PHILIPS

Data handbook

PHILIPS Electronic components and materials

Semiconductors and integrated circuits

Part 3 February 1973

High frequency transistors

Switching transistors

SEMICONDUCTORS AND INTEGRATED CIRCUITS

Part 3 **February 1973**

General

High frequency transistors

Switching transistors

Accessories

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November 1972

DATA HANDBOOK SYSTEM

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

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

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

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

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

December 1972

ELECTRON TUBES (BLUE SERIES)

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

Part 1	**Transmitting tubes (Tetrodes, Pentodes); Amplifier circuit assemblies**	**January 1972**
Part 2	**Tubes for microwave equipment**	**February 1972**
Part 3	**Special Quality tubes; Miscellaneous devices**	**March 1972**
Part 4	**Receiving tubes**	**June 1972**
Part 5	**Cathode-ray tubes; Photo tubes; Camera tubes**	**July 1972**
Part 6	**Devices for nuclear equipment**	**September 1972**
Part 7	**Gas-filled tubes**	**October 1972**
Part 8	**T.V.Picture tubes**	**November 1972**
Part 9	**Transmitting tubes (Triodes) ; Tubes for r.f. heating (Triodes)**	**December 1971**

Part 6:

Photomultiplier tubes
Channel electron multipliers
Scintillators
Photoscintillators
Radiation counter tubes
Semicinductor radiation detectors
Neutron generator tubes
Photo diodes

Part 7:

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

SEMICONDUCTORS AND INTEGRATED CIRCUITS (RED SERIES)

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

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

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

Part 1b Diodes — **December 1972**

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

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

Part 3 High frequency and switching transistors — **February 1973**

Part 4 Special types — **December 1971**

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

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

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

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

COMPONENTS AND MATERIALS (GREEN SERIES)

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

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

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

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

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

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

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

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

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

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

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

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

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

Part 7 Circuit Blocks — **September 1971**

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

*) These items have been discontinued

General

Type designation
Rating systems
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SOAR curves

PRO ELECTRON TYPE DESIGNATION CODE

FOR SEMICONDUCTOR DEVICES

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

The type designation consists of:

TWO LETTERS FOLLOWED BY A SERIAL NUMBER

The first letter gives an indication of the material

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

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

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

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

R Compound material as employed in Hall generators and photoconductive cells

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

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

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

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

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

The serial number consists of:

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

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

VERSION LETTER

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

TYPE DESIGNATION FOR A RANGE OF SEMICONDUCTOR DEVICES

The type designation of a range of variants of:

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

b) rectifying diodes (second letter Y)

c) thyristors (second letter T)

d) radiation detectors

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

The suffix part consists of:

a) for voltage reference or voltage regulator diodes

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

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

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

b) for rectifying diodes

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

c) for thyristors

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

d) for radiation detectors

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

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

RATING SYSTEMS

ACCORDING TO I.E.C. PUBLICATION 134

1. DEFINITIONS OF TERMS USED

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

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

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

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

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

Note: Limiting conditions may be either maxima or minima.

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

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

2. ABSOLUTE MAXIMUM RATING SYSTEM

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

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

p.t.o.

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

3. DESIGN MAXIMUM RATING SYSTEM

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

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

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

4. DESIGN CENTRE RATING SYSTEM

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

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

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

NOTE

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

Letter symbols

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

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

QUANTITY SYMBOLS

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

   Examples: i, v, p

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

   Examples: I, V, P

SUBSCRIPTS FOR QUANTITY SYMBOLS

1. Total values are indicated by upper case subscripts.

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

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

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

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

   For maximum (peak) values : M or m

   For average values : (AV) or (av) (only if it is necessary to distinguish between d.c. and average)

   For d.c. values : no additional subscript

   For root-mean-square values : (RMS) or (rms)

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

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

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

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

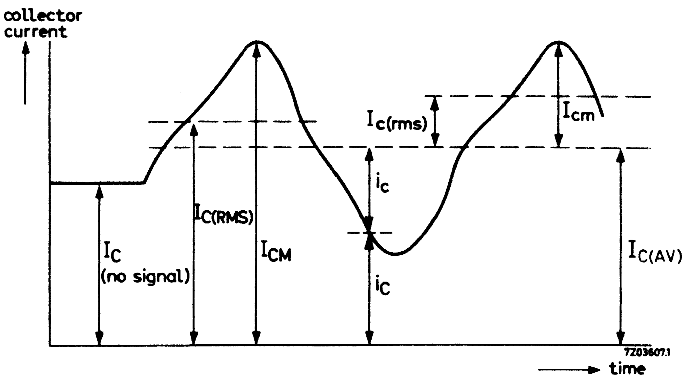


Fig.1

CONVENTIONS FOR SUBSCRIPT SEQUENCE

1. Currents

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

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

2. Voltages

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

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

3. Supply voltages

Supply voltages may be indicated by repeating the terminal subscript.

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

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

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

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

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

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

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

ELECTRICAL PARAMETER SYMBOLS

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

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

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

Examples: H_i, Z_o, H_F, Y_R

SUBSCRIPTS FOR PARAMETER SYMBOLS

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

Examples: h_{IB}, h_{FE}

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

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

Examples: h_{ib}, z_{ob}

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

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

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

Notes 1) The voltage and current symbols in matrix notation are indicated by a single digit subscript.
The subscript 1 = input; the subscript 2 = output
2) The voltages and currents in these equations may be complex quantities.

4. The second subscript identifies the circuit configuration.

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

Examples: (common base)

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

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

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

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

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

LIST OF LETTER SYMBOLS IN ALPHABETICAL ORDER

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

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

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

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

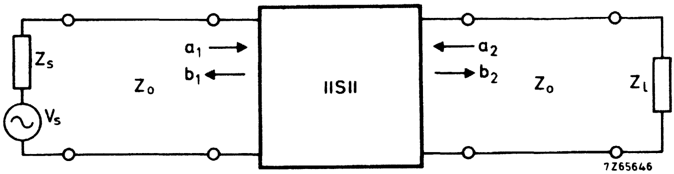
Letter symbol	Definition
r_D	Diode (internal) series resistance
r_{DS}	Drain-source resistance
r_{GS}	Gate-source resistance
R_L	Load resistance
R_S	Source resistance
R_{th}	Thermal resistance
$R_{th\ j\text{-}a}$	Thermal resistance from junction to ambient
$R_{th\ j\text{-}mb}$	Thermal resistance from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

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

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

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 travelling wave quantities a_1, b_1, a_2 and b_2, which are square roots of power.



a_1^2 = the power incident at the input $\left(= \frac{V_{i1}^2}{Z_o} \right)$

a_2^2 = the power incident at the output $\left(= \frac{V_{i2}^2}{Z_o} \right)$

b_1^2 = the power reflected from (or generated at) the input $\left(= \frac{V_{r1}^2}{Z_o} \right)$

b_2^2 = the power reflected from (or generated at) the output $\left(= \frac{V_{r2}^2}{Z_o} \right)$

Z_o = the 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, o for 22, f for 21 and r for 12, it follows that

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

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

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

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

a_1 can be made zero by terminating the input side with $Z_s = Z_o$ (no input power and no reflection from the source).

a_2 can be made zero by terminating the output side with $Z_l = Z_o$ (no reflection from the load).

Because $\frac{b_1}{a_1} = \frac{V_{r1}}{V_{i1}}$ it can be seen that s_i is the input reflection coefficient; in the same way s_o is the output reflection coefficient.

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

$s_i = s_{11}$ = Input reflection coefficient (for the given characteristic impedance) - Ratio between the square root of the power reflected from the input and the square root of the power incident at the input, output terminated with the characteristic impedance.

$s_f = s_{21}$ = Forward transmission coefficient (for the given characteristic impedance) - Ratio between the square root of the power generated at the output and the square root of the power incident at the input, output terminated with the characteristic impedance.

$s_o = s_{22}$ = Output reflection coefficient (for the given characteristic impedance) - Ratio between the square root of the power reflected from the output and the square root of the power incident at the output, input terminated with the characteristic impedance.

$s_r = s_{12}$ = Reverse transmission coefficient (for the given characteristic impedance) - Ratio between the square root of the power generated at the input and the square root of the power incident at the output, input terminated with the characteristic impedance.

SAFE OPERATING AREA CURVES

1. D.C. SOAR

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

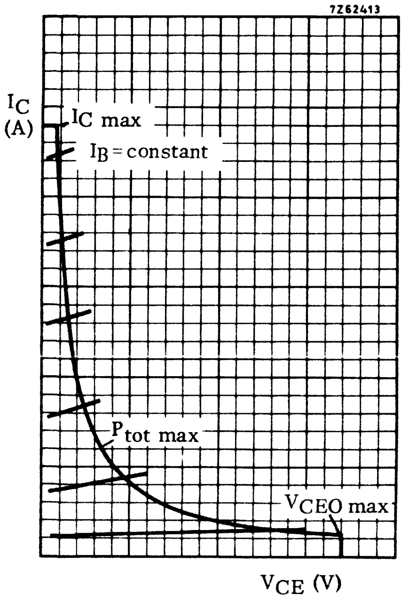


Fig. 1

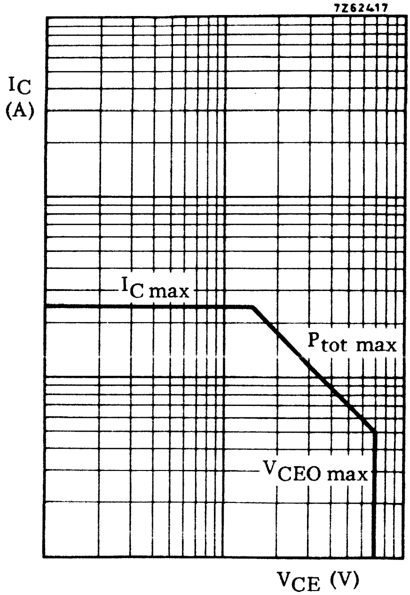


Fig. 2. D.C. SOAR curve

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

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

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

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

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

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

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

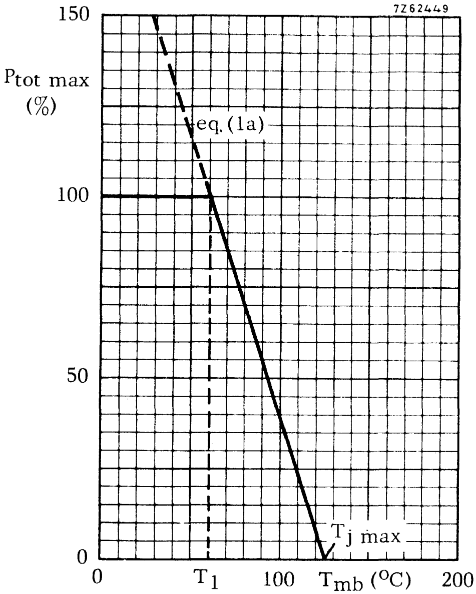


Fig. 3

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

2. Extension of the SOAR for pulse power

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

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

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

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

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

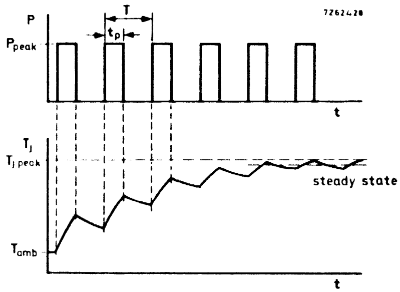


Fig. 4

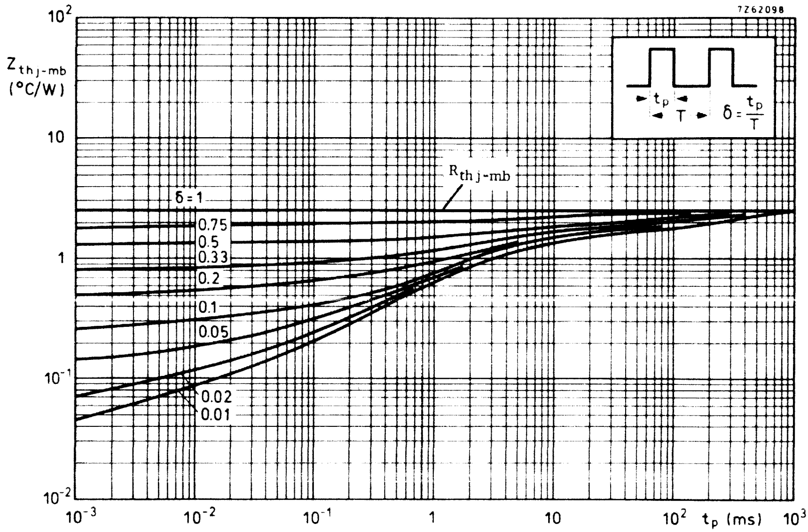


Fig. 5

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

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

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

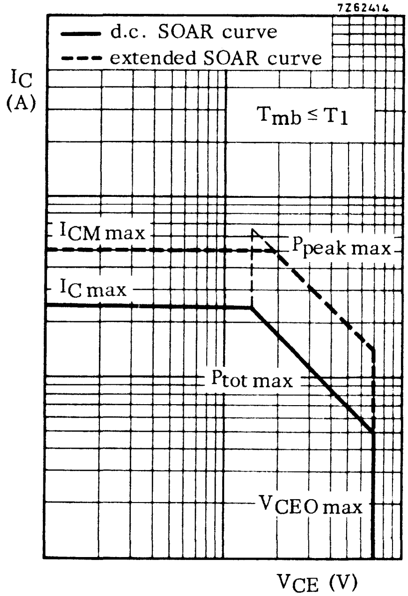


Fig. 6

3. Second Breakdown

3.1 The phenomenon

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

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

3.2 Second breakdown and the d.c. SOAR

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

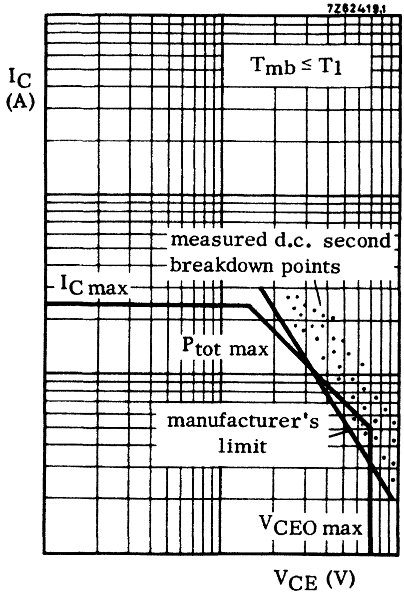


Fig. 7

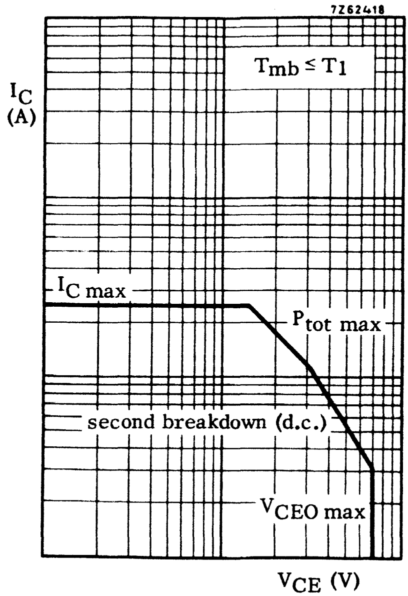


Fig. 8

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

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

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

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

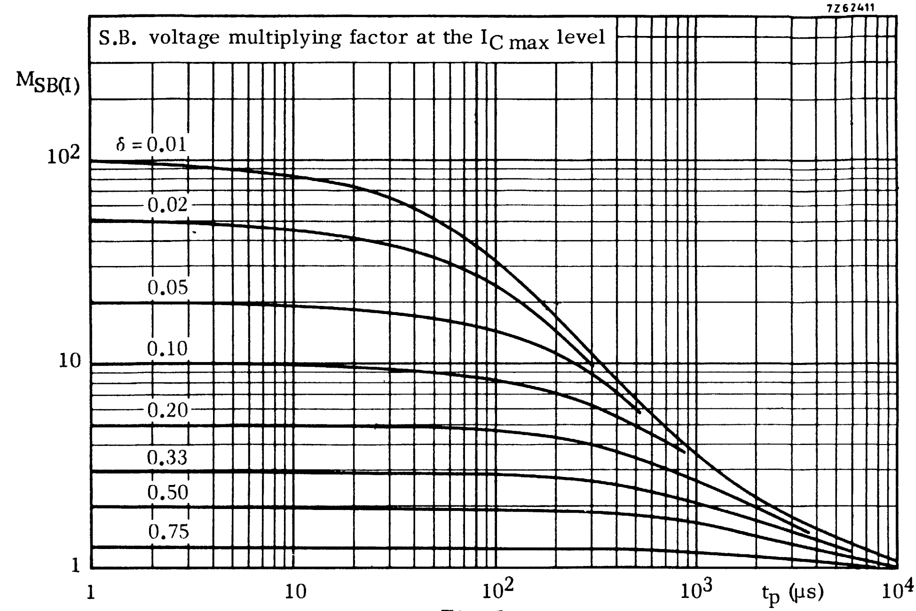

7Z62411
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
δ = 0.01
0.02
0.05
0.10
0.20
0.33
0.50
0.75
10^2
10
1
1
10
10^2
10^3
t_p (µs)
10^4

Fig. 9a

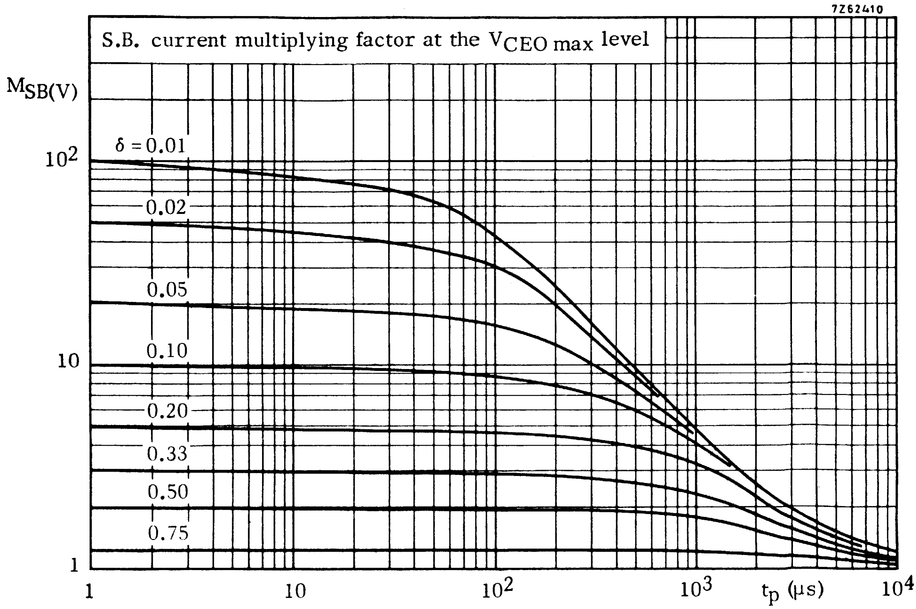

7Z62410
S.B. current multiplying factor at the $V_{CEO\,max}$ level
$M_{SB(V)}$
δ = 0.01
0.02
0.05
0.10
0.20
0.33
0.50
0.75
10^2
10
1
1
10
10^2
10^3
t_p (µs)
10^4

Fig. 9b

7Z62416

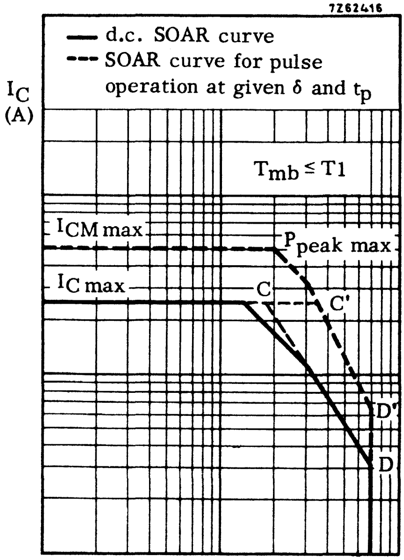


Fig. 10

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

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

4. Example of how to use the published SOAR information

4.1 Statement of the problem

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

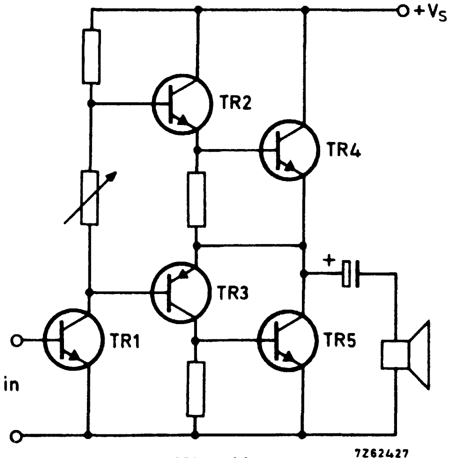


Fig. 11

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

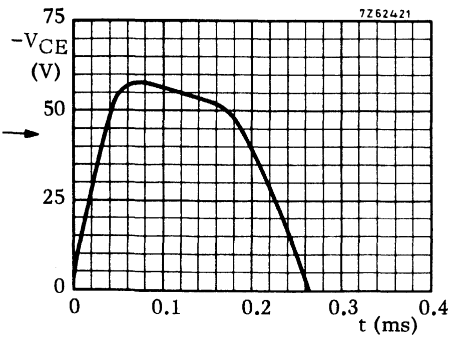


Fig. 12a

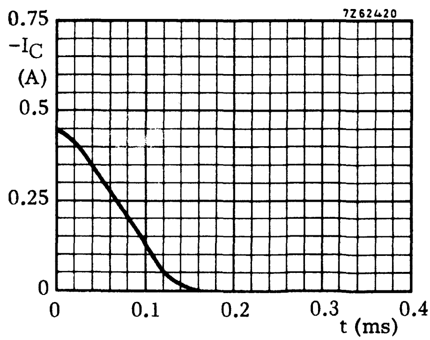


Fig. 12b

4.2 Information obtained from the published data of TR3

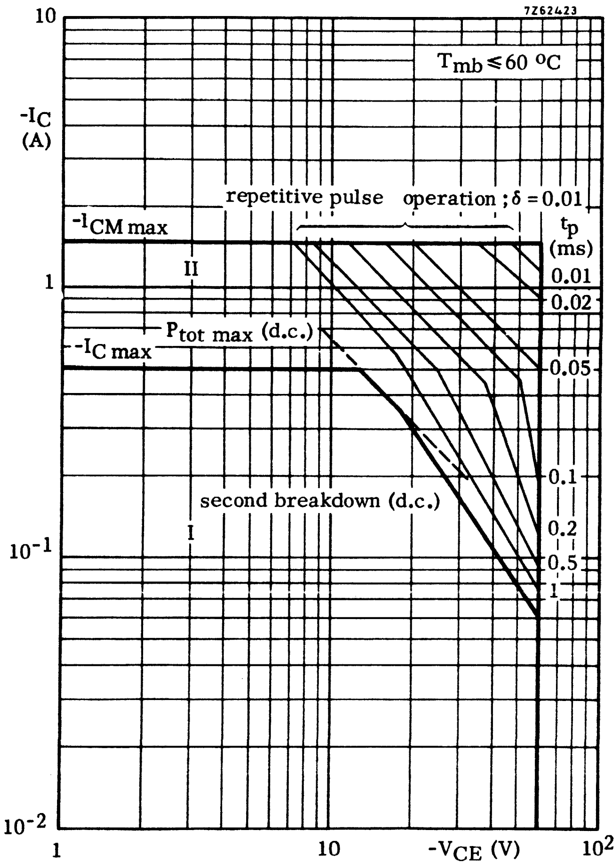
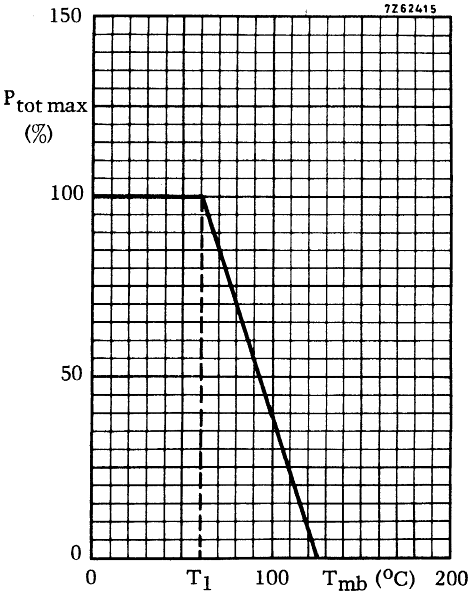


Fig. 13. Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation.



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

Fig. 14

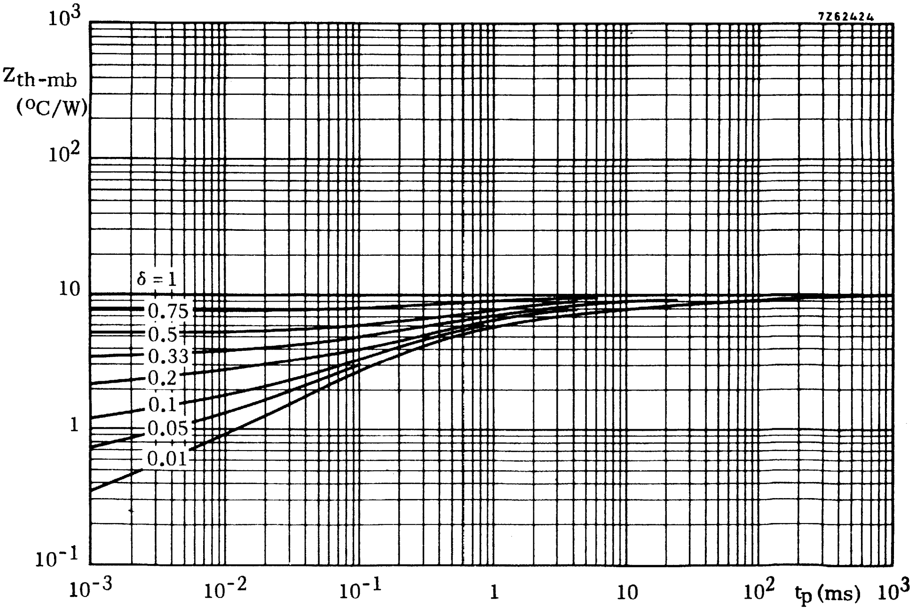


Fig. 15

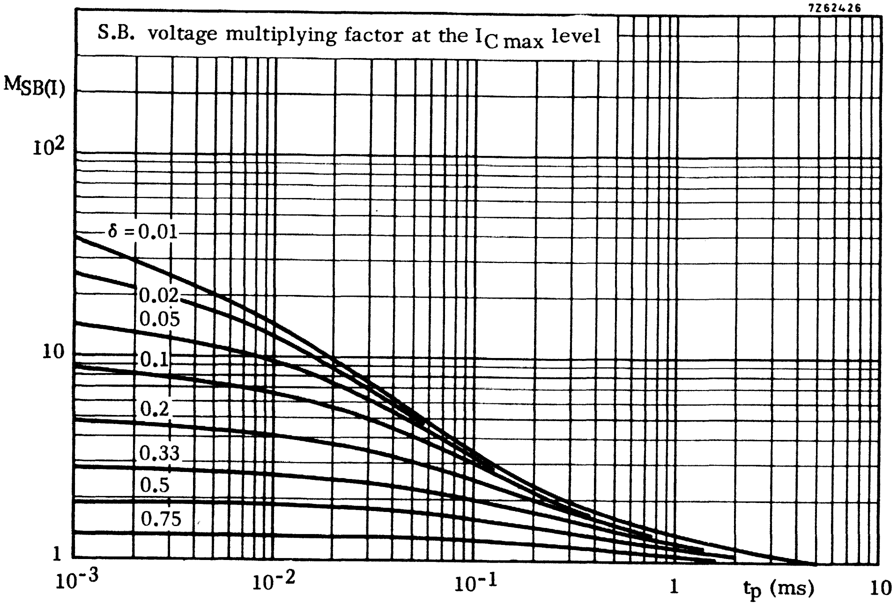

7Z62426
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
δ = 0.01
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

Fig. 16

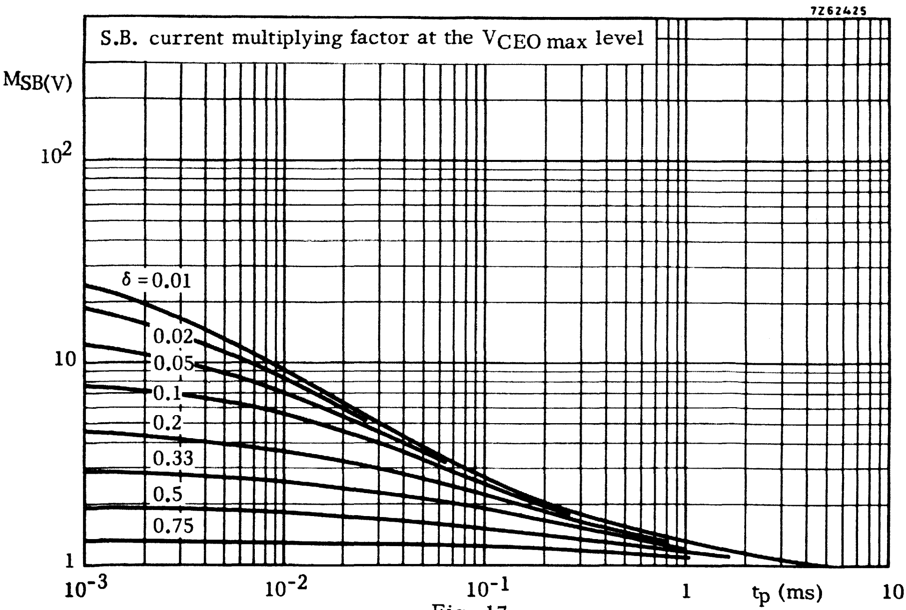

7Z62425
S.B. current multiplying factor at the $V_{CEO\,max}$ level
$M_{SB(V)}$
10^2
10
1
δ = 0.01
0.02
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

Fig. 17

4.3 Construction of the pulse SOAR of TR3 in this application

4.3.1

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

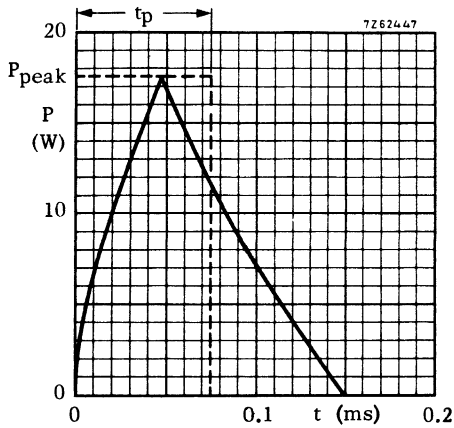


Fig. 18

4.3.2

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

$t_p = 75\ \mu s$

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

$\delta = 0.056$

$P_{peak} = 17.5$ W

4.3.3

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

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

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

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

4.3.4

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

$M_{SB(I)} = 3.6$

$M_{SB(V)} = 2.8$

4.3.5

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

- Multiply the value of the voltage at point A by the derating factor obtained from Fig. 14 (0.6) and by $M_p = 3.64$ to obtain A'.
  $V_A = 13$ V
  $V_A' = 13 \text{ V} \times 0.6 \times 3.64 = 28.4$ V
- Through point A' construct a line of constant power (45^o)
  $P_{peak\ max} = 28.4 \times I_{C\ max} = 14.2$ W.
- Multiply the value of V_{CE} at point C by $M_{SB(I)} = 3.6$ (see 4.3.4), to obtain C'.
- Multiply the value of I_C at point D by $M_{SB(V)} = 2.8$ (see 4.3.4), to obtain D'.
- Construct a new limit for second breakdown by drawing a line through point C' and D'.
- The SOAR for this particular case is formed by the $I_{CM\ max}$ line, the maximum peak dissipation line through A', the second breakdown limit line C' - D' and the V_{CEO} line.

4.3.6

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

4.3.7

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

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

$P_{peak} = 17.5$ W (see 4.3.2)

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

Therefore:

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

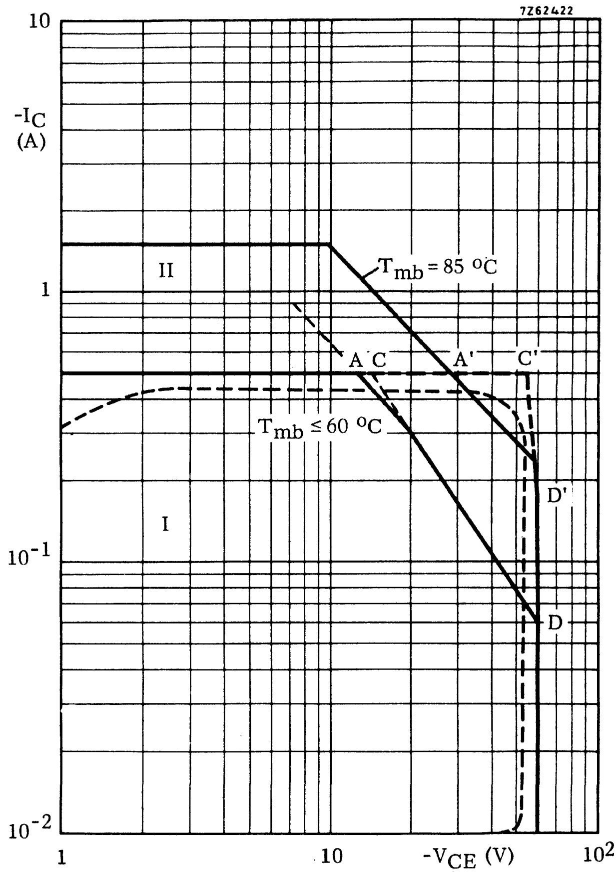


Fig. 19

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

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

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

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

High frequency transistors

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

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

Flat-lead mounting

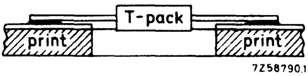


Fig. 1. Flat-lead mounting

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

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

Bent-lead mounting

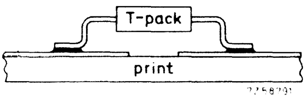


Fig. 2. Bent-lead mounting

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

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

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

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

- Diameter of mounting hole in heatsink: 4.1 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: 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.
- Recommend 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 ^{o}C are safely tolerable; the transistor can withstand an interior temperature of 250 ^{o}C for about ten minutes.
  The leads may be tinned, if required, by dipping them into a solder bath at about 230 ^{o}C; each lead may be dipped up to its full length. A flux of the quality of Super-Safe is recommended; after tinning, surplus flux should be rinsed away in tap water.

GERMANIUM ALLOY DIFFUSED TRANSISTOR

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

RATINGS (Limiting values) [1])

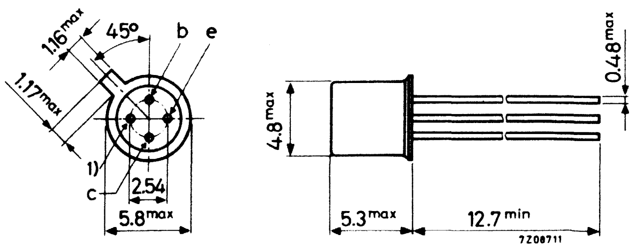
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	V
Collector-emitter voltage (Z_B/Z_E < 15)	$-V_{CER}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	15	V
Collector current (d.c.)	$-I_C$	max.	10	mA
Base current (d.c.)	$\|I_B\|$	max.	1	mA
Reverse emitter current	$-I_E$	max.	1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

THERMAL RESISTANCE

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

MECHANICAL DATA Dimensions in mm

TO-72



1) = shield lead (connected to case)

Accessories available: 56246, 56263

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

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

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

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

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

Transition frequency

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

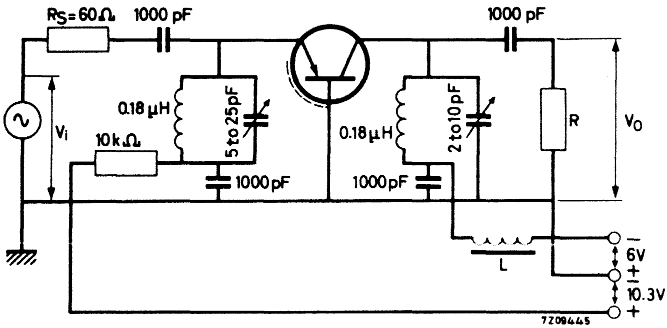
Noise figure at f = 100 MHz

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

Power gain at f = 100 MHz

$G_p = \frac{V_o2}{V_i2} \cdot \frac{4 R_S}{R_\ell} = 0.073 \frac{V_o2}{V_i2}$	G_p	>	12.5	dB
		typ.	14	dB

Test circuit

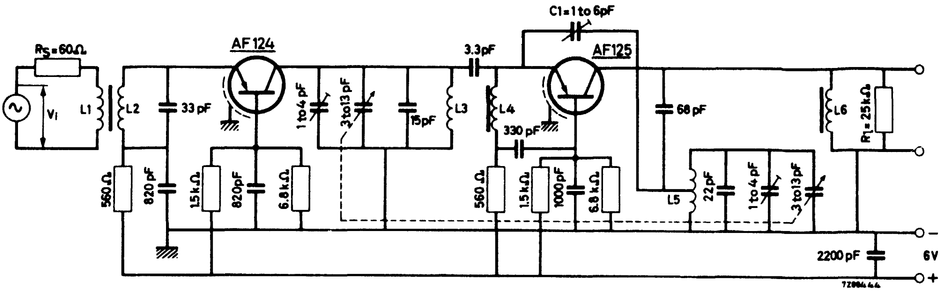


R is chosen such that the total load impedance R_l consisting of R and the tuned circuit in parallel is 3.3 kΩ.

L = ferrite bead

APPLICATION INFORMATION

Front-end unit of a f.m. tuner

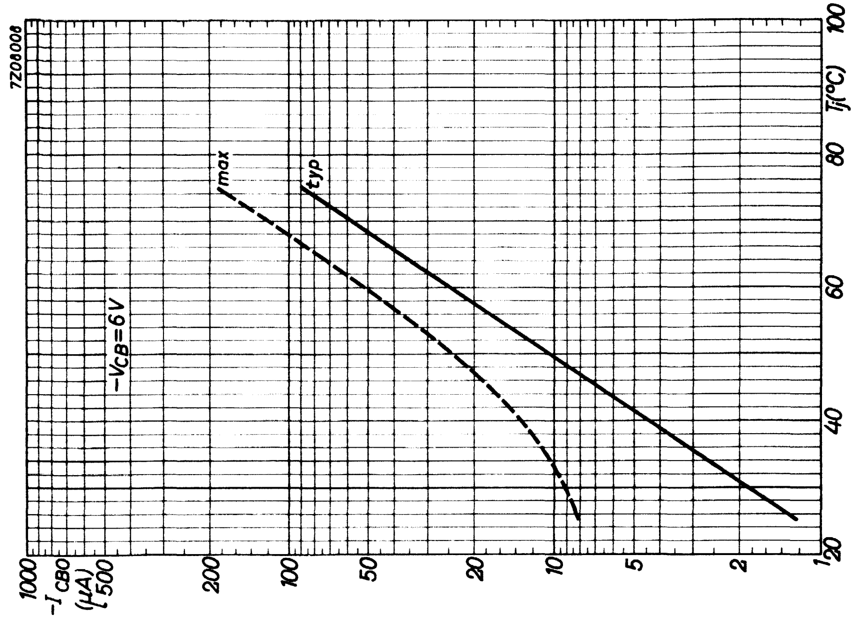


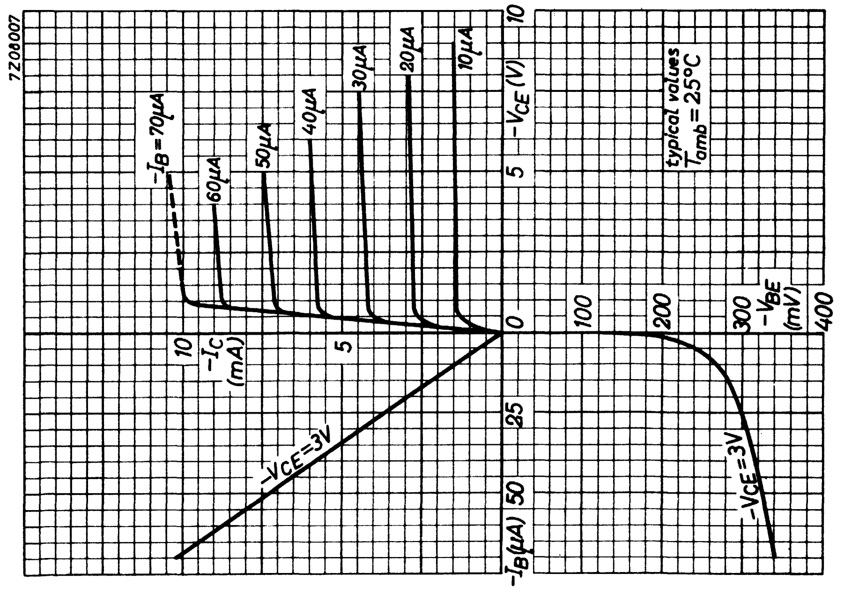
The oscillator voltage at the emitter of the AF 125 should be adjusted to 80 mV by means of C1 at a battery voltage V_S = 4 V

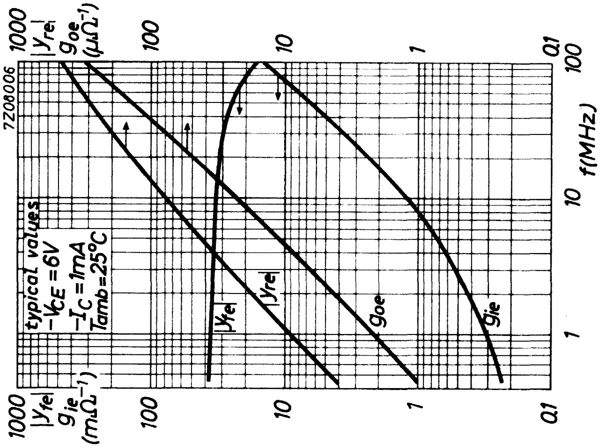
L1 = 4.5 turns enamelled Cu wire (0.3 mm), wound between L_2.
L2 = 4 turns enamelled Cu wire (1 mm), winding pitch 2 mm, inductance 0.18 μH, unloaded Q-factor 60 to 80.
L3 = 3.25 turns silvered Cu wire (1 mm), winding pitch 2 mm, inductance 0.086 μH, unloaded Q-factor 200.
L4 = 6 turns enamelled Cu wire (0.5 mm), closely wound, inductance 0.65 μH.
L5 = 2.5 turns silvered Cu wire (1 mm), winding pitch 2 mm, inductance 0.062 μH, unloaded Q-factor > 200; tap at 1.125 turns from earth.
L6 = 18 turns enamelled Cu wire (36 x 0.03), soldering graded, stranded, open covered, closely wound; inductance 2.9 μH; unloaded Q-factor 120; loaded Q-factor with 25 kΩ : 60.

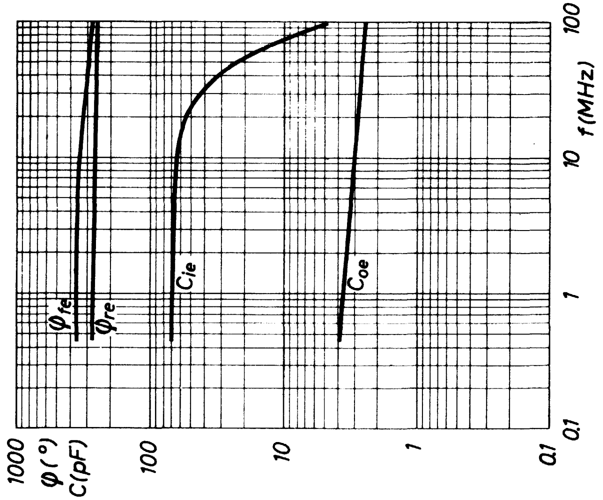
Frequency range	f		87 to 101	MHz
Collector current AF124	$-I_C$		1.4	mA
AF125	$-I_C$		1.5	mA
Total power gain	G_p	>	24	dB
		typ.	28	dB
Noise figure	F	typ.	8	dB
		<	9.5	dB
Oscillator voltage at aerial terminals		typ.	1.5	mV
Image rejection		typ.	27	dB

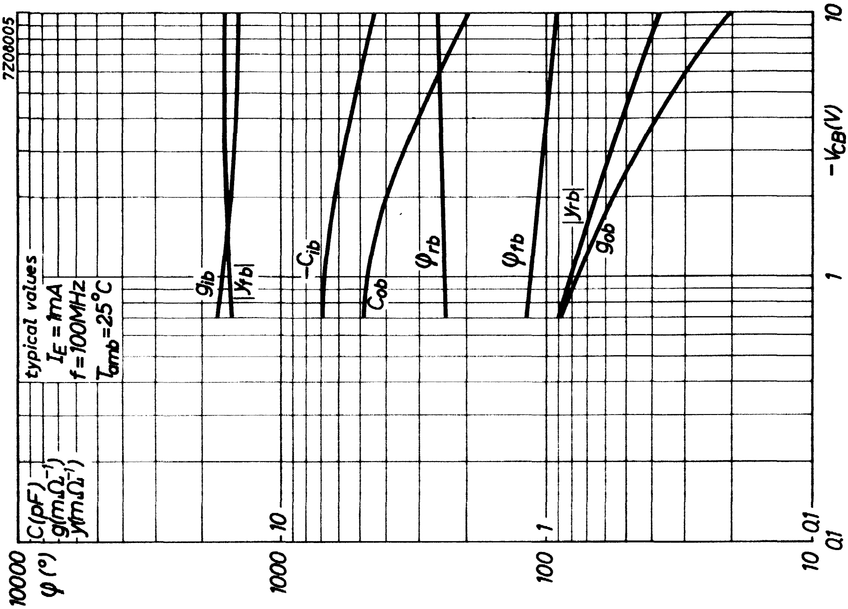
The shift of the oscillator frequency as a function of the battery voltage is about 50 kHz from 6 to 5 V and about 100 kHz from 5 to 4 V.

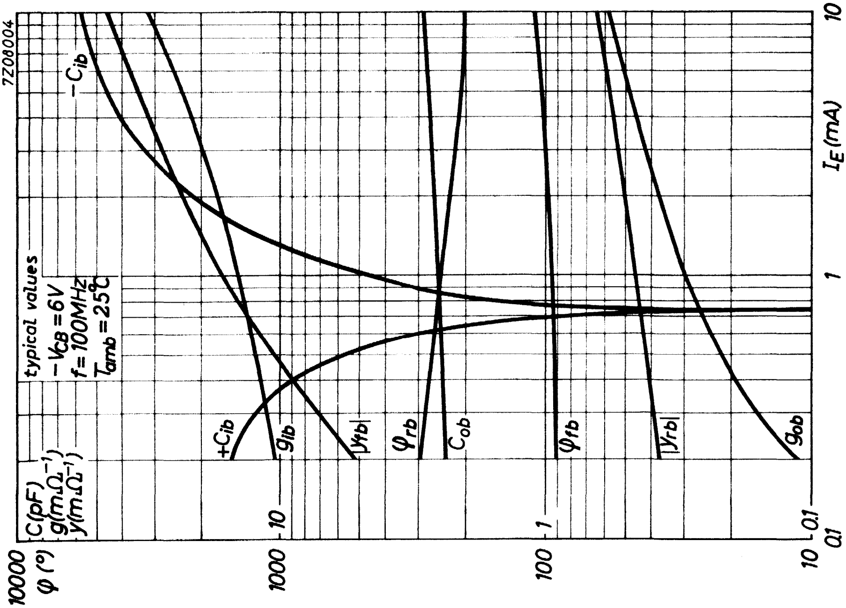

7Z08008
max
typ
$-V_{CB} = 6V$
$-I_{CBO}$ (μA)
T_j (°C)
1000
500
200
100
50
20
10
5
2
1
20
40
60
80
100

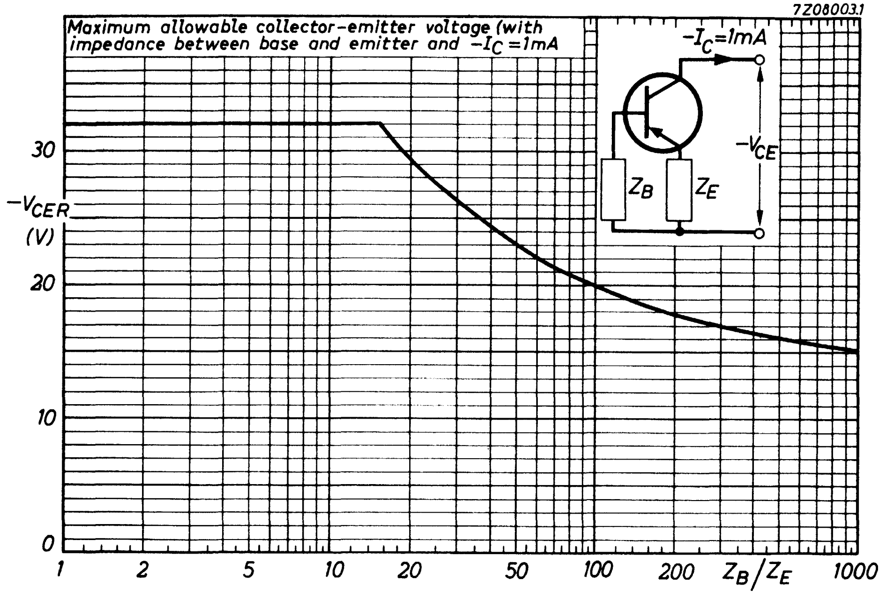

7Z08007
$-I_B = 70μA$
60μA
50μA
40μA
30μA
20μA
10μA
$-V_{CE}$ (V)
$-I_C$ (mA)
$-I_B$ (μA)
$-V_{CE} = 3V$
$-V_{BE}$ (mV)
typical values
$T_{amb} = 25°C$
0
5
10
25
50
100
200
300
400


7Z08006
typical values
$-V_{CE}=6V$
$-I_C=1mA$
$T_{amb}=25°C$
$|y_{re}|$
g_{oe}
$(\mu\Omega^{-1})$
$|y_{fe}|$
g_{ie}
$(m\Omega^{-1})$
g_{ie}
g_{oe}
f(MHz)
0.1
1
10
100
1000


$\varphi(°)$
C(pF)
φ_{fe}
φ_{re}
C_{ie}
C_{oe}
f(MHz)
0.1
1
10
100
1000


7Z08005
typical values
IE = 1mA
f = 100MHz
Tamb = 25°C
C(pF)
g(mΩ-1)
y(mΩ-1)
φ (°)
10000
1000
100
10
10
1
0.1
0.1
1
10
-VCB(V)
gib
|yfb|
-Cib
Cob
φrb
φfb
|yrb|
gob


7Z08004
typical values
-VCB = 6V
f = 100MHz
Tamb = 25°C
C(pF)
g(mΩ-1)
y(mΩ-1)
φ (°)
10000
1000
100
10
10
1
0.1
0.1
1
10
IE (mA)
-Cib
+Cib
gib
|yfb|
φrb
Cob
φfb
|yrb|
gob


7Z08003.1
Maximum allowable collector-emitter voltage (with impedance between base and emitter and $-I_C = 1mA$
$-I_C = 1mA$
$-V_{CE}$
Z_B
Z_E
$-V_{CER}$ (V)
30
20
10
0
1
2
5
10
20
50
100
200
Z_B/Z_E
1000

GERMANIUM ALLOY DIFFUSED TRANSISTOR

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

RATINGS (Limiting values) [1])

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

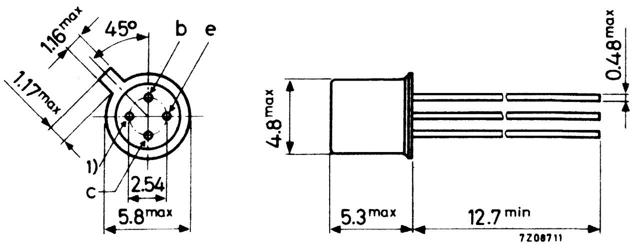
THERMAL RESISTANCE

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

MECHANICAL DATA

Dimensions in mm

TO-72



1) = shield lead (connected to case)

Accessories available: 56246, 56263

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

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $-V_{CB} = 6$ V	$-I_{CBO}$	typ.	1.2	μA
		<	8	μA
$I_E = 0$; $-V_{CB} = 6$ V; $T_j = 75$ °C	$-I_{CBO}$	typ.	90	μA
		<	180	μA
Base current				
$I_E = 1$ mA; $-V_{CB} = 6$ V	$-I_B$	typ.	7	μA
		<	25	μA
Base-emitter voltage				
$-I_C = 1$ mA; $-V_{CE} = 6$ V	$-V_{BE}$	typ.	270	mV
			210 to 330	mV
Small signal current gain at f = 1 kHz				
$-I_C = 1$ mA; $-V_{CE} = 6$ V	h_{fe}	typ.	150	
Feedback capacitance at f = 450 kHz				
$-I_C = 1$ mA; $-V_{CE} = 6$ V	$-C_{re}$	typ.	1.5	pF
y parameters [1]				
$I_E = 1$ mA; $-V_{CB} = 6$ V at f = 100 MHz				
Input conductance	g_{ib}	typ.	15	$m\Omega^{-1}$
Input capacitance	$-C_{ib}$	typ.	5	pF
Feedback admittance	$\|y_{rb}\|$	typ.	0.45	$m\Omega^{-1}$
Phase angle of feedback admittance	φ_{rb}	typ.	250°	
Transfer admittance	$\|y_{fb}\|$	typ.	15	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fb}	typ.	95°	
Output conductance	g_{ob}	typ.	0.35	$m\Omega^{-1}$
→ Output capacitance	C_{ob}	typ.	2.5	pF

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

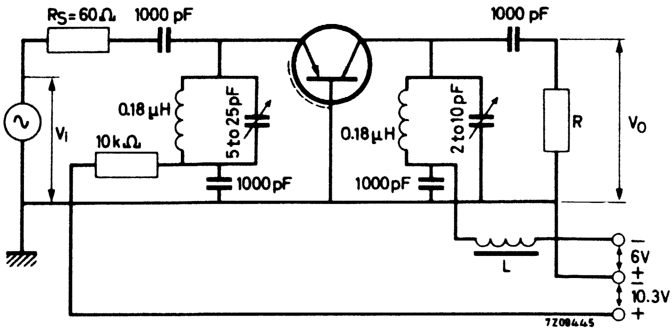
			f = 10.7	0.45	MHz
Input conductance	g_{ie}	typ.	1.3	0.25	$m\Omega^{-1}$
Input capacitance	C_{ie}	typ.	65	70	pF
Feedback admittance	$\|y_{re}\|$	typ.	80	4	$\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{re}	typ.	260°	270°	
Transfer admittance	$\|y_{fe}\|$	typ.	34	37	$m\Omega^{-1}$
Phase angle of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

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

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

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

Test circuit:

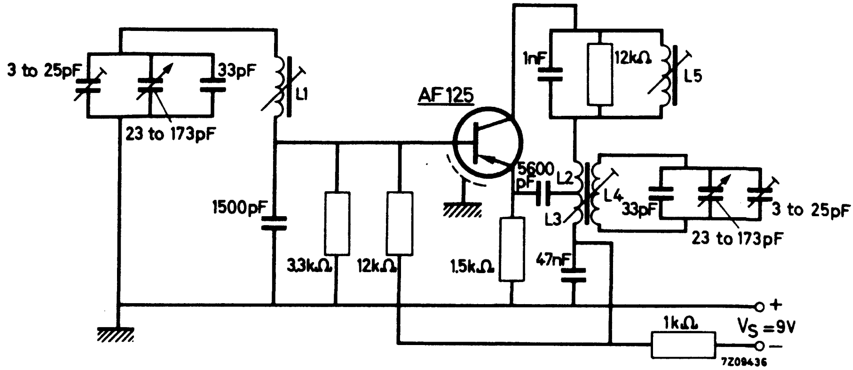


R is chosen such that the total load impedance R_ℓ consisting of R and the tuned circuit in parallel is 3.3 kΩ.

L = ferrite bead

APPLICATION INFORMATION

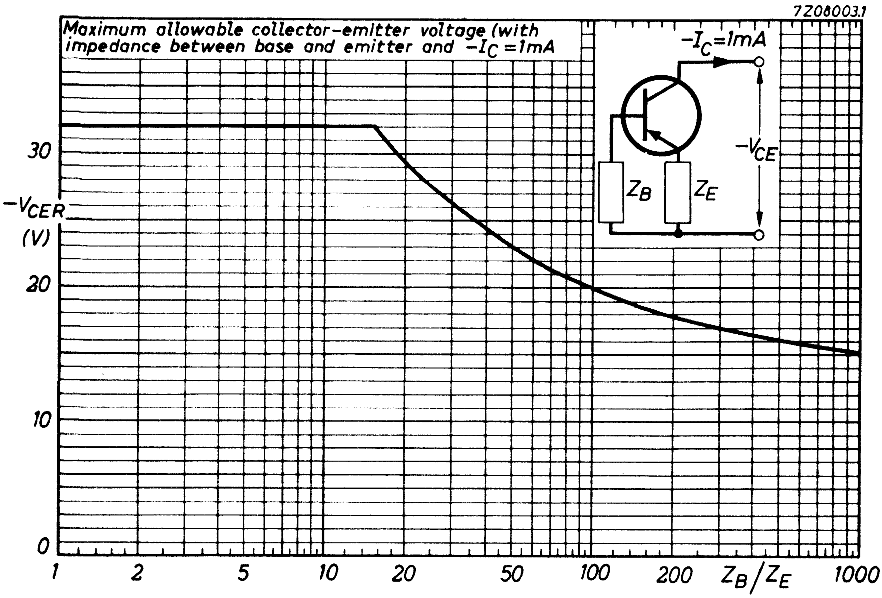
1. Front-end unit of a f.m. tuner see AF124
2. Self-oscillating mixer stage (15.1 to 26.1 MHz)

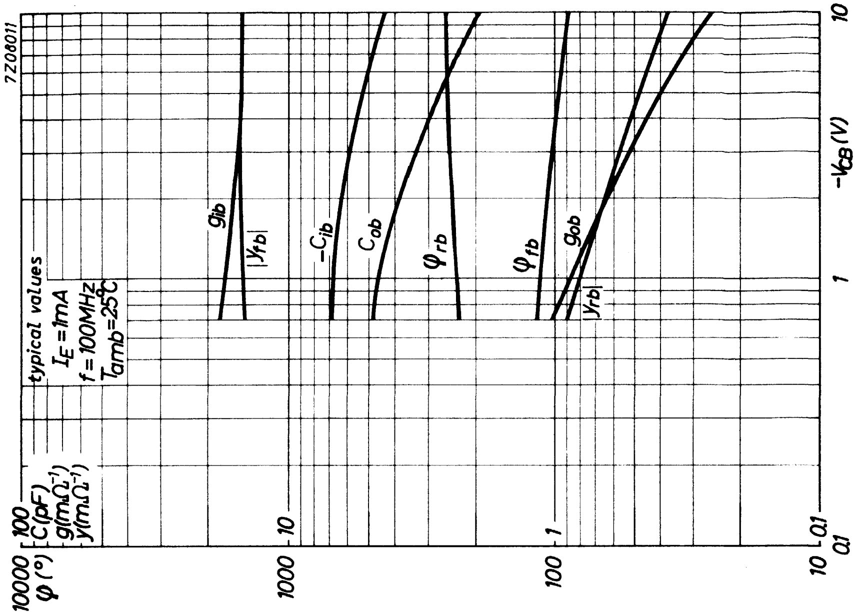


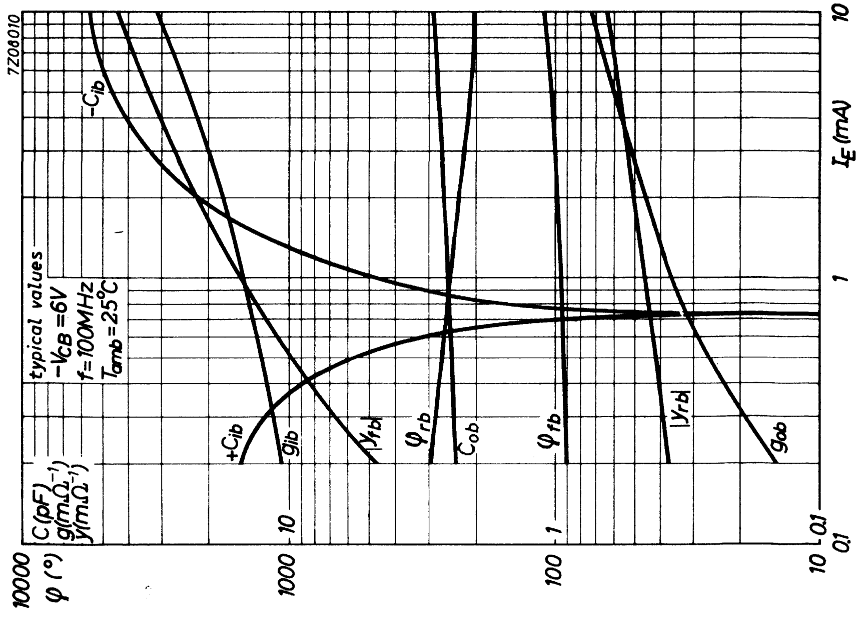
L_1 = 5.5 turns enamelled Cu wire (0.25 mm), closely wound on coil former with diameter of 7 mm; inductance 0.59 μH; unloaded Q-factor 100 at f = 15 MHz and 115 at f = 26 MHz.
L_2 = 1.25 turns enamelled Cu wire (0.25 mm), wound in L_4 at earth side.
L_3 = 1 turn enamelled Cu wire (0.25 mm), wound in L_4 at earth side.
L_4 = 6.5 turns enamelled Cu wire (0.9 mm), closely wound on coil former with diameter of 7 mm; inductance 0.46 μH; unloaded Q-factor 110 at f = 15 MHz and f = 26 MHz
L_5 = Inductance 125 μH; unloaded Q-factor 140.

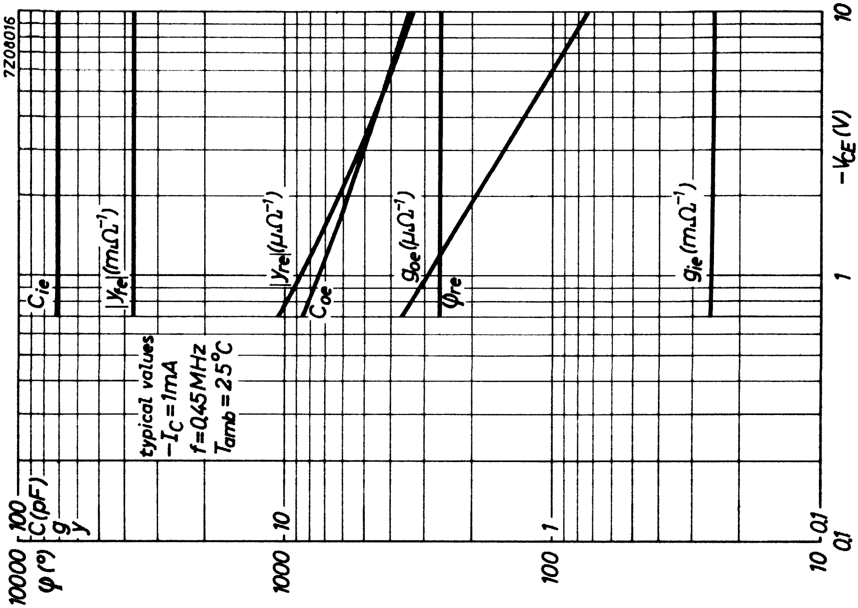
Battery voltage	V_S	=	9	V
Collector-emitter voltage	$-V_{CE}$	=	6	V
Emitter current	I_E	=	1	mA

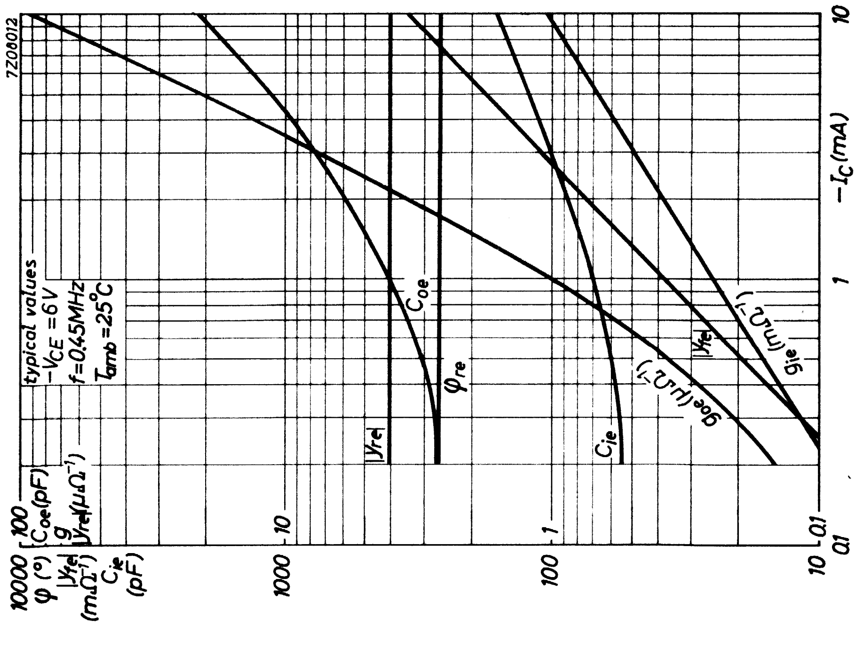
			f = 15	20	26	MHz
Oscillator voltage between emitter and earth	V_{osc}	typ.	0.11	0.14	0.15	V
Frequency shift by a battery voltage variation from 9 to 6 V	Δf_{osc}	typ.	3	2	10	kHz
Conversion gain, defined as the ratio between the i.f. power in a 10 kΩ load (the total i.f. impedance in the collector circuit) and the available r.f. power in the aerial circuit	$\frac{P_o}{P_i}$	typ.	26	23	20	dB

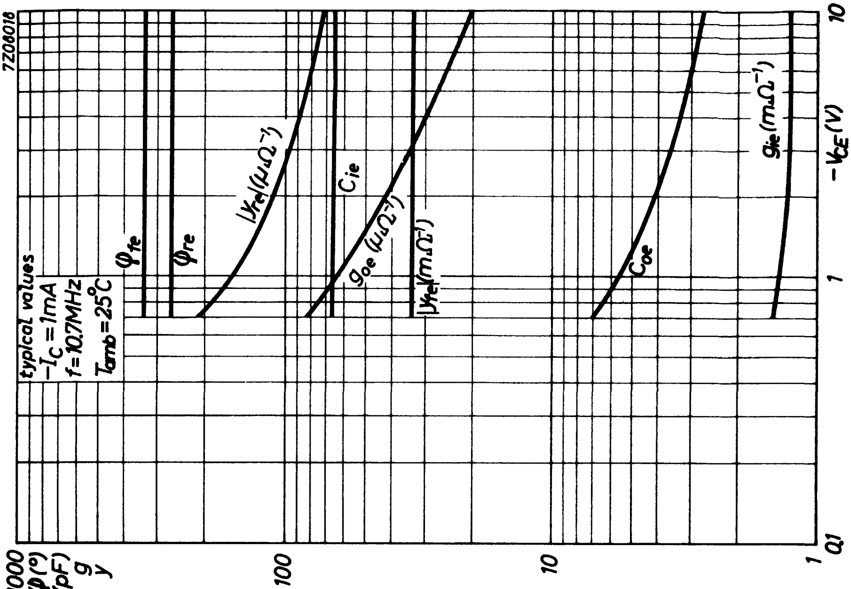

7Z08003.1
Maximum allowable collector-emitter voltage (with impedance between base and emitter and $-I_C$ = 1mA
$-I_C$=1mA
$-V_{CE}$
Z_B
Z_E
30
$-V_{CER}$
(V)
20
10
0
1
2
5
10
20
50
100
200
Z_B/Z_E
1000

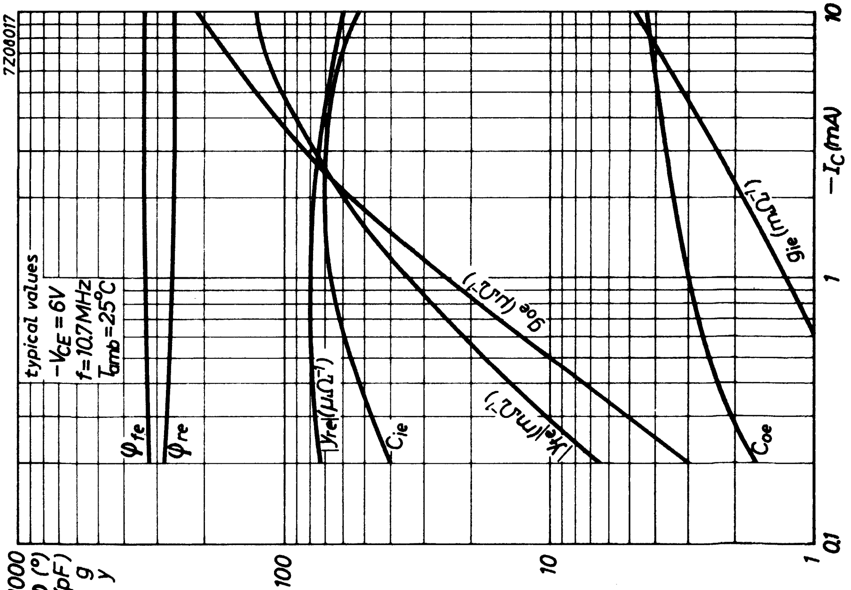

7Z08011
typical values
IE = 1mA
f = 100MHz
Tamb = 25°C
10000
φ (°)
100
C (pF)
g (mΩ-1)
y (mΩ-1)
1000
10
100
1
10
0.1
0.1
1
10
-VCB (V)
gib
|yfb|
-Cib
Cob
φrb
φfb
gob
|yrb|

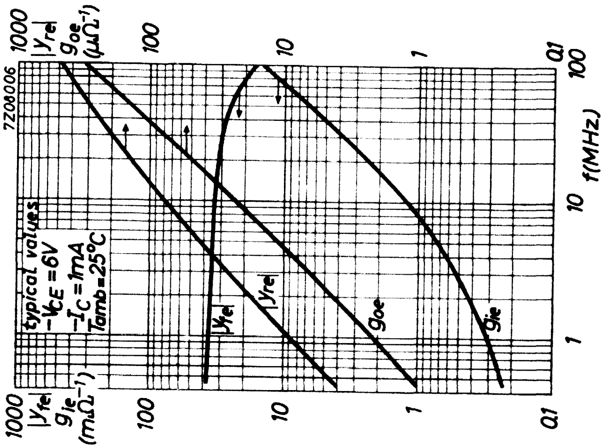

7Z08010
typical values
-VCB = 6V
f = 100MHz
Tamb = 25°C
10000
φ (°)
C (pF)
g (mΩ-1)
y (mΩ-1)
1000
10
100
1
10
0.1
0.1
1
10
IE (mA)
-Cib
+Cib
gib
|yfb|
φrb
Cob
φfb
|yrb|
gob

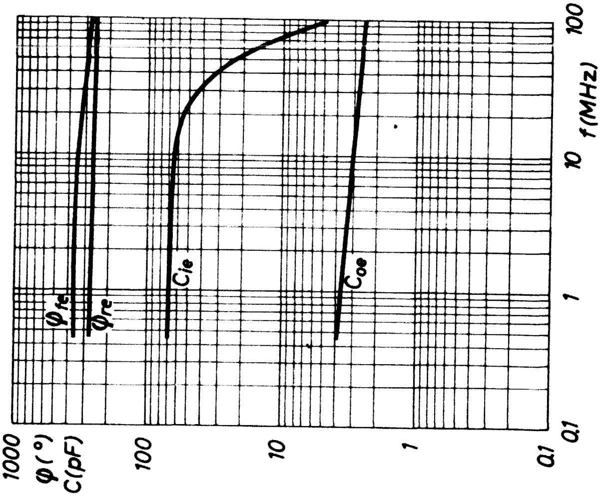

7Z08016
typical values
−I_C = 1mA
f = 0.45MHz
T_amb = 25°C
C_ie
|y_fe| (mΩ⁻¹)
|y_re| (μΩ⁻¹)
C_oe
g_oe (μΩ⁻¹)
φ_re
g_ie (mΩ⁻¹)
10000 φ (°)
100 C (pF) g y
1000
10
100
1
10
0.1
0.1
1
10
−V_CE (V)

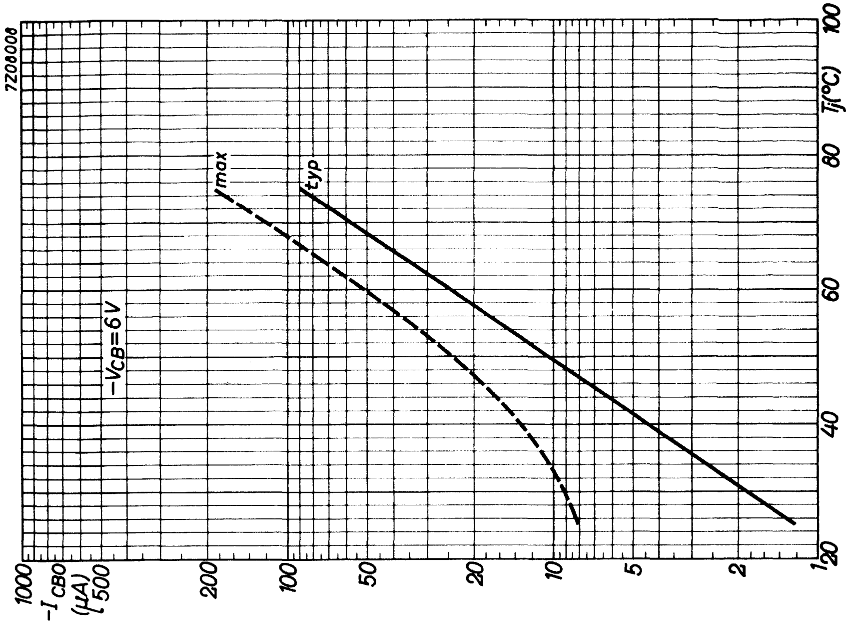

7Z08012
typical values
−V_CE = 6V
f = 0.45MHz
T_amb = 25°C
C_oe
φ_re
|y_re|
C_ie
g_oe (μΩ⁻¹)
|y_fe|
g_ie (mΩ⁻¹)
10000 φ (°) |y_fe| (mΩ⁻¹) C_ie (pF)
100 C_oe (pF) g |y_re| (μΩ⁻¹)
1000
10
100
1
10
0.1
0.1
1
10
−I_C (mA)

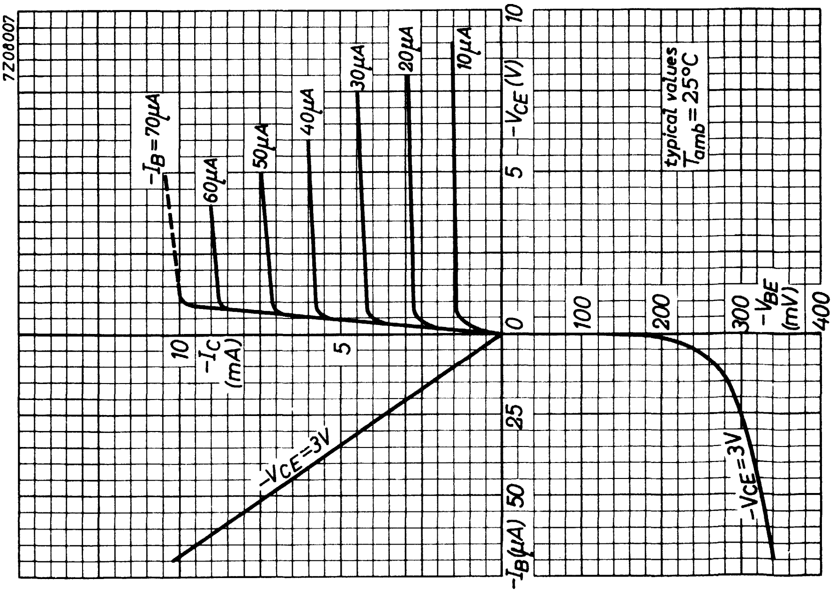

7Z08018
typical values
$-I_C = 1mA$
f = 10.7MHz
$T_{amb} = 25°C$
φ_{fe}
φ_{re}
$|y_{re}| (\mu\Omega^{-1})$
C_{ie}
$g_{oe} (\mu\Omega^{-1})$
$|y_{fe}| (m\Omega^{-1})$
C_{oe}
$g_{ie} (m\Omega^{-1})$
1000
φ (°)
C(pF)
g
y
100
10
1
0.1
1
10
$-V_{CE}$ (V)


7Z08017
typical values
$-V_{CE} = 6V$
f = 10.7MHz
$T_{amb} = 25°C$
φ_{fe}
φ_{re}
$|y_{re}| (\mu\Omega^{-1})$
C_{ie}
$|y_{fe}| (m\Omega^{-1})$
$g_{oe} (\mu\Omega^{-1})$
C_{oe}
$g_{ie} (m\Omega^{-1})$
1000
φ (°)
C(pF)
g
y
100
10
1
0.1
1
10
$-I_C$ (mA)


7Z08006
typical values
$-V_{CE}$ = 6V
$-I_C$ = 1mA
T_{amb} = 25°C
$|y_{fe}|$
g_{ie}
(mΩ⁻¹)
$|y_{re}|$
g_{oe}
(μΩ⁻¹)
g_{oe}
g_{ie}
f (MHz)
0.1
1
10
100
1000


φ (°)
C (pF)
$φ_{fe}$
$φ_{re}$
C_{ie}
C_{oe}
f (MHz)
0.1
1
10
100
1000


7Z08008
$-V_{CB}=6V$
max
typ
T_j(°C)
20
40
60
80
100
$-I_{CBO}$
(μA)
1000
500
200
100
50
20
10
5
2
1


7Z08007
$-I_B=70μA$
60μA
50μA
40μA
30μA
20μA
10μA
$-V_{CE}$(V)
10
5
0
typical values
$T_{amb}=25°C$
$-I_C$
(mA)
10
5
$-V_{CE}=3V$
25
50
$-I_B$(μA)
100
200
300
400
$-V_{BE}$
(mV)
$-V_{CE}=3V$

GERMANIUM ALLOY DIFFUSED TRANSISTOR

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

RATINGS (Limiting values) [1])

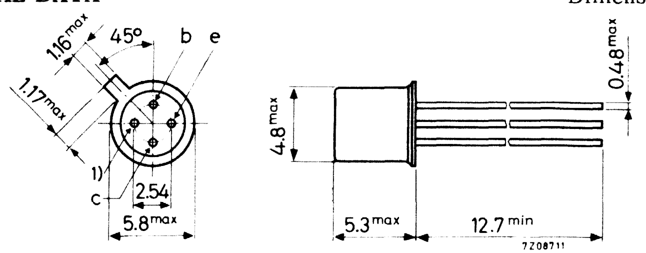
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	V
Collector-emitter voltage ($Z_B/Z_E < 15$)	$-V_{CER}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	15	V
Collector current (d.c.)	$-I_C$	max.	10	mA
Base current (d.c.)	$\|I_B\|$	max.	1	mA
Reverse emitter current	$-I_E$	max.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

THERMAL RESISTANCE

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

MECHANICAL DATA Dimensions in mm

TO-72



1) = shield lead (connected to case)

Accessories available: 56246, 56263

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

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

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

y parameters (common emitter)

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

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

Feedback impedance at f = 2 MHz				
$I_E = 1$ mA; $-V_{CB} = 6$ V	$\|z_{rb}\|$	typ.	27	Ω

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

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

Transition frequency

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

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

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

Conversion noise figure

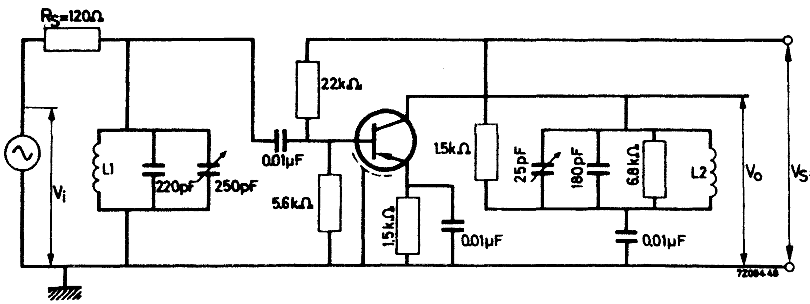
I_E = 1 mA; $-V_{CB}$ = 6 V

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

Power gain at f = 10.7 MHz

$G_p = \frac{V_o^2}{V_i^2} \cdot \frac{4 R_S}{R_l} = 0.1 \frac{V_o^2}{V_i^2}$	G_p	>	19	dB
		typ.	25	dB

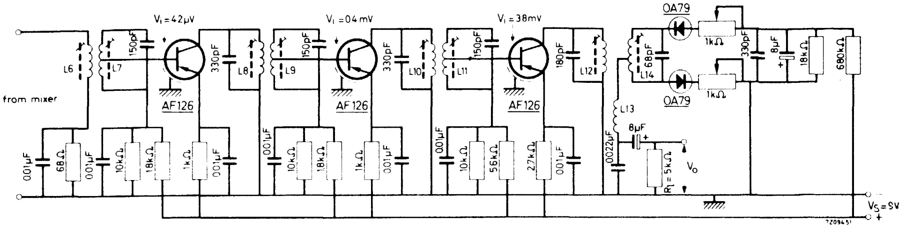
Test circuit:



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

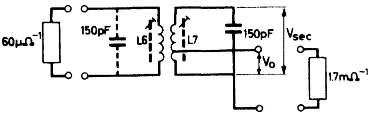
APPLICATION INFORMATION

I.F. amplifier for 10.7 MHz



Emitter current of each transistor $I_E = 1.0$ mA

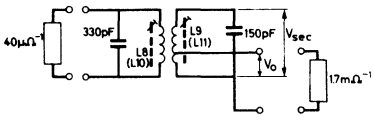
Coil data :



L6 = 1.4 μH; $Q_0 \geq 120$; $Q_L = 70$

L7 = 1.4 μH; $Q_0 \geq 110$; $Q_L = 92$

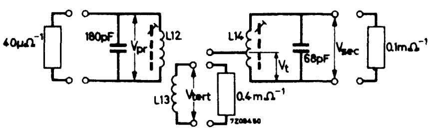
$kQ_L = 1.25$ $\frac{V_o}{V_{sec}} = 0.1$



L8 = L10 = 0.67 μH; $Q_0 \geq 110$; $Q_L = 92$

L9 = L11 = 1.4 μH; $Q_0 \geq 110$; $Q_L = 92$

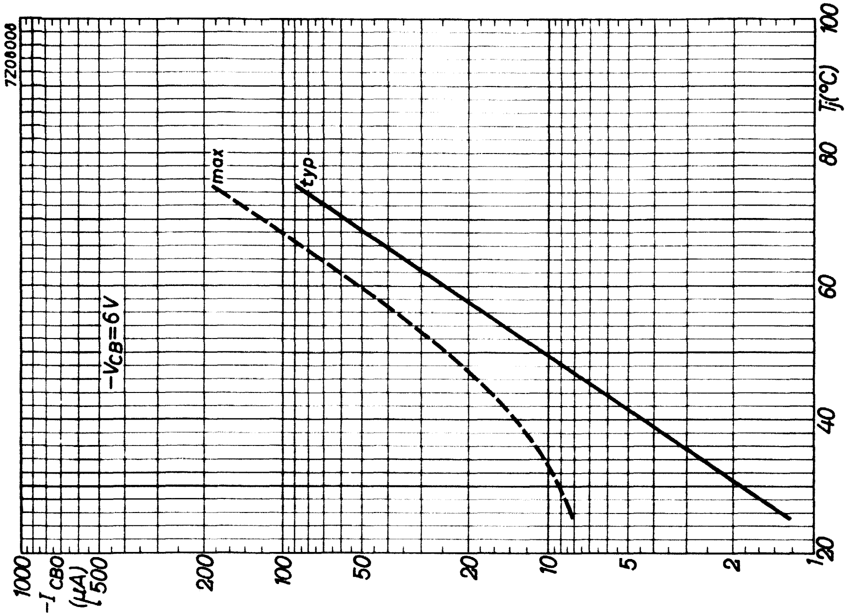
$kQ_L = 1.25$ $\frac{V_o}{V_{sec}} = 0.1$

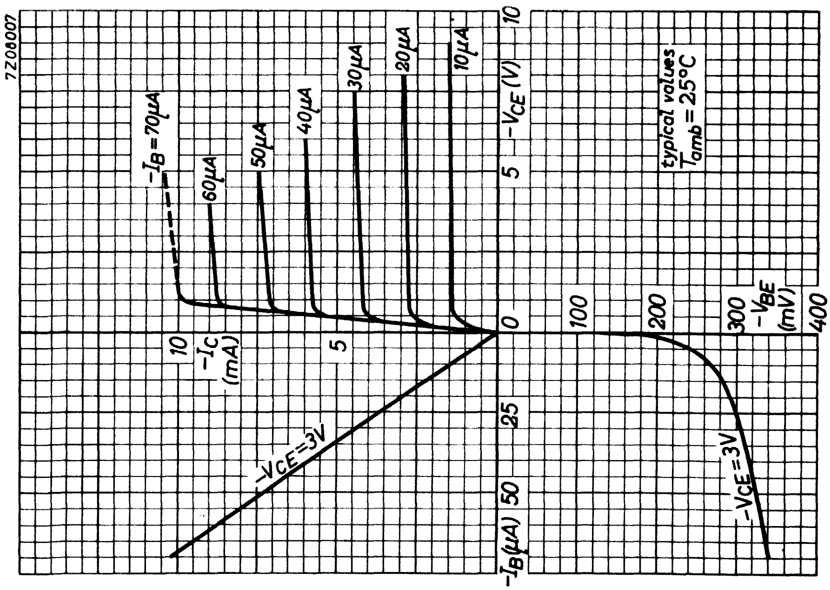


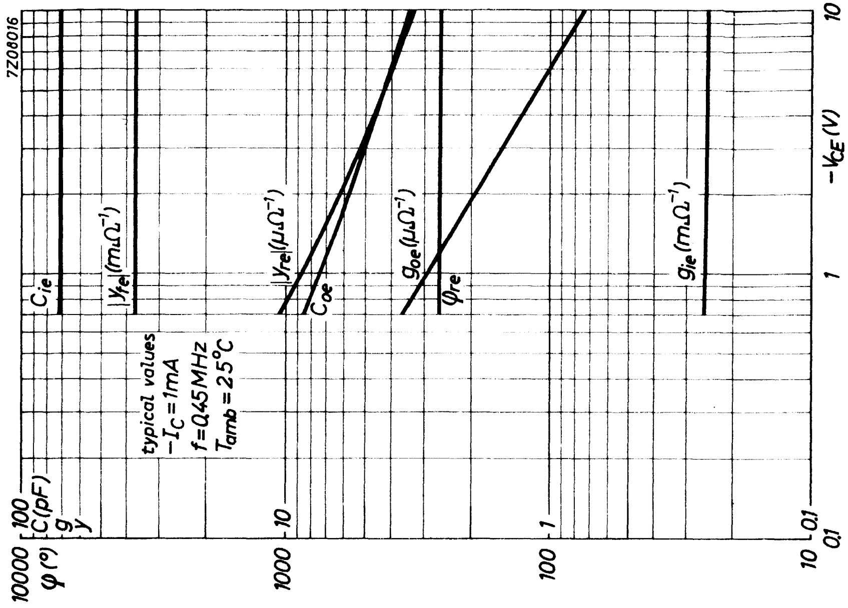
L12 = 1.2 μH; $Q_0 = 90$
L14 = 3.05 μH; $Q_0 = 90$ (bifilarly wound)

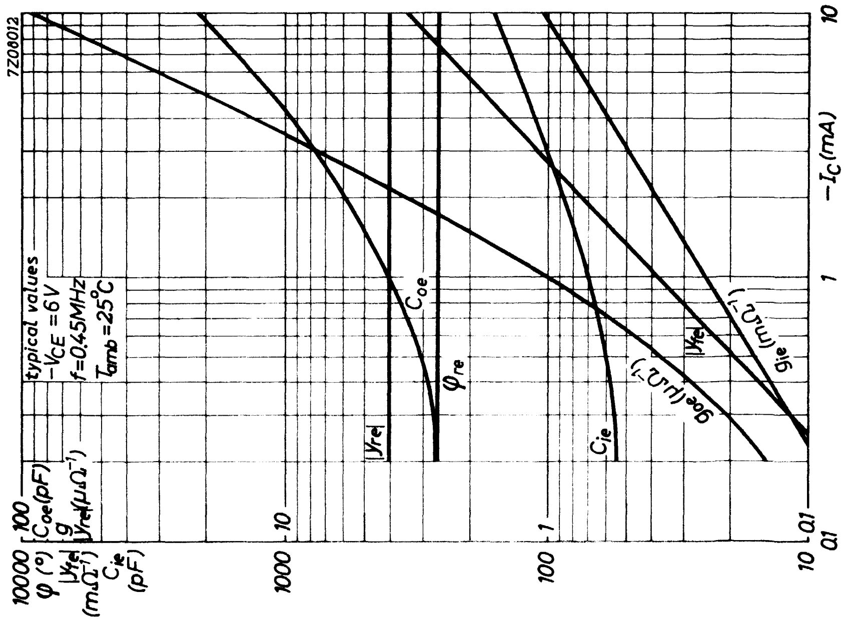
$kQ_L = 0.7$

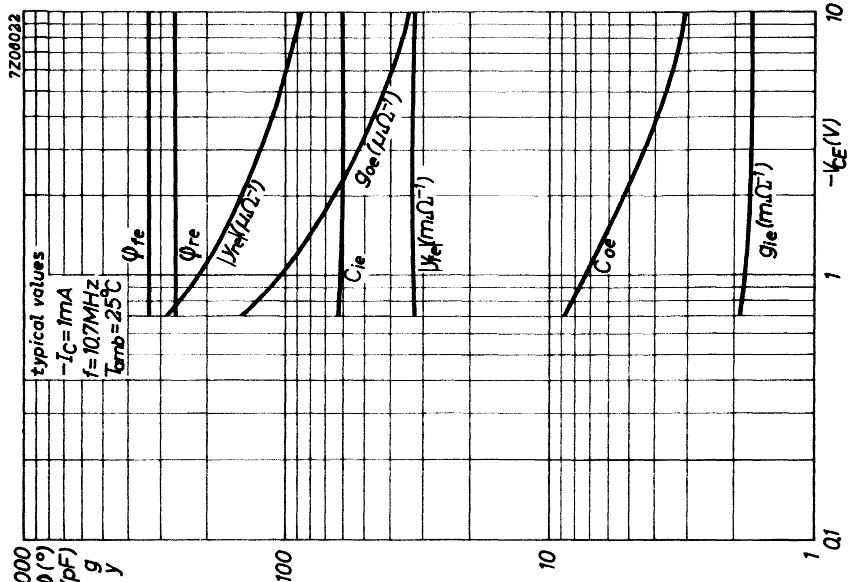
$\frac{V_{tert}}{V_{pr}} = 0.45$; $\frac{V_t}{V_{sec}} = 0.5$

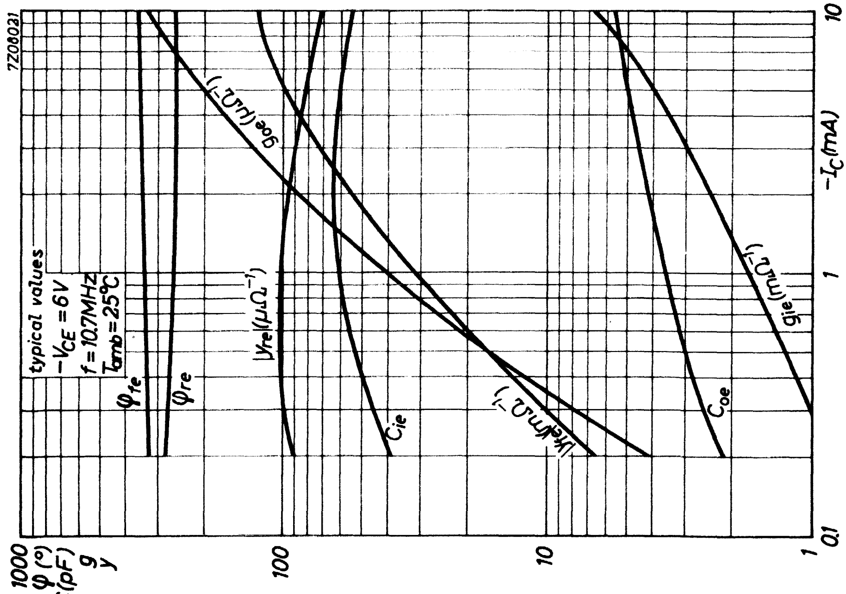

7Z08008
$-V_{CB}=6V$
max
typ
T_j(°C)
20
40
60
80
100
$-I_{CBO}$
(μA)
1000
500
200
100
50
20
10
5
2
1

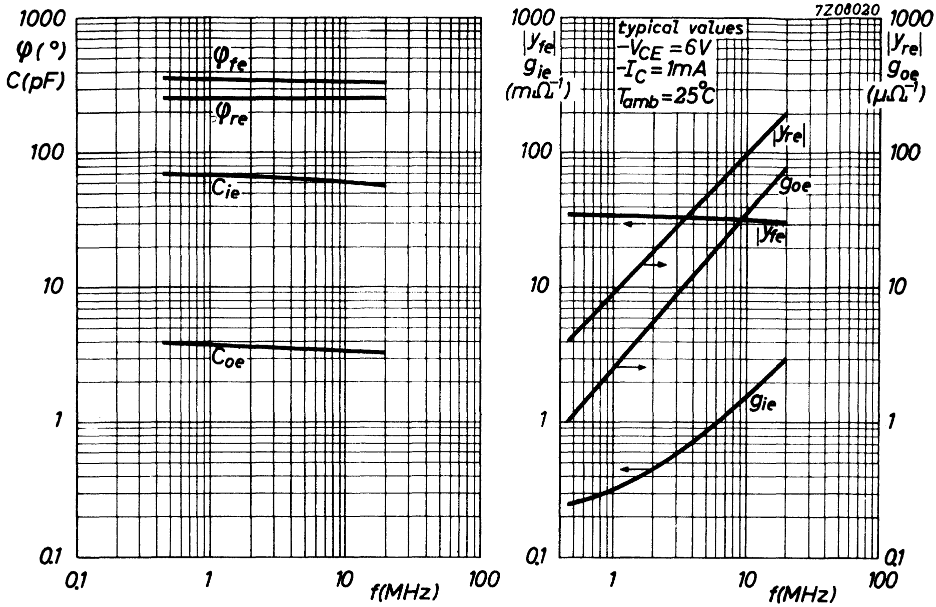

7Z08007
$-I_B=70\mu A$
60μA
50μA
40μA
30μA
20μA
10μA
$-V_{CE}$ (V)
0
5
10
$-I_C$
(mA)
10
5
typical values
$T_{amb}=25°C$
$-V_{CE}=3V$
$-V_{CE}=3V$
25
50
$-I_B$(μA)
100
200
300
400
$-V_{BE}$
(mV)

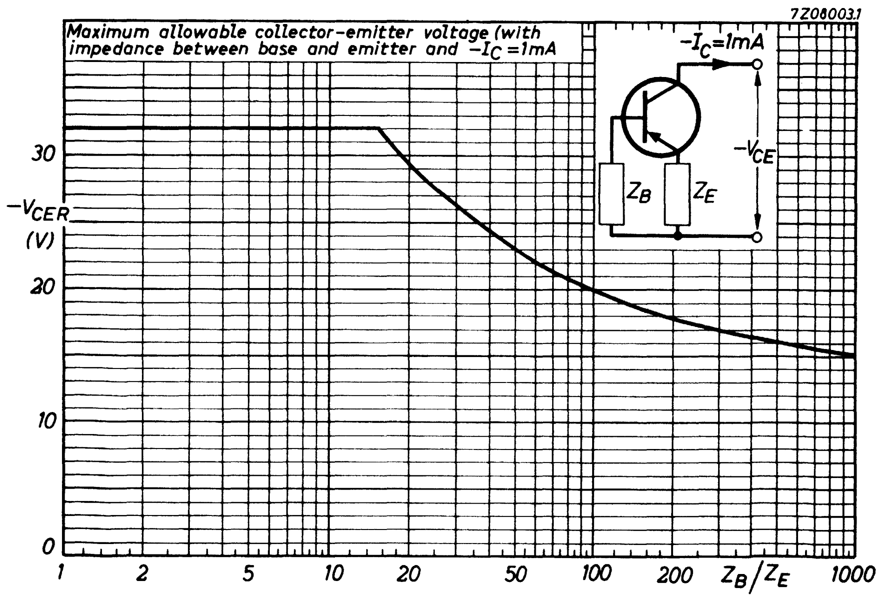

7Z08016
typical values
$-I_C = 1mA$
$f = 0.45MHz$
$T_{amb} = 25°C$
C_{ie}
$|y_{fe}| (m\Omega^{-1})$
$|y_{re}| (\mu\Omega^{-1})$
C_{oe}
$g_{oe} (\mu\Omega^{-1})$
φ_{re}
$g_{ie} (m\Omega^{-1})$
10000 φ (°)
100 C (pF) g y
$-V_{CE}$ (V)


7Z08012
typical values
$-V_{CE} = 6V$
$f = 0.45MHz$
$T_{amb} = 25°C$
C_{oe}
φ_{re}
$|y_{re}|$
C_{ie}
$g_{oe} (\mu\Omega^{-1})$
$|y_{fe}|$
$g_{ie} (m\Omega^{-1})$
10000 φ (°) $|y_{fe}|$ ($m\Omega^{-1}$) C_{ie} (pF)
100 C_{oe} (pF) g $|y_{re}|$ ($\mu\Omega^{-1}$)
$-I_C$ (mA)


7Z08022
typical values
$-I_C = 1mA$
$f = 10.7MHz$
$T_{amb} = 25°C$
φ_{fe}
φ_{re}
$|y_{re}|(\mu\Omega^{-1})$
C_{ie}
$g_{oe}(\mu\Omega^{-1})$
$|y_{fe}|(m\Omega^{-1})$
C_{oe}
$g_{ie}(m\Omega^{-1})$
1000
$\varphi(°)$
$C(pF)$
g
y
100
10
1
0.1
1
10
$-V_{CE}(V)$


7Z08021
typical values
$-V_{CE} = 6V$
$f = 10.7MHz$
$T_{amb} = 25°C$
φ_{fe}
φ_{re}
$|y_{re}|(\mu\Omega^{-1})$
C_{ie}
$|y_{fe}|(m\Omega^{-1})$
$g_{oe}(\mu\Omega^{-1})$
C_{oe}
$g_{ie}(m\Omega^{-1})$
1000
$\varphi(°)$
$C(pF)$
g
y
100
10
1
0.1
1
10
$-I_C(mA)$


7Z08020
φ(°)
C(pF)
φfe
φre
Cie
Coe
f(MHz)
|yfe|
gie
(mΩ⁻¹)
|yre|
goe
(μΩ⁻¹)
typical values
−VCE = 6V
−IC = 1mA
Tamb = 25°C
|yre|
goe
|yfe|
gie
f(MHz)


7Z08003.1
Maximum allowable collector-emitter voltage (with impedance between base and emitter and −IC = 1mA
−IC=1mA
−VCE
ZB
ZE
−VCER
(V)
ZB/ZE

GERMANIUM ALLOY DIFFUSED TRANSISTOR

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

RATINGS (Limiting values) [1])

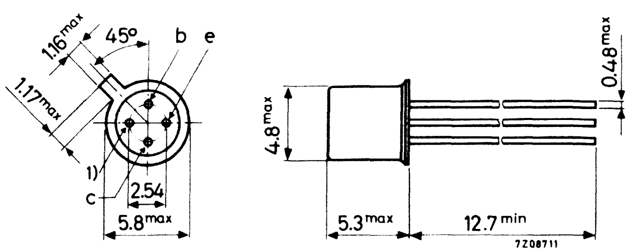
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	32	V
Collector-emitter voltage ($Z_B/Z_E < 15$)	$-V_{CER}$	max.	32	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	15	V
Collector current (d.c.)	$-I_C$	max.	10	mA
Base current (d.c.)	$\lvert I_B \rvert$	max.	1	mA
Reverse emitter current	$-I_E$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

THERMAL RESISTANCE

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

MECHANICAL DATA Dimensions in mm

TO-72



1) = shield lead (connected to case)

Accessories available: 56246, 56263

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

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $-V_{CB} = 6$ V	$-I_{CBO}$	typ.	1.2	μA
		<	8	μA
$I_E = 0$; $-V_{CB} = 6$ V; $T_j = 75$ °C	$-I_{CBO}$	typ.	90	μA
		<	180	μA
Base current				
$I_E = 1$ mA; $-V_{CB} = 6$ V	$-I_B$	typ.	7	μA
		<	25	μA
Base-emitter voltage				
$-I_C = 1$ mA; $-V_{CE} = 6$ V	$-V_{BE}$	typ.	270	mV
			210 to 330	mV
Small signal current gain at f = 1 kHz				
$-I_C = 1$ mA; $-V_{CE} = 6$ V	h_{fe}	typ.	150	
Feedback capacitance at f = 450 kHz				
$-I_C = 1$ mA; $-V_{CE} = 6$ V	$-C_{re}$	typ.	1.5	pF
y parameters at f = 0.45 MHz (common emitter)				
$-I_C = 1$ mA; $-V_{CE} = 6$ V [1]				
Input conductance	g_{ie}	typ.	0.25	$m\Omega^{-1}$
Input capacitance	C_{ie}	typ.	70	pF
Feedback admittance	$\lvert y_{re} \rvert$	typ.	4.0	$\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{re}	typ.	270°	
Transfer admittance	$\lvert y_{fe} \rvert$	typ.	37	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fe}	typ.	0	
Output conductance	g_{oe}	typ.	1.0	$\mu\Omega^{-1}$
Output capacitance	C_{oe}	typ.	4.0	pF
Feedback impedance at f = 2 MHz				
$I_E = 1$ mA; $-V_{CB} = 6$ V	$\lvert z_{rb} \rvert$	typ.	35	Ω

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

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

Transition frequency

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

Noise figure at f = 1.0 MHz

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

Conversion noise figure

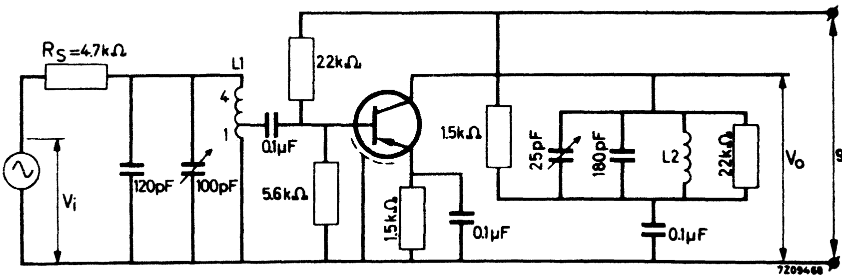
I_E = 1 mA; $-V_{CB}$ = 6 V

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

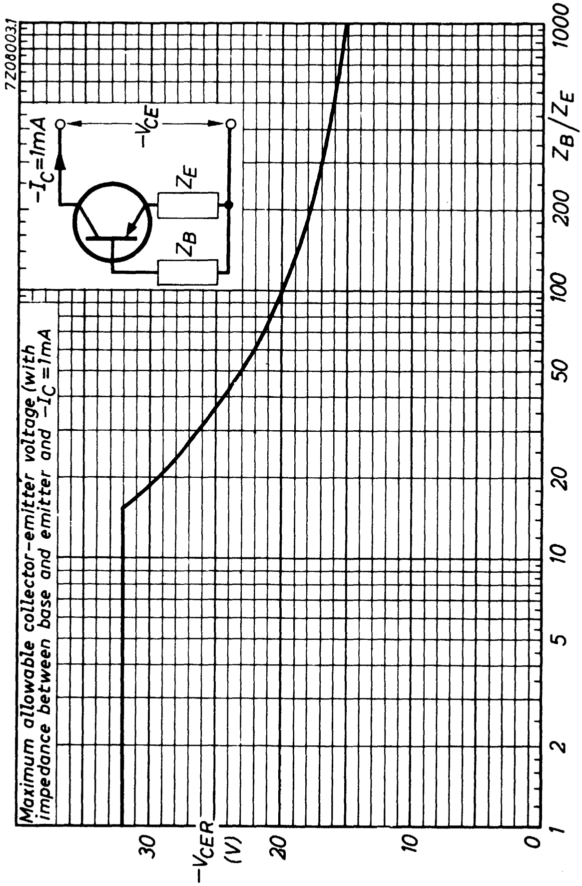
Power gain at f = 0.45 MHz

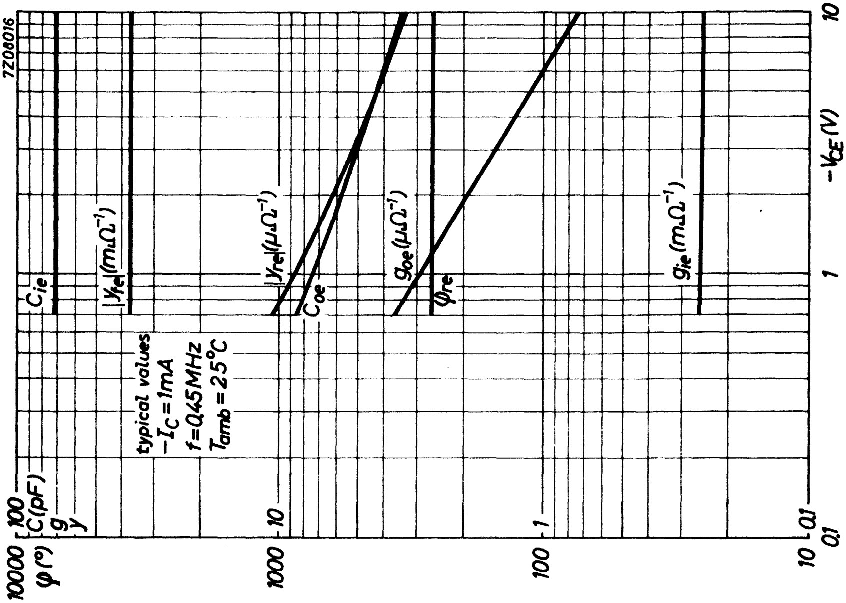
$G_p = \frac{V_o2}{V_i2} \cdot \frac{4\,R_S}{R_l} = 0.94\,\frac{V_o^2}{V_i^2}$	G_p	>	40	dB
		typ.	42	dB

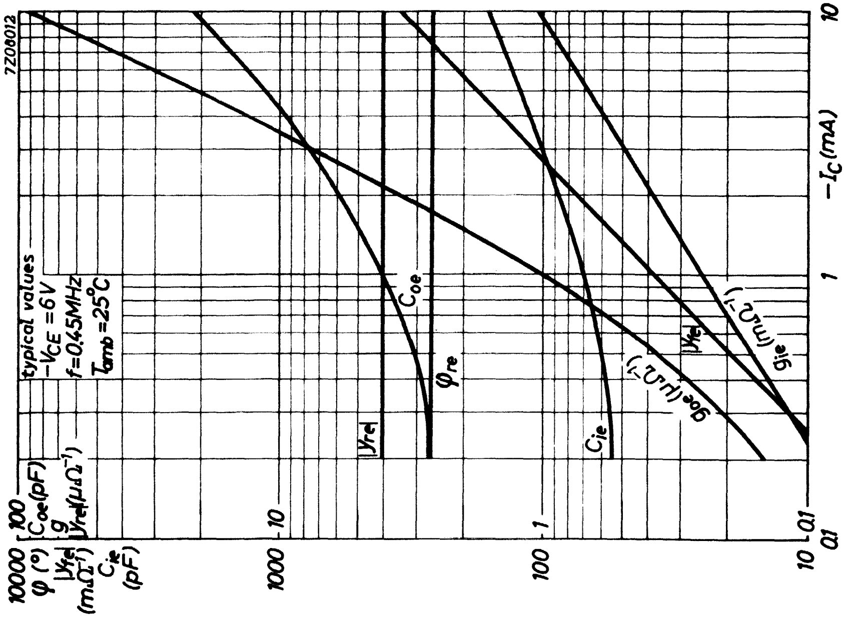
Test circuit :

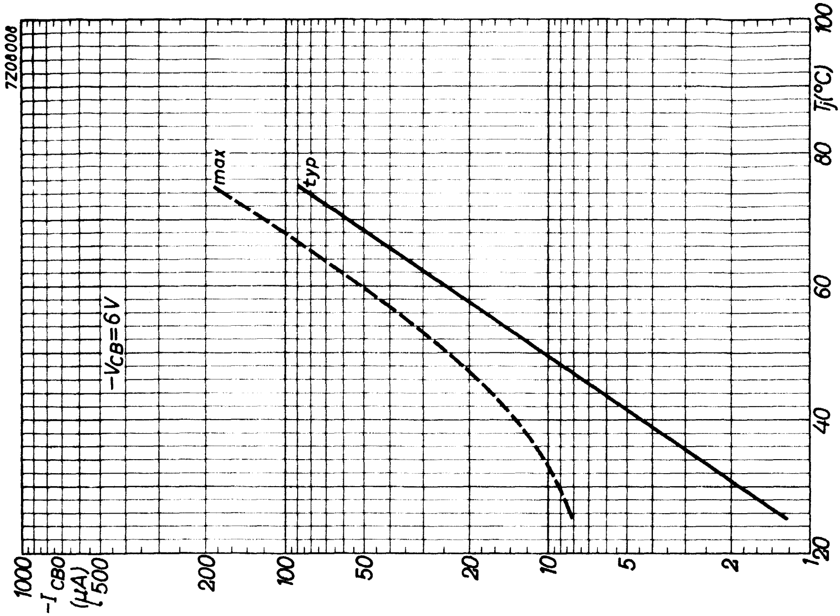


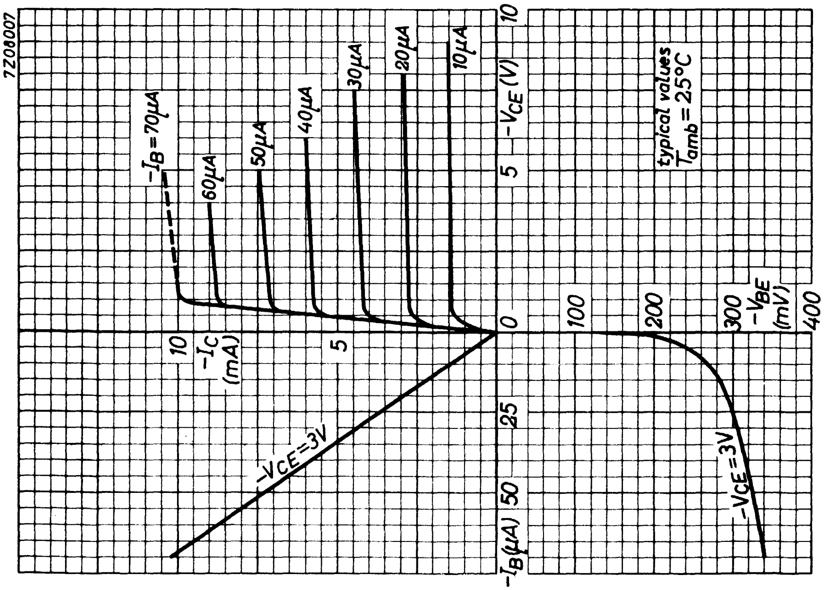
Total collector resistance R_ℓ = 20 kΩ
L1 = 625 μH; unloaded Q-factor 140; tap at 0.2
L2 = 625 μH; unloaded Q-factor 140


7Z08003.1
Maximum allowable collector-emitter voltage (with impedance between base and emitter and $-I_C = 1mA$
$-I_C = 1mA$
$-V_{CE}$
Z_E
Z_B
$-V_{CER}$ (V)
30
20
10
0
1
2
5
10
20
50
100
200
1000
Z_B/Z_E


7Z08016
typical values
−I_C = 1mA
f = 0.45MHz
T_amb = 25°C
C_ie
|y_fe| (mΩ⁻¹)
|y_re| (μΩ⁻¹)
C_oe
g_oe (μΩ⁻¹)
φ_re
g_ie (mΩ⁻¹)
10000
φ (°)
100
C (pF)
g
y
1000
10
100
1
10
0.1
0.1
1
10
−V_CE (V)


7Z08012
typical values
−V_CE = 6V
f = 0.45MHz
T_amb = 25°C
C_oe
φ_re
|y_fe|
C_ie
g_oe (μΩ⁻¹)
|y_re|
g_ie (mΩ⁻¹)
10000
φ (°)
|y_fe| (mΩ⁻¹)
C_ie (pF)
100
C_oe (pF)
g
|y_re| (μΩ⁻¹)
1000
10
100
1
10
0.1
0.1
1
10
−I_C (mA)


7Z08008
-V_CB=6V
max
typ
Tj(°C)
20
40
60
80
100
-I_CBO
(μA)
1000
500
200
100
50
20
10
5
2
1


7Z08007
-I_B=70μA
60μA
50μA
40μA
30μA
20μA
10μA
-V_CE (V)
0
5
10
typical values
T_amb=25°C
-I_C
(mA)
10
5
100
200
300
400
-V_BE
(mV)
-V_CE=3V
-I_B(μA)
25
50
-V_CE=3V

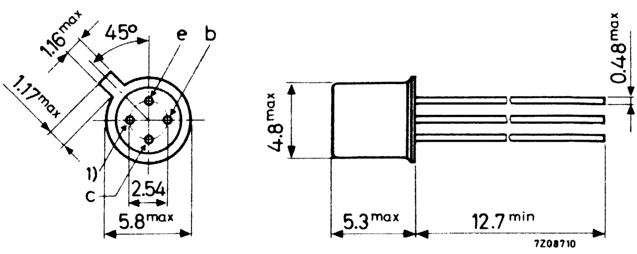
U.H.F. GERMANIUM MESA TRANSISTOR

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

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

MECHANICAL DATA Dimensions in mm

TO-72



1) = shield lead (connected to case)

Accessories available: 56246, 56263

RATINGS (Limiting values) [1]

Voltages

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

Currents

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

Power dissipation

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

Temperatures

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

THERMAL RESISTANCE

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

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

CHARACTERISTICS T_j = 25 °C unless otherwise specified

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

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

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

y parameters at f = 800 MHz [1]

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

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

y parameters at f = 200 MHz [1]

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

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

Maximum unilateralised power gain

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

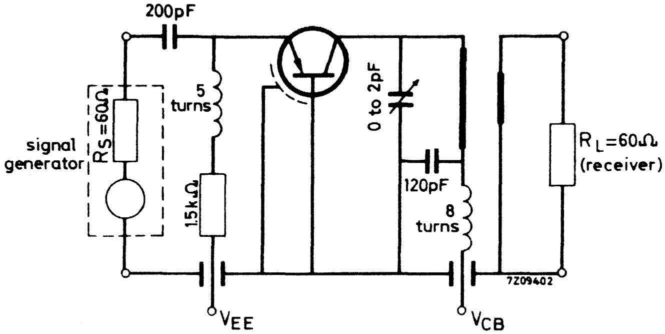
I_E = 1.5 mA; $-V_{CB}$ = 12 V; f = 800 MHz G_{UM} typ. 11.5 dB

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

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

Transducer gain

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



Total effective collector resistance R_C = 1.4 kΩ

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

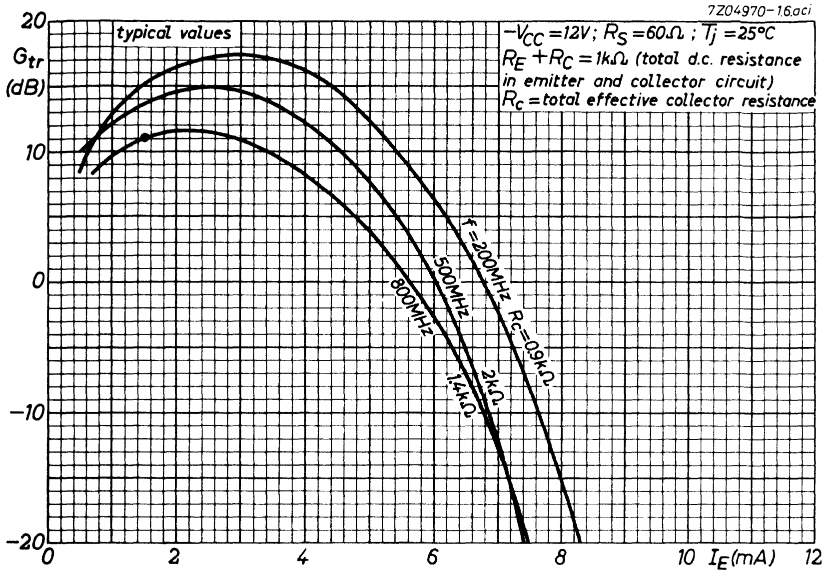
I_E = 1.5 mA; $-V_{CB}$ = 12 V

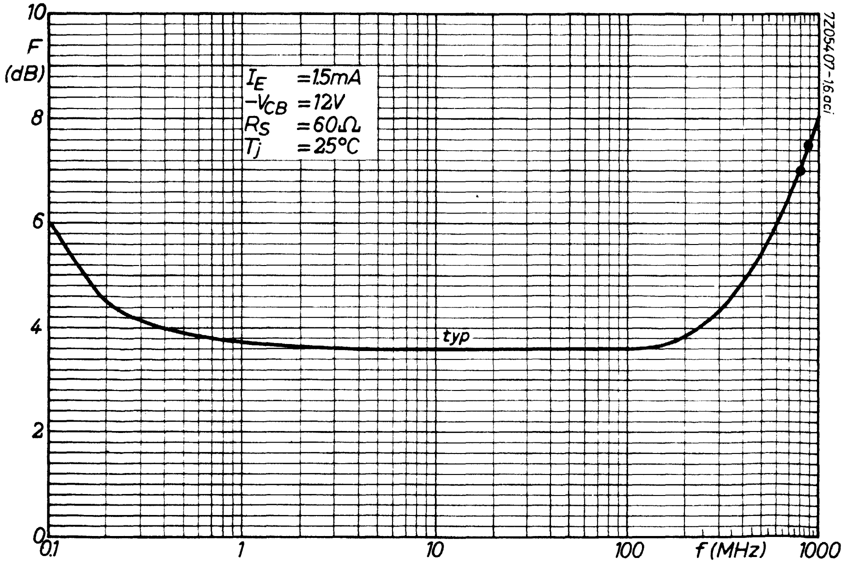
f = 800 MHz	G_{tr}	>	9	dB
		typ.	11	dB
f = 860 MHz	G_{tr}	>	7.5	dB
		typ.	10	dB

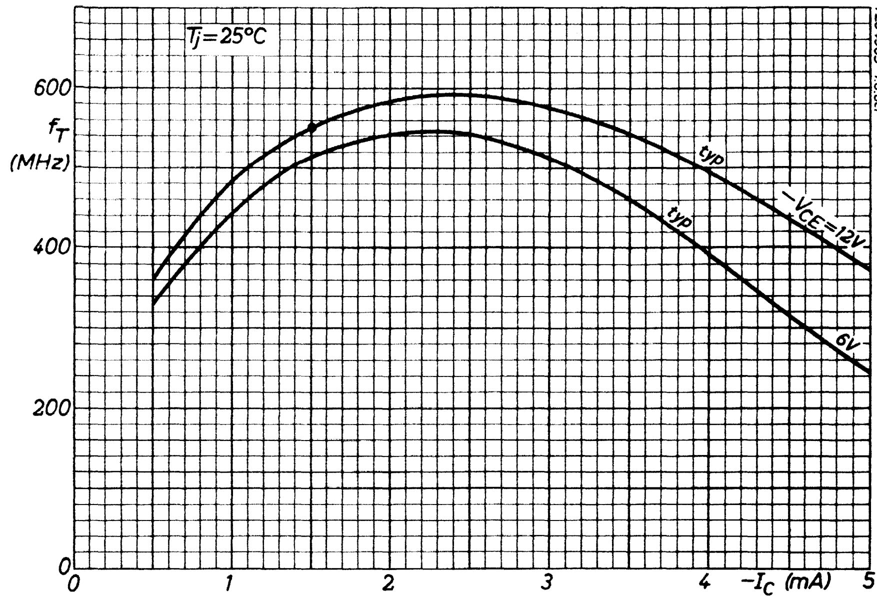
Reverse transducer gain

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

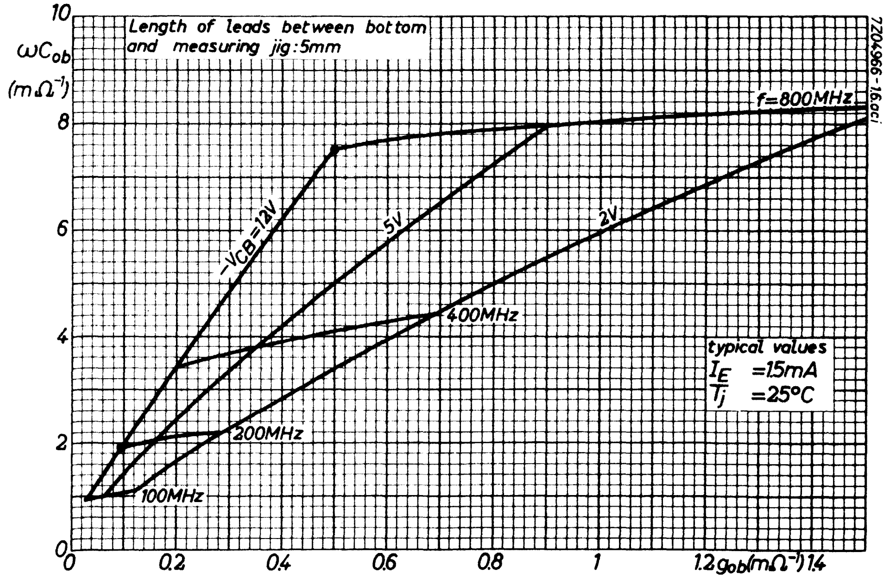
The reverse transducer gain is measured in the above circuit, with the signal generator and the load (receiver) interchanged.


