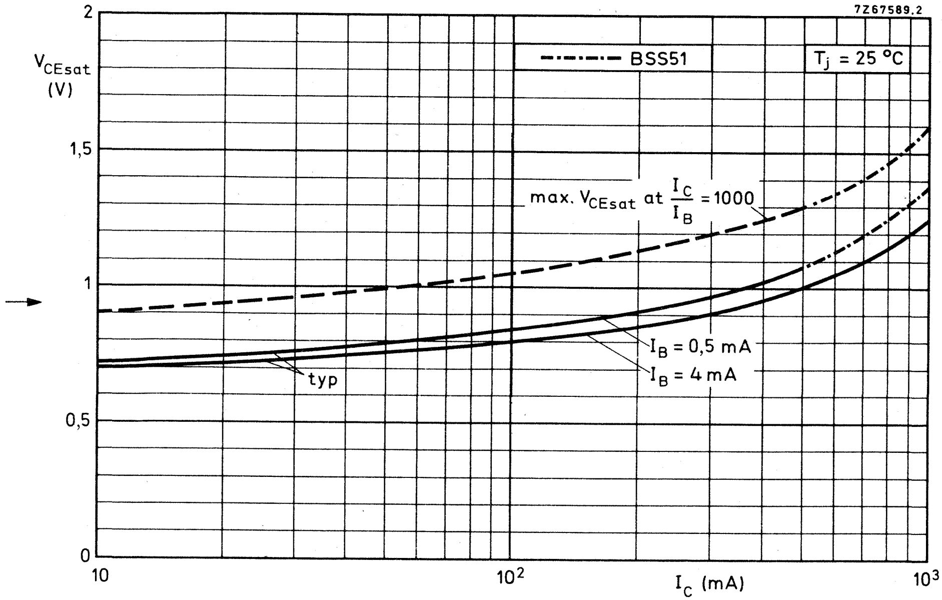

7Z72063
Z_th j-c (°C/W)
10^4
10^3
10^2
10
1
t_p
T
δ = t_p/T
δ = 1
0,5
0,2
0,1
≤0,01
stabilization time
10^-4
10^-3
10^-2
10^-1
1
10
10^2
t_p (s)

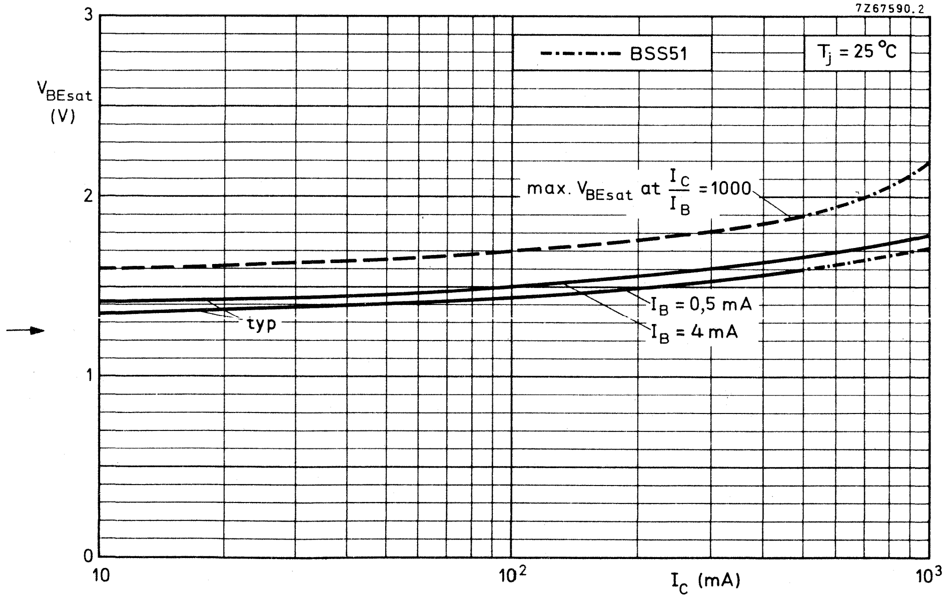

7Z67586.1
I_C (mA)
V_{CE} = 10 V
T_j = 25 °C
typ
10^3
10^2
10
1
0,5
1
1,5
2
V_{BE} (V)


7Z67585.1
h_{FE}
V_{CE} = 10 V
T_j = 25 °C
typ
min
10^5
10^4
10^3
10^2
10
10^{-2}
10^{-1}
1
5
I_C (A)


7Z72062.1
h_{FE} (x 10^3)
V_{CE} = 10 V
typ. values
I_C = 500 mA
150 mA
60
40
20
0
0
100
200
T_j (°C)


7Z72061
h_{fe}
V_{CE} = 5 V
f = 35 MHz
T_j = 25 °C
typ
10^3
10^2
10
1
10
10^2
I_C (mA)
10^3


7Z67589.2
V_{CEsat}
(V)
BSS51
T_j = 25 °C
max. V_{CEsat} at $\frac{I_C}{I_B}$ = 1000
I_B = 0,5 mA
I_B = 4 mA
typ
I_C (mA)
2
1,5
1
0,5
0
10
10^2
10^3


7Z67590.2
V_{BEsat}
(V)
BSS51
T_j = 25 °C
max. V_{BEsat} at $\frac{I_C}{I_B}$ = 1000
I_B = 0,5 mA
I_B = 4 mA
typ
I_C (mA)
3
2
1
0
10
10^2
10^3

HIGH-VOLTAGE P-N-P TRANSISTOR

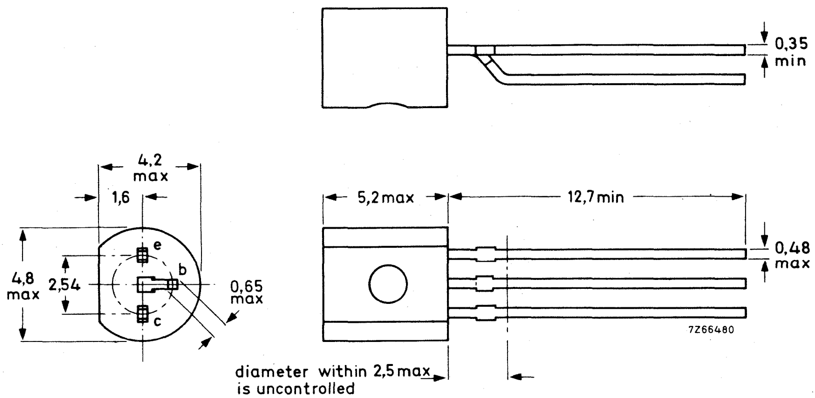
Silicon planar epitaxial transistor in a plastic TO-92 variant.
It is intended for anode switching in dynamically driven numerical indicator tubes and as general purpose switching device.

QUICK REFERENCE DATA				
Collector-emitter voltage (R_{BE} = 10 kΩ)	$-V_{CER}$	max.	110	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	100	V
Collector current (d.c.)	$-I_C$	max.	100	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	mW
Junction temperature	T_j	max.	150	°C
D.C. current gain at T_j = 25 °C				
$-I_C$ = 25 mA; $-V_{CE}$ = 5 V	h_{FE}	>	30	
Transition frequency at f = 35 MHz				
$-I_C$ = 25 mA; $-V_{CE}$ = 5 V	f_T	>	50	MHz

MECHANICAL DATA

Dimensions in mm

TO-92 variant



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

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	110	V
Collector-emitter voltage (R_{BE} = 10 kΩ)	$-V_{CER}$	max.	110	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	100	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	6	V

Current

Collector current (d.c.)	$-I_C$	max.	100	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

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

I_E = 0; $-V_{CB}$ = 100 V; T_j = 70 °C	$-I_{CBO}$	<	10	µA

Saturation voltages

$-I_C$ = 25 mA; $-I_B$ = 2,5 mA	$-V_{CEsat}$	<	250	mV
	$-V_{BEsat}$	<	900	mV

D.C. current gain

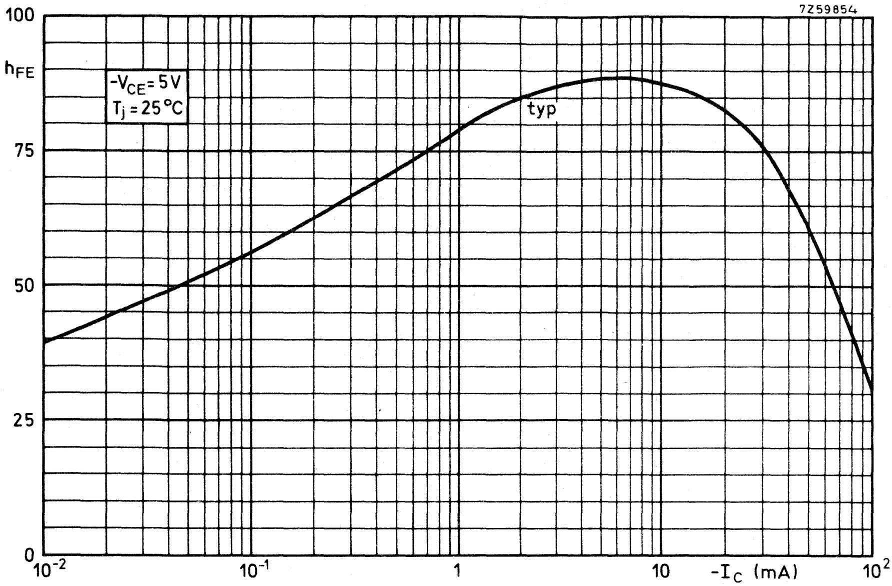
$-I_C$ = 10 mA; $-V_{CE}$ = 5 V	h_{FE}	>	30	
$-I_C$ = 25 mA; $-V_{CE}$ = 5 V	h_{FE}	>	30	

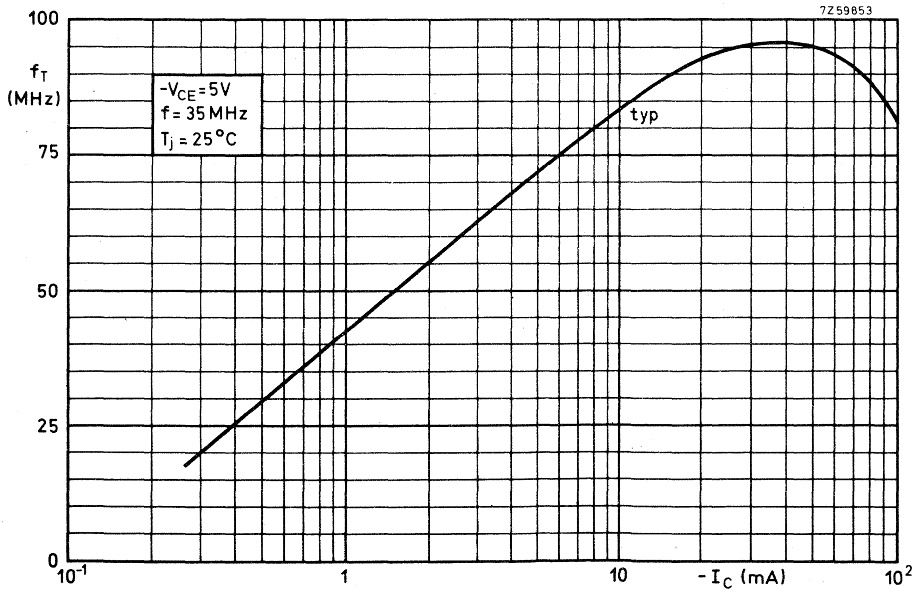
Collector capacitance at f = 1 MHz

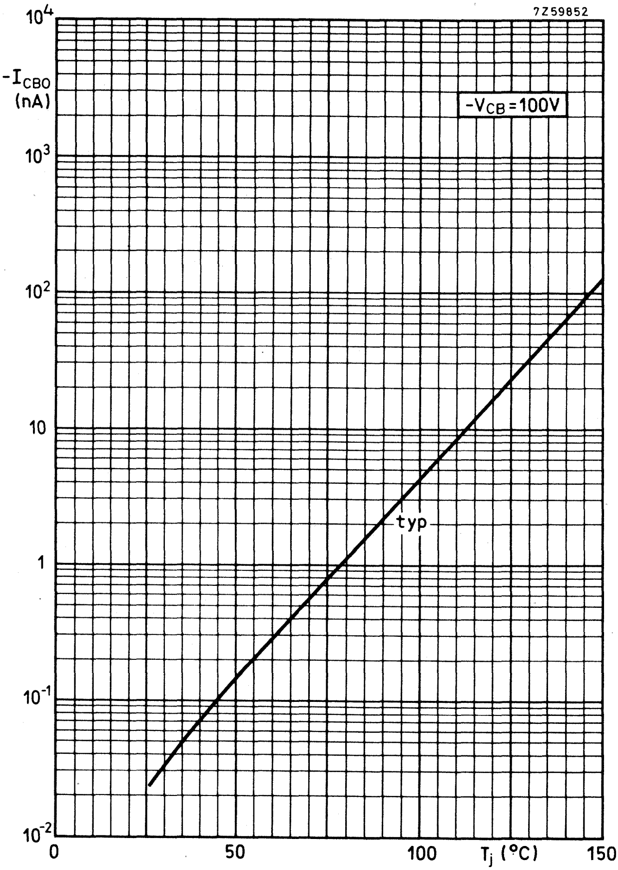
I_E = I_e = 0; $-V_{CB}$ = 10 V	C_c	<	5	pF

Transition frequency at f = 35 MHz

$-I_C$ = 25 mA; $-V_{CE}$ = 5 V	f_T	>	50	MHz


7Z59854
100
h_{FE}
$-V_{CE} = 5 V$
$T_j = 25 °C$
typ
75
50
25
0
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2


7Z59853
100
f_T
(MHz)
$-V_{CE} = 5 V$
f = 35 MHz
$T_j = 25 °C$
typ
75
50
25
0
10^{-1}
1
10
$-I_C$ (mA)
10^2


7Z59852
$-I_{CBO}$ (nA)
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}
$-V_{CB}$ = 100V
typ
0
50
100
T_j (°C)
150

SILICON PLANAR EPITAXIAL TRANSISTORS

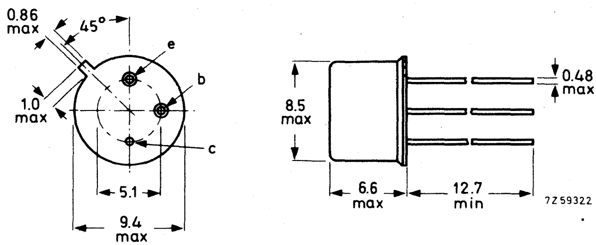
P-N-P transistors in a TO-39 metal envelope with the collector connected to the case. These transistors are intended for general industrial applications.

QUICK REFERENCE DATA

			BSV15	BSV16	BSV17	
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80	V
Collector current (d.c.)	$-I_C$	max.		1.0		A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.		0.8		W
up to T_{case} = 25 °C	P_{tot}	max.		5.0		W
Junction temperature	T_j	max.		200		°C
Transition frequency at f = 20 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 10 V	f_T	>		50		MHz
			BSV15-6 BSV16-6 BSV17-6	BSV15-10 BSV16-10 BSV17-10	BSV15-16 BSV16-16	
D.C. current gain $-I_C$ = 100 mA; $-V_{CE}$ = 1 V	h_{FE}		40 - 100	63 - 160	100 - 250	

MECHANICAL DATA Dimensions in mm

TO-39
Collector connected to case



max. lead diameter is guaranteed only for 12.7 mm

Accessories supplied on request: 56218, 56245.

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

Voltages			BSV15	BSV16	BSV17	
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80	V
Collector-emitter voltage (V_{BE} = 0)	$-V_{CES}$	max.	40	60	90	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	5	V

Currents				
Collector current (d.c.)	$-I_C$	max.	1.0	A
Base current (d.c.)	$-I_B$	max.	200	mA

Power dissipation				
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.8	W
up to T_{case} = 25 °C	P_{tot}	max.	5.0	W
up to T_{mb} = 50 °C	P_{tot}	max.	5.0	W

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	220	°C/W
From junction to case	$R_{th\ j-c}$	=	35	°C/W
From junction to mounting base	$R_{th\ j-mb}$	=	30	°C/W

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

			BSV15	BSV16	BSV17	
Collector cut-off currents						
$V_{BE} = 0$; $-V_{CE} = 40$ V	$-I_{CES}$	<	100	–	–	nA
$V_{BE} = 0$; $-V_{CE} = 40$ V; $T_{amb} = 150$ °C	$-I_{CES}$	<	50	–	–	μA
$V_{BE} = 0$; $-V_{CE} = 60$ V	$-I_{CES}$	<	–	100	–	nA
$V_{BE} = 0$; $-V_{CE} = 60$ V; $T_{amb} = 150$ °C	$-I_{CES}$	<	–	50	–	μA
$V_{BE} = 0$; $-V_{CE} = 80$ V	$-I_{CES}$	<	–	–	100	nA
$V_{BE} = 0$; $-V_{CE} = 80$ V; $T_{amb} = 150$ °C	$-I_{CES}$	<	–	–	50	μA
$-V_{BE} = 0.2$ V; $-V_{CE} = 40$ V; $T_{amb} = 100$ °C	$-I_{CEX}$	<	50	–	–	μA
$-V_{BE} = 0.2$ V; $-V_{CE} = 60$ V; $T_{amb} = 100$ °C	$-I_{CEX}$	<	–	50	–	μA
$-V_{BE} = 0.2$ V; $-V_{CE} = 80$ V; $T_{amb} = 100$ °C	$-I_{CEX}$	<	–	–	50	μA
Emitter cut-off current						
$I_C = 0$; $-V_{EB} = 4$ V	$-I_{EBO}$	<	50	50	50	nA
Breakdown voltages						
$I_B = 0$; $-I_C = 50$ mA; $t_p = 200$ μs; $\delta = 0.01$	$-V_{(BR)CEO}$	>	40	60	80	V
$V_{BE} = 0$; $-I_C = 10$ μA	$-V_{(BR)CES}$	>	40	60	90	V
$I_C = 0$; $-I_E = 10$ μA	$-V_{(BR)EBO}$	>	5	5	5	V

Base-emitter voltage

$-I_C = 100$ mA; $-V_{CE} = 1$ V	$-V_{BE}$	<	1.0	V
$-I_C = 500$ mA; $-V_{CE} = 1$ V	$-V_{BE}$	typ.	0.85	V
			0.7 to 1.4	V

Saturation voltage

$-I_C = 500$ mA; $-I_B = 25$ mA	$-V_{CEsat}$		0.25 to 1.0	V

Collector capacitance at f = 1 MHz

$I_E = I_e = 0$; $-V_{CB} = 10$ V — BSV15; BSV16	C_c	typ.	20	pF
		<	30	pF
$I_E = I_e = 0$; $-V_{CB} = 10$ V — BSV17	C_c	typ.	15	pF
		<	25	pF

Emitter capacitance at f = 1 MHz

$I_C = I_c = 0$; $-V_{EB} = 0.5$ V	C_e	typ.	180	pF

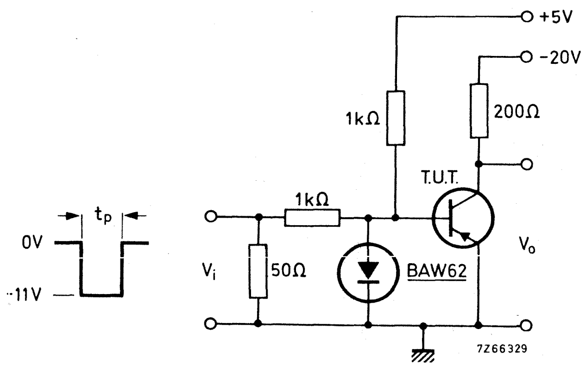
Transition frequency at f = 20 MHz

$-I_C = 50$ mA; $-V_{CE} = 10$ V	f_T	>	50	MHz

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

			BSV15-6 BSV16-6 BSV17-6	BSV15-10 BSV16-10 BSV17-10	BSV15-16 BSV16-16	
D.C. current gain						
$-I_C$ = 0.1 mA; $-V_{CE}$ = 1 V	h_{FE}	>	15	20	30	
		typ.	44	75	120	
$-I_C$ = 100 mA; $-V_{CE}$ = 1 V	h_{FE}	typ.	63	100	160	
			40 to 100	63 to 160	100 to 250	
$-I_C$ = 500 mA; $-V_{CE}$ = 1 V	h_{FE}	>	20	25	35	
		typ.	40	55	85	
h parameter at f = 1 kHz						
$-I_C$ = 1 mA; $-V_{CE}$ = 5 V						
Small signal current gain	h_{fe}	>		20		
Switching times						
Turn-on time						
$-I_C$ = 100 mA; $-I_B$ = $+I_{BM}$ = 5 mA	t_{on}	<		500		ns
Turn-off time						
$-I_C$ = 100 mA; $-I_B$ = $+I_{BM}$ = 5 mA						
Storage time	t_s	<		500		ns
Fall time	t_f	<		150		ns

Test circuit:

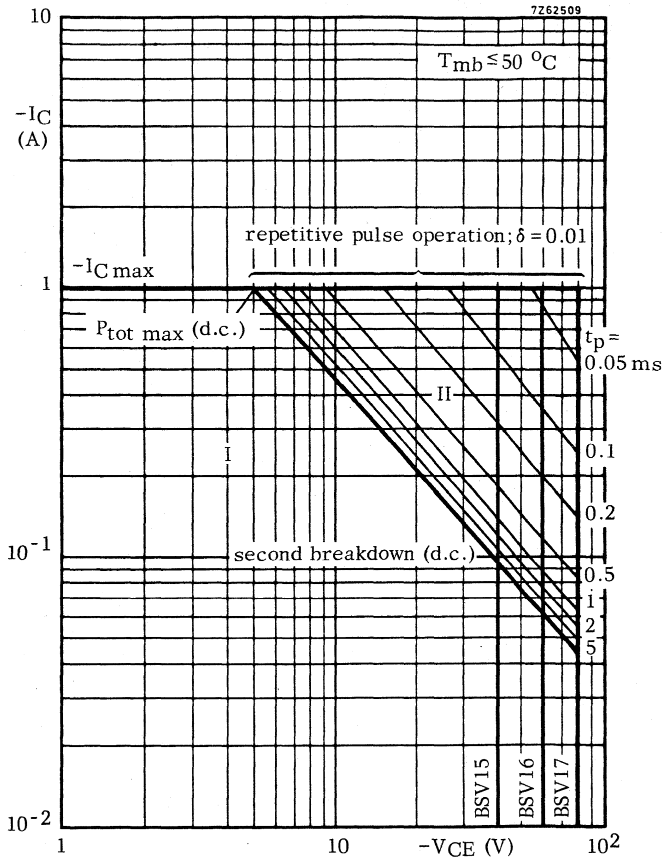


Pulse generator:

Pulse duration	$t_p \geq$ 10 µs
Rise time	$t_r \leq$ 15 ns
Fall time	$t_f \leq$ 15 ns
Source impedance	R_S = 50 Ω

Oscilloscope:

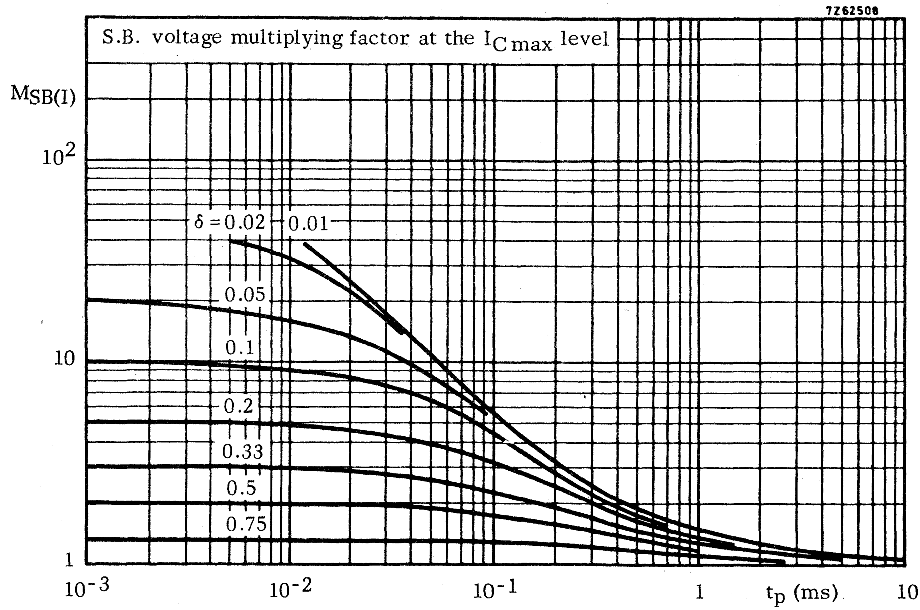
Rise time	≤ 15 ns
Input impedance	≥ 100 kΩ

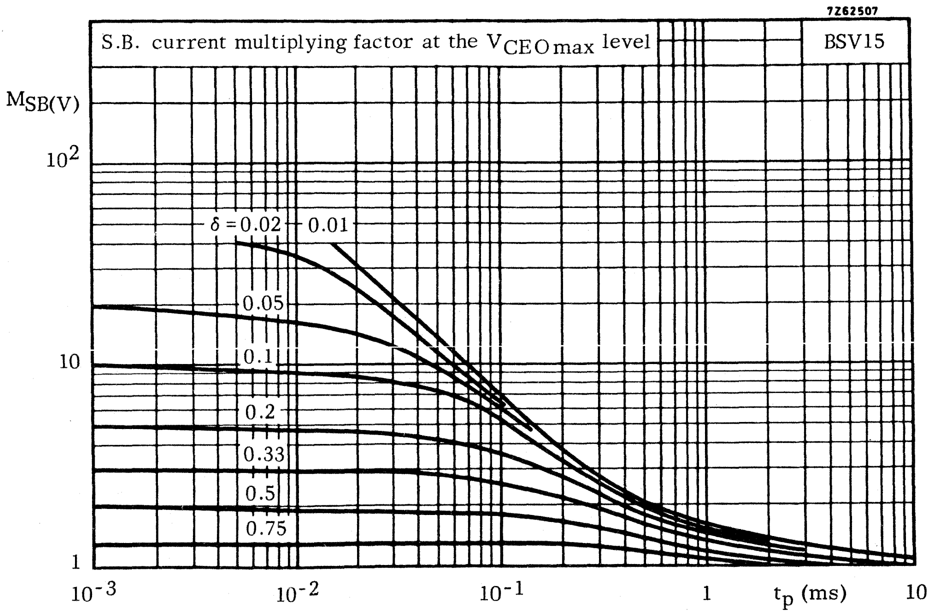


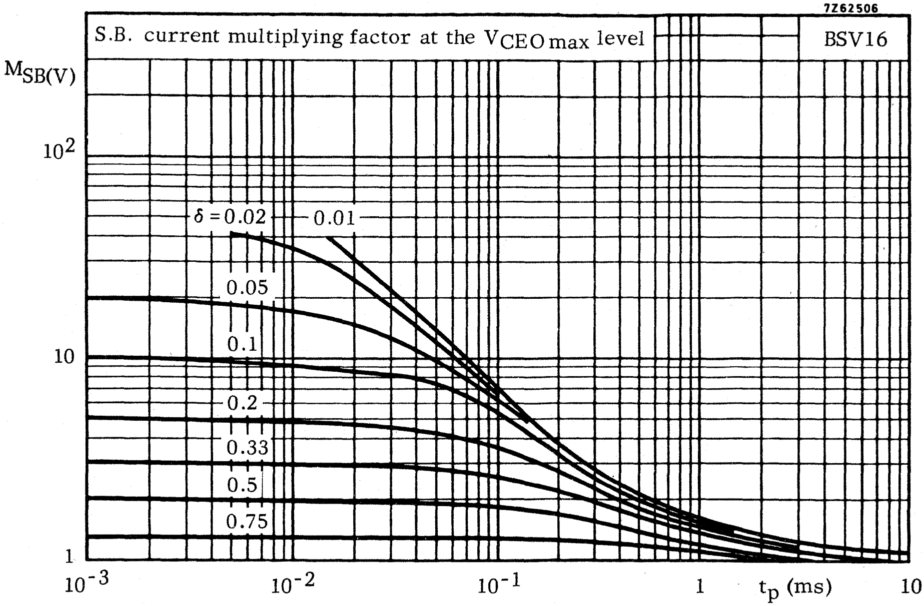
Safe Operating Area with the transistor forward biased

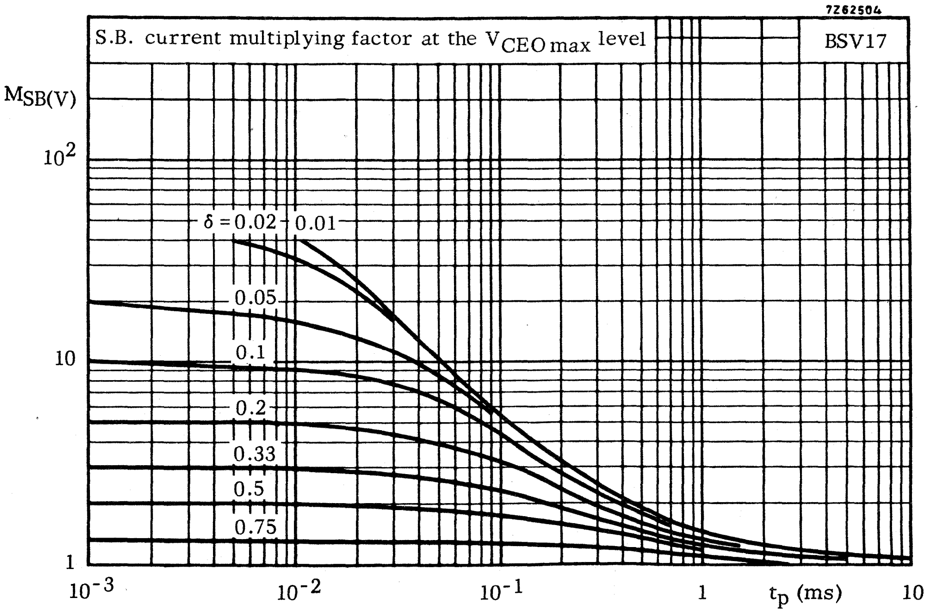
I Region of permissible d.c. operation

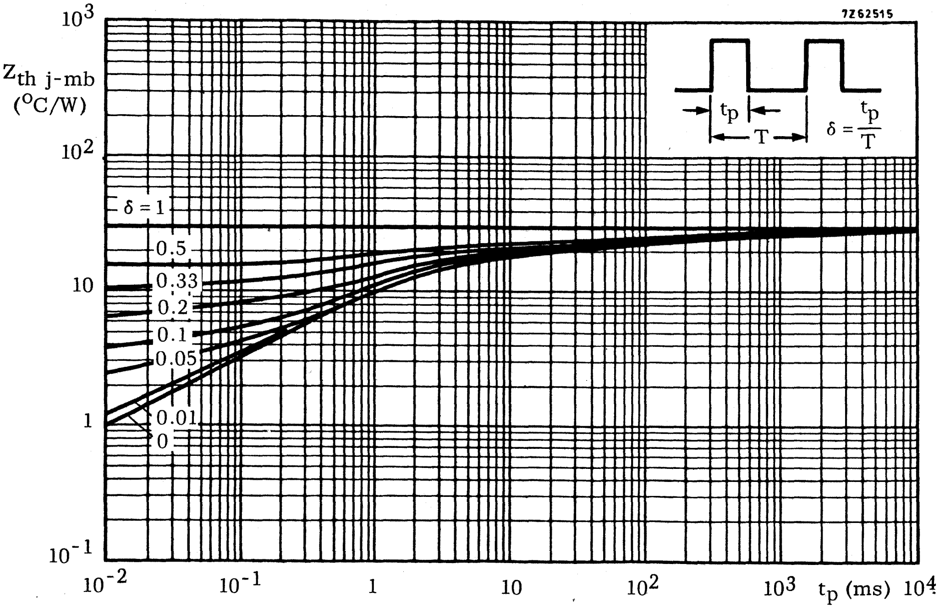
II Permissible extension for repetitive pulse operation

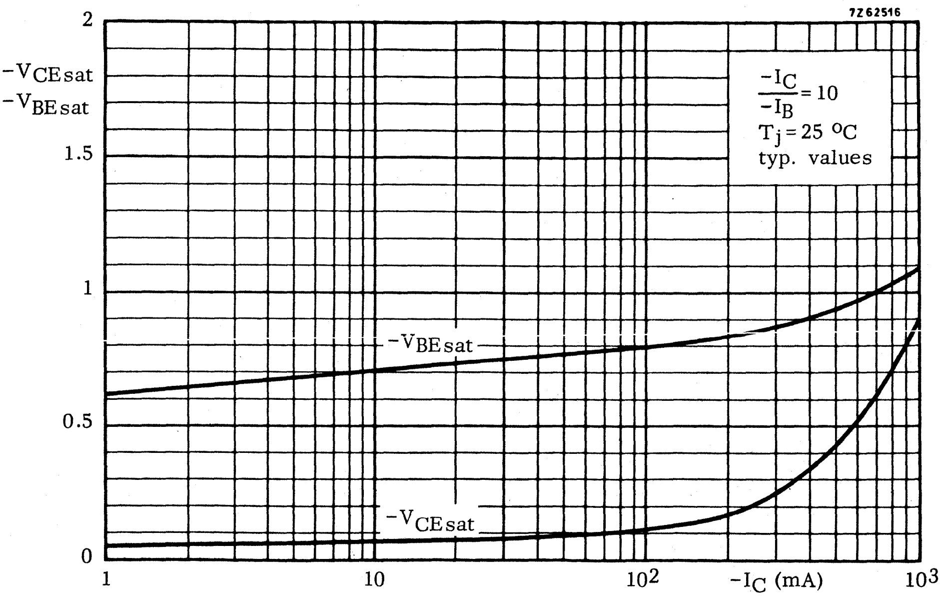

7Z62508
S.B. voltage multiplying factor at the I$_{C max}$ level
M$_{SB(I)}$
10^2
10
1
δ = 0.02
0.01
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t$_p$ (ms)
10

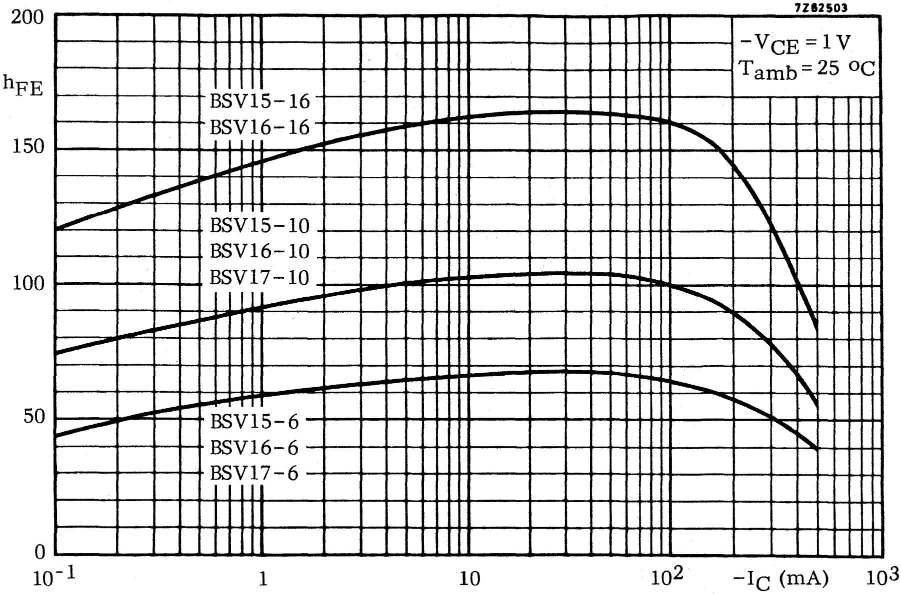

7Z62507
S.B. current multiplying factor at the V$_{CEO max}$ level
BSV15
M$_{SB(V)}$
10^2
10
1
δ = 0.02
0.01
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t$_p$ (ms)
10

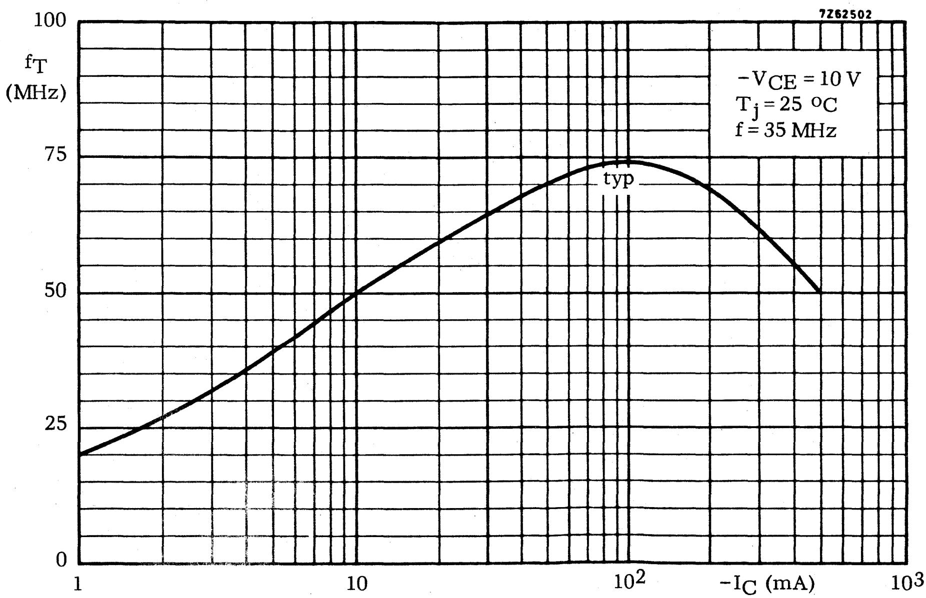

7Z62506
S.B. current multiplying factor at the $V_{CEO\,max}$ level
BSV16
$M_{SB(V)}$
10^2
10
1
δ = 0.02
0.01
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

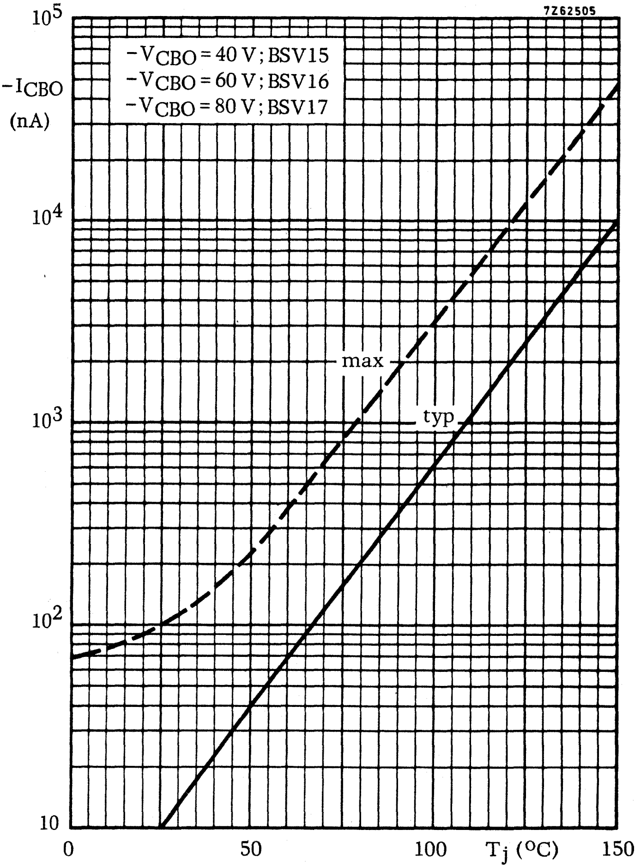

7Z62504
S.B. current multiplying factor at the $V_{CEO\,max}$ level
BSV17
$M_{SB(V)}$
10^2
10
1
δ = 0.02
0.01
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10


7Z62515
$Z_{th\ j-mb}$ (°C/W)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (ms) 10^4
δ = 1
0.5
0.33
0.2
0.1
0.05
0.01
0
t_p
T
$\delta = \frac{t_p}{T}$


7Z62516
$-V_{CEsat}$
$-V_{BEsat}$
2
1.5
1
0.5
0
1
10
10^2
$-I_C$ (mA)
10^3
$\frac{-I_C}{-I_B} = 10$
$T_j = 25\ ^oC$
typ. values
$-V_{BEsat}$
$-V_{CEsat}$


7Z62503
200
150
100
50
0
h_{FE}
BSV15−16
BSV16−16
BSV15−10
BSV16−10
BSV17−10
BSV15−6
BSV16−6
BSV17−6
$-V_{CE}$ = 1 V
T_{amb} = 25 °C
10^{-1}
1
10
10^2
$-I_C$ (mA)
10^3


7Z62502
100
75
50
25
0
f_T
(MHz)
$-V_{CE}$ = 10 V
T_j = 25 °C
f = 35 MHz
typ
1
10
10^2
$-I_C$ (mA)
10^3


7Z62505
10^5
$-I_{CBO}$
(nA)
$-V_{CBO}$ = 40 V; BSV15
$-V_{CBO}$ = 60 V; BSV16
$-V_{CBO}$ = 80 V; BSV17
10^4
max
typ
10^3
10^2
10
0
50
100
T_j (°C)
150

SILICON PLANAR EPITAXIAL TRANSISTOR

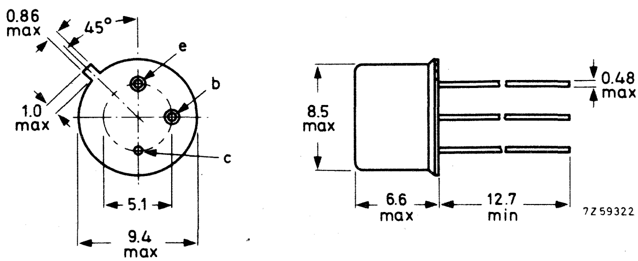
N-P-N transistor in a TO-39 metal envelope primarily intended for use as a print hammer drive. It has good high current saturation characteristics.

