Semiconductors and integrated circuits

Part 3 January 1978

High-frequency transistors

Switching transistors

Field-effect transistors

SEMICONDUCTORS AND INTEGRATED CIRCUITS

PART 3 — JANUARY 1978

HIGH-FREQUENCY, SWITCHING AND FIELD-EFFECT TRANSISTORS

GENERAL

Data Handbook system
Type designation
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DATA HANDBOOK SYSTEM

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

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

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

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

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

ELECTRON TUBES (BLUE SERIES)

Part 1a	December 1975	ET1a 12-75	**Transmitting tubes for communication, tubes for r.f. heating** Types PE05/25 to TBW15/25
Part 1b	August 1977	ET1b 08-77	**Transmitting tubes for communication, tubes for r.f. heating, amplifier circuit assemblies**
Part 2	May 1976	ET2 05-76	**Microwave products** (This book is valid until Part 2b becomes available.)
Part 2a	November 1977	ET2a 11-77	**Microwave tubes** Communication magnetrons, magnetrons for microwave heating, klystrons, travelling-wave tubes, diodes, triodes T-R switches
Part 3	January 1975	ET3 01-75	**Special Quality tubes, miscellaneous devices**
Part 4	March 1975	ET4 03-75	**Receiving tubes**
Part 5a	August 1976	ET5a 08-76	**Cathode-ray tubes** Instrument tubes, monitor and display tubes, C.R. tubes for special applications
Part 5b	May 1975	ET5b 05-75	**Camera tubes, image intensifier tubes**
Part 6	January 1977	ET6 01-77	**Products for nuclear technology** Channel electron multipliers, neutron tubes, Geiger-Müller tubes
Part 7a	March 1977	ET7a 03-77	**Gas-filled tubes** Thyratrons, industrial rectifying tubes, ignitrons, high-voltage rectifying tubes
Part 7b	March 1977	ET7b 03-77	**Gas-filled tubes** Segment indicator tubes, indicator tubes, switching diodes, dry reed contact units
Part 8	May 1977	ET8 05-77	**TV picture tubes**
Part 9	June 1976	ET9 06-76	**Photomultiplier tubes; phototubes**

SEMICONDUCTORS AND INTEGRATED CIRCUITS (RED SERIES)

Part 1a	**March 1976**	**SC1a 03-76**	**Rectifier diodes, thyristors, triacs** Rectifier diodes, voltage regulator diodes (> 1,5 W), transient suppressor diodes, rectifier stacks, thyristors, triacs
Part 1b	**May 1977**	**SC1b 05-77**	**Diodes** Small signal germanium diodes, small signal silicon diodes, special diodes, voltage regulator diodes (< 1,5 W), voltage reference diodes, tuner diodes
Part 2	**November 1977**	**SC2 11-77**	**Low-frequency and dual transistors**
Part 3	**January 1978**	**SC3 01-78**	**High-frequency, switching and field-effect transistors**
Part 4a	**June 1976**	**SC4a 06-76**	**Special semiconductors** Transmitting transistors, field-effect transistors, dual transistors, microminiature devices for thick and thin-film circuits
Part 4b	**July 1976**	**SC4b 07-76**	**Devices for optoelectronics** Photosensitive diodes and transistors, light emitting diodes, displays, photocouplers, infrared sensitive devices, photoconductive devices
Part 5a	**November 1976**	**SC5a 11-76**	**Professional analogue integrated circuits**
Part 5b	**March 1977**	**SC5b 03-77**	**Consumer integrated circuits** Radio-audio, television
Part 6	**October 1977**	**SC6 10-77**	**Digital integrated circuits** LOCMOS HE4000B family
Signetics integrated circuits 1976			Logic, Memories, Interface, Analogue, Microprocessor, Milrel

COMPONENTS AND MATERIALS (GREEN SERIES)

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

PRO ELECTRON TYPE DESIGNATION CODE

FOR SEMICONDUCTOR DEVICES

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

The type designation consists of:

TWO LETTERS FOLLOWED BY A SERIAL NUMBER

The first letter gives an indication of the material

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

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

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

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

R Compound material as employed in Hall generators and photoconductive cells

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

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

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

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

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

The serial number consists of:

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

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

VERSION LETTER

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

TYPE DESIGNATION FOR A RANGE OF SEMICONDUCTOR DEVICES

The type designation of a range of variants of:

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

b) rectifier diodes (second letter Y)

c) thyristors (second letter T)

d) radiation detectors

distinctly belonging to one basic type may be qualified by a suffix part which is clearly separated from the basic part by a hyphen (-)

THE BASIC PART being the same for the whole range, is in accordance with the designation code for discrete devices.

THE SUFFIX PART consists of:

a) **for voltage reference or voltage regulator diodes**

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

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

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

b) **for rectifier diodes**

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

c) **for thyristors**

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

d) **for radiation detectors**

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

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

RATING SYSTEMS

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

DEFINITIONS OF TERMS USED

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

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

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

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

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

Note
Limiting conditions may be either maxima or minima.

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

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

ABSOLUTE MAXIMUM RATING SYSTEM

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

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

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

DESIGN MAXIMUM RATING SYSTEM

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

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

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

DESIGN CENTRE RATING SYSTEM

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

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

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

LETTER SYMBOLS FOR TRANSISTORS AND SIGNAL DIODES

based on IEC Publication 148

LETTER SYMBOLS FOR CURRENTS, VOLTAGES AND POWERS

Basic letters

The basic letters to be used are:

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

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

Subscripts

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

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

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

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

Example I_B

b) instantaneous total values

Example i_B

c) average total values

Example $I_{B(AV)}$

d) peak total values

Example I_{BM}

e) root-mean-square total values

Example $I_{B(RMS)}$

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

a) instantaneous values

Example i_b

b) root-mean-square values

Example $I_{b(rms)}$

c) peak values

Example I_{bm}

d) average values

Example $I_{b(av)}$

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

Additional rules for subscripts

Subscripts for currents

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

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

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

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

Subscripts for voltages

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

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

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

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

Subscripts for supply voltages or supply currents

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

Examples: V_{CC}, I_{EE}

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

Example : V_{CCE}

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

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

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

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

Subscripts for multiple devices

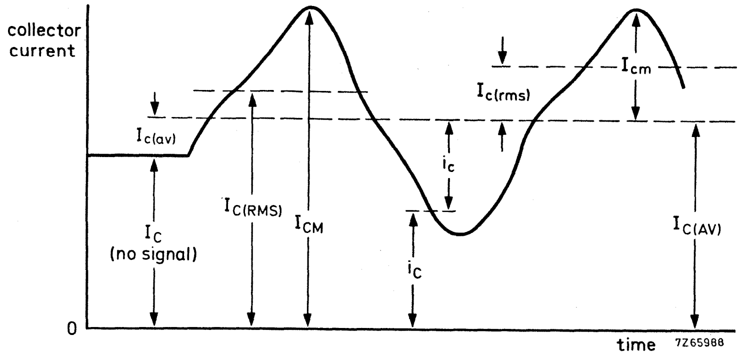
For multiple unit devices, the subscripts are modified by a number preceding the letter subscript; in the case of multiple subscripts, hyphens may be necessary to avoid misunderstanding.

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

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

Application of the rules

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



LETTER SYMBOLS FOR ELECTRICAL PARAMETERS

Definition

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

Basic letters

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

B, b = susceptance; imaginary part of an admittance

C = capacitance

G, g = conductance; real part of an admittance

H, h = hybrid parameter

L = inductance

R, r = resistance; real part of an impedance

X, x = reactance; imaginary part of an impedance

Y, y = admittance;

Z, z = impedance;

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

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

b) all inductances and capacitances.

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

Subscripts

General subscripts

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

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

Examples: Z_S, h_f, h_F

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

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

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

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

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

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

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

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

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

Subscripts for four-pole matrix parameters

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

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

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

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

Distinction between real and imaginary parts

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

Examples: $Z_i = R_i + jX_i$

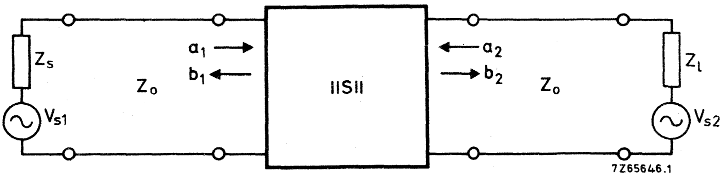
$y_{fe} = g_{fe} + jb_{fe}$

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

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

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:

$$s_i = s_{11} = \frac{b_1}{a_1}\Big|_{a_2 = 0}$$
$$s_r = s_{12} = \frac{b_1}{a_2}\Big|_{a_1 = 0}$$
$$s_f = s_{21} = \frac{b_2}{a_1}\Big|_{a_2 = 0}$$
$$s_o = s_{22} = \frac{b_2}{a_2}\Big|_{a_1 = 0}$$

[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° to the axes.

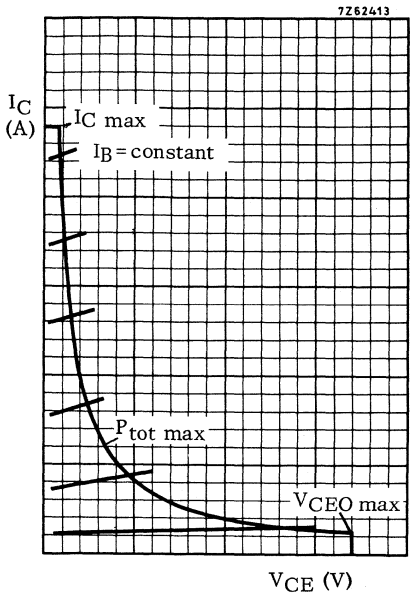


Fig. 1

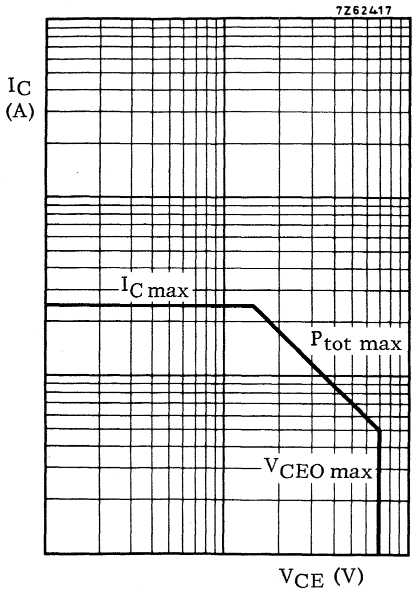


Fig. 2. D.C. SOAR curve

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%.

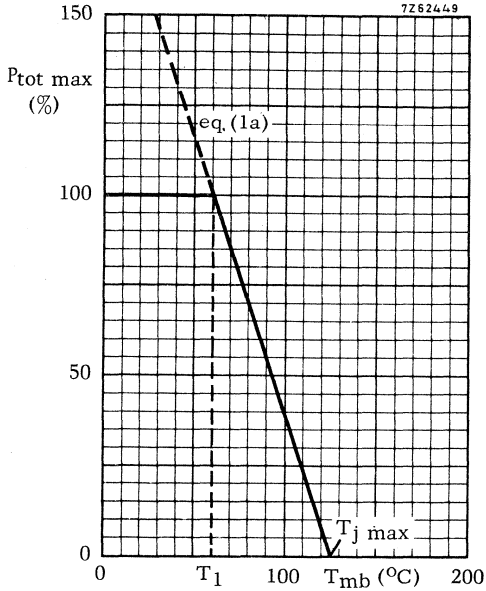


Fig. 3

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:

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

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:

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

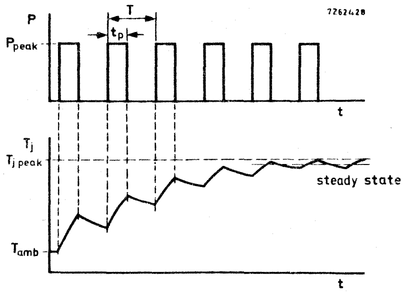


Fig. 4

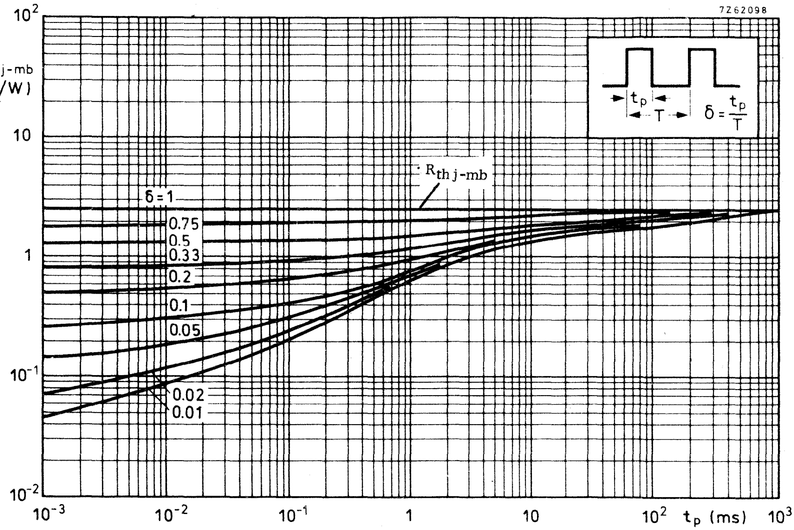


Fig. 5

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

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

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

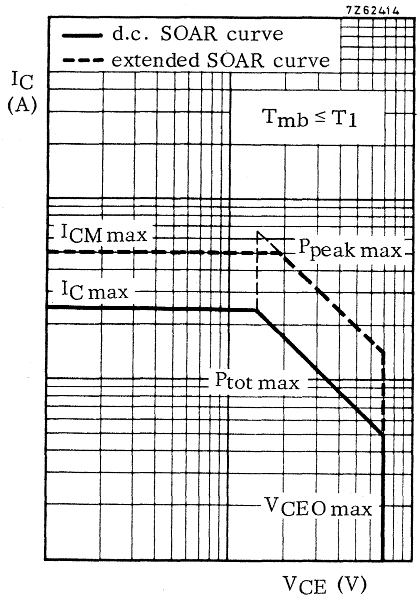


Fig. 6

3. Second Breakdown

3.1 The phenomenon

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

The SOAR curve must define an area that only precludes second breakdown but also the current concentration that precedes it.

3.2 Second breakdown and the d.c. SOAR

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

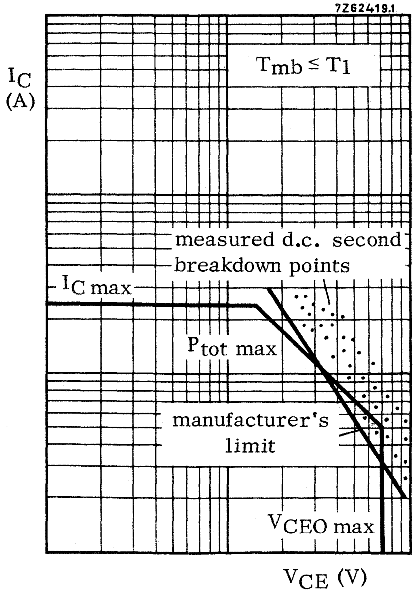


Fig. 7

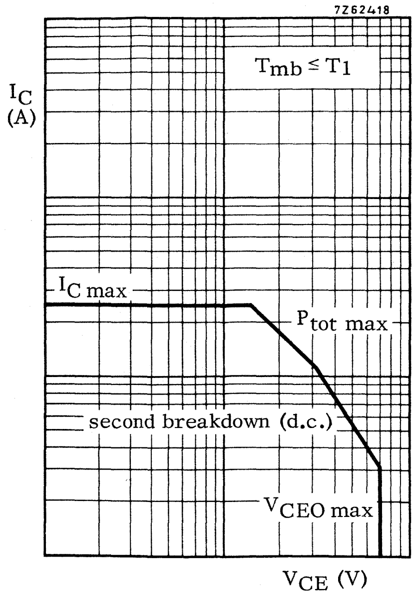


Fig. 8

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

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

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

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

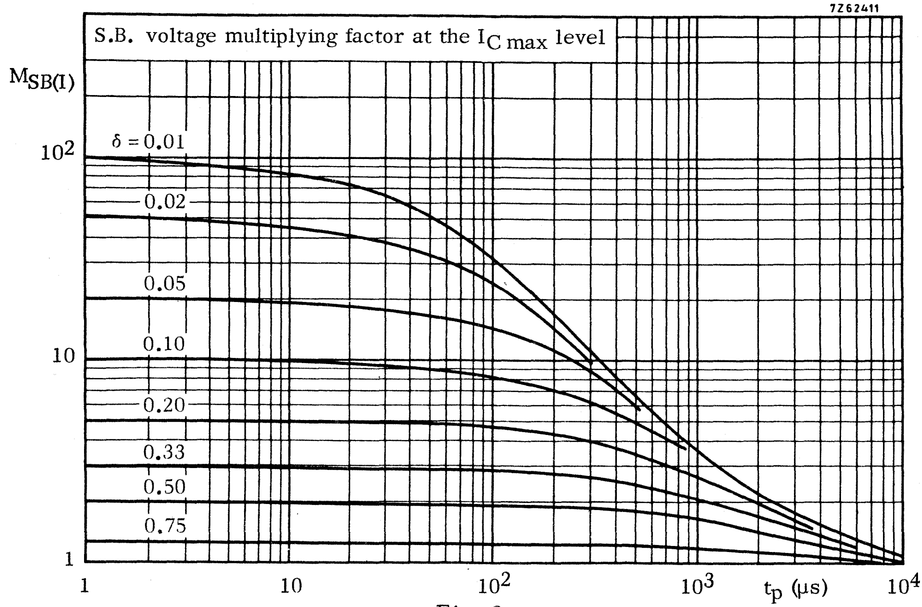

7Z62411
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
δ = 0.01
0.02
0.05
0.10
0.20
0.33
0.50
0.75
10^2
10
1
1
10
10^2
10^3
t_p (μs)
10^4

Fig. 9a

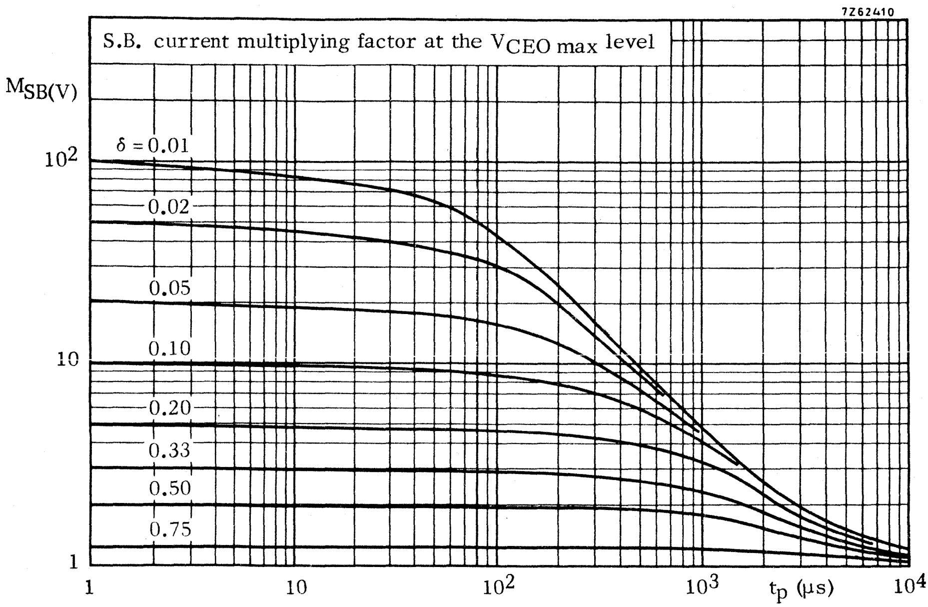

7Z62410
S.B. current multiplying factor at the $V_{CEO\,max}$ level
$M_{SB(V)}$
δ = 0.01
0.02
0.05
0.10
0.20
0.33
0.50
0.75
10^2
10
1
1
10
10^2
10^3
t_p (μs)
10^4

Fig. 9b

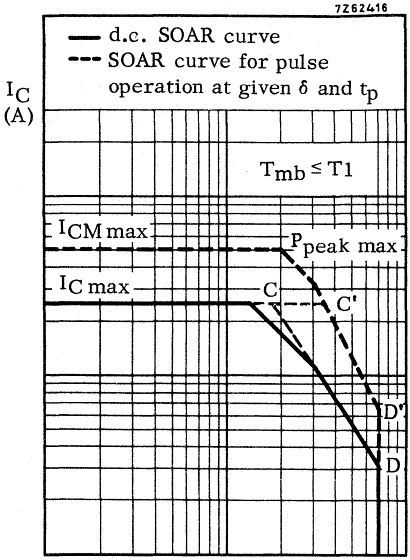


Fig. 10

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

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

4. Example of how to use the published SOAR information

4.1 Statement of the problem

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

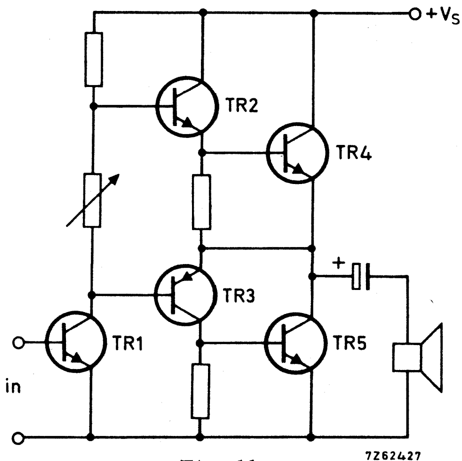


Fig. 11

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

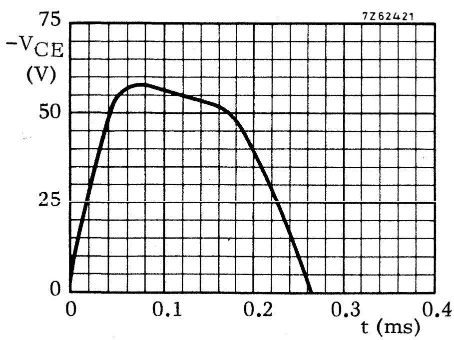


Fig. 12a

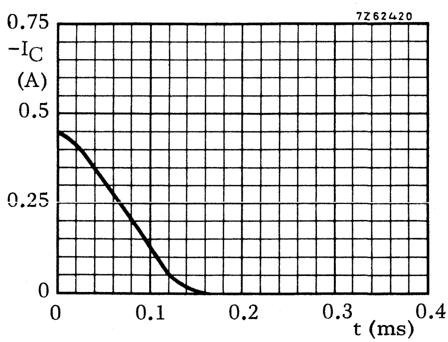


Fig. 12b

4.2 Information obtained from the published data of TR3

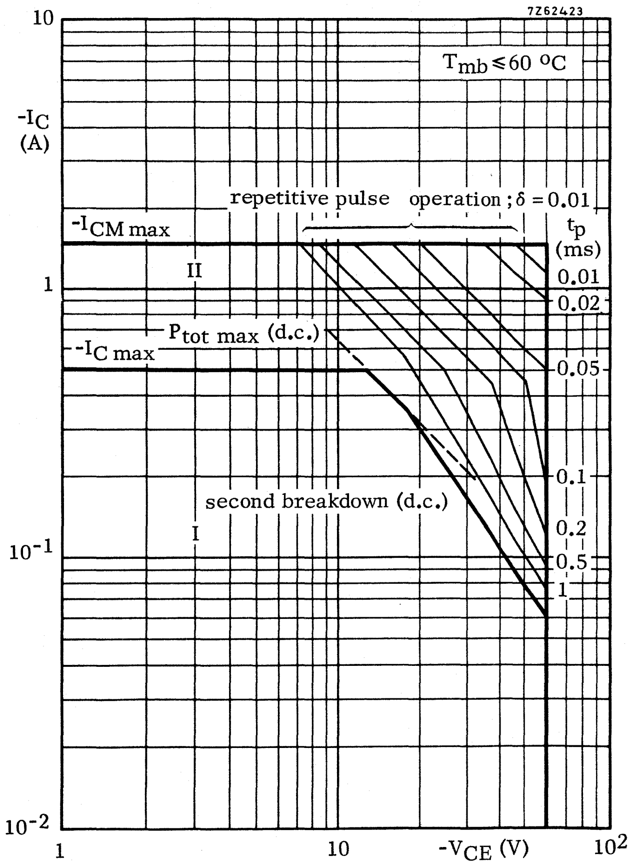
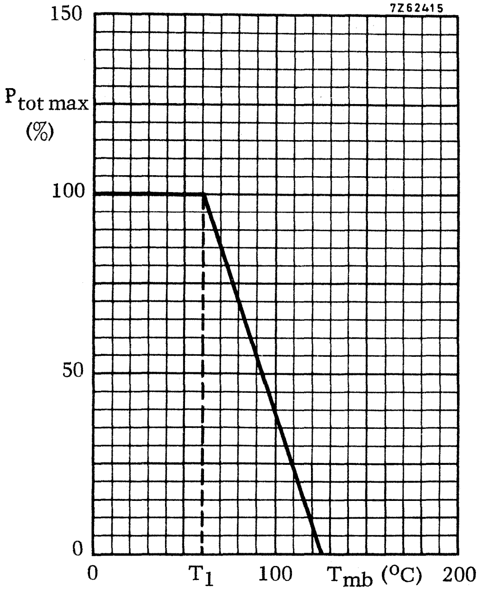


Fig. 13. Safe Operating Area with the transistor forward biased

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

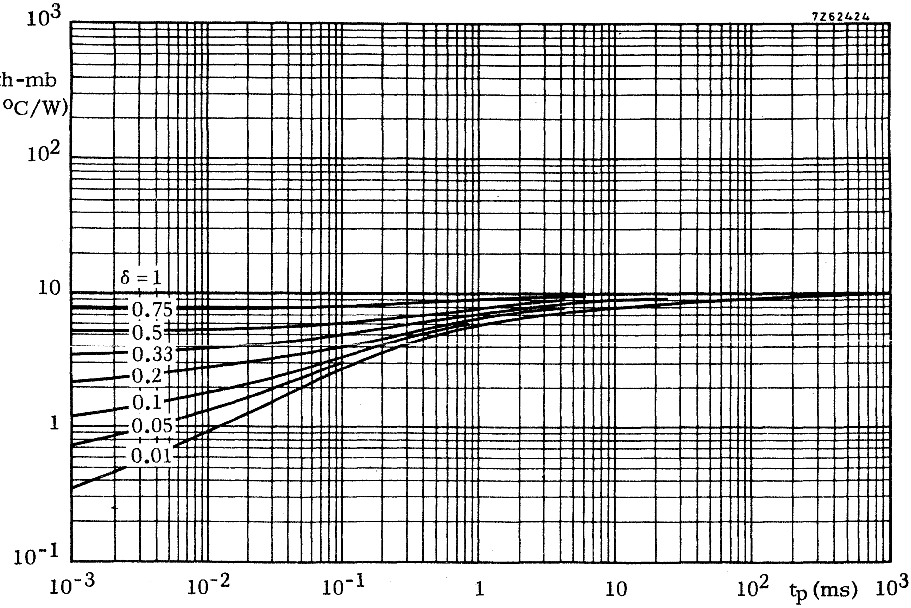


Fig. 15

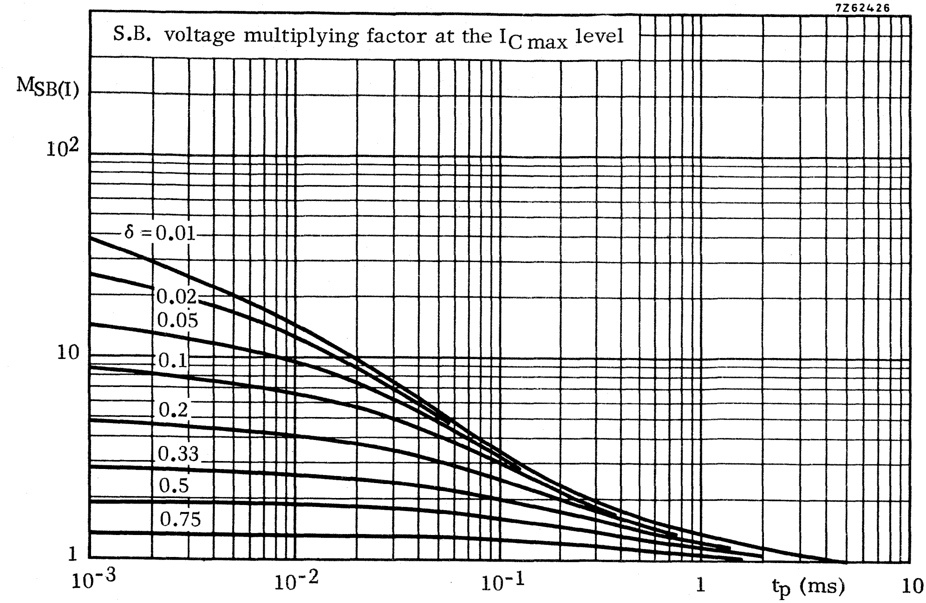

7Z62426
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
δ = 0.01
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

Fig. 16

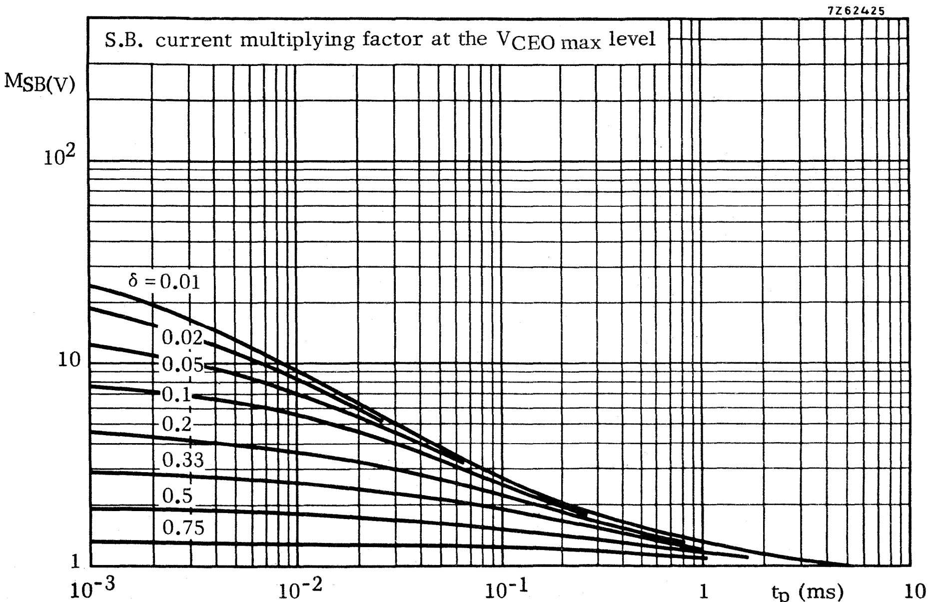

7Z62425
S.B. current multiplying factor at the $V_{CEO\,max}$ level
$M_{SB(V)}$
10^2
10
1
δ = 0.01
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

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.

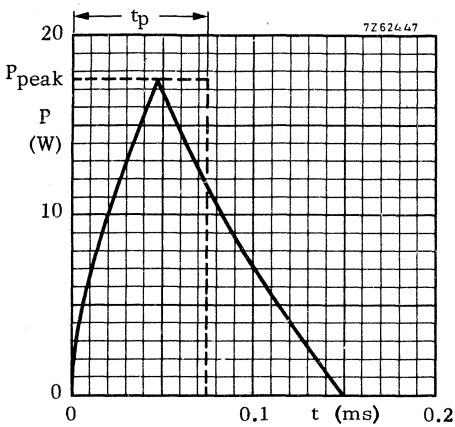


Fig. 18

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 ^{o}C. The result is 0.6.

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

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

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

4.3.4

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

$M_{SB(I)} = 3.6$

$M_{SB(V)} = 2.8$

4.3.5

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

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

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

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

4.3.6

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

4.3.7

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

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

P_{peak} = 17.5 W (see 4.3.2)

$Z_{th\ j\text{-}mb}$ = 2.75 °C/W

Therefore:

$T_{mb\ max}$ = 125 - 17.5 x 2.75 = 77 °C

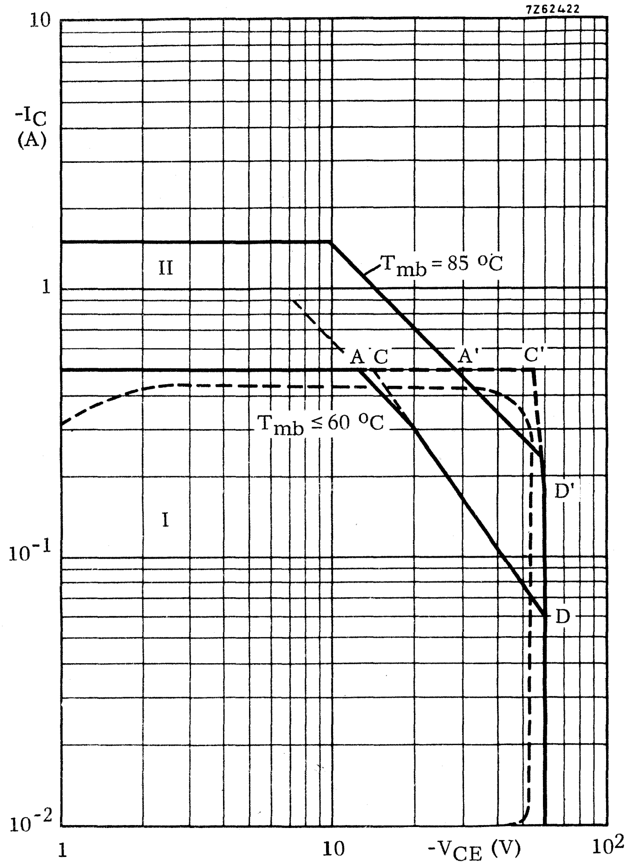


Fig. 19

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

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

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

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

HIGH-FREQUENCY AND SWITCHING TRANSISTORS

U.H.F. GERMANIUM PLANAR TRANSISTOR

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

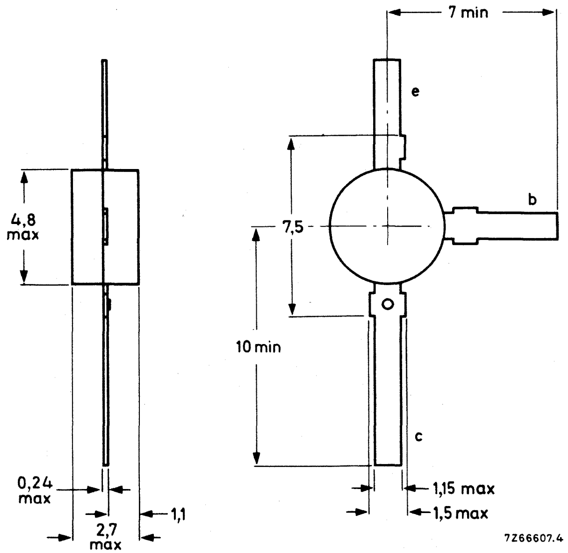
QUICK REFERENCE DATA

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; $-V_{CB}$ = 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 $T_{amb} = 54\ ^{o}C$	P_{tot}	max.	60	mW

Temperatures

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

THERMAL RESISTANCE

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

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)

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

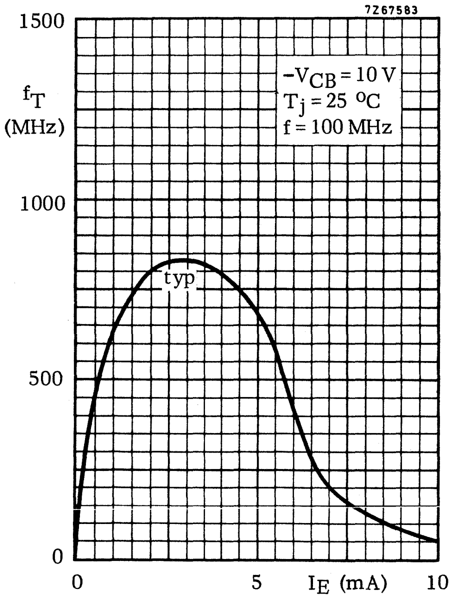
$I_E = 2$ mA; $-V_{CB} = 10$ V; $T_{amb} = 25\ ^oC$				
$G_S = 16,7$ mA/V; $G_L = 2$ mA/V	G_{tr}	>	10,5	dB
		typ.	12	dB

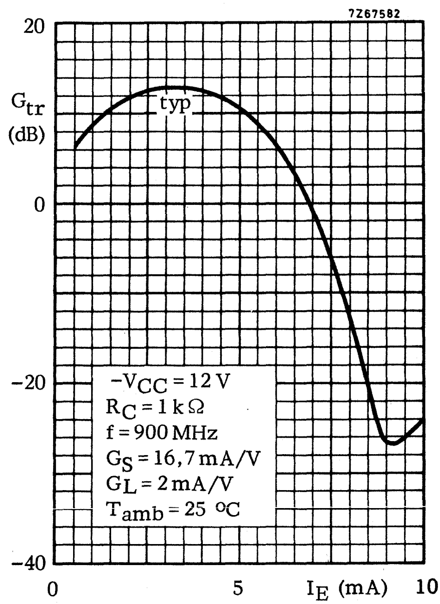
CHARACTERISTICS (continued)

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





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.

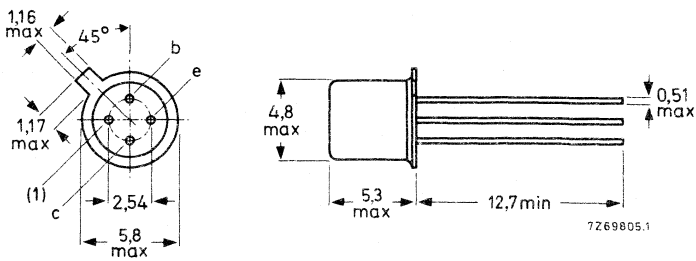
QUICK REFERENCE DATA

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

MECHANICAL DATA

Dimensions in mm

TO-72



(1) = shield lead (connected to case).

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

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

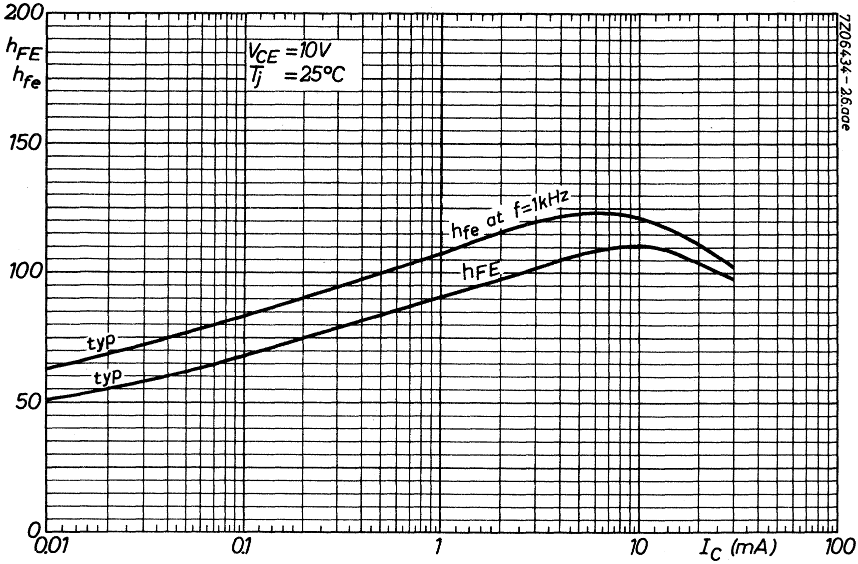
From junction to ambient in free air	$R_{th\ j-a}$	=	0.9	°C/mW

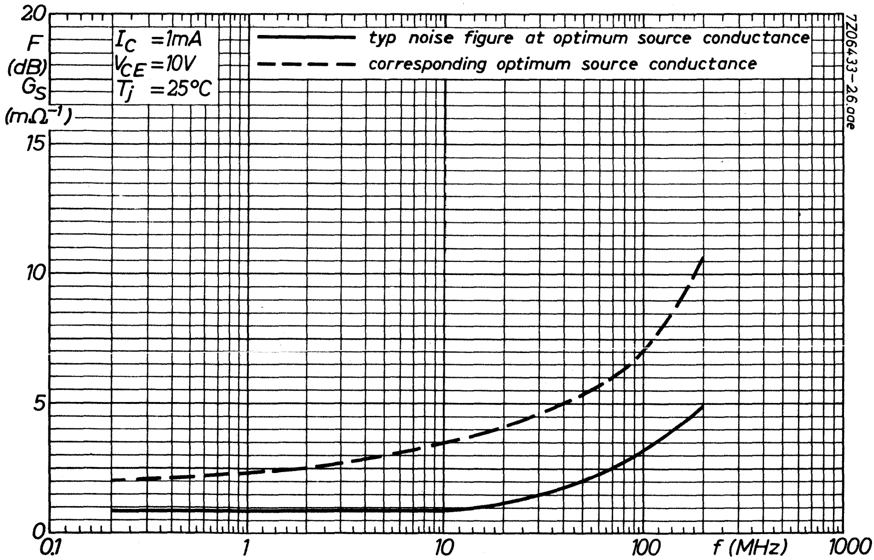
[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

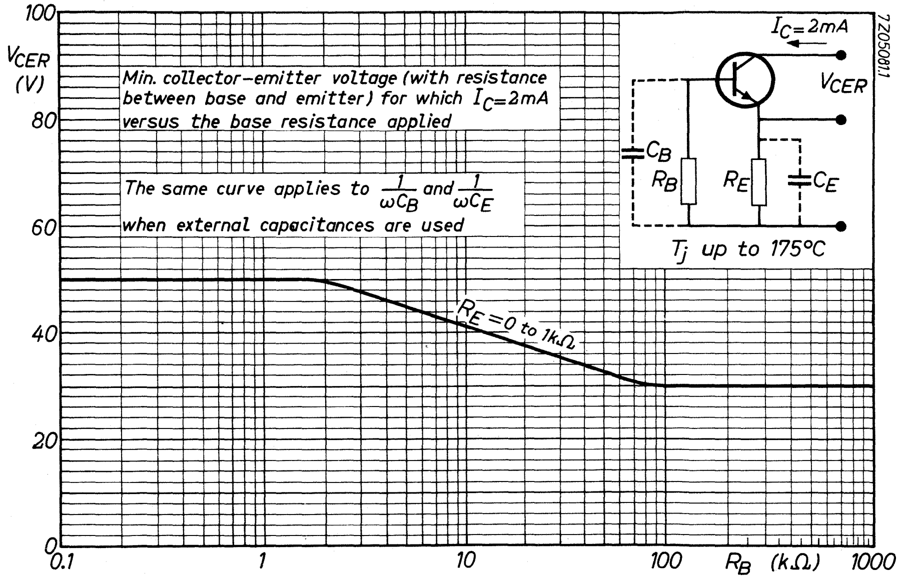
CHARACTERISTICS T_j = 25 °C unless otherwise specified

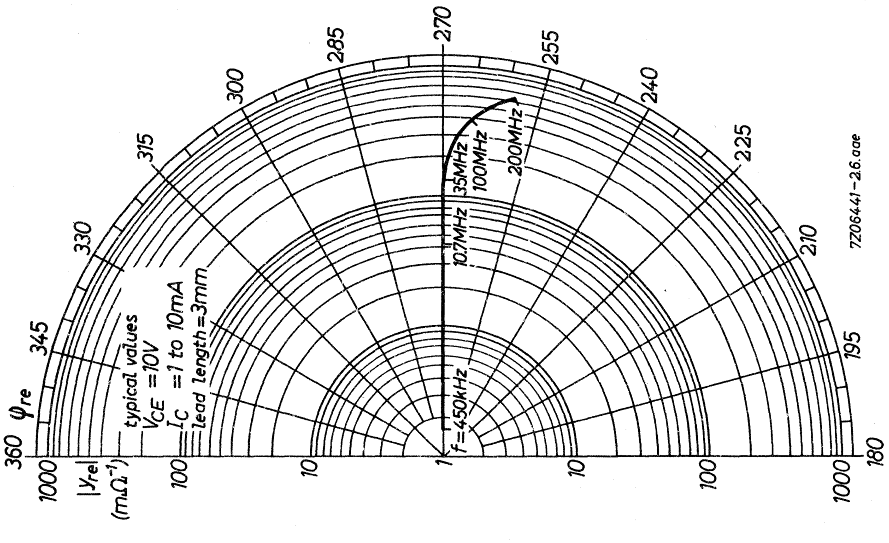
Emitter-base voltage [1]				
$-I_E$ = 1 mA; V_{CB} = 10 V	$-V_{EB}$		0.65 to 0.74	V
$-I_E$ = 20 mA; V_{CB} = 2 V; T_{amb} = 25 °C	$-V_{EB}$	<	1.0	V
Feedback capacitance at f = 0.45 MHz				
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	0.65	pF
D.C. current gain				
I_C = 1 mA; V_{CE} = 10 V	h_{FE}		45 to 165	
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.

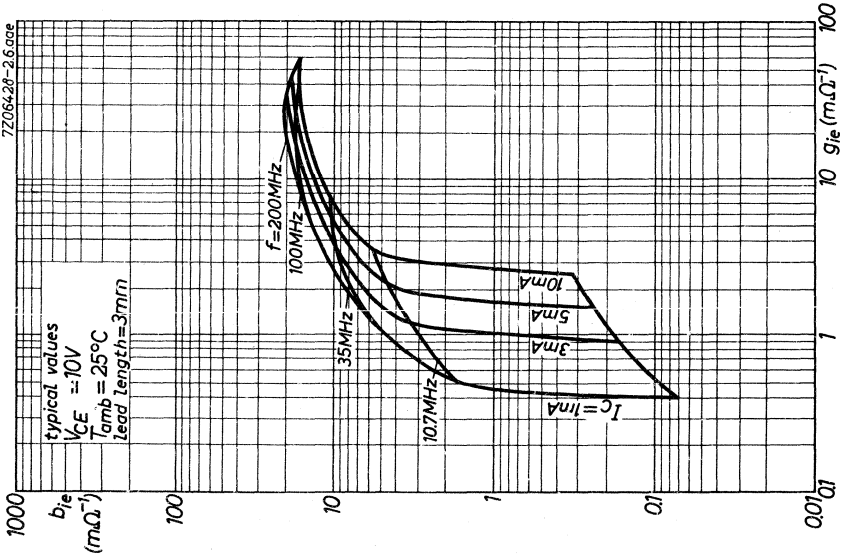

200
h_{FE}
h_{fe}
150
100
50
0
V_{CE} = 10V
T_j = 25°C
h_{fe} at f=1kHz
h_{FE}
typ
typ
0.01
0.1
1
10
I_C (mA)
100
7Z06434 – 26.aae


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

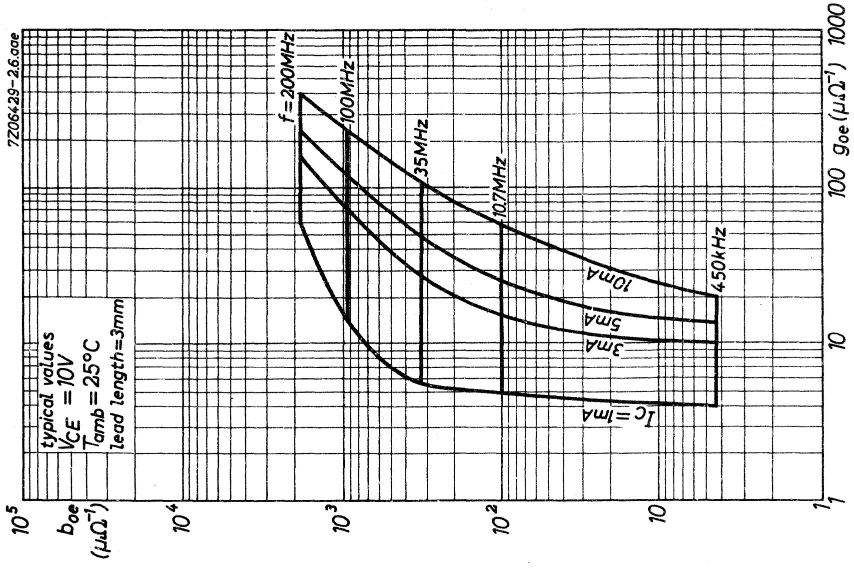

100
V_{CER}
(V)
80
60
40
20
0
Min. collector-emitter voltage (with resistance between base and emitter) for which I_C=2mA versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$ when external capacitances are used
R_E = 0 to 1kΩ
I_C = 2mA
V_{CER}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

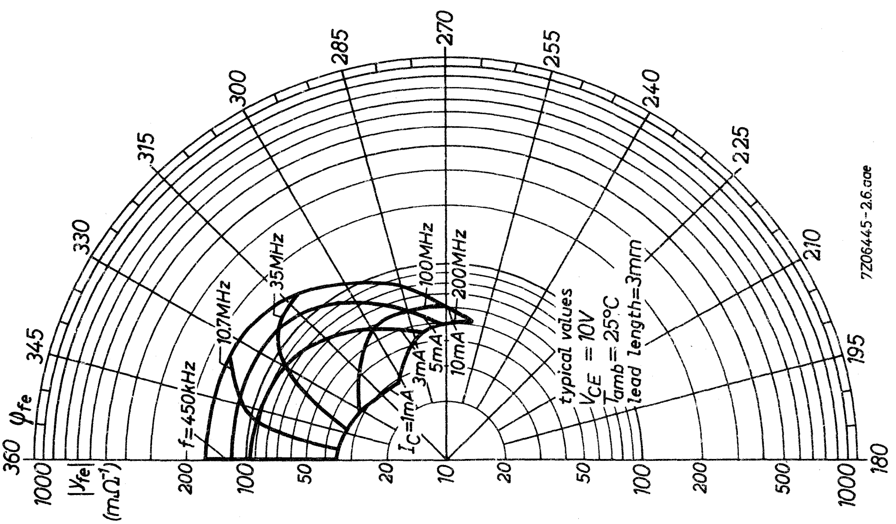


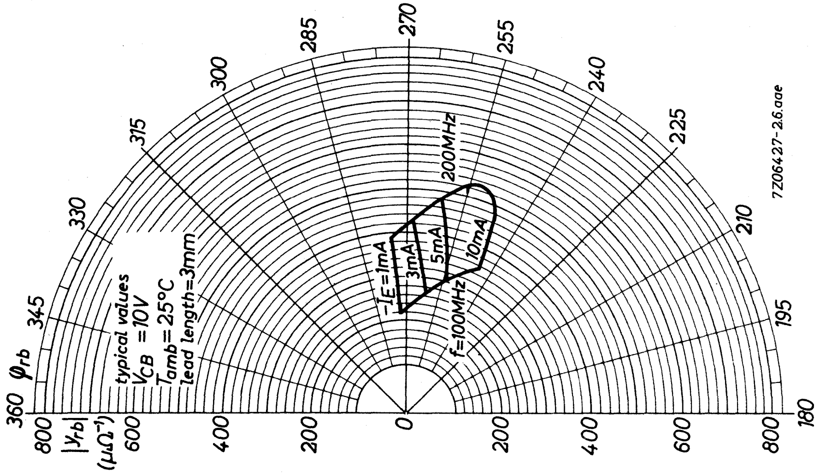
φ_{re}
typical values
V_{CE} = 10V
I_C = 1 to 10mA
lead length = 3mm
$|y_{re}|$ ($m\Omega^{-1}$)
f = 450kHz
10.7MHz
35MHz
100MHz
200MHz
7Z06441-2.6.aae



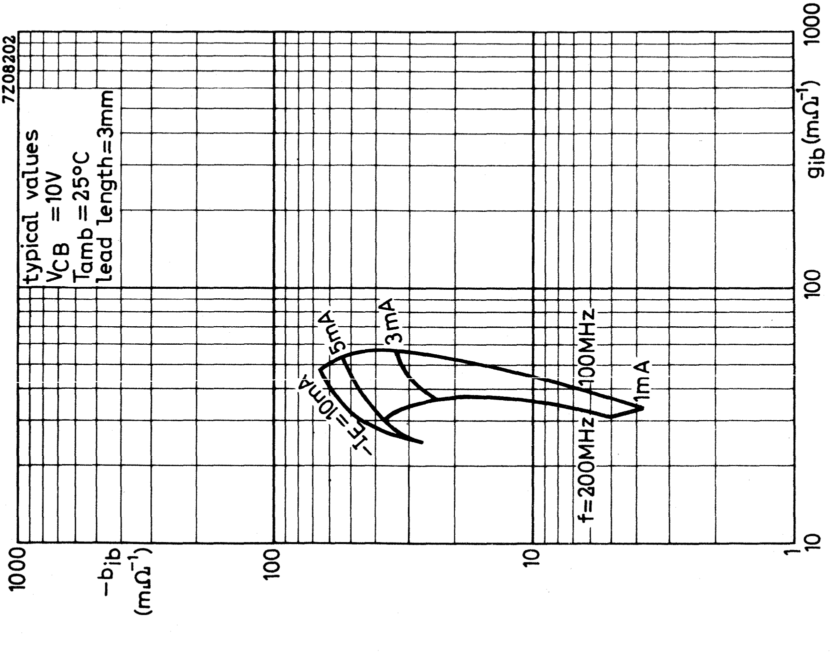
typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length = 3mm
b_{ie} ($m\Omega^{-1}$)
g_{ie} ($m\Omega^{-1}$)
f = 200MHz
100MHz
35MHz
10.7MHz
I_C = 1mA
3mA
5mA
10mA
7Z06428-2.6.aae


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} ($\mu\Omega^{-1}$)
10^5
10^4
10^3
10^2
10
1
100
1000

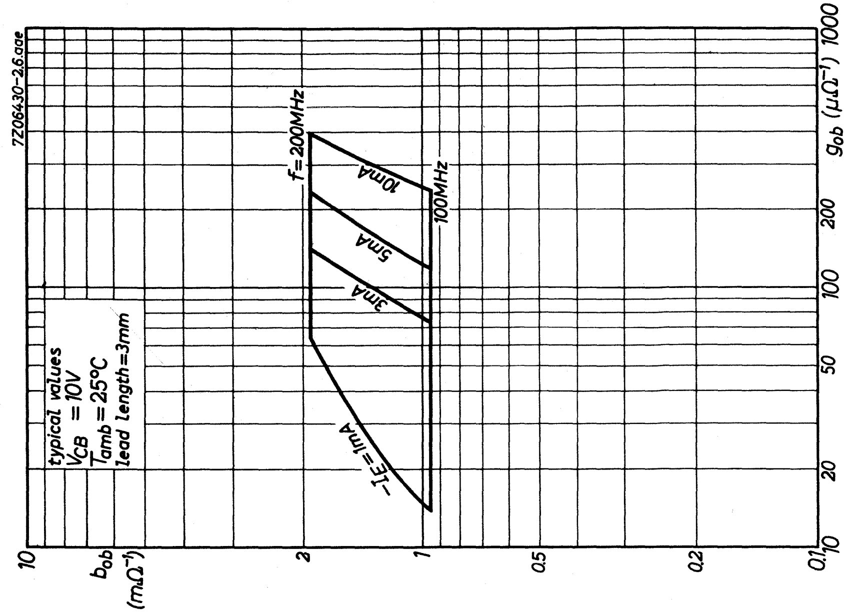

7Z06445-2.6.aae
φ_{fe}
$|y_{fe}|$ ($m\Omega^{-1}$)
360
345
330
315
300
285
270
255
240
225
210
195
180
1000
200
100
50
20
10
20
50
100
200
500
1000
f = 450kHz
10.7MHz
35MHz
100MHz
200MHz
I_C = 1mA
3mA
5mA
10mA
typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length = 3mm

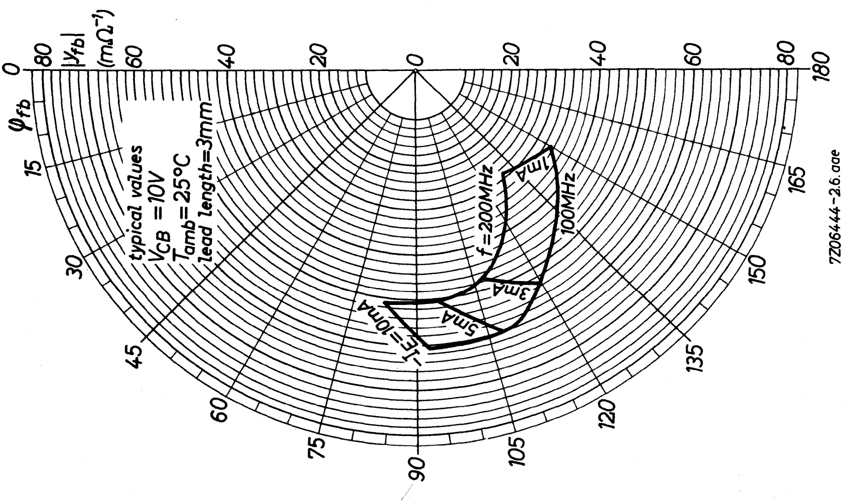


7Z06427-2.6.aae
φ_{rb}
$|y_{rb}|$ ($\mu\Omega^{-1}$)
typical values
V_{CB} = 10V
T_{amb} = 25°C
lead length = 3mm
$-I_E$ = 1mA
3mA
5mA
10mA
200MHz
f=100MHz
360
345
330
315
300
285
270
255
240
225
210
195
180
800
600
400
200
0
200
400
600
800



7Z08202
typical values
V_{CB} = 10V
T_{amb} = 25°C
lead length = 3mm
$-b_{ib}$ ($m\Omega^{-1}$)
g_{ib} ($m\Omega^{-1}$)
$-I_E$ = 10mA
5mA
3mA
1mA
f=200MHz
100MHz
1000
100
10
1
10
100
1000


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} ($m\Omega^{-1}$)
10
2
1
0.5
0.2
0.1
g_{ob} ($\mu\Omega^{-1}$)
10
20
50
100
200
1000


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

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.

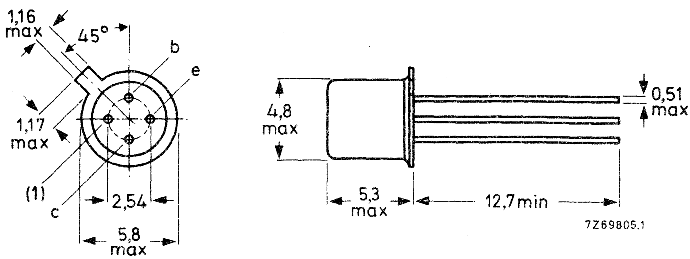
QUICK REFERENCE DATA

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
Maximum 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 supplied on request: 56246 (distance disc); 56263 (cooling fin).

FOR NEW DESIGN THE SUCCESSOR 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 $T_{amb} = 45\ ^{o}C$	P_{tot}	max.	130	mW

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	1.0	$^{o}C/mW$

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

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

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 $m\Omega^{-1}$; 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 $m\Omega^{-1}$
Input capacitance	C_{ie}	typ.	45 pF
Feedback admittance	$\|y_{re}\|$	typ.	37 $\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{re}	typ.	268°
Transfer admittance	$\|y_{fe}\|$	typ.	95 $m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fe}	typ.	337°
Output conductance	g_{oe}	typ.	30 $\mu\Omega^{-1}$
Output capacitance	C_{oe}	typ.	1.2 pF

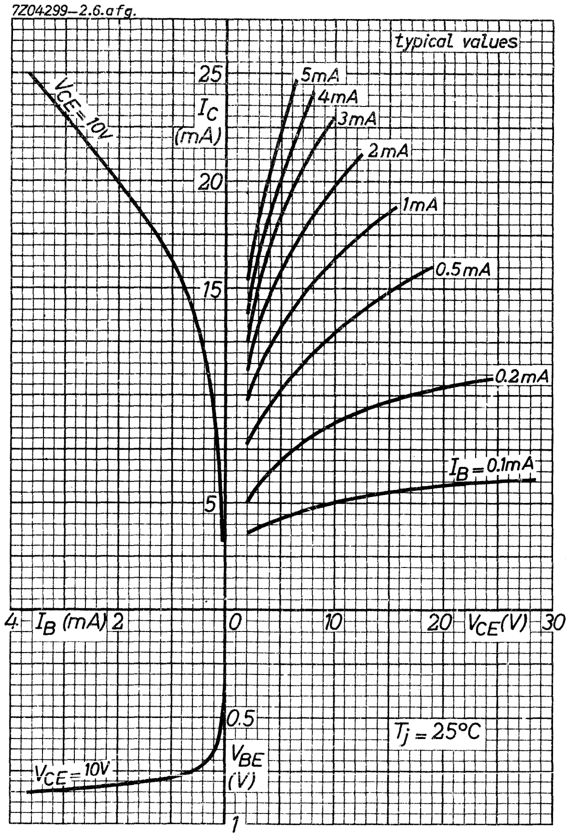
Maximum unilateralised power gain

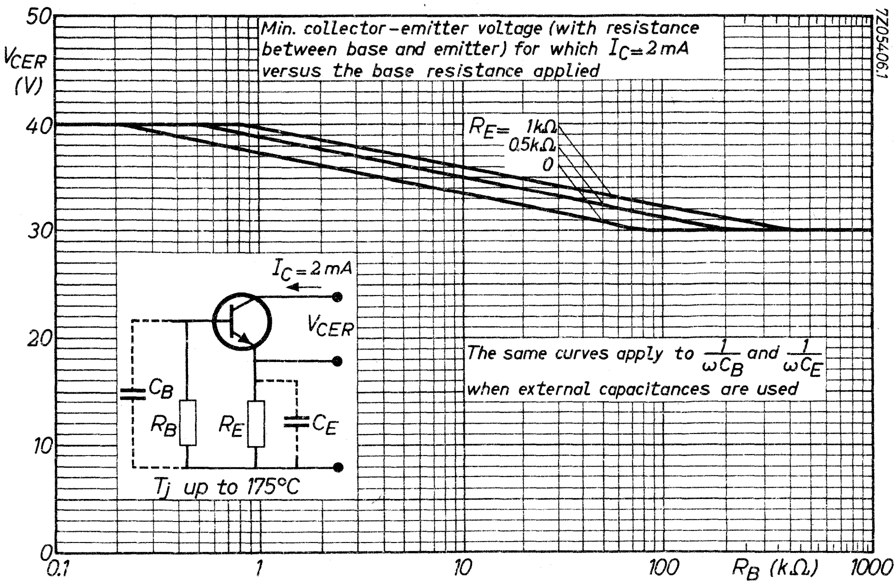
$$G_{UM} = \frac{|y_{fe}|^2}{4\, g_{ie}\, g_{oe}}$$

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

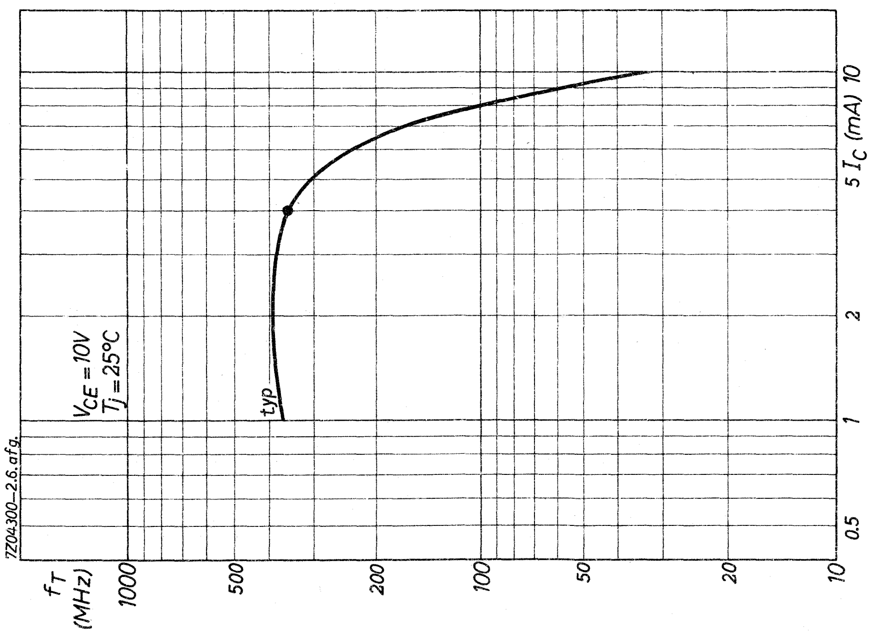
[1] V_{BE} decreases with about 1.7 mV/°C at increasing temperature

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


7Z04299—2.6.afg.
typical values
25
20
15
5
I_C (mA)
5mA
4mA
3mA
2mA
1mA
0.5mA
0.2mA
I_B = 0.1mA
V_{CE} = 10V
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



7Z05406.1
Min. collector-emitter voltage (with resistance between base and emitter) for which $I_C = 2$ mA versus the base resistance applied
V_{CER} (V)
50
40
30
20
10
0
0.1
1
10
100
1000
R_B (kΩ)
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



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

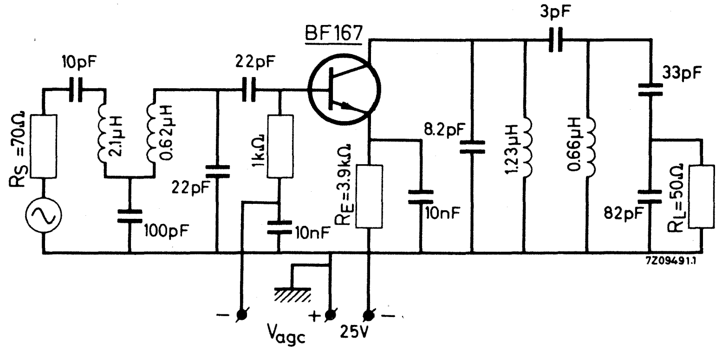
APPLICATION INFORMATION

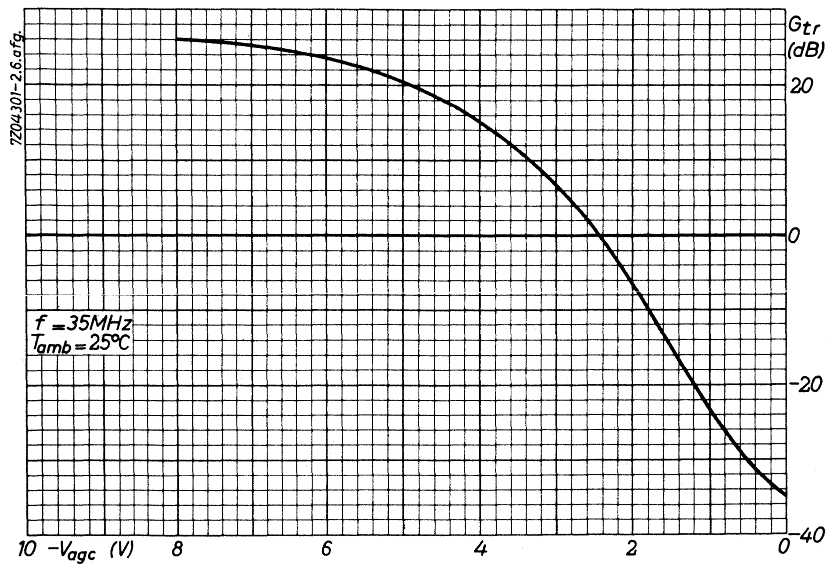
First stage of an intermediate frequency amplifier with a BF167 transistor. (Basic circuit with voltage gain control).

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.

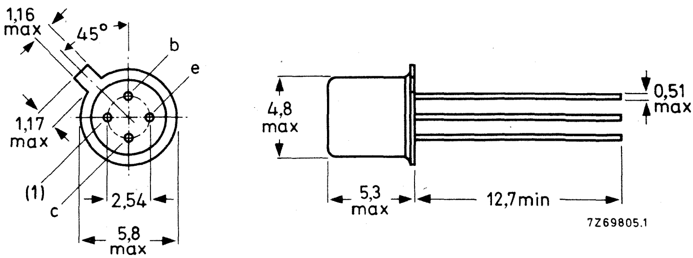
QUICK REFERENCE DATA

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
Maximum 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 on page 4	V_O	typ.	7,7	V

MECHANICAL DATA

Dimensions in mm

TO-72



(1) = shield lead (connected to case).

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

FOR NEW DESIGN THE SUCCESSOR 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

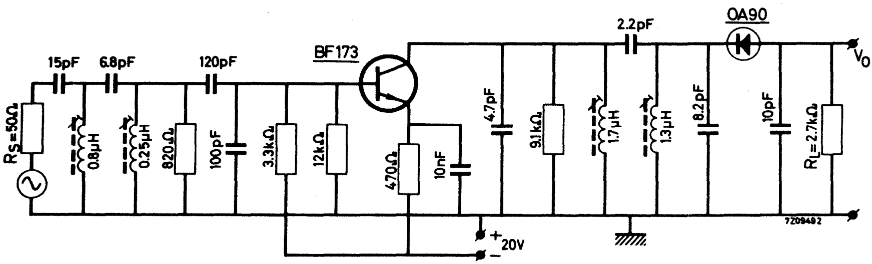
f = 38.9 MHz; I_C = 7.2 mA; V_{CE} = 16.6 V	V_O	>	6	V
		typ.	7.7	V

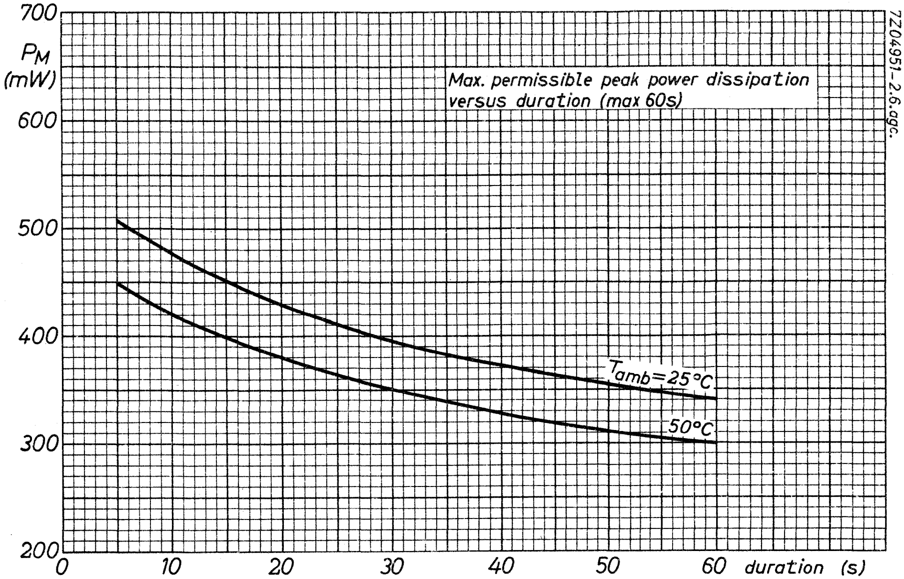
Transducer gain

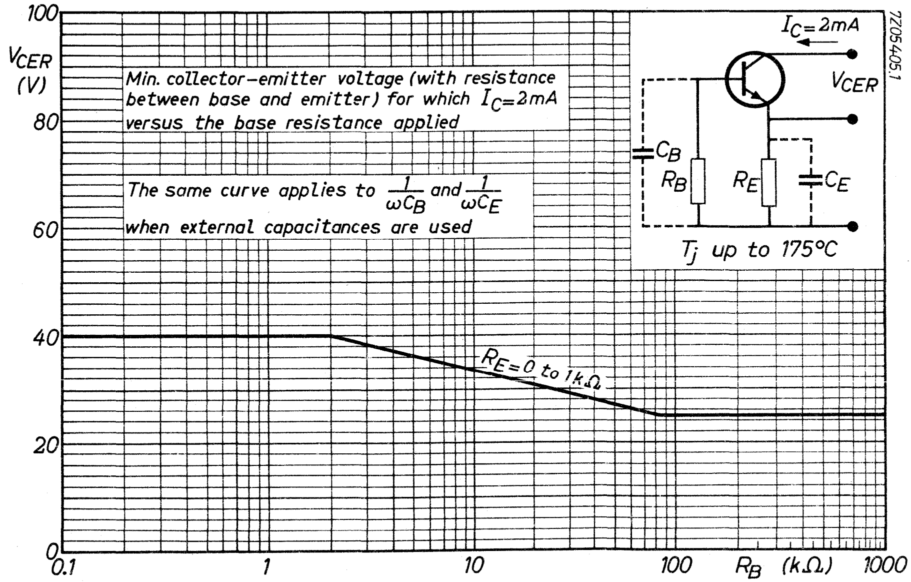
$$G_{tr} = \frac{\text{output power in load } R_L}{\text{available power from source with } R_S}$$

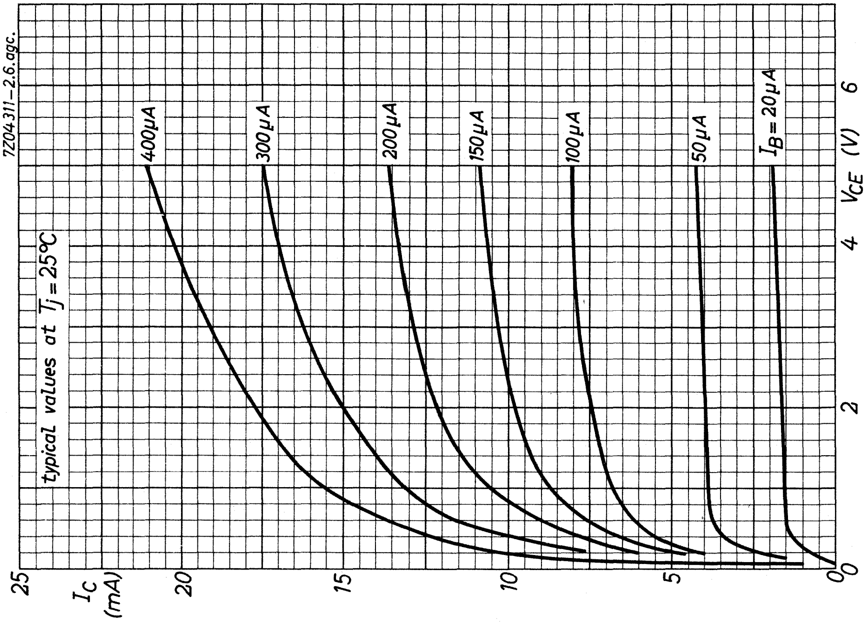
f = 36.4 MHz; I_C = 7.2 mA; V_{CE} = 16.6 V	G_{tr}	typ.	26	dB

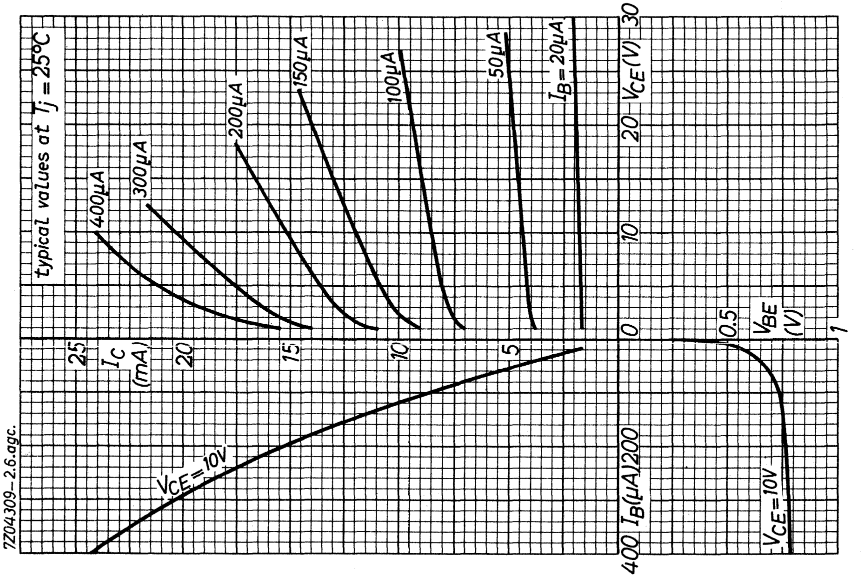
Tuning frequency for all tuned circuits is 37 MHz




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


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
7Z05405.1


7Z04311–2.6.agc.
typical values at Tj = 25°C
400µA
300µA
200µA
150µA
100µA
50µA
IB = 20µA
VCE (V)
IC (mA)
0
2
4
6
5
10
15
20
25


7Z04309–2.6.agc.
typical values at Tj = 25°C
400µA
300µA
200µA
150µA
100µA
50µA
IB = 20µA
VCE(V)
0
10
20
30
IC (mA)
25
20
15
10
5
VCE=10V
IB(µA)
400
200
VBE (V)
0.5
1
VCE=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 are for application in large screen black and white television receivers.

QUICK REFERENCE DATA

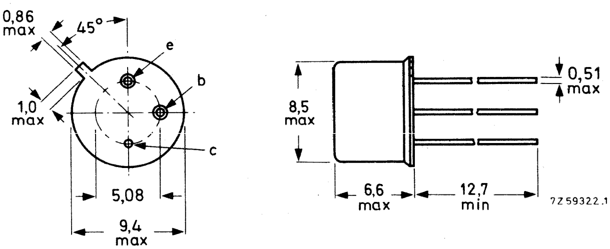
			BF177	BF178	BF179	
Collector-base voltage (open emitter)	V_{CBO}	max.	100	185	250	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	115	115	V
Collector current (peak value)	I_{CM}	max.	50	50	50	mA
Total power dissipation						
up to T_{amb} = 65 °C	P_{tot}	max.	0,6	0,6	0,6	W
up to T_{mb} = 130 °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

Collector connected to case

TO-39



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

Accessories supplied on request: 56218 (package); 56245 (distance disc).

FOR NEW DESIGN THE SUCCESSOR TYPES BF336 TO 338 ARE RECOMMENDED

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

			BF177	BF178	BF179	
Voltages						
Collector-base voltage (open emitter)	V_{CBO}	max.	100	185	250	V 1)
Collector-emitter voltage ($R_B \leq 1\ k\Omega$)	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 $T_{amb} = 65\ ^oC$ in free air	P_{tot}	max.	0.6	0.6	0.6	W
up to $T_{mb} = 130\ ^oC$	P_{tot}	max.		1.7	1.7	W

Temperatures

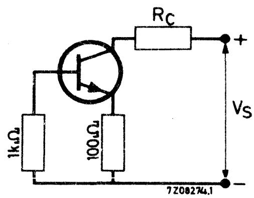
Storage temperature	T_{stg}		−55 to +175	^oC
Junction temperature	T_j	max.	200	^oC

THERMAL RESISTANCE

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

CHARACTERISTICS

			BF177	BF178	BF179	
Collector cut-off current at $T_j = 200\ ^oC$	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}; $T_j = 25\ ^oC$ 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

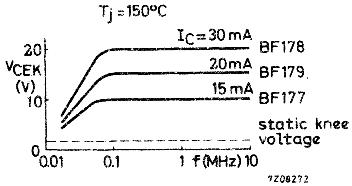
Base-emitter voltage [1])

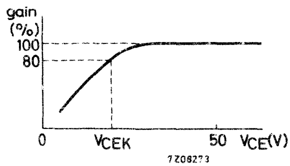
I_C = 15 mA; V_{CE} = 10 V for BF177				
I_C = 20 mA; V_{CE} = 15 V for BF179	V_{BE}	typ.	0.75	V
		<	1.2	V
I_C = 30 mA; V_{CE} = 20 V for BF178				

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 preamplifier in u.h.f. and integrated television tuners.

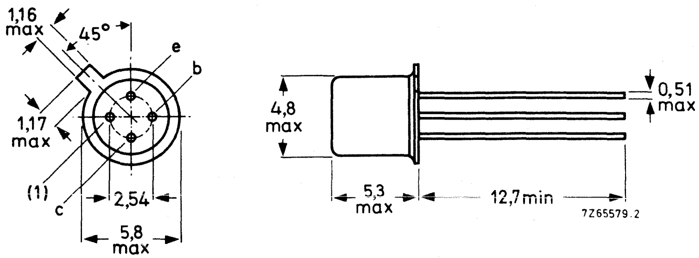
QUICK REFERENCE DATA

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
Maximum unilateralized 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



(1) = shield lead (connected to case).

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

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	$R_{th\ j-a}$	=	1	°C/mW

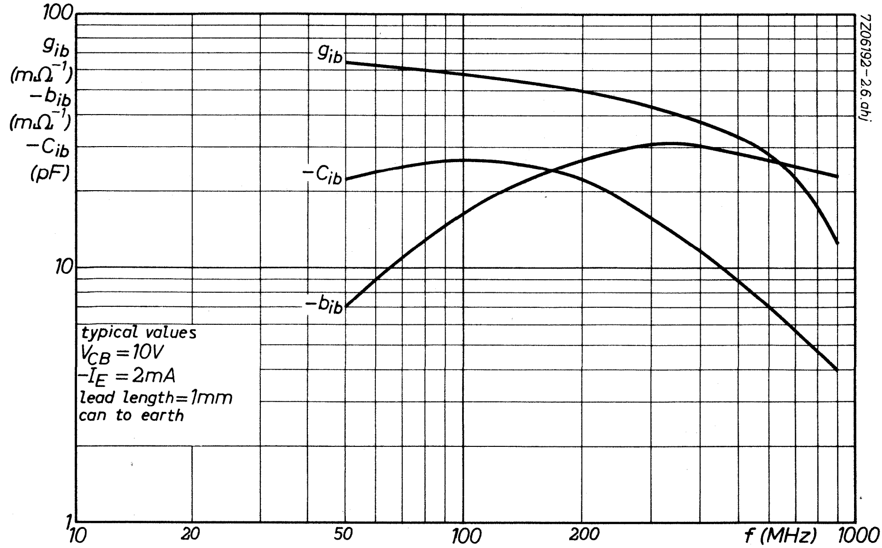
[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

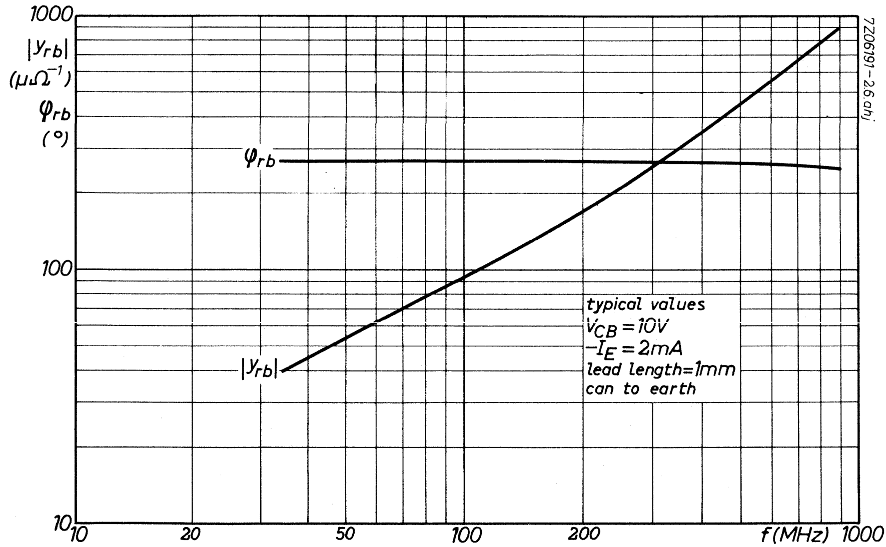
CHARACTERISTICS T_{amb} = 25 °C unless otherwise specified

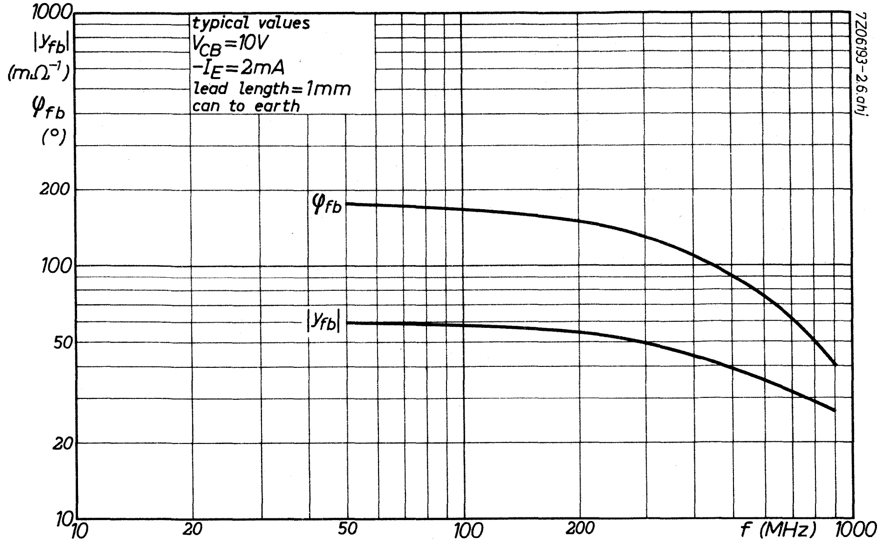
Base current				
$-I_E$ = 2 mA; V_{CB} = 10 V	I_B	typ.	45	µA
		<	150	µA
$-I_E$ = 12 mA; V_{CB} = 7 V	I_B	<	2.2	mA
Emitter-base voltage				
$-I_E$ = 2 mA; V_{CB} = 10 V	$-V_{EB}$	typ.	0.75	V
Feedback capacitance at f = 10.7 MHz				
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	280	fF [1]
Transition frequency				
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	dB
		<	9.5	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}	>	7.5	dB
		typ.	9	dB

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

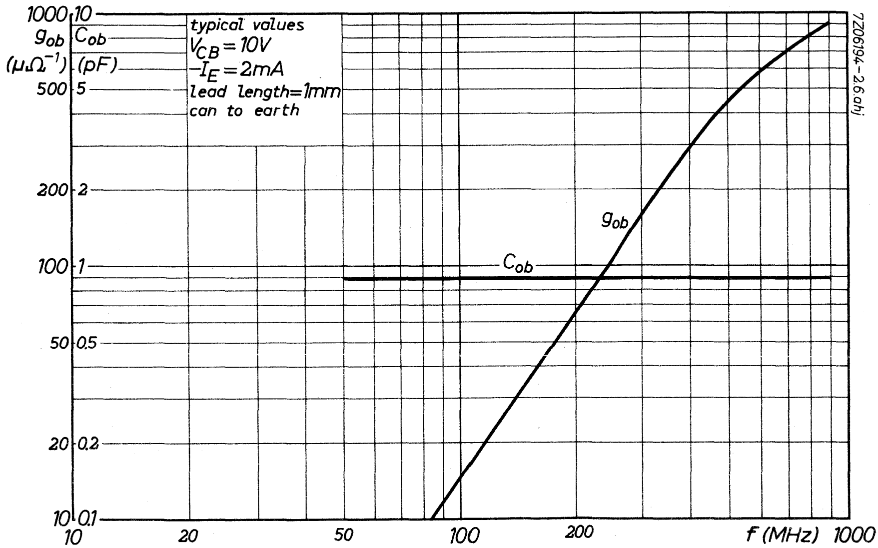
[2]) Common base configuration, metal envelope contacted to earth directly, external lead length: 1 mm.


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

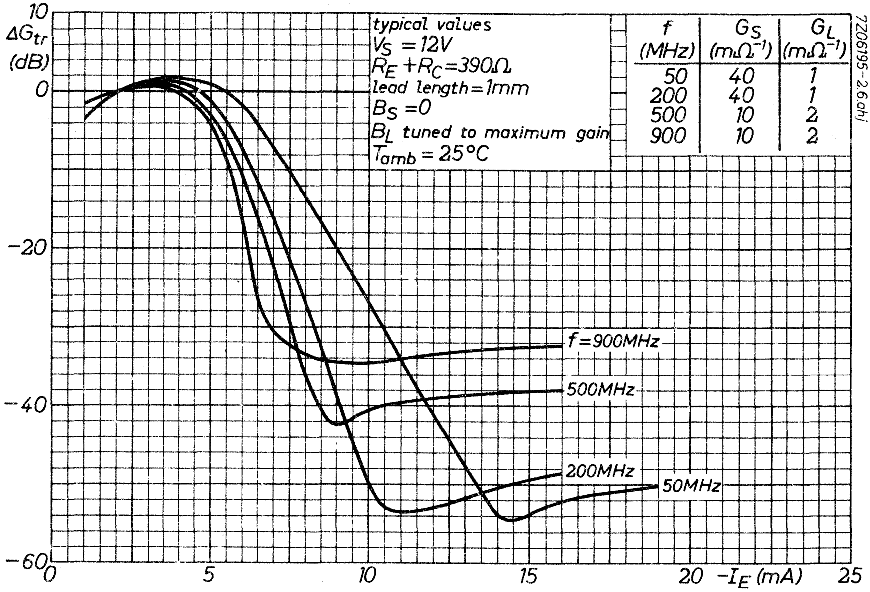

1000
$|y_{rb}|$
$(\mu\Omega^{-1})$
φ_{rb}
(°)
100
10
φ_{rb}
$|y_{rb}|$
typical values
$V_{CB} = 10V$
$-I_E = 2mA$
lead length=1mm
can to earth
10
20
50
100
200
f(MHz)
1000
7Z06191-2.6.ahj



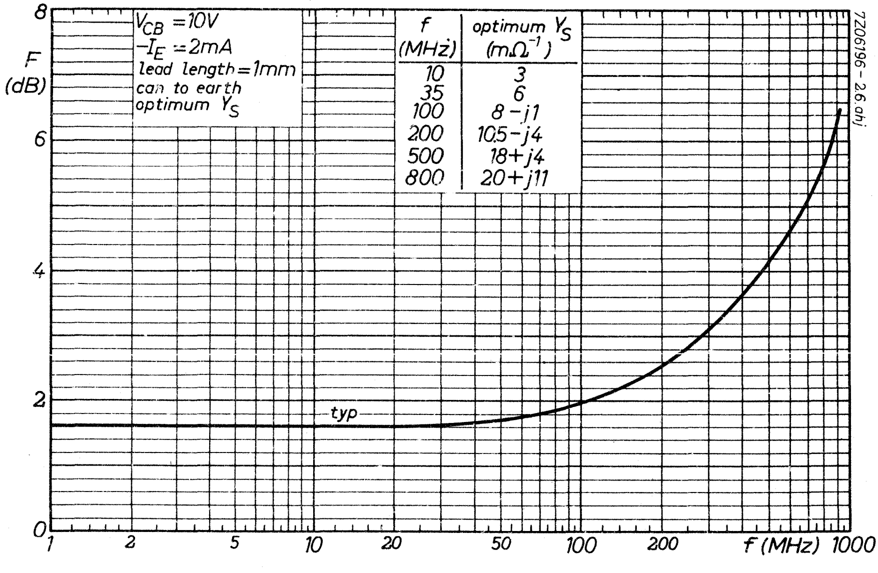
typical values
$V_{CB}=10V$
$-I_E=2mA$
lead length=1mm
can to earth
$|y_{fb}|$
$(m\Omega^{-1})$
φ_{fb}
(°)
1000
200
100
50
20
10
10
20
50
100
200
f (MHz)
1000
7Z06193-2.6.ahj



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}
1000 10
500 5
200 2
100 1
50 0.5
20 0.2
10 0.1
10
20
50
100
200
f (MHz)
1000
7Z06194-2.6.ahj



7Z06195-2.6.ahj
ΔG_tr (dB)
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
-I_E (mA)
10
0
-20
-40
-60
0
5
10
15
20
25



7Z06196-2.6.ahj
F (dB)
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
f (MHz)
8
6
4
2
0
1
2
5
10
20
50
100
200
1000

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.

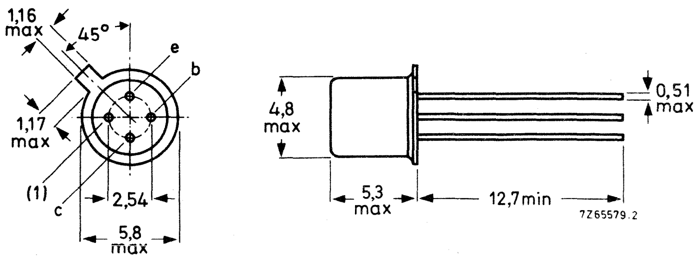
QUICK REFERENCE DATA

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
Maximum unilateralized 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



(1) = shield lead (connected to case).

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

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

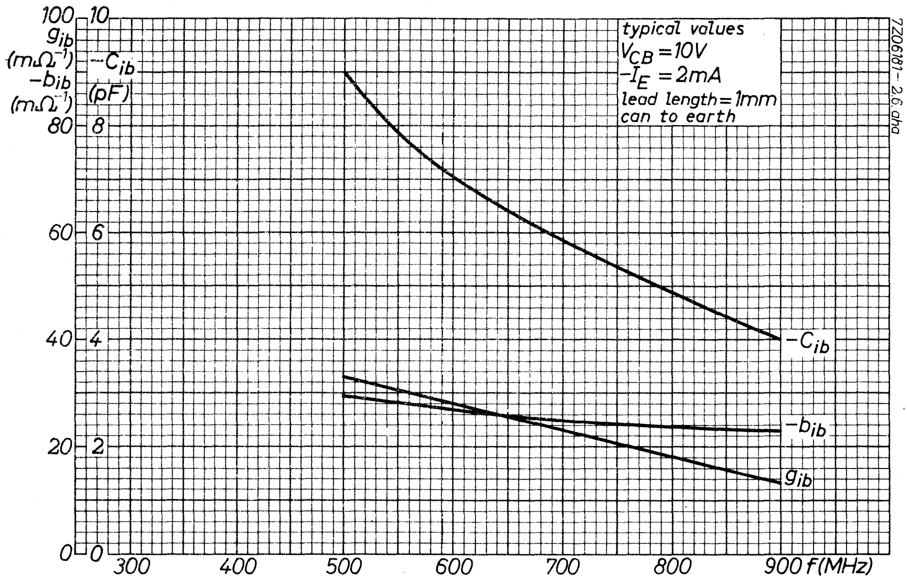
[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

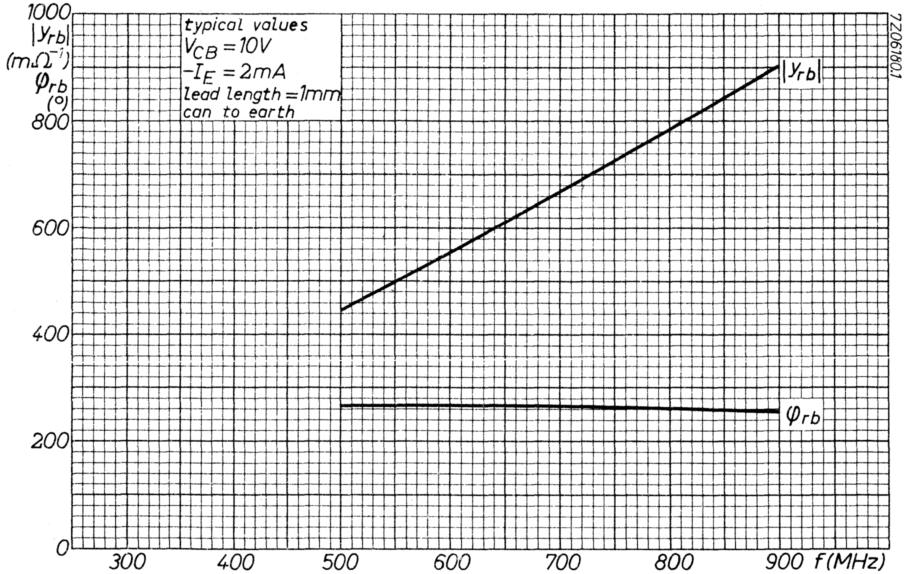
CHARACTERISTICS T_{amb} = 25 °C unless otherwise specified

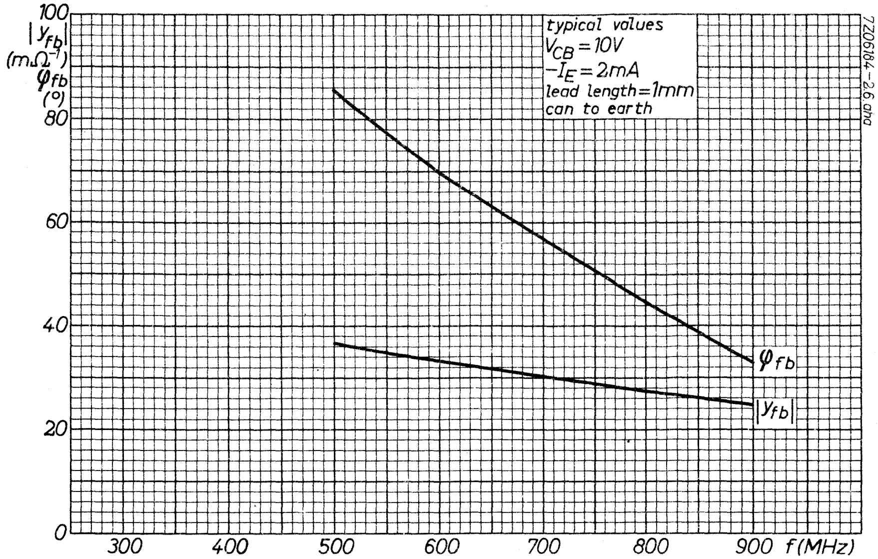
Base current				
$-I_E$ = 2 mA; V_{CB} = 10 V	I_B	typ. <	70 150	μA μA
Emitter-base voltage				
$-I_E$ = 2 mA; V_{CB} = 10 V	$-V_{EB}$	typ.	0.75	V
Feedback capacitance at f = 10.7 MHz				
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	280	fF [1]
Transition frequency				
I_C = 2 mA; V_{CE} = 10 V	f_T	typ.	600	MHz
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

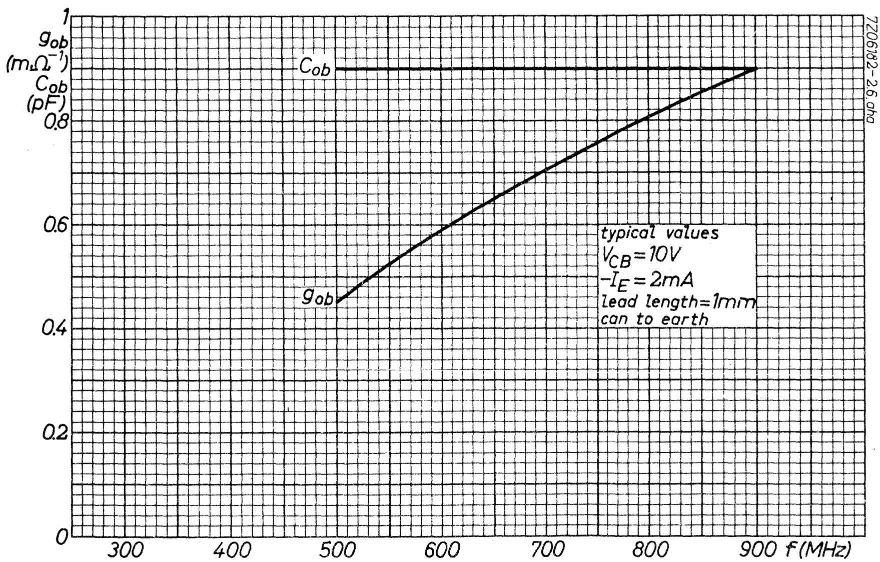
[1]) 1 fF = 1 femtofarad = 10^{-15} F.

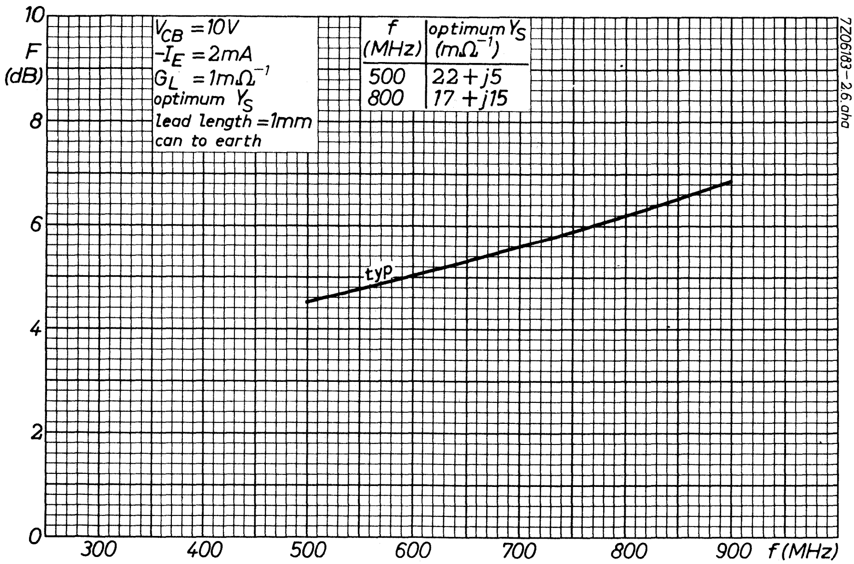
[2]) Common base configuration, metal envelope contacted to earth directly, external lead length: 1 mm.


typical values
$V_{CB} = 10V$
$-I_E = 2mA$
lead length = 1mm
can to earth
g_{ib} ($m\Omega^{-1}$)
$-b_{ib}$ ($m\Omega^{-1}$)
$-C_{ib}$ (pF)
$-C_{ib}$
$-b_{ib}$
g_{ib}
0
20
40
60
80
100
0
2
4
6
8
10
300
400
500
600
700
800
900
f (MHz)
7206181 - 2.6.aha


typical values
$V_{CB} = 10V$
$-I_E = 2mA$
lead length = 1mm
can to earth
$|y_{rb}|$ ($m\Omega^{-1}$)
φ_{rb} (°)
$|y_{rb}|$
φ_{rb}
0
200
400
600
800
1000
300
400
500
600
700
800
900
f (MHz)
7206180.1


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}
$|y_{fb}|$
7206164-2.6.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
7206182-2.6.aha


10
F
(dB)
8
6
4
2
0
V_{CB} = 10 V
$-I_E$ = 2 mA
G_L = 1 mΩ^{-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.cha

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.

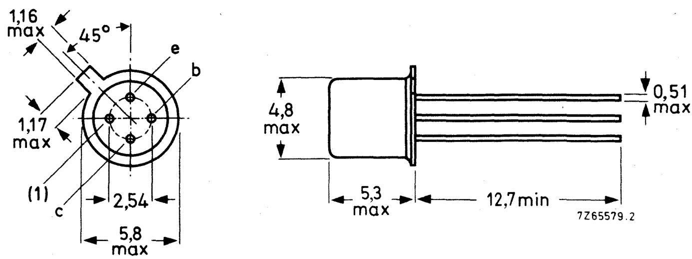
QUICK REFERENCE DATA

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
Maximum unilateralized 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



(1) = shield lead (connected to case).

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

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

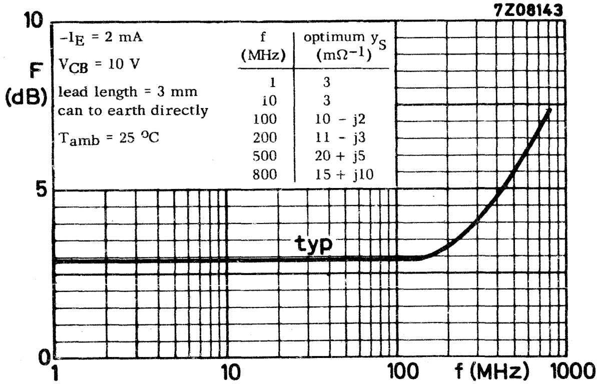
$$G_{UM} = \frac{|y_{fb}|^2}{4\, g_{ib} g_{ob}}$$

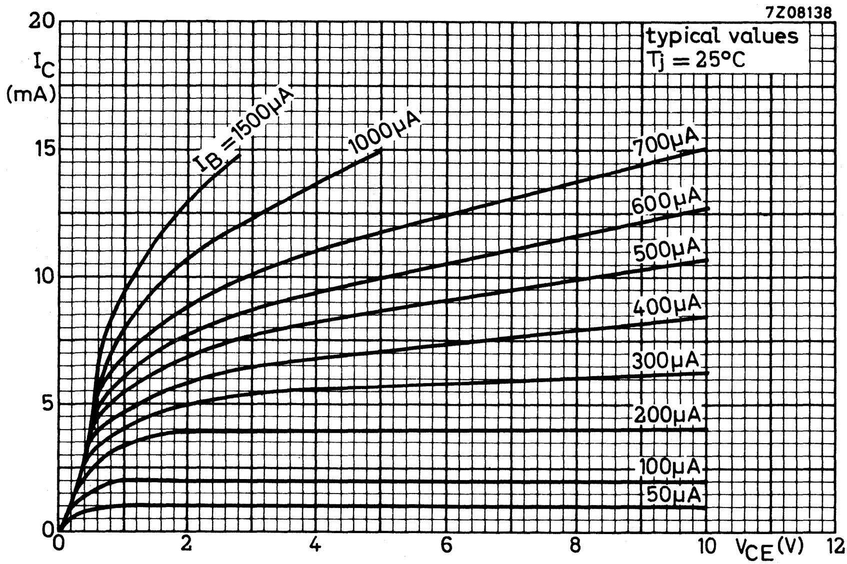
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 500 MHz	G_{UM}	typ.	15	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 900 MHz	G_{UM}	typ.	11	dB

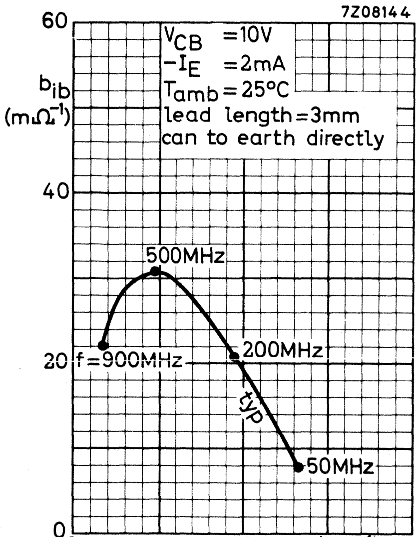
Noise figure at optimum source admittance

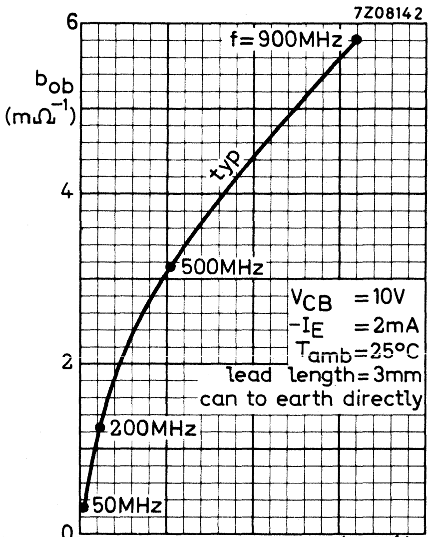
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 200 MHz	F	typ.	3.3	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 800 MHz	F	typ.	7.4	dB

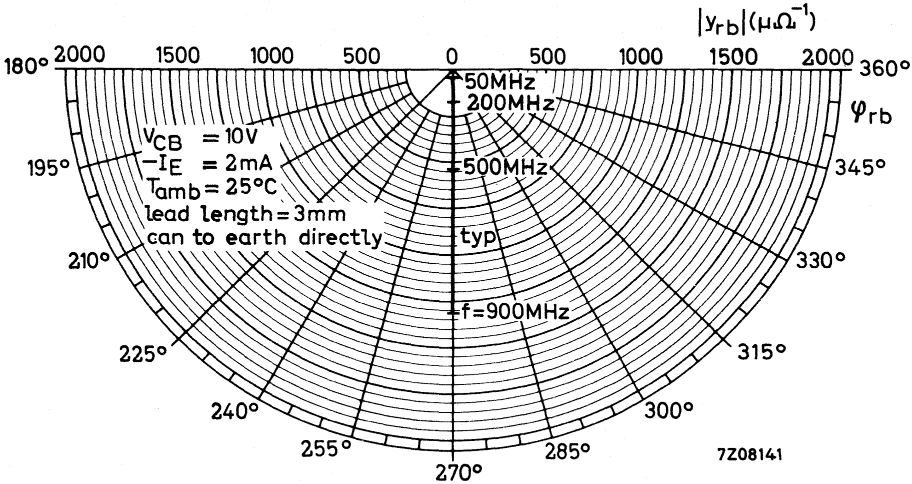
1) Envelope connected to earth directly, lead length = 3 mm.



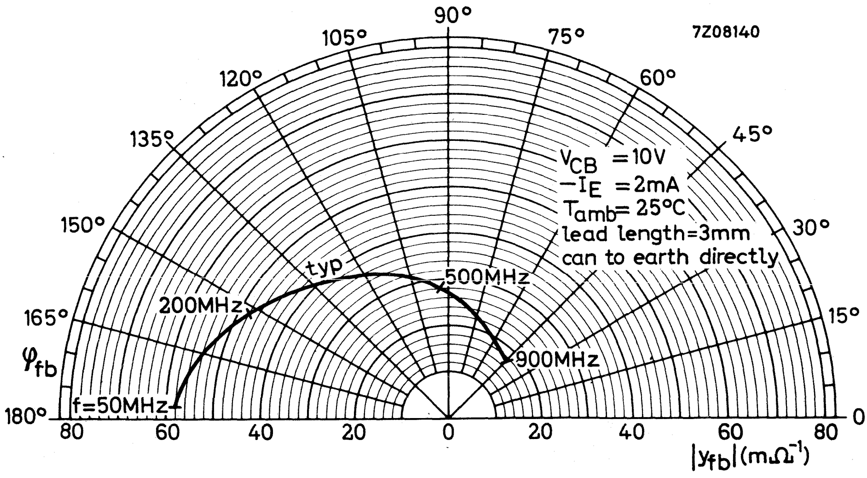

7Z08138
typical values
Tj = 25°C
I_C
(mA)
I_B = 1500μA
1000μA
700μA
600μA
500μA
400μA
300μA
200μA
100μA
50μA
V_{CE} (V)
0
2
4
6
8
10
12
5
15
20


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

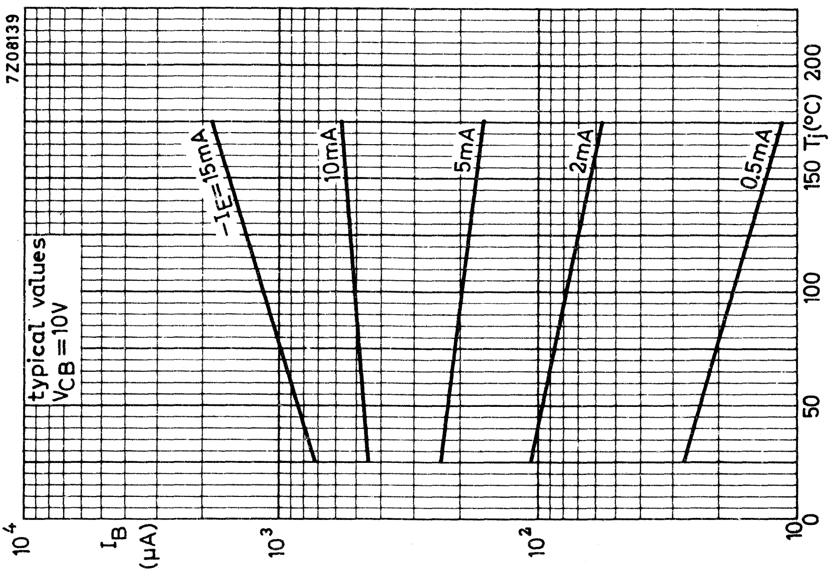

7Z08142
f = 900MHz
b_{ob}
(mΩ^{-1})
typ
500MHz
V_{CB} = 10V
$-I_E$ = 2mA
T_{amb} = 25°C
lead length = 3mm
can to earth directly
200MHz
50MHz
g_{ob} (mΩ^{-1})
0
0.5
1
2
4
6

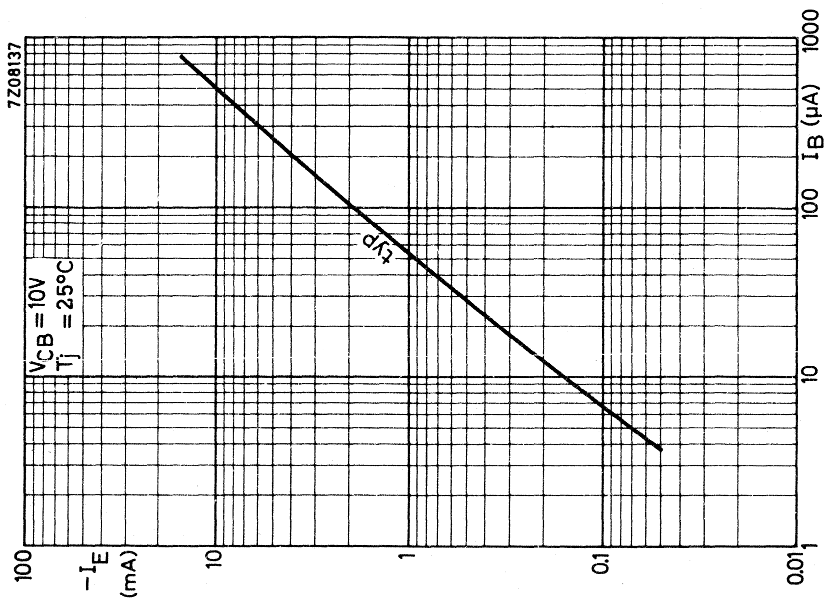


|y_rb| (μΩ⁻¹)
2000 1500 1000 500 0 500 1000 1500 2000
180° 195° 210° 225° 240° 255° 270° 285° 300° 315° 330° 345° 360°
φ_rb
50MHz
200MHz
500MHz
typ
f=900MHz
V_CB = 10V
−I_E = 2mA
T_amb = 25°C
lead length = 3mm
can to earth directly
7Z08141



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


7Z08139
typical values
VCB = 10V
−IE = 15mA
10mA
5mA
2mA
0.5mA
IB (μA)
10⁴
10³
10²
10
Tj (°C)
0
50
100
150
200


7Z08137
VCB = 10V
Tj = 25°C
typ
−IE (mA)
100
10
1
0.1
0.01
IB (μA)
1
10
100
1000

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.

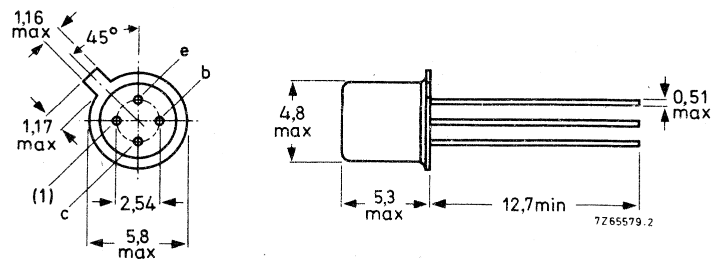
QUICK REFERENCE DATA

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
Maximum unilateralized 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



(1) = shield lead (connected to case).

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

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 ^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

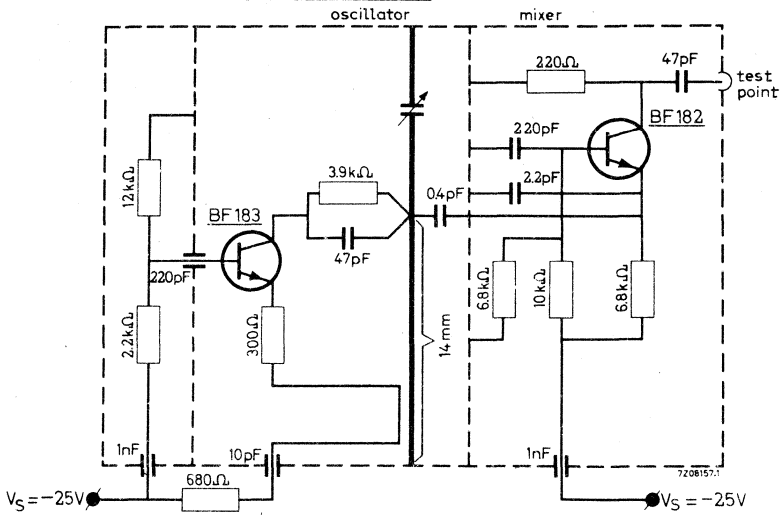
Base-current				
$-I_E$ = 3 mA; V_{CB} = 10 V	I_B	typ. <	125 300	µA µA
Emitter-base voltage [1]				
$-I_E$ = 3 mA; V_{CB} = 10 V	$-V_{EB}$	typ.	770	mV
Transition frequency				
I_C = 3 mA; V_{CE} = 10 V	f_T	typ.	800	MHz
Feedback capacitance at f = 10.7 MHz				
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	330	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}	> typ.	8.5 12	dB 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

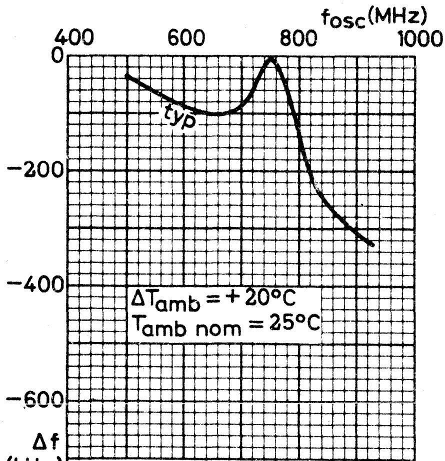
1) $-V_{EB}$ decreases by about 1.6 mV/°C with increasing temperature.

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

APPLICATION INFORMATION

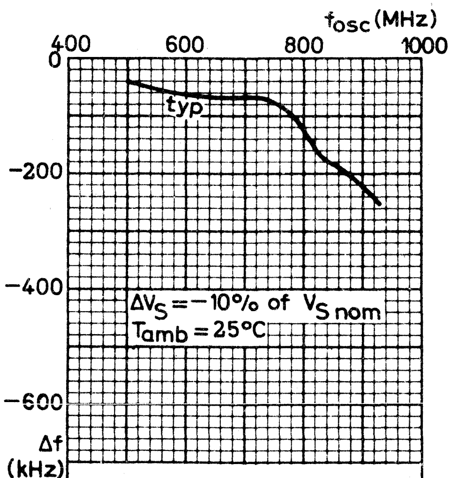
Oscillator circuit with simplified mixer stage





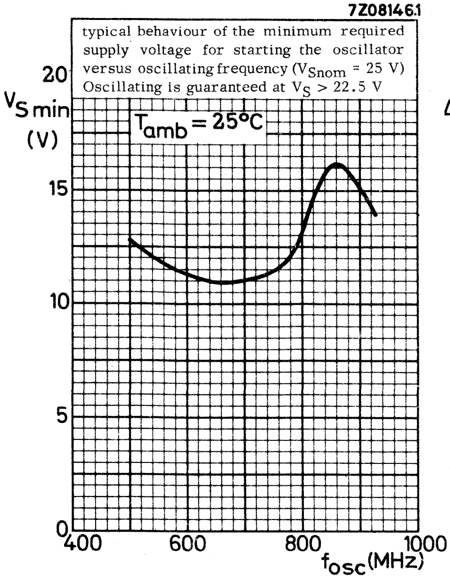
frequency change due to increase of the ambient temperature versus oscillator frequency

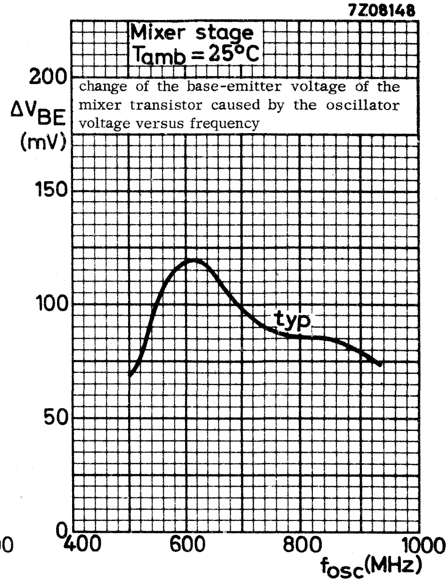
7Z08145

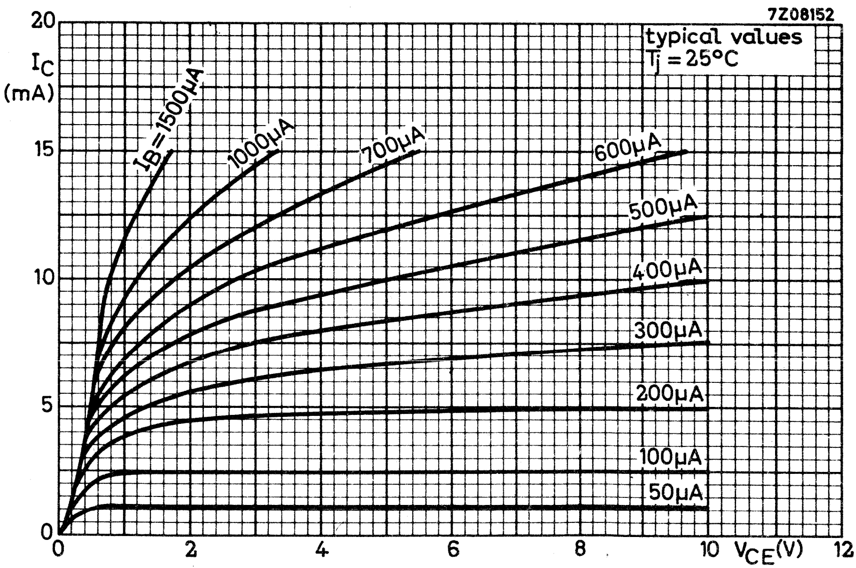


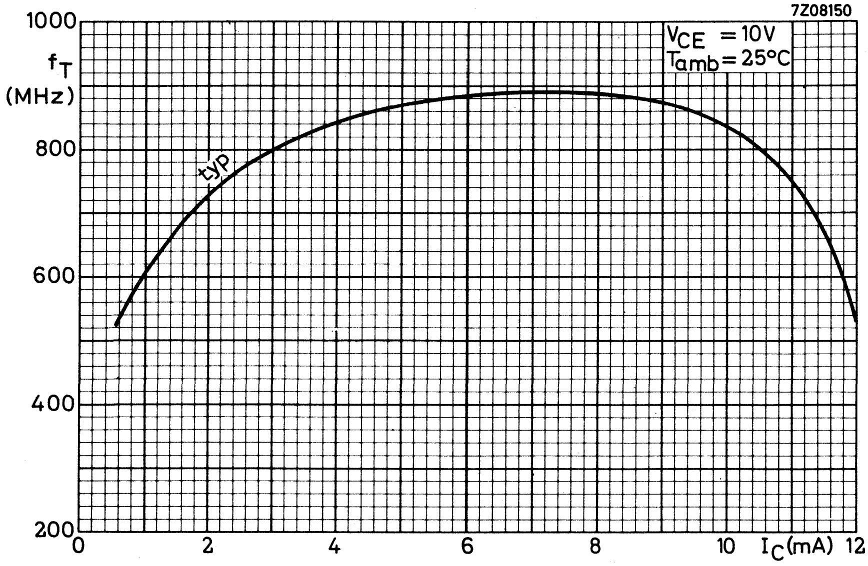
frequency change due to decrease of supply voltage versus oscillator frequency

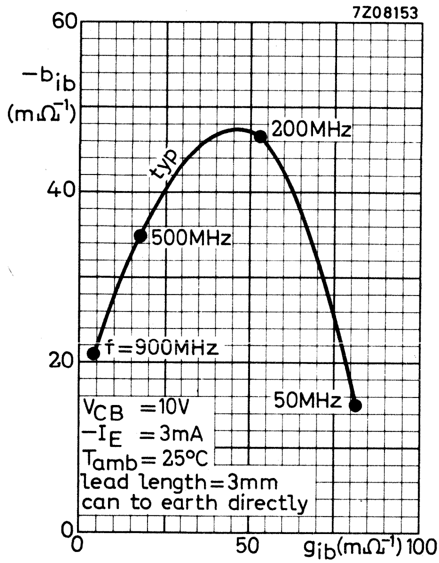
7Z08147

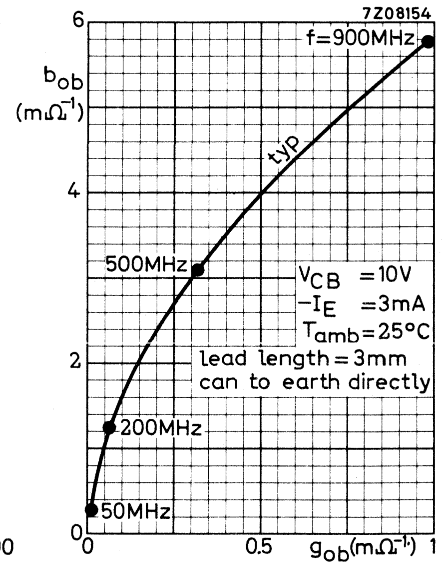

7Z08146.1
typical behaviour of the minimum required supply voltage for starting the oscillator versus oscillating frequency (V_{Snom} = 25 V)
Oscillating is guaranteed at V_S > 22.5 V
T_{amb} = 25°C
$V_{S\,min}$ (V)
f_{osc} (MHz)
0
5
10
15
20
400
600
800
1000

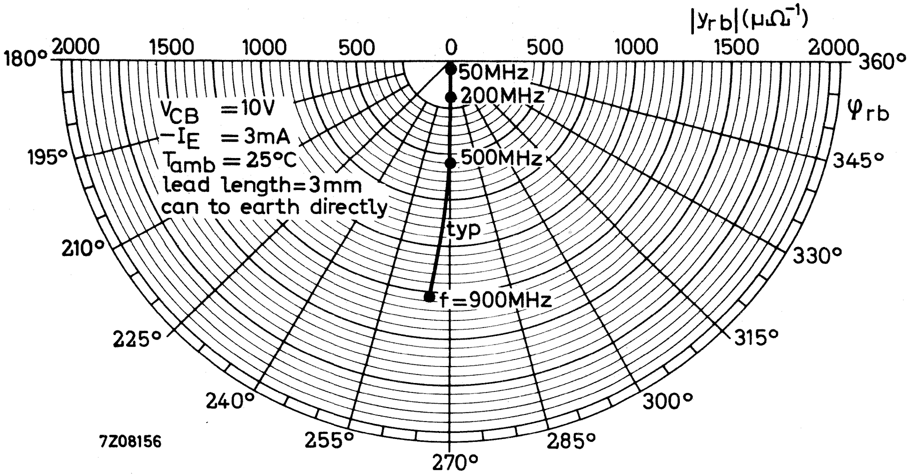

7Z08148
Mixer stage
T_{amb} = 25°C
change of the base-emitter voltage of the mixer transistor caused by the oscillator voltage versus frequency
ΔV_{BE} (mV)
typ
f_{osc} (MHz)
0
50
100
150
200
400
600
800
1000

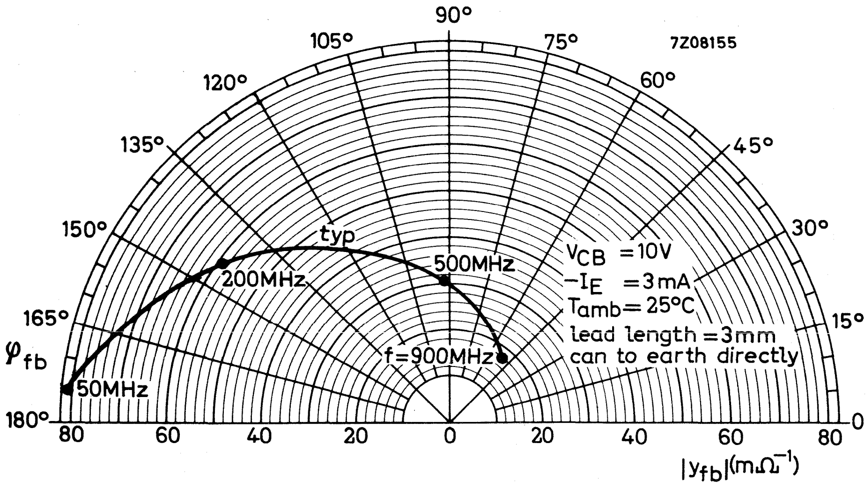

7Z08152
typical values
T_j = 25°C
I_C (mA)
I_B = 1500μA
1000μA
700μA
600μA
500μA
400μA
300μA
200μA
100μA
50μA
V_{CE} (V)
0
5
10
15
20
0
2
4
6
8
10
12

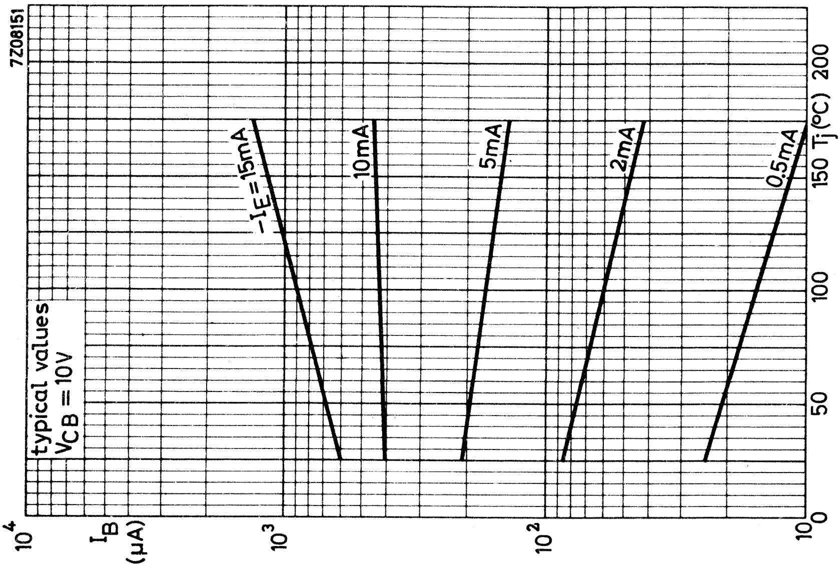

7Z08150
V_{CE} = 10V
T_{amb} = 25°C
f_T (MHz)
typ
I_C (mA)
1000
800
600
400
200
0
2
4
6
8
10
12

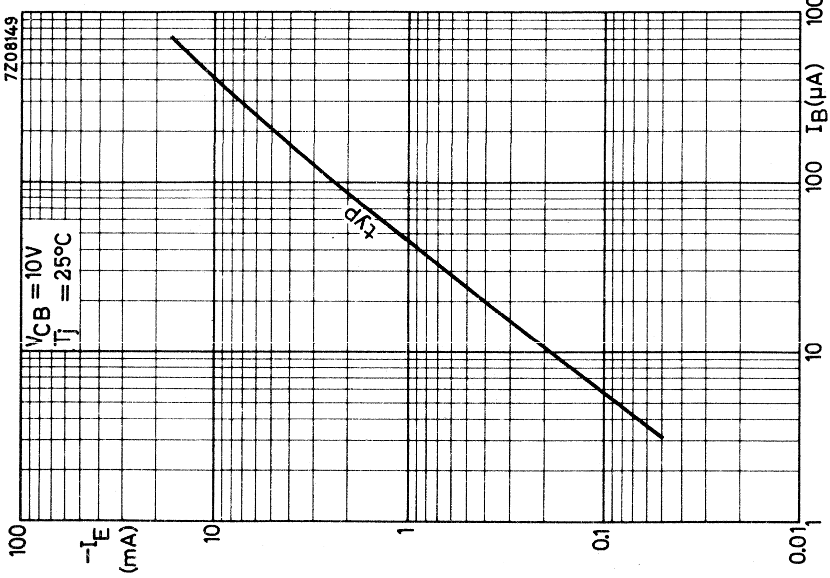

7Z08153
$-b_{ib}$ ($m\Omega^{-1}$)
typ
200MHz
500MHz
f=900MHz
50MHz
V_{CB} = 10V
$-I_E$ = 3mA
T_{amb} = 25°C
lead length = 3mm
can to earth directly
g_{ib} ($m\Omega^{-1}$)
60
40
20
0
0
50
100


7Z08154
b_{ob} ($m\Omega^{-1}$)
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} ($m\Omega^{-1}$)
6
4
2
0
0
0.5
1


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


90°
105°
75°
120°
60°
135°
45°
150°
30°
165°
15°
180°
0
φfb
7Z08155
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
VCB = 10V
−IE = 15mA
10mA
5mA
2mA
0.5mA
IB (µA)
10^4
10^3
10^2
10
Tj (°C)
0
50
100
150
200


7Z08149
VCB = 10V
Tj = 25°C
typ
−IE (mA)
100
10
1
0.1
0.01
IB (µA)
1
10
100
1000

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.

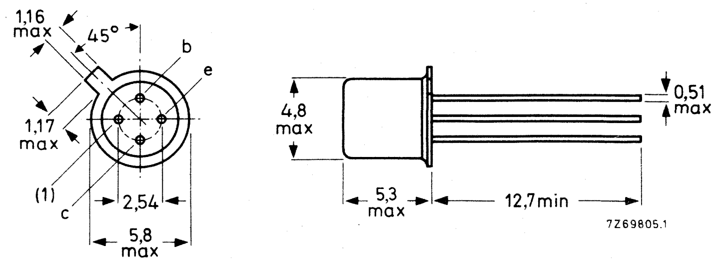
QUICK REFERENCE DATA

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 supplied on request: 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

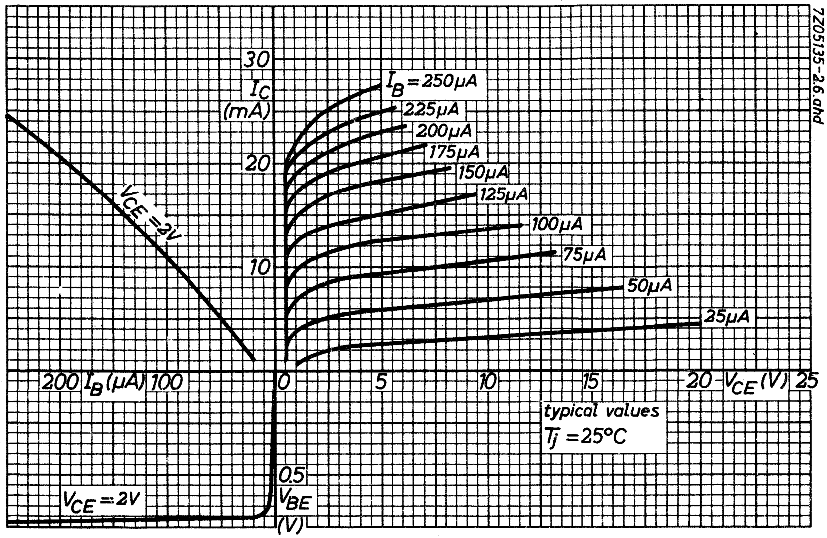
THERMAL RESISTANCE

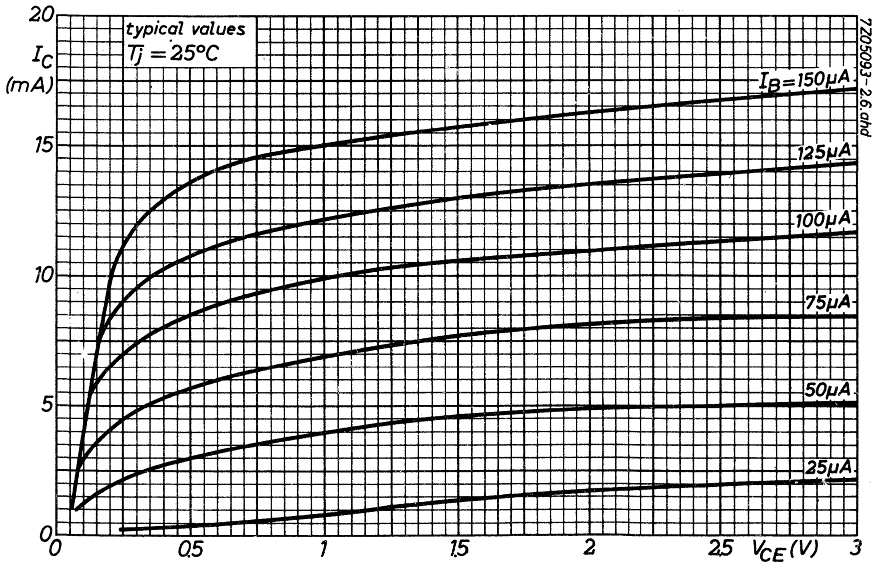
From junction to ambient in free air	$R_{th\ j-a}$	=	0.9	°C/mW

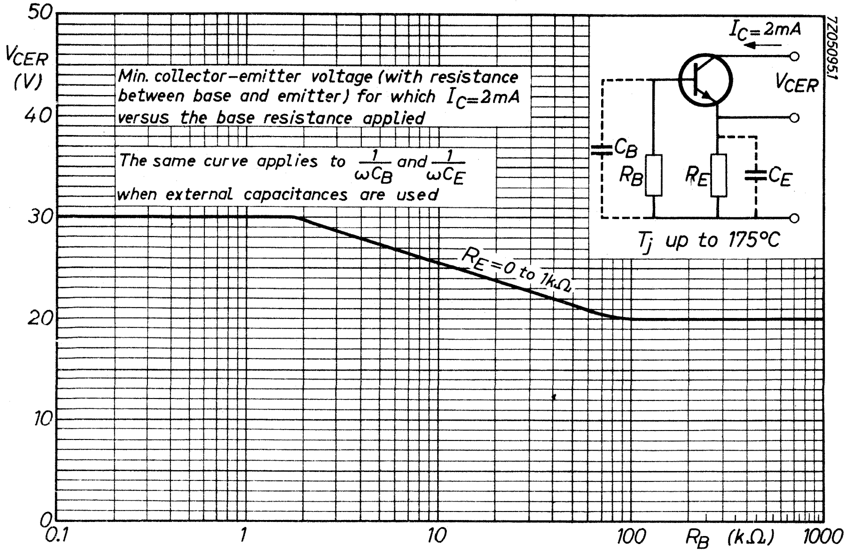
CHARACTERISTICS T_j = 25 °C unless otherwise specified

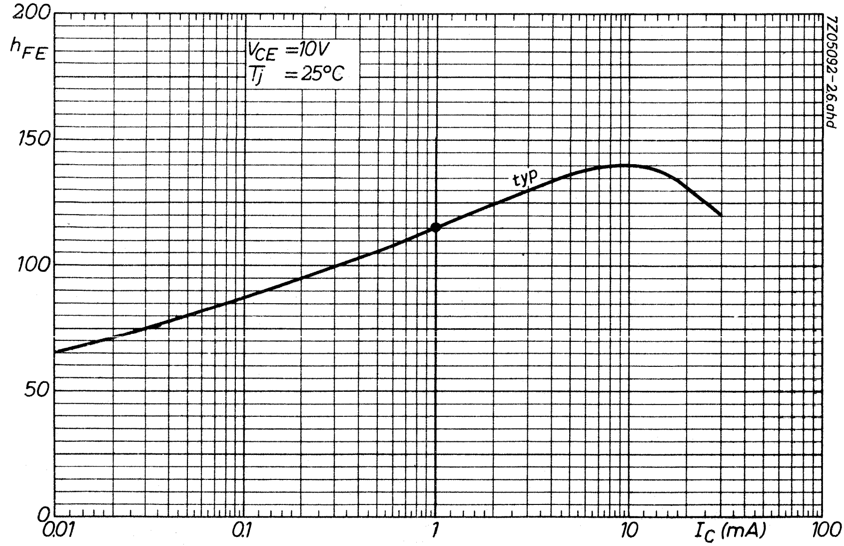
Base-emitter voltage [1]				
I_C = 1 mA; V_{CE} = 10 V	V_{BE}	0.65 to 0.74		V
I_C = 20 mA; V_{CE} = 2 V	V_{BE}	<	1.0	V
Feedback capacitance at f = 0.45 MHz				
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	0.65	pF
D.C. current gain				
I_C = 1 mA; V_{CE} = 10 V	h_{FE}	75 to	750	
		typ.	115	
Transition frequency				
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

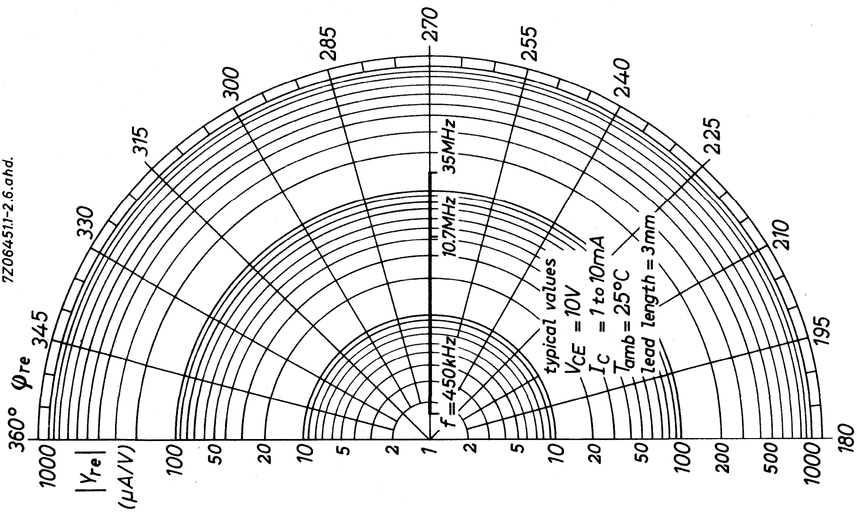
[1] V_{BE} decreases with about 1.7 mV/°C at increasing temperature.

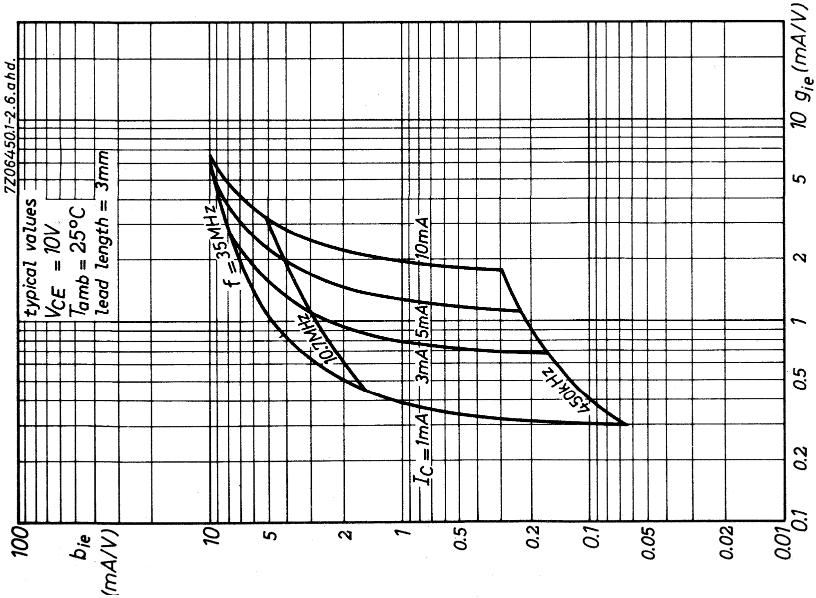

7Z05135-2.6.ahd
30
I_C
(mA)
20
10
I_B=250µA
225µA
200µA
175µA
150µA
125µA
100µA
75µA
50µA
25µA
V_{CE}=2V
200 I_B(µA) 100
0 5 10 15 20 V_{CE}(V) 25
typical values
T_j =25°C
0.5
V_{BE}
(V)
V_{CE}=2V

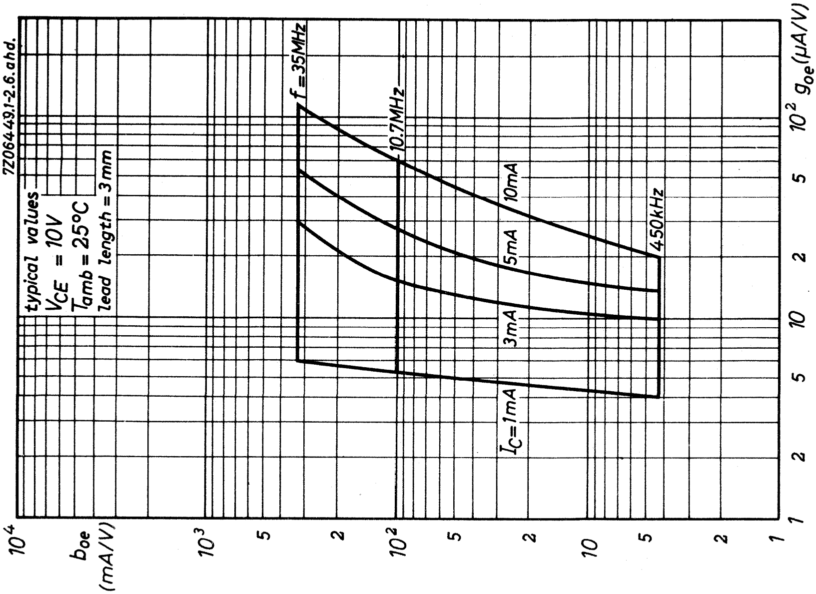

7Z05093-2.6.ahd
20
I_C
(mA)
15
10
5
0
typical values
T_j = 25°C
I_B=150µA
125µA
100µA
75µA
50µA
25µA
0 0.5 1 1.5 2 2.5 V_{CE}(V) 3

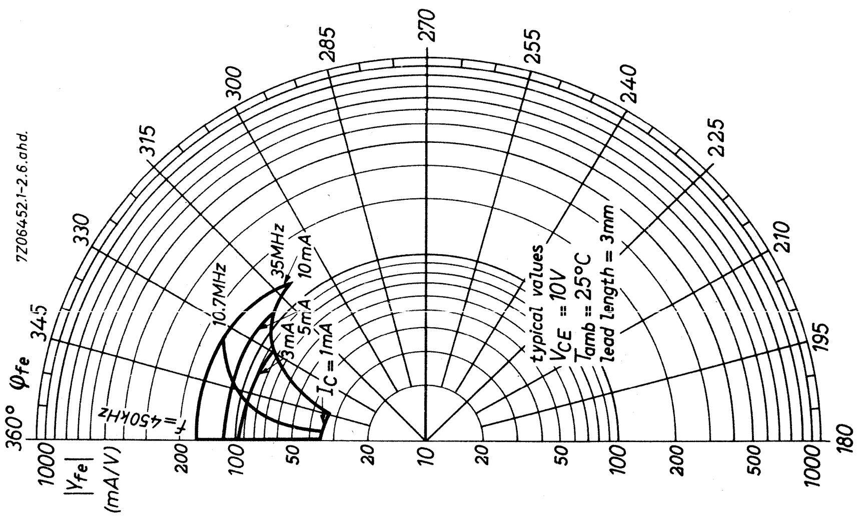

7Z05095I
V_{CER} (V)
Min. collector-emitter voltage (with resistance between base and emitter) for which I_C=2mA versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$ when external capacitances are used
I_C=2mA
V_{CER}
C_B
R_B
R_E
C_E
T_j up to 175°C
R_E=0 to 1kΩ
50
40
30
20
10
0
0.1
1
10
100
R_B (kΩ)
1000


7Z05092-26.ahd
h_{FE}
V_{CE} =10V
T_j =25°C
typ
200
150
100
50
0
0.01
0.1
1
10
I_C (mA)
100


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
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
f = 35MHz
10.7MHz
450kHz
I_C = 1mA
3mA
5mA
10mA


7Z06449.1-2.6.ahd.
typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length = 3mm
f = 35MHz
10.7MHz
450kHz
10mA
5mA
3mA
I_C=1mA
b_{oe} (mA/V)
g_{oe} (μA/V)


7Z06452.1-2.6.ahd.
φ_{fe}
$|y_{fe}|$ (mA/V)
typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length = 3mm
35MHz
10.7MHz
f=450kHz
10mA
5mA
3mA
I_C=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.

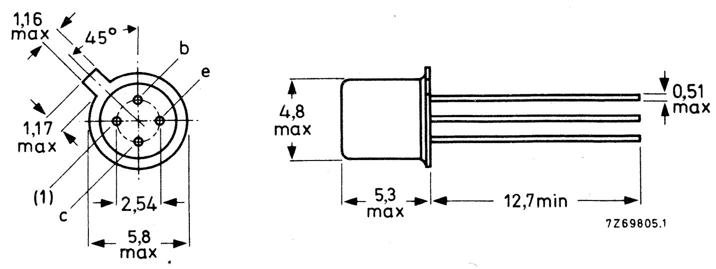
QUICK REFERENCE DATA

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 supplied on request: 56246 (distance disc); 56263 (cooling fin).

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	$R_{th\ j\text{-}a}$	=	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}	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

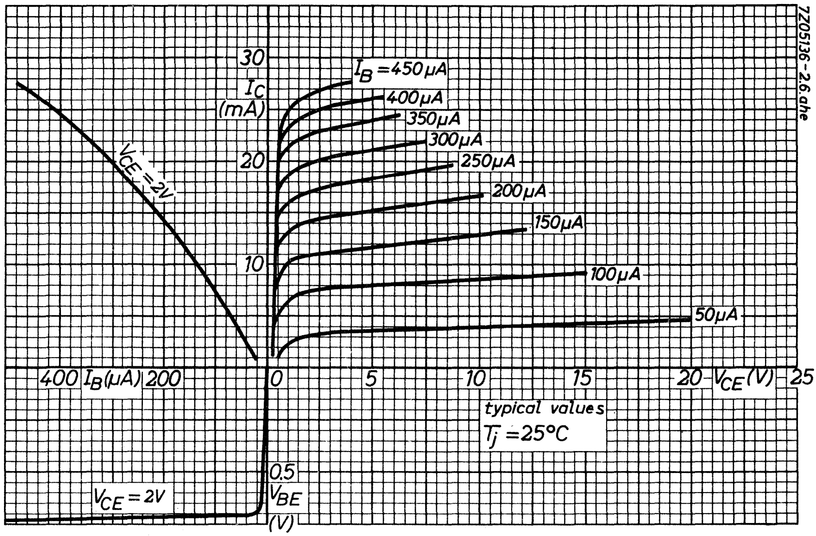
I_C = 1 mA; V_{CE} = 10 V				
f = 0, 2 MHz; G_S = 5 mA/V	F	typ.	2	dB
f = 1 MHz; G_S = 20 mA/V	F	typ.	3, 5	dB
f = 100 MHz; G_S = 10 mA/V	F	typ.	4	dB

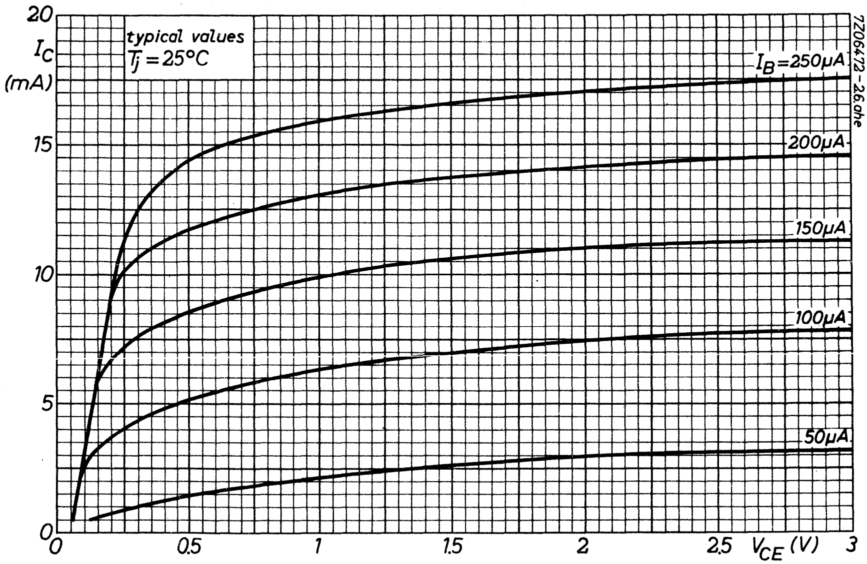
y parameters at f = 100 MHz (common base)

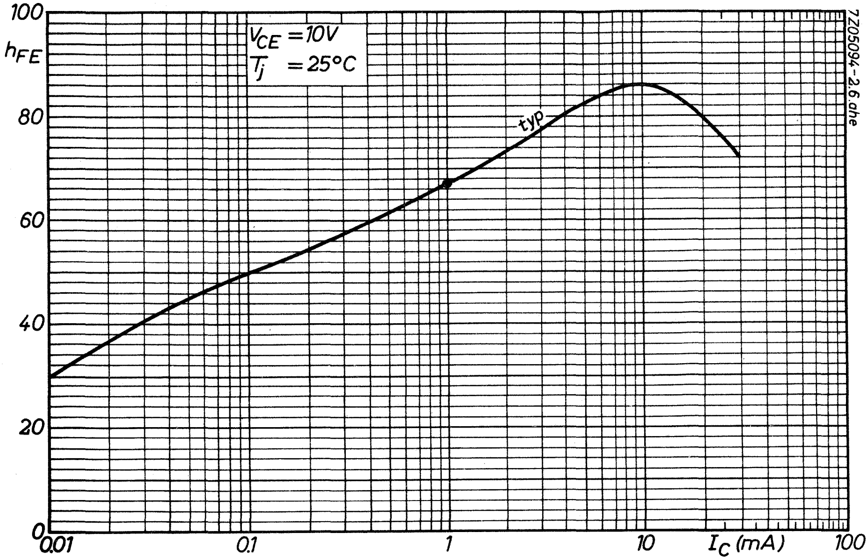
$-I_E$ = 1 mA; V_{CB} = 10 V				
Input conductance	g_{ib}	typ.	33	mA/V
Input capacitance	$-C_{ib}$	typ.	5, 5	pF
Feedback admittance	$\lvert y_{rb} \rvert$	typ.	220	mA/V
Phase angle of feedback admittance	φ_{rb}	typ.	273°	
Transfer admittance	$\lvert y_{fb} \rvert$	typ.	33	mA/V
Phase angle of transfer admittance	φ_{fb}	typ.	150°	
Output conductance	g_{ob}	typ.	12	μA/V
Output capacitance	C_{ob}	typ.	1, 5	pF

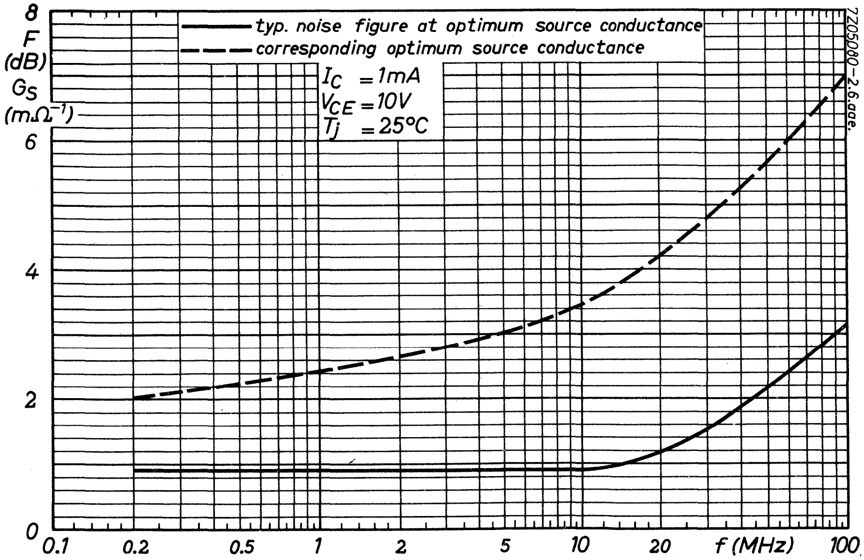
NOTE

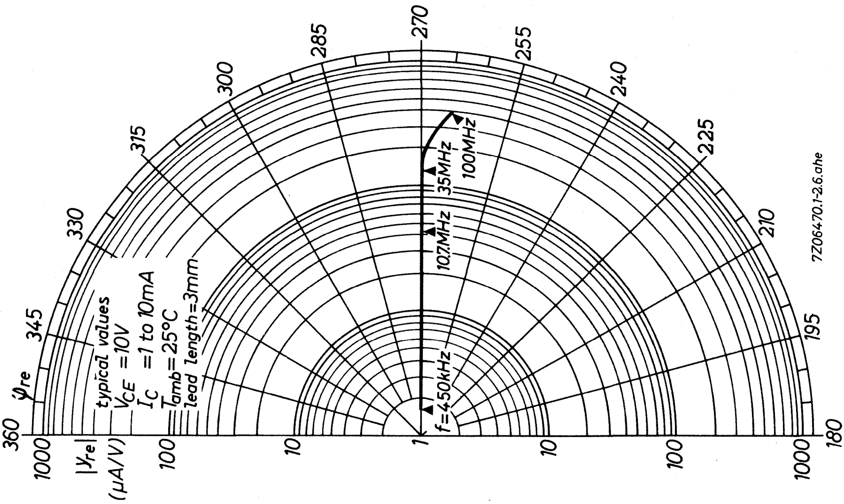
All small-signal quantities have been measured with a length of leads between the bottom of the transistor and measuring jig of 3 mm.

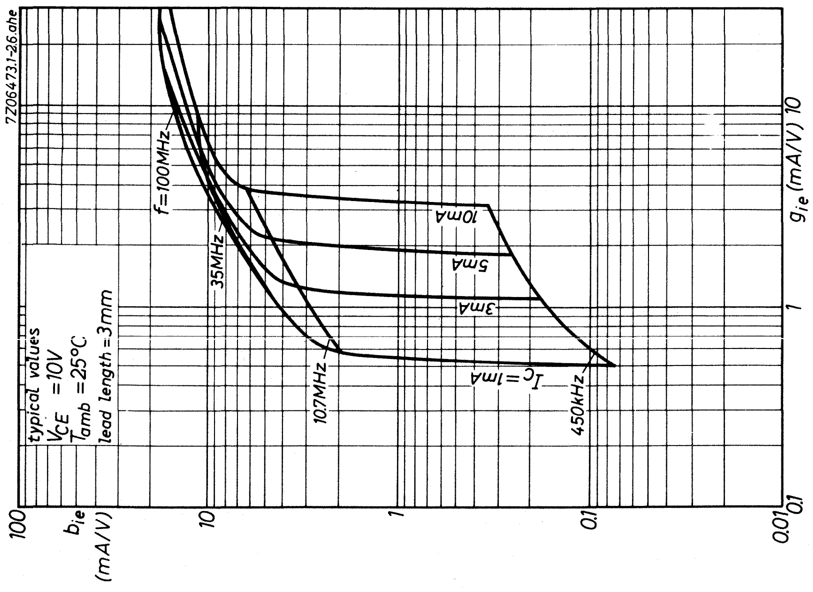

7Z05136-2.6.ahe
30
I_C
(mA)
20
10
I_B=450μA
400μA
350μA
300μA
250μA
200μA
150μA
100μA
50μA
V_{CE}=2V
400 I_B(μA) 200
0 5 10 15 20 V_{CE}(V) 25
typical values
T_j=25°C
0.5
V_{BE}
(V)
V_{CE}=2V

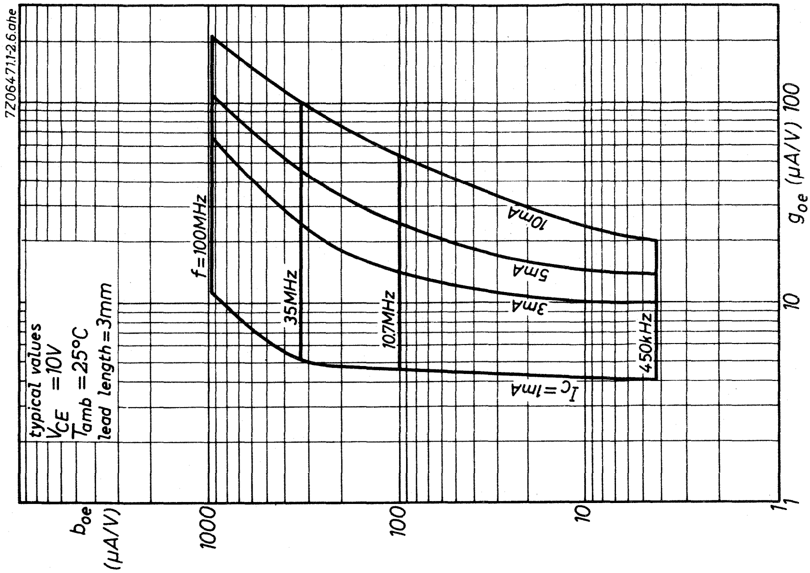

7Z06472-2.6.ahe
20
I_C
(mA)
15
10
5
0
typical values
T_j=25°C
I_B=250μA
200μA
150μA
100μA
50μA
0 0.5 1 1.5 2 2.5 V_{CE}(V) 3

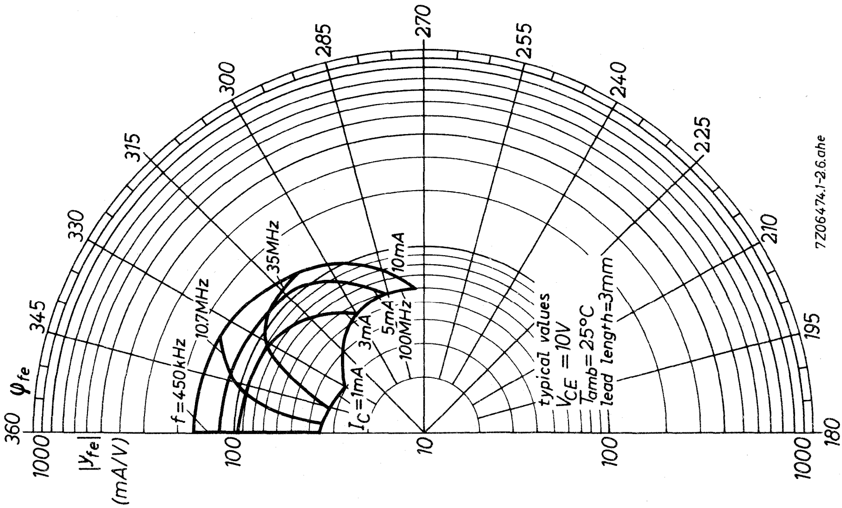

100
h_{FE}
80
60
40
20
0
V_{CE} = 10V
T_j = 25°C
typ
0.01
0.1
1
10
I_C (mA)
100
7Z05094-2.6.ahe

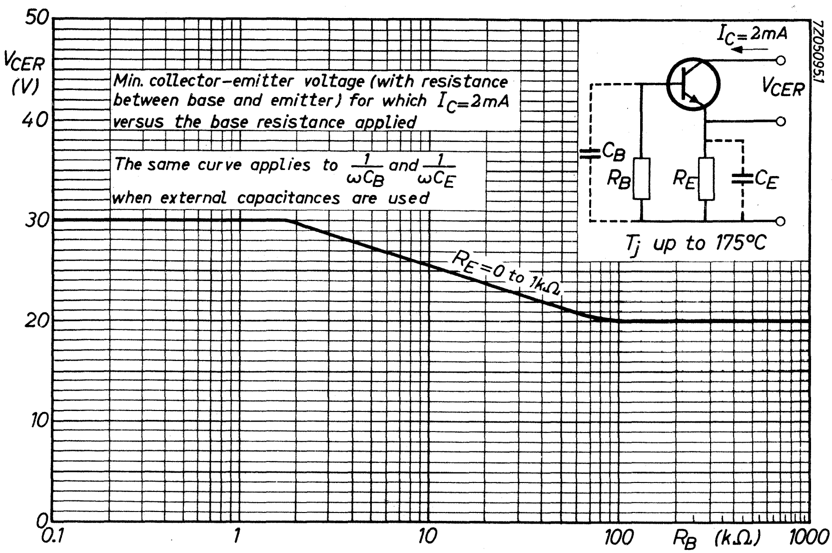

8
F
(dB)
G_S
($m\Omega^{-1}$)
6
4
2
0
typ. noise figure at optimum source conductance
corresponding optimum source conductance
I_C = 1mA
V_{CE} = 10V
T_j = 25°C
0.1
0.2
0.5
1
2
5
10
20
f (MHz)
100
7Z05080-2.6.aae.


φ_{re}
typical values
V_{CE} = 10V
I_C = 1 to 10mA
T_{amb} = 25°C
lead length = 3mm
$|y_{re}|$ (μA/V)
f = 450kHz
10.7MHz
35MHz
100MHz
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
I_C = 1mA
3mA
5mA
10mA
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
10mA
5mA
3mA
I_C = 1mA
g_{oe} (µA/V)
b_{oe} (µA/V)
1000
100
10
1


7Z06474.1-2.6.ahe
φ_{fe}
360
345
330
315
300
285
270
255
240
225
210
195
180
$|y_{fe}|$ (mA/V)
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


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
V_{CER} (V)
50
40
30
20
10
0
0.1
1
10
100
R_B (kΩ)
1000
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-circuit 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 °C	P_{tot}	max.	250	mW
Junction temperature	T_j	max.	125	°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

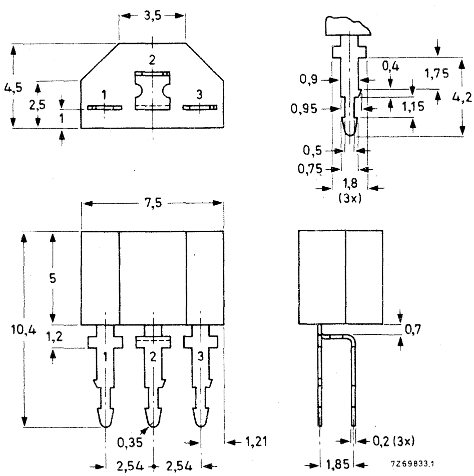
MECHANICAL DATA

Dimensions in mm

SOT-25

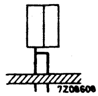
Connections

1. Base
2. Emitter
3. Collector

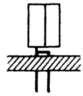


MOUNTING INSTRUCTIONS

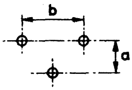
1. Thickness of printed board: max. 1.1 mm
   Hole diameter 0.77 to 0.83 mm



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



Bore plan



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

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

Voltages

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

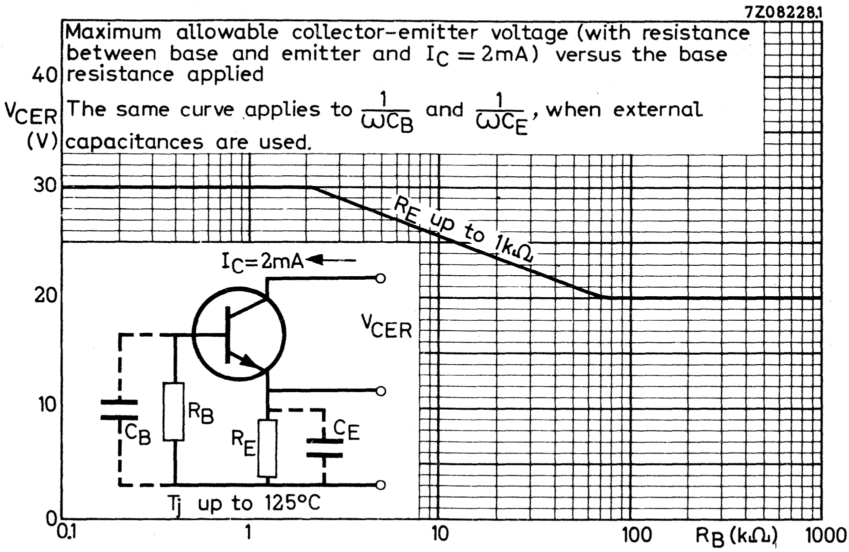
$T_j = 25\ ^oC$

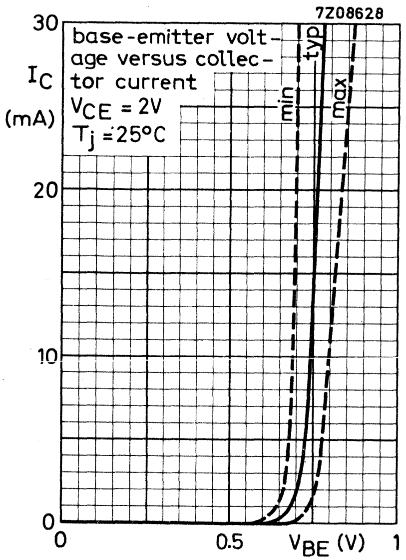
Base-emitter voltage 1)				
I_C = 1 mA; V_{CE} = 10 V	V_{BE}	0.65 to 0.74		V
Base current				
I_C = 1 mA; V_{CE} = 10 V	I_B	4.5 to	15	μA
		typ.	8.7	μA
Feedback capacitance at f = 0.45 MHz				
I_C = 1 mA; V_{CE} = 10 V	C_{re}	typ.	0.95	pF
Transition frequency				
I_C = 1 mA; V_{CE} = 10 V	f_T	typ.	260	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^o	
Tranfer admittance	$\|y_{fb}\|$	typ.	33	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fb}	typ.	146^o	
Output conductance	g_{ob}	typ.	22	$\mu\Omega^{-1}$
Output susceptance	b_{ob}	typ.	1.1	$m\Omega^{-1}$

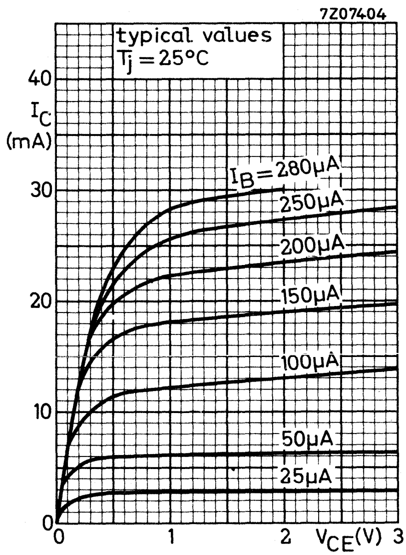
y parameters (common emitter)

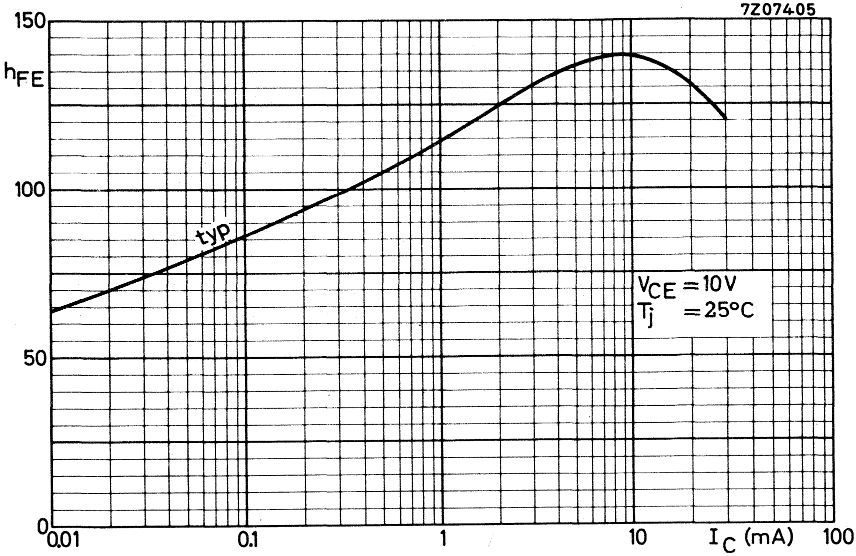
I_C = 1 mA; V_{CE} = 10 V (lead length = 3 mm)			f = 10.7 MHz	f = 0.45 MHz	
Input conductance	g_{ie}	<	0.64	0.54	$m\Omega^{-1}$
Output conductance	g_{oe}	<	13.5	11.5	$\mu\Omega^{-1}$

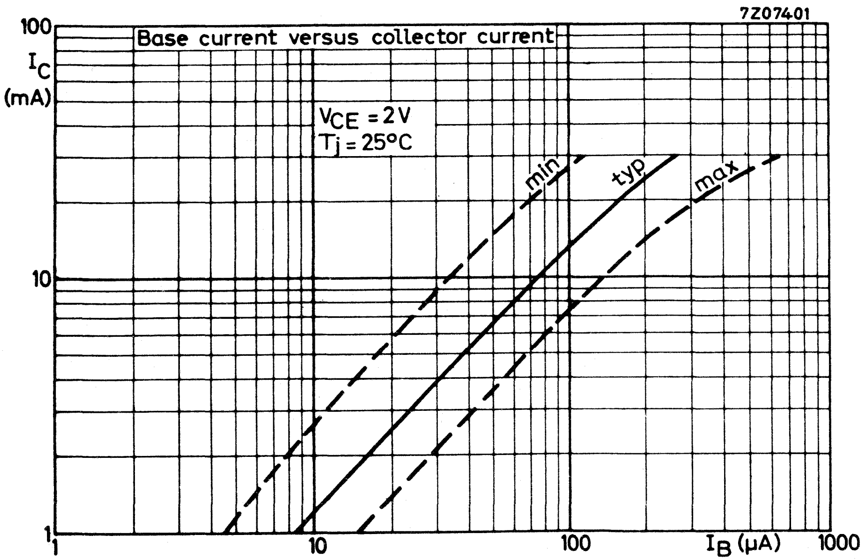
1) V_{BE} decreases by about 1.7 mV/^{o}C with increasing temperature.