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

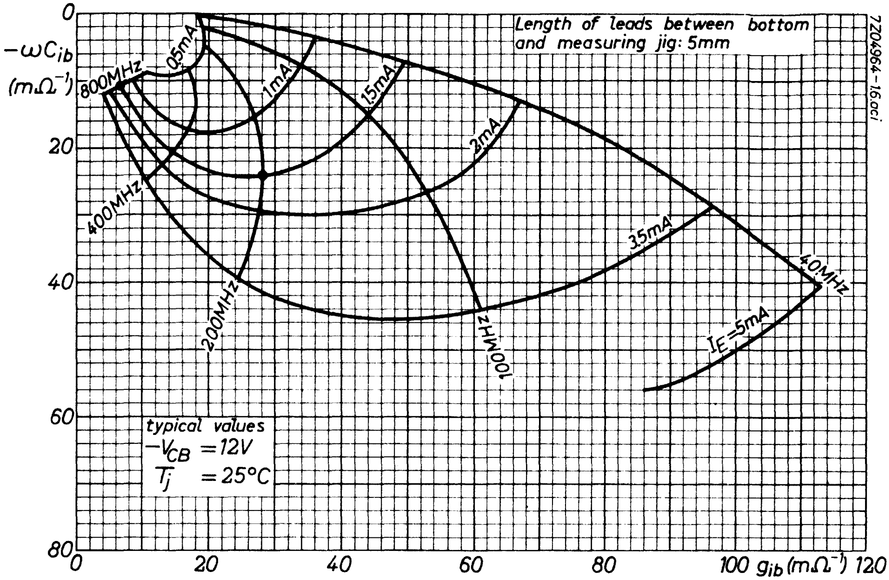

7Z05407-1.6.aci
F (dB)
10
8
6
4
2
0
I_E = 1.5mA
$-V_{CB}$ = 12V
R_S = 60Ω
T_j = 25°C
typ
0.1
1
10
100
f (MHz)
1000



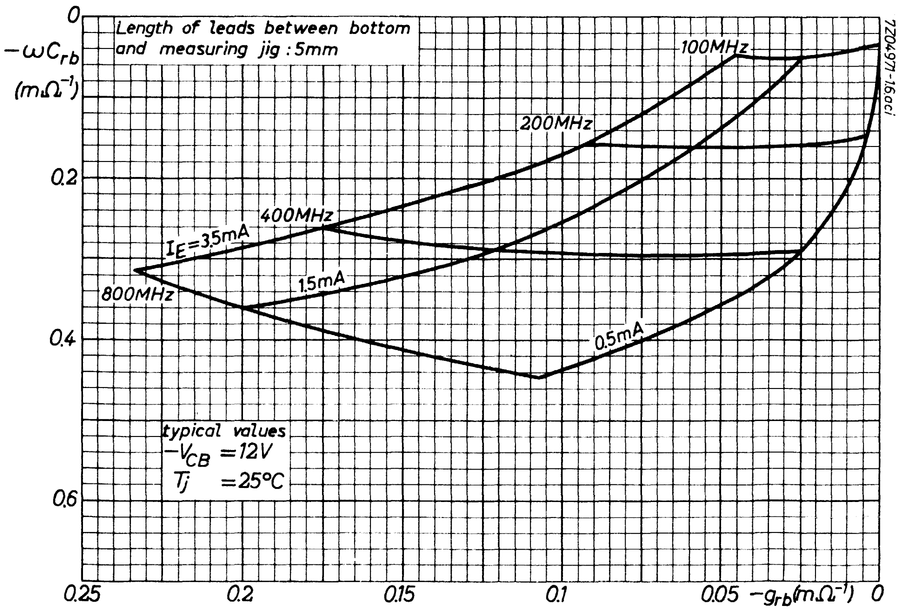
Tj=25°C
600
f_T
(MHz)
400
200
0
0
1
2
3
4
-I_C (mA)
5
typ
typ
-V_CE=12V
6V
7Z04963-1.6.aci



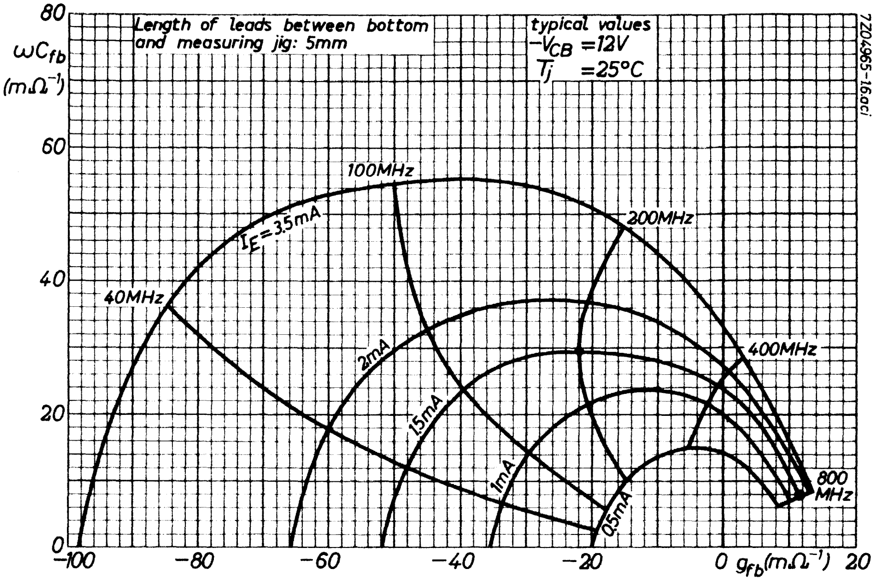
10
ωC_ob
(mΩ⁻¹)
8
6
4
2
0
0
0.2
0.4
0.6
0.8
1
1.2 g_ob (mΩ⁻¹) 1.4
Length of leads between bottom and measuring jig: 5mm
f=800MHz
-V_CB=12V
5V
2V
400MHz
200MHz
100MHz
typical values
I_E =1.5mA
T_j =25°C
7Z04966-1.6.aci



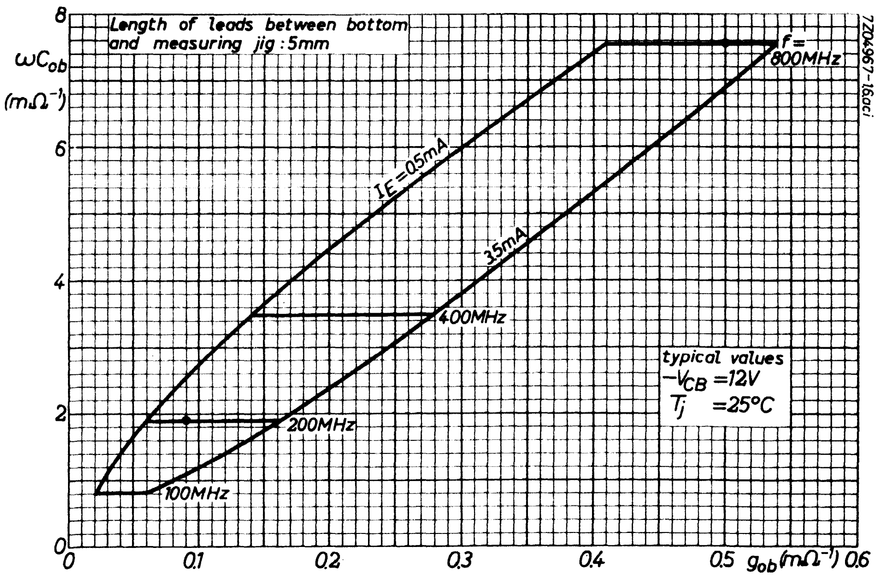
0
$-\omega C_{ib}$
$(m\Omega^{-1})$
20
40
60
80
0
20
40
60
80
100
g_{ib} $(m\Omega^{-1})$
120
Length of leads between bottom and measuring jig: 5mm
7Z04964-1.6.aci
800MHz
0.5mA
1mA
1.5mA
2mA
3.5mA
40MHz
I_E=5mA
400MHz
200MHz
100MHz
typical values
$-V_{CB}$ = 12V
T_j = 25°C



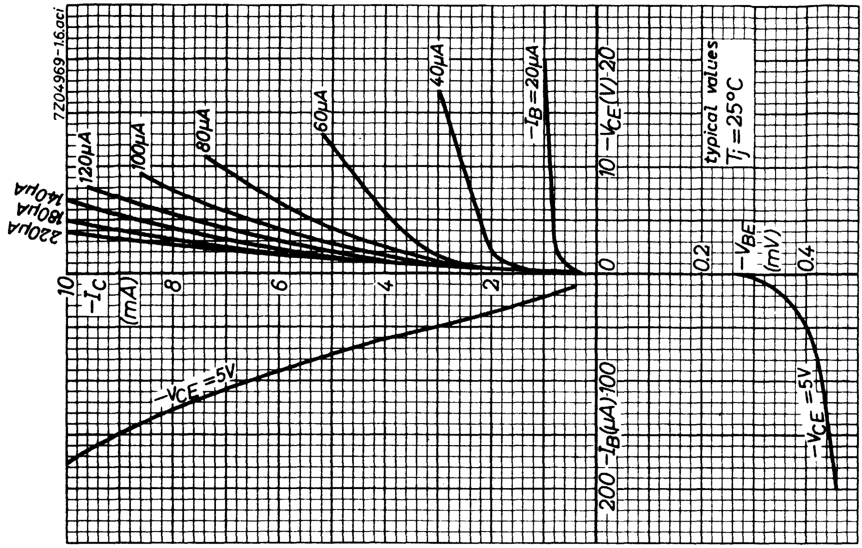
0
$-\omega C_{rb}$
$(m\Omega^{-1})$
0.2
0.4
0.6
0.25
0.2
0.15
0.1
0.05
$-g_{rb}$ $(m\Omega^{-1})$
0
Length of leads between bottom and measuring jig : 5mm
7Z04971-1.6.aci
100MHz
200MHz
400MHz
I_E=3.5mA
800MHz
1.5mA
0.5mA
typical values
$-V_{CB}$ = 12V
T_j = 25°C

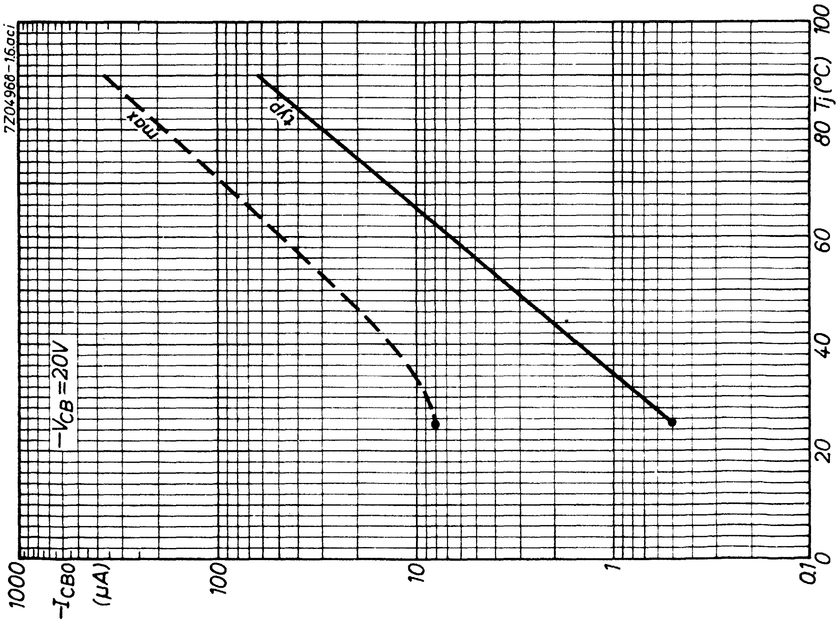


Length of leads between bottom and measuring jig: 5mm
typical values
$-V_{CB}$ =12V
T_j =25°C
7Z04965-16.aci
ωC_{fb} ($m\Omega^{-1}$)
80
60
40
20
0
100MHz
200MHz
400MHz
40MHz
800 MHz
I_E=3.5mA
2mA
1.5mA
1mA
0.5mA
−100
−80
−60
−40
−20
0
g_{fb} ($m\Omega^{-1}$)
20



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


7Z04969-1.6.aci
typical values
$T_j = 25°C$
$-I_B = 20\mu A$
40μA
60μA
80μA
100μA
120μA
140μA
180μA
220μA
$-I_C$ (mA)
10
8
6
4
2
0
10 $-V_{CE}$ (V) 20
$-V_{CE} = 5V$
100
200 $-I_B$ (μA)
0.2
0.4
$-V_{BE}$ (mV)
$-V_{CE} = 5V$


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

U.H.F GERMANIUM MESA TRANSISTOR

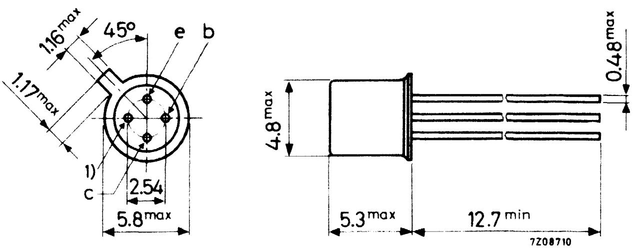
P-N-P transistor in a TO-72 metal envelope, primarily intended for use in pre-amplifier, mixer or oscillator circuits up to frequencies of 890 MHz.

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

MECHANICAL DATA

Dimensions in mm

TO-72



1) = shield lead (connected to case)

Accessories available: 56246, 56263

RATINGS (Limiting values) [1])

Voltages

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

Currents

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

Power dissipation

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

Temperatures

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

THERMAL RESISTANCE

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

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

CHARACTERISTICS T_j = 25 °C unless otherwise specified

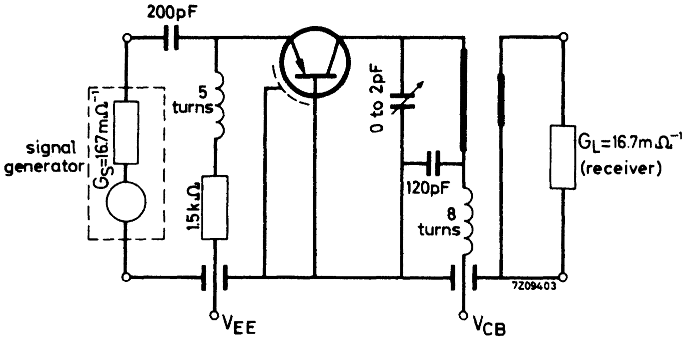
Collector cut-off current		
V_{EB} = 0; $-V_{CB}$ = 20 V	$-I_{CBS}$	typ. 0.5 μA < 8 μA
I_B = 0; $-V_{CE}$ = 15 V	$-I_{CEO}$	< 500 μA
Emitter cut-off current		
I_C = 0; $-V_{EB}$ = 0.3 V	$-I_{EBO}$	< 100 μA
Base current		
I_E = 2 mA; $-V_{CB}$ = 10 V	$-I_B$	typ. 60 μA < 200 μA
I_E = 5 mA; $-V_{CB}$ =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

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

CHARACTERISTICS (continued)

Transducer gain at T_{amb} = 25 °C

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

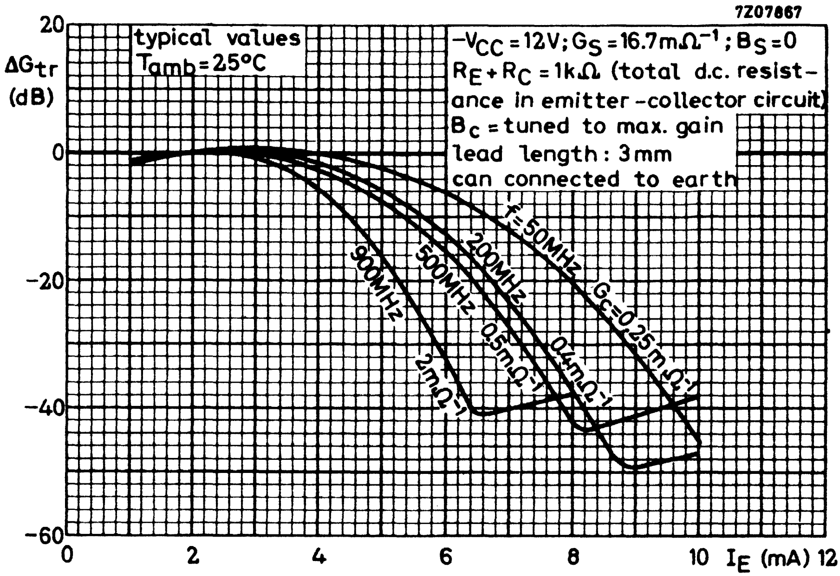


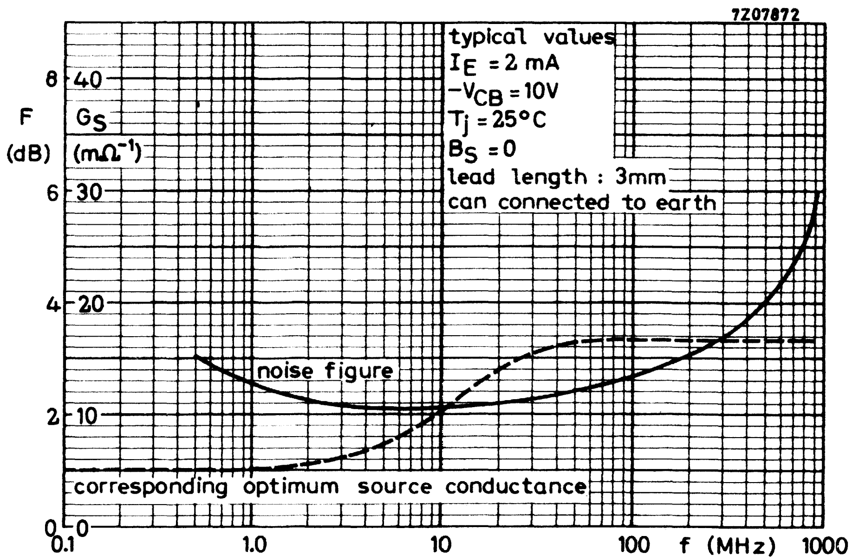
$$G_{tr} = \frac{\text{output power in load } G_L}{\text{available power from source } G_S}$$

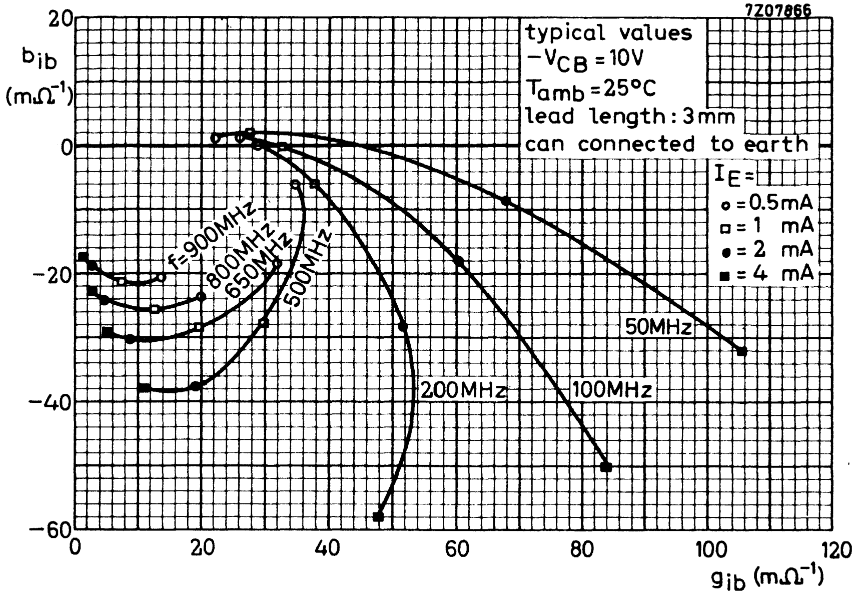
I_E = 2 mA; $-V_{CB}$ = 10 V; lead length: 3 mm; can connected to earth.

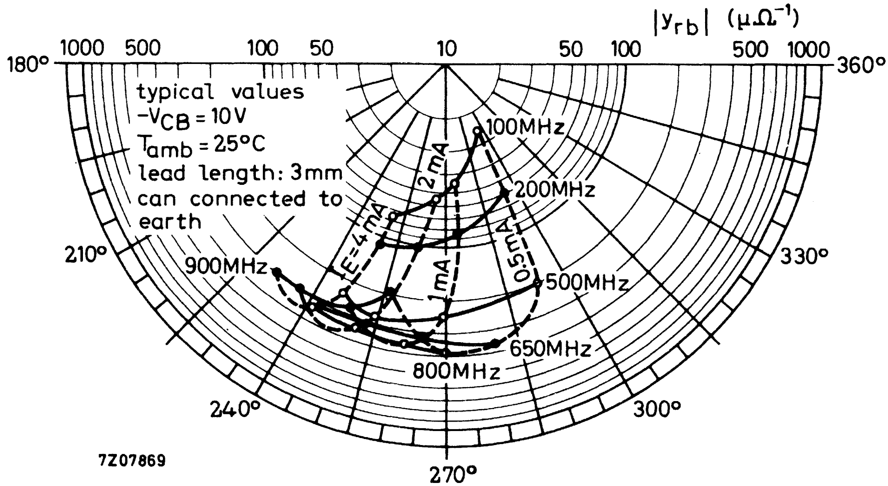
f = 50 MHz; G_c = 0.25 mΩ^{-1}	G_{tr}	typ.	22.5	dB
f = 200 MHz; G_c = 0.4 mΩ^{-1}	G_{tr}	typ.	21.5	dB
f = 500 MHz; G_c = 0.5 mΩ^{-1}	G_{tr}	typ.	18	dB
f = 800 MHz; G_c = 0.5 mΩ^{-1}	G_{tr}	>	11.5	dB
		typ.	14	dB
G_c = 2 mΩ^{-1}	G_{tr}	>	9	dB
		typ.	11.5	dB
f = 900 MHz; G_c = 0.5 mΩ^{-1}	G_{tr}	typ.	12.5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

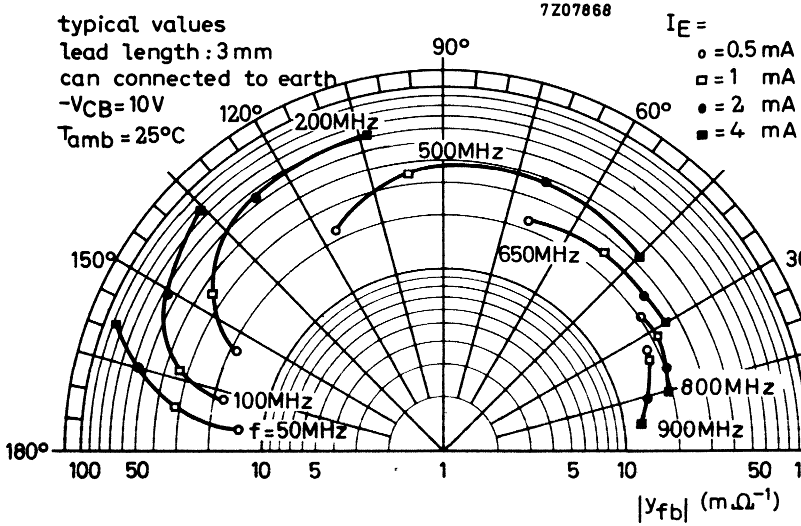
G_c = total effective collector conductance.

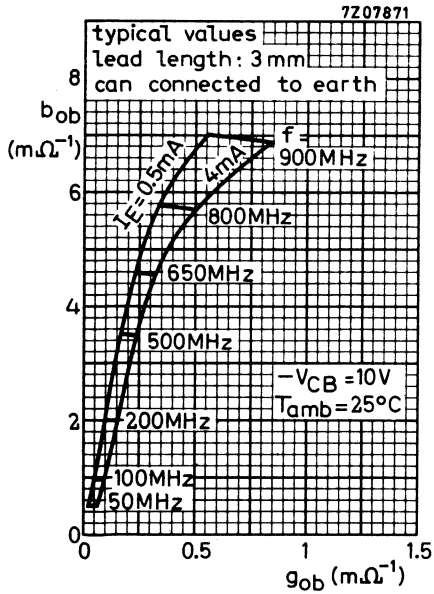

7Z07867
typical values
T_{amb} = 25°C
$-V_{CC}$ = 12V; G_S = 16.7mΩ⁻¹; B_S = 0
$R_E + R_C$ = 1kΩ (total d.c. resistance in emitter-collector circuit)
B_C = tuned to max. gain
lead length: 3mm
can connected to earth
ΔGtr (dB)
20
0
-20
-40
-60
0
2
4
6
8
10
IE (mA)
12
f = 50MHz
200MHz
500MHz
900MHz
Gc =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

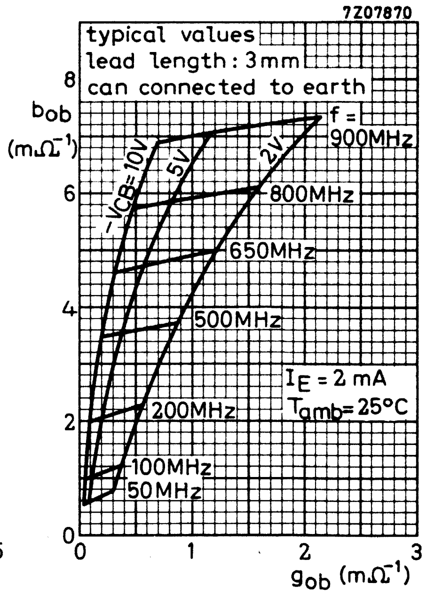

7Z07872
typical values
I_E = 2 mA
$-V_{CB}$ = 10V
T_j = 25°C
B_S = 0
lead length : 3mm
can connected to earth
F (dB)
Gs (mΩ⁻¹)
0
2
4
6
8
10
20
30
40
noise figure
corresponding optimum source conductance
0.1
1.0
10
100
f (MHz)
1000

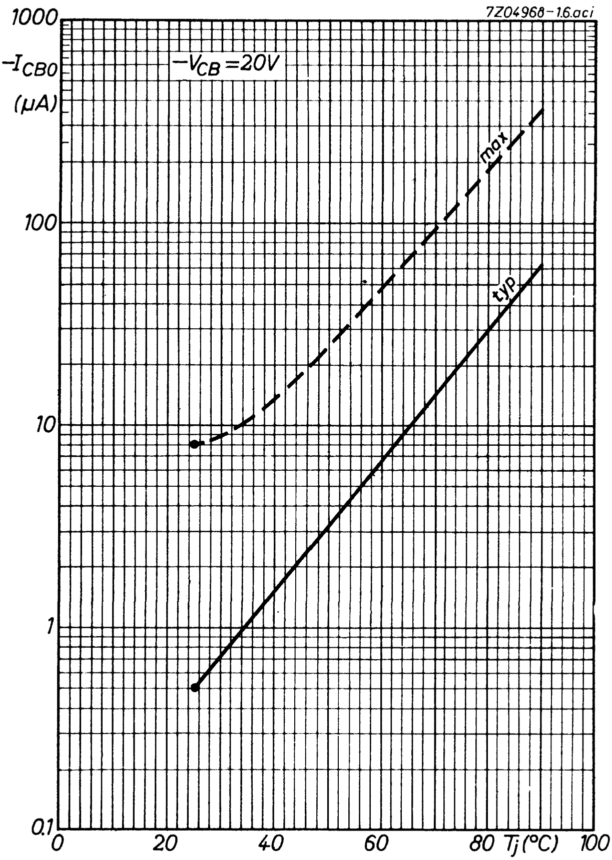

7Z07866
typical values
$-V_{CB}$ = 10V
T_{amb} = 25°C
lead length: 3mm
can connected to earth
I_E =
= 0.5mA
= 1 mA
= 2 mA
= 4 mA
b_{ib} (mΩ⁻¹)
20
0
−20
−40
−60
0
20
40
60
80
100
120
g_{ib} (mΩ⁻¹)
f = 900MHz
800MHz
650MHz
500MHz
200MHz
100MHz
50MHz


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


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


7Z07871
typical values
lead length : 3 mm
can connected to earth
b_{ob} (mΩ⁻¹)
I_E = 0.5mA
4mA
f = 900MHz
800MHz
650MHz
500MHz
200MHz
100MHz
50MHz
$-V_{CB}$ = 10V
T_{amb} = 25°C
0
2
4
6
8
0.5
1
1.5
g_{ob} (mΩ⁻¹)


7Z07870
typical values
lead length : 3 mm
can connected to earth
b_{ob} (mΩ⁻¹)
$-V_{CB}$ = 10V
5V
2V
f = 900MHz
800MHz
650MHz
500MHz
200MHz
100MHz
50MHz
I_E = 2 mA
T_{amb} = 25°C
0
2
4
6
8
1
2
3
g_{ob} (mΩ⁻¹)


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

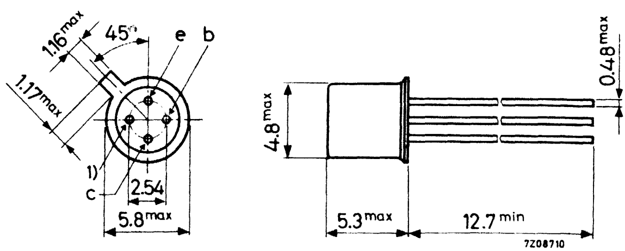
U.H.F. GERMANIUM MESA TRANSISTOR

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

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

MECHANICAL DATA Dimensions in mm

TO-72



1) = shield lead (connected to case)

Accessories available: 56246, 56263

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

Voltages

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

Currents

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

Power dissipation

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

Temperatures

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

THERMAL RESISTANCE

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

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

V_{EB} = 0; $-V_{CB}$ = 20 V	$-I_{CBS}$	typ.	0.5	μA
		<	8	μA
I_B = 0; $-V_{CE}$ = 15 V	$-I_{CEO}$	<	500	μA

Emitter cut-off current

I_C = 0; $-V_{EB}$ = 0.3 V	$-I_{EBO}$	<	100	μA

Base current

I_E = 2 mA; $-V_{CB}$ = 10 V	$-I_B$	typ.	60	μA
		<	200	μA
I_E = 5 mA; $-V_{CB}$ = 5 V	$-I_B$	typ.	167	μA
I_E = 10 mA; $-V_{CB}$ = 2 V	$-I_B$	<	1	mA

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

Emitter-base voltage

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

Transition frequency

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

Feedback capacitance at f = 1 MHz

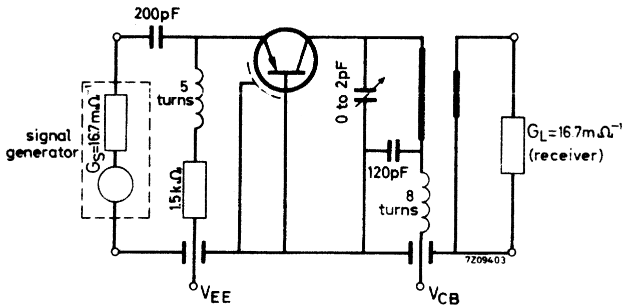
$-I_C$ = 2 mA; $-V_{CE}$ = 10 V	$-C_{re}$	typ.	200	fF

Noise figure

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

Transducer gain at T_{amb} = 25 °C

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

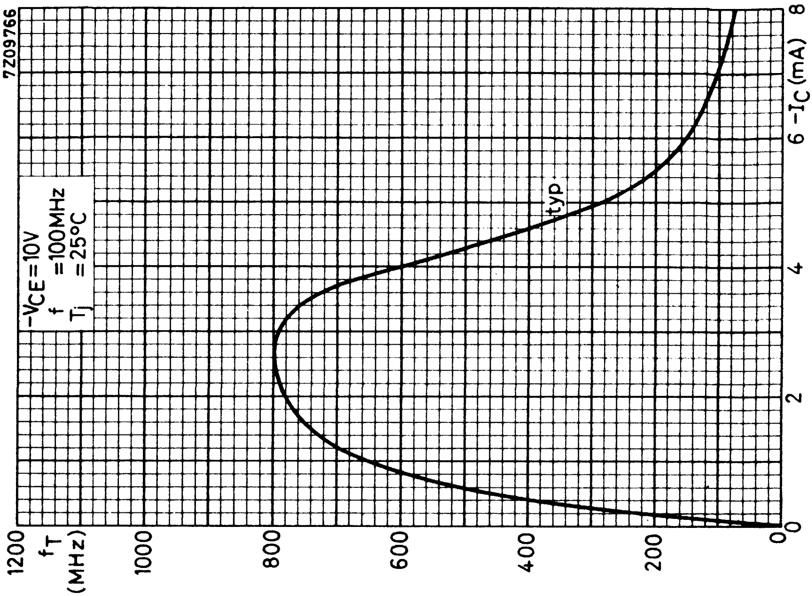


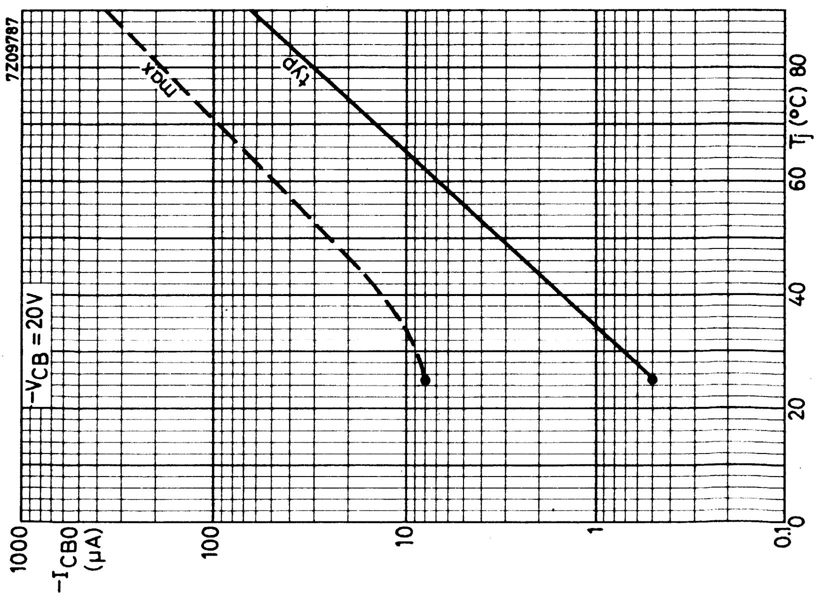
$$G_{tr} \text{ in dB} = 10 \log \frac{\text{output power in load } G_L}{\text{available power from source } G_S}$$

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

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

G_c = total effective collector conductance.


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

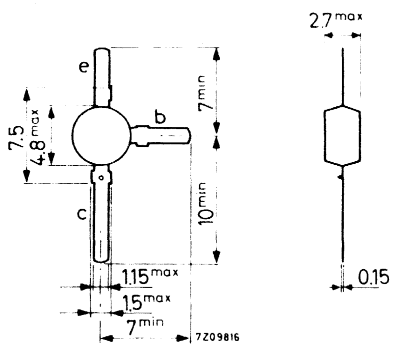

7Z09787
$-V_{CB} = 20V$
max
typ
$-I_{CBO}$ (μA)
1000
100
10
1
0.1
0
20
40
60
80
T_j (°C)

U.H.F. GERMANIUM SEMIPLANAR TRANSISTOR

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

QUICK REFERENCE DATA				
Collector-base voltage (V_{BE} = 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} = 50 °C	P_{tot}	max.	60	mW
Junction temperature	T_j	max.	90	°C
Transition frequency at f = 100 MHz $-I_C$ = 2 mA; $-V_{CE}$ = 10 V	f_T	typ.	780	MHz
Transducer gain at $-I_C$ = 2 mA; $-V_{CE}$ = 10 V f = 900 MHz; G_C = 2 mA/V	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



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

Voltages

Collector-base voltage (V_{BE} = 0)	$-V_{CBS}$	max.	20	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	15	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	0.3	V

Currents

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

Power dissipation

Total power dissipation up to T_{amb} = 50 °C	P_{tot}	max.	60	mW

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.6	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

$-V_{CB}$ = 20 V; V_{EB} = 0	$-I_{CBS}$	typ.	0.8	μA
		<	15	μA
$-V_{CE}$ = 15 V; I_B = 0	$-I_{CEO}$	<	500	μA

Emitter cut-off current

I_C = 0; $-V_{EB}$ = 0.3 V	$-I_{EBO}$	<	100	μA

D.C. current gain

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

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

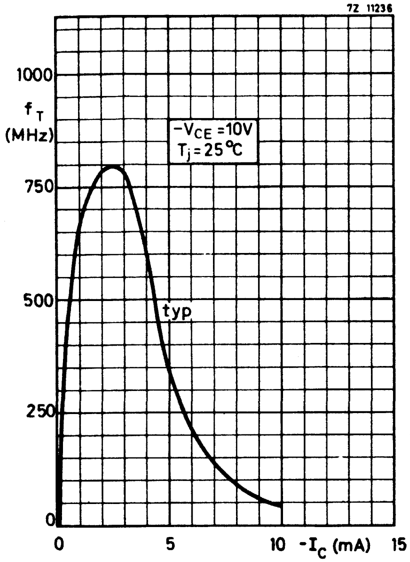
Base-emitter voltage				
$-I_C$ = 2 mA; $-V_{CE}$ = 10 V	$-V_{BE}$	typ.	350	mV
Transition frequency at f = 100 MHz				
$-I_C$ = 2 mA; $-V_{CE}$ = 10 V	f_T	typ.	780	MHz
Feedback capacitance at f = 0.45 MHz				
$-I_C$ = 2 mA; $-V_{CE}$ = 10 V	$-C_{re}$	typ.	400	fF
Output capacitance at f = 900 MHz				
$-I_C$ = 2 mA; $-V_{CE}$ = 10 V	C_{oe}	typ.	500	fF
Noise figure				
$-I_C$ = 2 mA; $-V_{CE}$ = 10 V G_S = 16.7 mA/V; B_S = 0 f = 900 MHz	F	<	6	dB

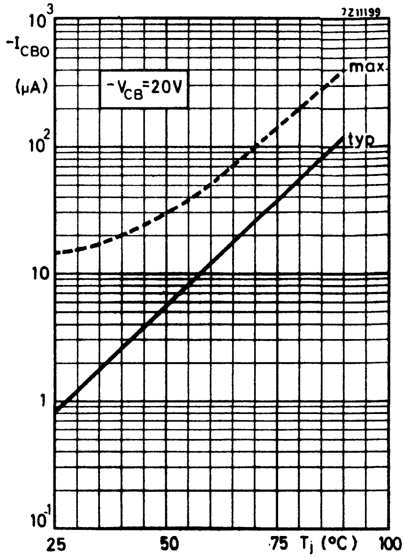
Transducer gain at T_{amb} = 25 °C

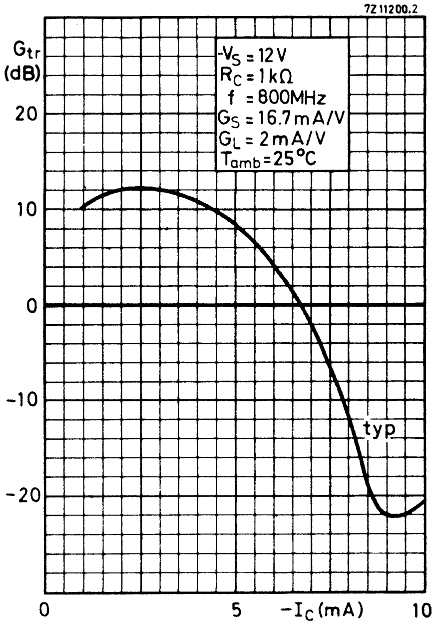
$$G_{tr} \text{ in dB} = 10 \log \frac{\text{output power in load } G_L}{\text{available power from source } G_S}$$

$-I_C$ = 2 mA; $-V_{CE}$ = 10 V f = 900 MHz; G_c = 2 mΩ^{-1}; G_S = 16.7 mA/V	G_{tr}	> typ.	10.5 12	dB dB

G_c = total effective collecor conductance.


7Z 11236
1000
f_T
(MHz)
750
500
250
0
$-V_{CE} = 10V$
$T_j = 25\,^{\circ}C$
typ
0
5
10
$-I_C$ (mA)
15


7Z11199
10^3
$-I_{CBO}$
(μA)
$-V_{CB} = 20V$
max.
10^2
typ
10
1
10^{-1}
25
50
75
T_j (°C)
100


7Z11200.2
G_{tr}
(dB)
20
10
0
-10
-20
$-V_S = 12\,V$
$R_C = 1\,k\Omega$
$f = 800MHz$
$G_S = 16.7\,mA/V$
$G_L = 2\,mA/V$
$T_{amb} = 25\,^{\circ}C$
typ
0
5
$-I_C$ (mA)
10

SILICON PLANAR EPITAXIAL TRANSISTOR

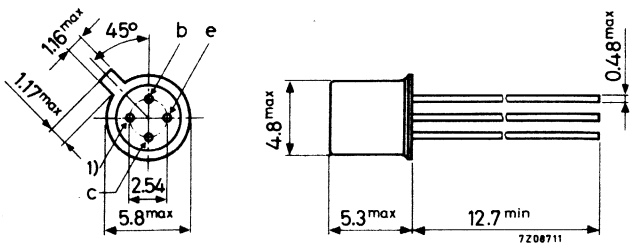
N-P-N transistor in TO-72 metal case with insulated electrodes and a shield lead connected to the case; the same transistor is available in lock-fit encapsulation under the type number BF194 or BF195. It is intended for general broadcast and television.

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

MECHANICAL DATA

Dimensions in mm

TO-72



1) = shield lead (connected to case)

Accessories available: 56246, 56263.

FOR NEW DESIGN THE SUCCESSOR TYPES
BF494 OR BF495 ARE RECOMMENDED

RATINGS (Limiting values) [1]

Voltages

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

Currents

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

Power dissipation

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

Temperatures

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

THERMAL RESISTANCE

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

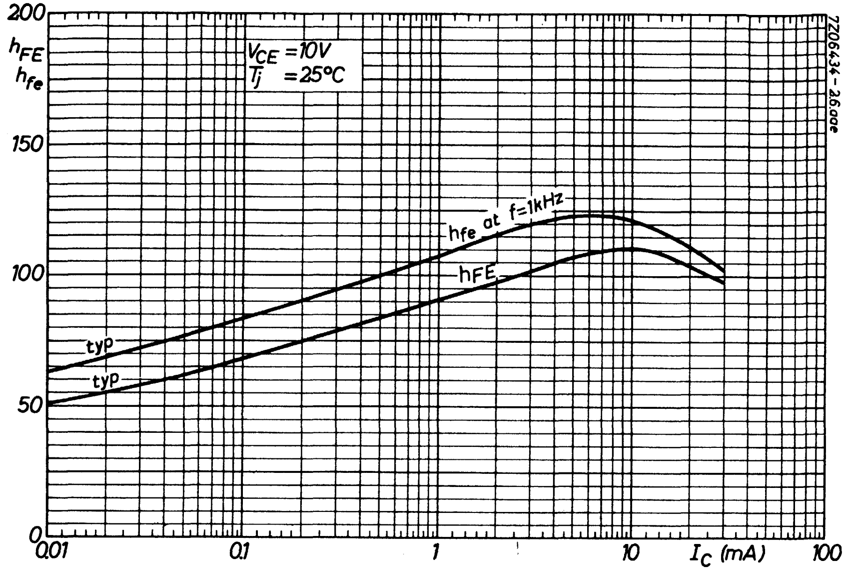
[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

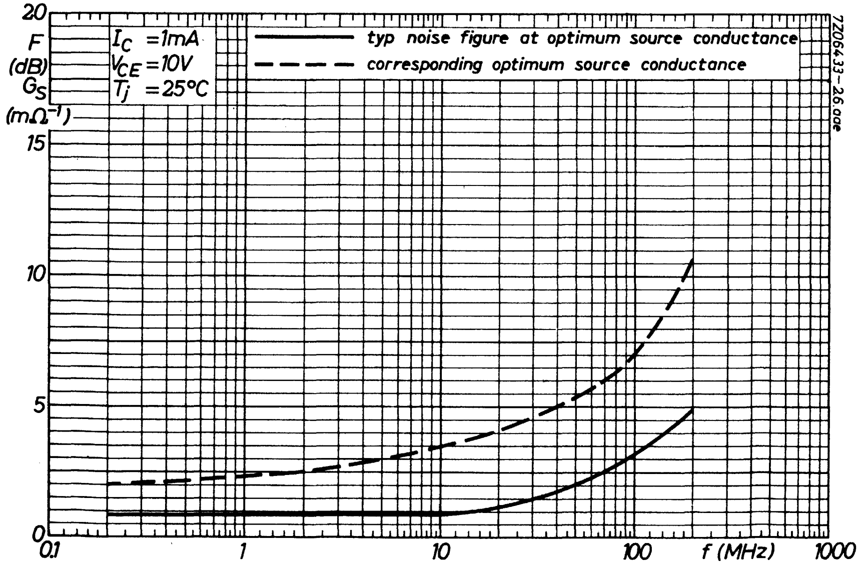
CHARACTERISTICS

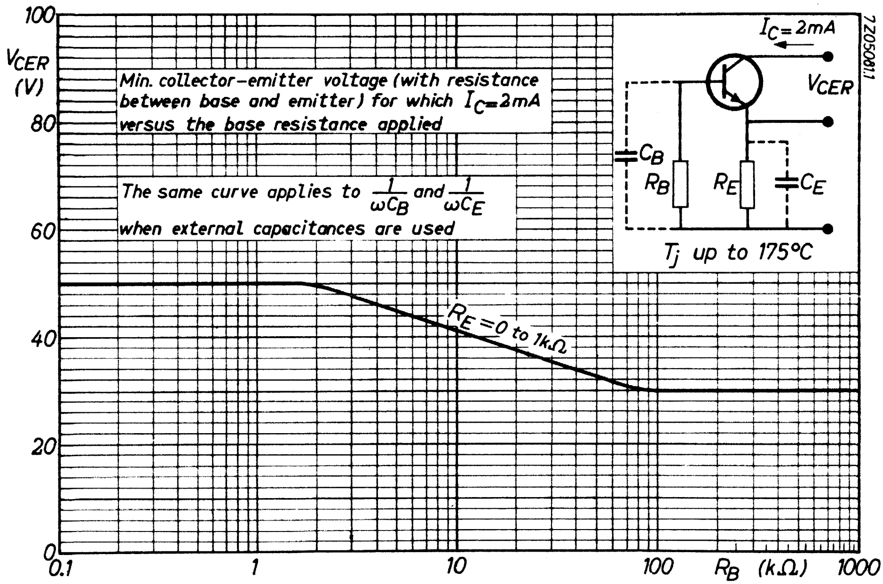
T_j = 25 °C unless otherwise specified

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

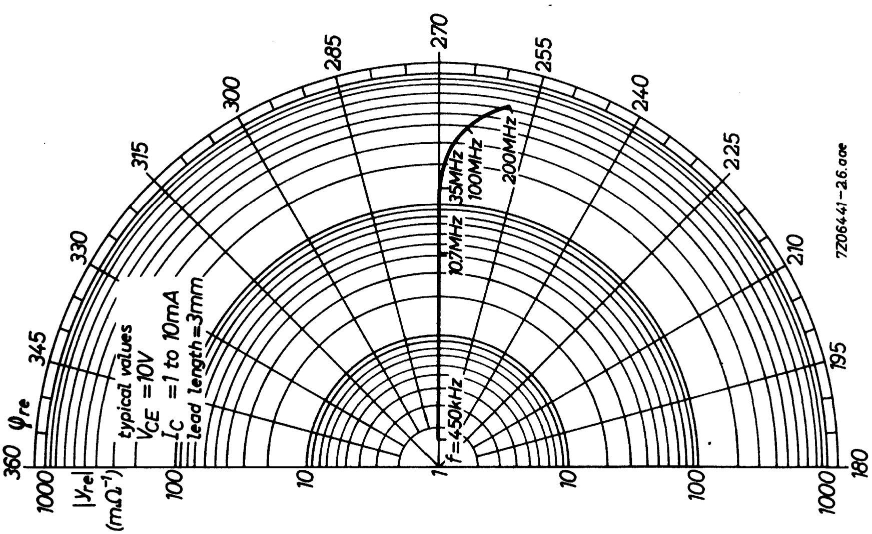
[1]) $-V_{EB}$ decreases by about 1.7 mV/°C with increasing temperature.

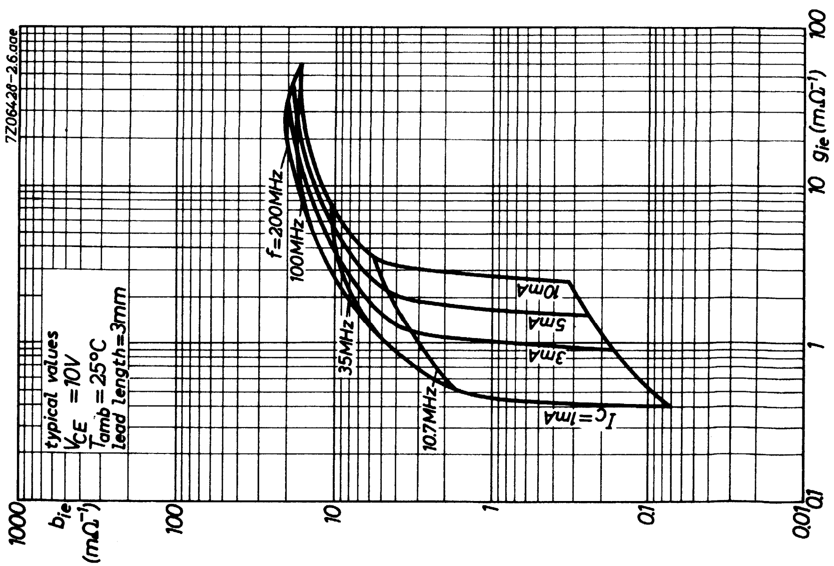

200
h_{FE}
h_{fe}
150
100
50
0
V_{CE} = 10V
T_j = 25°C
h_{fe} at f=1kHz
h_{FE}
typ
typ
0.01
0.1
1
10
I_C (mA)
100
7Z06434-26.aae

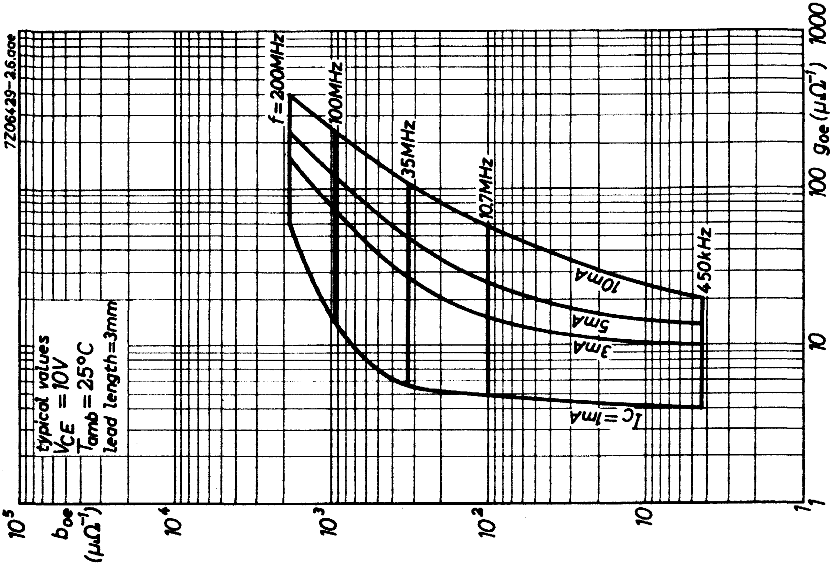

20
F
(dB)
G_S
(mΩ^{-1})
15
10
5
0
I_C = 1mA
V_{CE} = 10V
T_j = 25°C
typ noise figure at optimum source conductance
corresponding optimum source conductance
0.1
1
10
100
f (MHz)
1000
7Z06433-26.aae

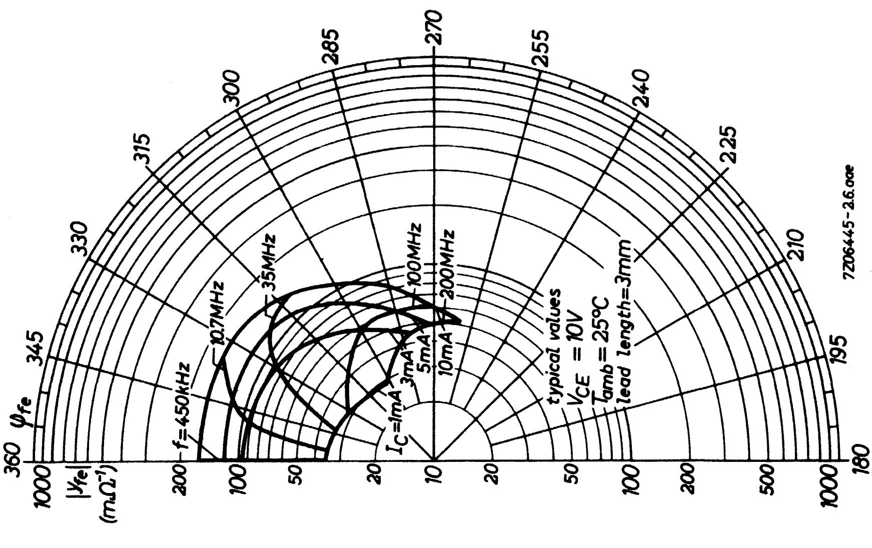


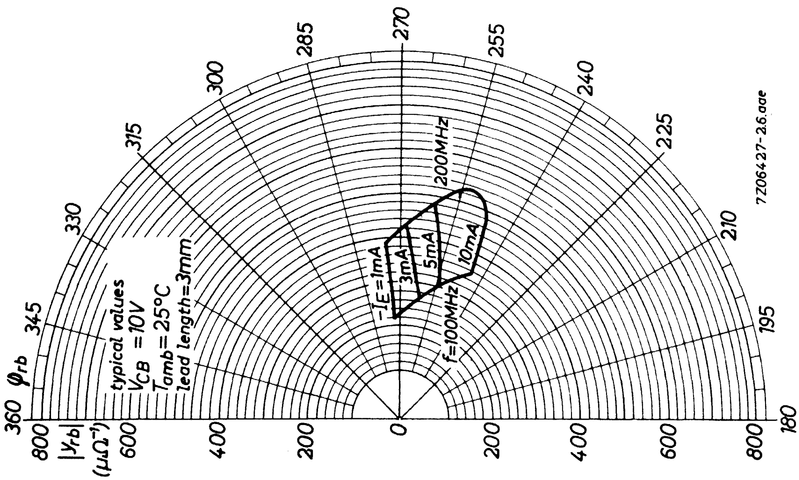
100
80
60
40
20
0
V_{CER} (V)
Min. collector-emitter voltage (with resistance between base and emitter) for which I_C=2mA versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$ when external capacitances are used
R_E=0 to 1kΩ
I_C=2mA
V_{CER}
C_B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

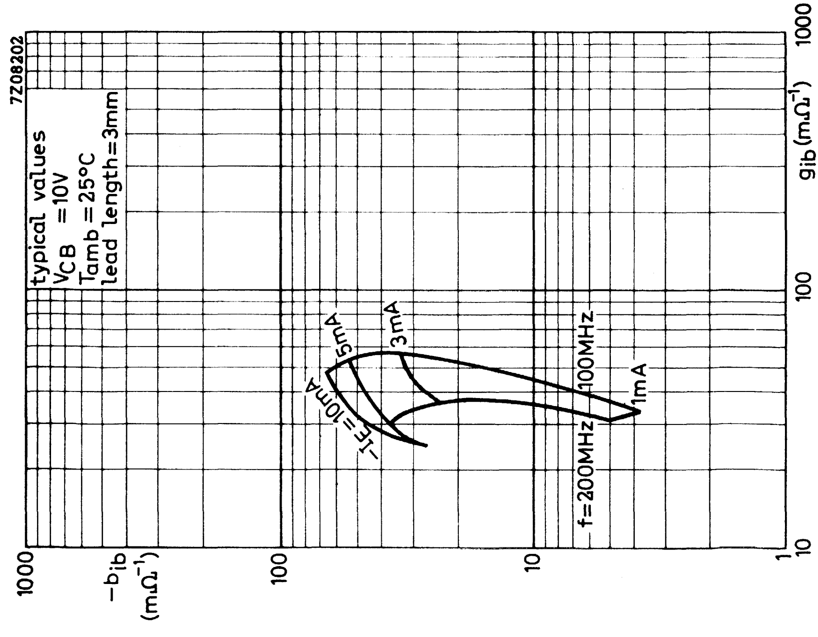

φre
360
345
330
315
300
285
270
255
240
225
210
195
180
|yre| (mΩ⁻¹)
1000
100
10
1
10
100
1000
typical values
VCE = 10V
IC = 1 to 10mA
lead length = 3mm
f = 450kHz
10.7MHz
35MHz
100MHz
200MHz
7Z06441-2.6.aae

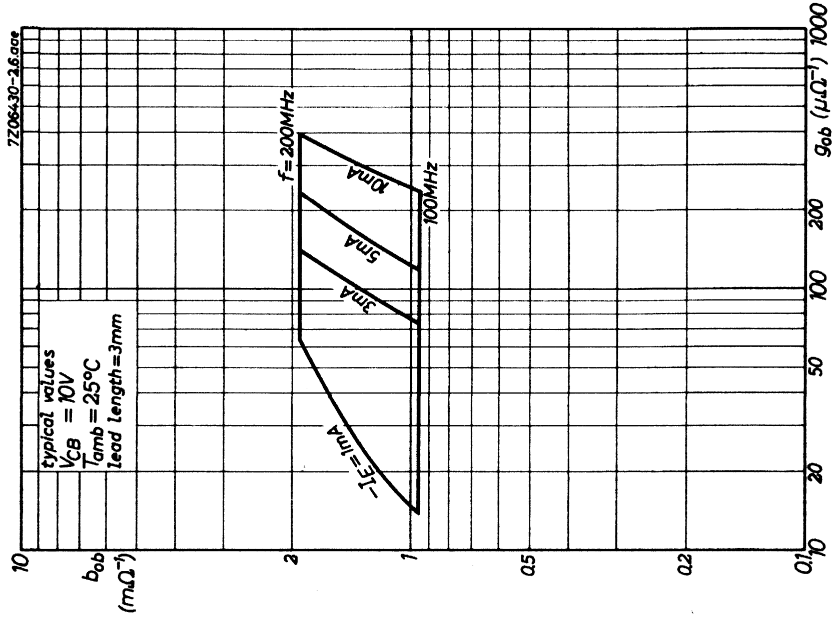

7Z06428-2.6.aae
typical values
VCE = 10V
Tamb = 25°C
lead length = 3mm
bie (mΩ⁻¹)
1000
100
10
1
0.1
0.01
0.1
1
10
100
gie (mΩ⁻¹)
f = 200MHz
100MHz
35MHz
10.7MHz
IC = 1mA
3mA
5mA
10mA

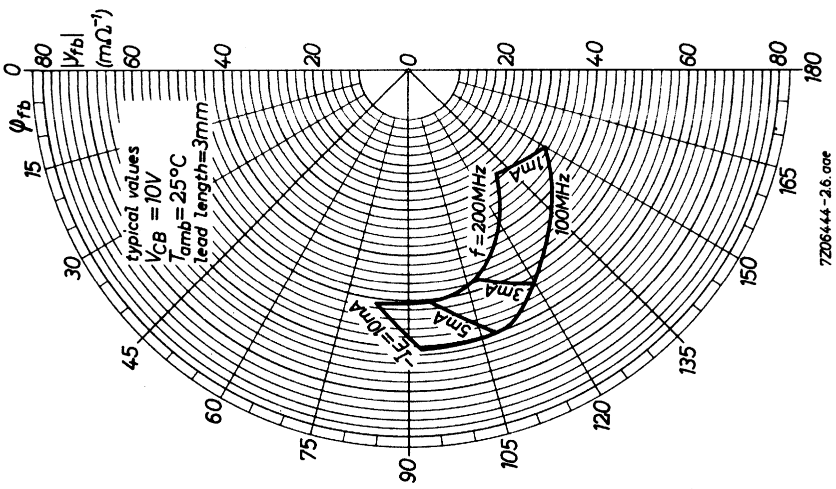

7Z06429-2.6.aoe
typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length=3mm
f=200MHz
100MHz
35MHz
10.7MHz
450kHz
10mA
5mA
3mA
I_C=1mA
b_{oe} ($\mu\Omega^{-1}$)
g_{oe} ($\mu\Omega^{-1}$)


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


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


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


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


φ_{fb}
$|y_{fb}|$ (mΩ⁻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

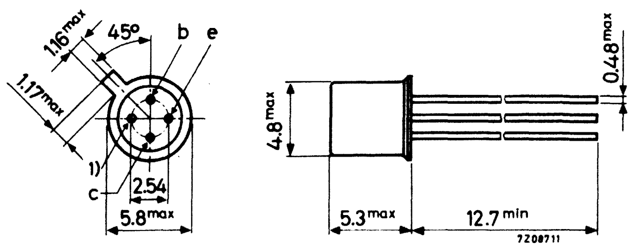
N-P-N transistor in a TO-72 metal envelope with a shield lead connected to the case; the same transistor is available in lock-fit encapsulation under the type-number BF196. It has a very low feedback capacitance and is intended for use in forward gain control stages in video intermediate frequency amplifiers of television receivers.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	V
Collector current (d.c.)	I_C	max.	25	mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	130	mW
Junction temperature	T_j	max.	175	°C
Transition frequency				
I_C = 4 mA; V_{CE} = 10 V	f_T	typ.	350	MHz
Feedback capacitance at f = 10.7 MHz				
I_C = 1 mA; V_{CE} = 10 V	$-C_{re}$	typ.	0.15	pF
Max. unilateralised 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 available: 56246, 56263

FOR NEW DESIGN THE TYPES BF196 OR BF198 ARE RECOMMENDED

RATINGS (Limiting values) [1]

Voltages

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

Currents

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

Power dissipation

Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	130	mW

Temperatures

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

THERMAL RESISTANCE

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

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

CHARACTERISTICS

T_{amb} = 25 °C unless otherwise specified

Base current				
I_C = 4 mA; V_{CE} = 10 V	I_B	typ.	70	μA
		<	150	μA
Base-emitter voltage				
I_C = 4 mA; V_{CE} = 10 V	V_{BE}	typ.	700	mV [1]
Feedback capacitance at f = 10.7 MHz				
I_C = 1 mA; V_{CE} = 10 V	$-C_{re}$	typ.	150	fF [2]
Transition frequency				
I_C = 4 mA; V_{CE} = 10 V	f_T	typ.	350	MHz
Noise figure at f = 35 MHz				
I_C = 4 mA; V_{CE} = 10 V; G_S = 10 $m\Omega^{-1}$; 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	$\lvert y_{re}\rvert$	typ.	37	$\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{re}	typ.	268°	
Transfer admittance	$\lvert y_{fe}\rvert$	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

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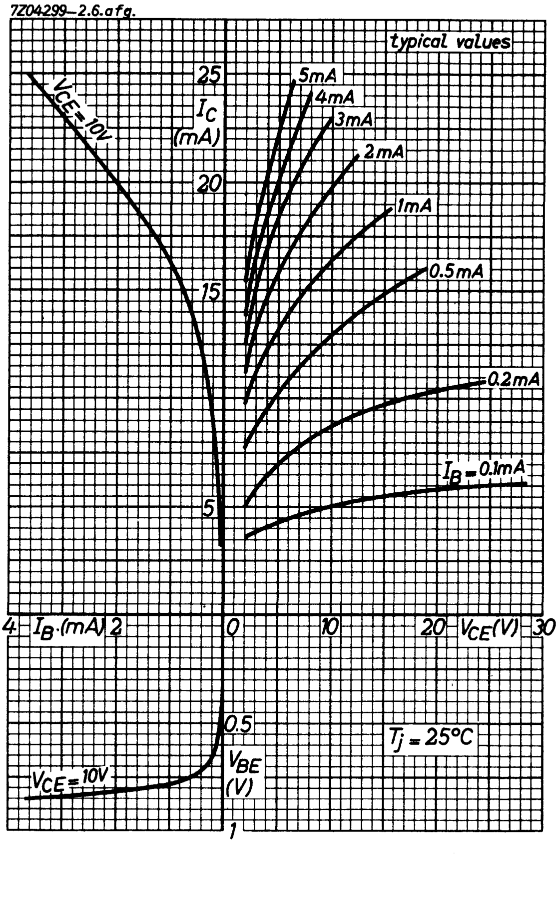
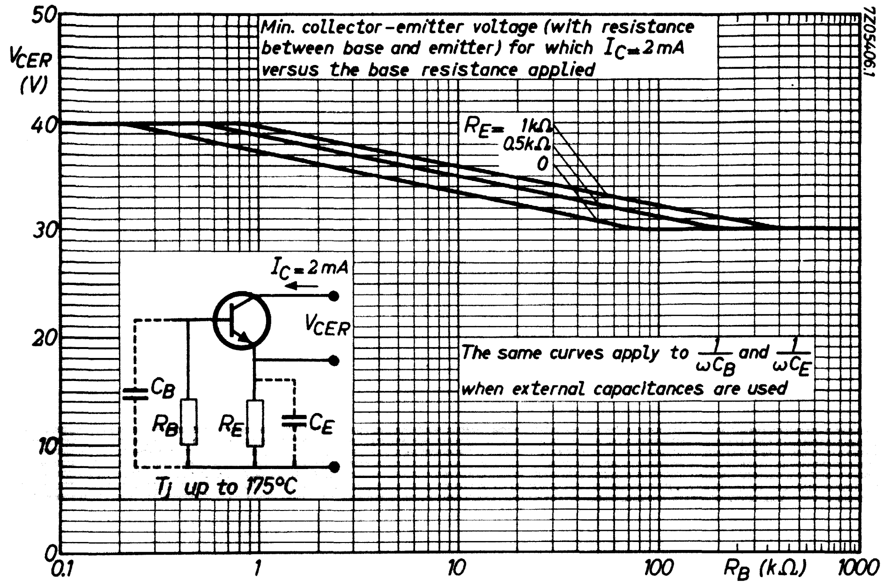
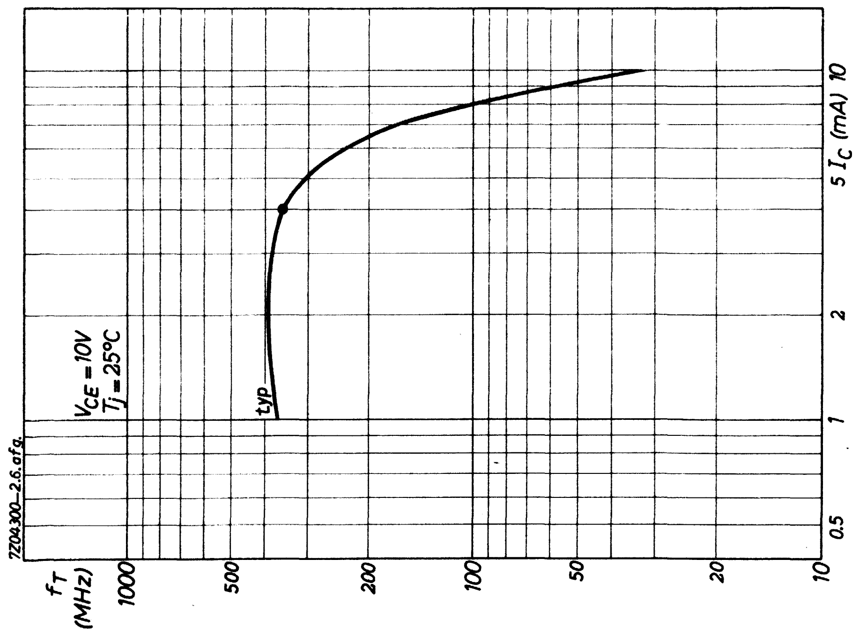
[1]) V_{BE} decreases with about 1.7 mV/°C at increasing temperature

[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


Min. collector-emitter voltage (with resistance between base and emitter) for which $I_C = 2\,mA$ versus the base resistance applied
V_{CER} (V)
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
R_B (kΩ)
7Z54061


$V_{CE} = 10V$
$T_j = 25°C$
typ
I_C (mA)
f_T (MHz)
7Z04300-2.6.afg.

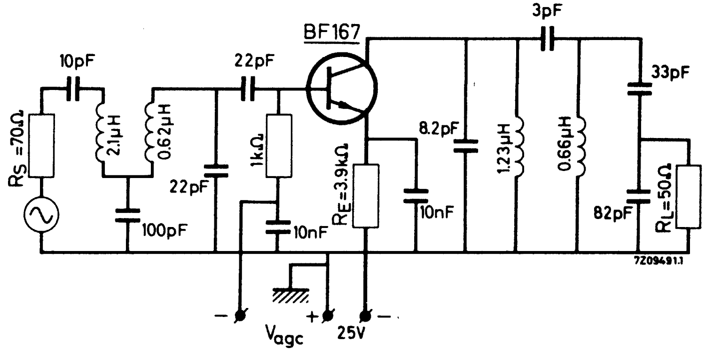
APPLICATION INFORMATION

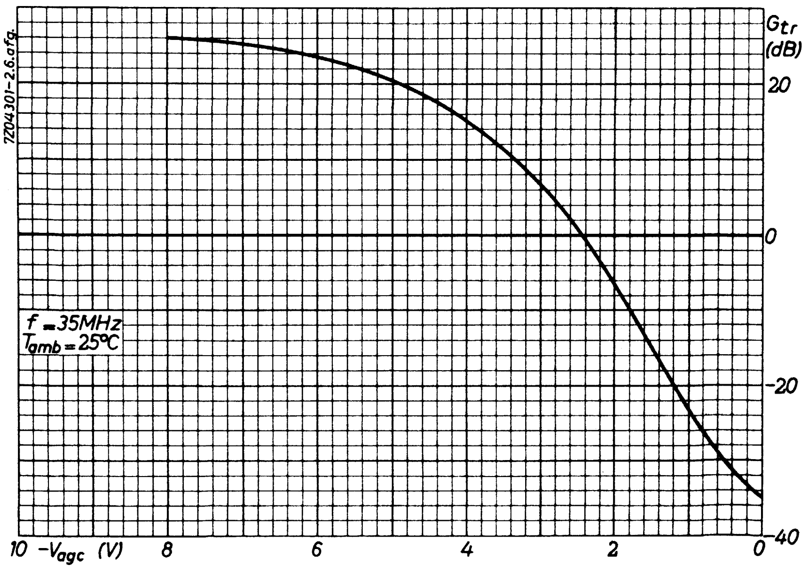
First stage of an intermediate frequency amplifier with a BF167 transistor.
(Basic circuit with voltage gain control).

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





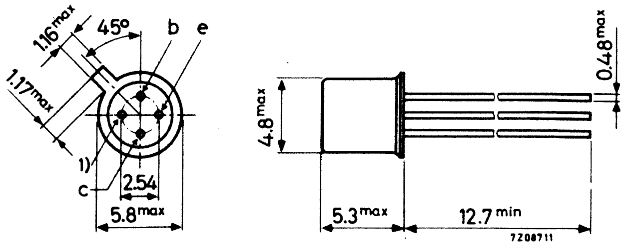
SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a TO-72 metal envelope with a shield lead connected to the case; the same transistor is available in lock-fit encapsulation under the type-number BF197. It has a very low feedback capacitance and is intended for use in video intermediate frequency amplifiers, in particular for the output stages.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Collector current (d.c.)	I_C	max.	25	mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	260	mW
Junction temperature	T_j	max.	175	°C
Transition frequency				
I_C = 5 mA; V_{CE} = 10 V	f_T	typ.	550	MHz
Feedback capacitance at f = 10.7 MHz				
I_C = 1 mA; V_{CE} = 10 V	$-C_{re}$	typ.	0.23	pF
Max. unilateralised power gain				
I_C = 7 mA; V_{CE} = 10 V; f = 35 MHz	G_{UM}	typ.	42.5	dB
Output voltage in the circuit of page 4	V_O	typ.	7.7	V

MECHANICAL DATA Dimensions in mm

TO-72



1) = shield lead (connected to case)

Accessories available: 56246, 56263

FOR NEW DESIGN THE TYPES BF197 OR BF199 ARE 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	$\lvert y_{re}\rvert$	typ. 55 $\mu\Omega^{-1}$	
Phase angle of feedback admittance	φ_{re}	typ. 266°	
Transfer admittance	$\lvert y_{fe}\rvert$	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

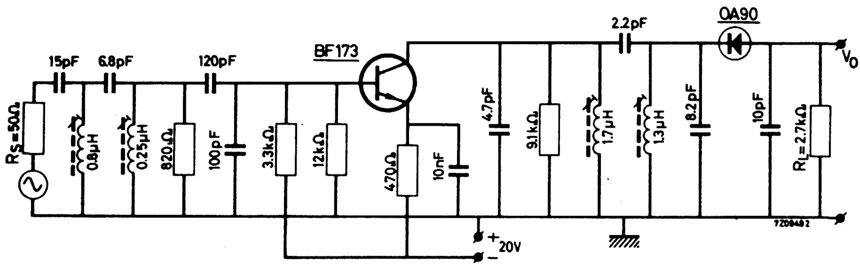
f = 38.9 MHz; I_C = 7.2 mA; V_{CE} = 16.6 V	V_O	>	6	V
		typ.	7.7	V

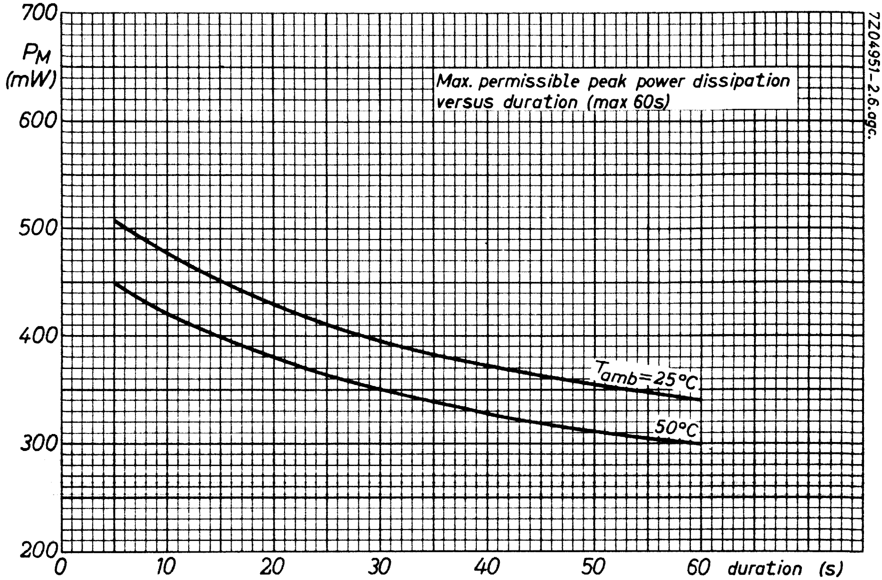
Transducer gain

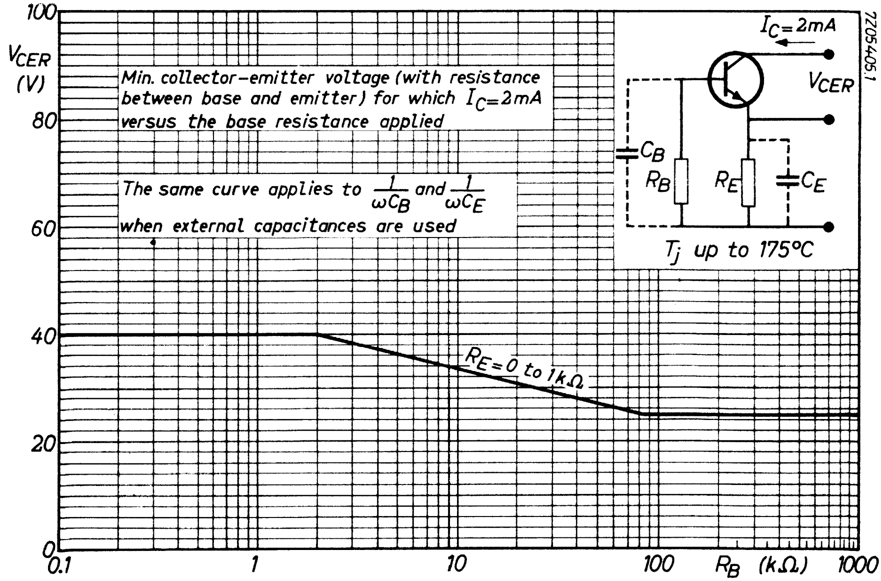
$$G_{tr} = \frac{\text{output power in load } R_L}{\text{available power from source with } R_S}$$

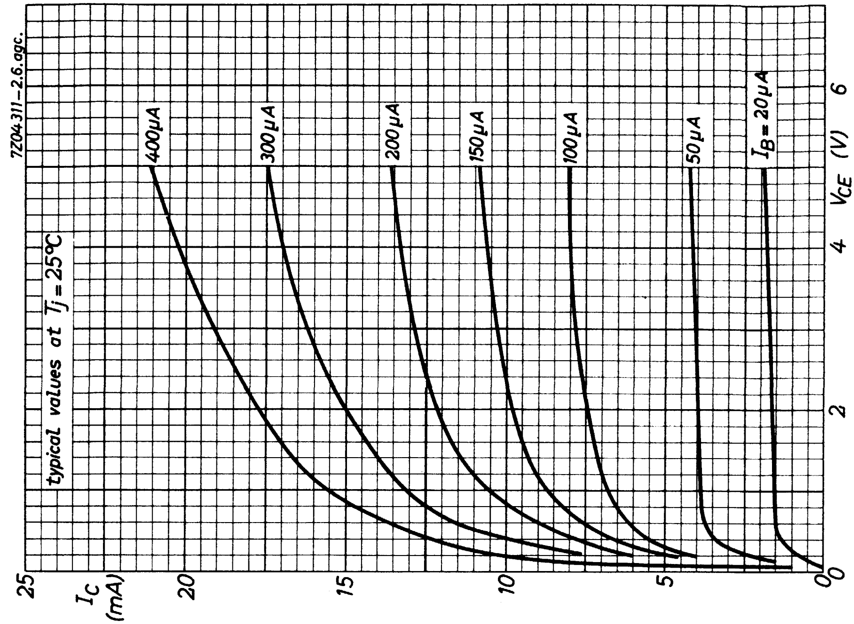
f = 36.4 MHz; I_C = 7.2 mA; V_{CE} = 16.6 V	G_{tr}	typ.	26	dB

Tuning frequency for all tuned circuits is 37 MHz

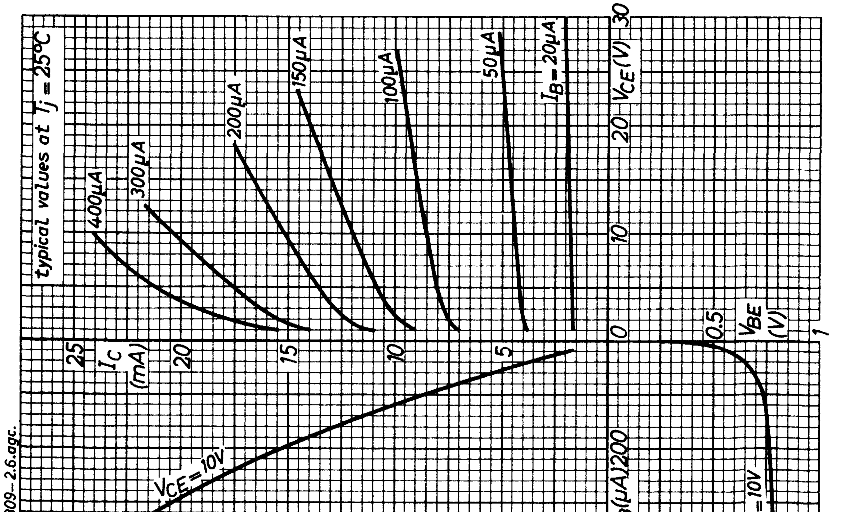



700
P_M
(mW)
600
500
400
300
200
0
10
20
30
40
50
60
duration (s)
Max. permissible peak power dissipation versus duration (max 60s)
T_{amb}=25°C
50°C
7Z04951-2.6.agc.


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 $T_j = 25^\circ C$
400μA
300μA
200μA
150μA
100μA
50μA
$I_B = 20\mu A$
I_C (mA)
V_{CE} (V)
0
5
10
15
20
25
2
4
6



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

VIDEO OUTPUT TRANSISTORS

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

QUICK REFERENCE DATA

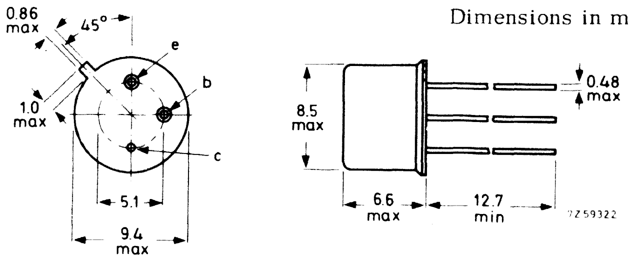
			BF177	BF178	BF179	
Collector-base voltage (open emitter)	V_{CBO}	max.	100	185	250	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	115	115	V
Collector current (peak value)	I_{CM}	max.	50	50	50	mA
Total power dissipation						
up to T_{amb} = 65 °C	P_{tot}	max.	0.6	0.6	0.6	W
up to T_{mb} = 130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

MECHANICAL DATA

Dimensions in mm

TO-39

Collector connected to case



Accessories available: 56218; 56245; 56265

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

Temperatures

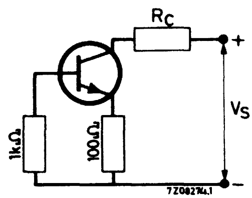
Storage temperature	T_{stg}	−55 to +175	°C
Junction temperature	T_j	max. 200	°C

THERMAL RESISTANCE

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

CHARACTERISTICS

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



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

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

[1] During switching on, a supply voltage of 1.2 times the rated V_{CER} value is permitted.
The current must be limited so that maximum dissipation and maximum junction temperature are not exceeded (see page 6).

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

Base current

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

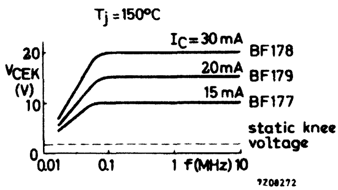
Base-emitter voltage [1]

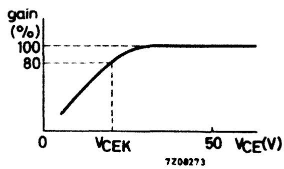
I_C = 15 mA; V_{CE} = 10 V for BF177 I_C = 20 mA; V_{CE} = 15 V for BF179 I_C = 30 mA; V_{CE} = 20 V for BF178	V_{BE}	typ.	0.75	V
		<	1.2	V

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

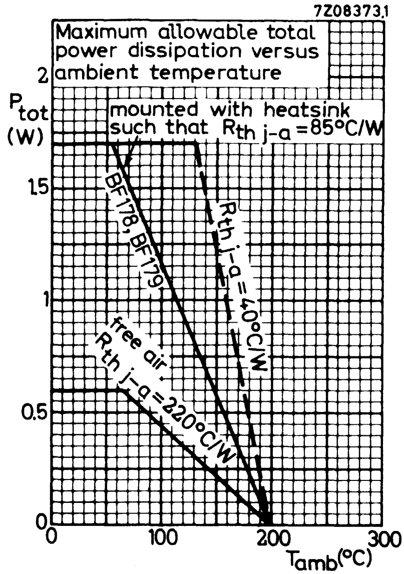
Feedback time constant at f = 10 MHz

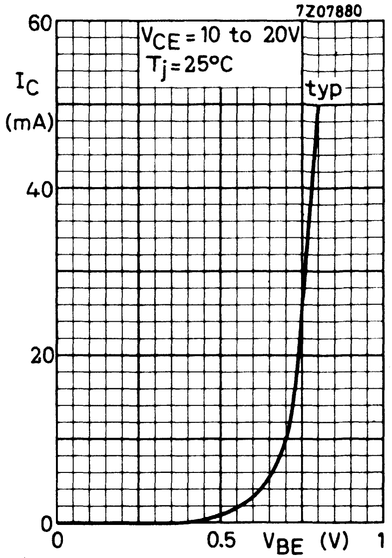
$-I_E$ = 10 mA; V_{CB} = 10 V	$r_{bb'} \cdot C_{b'c}$	typ.	25	ps
		<	100	ps

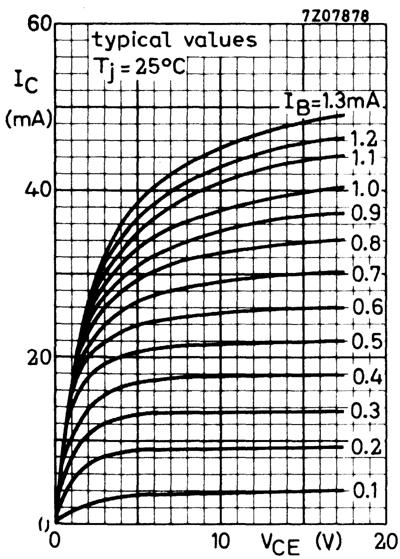
Transition frequency

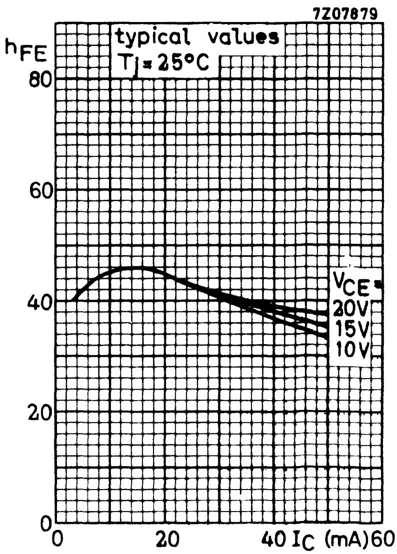
I_C = 10 mA; V_{CE} = 10 V	f_T	typ.	120	MHz

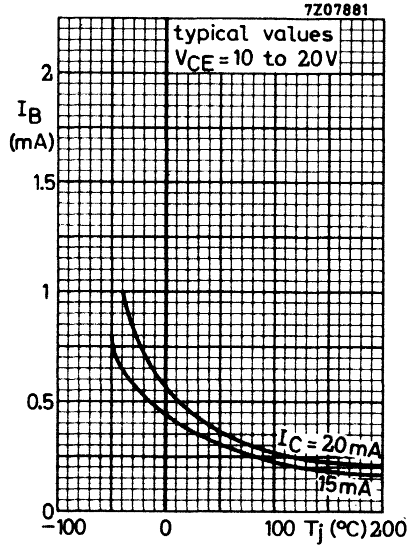
[1] V_{BE} decreases by about 1.6 mV/°C with increasing temperature.

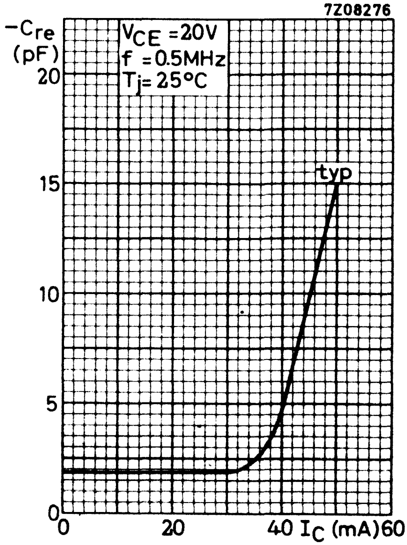

7Z08373.1
Maximum allowable total power dissipation versus ambient temperature
Ptot (W)
mounted with heatsink such that Rth j-a = 85°C/W
BF178, BF179
Rth j-a = 40°C/W
free air
Rth j-a = 220°C/W
Tamb (°C)

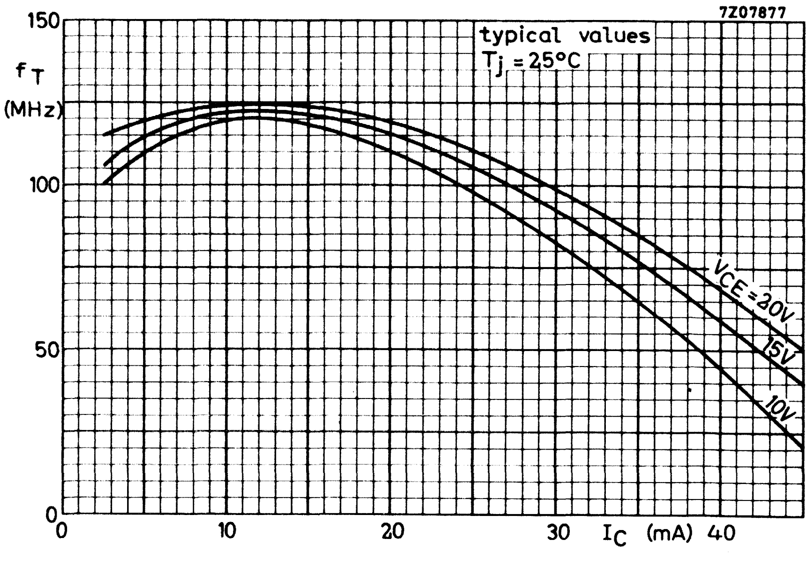

7Z07880
VCE = 10 to 20V
Tj = 25°C
IC (mA)
typ
VBE (V)


7Z07878
typical values
Tj = 25°C
IC (mA)
IB = 1.3mA
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
VCE (V)

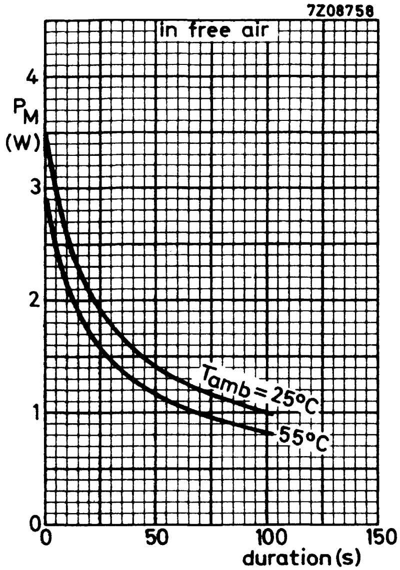

7Z07879
typical values
Tj = 25°C
hFE
VCE =
20V
15V
10V
IC (mA)

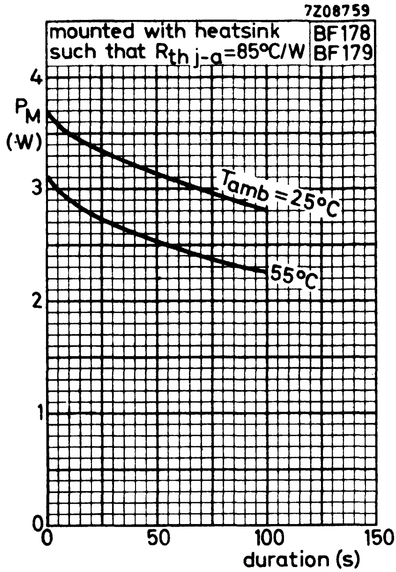

7Z07881
typical values
VCE = 10 to 20V
IB
(mA)
2
1.5
1
0.5
0
IC = 20mA
15mA
−100
0
100 Tj (°C) 200


7Z08276
−Cre
(pF)
VCE = 20V
f = 0.5MHz
Tj = 25°C
20
15
10
5
0
typ
0
20
40 IC (mA) 60


7Z07877
typical values
Tj = 25°C
fT
(MHz)
150
100
50
0
VCE = 20V
15V
10V
0
10
20
30
IC (mA) 40

maximum allowable peak power dissipation versus duration





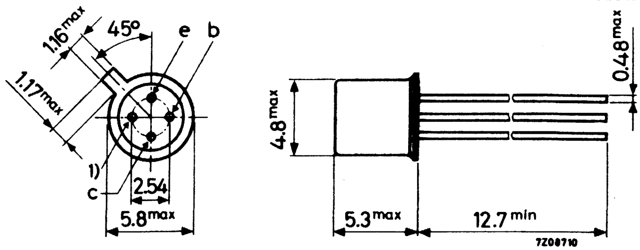
SILICON PLANAR TRANSISTOR

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

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

MECHANICAL DATA Dimensions in mm

TO-72



1) = shield lead (connected to case)

Accessories available: 56246, 56263.

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

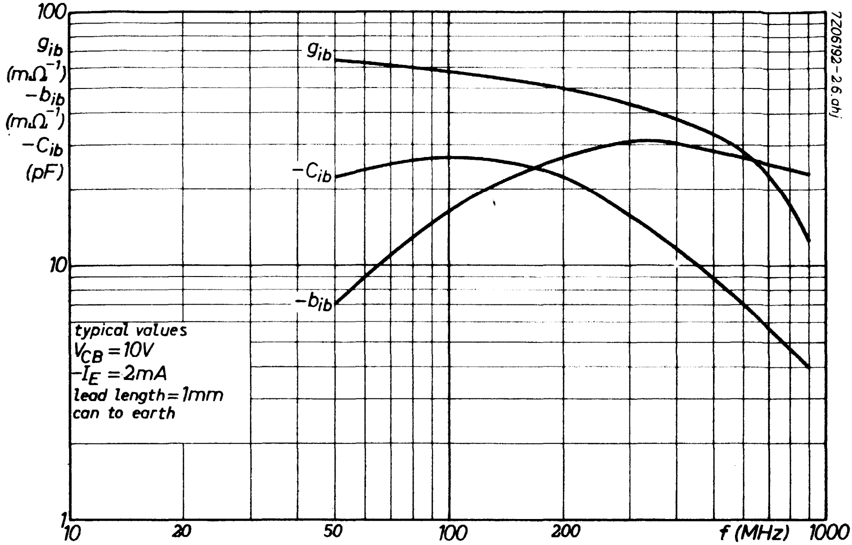
[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

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

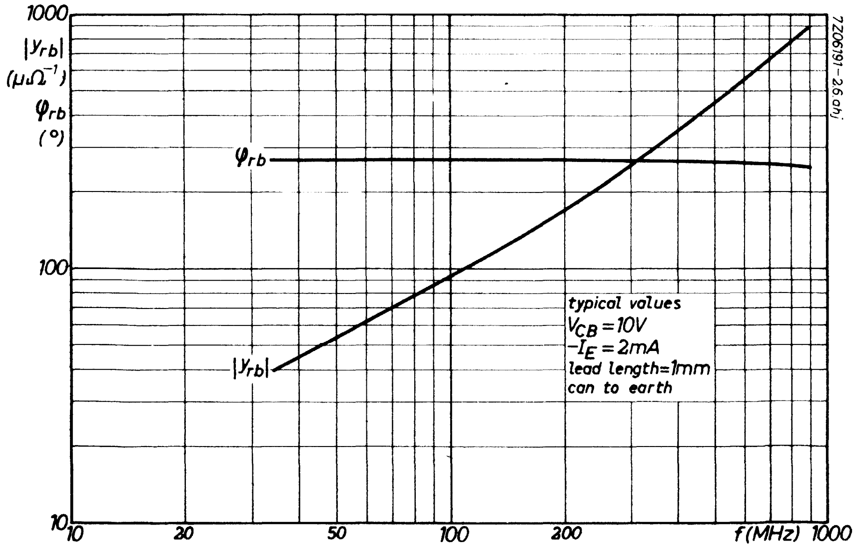
Base current				
$-I_E$ = 2 mA; V_{CB} = 10 V	I_B	typ. <</br>	45 150	μA μA
$-I_E$ = 12 mA; V_{CB} = 7 V	I_B	<	2.2	mA
Emitter-base voltage				
$-I_E$ = 2 mA; V_{CB} = 10 V	$-V_{EB}$	typ.	0.75	V
Feedback capacitance at f = 10.7 MHz				
I_C = 1 mA; V_{CE} = 10 V	$-C_{re}$	typ.	280	fF [1]
Transition frequency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

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

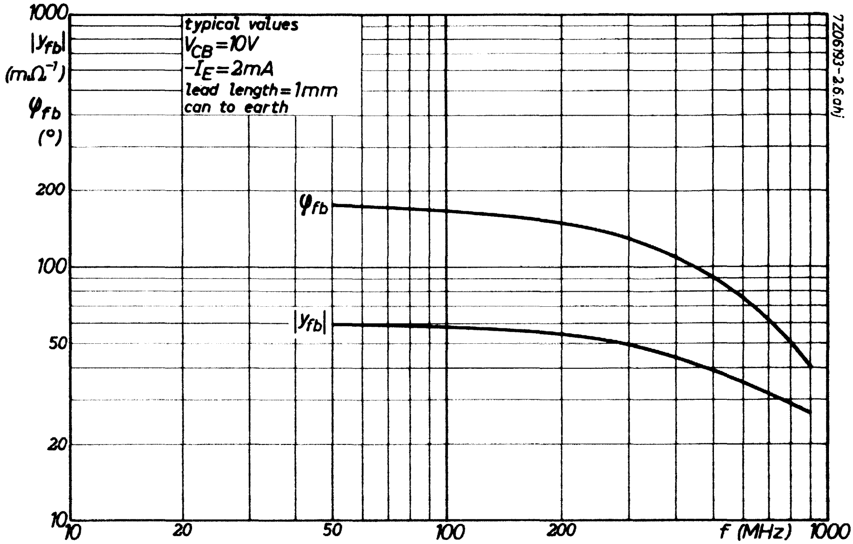
[2]) Common base configuration, metal envelope contacted to earth directly, external lead length: 1 mm.

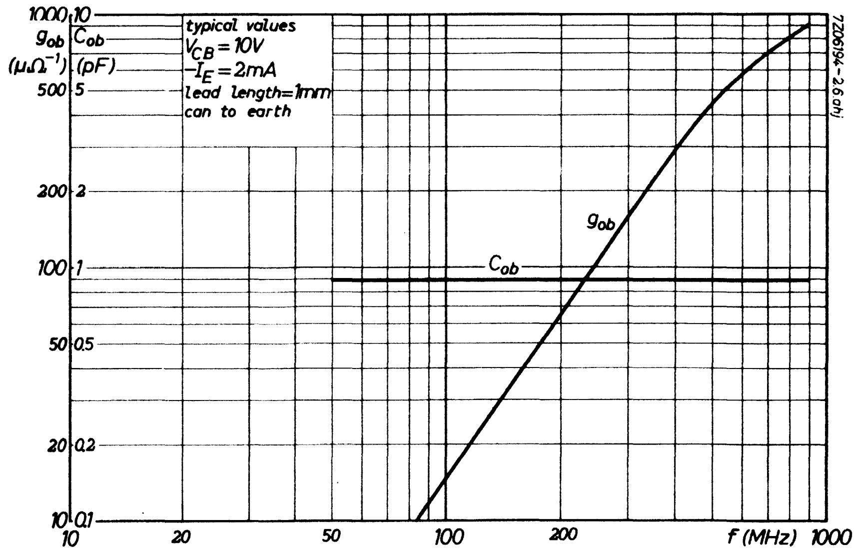


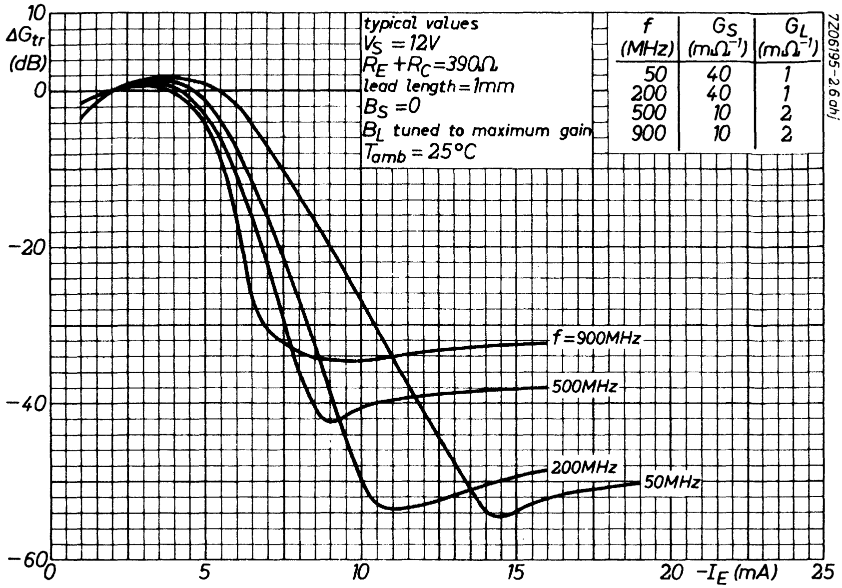
100
10
1
g_{ib} ($m\Omega^{-1}$)
$-b_{ib}$ ($m\Omega^{-1}$)
$-C_{ib}$ (pF)
g_{ib}
$-C_{ib}$
$-b_{ib}$
typical values
V_{CB} = 10V
$-I_E$ = 2mA
lead length = 1mm
can to earth
10
20
50
100
200
f (MHz)
1000
7Z06192-2.6.ahj

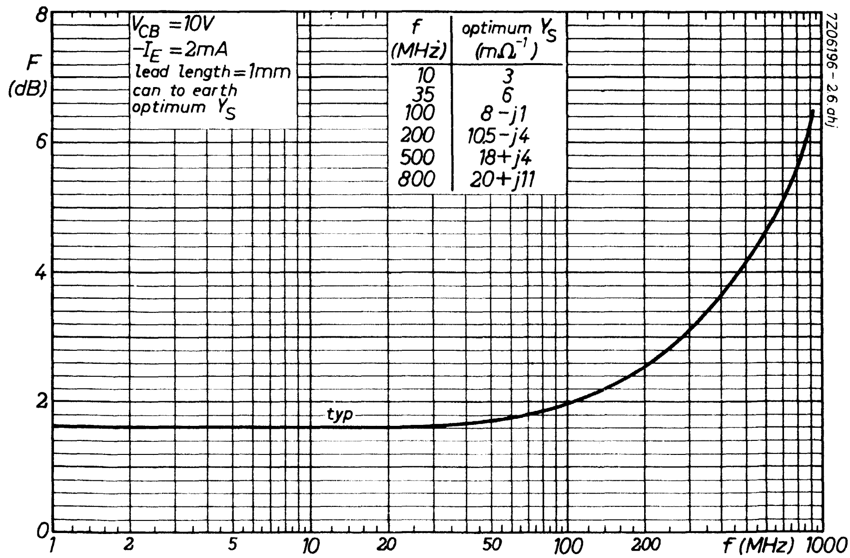


1000
100
10
$|y_{rb}|$ ($\mu\Omega^{-1}$)
φ_{rb} (°)
φ_{rb}
$|y_{rb}|$
typical values
V_{CB} = 10V
$-I_E$ = 2mA
lead length = 1mm
can to earth
10
20
50
100
200
f (MHz)
1000
7Z06191-2.6.ahj


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


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


typical values
$V_S = 12V$
$R_E + R_C = 390\Omega$
lead length = 1mm
$B_S = 0$
B_L tuned to maximum gain
$T_{amb} = 25°C$
f (MHz) | G_S ($m\Omega^{-1}$) | G_L ($m\Omega^{-1}$)
50 | 40 | 1
200 | 40 | 1
500 | 10 | 2
900 | 10 | 2
7Z06195-2.6.ahj
ΔG_{tr} (dB)
f = 900MHz
500MHz
200MHz
50MHz
$-I_E$ (mA)


$V_{CB} = 10V$
$-I_E = 2mA$
lead length = 1mm
can to earth
optimum Y_S
f (MHz) | optimum Y_S ($m\Omega^{-1}$)
10 | 3
35 | 6
100 | 8 − j1
200 | 10.5 − j4
500 | 18 + j4
800 | 20 + j11
7Z06196-2.6.ahj
F (dB)
typ
f (MHz)

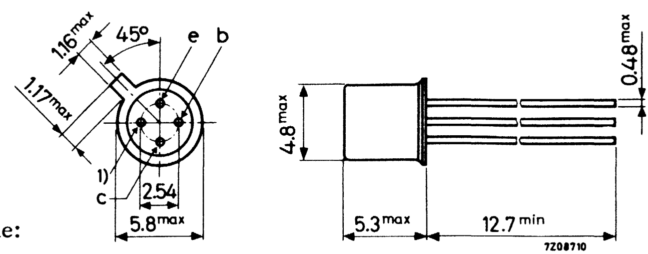
SILICON PLANAR TRANSISTOR

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 self-oscillating mixer in the u.h.f. band.

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

MECHANICAL DATA Dimensions in mm

TO-72



Accessories available:
56246, 56263

1) = shield lead (connected to case)

RATINGS (Limiting values) [1]

Voltages

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

Currents

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

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	mW

Temperatures

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

THERMAL RESISTANCE

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

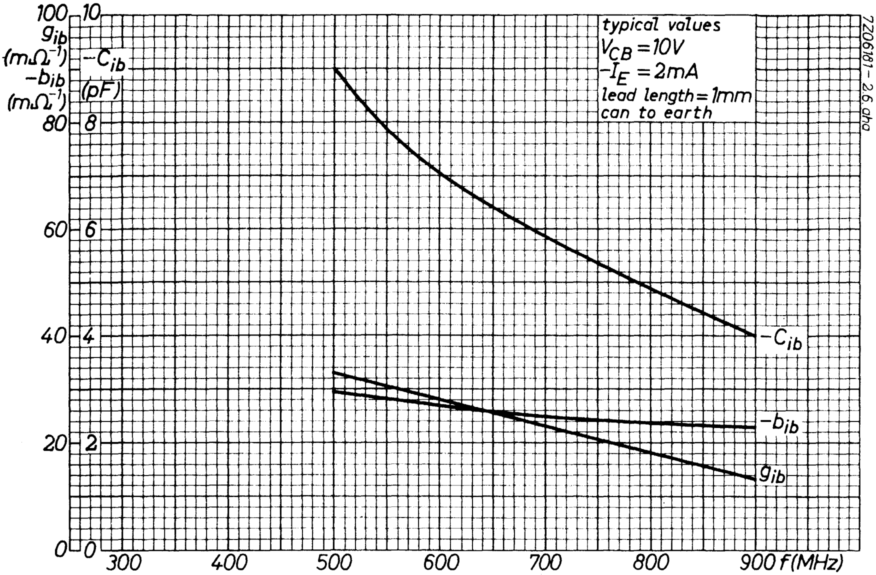
[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

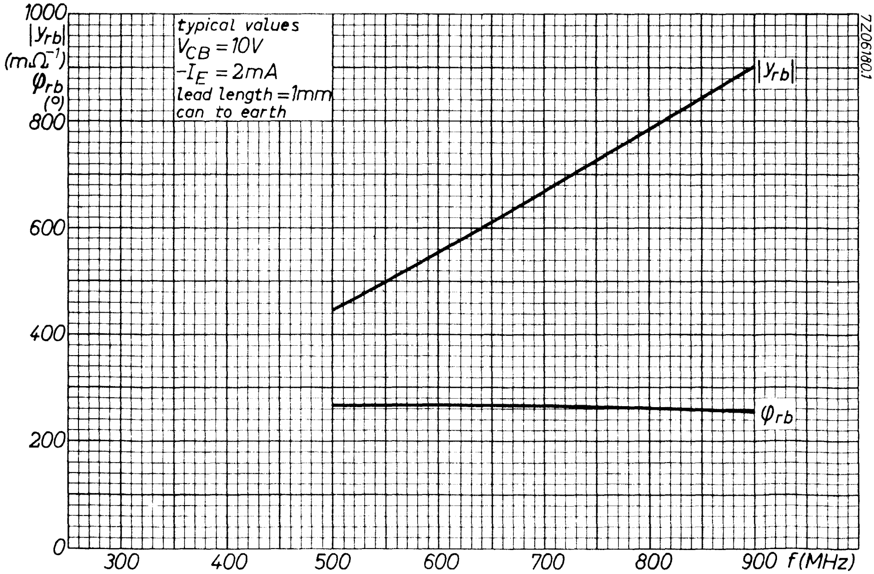
CHARACTERISTICS T_{amb} = 25 °C unless otherwise specified

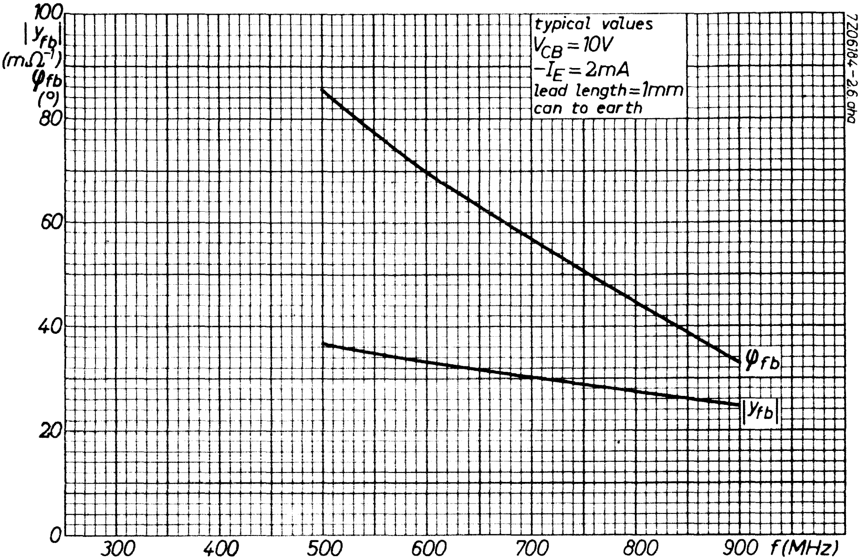
Base current				
$-I_E$ = 2 mA; V_{CB} = 10 V	I_B	typ. <	70 150	μA μA
Emitter-base voltage				
$-I_E$ = 2 mA; V_{CB} = 10 V	$-V_{EB}$	typ.	0.75	V
Feedback capacitance at f = 10.7 MHz				
I_C = 1 mA; V_{CE} = 10 V	$-C_{re}$	typ.	280	fF [1]
Transition frequency				
I_C = 2 mA; V_{CE} = 10 V	f_T	typ.	600	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 mΩ^{-1}; B_S = 0 G_L = 2 mΩ^{-1}; B_L : tuned	G_{tr}	typ.	8	dB

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

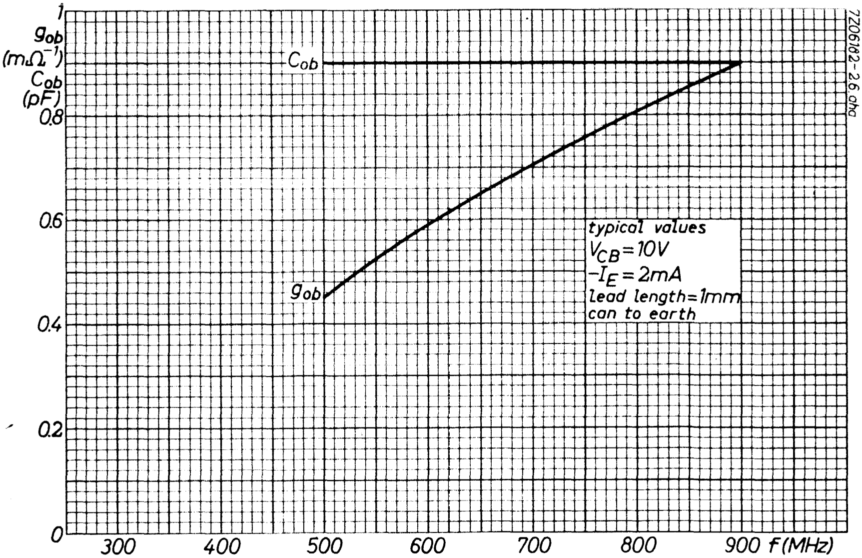
[2]) Common base configuration, metal envelope contacted to earth directly, external lead length: 1 mm.


100
10
g_{ib}
($m\Omega^{-1}$)
$-C_{ib}$
$-b_{ib}$
(pF)
($m\Omega^{-1}$)
80
8
60
6
40
4
20
2
0
0
300
400
500
600
700
800
900
f (MHz)
typical values
$V_{CB} = 10V$
$-I_E = 2mA$
lead length = 1mm
can to earth
7Z06181 - 2.6.aha
$-C_{ib}$
$-b_{ib}$
g_{ib}

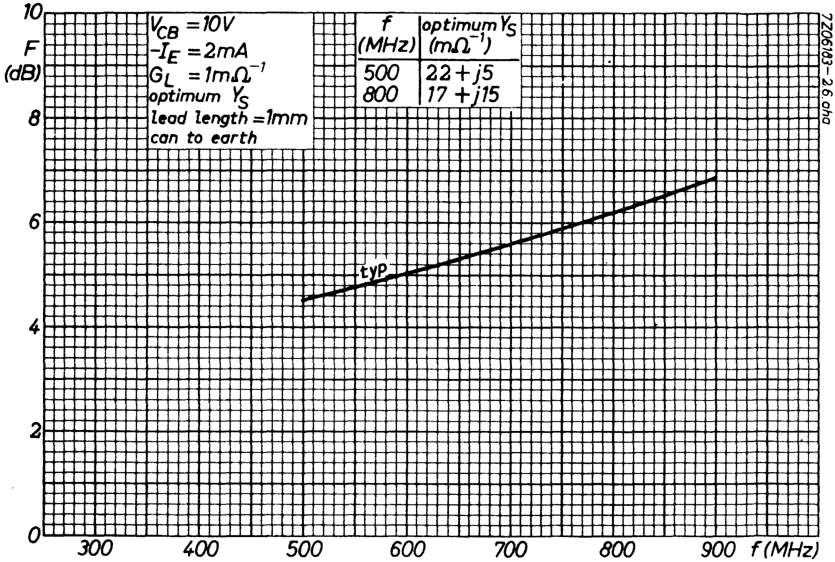

1000
$|y_{rb}|$
($m\Omega^{-1}$)
φ_{rb}
(°)
800
600
400
200
0
300
400
500
600
700
800
900
f (MHz)
typical values
$V_{CB} = 10V$
$-I_E = 2mA$
lead length = 1mm
can to earth
7Z06180.1
$|y_{rb}|$
φ_{rb}



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



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



10
F
(dB)
8
6
4
2
0
VCB = 10V
-IE = 2mA
GL = 1mΩ⁻¹
optimum YS
lead length = 1mm
can to earth
f (MHz)
optimum YS (mΩ⁻¹)
500
22 + j5
800
17 + j15
typ
300
400
500
600
700
800
900
f (MHz)
7Z06183-2.6.cha

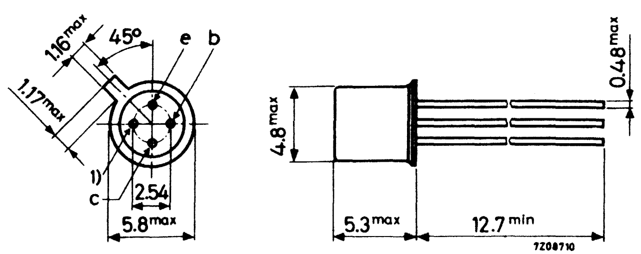
U.H.F. SILICON PLANAR TRANSISTOR

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 separate mixer in integrated television tuners.