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.	5.0	A
Total power dissipation up to T_{case} = 50 °C	P_{tot}	max.	5.0	W
Junction temperature	T_j	max.	175	°C
D.C. current gain I_C = 2 A; V_{CE} = 2 V	h_{FE}	>	40	
Transition frequency at f = 35 MHz I_C = 0.5 A; V_{CE} = 5 V	f_T	typ.	100	MHz
Turn off time when switched from I_C = 5 A; I_B = 0.5 A to cut-off with $-I_{BM}$ = 0.5 A	t_{off}	<	1.2	μs

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-39



max. lead diameter is guaranteed only for 12.7 mm

Accessories supplied on request: 56218; 56245

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

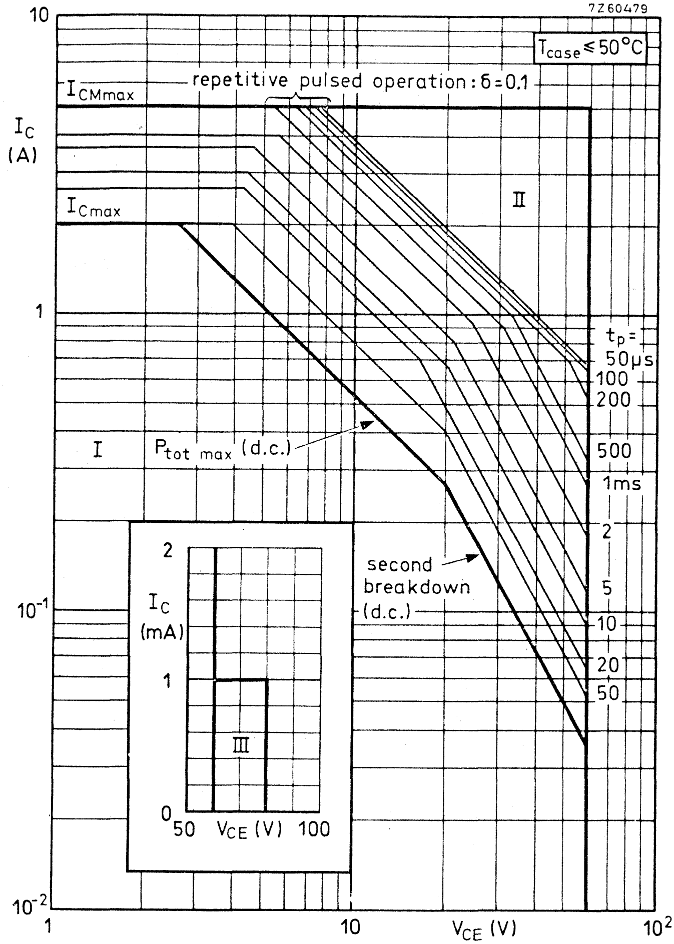
Voltages				
Collector-base voltage (open emitter)	V_{CBO}	max.	100	V
Collector-emitter voltage ($R_{BE} \leq 50\ \Omega$)	V_{CER}	max.	80	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V
Currents				
Collector current (d.c.)	I_C	max.	2,0	A
Collector current (peak value)	I_{CM}	max.	5,0	A
Base current (d.c.)	I_B	max.	1,0	A
Power dissipation				
Total power dissipation up to T_{case} = 50 ^{o}C	P_{tot}	max.	5,0	W
Temperatures				
Storage temperature	T_{stg}		−55 to +175	^{o}C
Junction temperature	T_j	max.	175	^{o}C

THERMAL RESISTANCE

From junction to case	$R_{th\ j\text{-}c}$	=	25	^{o}C/W

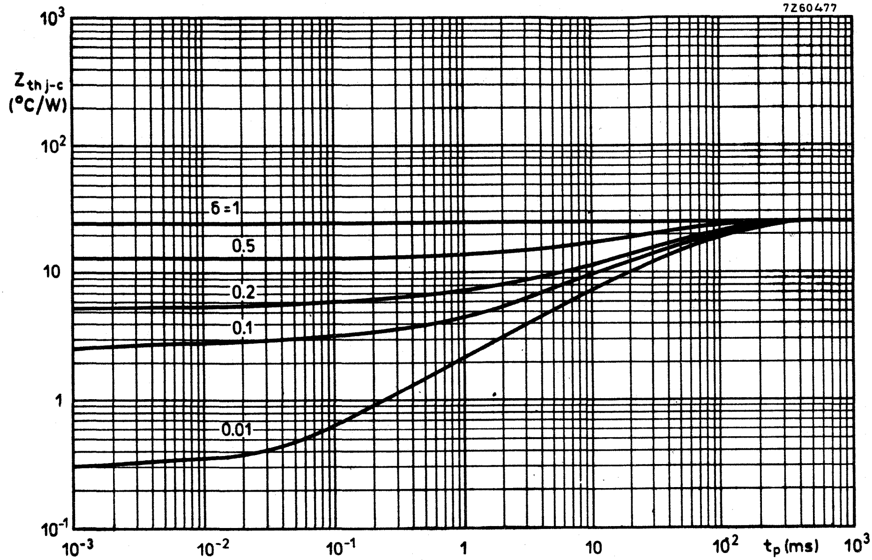
CHARACTERISTICS T_j = 25 °C unless otherwise specified

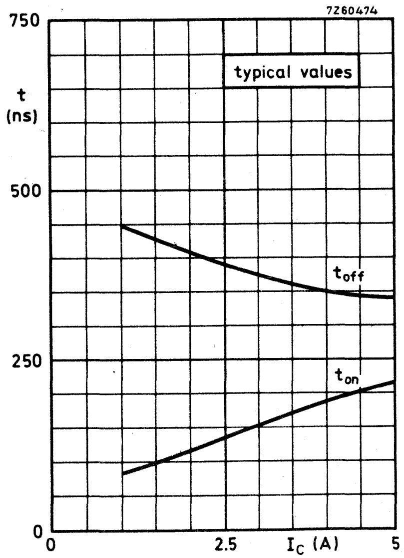
Collector cut-off current				
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	<	10	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 4$ V	I_{EBO}	<	10	μA
Saturation voltages				
$I_C = 5$ A; $I_B = 0.5$ A	V_{CEsat}	<	1.0	V
	V_{BEsat}	<	1.8	V
D.C. current gain				
$I_C = 2$ A; $V_{CE} = 2$ V	h_{FE}	>	40	
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	80	pF
Transition frequency at f = 35 MHz				
$I_C = 0.5$ A; $V_{CE} = 5$ V	f_T	typ.	100	MHz
Turn on time when switched from $-V_{BE} = 2.0$ V to $I_C = 5$ A; $I_B = 0.5$ A with $I_{BM} = 0.5$ A	t_{on}	<	0.6	μs
Turn off time when switched from $I_C = 5$ A; $I_B = 0.5$ A to $-V_{BE} = 2.0$ V with $-I_{BM} = 0.5$ A	t_{off}	<	1.2	μs

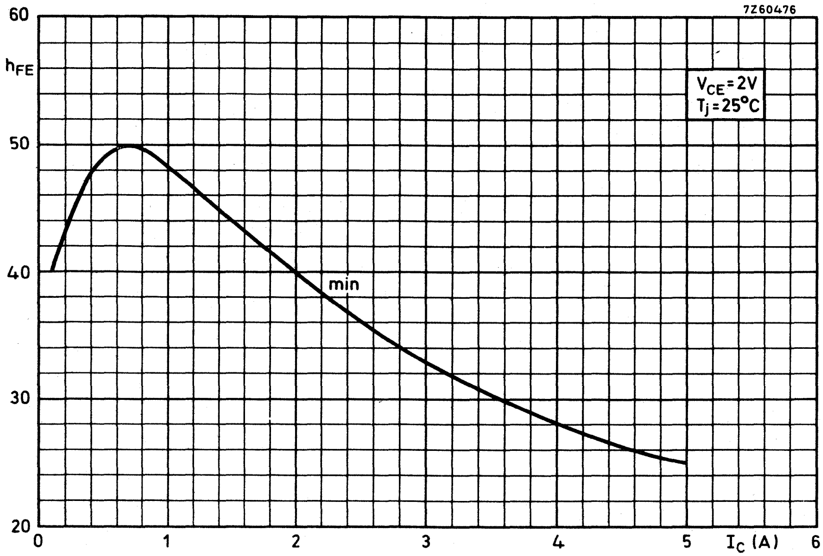


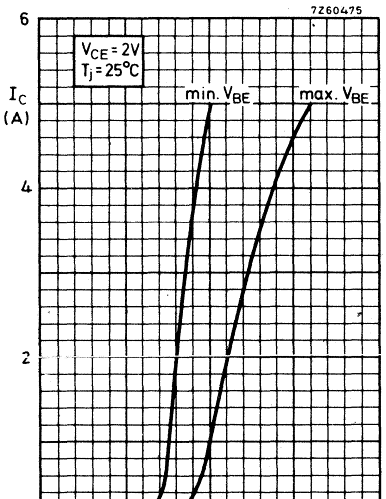
Safe Operating Area

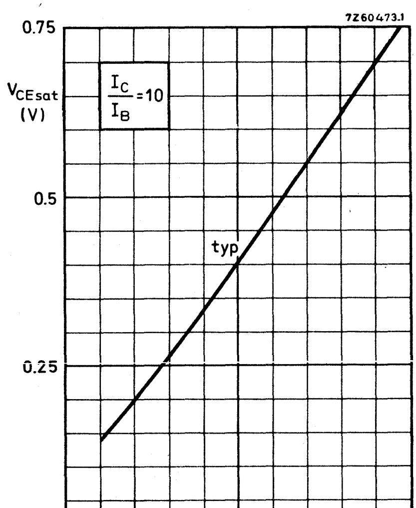
I Region of permissible d.c. operation
II Permissible extension for repetitive pulsed operation
III D.C. operation in this region is allowable, provided $R_{BE} \leq 50\ \Omega$


7Z60477
10^3
$Z_{th\,j\text{-}c}$ (°C/W)
10^2
10
1
10^{-1}
δ = 1
0.5
0.2
0.1
0.01
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3


7Z60474
750
t (ns)
500
250
0
typical values
t_{off}
t_{on}
0
2.5
I_C (A)
5


7Z60476
60
h_{FE}
50
40
30
20
V_{CE} = 2V
T_j = 25°C
min
0
1
2
3
4
5
I_C (A)
6


7Z60475
6
I_C
(A)
4
2
0
V_{CE} = 2V
T_j = 25°C
min. V_{BE}
max. V_{BE}
0
1
V_{BE} (V)
2


7Z60473.1
0.75
V_{CEsat}
(V)
0.5
0.25
0
$\frac{I_C}{I_B}$ = 10
typ
0
2.5
I_C (A)
5

SILICON PLANAR EPITAXIAL TRANSISTOR

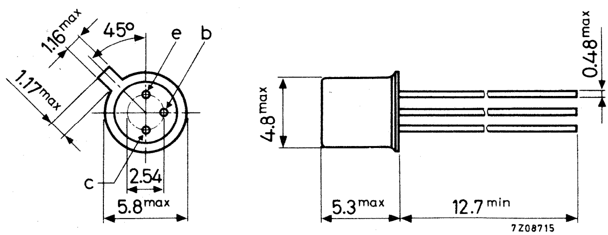
N-P-N transistor in a TO-18 metal envelope intended for core driver applications in small memories.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Collector current (peak value)	I_{CM}	max.	500	mA
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	1,0	W
Junction temperature	T_j	max.	200	°C
D.C. current gain I_C = 500 mA; V_{CE} = 1 V	h_{FE}	>	15	
Transition frequency I_C = 50 mA; V_{CE} = 10 V; f = 100 MHz	f_T	>	250	MHz
Turn-off time when switched from I_C = 500 mA; I_B = 50 mA to cut-off with $-I_{BM}$ = 50 mA	t_{off}	<	60	ns

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-18



Accessories supplied on request: 56246; 56263

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

Voltages

Collector-base voltage (open emitter) $I_C = 0,1$ mA	V_{CBO}	max.	40	V
Collector-emitter voltage (open base) $I_C = 30$ mA	V_{CEO}	max.	25	V
Emitter-base voltage (open collector) $I_E = 0,1$ mA	V_{EBO}	max.	5	V

Currents

Collector current (d.c.)	I_C	max.	300	mA
Collector current (peak value)	I_{CM}	max.	500	mA

Power dissipation

Total power dissipation up to $T_{case} = 25\ ^oC$	P_{tot}	max.	1,0	W

Temperatures

Storage temperature	T_{stg}		−65 to +200	^oC
Junction temperature	T_j	max.	200	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0,50	$^oC/mW$
From junction to case	$R_{th\ j\text{-}c}$	=	0,175	$^oC/mW$

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current				
$I_E = 0;\ V_{CB} = 30\ V$	I_{CBO}	<	0,5	μA
$I_E = 0;\ V_{CB} = 30\ V;\ T_j = 100\ ^oC$	I_{CBO}	<	50	μA
Breakdown voltages				
$I_C = 30\ mA;\ R_{BE} = 100\ \Omega$	$V_{(BR)CER}$	>	40	V
$I_C = 30\ mA;\ R_{BE} = 1\ k\Omega$	$V_{(BR)CER}$	>	30	V
Saturation voltages				
$I_C = 150\ mA;\ I_B = 15\ mA$	V_{CEsat}	<	0,5	V
	V_{BEsat}	<	1,3	V
$I_C = 500\ mA;\ I_B = 35\ mA$	V_{CEsat}	<	0,7	V
$I_C = 500\ mA;\ I_B = 50\ mA$	V_{BEsat}	<	1,8	V
D.C. current gain				
$I_C = 10\ mA;\ V_{CE} = 10\ V$	h_{FE}	>	30	
$I_C = 150\ mA;\ V_{CE} = 1\ V$	h_{FE}	>	40	
$I_C = 500\ mA;\ V_{CE} = 1\ V$	h_{FE}	>	15	
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0;\ V_{CB} = 10\ V$	C_c	<	8,0	pF
Transition frequency at f = 100 MHz				
$I_C = 50\ mA;\ V_{CE} = 10\ V$	f_T	>	250	MHz
Turn-on time when switched to				
a) $I_C = 150\ mA;\ I_B = 15\ mA$ (Fig. 1 on page 4)	t_{on}	<	60	ns
b) $I_C = 300\ mA;\ I_B = 40\ mA$ (Fig. 1 on page 4)	t_{on}	<	50	ns
Turn-off time when switched from				
c) $I_C = 150\ mA;\ I_B = 15\ mA$ to cut-off with $-I_{BM} = 15\ mA$ (Fig. 2 on page 4)	t_{off}	<	70	ns
d) $I_C = 300\ mA;\ I_B = 40\ mA$ to cut-off with $-I_{BM} = 20\ mA$ (Fig. 1 on page 4)	t_{off}	<	110	ns
e) $I_C = 400\ mA;\ I_B = 50\ mA$ to cut-off with $-I_{BM} = 1\ mA$ (Fig. 1 on page 4)	t_{off}	<	300	ns
f) $I_C = 500\ mA;\ I_B = 50\ mA$ to cut-off with $-I_{BM} = 50\ mA$ (Fig. 3 on page 4)	t_{off}	<	60	ns

CHARACTERISTICS (continued)

	I_C (mA)	I_B (mA)	I_{BM} (mA)	V_{CC} (V)	R1 (kΩ)	R2 (kΩ)	R3 (Ω)	R4 (Ω)	V_{BB} (V)	V_{BE} (V)	V_i (V)
a	150	15	–	10	1	∞	50	62	–	–	0 to +16
b	300	40	–	15, 5	0, 33	0, 33	56	50	−4, 5	−2, 25	0 to +20
c	150	15	−15	10	1	1	50	62	+16	–	0 to −30
d	300	40	−20	15, 5	0, 33	0, 33	56	50	+15, 3	–	0 to −20
e	400	50	− 1	12, 5	1	∞	50	30	–	–	+51 to 0
f	500	50	−50	21	0, 2	–	–	40	−3	–	+11, 3 to −8, 7

Test circuits:

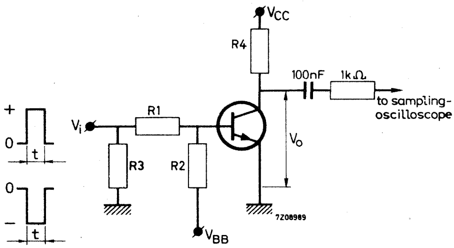


Fig. 1

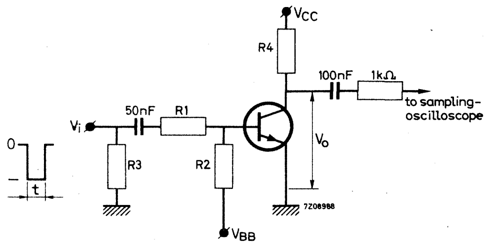


Fig. 2

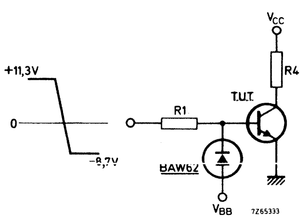
Pulse generator:

Rise time	t_r	≤ 2 ns
Pulse duration	t	= 200 ns
Fall time	t_f	≤ 2 ns
Output resistance	R_o	= 50 Ω

Oscilloscope:

Input resistance R_i = 50 Ω

Equivalent test circuit:



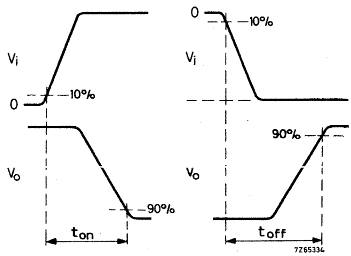
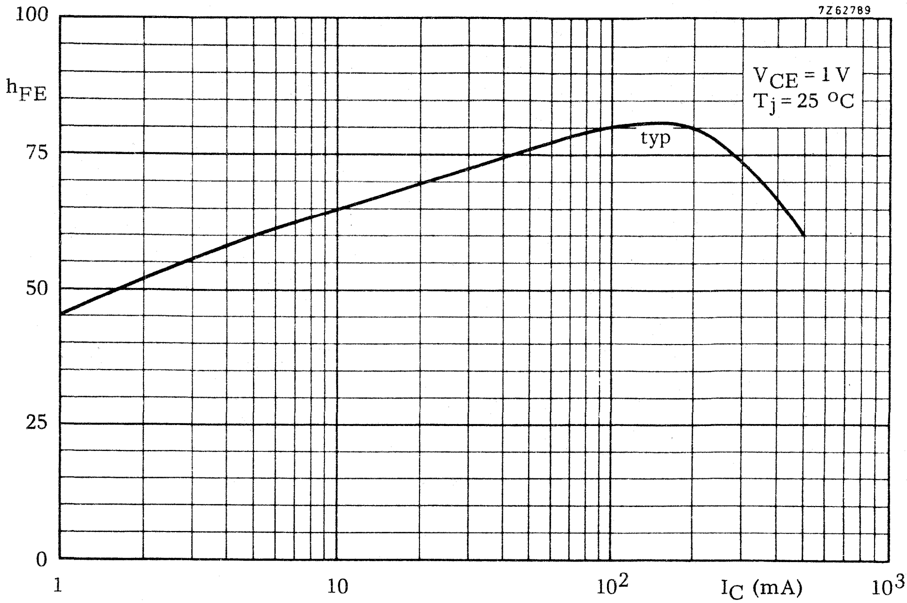
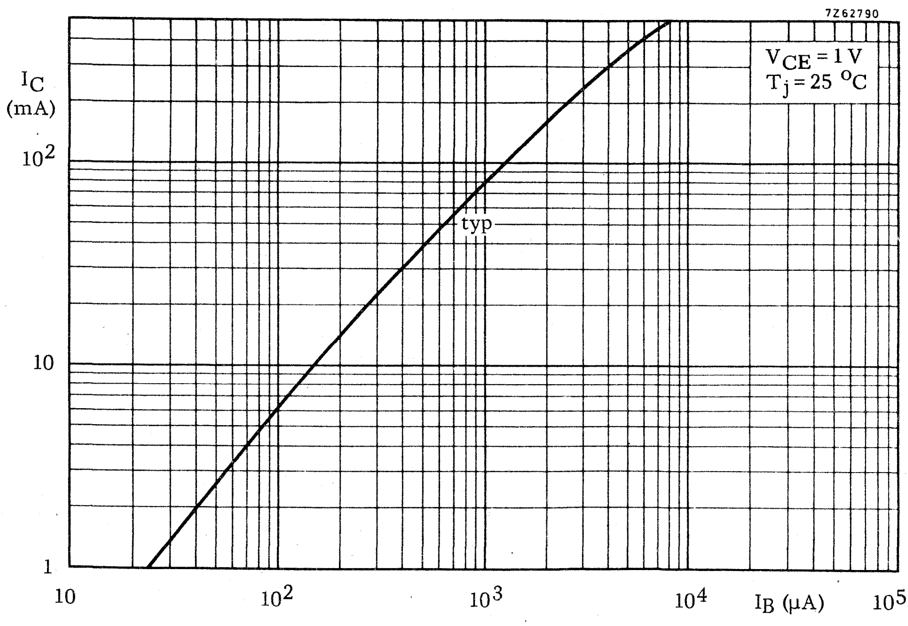
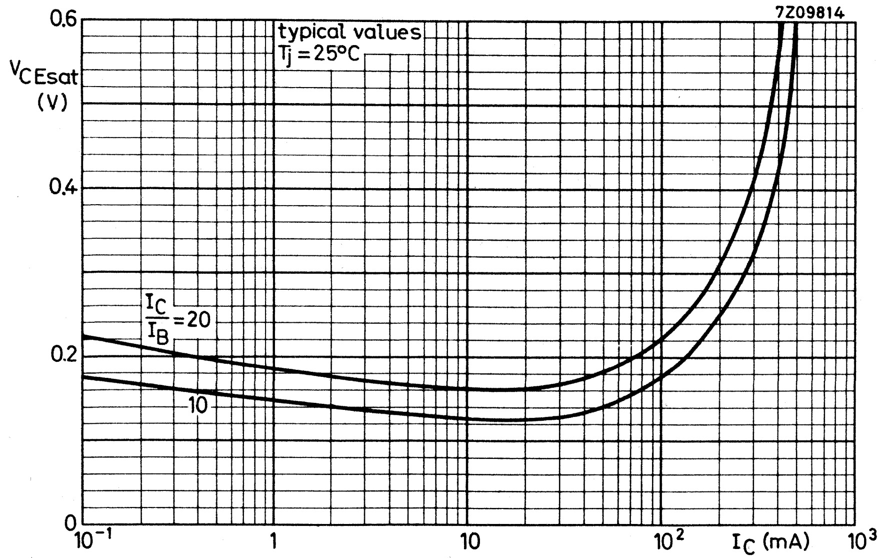
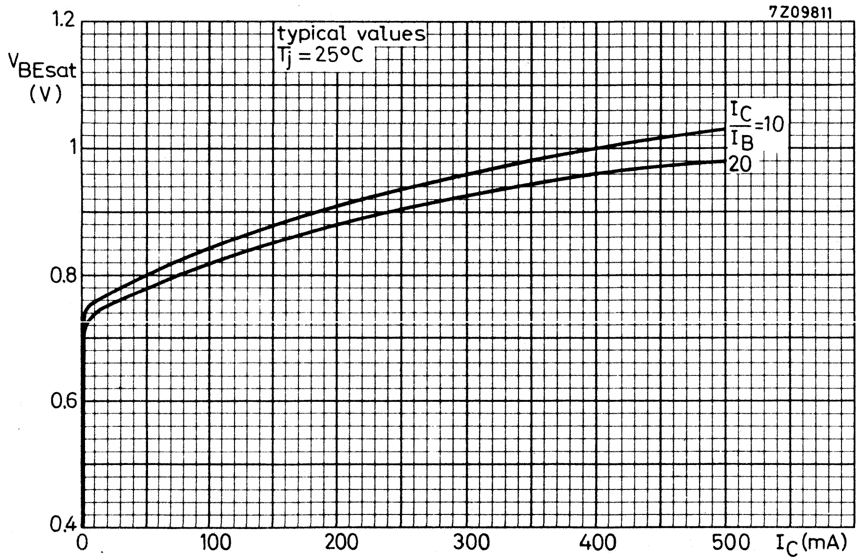


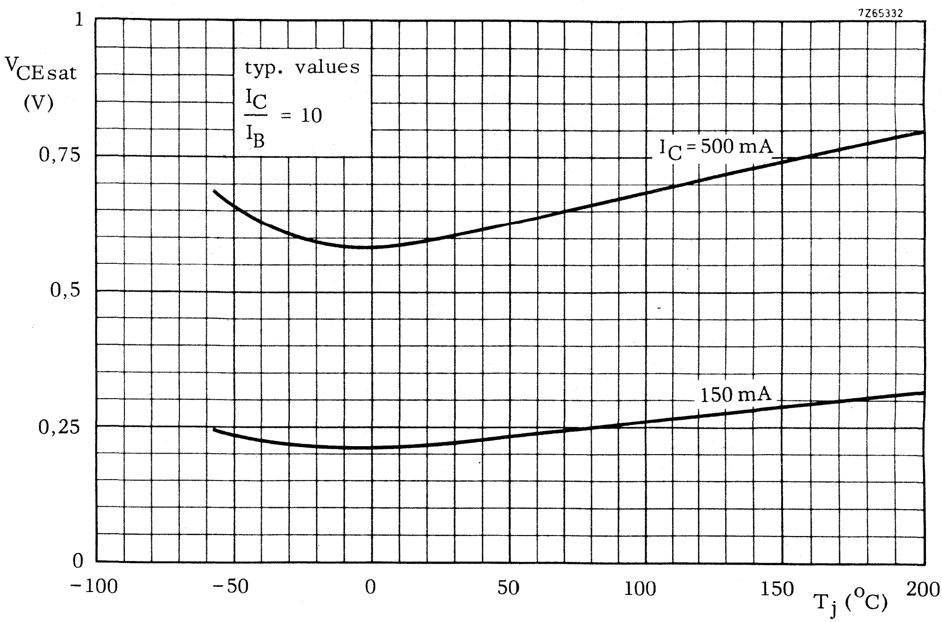
Fig. 3

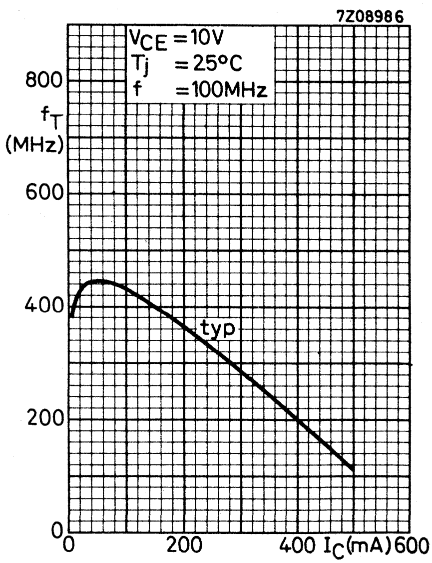

7Z62789
100
h_{FE}
75
50
25
0
1
10
10^2
I_C (mA)
10^3
V_{CE} = 1 V
T_j = 25 °C
typ

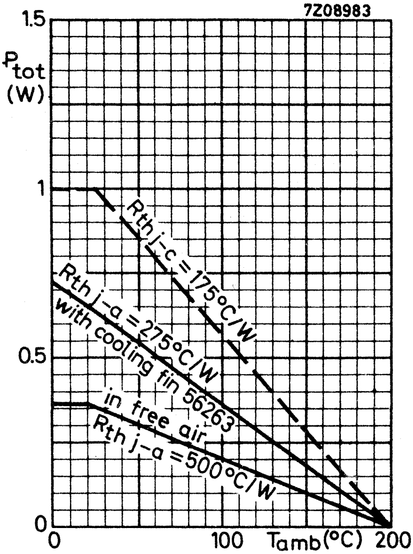

7Z62790
I_C
(mA)
10^2
10
1
10
10^2
10^3
10^4
I_B (μA)
10^5
V_{CE} = 1 V
T_j = 25 °C
typ

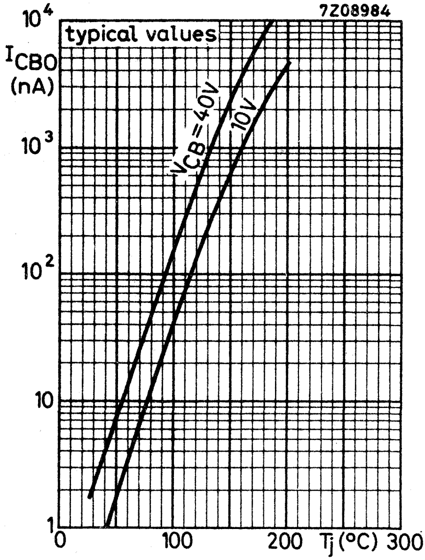

7Z09814
typical values
Tj = 25°C
VCEsat
(V)
0.6
0.4
0.2
0
IC/IB = 20
10
10−1
1
10
10²
IC (mA)
10³

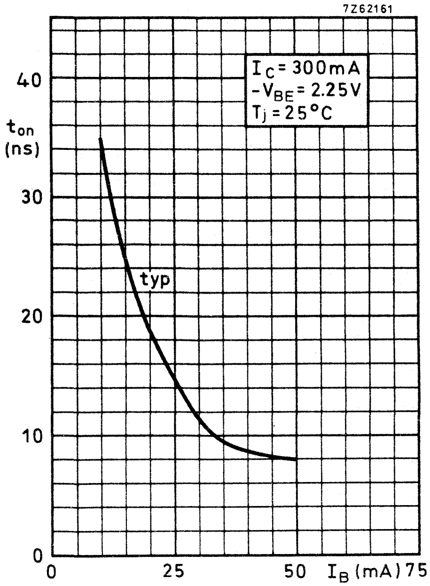

7Z09811
typical values
Tj = 25°C
VBEsat
(V)
1.2
1
0.8
0.6
0.4
IC/IB = 10
20
0
100
200
300
400
500
IC (mA)

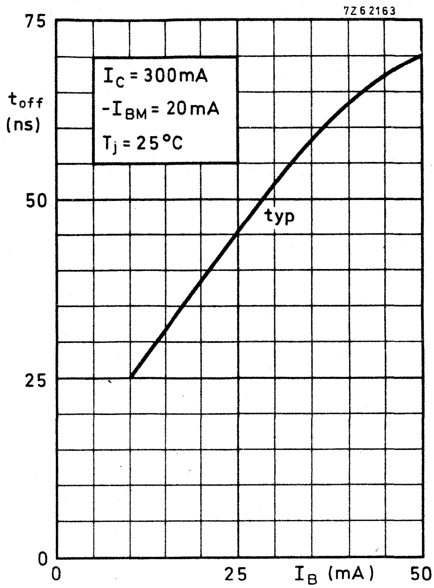

7Z65332
V_{CEsat}
(V)
1
0,75
0,5
0,25
0
typ. values
$\frac{I_C}{I_B}$ = 10
I_C = 500 mA
150 mA
−100
−50
0
50
100
150
200
T_j (°C)

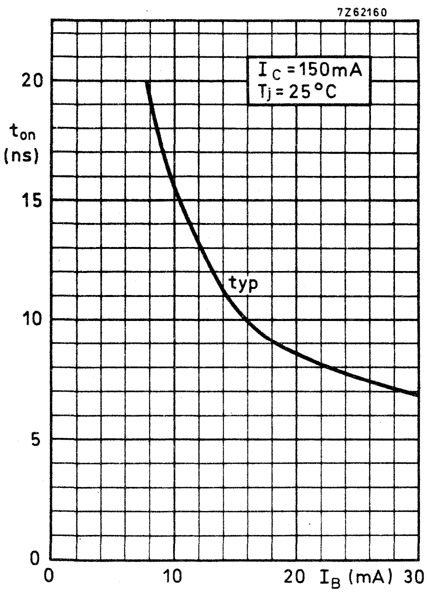

7Z08986
V_{CE} = 10V
T_j = 25°C
f = 100MHz
f_T
(MHz)
800
600
400
200
0
typ
0
200
400
I_C (mA)
600

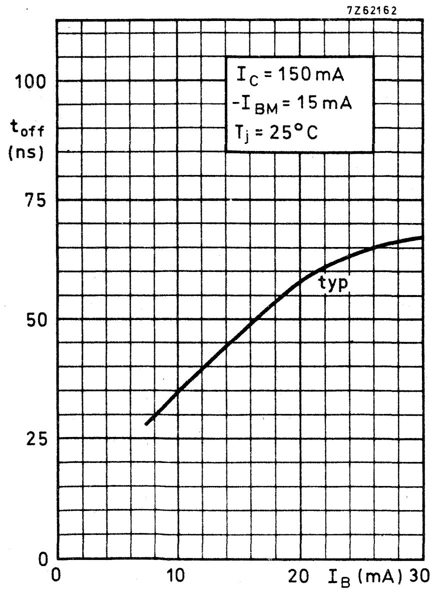

7Z08983
1.5
Ptot
(W)
1
0.5
0
0
100
Tamb(°C)
200
Rth j-c = 175°C/W
Rth j-a = 275°C/W
with cooling fin 56263
in free air
Rth j-a = 500°C/W


7Z08984
typical values
ICBO
(nA)
10^4
10^3
10^2
10
1
0
100
200
Tj (°C)
300
VCB = 40V
10V


7Z62161
I_C = 300mA
$-V_{BE}$ = 2.25V
T_j = 25°C
t_{on} (ns)
40
30
20
10
0
typ
0
25
50
I_B (mA)
75


7Z62163
I_C = 300mA
$-I_{BM}$ = 20mA
T_j = 25°C
t_{off} (ns)
75
50
25
0
typ
0
25
I_B (mA)
50


7Z62160
I_C = 150mA
T_j = 25°C
t_{on} (ns)
20
15
10
5
0
typ
0
10
20
I_B (mA)
30


7Z62162
I_C = 150 mA
$-I_{BM}$ = 15 mA
T_j = 25°C
t_{off} (ns)
100
75
50
25
0
typ
0
10
20
I_B (mA)
30

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in TO-39 metal envelopes with the collector connected to the case. They are primarily intended for switching with inductive load and for general purposes.

QUICK REFERENCE DATA

			BSW66	BSW67	BSW68	
Collector-base voltage (open emitter)	V_{CBO}	max.	100	120	150	V
Collector-emitter voltage (open base)	V_{CEO}	max.	100	120	150	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	6	6	V

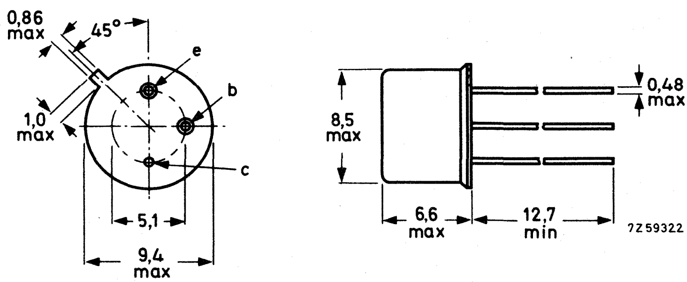
Collector current (peak value)	I_{CM}	max.	2	A
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	5,0	W
Junction temperature	T_j	max.	200	°C
Transition frequency at f = 35 MHz I_C = 100 mA; V_{CE} = 20 V	f_T	typ.	80	MHz
D.C. current gain I_C = 10 mA; V_{CE} = 5 V	h_{FE}	>	30	
I_C = 500 mA; V_{CE} = 5 V	h_{FE}	>	30	

MECHANICAL DATA

Dimensions in mm

Collector connected to case

TO-39



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

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

Voltages

			BSW66	BSW67	BSW68	
Collector-base voltage (open emitter)	V_{CBO}	max.	100	120	150	V
Collector-emitter voltage (open base) [1]	V_{CEO}	max.	100	120	150	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	6	6	V

Currents

Collector current (d.c. or average over any 20 ms period)	I_C	max.	1	A
Collector current (peak value)	I_{CM}	max.	2	A
Emitter current (peak value)	$-I_{EM}$	max.	2	A

Power dissipation

Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	0.8	W
$T_{case} = 25\ ^oC$	P_{tot}	max.	5.0	W

Switch off energy with inductive load

$I_C \leq 500$ mA	E	max.	5	mWs

Temperatures

Storage temperature	T_{stg}		-65 to +200	^oC
Junction temperature	T_j	max.	200	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	220	$^oC/W$
From junction to case	$R_{th\ j-c}$	=	35	$^oC/W$

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

Collector cut-off current

$I_E = 0;\ V_{CB} = V_{CBOmax}$	I_{CBO}	<	100	μA
$I_E = 0;\ V_{CB} = \frac{1}{2} V_{CBOmax}$	I_{CBO}	<	100	nA
$I_E = 0;\ V_{CB} = \frac{1}{2} V_{CBOmax};\ T_j = 150\ ^oC$	I_{CBO}	<	50	μA

Emitter cut-off current

$I_C = 0;\ V_{EB} = 6$ V	I_{EBO}	<	100	μA
$I_C = 0;\ V_{EB} = 3$ V	I_{EBO}	<	100	nA

[1]) $I_C = 100$ mA

CHARACTERISTICS (continued)

Saturation voltages

I_C = 100 mA; I_B = 10 mA		V_{CEsat}	<	150	mV
		V_{BEsat}	<	900	mV
I_C = 500 mA; I_B = 50 mA	BSW66; BSW67	V_{CEsat}	<	400	mV
	BSW68	V_{CEsat}	<	500	mV
		V_{BEsat}	<	1.1	V
I_C = 1 A; I_B = 150 mA		V_{CEsat}	<	1	V
		V_{BEsat}	<	1.4	V

D.C. current gain

I_C = 10 mA; V_{CE} = 5 V	h_{FE}	>	30	
I_C = 100 mA; V_{CE} = 5 V	h_{FE}	>	40	
I_C = 500 mA; V_{CE} = 5 V	h_{FE}	>	30	
I_C = 1 A; V_{CE} = 5 V	h_{FE}	>	15	

Collector capacitance at f = 1 MHz

$I_E = I_e = 0$; V_{CB} = 10 V	C_c	<	35	pF

Emitter capacitance at f = 1 MHz

$I_C = I_c = 0$; $V_{EB} = 0$	C_e	<	650	pF

Transition frequency at f = 35 MHz

I_C = 100 mA; V_{CE} = 20 V	f_T	typ.	80	MHz

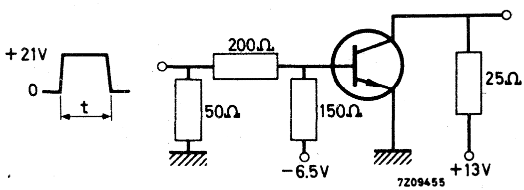
Turn on time when switched from

$-V_{BE}$ = 4 V to I_C = 500 mA; I_B = 50 mA	t_{on}	typ.	0.5	μs

Turn off time when switched from

I_C = 500 mA; I_B = 50 mA to $-V_{BB}$ = 6.5 V ($-I_{BM}$ = 50 mA)	t_{off}	typ.	1	μs

Test circuit:



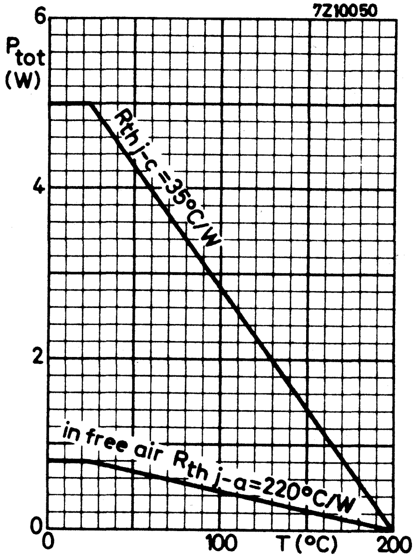
Pulse generator:

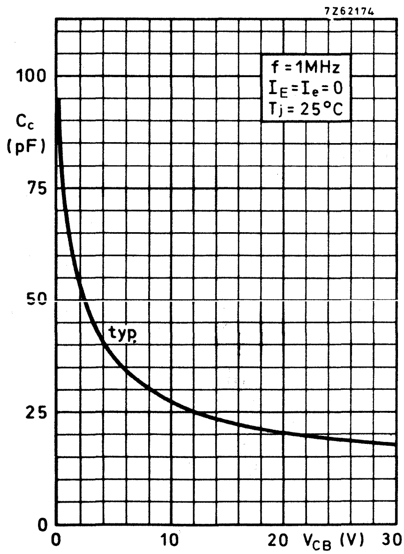
Pulse duration	t > 5 μs
Rise time	t_r < 10 ns
Fall time	t_f < 10 ns

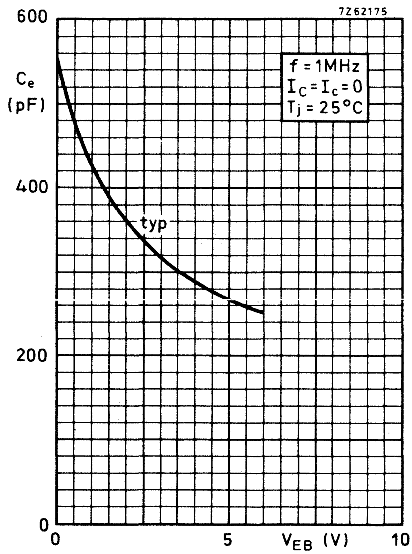
Note

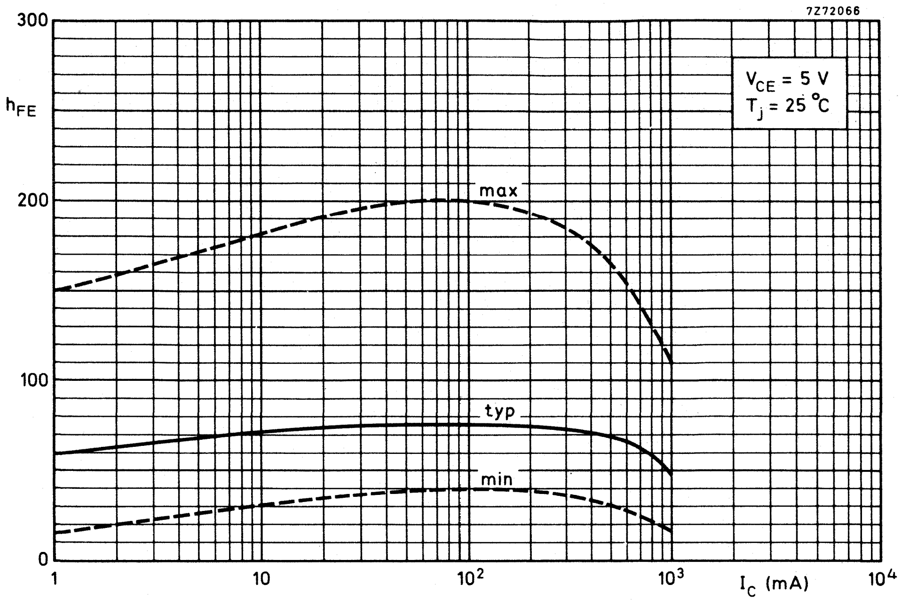
$-I_{BM}$ is the reverse current that can flow during switching off. The indicated $-I_{BM}$ is determined and limited by the applied cut-off voltage and series resistance.