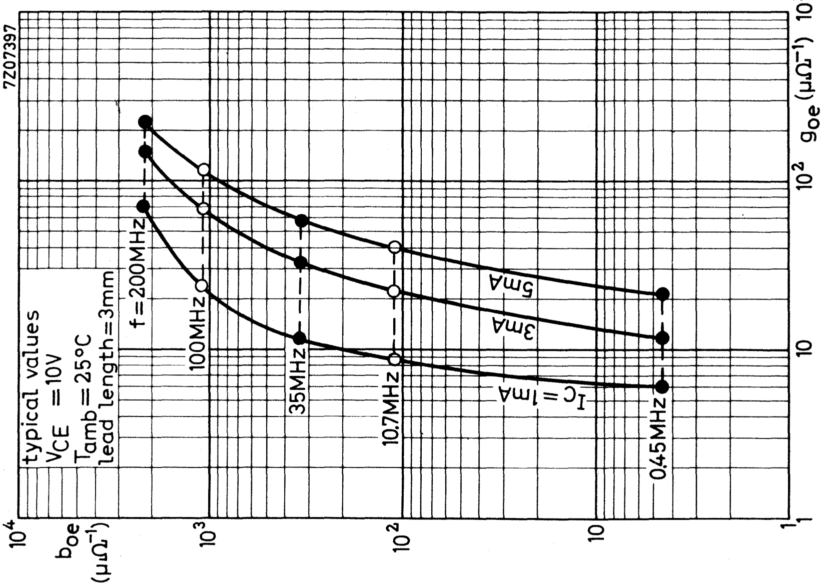

7Z08228.1
Maximum allowable collector-emitter voltage (with resistance between base and emitter and $I_C = 2mA$) versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$, when external capacitances are used.
V_{CER} (V)
RE up to 1kΩ
$I_C = 2mA$
V_{CER}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

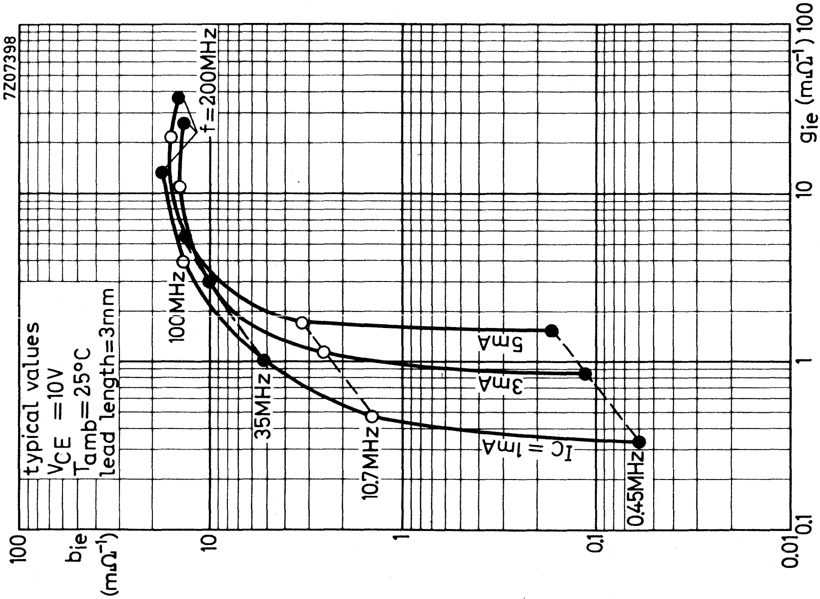

7Z08628
base-emitter voltage versus collector current
$V_{CE} = 2V$
$T_j = 25°C$
I_C (mA)
min
typ
max
V_{BE} (V)

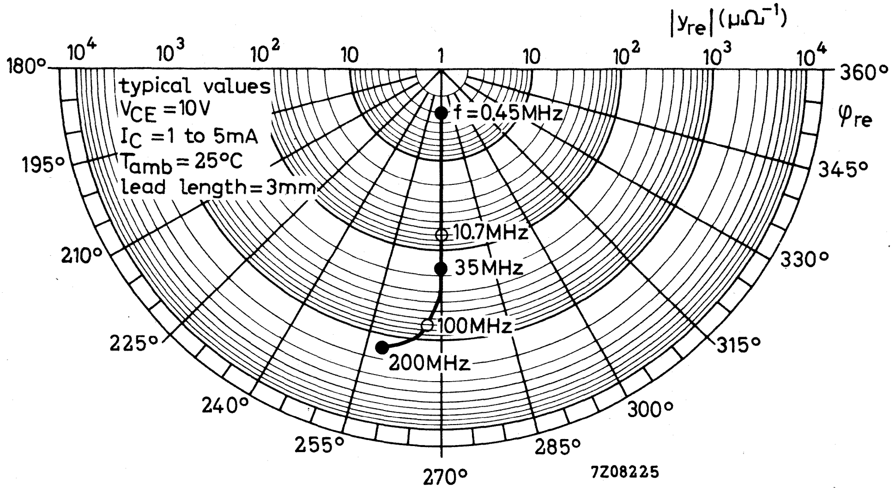

7Z07404
typical values
$T_j = 25°C$
I_C (mA)
$I_B = 280\mu A$
250μA
200μA
150μA
100μA
50μA
25μA
V_{CE} (V)


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

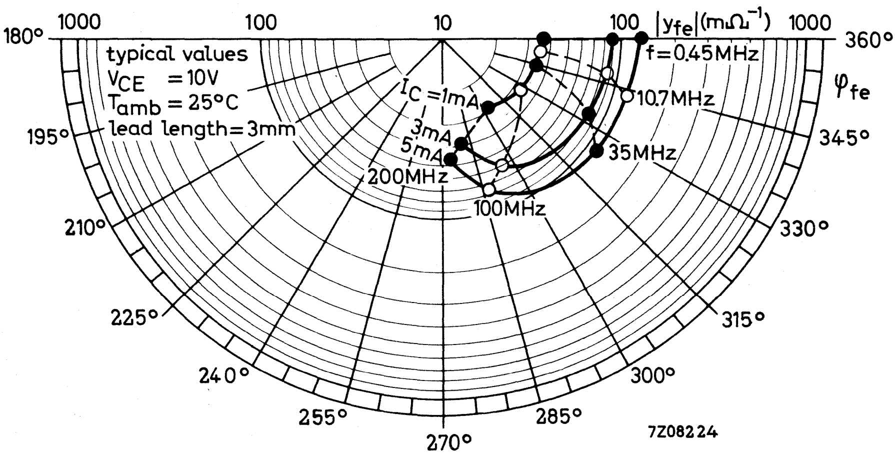

7Z07401
Base current versus collector current
100
I_C
(mA)
10
1
V_{CE} = 2 V
T_j = 25°C
min
typ
max
1
10
100
I_B (μA)
1000


7Z07397
typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length = 3mm
f = 200MHz
100MHz
35MHz
10.7MHz
0.45MHz
I_C = 1mA
3mA
5mA
b_{oe} ($\mu\Omega^{-1}$)
g_{oe} ($\mu\Omega^{-1}$)
10^4
10^3
10^2
10
1

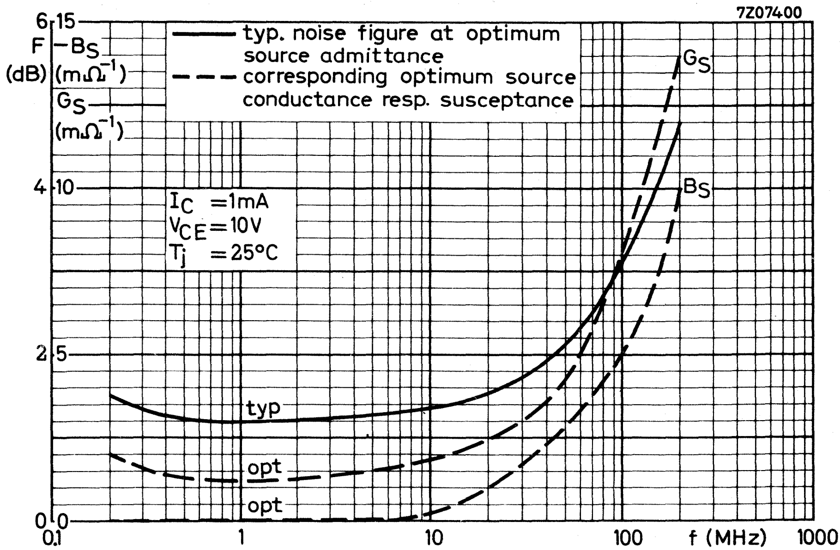

7Z07398
typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length = 3mm
f = 200MHz
100MHz
35MHz
10.7MHz
0.45MHz
I_C = 1mA
3mA
5mA
b_{ie} ($m\Omega^{-1}$)
g_{ie} ($m\Omega^{-1}$)
100
10
1
0.1
0.01
0.1

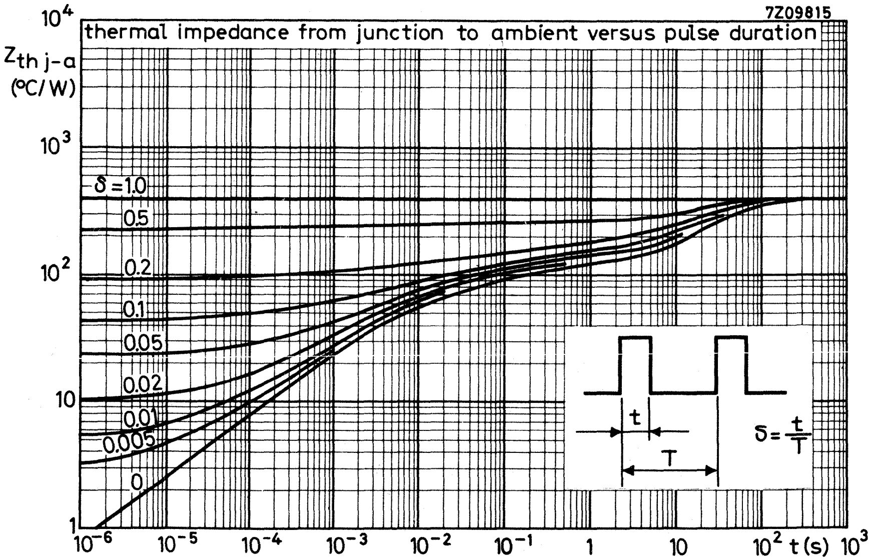


|yre| (μΩ⁻¹)
10^4 10^3 10^2 10 1 10 10^2 10^3 10^4
180° 195° 210° 225° 240° 255° 270° 285° 300° 315° 330° 345° 360°
φre
typical values
VCE = 10V
IC = 1 to 5mA
Tamb = 25°C
lead length = 3mm
f = 0.45MHz
10.7MHz
35MHz
100MHz
200MHz
7Z08225



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


7Z07400
F
(dB)
$-B_S$
$(m\Omega^{-1})$
G_S
$(m\Omega^{-1})$
typ. noise figure at optimum source admittance
corresponding optimum source conductance resp. susceptance
I_C = 1mA
V_{CE} = 10V
T_j = 25°C
typ
opt
opt
G_S
B_S
f (MHz)
0.1
1
10
100
1000
0
2
4
6
0
5
10
15


7Z09815
thermal impedance from junction to ambient versus pulse duration
$Z_{th\ j-a}$
(°C/W)
10^4
10^3
10^2
10
1
δ = 1.0
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0
t
T
$\delta = \frac{t}{T}$
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t (s)
10^3

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 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 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} = 25 °C	P_{tot}	max.	250	mW
Junction temperature	T_j	max.	125	°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

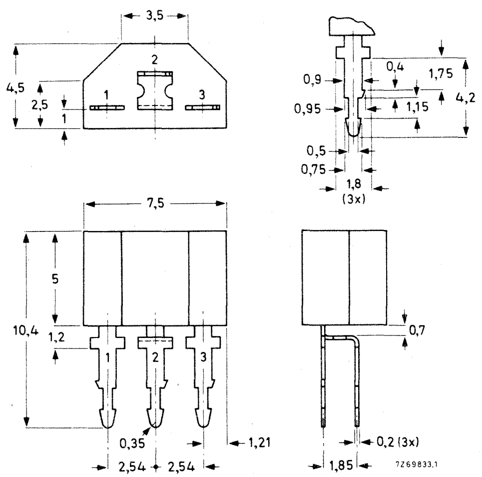
MECHANICAL DATA

Dimensions in mm

SOT-25

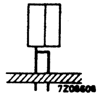
Connections

1. Base
2. Emitter
3. Collector

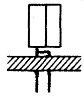


MOUNTING INSTRUCTIONS

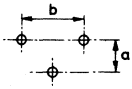
1. Thickness of printed board: max. 1.1 mm
   Hole diameter 0.77 to 0.83 mm



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



Bore plan



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

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

Voltages				
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

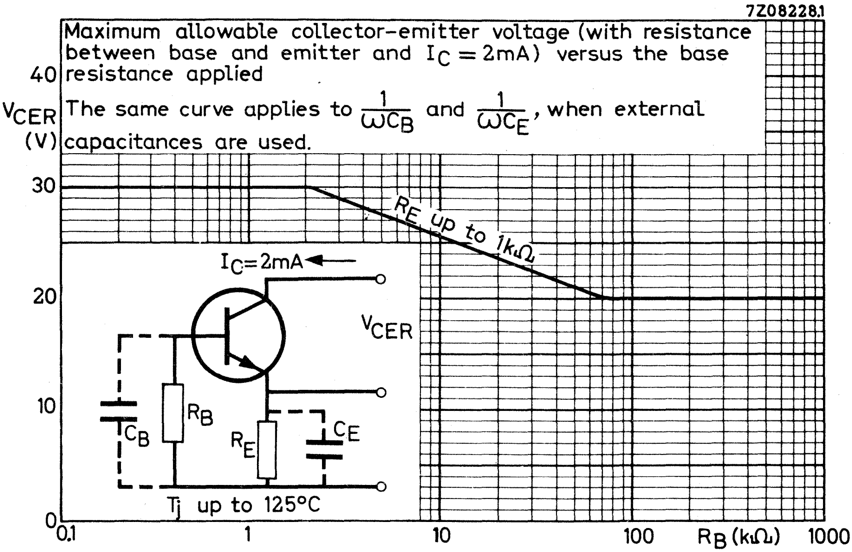
$T_j = 25\ ^oC$

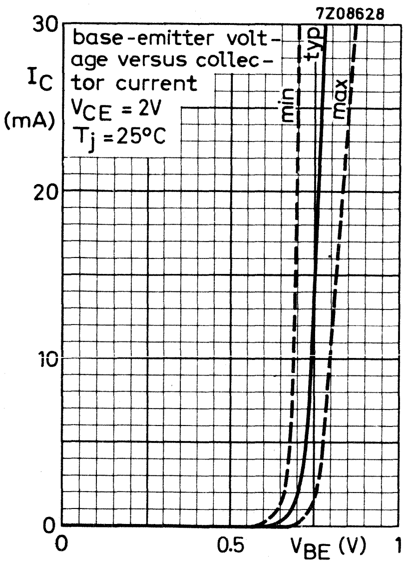
Base-emitter voltage[1]				
$I_C = 1$ mA; $V_{CE} = 10$ V	V_{BE}	0.65 to 0.74		V
Base current				
$I_C = 1$ mA; $V_{CE} = 10$ V	I_B	8 to	28	μA
		typ.	15	μA
Feedback capacitance at f = 0.45 MHz				
$I_C = 1$ mA; $V_{CE} = 10$ V	C_{re}	typ.	0.95	pF
Transition frequency				
$I_C = 1$ mA; $V_{CE} = 10$ V	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	$\|y_{rb}\|$	typ.	440	$\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{rb}	typ.	275^o	
Transfer admittance	$\|y_{fb}\|$	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	$m\Omega^{-1}$

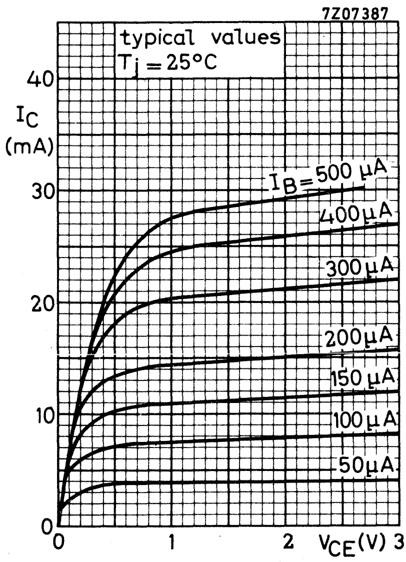
y parameters (common emitter)

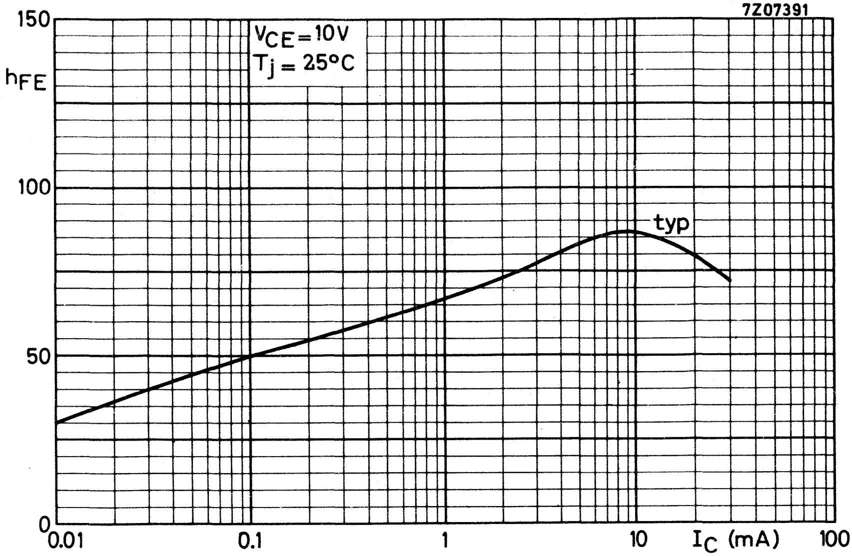
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)		f = 10.7 MHz	f = 0.45 MHz	
Input conductance	g_{ie}	< 0.96	0.86	$m\Omega^{-1}$
Output conductance	g_{oe}	< 9.5	7.0	$\mu\Omega^{-1}$

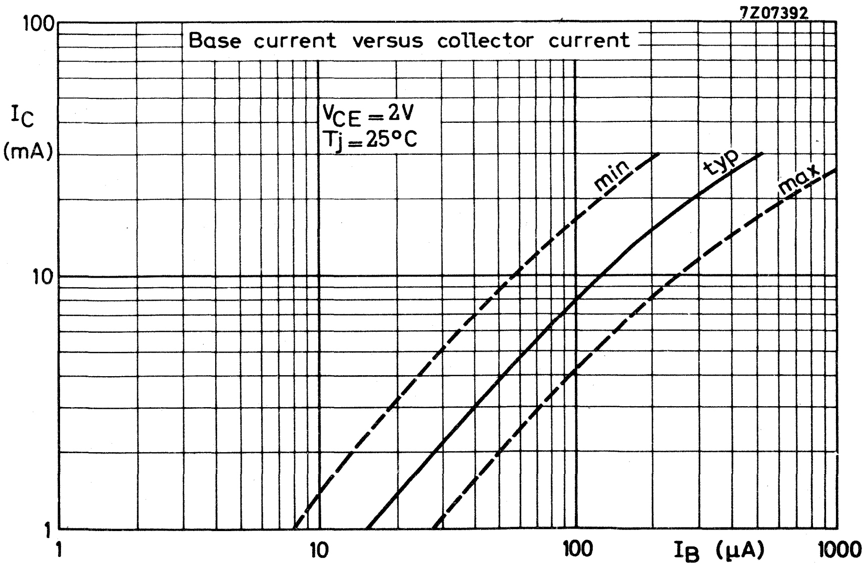
[1]) V_{BE} decreases by about 1.7 mV/^{o}C with increasing temperature.

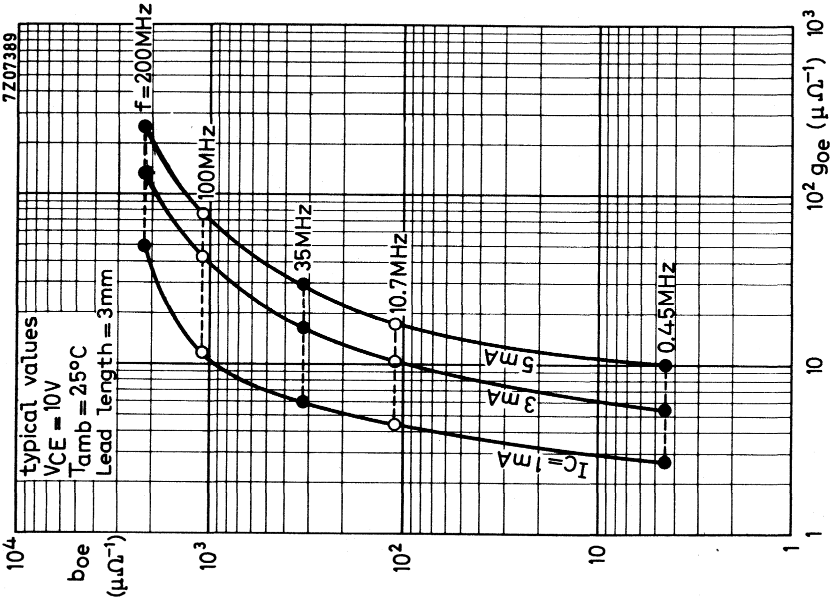

7Z08228.1
Maximum allowable collector-emitter voltage (with resistance between base and emitter and $I_C = 2mA$) versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$, when external capacitances are used.
V_{CER} (V)
40
30
20
10
0
0.1
1
10
100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

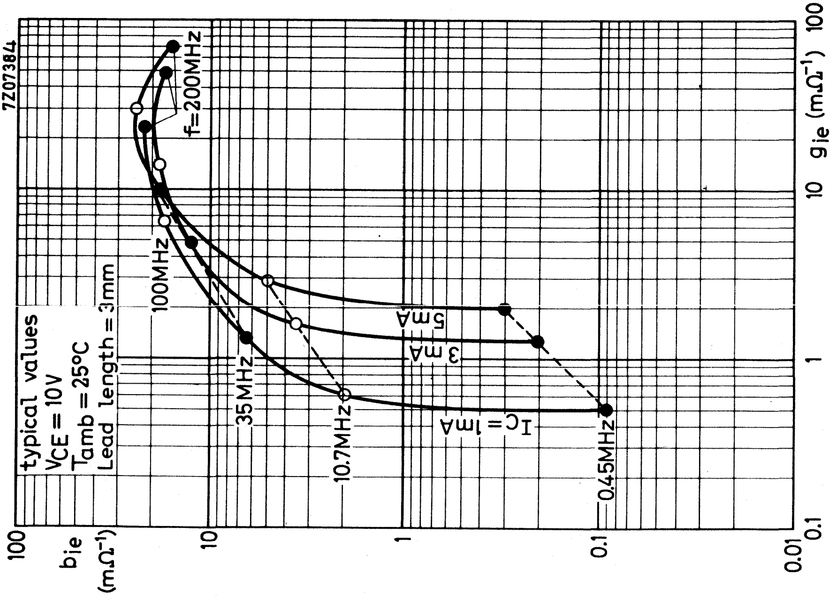

7Z08628
base-emitter voltage versus collector current
V_{CE} = 2V
T_j = 25°C
I_C (mA)
30
20
10
0
0.5
V_{BE} (V)
1
min
typ
max

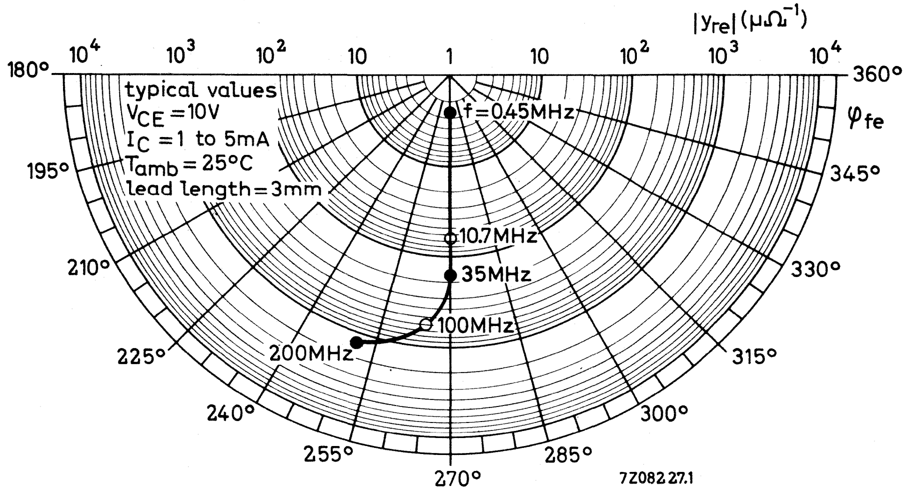

7Z07387
typical values
T_j = 25°C
I_C (mA)
40
30
20
10
0
1
2
V_{CE}(V) 3
I_B= 500 µA
400µA
300µA
200µA
150 µA
100 µA
50µA


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

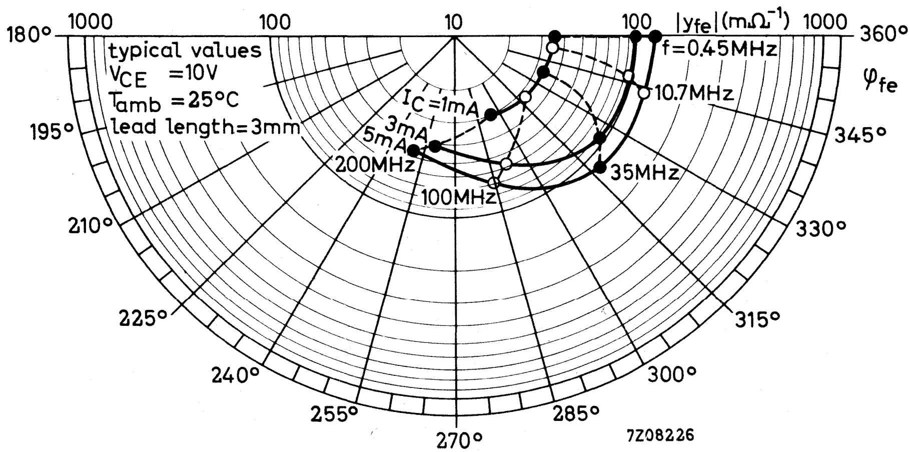

7Z07392
Base current versus collector current
100
I_C
(mA)
$V_{CE} = 2V$
$T_j = 25°C$
min
typ
max
10
1
1
10
100
I_B (μA)
1000


7Z07389
typical values
VCE = 10V
Tamb = 25°C
Lead length = 3mm
f = 200MHz
100MHz
35MHz
10.7MHz
0.45MHz
5 mA
3 mA
IC = 1 mA
boe (μΩ⁻¹)
goe (μΩ⁻¹)
10⁴
10³
10²
10
1

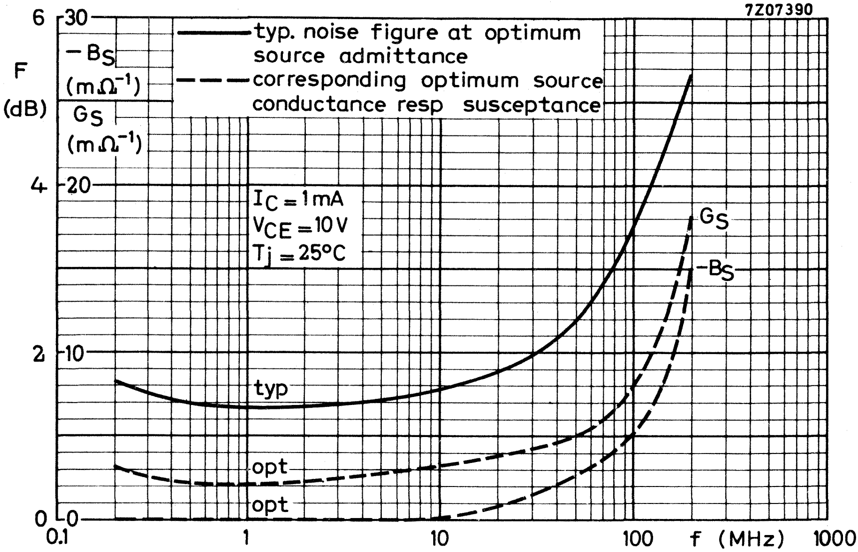

7Z07384
typical values
VCE = 10V
Tamb = 25°C
Lead length = 3mm
f = 200MHz
100MHz
35MHz
10.7MHz
0.45MHz
5 mA
3 mA
IC = 1 mA
bie (mΩ⁻¹)
gie (mΩ⁻¹)
100
10
1
0.1
0.01

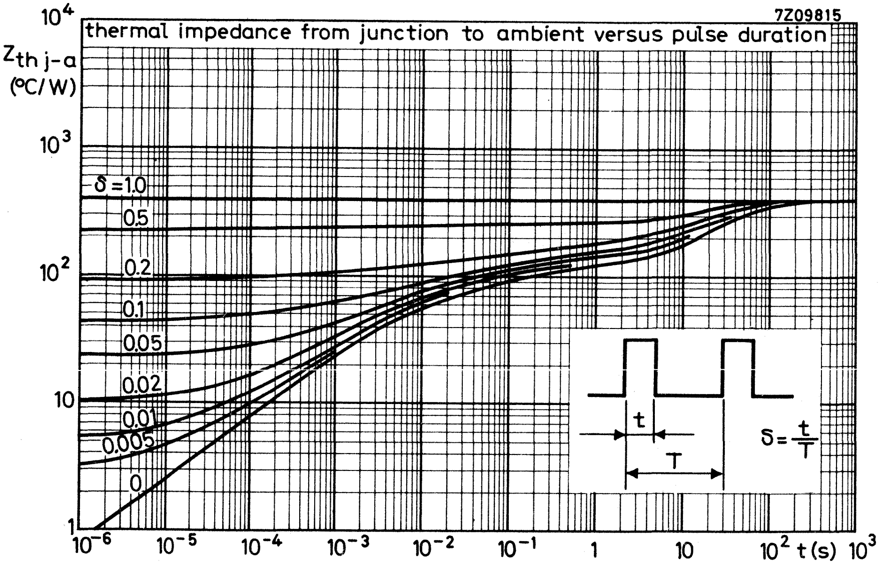


|yre| (μΩ⁻¹)
10⁴ 10³ 10² 10 1 10 10² 10³ 10⁴
180° 195° 210° 225° 240° 255° 270° 285° 300° 315° 330° 345° 360°
φfe
typical values
VCE = 10V
IC = 1 to 5mA
Tamb = 25°C
lead length = 3mm
f = 0.45MHz
10.7MHz
35MHz
100MHz
200MHz
7Z082 27.1



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


7Z07390
typ. noise figure at optimum source admittance
corresponding optimum source conductance resp susceptance
F (dB)
$-B_S$ ($m\Omega^{-1}$)
G_S ($m\Omega^{-1}$)
$I_C = 1 mA$
$V_{CE} = 10 V$
$T_j = 25°C$
typ
opt
opt
G_S
$-B_S$
f (MHz)
0
2
4
6
0
10
20
30
0.1
1
10
100
1000


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
$\delta = \frac{t}{T}$
t (s)
1
10
10^2
10^3
10^4
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3

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
Maximum unilateralized power gain I_C = 4 mA; V_{CE} = 10 V; f = 35 MHz	G_{UM}	typ.	42	dB
I_C = 4 mA; V_{CE} = 10 V; f = 45 MHz	G_{UM}	typ.	39	dB
Gain control range	ΔG_{tr}	typ.	60	dB

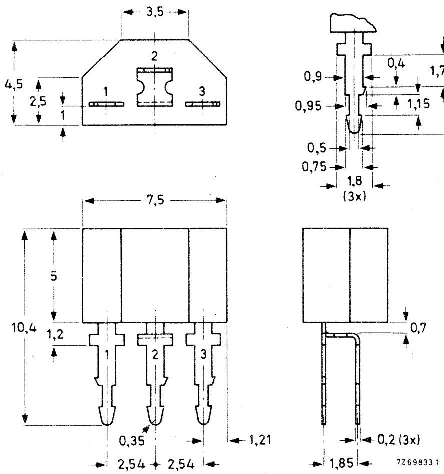
MECHANICAL DATA

Dimensions in mm

SOT-25

Connections

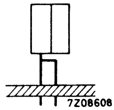
1. Base
2. Emitter
3. Collector



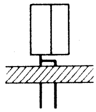
FOR NEW DESIGN THE SUCCESSOR TYPE BF198 IS RECOMMENDED

MOUNTING INSTRUCTIONS

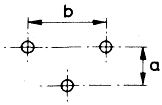
1. Thickness of printed board: max. 1.1 mm
   Hole diameter 0.77 to 0.83 mm



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 °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

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.

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 transistor 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 ^oC	P_{tot}	max.	250	mW
Junction temperature	T_j	max.	125	^oC
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
Maximum unilateralized power gain I_C = 7 mA; V_{CE} = 10 V; f = 35 MHz	G_{UM}	typ.	43	dB
I_C = 7 mA; V_{CE} = 10 V; f = 45 MHz	G_{UM}	typ.	41	dB
Video detector output voltage	V_O	typ.	7,7	V

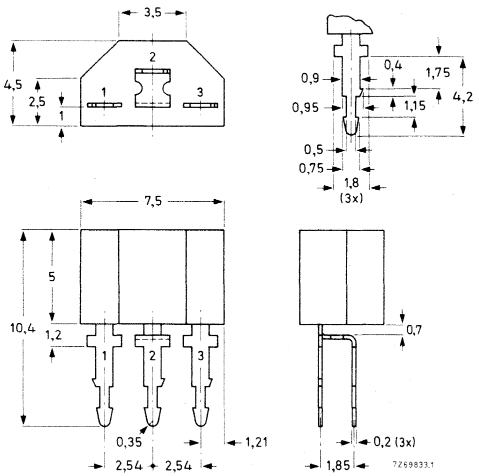
MECHANICAL DATA

Dimensions in mm

SOT-25

Connections

1. Base
2. Emitter
3. Collector

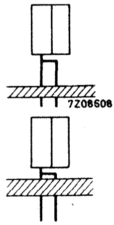


FOR NEW DESIGN THE SUCCESSOR TYPE BF199 IS RECOMMENDED

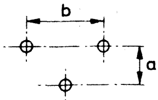
MOUNTING INSTRUCTIONS

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	$R_{th\ j\text{-}a}$	=	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	$\|y_{re}\|$	typ.	67	86	μA/V
Phase angle of feedback admittance	φ_{re}	typ.	268°	268°	
Transfer admittance	$\|y_{fe}\|$	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.

SILICON PLANAR TRANSISTOR

N-P-N transistor in a plastic TO-92 variant.
The BF 198 has a very low feedback capacitance and is intended for use in the forward gain control stage of the television i.f. amplifier.

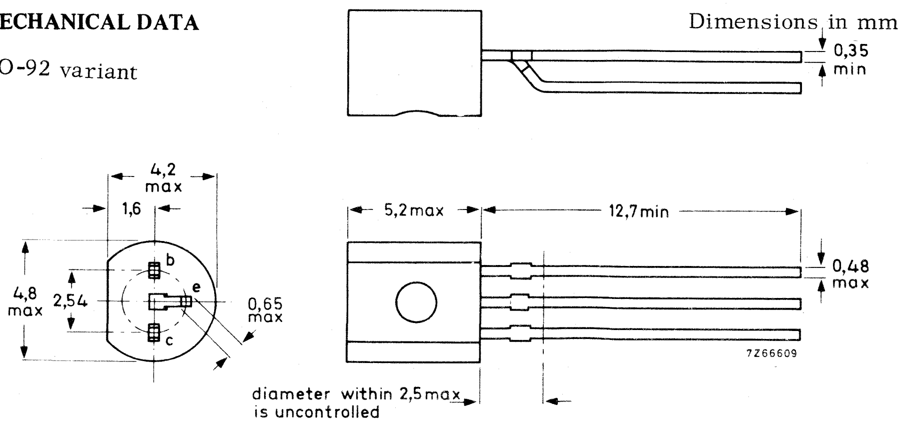
QUICK REFERENCE DATA

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	$R_{th\ j-a}$	=	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)

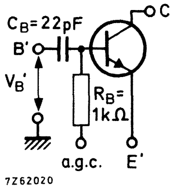
I_C = 4 mA; V_{CE} = 10 V

			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} (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.



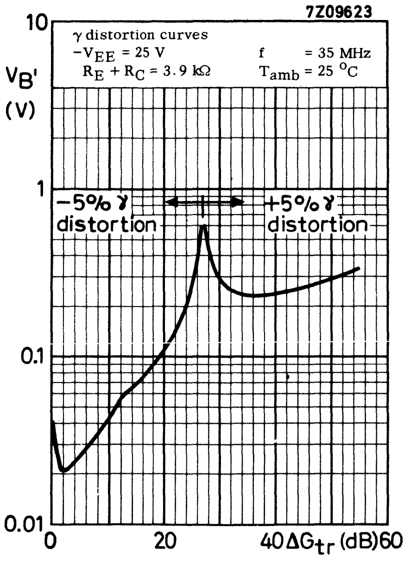
The transistor with these additional components is effectively an "equivalent transistor" for gain control purposes, the signal handling capability of which may be expressed in terms of voltage. (Without these components the varying input admittance means that the signal handling capability can only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

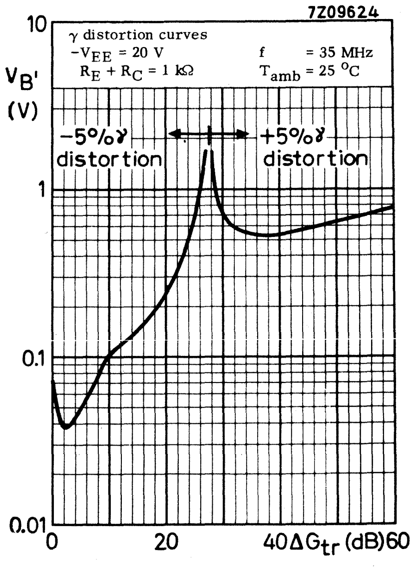
The signal handling capability of the equivalent transistor as a function of ΔG_{tr} (the reduction in transducer gain with gain control) will be found on pages 4 and 5.

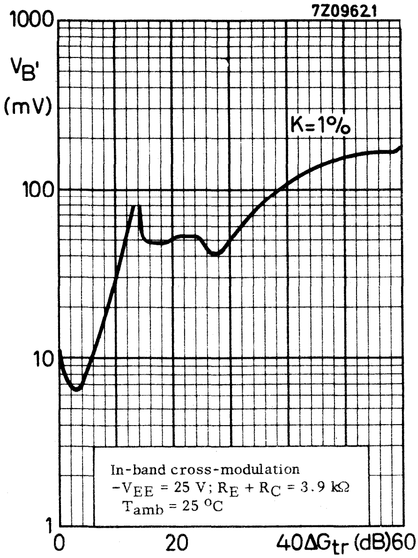
a. Voltage versus ΔG_{tr} curves for a γ distortion of 5% are below.

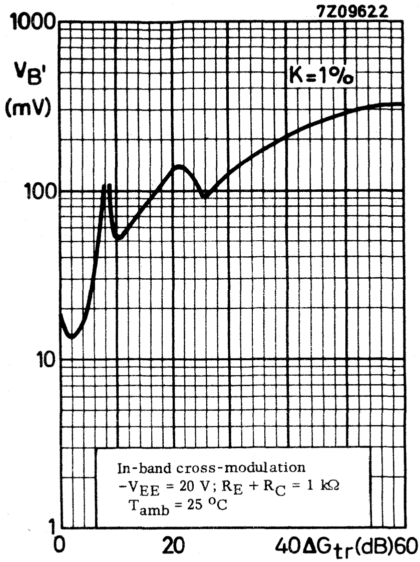
b. Voltage versus ΔG_{tr} curves for an in-band cross modulation factor of 1% are on page 5.

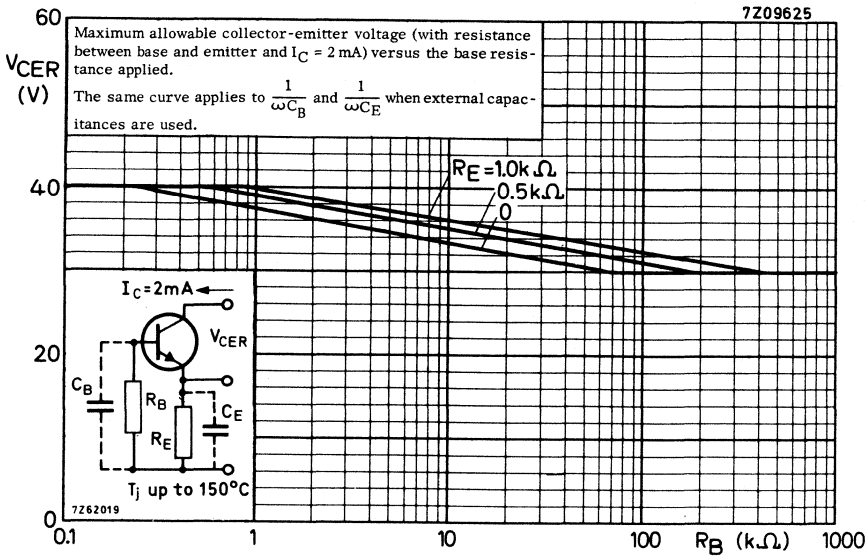
Graphs of the y-parameters are on pages 8 to 11.

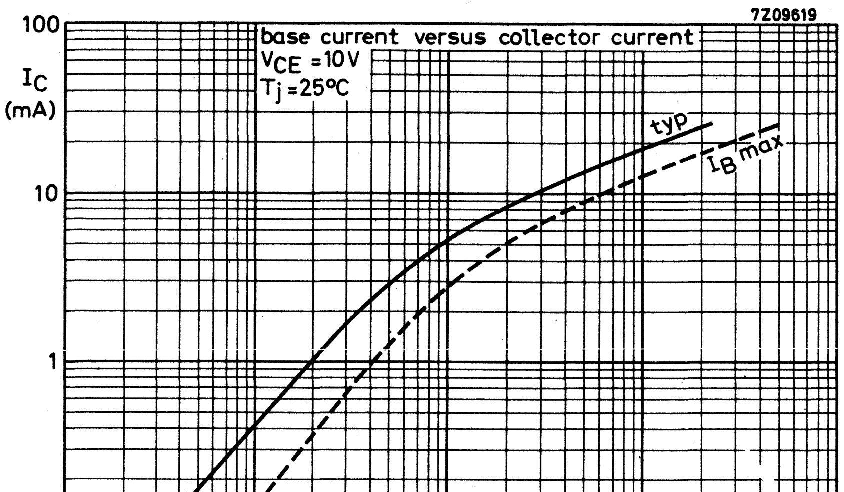


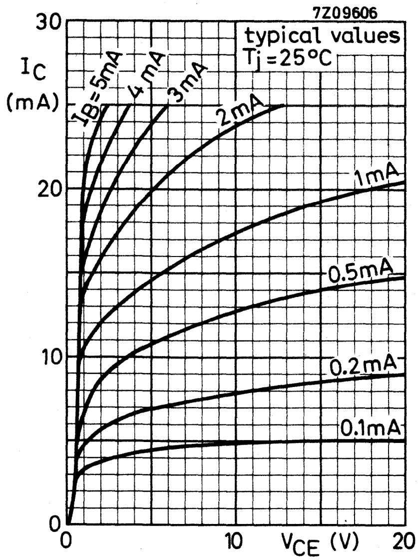


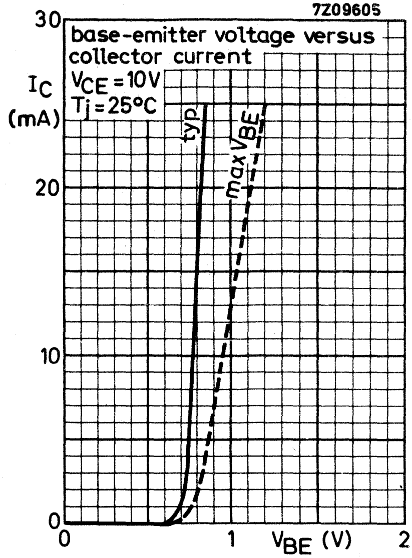

7Z09621
1000
$V_{B'}$
(mV)
K=1%
100
10
1
0
20
40 ΔG_{tr} (dB) 60
In-band cross-modulation
$-V_{EE}$ = 25 V; $R_E + R_C$ = 3.9 kΩ
T_{amb} = 25 °C

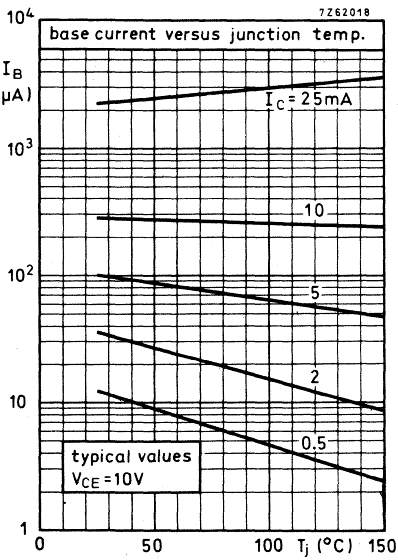

7Z09622
1000
$V_{B'}$
(mV)
K=1%
100
10
1
0
20
40 ΔG_{tr} (dB) 60
In-band cross-modulation
$-V_{EE}$ = 20 V; $R_E + R_C$ = 1 kΩ
T_{amb} = 25 °C

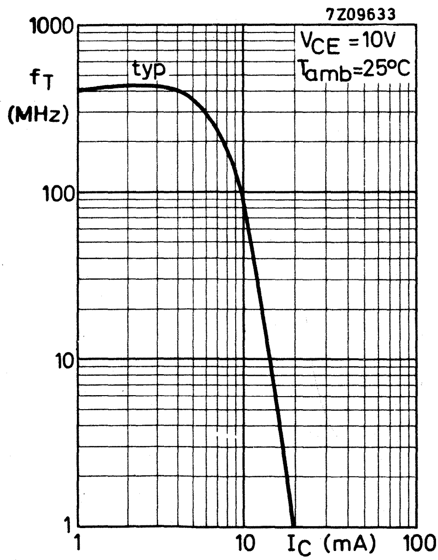

7Z09625
Maximum allowable collector-emitter voltage (with resistance between base and emitter and I_C = 2 mA) versus the base resistance applied.
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$ when external capacitances are used.
V_{CER} (V)
60
40
20
0
R_E = 1.0 kΩ
0.5 kΩ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

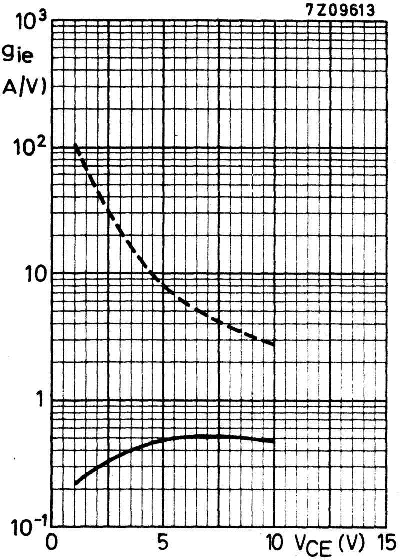

7Z09606
typical values
Tj = 25 °C
IC
(mA)
IB = 5mA
4 mA
3mA
2mA
1mA
0.5mA
0.2mA
0.1mA
VCE (V)

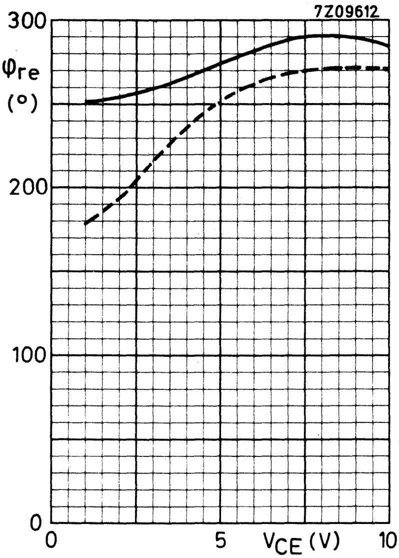

7Z09605
base-emitter voltage versus collector current
VCE = 10V
Tj = 25 °C
IC
(mA)
typ
max VBE
VBE (V)

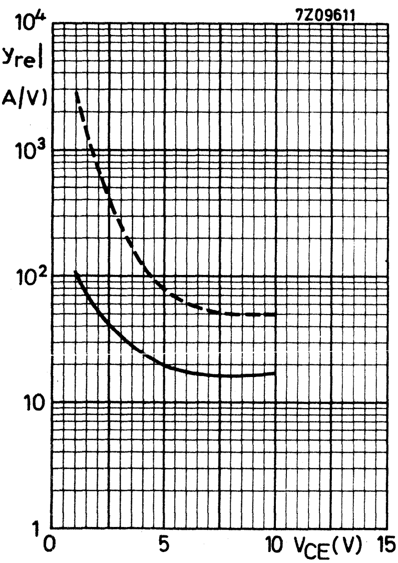

7Z62018
base current versus junction temp.
IB
(μA)
IC = 25mA
10
5
2
0.5
typical values
VCE = 10V
Tj (°C)

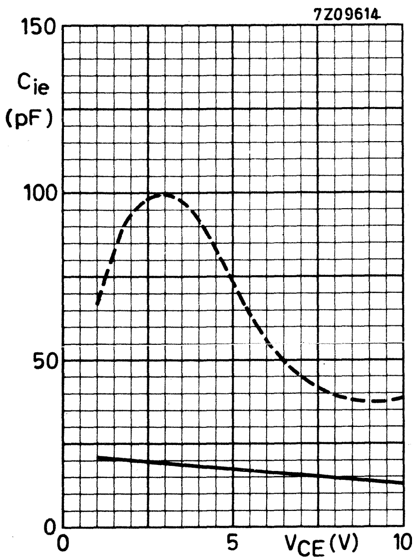

7Z09633
VCE = 10V
Tamb = 25 °C
fT
(MHz)
typ
IC (mA)

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



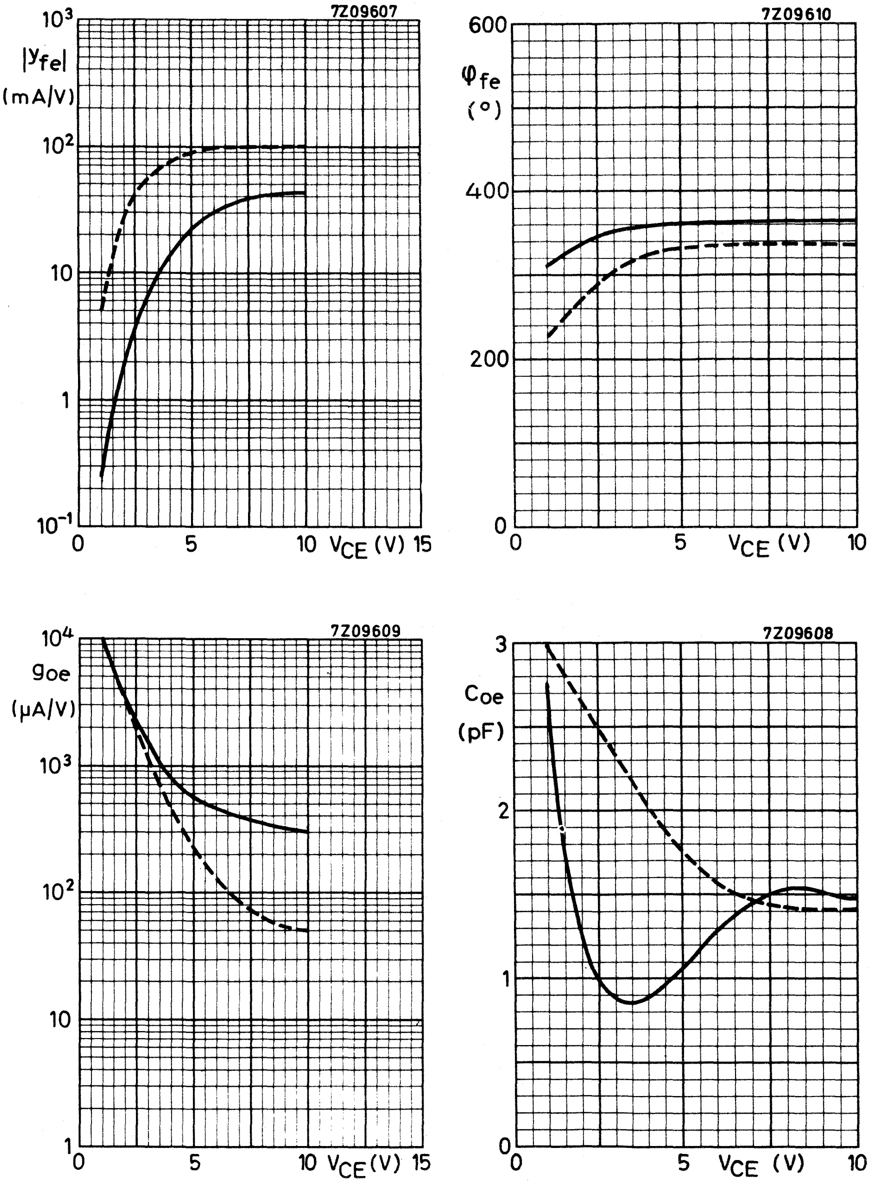






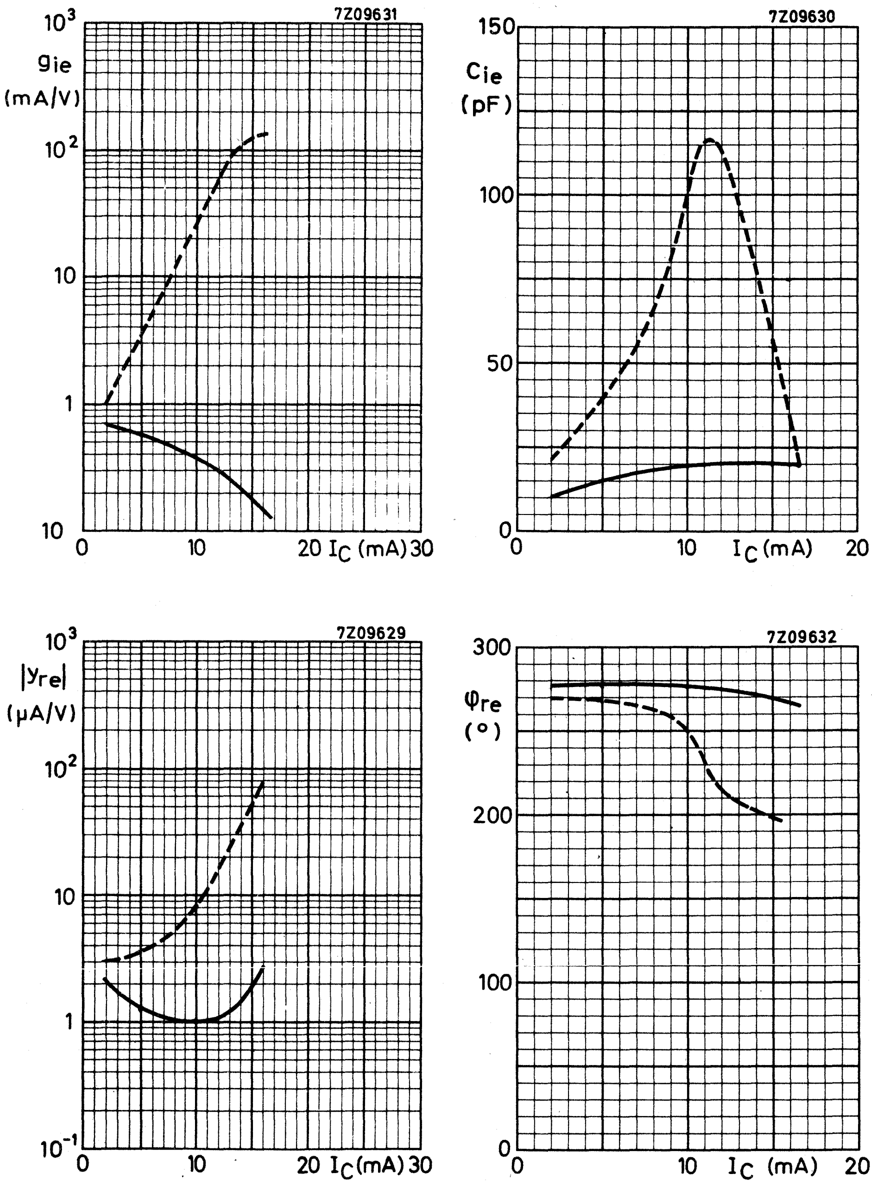
y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

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



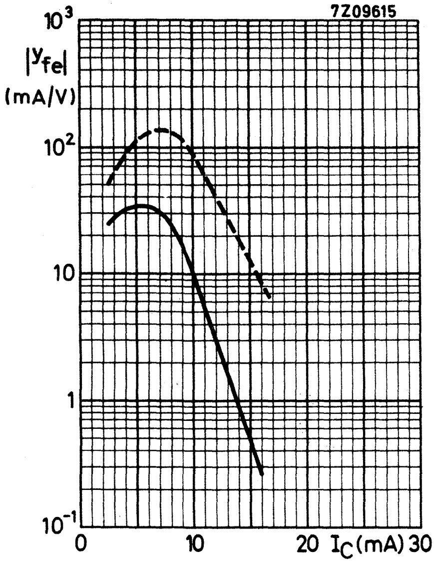
y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

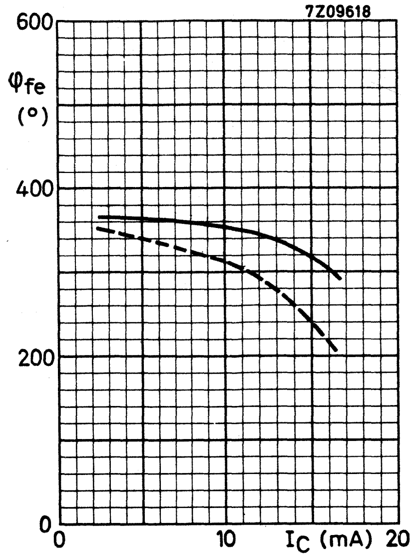
Current control; $-V_{EE}$ = 20 V; $R_E + R_C$ = 1 kΩ; f = 35 MHz

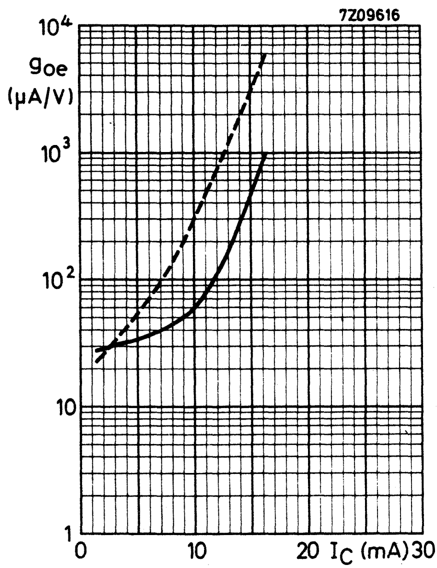


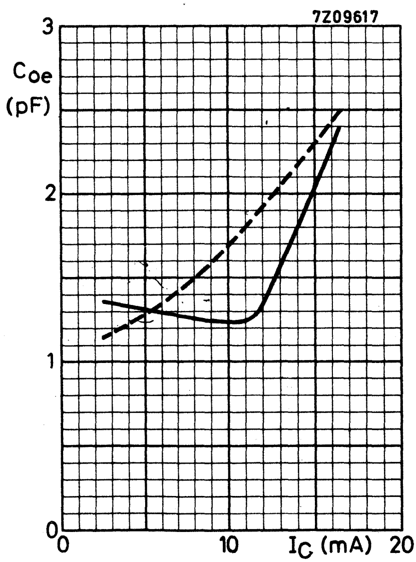
y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

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









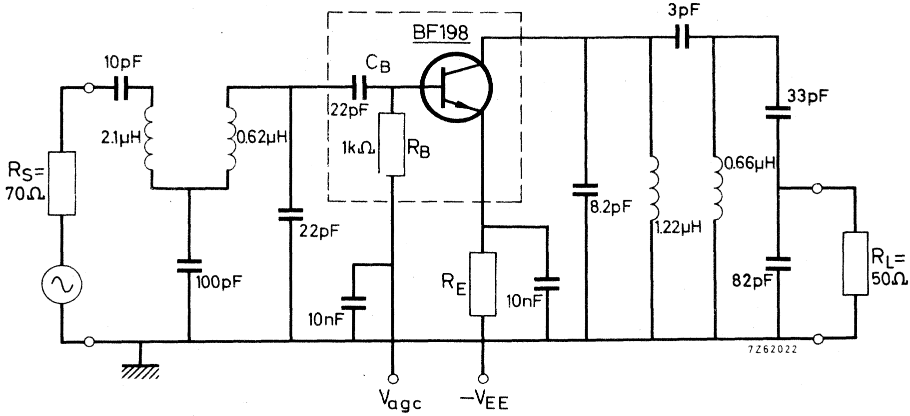
y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

APPLICATION INFORMATION

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

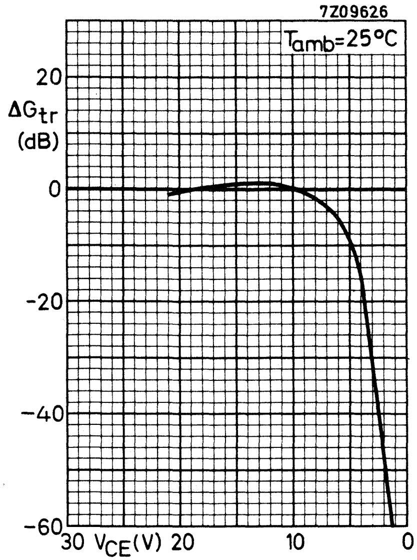


Transducer gain

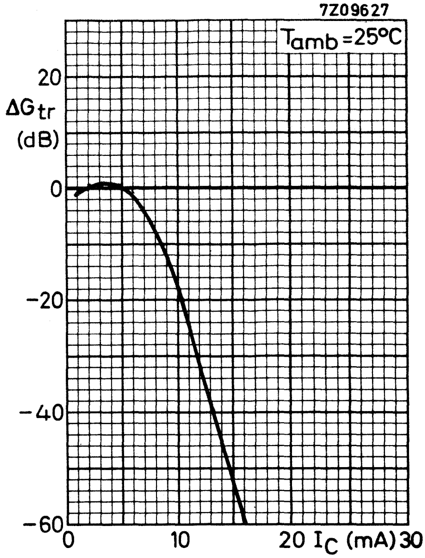
$$G_{tr}\ \text{(in dB)} = 10 \log \frac{\text{output power in load } R_L}{\text{available power from source } R_S}$$

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

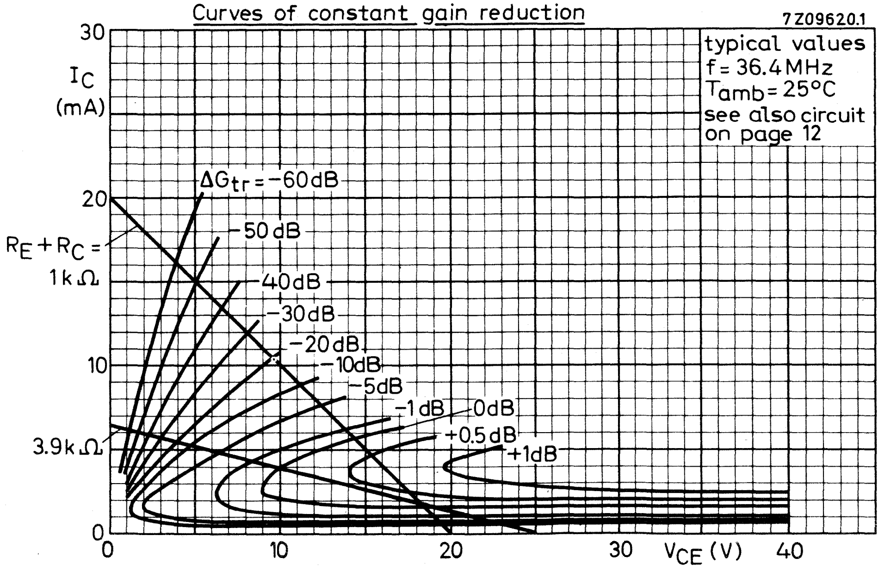
Voltage gain control



Current gain control



Curves of constant gain reduction



SILICON PLANAR EPITAXIAL TRANSISTOR

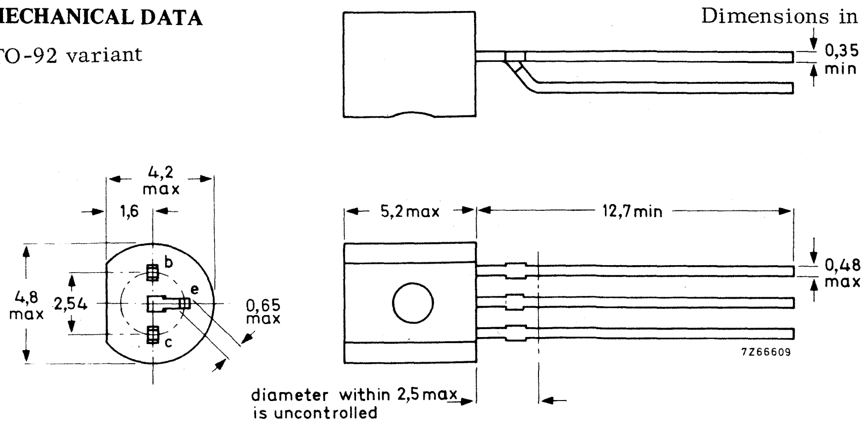
N-P-N transistor in a plastic TO-92 variant.
The BF199 has a very low feedback capacitance and is intended for use in the output stage of a vision i.f. amplifier.

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

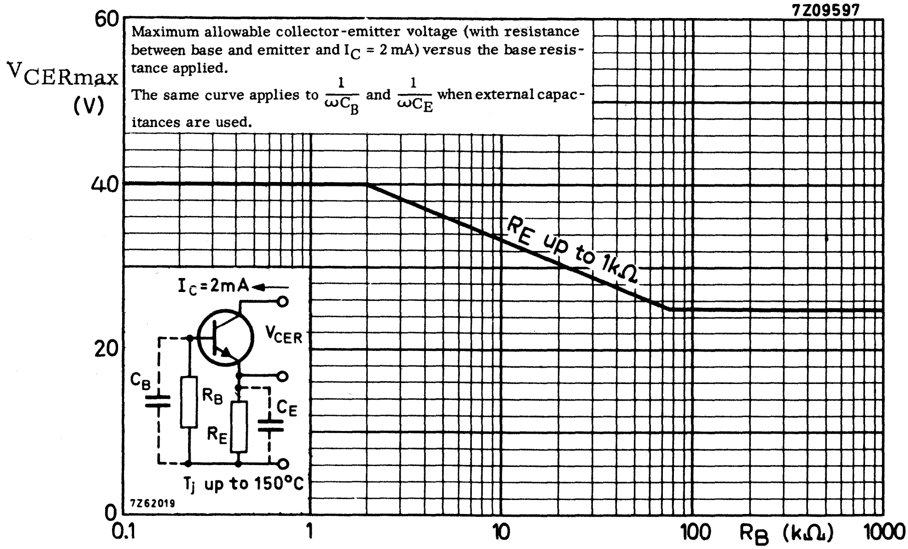
			f = 35	45	MHz
Input conductance	g_{ie}	typ.	4.5	5.5	mA/V
Input capacitance	C_{ie}	typ.	45	45	pF
Feedback admitance	$\|y_{re}\|$	typ.	67	86	µA/V
Phase angle of feedback admittance	φ_{re}	typ.	268°	268°	
Transfer admitance	$\|y_{fe}\|$	typ.	170	155	mA/V
Phase angle of transfer admittance	φ_{fe}	typ.	338°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

Maximum unilateralized power gain

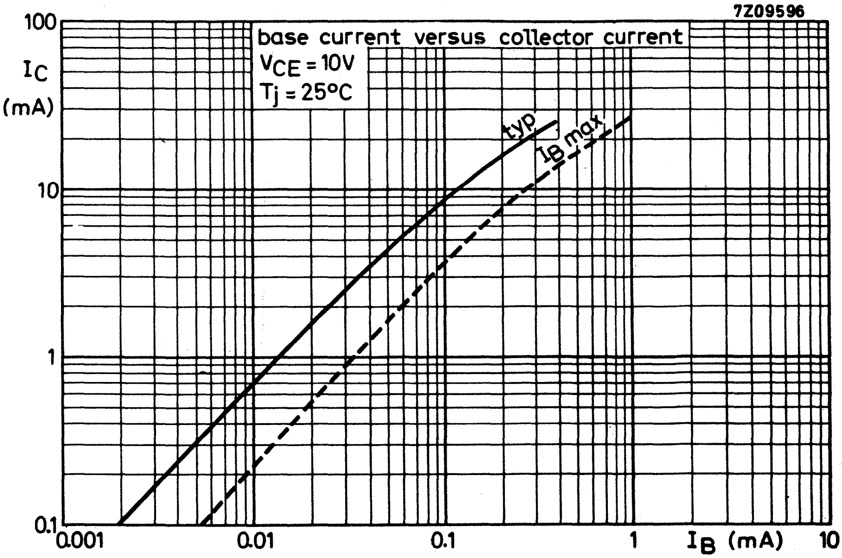
$$G_{UM} \text{ (in dB)} = 10 \log \frac{|y_{fe}|^2}{4 g_{ie} g_{oe}}$$

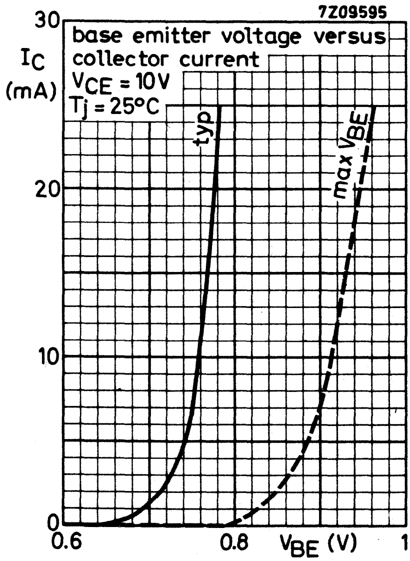
I_C = 7 mA; V_{CE} = 10 V	G_{UM}	typ.	43	41	dB

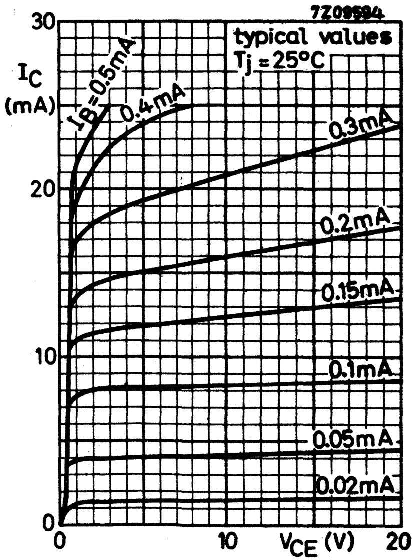
[1]) V_{BE} decreases by about 1.7 mV/°C with increasing temperature.

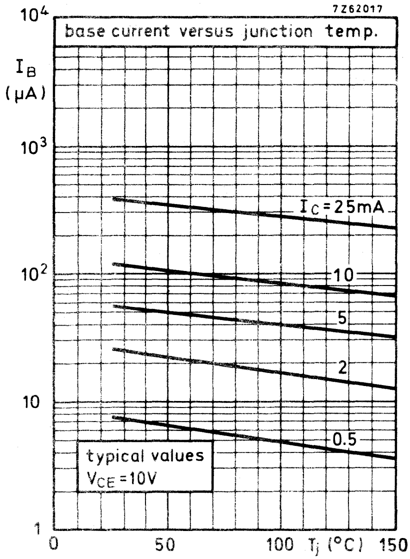


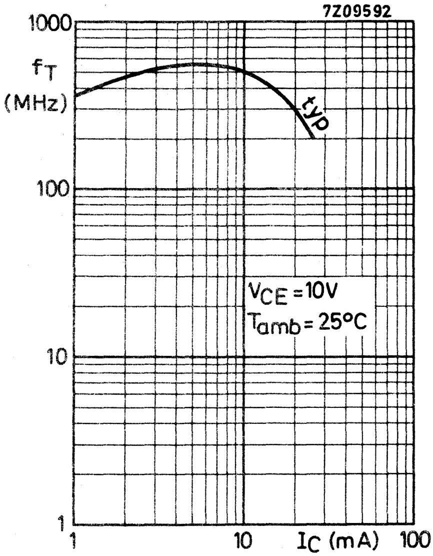
Maximum allowable collector-emitter voltage (with resistance between base and emitter and I_C = 2 mA) versus the base resistance applied.
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$ when external capacitances are used.


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


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

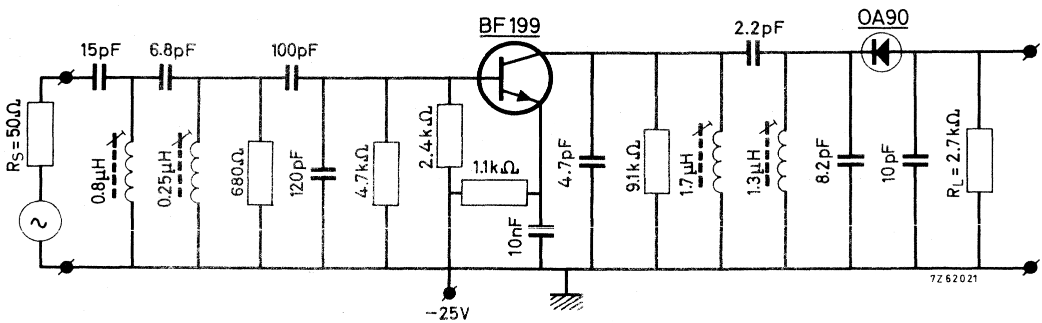

7Z09594
typical values
T_j = 25°C
I_C (mA)
30
20
10
0
10
20
V_{CE} (V)
I_B = 0.5mA
0.4mA
0.3mA
0.2mA
0.15mA
0.1mA
0.05mA
0.02mA





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

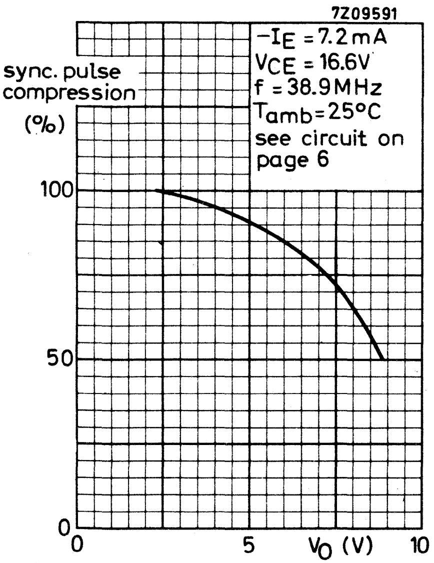
Transducer gain at f = 36.4 MHz

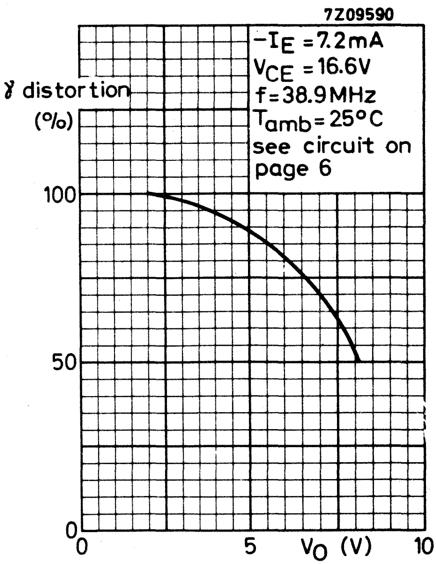
$$G_{tr} \text{ (in dB)} = 10 \log \frac{\text{output power in load } R_L}{\text{available power from source with } R_S}$$

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 preamplifier in v.h.f. television tuners and f.m. tuners.

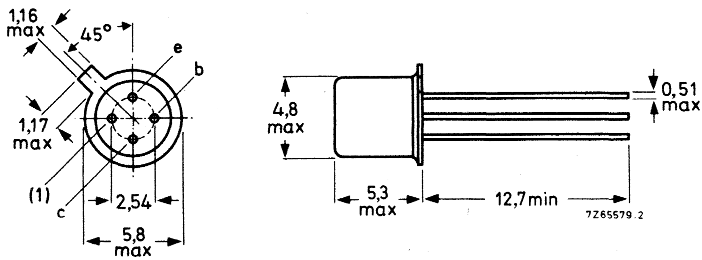
QUICK REFERENCE DATA

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
Maximum unilateralized power gain				
$-I_E$ = 3 mA; V_{CB} = 10 V; f = 50 MHz	G_{UM}	typ.	30	dB
$-I_E$ = 3 mA; V_{CB} = 10 V; 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



(1) = shield lead (connected to case).

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

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	$\lvert y_{re} \rvert$	typ.	0.16	$m\Omega^{-1}$
Phase angle of feedback admittance	φ_{re}	typ.	270°	
Transfer admittance	$\lvert y_{fe} \rvert$	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

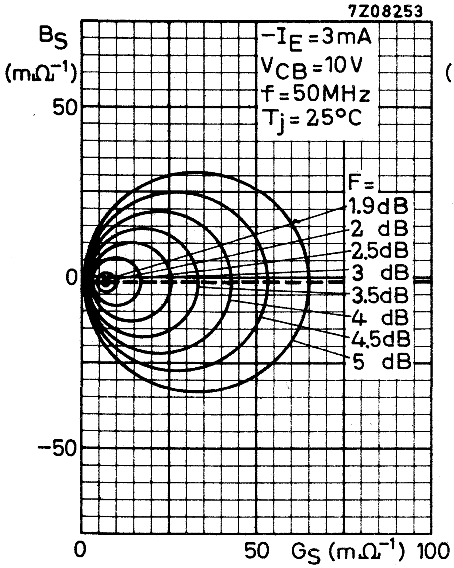
Input conductance	g_{ib}	typ.	85	$m\Omega^{-1}$
Input susceptance	$-b_{ib}$	typ.	15	$m\Omega^{-1}$
Feedback admittance	$\lvert y_{rb} \rvert$	typ.	55	$\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{rb}	typ.	270°	
Transfer admittance	$\lvert y_{fb} \rvert$	typ.	85	$m\Omega^{-1}$
Phase angle of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

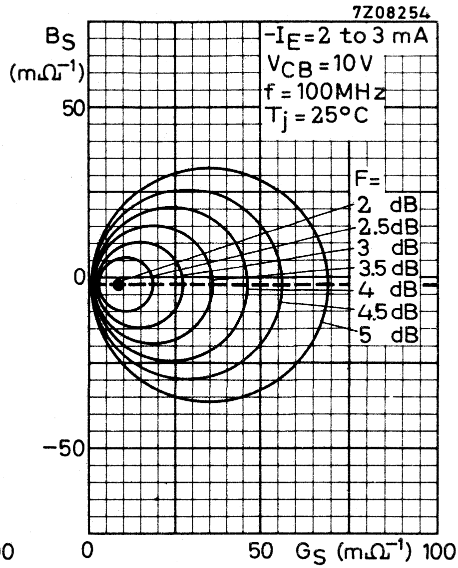
y parameters at f = 200 MHz (common base)

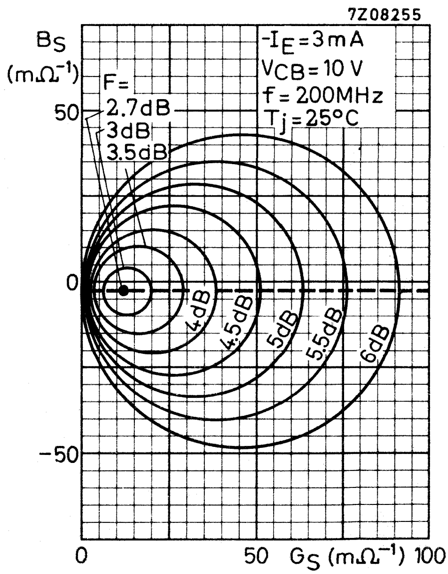
$-I_E$ = 3 mA; V_{CB} = 10 V

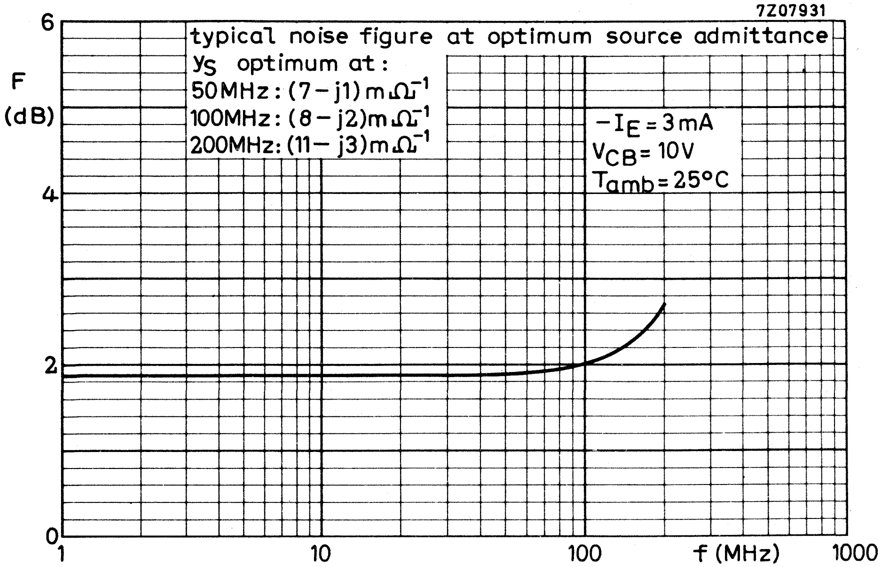
Input conductance	g_{ib}	typ.	62	$m\Omega^{-1}$
Input susceptance	$-b_{ib}$	typ.	38	$m\Omega^{-1}$
Feedback admittance	$\lvert y_{rb} \rvert$	typ.	180	$\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{rb}	typ.	270°	
Transfer admittance	$\lvert y_{fb} \rvert$	typ.	70	$m\Omega^{-1}$
Phase angle of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

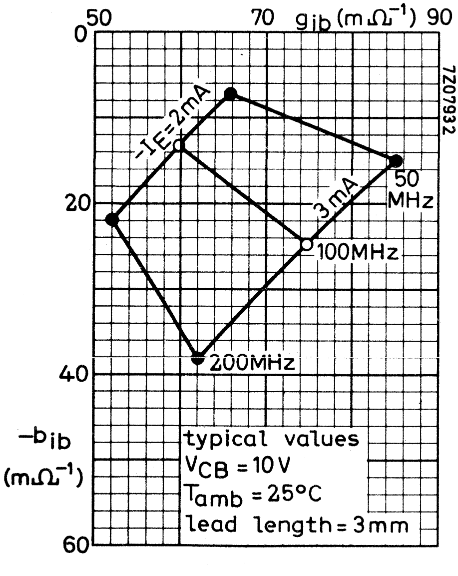
circles of constant noise figure

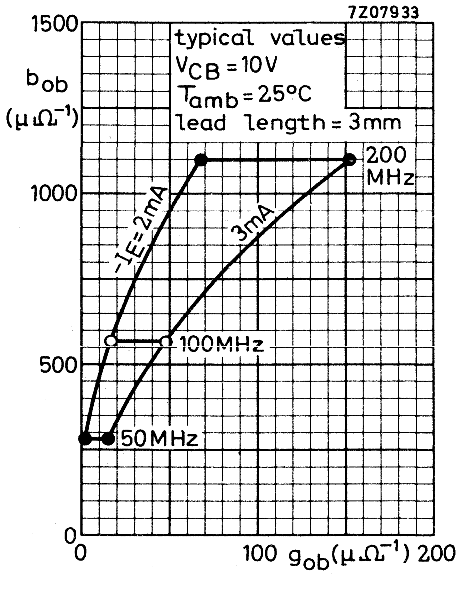


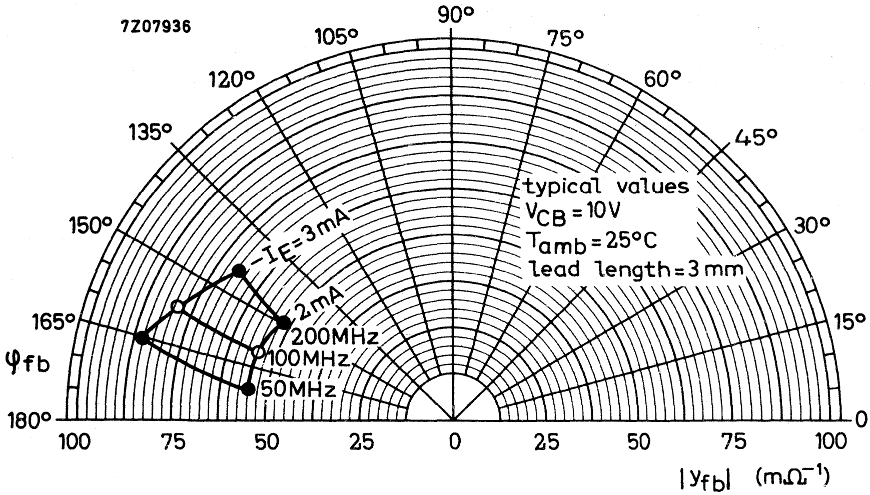


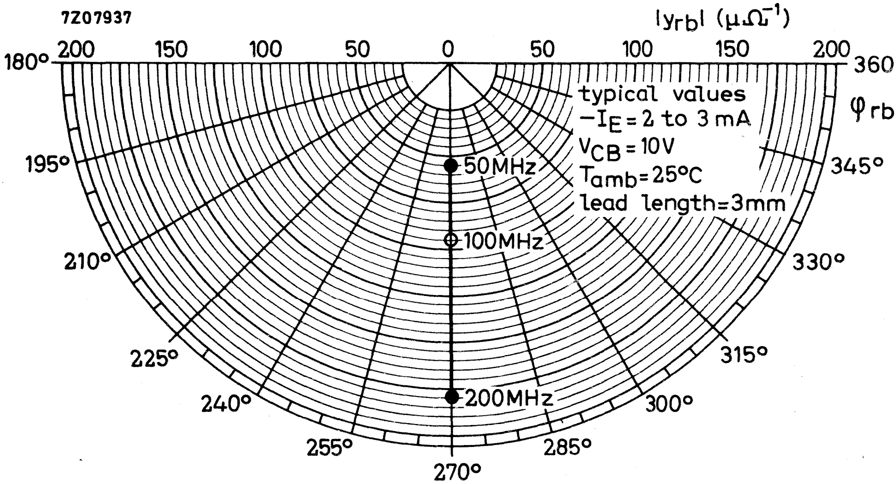


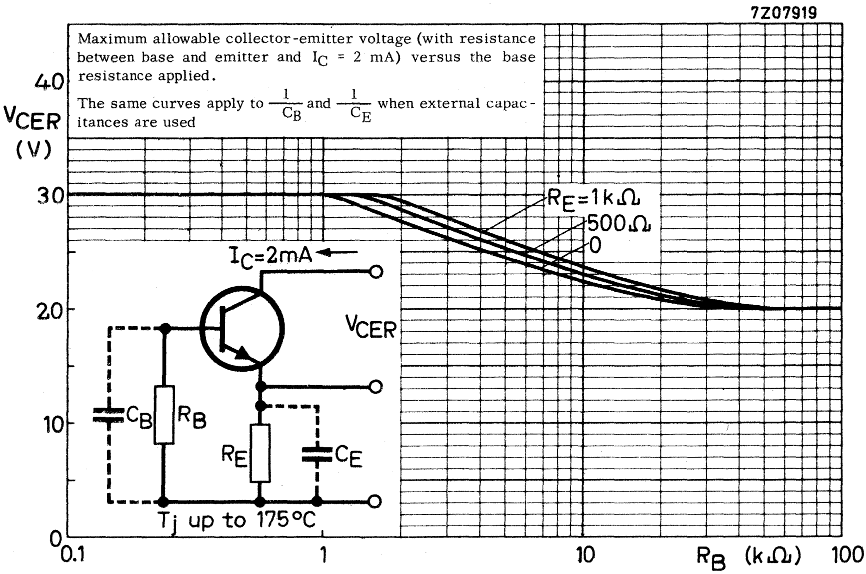

7Z07931
typical noise figure at optimum source admittance
y_S optimum at:
50MHz: (7 − j1) mΩ⁻¹
100MHz: (8 − j2) mΩ⁻¹
200MHz: (11 − j3) mΩ⁻¹
$-I_E$ = 3 mA
V_{CB} = 10 V
T_{amb} = 25 °C
F (dB)
f (MHz)
0
2
4
6
1
10
100
1000


7Z07932
g_{ib} (mΩ⁻¹)
50
70
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
typical values
V_{CB} = 10 V
T_{amb} = 25 °C
lead length = 3mm
b_{ob} (μΩ⁻¹)
1500
1000
500
0
$-I_E$ = 2mA
3mA
200 MHz
100MHz
50MHz
0
100
200
g_{ob} (μΩ⁻¹)

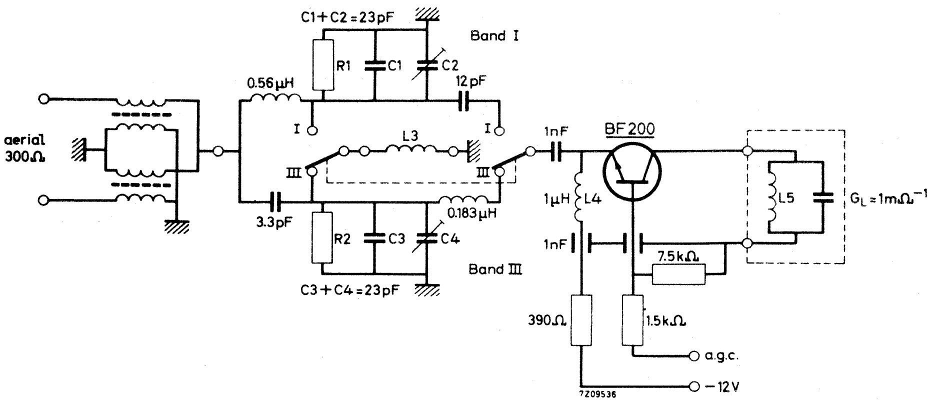

7Z07936
typical values
V_{CB} = 10V
T_{amb} = 25°C
lead length = 3 mm
$-I_E$ = 3 mA
2 mA
200MHz
100MHz
50MHz
φ_{fb}
$|y_{fb}|$ (mΩ^{-1})
90°
105°
75°
120°
60°
135°
45°
150°
30°
165°
15°
180°
0
100
75
50
25
0
25
50
75
100


7Z07937
$|y_{rb}|$ ($\mu\Omega^{-1}$)
typical values
$-I_E$ = 2 to 3 mA
V_{CB} = 10V
T_{amb} = 25°C
lead length = 3mm
50MHz
100MHz
200MHz
φ_{rb}
200
150
100
50
0
50
100
150
200
180°
360°
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
V_{CER} (V)
40
30
20
10
0
0.1
1
10
100
R_B (kΩ)
R_E=1kΩ
500Ω
0
I_C=2mA
V_{CER}
C_B
R_B
R_E
C_E
T_j up to 175°C

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.

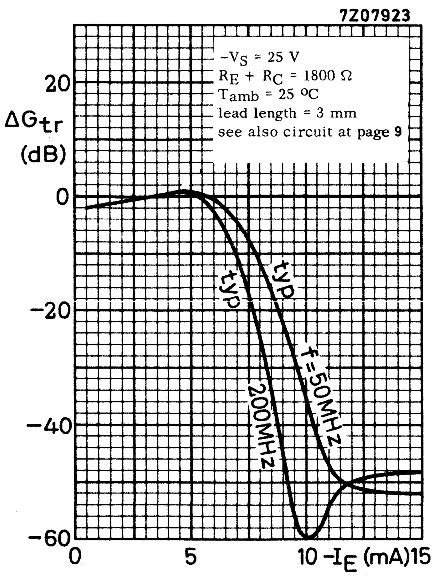
Measuring conditions

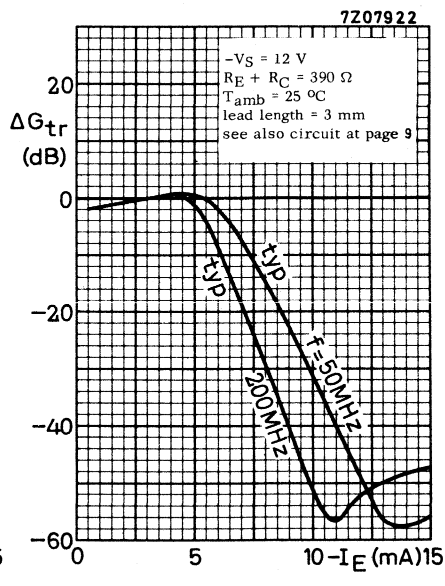
Desired signal at vision carrier frequency and interference signal at sound carrier frequency. Interference signal modulated with 4 kHz (modulation depth 100%).

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.

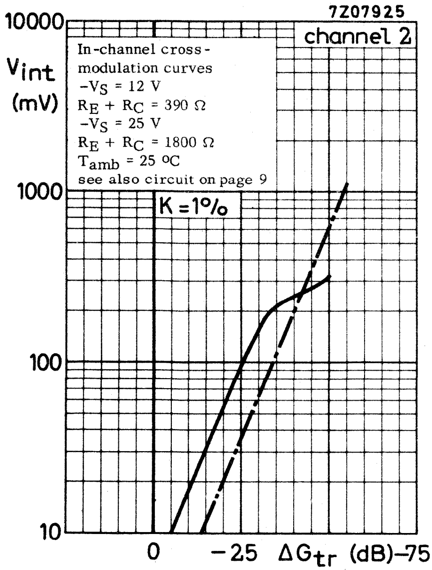
Measuring conditions

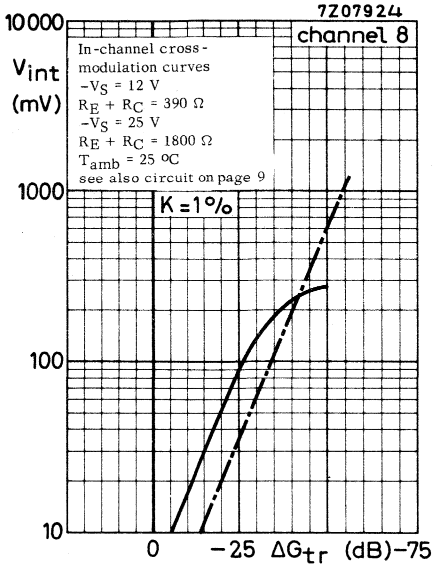
Desired signal at the vision carrier frequency and interference signal, 14 MHz above the desired signal. Interference signal modulated with 4 kHz (modulation depth 100%).

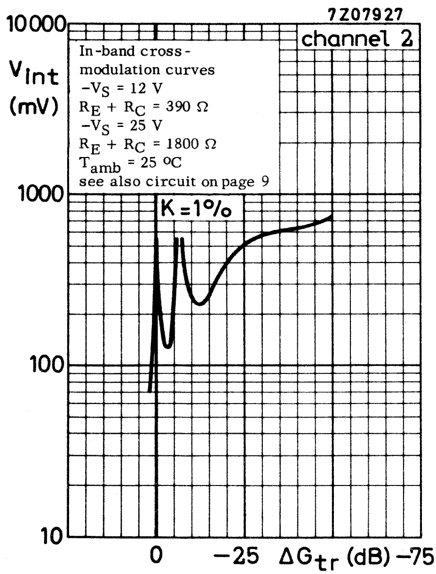


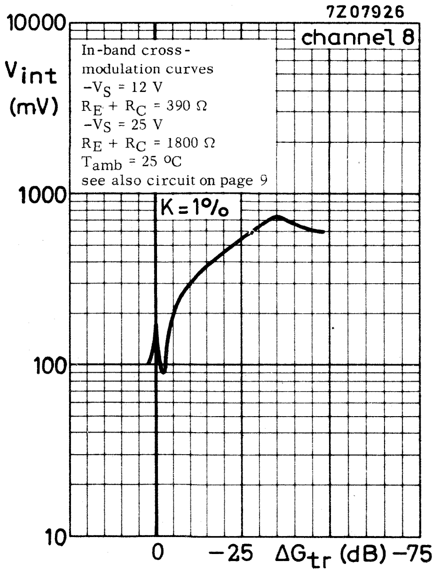


APPLICATION INFORMATION (continued)



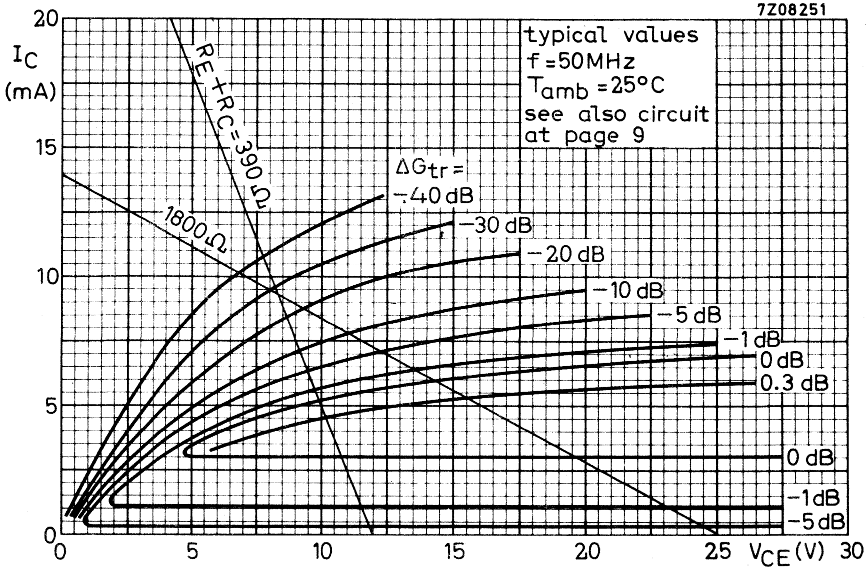


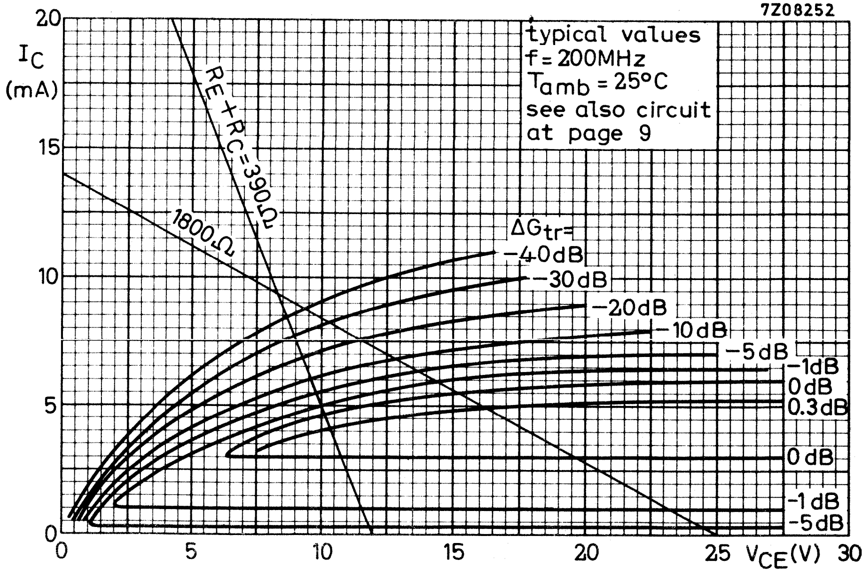




APPLICATION INFORMATION (continued)

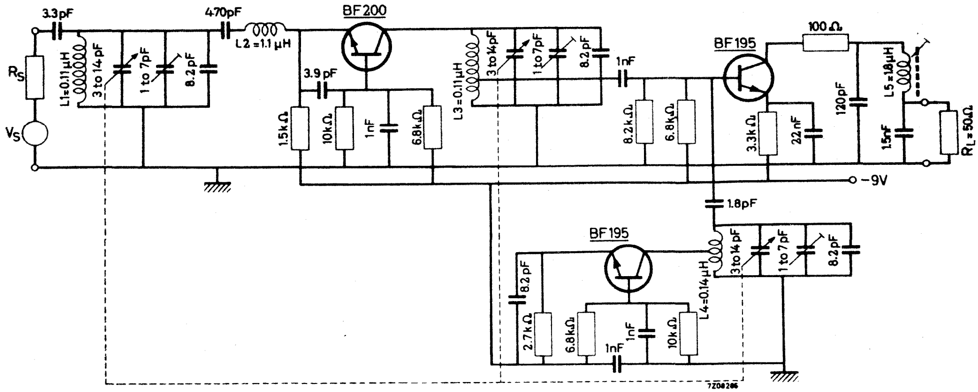
curves of constant gain reduction





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

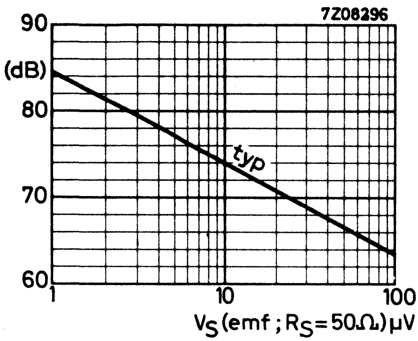
Coil former	AP3016/02	Ferroxcube core	3122 104 93041
Can	AP3015/02	Ferroxcube frame	AP3014/02

APPLICATION INFORMATION (continued)

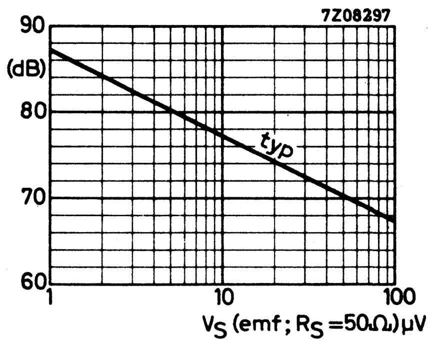
Typical performance of the f.m. tuner at T_{amb} = 25 °C; f = 98 MHz (oscillator frequency lower than tuning frequency)

Noise figure	F	4.5	dB
Transducer gain $G_{tr} = \dfrac{\text{output power in load}}{\text{available power from source}}$	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

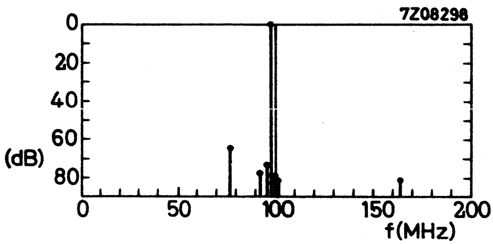


Repeat spot suppression



Spurious response suppression

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



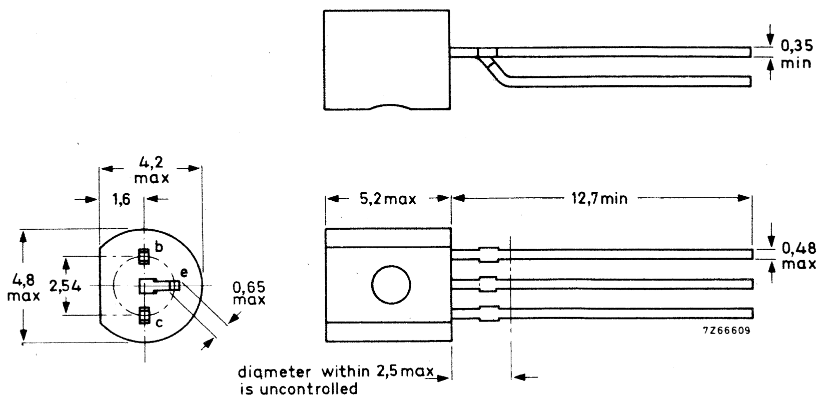
H.F. SILICON PLANAR EPITAXIAL TRANSISTORS

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					
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
			BF240	BF241	
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	$R_{th\ j-a}$	=	0, 4	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

			BF240	BF241	
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
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 Ω; f = 0, 2 MHz	F	typ.	1, 5	2, 0	dB
		<	3, 5	3, 5	dB

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

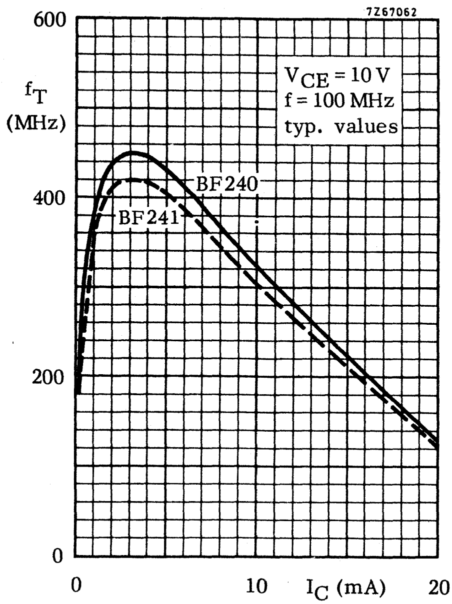
y parameters (common emitter) Lead length = 3 mm

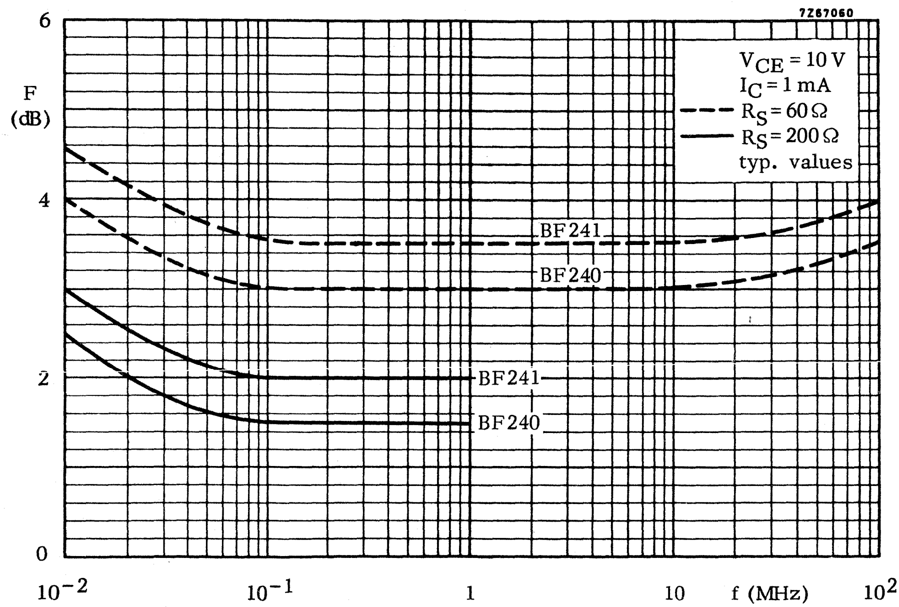
I_C = 1 mA; V_{CE} = 10 V

			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°	0°	0°	0°	
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°	270°	270°	270°	

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
f_T (MHz)
V_{CE} = 10 V
f = 100 MHz
typ. values
BF240
BF241
0
10
I_C (mA)
20


7Z67060
6
4
2
0
F (dB)
V_{CE} = 10 V
I_C = 1 mA
R_S = 60 Ω
R_S = 200 Ω
typ. values
BF241
BF240
BF241
BF240
10^{-2}
10^{-1}
1
10
f (MHz)
10^2

H.F. SILICON PLANAR EPITAXIAL TRANSISTOR

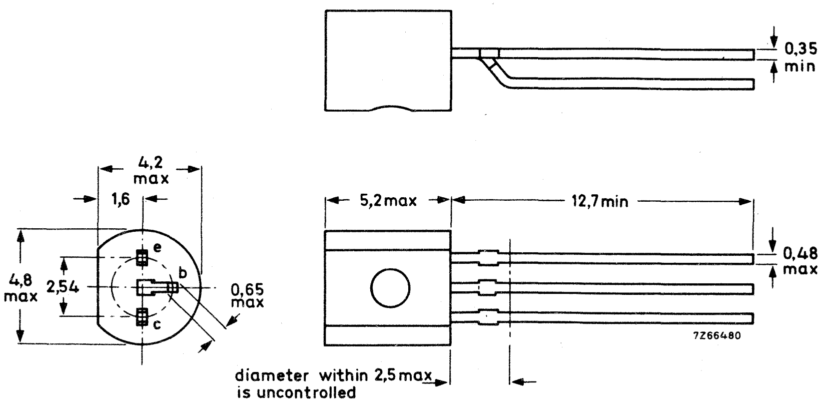
P-N-P transistor in a plastic envelope especially intended for r.f. stages in f.m. front-ends in common base configuration.

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 ^oC	P_{tot}	max.	250	mW

Temperatures

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

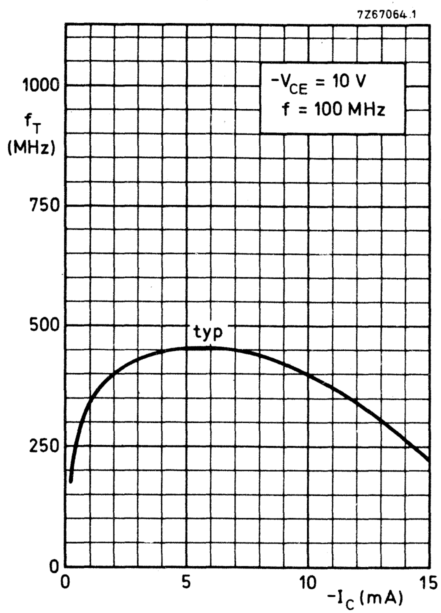
THERMAL RESISTANCE

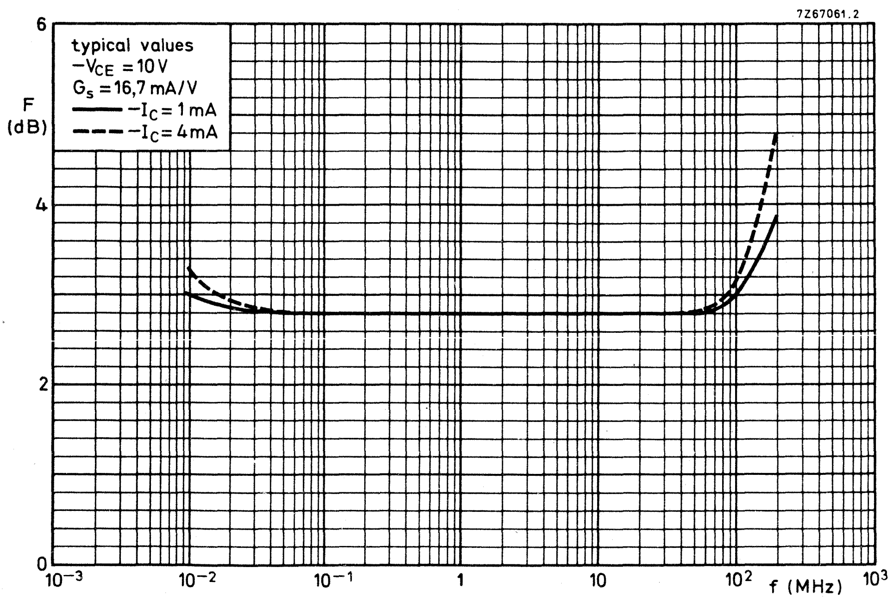
From junction to ambient in free air	$R_{th\ j-a}$	=	0,42	^oC/mW

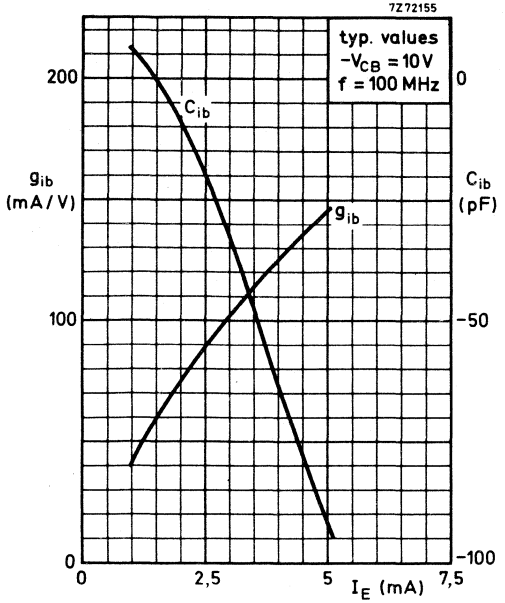
CHARACTERISTICS

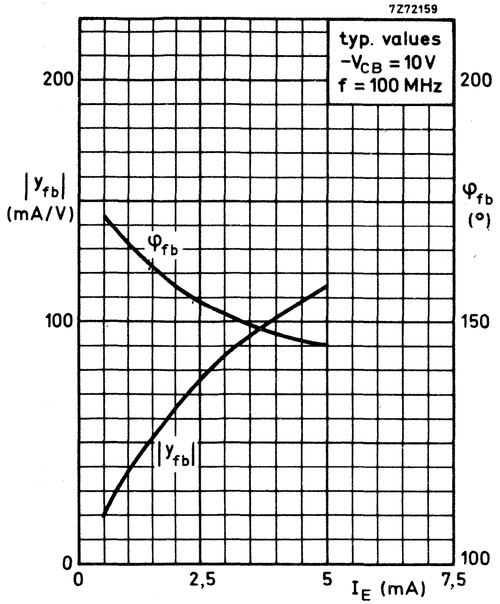
$T_j = 25\ ^oC$

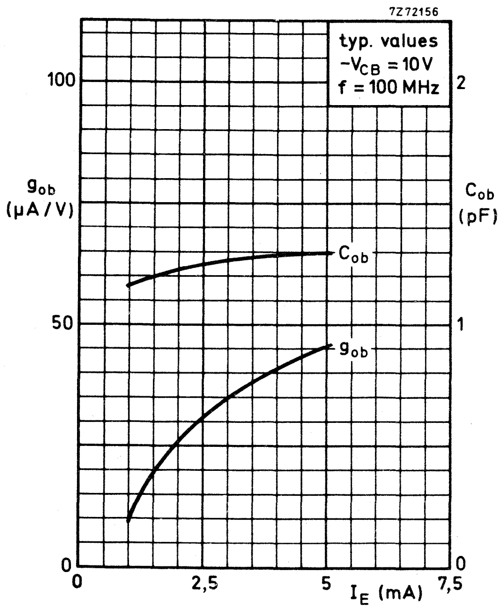
Collector cut-off current				
$I_E = 0; -V_{CB} = 30$ V	$-I_{CBO}$	<	50	nA
Emitter cut-off current				
$I_C = 0; -V_{EB} = 4$ V	$-I_{EBO}$	<	10	μA
Base current				
$-I_C = 4$ mA; $-V_{CE} = 10$ V	$-I_B$	typ. <	80 160	μA μA
$-I_C = 1$ mA; $-V_{CE} = 10$ V	$-I_B$	typ.	22	μA
Base-emitter voltage				
$-I_C = 4$ 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	$\|y_{fb}\|$	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	$\|y_{rb}\|$	typ.	220	μA/V
Phase angle of feedback admittance	$-\varphi_{rb}$	typ.	85^o	

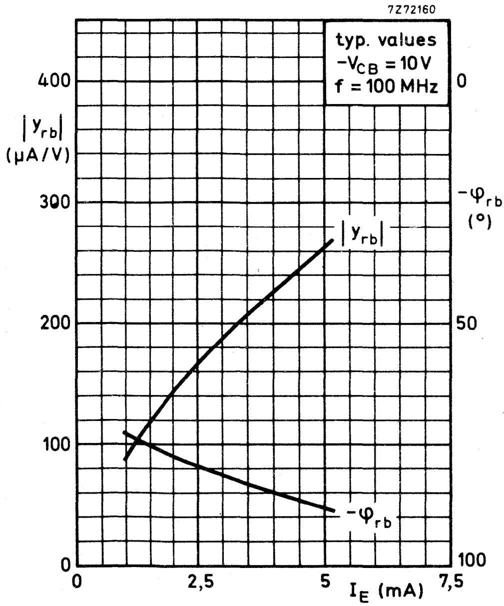

7Z67064.1
$-V_{CE}$ = 10 V
f = 100 MHz
f_T
(MHz)
1000
750
500
250
0
typ
0
5
10
15
$-I_C$ (mA)

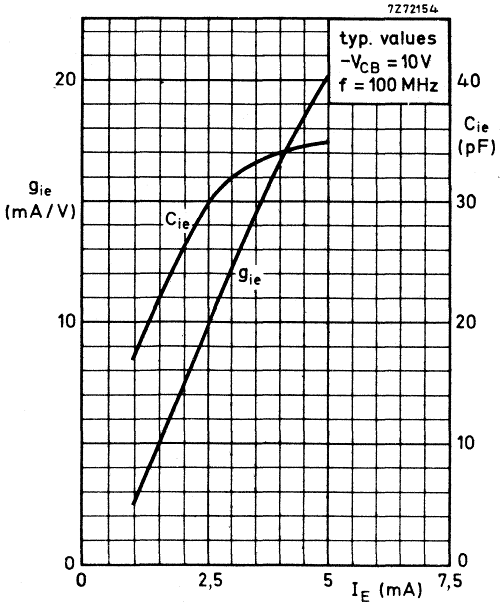

7Z67061.2
typical values
$-V_{CE}$ = 10 V
G_s = 16,7 mA/V
$-I_C$ = 1 mA
$-I_C$ = 4 mA
F
(dB)
6
4
2
0
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
10^3
f (MHz)

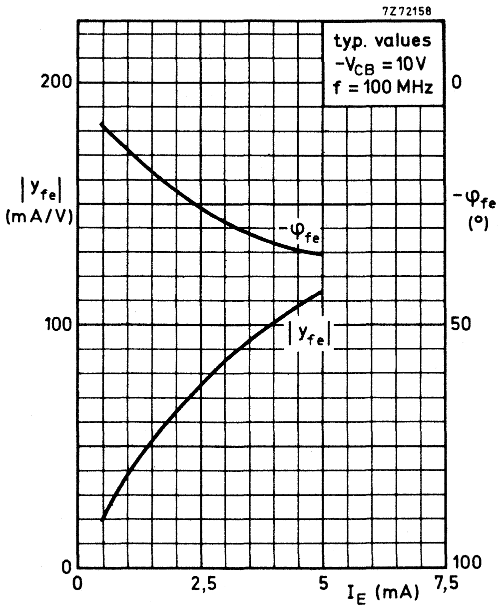

7Z72155
typ. values
$-V_{CB}$ = 10 V
f = 100 MHz
g_{ib} (mA/V)
C_{ib} (pF)
C_{ib}
g_{ib}
200
100
0
0
−50
−100
0
2,5
5
7,5
I_E (mA)

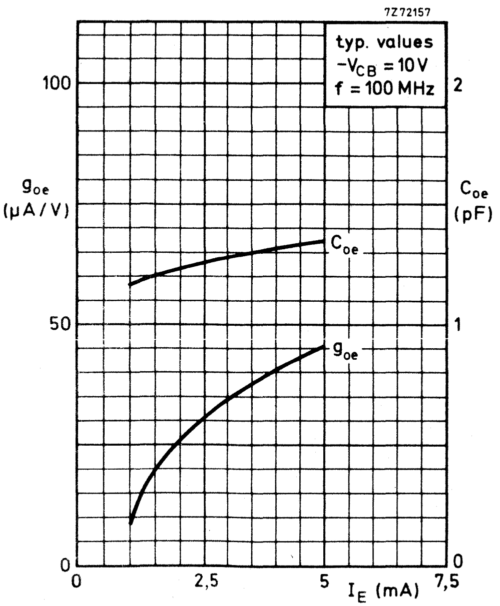

7Z72159
typ. values
$-V_{CB}$ = 10 V
f = 100 MHz
$|y_{fb}|$ (mA/V)
φ_{fb} (°)
φ_{fb}
$|y_{fb}|$
200
100
0
200
150
100
0
2,5
5
7,5
I_E (mA)

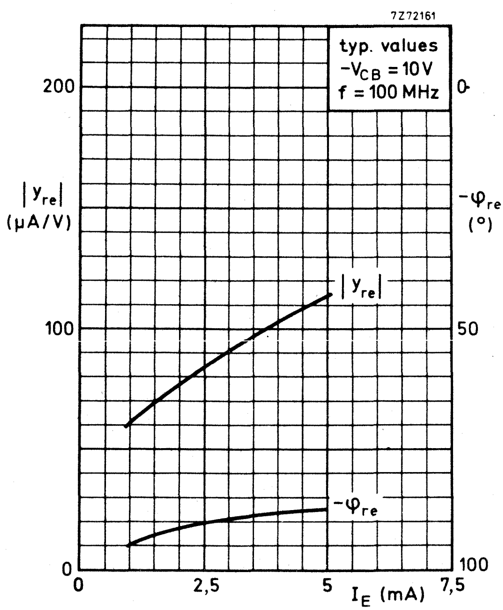

7Z72156
typ. values
$-V_{CB}$ = 10 V
f = 100 MHz
g_{ob} (μA/V)
C_{ob} (pF)
C_{ob}
g_{ob}
100
50
0
2
1
0
0
2,5
5
7,5
I_E (mA)


7Z72160
typ. values
$-V_{CB}$ = 10 V
f = 100 MHz
$|y_{rb}|$ (μA/V)
$-\varphi_{rb}$ (°)
$|y_{rb}|$
$-\varphi_{rb}$
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}
I_E (mA)
0
2,5
5
7,5
0
10
20
0
10
20
30
40


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


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


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

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

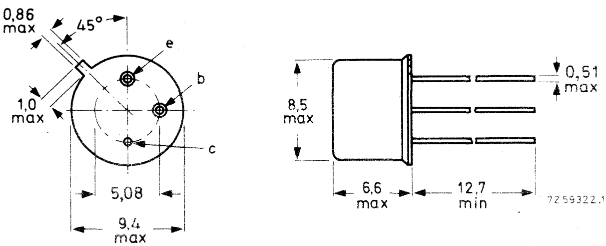
			BF336	BF337	BF338	
Collector-base voltage (open emitter)	V_{CBO}	max.	185	250	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	180	200	225	V
Collector current (peak value)	I_{CM}	max.		200		mA
Total power dissipation up to T_{mb} = 140 °C	P_{tot}	max.		3,0		W
Junction temperature	T_j	max.		200		°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

Collector connected to case

TO-39



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

Accessories supplied on request: 56218 (package); 56245 (distance disc).

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	$R_{th\ j\text{-}a}$	=	220	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	20	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	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. <	10 100	nA µA

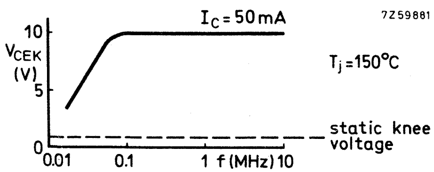
Base-emitter voltage

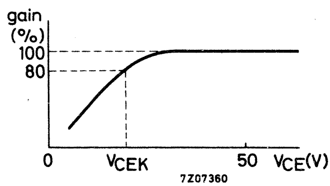
I_C = 30 mA; V_{CE} = 10 V	V_{BE}	typ. <	0,7 1,2	V V

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}	> typ.	20 60	

Feedback capacitance at f = 0.5 MHz

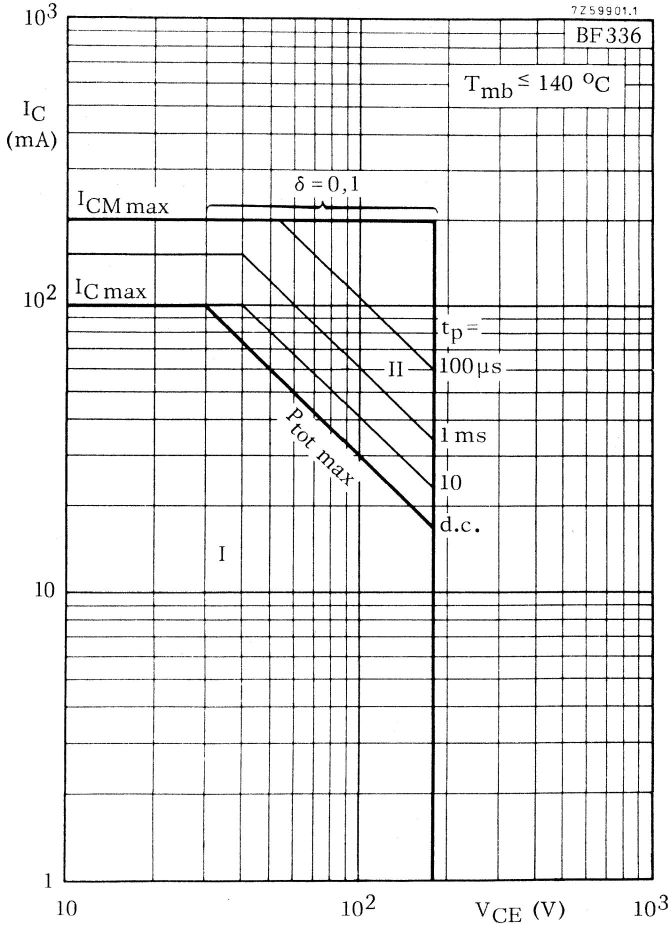
I_C = 10 mA; V_{CE} = 20 V	C_{re}	typ. <	3,0 3,5	pF pF

Feedback time constant at f = 10 MHz

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

Transition frequency at f = 100 MHz

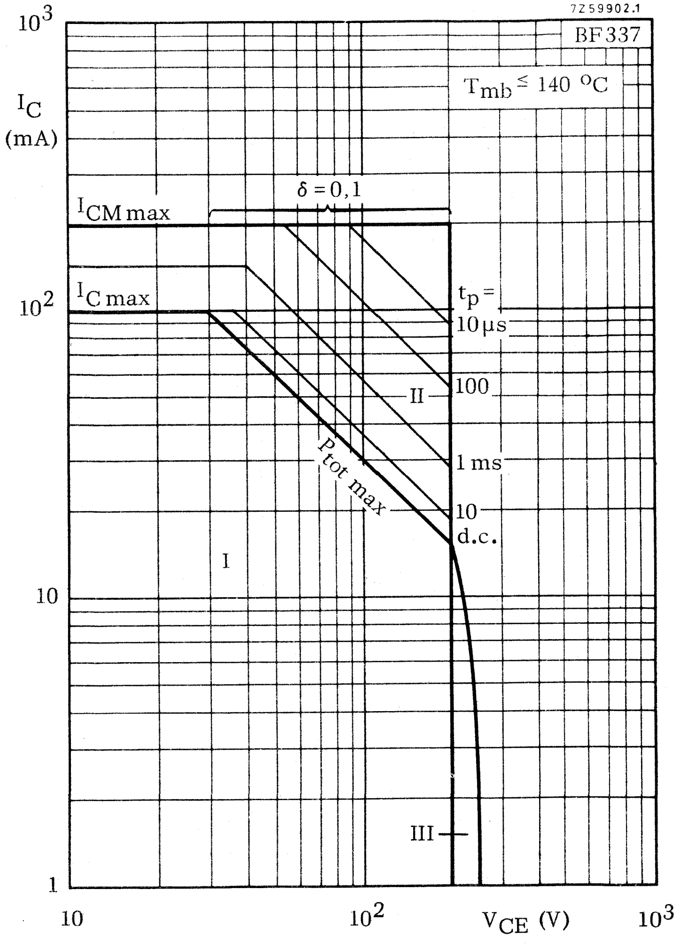
I_C = 30 mA; V_{CE} = 20 V	f_T	> typ.	80 130	MHz MHz



Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

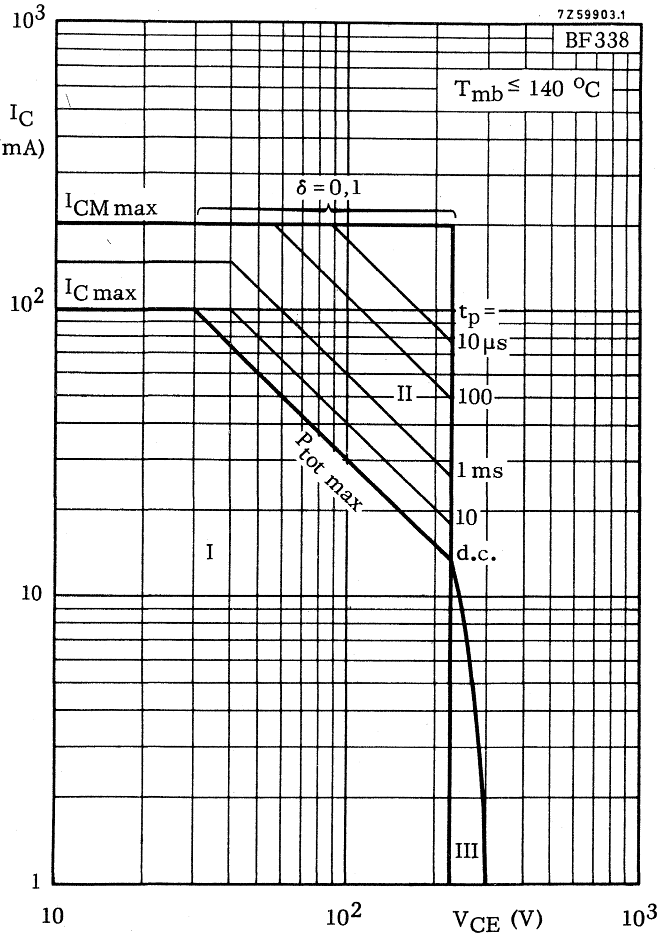


Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

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

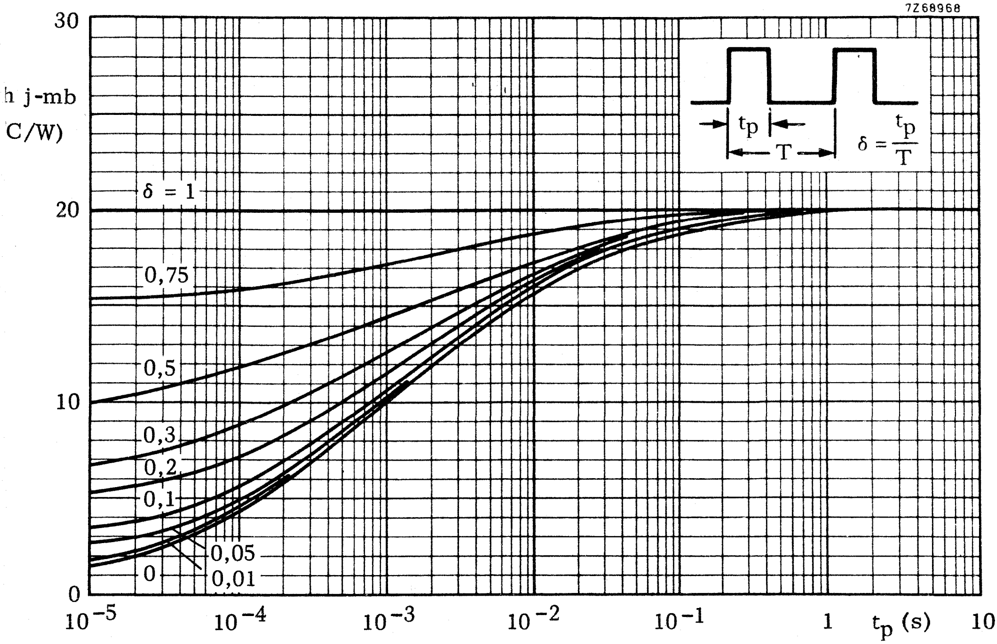


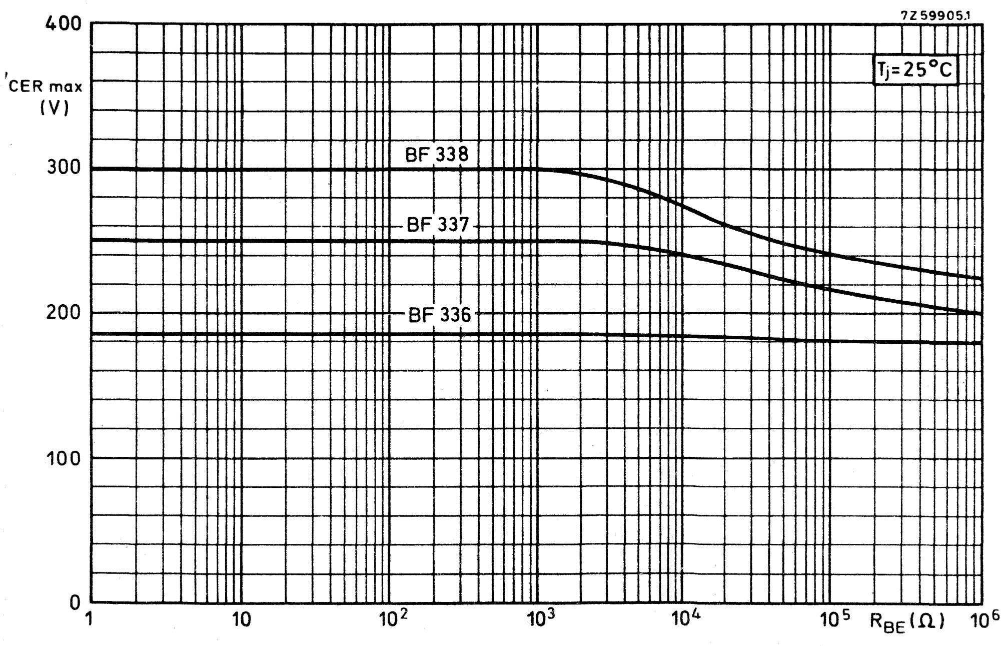
Safe Operating Area with the transistor forward biased

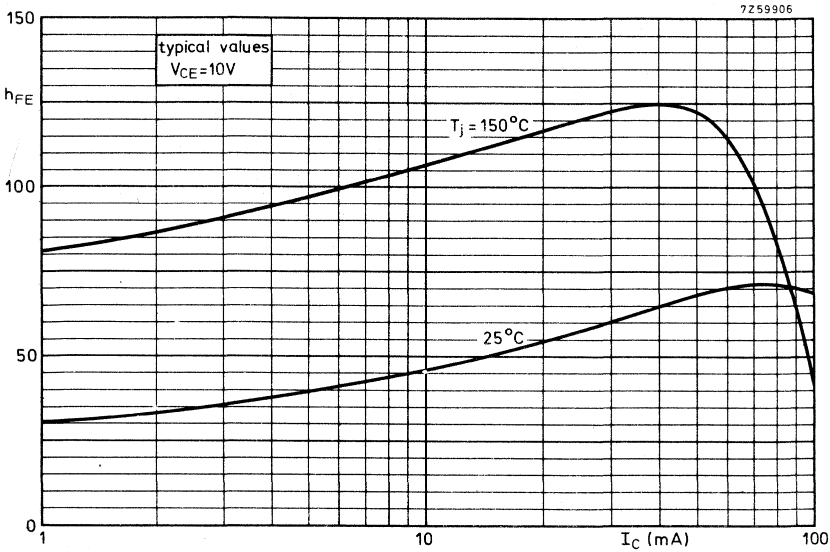
I Region of permissible d.c. operation

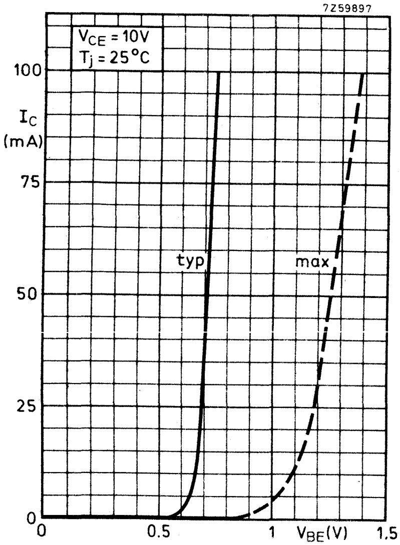
II Permissible extension for repetitive pulse operation

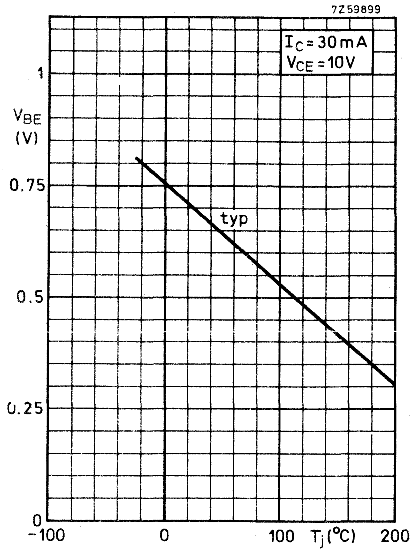
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 1\ k\Omega$

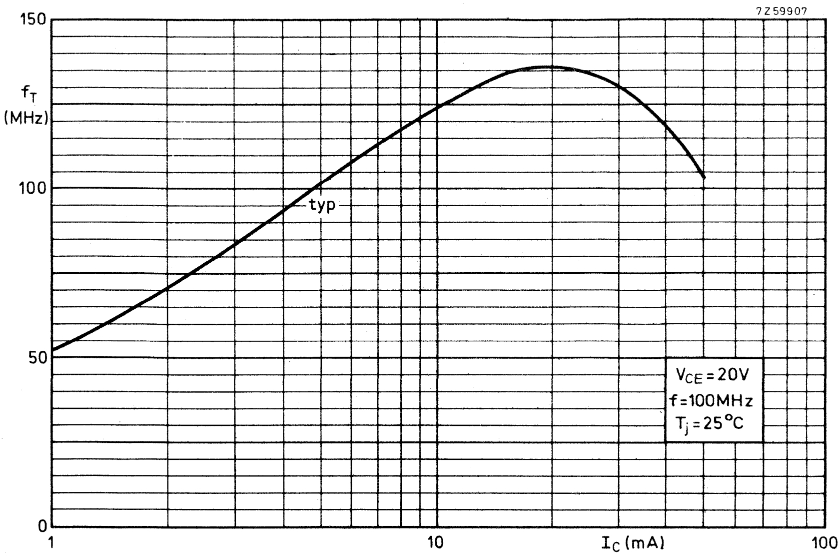

7Z68968
30
h j-mb
C/W)
20
10
0
δ = 1
0,75
0,5
0,3
0,2
0,1
0,05
0
0,01
tp
T
δ = tp/T
10−5
10−4
10−3
10−2
10−1
1
tp (s)
10

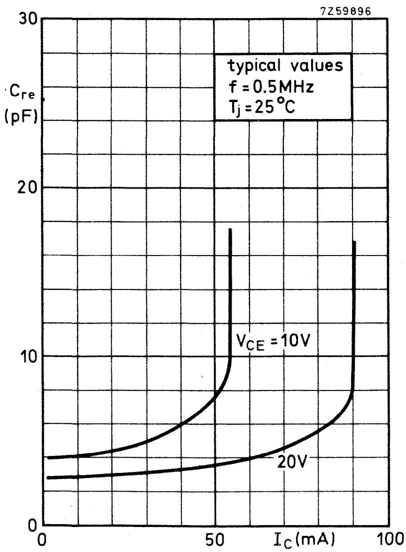

7Z59905.1
400
CER max
(V)
300
200
100
0
Tj=25°C
BF 338
BF 337
BF 336
1
10
10²
10³
10⁴
10⁵
RBE(Ω)
10⁶

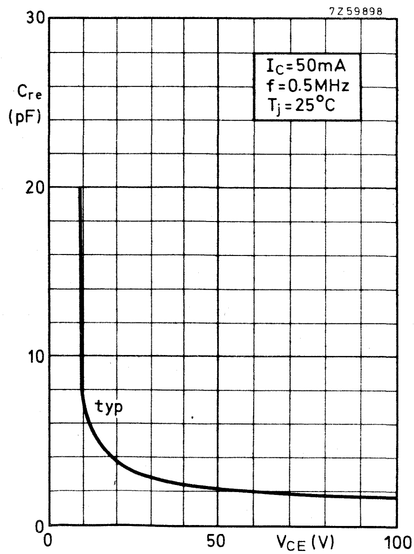

7Z59906
typical values
V_{CE} = 10V
h_{FE}
150
100
50
0
T_j = 150°C
25°C
1
10
I_C (mA)
100

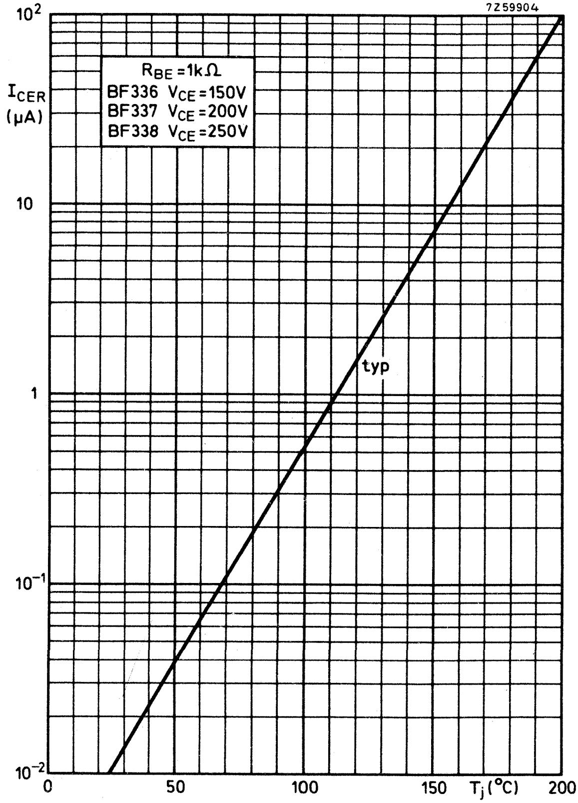

7Z59897
V_{CE} = 10V
T_j = 25°C
I_C (mA)
100
75
50
25
0
typ
max
0
0.5
1
V_{BE}(V)
1.5


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


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


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


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

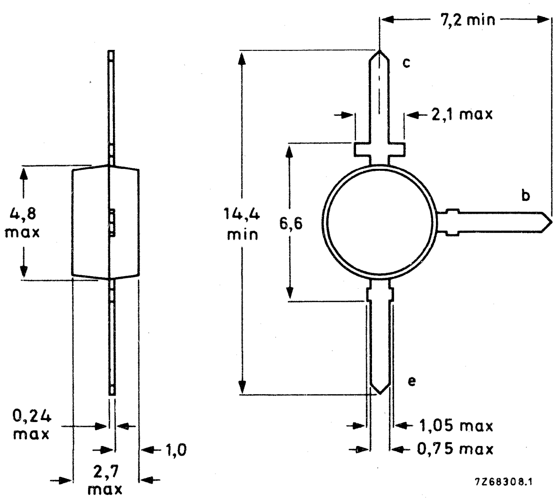
U.H.F. SILICON PLANAR TRANSISTORS

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	$R_{th\ j-a}$	=	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 °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

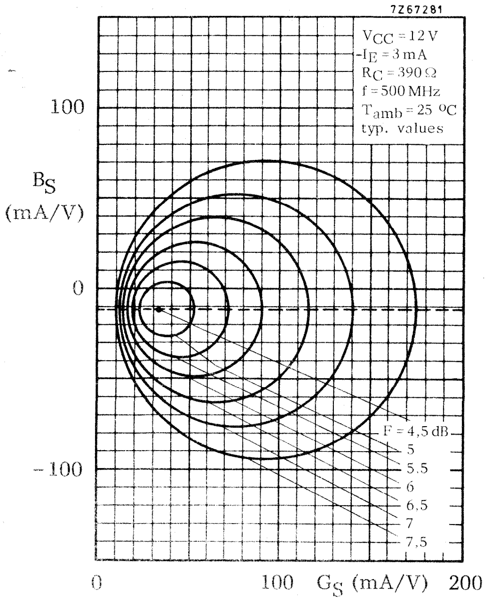
Transducer gain at f = 900 MHz

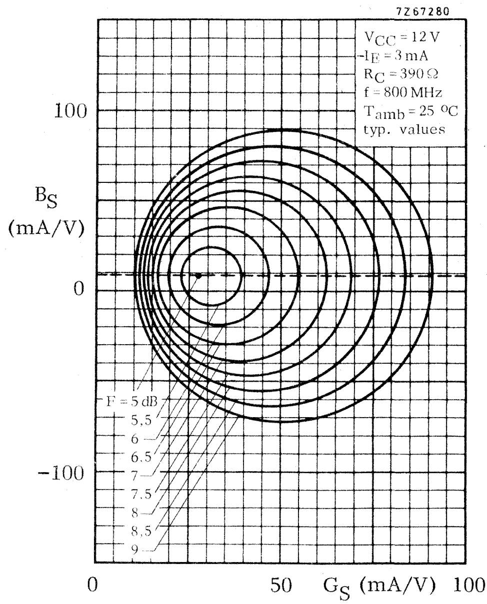
$-I_E$ = 3 mA; V_{CC} = 12 V				
G_S = 20 mA/V; B_S = 0				
G_L = 2 mA/V; B_L tuned; R_C = 390 Ω	G_{tr}	>	11	dB
		typ.	12	dB

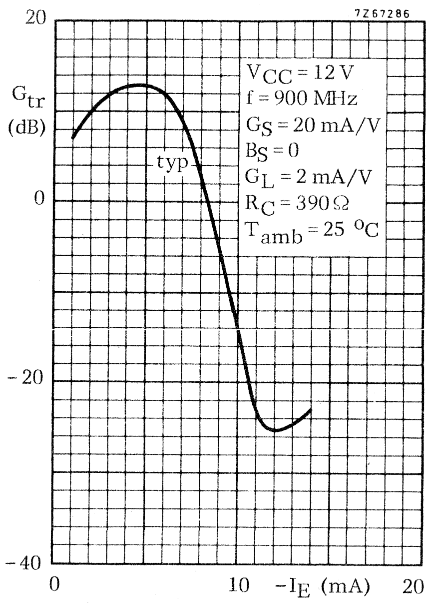
y-parameters (common base)

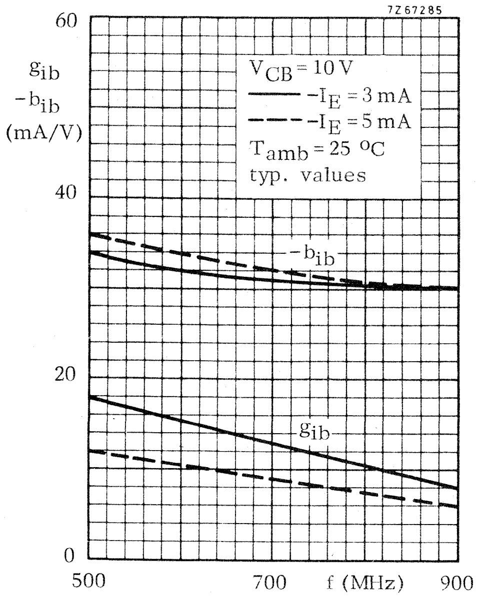
$-I_E$ = 3 mA; V_{CB} = 10 V

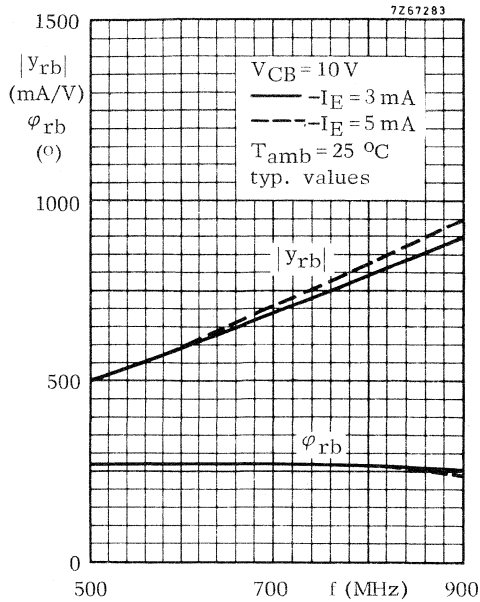
	f	=	500	900	MHz
Input conductance	g_{ib}	typ.	18	8	mA/V
Input susceptance	$-b_{ib}$	typ.	34	30	mA/V
Feedback admittance	$\|y_{rb}\|$	typ.	500	900	µA/V
Phase angle of feedback admittance	φ_{rb}	typ.	270°	250°	
Transfer admittance	$\|y_{fb}\|$	typ.	45	25	mA/V
Phase angle of transfer admittance	φ_{fb}	typ.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

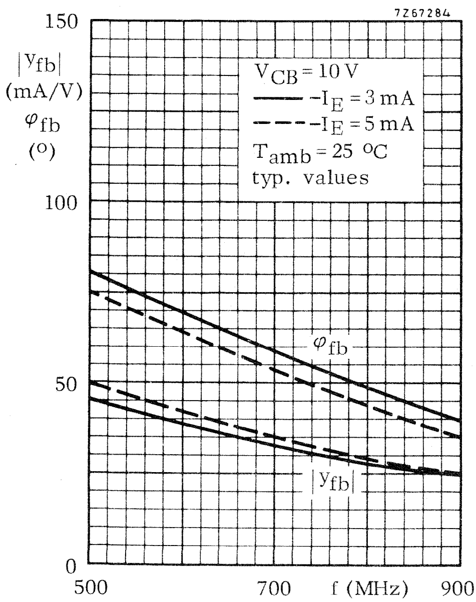

7Z67281
V_{CC} = 12 V
$-I_E$ = 3 mA
R_C = 390 Ω
f = 500 MHz
T_{amb} = 25 °C
typ. values
100
B_S (mA/V)
0
−100
F = 4,5 dB
5
5.5
6
6,5
7
7,5
0
100
G_S (mA/V)
200

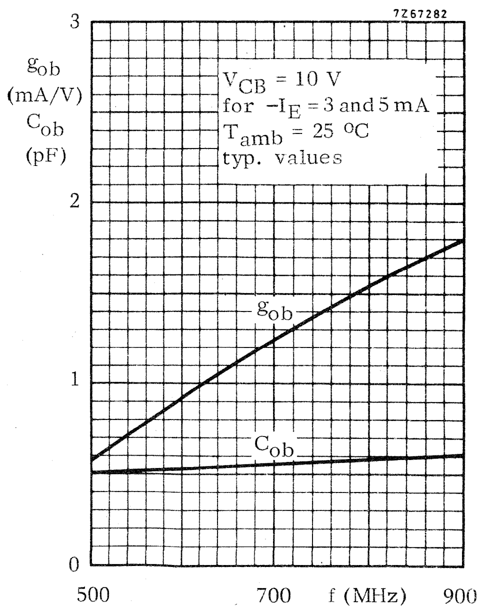

7Z67280
V_{CC} = 12 V
$-I_E$ = 3 mA
R_C = 390 Ω
f = 800 MHz
T_{amb} = 25 °C
typ. values
100
B_S (mA/V)
0
−100
F = 5 dB
5,5
6
6.5
7
7.5
8
8,5
9
0
50
G_S (mA/V)
100


7Z67286
20
G_{tr} (dB)
0
−20
−40
typ
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
0
10
$-I_E$ (mA)
20


7Z67285
g_ib
−b_ib
(mA/V)
V_CB = 10 V
—— −I_E = 3 mA
- - - −I_E = 5 mA
T_amb = 25 °C
typ. values
−b_ib
g_ib
60
40
20
0
500
700
f (MHz)
900


7Z67283
|y_rb|
(mA/V)
φ_rb
(°)
V_CB = 10 V
—— −I_E = 3 mA
- - - −I_E = 5 mA
T_amb = 25 °C
typ. values
|y_rb|
φ_rb
1500
1000
500
0
500
700
f (MHz)
900


7Z67284
|y_fb|
(mA/V)
φ_fb
(°)
V_CB = 10 V
—— −I_E = 3 mA
- - - −I_E = 5 mA
T_amb = 25 °C
typ. values
φ_fb
|y_fb|
150
100
50
0
500
700
f (MHz)
900


7Z67282
g_ob
(mA/V)
C_ob
(pF)
V_CB = 10 V
for −I_E = 3 and 5 mA
T_amb = 25 °C
typ. values
g_ob
C_ob
3
2
1
0
500
700
f (MHz)
900

SILICON EPITAXIAL TRANSISTOR

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.

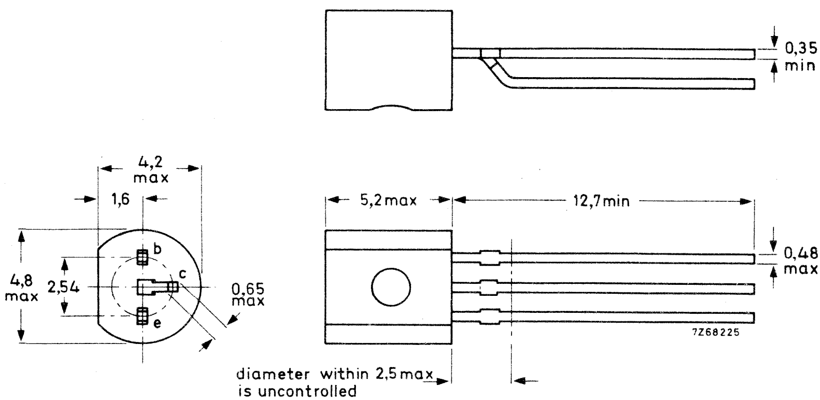
QUICK REFERENCE DATA

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 = 1 MHz I_E = 0; V_{CB} = 30 V	C_{re}	<	1,6	pF

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



Accessories supplied on request: 56356 (cooling clip).

RATINGS

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

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
→ Collector current (d.c.)	I_C	max.	50	mA
Collector current (peak value)	I_{CM}	max.	100	mA
→ Total power dissipation up to T_{amb} = 25 °C				
mounted on a printed-circuit board *	P_{tot}	max.	830	mW
mounted on a p.c.b. and using cooling clip 56356	P_{tot}	max.	960	mW
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 printed-circuit board *	$R_{th\ j\text{-}a}$	=	0,15	°C/mW
mounted on a p.c.b. and using cooling clip 56356	$R_{th\ j\text{-}a}$	=	0,13	°C/mW

* Transistor mounted on a printed-circuit board, mounting pad for collector lead minimum 10 mm x 10 mm; maximum lead length 4 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*			
$I_C = 25$ mA; $T_j = 150$ °C	V_{CEK}	typ.	20 V
Transition frequency			
$-I_E = 10$ mA; $V_{CB} = 10$ V	f_T	>	60 MHz
Feedback capacitance at f = 1 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**

* 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.

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

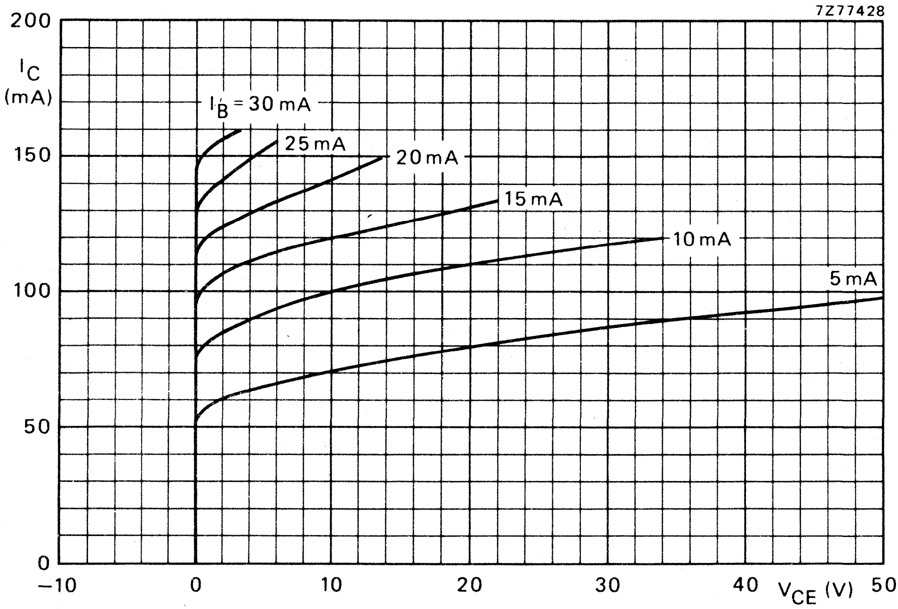


Fig. 2 Typical values at T_j = 25 °C.

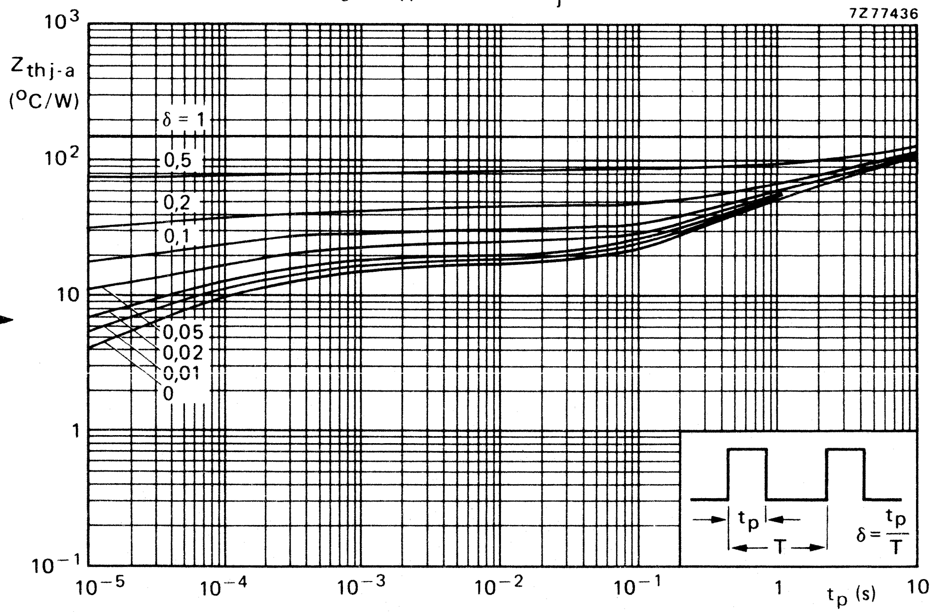


Fig. 3 Thermal impedance from junction to ambient versus pulse duration.
Maximum lead length 3 mm; mounting pad for collector lead minimum 10 mm x 10 mm.

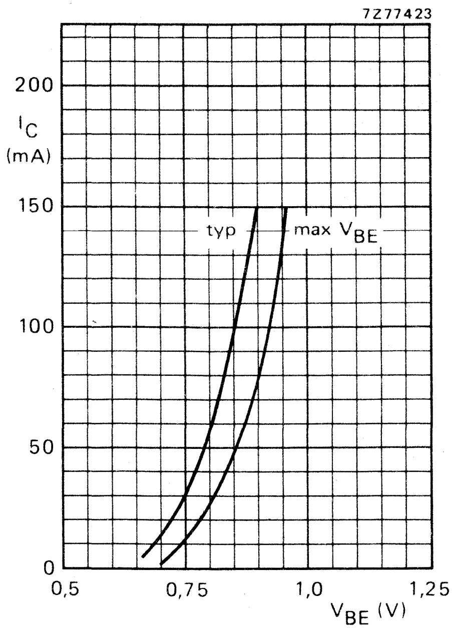


Fig. 4 V_{CB} = 20 V; T_j = 25 °C.

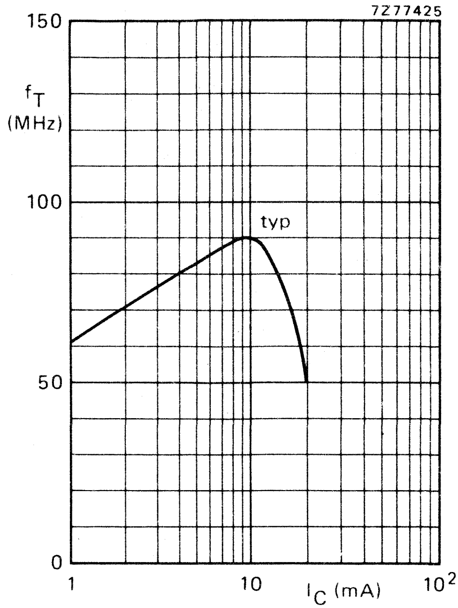


Fig. 5 V_{CE} = 10 V; T_j = 25 °C.

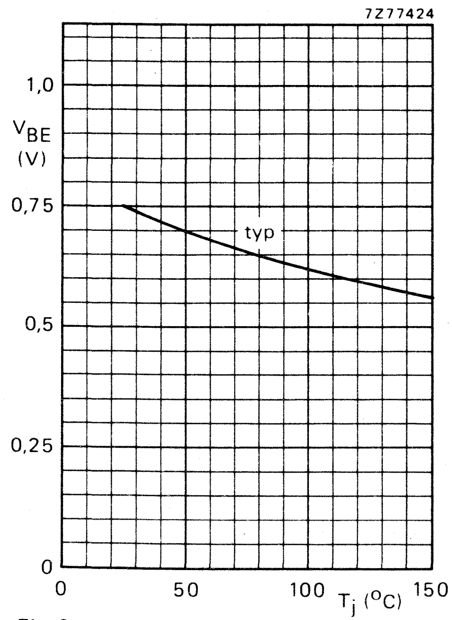


Fig. 6 I_C = 25 mA; V_{CE} = 20 V.

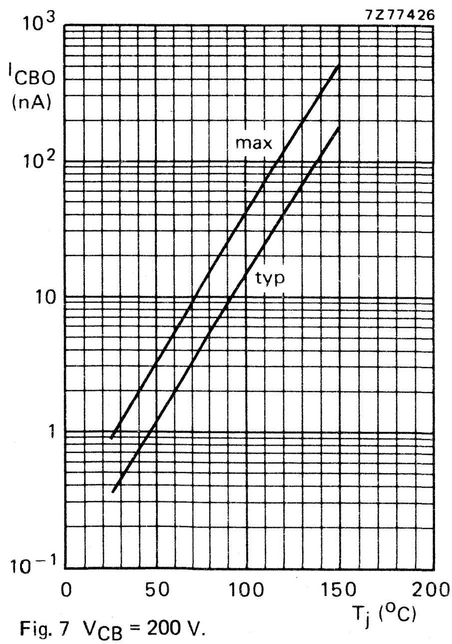


Fig. 7 V_{CB} = 200 V.

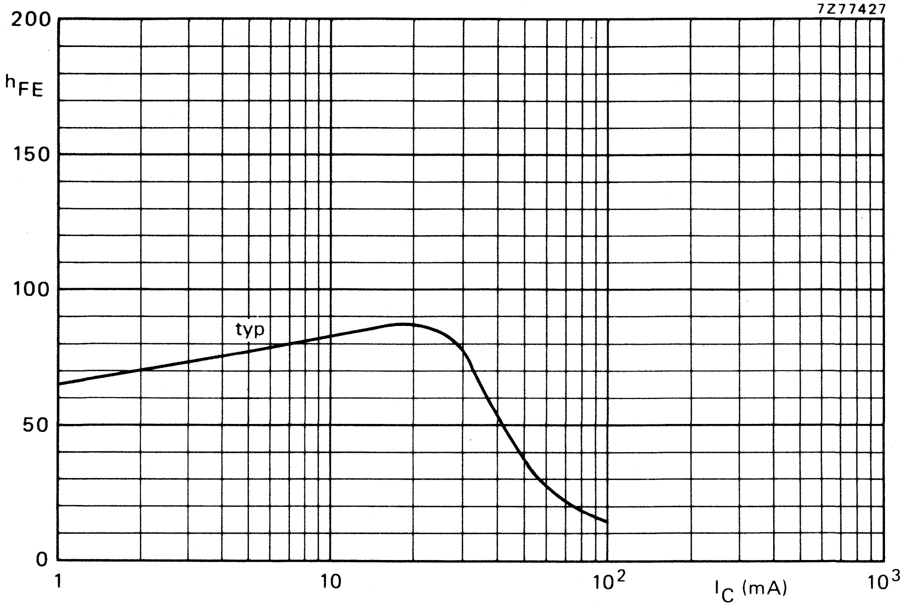


Fig. 8 V_{CE} = 20 V; T_j = 25 °C.

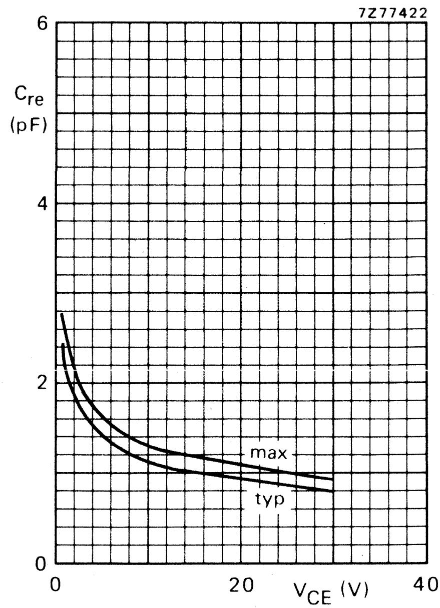


Fig. 9 I_C = 0; f = 1 MHz; T_j = 25 °C.

SILICON EPITAXIAL TRANSISTOR

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

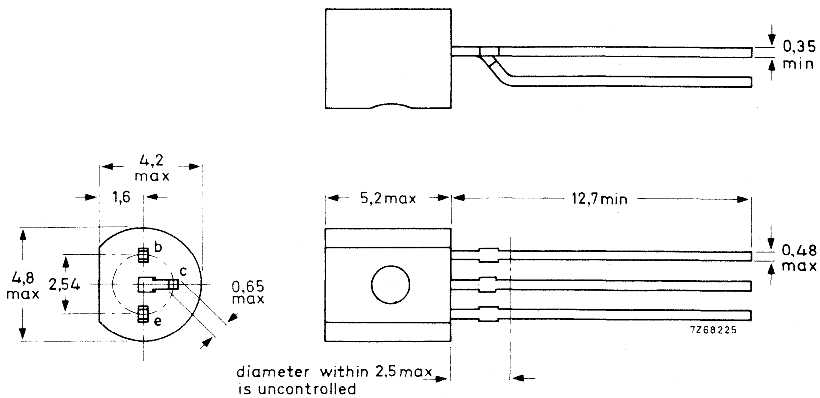
QUICK REFERENCE DATA

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 = 1 MHz I_E = 0; $-V_{CB}$ = 30 V	C_{re}	<	1,6	pF

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-92 variant.



Accessories supplied on request: 56356 (cooling clip).

RATINGS

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

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
→ Collector current (d.c.)	$-I_C$	max.	50	mA
Collector current (peak value)	$-I_{CM}$	max.	100	mA
→ Total power dissipation up to T_{amb} = 25 °C				
mounted on a printed-circuit board *	P_{tot}	max.	830	mW
mounted on a p.c.b. and using cooling clip 56356	P_{tot}	max.	960	mW
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 printed-circuit board *	$R_{th\ j\text{-}a}$	=	0,15	°C/mW
mounted on a p.c.b. and using cooling clip 56356	$R_{th\ j\text{-}a}$	=	0,13	°C/mW

* Transistor mounted on a printed-circuit board, mounting pad for collector lead minimum 10 mm x 10 mm; maximum length 4 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*			
$-I_C = 25$ mA; $T_j = 150$ °C	$-V_{CEK}$	typ.	20 V
Transition frequency			
$I_E = 10$ mA; $-V_{CB} = 10$ V	f_T	>	60 MHz
Feedback capacitance at f = 1 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**

* 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.

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

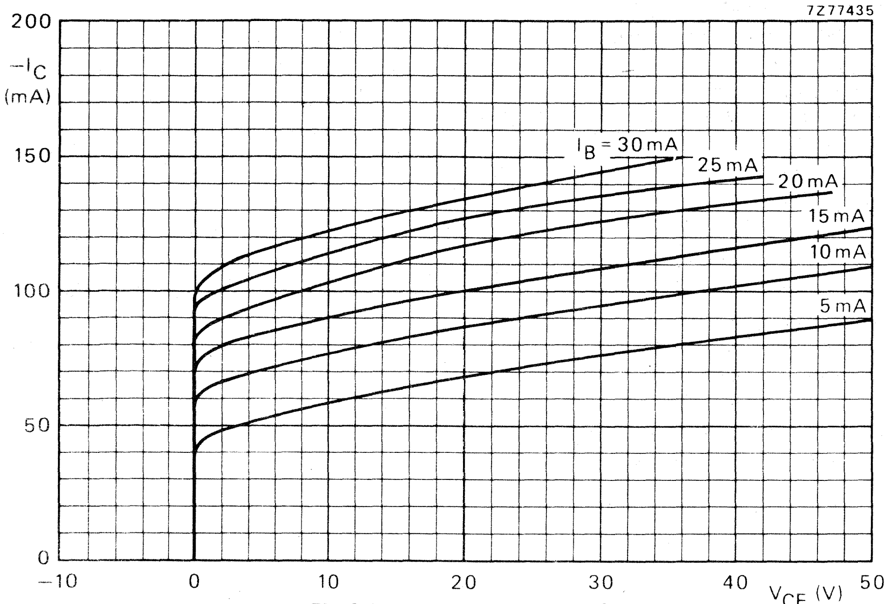


Fig. 2 Typical values at T_j = 25 °C.

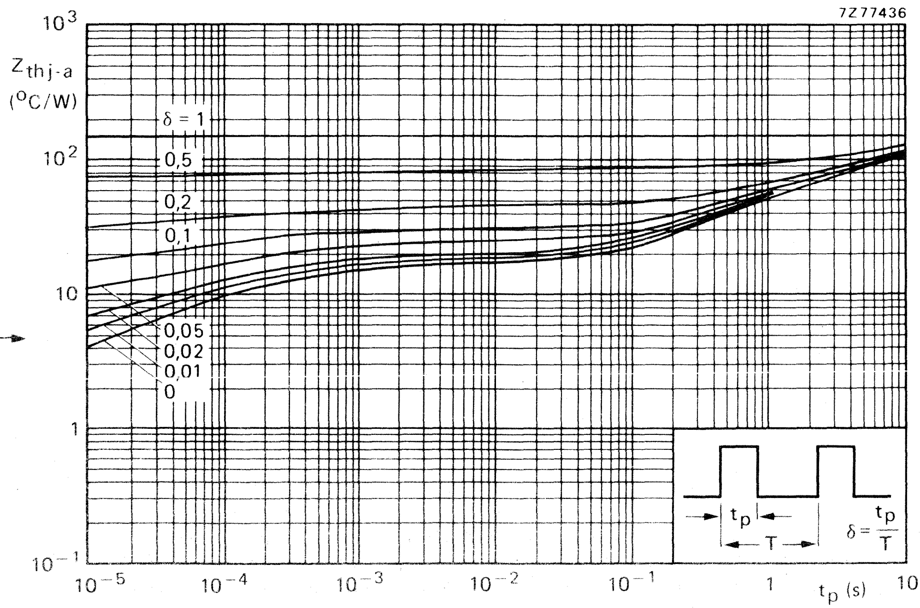


Fig. 3 Thermal impedance from junction to ambient versus pulse duration.
Maximum lead length 3 mm; mounting pad for collector lead minimum 10 mm x 10 mm.

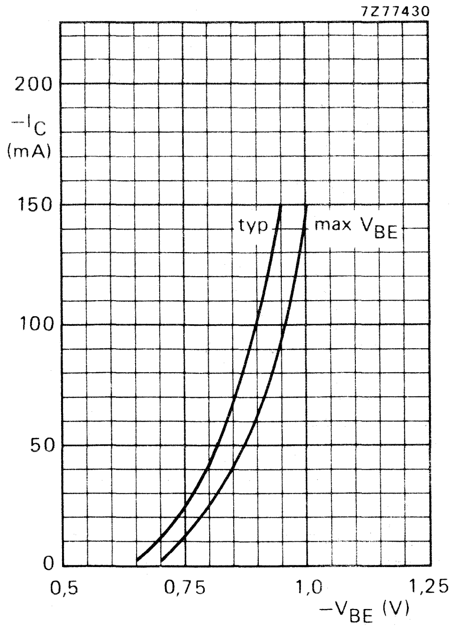


Fig. 4 $-V_{CE}$ = 20 V; T_j = 25 °C.

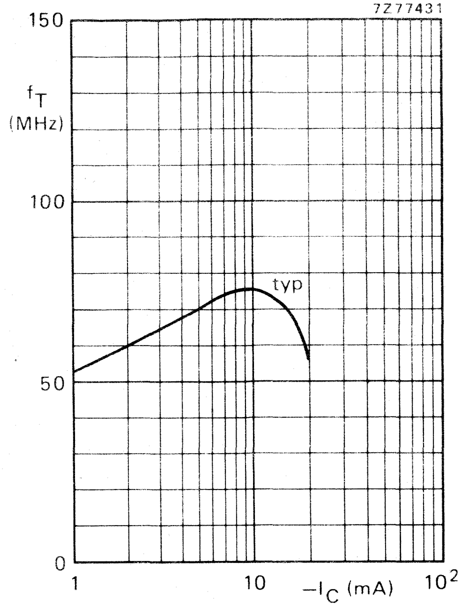


Fig. 5 $-V_{CE}$ = 10 V; T_j = 25 °C.

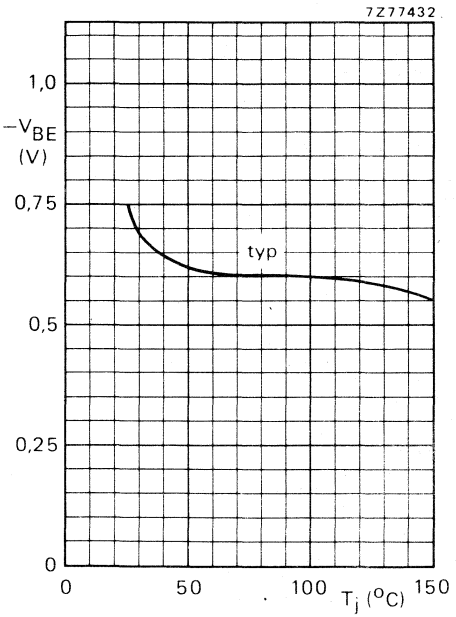


Fig. 6 $-I_C$ = 25 mA; $-V_{CE}$ = 20 V.

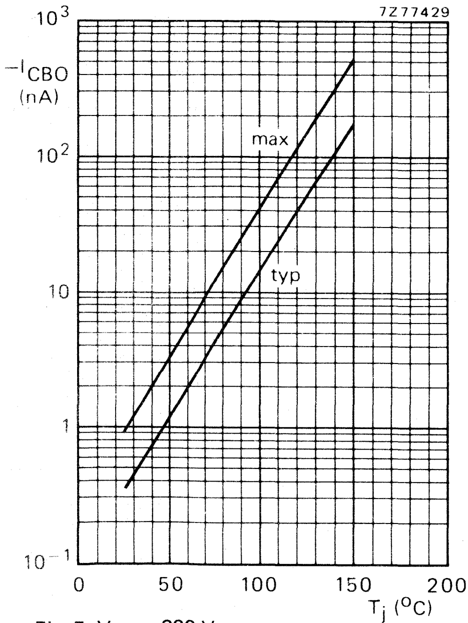


Fig. 7 V_{CB} = 200 V.

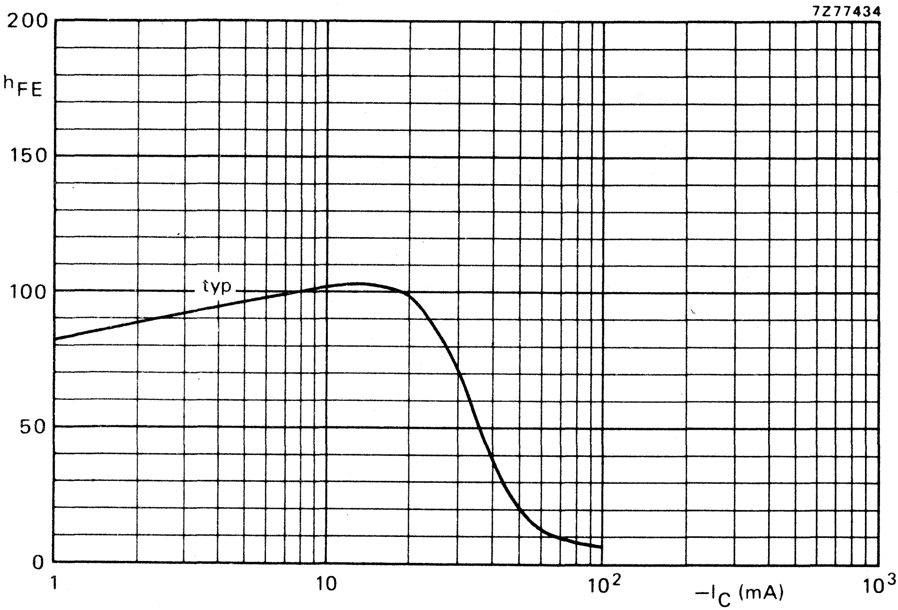


Fig. 8 $-V_{CE}$ = 20 V; T_j = 25 °C.

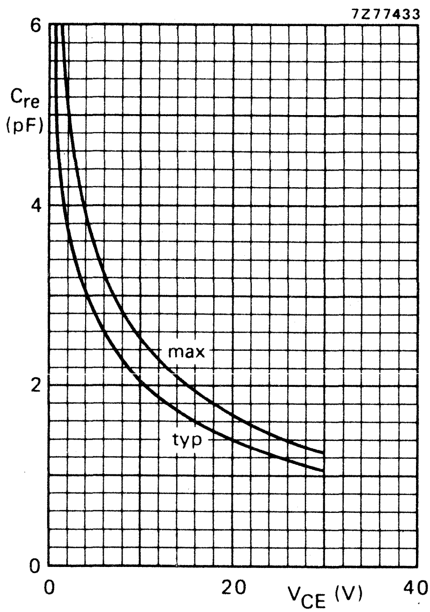


Fig. 9 I_C = 0; f = 1 MHz; T_j = 25 °C.

H.F. SILICON PLANAR EPITAXIAL TRANSISTORS

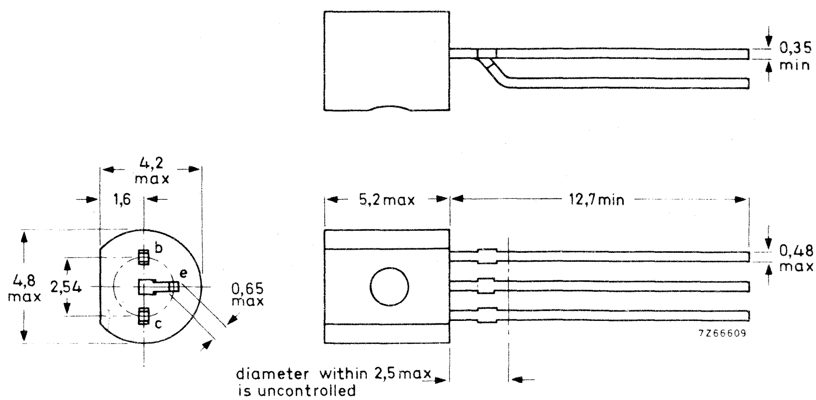
P-N-P transistors in a plastic envelope intended for h.f. and i.f. applications in radio receivers, especially for mixer stages in a.m. receivers and i.f. stages in a.m./f.m. receivers with negative earth.