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

MECHANICAL DATA Dimensions in mm

TO-72



1) = shield lead (connected to case)

Accessories available: 56246, 56263

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	μA
		<	200	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

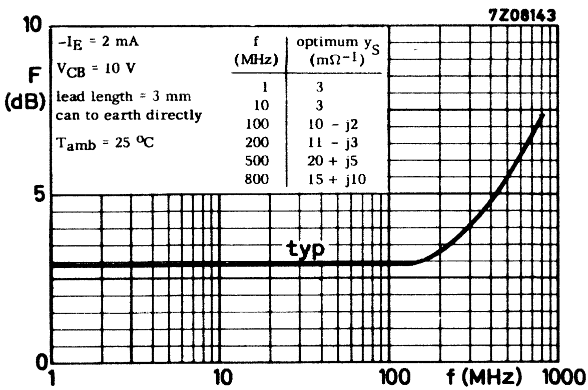
$$G_{UM} = \frac{|y_{fb}|^2}{4\, g_{ib} g_{ob}}$$

$-I_E$ = 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

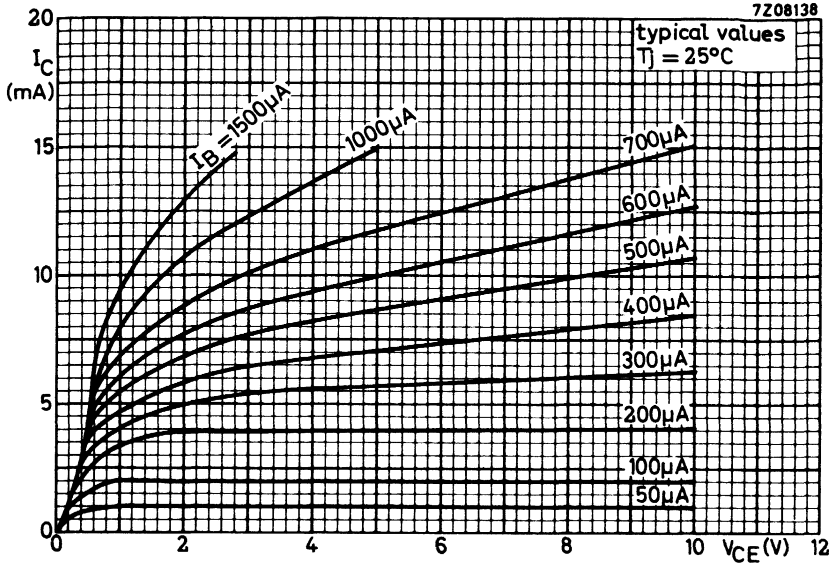
Noise figure at optimum source admittance

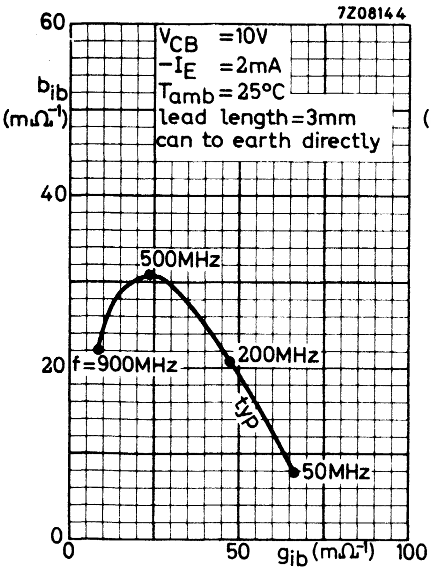
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 200 MHz	F	typ.	3.3	dB
$-I_E$ = 2 mA; V_{CB} = 10 V; f = 800 MHz	F	typ.	7.4	dB

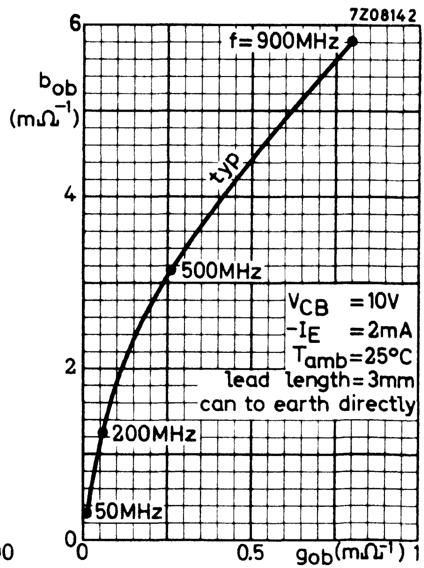
1) Envelope connected to earth directly, lead length = 3 mm.

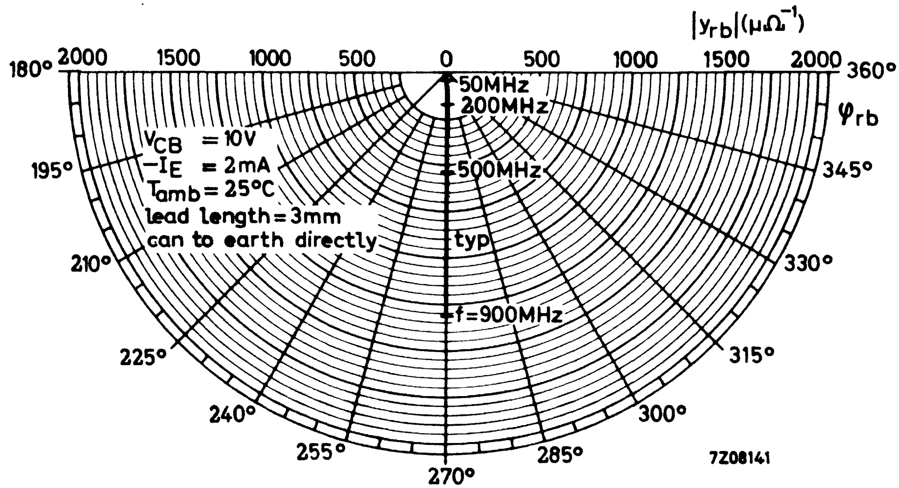


f (MHz)	optimum y_S (mΩ^{-1})
1	3
10	3
100	10 − j2
200	11 − j3
500	20 + j5
800	15 + j10

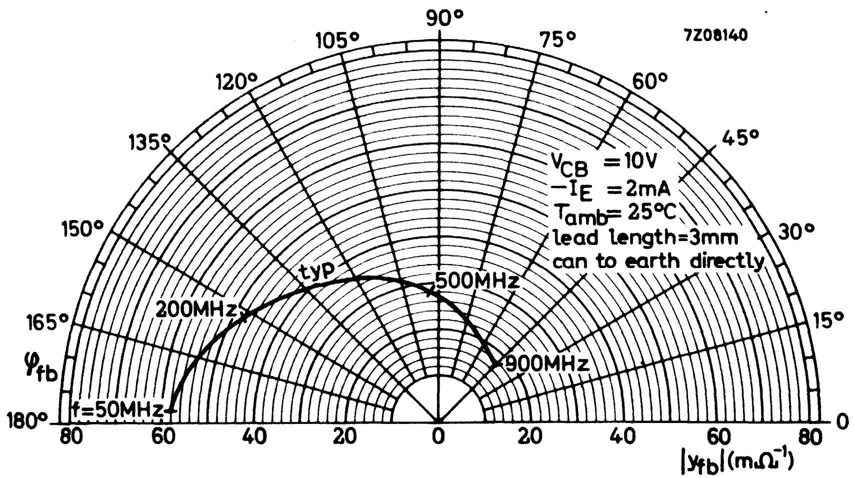

7Z08138
typical values
Tj = 25°C
I_C (mA)
20
15
10
5
0
I_B = 1500μA
1000μA
700μA
600μA
500μA
400μA
300μA
200μA
100μA
50μA
0
2
4
6
8
10
V_{CE} (V)
12


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

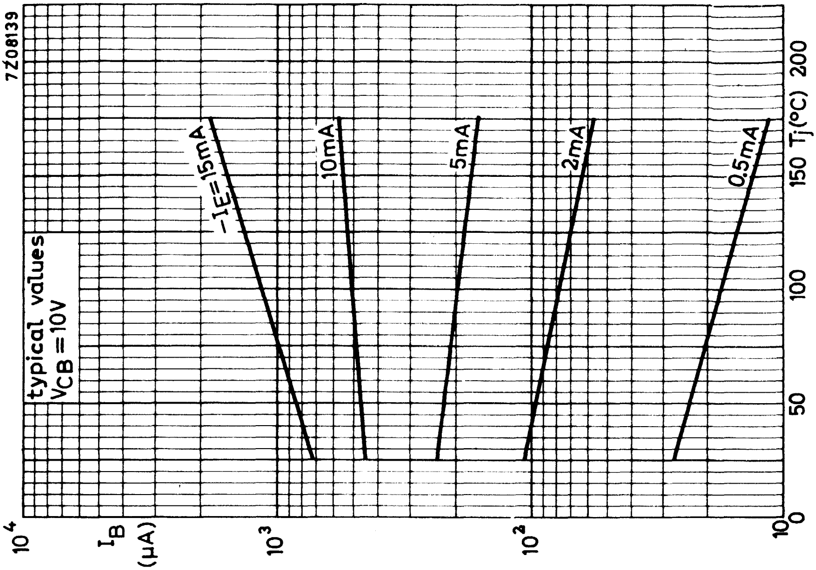

7Z08142
b_{ob} ($m\Omega^{-1}$)
6
4
2
0
f = 900MHz
typ
500MHz
200MHz
50MHz
V_{CB} = 10V
$-I_E$ = 2mA
T_{amb} = 25°C
lead length = 3mm
can to earth directly
0
0.5
g_{ob} ($m\Omega^{-1}$)
1

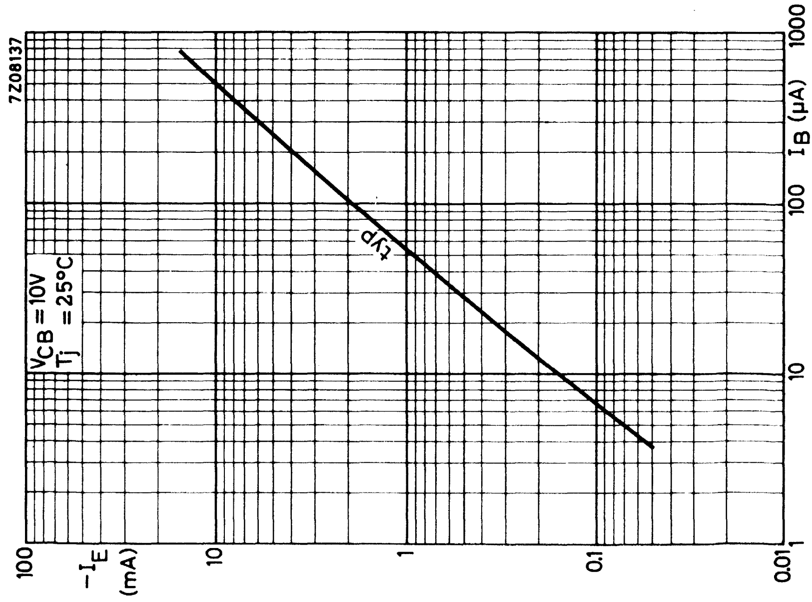


|y_rb| (μΩ⁻¹)
2000 1500 1000 500 0 500 1000 1500 2000
180° 195° 210° 225° 240° 255° 270° 285° 300° 315° 330° 345° 360°
φ_rb
50MHz
200MHz
500MHz
typ
f=900MHz
V_CB = 10V
−I_E = 2mA
T_amb = 25°C
lead length = 3mm
can to earth directly
7Z08141



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


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


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

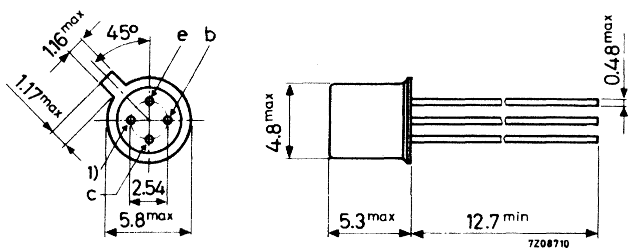
U.H.F. SILICON PLANAR TRANSISTOR

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
Max. unlilateralised power gain				
$-I_E$ = 3 mA; V_{CB} = 10 V; f = 900 MHz	G_{UM}	typ.	13	dB

MECHANICAL DATA Dimensions in mm

TO-72



1) = shield lead (connected to case)

Accessories available: 56246, 56263

RATINGS (Limiting values) [1]

Voltages

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

Currents

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

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	mW

Temperatures

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

THERMAL RESISTANCE

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

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

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

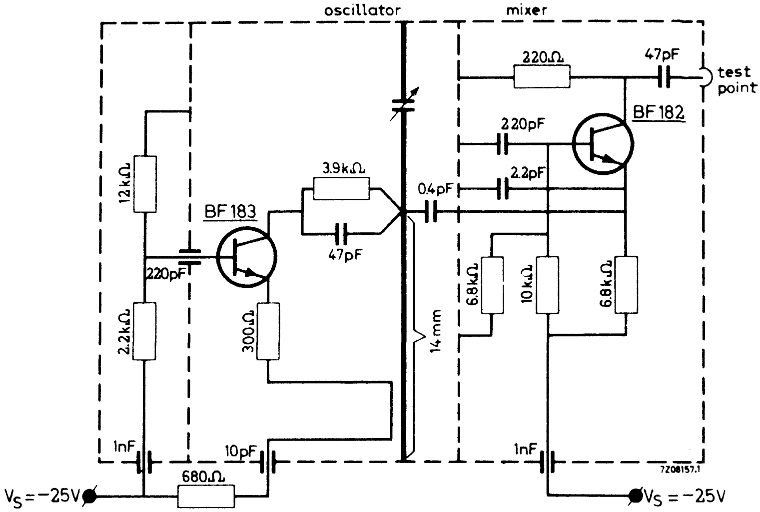
Base-current				
$-I_E$ = 3 mA; V_{CB} = 10 V	I_B	typ.	125	μA
		<	300	μA
Emitter-base voltage [1]				
$-I_E$ = 3 mA; V_{CB} = 10 V	$-V_{EB}$	typ.	770	mV
Transition frequency				
I_C = 3 mA; V_{CE} = 10 V	f_T	typ.	800	MHz
Feedback capacitance at f = 10.7 MHz				
I_C = 1 mA; V_{CE} = 10 V	$-C_{re}$	typ.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

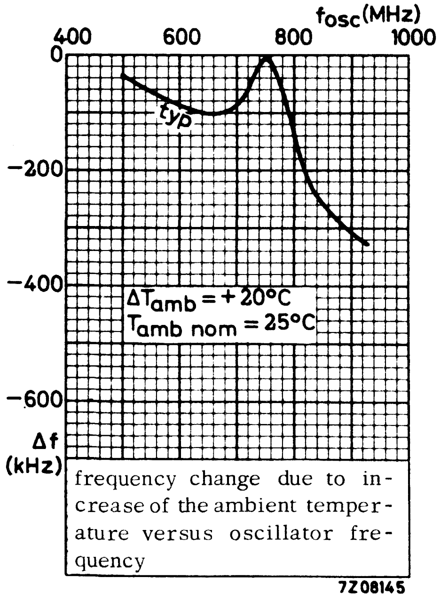
1) $-V_{EB}$ decreases by about 1.6 mV/°C with increasing temperature.

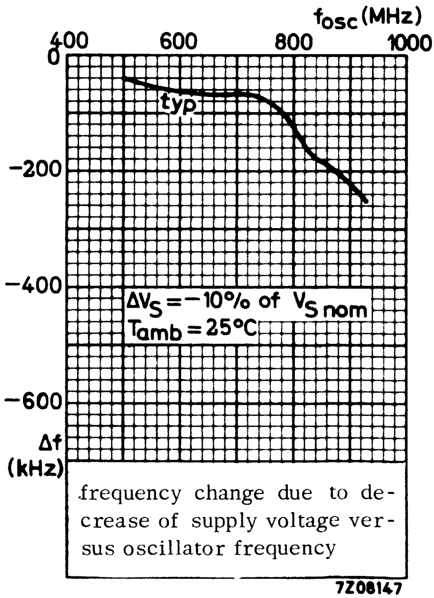
2) Envelope connected to earth directly, lead length = 3 mm.

APPLICATION INFORMATION

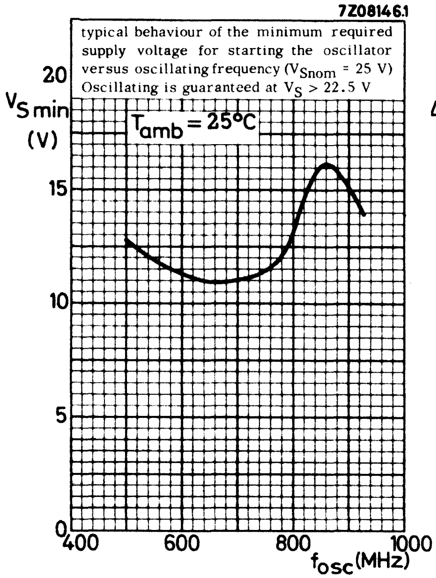
Oscillator circuit with simplified mixer stage

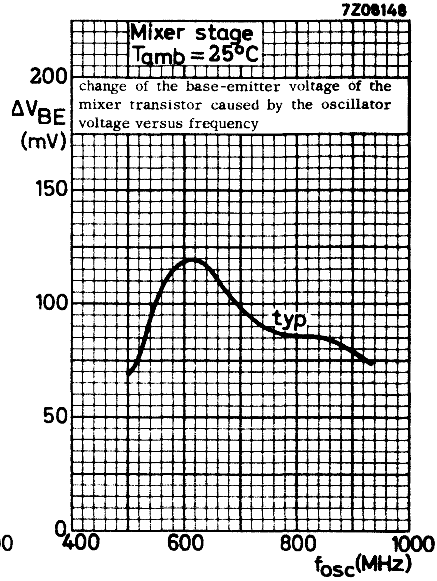


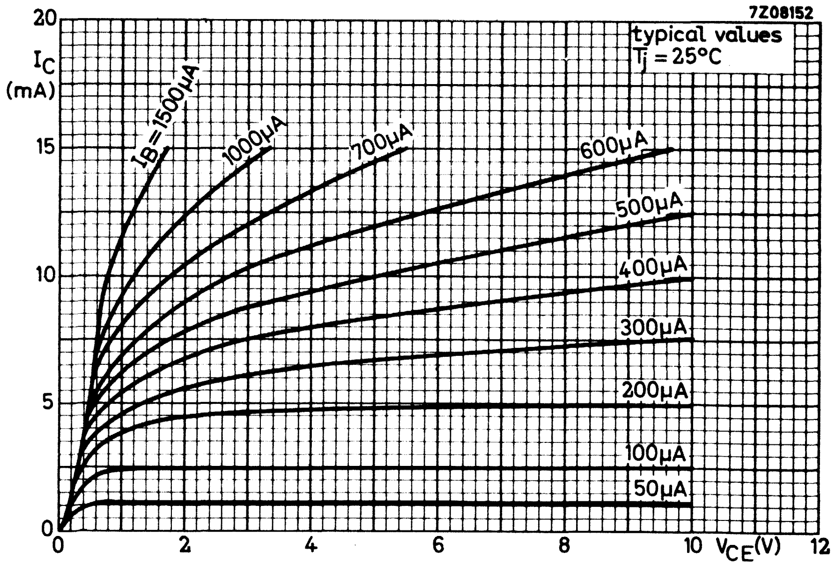


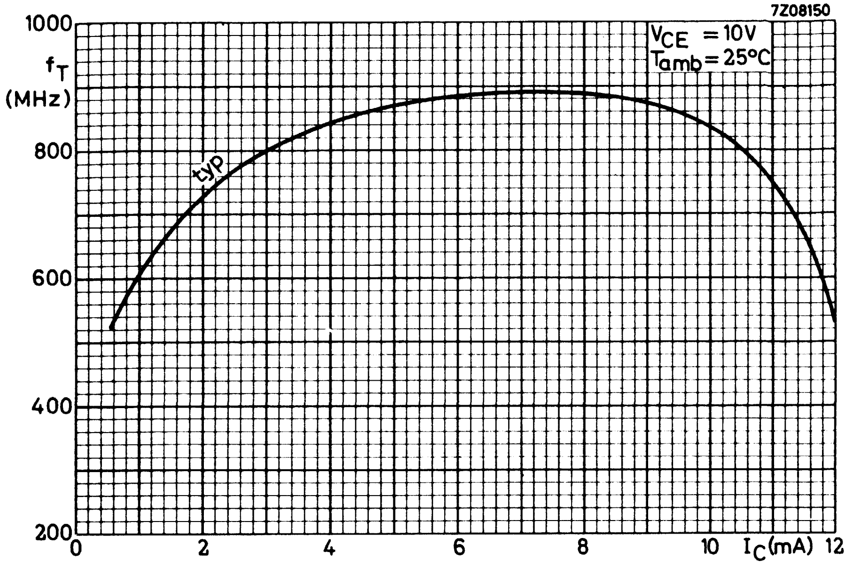


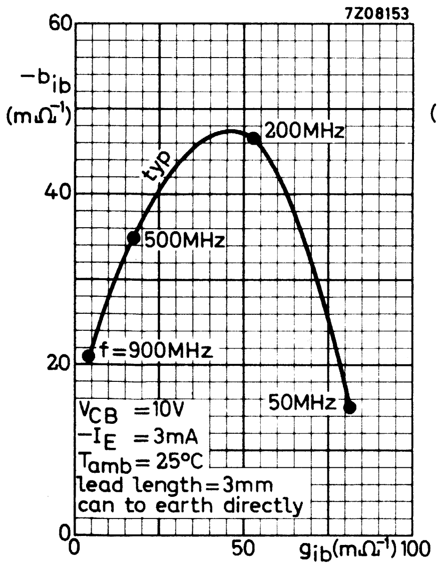
APPLICATION INFORMATION bulletin available on request

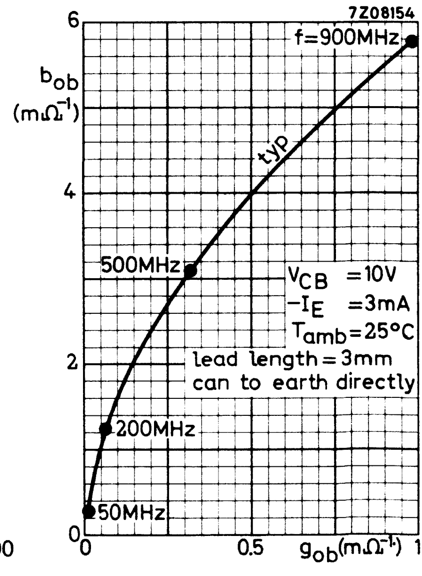

7Z08146.1
typical behaviour of the minimum required supply voltage for starting the oscillator versus oscillating frequency (V_{Snom} = 25 V)
Oscillating is guaranteed at V_S > 22.5 V
T_{amb} = 25°C
$V_{S\,min}$ (V)
f_{osc} (MHz)
0
5
10
15
20
400
600
800
1000

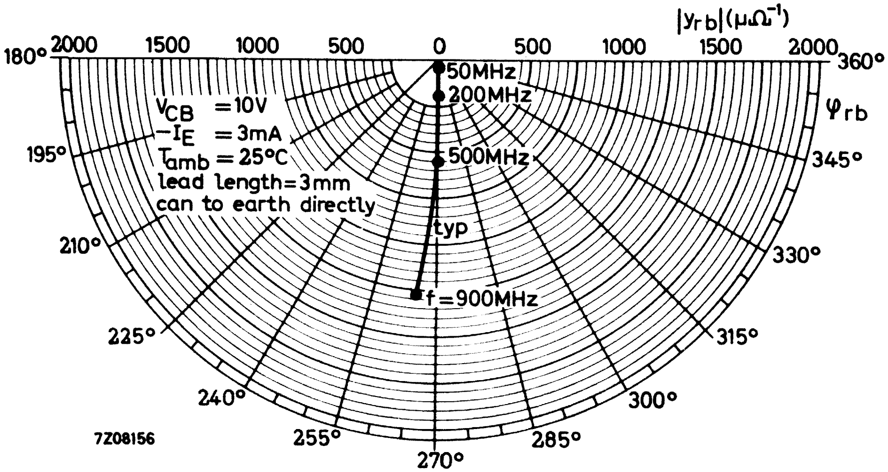

7Z08148
Mixer stage
T_{amb} = 25°C
change of the base-emitter voltage of the mixer transistor caused by the oscillator voltage versus frequency
ΔV_{BE} (mV)
typ
f_{osc} (MHz)
0
50
100
150
200
400
600
800
1000


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

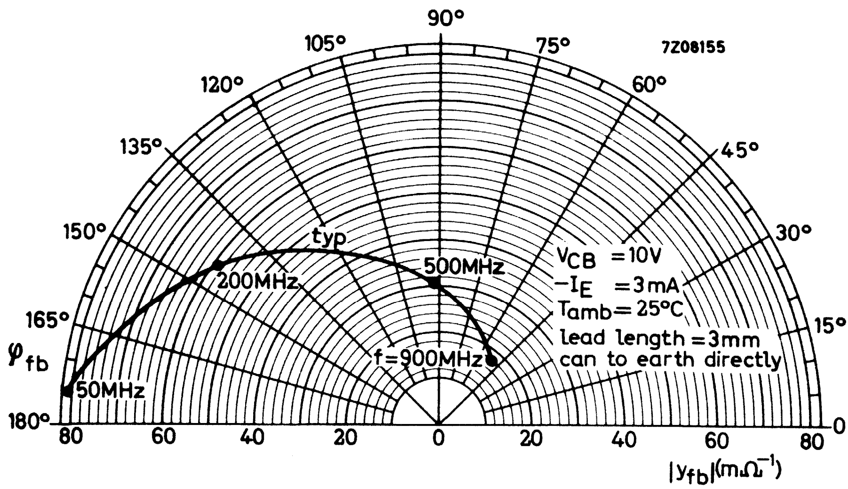

7Z08150
1000
f_T
(MHz)
800
600
400
200
0
2
4
6
8
10
I_C(mA)
12
V_{CE} = 10V
T_{amb} = 25°C
typ


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

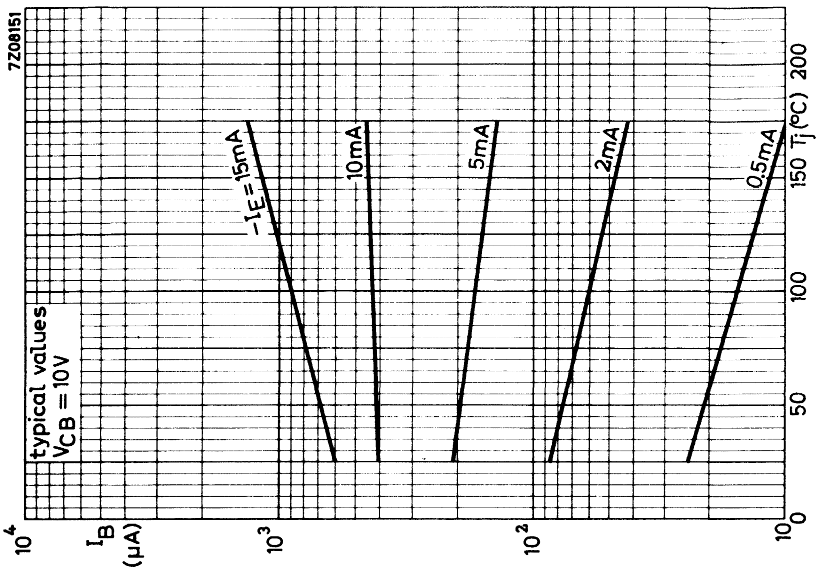

7Z08154
6
b_{ob}
($m\Omega^{-1}$)
4
2
0
0.5
g_{ob}($m\Omega^{-1}$) 1
f = 900MHz
typ
500MHz
200MHz
50MHz
V_{CB} = 10V
$-I_E$ = 3mA
T_{amb} = 25°C
lead length = 3mm
can to earth directly

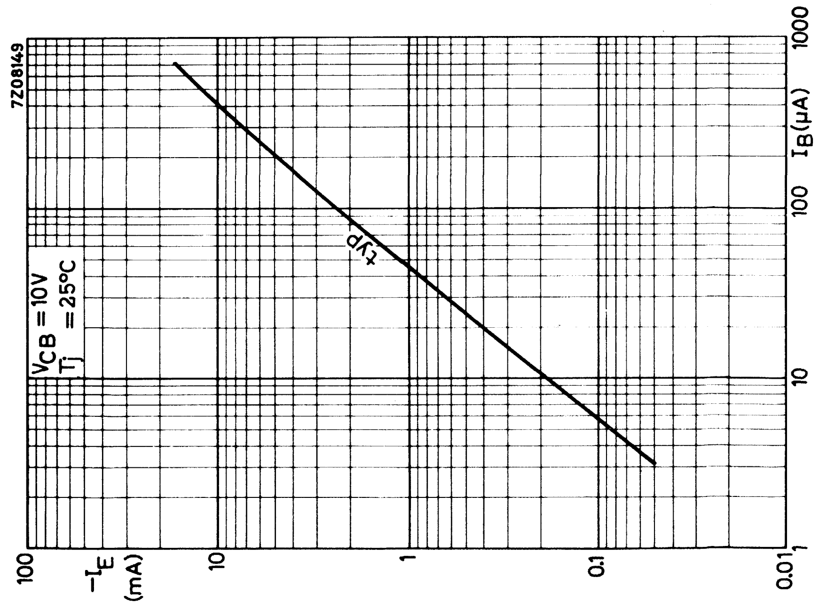


|yrb| (μΩ⁻¹)
2000 1500 1000 500 0 500 1000 1500 2000
180° 195° 210° 225° 240° 255° 270° 285° 300° 315° 330° 345° 360°
φrb
VCB = 10V
−IE = 3mA
Tamb = 25°C
lead length = 3mm
can to earth directly
50MHz
200MHz
500MHz
typ
f = 900MHz
7Z08156



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


7Z08151
typical values
V_CB = 10V
−I_E = 15mA
10mA
5mA
2mA
0.5mA
T_j (°C)
0
50
100
150
200
I_B (μA)
10^4
10^3
10^2
10


7Z08149
V_CB = 10V
T_j = 25°C
typ
I_B (μA)
1
10
100
1000
−I_E (mA)
100
10
1
0.1
0.01

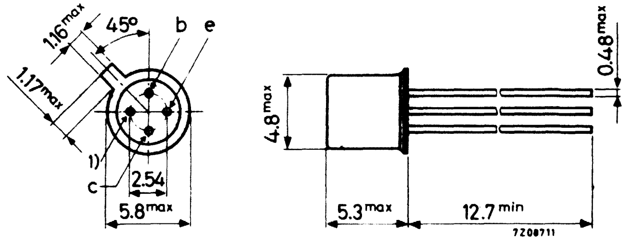
SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a 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.
The BF184 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} = 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
Insulated electrodes



1) = shield lead (connected to case)

Accessories available: 56246, 56263.

FOR NEW DESIGN THE SUCCESSOR TYPES BF194 OR BF494 ARE 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

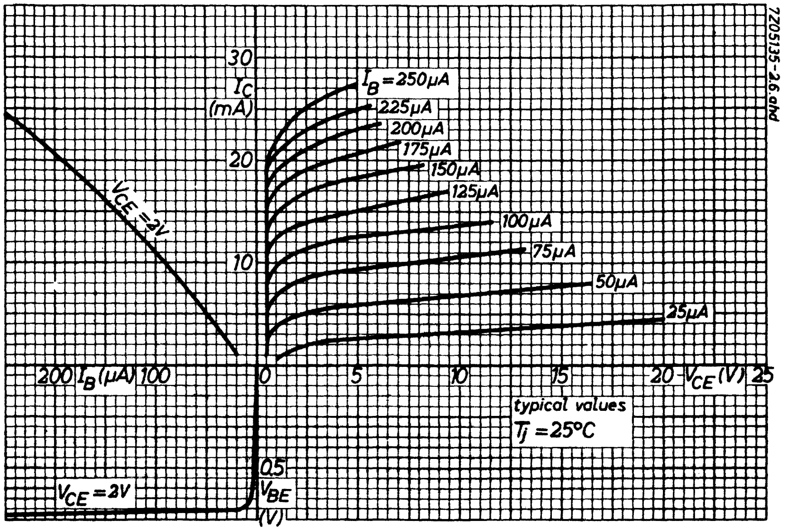
THERMAL RESISTANCE

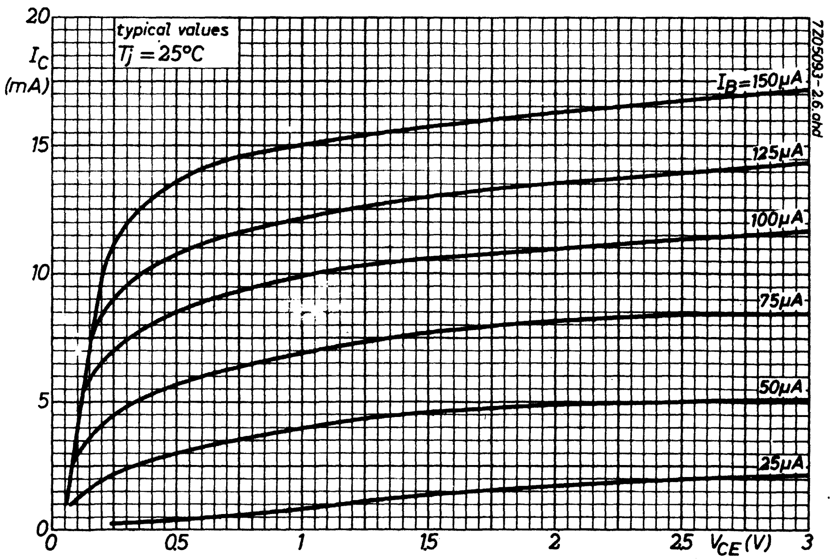
From junction to ambient in free air	$R_{th\ j-a}$	=	0.9	°C/mW

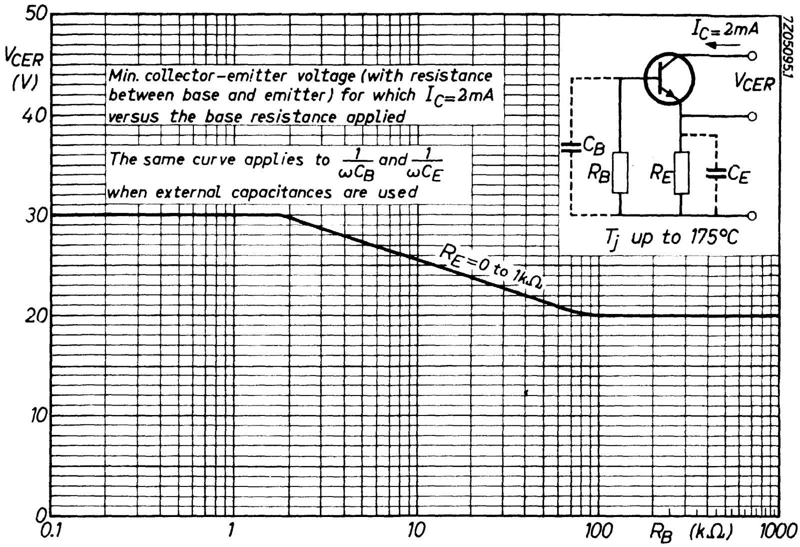
CHARACTERISTICS T_j = 25 °C unless otherwise specified

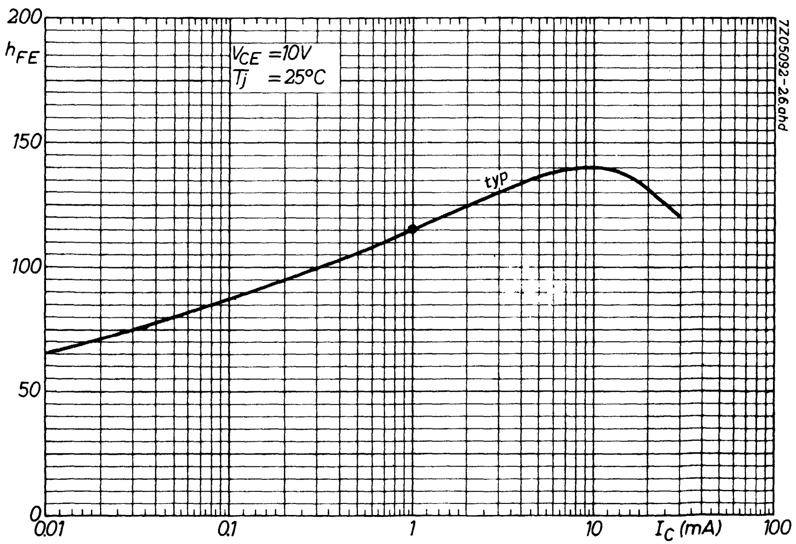
Base-emitter voltage [1]				
I_C = 1 mA; V_{CE} = 10 V	V_{BE}		0.65 to 0.74	V
I_C = 20 mA; V_{CE} = 2 V	V_{BE}	<	1.0	V
Feedback capacitance at f = 0.45 MHz				
I_C = 1 mA; V_{CE} = 10 V	$-C_{re}$	typ.	0.65	pF
D.C. current gain				
I_C = 1 mA; V_{CE} = 10 V	h_{FE}		75 to 750	
		typ.	115	
Transition frequency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

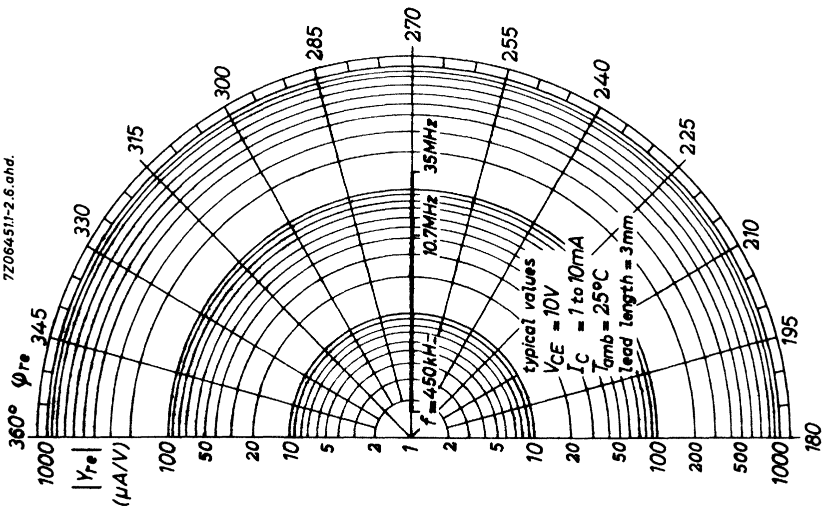
[1]) V_{BE} decreases with about 1.7 mV/°C at increasing temperature.

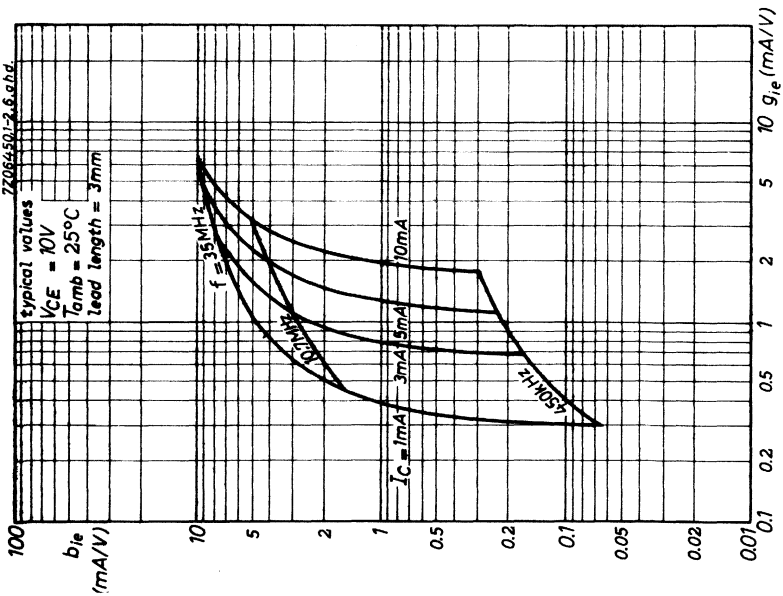

7Z05135-2.6.ahd
30
I_C (mA)
20
10
I_B = 250μA
225μA
200μA
175μA
150μA
125μA
100μA
75μA
50μA
25μA
V_{CE} = 2V
200 I_B (μA) 100
0 5 10 15 20 V_{CE} (V) 25
typical values
T_j = 25°C
0.5
V_{BE} (V)
V_{CE} = 2V

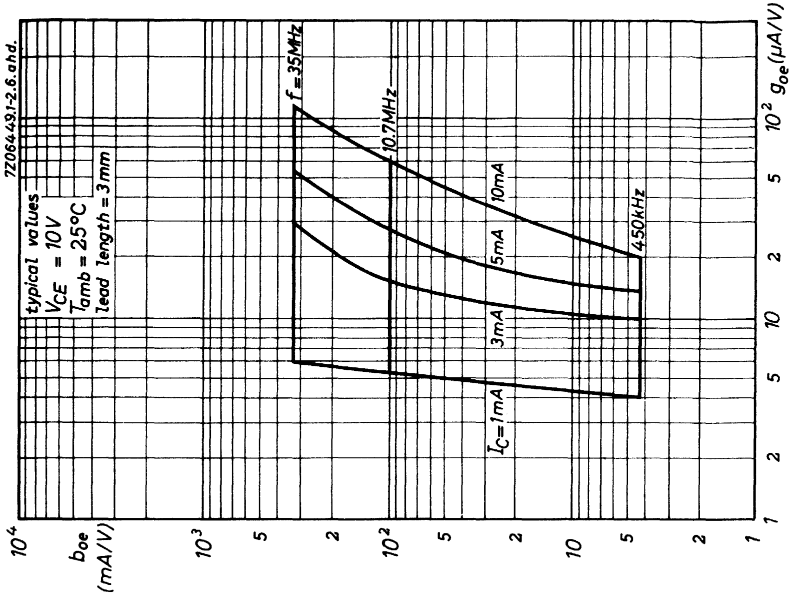

7Z05093-2.6.ahd
20
I_C (mA)
15
10
5
0
typical values
T_j = 25°C
I_B = 150μA
125μA
100μA
75μA
50μA
25μA
0 0.5 1 1.5 2 2.5 V_{CE} (V) 3

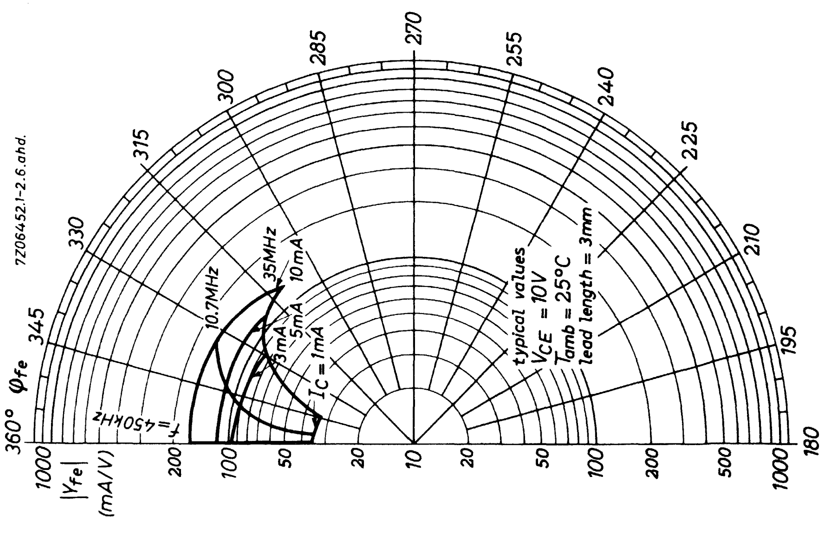

VCER (V)
50
40
30
20
10
0
Min. collector-emitter voltage (with resistance between base and emitter) for which IC=2mA versus the base resistance applied
The same curve applies to 1/ωCB and 1/ωCE when external capacitances are used
RE=0 to 1kΩ
IC=2mA
VCER
CB
RB
RE
CE
Tj up to 175°C
0.1
1
10
100
RB (kΩ)
1000
7Z05095.1


200
hFE
150
100
50
0
VCE =10V
Tj =25°C
typ
0.01
0.1
1
10
IC (mA)
100
7Z05092-26.ahd


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)
10^2 g_{oe} (μA/V)


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

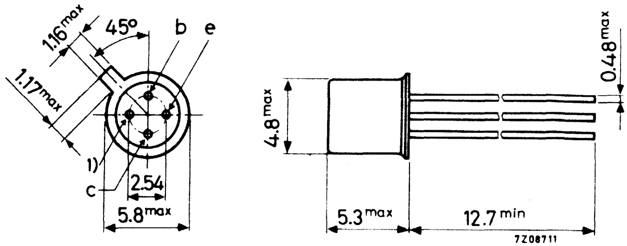
SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a 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 BF195.
The BF185 is intended for h.f. applications in radio and television receivers; it is especially recommended for f.m. tuners, i.f. amplifiers in a.m./f.m. receivers where a low transistor output conductance is of importance, a.m. input stages of carradios where a low noise figure at low source impedance is required.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector current (d.c.)	I_C	max.	30	mA
Total power dissipation up to T_{amb} = 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 available: 56246, 56263.

FOR NEW DESIGN THE SUCCESSOR TYPES BF195 OR BF495 ARE 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 ^oC	P_{tot}	max.	145	mW

Temperatures

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

THERMAL RESISTANCE

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

CHARACTERISTICS T_j = 25 ^oC 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/^oC at increasing temperature.

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

Noise figure

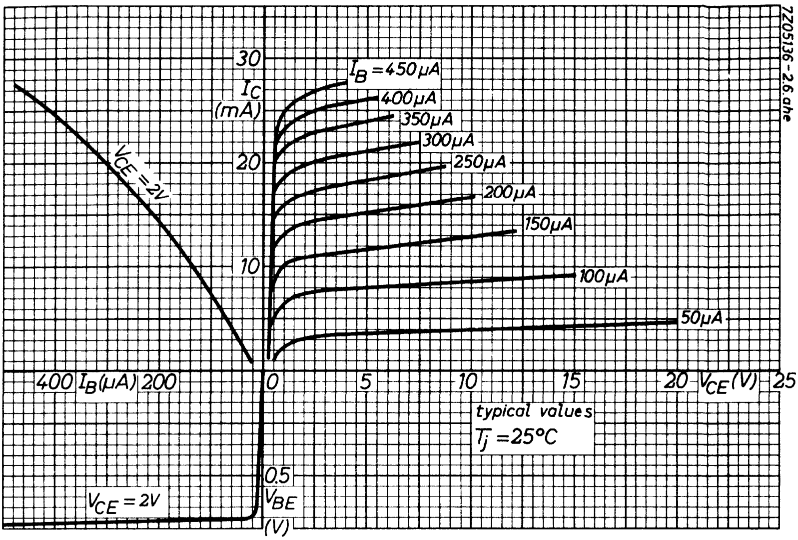
I_C = 1 mA; V_{CE} = 10 V			
f = 0.2 MHz; G_S = 5 mA/V	F	typ. 2	dB
f = 1 MHz; G_S = 20 mA/V	F	typ. 3.5	dB
f = 100 MHz; G_S = 10 mA/V	F	typ. 4	dB

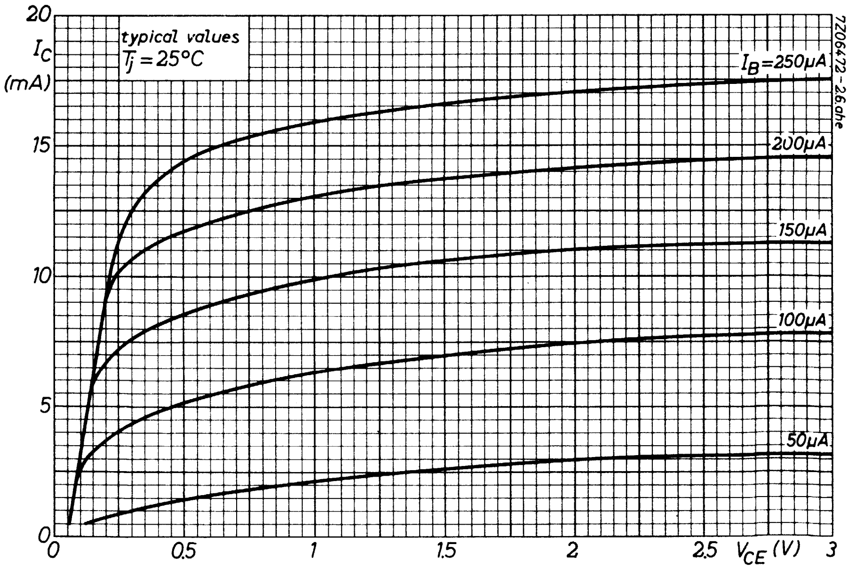
y parameters at f = 100 MHz (common base)

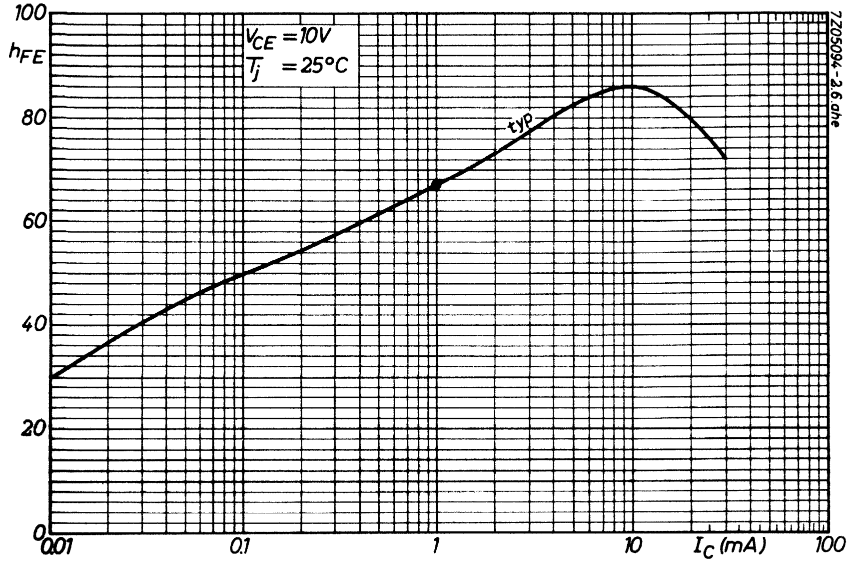
$-I_E$ = 1 mA; V_{CB} = 10 V			
Input conductance	g_{ib}	typ. 33	mA/V
Input capacitance	$-C_{ib}$	typ. 5.5	pF
Feedback admittance	$\lvert y_{rb} \rvert$	typ. 220	mA/V
Phase angle of feedback admittance	φ_{rb}	typ. 273°	
Transfer admittance	$\lvert y_{fb} \rvert$	typ. 33	mA/V
Phase angle of transfer admittance	φ_{fb}	typ. 150°	
Output conductance	g_{ob}	typ. 12	mA/V
Output capacitance	C_{ob}	typ. 1.5	pF

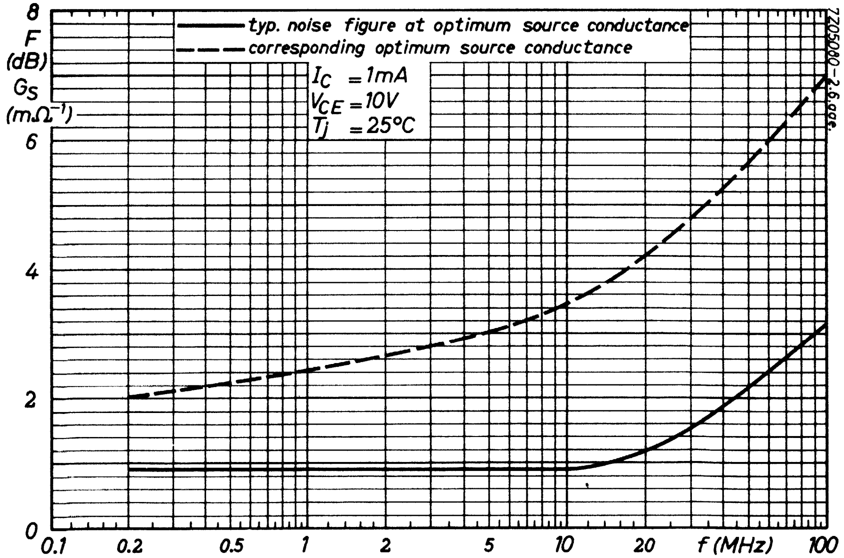
NOTE

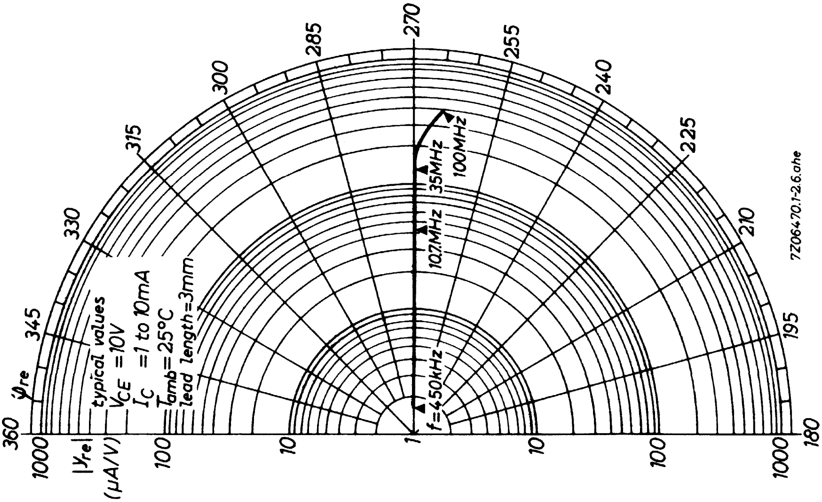
All small signal quantities have been measured with a length of leads between the bottom of the transistor and measuring jig of 3 mm.


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

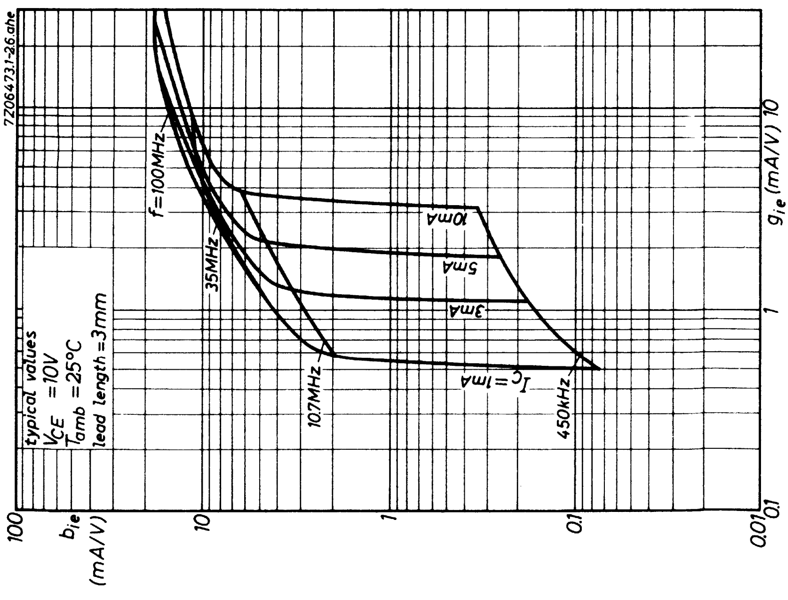

7Z06472-2.6.ahe
20
I_C
(mA)
15
10
5
0
typical values
T_j = 25°C
I_B=250μA
200μA
150μA
100μA
50μA
0
0.5
1
1.5
2
2.5 V_{CE} (V) 3


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

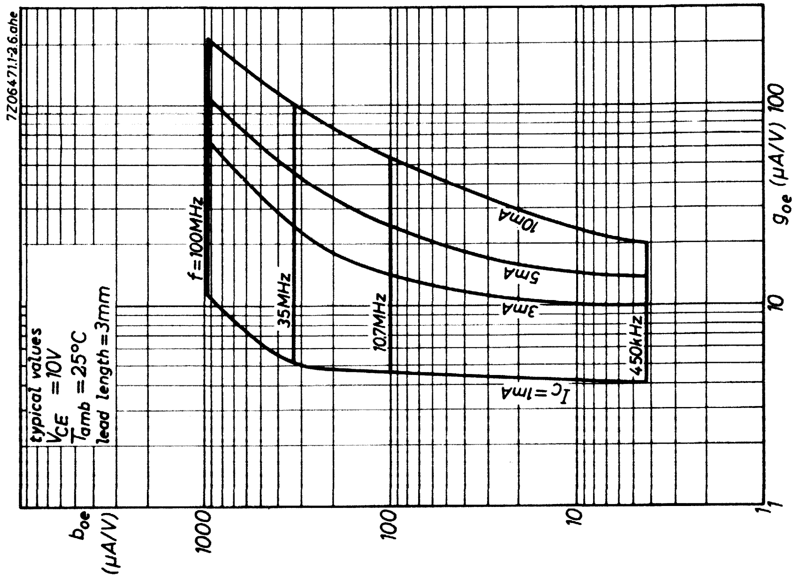

8
F
(dB)
G_S
($m\Omega^{-1}$)
6
4
2
0
typ. noise figure at optimum source conductance
corresponding optimum source conductance
I_C = 1mA
V_{CE} = 10V
T_j = 25°C
7Z05080-2.6.aae.
0.1
0.2
0.5
1
2
5
10
20
f (MHz)
100

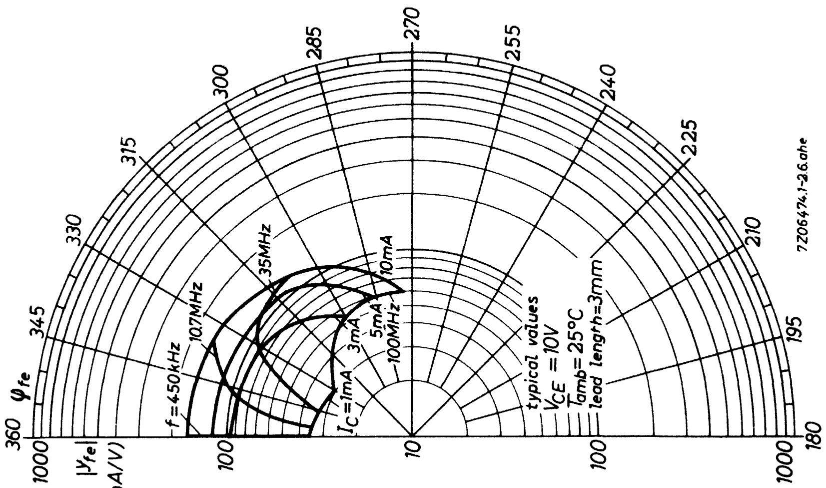


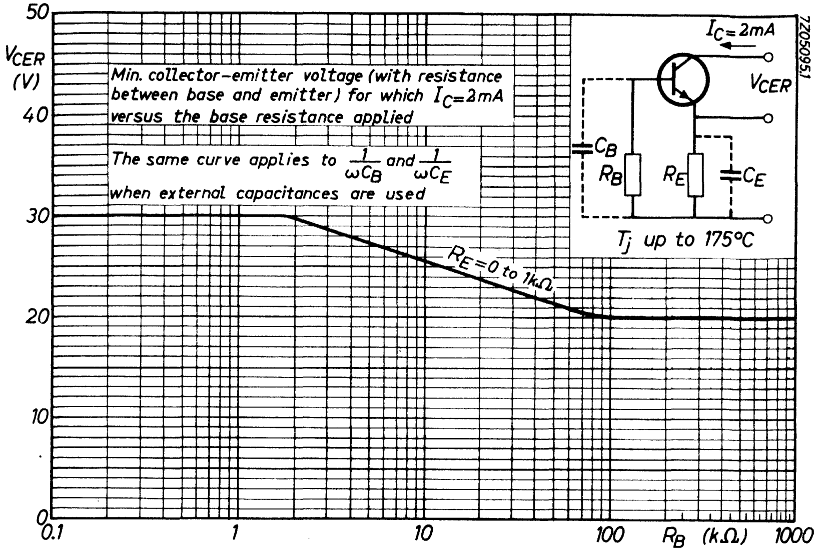
φ_{re}
typical values
V_{CE} = 10V
I_C = 1 to 10mA
T_{amb} = 25°C
lead length = 3mm
$|y_{re}|$ (µA/V)
f = 450kHz
10.7MHz
35MHz
100MHz
360
345
330
315
300
285
270
255
240
225
210
195
180
1000
100
10
1
10
100
1000
7Z06470.1-2.6.ahe



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


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
b_{oe} (μA/V)
1000
100
10
1
g_{oe} (μA/V)
100
10


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
100
1000
f = 450kHz
10.7MHz
35MHz
100MHz
10mA
5mA
3mA
I_C = 1mA
typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length = 3mm



50
V_{CER}
(V)
40
30
20
10
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 $1k\Omega$
$I_C = 2mA$
V_{CER}
C_B
R_B
R_E
C_E
T_j up to 175°C
7Z05095.1
0.1
1
10
100
R_B (kΩ)
1000

SILICON PLANAR EPITAXIAL TRANSISTOR

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

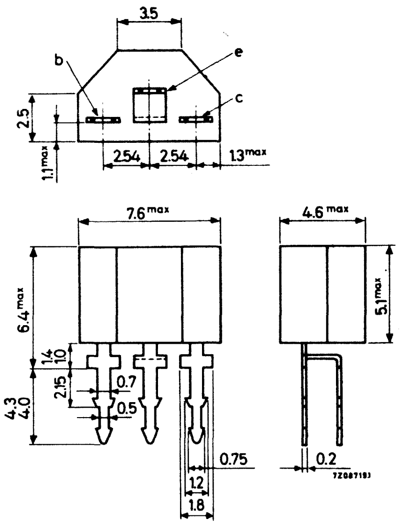
The BF194 is intended for h.f. applications in radio and television receivers; it is especially recommended for f.m. tuners, low noise a.m. mixer-oscillators with high source impedance and i.f. amplifiers in a.m./f.m. receivers where a high current gain is of importance.

QUICK REFERENCE DATA

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

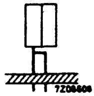
MECHANICAL DATA

Dimensions in mm

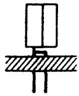


The envelope fulfils the accelerated damp heat test described in IEC publication 68-2 (test D, severity IV, 6 cycles).

MOUNTING INSTRUCTIONS

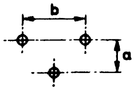


1. Thickness of printed board: max. 1.1 mm
   Hole diameter 0.77 to 0.83 mm



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

Bore plan



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

NOTE

For iron soldering or for dip soldering, the iron temperature or solder temperature may go up to 300 °C for a maximum of 3 seconds, with the transistor lock-fitted on printed boards in either of the possible mounting positions.

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	$R_{th\ j-a}$	=	0.4	°C/mW

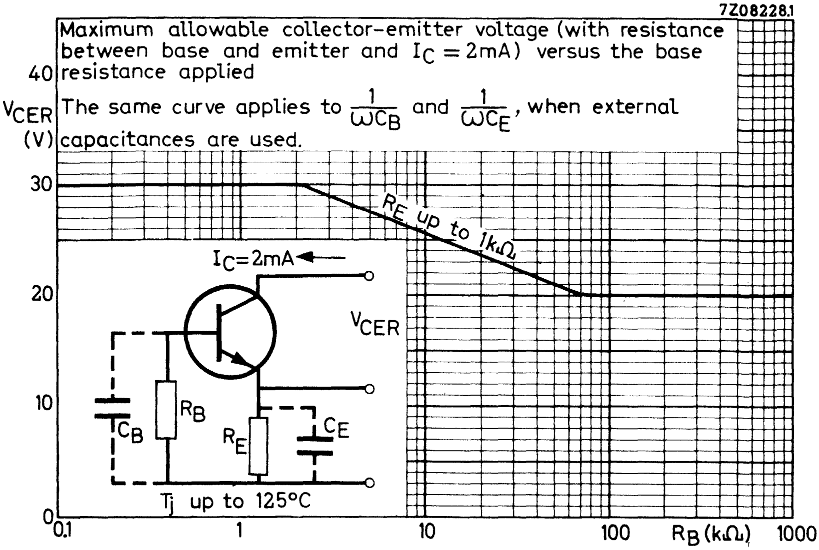
CHARACTERISTICS $T_j = 25\ ^oC$

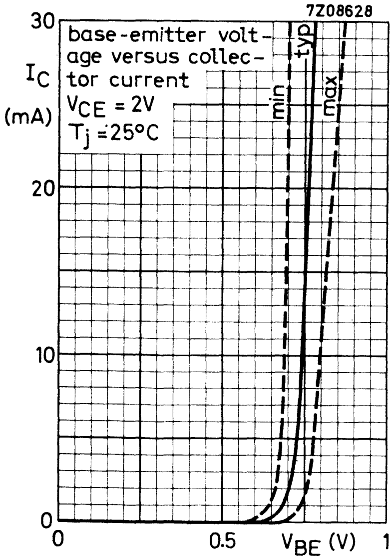
Base-emitter voltage [1])				
$I_C = 1$ mA; $V_{CE} = 10$ V	V_{BE}	0.65 to 0.74		V
Base current				
$I_C = 1$ mA; $V_{CE} = 10$ V	I_B	4.5 to	15	μA
		typ.	8.7	μA
Feedback capacitance at f = 0.45 MHz				
$I_C = 1$ mA; $V_{CE} = 10$ V	$-C_{re}$	typ.	0.95	pF
Transition frequency				
$I_C = 1$ mA; $V_{CE} = 10$ 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	$m\Omega^{-1}$

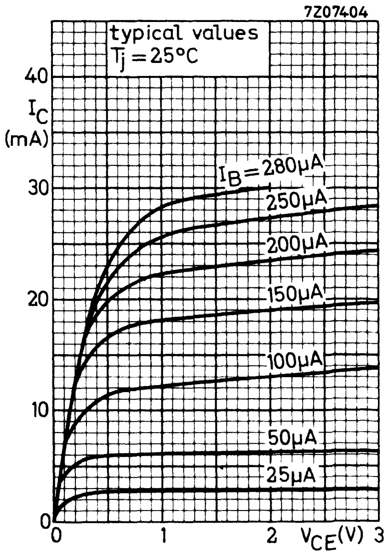
y parameters (common emitter)

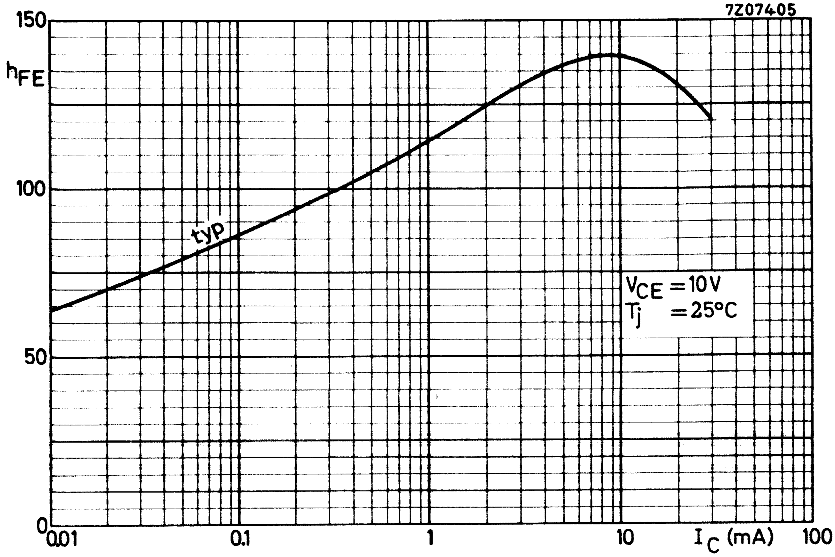
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)			f = 10.7 MHz	f = 0.45 MHz	
Input conductance	g_{ie}	<	0.64	0.54	$m\Omega^{-1}$
Output conductance	g_{oe}	<	13.5	11.5	$\mu\Omega^{-1}$

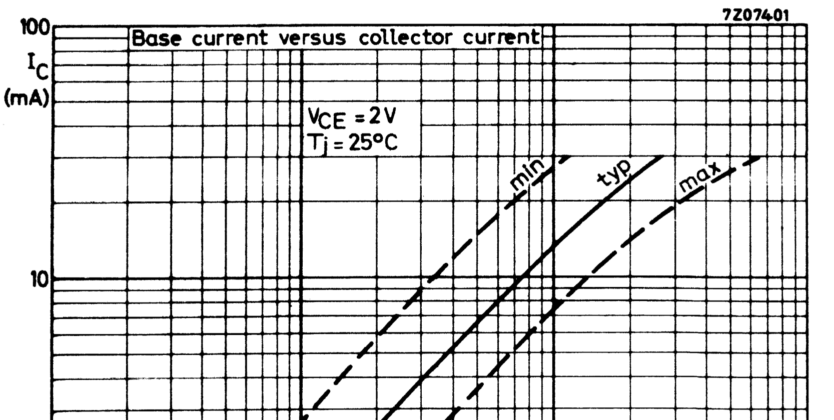
1) V_{BE} decreases by about 1.7 mV/^{o}C with increasing temperature.

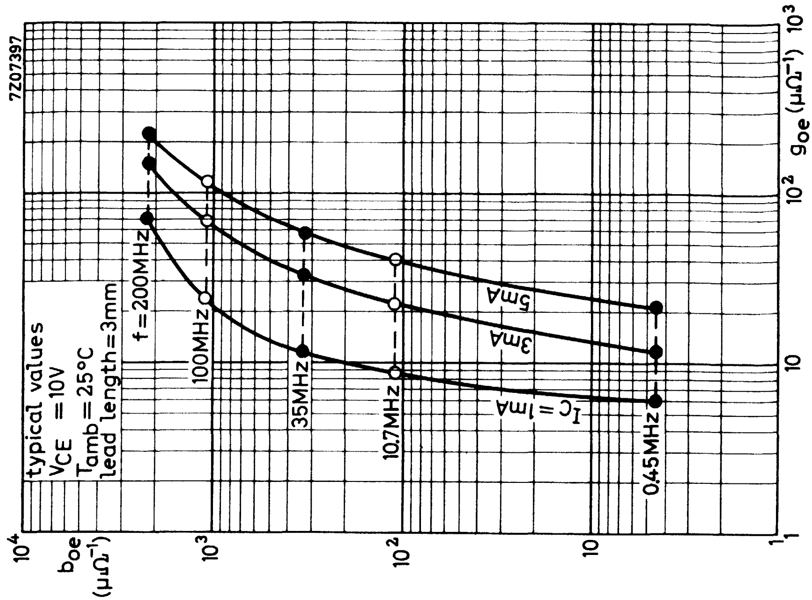

7Z08228.1
Maximum allowable collector-emitter voltage (with resistance between base and emitter and $I_C = 2mA$) versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$, when external capacitances are used.
V_{CER} (V)
RE up to 1kΩ
I_C=2mA
V_{CER}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

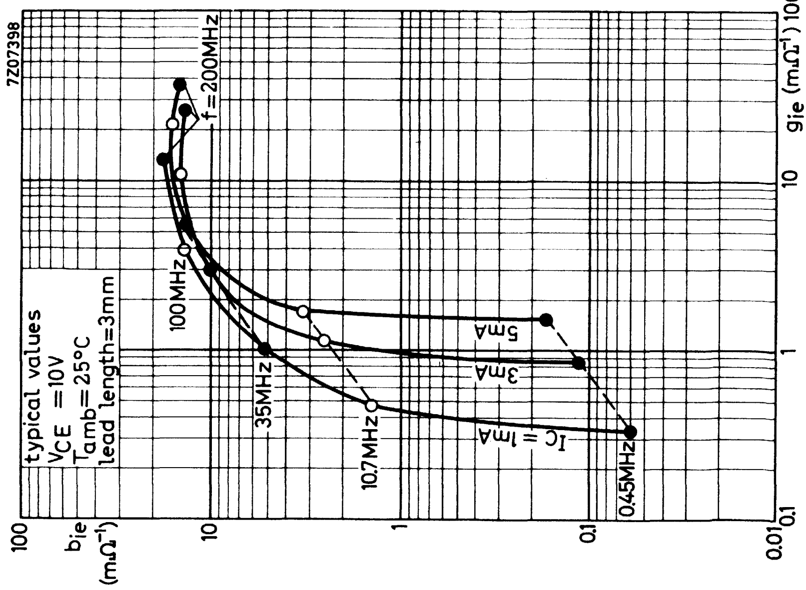

7Z08628
base-emitter voltage versus collector current
V_{CE} = 2V
T_j = 25°C
I_C (mA)
min
typ
max
V_{BE} (V)
0
10
20
30
0
0.5
1

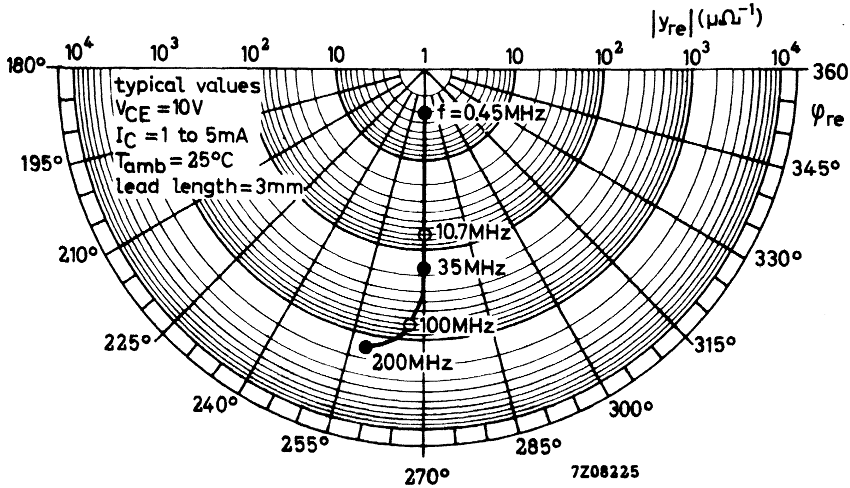

7Z07404
typical values
T_j = 25°C
I_C (mA)
I_B=280μA
250μA
200μA
150μA
100μA
50μA
25μA
V_{CE}(V)
0
10
20
30
40
0
1
2
3


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

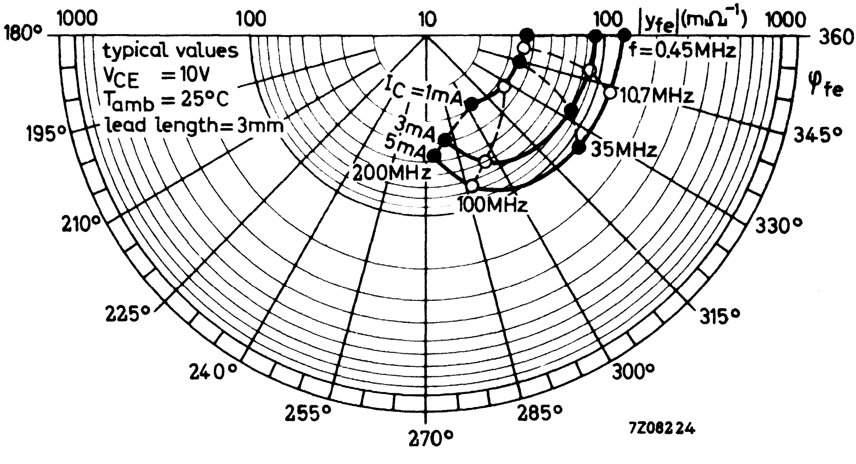

7Z07401
Base current versus collector current
100
I_C
(mA)
10
1
V_{CE} = 2 V
T_j = 25°C
min
typ
max
1
10
100
I_B (μA)
1000


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

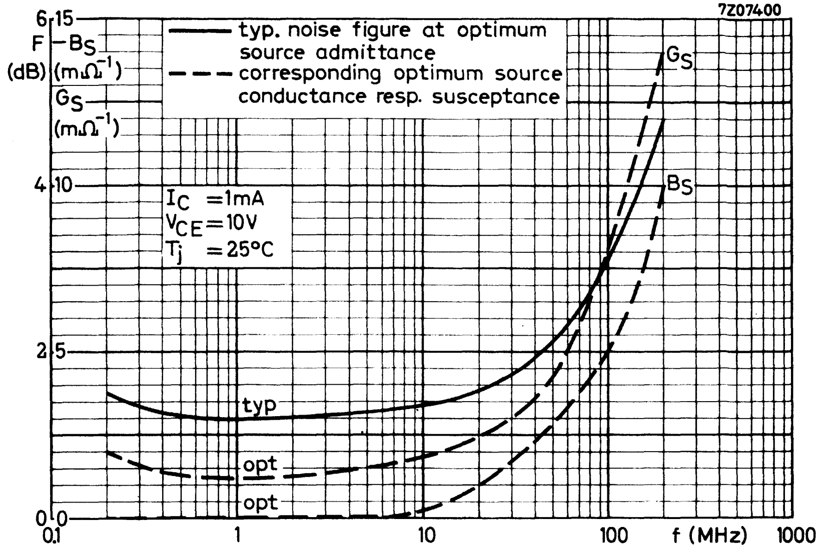

7Z07398
typical values
VCE = 10V
Tamb = 25°C
lead length = 3mm
f = 200MHz
100MHz
35MHz
10.7MHz
0.45MHz
5mA
3mA
IC = 1mA
bie (mΩ⁻¹)
gie (mΩ⁻¹)
100
10
1
0.1
0.01



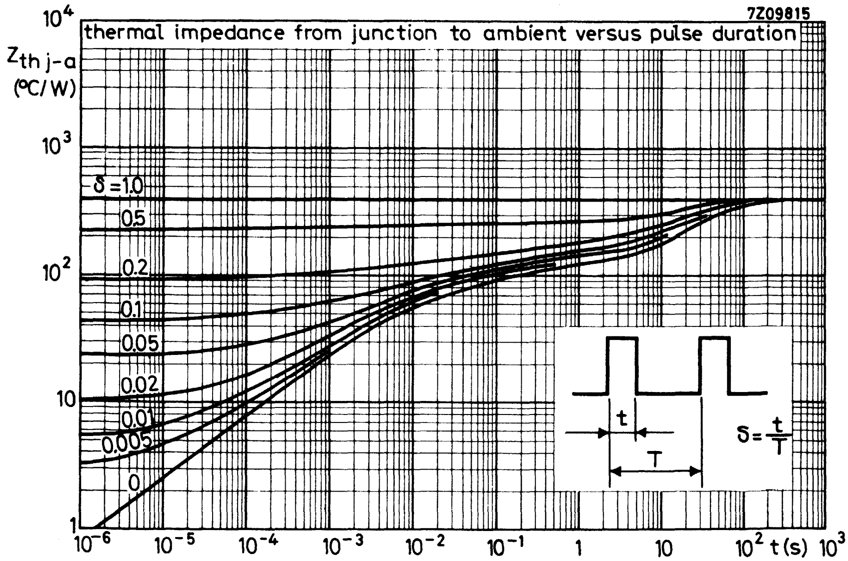
$|y_{re}|$ (μΩ^{-1})
10^4 10^3 10^2 10 1 10 10^2 10^3 10^4
180° 360°
φ_{re}
typical values
V_{CE} = 10V
I_C = 1 to 5mA
T_{amb} = 25°C
lead length = 3mm
f = 0.45MHz
10.7MHz
35MHz
100MHz
200MHz
195° 345°
210° 330°
225° 315°
240° 300°
255° 285°
270°
7Z08225



1000 100 10 100 1000
$|y_{fe}|$ (mΩ^{-1})
180° 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
195° 345°
210° 330°
225° 315°
240° 300°
255° 285°
270°
7Z08224



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



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
δ = 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

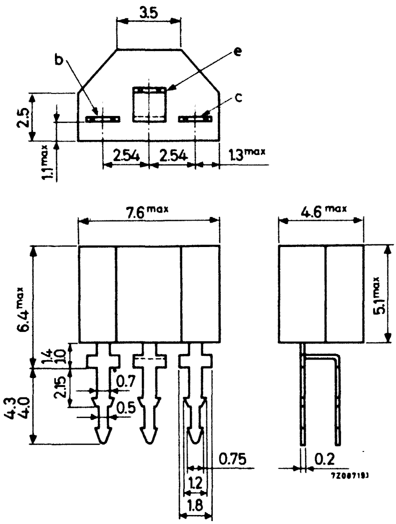
N-P-N transistor in a plastic envelope with stiff self-locking pins suitable for use with standard printed boards.
The BF195 is intended for h.f. applications in radio and television receivers; it is especially recommended for f.m. tuners, i.f. amplifiers in a.m./f.m. receivers where a low transistor output conductance is of importance, a.m. input stages of carradios where a low noise figure at low source impedance is required.

QUICK REFERENCE DATA

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

MECHANICAL DATA

Dimensions in mm

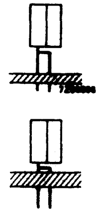


The envelope fulfils the accelerated damp heat test described in IEC publication 68-2 (test D, severity IV, 6 cycles).

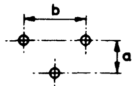
MOUNTING INSTRUCTIONS

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

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



Bore plan



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

NOTE

For iron soldering or for dip soldering, the iron temperature or solder temperature may go up to 300 °C for a maximum of 3 seconds, with the transistor lock-fitted on printed boards in either of the possible mounting positions.

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

Voltages				
Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base) (See also page 4)	V_{CEO}	max.	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V
Currents				
Collector current (d.c.)	I_C	max.	30	mA
Collector current (peak value)	I_{CM}	max.	30	mA
Power dissipation				
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	250	mW
Temperatures				
Storage temperature	T_{stg}	-65 to +125		°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

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

CHARACTERISTICS $T_j = 25\ ^oC$

Base-emitter voltage [1])

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

Base current

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

Feedback capacitance at f = 0.45 MHz

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

Transition frequency

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

Noise figure

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

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

Conversion noise figure

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

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

y parameters at f = 100 MHz (common base)

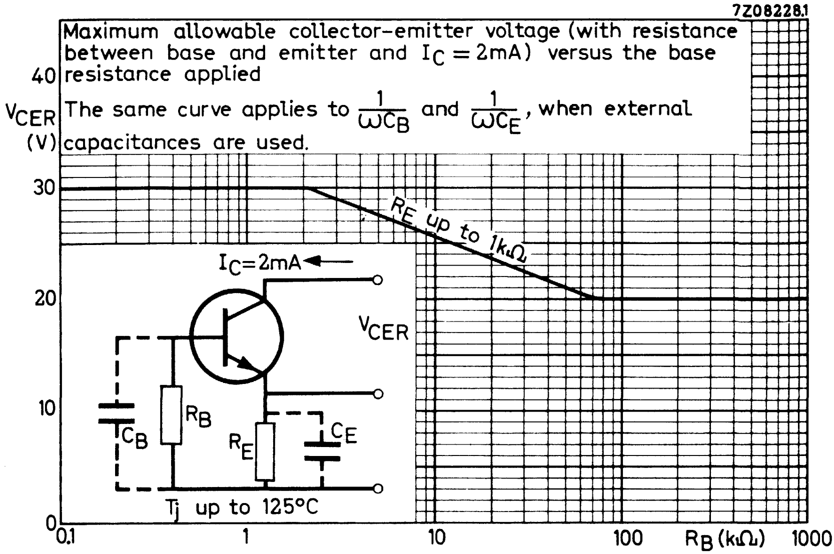
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)

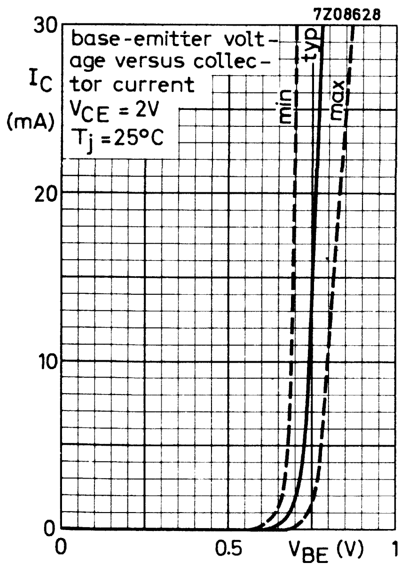
Input conductance	g_{ib}	typ.	38	$m\Omega^{-1}$
Input susceptance	$-b_{ib}$	typ.	1	$m\Omega^{-1}$
Feedback admittance	$\lvert y_{rb}\rvert$	typ.	440	$\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{rb}	typ.	275°	
Transfer admittance	$\lvert y_{fb}\rvert$	typ.	34	$m\Omega^{-1}$
Phase angle of transfer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

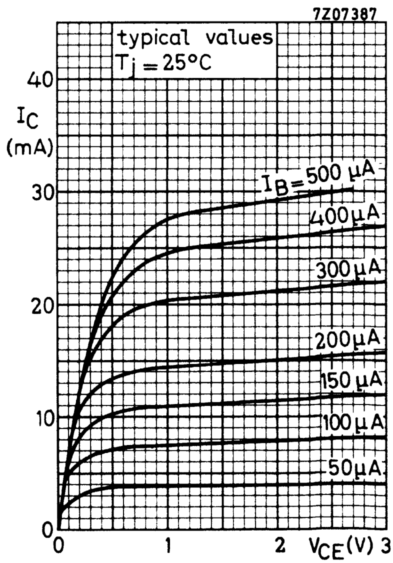
y parameters (common emitter)

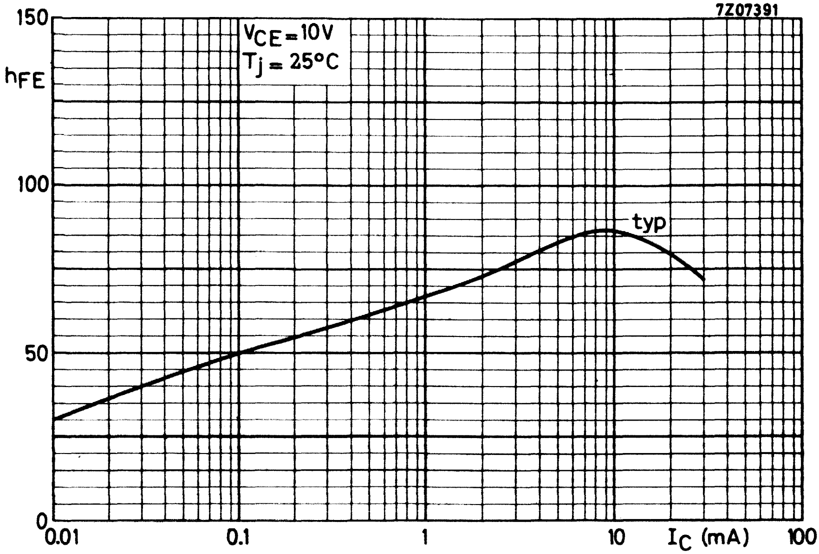
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)			f = 10.7 MHz	f = 0.45 MHz	
Input conductance	g_{ie}	<	0.96	0.86	$m\Omega^{-1}$
Output conductance	g_{oe}	<	9.5	7.0	$\mu\Omega^{-1}$

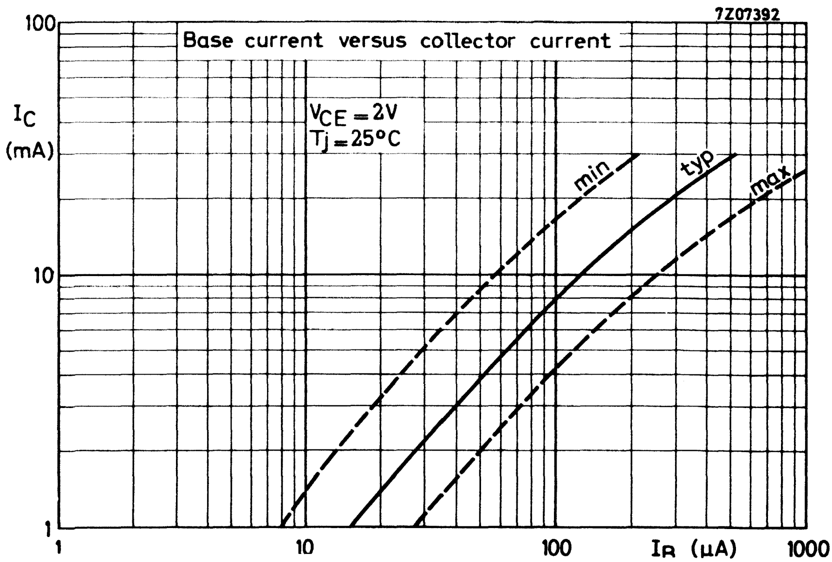
[1]) V_{BE} decreases by about 1.7 mV/°C with increasing temperature.

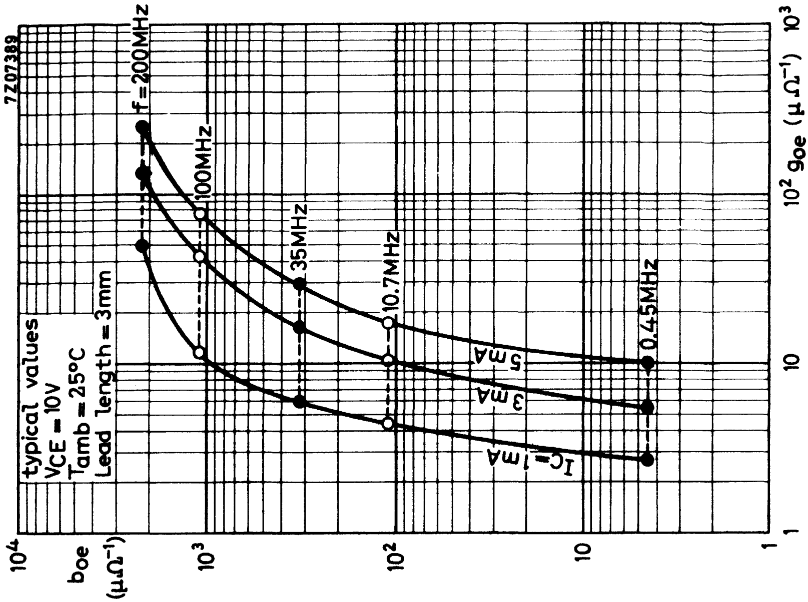

7Z08228.1
Maximum allowable collector-emitter voltage (with resistance between base and emitter and $I_C = 2mA$) versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$, when external capacitances are used.
V_{CER} (V)
40
30
20
10
0
RE up to 1kΩ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

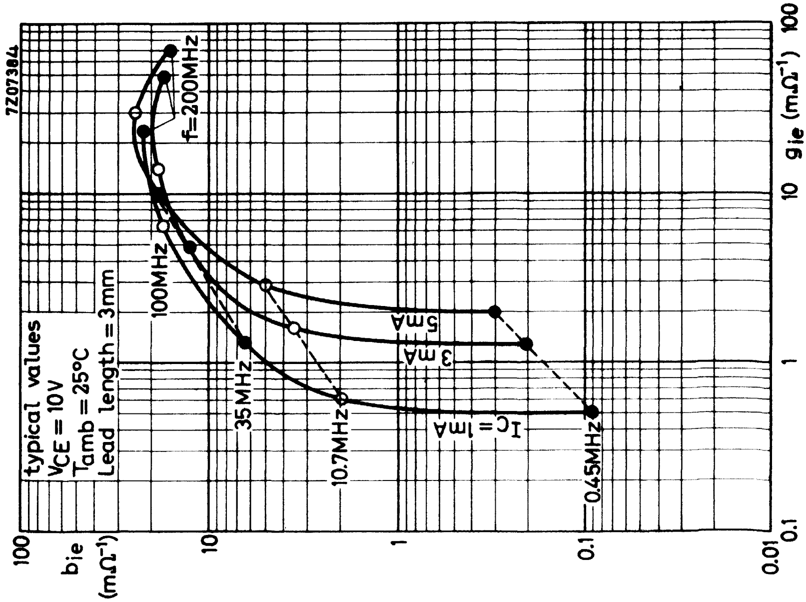

7Z08628
base-emitter voltage versus collector current
V_{CE} = 2V
T_j = 25°C
I_C (mA)
30
20
10
0
min
typ
max
0
0.5
V_{BE} (V)
1

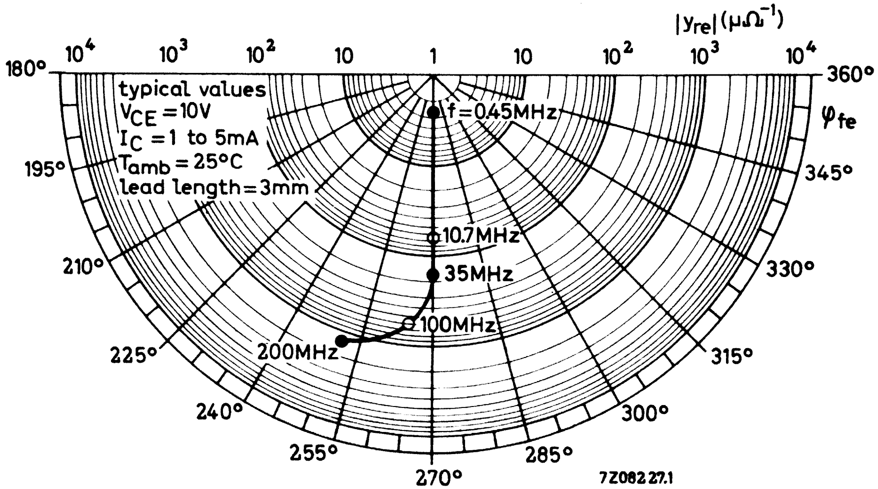

7Z07387
typical values
T_j = 25°C
I_C (mA)
40
30
20
10
0
I_B = 500 µA
400µA
300µA
200µA
150 µA
100 µA
50µA
0
1
2
V_{CE}(V)
3


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

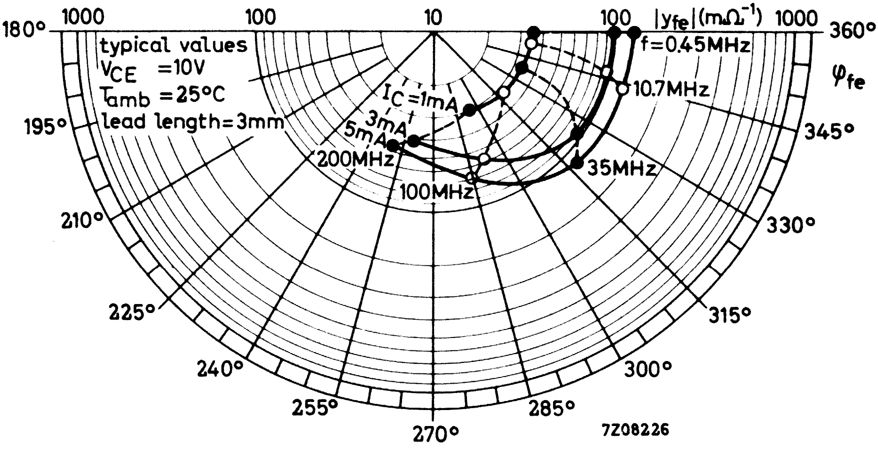

7Z07392
Base current versus collector current
100
I_C
(mA)
10
1
$V_{CE} = 2V$
$T_j = 25°C$
min
typ
max
1
10
100
I_B (μA)
1000


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

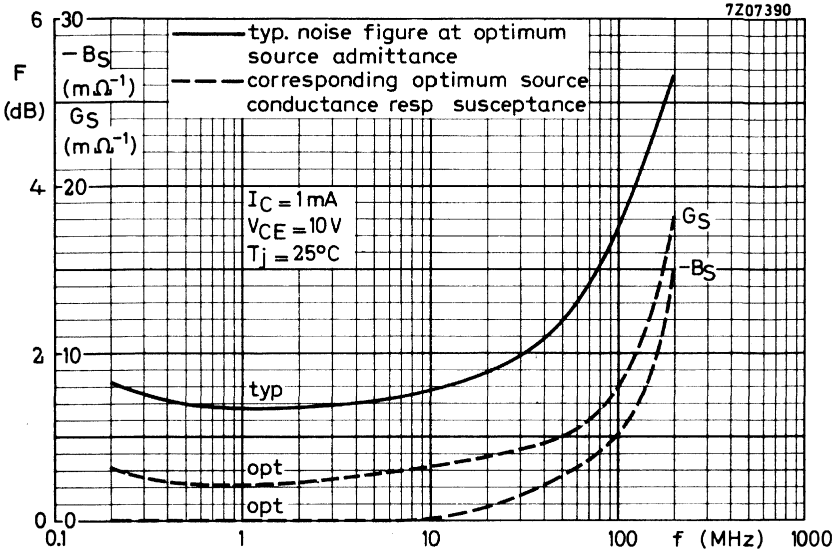

7Z07384
typical values
V_{CE} = 10V
T_{amb} = 25°C
Lead length = 3mm
f=200MHz
100MHz
35MHz
10.7MHz
0.45MHz
5 mA
3 mA
I_C = 1mA
b_{ie} ($m\Omega^{-1}$)
g_{ie} ($m\Omega^{-1}$)
100
10
1
0.1
0.01

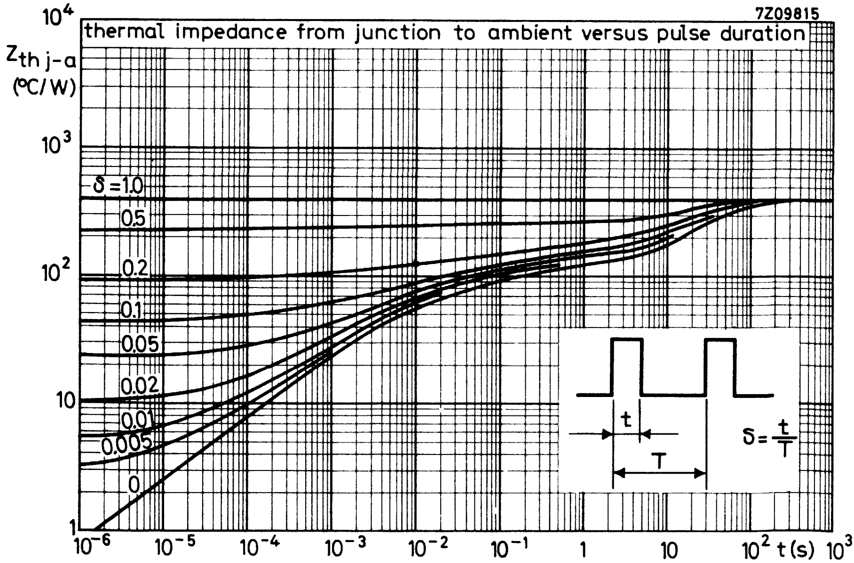


|yre| (μΩ⁻¹)
10⁴ 10³ 10² 10 1 10 10² 10³ 10⁴
180°
360°
φfe
typical values
VCE = 10V
IC = 1 to 5mA
Tamb = 25°C
lead length = 3mm
f = 0.45MHz
10.7MHz
35MHz
100MHz
200MHz
195°
210°
225°
240°
255°
270°
285°
300°
315°
330°
345°
7Z08227.1



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


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


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
δ = t/T
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t (s)
10^3

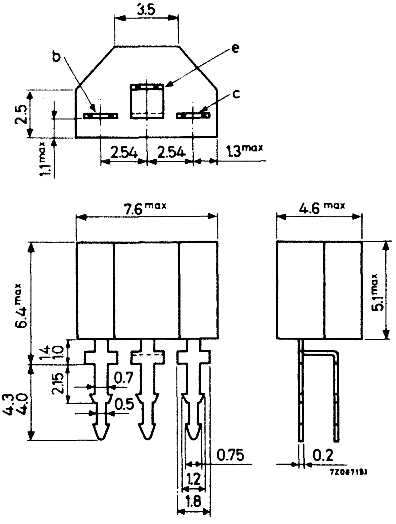
SILICON PLANAR TRANSISTOR

N-P-N transistor in a plastic envelope with stiff self-locking pins suitable for use with standard printed 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 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. unilateralised power gain I_C = 4 mA; V_{CE} = 10 V; f = 35 MHz	G_{UM}	typ.	42	dB
f = 45 MHz	G_{UM}	typ.	39	dB
Gain control range	ΔG_{tr}	typ.	60	dB

MECHANICAL DATA

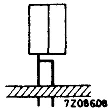
Dimensions in mm



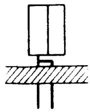
The envelope fulfils the accelerated damp heat test described in IEC publication 68-2 (test D, severity IV, 6 cycles).

MOUNTING INSTRUCTIONS

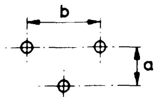
1. Thickness of printed board: max. 1.1 mm
   Hole diameter 0.77 to 0.83 mm



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



Bore plan



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

RATINGS (Limiting values) [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	$R_{th\ j-a}$	=	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	$\lvert y_{re}\rvert$	typ.	47	60	μΩ^{-1}
Phase angle of feedback admittance	φ_{re}	typ.	268°	268°	
Transfer admittance	$\lvert y_{fe}\rvert$	typ.	105	100	mΩ^{-1}
Phase angle of transfer admittance	φ_{fe}	typ.	340°	340°	
Output conductance	g_{oe}	typ.	50	60	μΩ^{-1}
Output capacitance	C_{oe}	typ.	1.3	1.3	pF

Maximum unilateralised power gain

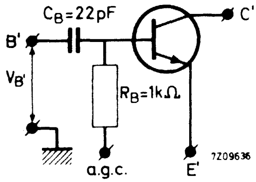
$$G_{UM} \text{ (in dB)} = 10 \log \frac{|y_{fe}|^2}{4 g_{ie} g_{oe}}$$

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

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

Equivalent gain control transistor

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



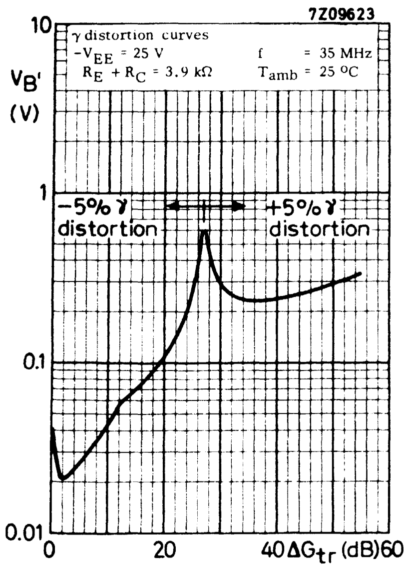
The transistor with these additional components is effectively an "equivalent transistor" for gain control purposes, the signal handling capability of which may be expressed in terms of voltage. (Without these components the varying input admittance means that the signal handling capability can only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

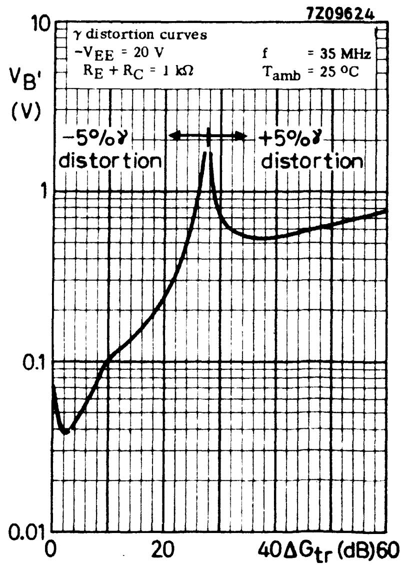
The signal handling capability of the equivalent transistor as a function of ΔG_{tr} (the reduction in transducer gain with gain control) will be found on pages 4 and 5.

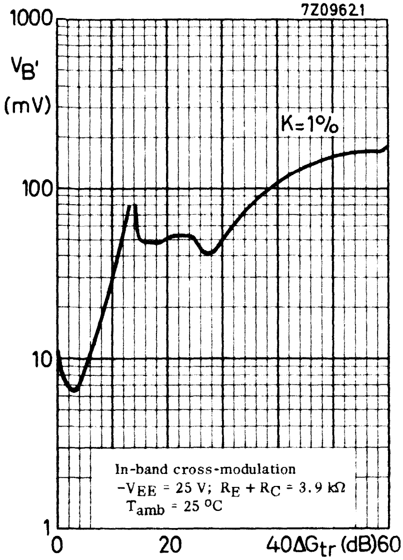
a. Voltage versus ΔG_{tr} curves for a γ distortion of 5% are below.

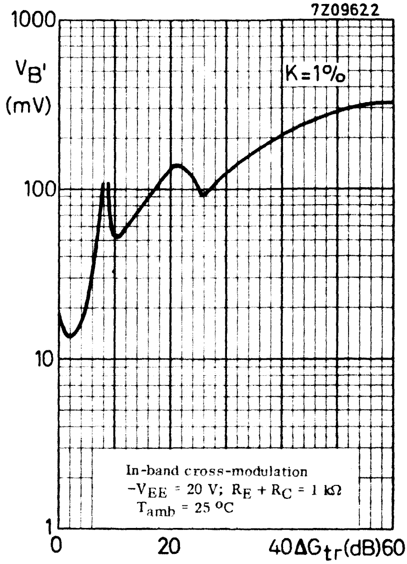
b. Voltage versus ΔG_{tr} curves for an in-band cross modulation factor of 1% are on page 5.

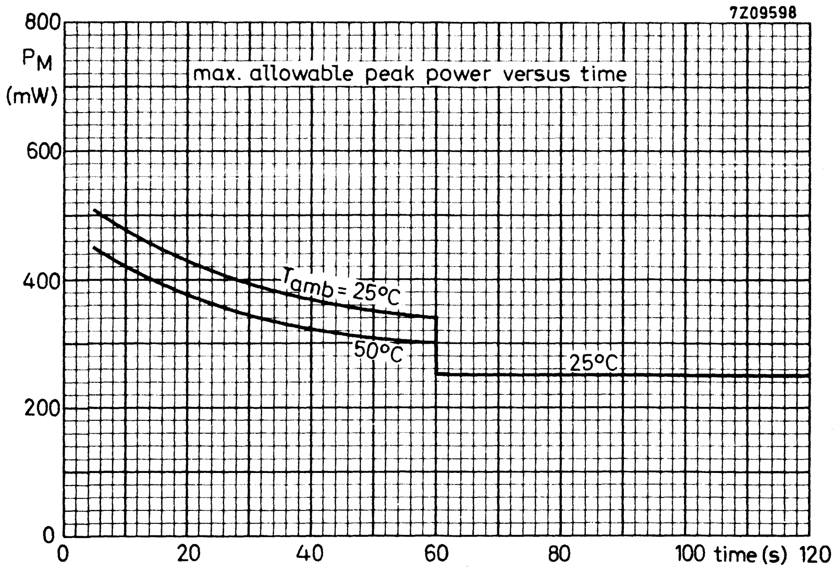
Graphs of the y-parameters are on pages 8 to 11.

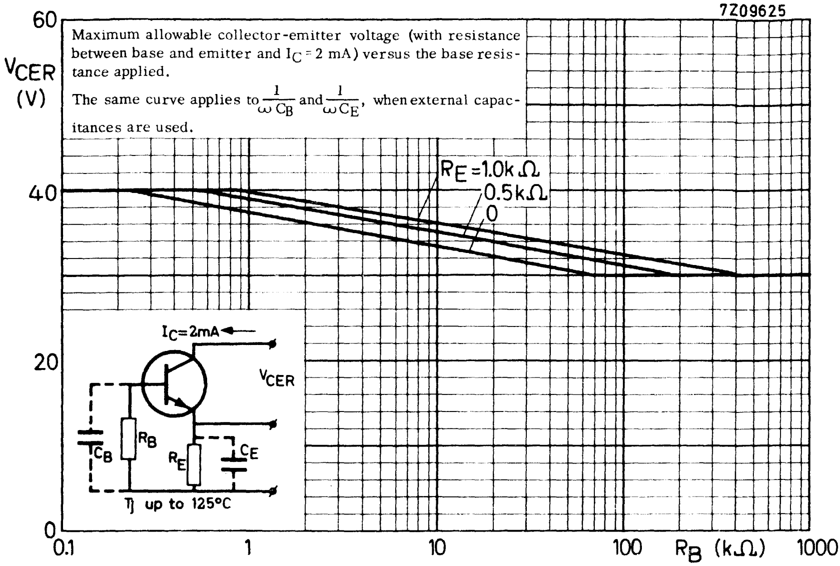


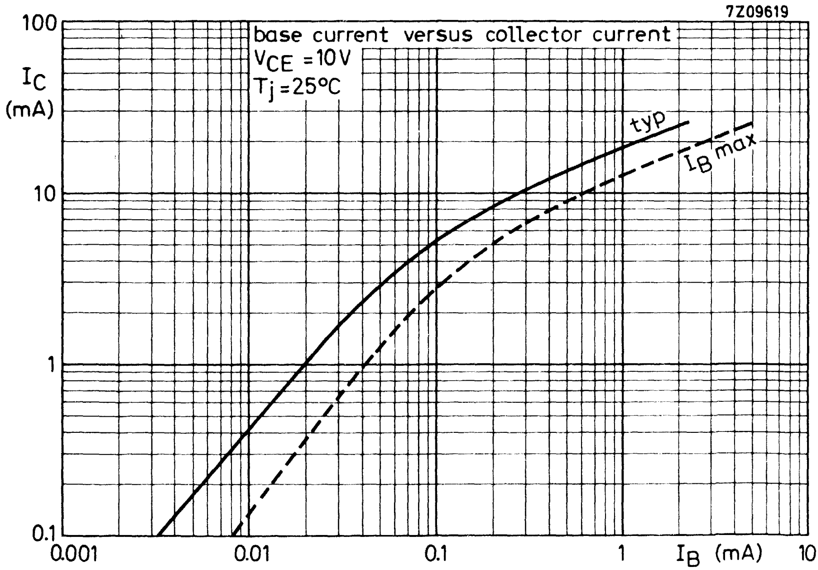


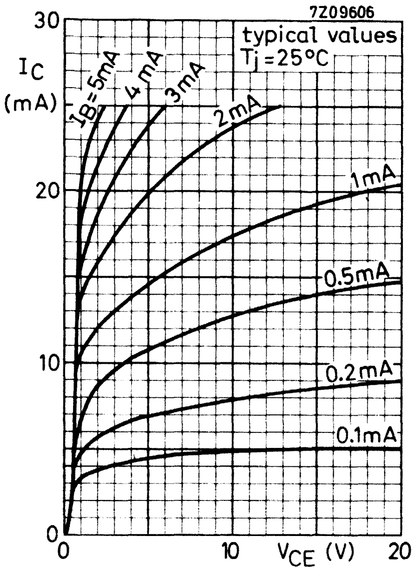

7Z09621
1000
$V_{B'}$
(mV)
K=1%
100
10
1
In-band cross-modulation
$-V_{EE}$ = 25 V; $R_E + R_C$ = 3.9 kΩ
T_{amb} = 25 °C
0
20
40 ΔG_{tr} (dB) 60

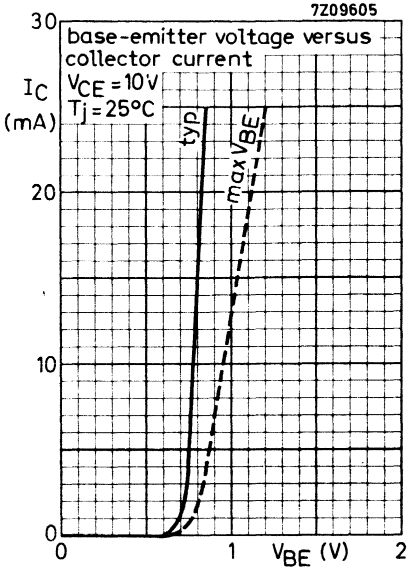

7Z09622
1000
$V_{B'}$
(mV)
K=1%
100
10
1
In-band cross-modulation
$-V_{EE}$ = 20 V; $R_E + R_C$ = 1 kΩ
T_{amb} = 25 °C
0
20
40 ΔG_{tr} (dB) 60

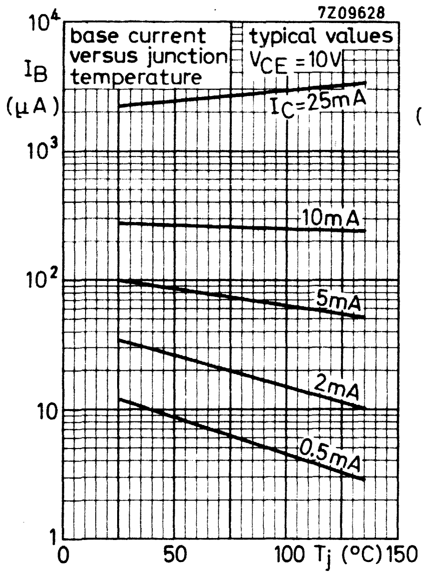

7Z09598
800
P_M
(mW)
max. allowable peak power versus time
600
400
T_{amb} = 25 °C
50 °C
25 °C
200
0
0
20
40
60
80
100 time (s) 120

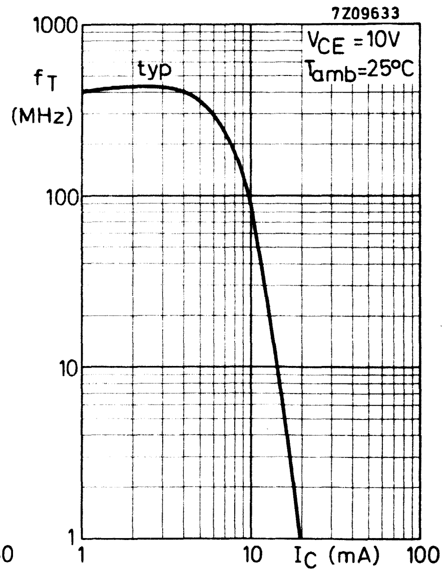

7Z09625
Maximum allowable collector-emitter voltage (with resistance between base and emitter and I_C = 2 mA) versus the base resistance applied.
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$, when external capacitances are used.
V_{CER} (V)
60
40
20
0
R_E = 1.0 kΩ
0.5 kΩ
0
I_C = 2mA
V_{CER}
C_B
R_B
R_E
C_E
T_j up to 125°C
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

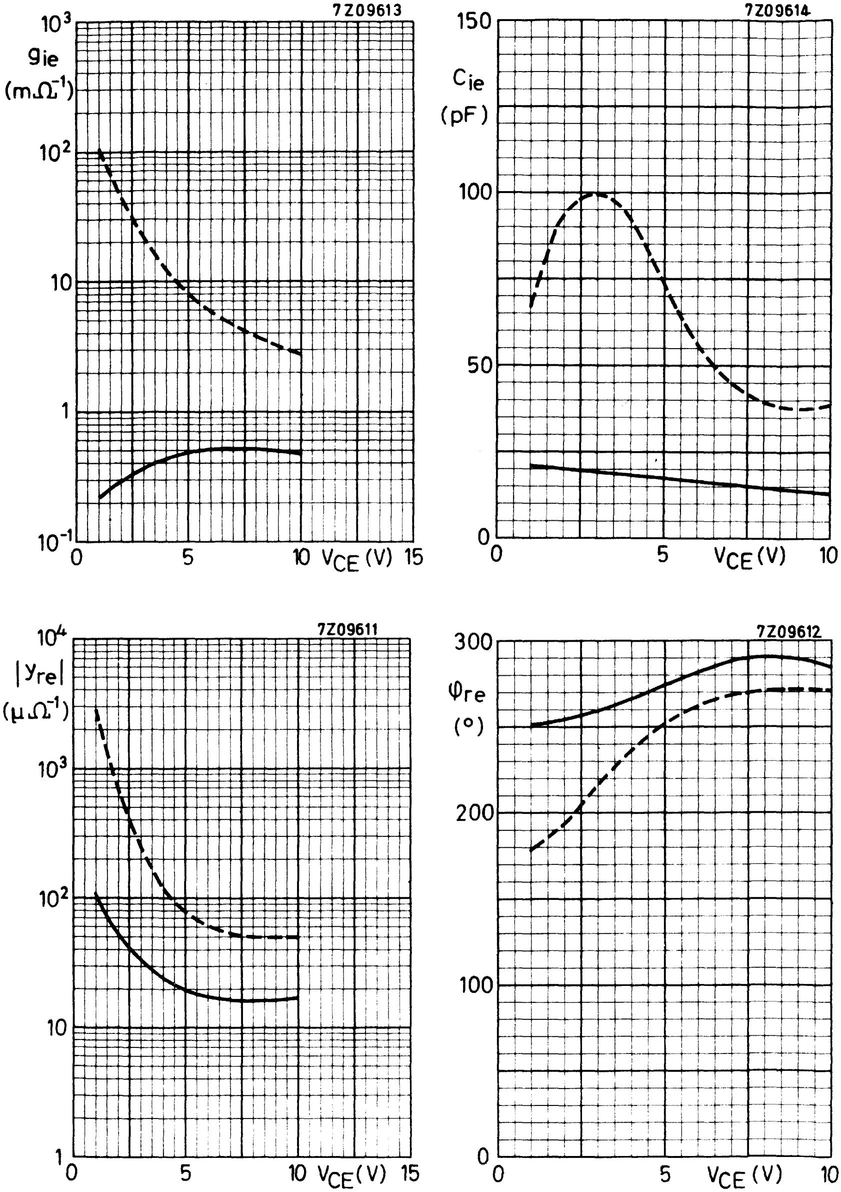

7Z09606
typical values
Tj = 25°C
IC
(mA)
IB = 5mA
4 mA
3mA
2 mA
1mA
0.5mA
0.2mA
0.1mA
30
20
10
0
0
10
VCE (V)
20


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


7Z09628
base current
versus junction
temperature
typical values
VCE = 10V
IB
(µA)
IC = 25mA
10mA
5mA
2mA
0.5mA
10^4
10^3
10^2
10
1
0
50
100 Tj (°C) 150

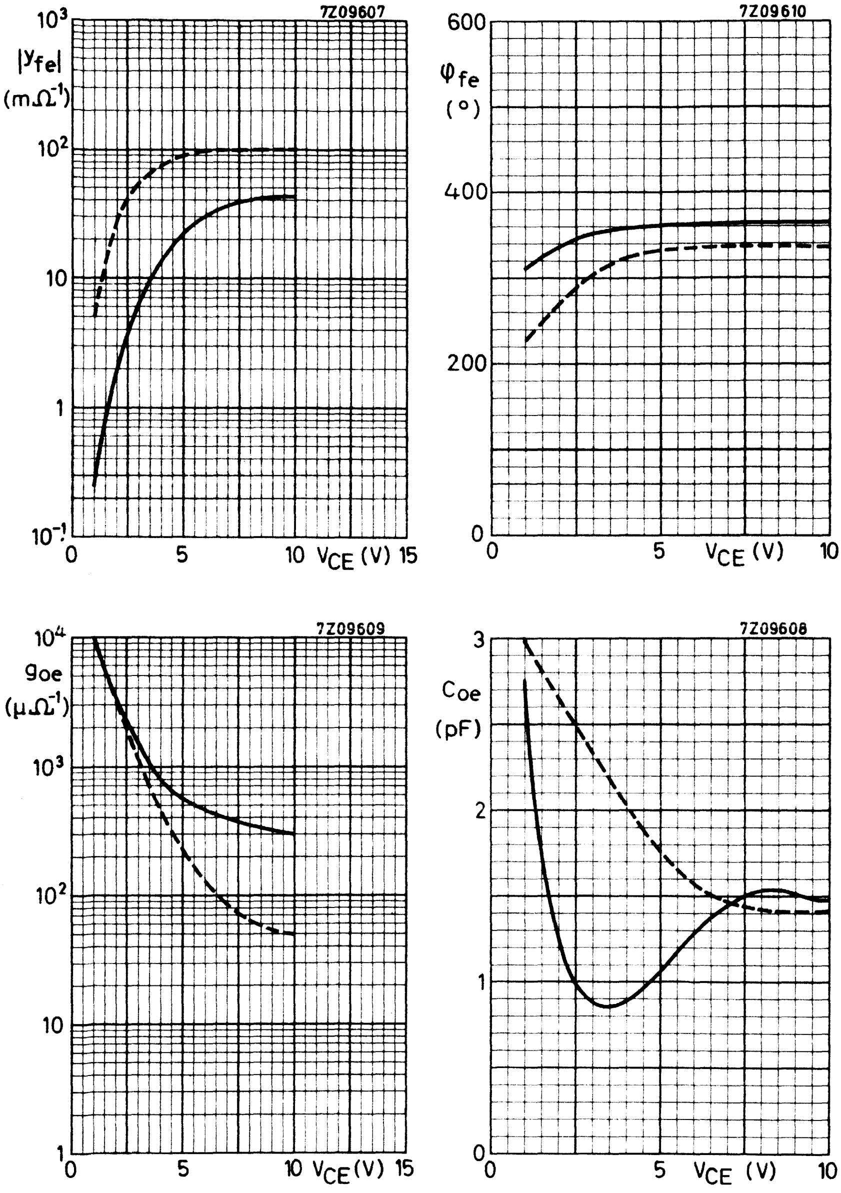

7Z09633
VCE = 10V
Tamb = 25°C
fT
(MHz)
typ
1000
100
10
1
1
10
IC (mA)
100

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



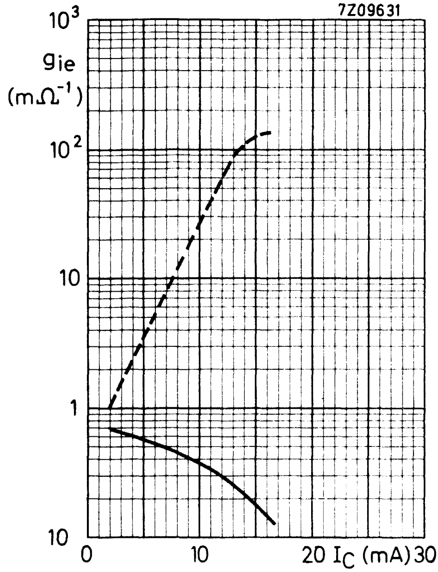
y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

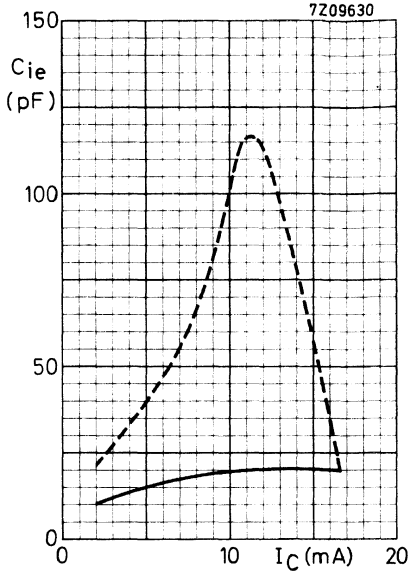
Voltage control; $-V_{EE} = 25$ V; $R_E + R_C = 3.9$ kΩ; f = 35 MHz

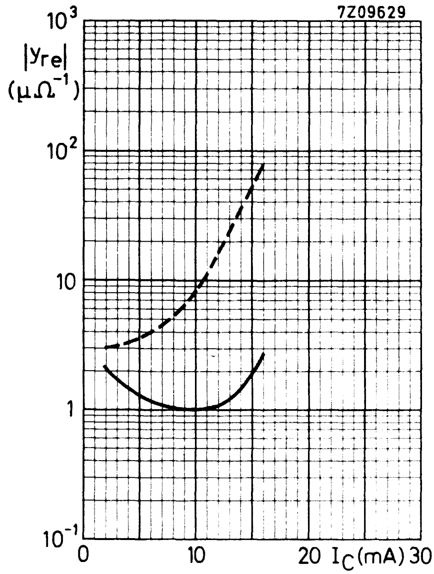


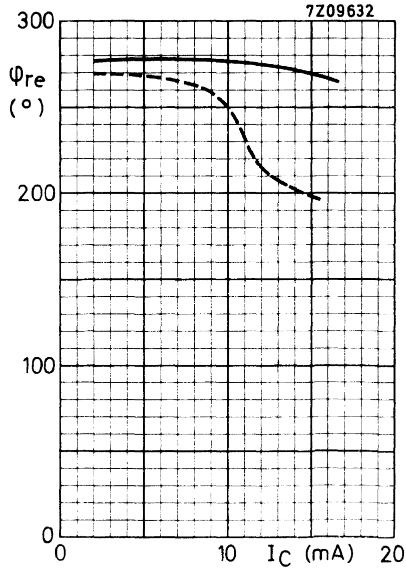
y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

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



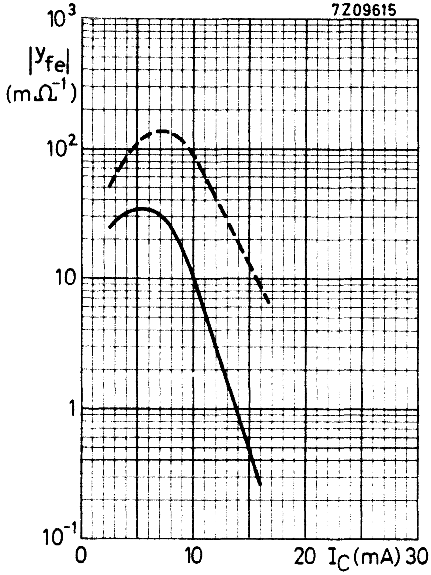


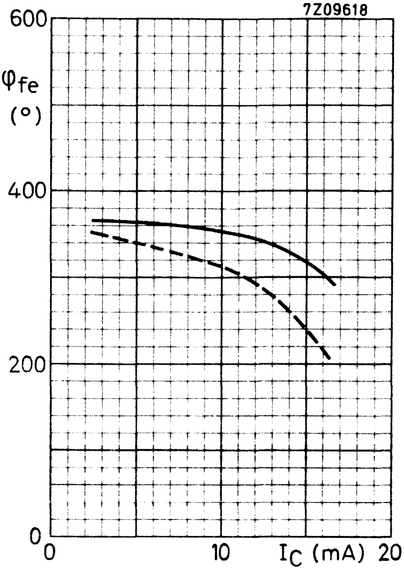


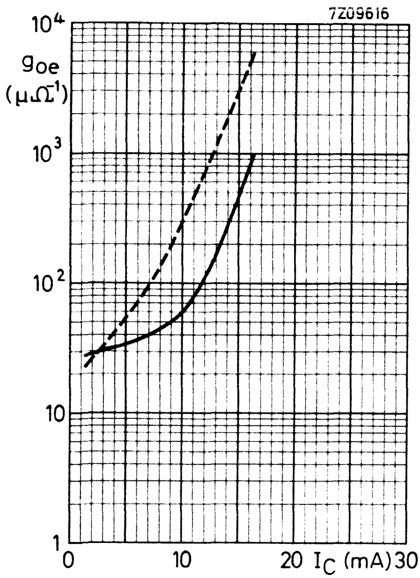


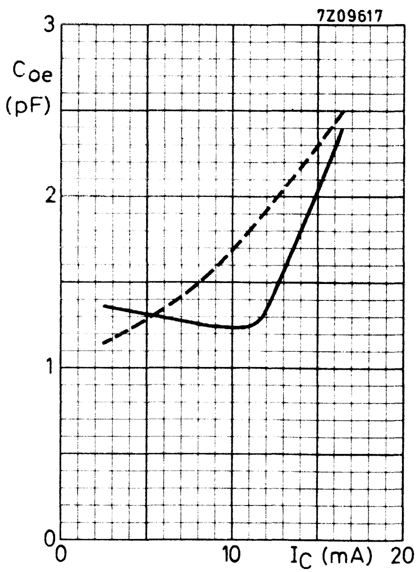
y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

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









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

APPLICATION INFORMATION

→ For application information see BF198.