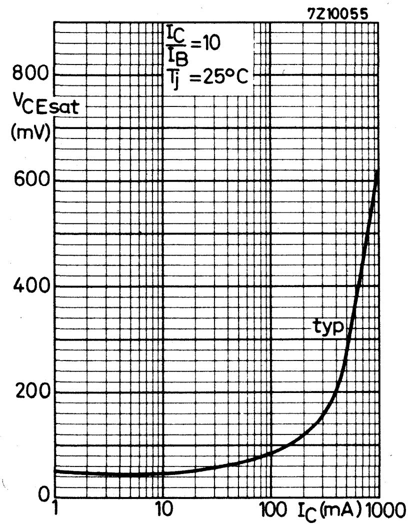
CHARACTERISTICS (continued)

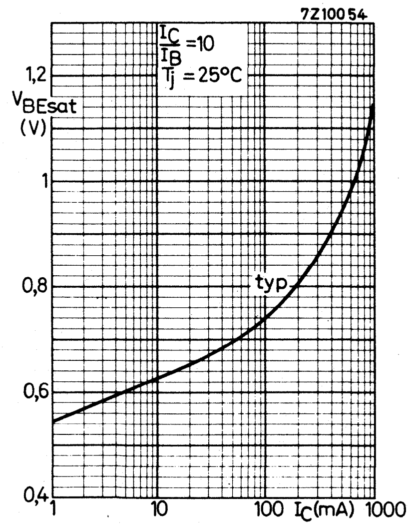


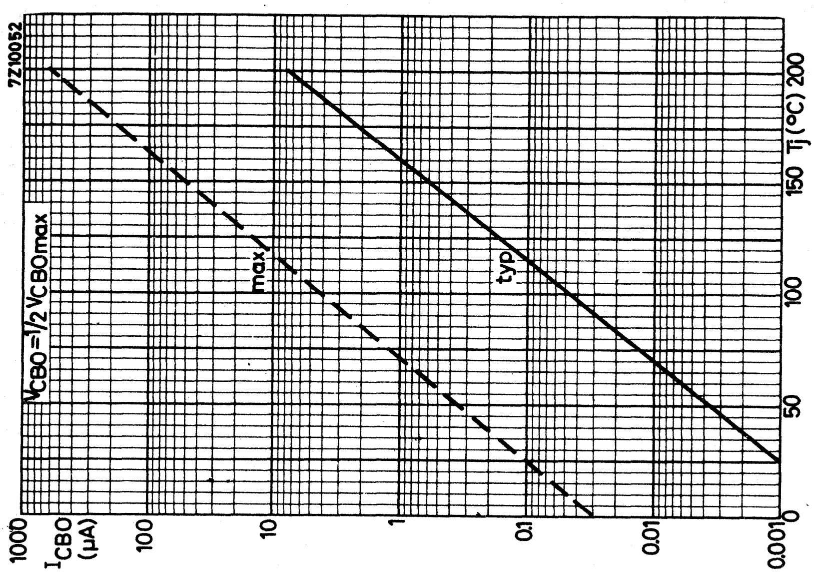


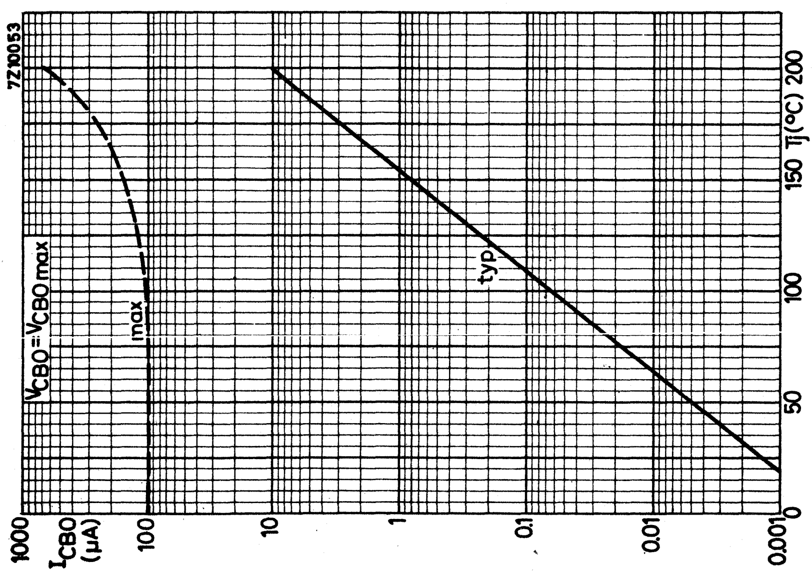



7Z72066
V_{CE} = 5 V
T_j = 25 °C
h_{FE}
300
200
100
0
max
typ
min
1
10
10^2
10^3
10^4
I_C (mA)


7Z10055
$\frac{I_C}{I_B}$ =10
T_j =25°C
V_{CEsat}
(mV)
800
600
400
200
0
typ
1
10
100
I_C(mA)
1000


7Z10054
$\frac{I_C}{I_B}$ =10
T_j =25°C
V_{BEsat}
(V)
1,2
1
0,8
0,6
0,4
typ
1
10
100
I_C(mA)
1000


7Z10052
$V_{CBO} = 1/2\ V_{CBO\,max}$
I_{CBO} (μA)
1000
100
10
1
0.1
0.01
0.001
max
typ
0
50
100
150
200
T_j (°C)


7Z10053
$V_{CBO} = V_{CBO\,max}$
I_{CBO} (μA)
1000
100
10
1
0.1
0.01
0.001
max
typ
0
50
100
150
200
T_j (°C)

VERY HIGH SPEED SWITCHING TRANSISTORS

N-P-N silicon planar epitaxial transistors in a TO-18 metal envelope with the collector connected to the case. The BSX19 and BSX20 are primarily intended for very high speed saturated switching.

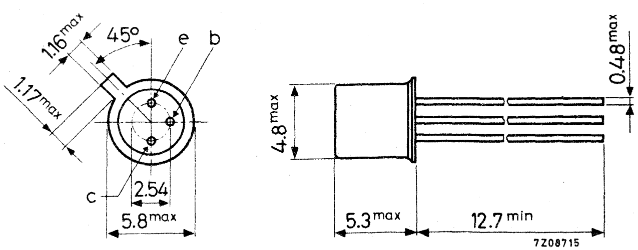
QUICK REFERENCE DATA

			BSX19	BSX20	
Collector-base voltage (open emitter)	V_{CBO}	max.	40	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	15	V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	40	40	V
Collector current (peak value)	I_{CM}	max.	500	500	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360	360	mW
D.C. current gain at T_j = 25 °C					
I_C = 10 mA; V_{CE} = 1 V	h_{FE}		20 to 60	40 to 120	
I_C = 100 mA; V_{CE} = 2 V	h_{FE}	>	10	20	
Transition frequency					
I_C = 10 mA; V_{CE} = 10 V	f_T	>	400	500	MHz
Storage time					
$I_C = I_B = -I_{BM}$ = 10 mA	t_s	<	10	13	ns

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-18



Accessories available: 56246, 56263

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector-emitter voltage with V_{BE} = 0	V_{CES}	max.	40	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4.5	V

Current

Collector current (peak value; t = 10 μs)	I_{CM}	max.	500	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	$R_{th\ j\text{-}a}$	=	0.48	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0.15	°C/mW

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

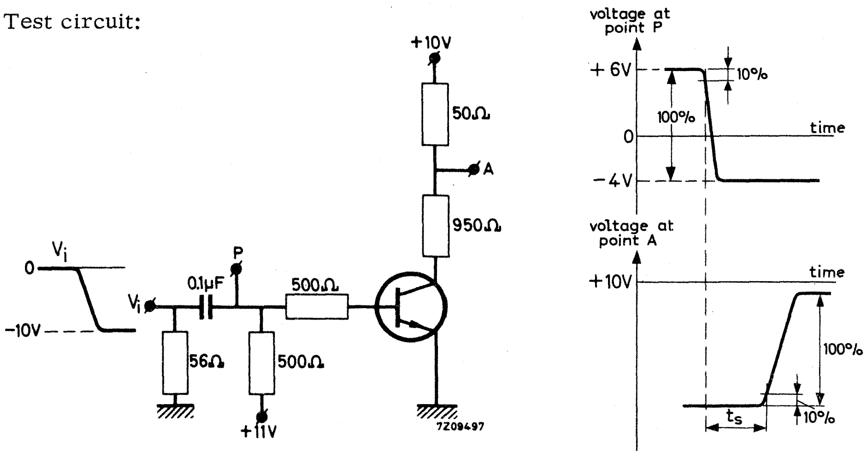
CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 20$ V	I_{CBO}	<	400	nA
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 150$ °C	I_{CBO}	<	30	μA
$V_{BE} = 0$; $V_{CE} = 15$ V; $T_j = 55$ °C	I_{CES}	<	0.40	μA
$V_{BE} = 0$; $V_{CE} = 40$ V	I_{CES}	<	1.0	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 4.5$ V	I_{EBO}	<	10	μA
Currents at reverse biased emitter junction				
$V_{CE} = 15$ V; $-V_{BE} = 3$ V; $T_j = 55$ °C	I_{CEX}	<	0.60	μA
	$-I_{BEX}$	<	0.60	μA
Sustaining voltages				
$I_C = 10$ mA; $I_B = 0$	$V_{CEOsust}$	>	15	V
$I_C = 10$ mA; $R_{BE} = 10\ \Omega$	$V_{CERsust}$	>	20	V
Base-emitter voltage (see also page 8)				
$I_C = 30\ \mu$A; $V_{CE} = 20$ V; $T_j = 100$ °C	V_{BE}	>	0.35	V
Saturation voltages				
$I_C = 10$ mA; BSX19: $I_B = 0.6$ mA; BSX20: $I_B = 0.3$ mA	V_{CEsat}	<	0.3	V
$I_C = 10$ mA; $I_B = 1$ mA	V_{CEsat}	<	0.25	V
	V_{BEsat}		0.70 to 0.85	V
$I_C = 100$ mA; $I_B = 10$ mA	V_{CEsat}	<	0.60	V
	V_{BEsat}	<	1.50	V
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	<	4	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 1$ V	C_e	<	4.5	pF

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

		BSX19	BSX20	
D.C. current gain				
I_C = 10 mA; V_{CE} = 1 V	h_{FE}	20 to 60	40 to 120	
I_C = 10 mA; V_{CE} = 1 V; T_j = −55 °C	h_{FE}	> 10	20	
I_C = 100 mA; V_{CE} = 2 V	h_{FE}	> 10	20	
Transition frequency				
I_C = 10 mA; V_{CE} = 10 V	f_T	> 400	500	MHz
		typ. 500	600	MHz
Switching times				
Storage time (see also pages 20 and 21)				
$I_C = I_B = -I_{BM}$ = 10 mA	t_s	typ. 5	6	ns
		< 10	13	ns

Test circuit:



Pulse generator:

Rise time	t_r	<	1	ns
Pulse duration	t	>	300	ns
Duty cycle	δ	<	0.02	
Source impedance	R_S	=	50	Ω

Oscilloscope:

Input impedance	R_i	=	50	Ω
Rise time	t_r	<	1	ns

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

Switching times

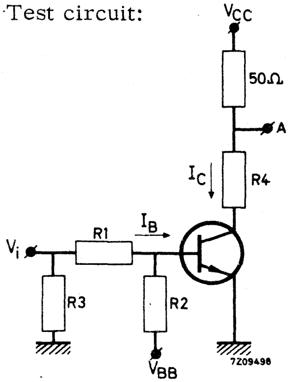
Turn on time (see also pages 14 and 15)

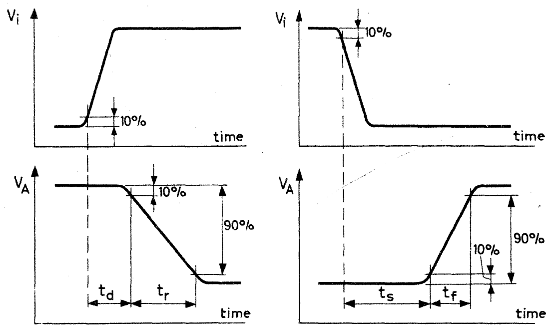
from $-V_{BE}$ = 1.5 V to I_C = 10 mA; I_B = 3 mA		t_{on}	< 12	ns
from $-V_{BE}$ = 2.25 V to I_C = 100 mA; I_B = 40 mA		t_{on}	< 7	ns

Turn off time (see also pages 16 to 19)

from I_C = 10 mA; I_B = 3 mA	BSX19	t_{off}	< 15	ns
to cut-off with $-I_{BM}$ = 1.5 mA	BSX20	t_{off}	< 18	ns
from I_C = 100 mA; I_B = 40 mA to cut-off	BSX19	t_{off}	< 18	ns
with $-I_{BM}$ = 20 mA	BSX20	t_{off}	< 21	ns

Test circuit:





Pulse generator:

Rise time	t_r	<	1	ns
Pulse duration	t	>	300	ns
Duty cycle	δ	<	0.02	
Source impedance	R_S	=	50	Ω

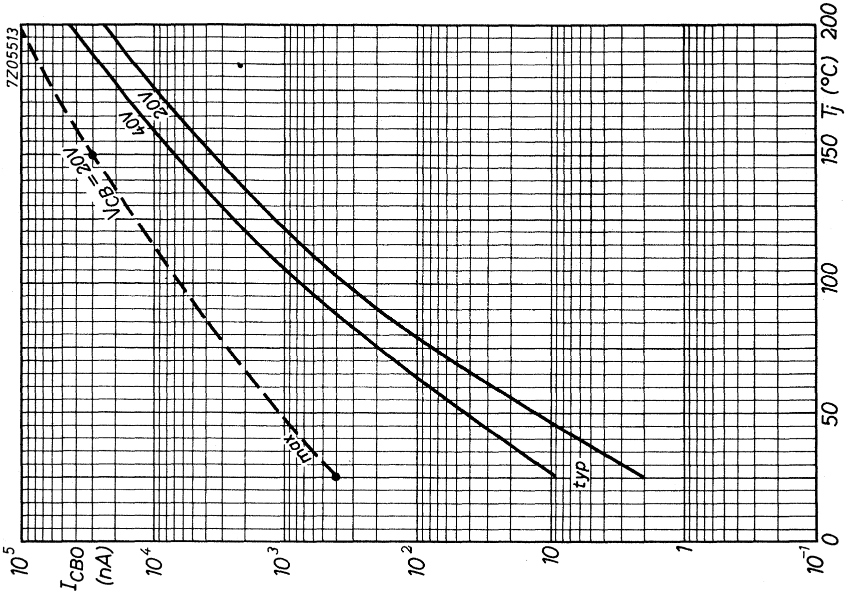
Oscilloscope:

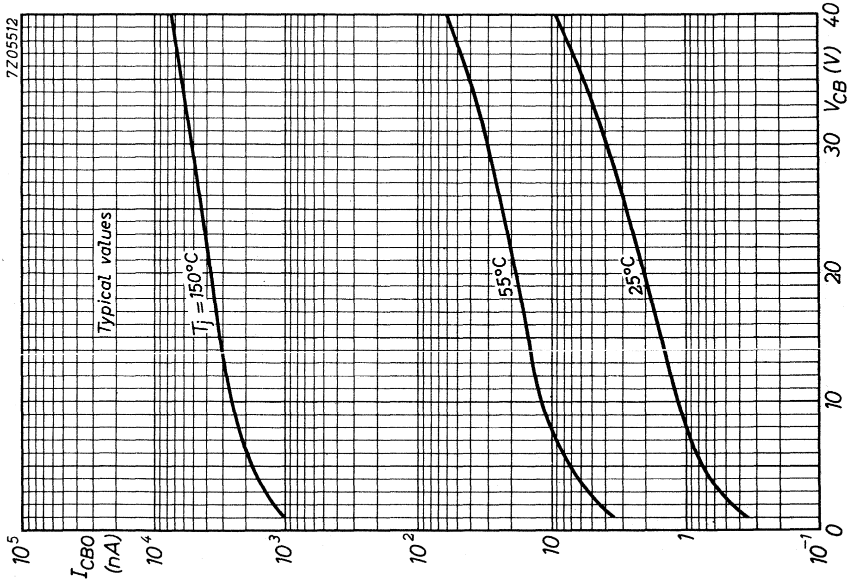
Input impedance	R_i	=	50	Ω
Rise time	t_r	<	1	ns

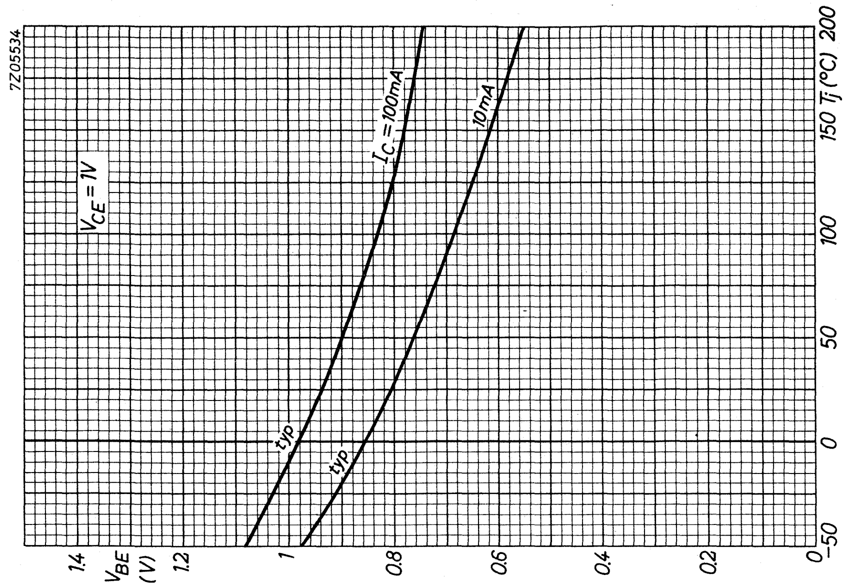
							turn on time			turn off time	
I_C (mA)	I_B (mA)	$-I_{BM}$ (mA)	V_{CC} (V)	R1;R2 (kΩ)	R3 (Ω)	R4 (Ω)	$-V_{BB}$ (V)	$-V_{BE}$ (V)	V_i (V)	V_{BB} (V)	$-V_i$ (V)
10	3	1.5	3	3.3	50	220	3.0	1.5	15	12.0	15
100	40	20	6	0.33	56	0	4.5	2.25	20	15.3	20

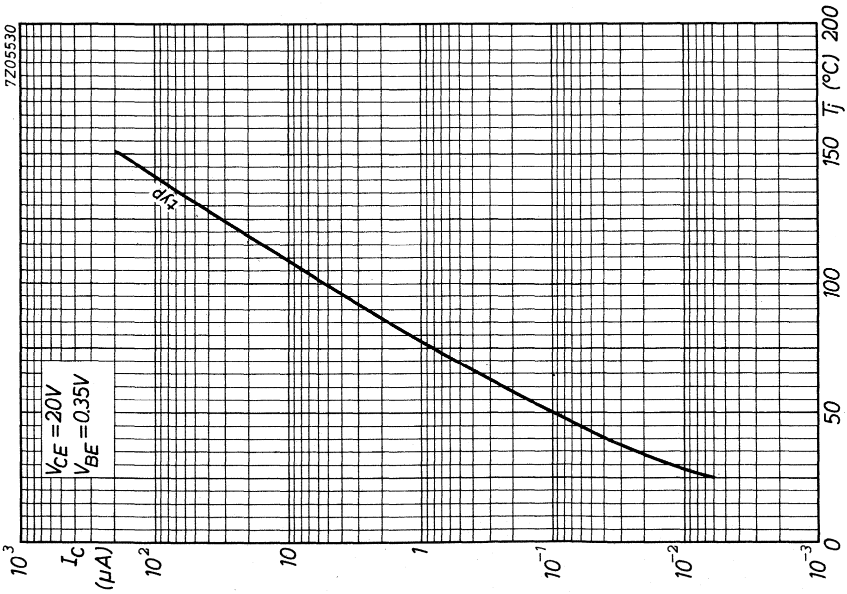
Note

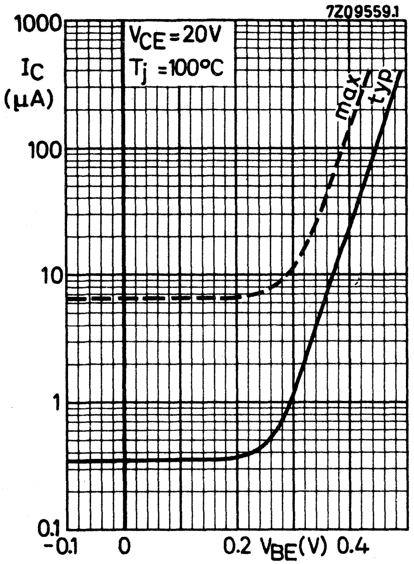
$-I_{BM}$ is the reverse current that can flow during switching off. The indicated $-I_{BM}$ is determined and limited by the applied cut-off voltage and series resistance.

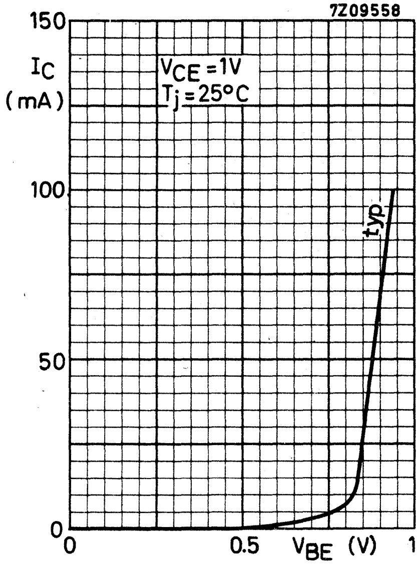

7Z05513
I_{CBO} (nA)
T_j (°C)
V_{CB} = 20V
40V
20V
max
typ

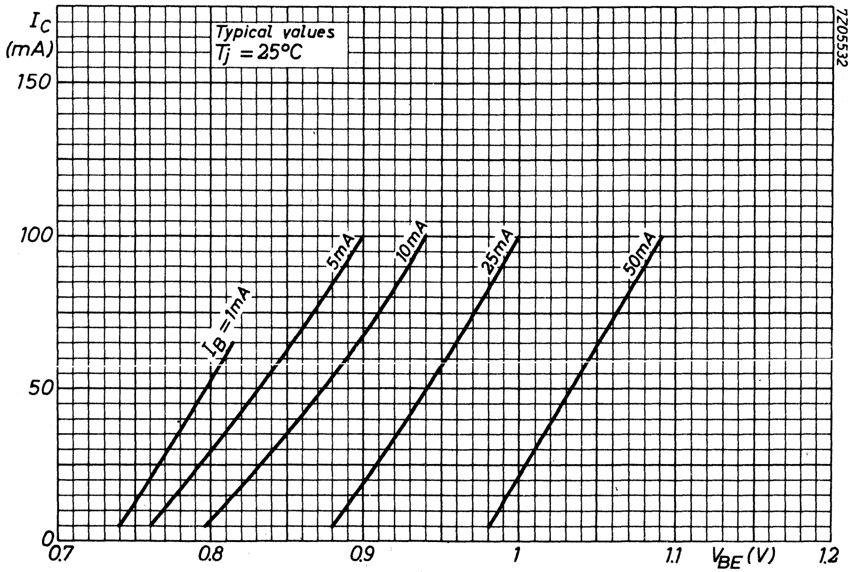

7Z05512
Typical values
T_j = 150°C
55°C
25°C
I_{CBO} (nA)
V_{CB} (V)

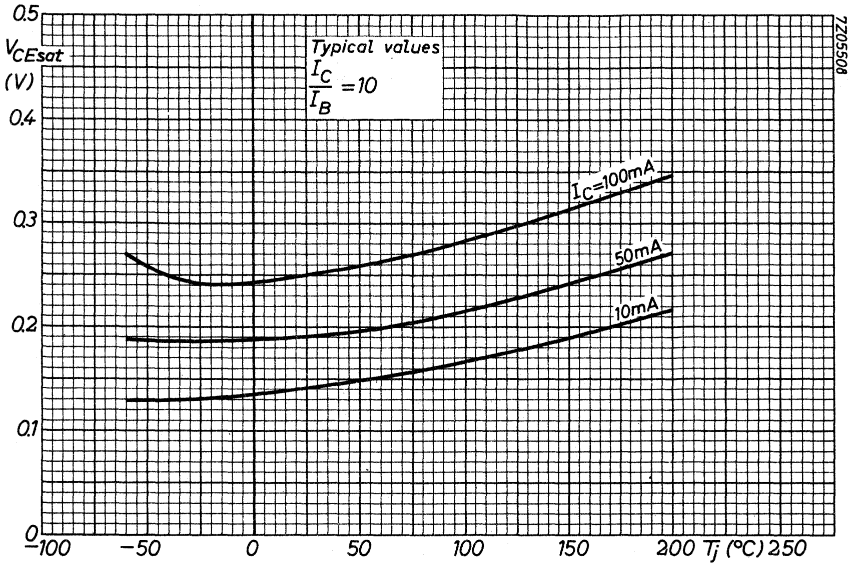

7Z05534
V_{CE} = 1V
I_C = 100mA
10mA
typ
typ
1.4
V_{BE} (V)
1.2
1
0.8
0.6
0.4
0.2
0
−50
0
50
100
150
200
T_j (°C)

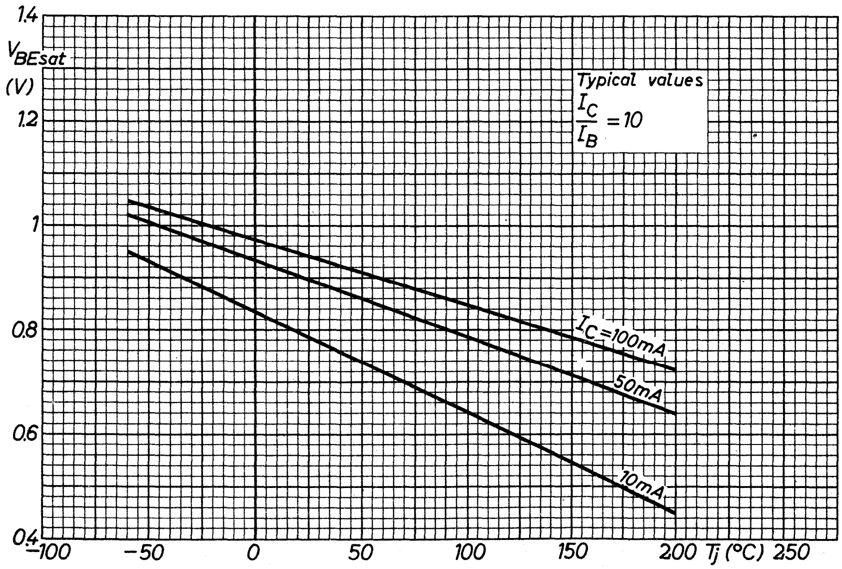

7Z05530
V_{CE} = 20V
V_{BE} = 0.35V
typ
10^3
I_C (μA)
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
0
50
100
150
200
T_j (°C)

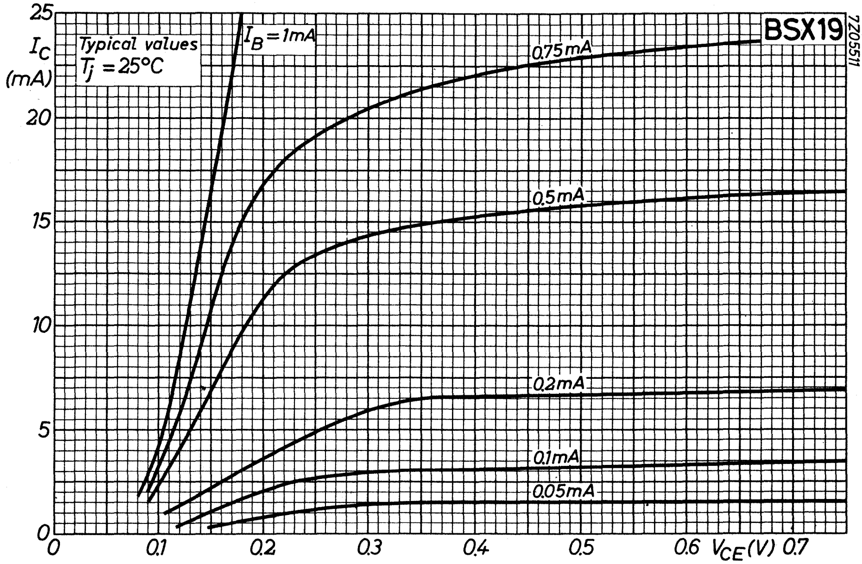

7Z09559.1
1000
I_C
(μA)
100
10
1
0.1
V_{CE} = 20V
T_j = 100°C
max
typ
-0.1
0
0.2
V_{BE}(V)
0.4

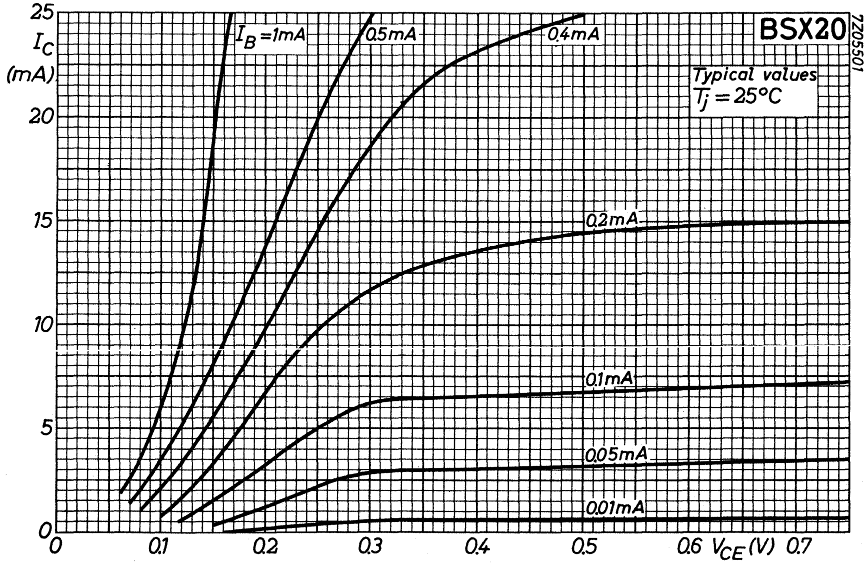

7Z09558
150
I_C
(mA)
100
50
0
V_{CE} = 1V
T_j = 25°C
typ
0
0.5
V_{BE} (V)
1

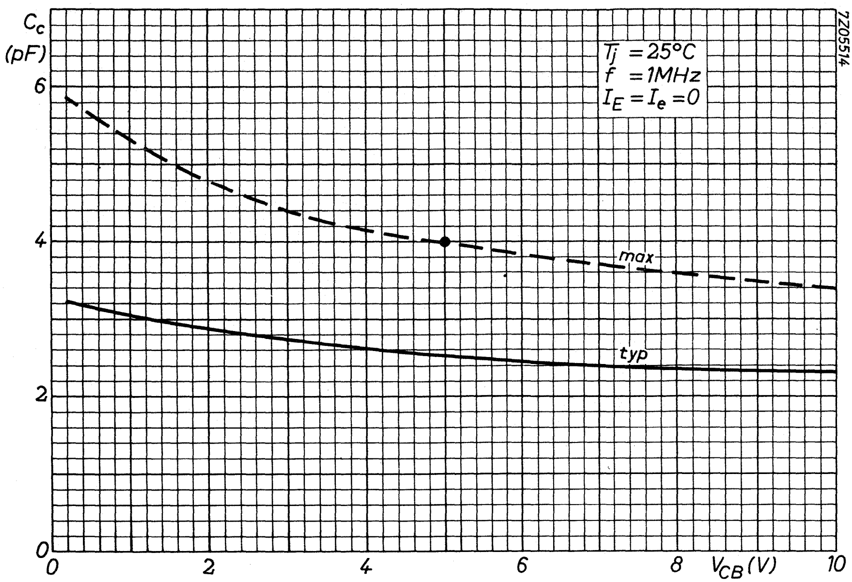

7Z05532
I_C
(mA)
150
100
50
0
Typical values
T_j = 25°C
I_B = 1mA
5mA
10mA
25mA
50mA
0.7
0.8
0.9
1
1.1
V_{BE} (V)
1.2

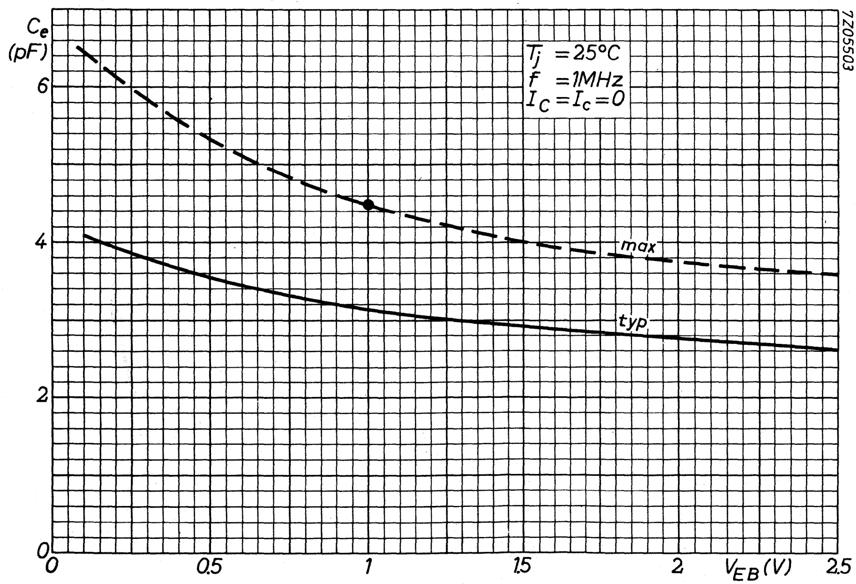

0.5
V_{CEsat}
(V)
0.4
0.3
0.2
0.1
0
Typical values
$\frac{I_C}{I_B} = 10$
I_C=100mA
50mA
10mA
7Z05508
−100
−50
0
50
100
150
200
T_j (°C)
250

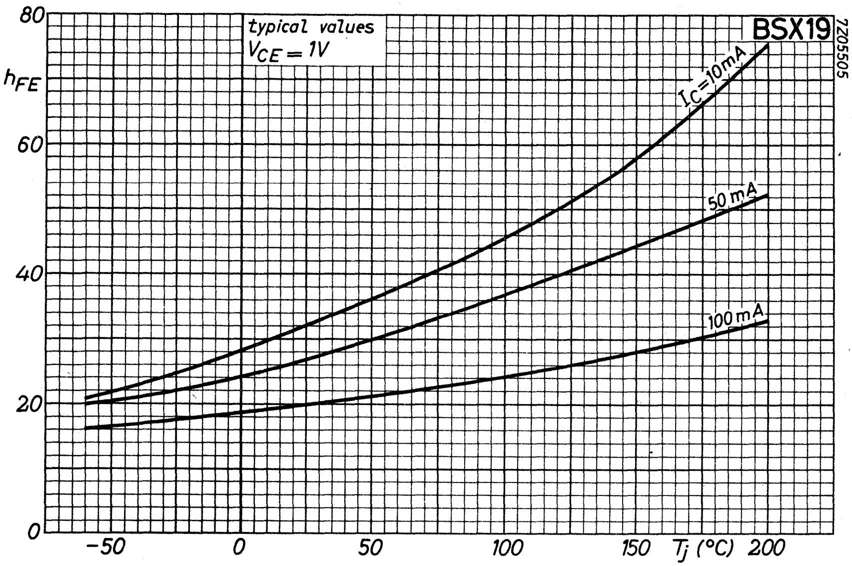

1.4
V_{BEsat}
(V)
1.2
1
0.8
0.6
0.4
Typical values
$\frac{I_C}{I_B} = 10$
I_C=100mA
50mA
10mA
−100
−50
0
50
100
150
200
T_j (°C)
250


25
I_C
(mA)
20
15
10
5
0
0
0.1
0.2
0.3
0.4
0.5
0.6
V_{CE}(V)
0.7
Typical values
T_j = 25°C
I_B = 1mA
0.75mA
0.5mA
0.2mA
0.1mA
0.05mA
BSX19
7Z05511

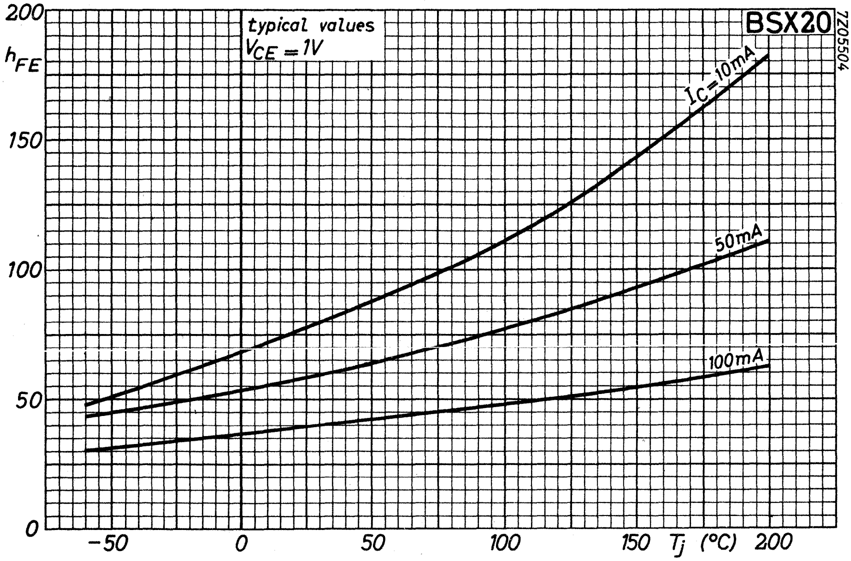

25
I_C
(mA)
20
15
10
5
0
0
0.1
0.2
0.3
0.4
0.5
0.6
V_{CE}(V)
0.7
I_B = 1mA
0.5mA
0.4mA
0.2mA
0.1mA
0.05mA
0.01mA
BSX20
Typical values
T_j = 25°C
7Z05501


C_c
(pF)
6
4
2
0
0
2
4
6
8
V_{CB} (V)
10
7Z05514
T_j = 25°C
f = 1MHz
$I_E = I_e = 0$
max
typ