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 $T_{amb} = 45\ ^oC$	P_{tot}	max.	250	mW

Temperatures

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

THERMAL RESISTANCE

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

CHARACTERISTICS $T_j = 25\ ^oC$

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

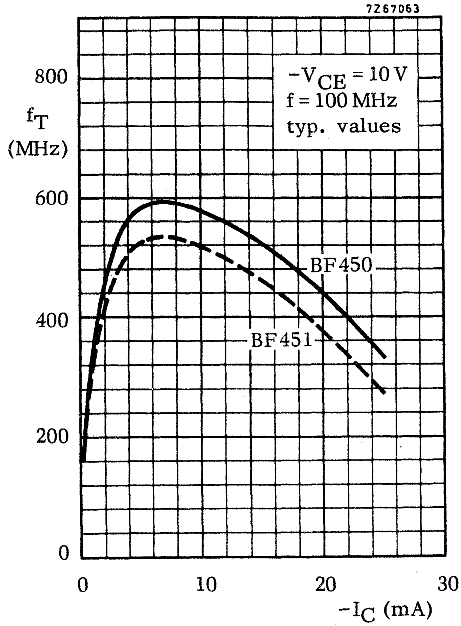
Noise figure at f = 100 kHz

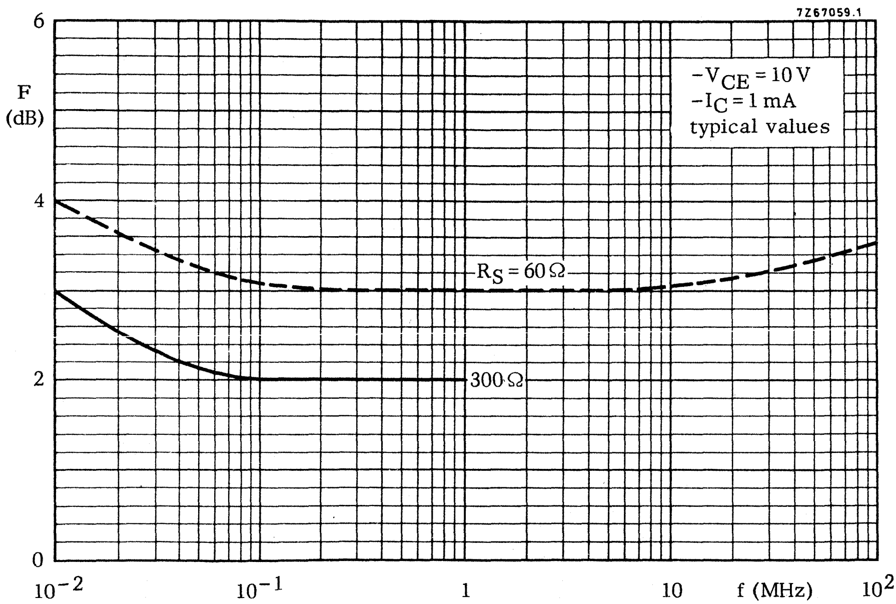
$-I_C = 1$ mA; $-V_{CE} = 10$ V; $R_S = 300\ \Omega$	F	typ.	2	dB

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 Ω
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

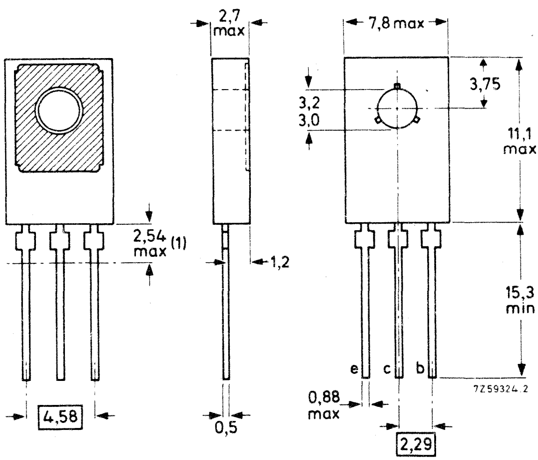
			BF457	BF458	BF459	
Collector-base voltage (open emitter)	V_{CBO}	max.	160	250	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	160	250	300	V
Collector current (peak value)	I_{CM}	max.		300		mA
Total power dissipation up to T_{mb} = 90 °C	P_{tot}	max.		6		W
Junction temperature	T_j	max.		150		°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

Collector connected to metal part of mounting surface

TO-126 (SOT-32)



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

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

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

Voltage

			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

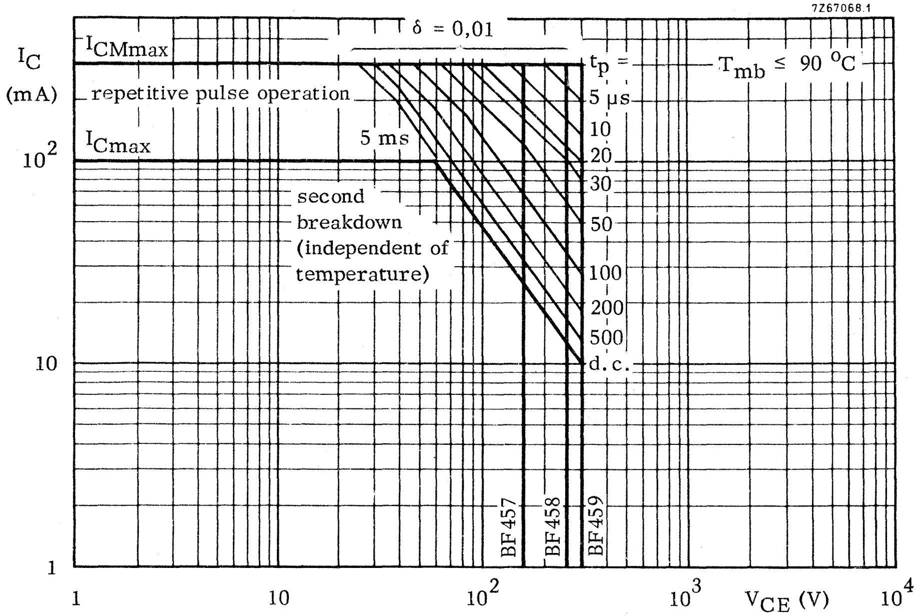
From junction to ambient	$R_{th\ j-a}$	=	104	°C/W
From junction to mounting base	$R_{th\ j-mb}$	=	10	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

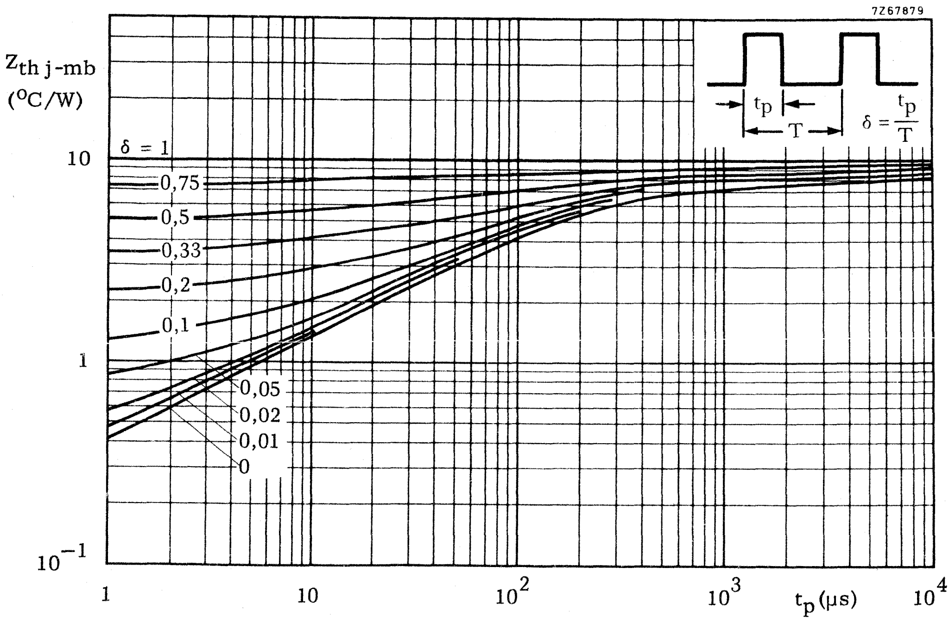
Collector cut-off current				
$I_E = 0$; V_{CB} = 100 V for BF457				
$I_E = 0$; V_{CB} = 200 V for BF458	I_{CBO}	<	50	nA
$I_E = 0$; V_{CB} = 250 V for BF459				
Emitter cut-off current				
$I_C = 0$; V_{EB} = 3 V	I_{EBO}	<	50	nA
D.C. current gain				
I_C = 30 mA; V_{CE} = 10 V	h_{FE}	>	26	
Collector-emitter 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

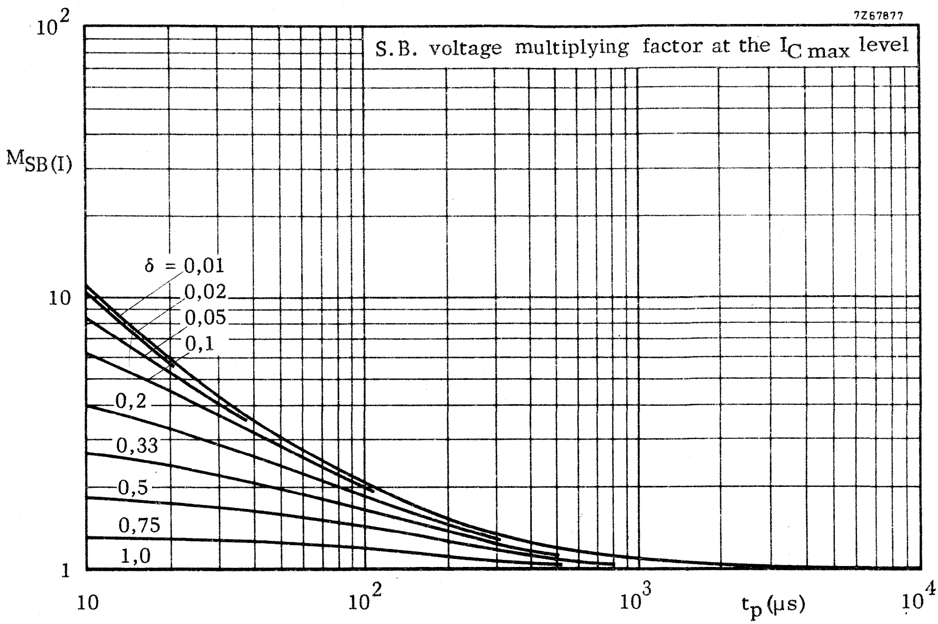
The high frequency knee voltage of a transistor is that value of the collector-emitter voltage at which the small signal gain, measured in a practical circuit, has dropped to 80% of the gain at V_{CE} = 50 V. A further reduction of the collector-emitter voltage results in a rapid increase of the distortion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

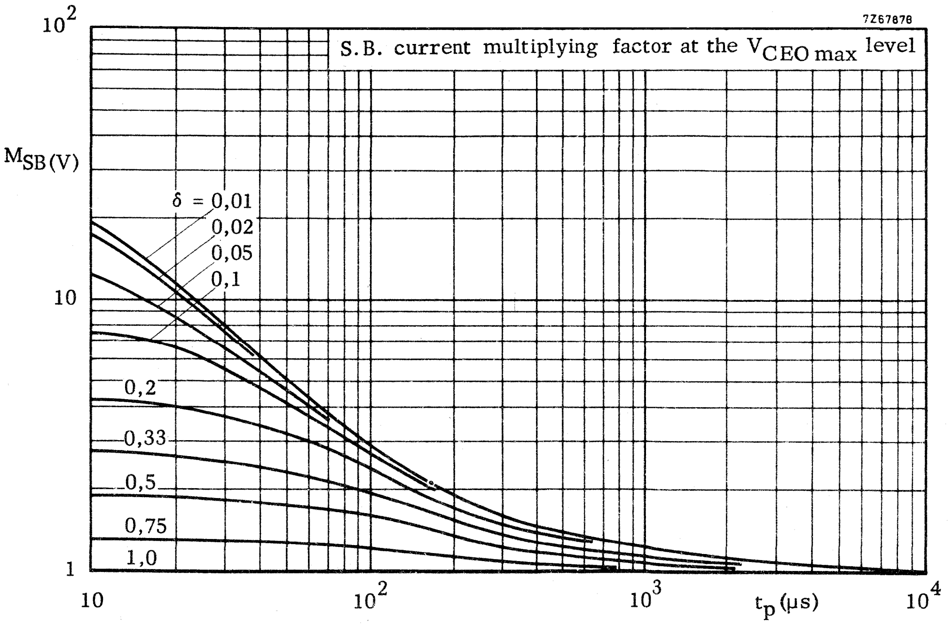
Transition frequency at f = 100 MHz				
I_C = 15 mA; V_{CE} = 10 V	f_T	typ.	90	MHz
Feedback capacitance at f = 1 MHz				
$I_E = 0$; V_{CB} = 30 V	C_{re}	<	3,5	pF
Output capacitance at f = 1 MHz				
$I_E = 0$; V_{CB} = 30 V	C_{oe}	<	4,5	pF

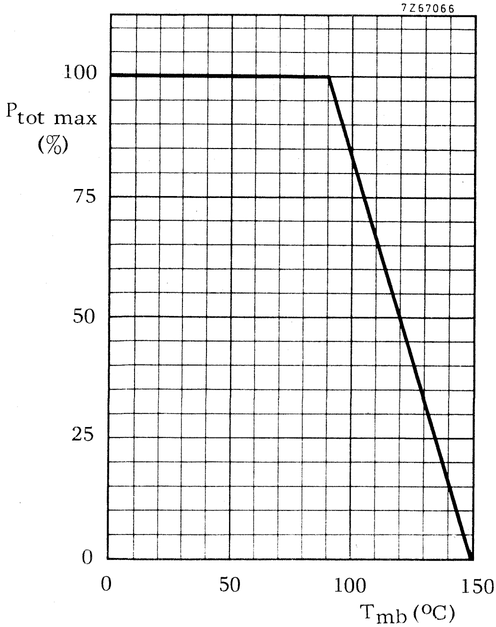


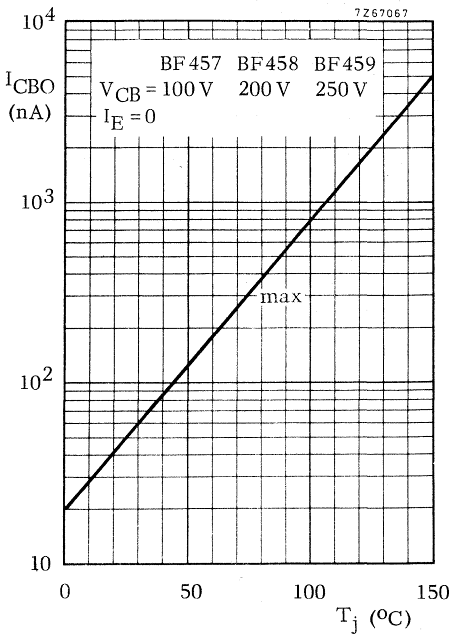
Safe Operating Area with the transistor forward biased




7Z67877
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
1,0
10^2
10
1
10
10^2
10^3
t_p (μs)
10^4


7Z67878
S.B. current multiplying factor at the $V_{CEO\,max}$ level
$M_{SB(V)}$
δ = 0,01
0,02
0,05
0,1
0,2
0,33
0,5
0,75
1,0
10^2
10
1
10
10^2
10^3
t_p (μs)
10^4


7Z67066
100
Ptot max
(%)
75
50
25
0
0
50
100
150
Tmb (°C)


7Z67067
10^4
ICBO
(nA)
BF457 BF458 BF459
VCB = 100 V 200 V 250 V
IE = 0
10^3
max
10^2
10
0
50
100
150
Tj (°C)

SILICON PLANAR TRANSISTOR

N-P-N transistor in a subminiature plastic T-package, primarily intended for application in r.f. stages of television tuners using p-i-n diode attenuators.

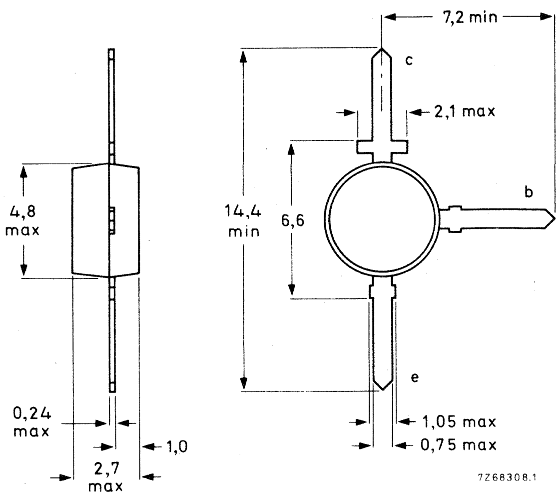
QUICK REFERENCE DATA

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} = 60 °C	P_{tot}	max	200	mW
Junction temperature	T_j	max	150	°C
Transition frequency, $-I_E$ = 10 mA; V_{CB} = 10 V	f_T	typ	2	GHz
Noise figure at optimum source admittance $-I_E$ = 10 mA, V_{CB} = 10 V, f = 800 MHz	F	typ	3,8	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)

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 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} = 60 °C	P_{tot}	max	200 mW

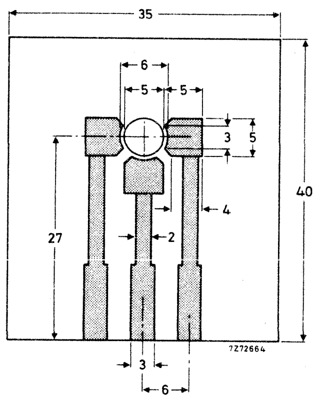
→ **Temperatures**

Storage temperature	T_s	−65 to +150 °C	
Junction temperature	T_j	max	150 °C

→ **THERMAL RESISTANCE**

From junction to ambient
mounted on the printed-circuit board
shown below, which is in free air $R_{th\ j\text{-}a}$ = 0,45 °C/mW

Dimensions in mm



Single-sided 35 µm Cu-clad epoxy fibre-glass printed-circuit board, thickness 1,5 mm.
Tracks are fully tin-lead plated. Board in horizontal position for R_{th} measurement.

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Base current

$-I_E$ = 10 mA; V_{CB} = 10 V	I_B	typ	350 μA
		<	750 μA

Emitter-base voltage

$-I_E$ = 10 mA; V_{CB} = 10 V	$-V_{EB}$	typ	0,8 V

Transition frequency at f = 500 MHz

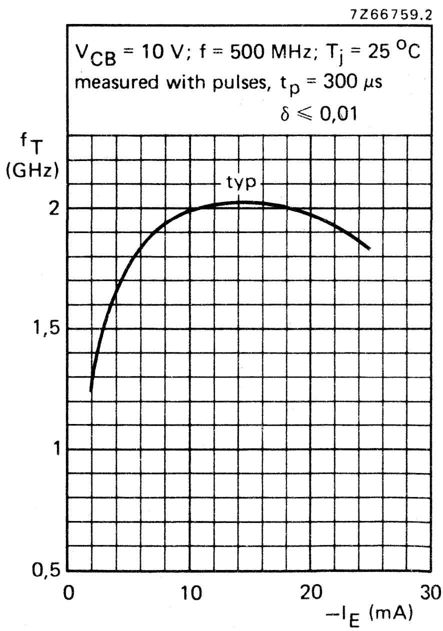
$-I_E$ = 10 mA; V_{CB} = 10 V	f_T	typ	2 GHz

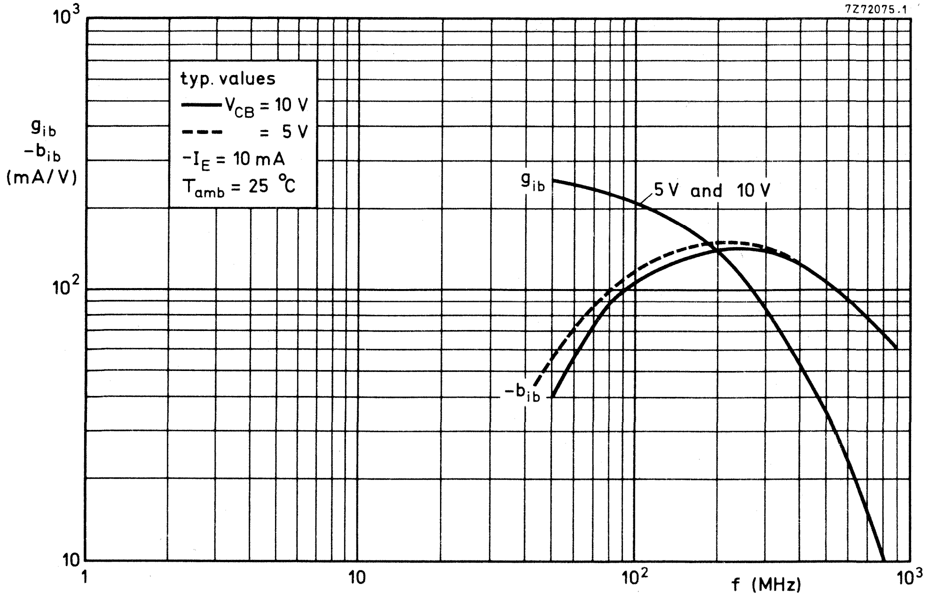
Noise figure at optimum source admittance (common base)

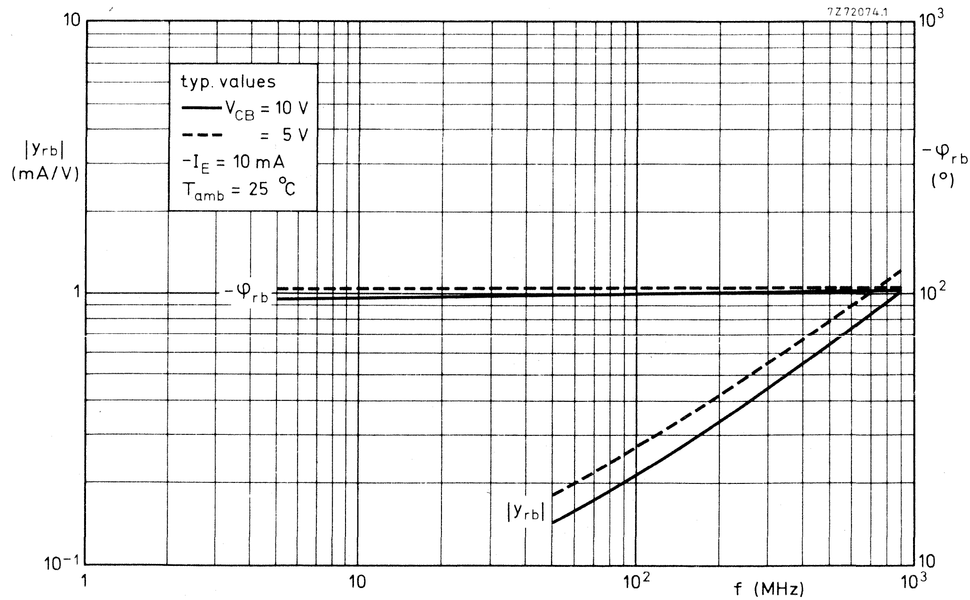
$-I_E$ = 10 mA; V_{CB} = 10 V; f = 800 MHz	F	typ	3,8 dB
$-I_E$ = 10 mA: V_{CB} = 10 V; f = 200 MHz	F	typ	2,9 dB

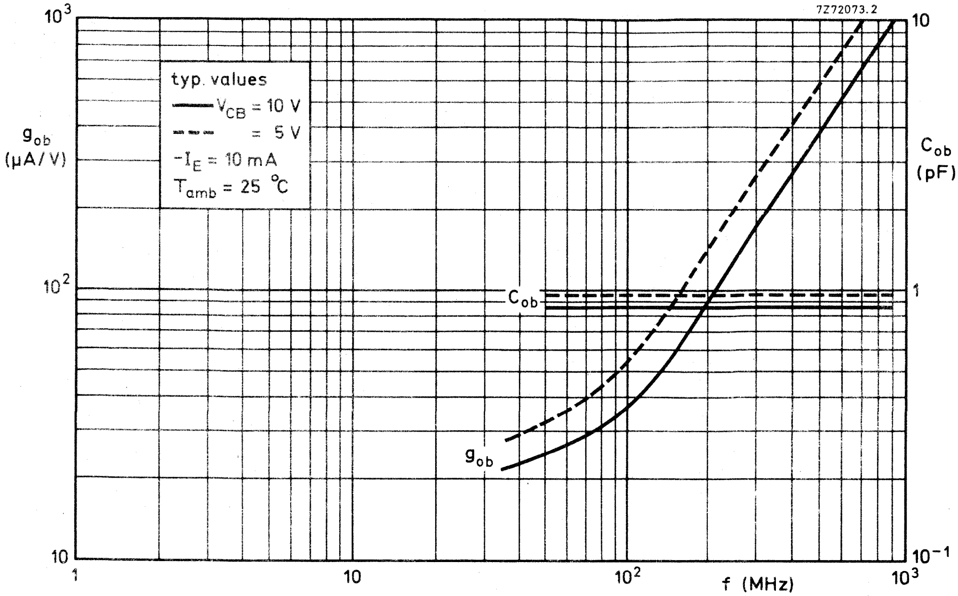
Transducer gain (common base)

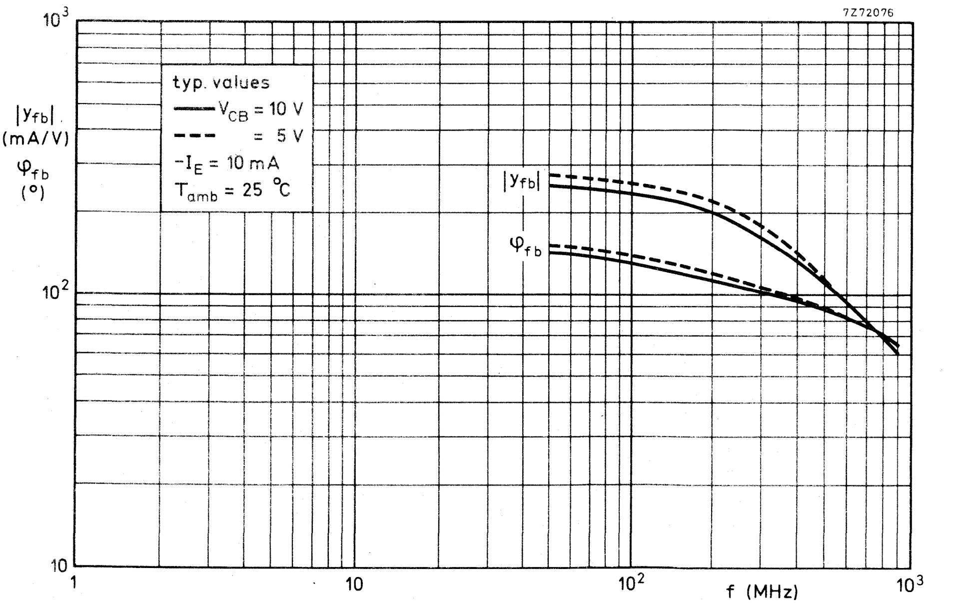
$-I_E$ = 10 mA; V_{CB} = 10 V; f = 900 MHz
G_s = 20 mA/V; B_s = 0
G_ℓ = 2 mA/V; B_ℓ = tuned — G_{tr} typ 15 dB



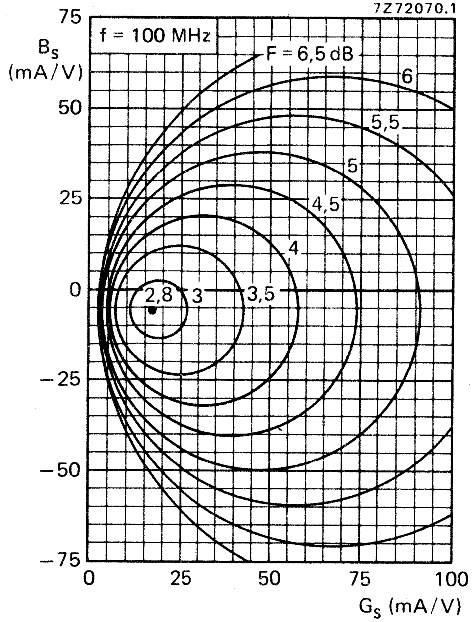

7Z72075.1
typ. values
V_{CB} = 10 V
= 5 V
$-I_E$ = 10 mA
T_{amb} = 25 °C
g_{ib}
$-b_{ib}$
(mA/V)
5 V and 10 V
f (MHz)

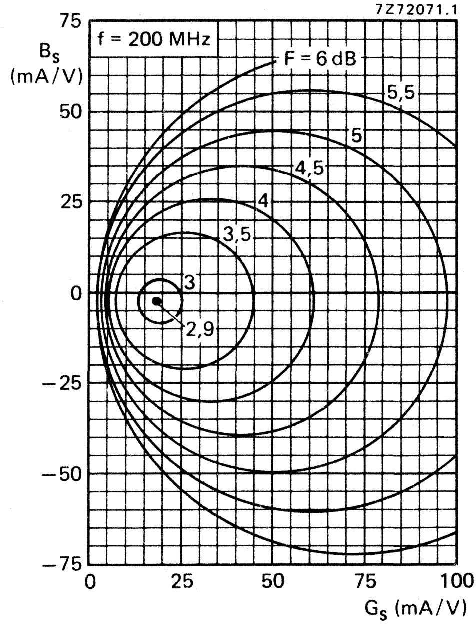

7Z72074.1
typ. values
V_{CB} = 10 V
= 5 V
$-I_E$ = 10 mA
T_{amb} = 25 °C
$|y_{rb}|$
(mA/V)
$-\varphi_{rb}$
(°)
f (MHz)

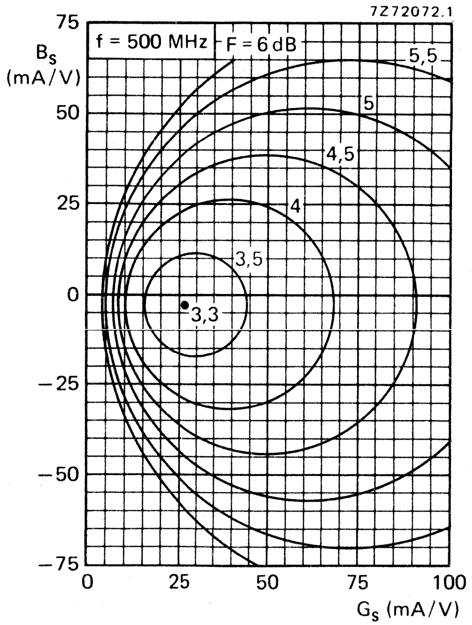

7Z72073.2
typ. values
VCB = 10 V
= 5 V
−IE = 10 mA
Tamb = 25 °C
gob
(μA/V)
Cob
(pF)
Cob
gob
10³
10²
10
10
1
10⁻¹
1
10
10²
10³
f (MHz)

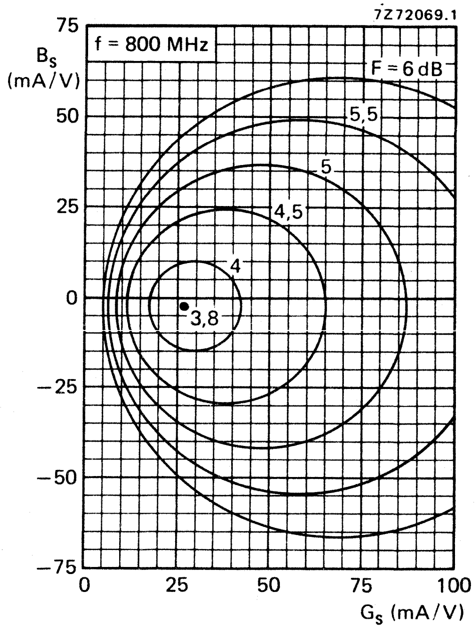

7Z72076
typ. values
VCB = 10 V
= 5 V
−IE = 10 mA
Tamb = 25 °C
|yfb|
(mA/V)
φfb
(°)
|yfb|
φfb
10³
10²
10
1
10
10²
10³
f (MHz)

Conditions for all four graphs: $-I_E$ = 10 mA; V_{CB} = 10 V; T_{amb} = 25 °C



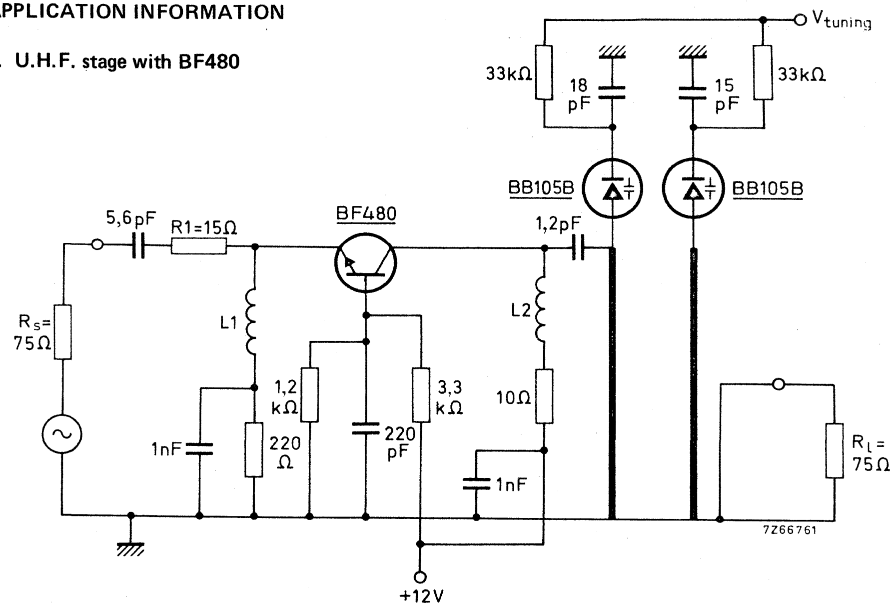






APPLICATION INFORMATION

1. U.H.F. stage with BF480



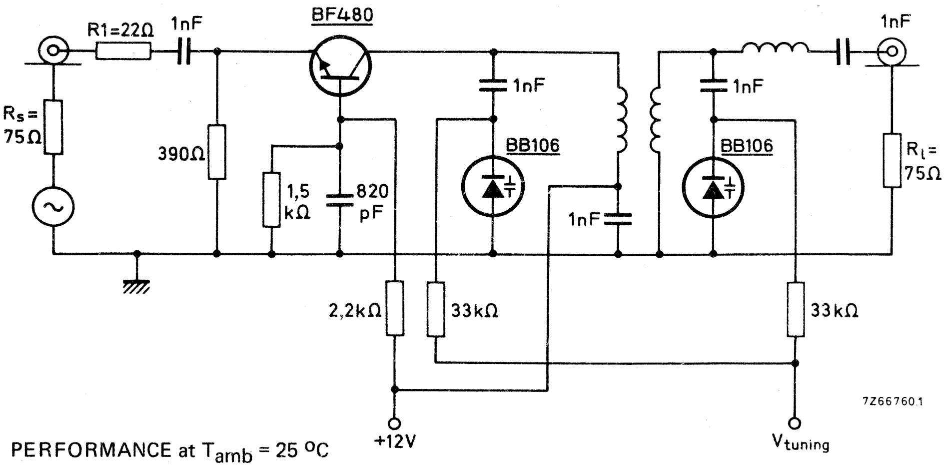
L_1 = 6 turns, Ø 3 mm
L_2 = 4,5 turns, Ø 3 mm

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	10	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 (See definition next page) Interference voltage for K = 1%	$V_{(int)rms}$	typ	300	mV

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 *				
Interference voltage for K = 1%	$V_{(int)rms}$	typ	330	mV

* 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.

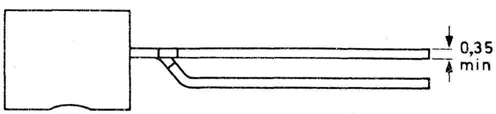
SILICON PLANAR EPITAXIAL TRANSISTOR

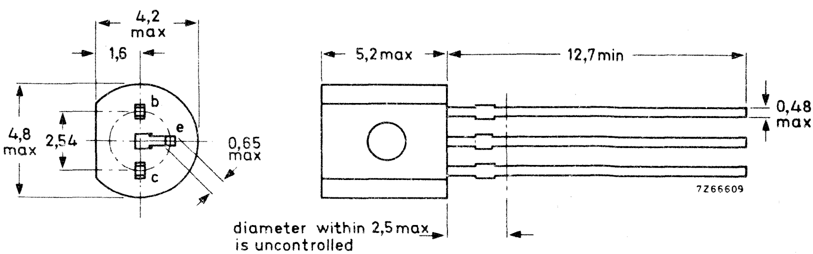
N-P-N transistor in a plastic TO-92 variant intended for h.f. applications in radio and television receivers; it is especially recommended for f.m. tuners, low noise a.m. mixer-oscillators with high source impedance and i.f. amplifiers in a.m./f.m. receivers where a high current gain is of importance.

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	$R_{th\ j\text{-}a}$	=	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_{rc}	typ.	0, 85	pF

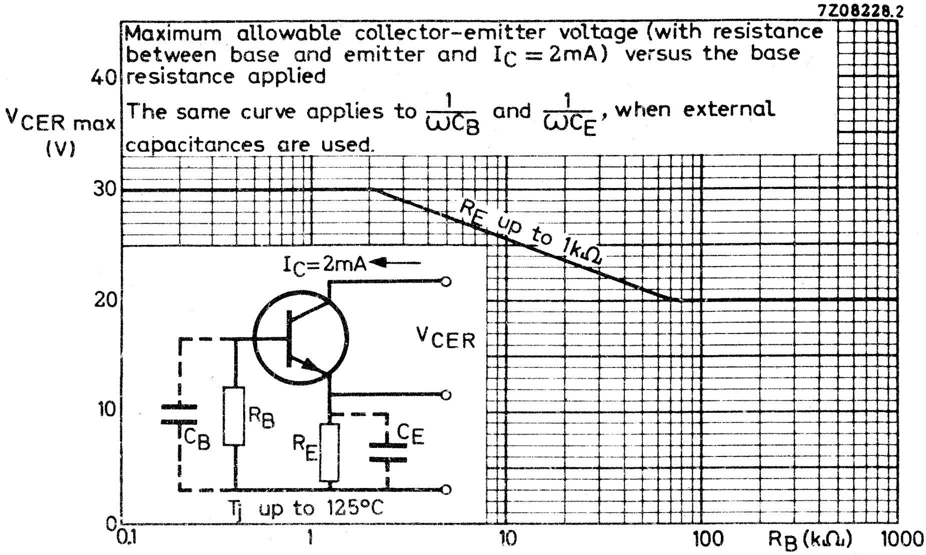
1) V_{BE} decreases by about 1, 7 mV/°C with increasing temperature.

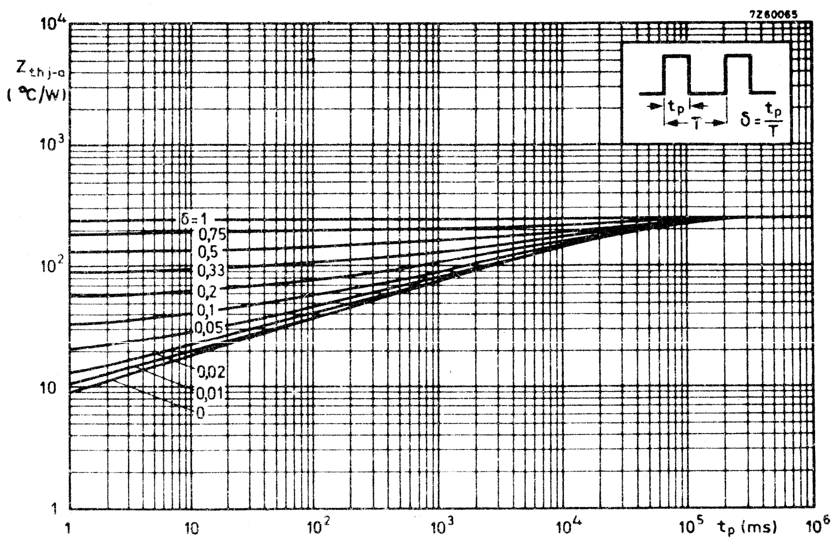
CHARACTERISTICS (continued) $T_j = 25\ ^oC$

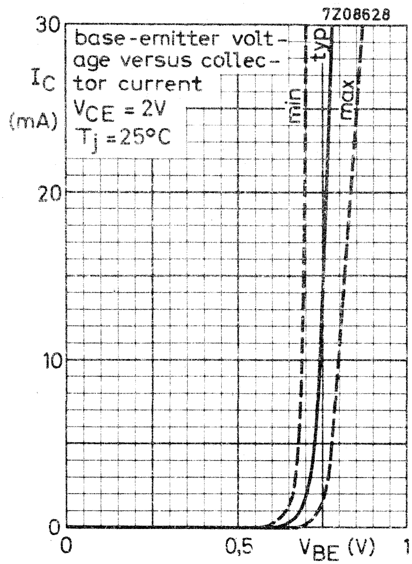
Transition frequency				
$I_C = 1$ mA; $V_{CE} = 10$ V	f_T	typ.	260	MHz
Noise figure				
$I_C = 1$ mA; $V_{CE} = 10$ V				
$G_S = 2$ mA/V; f = 0, 2 MHz	F	typ.	1, 5	dB
$G_S = 1,5$ mA/V; f = 1, 0 MHz	F	typ.	1, 2	dB
$G_S = 10$ mA/V; f = 100 MHz	F	typ.	4	dB
Conversion noise figure				
$I_C = 1$ mA; $V_{CE} = 10$ 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^o	
Transfer admittance	$\|y_{fb}\|$	typ.	33	mA/V
Phase angle of transfer admittance	φ_{fb}	typ.	150^o	
Output conductance	g_{ob}	typ.	22	μA/V
Output susceptance	b_{ob}	typ.	1, 1	mA/V

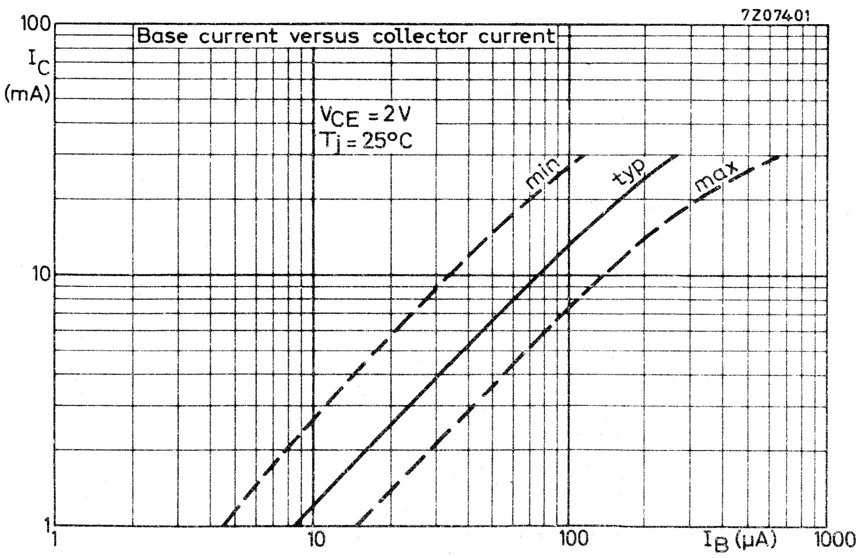
y parameters (common emitter)

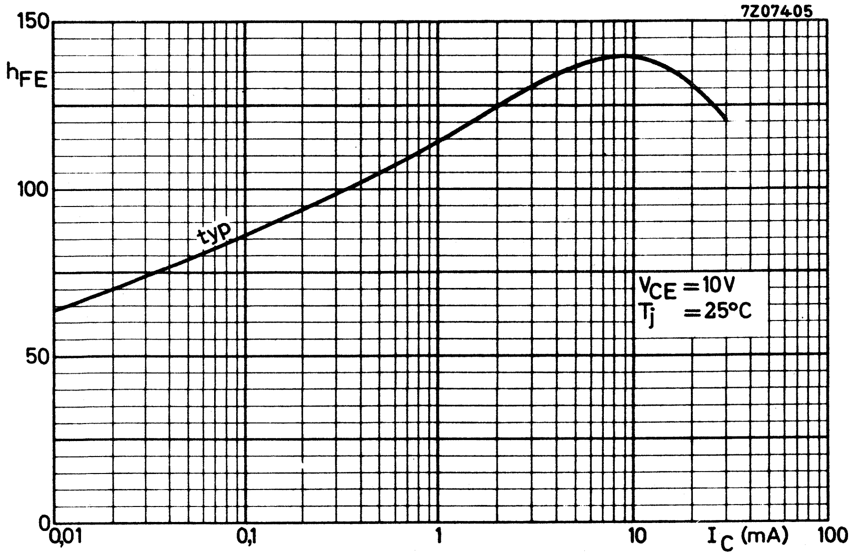
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)		f = 10, 7 MHz	f = 0, 45 MHz	
Input conductance	g_{ie}	< 0, 64	0, 54	mA/V
Output conductance	g_{oe}	< 13, 5	11, 5	μA/V


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)
40
30
20
10
0
RE up to 1kΩ
I_C=2mA
V_{CER}
R_B
C_B
R_E
C_E
T_j up to 125°C
0.1
1
10
100
R_B (kΩ)
1000

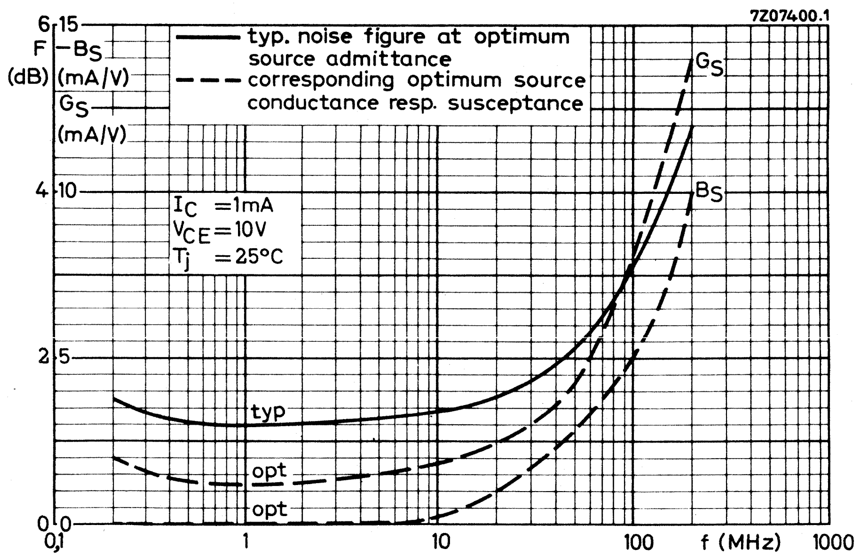

7Z60065
$Z_{th\,j-a}$ (°C/W)
10^4
10^3
10^2
10
1
δ=1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
0
t_p
T
$\delta = \frac{t_p}{T}$
1
10
10^2
10^3
10^4
10^5
t_p (ms)
10^6


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

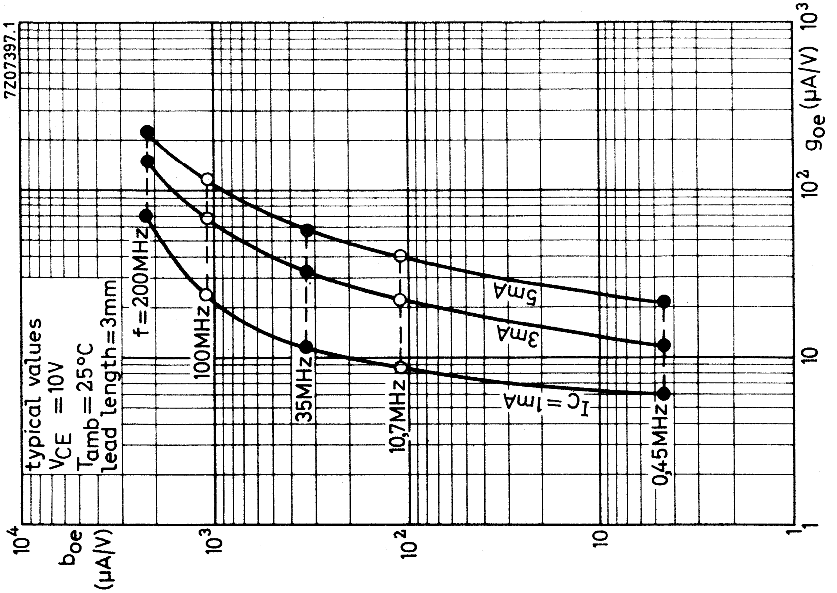

7Z07401
Base current versus collector current
V_{CE} = 2V
T_j = 25°C
I_C (mA)
100
10
1
min
typ
max
1
10
100
I_B (μA)
1000

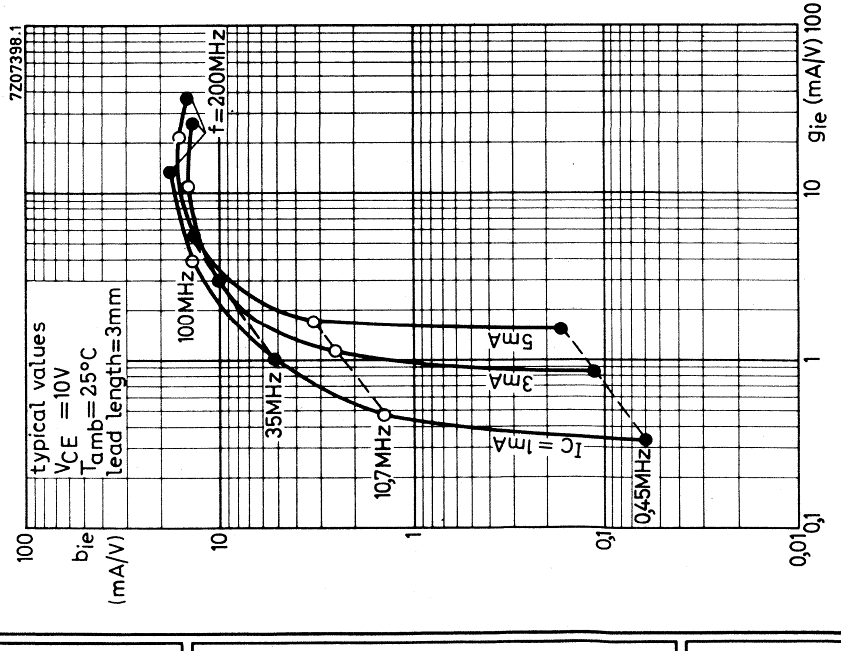


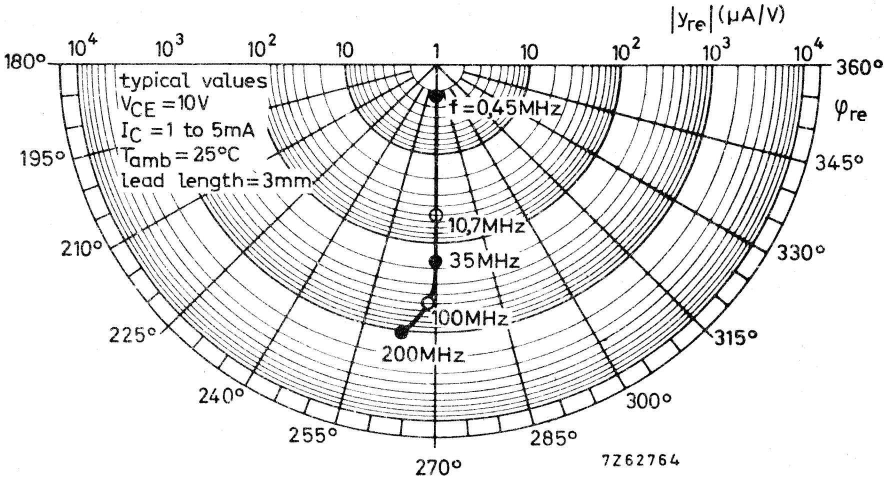
7Z07405
150
h_{FE}
100
typ
50
0
V_{CE} = 10 V
T_j = 25°C
0,01
0,1
1
10
I_C (mA)
100

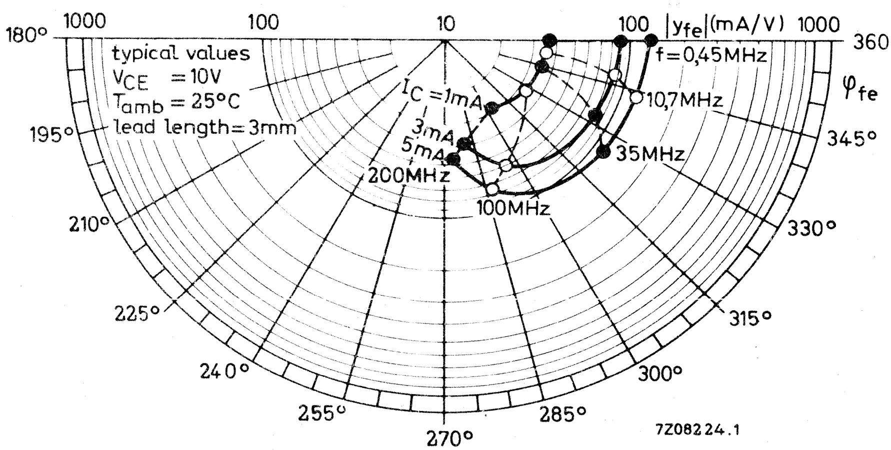


7Z07400.1
6
15
F
(dB)
$-B_S$
(mA/V)
G_S
(mA/V)
typ. noise figure at optimum source admittance
corresponding optimum source conductance resp. susceptance
4
10
I_C = 1 mA
V_{CE} = 10 V
T_j = 25°C
2
5
0
0
typ
opt
opt
G_S
B_S
0,1
1
10
100
f (MHz)
1000


7Z07397.1
typical values
V_{CE} =10V
T_{amb}=25°C
lead length=3mm
f=200MHz
100MHz
35MHz
10,7MHz
0,45MHz
I_C = 1mA
3mA
5mA
b_{oe} (μA/V)
10^4
10^3
10^2
10
1
g_{oe} (μA/V)
10^3
10^2
10
1


7Z07398.1
typical values
V_{CE} =10V
T_{amb}=25°C
lead length=3mm
f=200MHz
100MHz
35MHz
10,7MHz
0,45MHz
I_C = 1mA
3mA
5mA
b_{ie} (mA/V)
100
10
1
0,1
0,01
g_{ie} (mA/V)
100
10
1
0,1


|yre| (μA/V)
180°
10^4
10^3
10^2
10
1
10
10^2
10^3
10^4
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


180°
1000
100
10
100
|yfe| (mA/V)
1000
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

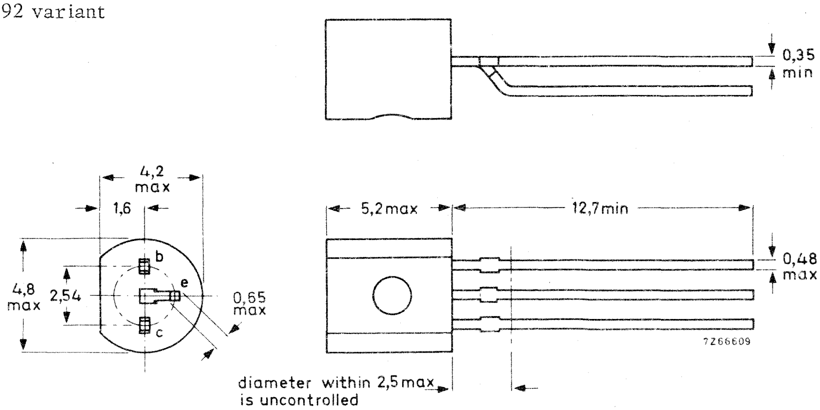
SILICON PLANAR EPITAXIAL TRANSISTOR

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

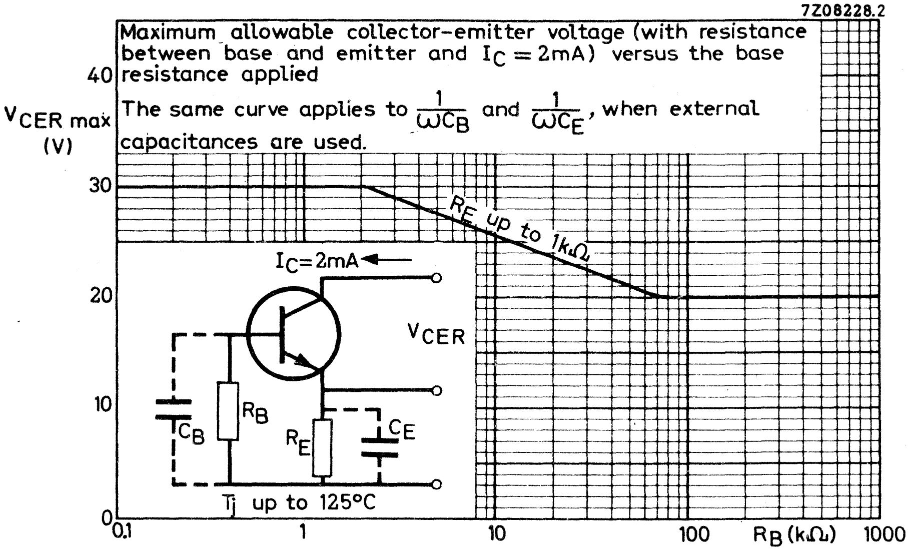
1) V_{BE} decreases by about 1, 7 mV/°C with increasing temperature.

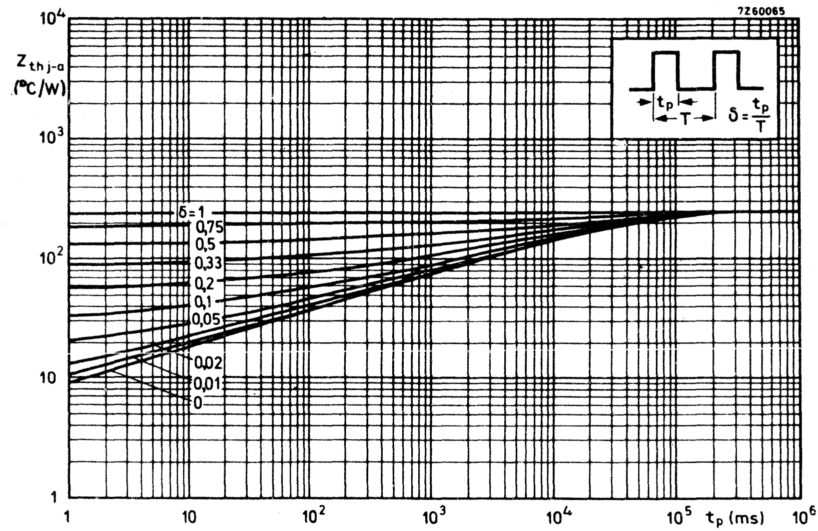
CHARACTERISTICS (continued) $T_j = 25\ ^oC$

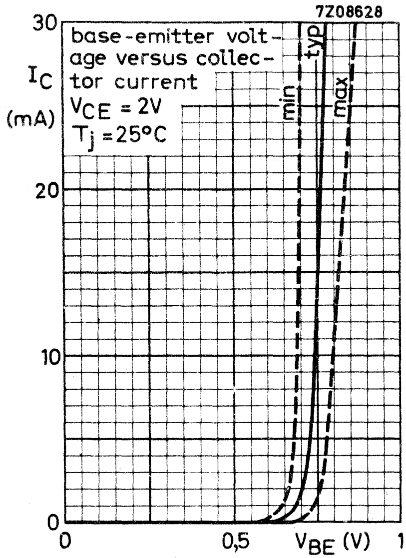
Transition frequency				
$I_C = 1$ mA; $V_{CE} = 10$ V	f_T	typ.	200	MHz
Noise figure				
$I_C = 1$ mA; $V_{CE} = 10$ V				
$G_S = 20$ mA/V; f = 1 MHz	F	typ.	3,5	dB
$G_S = 10$ mA/V; f = 100 MHz	F	typ.	4	dB
Conversion noise figure				
$I_C = 1$ mA; $V_{CE} = 10$ V				
$G_S = 1,2$ mA/V; f = 0,2 MHz	F_c	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

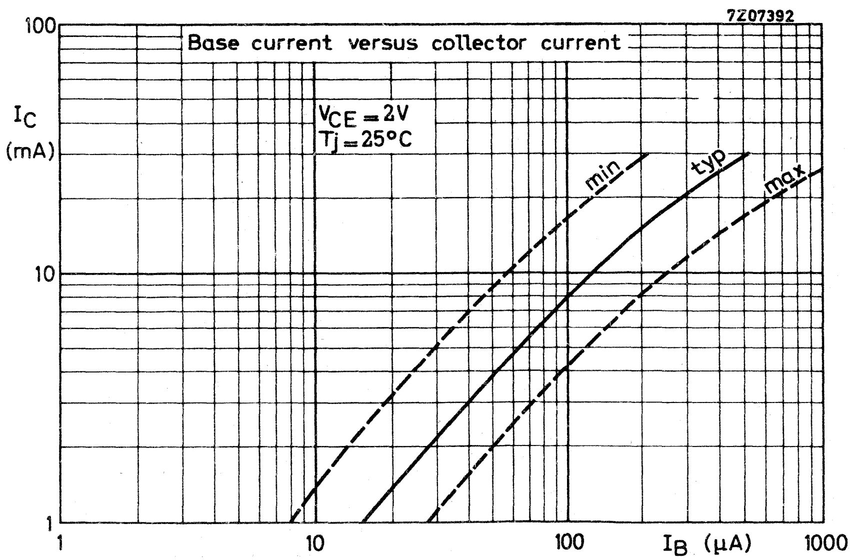
y parameters (common emitter)

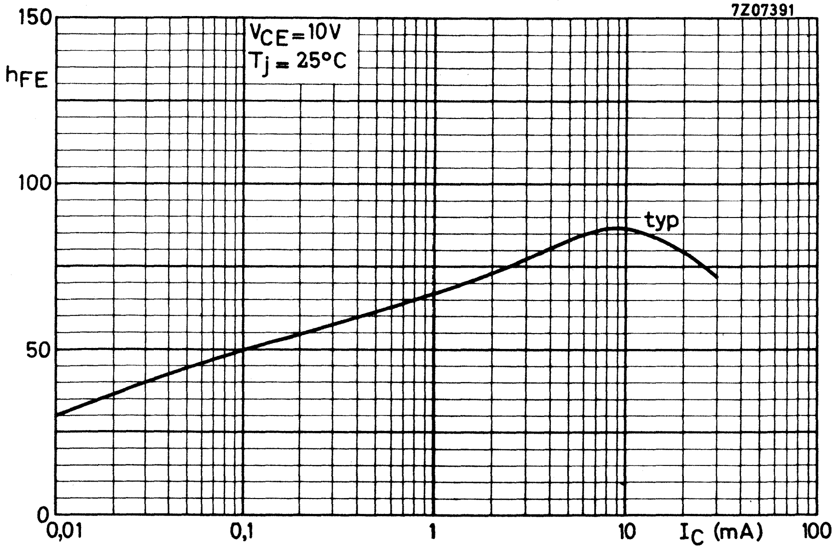
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)		f = 10,7 MHz	f = 0,45 MHz	
Input conductance	g_{ie}	< 0,96	0,86	mA/V
Output conductance	g_{oe}	< 9,5	7,0	µA/V

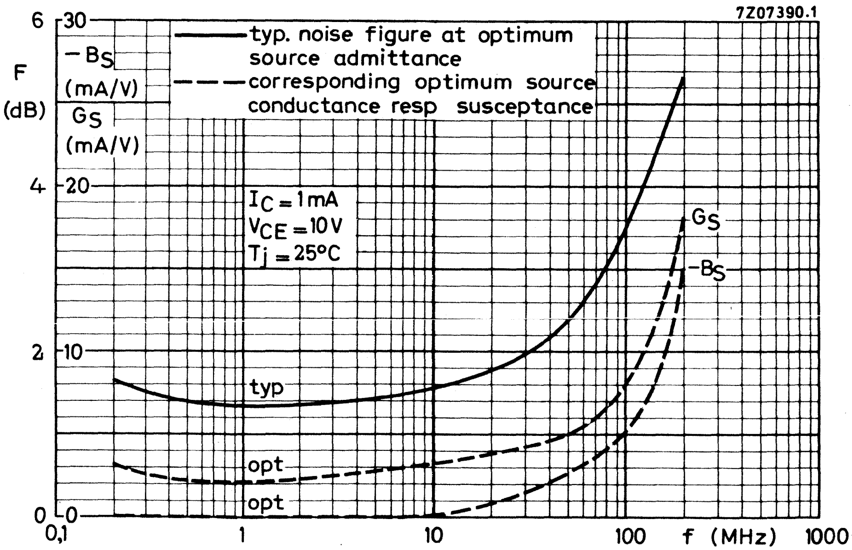

7Z08228.2
Maximum allowable collector-emitter voltage (with resistance between base and emitter and $I_C = 2mA$) versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$, when external capacitances are used.
$V_{CER\,max}$ (V)
RE up to 1kΩ
$I_C=2mA$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

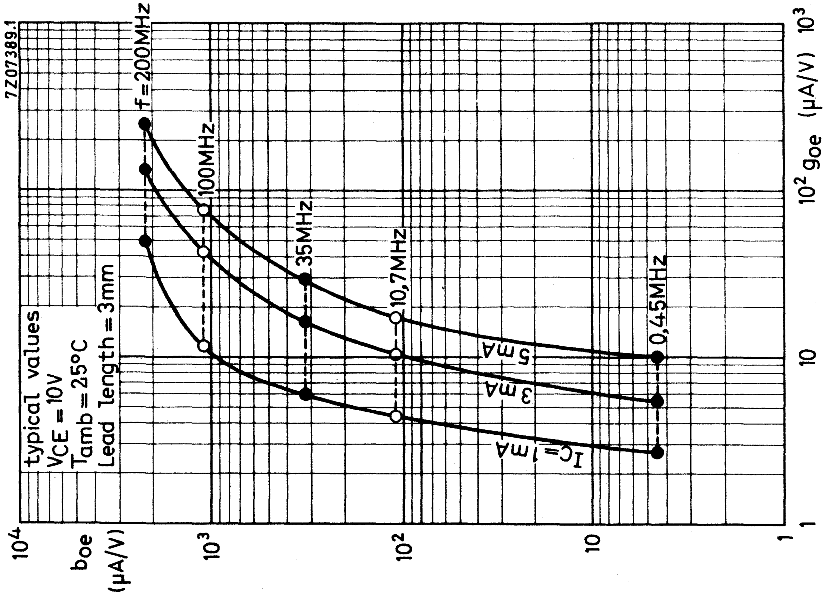

7Z60065
$Z_{th\,j-a}$ (°C/W)
t_p
T
$\delta = \frac{t_p}{T}$
δ=1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
0
t_p (ms)
1
10
10^2
10^3
10^4
10^5
10^6

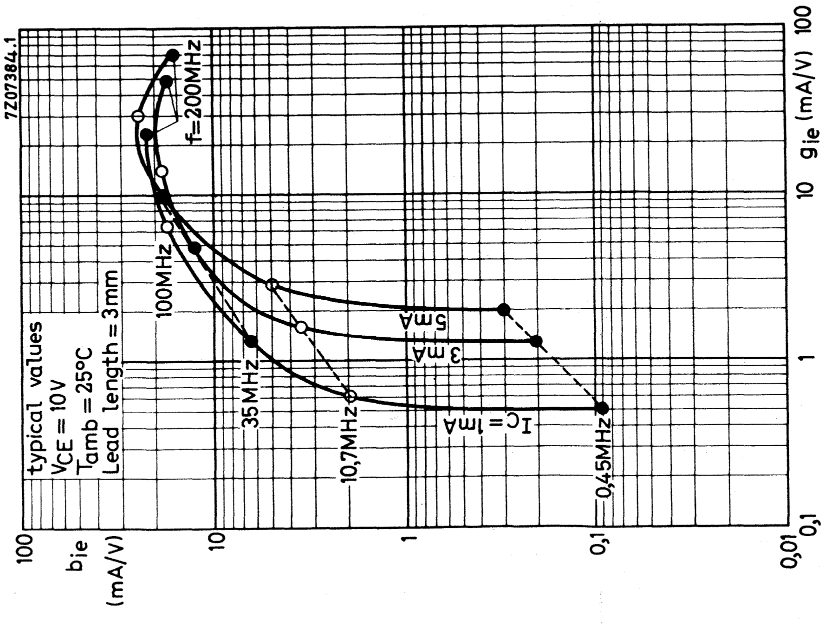

7Z08628
base-emitter voltage versus collector current
V_{CE} = 2V
T_j = 25°C
I_C (mA)
30
20
10
0
0
0,5
V_{BE} (V)
1
min
typ
max

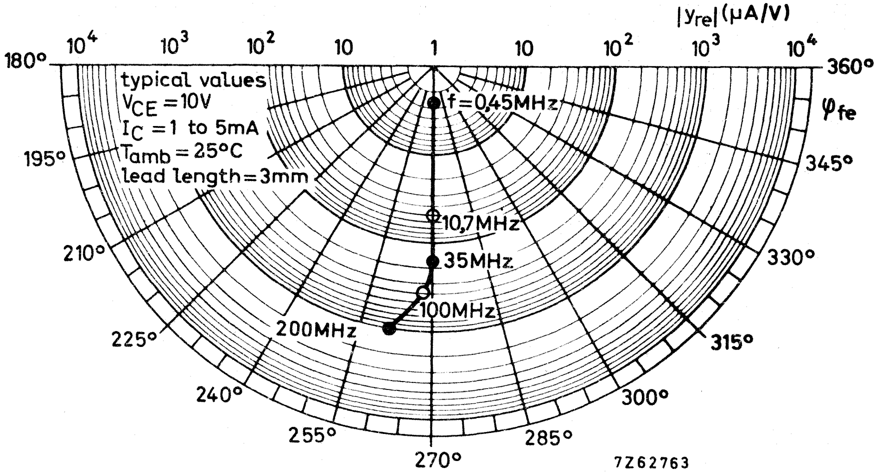

7Z07392
Base current versus collector current
V_{CE} = 2V
T_j = 25°C
I_C (mA)
100
10
1
1
10
100
I_B (μA)
1000
min
typ
max


7Z07391
h_{FE}
150
100
50
0
$V_{CE} = 10V$
$T_j = 25°C$
typ
0,01
0,1
1
10
I_C (mA)
100

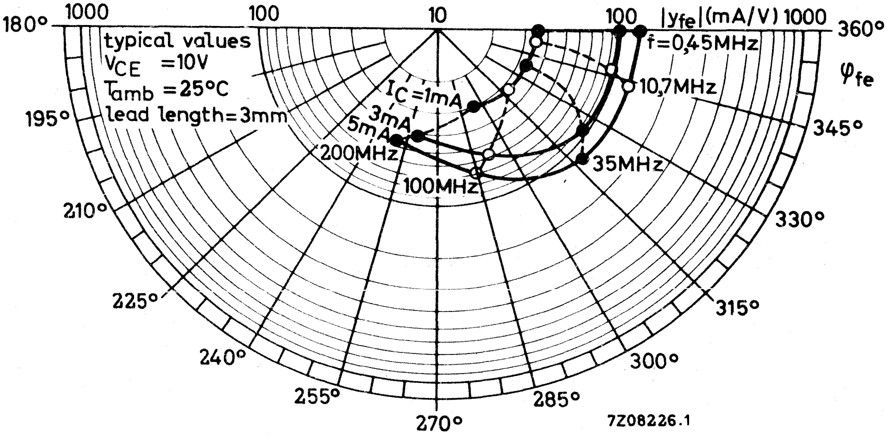

7Z07390.1
F (dB)
$-B_S$ (mA/V)
G_S (mA/V)
6
4
2
0
30
20
10
0
typ. noise figure at optimum source admittance
corresponding optimum source conductance resp susceptance
$I_C = 1mA$
$V_{CE} = 10V$
$T_j = 25°C$
typ
opt
opt
G_S
$-B_S$
0,1
1
10
100
f (MHz)
1000


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 = 1mA
b_{oe} (μA/V)
10^4
10^3
10^2
10
1
g_{oe} (μA/V)
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)
100
10
1
0,1
0,01
g_{ie} (mA/V)
0,1
1
10
100



|y_re| (µA/V)
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_fe
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
7Z62763



1000 100 10 100 |y_fe| (mA/V) 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
7Z08226.1

SILICON PLANAR EPITAXIAL TRANSISTOR

P-N-P 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.

N-P-N complement is BFR91.

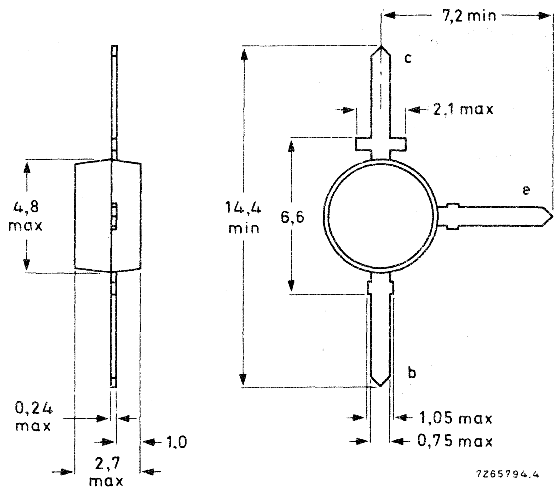
QUICK REFERENCE DATA

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	C_{re}	typ.	0,8	pF
Noise figure at optimum source impedance $-I_C$ = 2 mA; $-V_{CE}$ = 5 V; f = 500 MHz	F	typ.	2,4	dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-37



RATINGS

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

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	V
Collector current (d.c.)	$-I_C$	max.	35	mA
Collector current (peak value) at f > 1 MHz	$-I_{CM}$	max.	50	mA
Total power dissipation up to T_{amb} = 60 °C	P_{tot}	max.	180	mW
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 fibre-glass print of 40 mm x 25 mm x 1 mm	$R_{th\ j\text{-}a}$	=	0,5	°C/mW

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

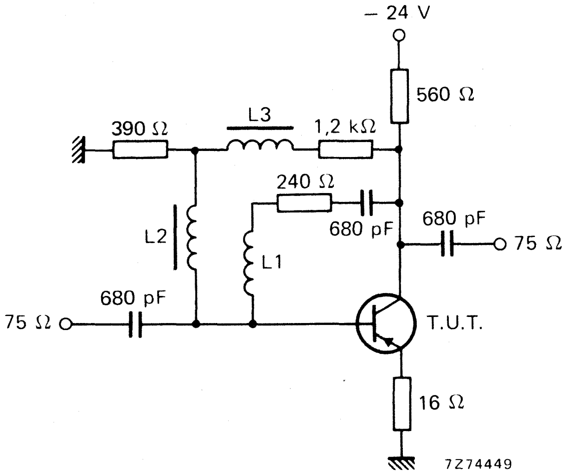
Collector cut-off current $I_E = 0; -V_{CB} = 5$ V	$-I_{CBO}$	<	50	nA
D.C. current gain $-I_C = 30$ mA; $-V_{CE} = 5$ V	h_{FE}	>	20	*
Transition frequency f = 500 MHz; $-I_C = 30$ mA; $-V_{CE} = 5$ V	f_T	typ.	5	GHz *
Collector capacitance f = 1 MHz; $I_E = I_e = 0; -V_{CB} = 5$ V	C_c	typ.	0,85	pF
Emitter capacitance f = 1 MHz; $I_C = I_c = 0; -V_{EB} = 0{,}5$ V	C_e	typ.	1,8	pF
Feedback capacitance f = 1 MHz; $-I_C = 2$ mA; $-V_{CE} = 5$ V	C_{re}	typ.	0,8	pF
Noise figure at optimum source impedance $-I_C = 2$ mA; $-V_{CE} = 5$ V; f = 500 MHz	F	typ.	2,4	dB

Maximum unilateral power gain
s_{re} assumed to be zero
$-I_C = 30$ mA; $-V_{CE} = 5$ V; f = 500 MHz

$$10 \log \frac{|s_{fe}|^2}{(1-|s_{ie}|^2)(1-|s_{oe}|^2)} = G_{UM} \quad \text{typ.} \quad 16{,}5 \text{ dB}$$

* Measured under pulse conditions.

Intermodulation distortion (see Fig. 2)
$-I_C = 30$ mA; $-V_{CE} = 5$ V; $R_L = 75\ \Omega$; VSWR < 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 *



L1: 4 turns Cu wire (0,35); winding pitch 1 mm; internal diameter 4 mm.
L2 and L3: 5 μH (code number 3122 108 20150)

Fig. 2 Intermodulation distortion test circuit.

* Measured under pulse conditions.

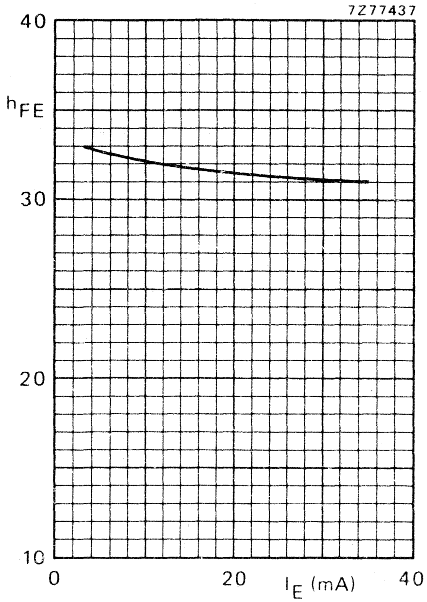


Fig. 3 Typical values; V_{CB} = 4 V.

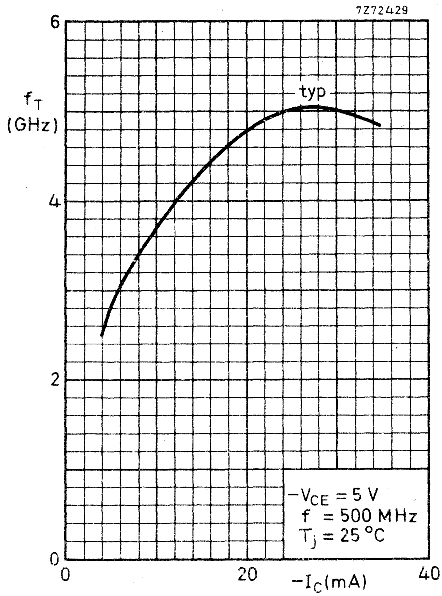


Fig. 4.

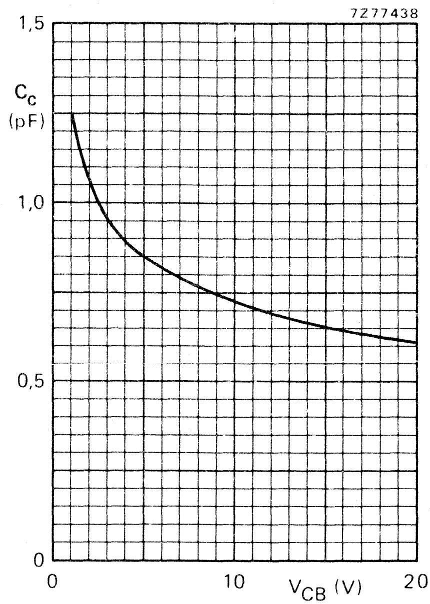


Fig. 5 Typical values; f = 1 MHz.

SILICON PLANAR EPITAXIAL TRANSISTOR

P-N-P transistor in a TO-72 metal envelope with insulated electrodes and a shield lead connected to the case. 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.

N-P-N complement is BFQ22.

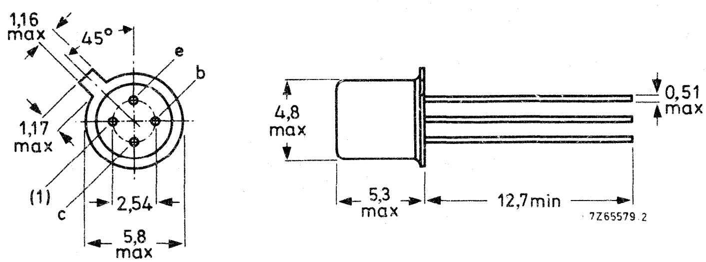
QUICK REFERENCE DATA

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.	150	mW
Junction temperature	T_j	max.	200	°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	C_{re}	typ.	0,6	pF
Noise figure at optimum source impedance $-I_C$ = 2 mA; $-V_{CE}$ = 5 V; f = 500 MHz	F	typ.	2,4	dB

MECHANICAL DATA

Dimensions in mm

Fig. 1 TO-72 with insulated electrodes.



(1) shield lead connected to case.

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

RATINGS

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

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	V
Collector current (d.c.)	$-I_C$	max.	35	mA
Collector current (peak value) at f > 1 MHz	$-I_{CM}$	max.	50	mA
Total power dissipation up to T_{amb} = 60 °C	P_{tot}	max.	150	mW
Storage temperature	T_{stg}	−65 to +	200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0,9	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0,6	°C/mW

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

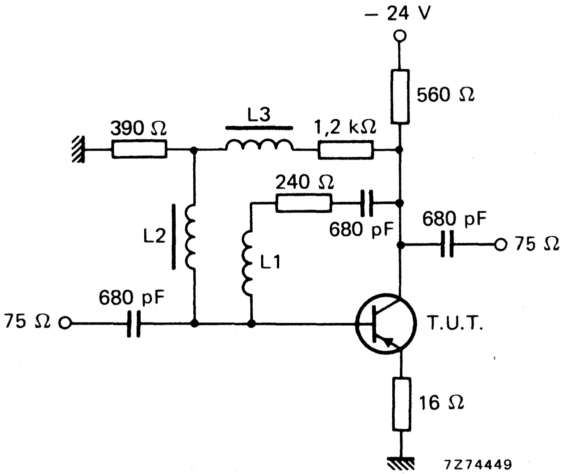
Collector cut-off current $I_E = 0$; $-V_{CB} = 5$ V	$-I_{CBO}$	<	50	nA
D.C. current gain (note 1) $-I_C = 30$ mA; $-V_{CE} = 5$ V	h_{FE}	>	20	
Transition frequency (note 1) f = 500 MHz; $-I_C = 30$ mA; $-V_{CE} = 5$ V	f_T	typ.	5	GHz
Collector capacitance (note 2) f = 1 MHz; $I_E = I_e = 0$; $-V_{CB} = 5$ V	C_c	typ.	1	pF
Emitter capacitance f = 1 MHz; $I_C = I_c = 0$; $-V_{EB} = 0,5$ V	C_e	typ.	1,8	pF
Feedback capacitance (note 3) f = 1 MHz; $-I_C = 2$ mA; $-V_{CE} = 5$ V	C_{re}	typ.	0,8	pF
Optimum source impedance noise figure (note 3) $-I_C = 2$ mA; $-V_{CE} = 5$ V; f = 500 MHz	F	typ.	2,4	dB

Maximum unilateral power gain (notes 3 and 4)
s_{re} assumed to be zero
$-I_C = 30$ mA; $-V_{CE} = 5$ V; f = 500 MHz

$$10 \log \frac{|s_{fe}|^2}{(1-|s_{ie}|^2)(1-|s_{oe}|^2)} = G_{UM} \quad \text{typ.} \quad 16,5 \text{ dB}$$

For the notes see page 3.

Intermodulation distortion (notes 1 and 4) see also Fig. 2
$-I_C = 30$ mA; $-V_{CE} = 5$ V; $R_L = 75\ \Omega$; VSWR < 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



L1: 4 turns Cu wire (0,35); winding pitch 1 mm; internal diameter 4 mm.
L2 and L3: 5 μH (code number 3122 108 20150).

Fig. 2 Intermodulation distortion test circuit; crystal mounted in a SOT-37 envelope.

Notes
1. Measured under pulse conditions.
2. Shield lead not connected.
3. Shield lead grounded.
4. Crystal mounted in a SOT-37 encapsulation (BFQ23).

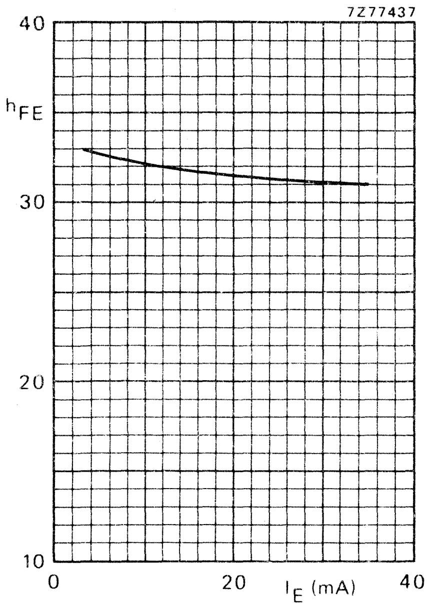


Fig. 3 Typical values; V_{CB} = 4 V.

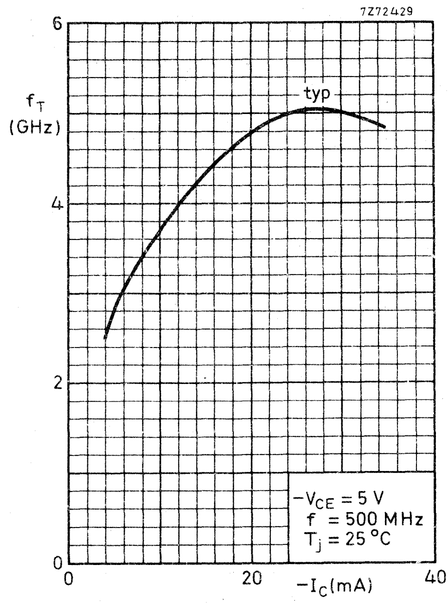


Fig. 4.

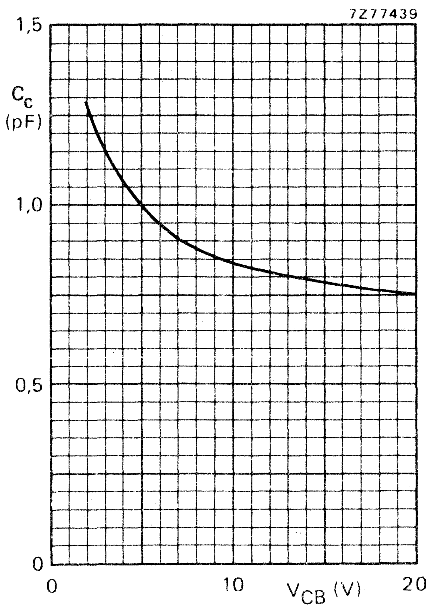


Fig. 5 Typical values; f = 1 MHz.

SILICON PLANAR EPITAXIAL TRANSISTOR

P-N-P transistor in a subminiature plastic transfer-moulded T-package.

It is intended for use in u.h.f. applications such as broadband aerial amplifiers (30 MHz to 860 MHz) and in microwave amplifiers such as radar systems, spectrum analysers etc.

The BFQ32 offers a high transition frequency and a low intermodulation distortion figure over a wide current range.

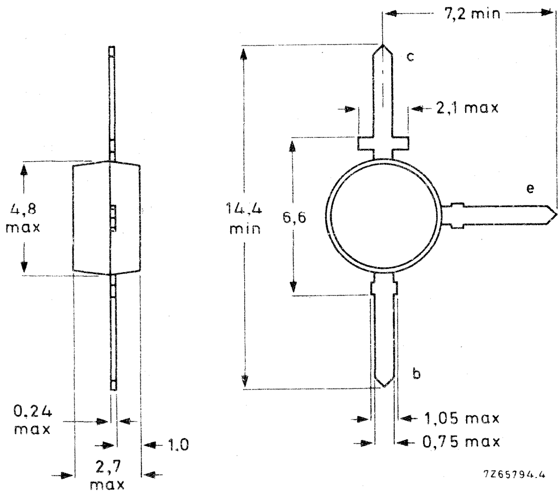
QUICK REFERENCE DATA

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	75	mA
Total power dissipation up to T_{amb} = 60 °C	P_{tot}	max	500	mW
Junction temperature	T_j	max	175	°C
Transition frequency at f = 500 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 10 V	f_T	>	3,6	GHz
Feedback capacitance at f = 1 MHz $-I_C$ = 10 mA; $-V_{CE}$ = 10 V	C_{re}	<	1,4	pF
Noise figure at optimum source impedance $-I_C$ = 50 mA; $-V_{CE}$ = 10 V; f = 500 MHz; T_{amb} = 25 °C	F	typ	3,75	dB
Intermodulation distortion at T_{amb} = 25 °C $-I_C$ = 50 mA; $-V_{CE}$ = 10 V; R_L = 75 Ω; V_o = 500 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 (IEC 134)

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	3	V
Collector current (d.c.)	$-I_C$	max	75	mA
Collector current (peak value); f > 1 MHz	$-I_{CM}$	max	150	mA
Total power dissipation up to T_{amb} = 60 °C mounted on a fibre-glass print of 40 mm x 25 mm x 1 mm	P_{tot}		500	mW
Storage temperature	T_{stg}	−65 to + 175		°C
Junction temperature	T_j	max	175	°C

THERMAL RESISTANCE

From junction to ambient in free air mounted on a fibre-glass print of 40 mm x 25 mm x 1 mm	$R_{th\ j\text{-}a}$	=	0,23	°C/mW

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Collector cut-off current $I_E = 0; -V_{CB} = 10$ V	$-I_{CBO}$	<	100	nA
D.C. current gain * $-I_C = 50$ mA; $-V_{CE} = 10$ V	h_{FE}	>	20	
$-I_C = 75$ mA; $-V_{CE} = 10$ V	h_{FE}	>	20	
Transition frequency at f = 500 MHz * $-I_C = 50$ mA; $-V_{CE} = 10$ V	f_T	>	3,6	GHz
		typ	4,2	GHz
$-I_C = 75$ mA; $-V_{CE} = 10$ V	f_T	>	4,0	GHz
		typ	4,6	GHz
Collector capacitance at f = 1 MHz $I_E = I_e = 0; -V_{CB} = 10$ V	C_c	typ	1,3	pF
Emitter capacitance at f = 1 MHz $I_C = I_c = 0; -V_{EB} = 0,5$ V	C_e	typ	6	pF
Feedback capacitance at f = 1 MHz $-I_C = 10$ mA; $-V_{CE} = 10$ V	C_{re}	<	1,4	pF
		typ	1,25	pF

* Measured under pulse conditions.

Noise figure at optimum source impedance

$-I_C$ = 50 mA; $-V_{CE}$ = 10 V; f = 500 MHz	F	typ	3,75 dB

Maximum unilateral power gain (s_{re} assumed to be zero)

$$G_{UM} \text{ (in dB)} = 10 \log \frac{|s_{fe}|^2}{(1-|s_{ie}|^2)(1-|s_{oe}|^2)}$$

$-I_C$ = 50 mA; $-V_{CE}$ = 10 V; f = 500 MHz	G_{UM}	typ	14 dB

Intermodulation distortion (see fig. 1)

$-I_C$ = 50 mA; $-V_{CE}$ = 10 V; R_L = 75 Ω

$V_p = V_o$ = 500 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

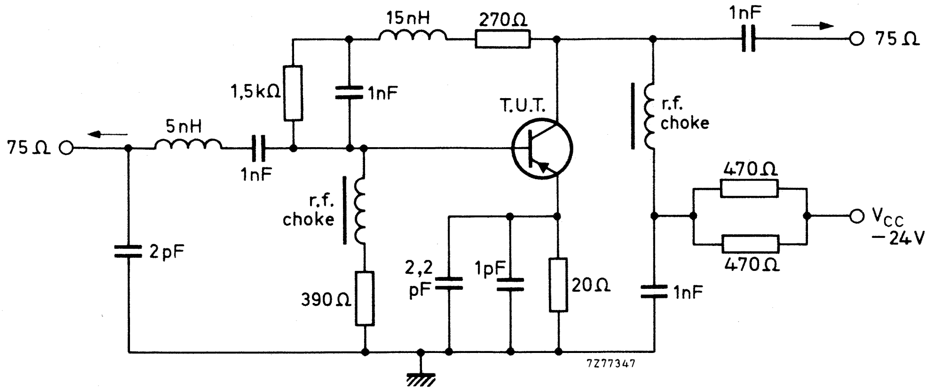
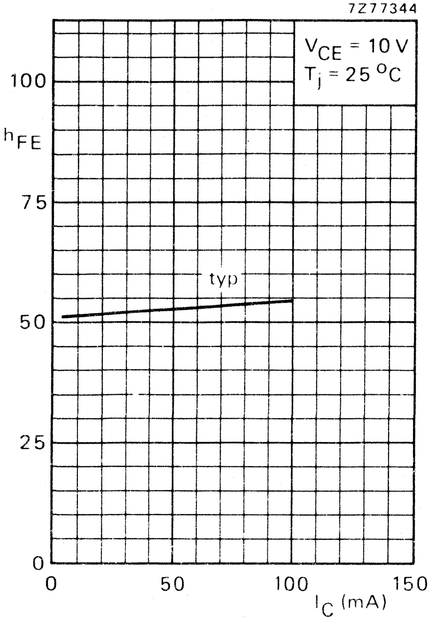
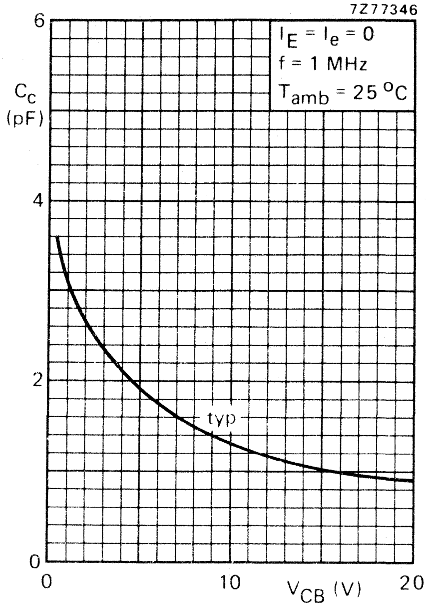
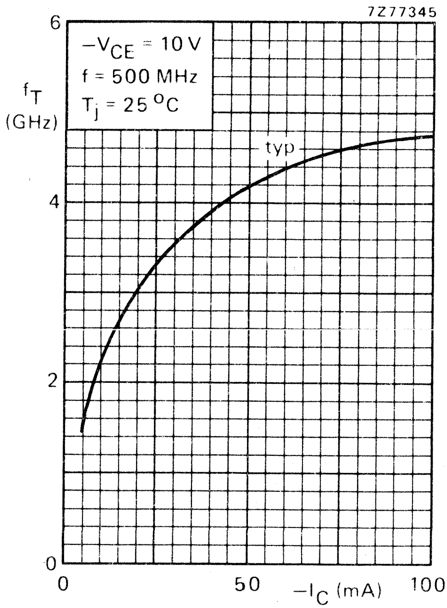


Fig. 1 Intermodulation test circuit.


7Z77344
V_{CE} = 10 V
T_j = 25 °C
h_{FE}
100
75
50
25
0
typ
0
50
100
150
I_C (mA)


7Z77346
I_E = I_e = 0
f = 1 MHz
T_{amb} = 25 °C
C_c (pF)
6
4
2
0
typ
0
10
20
V_{CB} (V)


7Z77345
$-V_{CE}$ = 10 V
f = 500 MHz
T_j = 25 °C
f_T (GHz)
6
4
2
0
typ
0
50
100
$-I_C$ (mA)

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a ¼″ capstan envelope with a ceramic cap primarily intended for MATV purposes.

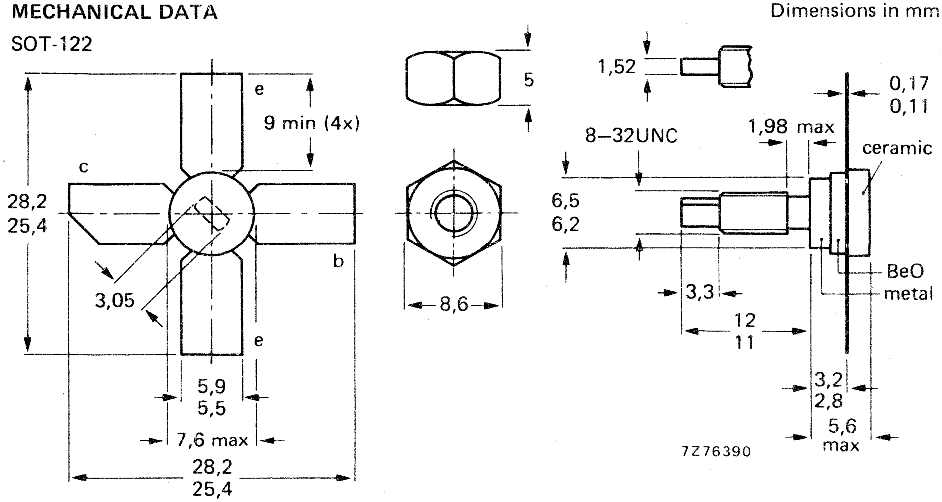
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max	25	V
Collector-emitter voltage (open base)	V_{CEO}	max	18	V
Collector current (d.c.)	I_C	max	150	mA
Total power dissipation (d.c.) up to T_{mb} = 125 °C	P_{tot}	max	2,25	W
Operating junction temperature	T_j	max	200	°C
Transition frequency I_C = 150 mA; V_{CE} = 15 V; T_j = 25 °C	f_T	>	3,5	GHz
Intermodulation distortion at T_{amb} = 25 °C I_C = 120 mA; V_{CE} = 15 V; R_L = 75 Ω; V_o = 1,2 V $f_{(p+q-r)}$ = 793,25 MHz (see page 3)	d_{im}	typ	−60	dB

MECHANICAL DATA

Dimensions in mm

SOT-122



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 4,2 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.

When locking is required an adhesive is preferred instead of a lock washer.

CAUTION This device incorporates beryllium oxide, the dust of which is toxic. The device is entirely safe provided that the BeO disc is not damaged.

RATINGS

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

Collector-base voltage (open emitter)	V_{CBO}	max	25	V
Collector-emitter voltage (open base) (see Fig. 2)	V_{CEO}	max	18	V
Emitter-base voltage (open collector)	V_{EBO}	max	2	V
Collector current (d.c.)	I_C	max	150	mA
Total power dissipation (d.c.) up to T_{mb} = 125 °C (see Fig. 2)	P_{tot}	max	2,25	W
Storage temperature	T_{stg}	−65 to + 150		°C
Operating junction temperature	T_j	max	200	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	15,0	°C/W
From mounting base to heatsink	$R_{th\ mb\text{-}h}$	=	0,6	°C/W

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 15$ V	I_{CBO}	<	100	μA
D.C. current gain *				
I_C = 75 mA; V_{CE} = 15 V	h_{FE}	>	25	
I_C = 150 mA; V_{CE} = 15 V	h_{FE}	>	25	
Transition frequency *				
I_C = 75 mA; V_{CE} = 15 V	f_T	>	3,0	GHz
		typ	3,5	GHz
I_C = 150 mA; V_{CE} = 15 V	f_T	>	3,5	GHz
		typ	4,0	GHz
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; V_{CB} = 15 V	C_c	typ	2,0	pF
		<	2,75	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; V_{EB} = 0,5 V	C_e	typ	11	pF
Feedback capacitance at f = 1 MHz				
I_C = 10 mA; V_{CE} = 15 V	C_{re}	typ	1,0	pF
		<	1,35	pF
Collector-stud capacitance	C_{cs}	typ	2	pF
Noise figure measured in MATV test circuit (see Fig. 1)				
I_C = 120 mA; V_{CE} = 15 V; f = 500 MHz	F	typ	8	dB

Maximum 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 = 120 mA; V_{CE} = 15 V; f = 500 MHz	G_{UM}	typ	16	dB

* Measured under pulse conditions.

Intermodulation distortion (see Fig. 1)

I_C = 120 mA; V_{CE} = 15 V; R_L = 75 Ω; T_{amb} = 25 °C

$V_p = V_o$ = 1,2 V at f_p = 795,25 MHz
$V_q = V_o$ −6 dB at f_q = 803,25 MHz
$V_r = V_o$ −6 dB at f_r = 805,25 MHz

Measured at $f_{(p+q-r)}$ = 793,25 MHz — d_{im} typ −60 dB

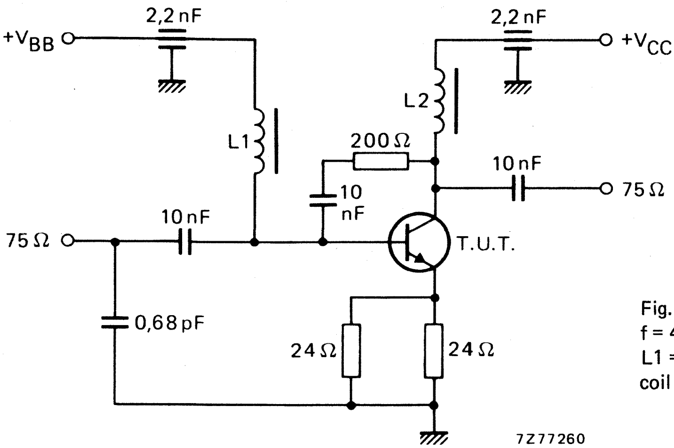


Fig. 1 MATV test circuit
f = 40 MHz to 860 MHz.
L1 = L2 = 5 μH Ferroxcube coil (cat. no. 3122 108 20153).

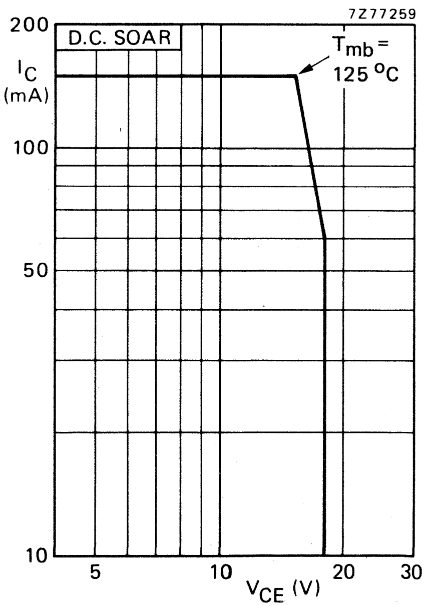
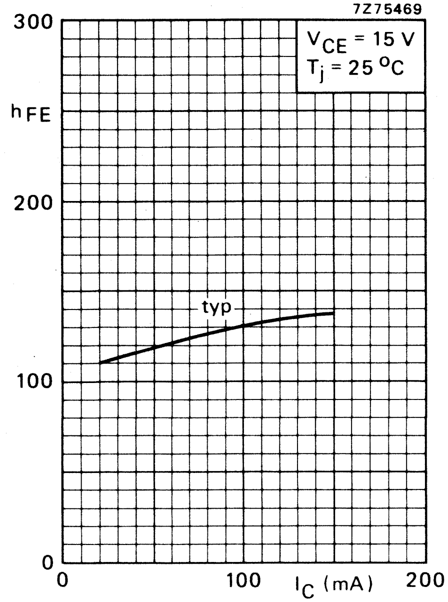
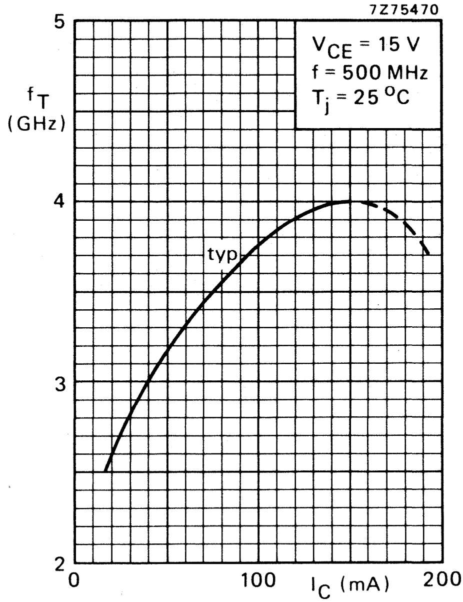
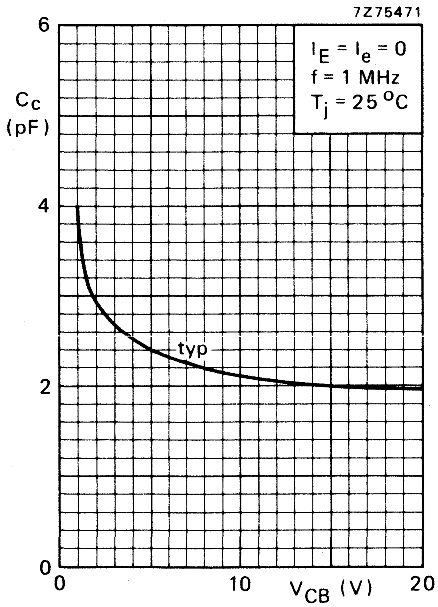
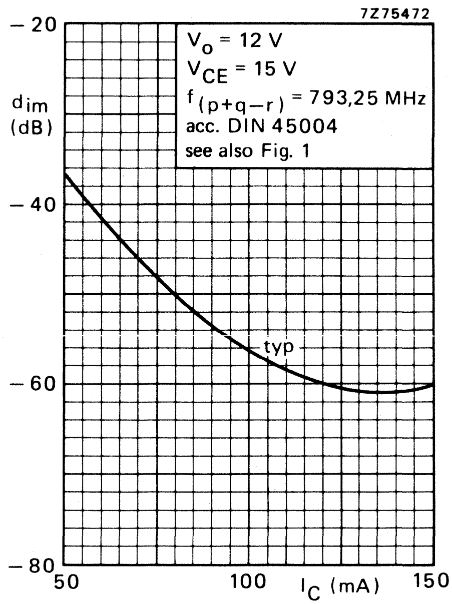


Fig. 2.


7Z75469
V_{CE} = 15 V
T_j = 25 °C
h_{FE}
typ
300
200
100
0
0
100
200
I_C (mA)


7Z75470
V_{CE} = 15 V
f = 500 MHz
T_j = 25 °C
f_T (GHz)
typ
5
4
3
2
0
100
200
I_C (mA)


7Z75471
$I_E = I_e = 0$
f = 1 MHz
T_j = 25 °C
C_c (pF)
typ
6
4
2
0
0
10
20
V_{CB} (V)


7Z75472
V_o = 12 V
V_{CE} = 15 V
$f_{(p+q-r)}$ = 793,25 MHz
acc. DIN 45004
see also Fig. 1
d_{im} (dB)
typ
−20
−40
−60
−80
50
100
150
I_C (mA)

N-P-N SILICON MICROWAVE TRANSISTOR

The BFR49 is a microwave transistor featuring a high transition frequency and low noise. A miniature ceramic encapsulation is used for compatibility with stripline and microwave circuits. It is suitable for amplifiers up to S-band frequencies in instrumentation and microwave systems.

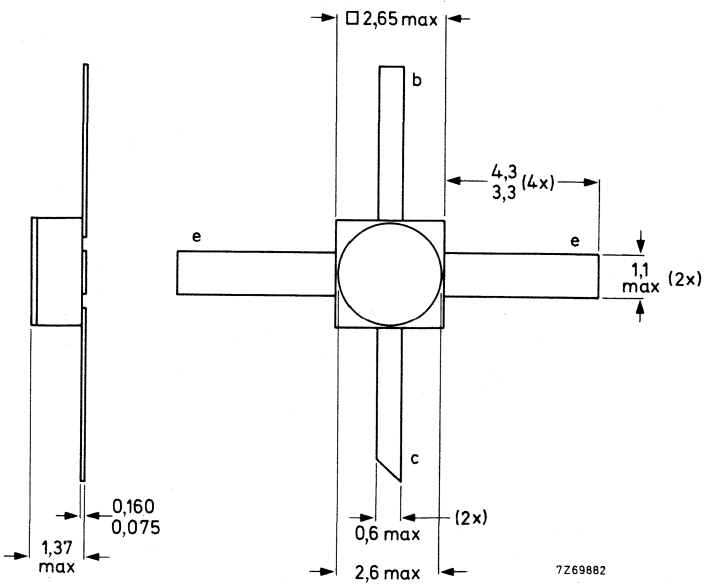
QUICK REFERENCE DATA

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} = 110 °C	P_{tot}	max	180	mW
Transition frequency I_C = 14 mA; V_{CE} = 10 V	f_T	typ	5	GHz
Noise figure at optimum source impedance I_C = 2 mA; V_{CE} = 10 V; f = 1 GHz	F	typ	2,5	dB
Transducer power gain I_C = 14 mA; V_{CE} = 10 V; f = 1 GHz	$\|s_{fe}\|^2$	typ	15,5	dB

MECHANICAL DATA

Dimensions in mm

SOT-100



RATINGS

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

Collector-base voltage (open emitter; I_C = 10 μA)	V_{CBO}	max	20	V
Collector-emitter voltage (open base; I_C = 10 mA)	V_{CEO}	max	15	V
Emitter-base voltage (open collector; I_E = 10 μA)	V_{EBO}	max	2	V
Collector current (d.c.)	I_C	max	25	mA
Total power dissipation up to T_{amb} = 110 °C	P_{tot}	max	180	mW
Storage temperature	T_{stg}	−65 to + 200		°C
Junction temperature	T_j	max	200	°C

THERMAL RESISTANCE

From junction to ambient in free air mounted on a fibre-glass print of 40 mm x 25 mm x 1 mm	$R_{th\ j\text{-}a}$	=	0,5	°C/mW

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

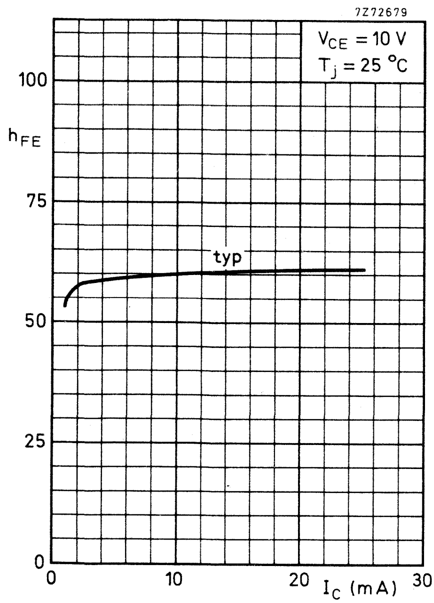
Collector cut-off current $I_E = 0$; V_{CB} = 10 V	I_{CBO}	<	50	nA
D.C. current gain * I_C = 14 mA; V_{CE} = 10 V	h_{FE}	>	25	
Transition frequency * I_C = 14 mA; V_{CE} = 10 V; f = 500 MHz	f_T	typ	5	GHz
Collector capacitance at f = 1 MHz $I_E = I_e = 0$; V_{CB} = 10 V	C_c	typ	0,35	pF
Emitter capacitance at f = 1 MHz $I_C = I_c = 0$; V_{EB} = 0,5 V	C_e	typ	1,1	pF
Feedback capacitance at f = 1 MHz I_C = 2 mA; V_{CE} = 10 V	C_{re}	typ	0,3	pF
Noise figure at optimum source impedance I_C = 2 mA; V_{CE} = 10 V; f = 1 GHz	F	typ	2,5	dB
I_C = 2 mA; V_{CE} = 10 V; f = 4 GHz	F	typ	6,5	dB

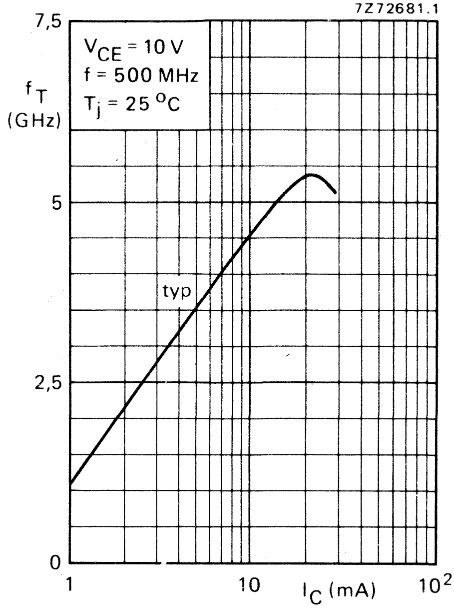
Maximum unilateral power gain (s_{re} assumed to be zero)

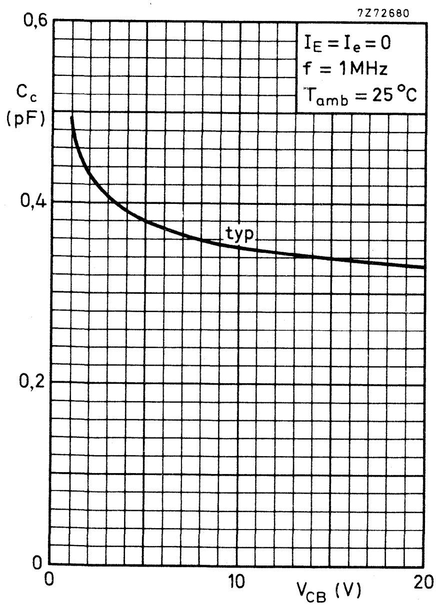
$$G_{UM} \text{ (in dB)} = 10 \log \frac{|s_{fe}|^2}{(1-|s_{ie}|^2)(1-|s_{oe}|^2)}$$

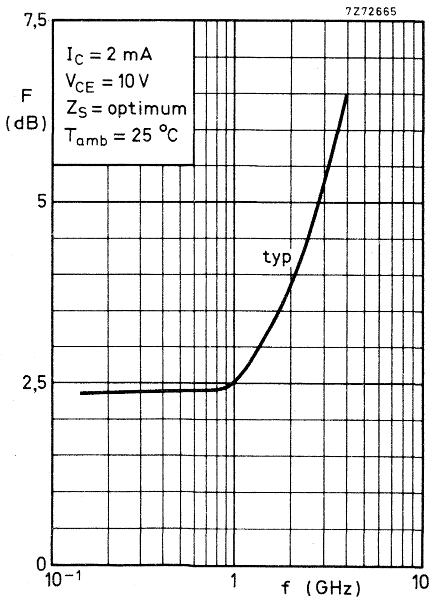
I_C = 14 mA; V_{CE} = 10 V; f = 1 GHz	G_{UM}	typ	17,0	dB
I_C = 14 mA; V_{CE} = 10 V; f = 4 GHz	G_{UM}	typ	6,5	dB
Transducer power gain I_C = 14 mA; V_{CE} = 10 V; f = 1 GHz	$\|s_{fe}\|^2$	typ	15,5	dB
I_C = 14 mA; V_{CE} = 10 V; f = 4 GHz	$\|s_{fe}\|^2$	typ	3,5	dB

* Measured under pulse conditions.

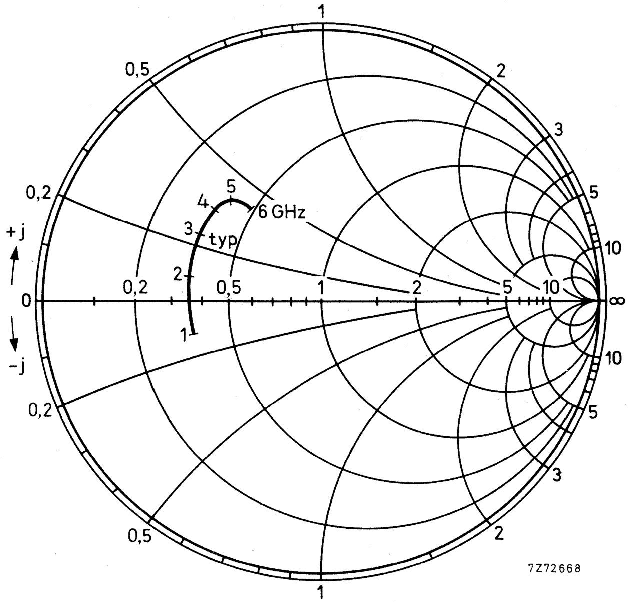

7Z72679
V_{CE} = 10 V
T_j = 25 °C
100
h_{FE}
75
typ
50
25
0
0
10
20
I_C (mA)
30


7Z72681.1
7,5
V_{CE} = 10 V
f = 500 MHz
T_j = 25 °C
f_T
(GHz)
5
typ
2,5
0
1
10
I_C (mA)
10^2


7Z72680
0,6
$I_E = I_e = 0$
f = 1MHz
T_{amb} = 25 °C
C_c
(pF)
0,4
typ
0,2
0
0
10
V_{CB} (V)
20

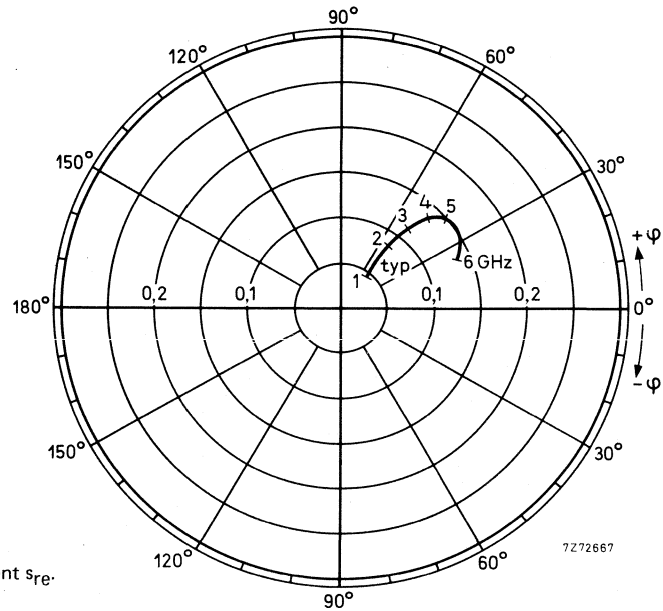

7Z72665
7,5
I_C = 2 mA
V_{CE} = 10 V
Z_S = optimum
T_{amb} = 25 °C
F
(dB)
5
typ
2,5
0
10^{-1}
1
f (GHz)
10

V_{CE} = 10 V
I_C = 14 mA
T_{amb} = 25 °C



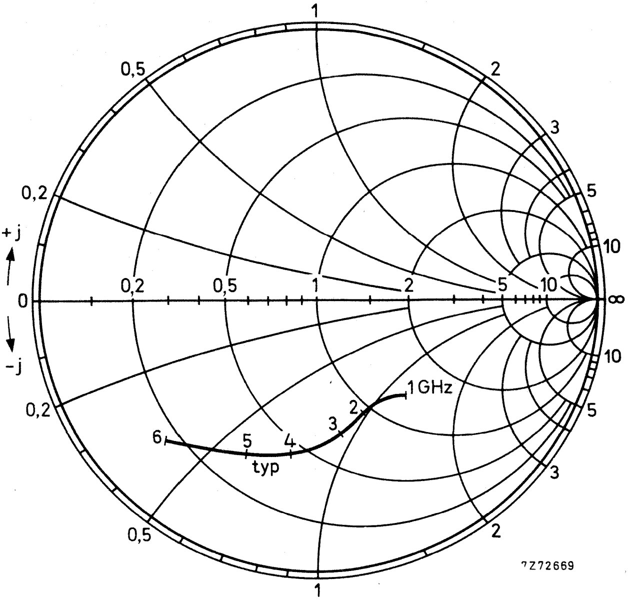
Input impedance derived from input reflection coefficient s_{ie} co-ordinates in ohm x 50.

V_{CE} = 10 V
I_C = 14 mA
T_{amb} = 25 °C



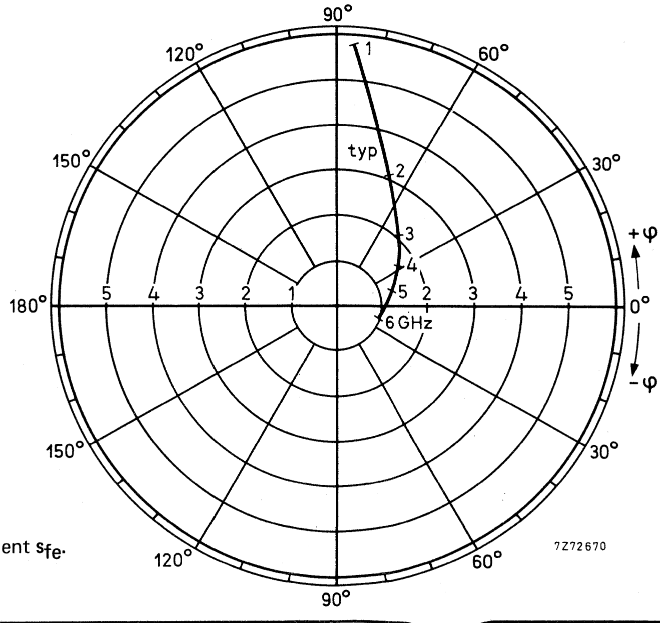
Reverse transmission coefficient s_{re}.

V_{CE} = 10 V
I_C = 14 mA
T_{amb} = 25 °C

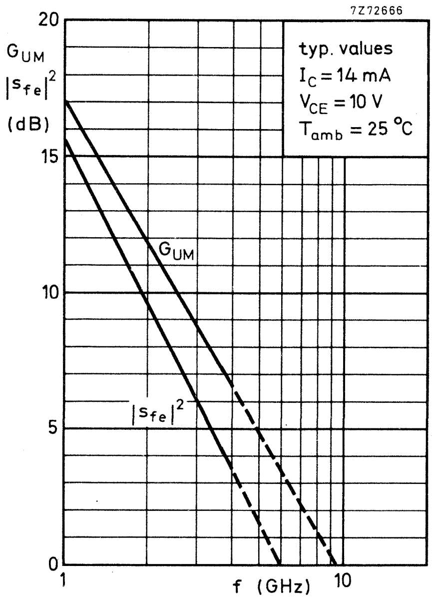


Output impedance derived from output reflection coefficient s_{oe} co-ordinates in ohm x 50.

V_{CE} = 10 V
I_C = 14 mA
T_{amb} = 25 °C



Forward transmission coefficient s_{fe}.


7Z72666
20
G_{UM}
$|s_{fe}|^2$
(dB)
15
10
5
0
1
f (GHz)
10
typ. values
$I_C = 14$ mA
$V_{CE} = 10$ V
$T_{amb} = 25$ °C
G_{UM}
$|s_{fe}|^2$

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

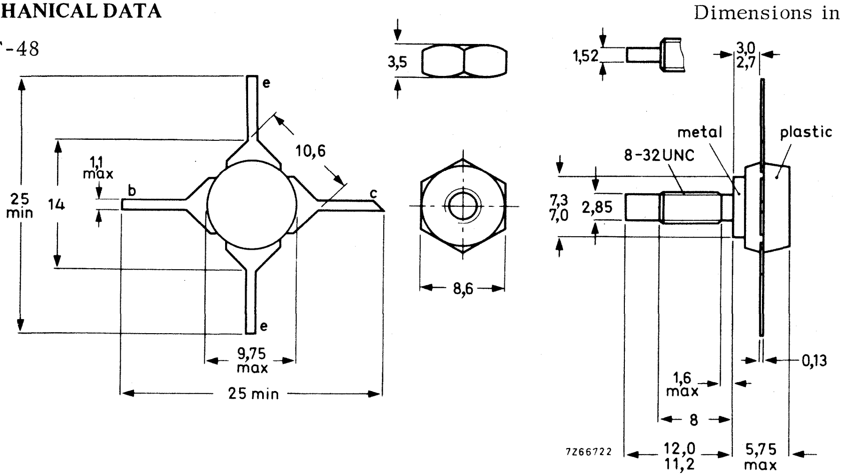
Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Collector current (peak value)	I_{CM}	max.	500	mA
Total power dissipation up to T_{mb} = 60 °C; f ≥ 1 MHz	P_{tot}	max.	3,5	W
Junction temperature	T_j	max.	150	°C
Transition frequency 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

SOT-48

Dimensions in mm



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	$R_{th\ j-mb}$	=	25	°C/W
From mounting base to heatsink	$R_{th\ mb-h}$	=	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

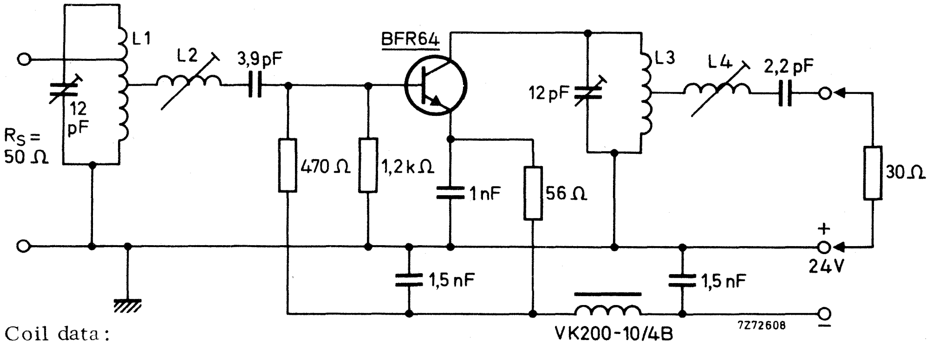
CHARACTERISTICS (continued)

Intermodulation characteristics

1. Output power at f = 200 MHz; T_{mb} = 25 ^{o}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.

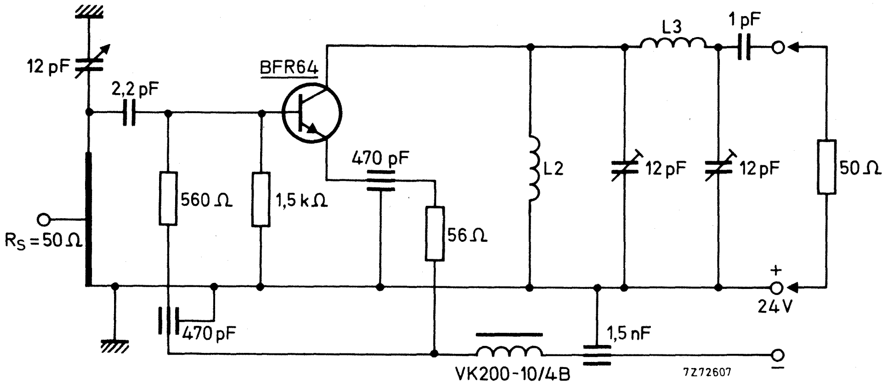
CHARACTERISTICS (continued)

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:

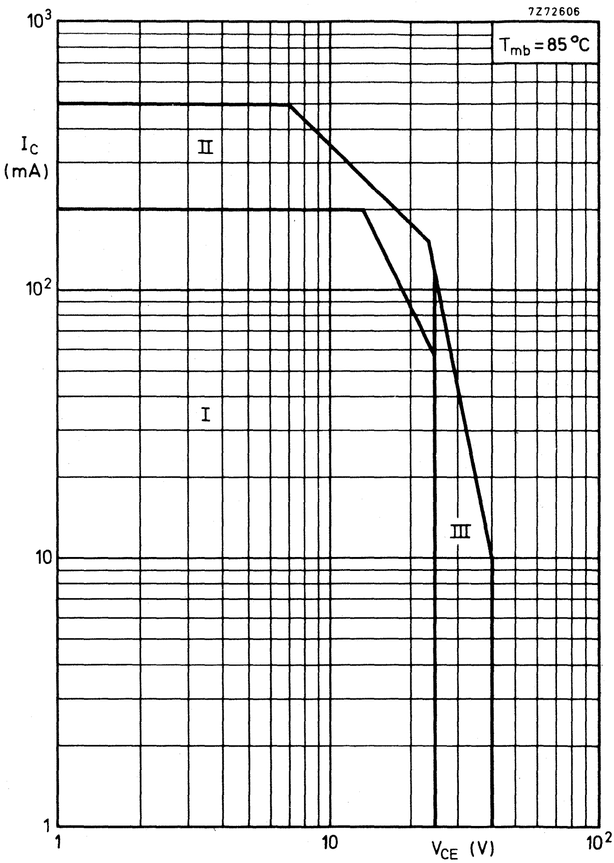
L1 = 25 mm x 7 mm x 0,85 mm silver-plated Cu strip
Tap of the input at 5 mm from earth.
L2 = 13 turns enamelled Cu wire (0,6 mm); int. dia. 8 mm
L3 = 1,5 turns Cu wire (1,3 mm); int. dia. 8 mm

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

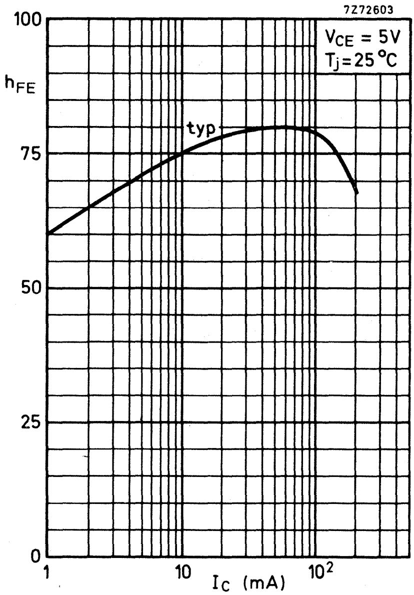
$$P_o = \frac{I_C(V_{CE} - V_{CEK})}{2} = 480 \text{ mW}.$$

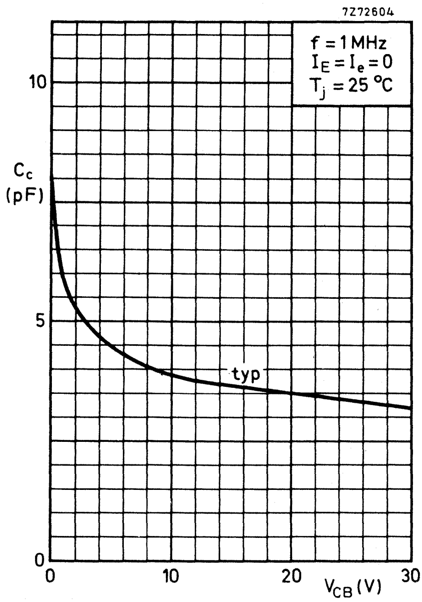
The output circuit is adjusted for minimum intermodulation if the input signal is as small as possible at P_o = 480 mW. With this adjusting method, care must be taken that the transistor is not damaged by second breakdown (the voltage swing may not exceed the rated V_{CER} value). Therefore as soon as 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.

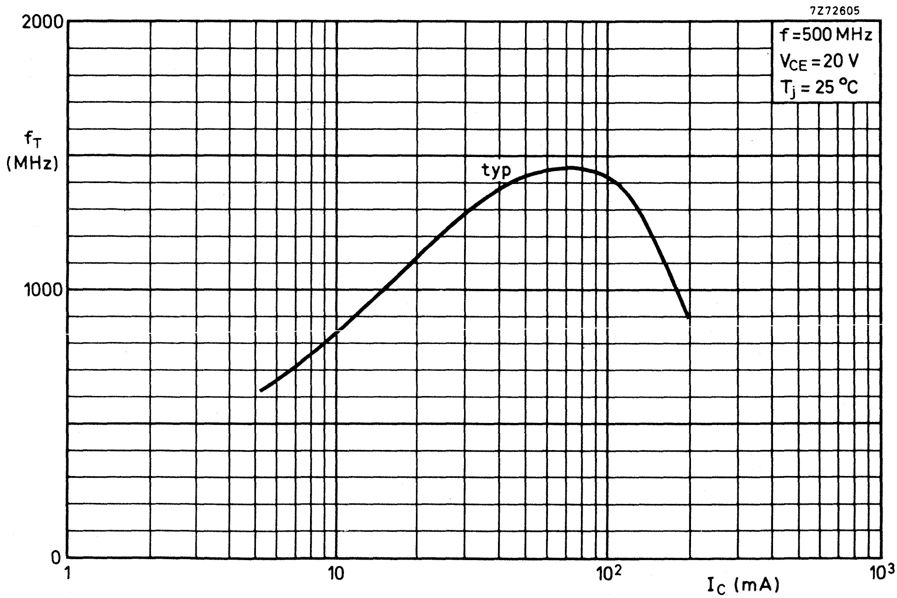


Safe Operating Area with the transistor forward biased

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
100
75
50
25
0
h_{FE}
V_{CE} = 5V
T_j = 25 °C
typ
1
10
10^2
I_C (mA)


7Z72604
10
5
0
C_c
(pF)
f = 1 MHz
$I_E = I_e = 0$
T_j = 25 °C
typ
0
10
20
30
V_{CB} (V)


7Z72605
2000
1000
0
f_T
(MHz)
f = 500 MHz
V_{CE} = 20 V
T_j = 25 °C
typ
1
10
10^2
10^3
I_C (mA)

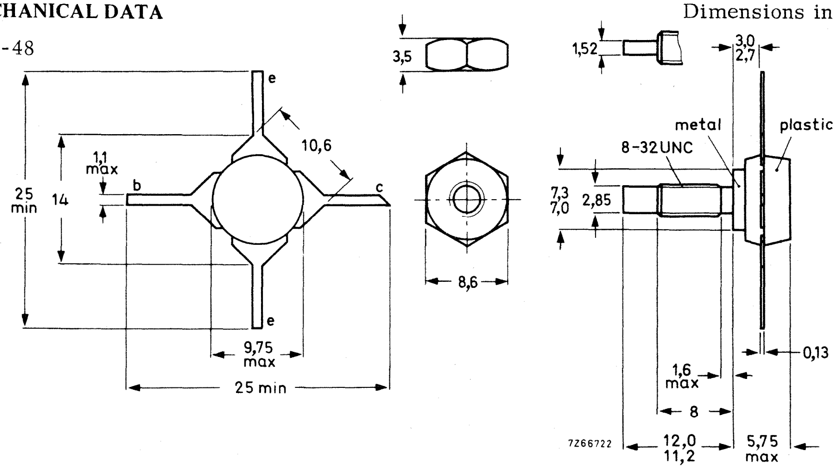
SILICON PLANAR EPITAXIAL TRANSISTOR

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	°C
Thermal resistance from junction to mounting base	$R_{th\ j\text{-}mb}$	=	15	°C/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); 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 (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 °C 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 Ω, 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 °C	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 °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)	P_o	typ.	450	mW
Power gain (not neutralized) T_{mb} = 25 °C				
I_C = 200 mA; V_{CE} = 20 V; f = 200 MHz	G_p	>	15	dB
		typ.	19	dB
I_C = 200 mA; V_{CE} = 20 V; f = 800 MHz	G_p	typ.	4.5	dB

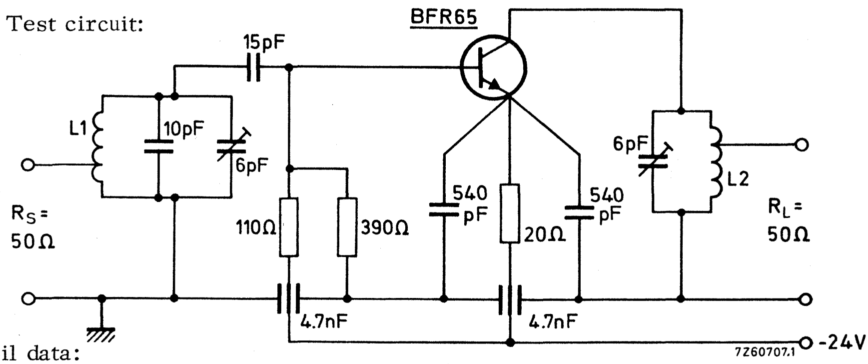
CHARACTERISTICS (continued)

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

$$R_L = \frac{V_{CE} - V_{CEK}}{I_C},$$

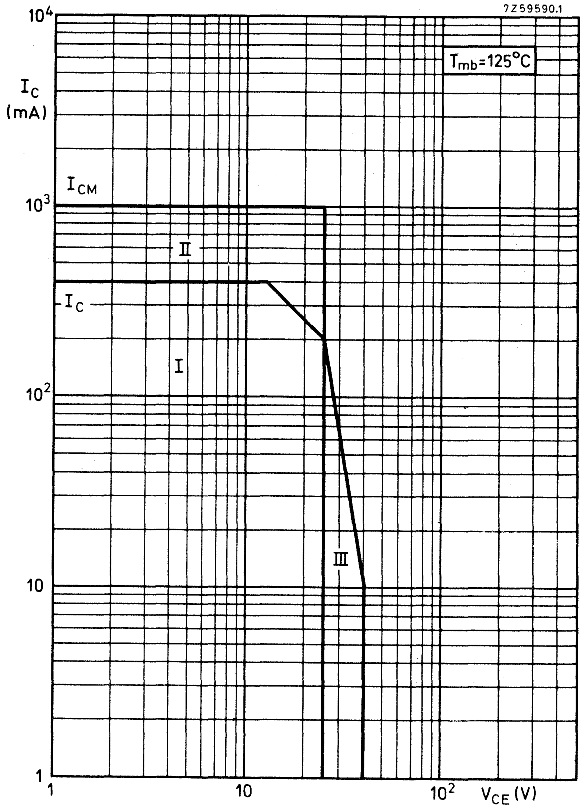
   in which V_{CEK} is the high frequency knee voltage.

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.

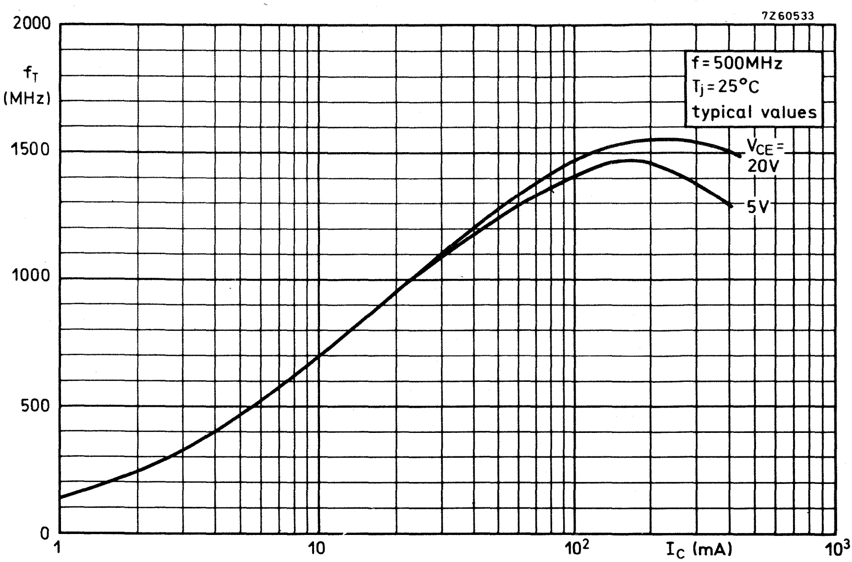
Adjustment procedure

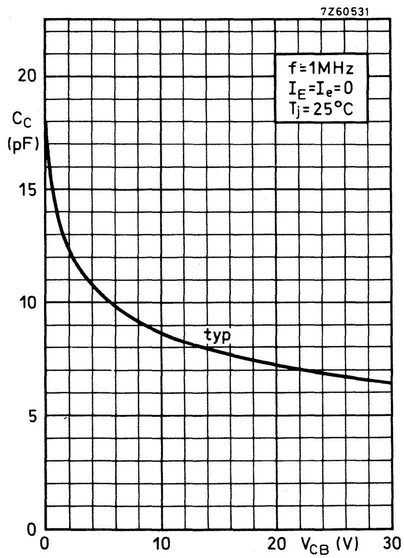
1. Remove the transistor and connect a dummy consisting of a 91 Ω resistor in parallel with a 6.8 pF capacitor between the collector and emitter connections of the output circuit.
2. Tune and match the output circuit for zero reflection at 205 MHz (V.S.W.R. = 1)
   After this adjustment, no further change 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.

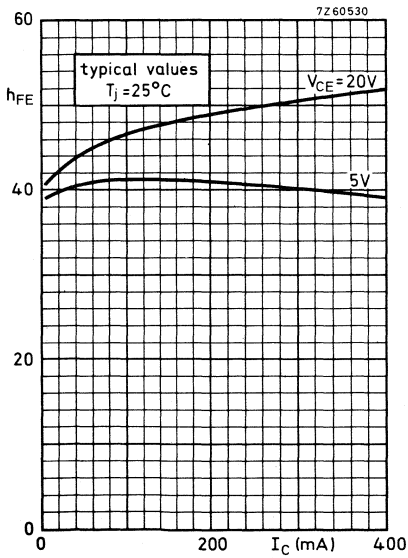


Safe Operating Area with the transistor forward biased

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.

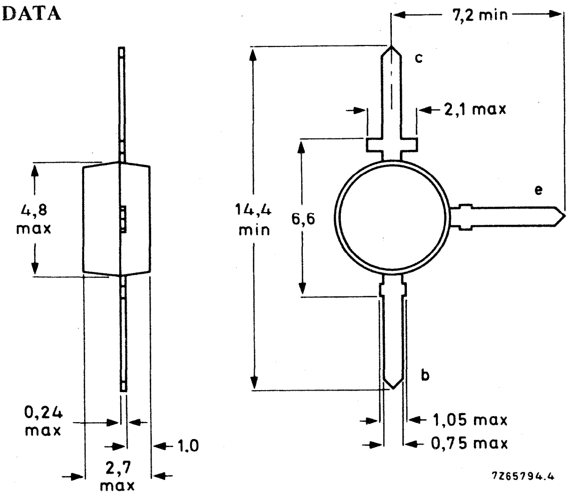
QUICK REFERENCE DATA

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

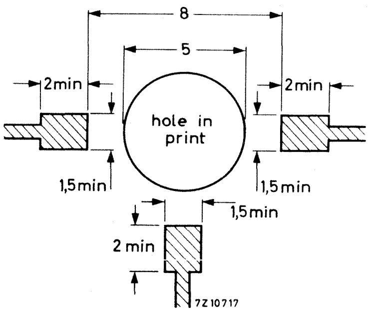
THERMAL RESISTANCE

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

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

Collector cut-off current				
$I_E = 0$; $V_{CB} = 10\,V$	I_{CBO}	<	50	nA
D.C. current gain [1]				
$I_C = 14\,mA$; $V_{CE} = 10\,V$	h_{FE}	> typ.	25 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				
$I_C = 2\,mA$; $V_{CE} = 10\,V$; $T_{amb} = 25\,^{o}C$	C_{re}	typ.	0,4	pF
Noise figure at optimum source impedance				
$I_C = 2\,mA$; $V_{CE} = 10\,V$; $f = 500\,MHz$; $T_{amb} = 25\,^{o}C$	F	typ.	2,4	dB

Max. unilateral power gain (s_{re} assumed to be zero)

$$G_{UM}\ (\text{in dB}) = 10 \log \frac{|s_{fe}|^2}{(1 - |s_{ie}|^2)(1 - |s_{oe}|^2)}$$

$I_C = 14\,mA$; $V_{CE} = 10\,V$; $f = 500\,MHz$; $T_{amb} = 25\,^{o}C$	G_{UM}	typ.	19,5	dB

[1]) Measured under pulse conditions.

CHARACTERISTICS (continued)

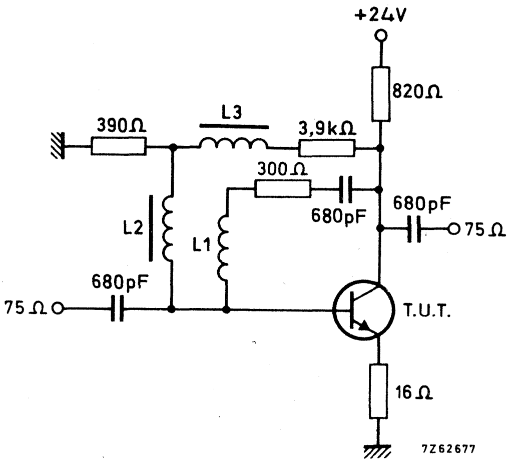
Intermodulation distortion at T_{amb} = 25 °C

I_C = 14 mA; V_{CE} = 10 V; R_L = 75 Ω; V.S.W.R. < 2

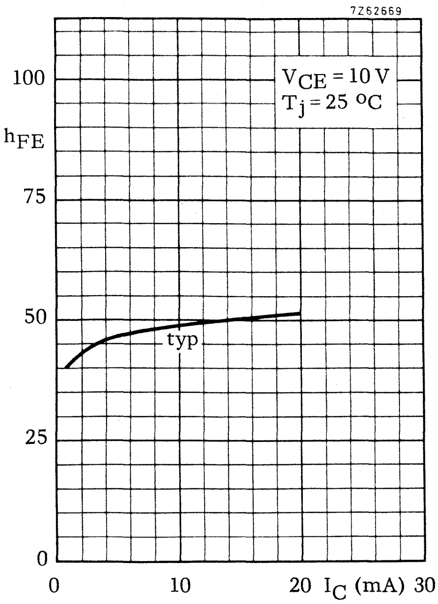
$V_p = V_o$ = 150 mV at f_p = 495, 25 MHz
$V_q = V_o$ − 6 dB at f_q = 503, 25 MHz
$V_r = V_o$ − 6 dB at f_r = 505, 25 MHz

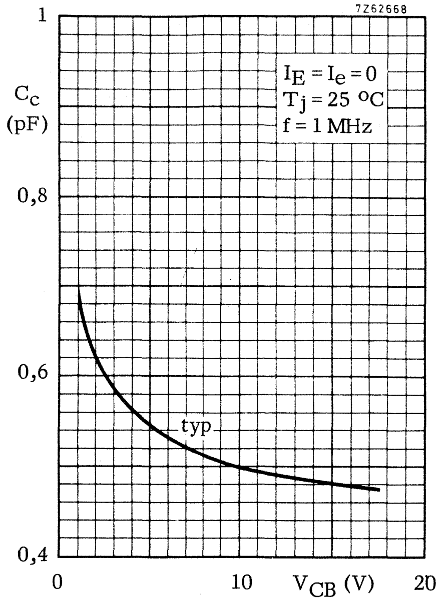
Measured at $f_{(p+q-r)}$ = 493, 25 MHz — d_{im} typ. −60 dB

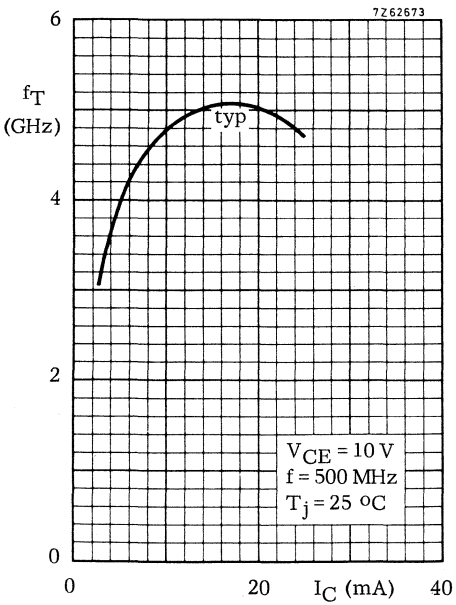
Intermodulation test circuit:

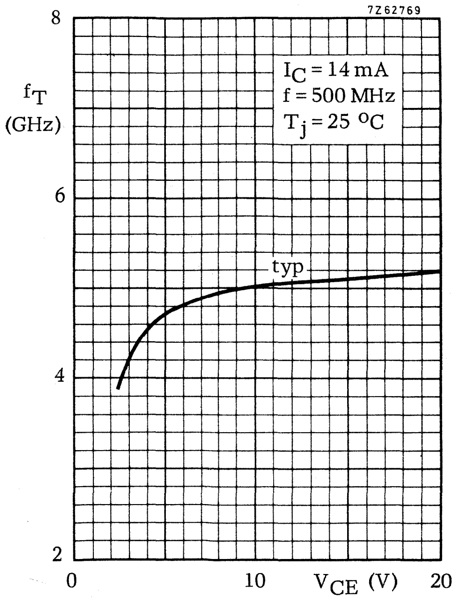


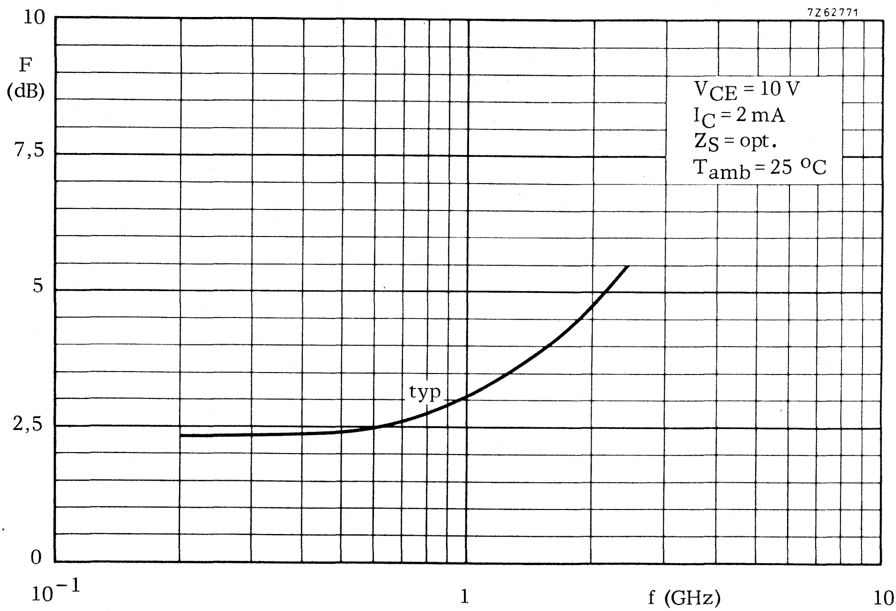
L1 = 4 turns Cu wire (0,35 mm); winding pitch 1 mm; int. diam. 4 mm
L2 and L3 5 μH (code number: 3122 108 20150)

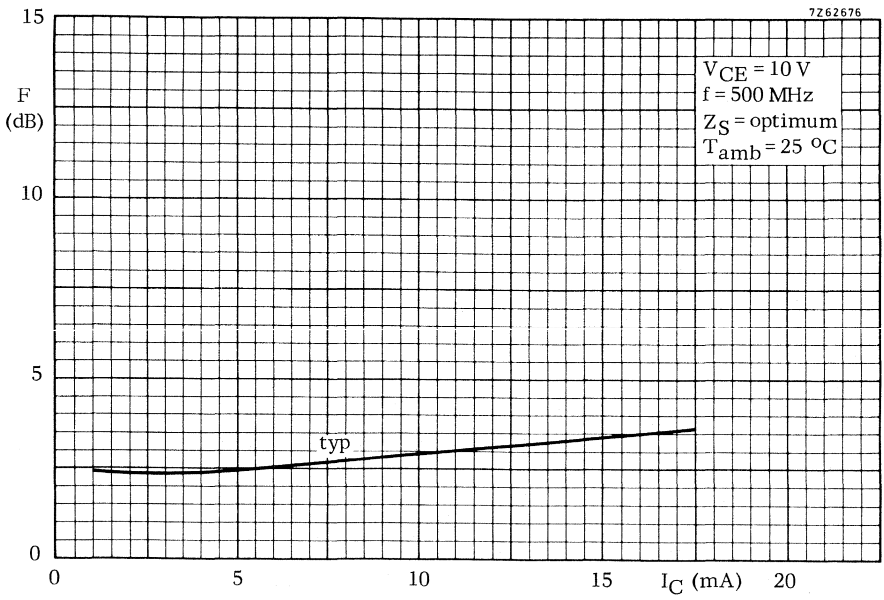

7Z62669
100
75
50
25
0
h_{FE}
V_{CE} = 10 V
T_j = 25 °C
typ
0
10
20
I_C (mA)
30

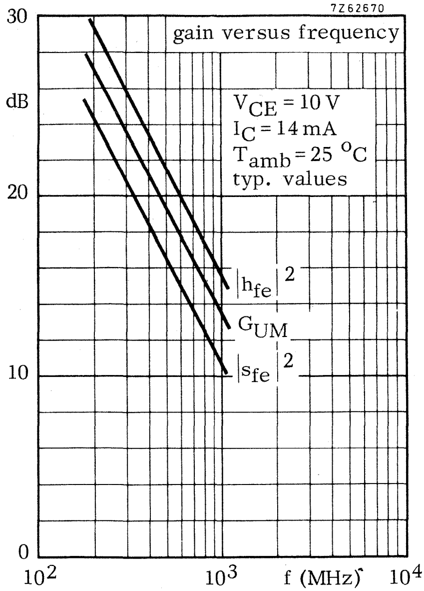

7Z62668
1
0,8
0,6
0,4
C_c
(pF)
$I_E = I_e = 0$
T_j = 25 °C
f = 1 MHz
typ
0
10
V_{CB} (V)
20


7Z62673
6
4
2
0
f_T
(GHz)
typ
V_{CE} = 10 V
f = 500 MHz
T_j = 25 °C
0
20
I_C (mA)
40

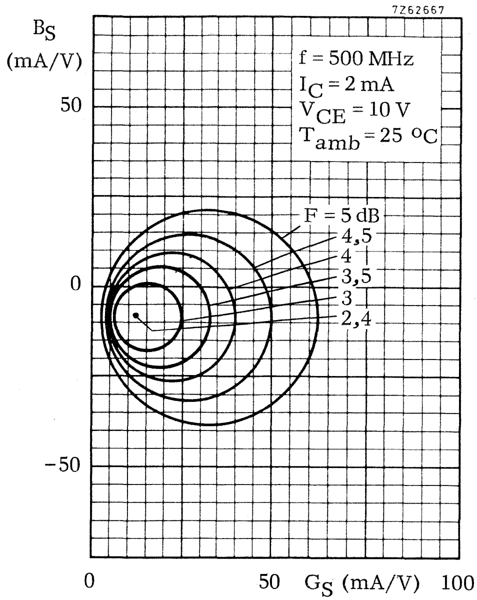

7Z62769
8
6
4
2
f_T
(GHz)
I_C = 14 mA
f = 500 MHz
T_j = 25 °C
typ
0
10
V_{CE} (V)
20


7Z62771
10
F
(dB)
7,5
5
2,5
0
V_{CE} = 10 V
I_C = 2 mA
Z_S = opt.
T_{amb} = 25 °C
typ
10^{-1}
1
f (GHz)
10

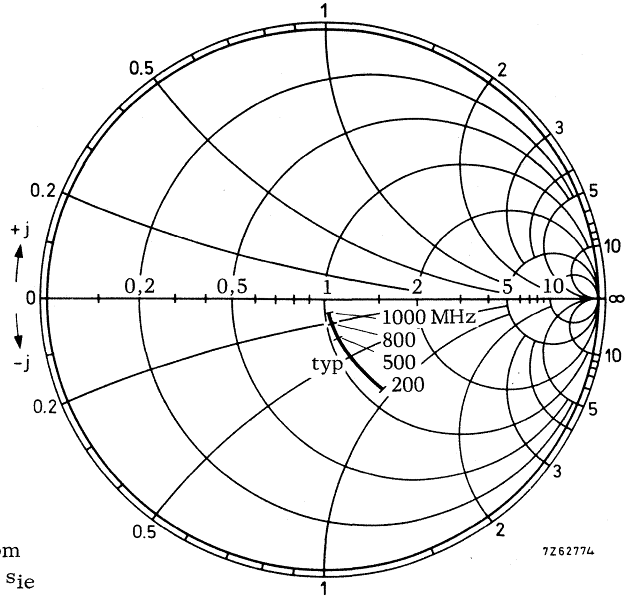

7Z62676
15
F
(dB)
10
5
0
V_{CE} = 10 V
f = 500 MHz
Z_S = optimum
T_{amb} = 25 °C
typ
0
5
10
15
I_C (mA)
20



circles of constant noise figure

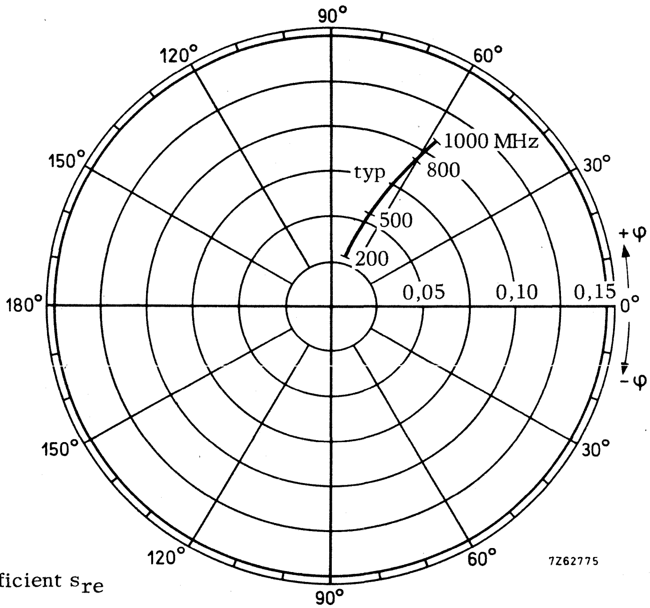


V_{CE} = 10 V
I_C = 14 mA
T_{amb} = 25 °C



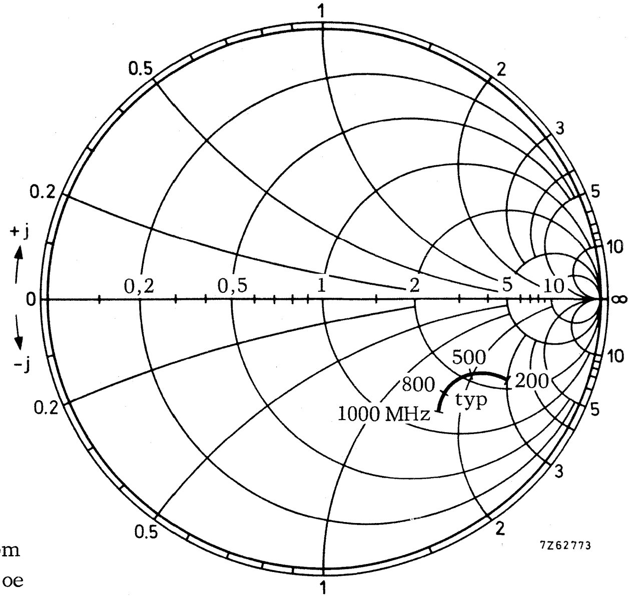
Input impedance derived from input reflection coefficient s_{ie} coordinates in ohm x 50

V_{CE} = 10 V
I_C = 14 mA
T_{amb} = 25 °C



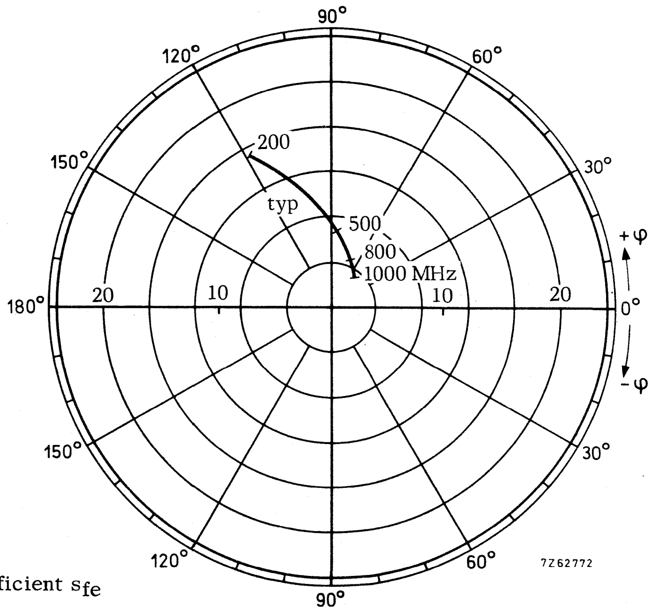
Reverse transmission coefficient s_{re}

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.
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 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.

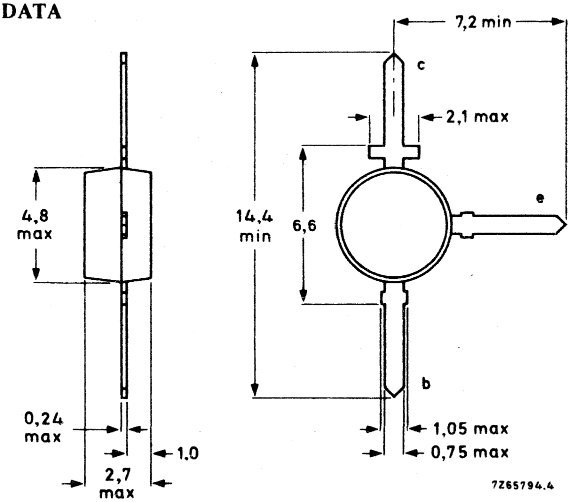
QUICK REFERENCE DATA

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

SOT-37

Dimensions in mm



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

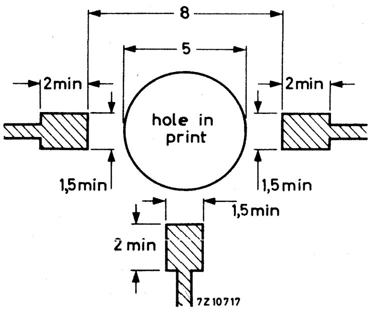
THERMAL RESISTANCE

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 °C 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; $T_{amb} = 25$ °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 (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; $T_{amb} = 25$ °C	G_{UM}	typ.	16,5	dB

1) Measured under pulse conditions.

CHARACTERISTICS (continued)

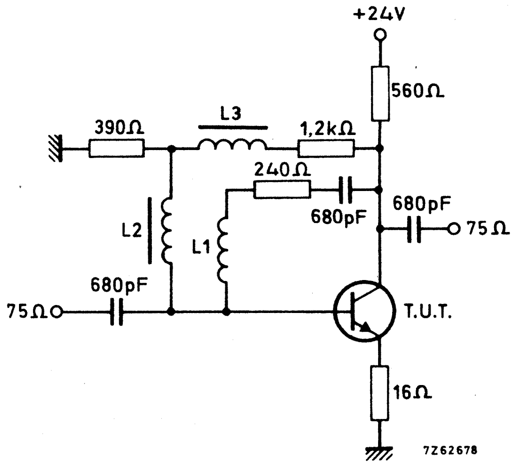
Intermodulation distortion at T_{amb} = 25 °C

I_C = 30 mA; V_{CE} = 5 V; R_L = 75 Ω; V.S.W.R. < 2

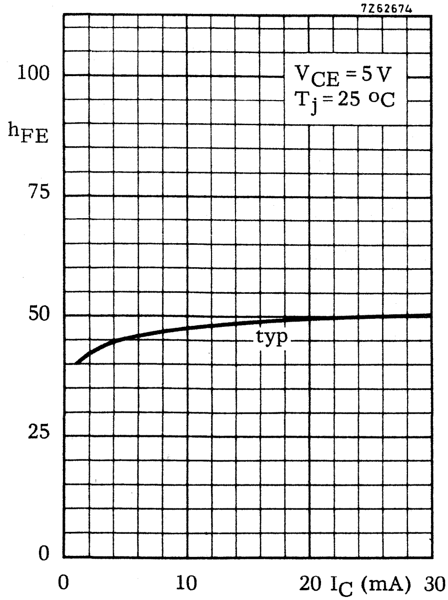
$V_p = V_o$ = 300 mV at f_p = 495,25 MHz
$V_q = V_o$ −6 dB at f_q = 503,25 MHz
$V_r = V_o$ −6 dB at f_r = 505,25 MHz

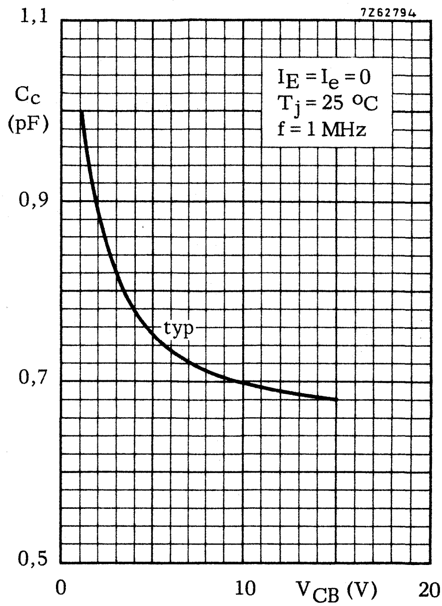
Measured at $f_{(p+q-r)}$ = 493,25 MHz — d_{im} typ. −60 dB

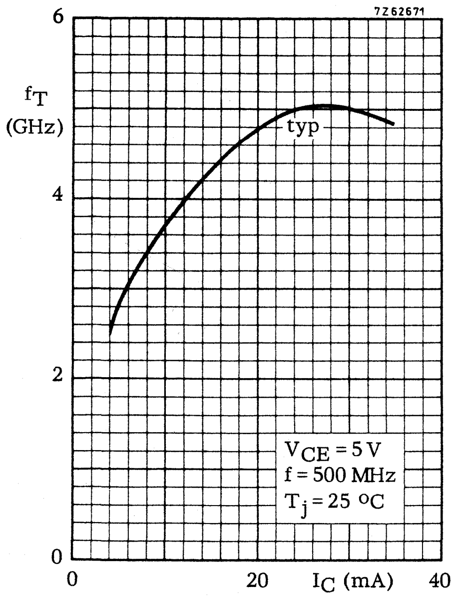
Intermodulation test circuit:

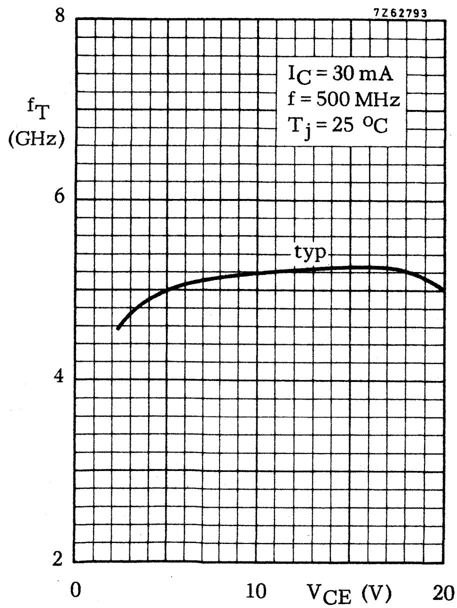


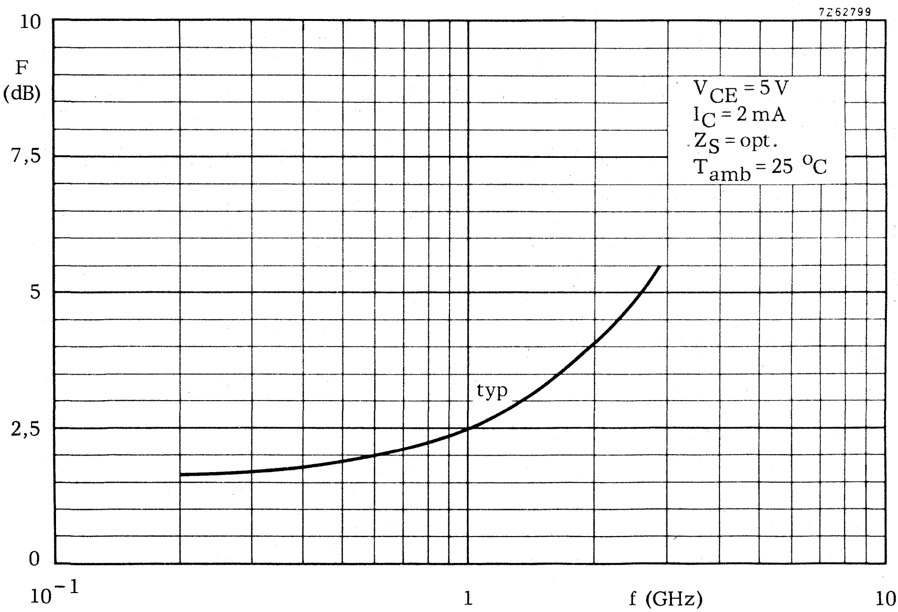
L1 = 4 turns Cu wire (0,35); winding pitch 1 mm; int. diam. 4 mm
L2 and L3 5 μH (code number: 3122 108 20150)

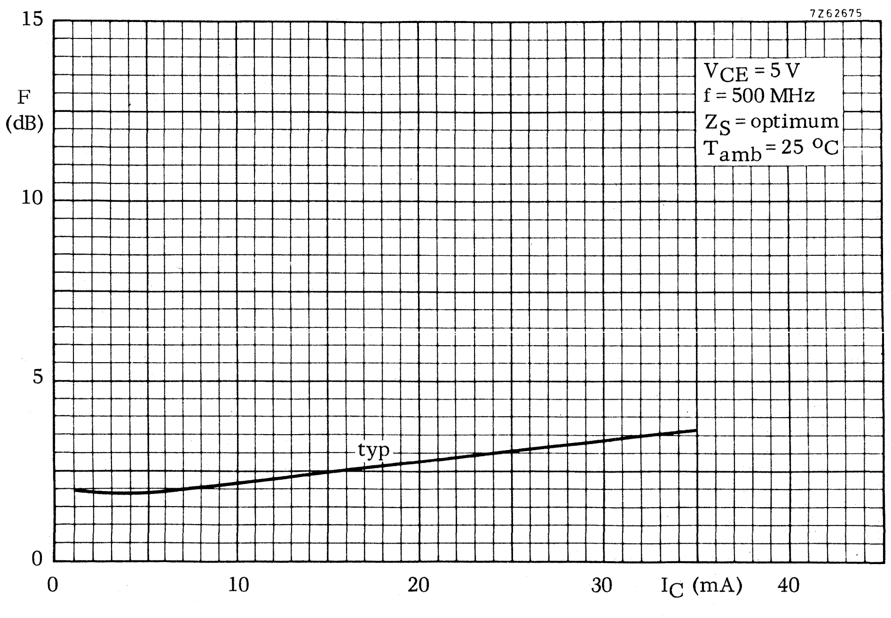

7Z62674
100
75
50
25
0
hFE
VCE = 5 V
Tj = 25 oC
typ
0
10
20
IC (mA)
30

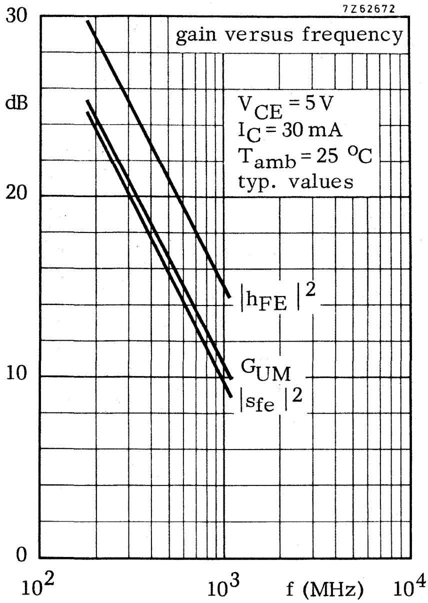

7Z62794
1,1
0,9
0,7
0,5
Cc
(pF)
IE = Ie = 0
Tj = 25 oC
f = 1 MHz
typ
0
10
VCB (V)
20


7Z62671
6
4
2
0
fT
(GHz)
typ
VCE = 5 V
f = 500 MHz
Tj = 25 oC
0
20
IC (mA)
40

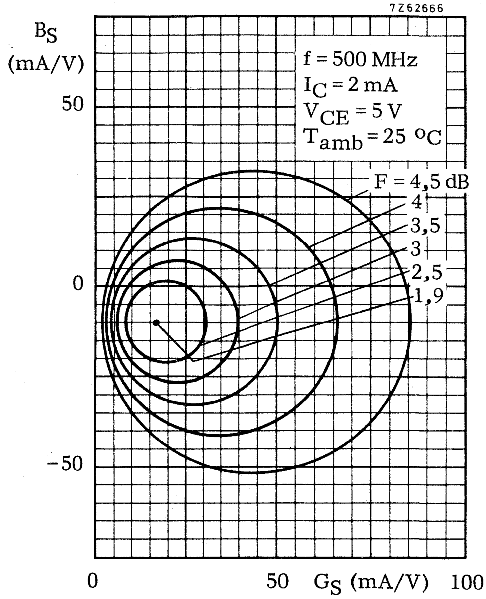

7Z62793
8
6
4
2
fT
(GHz)
IC = 30 mA
f = 500 MHz
Tj = 25 oC
typ
0
10
VCE (V)
20


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

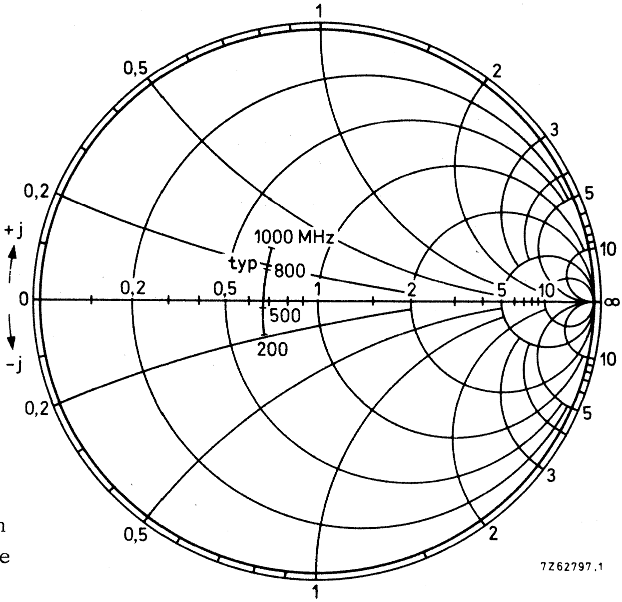

7Z62675
15
F
(dB)
10
5
0
V_{CE} = 5 V
f = 500 MHz
Z_S = optimum
T_{amb} = 25 °C
typ
0
10
20
30
I_C (mA)
40



circles of constant noise figure

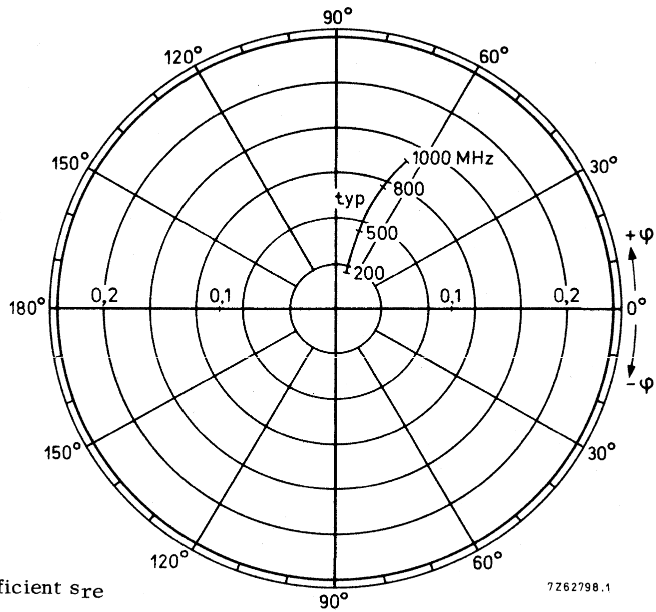


V_{CE} = 5 V
I_C = 30 mA
T_{amb} = 25 ^oC



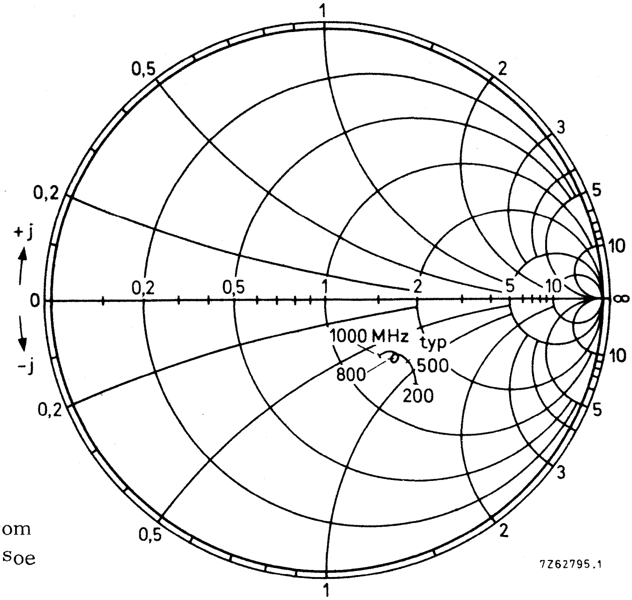
Input impedance derived from input reflection coefficient s_{ie} coordinates in ohm x 50

V_{CE} = 5 V
I_C = 30 mA
T_{amb} = 25 ^oC



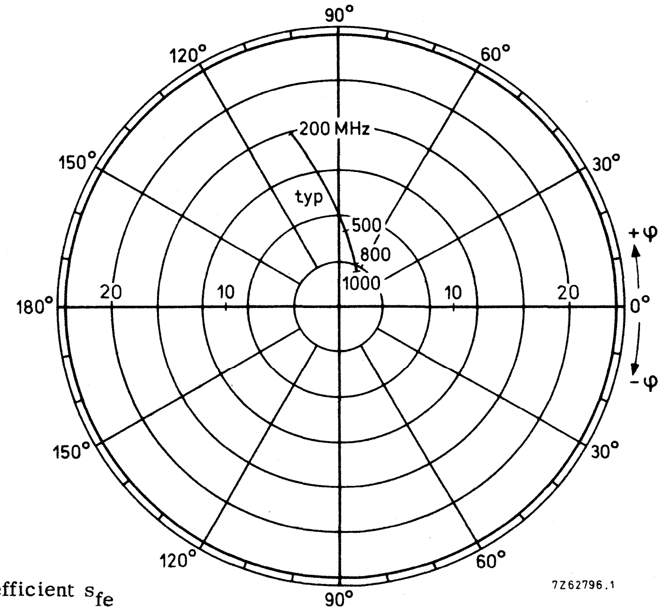
Reverse transmission coefficient s_{re}

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.

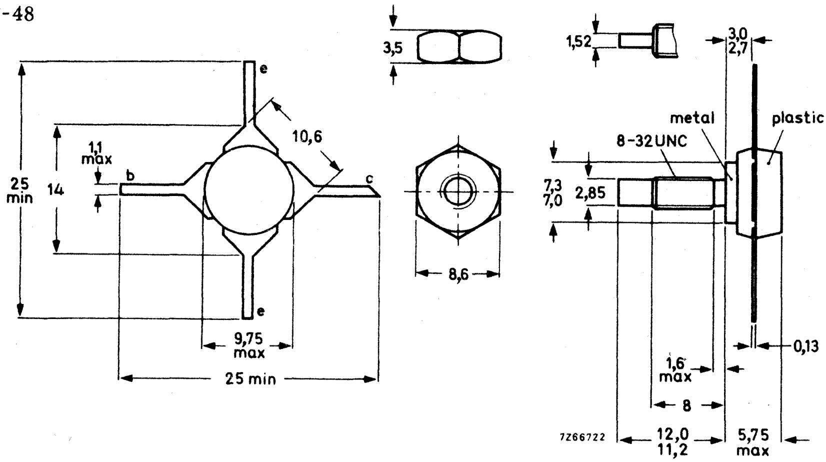
QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Collector current (d.c.)	I_C	max.	150	mA
Total power dissipation up to T_h = 145 °C; f > 1 MHz	P_{tot}	max.	3,5	W
Junction temperature	T_j	max.	200	°C
Transition frequency 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
2^{nd} 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.
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)	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)

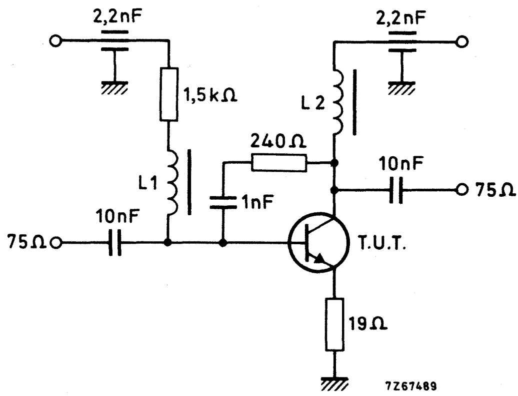
Intermodulation distortion at T_{amb} = 25 °C

I_C = 90 mA; V_{CE} = 20 V; R_L = 75 Ω

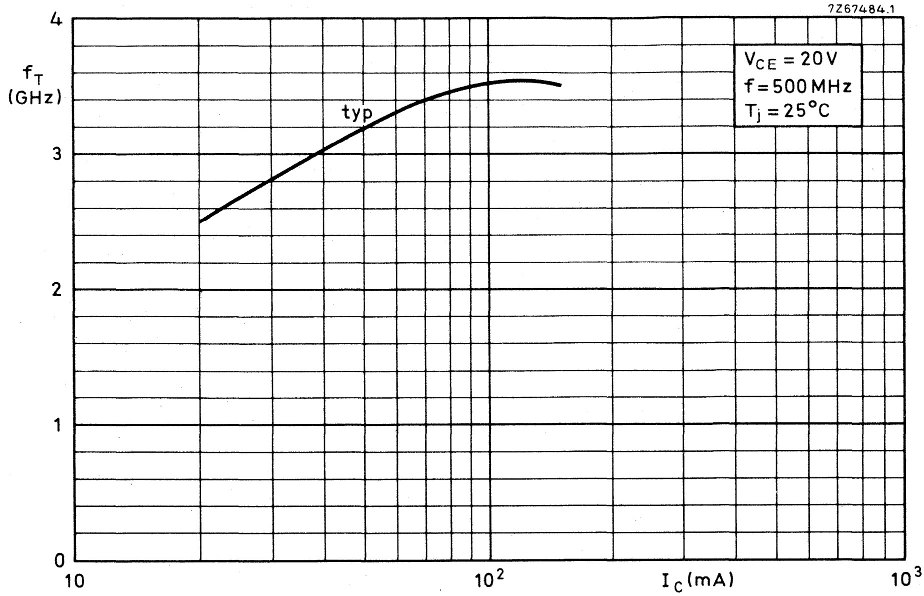
$V_p = V_o$ = 700 mV at f_p = 495, 25 MHz
$V_q = V_o$ −6 dB at f_q = 503, 25 MHz
$V_r = V_o$ −6 dB at f_r = 505, 25 MHz

Measured at $f_{(p+q-r)}$ = 493, 25 MHz — d_{im} typ. −60 dB

MATV test circuit



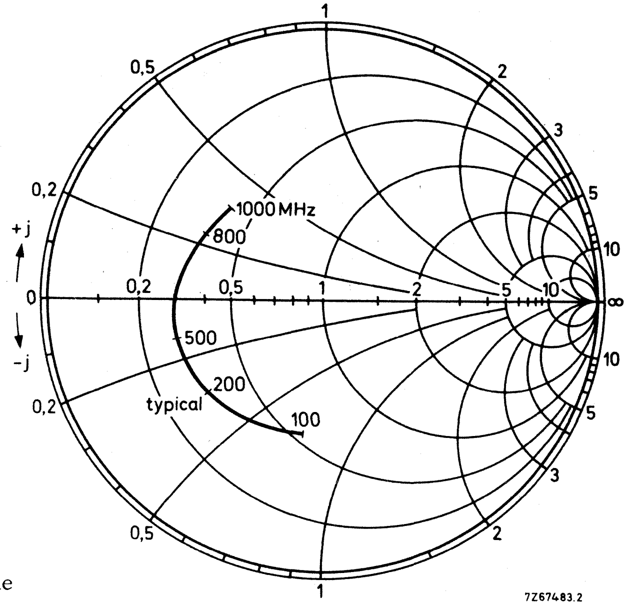
L1 = L2 = 5 μH ferroxcube coil (code number: 3122 108 20153)


7Z67484.1
4
3
2
1
0
f_T (GHz)
typ
$V_{CE} = 20V$
$f = 500 MHz$
$T_j = 25°C$
10
10^2
I_C (mA)
10^3

V_{CE} = 20 V

I_C = 90 mA

T_{amb} = 25 °C

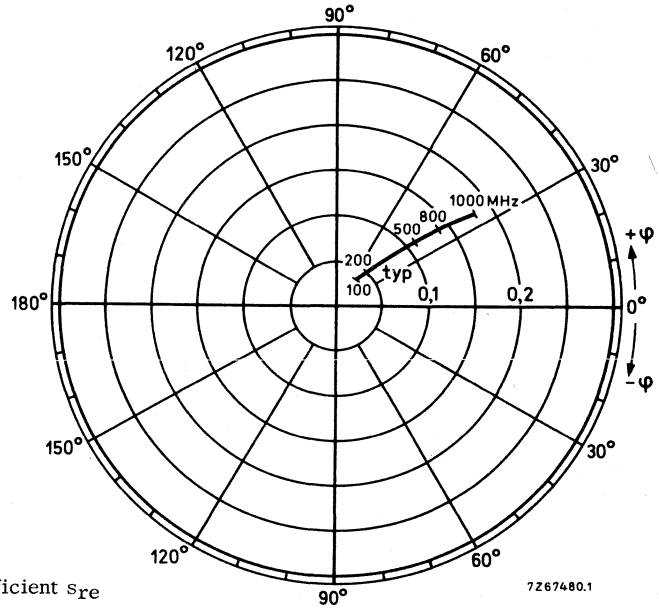


Input reflection coefficient s_{ie}

V_{CE} = 20 V

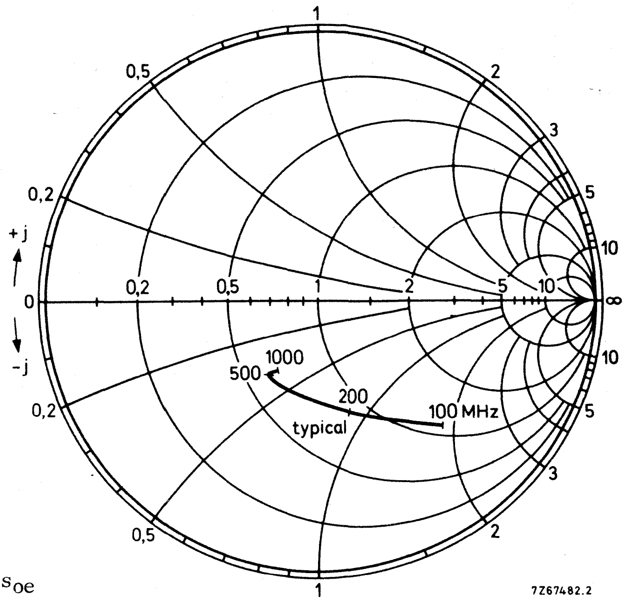
I_C = 90 mA

T_{amb} = 25 °C



Reverse transmission coefficient s_{re}

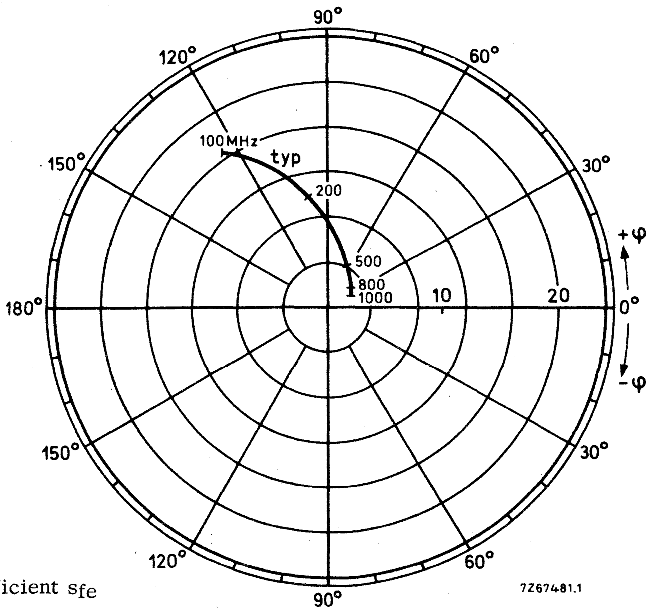
V_{CE} = 20 V
I_C = 90 mA
T_{amb} = 25 °C



Output reflection coefficient s_{oe}

7Z67482.2

V_{CE} = 20 V
I_C = 90 mA
T_{amb} = 25 °C



Forward transmission coefficient s_{fe}

7Z67481.1

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

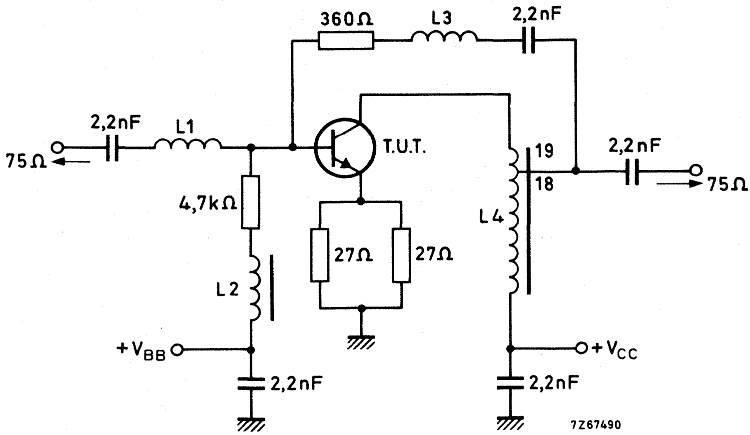
I_C = 90 mA; V_{CE} = 20 V

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)

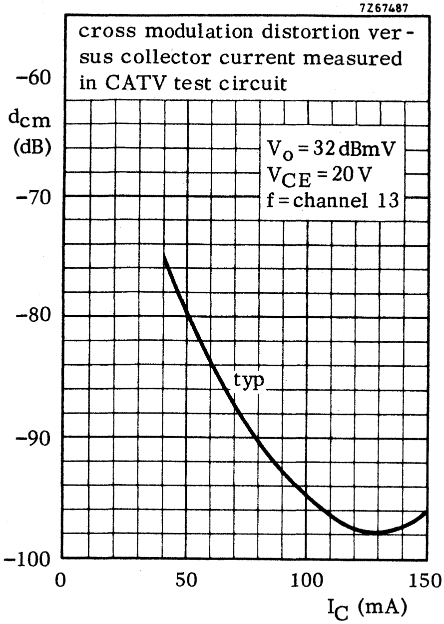
CATV test circuit

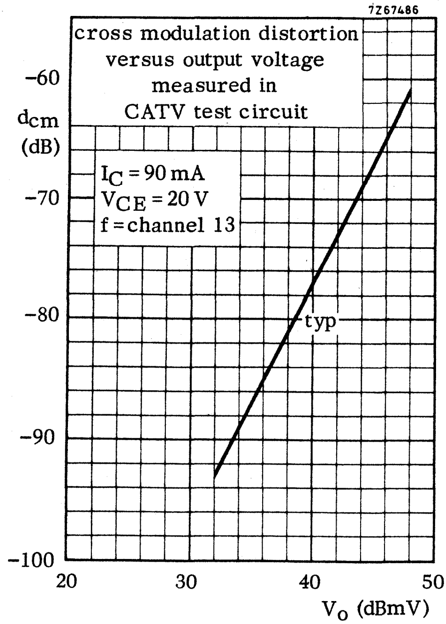


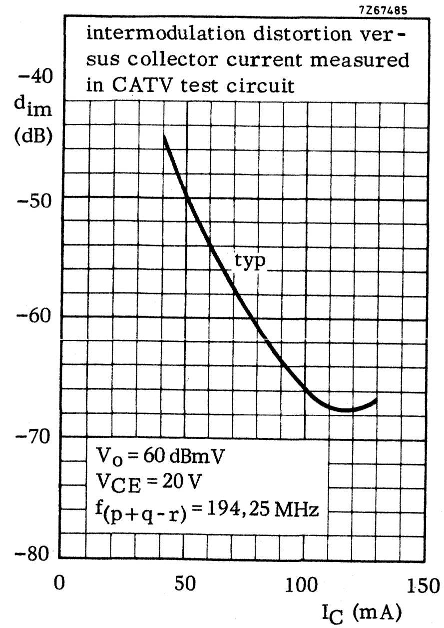
Frequency range 40 to 300 MHz (flatness gain ±0, 2 dB)			
Return losses input and output		<	−16 dB
Power gain	G_p	typ.	11 dB

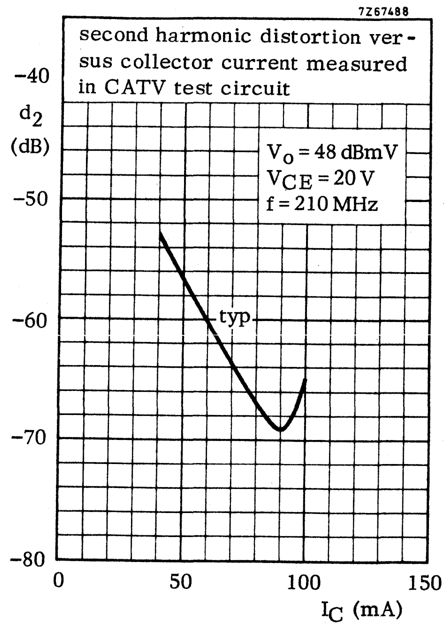
L1 = 2 turns closely wound enamelled Cu wire (0, 7 mm); int. diam. 3 mm
L2 = 5 μH ferroxcube coil (code number 3122 108 20153)
L3 = 5 turns closely wound enamelled Cu wire (0, 7 mm); int. diam. 4, 7 mm
L4 = 19 turns enamelled Cu wire (0, 3 mm) on ferroxcube core (code no. 4322 020 91001)

APPLICATION INFORMATION (continued)









SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N resistance stabilized transistor in a TO-39 metal envelope.