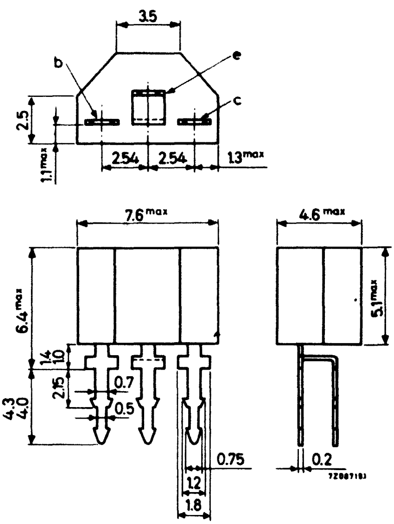
SILICON PLANAR EPITAXIAL TRANSISTOR

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

QUICK REFERENCE DATA

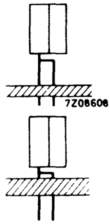
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Collector current (d.c.)	I_C	max.	25	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	250	mW
Junction temperature	T_j	max.	125	°C
Transition frequency at f = 100 MHz I_C = 5 mA; 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. unilateralised power gain I_C = 7 mA; V_{CE} = 10 V; f = 35 MHz	G_{UM}	typ.	43	dB
f = 45 MHz	G_{UM}	typ.	41	dB
Video detector output voltage	V_O	typ.	7.7	V

MECHANICAL DATA Dimensions in mm



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

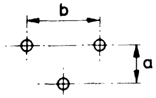
MOUNTING INSTRUCTIONS



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

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

Bore plan



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

RATINGS (Limiting values) [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)

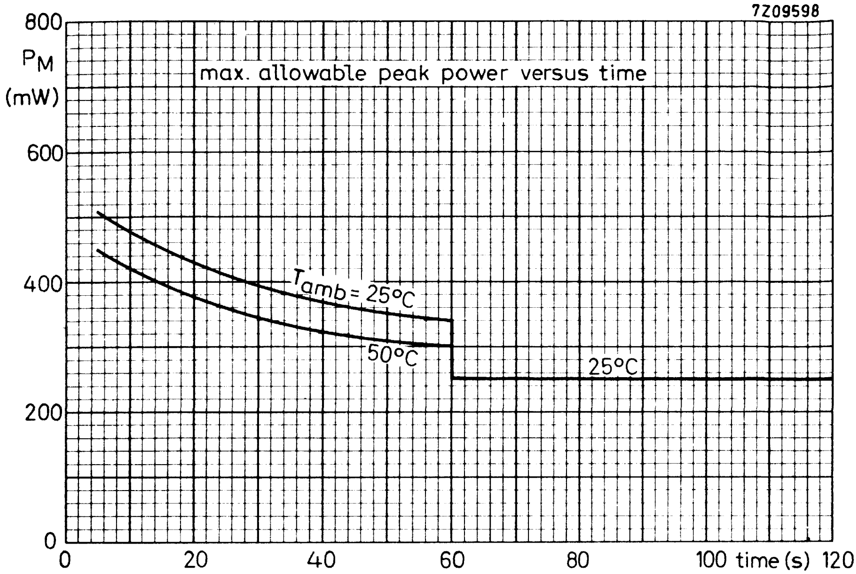
			f = 35	45	MHz
Input conductance	g_{ie}	typ.	4.5	5.5	$m\Omega^{-1}$
Input capacitance	C_{ie}	typ.	45	45	pF
Feedback admittance	$\lvert y_{re}\rvert$	typ.	67	86	$\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{re}	typ.	268°	268°	
Transfer admittance	$\lvert y_{fe}\rvert$	typ.	170	155	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fe}	typ.	338°	335°	
Output conductance	g_{oe}	typ.	85	95	$\mu\Omega^{-1}$
Output capacitance	C_{oe}	typ.	1.8	1.8	pF

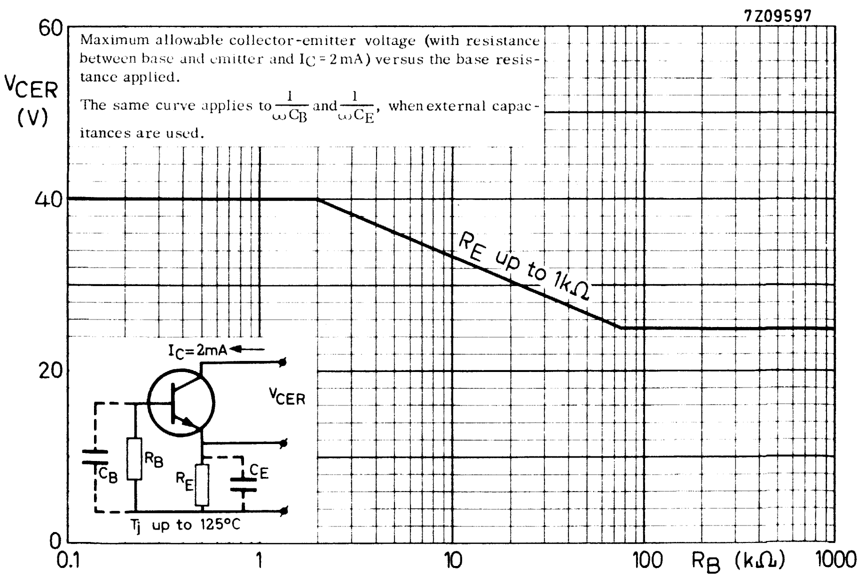
Maximum unilateralised power gain

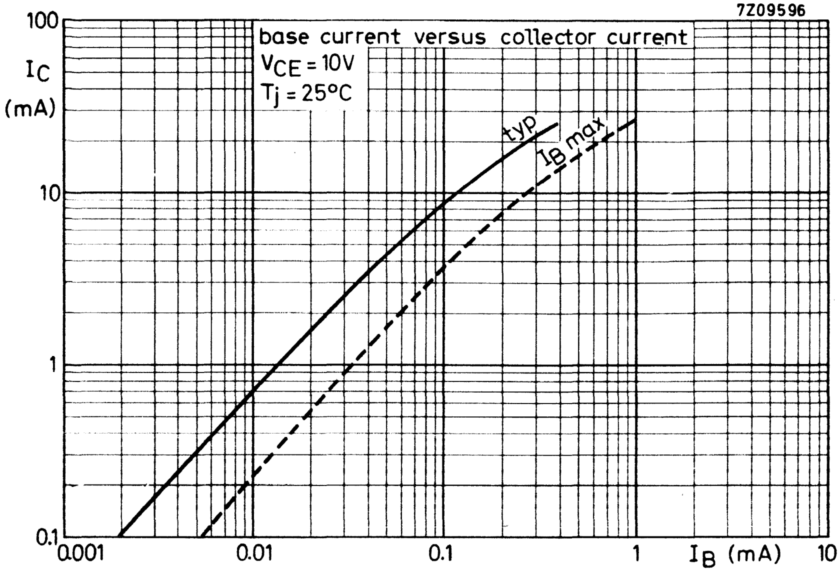
$$G_{UM} \text{ (in dB)} = 10 \log \frac{|y_{fe}|^2}{4 g_{ie} g_{oe}}$$

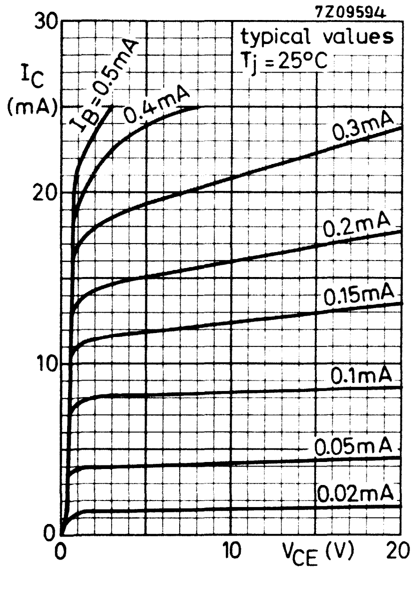
I_C = 7 mA; V_{CE} = 10 V	G_{UM}	typ.	43	41	dB

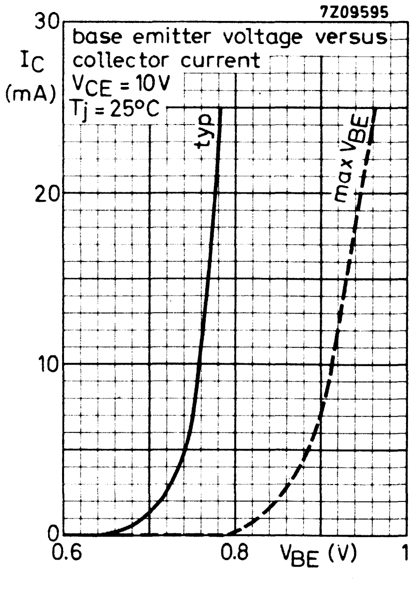
1) V_{BE} decreases by about 1.7 mV/°C with increasing temperature.

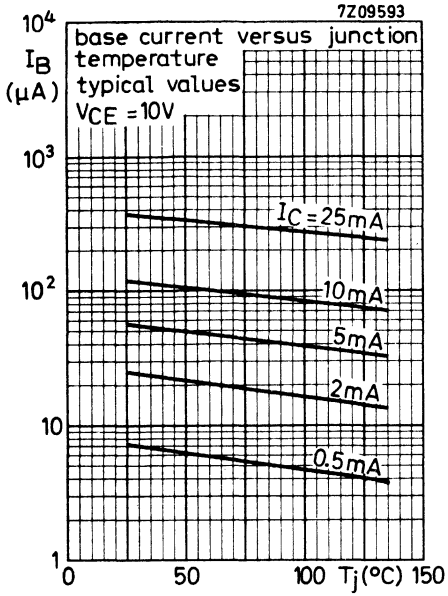

7Z09598
800
P_M
(mW)
600
400
200
0
max. allowable peak power versus time
T_{amb} = 25°C
50°C
25°C
0
20
40
60
80
100 time (s) 120

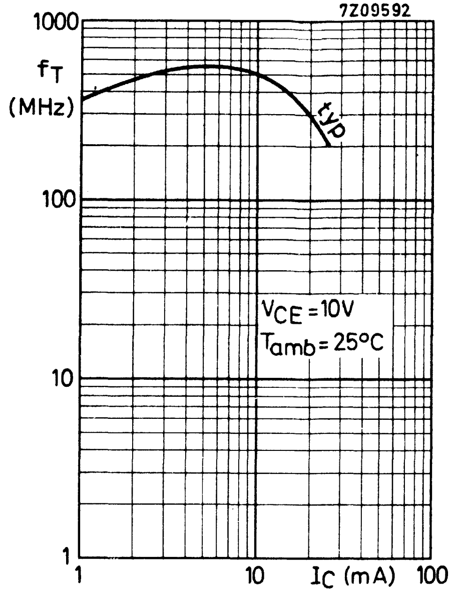

7Z09597
60
V_{CER}
(V)
40
20
0
Maximum allowable collector-emitter voltage (with resistance between base and emitter and I_C = 2 mA) versus the base resistance applied.
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$, when external capacitances are used.
R_E up to 1kΩ
I_C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


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


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


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





APPLICATION INFORMATION

For application information see BF199.

SILICON PLANAR TRANSISTOR

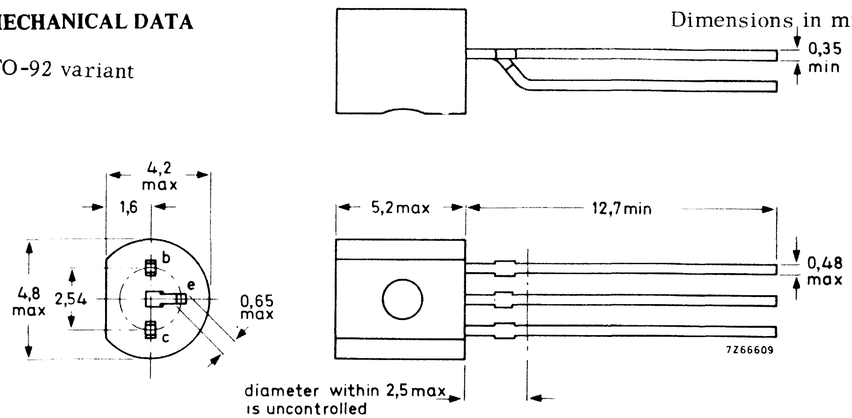
N-P-N transistor in a plastic TO-92 variant.
The BF198 has a very low feedback capacitance and is intended for use in the forward gain control stage of the television i.f. amplifier.

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

MECHANICAL DATA

TO-92 variant

Dimensions in mm



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

Voltages				
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	V [1]
Emitter-base voltage (open collector)	V_{EBO}	max.	4	V
Currents				
Collector current (d.c.)	I_C	max.	25	mA
Collector current (peak value)	I_{CM}	max.	25	mA
Power dissipation				
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	mW
Temperatures				
Storage temperature	T_{stg}	−65 to +150		°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.25	°C/mW

[1]) See also page 6.

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

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

y parameters (common emitter)

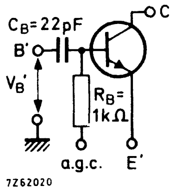
I_C = 4 mA; V_{CE} = 10 V

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



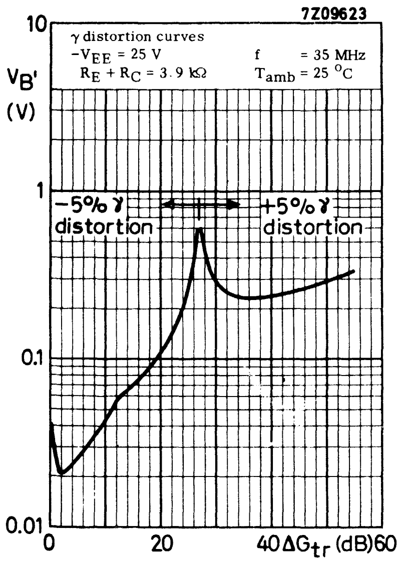
The transistor with these additional components is effectively an "equivalent transistor" for gain control purposes, the signal handling capability of which may be expressed in terms of voltage. (Without these components the varying input admittance means that the signal handling capability can only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

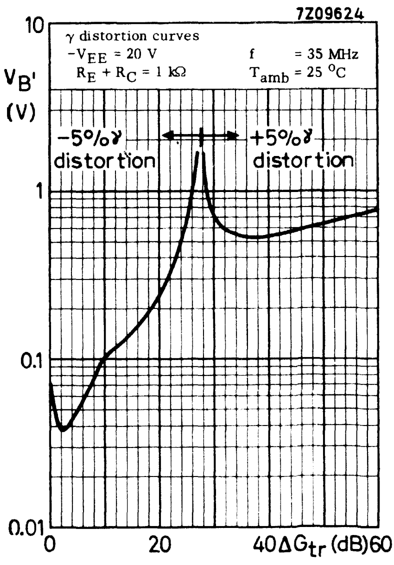
The signal handling capability of the equivalent transistor as a function of ΔG_{tr} (the reduction in transducer gain with gain control) will be found on pages 4 and 5.

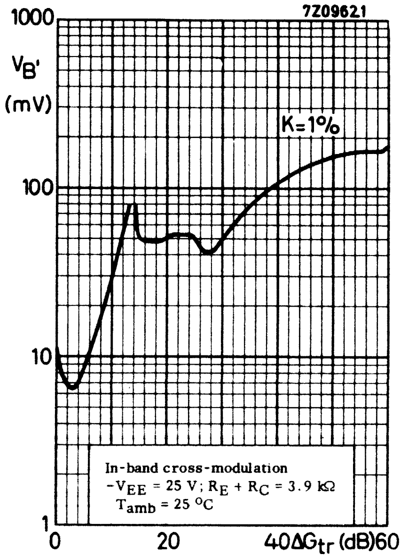
a. Voltage versus ΔG_{tr} curves for a γ distortion of 5% are below.

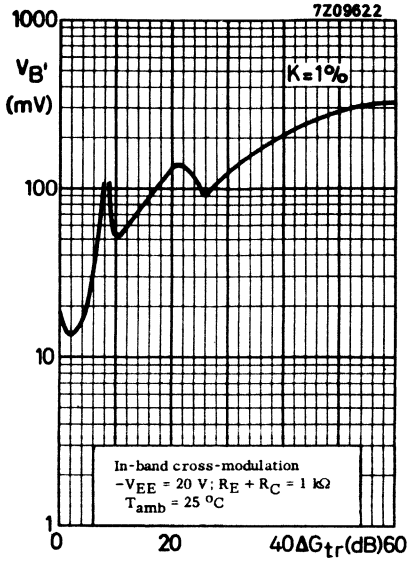
b. Voltage versus ΔG_{tr} curves for an in-band cross modulation factor of 1% are on page 5.

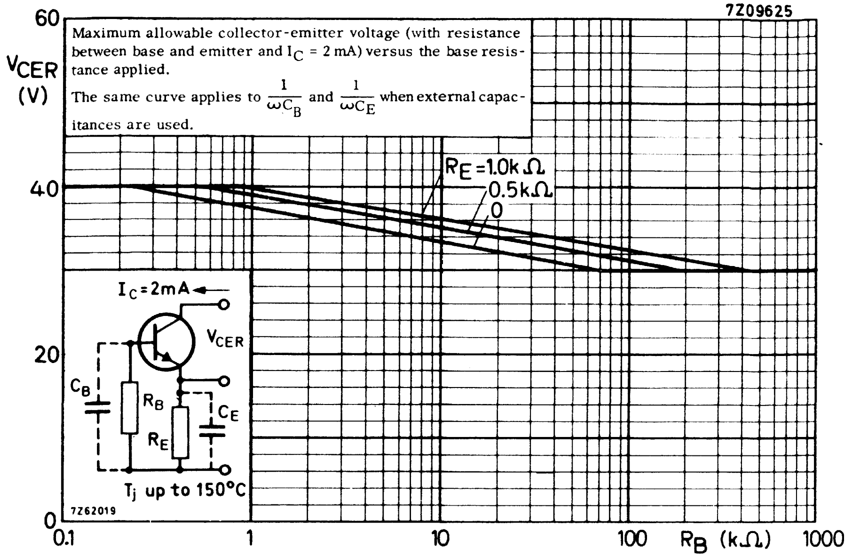
Graphs of the y-parameters are on pages 8 to 11.

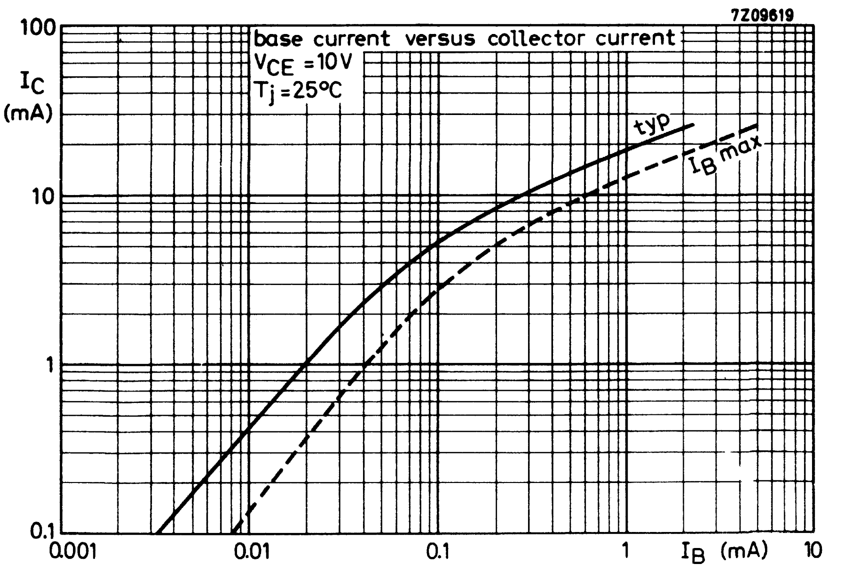


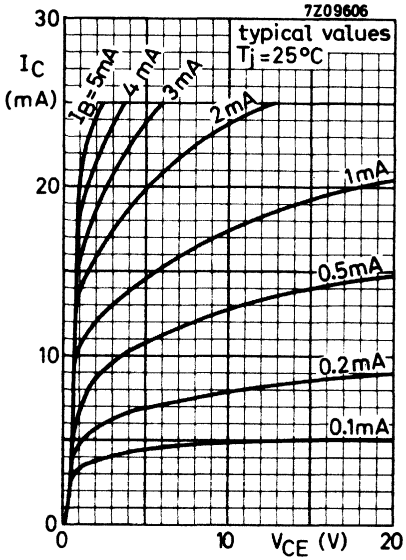


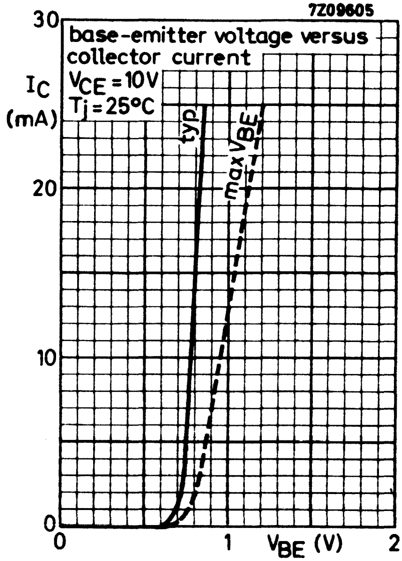

7Z09621
1000
100
10
1
$V_{B'}$
(mV)
K=1%
0
20
40 ΔG_{tr} (dB) 60
In-band cross-modulation
$-V_{EE}$ = 25 V; $R_E + R_C$ = 3.9 kΩ
T_{amb} = 25 °C

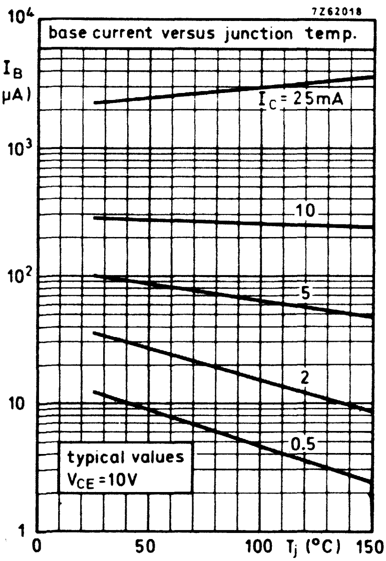

7Z09622
1000
100
10
1
$V_{B'}$
(mV)
K=1%
0
20
40 ΔG_{tr} (dB) 60
In-band cross-modulation
$-V_{EE}$ = 20 V; $R_E + R_C$ = 1 kΩ
T_{amb} = 25 °C

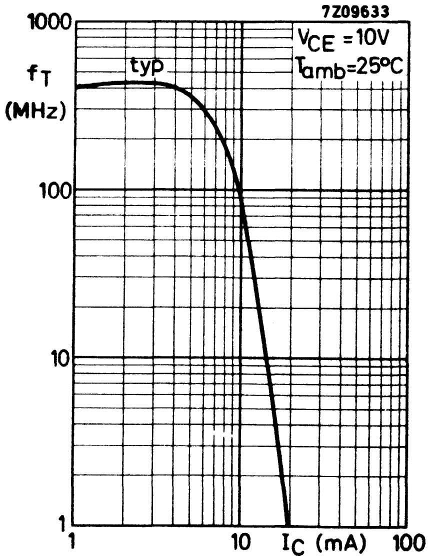

7Z09625
Maximum allowable collector-emitter voltage (with resistance between base and emitter and I_C = 2 mA) versus the base resistance applied.
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$ when external capacitances are used.
V_{CER} (V)
R_E = 1.0 kΩ
0.5 kΩ
0
I_C = 2mA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


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

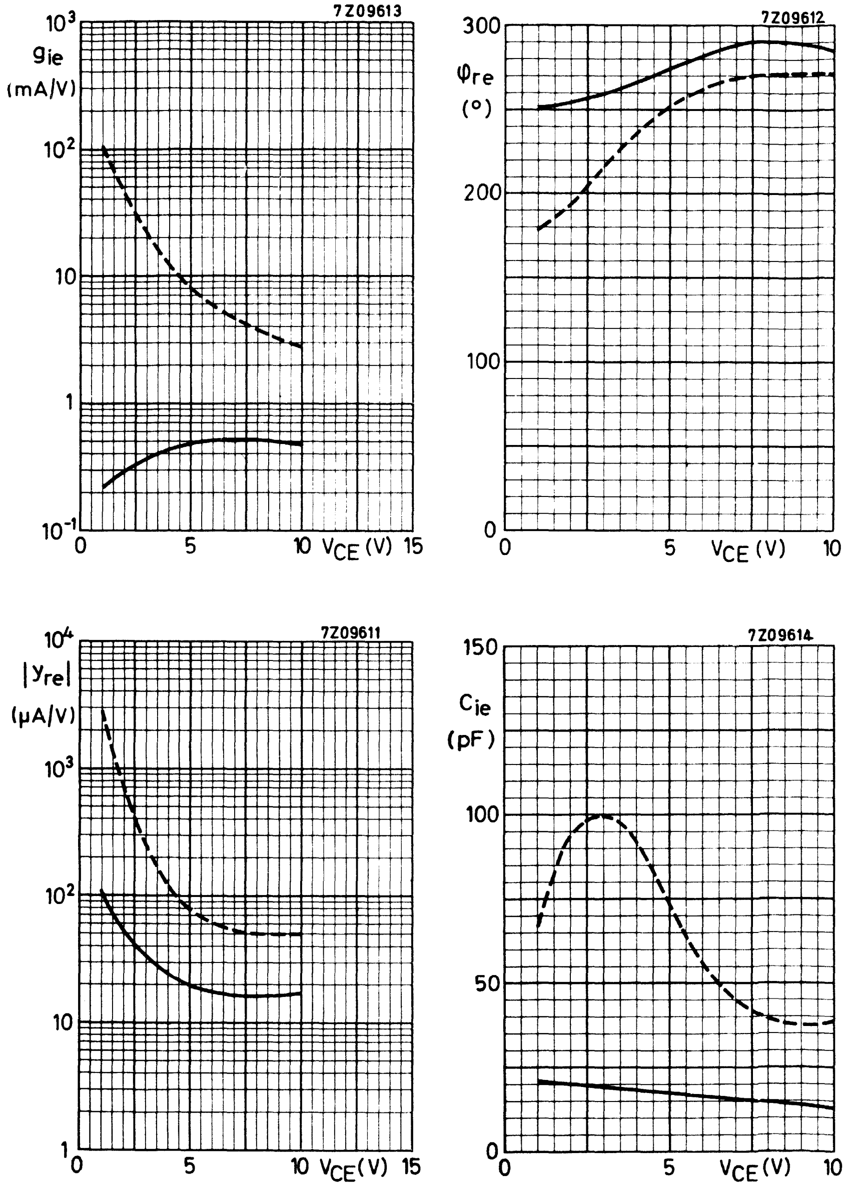

7Z09606
typical values
Tj = 25 °C
IC
(mA)
IB = 5mA
4 mA
3mA
2 mA
1mA
0.5mA
0.2mA
0.1mA
30
20
10
0
0
10
VCE (V)
20


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


7Z62018
base current versus junction temp.
IB
(μA)
IC = 25mA
10
5
2
0.5
typical values
VCE = 10V
10⁴
10³
10²
10
1
0
50
100
Tj (°C)
150

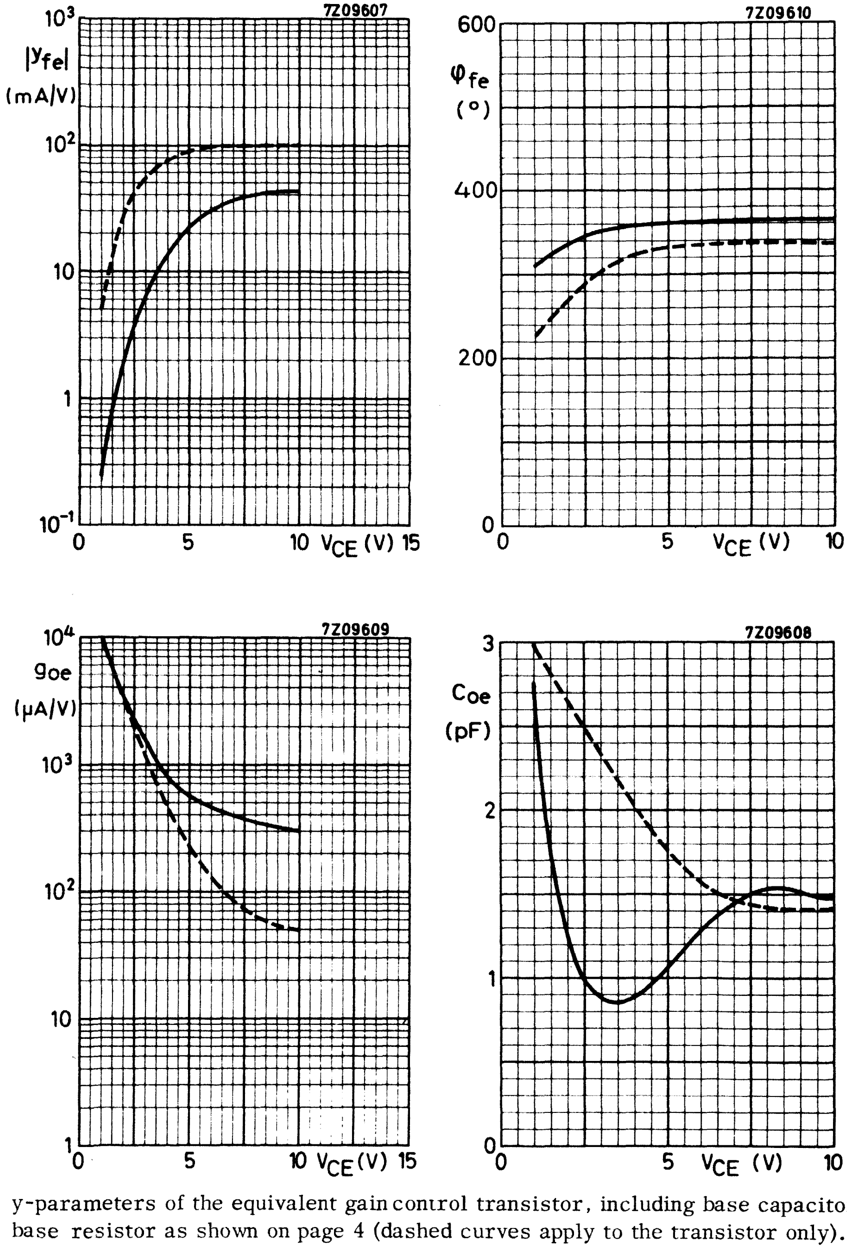

7Z09633
VCE = 10V
Tamb = 25 °C
fT
(MHz)
typ
1000
100
10
1
1
10
IC (mA)
100

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



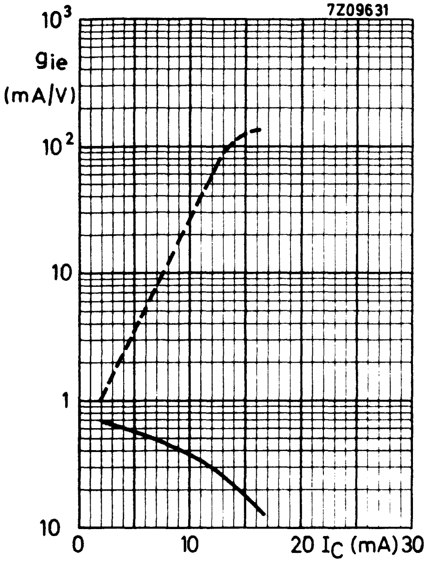
y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

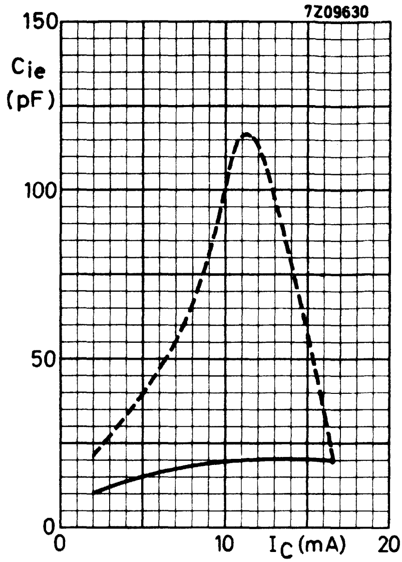
Voltage control; $-V_{EE}$ = 25 V; $R_E + R_C$ = 3.9 kΩ; f = 35 MHz

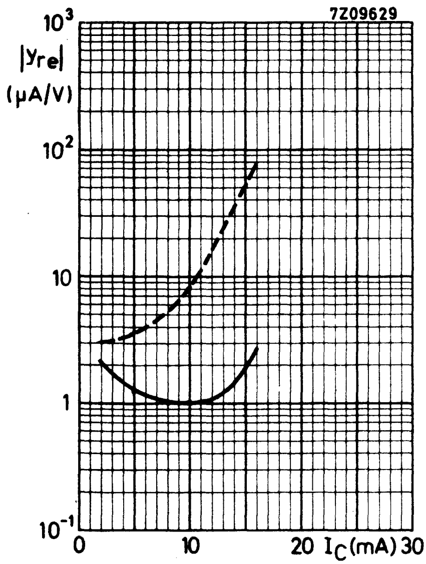


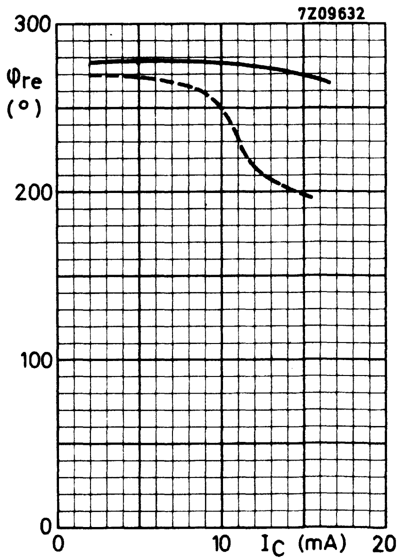
y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

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



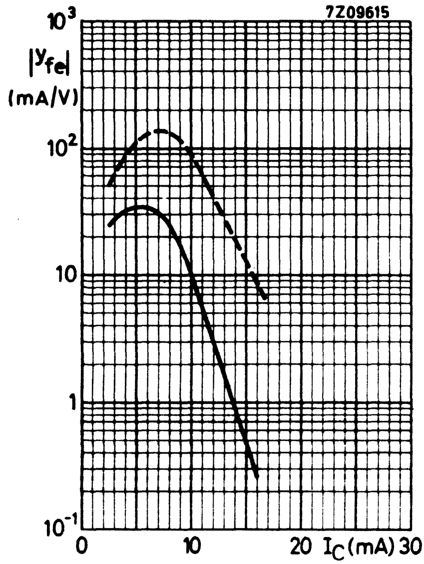


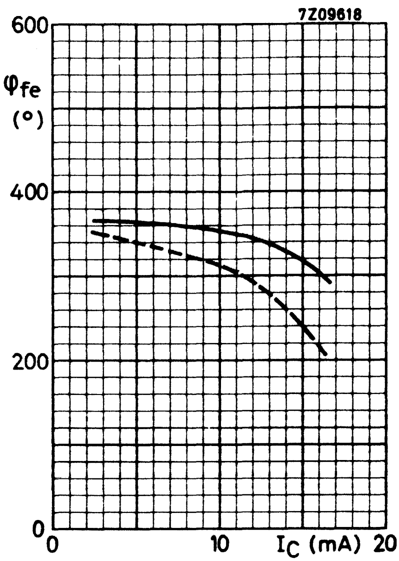


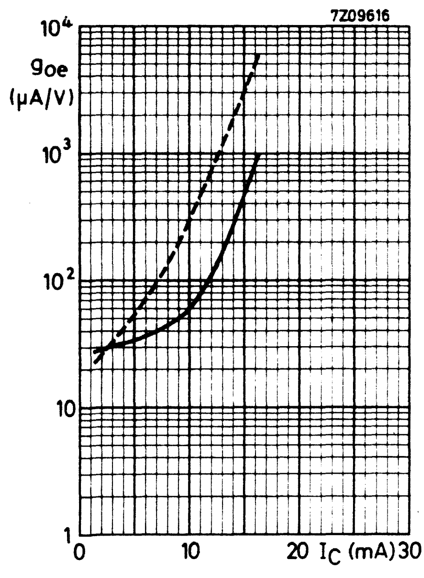


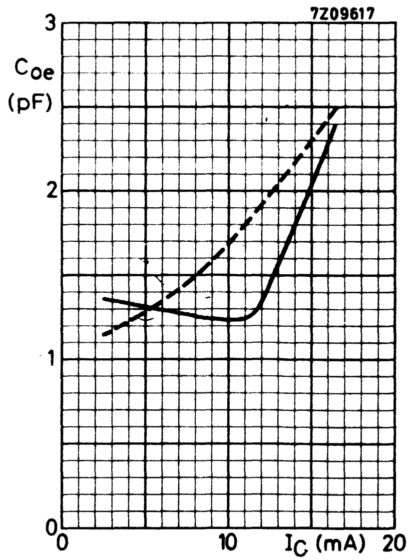
y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

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









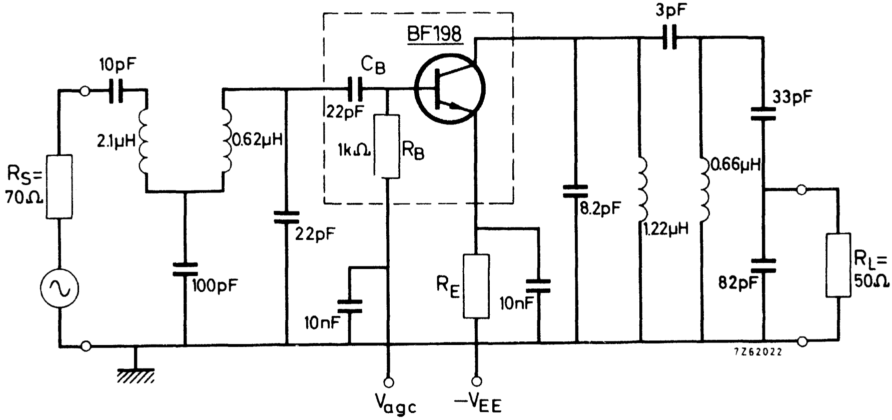
y-parameters of the equivalent gain control transistor, including base capacitor and base resistor as shown on page 4 (dashed curves apply to the transistor only).

APPLICATION INFORMATION

First stage of an i.f. amplifier

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

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

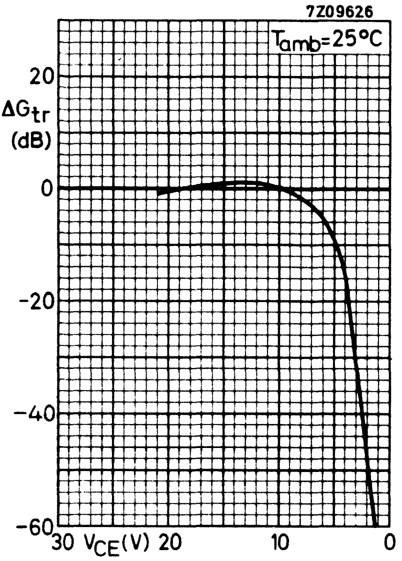


Transducer gain

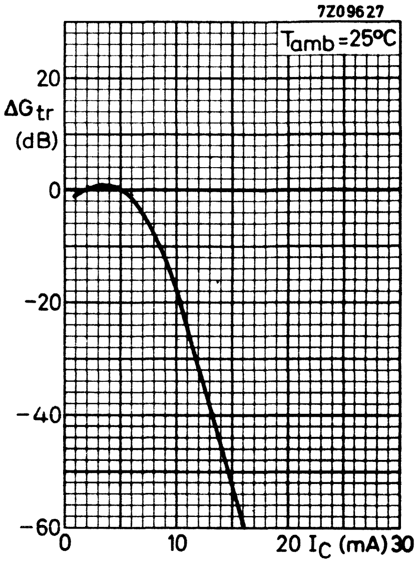
$$G_{tr}\ (\text{in dB}) = 10 \log \frac{\text{output power in load } R_L}{\text{available power from source } R_S}$$

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

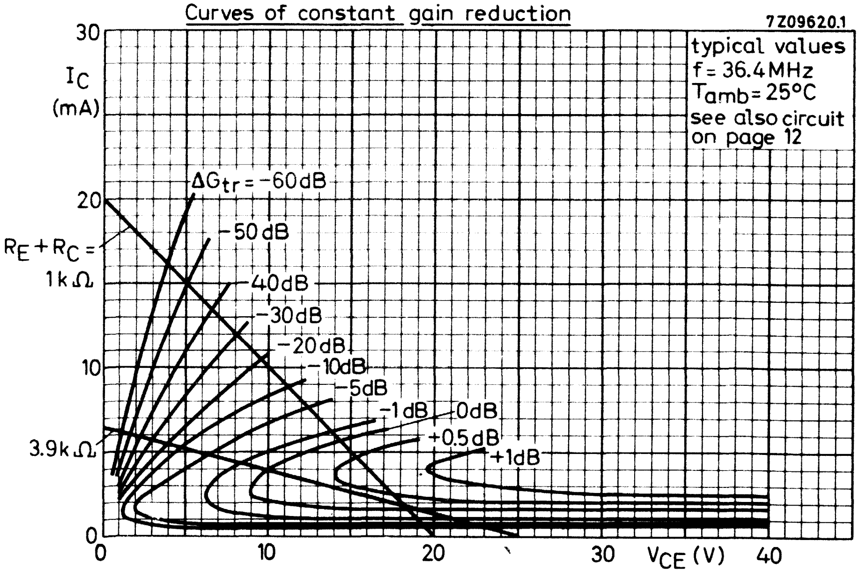
Voltage gain control



Current gain control



Curves of constant gain reduction



SILICON PLANAR EPITAXIAL TRANSISTOR

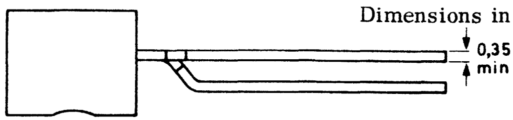
N-P-N transistor in a plastic TO-92 variant.
The BF199 has a very low feedback capacitance and is intended for use in the output stage of a television video i.f. amplifier.

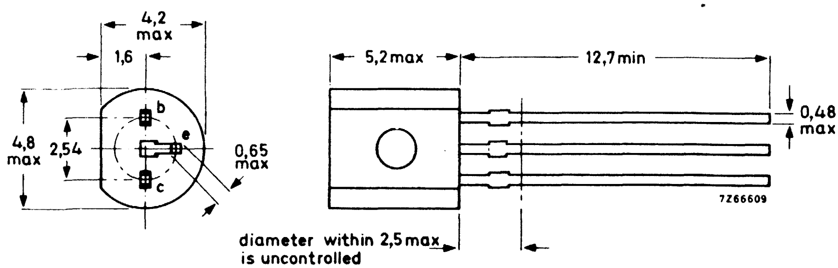
QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Collector current (d.c.)	I_C	max.	25	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	500	mW
Junction temperature	T_j	max.	150	°C
Transition frequency 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

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.	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. <	60 185	μA μA
Base-emitter voltage [1]				
I_C = 7 mA; V_{CE} = 10 V	V_{BE}	typ. <	775 925	mV mV
Feedback capacitance at f = 10.7 MHz				
I_C = 1 mA; V_{CE} = 10 V	$-C_{re}$	typ.	300	fF
Transition frequency at f = 100 MHz				
I_C = 5 mA; V_{CE} = 10 V	f_T	typ.	550	MHz

y parameters (common emitter)

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

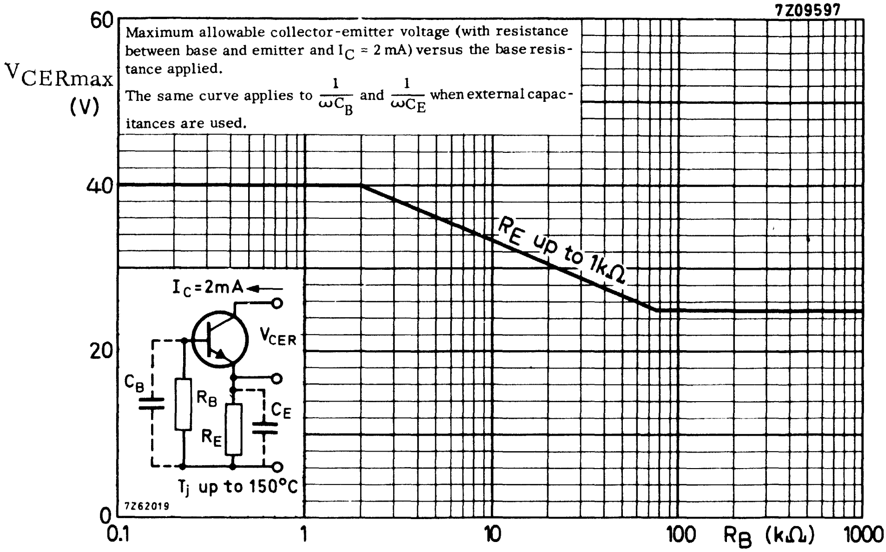
			f = 35	45	MHz
Input conductance	g_{ie}	typ.	4.5	5.5	mA/V
Input capacitance	C_{ie}	typ.	45	45	pF
Feedback admitance	$\|y_{re}\|$	typ.	67	86	μA/V
Phase angle of feedback admittance	φ_{re}	typ.	268°	268°	
Transfer admitance	$\|y_{fe}\|$	typ.	170	155	mA/V
Phase angle of transfer admittance	φ_{fe}	typ.	338°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

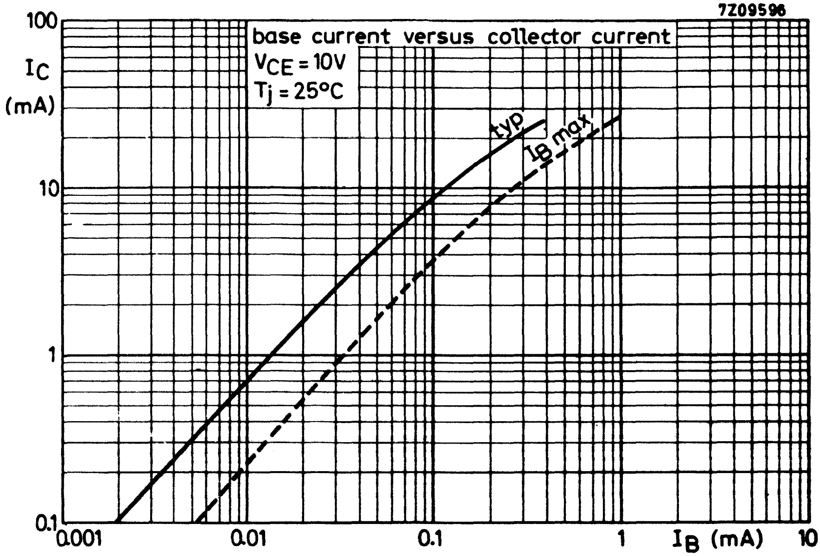
Maximum unilateralized power gain

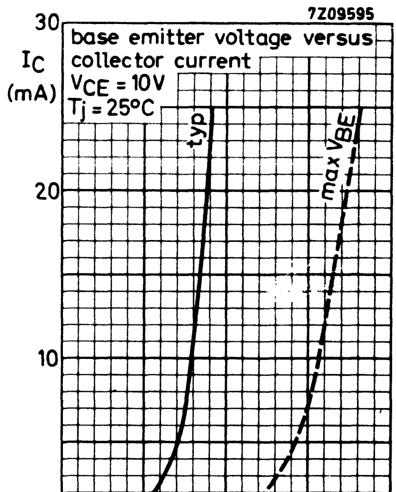
$$G_{UM} \text{ (in dB)} = 10 \log \frac{|y_{fe}|^2}{4 g_{ie} g_{oe}}$$

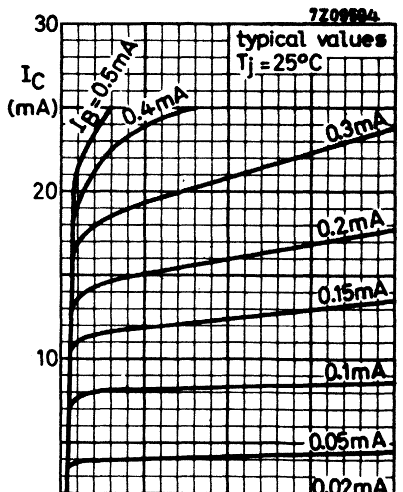
I_C = 7 mA; V_{CE} = 10 V	G_{UM}	typ.	43	41	dB

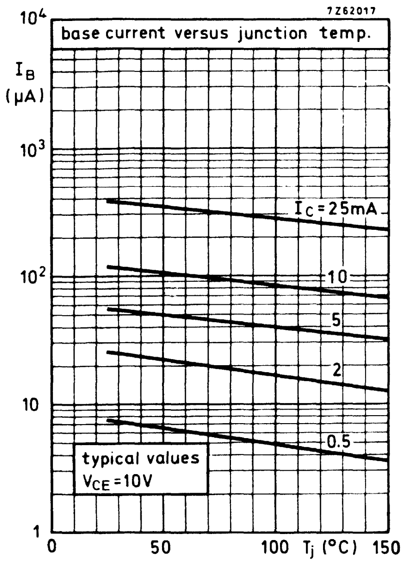
[1] V_{BE} decreases by about 1.7 mV/°C with increasing temperature.

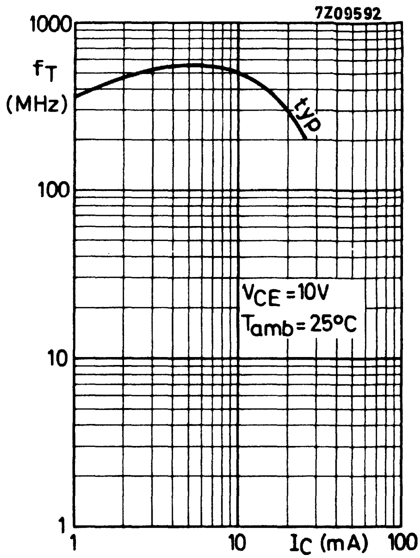

7Z09597
Maximum allowable collector-emitter voltage (with resistance between base and emitter and I_C = 2 mA) versus the base resistance applied.
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$ when external capacitances are used.
V_{CERmax} (V)
60
40
20
0
0.1
1
10
100
R_B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


7Z09596
base current versus collector current
VCE = 10V
Tj = 25°C
IC
(mA)
100
10
1
0.1
0.001
0.01
0.1
1
10
IB (mA)
typ
IB max


7Z09595
base emitter voltage versus
collector current
VCE = 10V
Tj = 25°C
IC
(mA)
30
20
10
0
0.6
0.8
1
VBE (V)
typ
max VBE

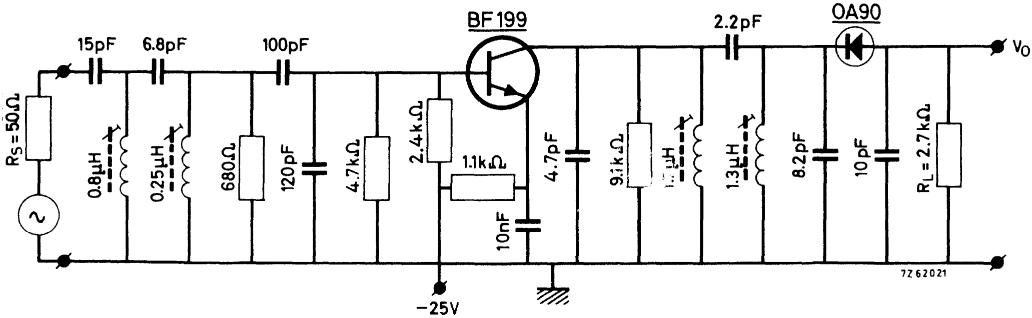

typical values
Tj = 25°C
IC
(mA)
30
20
10
0
10
20
VCE (V)
IB = 0.5mA
0.4mA
0.3mA
0.2mA
0.15mA
0.1mA
0.05mA
0.02mA





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

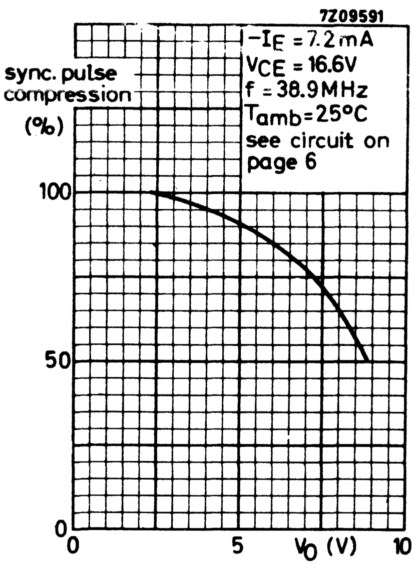
Transducer gain at f = 36.4 MHz

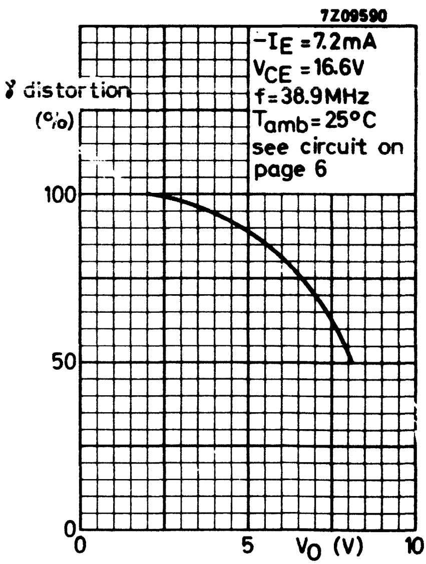
$$G_{tr} \text{ (in dB)} = 10 \log \frac{\text{output power in load } R_L}{\text{available power from source with } R_S}$$

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

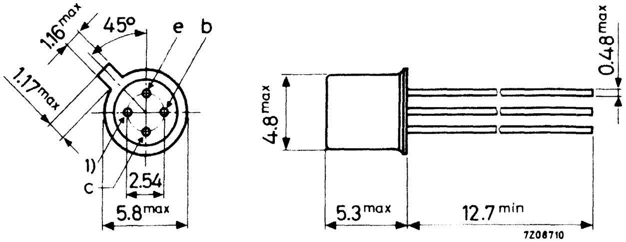
N-P-N transistor in a TO-72 metal envelope with insulated electrodes and a shield lead connected to the case. The BF200 is primarily intended for application in a forward gain controlled pre-amplifier in v.h.f. television tuners and f.m. tuners.

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

MECHANICAL DATA

Dimensions in mm

TO-72



1) = shield lead (connected to case)

Accessories available: 56246, 56263

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 °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				
$-I_E$ = 3 mA; V_{CB} = 10 V	I_B	typ. <	100 200	µA 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

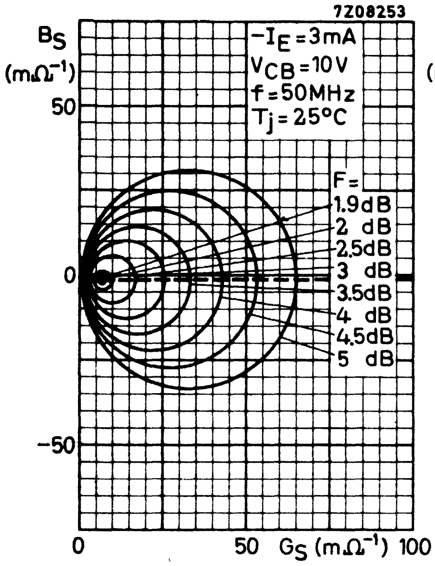
Input conductance	g_{ib}	typ.	85	$m\Omega^{-1}$
Input susceptance	$-b_{ib}$	typ.	15	$m\Omega^{-1}$
Feedback admittance	$\lvert y_{rb} \rvert$	typ.	55	$\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{rb}	typ.	270°	
Transfer admittance	$\lvert y_{fb} \rvert$	typ.	85	$m\Omega^{-1}$
Phase angle of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

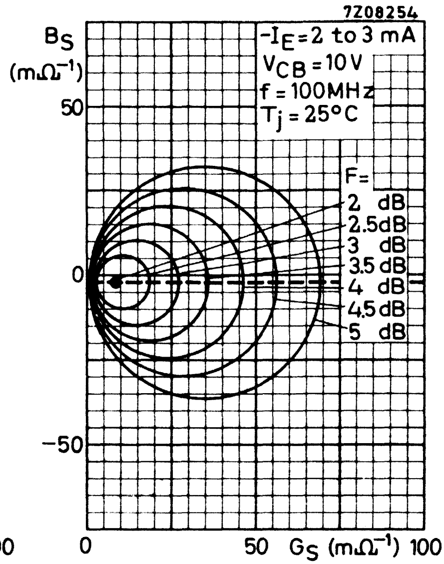
y parameters at f = 200 MHz (common base)

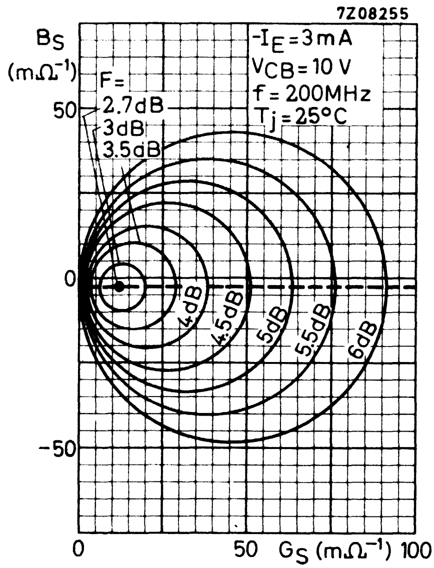
$-I_E$ = 3 mA; V_{CB} = 10 V

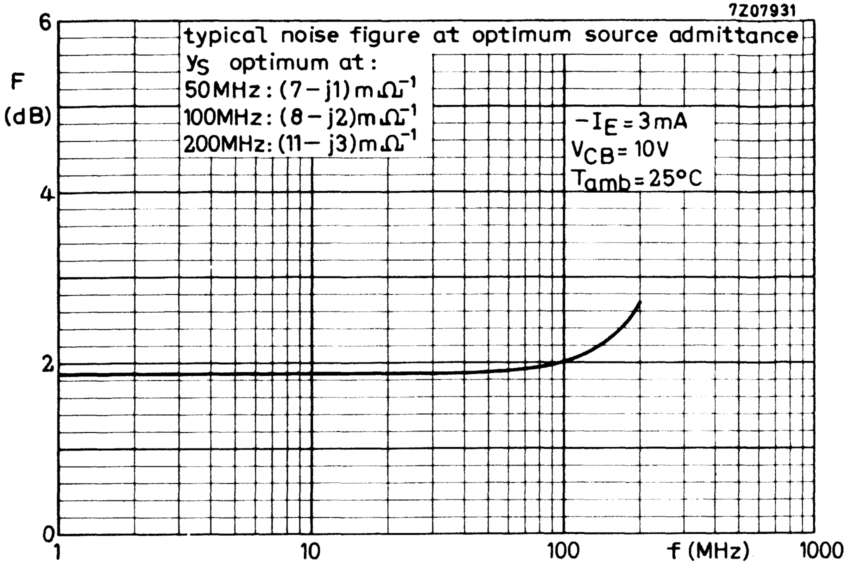
Input conductance	g_{ib}	typ.	62	$m\Omega^{-1}$
Input susceptance	$-b_{ib}$	typ.	38	$m\Omega^{-1}$
Feedback admittance	$\lvert y_{rb} \rvert$	typ.	180	$\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{rb}	typ.	270°	
Transfer admittance	$\lvert y_{fb} \rvert$	typ.	70	$m\Omega^{-1}$
Phase angle of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

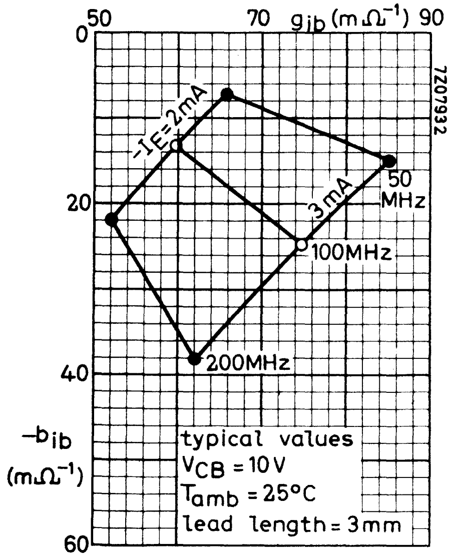
circles of constant noise figure

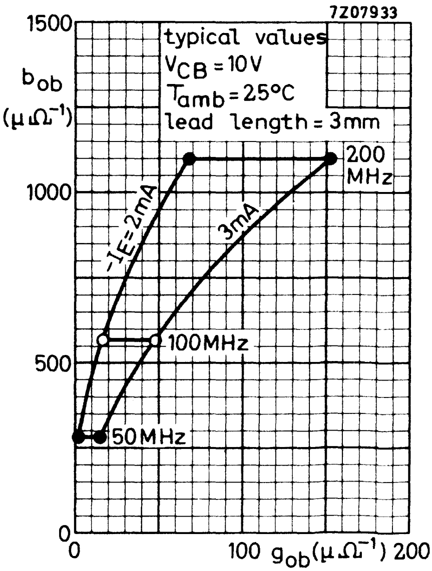


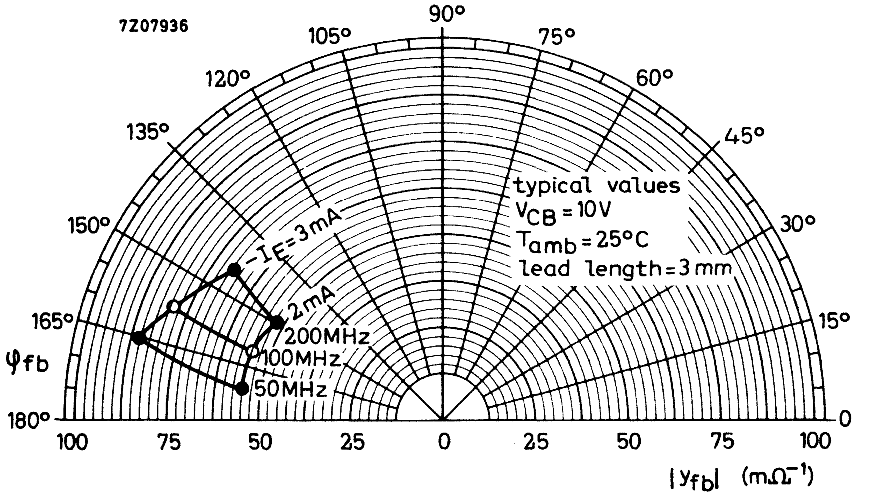


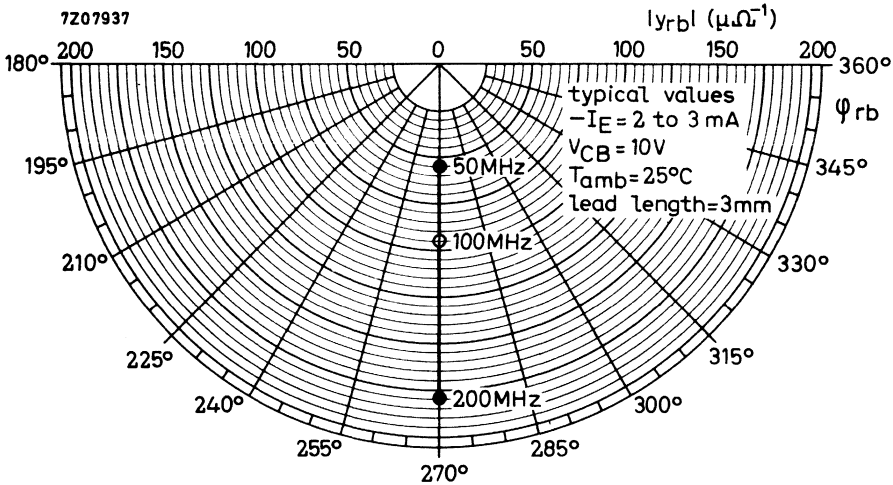


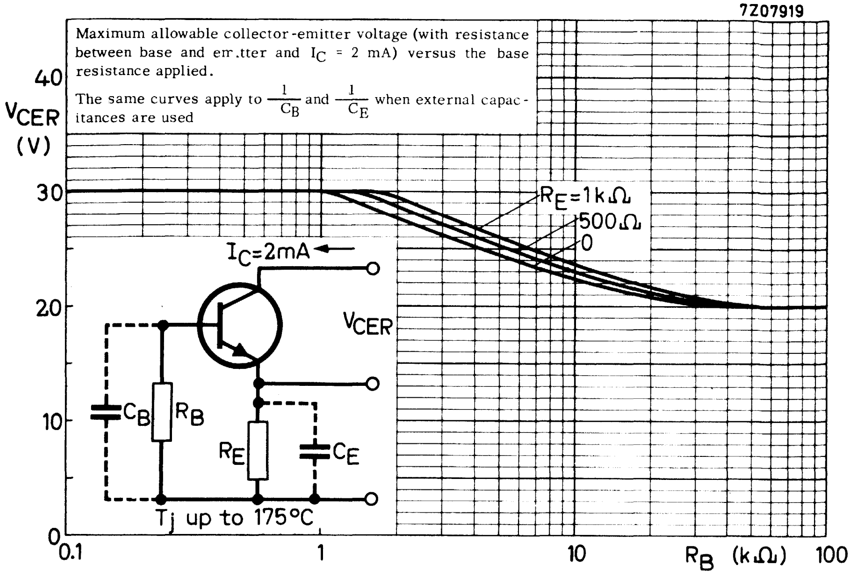

7Z07931
typical noise figure at optimum source admittance
y_S optimum at:
50MHz: (7 − j1) mΩ⁻¹
100MHz: (8 − j2) mΩ⁻¹
200MHz: (11 − j3) mΩ⁻¹
$-I_E$ = 3 mA
V_{CB} = 10 V
T_{amb} = 25 °C
F (dB)
6
4
2
0
1
10
100
f (MHz)
1000


7Z07932
g_{ib} (mΩ⁻¹)
50
70
90
$-b_{ib}$ (mΩ⁻¹)
0
20
40
60
$-I_E$ = 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
200 MHz
$-I_E$ = 2mA
3mA
100MHz
50MHz
0
100
g_{ob} (μΩ⁻¹)
200

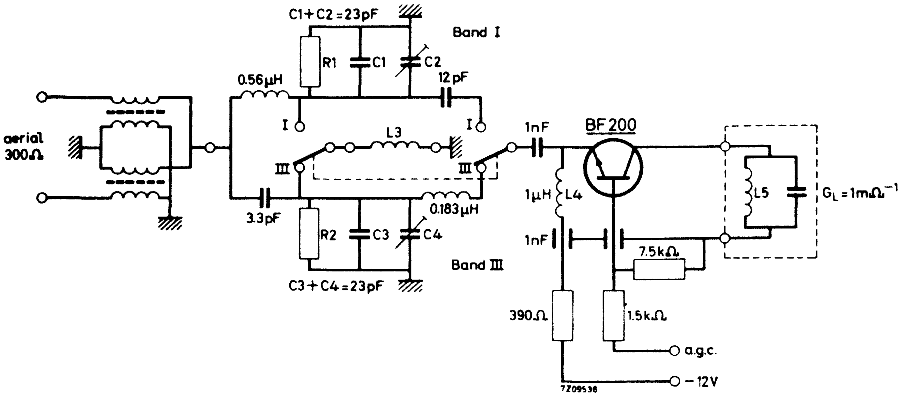

7Z07936
90°
105°
75°
120°
60°
135°
45°
150°
30°
165°
15°
180°
0
φfb
typical values
VCB = 10V
Tamb = 25°C
lead length = 3 mm
−IE = 3 mA
2 mA
200MHz
100MHz
50MHz
100
75
50
25
0
25
50
75
100
|yfb| (mΩ⁻¹)


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


7Z07919
Maximum allowable collector-emitter voltage (with resistance between base and emitter and I_C = 2 mA) versus the base resistance applied.
The same curves apply to $\frac{1}{C_B}$ and $\frac{1}{C_E}$ when external capacitances are used
40
V_{CER} (V)
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

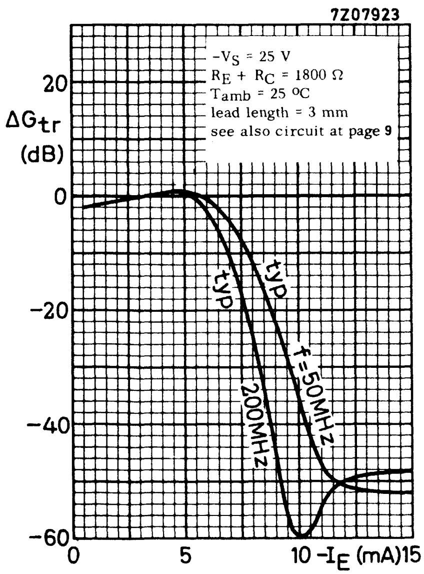
Desired signal at vision carrier frequency and interference signal at sound carrier frequency. Interference signal modulated with 4 kHz (modulation depth 100%).

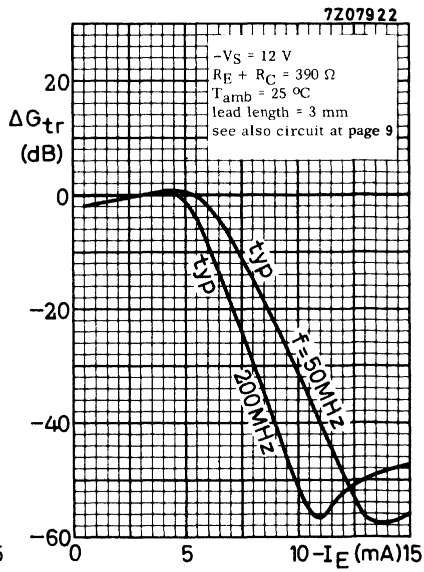
In-band cross-modulation curves of the tuner; showing the interfering signal e.m.f. (in a 300 Ω aerial) that will cause a cross-modulation factor of 1% (K), plotted against ΔG_{tr}, the reduction in transducer gain caused by gain control.

Measuring conditions

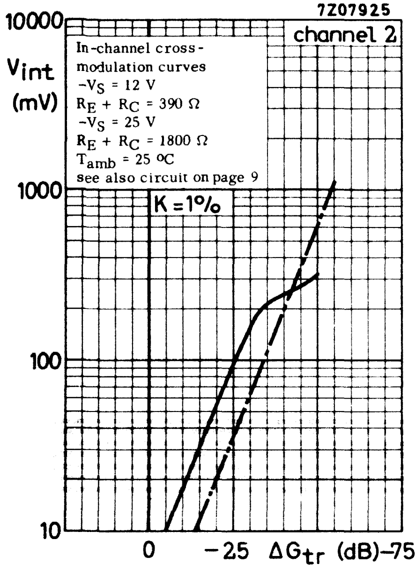
Desired signal at the vision carrier frequency and interference signal, 14 MHz above the desired signal. Interference signal modulated with 4 kHz (modulation depth 100%).

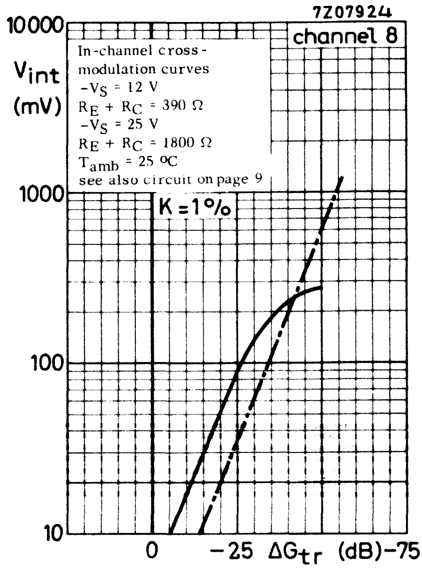
APPLICATION INFORMATION bulletins available on request

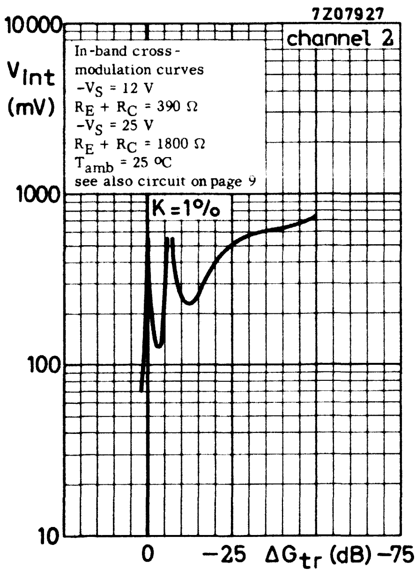


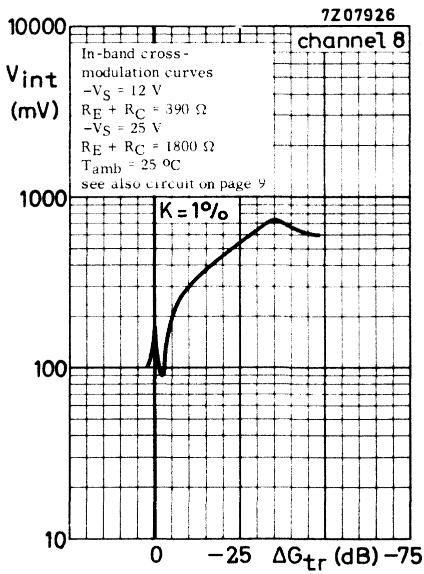


APPLICATION INFORMATION (continued)



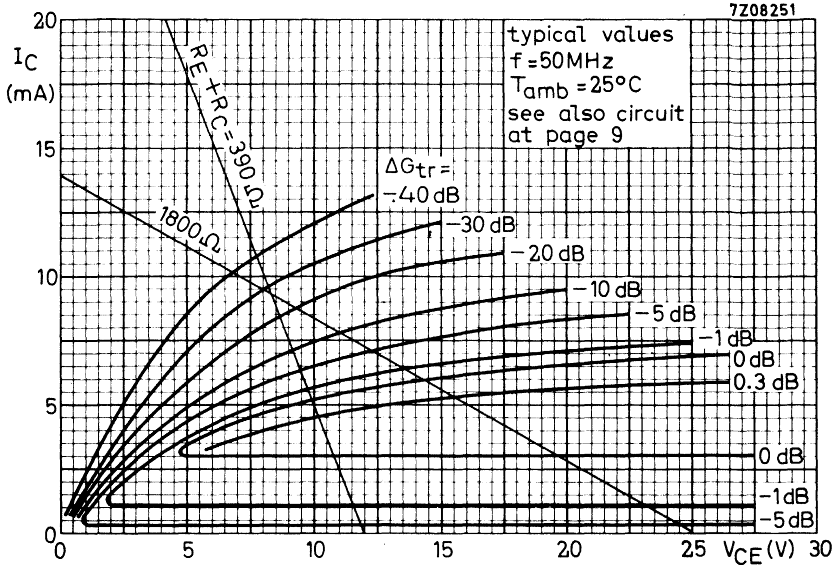


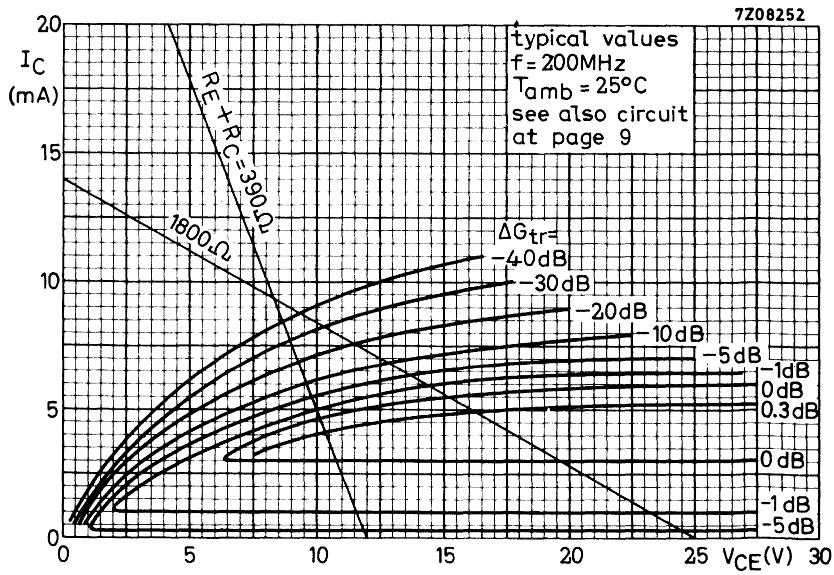




APPLICATION INFORMATION (continued)

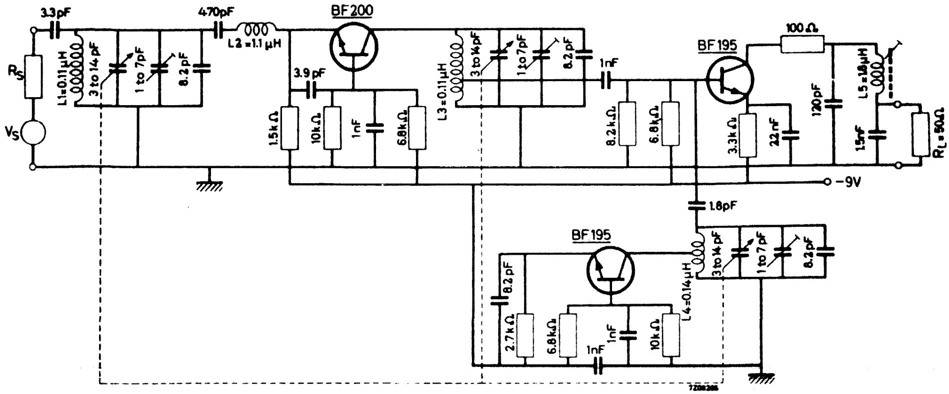
curves of constant gain reduction





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

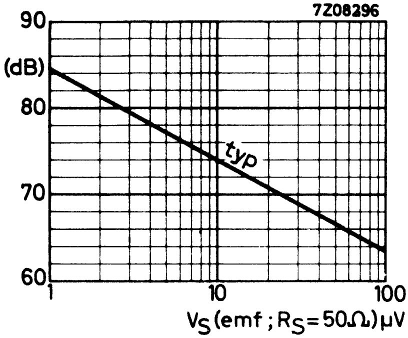
Coil former	AP3016/02	Ferroxcube core	3122 104 93041
Can	AP3015/02	Ferroxcube frame	AP3014/02

APPLICATION INFORMATION (continued)

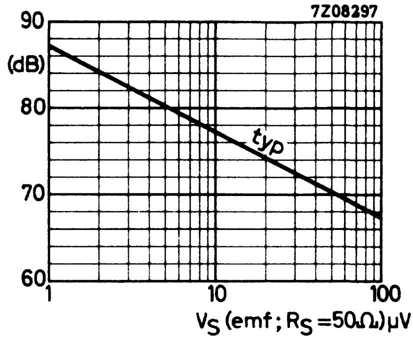
Typical performance of the f.m. tuner at T_{amb} = 25 °C; f = 98 MHz (oscillator frequency lower than tuning frequency)

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

Double beat suppression

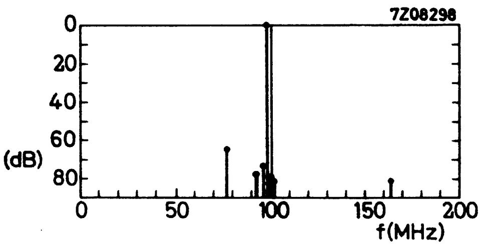


Repeat spot suppression



Spurious response suppression

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



H.F. SILICON PLANAR EPITAXIAL TRANSISTORS

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

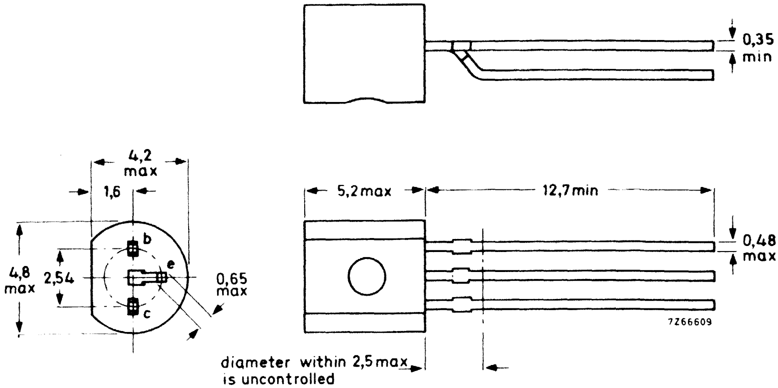
QUICK REFERENCE DATA

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

MECHANICAL DATA

Dimensions in mm

TO-92 variant



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

Voltages

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

Current

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

Power dissipation

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

Temperatures

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

THERMAL RESISTANCE

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

CHARACTERISTICS T_j = 25 °C unless otherwise specified

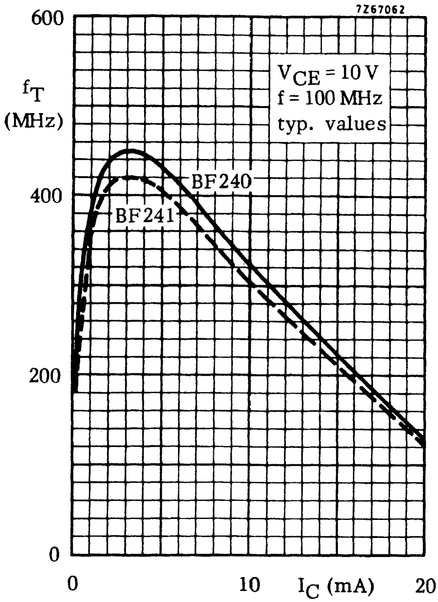
			BF240	BF241	
Collector cut-off current					
I_E = 0; V_{CB} = 20 V	I_{CBO}	<	100		nA
Base-emitter voltage					
I_C = 1 mA; V_{CE} = 10 V	V_{BE}	typ.	700		mV
			650 to 740		mV
Base current					
I_C = 1 mA; V_{CE} = 10 V	I_B		4,5-15	8-28	μA
Transition frequency at f = 100 MHz					
I_C = 1 mA; V_{CE} = 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

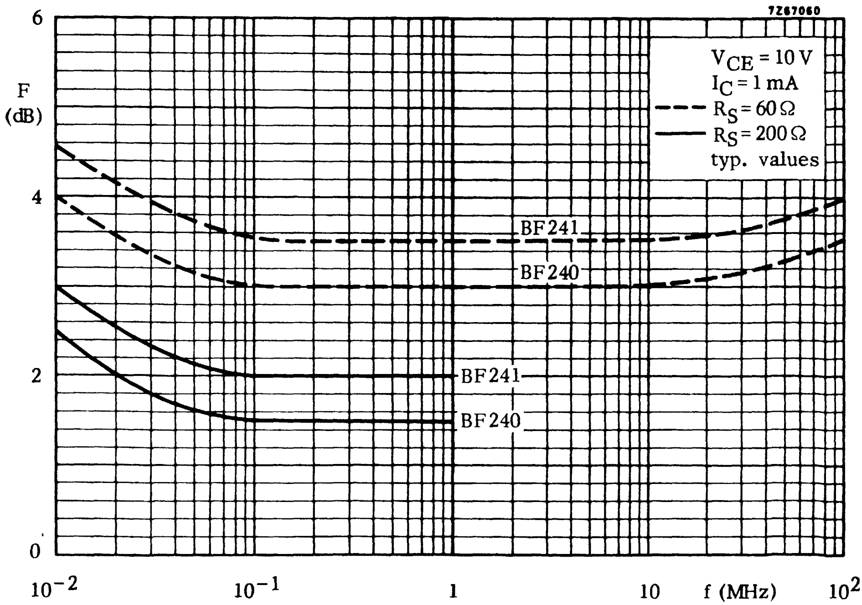
CHARACTERISTICS (continued) $T_j = 25\ ^oC$ unless otherwise specified

y parameters (common emitter)

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

			BF240		BF241		
	f	=	0, 45	10, 7	0, 45	10, 7	MHz
Input conductance	g_{ie}	typ.	0, 2	0, 3	0, 4	0, 5	mA/V
Input capacitance	C_{ie}	typ.	17	14	23	19	pF
Transfer admittance	$\|y_{fe}\|$	typ.	37	37	37	37	mA/V
Phase angle of transfer admittance	φ_{fe}	typ.	0^o	0^o	0^o	0^o	
Output conductance	g_{oe}	<	8, 3	10, 5	8, 3	10, 5	μA/V
Output capacitance	C_{oe}	typ.	1	1	1	1	pF
Feedback admittance	$\|y_{re}\|$	typ.	0, 75	18	0, 75	18	μA/V
Phase angle of feedback admittance	φ_{re}	typ.	90^o	90^o	90^o	90^o	


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

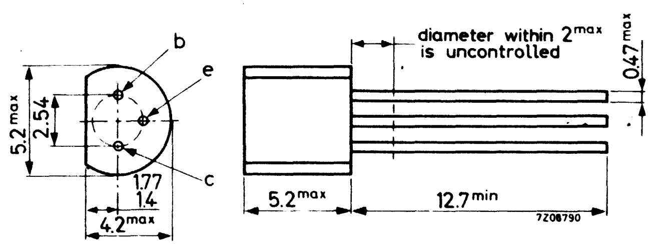
SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic envelope.
The BF254 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.	300	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 at f = 35 MHz 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 mΩ^{-1}	F	typ.	4	dB
Conversion noise figure at f = 1 MHz I_C = 1 mA; V_{CE} = 10 V; G_S = 1.2 mΩ^{-1}	F_c	typ.	2	dB

MECHANICAL DATA Dimensions in mm



FOR NEW DESIGN THE SUCCESSOR TYPE BF494 IS RECOMMENDED

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 $T_{amb} = 25\ ^oC$	P_{tot}	max.	300	mW

Temperatures

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

THERMAL RESISTANCE

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

CHARACTERISTICS

T_j = 25 °C

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	typ.	8.7	μA
		4.5 to	15	μA

Feedback capacitance at f = 0.45 MHz

I_C = 1 mA; V_{CE} = 10 V	$-C_{re}$	typ.	0.85	pF

Transition frequency at f = 35 MHz

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)

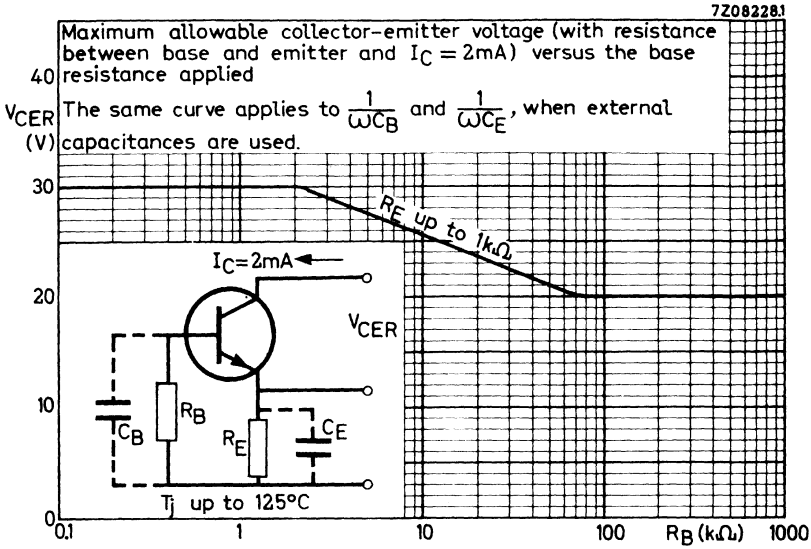
I_C = 1 mA; V_{CE} = 10 V (lead length = 3 mm)

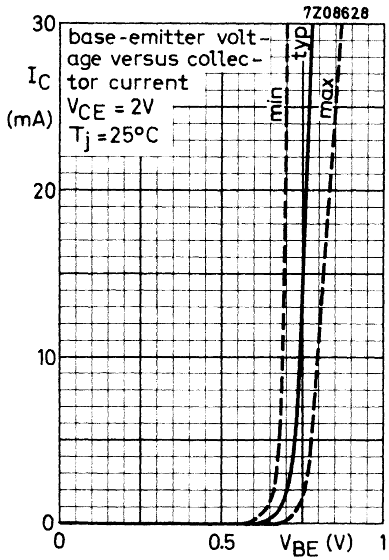
Input conductance	g_{ib}	typ.	36	$m\Omega^{-1}$
Input susceptance	$-b_{ib}$	typ.	3	$m\Omega^{-1}$
Feedback admittance	$\|y_{rb}\|$	typ.	410	$\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{rb}	typ.	272°	
Transfer admittance	$\|y_{fb}\|$	typ.	33	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fb}	typ.	146°	
Output conductance	g_{ob}	typ.	22	$\mu\Omega^{-1}$
Output susceptance	b_{ob}	typ.	1.1	$m\Omega^{-1}$

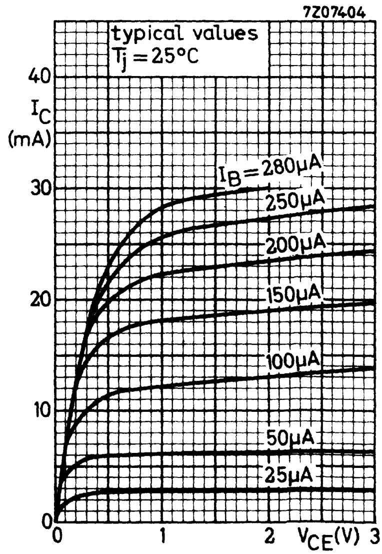
y parameters (common emitter)

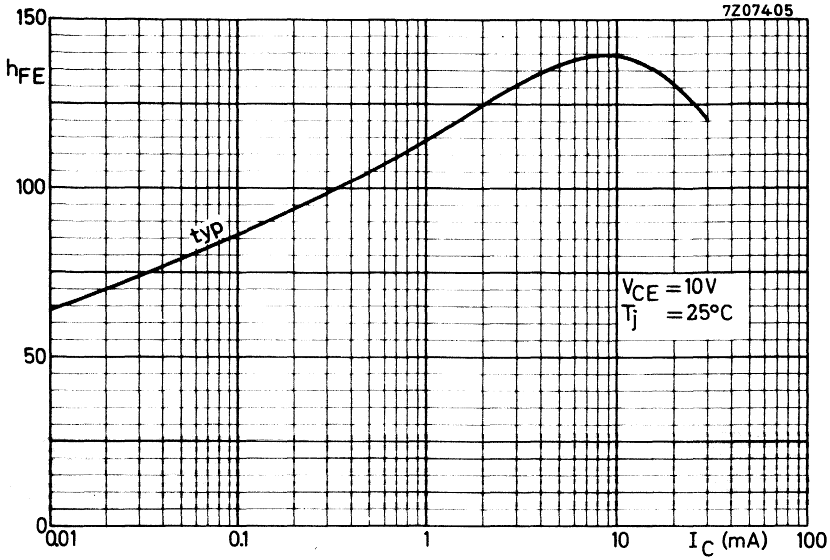
I_C = 1 mA; V_{CE} = 10 V (lead length = 3 mm)			f = 10.7 MHz	f = 0.45 MHz	
Input conductance	g_{ie}	<	0.64	0.54	$m\Omega^{-1}$
Output conductance	g_{oe}	<	13.5	11.5	$\mu\Omega^{-1}$

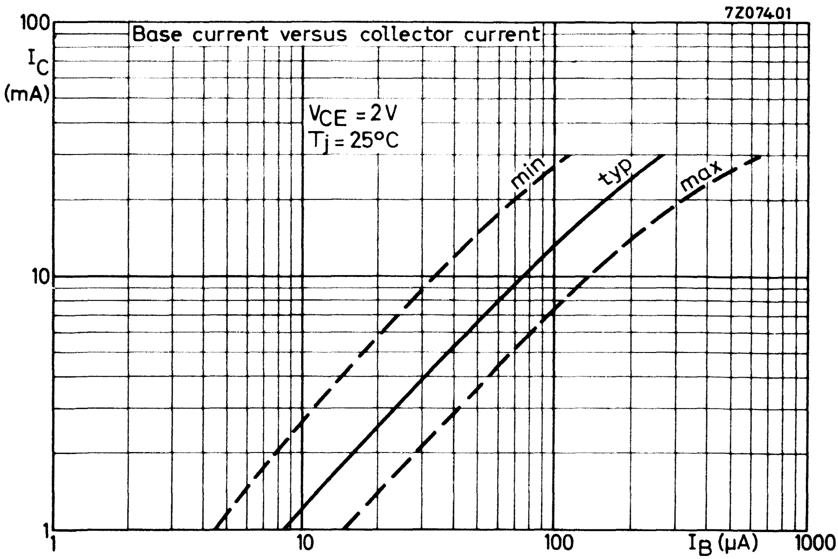
[1]) V_{BE} decreases by about 1.7 mV/°C with increasing temperature.

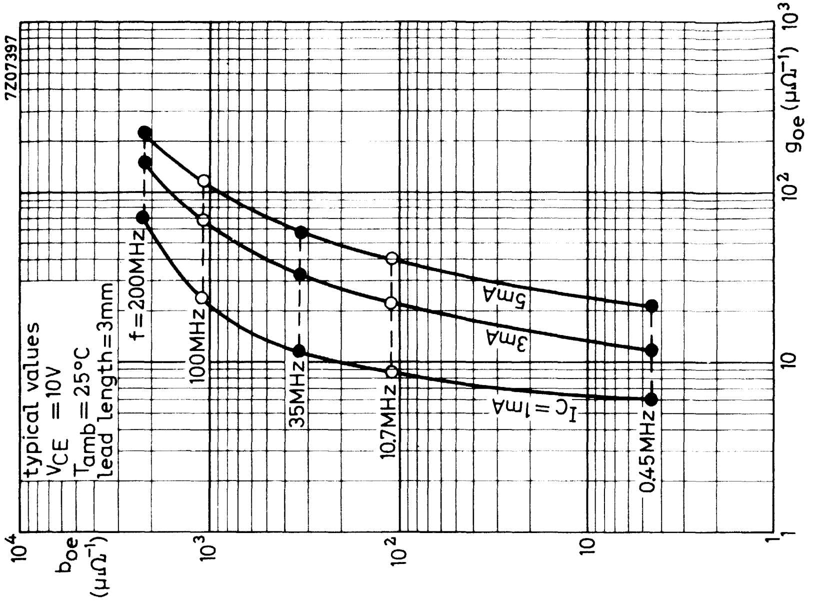

7Z08228.1
Maximum allowable collector-emitter voltage (with resistance between base and emitter and $I_C = 2mA$) versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$, when external capacitances are used.
V_{CER} (V)
R_E up to 1kΩ
$I_C = 2mA$
V_{CER}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

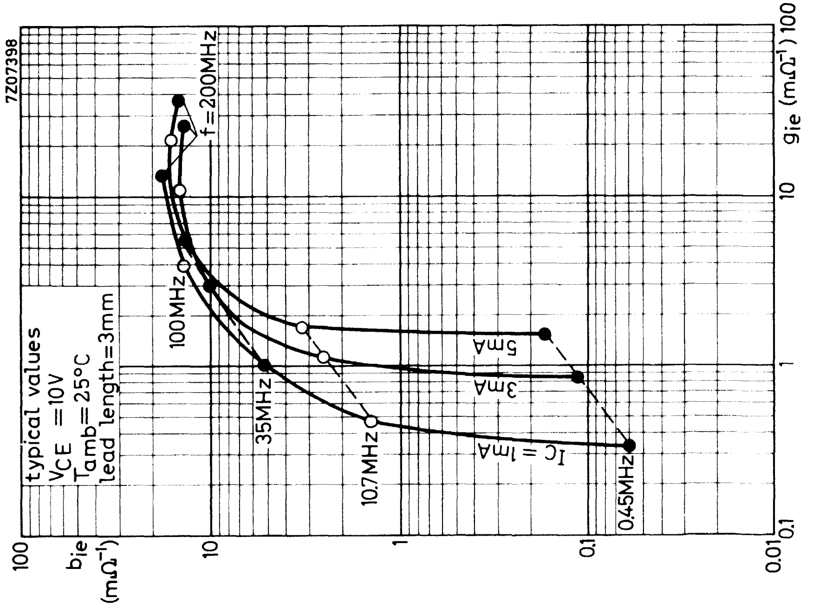

7Z08628
base-emitter voltage versus collector current
$V_{CE} = 2V$
$T_j = 25°C$
I_C (mA)
min
typ
max
V_{BE} (V)
0
10
20
30
0
0.5
1

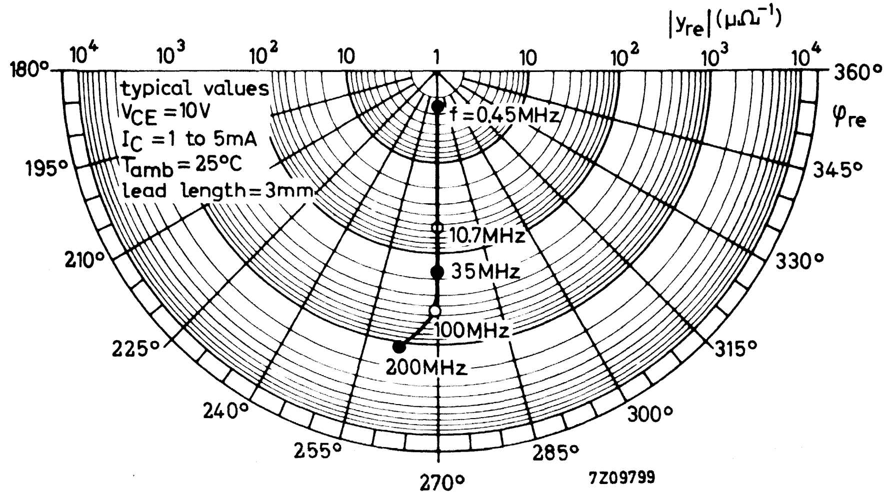

7Z07404
typical values
$T_j = 25°C$
I_C (mA)
$I_B = 280\mu A$
250μA
200μA
150μA
100μA
50μA
25μA
V_{CE}(V)
0
10
20
30
40
0
1
2
3

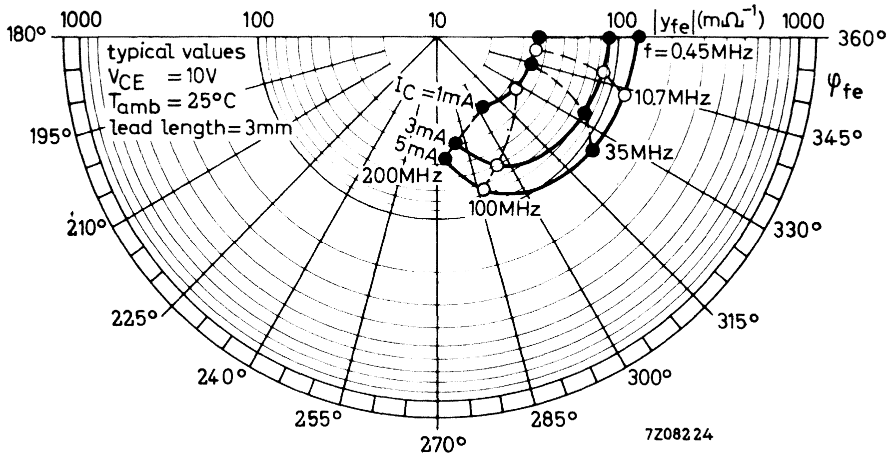

7Z07405
150
h_{FE}
100
50
0
typ
V_{CE} = 10 V
T_j = 25°C
0.01
0.1
1
10
I_C (mA)
100

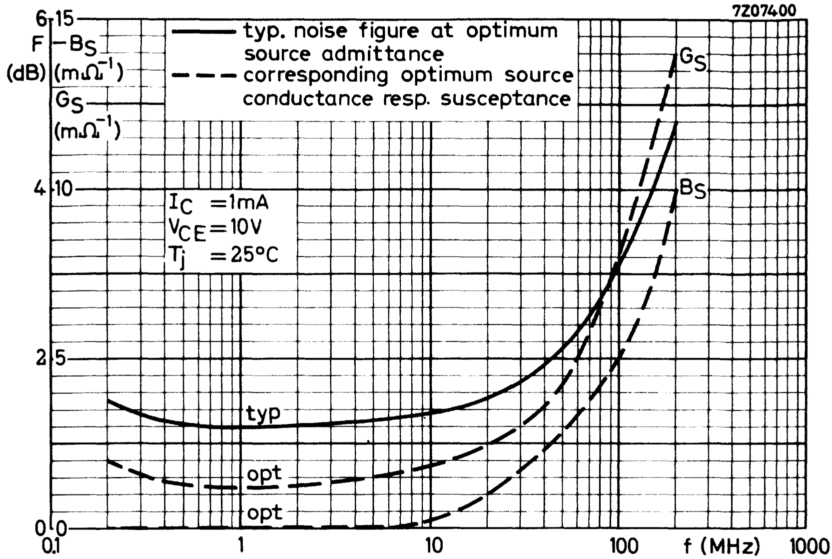

7Z07401
Base current versus collector current
100
I_C
(mA)
10
1
V_{CE} = 2 V
T_j = 25°C
min
typ
max
1
10
100
I_B (μA)
1000

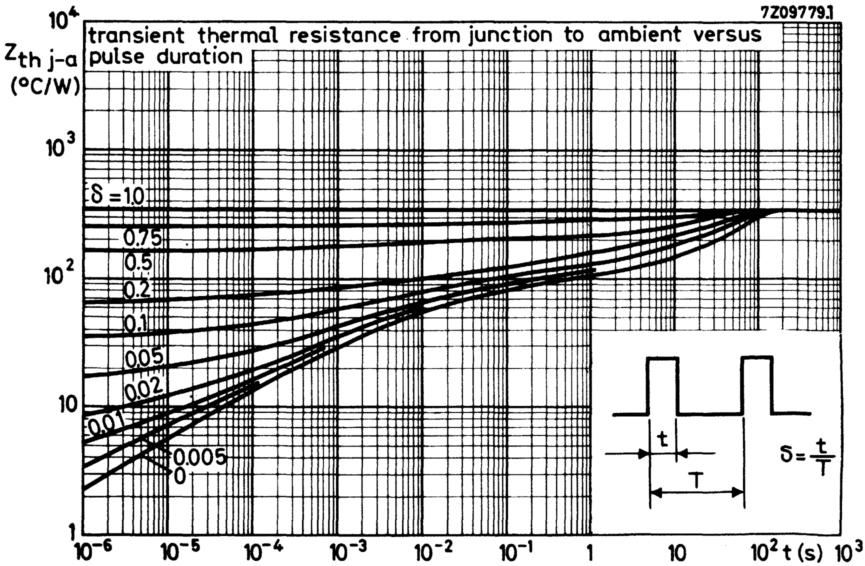

7Z07397
typical values
V_{CE} = 10V
T_{amb} = 25°C
lead length = 3mm
f = 200MHz
100MHz
35MHz
10.7MHz
0.45MHz
I_C = 1mA
3mA
5mA
b_{oe} (μΩ⁻¹)
g_{oe} (μΩ⁻¹)
10^4
10^3
10^2
10
1


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} (mΩ⁻¹)
g_{ie} (mΩ⁻¹)
100
10
1
0.1
0.01


|y_re| (μΩ^-1)
10^4 10^3 10^2 10 1 10 10^2 10^3 10^4
180° 195° 210° 225° 240° 255° 270° 285° 300° 315° 330° 345° 360°
φ_re
typical values
V_CE = 10V
I_C = 1 to 5mA
T_amb = 25°C
lead length = 3mm
f = 0.45MHz
10.7MHz
35MHz
100MHz
200MHz
7Z09799


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


7Z07400
typ. noise figure at optimum source admittance
corresponding optimum source conductance resp. susceptance
F (dB)
−Bs (mΩ⁻¹)
Gs (mΩ⁻¹)
IC = 1mA
VCE = 10V
Tj = 25°C
Gs
Bs
typ
opt
opt
0.1
1
10
100
f (MHz)
1000

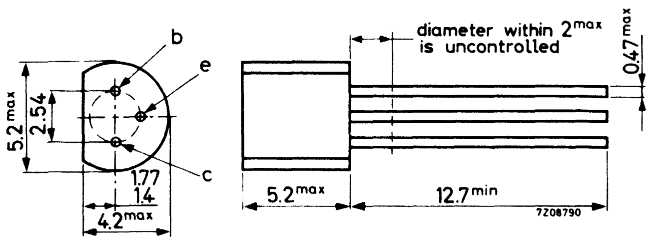

7Z09779.1
transient thermal resistance from junction to ambient versus pulse duration
Zth j-a (°C/W)
δ = 1.0
0.75
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0
δ = t/T
t
T
t (s)

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a plastic envelope.
The BF255 is intended for h.f. applications in radio and television receivers; it is especially recommended for f.m. tuners, i.f. amplifiers in a.m./f.m. receivers where a low transistor output conductance is of importance, a.m. input stages of carradios where a low noise figure at low source impedance is required.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	20	V
Collector current (d.c.)	I_C	max.	30	mA
Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	300	mW
Junction temperature	T_j	max.	125	^oC
D.C. current gain at $T_j = 25\ ^oC$ $I_C = 1$ mA; $V_{CE} = 10$ V	h_{FE}	typ.	67	
Transition frequency at f = 35 MHz $I_C = 1$ mA; $V_{CE} = 10$ V	f_T	typ.	200	MHz
Noise figure $I_C = 1$ mA; $V_{CE} = 10$ V $G_S = 20\ m\Omega^{-1}$; f = 1 MHz	F	typ.	3.5	dB
$G_S = 10\ m\Omega^{-1}$; f = 100 MHz	F	typ.	4	dB

MECHANICAL DATA Dimensions in mm



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 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 $T_{amb} = 25\ ^oC$	P_{tot}	max.	**300**	mW

Temperatures

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

THERMAL RESISTANCE

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

CHARACTERISTICS $T_j = 25\ ^oC$

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	typ.	15	μA
		8 to	28	μA

Feedback capacitance at f = 0.45 MHz

$I_C = 1$ mA; $V_{CE} = 10$ V	$-C_{re}$	typ.	0.85	pF

Transition frequency **at f = 35 MHz**

$I_C = 1$ 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)

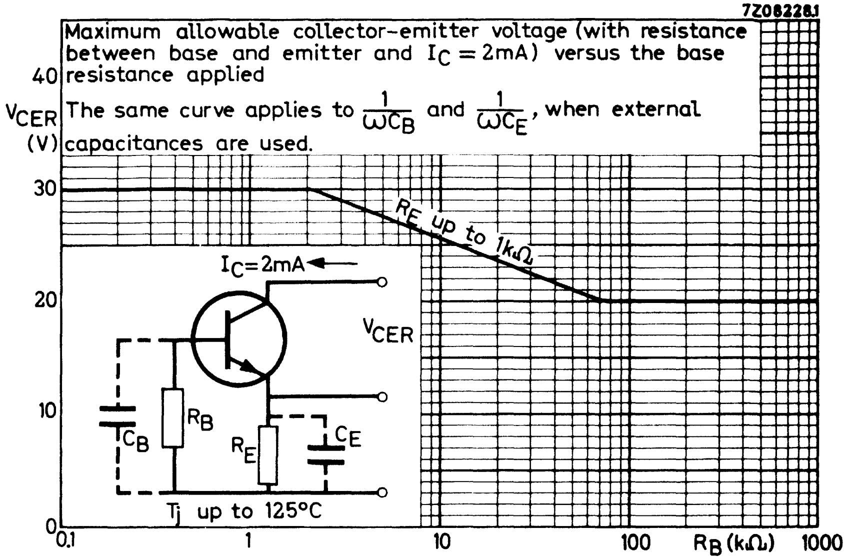
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)

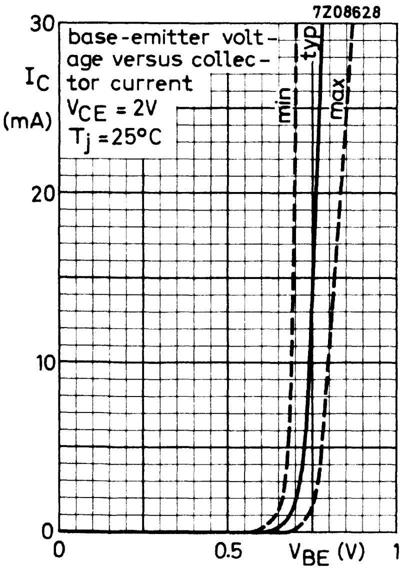
Input conductance	g_{ib}	typ.	38	$m\Omega^{-1}$
Input susceptance	$-b_{ib}$	typ.	1	$m\Omega^{-1}$
Feedback admittance	$\|y_{rb}\|$	typ.	400	$\mu\Omega^{-1}$
Phase angle of feedback admittance	φ_{rb}	typ.	275°	
Transfer admittance	$\|y_{fb}\|$	typ.	34	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fb}	typ.	140°	
Output conductance	g_{ob}	typ.	12	$\mu\Omega^{-1}$
Output susceptance	b_{ob}	typ.	1.1	$m\Omega^{-1}$

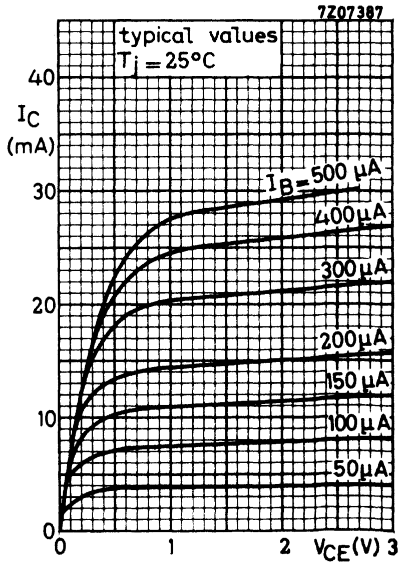
y parameters (common emitter)

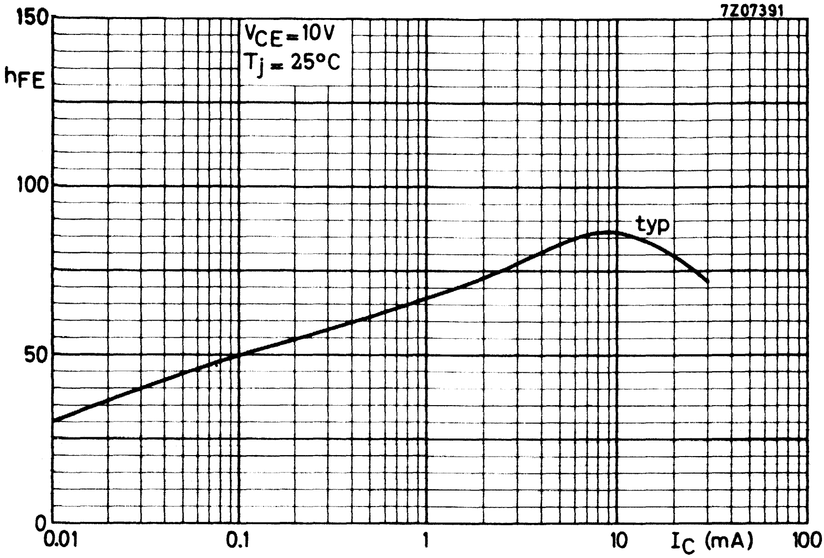
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)			f = 10.7 MHz	f = 0.45 MHz	
Input conductance	g_{ie}	<	0.96	0.86	$m\Omega^{-1}$
Output conductance	g_{oe}	<	9.5	7.0	$\mu\Omega^{-1}$

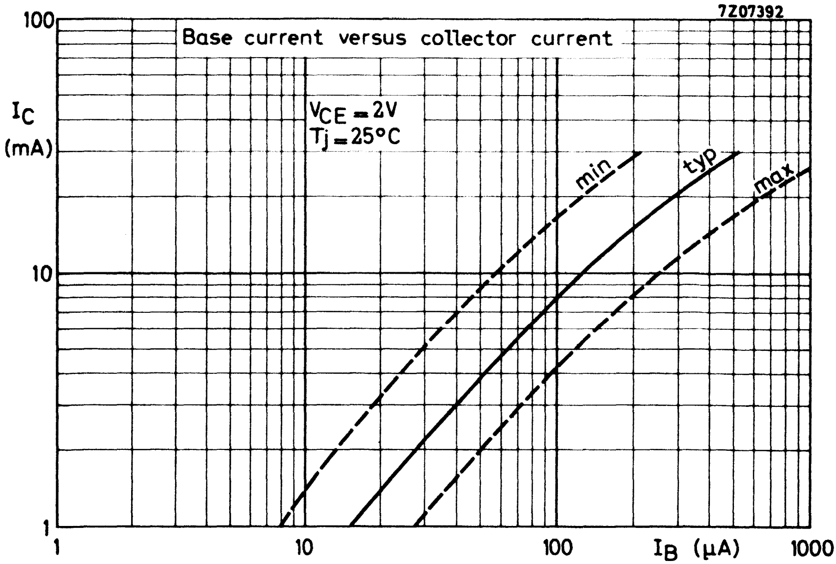
[1]) V_{BE} decreases by about 1.7 mV/°C with increasing temperature.