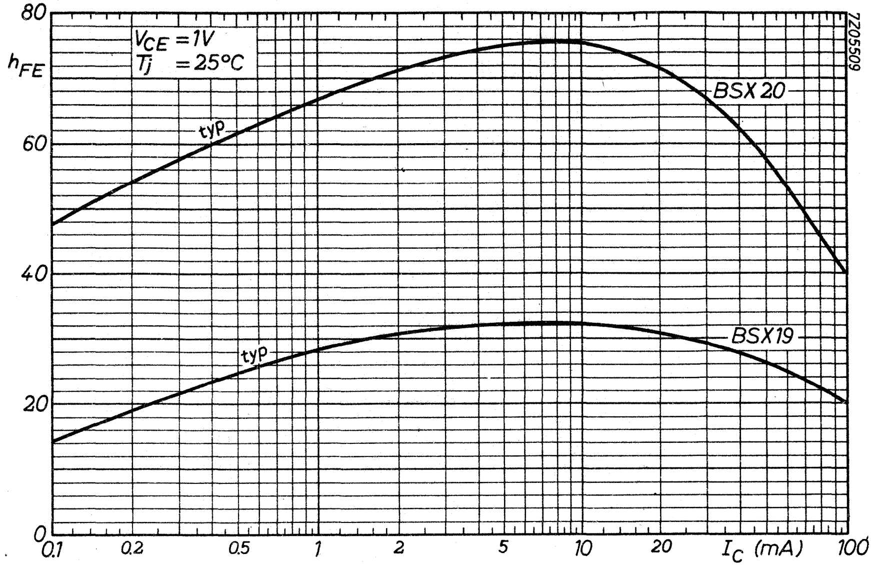

C_e
(pF)
6
4
2
0
0
0.5
1
1.5
2
V_{EB} (V)
2.5
7Z05503
T_j = 25°C
f = 1MHz
$I_C = I_c = 0$
max
typ

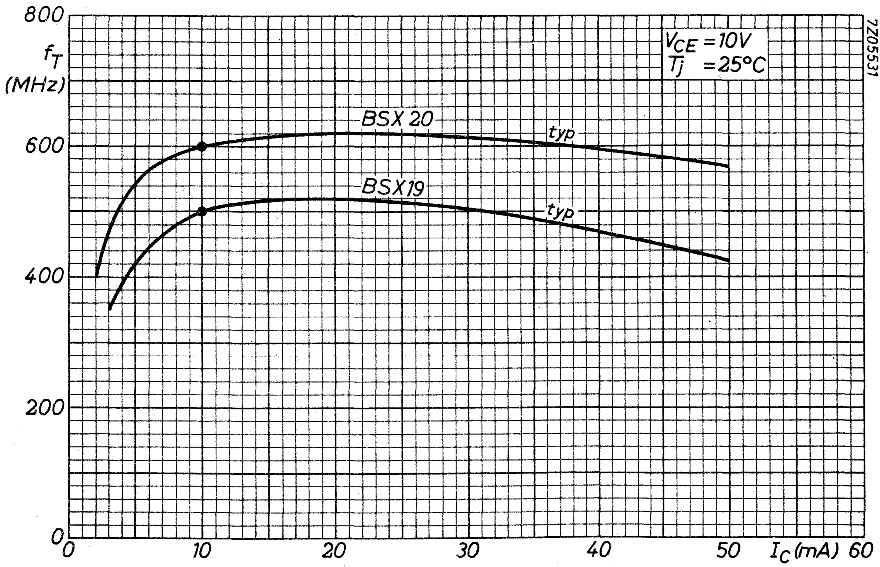


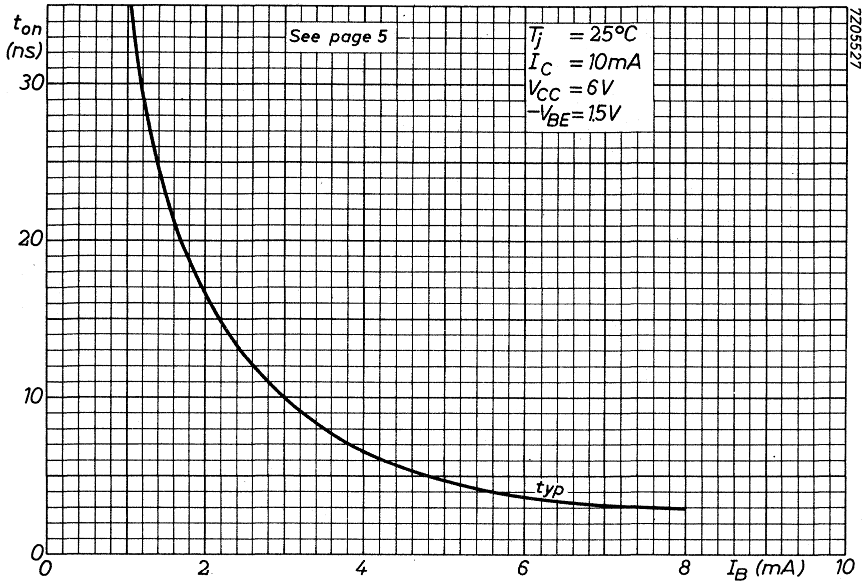
typical values
$V_{CE} = 1V$
BSX19
7Z05505
h_{FE}
80
60
40
20
0
$I_C = 10mA$
50 mA
100 mA
−50
0
50
100
150
T_j (°C)
200

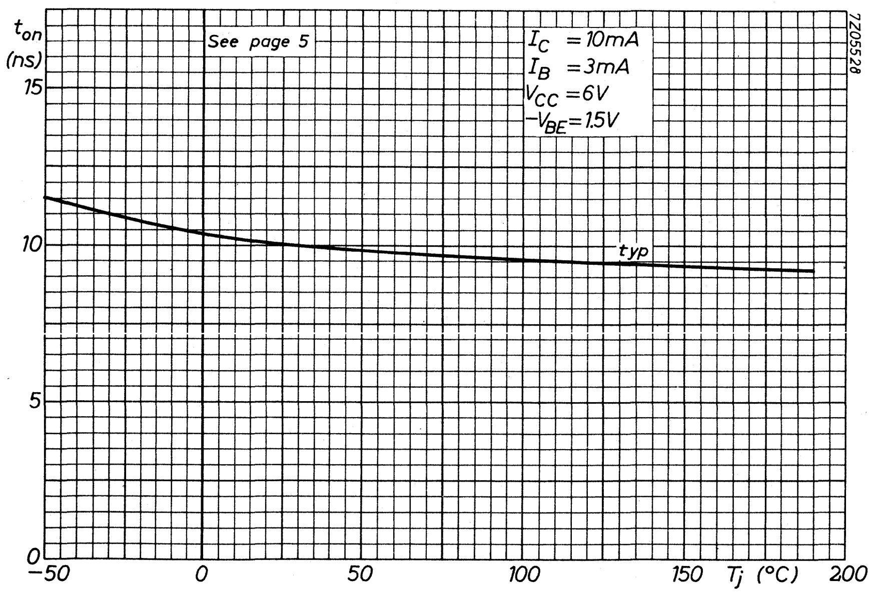


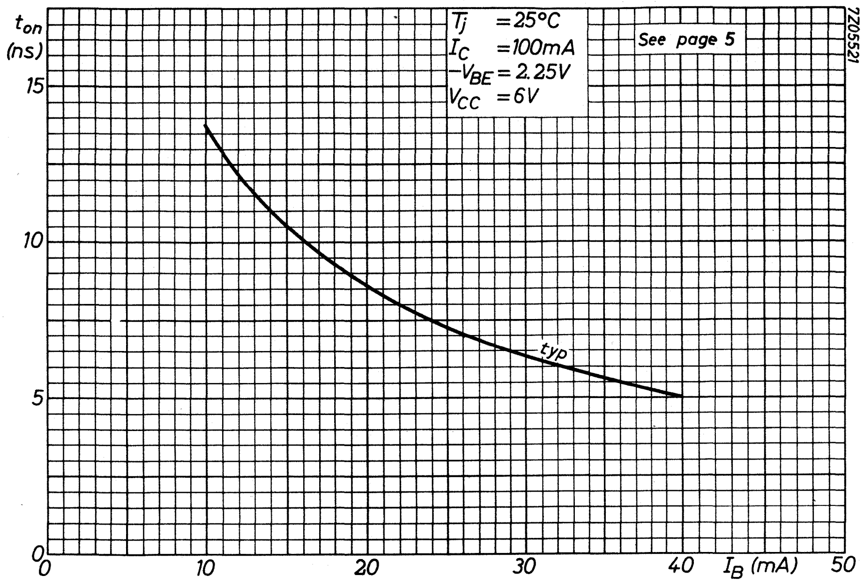
typical values
$V_{CE} = 1V$
BSX20
7Z05504
h_{FE}
200
150
100
50
0
$I_C = 10mA$
50mA
100mA
−50
0
50
100
150
T_j (°C)
200

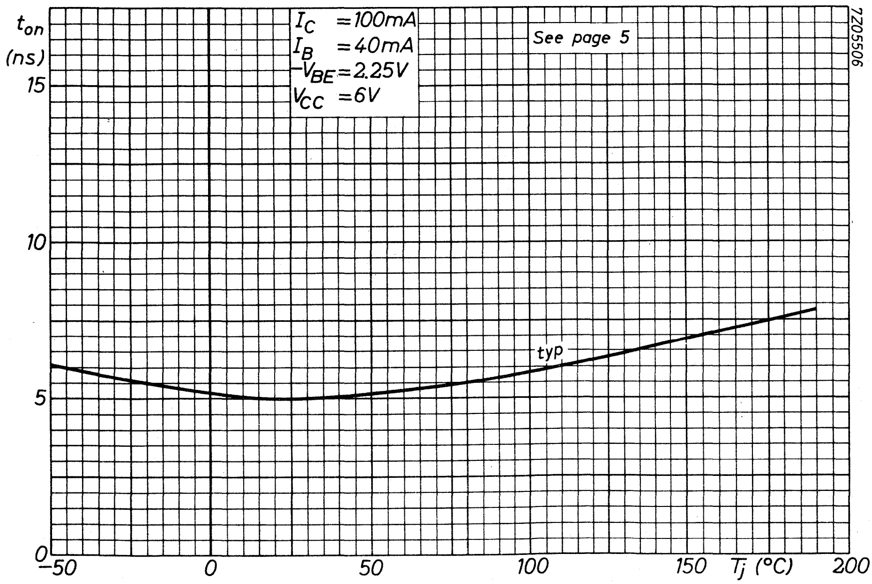

80
60
40
20
0
h_{FE}
V_{CE} = 1V
Tj = 25°C
typ
typ
BSX 20
BSX19
7Z05509
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100

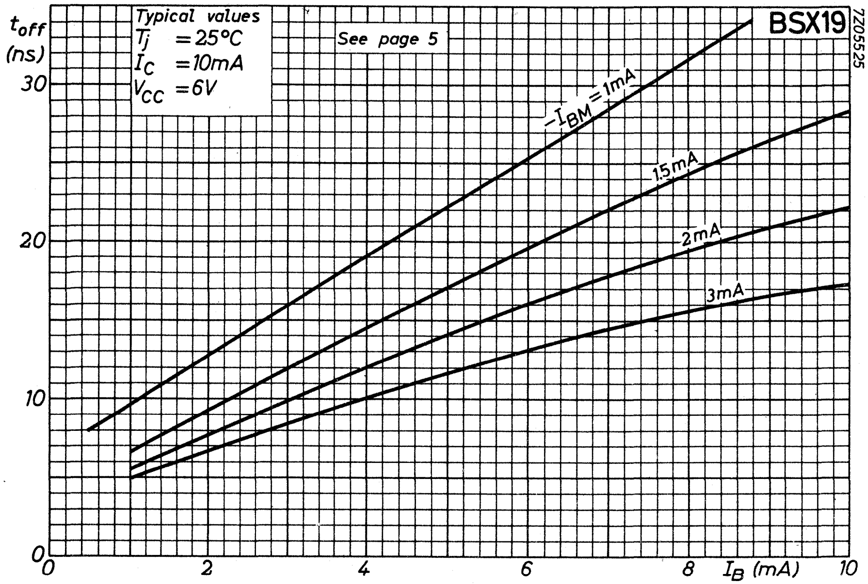

800
600
400
200
0
f_T
(MHz)
V_{CE} = 10V
Tj = 25°C
7Z05531
BSX 20
BSX19
typ
typ
0
10
20
30
40
50
I_C (mA)
60

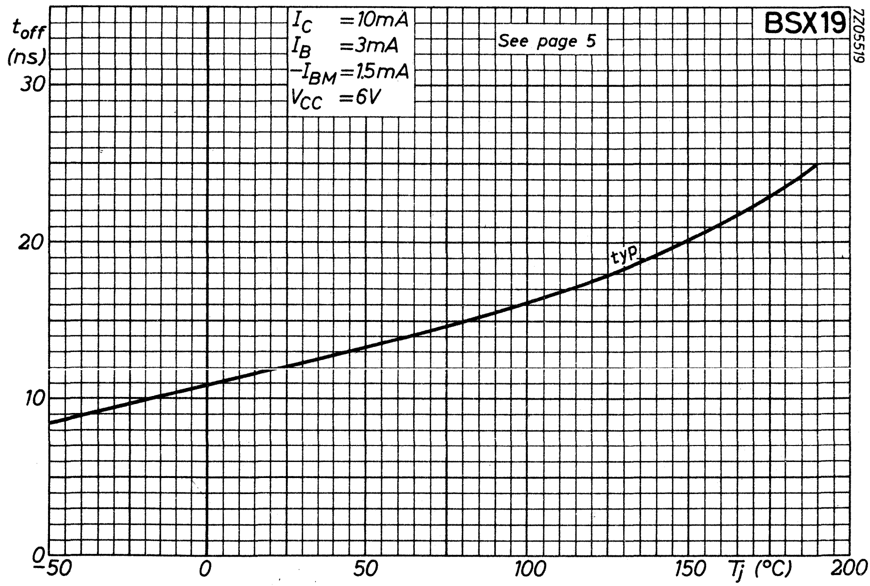

t_{on} (ns)
30
20
10
0
See page 5
T_j = 25°C
I_C = 10mA
V_{CC} = 6V
$-V_{BE}$ = 1.5V
7Z05527
typ
0
2
4
6
8
I_B (mA)
10

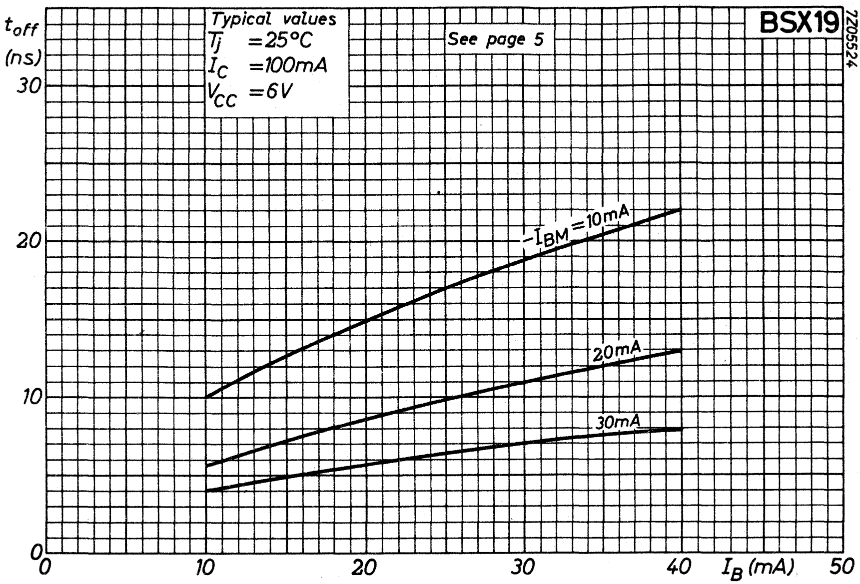

t_{on} (ns)
15
10
5
0
See page 5
I_C = 10mA
I_B = 3mA
V_{CC} = 6V
$-V_{BE}$ = 1.5V
7Z05528
typ
−50
0
50
100
150
T_j (°C)
200

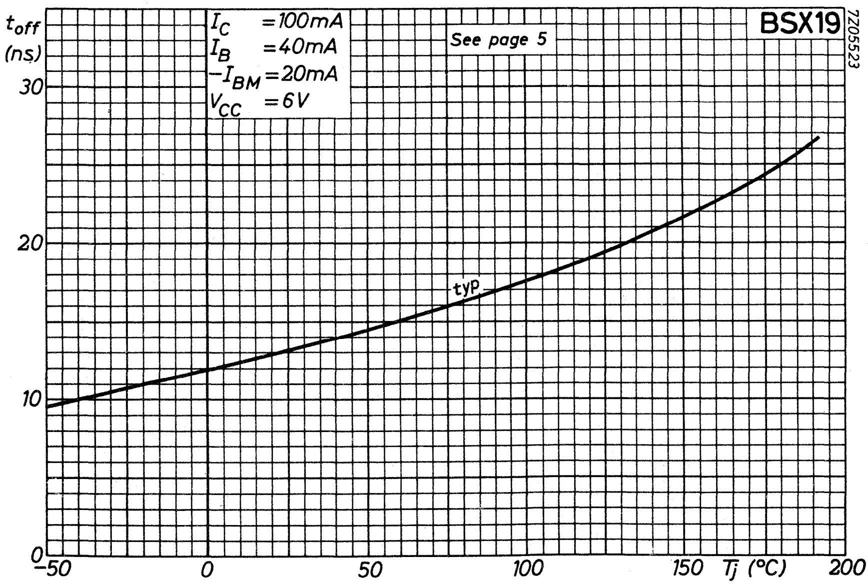

t_{on}
(ns)
15
10
5
0
0
10
20
30
40
I_B (mA)
50
T_j = 25°C
I_C = 100mA
$-V_{BE}$ = 2.25V
V_{CC} = 6V
See page 5
typ
7Z05521

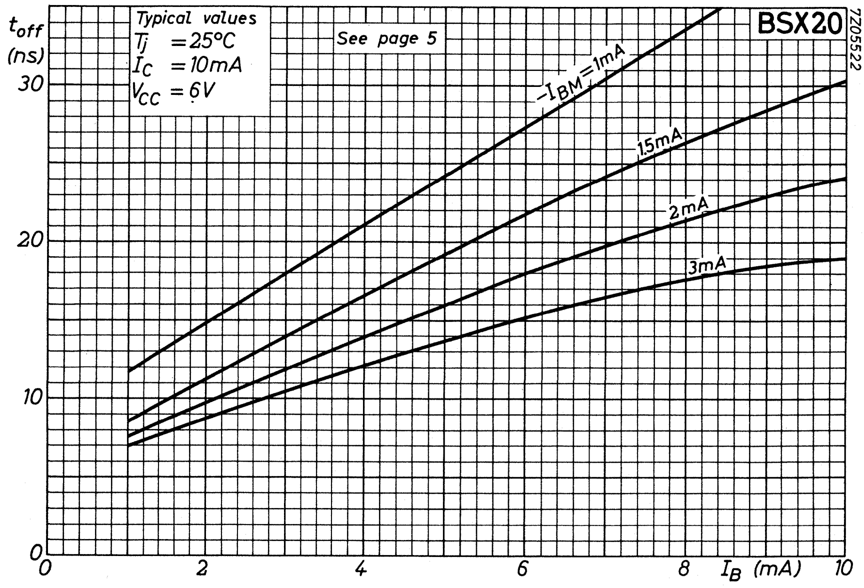

t_{on}
(ns)
15
10
5
0
−50
0
50
100
150
T_j (°C)
200
I_C = 100mA
I_B = 40mA
$-V_{BE}$ = 2.25V
V_{CC} = 6V
See page 5
typ
7Z05506

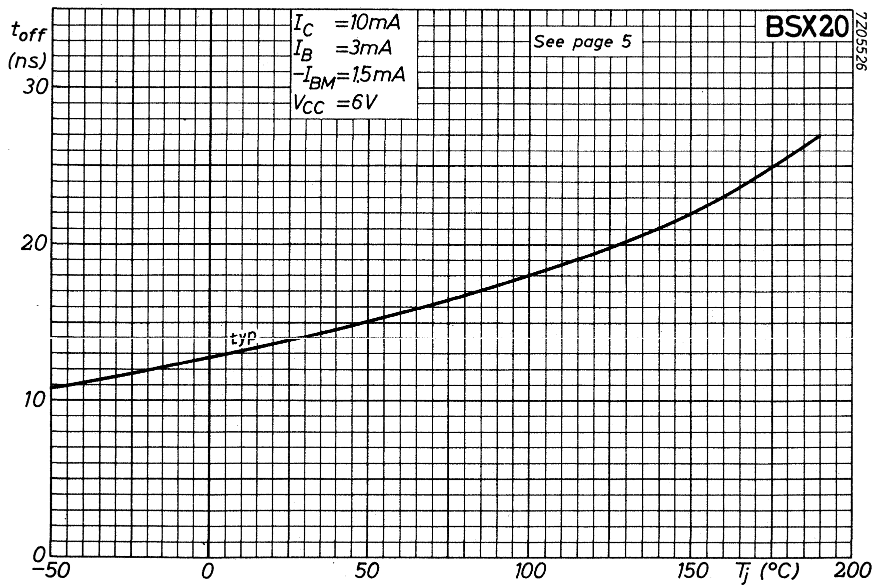

t_{off} (ns)
Typical values
T_j = 25°C
I_C = 10mA
V_{CC} = 6V
See page 5
BSX19
7205525
$-I_{BM}$ = 1mA
1.5mA
2mA
3mA
I_B (mA)
0
2
4
6
8
10
20
30

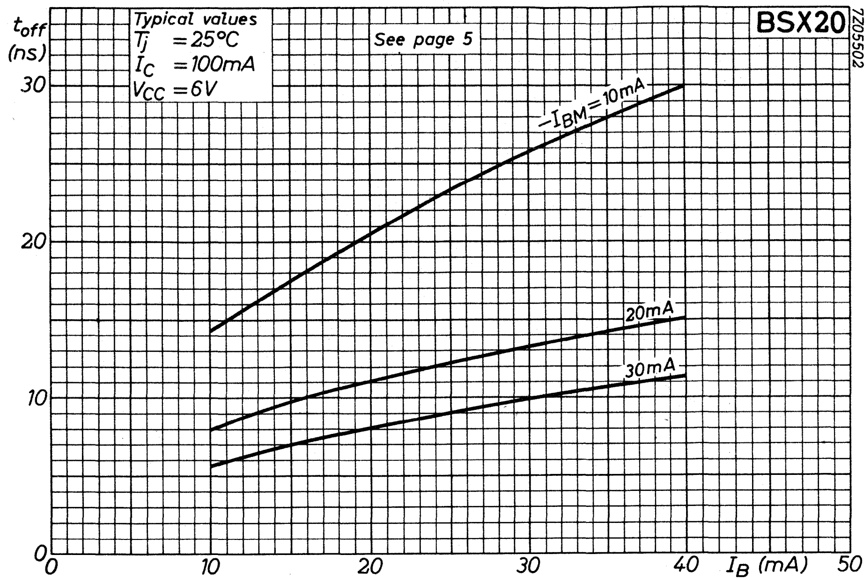

t_{off} (ns)
I_C = 10mA
I_B = 3mA
$-I_{BM}$ = 1.5mA
V_{CC} = 6V
See page 5
BSX19
7205519
typ
T_j (°C)
−50
0
50
100
150
200
10
20
30


t_{off} (ns)
Typical values
T_j = 25°C
I_C = 100mA
V_{CC} = 6V
See page 5
BSX19
7205524
$-I_{BM}$ = 10mA
20mA
30mA
0
10
20
30
40
50
I_B (mA)

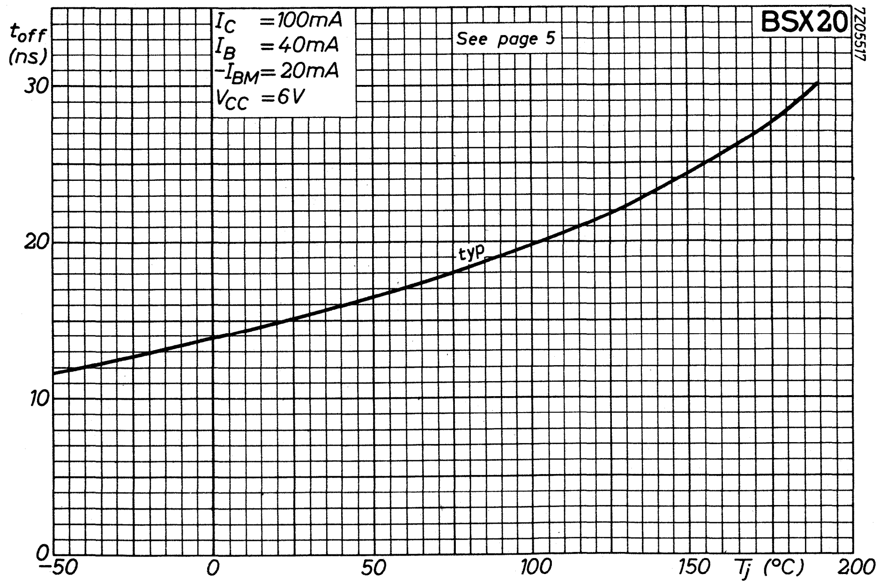

t_{off} (ns)
I_C = 100mA
I_B = 40mA
$-I_{BM}$ = 20mA
V_{CC} = 6V
See page 5
BSX19
7205523
typ
0
10
20
30
−50
50
100
150
200
T_j (°C)


t_off (ns)
Typical values
Tj = 25°C
IC = 10mA
VCC = 6V
See page 5
BSX20
7Z05522
−IBM = 1mA
1.5mA
2mA
3mA
IB (mA)
0
10
20
30
2
4
6
8
10

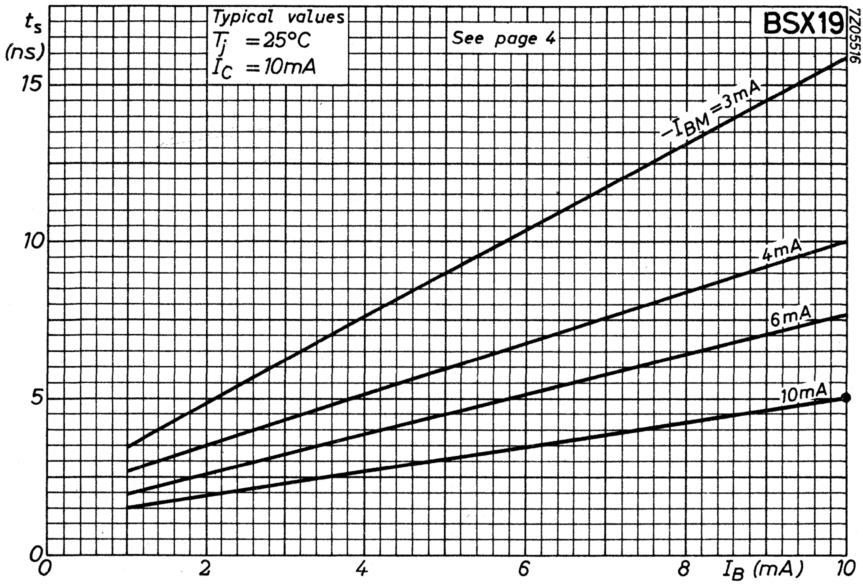

t_off (ns)
IC = 10mA
IB = 3mA
−IBM = 1.5mA
VCC = 6V
See page 5
BSX20
7Z05526
typ
Tj (°C)
0
10
20
30
−50
50
100
150
200

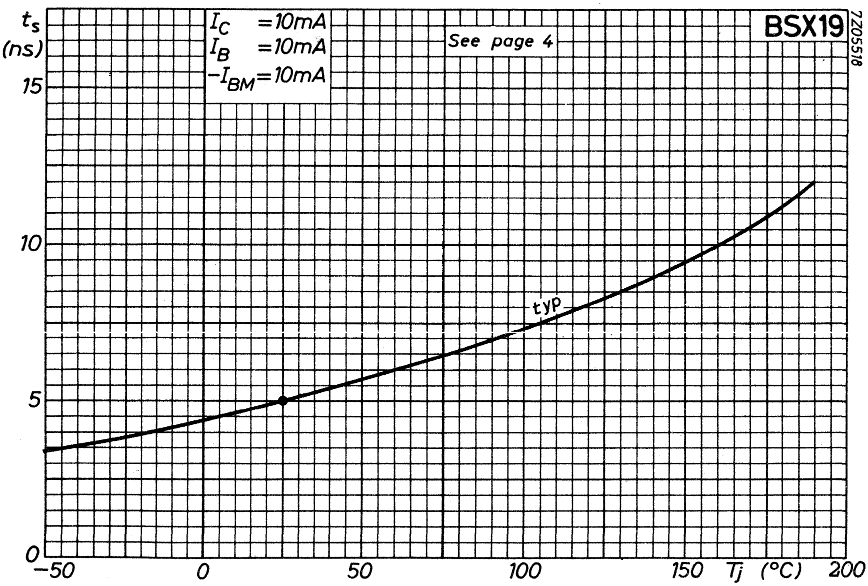


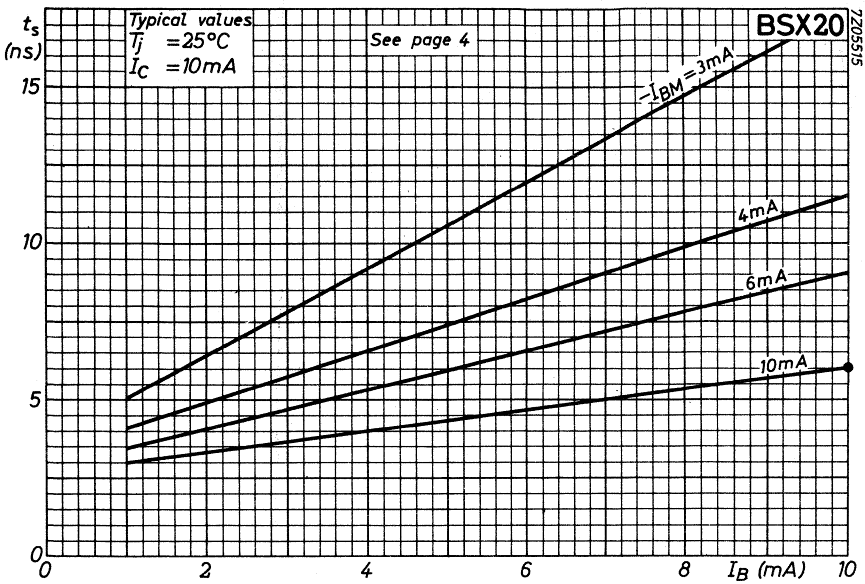
BSX20
7Z05502
Typical values
T_j = 25°C
I_C = 100mA
V_{CC} = 6V
See page 5
t_{off} (ns)
$-I_{BM}$ = 10mA
20mA
30mA
0
10
20
30
40
50
I_B (mA)

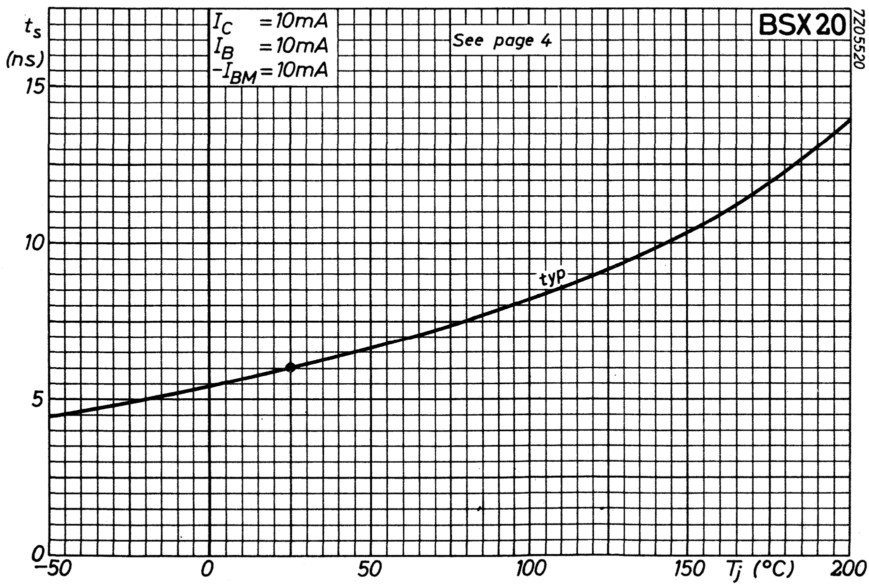


BSX20
7Z05517
I_C = 100mA
I_B = 40mA
$-I_{BM}$ = 20mA
V_{CC} = 6V
See page 5
t_{off} (ns)
typ
−50
0
50
100
150
200
T_j (°C)
10
20
30


Typical values
T_j = 25°C
I_C = 10mA
See page 4
BSX19
7Z05516
t_s (ns)
$-I_{BM}$=3mA
4mA
6mA
10mA
I_B (mA)
0
2
4
6
8
10
5
15

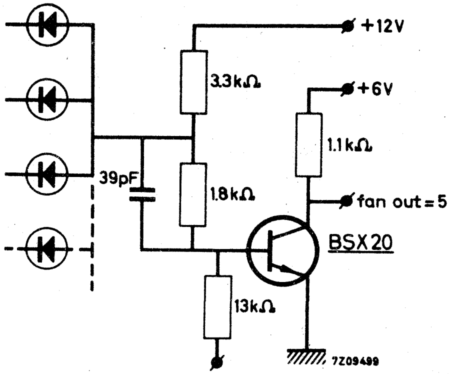

I_C = 10mA
I_B = 10mA
$-I_{BM}$ = 10mA
See page 4
BSX19
7Z05518
t_s (ns)
typ
T_j (°C)
−50
0
50
100
150
200
5
10
15


t_s (ns)
Typical values
T_j = 25°C
I_C = 10mA
See page 4
BSX20
7Z05515
$-I_{BM}$ = 3mA
4mA
6mA
10mA
I_B (mA)
0
2
4
6
8
10
5
15


t_s (ns)
I_C = 10mA
I_B = 10mA
$-I_{BM}$ = 10mA
See page 4
BSX20
7Z05520
typ
T_j (°C)
−50
0
50
100
150
200
5
10
15

APPLICATION INFORMATION

NAND gate circuit (Diode Transistor Logic)



Delay time per stage; fan in = 5 t_d typ. 15 ns

Note

Fan out = 5 means: The circuit may be loaded by maximum 5 circuits, each presenting a load identical to that of one input branch of the circuit itself.

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a TO-18 metal envelope, with the collector connected to the case.
It is primarily intended for driving numerical indicator tubes.

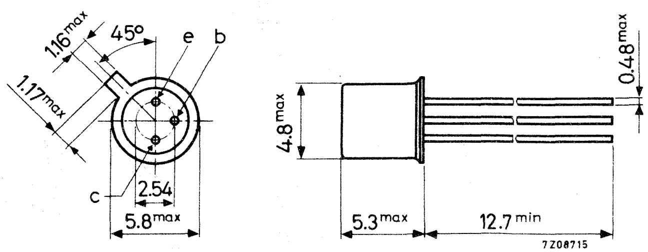
QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	80	V
Collector current (peak value)	I_{CM}	max.	250	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	mW
Junction temperature	T_j	max.	175	°C
D.C. current gain at T_j = 25 °C				
I_C = 4 mA; V_{CE} = 1 V	h_{FE}	> typ.	20 80	
Transition frequency at f = 35 MHz				
I_C = 4 mA; V_{CE} = 10 V	f_T	>	60	MHz

NOTE: The BSX21 may be operated in the breakdown region up to V_{CE} = 160 V, provided P_{tot} at T_{amb} = 85 °C does not exceed 100 mW.

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-18



Accessories available: 56246, 56263

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

Voltages				
Collector-base voltage (open emitter) I_C = 100 μA	V_{CBO}	max.	120	V [1]
Collector-emitter voltage (open base) I_C = 4 mA	V_{CEO}	max.	80	V [1]
Emitter-base boltage (open collector) I_E = 100 μA	V_{EBO}	max.	5	V
Currents				
Collector current (d.c. or average over any 20 ms period)	I_C	max.	100	mA
Collector current (peak value)	I_{CM}	max.	250	mA [2]
Emitter current (d.c. or average over any 20 ms period)	$-I_E$	max.	100	mA
Emitter current (peak value)	$-I_{EM}$	max.	250	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	$R_{th\ j\text{-}c}$	=	0.15	°C/mW

[1]) The BSX21 may be operated in the breakdown region up to V_{CE} = 160 V, provided P_{tot} at T_{amb} = 85 °C does not exceed 100 mW.