Due to very linear characteristics the transistor features low cross modulation, intermodulation and second harmonic distortion. Thanks to its high transition frequency it has a high power gain combined with excellent wideband properties and low noise up to high frequencies.

The BFR95 is primarily intended for CATV and MATV applications.

QUICK REFERENCE DATA

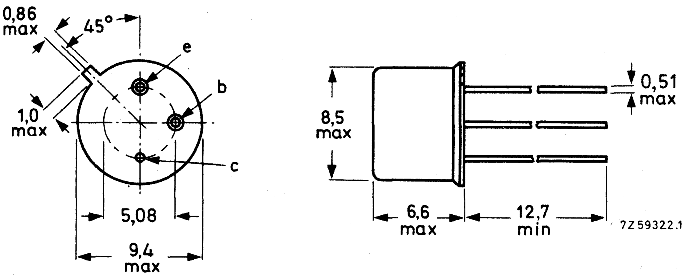
Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Collector current (d.c.)	I_C	max.	150	mA
Total power dissipation up to T_{mb} = 125 °C	P_{tot}	max.	1,5	W
Junction temperature	T_j	max.	200	°C
Transition frequency at f = 500 MHz I_C = 80 mA; V_{CE} = 20 V	f_T	typ.	3,5	GHz
Cross modulation distortion (channel 13) I_C = 80 mA; V_{CE} = 18 V; V_o = 48 dBmV	d_{cm}	typ. <	−61 −57	dB dB
I_C = 80 mA; V_{CE} = 18 V; V_o = 32 dBmV	d_{cm}	typ. <	−93 −89	dB dB
Intermodulation distortion at $f_{(p + q - r)}$ = 194,25 MHz I_C = 80 mA; V_{CE} = 18 V; V_o = 60 dBmV	d_{im}	typ.	−64	dB
Broadband power gain I_C = 80 mA; V_{CE} = 18 V	G_p	> typ.	8 9	dB dB
Noise figure at f = 200 MHz I_C = 80 mA; V_{CE} = 18 V	F	typ. <	9 10	dB dB
Second harmonic distortion at $f_{(p + q)}$ = 210 MHz I_C = 80 mA; V_{CE} = 18 V; V_o = 48 dBmV	d_2	typ.	−62	dB

MECHANICAL DATA see page 2.

MECHANICAL DATA

Fig. 1 TO-39
Collector connected to case

Dimensions in mm



Maximum lead diameter guaranteed only for 12,7 mm.
Accessories supplied on request: 56218 (package); 56245 (distance disc).

RATINGS

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

Collector-base voltage (open emitter) note 1	V_{CBO}	max.	30	V
Collector-emitter voltage (R_{BE} = 10 Ω) note 2	V_{CER}	max.	35	V
Collector-emitter voltage (open base) note 2	V_{CEO}	max.	25	V
Emitter-base voltage (open collector) note 3	V_{EBO}	max.	3	V
Collector current (d.c.)	I_C	max.	150	mA
Collector current (peak value); f > 1 MHz	I_{CM}	max.	300	mA
Total power dissipation				
up to T_{amb} = 25 °C	P_{tot}	max.	0,7	W
up to T_{mb} = 125 °C	P_{tot}	max.	1,5	W
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

Notes

1. At I_C = 100 μA.
2. At I_C = 10 mA.
3. At I_E = 100 μA.

CHARACTERISTICS

T_j = 25 ^oC unless otherwise specified

Collector cut-off current			
$I_E = 0$; $V_{CB} = 20$ V	I_{CBO}	<	50 μA
D.C. current gain (note 1)			
I_C = 50 mA; V_{CE} = 20 V	h_{FE}	>	30
I_C = 150 mA; V_{CE} = 20 V	h_{FE}	>	30
Transition frequency at f = 500 MHz (note 1)			
I_C = 80 mA; V_{CE} = 20 V	f_T	typ.	3,5 GHz
I_C = 150 mA; V_{CE} = 20 V	f_T	typ.	3,5 GHz
Collector capacitance at f = 1 MHz			
$I_E = I_e = 0$; V_{CB} = 20 V	C_c	typ.	3,5 pF
Feedback capacitance at f = 1 MHz			
I_C = 10 mA; V_{CE} = 20 V	C_{re}	typ.	1,6 pF

APPLICATION INFORMATION (see also test circuit on page 4)

Measuring conditions: I_C = 80 mA; V_{CE} = 18 V; T_{amb} = 25 ^oC

Cross modulation (channel 13) (note 2)			
V_o = 48 dBmV	d_{cm}	typ. <	−61 dB −57 dB
V_o = 32 dBmV	d_{cm}	typ. <	−93 dB −89 dB
Intermodulation distortion			
$V_p = V_o$ = 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.	−64 dB
Broadband power gain	G_p	> typ.	8 dB 9 dB
Noise figure at f = 200 MHz	F	typ. <	9 dB 10 dB
2nd harmonic distortion at $f_{(p+q)}$ = 210 MHz			
f_p = 66 MHz; f_q = 144 MHz; V_o = 48 dBmV	d_2	typ. <	−62 dB −56 dB

Notes

1. Measured under pulse conditions.
2. In 12-channel measuring equipment; channel 13 unmodulated.
   V_o = output level/signal, in accordance with NCTA measuring standard.

APPLICATION INFORMATION

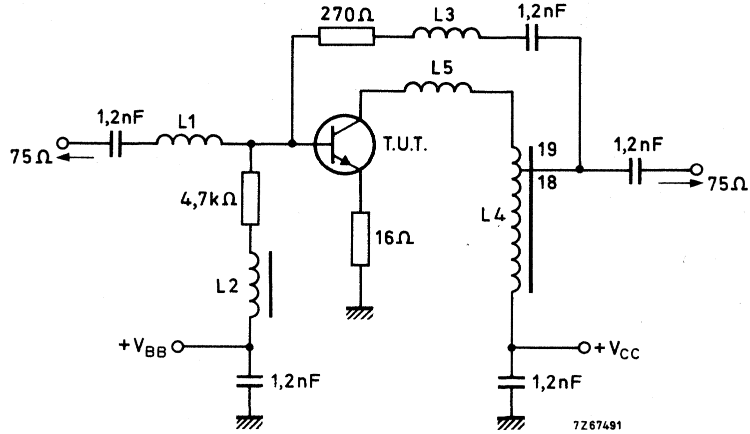


Fig. 2 CATV test circuit.
Frequency range 40 to 300 MHz
Power gain G_p typ. 9 dB

L1 = 2 turns closely wound enamelled Cu wire (0,7 mm); int. dia. 3 mm
L2 = 5 μH Ferroxcube coil (cat. no. 3122 108 20153)
L3 = 3 turns closely wound enamelled Cu wire (0,7 mm); int. dia. 4,7 mm
L4 = 19 turns enamelled Cu wire (0,3 mm) on Ferroxcube core (cat. no. 4322 020 91001)
L5 = 2 turns closely wound enamelled Cu wire (0,7 mm); int. dia. 3 mm.

SILICON PLANAR EPITAXIAL TRANSISTOR

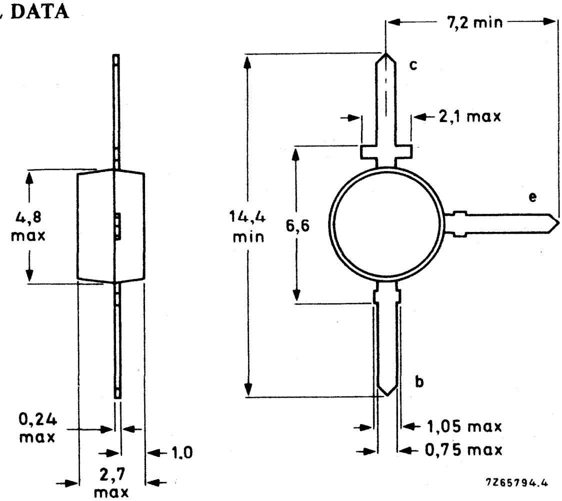
N-P-N transistor in a subminiature plastic transfer-moulded T-package.
It is primarily intended for use in u.h.f. and microwave amplifiers such as in aerial amplifiers, radar systems, oscilloscopes, spectrum analysers, etc.
The transistor features very low intermodulation distortion and high power gain; 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.	20	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector current (d.c.)	I_C	max.	75	mA
Total power dissipation up to T_{amb} = 60 °C	P_{tot}	max.	500	mW
Junction temperature	T_j	max.	175	°C
Transition frequency at f = 500 MHz I_C = 50 mA; V_{CE} = 10 V	f_T	typ.	5	GHz
Feedback capacitance at f = 1 MHz I_C = 10 mA; V_{CE} = 10 V; T_{amb} = 25 °C	C_{re}	<	1,4	pF
Noise figure at optimum source impedance I_C = 50 mA; V_{CE} = 10 V; f = 500 MHz; T_{amb} = 25 °C	F	typ.	3,3	dB
Max. unilateral power gain (see page 3) I_C = 50 mA; V_{CE} = 10 V; f = 500 MHz; T_{amb} = 25 °C	G_{UM}	typ.	16	dB
Intermodulation distortion at T_{amb} = 25 °C I_C = 50 mA; V_{CE} = 10 V; R_L = 75 Ω; V_o = 500 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 (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.	3,0	V

Currents

Collector current (d.c.)	I_C	max.	75	mA
Collector current (peak value); f > 1 MHz	I_{CM}	max.	150	mA

Power dissipation

Total power dissipation up to T_{amb} = 60 °C mounted on a fibre-glass print of 40 mm x 35 mm x 1,5 mm	P_{tot}	max.	500	mW

Temperatures

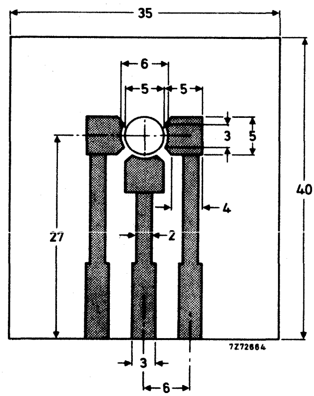
Storage temperature	T_{stg}		-65 to +175	°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

From junction to ambient in free air mounted on a fibre-glass print of 40 mm x 35 mm x 1,5 mm	$R_{th\ j-a}$	=	0,23	°C/mW

Requirements for fibre-glass print

Dimensions in mm



Single-sided 35 μm Cu-clad epoxy fibre-glass print, thickness 1,5 mm.
Tracks are fully tin-lead plated.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 10$ V	I_{CBO}	<	100	nA
D.C. current gain [1]				
$I_C = 50$ mA; $V_{CE} = 10$ V	h_{FE}	> typ.	25 50	
$I_C = 75$ mA; $V_{CE} = 10$ V	h_{FE}	> typ.	25 52	
Transition frequency at f = 500 MHz [1]				
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	> typ.	4,0 5,0	GHz GHz
$I_C = 75$ mA; $V_{CE} = 10$ V	f_T	> typ.	4,4 5,5	GHz GHz
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	1,3	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 0,5$ V	C_e	typ.	5,0	pF
Feedback capacitance at f = 1 MHz				
$I_C = 10$ mA; $V_{CE} = 10$ V; $T_{amb} = 25$ °C	C_{re}	typ. <	1,0 1,4	pF pF
Noise figure at optimum source impedance				
$I_C = 50$ mA; $V_{CE} = 10$ V; f = 500 MHz; $T_{amb} = 25$ °C	F	typ.	3,3	dB
$I_C = 50$ mA; $V_{CE} = 10$ V; f = 800 MHz; $T_{amb} = 25$ °C	F	typ.	3,8	dB
Max. unilateral power gain (s_{re} assumed to be zero)				
G_{UM} (in dB) $= 10 \log \dfrac{\lvert s_{fe}\rvert^2}{(1 - \lvert s_{ie}\rvert^2)(1 - \lvert s_{oe}\rvert^2)}$				
$I_C = 50$ mA; $V_{CE} = 10$ V; f = 500 MHz; $T_{amb} = 25$ °C	G_{UM}	typ.	16	dB

[1]) Measured under pulse conditions.

CHARACTERISTICS (continued)

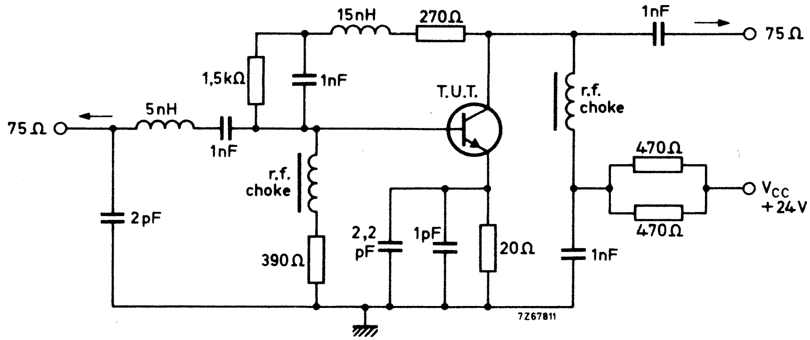
Intermodulation distortion at T_{amb} = 25 °C

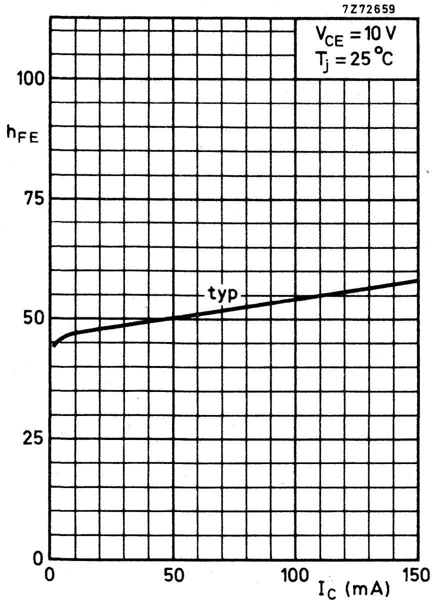
I_C = 50 mA; V_{CE} = 10 V; R_L = 75 Ω

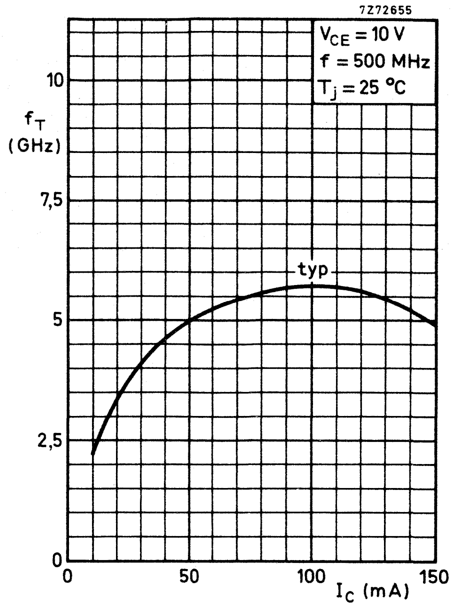
$V_p = V_o$ = 500 mV at f_p = 495,25 MHz
$V_q = V_o$ − 6 dB at f_q = 503,25 MHz
$V_r = V_o$ − 6 dB at f_r = 505,25 MHz

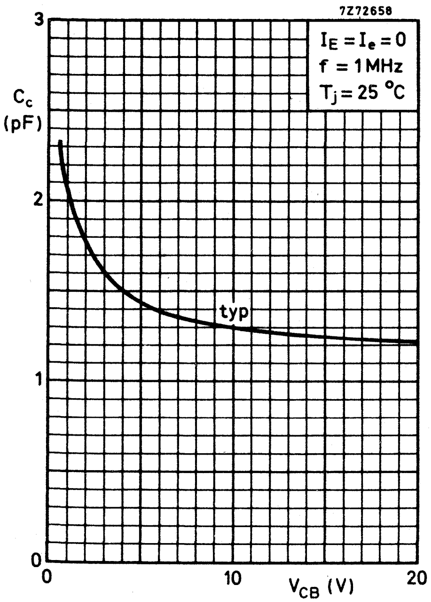
Measured at $f_{(p+q-r)}$ = 493,25 MHz | d_{im} | typ. | −60 | dB

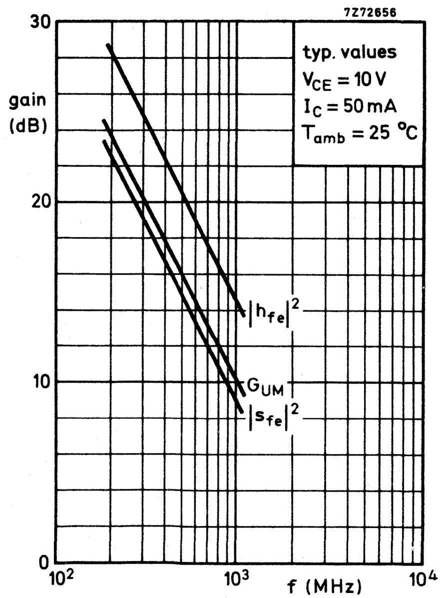
Intermodulation test circuit:



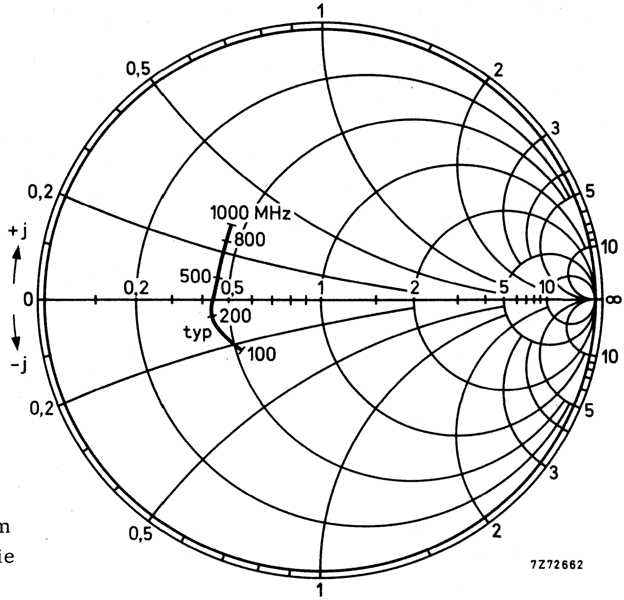

7Z72659
V_{CE} = 10 V
T_j = 25 °C
h_{FE}
100
75
50
25
0
typ
0
50
100
150
I_C (mA)


7Z72655
V_{CE} = 10 V
f = 500 MHz
T_j = 25 °C
f_T
(GHz)
10
7,5
5
2,5
0
typ
0
50
100
150
I_C (mA)


7Z72658
$I_E = I_e = 0$
f = 1 MHz
T_j = 25 °C
C_c
(pF)
3
2
1
0
typ
0
10
20
V_{CB} (V)

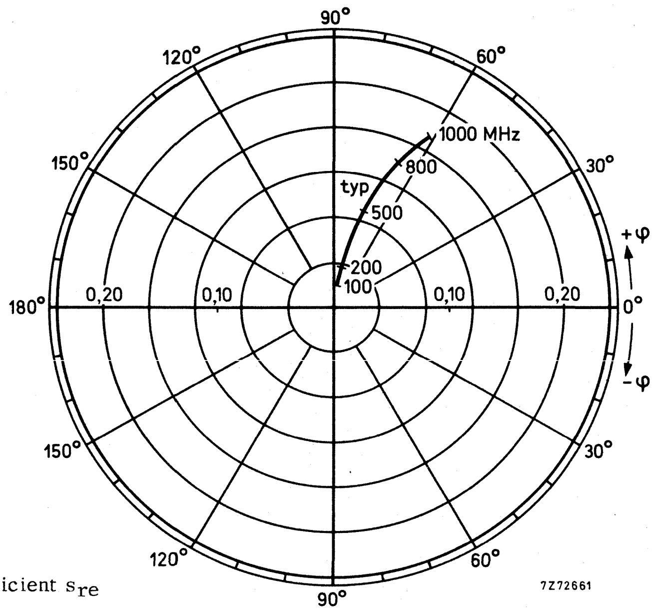

7Z72656
typ. values
V_{CE} = 10 V
I_C = 50 mA
T_{amb} = 25 °C
gain
(dB)
30
20
10
0
$|h_{fe}|^2$
G_{UM}
$|s_{fe}|^2$
10^2
10^3
10^4
f (MHz)

V_{CE} = 10 V
I_C = 50 mA
T_{amb} = 25 °C



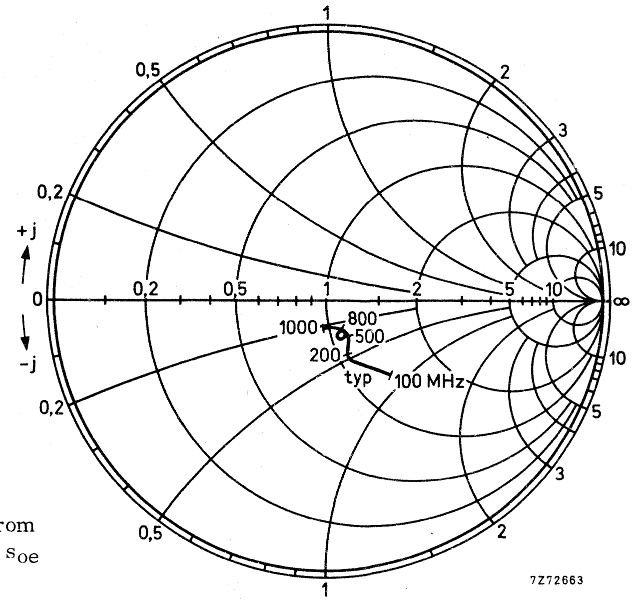
Input impedance derived from input reflection coefficient s_{ie} co-ordinates in ohm x 50

V_{CE} = 10 V
I_C = 50 mA
T_{amb} = 25 °C



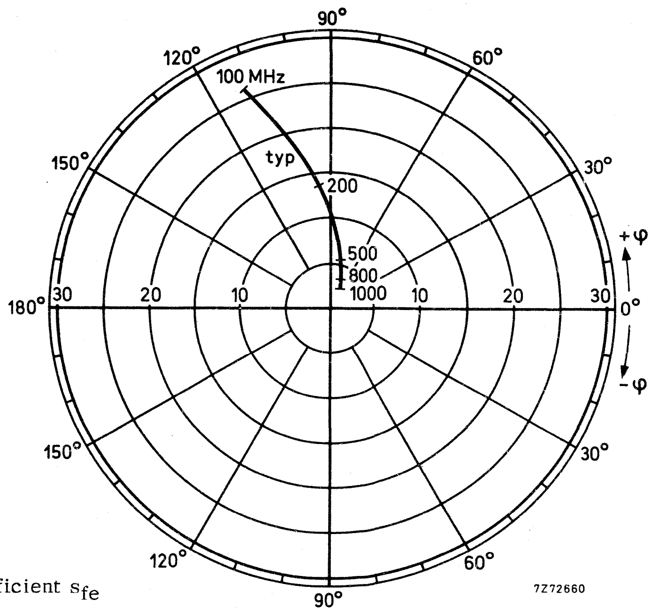
Reverse transmission coefficient s_{re}

V_{CE} = 10 V
I_C = 50 mA
T_{amb} = 25 ^oC

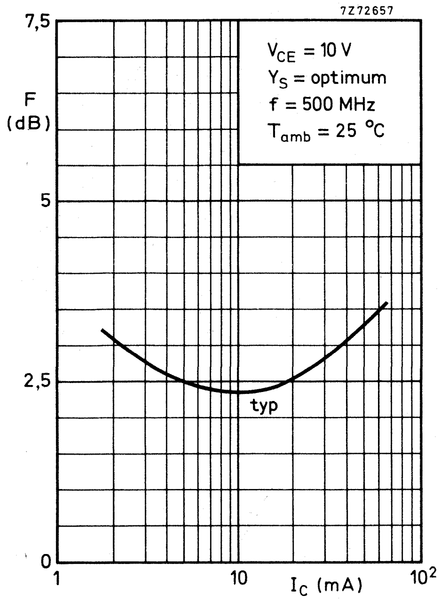


Output impedance derived from output reflection coefficient s_{oe} co-ordinates in ohm x 50

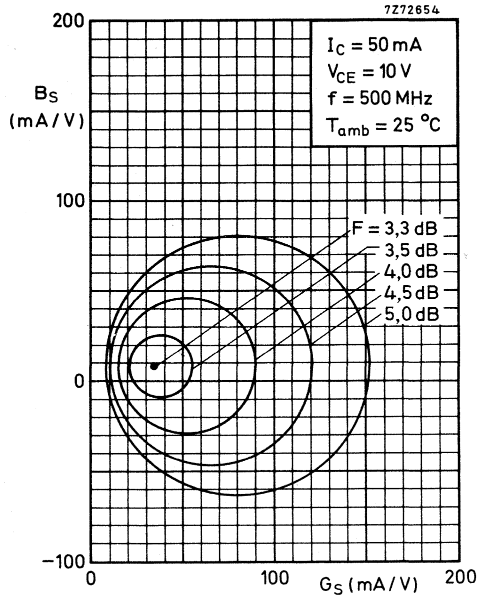
V_{CE} = 10 V
I_C = 50 mA
T_{amb} = 25 ^oC



Forward transmission coefficient s_{fe}



circles of constant noise figure



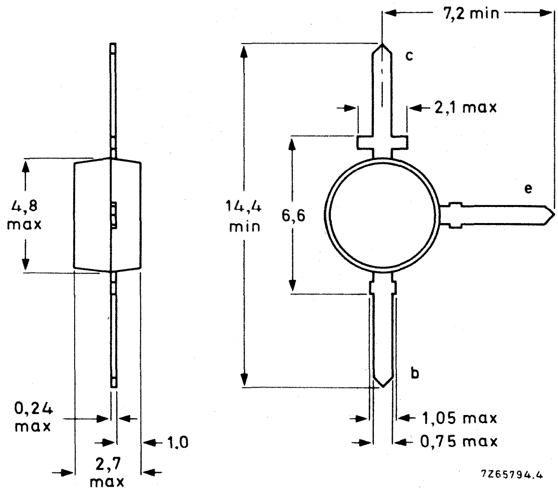
SILICON PLANAR EPITAXIAL TRANSISTOR

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

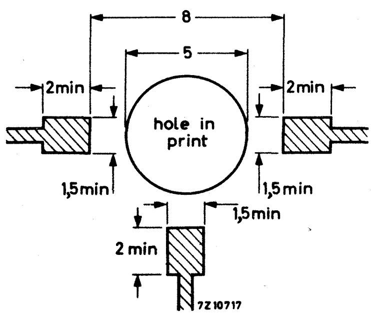
THERMAL RESISTANCE

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 °C unless otherwise specified

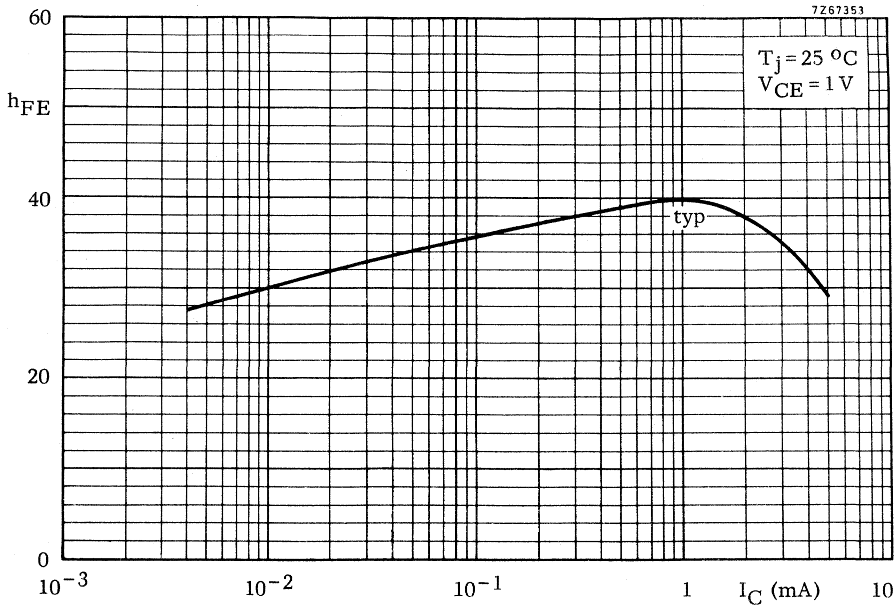
Collector cut-off current				
$I_E = 0$; $V_{CB} = 5$ V	I_{CBO}	<	50	nA
D.C. current gain 1)				
$I_C = 10\ \mu A$; $V_{CE} = 1$ V	h_{FE}	>	20	
		typ.	30	
$I_C = 1$ mA; $V_{CE} = 1$ V	h_{FE}	>	20	
		typ.	40	
Saturation voltages				
$I_C = 10\ \mu A$; $I_B = 1\ \mu A$	V_{CEsat}	<	100	mV
	V_{BEsat}	<	700	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; $T_{amb} = 25$ °C	C_{re}	<	0,4	pF
Noise figure at optimum source impedance				
$I_C = 0{,}1$ mA; $V_{CE} = 1$ V; f = 500 MHz; $T_{amb} = 25$ °C	F	typ.	5,5	dB
$I_C = 1$ mA; $V_{CE} = 1$ V; f = 500 MHz; $T_{amb} = 25$ °C	F	typ.	3,8	dB

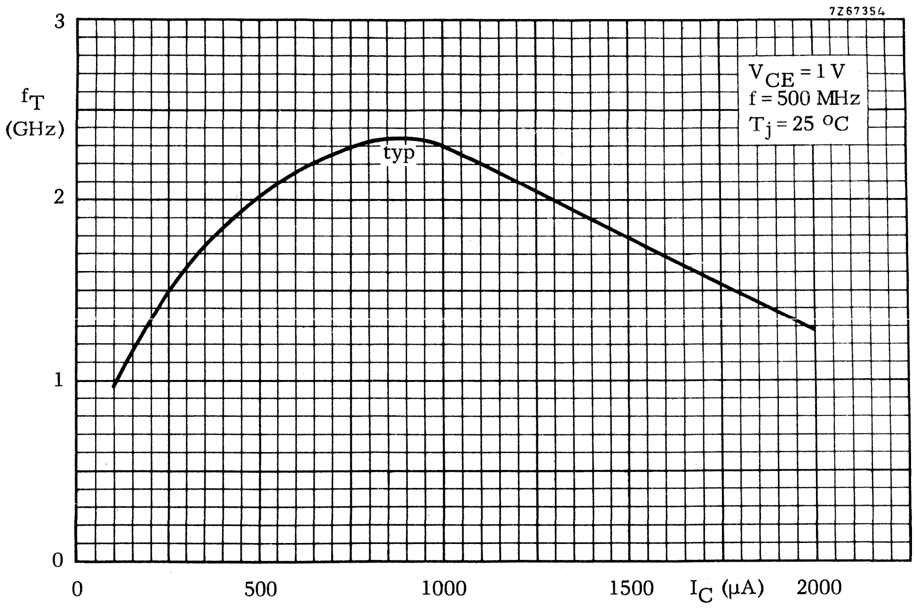
Max. unilateral power gain (s_{re} assumed to be zero)

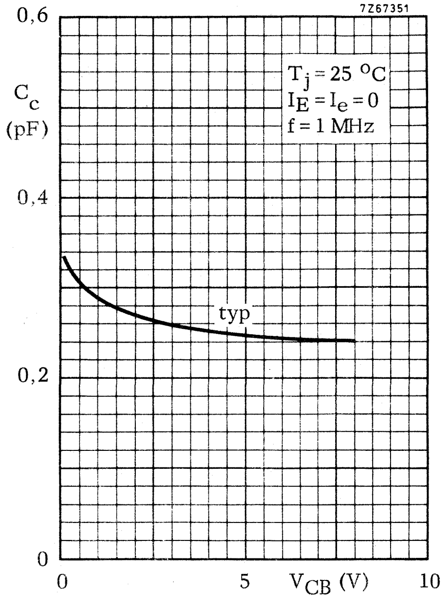
$$G_{UM} \text{ (in dB)} = 10 \log \frac{|s_{fe}|^2}{(1-|s_{ie}|^2)(1-|s_{oe}|^2)}$$

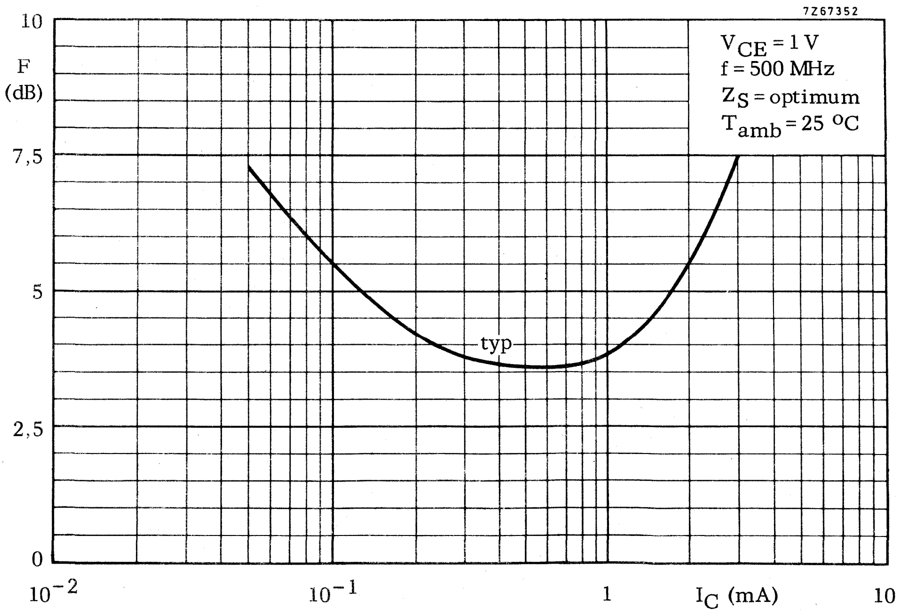
$I_C = 1$ mA; $V_{CE} = 1$ V; f = 200 MHz; $T_{amb} = 25$ °C	G_{UM}	typ.	24	dB
$I_C = 1$ mA; $V_{CE} = 1$ V; f = 500 MHz; $T_{amb} = 25$ °C	G_{UM}	typ.	17	dB
$I_C = 1$ mA; $V_{CE} = 1$ V; f = 800 MHz; $T_{amb} = 25$ °C	G_{UM}	typ.	11	dB

1) Measured under pulse conditions.

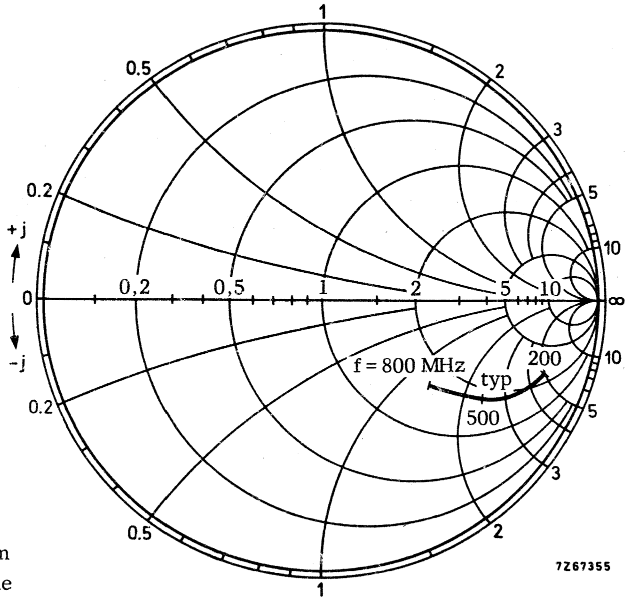

7Z67353
60
40
20
0
hFE
Tj = 25 °C
VCE = 1 V
typ
10−3
10−2
10−1
1
IC (mA)
10


7Z67354
3
2
1
0
fT
(GHz)
VCE = 1 V
f = 500 MHz
Tj = 25 °C
typ
0
500
1000
1500
IC (μA)
2000


7Z67351
0,6
C_c
(pF)
0,4
0,2
0
$T_j = 25\ ^oC$
$I_E = I_e = 0$
f = 1 MHz
typ
0
5
V_{CB} (V)
10

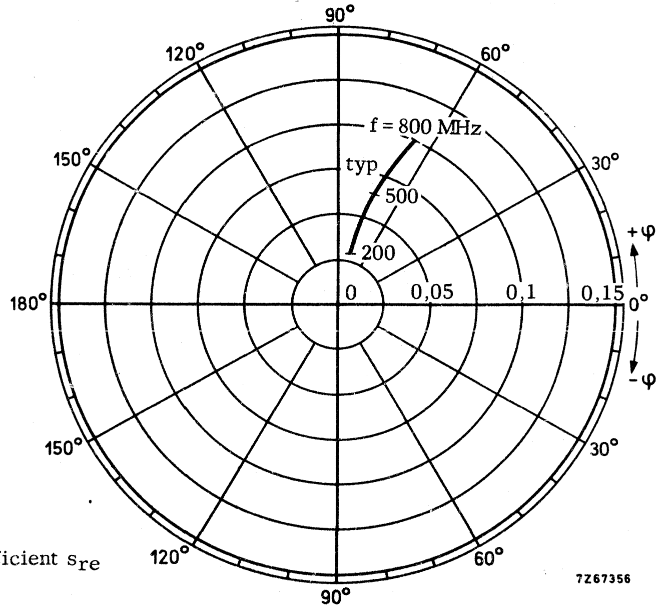

7Z67352
10
F
(dB)
7,5
5
2,5
0
$V_{CE} = 1$ V
f = 500 MHz
Z_S = optimum
$T_{amb} = 25\ ^oC$
typ
10^{-2}
10^{-1}
1
I_C (mA)
10

V_{CE} = 1 V
I_C = 1 mA
T_{amb} = 25 °C



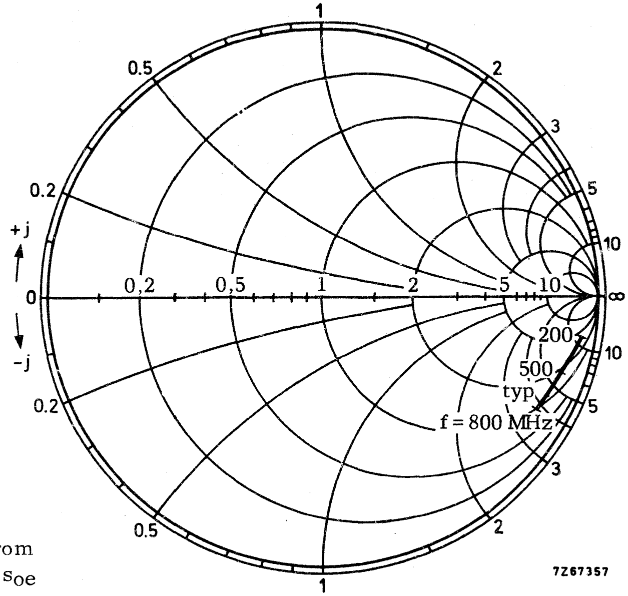
Input impedance derived from input reflection coefficient s_{ie} coordinates in ohm x 50

V_{CE} = 1 V
I_C = 1 mA
T_{amb} = 25 °C



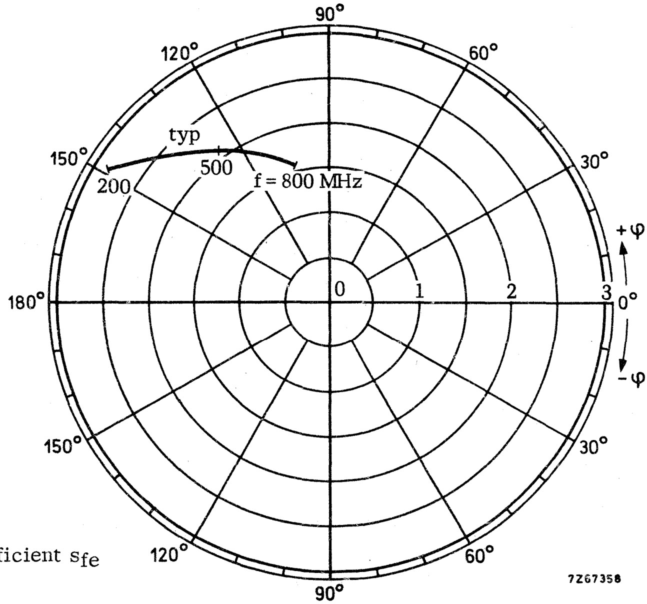
Reverse transmission coefficient s_{re}

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 P-N-P HIGH-VOLTAGE TRANSISTORS

Planar epitaxial transistors in TO-39 metal envelopes, intended as general purpose amplifiers and switching devices in industrial and telephone applications.

QUICK REFERENCE DATA

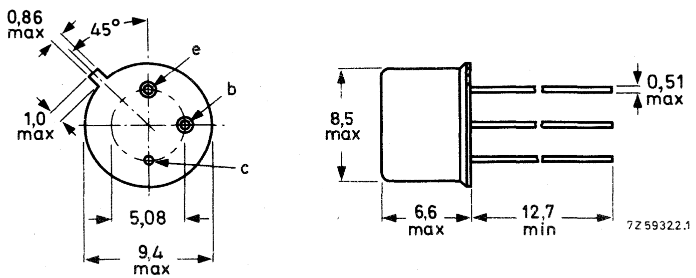
			BFT44	BFT45	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	300	250	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	300	250	V
Collector current (d.c.)	$-I_C$	max.	0,5		A
Total power dissipation up to T_{case} = 50 °C	P_{tot}	max.	5,0		W
Junction temperature	T_j	max.	200		°C
D.C. current gain $-I_C$ = 10 mA; $-V_{CE}$ = 10 V	h_{FE}		50 to 150		
Transition frequency at f = 35 MHz $-I_C$ = 15 mA; $-V_{CE}$ = 10 V	f_T	typ.	70		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

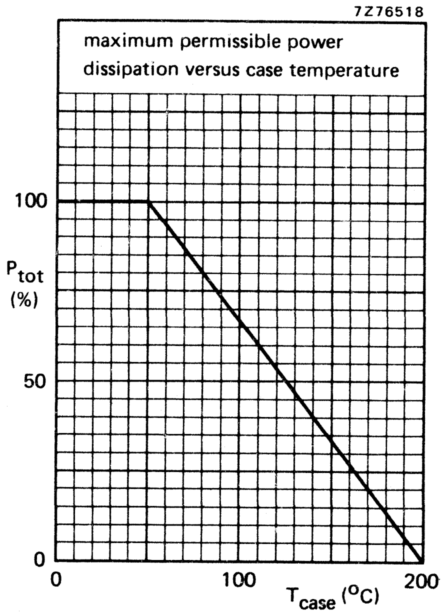
			BFT44	BFT45	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	300	250	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	300	250	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	V

Current

Collector current (d.c.)	$-I_C$	max.	0,5	A

Power dissipation

Total power dissipation up to T_{case} = 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	$R_{th\ j-a}$	=	200	°C/W
From junction to case	$R_{th\ j-c}$	=	30	°C/W

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

Collector cut-off current

$I_E = 0$; $-V_{CB} = 200$ V	$-I_{CBO}$	<	5	μA
$I_B = 0$; $-V_{CE} = 200$ V; $T_j = 125\ ^oC$	$-I_{CEO}$	<	300	μA

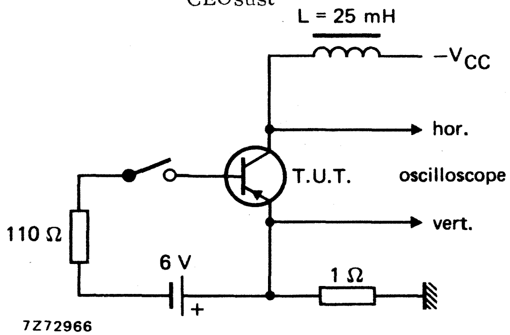
Emitter cut-off current

$I_C = 0$; $-V_{EB} = 3$ V	$-I_{EBO}$	<	5	μA

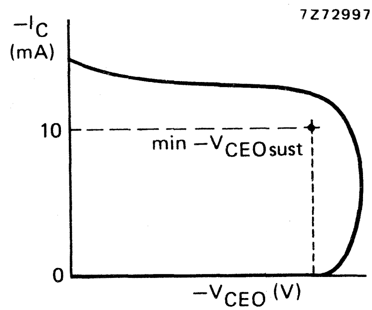
Collector-emitter sustaining voltage

			BFT44	BFT45	
$-I_C = 10$ mA; $I_B = 0$; $L = 25$ mH	$-V_{CEOsust}$	>	300	250	V 1)

Test circuit for $V_{CEOsust}$



Oscilloscope display for $V_{CEOsust}$



Saturation voltages

$-I_C = 10$ mA; $-I_B = 1$ mA		$-V_{CEsat}$	<	0,5	V
		$-V_{BEsat}$	<	0,8	V
$-I_C = 100$ mA; $-I_B = 10$ mA		$-V_{CEsat}$	<	1,4	V
		$-V_{BEsat}$	<	0,9	V
$-I_C = 500$ mA; $-I_B = 100$ mA	BFT44	$-V_{CEsat}$	<	5,0	V 2)
	BFT45	$-V_{CEsat}$	<	3,0	V 2)
		$-V_{BEsat}$	<	1,2	V 2)

D.C. current gain

$-I_C = 1$ mA; $-V_{CE} = 10$ V	h_{FE}	>	30	
$-I_C = 10$ mA; $-V_{CE} = 10$ V	h_{FE}		50 to 150	
$-I_C = 100$ mA; $-V_{CE} = 10$ V	h_{FE}	>	50	2)

Collector capacitance at f = 1 MHz

$I_E = I_e = 0$; $-V_{CB} = 20$ V	C_c	<	15	pF

1) $-V_{CC} = 0$ to 50 V; f = 400 Hz; $\delta = 0,5$ (see also test circuit).
2) Measured under pulse conditions: $t_p = 300\ \mu s$; $\delta \leq 0,02$.

CHARACTERISTICS (continued) $T_j = 25\ ^oC$

Transition frequency at f = 35 MHz

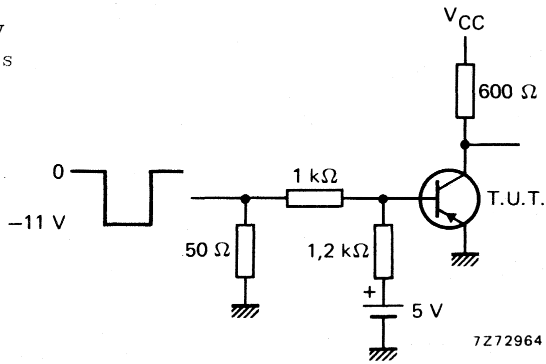
$-I_C$ = 15 mA; $-V_{CE}$ = 10 V	f_T	typ.	70	MHz

Switching times

$-I_{Con}$ = 50 mA; $-I_{Bon}$ = I_{Boff} = 5 mA (test circuit 1)	t_{on}	typ.	125	ns
	t_{off}	typ.	850	ns
$-I_{Con}$ = 500 mA; $-I_{Bon}$ = I_{Boff} = 100 mA (test circuit 2)	t_{on}	typ.	125	ns
	t_{off}	typ.	125	ns

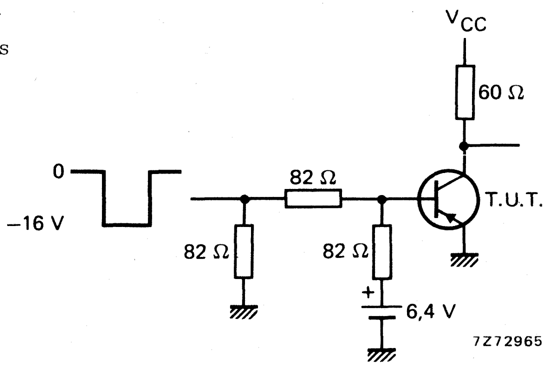
Test circuit 1

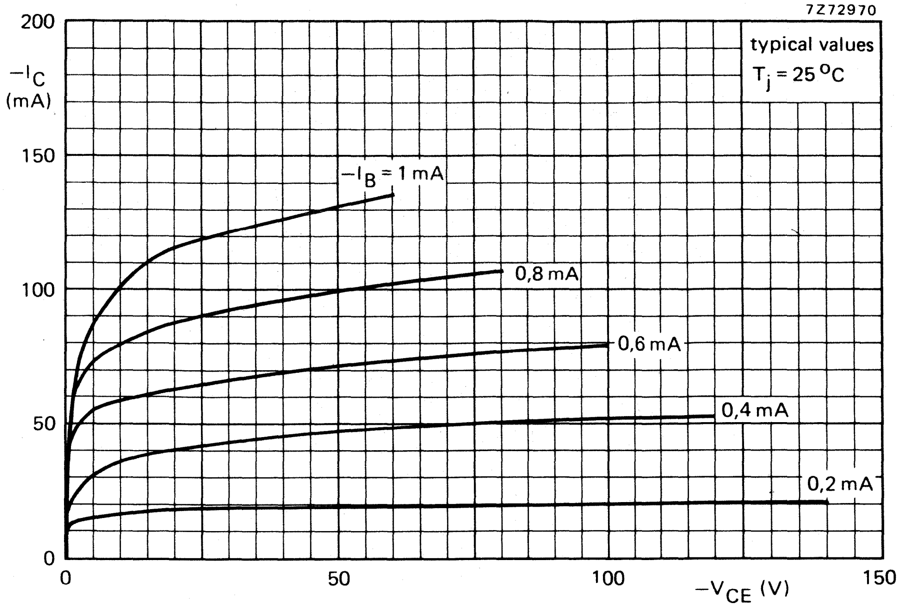
V_{CC} = −31 V
t_p = 10 μs

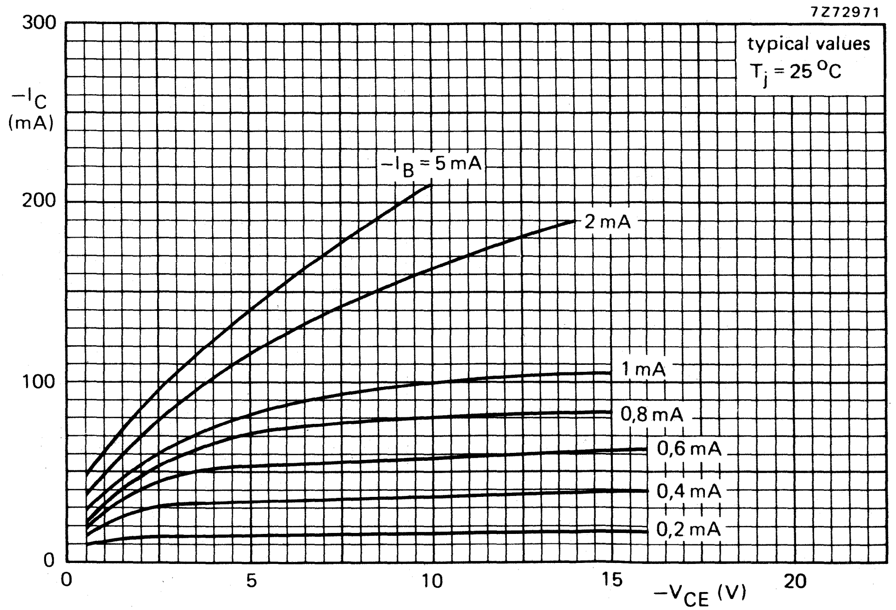


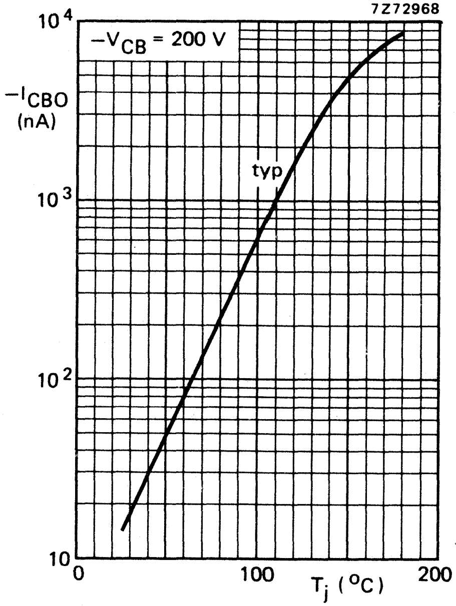
Test circuit 2

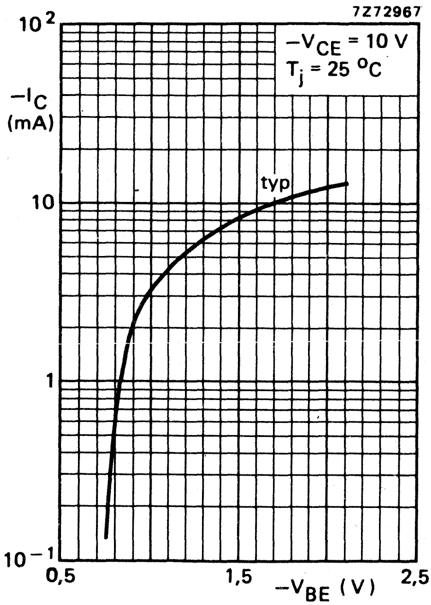
V_{CC} = −31 V
t_p = 10 μs

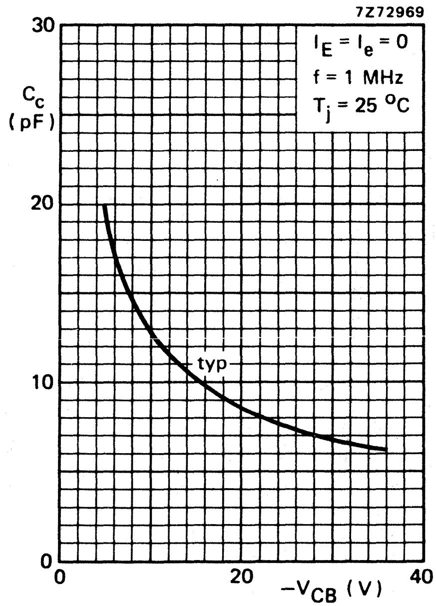


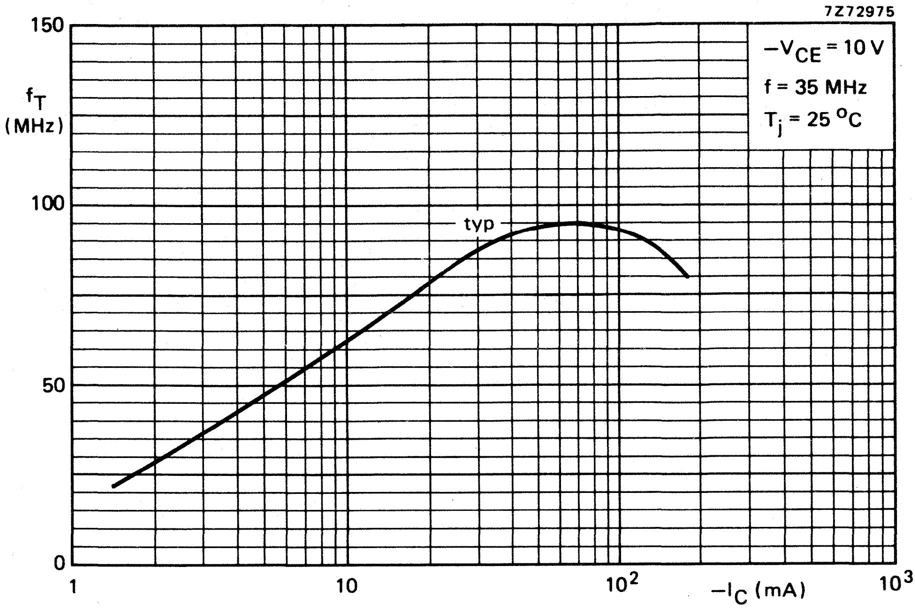

7Z72970
typical values
T_j = 25 °C
$-I_C$ (mA)
$-I_B$ = 1 mA
0,8 mA
0,6 mA
0,4 mA
0,2 mA
$-V_{CE}$ (V)
0
50
100
150
200

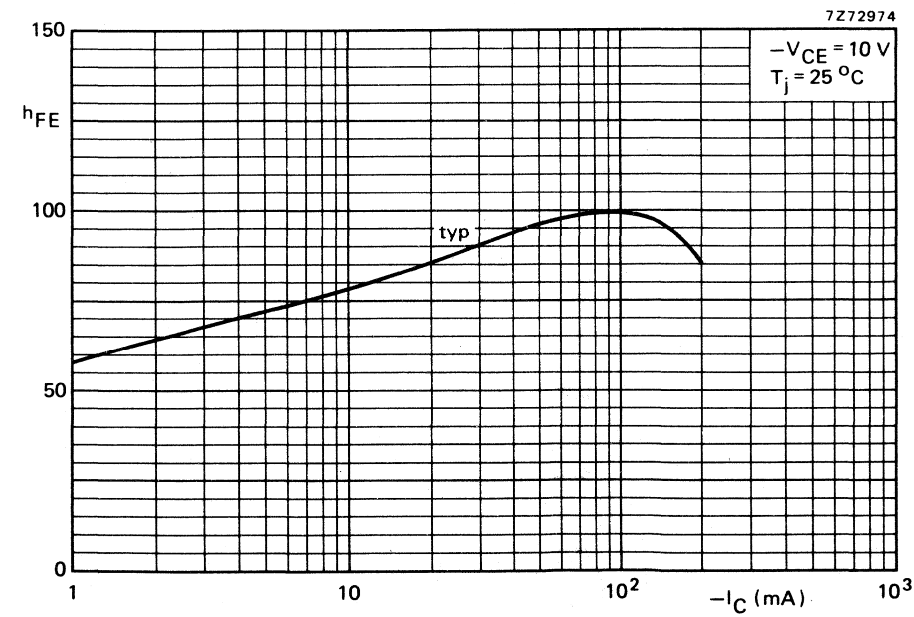

7Z72971
typical values
T_j = 25 °C
$-I_C$ (mA)
$-I_B$ = 5 mA
2 mA
1 mA
0,8 mA
0,6 mA
0,4 mA
0,2 mA
$-V_{CE}$ (V)
0
5
10
15
20
100
200
300

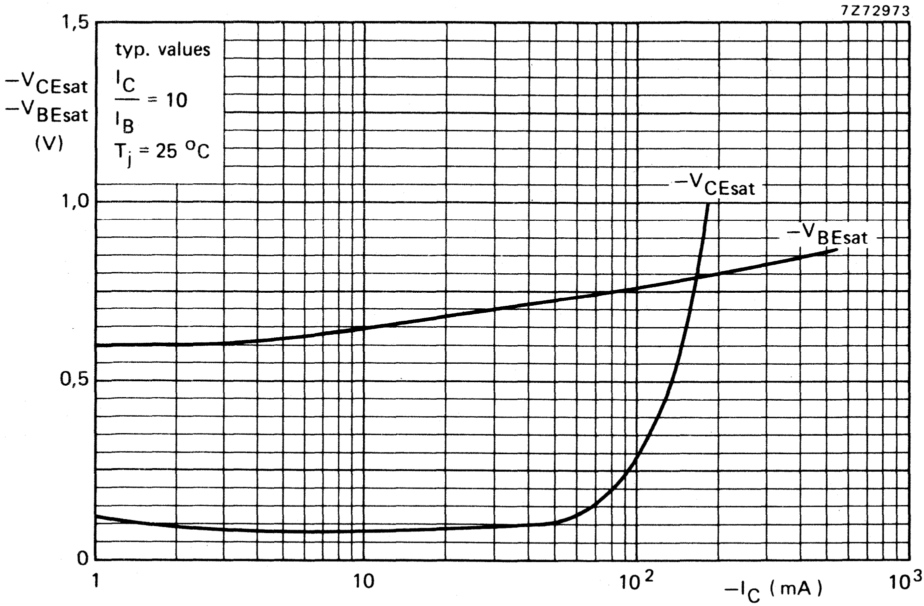

7Z72968
$-V_{CB}$ = 200 V
$-I_{CBO}$ (nA)
10^4
10^3
10^2
10
typ
0
100
200
T_j (°C)

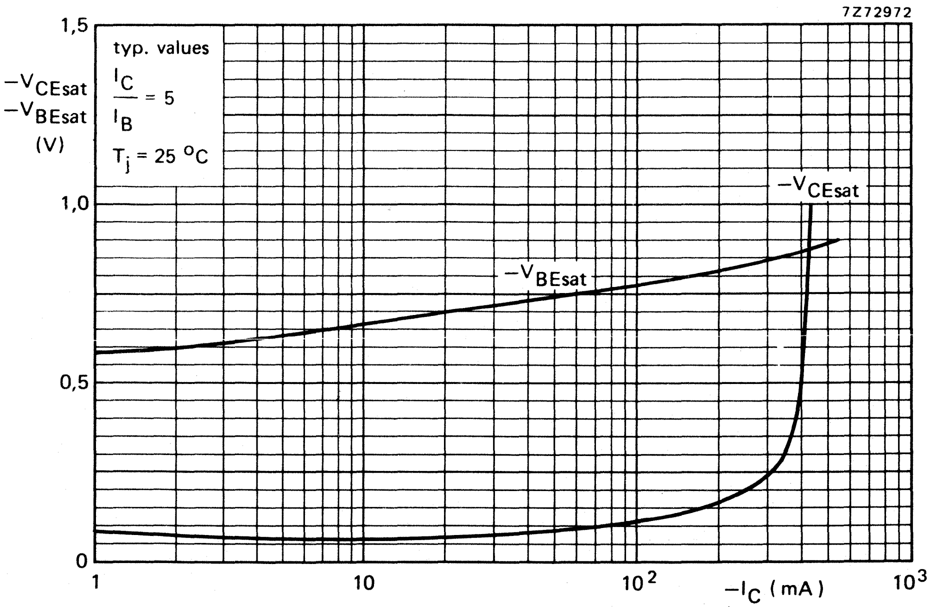

7Z72967
$-V_{CE}$ = 10 V
T_j = 25 °C
$-I_C$ (mA)
10^2
10
1
10^{-1}
typ
0,5
1,5
2,5
$-V_{BE}$ (V)


7Z72969
$I_E = I_e = 0$
f = 1 MHz
T_j = 25 °C
C_c (pF)
30
20
10
0
typ
0
20
40
$-V_{CB}$ (V)


7Z72975
150
100
50
0
f_T
(MHz)
$-V_{CE}$ = 10 V
f = 35 MHz
T_j = 25 °C
typ
1
10
10^2
$-I_C$ (mA)
10^3


7Z72974
150
100
50
0
h_{FE}
$-V_{CE}$ = 10 V
T_j = 25 °C
typ
1
10
10^2
$-I_C$ (mA)
10^3


7Z72973
typ. values
$\frac{I_C}{I_B} = 10$
$T_j = 25\ ^oC$
$-V_{CEsat}$
$-V_{BEsat}$
(V)
1,5
1,0
0,5
0
1
10
10^2
10^3
$-I_C$ (mA)
$-V_{CEsat}$
$-V_{BEsat}$


7Z72972
typ. values
$\frac{I_C}{I_B} = 5$
$T_j = 25\ ^oC$
$-V_{CEsat}$
$-V_{BEsat}$
(V)
1,5
1,0
0,5
0
1
10
10^2
10^3
$-I_C$ (mA)
$-V_{CEsat}$
$-V_{BEsat}$

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 extremely 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 bands I, II, III and IV/V (40–860 MHz).
- Final stage of the wideband vertical amplifier in high speed oscilloscopes.

QUICK REFERENCE DATA

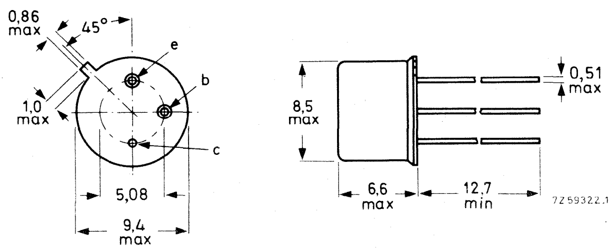
Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	40		V
Collector-emitter voltage (open base)	V_{CEO}	max.	25		V
Collector current (peak value; f > 1 MHz)	I_{CM}	max.	300		mA
Total power dissipation up to T_{mb} = 125 °C	P_{tot}	max.	1,5		W
Junction temperature	T_j	max.	200		°C
Feedback 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
Power gain (not neutralized)			f = 200	800	MHz
I_C = 70 mA; V_{CE} = 18 V	G_p	typ.	16	6,5	dB
Output power d_{im} = −30 dB; VSWR 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



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

Accessories supplied on request: 56218 (package); 56245 (distance disc).

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.

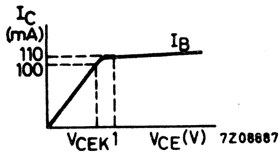
CHARACTERISTICS $T_j = 25\ ^oC$ unless otherwise specified

Collector cut-off current

$I_E = 0$; $V_{CB} = 20$ V; $T_j = 150\ ^oC$	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; $T_{amb} = 25\ ^oC$	C_{re}	typ.	1.7	pF

Noise figure at f = 200 MHz

$I_C = 30$ mA; $V_{CE} = 15$ V; $R_S = 75\ \Omega$; $T_{amb} = 25\ ^oC$	F	<	6	dB

Power gain (not neutralized)

		f = 200	800	MHz
$I_C = 70$ mA; $V_{CE} = 18$ V; $T_{amb} = 25\ ^oC$	G_p	typ. 16	6.5	dB

CHARACTERISTICS (continued)

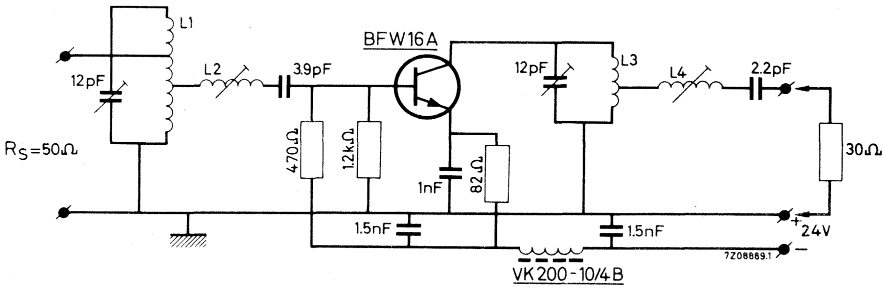
Intermodulation characteristics

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

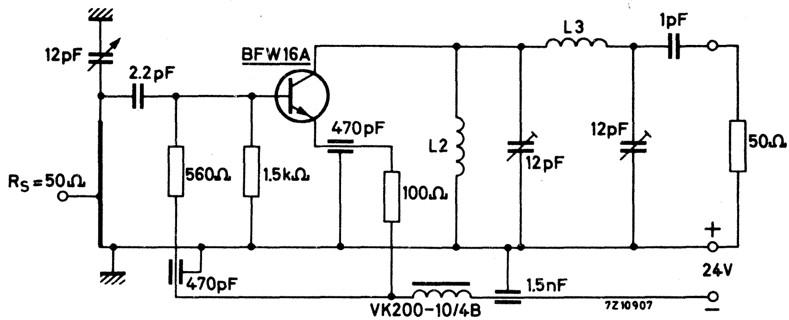
1. Remove the transistor and connect a dummy consisting of a 220 Ω resistor in parallel with a 5.6 pF capacitor between the collector and emitter connections of the output circuit.
2. Tune and match the output circuit for zero reflection at 205 MHz (V.S.W.R. = 1). After this adjustment, no further change 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:



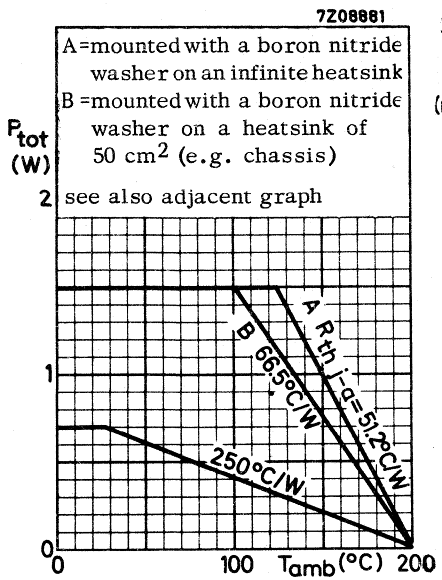
Coil data:
L1 = 25 mm x 7 mm x 0.85 mm silver plated Cu strip
Tap of the input at 5 mm from earth.
L2 = 13 turns enamelled Cu wire (0.6 mm); int. diam. 8 mm
L3 = 1.5 turns Cu wire (1.3 mm); int. diam. 8 mm

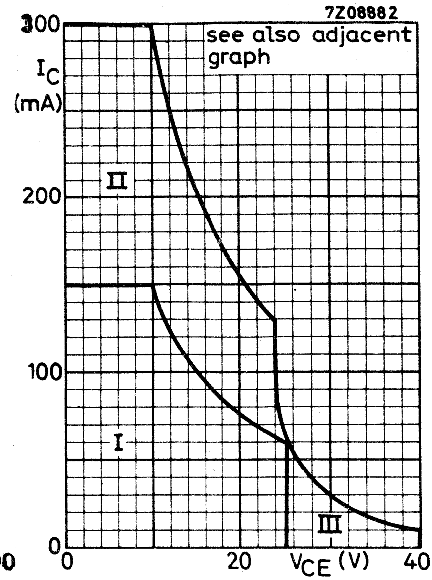
Basis of adjustment

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 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 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.

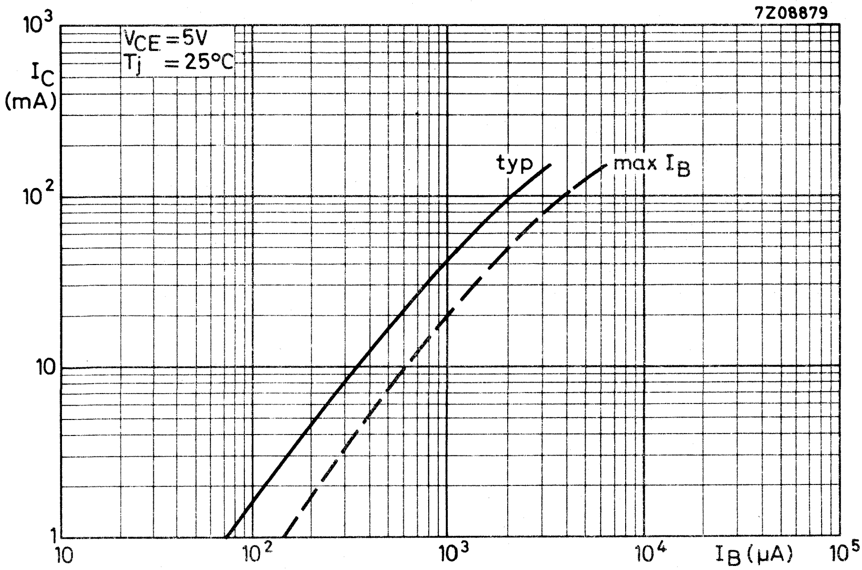


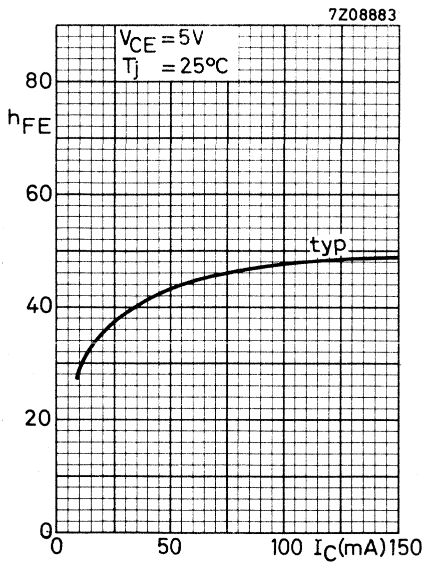


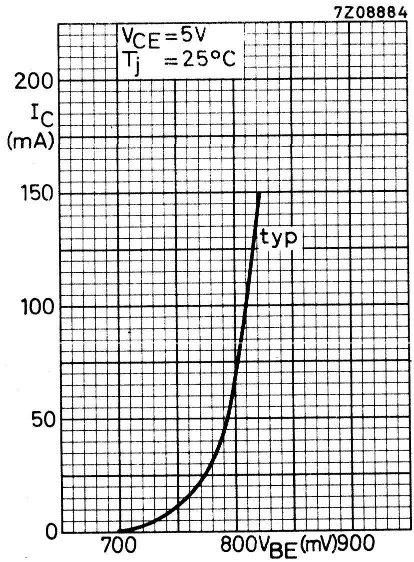
I = Region of permissible operation under all base-emitter conditions and at all frequencies, including d.c.

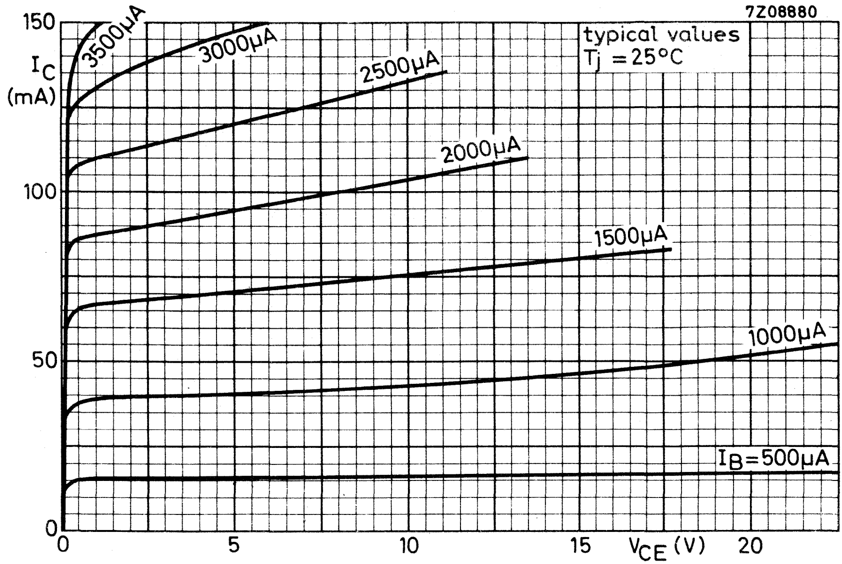
II = Additional region of operation at f ≥ 1 MHz.

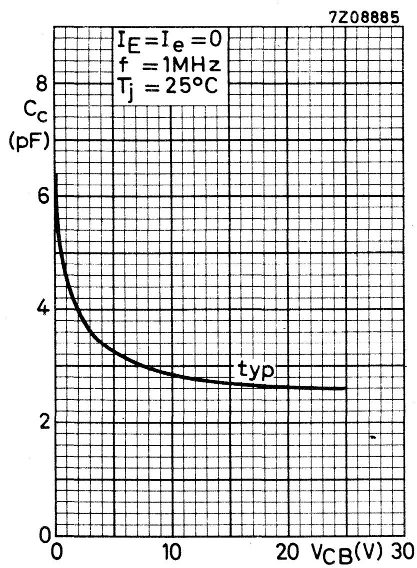
III = Operating under pulsed conditions is allowed, provided the transistor is cut-off with $R_{BE} \leq 50\ \Omega$ and f ≥ 1 MHz.

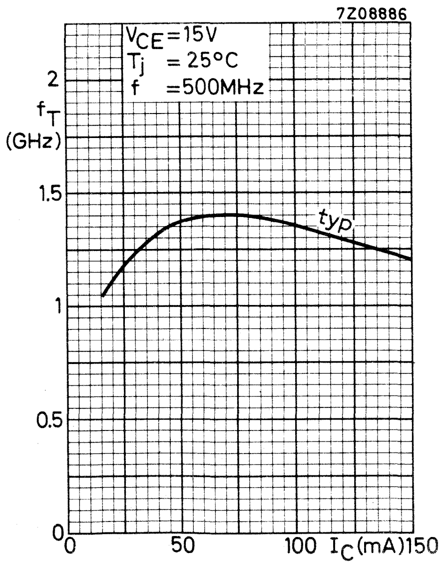

7Z08879
10^3
I_C (mA)
$V_{CE} = 5V$
$T_j = 25°C$
typ
max I_B
10^2
10
1
10
10^2
10^3
10^4
I_B (μA)
10^5


7Z08883
$V_{CE} = 5V$
$T_j = 25°C$
80
h_{FE}
60
typ
40
20
0
0
50
100
I_C (mA)
150


7Z08884
$V_{CE} = 5V$
$T_j = 25°C$
200
I_C (mA)
150
typ
100
50
0
700
800
V_{BE} (mV)
900


7Z08880
typical values
Tj = 25°C
150
IC
(mA)
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
8
Cc
(pF)
6
4
2
0
typ
0
10
20 VCB(V) 30


7Z08886
VCE=15V
Tj = 25°C
f = 500MHz
2
fT
(GHz)
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 extremely 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 bands I, II and III (40–230 MHz).

QUICK REFERENCE DATA

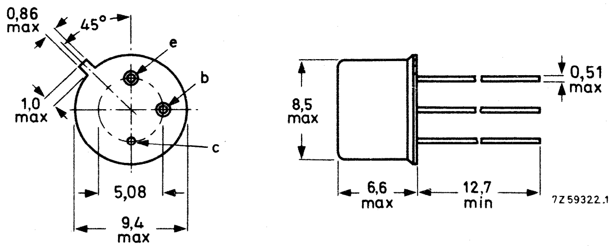
Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Collector current (peak value; f > 1 MHz)	I_{CM}	max.	300	mA
Total power dissipation up to T_{mb} = 125 °C	P_{tot}	max.	1,5	W
Junction temperature	T_j	max.	200	°C
Feedback capacitance 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; VSWR 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



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

Accessories supplied on request: 56218 (package); 56245 (distance disc).

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.

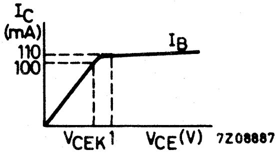
CHARACTERISTICS T_j = 25 °C unless otherwise specified

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.	1.1	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

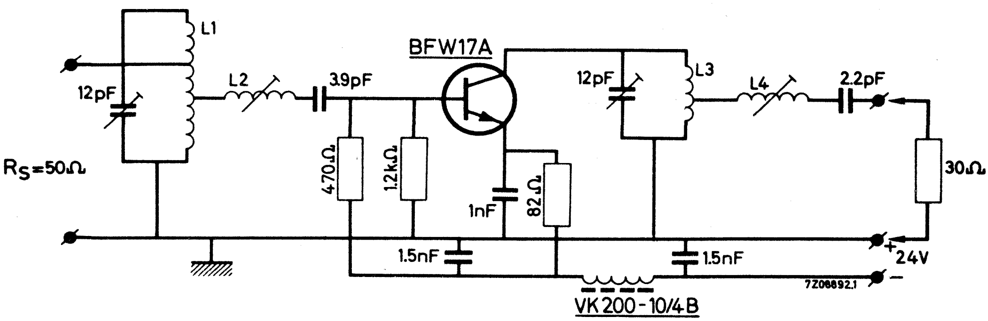
CHARACTERISTICS (continued)

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

$$R_L = \frac{V_{CE} - V_{CEK}}{I_C}$$

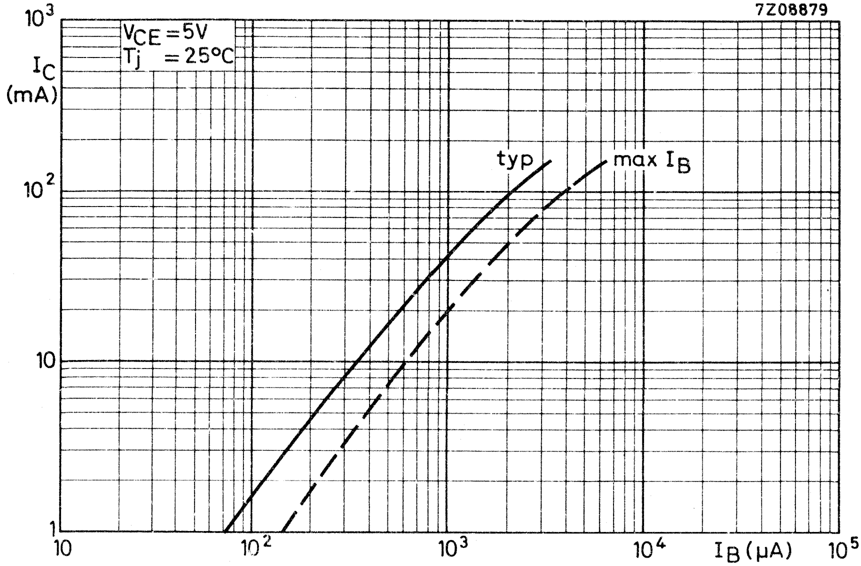
in which V_{CEK} is the high frequency knee voltage.

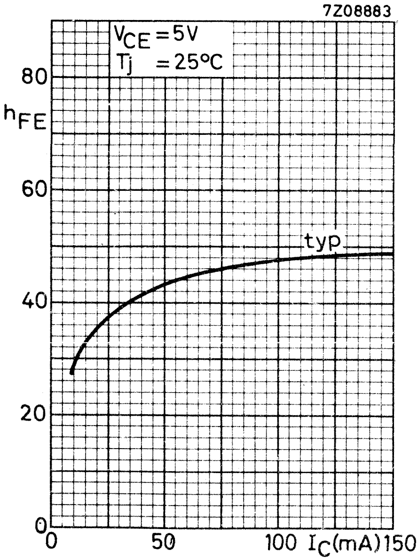
b. The h.f. collector current is as small as possible.
This is so if $-C_L = +C_{oe}$,
in which C_{oe} is the output capacitance of the transistor at short circuited input.

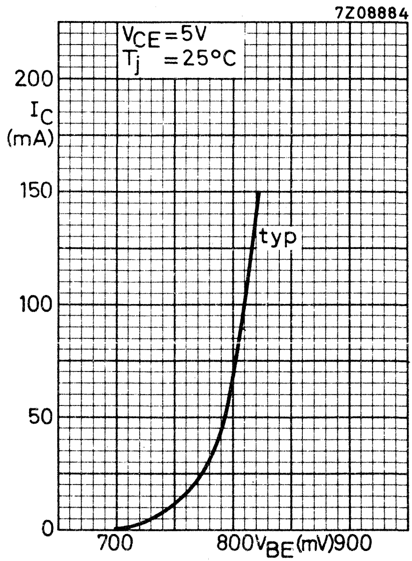
For maximum output power at an intermodulation distortion of −30 dB, the (experimentally found) values of R_L and C_L are:
$R_L = 220\ \Omega$; $C_L = -5.6$ pF.
C_{oe} is found by 4 pF of the transistor and 1.6 pF by the mounting system concerning of a borium nitride washer between the envelope of the transistor and the chassis.

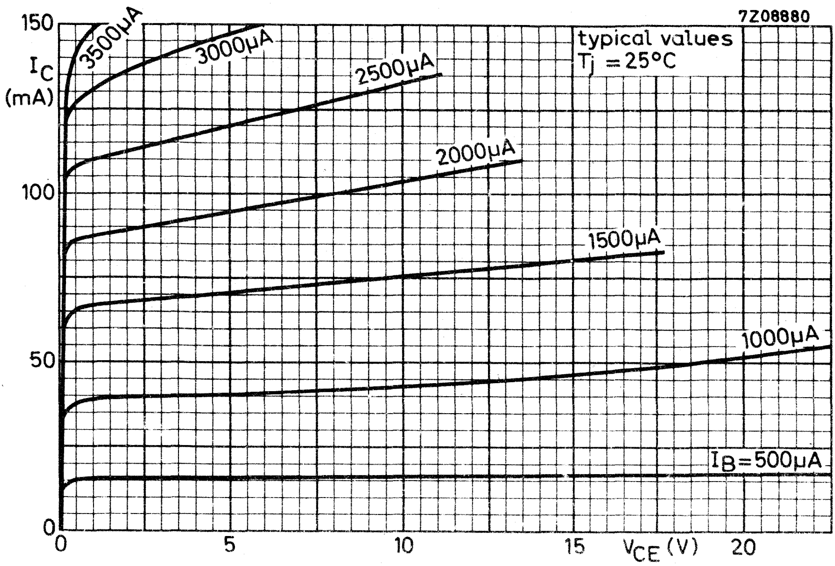
Adjustment procedure

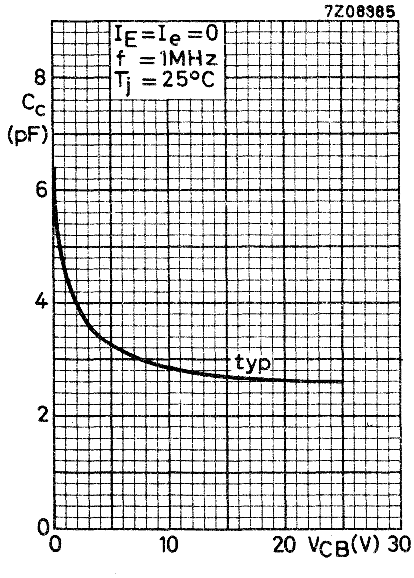
1. Remove the transistor and connect a dummy consisting of a 220 Ω resistor in parallel with a 5.6 pF capacitor between the collector and emitter connections of the output circuit.
2. Tune and match the output circuit for zero reflection at 205 MHz (V.S.W.R. = 1). After this adjustment, no further change 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.

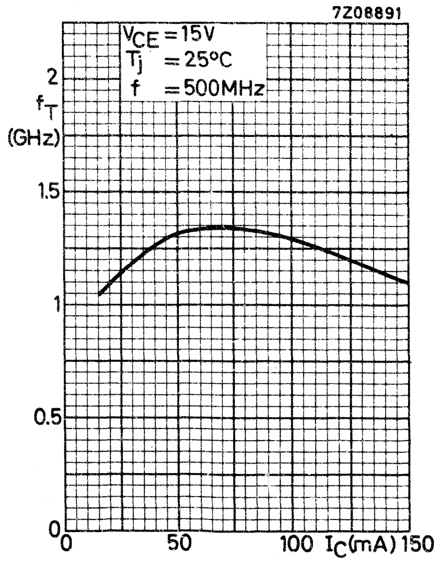

7Z08879
$V_{CE} = 5V$
$T_j = 25^oC$
I_C (mA)
typ
max I_B
I_B (μA)
10
10^2
10^3
10^4
10^5
1
10

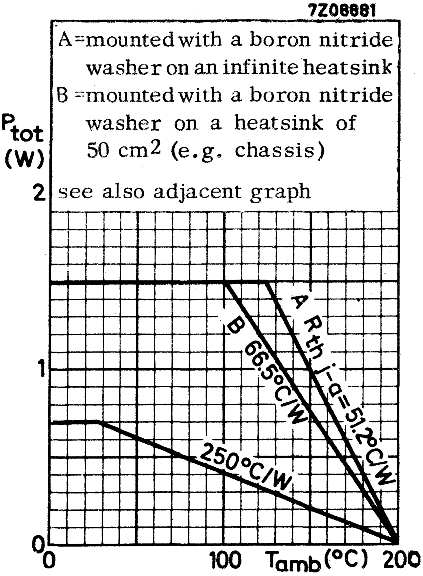

7Z08883
$V_{CE} = 5V$
$T_j = 25^oC$
h_{FE}
typ
I_C (mA)

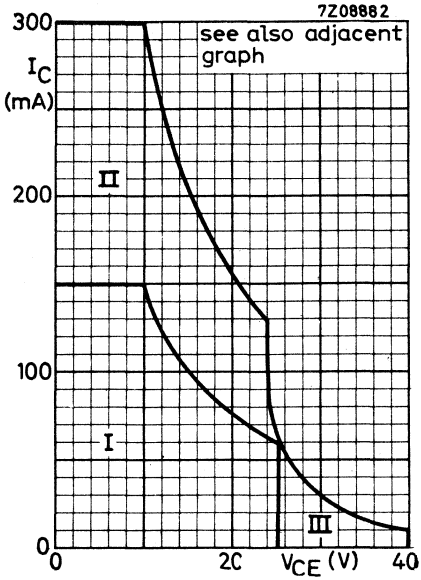

7Z08884
$V_{CE} = 5V$
$T_j = 25^oC$
I_C (mA)
typ
V_{BE} (mV)


7Z08880
typical values
Tj = 25°C
150
IC
(mA)
100
50
0
3500µA
3000µA
2500µA
2000µA
1500µA
1000µA
IB = 500µA
0
5
10
15
VCE (V)
20


7Z08385
IE = Ie = 0
f = 1MHz
Tj = 25°C
8
Cc
(pF)
6
4
2
0
typ
0
10
20 VCB(V) 30


7Z08891
VCE = 15V
Tj = 25°C
f = 500MHz
2
fT
(GHz)
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.

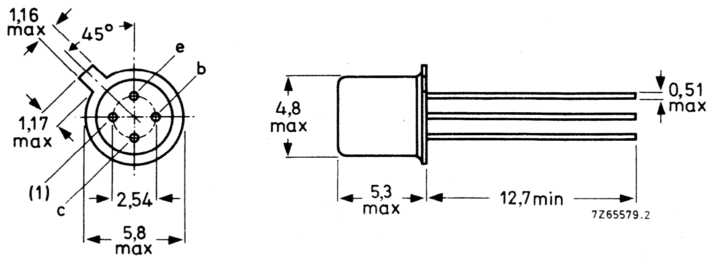
QUICK REFERENCE DATA

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



(1) = shield lead (connected to case).

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

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

Voltages				
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
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} = 25 °C	P_{tot}	max.	250	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	$R_{th\ j-a}$	=	0.7	°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)

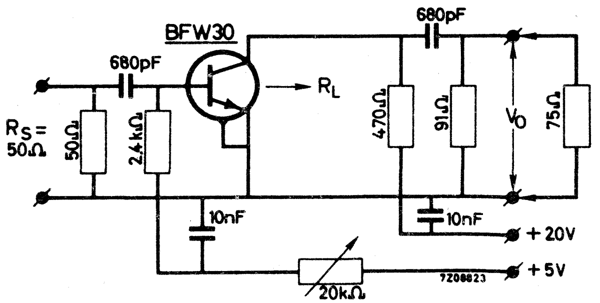
I_C = 30 mA; V_{CE} = 6 V; R_L = 37.5 Ω; T_{amb} = 25 °C

V_o = 100 mV at f_p = 183 MHz

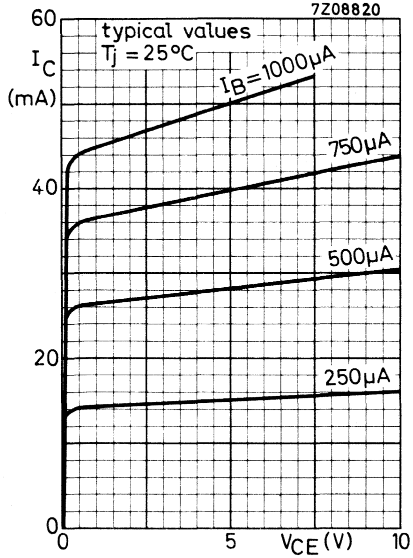
V_o = 100 mV at f_q = 200 MHz

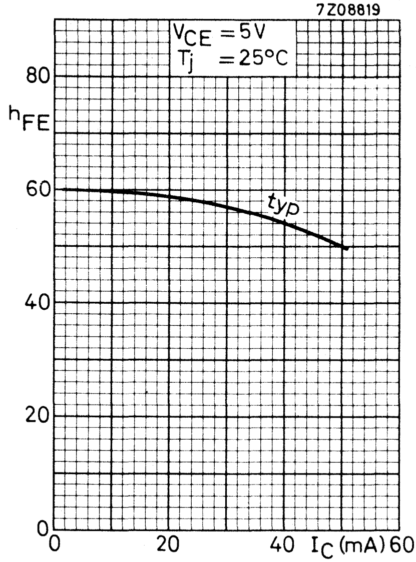
measured at $f_{(2q-p)}$ = 217 MHz — d_{im} typ. −60 dB

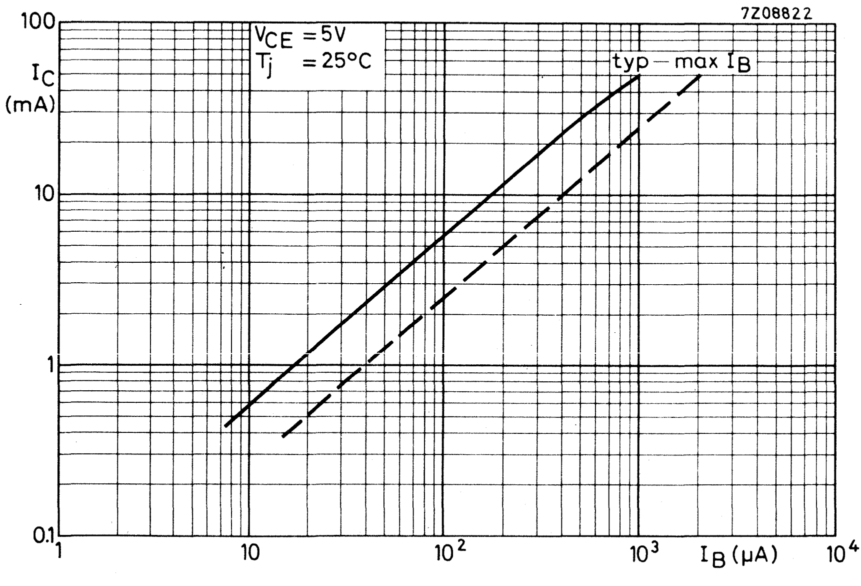
Test circuit

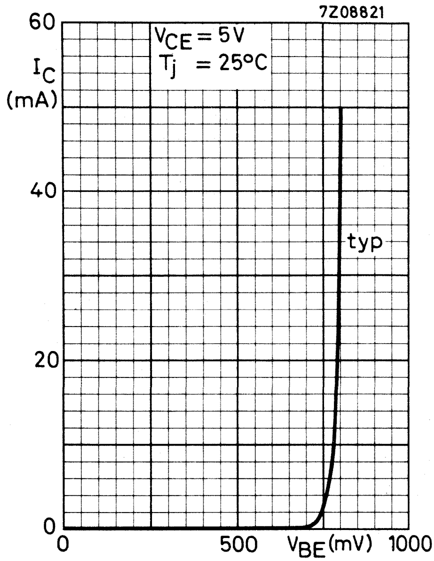


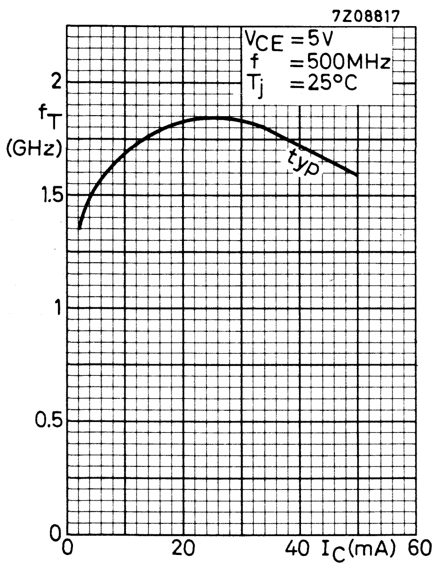
1) Shield lead grounded.
2) Shield lead not connected.

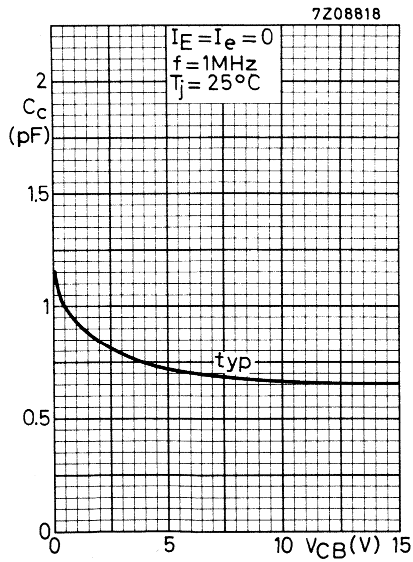

7Z08820
typical values
Tj = 25°C
IC (mA)
IB = 1000 μA
750 μA
500 μA
250 μA
60
40
20
0
0
5
10
VCE (V)


7Z08819
VCE = 5 V
Tj = 25°C
hFE
typ
80
60
40
20
0
0
20
40
60
IC (mA)


7Z08822
VCE = 5 V
Tj = 25°C
IC (mA)
typ
max IB
100
10
1
0.1
1
10
10²
10³
10⁴
IB (μA)


7Z08821
$V_{CE} = 5V$
$T_j = 25°C$
I_C (mA)
60
40
20
0
typ
0
500
V_{BE} (mV)
1000


7Z08817
$V_{CE} = 5V$
f = 500MHz
$T_j = 25°C$
f_T (GHz)
2
1.5
1
0.5
0
typ
0
20
40
I_C (mA)
60


7Z08818
$I_E = I_e = 0$
f = 1MHz
$T_j = 25°C$
C_c (pF)
2
1.5
1
0.5
0
typ
0
5
10
V_{CB} (V)
15

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 wideband oscilloscopes.

QUICK REFERENCE DATA

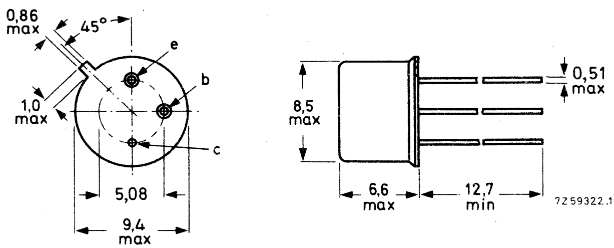
Collector-base voltage (open emitter)	V_{CBO}	max.	165	V
Collector-emitter voltage (open base)	V_{CEO}	max.	130	V
Collector current (peak value)	I_{CM}	max.	100	mA
Total power dissipation up to T_{mb} = 150 °C	P_{tot}	max.	2,5	W
Junction temperature	T_j	max.	200	°C
D.C. current gain I_C = 50 mA; V_{CE} = 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

Collector connected to case

TO-39



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

Accessories supplied on request: 56218 (package); 56245 (distance disc).

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	165	V
Collector-emitter voltage (open base)	V_{CEO}	max.	130	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Currents

Collector current (d.c.)	I_C	max.	50	mA
Collector current (peak value)	I_{CM}	max.	100	mA

Power dissipation

Total power dissipation up to T_{amb} = 40 °C	P_{tot}	max.	0.8	W
T_{mb} = 150 °C	P_{tot}	max.	2.5	W

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	200	°C/W
From junction to mounting base	$R_{th\ j-mb}$	=	20	°C/W [2])
From junction to case	$R_{th\ j-c}$	=	25	°C/W [2])

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

[2]) See also page 8.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $V_{CB} = 100$ V	I_{CBO}	<	100	nA
$I_E = 0$; $V_{CB} = 100$ V; $T_j = 150$ °C	I_{CBO}	<	10	μA

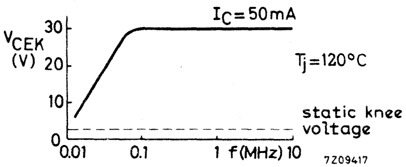
Base-emitter voltage [1]

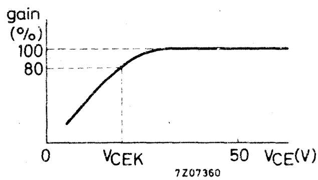
$I_C = 50$ mA; $V_{CE} = 20$ V	V_{BE}	<	1.3	V

High frequency knee voltage at T_j = 120 °C

$I_C = 50$ mA	V_{CEK}	<	27	V

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





Collector-emitter saturation voltage

$I_C = 10$ mA; $I_B = 1$ mA	V_{CEsat}	<	3	V
$I_C = 50$ mA; $I_B = 5$ mA	V_{CEsat}	<	10	V

D.C. current gain

$I_C = 50$ mA; $V_{CE} = 20$ V	h_{FE}		20 to 120	

Feedback capacitance at f = 1 MHz

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

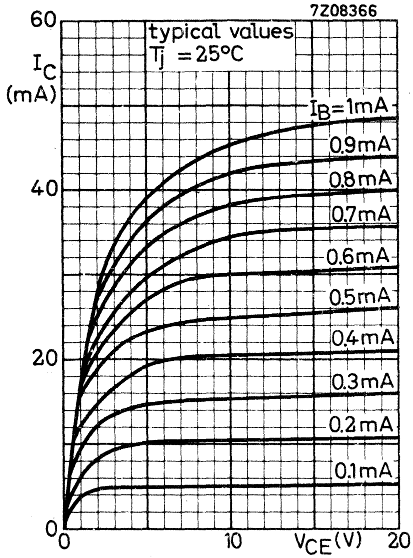
Collector capacitance at f = 1 MHz

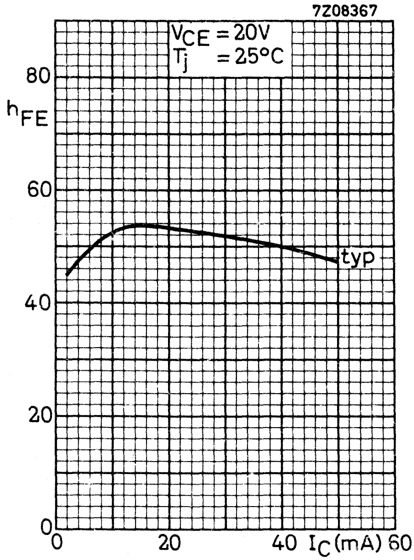
$I_E = I_e = 0$; $V_{CB} = 20$ V	C_c	<	6	pF

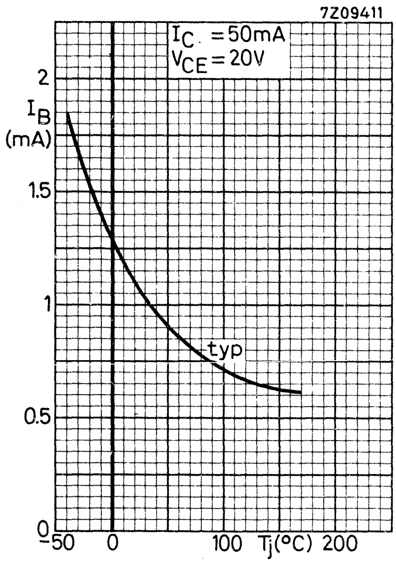
Transition frequency at f = 100 MHz

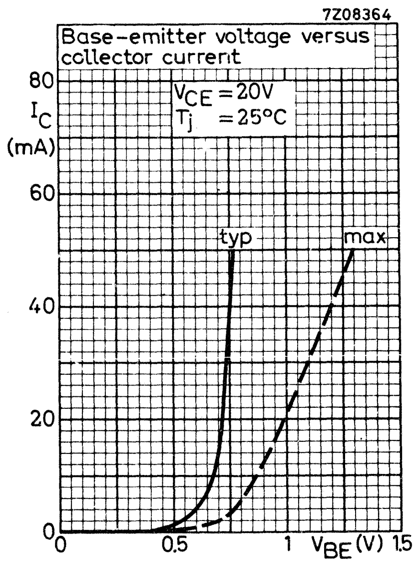
$I_C = 10$ mA; $V_{CE} = 10$ V	f_T	>	80	MHz
		typ.	120	MHz

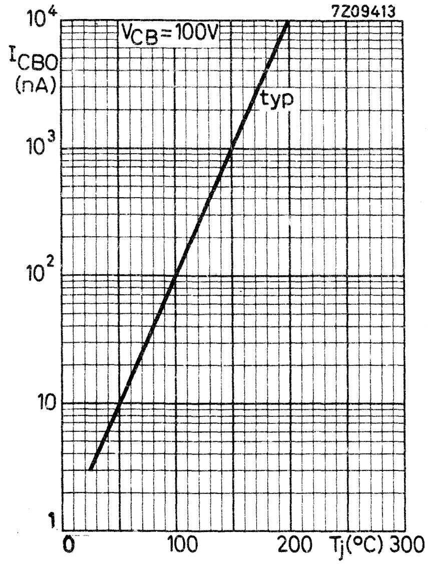
[1] V_{BE} decreases by about 1.6 mV/°C with increasing temperature.

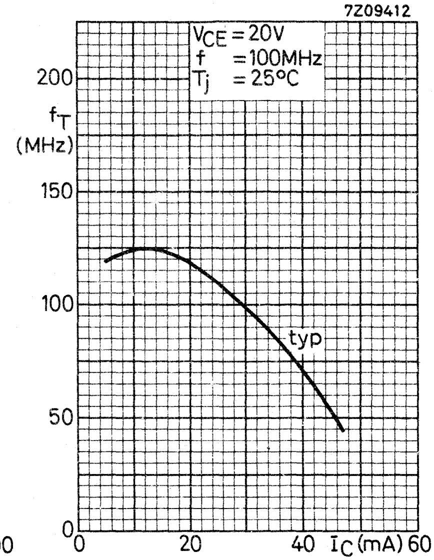

7Z08366
typical values
T_j = 25°C
I_C (mA)
I_B=1mA
0.9mA
0.8mA
0.7mA
0.6mA
0.5mA
0.4mA
0.3mA
0.2mA
0.1mA
V_{CE} (V)
0
10
20
40
60

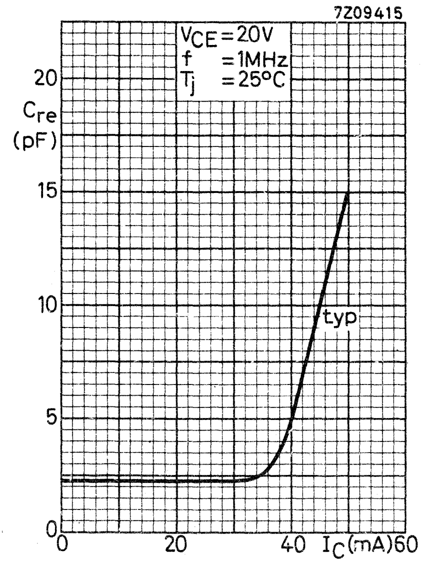

7Z08367
V_{CE} = 20V
T_j = 25°C
h_{FE}
typ
I_C (mA)
0
20
40
60
80

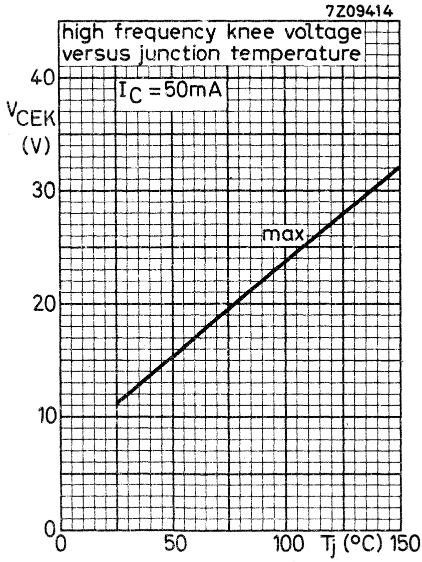

7Z09411
I_C = 50mA
V_{CE} = 20V
I_B (mA)
typ
T_j (°C)
-50
0
100
200
0.5
1
1.5
2

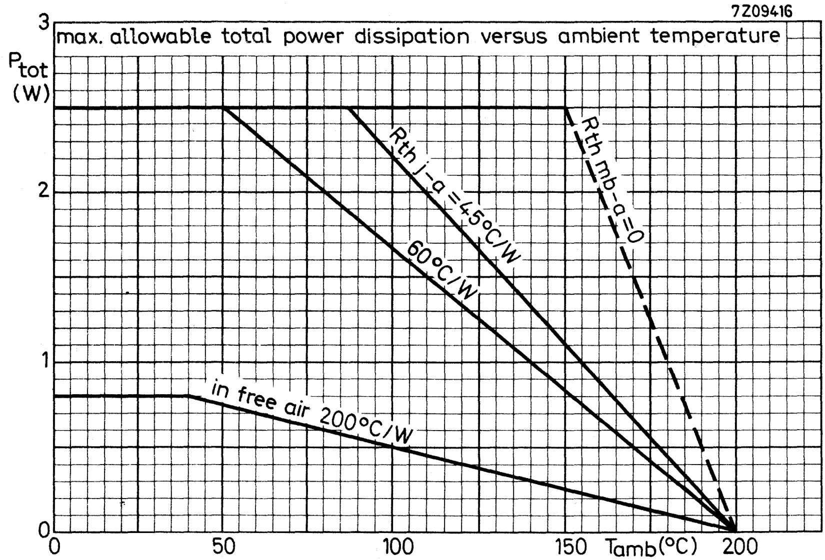

7Z08364
Base-emitter voltage versus collector current
V_{CE} = 20V
T_j = 25°C
I_C (mA)
typ
max
V_{BE} (V)
0
0.5
1
1.5
20
40
60
80

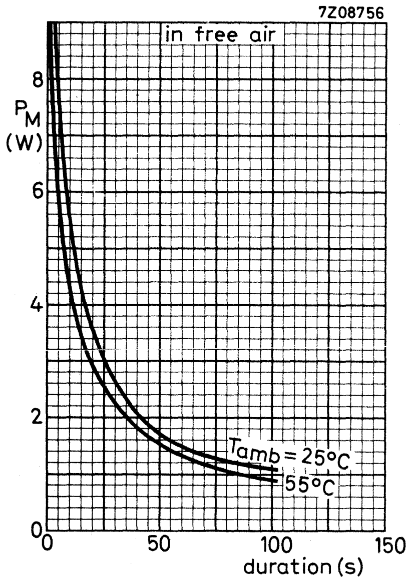

7Z09413
V_CB = 100V
I_CBO (nA)
typ
T_j (°C)

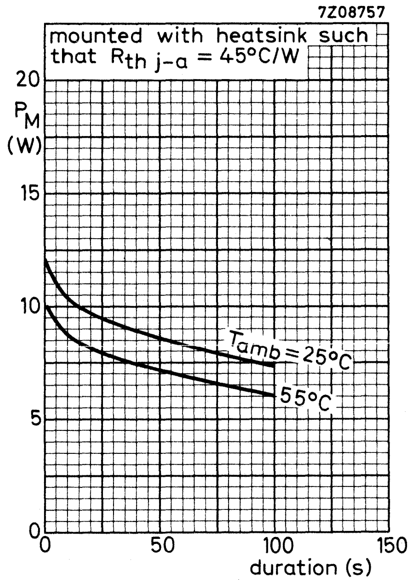

7Z09412
V_CE = 20V
f = 100MHz
T_j = 25°C
f_T (MHz)
typ
I_C (mA)


7Z09415
V_CE = 20V
f = 1MHz
T_j = 25°C
C_re (pF)
typ
I_C (mA)


7Z09414
high frequency knee voltage
versus junction temperature
I_C = 50mA
V_CEK (V)
max
T_j (°C)







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

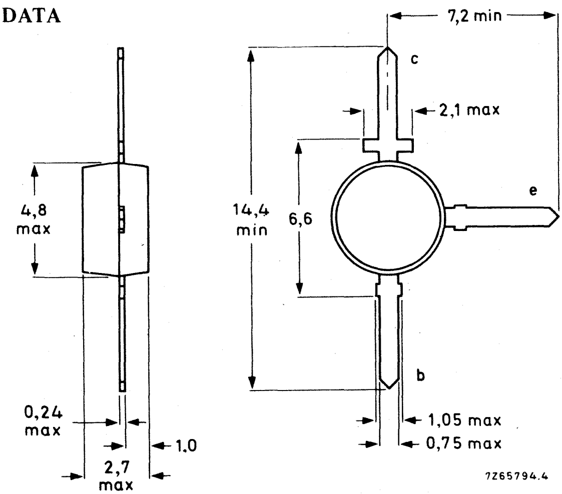
QUICK REFERENCE DATA

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

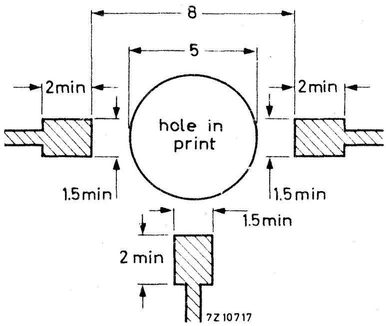
Storage temperature	T_{stg}	-65 to +150		°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air mounted on a glass-fibre print *) of 40 mm x 25 mm x 1 mm — $R_{th\ j\text{-}a}$ = 0.4 °C/mW

*) Requirements for glass-fibre print

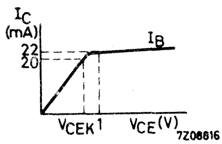
(dimensions in mm)



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}	> <	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.

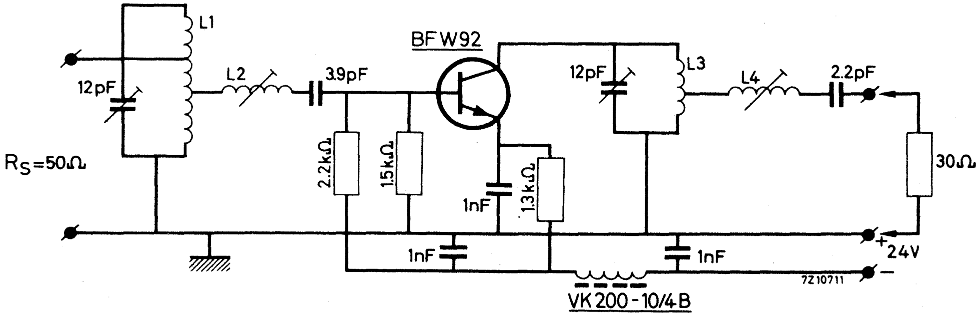
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

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:
$R_L = 820\ \Omega$; $C_L = -1.0$ pF

Adjustment procedure

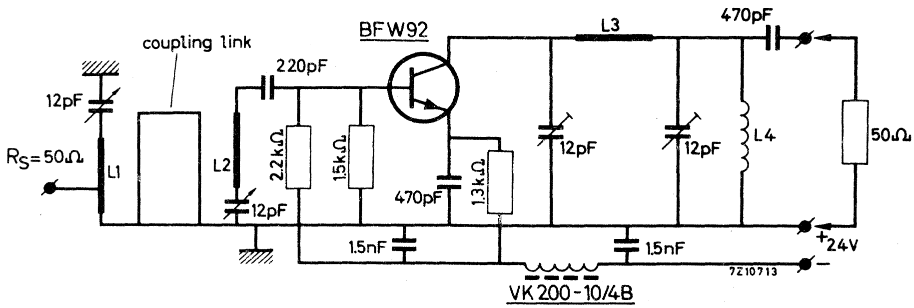
1. Remove the transistor and connect a dummy consisting of a 820 Ω resistor in parallel with a 1.0 pF capacitor between the collector and emitter connections of the output circuit.
2. Tune and match the output circuit for zero reflection at 205 MHz (V.S.W.R. = 1). After this adjustment, no further change 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 (0.5mm); winding pitch 1.5mm; int. diam. 4mm
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

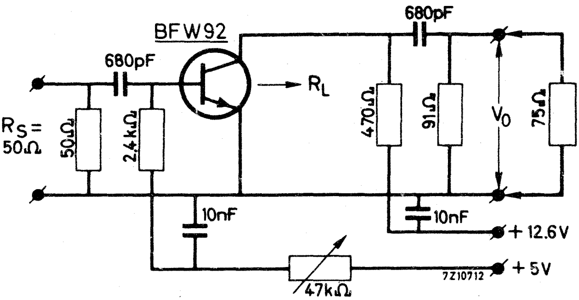
3. Intermodulation distortion

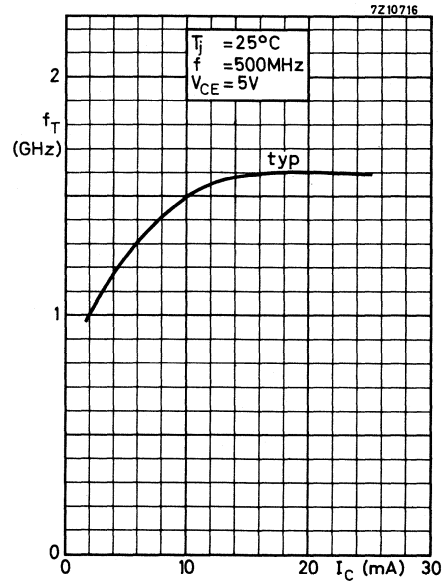
I_C = 10 mA; V_{CE} = 6 V; R_L = 37.5 Ω; T_{amb} = 25 °C

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

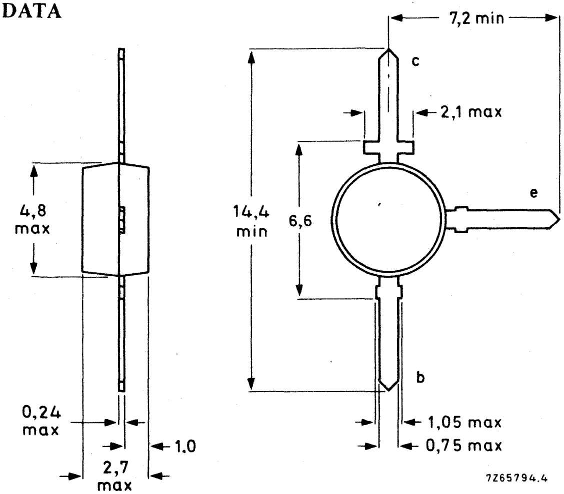
N-P-N transistor in a subminiature plastic transfer-moulded T-package.
The device is intended for use in v.h.f. - u.h.f. applications, primarily wideband aerial amplifiers 40 - 800 MHz.
It is intended for mounting on miniature printed-circuit boards.

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

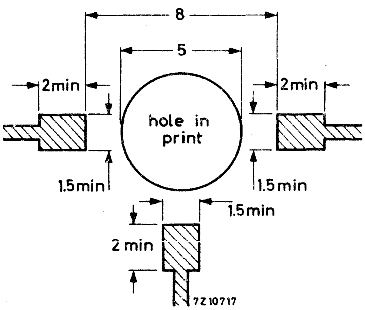
Temperatures

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

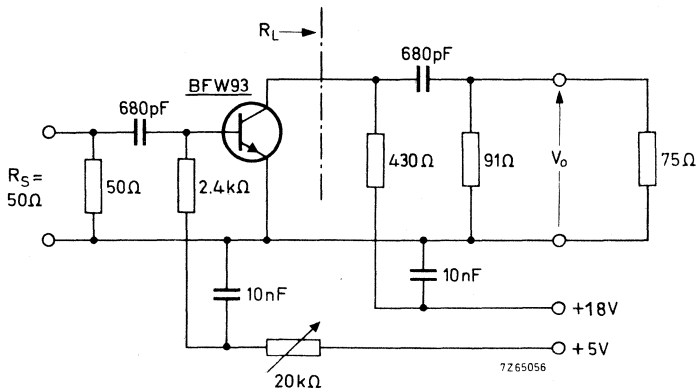
I_C = 30 mA; V_{CE} = 5 V; R_L = 37.5 Ω

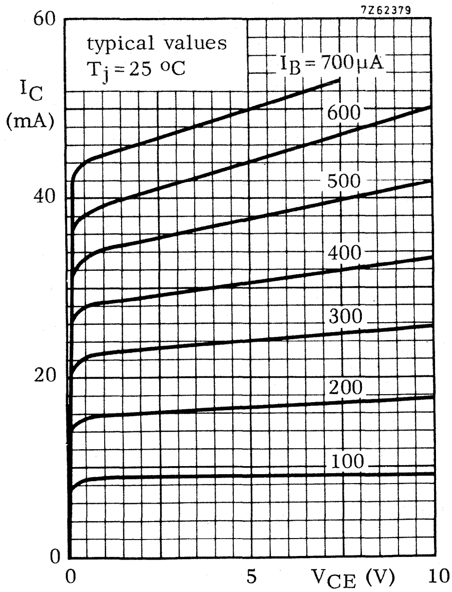
V_o = 100 mV at f_p = 183 MHz

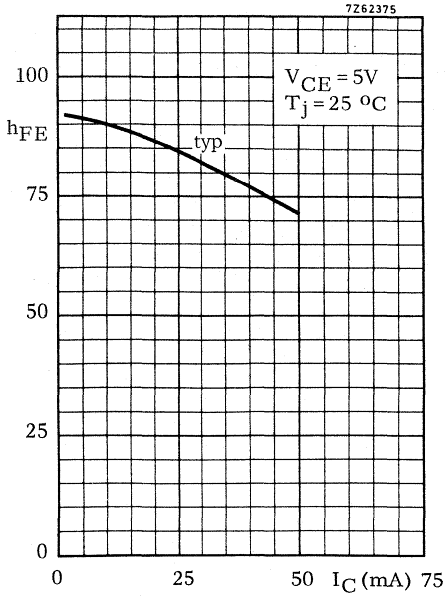
V_o = 100 mV at f_q = 200 MHz

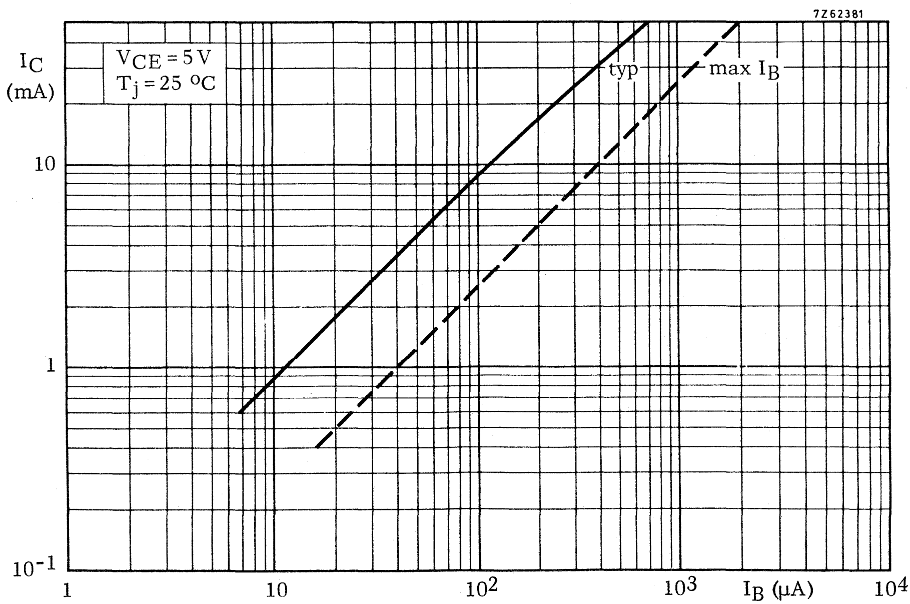
measured at $f_{(2q-p)}$ = 217 MHz	d_{im}	typ.	−60	dB

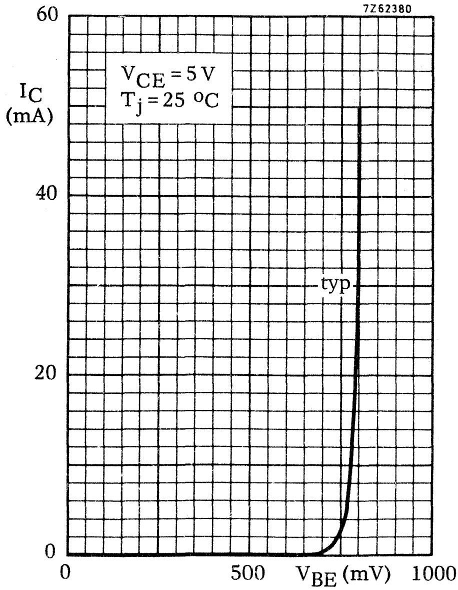
Test circuit:

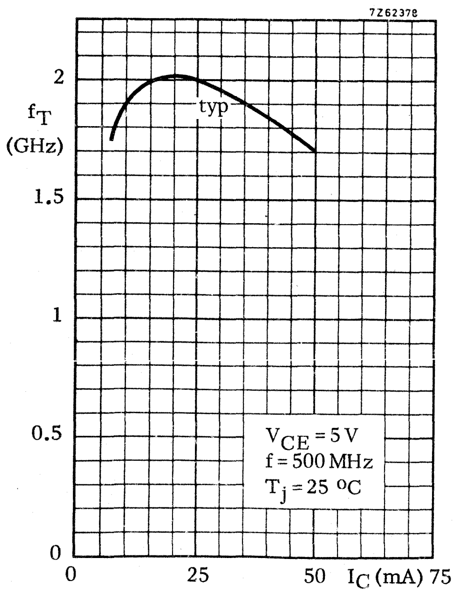


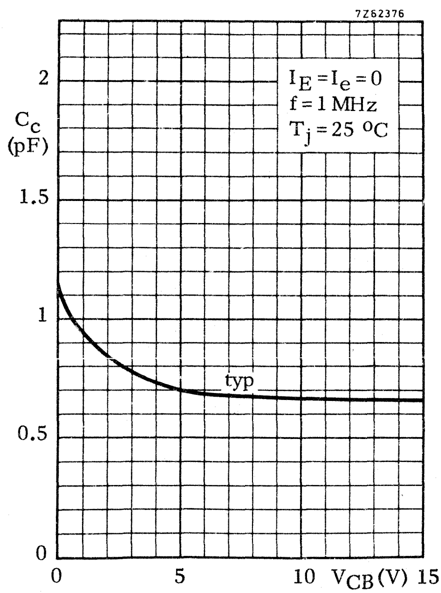

7Z62379
typical values
$T_j = 25\ ^oC$
$I_B = 700\ \mu A$
600
500
400
300
200
100
I_C (mA)
60
40
20
0
0
5
V_{CE} (V)
10


7Z62375
$V_{CE} = 5V$
$T_j = 25\ ^oC$
typ
h_{FE}
100
75
50
25
0
0
25
50
I_C (mA)
75

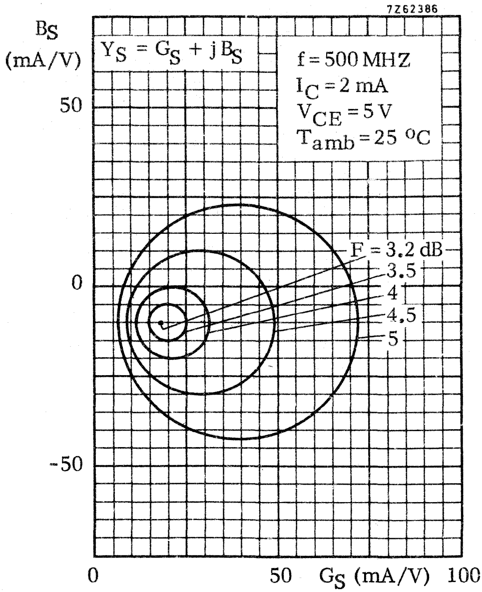

7Z62381
$V_{CE} = 5\ V$
$T_j = 25\ ^oC$
typ
max I_B
I_C (mA)
10
1
10^{-1}
1
10
10^2
10^3
I_B (μA)
10^4

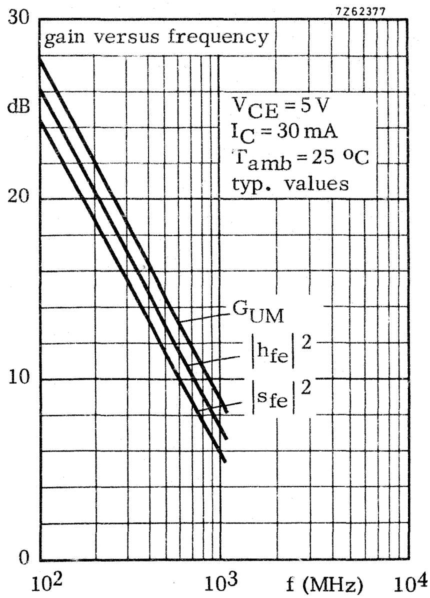

7Z62380
60
40
20
0
I_C
(mA)
V_{CE} = 5 V
T_j = 25 °C
typ
0
500
V_{BE} (mV)
1000

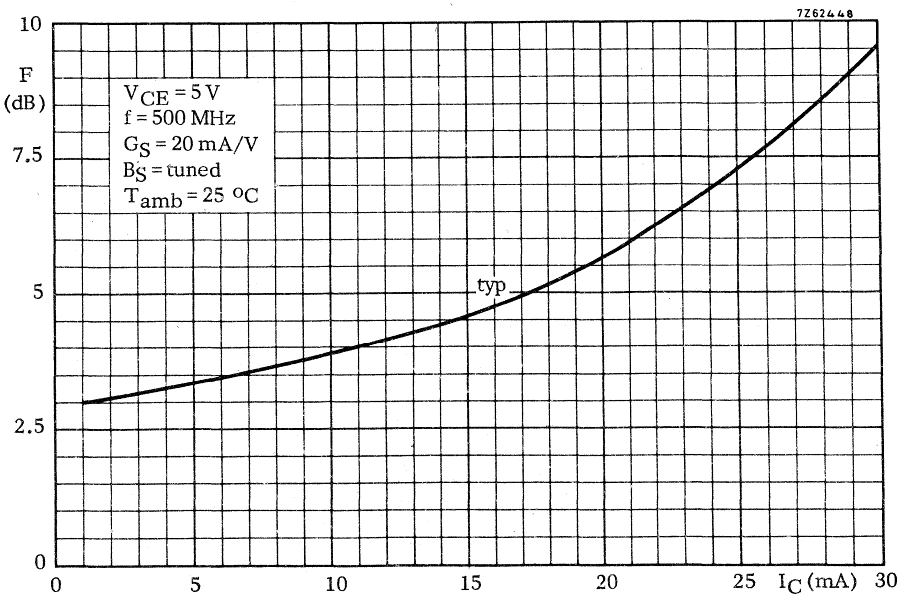

7Z62378
2
1.5
1
0.5
0
f_T
(GHz)
typ
V_{CE} = 5 V
f = 500 MHz
T_j = 25 °C
0
25
50
I_C (mA) 75


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



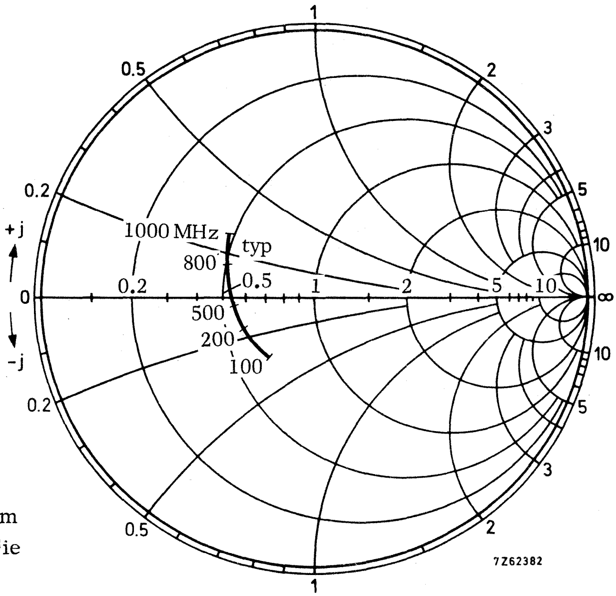




V_{CE} = 5 V

I_C = 30 mA

T_{amb} = 25 ^oC

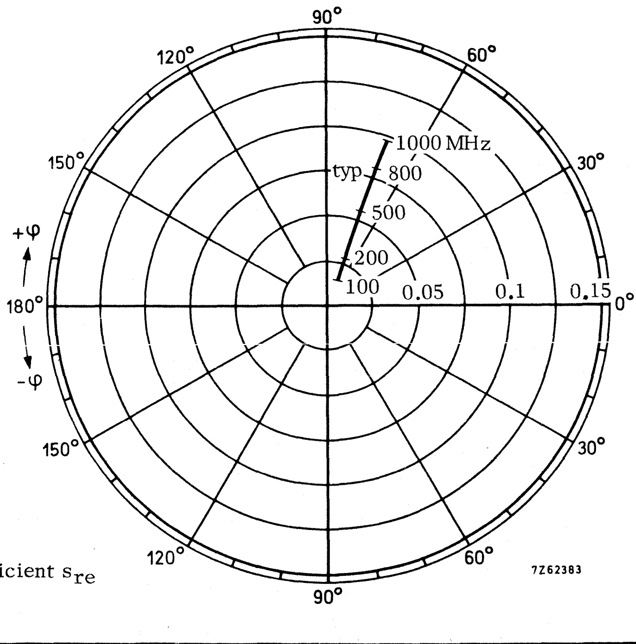


Input impedance derived from input reflection coefficient s_{ie} coordinates in ohm x 50

V_{CE} = 5 V

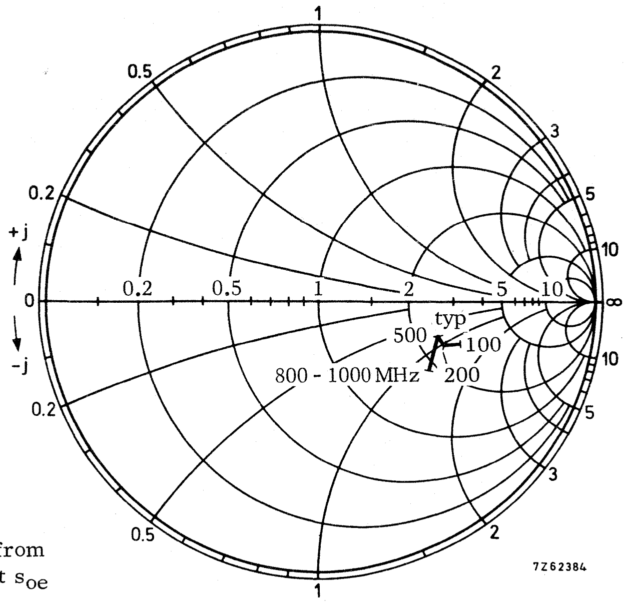
I_C = 30 mA

T_{amb} = 25 ^oC



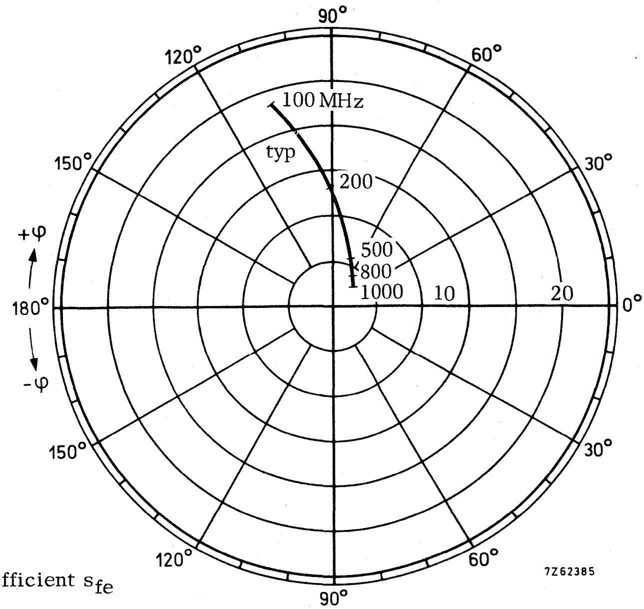
Reverse transmission coefficient s_{re}

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
T_{amb} = 25 °C



Forward transmission coefficient s_{fe}

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

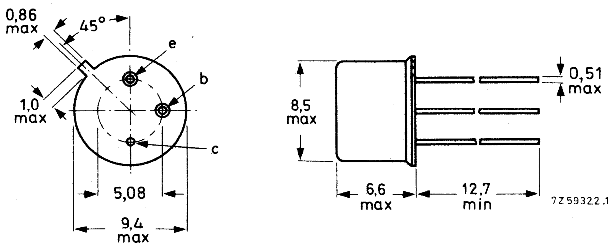
Collector-base voltage (open emitter)	V_{CBO}	max.	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	V
Collector current (peak value)	I_{CM}	max.	5,0	A
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	5,0	W
Junction temperature	T_j	max.	200	°C
D.C. current gain I_C = 2 A; V_{CE} = 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



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

Accessories supplied on request: 56218 (package); 56254 (distance disc).

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

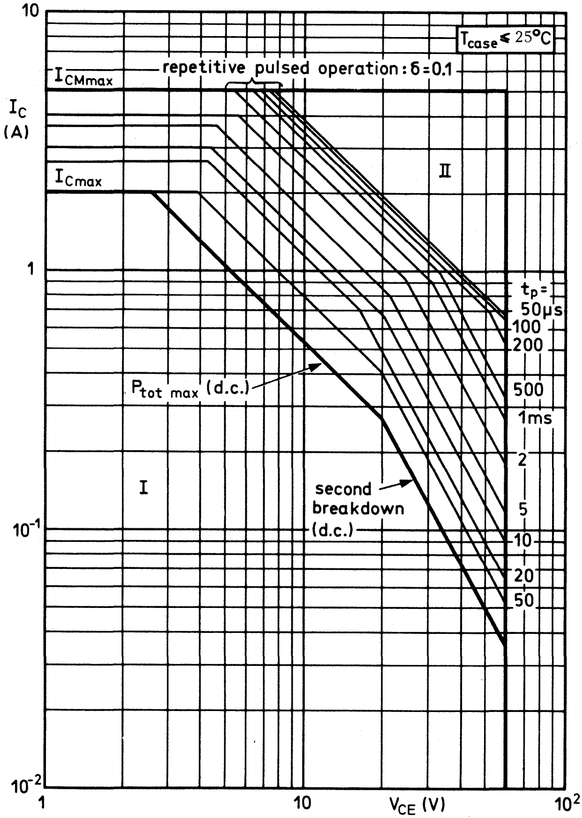
Storage temperature	T_{stg}		−55 to +200	°C
Junction temperature	T_j	max.	200	°C

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

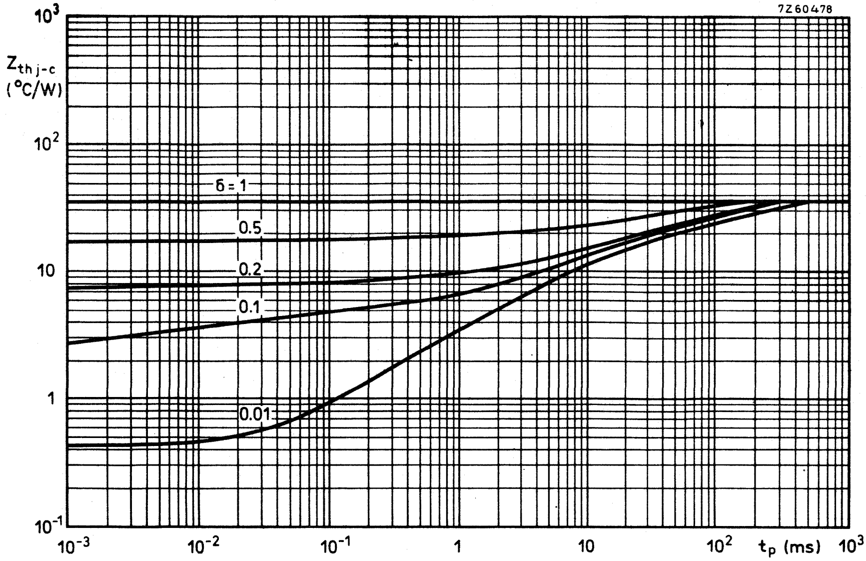
CHARACTERISTICS $T_j = 25\,^{o}C$ unless otherwise specified

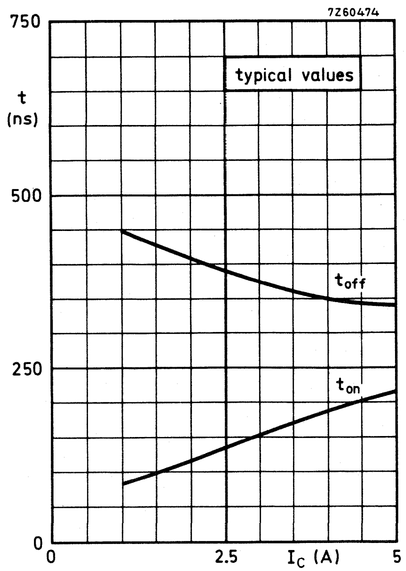
Parameter / conditions	Symbol		Value	Unit
Collector cut-off current				
$V_{EB} = 0$; $V_{CE} = 60\ V$	I_{CES}	<	10	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 4\ V$	I_{EBO}	typ.	0.01	μA
		<	10	μA
Saturation voltages				
$I_C = 5\ A$; $I_B = 0.5\ A$	V_{CEsat}	typ.	0.77	V
		<	1.0	V
	V_{BEsat}	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

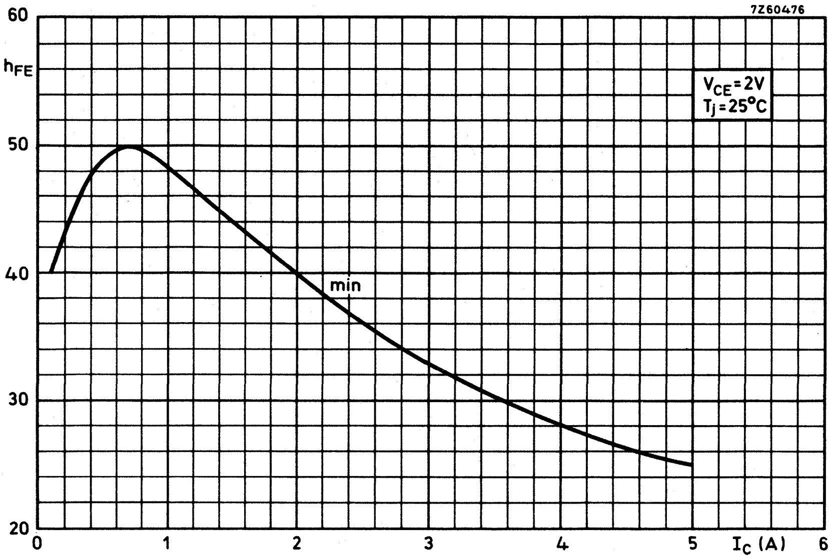


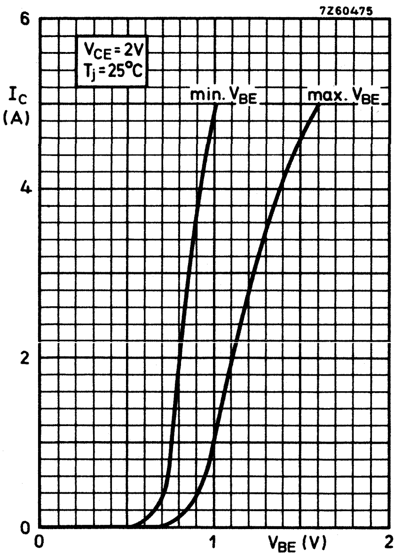
Safe Operation Area with the transistor forward biased

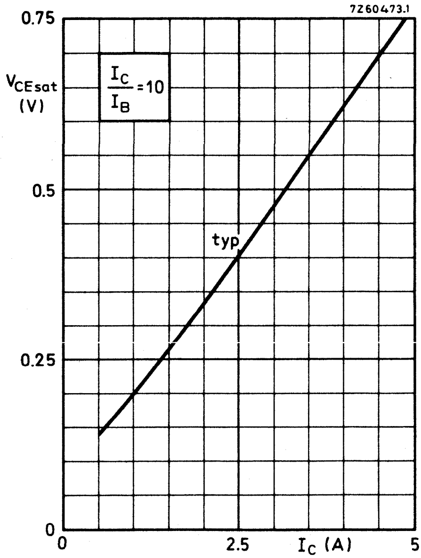
I Region of permissible d. c. operation
II Permissible extension for repetitive pulsed operation


7Z60478
$Z_{th\,j\text{-}c}$ (°C/W)
10^3
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
typical values
t (ns)
750
500
250
0
0
2.5
I_C (A)
5
t_{off}
t_{on}


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
4
2
0
I_C
(A)
$V_{CE} = 2V$
$T_j = 25°C$
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 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 bands I, II, III and IV/V (40–860 MHz).
- Wideband aerial amplifiers (40–860 MHz).

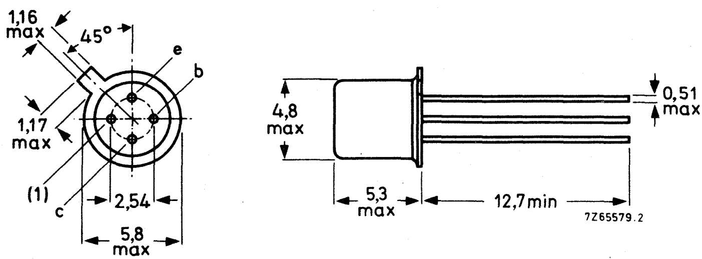
QUICK REFERENCE DATA

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; VSWR at output < 2; I_C = 8 mA; V_{CE} = 10 V	P_o	typ.	6	6	mW

MECHANICAL DATA

Dimensions in mm

TO-72



(1) = shield lead (connected to case).

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

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

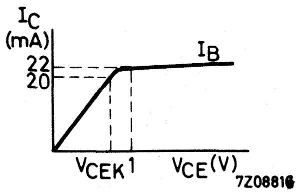
THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.88	°C/mW
From junction to case	$R_{th\ j-c}$	=	0.58	°C/mW

[1] I_C = 10 mA.

CHARACTERISTICS $T_j = 25\ ^oC$ 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; $T_{amb} = 25\ ^oC$	G_p	>	19	–	dB
		typ.	22	7	dB

[1]) Shield lead grounded.
[2]) Shield lead not connected.

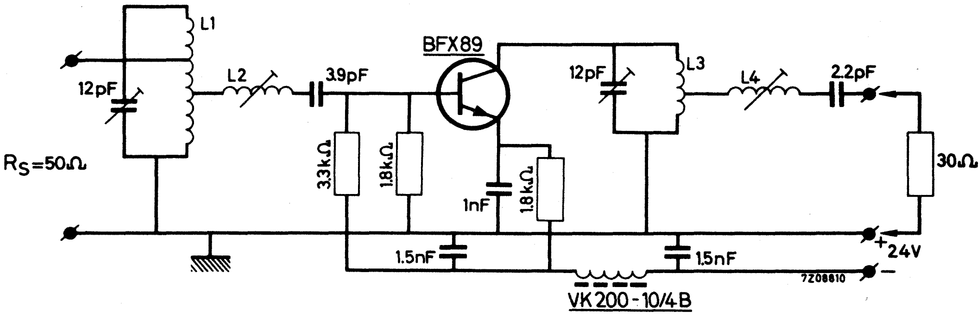
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

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.

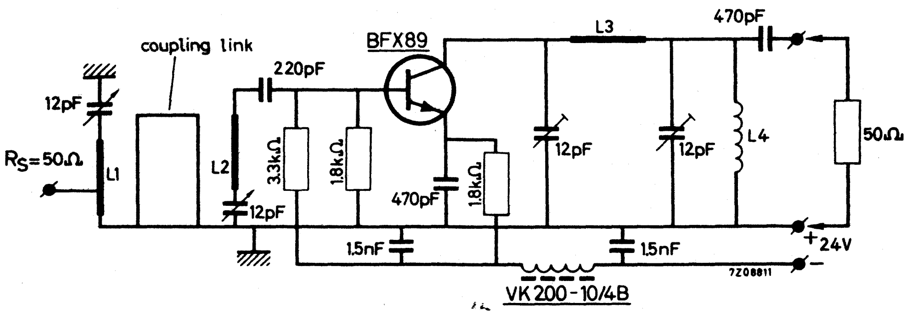
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

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

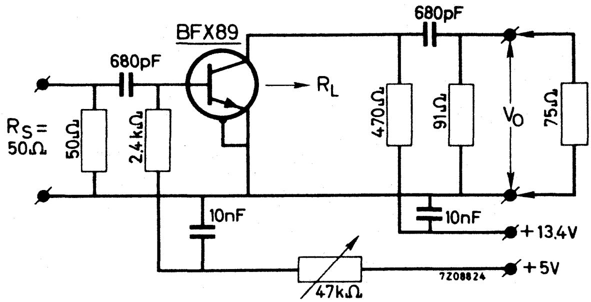
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Intermodulation characteristics [1]

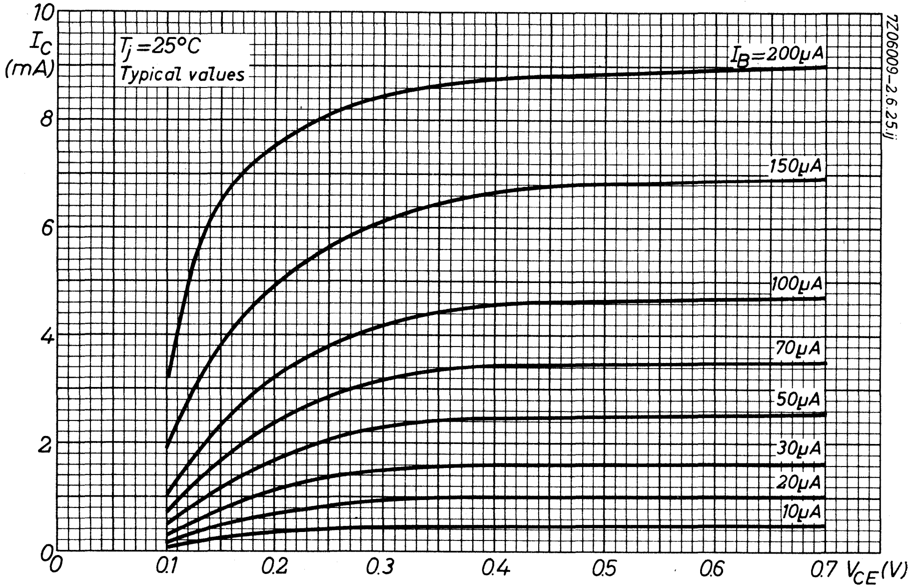
3. Intermodulation distortion

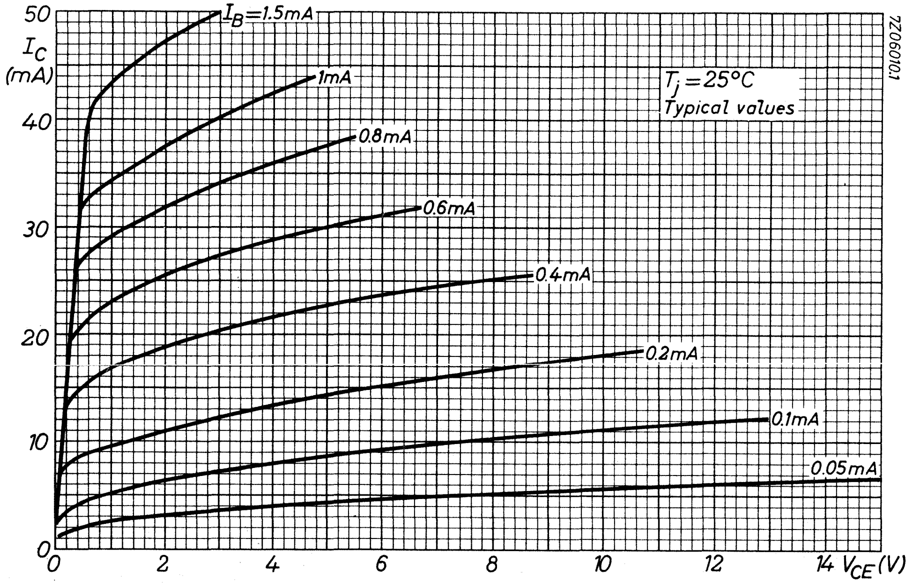
I_C = 8 mA; V_{CE} = 6 V; R_L = 37.5 Ω; T_{amb} = 25 °C
V_o = 100 mV at f_p = 183 MHz
V_o = 100 mV at f_q = 200 MHz
measured at $f_{(2q-p)}$ = 217 MHz d_{im} typ. −40 dB

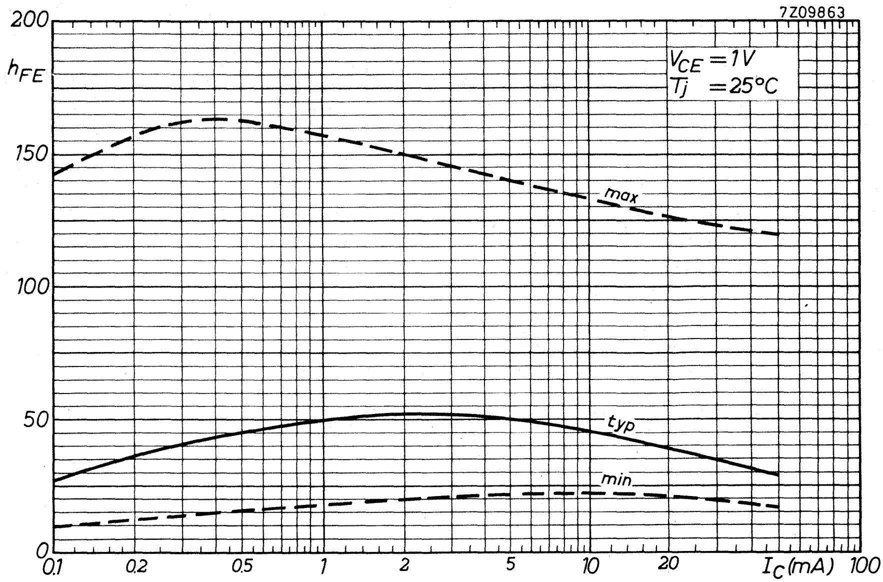
Test circuit:

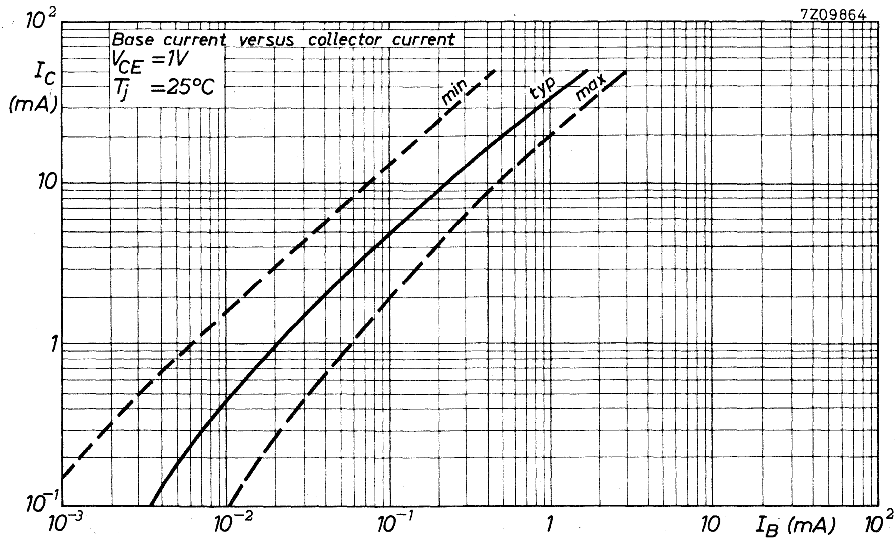


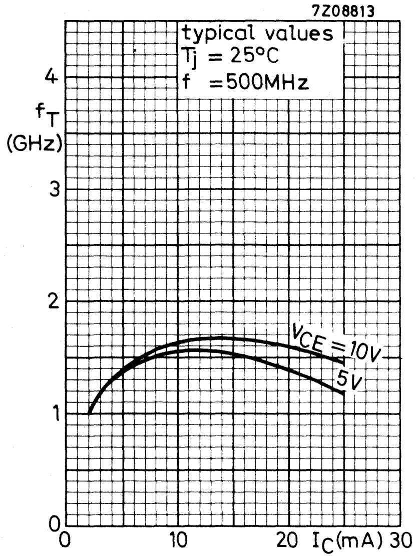
1) Shield lead grounded.

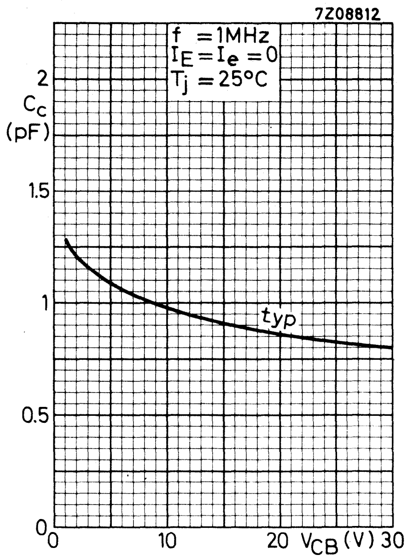

10
I_C
(mA)
8
6
4
2
0
$T_j = 25°C$
Typical values
$I_B = 200\mu A$
150μA
100μA
70μA
50μA
30μA
20μA
10μA
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7 V_{CE} (V)
7Z06009-2.6.25.ij

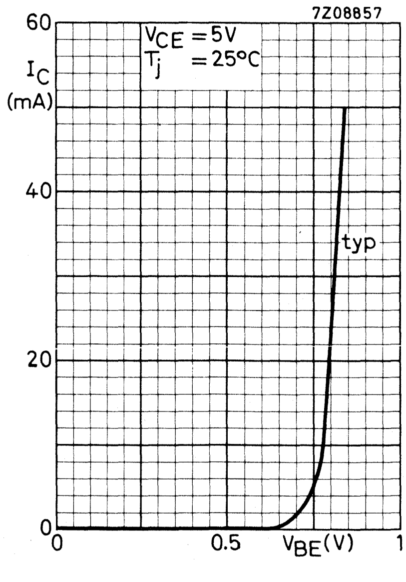

50
I_C
(mA)
40
30
20
10
0
$I_B = 1.5mA$
1mA
0.8mA
0.6mA
0.4mA
0.2mA
0.1mA
0.05mA
$T_j = 25°C$
Typical values
0
2
4
6
8
10
12
14 V_{CE} (V)
7Z06010.1

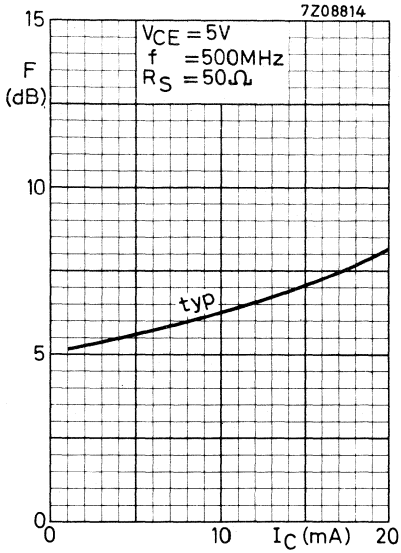

7Z09863
h_{FE}
200
150
100
50
0
V_{CE} = 1V
T_j = 25°C
max
typ
min
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100

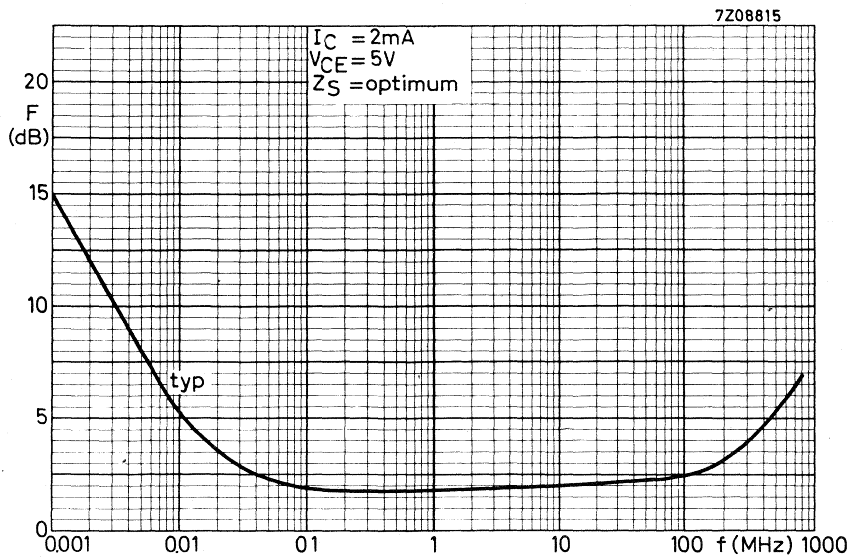

7Z09864
Base current versus collector current
V_{CE} = 1V
T_j = 25°C
I_C
(mA)
10^2
10
1
10^{-1}
min
typ
max
10^{-3}
10^{-2}
10^{-1}
1
10
I_B (mA)
10^2


7Z08813
typical values
Tj = 25°C
f = 500MHz
fT
(GHz)
4
3
2
1
0
0
10
20
IC(mA) 30
VCE = 10V
5V


7Z08812
f = 1MHz
IE = Ie = 0
Tj = 25°C
Cc
(pF)
2
1.5
1
0.5
0
0
10
20
VCB (V) 30
typ


7Z08857
VCE = 5V
Tj = 25°C
IC
(mA)
60
40
20
0
0
0.5
VBE(V)
1
typ


7Z08814
V_{CE} = 5V
f = 500MHz
R_S = 50Ω
F (dB)
typ
I_C (mA)
0
5
10
15
20


7Z08815
I_C = 2mA
V_{CE} = 5V
Z_S = optimum
F (dB)
typ
f (MHz)
0,001
0,01
0,1
1
10
100
1000
0
5
10
15
20

SILICON PLANAR EPITAXIAL 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

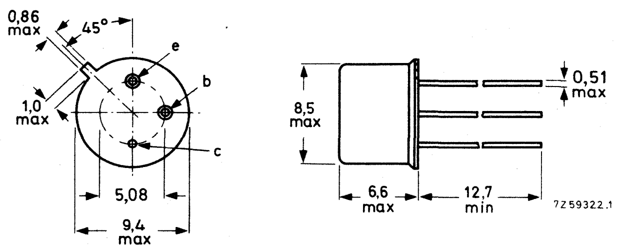
			BFY50	BFY51	BFY52	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	60	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	35	30	20	V
Collector current (peak value)	I_{CM}	max.	1	1	1	A
Total dissipation up to T_{mb} = 50 °C	P_{tot}	max.	5	5	5	W
Junction temperature	T_j	max.	200	200	200	°C
D.C. 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

Collector connected to case

TO-39



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

Accessories supplied on request: 56218 (package); 56245 (distance disc).

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

Condition	Symbol		BFY50	BFY51	BFY52	Unit
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

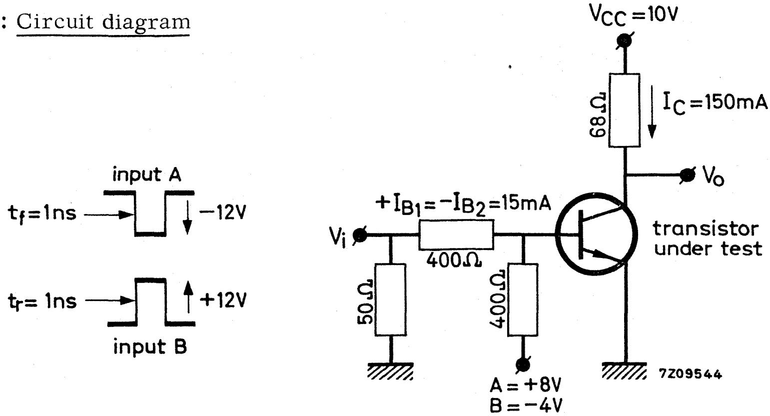
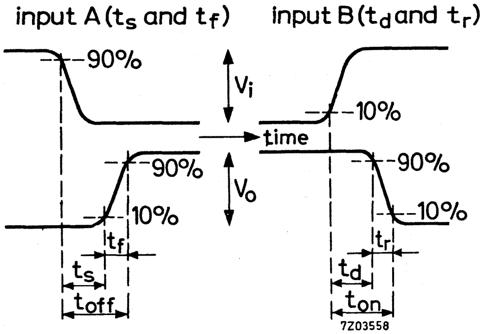


Fig. 2 : Waveforms



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)

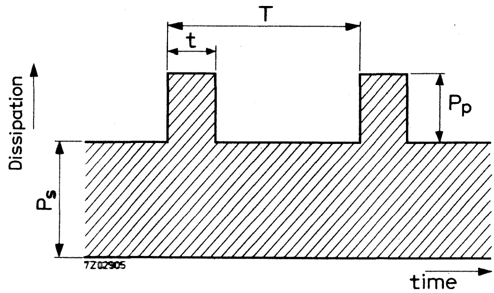
1. Steady-state conditions

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 ^oC. 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 $^oC/W$ (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

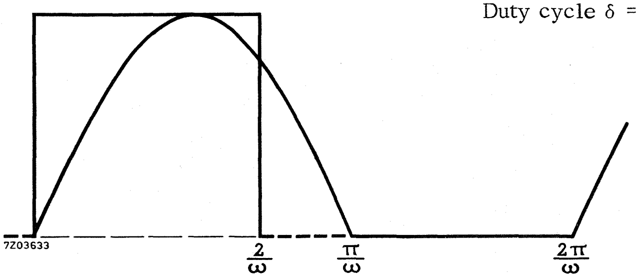
The following example illustrates how to find the maximum permissible peak dissipation of a BFY52 operating in a class "B" circuit at 1 kHz. The device is mounted on a heatsink of thermal resistance equal to 50 °C/W and at an ambient temperature not exceeding 100 °C. Assuming that the waveform is sinusoidal 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,

$$t = \frac{2}{\omega} = \frac{2}{2\,\pi \times 10^3} = 0.318\ \text{ms}$$

$$\text{Duty cycle } \delta = \frac{2/\omega}{2\pi/\omega} = \frac{1}{\pi}$$

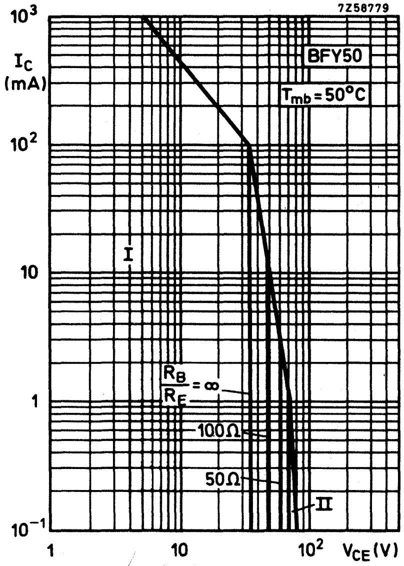


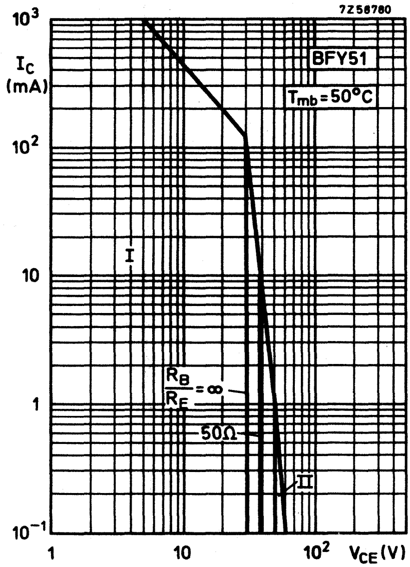
From page 9: $Z_{th\ 0} = 6.0\ ^{\circ}C/W$ $R_{th\ j\text{-}mb} = 30\ ^{\circ}C/W$

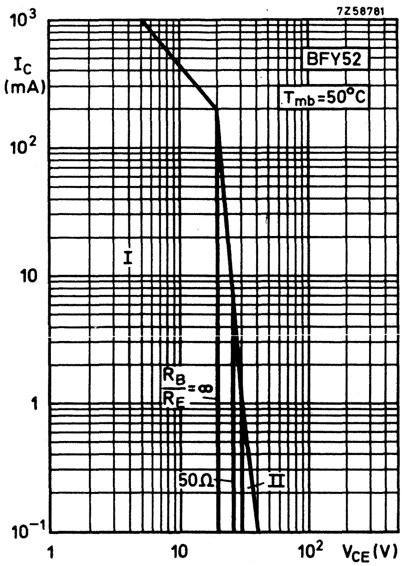
$$Z_{th}\ (\text{at } \delta = 0.318) = 6.0 + 0.318\ (30-6.0) = 13.6\ ^{\circ}C/W$$

$$P_{p\,max} = \frac{(200-100) - 0}{13.6 + 0.318 \times 50} = 3.39\ W$$

A peak power of 3.39 W is therefore permissible provided that the voltage and current ratings of the device are not exceeded.