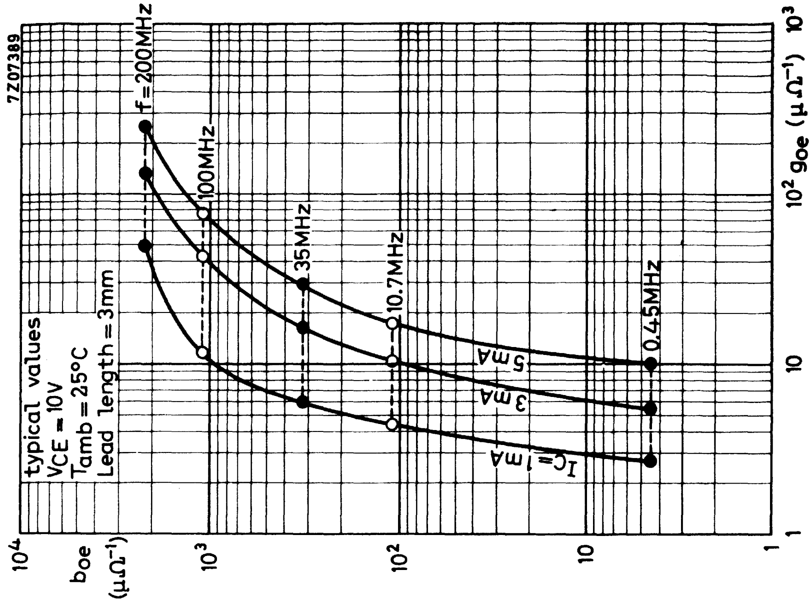

7Z08228.1
Maximum allowable collector-emitter voltage (with resistance between base and emitter and $I_C = 2mA$) versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$, when external capacitances are used.
V_{CER} (V)
40
30
20
10
0
0.1
1
10
100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

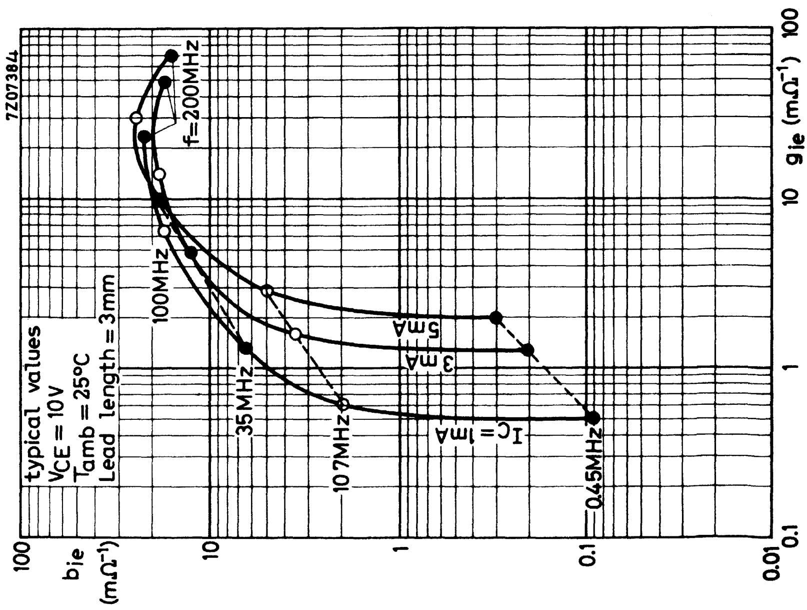

7Z08628
base-emitter voltage versus collector current
V_{CE} = 2V
T_j =25°C
I_C (mA)
30
20
10
0
0
0.5
V_{BE} (V)
1
min
typ
max

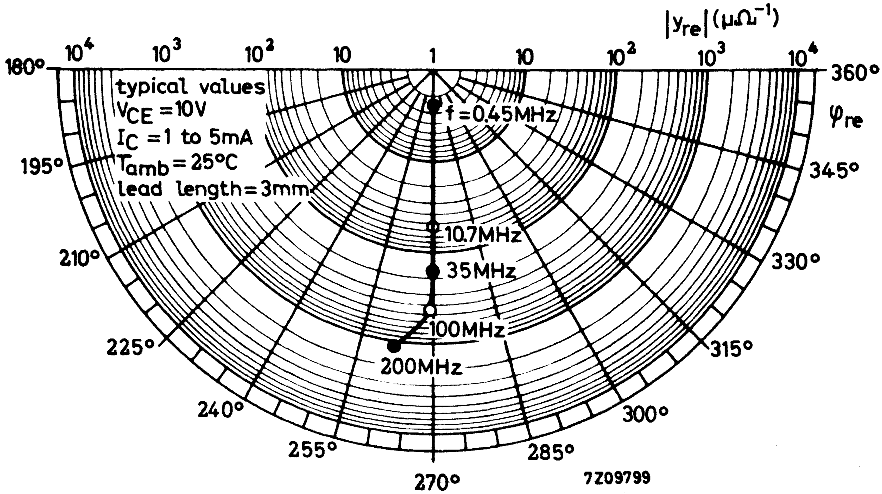

7Z07387
typical values
T_j = 25°C
I_C (mA)
40
30
20
10
0
0
1
2
V_{CE}(V) 3
I_B= 500 μA
400μA
300μA
200μA
150 μA
100 μA
50μA


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

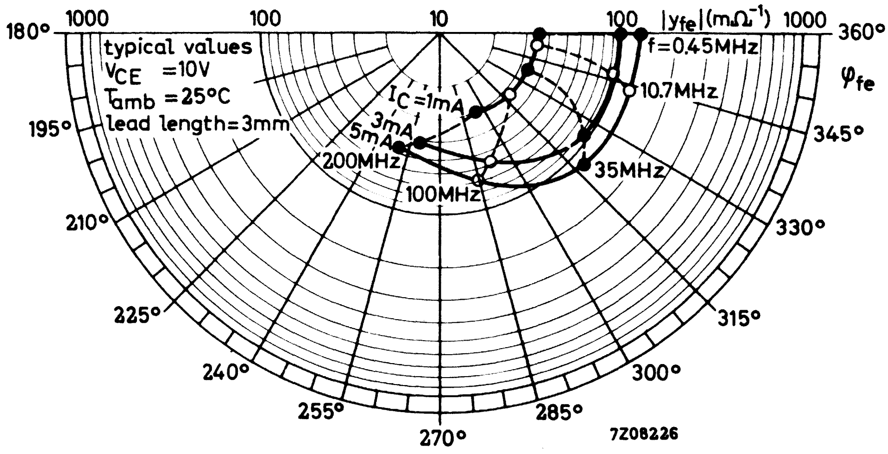

7Z07392
Base current versus collector current
I_C
(mA)
100
10
1
V_{CE} = 2 V
T_j = 25 °C
min
typ
max
1
10
100
I_B (μA)
1000


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

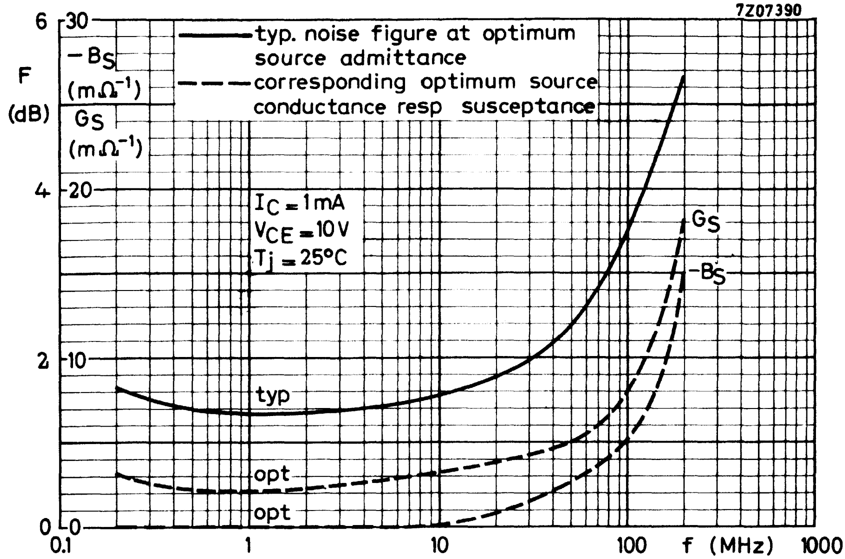

7Z07384
typical values
V_{CE} = 10V
T_{amb} = 25°C
Lead length = 3mm
f = 200MHz
100MHz
35MHz
107MHz
0.45MHz
5 mA
3 mA
I_C = 1 mA
b_{ie} ($m\Omega^{-1}$)
100
10
1
0.1
0.01
g_{ie} ($m\Omega^{-1}$)
0.1
1
10
100



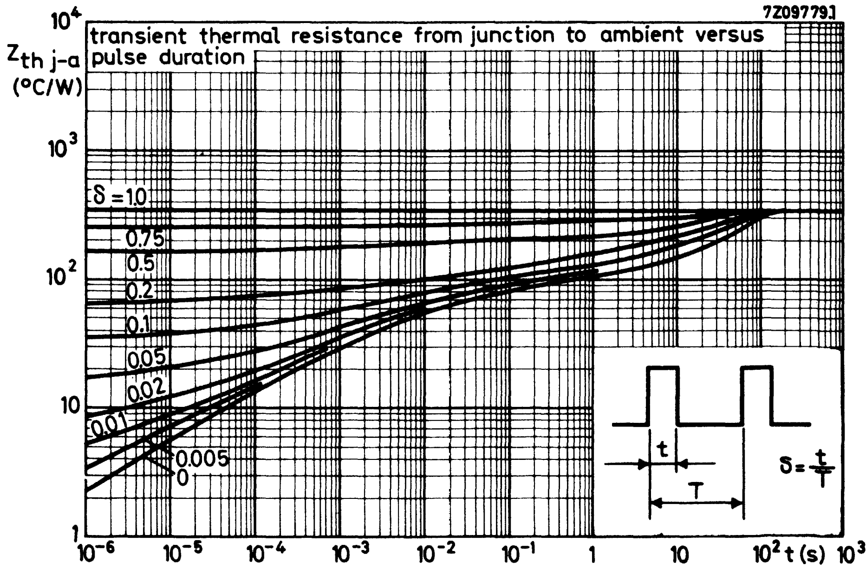
$|y_{re}|$ (μΩ⁻¹)
10⁴
10³
10²
10
1
10
10²
10³
10⁴
180°
360°
φ_{re}
typical values
V_{CE} = 10V
I_C = 1 to 5mA
T_{amb} = 25°C
lead length = 3mm
f = 0.45MHz
10.7MHz
35MHz
100MHz
200MHz
195°
345°
210°
330°
225°
315°
240°
300°
255°
285°
270°
7Z09799



1000
100
10
100
$|y_{fe}|$ (mΩ⁻¹)
1000
180°
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
195°
345°
210°
330°
225°
315°
240°
300°
255°
285°
270°
7Z08226



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



7Z09779.1
transient thermal resistance from junction to ambient versus pulse duration
Zth j-a (°C/W)
δ = 1.0
0.75
0.5
0.2
0.1
0.05
0.02
0.01
0.005
0
t
T
δ = t/T
t (s)

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

N-P-N transistors in a TO-39 metal envelope with the collector connected to the case. The transistors are intended for video amplifiers in black-and-white and in colour television receivers.

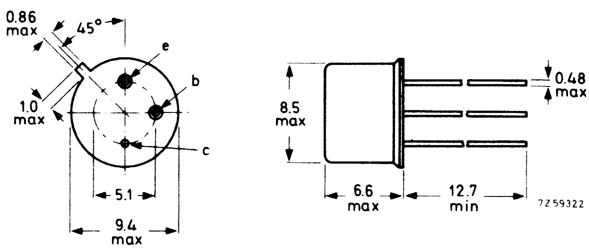
QUICK REFERENCE DATA

			BF257	BF258	BF259	
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.		200		mA
Total power dissipation up to T_{mb} = 50 °C	P_{tot}	max.		5		W
Junction temperature	T_j	max.		175		°C
D.C. current gain at T_j = 25 °C						
I_C = 30 mA; V_{CE} = 10 V	h_{FE}	>		25		
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	$-C_{re}$	typ.		3.5		pF

MECHANICAL DATA

Dimensions in mm

TO-39
Collector connected to case



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

Accessories supplied on request: 56218; 56245; 56265

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

Voltages			BF257	BF258	BF259	
Collector-base voltage (open emitter)	V_{CBO}	max.	160	250	300	V
Collector-emitter voltage ($R_{BE} \leq 1$ kΩ)	V_{CER}	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

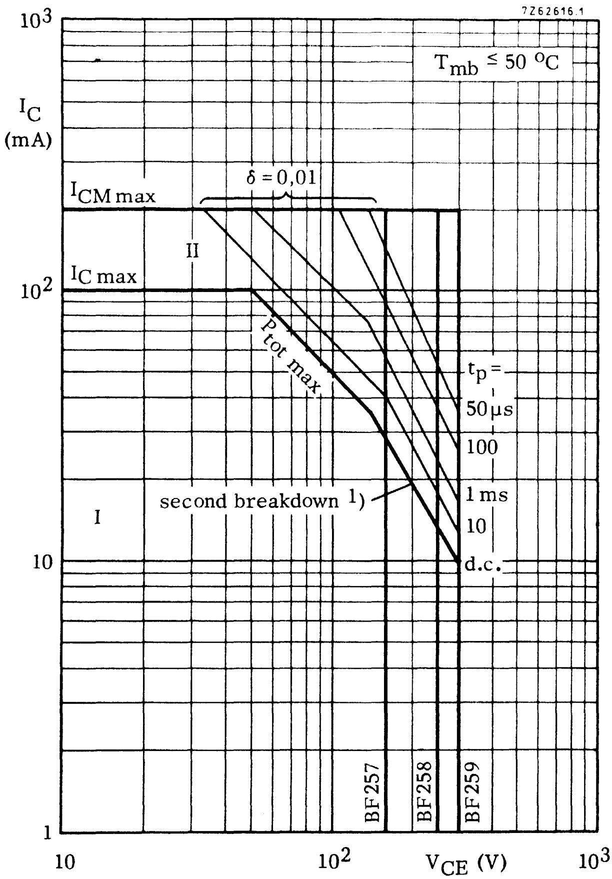
Currents				
Collector current (d.c.)	I_C	max.	100	mA
Collector current (peak value)	I_{CM}	max.	200	mA
Power dissipation				
Total power dissipation up to $T_{mb} = 50\ ^oC$	P_{tot}	max.	5	W
Temperatures				
Storage temperature	T_{stg}		−65 to +175	^oC
Junction temperature	T_j	max.	175	^oC

THERMAL RESISTANCE

From junction to ambient	$R_{th\ j\text{-}a}$	=	220	$^oC/W$
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	25	$^oC/W$
From junction to case	$R_{th\ j\text{-}c}$	=	30	$^oC/W$

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

Collector cut-off current				
$I_E = 0$; $V_{CB} = 100$ V for BF257 $I_E = 0$; $V_{CB} = 200$ V for BF258 $I_E = 0$; $V_{CB} = 250$ V for BF259	I_{CBO}	typ. <	1 50	nA nA
Base-emitter voltage				
$I_C = 30$ mA; $V_{CE} = 10$ V	V_{BE}	typ. <	0,7 1,2	V V
Saturation voltage				
$I_C = 30$ mA; $I_B = 6$ mA	$V_{CE\ sat}$	typ. <	150 1	mV V
D.C. current gain				
$I_C = 30$ mA; $V_{CE} = 10$ V	h_{FE}	> typ.	25 60	
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 30$ V	C_c	typ.	5,5	pF
Feedback capacitance at f = 1 MHz				
$I_E = 0$; $V_{CB} = 30$ V	$-C_{re}$	typ.	3,5	pF
Transition frequency at f = 100 MHz				
$I_C = 15$ mA; $V_{CE} = 10$ V	f_T	typ.	90	MHz

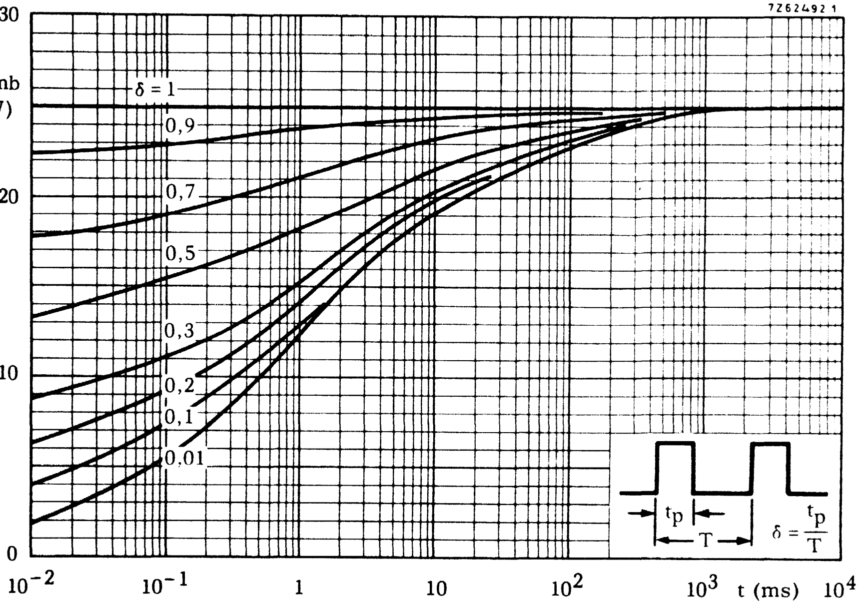


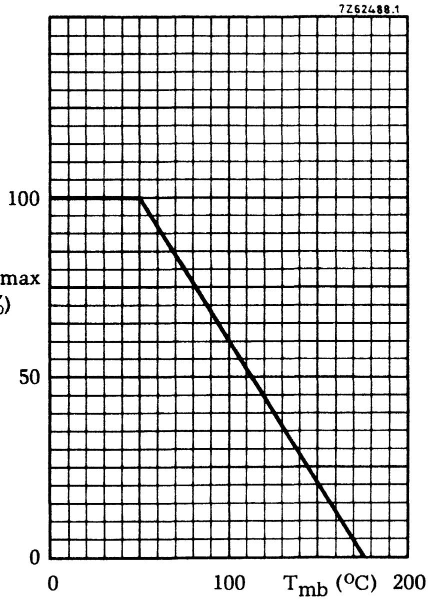
Safe Operating Area with the transistor forward biased

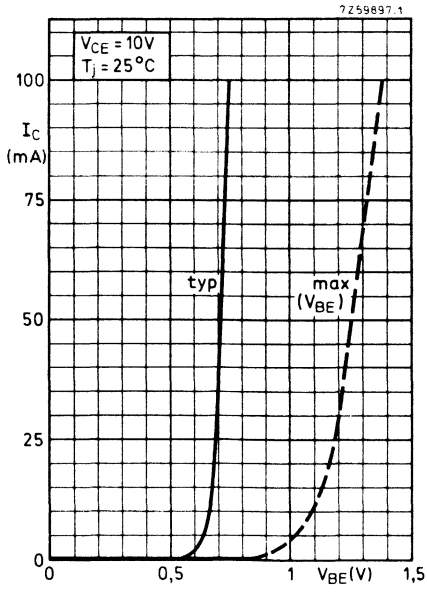
I Region of permissible d.c. operation

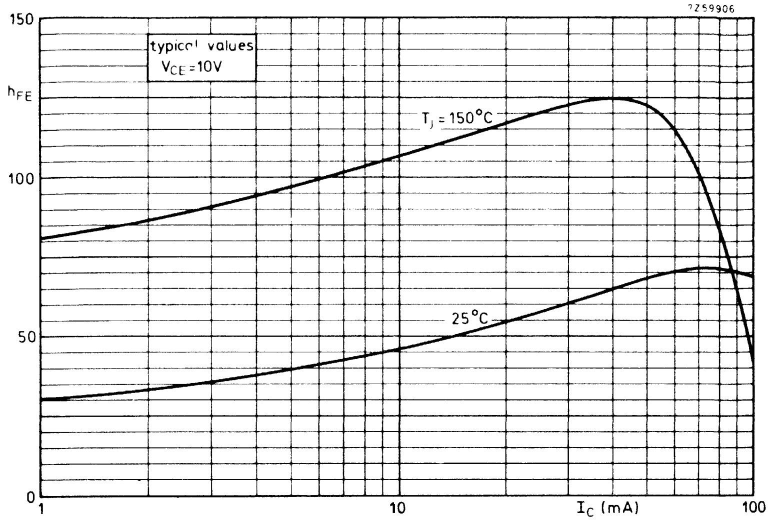
II Permissible extension for repetitive pulse operation

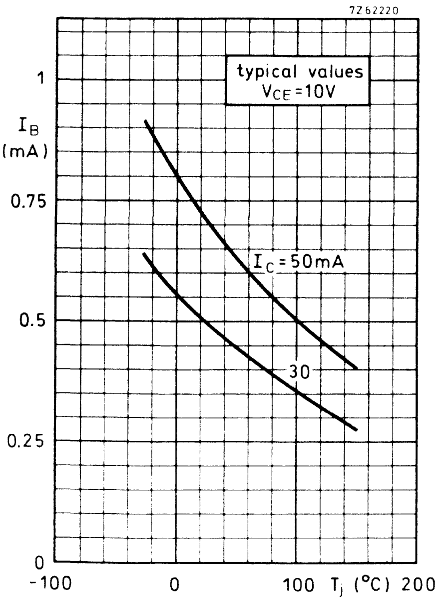
[1]) Independent of temperature

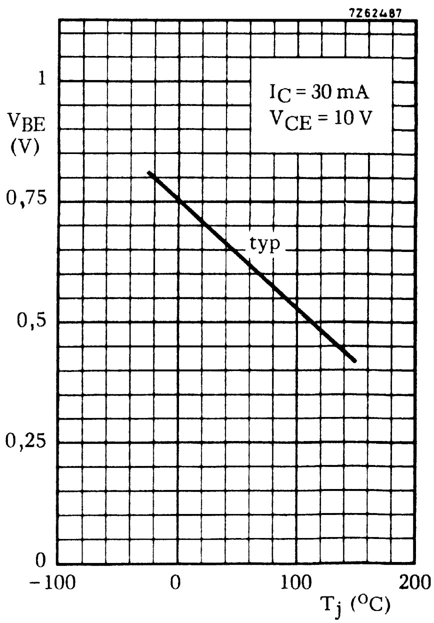

7Z62492.1
30
20
10
0
$Z_{th\ j\text{-}mb}$
(°C/W)
δ = 1
0,9
0,7
0,5
0,3
0,2
0,1
0,01
10^{-2}
10^{-1}
1
10
10^2
10^3
t (ms)
10^4
t_p
T
$\delta = \frac{t_p}{T}$

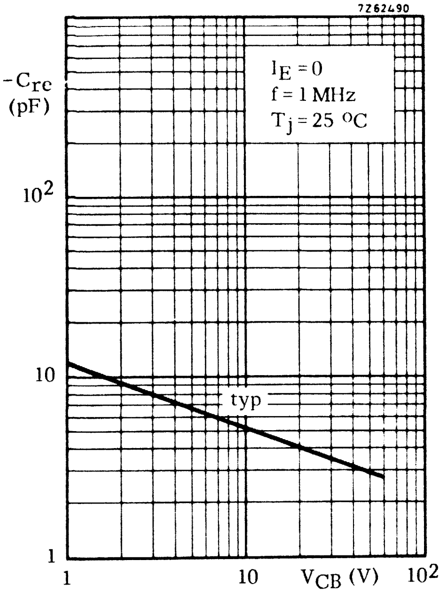

7Z62488.1
100
50
0
$P_{tot\ max}$
(%)
0
100
T_{mb} (°C)
200

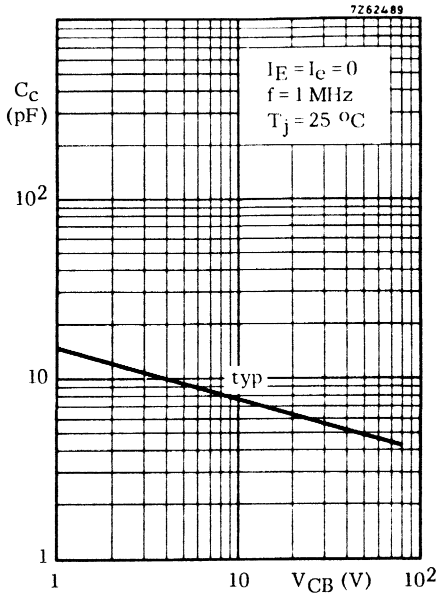

7Z59897.1
V_{CE} = 10V
T_j = 25°C
100
75
50
25
0
I_C
(mA)
typ
max
(V_{BE})
0
0,5
1
V_{BE}(V)
1,5

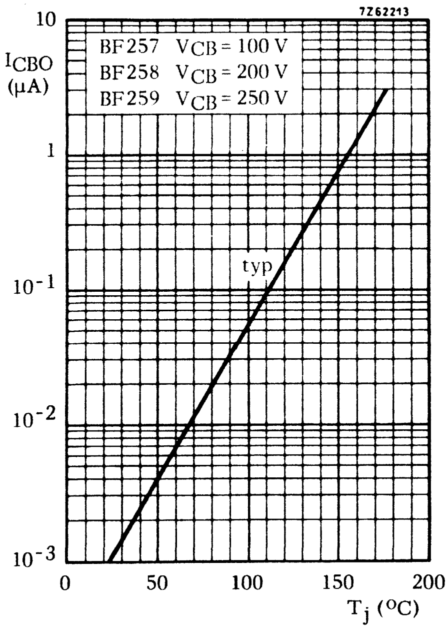

7Z59906
typical values
V_{CE} = 10V
h_{FE}
150
100
50
0
T_j = 150 °C
25 °C
1
10
I_C (mA)
100


7Z62220
typical values
V_{CE} = 10V
I_B
(mA)
1
0.75
0.5
0.25
0
I_C = 50mA
30
-100
0
100
T_j (°C)
200


7Z62487
I_C = 30 mA
V_{CE} = 10 V
V_{BE}
(V)
1
0,75
0,5
0,25
0
typ
-100
0
100
200
T_j (°C)


7Z62490
$-C_{re}$ (pF)
$I_E = 0$
f = 1 MHz
$T_j = 25\ ^oC$
10^2
10
1
typ
1
10
V_{CB} (V)
10^2


7Z62489
C_c (pF)
$I_E = I_e = 0$
f = 1 MHz
$T_j = 25\ ^oC$
10^2
10
1
typ
1
10
V_{CB} (V)
10^2


7Z62213
I_{CBO} (μA)
10
1
10^{-1}
10^{-2}
10^{-3}
BF257 $V_{CB} = 100$ V
BF258 $V_{CB} = 200$ V
BF259 $V_{CB} = 250$ V
typ
0
50
100
150
200
T_j (^oC)

H.F. SILICON PLANAR EPITAXIAL TRANSISTOR

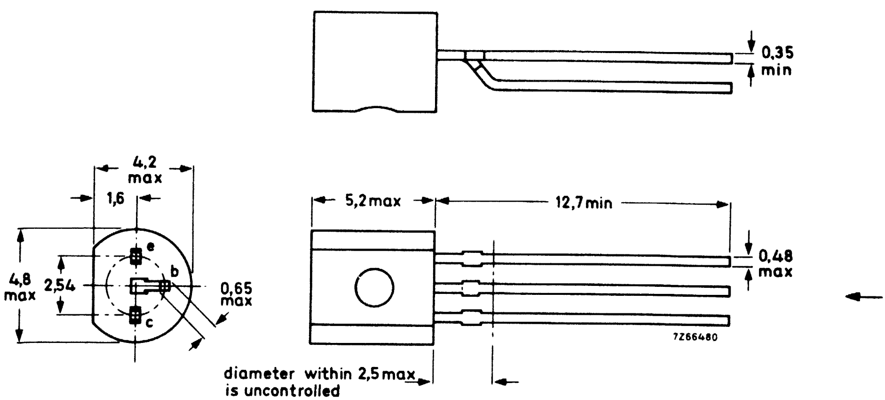
P-N-P transistor in a plastic envelope especially intended for r.f. stages in f.m. front-ends in common base configuration.

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.	550	MHz
Noise figure at f = 100 MHz $-I_C$ = 2 mA; $-V_{CE}$ = 10 V; G_S = 16,7 mA/V	F	typ.	3	dB
Feedback capacitance at f = 1 MHz V_{EB} = 0; $-V_{CB}$ = 10 V	$-C_{rb}$	typ.	0,1	pF

MECHANICAL DATA

Dimensions in mm

TO-92 variant



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

Voltages

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

Current

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

Power dissipation

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

Temperatures

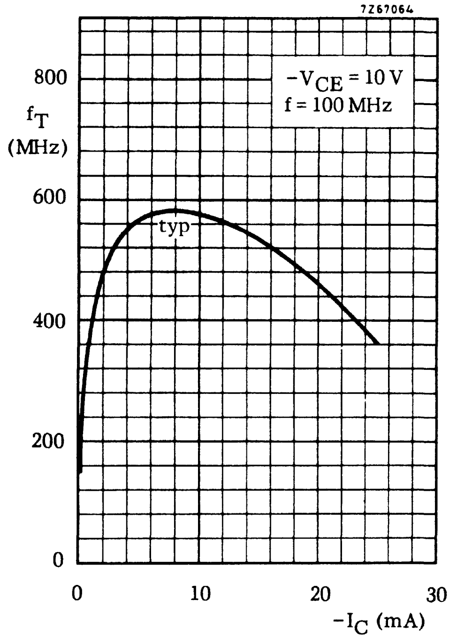
Storage temperature	T_{stg}		-55 to +150	°C
Junction temperature	T_j	max.	150	°C

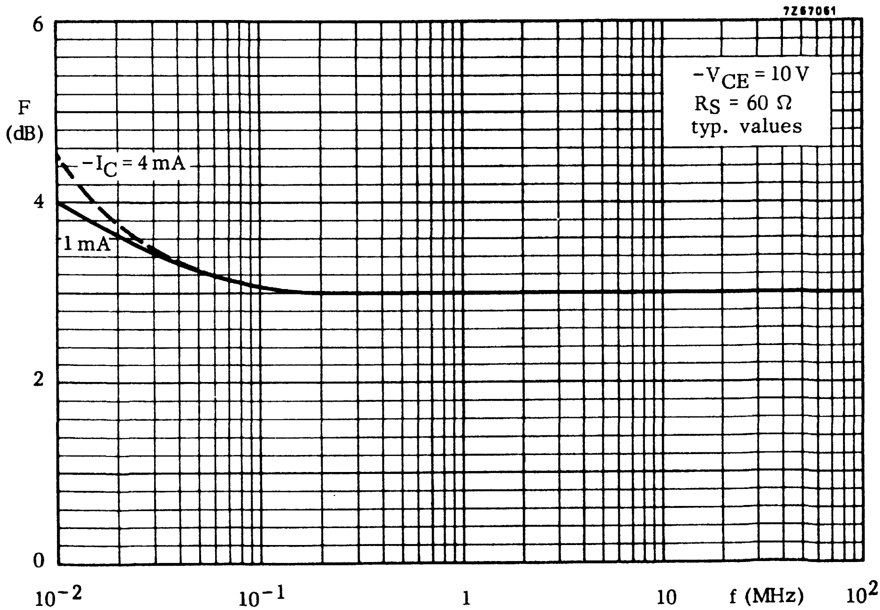
THERMAL RESISTANCE

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

CHARACTERISTICS $T_j = 25\ ^oC$

Collector cut-off current				
$I_E = 0;\ -V_{CB} = 30$ V	$-I_{CBO}$	<	50	nA
Emitter cut-off current				
$I_C = 0;\ -V_{EB} = 4$ V	$-I_{EBO}$	<	10	μA
Base current				
$-I_C = 4$ mA; $-V_{CE} = 10$ V	$-I_B$	typ. <	80 160	μA μA
$-I_C = 1$ mA; $-V_{CE} = 10$ V	$-I_B$	typ.	22	μA
Transition frequency at f = 100 MHz				
$-I_C = 1$ mA; $-V_{CE} = 10$ V	f_T	typ.	380	MHz
$-I_C = 4$ mA; $-V_{CE} = 10$ V	f_T	typ.	550	MHz
$-I_C = 8$ mA; $-V_{CE} = 10$ V	f_T	typ.	580	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.	110	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.	150^o	
Output conductance	g_{ob}	typ.	40	μA/V
Output capacitance	C_{ob}	typ.	1,6	pF


7Z67064
800
600
400
200
0
f_T
(MHz)
$-V_{CE}$ = 10 V
f = 100 MHz
typ
0
10
20
30
$-I_C$ (mA)


7Z67061
6
4
2
0
F
(dB)
$-V_{CE}$ = 10 V
R_S = 60 Ω
typ. values
$-I_C$ = 4 mA
1 mA
10^{-2}
10^{-1}
1
10
f (MHz)
10^2

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

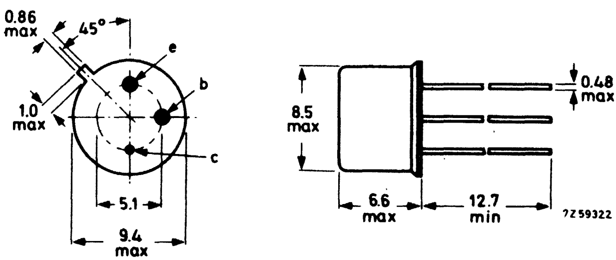
N-P-N transistors in a TO-39 metal envelope with the collector connected to the case. The transistors are intended for video amplifiers in black-and-white and in colour television receivers.

QUICK REFERENCE DATA

			BF336	BF337	BF338	
Collector-base voltage (open emitter)	V_{CBO}	max.	185	250	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	180	200	225	V
Collector current (peak value)	I_{CM}	max.		200	mA	
Total power dissipation up to T_{mb} = 140 °C	P_{tot}	max.		3.0	W	
Junction temperature	T_j	max.		200	°C	
D.C. current gain at T_j = 25 °C; I_C = 30 mA; V_{CE} = 10 V	h_{FE}	>		20		
Transition frequency; I_C = 30 mA; V_{CE} = 20 V	f_T	>		80	MHz	
Feedback capacitance at f = 0.5 MHz; I_C = 10 mA; V_{CE} = 20 V	$-C_{re}$	<		3.5	pF	

MECHANICAL DATA Dimensions in mm

TO-39
Collector connected to case



Max. lead diameter is guaranteed only for 12.7 mm

Accessories supplied on request: 56218; 56245; 56265

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

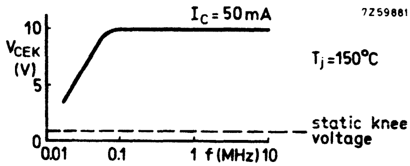
From junction to ambient	$R_{th\ j\text{-}a}$	=	220	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	20	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	25	°C/W

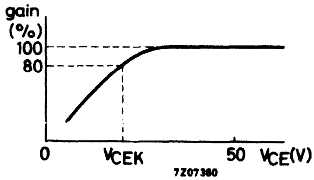
CHARACTERISTICS

T_j = 25 °C unless otherwise specified

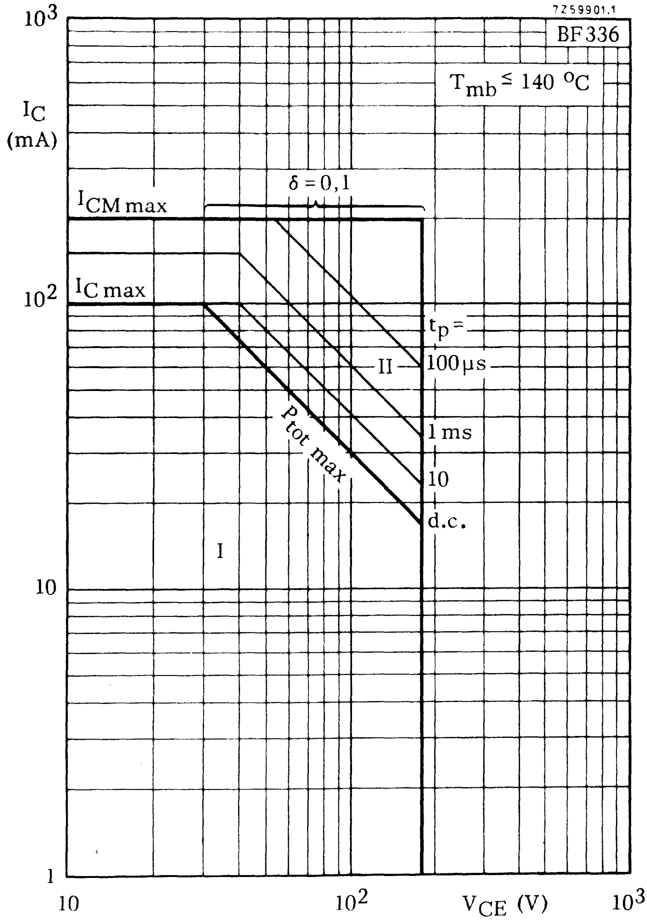
Collector cut-off current at R_{BE} = 1 kΩ				
V_{CE} = 150 V for BF336; V_{CE} = 200 V for BF337; V_{CE} = 250 V for BF338	I_{CER}	typ.	10	nA
		<	100	μA
Base-emitter voltage				
I_C = 30 mA; V_{CE} = 10 V	V_{BE}	typ.	0.7	V
		<	1.2	V
High frequency knee voltage at T_j = 150 °C				
I_C = 50 mA	V_{CEK}	typ.	10	V

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





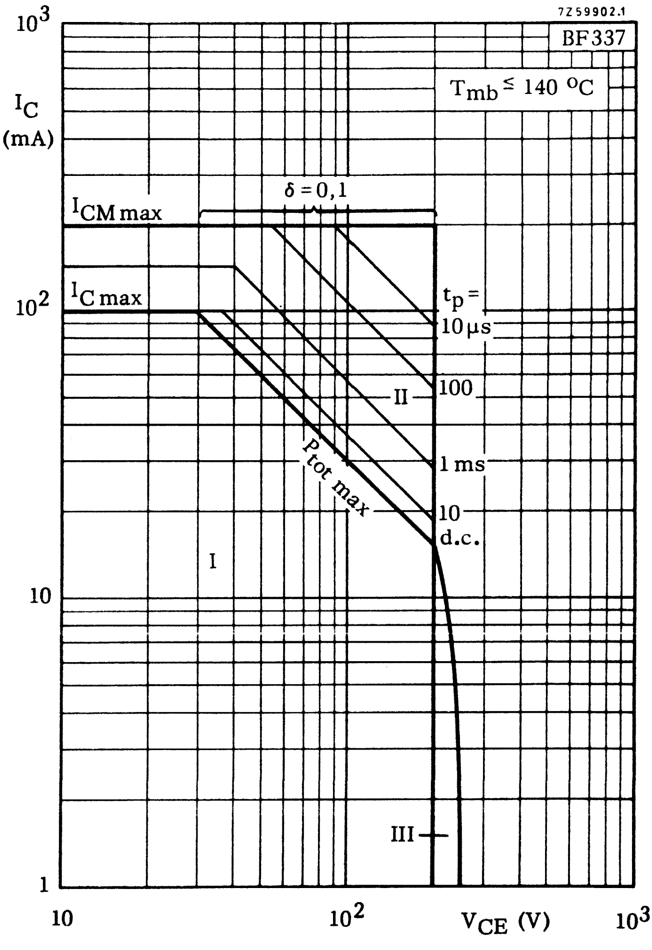
D.C. current gain				
I_C = 30 mA; V_{CE} = 10 V	h_{FE}	>	20	
		typ.	60	
Feedback capacitance at f = 0.5 MHz				
I_C = 10 mA; V_{CE} = 20 V	$-C_{re}$	typ.	3.0	pF
		<	3.5	pF
Feedback time constant at f = 10 MHz				
I_E = 30 mA; V_{CB} = 20 V	$r_{bb'}C_{b'c}$	typ.	30	ps
		<	100	ps
Transition frequency at f = 100 MHz				
I_C = 30 mA; V_{CE} = 20 V	f_T	>	80	MHz
		typ.	130	MHz



Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

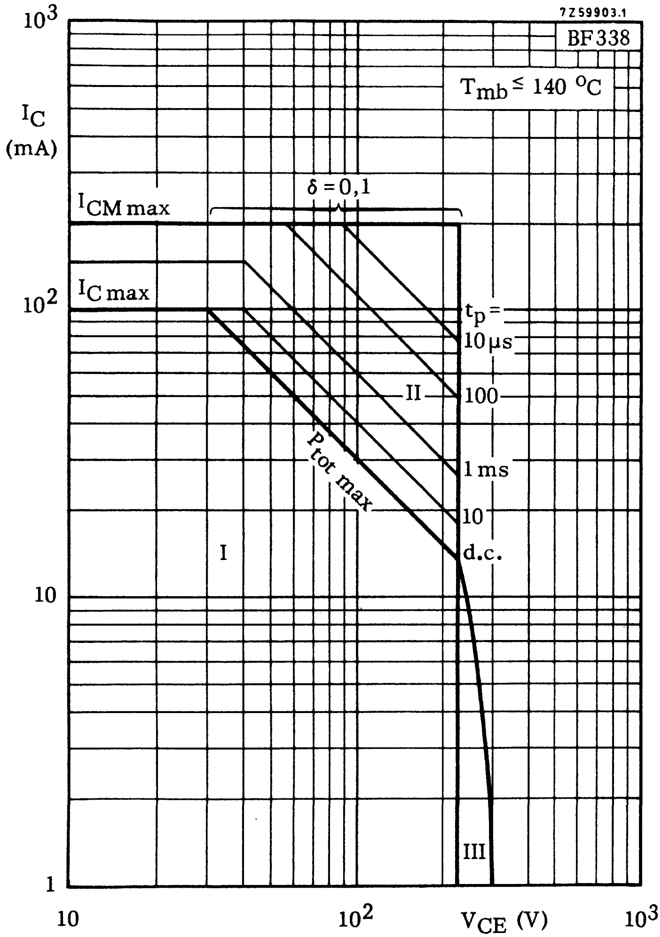


Safe Operating Area with the transistor forward biased

I Region of permissible d.c. operation

II Permissible extension for repetitive pulse operation

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

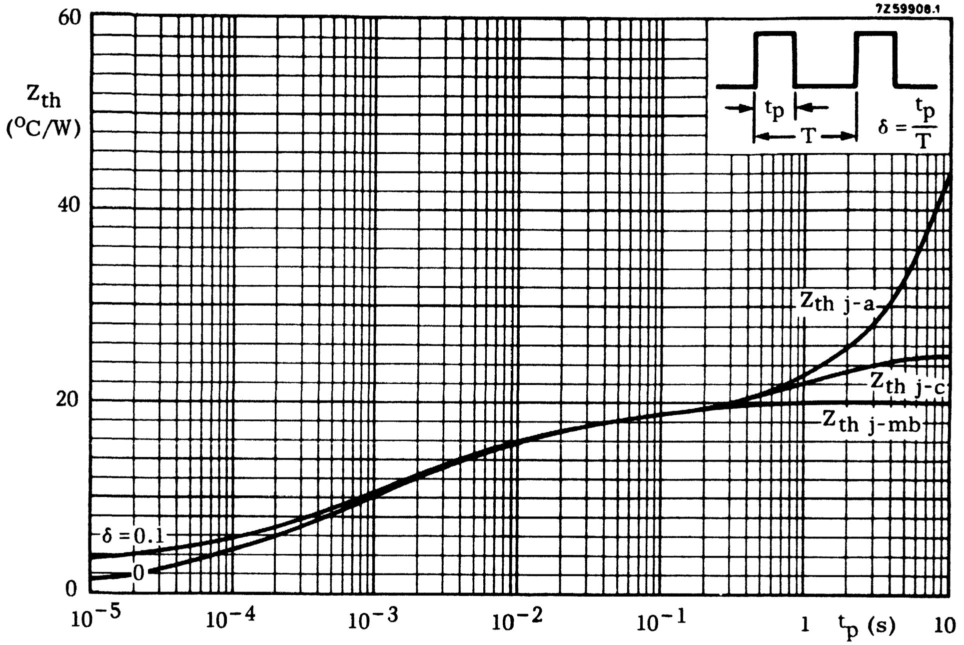


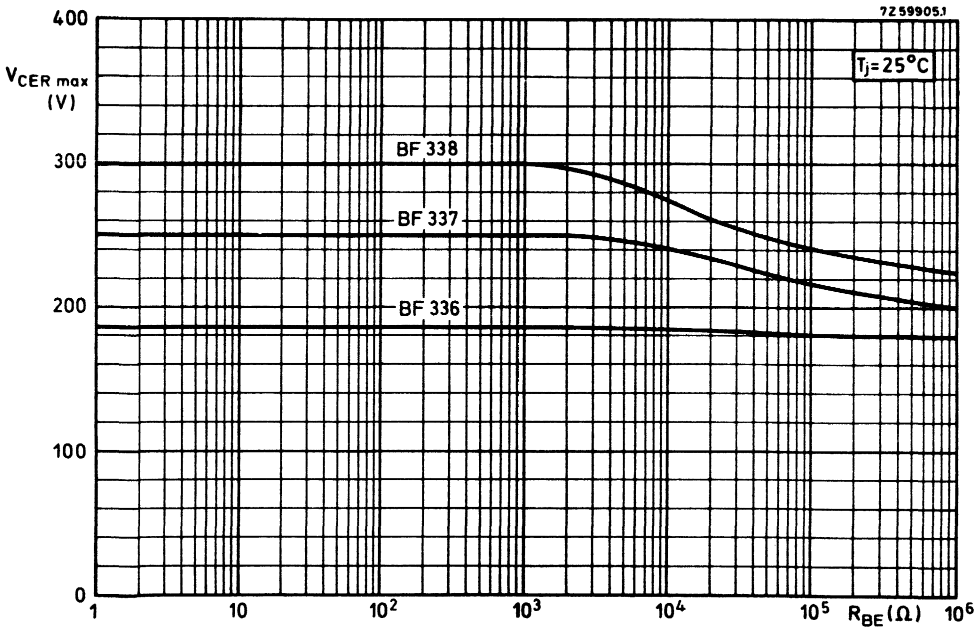
Safe Operating Area with the transistor forward biased

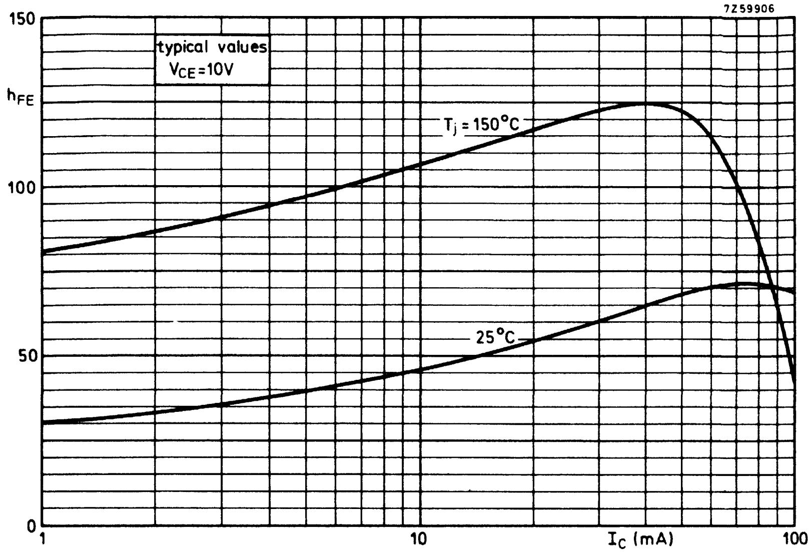
I Region of permissible d.c. operation

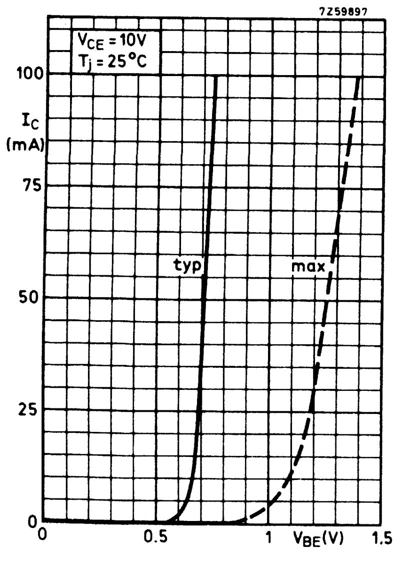
II Permissible extension for repetitive pulse operation

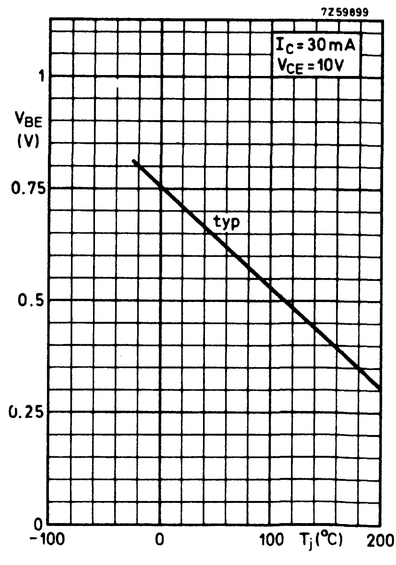
III Repetitive pulse operation in this region is allowable, provided $R_{BE} \leq 1\ k\Omega$

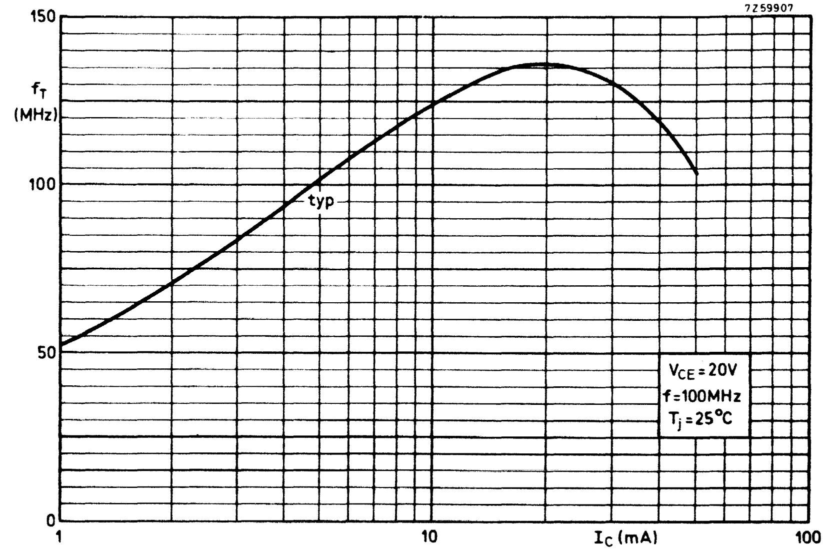

7Z59908.1
Z_{th} (°C/W)
60
40
20
0
t_p
T
$\delta = \frac{t_p}{T}$
Z_{th} j-a
Z_{th} j-c
Z_{th} j-mb
δ = 0.1
0
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t_p (s)
10

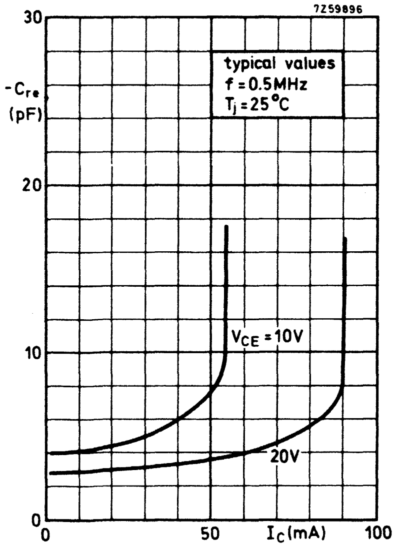

7Z59905.1
$V_{CER\ max}$ (V)
400
300
200
100
0
$T_j = 25°C$
BF 338
BF 337
BF 336
1
10
10^2
10^3
10^4
10^5
R_{BE} (Ω)
10^6

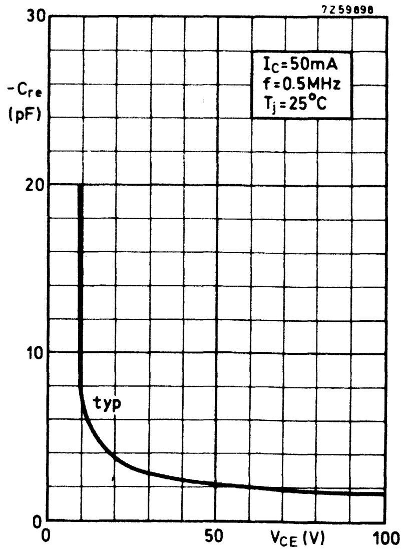

7Z59906
typical values
V_{CE} = 10V
h_{FE}
150
100
50
0
T_j = 150°C
25°C
1
10
I_C (mA)
100

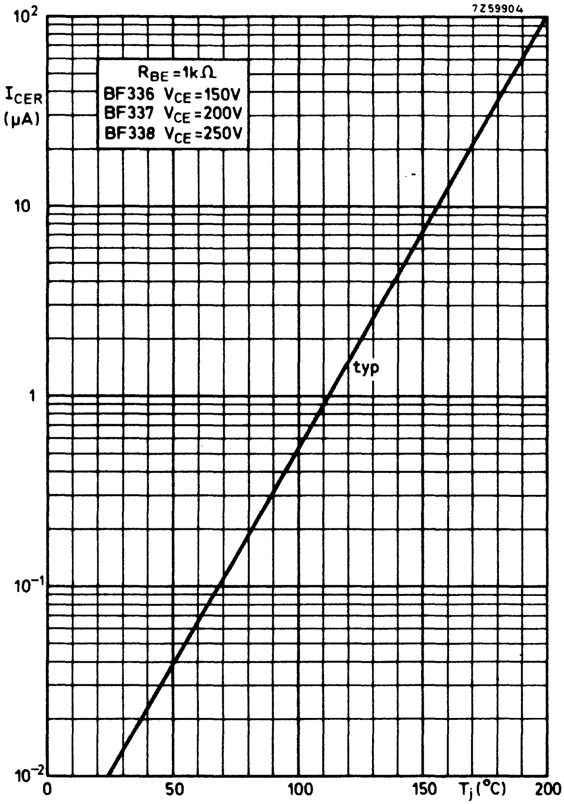

7Z59897
V_{CE} = 10V
T_j = 25°C
100
I_C
(mA)
75
50
25
0
typ
max
0
0.5
1
V_{BE}(V)
1.5


7Z59899
I_C = 30mA
V_{CE} = 10V
1
V_{BE}
(V)
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
R_{BE} = 1kΩ
BF336 V_{CE} = 150V
BF337 V_{CE} = 200V
BF338 V_{CE} = 250V
I_{CER} (μA)
10^2
10
1
10^{-1}
10^{-2}
typ
0
50
100
150
T_j (°C)
200

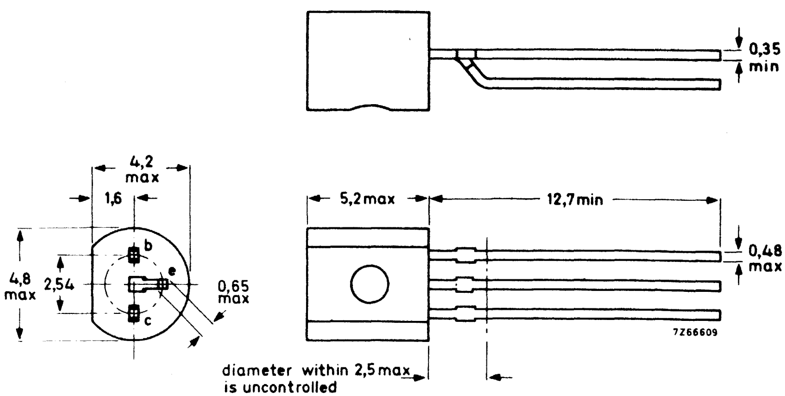
H.F. SILICON PLANAR EPITAXIAL TRANSISTORS

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 wit 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:	$-I_B$	<	16,5	μA
	BF451:	$-I_B$	<	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:	$-I_B$	<	16,5	μA
	BF451:	$-I_B$	<	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

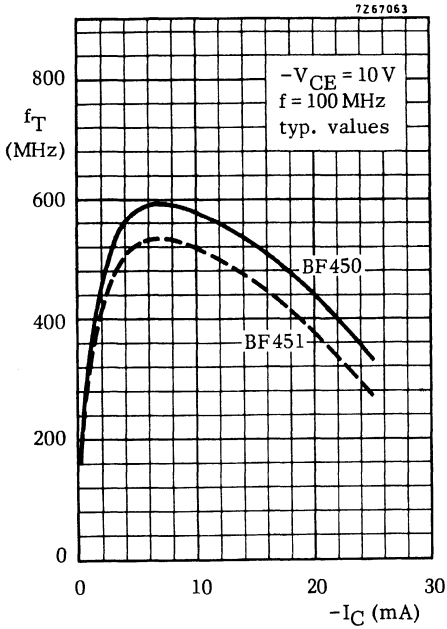
Noise figure at f = 100 kHz

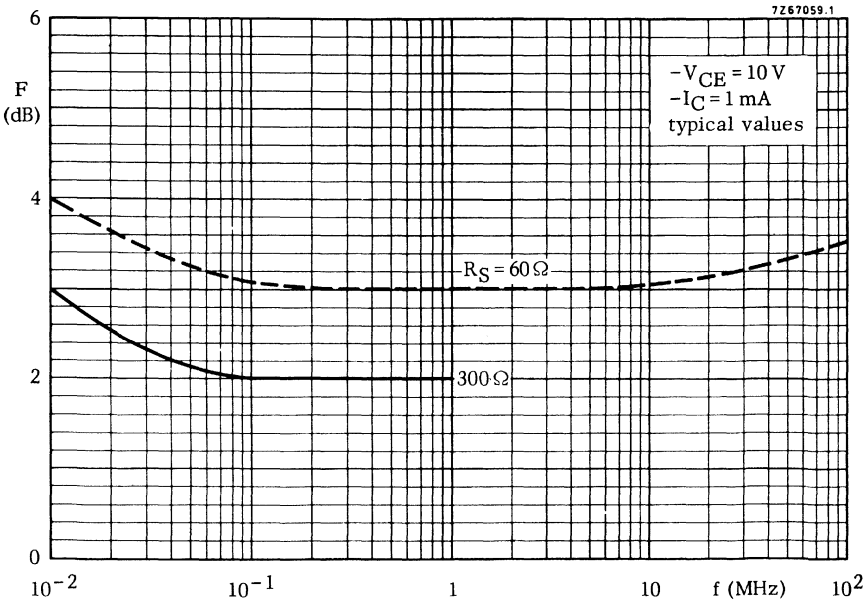
$-I_C = 1$ mA; $-V_{CE} = 10$ V; $R_S = 300\ \Omega$	F	typ.	2	dB

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.	90^o	90^o	90^o	90^o	


7Z67063
800
600
400
200
0
fT
(MHz)
−VCE = 10 V
f = 100 MHz
typ. values
BF450
BF451
0
10
20
30
−IC (mA)


7Z67059.1
6
4
2
0
F
(dB)
−VCE = 10 V
−IC = 1 mA
typical values
RS = 60 Ω
300 Ω
10−2
10−1
1
10
f (MHz)
102

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

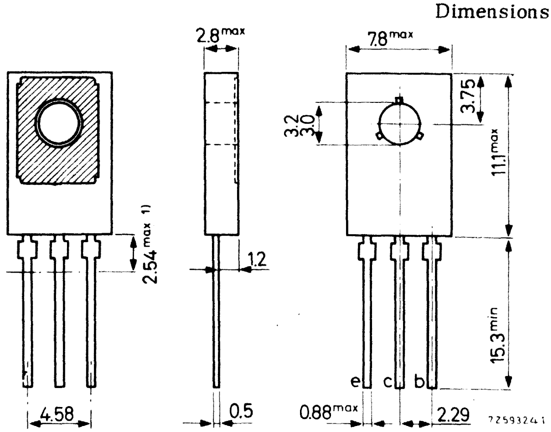
			BF457	BF458	BF459	
Collector-base voltage (open emitter)	V_{CBO}	max.	160	250	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	160	250	300	V
Collector current (peak value)			I_{CM}	max.	300	mA
Total power dissipation up to T_{mb} = 90 °C			P_{tot}	max.	6	W
Junction temperature			T_j	max.	150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

SOT-32 (TO-126)

Collector connected to metal part of mounting surface



Accessories available: 56333 for insulated mounting; 56326 for non-insulated mounting.

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

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

Voltage

			BF457	BF458	BF459	
Collector-base voltage (open emitter)	V_{CBO}	max.	160	250	300	V
Collector-emitter voltage (open base)	V_{CEO}	max.	160	250	300	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	5	V

Current

Collector current (d.c.)	I_C	max.	100	mA
Collector current (peak value)	I_{CM}	max.	300	mA
Base current (d.c.)	I_B	max.	50	mA

Power dissipation

Total power dissipation up to T_{mb} = 90 °C	P_{tot}	max.	6	W

Temperature

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

THERMAL RESISTANCE

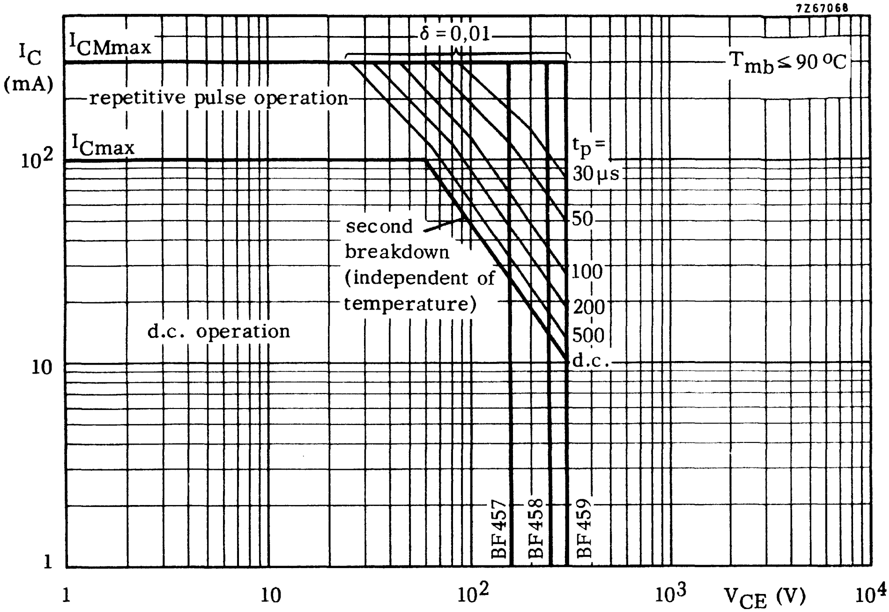
From junction to ambient	$R_{th\ j-a}$	=	104	°C/W
From junction to mounting base	$R_{th\ j-mb}$	=	10	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

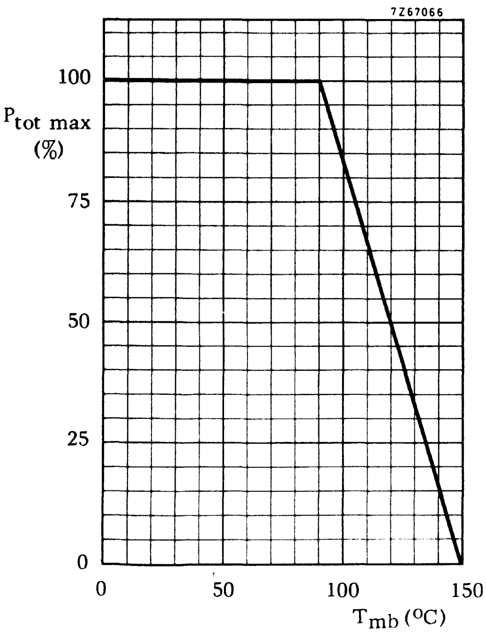
Collector cut-off current				
$I_E = 0$; $V_{CB} = 100$ V for BF457				
$I_E = 0$; $V_{CB} = 200$ V for BF458	I_{CBO}	<	50	nA
$I_E = 0$; $V_{CB} = 250$ V for BF459				
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 3$ V	I_{EBO}	<	50	nA
D.C. current gain				
$I_C = 30$ mA; $V_{CE} = 10$ V	h_{FE}	>	26	
Collector-emitter saturation voltage				
$I_C = 30$ mA; $I_B = 6$ mA	V_{CEsat}	<	1	V
High frequency knee voltage at $T_j = 150$ °C				
$I_C = 50$ mA	V_{CEK}	typ.	15	V

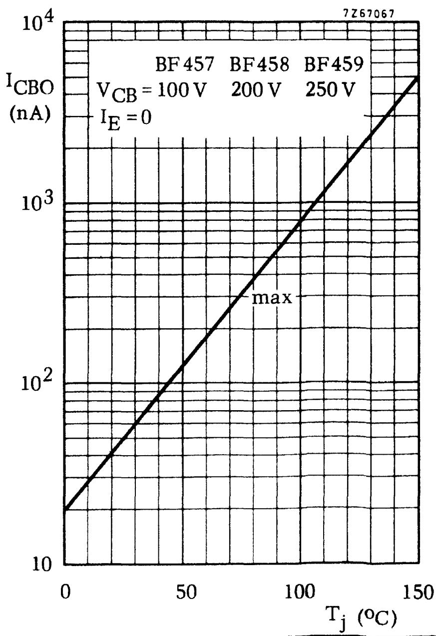
The high frequency knee voltage of a transistor is that value of the collector-emitter voltage at which the small signal gain, measured in a practical circuit, has dropped to 80% of the gain at $V_{CE} = 50$ V. A further decrease of the collector-emitter voltage results in a rapid increase of the distortion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





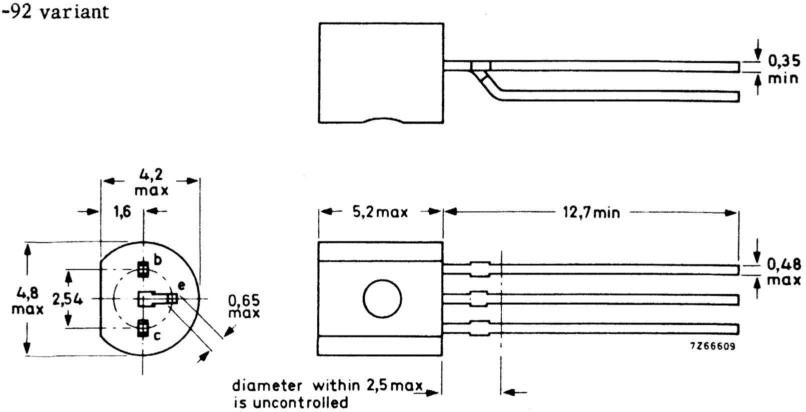
SILICON PLANAR EPITAXIAL TRANSISTOR

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 = 10 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	$-C_{re}$	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.	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

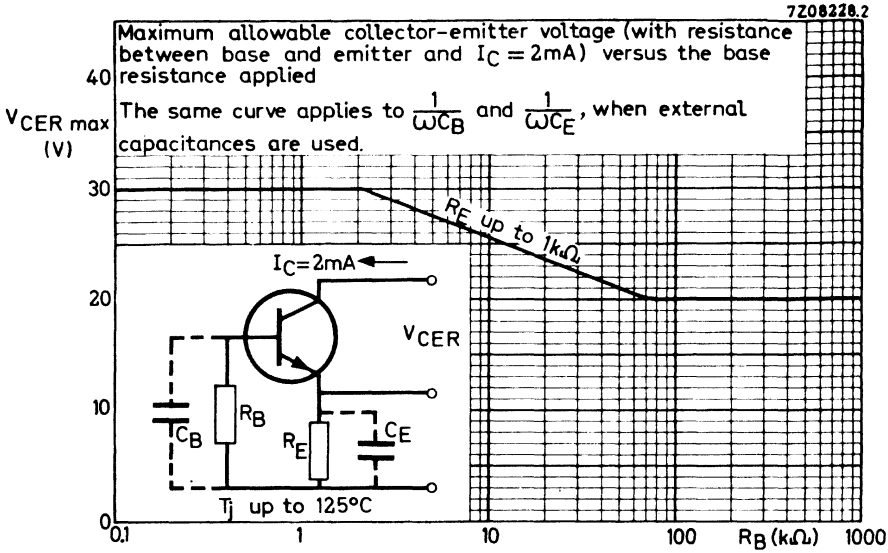
$I_C = 1$ mA; $V_{CE} = 10$ V				
$G_S = 0,6$ mA/V; f = 0,2 MHz	F_c	typ.	3	dB
$G_S = 1,2$ mA/V; f = 1,0 MHz	F_c	typ.	2	dB

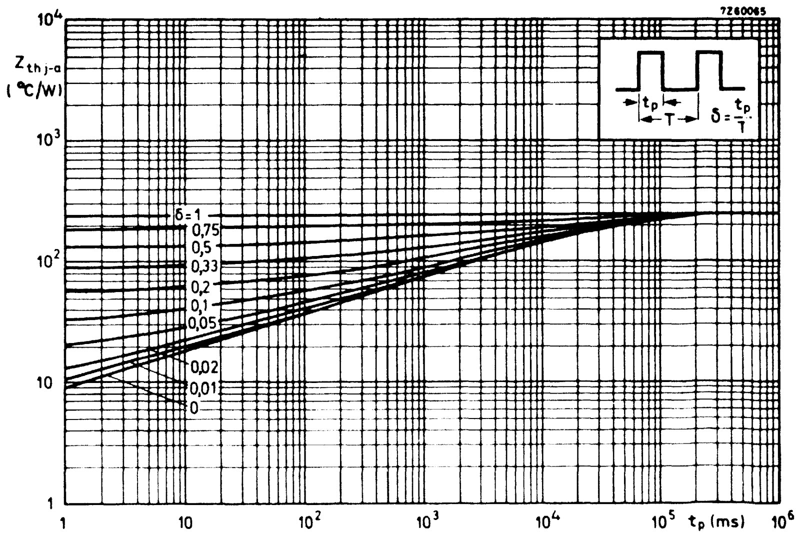
y parameters at f = 100 MHz (common base)

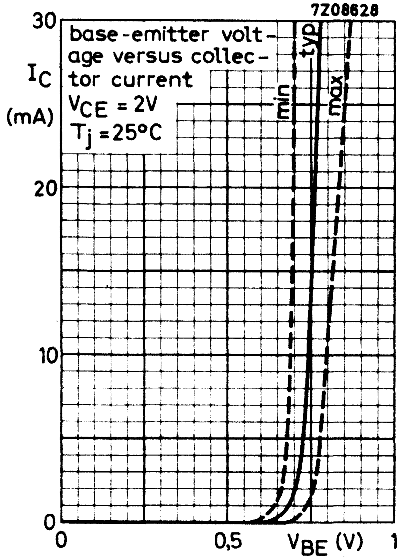
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)				
Input conductance	g_{ib}	typ.	32	mA/V
Input susceptance	$-b_{ib}$	typ.	3	mA/V
Feedback admittance	$\|y_{rb}\|$	typ.	500	µA/V
Phase angle of feedback admittance	φ_{rb}	typ.	272^o	
Transfer admittance	$\|y_{fb}\|$	typ.	33	mA/V
Phase angle of transfer admittance	φ_{fb}	typ.	150^o	
Output conductance	g_{ob}	typ.	22	µA/V
Output susceptance	b_{ob}	typ.	1,1	mA/V

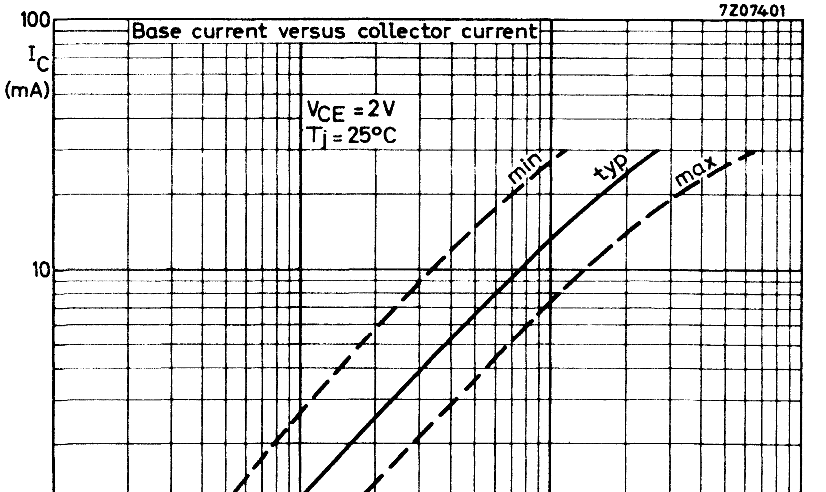
y parameters (common emitter)

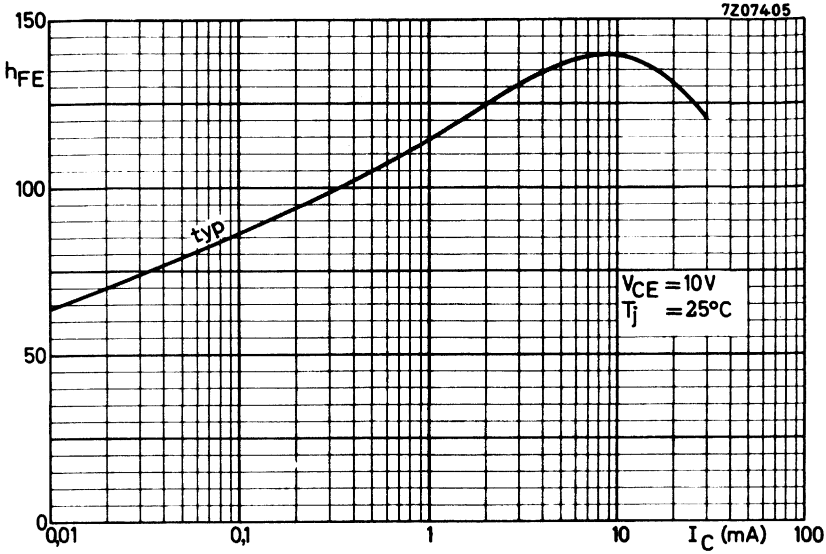
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)		f = 10,7 MHz	f = 0,45 MHz	
Input conductance	g_{ie}	< 0,64	0,54	mA/V
Output conductance	g_{oe}	< 13,5	11,5	µA/V

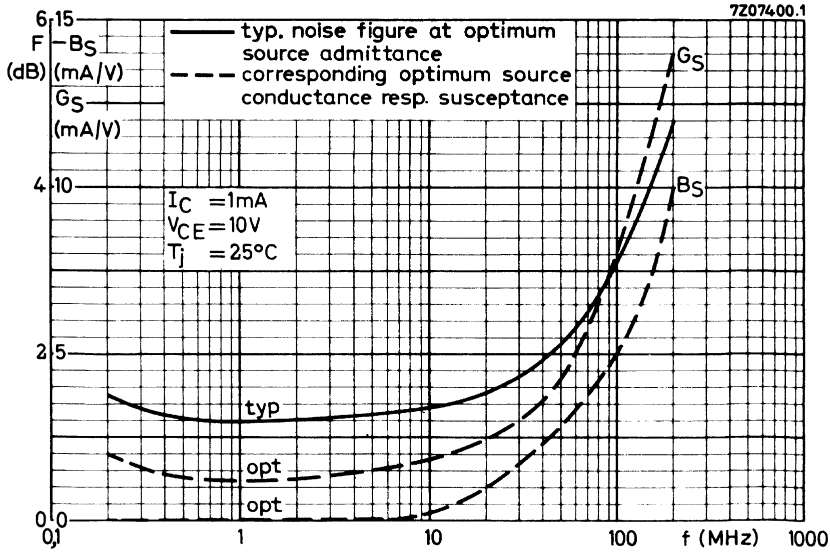

7Z08228.2
Maximum allowable collector-emitter voltage (with resistance between base and emitter and $I_C = 2mA$) versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$, when external capacitances are used.
$V_{CER\,max}$ (V)
R_E up to 1kΩ
I_C=2mA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

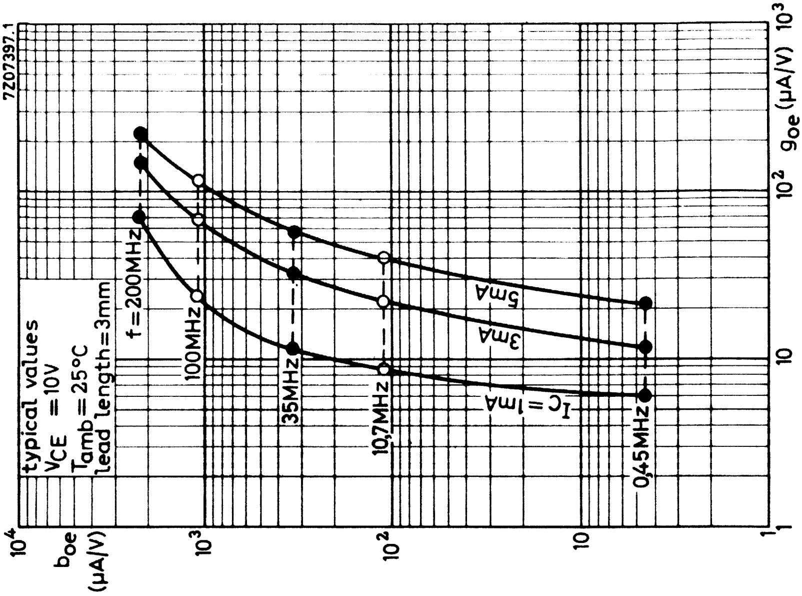

7Z60065
$Z_{th\,j-a}$ (°C/W)
t_p
T
$\delta = \frac{t_p}{T}$
δ=1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
0
t_p (ms)
1
10
10^2
10^3
10^4
10^5
10^6

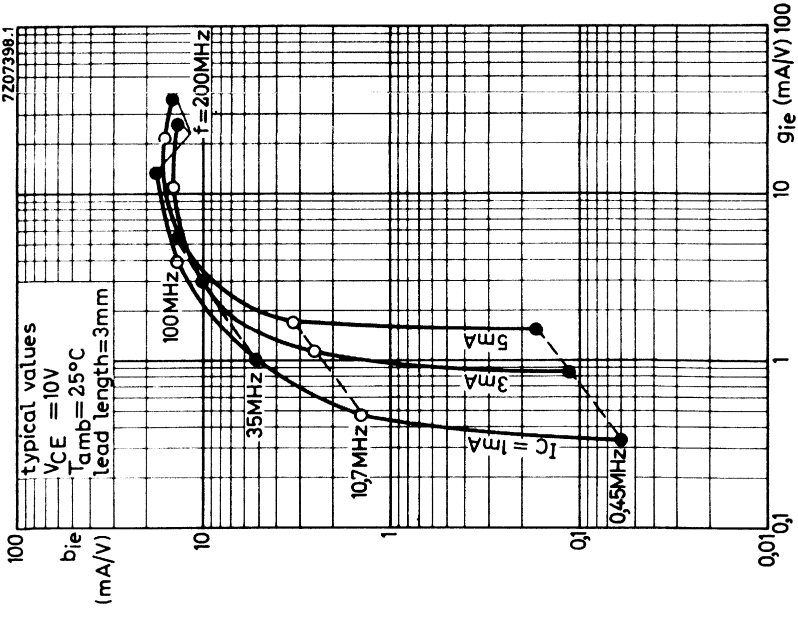

7Z08628
base-emitter voltage versus collector current
V_{CE} = 2V
T_j = 25°C
I_C (mA)
30
20
10
0
min
typ
max
0
0,5
V_{BE} (V)
1

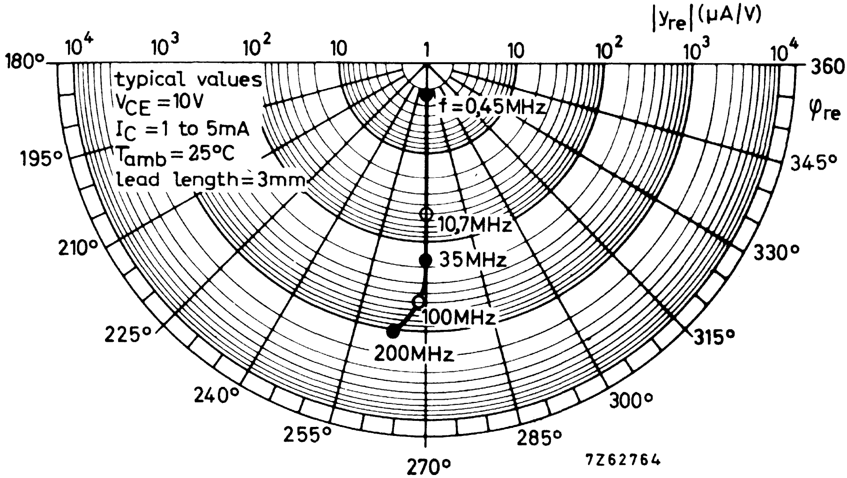

7Z07401
Base current versus collector current
V_{CE} = 2V
T_j = 25°C
I_C (mA)
100
10
1
min
typ
max
1
10
100
I_B (μA)
1000

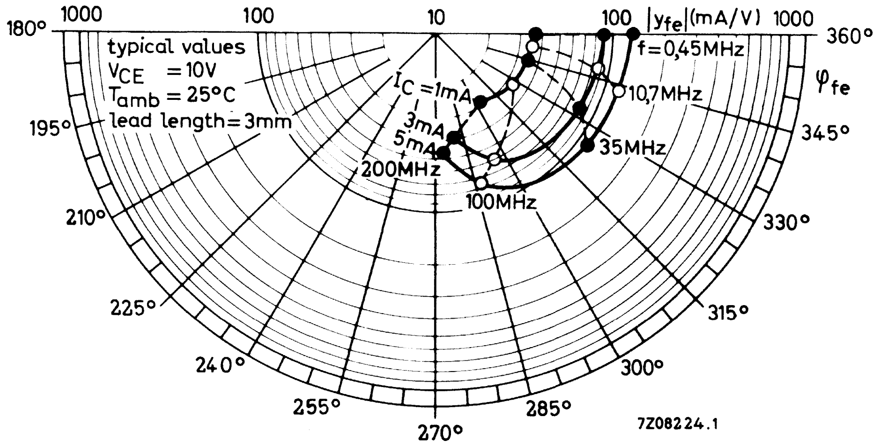

7Z07405
150
h_{FE}
100
50
0
typ
V_{CE} = 10 V
T_j = 25 °C
0,01
0,1
1
10
I_C (mA)
100


7Z07400.1
6
F
(dB)
15
$-B_S$
(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)
g_{oe} (μA/V)


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)
g_{ie} (mA/V)


|y_re| (μA/V)
10^4 10^3 10^2 10 1 10 10^2 10^3 10^4
180° 360°
φ_re
typical values
V_{CE} = 10V
I_C = 1 to 5mA
T_{amb} = 25°C
lead length = 3mm
f = 0,45MHz
10,7MHz
35MHz
100MHz
200MHz
195° 210° 225° 240° 255° 270° 285° 300° 315° 330° 345°
7Z62764


1000 100 10 100 |y_fe| (mA/V) 1000
180° 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
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.

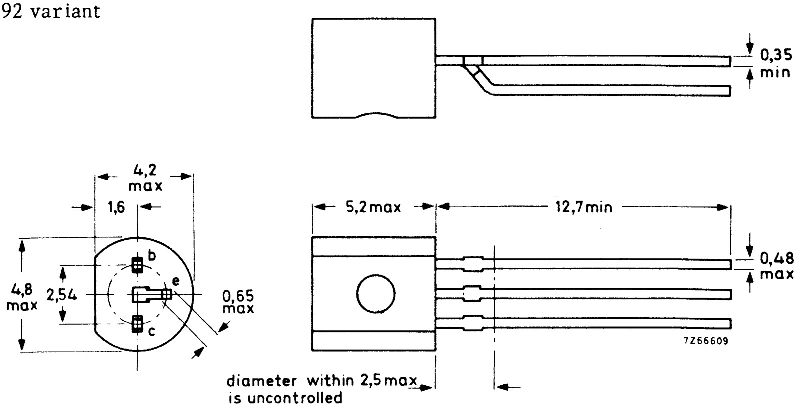
QUICK REFERENCE DATA

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 = 10 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

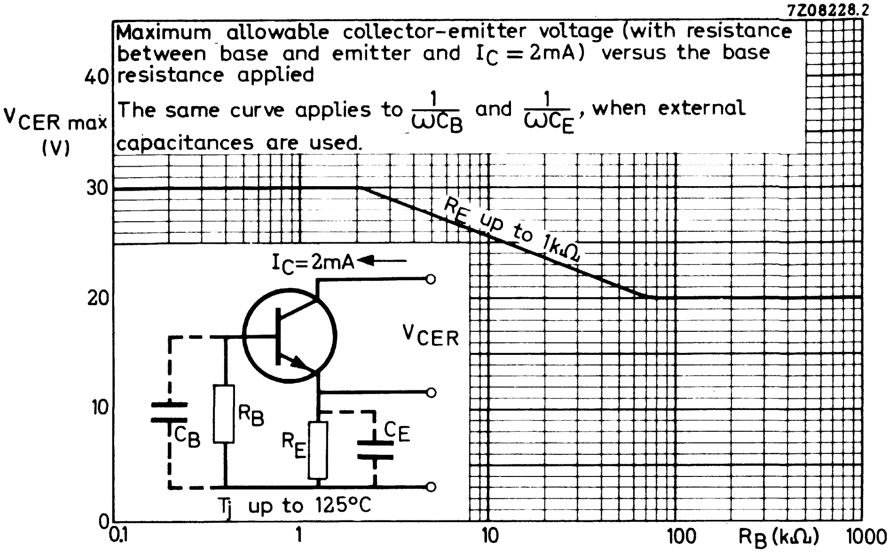
$I_C = 1$ mA; $V_{CE} = 10$ V				
$G_S = 1,2$ mA/V; f = 0,2 MHz	F_c	typ.	4	dB
$G_S = 1,5$ mA/V; f = 1 MHz	F_c	typ.	2,5	dB

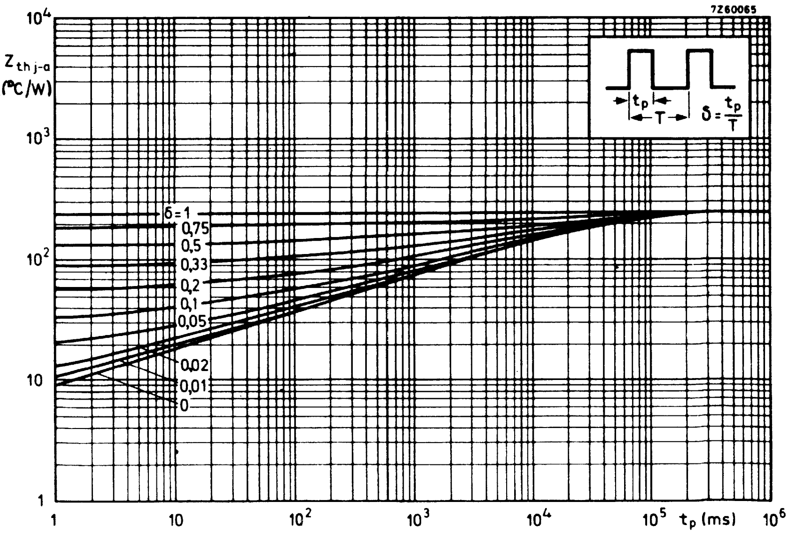
y parameters at f = 100 MHz (common base)

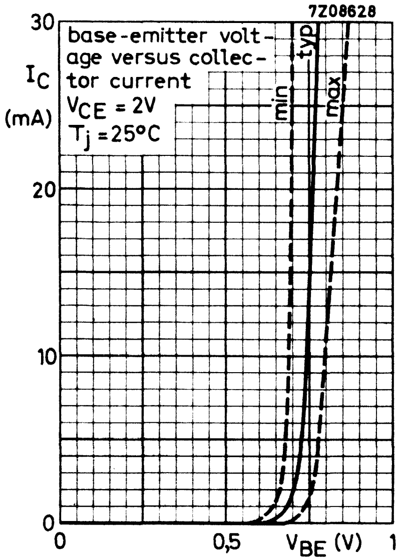
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)				
Input conductance	g_{ib}	typ.	34	mA/V
Input susceptance	$-b_{ib}$	typ.	1	mA/V
Feedback admittance	$\|y_{rb}\|$	typ.	490	µA/V
Phase angle of feedback admittance	φ_{rb}	typ.	272^o	
Transfer admittance	$\|y_{fb}\|$	typ.	34	mA/V
Phase angle of transfer admittance	φ_{fb}	typ.	144^o	
Output conductance	g_{ob}	typ.	12	µA/V
Output susceptance	b_{ob}	typ.	1,1	mA/V

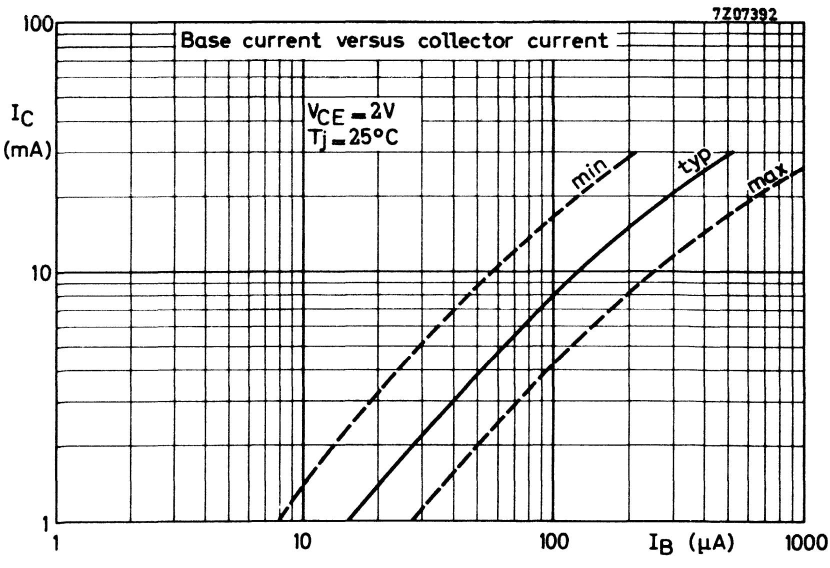
y parameters (common emitter)

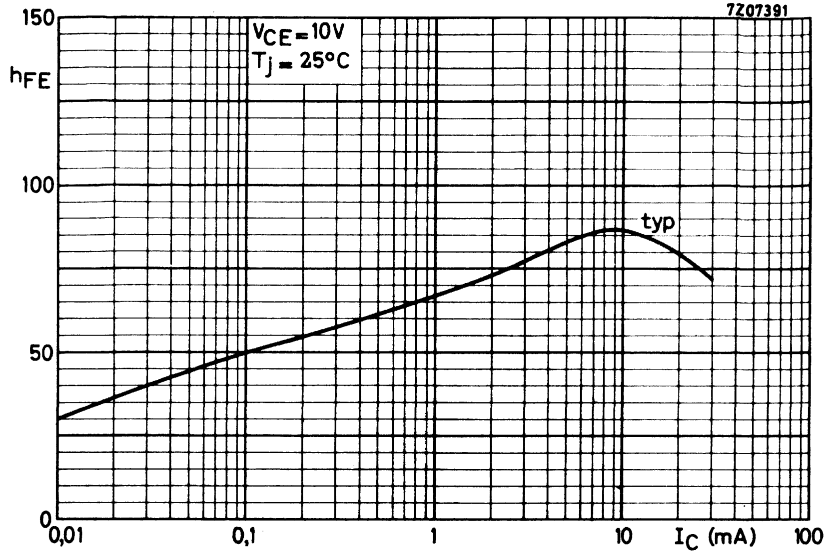
$I_C = 1$ mA; $V_{CE} = 10$ V (lead length = 3 mm)		f = 10,7 MHz	f = 0,45 MHz	
Input conductance	g_{ie}	< 0,96	0,86	mA/V
Output conductance	g_{oe}	< 9,5	7,0	µA/V

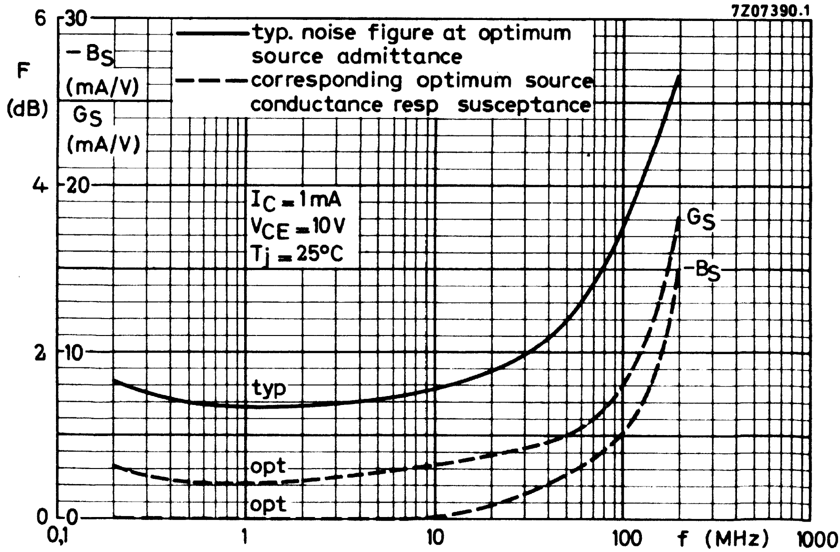

7Z08228.2
Maximum allowable collector-emitter voltage (with resistance between base and emitter and $I_C = 2mA$) versus the base resistance applied
The same curve applies to $\frac{1}{\omega C_B}$ and $\frac{1}{\omega C_E}$, when external capacitances are used.
$V_{CER\,max}$ (V)
40
30
20
10
0
0,1
1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

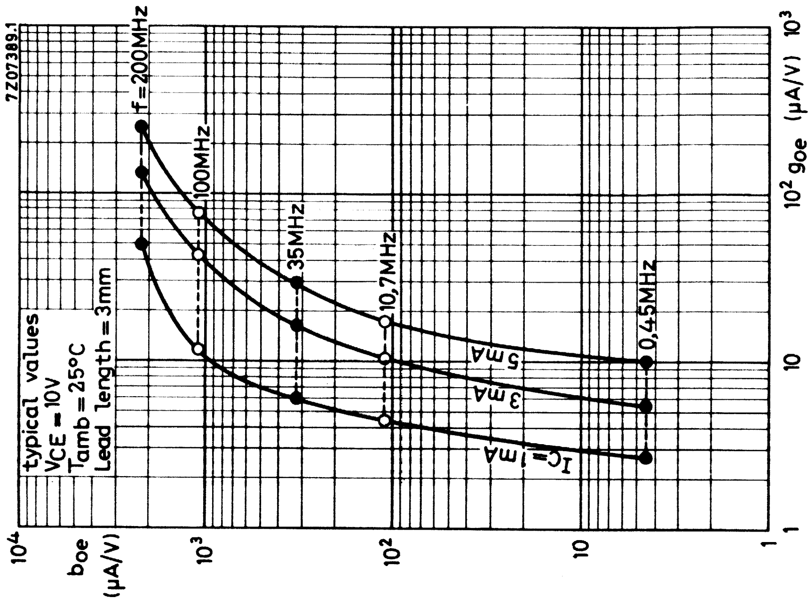

7Z60065
$Z_{th\,j-a}$ (°C/W)
10^4
10^3
10^2
10
1
1
10
10^2
10^3
10^4
10^5
t_p (ms)
10^6
δ = 1
0,75
0,5
0,33
0,2
0,1
0,05
0,02
0,01
0
t_p
T
$\delta = \frac{t_p}{T}$

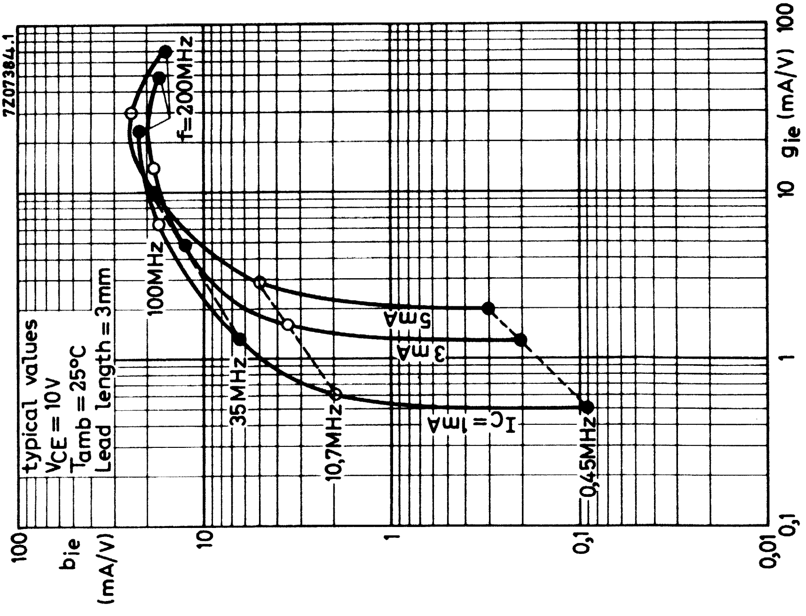

7Z08628
base-emitter voltage versus collector current
V_{CE} = 2V
T_j = 25°C
I_C (mA)
30
20
10
0
0
0,5
1
V_{BE} (V)
min
typ
max

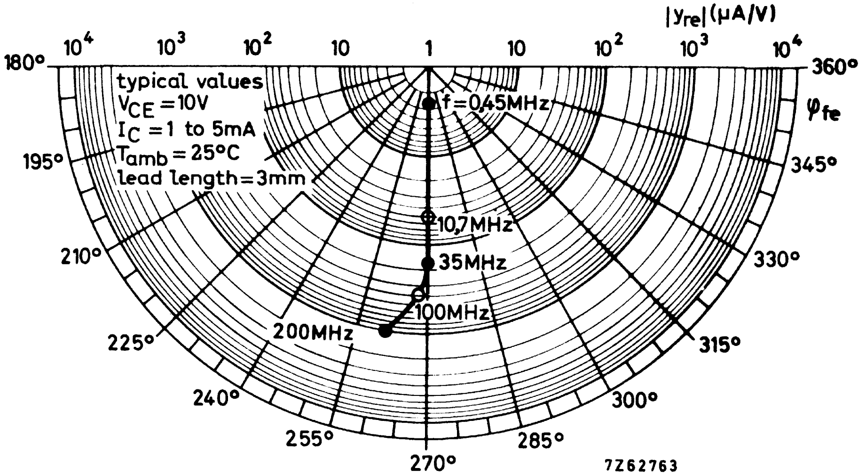

7Z07392
Base current versus collector current
V_{CE} = 2V
T_j = 25°C
I_C (mA)
100
10
1
1
10
100
1000
I_B (μA)
min
typ
max


7Z07391
150
hFE
100
50
0
VCE = 10V
Tj = 25°C
typ
0,01
0,1
1
10
IC (mA)
100

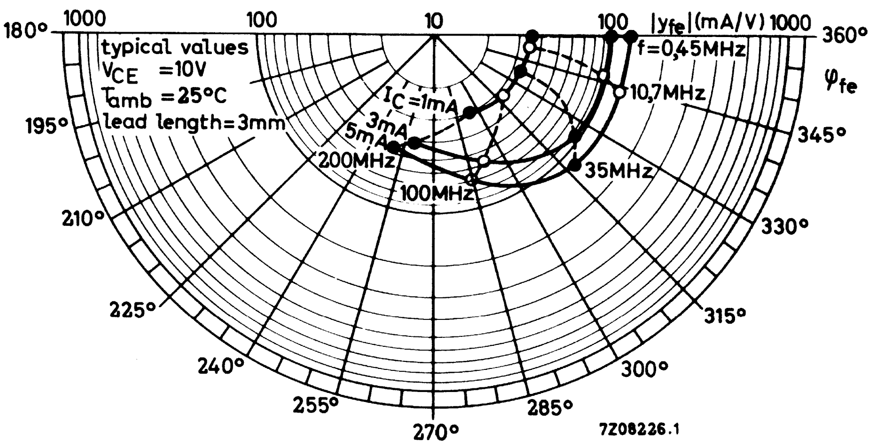

7Z07390.1
6
F
(dB)
4
2
0
30
−BS
(mA/V)
GS
(mA/V)
20
10
0
typ. noise figure at optimum source admittance
corresponding optimum source conductance resp susceptance
IC = 1mA
VCE = 10V
Tj = 25°C
GS
−BS
typ
opt
opt
0,1
1
10
100
f (MHz)
1000


7Z07389.1
typical values
V_{CE} = 10V
T_{amb} = 25°C
Lead length = 3mm
f = 200MHz
100MHz
35MHz
10,7MHz
0,45MHz
5 mA
3 mA
I_C = 1 mA
b_{oe}
(μA/V)
10^4
10^3
10^2
10
1
g_{oe} (μA/V)


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 = 1 mA
b_{ie}
(mA/V)
100
10
1
0,1
0,01
g_{ie} (mA/V)



|yre| (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°
φfe
typical values
VCE = 10V
IC = 1 to 5mA
Tamb = 25°C
lead length = 3mm
f = 0,45MHz
10,7MHz
35MHz
100MHz
200MHz
7Z62763



1000 100 10 100 |yfe| (mA/V) 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
f = 0,45MHz
10,7MHz
IC = 1mA
3mA
5mA
35MHz
100MHz
200MHz
7Z08226.1

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N multi-emitter silicon transistors in a capstan envelope. The transistors have 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 wide band amplifiers (40–230 MHz).
c- Final stages of the wide band vertical amplifier in high speed oscilloscopes.
d- Frequency multiplier and oscillator circuits.

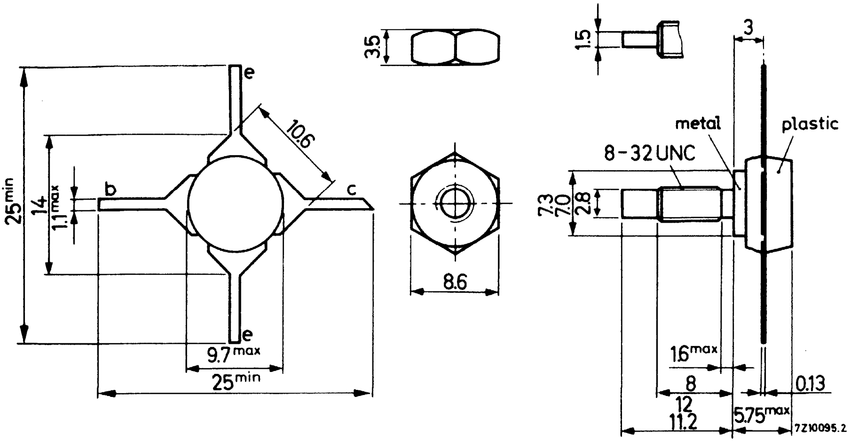
QUICK REFERENCE DATA

			BFR63	BFR64	
Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	40	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	25	V
Collector current (peak value)	I_{CM}	max.	500	500	mA
Total power dissipation up to T_{mb} = 60 °C; f ≥ 1 MHz	P_{tot}	max.	3.5	3.5	W
Junction temperature	T_j	max.	150	150	°C
Transition frequency at f = 500 MHz; I_C = 75 mA; V_{CE} = 20 V	f_T	>	1000	1200	MHz
Output power at f = 200 MHz; I_C = 70 mA; V_{CE} = 20 V; d_{im} = −30 dB	P_o	typ.	150	150	mW
Power gain at f = 200 MHz; I_C = 70 mA; V_{CE} = 20 V	G_p	typ.	16	16	dB

MECHANICAL DATA See page 2

MECHANICAL DATA

Dimensions in mm



Diameter of hole in heatsink: max. 4.17 mm
Torque on nut: min. 7.5 cm kg
max. 8.5 cm kg
When locking is required an adhesive instead of a lock washer is preferred.

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 [1])
Collector-emitter voltage (R_{BE} = 10 Ω; peak value)	V_{CERM}	max.	40	V [2])
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V [2])
Emitter-base voltage (open collector)	V_{EBO}	max.	3.5	V [3])
Currents				
Collector current (d.c.)	I_C	max.	200	mA
Collector current (peak value) f > 1 MHz	I_{CM}	max.	500	mA
Power dissipation (f ≥ 1 MHz; see SOAR)				
Total power dissipation up to T_{mb} = 60 °C	P_{tot}	max.	3.5	W
Temperatures				
Storage temperature	T_{stg}		-40 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to mounting base	$R_{th\ j\text{-}mb}$	=	25	°C/W
From mounting base to heatsink	$R_{th\ mb\text{-}h}$	=	0.5	°C/W

[1]) at I_C = 100 μA [2]) at I_C = 10 mA [3]) at I_E = 100 μA

CHARACTERISTICS

$T_j = 25\,^{o}C$ 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; $T_{mb} = 25\,^{o}C$	$-C_{re}$	typ.	1.7	pF
Noise figure at f = 200 MHz				
$I_C = 40$ mA; $V_{CE} = 20$ V; $R_S = 75\ \Omega$; $T_{mb} = 25\,^{o}C$	F	typ.	6	dB

			BFR63	BFR64	
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	>	1000	1200	MHz
$I_C = 150$ mA; $V_{CE} = 20$ V	f_T	typ.	1100	1200	MHz
Output power at f = 200 MHz; $T_{mb} = 25\,^{o}C$					
$I_C = 70$ 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	>	-	130	mW
		typ.	150	150	mW
Output power at f = 800 MHz; $T_{mb} = 25\,^{o}C$					
$I_C = 70$ mA; $V_{CE} = 20$ 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
Power gain (not neutralized) $T_{mb} = 25\,^{o}C$					
$I_C = 70$ mA; $V_{CE} = 20$ V; f = 200 MHz	G_p	>	-	15	dB
		typ.	16	16	dB
$I_C = 70$ mA; $V_{CE} = 20$ V; f = 800 MHz	G_p	typ.	-	6.5	dB

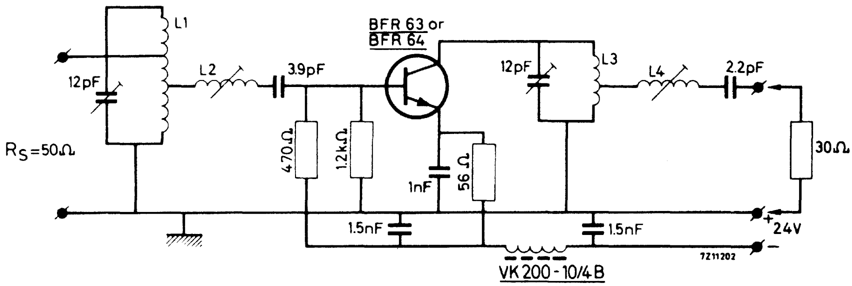
CHARACTERISTICS (continued)

Intermodulation characteristics

1. Output power at f = 200 MHz; T_{mb} = 25 °C

   I_C = 70 mA; V_{CE} = 20 V; 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 = 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 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 Ω; 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 (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.

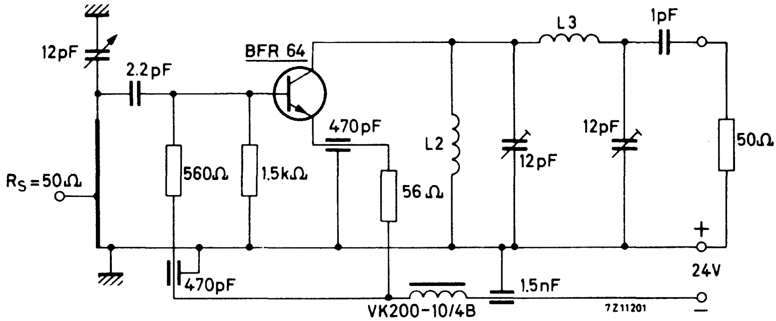
CHARACTERISTICS (continued)

Intermodulation characteristics

2. Output power at f = 800 MHz; T_{mb} = 25 °C

I_C = 70 mA; V_{CE} = 20 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)

Test circuit:



Coil data:

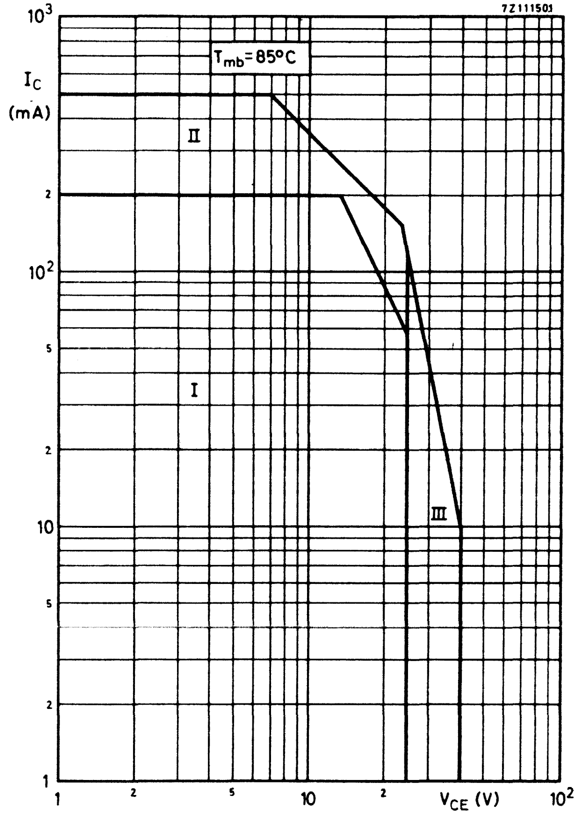
L1 = 25 mm x 7 mm x 0.85 mm silver plated Cu strip
Tap of the input at 5 mm from earth.
L2 = 13 turns enamelled Cu wire (0.6 mm); int. diam. 8 mm
L3 = 1.5 turns Cu wire (1.3 mm); int. diam. 8 mm

Basis of adjustment

At 800 MHz no dummy can be used to adjust for optimum collector load because at these frequencies the impedance transformations of a dummy are too high. A small signal at the mid-channel frequency of 802 MHz is fed to the input and increased until clipping occurs; that is, until the output power no longer increases linearly with the input signal. This clipping can be eliminated by tuning the output circuit, thereby making the output power equal to

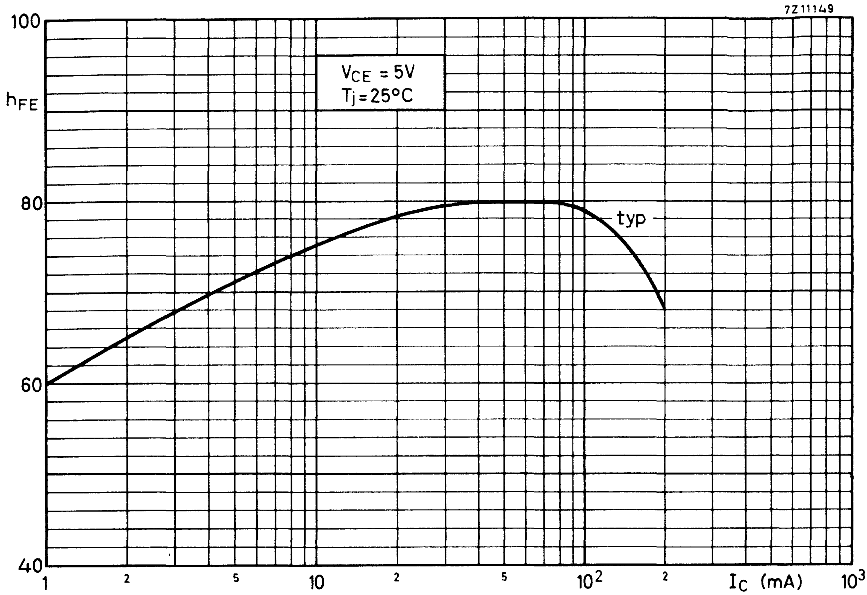
$$P_o = \frac{I_C(V_{CE} - V_{CEK})}{2} = 480 \text{ mW}.$$

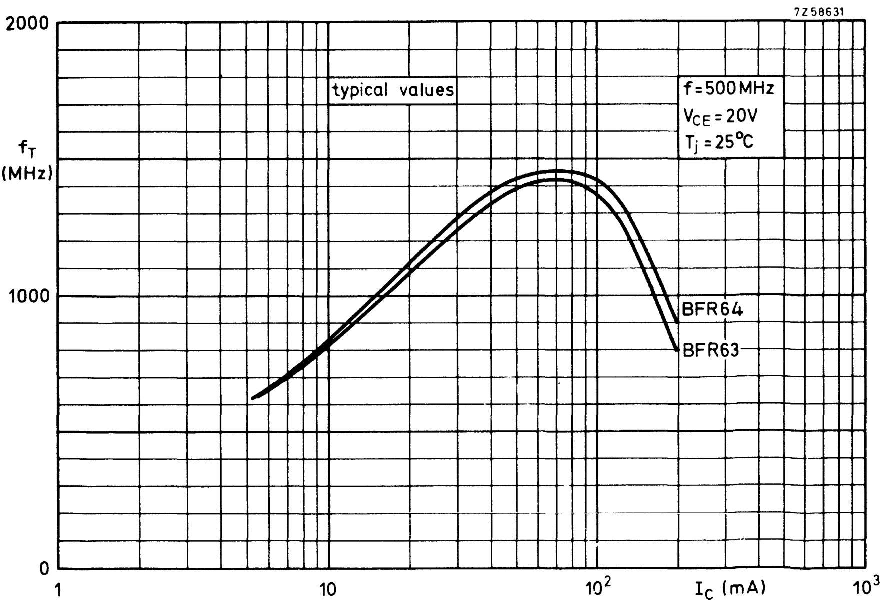
The output circuit is adjusted for minimum intermodulation if the input signal is as small as possible at P_o = 480 mW. With this adjusting method care must be taken, that the transistor is not destructed by second breakdown (the voltage swing may not exceed the rated V_{CER} value). Therefore as soon as clipping occurs, the increase of the input signal should be stopped until the clipping has been eliminated. After this adjustment has been made no further change may be made in the output circuit. Adjust the input circuit for maximum power gain and good band pass curve. The V.S.W.R. of the output is then ≤ 2 over the whole channel.

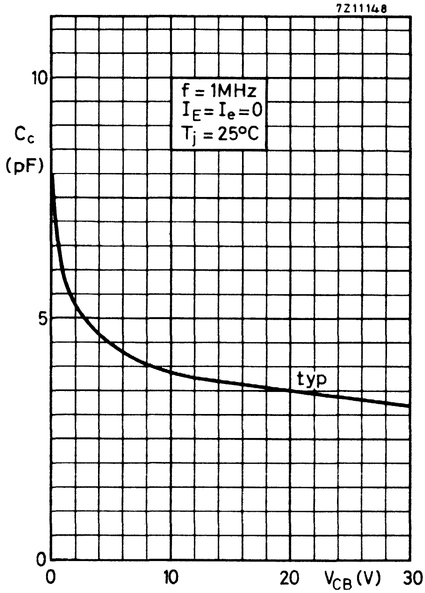


Safe Operating Area with the transistor forward biased

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 $R_{BE} < 10\ \Omega$ and $f > 1$ MHz


7Z11149
100
80
60
40
hFE
VCE = 5V
Tj = 25°C
typ
1
2
5
10
2
5
10^2
2
IC (mA)
10^3


7Z58631
2000
1000
0
fT
(MHz)
typical values
f = 500 MHz
VCE = 20V
Tj = 25°C
BFR64
BFR63
1
10
10^2
IC (mA)
10^3


7Z11148
f = 1MHz
$I_E = I_e = 0$
$T_j = 25°C$
C_c
(pF)
10
5
0
typ
0
10
20
V_{CB} (V)
30

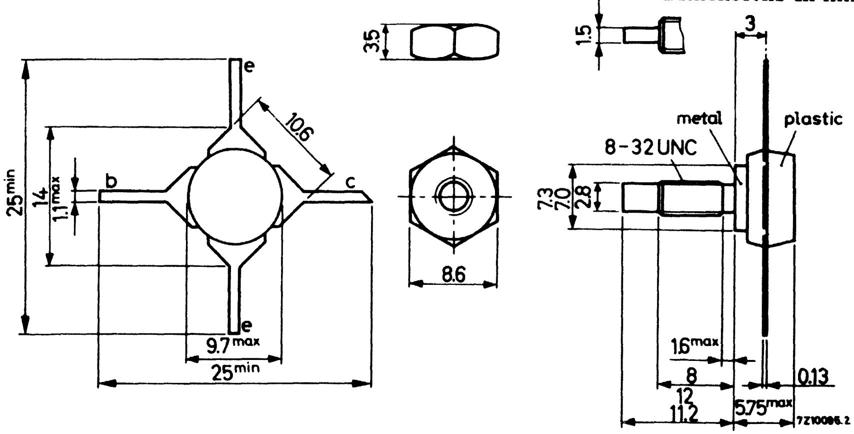
SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N multi-emitter silicon transistor in a capstan envelope. The transistor has extremely good intermodulation properties and high power gain.
The device is primarily intended for channel amplifiers in aerial amplifier systems as well as other applications where an excellent f_T linearity and higher signal handling capabilities than available in existing devices are required.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Collector current (peak value)	I_{CM}	max.	1000	mA
Junction temperature	T_j	max.	200	^oC
Thermal resistance from junction to mounting base	$R_{th\ j\text{-}mb}$	=	15	$^oC/W$
Transition frequency at f = 500 MHz I_C = 200 mA; V_{CE} = 20 V	f_T	>	1200	MHz
Output power at f = 200 MHz I_C = 200 mA; V_{CE} = 20 V; d_{im} = −30 dB	P_o	typ.	450	mW
Power gain at f = 200 MHz I_C = 200 mA; V_{CE} = 20 V	G_p	typ.	19	dB

MECHANICAL DATA

Dimensions in mm



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

Torque on nut: min. 7.5 kg cm (0.75 Newton metres)
max. 8.5 kg cm (0.85 Newton metres)

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

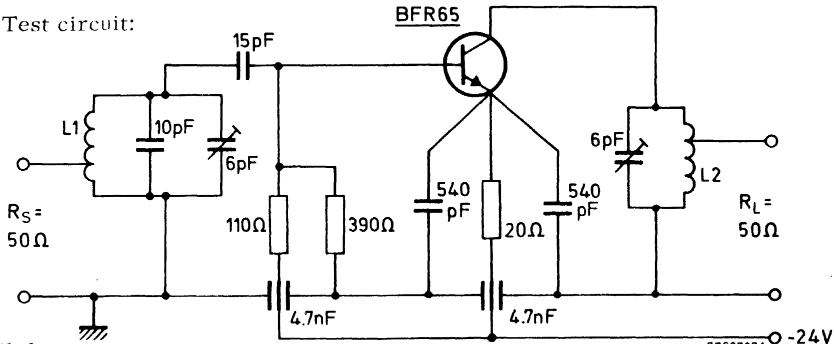
CHARACTERISTICS (continued)

Intermodulation characteristics

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

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

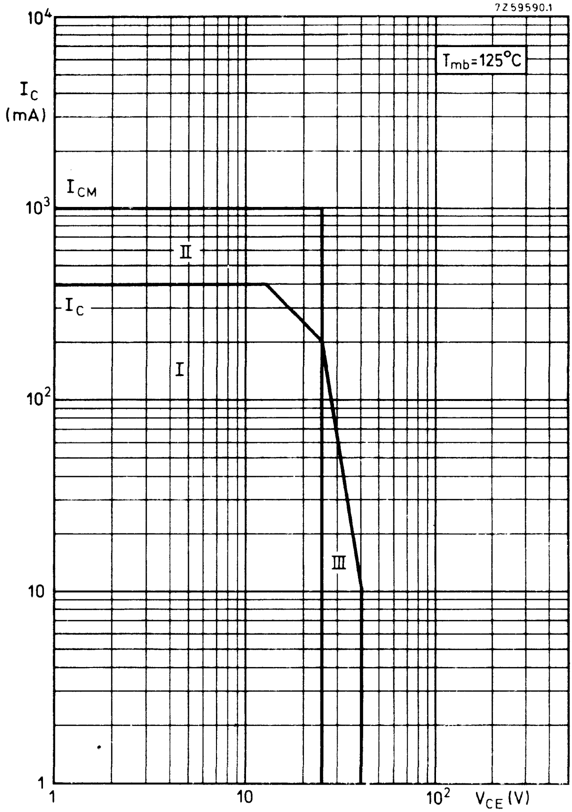
in which V_{CEK} is the high frequency knee voltage.