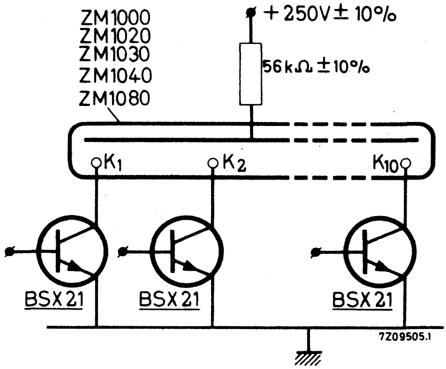
[2]) The transistor can withstand a capacitive load of 500 pF, combined with a collector-base voltage of max. 150 V before switching on.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

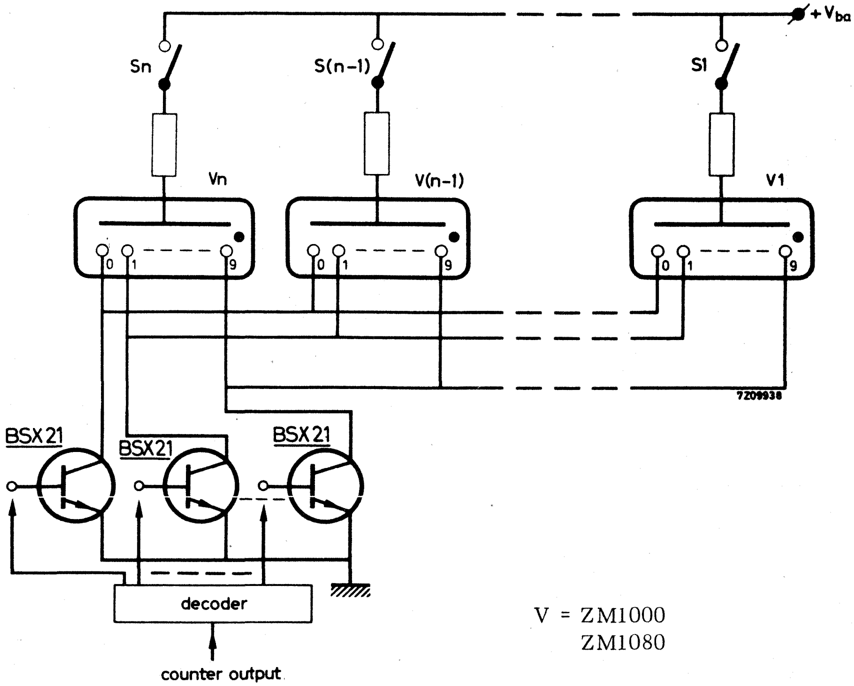
Collector cut-off current				
I_E = 0; V_{CB} = 90 V	I_{CBO}	typ.	1	nA
		<	200	nA
I_E = 0; V_{CB} = 90 V; T_j = 150 °C	I_{CBO}	typ.	0.25	μA
		<	50	μA
V_{BE} = 0; V_{CE} = 80 V; T_j = 85 °C	I_{CES}	typ.	0.01	μA
		<	20	μA
Emitter cut-off current				
I_C = 0; V_{EB} = 4 V	I_{EBO}	typ.	0.5	nA
		<	200	nA
I_C = 0; V_{EB} = 4 V; T_j = 150 °C	I_{EBO}	typ.	0.05	μA
		<	50	μA
Saturation voltages				
I_C = 4 mA; I_B = 400 μA	V_{CEsat}	<	0.7	V
	V_{BEsat}	<	1.2	V
D.C. current gain				
I_C = 1 mA; V_{CE} = 1 V	h_{FE}	typ.	60	
I_C = 4 mA; V_{CE} = 1 V	h_{FE}	>	20	
		typ.	80	
I_C = 10 mA; V_{CE} = 1 V	h_{FE}	typ.	82	
I_C = 20 mA; V_{CE} = 1 V	h_{FE}	typ.	55	
Collector capacitance at f = 1 MHz				
$I_E = I_e$ = 0; V_{CB} = 10 V	C_c	typ.	3.4	pF
		<	4.5	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c$ = 0; V_{EB} = 0.5 V	C_e	typ.	12	pF
		<	17	pF
Transition frequency at f = 35 MHz				
I_C = 4 mA; V_{CE} = 10 V	f_T	>	60	MHz
		typ.	160	MHz

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

Practical circuit for static operation

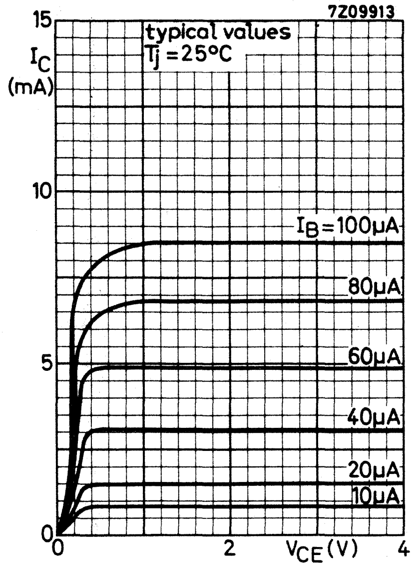


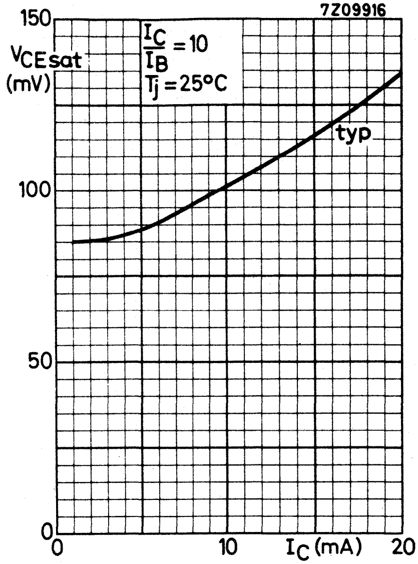
Practical circuit for dynamic operation

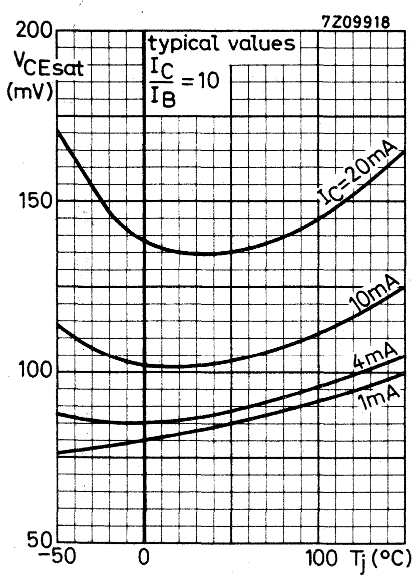


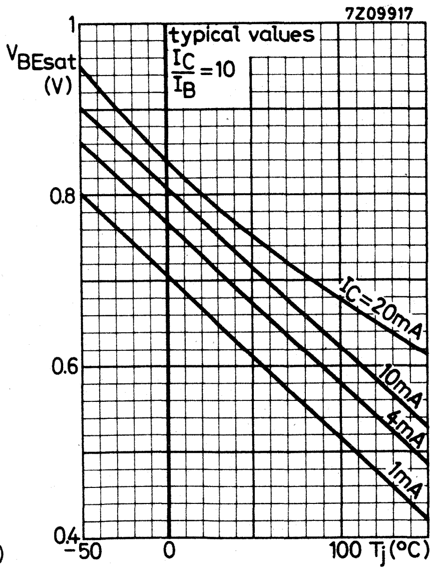
V = ZM1000
ZM1080

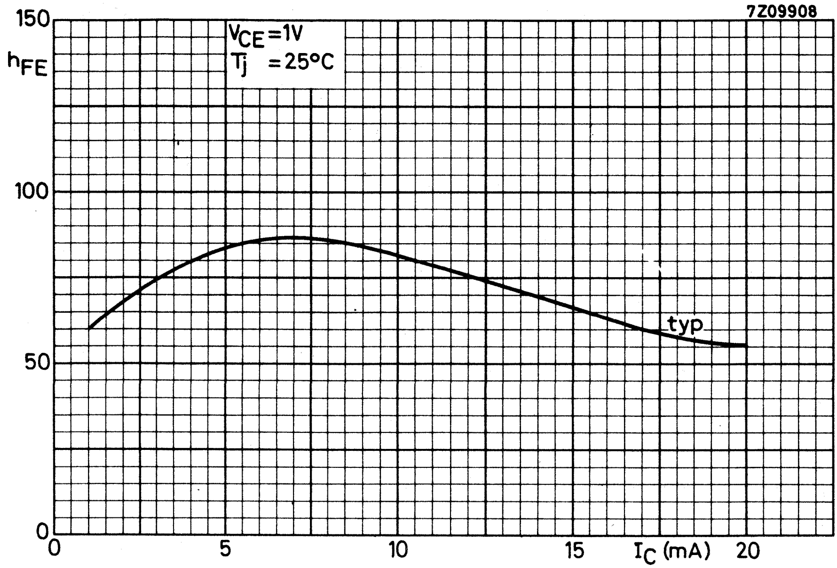
APPLICATION INFORMATION bulletins available on request

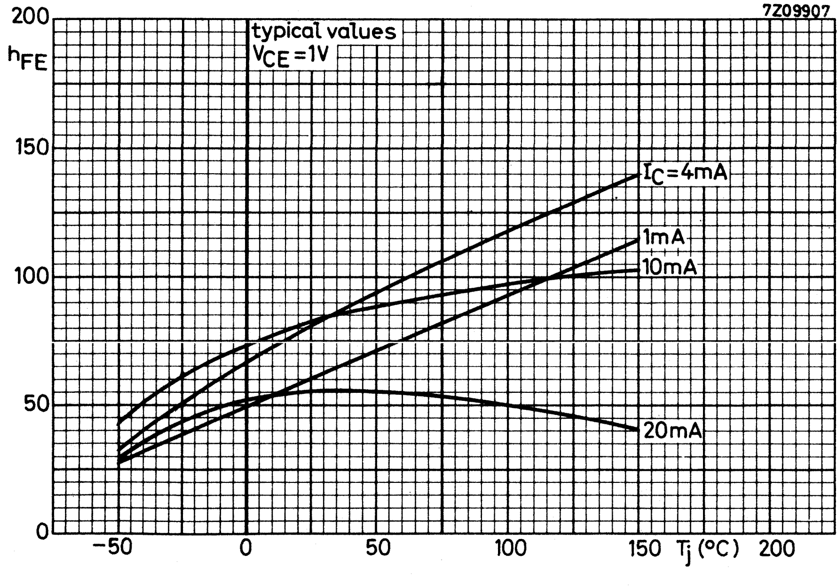

7Z09913
typical values
Tj = 25°C
IC
(mA)
15
10
5
0
IB = 100μA
80μA
60μA
40μA
20μA
10μA
0
2
VCE (V)
4

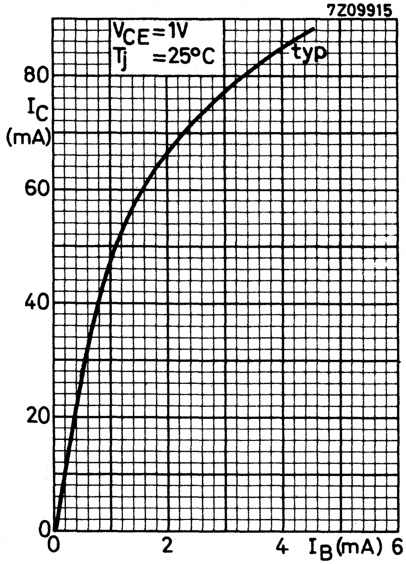

7Z09916
IC/IB = 10
Tj = 25°C
VCEsat
(mV)
150
100
50
0
typ
0
10
IC (mA)
20

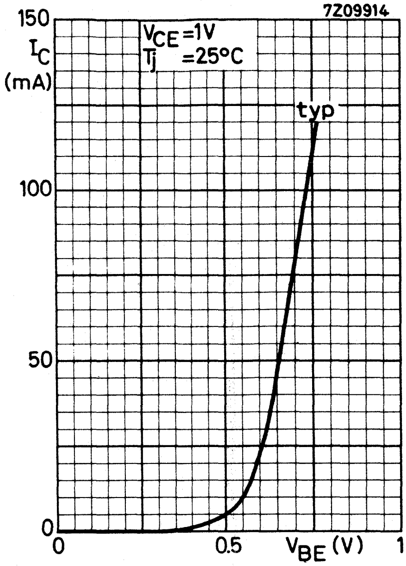

7Z09918
typical values
IC/IB = 10
VCEsat
(mV)
200
150
100
50
IC=20mA
10mA
4mA
1mA
−50
0
100
Tj (°C)

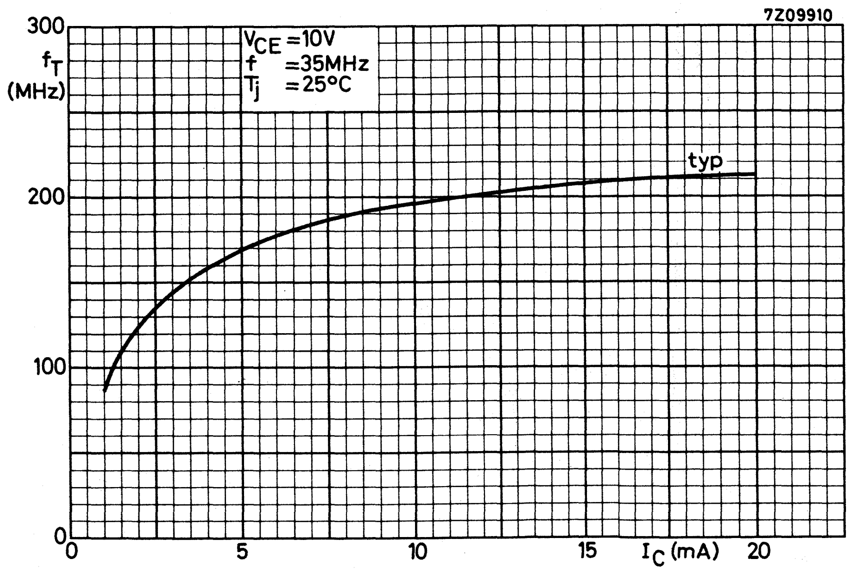

7Z09917
typical values
IC/IB = 10
VBEsat
(V)
1
0.8
0.6
0.4
IC=20mA
10mA
4mA
1mA
−50
0
100
Tj (°C)

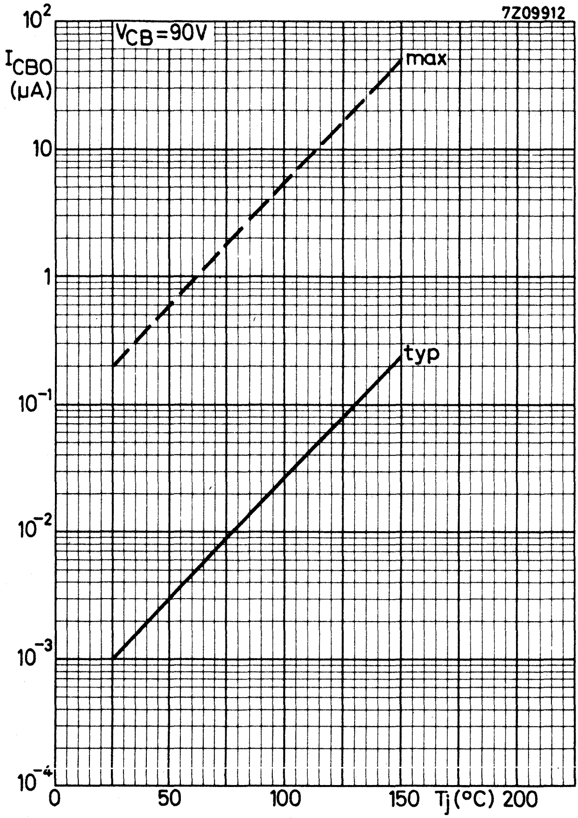

7Z09908
V_{CE} = 1V
T_j = 25°C
h_{FE}
150
100
50
0
typ
0
5
10
15
I_C (mA)
20

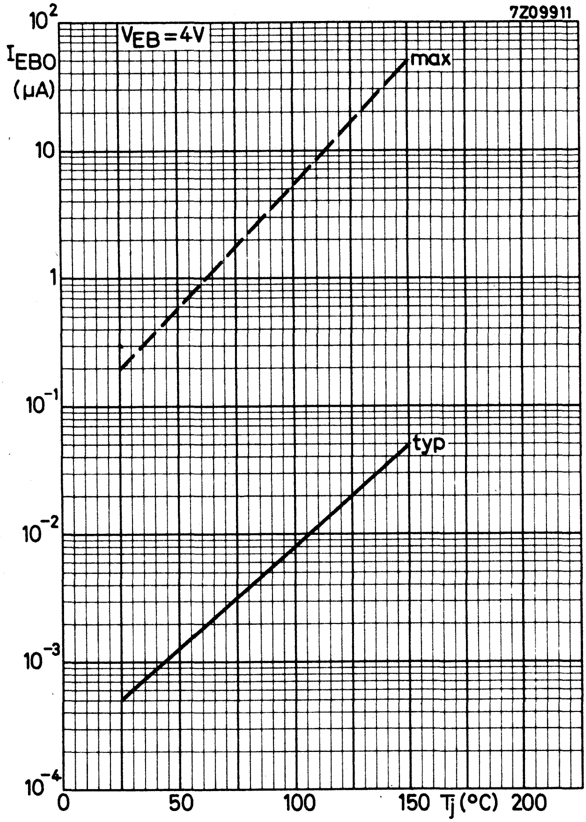

7Z09907
typical values
V_{CE} = 1V
h_{FE}
200
150
100
50
0
I_C = 4mA
1mA
10mA
20mA
−50
0
50
100
150
T_j (°C)
200

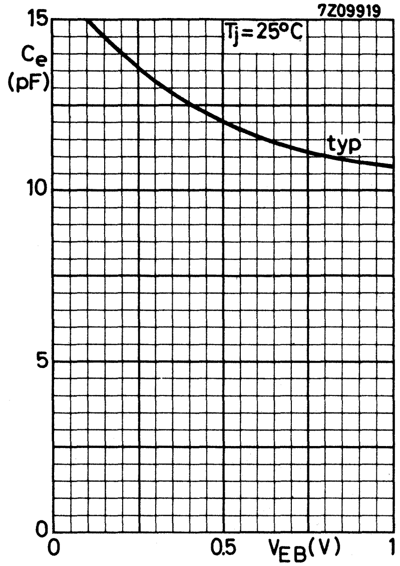

7Z09915
VCE = 1V
Tj = 25°C
typ
80
IC
(mA)
60
40
20
0
0
2
4
IB (mA)
6

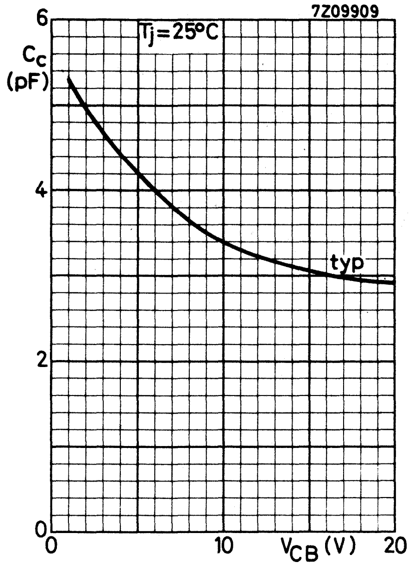

7Z09914
150
IC
(mA)
VCE = 1V
Tj = 25°C
typ
100
50
0
0
0.5
VBE (V)
1


7Z09910
300
fT
(MHz)
VCE = 10V
f = 35MHz
Tj = 25°C
typ
200
100
0
0
5
10
15
IC (mA)
20


7Z09912
V_{CB}=90V
I_{CBO} (μA)
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
max
typ
0
50
100
150
T_j(°C)
200


7Z09911
10^2
I_{EBO}
(μA)
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
$V_{EB} = 4V$
max
typ
0
50
100
150
T_j (°C)
200


7Z09919
Tj = 25°C
Ce
(pF)
typ
15
10
5
0
0
0.5
VEB (V)
1


7Z09909
Tj = 25°C
Cc
(pF)
typ
6
4
2
0
0
10
VCB (V)
20

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a TO-39 metal envelope with the collector connected to the case. The BSX59, BSX60 and BSX61 are primarily intended for very high speed core-driving purposes.

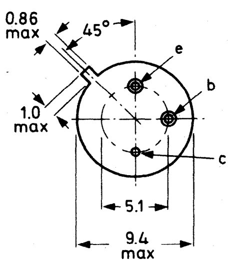
QUICK REFERENCE DATA

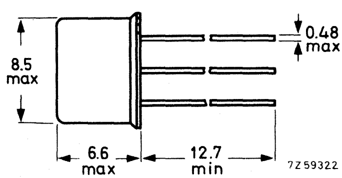
			BSX59	BSX60	BSX61	
Collector-base voltage (open emitter)	V_{CBO}	max.	70	70	70	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	30	45	V
Collector current (peak value)	I_{CM}	max.	1	1	1	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.8	0.8	0.8	W
Junction temperature	T_j	max.	200	200	200	°C
D.C. current gain I_C = 500 mA; V_{CE} = 1 V	h_{FE}	>	30	30	30	
Saturation voltage I_C = 500 mA; I_B = 50 mA	V_{CEsat}	<	0.5	0.5	0.7	V
Transition frequency I_C = 50 mA; V_{CE} = 10 V	f_T	typ.	450	475	475	MHz
Turn-off time I_C = 500 mA; I_B = 50 mA	t_{off}	<	60	70	100	ns

MECHANICAL DATA

Dimensions in mm

Collector connected to case.
TO-39





max. lead diameter is guaranteed only for 12.7 mm

Accessories available: 56218; 56245.

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

Voltages

			BSX59	BSX60	BSX61	
Collector-base voltage (open emitter)	V_{CBO}	max.	70	70	70	V
Collector-emitter voltage (open base) I_C = 10 mA	V_{CEO}	max.	45	30	45	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	A
Emitter current (peak value)	$-I_{EM}$	max.	1	A

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.8	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	$R_{th\,j\text{-}a}$	=	220	°C/W
From junction to case	$R_{th\,j\text{-}c}$	=	43	°C/W
From junction to mounting base	$R_{th\,j\text{-}mb}$	=	35	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

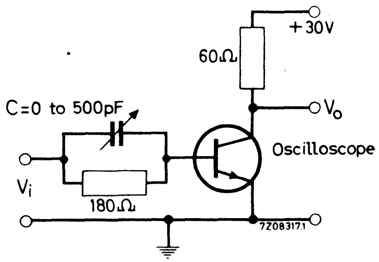
			BSX59	BSX60	BSX61	
Collector cut-off current						
$I_E = 0$; $V_{CB} = 40$ V	I_{CBO}	<	500	500	500	nA
$I_E = 0$; $V_{CB} = 40$ V; $T_j = 150$ °C	I_{CBO}	<	300	300	300	µA
Emitter cut-off current						
$I_C = 0$; $V_{EB} = 4$ V	I_{EBO}	<	300	300	500	nA
$I_C = 0$; $V_{EB} = 4$ V; $T_j = 150$ °C	I_{EBO}	<	50	50	50	µA
Currents at reverse biased emitter junction						
$-V_{BE} = 4$ V; $V_{CE} = 40$ V	$+I_{CEX}$	<	500	500	1000	nA
	$-I_{BEX}$	<	500	500	1000	nA
$-V_{BE} = 4$ V; $V_{CE} = 40$ V; $T_j = 150$ °C	$+I_{CEX}$	<	300	300	500	µA
	$-I_{BEX}$	<	300	300	500	µA
Saturation voltages						
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0.3	0.3	0.5	V
	V_{BEsat}	<	1.0	1.0	1.0	V
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	0.5	0.5	0.7	V
	V_{BEsat}	>	0.85	0.7	0.7	V
		<	1.2	1.3	1.3	V
$I_C = 1$ A; $I_B = 100$ mA	V_{CEsat}	<	1.0	1.0	1.3	V
	V_{BEsat}	<	1.8	1.8	1.8	V
D.C. current gain						
$I_C = 150$ mA; $V_{CE} = 1$ V	h_{FE}	>	30	30	30	
		typ.	70	90	105	
$I_C = 500$ mA; $V_{CE} = 1$ V	h_{FE}	>	30	30	30	
		<	90	90	90	
$I_C = 1$ A; $V_{CE} = 5$ V	h_{FE}	>	20	25	20	
		typ.	40	50	55	
Transition frequency						
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	>	250	250	250	MHz
		typ.	450	475	475	MHz
Collector capacitance at f = 1 MHz						
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	6	6	6	pF
		<	10	10	10	pF
Emitter capacitance at f = 1 MHz						
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	typ.	36	36	36	pF
		<	50	50	50	pF

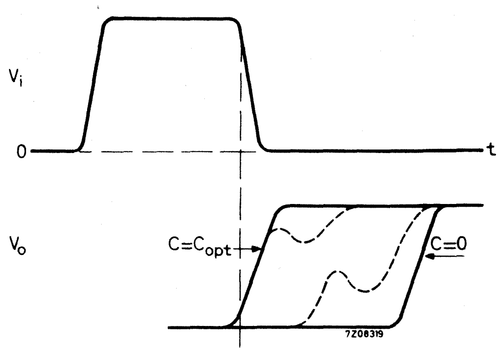
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Recovered charge

I_C = 500 mA; I_B = 50 mA BSX60 Q_s < 5 nC

Test circuit:





Adjust C from zero to C_{opt}

$Q_s = C_{opt} \cdot V_i$

Pulse generator:

Pulse duration t_p = 10 μs

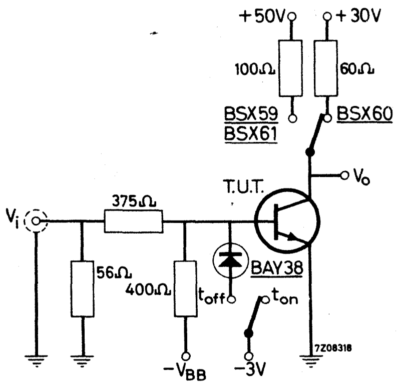
Duty cycle δ = 0.02

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

Switching times (see also page 10)

			BSX59	BSX60	BSX61	
Turn on time when switched from $-V_{BE}$ = 2 V to I_C = 500 mA; I_B = 50 mA	t_{on}	typ.	17	17	18	ns
		<	35	40	50	ns
Turn off time when switched from I_C = 500 mA; I_B = 50 mA to cut-off with $-I_{BM}$ = 50 mA [1]	t_{off}	typ.	45	58	70	ns
		<	60	70	100	ns

Test circuit:

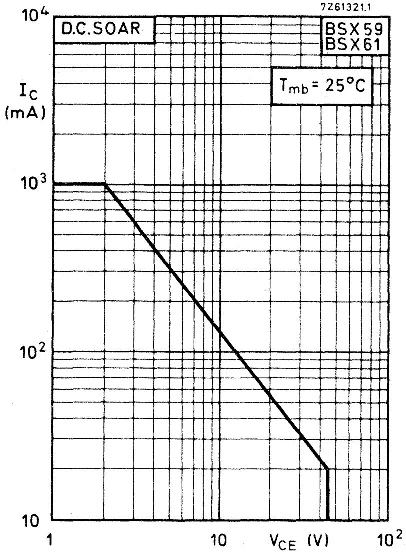


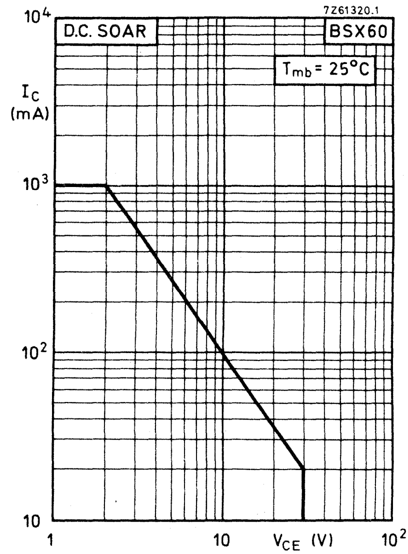
	t_{on}	t_{off}	
V_{BB}	4	16.7	V
V_i	24.75	37.5	V

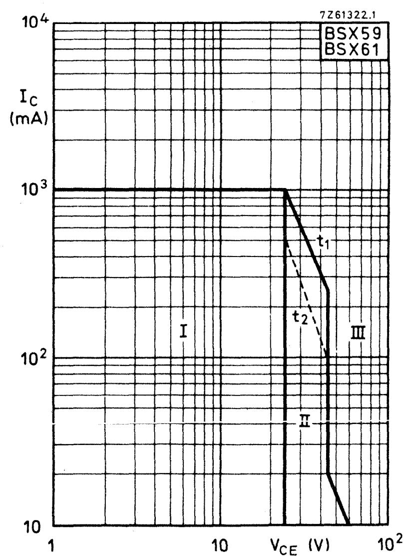
Pulse generator:

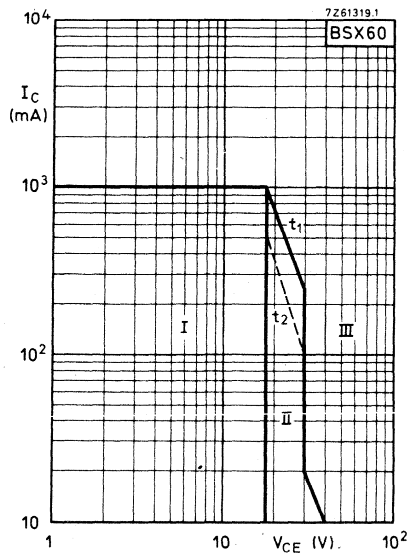
Pulse duration	t_p	$\geq$	500 ns
Rise time	t_r	$\leq$	5 ns
Fall time	t_f	$\leq$	5 ns
Output resistance	R_o	=	50 Ω (during pulse, otherwise infinite)

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



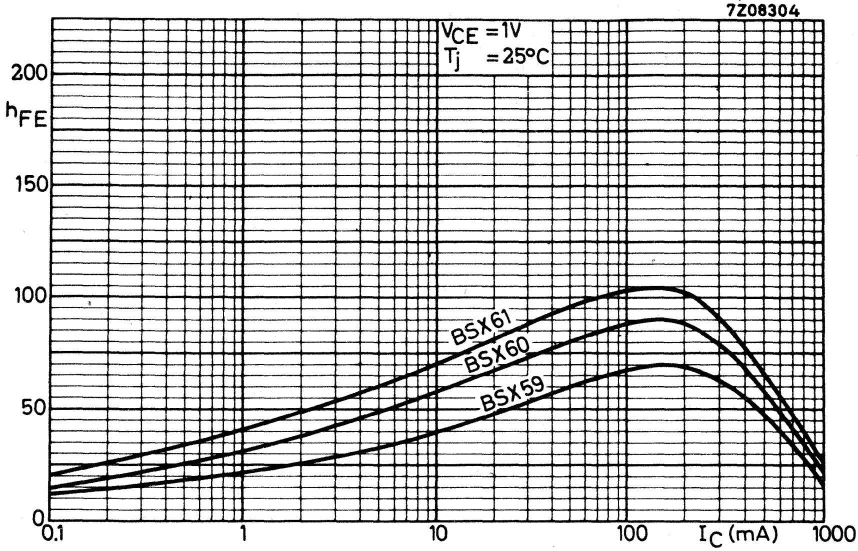


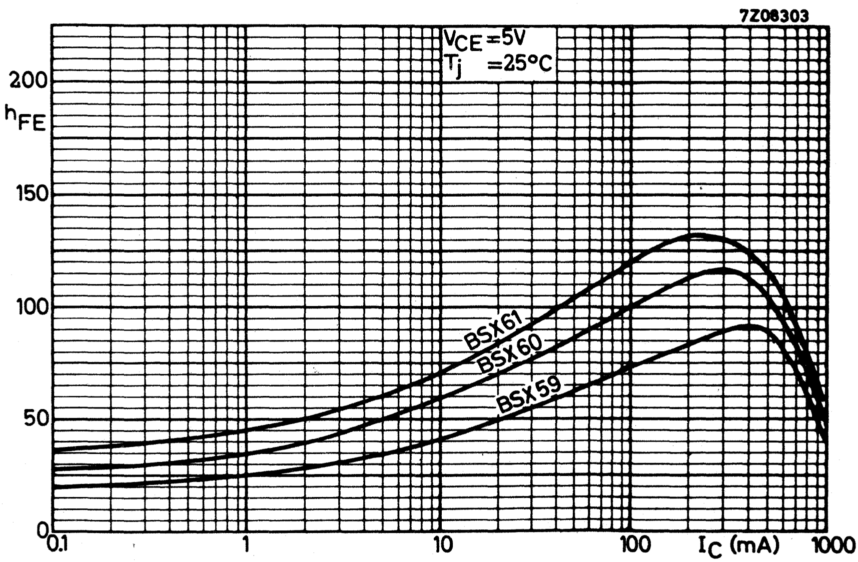


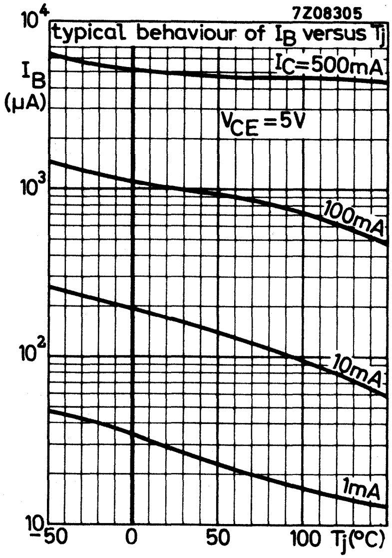


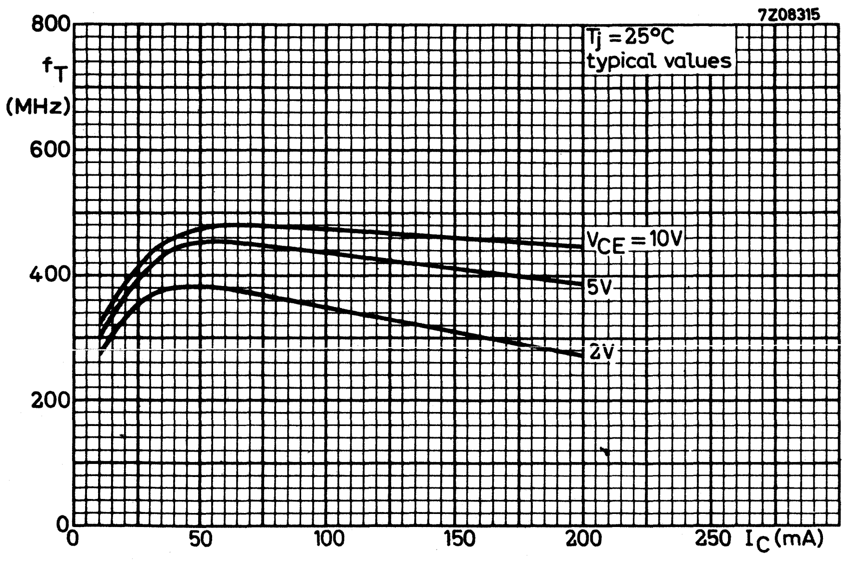
I Region of permissible operation during switching off with $-V_{BB}$ = 4 V; R_{BE} = 39 Ω
II Permissible extension for repetitive pulsed operation.
t_1 limits operations with $t_p \leq 0.1$ μs; $\delta = 0.25$
t_2 limits operations with $t_p \leq 1$ μs; $\delta = 0.25$
III Operation in this area is not allowed.

Typical behaviour of d.c. current gain versus I_C

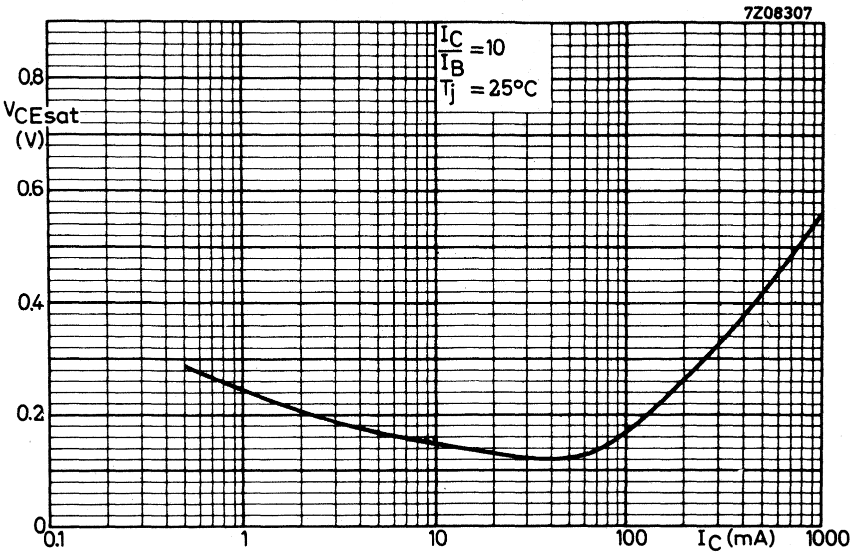


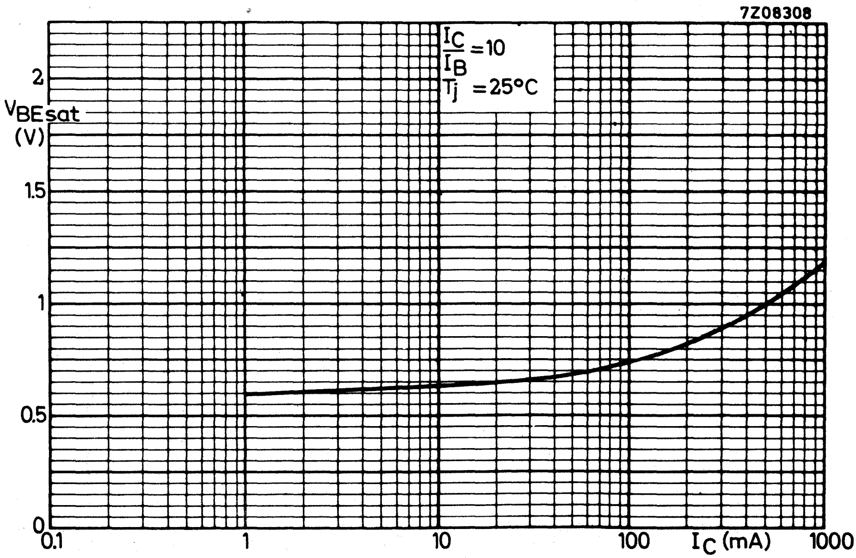



7Z08305
typical behaviour of I_B versus T_j
I_C=500mA
V_{CE}=5V
100mA
10mA
1mA
10^4
10^3
10^2
10
I_B
(μA)
−50
0
50
100
T_j(°C)

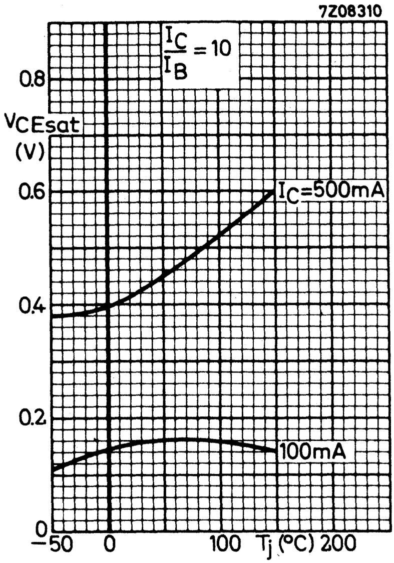

7Z08315
T_j = 25°C
typical values
V_{CE} = 10V
5V
2V
800
f_T
(MHz)
600
400
200
0
0
50
100
150
200
250
I_C (mA)

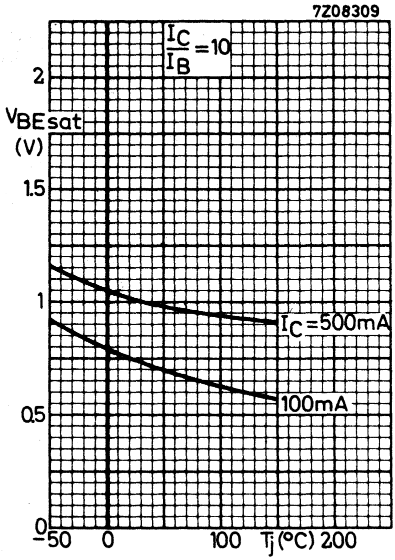
Typical behaviour of saturation voltages versus I_C

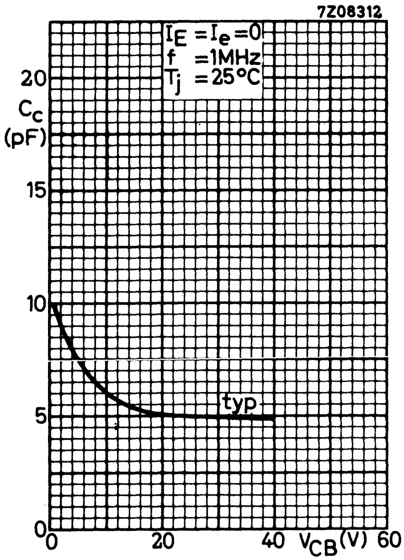


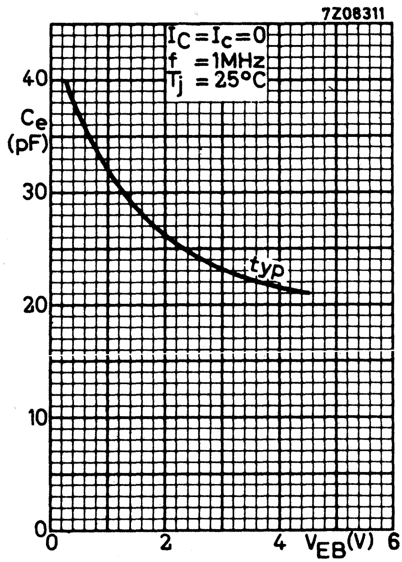


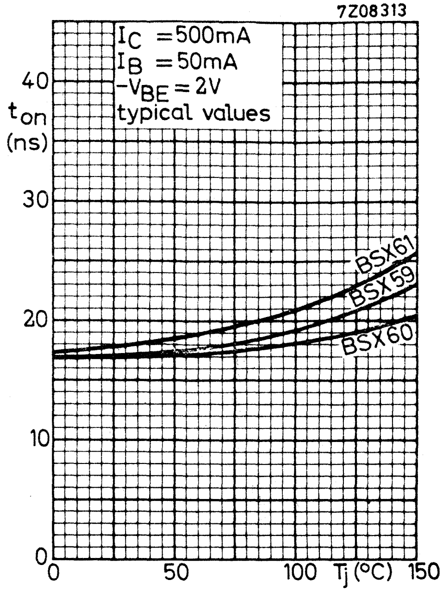
Typical behaviour of saturation voltages versus T_j

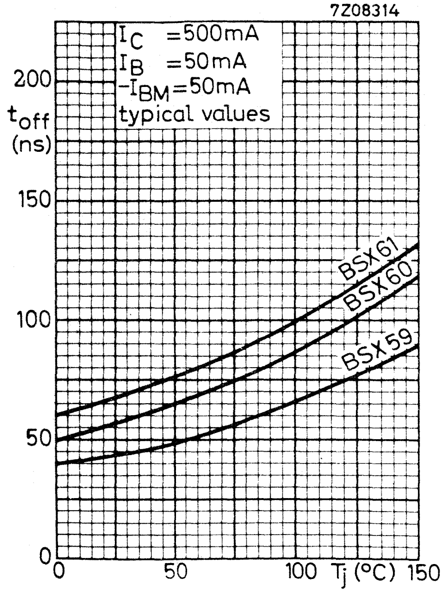


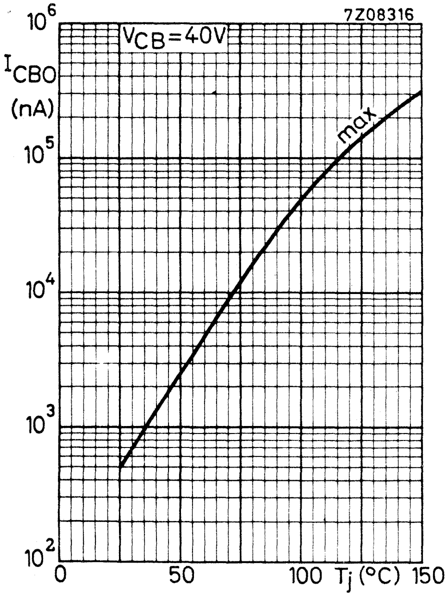


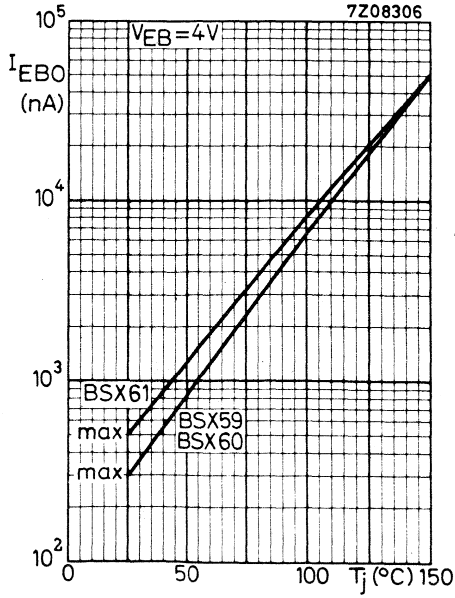





7Z08313
I_C = 500mA
I_B = 50mA
$-V_{BE}$ = 2V
typical values
t_{on} (ns)
BSX61
BSX59
BSX60
T_j (°C)


7Z08314
I_C = 500mA
I_B = 50mA
$-I_{BM}$ = 50mA
typical values
t_{off} (ns)
BSX61
BSX60
BSX59
T_j (°C)


7Z08316
V_{CB} = 40V
I_{CBO} (nA)
max
T_j (°C)


7Z08306
V_{EB} = 4V
I_{EBO} (nA)
BSX61
max
BSX59
BSX60
max
T_j (°C)

GERMANIUM ALLOYED TRANSISTORS

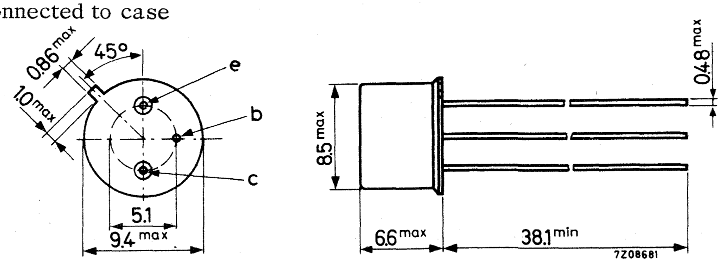
N-P-N transistors in a TO-5 metal envelope with the base connected to the case. These general purpose transistors are primarily intended for medium current medium speed computer logic applications.