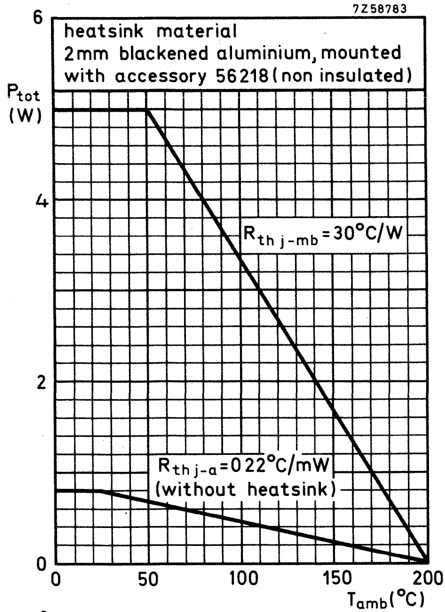


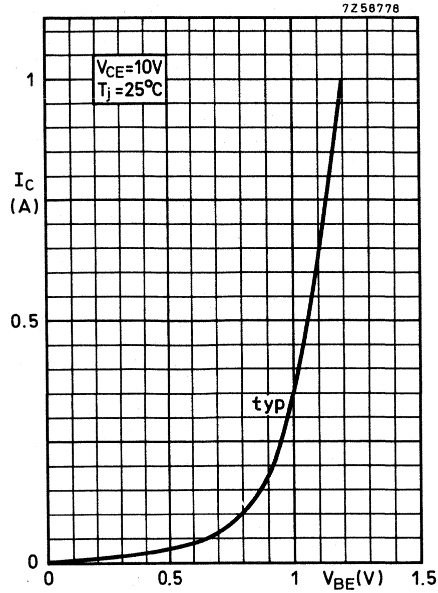


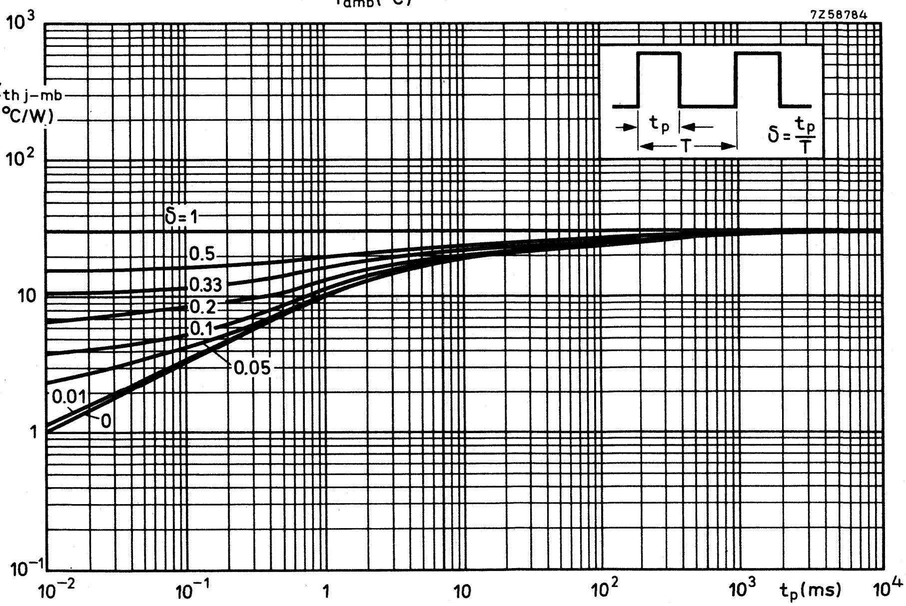
Safe Operating Area with the transistor forward biased

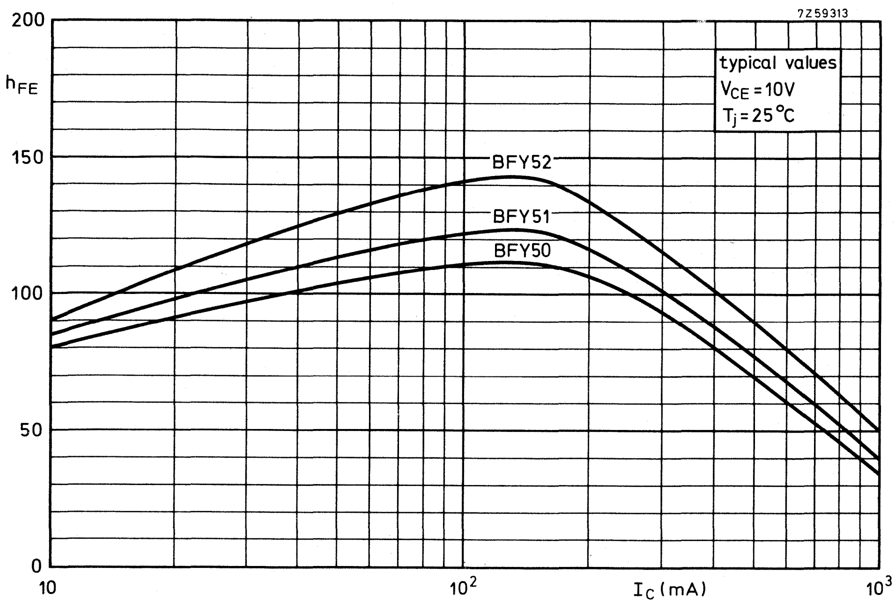
I. Region of permissible d.c. operation

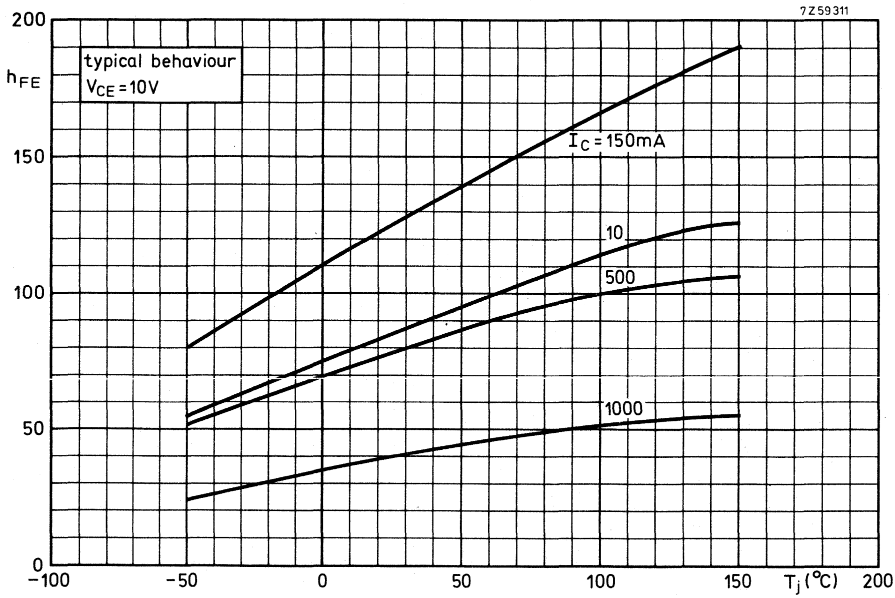
II. Additional area for d.c. operation when $R_B / R_E < 10\ \Omega$

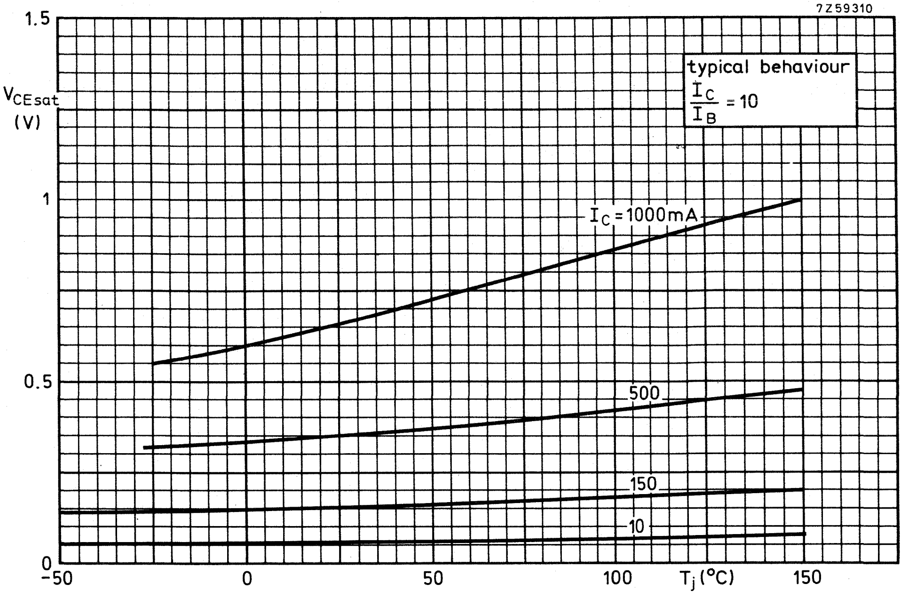

7Z58783
heatsink material
2mm blackened aluminium, mounted
with accessory 56218 (non insulated)
Ptot
(W)
6
4
2
0
Rth j-mb = 30°C/W
Rth j-a = 0.22°C/mW
(without heatsink)
0
50
100
150
200
Tamb(°C)

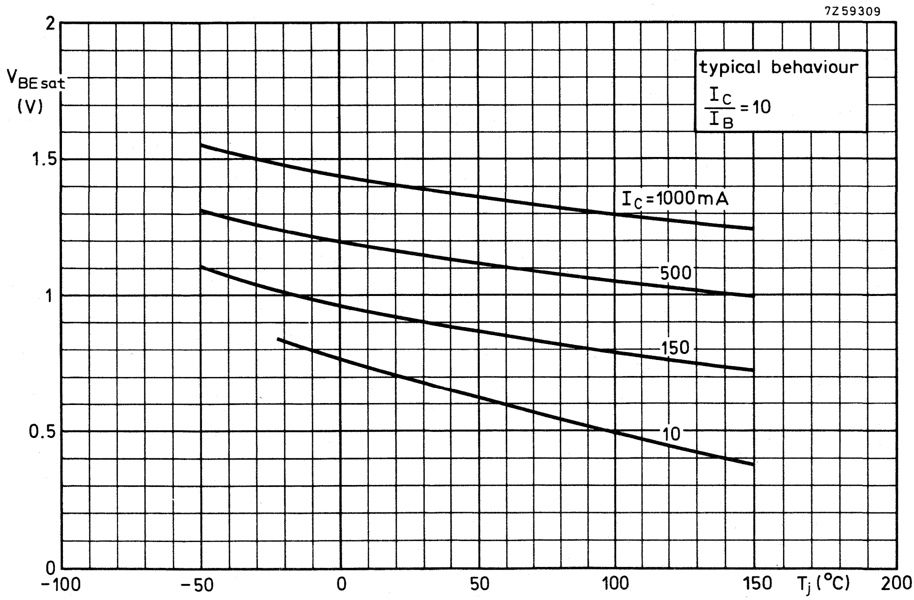

7Z58778
VCE = 10V
Tj = 25°C
IC
(A)
1
0.5
0
typ
0
0.5
1
VBE(V)
1.5

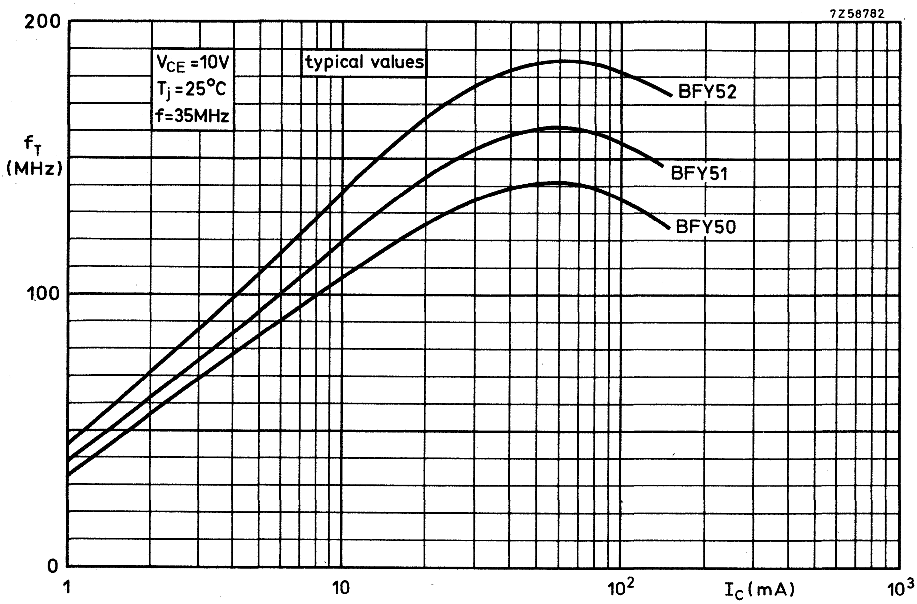

7Z58784
Zth j-mb
(°C/W)
10^3
10^2
10
1
10^-1
δ = 1
0.5
0.33
0.2
0.1
0.05
0.01
0
tp
T
δ = tp/T
10^-2
10^-1
1
10
10^2
10^3
tp(ms)
10^4

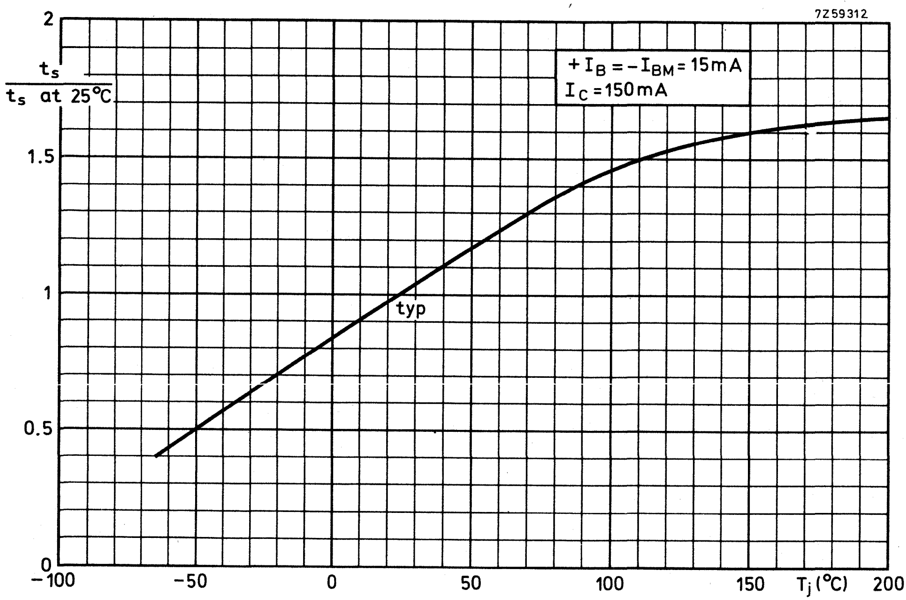

7Z59313
typical values
V_{CE} = 10V
T_j = 25 °C
h_{FE}
200
150
100
50
0
BFY52
BFY51
BFY50
10
10^2
I_C (mA)
10^3

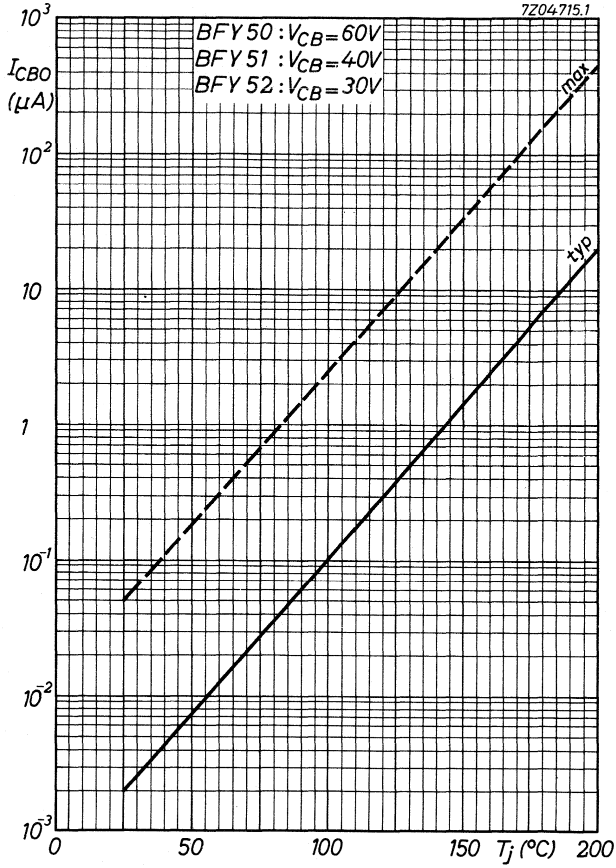

7Z59311
typical behaviour
V_{CE} = 10V
h_{FE}
200
150
100
50
0
I_C = 150mA
10
500
1000
−100
−50
0
50
100
150
T_j (°C)
200

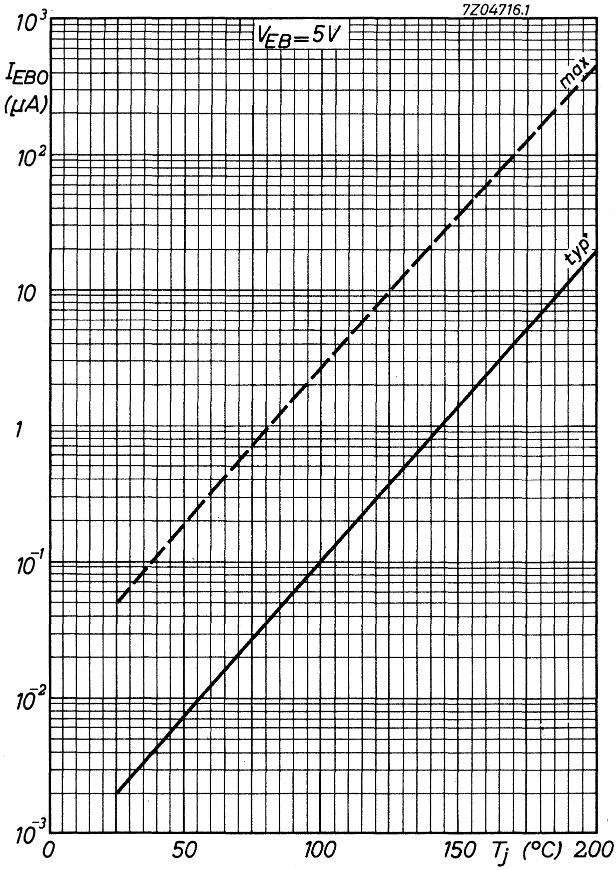

7Z59310
1.5
V_{CEsat}
(V)
1
0.5
0
typical behaviour
$\frac{I_C}{I_B} = 10$
$I_C = 1000 mA$
500
150
10
−50
0
50
100
150
T_j (°C)


7Z59309
2
V_{BEsat}
(V)
1.5
1
0.5
0
typical behaviour
$\frac{I_C}{I_B} = 10$
$I_C = 1000 mA$
500
150
10
−100
−50
0
50
100
150
200
T_j (°C)


7Z58782
200
100
0
f_T (MHz)
V_{CE} = 10V
T_j = 25°C
f = 35MHz
typical values
BFY52
BFY51
BFY50
1
10
10^2
I_C (mA)
10^3


7Z59312
2
1.5
1
0.5
0
$\frac{t_s}{t_s \text{ at } 25°C}$
$+I_B = -I_{BM} = 15$ mA
$I_C = 150$ mA
typ
−100
−50
0
50
100
150
T_j (°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

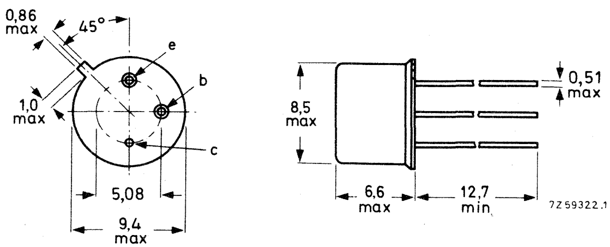
Collector-base voltage (open emitter)	V_{CBO}	max.	80	V
Collector-emitter voltage (open base)	V_{CEO}	max.	35	V
Collector current (d.c.)	I_C	max.	1	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	800	mW
Junction temperature	T_j	max.	200	°C
D.C. current gain at T_j = 25 °C I_C = 150 mA; V_{CE} = 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

Collector connected to case

TO-39



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

Accessories supplied on request: 56218 (package); 56245 (distance disc).

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	$R_{th\ j-a}$	=	0.22	°C/mW
From junction to case	$R_{th\ j-c}$	=	0.035	°C/mW

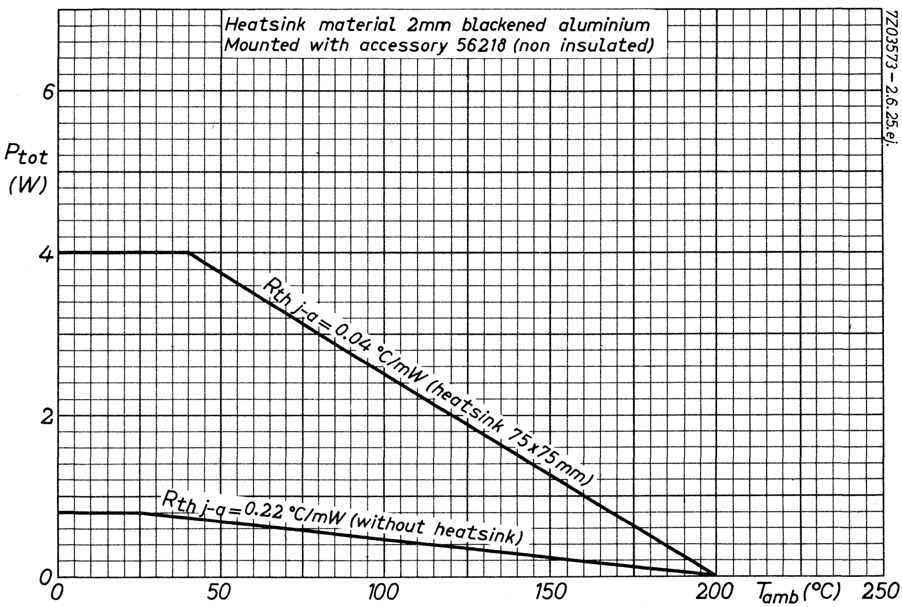
[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

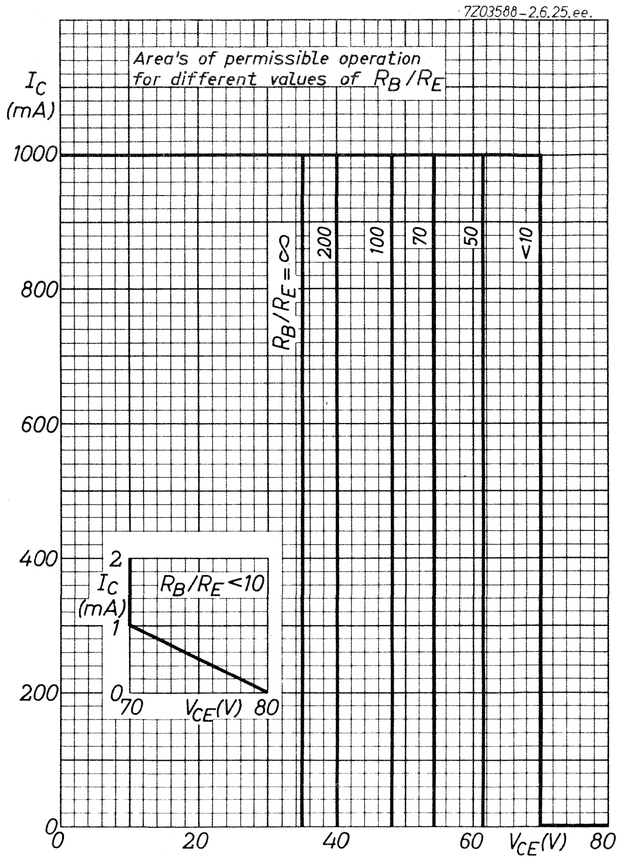
CHARACTERISTICS T_j = 25 °C unless otherwise specified

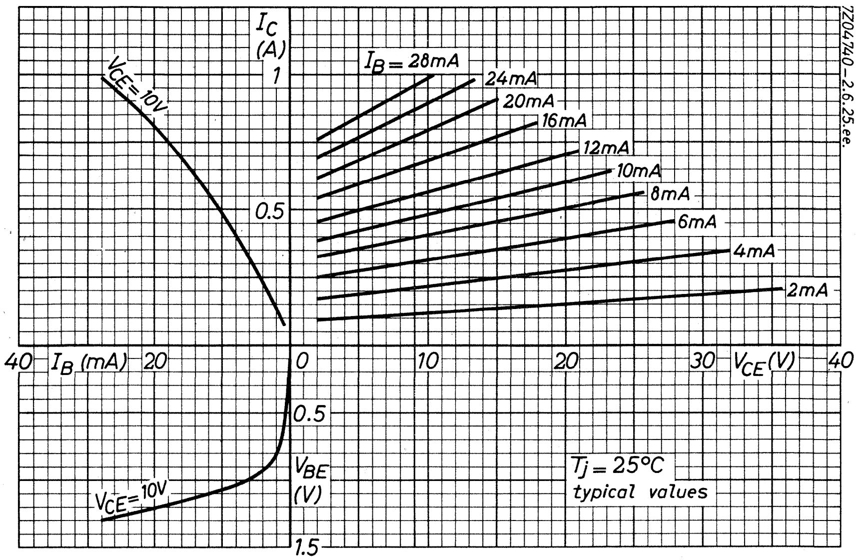
Collector cut-off current				
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	<	10	nA
$I_E = 0$; $V_{CB} = 60$ V; $T_j = 150$ °C	I_{CBO}	<	10	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	nA
Saturation voltages				
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0.2	V
$I_C = 1$ A; $I_B = 100$ mA [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.

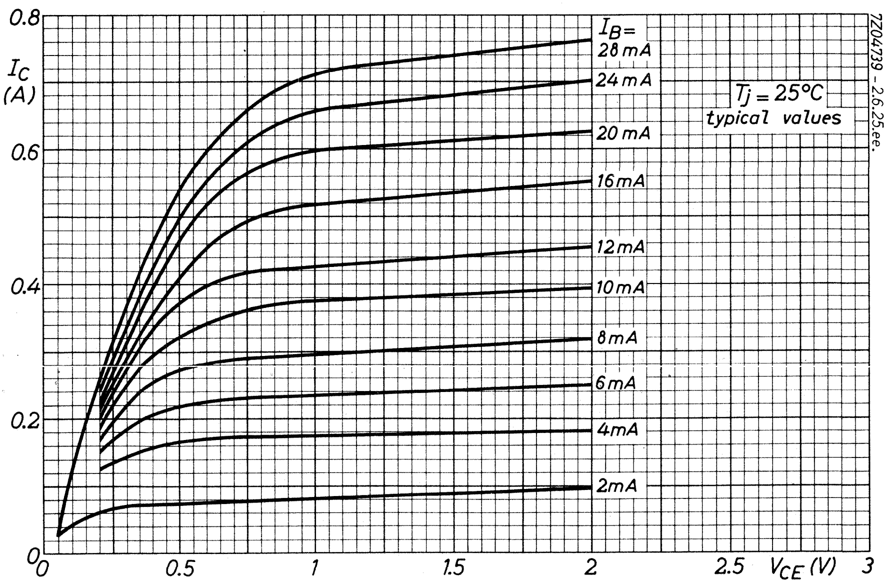
[2]) Measured under pulsed conditions to avoid excessive dissipation.
Pulse duration = 300 μs; duty cycle $\delta < 0.01$


Heatsink material 2mm blackened aluminium
Mounted with accessory 56218 (non insulated)
7Z03573 - 2.6.25.ej.
6
4
2
0
Ptot
(W)
Rth j-a = 0.04 °C/mW (heatsink 75 x 75 mm)
Rth j-a = 0.22 °C/mW (without heatsink)
0
50
100
150
200
Tamb (°C)
250

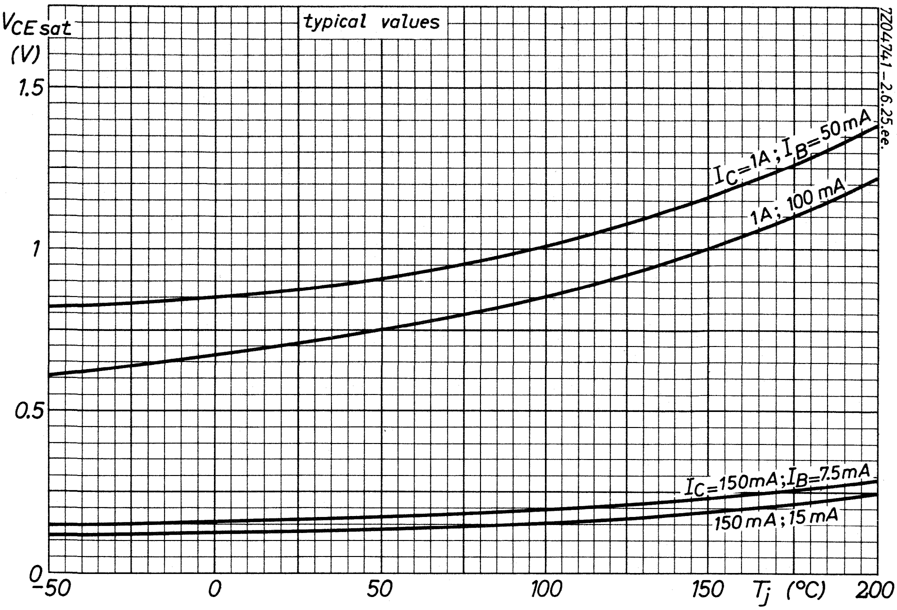

7Z03588-2.6.25.ee.
Area's of permissible operation
for different values of R_B/R_E
I_C
(mA)
1000
800
600
400
200
0
$R_B/R_E = \infty$
200
100
70
50
<10
0
20
40
60
V_{CE}(V)
80
2
I_C
(mA)
1
0
R_B/R_E<10
70
V_{CE}(V)
80

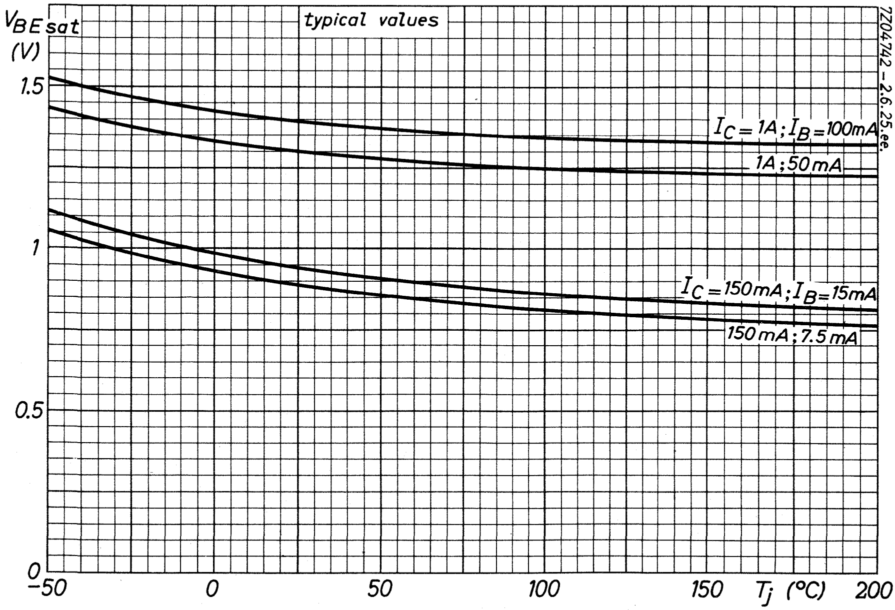


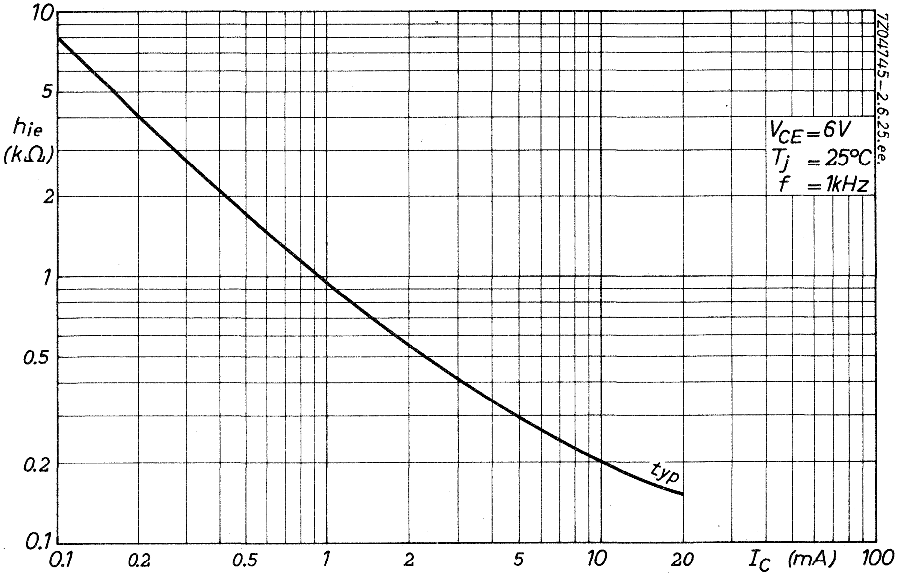
I_C (A)
1
0.5
I_B = 28mA
24mA
20mA
16mA
12mA
10mA
8mA
6mA
4mA
2mA
V_{CE} = 10V
40
I_B (mA)
20
0
10
20
30
V_{CE} (V)
40
0.5
V_{BE} (V)
1.5
V_{CE} = 10V
T_j = 25°C
typical values
7Z04740 - 2.6.25.ee.

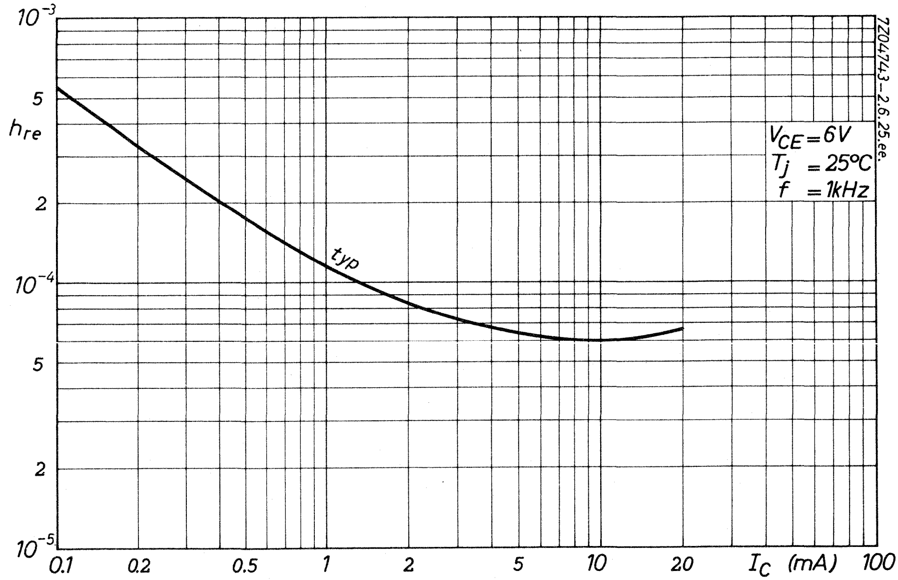


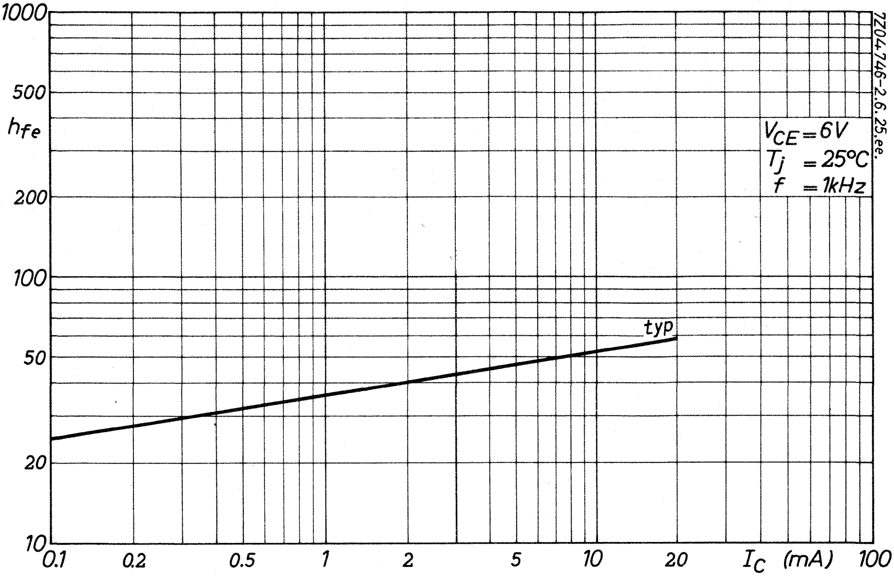
0.8
I_C (A)
0.6
0.4
0.2
0
I_B = 28 mA
24 mA
20 mA
16 mA
12 mA
10 mA
8 mA
6 mA
4 mA
2 mA
T_j = 25°C
typical values
0
0.5
1
1.5
2
2.5
V_{CE} (V)
3
7Z04739 - 2.6.25.ee.

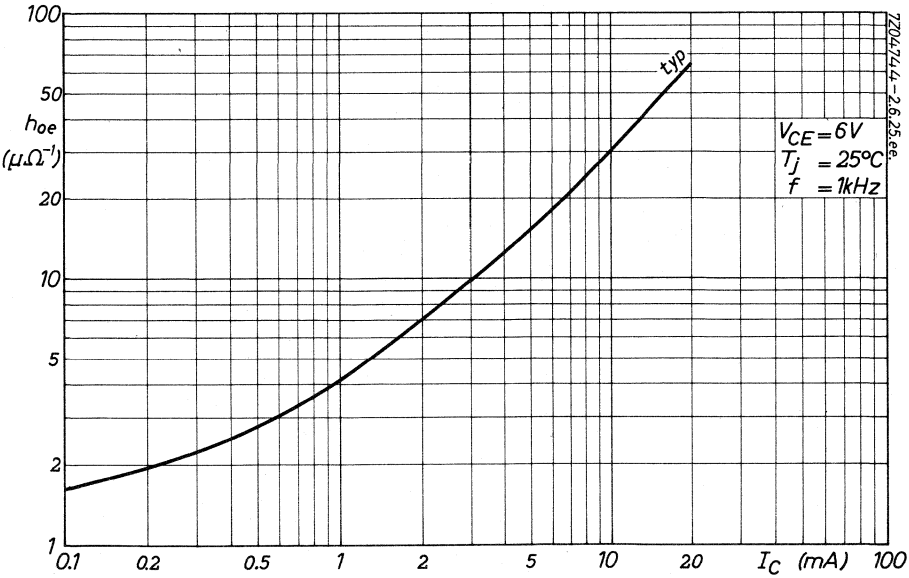

$V_{CE\,sat}$
(V)
typical values
7Z04741 - 2.6.25.ee.
1.5
1
0.5
0
I_C=1A; I_B=50mA
1A; 100 mA
I_C=150mA; I_B=7.5mA
150 mA; 15 mA
-50
0
50
100
150
T_j (°C)
200

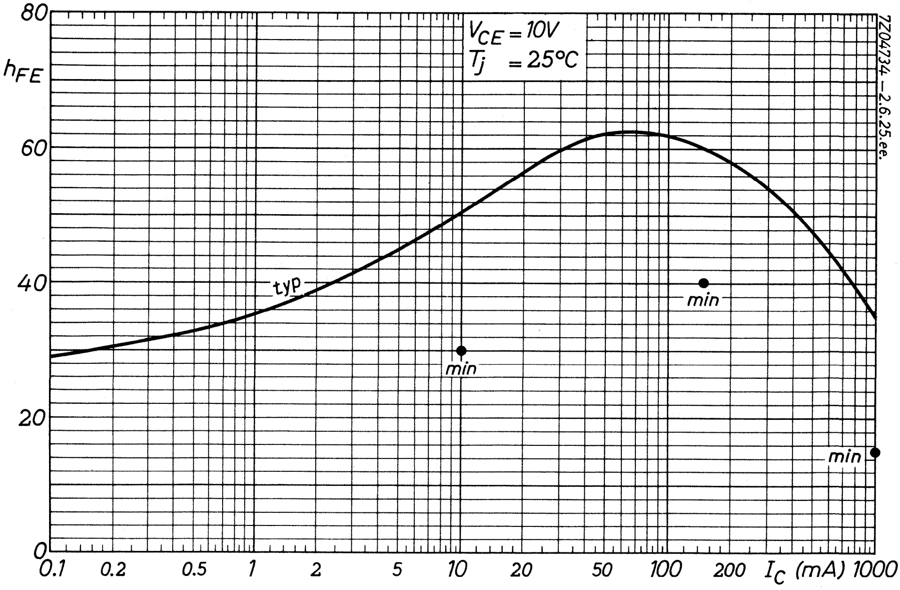

$V_{BE\,sat}$
(V)
typical values
7Z04742 - 2.6.25.ee.
1.5
1
0.5
0
I_C = 1A; I_B = 100mA
1A; 50 mA
I_C = 150mA; I_B = 15mA
150 mA; 7.5 mA
-50
0
50
100
150
T_j (°C)
200


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.

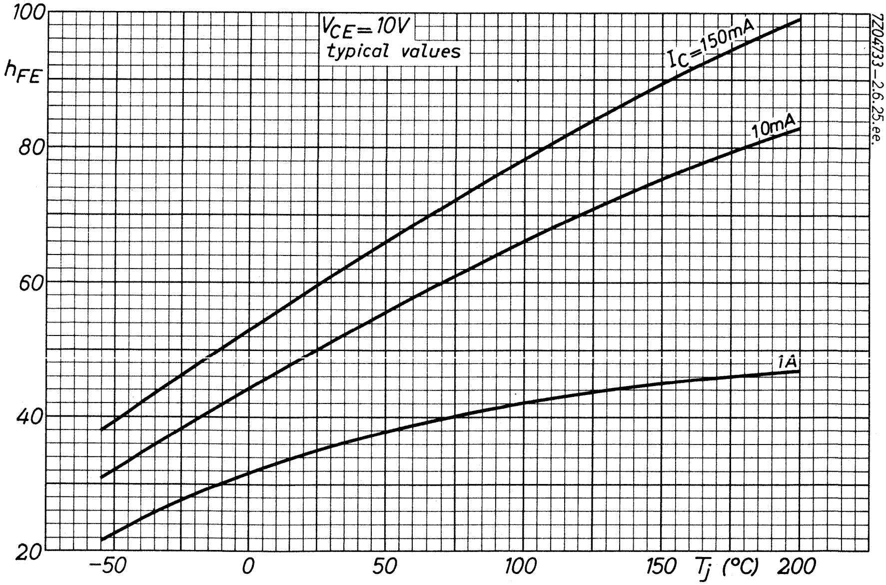

10^{-3}
5
h_{re}
2
10^{-4}
5
2
10^{-5}
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100
typ
V_{CE} = 6V
T_j = 25°C
f = 1kHz
7Z04743-2.6.25.ee.


1000
500
h_{fe}
200
100
50
20
10
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
7Z04746-2.6.25.ee.

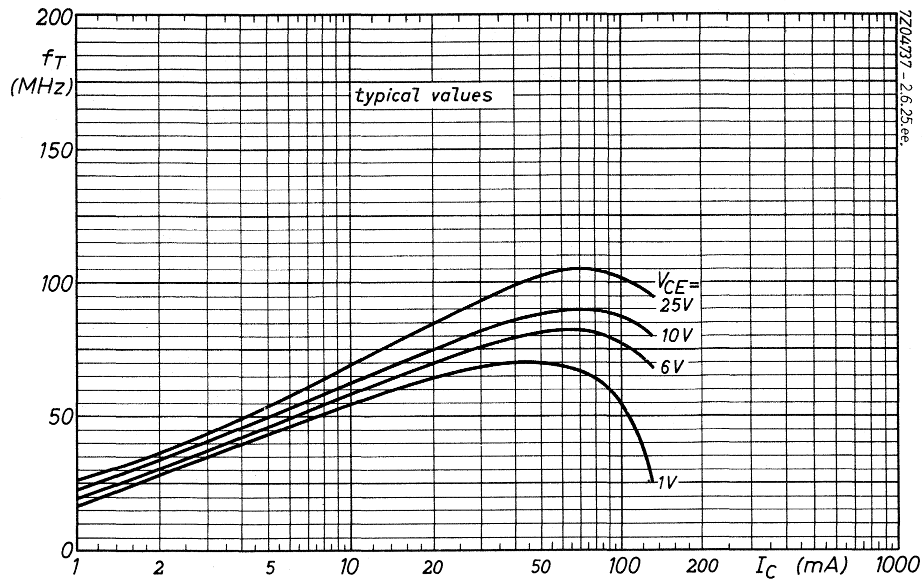

100
50
h_{oe}
($\mu\Omega^{-1}$)
20
10
5
2
1
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100
typ
V_{CE} = 6V
T_j = 25°C
f = 1kHz
7Z04744-2.6.25.ee.

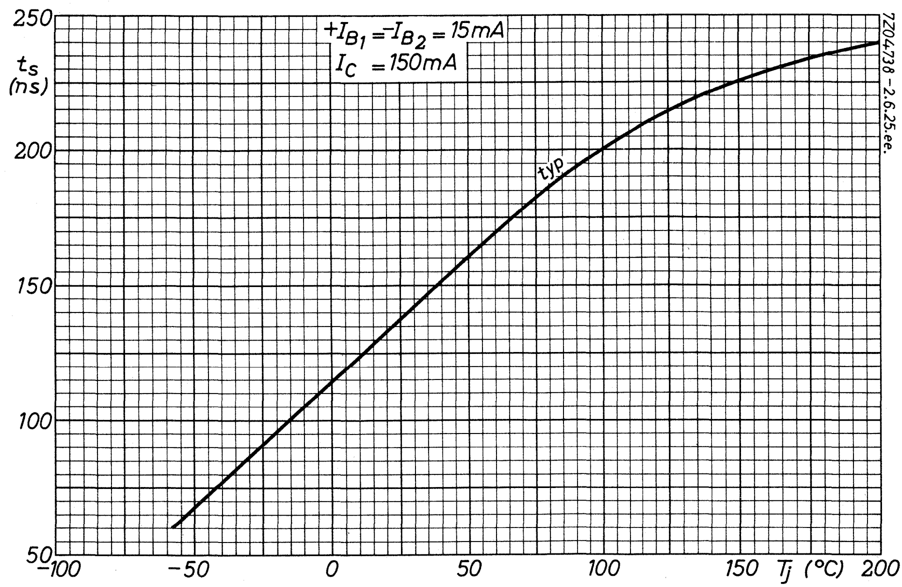


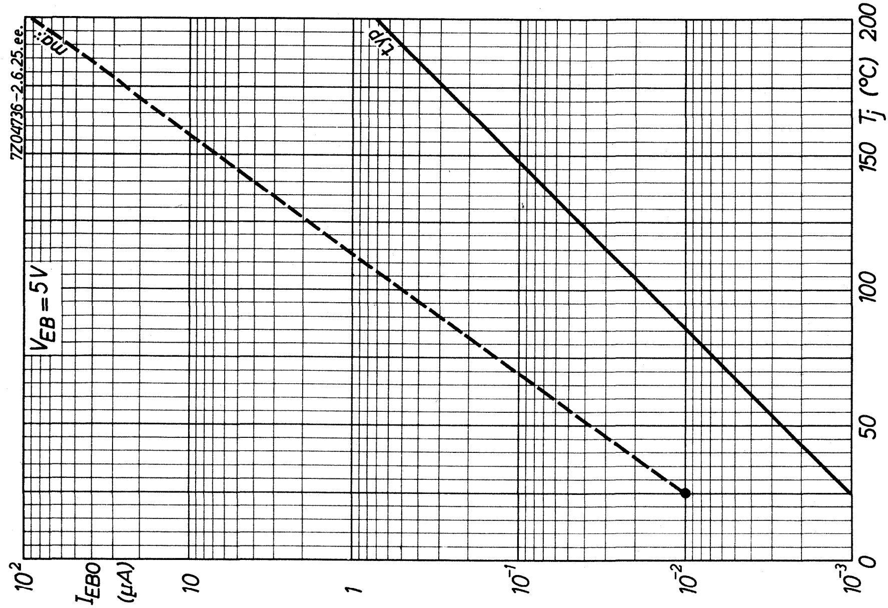
80
60
40
20
0
h_{FE}
$V_{CE} = 10V$
$T_j = 25°C$
typ
min
min
min
0.1 0.2 0.5 1 2 5 10 20 50 100 200 I_C (mA) 1000
7Z04734–2.6.25.ee.

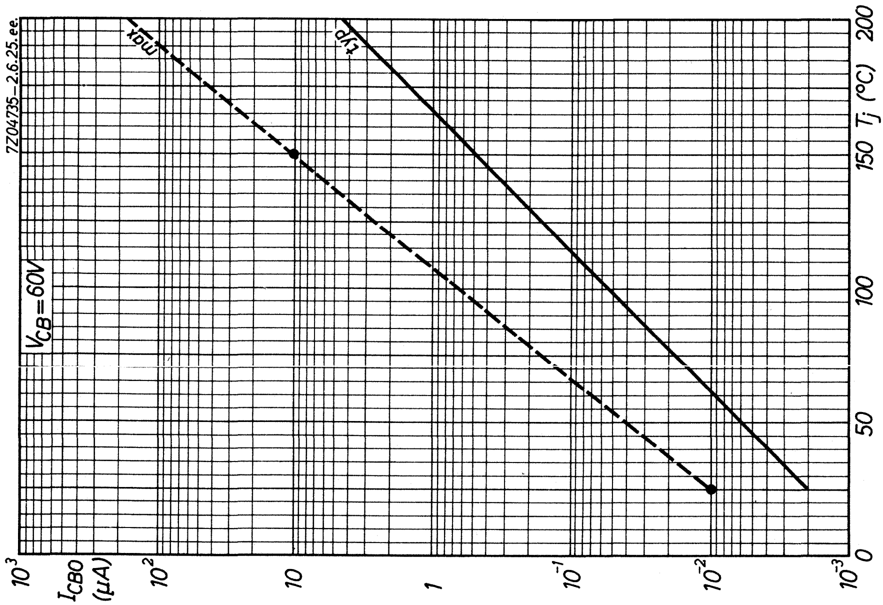


100
80
60
40
20
h_{FE}
$V_{CE} = 10V$
typical values
I_C=150mA
10mA
1A
−50 0 50 100 150 T_j (°C) 200
7Z04733–2.6.25.ee.


7Z04737 - 2.6.25.ee.
f_T (MHz)
typical values
V_{CE} =
25V
10V
6V
1V
I_C (mA)
200
150
100
50
0
1
2
5
10
20
50
100
200
1000


7Z04738 - 2.6.25.ee.
t_s (ns)
$+I_{B1} = -I_{B2} = 15mA$
$I_C = 150mA$
typ
T_j (°C)
250
200
150
100
50
−100
−50
0
50
100
150
200


7Z04736-2.6.25.ee.
$V_{EB} = 5V$
max.
typ
I_{EBO} (μA)
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
0
50
100
150
200
T_j (°C)


7Z04735-2.6.25.ee.
$V_{CB} = 60V$
max.
typ
I_{CBO} (μA)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
0
50
100
150
200
T_j (°C)

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

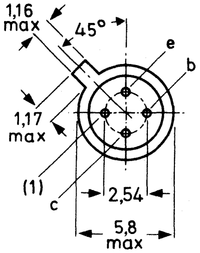
QUICK REFERENCE DATA					
Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	30		V
Collector-emitter voltage (open base)	V_{CEO}	max.	15		V
Collector current (peak value; f > 1 MHz)	I_{CM}	max.	50		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	200		mW
Junction temperature	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

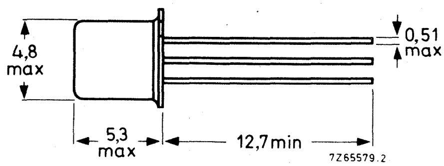
MECHANICAL DATA see page 2.

MECHANICAL DATA

Dimensions in mm

TO-72





(1) = shield lead (connected to case).

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

RATINGS

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

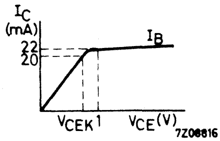
Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	30	V
Collector-emitter voltage (peak value) $R_{BE} \leqslant 50\,\Omega$; $I_C = 10$ mA	V_{CERM}	max.	30	V
Collector-emitter voltage (open base); $I_C = 10$ mA	V_{CEO}	max.	15	V
Emitter-base voltage (open collector)	V_{EBO}	max.	2,5	V
Collector current (d.c.)	I_C	max.	25	mA
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
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

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; $R_S = 50\ \Omega$	F	<	5	dB
f = 800 MHz; optimum source impedance	F	typ.	5.5	dB

			f = 200	800	MHz
Power gain (not neutralized) [1]					
$I_C = 14$ mA; $V_{CE} = 10$ V; $T_{amb} = 25$ °C	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

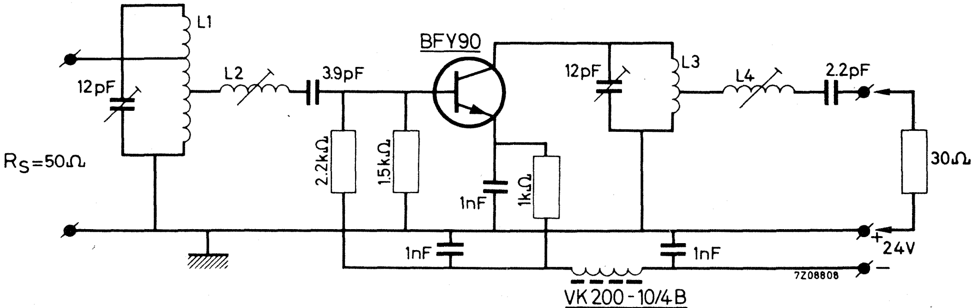
Intermodulation characteristics [1])

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.

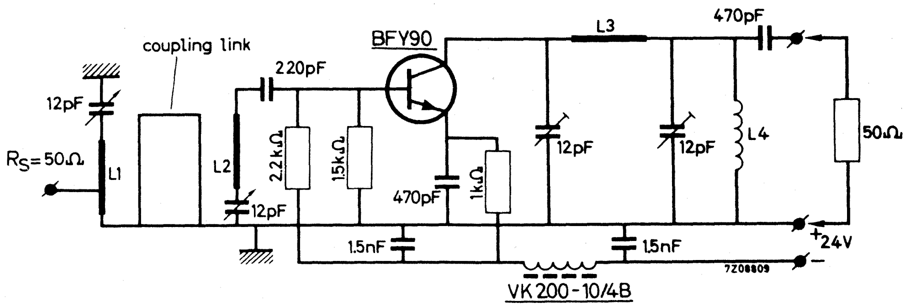
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

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

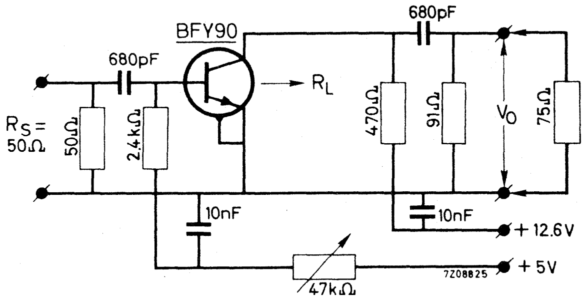
I_C = 14 mA; V_{CE} = 6 V; R_L = 37.5 Ω; T_{amb} = 25 °C

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

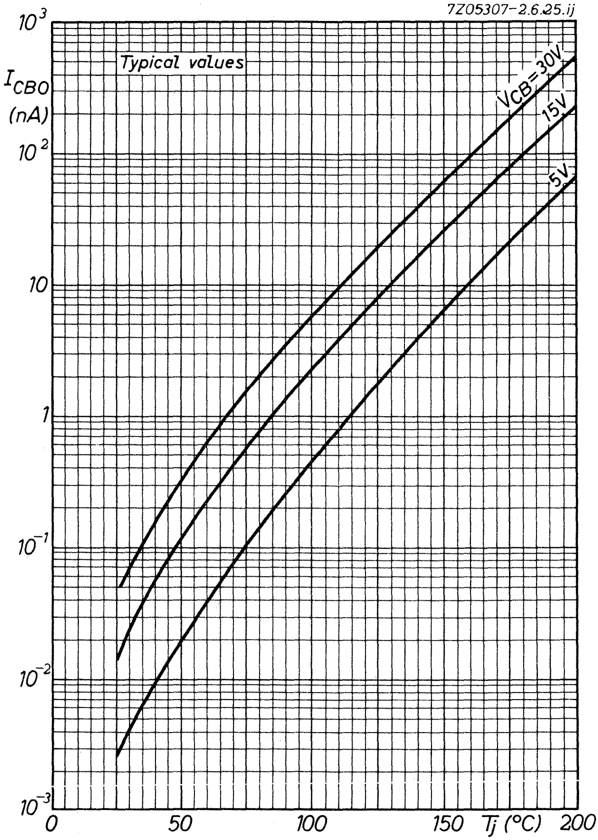
Input conductance	g_{ie}	typ.	16	$m\Omega^{-1}$
Input capacitance	C_{ie}	typ.	3.75	pF
Feedback admittance	$\|y_{re}\|$	typ.	1.55	$m\Omega^{-1}$
Phase angle of feedback admittance	φ_{re}	typ.	258°	
Transfer admittance	$\|y_{fe}\|$	typ.	45	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fe}	typ.	285°	
Output conductance	g_{oe}	typ.	0.19	$m\Omega^{-1}$
Output capacitance	C_{oe}	typ.	1.9	pF

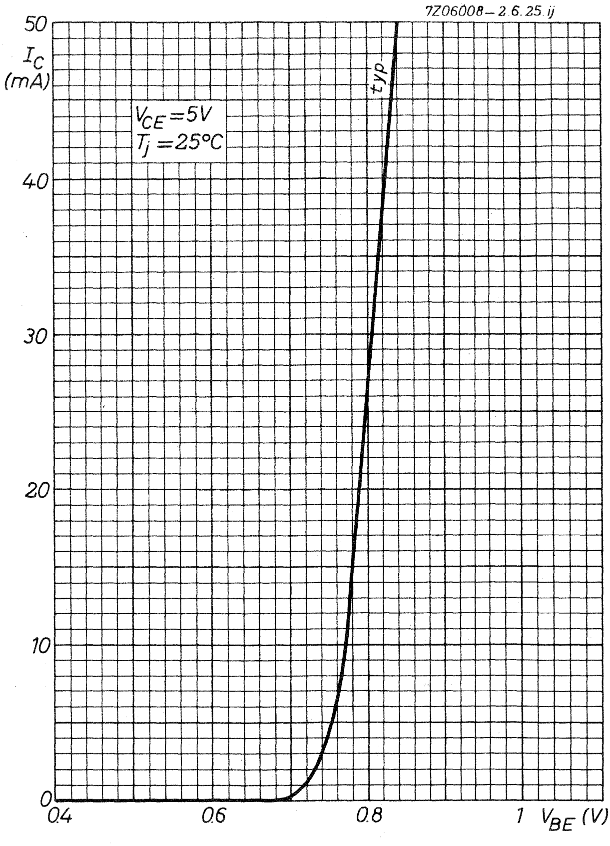
Maximum unilateralised power gain

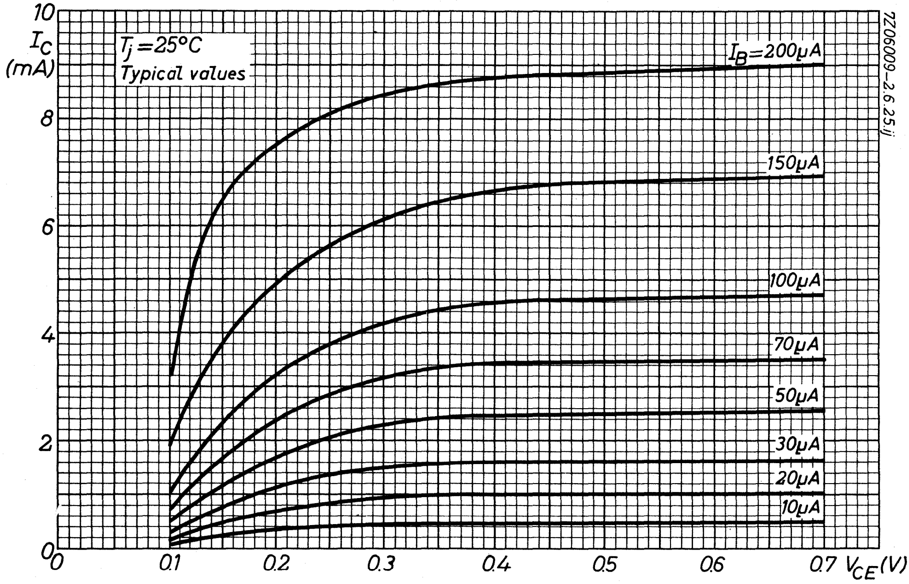
$$G_{UM} = \frac{|y_{fe}|^2}{4 g_{ie} g_{oe}}$$

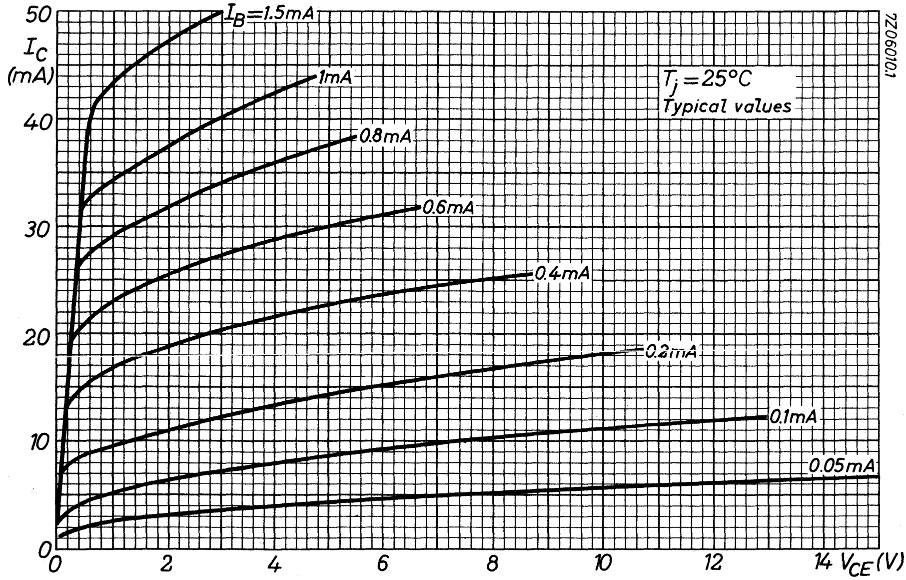
I_C = 2 mA; V_{CE} = 5 V; f = 500 MHz	G_{UM}	typ.	22	dB

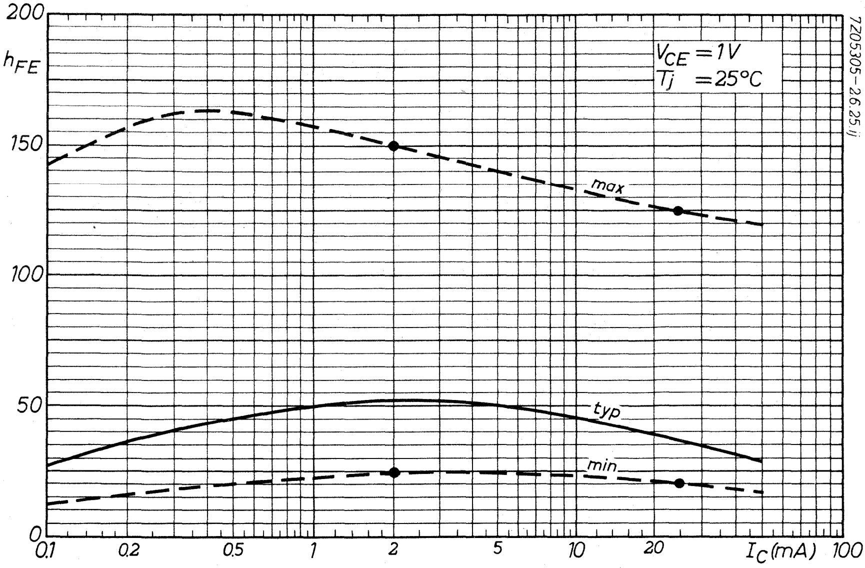
[1] Shield lead grounded


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
200
T_j (°C)
V_{CB}=30V
15V
5V

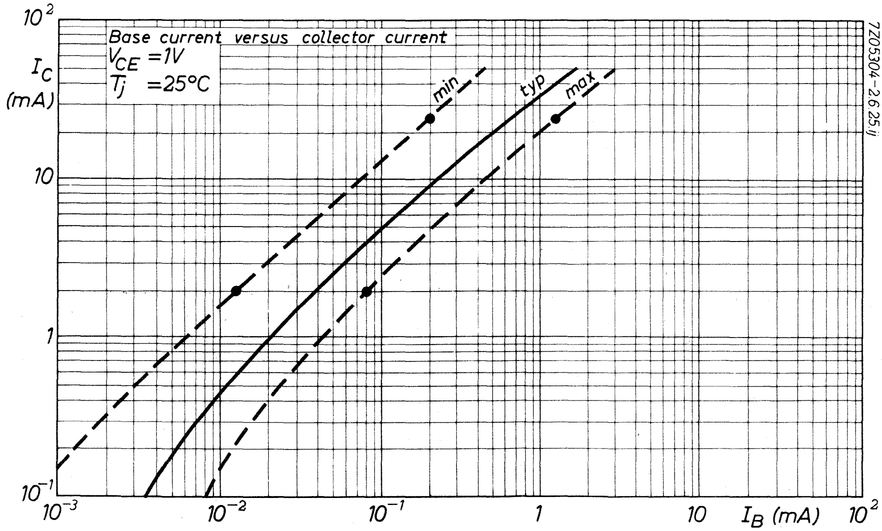

7Z06008–2.6.25.ij
50
I_C
(mA)
V_{CE} = 5V
T_j = 25°C
typ
40
30
20
10
0
0.4
0.6
0.8
1
V_{BE} (V)


10
I_C
(mA)
8
6
4
2
0
T_j = 25°C
Typical values
I_B = 200μA
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

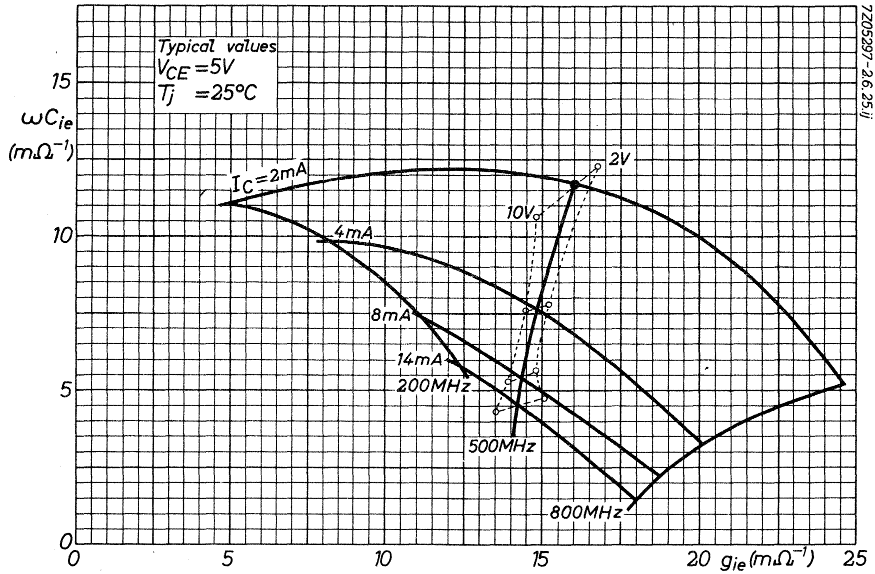

50
I_C
(mA)
40
30
20
10
0
I_B = 1.5mA
1mA
0.8mA
0.6mA
0.4mA
0.2mA
0.1mA
0.05mA
T_j = 25°C
Typical values
0
2
4
6
8
10
12
14 V_{CE} (V)
7Z06010.1

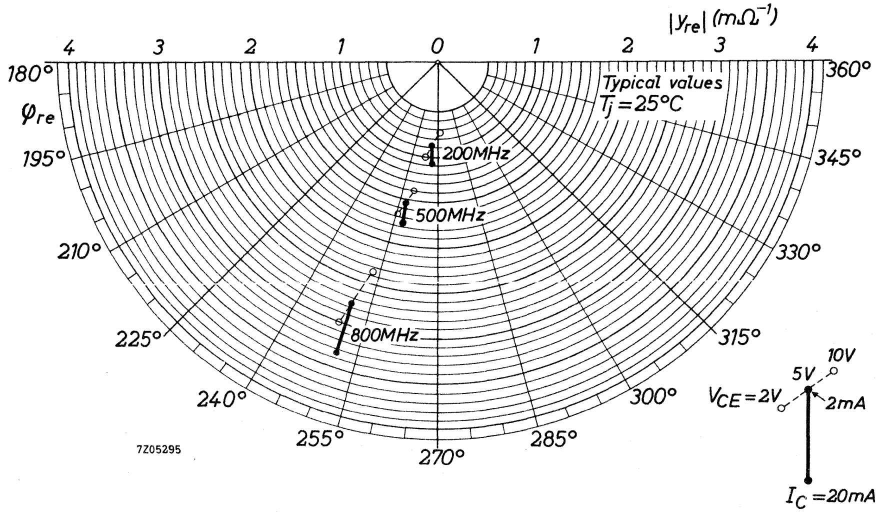


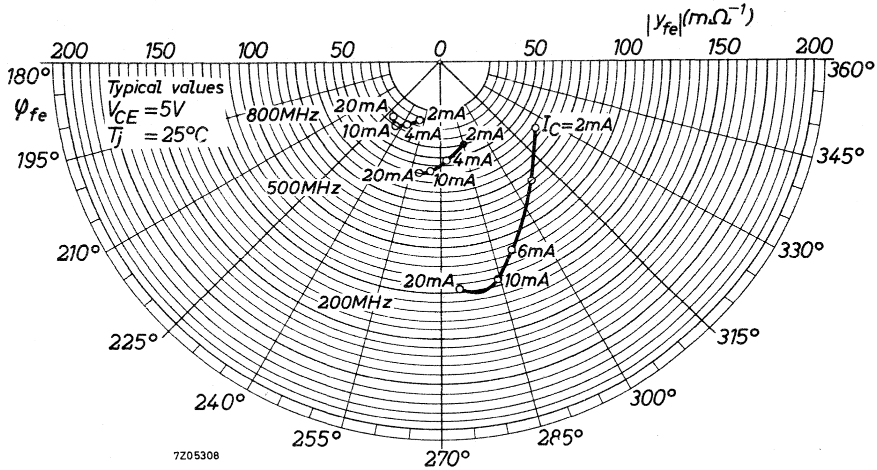
200
h_{FE}
150
100
50
0
0.1
0.2
0.5
1
2
5
10
20
I_C(mA)
100
V_{CE} = 1V
T_j = 25°C
max
typ
min
7Z05305-26.25.ij

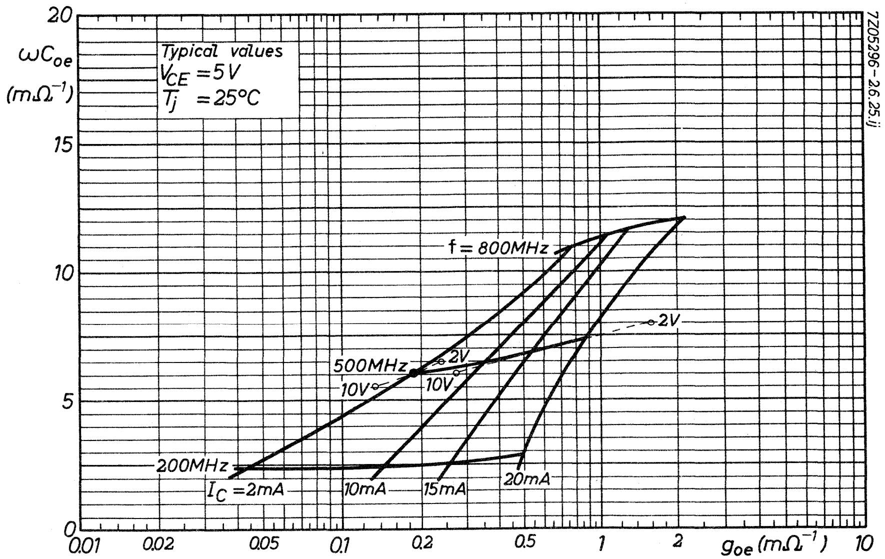


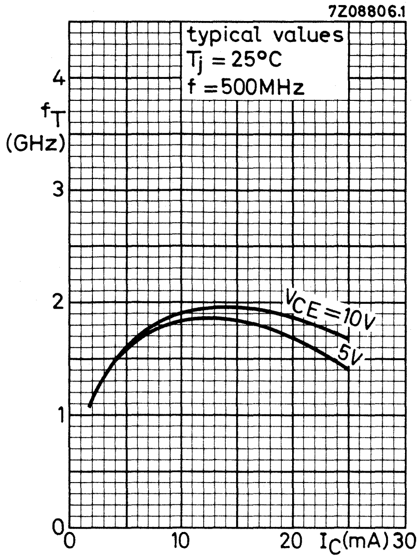
Base current versus collector current
V_{CE} = 1V
T_j = 25°C
I_C
(mA)
10^2
10
1
10^{-1}
10^{-3}
10^{-2}
10^{-1}
1
10
I_B (mA)
10^2
min
typ
max
7Z05304-26.25.ij

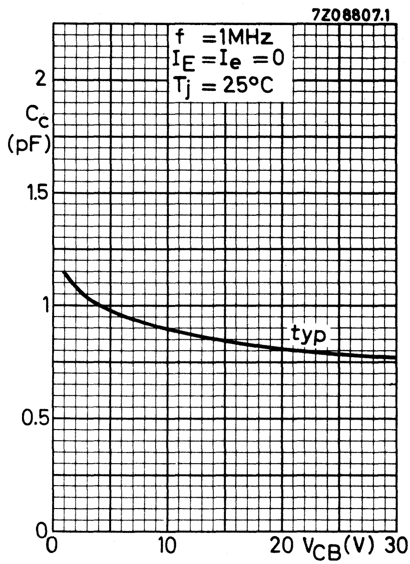

Typical values
V_{CE} = 5V
T_j = 25°C
ωCie (mΩ⁻¹)
gie (mΩ⁻¹)
IC = 2mA
4mA
8mA
14mA
200MHz
500MHz
800MHz
2V
10V
7Z05297-2.6.25.ij

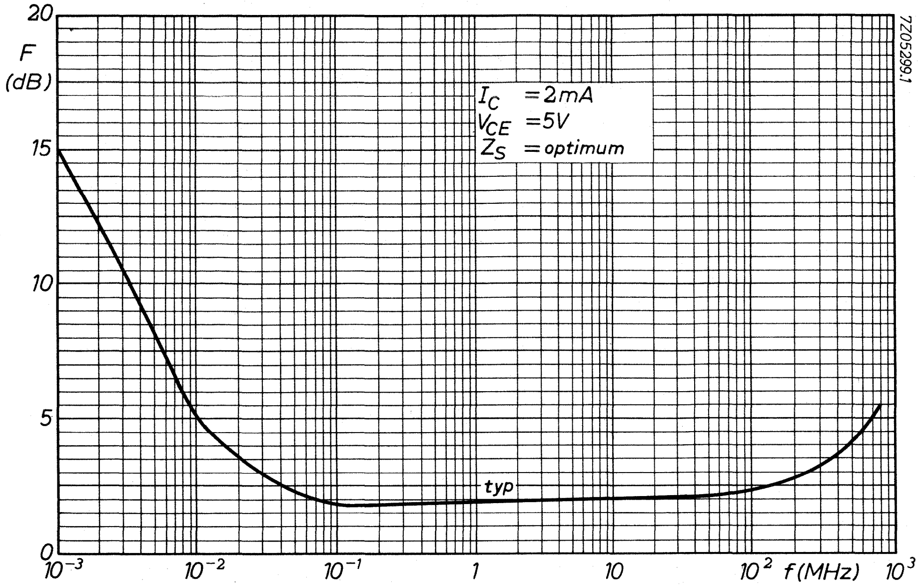

|yre| (mΩ⁻¹)
φre
Typical values
T_j = 25°C
200MHz
500MHz
800MHz
VCE = 2V
5V
10V
2mA
IC = 20mA
7Z05295

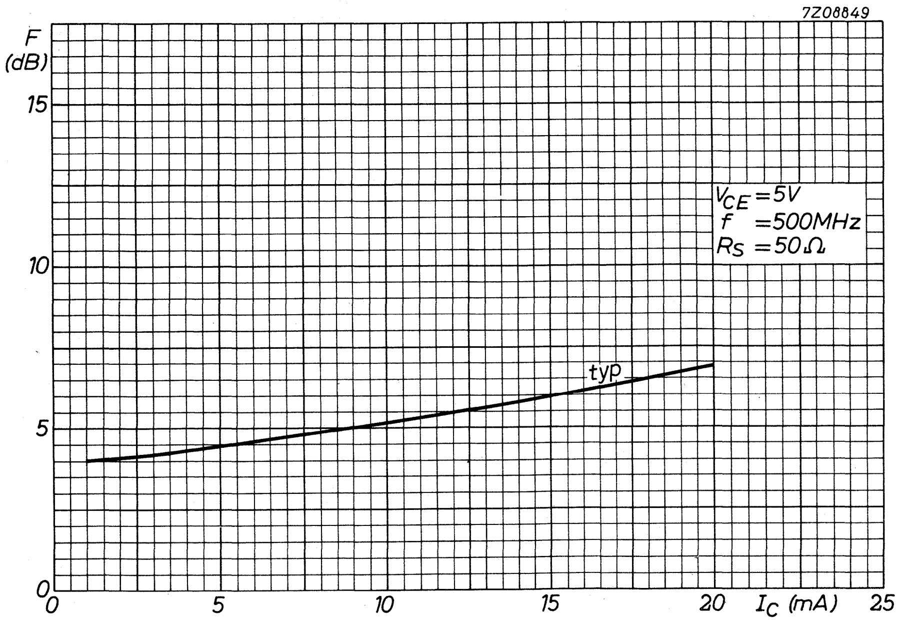

|yfe|(mΩ⁻¹)
200 150 100 50 0 50 100 150 200
180°
φfe
195°
210°
225°
240°
255°
270°
285°
300°
315°
330°
345°
360°
Typical values
VCE = 5V
Tj = 25°C
800MHz
500MHz
200MHz
20mA
10mA
4mA
2mA
IC = 2mA
6mA
7Z05308


ωCoe
(mΩ⁻¹)
Typical values
VCE = 5 V
Tj = 25°C
f = 800MHz
500MHz
200MHz
2V
10V
IC = 2mA
10mA
15mA
20mA
goe (mΩ⁻¹)
7Z05296-26.25.1


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.

HYBRID V.H.F. PUSH-PULL AMPLIFIER MODULE

Two-stage amplifier in a plastic envelope intended for CATV purposes.

QUICK REFERENCE DATA

Frequency range	f		40 to 300	MHz
Source impedance and load impedance	$Z_S = Z_L$	=	75	Ω
D.C. supply voltage	$+V_B$	=	24	V *
D.C. power dissipation	P_{tot}	max	5,3	W
Operating case temperature	T_{case}	max	90	°C
Power gain at f = 50 MHz	G_p		16,4 ± 0,4	dB
Slope cable equivalent f = 40 MHz to 300 MHz			0 to + 1,0	dB
Flatness of frequency response f = 40 MHz to 300 MHz	ΔG_p	⩽	± 0,1	dB
Return losses at input and output f = 40 MHz	$\lvert s_r \rvert^2$	⩾	20	dB
f = 300 MHz	$\lvert s_r \rvert^2$	⩾	20	dB
Output voltage at d_{im} = −60 dB (DIN 45004, par. 6.3: 3-tone)	V_o	⩾	65	dBmV
2nd harmonic distortion at V_o = 50 dBmV	d_2	⩽	−70	dB
Cross-modulation distortion (channel 13) V_o = 32,0 dBmV per signal	d_{cm}	typ	−102	dB
V_o per signal at d_{cm} = −57 dB	V_o	typ	54,5	dBmV
Noise figure f = 40 MHz to 300 MHz	F	⩽	7	dB

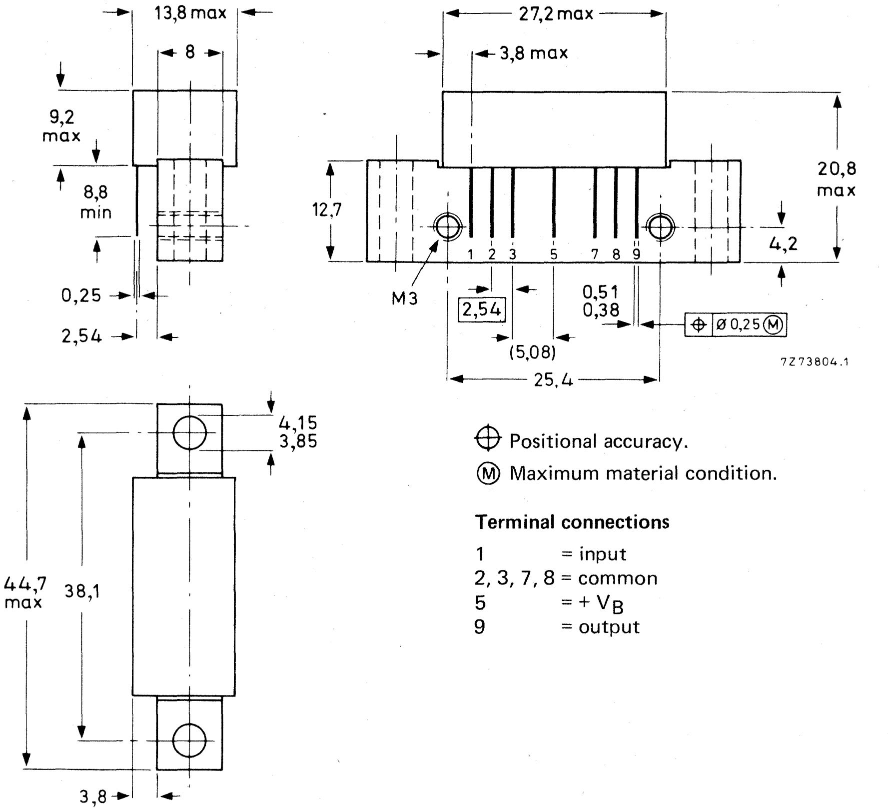
MECHANICAL DATA see page 2.

* The module is able to withstand incidentally short peaks in the supply voltage up to a maximum of 30 V.

MECHANICAL DATA

Dimensions in mm

SOT-115



⊕ Positional accuracy.

Ⓜ Maximum material condition.

Terminal connections

1 = input
2, 3, 7, 8 = common
5 = + V_B
9 = output

Soldering recommendations

The maximum permissible temperature of the soldering iron is 260 °C for a contact time of maximum 3 s, when the soldered joints are 3 mm or more from the module.

RATINGS

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

D.C. power dissipation	P_{tot}	max	5,3	W
Storage temperature	T_{stg}	−40 to + 125		°C
Operating junction temperature	T_j	max	150	°C
Operating case temperature	T_{case}	−20 to	+ 90	°C *

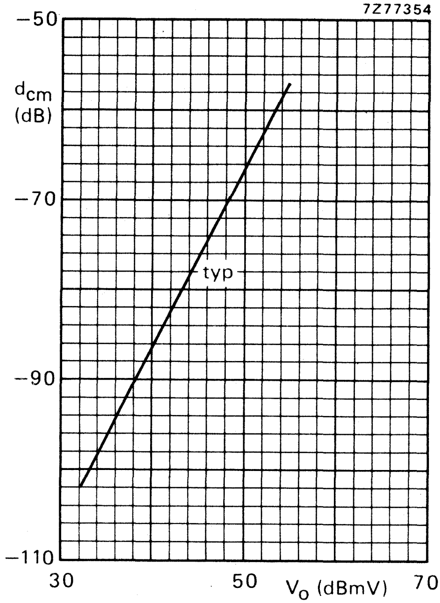
* With a heatsink ⩽ 4,7 °C/W a maximum ambient temperature of + 65 °C is permissible.

CHARACTERISTICS

Supply voltage $V_B = +24$ V; $T_{amb} = 25$ °C

Power gain at f = 50 MHz	G_p		16,4 ± 0,4 dB
Slope cable equivalent f = 40 MHz to 300 MHz			0 to + 1,0 dB
Flatness of frequency response f = 40 MHz to 300 MHz	ΔG_p	⩽	± 0,1 dB
Return losses at input and output $Z_S = Z_L = 75\ \Omega$; f = 40 MHz	$\lvert s_r \rvert^2$	⩾	20 dB
$Z_S = Z_L = 75\ \Omega$; f = 300 MHz	$\lvert s_r \rvert^2$	⩾	20 dB
Output voltage at $d_{im} = -60$ dB (DIN 45004, par. 6.3: 3-tone) $V_p = V_o$; $f_p = 196{,}25$ MHz $V_q = V_o - 6$ dB; $f_q = 203{,}25$ MHz $V_r = V_o - 6$ dB; $f_r = 205{,}25$ MHz Measured at $f_{(p+q-r)} = 194{,}25$ MHz	V_o	⩾	65 dBmV
2nd harmonic distortion $V_p = V_o = 50$ dBmV; $f_p = 66$ MHz $V_q = V_o = 50$ dBmV; $f_q = 144$ MHz Measured at $f_{(p+q)} = 210$ MHz	d_2	⩽	−70 dB
Cross-modulation distortion (channel 13) * $V_o = 32{,}0$ dBmV per signal	d_{cm}	typ	−102 dB
V_o per signal at $d_{cm} = -57$ dB	V_o	typ	54,5 dBmV
Noise figure f = 40 MHz to 300 MHz	F	⩽	7 dB

* In 12-channel measuring equipment; channel 13 unmodulated.
V_o = output level/signal, in accordance with NCTA measuring standard.


7Z77354
−50
d_{cm} (dB)
−70
typ
−90
−110
30
50
V_o (dBmV)
70

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 p-n-p/n-p-n transistor pair of which all electrodes are accessible. The collector of the n-p-n transistor is connected to the case.

QUICK REFERENCE DATA

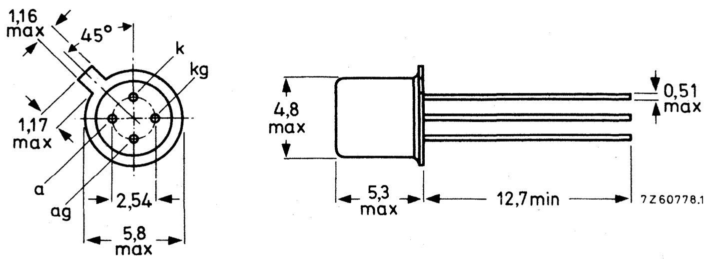
p-n-p transistor				
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	50	V
n-p-n transistor				
Collector-base voltage (open emitter)	V_{CBO}	max.	50	V
Repetitive peak emitter current (peak value)	$-I_{ERM}$	max.	2,5	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	275	mW
Junction temperature	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 (ag = anode gate) connected to the case

TO-72



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

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

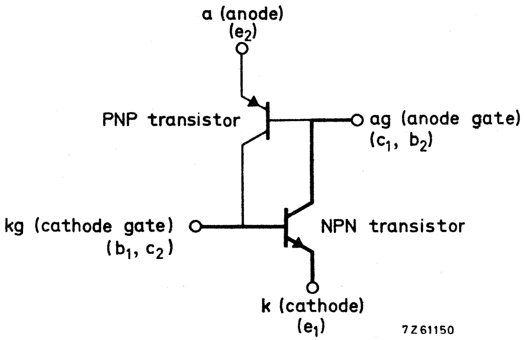
THERMAL RESISTANCE

From junction to ambient	$R_{th\ j-a}$	=	0,45	°C/mW

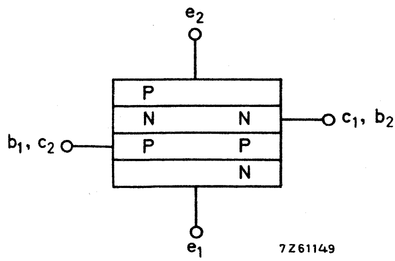
1) Exceeding of this voltage is allowed during the discharge of a capacitor of max. 390 pF, provided the charge does not exceed 50 nC.
2) Provided the I_E rating will not be exceeded.

MEANING OF SYMBOLS , used in the schematic presentation of the S.C.S.

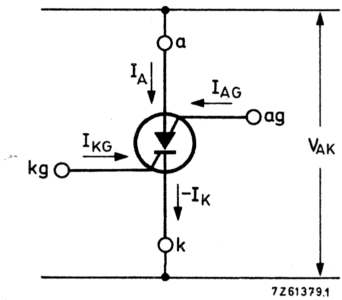
2 transistors equivalent circuit
n-p-n transistor + p-n-p transistor



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 °C unless otherwise specified

Individual N-P-N transistor

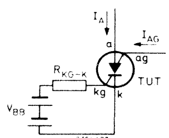
Saturation voltages				
I_C = 10 mA; I_B = 1 mA	V_{CEsat}	<	500	mV
	V_{BEsat}	<	900	mV
D.C. current gain				
I_C = 10 mA; V_{CE} = 2 V	h_{FE}	>	50	
Transition frequency				
I_C = 10 mA; V_{CE} = 2 V	f_T	typ.	300	MHz
Collector capacitance				
$I_E = I_e$ = 0; V_{CB} = 20 V	C_c	<	5	pF
Emitter capacitance				
$I_C = I_c$ = 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 °C	$-I_{CEO}$	<	50	μA
Emitter cut-off current				
I_C = 0; $-V_{EB}$ = 50 V; T_j = 150 °C	$-I_{EBO}$	<	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 kΩ				
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 kΩ				
I_{AG} = 10 mA; $-V_{BB}$ = 2 V	I_H	<	1,0	mA



SILICON CONTROLLED SWITCH

The BRY39 is a planer 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 p-n-p/n-p-n 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.

QUICK REFERENCE DATA

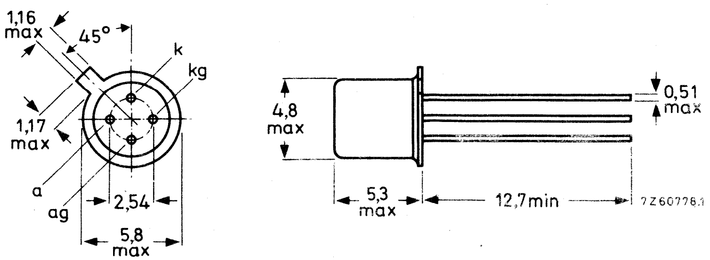
p-n-p transistor				
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	70	V
n-p-n transistor				
Collector-base voltage (open emitter)	V_{CBO}	max.	70	V
Repetitive peak emitter current	$-I_{ERM}$	max.	2,5	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	275	mW
Junction temperature	T_j	max.	150	°C
Forward on-state voltage I_A = 50 mA; I_{AG} = 0; $R_{KG\text{-}K}$ = 10 kΩ	V_{AK}	<	1,4	V
Holding current I_{AG} = 10 mA; $-V_{BB}$ = 2 V; $R_{KG\text{-}K}$ = 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 (ag = anode gate) connected to the case

TO-72



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

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

Voltages

			p-n-p	n-p-n	
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

			p-n-p	n-p-n	
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.

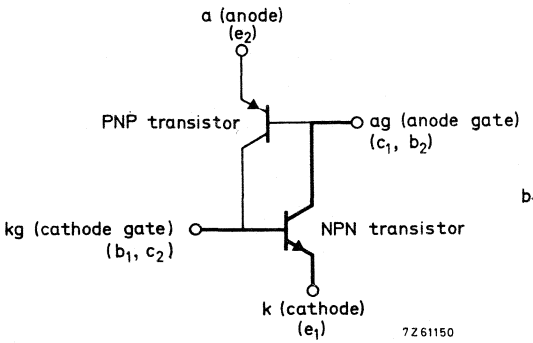
2) In numerical indicator tube driver circuits higher voltages are allowed during the discharge of a capacitor of max. 390 pF, provided the charge does not exceed 50 nC.

3) Provided the I_E rating will not be exceeded.

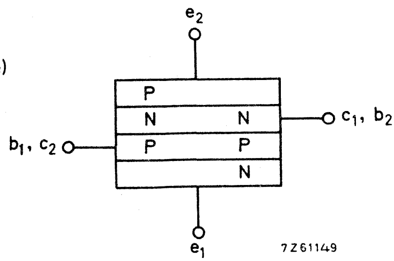
4) During switching on, the device can withstand a discharge of a capacitor of max. 500 pF. This capacitor is charged, when the transistor is in cut-off condition, with a collector supply voltage of 160 V with a series resistance of 100 kΩ.

MEANING OF SYMBOLS, used in the schematic presentation of the S.C.S.

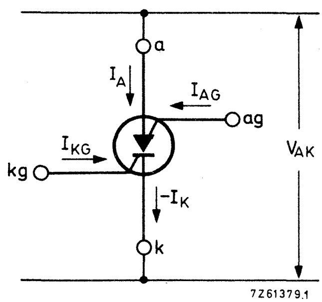
2 transistor equivalent circuit



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 °C unless otherwise specified

Individual N-P-N transistor

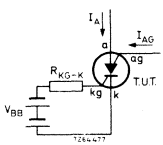
Saturation voltages				
I_C = 10 mA; I_B = 1 mA	V_{CEsat}	<	500	mV
	V_{BEsat}	<	900	mV
D.C. current gain				
I_C = 10 mA; V_{CE} = 2 V	h_{FE}	>	50	
Transition frequency				
I_C = 10 mA; V_{CE} = 2 V	f_T	typ.	300	MHz
Collector capacitance				
$I_E = I_e$ = 0; V_{CB} = 20 V	C_c	<	5	pF
Emitter capacitance				
$I_C = I_c$ = 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 °C	$-I_{CEO}$	<	10	μA
Emitter cut-off current				
I_C = 0; $-V_{EB}$ = 70 V; T_j = 150 °C	$-I_{EBO}$	<	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 °C	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

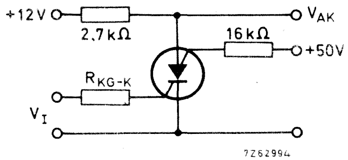


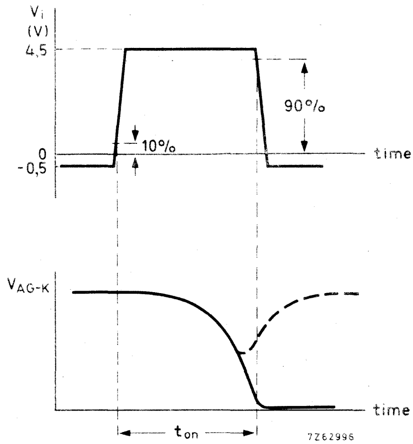
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Switching times see also page 6

Turn-on time when switched from

$-V_{KG-K}$ = 0,5 V to $+V_{KG-K}$ = 4,5 V; R_{KG-K} = 1 kΩ	t_{on}	<	0,25	μs
R_{KG-K} = 10 kΩ	t_{on}	<	1,5	μs

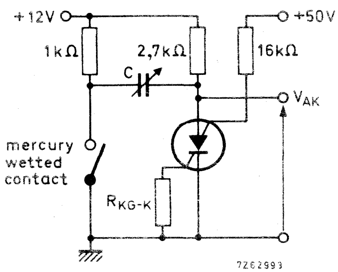


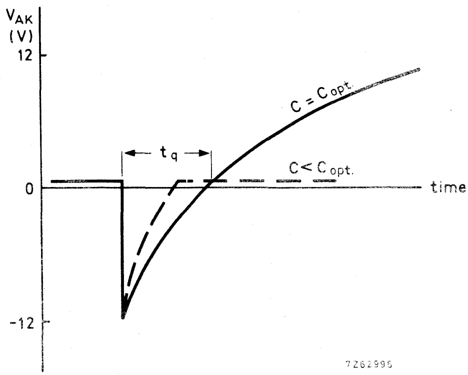


Pulse duration increased until
dashed curve disappears

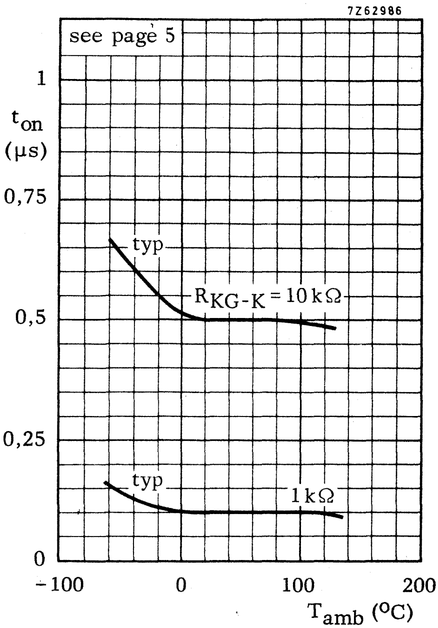
Turn-off time

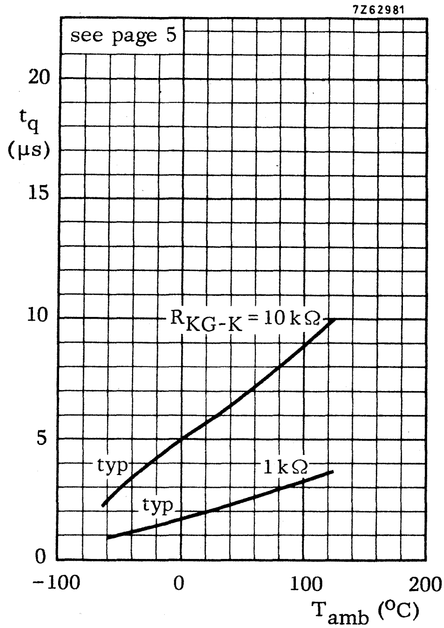
R_{KG-K} = 1 kΩ	t_q	<	5	μs
R_{KG-K} = 10 kΩ	t_q	<	8	μs
T_j = 125 °C; R_{KG-K} = 10 kΩ	t_q	<	15	μs

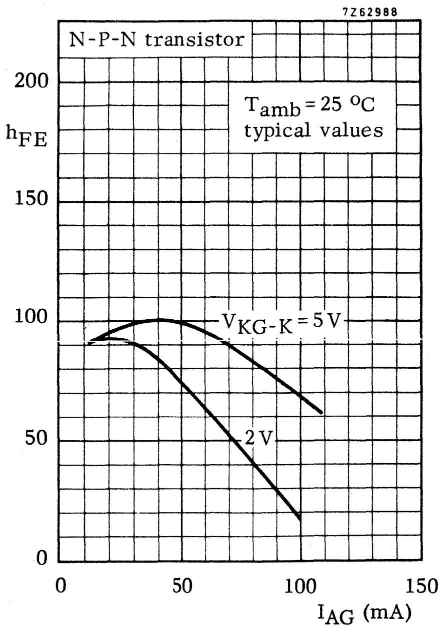


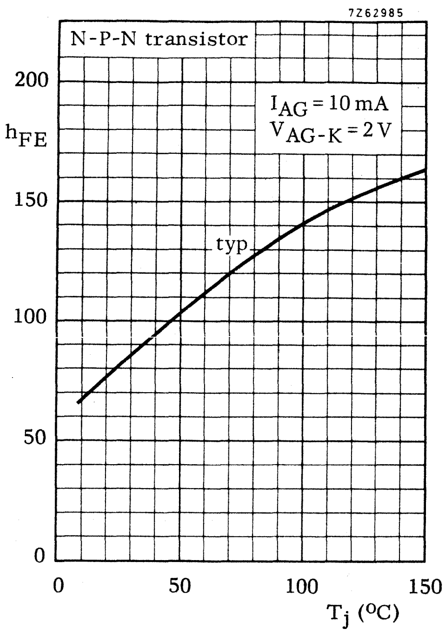


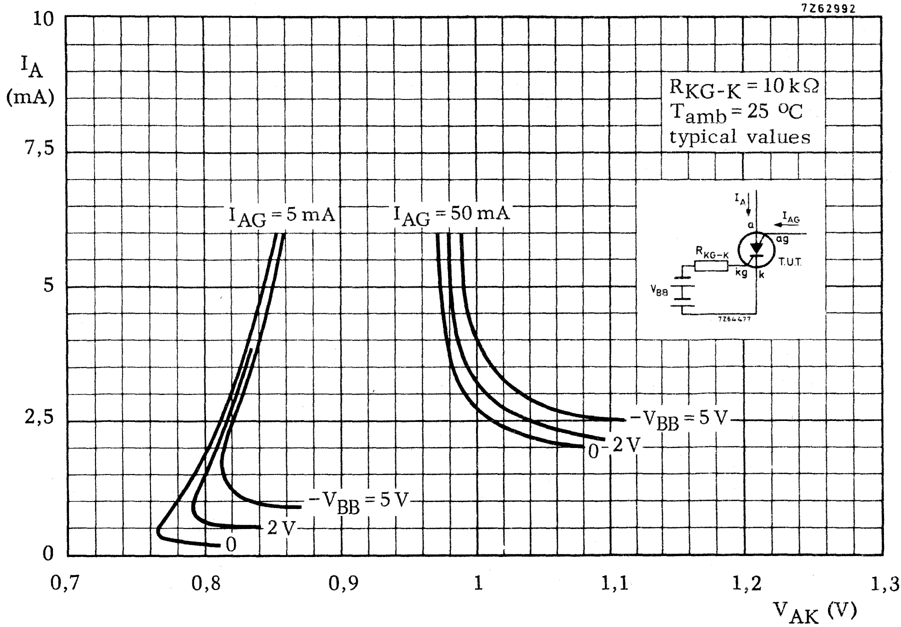
Capacitance increased until
dashed curve disappears at C = C_{opt}

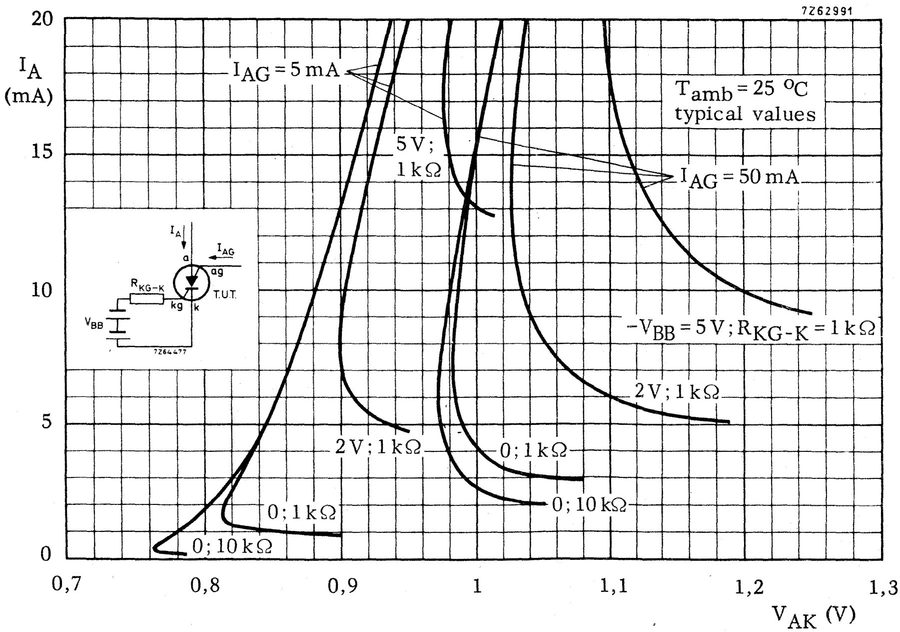

7Z62986
see page 5
1
t_{on}
(μs)
0,75
0,5
0,25
0
typ
R_{KG-K} = 10 kΩ
typ
1 kΩ
−100
0
100
200
T_{amb} (°C)

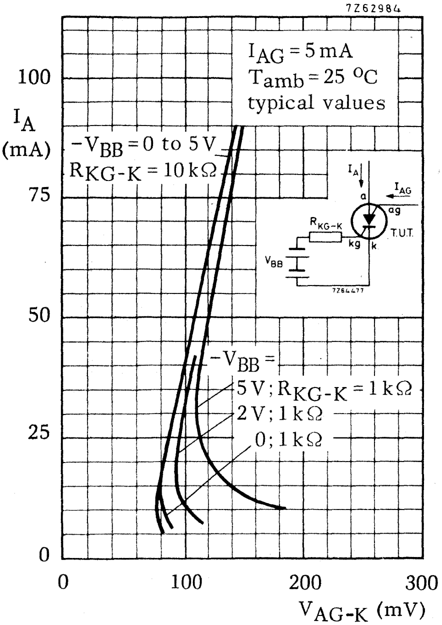

7Z62981
see page 5
20
t_q
(μs)
15
10
5
0
R_{KG-K} = 10 kΩ
typ
1 kΩ
typ
−100
0
100
200
T_{amb} (°C)

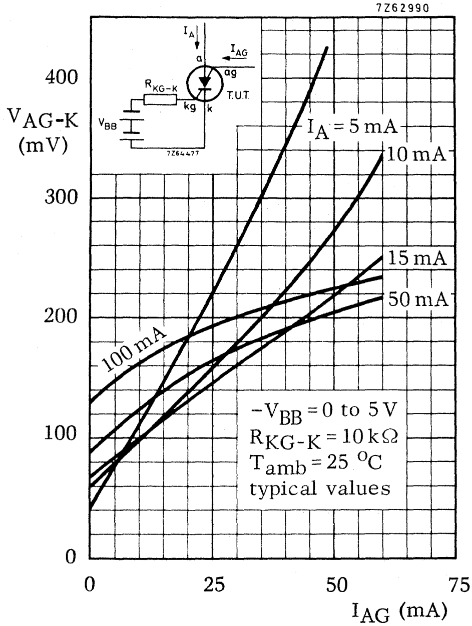

7Z62988
N-P-N transistor
T_{amb} = 25 °C
typical values
200
h_{FE}
150
100
50
0
V_{KG-K} = 5 V
2 V
0
50
100
150
I_{AG} (mA)

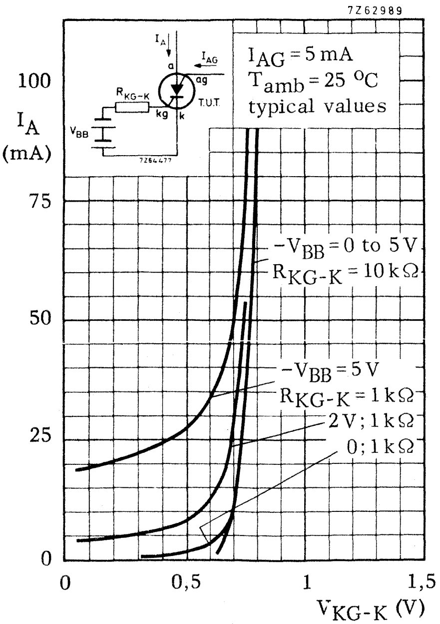

7Z62985
N-P-N transistor
I_{AG} = 10 mA
V_{AG-K} = 2 V
200
h_{FE}
150
100
50
0
typ
0
50
100
150
T_j (°C)

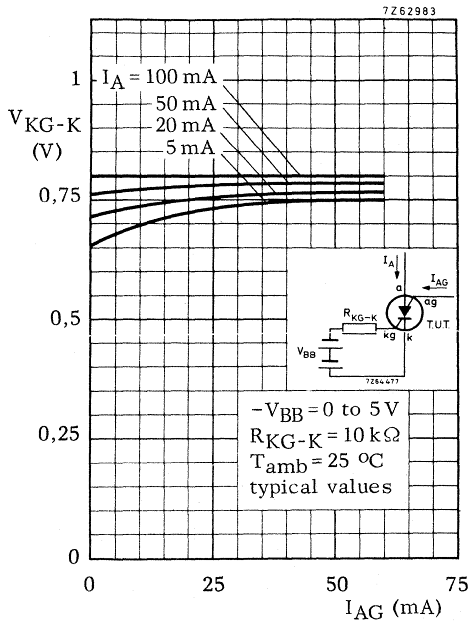

7Z62992
10
I_A
(mA)
7,5
5
2,5
0
0,7
0,8
0,9
1
1,1
1,2
1,3
V_{AK} (V)
R_{KG-K} = 10 kΩ
T_{amb} = 25 °C
typical values
I_{AG} = 5 mA
I_{AG} = 50 mA
$-V_{BB}$ = 5 V
2 V
0
$-V_{BB}$ = 5 V
0
2 V
I_A
a
I_{AG}
ag
R_{KG-K}
kg
k
T.U.T.
V_{BB}
7Z64477

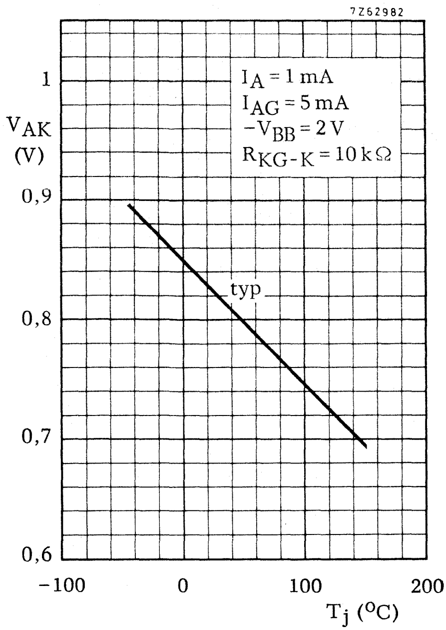

7Z62991
20
I_A
(mA)
15
10
5
0
0,7
0,8
0,9
1
1,1
1,2
1,3
V_{AK} (V)
T_{amb} = 25 °C
typical values
I_{AG} = 5 mA
I_{AG} = 50 mA
5 V;
1 kΩ
$-V_{BB}$ = 5 V; R_{KG-K} = 1 kΩ
2 V; 1 kΩ
2 V; 1 kΩ
0; 1 kΩ
0; 10 kΩ
0; 1 kΩ
0; 10 kΩ
I_A
a
I_{AG}
ag
R_{KG-K}
kg
k
T.U.T.
V_{BB}
7Z64477

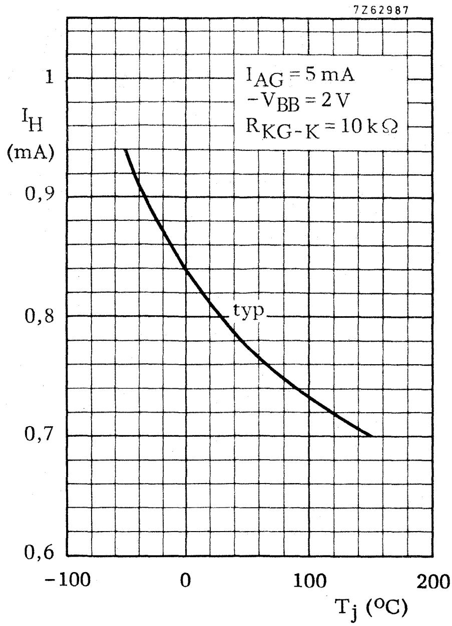

7Z62984
I_{AG} = 5 mA
T_{amb} = 25 °C
typical values
I_A (mA)
$-V_{BB}$ = 0 to 5 V
R_{KG-K} = 10 kΩ
$-V_{BB}$ =
5 V; R_{KG-K} = 1 kΩ
2 V; 1 kΩ
0; 1 kΩ
V_{AG-K} (mV)
T.U.T.
7Z64477

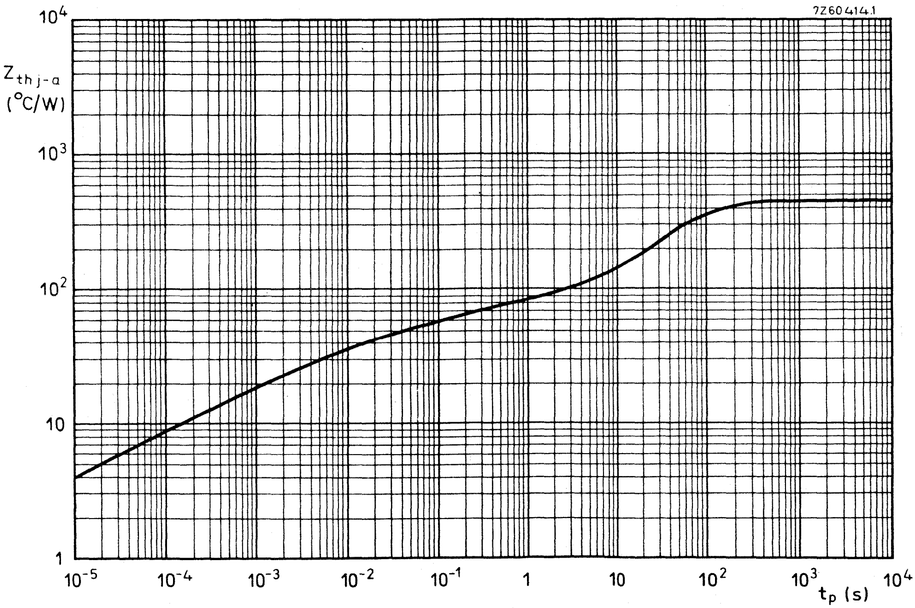

7Z62990
V_{AG-K} (mV)
I_A = 5 mA
10 mA
15 mA
50 mA
100 mA
$-V_{BB}$ = 0 to 5 V
R_{KG-K} = 10 kΩ
T_{amb} = 25 °C
typical values
I_{AG} (mA)
T.U.T.
7Z64477

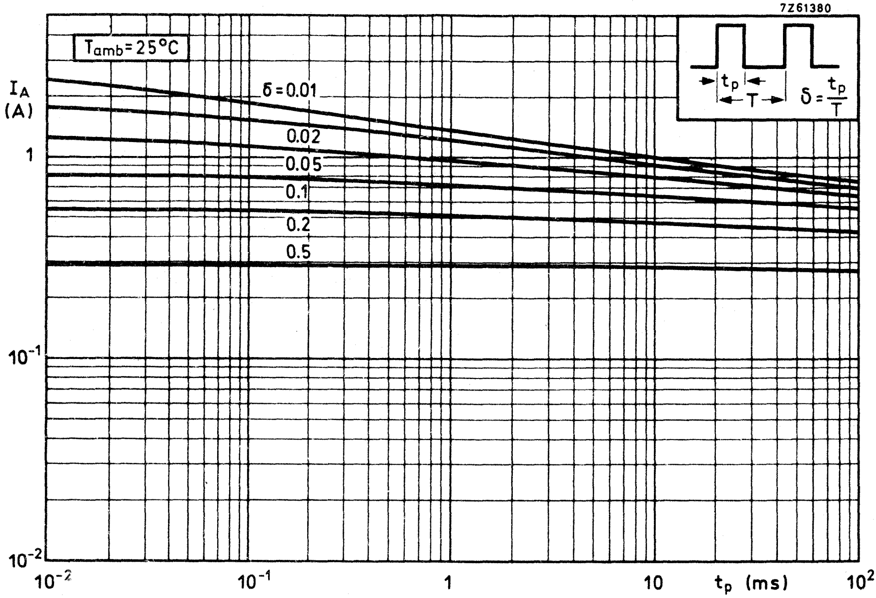

7Z62989
I_{AG} = 5 mA
T_{amb} = 25 °C
typical values
I_A (mA)
$-V_{BB}$ = 0 to 5 V
R_{KG-K} = 10 kΩ
$-V_{BB}$ = 5 V
R_{KG-K} = 1 kΩ
2 V; 1 kΩ
0; 1 kΩ
V_{KG-K} (V)
T.U.T.
7Z64477

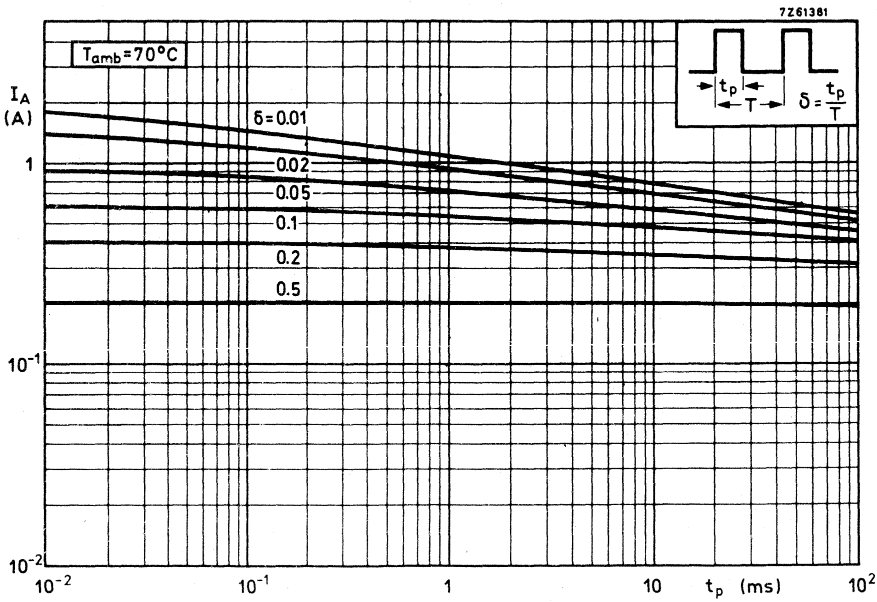

7Z62983
V_{KG-K} (V)
I_A = 100 mA
50 mA
20 mA
5 mA
$-V_{BB}$ = 0 to 5 V
R_{KG-K} = 10 kΩ
T_{amb} = 25 °C
typical values
I_{AG} (mA)
T.U.T.
7Z64477


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)

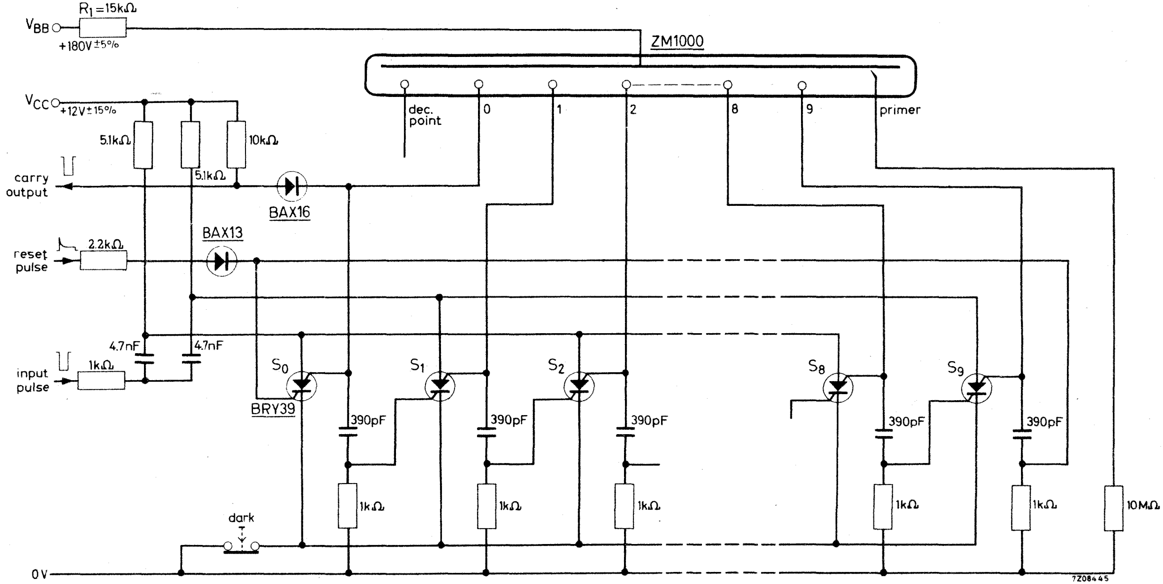

7Z61380
T_{amb} = 25 °C
I_A (A)
δ = 0.01
0.02
0.05
0.1
0.2
0.5
t_p (ms)
$\delta = \frac{t_p}{T}$


7Z61381
T_{amb} = 70 °C
I_A (A)
δ = 0.01
0.02
0.05
0.1
0.2
0.5
t_p (ms)
$\delta = \frac{t_p}{T}$

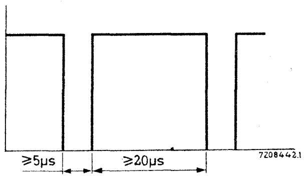
APPLICATION INFORMATION

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 planer 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 THYRISTOR TETRODE see Handbook Part 1a, section THYRISTORS. (For explanation of symbols see page 2).

QUICK REFERENCE DATA

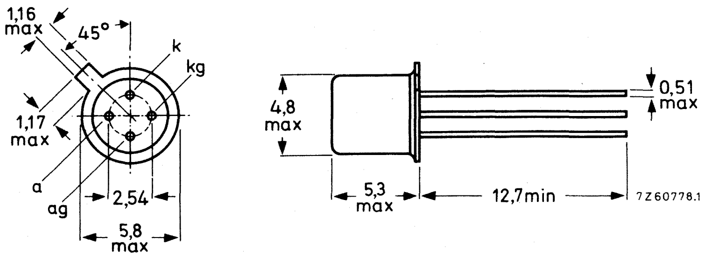
Gate-anode voltage	V_{GA}	max.	70	V
Anode current (d.c.) up to T_{case} = 85 °C	I_A	max.	250	mA
Junction temperature	T_j	max.	150	°C
Peak point current V_S = 10 V; R_G = 10 kΩ	I_P	<	5	μA
Valley point current V_S = 10 V; R_G = 10 kΩ	I_V	>	50	μA

MECHANICAL DATA

Dimensions in mm

Anode gate (ag) connected to case

TO-72



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

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

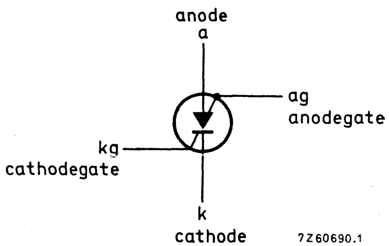
Voltage				
Gate-anode voltage	V_{GA}	max.	70	V
Currents				
Anode current (d.c.) up to T_{amb} = 25 °C	I_A	max.	175	mA
Anode current (d.c.) up to T_{case} = 85 °C	I_A	max.	250	mA
Repetitive peak anode current t = 10 µs; δ = 0.01	I_{ARM}	max.	2.5	A
Non-repetitive peak anode current t = 10 µs; T_j = 150 °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

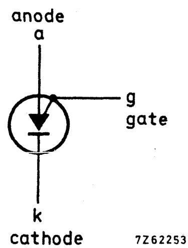
THERMAL RESISTANCE

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.





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

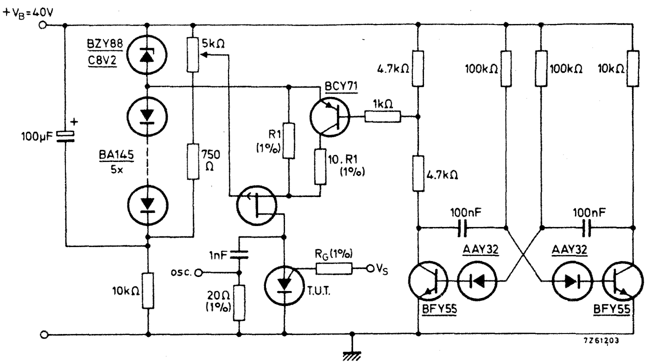
Peak point current

V_S = 10 V; R_G = 10 kΩ	I_P	<	5	μA
V_S = 10 V; R_G = 1 MΩ	I_P	<	1	μA

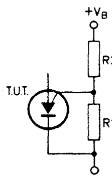
Valley point current

V_S = 10 V; R_G = 10 kΩ	I_V	>	50	μA
V_S = 10 V; R_G = 1 MΩ	I_V	<	50	μA

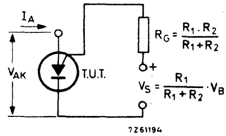
Practical test circuit: 1 Remove BCY71 during measurement of I_P
2 Value of R_1 depends on the voltage range of voltmeter



Equivalent test circuit



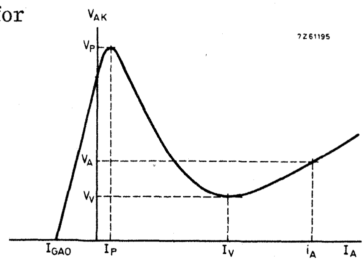
BRY39 with "program" resistors R_1 and R_2



Equivalent test circuit for characteristics testing

Offset voltage $V_{offset} = V_P - V_S \ (I_A = 0)$

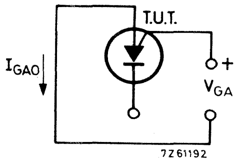
See graph on page 6.



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

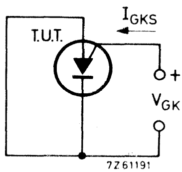
Gate-anode leakage current

$I_K = 0$; $V_{GA} = 70$ V	I_{GAO}	<	10	nA



Gate-cathode leakage current

$V_{AK} = 0$; $V_{GK} = 70$ V	I_{GKS}	<	100	nA



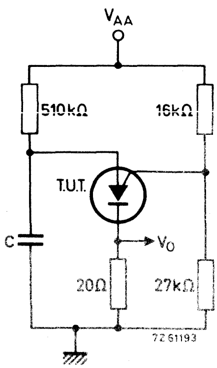
Anode voltage at I_A = 100 mA	V_A	<	1.4	V

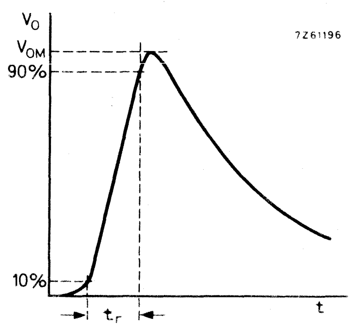
Peak output voltage

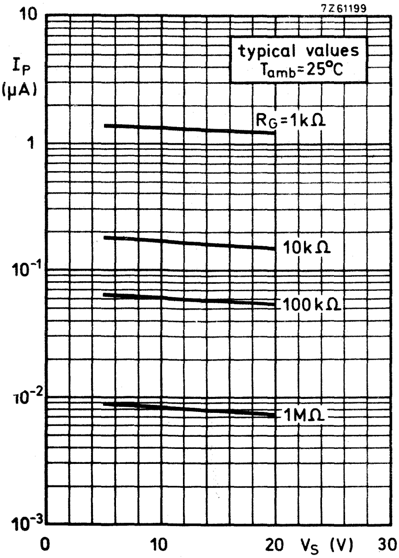
V_{AA} = 20 V; C = 0.2 μF	V_{OM}	>	6	V

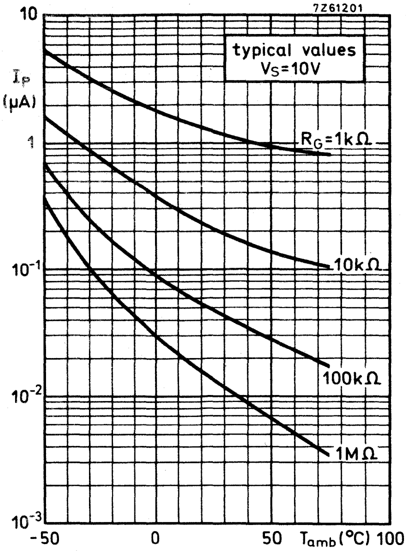
Rise time

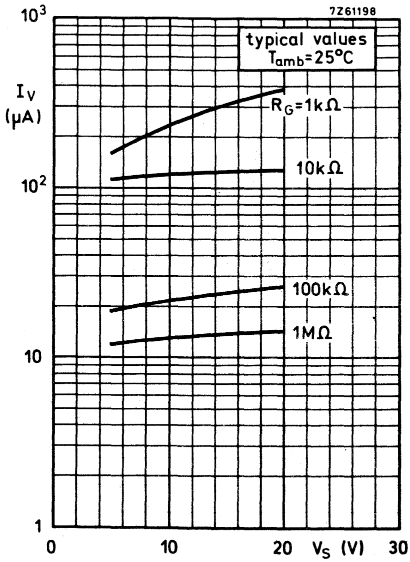
V_{AA} = 20 V; C = 10 nF	t_r	<	80	ns

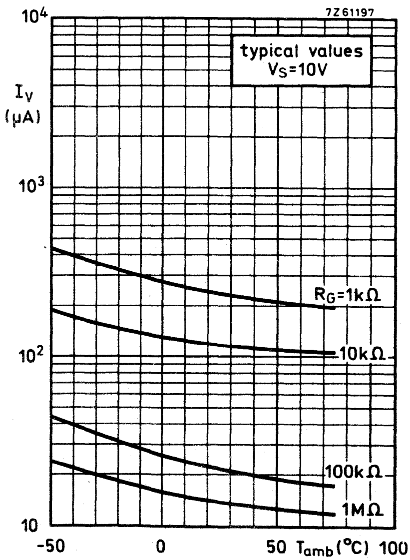


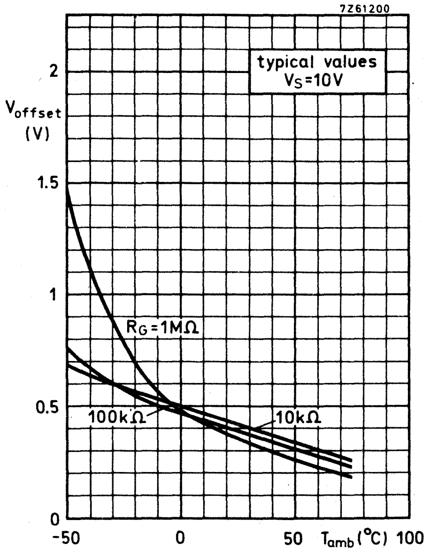


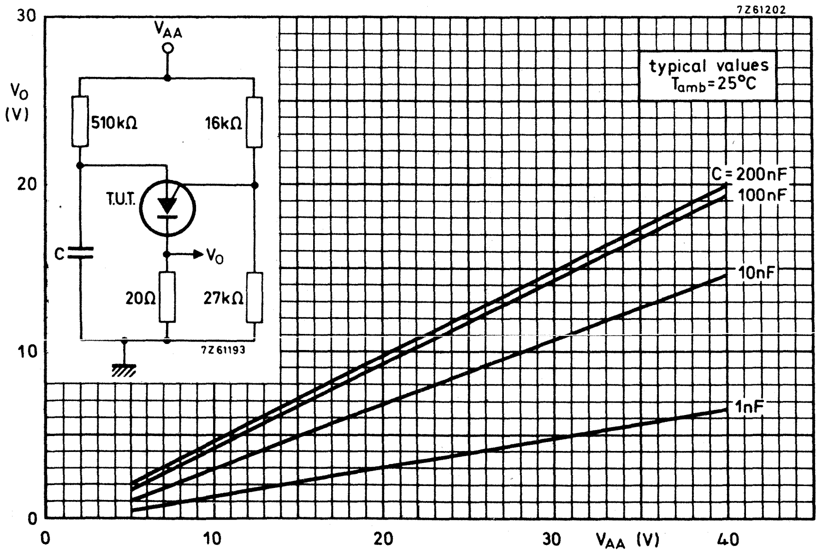

7Z61199
typical values
T_{amb}=25°C
I_P
(μA)
R_G=1kΩ
10kΩ
100kΩ
1MΩ
10
1
10^{-1}
10^{-2}
10^{-3}
0
10
20
V_S (V)
30


7Z61201
typical values
V_S=10V
I_P
(μA)
R_G=1kΩ
10kΩ
100kΩ
1MΩ
10
1
10^{-1}
10^{-2}
10^{-3}
−50
0
50
T_{amb}(°C)
100


7Z61198
typical values
T_{amb}=25°C
I_V
(μA)
R_G=1kΩ
10kΩ
100kΩ
1MΩ
10^3
10^2
10
1
0
10
20
V_S (V)
30


7Z61197
typical values
V_S=10V
I_V
(μA)
R_G=1kΩ
10kΩ
100kΩ
1MΩ
10^4
10^3
10^2
10
−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
30
20
10
0
V_O
(V)
V_{AA}
510kΩ
16kΩ
T.U.T.
C
V_O
20Ω
27kΩ
7Z61193
typical values
T_{amb}=25°C
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

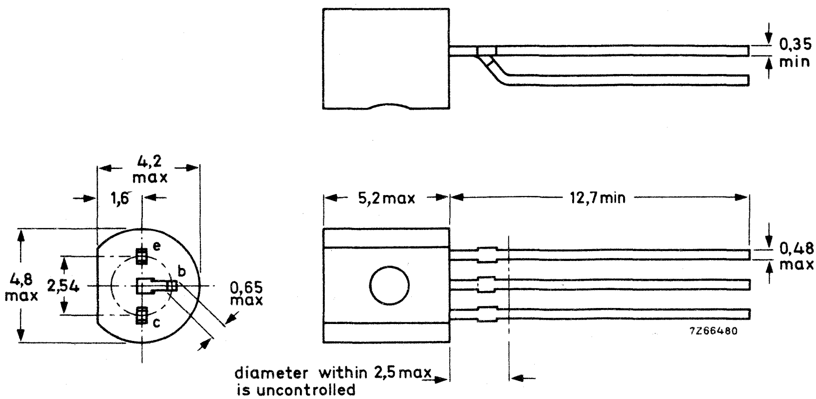
Collector-base voltage (open emitter)	V_{CBO}	max.	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	100	V
Collector current (peak value)	I_{CM}	max.	250	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	mW
Junction temperature	T_j	max.	150	°C
D.C. current gain I_C = 4 mA; V_{CE} = 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

Note
The BSS38 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

TO-92 variant



RATINGS

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

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
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
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500 mW
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

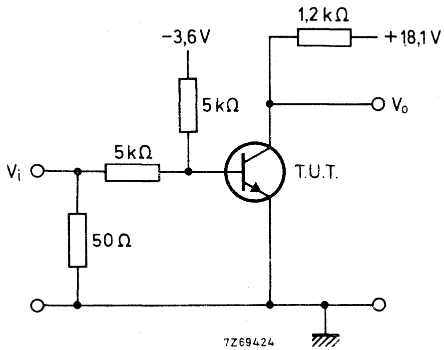
Collector cut-off current			
$I_E = 0$; V_{CB} = 90 V	I_{CBO}	<	200 nA
$I_E = 0$; V_{CB} = 90 V; T_j = 150 °C	I_{CBO}	<	50 μA
$V_{BE} = 0$; V_{CE} = 80 V; T_j = 85 °C	I_{CES}	<	20 μA
Emitter cut-off current			
$I_C = 0$; V_{EB} = 4 V	I_{EBO}	<	200 nA
$I_C = 0$; V_{EB} = 4 V; T_j = 150 °C	I_{EBO}	<	50 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

→ * The BSS38 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.

CHARACTERISTICS (continued)

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

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

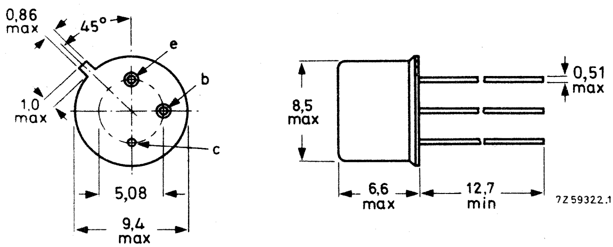
				BSS50	BSS51	BSS52	
Collector-base voltage (open emitter)		V_{CBO}	max.	60	80	100	V
Collector-emitter voltage (see page 5)		V_{CER}	max.	45	60	80	V
Collector current (d.c.)		I_C	max.		1,0		A
Total power dissipation up to T_{amb} = 25 °C		P_{tot}	max.		0,8		W
Total power dissipation up to T_{case} = 25 °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

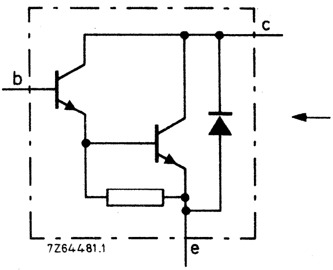
MECHANICAL DATA

Dimensions in mm

Collector connected to case

TO-39





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

Accessories supplied on request: 56218 (package); 56245 (distance disc).

RATINGS

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

			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
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
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
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

→ * Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

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

Collector cut-off current					
$I_E = 0;\ V_{CB} = 45$ 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; $T_j = 200\ ^oC$		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; $T_j = 200\ ^oC$	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; $T_j = 200\ ^oC$	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; $T_j = 200\ ^oC$	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/^oC with increasing temperature.

2) V_{BEsat} decreases by about 2,5 mV/^oC with increasing temperature.

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

Switching times

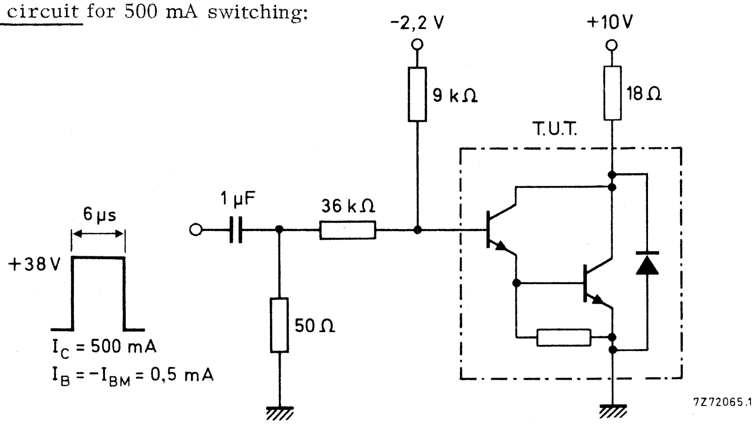
I_C = 0,5 A; I_B = $-I_{BM}$ = 0,5 mA

Turn-on time	t_{on}	<	400	ns
Turn-off time	t_{off}	typ.	1,0	µs
		<	2,0	µs

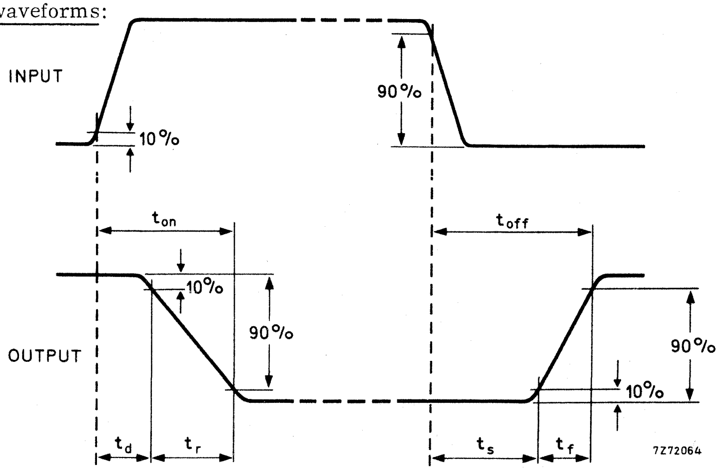
I_C = 1,0 A; I_B = $-I_{BM}$ = 1,0 mA

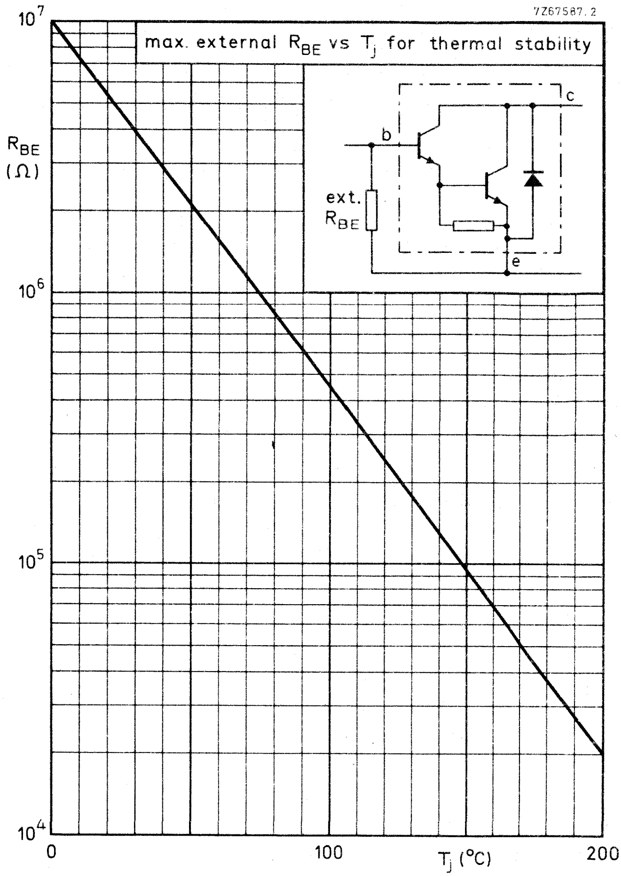
Turn-on time	t_{on}	<	400	ns
Turn-off time	t_{off}	typ.	1,0	µs
		<	2,0	µs

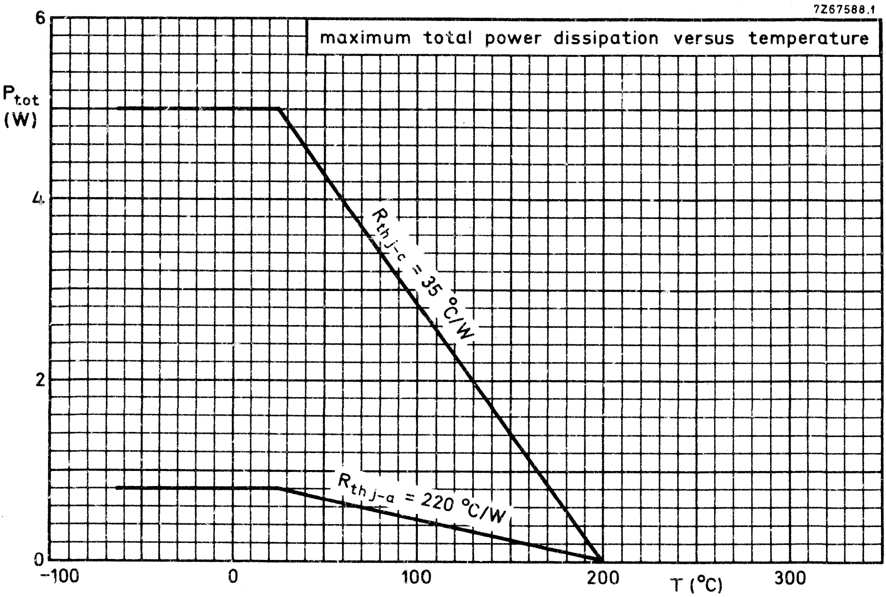
Test circuit for 500 mA switching:

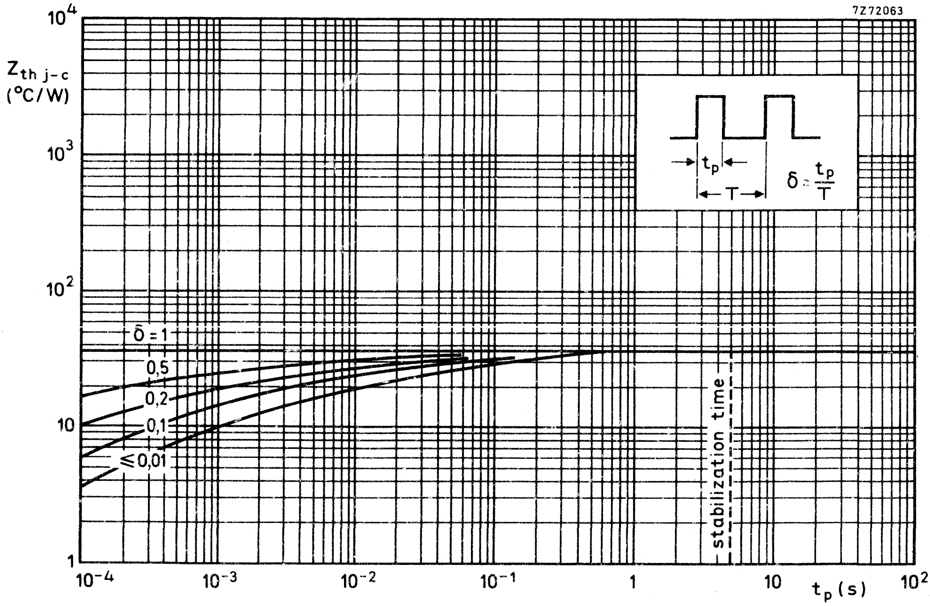


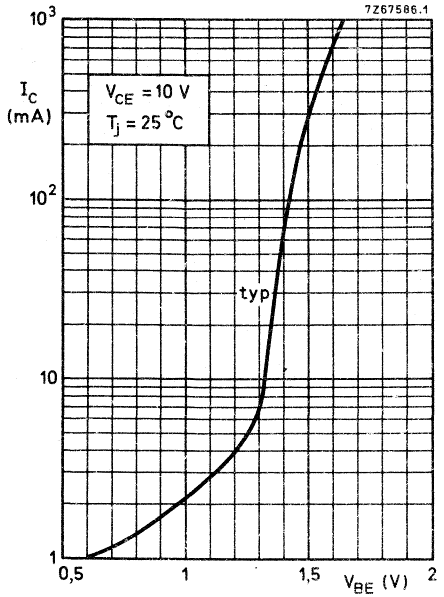
Switching waveforms:

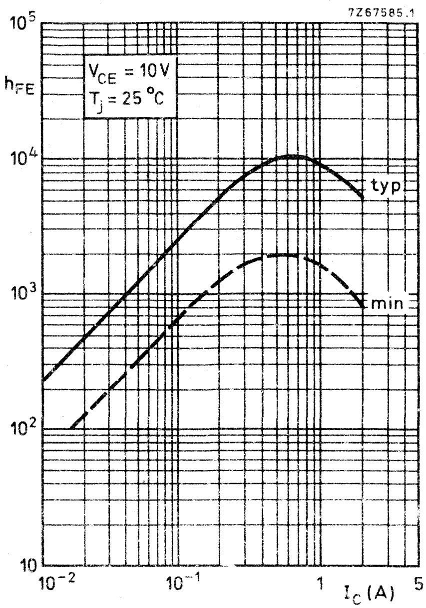


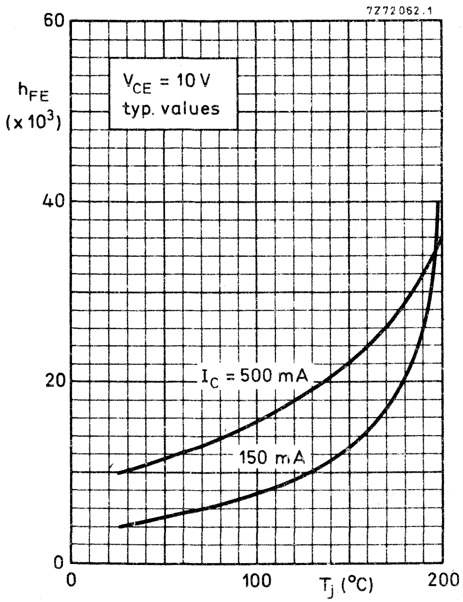

7Z67587.2
max. external R_{BE} vs T_j for thermal stability
R_{BE} (Ω)
10^7
10^6
10^5
10^4
0
100
200
T_j (°C)
c
b
ext. R_{BE}
e

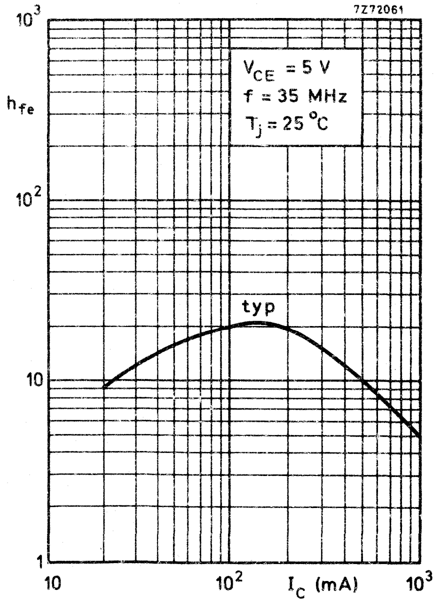

7Z67588.1
maximum total power dissipation versus temperature
P tot (W)
6
4
2
0
−100
0
100
200
300
T (°C)
R th j-c = 35 °C/W
R th j-a = 220 °C/W

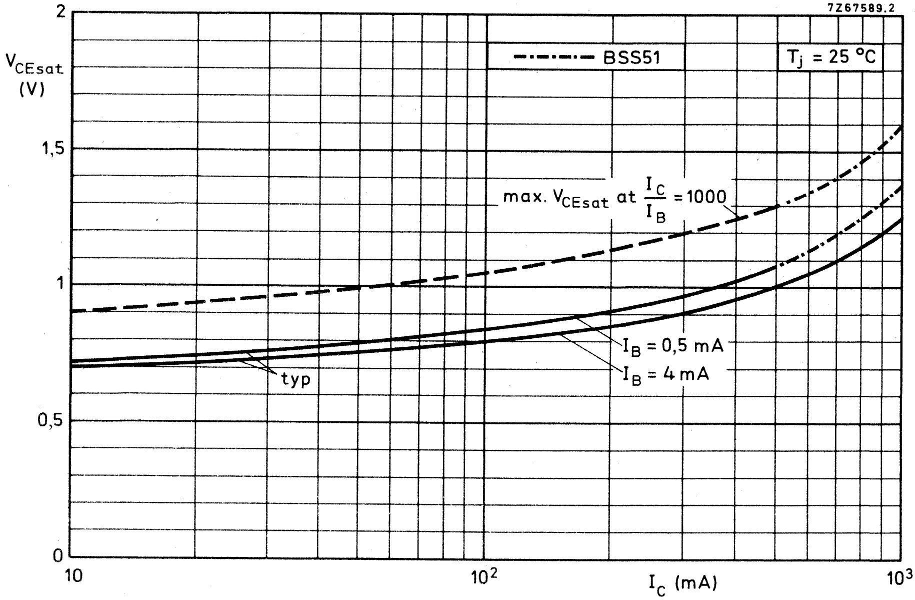

7Z72063
Z th j-c (°C/W)
10^4
10^3
10^2
10
1
δ = 1
0,5
0,2
0,1
⩽0,01
t p
T
δ = t p / T
stabilization time
10^-4
10^-3
10^-2
10^-1
1
10
10^2
t p (s)

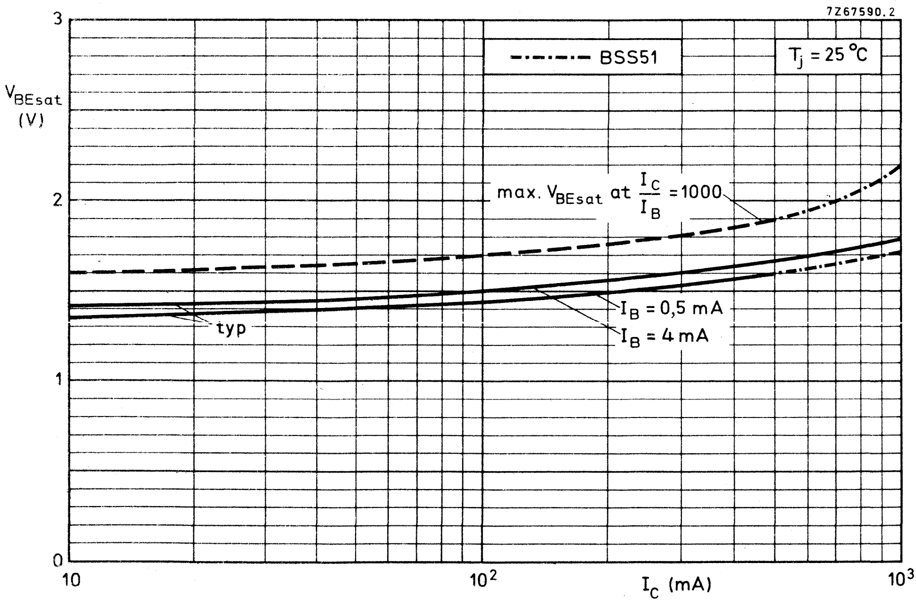

7Z67586.1
I_C (mA)
V_{CE} = 10 V
T_j = 25 °C
typ
V_{BE} (V)
10^3
10^2
10
1
0,5
1
1,5
2


7Z67585.1
h_{FE}
V_{CE} = 10 V
T_j = 25 °C
typ
min
I_C (A)
10^5
10^4
10^3
10^2
10
10^{-2}
10^{-1}
1
5


7Z72062.1
h_{FE} (x 10^3)
V_{CE} = 10 V
typ. values
I_C = 500 mA
150 mA
T_j (°C)
60
40
20
0
0
100
200


7Z72061
h_{fe}
V_{CE} = 5 V
f = 35 MHz
T_j = 25 °C
typ
I_C (mA)
10^3
10^2
10
1
10
10^2
10^3


7Z67589.2
BSS51
T_j = 25 °C
V_{CEsat} (V)
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
BSS51
T_j = 25 °C
V_{BEsat} (V)
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

P-N-P DARLINGTON TRANSISTORS

Silicon planar transistors in TO-39 metal envelopes with the collector connected to the case, intended for industrial switching applications e.g. print hammer, solenoid, relay and lamp driving.

QUICK REFERENCE DATA

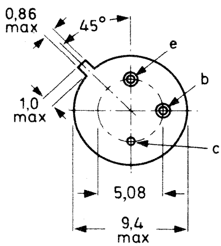
				BSS60	BSS61	
Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60	80	V
Collector-emitter voltage (see page 5)		$-V_{CER}$	max.	45	60	V
Collector current (d.c.)		$-I_C$	max.	1,0		A
Total power dissipation						
up to T_{amb} = 25 °C		P_{tot}	max.	0,8		W
up to T_{case} = 25 °C		P_{tot}	max.	5,0		W
D.C. current gain						
$-I_C$ = 500 mA; $-V_{CE}$ = 10 V		h_{FE}	>	2000		
Collector-emitter saturation voltage						
$-I_C$ = 1,0 A; $-I_B$ = 1,0 mA	**BSS61**	$-V_{CEsat}$	<	1,6		V
$-I_C$ = 1,0 A; $-I_B$ = 4,0 mA	**BSS60**	$-V_{CEsat}$	<	1,6		V
Turn-off time when switched from $-I_{Con}$ = 500 mA; $-I_{Bon}$ = 0,5 mA to cut-off with I_{Boff} = 0,5 mA		t_{off}	<	1,5		µs

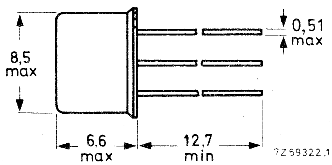
MECHANICAL DATA

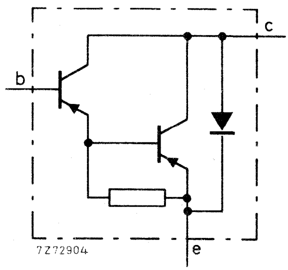
Dimensions in mm

Collector connected to case

TO-39







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

Accessories supplied on request: 56218 (package); 56245 (distance disc).

RATINGS

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

			BSS60	BSS61	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	V
Collector-emitter voltage (see page 5)	$-V_{CER}$	max.	45	60	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	V
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
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
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

→ * Based on maximum average junction temperature in line with common industrial practice. The resulting higher junction temperature of the output transistor part is taken into account.

CHARACTERISTICS $T_j = 25\ ^oC$

Collector cut-off current					
$I_E = 0;\ -V_{CB} = 45\ V$	BSS60	$-I_{CBO}$	<	50	nA
$I_E = 0;\ -V_{CB} = 60\ V$	BSS61	$-I_{CBO}$	<	50	nA
Emitter cut-off current					
$I_C = 0;\ -V_{EB} = 4\ V$		$-I_{EBO}$	<	50	nA
Saturation voltages					
$-I_C = 0,5\ A;\ -I_B = 0,5\ mA$		$-V_{CEsat}$	<	1,3	V
		$-V_{BE\ sat}$	<	1,9	V
$-I_C = 1,0\ A;\ -I_B = 4,0\ mA$	BSS60	$-V_{CEsat}$	<	1,6	V
		$-V_{BE\ sat}$	<	2,2	V
$-I_C = 1,0\ A;\ -I_B = 1,0\ mA$	BSS61	$-V_{CEsat}$	<	1,6	V
		$-V_{BE\ sat}$	<	2,2	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					
$-I_C = 500\ mA;\ -V_{CE} = 5\ V$		h_{fe}	typ.	30	

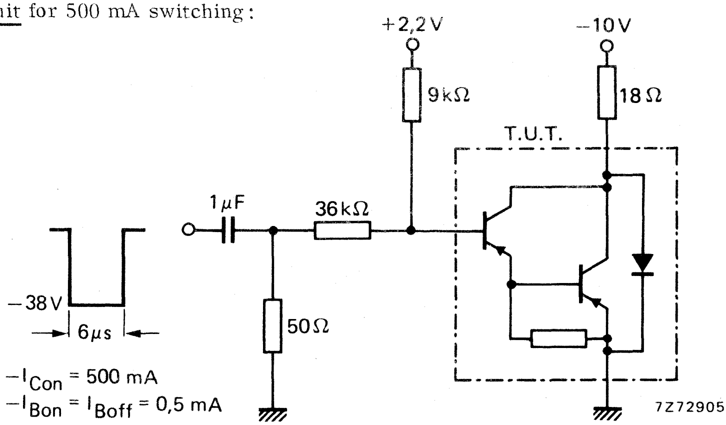
CHARACTERISTICS (continued) T_j = 25 °C

Switching times

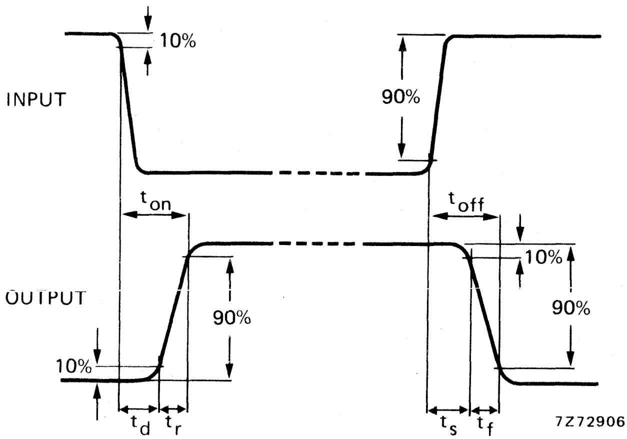
$-I_{Con}$ = 500 mA; $-I_{Bon}$ = I_{Boff} = 0,5 mA

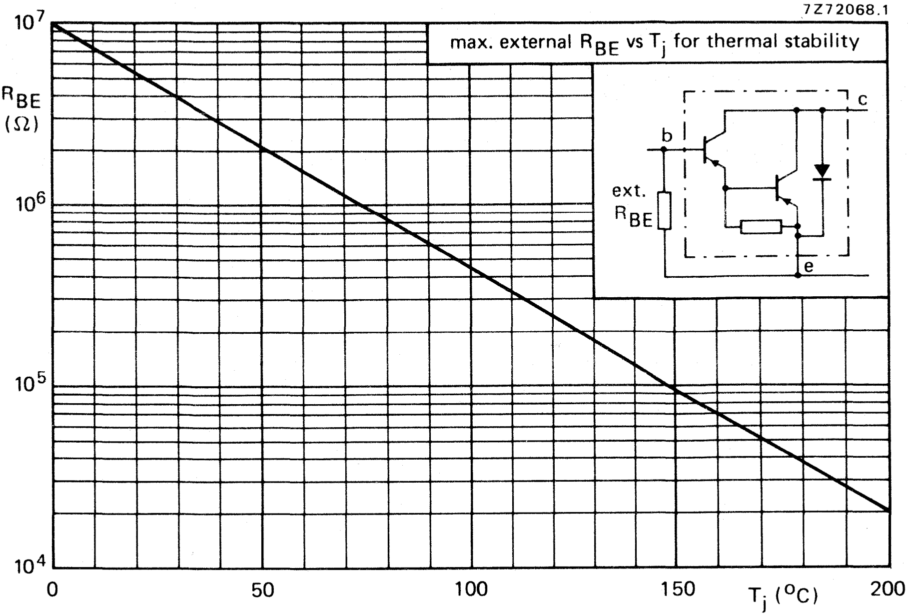
Turn-on time	t_{on}	<	1,0	µs
Turn-off time	t_{off}	<	1,5	µs

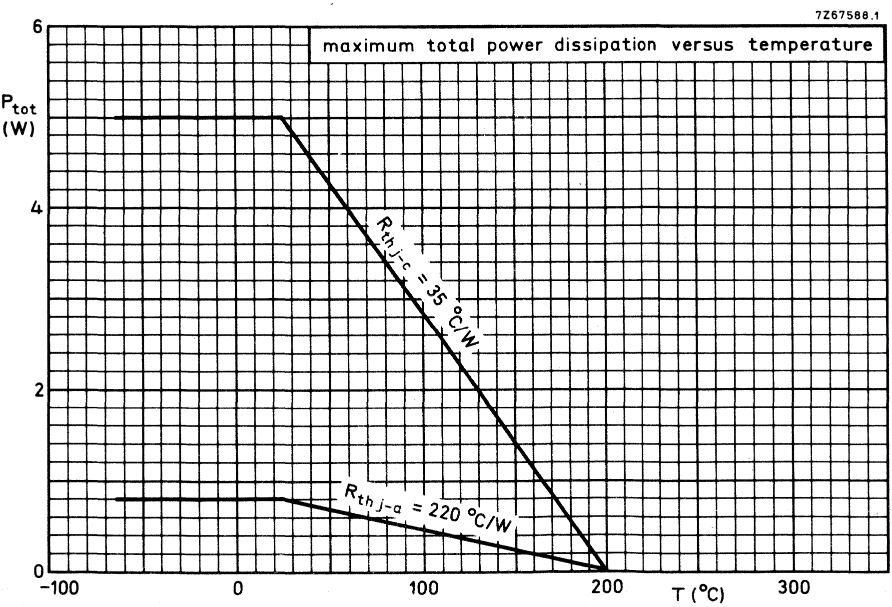
Test circuit for 500 mA switching:

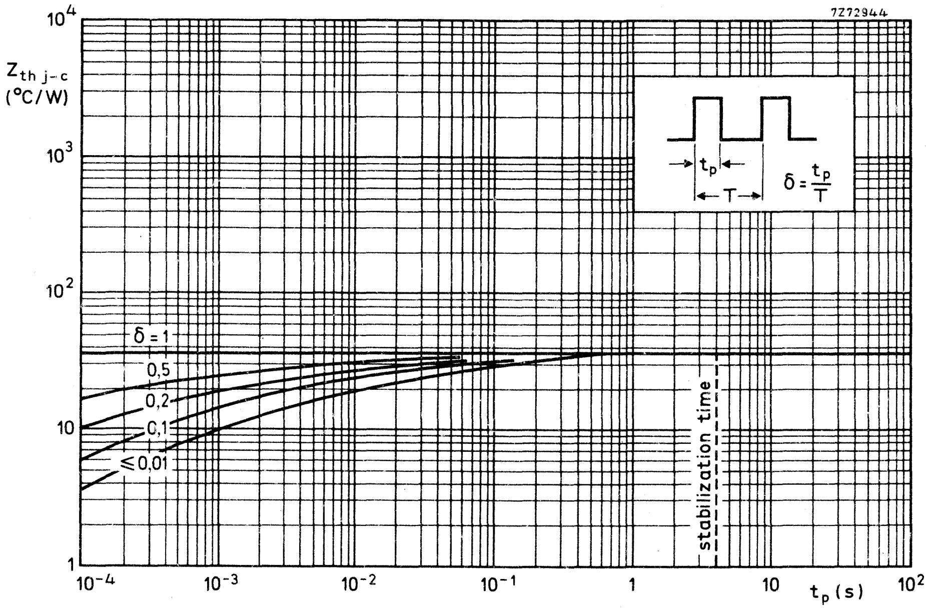


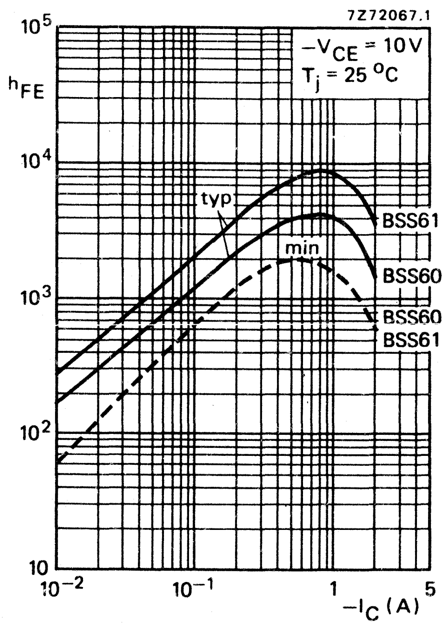
Switching waveforms:




7Z72068.1
max. external R_{BE} vs T_j for thermal stability
R_{BE} (Ω)
10^7
10^6
10^5
10^4
0
50
100
150
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
−100
0
100
200
300
T (°C)
$R_{th\,j-c}$ = 35 °C/W
$R_{th\,j-a}$ = 220 °C/W


7Z72944
$Z_{th\ j-c}$
(°C/W)
10^4
10^3
10^2
10
1
δ = 1
0,5
0,2
0,1
≤ 0,01
t_p
T
$\delta = \frac{t_p}{T}$
stabilization time
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (s)


7Z72067.1
h_{FE}
$-V_{CE}$ = 10 V
T_j = 25 °C
10^5
10^4
10^3
10^2
10
typ
min
BSS61
BSS60
BSS60
BSS61
10^{-2}
10^{-1}
1
5
$-I_C$ (A)

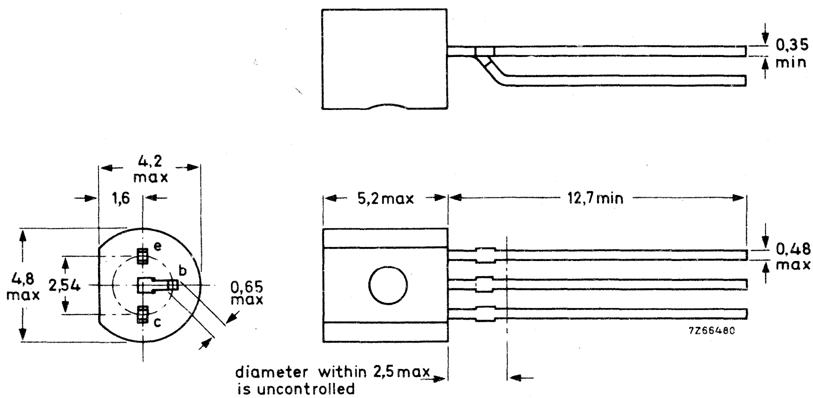
HIGH-VOLTAGE P-N-P TRANSISTOR

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 (IEC 134)

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	$R_{th\ j\text{-}a}$	=	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

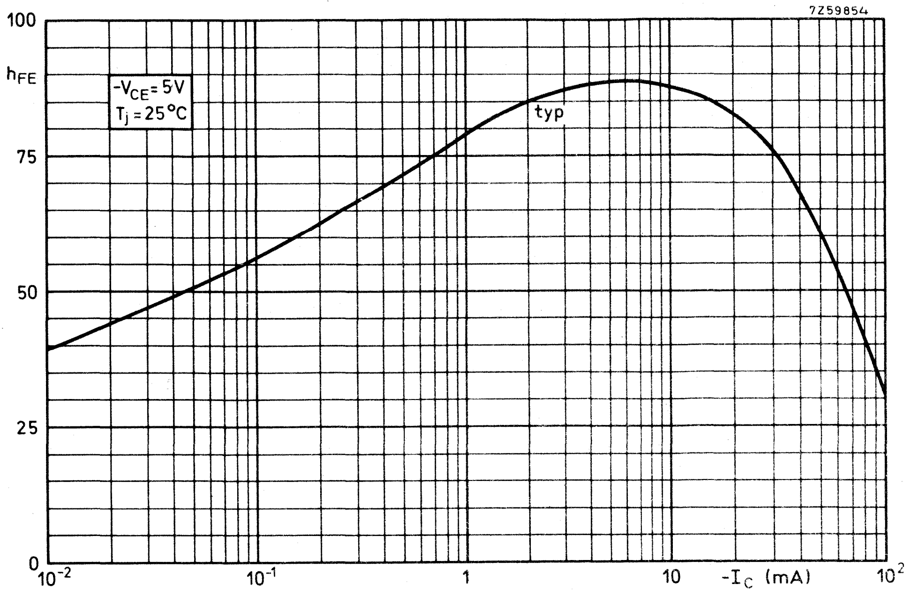
$-I_C$ = 10 mA; $-V_{CE}$ = 5 V	h_{FE}	>	30	
$-I_C$ = 25 mA; $-V_{CE}$ = 5 V	h_{FE}	>	30	

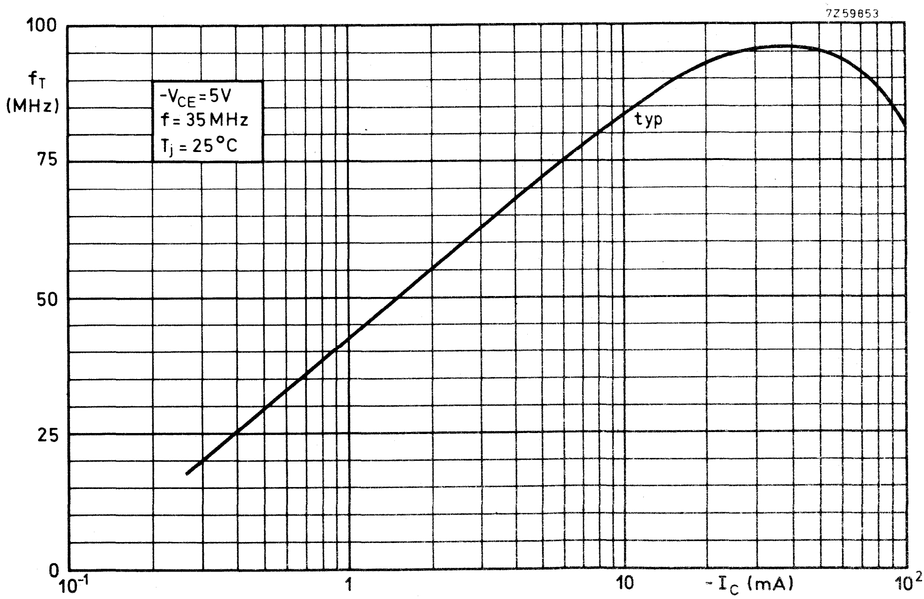
Collector capacitance at f = 1 MHz

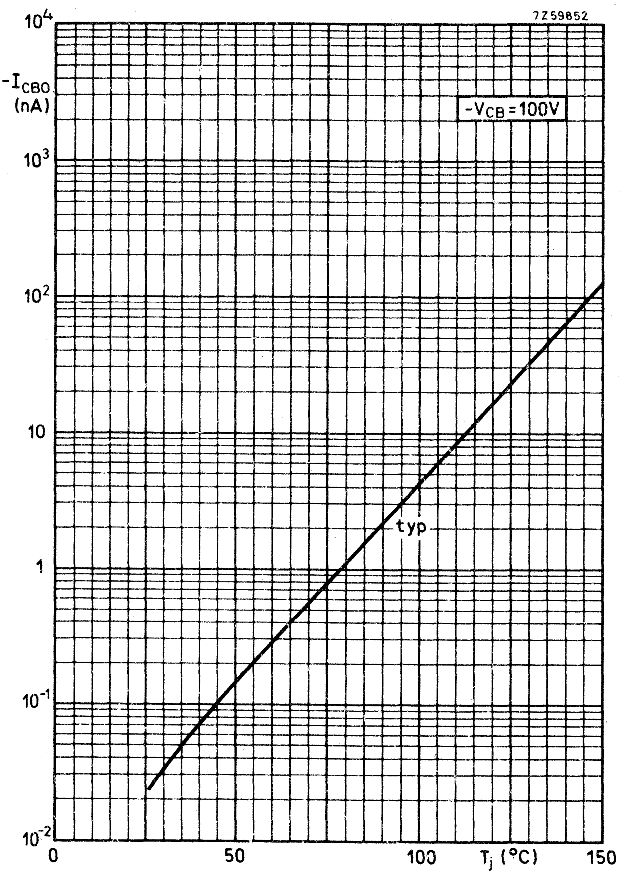
$I_E = I_e$ = 0; $-V_{CB}$ = 10 V	C_c	<	5	pF

Transition frequency at f = 35 MHz

$-I_C$ = 25 mA; $-V_{CE}$ = 5 V	f_T	>	50	MHz


7Z59854
100
h_{FE}
$-V_{CE} = 5V$
$T_j = 25°C$
typ
75
50
25
0
10^{-2}
10^{-1}
1
10
$-I_C$ (mA)
10^2


7Z59853
100
f_T
(MHz)
$-V_{CE} = 5V$
f = 35 MHz
$T_j = 25°C$
typ
75
50
25
0
10^{-1}
1
10
$-I_C$ (mA)
10^2


7Z59852
10^4
$-I_{CBO}$ (nA)
$-V_{CB} = 100V$
10^3
10^2
10
typ
1
10^{-1}
10^{-2}
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

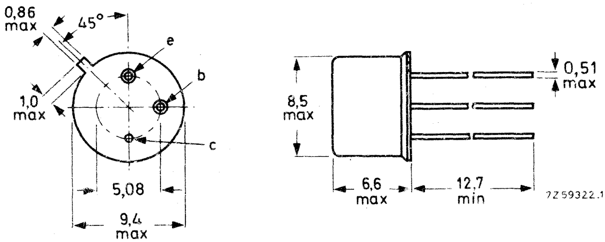
		BSV15–6 BSV16–6 BSV17–6	BSV15–10 BSV16–10 BSV17–10	BSV15–16 BSV16–16
D.C. current gain $-I_C$ = 100 mA; $-V_{CE}$ = 1 V	h_{FE}	40–100	63–160	100–250

MECHANICAL DATA

Dimensions in mm

Collector connected to case

TO-39



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

Accessories supplied on request: 56218 (package); 56245 (distance disc).