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.

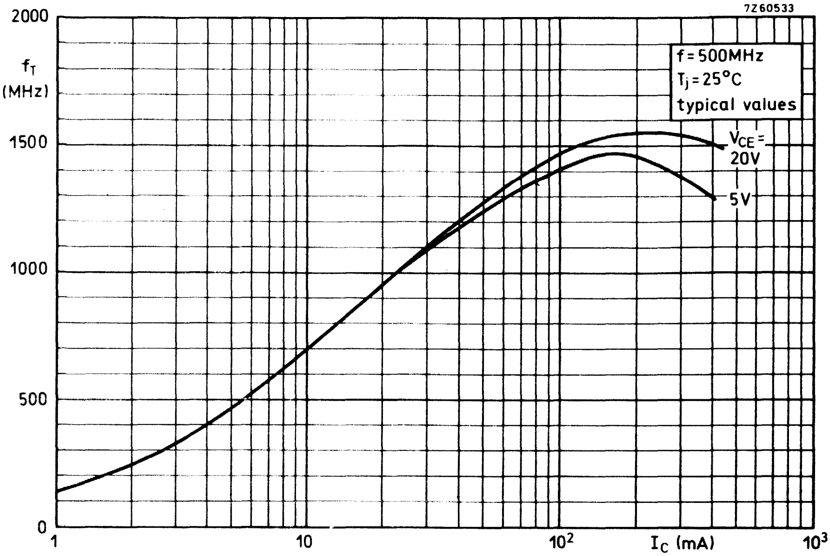


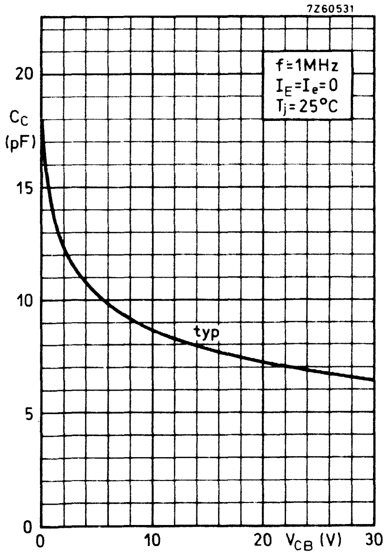
Safe Operating Area with the transistor forward biased

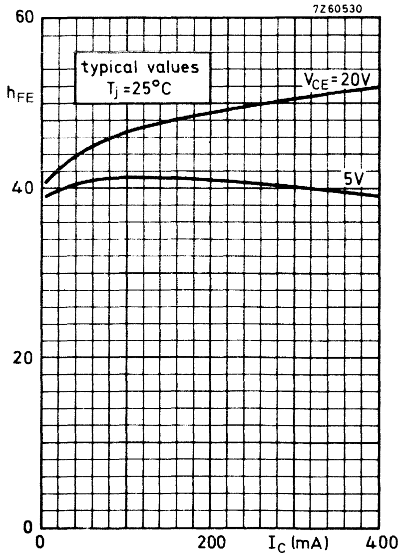
I Region of permissible d.c. operation

II Permissible extension for repetitive pulsed operation; $f > 1\,MHz$

III Repetitive pulsed operation in this region is allowable, provided $f > 1\,MHz$; $R_{BE} < 10\,\Omega$


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

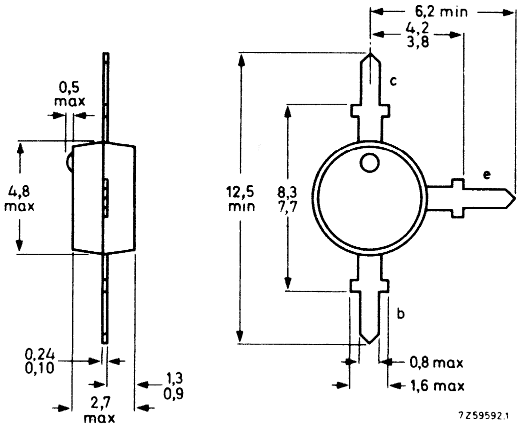
N-P-N transistor in a subminiature plastic transfermoulded T-package.
It is primarily intended for use in u.h.f. and microwave amplifiers such as in aerial amplifiers, radar systems, oscilloscopes, spectrum analysers etc.
The transistor features low intermodulation distortion and high power gain; thanks 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



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

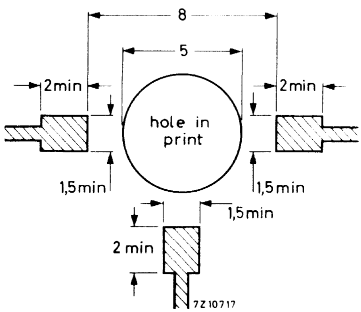
THERMAL RESISTANCE

From junction to ambient in free air

mounted on a glass-fibre print *)
of 40 mm x 25 mm x 1 mm — $R_{th\,j\text{-}a}$ = 0,5 °C/mW

*) Requirements for glas-fibre print

(dimensions in mm)



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

Collector cut-off current				
$I_E = 0$; $V_{CB} = 10\,V$	I_{CBO}	<	50	nA
D.C. current gain [1]				
$I_C = 14\,mA$; $V_{CE} = 10\,V$	h_{FE}	>	25	
		typ.	50	
Transition frequency at f = 500 MHz [1]				
$I_C = 14\,mA$; $V_{CE} = 10\,V$	f_T	typ.	5	GHz
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10\,V$	C_c	typ.	0,5	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 0{,}5\,V$	C_e	typ.	0,8	pF
Feedback capacitance at f = 1 MHz				
$I_C = 2\,mA$; $V_{CE} = 10\,V$; $T_{amb} = 25\,^oC$	C_{re}	typ.	0,4	pF
Noise figure at optimum source impedance				
$I_C = 2\,mA$; $V_{CE} = 10\,V$; f = 500 MHz; $T_{amb} = 25\,^oC$	F	typ.	2.4	dB

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

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

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

[1]) Measured under pulse conditions.

CHARACTERISTICS (continued)

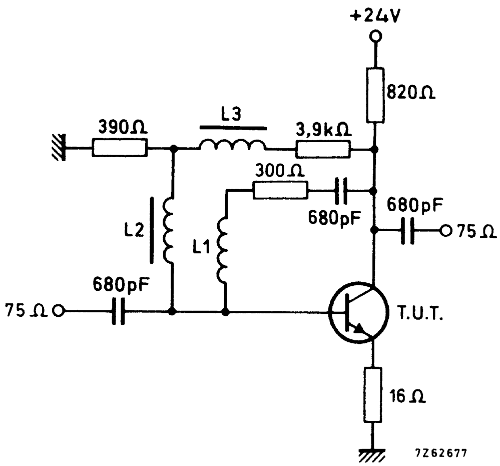
Intermodulation distortion at $T_{amb} = 25\,^oC$

$I_C = 14\,mA$; $V_{CE} = 10\,V$; $R_L = 75\,\Omega$; V.S.W.R. < 2

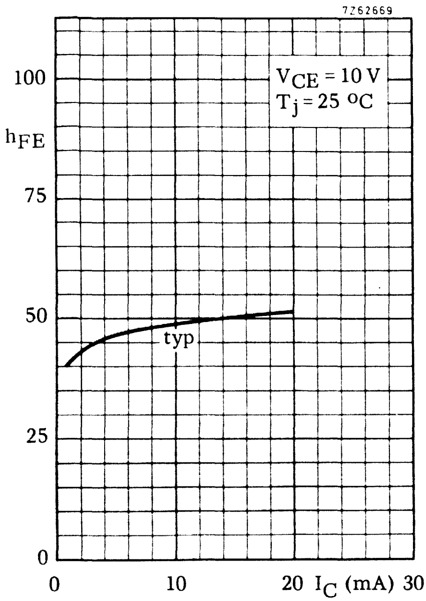
$V_p = V_o = 150\,mV$ at $f_p = 495,25\,MHz$
$V_q = V_o - 6\,dB$ at $f_q = 503,25\,MHz$
$V_r = V_o - 6\,dB$ at $f_r = 505,25\,MHz$

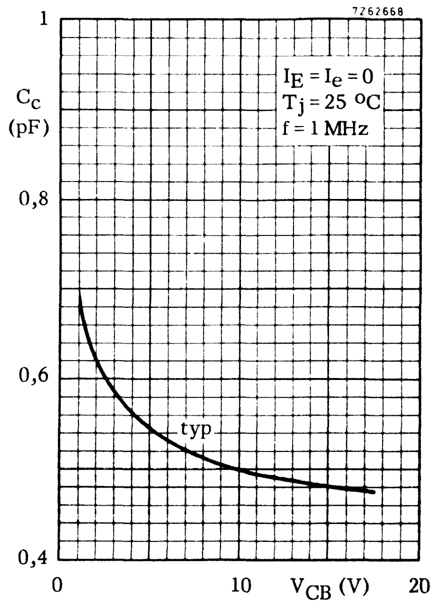
Measured at $f_{(p+q-r)} = 493,25\,MHz$ d_{im} typ. −60 dB

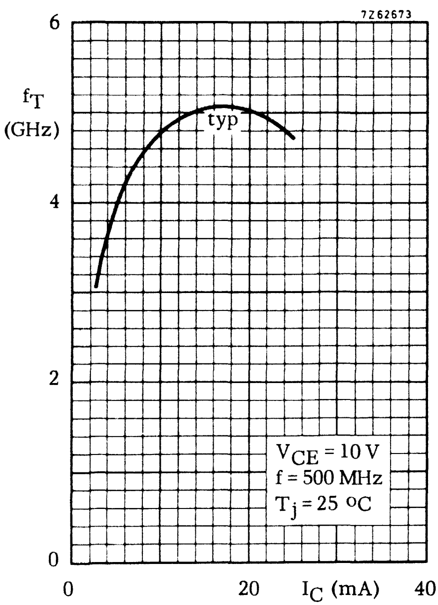
Intermodulation test circuit:

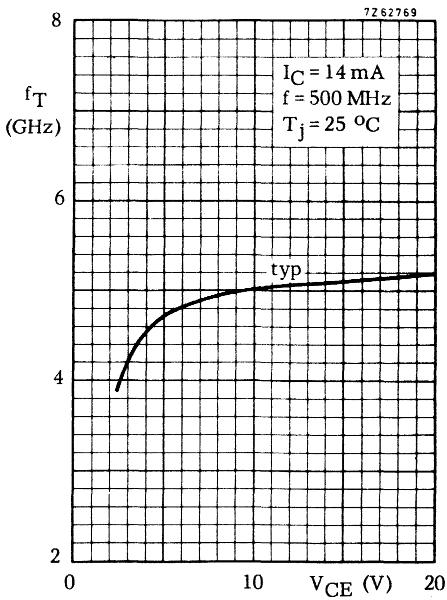


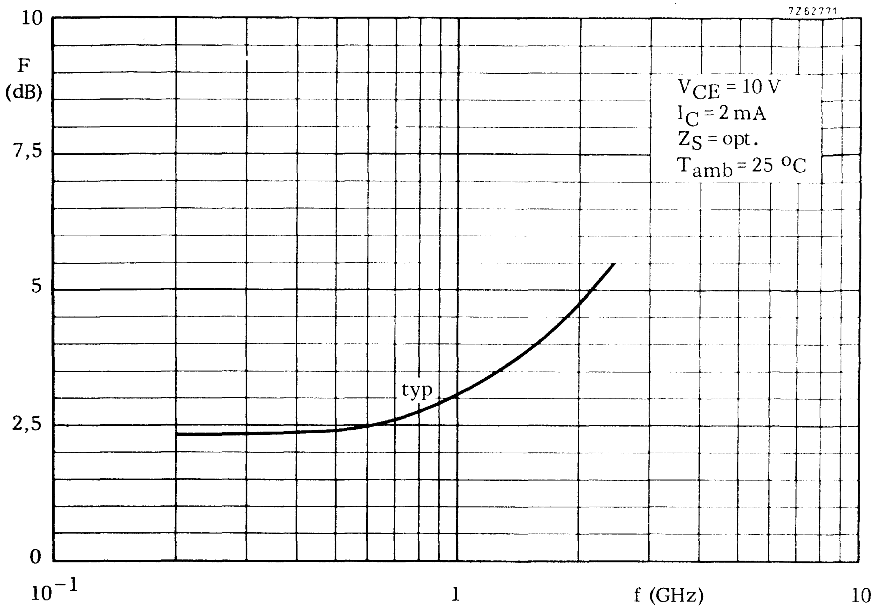
L1 = 4 turns Cu wire (0,35 mm); winding pitch 1 mm; int. diam. 4 mm
L2 and L3 5μH (code number: 3122 108 20150)

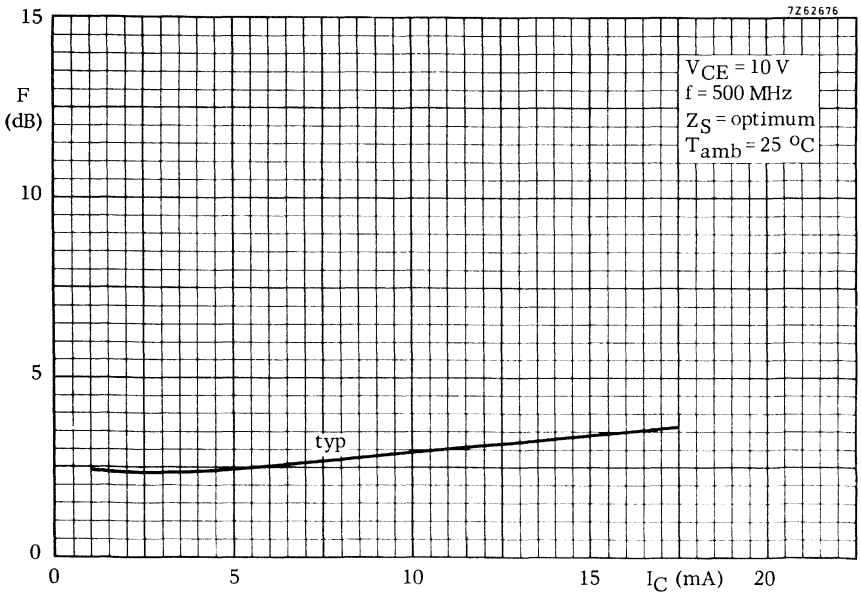

7Z62669
h_{FE}
100
75
50
25
0
V_{CE} = 10 V
T_j = 25 °C
typ
0
10
20
I_C (mA)
30

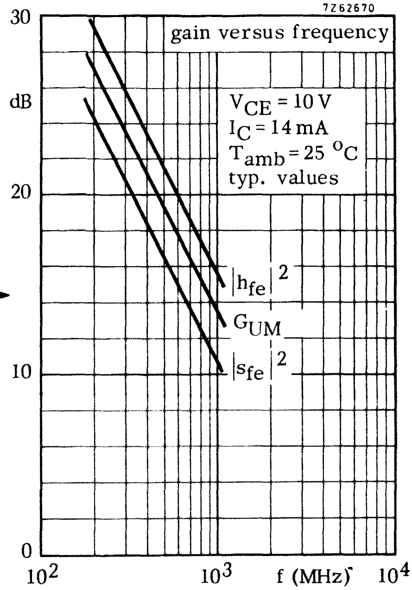

7Z62668
C_c
(pF)
1
0,8
0,6
0,4
I_E = I_e = 0
T_j = 25 °C
f = 1 MHz
typ
0
10
V_{CB} (V)
20


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

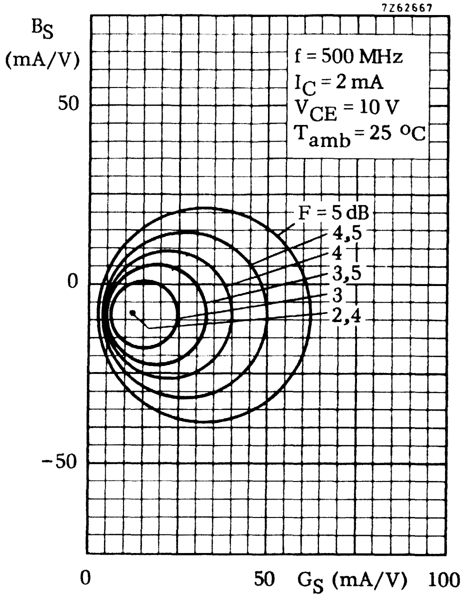

7Z62769
f_T
(GHz)
8
6
4
2
I_C = 14 mA
f = 500 MHz
T_j = 25 °C
typ
0
10
V_{CE} (V)
20


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

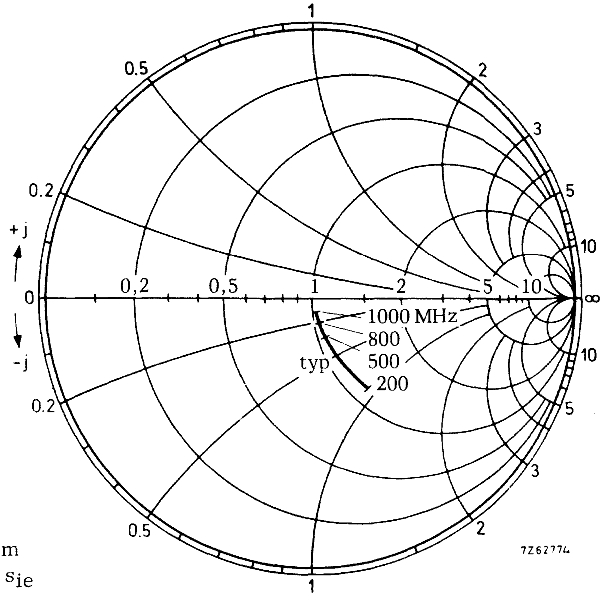

7Z62676
15
F
(dB)
10
5
0
V_{CE} = 10 V
f = 500 MHz
Z_S = optimum
T_{amb} = 25 °C
typ
0
5
10
15
I_C (mA)
20



circles of constant noise figure

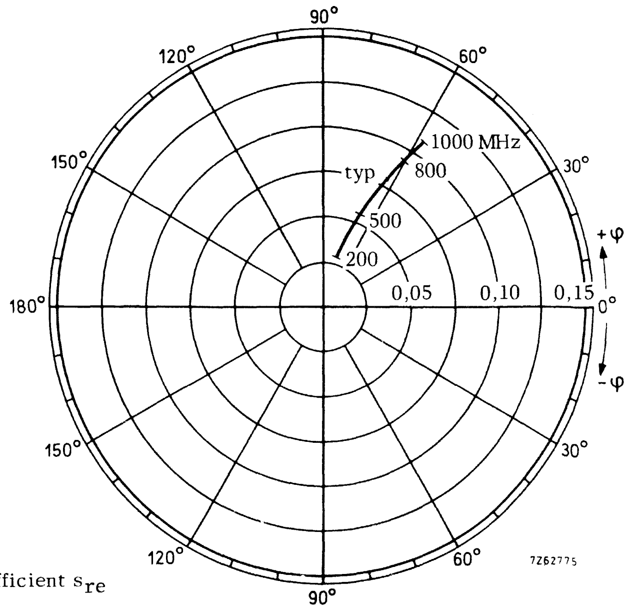


V_{CE} = 10 V
I_C = 14 mA
T_{amb} = 25 °C



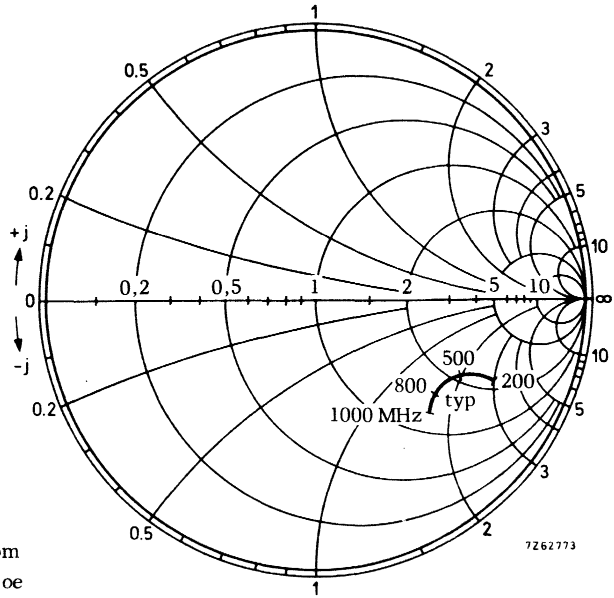
Input impedance derived from input reflection coefficient s_{ie} coordinates in ohm x 50

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



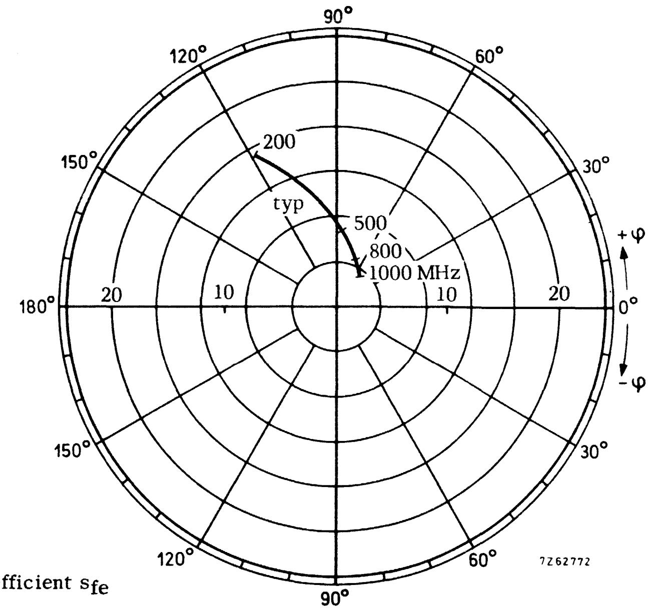
→ Reverse transmission coefficient s_{re}

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

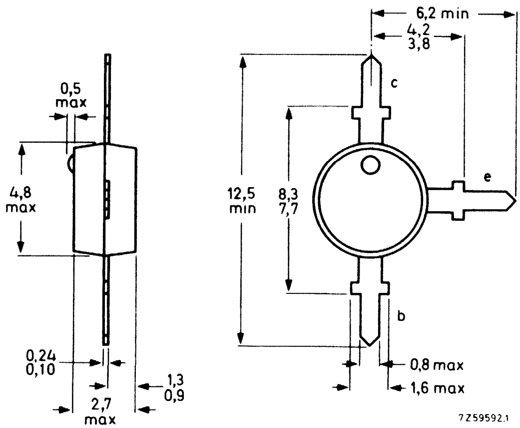
N-P-N transistor in a subminiature plastic transfermoulded T-package.
It is primarily intended for use in u.h.f. and microwave amplifiers such as in aerial amplifiers, radar systems, oscilloscopes, spectrum analysers etc.
The transistor features very low intermodulation distortion and high power gain; 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

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

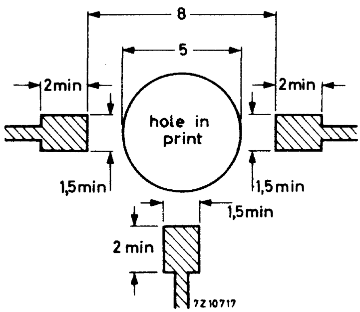
THERMAL RESISTANCE

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)

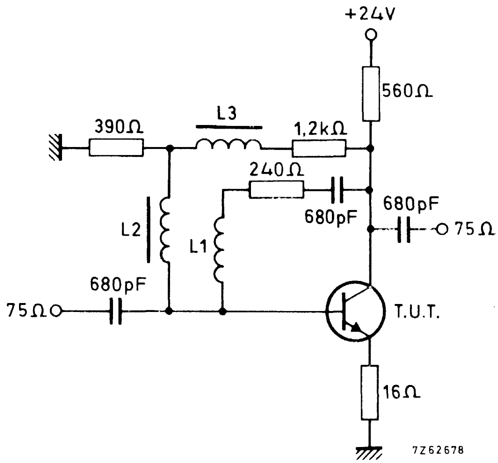
Intermodulation distortion at T_{amb} = 25 °C

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

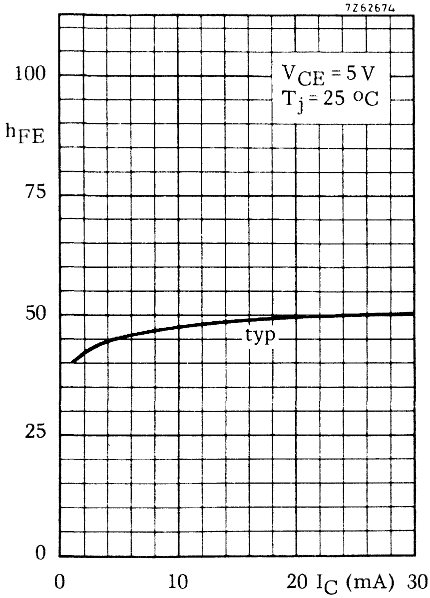
$V_p = V_o$ = 300 mV at f_p = 495,25 MHz
$V_q = V_o$ −6 dB at f_q = 503,25 MHz
$V_r = V_o$ −6 dB at f_r = 505,25 MHz

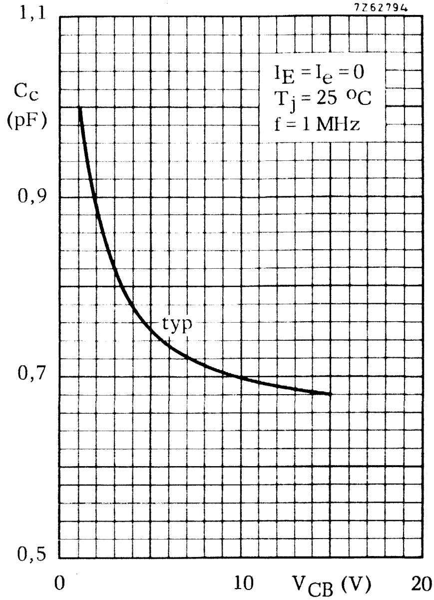
Measured at $f_{(p+q-r)}$ = 493,25 MHz d_{im} typ. −60 dB

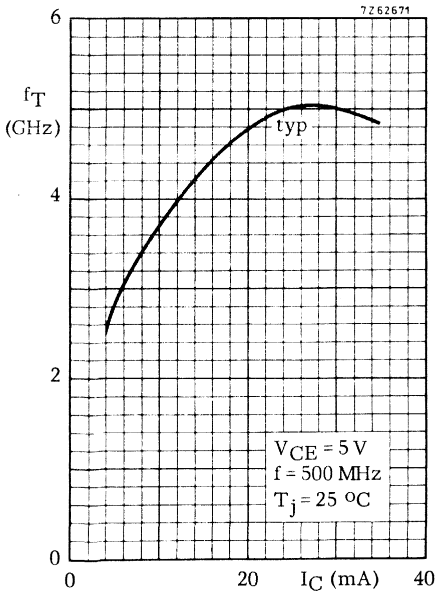
Intermodulation test circuit:

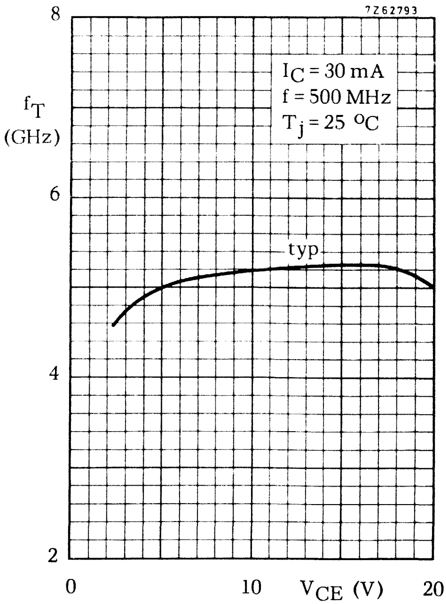


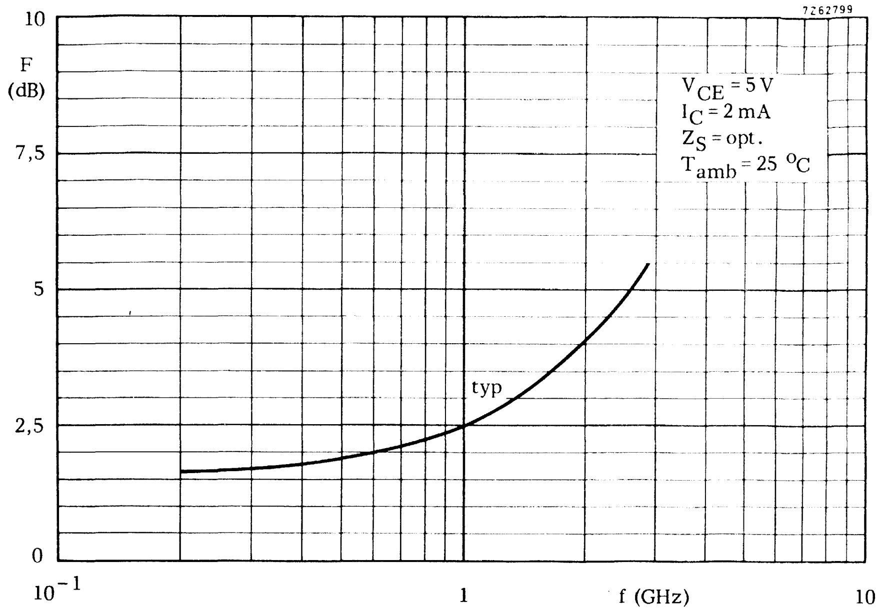
L1 = 4 turns Cu wire (0,35); winding pitch 1 mm; int. diam. 4 mm
L2 and L3 5 μH (code number: 3122 108 20150)

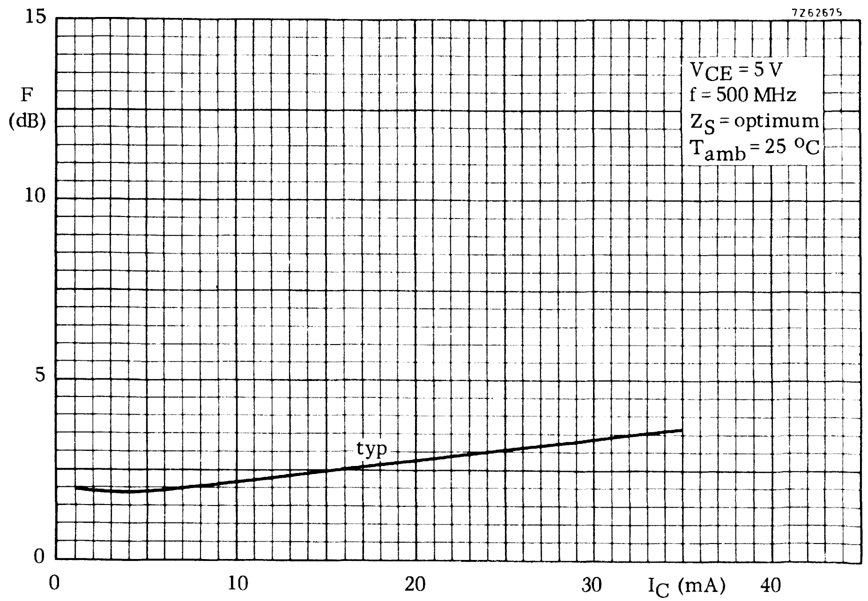

7Z62674
hFE
100
75
50
25
0
VCE = 5 V
Tj = 25 oC
typ
0
10
20
IC (mA)
30

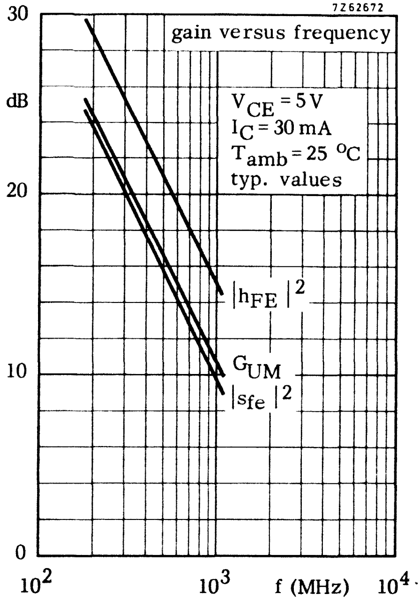

7Z62794
Cc
(pF)
1,1
0,9
0,7
0,5
IE = Ie = 0
Tj = 25 oC
f = 1 MHz
typ
0
10
VCB (V)
20


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

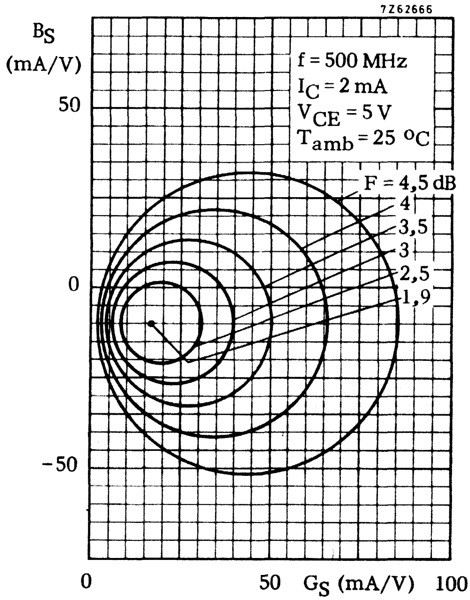

7Z62793
fT
(GHz)
8
6
4
2
IC = 30 mA
f = 500 MHz
Tj = 25 oC
typ
0
10
VCE (V)
20


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

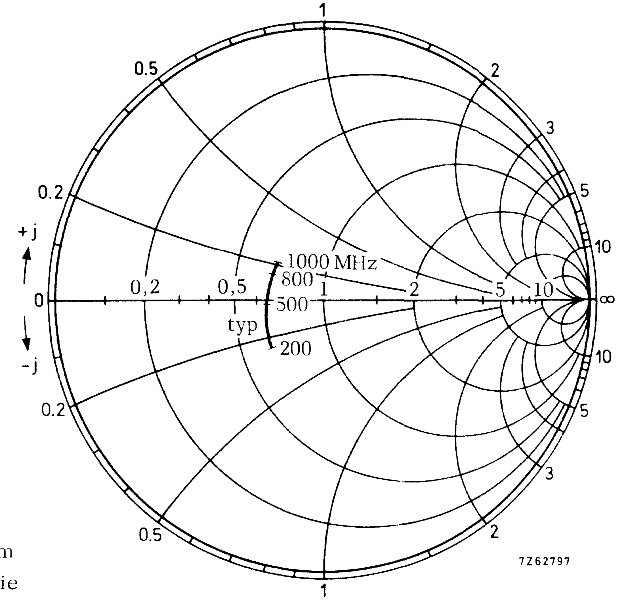

7Z62675
15
F
(dB)
10
5
0
$V_{CE} = 5$ V
f = 500 MHz
Z_S = optimum
$T_{amb} = 25$ °C
typ
0
10
20
30
I_C (mA)
40



circles of constant noise figure

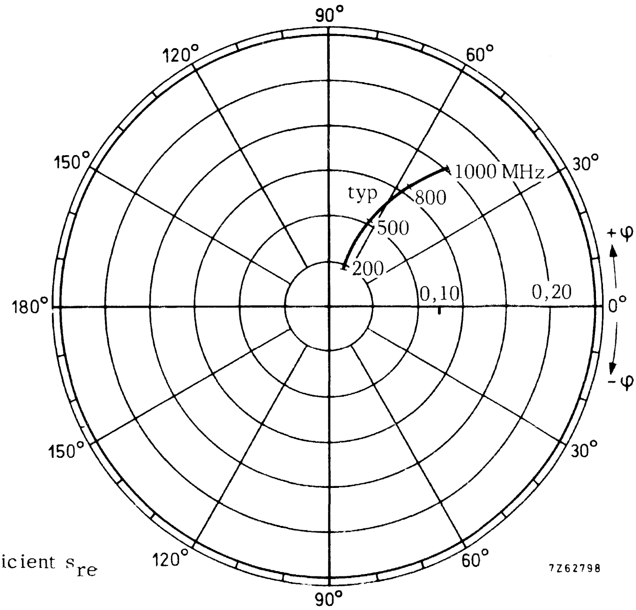


V_{CE} = 5 V
I_C = 30 mA
T_{amb} = 25 °C



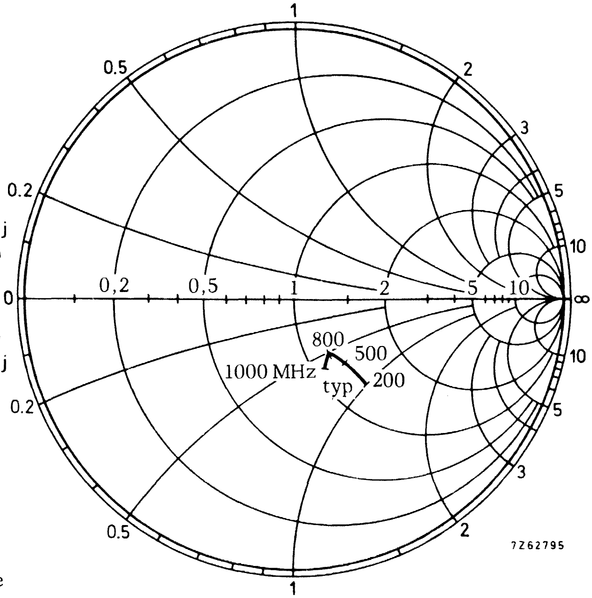
Input impedance derived from input reflection coefficient s_{ie} coordinates in ohm x 50

V_{CE} = 5 V
I_C = 30 mA
T_{amb} = 25 °C



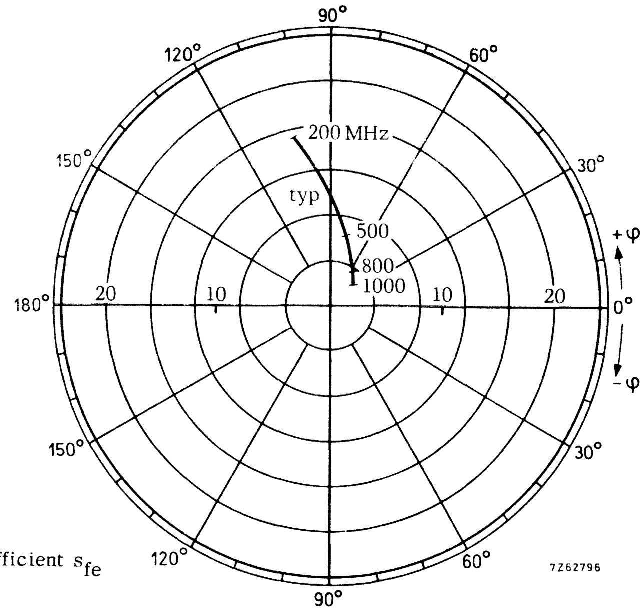
→ Reverse transmission coefficient s_{re}

$V_{CE} = 5$ V
$I_C = 30$ mA
$T_{amb} = 25$ °C



Output impedance derived from output reflection coefficient s_{oe} coordinates in ohm x 50

$V_{CE} = 5$ V
$I_C = 30$ mA
$T_{amb} = 25$ °C



Forward transmission coefficient s_{fe}

SILICON EPITAXIAL PLANAR TRANSISTORS

P-N-P transistors in a TO-39 metal envelope with the collector connected to the case. These transistors are intended for general industrial applications.

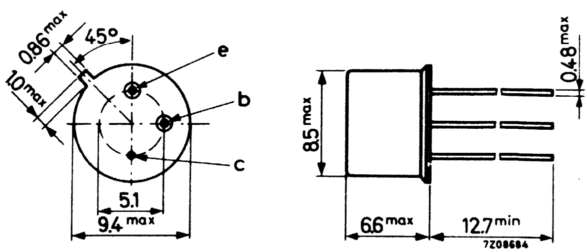
QUICK REFERENCE DATA

			BFS 92	BFS 93	BFS 94	BFS 95	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	100	100	80	40	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	60	40	35	V
Collector current (d. c.)	$-I_C$	max.	1.0	1.0	1.0	1.0	A
Total power dissipation up to T_{mb} = 50 °C	P_{tot}	max.	5	5	5	5	W
Junction temperature	T_j	max.	200	200	200	200	°C
Collector-emitter saturation voltage $-I_C$ = 500 mA; $-I_B$ = 50 mA	$-V_{CEsat}$	<	1.0	1.0	0.7	0.7	V
D. C. current gain $-I_C$ = 150 mA; $-V_{CE}$ = 10 V	h_{FE}	>	30	70	40	70	
Transition frequency at f = 35 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 10 V	f_T	typ.	70	70	70	70	MHz

MECHANICAL DATA

Dimensions in mm

TO-39
Collector connected to case



max. lead diameter is guaranteed only for 12.7 mm.

Accessories supplied on request: 56218, 56245, 56265.

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

Voltages

			BFS 92	BFS 93	BFS 94	BFS 95	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	100	100	80	40	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	60	60	40	35	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	6	6	6	6	V

Currents

Collector current (d.c.)	$-I_C$	max.	1.0	A
Collector current (peak value)	$-I_{CM}$	max.	1.0	A
Emitter current (d.c.)	I_E	max.	1.0	A
Emitter current (peak value)	I_{EM}	max.	1.0	A
Reverse base current (peak value)	$+I_{BM}$	max.	100	mA

Power dissipation

Total power dissipation up to T_{mb} = 50 °C See page 6	P_{tot}	max.	5	W

Temperatures

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

THERMAL RESISTANCE

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

Collector cut-off current

$I_E = 0$; $-V_{CB} = 80$ V; $T_j = 25$ °C	BFS92; BFS93	$-I_{CBO}$	<	50	nA
$T_j = 100$ °C		$-I_{CBO}$	<	2.5	μA
$I_E = 0$; $-V_{CB} = 60$ V; $T_j = 25$ °C	BFS94	$-I_{CBO}$	<	50	nA
$T_j = 100$ °C		$-I_{CBO}$	<	2.5	μA
$I_E = 0$; $-V_{CB} = 30$ V; $T_j = 25$ °C	BFS95	$-I_{CBO}$	<	50	nA
$T_j = 100$ °C		$-I_{CBO}$	<	2.5	μA

Emitter cut-off current

$I_C = 0$; $-V_{EB} = 5$ V; $T_j = 25$ °C	$-I_{EBO}$	<	50	nA
$T_j = 100$ °C	$-I_{EBO}$	<	2.5	μA

Saturation voltages			BFS92	BFS93	BFS94	BFS95	
$-I_C = 10$ mA; $-I_B = 1$ mA	$-V_{CEsat}$	<	0.15	0.15	0.10	0.10	V
	$-V_{BEsat}$	<	1.2	1.2	1.2	1.2	V
$-I_C = 150$ mA; $-I_B = 15$ mA	$-V_{CEsat}$	<	0.35	0.35	0.20	0.20	V
	$-V_{BEsat}$	<	1.3	1.3	1.3	1.3	V
$-I_C = 500$ mA; $-I_B = 50$ mA	$-V_{CEsat}$	<	1.00	1.00	0.70	0.70	V
	$-V_{BEsat}$	<	1.5	1.5	1.5	1.5	V
$-I_C = 1$ A; $-I_B = 100$ mA	$-V_{CEsat}$	<	2.00	1.60	1.00	1.00	V
	$-V_{BEsat}$	<	2.0	2.0	2.0	2.0	V
D.C. current gain							
$-I_C = 10$ mA; $-V_{CE} = 10$ V	h_{FE}	>	20	50	30	50	
$-I_C = 150$ mA; $-V_{CE} = 10$ V	h_{FE}	>	30	70	40	70	
$-I_C = 500$ mA; $-V_{CE} = 10$ V	h_{FE}	>	20	30	25	30	
$-I_C = 1$ A; $-V_{CE} = 10$ V	h_{FE}	>	15	15	15	15	

Collector capacitance at f = 1 MHz

$I_E = I_e = 0$; $-V_{CB} = 10$ V	C_c	<	20	pF

Transition frequency at f = 35 MHz

$-I_C = 50$ mA; $-V_{CE} = 10$ V	f_T	>	40	MHz
		typ.	70	MHz

CHARACTERISTICS (continued)

h parameters at f = 1 kHz

$-I_C = 10$ mA; $-V_{CE} = 5$ V

Input impedance	h_{ie}	typ.	300	Ω
Reverse voltage transfer ratio	h_{re}	typ.	70	10^{-6}
Small signal current gain	h_{fe}	typ.	100	
Output admittance	h_{oe}	typ.	60	$\mu\Omega^{-1}$

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

Small signal current gain	h_{fe}	typ.	90	

Switching times (see also page 5)

Turn on time

$-I_C = 150$ mA; $-I_B = +I_{BM} = 15$ mA

delay time	t_d	typ.	20	ns
rise time	t_r	typ.	35	ns

Turn off time

$-I_C = 150$ mA; $-I_B = +I_{BM} = 15$ mA

storage time	t_s	typ.	500	ns
fall time	t_f	typ.	65	ns

MEASUREMENT OF SWITCHING TIMES

Fig. 1: Circuit diagram

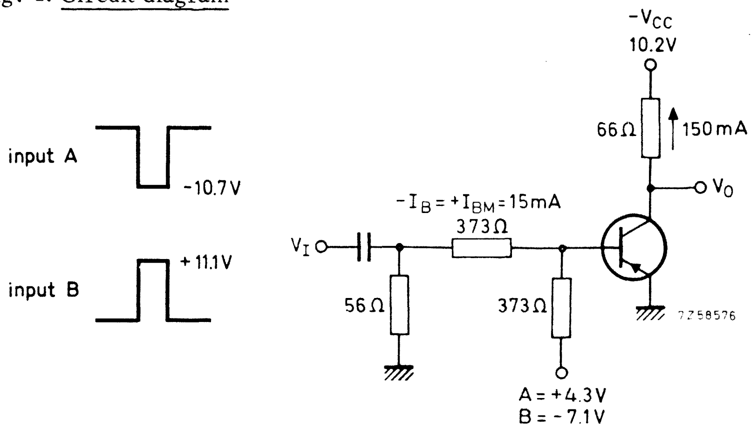
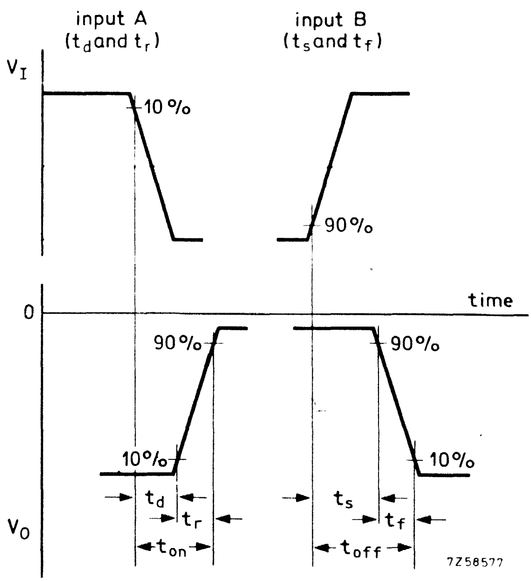
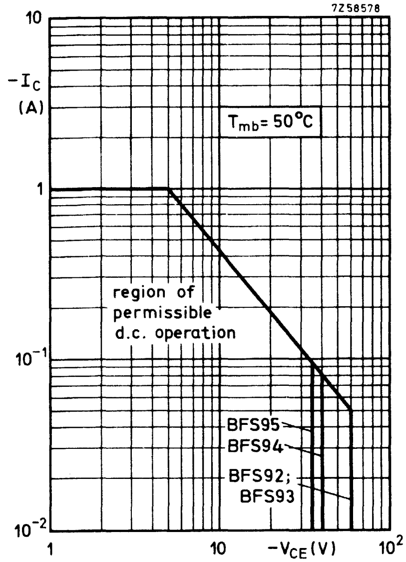


Fig. 2: Waveforms

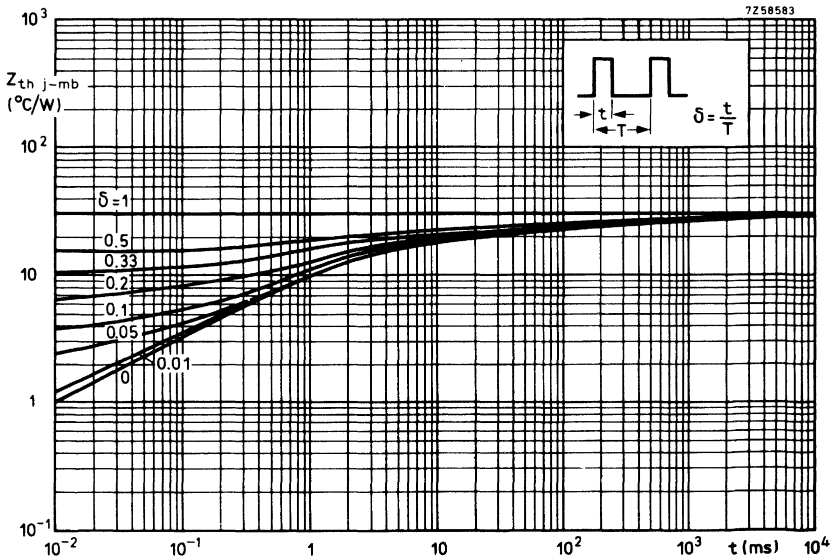


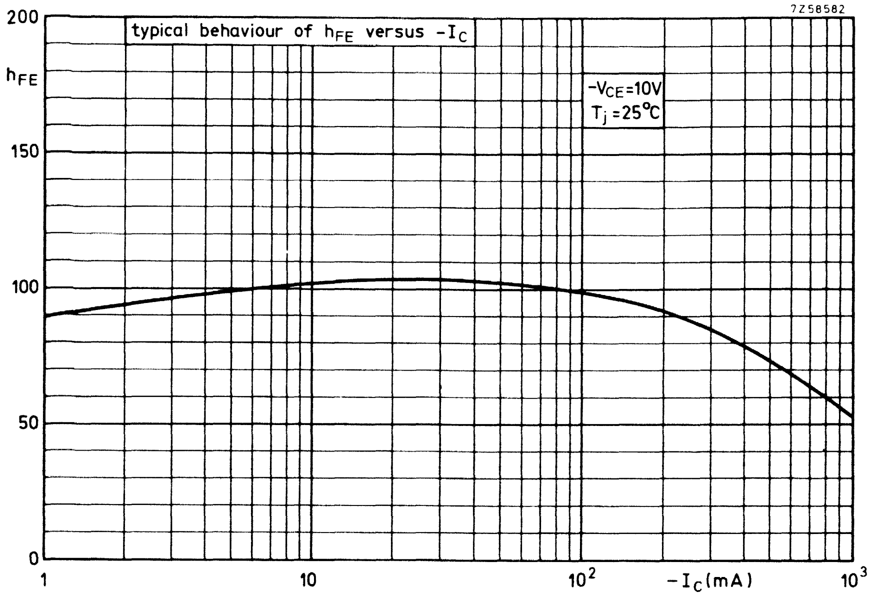
Equipment: Pulse generator (rise time = 1 ns)
Double beam or dual trace oscilloscope (rise time < 5 ns)

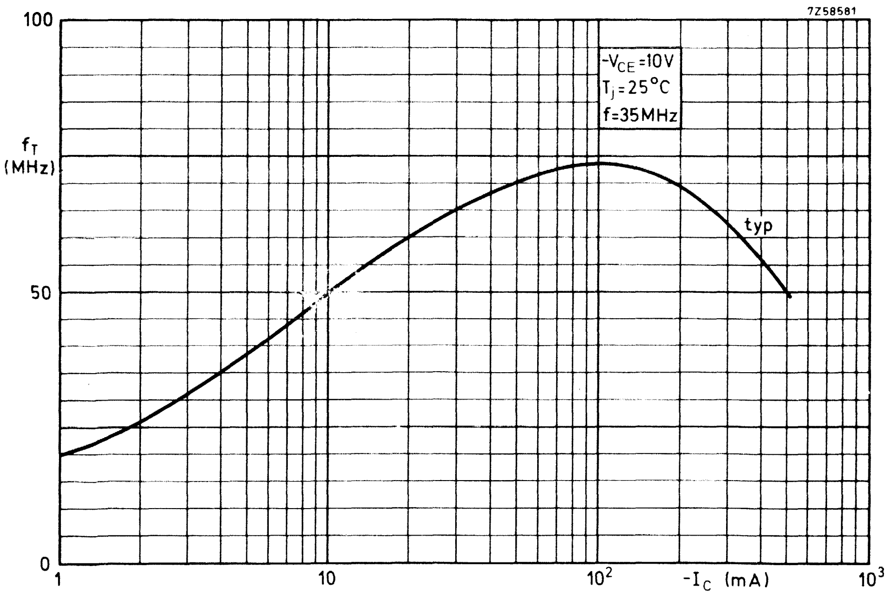


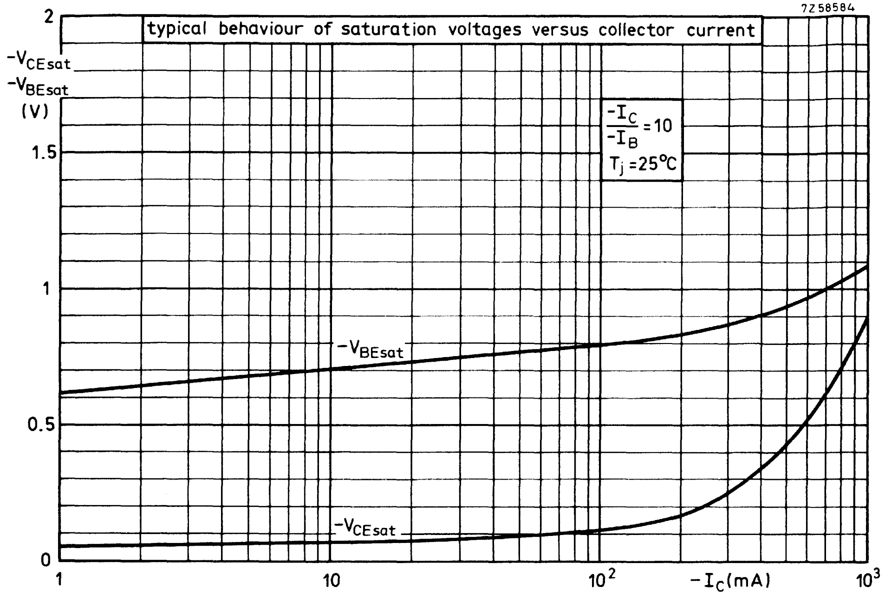
Safe Operating Area

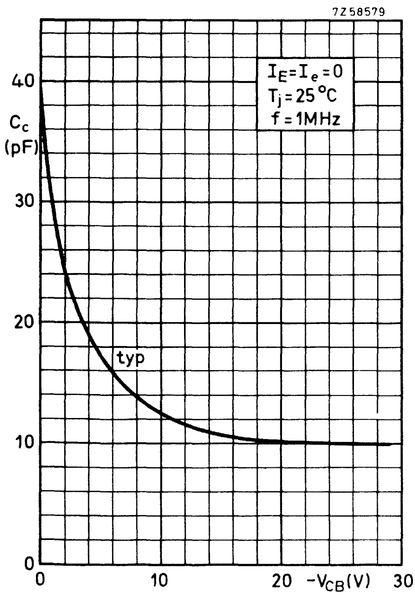
with the transistor forward biased

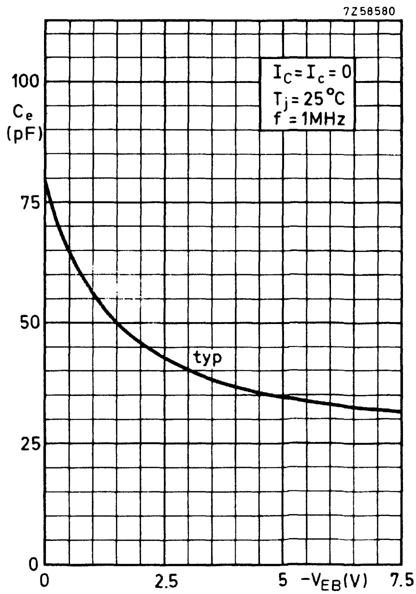



7Z58582
typical behaviour of h_{FE} versus $-I_C$
h_{FE}
200
150
100
50
0
$-V_{CE}$=10V
T_j=25°C
1
10
10^2
$-I_C$(mA)
10^3


7Z58581
f_T
(MHz)
100
50
0
$-V_{CE}$=10V
T_j=25°C
f=35MHz
typ
1
10
10^2
$-I_C$ (mA)
10^3


7Z58584
typical behaviour of saturation voltages versus collector current
$-V_{CEsat}$
$-V_{BEsat}$
(V)
2
1.5
1
0.5
0
$\frac{-I_C}{-I_B} = 10$
$T_j = 25°C$
$-V_{BEsat}$
$-V_{CEsat}$
1
10
10^2
$-I_C$(mA)
10^3


7Z58579
$I_E = I_e = 0$
$T_j = 25°C$
f = 1MHz
C_c
(pF)
40
30
20
10
0
typ
0
10
20
$-V_{CB}$(V)
30


7Z58580
$I_C = I_c = 0$
$T_j = 25°C$
f = 1MHz
C_e
(pF)
100
75
50
25
0
typ
0
2.5
5
$-V_{EB}$(V)
7.5

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N multi-emitter transistor in a TO-39 metal envelope, with the collector connected to the case. The transistor has extreme good intermodulation properties and a high power gain. It is a ruggedized version of the BFW16, which it succeeds. It is primarily intended for:

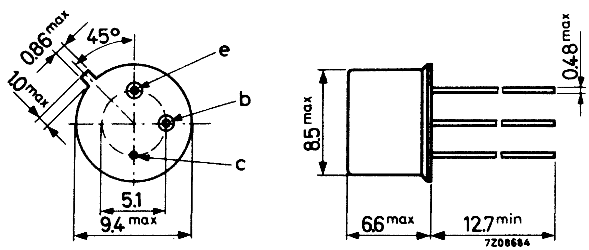
- Final and driver stages of channel- and band aerial amplifiers with high output power for band I, II, III and IV/V (40-860 MHz).
- Final stage of the wide band vertical amplifier in high speed oscilloscopes.

QUICK REFERENCE DATA					
Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.		40	V
Collector-emitter voltage (open base)	V_{CEO}	max.		25	V
Collector current (peak value; f > 1 MHz)	I_{CM}	max.		300	mA
Total power dissipation up to T_{mb} = 125 °C	P_{tot}	max.		1.5	W
Junction temperature	T_j	max.		200	°C
Feedback capacitance at f = 1 MHz I_C = 10 mA; V_{CE} = 15 V	$-C_{re}$	typ.		1.7	pF
Transition frequency I_C = 150 mA; V_{CE} = 15 V; f = 500 MHz	f_T	typ.		1.2	GHz
		f =	200	800	MHz
Power gain (not neutralized) I_C = 70 mA; V_{CE} = 18 V	G_p	typ.	16	6.5	dB
Output power d_{im} = −30 dB; V.S.W.R. at output <2 I_C = 70 mA; V_{CE} = 18 V	P_o	typ.	150	90	mW

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-39



Accessories available: 56218; 56245; 56265

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

Voltages

Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	40	V
Collector-emitter voltage ($R_{BE} \leq 50\ \Omega$) peak value	V_{CERM}	max.	40	V [1]
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V [1]
Emitter-base voltage (open collector)	V_{EBO}	max.	2	V

Currents

Collector current (d.c.)	I_C	max.	150	mA
Collector current (peak value; f > 1 MHz)	I_{CM}	max.	300	mA

Power dissipation

Total power dissipation up to T_{mb} = 125 °C	P_{tot}	max.	1.5	W

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	250	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	50	°C/W
From mounting base to heatsink mounted with top clamping washer of 56218 and a boron nitride washer for electrical insulation	$R_{th\ mb\text{-}h}$	=	1.2	°C/W

[1] I_C = 10 mA.

CHARACTERISTICS

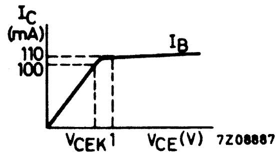
T_j = 25 °C unless otherwise specified

Collector cut-off current

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

Knee voltage

$I_C = 100$ mA; I_B = value for which $I_C = 110$ mA at $V_{CE} = 1$ V	V_{CEK}	<	0.75	V



D.C. current gain

$I_C = 50$ mA; $V_{CE} = 5$ V	h_{FE}	>	25	
$I_C = 150$ mA; $V_{CE} = 5$ V	h_{FE}	>	25	

Transition frequency

$I_C = 150$ mA; $V_{CE} = 15$ V; f = 500 MHz	f_T	typ.	1.2	GHz

Collector capacitance at f = 1 MHz

$I_E = I_e = 0$; $V_{CB} = 15$ V	C_c	<	4	pF

Feedback capacitance at f = 1 MHz

$I_C = 10$ mA; $V_{CE} = 15$ V; $T_{amb} = 25$ °C	$-C_{re}$	typ.	1.7	pF

Noise figure at f = 200 MHz

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

Power gain (not neutralized)

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

CHARACTERISTICS (continued)

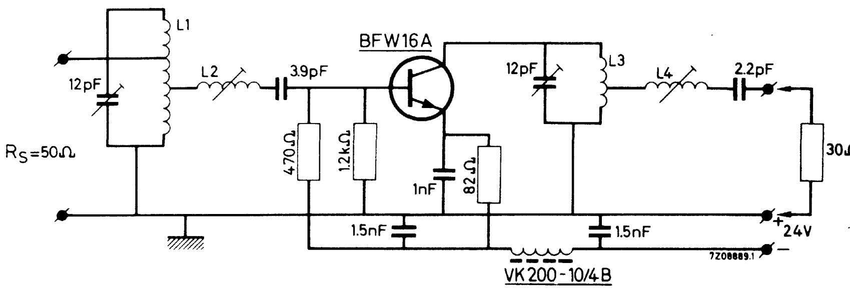
Intermodulation characteristics

1. Output power at f = 200 MHz; T_{amb} = 25 °C

I_C = 70 mA; V_{CE} = 18 V; V.S.W.R. at output < 2
f_p = 202 MHz; f_q = 205 MHz; d_{im} = −30 dB
measured at $f_{(2q-p)}$ = 208 MHz (Channel 9)

P_o	>	130	mW
	typ.	150	mW

Test circuit:



Coil data:

L1 = 3 turns silver plated Cu wire (1.4 mm); winding pitch 2.7 mm; int. diam. 8 mm; taps at 0.5 turn and 1.5 turns from earth.
L2 = 5.5 turns silver plated Cu wire (1.4 mm); winding pitch 2.2 mm; int. diam. 8 mm.
L3 = 3 turns silver plated Cu wire (1.4 mm); winding pitch 3.3 mm; int. diam. 8 mm.
L4 = 5.5 turns silver plated Cu wire (1.4 mm); winding pitch 2.2 mm; int. diam. 11 mm.

CHARACTERISTICS (continued)

Basis of adjustment

The intermodulation at an intermodulation distortion of −30 dB is caused by h.f. output current - voltage clipping.
The maximum undistorted output power is realised, if

a. Current and voltage clipping take place concurrently.
   This occurs if

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

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

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

For maximum output power at an intermodulation distortion of −30 dB, the (experimentally found) values of R_L and C_L are:
$R_L = 220\ \Omega$; $C_L = -5.6$ pF.

C_{oe} is found by 4 pF of the transistor and 1.6 pF by the mounting system concerning of a borium nitride washer between the envelope of the transistor and the chassis. See also page 10, note 1.

Adjustment procedure

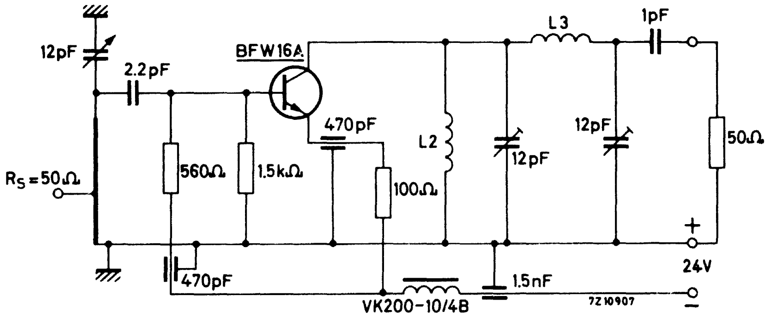
1. Remove the transistor and connect a dummy consisting of a 220 Ω resistor in parallel with a 5.6 pF capacitor between the collector and emitter connections of the output circuit.
2. Tune and match the output circuit for zero reflection at 205 MHz (V.S.W.R. = 1). After this adjustment, no further change may be made in the output circuit.
3. Replace the dummy by the transistor. Tune and match the input circuit for maximum power gain and good band pass curve.
   The V.S.W.R. of the output will then, in most cases, be ≤ 2 over the whole channel.
   Corrections can be made by tuning L2; this will not disturb the band pass curve.

CHARACTERISTICS (continued)

Intermodulation characteristics

2. Output power at f = 800 MHz; T_{amb} = 25 °C
   I_C = 70 mA; V_{CE} = 18 V; V.S.W.R. at output < 2
   f_p = 798 MHz; f_q = 802 MHz; d_{im} = −30 dB
   measured at $f_{(2q-p)}$ = 806 MHz (Channel 62) — P_o > 70 mW; typ. 90 mW

   Test circuit:



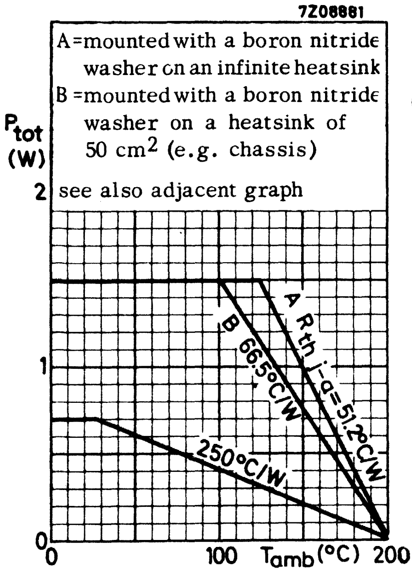
   Coil data:
   L1 = 25 mm x 7 mm x 0.85 mm silver plated Cu strip
   Tap of the input at 5 mm from earth.
   L2 = 13 turns enamelled Cu wire (0.6 mm); int. diam. 8 mm
   L3 = 1.5 turns Cu wire (1.3 mm); int. diam. 8 mm

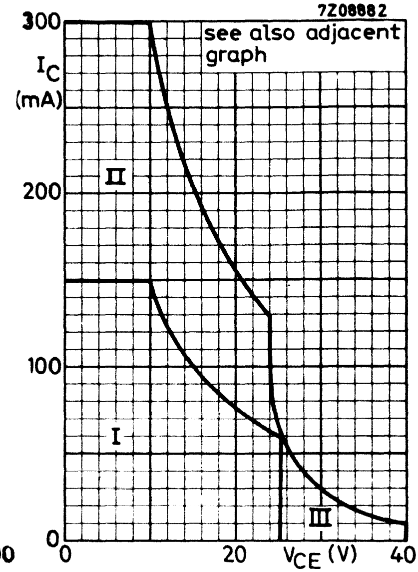
Basis of adjustment

At 800 MHz no dummy can be used to adjust for optimum collector load because at these frequencies the impedance transformations of a dummy are too high. A small signal at the mid-channel frequency of 802 MHz is fed to the input and increased until clipping occurs; that is, until the output power no longer increases 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.

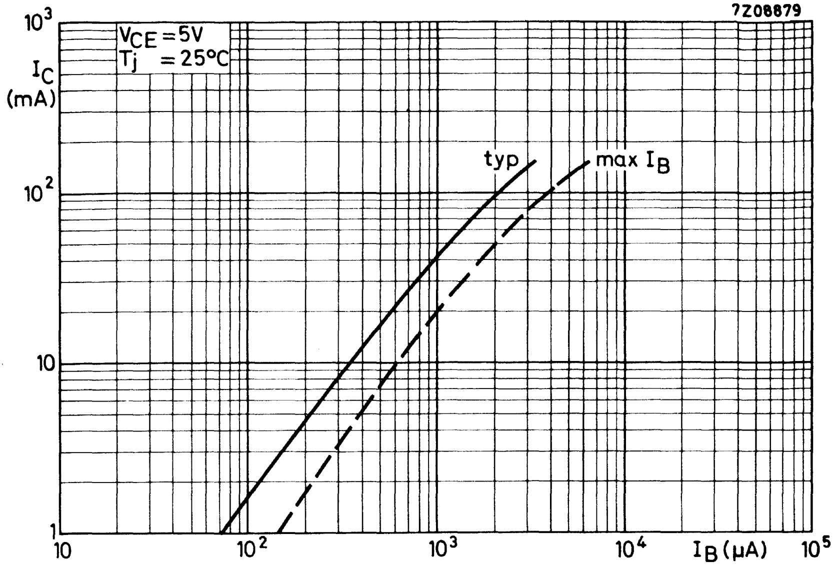


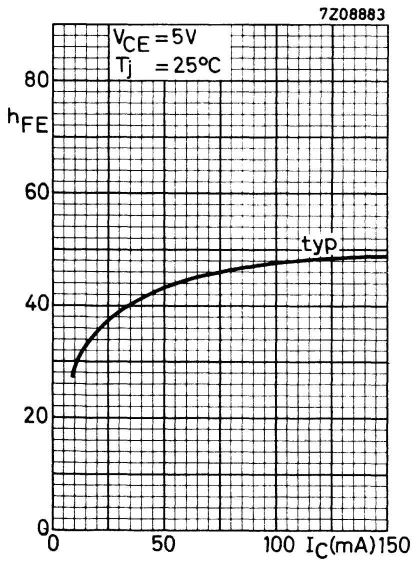


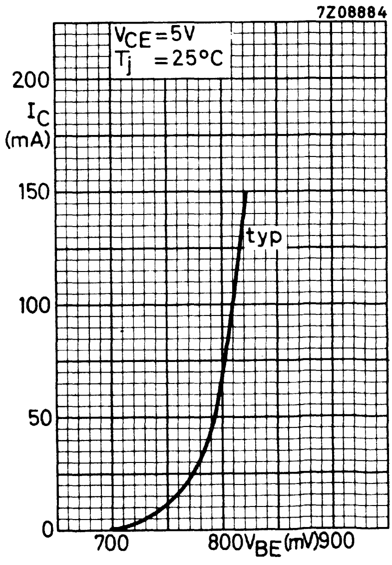
I = Region of permissible operation under all base-emitter conditions and at all frequencies, including d.c.

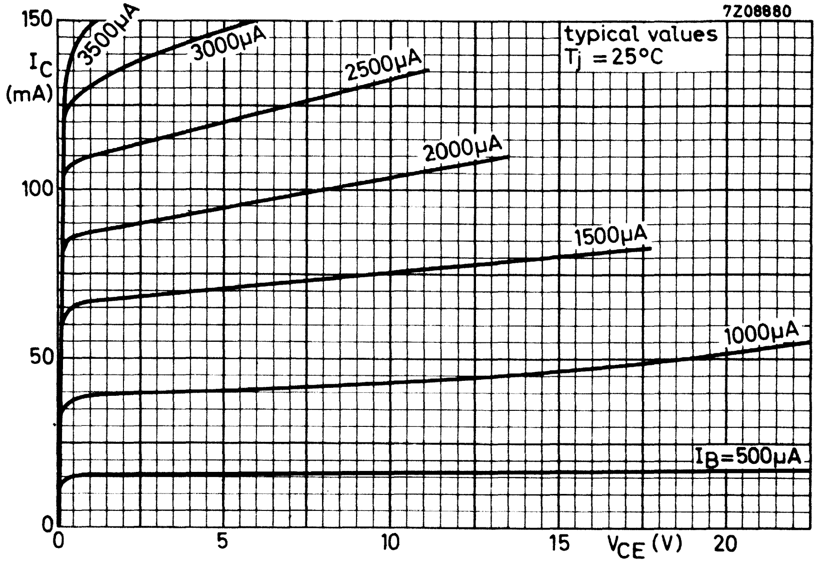
II = Additional region of operation at f $\geq$ 1 MHz.

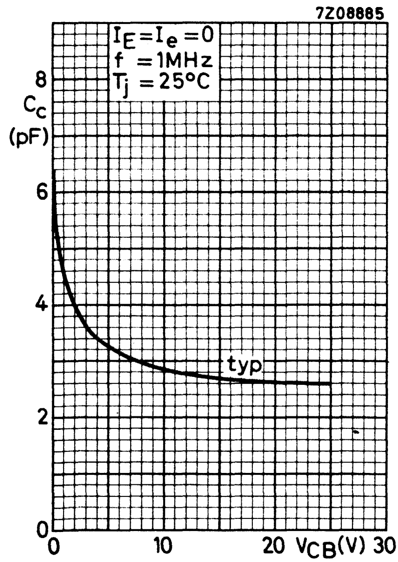
III = Operating under pulsed conditions is allowed, provided the transistor is cut-off with $R_{BE} \leq 50\ \Omega$ and f $\geq$ 1 MHz.

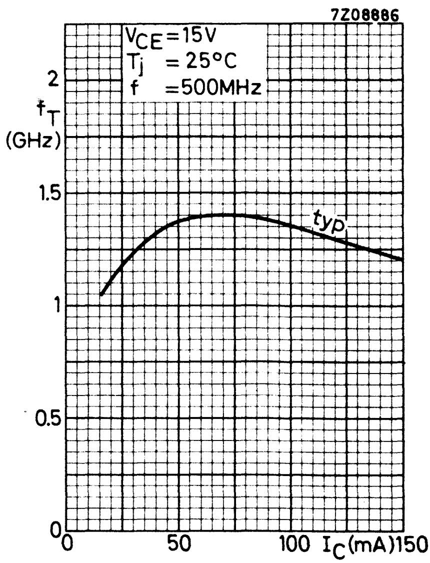

7Z08879
VCE = 5V
Tj = 25°C
IC (mA)
10³
10²
10
1
10
10²
10³
10⁴
10⁵
IB (μA)
typ
max IB


7Z08883
VCE = 5V
Tj = 25°C
hFE
80
60
40
20
0
0
50
100
IC(mA) 150
typ


7Z08884
VCE = 5V
Tj = 25°C
IC (mA)
200
150
100
50
0
700
800
VBE (mV) 900
typ


7Z08880
typical values
T_j = 25°C
I_C (mA)
150
100
50
0
3500μA
3000μA
2500μA
2000μA
1500μA
1000μA
I_B=500μA
0
5
10
15
20
V_{CE} (V)


7Z08885
I_E = I_e = 0
f = 1MHz
T_j = 25°C
C_c (pF)
8
6
4
2
0
typ
0
10
20
30
V_{CB}(V)


7Z08886
V_{CE} = 15V
T_j = 25°C
f = 500MHz
f_T (GHz)
2
1.5
1
0.5
0
typ
0
50
100
150
I_C(mA)

APPLICATION INFORMATION

Performance of channel- and band amplifiers [1]

Frequency range	channel 4 61-68	channel 9 202-209	channel 55 742-750	band I 47-68	band II 87.5-108	band III 174-230	MHz
Transistor used in							
final stage	BFW16A	BFW16A	BFW16A	BFW16A	BFW16A	BFW16A	
driver stage		BFW16A	BFW16A			BFW16A	
second stage			BFY90				
first stage	BFY90	BFY90	BFY90	BFY90	BFY90	BFY90	
Output power at							
d_{im} = −30 dB	150 [2]	150 [2]	100				mW
d_{im} = −50 dB					30		mW
d_{im} = −60 dB				10		10	mW
Power gain	50	44	26.5	51	43	39	dB
Noise figure	7	6	8	6.0-6.5	6.5	6.5	dB
V.S.W.R. over the whole channel or band							
for the input	< 2	< 2	< 2	< 2	< 2	< 2	
for the output	< 2	< 2	< 2	< 2	< 2	< 2	
Load impedance	30	30	50	30	30	30	Ω
Source impedance	60	60	50	60	60	60	Ω

1) Application information bulletins of all these amplifiers and a study of intermodulation are available on request.

2) V_o = 2.2 V over R_L = 30 Ω or
V_o = 3 V over R_L = 60 Ω.

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N multi-emitter transistor in a TO-39 metal envelope, with the collector connected to the case. The transistor has extreme good intermodulation properties and a high power gain. It is a ruggedized version of the BFW17, which it succeeds.
It is primarily intended for final and driver stages of channel- and band aerial amplifiers with high output power for band I; II and III (40-230 MHz).

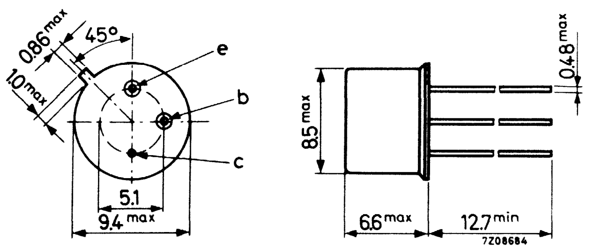
QUICK REFERENCE DATA				
Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Collector current (peak value; f > 1 MHz)	I_{CM}	max.	300	mA
Total power dissipation up to T_{mb} = 125 °C	P_{tot}	max.	1.5	W
Junction temperature	T_j	max.	200	°C
Feedback capacitance at f = 1 MHz I_C = 10 mA; V_{CE} = 15 V	$-C_{re}$	typ.	1.7	pF
Transition frequency I_C = 150 mA; V_{CE} = 15 V; f = 500 MHz	f_T	typ.	1.1	GHz
Power gain (not neutralized) I_C = 70 mA; V_{CE} = 18 V; f = 200 MHz	G_p	typ.	16	dB
Output power d_{im} = −30 dB; V.S.W.R. at output < 2 I_C = 70 mA; V_{CE} = 18 V	P_o	typ.	150	mW

MECHANICAL DATA

Dimensions in mm

Collector connected to case

TO-39



Accessories available: 56218; 56245; 56265

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

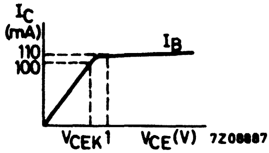
THERMAL RESISTANCE

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

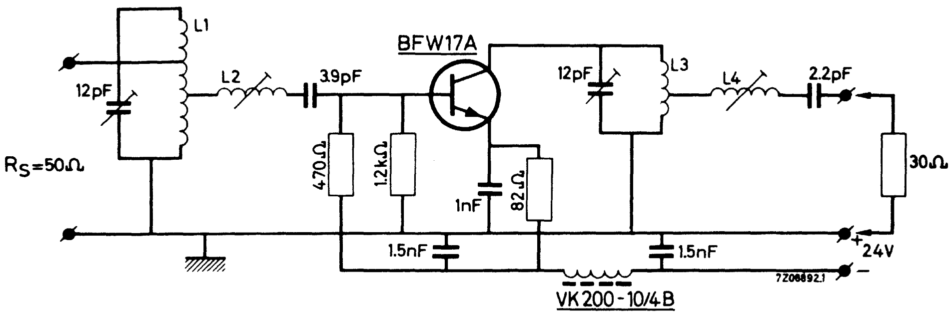
CHARACTERISTICS (continued)

Intermodulation characteristics

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

   I_C = 70 mA; V_{CE} = 18 V; V.S.W.R. at output < 2
   f_p = 202 MHz; f_q = 205 MHz; d_{im} = −30 dB
   measured at $f_{(2q-p)}$ = 208 MHz (Channel 9) P_o typ. 150 mW

   Test circuit:



Coil data:

L1 = 3 turns silver plated Cu wire (1.4 mm); winding pitch 2.7 mm; int. diam. 8 mm; taps at 0.5 turn and 1.5 turns from earth.
L2 = 5.5 turns silver plated Cu wire (1.4 mm); winding pitch 2.2 mm; int. diam. 8 mm.
L3 = 3 turns silver plated Cu wire (1.4 mm); winding pitch 3.3 mm; int. diam. 8 mm.
L4 = 5.5 turns silver plated Cu wire (1.4 mm); winding pitch 2.2 mm; int. diam. 11 mm.

CHARACTERISTICS (continued)

Basis of adjustment

The intermodulation at an intermodulation distortion of −30 dB is caused by h.f. output current - voltage clipping.
The maximum undistorted output power is realised, if

a. Current and voltage clipping take place concurrently.
   This occurs if

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

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

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

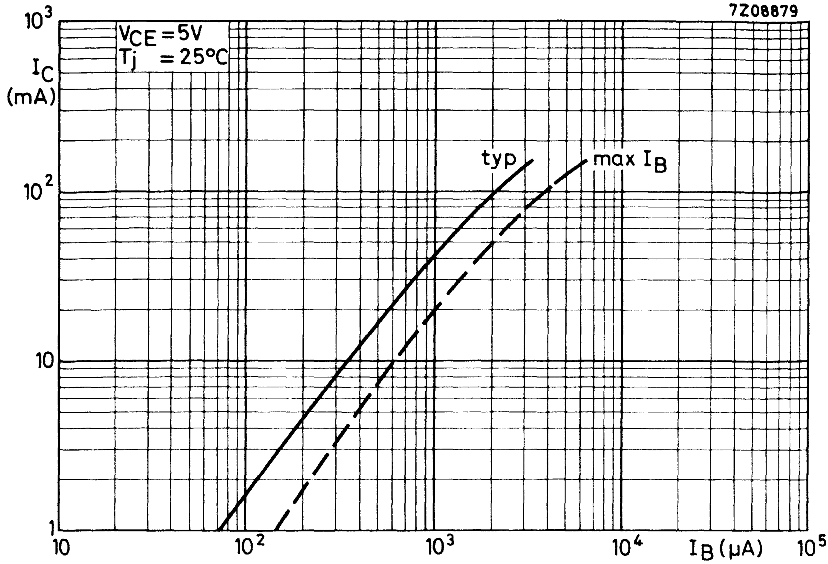
For maximum output power at an intermodulation distortion of −30 dB, the (experimentally found) values of R_L and C_L are:
$R_L = 220\ \Omega$; $C_L = -5.6$ pF.
C_{oe} is found by 4 pF of the transistor and 1.6 pF by the mounting system concerning of a borium nitride washer between the envelope of the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

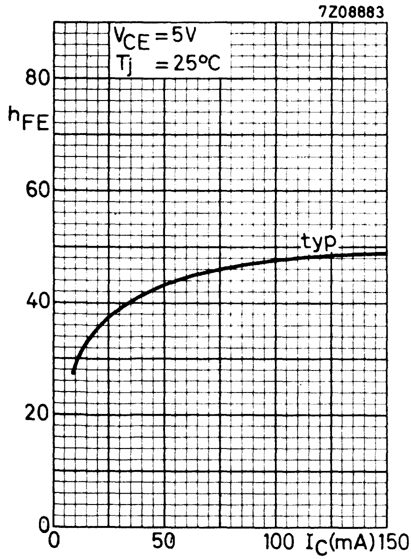
Adjustment procedure

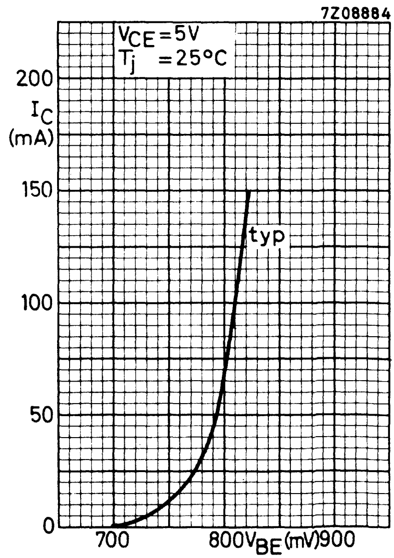
1. Remove the transistor and connect a dummy consisting of a 220 Ω resistor in parallel with a 5.6 pF capacitor between the collector and emitter connections of the output circuit.

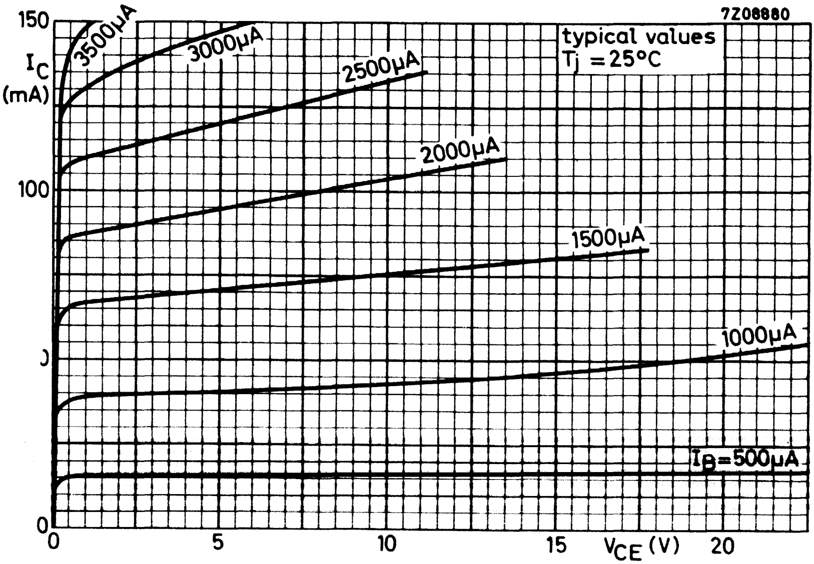
2. Tune and match the output circuit for zero reflection at 205 MHz (V.S.W.R. = 1). After this adjustment, no further change may be made in the output circuit.

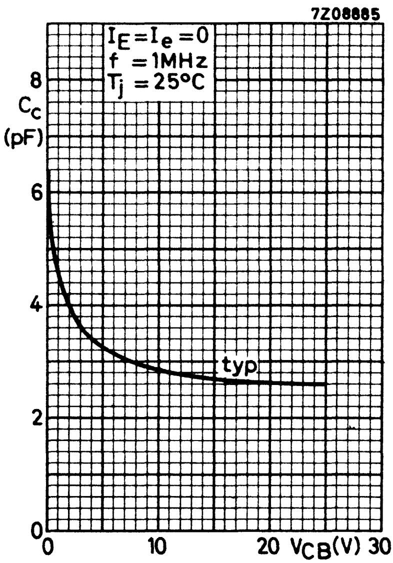
3. Replace the dummy by the transistor. Tune and match the input circuit for maximum power gain and good band pass curve.
   The V.S.W.R. of the output will then, in most cases, be ≤ 2 over the whole channel.
   Corrections can be made by tuning L2; this will not disturb the band pass curve.

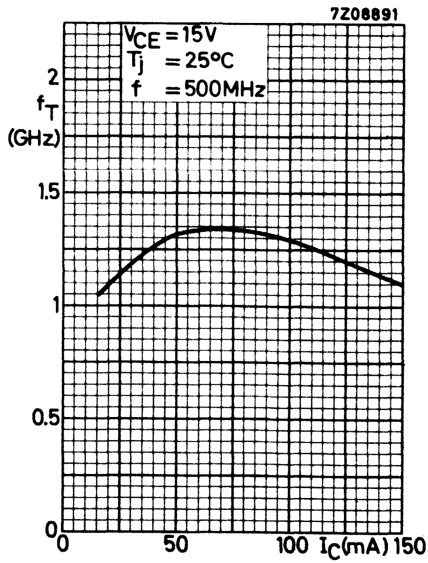

7Z08879
V_{CE} = 5V
T_j = 25°C
I_C (mA)
10^3
10^2
10
1
typ
max I_B
10
10^2
10^3
10^4
I_B (μA)
10^5

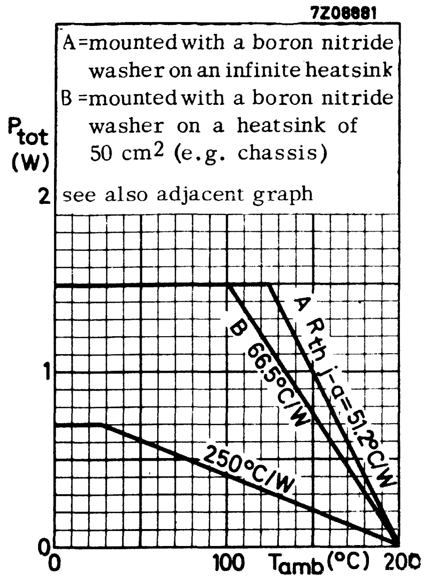

7Z08883
V_{CE} = 5V
T_j = 25°C
h_{FE}
80
60
40
20
0
typ
0
50
100
I_C (mA)
150

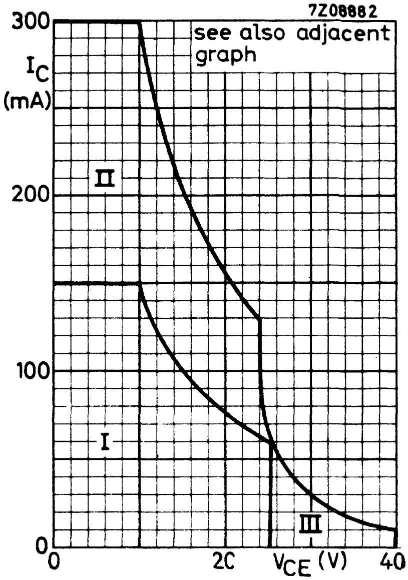

7Z08884
V_{CE} = 5V
T_j = 25°C
I_C (mA)
200
150
100
50
0
typ
700
800
V_{BE} (mV)
900


7Z08880
typical values
Tj = 25°C
150
IC
(mA)
100
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


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 $\geq$ 1 MHz

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

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N multi-emitter transistor in a TO-72 metal envelope, with insulated electrodes and a shield lead connected to the case. The transistor has very low intermodulation distortion and very high power gain.

It is primarily intended for:
- Wideband vertical amplifiers in high speed oscilloscopes.
- Wideband aerial amplifiers (40-860 MHz)
- Television distribution amplifiers

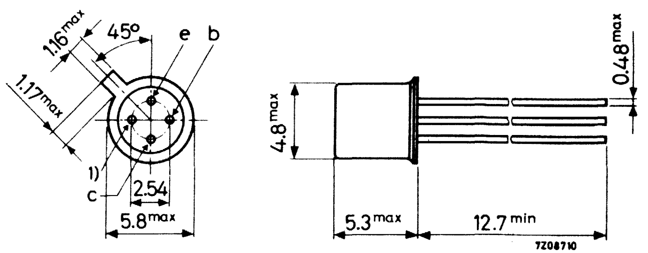
QUICK REFERENCE DATA

Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	20		V
Collector-emitter voltage (open base)	V_{CEO}	max.	10		V
Collector current (peak value; f > 1 MHz)	I_{CM}	max.	100		mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	250		mW
Junction temperature	T_j	max.	200		°C
Feedback capacitance at f = 1 MHz I_C = 2 mA; V_{CE} = 5 V	$-C_{re}$	typ.	0.8		pF
Transition frequency I_C = 50 mA; V_{CE} = 5 V; f = 500 MHz	f_T	typ.	1.6		GHz
Power gain (not neutralized)		f =	200	800	MHz
I_C = 30 mA; V_{CE} = 5 V	G_p	typ.	21	7.5	dB
Intermodulation distortion I_C = 30 mA; V_{CE} = 6 V; R_L = 37.5 Ω V_o = 100 mV at f_p = 183 MHz V_o = 100 mV at f_q = 200 MHz measured at $f_{(2q-p)}$ = 217 MHz	d_{im}	typ.	-60		dB

MECHANICAL DATA

Dimensions in mm

TO-72
insulated electrodes



1) = shield lead (connected to case)

Accessories available: 56246; 56263

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

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	2)
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

G_p	f = 200	800	MHz
	> 19		dB
	typ. 21	7.5	dB

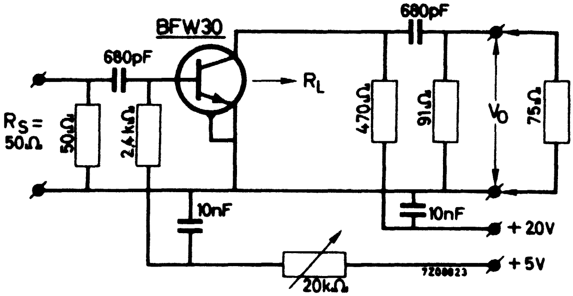
Intermodulation distortion [1]

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

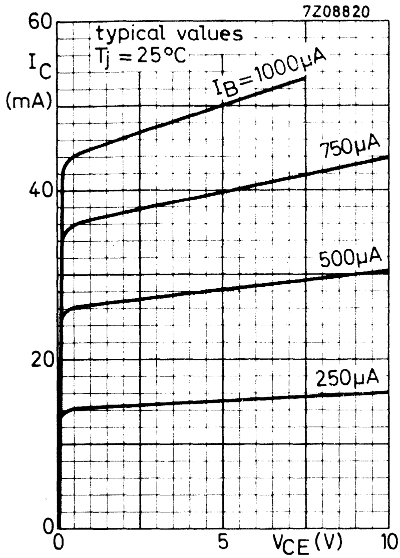
V_o = 100 mV at f_p = 183 MHz

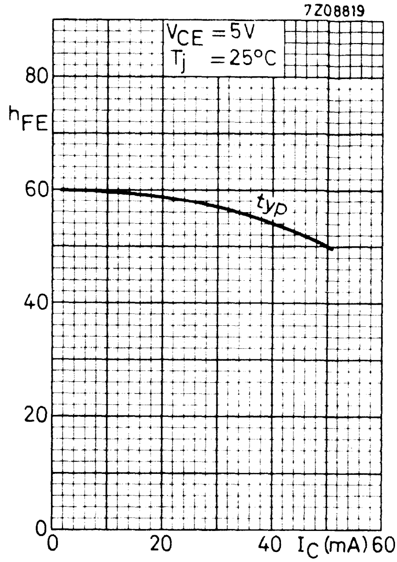
V_o = 100 mV at f_q = 200 MHz
measured at $f_{(2q-p)}$ = 217 MHz — d_{im} typ. −60 dB

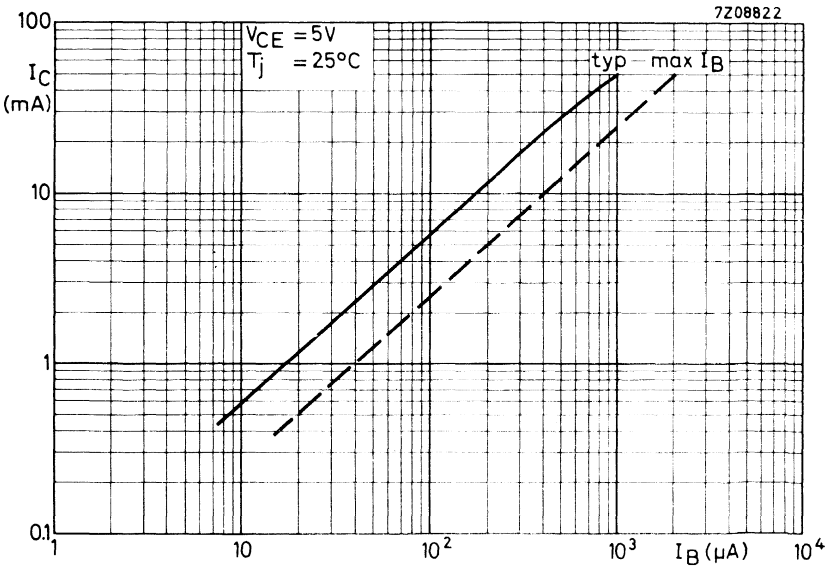
Test circuit

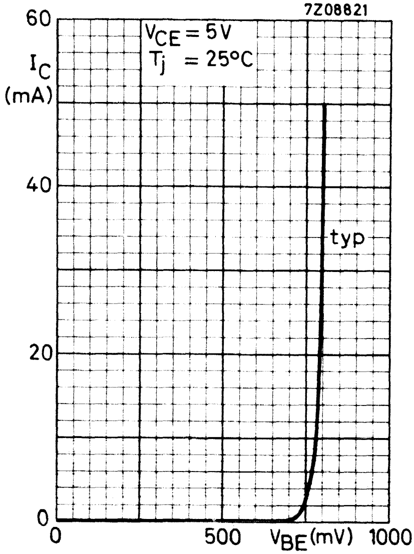


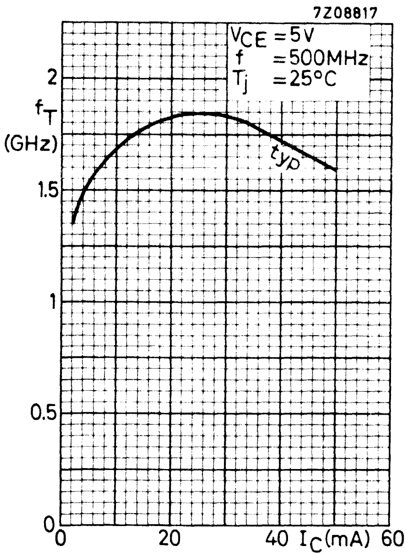
[1] Shield lead grounded.
[2] Shield lead not connected.

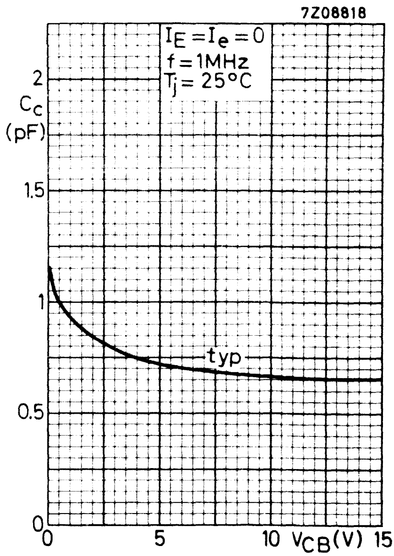

7Z08820
typical values
$T_j = 25°C$
I_C (mA)
$I_B = 1000 \mu A$
$750 \mu A$
$500 \mu A$
$250 \mu A$
V_{CE} (V)
0
5
10
20
40
60


7Z08819
$V_{CE} = 5V$
$T_j = 25°C$
h_{FE}
typ
I_C (mA)
0
20
40
60
80


7Z08822
$V_{CE} = 5V$
$T_j = 25°C$
I_C (mA)
typ
max I_B
I_B (μA)
0.1
1
10
100
10^2
10^3
10^4


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


7Z08817
$V_{CE} = 5 V$
f = 500 MHz
$T_j = 25 °C$
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 = 1 MHz
$T_j = 25 °C$
C_c (pF)
2
1.5
1
0.5
0
typ
0
5
10
V_{CB} (V)
15

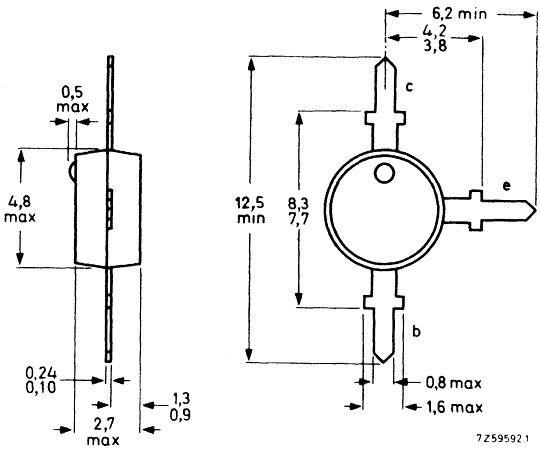
SILICON PLANAR EPITAXIAL TRANSISTOR

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:
- Wide band 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 wide band 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; R_S = 50 Ω	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; V.S.W.R. at output < 2; I_C = 10 mA; V_{CE} = 10 V	P_o	typ.	8	8	mW

MECHANICAL DATA Dimensions in mm



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

Voltages

Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V [1])
Emitter-base voltage (open collector)	V_{EBO}	max.	2.5	V

Currents

Collector current (d.c.)	I_C	max.	25	mA
Collector current (peak value; f > 1 MHz)	I_{CM}	max.	50	mA

Power dissipation

→ Total power dissipation up to T_{amb} = 73 °C	P_{tot}	max.	190	mW

→ Temperatures

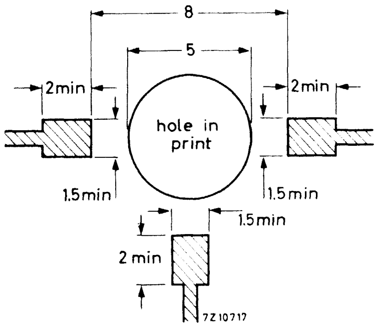
Storage temperature	T_{stg}		-65 to +150	°C
Junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

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

*) Requirements for glass-fibre print

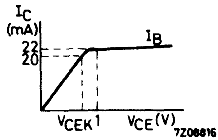
(dimensions in mm)



1) At I_C = 10 mA

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 10$ V	I_{CBO}	<	50	nA
Knee voltage [1]				
$I_C = 20$ mA; I_B = value for which				
$I_C = 22$ mA at $V_{CE} = 1$ V	V_{CEK}	<	0.75	V



D.C. current gain				
$I_C = 2$ mA; $V_{CE} = 1$ V	h_{FE}	> <	20 150	
$I_C = 25$ mA; $V_{CE} = 1$ V [1]	h_{FE}	>	20	
Transition frequency at f = 500 MHz				
$I_C = 2$ mA; $V_{CE} = 5$ V	f_T	typ.	1.0	GHz
$I_C = 25$ mA; $V_{CE} = 5$ V [1]	f_T	typ.	1.6	GHz
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	0.7	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	typ.	1.5	pF
Feedback capacitance at f = 1 MHz				
$I_C = 2$ mA; $V_{CE} = 5$ V; $T_{amb} = 25$ °C	$-C_{re}$	typ.	0.6	pF
Noise figure at f = 500 MHz				
$I_C = 2$ mA; $V_{CE} = 5$ V; $R_S = 50\ \Omega$; $T_{amb} = 25$ °C	F	typ.	4.0	dB

			f = 200	800	MHz
Power gain (not neutralized)					
$I_C = 10$ mA; $V_{CE} = 10$ V; $T_{amb} = 25$ °C	G_p	typ.	23	11	dB

[1]) Measured under pulsed conditions.

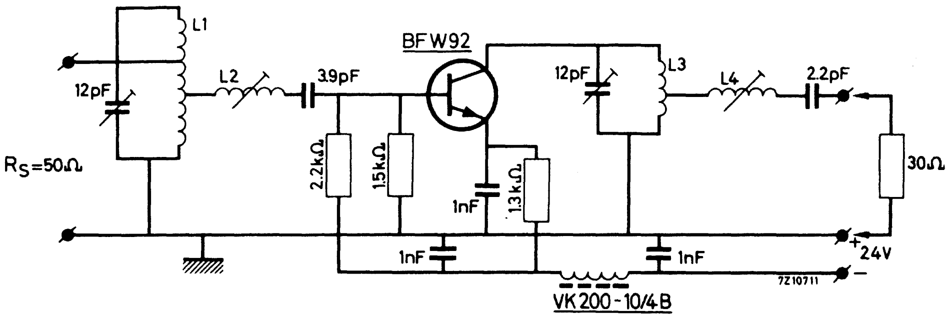
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Intermodulation characteristics

1. Output power at f = 200 MHz; T_{amb} = 25 °C

   I_C = 10 mA; V_{CE} = 10 V; V.S.W.R. at output < 2
   f_p = 202 MHz; f_q = 205 MHz; d_{im} = −30 dB
   measured at $f_{(2q-p)}$ = 208 MHz (Channel 9) P_o typ. 8 mW

   Test circuit:



Coil data:

L1 = 3 turns silver plated Cu wire (1.4 mm); winding pitch 2.7 mm; int. diam. 8 mm; taps at 0.5 turn and 1.5 turns from earth.
L2 = 5.5 turns silver plated Cu wire (1.4 mm); winding pitch 2.2 mm; int. diam. 8 mm.
L3 = 3 turns silver plated Cu wire (1.4 mm); winding pitch 3.3 mm; int. diam. 8 mm.
L4 = 5.5 turns silver plated Cu wire (1.4 mm); winding pitch 2.2 mm; int. diam. 11 mm.

CHARACTERISTICS (continued)

Basis of adjustment

The intermodulation at an intermodulation distortion of −30 dB is caused by h.f. output current - voltage clipping.
The maximum undistorted output power is realised, if

a. Current and voltage clipping take place concurrently.
This occurs if

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

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

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

For maximum output power at an intermodulation distortion of −30 dB, the (experimentally found) values of R_L and C_L are:
R_L = 820 Ω; C_L = −1.0 pF

Adjustment procedure

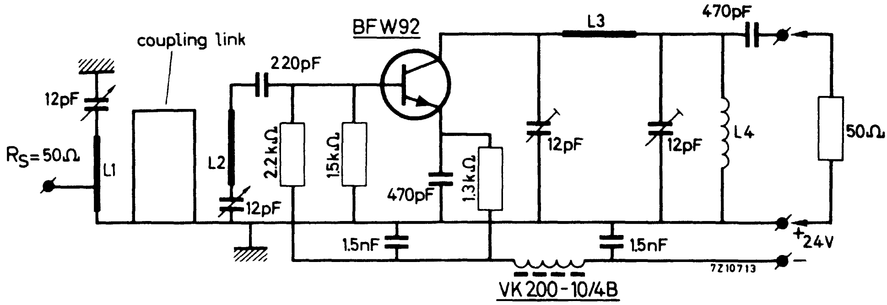
1. Remove the transistor and connect a dummy consisting of a 820 Ω resistor in parallel with a 1.0 pF capacitor between the collector and emitter connections of the output circuit.
2. Tune and match the output circuit for zero reflection at 205 MHz (V.S.W.R. = 1). After this adjustment, no further change may be made in the output circuit.
3. Replace the dummy by the transistor. Tune and match the input circuit for maximum power gain and good band pass curve.
The V.S.W.R. of the output will then, in most cases, be ≤ 2 over the whole channel.
Corrections can be made by tuning L2; this will not disturb the band pass curve.

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

Intermodulation characteristics

2. Output power at f = 800 MHz; T_{amb} = 25 °C

I_C = 10 mA; V_{CE} = 10 V; V.S.W.R. at output < 2
f_p = 798 MHz; f_q = 802 MHz; d_{im} = −30 dB
measured at $f_{(2q-p)}$ = 806 MHz (Channel 62) P_o typ. 8 mW



Coil data:
L1 = 24 mm x 6 mm x 0.5 mm silver plated Cu strip.
Tap of the input at 5 mm from earth.
L2 = 15 mm x 6 mm x 0.5 mm silver plated Cu strip.
L3 = 20 mm x 8 mm x 0.5 mm silver plated Cu strip.
L4 = 4 turns enamelled Cu wire (0.5mm); 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

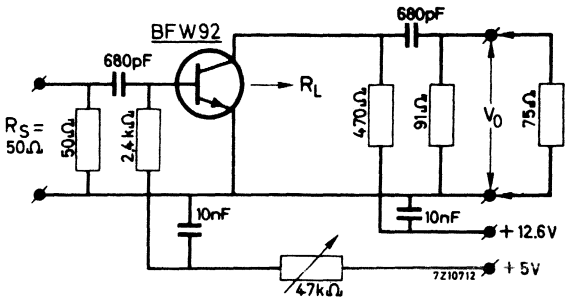
3. Intermodulation distortion

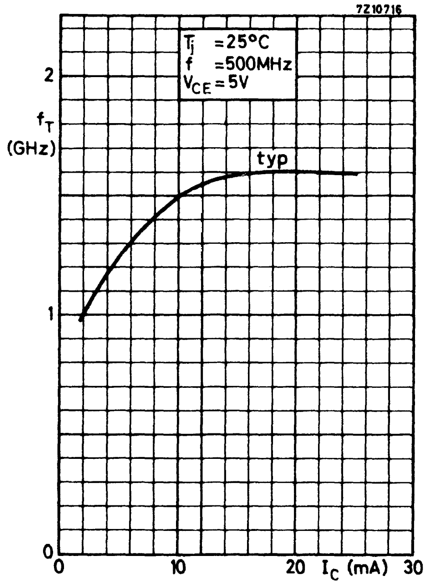
I_C = 10 mA; V_{CE} = 6 V; R_L = 37.5 Ω; T_{amb} = 25 °C

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

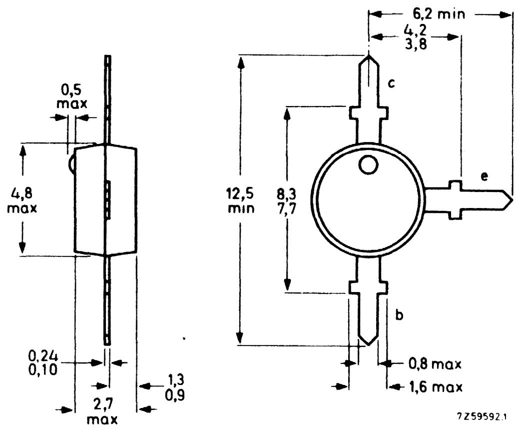
N-P-N transistor in a subminiature plastic transfermoulded T-package.
The device is intended for use in VHF - UHF applications, primarily wide-band aerial amplifiers 40 - 800 MHz.
It is intended for mounting on miniature printed circuit boards.