QUICK REFERENCE DATA

			2N1302	1304	1306	1308	
Collector-base voltage (open emitter)	V_{CBO}	max.	25	25	25	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	20	15	15	V
Collector current (peak value)	I_{CM}	max.	300	300	300	300	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	150	150	150	mW
Junction temperature	T_j	max.	85	85	85	85	°C
D.C. current gain at T_j = 25 °C; I_C = 10 mA; V_{CE} = 1 V	h_{FE}	>	20	40	60	80	
Saturation voltage I_C = 10 mA; $I_B = \frac{I_C}{h_{FEmin}}$	V_{CEsat}	<	0.2	0.2	0.2	0.2	V
Transition frequency I_C = 1 mA; V_{CE} = 5 V	f_T	typ.	10	15	20	30	MHz
Turn on time ($t_d + t_r$)	t_{on}	typ.	285	270	225	220	ns
Turn off time ($t_s + t_f$)	t_{off}	typ.	865	850	815	790	ns

MECHANICAL DATA Dimensions in mm

TO-5
Base connected to case



Accessories available: 56218, 56245

RATINGS (Limiting values) [1]

Voltages

			2N1302	1304	1306	1308	
Collector-base voltage (open emitter)	V_{CBO}	max.	25	25	25	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	20	15	15	V
Emitter-base voltage (open collector)	V_{EBO}	max.	25	25	25	25	V

Currents

Collector current (d.c. or average over any 20 ms period)	I_C	max.	200	mA
Collector current (peak value)	I_{CM}	max.	300	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	mW

Temperatures

Storage temperature	T_{stg}		−65 to +100	°C
Junction temperature	T_j	max.	85	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\,j-a}$	=	0.4	°C/mW
From junction to case	$R_{th\,j-c}$	=	0.2	°C/mW

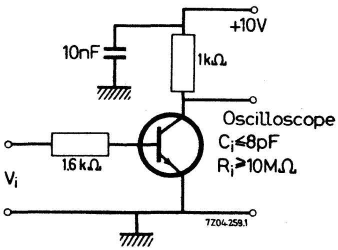
[1] Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

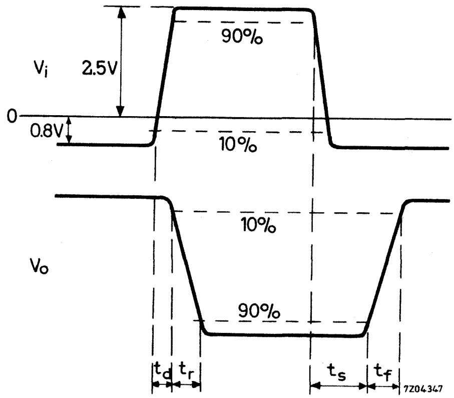
CHARACTERISTICS T_j = 25 °C unless otherwise specified

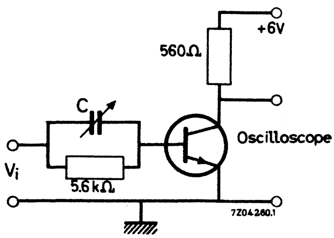
			2N1302	1304	1306	1308	
Collector cut-off current I_E = 0; V_{CB} = 25 V	I_{CBO}	typ.	3	3	3	3	μA
		<	6	6	6	6	μA
Emitter cut-off current I_C = 0; V_{EB} = 25 V	I_{EBO}	typ.	2.2	2.2	2.2	2.2	μA
		<	6	6	6	6	μA
Collector current at reverse biased emitter junction $-V_{BE}$ = 0.2 V; T_j = 55 °C							
V_{CE} = 20 V	I_{CEX}	<	50	50			μA
V_{CE} = 15 V	I_{CEX}	<			50	50	μA
Saturation voltages		>	0.15	0.15	0.15	0.15	V
I_C = 10 mA; I_B = 0.5 mA	V_{BEsat}	typ.	0.30	0.25	0.24	0.23	V
		<	0.40	0.35	0.35	0.35	V
	V_{CEsat}	typ.	0.1				V
		<	0.2				V
I_C = 10 mA; I_B = 0.25 mA	V_{CEsat}	typ.		0.1			V
		<		0.2			V
I_C = 10 mA; I_B = 0.17 mA	V_{CEsat}	typ.			0.1		V
		<			0.2		V
I_C = 10 mA; I_B = 0.13 mA	V_{CEsat}	typ.				0.1	V
		<				0.2	V
Punch through voltage	V_{pt}	>	25	20	15	15	V
D.C. current gain		>	20	40	60	80	
I_C = 10 mA; V_{CE} = 1 V	h_{FE}	typ.	50	70	100	150	
		<		100	200	300	
I_C = 200 mA; V_{CE} = 0.35 V	h_{FE}	>	10	15	20	20	
		typ.	48	65	95	145	
Collector capacitance at f = 1 MHz $I_E = I_e$ = 0; V_{CB} = 5 V	C_c	typ.	12	12	12	12	pF
		<	20	20	20	20	pF
Emitter capacitance at f = 1 MHz $I_C = I_c$ = 0; V_{EB} = 5 V	C_e	typ.	8	8	8	8	pF
Transition frequency I_C = 1 mA; V_{CE} = 5 V	f_T	>	3	5	10	15	MHz
		typ.	10	15	20	30	MHz

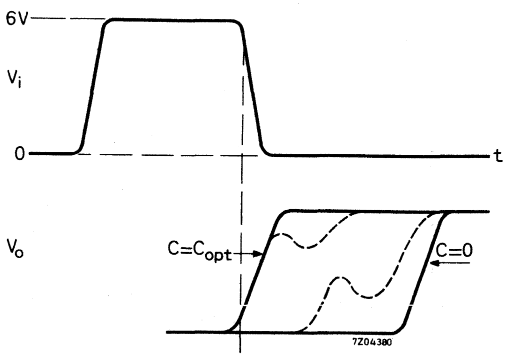
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

			2N1302	1304	1306	1308	
Switching times							
delay time	t_d	typ.	65	60	55	55	ns
rise time	t_r	typ.	220	210	170	165	ns
storage time	t_s	typ.	500	500	500	500	ns
fall time	t_f	typ.	365	350	315	290	ns
Recovered charge	Q_s	typ.	800	700	650	600	pC









Adjust C from zero to C_{opt}

$Q_s = C_{opt} \cdot V_i$

GERMANIUM ALLOYED TRANSISTORS

P-N-P transistors in a TO-5 metal envelope with the base connected to the case. These general purpose transistors are primarily intended for medium current medium speed computer logic applications.

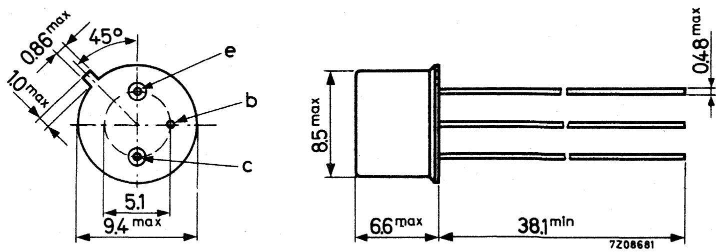
QUICK REFERENCE DATA

			2N1303	1305	1307	1309	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30	30	30	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	25	20	15	15	V
Collector current (peak value)	$-I_{CM}$	max.	300	300	300	300	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	150	150	150	mW
Junction temperature	T_j	max.	85	85	85	85	°C
D.C. current gain at T_j = 25°C; $-I_C$ = 10 mA; $-V_{CE}$ = 1 V	h_{FE}	>	20	40	60	80	
Saturation voltage $-I_C$ = 10 mA; $-I_B = \frac{-I_C}{h_{FEmin}}$	$-V_{CEsat}$	<	0.2	0.2	0.2	0.2	V
Transition frequency $-I_C$ = 1 mA; $-V_{CE}$ = 5 V	f_T	typ.	5	10	15	20	MHz
Turn on time ($t_d + t_r$)	t_{on}	typ.	360	255	230	200	ns
Turn off time ($t_s + t_f$)	t_{off}	typ.	1300	1150	1050	1050	ns

MECHANICAL DATA Dimensions in mm

TO-5

Base connected to case



Accessories available: 56218, 56245

RATINGS (Limiting values) [1]

Voltages

			2N1303	1305	1307	1309	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30	30	30	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	25	20	15	15	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	25	25	25	25	V

Currents

Collector current (d.c. or average over any 20 ms period)	$-I_C$	max.	200	mA
Collector current (peak value)	$-I_{CM}$	max.	300	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	mW

Temperatures

Storage temperature	T_{stg}		-65 to +100	°C
Junction temperature	T_j	max.	85	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.4	°C/mW
From junction to case	$R_{th\ j-c}$	=	0.2	°C/mW

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

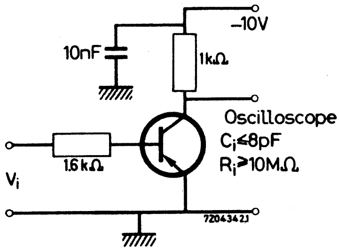
CHARACTERISTICS

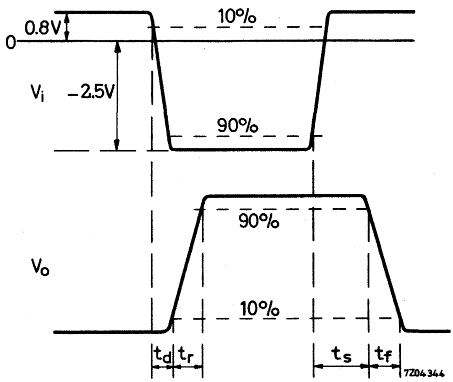
T_j = 25 °C unless otherwise specified

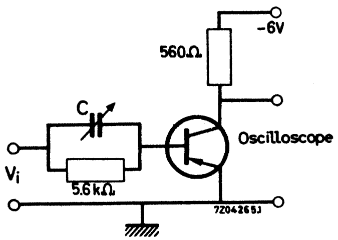
			2N1303	1305	1307	1309	
Collector cut-off current							
I_E = 0; $-V_{CB}$ = 25 V	$-I_{CBO}$	typ.	3	3	3	3	μA
		<	6	6	6	6	μA
Emitter cut-off current							
I_C = 0; $-V_{EB}$ = 25 V	$-I_{EBO}$	typ.	1.7	1.7	1.7	1.7	μA
		<	6	6	6	6	μA
Collector current at reverse biased emitter junction							
$-V_{CE}$ = 15 V; $+V_{BE}$ = 0.2 V; T_j = 55 °C	$-I_{CEX}$	<	50	50	50	50	μA
Saturation voltages							
$-I_C$ = 10 mA; $-I_B$ = 0.5 mA	$-V_{BEsat}$	>	0.15	0.15	0.15	0.15	V
		typ.	0.30	0.25	0.24	0.23	V
		<	0.40	0.35	0.35	0.35	V
	$-V_{CEsat}$	typ.	0.1				V
		<	0.2				V
$-I_C$ = 10 mA; $-I_B$ = 0.25 mA	$-V_{CEsat}$	typ.		0.1			V
		<		0.2			V
$-I_C$ = 10 mA; $-I_B$ = 0.17 mA	$-V_{CEsat}$	typ.			0.1		V
		<			0.2		V
$-I_C$ = 10 mA; $-I_B$ = 0.13 mA	$-V_{CEsat}$	typ.				0.1	V
		<				0.2	V
Punch through voltage	V_{pt}	>	25	20	15	15	V
D.C. current gain							
$-I_C$ = 10 mA; $-V_{CE}$ = 1 V	h_{FE}	>	20	40	60	80	
		typ.	50	70	100	150	
		<		100	200	300	
$-I_C$ = 200 mA; $-V_{CE}$ = 0.35 V	h_{FE}	>	10	15	20	20	
		typ.	35	55	90	130	
Collector capacitance at f = 1 MHz							
$I_E = I_e$ = 0; $-V_{CB}$ = 5 V	C_c	typ.	10	10	10	10	pF
		<	20	20	20	20	pF
Emitter capacitance at f = 1 MHz							
$I_C = I_c$ = 0; $-V_{EB}$ = 5 V	C_e	typ.	7	7	7	7	pF
Transition frequency							
$-I_C$ = 1 mA; $-V_{CE}$ = 5 V	f_T	>	3	5	10	15	MHz
		typ.	5	10	15	20	MHz

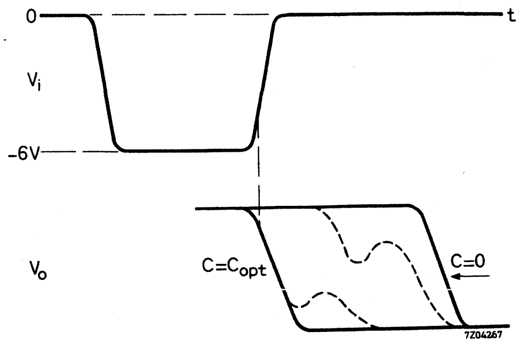
CHARACTERISTICS (continued) $T_j = 25\ ^oC$

			2N1303	1305	1307	1309	
Switching times							
delay time	t_d	typ.	60	55	50	45	ns
rise time	t_r	typ.	300	200	180	155	ns
storage time	t_s	typ.	700	700	700	700	ns
fall time	t_f	typ.	600	450	350	350	ns
Recovered charge	Q_s	typ.	1000	1000	1000	1000	pC









Adjust C from zero to C_{opt}
$Q_s = C_{opt} \cdot V_i$

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a TO-39 metal envelope with the collector connected to the case. They are primarily intended for high speed switching.
The 2N2218 is also suitable for d.c. and v.h.f.-u.h.f. amplifiers.

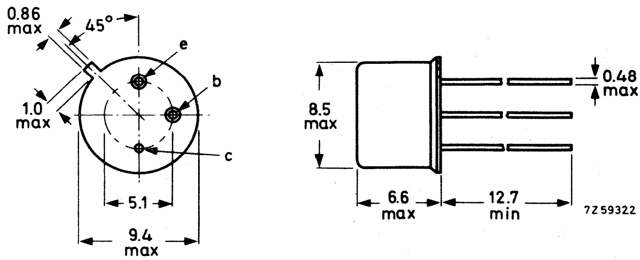
QUICK REFERENCE DATA

			2N2218	2N2218A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40	V
Collector current (d.c.)	I_C	max.	800	800	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.8	0.8	W
Junction temperature	T_j	max.	175	175	°C
D.C. current gain at T_j = 25 °C I_C = 10 mA; V_{CE} = 10 V	h_{FE}	>	35	35	
Transition frequency at f = 100 MHz I_C = 20 mA; V_{CE} = 20 V	f_T	>	250	250	MHz
Storage time I_C = 150 mA; I_B = $-I_{BM}$ = 15 mA	t_s	<	–	225	ns

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-39



max. lead diameter is guaranteed only for 12.7 mm

Accessories available: 56218; 56245

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

Voltages

			2N2218	2N2218A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40 [1]	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	6	V

Current

Collector current (d.c.)	I_C	max.	800	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.8	W
up to T_{case} = 25 °C	P_{tot}	max.	3	W

Temperatures

Storage temperature	T_{stg}		−65 to +200	°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	190	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	50	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

			2N2218	2N2218A	
Collector-cut-off current					
I_E = 0; V_{CB} = 50 V	I_{CBO}	<	10	−	nA
I_E = 0; V_{CB} = 50 V; T_{amb} = 150 °C	I_{CBO}	<	10	−	μA
I_E = 0; V_{CB} = 60 V	I_{CBO}	<	−	10	nA
I_E = 0; V_{CB} = 60 V; T_{amb} = 150 °C	I_{CBO}	<	−	10	μA
Emitter cut-off current					
I_C = 0; V_{EB} = 3 V	I_{EBO}	<	10	10	nA
Currents at reverse biased emitter junction					
V_{CE} = 60 V; $-V_{BE}$ = 3 V	I_{CEX}	<	−	10	nA
	$-I_{BEX}$	<	−	20	nA

1) Applicable up to I_C = 500 mA

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

			2N2218	2N2218A	
Breakdown voltages					
$I_E = 0$; $I_C = 10\ \mu A$	$V_{(BR)CBO}$	>	60	75	V
$I_B = 0$; $I_C = 10$ mA	$V_{(BR)CEO}$	>	30	40	V
$I_C = 0$; $I_E = 10\ \mu A$	$V_{(BR)EBO}$	>	5	6	V
Saturation voltages [1]					
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0.4	0.3	V
	V_{BEsat}	>	–	0.6	V
		<	1.3	1.2	V
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	1.6	1.0	V
	V_{BEsat}	<	2.6	2.0	V
D.C. current gain					
$I_C = 0.1$ mA; $V_{CE} = 10$ V	h_{FE}	>	20	20	
$I_C = 1$ mA; $V_{CE} = 10$ V	h_{FE}	>	25	25	
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	35	35	
$I_C = 10$ mA; $V_{CE} = 10$ V; $T_{amb} = -55\ ^{o}C$	h_{FE}	>	–	15	
$I_C = 150$ mA; $V_{CE} = 1$ V [1]	h_{FE}	>	20	20	
$I_C = 150$ mA; $V_{CE} = 10$ V [1]	h_{FE}		40 to 120	40 to 120	
$I_C = 500$ mA; $V_{CE} = 10$ V [1]	h_{FE}	>	20	25	
Transition frequency at f = 100 MHz					
$I_C = 20$ mA; $V_{CE} = 20$ V	f_T	>	250	250	MHz
Collector capacitance at f = 100 kHz					
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	8	8	pF
Emitter capacitance at f = 100 kHz					
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	<	–	25	pF
Feedback time constant at f = 31.8 MHz					
$I_C = 20$ mA; $V_{CE} = 20$ V	$r_b\ C_c$	<	–	150	ps

[1]) Pulse duration ≤ 300 μs; duty cycle ≤ 2%.

CHARACTERISTICS (continued) $T_j = 25\ ^oC$

h parameters (common emitter)

$I_C = 1$ mA; $V_{CE} = 10$ V; f = 1 kHz

		2N2218A	
Input impedance	h_{ie}	1 to 3.5	kΩ
Reverse voltage transfer ratio	h_{re}	< 5	10^{-4}
Small signal current gain	h_{fe}	30 to 150	
Output admittance	h_{oe}	3 to 15	$\mu\Omega^{-1}$

$I_C = 10$ mA; $V_{CE} = 10$ V; f = 1 kHz

		2N2218A	
Input impedance	h_{ie}	0.2 to 1.0	kΩ
Reverse voltage transfer ratio	h_{re}	< 2.5	10^{-4}
Small signal current gain	h_{fe}	50 to 300	
Output admittance	h_{oe}	10 to 100	$\mu\Omega^{-1}$

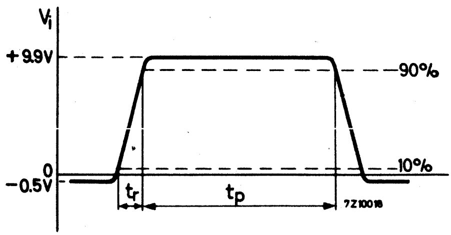
		2N2218	2N2218A	
$I_C = 20$ mA; $V_{CE} = 20$ V; f = 100 MHz				
Small signal current gain	h_{fe}	> 2.5	2.5	
$I_C = 20$ mA; $V_{CE} = 20$ V; f = 300 MHz				
Real part of input impedance	$Re(h_{ie})$	< 60	60	Ω

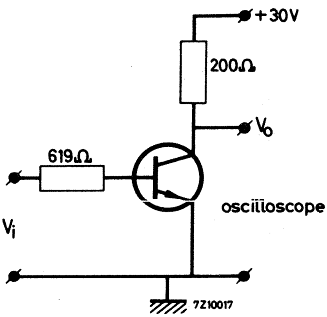
Switching times for 2N2218A

Turn on time when switched from
$-V_{BE} = 0.5$ V to $I_C = 150$ mA; $I_B = 15$ mA

Delay time	t_d	<	10	ns
Rise time	t_r	<	25	ns

Test circuit:





Pulse generator:
pulse duration $t_p \leq 200$ ns
rise time $t_r \leq 2$ ns

Oscilloscope:
input resistance $R_i > 100$ kΩ
input capacitance $C_i < 12$ pF
rise time $t_r < 5$ ns

CHARACTERISTICS (continued) T_j = 25 °C

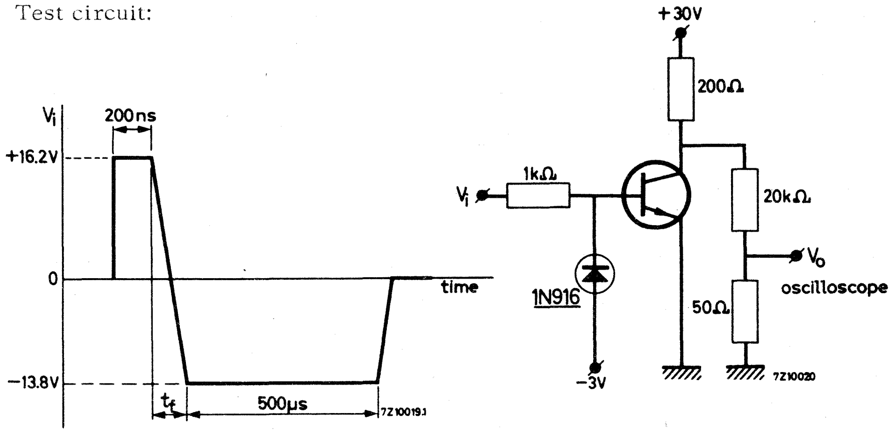
Switching times for 2N2218A

Turn off time

I_C = 150 mA; I_B = $-I_{BM}$ = 15 mA

Storage time	t_s	<	225	ns
Fall time	t_f	<	60	ns

Test circuit:



Pulse generator:

fall time t_f < 5 ns

Oscilloscope:

input impedance	R_i	>	100 kΩ
input capacitance	C_i	<	12 pF
rise time	t_r	<	5 ns

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a TO-39 metal envelope with the collector connected to the case. They are primarily intended for high speed switching.
The 2N2219 is also suitable for d.c. and v.h.f.-u.h.f. amplifiers.

QUICK REFERENCE DATA

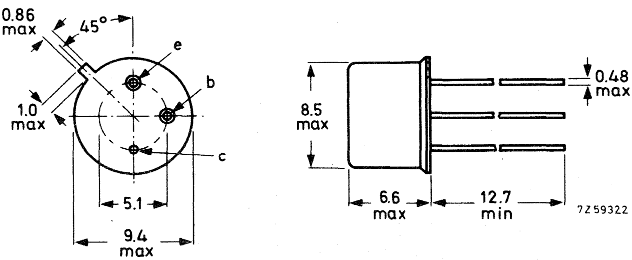
			2N2219	2N2219A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40	V
Collector current (d.c.)	I_C	max.	800	800	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.8	0.8	W
Junction temperature	T_j	max.	175	175	°C
D.C. current gain at T_j = 25 °C I_C = 10 mA; V_{CE} = 10 V	h_{FE}	>	75	75	
Transition frequency at f = 100 MHz I_C = 20 mA; V_{CE} = 20 V	f_T	>	250	300	MHz
Storage time I_C = 150 mA; I_B = $-I_{BM}$ = 15 mA	t_s	>	-	225	ns

MECHANICAL DATA

Dimensions in mm

Collecter connected to case

TO-39



max. lead diameter is guaranteed only for 12.7 mm

Accessories available: 56218, 56245

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

Voltages			2N2219	2N2219A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40[1]	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	6	V

Current				
Collector current (d.c.)	I_C	max.	800	mA
Power dissipation				
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.8	W
up to T_{case} = 25 °C	P_{tot}	max.	3	W
Temperatures				
Storage temperature	T_{stg}		−65 to +200	°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	190	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	50	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

			2N2219	2N2219A	
Collector cut-off current					
$I_E = 0$; $V_{CB} = 50$ V	I_{CBO}	<	10	–	nA
$I_E = 0$; $V_{CB} = 50$ V; $T_{amb} = 150$ °C	I_{CBO}	<	10	–	µA
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	<	–	10	nA
$I_E = 0$; $V_{CB} = 60$ V; $T_{amb} = 150$ °C	I_{CBO}	<	–	10	µA
Emitter cut-off current					
$I_C = 0$; $V_{EB} = 3$ V	I_{EBO}	<	10	10	nA
Currents at reverse biased emitter junction					
$V_{CE} = 60$ V; $-V_{BE} = 3$ V	I_{CEX}	<	–	10	nA
	$-I_{BEX}$	<	–	20	nA

1) Applicable up to I_C = 500 mA

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

			2N2219	2N2219A	
Breakdown voltages					
$I_E = 0$; $I_C = 10\ \mu A$	$V_{(BR)CBO}$	>	60	75	V
$I_B = 0$; $I_C = 10$ mA	$V_{(BR)CEO}$	>	30	40	V
$I_C = 0$; $I_E = 10\ \mu A$	$V_{(BR)EBO}$	>	5	6	V
Saturation voltages [1]					
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0.4	0.3	V
	V_{BEsat}	>	–	0.6	V
		<	1.3	1.2	V
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	1.6	1.0	V
	V_{BEsat}	<	2.6	2.0	V
D.C. current gain					
$I_C = 0.1$ mA; $V_{CE} = 10$ V	h_{FE}	>	35	35	
$I_C = 1$ mA; $V_{CE} = 10$ V	h_{FE}	>	50	50	
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	75	75	
$I_C = 10$ mA; $V_{CE} = 10$ V; $T_{amb} = -55$ °C	h_{FE}	>	–	35	
$I_C = 150$ mA; $V_{CE} = 1$ V [1]	h_{FE}	>	50	50	
$I_C = 150$ mA; $V_{CE} = 10$ V [1]	h_{FE}		100 to 300	100 to 300	
$I_C = 500$ mA; $V_{CE} = 10$ V [1]	h_{FE}	>	30	40	
Transition frequency at f = 100 MHz					
$I_C = 20$ mA; $V_{CE} = 20$ V	f_T	>	250	300	MHz
Collector capacitance at f = 100 kHz					
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	8	8	pF
Emitter capacitance at f = 100 kHz					
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	<	–	25	pF
Feedback time constant at f = 31.8 MHz					
$I_C = 20$ mA; $V_{CE} = 20$ V	$r_{b'} C_c$	<	–	150	ps

[1]) Pulse duration ≤ 300 μs; duty cycle ≤ 2%.

CHARACTERISTICS (continued) $T_J = 25\ ^oC$

h parameters (common emitter)

I_C = 1 mA; V_{CE} = 10 V; f = 1 kHz

		2N2219A	
Input impedance	h_{ie}	2 to 8	kΩ
Reverse voltage transfer ratio	h_{re}	< 8	10^{-4}
Small signal current gain	h_{fe}	50 to 300	
Output admittance	h_{oe}	5 to 35	$\mu\Omega^{-1}$

I_C = 10 mA; V_{CE} = 10 V; f = 1 kHz

Input impedance	h_{ie}	0.25 to 1.25	kΩ
Reverse voltage transfer ratio	h_{re}	< 4	10^{-4}
Small signal current gain	h_{fe}	75 to 375	
Output admittance	h_{oe}	25 to 200	$\mu\Omega^{-1}$

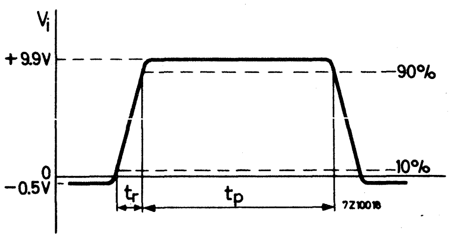
			2N2219	2N2219A	
I_C = 20 mA; V_{CE} = 20 V; f = 100 MHz					
Small signal current gain	h_{fe}	>	2.5	3.0	
I_C = 20 mA; V_{CE} = 20 V; f = 300 MHz					
Real part of input impedance	$Re(h_{ie})$	<	60	60	Ω
Noise figure at f = 1 kHz					
I_C = 0.1 mA; V_{CE} = 10 V R_G = 1 kΩ; B = 1 Hz	F	<	–	4	dB

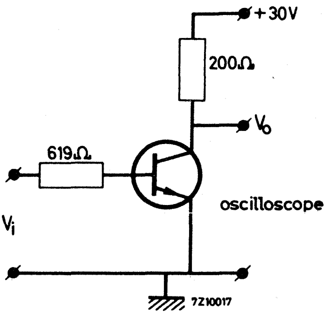
Switching times for 2N2219A

Turn on time when switched from
$-V_{BE}$ = 0.5 V to I_C = 150 mA; I_B = 15mA

Delay time	t_d	<	10	ns
Rise time	t_r	<	25	ns

Test circuit:





Pulse generator:
pulse duration $t_p \leq 200$ ns
rise time $t_r \leq 2$ ns

Oscilloscope:
input resistance $R_i > 100$ kΩ
input capacitance $C_i < 12$ pF
rise time $t_r < 5$ ns

CHARACTERISTICS (continued) $T_j = 25\ ^oC$

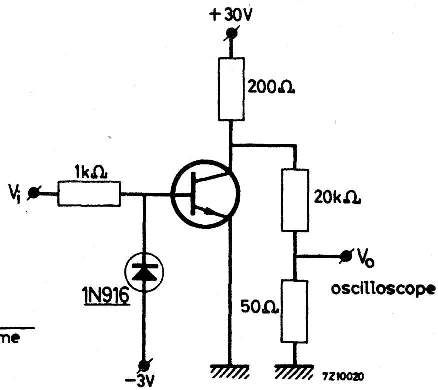
Switching times for 2N2219A

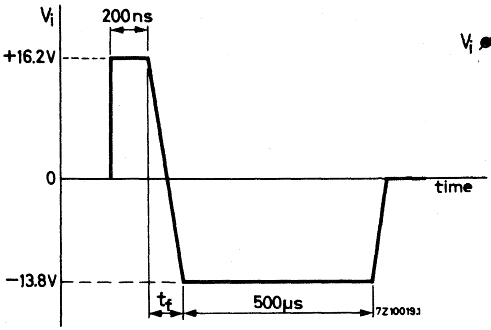
Turn off time

$I_C = 150$ mA; $I_B = -I_{BM} = 15$ mA

Storage time	t_s	<	225	ns
Fall time	t_f	<	60	ns

Test circuit:





Pulse generator:

fall time $t_f < 5$ ns

Oscilloscope:

input impedance	R_i	>	100 kΩ
input capacitance	C_i	<	12 pF
rise time	t_r	<	5 ns

SILICON PLANAR EPITAXIAL TRANSISTORS

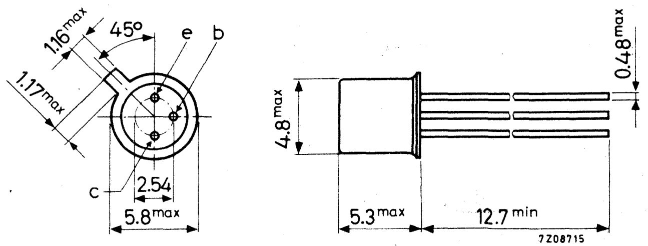
N-P-N transistors in a TO-18 metal envelope with the collector connected to the case. They are primarily intended for high speed switching.
The 2N2221 is also suitable for d.c. and v.h.f.-u.h.f. amplifiers.

QUICK REFERENCE DATA

			2N2221	2N2221A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40	V
Collector current (d.c.)	I_C	max.	800	800	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.5	0.5	W
Junction temperature	T_j	max.	175	175	°C
D.C. current gain at T_j = 25 °C I_C = 10 mA; V_{CE} = 10 V	h_{FE}	>	35	35	
Transition frequency at f = 100 MHz I_C = 20 mA; V_{CE} = 20 V	f_T	>	250	250	MHz
Storage time I_C = 150 mA; I_B = $-I_{BM}$ = 15 mA	t_s	<	–	225	ns

MECHANICAL DATA Dimensions in mm

Collector connected to case
TO-18



Accessories available: 56246, 56263

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

Voltages			2N2221	2N2221A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40[1]	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	6	V

Current

Collector current (d.c.)	I_C	max.	800	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.5	W
up to T_{case} = 25 °C	P_{tot}	max.	1.8	W

Temperatures

Storage temperature	T_{stg}		−65 to +200	°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	300	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	83	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			2N2221	2N2221A	
Collector cut-off current					
I_E = 0; V_{CB} = 50 V	I_{CBO}	<	10	−	nA
I_E = 0; V_{CB} = 50 V; T_{amb} = 150 °C	I_{CBO}	<	10	−	μA
I_E = 0; V_{CB} = 60 V	I_{CBO}	<	−	10	nA
I_E = 0; V_{CB} = 60 V; T_{amb} = 150 °C	I_{CBO}	<	−	10	μA
Emitter cut-off current					
I_C = 0; V_{EB} = 3 V	I_{EBO}	<	10	10	nA
Currents at reverse biased emitter junction					
V_{CE} = 60 V; $-V_{BE}$ = 3 V	I_{CEX}	<	−	10	nA
	$-I_{BEX}$	<	−	20	nA

1) Applicable up to I_C = 500 mA

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

			2N2221	2N2221A	
Breakdown voltages					
$I_E = 0$; $I_C = 10\ \mu A$	$V_{(BR)CBO}$	$>$	60	75	V
$I_B = 0$; $I_C = 10$ mA	$V_{(BR)CEO}$	$>$	30	40	V
$I_C = 0$; $I_E = 10\ \mu A$	$V_{(BR)EBO}$	$>$	5	6	V
Saturation voltages [1]					
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	$<$	0.4	0.3	V
	V_{BEsat}	$>$	–	0.6	V
		$<$	1.3	1.2	V
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	$<$	1.6	1.0	V
	V_{BEsat}	$<$	2.6	2.0	V
D.C. current gain					
$I_C = 0.1$ mA; $V_{CE} = 10$ V	h_{FE}	$>$	20	20	
$I_C = 1$ mA; $V_{CE} = 10$ V	h_{FE}	$>$	25	25	
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	$>$	35	35	
$I_C = 10$ mA; $V_{CE} = 10$ V; $T_{amb} = -55\ ^{o}C$	h_{FE}	$>$	–	15	
$I_C = 150$ mA; $V_{CE} = 1$ V [1]	h_{FE}	$>$	20	20	
$I_C = 150$ mA; $V_{CE} = 10$ V [1]	h_{FE}		40 to 120	40 to 120	
$I_C = 500$ mA; $V_{CE} = 10$ V [1]	h_{FE}	$>$	20	25	
Transition frequency at f = 100 MHz					
$I_C = 20$ mA; $V_{CE} = 20$ V	f_T	$>$	250	250	MHz
Collector capacitance at f = 100 kHz					
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	$<$	8	8	pF
Emitter capacitance at f = 100 kHz					
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	$<$	–	25	pF
Feedback time constant at f = 31.8 MHz					
$I_C = 20$ mA; $V_{CE} = 20$ V	$r_{b'} C_c$	$<$	–	150	ps

[1]) Pulse duration $\leq 300\ \mu s$; duty cycle $\leq 2\%$.

CHARACTERISTICS (continued) $T_j = 25\ ^oC$

h parameters (common emitter)

$I_C = 1$ mA; $V_{CE} = 10$ V; f = 1 kHz

			2N2221A	
Input impedance	h_{ie}		1 to 3.5	kΩ
Reverse voltage transfer ratio	h_{re}	<	5	10^{-4}
Small signal current gain	h_{fe}		30 to 150	
Output admittance	h_{oe}		3 to 15	$\mu\Omega^{-1}$

$I_C = 10$ mA; $V_{CE} = 10$ V; f = 1 kHz

Input impedance	h_{ie}		0.2 to 1.0	kΩ
Reverse voltage transfer ratio	h_{re}	<	2.5	10^{-4}
Small signal current gain	h_{fe}		50 to 300	
Output admittance	h_{oe}		10 to 100	$\mu\Omega^{-1}$

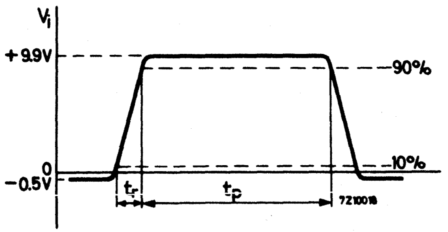
		2N2221	2N2221A	
$I_C = 20$ mA; $V_{CE} = 20$ V; f = 100 MHz				
Small signal current gain	h_{fe}	> 2.5	2.5	
$I_C = 20$ mA; $V_{CE} = 20$ V; f = 300 MHz				
Real part of input impedance	$Re(h_{ie})$	< 60	60	Ω

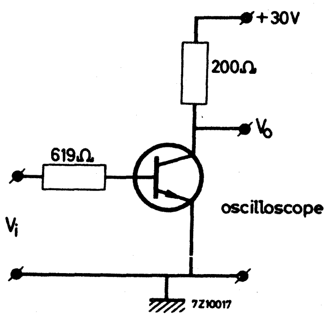
Switching times for 2N2221A

Turn on time when switched from
$-V_{BE} = 0.5$ V to $I_C = 150$ mA; $I_B = 15$ mA

Delay time	t_d	<	10	ns
Rise time	t_r	<	25	ns

Test circuit:





Pulse generator:		
pulse duration	$t_p \leq$	200 ns
rise time	$t_r \leq$	2 ns

Oscilloscope:		
input resistance	$R_i >$	100 kΩ
input capacitance	$C_i <$	12 pF
rise time	$t_r <$	5 ns

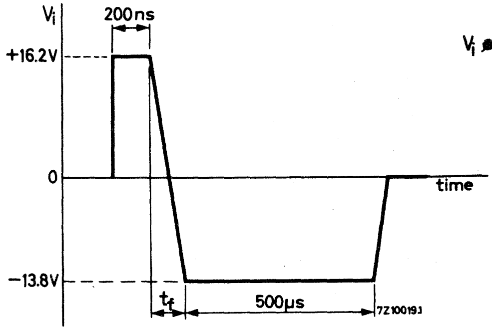
CHARACTERISTICS (continued) $T_j = 25\ ^oC$

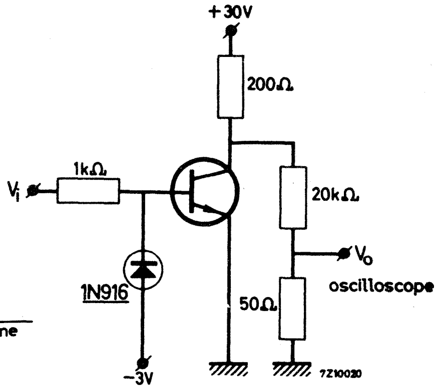
Switching times for 2N2221A

Turn off time
I_C = 150 mA; $I_B = -I_{BM}$ = 15 mA

Storage time	t_s	<	225	ns
Fall time	t_f	<	60	ns

Test circuit:





Pulse generator:
fall time t_f < 5 ns

Oscilloscope:

input impedance	R_i	>	100 kΩ
input capacitance	C_i	<	12 pF
rise time	t_r	<	5 ns

SILICON PLANAR EPITAXIAL TRANSISTORS

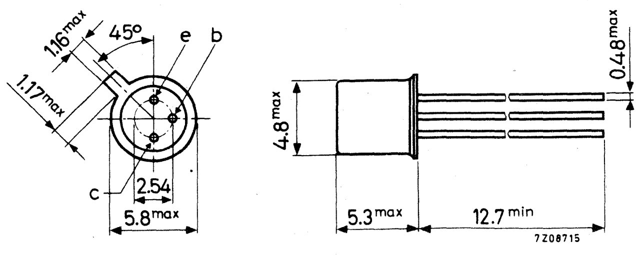
N-P-N transistors in a TO-18 metal envelope with the collector connected to the case. They are primarily intended for high speed switching.
The 2N2222 is also suitable for d.c. and v.h.f.-u.h.f. amplifiers.