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

Parameter / conditions	Symbol		BSV15	BSV16	BSV17	Unit
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; δ = 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) T_{amb} = 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

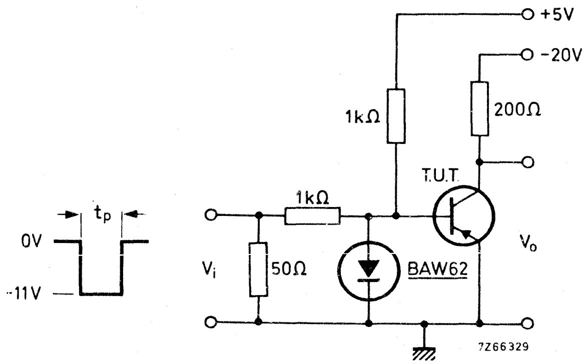
$-I_C$ = 1 mA; $-V_{CE}$ = 5 V

Small signal current gain	h_{fe}	>	20	

Switching times

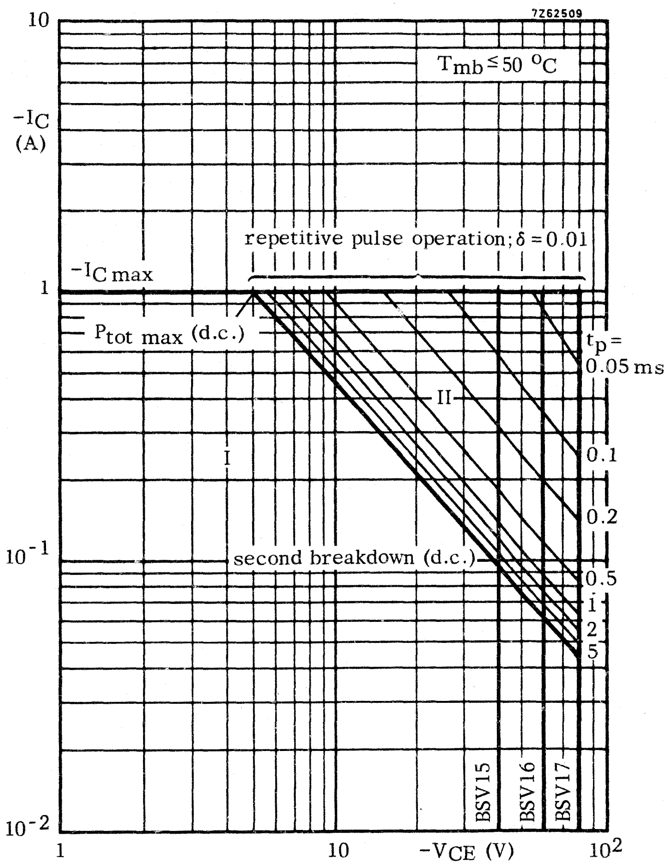
Turn-on time				
$-I_C$ = 100 mA; $-I_B$ = $+I_{BM}$ = 5 mA	t_{on}	<	500	ns
Turn-off time				
$-I_C$ = 100 mA; $-I_B$ = $+I_{BM}$ = 5 mA				
Storage time	t_s	<	500	ns
Fall time	t_f	<	150	ns

Test circuit:



Pulse generator:
Pulse duration $t_p \geq 10\ \mu s$
Rise time $t_r \leq 15$ ns
Fall time $t_f \leq 15$ ns
Source impedance R_S = 50 Ω

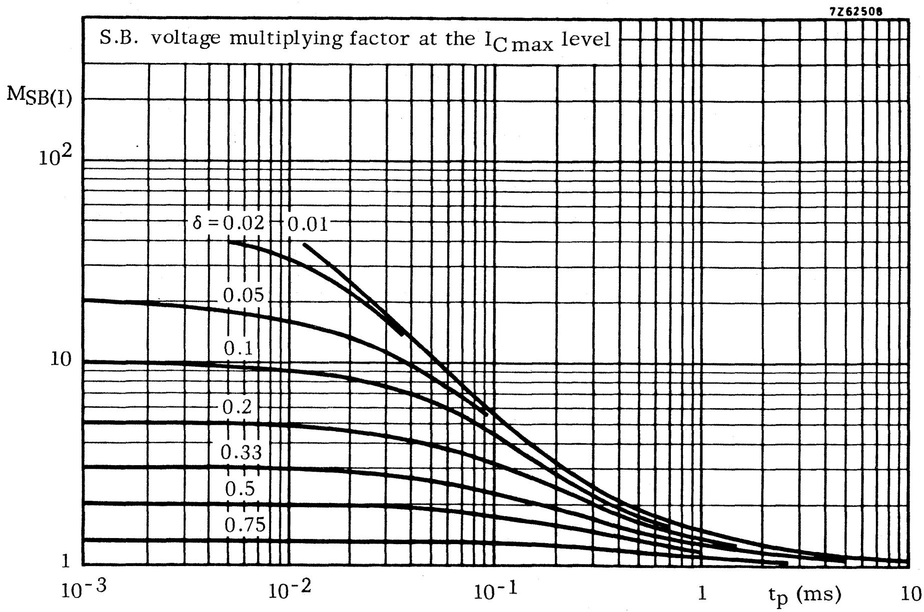
Oscilloscope:
Rise time ≤ 15 ns
Input impedance ≥ 100 kΩ

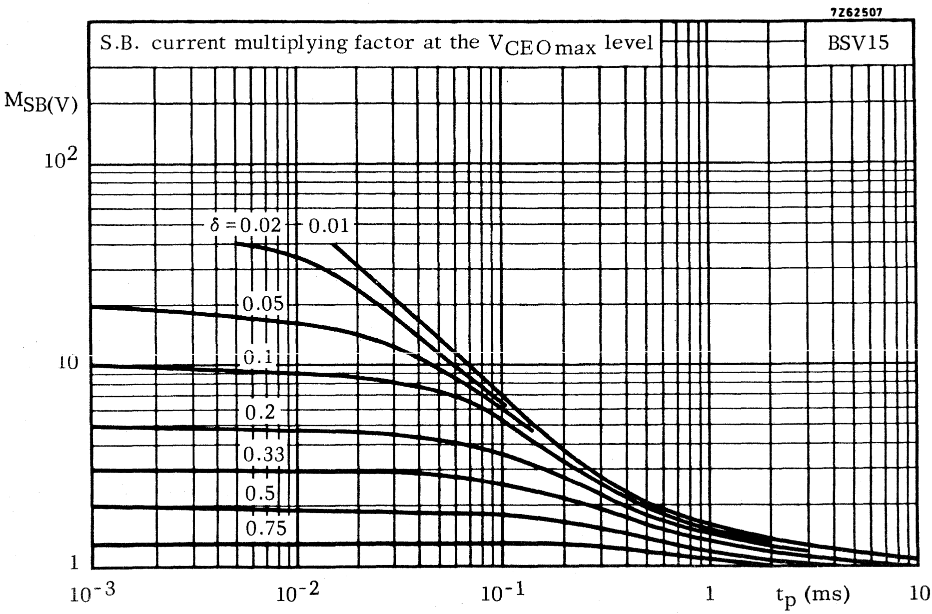


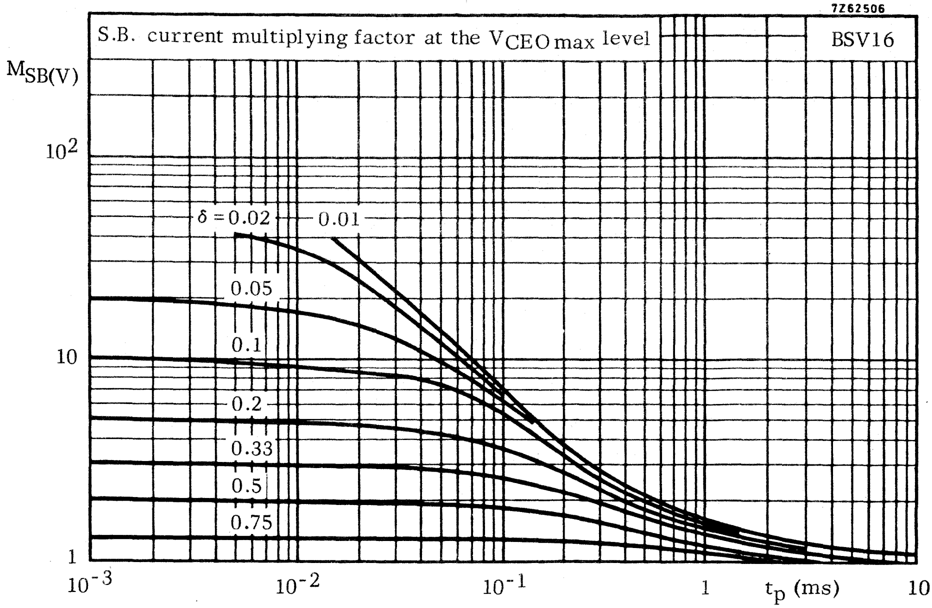
Safe Operating Area with the transistor forward biased

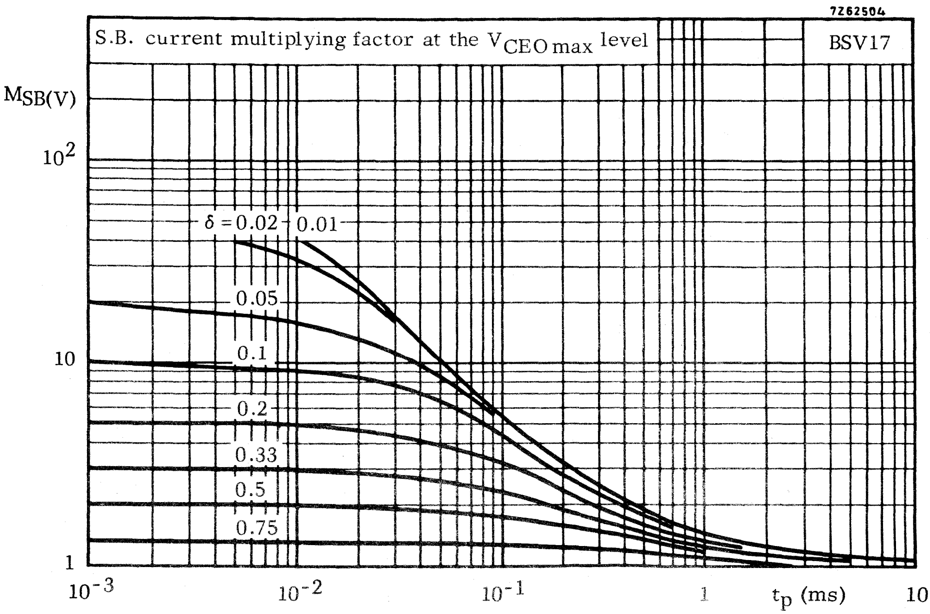
I Region of permissible d.c. operation

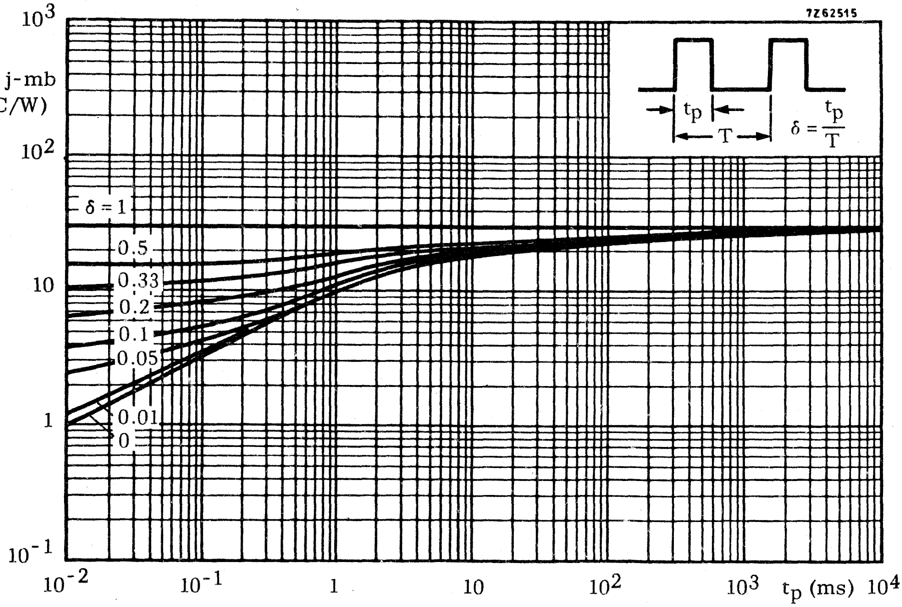
II Permissible extension for repetitive pulse operation

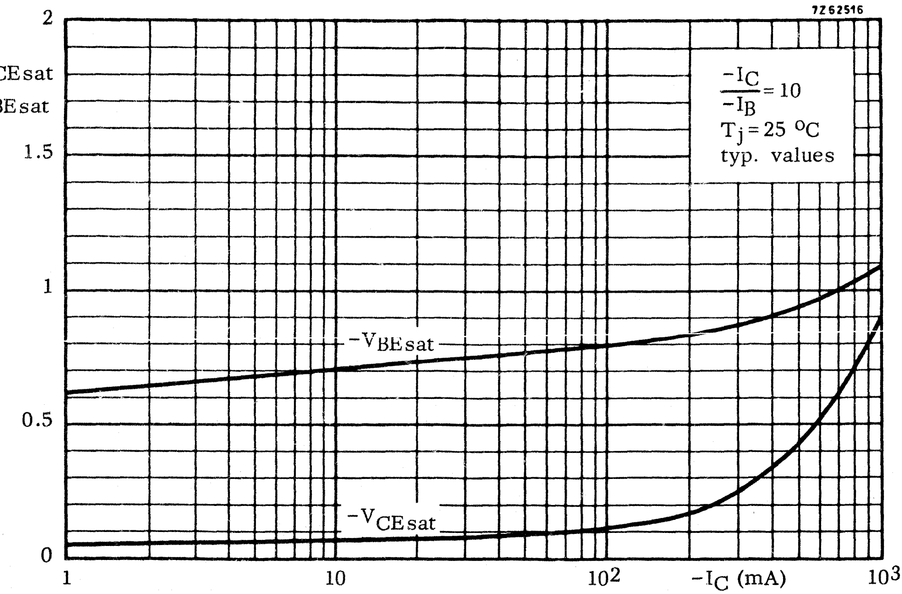

7Z62508
S.B. voltage multiplying factor at the $I_{C max}$ level
$M_{SB(I)}$
10^2
10
1
δ = 0.02
0.01
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

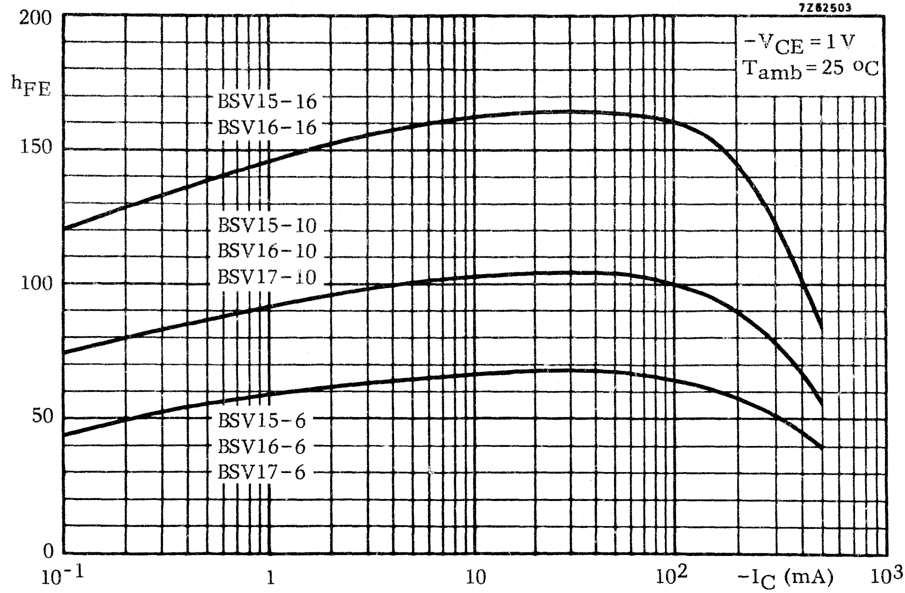

7Z62507
S.B. current multiplying factor at the $V_{CEO max}$ level
BSV15
$M_{SB(V)}$
10^2
10
1
δ = 0.02
0.01
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

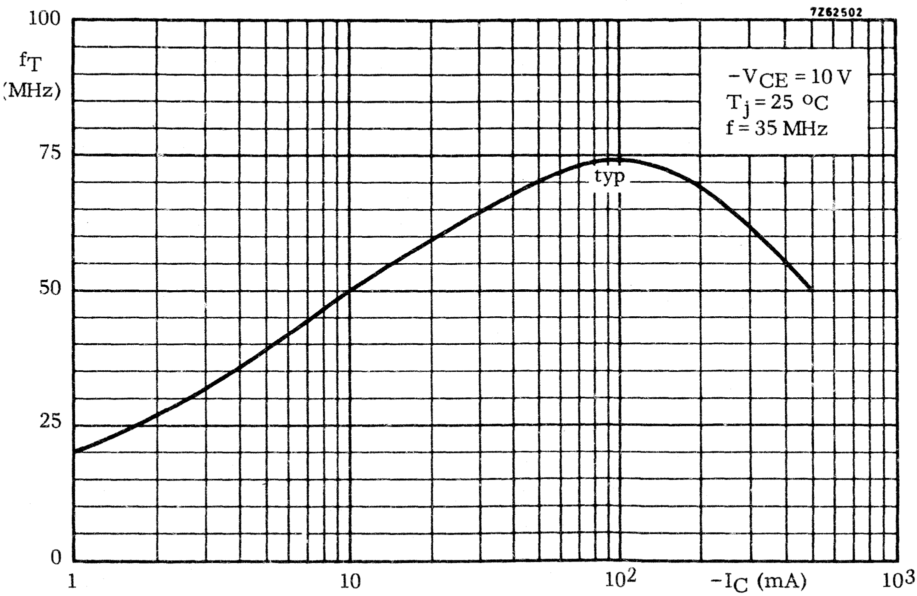

7Z62506
S.B. current multiplying factor at the $V_{CEO\,max}$ level
BSV16
$M_{SB(V)}$
10^2
10
1
δ = 0.02
0.01
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

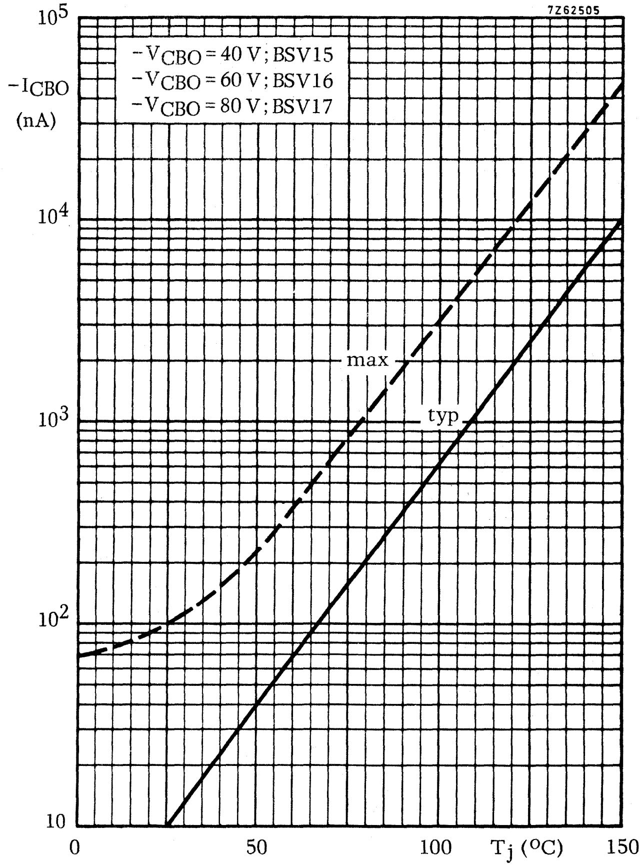

7Z62504
S.B. current multiplying factor at the $V_{CEO\,max}$ level
BSV17
$M_{SB(V)}$
10^2
10
1
δ = 0.02
0.01
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10


7Z62515
$Z_{th\ j\text{-}mb}$ (°C/W)
10^3
10^2
10
1
10^{-1}
$\delta = 1$
0.5
0.33
0.2
0.1
0.05
0.01
0
t_p
T
$\delta = \frac{t_p}{T}$
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (ms)
10^4


7Z62516
$-V_{CEsat}$
$-V_{BEsat}$
2
1.5
1
0.5
0
$\frac{-I_C}{-I_B} = 10$
$T_j = 25$ °C
typ. values
$-V_{BEsat}$
$-V_{CEsat}$
1
10
10^2
$-I_C$ (mA)
10^3


7Z62503
200
h_{FE}
150
100
50
0
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
f_T
(MHz)
75
50
25
0
typ
$-V_{CE}$ = 10 V
T_j = 25 °C
f = 35 MHz
1
10
10^2
$-I_C$ (mA)
10^3


7Z62505
$-V_{CBO}$ = 40 V; BSV15
$-V_{CBO}$ = 60 V; BSV16
$-V_{CBO}$ = 80 V; BSV17
$-I_{CBO}$ (nA)
10^5
10^4
10^3
10^2
10
max
typ
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

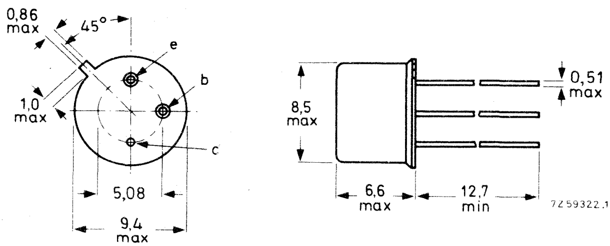
Collector-base voltage (open emitter)	V_{CBO}	max.	100	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	V
Collector current (peak value)	I_{CM}	max.	5,0	A
Total power dissipation up to T_{case} = 50 °C	P_{tot}	max.	5,0	W
Junction temperature	T_j	max.	175	°C
D.C. current gain I_C = 2 A; V_{CE} = 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



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

Accessories supplied on request: 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.	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 °C	P_{tot}	max.	5,0	W

Temperatures

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

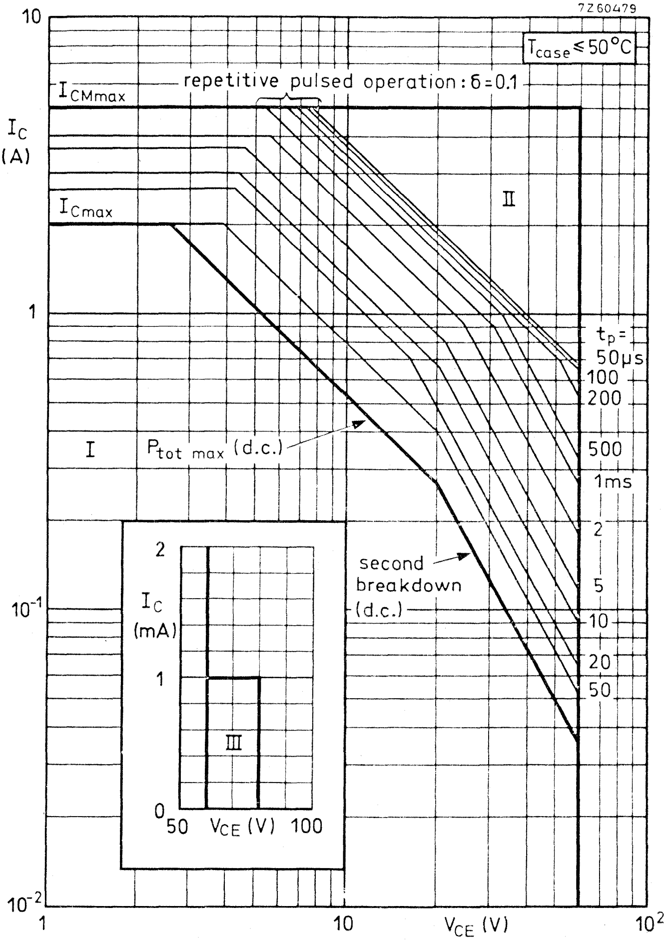
THERMAL RESISTANCE

From junction to case	$R_{th\ j-c}$	=	25	°C/W

CHARACTERISTICS

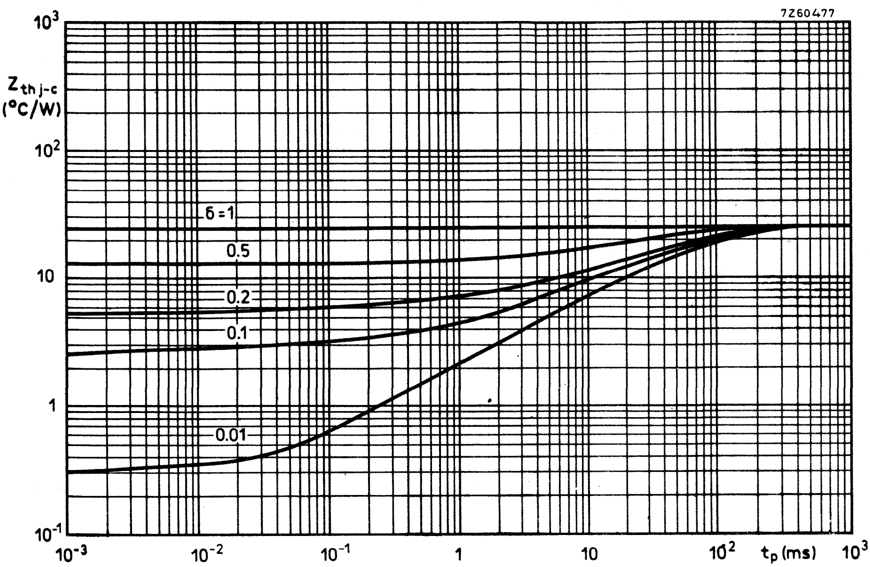
T_j = 25 °C unless otherwise specified

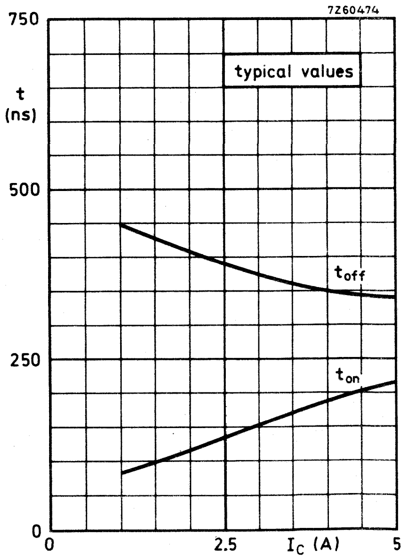
Collector cut-off current				
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	<	10	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 4$ V	I_{EBO}	<	10	μA
Saturation voltages				
$I_C = 5$ A; $I_B = 0.5$ A	V_{CEsat}	<	1.0	V
	V_{BEsat}	<	1.8	V
D.C. current gain				
$I_C = 2$ A; $V_{CE} = 2$ V	h_{FE}	>	40	
Collector 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

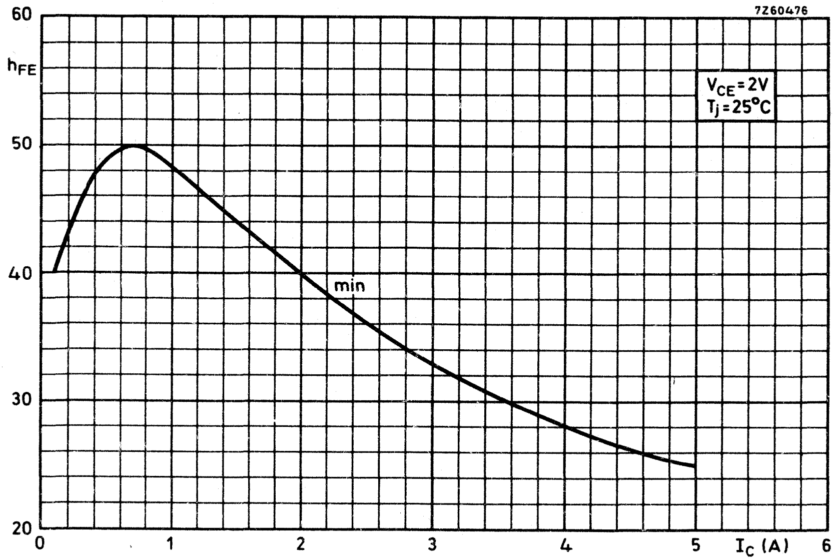


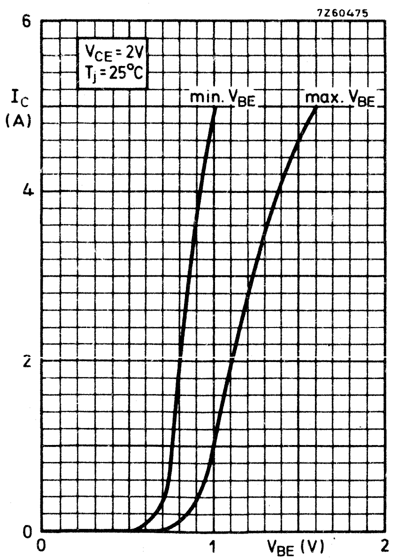
Safe Operating Area

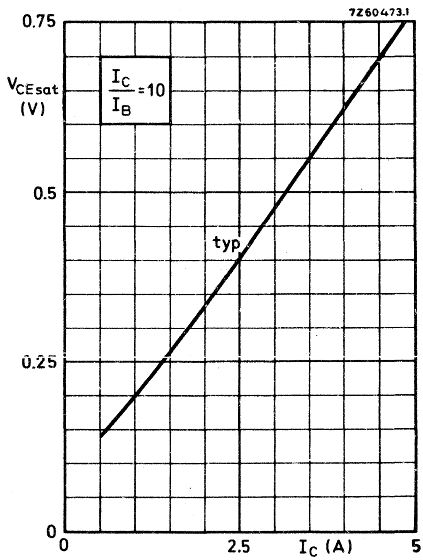
I Region of permissible d.c. operation
II Permissible extension for repetitive pulsed operation
III D.C. operation in this region is allowable, provided $R_{BE} \leq 50\ \Omega$


7Z60477
$Z_{th\,j\text{-}c}$ (°C/W)
10^3
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
typical values
t (ns)
750
500
250
0
t_{off}
t_{on}
0
2.5
I_C (A)
5


7Z60476
60
h_{FE}
50
40
30
20
0
1
2
3
4
5
I_C (A)
6
V_{CE} = 2V
T_j = 25°C
min


7Z60475
6
I_C
(A)
4
2
0
0
1
V_{BE} (V)
2
V_{CE} = 2V
T_j = 25°C
min. V_{BE}
max. V_{BE}


7Z60473.1
0.75
V_{CEsat}
(V)
0.5
0.25
0
0
2.5
I_C (A)
5
$\frac{I_C}{I_B}$ = 10
typ

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a TO-18 metal envelope intended for core driver applications in small memories.

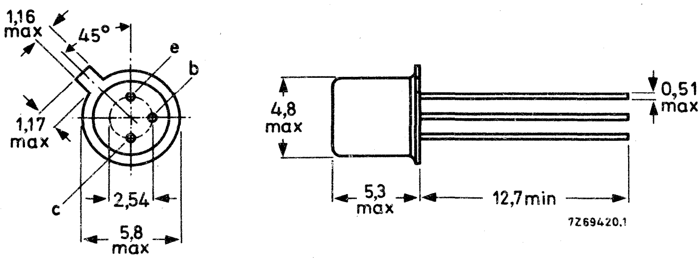
QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Collector current (peak value)	I_{CM}	max.	500	mA
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	1,0	W
Junction temperature	T_j	max.	200	°C
D.C. current 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	>	150	MHz
Turn-off time when switched from I_{Con} = 500 mA; I_{Bon} = 50 mA to cut-off with $-I_{Boff}$ = 50 mA	t_{off}	<	60	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 (IEC 134)

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	$R_{th\ j-a}$	=	0,50	$^oC/mW$
From junction to case	$R_{th\ j-c}$	=	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 voltage				
$I_C = 30$ 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
	$V_{BE\ sat}$	<	1,3	V
$I_C = 500$ mA; $I_B = 35$ mA	V_{CEsat}	<	0,7	V
$I_C = 500$ mA; $I_B = 50$ mA	$V_{BE\ sat}$	<	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	>	150	MHz
Turn-on time when switched to				
a) $I_{Con} = 150$ mA; $I_{Bon} = 15$ mA (Fig. 1 on page 4)	t_{on}	<	60	ns
b) $I_{Con} = 300$ mA; $I_{Bon} = 40$ mA (Fig. 1 on page 4)	t_{on}	<	50	ns
Turn-off time when switched from				
c) $I_{Con} = 150$ mA; $I_{Bon} = 15$ mA to cut-off with $-I_{Boff} = 15$ mA (Fig. 2 on page 4)	t_{off}	<	70	ns
d) $I_{Con} = 300$ mA; $I_{Bon} = 40$ mA to cut-off with $-I_{Boff} = 20$ mA (Fig. 1 on page 4)	t_{off}	<	110	ns
e) $I_{Con} = 400$ mA; $I_{Bon} = 50$ mA to cut-off with $-I_{Boff} = 1$ mA (Fig. 1 on page 4)	t_{off}	<	300	ns
f) $I_{Con} = 500$ mA; $I_{Bon} = 50$ mA to cut-off with $-I_{Boff} = 50$ mA (Fig. 3 on page 4)	t_{off}	<	60	ns

CHARACTERISTICS (continued) $T_j = 25\ ^oC$

	I_{Con} (mA)	I_{Bon} (mA)	I_{Boff} (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:

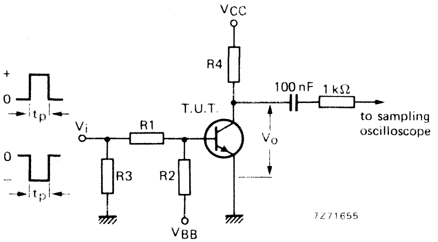


Fig. 1

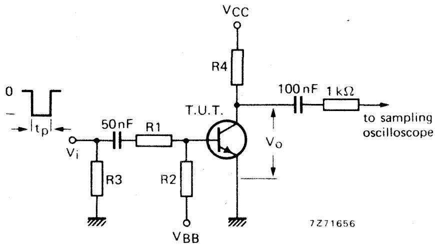


Fig. 2

Pulse generator:

Rise time	t_r	≤ 2 ns
Pulse duration	t_p	= 200 ns
Fall time	t_f	≤ 2 ns
Output resistance	R_o	= 50 Ω

Oscilloscope:

Input resistance $R_i = 50\ \Omega$

Equivalent test circuit:

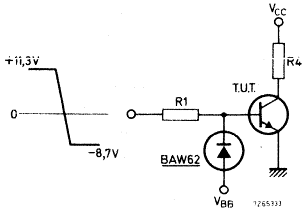
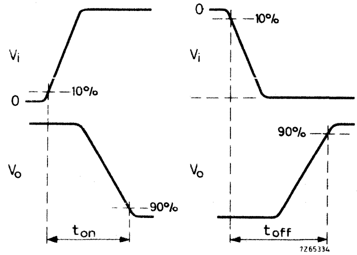


Fig. 3



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

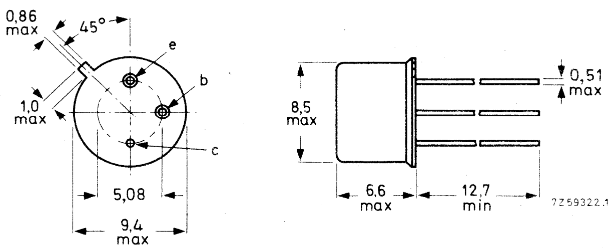
Collector current (peak value)	I_{CM}	max.	2	A
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	5,0	W
Junction temperature	T_j	max.	200	°C
Transition frequency at f = 35 MHz I_C = 100 mA; V_{CE} = 20 V	f_T	typ.	80	MHz
D.C. current gain I_C = 10 mA; V_{CE} = 5 V	h_{FE}	>	30	
I_C = 500 mA; V_{CE} = 5 V	h_{FE}	>	30	

MECHANICAL DATA

Dimensions in mm

Collector connected to case

TO-39



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

Accessories supplied on request: 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

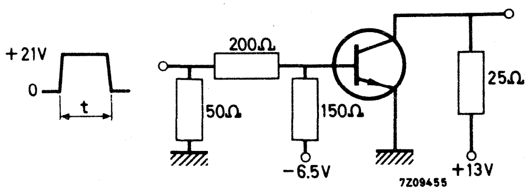
$I_C = 0$; $V_{EB} = 6$ V	I_{EBO}	<	100	μA
$I_C = 0$; $V_{EB} = 3$ V	I_{EBO}	<	100	nA

[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:



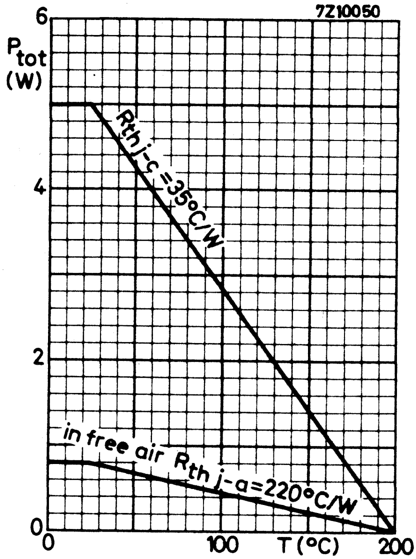
Pulse generator:

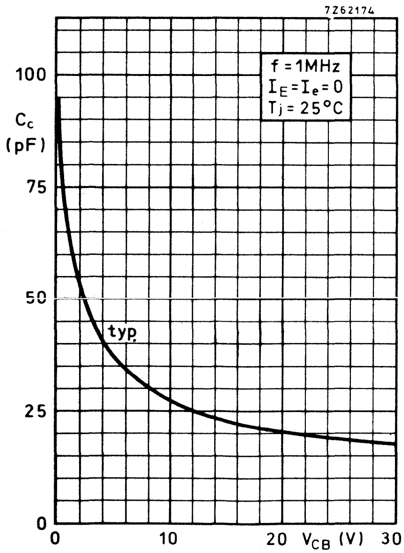
Pulse duration	t	> 5 μs
Rise time	t_r	< 10 ns
Fall time	t_f	< 10 ns

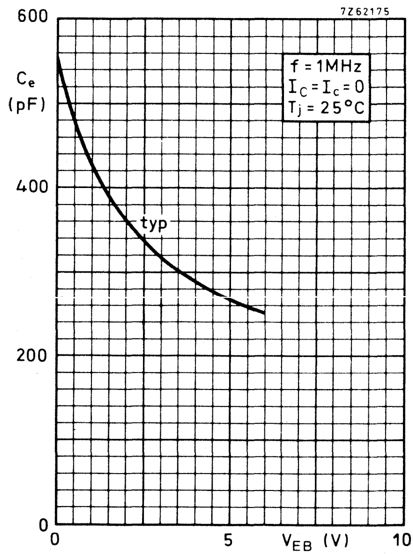
Note

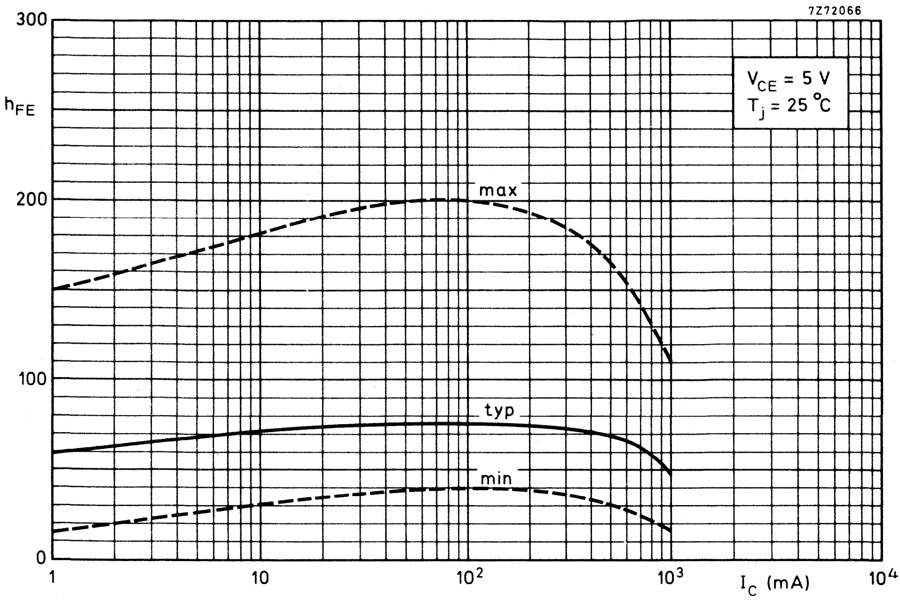
$-I_{BM}$ is the reverse current that can flow during switching off. The indicated $-I_{BM}$ is determined and limited by the applied cut-off voltage and series resistance.

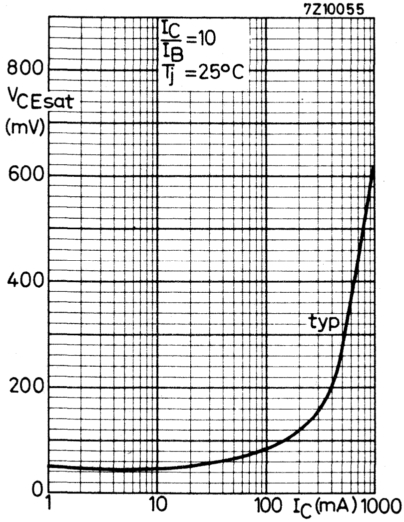
CHARACTERISTICS (continued)

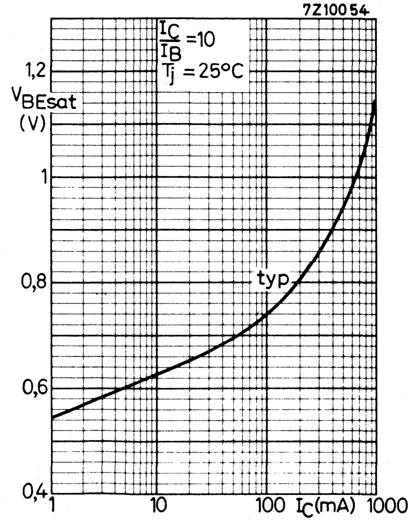


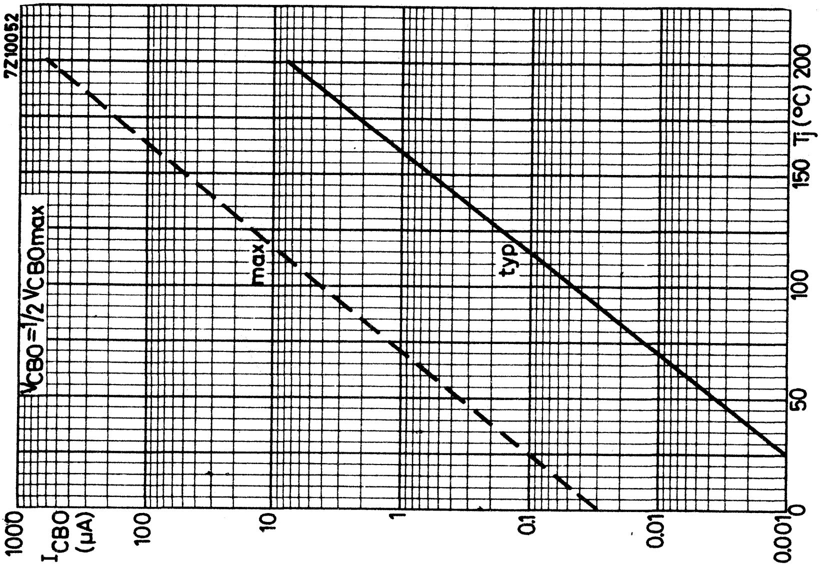


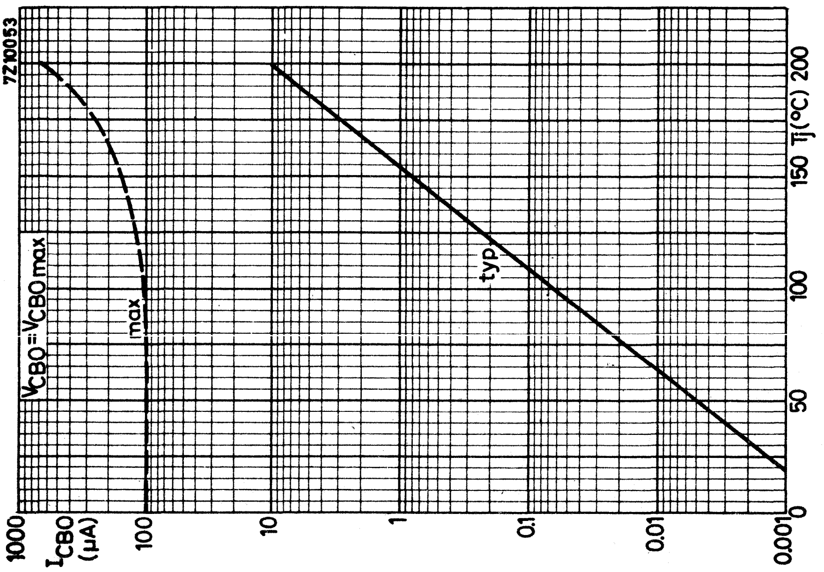



7Z72066
300
200
100
0
hFE
VCE = 5 V
Tj = 25 °C
max
typ
min
1
10
10²
10³
10⁴
IC (mA)


7Z10055
IC/IB =10
Tj =25°C
800
600
400
200
0
VCEsat
(mV)
typ
1
10
100
1000
IC(mA)


7Z10054
IC/IB =10
Tj =25°C
1,2
1
0,8
0,6
0,4
VBEsat
(V)
typ
1
10
100
1000
IC(mA)


7Z10052
VCBO = 1/2 VCBOmax
max
typ
ICBO (µA)
1000
100
10
1
0.1
0.01
0.001
0
50
100
150
200
Tj (°C)


7Z10053
VCBO = VCBOmax
max
typ
ICBO (µA)
1000
100
10
1
0.1
0.01
0.001
0
50
100
150
200
Tj (°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

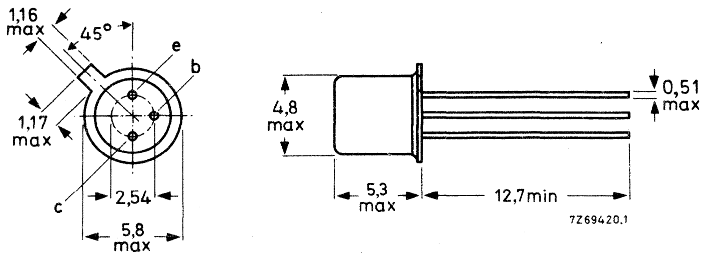
			BSX19	BSX20	
Collector-base voltage (open emitter)	V_{CBO}	max.	40	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	15	V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	40	40	V
Collector current (peak value)	I_{CM}	max.	500	500	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	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 supplied on request: 56246 (distance disc); 56263 (cooling fin).

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	$R_{th\ j-c}$	=	0.15	°C/mW

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

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

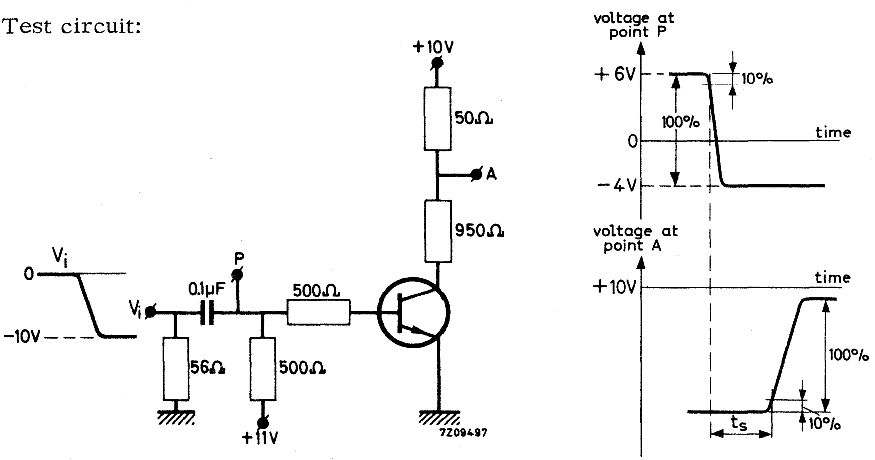
Collector cut-off current				
$I_E = 0;\ V_{CB} = 20$ V	I_{CBO}	<	400	nA
$I_E = 0;\ V_{CB} = 20$ V; $T_j = 150\ ^oC$	I_{CBO}	<	30	μA
$V_{BE} = 0;\ V_{CE} = 15$ V; $T_j = 55\ ^oC$	I_{CES}	<	0.40	μA
$V_{BE} = 0;\ V_{CE} = 40$ V	I_{CES}	<	1.0	μA
Emitter cut-off current				
$I_C = 0;\ V_{EB} = 4.5$ V	I_{EBO}	<	10	μA
Currents at reverse biased emitter junction				
$V_{CE} = 15$ V; $-V_{BE} = 3$ V; $T_j = 55\ ^oC$	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; $T_j = 100\ ^oC$	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

D.C. current gain

		BSX19	BSX20	
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

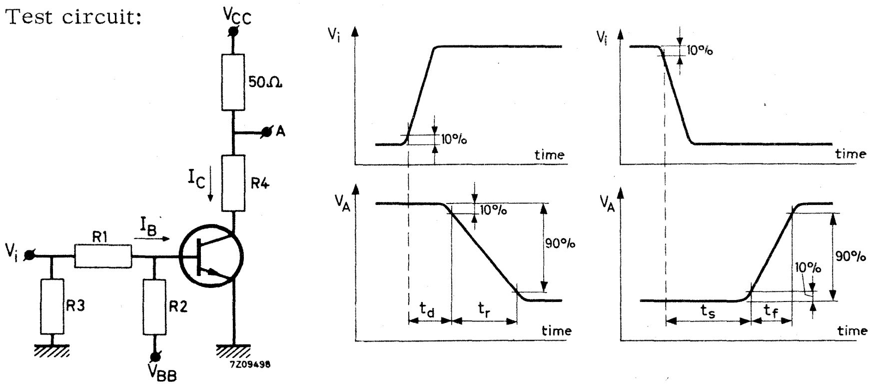
Turn on time (see also pages 14 and 15)

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:



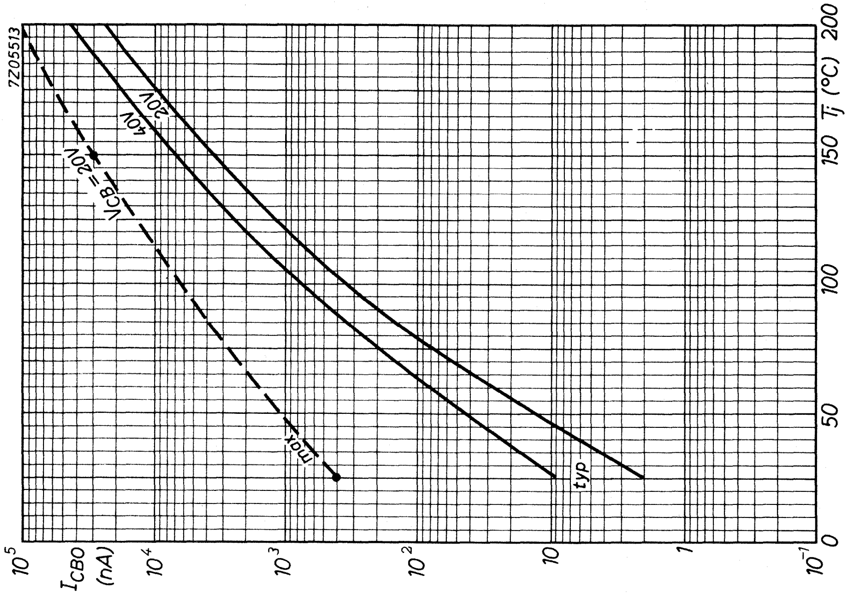
Pulse generator:				
Rise time	t_r	<	1	ns
Pulse duration	t	>	300	ns
Duty cycle	δ	<	0.02	
Source impedance	R_S	=	50	Ω

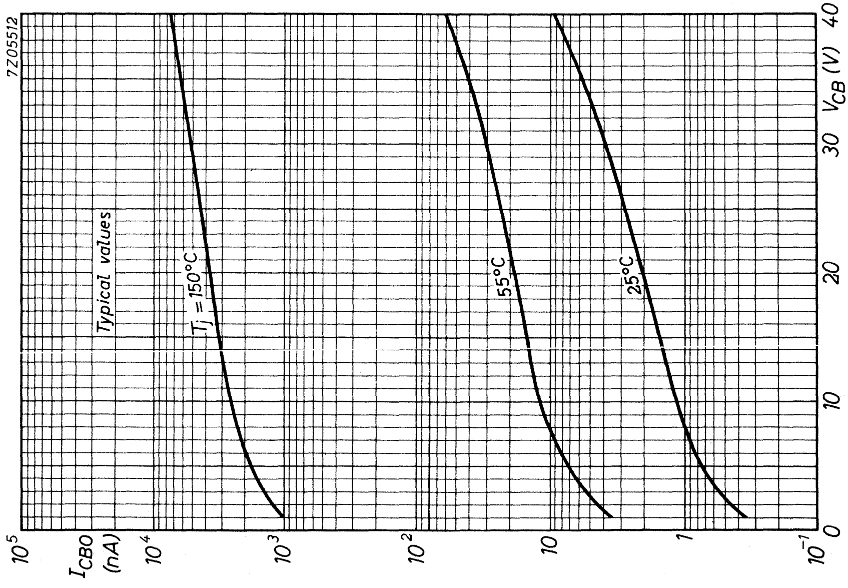
Oscilloscope:				
Input impedance	R_i	=	50	Ω
Rise time	t_r	<	1	ns

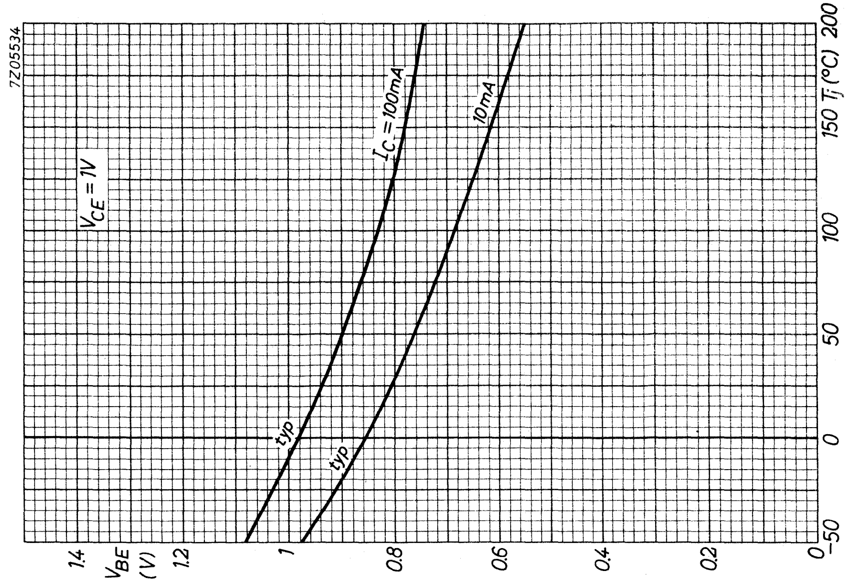
							turn on time			turn off time	
I_C (mA)	I_B (mA)	$-I_{BM}$ (mA)	V_{CC} (V)	R1;R2 (kΩ)	R3 (Ω)	R4 (Ω)	$-V_{BB}$ (V)	$-V_{BE}$ (V)	V_i (V)	V_{BB} (V)	$-V_i$ (V)
10	3	1.5	3	3.3	50	220	3.0	1.5	15	12.0	15
100	40	20	6	0.33	56	0	4.5	2.25	20	15.3	20

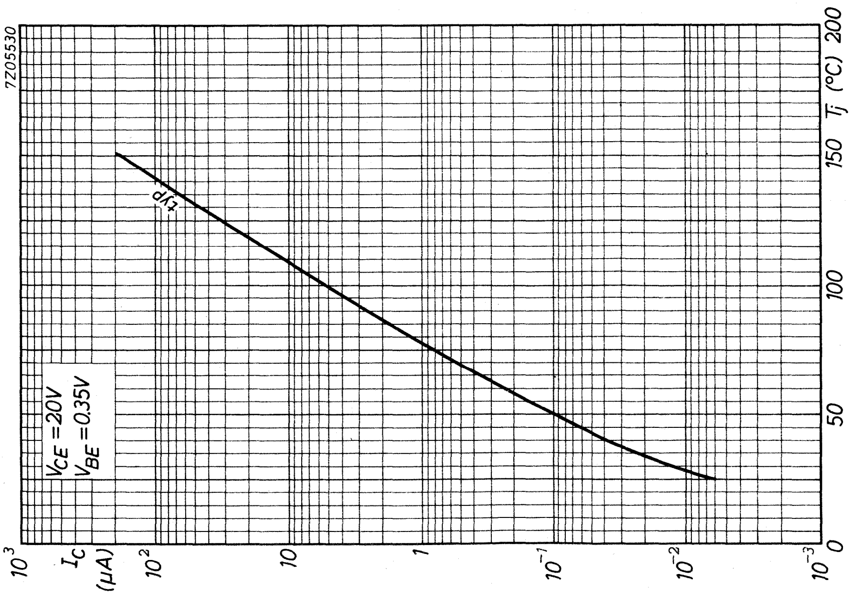
Note

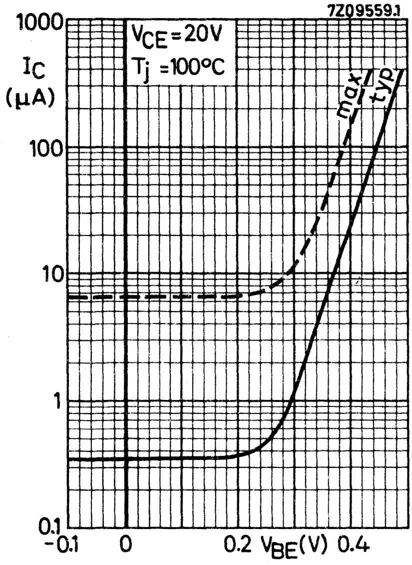
$-I_{BM}$ is the reverse current that can flow during switching off. The indicated $-I_{BM}$ is determined and limited by the applied cut-off voltage and series resistance.

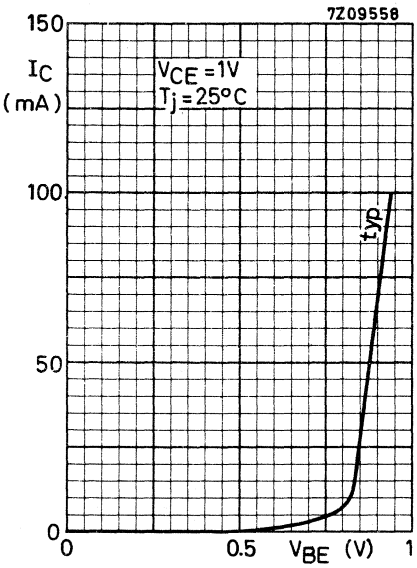

7Z05513
T_j (°C)
0
50
100
150
200
I_{CBO} (nA)
10^5
10^4
10^3
10^2
10
1
10^{-1}
$V_{CB} = 20V$
40V
20V
max
typ

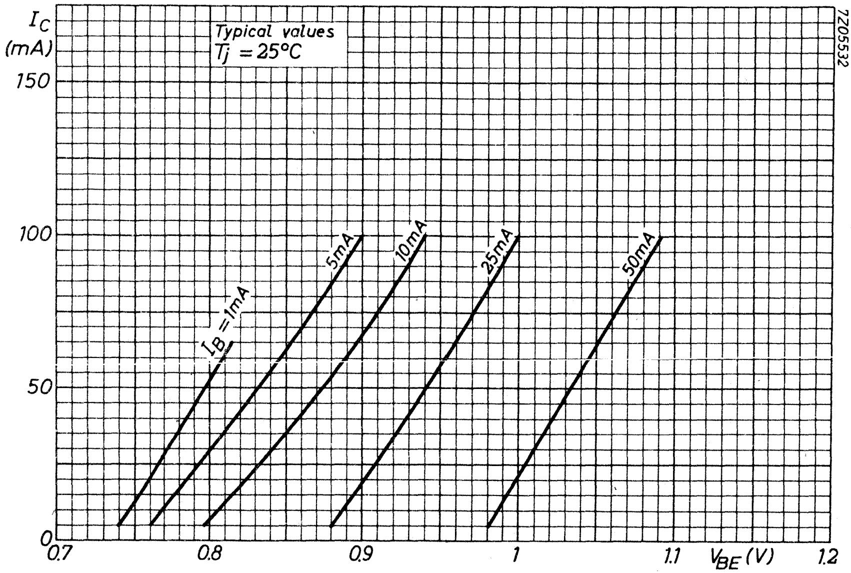

7Z05512
V_{CB} (V)
0
10
20
30
40
I_{CBO} (nA)
10^5
10^4
10^3
10^2
10
1
10^{-1}
Typical values
$T_j = 150°C$
55°C
25°C

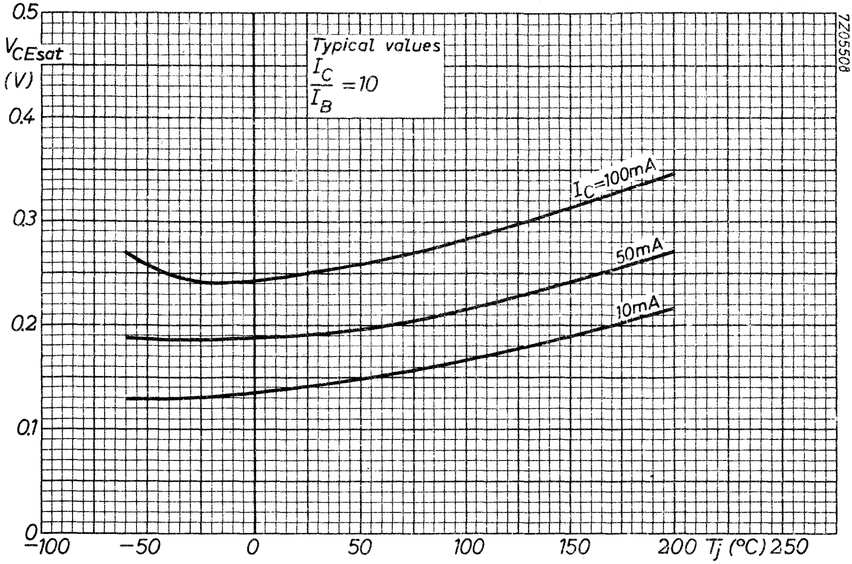

7Z05534
VCE = 1V
IC = 100mA
10mA
typ
typ
Tj (°C)
VBE (V)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
−50
0
50
100
150
200

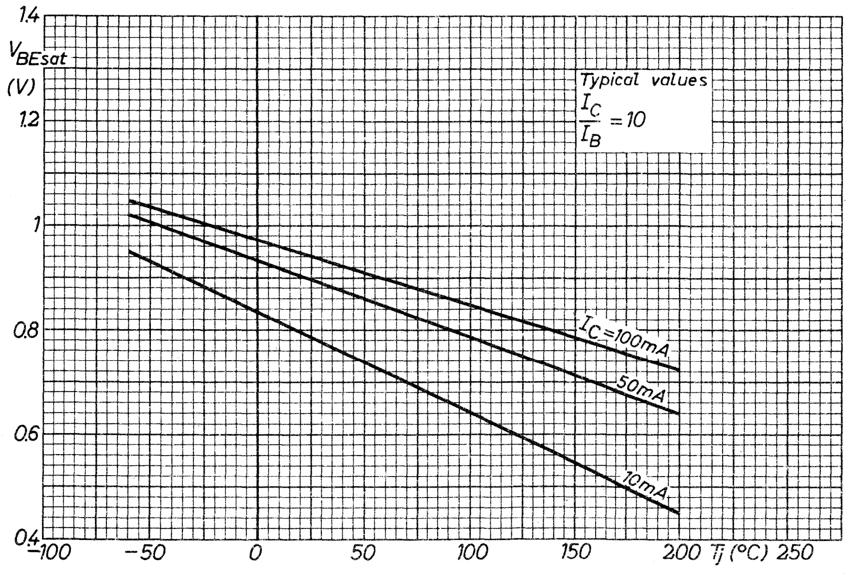

7Z05530
VCE = 20V
VBE = 0.35V
typ
Tj (°C)
IC (μA)
10^3
10^2
10
1
10^-1
10^-2
10^-3
0
50
100
150
200

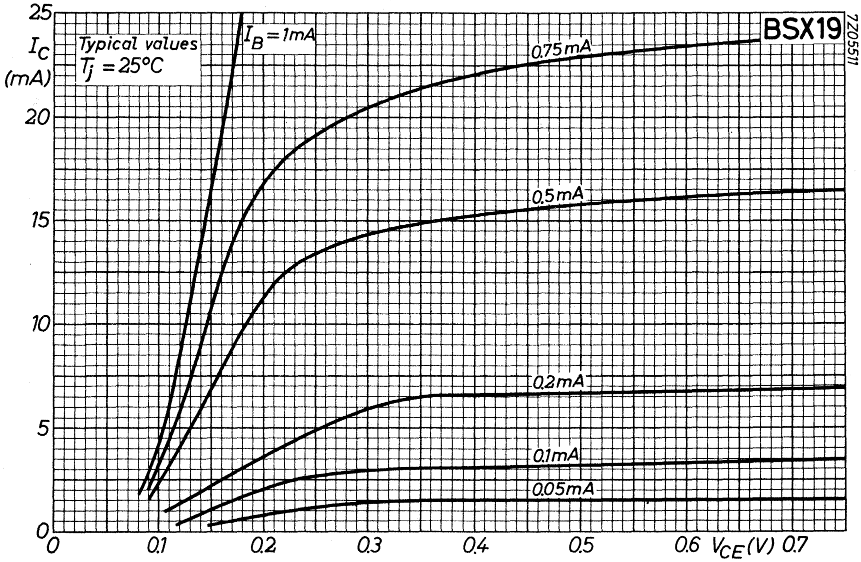

7Z09559.1
V_{CE} = 20V
T_j = 100°C
I_C (μA)
1000
100
10
1
0.1
max
typ
−0.1
0
0.2
V_{BE} (V)
0.4

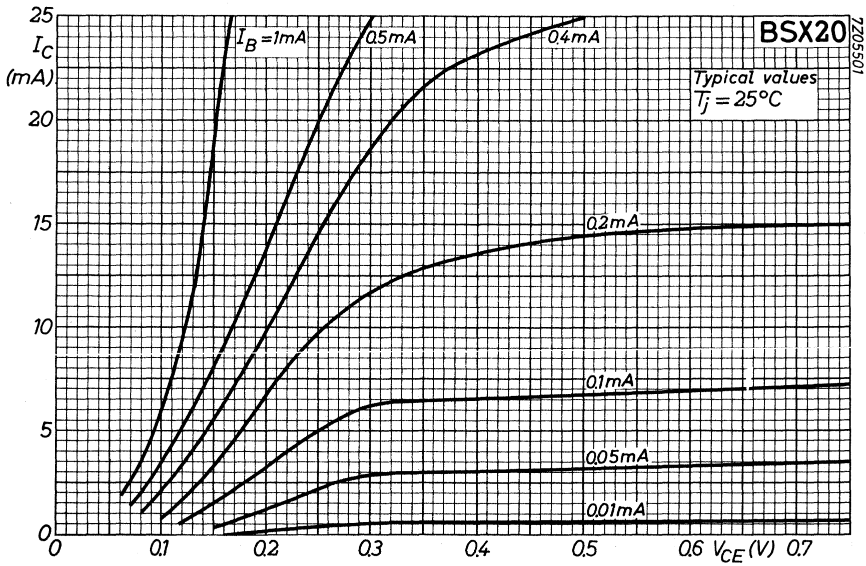

7Z09558
V_{CE} = 1V
T_j = 25°C
I_C (mA)
150
100
50
0
typ
0
0.5
V_{BE} (V)
1

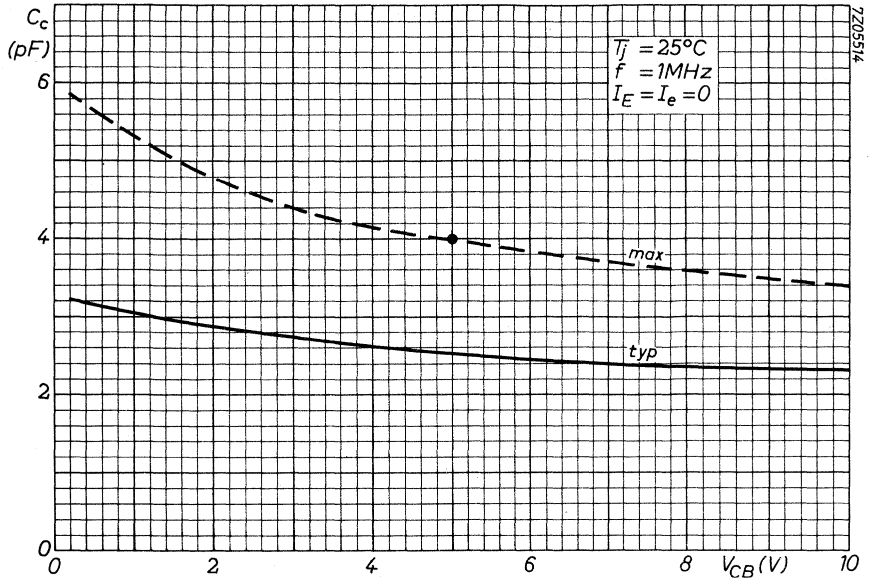

7Z05532
Typical values
T_j = 25°C
I_C (mA)
150
100
50
0
I_B = 1mA
5mA
10mA
25mA
50mA
0.7
0.8
0.9
1
1.1
V_{BE} (V)
1.2

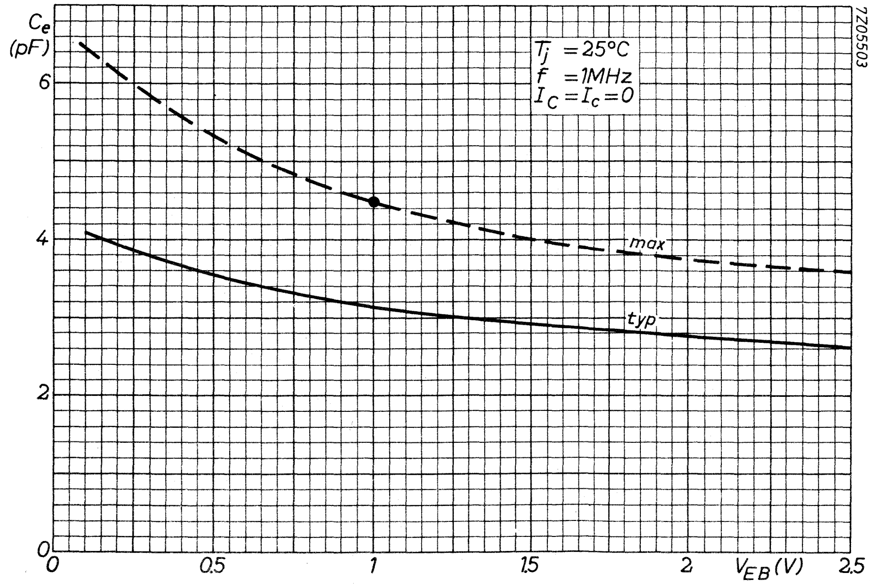

0.5
V_{CEsat}
(V)
0.4
0.3
0.2
0.1
0
Typical values
$\frac{I_C}{I_B} = 10$
7Z05508
I_C=100mA
50mA
10mA
−100
−50
0
50
100
150
200
T_j (°C)
250

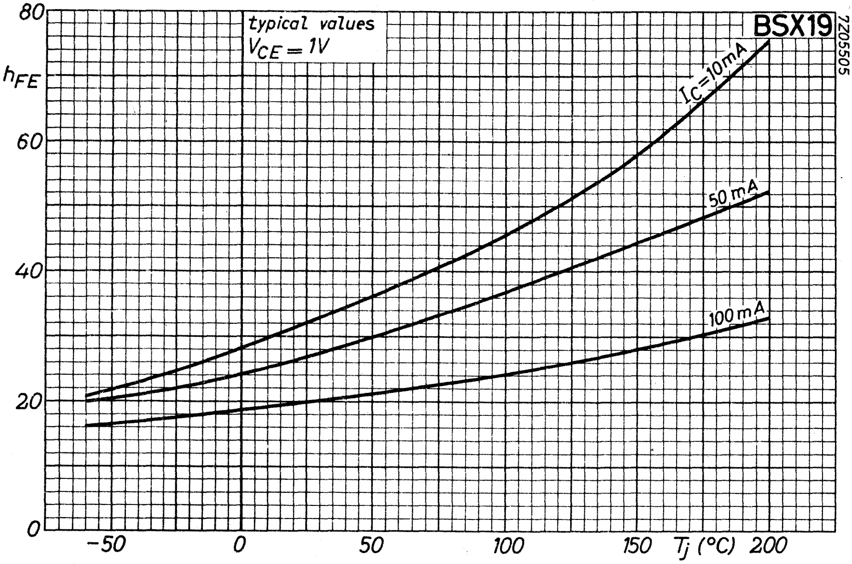

1.4
V_{BEsat}
(V)
1.2
1
0.8
0.6
0.4
Typical values
$\frac{I_C}{I_B} = 10$
I_C=100mA
50mA
10mA
−100
−50
0
50
100
150
200
T_j (°C)
250

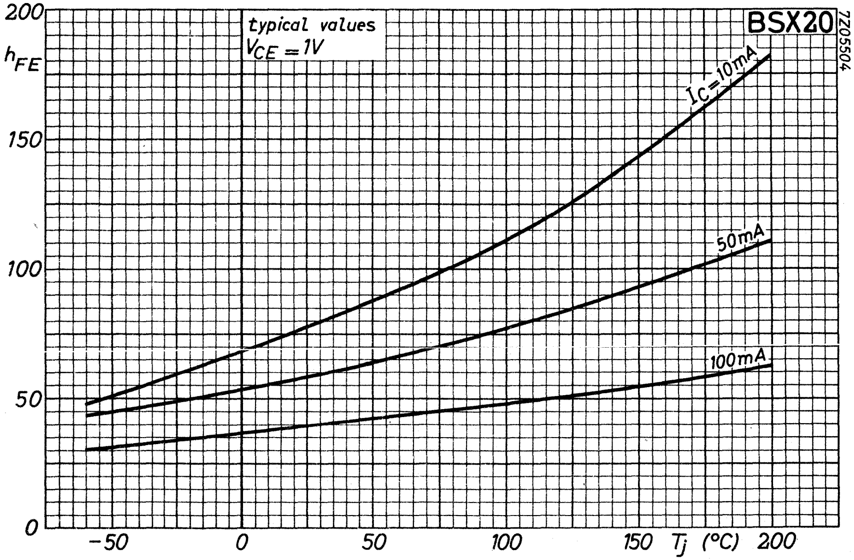

BSX19
7Z05511
Typical values
T_j = 25°C
I_C (mA)
I_B = 1mA
0.75mA
0.5mA
0.2mA
0.1mA
0.05mA
V_{CE} (V)
0
5
10
15
20
25
0.1
0.2
0.3
0.4
0.5
0.6
0.7

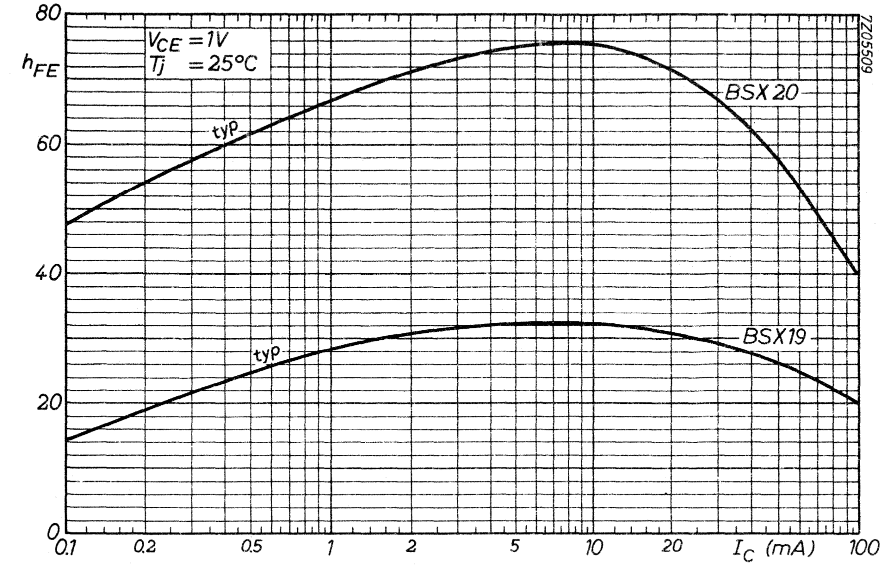

BSX20
7Z05501
Typical values
T_j = 25°C
I_C (mA)
I_B = 1mA
0.5mA
0.4mA
0.2mA
0.1mA
0.05mA
0.01mA
V_{CE} (V)
0
5
10
15
20
25
0.1
0.2
0.3
0.4
0.5
0.6
0.7

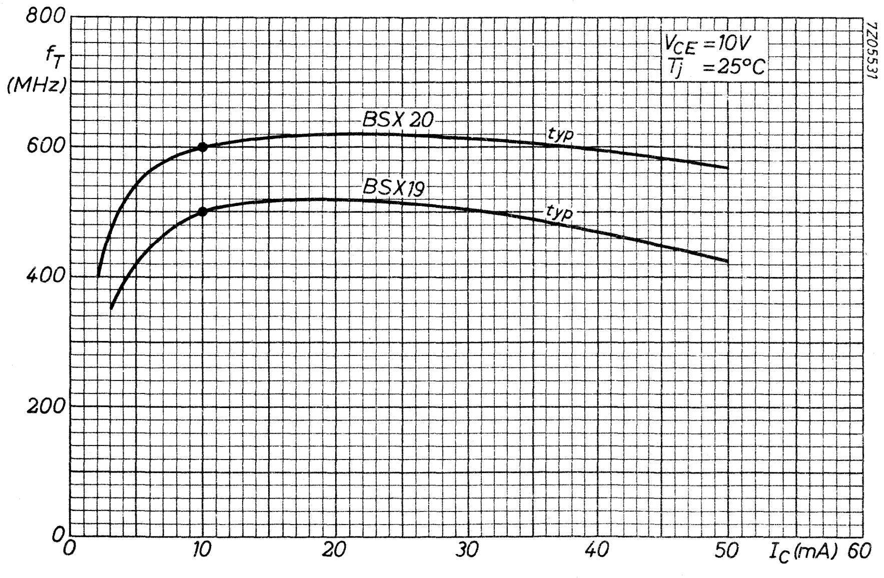

C_c
(pF)
6
4
2
0
0
2
4
6
8
V_{CB} (V)
10
7Z05514
T_j = 25°C
f = 1MHz
$I_E = I_e = 0$
max
typ

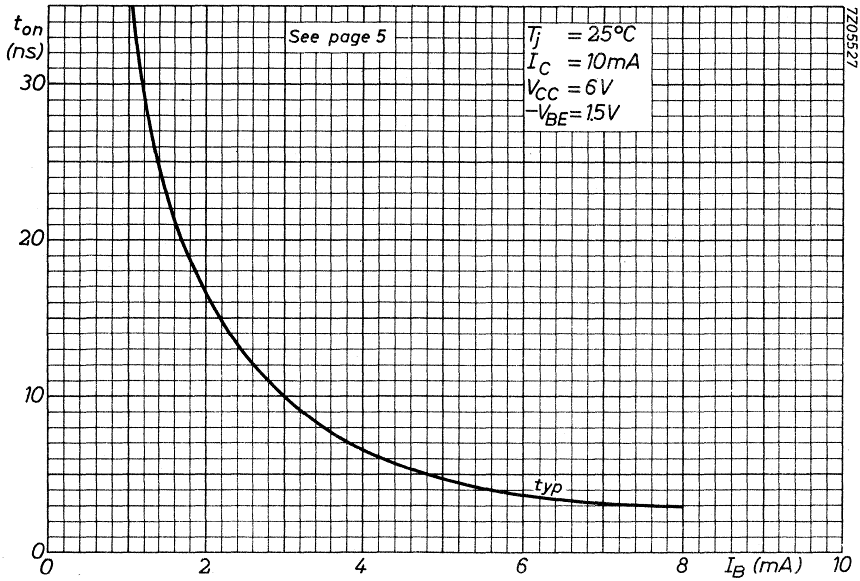

C_e
(pF)
6
4
2
0
0
0.5
1
1.5
2
V_{EB} (V)
2.5
7Z05503
T_j = 25°C
f = 1MHz
$I_C = I_c = 0$
max
typ

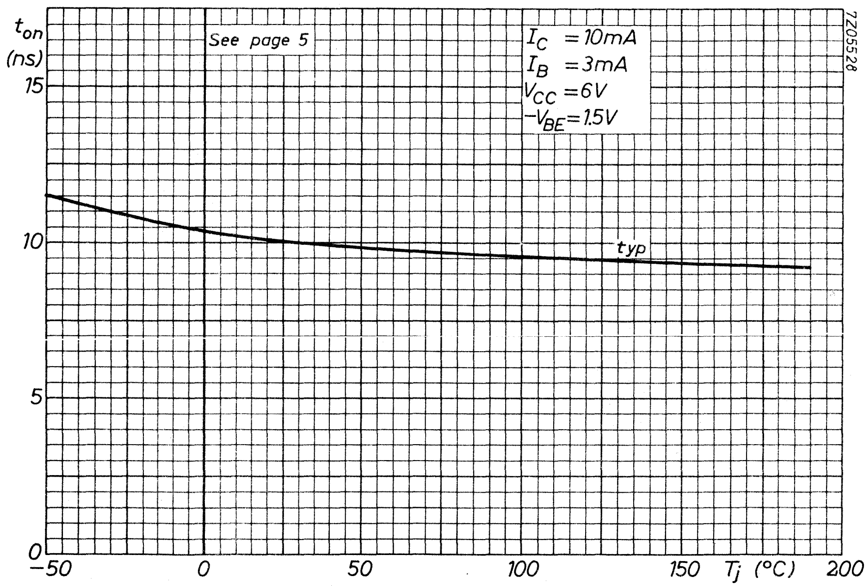

typical values
$V_{CE} = 1V$
BSX19
7Z05505
h_{FE}
$I_C = 10 mA$
50 mA
100 mA
T_j (°C)
80
60
40
20
0
−50
0
50
100
150
200

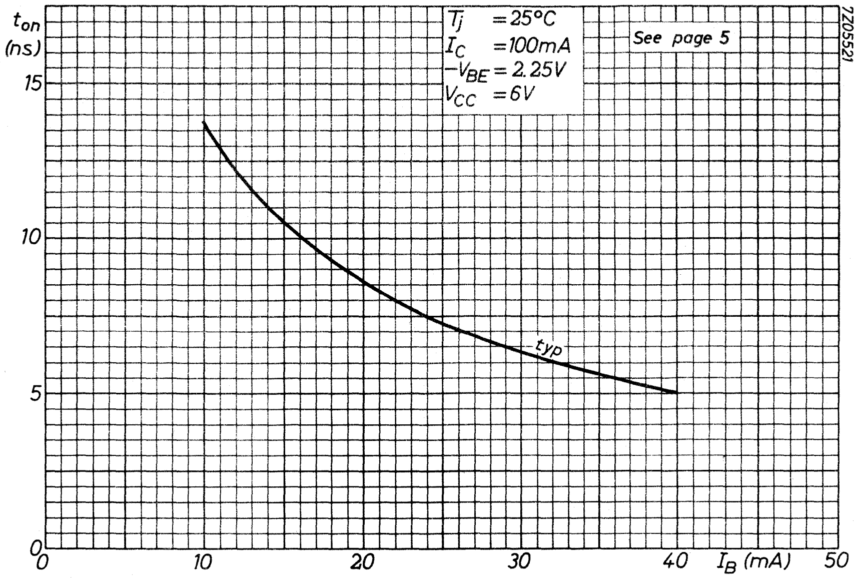

typical values
$V_{CE} = 1V$
BSX20
7Z05504
h_{FE}
$I_C = 10 mA$
50 mA
100 mA
T_j (°C)
200
150
100
50
0
−50
0
50
100
150
200

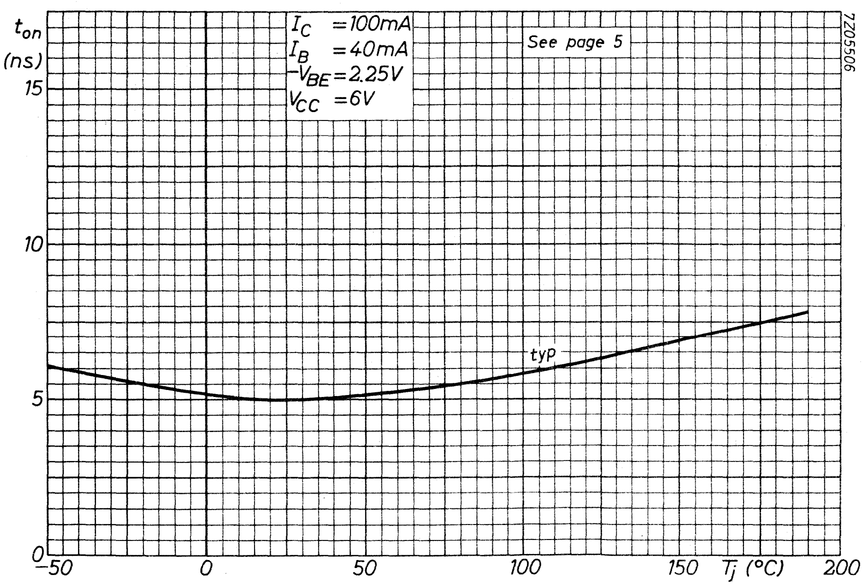

7Z05509
V_{CE} = 1V
T_j = 25°C
h_{FE}
BSX 20
BSX19
typ
typ
I_C (mA)
0
20
40
60
80
0.1
0.2
0.5
1
2
5
10
20
100

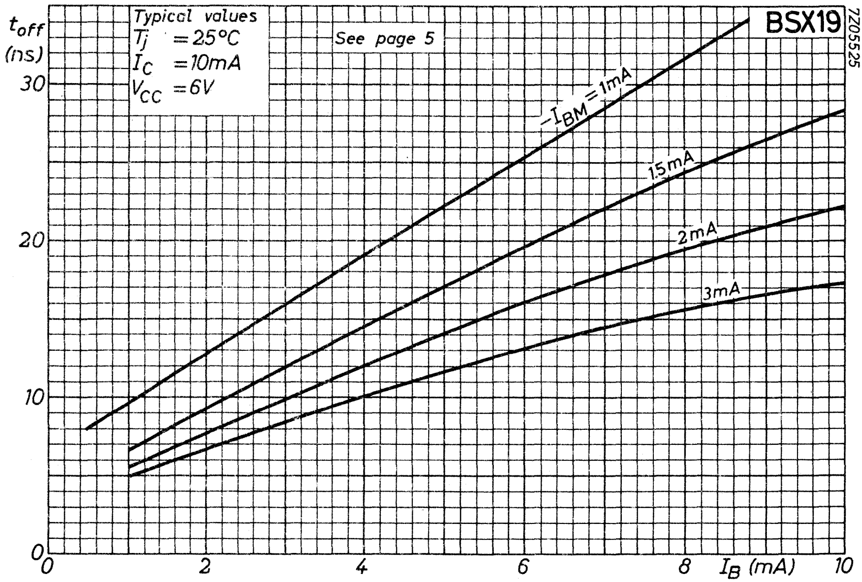

7Z05531
V_{CE} = 10V
T_j = 25°C
f_T
(MHz)
BSX 20
BSX19
typ
typ
I_C (mA)
0
200
400
600
800
10
20
30
40
50
60

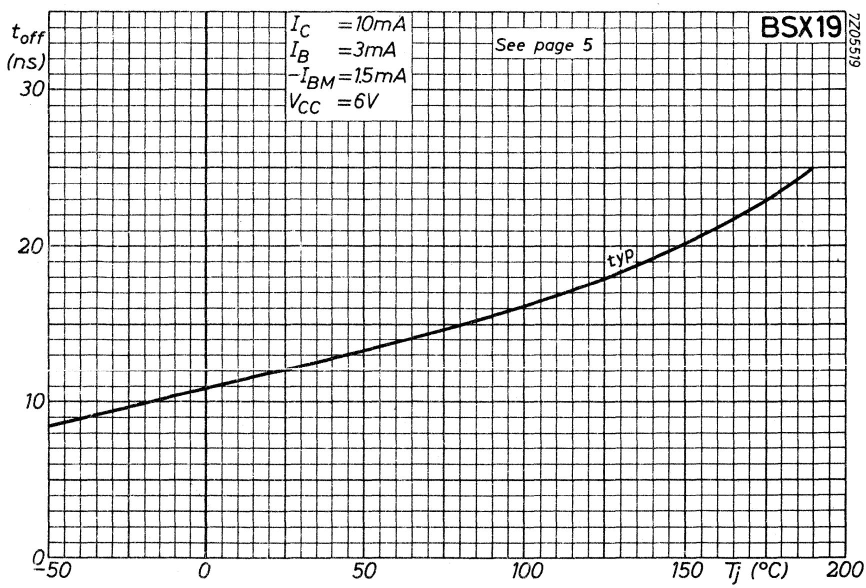

t_{on} (ns)
See page 5
T_j = 25°C
I_C = 10mA
V_{CC} = 6V
$-V_{BE}$ = 1.5V
typ
I_B (mA)
7Z05527
0
10
20
30
0
2
4
6
8
10

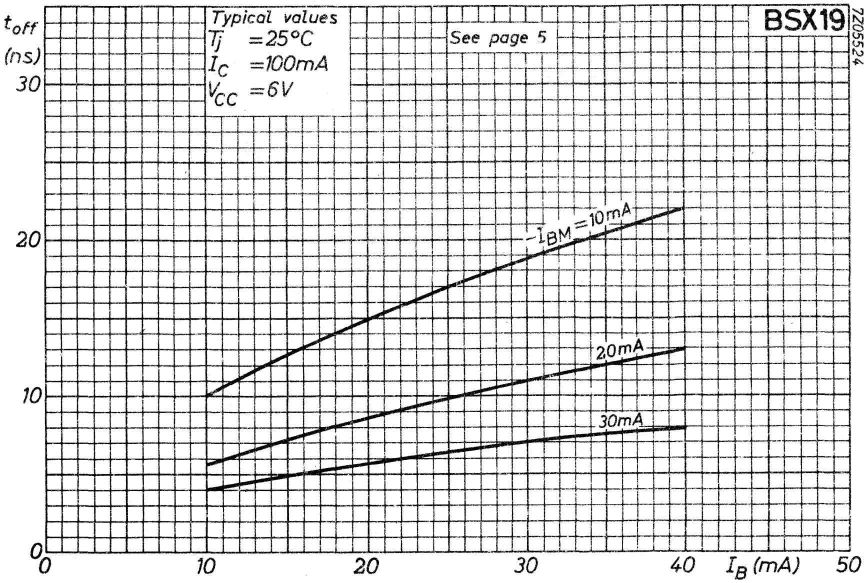

t_{on} (ns)
See page 5
I_C = 10mA
I_B = 3mA
V_{CC} = 6V
$-V_{BE}$ = 1.5V
typ
T_j (°C)
7Z05528
0
5
10
15
−50
0
50
100
150
200

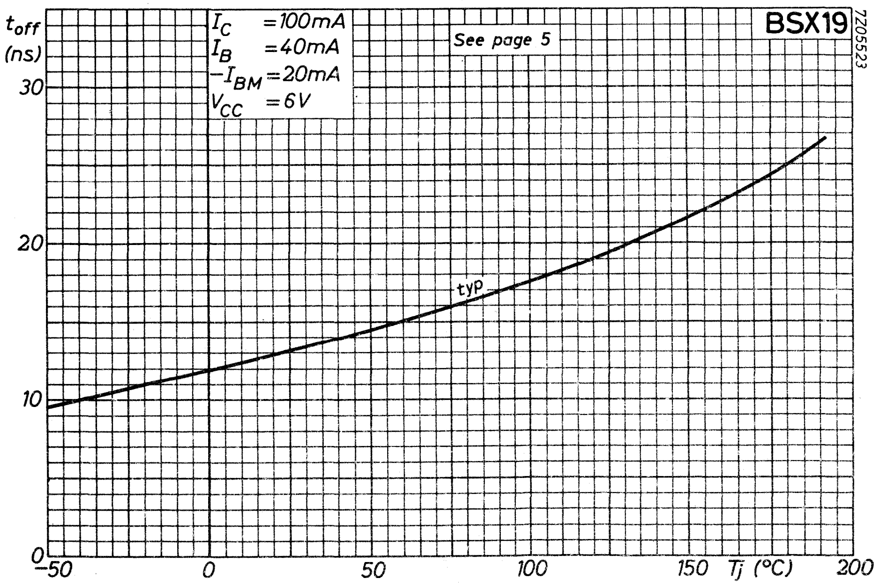

t_{on}
(ns)
15
10
5
0
T_j = 25°C
I_C = 100mA
$-V_{BE}$ = 2.25V
V_{CC} = 6V
See page 5
7Z05521
typ
0
10
20
30
40
I_B (mA)
50

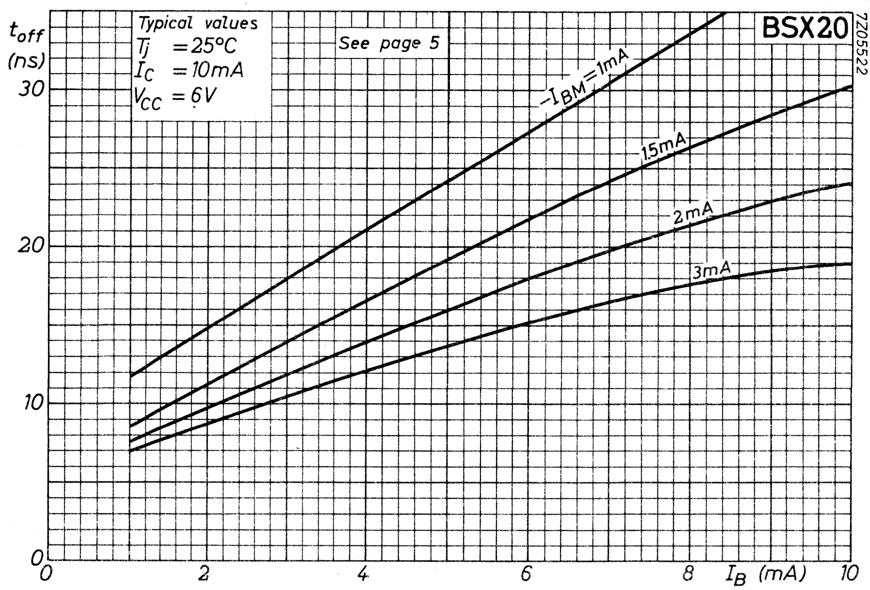

t_{on}
(ns)
15
10
5
0
I_C = 100mA
I_B = 40mA
$-V_{BE}$ = 2.25V
V_{CC} = 6V
See page 5
7Z05506
typ
−50
0
50
100
150
T_j (°C)
200

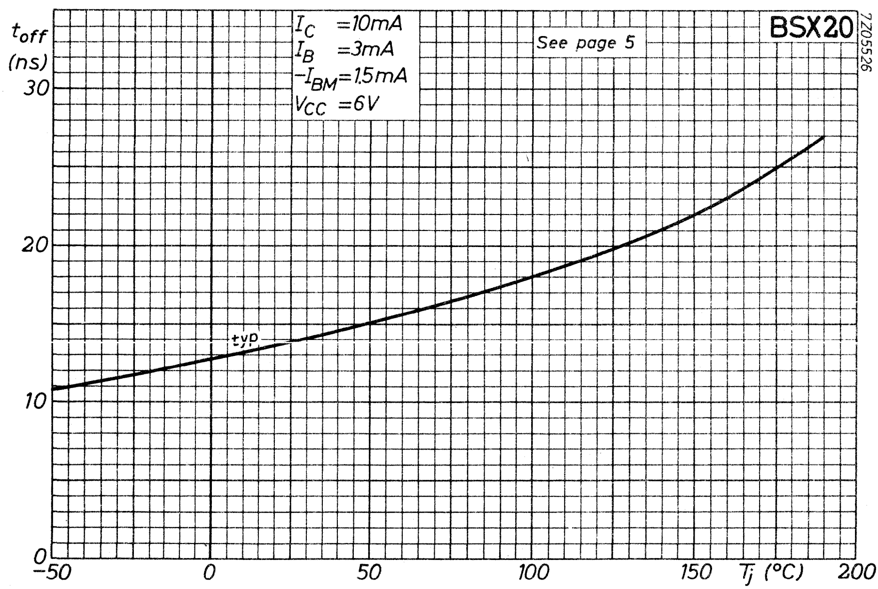

Typical values
T_j = 25°C
I_C = 10mA
V_{CC} = 6V
See page 5
BSX19
7Z05525
t_{off} (ns)
30
20
10
0
0
2
4
6
8
I_B (mA)
10
$-I_{BM}$ = 1mA
1.5mA
2mA
3mA

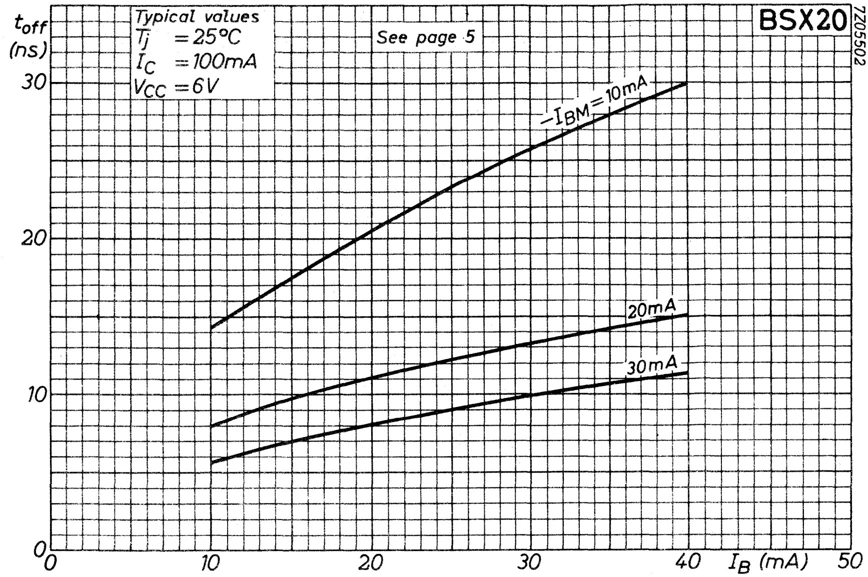

I_C = 10mA
I_B = 3mA
$-I_{BM}$ = 1.5mA
V_{CC} = 6V
See page 5
BSX19
7Z05519
t_{off} (ns)
30
20
10
0
−50
0
50
100
150
T_j (°C)
200
typ

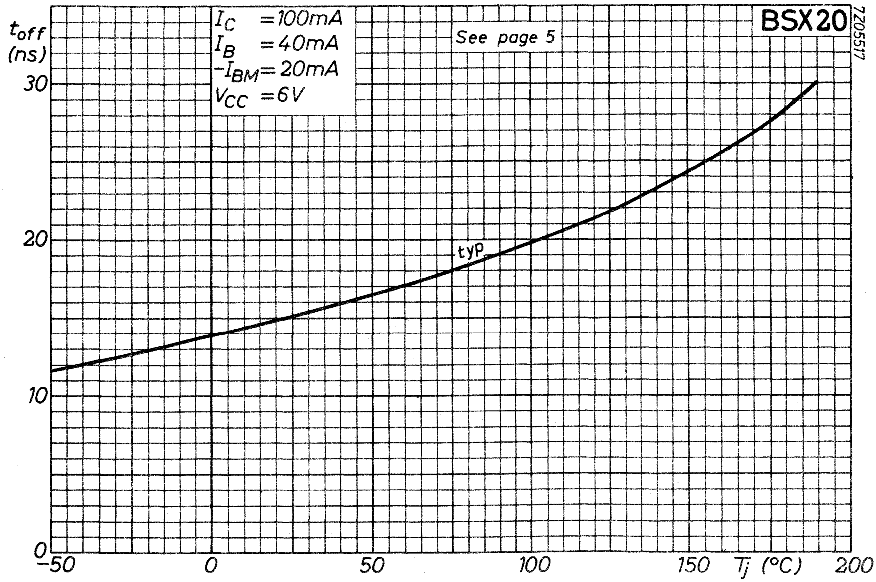

t_{off} (ns)
Typical values
T_j = 25°C
I_C = 100mA
V_{CC} = 6V
See page 5
BSX19
7Z05524
$-I_{BM}$ = 10mA
20mA
30mA
0
10
20
30
40
50
I_B (mA)

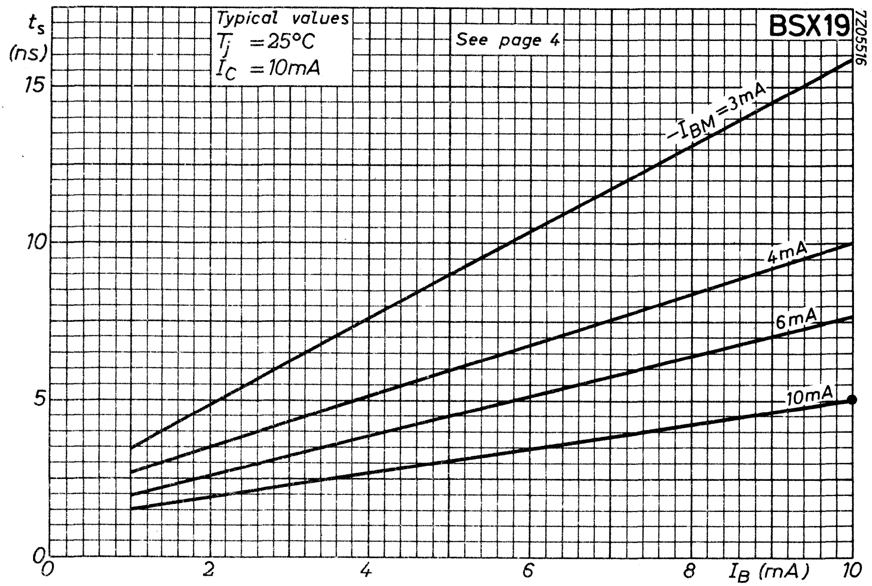

t_{off} (ns)
I_C = 100mA
I_B = 40mA
$-I_{BM}$ = 20mA
V_{CC} = 6V
See page 5
BSX19
7Z05523
typ
0
10
20
30
−50
50
100
150
200
T_j (°C)

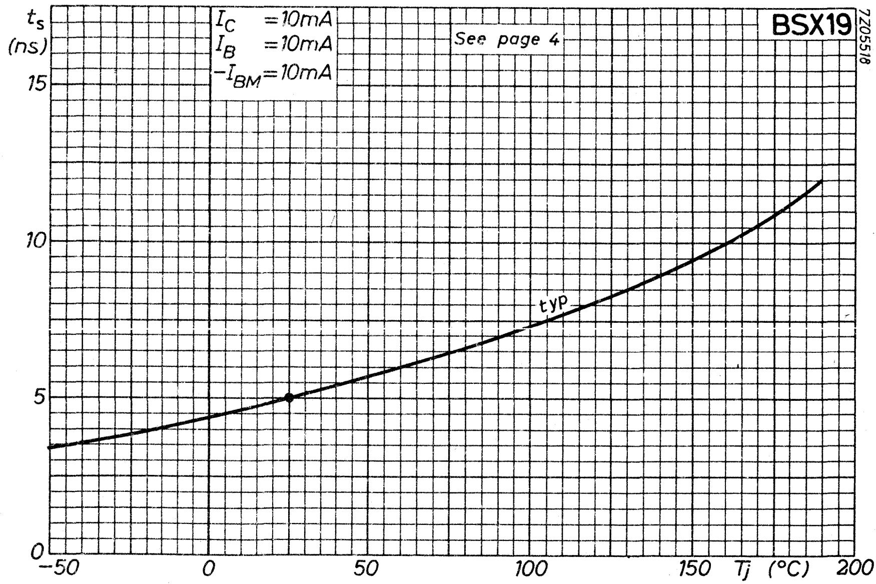

Typical values
T_j = 25°C
I_C = 10mA
V_{CC} = 6V
See page 5
BSX20
7Z05522
t_{off} (ns)
$-I_{BM}$=1mA
1.5mA
2mA
3mA
I_B (mA)
0
2
4
6
8
10
10
20
30

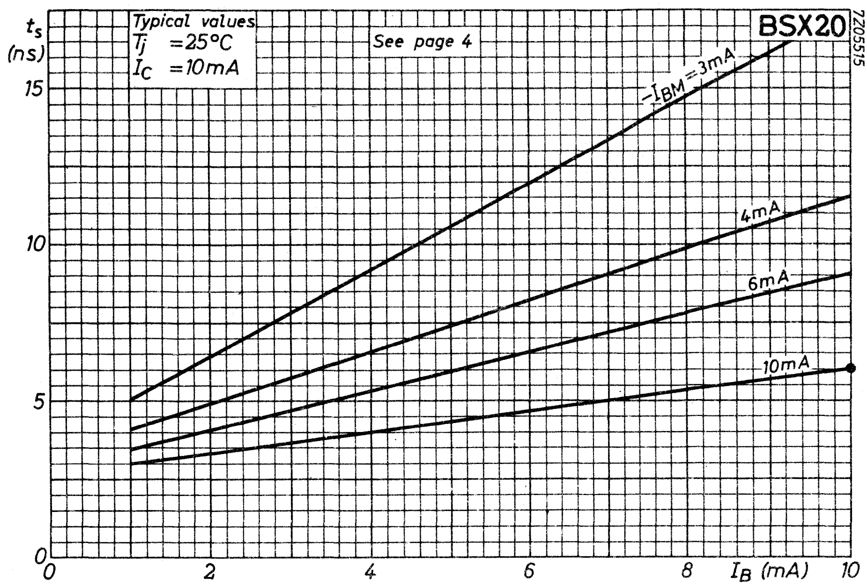

I_C = 10mA
I_B = 3mA
$-I_{BM}$=1.5mA
V_{CC} = 6V
See page 5
BSX20
7Z05526
t_{off} (ns)
typ
T_j (°C)
−50
0
50
100
150
200
10
20
30

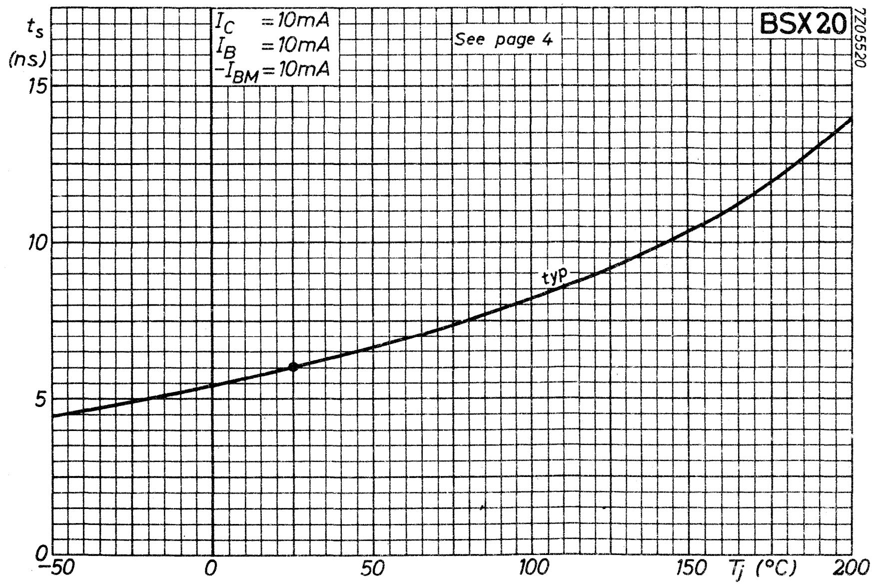

t_{off} (ns)
Typical values
T_j = 25°C
I_C = 100mA
V_{CC} = 6V
See page 5
BSX20
7Z05502
$-I_{BM}$ = 10mA
20mA
30mA
0
10
20
30
0
10
20
30
40
I_B (mA)
50


t_{off} (ns)
I_C = 100mA
I_B = 40mA
$-I_{BM}$ = 20mA
V_{CC} = 6V
See page 5
BSX20
7Z05517
typ
0
10
20
30
−50
0
50
100
150
T_j (°C)
200


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
5
10
15
0
2
4
6
8
10

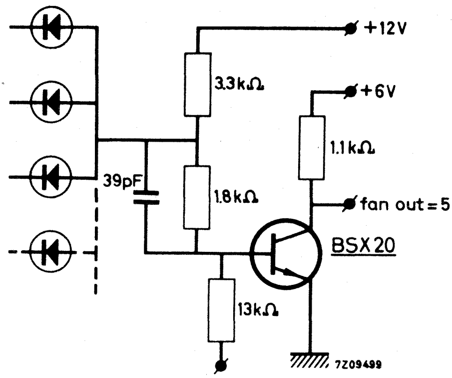

I_C = 10mA
I_B = 10mA
$-I_{BM}$ = 10mA
See page 4
BSX19
7Z05518
t_s (ns)
typ
T_j (°C)
0
5
10
15
−50
0
50
100
150
200


Typical values
T_j = 25°C
I_C = 10mA
See page 4
BSX20
7Z05515
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
BSX20
7Z05520
t_s (ns)
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}	>	20	
		typ.	80	
Transition frequency at f = 35 MHz; I_C = 4 mA; V_{CE} = 10 V	f_T	>	60	MHz

NOTE

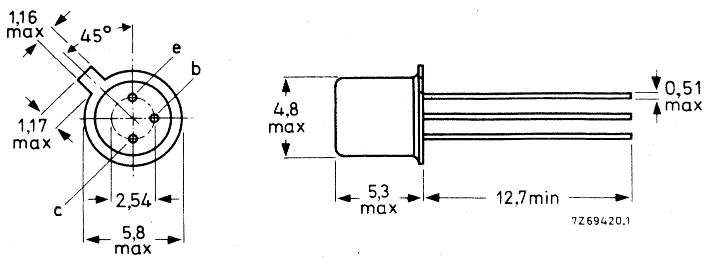
The BSX21 may be operated in the breakdown region up to V_{CE} = 160 V, provided P_{tot} at T_{amb} = 85 °C does not exceed 100 mW.

MECHANICAL DATA

Dimensions in mm

Collector connected to case

TO-18



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

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.

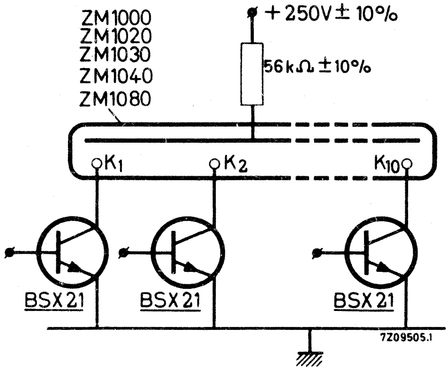
[2] The transistor can withstand a capacitive load of 500 pF, combined with a collector-base voltage of max. 150 V before switching on.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

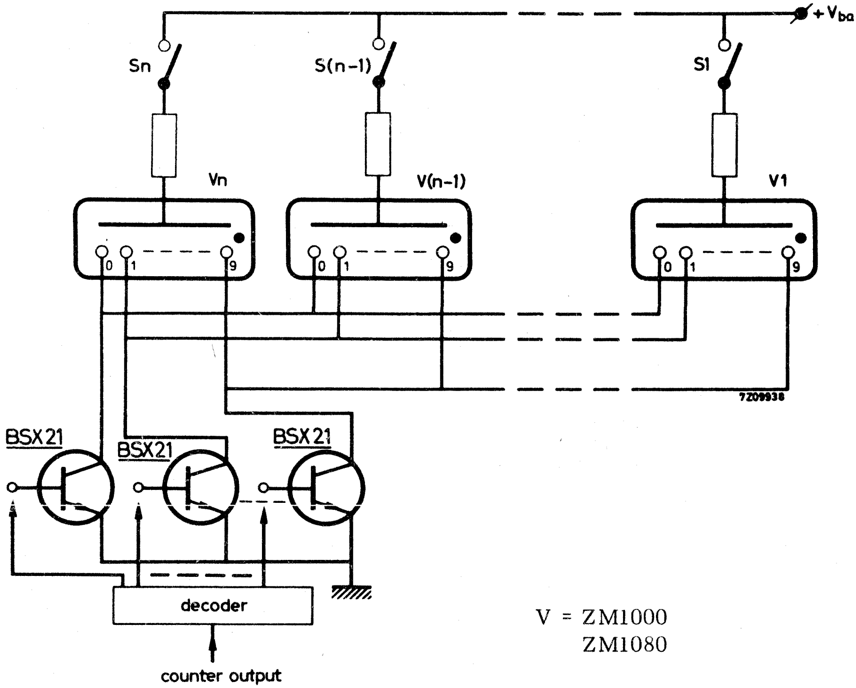
Collector cut-off current				
I_E = 0; V_{CB} = 90 V	I_{CBO}	typ.	1	nA
		<	200	nA
I_E = 0; V_{CB} = 90 V; T_j = 150 °C	I_{CBO}	typ.	0.25	μA
		<	50	μA
V_{BE} = 0; V_{CE} = 80 V; T_j = 85 °C	I_{CES}	typ.	0.01	μA
		<	20	μA
Emitter cut-off current				
I_C = 0; V_{EB} = 4 V	I_{EBO}	typ.	0.5	nA
		<	200	nA
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

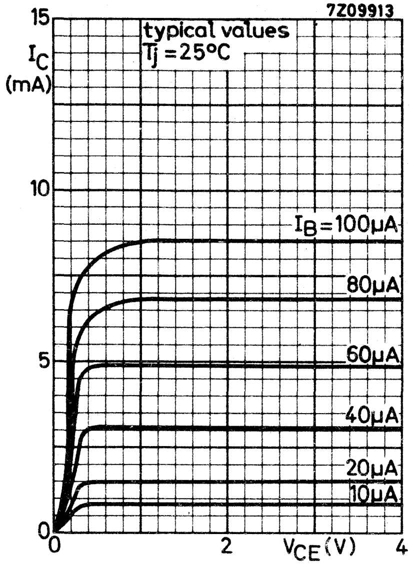


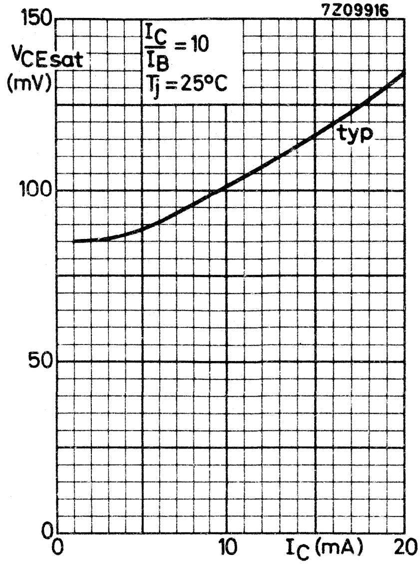
Practical circuit for dynamic operation

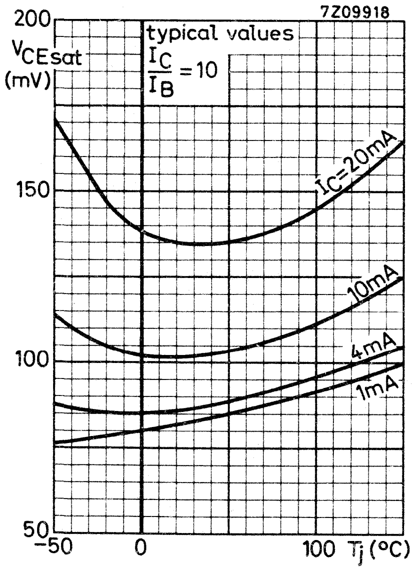


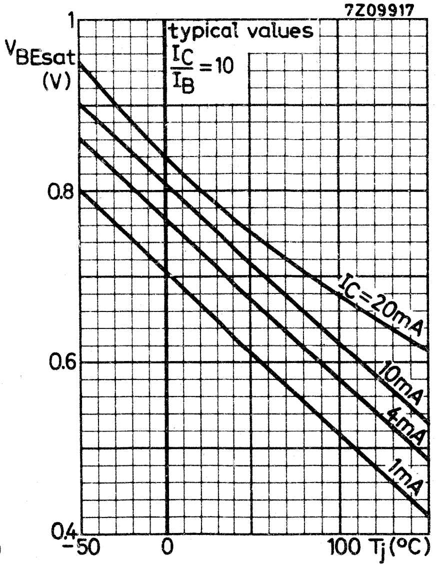
V = ZM1000
ZM1080

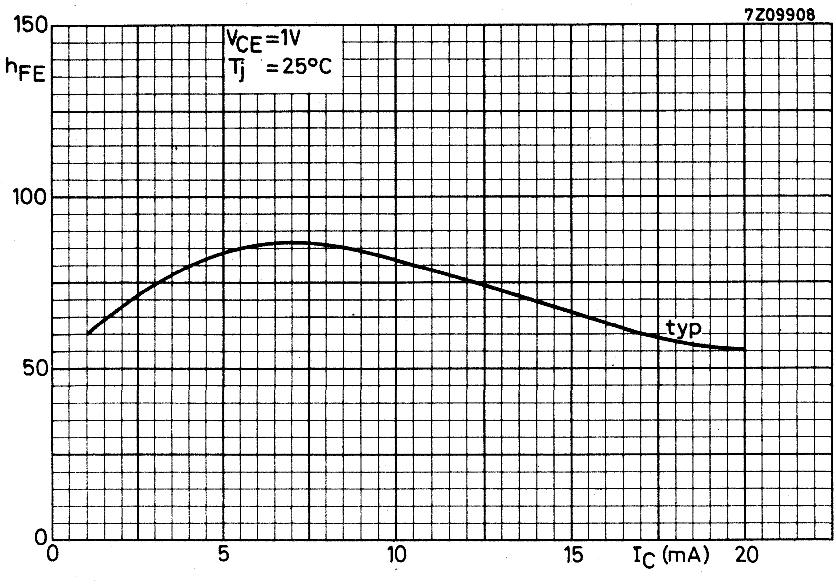
APPLICATION INFORMATION bulletins available on request

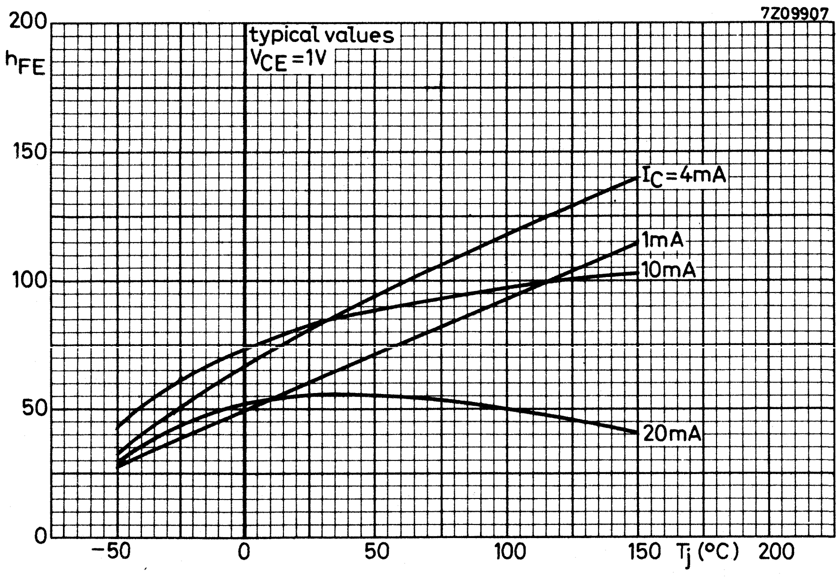

7Z09913
typical values
$T_j = 25°C$
I_C (mA)
15
10
5
0
$I_B = 100 \mu A$
80μA
60μA
40μA
20μA
10μA
0
2
V_{CE} (V)
4

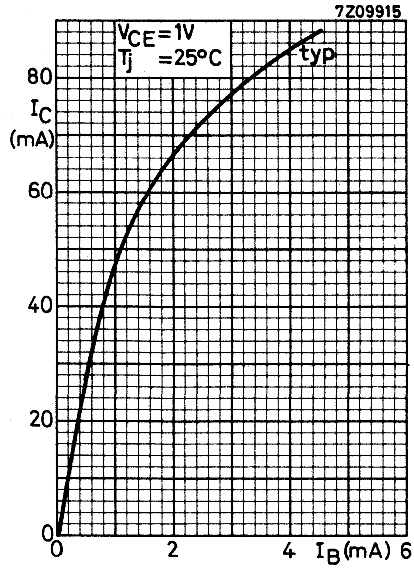

7Z09916
$\frac{I_C}{I_B} = 10$
$T_j = 25°C$
V_{CEsat} (mV)
150
100
50
0
typ
0
10
I_C (mA)
20

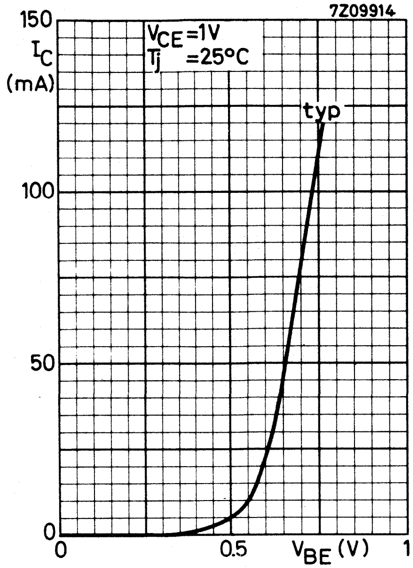

7Z09918
typical values
$\frac{I_C}{I_B} = 10$
V_{CEsat} (mV)
200
150
100
50
$I_C = 20 mA$
10mA
4mA
1mA
−50
0
100
T_j (°C)

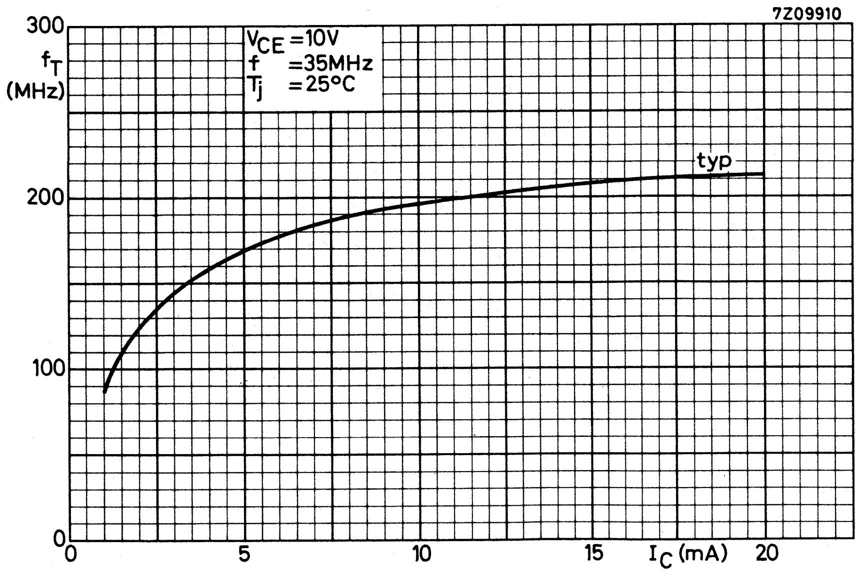

7Z09917
typical values
$\frac{I_C}{I_B} = 10$
V_{BEsat} (V)
1
0.8
0.6
0.4
$I_C = 20 mA$
10mA
4mA
1mA
−50
0
100
T_j (°C)

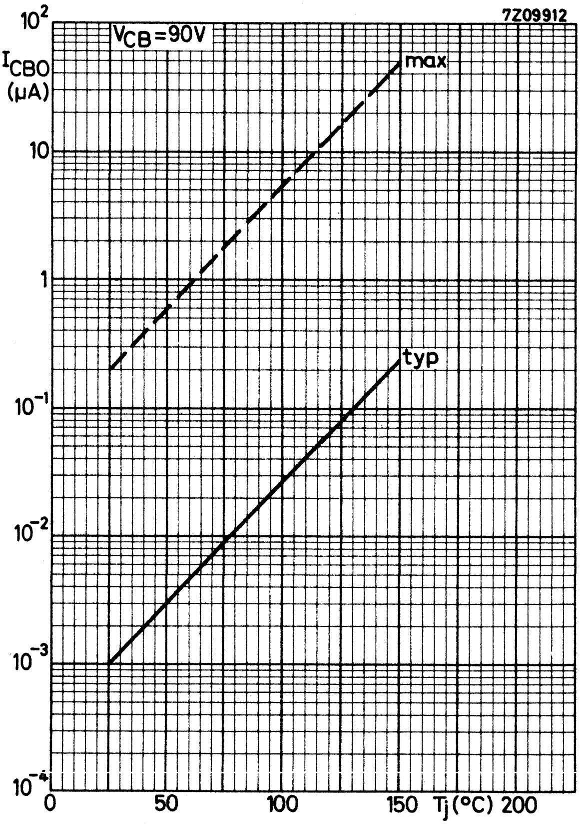

7Z09908
V_{CE} = 1V
T_j = 25°C
h_{FE}
150
100
50
0
0
5
10
15
20
I_C (mA)
typ

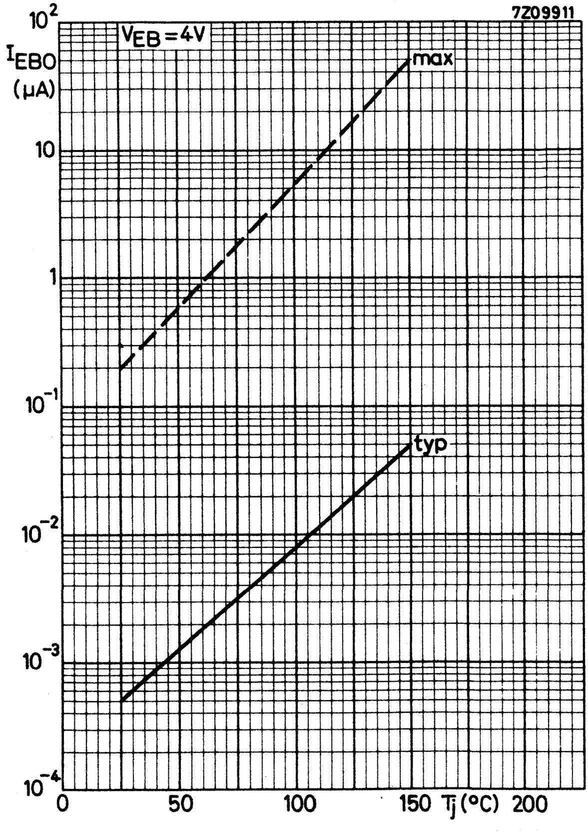

7Z09907
typical values
V_{CE} = 1V
h_{FE}
200
150
100
50
0
−50
0
50
100
150
200
T_j (°C)
I_C = 4mA
1mA
10mA
20mA

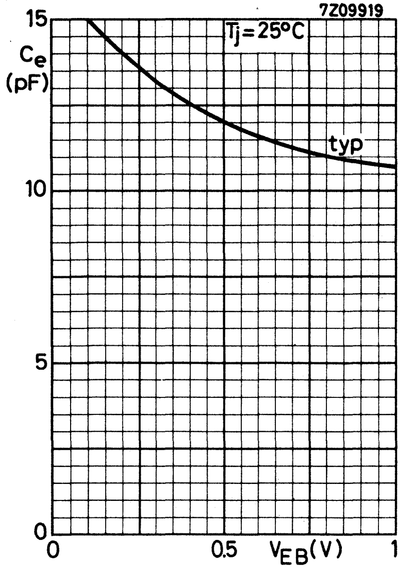

7Z09915
V_{CE} = 1V
T_j = 25°C
typ
80
I_C
(mA)
60
40
20
0
0
2
4
I_B (mA)
6

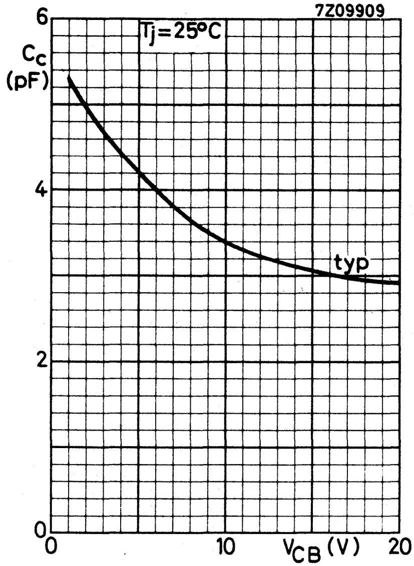

7Z09914
150
I_C
(mA)
V_{CE} = 1V
T_j = 25°C
typ
100
50
0
0
0.5
V_{BE} (V)
1


7Z09910
300
f_T
(MHz)
V_{CE} = 10V
f = 35MHz
T_j = 25°C
typ
200
100
0
0
5
10
15
I_C (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
$V_{EB} = 4V$
I_{EBO} (μA)
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
10^{-4}
max
typ
0
50
100
150
T_j (°C)
200


7Z09919
15
Ce
(pF)
Tj=25°C
typ
10
5
0
0
0.5
VEB(V)
1


7Z09909
6
Cc
(pF)
Tj=25°C
typ
4
2
0
0
10
VCB(V)
20

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in TO-39 metal envelopes with the collector connected to the case. These transistors are intended for general industrial applications.

QUICK REFERENCE DATA

			BSX45	BSX46	BSX47	
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	80	V
Collector current (d.c.)	I_C	max.		1		A
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.		5		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

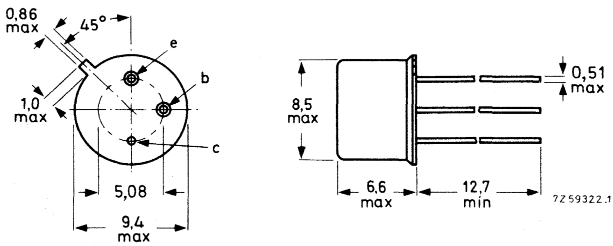
			BSX45–6 BSX46–6 BSX47–6	BSX45–10 BSX46–10 BSX47–10	BSX45–16 BSX46–16
D.C. current gain I_C = 100 mA; V_{CE} = 1 V	h_{FE}	>	40	63	100
		<	100	160	250

MECHANICAL DATA

Dimensions in mm

Collector connected to case

TO-39



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

Accessories supplied on request: 56218 (package); 56245 (distance disc).

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

Voltages

			BSX 45	BSX 46	BSX 47	
Collector-emitter voltage (open base)	V_{CEO}	max.	40	60	80	V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	80	100	120	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	7	7	V

Currents

Collector current (d.c.)	I_C	max.	1	A
Base current (d.c.)	I_B	max.	200	mA

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 ambient in free air	$R_{th\ j-a}$	=	200	°C/W
From junction to case	$R_{th\ j-c}$	=	35	°C/W

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

			BSX 45	BSX 46	BSX 47	
Collector cut-off currents						
V_{BE} = 0; V_{CE} = 60 V	I_{CES}	typ.	1	1	–	nA
		<	30	30	–	nA
V_{BE} = 0; V_{CE} = 60 V; T_{amb} = 150 °C	I_{CES}	typ.	1	1	–	μA
		<	10	10	–	μA
V_{BE} = 0; V_{CE} = 80 V	I_{CES}	<	–	–	30	nA
V_{BE} = 0; V_{CE} = 80 V; T_{amb} = 150 °C	I_{CES}	<	–	–	10	μA
V_{BE} = 0,2 V; V_{CE} = 60 V; T_{amb} = 100 °C	I_{CEX}	<	50	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} = 5 V	I_{EBO}	<	10	10	10	nA
Breakdown voltages						
I_B = 0; I_C = 50 mA	$V_{(BR)CEO}$	>	40	60	80	V
V_{BE} = 0; I_C = 100 μA	$V_{(BR)CES}$	>	80	100	120	V
I_C = 0; I_E = 100 μA	$V_{(BR)EBO}$	>	7	7	7	V
Base-emitter voltage						
I_C = 100 mA; V_{CE} = 1 V	V_{BE}	<	1	1	1	V
I_C = 500 mA; V_{CE} = 1 V	V_{BE}	>	0,75	0,75	0,75	V
		<	1,50	1,50	1,50	V
I_C = 1 A; V_{CE} = 1 V	V_{BE}	typ.	1,30	1,30	1,30	V
		<	2,00	2,00	2,00	V
Saturation voltages						
I_C = 1000 mA; I_B = 100 mA	V_{CEsat}	typ.	0,7	0,7	–	V
		<	1,0	1,0	–	V
I_C = 500 mA; I_B = 25 mA	V_{CEsat}	typ.	–	–	0,5	V
		<	–	–	0,9	V
Transition frequency at f = 20 MHz						
I_C = 50 mA; V_{CE} = 10 V	f_T	>	50	50	50	MHz
Collector capacitance at f = 1 MHz						
I_E = I_e = 0; V_{CB} = 10 V	C_c	<	25	20	15	pF
Emitter capacitance at f = 1 MHz						
I_C = I_c = 0; V_{EB} = 0,5 V	C_e	<	80	80	80	pF

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

Noise figure at f = 1 kHz

I_C = 100 μA; V_{CE} = 10 V R_S = 1 kΩ; B = 200 Hz	F	typ.	3,5	dB

D.C. current gain

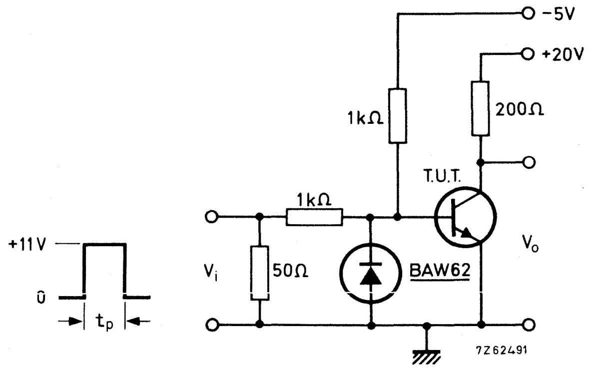
			BSX45-6 BSX46-6 BSX47-6	BSX45-10 BSX46-10 BSX47-10	BSX45-16 BSX46-16
I_C = 100 μA ; V_{CE} = 1 V	h_{FE}	>	10	15	25
		typ.	28	40	90
I_C = 100 mA; V_{CE} = 1 V	h_{FE}	>	40	63	100
		typ.	63	100	160
		<	100	160	250
I_C = 500 mA; V_{CE} = 1 V	h_{FE}	>	15	25	35
		typ.	25	40	60
I_C = 1 A ; V_{CE} = 1 V	h_{FE}	typ.	15	20	30

Switching times

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

Turn-on time	t_{on}	<	200	ns
Turn-off time	t_{off}	<	850	ns

Test circuit:



Pulse generator:		Oscilloscope:	
Pulse duration	t_p = 10 μs	Rise time	t_r ≤ 15 ns
Rise time	t_r ≤ 15 ns	Input impedance	Z_I ≥ 100 kΩ
Fall time	t_f ≤ 15 ns		
Source impedance	Z_S = 50 Ω		

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

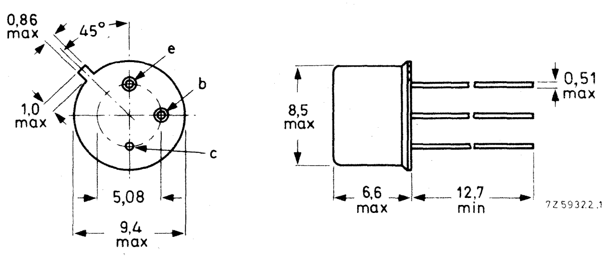
			BSX59	BSX60	BSX61	
Collector-base voltage (open emitter)	V_{CBO}	max.	70	70	70	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	30	45	V
Collector current (peak value)	I_{CM}	max.	1	1	1	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8	0,8	0,8	W
Junction temperature	T_j	max.	200	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



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

Accessories supplied on request: 56218 (package); 56245 (distance disc).

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

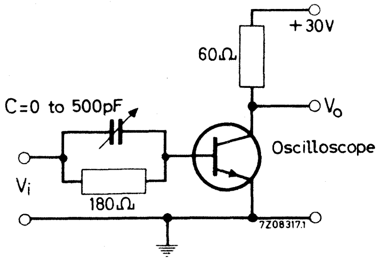
			BSX59	BSX60	BSX61	
Collector cut-off current						
$I_E = 0$; $V_{CB} = 40$ V	I_{CBO}	<	500	500	500	nA
$I_E = 0$; $V_{CB} = 40$ V; $T_j = 150$ °C	I_{CBO}	<	300	300	300	µA
Emitter cut-off current						
$I_C = 0$; $V_{EB} = 4$ V	I_{EBO}	<	300	300	500	nA
$I_C = 0$; $V_{EB} = 4$ V; $T_j = 150$ °C	I_{EBO}	<	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

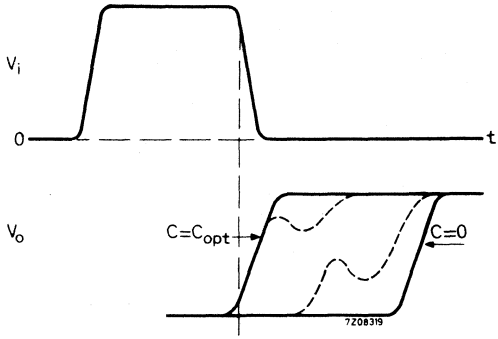
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

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:

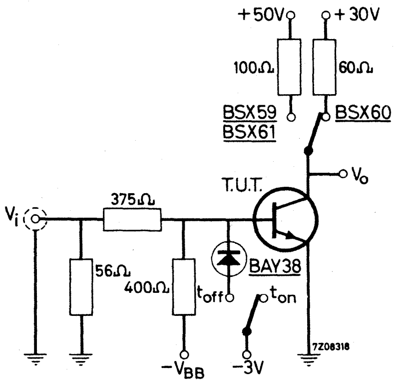
Pulse duration	t_p =	10 μs
Duty cycle	δ =	0.02

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

Switching times (see also page 11)

			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

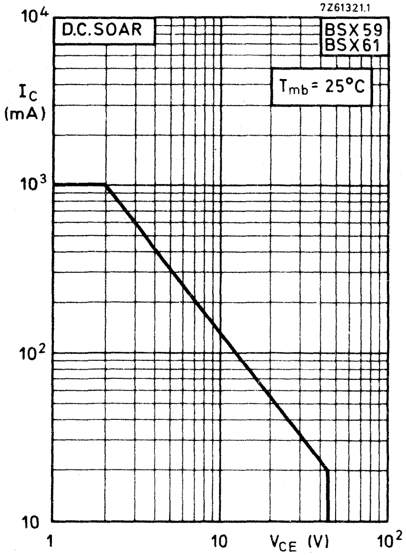
Test circuit:

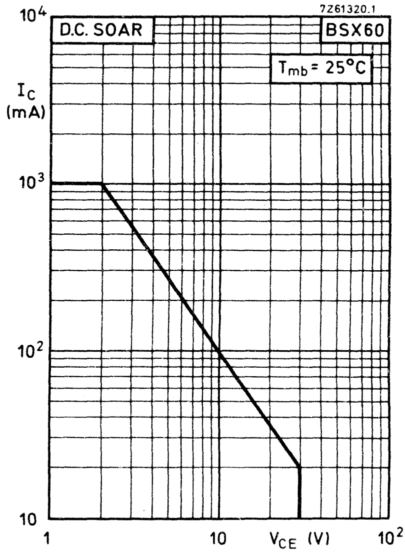


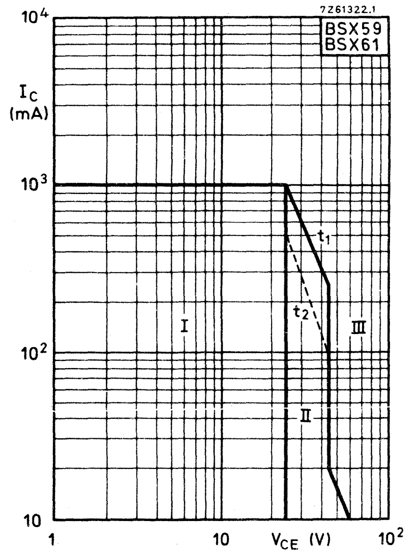
	t_{on}	t_{off}	
V_{BB}	4	16.7	V
V_i	24.75	37.5	V

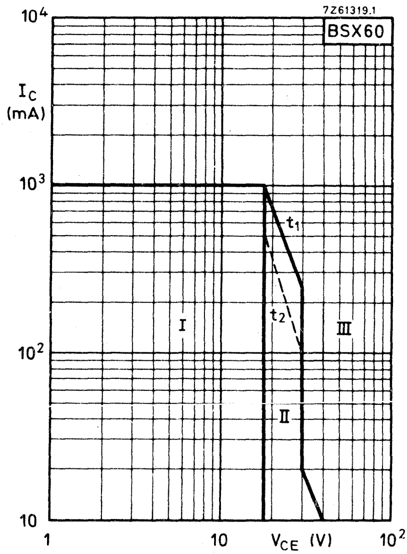
Pulse generator:	Pulse duration	t_p	$\geq$	500 ns
	Rise time	t_r	$\leq$	5 ns
	Fall time	t_f	$\leq$	5 ns
	Output resistance	R_o	=	50 Ω (during pulse, otherwise infinite)

[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.



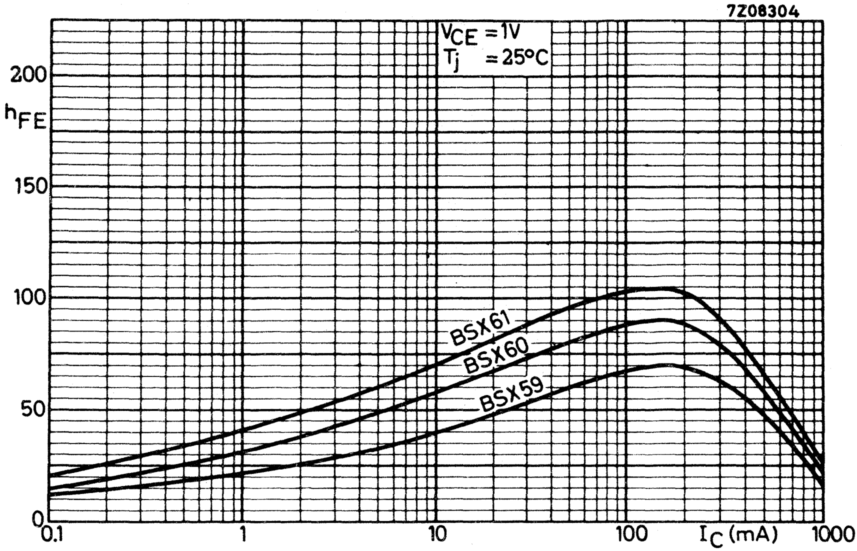


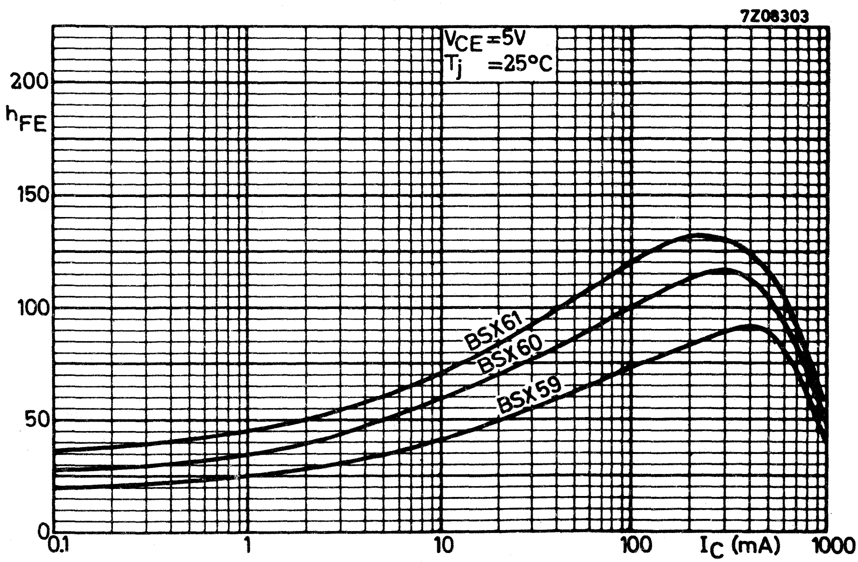


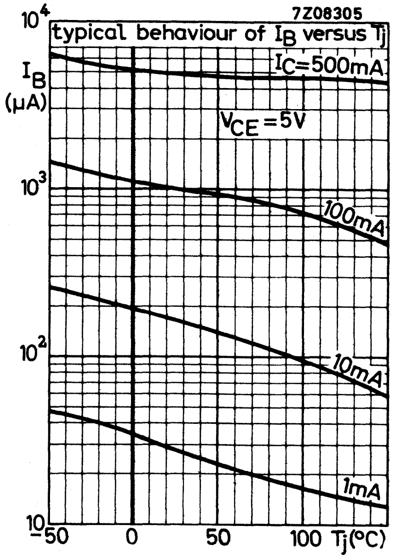


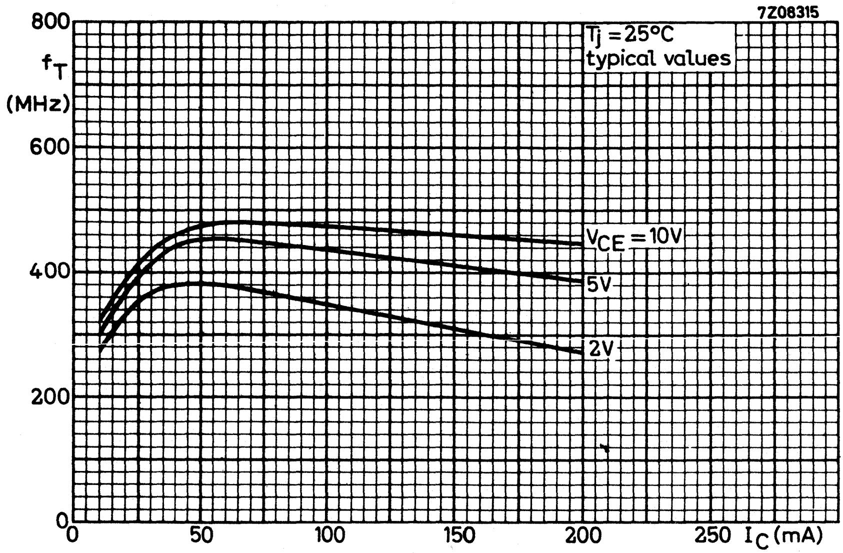
I Region of permissible operation during switching off with $-V_{BB}$ = 4 V; R_{BE} = 39 Ω
II Permissible extension for repetitive pulsed operation.
t_1 limits operations with $t_p \leq 0.1$ μs; δ = 0.25
t_2 limits operations with $t_p \leq 1$ μs; δ = 0.25
III Operation in this area is not allowed.

Typical behaviour of d.c. current gain versus I_C

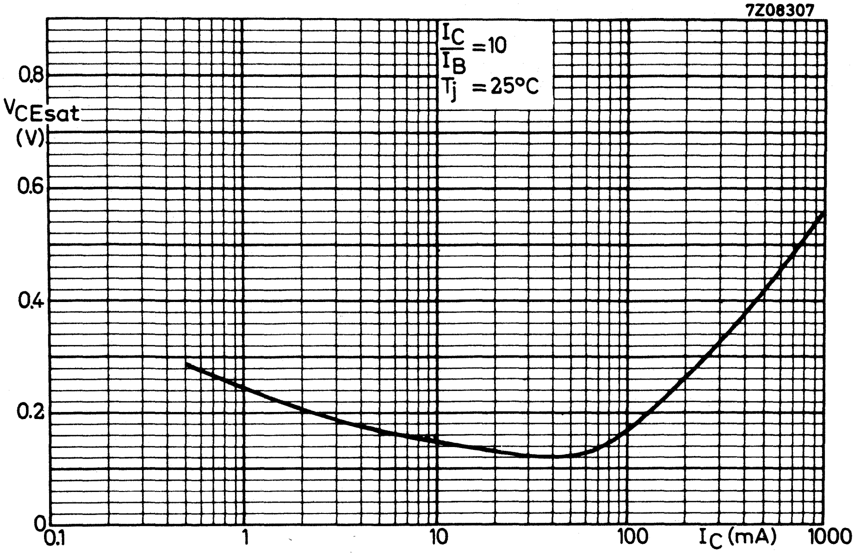


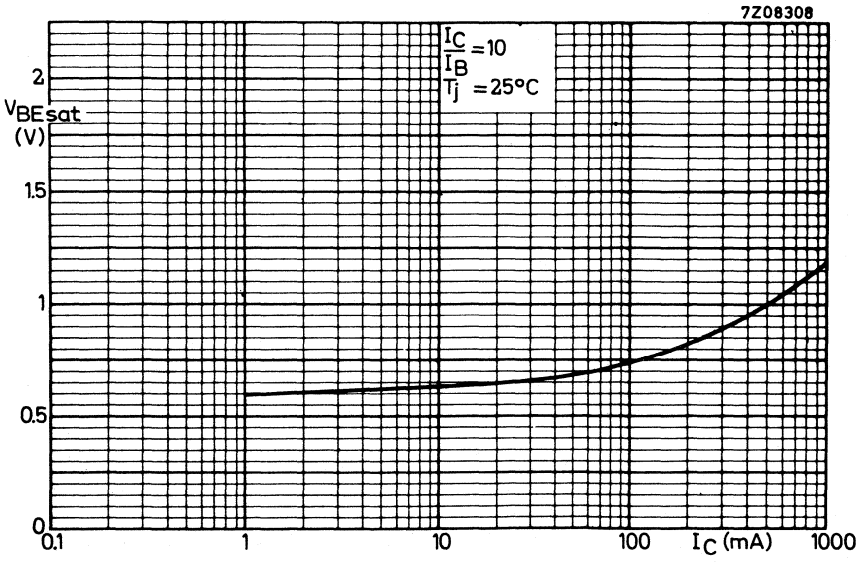



7Z08305
typical behaviour of I_B versus T_j
I_B (µA)
I_C=500mA
V_{CE}=5V
100mA
10mA
1mA
10^4
10^3
10^2
10
−50
0
50
100
T_j(°C)

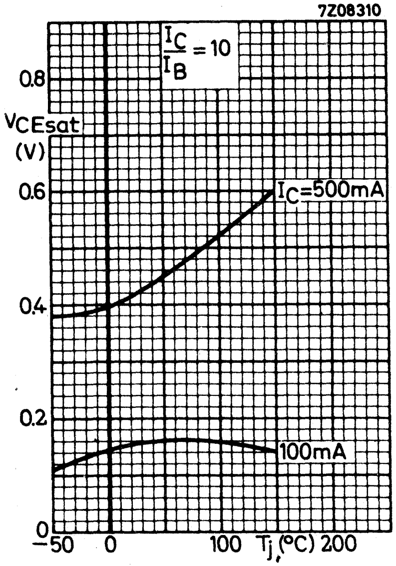

7Z08315
T_j = 25°C
typical values
f_T (MHz)
V_{CE}=10V
5V
2V
800
600
400
200
0
0
50
100
150
200
250
I_C (mA)

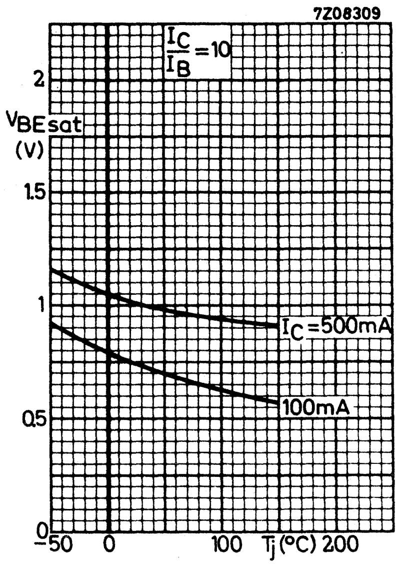
Typical behaviour of saturation voltages versus I_C

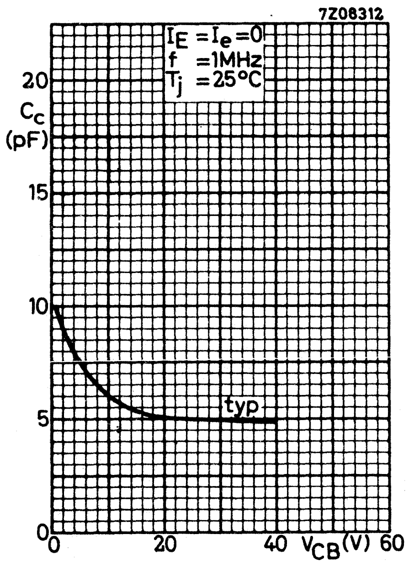


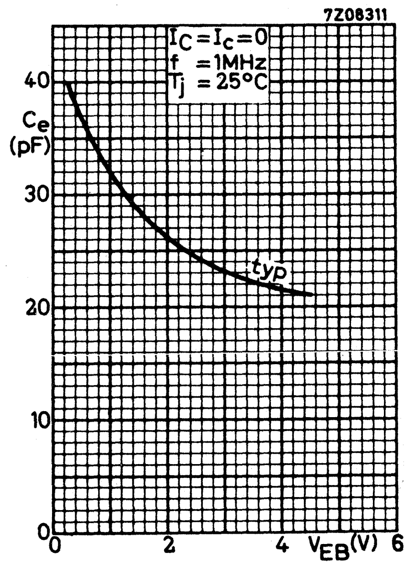


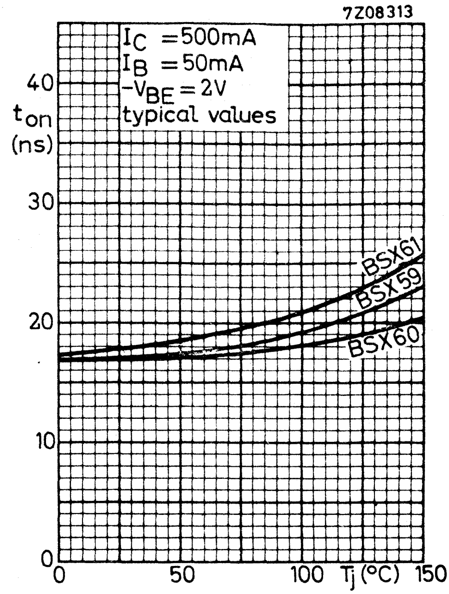
Typical behaviour of saturation voltages versus T_j

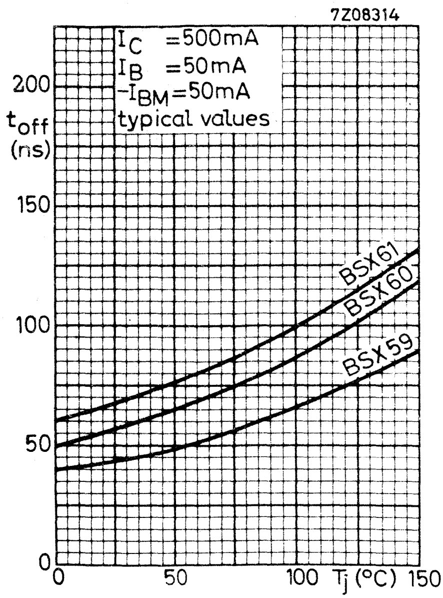


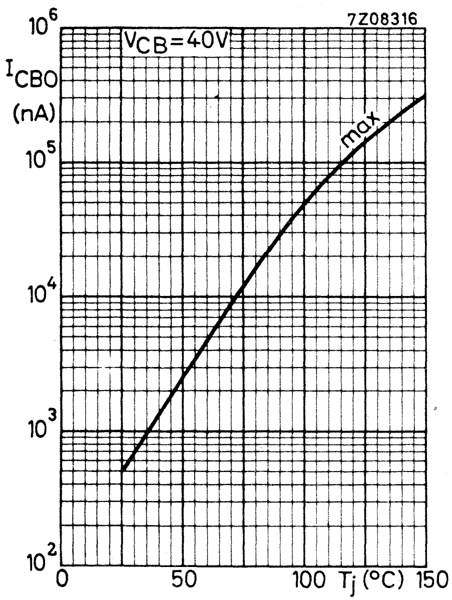


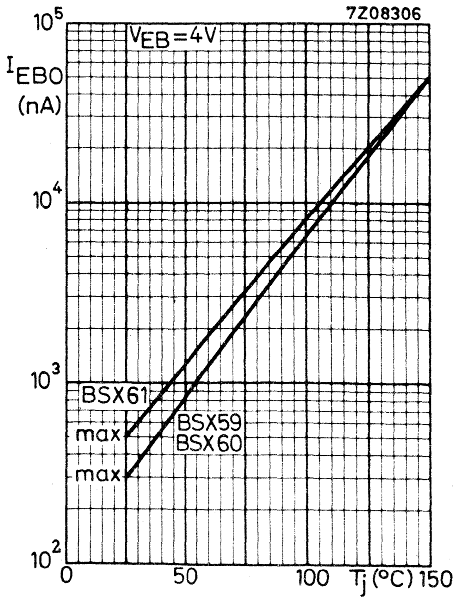





7Z08313
I_C =500mA
I_B =50mA
$-V_{BE}$=2V
typical values
t_{on}
(ns)
BSX61
BSX59
BSX60
T_j (°C)


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)

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.

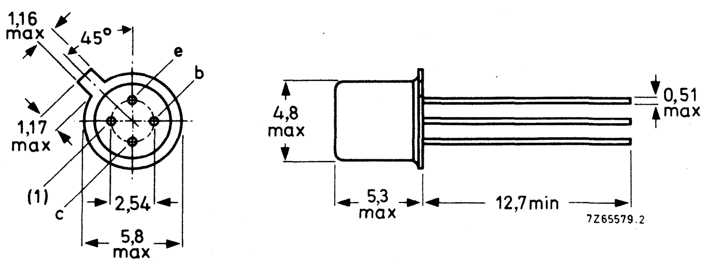
QUICK REFERENCE DATA

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 unilateralized 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



(1) = shield lead (connected to case).

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

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	$R_{th\ j-a}$	=	0.88	°C/mW
From junction to case	$R_{th\ j-c}$	=	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.

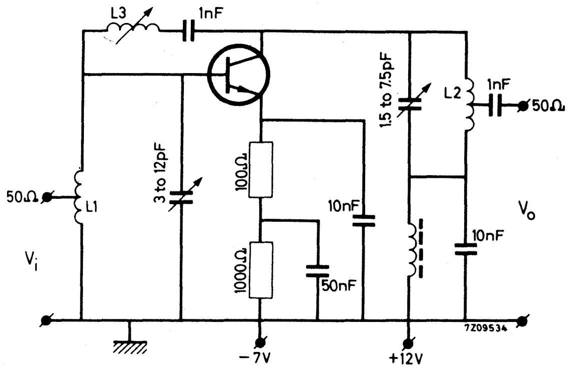
CHARACTERISTICS (continued) $T_j = 25\ ^oC$

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

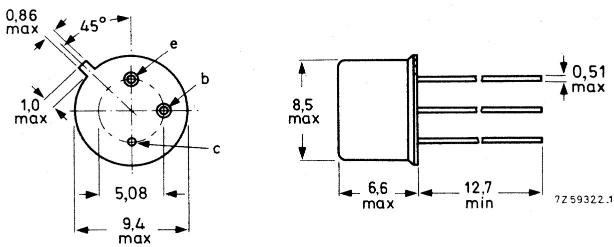
Collector-base voltage (open emitter)	V_{CBO}	max.	75	V
Collector-emitter voltage ($R_{BE} < 10\ \Omega$)	V_{CER}	max.	50	V
Collector current (peak value)	I_{CM}	max.	1	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8	W
Junction temperature	T_j	max.	200	°C
D.C. current gain				
I_C = 0,1 mA; V_{CE} = 10 V	h_{FE}	>	20	
I_C = 10 mA; V_{CE} = 10 V	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



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

Accessories supplied on request: 56218 (package); 56245 (distance disc).

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. It is intended for use in a wide variety of applications, such as d.c. and high frequency amplifiers and switching applications.

QUICK REFERENCE DATA

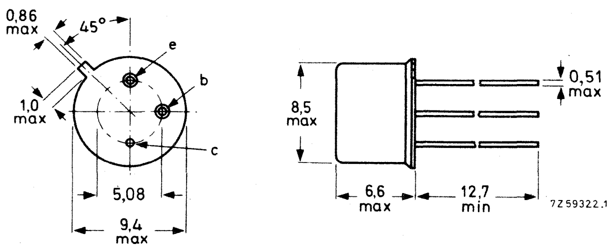
Collector-base voltage (open emitter)	V_{CBO}	max.	75	V
Collector-emitter voltage ($R_{BE} < 10\ \Omega$)	V_{CER}	max.	50	V
Collector current (peak value)	I_{CM}	max.	1	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8	W
Junction temperature	T_j	max.	200	°C
D.C. current gain				
I_C = 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



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

Accessories supplied on request: 56218 (package); 56245 (distance disc).

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}	<	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

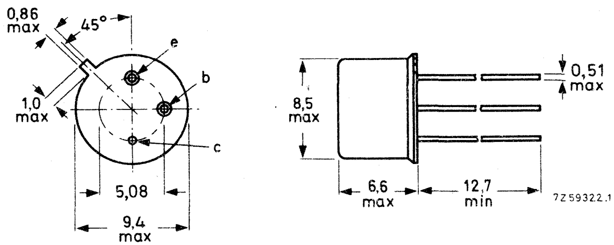
Collector-base voltage (open emitter)	V_{CBO}	max.	120	V
Collector-emitter voltage ($R_{BE} \leq 10\ \Omega$)	V_{CER}	max.	100	V
Collector current (d.c.)	I_C	max.	500	mA
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	3,0	W
Junction temperature	T_j	max.	200	°C
D.C. current gain				
I_C = 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



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

Accessories supplied on request: 56218 (package); 56245 (distance disc).

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				
$I_E = 0$; $I_C = 100\ \mu$A	$V_{(BR)\ CBO}$	>	120	V
$I_C = 0$; $I_E = 100\ \mu$A	$V_{(BR)\ EBO}$	>	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 $t \leq 300\ \mu s$, 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 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

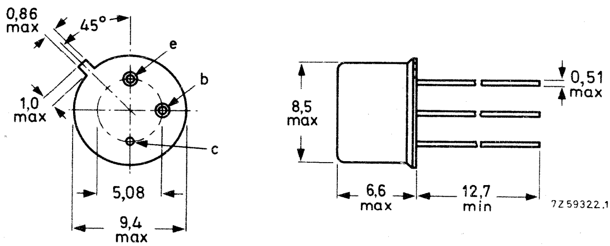
			2N2218	2N2218A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40	V
Collector current (d.c.)	I_C	max.	800	800	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8	0,8	W
Junction temperature	T_j	max.	175	175	°C
D.C. current 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



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

Accessories supplied on request: 56218 (package); 56245 (distance disc).

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	$R_{th\ j-a}$	=	190	°C/W
From junction to case	$R_{th\ j-c}$	=	50	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector-cut-off current			2N2218	2N2218A	
$I_E = 0$; $V_{CB} = 50$ 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; $T_{amb} = -55$ °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	$\mu\Omega^{-1}$

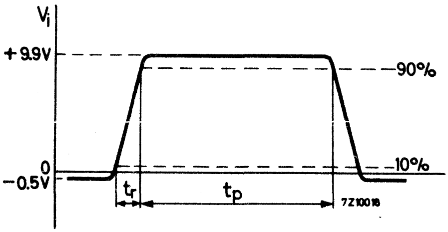
		2N2218	2N2218A	
$I_C = 20$ mA; $V_{CE} = 20$ V; f = 100 MHz				
Small signal current gain	h_{fe}	> 2.5	2.5	
$I_C = 20$ mA; $V_{CE} = 20$ V; f = 300 MHz				
Real part of input impedance	$Re(h_{ie})$	< 60	60	Ω

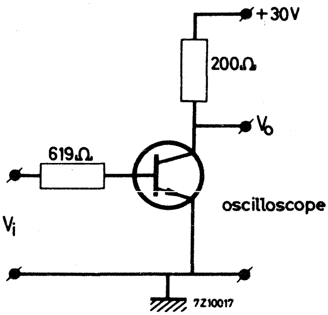
Switching times for 2N2218A

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

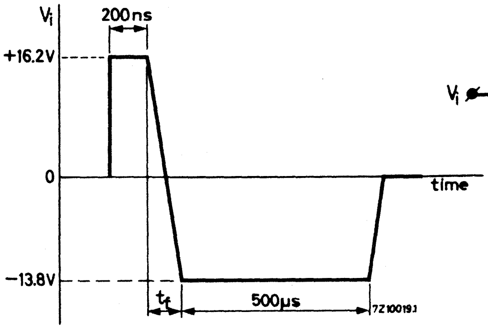
CHARACTERISTICS (continued) $T_j = 25\ ^oC$

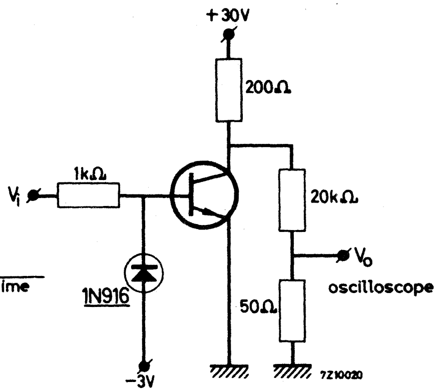
Switching times for 2N2218A

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

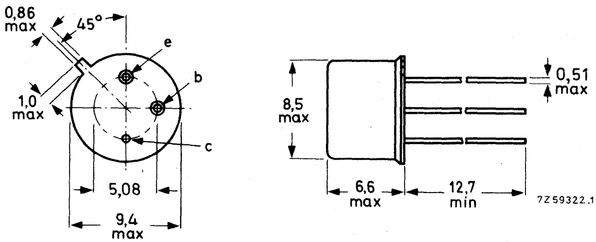
			2N2219	2N2219A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40	V
Collector current (d.c.)	I_C	max.	800	800	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8	0,8	W
Junction temperature	T_j	max.	175	175	°C
D.C. current 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

Collector connected to case

TO-39



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

Accessories supplied on request: 56218 (package); 56245 (distance disc).

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

Collector cut-off current			2N2219	2N2219A	
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 μA	$V_{(BR)CBO}$	>	60	75	V
I_B = 0; I_C = 10 mA	$V_{(BR)CEO}$	>	30	40	V
I_C = 0; I_E = 10 μA	$V_{(BR)EBO}$	>	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 °C

h parameters (common emitter)

		2N2219	2N2219A	
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 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	$\mu\Omega^{-1}$
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

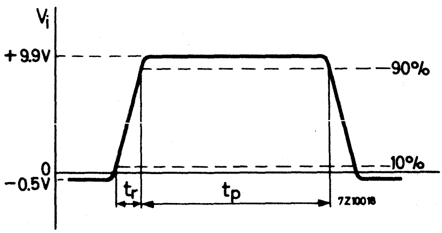
		2N2219	2N2219A	
I_C = 0.1 mA; V_{CE} = 10 V R_G = 1 kΩ; B = 1 Hz	F	< –	4	dB

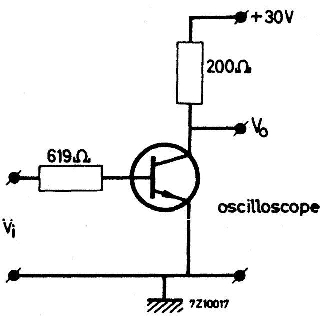
Switching times for 2N2219A

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	≤ 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

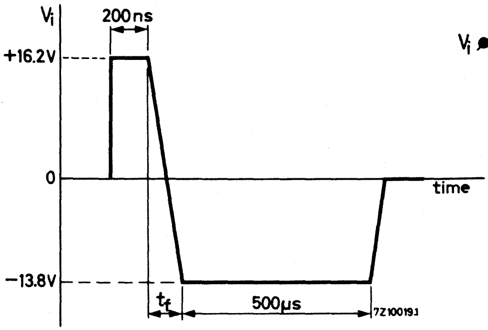
CHARACTERISTICS (continued) $T_j = 25\ ^oC$

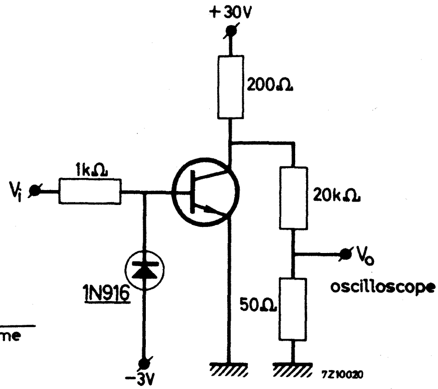
Switching times for 2N2219A

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

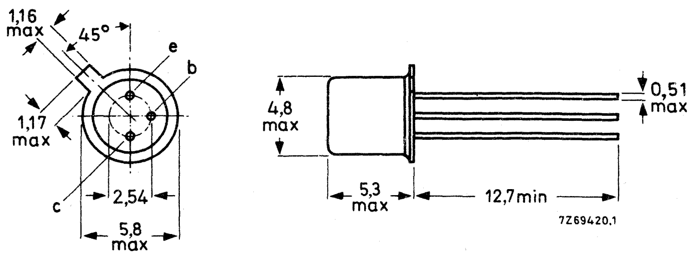
			2N2221	2N2221A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40	V
Collector current (d.c.)	I_C	max.	800	800	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,5	0,5	W
Junction temperature	T_j	max.	175	175	°C
D.C. current 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 supplied on request: 56246 (distance disc); 56263 (cooling fin).

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 °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 ≤ 300 μs; duty cycle ≤ 2%.

CHARACTERISTICS (continued) T_j = 25 °C

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

		2N2221A	
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	$\mu\Omega^{-1}$

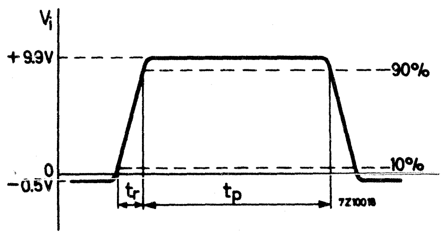
		2N2221	2N2221A	
I_C = 20 mA; V_{CE} = 20 V; f = 100 MHz				
Small signal current gain	h_{fe}	> 2.5	2.5	
I_C = 20 mA; V_{CE} = 20 V; f = 300 MHz				
Real part of input impedance	$Re(h_{ie})$	< 60	60	Ω

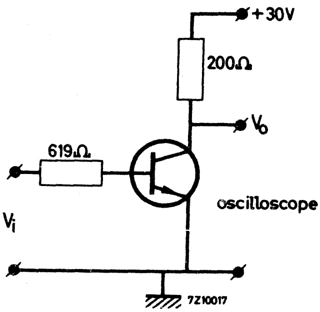
Switching times for 2N2221A

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

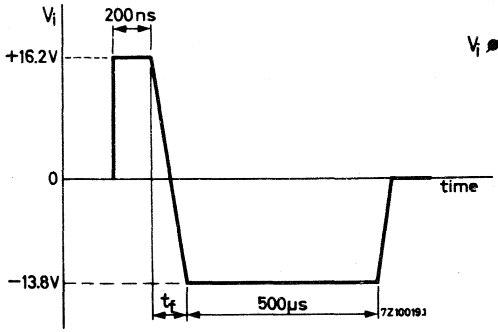
CHARACTERISTICS (continued) T_j = 25 °C

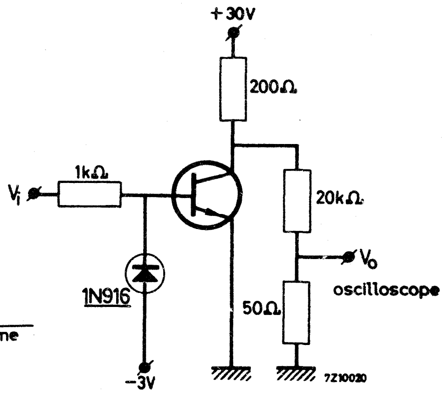
Switching times for 2N2221A

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

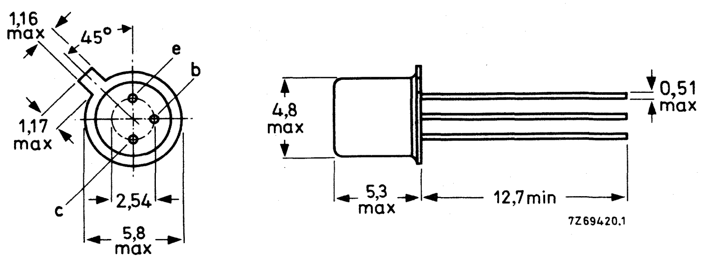
			2N2222	2N2222A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40	V
Collector current (d.c.)	I_C	max.	800	800	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,5	0,5	W
Junction temperature	T_j	max.	175	175	°C
D.C. current gain at T_j = 25 °C I_C = 10 mA; V_{CE} = 10 V	h_{FE}	>	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 supplied on request: 56246 (distance disc); 56263 (cooling fin).

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	$R_{th\ j-a}$	=	300	°C/W
From junction to case	$R_{th\ j-c}$	=	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 μA	$V_{(BR)CBO}$	>	60	75	V
I_B = 0; I_C = 10 mA	$V_{(BR)CEO}$	>	30	40	V
I_C = 0; I_E = 10 μA	$V_{(BR)EBO}$	>	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

		2N2222A	
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

		2N2222A	
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	$\mu\Omega^{-1}$

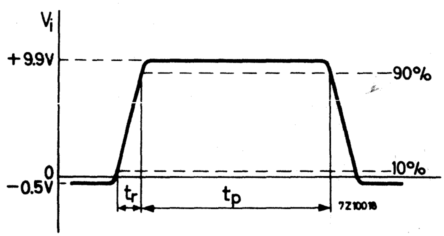
		2N2222	2N2222A	
$I_C = 20$ mA; $V_{CE} = 20$ V; f = 100 MHz				
Small signal current gain	h_{fe}	> 2.5	3.0	
$I_C = 20$ mA; $V_{CE} = 20$ V; f = 300 MHz				
Real part of input impedance	$Re(h_{ie})$	< 60	60	Ω
Noise figure at f = 1 kHz				
$I_C = 0.1$ mA; $V_{CE} = 10$ V $R_G = 1$ kΩ; B = 1 Hz	F	< –	4	dB

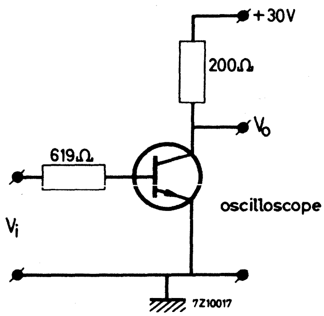
Switching times for 2N2222A

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:				Oscilloscope:			
pulse duration	t_p	≤	200 ns	input resistance	R_i	>	100 kΩ
rise time	t_r	≤	2 ns	input capacitance	C_i	<	12 pF
				rise time	t_r	<	5 ns

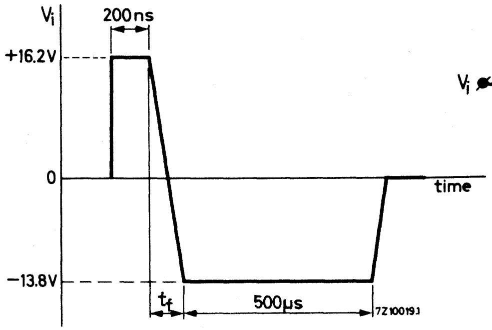
CHARACTERISTICS (continued) $T_j = 25\ ^oC$

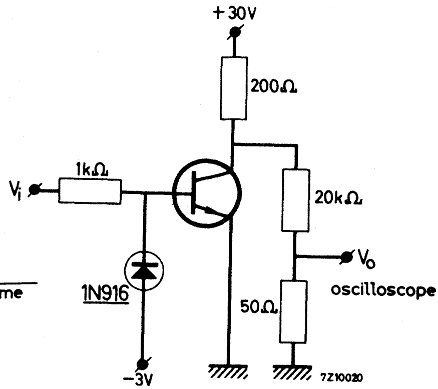
Switching times for 2N2222A

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
input capacitance	C_i	<	12 pF
rise time	t_r	<	5 ns

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 in accordance with the Absolute Maximum System (IEC 134)

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
Collector current (d.c. or average over any 20 ms period)	I_C	max.	1	A
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
Storage temperature	T_{stg}	−65 to + 200		°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

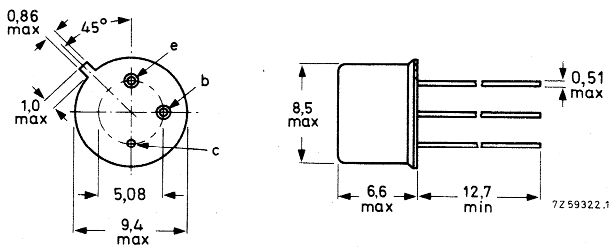
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0,22	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0,035	°C/mW

MECHANICAL DATA

Dimensions in mm

Collector connected to case

TO-39



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

Accessories supplied on request: 56218 (package); 56245 (distance disc).

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 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

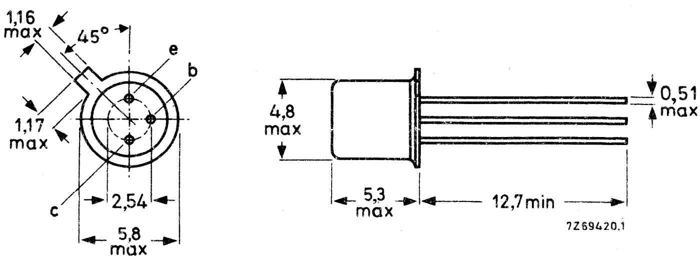
Collector-base voltage (open emitter)		V_{CBO}	max.	40	V
Collector-emitter voltage (open base)		V_{CEO}	max.	15	V
Collector current (peak value)		I_{CM}	max.	500	mA
Total power dissipation up to T_{amb} = 25 °C		P_{tot}	max.	360	mW
Junction temperature		T_j	max.	200	°C
D.C. current gain at T_j = 25 °C; I_C = 10 mA; V_{CE} = 1 V	**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 supplied on request: 56246 (distance disc); 56263 (cooling fin).

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

D.C. current gain [1]

			2N2368	2N2369	
$I_C = 10$ 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

			2N2368	2N2369	
$I_C = 10$ 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

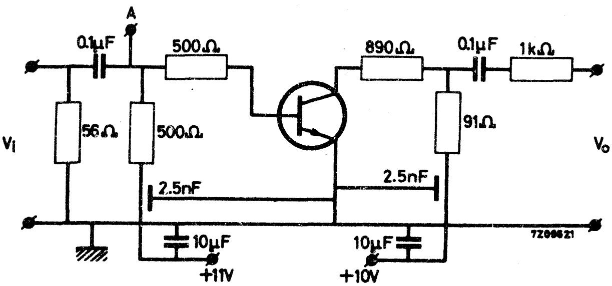
CHARACTERISTICS (continued) $T_j = 25\ ^{o}C$

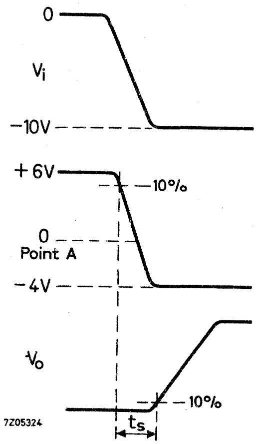
Storage time

$I_C = I_B = -I_{BM} = 10$ mA

2N2368	t_s	<	10	ns
2N2369	t_s	<	13	ns

Test circuit: [1])





Turn on time

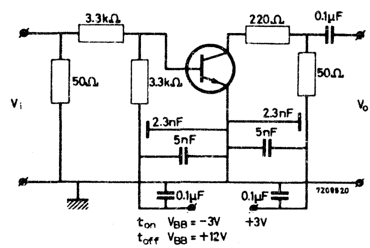
$I_C = 10$ mA; $I_B = 3$ mA; $-V_{BE} = 1.5$ V — t_{on} < 12 ns

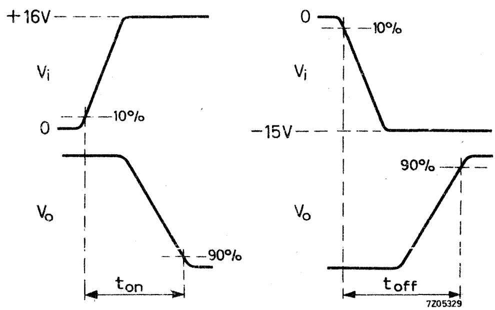
Turn off time

$I_C = 10$ mA; $I_B = 3$ mA; $-I_{BM} = 1.5$ mA

2N2368	t_{off}	<	15	ns
2N2369	t_{off}	<	18	ns

Test circuit: [1])





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1) Pulse generator:

Pulse duration	t	$\geq$	300	ns
Duty cycle	δ	$\leq$	0.02	
Rise time	t_r	$\leq$	1	ns
Source impedance	R_S	=	50	Ω

Oscilloscope:

Rise time	t_r	$\leq$	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

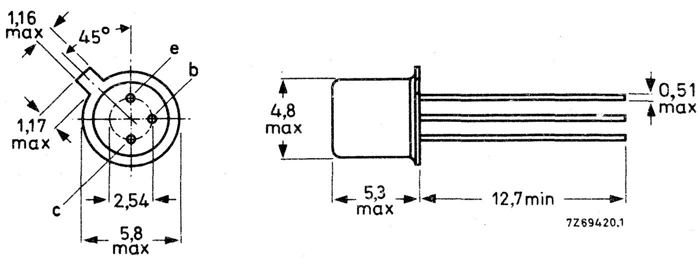
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector current (peak value)	I_{CM}	max.	500	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360	mW
Junction temperature	T_j	max.	200	°C
D.C. current gain at T_j = 25 °C I_C = 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 case

TO-18



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

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	$R_{th\ j-a}$	=	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				
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

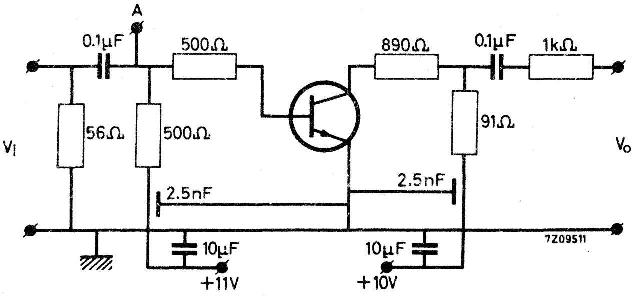
[1] Measured under pulsed conditions to avoid excessive dissipation
Pulse duration t = 300 μs; duty cycle δ < 0.01

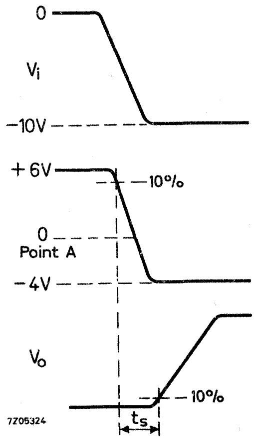
CHARACTERISTICS (continued) $T_j = 25\ ^oC$

Storage time

$I_C = I_B = -I_{BM} = 10$ mA $t_s < 13$ ns

Test circuit: [1])





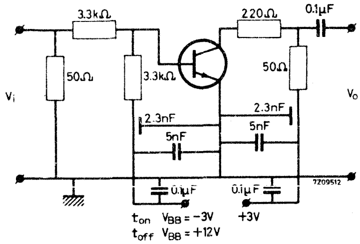
Turn on time

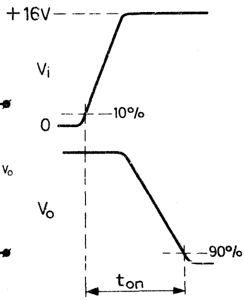
$I_C = 10$ mA; $I_B = 3$ mA; $-V_{BE} = 1.5$ V $t_{on} < 12$ ns

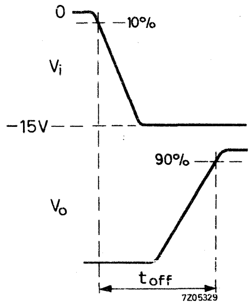
Turn off time

$I_C = 10$ mA; $I_B = 3$ mA; $-I_{BM} = 1.5$ mA $t_{off} < 18$ ns

Test circuit: [1])







[1]) Pulse generator:

Pulse duration	t	$\geq$	300	ns
Duty cycle	δ	$\leq$	0.02	
Rise time	t_r	$\leq$	1	ns
Source impedance	R_S	=	50	Ω

Oscilloscope:

Rise time	t_r	$\leq$	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

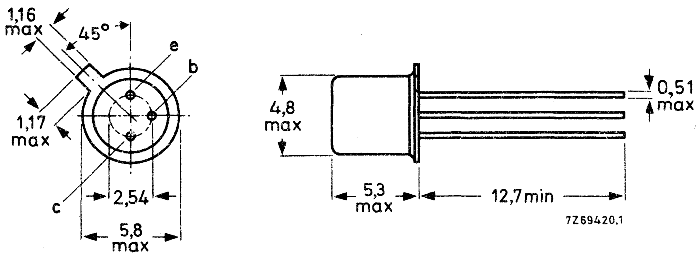
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	12		V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	12		V
Collector current (d.c.)	$-I_C$	max.	200		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360		mW
Junction temperature	T_j	max.	200		°C
D.C. current gain at T_{amb} = 25 °C $-I_C$ = 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 (distance disc); 56263 (cooling fin).

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	$R_{th\ j-a}$	=	486	°C/W
From junction to case	$R_{th\ j-c}$	=	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

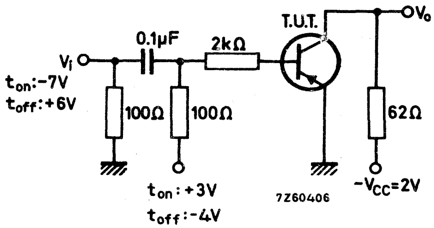
Switching times

T_{amb} = 25 °C

$-I_C$ = 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

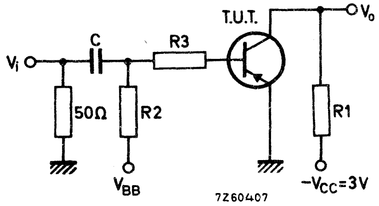
Sampling scope:

Rise time	t_r	<	1 ns
Input impedance	Z_i	=	100 kΩ

Switching times (continued) $T_{amb} = 25\ ^{o}C$

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

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

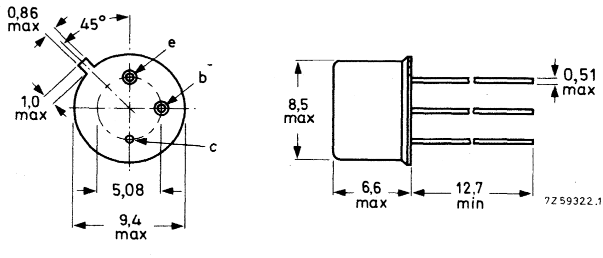
D.C. current gain at T_j = 25 °C			2N2904	2N2904A
$-I_C$ = 0,1 mA; $-V_{CE}$ = 10 V	h_{FE}	>	20	40
$-I_C$ = 10 mA; $-V_{CE}$ = 10 V	h_{FE}	>	35	40
$-I_C$ = 500 mA; $-V_{CE}$ = 10 V	h_{FE}	>	20	40

MECHANICAL DATA

Dimensions in mm

Collector connected to case

TO-39



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

Accessories supplied on request: 56218 (package); 56245 (distance disc).