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



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 ^oC	P_{tot}	max.	190	mW

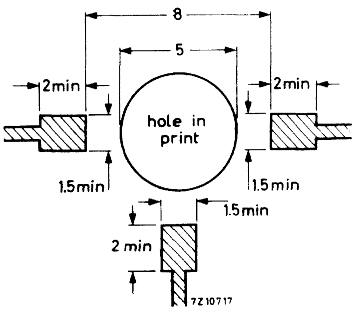
Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air mounted on a glass-fibre print of 40 mm x 25 mm x 1 mm	$R_{th\ j-a}$	=	0.4	$^oC/mW$

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

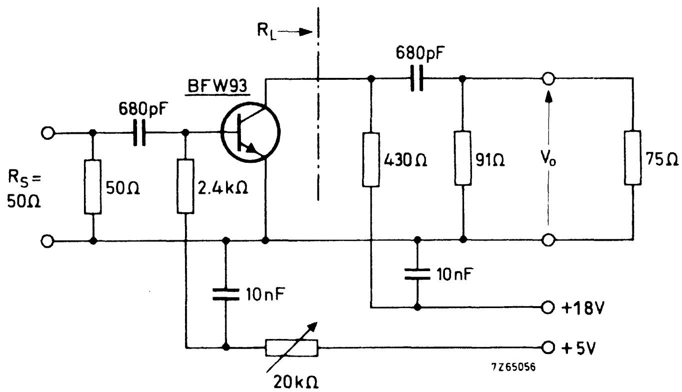
I_C = 30 mA; V_{CE} = 5 V; R_L = 37.5 Ω

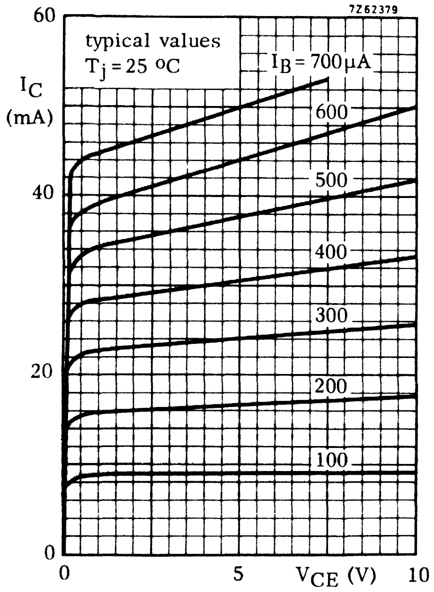
V_o = 100 mV at f_p = 183 MHz

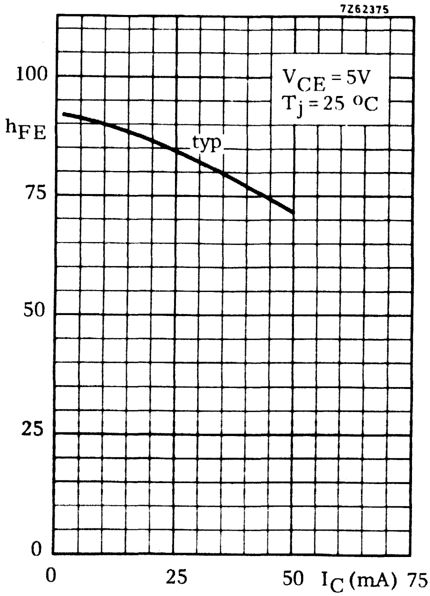
V_o = 100 mV at f_q = 200 MHz

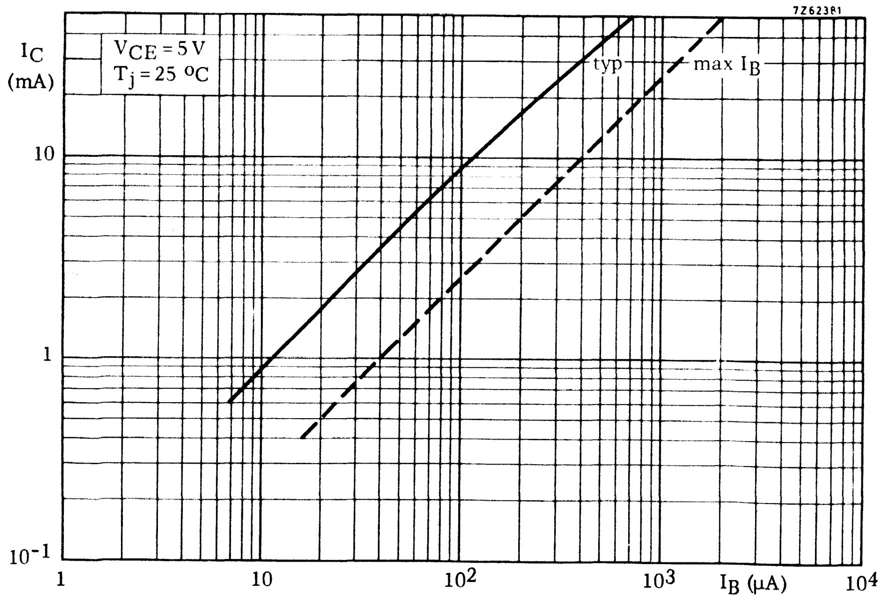
measured at $f_{(2q-p)}$ = 217 MHz — d_{im} typ. −60 dB

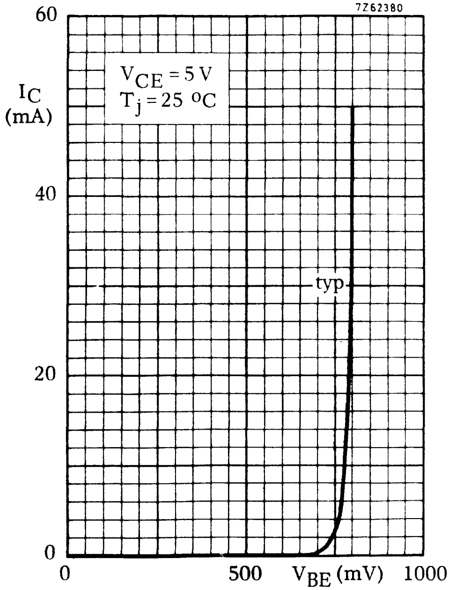
Test circuit:

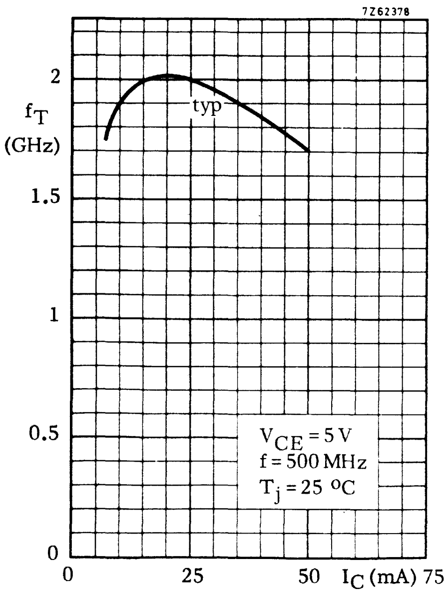


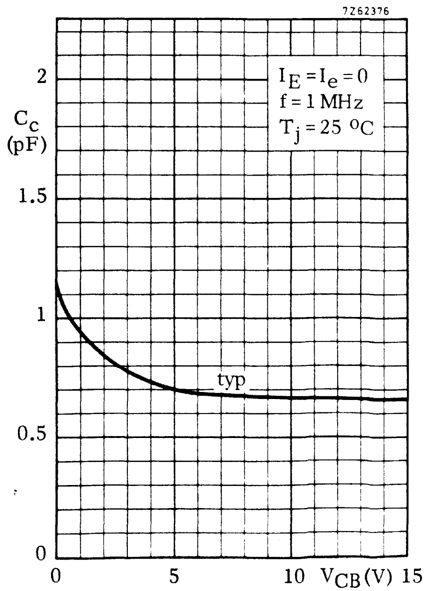

7Z62379
typical values
$T_j = 25\ ^oC$
I_C (mA)
$I_B = 700\ \mu A$
600
500
400
300
200
100
60
40
20
0
0
5
V_{CE} (V)
10


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

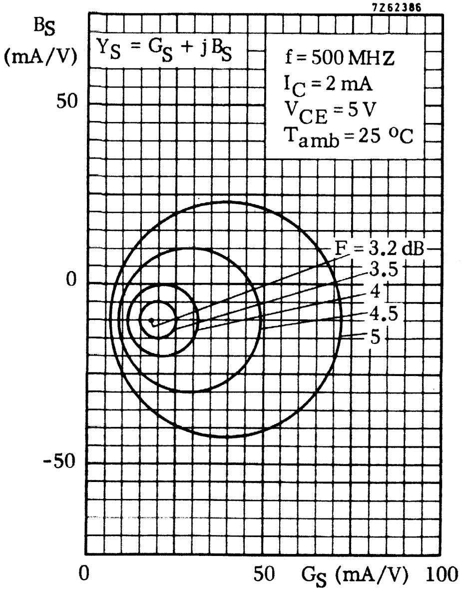

7Z62381
I_C (mA)
$V_{CE} = 5\ V$
$T_j = 25\ ^oC$
typ
max I_B
10
1
10^{-1}
1
10
10^2
10^3
I_B (μA)
10^4

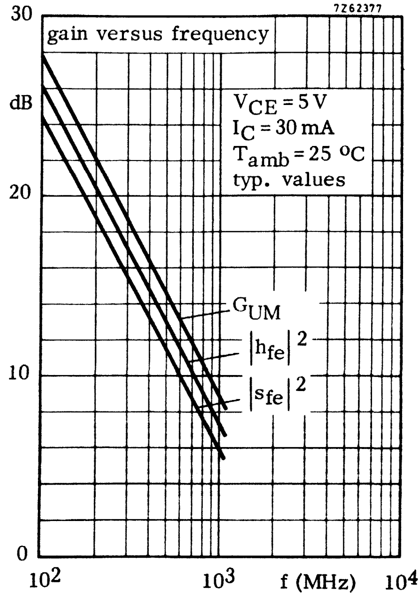

7Z62380
60
40
20
0
I_C (mA)
V_{CE} = 5 V
T_j = 25 °C
typ
0
500
V_{BE} (mV)
1000

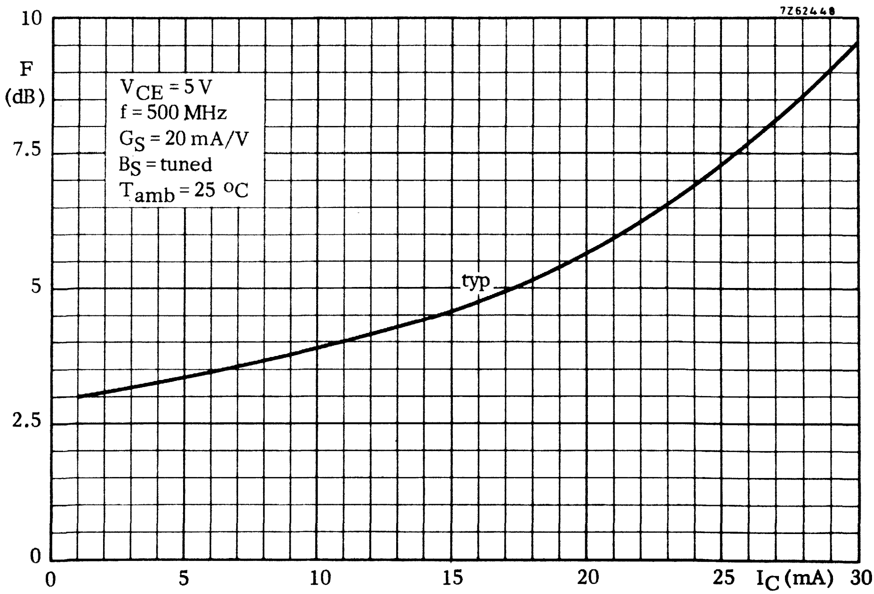

7Z62378
2
1.5
1
0.5
0
f_T (GHz)
typ
V_{CE} = 5 V
f = 500 MHz
T_j = 25 °C
0
25
50
I_C (mA)
75


7Z62376
2
1.5
1
0.5
0
C_c (pF)
$I_E = I_e = 0$
f = 1 MHz
T_j = 25 °C
typ
0
5
10
V_{CB} (V)
15

circles of constant noise figure



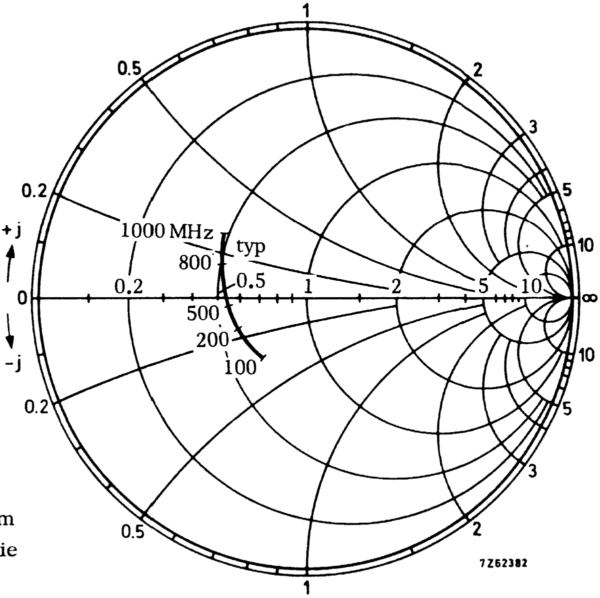




V_{CE} = 5 V

I_C = 30 mA

T_{amb} = 25 °C

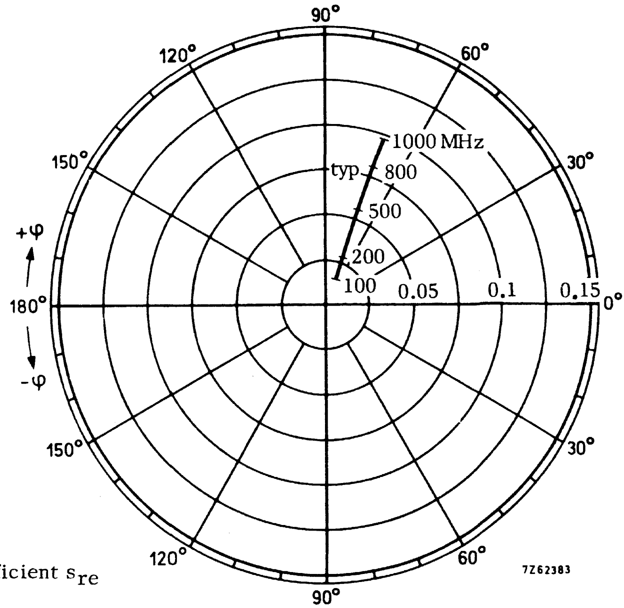


Input impedance derived from input reflection coefficient s_{ie} coordinates in ohm x 50

V_{CE} = 5 V

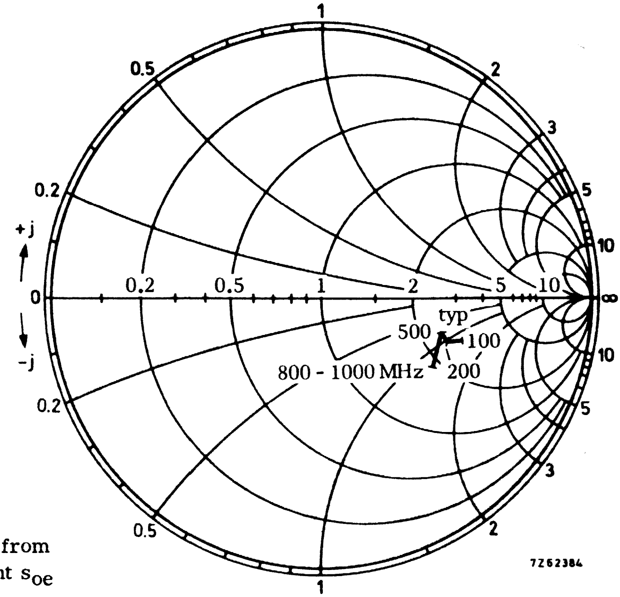
I_C = 30 mA

T_{amb} = 25 °C



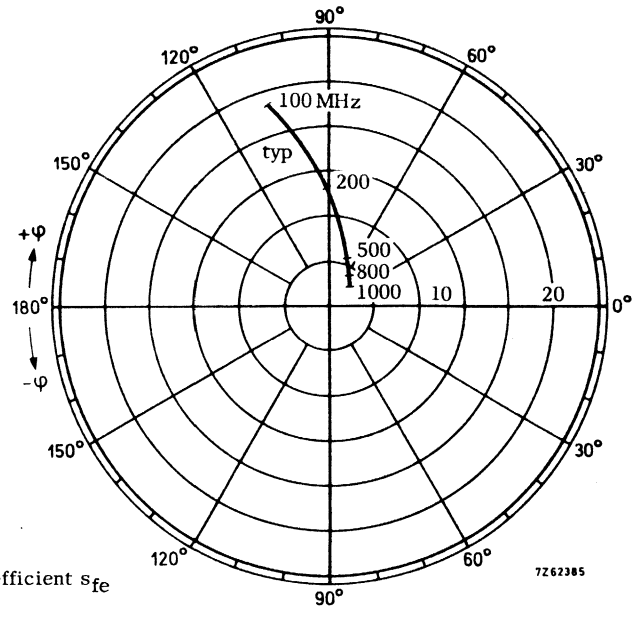
→ Reverse transmission coefficient s_{re}

V_{CE} = 5 V
I_C = 30 mA
T_{amb} = 25 °C



Output impedance derived from output reflection coefficient s_{oe} coordinates in ohm x 50

V_{CE} = 5 V
I_C = 30 mA
T_{amb} = 25 °C



→ Forward transmission coefficient s_{fe}

SILICON PLANAR EPITAXIAL TRANSISTOR

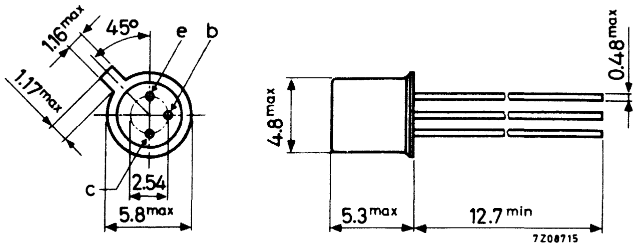
N-P-N transistor in a TO-18 metal envelope with the collector connected to the case. The BFX44 is primarily intended for use as a low distortion common base linear output amplifier, capable of delivering an output voltage swing of at least 20 V across a 400 Ω load at frequencies up to 150 MHz (e.g. as required for the output stage of a d.c. to 150 MHz vertical amplifier of a wide band oscilloscope)

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (R_{BE} = 10 Ω)	V_{CER}	max.	23	V
Collector current (peak value)	I_{CM}	max.	250	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360	mW
Junction temperature	T_j	max.	200	°C
Transition frequency				
I_C = 10 mA; V_{CE} = 10 V	f_T	>	500	MHz
I_C = 100 mA; V_{CE} = 3 V	f_T	>	300	MHz

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-18



Accessories available: 56246, 56263

RATINGS (Limiting values) [1]

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V [2]
Collector-emitter voltage with R_{BE} = 10 Ω	V_{CER}	max.	23	V [2]
Collector-emitter voltage with V_{BE} = 0	V_{CES}	max.	40	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4	V

Currents

Collector current (d.c. or average over any 20 ms period)	I_C	max.	125	mA
Collector current (peak value)	I_{CM}	max.	250	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360	mW

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.48	°C/mW
From junction to ambient with cooling clip 56263	$R_{th\ j\text{-}a}$	=	0.28	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0.145	°C/mW

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

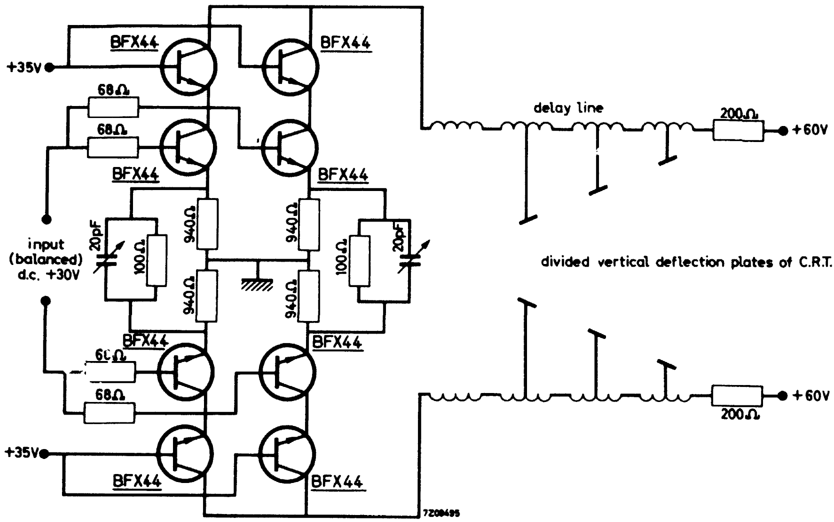
[2] I_C = 10 mA.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
$I_E = 0$; $V_{CB} = 20$ V	I_{CBO}	max.	100	nA
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 150$ °C	I_{CBO}	max.	20	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 2$ V	I_{EBO}	max.	50	nA
$I_C = 0$; $V_{EB} = 2$ V; $T_j = 150$ °C	I_{EBO}	max.	20	μA
Saturation voltages				
$I_C = 100$ mA; $I_B = 10$ mA	V_{CEsat}	<	0.6	V
	V_{BEsat}	<	1.5	V
D.C. current gain				
$I_C = 10$ mA; $V_{CE} = 1$ V	h_{FE}	40 to 120		
$I_C = 100$ mA; $V_{CE} = 1$ V	h_{FE}	>	20	
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CE} = 5$ V	C_c	<	4	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	<	4.5	pF
Transition frequency				
$I_C = 10$ mA; $V_{CE} = 10$ V	f_T	>	500	MHz
$I_C = 100$ mA; $V_{CE} = 3$ V	f_T	>	300	MHz
Feedback time constant				
$-I_E = 1$ mA; $V_{CB} = 5$ V; f = 10.7 MHz	$r_{bb'}C_{b'c}$	<	40	ps
Storage time				
$I_C = I_B = -I_{BM} = 10$ mA	t_s	<	30	ns

APPLICATION INFORMATION

Vertical deflection stage of a wide band oscilloscope.



This circuit is capable of delivering an output voltage swing of at least 40 V (typ. 45 V) with a rise time of typ. 2.2 ns.

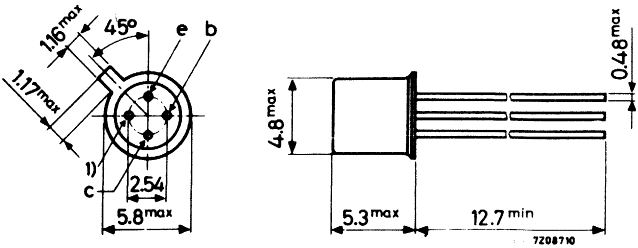
SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a TO-72 metal envelope, with insulated electrodes and a shield lead connected to the case.
The transistor has a low noise, a very high power gain and good intermodulation properties.
It is primarily intended for:
- Channel aerial amplifiers for band I, II, III and IV/V (40-860 MHz)
- Wide band aerial amplifiers (40-860 MHz).

QUICK REFERENCE DATA						
Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	30			V
Collector-emitter voltage (open base)	V_{CEO}	max.	15			V
Collector current (peak value; f > 1 MHz)	I_{CM}	max.	50			mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	200			mW
Junction temperature	T_j	max.	200			°C
Transition frequency I_C = 25 mA; V_{CE} = 5 V; f = 500 MHz	f_T	typ.	1.2			GHz
Feedback capacitance I_C = 2 mA; V_{CE} = 5 V; f = 1 MHz	$-C_{re}$	typ.	0.6			pF
			f = 200	800	MHz	
Noise figure at optimum source impedance I_C = 2 mA; V_{CE} = 5 V	F	typ.	3.3	7	dB	
Power gain (not neutralized) I_C = 8 mA; V_{CE} = 10 V	G_p	typ.	22	7	dB	
Output power d_{im} = −30 dB; V.S.W.R. at output <2 I_C = 8 mA; V_{CE} = 10 V	P_o	typ.	6	6	mW	

MECHANICAL DATA Dimensions in mm

TO-72
insulated electrodes



Accessories available: 56246, 56263

1) = shield lead (connected to case)

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

Voltages

Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	30	V
Collector-emitter voltage (peak value) $R_{BE} \leq 50\ \Omega$	V_{CERM}	max.	30	V [1]
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V [1]
Emitter-base voltage (open collector)	V_{EBO}	max.	2.5	V

Currents

Collector current (d.c.)	I_C	max.	25	mA
Collector current (peak value; f > 1 MHz)	I_{CM}	max.	50	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	200	mW

Temperatures

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

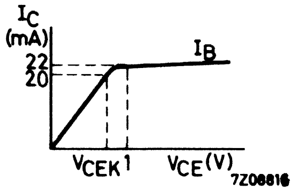
THERMAL RESISTANCE

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

[1] I_C = 10 mA.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
I_E = 0; V_{CB} = 15 V	I_{CBO}	<	10	nA
Knee voltage				
I_C = 20 mA; I_B = value for which I_C = 22 mA at V_{CE} = 1 V	V_{CEK}	<	0.75	V



D.C. current gain				
I_C = 2 mA; V_{CE} = 1 V	h_{FE}	20 to 150		
I_C = 25 mA; V_{CE} = 1 V	h_{FE}	20 to 125		
Transition frequency [1]				
I_C = 2 mA; V_{CE} = 5 V; f = 500 MHz	f_T	typ.	1.0	GHz
I_C = 25 mA; V_{CE} = 5 V; f = 500 MHz	f_T	typ.	1.2	GHz
Collector capacitance at f = 1 MHz [2]				
I_E = I_e = 0; V_{CB} = 10 V	C_c	<	1.7	pF
Feedback capacitance at f = 1 MHz [1]				
I_C = 2 mA; V_{CE} = 5 V	$-C_{re}$	typ.	0.6	pF
Noise figure [1]				
I_C = 2 mA; V_{CE} = 5 V				
f = 200 MHz; optimum source impedance	F	<	4	dB
f = 500 MHz; R_S = 50 Ω	F	<	6.5	dB
f = 800 MHz; optimum source impedance	F	typ.	7.0	dB

Power gain (not neutralized) [1]

			f = 200	800	MHz
I_C = 8 mA; V_{CE} = 10 V; T_{amb} = 25 °C	G_p	>	19	–	dB
		typ.	22	7	dB

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

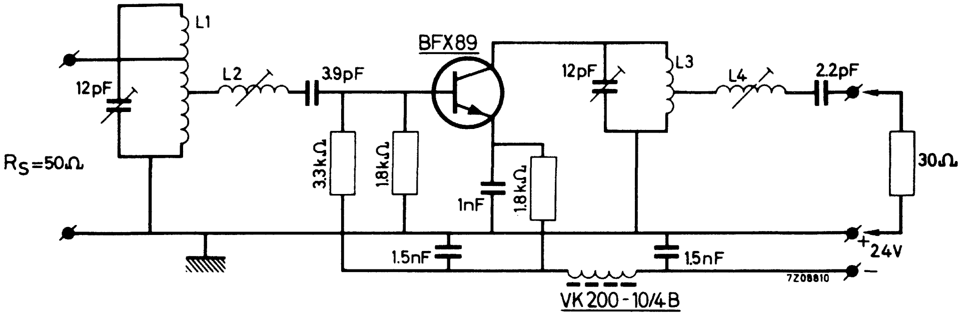
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Intermodulation characteristics [1]

1. Output power at f = 200 MHz; T_{amb} = 25 °C

I_C = 8 mA; V_{CE} = 10 V; V.S.W.R. at output < 2
f_p = 202 MHz; f_q = 205 MHz; d_{im} = −30 dB
measured at $f_{(2q-p)}$ = 208 MHz (Channel 9) P_o typ. 6 mW

Test circuit:



Coil data:

L1 = 3 turns silver plated Cu wire (1.4 mm); winding pitch 2.7 mm; int. diam. 8 mm; taps at 0.5 turn and 1.5 turns from earth.
L2 = 5.5 turns silver plated Cu wire (1.4 mm); winding pitch 2.2 mm; int. diam. 8 mm.
L3 = 3 turns silver plated Cu wire (1.4 mm) winding pitch 3.3 mm; int. diam. 8 mm.
L4 = 5.5 turns silver plated Cu wire (1.4 mm) winding pitch 2.2 mm; int. diam. 11 mm.

[1] Shield lead grounded.

CHARACTERISTICS (continued)

Basis of adjustment

The intermodulation at an intermodulation distortion of −30 dB is caused by h.f. output current - voltage clipping.
The maximum undistorted output power is realised, if

a. Current and voltage clipping take place concurrently.
   This occurs if

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

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

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

For maximum output power at an intermodulation distortion of −30 dB, the (experimentally found) values of R_L and C_L are:
$R_L = 1\ k\Omega$; $C_L = -1.8\ pF$

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.

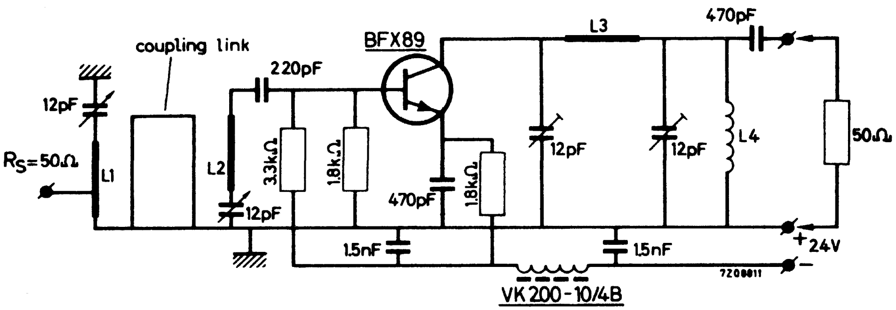
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

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

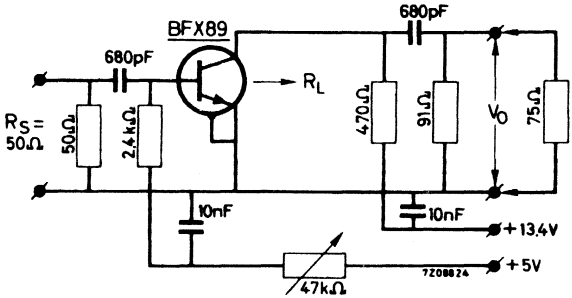
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Intermodulation characteristics [1])

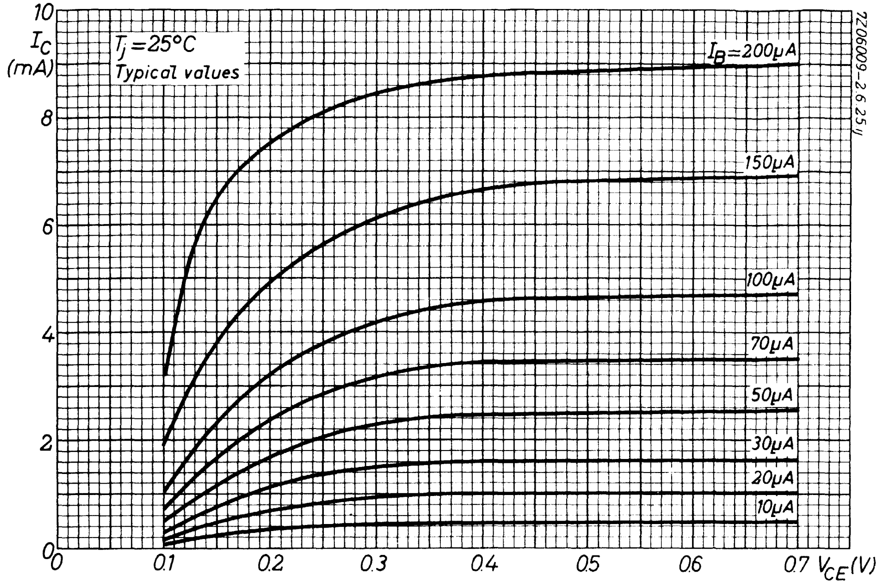
3. Intermodulation distortion

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

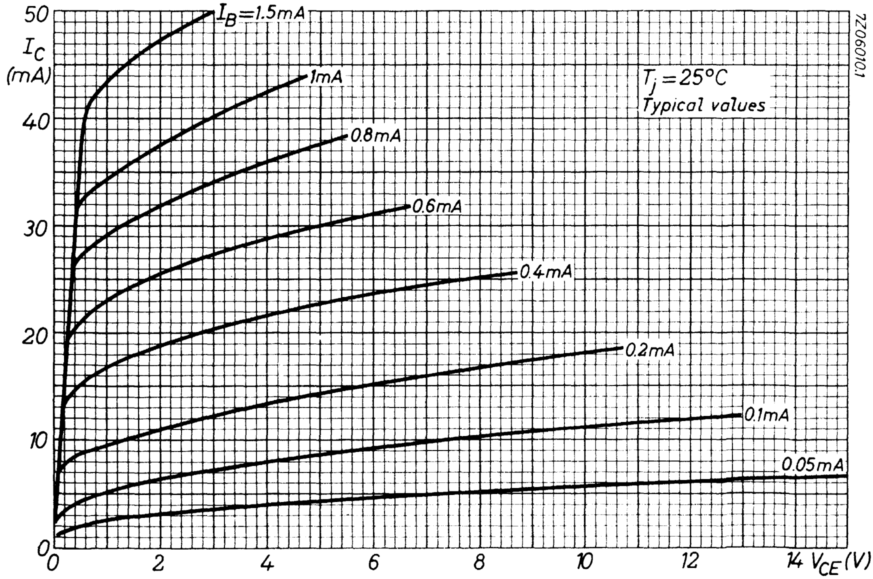
Test circuit:



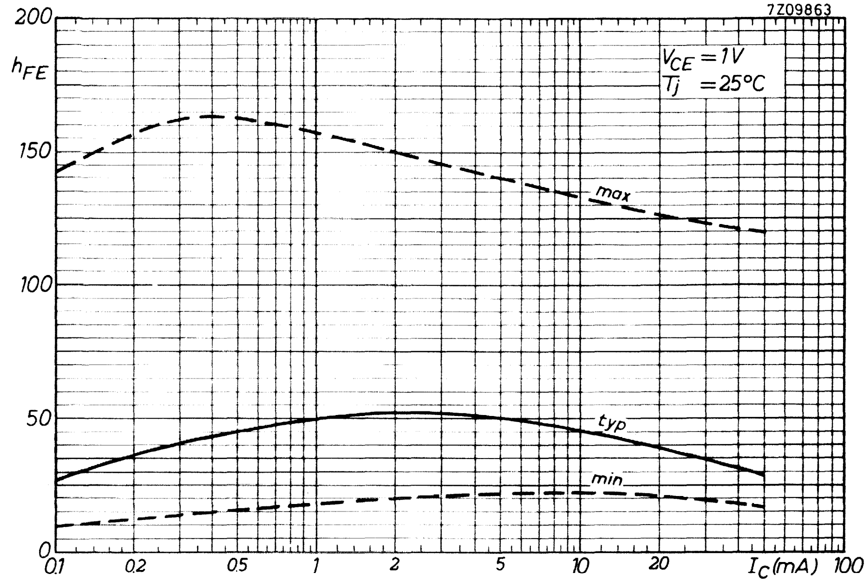
[1]) Shield lead grounded.

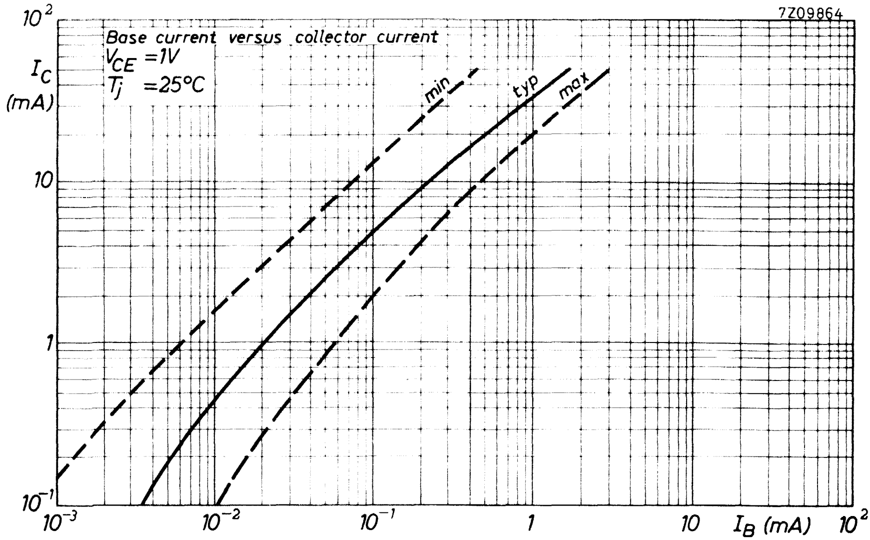


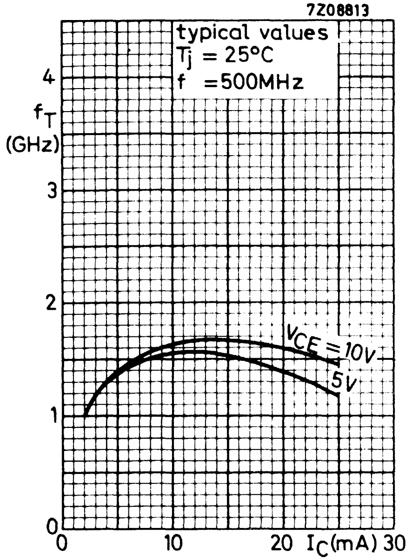
10
I_C
(mA)
8
6
4
2
0
$T_j = 25°C$
Typical values
$I_B = 200\mu A$
150µA
100µA
70µA
50µA
30µA
20µA
10µA
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7 V_{CE} (V)
7Z06009-2.6.25.1

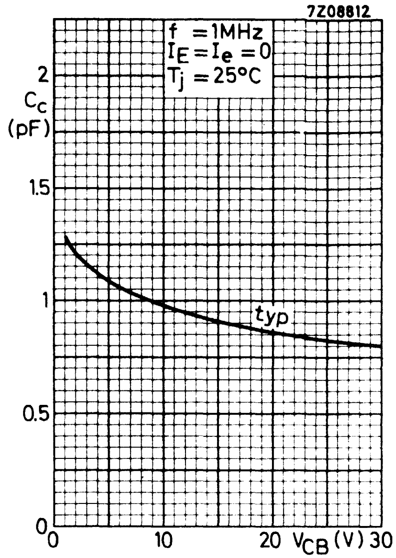


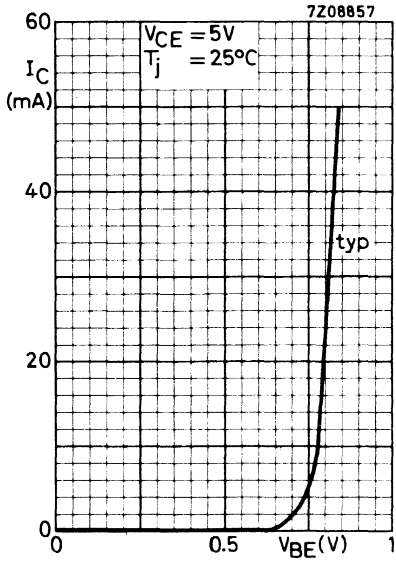
50
I_C
(mA)
40
30
20
10
0
$I_B = 1.5mA$
1mA
0.8mA
0.6mA
0.4mA
0.2mA
0.1mA
0.05mA
$T_j = 25°C$
Typical values
0
2
4
6
8
10
12
14 V_{CE} (V)
7Z06010.1

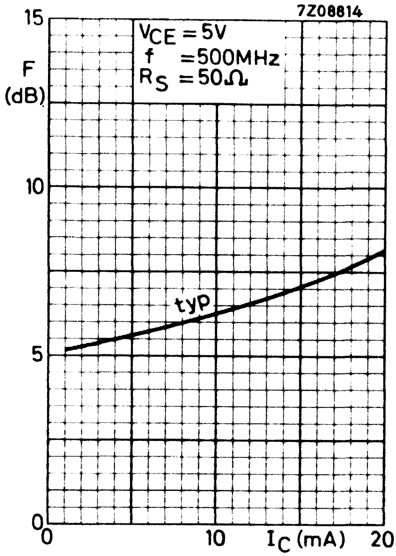

7Z09863
200
h_{FE}
150
100
50
0
V_{CE} = 1V
T_j = 25°C
max
typ
min
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100

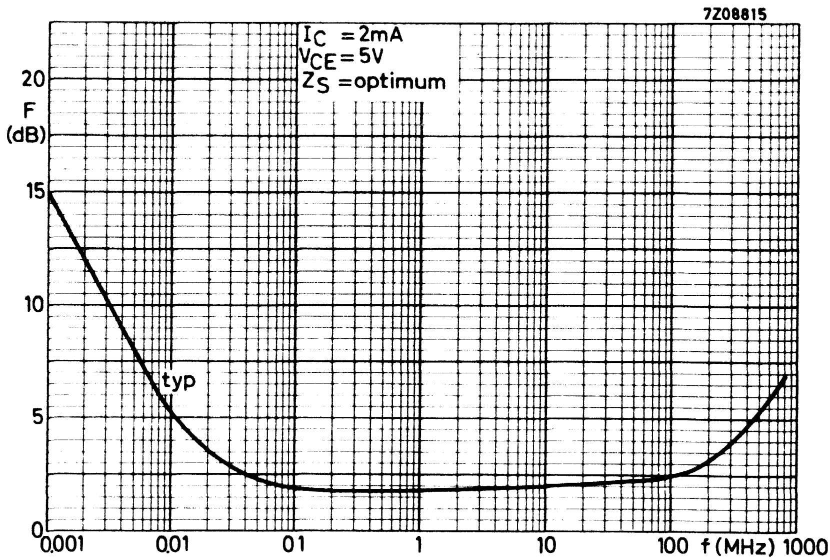

7Z09864
Base current versus collector current
V_{CE} = 1V
T_j = 25°C
10^2
I_C
(mA)
10
1
10^{-1}
min
typ
max
10^{-3}
10^{-2}
10^{-1}
1
10
I_B (mA)
10^2


7Z08813
typical values
T_j = 25°C
f = 500MHz
f_T
(GHz)
V_{CE} = 10V
5V
I_C(mA)
0
10
20
30
1
2
3
4


7Z08812
f = 1MHz
$I_E = I_e = 0$
T_j = 25°C
C_c
(pF)
typ
V_{CB} (V)
0
0.5
1
1.5
2
10
20
30


7Z08857
V_{CE} = 5V
T_j = 25°C
I_C
(mA)
typ
V_{BE}(V)
0
20
40
60
0.5
1


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


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

SILICON EPITAXIAL PLANAR TRANSISTORS

N-P-N transistors in a TO-39 metal envelope with the collector connected to the case. These transistors are intended for general **purpose industrial applications.**

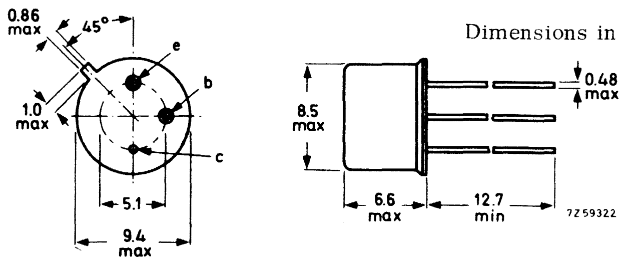
QUICK REFERENCE DATA

			BFY50	BFY51	BFY52	
Collector-base voltage (open emitter)	V_{CBO}	max.	80	60	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	35	30	20	V
Collector current (peak value)	I_{CM}	max.	1	1	1	A
Total dissipation up to T_{mb} = 50 °C	P_{tot}	max.	5	5	5	W
Junction temperature	T_j	max.	200	200	200	°C
D.C. current gain at T_j = 25 °C						
I_C = 150 mA; V_{CE} = 10 V	h_{FE}	typ.	112	123	142	
Transition frequency						
I_C = 50 mA; V_{CE} = 10 V	f_T	typ.	140	160	185	MHz
Saturation voltage						
I_C = 500 mA; I_B = 50 mA	V_{CEsat}	<	0.7	1.0	1.0	V

MECHANICAL DATA

Dimensions in mm

TO-39
Collector connected to case



max. lead diameter is guaranteed only for 12.7 mm.
Accessories **supplied on request: 56218, 56245, 56265.**

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

Voltages			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
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	$R_{th\ j\text{-}a}$	=	220	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	35	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	30	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

			BFY50	BFY51	BFY52	
Collector cut-off current						
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	typ.	2			nA
		<	50			nA
$I_E = 0$; $V_{CB} = 40$ V	I_{CBO}	typ.		2		nA
		<		50		nA
$I_E = 0$; $V_{CB} = 30$ V	I_{CBO}	typ.			2	nA
		<			50	nA
$I_E = 0$; $V_{CB} = 60$ V; $T_j = 100$ °C	I_{CBO}	typ.	100			nA
		<	2.5			μA
$I_E = 0$; $V_{CB} = 40$ V; $T_j = 100$ °C	I_{CBO}	typ.		100		nA
		<		2.5		μA
$I_E = 0$; $V_{CB} = 30$ V; $T_j = 100$ °C	I_{CBO}	typ.			100	nA
		<			2.5	μA
Emitter cut-off current						
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	typ.	2	2	2	nA
		<	50	50	50	nA
$I_C = 0$; $V_{EB} = 5$ V; $T_j = 100$ °C	I_{EBO}	typ.	0.1	0.1	0.1	μA
		<	2.5	2.5	2.5	μA
Saturation voltages						
$I_C = 10$ mA; $I_B = 1.0$ mA	V_{CEsat}	typ.	0.06	0.06	0.06	V
		<	0.10	0.15	0.15	V
	V_{BEsat}	typ.	0.69	0.69	0.69	V
		<	1.2	1.2	1.2	V
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	typ.	0.15	0.15	0.15	V
		<	0.20	0.35	0.35	V
	V_{BEsat}	typ.	0.92	0.92	0.92	V
		<	1.3	1.3	1.3	V
$I_C = 500$ mA; $I_B = 50$ mA 1)	V_{CEsat}	typ.	0.35	0.35	0.35	V
		<	0.70	1.00	1.00	V
	V_{BEsat}	typ.	1.15	1.15	1.15	V
		<	1.5	1.5	1.5	V
$I_C = 1$ A; $I_B = 100$ mA 1)	V_{CEsat}	typ.	0.66	0.66	0.66	V
		<	1.00	1.60	1.60	V
	V_{BEsat}	typ.	1.40	1.40	1.40	V
		<	2.0	2.0	2.0	V

1) Measured under pulsed conditions to avoid excessive dissipation.

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

			BFY50	BFY51	BFY52	
D.C. current gain						
I_C = 10 mA; V_{CE} = 10 V	h_{FE}	>	20	30	30	
		typ.	80	85	90	
I_C = 150 mA; V_{CE} = 10 V [1]	h_{FE}	>	30	40	60	
		typ.	112	123	142	
I_C = 500 mA; V_{CE} = 10 V [1]	h_{FE}	>	20	25	30	
		typ.	70	79	90	
I_C = 1 A ; V_{CE} = 10 V [1]	h_{FE}	>	15	15	15	
		typ.	35	40	50	
Switching times (See also page 5)						
I_C = 150 mA; $+I_B = -I_{BM}$ = 15 mA						
delay time	t_d	typ.	15	15	15	ns
rise time	t_r	typ.	40	40	40	ns
storage time	t_s	typ.	300	300	300	ns
fall time	t_f	typ.	60	60	60	ns
Collector capacitance at f = 1 MHz						
$I_E = I_e$ = 0; V_{CB} = 10 V	C_c	<	12	12	12	pF
Transition frequency at f = 35 MHz						
I_C = 50 mA; V_{CE} = 10 V	f_T	>	60	50	50	MHz
		typ.	140	160	185	MHz
h parameters at f = 1 kHz						
I_C = 10 mA; V_{CE} = 5 V						
Input impedance	h_{ie}	<	750	750	750	Ω
Reverse voltage transfer ratio	h_{re}	<	5.0	5.0	5.0	10^{-4}
Small signal current gain	h_{fe}	>	15	45	45	
		typ.	90	100	110	
Output admittance	h_{oe}	<	80	80	80	$\mu\Omega^{-1}$
I_C = 1 mA; V_{CE} = 5 V						
Small signal current gain	h_{fe}	>	10	30	30	
		typ.	60	65	70	

[1] Measured under pulsed conditions to avoid excessive dissipation.

MEASUREMENT OF SWITCHING TIMES

Fig. 1 : Circuit diagram

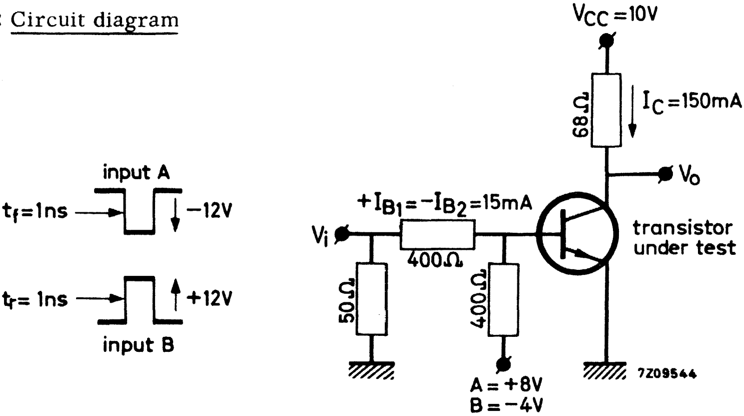
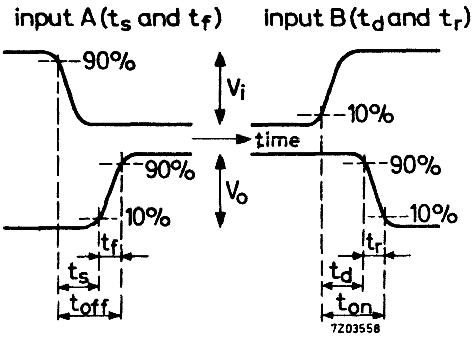


Fig. 2 : Waveforms



Equipment	Pulse generator:	rise time	t_r = 1 ns
		pulse duration	t_p = 1 μs
	Double beam or dual trace oscilloscope:	rise time	t_r < 5 ns

OPERATING NOTES (Dissipation and heatsink considerations)

1. Steady-state conditions

The max. allowable steady-state dissipation P_S is given by the relationship

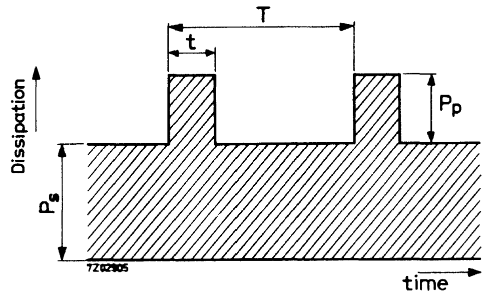
$$P_{S\,max.} = \frac{T_{j\,max.} - T_{amb}}{R_{th\,j\text{-}a}}$$

where $T_{j\,max.}$ is the maximum permissible operating junction temperature,

T_{amb} is the ambient temperature,

$R_{th\,j\text{-}a}$ is the total thermal resistance between junction and ambient.

2. Pulse conditions (rectangular pulses)



The maximum allowable pulse power P_p is given by the formula

$$P_p = \frac{(T_{j\,max.} - T_{amb}) - (P_S \,.\, R_{th\,j\text{-}a})}{Z_{th} + \delta . R_{th\,mb\text{-}a}}$$

where Z_{th} is the thermal impedance of the device between junction and mounting base and is a function of the pulse duration t and duty cycle δ (see page 9),

δ is the duty cycle and is equal to the pulse duration t divided by the periodic time T,

$R_{th\,mb\text{-}a}$ is the total thermal resistance between mounting base and ambient.

Example

The following example shows how to calculate the maximum permissible peak dissipation of a BFY50 mounted in free air at a temperature not exceeding 65 ^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

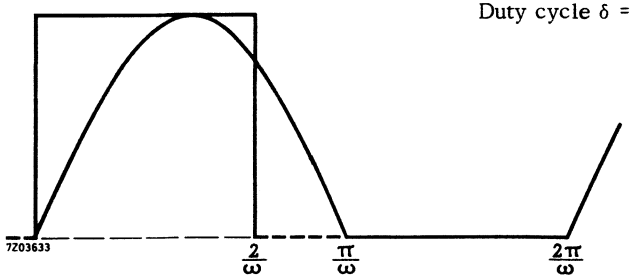
The following example illustrates how to find the maximum permissible peak dissipation of a BFY52 operating in a class "B" circuit at 1 kHz. The device is mounted on a heatsink of thermal resistance equal to 50 °C/W and at an ambient temperature not exceeding 100 °C. Assuming that the waveform is sinusoidal 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,

$$t = \frac{2}{\omega} = \frac{2}{2\pi \times 10^3} = 0.318\ \text{ms}$$

$$\text{Duty cycle } \delta = \frac{2/\omega}{2\pi/\omega} = \frac{1}{\pi}$$

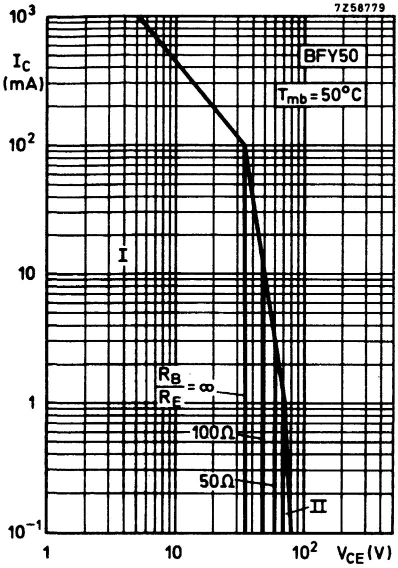


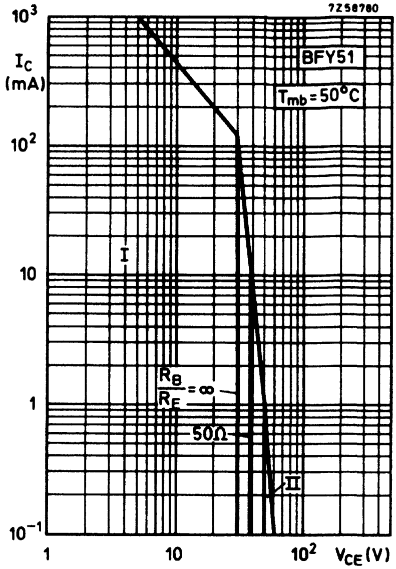
From page 9: $Z_{th\,0} = 6.0\ ^{o}C/W$ $R_{th\,j\text{-}mb} = 30\ ^{o}C/W$

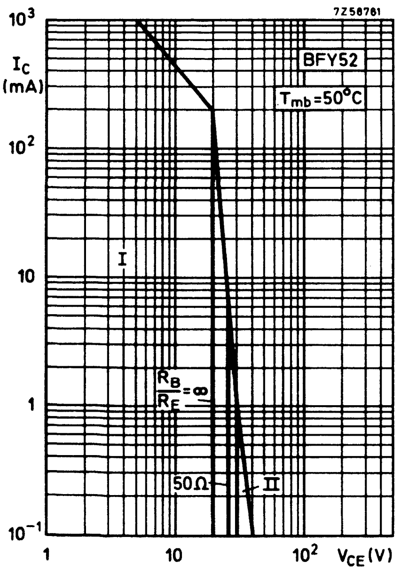
$$Z_{th}\ (\text{at } \delta = 0.318) = 6.0 + 0.318\,(30-6.0) = 13.6\ ^{o}C/W$$

$$P_{p\,max} = \frac{(200-100) - 0}{13.6 + 0.318 \times 50} = 3.39\ W$$

A peak power of 3.39 W is therefore permissible provided that the voltage and current ratings of the device are not exceeded.



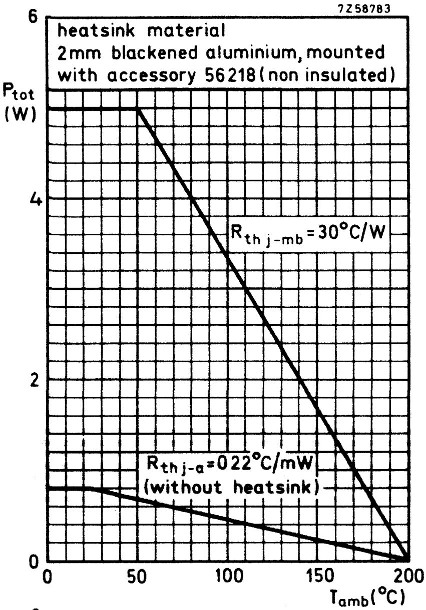


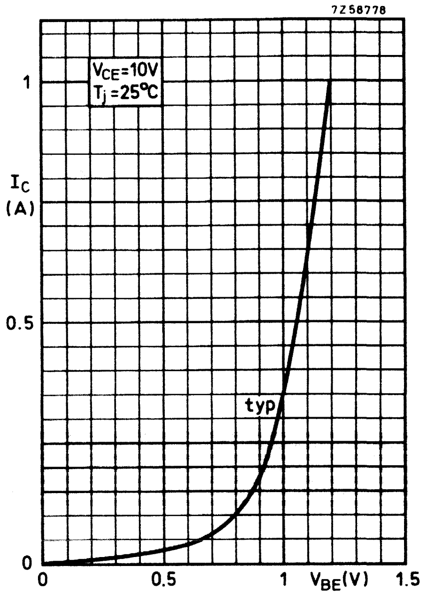


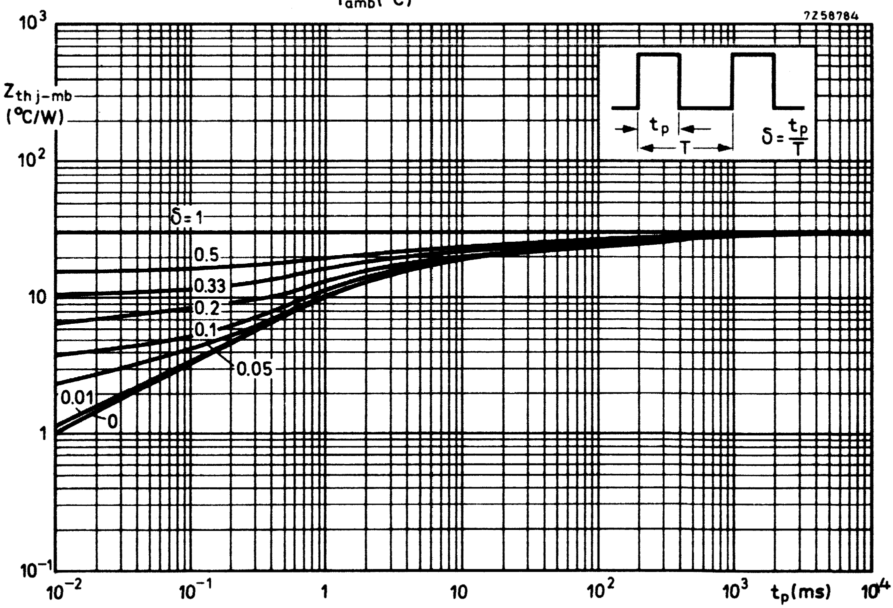
Safe Operating Area with the transistor forward biased

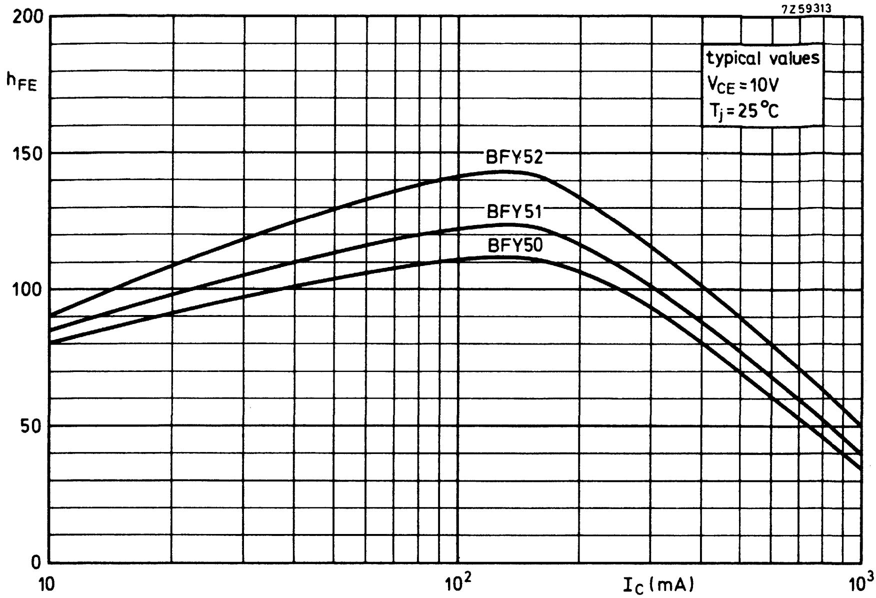
I. Region of permissible d.c. operation

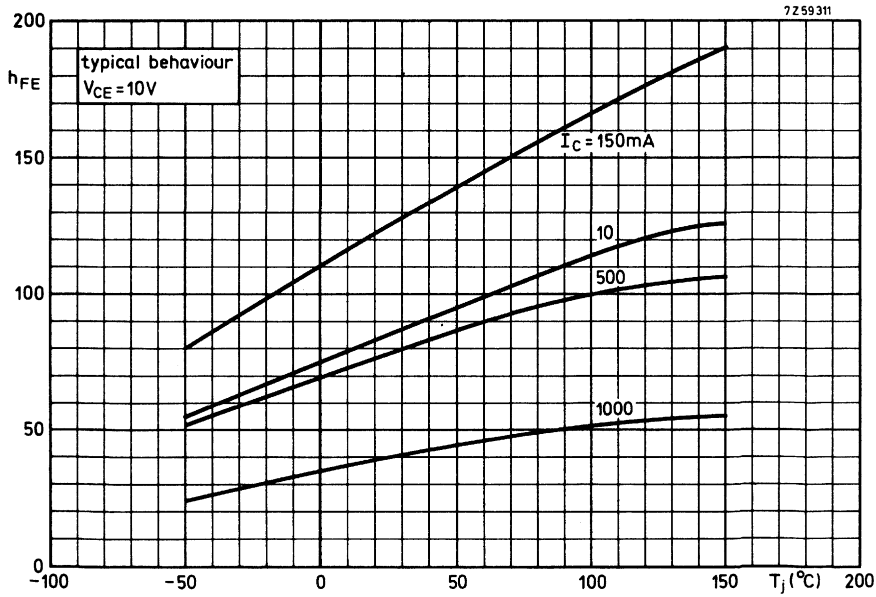
II. Additional area for d.c. operation when $R_B / R_E < 10\,\Omega$

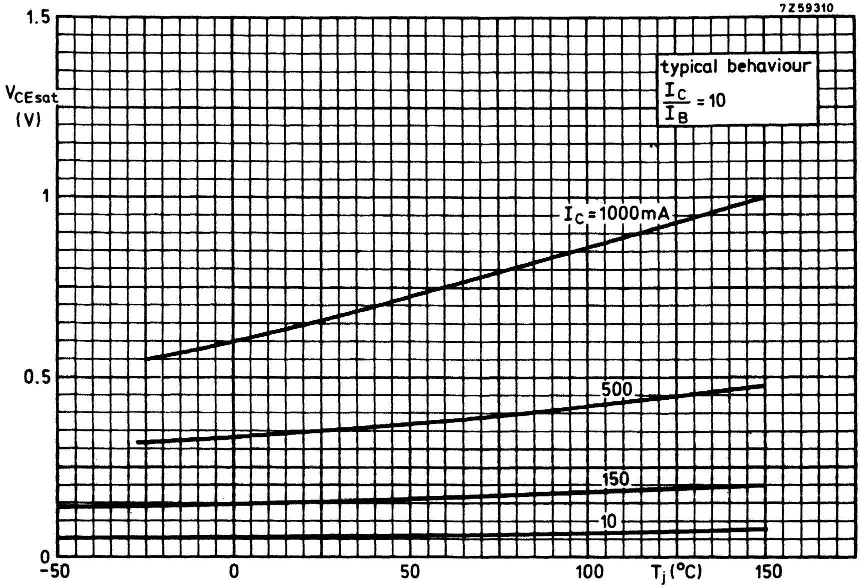

7Z58783
heatsink material
2mm blackened aluminium, mounted
with accessory 56218 (non insulated)
Ptot
(W)
Rth j-mb = 30°C/W
Rth j-a = 0.22°C/mW
(without heatsink)
Tamb (°C)
0
2
4
6
0
50
100
150
200

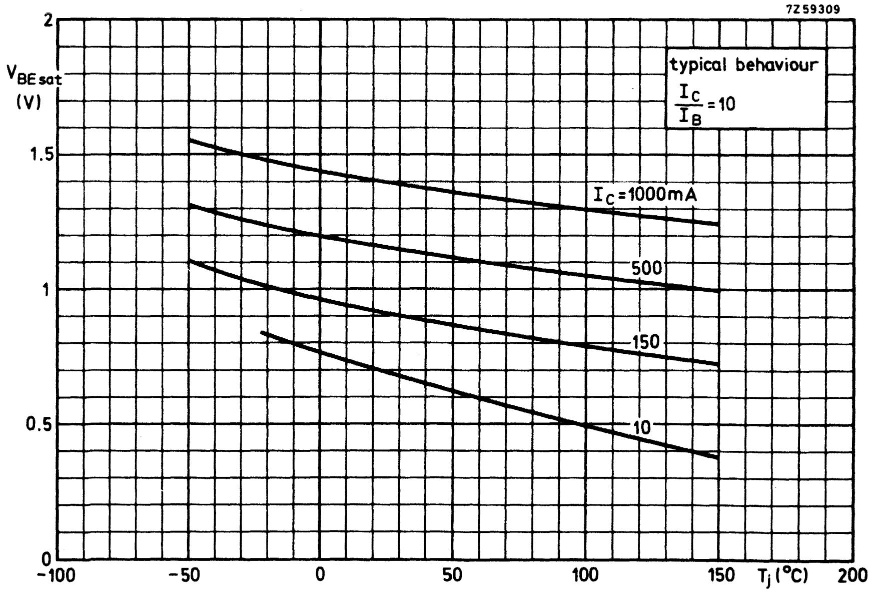

7Z58778
VCE = 10V
Tj = 25°C
IC
(A)
typ
VBE (V)
0
0.5
1
0
0.5
1
1.5

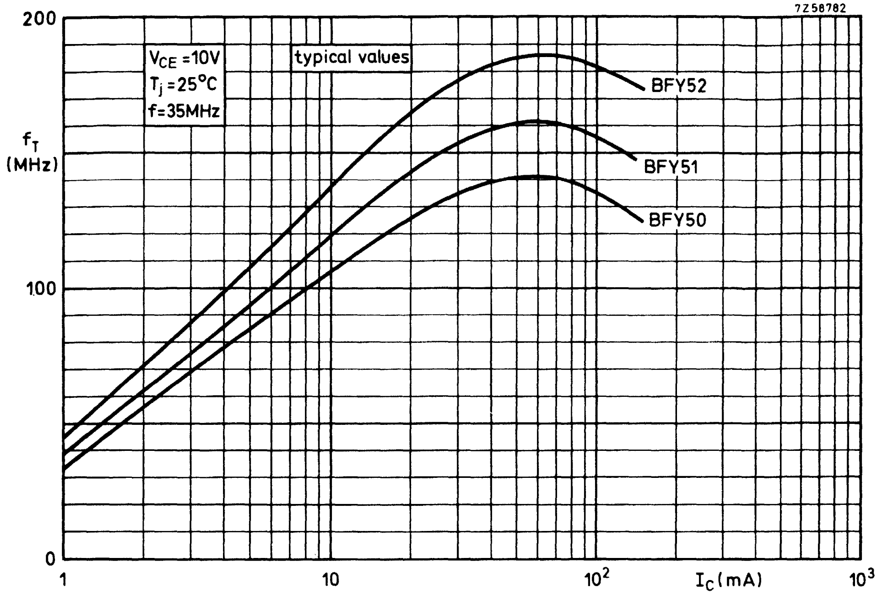

7Z58784
Zth j-mb
(°C/W)
δ = 1
0.5
0.33
0.2
0.1
0.05
0.01
0
tp
T
δ = tp/T
tp (ms)
10^-1
1
10
10^2
10^3
10^-2
10^-1
1
10
10^2
10^3
10^4


7Z59313
typical values
V_{CE} = 10V
T_j = 25 °C
h_{FE}
BFY52
BFY51
BFY50
200
150
100
50
0
10
10^2
I_C (mA)
10^3

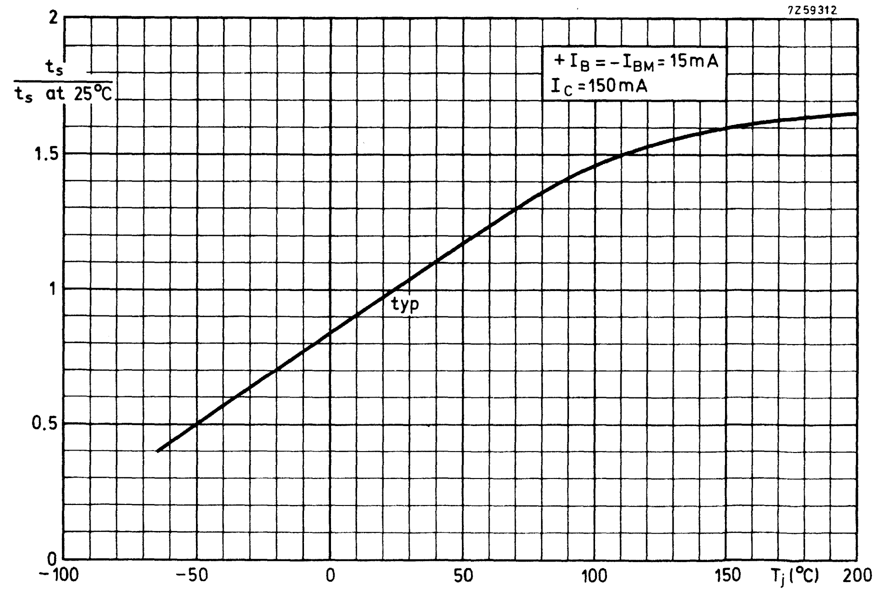

7Z59311
typical behaviour
V_{CE} = 10V
h_{FE}
I_C = 150mA
10
500
1000
200
150
100
50
0
−100
−50
0
50
100
150
T_j (°C)
200


7Z59310
typical behaviour
$\frac{I_C}{I_B} = 10$
V_{CEsat} (V)
1.5
1
0.5
0
$I_C = 1000 mA$
500
150
10
-50
0
50
100
150
T_j (°C)

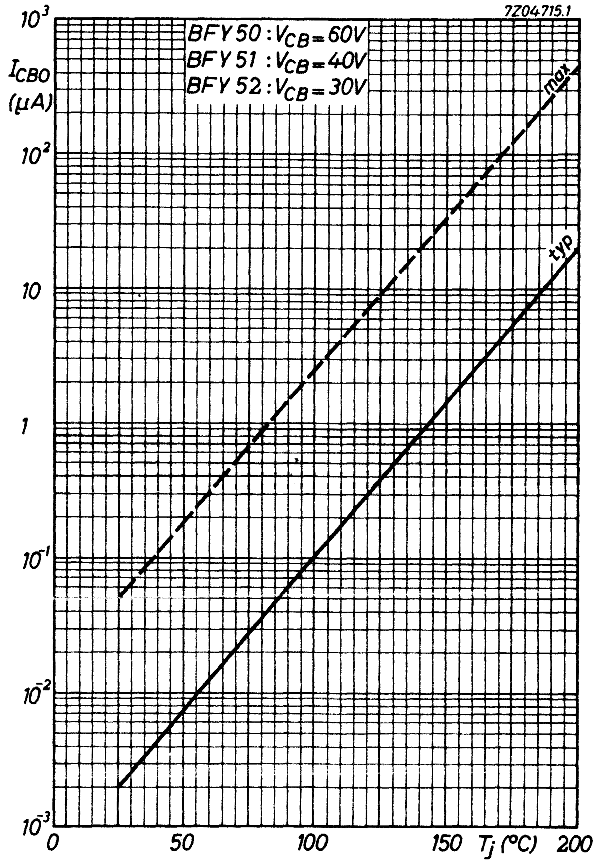

7Z59309
typical behaviour
$\frac{I_C}{I_B} = 10$
V_{BEsat} (V)
2
1.5
1
0.5
0
$I_C = 1000 mA$
500
150
10
-100
-50
0
50
100
150
200
T_j (°C)

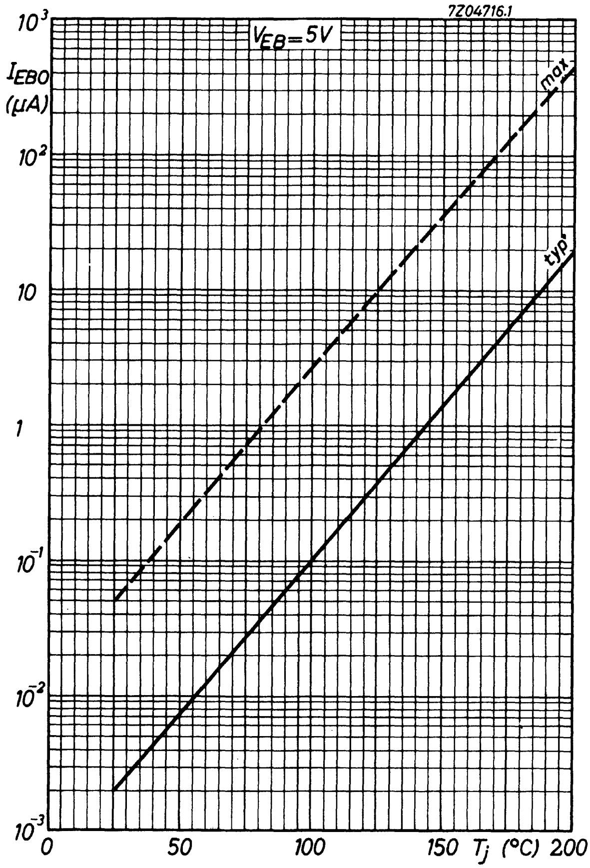


7Z58782
200
100
0
fT
(MHz)
VCE =10V
Tj =25°C
f=35MHz
typical values
BFY52
BFY51
BFY50
1
10
10²
IC (mA)
10³



7Z59312
2
1.5
1
0.5
0
ts
ts at 25°C
+IB = −IBM = 15mA
IC = 150mA
typ
−100
−50
0
50
100
150
Tj (°C)
200


7Z04715.1
BFY 50 : V_{CB} = 60V
BFY 51 : V_{CB} = 40V
BFY 52 : V_{CB} = 30V
I_{CBO} (μA)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
max
typ
0
50
100
150
T_j (°C)
200


7Z04716.1
$V_{EB} = 5V$
I_{EBO} (μA)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
max
typ
0
50
100
150
T_j (°C)
200

SILICON PLANAR EPITAXIAL TRANSISTOR

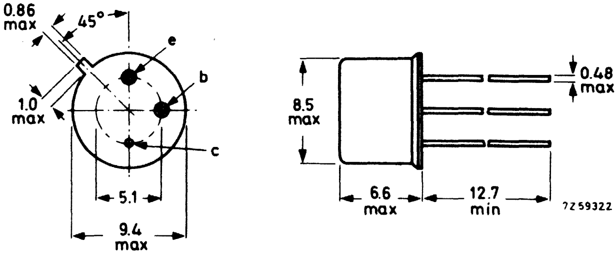
N-P-N transistor in TO-39 metal case with the collector connected to the case. It is primarily intended for use in high frequency and very high frequency oscillators and amplifiers as well as for output stages of servo amplifiers.

QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	80	V
Collector-emitter voltage (open base)	V_{CEO}	max.	35	V
Collector current (d.c.)	I_C	max.	1	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	800	mW
Junction temperature	T_j	max.	200	°C
D.C. current gain at T_j = 25 °C				
I_C = 150 mA; V_{CE} = 10 V	h_{FE}	>	40	
Transition frequency				
I_C = 50 mA; V_{CE} = 10 V	f_T	>	60	MHz
Collector-emitter saturation voltage				
I_C = 1 A; I_B = 100 mA	V_{CEsat}	<	1	V

MECHANICAL DATA Dimensions in mm

Collecter connected to case
TO-39



max.lead diameter is guaranteed only for 12.7 mm

Accessories available: 56218, 56245, 56265

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

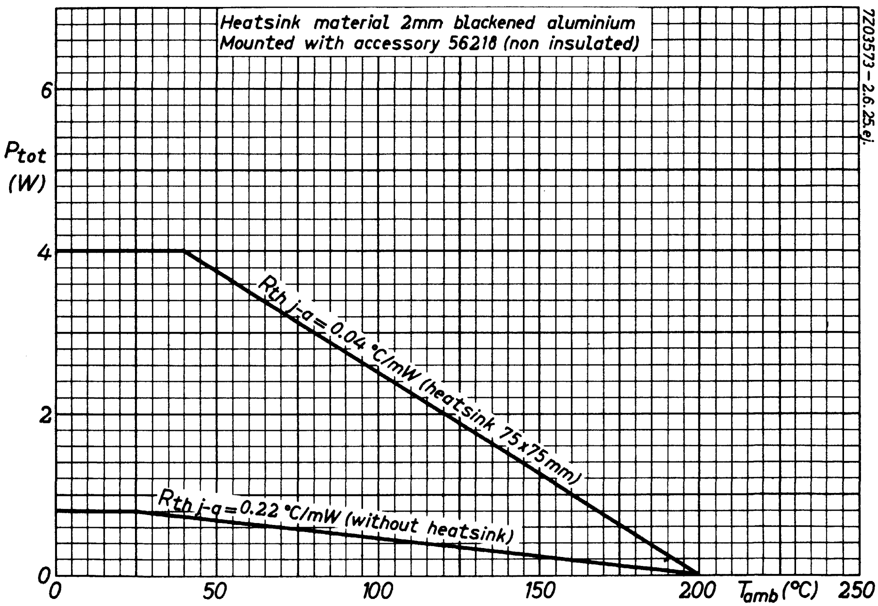
[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

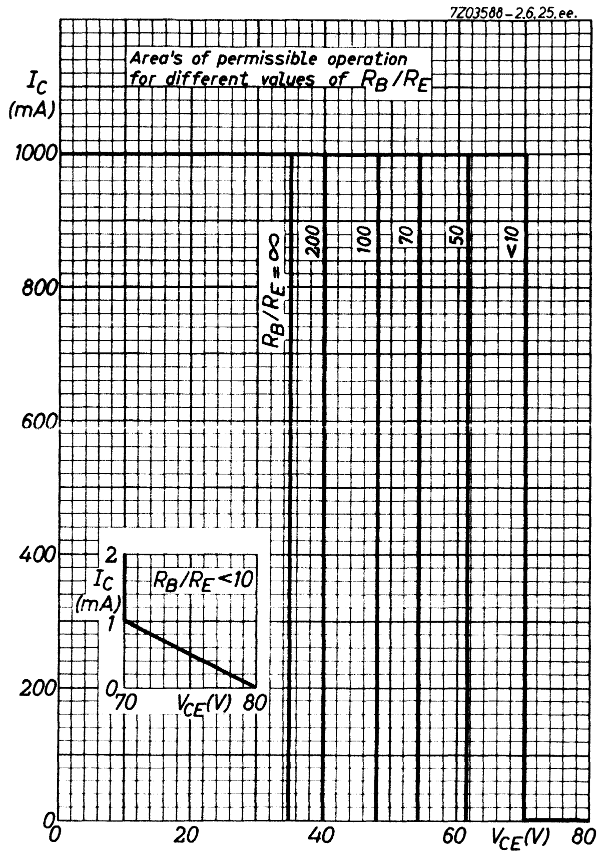
CHARACTERISTICS T_j = 25 °C unless otherwise specified

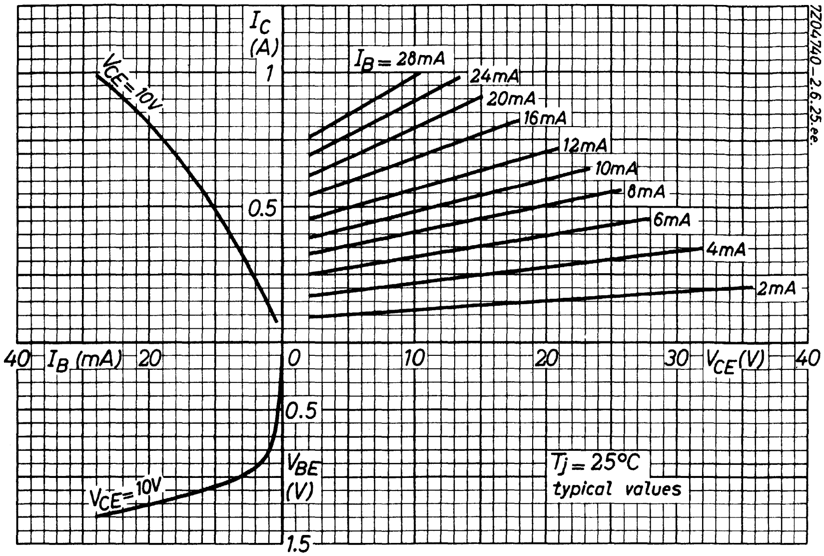
Collector cut-off current				
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	<	10	nA
$I_E = 0$; $V_{CB} = 60$ V; $T_j = 150$ °C	I_{CBO}	<	10	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	nA
Saturation voltages				
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0.2	V
$I_C = 1$ A; $I_B = 100$ mA [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

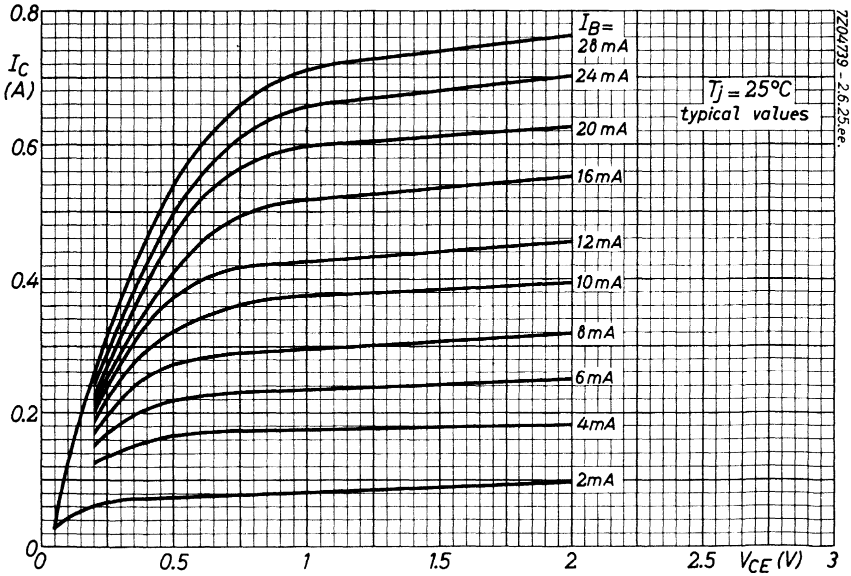
[1]) Measured with a lead length of 1 cm.

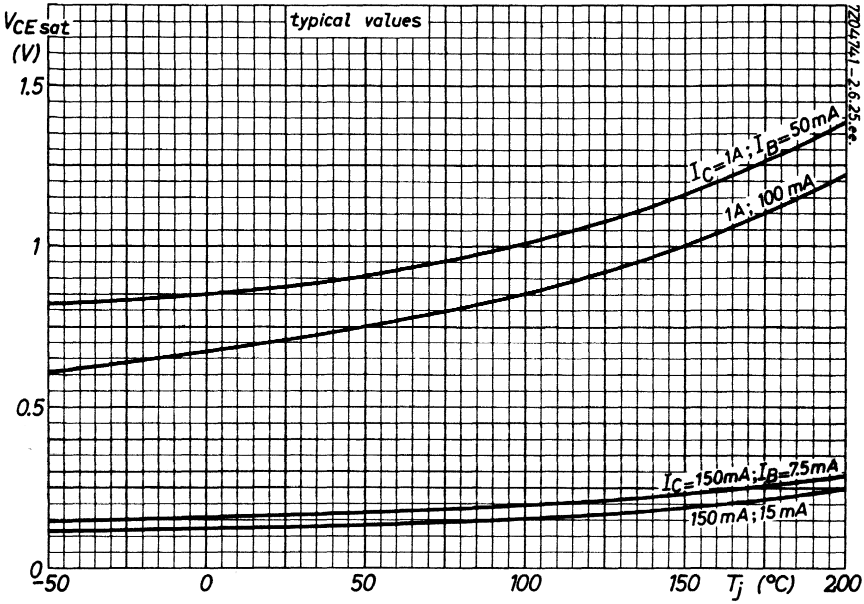
[2]) Measured under pulsed conditions to avoid excessive dissipation.
Pulse duration = 300 μs; duty cycle $\delta < 0.01$


Heatsink material 2mm blackened aluminium
Mounted with accessory 56218 (non insulated)
7Z03573-2.6.25.ej.
Ptot
(W)
6
4
2
0
Rth j-a = 0.04 °C/mW (heatsink 75x75mm)
Rth j-a = 0.22 °C/mW (without heatsink)
0
50
100
150
200
Tamb (°C)
250

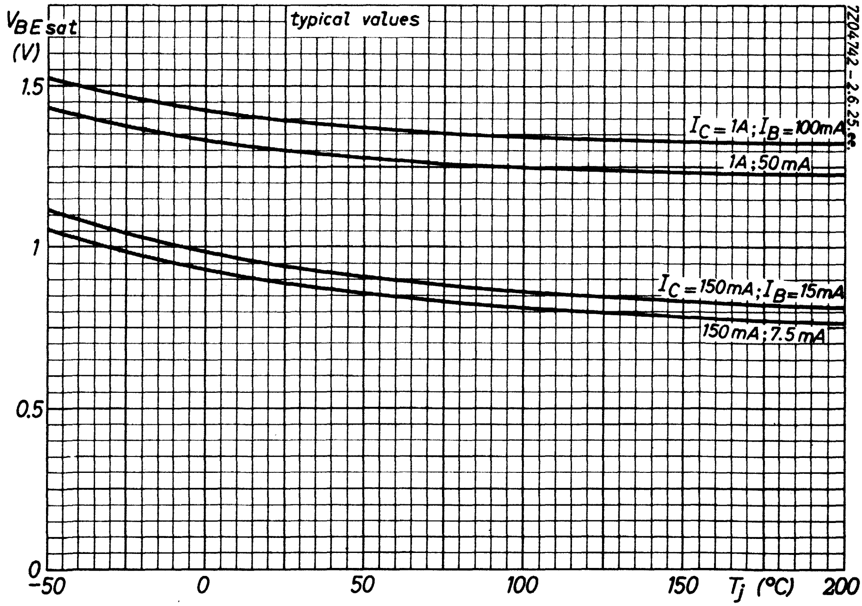

7Z03588-2.6.25.ee.
Area's of permissible operation
for different values of R_B/R_E
I_C (mA)
1000
800
600
400
200
0
$R_B/R_E = \infty$
200
100
70
50
<10
0
20
40
60
V_{CE}(V)
80
2
I_C (mA)
R_B/R_E<10
1
0
70
V_{CE}(V)
80


7Z04740 - 2.6.25.ee.
I_C (A)
1
0.5
V_{CE} = 10V
I_B = 28mA
24mA
20mA
16mA
12mA
10mA
8mA
6mA
4mA
2mA
40
I_B (mA)
20
0
10
20
30
V_{CE} (V)
40
0.5
V_{BE} (V)
1.5
V_{CE} = 10V
T_j = 25°C
typical values

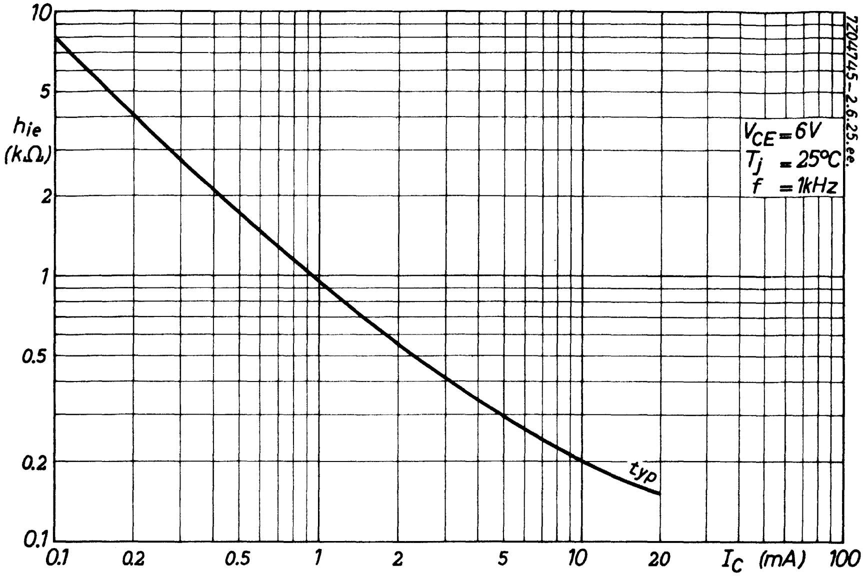

7Z04739 - 2.6.25.ee.
0.8
I_C (A)
0.6
0.4
0.2
0
I_B =
28 mA
24 mA
20 mA
16mA
12mA
10mA
8mA
6mA
4mA
2mA
T_j = 25°C
typical values
0
0.5
1
1.5
2
2.5
V_{CE} (V)
3

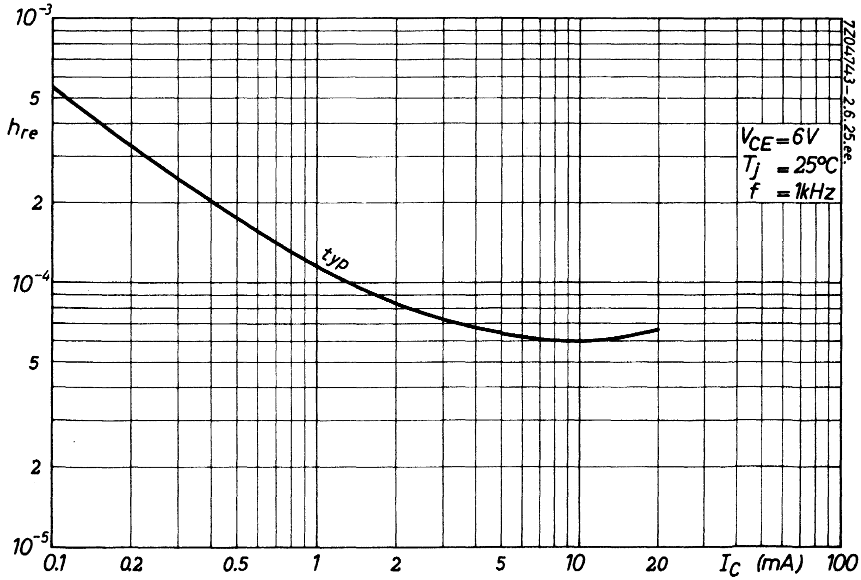


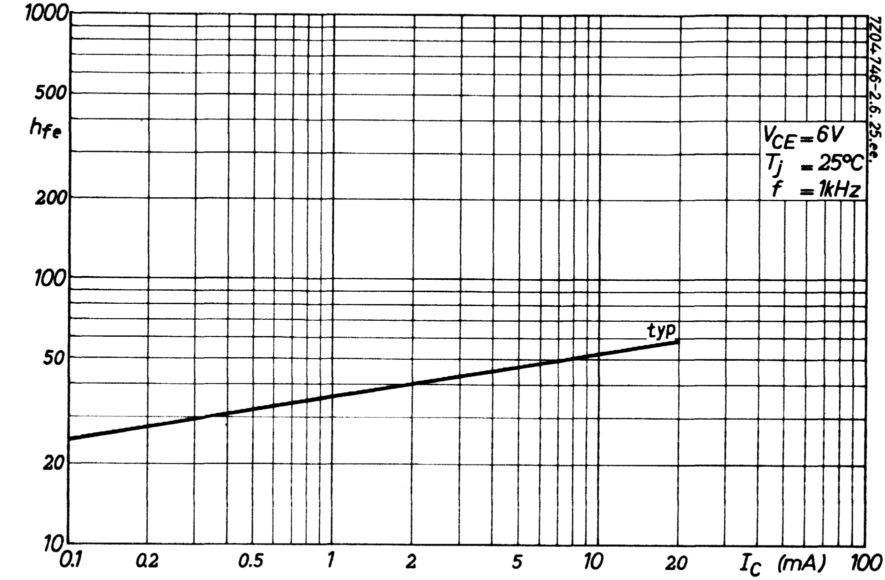
typical values
$V_{CE\,sat}$ (V)
1.5
1
0.5
0
-50
0
50
100
150
200
T_j (°C)
I_C=1A; I_B=50mA
1A; 100 mA
I_C=150mA; I_B=7.5mA
150 mA; 15 mA
7Z04741-2.6.25.ee.

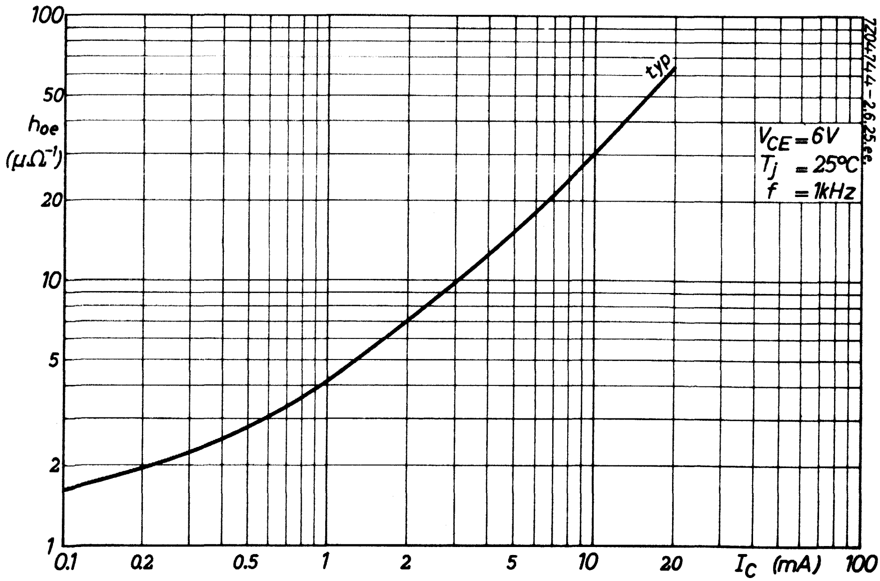


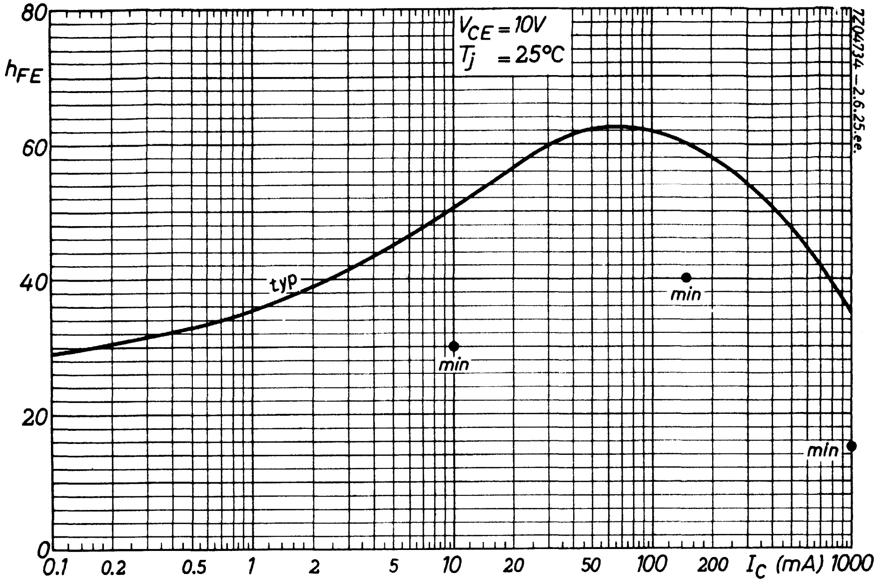
typical values
$V_{BE\,sat}$ (V)
1.5
1
0.5
0
-50
0
50
100
150
200
T_j (°C)
I_C = 1A; I_B=100mA
1A; 50 mA
I_C =150mA; I_B=15mA
150 mA; 7.5 mA
7Z04742-2.6.25.ee.


10
5
h_{ie}
(kΩ)
2
1
0.5
0.2
0.1
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100
typ
V_{CE} = 6V
T_j = 25°C
f = 1kHz
7Z04745–2.6.25.ee.

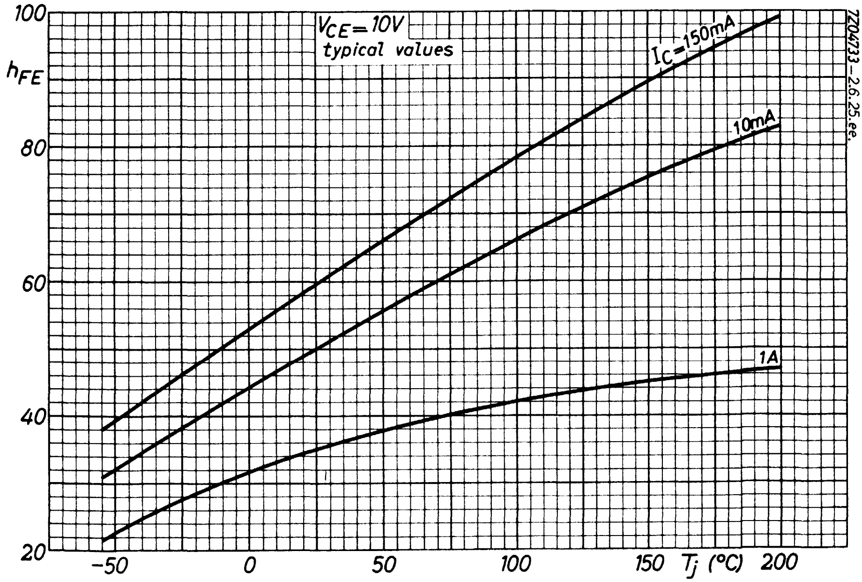

10^{-3}
5
h_{re}
2
10^{-4}
5
2
10^{-5}
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100
typ
V_{CE} = 6V
T_j = 25°C
f = 1kHz
7Z04743–2.6.25.ee.


7Z04746-2.6.25.ee.
1000
500
h_{fe}
200
100
50
20
10
V_{CE} = 6V
T_j = 25°C
f = 1kHz
typ
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100

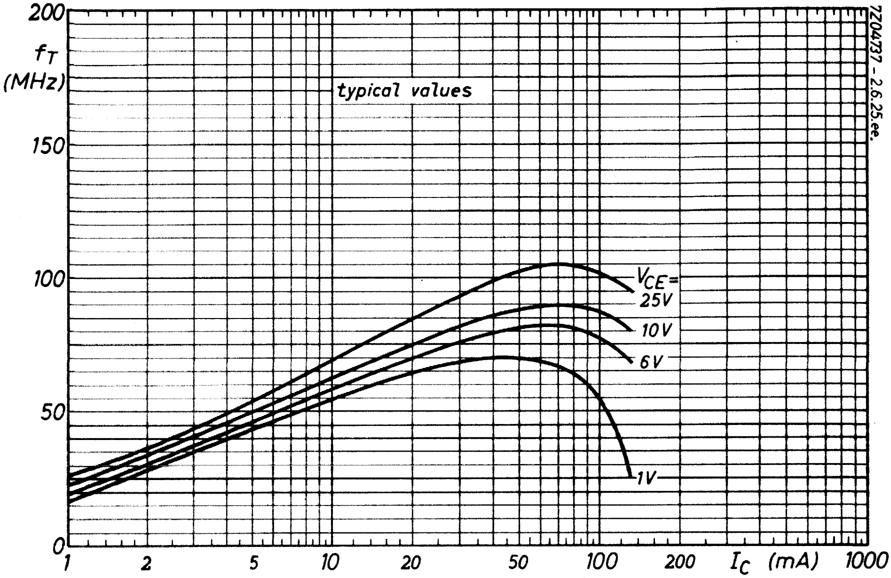

7Z04744-2.6.25.ee.
100
50
h_{oe}
($\mu\Omega^{-1}$)
20
10
5
2
1
V_{CE} = 6V
T_j = 25°C
f = 1kHz
typ
0.1
0.2
0.5
1
2
5
10
20
I_C (mA)
100

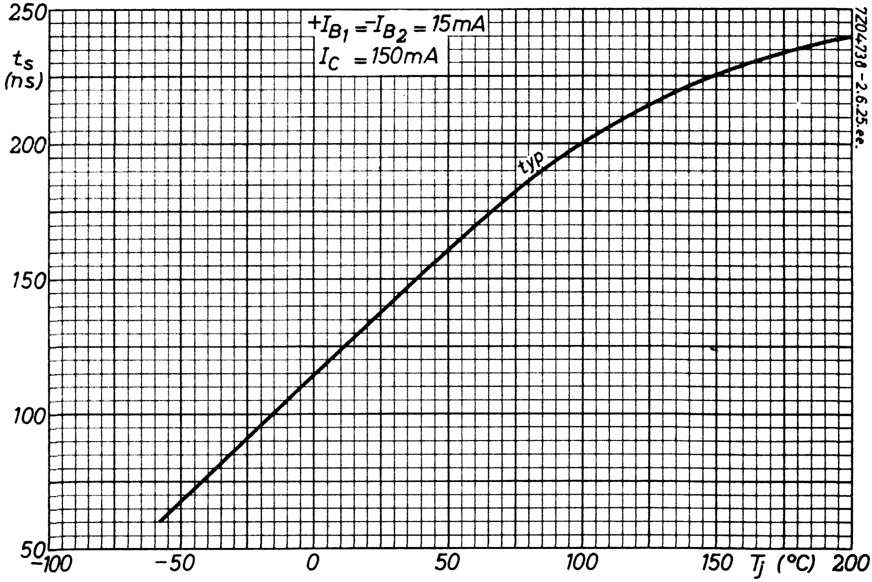


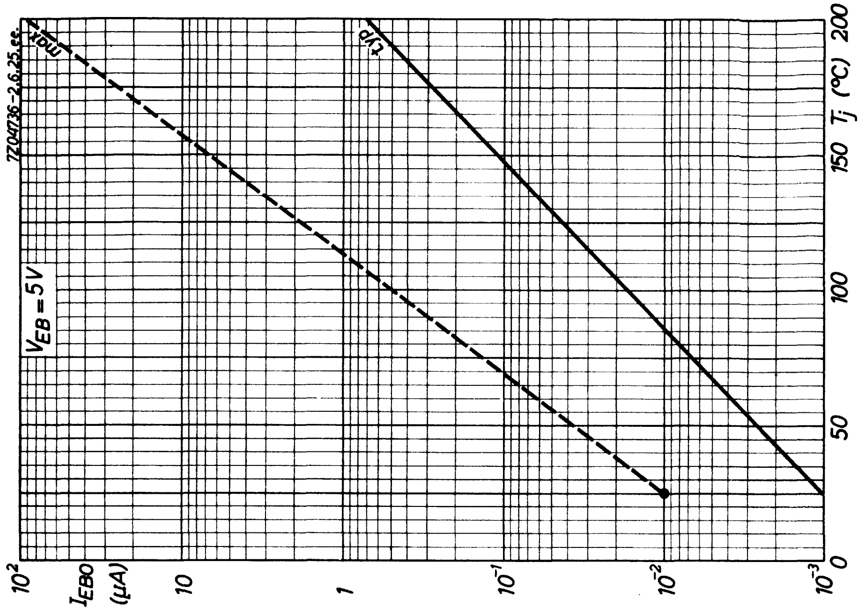
80
60
40
20
0
h_{FE}
V_{CE} = 10V
T_j = 25°C
typ
min
min
min
0.1
0.2
0.5
1
2
5
10
20
50
100
200
I_C (mA)
1000
7Z04734 – 2.6.25.ee.

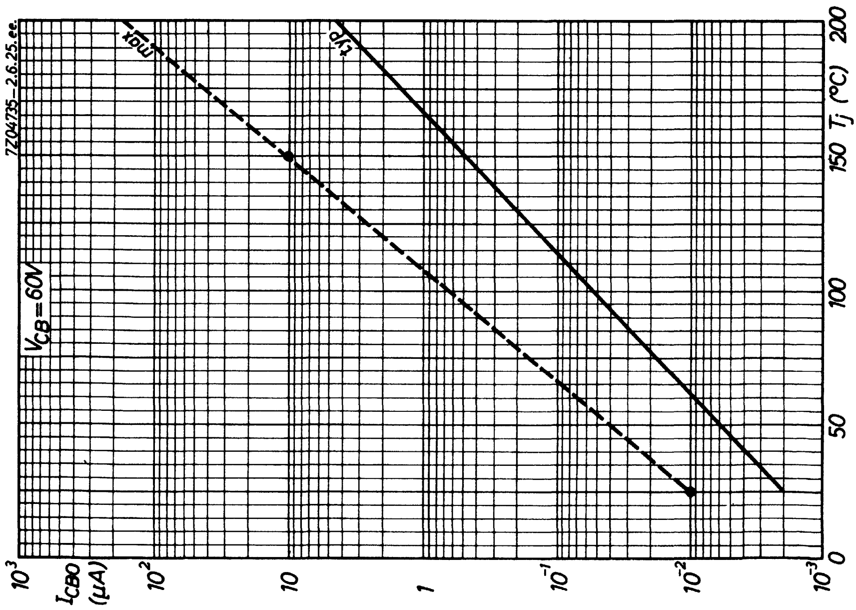


100
80
60
40
20
h_{FE}
V_{CE} = 10V
typical values
I_C = 150mA
10mA
1A
−50
0
50
100
150
T_j (°C)
200
7Z04733 – 2.6.25.ee.


7Z04737 - 2.6.25.ee.
f_T (MHz)
typical values
V_{CE} =
25V
10V
6V
1V
200
150
100
50
0
1
2
5
10
20
50
100
200
I_C (mA)
1000


7Z04738 - 2.6.25.ee.
t_s (ns)
$+I_{B1} = -I_{B2} = 15mA$
$I_C = 150mA$
typ
250
200
150
100
50
-100
-50
0
50
100
150
T_j (°C)
200


7Z04736-2.6.25.ee.
$V_{EB} = 5 V$
max
typ
10^2
I_{EBO} (μA)
10
1
10^{-1}
10^{-2}
10^{-3}
0
50
100
150
200
T_j (°C)


7Z04735-2.6.25.ee.
$V_{CB} = 60 V$
max
typ
10^3
I_{CBO} (μA)
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

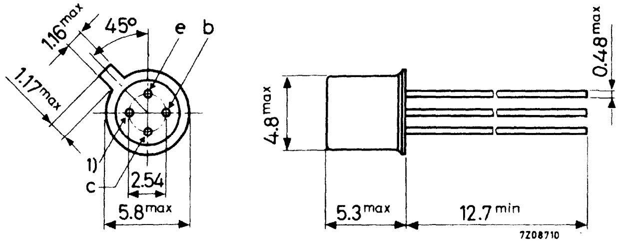
It is also suitable for military- and industrial applications, such as:
- R.F. amplifiers and mixers for communication equipment
- **Microwave telephony link systems, wide band i.f. amplifiers**
- Large bandwidth radar i.f. amplifiers

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 Dimensions in mm

TO-72
insulated electrodes



1) = shield lead (connected to case)

Accessories available: 56246; 56263

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter; peak value)	V_{CBOM}	max.	30	V	
Collector-emitter voltage (peak value) $R_{BE} \leq 50\ \Omega$	V_{CERM}	max.	30	V	2)
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V	2)
Emitter-base voltage (open collector)	V_{EBO}	max.	2.5	V	

Currents

Collector current (d.c.)	I_C	max.	25	mA
Collector current (peak value; f > 1 MHz)	I_{CM}	max.	50	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	200	mW

Temperatures

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

THERMAL RESISTANCE

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

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

[2]) I_C = 10 mA

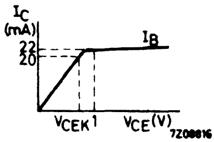
CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

I_E = 0; V_{CB} = 15 V	I_{CBO}	<	10	nA

Knee voltage

I_C = 20 mA; I_B = value for which I_C = 22 mA at V_{CE} = 1 V	V_{CEK}	<	0.75	V



D.C. current gain

I_C = 2 mA; V_{CE} = 1 V	h_{FE}	25 to 150
I_C = 25 mA; V_{CE} = 1 V	h_{FE}	20 to 125

Transition frequency [1]

I_C = 2 mA; V_{CE} = 5 V; f = 500 MHz	f_T	>	1.0	GHz
		typ.	1.1	GHz
I_C = 25 mA; V_{CE} = 5 V; f = 500 MHz	f_T	>	1.3	GHz
		typ.	1.4	GHz

Collector capacitance at f = 1 MHz [2]

I_E = I_e = 0; V_{CB} = 10 V	C_c	<	1.5	pF

Feedback capacitance at f = 1 MHz [1]

I_C = 2 mA; V_{CE} = 5 V	$-C_{re}$	typ.	0.6	pF
		<	0.8	pF

Noise figure [1]

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

f = 100 kHz; optimum source resistance	F	<	4	dB
f = 200 MHz; optimum source impedance	F	<	3.5	dB
f = 500 MHz; R_S = 50 Ω	F	<	5	dB
f = 800 MHz; optimum source impedance	F	typ.	5.5	dB

Power gain (not neutralized) [1]

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

		f = 200	800	MHz
G_p	>	21		dB
	typ.	23	8	dB

1) Shield lead grounded.

2) Shield lead not connected.

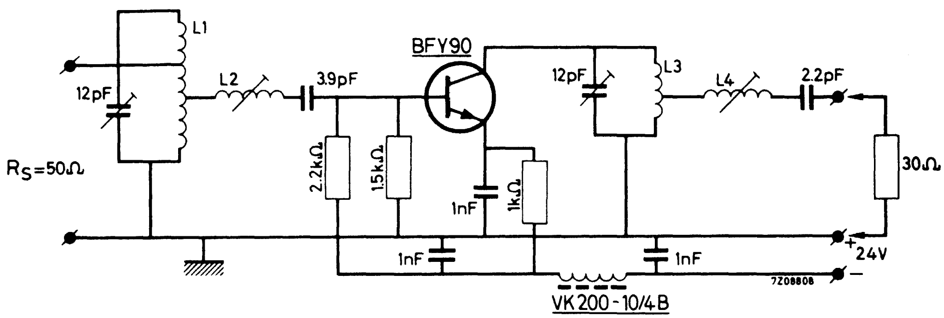
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Intermodulation characteristics [1])

1. Output power at f = 200 MHz; T_{amb} = 25 °C

I_C = 14 mA; V_{CE} = 10 V; V.S.W.R. at output < 2
f_p = 202 MHz; f_q = 205 MHz; d_{im} = −30 dB
measured at $f_{(2q-p)}$ = 208 MHz (Channel 9) P_o > 10 mW, typ. 12 mW

Test circuit:



Coil data:

L1 = 3 turns silver plated Cu wire (1.4 mm); winding pitch 2.7 mm;
int. diam. 8 mm; taps at 0.5 turn and 1.5 turns from earth.
L2 = 5.5 turns silver plated Cu wire (1.4 mm); winding pitch 2.2 mm;
int. diam. 8 mm.
L3 = 3 turns silver plated Cu wire (1.4 mm); winding pitch 3.3 mm;
int. diam. 8 mm.
L4 = 5.5 turns silver plated Cu wire (1.4 mm); winding pitch 2.2 mm;
int. diam. 11 mm.

[1]) Shield lead grounded

CHARACTERISTICS (continued)

Basis of adjustment

The intermodulation at an intermodulation distortion of −30 dB is caused by h.f. output current - voltage clipping.
The maximum undistorted output power is realised, if

a. Current and voltage clipping take place concurrently.
   This occurs if

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

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

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

For maximum output power at an intermodulation distortion of −30 dB, the (experimentally found) values of R_L and C_L are:
$R_L = 560\ \Omega$; $C_L = -1.8$ pF

Adjustment procedure

1. Remove the transistor and connect a dummy consisting of a 560 Ω resistor in parallel with a 1.8 pF capacitor between the collector and emitter connections of the output circuit.
2. Tune and match the output circuit for zero reflection at 205 MHz (V.S.W.R. = 1). After this adjustment, no further change may be made in the output circuit.
3. Replace the dummy by the transistor. Tune and match the input circuit for maximum power gain and good band pass curve.
   The V.S.W.R. of the output will then, in most cases, be ≤ 2 over the whole channel.
   Corrections can be made by tuning L2; this will not disturb the band pass curve.

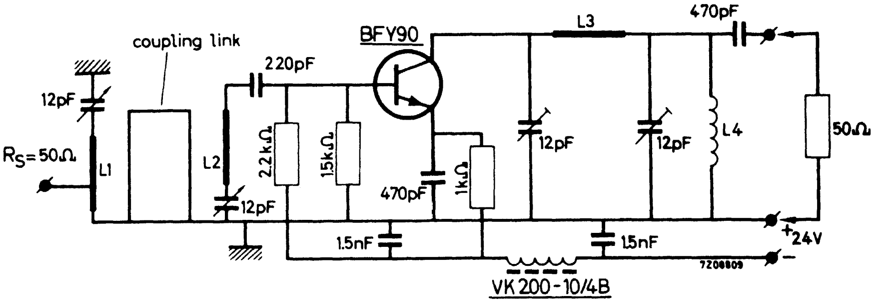
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Intermodulation characteristics [1]

2. Output power at f = 800 MHz; T_{amb} = 25 °C

   I_C = 14 mA; V_{CE} = 10 V; V.S.W.R. at output < 2
   f_p = 798 MHz; f_q = 802 MHz; d_{im} = −30 dB
   measured at $f_{(2q-p)}$ = 806 MHz (Channel 62) P_o typ. 12 mW

   Test circuit:



   Coil data:
   L1 = 24 mm x 6 mm x 0.5 mm silver plated Cu strip.
   Tap of the input at 5 mm from earth.
   L2 = 15 mm x 6 mm x 0.5 mm silver plated Cu strip.
   L3 = 20 mm x 8 mm x 0.5 mm silver plated Cu strip.
   L4 = 4 turns enamelled Cu wire (0.5 mm); winding pitch 1.5 mm; int. diam. 4 mm
   Coupling link: 42 mm silver plated Cu wire (1 mm).

Basis of adjustment.

At 800 MHz no dummy can be used to adjust for optimum collector load because at these frequencies the impedance transformations of a dummy are too high. A small signal at the mid-channel frequency of 802 MHz is fed to the input and increased until clipping occurs; that is, until the output power no longer increases linearily with the input signal. This clipping can be eliminated by tuning the output circuit, thereby making the output power equal to

$$P_o = \frac{I_C\,(V_{CE} - V_{CEK})}{2} = 60\ \text{mW}$$

The output circuit is adjusted for minimum intermodulation if the input signal is as small as possible at P_o = 60 mW.
After this adjustment has been made no further change may be made in the output circuit.
Adjust the input circuit for maximum power gain and good band pass curve.
The V.S.W.R. of the output is then ≤ 2 over the whole channel.

[1]) Shield lead grounded

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

Intermodulation characteristics [1])

3. Intermodulation distortion

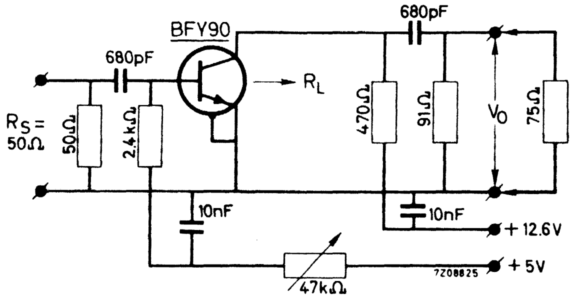
I_C = 14 mA; V_{CE} = 6 V; R_L = 37.5 Ω; T_{amb} = 25 °C

V_o = 100 mV at f_p = 183 MHz

V_o = 100 mV at f_q = 200 MHz

measured at $f_{(2q-p)}$ = 217 MHz	d_{im}	typ.	−50	dB

Test circuit:



y parameters at f = 500 MHz (common emitter) [1])

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

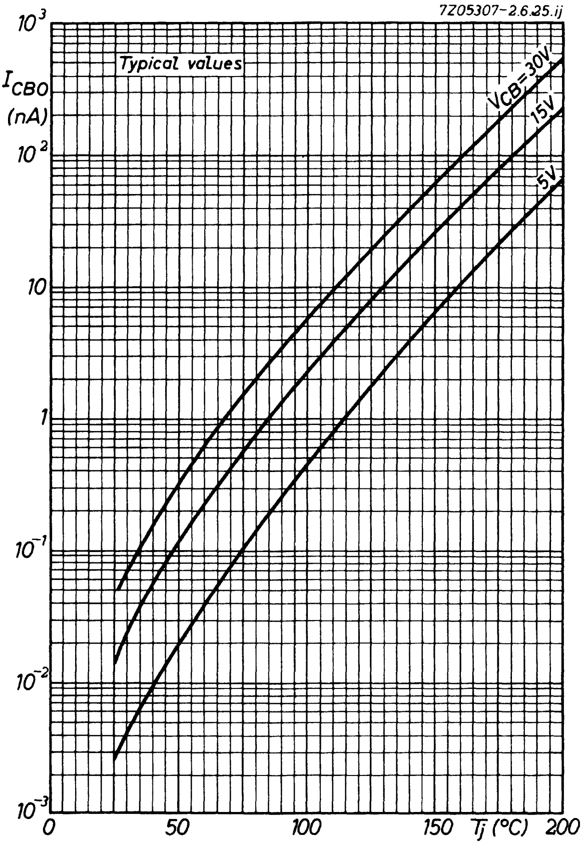
Input conductance	g_{ie}	typ.	16	$m\Omega^{-1}$
Input capacitance	C_{ie}	typ.	3.75	pF
Feedback admittance	$\lvert y_{re}\rvert$	typ.	1.55	$m\Omega^{-1}$
Phase angle of feedback admittance	φ_{re}	typ.	258°	
Transfer admittance	$\lvert y_{fe}\rvert$	typ.	45	$m\Omega^{-1}$
Phase angle of transfer admittance	φ_{fe}	typ.	285°	
Output conductance	g_{oe}	typ.	0.19	$m\Omega^{-1}$
Output capacitance	C_{oe}	typ.	1.9	pF

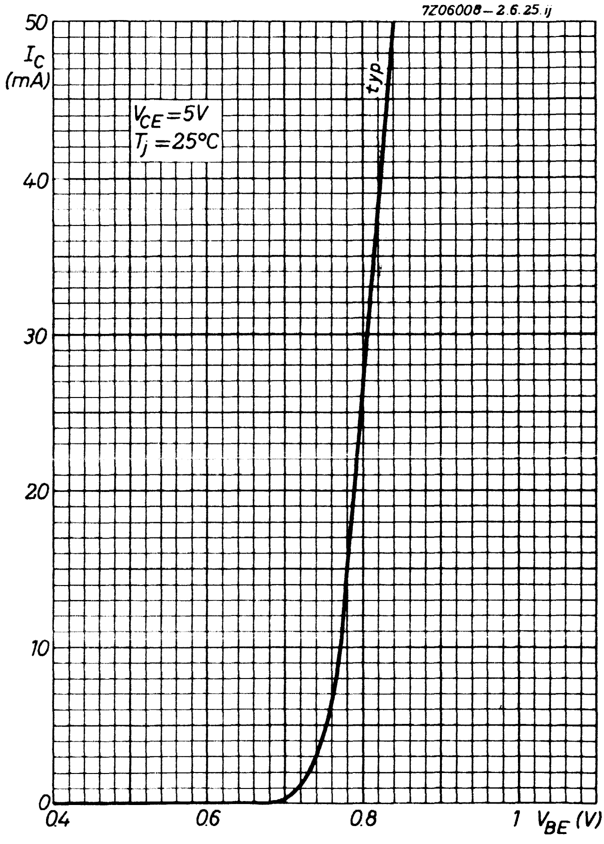
Maximum unilateralised power gain

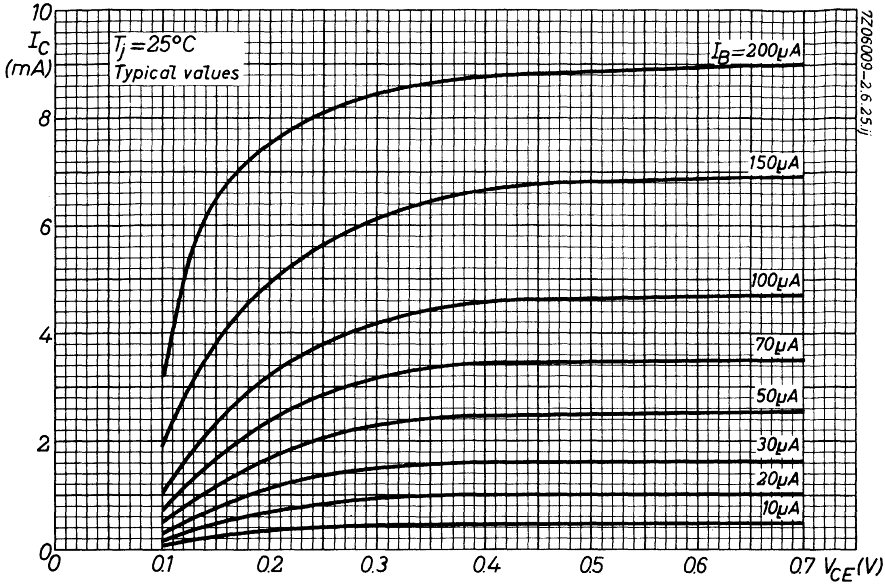
$$G_{UM} = \frac{|y_{fe}|^2}{4 g_{ie} g_{oe}}$$

I_C = 2 mA; V_{CE} = 5 V; f = 500 MHz	G_{UM}	typ.	22	dB

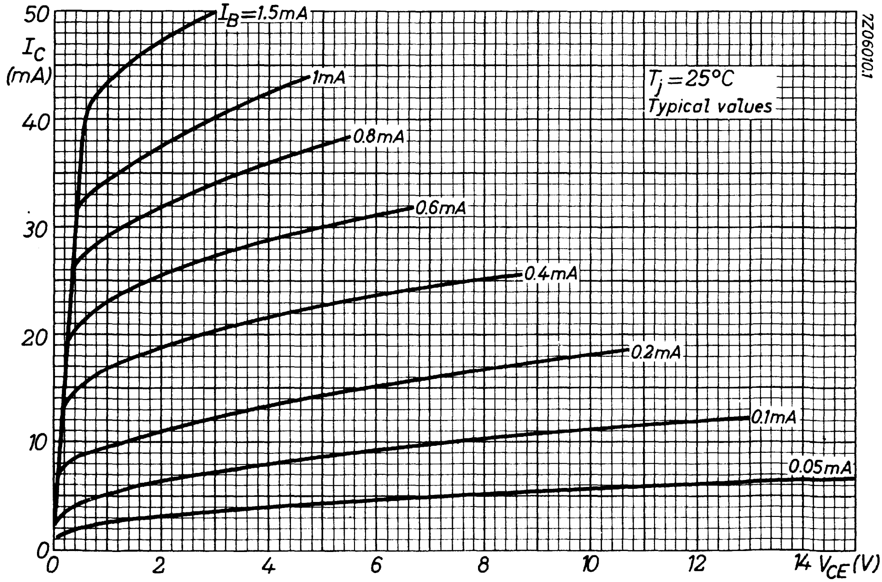
[1]) Shield lead grounded


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

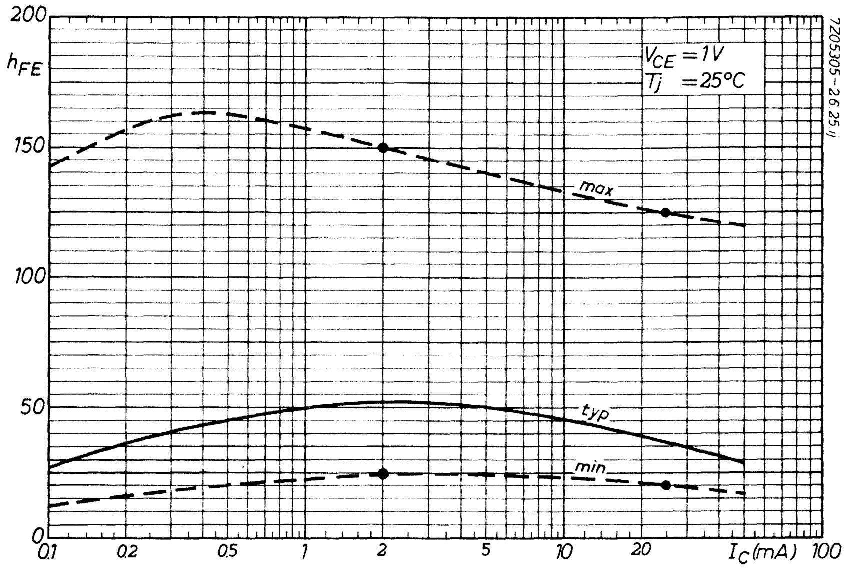

7Z06008 – 2.6.25.ij
50
I_C
(mA)
V_{CE} = 5V
T_j = 25°C
typ
40
30
20
10
0
0.4
0.6
0.8
1
V_{BE} (V)

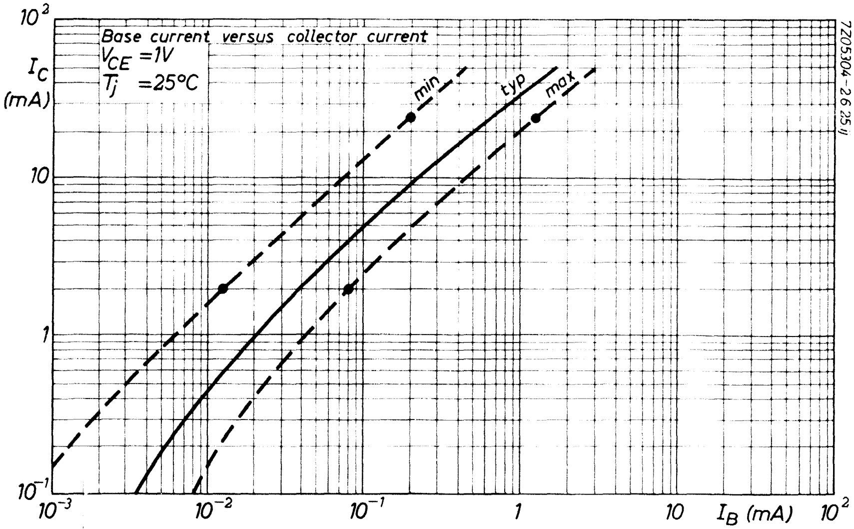


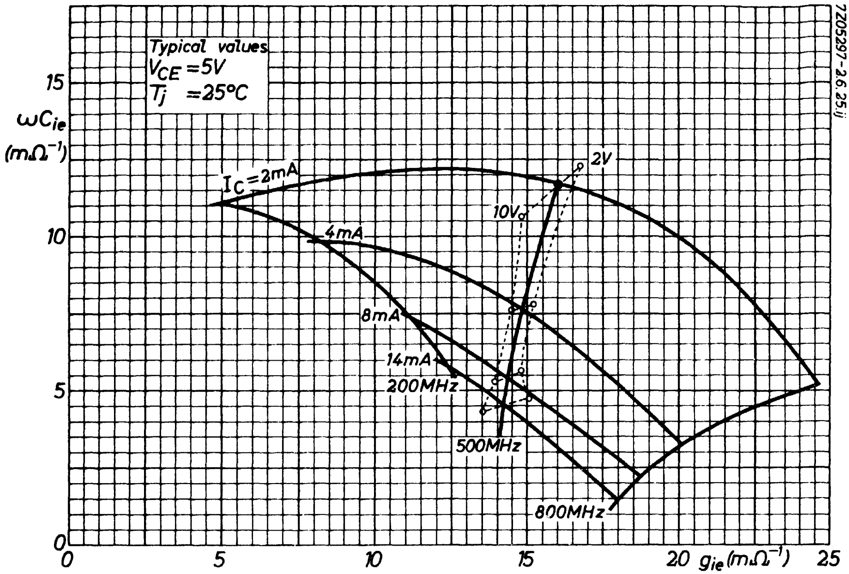
10
I_C
(mA)
8
6
4
2
0
$T_j = 25°C$
Typical values
$I_B = 200 \mu A$
150μA
100μA
70μA
50μA
30μA
20μA
10μA
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7 V_{CE}(V)
7Z06009-2.6.25.ij



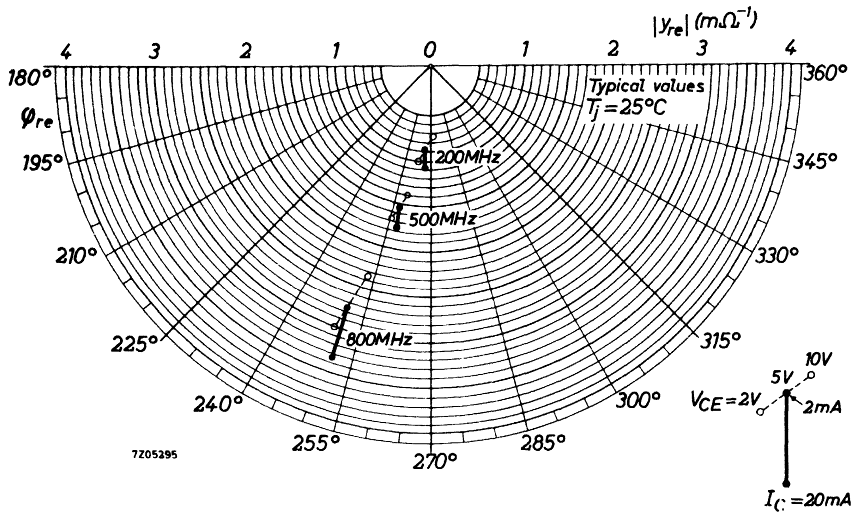
50
I_C
(mA)
40
30
20
10
0
$I_B = 1.5 mA$
1mA
0.8mA
0.6mA
0.4mA
0.2mA
0.1mA
0.05mA
$T_j = 25°C$
Typical values
0
2
4
6
8
10
12
14 V_{CE}(V)
7Z06010.1


7Z05305-2 6 25 ij
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

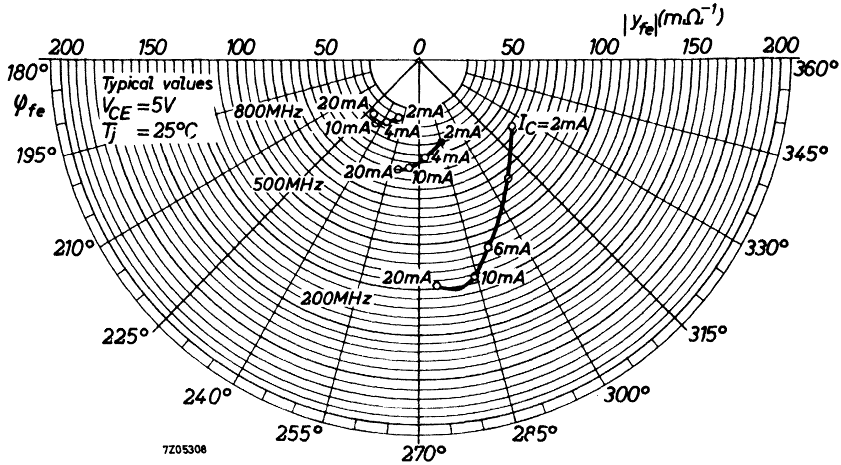

7Z05304-2 6 25 ij
Base current versus collector current
V_{CE} = 1V
T_j = 25°C
I_C (mA)
10^2
10
1
10^{-1}
min
typ
max
10^{-3}
10^{-2}
10^{-1}
1
10
I_B (mA)
10^2



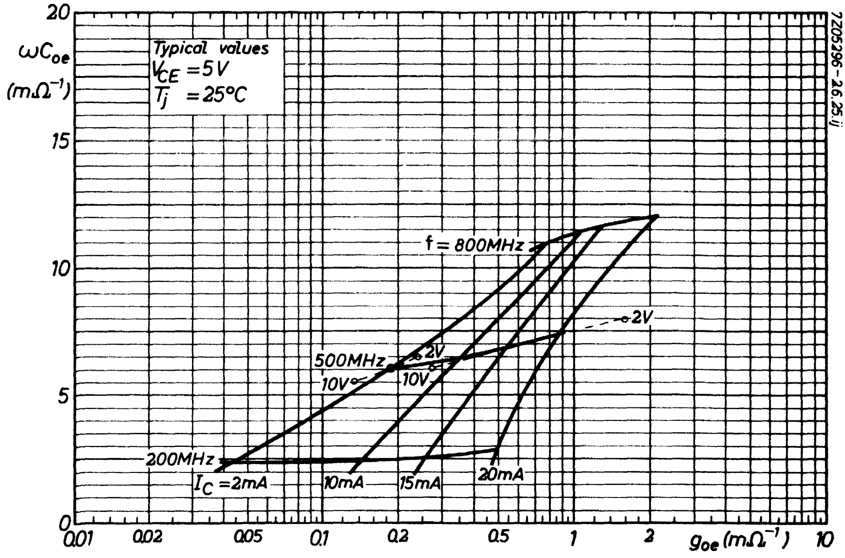
Typical values
V_{CE} = 5V
T_j = 25°C
ωC_{ie} ($m\Omega^{-1}$)
g_{ie} ($m\Omega^{-1}$)
I_C = 2mA
4mA
8mA
14mA
200MHz
500MHz
800MHz
2V
10V
0
5
10
15
20
25
7Z05297-2.6.25.(j)



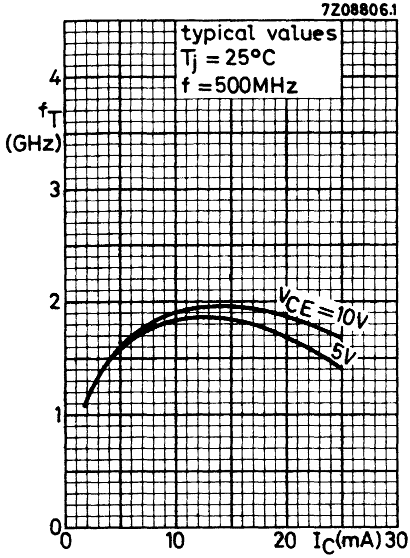
$|y_{re}|$ ($m\Omega^{-1}$)
4
3
2
1
0
180°
φ_{re}
195°
210°
225°
240°
255°
270°
285°
300°
315°
330°
345°
360°
Typical values
T_j = 25°C
200MHz
500MHz
800MHz
10V
5V
V_{CE} = 2V
2mA
I_C = 20mA
7Z05295

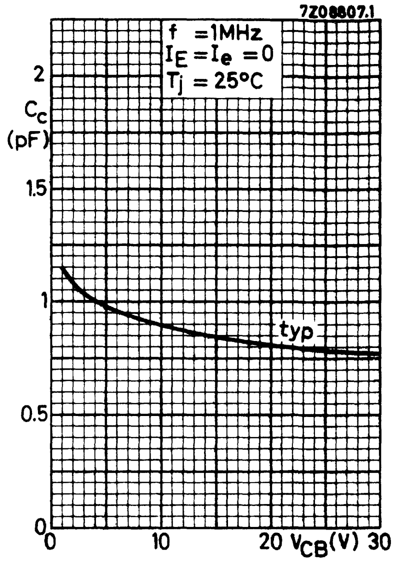


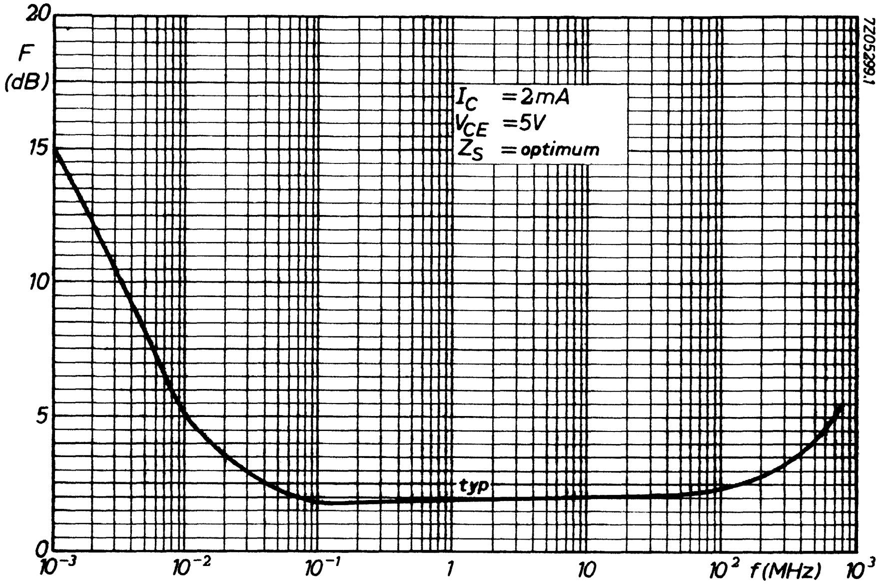
|yfe|(mΩ⁻¹)
200 150 100 50 0 50 100 150 200
180°
φfe
195°
210°
225°
240°
255°
270°
285°
300°
315°
330°
345°
360°
Typical values
VCE = 5V
Tj = 25°C
800MHz
500MHz
200MHz
20mA
10mA
2mA
4mA
10mA
IC = 2mA
6mA
7Z05308

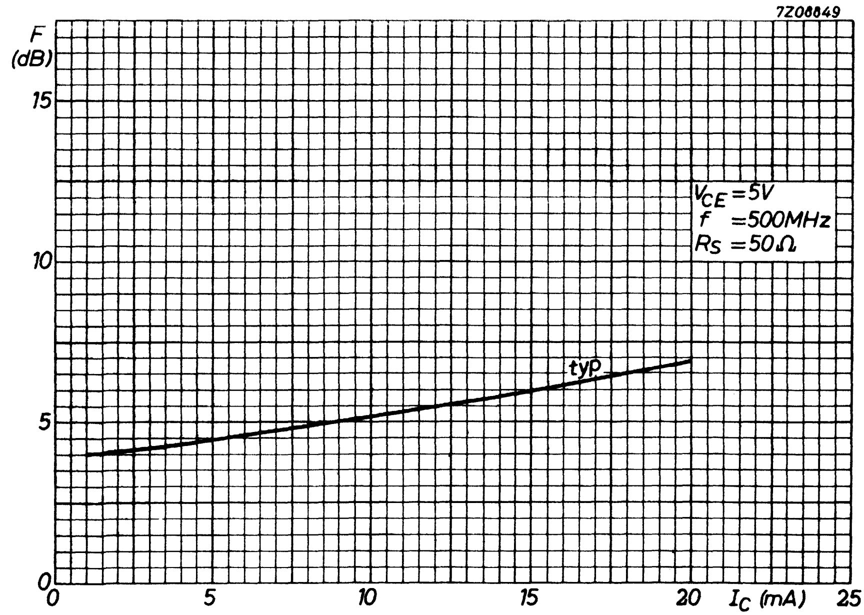


ωCoe
(mΩ⁻¹)
Typical values
VCE = 5V
Tj = 25°C
f = 800MHz
500MHz
200MHz
2V
10V
IC = 2mA
10mA
15mA
20mA
goe (mΩ⁻¹)
0 5 10 15 20
0.01 0.02 0.05 0.1 0.2 0.5 1 2 10
7Z05296-26.25.ii


7Z08806.1
typical values
$T_j = 25°C$
f = 500MHz
f_T
(GHz)
4
3
2
1
0
$V_{CE} = 10V$
5V
0
10
20
I_C(mA)
30


7Z08807.1
f = 1MHz
$I_E = I_e = 0$
$T_j = 25°C$
C_c
(pF)
2
1.5
1
0.5
0
typ
0
10
20
V_{CB}(V)
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]

	Channel 9			Channel 55	Band II	Band III	
Frequency range	202-209			742-750	87.5-108	174-230	MHz
Transistor used in							
final stage	BFW16	BFW16	BFY90	BFW16	BFW16	BFW16	
driver stage	BFW16	BFY90	BF183	BFW16		BFW16	
second stage				BFY90			
first stage	BFY90	BF200	BF200	BFY90	BFY90	BFY90	
Output power at							
d_{im} = −30 dB	150[2]	60	10	80			mW
d_{im} = −50 dB					25		mW
d_{im} = −60 dB						10	mW
Power gain	44	48	49	30	42.5	39	dB
Noise figure	6.3	5.7	5.5	7	6.0-6.5	6.2-6.7	dB
V.S.W.R. over the whole channel or band							
for the input	< 2	< 2	< 2	< 2	< 2	< 2	
for the output	< 2	< 2	< 2	< 2	< 2	< 2	
Load impedance	30	30	30	50	30	30	Ω
Source impedance	60	60	60	50	60	60	Ω

[1] Application information bulletins with detailed informations of all these amplifiers and a study of intermodulation are available on request.