QUICK REFERENCE DATA

			2N2222	2N2222A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40	V
Collector current (d.c.)	I_C	max.	800	800	mA
Total power dissipation up to $T_{amb} = 25\,^oC$	P_{tot}	max.	0.5	0.5	W
Junction temperature	T_j	max.	175	175	^oC
D.C. current gain at $T_j = 25\,^oC$ $I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	75	75	
Transition frequency at f = 100 MHz $I_C = 20$ mA; $V_{CE} = 20$ V	f_T	>	250	300	MHz
Storage time $I_C = 150$ mA; $I_B = -I_{BM} = 15$ mA	t_s	<	–	225	ns

MECHANICAL DATA Dimensions in mm

Collector connected to case
TO-18



Accessories available: 56246, 56263

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

			2N2222	2N2222A	
Voltages					
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40[1]	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	6	V
Current					
Collector current (d.c.)	I_C	max.	800		mA
Power dissipation					
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.5		W
up to T_{case} = 25 °C	P_{tot}	max.	1.8		W
Temperatures					
Storage temperature	T_{stg}		−65 to + 200		°C
Junction temperature	T_j	max.	175		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	300	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	83	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

			2N2222	2N2222A	
Collector cut-off current					
$I_E = 0$; $V_{CB} = 50$ V	I_{CBO}	<	10	–	nA
$I_E = 0$; $V_{CB} = 50$ V; $T_{amb} = 150$ °C	I_{CBO}	<	10	–	μA
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	<	–	10	nA
$I_E = 0$; $V_{CB} = 60$ V; $T_{amb} = 150$ °C	I_{CBO}	<	–	10	μA
Emitter cut-off current					
$I_C = 0$; $V_{EB} = 3$ V	I_{EBO}	<	10	10	nA
Currents at reverse biased emitter junction					
$V_{CE} = 60$ V; $-V_{BE} = 3$ V	I_{CEX}	<	–	10	nA
	$-I_{BEX}$	<	–	20	nA

1) Applicable up to I_C = 500 mA

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

			2N2222	2N2222A	
Breakdown voltages					
$I_E = 0$; $I_C = 10\ \mu A$	$V_{(BR)CBO}$	>	60	75	V
$I_B = 0$; $I_C = 10$ mA	$V_{(BR)CEO}$	>	30	40	V
$I_C = 0$; $I_E = 10\ \mu A$	$V_{(BR)EBO}$	>	5	6	V
Saturation voltages [1]					
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0.4	0.3	V
	V_{BEsat}	>	–	0.6	V
		<	1.3	1.2	V
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	1.6	1.0	V
	V_{BEsat}	<	2.6	2.0	V
D.C. current gain					
$I_C = 0.1$ mA; $V_{CE} = 10$ V	h_{FE}	>	35	35	
$I_C = 1$ mA; $V_{CE} = 10$ V	h_{FE}	>	50	50	
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	75	75	
$I_C = 10$ mA; $V_{CE} = 10$ V; $T_{amb} = -55$ °C	h_{FE}	>	–	35	
$I_C = 150$ mA; $V_{CE} = 1$ V [1]	h_{FE}	>	50	50	
$I_C = 150$ mA; $V_{CE} = 10$ V [1]	h_{FE}		100 to 300	100 to 300	
$I_C = 500$ mA; $V_{CE} = 10$ V [1]	h_{FE}	>	30	40	
Transition frequency at f = 100 MHz					
$I_C = 20$ mA; $V_{CE} = 20$ V	f_T	>	250	300	MHz
Collector capacitance at f = 100 kHz					
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	8	8	pF
Emitter capacitance at f = 100 kHz					
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	<	–	25	pF
Feedback time constant at f = 31.8 MHz					
$I_C = 20$ mA; $V_{CE} = 20$ V	$r_b' C_c$	<	–	150	ps

[1]) Pulse duration ≤ 300 μs; duty cycle ≤ 2%.

CHARACTERISTICS (continued) $T_j = 25\ ^oC$

h parameters (common emitter)

		2N2222A	
I_C = 1 mA; V_{CE} = 10 V; f = 1 kHz			
Input impedance	h_{ie}	2 to 8	kΩ
Reverse voltage transfer ratio	h_{re}	< 8	10^{-4}
Small signal current	h_{fe}	50 to 300	
Output admittance	h_{oe}	5 to 35	$\mu\Omega^{-1}$
I_C = 10 mA; V_{CE} = 10 V; f = 1 kHz			
Input impedance	h_{ie}	0.25 to 1.25	kΩ
Reverse voltage transfer ratio	h_{re}	< 4	10^{-4}
Small signal current gain	h_{fe}	75 to 375	
Output admittance	h_{oe}	25 to 200	$\mu\Omega^{-1}$

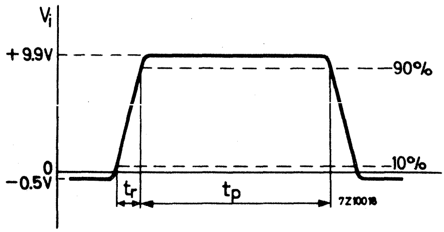
			2N2222	2N2222A	
I_C = 20 mA; V_{CE} = 20 V; f = 100 MHz					
Small signal current gain	h_{fe}	>	2.5	3.0	
I_C = 20 mA; V_{CE} = 20 V; f = 300 MHz					
Real part of input impedance	$Re(h_{ie})$	<	60	60	Ω
Noise figure at f = 1 kHz					
I_C = 0.1 mA; V_{CE} = 10 V R_G = 1 kΩ; B = 1 Hz	F	<	–	4	dB

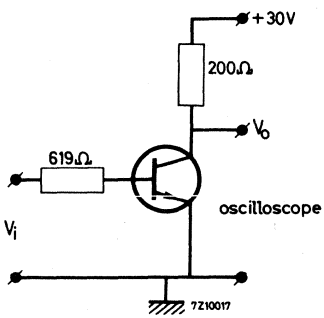
Switching times for 2N2222A

Turn on time when switched from
$-V_{BE}$ = 0.5 V to I_C = 150 mA; I_B = 15 mA

Delay time	t_d	<	10	ns
Rise time	t_r	<	25	ns

Test circuit:





Pulse generator:

pulse duration	t_p	≤	200 ns
rise time	t_r	≤	2 ns

Oscilloscope:

input resistance	R_i	>	100 kΩ
input capacitance	C_i	<	12 pF
rise time	t_r	<	5 ns

CHARACTERISTICS (continued) T_j = 25 °C

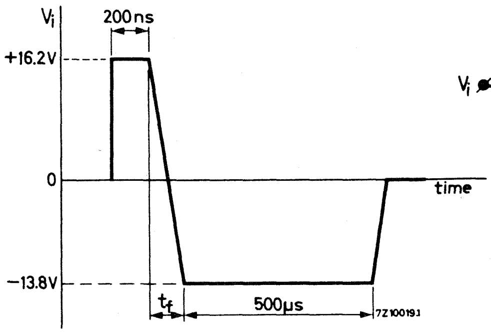
Switching times for 2N2222A

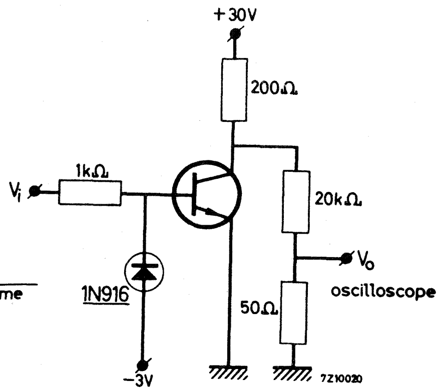
Turn off time

I_C = 150 mA; I_B = $-I_{BM}$ = 15 mA

Storage time	t_s	<	225	ns
Fall time	t_f	<	60	ns

Test circuit:





Pulse generator:

fall time t_f < 5 ns

Oscilloscope:

input impedance	R_i	>	100 kΩ
input capacitance	C_i	<	12 pF
rise time	t_r	<	5 ns

SILICON PLANAR EPITAXIAL TRANSISTORS

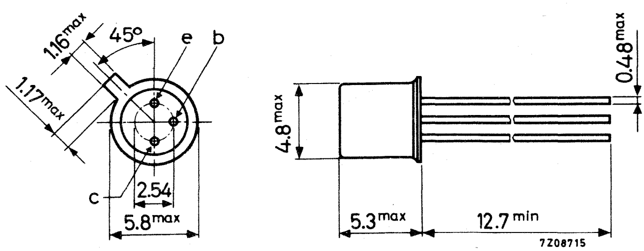
N-P-N transistors in a TO-18 metal envelope with the collector connected to the case. The 2N2368 and 2N2369 are primarily intended for use in very high-speed saturated switching and v.h.f. amplification.

QUICK REFERENCE DATA					
Collector-base voltage (open emitter)		V_{CBO}	max.	40	V
Collector-emitter voltage (open base)		V_{CEO}	max.	15	V
Collector current (peak value)		I_{CM}	max.	500	mA
Total power dissipation up to $T_{amb} = 25\ ^{o}C$		P_{tot}	max.	360	mW
Junction temperature		T_j	max.	200	^{o}C
D.C. current gain at $T_j = 25\ ^{o}C$					
$I_C = 10$ mA; $V_{CE} = 1$ V	2N2368	h_{FE}	20 to	60	
	2N2369	h_{FE}	40 to	120	
Transition frequency					
$I_C = 10$ mA; $V_{CE} = 10$ V	2N2368	f_T	>	400	MHz
	2N2369	f_T	>	500	MHz
Storage time					
$I_C = I_B = -I_{BM} = 10$ mA	2N2368	t_s	<	10	ns
	2N2369	t_s	<	13	ns

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-18



Accessories available: 56246, 56263

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector-emitter voltage with V_{BE} = 0	V_{CES}	max.	40	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4.5	V

Current

Collector current (peak value; t = 10 μs)	I_{CM}	max.	500	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	$R_{th\ j-c}$	=	0.145	°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} = 20 V	I_{CBO}	<	0.4	μA
I_E = 0; V_{CB} = 20 V; T_j = 150 °C	I_{CBO}	<	30	μA

Sustaining voltage 1)

I_C = 10 mA; I_B = 0	$V_{CEOsust}$	>	15	V 1)

Saturation voltages

I_C = 10 mA; I_B = 1 mA	V_{CEsat}	<	0.25	V
	V_{BEsat}		0.7 to 0.85	V

Collector capacitance at f = 140 kHz

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

			2N2368	2N2369	
D.C. current gain 1)					
I_C = 10 mA; V_{CE} = 1 V	h_{FE}		20 to 60	40 to 120	
I_C = 10 mA; V_{CE} = 1 V; T_j = −55 °C	h_{FE}	>	10	20	
I_C = 100 mA; V_{CE} = 2 V	h_{FE}	>	10	20	
Transition frequency					
I_C = 10 mA; V_{CE} = 10 V	f_T	>	400	500	MHz

1) Measured under pulsed conditions to avoid excessive dissipation
Pulse duration t = 300 μs; duty cycle δ = 0.01

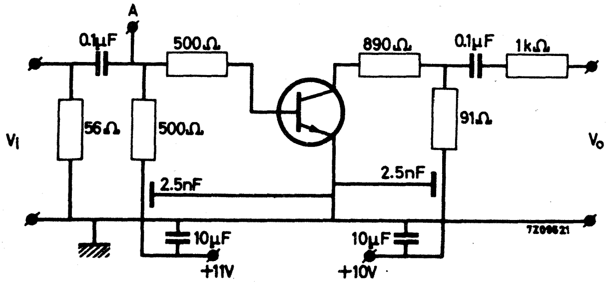
CHARACTERISTICS (continued) $T_j = 25\ ^oC$

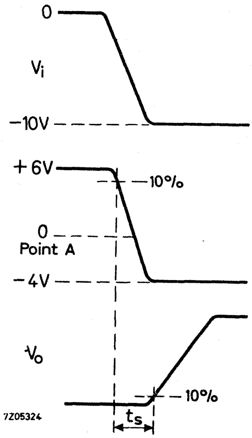
Storage time

$I_C = I_B = -I_{BM} = 10$ mA

2N2368	t_s	<	10	ns
2N2369	t_s	<	13	ns

Test circuit: [1])





Turn on time

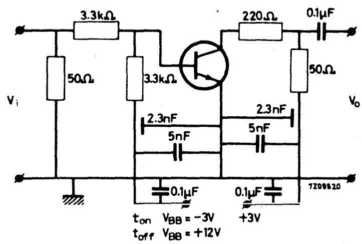
$I_C = 10$ mA; $I_B = 3$ mA; $-V_{BE} = 1.5$ V t_{on} < 12 ns

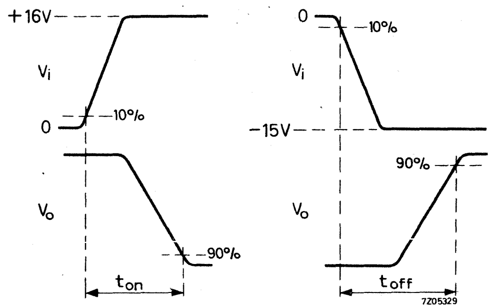
Turn off time

$I_C = 10$ mA; $I_B = 3$ mA; $-I_{BM} = 1.5$ mA

2N2368	t_{off}	<	15	ns
2N2369	t_{off}	<	18	ns

Test circuit: [1])





[1]) Pulse generator:

Pulse duration	t	≥	300	ns
Duty cycle	δ	≤	0.02	
Rise time	t_r	≤	1	ns
Source impedance	R_S	=	50	Ω

Oscilloscope:

Rise time	t_r	≤	1	ns
Input impedance	R_i	=	50	Ω

SILICON PLANAR EPITAXIAL TRANSISTOR

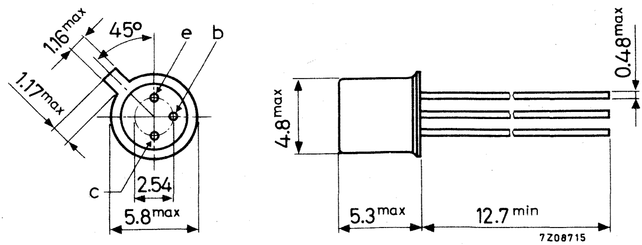
N-P-N transistor in a TO-18 metal envelope with the collector connected to the case. The 2N2369A is primarily intended for low-power very high-speed saturated switching applications in industrial service.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector current (peak value)	I_{CM}	max.	500	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360	mW
Junction temperature	T_j	max.	200	°C
D.C. current gain at T_j = 25 °C				
I_C = 10 mA; V_{CE} = 1 V	h_{FE}		40 to 120	
Transition frequency				
I_C = 10 mA; V_{CE} = 10 V	f_T	>	500	MHz
Storage time				
$I_C = I_B = -I_{BM}$ = 10 mA	t_s	<	13	ns

MECHANICAL DATA Dimensions in mm

Collector connected to the case

TO-18



Accessories available: 56246, 56263

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base) I_C = 0.01 to 10 mA	V_{CEO}	max.	15	V
Collector-emitter voltage with V_{BE} = 0	V_{CES}	max.	40	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4.5	V

Currents

Collector currents (d.c. or average over any 20 ms period)	I_C	max.	200	mA
Collector current (peak value; t = 10 μs)	I_{CM}	max.	500	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	$R_{th\ j\text{-}a}$	=	0.48	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0.145	°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				
V_{BE} = 0; V_{CE} = 20 V	I_{CES}	<	0.4	μA
I_E = 0; V_{CB} = 20 V; T_j = 150 °C	I_{CBO}	<	30	μA
Base current				
V_{BE} = 0; V_{CE} = 20 V	$-I_{BEX}$	<	0.4	μA
Sustaining voltage [1]				
I_C = 10 mA; I_B = 0	$V_{CEOsust}$	>	15	V
Saturation voltages				
I_C = 10 mA; I_B = 1 mA	V_{CEsat}	<	0.2	V
	V_{BEsat}	0.7 to	0.85	V
I_C = 30 mA; I_B = 3 mA	V_{CEsat}	<	0.25	V
	V_{BEsat}	<	1.15	V
I_C = 100 mA; I_B = 10 mA	V_{CEsat}	<	0.5	V
	V_{BEsat}	<	1.6	V
I_C = 10 mA; I_B = 1 mA; T_j = 125 °C	V_{CEsat}	<	0.3	V
	V_{BEsat}	>	0.59	V
I_C = 10 mA; I_B = 1 mA; T_j = −55 °C	V_{BEsat}	<	1.02	V
D.C. current gain [1]				
I_C = 10 mA; V_{CE} = 1 V	h_{FE}	40 to	120	
I_C = 30 mA; V_{CE} = 0.4 V	h_{FE}	>	30	
I_C = 100 mA; V_{CE} = 1 V	h_{FE}	>	20	
I_C = 10 mA; V_{CE} = 1 V; T_j = −55 °C	h_{FE}	>	20	
Collector capacitance at f = 140 kHz				
$I_E = I_e$ = 0; V_{CB} = 5 V	C_c	<	4	pF
Transition frequency				
I_C = 10 mA; V_{CE} = 10 V	f_T	>	500	MHz

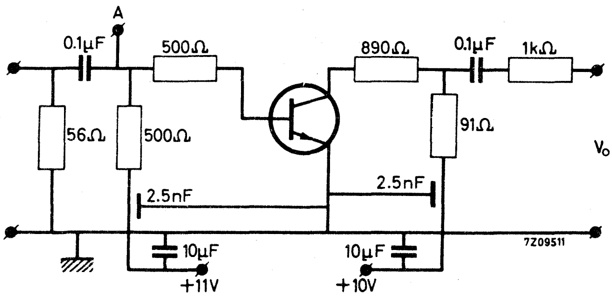
[1] Measured under pulsed conditions to avoid excessive dissipation
Pulse duration t = 300 μs; duty cycle $\delta < 0.01$

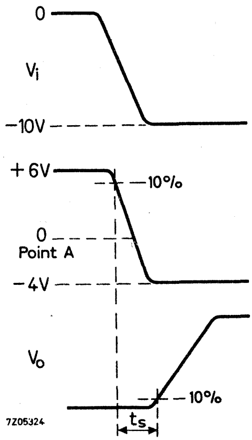
CHARACTERISTICS (continued) T_j = 25 °C

Storage time

$I_C = I_B = -I_{BM}$ = 10 mA t_s < 13 ns

Test circuit: [1])





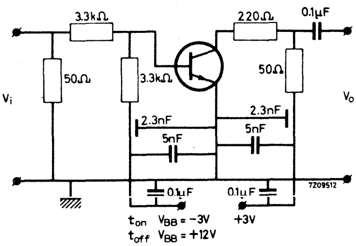
Turn on time

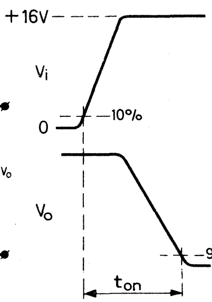
I_C = 10 mA; I_B = 3 mA; $-V_{BE}$ = 1.5 V t_{on} < 12 ns

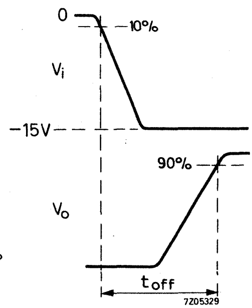
Turn off time

I_C = 10 mA; I_B = 3 mA; $-I_{BM}$ = 1.5 mA t_{off} < 18 ns

Test circuit: [1])







[1]) Pulse generator:

Pulse duration	t	≥	300	ns
Duty cycle	δ	≤	0.02	
Rise time	t_r	≤	1	ns
Source impedance	R_S	=	50	Ω

Oscilloscope:

Rise time	t_r	≤	1	ns
Input impedance	R_i	=	50	Ω

SILICON LOW POWER SWITCHING TRANSISTORS

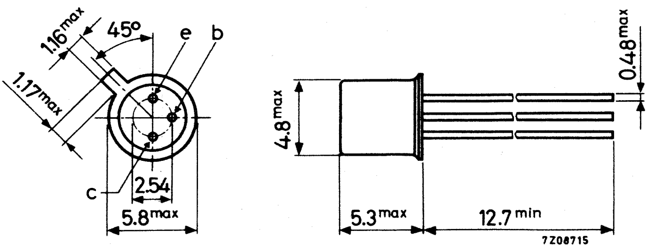
P-N-P transistors in a TO-18 metal envelope with the collector connected to the case. The 2N2894 is intended for medium speed, while the 2N2894A is intended for high speed, saturated switching applications for industrial service.

QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	12		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 $T_{amb} = 25\ ^oC$	P_{tot}	max.	360		mW
Junction temperature	T_j	max.	200		^oC
D.C. current gain at $T_{amb} = 25\ ^oC$ $-I_C = 30$ mA; $-V_{CE} = 0.5$ V	h_{FE}	>	40		
			2N2894	2N2894A	
Turn-off time $-I_C = 30$ mA; $-I_{B1} = +I_{B2} = 1.5$ mA	t_{off}	<	90	35	ns

MECHANICAL DATA Dimensions in mm

Collector connected to case
TO-18



Accessories supplied on request: 56246, 56263

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

Voltages			2N2894	2N2894A	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	12	12	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	12	12	V [1]
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	4.0	4.5	V

Current				
Collector current (d.c.)	$-I_C$	max.	200	mA
Power dissipation				
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.36	W
up to T_{case} = 25 °C	P_{tot}	max.	1.2	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	$R_{th\ j\text{-}a}$	=	486	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	146	°C/W

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

Collector cut-off current			2N2894	2N2894A	
I_E = 0; $-V_{CB}$ = 6.0 V; T_{amb} = 125 °C	$-I_{CBO}$	<	10	–	µA
I_E = 0; $-V_{CB}$ = 10 V; T_{amb} = 125 °C	$-I_{CBO}$	<	–	10	µA
V_{BE} = 0; $-V_{CE}$ = 6.0 V	$-I_{CES}$	<	80	–	nA
V_{BE} = 0; $-V_{CE}$ = 10 V	$-I_{CES}$	<	–	50	nA
Breakdown voltages					
I_E = 0; $-I_C$ = 10 µA	$-V_{(BR)CBO}$	>	12	12	V
V_{BE} = 0; $-I_C$ = 10 µA	$-V_{(BR)CES}$	>	12	12	V
I_C = 0; $-I_E$ = 100 µA	$-V_{(BR)EBO}$	>	4.0	4.5	V

[1]) Applicable up to $-I_C$ = 10 mA

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

			2N2894	2N2894A	
Sustaining voltage [1]					
$I_B = 0$; $-I_C = 10$ mA	$-V_{CEOsust}$	>	12	12	V
Saturation voltages [1]					
$-I_C = 10$ mA; $-I_B = 1.0$ mA	$-V_{CEsat}$	<	0.15	0.13	V
	$-V_{BEsat}$		0.78 to 0.98	0.78 to 0.92	V
$-I_C = 30$ mA; $-I_B = 3.0$ mA	$-V_{CEsat}$	<	0.2	0.19	V
	$-V_{BEsat}$		0.85 to 1.2	0.85 to 1.15	V
$-I_C = 100$ mA; $-I_B = 10$ mA	$-V_{CEsat}$	<	0.5	0.45	V
	$-V_{BEsat}$	>	–	1.0	V
		<	1.7	1.5	V
D.C. current gain [1]					
$-I_C = 1.0$ mA; $-V_{CE} = 0.5$ V	h_{FE}	>	–	20	
$-I_C = 10$ mA; $-V_{CE} = 0.3$ V	h_{FE}	>	30	30	
$-I_C = 30$ mA; $-V_{CE} = 0.5$ V	h_{FE}		40 to 150	40 to 120	
$-I_C = 30$ mA; $-V_{CE} = 0.5$ V; $T_{amb} = -55$ °C	h_{FE}	>	17	20	
$-I_C = 100$ mA; $-V_{CE} = 1.0$ V	h_{FE}	>	25	30	
Collector capacitance at f = 140 kHz					
$I_E = I_e = 0$; $-V_{CB} = 5.0$ V	C_c	<	6.0	4.5	pF
Emitter capacitance at f = 140 kHz					
$I_C = I_c = 0$; $-V_{EB} = 0.5$ V	C_e	<	6.0	6.0	pF
h parameter at f = 100 MHz (common emitter)					
$-I_C = 30$ mA; $-V_{CE} = 10$ V	h_{fe}	>	4.0	8.0	

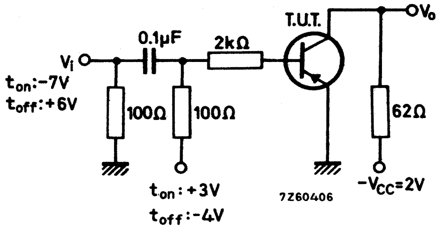
[1] Pulse duration = 300 μs; duty cycle = 0.01

Switching times $T_{amb} = 25\ ^oC$

$-I_C = 30$ mA; $-I_{B1} = +I_{B2} = 1.5$ mA

			2N2894	2N2894A	
Turn-on time	t_{on}	<	60	60	ns
Turn-off time	t_{off}	<	90	35	ns

Test circuit:



Pulse generator:

Pulse duration	t_p	>	200 ns
Rise time	t_r	<	1 ns
Output impedance	Z_o	=	50 Ω

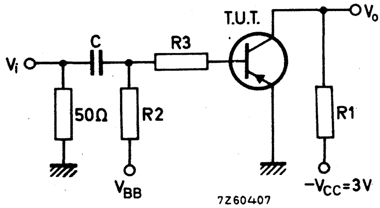
Sampling scope:

Rise time	t_r	<	1 ns
Input impedance	Z_i	=	100 kΩ

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

Turn-on time	2N2894A	t_{on}	<	20	ns
Turn-off time	2N2894A	t_{off}	<	25	ns
Storage time	2N2894A	τ_s	<	20	ns

Test circuit:



Pulse generator:

Pulse duration = 400 ns
Rise time < 1 ns
Output impedance = 50 Ω

Sampling scope:

Rise time < 1 ns
Input impedance = 100 kΩ

	V_i (V)	V_{BB} (V)	R_1 (Ω)	R_2 (kΩ)	R_3 (kΩ)	$-I_C$ (mA)	$-I_{B1}$ (mA)	I_{B2} (mA)	C (μF)
t_{on}	-6.85	0	94	1.0	2.0	30	3.0	-	0.1
t_{off}	11.7	-9.85	94	1.0	2.0	30	3.0	3.0	0.1
τ_s	10	-11	270	0.5	0.5	10	10	10	0.33

P-N-P MEDIUM POWER GENERAL PURPOSE TRANSISTORS

P-N-P silicon planar epitaxial transistors in a TO-39 metal envelope with the collector connected to the case. These transistors are primarily intended for saturated switching and driver applications for industrial service.

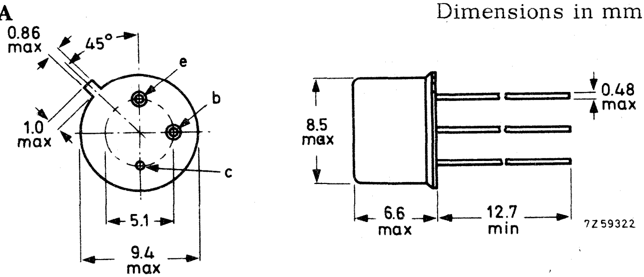
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base)				
2N2904	$-V_{CEO}$	max.	40	V
2N2904A	$-V_{CEO}$	max.	60	V
Collector current (d.c.)	$-I_C$	max.	0.6	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.6	W
Junction temperature	T_j	max.	200	°C
Transition frequency				
$-I_C$ = 50 mA; $-V_{CE}$ = 20 V	f_T	>	200	MHz
D.C. current gain at T_j = 25 °C			2N2904	2N2904A
$-I_C$ = 0.1 mA; $-V_{CE}$ = 10 V	h_{FE}	>	20	40
$-I_C$ = 10 mA; $-V_{CE}$ = 10 V	h_{FE}	>	35	40
$-I_C$ = 500 mA; $-V_{CE}$ = 10 V	h_{FE}	>	20	40

MECHANICAL DATA

Dimensions in mm

Collecter connected to case
TO-39



max. lead diameter is guaranteed only for 12.7 mm

Accessories available: 56218, 56245

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base) $-I_C < 100$ mA — 2N2904	$-V_{CEO}$	max.	40	V
2N2904A	$-V_{CEO}$	max.	60	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	V

Current

Collector current (d.c.)	$-I_C$	max.	0.6	A

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.6	W
up to T_{case} = 25 °C	P_{tot}	max.	3	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	$R_{th\ j\text{-}a}$	=	290	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	58	°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

			2N2904	2N2904A	
Collector cut-off current					
$I_E = 0$; $-V_{CB} = 50$ V	$-I_{CBO}$	<	20	10	nA
$I_E = 0$; $-V_{CB} = 50$ V; $T_j = 150$ °C	$-I_{CBO}$	<	20	10	μA
$+V_{BE} = 0.5$ V; $-V_{CE} = 30$ V	$-I_{CEX}$	<	50		nA
Breakdown voltages					
$I_E = 0$; $-I_C = 10$ μA	$-V_{(BR)CBO}$	>	60		V
$I_B = 0$; $-I_C = 10$ mA — 2N2904	$-V_{(BR)CEO}$	>	40		V
2N2904A	$-V_{(BR)CEO}$	>	60		V
$I_C = 0$; $-I_E = 10$ μA	$-V_{(BR)EBO}$	>	5		V
Saturation voltages [1]					
$-I_C = 150$ mA; $-I_B = 15$ mA	$-V_{CEsat}$	<	0.4		V
	$-V_{BEsat}$	<	1.3		V
$-I_C = 500$ mA; $-I_B = 50$ mA	$-V_{CEsat}$	<	1.6		V
	$-V_{BEsat}$	<	2.6		V

D.C. current gain			2N2904	2N2904A
$-I_C = 0.1$ mA; $-V_{CE} = 10$ V	h_{FE}	>	20	40
$-I_C = 1$ mA; $-V_{CE} = 10$ V	h_{FE}	>	25	40
$-I_C = 10$ mA; $-V_{CE} = 10$ V	h_{FE}	>	35	40
$-I_C = 150$ mA; $-V_{CE} = 10$ V [1]	h_{FE}	>	40	40
		<	120	120
$-I_C = 500$ mA; $-V_{CE} = 10$ V [1]	h_{FE}	>	20	40

Collector capacitance at f = 100 kHz				
$I_E = I_e = 0$; $-V_{CB} = 10$ V	C_c	<	8	pF
Emitter capacitance at f = 100 kHz				
$I_C = I_c = 0$; $-V_{EB} = 2$ V	C_e	<	30	pF
Transition frequency				
$-I_C = 50$ mA; $-V_{CE} = 20$ V	f_T	>	200	MHz

[1]) Measured under pulsed conditions to avoid excessive dissipation.
Pulse duration $t \leq 300$ μs; duty cycle $\delta \leq 0.02$.

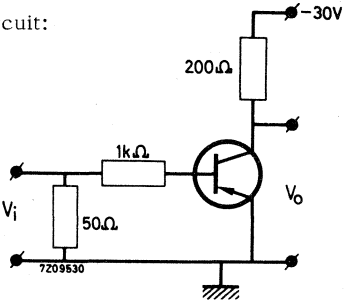
CHARACTERISTICS (continued) T_j = 25 °C

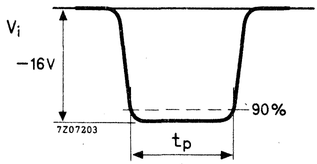
Switching times

Turn on time when switched to $-I_C$ = 150 mA; $-I_B$ = 15 mA

delay time	t_d	<	10	ns
rise time	t_r	<	40	ns
turn on time	t_{on}	<	45	ns

Test circuit:





Oscilloscope:

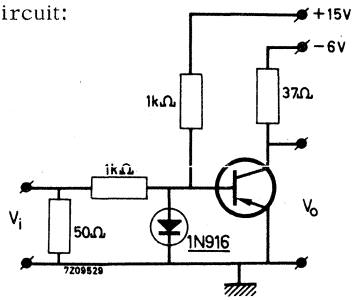
Rise time	t_r	≤	5 ns
Input impedance	Z_i	=	10 MΩ

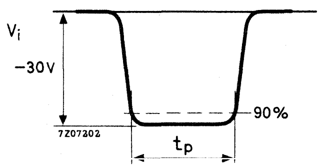
Pulse generator:			
Frequency	f	=	150 Hz
Pulse duration	t_p	=	200 ns
Rise time	t_r	≤	2 ns
Output impedance	Z_o	=	50 Ω

Turn off time when switched from
$-I_C$ = 150 mA; $-I_B$ = 15 mA to cut-off with $+I_{BM}$ = 15 mA

storage time	t_s	<	80	ns
fall time	t_f	<	30	ns
turn off time	t_{off}	<	100	ns

Test circuit:





Oscilloscope:

Rise time	t_r	≤	5 ns
Input impedance	Z_i	=	10 MΩ

Pulse generator:			
Frequency	f	=	150 Hz
Pulse duration	t_p	=	200 ns
Rise time	t_r	≤	2 ns
Output impedance	Z_o	=	50 Ω

P-N-P MEDIUM POWER GENERAL PURPOSE TRANSISTORS

P-N-P silicon planar epitaxial transistors in a TO-39 metal envelope with the collector connected to the case. These transistors are primarily intended for saturated switching and driver applications for industrial service.

QUICK REFERENCE DATA

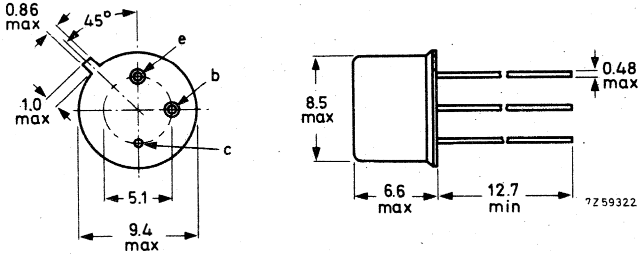
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60		V
Collector-emitter voltage (open base)					
2N2905	$-V_{CEO}$	max.	40		V
2N2905A	$-V_{CEO}$	max.	60		V
Collector current (d.c.)	$-I_C$	max.	0.6		A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.6		W
Junction temperature	T_j	max.	200		°C
Transition frequency					
$-I_C$ = 50 mA; $-V_{CE}$ = 20 V	f_T	>	200		MHz
D.C. current gain at T_j = 25 °C			2N2905	2N2905A	
$-I_C$ = 0.1 mA; $-V_{CE}$ = 10 V	h_{FE}	>	35	75	
$-I_C$ = 10 mA; $-V_{CE}$ = 10 V	h_{FE}	>	75	100	
$-I_C$ = 500 mA; $-V_{CE}$ = 10 V	h_{FE}	>	30	50	

MECHANICAL DATA

Dimensions in mm

Collecter connected to case

TO-39



max. lead diameter is guaranteed only for 12.7 mm

Accessories available: 56218, 56245

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base) $-I_C < 100$ mA — 2N2905	$-V_{CEO}$	max.	40	V
2N2905A	$-V_{CEO}$	max.	60	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	V

Current

Collector current (d.c.)	$-I_C$	max.	0.6	A

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.6	W
up to T_{case} = 25 °C	P_{tot}	max.	3	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	$R_{th\ j\text{-}a}$	=	290	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	58	°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			2N2905	2N2905A	
I_E = 0; $-V_{CB}$ = 50 V	$-I_{CBO}$	<	20	10	nA
I_E = 0; $-V_{CB}$ = 50 V; T_j = 150 °C	$-I_{CBO}$	<	20	10	μA
$+V_{BE}$ = 0.5 V; $-V_{CE}$ = 30 V	$-I_{CEX}$	<	50		nA

Breakdown voltages

I_E = 0; $-I_C$ = 10 μA		$-V_{(BR)CBO}$	>	60	V
I_B = 0; $-I_C$ = 10 mA	2N2905	$-V_{(BR)CEO}$	>	40	V
	2N2905A	$-V_{(BR)CEO}$	>	60	V
I_C = 0; $-I_E$ = 10 μA		$-V_{(BR)EBO}$	>	5	V

Saturation voltages [1]

$-I_C$ = 150 mA; $-I_B$ = 15 mA	$-V_{CEsat}$	<	0.4	V
	$-V_{BEsat}$	<	1.3	V
$-I_C$ = 500 mA; $-I_B$ = 50 mA	$-V_{CEsat}$	<	1.6	V
	$-V_{BEsat}$	<	2.6	V

D.C. current gain			2N2905	2N2905A
$-I_C$ = 0.1 mA; $-V_{CE}$ = 10 V	h_{FE}	>	35	75
$-I_C$ = 1 mA; $-V_{CE}$ = 10 V	h_{FE}	>	50	100
$-I_C$ = 10 mA; $-V_{CE}$ = 10 V	h_{FE}	>	75	100
$-I_C$ = 150 mA; $-V_{CE}$ = 10 V [1]	h_{FE}	>	100	100
		<	300	300
$-I_C$ = 500 mA; $-V_{CE}$ = 10 V [1]	h_{FE}	>	30	50

Collector capacitance at f = 100 kHz

$I_E = I_e$ = 0; $-V_{CB}$ = 10 V	C_c	<	8	pF

Emitter capacitance at f = 100 kHz

$I_C = I_c$ = 0; $-V_{EB}$ = 2 V	C_e	<	30	pF

Transition frequency

$-I_C$ = 50 mA; $-V_{CE}$ = 20 V	f_T	>	200	MHz

[1]) Measured under pulsed conditions to avoid excessive dissipation.
Pulse duration $t \leq 300$ μs; duty cycle $\delta \leq 0.02$.

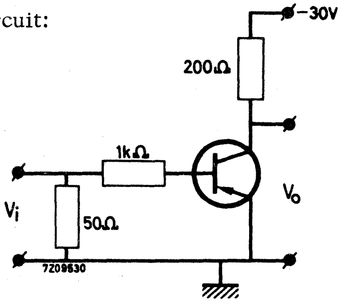
CHARACTERISTICS (continued) $T_j = 25\,^{o}C$

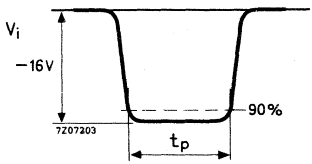
Switching times

Turn on time when switched to $-I_C = 150$ mA; $-I_B = 15$ mA

delay time	t_d	<	10	ns
rise time	t_r	<	40	ns
turn on time	t_{on}	<	45	ns

Test circuit:





Oscilloscope:

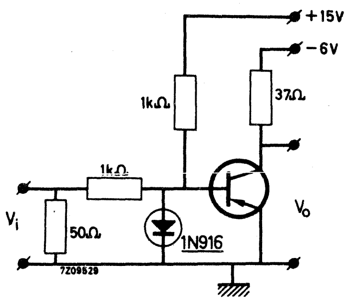
Rise time	t_r	≤	5	ns
Input impedance	Z_i	=	10	MΩ

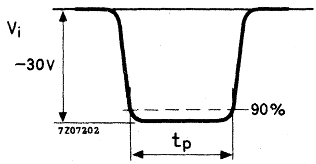
Pulse generator: Frequency	f	=	150	Hz
Pulse duration	t_p	=	200	ns
Rise time	t_r	≤	2	ns
Output impedance	Z_o	=	50	Ω

Turn off time when switched from
$-I_C = 150$ mA; $-I_B = 15$ mA to cut-off with $+I_{BM} = 15$ mA

storage time	t_s	<	80	ns
fall time	t_f	<	30	ns
turn off time	t_{off}	<	100	ns

Test circuit:





Oscilloscope:

Rise time	t_r	≤	5	ns
Input impedance	Z_i	=	10	MΩ

Pulse generator: Frequency	f	=	150	Hz
Pulse duration	t_p	=	200	ns
Rise time	t_r	≤	2	ns
Output impedance	Z_o	=	50	Ω

2N2906
2N2906A

P-N-P MEDIUM POWER
GENERAL PURPOSE TRANSISTORS

P-N-P silicon planar epitaxial transistors in a TO-18 metal envelope with the collector connected to the case. These transistors are primarily intended for saturated switching and driver applications for industrial service.

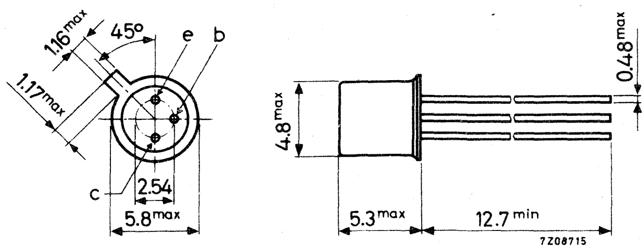
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base)				
2N2906	$-V_{CEO}$	max.	40	V
2N2906A	$-V_{CEO}$	max.	60	V
Collector current (d.c.)	$-I_C$	max.	0.6	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.4	W
Junction temperature	T_j	max.	200	°C
Transition frequency at f = 100 MHz				
$-I_C$ = 50 mA; $-V_{CE}$ = 20 V; T_{amb} = 25 °C	f_T	>	200	MHz
D.C. current gain at T_j = 25 °C			2N2906	2N2906A
$-I_C$ = 0.1 mA; $-V_{CE}$ = 10 V	h_{FE}	>	20	40
$-I_C$ = 10 mA; $-V_{CE}$ = 10 V	h_{FE}	>	35	40
$-I_C$ = 500 mA; $-V_{CE}$ = 10 V	h_{FE}	>	20	40

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-18



Accessories available: 56246, 56263

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

Voltages

Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base) $-I_C < 100$ mA	2N2906	$-V_{CEO}$	max.	40	V
	2N2906A	$-V_{CEO}$	max.	60	V
Emitter-base voltage (open collector)		$-V_{EBO}$	max.	5	V

Current

Collector current (d.c.)	$-I_C$	max.	0.6	A

Power dissipation

Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	0.4	W
up to $T_{case} = 25\ ^oC$	P_{tot}	max.	1.8	W

Temperatures

Storage temperature	T_{stg}	−65 to +200		^oC
Junction temperature	T_j	max.	200	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	438	$^oC/W$
From junction to case	$R_{th\ j\text{-}c}$	=	97	$^oC/W$

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Condition		Symbol		2N2906	2N2906A	Unit
Collector cut-off current						
$I_E = 0$; $-V_{CB} = 50$ V		$-I_{CBO}$	<	20	10	nA
$I_E = 0$; $-V_{CB} = 50$ V; $T_j = 150$ °C		$-I_{CBO}$	<	20	10	μA
$+V_{BE} = 0.5$ V; $-V_{CE} = 30$ V		$-I_{CEX}$	<	50	50	nA
Breakdown voltages						
$I_E = 0$; $-I_C = 10$ μA		$-V_{(BR)CBO}$	>	60		V
$I_B = 0$; $-I_C = 10$ mA	2N2906	$-V_{(BR)CEO}$	>	40		V
	2N2906A	$-V_{(BR)CEO}$	>	60		V
$I_C = 0$; $-I_E = 10$ μA		$-V_{(BR)EBO}$	>	5		V
Saturation voltages [1]						
$-I_C = 150$ mA; $-I_B = 15$ mA		$-V_{CEsat}$	<	0.4		V
		$-V_{BEsat}$	<	1.3		V
$-I_C = 500$ mA; $-I_B = 50$ mA		$-V_{CEsat}$	<	1.6		V
		$-V_{BEsat}$	<	2.6		V
D.C. current gain				2N2906	2N2906A	
$-I_C = 0.1$ mA; $-V_{CE} = 10$ V		h_{FE}	>	20	40	
$-I_C = 1$ mA; $-V_{CE} = 10$ V		h_{FE}	>	25	40	
$-I_C = 10$ mA; $-V_{CE} = 10$ V		h_{FE}	>	35	40	
$-I_C = 150$ mA; $-V_{CE} = 10$ V [1]		h_{FE}	>	40	40	
			<	120	120	
$-I_C = 500$ mA; $-V_{CE} = 10$ V [1]		h_{FE}	>	20	40	
Collector capacitance at f = 100 kHz						
$I_E = I_e = 0$; $-V_{CB} = 10$ V		C_c	<	8		pF
Emitter capacitance at f = 100 kHz						
$I_C = I_c = 0$; $-V_{EB} = 2$ V		C_e	<	30		pF
Transition frequency at f = 100 MHz						
$-I_C = 50$ mA; $-V_{CE} = 20$ V; $T_{amb} = 25$ °C		f_T	>	200		MHz

[1]) Measured under pulsed conditions to avoid excessive dissipation.
Pulse duration $t \leq 300$ μs; duty cycle $\delta \leq 0.02$.