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	$R_{th\ j-a}$	=	290	°C/W
From junction to case	$R_{th\ j-c}$	=	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 ≤ 300 μs; duty cycle $\delta \leq 0.02$.

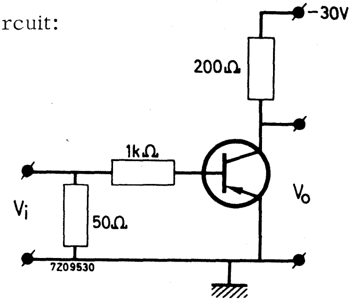
CHARACTERISTICS (continued) T_j = 25 °C

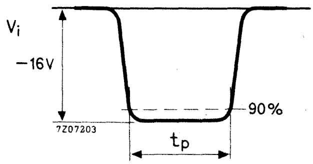
Switching times

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:

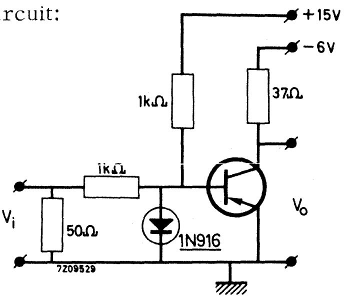
Rise time	t_r	≤	5 ns
Input impedance	Z_i	=	10 MΩ

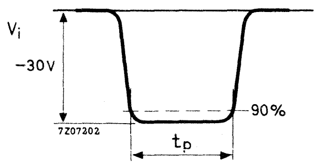
Pulse generator:	Frequency	f	=	150 Hz
	Pulse duration	t_p	=	200 ns
	Rise time	t_r	≤	2 ns
	Output impedance	Z_o	=	50 Ω

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

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

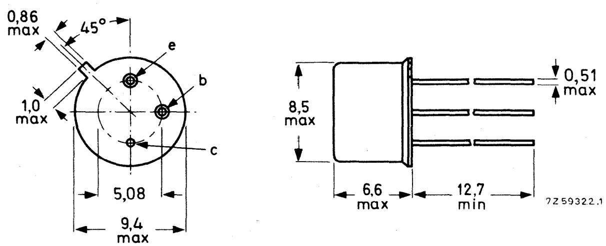
Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60		V
Collector-emitter voltage (open base)	**2N2905**	$-V_{CEO}$	max.	40		V
	2N2905A	$-V_{CEO}$	max.	60		V
Collector current (d.c.)		$-I_C$	max.	0,6		A
Total power dissipation up to T_{amb} = 25 °C		P_{tot}	max.	0,6		W
Junction temperature		T_j	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

Collector connected to case

TO-39



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

Accessories supplied on request: 56218 (package); 56245 (distance disc).

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	$R_{th\ j-a}$	=	290	°C/W
From junction to case	$R_{th\ j-c}$	=	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

			2N2905	2N2905A	
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	60	V
$I_B = 0$; $-I_C = 10$ mA (2N2905)	$-V_{(BR)CEO}$	>	40		V
$I_B = 0$; $-I_C = 10$ mA (2N2905A)	$-V_{(BR)CEO}$	>		60	V
$I_C = 0$; $-I_E = 10$ μA	$-V_{(BR)EBO}$	>	5	5	V
Saturation voltages [1]					
$-I_C = 150$ mA; $-I_B = 15$ mA	$-V_{CEsat}$	<	0.4	0.4	V
	$-V_{BEsat}$	<	1.3	1.3	V
$-I_C = 500$ mA; $-I_B = 50$ mA	$-V_{CEsat}$	<	1.6	1.6	V
	$-V_{BEsat}$	<	2.6	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 ≤ 300 μs; duty cycle $\delta \leq 0.02$.

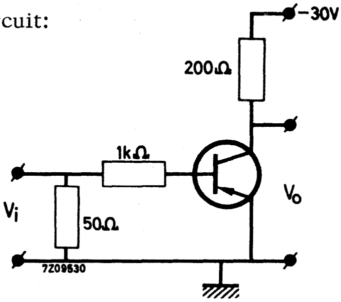
CHARACTERISTICS (continued) $T_j = 25\ ^oC$

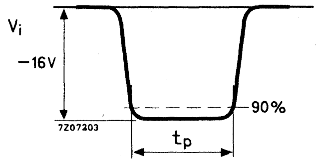
<u>Switching times</u>

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

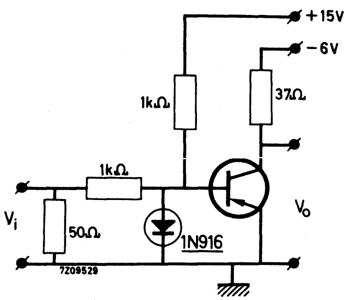
Pulse generator:

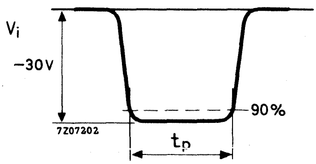
Frequency	f	=	150 Hz
Pulse duration	t_p	=	200 ns
Rise time	t_r	≤	2 ns
Output impedance	Z_o	=	50 Ω

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

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

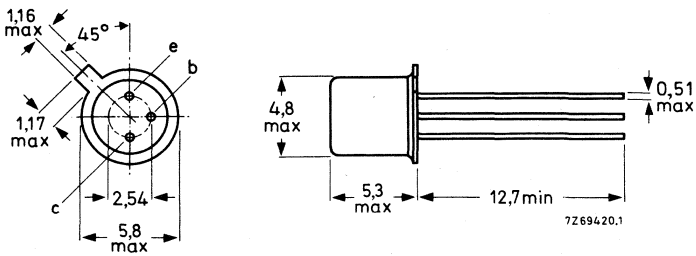
D.C. current gain at T_j = 25 °C			2N2906	2N2906A
$-I_C$ = 0,1 mA; $-V_{CE}$ = 10 V	h_{FE}	>	20	40
$-I_C$ = 10 mA; $-V_{CE}$ = 10 V	h_{FE}	>	35	40
$-I_C$ = 500 mA; $-V_{CE}$ = 10 V	h_{FE}	>	20	40

MECHANICAL DATA

Dimensions in mm

Collector connected to case

TO-18



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

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

Voltages

Collector-base voltage (open emitter)		$-V_{CBO}$	max.	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	$R_{th\ j-a}$	=	438	$^oC/W$
From junction to case	$R_{th\ j-c}$	=	97	$^oC/W$

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

				2N2906	2N2906A	
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	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 $\delta \leq 0.02$.

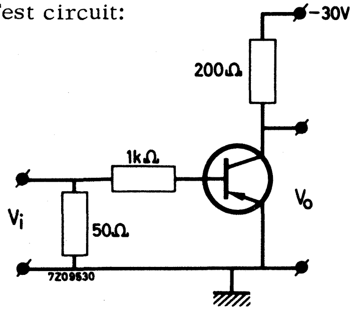
CHARACTERISTICS (continued) T_j = 25 °C

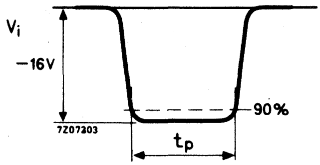
Switching times

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:





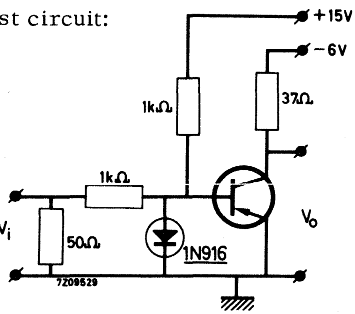
Oscilloscope:
Rise time $t_r \leq$ 5 ns
Input impedance Z_i = 10 MΩ

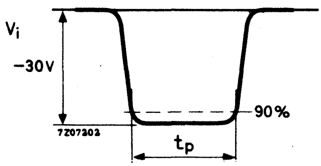
Pulse generator:	Frequency	f	=	150 Hz
	Pulse duration	t_p	=	200 ns
	Rise time	t_r	≤	2 ns
	Output impedance	Z_o	=	50 Ω

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	≤	2 ns
	Output impedance	Z_o	=	50 Ω

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

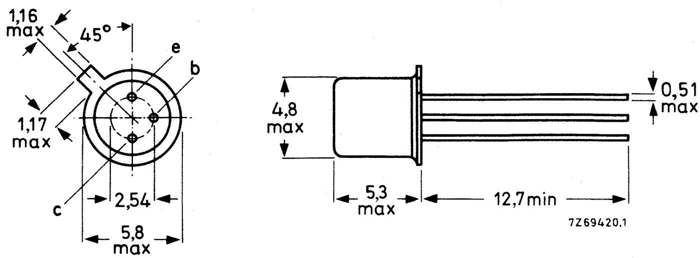
Collector-base voltage (open emitter)		$-V_{CBO}$	max.	60		V
Collector-emitter voltage (open base)	**2N2907**	$-V_{CEO}$	max.	40		V
	2N2907A	$-V_{CEO}$	max.	60		V
Collector current (d.c.)		$-I_C$	max.	0,6		A
Total power dissipation up to T_{amb} = 25 °C		P_{tot}	max.	0,4		W
Junction temperature		T_j	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 supplied on request: 56246 (distance disc); 56263 (cooling fin).

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

		2N2907	2N2907A	
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				
$I_E = 0$; $-I_C = 10\ \mu$A	$-V_{(BR)CBO}$	> 60		V
$I_B = 0$; $-I_C = 10$ mA 2N2907	$-V_{(BR)CEO}$	> 40		V
2N2907A	$-V_{(BR)CEO}$	> 60		V
$I_C = 0$; $-I_E = 10\ \mu$A	$-V_{(BR)EBO}$	> 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 < 300	100 300
$-I_C = 500$ 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 $t \leq 300\ \mu s$; duty cycle $\delta \leq 0.02$.

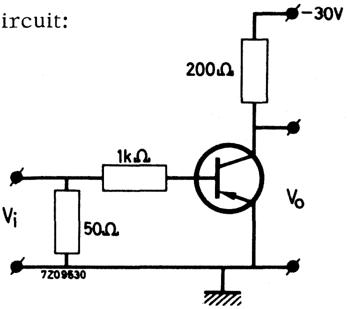
CHARACTERISTICS (continued) T_j = 25 °C

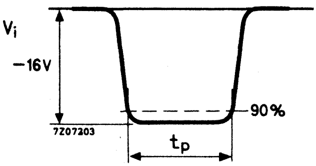
Switching times

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

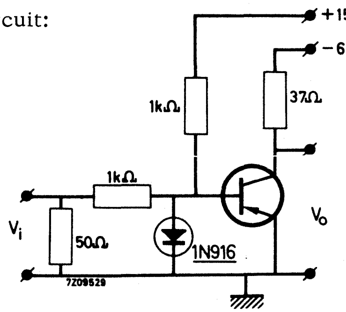
Pulse generator:

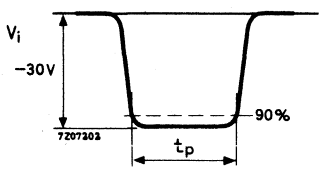
Frequency	f	=	150 Hz
Pulse duration	t_p	=	200 ns
Rise time	t_r	≤	2 ns
Output impedance	Z_o	=	50 Ω

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

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

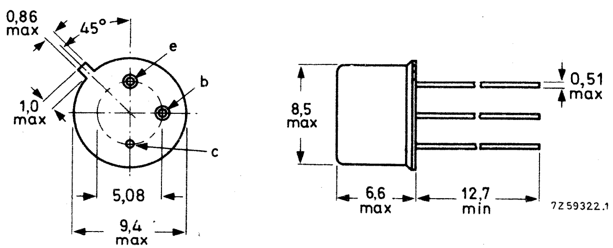
Collector-base voltage (open emitter)	V_{CBO}	max.	140		V
Collector-emitter voltage (open base)	V_{CEO}	max.	80		V
Collector current (d.c.)	I_C	max.	1		A
Total power dissipation					
up to T_{amb} = 25 °C	P_{tot}	max.	0,8		W
up to T_{case} = 25 °C	P_{tot}	max.	5,0		W
Junction temperature	T_j	max.	200		°C
			2N3019	2N3020	
D.C. current gain					
I_C = 150 mA; V_{CE} = 10 V	h_{FE}	>	100	40	
		<	300	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



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

Accessories supplied on request: 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 °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	40	
		<	300	120	
I_C = 150 mA; V_{CE} = 10 V; T_{case} = −55 °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	30	
		<	400	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; $\delta \leq 0,01$.

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in TO-39 metal envelopes primarily intended for large signal, low-noise, low-power audio frequency applications for industrial service.

QUICK REFERENCE DATA

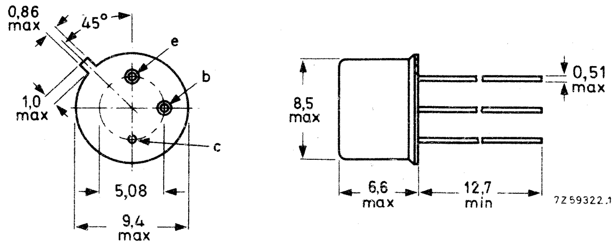
			2N4030 2N4032	2N4031 2N4033	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	V
Collector current (d.c.)	$-I_C$	max.	1		A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0,8		W
Junction temperature	T_j	max.	200		°C
			2N4030 2N4031	2N4032 2N4033	
D.C. current gain $-I_C$ = 500 mA; $-V_{CE}$ = 5 V	h_{FE}	>	25	70	
Transition frequency at f = 100 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 10 V	f_T	>	100	150	MHz

MECHANICAL DATA

Dimensions in mm

Collector connected to case

TO-39



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

Accessories supplied on request: 56218 (package); 56245 (distance disc).

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

Voltages			2N4030 2N4032	2N4031 2N4033	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	80	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	80	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	5	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.	4,0		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	$R_{th\ j-c}$	=	44	°C/W

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

			2N4030 2N4032	2N4031 2N4033	
Collector cut-off current					
$I_E = 0$; $-V_{CB} = 50$ V	$-I_{CBO}$	<	50	–	nA
$I_E = 0$; $-V_{CB} = 60$ V	$-I_{CBO}$	<	–	50	nA
$I_E = 0$; $-V_{CB} = 50$ V; $T_{amb} = 150$ °C	$-I_{CBO}$	<	50	–	μA
$I_E = 0$; $-V_{CB} = 60$ V; $T_{amb} = 150$ °C	$-I_{CBO}$	<	–	50	μA
Emitter cut-off current					
$I_C = 0$; $-V_{EB} = 5$ V	$-I_{EBO}$	<	10	10	μA
Breakdown voltages					
$I_E = 0$; $-I_C = 10$ μA	$-V_{(BR)CBO}$	>	60	80	V
$I_B = 0$; $-I_C = 10$ mA	$-V_{(BR)CEO}$	>	60	80	V [1]
$I_C = 0$; $-I_E = 10$ μA	$-V_{(BR)EBO}$	>	5	5	V

[1]) Measured under pulse conditions: t_p = 300 μs; δ ≤ 0,01.

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

			2N4030 2N4032	2N4031 2N4033	
Base-emitter voltage					
$-I_C$ = 500 mA; $-V_{CE}$ = 0,5 V	$-V_{BE}$	<	1,1	1,1	V [1]
$-I_C$ = 1000 mA; $-V_{CE}$ = 1,0 V	$-V_{BE}$	<	1,2	-	V [1]
Saturation voltages					
$-I_C$ = 150 mA; $-I_B$ = 15 mA	$-V_{CEsat}$	<	0,15	0,15	V
	$-V_{BEsat}$	<	0,90	0,90	V [1]
$-I_C$ = 500 mA; $-I_B$ = 50 mA	$-V_{CEsat}$	<	0,50	0,50	V
$-I_C$ = 1000 mA; $-I_B$ = 100 mA	$-V_{CEsat}$	<	1,00	-	V

				2N4030 2N4031	2N4032 2N4033
D.C. current gain [1]					
$-I_C$ = 100 µA ; $-V_{CE}$ = 5 V		h_{FE}	>	30	75
$-I_C$ = 100 mA; $-V_{CE}$ = 5 V		h_{FE}	>	40	100
			<	120	300
$-I_C$ = 100 mA; $-V_{CE}$ = 5 V; T_{amb} = −55 °C		h_{FE}	>	15	40
$-I_C$ = 500 mA; $-V_{CE}$ = 5 V		h_{FE}	>	25	70
$-I_C$ = 1000 mA; $-V_{CE}$ = 5 V	2N4030	h_{FE}	>	15	
	2N4031	h_{FE}	>	10	
	2N4032	h_{FE}	>	40	
	2N4033	h_{FE}	>	25	

Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $-V_{CB}$ = 10 V	C_c	<	20	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $-V_{EB}$ = 0,5 V	C_e	<	110	pF

			2N4030 2N4031	2N4032 2N4033	
Transition frequency at f = 100 MHz					
$-I_C$ = 50 mA; $-V_{CE}$ = 10 V	f_T	>	100	150	MHz
		<	400	500	MHz

[1]) Measured under pulse conditions: t_p = 300 µs; $\delta \le 0,01$.

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

Switching times [1])

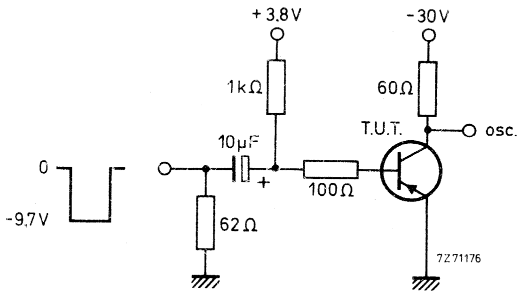
$-I_{Con} = 500$ mA; $-I_{Bon} = 50$ mA

Turn-on time	t_{on}	<	100	ns

$-I_{Con} = 500$ mA; $-I_{Bon} = +I_{Boff} = 50$ mA

Storage time	t_s	<	350	ns
Fall time	t_f	<	50	ns

Switching circuit:



Pulse generator:

Rise time	t_r <	20 ns
Fall time	t_f <	20 ns
Pulse duration	t_p =	10 μs
Duty factor	δ <	0,02
Source impedance	Z_S =	50 Ω

Oscilloscope:

Rise time	t_r =	10 ns
Input impedance	Z_I >	100 kΩ

1) See switching circuit for exact values of I_{Con}; I_{Bon} and I_{Boff}.

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

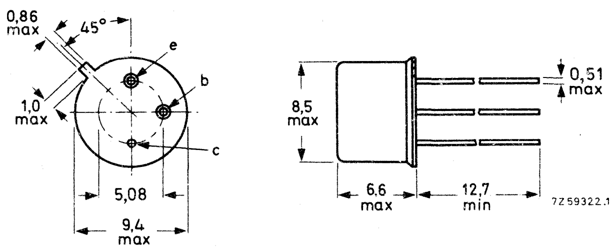
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	90	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	65	V
Collector current (d.c.)	$-I_C$	max.	1,0	A
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	5	W
Junction temperature	T_j	max.	200	°C
Collector-emitter saturation voltage $-I_C$ = 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

Collector connected to case

TO-39



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

Accessories supplied on request: 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.	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 $T_j = 25\,^{\circ}C$ 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; $T_{case} = 150\,^{\circ}C$	$-I_{CEX}$	<	100	μA
Breakdown voltages				
Collector-base voltage				
$I_E = 0$; $-I_C = 100$ μA	$-V_{(BR)CBO}$	>	90	V
Collector-emitter voltage				
$+V_{BE} = 1.5$ V; $-I_C = 100$ mA	$-V_{(BR)CEX}$	>	85	V
Emitter-base voltage				
$I_C = 0$; $I_E = 100$ μA	$-V_{(BR)EBO}$	>	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

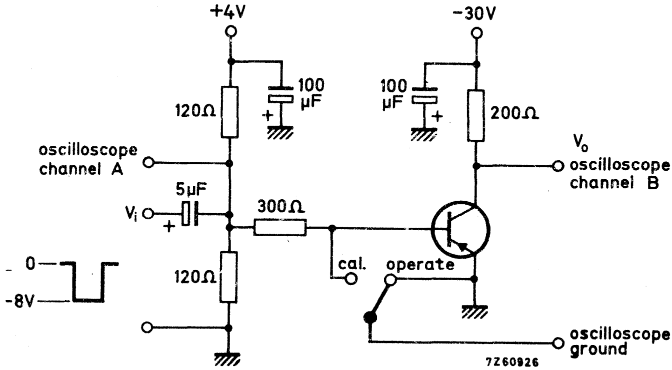
rise time	t_r	<	70	ns
turn on time	t_{on}	<	110	ns

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

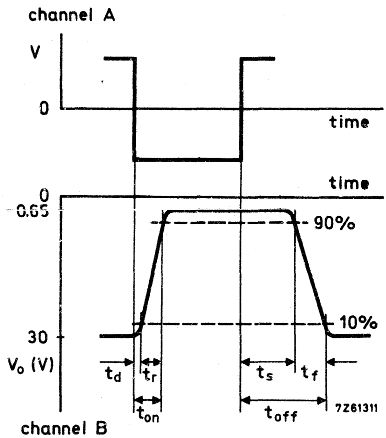
t_p = 20 μs

Oscilloscope:

Z_i = 10 MΩ

C_i = 20 pF

t_r < 15 ns



SILICON P-N-P HIGH-VOLTAGE TRANSISTORS

Transistors in TO-39 metal envelopes with the collector connected to the case.
They are intended for high-speed switching and linear amplifier applications in military, industrial and commercial equipment.

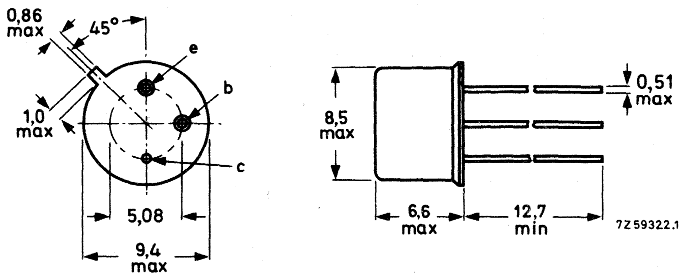
QUICK REFERENCE DATA

			2N5415	2N5416	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	200	350	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	200	300	V
Collector current (d.c.)	$-I_C$	max.	1	1	A
Total power dissipation up to T_{amb} = 50 °C	P_{tot}	max.	1	1	W
Junction temperature	T_j	max.	200	200	°C
D.C. current gain $-I_C$ = 50 mA; $-V_{CE}$ = 10 V	h_{FE}	>	30	30	
		<	150	120	

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

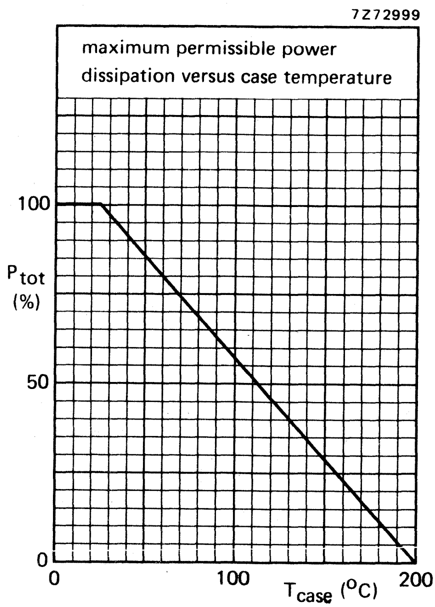
			2N5415	2N5416	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	200	350	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	200	300	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	4	6	V

Currents

Collector current (d.c.)	$-I_C$	max.	1	A
Base current (d.c.)	$-I_B$	max.	0,5	A

Power dissipation

Total power dissipation up to T_{case} = 25 ^oC	P_{tot}	max.	10	W
Total power dissipation up to T_{amb} = 50 ^oC	P_{tot}	max.	1	W



Temperatures

Storage temperature	T_{stg}		−65 to +200	^oC
Junction temperature	T_j	max.	200	^oC

THERMAL RESISTANCE

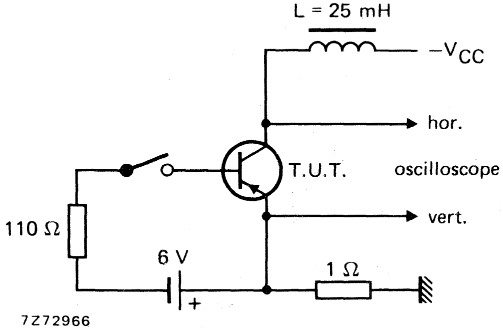
From junction to case	$R_{th\ j-c}$	=	17,5	$^oC/W$
From junction to ambient in free air	$R_{th\ j-a}$	=	150	$^oC/W$

CHARACTERISTICS

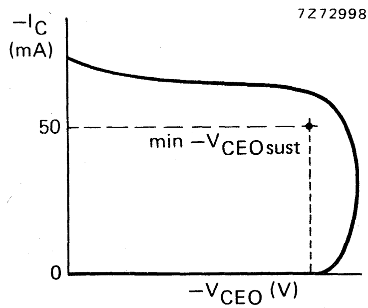
$T_{case} = 25\ ^{o}C$

			2N5415	2N5416		
Collector cut-off currents						
$I_E = 0$; $-V_{CB} = 175$ V	$-I_{CBO}$	<	50	–	μA	
$I_E = 0$; $-V_{CB} = 280$ V	$-I_{CBO}$	<	–	50	μA	
$I_B = 0$; $-V_{CE} = 150$ V	$-I_{CEO}$	<	50	–	μA	
$I_B = 0$; $-V_{CE} = 250$ V	$-I_{CEO}$	<	–	50	μA	
Emitter cut-off current						
$I_C = 0$; $-V_{EB} = 4$ V	$-I_{EBO}$	<	20	–	μA	
$I_C = 0$; $-V_{EB} = 6$ V	$-I_{EBO}$	<	–	20	μA	
Sustaining voltage						
$I_B = 0$; $-I_C = 0$ to 50 mA	$-V_{CEOsust}$	>	200	300	V	1)
$R_{BE} = 50\ \Omega$; $-I_C = 50$ mA	$-V_{CERsust}$	>	–	350	V	1)

Test circuit for $V_{CEOsust}$



Oscilloscope display for $V_{CEOsust}$



			2N5415	2N5416	
Saturation voltages					
$-I_C = 50$ mA; $-I_B = 5$ mA	$-V_{CEsat}$	<	2,5	2,0	V
	$-V_{BEsat}$	<	1,5	1,5	V
D.C. current gain					
$-I_C = 50$ mA; $-V_{CE} = 10$ V	h_{FE}	>	30	30	
		<	150	120	
Collector capacitance at f = 1 MHz					
$I_E = I_e = 0$; $-V_{CB} = 10$ V	C_c	<	15		pF
Emitter capacitance at f = 1 MHz					
$I_C = I_c = 0$; $-V_{EB} = -V_{EBOmax}$	C_e	<	75		pF

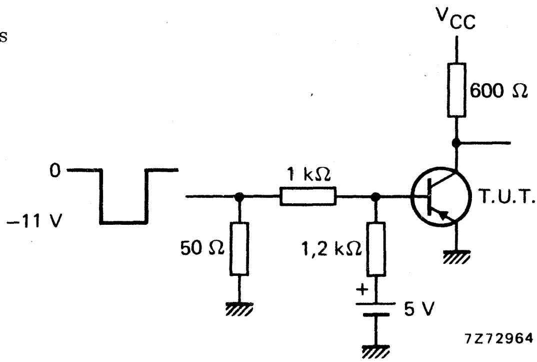
1) Measured under pulse conditions to avoid excessive dissipation.

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

Transition frequency at f = 5 MHz				
$-I_C$ = 10 mA; $-V_{CE}$ = 10 V	f_T	>	15	MHz
h-parameters (common emitter)				
$-I_C$ = 5 mA; $-V_{CE}$ = 10 V real part of input impedance at f = 1 MHz	$R_e(h_{ie})$	<	300	Ω
small-signal current gain at f = 1 kHz	h_{fe}	>	25	
Switching times				
$-I_{Con}$ = 50 mA; $-I_{Bon}$ = I_{Boff} = 5 mA (test circuit 1)	t_{on}	typ.	125	ns
	t_{off}	typ.	850	ns
$-I_{Con}$ = 500 mA; $-I_{Bon}$ = I_{Boff} = 100 mA (test circuit 2)	t_{on}	typ.	125	ns
	t_{off}	typ.	125	ns

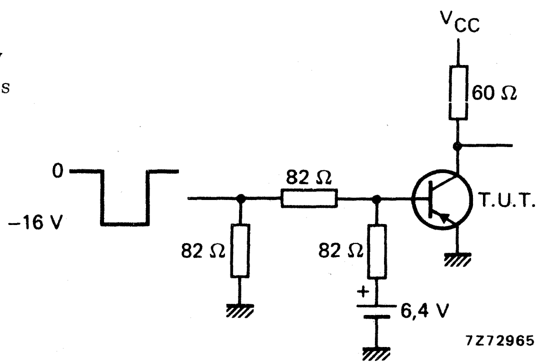
Test circuit 1

V_{CC} = −31 V
t_p = 10 μs



Test circuit 2

V_{CC} = −31 V
t_p = 10 μs



HIGH FREQUENCY PACKAGE

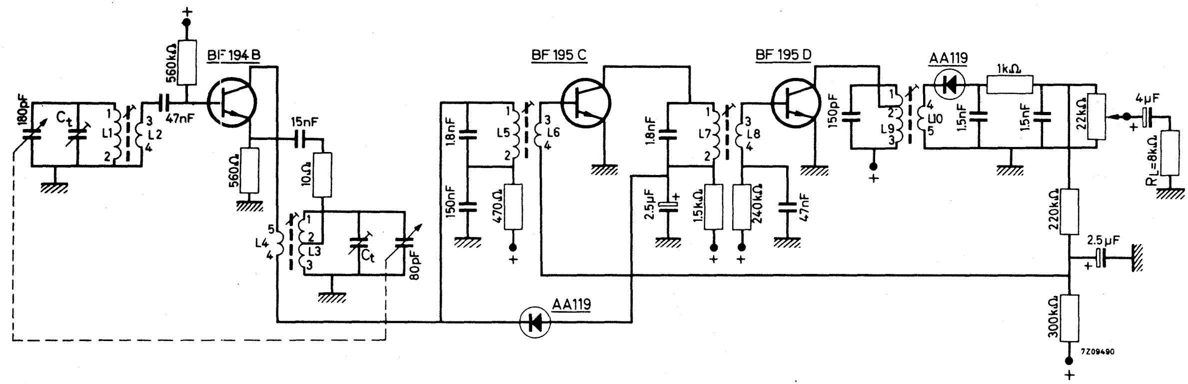
The high frequency package 40820 contains three silicon transistors selected from the BF194 and BF195 products.
The BF194B is intended for use as mixer-oscillator transistor,
the BF195C for controlled first i.f. transistor,
the BF195D for second i.f. transistor.
The low h_{FE} spread of the transistors 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				
$G_S = 1.0\ m\Omega^{-1}$; 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}

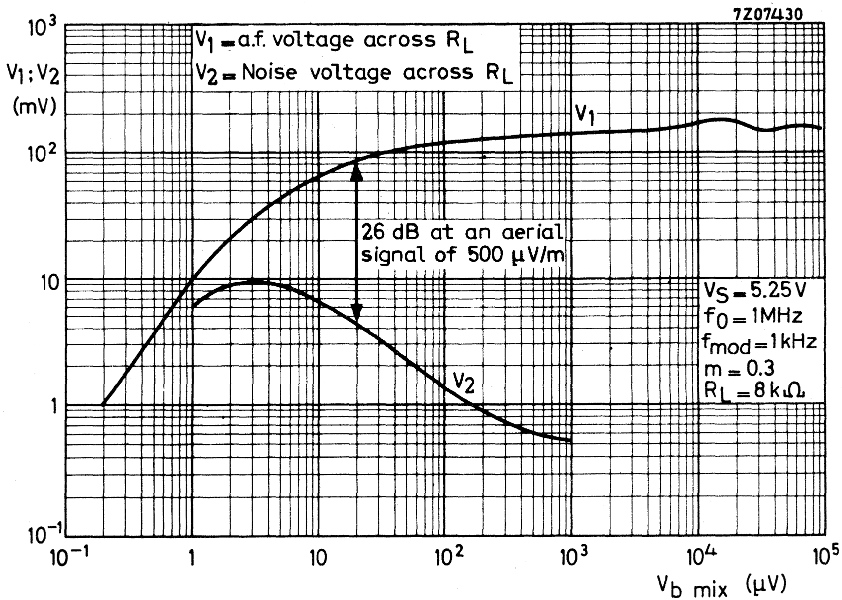
Voltage ratio $\frac{n_{4-5}}{n_{1-3}}$: 59.2×10^{-2}

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

$T_j = 25\ ^oC$ 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

$G_S = 1.0\ m\Omega^{-1}$; 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	$m\Omega^{-1}$
	BF195C:	g_{ie}	<	0.64	0.54	$m\Omega^{-1}$
	BF195D:	g_{ie}	<	0.95	0.85	$m\Omega^{-1}$
Output conductance	BF194B:	g_{oe}	typ.	10	6.5	$\mu\Omega^{-1}$
			<	13.5	11.5	$\mu\Omega^{-1}$
	BF195C:	g_{oe}	typ.	6.5	4	$\mu\Omega^{-1}$
			<	9.5	7	$\mu\Omega^{-1}$
	BF195D:	g_{oe}	typ.	4	2	$\mu\Omega^{-1}$
			<	9.5	7	$\mu\Omega^{-1}$

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				
	BF494B	I_B	5 to 9	μA
I_C = 1 mA; V_{CE} = 10 V	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 °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.

FIELD-EFFECT TRANSISTORS

N-CHANNEL SILICON FIELD-EFFECT TRANSISTORS

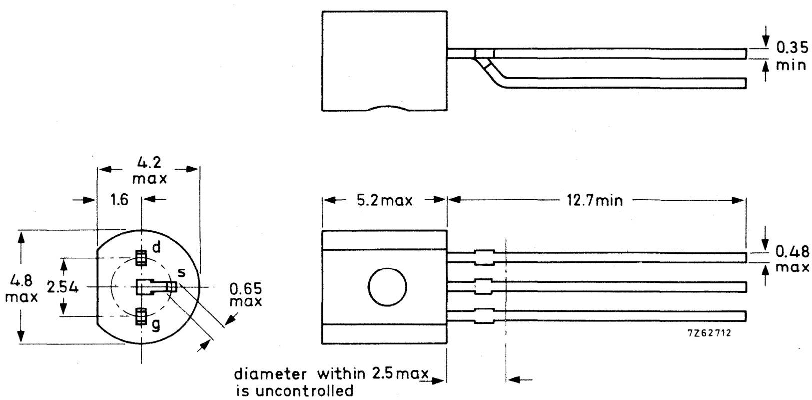
Planar epitaxial junction field-effect transistors in a plastic TO-92 variant; intended for hi-fi amplifiers and other audio frequency equipment.

QUICK REFERENCE DATA

Drain-source voltage	$\pm V_{DS}$	max.	30	V
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	mW
Junction temperature	T_j	max.	150	°C
Drain current V_{DS} = 15 V; V_{GS} = 0	I_{DSS}		2 to 12	mA
Transfer admittance (common source) V_{DS} = 15 V; V_{GS} = 0; f = 1 kHz	$\|y_{fs}\|$	typ.	3, 5	mA/V
Noise figure at V_{DS} = 15 V; V_{GS} = 0 f = 1 kHz; R_G = 1 MΩ	F	<	2	dB

MECHANICAL DATA Dimensions in mm

TO-92 variant



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

Voltages

Drain-source voltage	$\pm V_{DS}$	max.	30	V
Drain-gate voltage (open source)	V_{DGO}	max.	30	V
Gate-source voltage (open drain)	$-V_{GSO}$	max.	30	V

Current

Gate current	I_G	max.	10	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °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	$R_{th\ j\text{-}a}$	=	0, 42	°C/mW

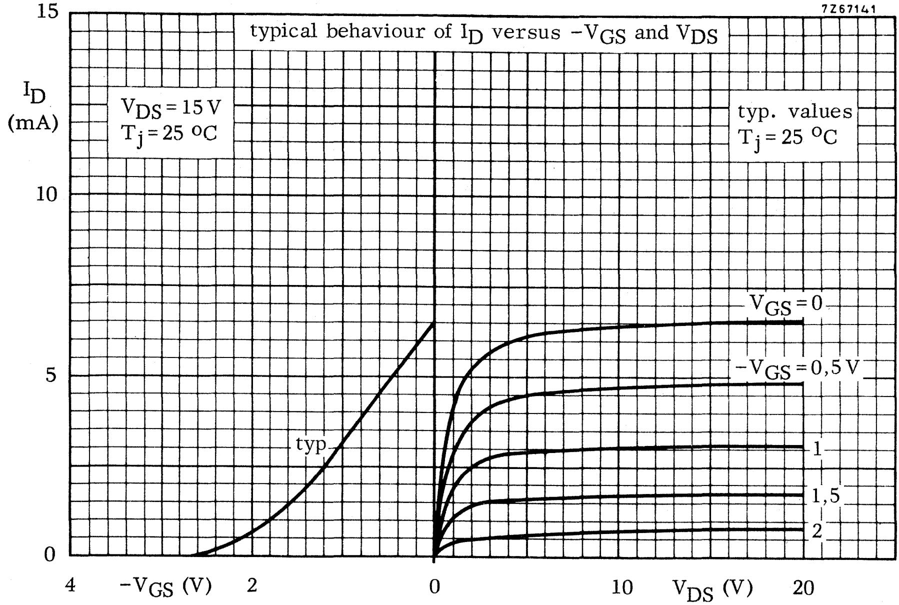
CHARACTERISTICS

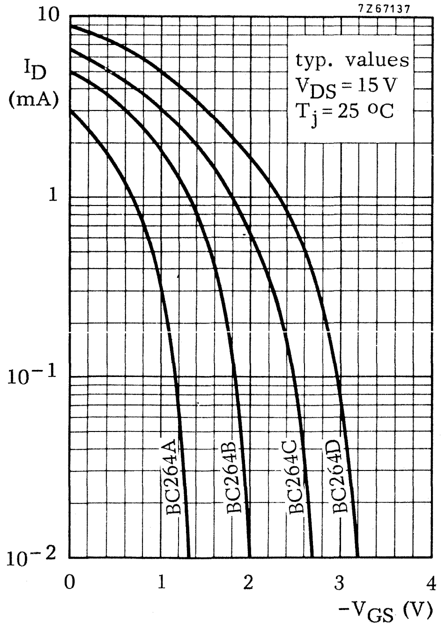
$T_j = 25\ ^oC$ unless otherwise specified

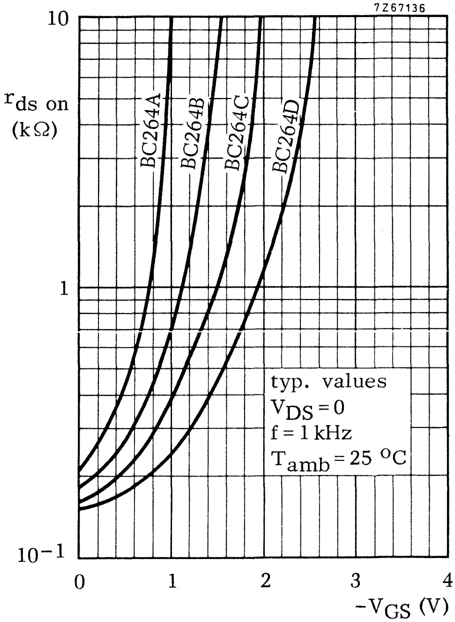
			BC264A	B	C	D	
Gate cut-off current							
$-V_{GS} = 20$ V; $V_{DS} = 0$	$-I_{GSS}$	<	10	10	10	10	nA
Drain current 1)							
$V_{DS} = 15$ V; $V_{GS} = 0$	I_{DSS}	>	2,0	3,5	5,0	7,0	mA
		<	4,5	6,5	8,0	12,0	mA
Gate-source breakdown voltage							
$-I_G = 1\ \mu A$; $V_{DS} = 0$	$-V_{(BR)GSS}$	>	30	30	30	30	V
Gate-source voltage							
$I_D = 200\ \mu A$; $V_{DS} = 15$ V	$-V_{GS}$	>	0,4	0,4	0,4	0,4	V
$I_D = 1,0$ mA; $V_{DS} = 15$ V	$-V_{GS}$	>	0,2	–	–	–	V
		<	1,2	–	–	–	V
$I_D = 1,5$ mA; $V_{DS} = 15$ V	$-V_{GS}$	>	–	0,4	–	–	V
		<	–	1,4	–	–	V
$I_D = 2,5$ mA; $V_{DS} = 15$ V	$-V_{GS}$	>	–	–	0,5	–	V
		<	–	–	1,5	–	V
$I_D = 3,5$ mA; $V_{DS} = 15$ V	$-V_{GS}$	>	–	–	–	0,6	V
		<	–	–	–	1,6	V
Gate-source cut-off voltage							
$I_D = 10$ nA ; $V_{DS} = 15$ V	$-V_{(P)GS}$	>	0,5	0,5	0,5	0,5	V
y-parameters at $T_{amb} = 25\ ^oC$							
$V_{DS} = 15$ V; $V_{GS} = 0$; f = 1 kHz							
Transfer admittance	$\|y_{fs}\|$	>	2,5	3,0	3,5	4,0	mA/V

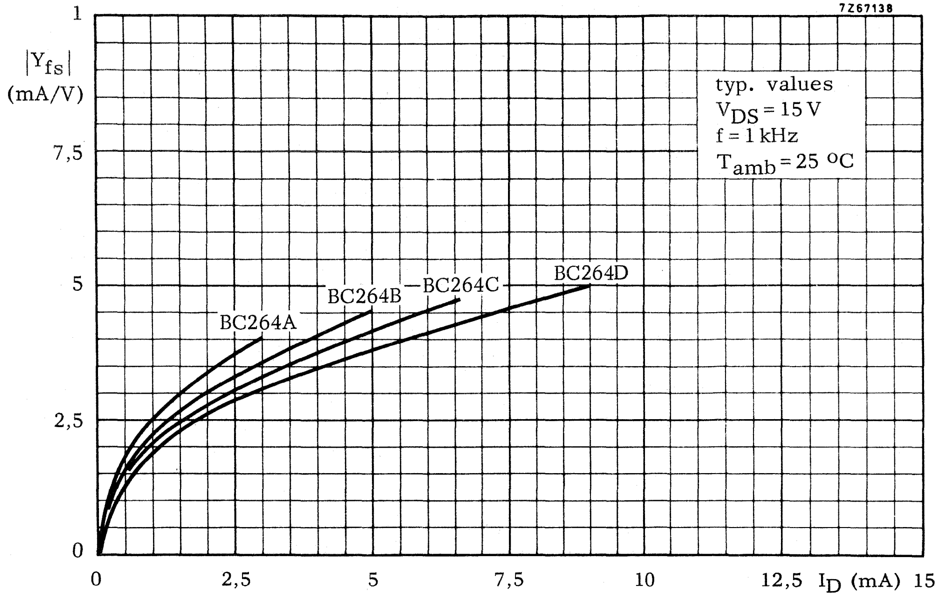
$V_{DS} = 15$ V; $-V_{GS} = 1$ V; f = 1 MHz				
Input capacitance	C_{is}	typ.	4,0	pF
Feedback capacitance	C_{rs}	typ.	1,2	pF
Output capacitance	C_{os}	typ.	1,6	pF
Noise figure at f = 1 kHz; $R_G = 1\ M\Omega$				
$V_{DS} = 15$ V; $V_{GS} = 0$; $T_{amb} = 25\ ^oC$	F	typ.	0,5	dB
		<	2	dB
Equivalent noise voltage at $T_{amb} = 25\ ^oC$				
$V_{DS} = 15$ V; $V_{GS} = 0$; f = 10 Hz	$V_n/\sqrt{B}$	typ.	40	$nV/\sqrt{Hz}$

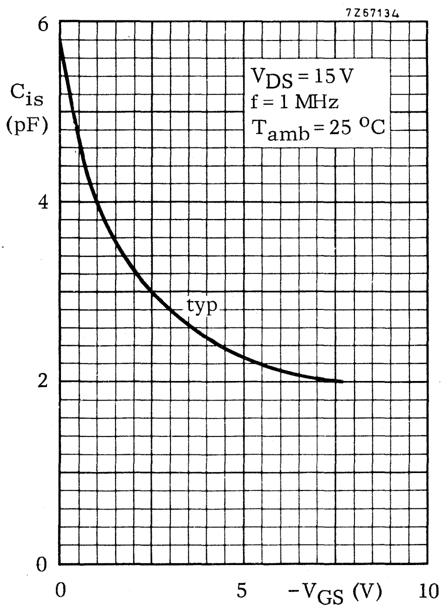
1) Measured under pulse conditions.

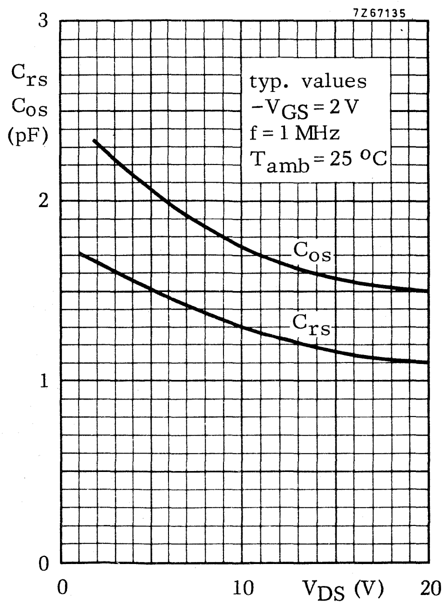

7Z67141
typical behaviour of I_D versus $-V_{GS}$ and V_{DS}
I_D (mA)
$V_{DS} = 15$ V
$T_j = 25$ °C
typ. values
$T_j = 25$ °C
$V_{GS} = 0$
$-V_{GS} = 0,5$ V
1
1,5
2
typ
15
10
5
0
4
$-V_{GS}$ (V)
2
0
10
V_{DS} (V)
20

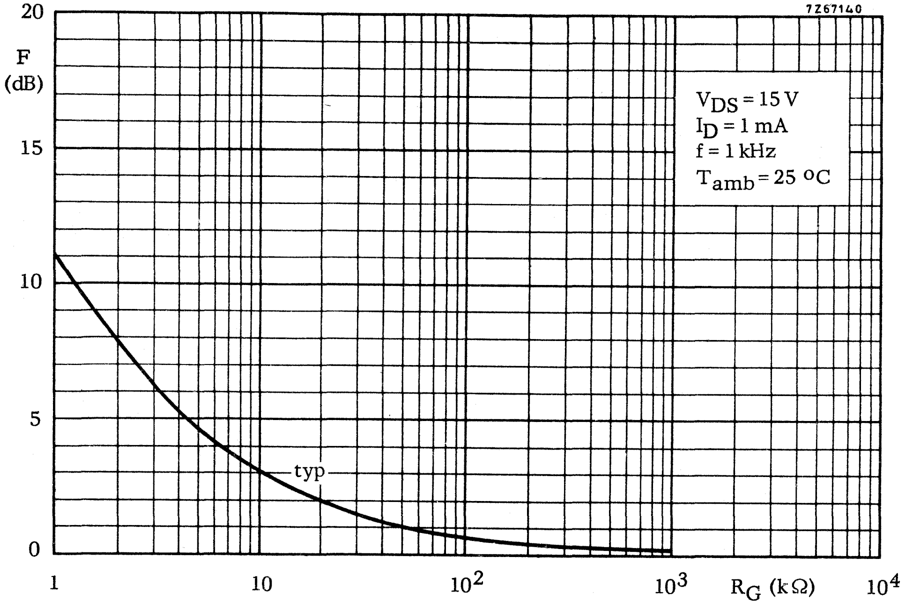

7Z67137
I_D (mA)
typ. values
$V_{DS} = 15$ V
$T_j = 25$ °C
BC264A
BC264B
BC264C
BC264D
10
1
10^{-1}
10^{-2}
0
1
2
3
4
$-V_{GS}$ (V)


7Z67136
$r_{ds\ on}$ (kΩ)
BC264A
BC264B
BC264C
BC264D
typ. values
$V_{DS} = 0$
f = 1 kHz
$T_{amb} = 25$ °C
10
1
10^{-1}
0
1
2
3
4
$-V_{GS}$ (V)


7Z67138
|Yfs|
(mA/V)
1
7,5
5
2,5
0
typ. values
VDS = 15 V
f = 1 kHz
Tamb = 25 oC
BC264A
BC264B
BC264C
BC264D
0
2,5
5
7,5
10
12,5
ID (mA)
15


7Z67134
Cis
(pF)
6
4
2
0
VDS = 15 V
f = 1 MHz
Tamb = 25 oC
typ
0
5
−VGS (V)
10


7Z67135
Crs
Cos
(pF)
3
2
1
0
typ. values
−VGS = 2 V
f = 1 MHz
Tamb = 25 oC
Cos
Crs
0
10
VDS (V)
20


7Z67140
F
(dB)
20
15
10
5
0
$V_{DS} = 15$ V
$I_D = 1$ mA
f = 1 kHz
$T_{amb} = 25$ °C
typ
1
10
10^2
10^3
R_G (kΩ)
10^4

N-CHANNEL SILICON FIELD-EFFECT TRANSISTORS

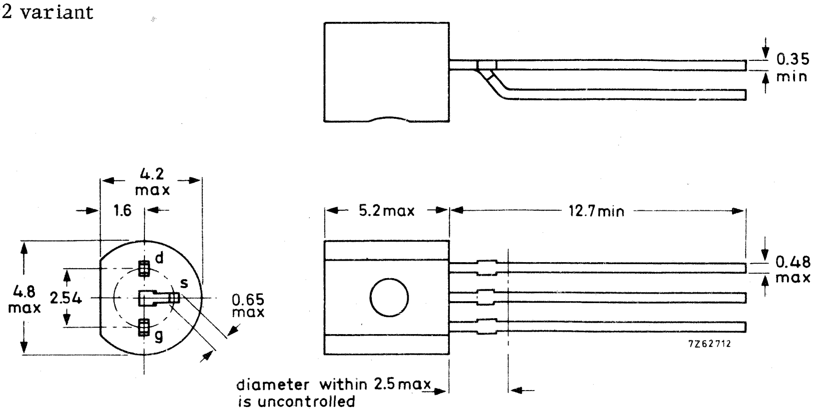
General purpose symmetrical N-channel planar epitaxial junction field-effect transistors in a plastic TO-92 variant; intended for applications in l.f. and d.c. amplifiers, and in h.f. amplifiers.

QUICK REFERENCE DATA

Drain-source voltage	$\pm V_{DS}$	max.		30	V
Gate-source voltage (open drain)	$-V_{GSO}$	max.		30	V
Total power dissipation up to T_{amb} = 75 °C	P_{tot}	max.		300	mW
		BF245A	B	C	
Drain current V_{DS} = 15 V; V_{GS} = 0	I_{DSS} >	2	6,0	12	mA
	I_{DSS} <	6,5	15,0	25	mA
Gate-source cut-off voltage I_D = 10 nA; V_{DS} = 15 V	$-V_{(P)GS}$			0,5 to 8,0	V
Feedback capacitance V_{DS} = 20 V; $-V_{GS}$ = 1 V	C_{rs}	typ.		1,1	pF
Transfer admittance (common source) V_{DS} = 15 V; V_{GS} = 0	$\lvert y_{fs} \rvert$			3,0 to 6,5	mA/V

MECHANICAL DATA Dimensions in mm

TO-92 variant



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

Voltages

Drain-source voltage	$\pm V_{DS}$	max.	30	V	
Drain-gate voltage (open source)	V_{DGO}	max.	30	V	
Gate-source voltage (open drain)	$-V_{GSO}$	max.	30	V	

Currents

Drain current	I_D	max.	25	mA	
Gate current	I_G	max.	10	mA	

Power dissipation

Power dissipation up to T_{amb} = 75 °C	P_{tot}	max.	300	mW	
up to T_{amb} = 90 °C	P_{tot}	max.	300	mW	1)

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0, 25	°C/mW	
From junction to ambient	$R_{th\ j\text{-}a}$	=	0, 20	°C/mW	1)

1) Transistor mounted on printed circuit board, max. lead length 3 mm, mounting pad for drain lead minimum 10 mm x 10 mm.

CHARACTERISTICS

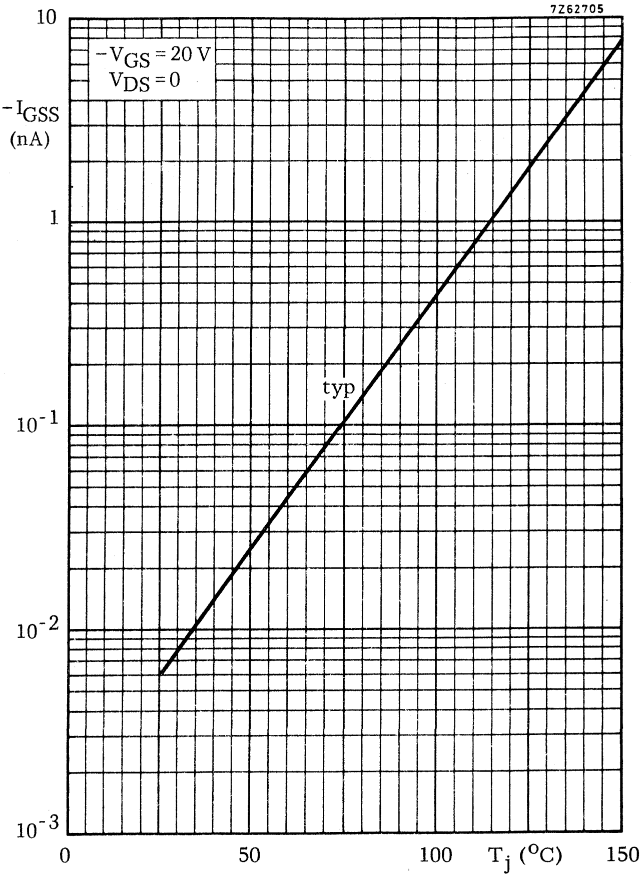
T_j = 25 °C unless otherwise specified

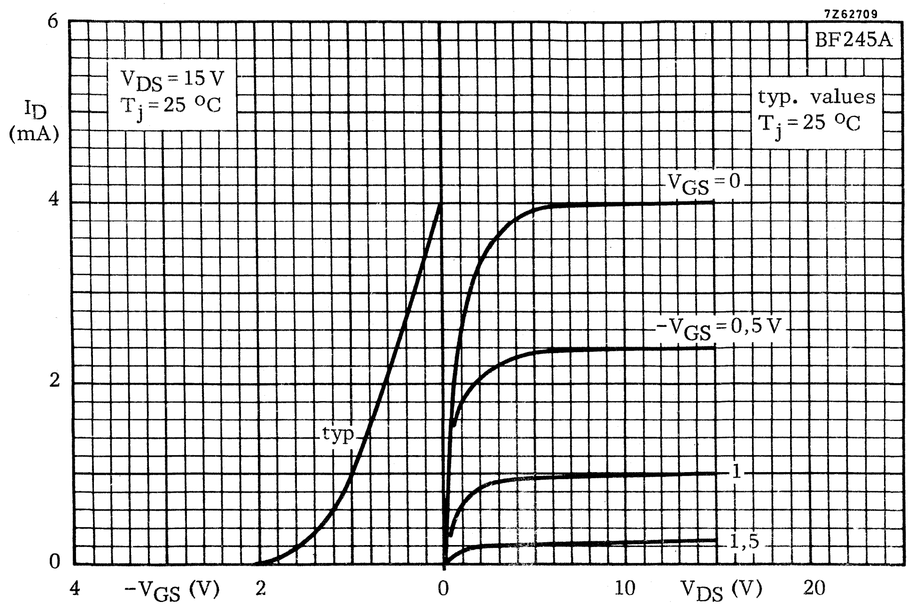
		BF245A	B	C	
Gate cut-off current					
$-V_{GS}$ = 20 V; V_{DS} = 0	$-I_{GSS}$	< 5	5	5	nA
$-V_{GS}$ = 20 V; V_{DS} = 0; T_j = 125 °C	$-I_{GSS}$	< 0,5	0,5	0,5	μA
Drain current 1)					
V_{DS} = 15 V; V_{GS} = 0	I_{DSS}	> 2	6,0	12	mA
		< 6,5	15,0	25	mA
Gate-source breakdown voltage					
$-I_G$ = 1 μA; V_{DS} = 0	$-V_{(BR)GSS}$	> 30	30	30	V
Gate-source voltage					
I_D = 200 μA; V_{DS} = 15 V	$-V_{GS}$	> 0,4	1,6	3,2	V
		< 2,2	3,8	7,5	V

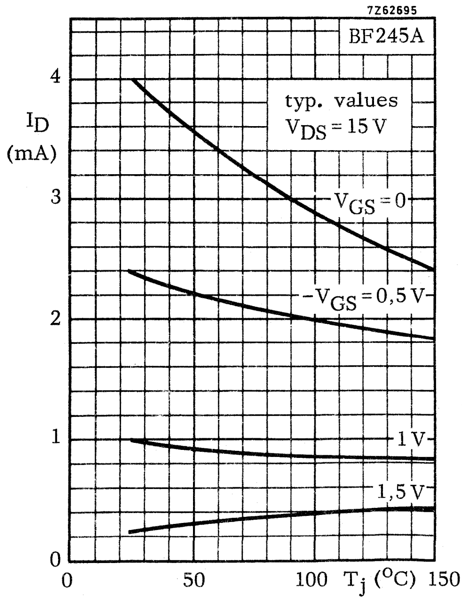
Gate-source cut-off voltage			
I_D = 10 nA; V_{DS} = 15 V	$-V_{(P)GS}$	0,5 to 8,0	V
y-parameters at T_{amb} = 25 °C (common source)			
V_{DS} = 15 V; V_{GS} = 0			
f = 1 kHz — Transfer admittance	$\|y_{fs}\|$	3,0 to 6,5	mA/V
Output admittance	$\|y_{os}\|$	typ. 25	μA/V
f = 200 MHz — Input conductance	g_{is}	typ. 250	μA/V
Reverse transfer admittance	$\|y_{rs}\|$	typ. 1,4	mA/V
Transfer admittance	$\|y_{fs}\|$	typ. 6	mA/V
Output conductance	g_{os}	typ. 40	μA/V
V_{DS} = 20 V; $-V_{GS}$ = 1 V			
f = 1 MHz — Input capacitance	C_{is}	typ. 4,0	pF
Feedback capacitance	C_{rs}	typ. 1,1	pF
Output capacitance	C_{os}	typ. 1,6	pF
Cut-off frequency 2)			
V_{DS} = 15 V; V_{GS} = 0	f_{gfs}	typ. 700	MHz
Noise figure at f = 100 MHz; R_G = 1 kΩ (common source)			
V_{DS} = 15 V; V_{GS} = 0; T_{amb} = 25 °C; input tuned to minimum noise	F	typ. 1,5	dB

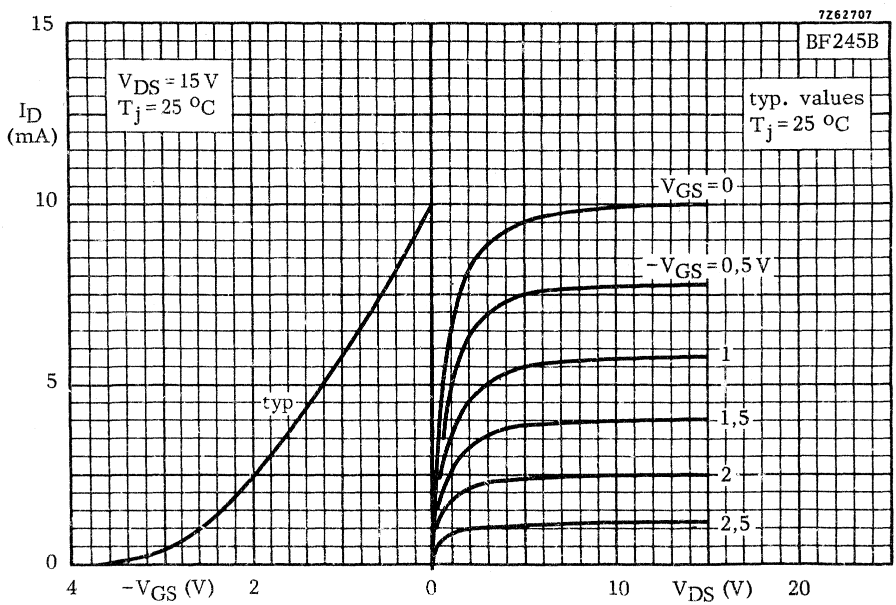
1) Measured under pulse condition: t_p = 300 μs; $\delta \leq 0,02$

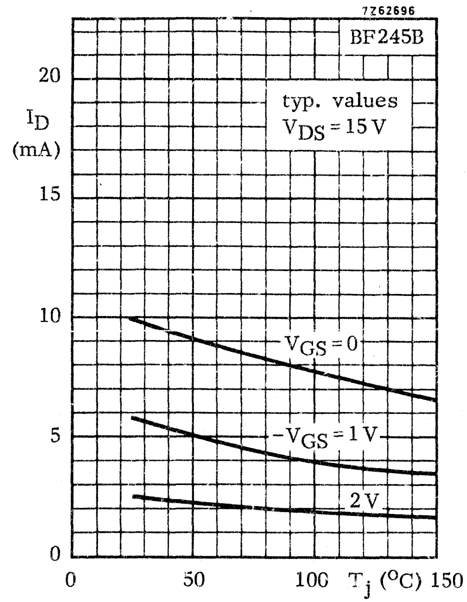
2) The frequency at which g_{fs} is 0,7 of its value at 1 kHz.

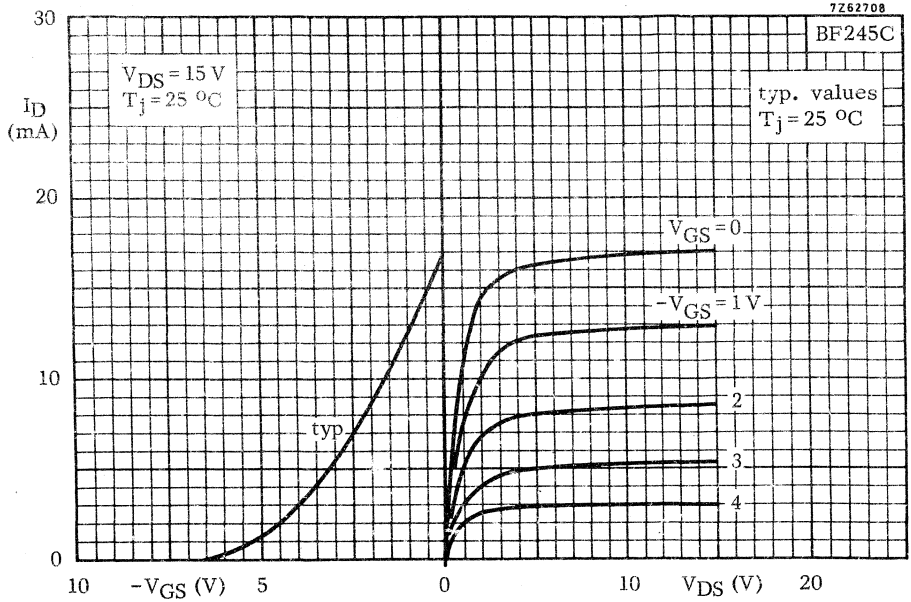

7Z62705
$-V_{GS} = 20$ V
$V_{DS} = 0$
$-I_{GSS}$ (nA)
10
1
10^{-1}
10^{-2}
10^{-3}
typ
0
50
100
150
T_j (°C)

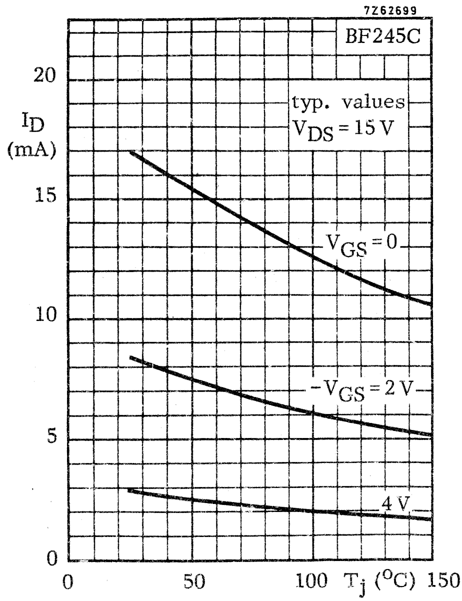

7Z62709
BF245A
V_{DS} = 15 V
T_j = 25 °C
I_D (mA)
typ. values
T_j = 25 °C
V_{GS} = 0
$-V_{GS}$ = 0,5 V
1
1,5
typ
6
4
2
0
4
$-V_{GS}$ (V)
2
0
10
V_{DS} (V)
20

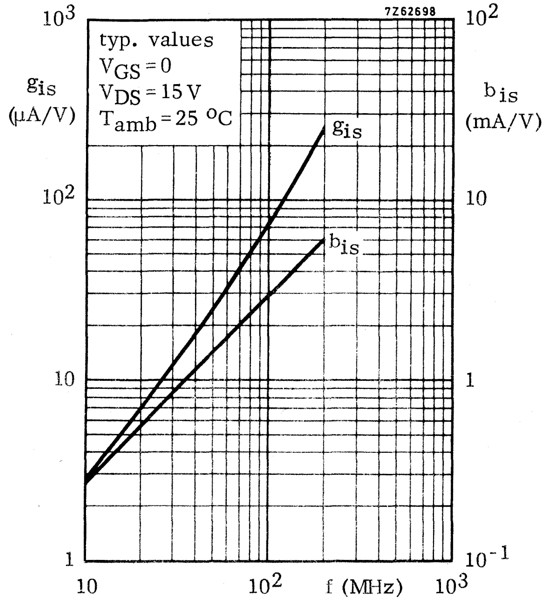

7Z62695
BF245A
I_D (mA)
typ. values
V_{DS} = 15 V
V_{GS} = 0
$-V_{GS}$ = 0,5 V
1 V
1,5 V
4
3
2
1
0
0
50
100
T_j (°C)
150

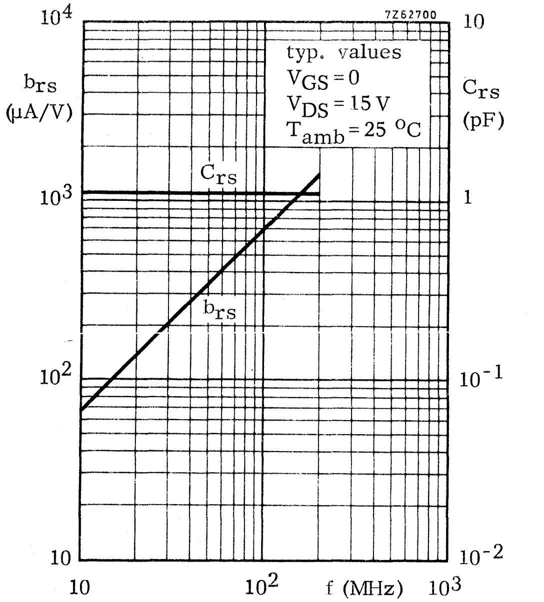

7Z62707
BF245B
V_{DS} = 15 V
T_j = 25 °C
I_D (mA)
typ. values
T_j = 25 °C
V_{GS} = 0
$-V_{GS}$ = 0,5 V
1
1,5
2
2,5
typ
15
10
5
0
4
$-V_{GS}$ (V)
2
0
10
V_{DS} (V)
20

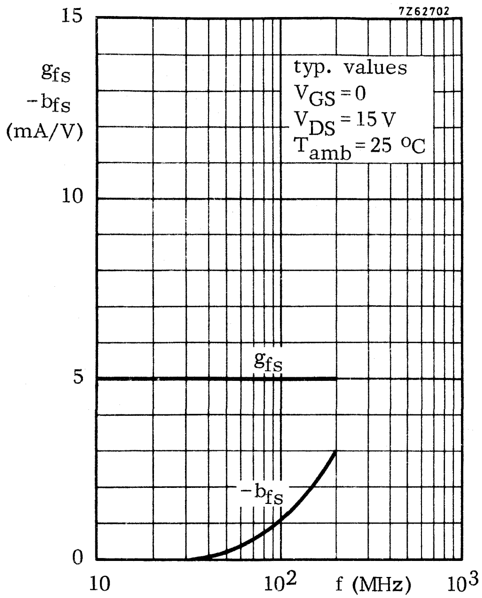

7Z62696
BF245B
typ. values
V_{DS} = 15 V
I_D (mA)
V_{GS} = 0
$-V_{GS}$ = 1 V
2 V
20
15
10
5
0
0
50
100
T_j (°C)
150

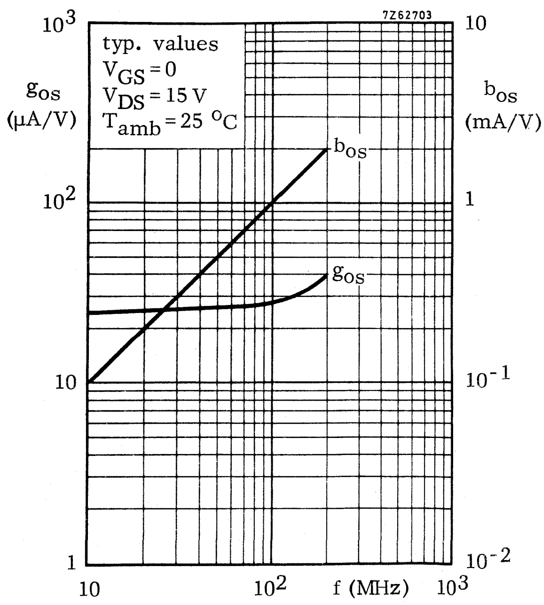

7Z62708
BF245C
V_{DS} = 15 V
T_j = 25 °C
I_D (mA)
typ. values
T_j = 25 °C
V_{GS} = 0
$-V_{GS}$ = 1 V
2
3
4
typ
30
20
10
0
10
$-V_{GS}$ (V)
5
0
10
V_{DS} (V)
20

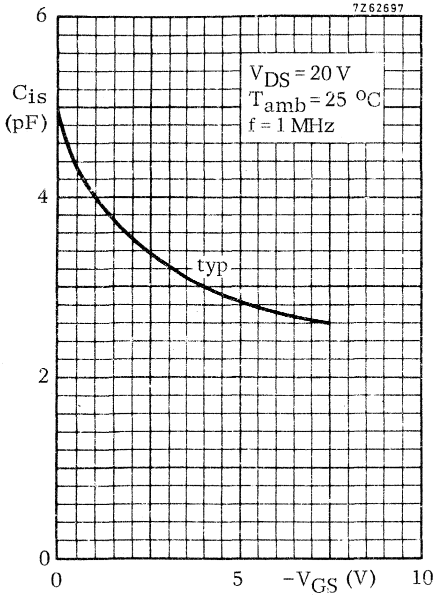

7Z62699
BF245C
typ. values
V_{DS} = 15 V
I_D (mA)
V_{GS} = 0
$-V_{GS}$ = 2 V
4 V
20
15
10
5
0
0
50
100
T_j (°C)
150

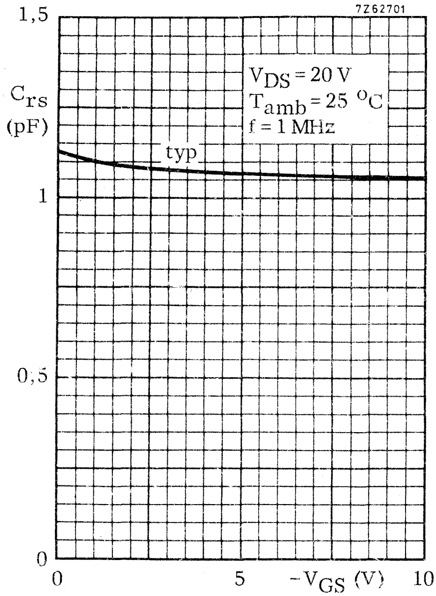

7Z62698
typ. values
$V_{GS} = 0$
$V_{DS} = 15$ V
$T_{amb} = 25$ °C
g_{is} (µA/V)
b_{is} (mA/V)
g_{is}
b_{is}
10^3
10^2
10
1
10^2
10
1
10^{-1}
10
10^2
f (MHz)
10^3

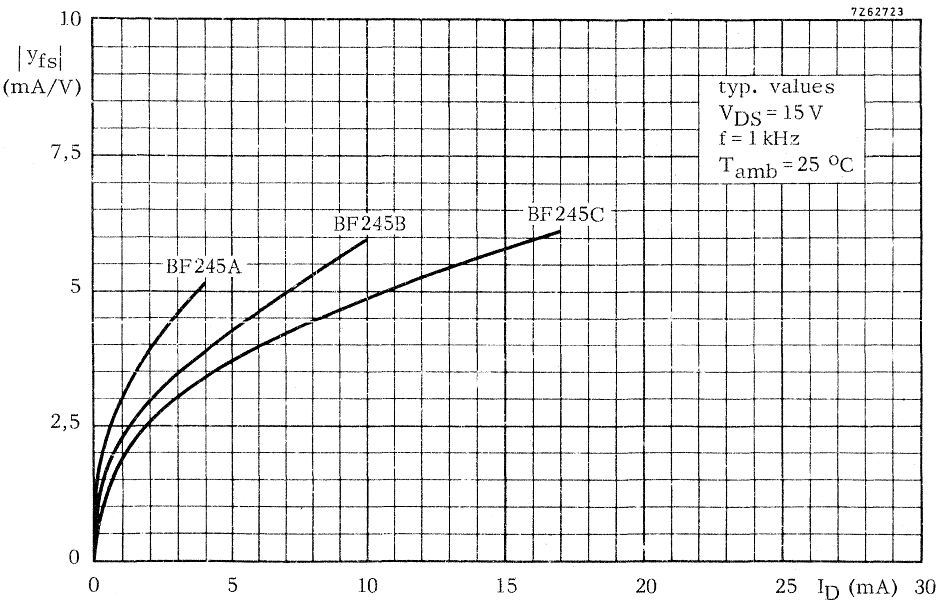

7Z62700
typ. values
$V_{GS} = 0$
$V_{DS} = 15$ V
$T_{amb} = 25$ °C
b_{rs} (µA/V)
C_{rs} (pF)
C_{rs}
b_{rs}
10^4
10^3
10^2
10
10
1
10^{-1}
10^{-2}
10
10^2
f (MHz)
10^3

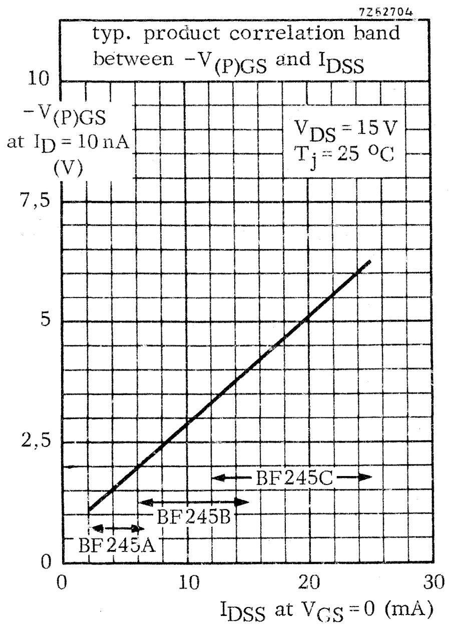

7Z62702
15
g_{fs}
$-b_{fs}$
(mA/V)
typ. values
$V_{GS} = 0$
$V_{DS} = 15$ V
$T_{amb} = 25$ °C
10
g_{fs}
5
$-b_{fs}$
0
10
10^2
f (MHz)
10^3

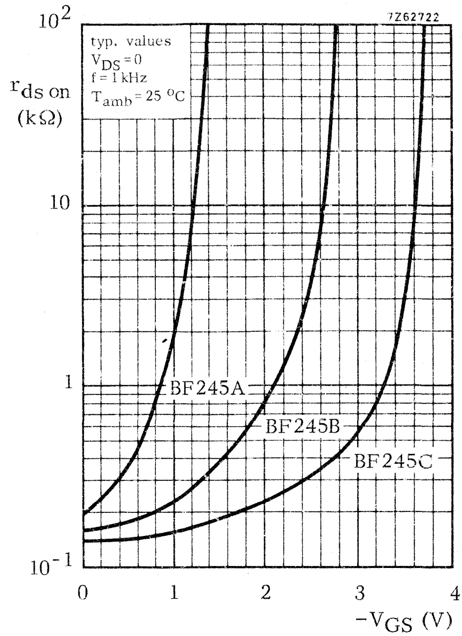

7Z62703
10^3
g_{os}
(μA/V)
typ. values
$V_{GS} = 0$
$V_{DS} = 15$ V
$T_{amb} = 25$ °C
10
b_{os}
(mA/V)
b_{os}
10^2
1
g_{os}
10
10^{-1}
1
10^{-2}
10
10^2
f (MHz)
10^3

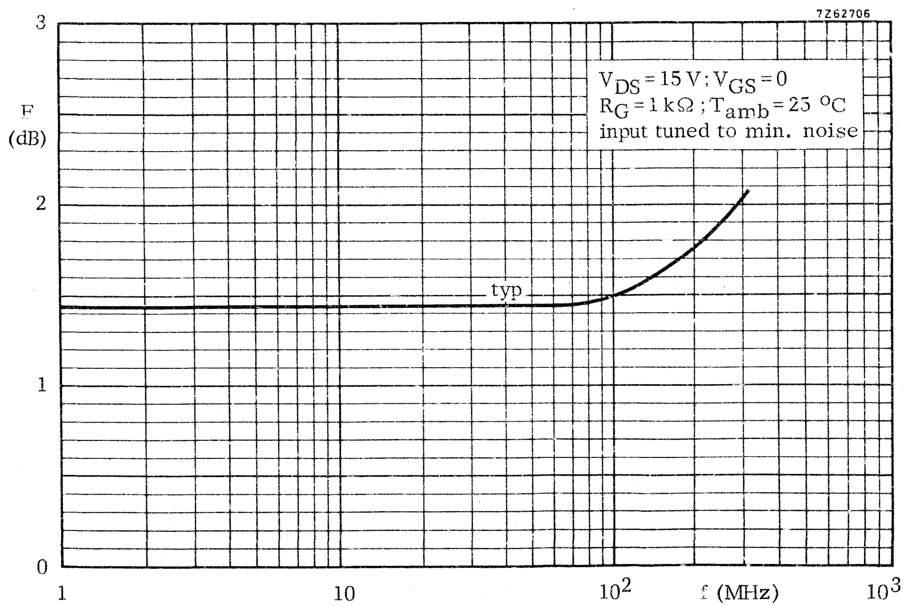

7Z62697
6
4
2
0
Cis
(pF)
VDS = 20 V
Tamb = 25 °C
f = 1 MHz
typ
0
5
−VGS (V)
10


7Z62701
1,5
1
0,5
0
Crs
(pF)
VDS = 20 V
Tamb = 25 °C
f = 1 MHz
typ
0
5
−VGS (V)
10


7Z62723
10
7,5
5
2,5
0
|yfs|
(mA/V)
typ. values
VDS = 15 V
f = 1 kHz
Tamb = 25 °C
BF245A
BF245B
BF245C
0
5
10
15
20
25
ID (mA)
30


7Z62704
typ. product correlation band between $-V_{(P)GS}$ and I_{DSS}
$-V_{(P)GS}$ at $I_D = 10$ nA (V)
$V_{DS} = 15$ V
$T_j = 25$ °C
BF245C
BF245B
BF245A
10
7,5
5
2,5
0
0
10
20
30
I_{DSS} at $V_{GS} = 0$ (mA)


7Z62722
typ. values
$V_{DS} = 0$
f = 1 kHz
$T_{amb} = 25$ °C
$r_{ds\ on}$ (kΩ)
10^2
10
1
10^{-1}
BF245A
BF245B
BF245C
0
1
2
3
4
$-V_{GS}$ (V)


7Z62706
$V_{DS} = 15$ V; $V_{GS} = 0$
$R_G = 1$ kΩ ; $T_{amb} = 25$ °C
input tuned to min. noise
F (dB)
3
2
1
0
typ
1
10
10^2
f (MHz)
10^3

N-CHANNEL SILICON FIELD-EFFECT TRANSISTORS

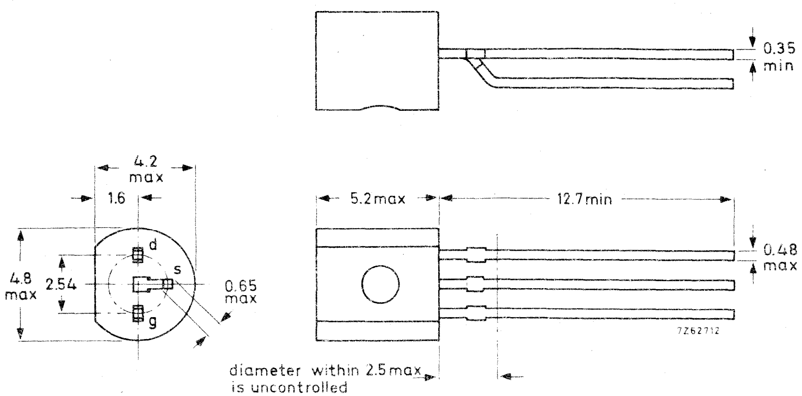
Symmetrical N-channel planar epitaxial junction field-effect transistors in a plastic TO-92 variant; intended for v.h.f. and u.h.f. applications.

QUICK REFERENCE DATA

Drain-source voltage	$\pm V_{DS}$	max.	30			V
Gate-source voltage (open drain)	$-V_{GSO}$	max.	30			V
Total power dissipation up to $T_{amb} = 75\ ^{o}C$	P_{tot}	max.	300			mW
			BF256A	B	C	
Drain current $V_{DS} = 15\ V;\ V_{GS} = 0$	I_{DSS}	>	3	6	11	mA
		<	7	13	18	mA
Feedback capacitance at f = 1 MHz $V_{DS} = 20\ V;\ -V_{GS} = 1\ V;\ T_{amb} = 25\ ^{o}C$	C_{rs}	typ.	0,7			pF
Transfer admittance (common source) $V_{DS} = 15\ V;\ V_{GS} = 0;\ f = 1\ kHz;\ T_{amb} = 25\ ^{o}C$	$\lvert y_{fs} \rvert$	>	4,5			mA/V
Power gain at f = 800 MHz $V_{DS} = 15\ V;\ R_S = 47\ \Omega$	G_p	typ.	11			dB

MECHANICAL DATA Dimensions in mm

TO-92 variant



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

Voltages

Drain-source voltage	$\pm V_{DS}$	max.	30	V	
Drain-gate voltage (open source)	V_{DGO}	max.	30	V	
Gate-source voltage (open drain)	$-V_{GSO}$	max.	30	V	

Current

Gate current	I_G	max.	10	mA	

Power dissipation

Total power dissipation up to T_{amb} = 75 °C	P_{tot}	max.	300	mW	
up to T_{amb} = 90 °C	P_{tot}	max.	300	mW	1)

Temperatures

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

THERMAL RESISTANCE

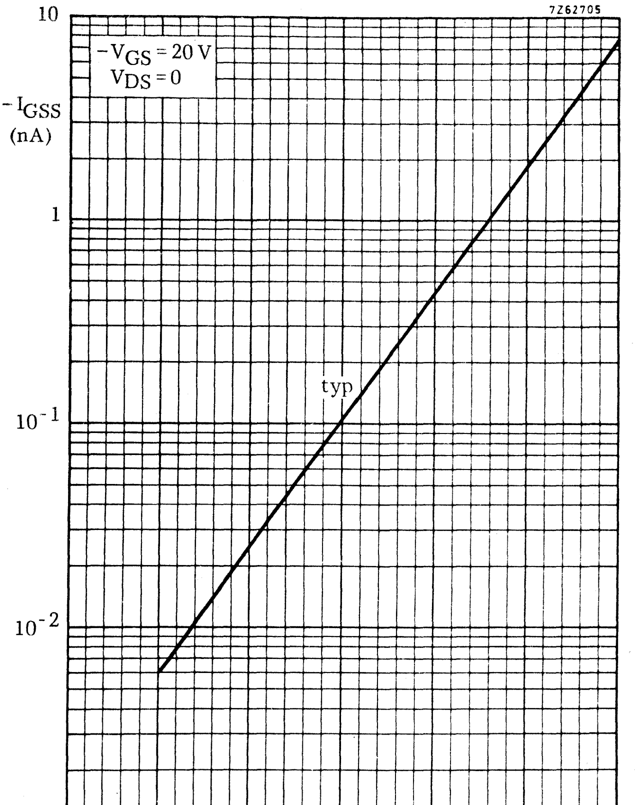
From junction to ambient in free air	$R_{th\ j-a}$	=	0,25	°C/mW	
From junction to ambient	$R_{th\ j-a}$	=	0,20	°C/mW	1)

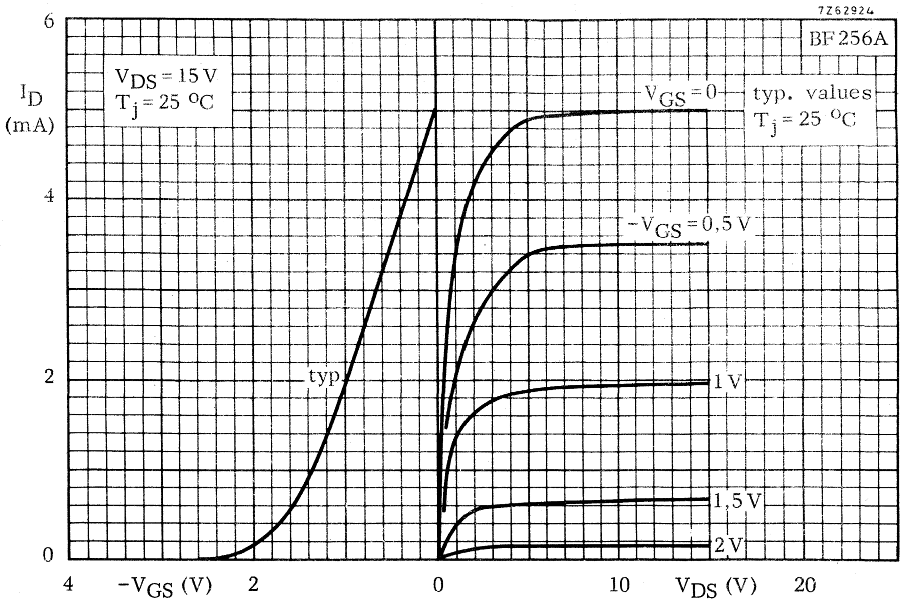
1) Transistor mounted on printed circuit board, max. lead length 3 mm, mounting pad for drain lead minimum 10 mm x 10 mm.

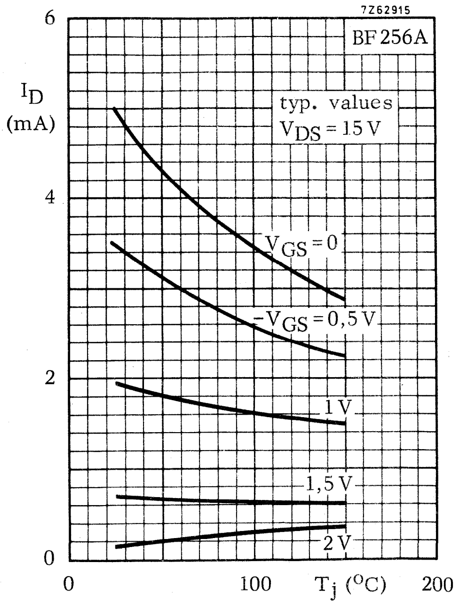
CHARACTERISTICS T_{amb} = 25 °C unless otherwise specified

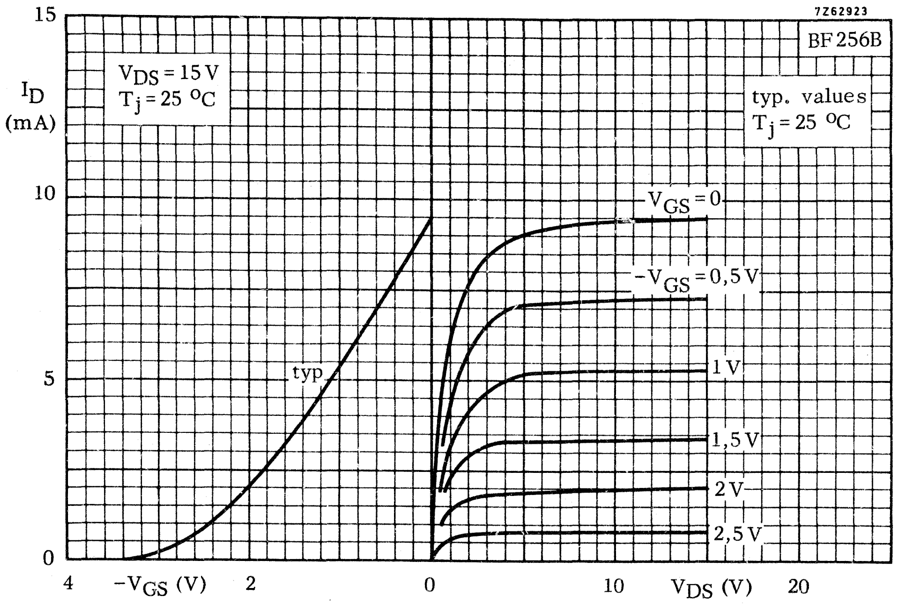
			BF256A	B	C		
Gate cut-off current							
$-V_{GS}$ = 20 V; V_{DS} = 0	$-I_{GSS}$	<			5	nA	
Drain current							
V_{DS} = 15 V; V_{GS} = 0	I_{DSS}	>	3	6	11	mA	1)
		<	7	13	18	mA	1)
Gate-source breakdown voltage							
$-I_G$ = 1 µA; V_{DS} = 0	$-V_{(BR)GSS}$	>			30	V	
Gate-source voltage							
I_D = 200 µA; V_{DS} = 15 V	$-V_{GS}$				0,5 to 7,5	V	
y-parameters (common source)							
Transfer admittance at f = 1 kHz V_{DS} = 15 V; V_{GS} = 0	$\|y_{fs}\|$	>			4,5	mA/V	1)
		typ.			5	mA/V	1)
Output capacitance at f = 1 MHz V_{DS} = 20 V; V_{GS} = 0	C_{os}	typ.			1,2	pF	
Feedback capacitance at f = 1 MHz V_{DS} = 20 V; $-V_{GS}$ = 1 V	C_{rs}	typ.			0,7	pF	
Cut-off frequency							
V_{DS} = 15 V; V_{GS} = 0	f_{gfs}	typ.			1	GHz	2)
Noise figure at f = 800 MHz							
V_{DS} = 10 V; R_S = 47 Ω	F	typ.			7,5	dB	
Power gain at f = 800 MHz							
V_{DS} = 15 V; R_S = 47 Ω	G_p	typ.			11	dB	

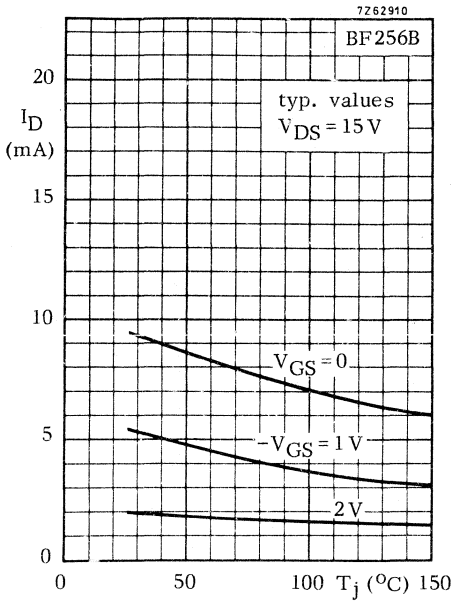
1) Measured under pulse conditions: t_p = 300 µs; $\delta \leq 0{,}02$
2) The frequency at which g_{fs} is 0,7 of its value at 1 kHz.

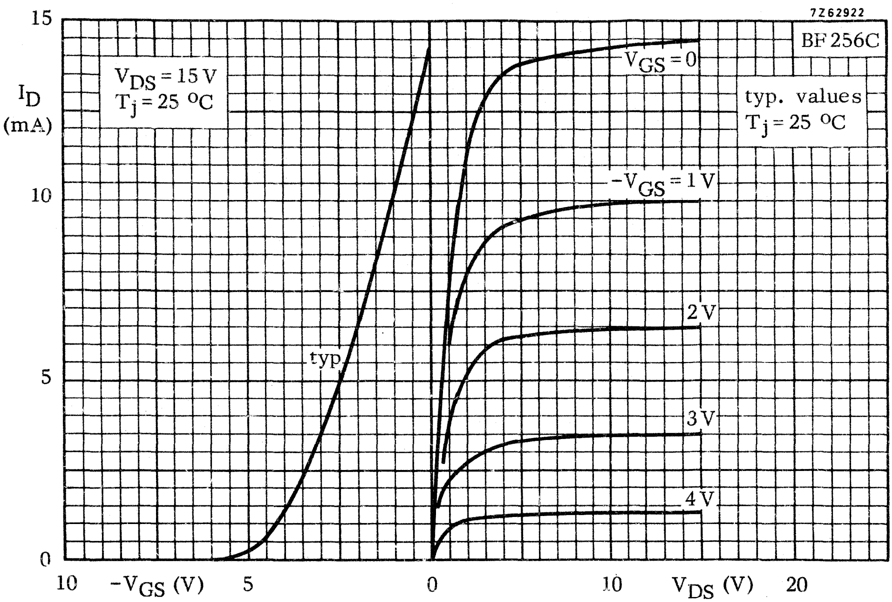

7Z62705
$-V_{GS} = 20$ V
$V_{DS} = 0$
$-I_{GSS}$ (nA)
10
1
10^{-1}
10^{-2}
10^{-3}
typ
0
50
100
T_j (°C)
150

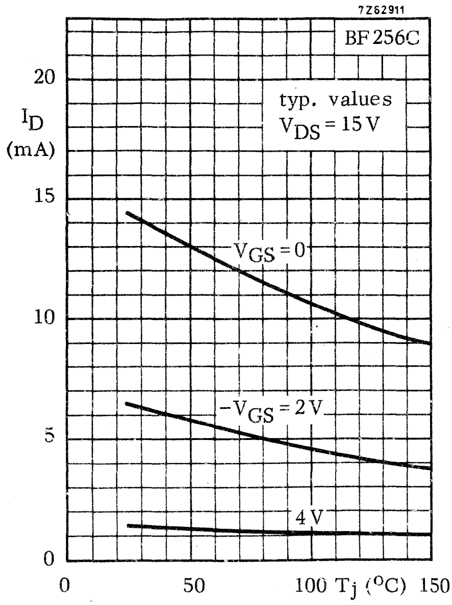

7Z62924
BF256A
V_{DS} = 15 V
T_j = 25 °C
I_D (mA)
typ. values
T_j = 25 °C
V_{GS} = 0
$-V_{GS}$ = 0,5 V
1 V
1,5 V
2 V
typ
6
4
2
0
4
$-V_{GS}$ (V)
2
0
10
V_{DS} (V)
20

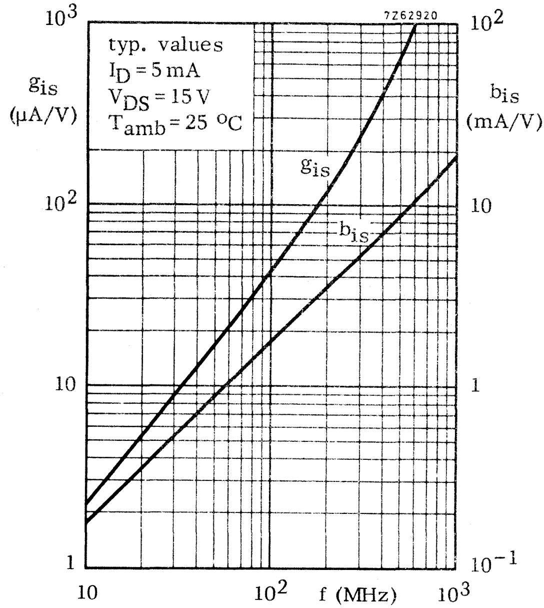

7Z62915
BF256A
I_D (mA)
typ. values
V_{DS} = 15 V
V_{GS} = 0
$-V_{GS}$ = 0,5 V
1 V
1,5 V
2 V
6
4
2
0
0
100
T_j (°C)
200

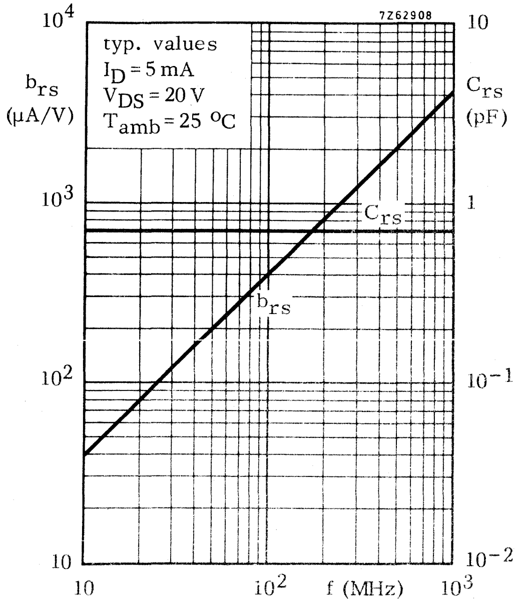

7Z62923
BF256B
V_{DS} = 15 V
T_j = 25 °C
I_D (mA)
typ. values
T_j = 25 °C
V_{GS} = 0
$-V_{GS}$ = 0,5 V
1 V
1,5 V
2 V
2,5 V
typ
15
10
5
0
4
$-V_{GS}$ (V)
2
0
10
V_{DS} (V)
20

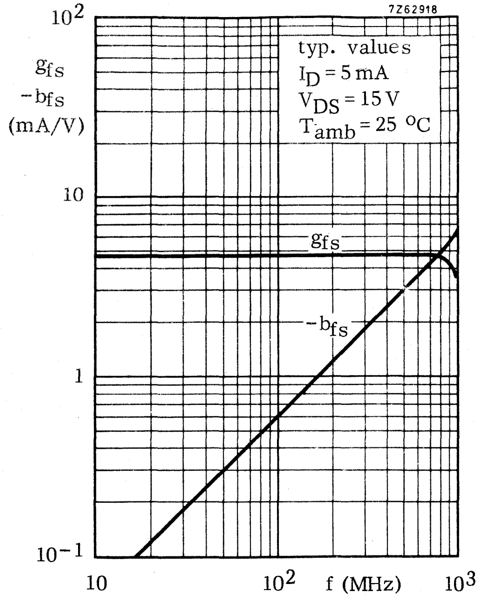

7Z62910
BF256B
typ. values
V_{DS} = 15 V
I_D (mA)
V_{GS} = 0
$-V_{GS}$ = 1 V
2 V
20
15
10
5
0
0
50
100
T_j (°C)
150

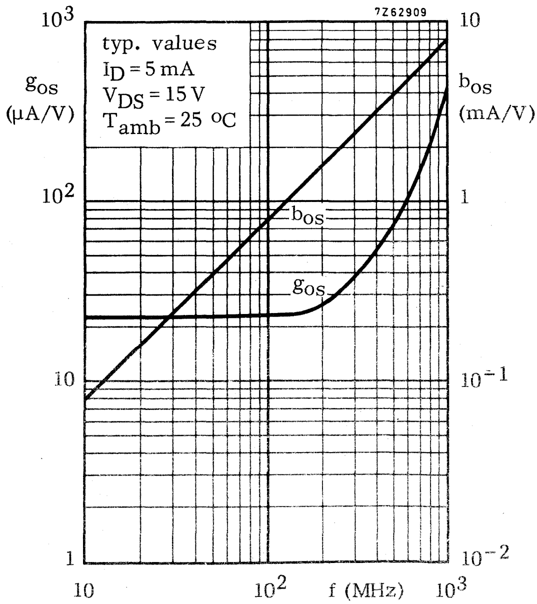

7Z62922
BF 256C
V_{DS} = 15 V
T_j = 25 °C
typ. values
T_j = 25 °C
I_D
(mA)
15
10
5
0
V_{GS} = 0
$-V_{GS}$ = 1 V
2 V
3 V
4 V
typ
10
$-V_{GS}$ (V)
5
0
10
V_{DS} (V)
20

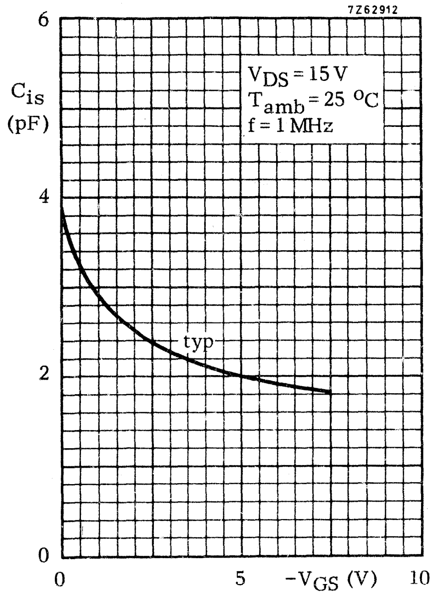

7Z62911
BF 256C
typ. values
V_{DS} = 15 V
I_D
(mA)
20
15
10
5
0
V_{GS} = 0
$-V_{GS}$ = 2 V
4 V
0
50
100 T_j (°C) 150

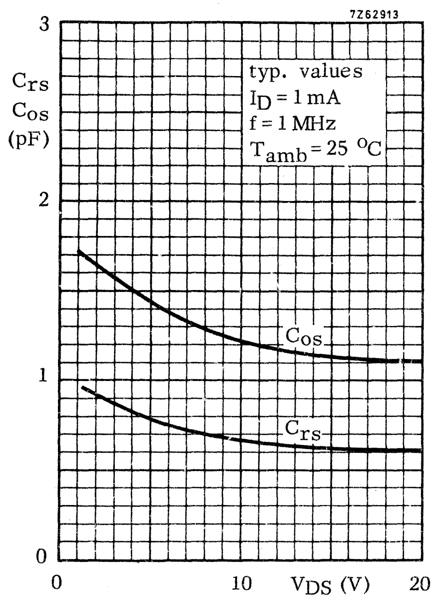

7Z62920
typ. values
I_D = 5 mA
V_{DS} = 15 V
T_{amb} = 25 °C
g_{is} (μA/V)
b_{is} (mA/V)
g_{is}
b_{is}
10^3
10^2
10
1
10^2
10
1
10^{-1}
10
10^2
f (MHz)
10^3

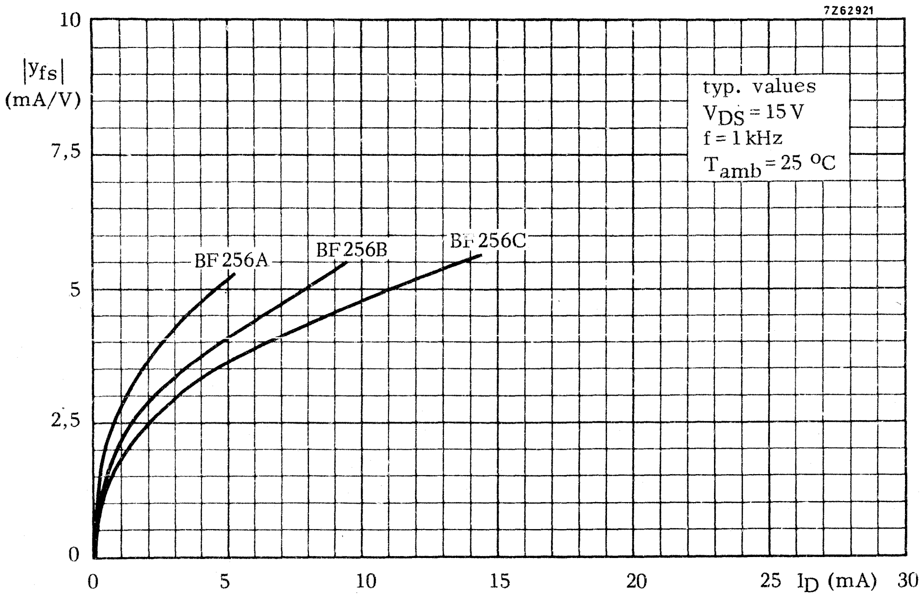

7Z62908
typ. values
I_D = 5 mA
V_{DS} = 20 V
T_{amb} = 25 °C
b_{rs} (μA/V)
C_{rs} (pF)
C_{rs}
b_{rs}
10^4
10^3
10^2
10
10
1
10^{-1}
10^{-2}
10
10^2
f (MHz)
10^3

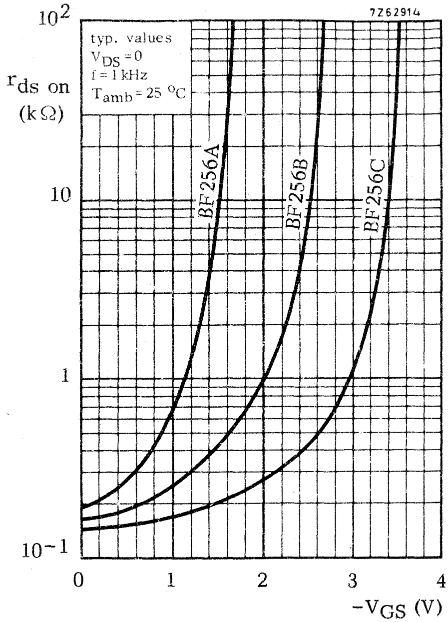

7Z62918
typ. values
I_D = 5 mA
V_{DS} = 15 V
T_{amb} = 25 °C
g_{fs}
$-b_{fs}$
(mA/V)
10^2
10
1
10^{-1}
g_{fs}
$-b_{fs}$
10
10^2
f (MHz)
10^3

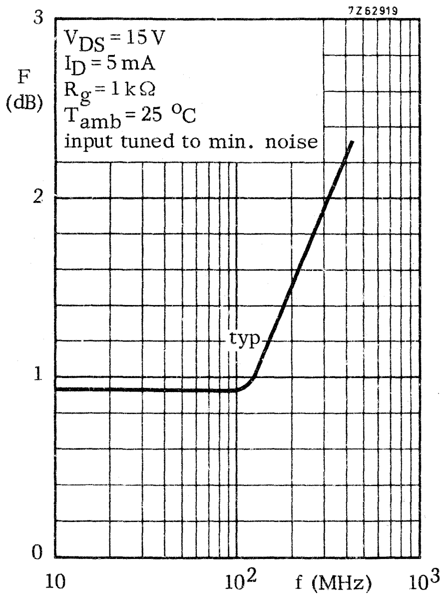

7Z62909
typ. values
I_D = 5 mA
V_{DS} = 15 V
T_{amb} = 25 °C
g_{os}
(µA/V)
b_{os}
(mA/V)
10^3
10^2
10
1
10
1
10^{-1}
10^{-2}
b_{os}
g_{os}
10
10^2
f (MHz)
10^3

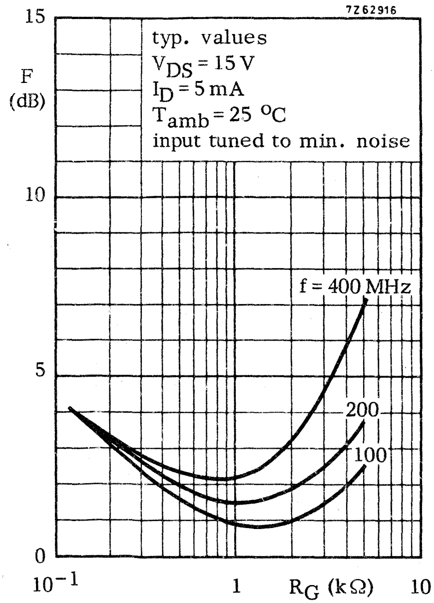

7Z62912
6
4
2
0
C_{is}
(pF)
V_{DS} = 15 V
T_{amb} = 25 °C
f = 1 MHz
typ
0
5
$-V_{GS}$ (V)
10


7Z62913
3
2
1
0
C_{rs}
C_{os}
(pF)
typ. values
I_D = 1 mA
f = 1 MHz
T_{amb} = 25 °C
C_{os}
C_{rs}
0
10
V_{DS} (V)
20


7Z62921
10
7,5
5
2,5
0
$|y_{fs}|$
(mA/V)
typ. values
V_{DS} = 15 V
f = 1 kHz
T_{amb} = 25 °C
BF256A
BF256B
BF256C
0
5
10
15
20
25
I_D (mA)
30


7Z62914
typ. values
V DS = 0
f = 1 kHz
T amb = 25 °C
r ds on
(kΩ)
BF256A
BF256B
BF256C
-V GS (V)


7Z62919
V DS = 15 V
I D = 5 mA
R g = 1 kΩ
T amb = 25 °C
input tuned to min. noise
F
(dB)
typ
f (MHz)


7Z62916
typ. values
V DS = 15 V
I D = 5 mA
T amb = 25 °C
input tuned to min. noise
F
(dB)
f = 400 MHz
200
100
R G (kΩ)

SILICON N-CHANNEL DUAL GATE FET

Depletion type field-effect transistor in a sub-miniature transfer-moulded X-package with source and substrate interconnected, intended for a wide range of v.h.f. applications, such as v.h.f. television tuners and f.m. tuners.

This MOS-FET tetrode is protected against excessive input voltage surges by integrated back-to-back diodes between gates and source.

The tetrode configuration, a series arrangement of two gate-controlled channels, offers:
a. very low feedback capacitance providing the possibility of more than 40 dB gain control in r.f. amplifiers requiring negligible a.g.c. power.
b. excellent signal handling capability over the entire gain control range.
c. low noise figure combined with high gain.

QUICK REFERENCE DATA

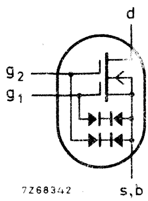
Drain-source voltage	V_{DS}	max.	20	V
Drain current	I_D	max.	25	mA
Total power dissipation up to T_{amb} = 75 °C	P_{tot}	max.	225	mW
Junction temperature	T_j	max.	150	°C
Transfer admittance at f = 1 kHz I_D = 10 mA; V_{DS} = 10 V; + V_{G2-S} = 4 V	$\|y_{fs}\|$	typ.	16	mA/V
Feedback capacitance at f = 1 MHz I_D = 10 mA; V_{DS} = 10 V; + V_{G2-S} = 4 V	C_{rs}	typ.	30	fF
Noise figure at optimum source admittance I_D = 10 mA; V_{DS} = 10 V; + V_{G2-S} = 4 V; f = 200 MHz	F	typ.	2,0	dB

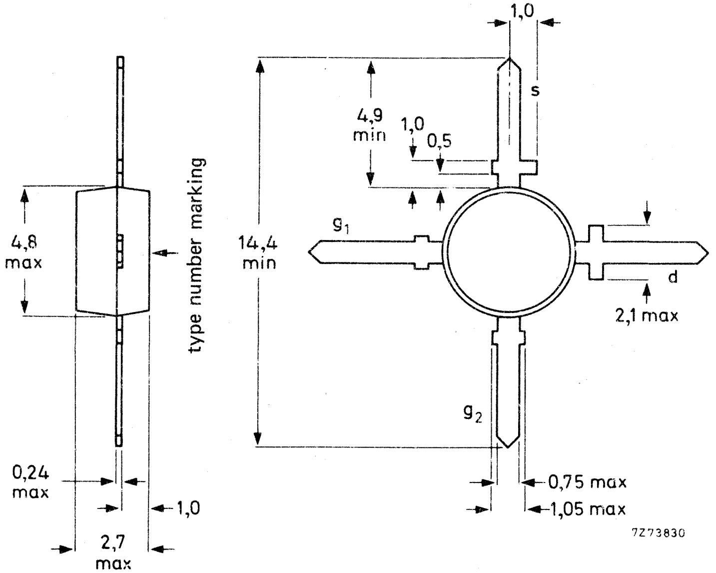
MECHANICAL DATA see page 2.

MECHANICAL DATA

Dimensions in mm

Fig. 1 SOT-103.





RATINGS

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

Drain-source voltage	V_{DS}	max.	20	V
Drain current (d.c. or average)	I_D	max.	25	mA
Drain current (peak value)	I_{DM}	max.	100	mA
Gate 1 - source current	$\pm I_{G1\text{-}S}$	max.	10	mA
Gate 2 - source current	$\pm I_{G2\text{-}S}$	max.	10	mA
Total power dissipation up to T_{amb} = 75 °C	P_{tot}	max.	225	mW
Storage temperature	T_{stg}	–65 to + 150		°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE see page 3.

STATIC CHARACTERISTICS

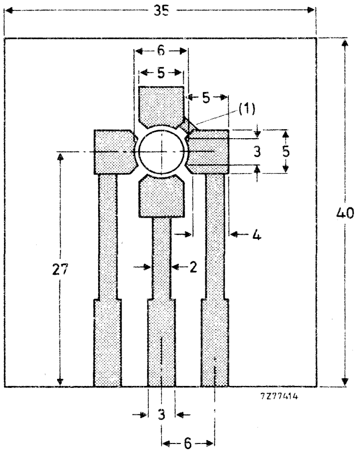
T_{amb} = 25 °C; unless otherwise specified

Gate cut-off currents			
$\pm V_{G1\text{-}S}$ = 5 V; $V_{G2\text{-}S} = V_{DS}$ = 0	$\pm I_{G1\text{-}SS}$	<	10 nA
$\pm V_{G1\text{-}S}$ = 5 V; $V_{G2\text{-}S} = V_{DS}$ = 0; T_j = 125 °C	$\pm I_{G1\text{-}SS}$	<	10 μA
$\pm V_{G2\text{-}S}$ = 5 V; $V_{G1\text{-}S} = V_{DS}$ = 0	$\pm I_{G2\text{-}SS}$	<	10 nA
$\pm V_{G2\text{-}S}$ = 5 V; $V_{G1\text{-}S} = V_{DS}$ = 0; T_j = 125 °C	$\pm I_{G2\text{-}SS}$	<	10 μA
Gate-source break down voltages			
$\pm I_{G1\text{-}SS}$ = 0,1 mA; $V_{G2\text{-}S} = V_{DS}$ = 0	$\pm V_{(BR)G1\text{-}SS}$		6,0 to 20 V
$\pm I_{G2\text{-}SS}$ = 0,1 mA; $V_{G1\text{-}S} = V_{DS}$ = 0	$\pm V_{(BR)G2\text{-}SS}$		6,0 to 20 V
Drain current			
V_{DS} = 10 V; $V_{G1\text{-}S}$ = 0; $+V_{G2\text{-}S}$ = 4 V	I_{DSS}		20 to 55 mA*
Gate 1 - source voltage			
I_D = 10 mA; V_{DS} = 10 V; $+V_{G2\text{-}S}$ = 4 V	$-V_{g1\text{-}S}$		0,6 to 2,1 V
Gate-source cut-off voltages			
I_D = 10 μA; V_{DS} = 10 V; $+V_{G2\text{-}S}$ = 4 V	$-V_{(P)G1\text{-}S}$		1,5 to 3,8 V
I_D = 10 μA; V_{DS} = 10 V; $V_{G1\text{-}S}$ = 0	$-V_{(P)G2\text{-}S}$		1,5 to 3,4 V

THERMAL RESISTANCE

From junction to ambient in free air mounted on the printed-circuit board $R_{th\ j\text{-}a}$ = 0,335 °C/mW

Dimensions in mm



(1) Connection made by a strip or Cu wire.

Fig. 2 Single-sided 35 μm Cu-clad epoxy fibre-glass printed-circuit board, thickness 1,5 mm. Tracks are fully tin-lead plated. Board in horizontal position for R_{th} measurement.

* Measured under pulse conditions.

DYNAMIC CHARACTERISTICS

Measuring conditions (common source): I_D 10 mA; V_{DS} = 10 V; + $V_{G2\text{-}S}$ = 4 V; T_{amb} = 25 °C

Transfer admittance at f = 1 kHz	$\|y_{fs}\|$	> typ.	12 mA/V 16 mA/V
Input capacitance at f = 1 MHz	C_{is}	typ.	5,0 pF
Feedback capacitance at f = 1 MHz	C_{rs}	typ.	30 fF
Output capacitance at f = 1 MHz	C_{os}	typ.	2,7 pF
Noise figure at optimum source admittance; f = 200 MHz	F	typ. <	2,0 dB 3,0 dB
Cross-modulation at f = 200 MHz wanted signal at f_o = 197,5 MHz unwanted signal at f_{int} = 202,5 MHz interference voltage at g_1 for K = 1%	V_{int}	typ.	100 mV*

* Cross-modulation is defined here as the voltage at g_1 of an unwanted signal with 80% modulation depth, giving 0,8% modulation depth on the wanted signal (a.m. definition).

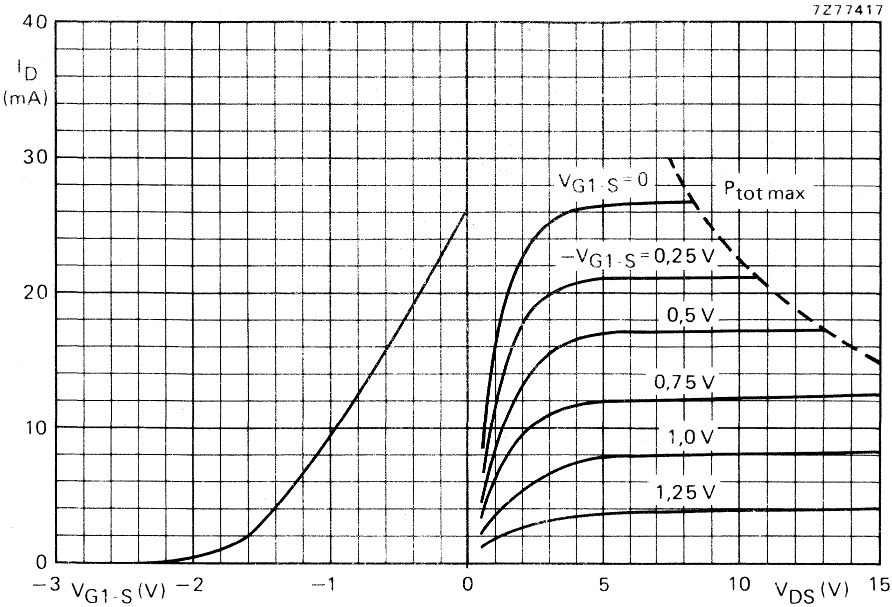


Fig. 3 Typical values. Left-hand side V_{DS} = 10 V; + $V_{G2\text{-}S}$ = 4 V; T_{amb} = 25 ^oC. Right-hand side + $V_{G2\text{-}S}$ = 4 V; T_{amb} = 25 ^oC.

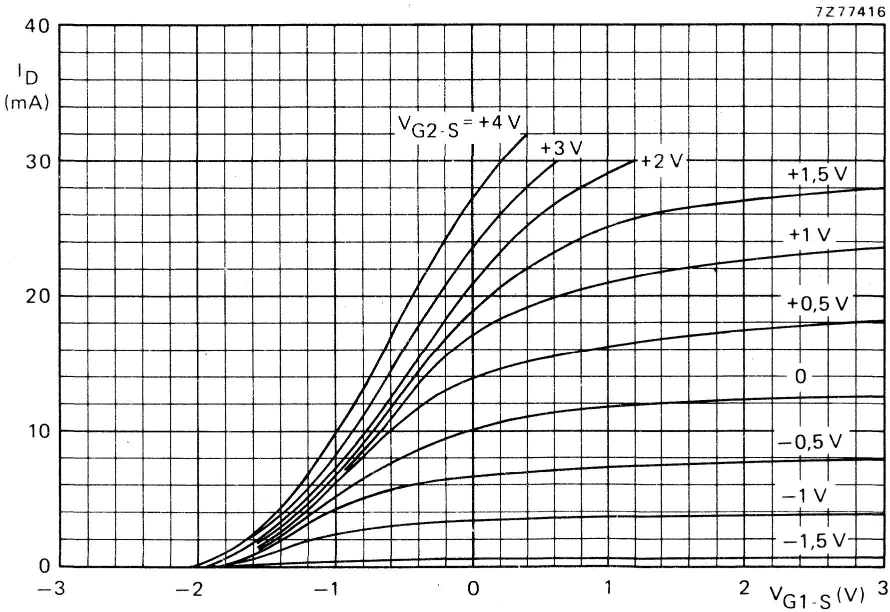


Fig. 4 Typical values; V_{DS} = 10 V; T_{amb} = 25 ^oC.

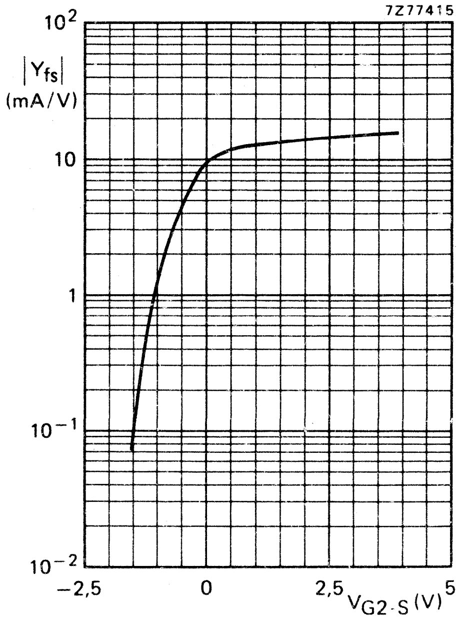


Fig. 5 Typical values at V_{DS} = 10 V; V_{G1-S} = adjusted for I_D = 10 mA at + V_{G2-S} = 4 V; f = 1 kHz; T_{amb} = 25 °C.

DUAL N-CHANNEL FETS

Dual n-channel silicon planar epitaxial junction field-effect transistors in a TO-71 metal envelope, with electrically insulated gates and a common substrate connected to the envelope; intended for high performance low level differential amplifiers.

QUICK REFERENCE DATA

Characteristics measured at T_{amb} = 25 °C; I_D = 200 μA; V_{DG} = 15 V

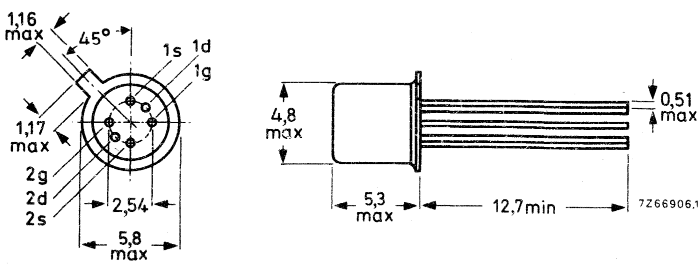
			BFQ10	11	12	13	14	15	16	
Difference in gate current	$\|\Delta I_G\|$	<	10	10	10	10	10	10	10	pA
Gate-source voltage difference	$\|\Delta V_{GS}\|$	<	5	10	10	10	15	20	50	mV
Thermal drift of gate-source voltage difference	$\left\|\frac{d\Delta V_{GS}}{dT}\right\|$	<	5	5	10	20	20	40	50	μV/°C
Transfer conductance ratio	$\frac{g_{1fs}}{g_{2fs}}$	> <	0,98 1,02	0,98 1,02	0,98 1,02	0,98 1,02	0,98 1,02	0,95 10,5	0,95 1,05	
Difference in transfer impedance	$\left\|\Delta \frac{1}{g_{fs}}\right\|$	<	6	6	12	12	12	20	30	Ω
Difference in penetration factor	$\left\|\Delta \frac{g_{os}}{g_{fs}}\right\|$	<	10	30	30	30	30	30	100	μV/V
Common mode rejection ratio	CMRR	>	100	90	90	90	90	90	80	dB

MECHANICAL DATA

Dimensions in mm

All leads insulated from the case

TO-71



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

Voltages

Drain-source voltage	$\pm V_{DS}$	max.	30	V
Drain-gate voltage (open source)	V_{DGO}	max.	30	V
Gate-source voltage (open drain)	$-V_{GSO}$	max.	30	V
Voltage between gate 1 and gate 2	$\pm V_{1G-2G}$	max.	40	V

Currents

Drain current	I_D	max.	30	mA
Gate current	I_G	max.	10	mA

Power dissipation

Total power dissipation up to T_{amb} = 75 °C	P_{tot}	max.	250	mW

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0,5	°C/mW

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

Measured at: I_D = 200 μA; V_{DG} = 15 V except for drain current ratio.

			BFQ10	11	12	13	14	15	16	
Drain current ratio 1) V_{DG} = 15 V; V_{GS} = 0	$\frac{I_{1D-1SS}}{I_{2D-2SS}}$	> <	0,97 1,03	0,95 1,05	0,95 1,05	0,95 1,05	0,92 1,08	0,90 1,10	0,80 1,20	
Difference in gate current	$\lvert \Delta I_G \rvert$	<	10	10	10	10	10	10	10	pA
Gate-source voltage difference	$\lvert \Delta V_{GS} \rvert$	<	5	10	10	10	15	20	50	mV
Thermal drift of gate-source voltage difference	$\left\lvert \frac{d\,\Delta V_{GS}}{dT} \right\rvert$	<	5	5	10	20	20	40	50	μV/°C
Transfer conductance ratio	$\frac{g_{1fs}}{g_{2fs}}$	> <	0,98 1,02	0,98 1,02	0,98 1,02	0,98 1,02	0,98 1,02	0,95 1,05	0,95 1,05	
Difference in transfer impedance 2)	$\left\lvert \Delta \frac{1}{g_{fs}} \right\rvert$	<	6	6	12	12	12	20	30	Ω
Difference in penetration factor 3)	$\left\lvert \Delta \frac{g_{os}}{g_{fs}} \right\rvert$	<	10	30	30	30	30	30	100	μV/V
Common mode rejection ratio 4)	CMRR	>	100	90	90	90	90	90	80	dB

1) Measured under pulse conditions.

2) The difference in transfer impedance is equal to the ratio of the change of the gate-source voltage difference to the change of drain current, at constant drain-gate voltage.
($\Delta \frac{1}{g_{fs}} = \frac{d\,\Delta V_{GS}}{d\,I_D}$ at V_{DG} = constant)

3) The difference in penetration factor is equal to the ratio of the change of the gate-source voltage difference to the change of drain-gate voltage, at constant drain current.
($\Delta \frac{g_{os}}{g_{fs}} = \frac{d\,\Delta V_{GS}}{d\,V_{DG}}$ at I_D = constant)

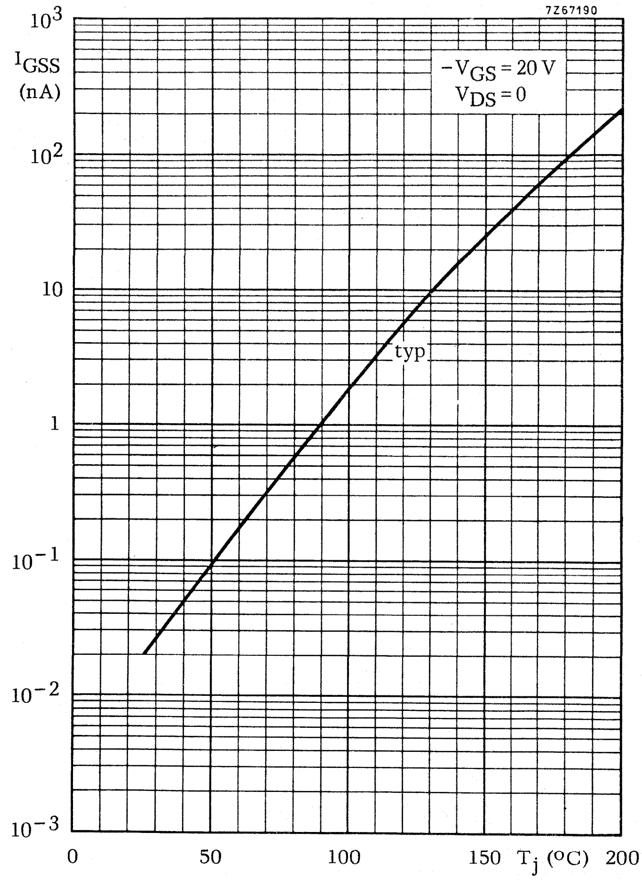
4) Common mode rejection ratio

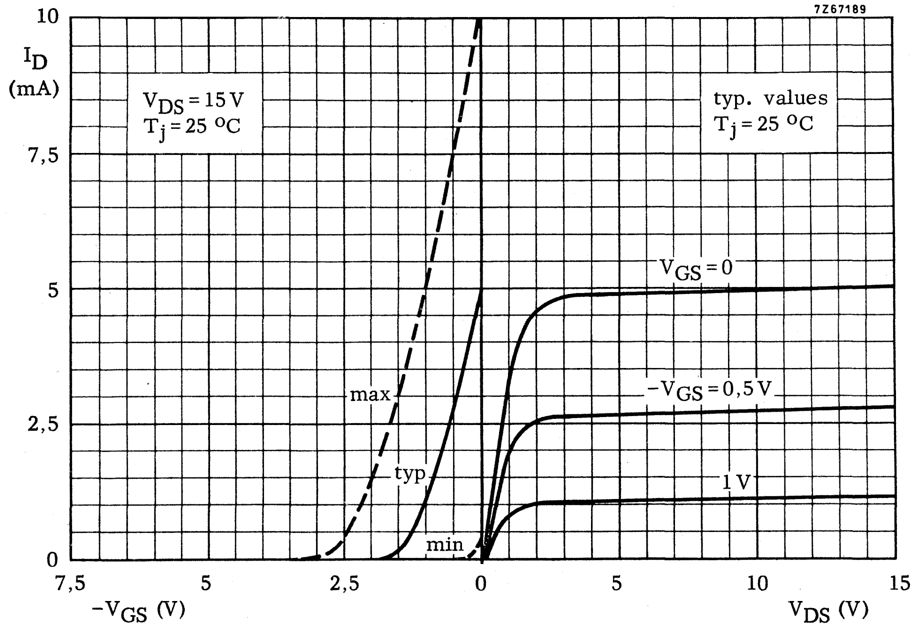
$$\text{CMRR (in dB)} = -20 \log \left\lvert \Delta \frac{g_{os}}{g_{fs}} \right\rvert$$

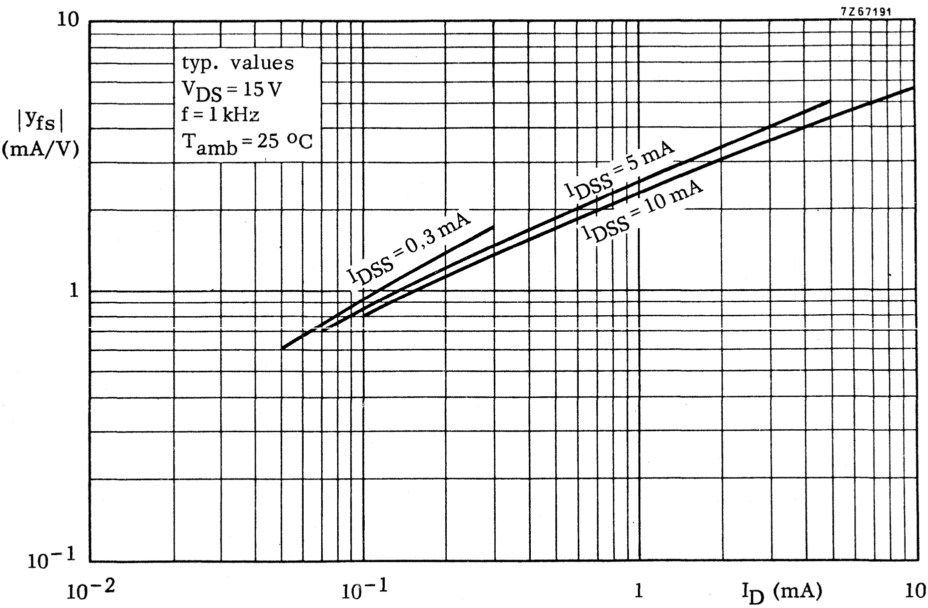
CHARACTERISTICS (Individual transistor) T_{amb} = 25 °C unless otherwise specified

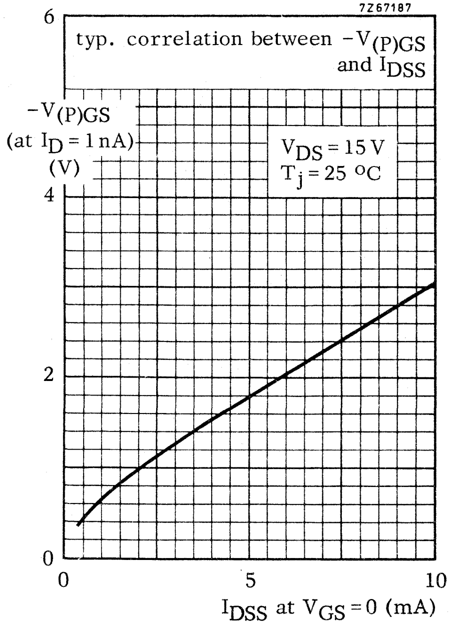
Gate cut-off current				
$-V_{GS}$ = 20 V; V_{DS} = 0	$-I_{GSS}$	<	100	pA
$-V_{GS}$ = 20 V; V_{DS} = 0; T_{amb} = 125 °C	$-I_{GSS}$	<	20	nA
Gate current				
I_D = 200 μA; V_{DG} = 15 V; T_{amb} = 125 °C	I_G	<	10	nA
Drain current				
V_{DS} = 15 V; V_{GS} = 0	I_{DSS}		0,5 to 10	mA 1)
Gate-source voltage				
I_D = 200 μA; V_{DG} = 15 V	$-V_{GS}$	<	2,7	V
Gate-source cut-off voltage				
I_D = 1 nA; V_{DG} = 15 V	$-V_{(P)GS}$		0,5 to 3,5	V
Transfer conductance at f = 1 kHz				
I_D = 200 μA; V_{DG} = 15 V	g_{fs}	>	1,0	mA/V
Output conductance at f = 1 kHz				
I_D = 200 μA; V_{DG} = 15 V	g_{os}	<	5	μA/V
Input capacitance at f = 1 MHz				
I_D = 200 μA; V_{DG} = 15 V	C_{is}	<	8	pF 2)
Feedback capacitance at f = 1 MHz				
I_D = 200 μA; V_{DG} = 15 V	C_{rs}	<	1,0	pF 2)
Equivalent noise voltage				
I_D = 200 μA; V_{DS} = 15 V B = 0,6 to 100 Hz	V_n	<	0,5	μV

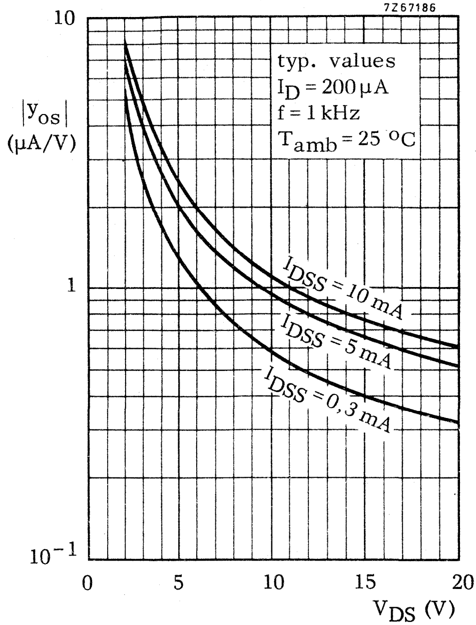
1) Measured under pulse conditions.
2) Measured with case grounded.

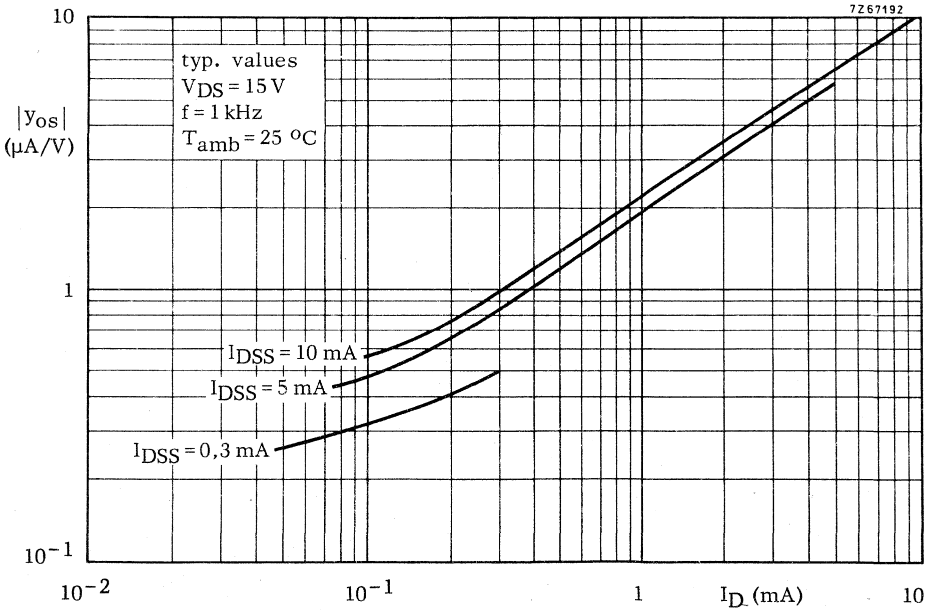

7Z67190
10^3
I_{GSS}
(nA)
$-V_{GS} = 20$ V
$V_{DS} = 0$
10^2
10
typ
1
10^{-1}
10^{-2}
10^{-3}
0
50
100
150
T_j (°C)
200

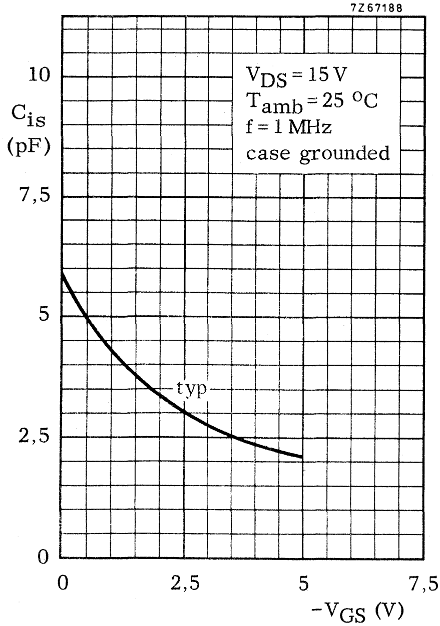

7Z67189
I_D
(mA)
$V_{DS} = 15$ V
$T_j = 25$ °C
typ. values
$T_j = 25$ °C
$V_{GS} = 0$
$-V_{GS} = 0,5$ V
1 V
max
typ
min
10
7,5
5
2,5
0
7,5
5
2,5
0
5
10
15
$-V_{GS}$ (V)
V_{DS} (V)

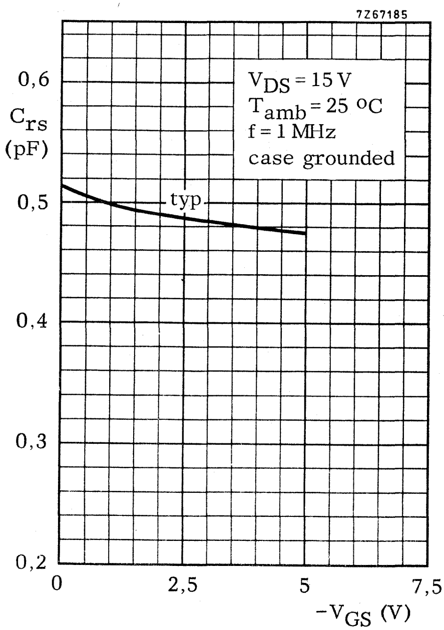

7Z67191
$|y_{fs}|$
(mA/V)
typ. values
$V_{DS} = 15$ V
f = 1 kHz
$T_{amb} = 25$ °C
$I_{DSS} = 0,3$ mA
$I_{DSS} = 5$ mA
$I_{DSS} = 10$ mA
10
1
10^{-1}
10^{-2}
10^{-1}
1
I_D (mA)
10

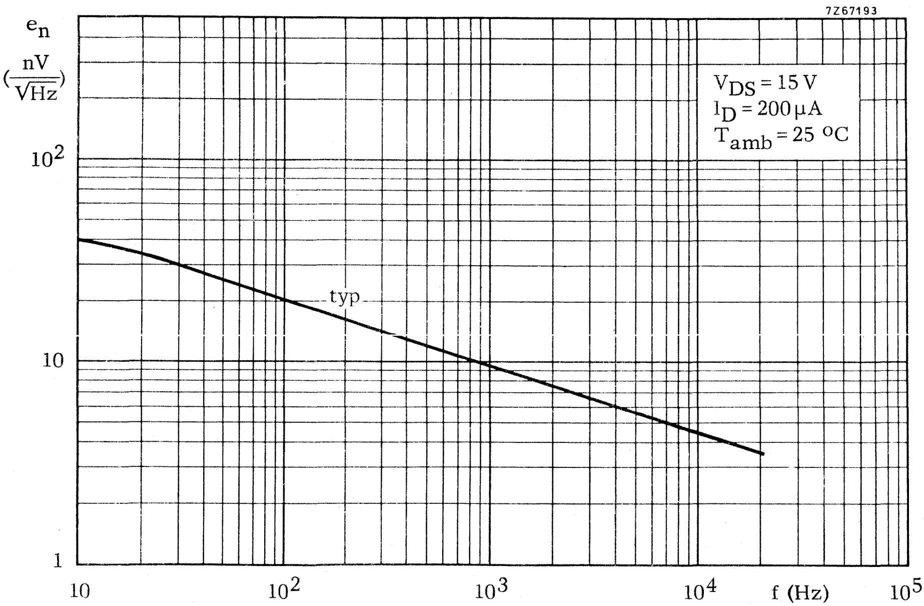

7Z67187
typ. correlation between $-V_{(P)GS}$ and I_{DSS}
$-V_{(P)GS}$ (at $I_D = 1$ nA) (V)
$V_{DS} = 15$ V
$T_j = 25$ °C
0
2
4
6
0
5
10
I_{DSS} at $V_{GS} = 0$ (mA)


7Z67186
typ. values
$I_D = 200$ μA
f = 1 kHz
$T_{amb} = 25$ °C
$|y_{os}|$ (μA/V)
$I_{DSS} = 10$ mA
$I_{DSS} = 5$ mA
$I_{DSS} = 0,3$ mA
10^{-1}
1
10
0
5
10
15
20
V_{DS} (V)


7Z67192
typ. values
$V_{DS} = 15$ V
f = 1 kHz
$T_{amb} = 25$ °C
$|y_{os}|$ (μA/V)
$I_{DSS} = 10$ mA
$I_{DSS} = 5$ mA
$I_{DSS} = 0,3$ mA
10^{-1}
1
10
10^{-2}
10^{-1}
1
I_D (mA)
10


7Z67188
10
7,5
5
2,5
0
Cis
(pF)
VDS = 15 V
Tamb = 25 oC
f = 1 MHz
case grounded
typ
0
2,5
5
7,5
−VGS (V)


7Z67185
0,6
0,5
0,4
0,3
0,2
Crs
(pF)
VDS = 15 V
Tamb = 25 oC
f = 1 MHz
case grounded
typ
0
2,5
5
7,5
−VGS (V)


7Z67193
en
(nV/√Hz)
10²
10
1
VDS = 15 V
ID = 200 μA
Tamb = 25 oC
typ
10
10²
10³
10⁴
f (Hz)
10⁵

N-CHANNEL INSULATED GATE FIELD EFFECT TRANSISTOR

Depletion type insulated gate field effect transistor in a TO-72 metal envelope with the substrate connected to the case.
It is intended for linear applications in the audio as well as the i.f. and v.h.f. frequency region, and in cases where high input impedance, low gate leakage currents and low noise figures are of importance.

QUICK REFERENCE DATA

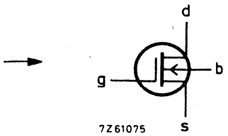
Drain-substrate voltage	V_{DB}	max.	30	V
Gate-substrate voltage	V_{GB}	max. min.	10 −10	V V
Drain current V_{DS} = 15 V; V_{GS} = 0	I_{DSS}	10 to	40	mA
Transfer admittance I_D = 5 mA; V_{DS} = 15 V; f = 1 kHz	$\|y_{fs}\|$	>	6	mA/V
Feedback capacitance I_D = 5 mA; V_{DS} = 15 V; f = 1 MHz	C_{rs}	<	0.7	pF
Noise figure at f = 200 MHz ; T_{amb} = 25 °C I_D = 5 mA; V_{DS} = 15 V G_S = 1 mΩ^{-1}; B_S = B_{Sopt}	F	<	5	dB
Equivalent noise voltage ; T_{amb} = 25 °C I_D = 5 mA; V_{DS} = 15 V; f = 1 kHz	$V_n/\sqrt{B}$	typ.	100	nV/$\sqrt{Hz}$

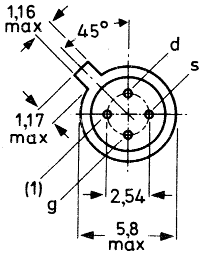
MECHANICAL DATA see page 2

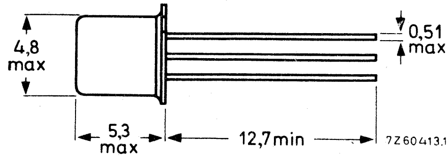
MECHANICAL DATA

Dimensions in mm

TO-72







(1) = substrate (b) connected to case.

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

Note

To safeguard the gates against damage due to accumulation of static charge during transport or handling, the leads are encircled by a ring of conductive rubber which should be removed just after the transistor is soldered into the circuit.

RATINGS

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

Drain-substrate voltage	V_{DB}	max.	30	V
Source-substrate voltage	V_{SB}	max.	30	V
Gate-substrate voltage (continuous)	V_{GB}	max.	10	V
		min.	−10	V
Repetitive peak gate to all other terminals voltage $V_{SB} = V_{DB} = 0$; $f > 100$ Hz	V_{G-N}	max.	15	V
		min.	−15	V
Drain current (d.c.)	I_D	max.	20	mA
Drain current (peak value) $t_r = 20$ ms; $\delta = 0,1$	I_{DM}	max.	50	mA
Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	200	mW
Storage temperature	T_{stg}	−65 to + 125		^oC
Junction temperature	T_j	max.	125	^oC

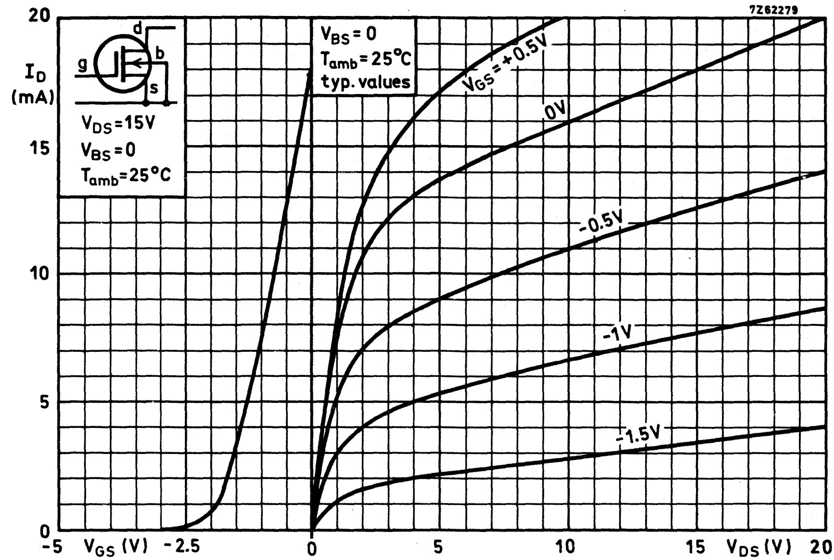
THERMAL RESISTANCE

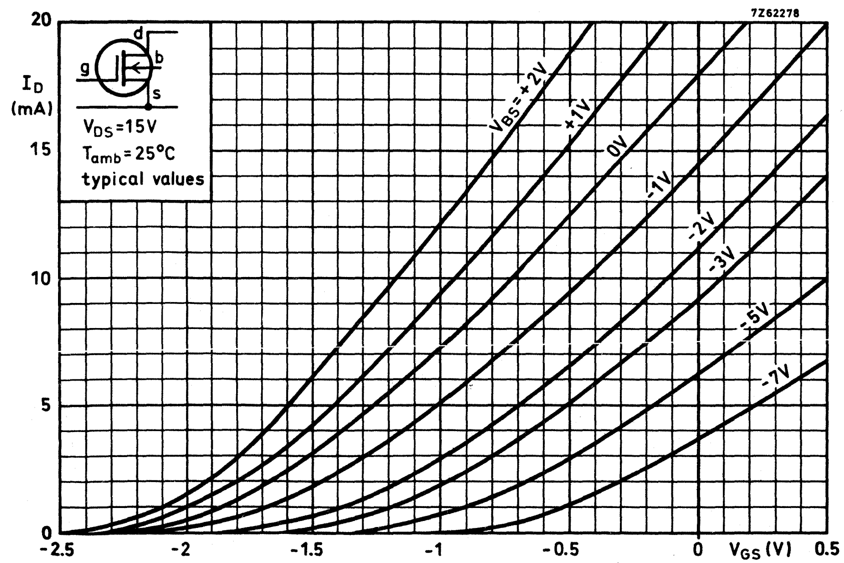
From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0,5	$^oC/mW$

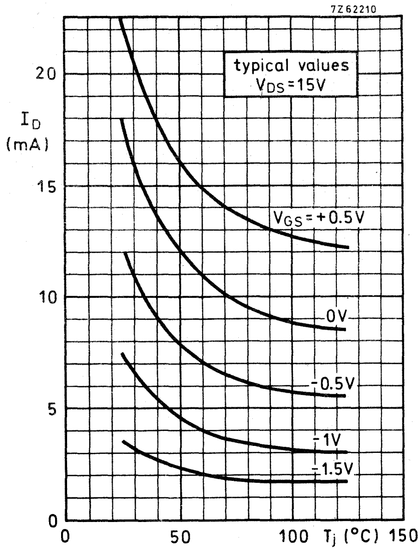
CHARACTERISTICS

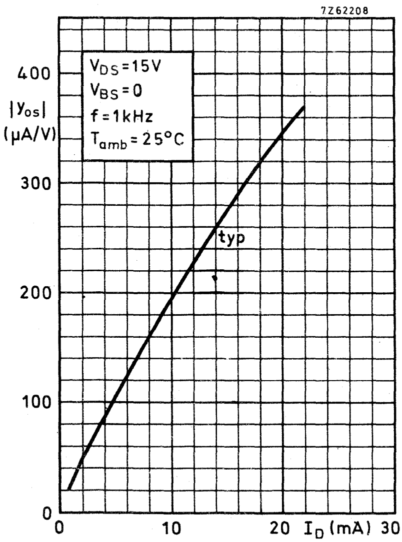
$T_j = 25\ ^oC$ unless otherwise specified

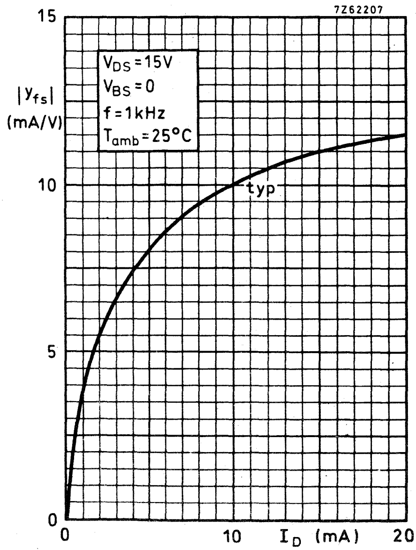
Gate currents; $V_{BS} = 0$				
$-V_{GS} = 10$ V; $V_{DS} = 0$	$-I_{GSS}$	<	10	pA
$V_{GS} = 10$ V; $V_{DS} = 0$	I_{GSS}	<	10	pA
$-V_{GS} = 10$ V; $V_{DS} = 0$; $T_j = 125\ ^oC$	$-I_{GSS}$	<	200	pA
$V_{GS} = 10$ V; $V_{DS} = 0$; $T_j = 125\ ^oC$	I_{GSS}	<	200	pA
Bulk currents; $V_{GB} = 0$				
$-V_{BD} = 30$ V; $I_S = 0$	$-I_{BDO}$	<	10	μA
$-V_{BS} = 30$ V; $I_D = 0$	$-I_{BSO}$	<	10	μA
Drain current				
$V_{DS} = 15$ V; $V_{GS} = 0$	I_{DSS}	10 to	40	mA
Gate-source voltage				
$I_D = 100$ nA; $V_{DS} = 15$ V	$-V_{GS}$	0.5 to	3.5	V
Gate-source cut-off voltage				
$I_D = 100$ nA ; $V_{DS} = 15$ V	$-V_{(P)GS}$	<	4	V
y parameters $T_{amb} = 25\ ^oC$				
$I_D = 5$ mA; $V_{DS} = 15$ V				
Transfer admittance at f = 1 kHz	$\|y_{fs}\|$	>	6	mA/V
Output admittance at f = 1 kHz	$\|y_{os}\|$	<	0.4	mA/V
Input capacitance at f = 1 MHz	C_{is}	<	5	pF
Feedback capacitance at f = 1 MHz	C_{rs}	<	0.7	pF
Output capacitance at f = 1 MHz	C_{os}	<	3	pF
Noise figure at f = 200 MHz $T_{amb} = 25\ ^oC$				
$I_D = 5$ mA; $V_{DS} = 15$ V				
$G_S = 1\ m\Omega^{-1}$; $B_S = B_{Sopt}$	F	<	5	dB
Equivalent noise voltage $T_{amb} = 25\ ^oC$				
$I_D = 5$ mA; $V_{DS} = 15$ V; f = 120 Hz	$V_n/\sqrt{B}$	typ.	300	nV/$\sqrt{Hz}$
f = 1 kHz	$V_n/\sqrt{B}$	typ.	100	nV/$\sqrt{Hz}$
f = 10 kHz	$V_n/\sqrt{B}$	typ.	35	nV/$\sqrt{Hz}$

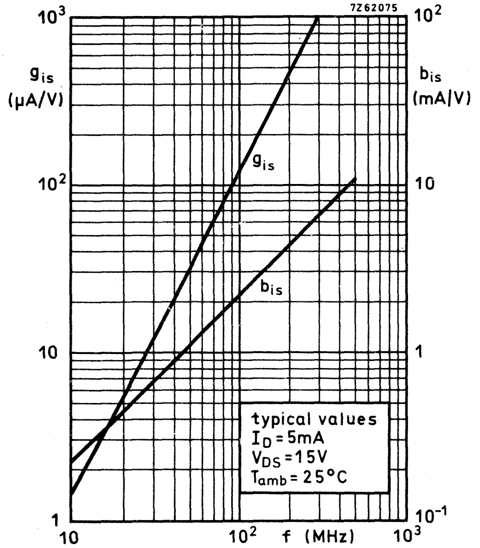

7Z62279
I_D (mA)
20
15
10
5
0
-5
V_{GS} (V)
-2.5
0
5
10
15
V_{DS} (V)
20
d
g
b
s
V_{DS}=15V
V_{BS}=0
T_{amb}=25°C
V_{BS} = 0
T_{amb} = 25°C
typ. values
V_{GS} = +0.5V
0V
-0.5V
-1V
-1.5V

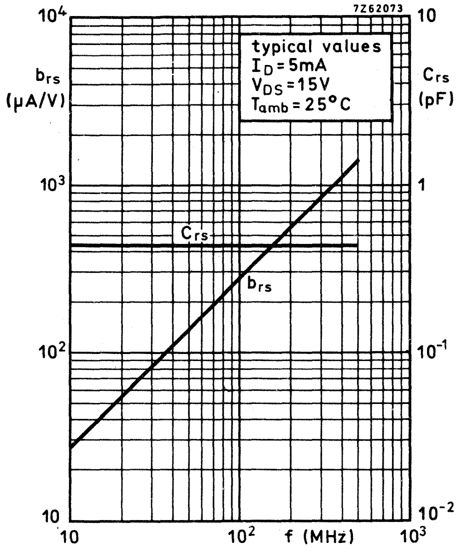

7Z62278
I_D (mA)
20
15
10
5
0
-2.5
-2
-1.5
-1
-0.5
0
V_{GS} (V)
0.5
d
g
b
s
V_{DS}=15V
T_{amb}=25°C
typical values
V_{BS} = +2V
+1V
0V
-1V
-2V
-3V
-5V
-7V

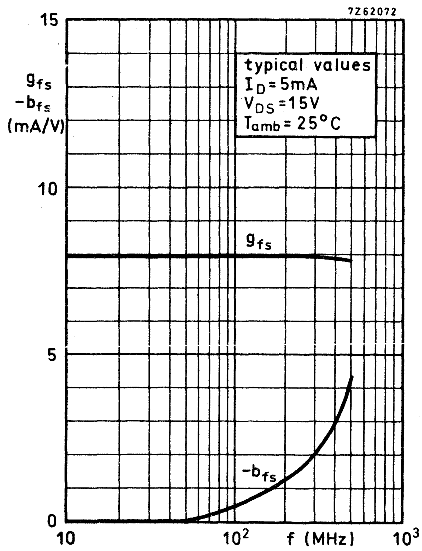

7Z62210
typical values
V_{DS}=15V
I_D (mA)
V_{GS}=+0.5V
0V
-0.5V
-1V
-1.5V
0
5
10
15
20
0
50
100
T_j (°C)
150

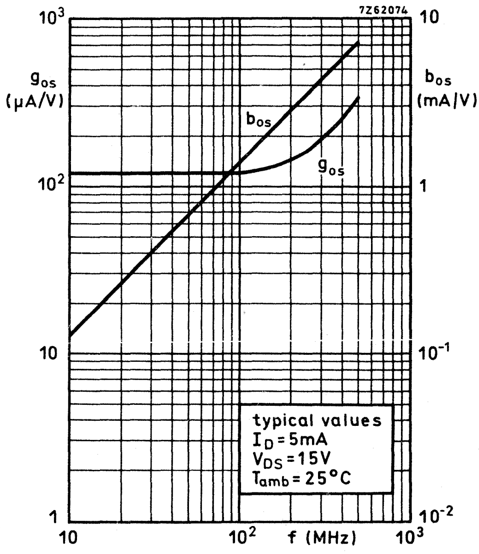

7Z62208
V_{DS}=15V
V_{BS}=0
f=1kHz
T_{amb}=25°C
$|y_{os}|$ (μA/V)
typ
0
100
200
300
400
0
10
20
I_D (mA)
30

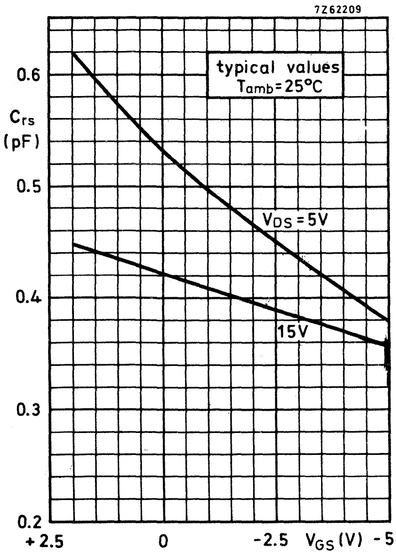

7Z62207
V_{DS}=15V
V_{BS}=0
f=1kHz
T_{amb}=25°C
$|y_{fs}|$ (mA/V)
typ
0
5
10
15
0
10
I_D (mA)
20

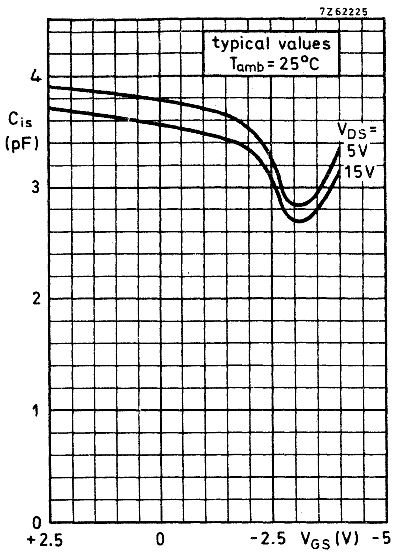

7Z62075
g_{is} (μA/V)
b_{is} (mA/V)
g_{is}
b_{is}
typical values
I_D = 5mA
V_{DS} = 15V
T_{amb} = 25°C
f (MHz)


7Z62073
typical values
I_D = 5mA
V_{DS} = 15V
T_{amb} = 25°C
b_{rs} (μA/V)
C_{rs} (pF)
C_{rs}
b_{rs}
f (MHz)


7Z62072
g_{fs}
$-b_{fs}$
(mA/V)
typical values
I_D = 5mA
V_{DS} = 15V
T_{amb} = 25°C
g_{fs}
$-b_{fs}$
f (MHz)


7Z62074
g_{os} (μA/V)
b_{os} (mA/V)
b_{os}
g_{os}
typical values
I_D = 5mA
V_{DS} = 15V
T_{amb} = 25°C
f (MHz)


7Z62209
typical values
T_{amb} = 25°C
C_{rs}
(pF)
0.6
0.5
0.4
0.3
0.2
V_{DS} = 5V
15V
+2.5
0
-2.5
V_{GS} (V)
-5


7Z62225
typical values
T_{amb} = 25°C
C_{is}
(pF)
4
3
2
1
0
V_{DS} =
5V
15V
+2.5
0
-2.5
V_{GS} (V)
-5

For data and curves of these types please refer to section
Microminiature devices for thick- and thin-film circuits
in Handbook SC4a 06-76

SILICON N-CHANNEL DUAL IG-FET

Depletion type field-effect transistor in a TO-72 metal envelope with source and substrate connected to the case, intended for a wide range of v.h.f. applications, such as v.h.f. television tuners, f.m. tuners, as well as for applications in communication, instrumentation and control.

This MOS-FET tetrode is protected against excessive input voltage surges by integrated back-to-back diodes between gates and source.

The tetrode configuration, a series arrangement of two gate controlled channels, offers:

a) very low feedback capacitance providing the possibility of more than 40 dB gain control in r.f. amplifiers requiring negligible a.g.c. power.
b) excellent signal handling capability over the entire gain control range.
c) low noise figure combined with high gain.

QUICK REFERENCE DATA

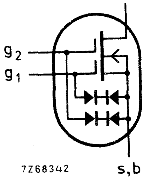
Drain-source voltage	V_{DS}	max.	20	V
Drain current	I_D	max.	50	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	mW
Junction temperature	T_j	max.	175	°C
Transfer admittance at f = 1 kHz I_D = 10 mA; V_{DS} = 10 V; + V_{G2-S} = 4 V	$\|y_{fs}\|$	typ.	15	mA/V
Feedback capacitance at f = 1 MHz I_D = 10 mA; V_{DS} = 10 V; + V_{G2-S} = 4 V	C_{rs}	typ.	30	fF
Noise figure at optimum source admittance I_D = 10 mA; V_{DS} = 10 V; + V_{G2-S} = 4 V G_S = 1,2 mA/V; $-B_S$ = 5,7 mA/V; f = 200 MHz	F	typ.	2,3	dB

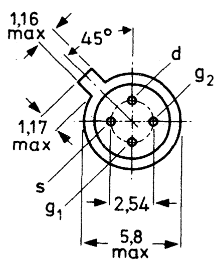
MECHANICAL DATA

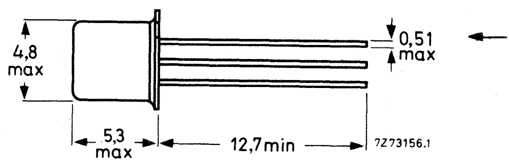
Dimensions in mm

Source and substrate connected to the case

TO-72







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

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

Voltage

Drain-source voltage	V_{DS}	max.	20	V

Currents

Drain current (d.c. or average)	I_D	max.	50	mA
Drain current (peak value)	I_{DM}	max.	100	mA
Gate 1-source current	$\pm I_{G1-S}$	max.	10	mA
Gate 2-source current	$\pm I_{G2-S}$	max.	10	mA

Power dissipation

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

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0,5	°C/mW

STATIC CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Gate cut-off currents

$\pm V_{G1-S}$ = 5 V; $V_{G2-S} = V_{DS}$ = 0	$\pm I_{G1-SS}$	<	10	nA
$\pm V_{G1-S}$ = 5 V; $V_{G2-S} = V_{DS}$ = 0; T_j = 150 °C	$\pm I_{G1-SS}$	<	10	μA
$\pm V_{G2-S}$ = 5 V; $V_{G1-S} = V_{DS}$ = 0	$\pm I_{G2-SS}$	<	10	nA
$\pm V_{G2-S}$ = 5 V; $V_{G1-S} = V_{DS}$ = 0; T_j = 150 °C	$\pm I_{G2-SS}$	<	10	μA

Gate-source breakdown voltages

$\pm I_{G1-SS}$ = 0,1 mA; $V_{G2-S} = V_{DS}$ = 0	$\pm V_{(BR)G1-SS}$	6,0 to 20	V
$\pm I_{G2-SS}$ = 0,1 mA; $V_{G1-S} = V_{DS}$ = 0	$\pm V_{(BR)G2-SS}$	6,0 to 20	V

Drain current

V_{DS} = 10 V; V_{G1-S} = 0; $+V_{G2-S}$ = 4 V	I_{DSS}	20 to 55	mA [1])

Gate 1-source voltage

I_D = 10 mA; V_{DS} = 10 V; $+V_{G2-S}$ = 4 V	$-V_{G1-S}$	0,6 to 2,1	V

Gate-source cut-off voltages

I_D = 10 μA ; V_{DS} = 10 V; $+V_{G2-S}$ = 4 V	$-V_{(P)G1-S}$	1,5 to 3,8	V
I_D = 10 μA ; V_{DS} = 10 V; V_{G1-S} = 0	$-V_{(P)G2-S}$	1,5 to 3,4	V

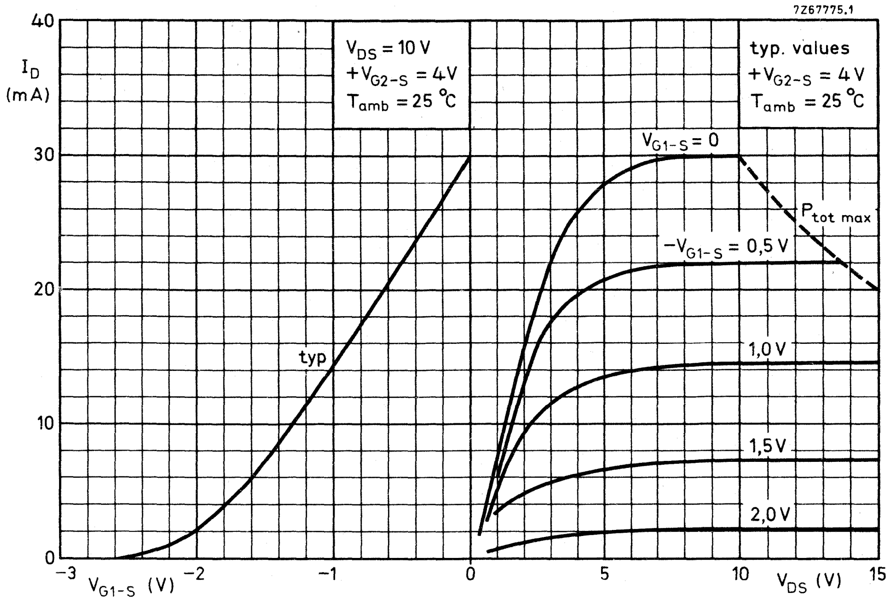
[1]) Measured under pulse conditions.

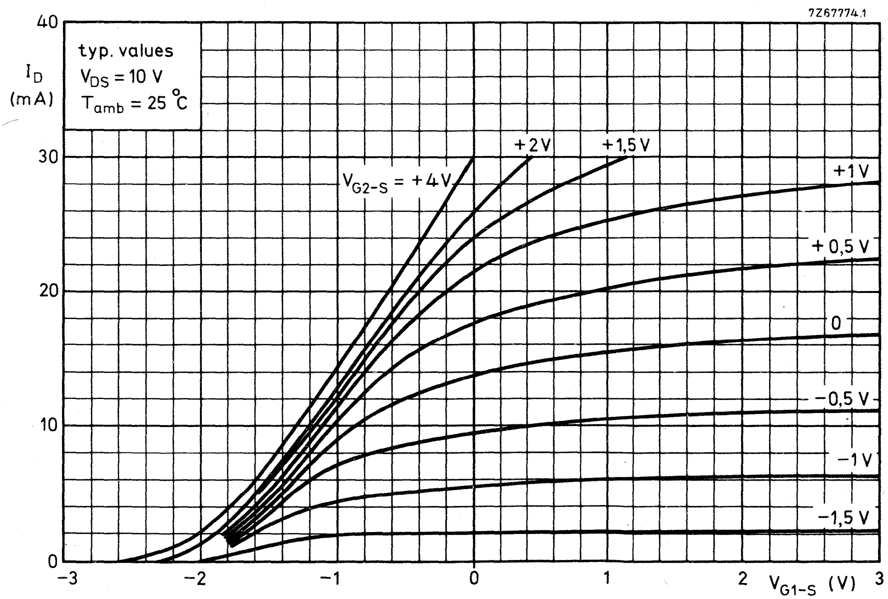
DYNAMIC CHARACTERISTICS

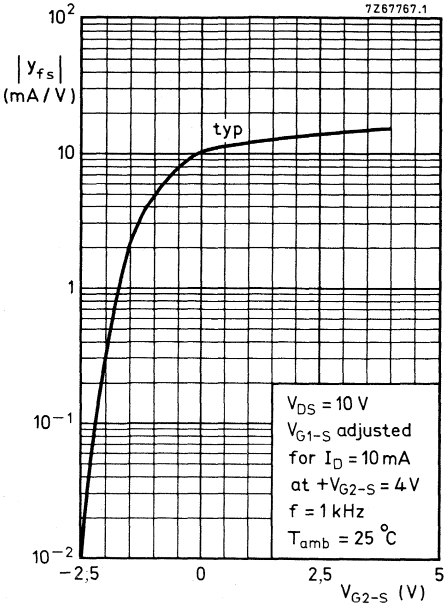
Measuring conditions (common source): I_D = 10 mA; V_{DS} = 10 V; $+V_{G2-S}$ = 4 V; T_{amb} = 25 °C

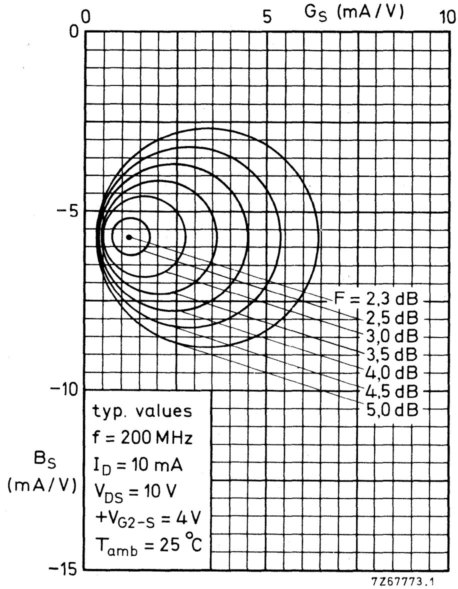
Transfer admittance at f = 1 kHz	$\|y_{fs}\|$	>	12	mA/V
		typ.	15	mA/V
Input capacitance at f = 1 MHz	C_{is}	typ.	5, 5	pF
Feedback capacitance at f = 1 MHz	C_{rs}	typ.	30	fF
Output capacitance at f = 1 MHz	C_{os}	typ.	3, 5	pF
Noise figure at optimum source admittance				
G_S = 0, 95 mA/V; $-B_S$ = 5, 0 mA/V; f = 100 MHz	F	typ.	1, 9	dB
G_S = 1, 20 mA/V; $-B_S$ = 5, 7 mA/V; f = 200 MHz	F	typ.	2, 3	dB
		<	3, 0	dB
Cross modulation at f = 200 MHz				
Wanted signal at f_o = 197, 5 MHz				
Unwanted signal at f_{int} = 202, 5 MHz				
Interference voltage at g_1 for K = 1%	V_{int}	typ.	100	mV [1]

[1] Cross modulation is defined here as the voltage at g_1 of an unwanted signal with 80% modulation depth, giving 0, 8% modulation depth on the wanted signal (a. m. definition).


7Z67775.1
I_D (mA)
V_{DS} = 10 V
$+V_{G2-S}$ = 4 V
T_{amb} = 25 °C
typ. values
$+V_{G2-S}$ = 4 V
T_{amb} = 25 °C
V_{G1-S} = 0
$P_{tot\ max}$
$-V_{G1-S}$ = 0,5 V
1,0 V
1,5 V
2,0 V
typ
V_{G1-S} (V)
V_{DS} (V)


7Z67774.1
I_D (mA)
typ. values
V_{DS} = 10 V
T_{amb} = 25 °C
V_{G2-S} = +4 V
+2 V
+1,5 V
+1 V
+0,5 V
0
−0,5 V
−1 V
−1,5 V
V_{G1-S} (V)





circles of constant noise figure

MATCHED N-CHANNEL FET's

Matched pair of n-channel silicon epitaxial planar junction field effect transistors in TO-72 metal envelopes held together by a metal S-clip.
It is intended for low level differential amplifiers.

QUICK REFERENCE DATA

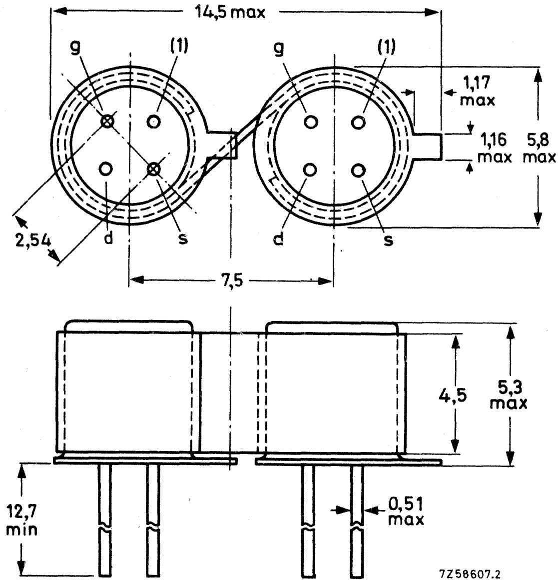
Characteristics $T_{amb} = 25\ ^oC$; $V_{DG} = 15$ V; $I_D = 0.5$ mA			BFS21	BFS21A	
Gate cut-off current	I_G	<	0.5	0.5	nA
Gate-source voltage difference	$\lvert \Delta V_{GS} \rvert$	<	20	10	mV
Thermal drift of gate-source voltage difference	$\left\lvert \frac{d\ \Delta V_{GS}}{dT} \right\rvert$	<	75	40	$\mu V/^oC$
Difference of penetration factor	$\left\lvert \Delta \frac{g_{os}}{g_{fs}} \right\rvert$	<	1	0.5	10^{-3}
Difference of transfer impedance	$\left\lvert \Delta \frac{1}{g_{fs}} \right\rvert$	<	15	7.5	Ω
Common mode rejection ratio	CMRR	>	60	66	dB

TOTAL DEVICE

Dimensions in mm

MECHANICAL DATA

SOT-52



(1) = shield lead (connected to case).

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

RATINGS

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

Voltage between any 2 terminals	V	max.	30	V
Drain current	I_D	max.	4	mA
Gate current	I_G	max.	0,5	mA
Total power dissipation up to T_{amb} = 100 °C	P_{tot}	max.	30	mW
Operating ambient temperature	T_{amb}		−20 to + 100	°C

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

			BFS21	BFS21A	
Drain current ratio					
V_{DG} = 15 V; V_{GS} = 0; T_j = 25 °C	$\frac{I_{D1-S1S}}{I_{D2-S2S}}$	>	0.95	0.95	
		<	1.05	1.05	
Gate-source voltage difference					
I_D = 500 μA; V_{DG} = 15 V	$\lvert\Delta V_{GS}\rvert$	<	20	10	mV
I_D = 100 μA; V_{DG} = 15 V	$\lvert\Delta V_{GS}\rvert$	<	20	10	mV
Thermal drift of gate-source voltage difference					
I_D = 500 μA; V_{DG} = 15 V	$\left\lvert\frac{d\ \Delta V_{GS}}{dT}\right\rvert$	<	75	40	μV/°C
I_D = 100 μA; V_{DG} = 15 V	$\left\lvert\frac{d\ \Delta V_{GS}}{dT}\right\rvert$	<	75	40	μV/°C
Change of gate-source voltage difference with ambient temperature					
T_{amb} = 25 to 100 °C					
I_D = 500 μA; V_{DG} = 15 V	$\lvert\Delta V_{GS}(T_{amb2}) - \Delta V_{GS}(T_{amb1})\rvert$	<	6	3	mV
I_D = 100 μA; V_{DG} = 15 V	$\lvert\Delta V_{GS}(T_{amb2}) - \Delta V_{GS}(T_{amb1})\rvert$	<	6	3	mV
Difference of penetration factors 1)					
I_D = 500 μA; V_{DG} = 15 V	$\left\lvert\Delta \frac{g_{os}}{g_{fs}}\right\rvert$	<	1	0.5	10^{-3}
I_D = 100 μA; V_{DG} = 15 V	$\left\lvert\Delta \frac{g_{os}}{g_{fs}}\right\rvert$	<	1	0.5	10^{-3}
Difference of transfer impedances 2)					
I_D = 500 μA; V_{DG} = 15 V	$\left\lvert\Delta \frac{1}{g_{fs}}\right\rvert$	<	15	7.5	Ω
I_D = 100 μA; V_{DG} = 15 V	$\left\lvert\Delta \frac{1}{g_{fs}}\right\rvert$	<	75	37.5	Ω

1) The difference between the penetration factors is equal to the ratio of the change of the gate-source voltage difference to the change of drain-gate voltage, at constant drain current.

$$\left(\Delta \frac{g_{os}}{g_{fs}} = \frac{d\ \Delta V_{GS}}{d\ V_{DG}} \text{ at } I_D = \text{constant}\right)$$

2) The difference between the transfer impedances is equal to the ratio of the change of the gate-source voltage difference to the change of drain current, at constant drain-gate voltage.

$$\left(\Delta \frac{1}{g_{fs}} = \frac{d\ \Delta V_{GS}}{d\ I_D} \text{ at } V_{DG} = \text{constant}\right)$$

CHARACTERISTICS (continued) (total device)

Common mode rejection ratio [1]

			BFS21	BFS21A	
I_D = 500 μA; V_{DG} = 15 V	CMRR	>	60	66	dB
I_D = 100 μA; V_{DG} = 15 V	CMRR	>	60	66	dB

INDIVIDUAL TRANSISTOR

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

Voltages

Drain-source voltage	$\pm V_{DS}$	max.	30	V
Drain-gate voltage (open source)	V_{DGO}	max.	30	V
Gate-source voltage (open drain)	$-V_{GSO}$	max.	30	V

Currents

Drain current	I_D	max.	20	mA
Gate current	I_G	max.	10	mA

Power dissipation

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

Temperatures

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

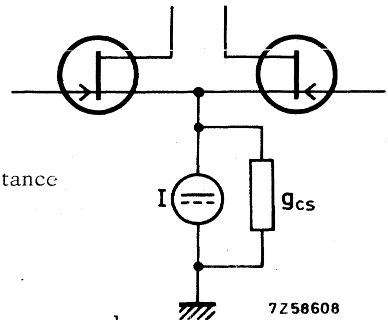
THERMAL RESISTANCE

From junction to ambient in free air (for individual transistor without S-clip) $R_{th\ j-a}$ = 0.59 ^{o}C/mW

[1]) Common mode rejection ratio

$$(CMRR)^{-1} = \Delta \frac{g_{os}}{g_{fs}} + \frac{1}{2} g_{cs} \Delta \frac{1}{g_{fs}}$$

where g_{cs} in this formula is the output conductance of the summing current source.



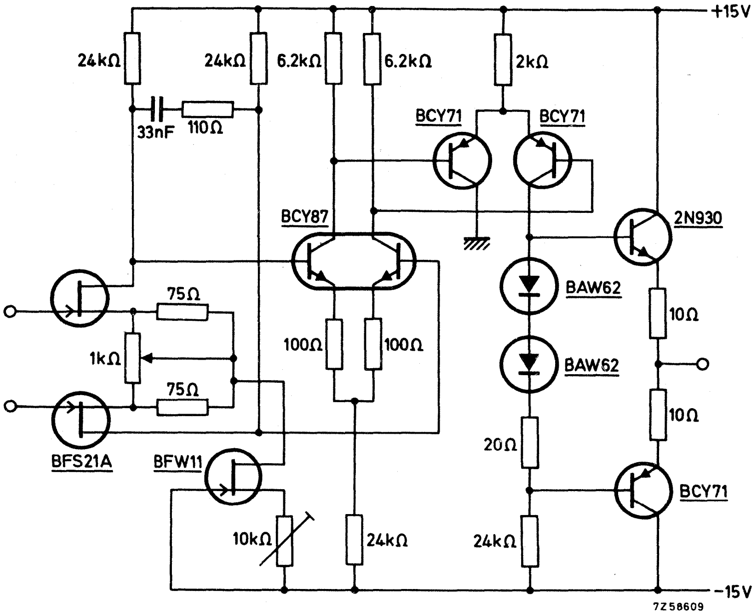
The guaranteed values of CMRR apply at g_{cs} = 0.1 $\mu\Omega^{-1}$

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

Gate cut-off current				
I_D = 500 μA; V_{DS} = 15 V	I_G	<	0.5	nA
I_D = 500 μA; V_{DS} = 15 V; T_{amb} = 100 °C	I_G	<	25	nA
Drain current				
V_{DS} = 15 V, V_{GS} = 0, T_j = 25 °C	I_{DSS}	>	1	mA
Gate-source cut-off voltage				
I_D = 0.5 nA, V_{DS} = 15 V	$-V_{(P)GS}$	<	6	V
Transfer conductance at f = 1 kHz				
I_D = 500 μA; V_{DS} = 15 V	g_{fs}	>	1.0	$m\Omega^{-1}$
Output conductance at f = 1 kHz				
I_D = 500 μA; V_{DS} = 15 V	g_{os}	<	15	$\mu\Omega^{-1}$
Input capacitance at f = 1 MHz				
I_D = 500 μA; V_{DS} = 15 V	C_{is}	<	5	pF
Feedback capacitance at f = 1 MHz				
I_D = 500 μA; V_{DS} = 15 V	C_{rs}	<	0.75	pF
Equivalent noise voltage				
f = 10 Hz				
I_D = 500 μA; V_{DS} = 15 V	$V_n/\sqrt{B}$	<	200	$nV/\sqrt{Hz}$
V_{DS} = 15 V, V_{GS} = 0	$V_n/\sqrt{B}$	<	75	$nV/\sqrt{Hz}$

APPLICATION INFORMATION

Operational amplifier



APPLICATION INFORMATION (continued)

Input voltages

Initial off-set voltage	<	10	mV
Differential off-set voltage change with temperature	<	40	μV/°C
Differential off-set voltage change with time	<	40	μV/day
Noise voltage (B = 100 kHz)	<	2	μV
Common mode rejection ratio	>	65	dB
Supply rejection ratio	<	500	10^{-6}
Input voltage range	±	10	V

Input currents

Input bias current; T_{amb} = 25 °C	typ.	50	pA
; T_{amb} = 100 °C	<	25	nA
Off-set current ; T_{amb} = 25 °C	typ.	20	pA
; T_{amb} = 100 °C	<	25	nA

Input impedance

Input resistance	typ.	100	GΩ
Input resistance (common mode)	typ.	100	GΩ
Input capacitance	typ.	3	pF
Input capacitance (common mode)	typ.	3	pF

Frequency response

Bandwidth (G_V = 1)	typ.	10	MHz
Slewing rate	typ.	10	V/μs

Output voltage range	±	10	V
Output current range	±	10	mA
Output resistance	typ.	300	Ω

SILICON N-CHANNEL DUAL INSULATED GATE FIELD EFFECT TRANSISTOR

Depletion type field effect transistor in a TO-72 metal envelope with source and substrate connected to the case.
This M.O.S.-tetrode is intended for a wide range of applications in communication, instrumentation and control.
The tetrode configuration, a series arrangement of two gate controlled channels offers:
a. very low feedback capacitance providing the possibility of more than 40 dB gain control in r.f. amplifiers requiring negligible a.g.c. power.
b. excellent signal handling capability over the entire gain control range.
c. low noise figure combined with high gain.

QUICK REFERENCE DATA

Drain-source voltage	V_{DS}	max.	20	V
Gate 1-source voltage	$\pm V_{G1-S}$	max.	8	V
Gate 2-source voltage	$\pm V_{G2-S}$	max.	8	V
Drain current	I_D	max.	20	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	200	mW
Junction temperature	T_j	max.	135	°C
Transfer admittance at f = 1 kHz I_D = 10 mA; V_{DS} = 13 V; $+V_{G2-S}$ = 4 V	$\|y_{fs}\|$	> typ.	8 13	mA/V mA/V
Feedback capacitance at f = 10 MHz I_D = 10 mA; V_{DS} = 13 V; $+V_{G2-S}$ = 4 V	C_{rs}	typ.	25	fF
Transducer gain at f = 200 MHz I_D = 10 mA; V_{DS} = 13 V; $+V_{G2-S}$ = 4 V B_S and B_L tuned for maximum gain	G_{tr}	typ.	18	dB
Noise figure at optimum source admittance I_D = 10 mA; V_{DS} = 13 V; $+V_{G2-S}$ = 4 V; f = 200 MHz	F_{min}	typ. <	3 4	dB dB

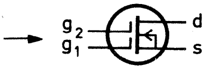
MECHANICAL DATA see page 2.

MECHANICAL DATA

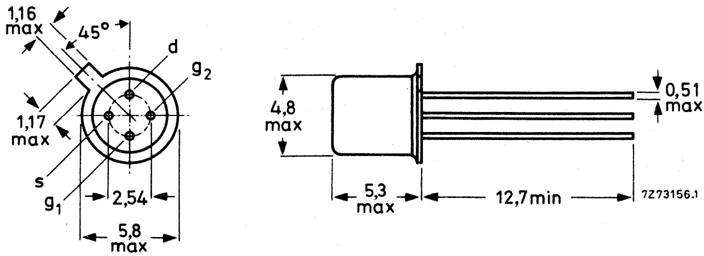
Dimensions in mm

Source and substrate connected to the case

TO-72



7Z73157



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

Note

To safeguard the gates against damage due to accumulation of static charge during transport or handling, the leads are encircled by a ring of conductive rubber which should be removed just after the transistor is soldered into the circuit.

RATINGS

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

Drain-source voltage	V_{DSX}	max.	20	V
Gate 1-source voltage	$\pm V_{G1-S}$	max.	8	V
Gate 2-source voltage	$\pm V_{G2-S}$	max.	8	V
Non-repetitive peak voltage ($t \leqslant 10$ ms)				
gate 1-source voltage	$\pm V_{G1-SM}$	max.	50	V
gate 2-source voltage	$\pm V_{G2-SM}$	max.	50	V
Drain current	I_D	max.	20	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	200	mW
Storage temperature	T_{stg}	−65 to + 135		°C
Junction temperature	T_j	max.	135	°C

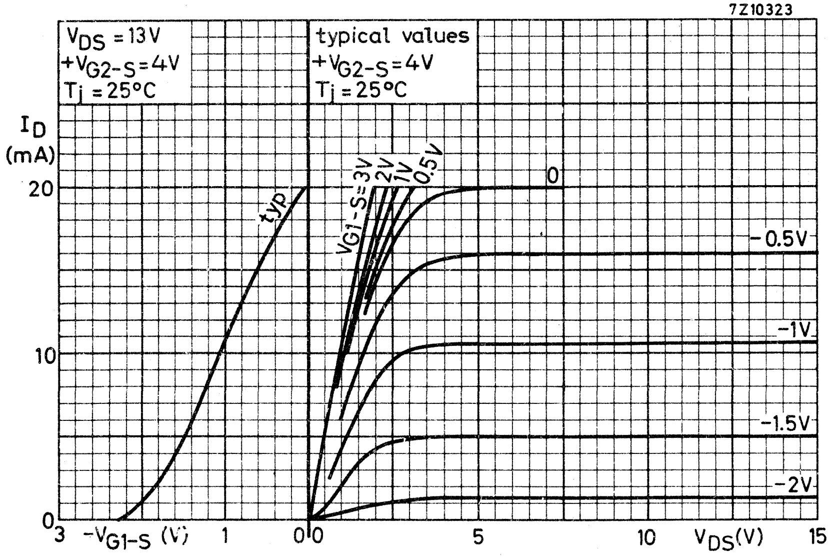
THERMAL RESISTANCE

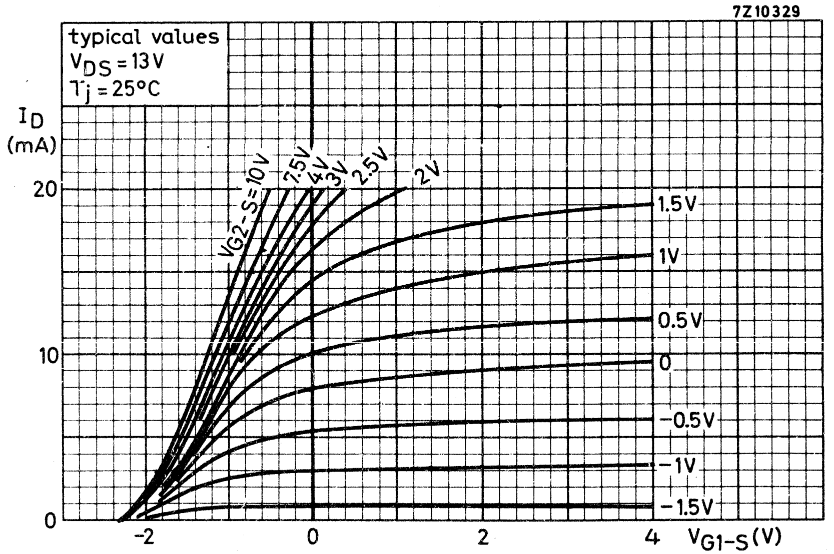
From junction to ambient in free air	$R_{th\ j-a}$	=	0,55	°C/mW

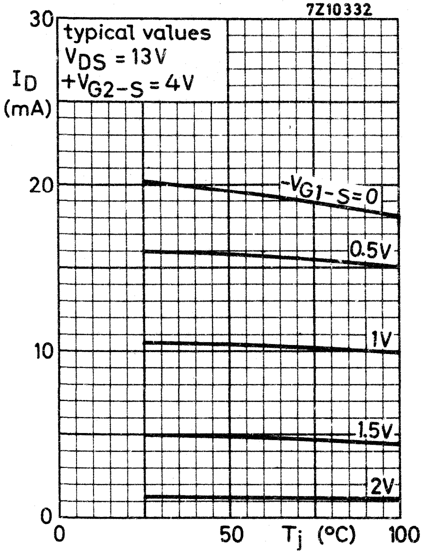
CHARACTERISTICS

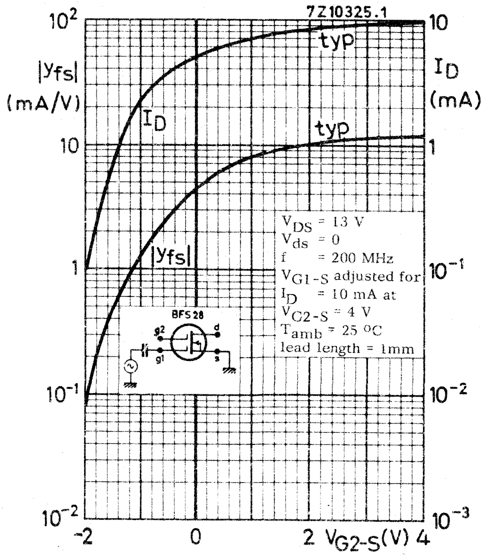
T_j = 25 °C unless otherwise specified

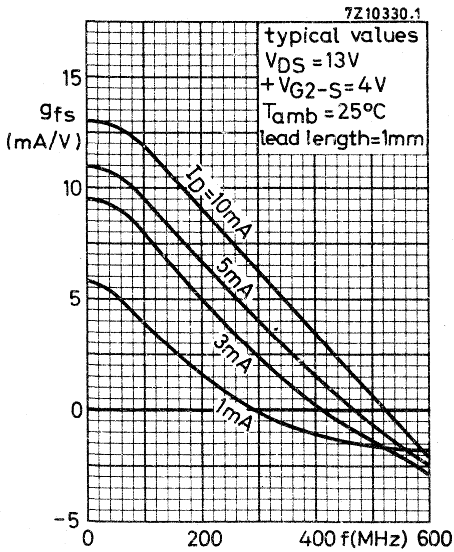
Gate 1 cut-off current			
$\pm V_{G1-S}$ = 8 V; V_{G2-S} = 0; V_{DS} = 0; T_j = 135 °C	$\pm I_{G1-SS}$	< 1	nA
Gate 2 cut-off current			
$\pm V_{G2-S}$ = 8 V; V_{G1-S} = 0; V_{DS} = 0; T_j = 135 °C	$\pm I_{G2-SS}$	< 1	nA
Gate 1-source voltage			
I_D = 10 mA; V_{DS} = 13 V; $+V_{G2-S}$ = 4 V	$-V_{G1-S}$	0.6 to 2.8	V
Gate 1-source cut-off voltage			
I_D = 100 μA; V_{DS} = 20 V; $+V_{G2-S}$ = 4 V	$-V_{G1-S}$	< 5	V
Gate 2-source cut-off voltage			
I_D = 50 μA; V_{DS} = 20 V; V_{G1-S} = 0	$-V_{G2-S}$	< 4	V
y parameters (common source)			
I_D = 10 mA; V_{DS} = 13 V; $+V_{G2-S}$ = 4 V; T_{amb} = 25 °C			
Transfer admittance f = 1 kHz	$\|y_{fs}\|$	> 8	mA/V
		typ. 13	mA/V
f = 200 MHz	$\|y_{fs}\|$	typ. 12.1	mA/V
f = 500 MHz	$\|y_{fs}\|$	typ. 11.2	mA/V
Feedback capacitance f = 10 MHz	C_{rs}	typ. 25	fF
Transducer gain at f = 200 MHz			
I_D = 10 mA; V_{DS} = 13 V; $+V_{G2-S}$ = 4 V			
G_S = 1.3 mA/V; G_L = 1 mA/V; T_{amb} = 25 °C			
B_S and B_L tuned for maximum gain	G_{tr}	typ. 18	dB
Maximum unilateralised power gain at T_{amb} = 25 °C			
G_{UM} in dB = 10 log $\frac{\|y_{fs}\|^2}{4 g_{is} g_{os}}$			
I_D = 10 mA; V_{DS} = 13 V; $+V_{G2-S}$ = 4 V; f = 200 MHz	G_{UM}	typ. 21.3	dB
f = 500 MHz	G_{UM}	typ. 7.3	dB
Noise figure at optimum source admittance at f = 200 MHz			
I_D = 10 mA; V_{DS} = 13 V; $+V_{G2-S}$ = 4 V			
G_{Sopt} = 1.4 mA/V; B_{Sopt} = 5.5 mA/V; T_{amb} = 25 °C	F_{min}	typ. 3	dB
		< 4	dB

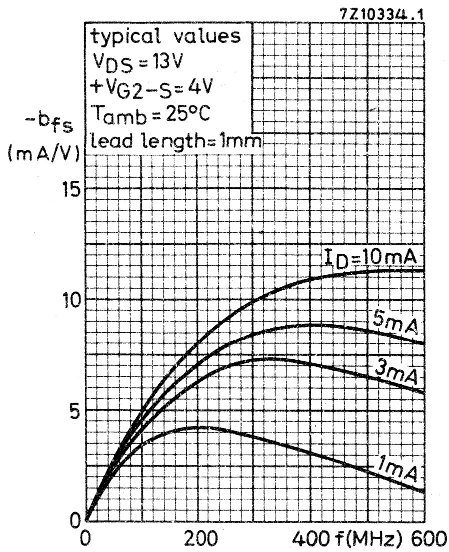

7Z10323
V_{DS} = 13 V
+V_{G2-S} = 4 V
T_j = 25 °C
typical values
+V_{G2-S} = 4 V
T_j = 25 °C
I_D (mA)
typ
V_{G1-S} = 3V
2V
1V
0.5V
0
−0.5V
−1V
−1.5V
−2V
$-V_{G1-S}$ (V)
V_{DS} (V)
20
10
0
3
1
0
0
5
10
15

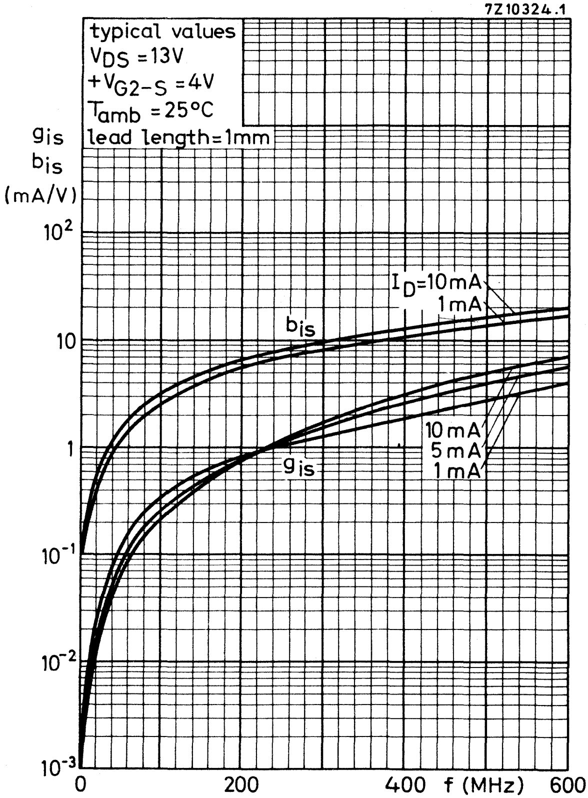

7Z10329
typical values
V_{DS} = 13 V
T_j = 25 °C
I_D (mA)
V_{G2-S} = 10V
7.5V
4V
3V
2.5V
2V
1.5V
1V
0.5V
0
−0.5V
−1V
−1.5V
V_{G1-S} (V)
20
10
0
−2
0
2
4

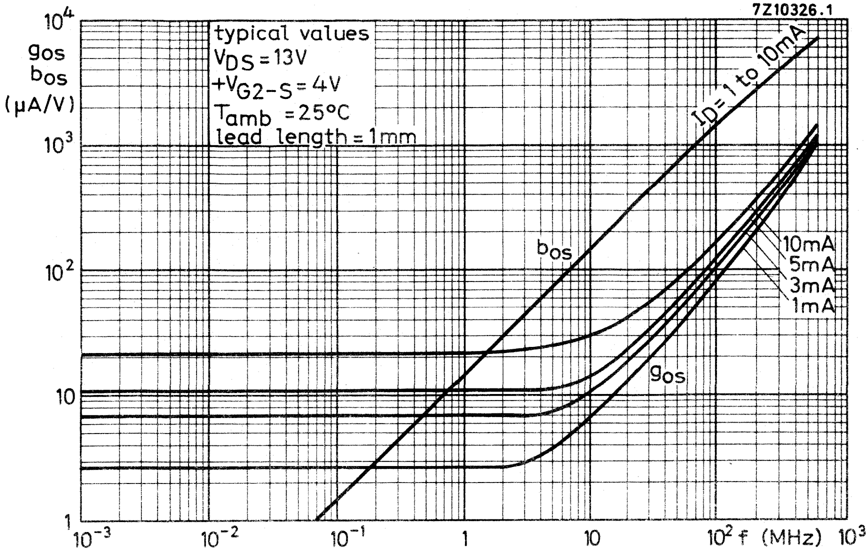

7Z10332
typical values
V_{DS} = 13 V
$+V_{G2-S}$ = 4 V
I_D (mA)
$-V_{G1-S}$ = 0
0.5 V
1 V
1.5 V
2 V
T_j (°C)
0
50
100
10
20
30

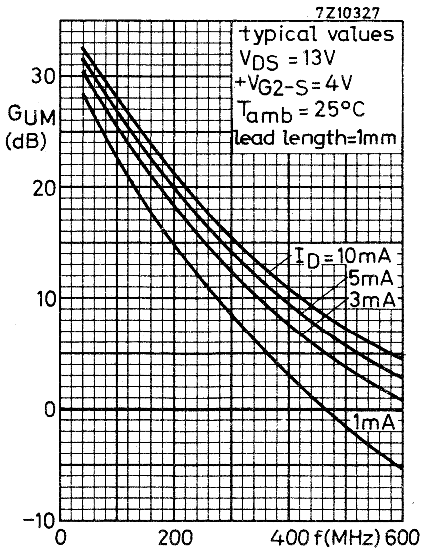

7Z10325.1
$|y_{fs}|$ (mA/V)
I_D (mA)
typ
I_D
$|y_{fs}|$
V_{DS} = 13 V
V_{ds} = 0
f = 200 MHz
V_{G1-S} adjusted for
I_D = 10 mA at
V_{G2-S} = 4 V
T_{amb} = 25 °C
lead length = 1mm
BFS 28
g2
d
g1
s
V_{G2-S} (V)
-2
0
2
4
10^{-2}
10^{-1}
1
10
10^2
10^{-3}
10^{-2}
10^{-1}
1
10

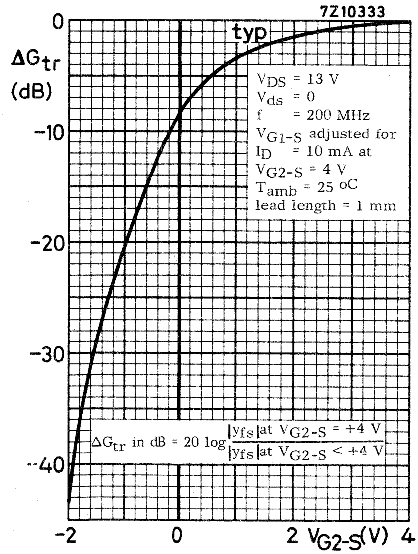

7Z10330.1
typical values
V_{DS} = 13 V
$+V_{G2-S}$ = 4 V
T_{amb} = 25 °C
lead length = 1mm
g_{fs} (mA/V)
I_D = 10 mA
5 mA
3 mA
1 mA
f (MHz)
0
200
400
600
-5
0
5
10
15

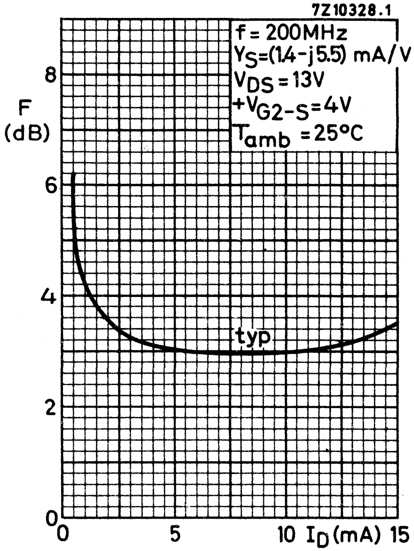

7Z10334.1
typical values
V_{DS} = 13 V
$+V_{G2-S}$ = 4 V
T_{amb} = 25 °C
lead length = 1mm
$-b_{fs}$ (mA/V)
I_D = 10 mA
5 mA
3 mA
1 mA
f (MHz)
0
200
400
600
0
5
10
15

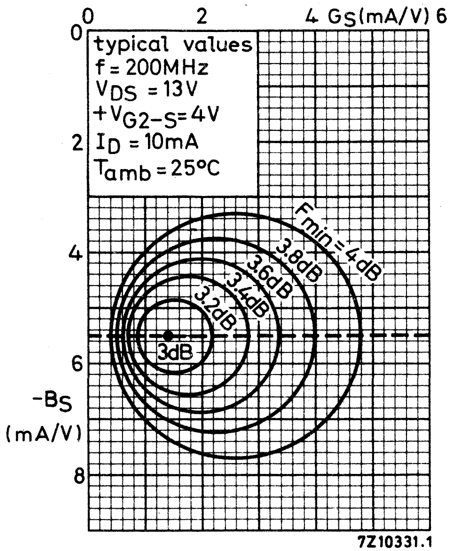

7Z10324.1
typical values
V_{DS} = 13V
+V_{G2-S} = 4V
T_{amb} = 25°C
lead length = 1mm
g_{is}
b_{is}
(mA/V)
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
I_D=10mA
1mA
b_{is}
10 mA
5 mA
1 mA
g_{is}
0
200
400
f (MHz)
600


7Z10326.1
typical values
V_{DS} = 13V
$+V_{G2-S}$ = 4V
T_{amb} = 25°C
lead length = 1mm
g_{os}
b_{os}
(μA/V)
10^4
10^3
10^2
10
1
I_D = 1 to 10mA
b_{os}
g_{os}
10mA
5mA
3mA
1mA
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
f (MHz)
10^3


7Z10327
typical values
V_{DS} = 13V
$+V_{G2-S}$ = 4V
T_{amb} = 25°C
lead length=1mm
G_{UM}
(dB)
30
20
10
0
−10
I_D = 10mA
5mA
3mA
1mA
0
200
400
f(MHz)
600


7Z10333
ΔG_{tr}
(dB)
0
−10
−20
−30
−40
typ
V_{DS} = 13 V
V_{ds} = 0
f = 200 MHz
V_{G1-S} adjusted for
I_D = 10 mA at
V_{G2-S} = 4 V
T_{amb} = 25 °C
lead length = 1 mm
ΔG_{tr} in dB = $20 \log \frac{|y_{fs}| \text{ at } V_{G2-S} = +4\text{ V}}{|y_{fs}| \text{ at } V_{G2-S} < +4\text{ V}}$
−2
0
2
V_{G2-S}(V)
4


7Z10328.1
f = 200MHz
YS=(1.4-j5.5) mA/V
VDS = 13V
+VG2-S=4V
Tamb = 25°C
F
(dB)
typ
ID(mA)


GS(mA/V)
typical values
f = 200MHz
VDS = 13V
+VG2-S=4V
ID = 10mA
Tamb = 25°C
Fmin = 4dB
3.8dB
3.6dB
3.4dB
3.2dB
3dB
-BS
(mA/V)
7Z10331.1

N-CHANNEL SILICON FETS

N-channel silicon epitaxial planar junction field-effect transistors in a TO-72 metal envelope with the shield lead connected to the case. The transistors are designed for broad band amplifiers (0 to 300 MHz). Their very low noise at low frequencies makes these devices very suitable for differential amplifiers, electro-medical and nuclear detector preamplifiers.

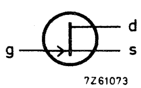
QUICK REFERENCE DATA

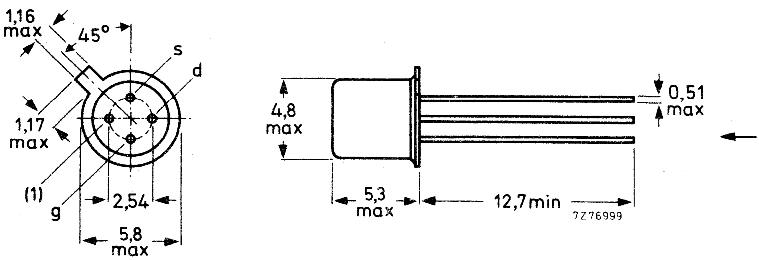
Drain-source voltage	$\pm V_{DS}$	max.	30		V
Gate-source voltage (open drain)	$-V_{GSO}$	max.	30		V
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300		mW
			BFW10	BFW11	
Drain current V_{DS} = 15 V; V_{GS} = 0	I_{DSS}	> <	8 20	4 10	mA mA
Gate-source cut-off voltage I_D = 0,5 nA; V_{DS} = 15 V	$-V_{(P)GS}$	<	8	6	V
Feedback capacitance at f = 1 MHz V_{DS} = 15 V; V_{GS} = 0	C_{rs}	<	0,80	0,80	pF
Transfer admittance (common source) V_{DS} = 15 V; V_{GS} = 0; f = 200 MHz	$\lvert y_{fs} \rvert$	>	3,2	3,2	mA/V
Noise figure at V_{DS} = 15 V; V_{GS} = 0 f = 100 MHz; R_G = 1 kΩ	F	<	2,5	2,5	dB
Equivalent noise voltage f = 10 Hz	$V_n/\sqrt{B}$	<	75	75	$nV/\sqrt{Hz}$

MECHANICAL DATA

Dimensions in mm

TO-72





(1) = shield lead (connected to case).

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

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

Voltages

Drain-source voltage	$\pm V_{DS}$	max.	30	V
Drain-gate voltage (open source)	V_{DGO}	max.	30	V
Gate-source voltage (open drain)	$-V_{GSO}$	max.	30	V

Currents

Drain current	I_D	max.	20	mA
Gate current	I_G	max.	10	mA

Power dissipation

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

Temperatures

Storage temperature	T_{stg}		−65 to +200	^oC
Junction temperature	T_j	max.	200	^oC

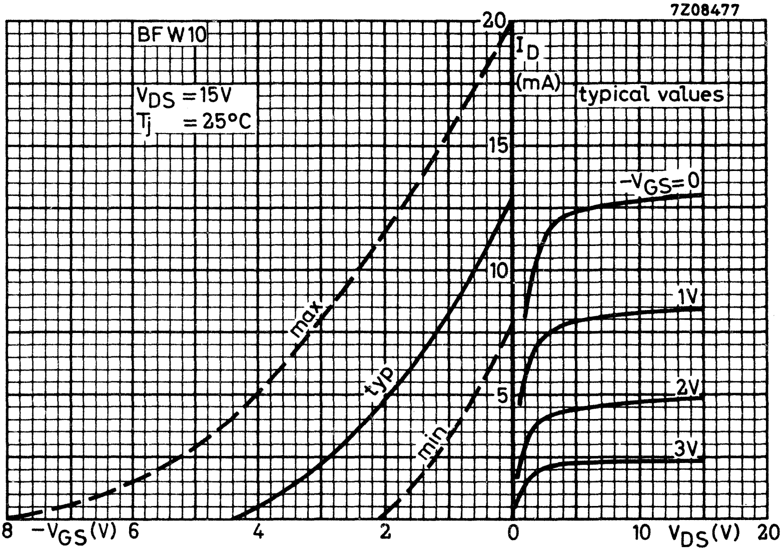
THERMAL RESISTANCE

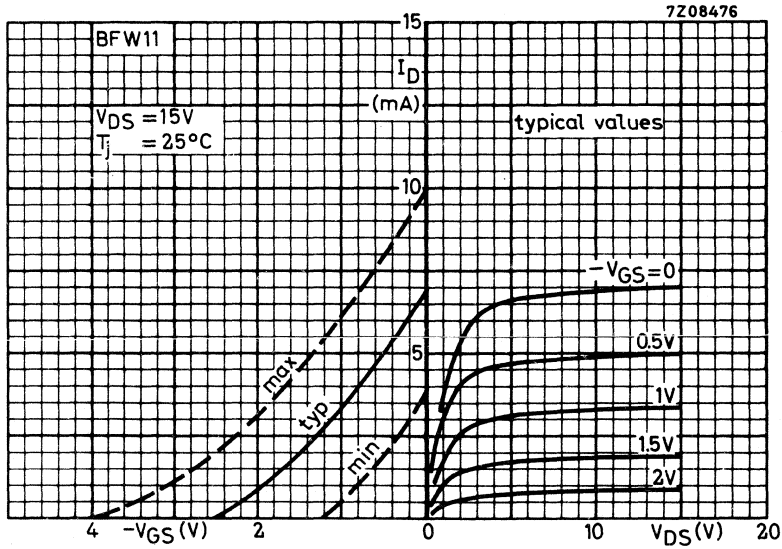
From junction to ambient	$R_{th\ j\text{-}a}$	=	0.59	$^oC/mW$

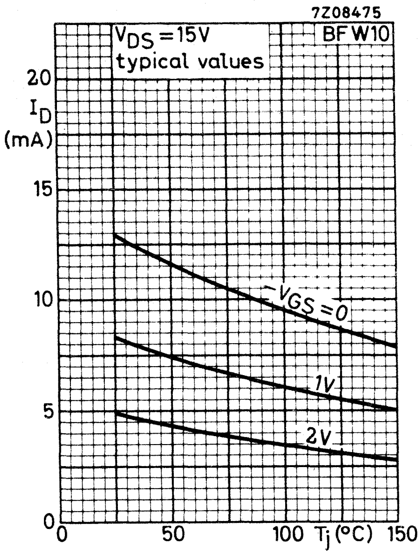
CHARACTERISTICS T_j = 25 °C unless otherwise specified

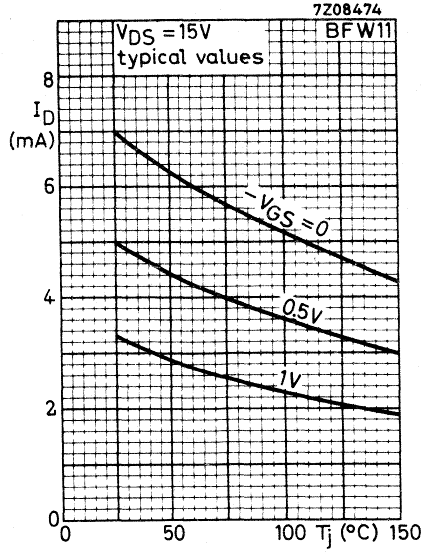
			BFW10	BFW11	
Gate cut-off current					
$-V_{GS}$ = 20 V; V_{DS} = 0	$-I_{GSS}$	<	0.1	0.1	nA
$-V_{GS}$ = 20 V; V_{DS} = 0; T_j = 150 °C	$-I_{GSS}$	<	0.5	0.5	µA
Drain current [1]					
V_{DS} = 15 V; V_{GS} = 0	I_{DSS}	>	8	4	mA
		<	20	10	mA
Gate-source voltage					
I_D = 400 µA; V_{DS} = 15 V	$-V_{GS}$	>	2.0		V
		<	7.5		V
I_D = 50 µA; V_{DS} = 15 V	$-V_{GS}$	>		1.25	V
		<		4.0	V
Gate-source cut-off voltage					
I_D = 0.5 nA; V_{DS} = 15 V	$-V_{(P)GS}$	<	8	6	V
y parameters					
V_{DS} = 15 V; V_{GS} = 0; T_{amb} = 25 °C					
f = 1 kHz Transfer admittance	$\|y_{fs}\|$	>	3.5	3.0	mA/V
		<	6.5	6.5	mA/V
Output admittance	$\|y_{os}\|$	<	85	50	µA/V
f = 1 MHz Input capacitance	C_{is}	typ.	4	4	pF
		<	5	5	pF
Feedback capacitance	C_{rs}	typ.	0.6	0.6	pF
		<	0.80	0.80	pF
f = 200 MHz Transfer admittance	$\|y_{fs}\|$	>	3.2	3.2	mA/V
Input conductance	g_{is}	<	800	800	µA/V
Output conductance	g_{os}	<	200	100	µA/V
Noise figure at f = 100 MHz; R_G = 1 kΩ					
V_{DS} = 15 V; V_{GS} = 0; T_{amb} = 25 °C input tuned to minimum noise	F	<	2.5	2.5	dB
Equivalent noise voltage					
V_{DS} = 15 V; V_{GS} = 0; T_{amb} = 25 °C					
f = 10 Hz	$V_n/\sqrt{B}$	<	75	75	nV/$\sqrt{Hz}$

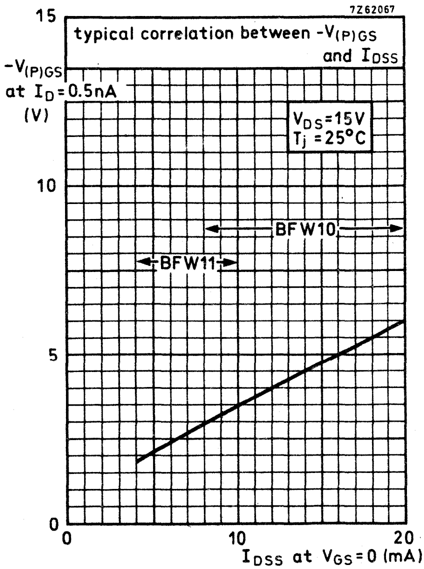
[1]) Measured under pulsed conditions.

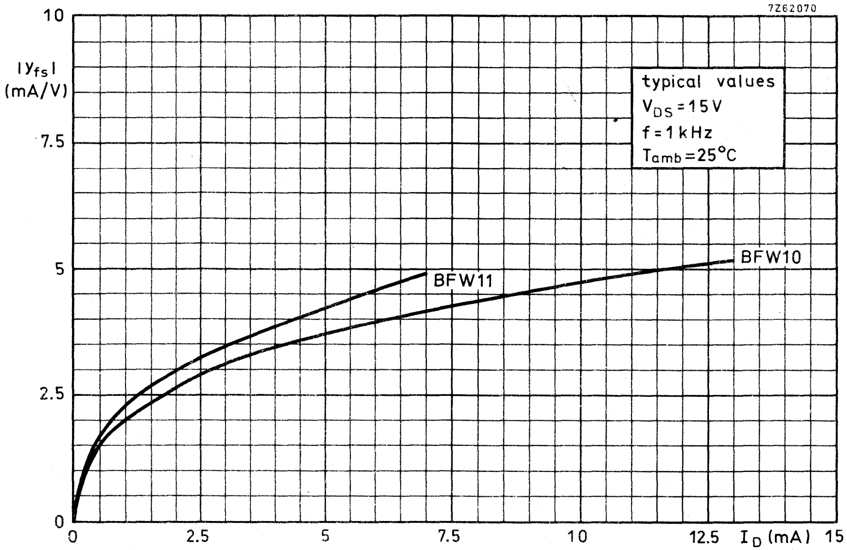

7Z08477
BFW10
VDS = 15V
Tj = 25°C
ID (mA)
typical values
−VGS = 0
1V
2V
3V
max
typ
min
20
15
10
5
8
−VGS (V)
6
4
2
0
10
VDS (V)
20

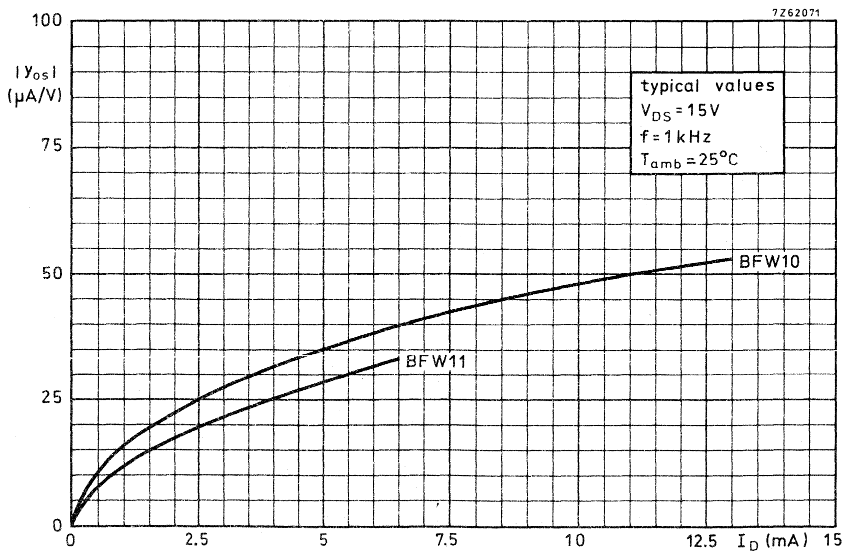

7Z08476
BFW11
VDS = 15V
Tj = 25°C
ID (mA)
typical values
−VGS = 0
0.5V
1V
1.5V
2V
max
typ
min
15
10
5
4
−VGS (V)
2
0
10
VDS (V)
20

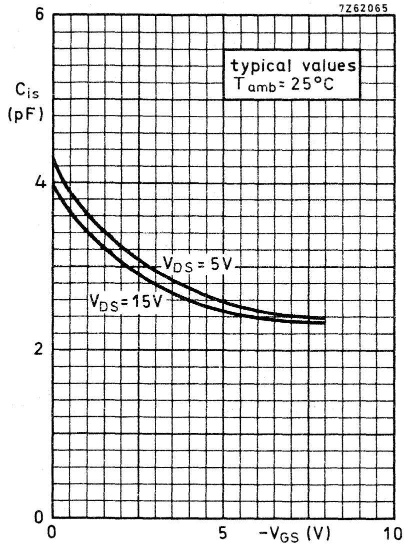

7Z08475
V_{DS} = 15 V
typical values
BFW10
I_D (mA)
$-V_{GS}$ = 0
1V
2V
T_j (°C)

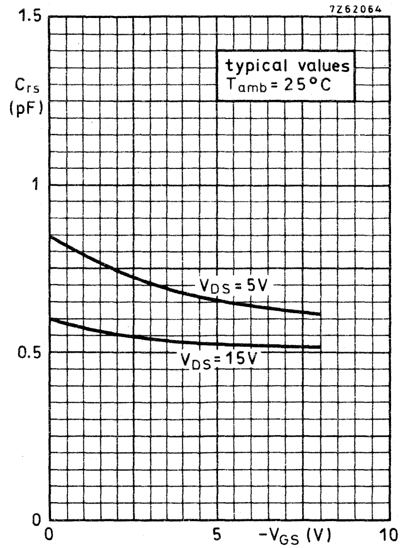

7Z08474
V_{DS} = 15 V
typical values
BFW11
I_D (mA)
$-V_{GS}$ = 0
0.5V
1V
T_j (°C)

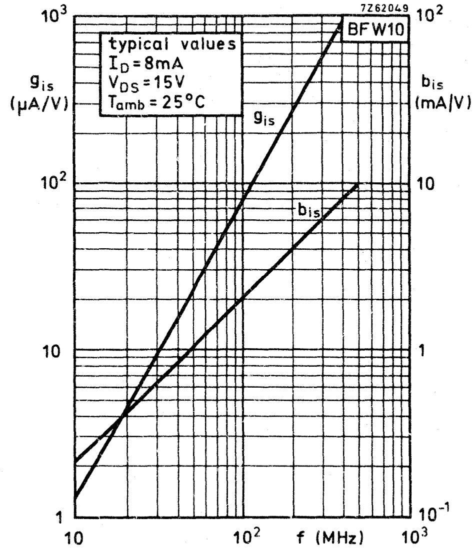

7Z62067
typical correlation between $-V_{(P)GS}$ and I_{DSS}
$-V_{(P)GS}$ at I_D = 0.5nA (V)
V_{DS} = 15V
T_j = 25°C
BFW10
BFW11
I_{DSS} at V_{GS} = 0 (mA)

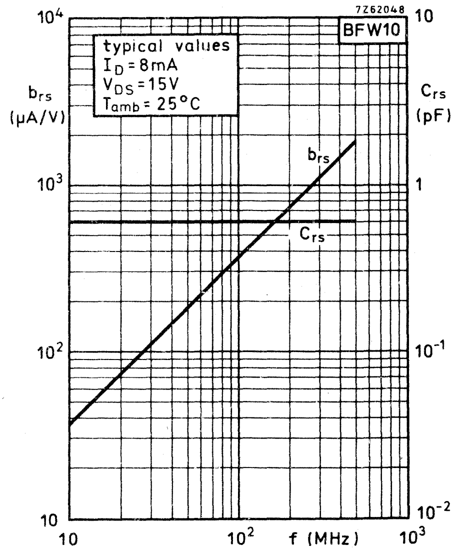

7Z62070
10
$|y_{fs}|$
(mA/V)
7.5
5
2.5
0
0
2.5
5
7.5
10
12.5
I_D (mA)
15
typical values
V_{DS} = 15 V
f = 1 kHz
T_{amb} = 25 °C
BFW11
BFW10

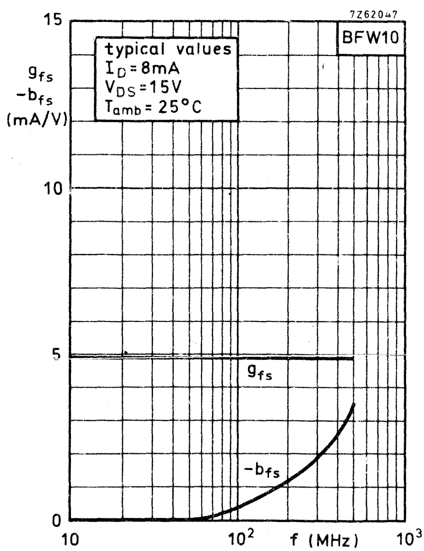

7Z62071
100
$|y_{os}|$
(µA/V)
75
50
25
0
0
2.5
5
7.5
10
12.5
I_D (mA)
15
typical values
V_{DS} = 15 V
f = 1 kHz
T_{amb} = 25 °C
BFW10
BFW11

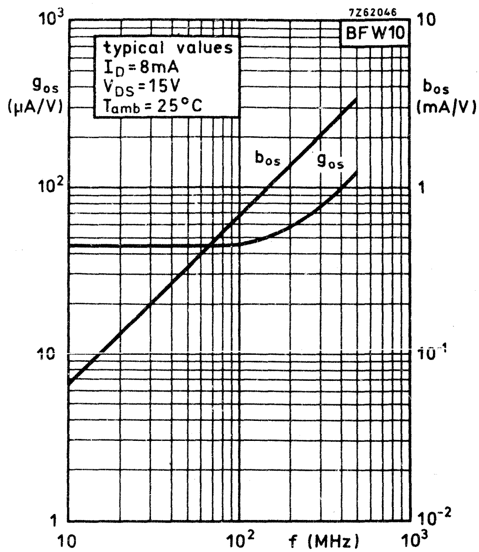

7Z62065
typical values
T_{amb} = 25°C
C_{is} (pF)
V_{DS} = 5V
V_{DS} = 15V
$-V_{GS}$ (V)
0
2
4
6
5
10

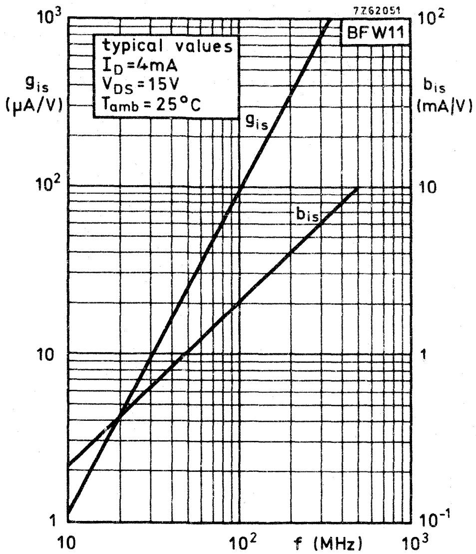

7Z62064
typical values
T_{amb} = 25°C
C_{rs} (pF)
V_{DS} = 5V
V_{DS} = 15V
$-V_{GS}$ (V)
0
0.5
1
1.5
5
10

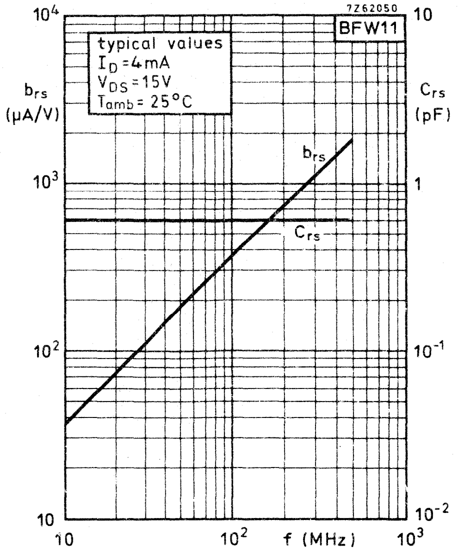

7Z62049
BFW10
typical values
$I_D = 8mA$
$V_{DS} = 15V$
$T_{amb} = 25°C$
g_{is} (µA/V)
b_{is} (mA/V)
g_{is}
b_{is}
10^3
10^2
10
1
10^2
10
1
10^{-1}
10
10^2
f (MHz)
10^3

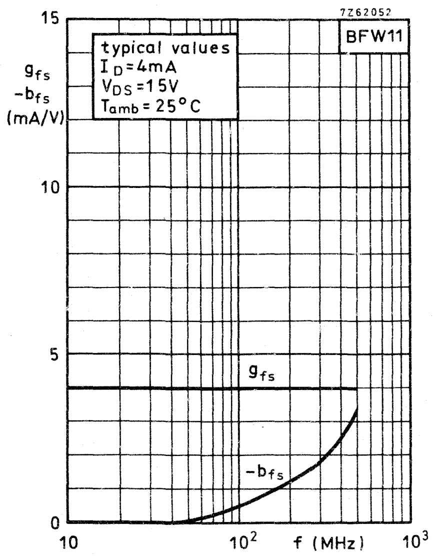

7Z62048
BFW10
typical values
$I_D = 8mA$
$V_{DS} = 15V$
$T_{amb} = 25°C$
b_{rs} (µA/V)
C_{rs} (pF)
b_{rs}
C_{rs}
10^4
10^3
10^2
10
10
1
10^{-1}
10^{-2}
10
10^2
f (MHz)
10^3

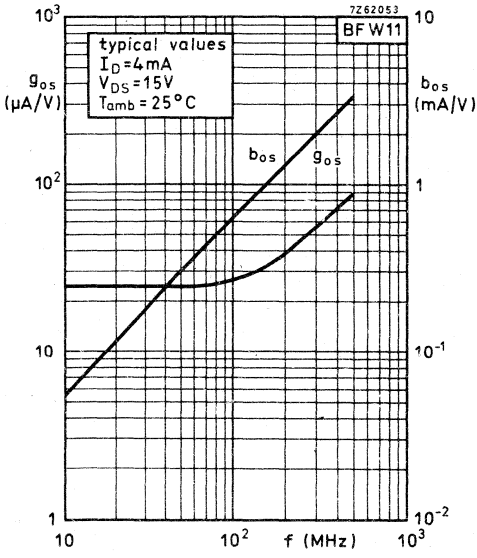

7Z62047
BFW10
typical values
$I_D = 8mA$
$V_{DS} = 15V$
$T_{amb} = 25°C$
g_{fs}
$-b_{fs}$
(mA/V)
g_{fs}
$-b_{fs}$
15
10
5
0
10
10^2
f (MHz)
10^3

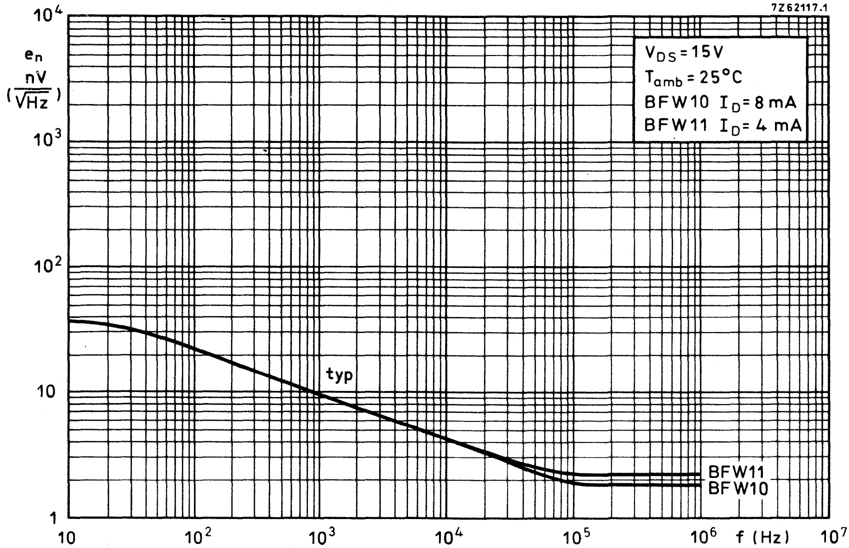

7Z62046
BFW10
typical values
$I_D = 8mA$
$V_{DS} = 15V$
$T_{amb} = 25°C$
g_{os} (µA/V)
b_{os} (mA/V)
b_{os}
g_{os}
10^3
10^2
10
1
10
1
10^{-1}
10^{-2}
10
10^2
f (MHz)
10^3

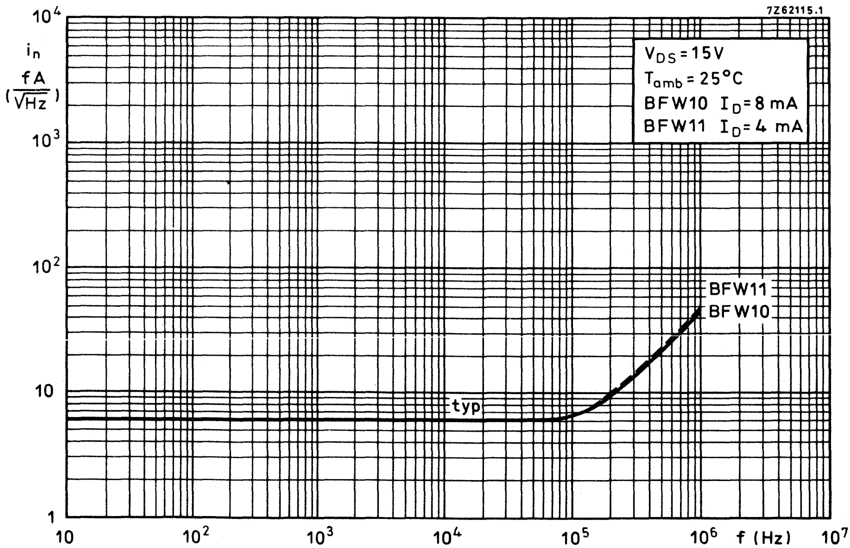

7Z62051
BFW11
typical values
I_D = 4mA
V_{DS} = 15V
T_{amb} = 25°C
g_{is} (μA/V)
b_{is} (mA/V)
g_{is}
b_{is}
f (MHz)

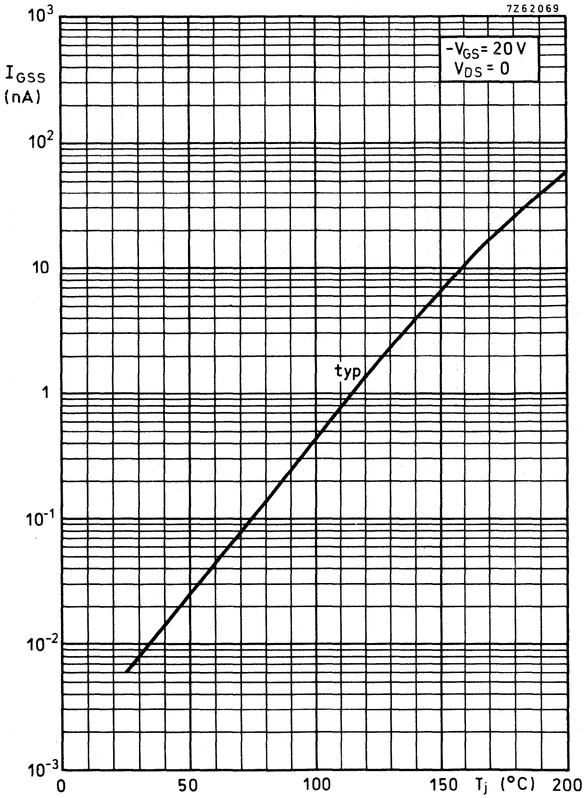

7Z62050
BFW11
typical values
I_D = 4mA
V_{DS} = 15V
T_{amb} = 25°C
b_{rs} (μA/V)
C_{rs} (pF)
b_{rs}
C_{rs}
f (MHz)


7Z62052
BFW11
typical values
I_D = 4mA
V_{DS} = 15V
T_{amb} = 25°C
g_{fs}
$-b_{fs}$
(mA/V)
g_{fs}
$-b_{fs}$
f (MHz)


7Z62053
BFW11
typical values
I_D = 4mA
V_{DS} = 15V
T_{amb} = 25°C
g_{os} (μA/V)
b_{os} (mA/V)
b_{os}
g_{os}
f (MHz)

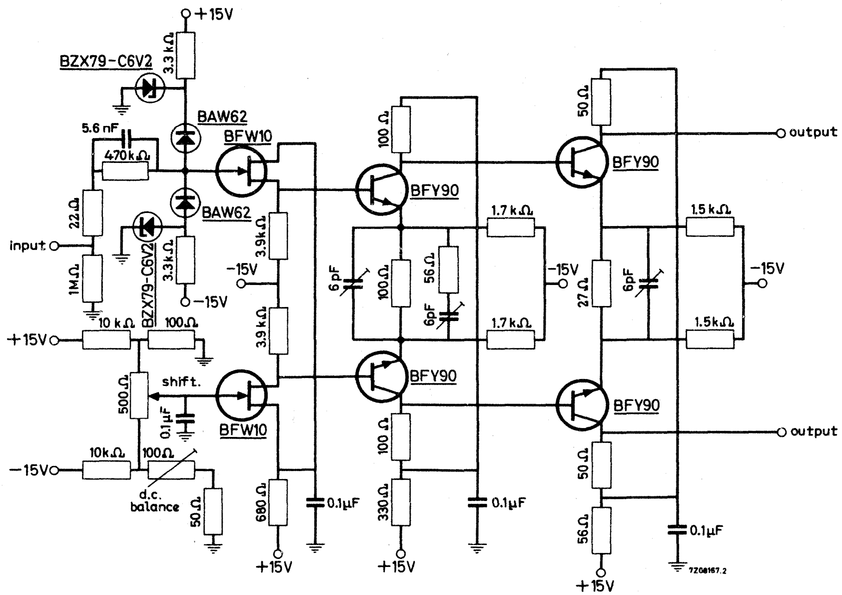

7Z62117.1
e_n
$(\frac{nV}{\sqrt{Hz}})$
10^4
10^3
10^2
10
1
$V_{DS} = 15V$
$T_{amb} = 25°C$
BFW10 $I_D = 8$ mA
BFW11 $I_D = 4$ mA
typ
BFW11
BFW10
10
10^2
10^3
10^4
10^5
10^6
f (Hz)
10^7


7Z62115.1
i_n
$(\frac{fA}{\sqrt{Hz}})$
10^4
10^3
10^2
10
1
$V_{DS} = 15V$
$T_{amb} = 25°C$
BFW10 $I_D = 8$ mA
BFW11 $I_D = 4$ mA
BFW11
BFW10
typ
10
10^2
10^3
10^4
10^5
10^6
f (Hz)
10^7


7Z62069
I_{GSS} (nA)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
$-V_{GS} = 20$ V
$V_{DS} = 0$
typ
0
50
100
150
T_j (°C)
200

APPLICATION INFORMATION

Input amplifier circuit for an oscilloscope.

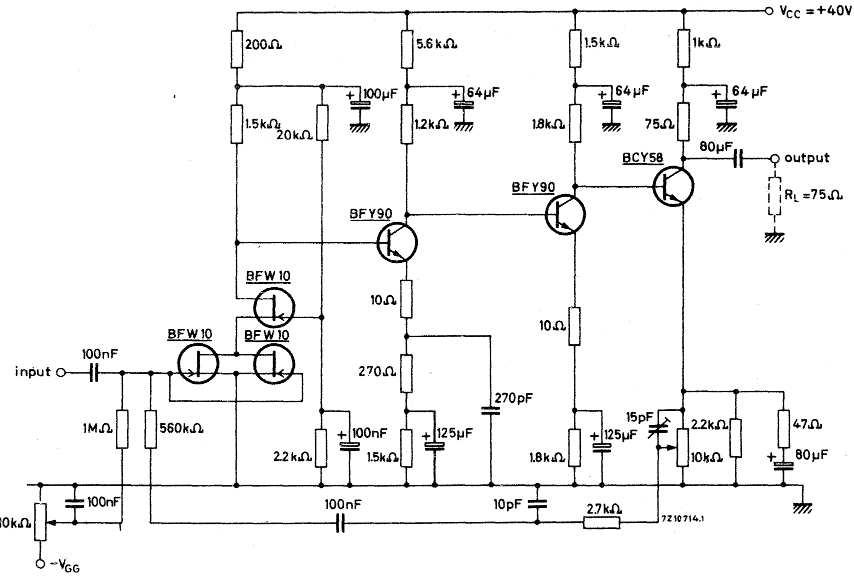


Performance:

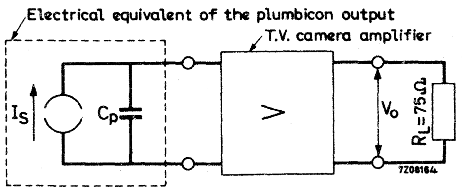
Input resistance	1 MΩ
Input capacitance	7.5 pF
Bandwidth	From d.c. to 300 MHz
Rise time	< 1 ns
Voltage gain	3.6
R.M.S. noise voltage (B = 300 MHz)	≤ 0.2 mV (input short-circuited)
Input sensitivity	This input amplifier is intended for an oscilloscope with a maximum input sensitivity of 5 or 10 mV/cm and a total bandwidth of 150 MHz
Input voltage	Max. permissible input voltage: peak to peak 600 V d.c. 300 V

APPLICATION INFORMATION (continued)

Television camera amplifier with BFW10



The circuit is designed for the Plumbicon Television Camera tube No. 55876. The electrical behaviour of this tube can be described as consisting of a current source I_S, shunted by a capacitance C_p ($C_p \approx 12$ pF).



Performance:

Transfer impedance (40 Hz to 5 MHz)	$\frac{V_O}{I_S}$	=	10^6 V/A
Output resistance	R_o	=	75 Ω
Output voltage (peak to peak) (d $\leq$ 5%)	V_O	<	1.3 V
Signal-noise ratio			
Ratio of V_O p-p (at I_S p-p = 0.3 µA) and the effective output noise voltage V_n (f from 40 Hz to 5 MHz)	$\frac{V_{O\,p\text{-}p}}{V_n}$	=	46 dB

N-CHANNEL SILICON FETS

N-channel silicon epitaxial planar junction field-effect transistors in a TO-72 metal envelope with the shield lead connected to the case. The transistors are intended for battery powered equipment and other low current-low voltage applications.

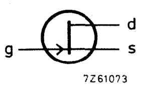
QUICK REFERENCE DATA

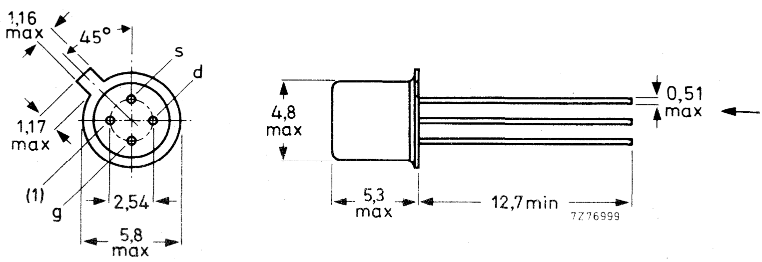
Drain-source voltage	$\pm V_{DS}$	max.	30		V
Gate-source voltage (open drain)	$-V_{GSO}$	max.	30		V
Total power dissipation up to T_{amb} = 110 °C	P_{tot}	max.	150		mW
			BFW12	BFW13	
Drain current V_{DS} = 15 V; V_{GS} = 0	I_{DSS}	>	1	0,2	mA
		<	5	1,5	mA
Gate-source cut-off voltage I_D = 0,5 nA; V_{DS} = 15 V	$-V_{(P)GS}$	<	2,5	1,2	V
Feedback capacitance at f = 1 MHz V_{DS} = 15 V; V_{GS} = 0	C_{rs}	<	0,80	0,80	pF
Transfer admittance (common source) V_{DS} = 15 V; I_D = 200 μA; f = 1 kHz	$\lvert y_{fs} \rvert$	>	0,5	0,5	mA/V
Equivalent noise voltage V_{DS} = 15 V; I_D = 200 μA B = 0,6 to 100 Hz	V_n	<	0,5	0,5	μV

MECHANICAL DATA

Dimensions in mm

TO-72





(1) = shield lead (connected to case).

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

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

Voltages

Drain-source voltage	$\pm V_{DS}$	max.	30	V
Drain-gate voltage (open source)	V_{DGO}	max.	30	V
Gate-source voltage (open drain)	$-V_{GSO}$	max.	30	V

Currents

Drain current	I_D	max.	10	mA
Gate current	I_G	max.	5	mA

Power dissipation

Total power dissipation up to T_{amb} = 110 °C	P_{tot}	max.	150	mW

Temperatures

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

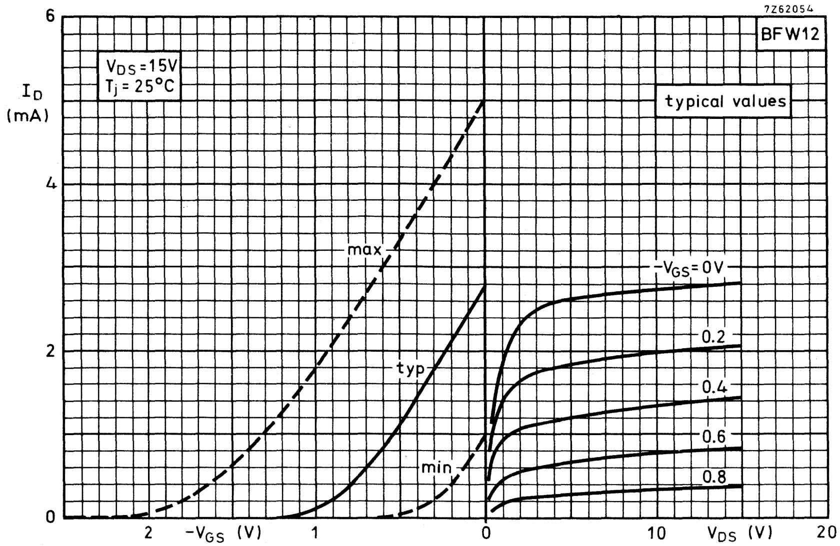
THERMAL RESISTANCE

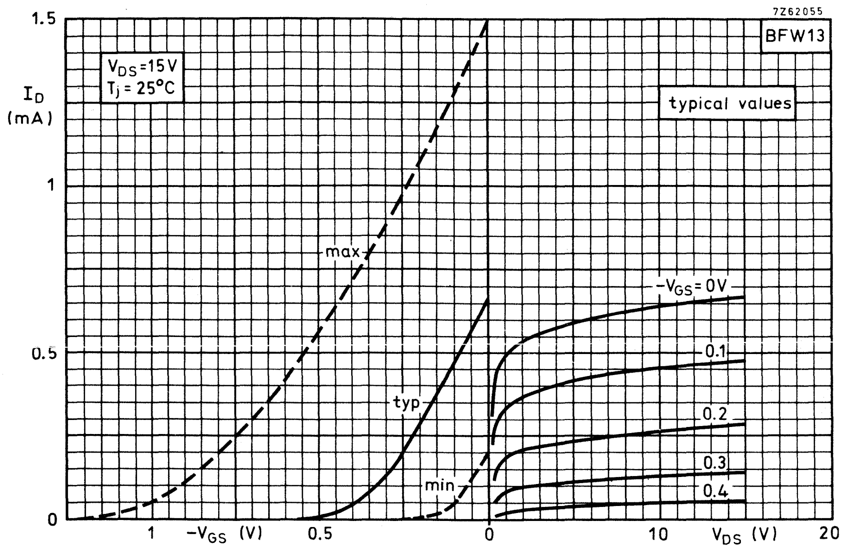
From junction to ambient	$R_{th\ j-a}$	=	0.59	°C/mW

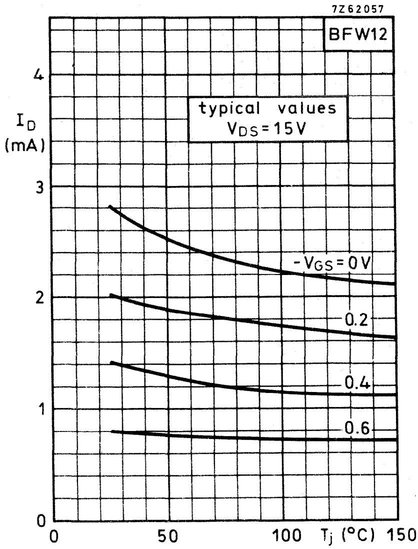
CHARACTERISTICS T_j = 25 °C unless otherwise specified

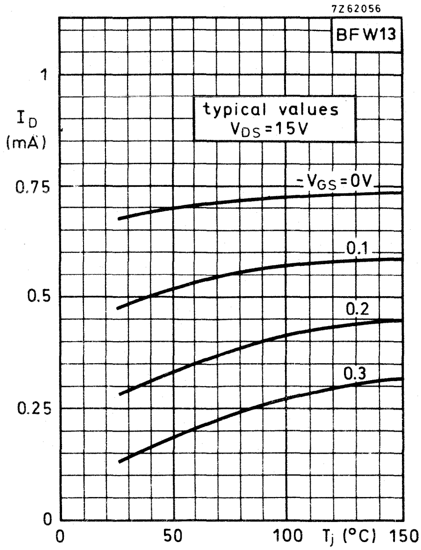
			BFW12	BFW13	
Gate cut-off current					
$-V_{GS}$ = 10 V; V_{DS} = 0	$-I_{GSS}$	<	0.1	0.1	nA
$-V_{GS}$ = 10 V; V_{DS} = 0; T_j = 150 °C	$-I_{GSS}$	<	0.1	0.1	μA
Drain current [1]					
V_{DS} = 15 V; V_{GS} = 0	I_{DSS}	>	1	0.2	mA
		<	5	1.5	mA
Gate-source voltage					
I_D = 50 μA; V_{DS} = 15 V	$-V_{GS}$	>	0.5	0.1	V
		<	2.0	1.0	V
Gate-source cut-off voltage					
I_D = 0.5 nA; V_{DS} = 15 V	$-V_{(P)GS}$	<	2.5	1.2	V
y parameters at f = 1 kHz; T_{amb} = 25 °C					
V_{DS} = 15 V; V_{GS} = 0					
Transfer admittance	$\|y_{fs}\|$	>	2.0	1.0	mA/V
Output admittance	$\|y_{os}\|$	<	30	10	μA/V
V_{DS} = 15 V; I_D = 500 μA					
Transfer admittance	$\|y_{fs}\|$	>	1.5	–	mA/V
Output admittance	$\|y_{os}\|$	<	10	–	μA/V
V_{DS} = 15 V; I_D = 200 μA					
Transfer admittance	$\|y_{fs}\|$	>	0.5	0.5	mA/V
Output admittance	$\|y_{os}\|$	<	5	5	μA/V
f = 1 MHz; T_{amb} = 25 °C					
V_{DS} = 15 V; V_{GS} = 0					
Input capacitance	C_{iss}	<	5	5	pF
Feedback capacitance	C_{rs}	<	0.80	0.80	pF
Equivalent noise voltage					
V_{DS} = 15 V; I_D = 200 μA; T_{amb} = 25 °C; B = 0.6 to 100 Hz	V_n	<	0.5	0.5	μV

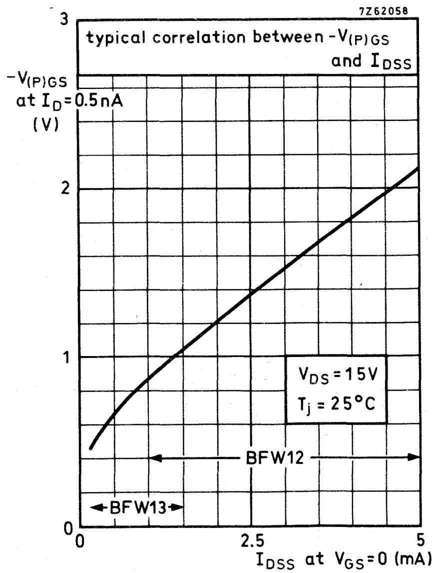
[1] Measured under pulse conditions.

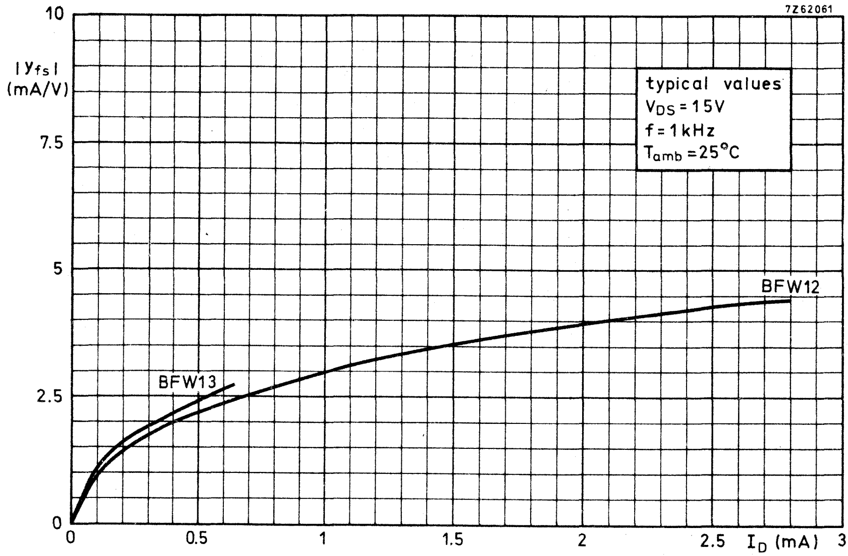

7Z62054
BFW12
V_{DS} = 15 V
T_j = 25 °C
I_D (mA)
typical values
max
typ
min
$-V_{GS}$ = 0 V
0.2
0.4
0.6
0.8
0
2
4
6
2
$-V_{GS}$ (V)
1
0
10
V_{DS} (V)
20

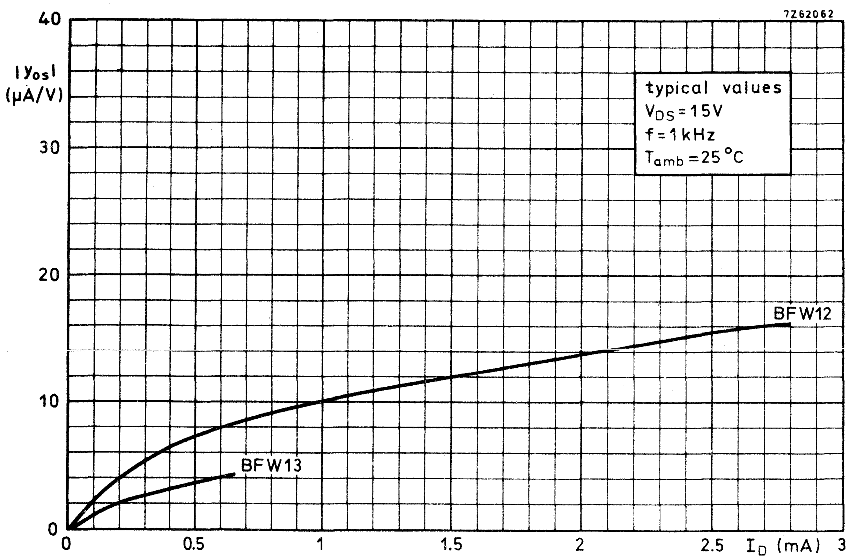

7Z62055
BFW13
V_{DS} = 15 V
T_j = 25 °C
I_D (mA)
typical values
max
typ
min
$-V_{GS}$ = 0 V
0.1
0.2
0.3
0.4
0
0.5
1
1.5
1
$-V_{GS}$ (V)
0.5
0
10
V_{DS} (V)
20

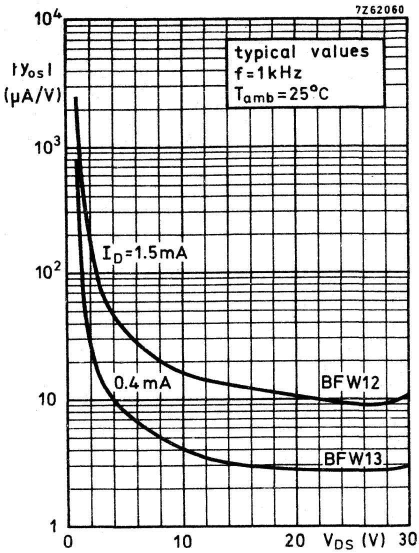

7Z62057
BFW12
typical values
V_{DS}=15V
I_D
(mA)
$-V_{GS}$=0V
0.2
0.4
0.6
4
3
2
1
0
0
50
100
T_j (°C)
150

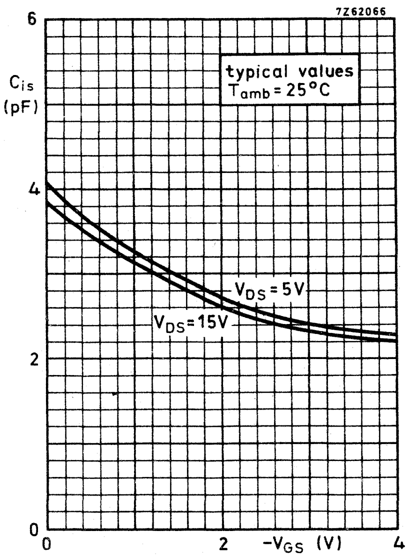

7Z62056
BFW13
typical values
V_{DS}=15V
I_D
(mA)
$-V_{GS}$=0V
0.1
0.2
0.3
1
0.75
0.5
0.25
0
0
50
100
T_j (°C)
150

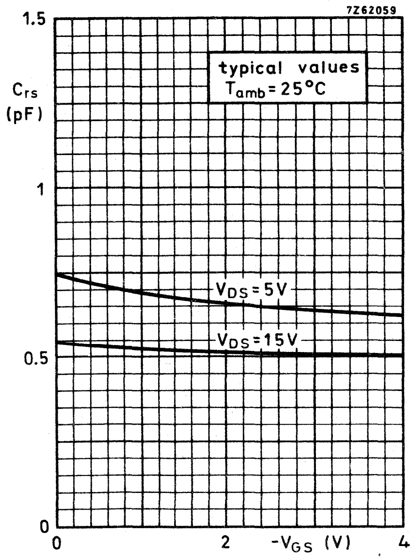

7Z62058
typical correlation between $-V_{(P)GS}$ and I_{DSS}
$-V_{(P)GS}$
at I_D=0.5nA
(V)
V_{DS}=15V
T_j = 25°C
BFW12
BFW13
3
2
1
0
0
2.5
5
I_{DSS} at V_{GS}=0 (mA)

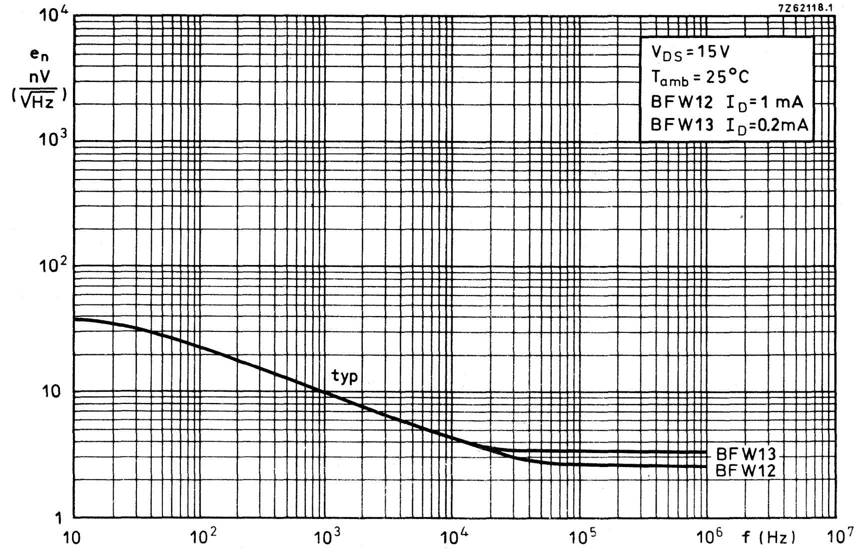

7Z62061
|yfs|
(mA/V)
10
7.5
5
2.5
0
typical values
VDS = 15V
f = 1 kHz
Tamb = 25°C
BFW12
BFW13
0
0.5
1
1.5
2
2.5
ID (mA)
3

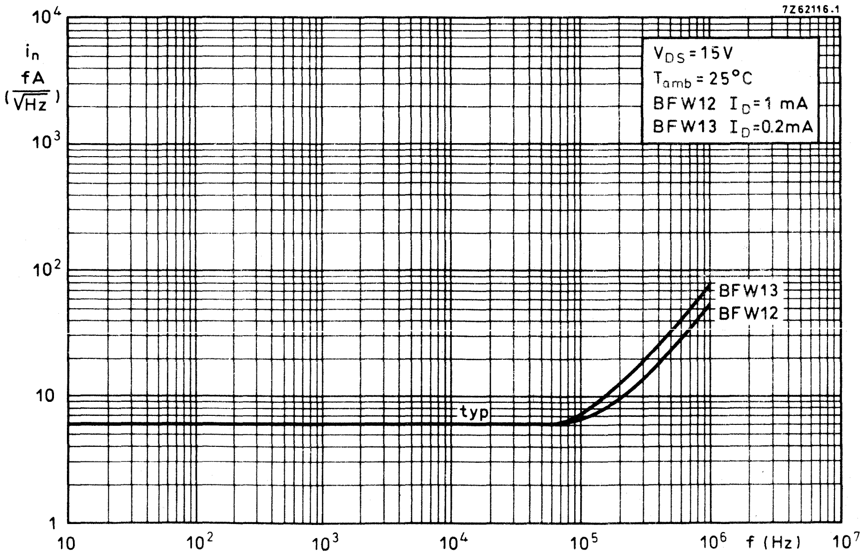

7Z62062
|yos|
(μA/V)
40
30
20
10
0
typical values
VDS = 15V
f = 1 kHz
Tamb = 25 °C
BFW12
BFW13
0
0.5
1
1.5
2
2.5
ID (mA)
3

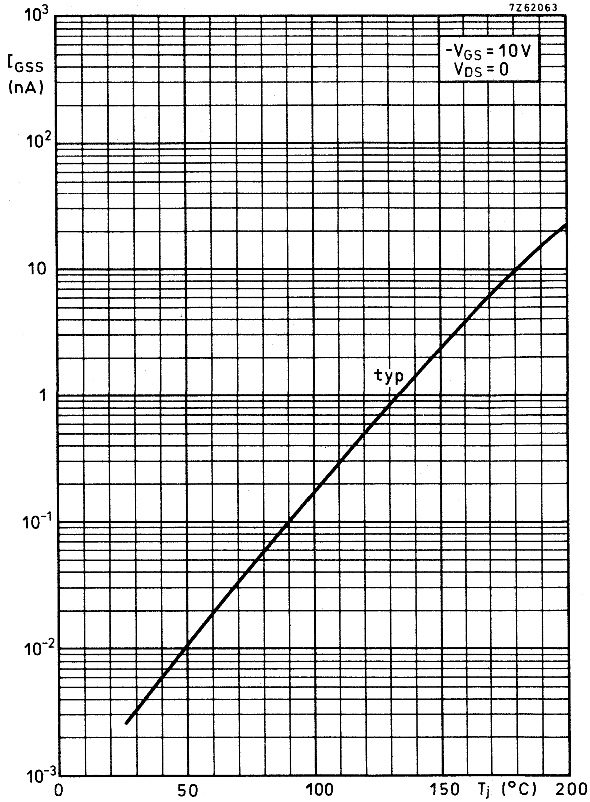

7Z62060
typical values
f = 1 kHz
T_{amb} = 25 °C
$|y_{os}|$ (µA/V)
10^4
10^3
10^2
10
1
I_D = 1.5 mA
0.4 mA
BFW12
BFW13
0
10
20
V_{DS} (V)
30


7Z62066
typical values
T_{amb} = 25 °C
C_{is} (pF)
6
4
2
0
V_{DS} = 5 V
V_{DS} = 15 V
0
2
$-V_{GS}$ (V)
4


7Z62059
typical values
T_{amb} = 25 °C
C_{rs} (pF)
1.5
1
0.5
0
V_{DS} = 5 V
V_{DS} = 15 V
0
2
$-V_{GS}$ (V)
4


7Z62118.1
e_n
nV
(√Hz)
V_DS = 15 V
T_amb = 25 °C
BFW12 I_D = 1 mA
BFW13 I_D = 0.2 mA
typ
BFW13
BFW12
f (Hz)
10
10^2
10^3
10^4
10^5
10^6
10^7
1


7Z62116.1
i_n
fA
(√Hz)
V_DS = 15 V
T_amb = 25 °C
BFW12 I_D = 1 mA
BFW13 I_D = 0.2 mA
typ
BFW13
BFW12
f (Hz)
10
10^2
10^3
10^4
10^5
10^6
10^7
1


7Z62063
I_{GSS} (nA)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
$-V_{GS} = 10\,V$
$V_{DS} = 0$
typ
0
50
100
150
200
T_j (°C)

N-CHANNEL SILICON FET

N-channel silicon epitaxial planar junction field-effect transistor in a TO-72 metal envelope with the shield lead connected to the case. The transistor is designed for general purpose amplifiers.

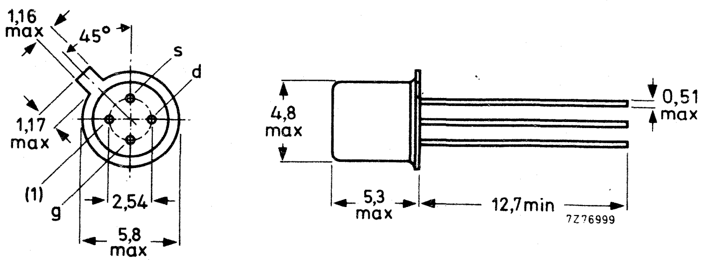
QUICK REFERENCE DATA

Drain-source voltage	$\pm V_{DS}$	max.	25	V
Gate-source voltage (open drain)	$-V_{GSO}$	max.	25	V
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	mW
Drain current V_{DS} = 15 V; V_{GS} = 0	I_{DSS}		2 to 20	mA
Gate-source cut-off voltage I_D = 1,0 nA; V_{DS} = 15 V	$-V_{(P)GS}$	<	8	V
Feedback capacitance at f = 1 MHz V_{DS} = 15 V; V_{GS} = 0	C_{rs}	<	2,0	pF
Transfer admittance (common source) V_{DS} = 15 V; V_{GS} = 0; f = 10 MHz	$\lvert y_{fs} \rvert$	>	1,6	mA/V

MECHANICAL DATA

Dimensions in mm

TO-72



(1) = shield lead (connected to case).

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

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

Voltages

Drain-source voltage	$\pm V_{DS}$	max.	25	V
Drain-gate voltage (open source)	V_{DGO}	max.	25	V
Gate-source voltage (open drain)	$-V_{GSO}$	max.	25	V

Currents

Drain current	I_D	max.	20	mA
Gate current	I_G	max.	10	mA

Power dissipation

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

Temperatures

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

THERMAL RESISTANCE

From junction to ambient	$R_{th\ j-a}$	=	0.59	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Gate cut-off current				
$-V_{GS}$ = 20 V; V_{DS} = 0	$-I_{GSS}$	<	1.0	nA
$-V_{GS}$ = 20 V; V_{DS} = 0; T_j = 150 °C	$-I_{GSS}$	<	1.0	μA
Drain current [1]				
V_{DS} = 15 V; V_{GS} = 0	I_{DSS}	2 to	20	mA
Gate-source voltage				
I_D = 200 μA; V_{DS} = 15 V	$-V_{GS}$	0.5 to	7.5	V
Gate-source cut-off voltage				
I_D = 1.0 nA; V_{DS} = 15 V	$-V_{(P)GS}$	<	8	V
y parameters (common source)				
V_{DS} = 15 V; V_{GS} = 0				
f = 1 kHz Transfer admittance	$\|y_{fs}\|$	2.0 to	6.5	$m\Omega^{-1}$
Output admittance	$\|y_{os}\|$	<	85	$\mu\Omega^{-1}$
f = 1 MHz Input capacitance	C_{is}	<	6	pF
Feedback capacitance	C_{rs}	<	2.0	pF
f = 10 MHz Transfer admittance	$\|y_{fs}\|$	>	1.6	$m\Omega^{-1}$

[1]) Measured under pulsed conditions.

N-CHANNEL FETS

Silicon n-channel junction field-effect transistors in a TO-18 metal envelope with the gate connected to the case. The transistors are intended for switching applications. The devices are symmetrical and have the feature: low 'on' resistance at zero gate voltage.

QUICK REFERENCE DATA

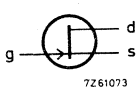
			BSV78	BSV79	BSV80	
Drain-source voltage	V_{DS}	max.		40		V
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.		350		mW
Drain current V_{DS} = 15 V; V_{GS} = 0	I_{DSS}	>	50	20	10	mA
Gate-source cut-off voltage I_D = 1 nA; V_{GS} = 15 V	$-V_{(P)GS}$	>	3,75	2,0	1,0	V
		<	11	7,0	5,0	V
Drain-source resistance (on) at f = 1 kHz I_D = 0; V_{GS} = 0	$r_{ds\ on}$	<	25	40	60	Ω
Feedback capacitance at f = 1 MHz V_{DS} = 0; $-V_{GS}$ = 10 V	C_{rs}	<	5	5	5	pF
Turn-on time	t_{on}	<	10	15	15	ns
Turn-off time	t_{off}	<	10	15	25	ns

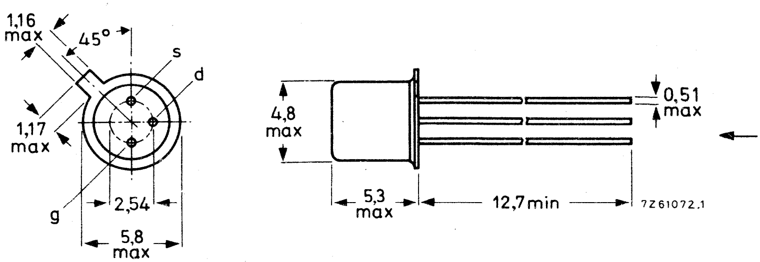
MECHANICAL DATA

Dimensions in mm

Gate connected to case

TO-18





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

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

Voltages

Drain-source voltage	V_{DS}	max.	40	V
Drain-gate voltage (open source)	V_{DGO}	max.	40	V
Gate-source voltage (open drain)	$-V_{GSO}$	max.	40	V

Current

Forward gate current	I_G	max.	50	mA

Power dissipation

Total power dissipation up to $T_{amb} = 25\,^{o}C$	P_{tot}	max.	350	mW

Temperatures

Storage temperature	T_{stg}		-65 to +200	^{o}C
Junction temperature	T_j	max.	175	^{o}C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.43	$^{o}C/mW$

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BSV78	BSV79	BSV80	
Gate cut-off current						
$-V_{GS}$ = 20 V; V_{DS} = 0	$-I_{GSS}$	<		0.25		nA
$-V_{GS}$ = 20 V; V_{DS} = 0; T_j = 150 °C	$-I_{GSS}$	<		0.5		μA
Drain cut-off current						
V_{DS} = 15 V; $-V_{GS}$ = 12 V	I_{DSX}	<		0.25		nA
V_{DS} = 15 V; $-V_{GS}$ = 12 V; T_j = 150 °C	I_{DSX}	<		0.5		μA
Drain current						
V_{DS} = 15 V; V_{GS} = 0	I_{DSS}	>	50	20	10	mA
Gate-source cut-off voltage						
I_D = 1 nA; V_{DS} = 15 V	$-V_{(P)GS}$	>	3.75	2.0	1.0	V
		<	11	7.0	5.0	V
Gate-source voltage						
I_D = 1.5 μA; V_{DS} = 15 V	$-V_{GS}$	>	3.5	1.75	0.75	V
		<	10	6.0	4.0	V
Drain-source voltage (on)						
I_D = 20 mA; V_{GS} = 0	V_{DSon}	<	500			mV
I_D = 10 mA; V_{GS} = 0	V_{DSon}	<		400		mV
I_D = 5 mA; V_{GS} = 0	V_{DSon}	<			325	mV
Drain-source resistance (on) at f = 1 kHz						
I_D = 0; V_{GS} = 0	$r_{ds\ on}$	<	25	40	60	Ω
y parameters at f = 1 MHz (common source)						
$-V_{GS}$ = 10 V; V_{DS} = 0						
Input capacitance	C_{is}	<	10	10	10	pF
Feedback capacitance	C_{rs}	<	5	5	5	pF

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

Turn on time when switched from

$-V_{GS}$ = 11 V to I_D = 20 mA: BSV78
$-V_{GS}$ = 7 V to I_D = 10 mA: BSV79
$-V_{GS}$ = 5 V to I_D = 5 mA: BSV80
} at V_{DD} = 10 V

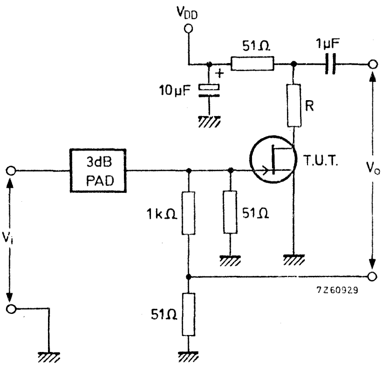
			BSV78	BSV79	BSV80	
delay time	t_d	<	5	10	8	ns
rise time	t_r	<	5	5	7	ns
turn on time	t_{on}	<	10	15	15	ns

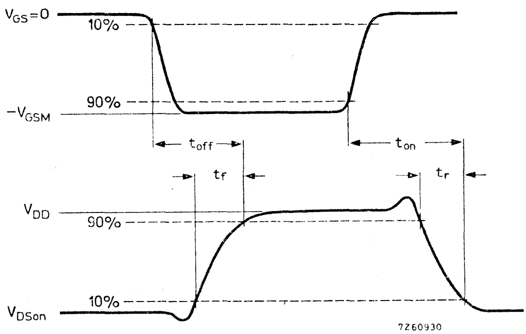
Turn off time when switched from

I_D = 20 mA to $-V_{GS}$ = 11 V (BSV78)
I_D = 10 mA to $-V_{GS}$ = 7 V (BSV79)
I_D = 5 mA to $-V_{GS}$ = 5 V (BSV80)
} at V_{DD} = 10 V

			BSV78	BSV79	BSV80	
fall time	t_f	<	6	10	20	ns
storage time	t_s	<	4	5	5	ns
turn off time	t_{off}	<	10	15	25	ns

Test circuit:





$$R_L = \frac{10 - V_{DSon}}{I_{Don}} - 51 \quad \Omega$$

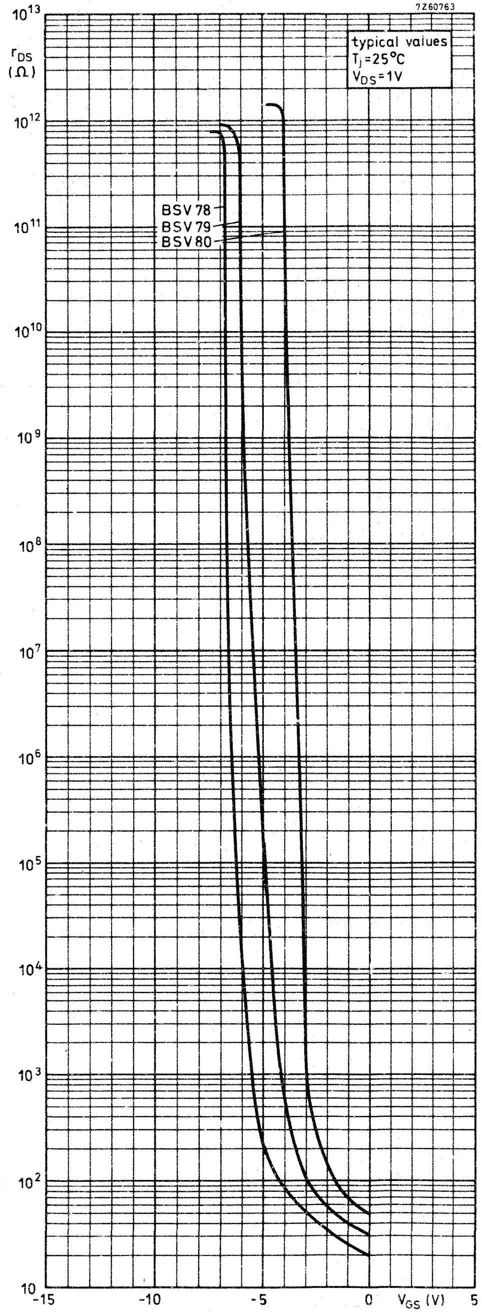
	BSV78	BSV79	BSV80	
R_L =	424	909	1885	Ω

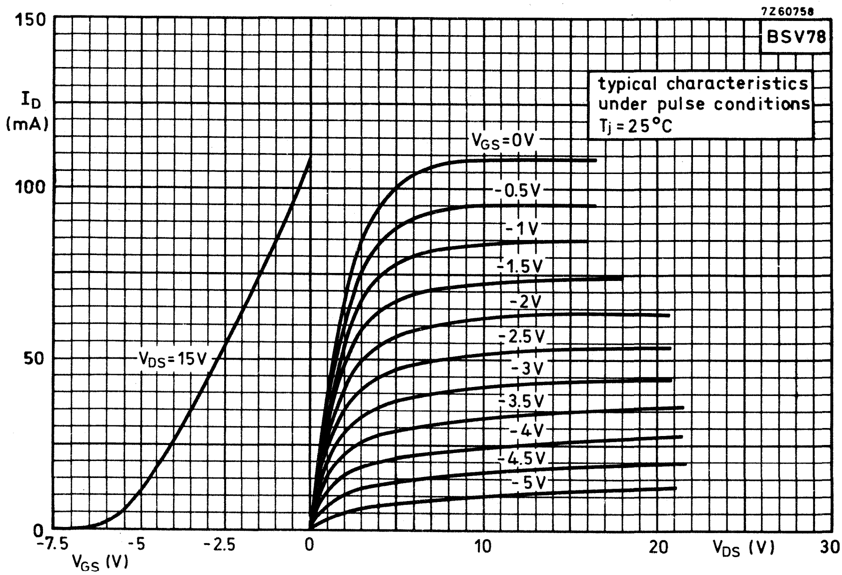
Pulse generator:

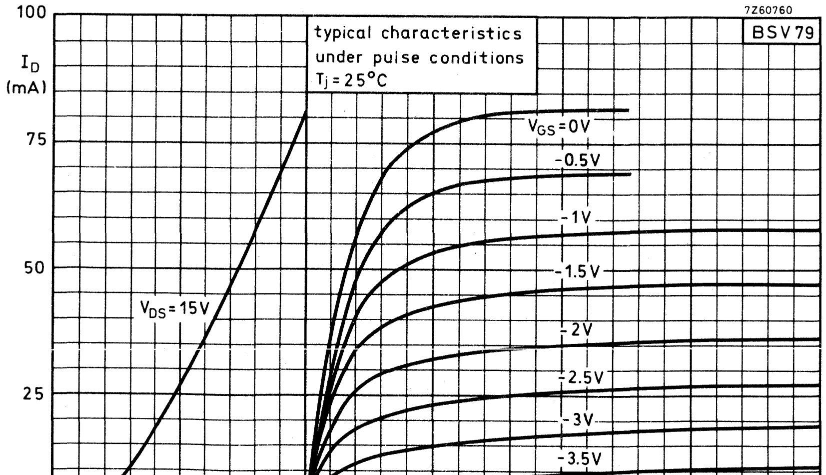
R_i = 50 Ω
t_r < 0.5 ns
t_f < 5 ns

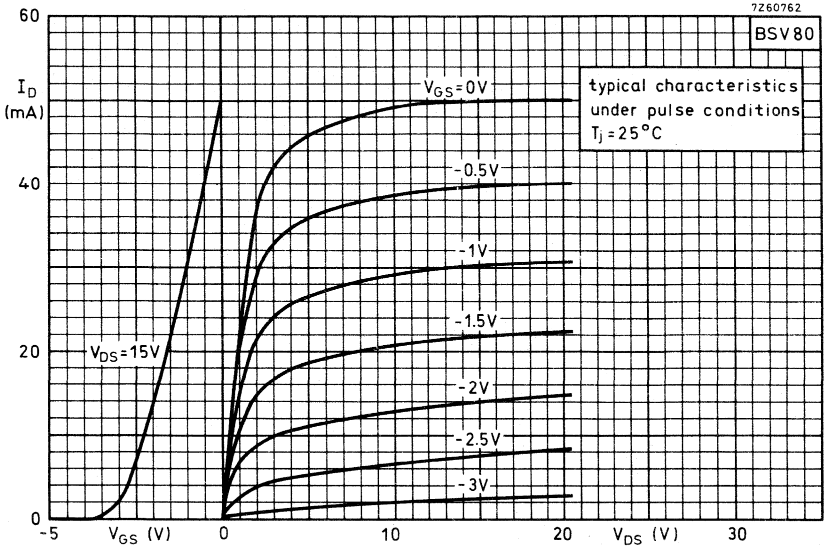
Oscilloscope:

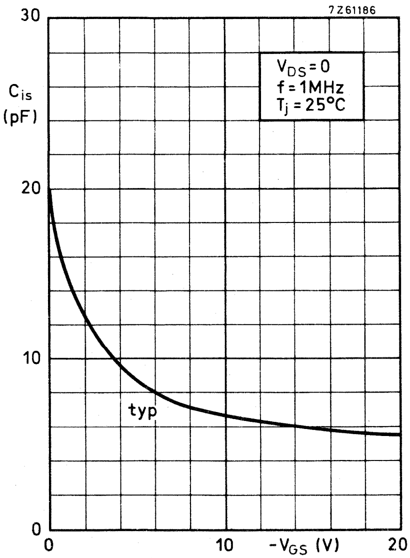
R_i = 50 Ω
t_r < 1 ns
t_f < 1 ns

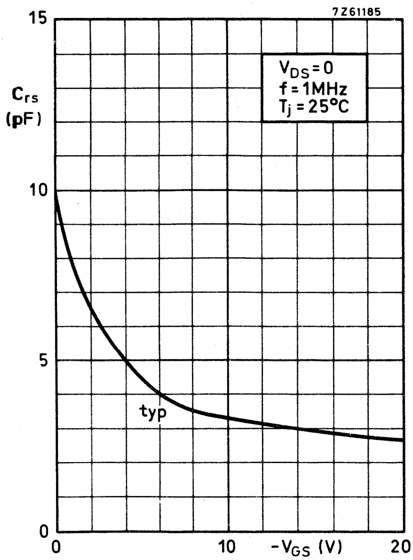

7Z60763
typical values
$T_j = 25\,^{\circ}C$
$V_{DS} = 1V$
r_{DS} (Ω)
BSV78
BSV79
BSV80
V_{GS} (V)
10^{13}
10^{12}
10^{11}
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
10^{4}
10^{3}
10^{2}
10
−15
−10
−5
0
5

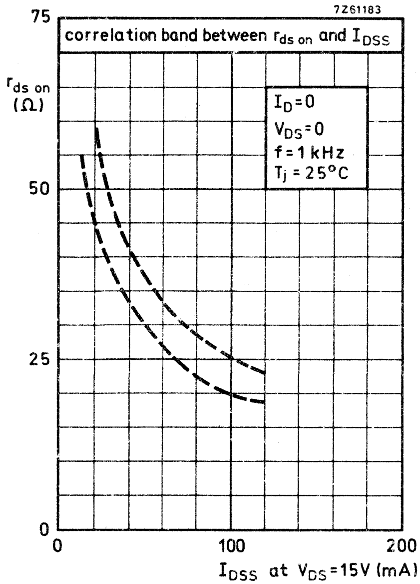

7Z60758
BSV78
typical characteristics under pulse conditions
$T_j = 25\,°C$
I_D (mA)
150
100
50
0
$V_{GS} = 0\,V$
-0.5 V
-1 V
-1.5 V
-2 V
-2.5 V
-3 V
-3.5 V
-4 V
-4.5 V
-5 V
$V_{DS} = 15\,V$
-7.5
-5
-2.5
0
10
20
30
V_{GS} (V)
V_{DS} (V)

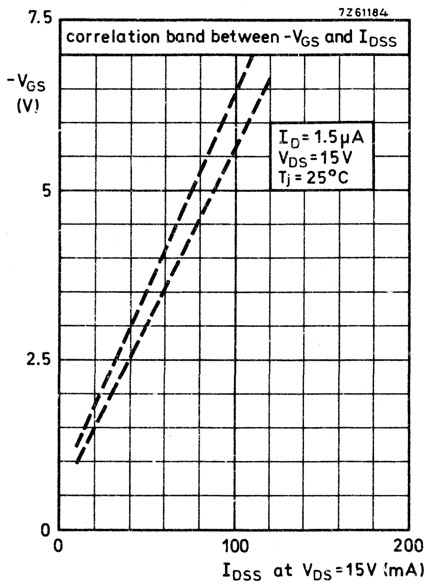

7Z60760
BSV79
typical characteristics under pulse conditions
$T_j = 25\,°C$
I_D (mA)
100
75
50
25
0
$V_{GS} = 0\,V$
-0.5 V
-1 V
-1.5 V
-2 V
-2.5 V
-3 V
-3.5 V
-4 V
$V_{DS} = 15\,V$
-5
V_{GS} (V)
-2.5
0
5
10
15
V_{DS} (V)
20


7Z60762
BSV80
typical characteristics
under pulse conditions
T_j = 25°C
I_D
(mA)
60
40
20
0
V_{GS} = 0V
-0.5V
-1V
-1.5V
-2V
-2.5V
-3V
V_{DS} = 15V
-5
V_{GS} (V)
0
10
20
V_{DS} (V)
30


7Z61186
V_{DS} = 0
f = 1MHz
T_j = 25°C
C_{is}
(pF)
30
20
10
0
typ
0
10
$-V_{GS}$ (V)
20

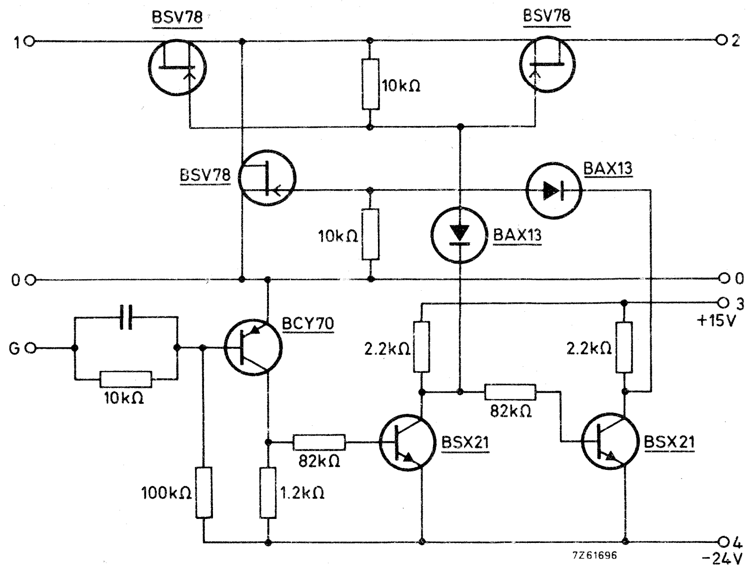

7Z61185
V_{DS} = 0
f = 1MHz
T_j = 25°C
C_{rs}
(pF)
15
10
5
0
typ
0
10
$-V_{GS}$ (V)
20


7Z61183
correlation band between $r_{ds\,on}$ and I_{DSS}
$r_{ds\,on}$ (Ω)
$I_D = 0$
$V_{DS} = 0$
f = 1 kHz
$T_j = 25\,^\circ C$
75
50
25
0
0
100
200
I_{DSS} at $V_{DS} = 15\,V$ (mA)


7Z61184
correlation band between $-V_{GS}$ and I_{DSS}
$-V_{GS}$ (V)
$I_D = 1.5\,\mu A$
$V_{DS} = 15\,V$
$T_j = 25\,^\circ C$
7.5
5
2.5
0
0
100
200
I_{DSS} at $V_{DS} = 15\,V$ (mA)

APPLICATION INFORMATION

Floating bidirectional 50 mA switch with BSV78



Maximum allowable voltages:

V_{10}	max.	±	15	V
V_{20}	max.	±	15	V
V_{12}	max.	±	30	V

Maximum allowable current to be switched:

I_{12}	max.	±	50	mA

Supply currents:

on-state	I_3 = 20 mA		off-state	I_3 =	20 mA
	I_4 = 20 mA			I_4 =	40 mA

Performance:

		on-state	off-state	
Gate voltage	typ.	6	0	V
Resistance between terminals 1 and 2	typ.	50	10^{10}	Ω
terminals 1 and 0	>	10^{10}	10^{10}	Ω
terminals 2 and 0	>	10^{10}	10^{10}	Ω

Switching times with R_L = 1 kΩ, when

switched to $V_{G\,on}$ = 6 V	t_{on}	<	50	ns
switched to $V_{G\,off}$ = 0	t_{off}	<	50	ns

N-CHANNEL IG-FET

Symmetrical depletion type field-effect transistor in a TO-72 metal envelope with the substrate connected to the case. It is intended for chopper and other special switching applications, e.g. timing circuits, multiplex circuits, etc. The features are a very low drain-source 'on' resistance, a very high drain-source 'off' resistance and low feedback capacitances.

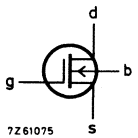
QUICK REFERENCE DATA

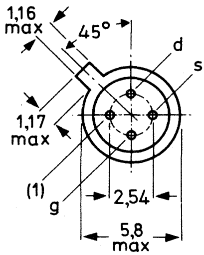
Drain-source resistance (on) at f = 1 kHz			
$V_{DS} = 0$; $V_{GS} = 5$ V; $V_{BS} = 0$	$r_{ds\ on}$	<	50 Ω
Drain-source resistance (off)			
$V_{DS} = 10$ V; $-V_{GS} = 5$ V; $V_{BS} = 0$	r_{DSoff}	>	10 GΩ
Feedback capacitance at f = 1 MHz			
$-V_{GS} = 5$ V; $V_{DS} = 0$; $I_B = 0$	C_{rs}	<	0,5 pF
$-V_{GD} = 5$ V; $V_{SD} = 0$; $I_B = 0$	C_{rd}	<	0,5 pF

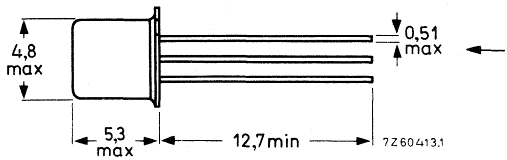
MECHANICAL DATA

Dimensions in mm

TO-72







(1) = substrate connected to case.

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

Note

To safeguard the gates against damage due to accumulation of static charge during transport or handling, the leads are encircled by a ring of conductive rubber which should be removed just after the transistor is soldered into the circuit.

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

Voltages

Drain-substrate voltage	V_{DB}	max.	30	V
Source-substrate voltage	V_{SB}	max.	30	V
Gate-substrate voltage (continuous)	V_{GB}	max.	10	V
		min.	−10	V
Repetitive peak gate to all other terminals voltage $V_{SB} = V_{DB} = 0$; $f > 100$ Hz	V_{G-N}	max.	15	V
		min.	−15	V
Non-repetitive peak gate to all other terminals voltage $V_{SB} = V_{DB} = 0$; $t < 10$ ms	V_{G-N}	max.	50	V
		min.	−50	V

Currents

Drain current (peak value) $t_r = 20$ ms; $\delta = 0,1$	I_{DM}	max.	50	mA
Source current (peak value) $t_r = 20$ ms; $\delta = 0,1$	I_{SM}	max.	50	mA

Power dissipation

Total power dissipation up to $T_{amb} = 25$ °C	P_{tot}	max.	200	mW

Temperatures

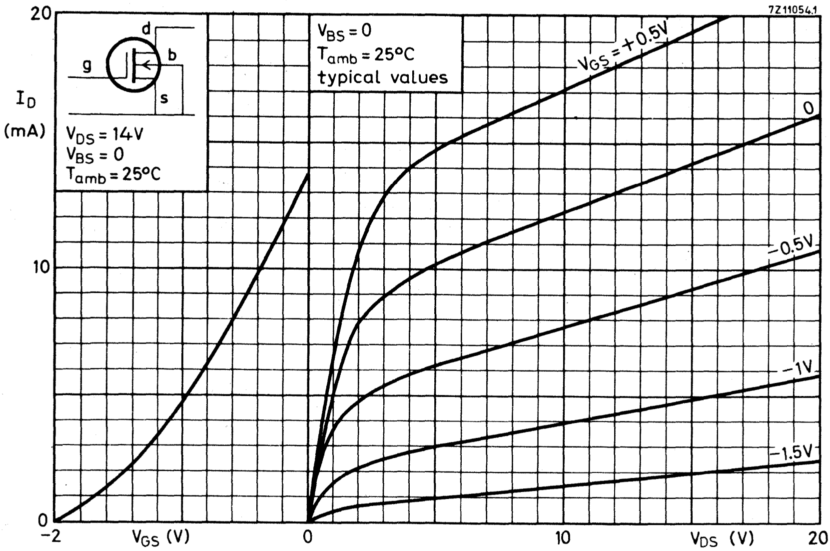
Storage temperature	T_{stg}	−65 to +125		°C
Junction temperature	T_j	max.	125	°C

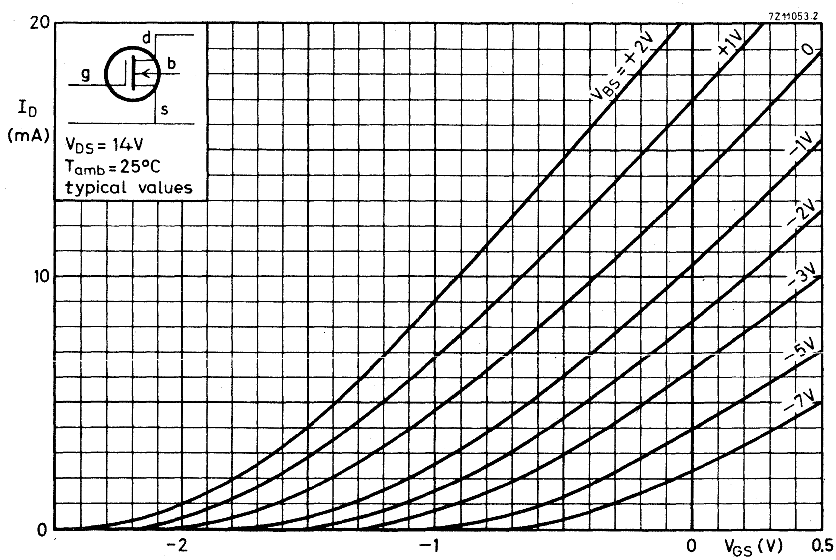
THERMAL RESISTANCE

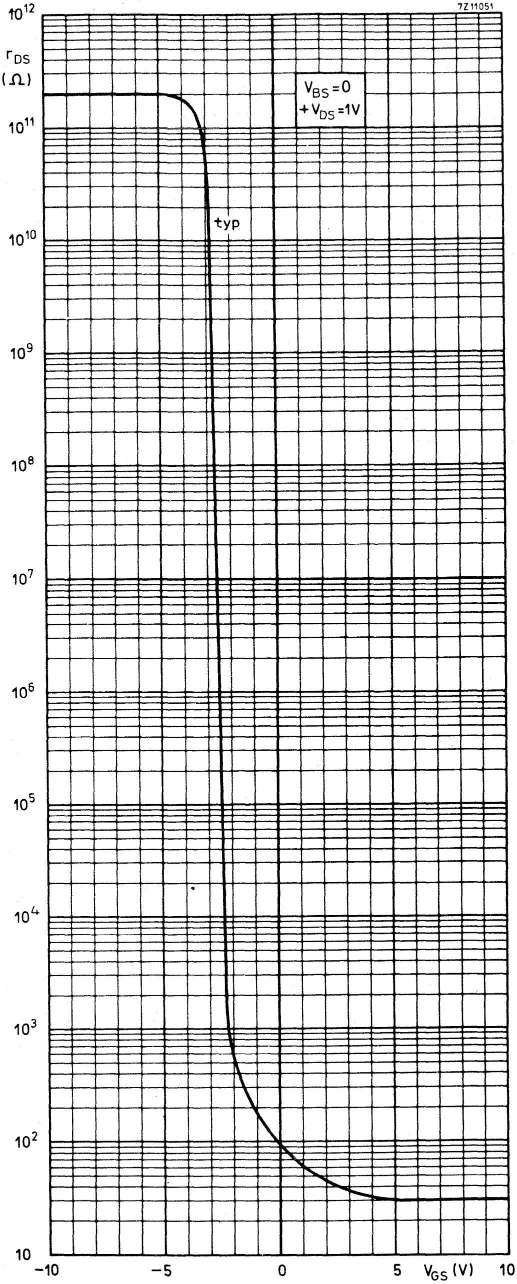
From junction to ambient in free air	$R_{th\ j-a}$	=	0,5	°C/mW

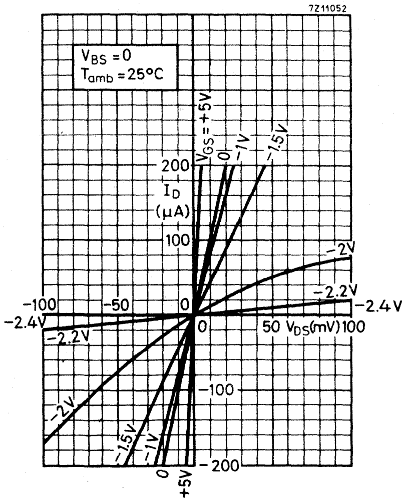
CHARACTERISTICS T_j = 25 °C unless otherwise specified

Drain cut-off currents; V_{BS} = 0				
V_{DS} = 10 V; $-V_{GS}$ = 5 V	I_{DSX}	<	1	nA
V_{DS} = 10 V; $-V_{GS}$ = 5 V; T_j = 125 °C	I_{DSX}	<	1	μA
Source cut-off currents; V_{BD} = 0				
V_{SD} = 10 V; $-V_{GD}$ = 5 V	I_{SDX}	<	1	nA
V_{SD} = 10 V; $-V_{GD}$ = 5 V; T_j = 125 °C	I_{SDX}	<	1	μA
Gate currents; V_{BS} = 0				
$-V_{GS}$ = 10 V; V_{DS} = 0	$-I_{GSS}$	<	10	pA
V_{GS} = 10 V; V_{DS} = 0	I_{GSS}	<	10	pA
$-V_{GS}$ = 10 V; V_{DS} = 0; T_j = 125 °C	$-I_{GSS}$	<	200	pA
V_{GS} = 10 V; V_{DS} = 0; T_j = 125 °C	I_{GSS}	<	200	pA
Bulk currents; V_{GB} = 0				
$-V_{BD}$ = 30 V; I_S = 0	$-I_{BDO}$	<	10	μA
$-V_{BS}$ = 30 V; I_D = 0	$-I_{BSO}$	<	10	μA
Drain-source resistance (on) at f = 1 kHz; V_{BS} = 0				
V_{GS} = 0 ; V_{DS} = 0	r_{dson}	<	100	Ω
V_{GS} = 0 ; V_{DS} = 0; T_j = 125 °C	r_{dson}	<	150	Ω
$+V_{GS}$ = 5 V; V_{DS} = 0	r_{dson}	<	50	Ω
Drain-source resistance (off)				
$-V_{GS}$ = 5 V; V_{DS} = 10 V; V_{BS} = 0	r_{DSoff}	>	10	GΩ
Feedback capacitances at f = 1 MHz				
$-V_{GS}$ = 5 V; V_{DS} = 0; I_B = 0	C_{rs}	<	0,5	pF
$-V_{GD}$ = 5 V; V_{SD} = 0; I_B = 0	C_{rd}	<	0,5	pF
Gate to all other terminals capacitance at f = 1 MHz				
$-V_{GB}$ = 5 V; V_{SB} = V_{DB} = 0	C_{g-n}	<	6	pF


7Z11054.1
I_D (mA)
V_DS = 14V
V_BS = 0
T_amb = 25°C
V_BS = 0
T_amb = 25°C
typical values
V_GS = +0.5V
0
−0.5V
−1V
−1.5V
d
b
g
s
20
10
0
−2
V_GS (V)
0
10
V_DS (V)
20


7Z11053.2
I_D (mA)
V_DS = 14V
T_amb = 25°C
typical values
V_BS = +2V
+1V
0
−1V
−2V
−3V
−5V
−7V
d
b
g
s
20
10
0
−2
−1
0
V_GS (V)
0.5


7Z11051
r_{DS} (Ω)
10^{12}
10^{11}
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
10^{4}
10^{3}
10^{2}
10
$V_{BS} = 0$
$+V_{DS} = 1V$
typ
−10
−5
0
5
V_{GS} (V)
10


7Z11052
$V_{BS} = 0$
$T_{amb} = 25°C$
$V_{GS} = +5V$
0
−1V
−1.5V
−2V
−2.2V
−2.4V
I_D (μA)
200
100
−100
−200
−100
−50
0
50
V_{DS}(mV)
100
+5V

N-CHANNEL SILICON FET

Silicon n-channel depletion type junction-triode field-effect transistor in a TO-72 metal envelope, primarily intended for depletion mode operation in low power i.f./r.f. amplifiers for industrial applications.

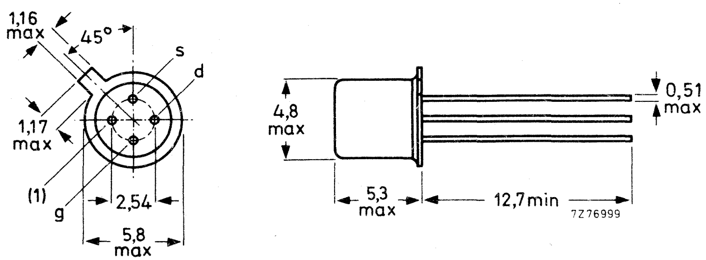
QUICK REFERENCE DATA

Drain-source voltage	V_{DS}	max.	30	V
Gate-source voltage	$-V_{GS}$	max.	30	V
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	mW
Gate cut-off current $-V_{GS}$ = 20 V; V_{DS} = 0	$-I_{GSS}$	<	0,5	nA
Feedback capacitance at f = 1 MHz V_{DS} = 15 V; V_{GS} = 0	C_{rs}	<	2	pF
Transfer admittance (common source) V_{DS} = 15 V; V_{GS} = 0; f = 200 MHz; T_{amb} = 25 °C	$\lvert y_{fs} \rvert$	>	3,2	mA/V

MECHANICAL DATA

Dimensions in mm

TO-72



(1) = shield lead (connected to case).

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

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

Voltages				
Drain-source voltage	V_{DS}	max.	30	V
Drain-gate voltage	V_{DG}	max.	30	V
Gate-source voltage	$-V_{GS}$	max.	30	V
Current				
Gate current	I_G	max.	10	mA
Power dissipation				
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	mW
Linear derating factor			2	mW/°C
Temperatures				
Storage temperature	T_{stg}	−65 to +200		°C
Junction temperature	T_j	max.	200	°C

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Gate cut-off current				
$-V_{GS}$ = 20 V; V_{DS} = 0	$-I_{GSS}$	<	0.5	nA
$-V_{GS}$ = 20 V; V_{DS} = 0; T_j = 150 °C	$-I_{GSS}$	<	0.5	μA
Drain current [1]				
V_{DS} = 15 V; V_{GS} = 0	I_{DSS}	4 to	20	mA
Gate-source voltage				
I_D = 400 μA; V_{DS} = 15 V	$-V_{GS}$	1 to	7.5	V
Gate-source cut-off voltage				
I_D = 0.5 nA; V_{DS} = 15 V	$-V_{(P)GS}$	<	8	V
Gate-source breakdown voltage				
$-I_G$ = 1 μA; V_{DS} = 0	$-V_{(BR)GSS}$	>	30	V

1) Measured under pulsed conditions; pulse duration t = 100 ms; duty cycle $\delta \leq 0.1$.

CHARACTERISTICS (continued)

y parameters (common source)

V_{DS} = 15 V; V_{GS} = 0 T_{amb} = 25 °C

f = 1 kHz	Transfer admittance [1]	$\|y_{fs}\|$		3.5 to 6.5	$m\Omega^{-1}$
	Output admittance [1]	$\|y_{os}\|$	<	35	$\mu\Omega^{-1}$
f = 1 MHz	Input capacitance	C_{is}	<	6	pF
	Feedback capacitance	C_{rs}	<	2	pF
f = 200 MHz	Transfer admittance	$\|y_{fs}\|$	>	3.2	$m\Omega^{-1}$
	Real part of input conductance	$R_e(y_{is})$	<	0.8	$m\Omega^{-1}$
	Real part of output conductance	$R_e(y_{os})$	<	0.2	$m\Omega^{-1}$

Noise figure at f = 100 MHz T_{amb} = 25 °C

V_{DS} = 15 V; V_{GS} = 0; R_G = 1 kΩ input tuned to minimum noise	F	<	2.5	dB

[1]) Measured under pulsed conditions; Pulse duration t = 100 ms; duty cycle $\delta \leqslant 0.1$

N-CHANNEL SILICON FET

N-channel silicon epitaxial planar junction field-effect transistor in a TO-72 metal envelope with the shield lead connected to the case. The transistor is suitable in a variety of low power switching applications, e.g. in multiplexing systems.

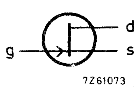
QUICK REFERENCE DATA

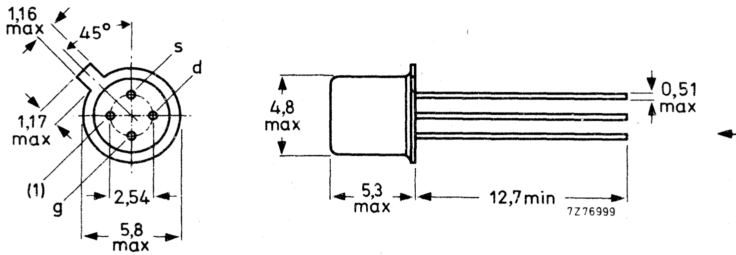
Drain-source voltage	$\pm V_{DS}$	max.	30	V
Gate-source voltage (open drain)	$-V_{GSO}$	max.	30	V
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	mW
Drain current V_{DS} = 20 V; V_{GS} = 0	I_{DSS}	>	2	mA
Gate-source cut-off voltage I_D = 10 nA; V_{DS} = 10 V	$-V_{(P)GS}$		4 to 6	V
Feedback capacitance at f = 1 MHz V_{DS} = 0; V_{GS} = 7 V	C_{rs}	<	1,5	pF
Drain-source resistance (on) at f = 1 kHz V_{GS} = 0; I_D = 0	$r_{ds\,on}$	<	220	Ω

MECHANICAL DATA

Dimensions in mm

TO-72





(1) = shield lead (connected to case).

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

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

Voltages				
Drain-source voltage	$\pm V_{DS}$	max.	30	V
Drain-gate voltage (open source)	V_{DGO}	max.	30	V
Gate-source voltage (open drain)	$-V_{GSO}$	max.	30	V
Current				
Gate current	I_G	max.	10	mA
Power dissipation				
Total power dissipation up to T_{amb} = 25 ^{o}C	P_{tot}	max.	300	mW
Temperatures				
Storage temperature	T_{stg}	−55 to +200		^{o}C
Junction temperature	T_j	max.	200	^{o}C

THERMAL RESISTANCE

From junction to ambient	$R_{th\ j\text{-}a}$	=	0.59	^{o}C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Gate cut-off current				
$-V_{GS}$ = 20 V; V_{DS} = 0	$-I_{GSS}$	<	0.1	nA
Drain current				
V_{DG} = 20 V; I_S = 0	I_{DGO}	<	0.1	nA
V_{DG} = 20 V; I_S = 0; T_{amb} = 150 °C	I_{DGO}	<	0.2	μA
Drain current [1])				
V_{DS} = 20 V; V_{GS} = 0	I_{DSS}	>	2	mA
Gate-source breakdown voltage				
$-I_G$ = 1.0 μA; V_{DS} = 0	$-V_{(BR)GS}$	>	30	V
Gate-source voltage				
I_D = 10 nA; V_{DS} = 10 V	$-V_{(P)GS}$		4 to 6	V
Drain-source voltage				
I_D = 1.0 mA; V_{GS} = 0	V_{DS}	<	0.25	V
Drain cut-off current				
V_{DS} = 10 V; $-V_{GS}$ = 7.0 V	I_D	<	1.0	nA
V_{DS} = 10 V; $-V_{GS}$ = 7.0 V; T_{amb} = 150 °C	I_D	<	2.0	μA
Drain-source resistance (on) at f = 1 kHz				
V_{GS} = 0; I_D = 0	$r_{ds\,on}$	<	220	Ω
Input capacitance at f = 1 MHz				
V_{DS} = 20 V; V_{GS} = 0	C_{is}	<	6	pF
Feedback capacitance at f = 1 MHz				
V_{DS} = 0; V_{GS} = 7 V	C_{rs}	<	1.5	pF
Switching times				
V_{DD} = 1.5 V; $I_{D\,on}$ = 1.0 mA				
$V_{GS\,on}$ = 0; $-V_{GS\,off}$ = 6 V				
delay time	t_d	<	20	ns
rise time	t_r	<	100	ns
turn off time	t_{off}	<	100	ns

CHARACTERISTICS (continued)

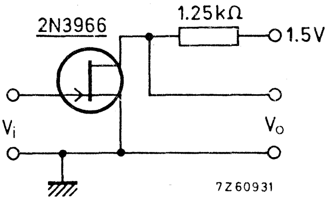
Switching times

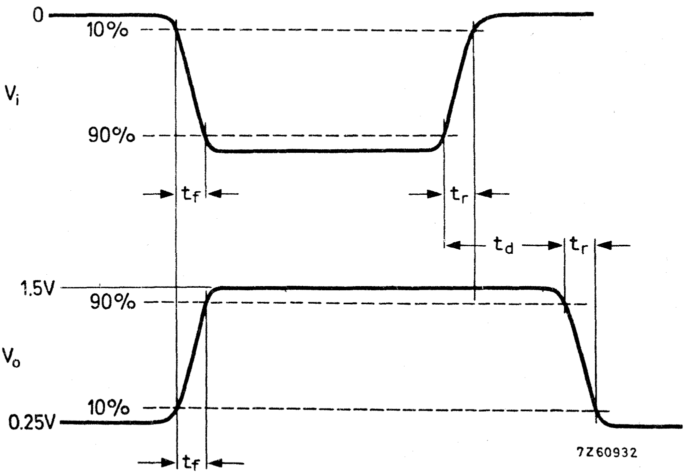
$V_{DD} = 1.5$ V; $I_{D\,on} = 1.0$ mA

$V_{GS\,on} = 0$; $-V_{GS\,off} = 6$ V

delay time	t_d	<	20	ns
rise time	t_r	<	100	ns
turn off time	t_{off}	<	100	ns

Test circuit:





Pulse generator:

t_r < 1.0 ns
t_f < 1.0 ns
t_p = 1.0 µs
δ < 0.5
R_S = 50 Ω

Oscilloscope:

t_r < 10 ns
R_i > 5 MΩ
C_i < 10 pF

N-CHANNEL FETS

Silicon n-channel depletion type junction-triode field-effect transistors in a TO-18 metal envelope with the gate connected to the case. The transistors are intended for low power switching applications in industrial service.

QUICK REFERENCE DATA

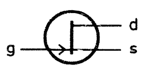
Drain-source voltage	$\pm V_{DS}$	max.		40		V
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max		1,8		W
			2N4091	2N4092	2N4093	
Drain current V_{DS} = 20 V; V_{GS} = 0	I_{DSS}	>	30	15	8	mA
Gate-source cut-off voltage I_D = 1 nA; V_{DS} = 20 V	$-V_{(P)GS}$	>	5,0	2,0	1,0	V
		<	10	7,0	5,0	V
Drain-source resistance (on) at f = 1 kHz I_D = 0; V_{GS} = 0	$r_{ds\,on}$	<	30	50	80	Ω
Feedback capacitance at f = 1 MHz V_{DS} = 0; $-V_{GS}$ = 20 V	C_{rs}	<		5,0		pF
Turn-off time V_{DD} = 3,0 V; V_{GS} = 0						
I_D = 6,6 mA; $-V_{GSM}$ = 12 V **2N4091**	t_{off}	<		40		ns
I_D = 4,0 mA; $-V_{GSM}$ = 8 V **2N4092**	t_{off}	<		60		ns
I_D = 2,5 mA; $-V_{GSM}$ = 6 V **2N4093**	t_{off}	<		80		ns

MECHANICAL DATA

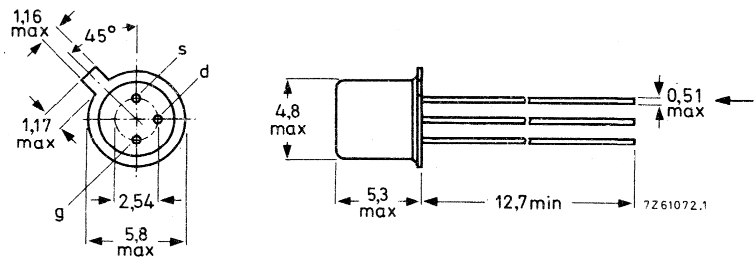
Dimensions in mm

Gate connected to case

TO-18



7Z61073



7Z61072.1

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

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

Voltages				
Drain-source voltage	$\pm V_{DS}$	max.	40	V
Drain-gate voltage (open source)	V_{DGO}	max.	40	V
Gate-source voltage (open drain)	$-V_{GSO}$	max.	40	V
Current				
Forward gate current (d.c.)	I_G	max.	10	mA
Power dissipation				
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	1.8	W
Temperatures				
Storage temperature	T_{stg}	-55 to	+200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to case in free air	$R_{th\ j-c}$	=	0.1	°C/mW

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

			2N4091	2N4092	2N4093	
Drain current						
$V_{DG} = 20\ V;\ I_S = 0$	I_{DGO}	<		0.2		nA
$V_{DG} = 20\ V;\ I_S = 0;\ T_{amb} = 150\ ^oC$	I_{DGO}	<		0.4		μA
Source current						
$V_{SG} = 20\ V;\ I_D = 0$	I_{SGO}	<		0.2		nA
Drain cut-off current						
$V_{DS} = 20\ V;\ -V_{GS} = 12\ V$	I_{DSX}	<	0.2	–	–	nA
$V_{DS} = 20\ V;\ -V_{GS} = 8\ V$	I_{DSX}	<	–	0.2	–	nA
$V_{DS} = 20\ V;\ -V_{GS} = 6\ V$	I_{DSX}	<	–	–	0.2	nA
$V_{DS} = 20\ V;\ -V_{GS} = 12\ V;\ T_{amb} = 150\ ^oC$	I_{DSX}	<	0.4	–	–	μA
$V_{DS} = 20\ V;\ -V_{GS} = 8\ V;\ T_{amb} = 150\ ^oC$	I_{DSX}	<	–	0.4	–	μA
$V_{DS} = 20\ V;\ -V_{GS} = 6\ V;\ T_{amb} = 150\ ^oC$	I_{DSX}	<	–	–	0.4	μA
Gate-source breakdown voltage						
$-I_G = 1.0\ \mu A;\ V_{DS} = 0$	$-V_{(BR)GSS}$	>	40	40	40	V
Drain current [1]						
$V_{DS} = 20\ V;\ V_{GS} = 0$	I_{DSS}	>	30	15	8	mA
Gate-source cut-off voltage						
$I_D = 1\ nA;\ V_{DS} = 20\ V$	$-V_{(P)GS}$	>	5.0	2.0	1.0	V
		<	10	7.0	5.0	V
Drain-source voltage (on)						
$I_D = 6.6\ mA;\ V_{GS} = 0$	V_{DSon}	<	0.2	–	–	V
$I_D = 4.0\ mA;\ V_{GS} = 0$	V_{DSon}	<	–	0.2	–	V
$I_D = 2.5\ mA;\ V_{GS} = 0$	V_{DSon}	<	–	–	0.2	V
Drain-source resistance (on)						
$I_D = 1.0\ mA;\ V_{GS} = 0$	r_{DSon}	<	30	50	80	Ω
Drain-source resistance (on) at f = 1 kHz						
$I_D = 0;\ V_{GS} = 0$	$r_{ds\ on}$	<	30	50	80	Ω

[1]) Measured under pulsed conditions: $t_p \leq 300\ \mu s;\ \delta \leq 0.03$

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

y-parameters at f = 1 MHz (common source)

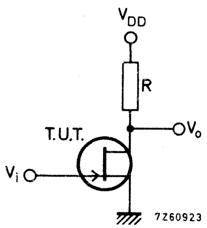
Input capacitance				
V_{DS} = 20 V ; V_{GS} = 0	C_{is}	<	16	pF
Feedback capacitance				
V_{DS} = 0 ; $-V_{GS}$ = 20 V	C_{rs}	<	5	pF

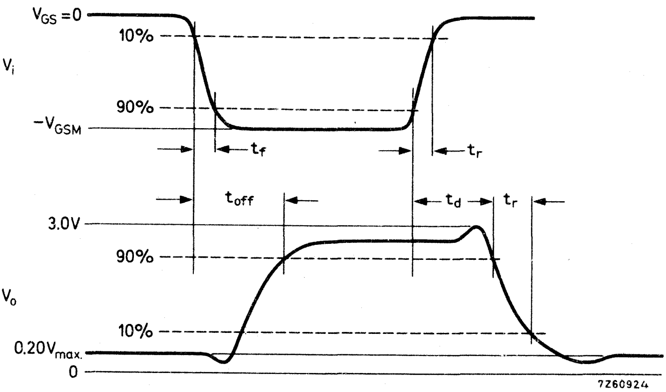
Switching times

V_{DD} = 3,0 V; V_{GS} = 0

			2N4091	2N4092	2N4093	
	I_D	=	6,6	4,0	2,5	mA
	$-V_{GSM}$	=	12	8	6	V
Delay time	t_d	<	15	15	20	ns
Rise time	t_r	<	10	20	40	ns
Turn-off time	t_{off}	<	40	60	80	ns

Test circuit:





$R = \frac{2,8}{I_D}$

Pulse generator:

t_r	<	1	ns
t_f	<	1	ns
t_p	=	1,0	µs
δ	=	0,1	
R_S	=	50	Ω

Oscilloscope:

t_r	<	0,4	ns
R_i	>	9,8	MΩ
C_i	<	1,7	pF

N-CHANNEL FETS

Silicon n-channel depletion type junction-triode field-effect transistors in a TO-18 metal envelope with the gate connected to the case. The transistors are intended for low power, chopper or switching, application in industrial service.

QUICK REFERENCE DATA

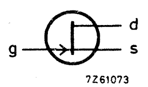
Drain-source voltage		$\pm V_{DS}$	max.		40		V
Total power dissipation up to T_{case} = 25 °C		P_{tot}	max.		1,8		W
				2N4391	2N4392	2N4393	
Drain current V_{DS} = 20 V; V_{GS} = 0		I_{DSS}	>	50	25	5	mA
Gate-source cut-off voltage I_D = 1 nA; V_{DS} = 20 V		$-V_{(P)GS}$	>	4,0	2,0	0,5	V
			<	10	5,0	3,0	V
Drain-source resistance (on) at f = 1 kHz I_D = 1 mA; V_{GS} = 0		$r_{ds\ on}$	<	30	60	100	Ω
Feedback capacitance at f = 1 MHz V_{DS} = 0; $-V_{GS}$ = 12 V	**2N4391**	C_{rs}	<	3,5	3,5	3,5	pF
V_{DS} = 0; $-V_{GS}$ = 7 V	**2N4392**						
V_{DS} = 0; $-V_{GS}$ = 5 V	**2N4393**						
Turn-off time V_{DD} = 10 V; V_{GS} = 0							
I_D = 12 mA; $-V_{GSM}$ = 12 V	**2N4391**	t_{off}	<	20	–	–	ns
I_D = 6,0 mA; $-V_{GSM}$ = 7 V	**2N4392**	t_{off}	<	–	35	–	ns
I_D = 3,0 mA; $-V_{GSM}$ = 5 V	**2N4393**	t_{off}	<	–	–	50	ns

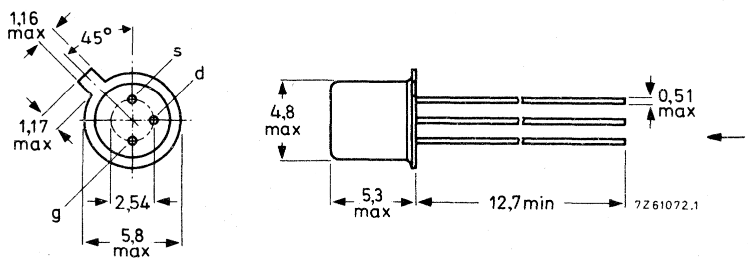
MECHANICAL DATA

Dimensions in mm

Gate connected to case

TO-18





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

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

Voltages

Drain-source voltage	$\pm V_{DS}$	max.	40	V
Drain-gate voltage (open source)	V_{DGO}	max.	40	V
Gate-source voltage	$-V_{GSO}$	max.	40	V

Current

Gate current (d.c.)	I_G	max.	50	mA

Power dissipation

Total power dissipation 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.	200	°C

Thermal resistance

From junction to case in free air	$R_{th\ j\text{-}c}$	=	0.1	°C/mW

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

Gate cut-off current

$-V_{GS}$ = 20 V; V_{DS} = 0	$-I_{GSS}$ <	0.1	nA
$-V_{GS}$ = 20 V; V_{DS} = 0; T_{amb} = 150 °C	$-I_{GSS}$ <	0.2	μA

Drain cut-off current

		2N4391	2N4392	2N4393	
V_{DS} = 20 V; $-V_{GS}$ = 12 V	I_{DSX} <	0.1	–	–	nA
V_{DS} = 20 V; $-V_{GS}$ = 7 V	I_{DSX} <	–	0.1	–	nA
V_{DS} = 20 V; $-V_{GS}$ = 5 V	I_{DSX} <	–	–	0.1	nA
V_{DS} = 20 V; $-V_{GS}$ = 12 V; T_{amb} = 150 °C	I_{DSX} <	0.2	–	–	μA
V_{DS} = 20 V; $-V_{GS}$ = 7 V; T_{amb} = 150 °C	I_{DSX} <	–	0.2	–	μA
V_{DS} = 20 V; $-V_{GS}$ = 5 V; T_{amb} = 150 °C	I_{DSX} <	–	–	0.2	μA

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

			2N4391	2N4392	2N4393	
Drain current [1]						
$V_{DS} = 20$ V; $V_{GS} = 0$	I_{DSS}	>	50	–	–	mA
		<	150	–	–	mA
$V_{DS} = 20$ V; $V_{GS} = 0$	I_{DSS}	>	–	25	–	mA
		<	–	75	–	mA
$V_{DS} = 20$ V; $V_{GS} = 0$	I_{DSS}	>	–	–	5	mA
		<	–	–	30	mA
Gate-source breakdown voltage						
$-I_G = 1\ \mu A$; $V_{DS} = 0$	$-V_{(BR)GSS}$	>	40	40	40	V
Gate-source voltage						
$I_G = 1$ mA; $V_{DS} = 0$	V_{GSon}	<	1.0	1.0	1.0	V
Gate-source cut-off voltage						
$I_D = 1$ nA; $V_{DS} = 20$ V	$-V_{(P)GS}$	>	4.0	2.0	0.5	V
		<	10	5.0	3.0	V
Drain-source voltage (on)						
$I_D = 12$ mA; $V_{GS} = 0$	V_{DSon}	<	0.4	–	–	V
$I_D = 6.0$ mA; $V_{GS} = 0$	V_{DSon}	<	–	0.4	–	V
$I_D = 3.0$ mA; $V_{GS} = 0$	V_{DSon}	<	–	–	0.4	V
Drain-source resistance (on)						
$I_D = 1$ mA; $V_{GS} = 0$	r_{DSon}	<	30	60	100	Ω
Drain-source resistance (on) at f = 1 kHz						
$I_D = 0$; $V_{GS} = 0$	r_{dson}	<	30	60	100	Ω
y parameters at f = 1 MHz (common source)						
Input capacitance						
$V_{DS} = 20$ V; $V_{GS} = 0$	C_{is}	<	14	14	14	pF
Feedback capacitance						
$-V_{GS} = 12$ V; $V_{DS} = 0$	C_{rs}	<	3.5	–	–	pF
$-V_{GS} = 7$ V; $V_{DS} = 0$	C_{rs}	<	–	3.5	–	pF
$-V_{GS} = 5$ V; $V_{DS} = 0$	C_{rs}	<	–	–	3.5	pF

[1]) measured under pulsed conditions: $t_p = 100\ \mu s$; $\delta = 0.01$

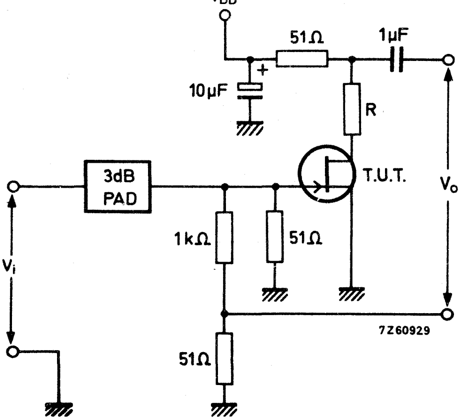
CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

Switching times

V_{DD} = 10 V; V_{GS} = 0

			2N4391	2N4392	2N4393	
	I_D	=	12	6.0	3.0	mA
	$-V_{GSM}$	=	12	7	5	V
Rise time	t_r	<	5	5	5	ns
Turn on time	t_{on}	<	15	15	15	ns
Fall time	t_f	<	15	20	30	ns
Turn off time	t_{off}	<	20	35	50	ns

Test circuit:



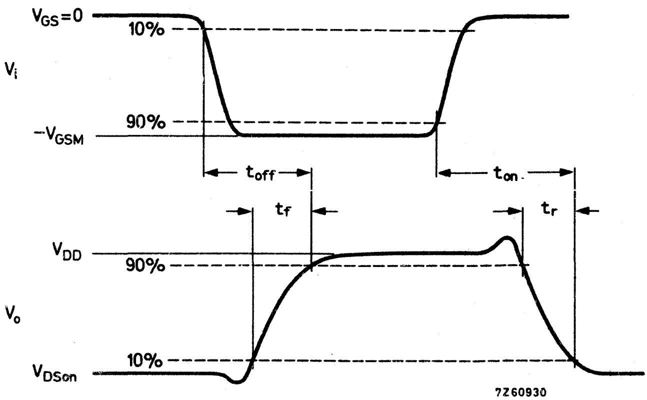
$$R = \frac{9.6}{I_D} - 51\,\Omega$$

Pulse generator:

t_r	<	0.5	ns
t_f	<	0.5	ns
t_p	=	100	μs
δ	=	0.01	

Oscilloscope:

R_i = 50 Ω



N-CHANNEL FETS

Silicon n-channel depletion type junction-triode field-effect transistors in a TO-18 metal envelope with the gate connected to the case. The transistors are intended for low power, chopper or switching, applications in industrial service.

QUICK REFERENCE DATA

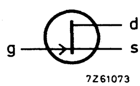
Drain-source voltage	2N4856 to 2N4858	$\pm V_{DS}$	max.		40		V
	2N4859 to 2N4861	$\pm V_{DS}$	max.		30		V
Total power dissipation up to T_{amb} = 25 °C		P_{tot}	max.		360		mW
				2N4856 2N4859	2N4857 2N4860	2N4858 2N4861	
Drain current V_{DS} = 15 V; V_{GS} = 0		I_{DSS}	>	50	20	8	mA
Gate-source cut-off voltage I_D = 0,5 nA; V_{DS} = 15 V		$-V_{(P)GS}$	>	4	2	0,8	V
			<	10	6	4	V
Drain-source resistance (on) at f = 1 kHz I_D = 0; V_{GS} = 0		$r_{ds\,on}$	<	25	40	60	Ω
Feedback capacitance at f = 1 MHz V_{DS} = 0; $-V_{GS}$ = 10 V		C_{rs}	<		8		pF
Turn-off time V_{DD} = 10 V; V_{GS} = 0							
I_D = 20 mA; $-V_{GSM}$ = 10 V	2N4856; 2N4859	t_{off}	<		25		ns
I_D = 10 mA; $-V_{GSM}$ = 6 V	2N4857; 2N4860	t_{off}	<		50		ns
I_D = 5 mA; $-V_{GSM}$ = 4 V	2N4858; 2N4861	t_{off}	<		100		ns

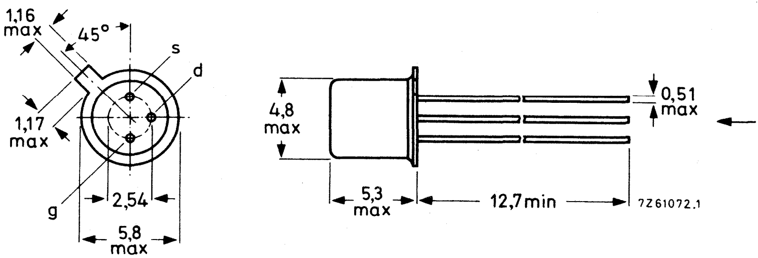
MECHANICAL DATA

Dimensions in mm

Gate connected to case

TO-18





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

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

			2N4856 2N4857 2N4858	2N4859 2N4860 2N4861	
Voltages					
Drain-source voltage	$\pm V_{DS}$	max.	40	30	V
Drain-gate voltage (open source)	V_{DGO}	max.	40	30	V
Gate-source voltage (open drain)	$-V_{GSO}$	max.	40	30	V
Current					
Gate current (d.c.)	I_G	max.	50		mA
Power dissipation					
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360		mW
Temperatures					
Storage temperature	T_{stg}	−65 to	+200		°C
Junction temperature	T_j	max.	200		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.49	°C/mW

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

			2N4856 2N4857 2N4858	2N4859 2N4860 2N4861	
Gate cut-off current					
$-V_{GS}$ = 20 V; V_{DS} = 0	$-I_{GSS}$	<	0.25	–	nA
$-V_{GS}$ = 15 V; V_{DS} = 0	$-I_{GSS}$	<	–	0.25	nA
$-V_{GS}$ = 20 V; V_{DS} = 0; T_{amb} = 150 °C	$-I_{GSS}$	<	0.5	–	μA
$-V_{GS}$ = 15 V; V_{DS} = 0; T_{amb} = 150 °C	$-I_{GSS}$	<	–	0.5	μA
Drain cut-off current					
V_{DS} = 15 V; $-V_{GS}$ = 10 V	I_{DSX}	<	0.25	0.25	nA
V_{DS} = 15 V; $-V_{GS}$ = 10 V; T_{amb} = 150 °C	I_{DSX}	<	0.5	0.5	μA

			2N4856 2N4859	2N4857 2N4860	2N4858 2N4861	
Drain current [1]						
V_{DS} = 15 V; V_{GS} = 0	I_{DSS}	>	50	20	8	mA
	I_{DSS}	<	–	100	80	mA

		2N4856 2N4857 2N4858	2N4859 2N4860 2N4861	
Gate-source breakdown voltage				
$-I_G$ = 1 μA; V_{DS} = 0	$-V_{(BR)GSS}$	40	30	V

			2N4856 2N4859	2N4857 2N4860	2N4858 2N4861	
Gate-source cut-off voltage						
I_D = 0.5 nA; V_{DS} = 15 V	$-V_{(P)GS}$	>	4	2	0.8	V
		<	10	6	4	V
Drain-source voltage (on)						
I_D = 20 mA; V_{GS} = 0	V_{DSon}	<	0.75	–	–	V
I_D = 10 mA; V_{GS} = 0	V_{DSon}	<	–	0.50	–	V
I_D = 5 mA; V_{GS} = 0	V_{DSon}	<	–	–	0.50	V
Drain-source resistance (on) at f = 1 kHz						
I_D = 0; V_{GS} = 0	r_{dson}	<	25	40	60	Ω

[1]) measured under pulsed conditions: t_p = 100 ms; $\delta \leq 0.1$

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

y-parameters at f = 1 MHz (common source)

$-V_{GS}$ = 10 V; V_{DS} = 0

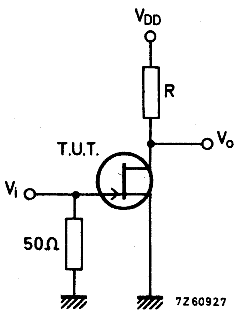
Input capacitance	C_{is}	<	18	pF
Feedback capacitance	C_{rs}	<	8	pF

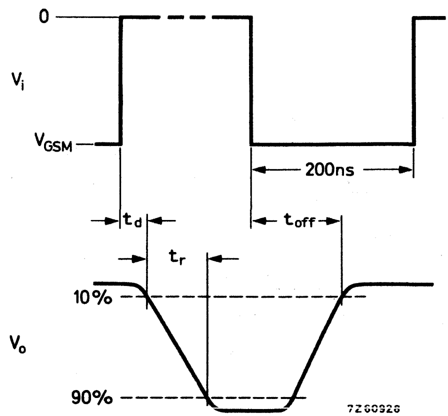
Switching times

V_{DD} = 10 V; V_{GS} = 0

			2N4856 2N4859	2N4857 2N4860	2N4858 2N4861	
	I_D	=	20	10	5	mA
	$-V_{GSM}$	=	10	6	4	V
Delay time	t_d	<	6	6	10	ns
Rise time	t_r	<	3	4	10	ns
Turn off time	t_{off}	<	25	50	100	ns

Test circuit:





		2N4856 2N4859	2N4857 2N4860	2N4859 2N4861	
R	=	464	953	1910	Ω

Pulse generator:

t_r	≤	1	ns
t_f	≤	1	ns
δ	=	0.02	
Z_o	=	50	Ω

Oscilloscope:

t_r	≤	0.75	ns
R_i	≥	1	MΩ
C_i	≤	2.5	pF

MOUNTING INSTRUCTIONS AND ACCESSORIES

Soldering recommendations

SOLDERING RECOMMENDATIONS SOT-37

Transistors in SOT-37 envelopes may be mounted with leads flat (Fig. 1) or bent (Figs 2 and 3). Different soldering procedures apply for the different styles of mounting.

FLAT-LEAD MOUNTING

Soldering by hand

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 lead, *not* to the opposite one.

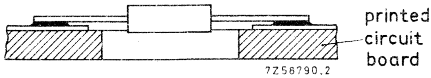


Fig. 1

Solder temperature	max.	300 °C
Soldering time	max.	5 s
Solder-to-case distance	min.	2 mm

BENT-LEAD MOUNTING

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

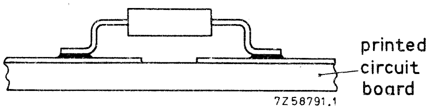


Fig. 2

Solder temperature	max.	300 °C
Soldering time	max.	10 s

DIP OR WAVE SOLDERING

When dip or wave soldering, the maximum allowable temperature of the solder is 260 °C. This temperature must not be in contact with the joint for more than 5 seconds. The total contact time of successive solder waves must not exceed 5 seconds. The device may be mounted up to the lead projections, but the temperature of the body must not exceed the specified storage maximum.

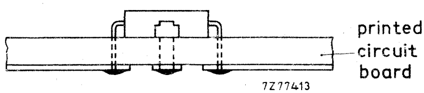


Fig. 3

Solder temperature	max.	260 °C
Soldering time	max.	5 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.

Introduction

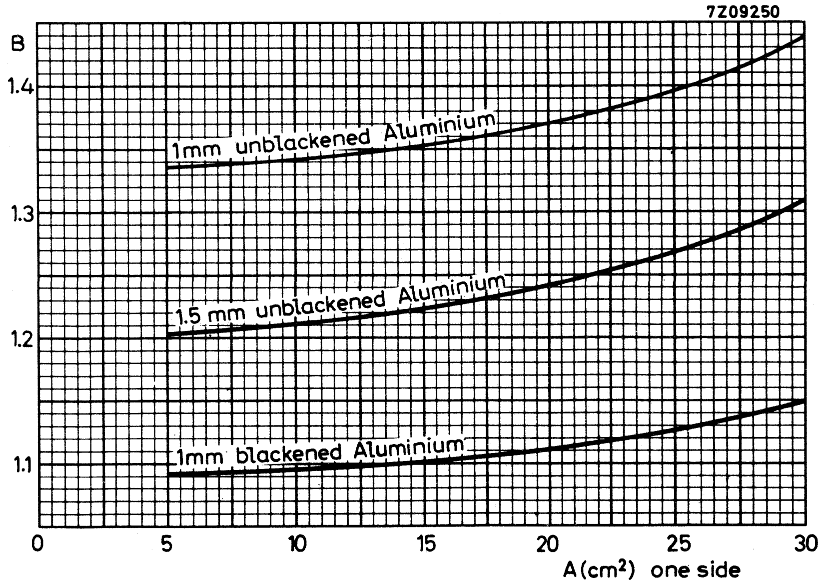
All information on thermal resistances of the accessories combined with flat heatsinks is valid for square heatsinks of 1.5 mm blackened aluminium.
For a few variations the thermal resistance may be derived as follows:

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

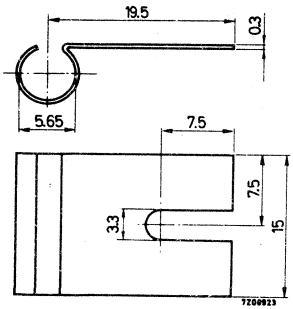
Multiply by the factor B given below as a function of the heatsink size A.



COOLING FIN

MECHANICAL DATA

Dimensions in mm

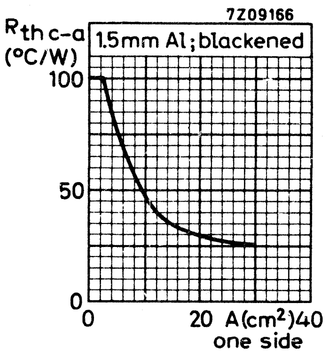


Fin material: brass, nickel plated

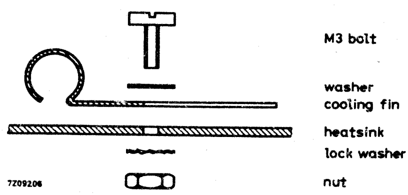
THERMAL RESISTANCE

From case to ambient with cooling fin only — $R_{th\ c-a}$ = 100 °C/W

with heatsink — see graph



MOUNTING INSTRUCTIONS



Torque on nut for good heat transfer: 5 cm kg

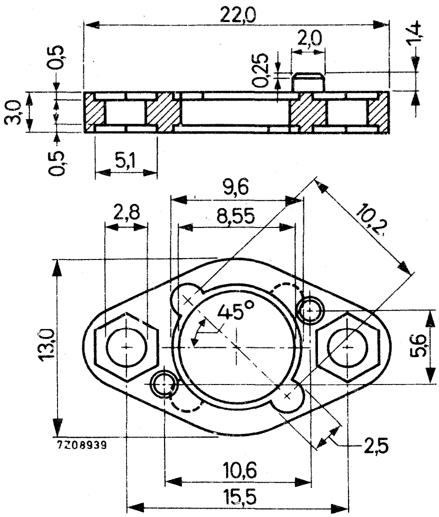
MOUNTING ACCESSORIES

Mounting accessories for TO-5 envelopes. The package consists of:

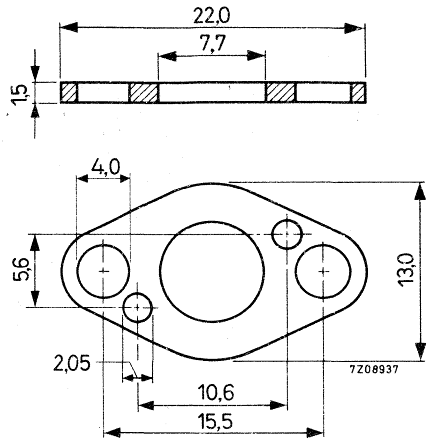
1 top clamping piece
1 bottom clamping piece
1 mylar insulator

MECHANICAL DATA

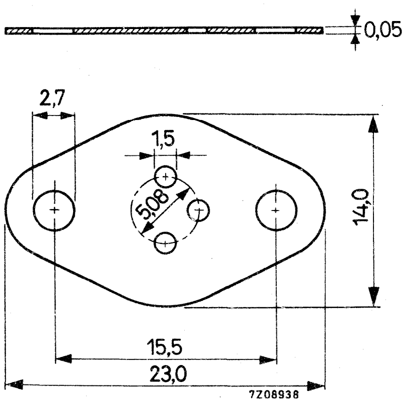
Dimensions in mm



top clamping piece
of insulating material



bottom clamping piece
material: brass, tin-plated



mylar insulator

THERMAL RESISTANCE

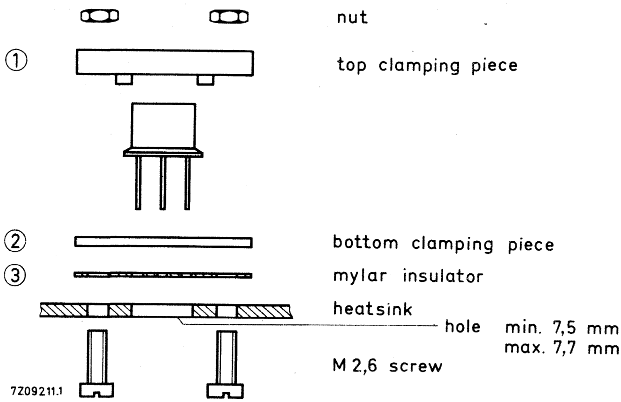
From mounting base to heatsink direct mounting	$R_{th\ mb-h}$	=	3	$^oC/W$
insulated mounting	$R_{th\ mb-h}$	=	6	$^oC/W$

TEMPERATURE

Maximum permissible temperature	T_{max}	=	100	^oC

MOUNTING INSTRUCTIONS

Insulated mounting:



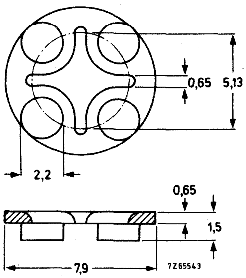
Direct mounting: without items 2 and 3; item 1 to be mounted upside-down.

DISTANCE DISCS

MECHANICAL DATA

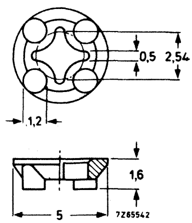
Dimensions in mm

56245



Insulating material

56246



Insulating material

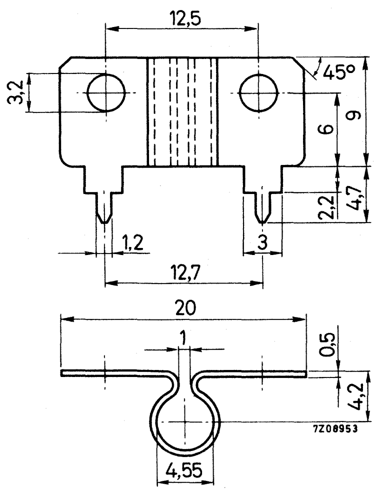
TEMPERATURE

Maximum permissible temperature	T	max.	100	°C

56263 COOLING FIN

MECHANICAL DATA

Dimensions in mm



Material: copper, tin plated

THERMAL RESISTANCE

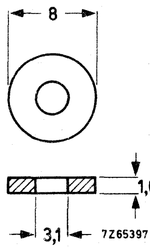
From case to ambient	$R_{th\ c-a}$	=	100	°C/W

WASHER

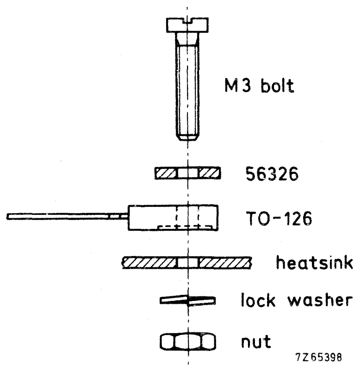
Flat metal washer for direct mounting of envelope SOT-32 (TO-126).

MECHANICAL DATA

Dimensions in mm



MOUNTING INSTRUCTIONS



Minimum torque on nut for good heat transfer	0,4 Nm (4 kg cm)
Maximum torque on nut	0,6 Nm (6 kg cm)
Minimum thickness of heatsink	2 mm

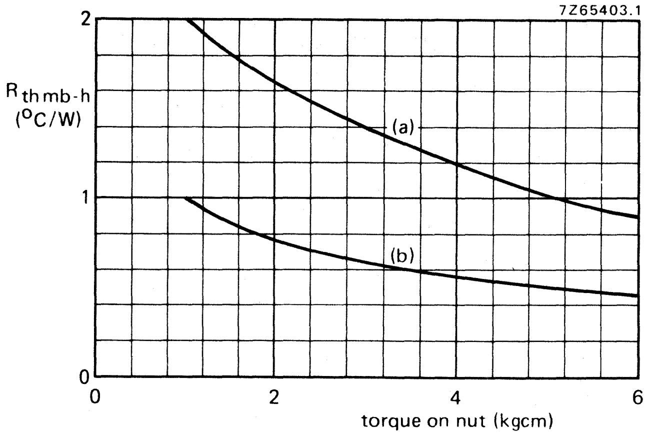
The heatsink surface must appear flat and smooth, without burrs or scratches. If the hole in the heatsink is threaded, it should be countersunk and free of burrs; the hole should also be perpendicular to the plane of the heatsink, within 2^o tolerance (for M3 thread).
For mounting on a heatsink the use of a heatsink compound is recommended.

→ **THERMAL RESISTANCE** (see also the graph)

From mounting base to heatsink

without heatsink compound (a)	$R_{th\ mb\text{-}h}$	=	1,0	$^oC/W$
with heatsink compound (b)	$R_{th\ mb\text{-}h}$	=	0,5	$^oC/W$

→

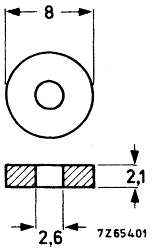


MOUNTING ACCESSORIES

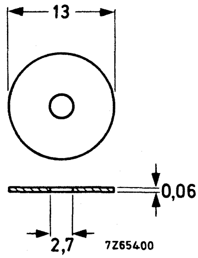
Mounting accessories for insulated mounting of envelope SOT-32 (TO-126); the set con-consists of a metal washer, a mica washer and an insulating bush.

MECHANICAL DATA

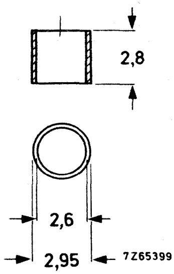
Dimensions in mm



Metal washer

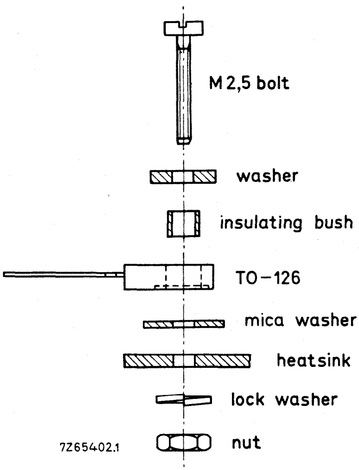


Mica washer



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

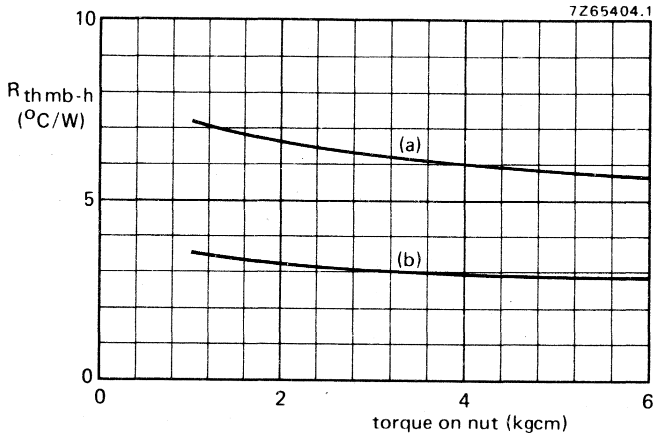
MOUNTING INSTRUCTIONS (continued)

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° tolerance (for M2, 5 thread). For good heat transfer the use of a metallic heatsink compound is recommended and should be applied to the bottom of both device and insulator.

THERMAL RESISTANCE (see also the graph)

From mounting base to heatsink

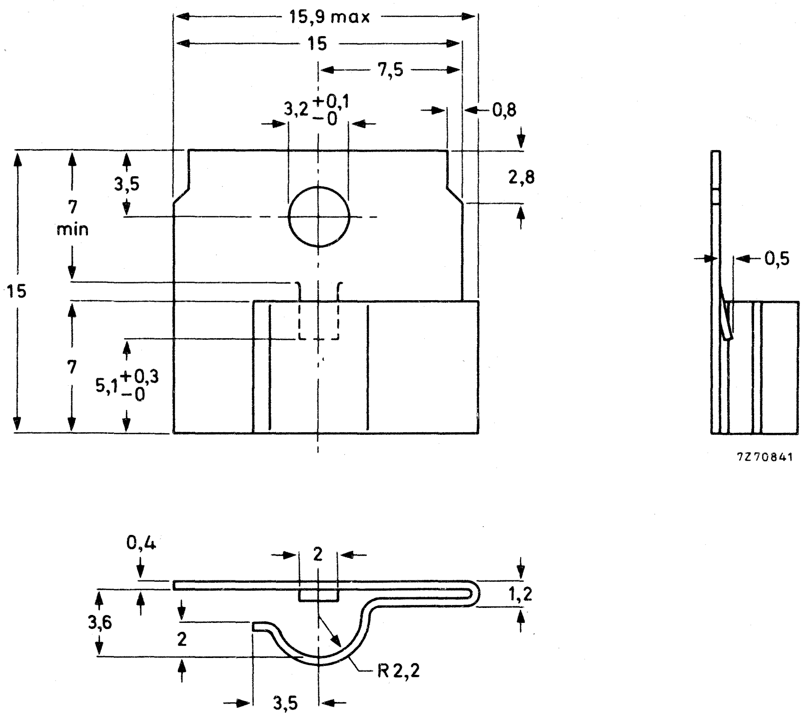
without heatsink compound (a)	$R_{th\ mb\text{-}h}$	= 6 °C/W
with heatsink compound (b)	$R_{th\ mb\text{-}h}$	= 3 °C/W



COOLING CLIP FOR TO-92 VARIANT

MECHANICAL DATA

Dimensions in mm



Material: steel, aluminium plated.

INDEX AND MAINTENANCE TYPE LIST

INDEX OF TYPE NUMBERS

Data Handbooks SC1a to SC4b

The inclusion of a type number in this publication does not necessarily imply its availability.

type no.	part	section	type no.	part	section	type no.	part	section
AA119	1b	PC	BA220	1b	WD	BAX15	1b	WD
AAZ15	1b	GB	BA221	1b	WD	BAX16	1b	WD
AAZ17	1b	GB	BA222	1b	WD	BAX17	1b	WD
AAZ18	1b	GB	BA243	1b	T	BAX18	1b	WD
AC125	2	LF	BA244	1b	T	BAX18A	1b	WD
AC126	2	LF	BA280	1b	T	BB105A	1b	T
AC127	2	LF	BA314	1b	Vrg	BB105B	1b	T
AC128	2	LF	BA314A	1b	Vrg	BB105G	1b	T
AC128/01	2	LF	BA315	1b	Vrg	BB106	1b	T
AC132	2	LF	BA316	1b	WD	BB110B	1b	T
AC187	2	LF	BA317	1b	WD	BB110G	1b	T
AC187/01	2	LF	BA318	1b	WD	BB117	1b	T
AC188	2	LF	BA379	1b	T	BB119	1b	T
AC188/01	2	LF	BAV10	1b	WD	BB204B	1b	T
AD161	2	P	BAV18	1b	WD	BB204G	1b	T
AD162	2	P	BAV19	1b	WD	BB205A	1b	T
AF367	3	HFSW	BAV20	1b	WD	BB205B	1b	T
ASZ15	2	P	BAV21	1b	WD	BB205G	1b	T
ASZ16	2	P	BAV45	1b	Sp	BBY31	4a	Mm
ASZ17	2	P	BAV70	4a	Mm	BC107	2	LF
ASZ18	2	P	BAV99	4a	Mm	BC108	2	LF
BA100	1b	AD	BAW21A	1b	WD	BC109	2	LF
BA102	1b	T	BAW21B	1b	WD	BC140	2	LF
BA145	1a	R	BAW56	4a	Mm	BC141	1	LF
BA148	1a	R	BAW62	1b	WD	BC146	2	LF
BA182	1b	T	BAX12	1b	WD	BC147	2	LF
BA216	1b	WD	BAX12A	1b	WD	BC148	2	LF
BA217	1b	WD	BAX13	1b	WD	BC149	2	LF
BA218	1b	WD	BAX14	1b	WD	BC157	2	LF
BA219	1b	WD	BAX14A	1b	WD	BC158	2	LF

AD = Silicon alloyed diodes
GB = Germanium gold bonded diodes
HFSW = High-frequency and switching 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
T = Tuner diodes
Vrg = Voltage regulator diodes
WD = Silicon whiskerless diodes

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
HFSW = High-frequency and switching transistors
Mm = Microminiature devices for thick and thin-film circuits
P = Low-frequency power transistors

FET = Field-effect transistors
HFSW = High-frequency and switching transistors
Mm = Microminiature devices for thick and thin-film circuits
PDT = Photodiodes or transistors
R = Rectifier diodes
Th = Thyristors
Tra = Transmitting transistors
Tri = Triacs

type no.	part	section	type no.	part	section	type no.	part	section
BTW38 series	1a	Th	BY188 series	1a	R	BZV38	1b	Vrf
BTW40 series	1a	Th	BY206	1a	R	BZW70 series	1a	TS
BTW42 series	1a	Th	BY207	1a	R	BZW86 series	1a	TS
BTW43 series	1a	Tri	BY208 series	1a	R	BZW91 series	1a	TS
BTW45 series	1a	Th	BY209	1a	R	BZW93 series	1a	TS
BTW47 series	1a	Th	BY223	1a	R	BZX55 series	1b	Vrg
BTW92 series	1a	Th	BY409	1a	R	BZX61 series	1b	Vrg
BTX18 series	1a	Th	BY476	1a	R	BZX70 series	1a	Vrg
BTX94 series	1a	Tri	BYX10	1a	R	BZX75 series	1b	Vrg
BTX95 series	1a	Th	BYX22 series	1a	R	BZX79 series	1b	Vrg
BTY79 series	1a	Th	BYX25 series	1a	R	BZX84 series	4a	Mm
BTY87 series	1a	Th	BYX29 series	1a	R	BZX87 series	1b	Vrg
BTY91 series	1a	Th	BYX30 series	1a	R	BZX90	1b	Vrf
BU105	2	P	BYX32 series	1a	R	BZX91	1b	Vrf
BU108	2	P	BYX35	1a	R	BZX92	1b	Vrf
BU126	2	P	BYX36 series	1a	R	BZX93	1b	Vrf
BU132	2	P	BYX38 series	1a	R	BZY78	1b	Vrf
BU133	2	P	BYX39 series	1a	R	BZY88 series	1b	Vrg
BU204	2	P	BYX42 series	1a	R	BZY91 series	1a	Vrg
BU205	2	P	BYX45 series	1a	R	BZY93 series	1a	Vrg
BU206	2	P	BYX46 series	1a	R	BZY95 series	1a	Vrg
BU207A	2	P	BYX48 series	1a	R	BZY96 series	1a	Vrg
BU208A	2	P	BYX49 series	1a	R	BZZ14	1a	Vrg
BU209A	2	P	BYX50 series	1a	R	BZZ15	1a	Vrg
BU326A	2	P	BYX52 series	1a	R	BZZ16	1a	Vrg
BUX80	2	P	BYX55 series	1a	R	BZZ17	1a	Vrg
BUX81	2	P	BYX56 series	1a	R	BZZ18	1a	Vrg
BUX82	2	P	BYX71 series	1a	R	BZZ19	1a	Vrg
BUX83	2	P	BYX90	1a	R	BZZ20	1a	Vrg
BUX84	2	P	BYX91 series	1a	R	BZZ21	1a	Vrg
BUX85	2	P	BYX96 series	1a	R	BZZ22	1a	Vrg
BUX86	2	P	BYX97 series	1a	R	BZZ23	1a	Vrg
BUX87	2	P	BYX98 series	1a	R	BZZ24	1a	Vrg
BY126	1a	R	BYX99 series	1a	R	BZZ25	1a	Vrg
BY127	1a	R	BZV10	1b	Vrf	BZZ26	1a	Vrg
BY164	1a	R	BZV11	1b	Vrf	BZZ27	1a	Vrg
BY176	1a	R	BZV12	1b	Vrf	BZZ28	1a	Vrg
BY179	1a	R	BZV13	1b	Vrf	BZZ29	1a	Vrg
BY184	1a	R	BZV14	1b	Vrf	CNY22	4b	PhC
BY187	1a	R	BZV15 series	1a	Vrg	CNY23	4b	PhC

Mm = Microminiature devices for thick and thin-film circuits
P = Low-frequency power transistors
PhC = Photocouplers
R = Rectifier diodes
Th = Thyristors
Tri = Triacs
TS = Transient suppressor diodes
Vrf = Voltage reference diodes
Vrg = Voltage regulator diodes

INDEX

AD = Silicon alloyed diodes
D = Display
GB = Germanium gold bonded diodes
HFSW = High-frequency and switching transistors
I = Infrared devices
LED = Light-emitting diodes
LF = Low-frequency transistors
PC = Germanium point contact diodes
Ph = Photoconductive devices
PhC = Photocouplers
St = Rectifier stacks
Vrf = Voltage reference diodes
Vrg = Voltage regulator diodes
WD = Silicon whiskerless diodes

A = Accessories
DH = Diecast heatsinks
FET = Field-effect transistors
HE = Heatsink extrusions
HFSW = High-frequency and switching transistors
I = Infrared devices
LF = Low-frequency transistors
P = Low-frequency power transistors
Tra = Transmitting transistors

MAINTENANCE TYPES

Data Handbook SC3

The types listed below are not included in this handbook except for those marked with an asterisk. Detailed information will be supplied on request.

ASY26	ASY74	BF178 *	BFS95
ASY27	ASY75	BF179 *	BSS40
ASY28	BF167 *	BFS92	BSS41
ASY29	BF173 *	BFS93	BSW41
ASY73	BF177 *	BFS94	

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