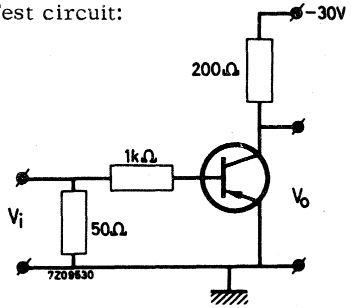
CHARACTERISTICS (continued) $T_j = 25\ ^oC$

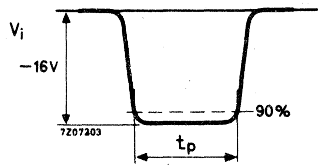
Switching times

Turn on time when switched to $-I_C = 150$ mA; $-I_B = 15$ mA

delay time	t_d	<	10	ns
rise time	t_r	<	40	ns
turn on time	t_{on}	<	45	ns

Test circuit:





Oscilloscope:

Rise time	$t_r \leq$	5 ns
Input impedance	$Z_i =$	10 MΩ

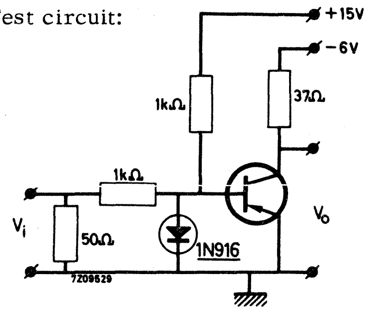
Pulse generator:

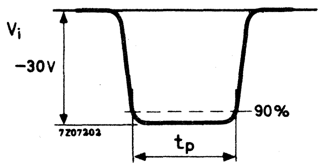
Frequency	$f =$	150 Hz
Pulse duration	$t_p =$	200 ns
Rise time	$t_r \leq$	2 ns
Output impedance	$Z_o =$	50 Ω

Turn off time when switched from
$-I_C = 150$ mA; $-I_B = 15$ mA to cut-off with $+I_{BM} = 15$ mA

storage time	t_s	<	80	ns
fall time	t_f	<	30	ns
turn off time	t_{off}	<	100	ns

Test circuit:





Oscilloscope:

Rise time	$t_r \leq$	5 ns
Input impedance	$Z_i =$	10 MΩ

Pulse generator:

Frequency	$f =$	150 Hz
Pulse duration	$t_p =$	200 ns
Rise time	$t_r \leq$	2 ns
Output impedance	$Z_o =$	50 Ω

P-N-P MEDIUM POWER GENERAL PURPOSE TRANSISTORS

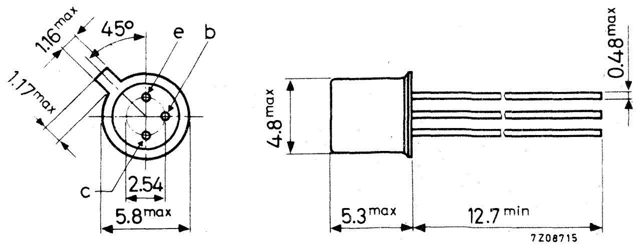
P-N-P silicon planar epitaxial transistors in a TO-18 metal envelope with the collector connected to the case. These transistors are primarily intended for saturated switching and driver applications for industrial service.

QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base)				
2N2907	$-V_{CEO}$	max.	40	V
2N2907A	$-V_{CEO}$	max.	60	V
Collector current (d.c.)	$-I_C$	max.	0.6	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.4	W
Junction temperature	T_j	max.	200	°C
Transition frequency at f = 100 MHz				
$-I_C$ = 50 mA; $-V_{CE}$ = 20 V; T_{amb} = 25 °C	f_T	>	200	MHz
D.C. current gain at T_j = 25 °C			2N2907	2N2907A
$-I_C$ = 0.1 mA; $-V_{CE}$ = 10 V	h_{FE}	>	35	75
$-I_C$ = 10 mA; $-V_{CE}$ = 10 V	h_{FE}	>	75	100
$-I_C$ = 500 mA; $-V_{CE}$ = 10 V	h_{FE}	>	30	50

MECHANICAL DATA Dimensions in mm

Collector connected to case
TO-18



Accessories available: 56246, 56263

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

Voltages				
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base) $-I_C < 100$ mA				
2N2907	$-V_{CEO}$	max.	40	V
2N2907A	$-V_{CEO}$	max.	60	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	V
Current				
Collector current (d.c.)	$-I_C$	max.	0.6	A
Power dissipation				
Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	0.4	W
up to $T_{case} = 25\ ^oC$	P_{tot}	max.	1.8	W
Temperatures				
Storage temperature	T_{stg}		-65 to +200	^oC
Junction temperature	T_j	max.	200	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	438	$^oC/W$
From junction to case	$R_{th\ j-c}$	=	97	$^oC/W$

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

			2N2907	2N2907A	
I_E = 0; $-V_{CB}$ = 50 V	$-I_{CBO}$	<	20	10	nA
I_E = 0; $-V_{CB}$ = 50 V; T_j = 150 °C	$-I_{CBO}$	<	20	10	μA
$+V_{BE}$ = 0.5 V; $-V_{CE}$ = 30 V	$-I_{CEX}$	<	50	50	nA

Breakdown voltages

I_E = 0; $-I_C$ = 10 μA		$-V_{(BR)CBO}$	>	60	V
I_B = 0; $-I_C$ = 10 mA	2N2907	$-V_{(BR)CEO}$	>	40	V
	2N2907A	$-V_{(BR)CEO}$	>	60	V
I_C = 0; $-I_E$ = 10 μA		$-V_{(BR)EBO}$	>	5	V

Saturation voltages [1]

$-I_C$ = 150 mA; $-I_B$ = 15 mA	$-V_{CEsat}$	<	0.4	V
	$-V_{BEsat}$	<	1.3	V
$-I_C$ = 500 mA; $-I_B$ = 50 mA	$-V_{CEsat}$	<	1.6	V
	$-V_{BEsat}$	<	2.6	V

D.C. current gain

			2N2907	2N2907A
$-I_C$ = 0.1 mA; $-V_{CE}$ = 10 V	h_{FE}	>	35	75
$-I_C$ = 1 mA; $-V_{CE}$ = 10 V	h_{FE}	>	50	100
$-I_C$ = 10 mA; $-V_{CE}$ = 10 V	h_{FE}	>	75	100
$-I_C$ = 150 mA; $-V_{CE}$ = 10 V [1]	h_{FE}	>	100	100
		<	300	300
$-I_C$ = 500 mA; $-V_{CE}$ = 10 V [1]	h_{FE}	>	30	50

Collector capacitance at f = 100 kHz				
$I_E = I_e$ = 0; $-V_{CB}$ = 10 V	C_c	<	8	pF
Emitter capacitance at f = 100 kHz				
$I_C = I_c$ = 0; $-V_{EB}$ = 2 V	C_e	<	30	pF
Transition frequency at f = 100 MHz				
$-I_C$ = 50 mA; $-V_{CE}$ = 20 V; T_{amb} = 25 °C	f_T	>	200	MHz

[1]) Measured under pulsed conditions to avoid excessive dissipation.
Pulsed duration t ≤ 300 μs; duty cycle $\delta \leq 0.02$.

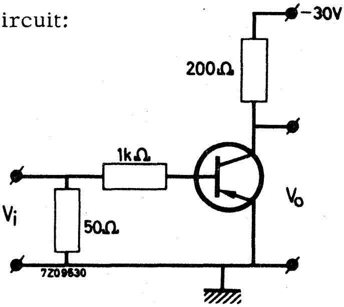
CHARACTERISTICS (continued) $T_j = 25\ ^oC$

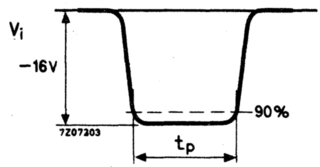
Switching times

Turn on time when switched to $-I_C = 150$ mA; $-I_B = 15$ mA

delay time	t_d	<	10	ns
rise time	t_r	<	40	ns
turn on time	t_{on}	<	45	ns

Test circuit:





Oscilloscope:

Rise time	t_r	≤	5	ns
Input impedance	Z_i	=	10	MΩ

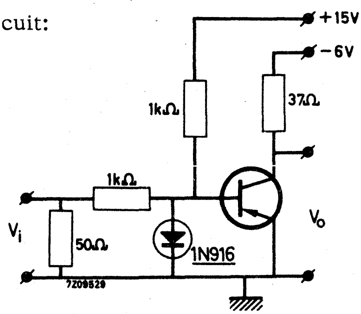
Pulse generator:

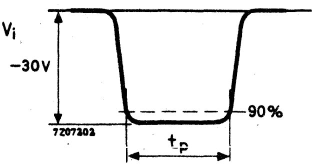
Frequency	f	=	150	Hz
Pulse duration	t_p	=	200	ns
Rise time	t_r	≤	2	ns
Output impedance	Z_o	=	50	Ω

Turn off time when switched from
$-I_C = 150$ mA; $-I_B = 15$ mA to cut-off with $+I_{BM} = 15$ mA

storage time	t_s	<	80	ns
fall time	t_f	<	30	ns
turn off time	t_{off}	<	100	ns

Test circuit:





Oscilloscope:

Rise time	t_r	≤	5	ns
Input impedance	Z_i	=	10	MΩ

Pulse generator:

Frequency	f	=	150	Hz
Pulse duration	t_p	=	200	ns
Rise time	t_r	≤	2	ns
Output impedance	Z_o	=	50	Ω

SILICON PLANAR EPITAXIAL TRANSISTORS

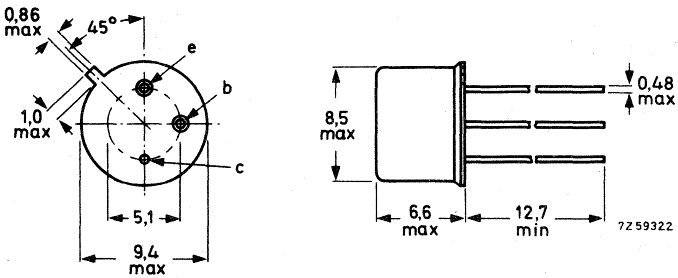
N-P-N transistors in TO-39 metal envelopes intended for use as amplifiers and in switching circuits.

QUICK REFERENCE DATA					
Collector-base voltage (open emitter)	V_{CBO}	max.	140		V
Collector-emitter voltage (open base)	V_{CEO}	max.	80		V
Collector current (d.c.)	I_C	max.	1		A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8		W
up to T_{case} = 25 °C	P_{tot}	max.	5,0		W
Junction temperature	T_j	max.	200		°C
			2N3019	2N3020	
D.C. current gain I_C = 150 mA; V_{CE} = 10 V	h_{FE}	> <	100 300	40 120	
Transition frequency at f = 20 MHz I_C = 50 mA; V_{CE} = 10 V	f_T	>	100	80	MHz

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)

Voltages				
Collector-base voltage (open emitter)	V_{CBO}	max.	140	V
Collector-emitter voltage (open base)	V_{CEO}	max.	80	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	V
Current				
Collector current (d.c.)	I_C	max.	1	A
Power dissipation				
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8	W
up to T_{case} = 25 °C	P_{tot}	max.	5,0	W
Temperatures				
Storage temperature	T_{stg}		−65 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	218	°C/W
From junction to case	$R_{th\ j-c}$	=	35	°C/W

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

Collector cut-off current				
$I_E = 0$; $V_{CB} = 90$ V	I_{CBO}	<	10	nA
$I_E = 0$; $V_{CB} = 90$ V; $T_{amb} = 150$ °C	I_{CBO}	<	10	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	nA
Breakdown voltages				
$I_E = 0$; $I_C = 100$ μA	$V_{(BR)CBO}$	>	140	V
$I_B = 0$; $I_C = 30$ mA	$V_{(BR)CEO}$	>	80	V [1]
$I_C = 0$; $I_E = 100$ μA	$V_{(BR)EBO}$	>	7	V
Saturation voltages				
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0,2	V
	V_{BEsat}	<	1,1	V [1]
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	0,5	V [1]

[1]) Measured under pulse conditions: $t_p = 300$ μs; $\delta \leq 0,01$.

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

			2N3019	2N3020	
D.C. current gain [1]					
$I_C = 0,1$ mA; $V_{CE} = 10$ V	h_{FE}	> <	50 –	30 100	
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	> <	90 –	40 120	
$I_C = 150$ mA; $V_{CE} = 10$ V	h_{FE}	> <	100 300	40 120	
$I_C = 150$ mA; $V_{CE} = 10$ V; $T_{case} = -55\ ^{o}C$	h_{FE}	>	40	–	
$I_C = 500$ mA; $V_{CE} = 10$ V	h_{FE}	> <	50 –	30 100	
$I_C = 1000$ mA; $V_{CE} = 10$ V	h_{FE}	>	15	15	
Transition frequency at f = 20 MHz					
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	>	100	80	MHz
Collector capacitance at f = 1 MHz					
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	12	12	pF
Emitter capacitance at f = 1 MHz					
$I_C = I_c = 0$; $V_{EB} = 0,5$ V	C_e	<	60	60	pF
Feedback time constant at f = 4 MHz					
$I_C = 10$ mA; $V_{CB} = 10$ V	$r_{bb'}C_{b'c}$	<	400	400	ps
Small-signal current gain at f = 1 kHz					
$I_C = 1,0$ mA; $V_{CE} = 5$ V	h_{fe}	> <	80 400	30 200	
Noise figure at f = 1 kHz					
$I_C = 0,1$ mA; $V_{CE} = 10$ V; $R_S = 1$ kΩ	F	<	4	–	dB

[1] Measured under pulse conditions : $t_p = 300$ µs; $\delta \le 0,01$.

SILICON EPITAXIAL TRANSISTOR

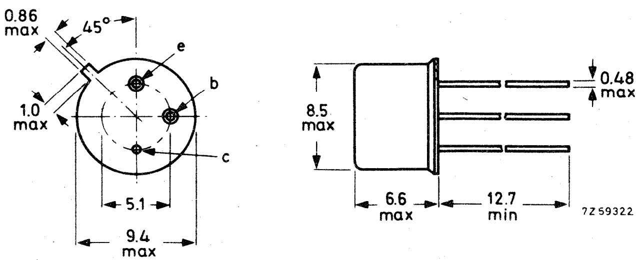
P-N-P transistor in a TO-39 metal envelope with the collector connected to the case. The transistor is intended for general industrial applications.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	90	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	65	V
Collector current (d.c.)	$-I_C$	max.	1.0	A
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	5	W
Junction temperature	T_j	max.	200	°C
Collector-emitter saturation voltage $-I_C$ = 150 mA; $-I_B$ = 15 mA	$-V_{CEsat}$	<	0.65	V
D.C. current gain $-I_C$ = 150 mA; $-V_{CE}$ = 10 V	h_{FE}		40 to 140	
Transition frequency at f = 20 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 10 V	f_T	>	60	MHz

MECHANICAL DATA

Dimensions in mm

TO-39
Collector connected
to case



max. lead diameter is guaranteed only for 12.7 mm.

Accessories supplied on request: 56218, 56245

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.	65	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	7	V
Currents				
Collector current (d.c.)	$-I_C$	max.	1.0	A
Base current (d.c.)	$-I_B$	max.	0.5	A
Power dissipation				
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	5	W
Temperatures				
Storage temperature	T_{stg}		−65 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to case	$R_{th\ j-c}$	=	35	°C/W

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

Collector cut-off current				
$I_E = 0;\ -V_{CB} = 60\ V$	$-I_{CBO}$	<	20	nA
$+V_{BE} = 1.5\,V;\ V_{CE} = 30\,V;\ T_{case} = 150\,^{o}C$	$-I_{CEX}$	<	100	μA
Breakdown voltages				
Collector-base voltage				
$I_E = 0;\ -I_C = 100\ \mu A$	$-V_{(BR)CBO}$	>	90	V
Collector-emitter voltage				
$+V_{BE} = 1.5\,V;\ -I_C = 100\ mA$	$-V_{(BR)CEX}$	>	85	V
Emitter-base voltage				
$I_C = 0;\ I_E = 100\ \mu A$	$-V_{(BR)EBO}$	>	7	V
Collector-emitter sustaining voltage				
$I_B = 0;\ -I_C = 100\ mA$	$-V_{CEOsust}$	>	65	V
Saturation voltage				
$-I_C = 150\ mA;\ -I_B = 15\ mA$	$-V_{CEsat}$	<	0.65	V
	$-V_{BEsat}$	<	1.4	V
D.C. current gain				
$-I_C = 0.1\ mA;\ -V_{CE} = 10\ V$	h_{FE}	>	20	
$-I_C = 150\ mA;\ -V_{CE} = 10\ V$	h_{FE}		40 to 140	
$-I_C = 150\ mA;\ -V_{CE} = 2\ V$	h_{FE}		20 to 200	
$-I_C = 500\ mA;\ -V_{CE} = 10\ V$	h_{FE}	>	20	
Transition frequency at f = 20 MHz				
$-I_C = 50\ mA;\ -V_{CE} = 10\ V$	f_T	>	60	MHz
Collector-base capacitance at f = 1 MHz				
$I_E = I_e = 0;\ -V_{CB} = 10\ V$	C_c	<	30	pF

Switching times

Turn on time

$-I_C$ = 150 mA; $-I_B = +I_{BM}$ = 15 mA

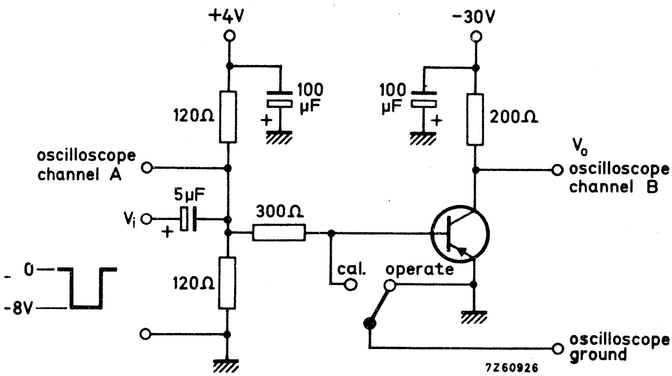
rise time	t_r	<	70	ns
turn on time	t_{on}	<	110	ns

Turn off time

$-I_C$ = 150 mA; $-I_B = +I_{BM}$ = 15 mA

storage time	t_s	<	600	ns
fall time	t_f	<	100	ns
turn off time	t_{off}	<	700	ns

Test circuit:



Pulse generator:

f = 10 kHz

t_r < 10 ns

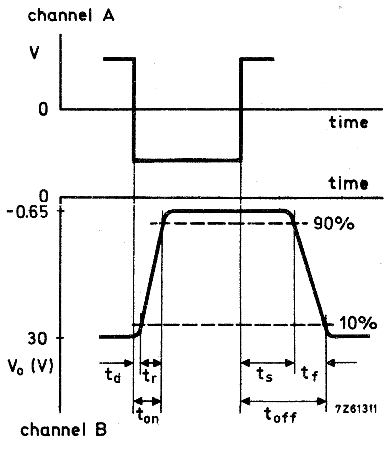
t_p = 20 μs

Oscilloscope:

Z_i = 10 MΩ

C_i = 20 pF

t_r < 15 ns



Accessories

Introduction

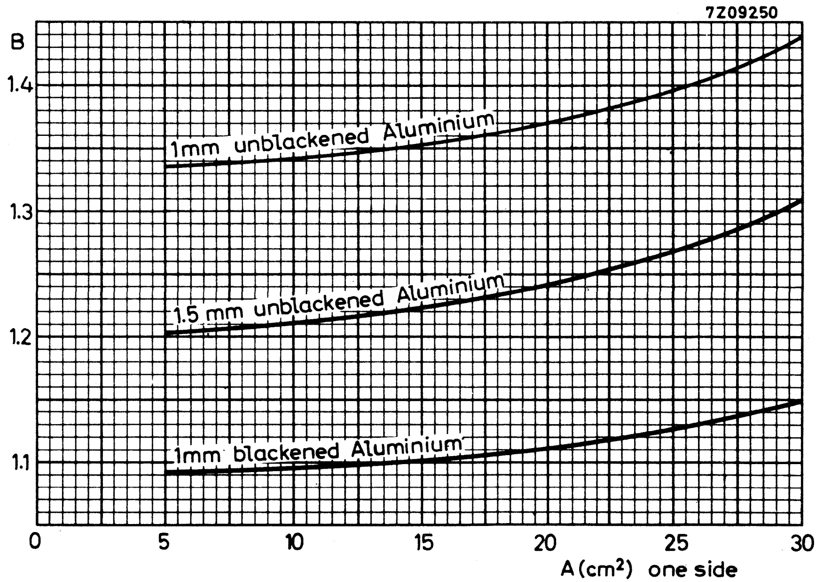
All information on thermal resistances of the accessories combined with flat heatsinks is valid for square heatsinks of 1.5 mm blackened aluminium.
For a few variations the thermal resistance may be derived as follows:

a. Rectangular heatsinks (sides a and 2a)

When mounted with long side horizontal, multiply by 0.95.
When mounted with short side horizontal, multiply by 1.10.

b. Unblackened or thinner heatsinks

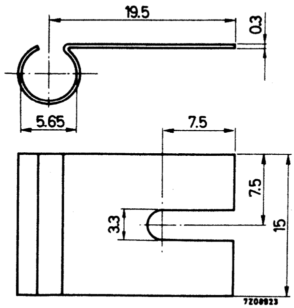
Multiply by the factor B given below as a function of the heatsink size A.



COOLING FIN

MECHANICAL DATA

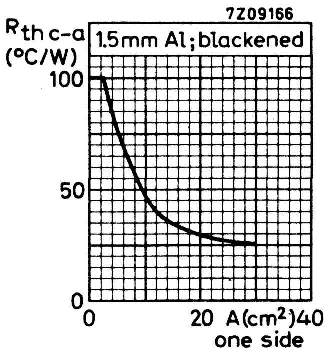
Dimensions in mm



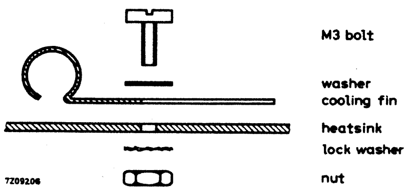
Fin material: brass, nickel plated

THERMAL RESISTANCE

From case to ambient with cooling fin only	$R_{th\ c\text{-}a}$	= 100 °C/W
with heatsink		see graph



MOUNTING INSTRUCTIONS



Torque on nut for good heat transfer: 5 cm kg

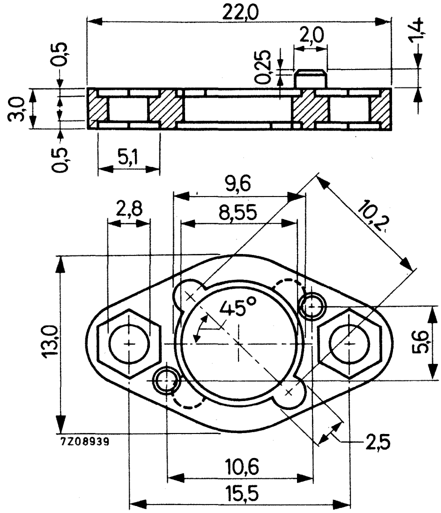
MOUNTING ACCESSORIES

Mounting accessories for TO-5 envelopes. The package consists of:

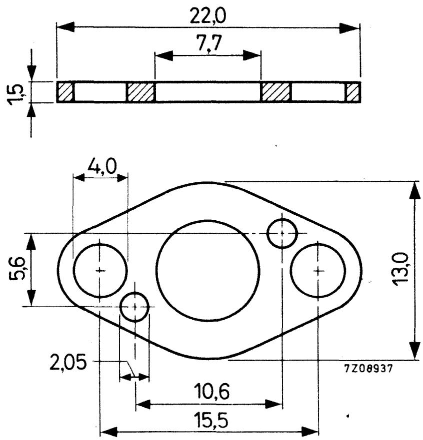
1 top clamping piece
1 bottom clamping piece
1 mylar insulator

MECHANICAL DATA

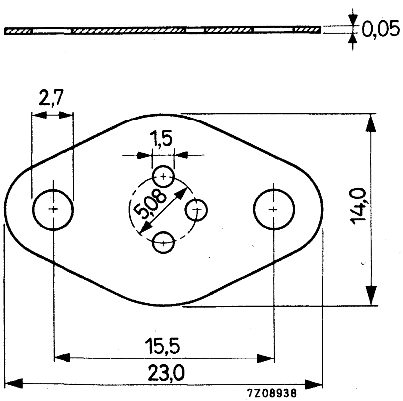
Dimensions in mm



top clamping piece
of insulating material



bottom clamping piece
material: brass, tin-plated



mylar insulator

THERMAL RESISTANCE

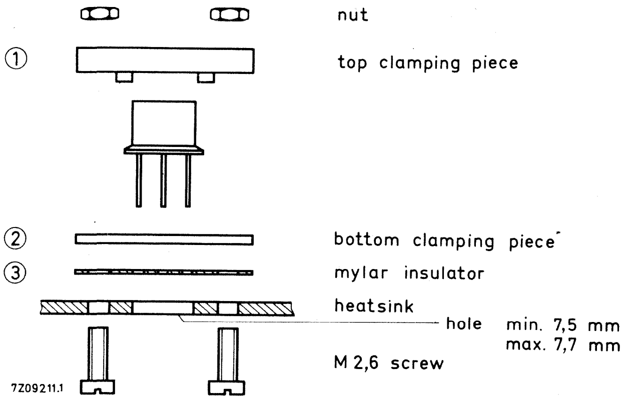
From mounting base to heatsink direct mounting	$R_{th\ mb-h}$	=	3	°C/W
insulated mounting	$R_{th\ mb-h}$	=	6	°C/W

TEMPERATURE

Maximum permissible temperature	T_{max}	=	100	°C

MOUNTING INSTRUCTIONS

Insulated mounting:



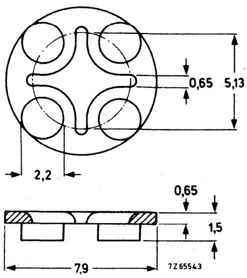
Direct mounting: without items 2 and 3; item 1 to be mounted upside-down.

DISTANCE DISCS

MECHANICAL DATA

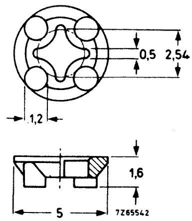
Dimensions in mm

56245



Insulating material

56246



Insulating material

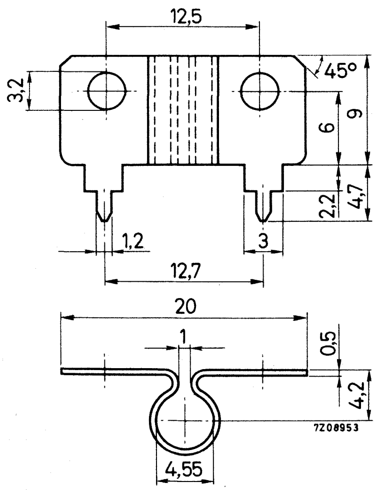
TEMPERATURE

Maximum permissible temperature	T	max.	100	°C

56263 COOLING FIN

MECHANICAL DATA

Dimensions in mm



Material: copper, tin plated

THERMAL RESISTANCE

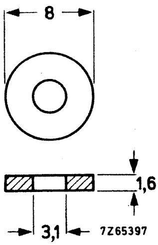
From case to ambient	$R_{th\ c-a}$	=	100	°C/W

WASHER

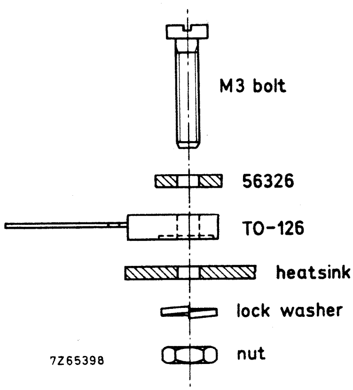
Flat metal washer for non-insulated mounting of envelope SOT-32 (TO-126).

MECHANICAL DATA

Dimensions in mm



MOUNTING INSTRUCTIONS



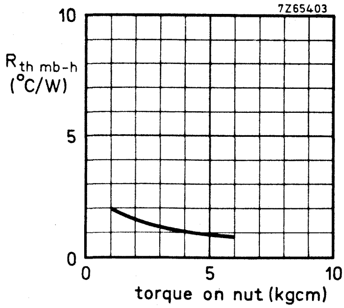
Minimum torque on nut for good heat transfer	4 kgcm (0, 4 Nm)
Maximum torque on nut	6 kgcm (0, 6 Nm)
Minimum thickness of heatsink	2 mm

The heatsink surface must appear flat and smooth, without burrs or scratches. If the hole in the heatsink is threaded, it should be countersunk and free of burrs; the hole should also be perpendicular to the plane of the heatsink, within 2^{o} tolerance (for M3 thread).
For mounting on a heatsink the use of a heat conducting compound is recommended.

THERMAL RESISTANCE

From mounting base to heatsink $R_{th\ mb-h}$ = 1 °C/W

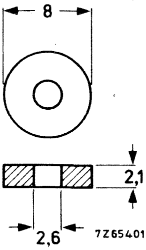
See also the graph.



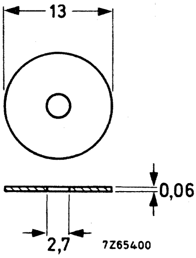
MOUNTING ACCESSORIES

Mounting accessories for insulated mounting of envelope SOT-32 (TO-126); the set con-consists of a metal washer, a mica washer and an insulating bush.

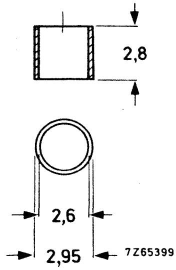
MECHANICAL DATA Dimensions in mm



Metal washer

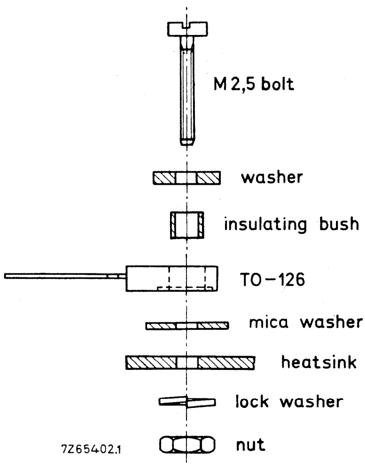


Mica washer



Insulating bush

MOUNTING INSTRUCTIONS



Minimum torque on nut for good heat transfer	4 kgcm (0, 4 Nm)
Maximum torque on nut	6 kgcm (0, 6 Nm)
Minimum thickness of heatsink	2 mm

MOUNTING INSTRUCTIONS (continued)

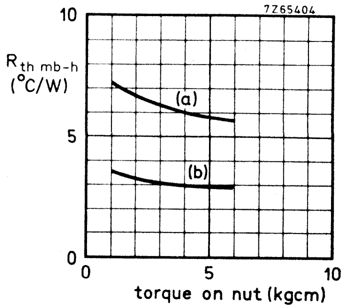
The heatsink surface must appear flat and smooth, without burrs or scratches. If the hole in the heatsink is threaded, it should be countersunk and free of burrs; the hole should also be perpendicular to the plane of the heatsink, within 10^{o} tolerance (for M2,5 thread). For good heat transfer the use of a heatsink compound is recommended.

THERMAL RESISTANCE

From mounting base to heatsink

(a) without heatsink compound	$R_{th\ mb-h}$	=	6	$^{o}C/W$
(b) with heatsink compound	$R_{th\ mb-h}$	=	3	$^{o}C/W$

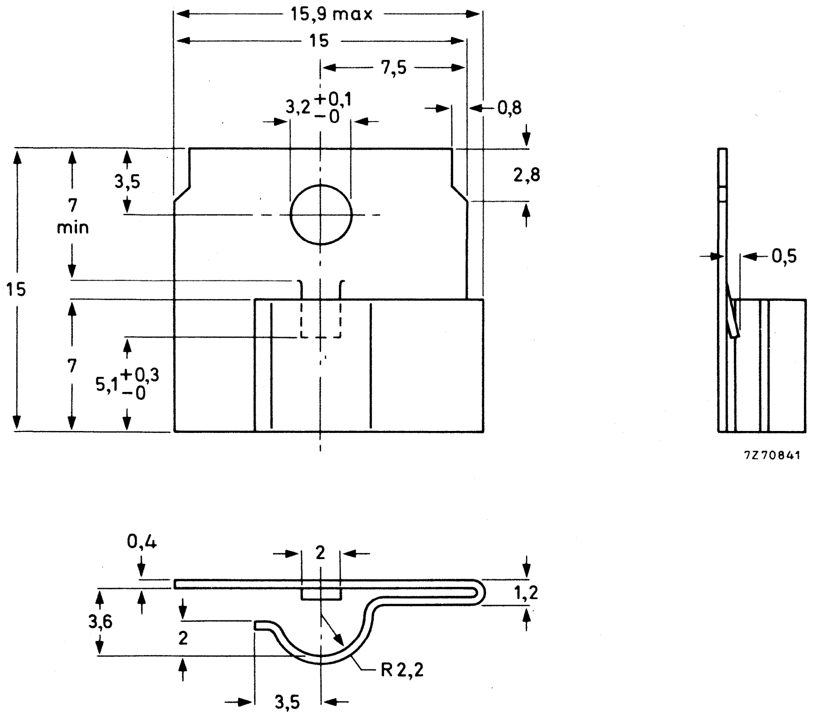
See also the graph.



COOLING CLIP FOR TO-92 VARIANT

MECHANICAL DATA

Dimensions in mm



Material: steel, aluminium plated.

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

Type No.	Part	Section	Type No.	Part	Section	Type No.	Part	Section
BC107	2	LF	BC556	2	LF	BCY71	2	LF
BC108	2	LF	BC557	2	LF	BCY72	2	LF
BC109	2	LF	BC558	2	LF	BCY87	4a	DT
BC146	2	LF	BC559	2	LF	BCY88	4a	DT
BC147	2	LF	BC560	2	LF	BCY89	4a	DT
BC148	2	LF	BC635	2	LF	BD115	2	P
BC149	2	LF	BC636	2	LF	BD131	2	P
BC157	2	LF	BC637	2	LF	BD132	2	P
BC158	2	LF	BC638	2	LF	BD133	2	P
BC159	2	LF	BC639	2	LF	BD135	2	P
BC177	2	LF	BC640	2	LF	BD136	2	P
BC178	2	LF	BCW29	4a	Mm	BD137	2	P
BC179	2	LF	BCW30	4a	Mm	BD138	2	P
BC200	2	LF	BCW31	4a	Mm	BD139	2	P
BC264A	4a	FET	BCW32	4a	Mm	BD140	2	P
BC264B	4a	FET	BCW33	4a	Mm	BD181	2	P
BC264C	4a	FET	BCW69	4a	Mm	BD182	2	P
BC264D	4a	FET	BCW70	4a	Mm	BD183	2	P
BC327	2	LF	BCW71	4a	Mm	BD201	2	P
BC328	2	LF	BCW72	4a	Mm	BD202	2	P
BC337	2	LF	BCX17	4a	Mm	BD203	2	P
BC338	2	LF	BCX18	4a	Mm	BD204	2	P
BC368	2	LF	BCX19	4a	Mm	BD226	2	P
BC369	2	LF	BCX20	4a	Mm	BD227	2	P
BC407	2	LF	BCY30A	2	LF	BD228	2	P
BC408	2	LF	BCY31A	2	LF	BD229	2	P
BC409	2	LF	BCY32A	2	LF	BD230	2	P
BC417	2	LF	BCY33A	2	LF	BD231	2	P
BC418	2	LF	BCY34A	2	LF	BD232	2	P
BC419	2	LF	BCY55	4a	DT	BD233	2	P
BC546	2	LF	BCY56	2	LF	BD234	2	P
BC547	2	LF	BCY57	2	LF	BD235	2	P
BC548	2	LF	BCY58	2	LF	BD236	2	P
BC549	2	LF	BCY59	2	LF	BD237	2	P
BC550	2	LF	BCY70	2	LF	BD238	2	P

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

FET = Field-effect transistors
HF = High-frequency transistors
P = Low-frequency power transistors

Type No.	Part	Section	Type No.	Part	Section	Type No.	Part	Section
BF338	3	HF	BFS21	4a	FET	BLX65	4a	Tra
BF362	3	HF	BFS21A	4a	FET	BLX66	4a	Tra
BF363	3	HF	BFS22A	4a	Tra	BLX67	4a	Tra
BF422	3	HF	BFS23A	4a	Tra	BLX68	4a	Tra
BF423	3	HF	BFS28	4a	FET	BLX69	4a	Tra
BF450	3	HF	BFS92	3	HF	BLX91	4a	Tra
BF451	3	HF	BFS93	3	HF	BLX92	4a	Tra
BF457	3	HF	BFS94	3	HF	BLX93	4a	Tra
BF458	3	HF	BFS95	3	HF	BLX94A	4a	Tra
BF459	3	HF	BFT24	3	HF	BLX95	4a	Tra
BF480	3	HF	BFT25	4a	Mm	BLX96	4a	Tra
BF494	3	HF	BFW10	4a	FET	BLX97	4a	Tra
BF495	3	HF	BFW11	4a	FET	BLY83	4a	Tra
BFQ10	4a	FET	BFW12	4a	FET	BLY84	4a	Tra
BFQ11	4a	FET	BFW13	4a	FET	BLY87A	4a	Tra
BFQ12	4a	FET	BFW16A	3	HF	BLY88A	4a	Tra
BFQ13	4a	FET	BFW17A	3	HF	BLY89A	4a	Tra
BFQ14	4a	FET	BFW30	3	HF	BLY90	4a	Tra
BFQ15	4a	FET	BFW45	3	HF	BLY91A	4a	Tra
BFQ16	4a	FET	BFW61	4a	FET	BLY92A	4a	Tra
BFR29	4a	FET	BFW92	3	HF	BLY93A	4a	Tra
BFR30	4a	Mm	BFW93	3	HF	BLY94	4a	Tra
BFR31	4a	Mm	BFX34	3	Sw	BPX25	4b	PDT
BFR53	4a	Mm	BFX89	3	HF	BPX29	4b	PDT
BFR64	3	HF	BFY50	3	HF	BPX40	4b	PDT
BFR65	3	HF	BFY51	3	HF	BPX41	4b	PDT
BFR90	3	HF	BFY52	3	HF	BPX42	4b	PDT
BFR91	3	HF	BFY55	3	HF	BPX66P	4b	PDT
BFR92	4a	Mm	BFY90	3	HF	BPX70	4b	PDT
BFR93	4a	Mm	BG1895-541	1a	R	BPX71	4b	PDT
BFR94	3	HF	BG1895-641	1a	R	BPX72	4b	PDT
BFS17	4a	Mm	BLW60	4a	Tra	BPX95	4b	PDT
BFS18	4a	Mm	BLX13	4a	Tra	BR100	1a	Th
BFS19	4a	Mm	BLX14	4a	Tra	BR101	3	Sw
BFS20	4a	Mm	BLX15	4a	Tra	BRY39	1a	Th

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

FET = Field-effect transistors
Mm = Microminiature devices for thick- and thin-film circuits
P = Low-frequency power transistors
R = Rectifier diodes
Sw = Switching transistors
Th = Thyristors, diacs
Tri = Triacs
Vrf = Voltage reference diodes

AD = Silicon alloyed diodes
GB = Germanium gold-bonded diodes
I = Infrared devices
LED = Light emitting diodes
Mm = Microminiature devices for thick- and thin-film circuits
PC = Germanium point contact diodes
Ph = Photoconductive devices
PhC = Photocouplers
St = Rectifier stacks
TS = Transient suppressor diodes
Vrf = Voltage reference diodes
Vrg = Voltage regulator diodes

FET = Field-effect transistors
HF = High-frequency transistors
LF = Low-frequency transistors
P = Low-frequency power transistors
Sw = Switching transistors
Tra = Transmitting transistors
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
LF = Low-frequency transistors

MAINTENANCE TYPE LIST

The type numbers listed below are not included in this handbook except for those marked with an asterisk.

Detailed information will be supplied on request.

AF121
* AF124
* AF125
* AF126
* AF127

AF240
AF267
AFZ12
ASY76
ASY77

ASY80
* BF177
* BF178
* BF179
BFX44

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