[2] V_o = 2.2 V over R_L = 30 Ω or
V_o = 3 V over R_L = 60 Ω.

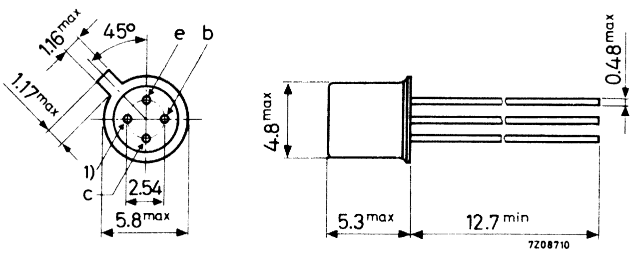
SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in TO-72 metal envelope with insulated electrodes and a shield lead connected to the case. The 2N918 is primarily intended for low power amplifiers and oscillators in the v.h.f. and u.h.f. ranges for industrial service.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector current (d.c.)	I_C	max.	50	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	200	mW
Junction temperature	T_j	max.	200	°C
Transition frequency I_C = 6 mA; V_{CE} = 10 V	f_T	>	900	MHz
Maximum unilaterised power gain I_C = 6 mA; V_{CE} = 12 V; f = 200 MHz	G_{UM}	typ.	36	dB
Noise figure at f = 60 MHz I_C = 1 mA; V_{CE} = 6 V; R_S = 400 Ω	F	<	6	dB

MECHANICAL DATA Dimensions in mm

TO-72
Insulated electrodes



1) = shield lead (connected to case)

Accessories available: 56246, 56263

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

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base) I_C = 3 mA	V_{CEO}	max.	15	V
Emitter-base voltage (open collector)	V_{EBO}	max.	3	V

Currents

Collector current (d.c.)	I_C	max.	50	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	200	mW

Temperatures

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

THERMAL RESISTANCE

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

CHARACTERISTICS T_j = 25 °C unless otherwise specified
All measurements taken with ungrounded shield lead

Collector cut-off current

$I_E = 0$; $V_{CB} = 15$ V	I_{CBO}	<	10	nA
$I_E = 0$; $V_{CB} = 15$ V; $T_j = 150$ °C	I_{CBO}	<	1	μA

Saturation voltages

$I_C = 10$ mA; $I_B = 1$ mA	V_{CEsat}	<	0.4	V
	V_{BEsat}	<	1	V

D.C. current gain

$I_C = 3$ mA; $V_{CE} = 1$ V	h_{FE}	>	20	

Collector capacitance at f = 140 kHz

$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	1.7	pF
$I_E = I_e = 0$; $V_{CB} = 0$	C_c	<	3.0	pF

Emitter capacitance at f = 140 kHz

$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	<	2.0	pF

Transition frequency

$I_C = 6$ mA; $V_{CE} = 10$ V [1]	f_T	>	900	MHz

Noise figure at f = 60 MHz

$I_C = 1$ mA; $V_{CE} = 6$ V; $R_S = 400\ \Omega$	F	<	6	dB

Oscillator power output at f = 500 MHz

$-I_E = 8$ mA; $V_{CB} = 15$ V	P_o	>	30	mW

Maximum unilateralised power gain

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

$I_C = 6$ 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.

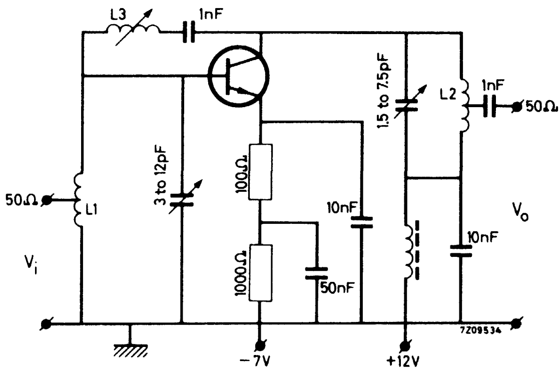
CHARACTERISTICS (continued) $T_j = 25\ ^{o}C$

Available power gain at f = 200 MHz

I_C = 6 mA	G_p	> 15	dB

Basic circuit for measuring the available neutralised power gain

Grounded shield lead



L1 = 3.5 turns tinned Cu wire, 1.3 mm
d = 8 mm; length = 11 mm

Tap at ≈ 2 turns from earth side

L2 = 8 turns tinned Cu wire, 1.3 mm
d = 3 mm; length = 22 mm

Tap at 1 turn from earth side

L3 = 0.4 to 0.65 μH

SILICON PLANAR TRANSISTOR

N-P-N double diffused transistor in a TO-39 metal envelope with the collector connected to the case. The 2N1613 is intended for use in a wide variety of applications, such as d.c. and high frequency amplifiers and switching applications.

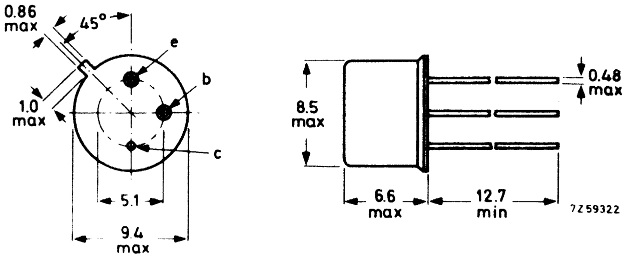
QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	75	V
Collector-emitter voltage ($R_{BE} < 10\,\Omega$)	V_{CER}	max.	50	V
Collector current (peak value)	I_{CM}	max.	1	A
Total power dissipation up to $T_{amb} = 25\,^{o}C$	P_{tot}	max.	0.8	W
Junction temperature	T_j	max.	200	^{o}C
D.C. current gain				
$I_C = 0.1$ mA; $V_{CE} = 10$ V	h_{FE}	>	20	
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	35	
$I_C = 150$ mA; $V_{CE} = 10$ V	h_{FE}		40 to 120	
Transition frequency				
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	>	60	MHz

MECHANICAL DATA

Dimensions in mm

Collector connected to case

TO-39



max. lead diameter is guaranteed only for 12.7 mm

Accessories available: 56218, 56245, 56265.

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; $R_{BE} < 10$ Ω	$V_{CERsust}$	>	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 μs, duty cycle $\delta < 0.01$

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

Transition frequency				
I_C = 50 mA; V_{CE} = 10 V	f_T	>	60	MHz
Collector capacitance at f = 1 MHz				
I_E = I_e = 0; V_{CB} = 10 V	C_c	<	25	pF
Emitter capacitance at f = 1 MHz				
I_C = I_c = 0; V_{EB} = 0.5 V	C_e	<	80	pF
Noise figure at f = 1 kHz				
I_C = 0.3 mA; V_{CE} = 10 V R_S = 510 Ω; Bandwidth: 200 Hz	F	<	12	dB

SILICON PLANAR TRANSISTOR

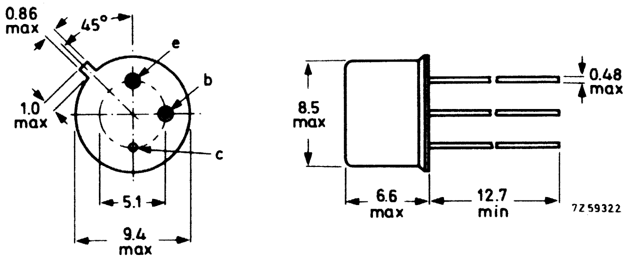
N-P-N double diffused transistor in a TO-39 metal envelope with the collector connected to the case. The 2N1711 is intended for use in a wide variety of applications, such as d.c. and high frequency amplifiers and switching applications.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	75	V
Collector-emitter voltage ($R_{BE} < 10\,\Omega$)	V_{CER}	max.	50	V
Collector current (peak value)	I_{CM}	max.	1	A
Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	0.8	W
Junction temperature	T_j	max.	200	^oC
D.C. current gain				
$I_C = 0.1$ mA; $V_{CE} = 10$ V	h_{FE}	>	35	
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	75	
$I_C = 150$ mA; $V_{CE} = 10$ V	h_{FE}	100 to 300		
Transition frequency				
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	>	70	MHz

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-39



max. lead diameter is guaranteed only for 12.7 mm

Accessories available: 56218, 56245, 56265.

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	$R_{th\ j-a}$	=	220	°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_{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

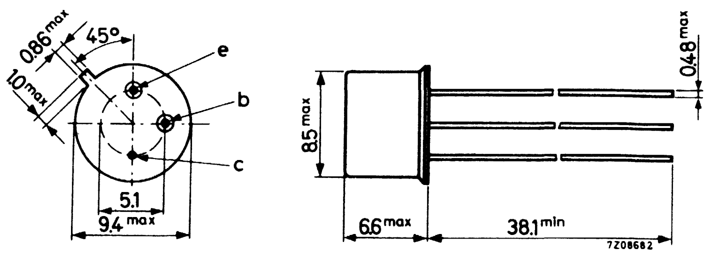
High voltage n-p-n transistor in a TO-5 metal envelope with the collector connected to the case.
It is intended for use in high performance amplifier, oscillator and switching applications.

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-5



Accessories available: 56218, 56245, 56265.

RATINGS (Limiting values) [1]

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	80	V
Collector-emitter voltage ($R_{BE} \leq 10\ \Omega$)	V_{CER}	max.	100	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7.0	V

Current

Collector current (d.c.)	I_C	max.	500	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.8	W
up to T_{case} = 100 °C	P_{tot}	max.	1.7	W
up to T_{case} = 25 °C	P_{tot}	max.	3.0	W

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	219	°C/W
From junction to case	$R_{th\ j-c}$	=	58.3	°C/W

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

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

Collector cut-off current				
$I_E = 0$; $V_{CB} = 90$ V	I_{CBO}	<	10	nA
$I_E = 0$; $V_{CB} = 90$ V; $T_{amb} = 150$ °C	I_{CBO}	<	15	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	nA
Collector-emitter sustaining voltage [1]				
$I_C = 100$ mA; $R_{BE} \geq 10\ \Omega$	$V_{CER\ sust}$	>	100	V
$I_C = 30$ mA; $I_B = 0$	$V_{CEO\ sust}$	>	80	V
Saturation voltages [1]				
$I_C = 150$ mA; $I_B = 15$ mA	$V_{CE\ sat}$	<	5.0	V
	$V_{BE\ sat}$	<	1.3	V
$I_C = 50$ mA; $I_B = 5$ mA	$V_{CE\ sat}$	<	1.2	V
	$V_{BE\ sat}$	<	0.9	V
Breakdown voltages				
$I_E = 0$; $I_C = 100$ μA	$V_{(BR)\ CBO}$	>	120	V
$I_C = 0$; $I_E = 100$ μA	$V_{(BR)\ EBO}$	>	7.0	V
D.C. current gain				
$I_C = 0.1$ mA; $V_{CE} = 10$ V	h_{FE}	>	20	
$I_C = 10$ mA; $V_{CE} = 10$ V; $T = -55$ °C	h_{FE}	>	20	
$I_C = 10$ mA; $V_{CE} = 10$ V [1]	h_{FE}	>	35	
$I_C = 150$ mA; $V_{CE} = 10$ V [1]	h_{FE}	40 to	120	

[1]) Measured under pulsed conditions to avoid excessive dissipation.
Pulse duration $t \leq 300$ μs, duty cycle $\delta < 0.02$

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

h parameters at f = 1 kHz (common base)

I_C = 1 mA; V_{CE} = 5 V			
Input impedance	h_{ib}	20 to 30	Ω
Reverse voltage transfer ratio	h_{rb}	1.25	10^{-4}
Output conductance	h_{ob}	0.5	$\mu\Omega^{-1}$
I_C = 5 mA; V_{CE} = 10 V			
Input impedance	h_{ib}	4 to 8	Ω
Reverse voltage transfer ratio	h_{rb}	1.50	10^{-4}
Output conductance	h_{ob}	0.5	$\mu\Omega^{-1}$

Small signal current gain (common emitter)

I_C = 1 mA; V_{CE} = 5 V; f = 1 kHz	h_{fe}	30 to 100	
I_C = 5 mA; V_{CE} = 10 V; f = 1 kHz	h_{fe}	> 45	
I_C = 50 mA; V_{CE} = 10 V; f = 20 MHz	h_{fe}	> 2.5	

Collector capacitance

$I_E = I_e$ = 0; V_{CB} = 10 V	C_c	< 15	pF

Emitter capacitance

$I_C = I_c$ = 0; V_{EB} = 0.5 V	C_e	< 85	pF

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a TO-39 metal envelope with the collector connected to the case. It is primarily intended for use in high frequency and very high frequency oscillators and amplifiers as well as for output stages of servo amplifiers.

RATINGS (Limiting values)

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	80	V
Collector-emitter voltage (open base)	V_{CEO}	max.	35	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	V

Current

Collector current (d.c. or average over any 20 ms period)	I_C	max.	1	A

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.8	W
up to T_{case} = 100 °C	P_{tot}	max.	2.8	W
up to T_{case} = 25 °C	P_{tot}	max.	5.0	W

Temperatures

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

THERMAL RESISTANCE

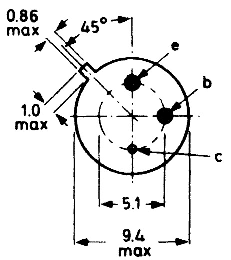
From junction to ambient in free air	$R_{th\,j\text{-}a}$	=	0.22	°C/mW
From junction to case	$R_{th\,j\text{-}c}$	=	0.035	°C/mW

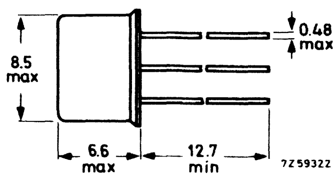
MECHANICAL DATA

Dimensions in mm

Collecter connected to case

TO-39





max. lead diameter is guaranteed only for 12.7 mm

Accessories available: 56218, 56245, 56265

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

Collector cut-off current				
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	<	10	nA
$I_E = 0$; $V_{CB} = 60$ V; $T_{amb} = 150$ °C	I_{CBO}	<	10	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	nA
Sustaining voltage				
$I_C = 30$ mA; $I_B = 0$ 2)	$V_{CEOsust}$	>	35	V
Saturation voltages				
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0.2	V
$I_C = 1$ A; $I_B = 100$ mA 1)2)	V_{CEsat}	<	1.0	V
	V_{BEsat}	<	1.6	V
D.C. current gain 2)				
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	30	
$I_C = 150$ mA; $V_{CE} = 10$ V	h_{FE}	40 to	120	
$I_C = 1$ A; $V_{CE} = 10$ V	h_{FE}	>	15	
Feedback time constant				
$I_C = 10$ mA; $V_{CB} = 10$ V; f = 4 MHz	$r_{b'}C_c$	<	800	ps
Collector capacitance at f = 500 kHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	12	pF
Emitter capacitance at f = 500 kHz				
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	<	80	pF
Transition frequency				
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	>	60	MHz

1) Measured with a lead length of 1 cm.

2) Measured under pulsed conditions to avoid excessive dissipation.
Pulse duration t = 300 μs; duty cycle $\delta < 0.01$

SILICON PLANAR TRANSISTORS

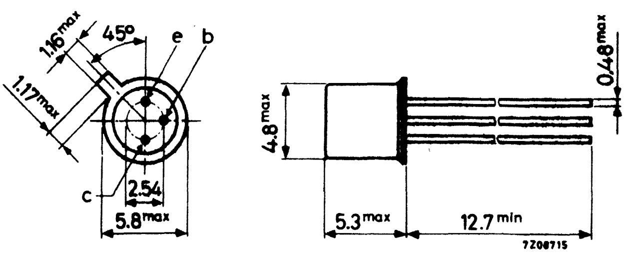
N-P-N transistors in a TO-18 metal envelope with the collector connected to the case.
These transistors are primarily intended for use in high performance, low level, low noise amplifier applications both for d.c. and frequencies up to 100 MHz.

QUICK REFERENCE DATA

			2N2483	2N2484	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	60	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	60	V
Collector current (peak value)	I_{CM}	max.	50	50	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360	360	mW
Junction temperature	T_j	max.	200	200	°C
D.C. current gain at T_j = 25 °C					
I_C = 10 μA ; V_{CE} = 5 V	h_{FE}		40 to 120	100 to 500	
I_C = 1 mA; V_{CE} = 5 V	h_{FE}	>	175	250	
I_C = 10 mA; V_{CE} = 5 V	h_{FE}	<	500	800	
Transition frequency					
I_C = 0.5 mA; V_{CE} = 5 V	f_T	typ.	80	80	MHz
Noise figure					
I_C = 10 μA; V_{CE} = 5 V; R_S = 10 kΩ					
Bandwidth: 15.7 kHz	F	<	4	3	dB

MECHANICAL DATA Dimensions in mm

Collector connected to case
TO-18



Accessories available: 56246, 56263

RATINGS (Limiting values) [1])

Voltages

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

Currents

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

Power dissipation

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

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

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

I_E = 0; V_{CB} = 45 V	I_{CBO}	<	10	nA
I_E = 0; V_{CB} = 45 V; T_j = 150 °C	I_{CBO}	<	10	μA

Emitter cut-off current

I_C = 0; V_{EB} = 5 V	I_{EBO}	<	10	nA

Base-emitter voltage

I_C = 0.1 mA; V_{CE} = 5 V	V_{BE}	0.5 to 0.7	V

Collector-emitter saturation voltage

I_C = 1 mA; I_B = 0.1 mA	V_{CEsat}	<	350	mV

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

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

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

			2N2483	2N2484	
Noise figure					
I_C = 10 μA; V_{CE} = 5 V; R_S = 10 kΩ					
f = 100 Hz; bandwidth 20 Hz	F	<	15	10	dB
f = 1 kHz; bandwidth 200 Hz	F	<	4	3	dB
f = 10 kHz; bandwidth 2 kHz	F	<	3	2	dB
Wide band: bandwidth 15.7 kHz	F	<	4	3	dB
h parameters at f = 1 kHz					
I_C = 1 mA; V_{CE} = 5 V					
Input impedance	h_{ie}		1.5 to 13	3.5 to 24	kΩ
Reverse voltage transfer	h_{re}	<	8	8	10^{-4}
Small signal current gain	h_{fe}		80 to 450	150 to 900	
Output admittance	h_{oe}	<	30	40	$\mu\Omega^{-1}$

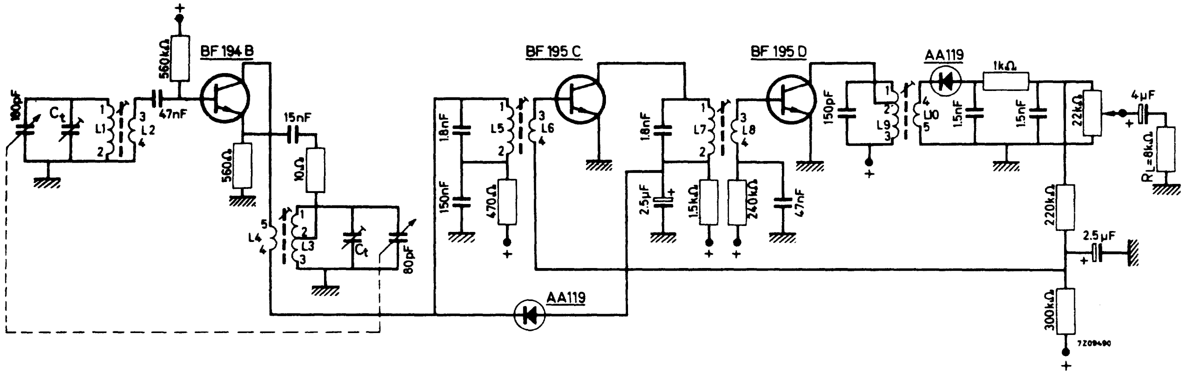
HIGH FREQUENCY PACKAGE

The high frequency package 40820 contains three silicon transistors selected from the BF194 and BF195 products.
The BF194B is intended for use as mixer-oscillator transistor,
the BF195C for controlled first i.f. transistor,
the BF195D for second i.f. transistor.
The low h_{FE} spread of the transistors makes it possible to apply current biasing (one base resistor) and achieve a gain with small spread and low dependence on supply voltage, even at low battery voltages.
The transistors have a plastic envelope with stiff, self-locking pins suitable for use with standard printed wiring-boards.

QUICK REFERENCE DATA				
Base current				
I_C = 1 mA; V_{CE} = 10 V	BF194B	I_B	5 to 9	μA
	BF195C	I_B	9 to 14	μA
	BF195D	I_B	14 to 26	μA
Conversion noise figure of mixer BF194B				
I_C = 1 mA; V_{CE} = 10 V				
$G_S = 1.0\ m\Omega^{-1}$; 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}

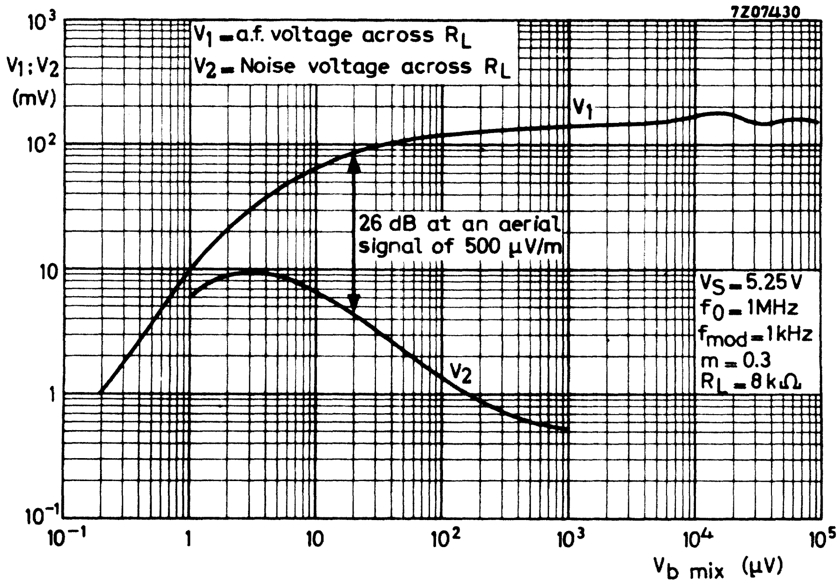
Voltage ratio $\frac{n_{4-5}}{n_{1-3}}$: 59.2×10^{-2}

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 °C unless otherwise specified

Base current

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

BF194B	I_B	5 to 9	µA
BF195C	I_B	9 to 14	µA
BF195D	I_B	14 to 26	µA

Conversion noise figure of mixer BF194B

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

G_S = 1.0 $m\Omega^{-1}$; 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

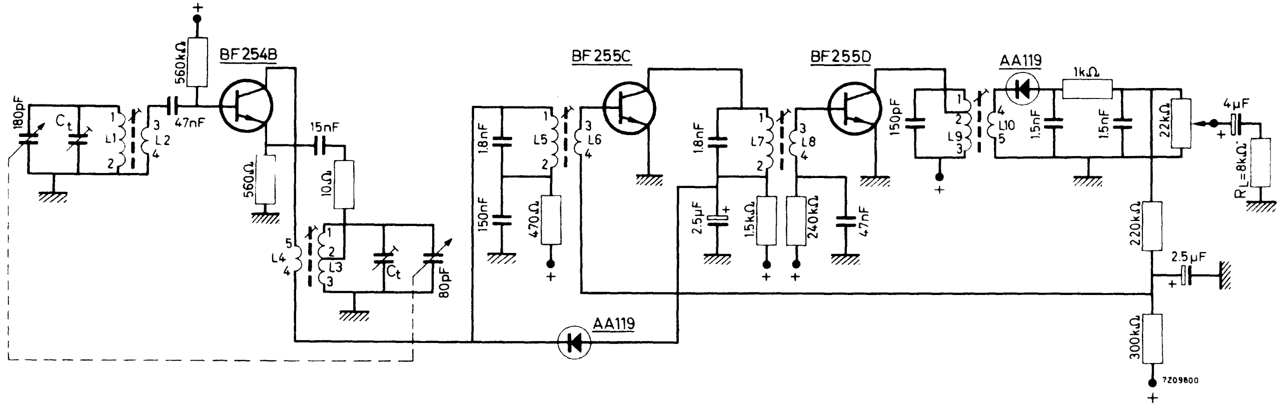
The high frequency package 40829 contains three silicon transistors selected from the BF254 and BF255 products.
The BF254B is intended for use as mixer-oscillator transistor,
the BF255C for controlled first i.f. transistor,
the BF255D for second i.f. transistor.
The low h_{FE} spread of the transistors 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.

QUICK REFERENCE DATA

Base current				
I_C = 1 mA; V_{CE} = 10 V	BF254B	I_B	5 to 9	μA
	BF255C	I_B	9 to 14	μA
	BF255D	I_B	14 to 26	μA
Conversion noise figure of mixer BF254B				
I_C = 1 mA; V_{CE} = 10 V				
G_S = 1.0 mΩ^{-1}; f = 1 MHz		F_c	typ. 2	dB

APPLICATION INFORMATION

H.F. section of a 6 V medium wave portable radio receiver



COIL DATA

L1 = 450 μH; Q_0 at f = 1 MHz : 120

Voltage ratio $\frac{n_{3-4}}{n_{1-2}}$: 5.7×10^{-2}

L3 = 260 μH; Q_0 at f = 1.2 MHz : 120

Voltage ratio $\frac{n_{2-3}}{n_{1-3}}$: 3×10^{-2}

Voltage ratio $\frac{n_{4-5}}{n_{1-3}}$: 5.4×10^{-2}

L5 = L7 = 69 μH; Q_0 at f = 0.45 MHz : 80

Voltage ratio $\frac{n_{3-4}}{n_{1-2}}$: 7.35×10^{-2}

L9 = 800 μH; Q_0 at f = 0.45 MHz : 110

Voltage ratio $\frac{n_{2-3}}{n_{1-3}}$: 41.5×10^{-2}

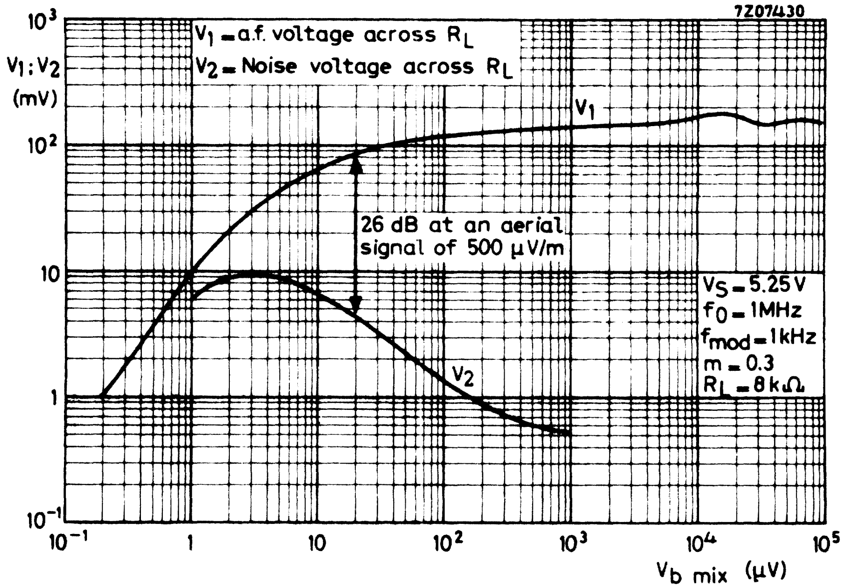
Voltage ratio $\frac{n_{4-5}}{n_{1-3}}$: 59.2×10^{-2}

PERFORMANCE at f = 1 MHz; T_{amb} = 25 °C

Supply voltage (from 6 V, via a RC-smoothing filter)	V_S	=	5.25	V
Total current drain	I_{tot}	=	3	mA
Gain spread of the h.f. part	ΔG	=	±3.6	dB
Signal handling capability d_{tot} = 10 %; m = 0.8		≥	2	V/m

Sensitivity

Signal to obtain V_o = 10 mV across R_L = 8 kΩ	25	µV/m
Signal to obtain 26 dB signal/noise ratio	500	µV/m
Decrease of sensitivity at $V_S \approx 3.2$ V	15	dB



CHARACTERISTICS

$T_j = 25\ ^oC$

Base current

$I_C = 1$ mA; $V_{CE} = 10$ V	BF254B	I_B	5 to 9	μA
	BF255C	I_B	9 to 14	μA
	BF255D	I_B	14 to 26	μA

Conversion noise figure of mixer BF254B

$I_C = 1$ 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	BF254B :	g_{ie}	<	0.5	0.4	$m\Omega^{-1}$
	BF255C :	g_{ie}	<	0.64	0.54	$m\Omega^{-1}$
	BF255D :	g_{ie}	<	0.95	0.85	$m\Omega^{-1}$
Output conductance	BF254B :	g_{oe}	typ.	10	6.5	$\mu\Omega^{-1}$
			<	13.5	11.5	$\mu\Omega^{-1}$
	BF255C :	g_{oe}	typ.	6.5	4	$\mu\Omega^{-1}$
			<	9.5	7	$\mu\Omega^{-1}$
	BF255D :	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 BF254 AND THE BF255

HIGH FREQUENCY PACKAGE

The high frequency package 40835 contains three silicon transistors selected from the BF494 and BF495 products.
The BF494B is intended for use as mixer-oscillator transistor,
the BF495C for controlled first i.f. transistor,
the BF495D for second i.f. transistor.
The low h_{FE} spread of the transistors makes it possible to apply current biasing (one base resistor) and achieve a gain with small spread and low dependence on supply voltage, even at low battery voltages.

QUICK REFERENCE DATA				
Base current				
I_C = 1 mA; V_{CE} = 10 V	BF494B	I_B	5 to 9	μA
	BF495C	I_B	9 to 14	μA
	BF495D	I_B	14 to 26	μA
Conversion noise figure of mixer BF494B				
I_C = 1 mA; V_{CE} = 10 V				
G_S = 1 mA/V; f = 1 MHz		F_c	typ. 2	dB

CHARACTERISTICS T_j = 25 °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.

Switching transistors

GERMANIUM ALLOYED TRANSISTORS

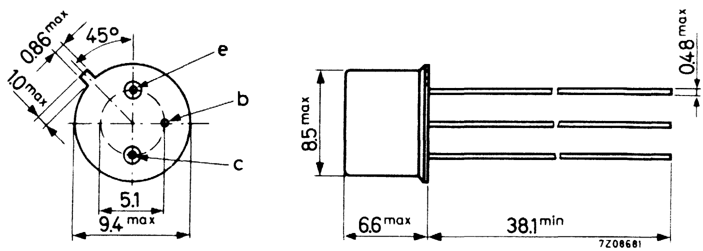
P-N-P transistors in a TO-5 metal envelope with the base connected to the case. These general purpose transistors are primarily intended for medium current medium speed computer logic applications.

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

			ASY26	ASY27	
Voltages					
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30	25	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	15	15	V
Collector-emitter voltage at $+V_{BE} = 0.2$ V	$-V_{CEX}$	max.	25	20	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	20	20	V
Currents					
Collector current (d.c. or average over any 20 ms period)	$-I_C$	max.		200	mA
Collector current (peak value)	$-I_{CM}$	max.		300	mA
Power dissipation					
Total power dissipation up to $T_{amb} = 25$ °C	P_{tot}	max.		150	mW
Temperatures					
Storage temperature	T_{stg}		-65 to	+100	°C
Junction temperature	T_j	max.		85	°C

MECHANICAL DATA Dimensions in mm

TO-5
Base connected to case



Accessories available: 56218, 56245, 56265

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.4	$^{o}C/mW$
From junction to case	$R_{th\ j\text{-}c}$	=	0.2	$^{o}C/mW$

CHARACTERISTICS

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

			ASY26	ASY27	
Collector cut-off current					
$I_E = 0;\ -V_{CB} = 30\ V$	$-I_{CBO}$	<	7		μA
$I_E = 0;\ -V_{CB} = 25\ V$	$-I_{CBO}$	<		7	μA
$I_E = 0;\ -V_{CB} = 30\ V;\ T_j = 60\ ^{o}C$	$-I_{CBO}$	<	35		μA
$I_E = 0;\ -V_{CB} = 25\ V;\ T_j = 60\ ^{o}C$	$-I_{CBO}$	<		35	μA
Emitter cut-off current					
$I_C = 0;\ -V_{EB} = 5\ V$	$-I_{EBO}$	<	3	3	μA
Currents at reverse biased emitter junction					
$-V_{CE} = 25\ V;\ +V_{BE} = 0.2\ V;\ T_j = 60\ ^{o}C$	$-I_{CEX}$	<	35		μA
$-V_{CE} = 20\ V;\ +V_{BE} = 0.2\ V;\ T_j = 60\ ^{o}C$	$-I_{CEX}$	<		35	μA
$-V_{CE} = 20\ V;\ +V_{BE} = 5\ V;\ T_j = 60\ ^{o}C$	$+I_{BEX}$	<	35	35	μA
Base-emitter voltage					
$-I_C = 100\ mA;\ -V_{CE} = 1\ V$	$-V_{BE}$	<	0.65	0.55	V
$-I_C = 300\ mA;\ -V_{CE} = 1\ V$	$-V_{BE}$	<	1.5	1.4	V
Collector-emitter saturation voltage					
$-I_C = 10\ mA;\ -I_B = 0.33\ mA$	$-V_{CE\,sat}$	<	0.20		V
$-I_C = 10\ mA;\ -I_B = 0.2\ mA$	$-V_{CE\,sat}$	<		0.20	V
$-I_C = 50\ mA;\ -I_B = 2\ mA$	$-V_{CE\,sat}$	<	0.25		V
$-I_C = 50\ mA;\ -I_B = 1.25\ mA$	$-V_{CE\,sat}$	<		0.25	V
Base-emitter saturation voltage					
$-I_C = 10\ mA;\ -I_B = 0.4\ mA$	$-V_{BE\,sat}$	>	0.20		V
		<	0.37		V
$-I_C = 10\ mA;\ -I_B = 0.25\ mA$	$-V_{BE\,sat}$	>		0.15	V
		<		0.32	V
$-I_C = 50\ mA;\ -I_B = 2.4\ mA$	$-V_{BE\,sat}$	<	0.55		V
$-I_C = 50\ mA;\ -I_B = 1.55\ mA$	$-V_{BE\,sat}$	<		0.45	V

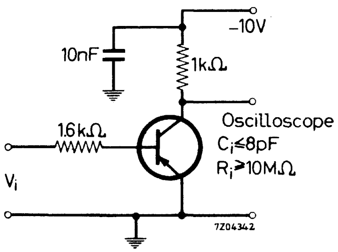
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

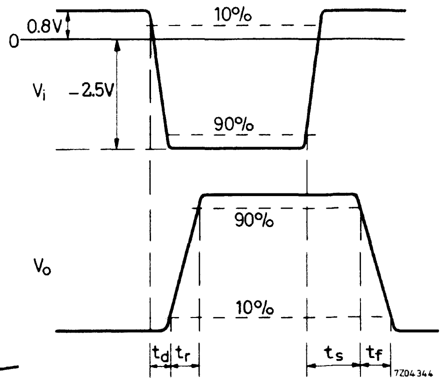
			ASY26	ASY27	
Collector-emitter sustaining voltage					
$-I_C$ = 5 mA; I_B = 0	$-V_{CEO\,sust}$	>	15	15	V
Punch through voltage	V_{pt}	>	25	20	V
Base-emitter floating voltage					
I_B = 0; $-V_{CE}$ = 25 V; T_j = 60 °C	$-V_{BE\,fl}$	<	0.20		V
I_B = 0; $-V_{CE}$ = 20 V; T_j = 60 °C	$-V_{BE\,fl}$	<		0.20	V
D.C. current gain					
$-I_C$ = 10 mA; $-V_{CE}$ = 1 V	h_{FE}	>	30	50	
		typ.	45	80	
$-I_C$ = 20 mA; $-V_{CE}$ = 1 V	h_{FE}	>	30	50	
		typ.	47	78	
		<	80	150	
$-I_C$ = 100 mA; $-V_{CE}$ = 1 V	h_{FE}	>	20	30	
		typ.	39	58	
$-I_C$ = 200 mA; $-V_{CE}$ = 1 V	h_{FE}	>	15	20	
		typ.	27	40	
Collector capacitance at f = 1 MHz					
$I_E = I_e$ = 0; $-V_{CB}$ = 5 V	C_c	typ.	11	11	pF
		<	16	16	pF
Emitter capacitance at f = 1 MHz					
$I_C = I_c$ = 0; $-V_{EB}$ = 5 V	C_e	typ.	7	6	pF
		<	13	13	pF
Transition frequency					
$-I_C$ = 3 mA; $-V_{CE}$ = 5 V	f_T	>	4	6	MHz
		typ.	8	14	MHz
h parameters at f = 1 kHz					
$-I_C$ = 2 mA; $-V_{CE}$ = 5 V					
Input impedance	h_{ie}	typ.	0.75	1.4	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	5.0	7.5	10^{-4}
Small signal current gain	h_{fe}	typ.	50	90	
Output admittance	h_{oe}	typ.	65	100	$\mu\Omega^{-1}$

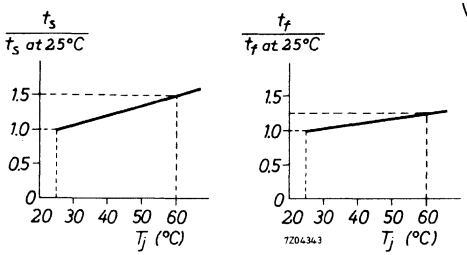
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Switching characteristics			ASY26	ASY27	
Desaturation time constant $I_C = 0;\ -I_B = 1$ mA	τ_s	<	1.25	1.25	µs
Current feed time constant $-I_{CM} = 50$ mA; $-V_{CE} = 0.75$ V	τ_c	<	2.2	2.2	µs
Voltage feed time constant $-I_{CM} = 1$ mA; $-V_{CE} = 0.75$ V	τ_v	<	0.2	0.2	µs
Switching times (See test circuit)					
delay time	t_d	typ.	65	50	ns
		<	90	75	ns
rise time	t_r	typ.	275	200	ns
		<	490	350	ns
storage time	t_s	typ.	500	600	ns
		<	1350	1500	ns
fall time	t_f	typ.	475	400	ns
		<	730	620	ns

Test circuit:







GERMANIUM ALLOYED TRANSISTORS

N-P-N transistors in a TO-5 metal envelope with the base connected to the case. These general purpose transistors are primarily intended for medium current medium speed computor logic applications.

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

Voltages			ASY28	ASY29	
Collector-base voltage (open emitter)	V_{CBO}	max.	30	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	15	V
Collector-emitter voltage at $-V_{BE}$ = 0.2 V	V_{CEX}	max.	25	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	20	20	V

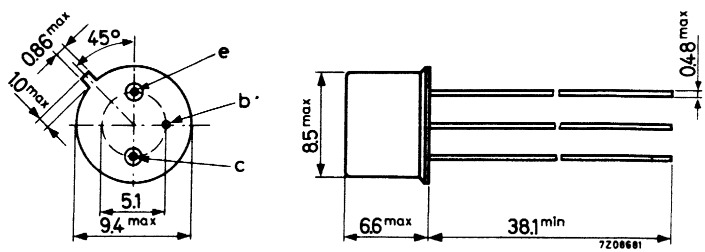
Currents				
Collector current (d.c. or average over any 20 ms period)	I_C	max.	200	mA
Collector current (peak value)	I_{CM}	max.	300	mA

Power dissipation				
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	mW

Temperatures				
Storage temperature	T_{stg}		-65 to +100	°C
Junction temperature	T_j	max.	85	°C

MECHANICAL DATA Dimensions in mm

TO-5
Base connected to case



Accessories available: 56218, 56245, 56263.

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.4	°C/mW
From junction to case	$R_{th\ j-c}$	=	0.2	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

			ASY28	ASY29	
Collector cut-off current					
I_E = 0; V_{CB} = 30 V	I_{CBO}	<	7		µA
I_E = 0; V_{CB} = 25 V	I_{CBO}	<		7	µA
I_E = 0; V_{CB} = 30 V; T_j = 60 °C	I_{CBO}	<	35		µA
I_E = 0; V_{CB} = 25 V; T_j = 60 °C	I_{CBO}	<		35	µA
Emitter cut-off current					
I_C = 0; V_{EB} = 5 V	I_{EBO}	<	3	3	µA
Currents at reverse biased emitter junction					
V_{CE} = 25 V; $-V_{BE}$ = 0.2 V; T_j = 60 °C	I_{CEX}	<	35		µA
V_{CE} = 20 V; $-V_{BE}$ = 0.2 V; T_j = 60 °C	I_{CEX}	<		35	µA
V_{CE} = 20 V; $-V_{BE}$ = 5 V; T_j = 60 °C	$-I_{BEX}$	<	35	35	µA
Base-emitter voltage					
I_C = 100 mA; V_{CE} = 1 V	V_{BE}	<	0.65	0.55	V
I_C = 300 mA; V_{CE} = 1 V	V_{BE}	<	1.5	1.4	V
Collector-emitter saturation voltage					
I_C = 10 mA; I_B = 0.33 mA	$V_{CE\,sat}$	<	0.20		V
I_C = 10 mA; I_B = 0.2 mA	$V_{CE\,sat}$	<		0.20	V
I_C = 50 mA; I_B = 2 mA	$V_{CE\,sat}$	<	0.25		V
I_C = 50 mA; I_B = 1.25 mA	$V_{CE\,sat}$	<		0.25	V
Base-emitter saturation voltage					
I_C = 10 mA; I_B = 0.4 mA	$V_{BE\,sat}$	>	0.20		V
		<	0.37		V
I_C = 10 mA; I_B = 0.25 mA	$V_{BE\,sat}$	>		0.15	V
		<		0.32	V
I_C = 50 mA; I_B = 2.4 mA	$V_{BE\,sat}$	<	0.55		V
I_C = 50 mA; I_B = 1.55 mA	$V_{BE\,sat}$	<		0.45	V

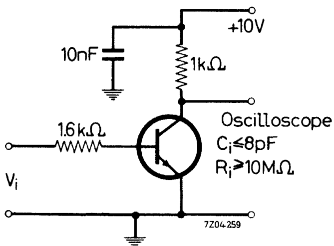
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

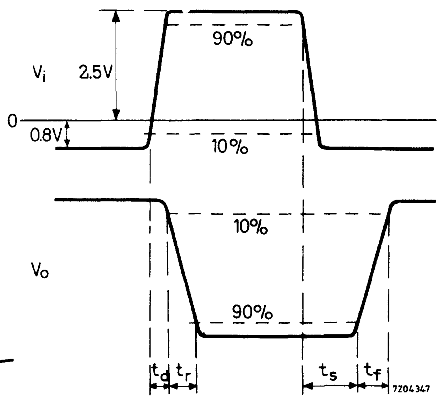
			ASY28	ASY29	
Collector-emitter sustaining voltage					
I_C = 5 mA; I_B = 0	$V_{CEO\,sust}$	>	15	15	V
Punch through voltage	V_{pt}	>	25	20	V
Base-emitter floating voltage					
I_B = 0; V_{CE} = 25 V; T_j = 60 °C	$V_{BE\,fl}$	<	0.20		V
I_B = 0; V_{CE} = 20 V; T_j = 60 °C	$V_{BE\,fl}$	<		0.20	V
D.C. current gain					
I_C = 10 mA; V_{CE} = 1 V	h_{FE}	>	30	50	
		typ.	43	113	
I_C = 20 mA; V_{CE} = 1 V	h_{FE}	>	30	50	
		typ.	46	113	
		<	80	150	
I_C = 100 mA; V_{CE} = 1 V	h_{FE}	>	20	30	
		typ.	43	102	
I_C = 200 mA; V_{CE} = 1 V	h_{FE}	>	15	20	
		typ.	32	84	
Collector capacitance at f = 1 MHz					
$I_E = I_e$ = 0; V_{EB} = 5 V	C_c	typ.	11	11	pF
		<	16	16	pF
Emitter capacitance at f = 1 MHz					
$I_C = I_c$ = 0; V_{EB} = 5 V	C_e	typ.	7	6	pF
		<	13	13	pF
Transition frequency					
I_C = 3 mA; V_{CE} = 5 V	f_T	>	4	10	MHz
		typ.	14	20	MHz
h parameters at f = 1 kHz					
I_C = 2 mA; V_{CE} = 5 V					
Input impedance	h_{ie}	typ.	0.75	1.4	kΩ
Reverse voltage transfer ratio	h_{re}	typ.	3.5	5.0	10^{-4}
Small signal current gain	h_{fe}	typ.	50	90	
Output admittance	h_{oe}	typ.	45	70	$\mu\Omega^{-1}$

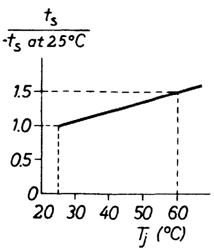
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

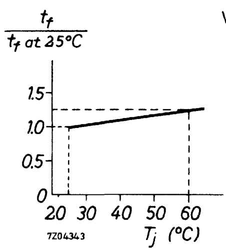
Switching characteristics			ASY28	ASY29	
Desaturation time constant I_C = 0; I_B = 1 mA	τ_s	<	1.4	1.4	μs
Current feed time constant I_{CM} = 50 mA; V_{CE} = 0.75 V	τ_c	<	2.2	2.2	μs
Voltage feed time constant I_{CM} = 1 mA; V_{CE} = 5 V	τ_v	<	0.2	0.2	μs
Switching times (See test circuit)					
delay time	t_d	typ.	50	45	ns
		<	90	75	ns
rise time	t_r	typ.	175	140	ns
		<	400	300	ns
storage time	t_s	typ.	450	500	ns
		<	700	800	ns
fall time	t_f	typ.	325	300	ns
		<	620	520	ns

Test circuit:









SYMMETRICAL N-P-N SWITCHING TRANSISTORS

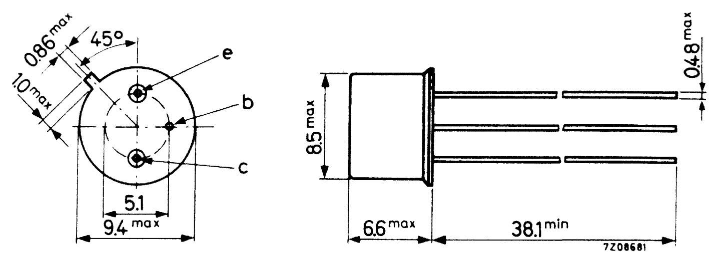
Symmetrical N-P-N germanium alloy transistors in a TO-5 metal envelope with the base connected to the case intended for high current medium speed switching applications.

QUICK REFERENCE DATA

			ASY73	ASY74	ASY75	
Collector-base voltage (open emitter)	V_{CBO}	max.	30	30	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	15	15	V
Collector-current (d.c. or average)	I_C	max.	400	400	400	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	140	140	140	mW
Junction temperature	T_j	max.	75	75	75	°C
D.C. current gain at T_j = 25 °C						
$-I_E$ = 200 mA; V_{CB} = 0	h_{FE}	>	20	35	50	
$-I_C$ = 200 mA; V_{EB} = 0	h_{FC}	>	12	20	20	
Transition frequency						
$-I_E$ = 3 mA; V_{CB} = 5 V	f_T	>	4	6	10	MHz
Desaturation time constant						
I_B = 1 mA; I_C = 0	τ_s		<1.75	1.75	1.75	μs

MECHANICAL DATA Dimensions in mm

TO-5
Base connected to case



Accessories available: 56218, 56245, 56265.

RATINGS (Limiting values) [1]

Voltages

Collector-base voltage (open-emitter)	V_{CBO}	max.	30	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V [2]
Collector-emitter voltage with $-V_{BE}$ = 0.2 V	V_{CEX}	max.	20	V [2]
Emitter-base voltage (open collector)	V_{EBO}	max.	30	V

Currents

Collector current (d.c. or average over any 20 ms period)	I_C	max.	400	mA
Emitter current (d.c. or average over any 20 ms period)	$-I_E$	max.	400	mA
Base current (d.c. or average over any 20 ms period)	I_B	max.	40	mA
Base current (peak value)	I_{BM}	max.	400	mA

Power dissipation

Total steady state power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	140	mW

Temperatures

Storage temperature	T_{stg}		-55 to 85	°C
Operating junction temperature	T_j	max.	75	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.35	°C/mW
From junction to case	$R_{th\ j-c}$	=	0.2	°C/mW

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

[2]) For switch-off transients with inductive load see page 12

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $V_{CB} = 5$ V	I_{CBO}	<	3	μA
$V_{CB} = 30$ V; $T_j = 55$ °C	I_{CBO}	<	100	μA

Emitter cut-off current

$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	3	μA
$V_{EB} = 30$ V; $T_j = 55$ °C	I_{EBO}	<	100	μA

Currents at reverse biased emitter junction

$V_{CE} = 20$ V; $-V_{BE} = 0.2$ V; $T_j = 55$ °C	I_{CEX}	<	50	μA
$-V_{BE} = 20$ V; $V_{CB} = 20$ V; $T_j = 55$ °C	$-I_{BEX}$	<	50	μA

Saturation voltages

ASY73.	I_C = 50 mA; I_B = 2.5 mA	V_{CEsat}	<	0.22	V
	I_C = 200 mA; I_B = 10 mA	V_{CEsat}	<	0.30	V
	I_E = 200 mA; I_B = 16.5 mA	V_{ECsat}	<	0.30	V
	I_C = 50 mA; I_B = 3 mA	$V_{BE\,sat}$	<	0.50	V
	I_C = 200 mA; I_B = 12 mA	$V_{BE\,sat}$	<	0.90	V
ASY74.	I_C = 50 mA; I_B = 1.25 mA	V_{CEsat}	<	0.22	V
	I_C = 200 mA; I_B = 5.7 mA	V_{CEsat}	<	0.30	V
	I_C = 400 mA; I_B = 20 mA	V_{CEsat}	<	0.37	V
	I_E = 200 mA; I_B = 10 mA	V_{ECsat}	<	0.30	V
	I_C = 50 mA; I_B = 1.5 mA	$V_{BE\,sat}$	<	0.38	V
	I_C = 200 mA; I_B = 7 mA	$V_{BE\,sat}$	<	0.70	V
	I_C = 400 mA; V_{CB} = 0	$V_{BE\,sat}$	<	0.90	V
ASY75.	I_C = 50 mA; I_B = 0.75 mA	V_{CEsat}	<	0.22	V
	I_C = 200 mA; I_B = 4 mA	V_{CEsat}	<	0.30	V
	I_C = 400 mA; I_B = 13.5 mA	V_{CEsat}	<	0.37	V
	I_E = 200 mA; I_B = 10 mA	V_{ECsat}	<	0.30	V
	I_C = 50 mA; I_B = 0.95 mA	$V_{BE\,sat}$	<	0.34	V
	I_C = 200 mA; I_B = 5 mA	$V_{BE\,sat}$	<	0.60	V
	I_C = 400 mA; V_{CB} = 0	$V_{BE\,sat}$	<	0.70	V

Sustaining voltage

$I_C = 10$ mA; $I_B = 0$	$V_{CEOsust}$	>	15	V

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

Punch-through voltage		V_{pt}	>	20	V
Floating potential					
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 55$ °C		V_{EBfl}	<	180	mV
$I_C = 0$; $V_{CB} = 20$ V; $T_j = 55$ °C		V_{CBfl}	<	180	mV
D.C. current gain					
ASY73	$V_{CB} = 0$; $-I_E = 50$ mA	h_{FE}	>	25	
	$V_{CB} = 0$; $-I_E = 200$ mA	h_{FE}	>	20	
	$V_{EB} = 0$; $-I_C = 200$ mA	h_{FC}	>	12	
ASY74	$V_{CB} = 0$; $-I_E = 50$ mA	h_{FE}	>	40	
	$V_{CB} = 0$; $-I_E = 200$ mA	h_{FE}	>	35	
	$V_{CB} = 0$; $-I_E = 400$ mA	h_{FE}	>	20	
	$V_{EB} = 0$; $-I_C = 200$ mA	h_{FC}	>	20	
ASY75	$V_{CB} = 0$; $-I_E = 50$ mA	h_{FE}	>	65	
	$V_{CB} = 0$; $-I_E = 200$ mA	h_{FE}	>	50	
	$V_{CB} = 0$; $-I_E = 400$ mA	h_{FE}	>	30	
	$V_{EB} = 0$; $-I_C = 200$ mA	h_{FC}	>	20	
Switching parameters					
Desaturation time constant $I_B = 1$ mA; $I_C = 0$		τ_s	<	1.75	μs
Current-feed time constant $I_{CM} = 200$ mA; $V_{CE} = 0.75$ V		τ_c	<	1.75	μs
Voltage-feed time constant $I_{CM} = 1$ mA; $V_{CE} = 5$ V		τ_v	<	0.20	μs
Collector capacitance at f = 1 MHz					
$I_E = I_e = 0$; $V_{CB} = 5$ V		C_c	<	30	pF
Emitter capacitance at f = 1 MHz					
$I_C = I_c = 0$; $V_{EB} = 5$ V		C_e	<	30	pF
Transition frequency					
$-I_E = 3$ mA; $V_{CB} = 5$ V	ASY73	f_T	>	4	MHz
	ASY74	f_T	>	6	MHz
	ASY75	f_T	>	10	MHz

P-N-P SWITCHING TRANSISTORS

Germanium p-n-p transistors in a TO-5 metal envelope with the base connected to the case. The ASY76, ASY77 and ASY80 are primarily intended for amplifying, switching and pulse oscillating applications.

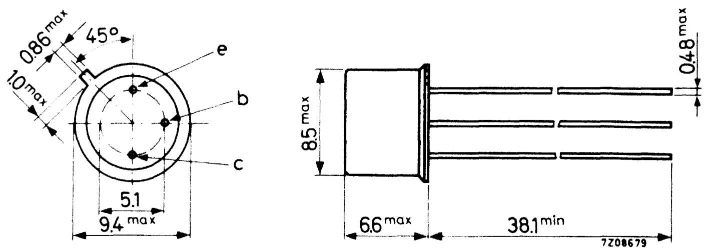
QUICK REFERENCE DATA

			ASY76	ASY77	ASY80	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40	60	40	V
Collector-emitter voltage ($+V_{BE} = 0.6$ V)	$-V_{CEX}$	max.	32	60	40	V

Collector current (peak value)	$-I_{CM}$	max.	1000	mA
Total power dissipation up to $T_{amb} = 25\ ^{o}C$	P_{tot}	max.	500	mW
Junction temperature	T_j	max.	85	^{o}C
Thermal resistance from junction to case	$R_{th\ j\text{-}c}$	=	75	$^{o}C/W$
D.C. current gain at $T_j = 25\ ^{o}C$				
$-I_C = 600$ mA; $-V_{CE} = 1$ V ASY76, ASY77	h_{FE}	>	20	
ASY80	h_{FE}	>	40	
Transition frequency $-I_C = 1$ mA; $-V_{CE} = 10$ V	f_T	typ.	0.9	MHz

MECHANICAL DATA Dimensions in mm

TO-5
Base connected to case



Accessories available: 56218, 56245, 56265

RATINGS (Limiting values) [1]

Voltages

			ASY76	ASY77	ASY80	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	40	60	40	V
Collector-emitter voltage with $+V_{BE} = 0.6$ V	$-V_{CEX}$	max.	32	60	40	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	10	10	20	V

Currents

Collector current (d.c. or average over any 20 ms period)	$-I_C$	max.	500	mA
Collector current (peak value)	$-I_{CM}$	max.	1000	mA
Base current (d.c. or average over any 20 ms period)	$-I_B$	max.	40	mA
Base current (peak value)	$-I_{BM}$	max.	200	mA

Power dissipation

Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	500	mW

Temperatures

Storage temperature	T_{stg}		-65 to +85	^oC
Junction temperature	T_j	max.	85	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	250	$^oC/W$
From junction to case	$R_{th\ j-c}$	=	75	$^oC/W$
From junction to ambient with cooling fin 56265 on a heatsink of 12.5 cm^2	$R_{th\ j-a}$	=	120	$^oC/W$

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

CHARACTERISTICS T_j = 25 °C unless otherwise specified

			ASY76	ASY77	ASY80	
Collector cut-off current						
$I_E = 0$; $-V_{CB} = 10$ V	$-I_{CBO}$	typ.	4.5	4.5	4.5	μA
		<	10	10	10	μA
$I_E = 0$; $-V_{CB} = 40$ V	$-I_{CBO}$	<	40	–	40	μA
$I_E = 0$; $-V_{CB} = 60$ V	$-I_{CBO}$	<	–	40	–	μA
Emitter cut-off current						
$I_C = 0$; $-V_{EB} = 10$ V	$-I_{EBO}$	<	20	20	20	μA
Currents at reverse biased emitter junction						
$-V_{CE} = 30$ V; $+V_{BE} = 0.5$ V	$-I_{CEX}$	<	30	–	30	μA
$-V_{CE} = 60$ V; $+V_{BE} = 0.5$ V	$-I_{CEX}$	<	–	30	–	μA
$-V_{CE} = 30$ V; $+V_{BE} = 0.5$ V, $T_j = 60$ °C	$-I_{CEX}$	<	200	–	200	μA
$-V_{CE} = 60$ V; $+V_{BE} = 0.5$ V, $T_j = 60$ °C	$-I_{CEX}$	<	–	200	–	μA
Sustaining voltage						
$-I_C = 600$ mA; $+V_{BE} = 0.6$ V	$-V_{CEXsust}$	>	–	–	32	V
Base-emitter voltage						
$I_E = 300$ mA; $V_{CB} = 0$	$-V_{BE}$	typ.	420	420	420	mV
		<	750	750	750	mV
Saturation voltages						
$-I_C = 300$ mA; $-I_B = 12$ mA	$-V_{CEsat}$	<	300	300	–	mV
$-I_C = 300$ mA; $-I_B = 6$ mA	$-V_{CEsat}$	<	–	–	400	mV
Emitter-base floating voltage						
$I_E = 0$; $-V_{CB} = 40$ V	$-V_{EBfl}$	<	300	–	300	mV
$I_E = 0$; $-V_{CB} = 60$ V	$-V_{EBfl}$	<	–	300	–	mV
D.C. current gain						
$-I_C = 10$ mA; $-V_{CE} = 6$ V	h_{FE}	>	45	45	–	
$-I_C = 50$ mA; $-V_{CB} = 0$	h_{FE}		–	–	60 to 165	
$-I_C = 300$ mA; $V_{CB} = 0$	h_{FE}		25 to 130	25 to 130	> 50	

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

Collector capacitance at f = 1 MHz					
$I_E = I_e = 0$; $-V_{CB} = 5$ V		C_c	typ.	40	pF
			<	60	pF
Emitter capacitance at f = 1 MHz					
$I_C = I_c = 0$; $-V_{EB} = 5$ V		C_e	typ.	30	pF
			<	50	pF
Transition frequency					
$-I_C = 10$ mA; $-V_{CE} = 5$ V	ASY76, ASY77	f_T	>	500	kHz
	ASY80	f_T	>	700	kHz
Noise figure at f = 1 kHz					
$I_E = 0.5$ mA; $-V_{CB} = 2$ V					
Bandwidth 200 Hz; $R_S = 500\ \Omega$		F	<	15	dB
Feedback impedance at f = 0.5 MHz					
$I_E = 1$ mA; $-V_{CB} = 5$ V		$\lvert z_{rb} \rvert$	typ.	75	Ω

GERMANIUM ALLOY DIFFUSED TRANSISTOR

P-N-P transistor in a TO-18 metal envelope. It is intended for use in high-speed saturated logic applications.

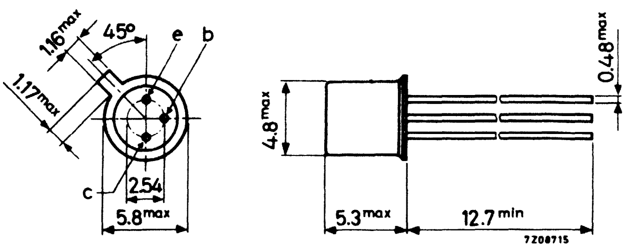
QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	20	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	15	V
Collector current (peak value)	$-I_{CM}$	max.	50	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	120	mW
Junction temperature	T_j	max.	85	°C
D.C. current gain at T_{amb} = 25 °C				
$-I_C$ = 10 mA; $-V_{CE}$ = 0.5 V	h_{FE}	>	30	
Transition frequency				
I_E = 10 mA; $-V_{CB}$ = 2 V	f_T	>	300	MHz

MECHANICAL DATA

Dimensions in mm

TO-18

Collector connected to case



Accessories available: 56246, 56263

RATINGS (Limiting values) [1]

Voltages

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

Currents

Collector current (d.c. or average over any 20 ms period)	$-I_C$	max.	30	mA
Collector current (peak value)	$-I_{CM}$	max.	50	mA
Emitter current (d.c. or average over any 20 ms period)	I_E	max.	5	mA
Emitter current (peak value)	I_{EM}	max.	10	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	120	mW

Temperatures

Storage temperature	T_{stg}		−55 to +75	°C
Junction temperature	T_j	max.	85	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.50	°C/mW
From junction to case	$R_{th\ j-c}$	=	0.18	°C/mW

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

Emitter cut-off current

$I_C = 0$; $-V_{EB} = 0.5$ V	$-I_{EBO}$	<	2	μA

Currents at reverse biased emitter junction

$-V_{CE} = 15$ V; $-V_{EB} = 0.2$ V; $T_{amb} = 60$ °C	$-I_{CEX}$	<	60	μA
	$+I_{BEX}$	<	60	μA

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

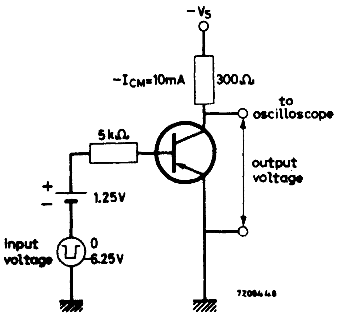
CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

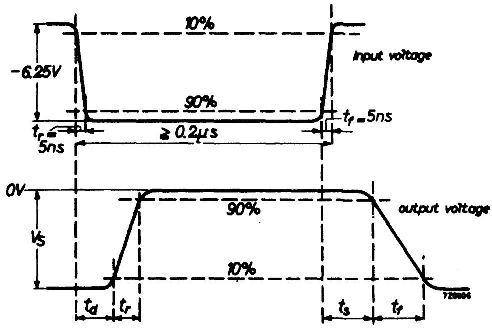
Breakdown voltages at T_{amb} = 60 °C				
$I_E = 0$; $-I_C = 100\ \mu A$	$-V_{(BR)\ CBO}$	>	20	V
$I_C = 0$; $-I_E = 100\ \mu A$	$-V_{(BR)\ EBO}$	>	2.5	V
Sustaining voltage				
$I_B = 0$; $-I_C = 5$ mA	$-V_{CEO\ sust}$	>	9	V
Saturation voltage				
$-I_C = 10$ mA; $-I_B = 1$ mA	$-V_{CE\ sat}$	<	0.35	V
$-I_C = 50$ mA; $-I_B = 3$ mA	$-V_{CE\ sat}$	<	1.10	V
Base-emitter voltage				
$-I_C = 10$ mA; $-I_B = 0.44$ mA	$-V_{BE}$	0.25 to	0.5	V
$-I_C = 30$ mA; $-I_B = 0.9$ mA	$-V_{BE}$	0.35 to	0.75	V
D.C. current gain				
$-I_C = 10$ mA; $-V_{CE} = 0.5$ V	h_{FE}	>	30	
$-I_C = 30$ mA; $-V_{CE} = 1.0$ V	h_{FE}	>	50	
Collector capacitance				
$I_E = I_e = 0$; $-V_{CB} = 6$ V	C_c	<	5	pF
Emitter capacitance				
$I_C = I_c = 0$; $-V_{EB} = 1$ V	C_e	<	12	pF
Transition frequency				
$I_E = 10$ mA; $-V_{CB} = 2$ V	f_T	>	300	MHz

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

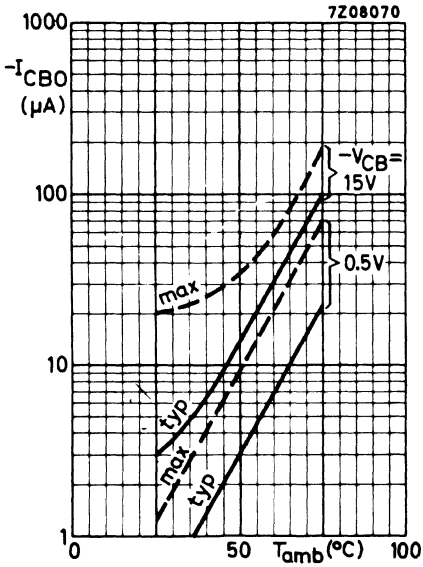
Switching characteristics

Test circuit:





Delay time	t_d	typ. 30	ns
		15 to 40	ns
Rise time	t_r	typ. 20	ns
		10 to 35	ns
Storage time	t_s	typ. 40	ns
		25 to 60	ns
Fall time	t_f	typ. 40	ns
		25 to 55	ns



SILICON PLANAR EPITAXIAL TRANSISTOR

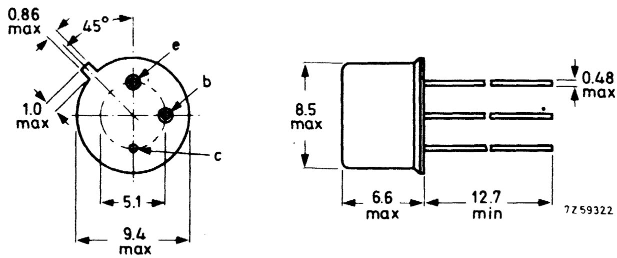
N-P-N transistor in a TO-39 metal envelope primarily intended for use as high current switching device, e.g. inverters and switching regulators.

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



max. lead diameter is guaranteed only for 12.7 mm

Accessories supplied on request: 56218, 56254, 56265

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

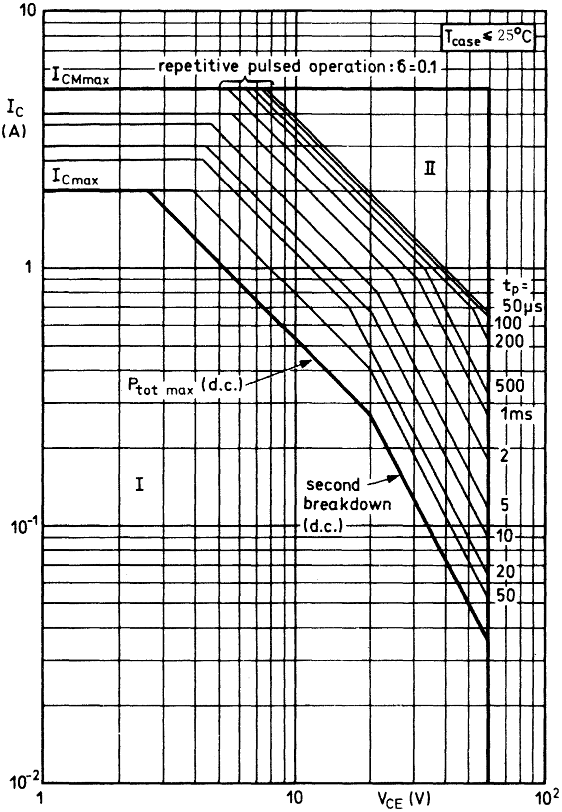
Voltages				
Collector-base voltage (open emitter)	V_{CBO}	max.	120	V
Collector-emitter voltage (open base)	V_{CEO}	max.	60	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	V
Currents				
Collector current (d.c.)	I_C	max.	2.0	A
Collector current (peak value)	I_{CM}	max.	5.0	A
Base current (d.c.)	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

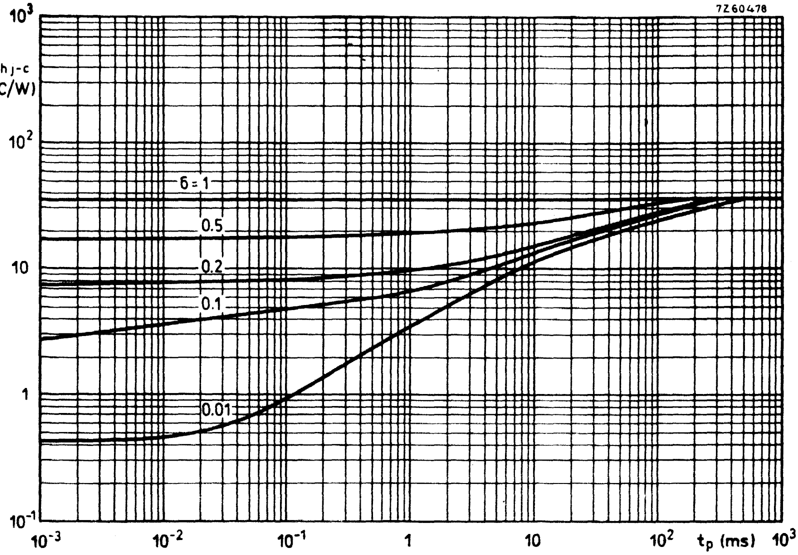
CHARACTERISTICS T_j = 25 °C unless otherwise specified

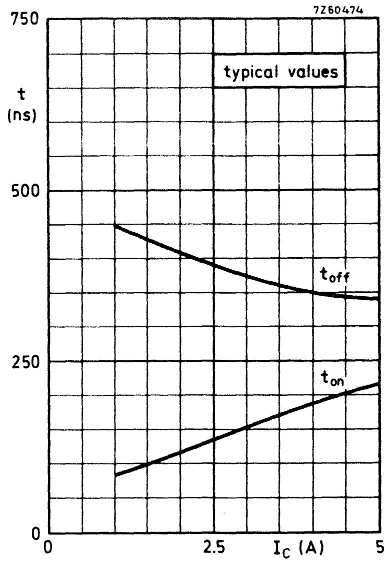
Collector cut-off current				
V_{EB} = 0; V_{CE} = 60 V	I_{CES}	<	10	μA
Emitter cut-off current				
I_C = 0; V_{EB} = 4 V	I_{EBO}	typ. <	0.01 10	μA μA
Saturation voltages				
I_C = 5 A; I_B = 0.5 A	V_{CEsat}	typ. <	0.77 1.0	V V
	V_{BEsat}	typ. <	1.43 1.8	V V
D.C. current gain				
I_C = 1.0 A; V_{CE} = 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. 40 to	110 150	
Collector capacitance at f = 1 MHz				
$I_E = I_e$ = 0; V_{CB} = 10 V	C_c	typ. <	36 100	pF 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	> typ.	70 100	MHz 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 0.6	μs 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 1.2	μs μs

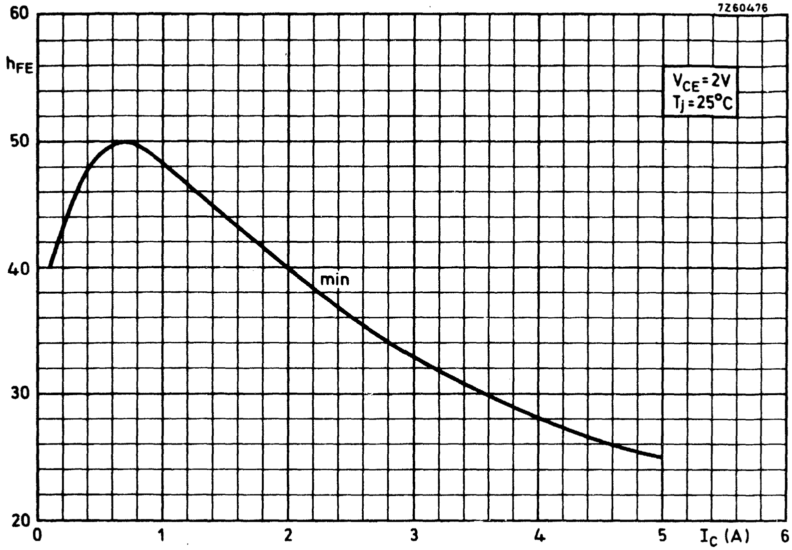


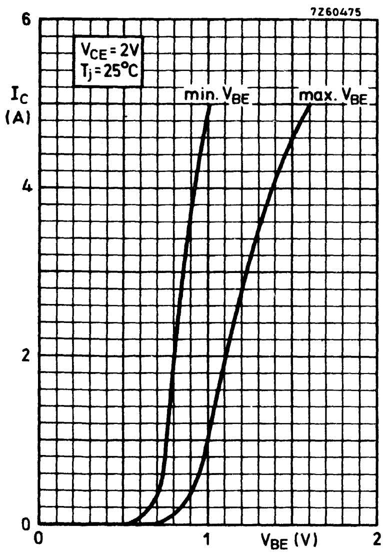
Safe Operation Area with the transistor forward biased

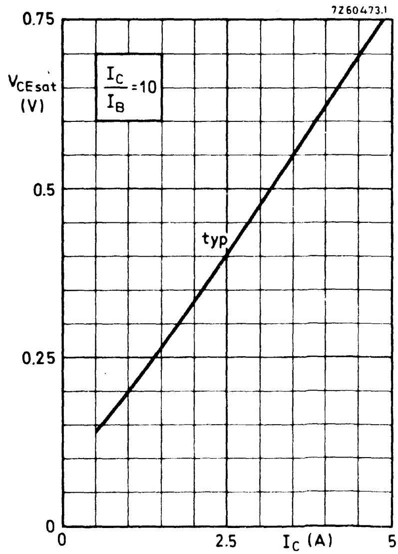
I Region of permissible d.c. operation
II Permissible extension for repetitive pulsed operation


7Z60478
10^3
$Z_{th\,j\text{-}c}$
(°C/W)
10^2
δ = 1
0.5
10
0.2
0.1
1
0.01
10^{-1}
10^{-3}
10^{-2}
10^{-1}
1
10
10^2
t_p (ms)
10^3


7Z60474
750
typical values
t
(ns)
500
t_{off}
250
t_{on}
0
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 CONTROLLED SWITCH

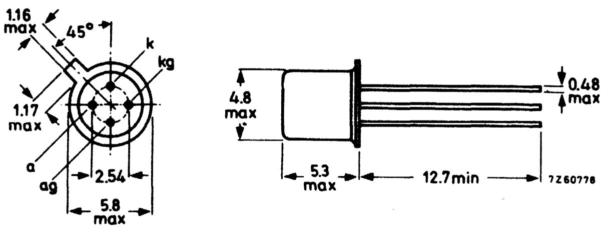
The BR101 is a planar p-n-p-n switch in a TO-72 metal envelope, intended for time base circuits and other television applications. It is also suitable as trigger device for thyristors. It is an integrated pnp-npn transistor pair of which all electrodes are accessible.
The collector of the n-p-n transistor is connected to the case.

QUICK REFERENCE DATA				
P-N-P transistor				
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	50	V
N-P-N transistor				
Collector-base voltage (open emitter)	V_{CBO}	max.	50	V
Repetitive peak emitter current (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 (anode gate) connected to the case.
TO-72



Accessories supplied on request: 56246; 56263.

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

			p-n-p	n-p-n	
Voltages					
Collector-base voltage (open emitter)	V_{CBO}	max.	-50	50	V
Collector-emitter voltage (R_{BE} = 10 kΩ)	V_{CER}	max.	–	50	V
Collector-emitter voltage (open base)	V_{CEO}	max.	-50	–	V
Emitter-base voltage (open collector)	V_{EBO}	max.	-50	5 1)	V
Currents					
Emitter current (d.c.)	I_E	max.	175	-175	mA
Repetitive peak emitter current (peak value) 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

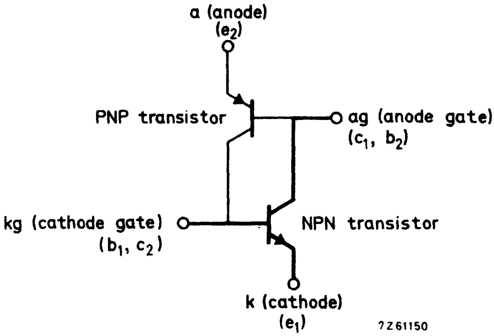
From junction to ambient	$R_{th\ j-a}$	=	0,45	°C/mW

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.

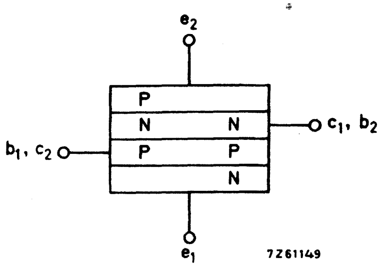
2) Provided the I_E rating will not be exceeded.

MEANING OF SYMBOLS , used in the schematic presentation of the S.C.S.

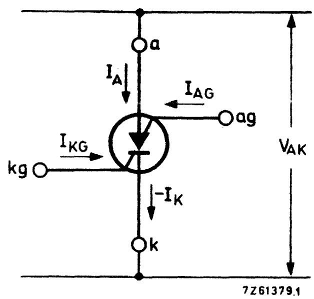
2 transistors equivalent circuit
n-p-n transistor + p-n-p transistor



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

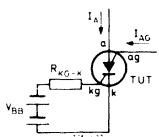
Saturation voltages				
I_C = 10 mA; I_B = 1 mA	V_{CEsat}	<	500	mV
	V_{BEsat}	<	900	mV
D.C. current gain				
I_C = 10 mA; V_{CE} = 2 V	h_{FE}	>	50	
Transition frequency				
I_C = 10 mA; V_{CE} = 2 V	f_T	typ.	300	MHz
Collector capacitance				
$I_E = I_e = 0$; V_{CB} = 20 V	C_c	<	5	pF
Emitter capacitance				
$I_C = I_c = 0$; 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



APPLICATION INFORMATION

In an oscillator circuit the BR101 can be applied in two basic circuit arrangements viz. common anode and common cathode arrangement.
These circuit arrangements are given in Figs. 1, 1a and 2, 2a.
To ease the design of these oscillators and to be sure that, within a certain temperature range, all samples of the BR101 product can be used, the graphs on page 6 show curves for finding the values of the different components corresponding to a given frequency and amplitude of the output voltage.
In these figures the region in which the BR101 oscillates is given by two curves representing the maximum and minimum allowable gate resistances.

$$R = \frac{R1 . R2}{R1 + R2}$$

Page 7 shows the circuit diagrams of a practical vertical and a horizontal time base oscillator with the BR101.

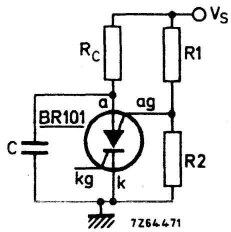


Fig. 1

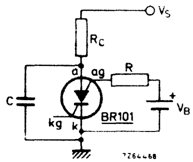


Fig. 1a

Common cathode arrangement

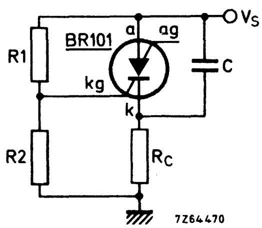


Fig. 2

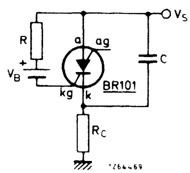
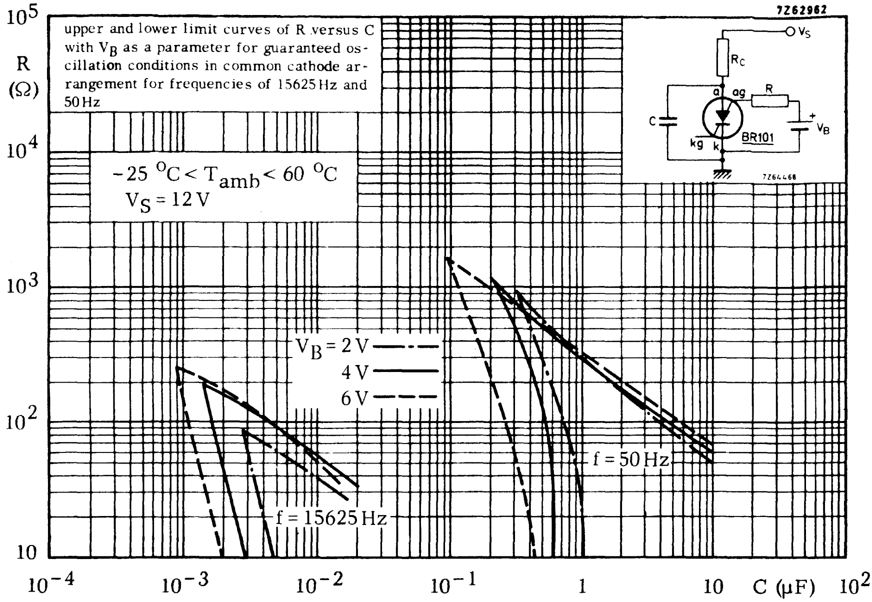
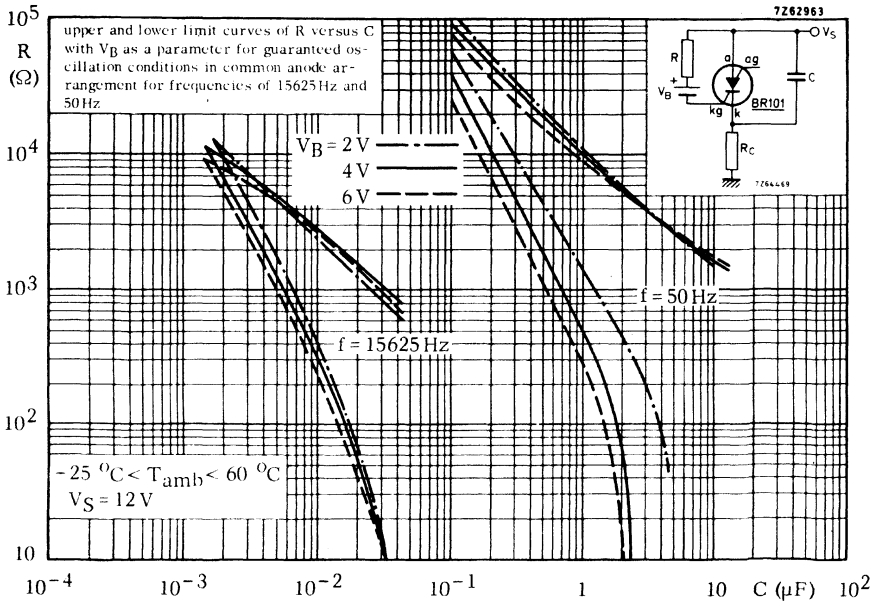


Fig. 2a

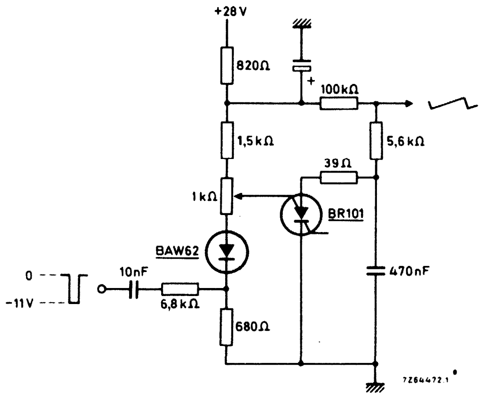
Common anode arrangement

Note: Detailed application information on request.

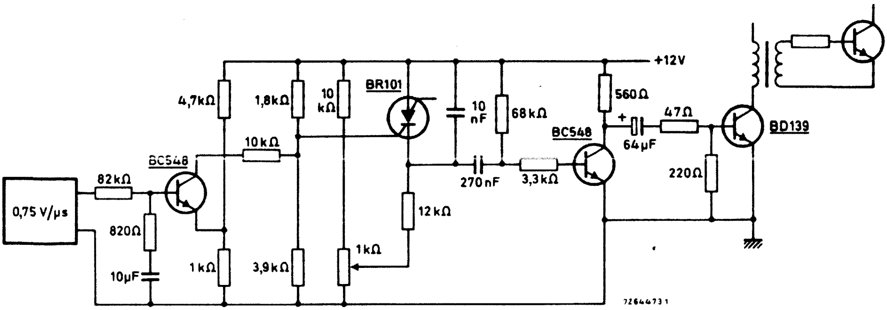

7Z62962
upper and lower limit curves of R versus C with V_B as a parameter for guaranteed oscillation conditions in common cathode arrangement for frequencies of 15625 Hz and 50 Hz
-25 °C < T_{amb} < 60 °C
V_S = 12 V
V_B = 2 V
4 V
6 V
f = 15625 Hz
f = 50 Hz
R (Ω)
C (μF)
V_S
R_C
a
ag
R
C
kg
k
BR101
V_B
7Z64468


7Z62963
upper and lower limit curves of R versus C with V_B as a parameter for guaranteed oscillation conditions in common anode arrangement for frequencies of 15625 Hz and 50 Hz
-25 °C < T_{amb} < 60 °C
V_S = 12 V
V_B = 2 V
4 V
6 V
f = 15625 Hz
f = 50 Hz
R (Ω)
C (μF)
V_S
R
V_B
a
ag
C
kg
k
BR101
R_C
7Z64469

APPLICATION INFORMATION (continued)



Black and white field deflection circuit



Circuit diagram of a horizontal time base oscillator with frequency control stage.

Further information available on request

SILICON CONTROLLED SWITCH

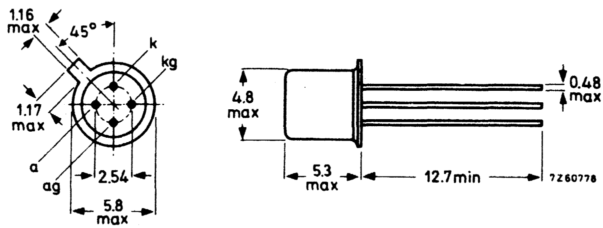
The BRY39 is a planar p-n-p-n switch in a TO-72 metal envelope, intended as driver for numerical indicator tubes and other switching applications.
It is an integrated pnp-npn transistor pair of which all electrodes are accessible.
The collector of the n-p-n transistor is connected to the case.
For the applications of the BRY39 as THYRISTOR TETRODE see Handbook Part 1a, section THYRISTORS, DIACS, TRIACS and as PROGRAMMABLE UNIJUNCTION TRANSISTOR see Handbook Part 3, section SWITCHING TRANSISTORS.

QUICK REFERENCE DATA				
P-N-P transistor				
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	70	V
N-P-N transistor				
Collector-base voltage (open emitter)	V_{CBO}	max.	70	V
Repetitive peak emitter current (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
Turn-on time	t_{on}	<	0,25	μs
Turn-off time	t_q	<	5,0	μs

MECHANICAL DATA

Dimensions in mm

Collector of the n-p-n transistor (anode gate) connected to the case.
TO-72



Accessories supplied on request: 56246; 56263.

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

			p-n-p	n-p-n	
Voltages					
Collector-base voltage (open emitter)	V_{CBO}	max.	-70	70 [1]	V
Collector-emitter voltage (R_{BE} = 10 kΩ)	V_{CER}	max.	–	70 [1]	V
Collector-emitter voltage (open base)	V_{CEO}	max.	-70	–	V
Emitter-base voltage (open collector)	V_{EBO}	max.	-70 [1]	5 [2]	V
Currents					
Emitter current (d.c.)	I_E	max.	175	-175	mA
Repetitive peak emitter current (peak value) t_p = 10 µs: δ = 0,01	I_{ERM}	max.	2,5	-2,5	A
→ Collector current (d.c.)	I_C	max.	–	175 [3]	mA
→ Collector current (peak value)	I_{CM}	max.	–	175 [4]	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	275	mW

Temperatures

Storage temperature	T_{stg}	-65 to +200		°C
Operating junction temperature	T_j	max.	150	°C

THERMAL RESISTANCE

From junction to ambient	$R_{th\ j-a}$	=	0,45	°C/mW

1) In numerical indicator tube driver circuits higher voltages are allowed, provided the collector current does not exceed a d.c. current of 1 mA.

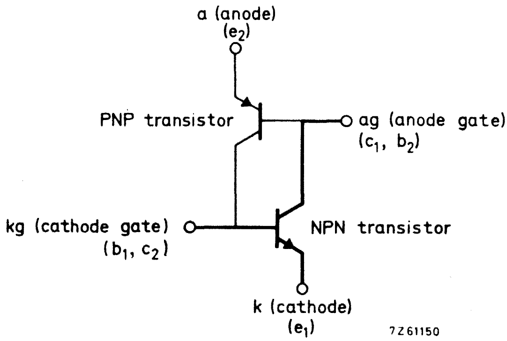
2) In numerical indicator tube driver circuits higher voltages are allowed during the discharge of a capacitor of max. 390 pF, provided the charge does not exceed 50 nC.

→ 3) Provided the I_E rating will not be exceeded.

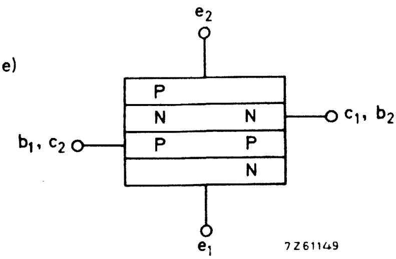
4) During switching on, the device can withstand a discharge of a capacitor of max. 500 pF. This capacitor is charged, when the transistor is in cut-off condition, with a collector supply voltage of 160 V with a series resistance of 100 kΩ.

MEANING OF SYMBOLS, used in the schematic presentation of the S.C.S.

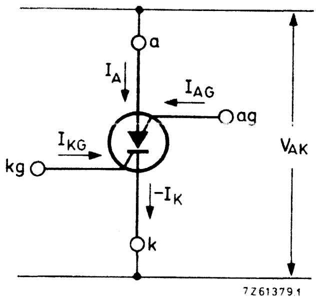
2 transistor equivalent circuit



p-n-p-n S.C.S. equivalent circuit



S.C.S. symbol



CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Individual N-P-N transistor

Collector cut-off current

V_{CE} = 70 V; R_{BE} = 10 kΩ	I_{CER}	<	100 nA
V_{CE} = 70 V; R_{BE} = 10 kΩ; T_j = 150 °C	I_{CER}	<	10 µA

Emitter cut-off current

I_C = 0; V_{EB} = 5 V; T_j = 150 °C	I_{EBO}	<	10 µA

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

Individual N-P-N transistor

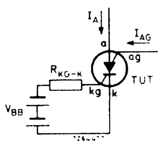
Saturation voltages				
$I_C = 10$ mA; $I_B = 1$ mA	V_{CEsat}	<	500	mV
	V_{BEsat}	<	900	mV
D.C. current gain				
$I_C = 10$ mA: $V_{CE} = 2$ V	h_{FE}	>	50	
Transition frequency				
$I_C = 10$ mA; $V_{CE} = 2$ V	f_T	typ.	300	MHz
Collector capacitance				
$I_E = I_e = 0$; $V_{CB} = 20$ V	C_c	<	5	pF
Emitter capacitance				
$I_C = I_c = 0$; $V_{EB} = 1$ V	C_e	<	25	pF

Individual P-N-P transistor

Collector cut-off current				
$I_B = 0$; $-V_{CE} = 70$ V; $T_j = 150\ ^oC$	$-I_{CEO}$	<	10	μA
Emitter cut-off current				
$I_C = 0$; $-V_{EB} = 70$ V; $T_j = 150\ ^oC$	$-I_{EBO}$	<	10	μA
D.C. current gain				
→ $I_E = 1$ mA; $V_{CB} = 0$	h_{FE}	0,25 to 2,5		

Combined device

Forward on-state voltage at $R_{KG-K} = 10$ kΩ				
$I_A = 50$ mA; $I_{AG} = 0$	V_{AK}	<	1,4	V
$I_A = 50$ mA; $I_{AG} = 0$; $T_j = -55\ ^oC$	V_{AK}	<	1,9	V
$I_A = 1$ mA; $I_{AG} = 10$ mA	V_{AK}	<	1,2	V
→ Holding current at $R_{KG-K} = 10$ kΩ				
$I_{AG} = 10$ mA; $-V_{BB} = 2$ V	I_H	<	1,0	mA

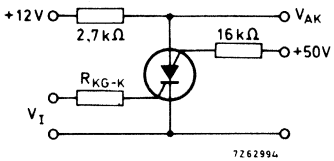


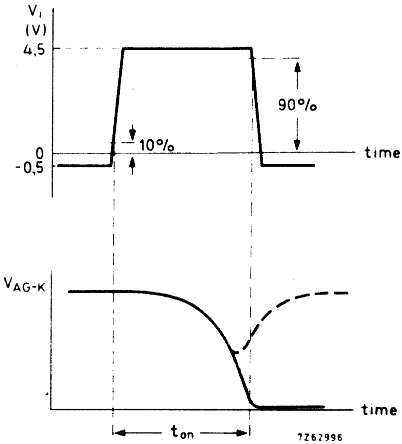
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Switching times see also page 6

Turn-on time when switched from

$-V_{KG-K}$ = 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

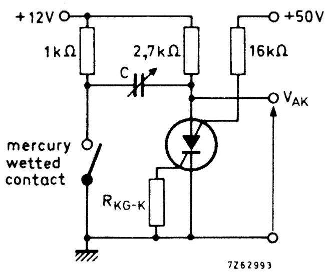


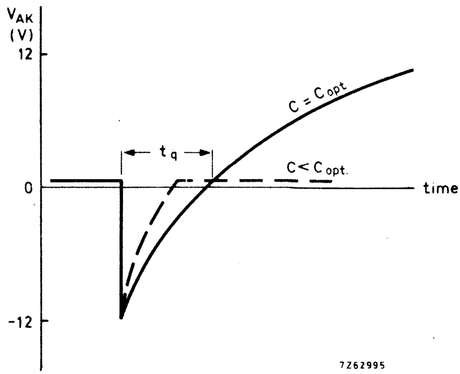


Pulse duration increased until dashed curve disappears

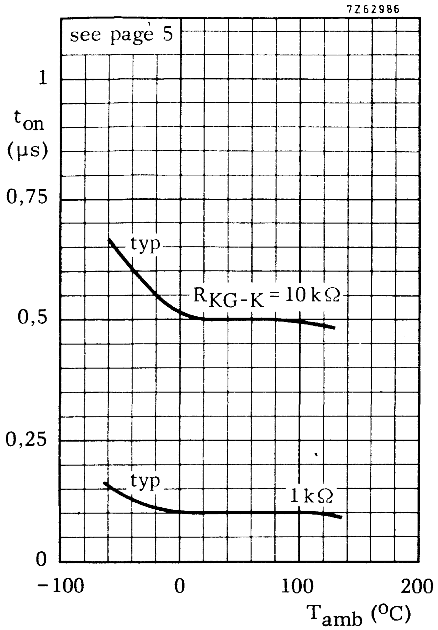
Turn-off time

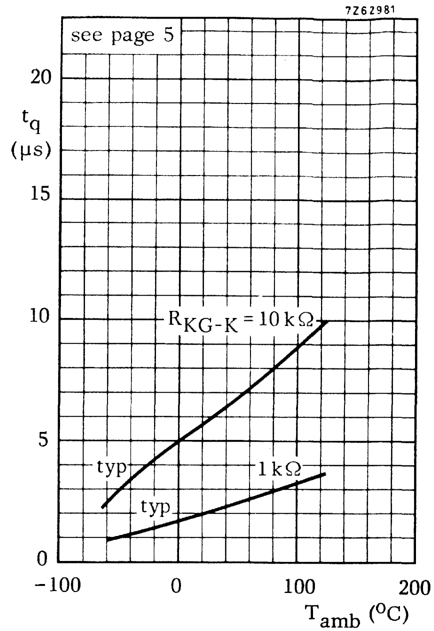
R_{KG-K} = 1 kΩ	t_q	<	5	μs
R_{KG-K} = 10 kΩ	t_q	<	8	μs
T_j = 125 °C; R_{KG-K} = 10 kΩ	t_q	<	15	μs

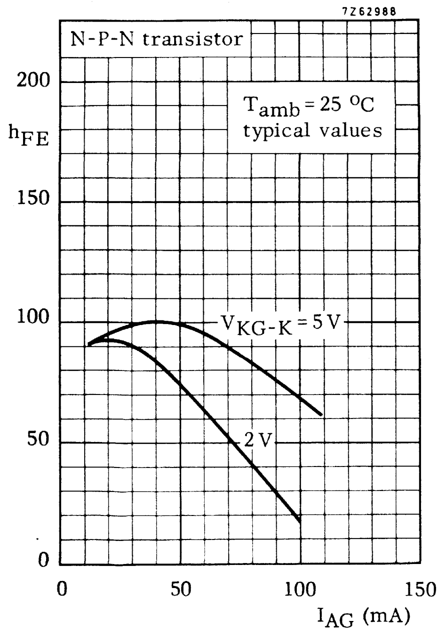


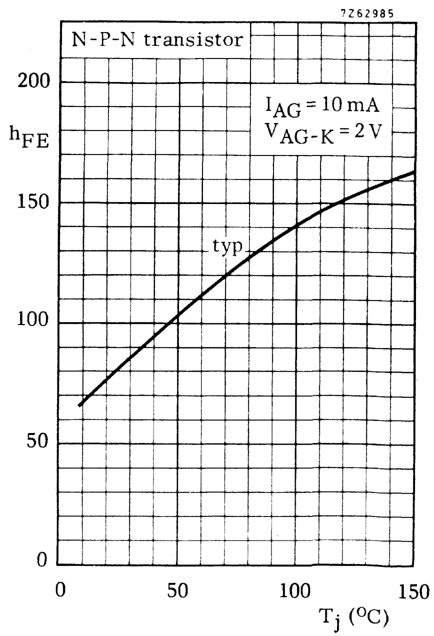


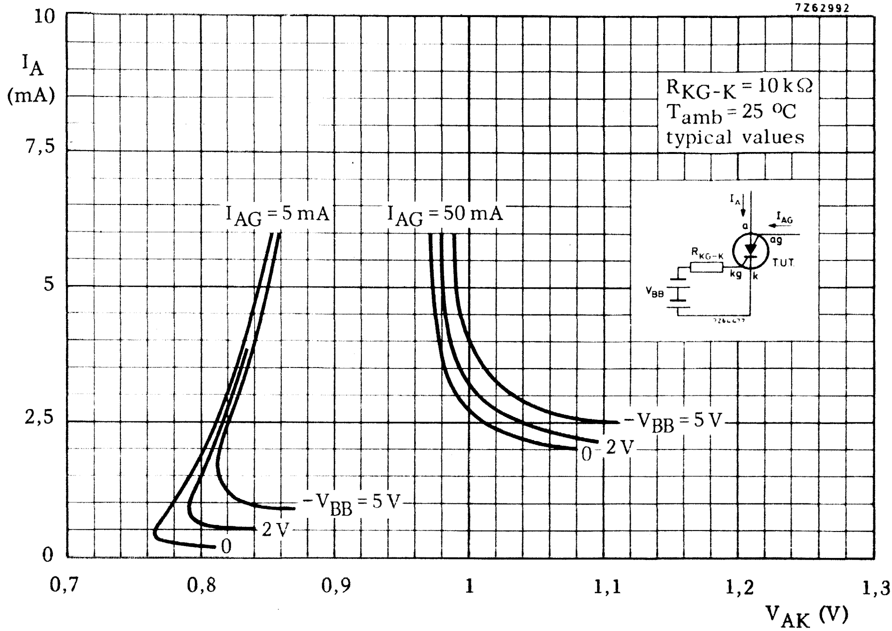
Capacitance increased until dashed curve disappears at C = C_{opt}

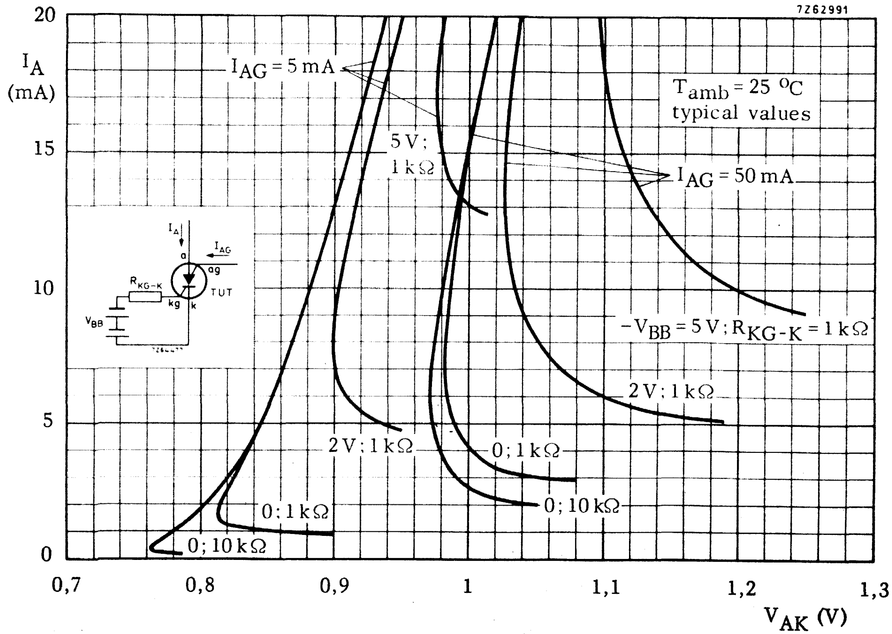

7Z62986
see page 5
1
t_{on}
(μs)
0,75
typ
R_{KG-K} = 10 kΩ
0,5
0,25
typ
1 kΩ
0
−100
0
100
200
T_{amb} (°C)

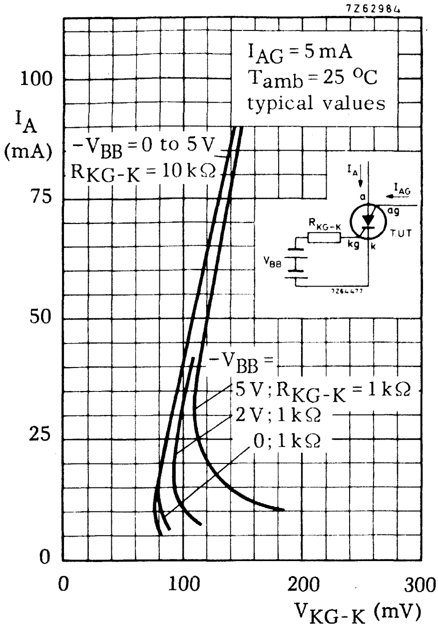

7Z62981
see page 5
20
t_q
(μs)
15
10
R_{KG-K} = 10 kΩ
5
typ
1 kΩ
typ
0
−100
0
100
200
T_{amb} (°C)

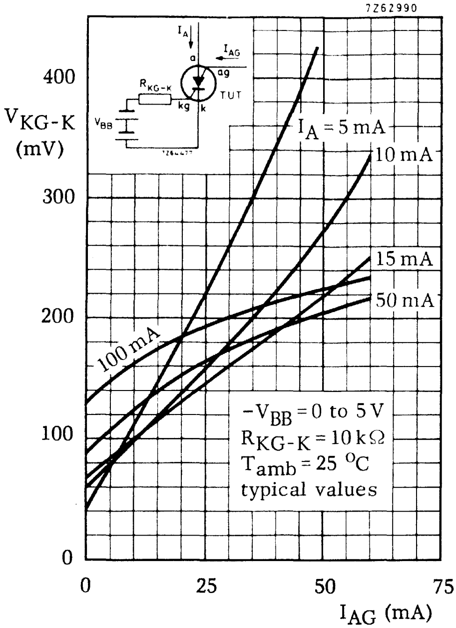

7Z62988
N-P-N transistor
200
h_{FE}
T_{amb} = 25 °C
typical values
150
100
V_{KG-K} = 5 V
50
2 V
0
0
50
100
150
I_{AG} (mA)

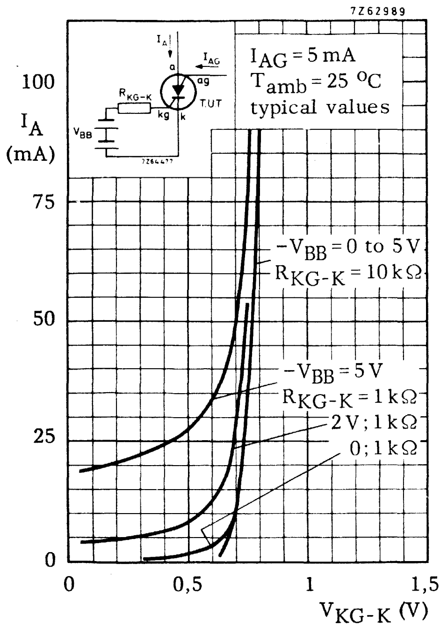

7Z62985
N-P-N transistor
200
h_{FE}
I_{AG} = 10 mA
V_{AG-K} = 2 V
150
typ
100
50
0
0
50
100
150
T_j (°C)

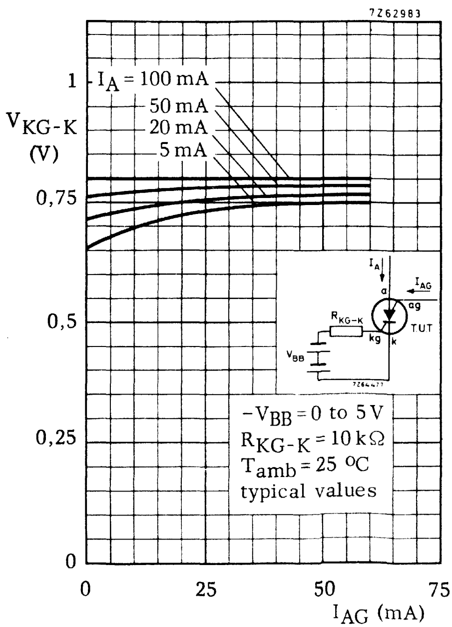

7Z62992
10
I_A
(mA)
7,5
5
2,5
0
0,7
0,8
0,9
1
1,1
1,2
1,3
V_{AK} (V)
R_{KG-K} = 10 kΩ
T_{amb} = 25 °C
typical values
I_{AG} = 5 mA
I_{AG} = 50 mA
$-V_{BB}$ = 5 V
2 V
0
I_A
I_{AG}
a
ag
R_{KG-K}
kg
k
TUT
V_{BB}

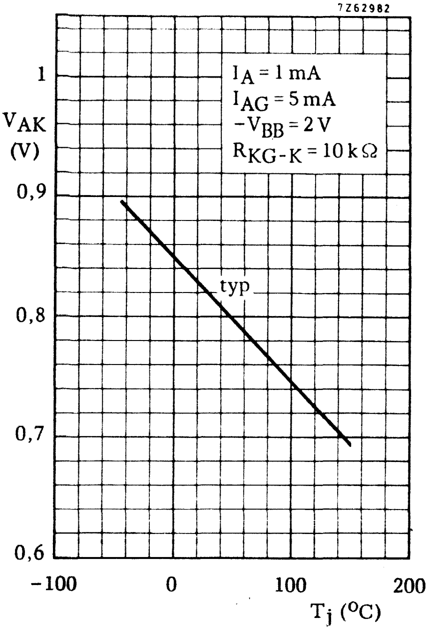

7Z62991
20
I_A
(mA)
15
10
5
0
0,7
0,8
0,9
1
1,1
1,2
1,3
V_{AK} (V)
T_{amb} = 25 °C
typical values
I_{AG} = 5 mA
5 V;
1 kΩ
I_{AG} = 50 mA
$-V_{BB}$ = 5 V; R_{KG-K} = 1 kΩ
2 V; 1 kΩ
2 V; 1 kΩ
0; 1 kΩ
0; 10 kΩ
0; 1 kΩ
0; 10 kΩ
I_A
I_{AG}
a
ag
R_{KG-K}
kg
k
TUT
V_{BB}

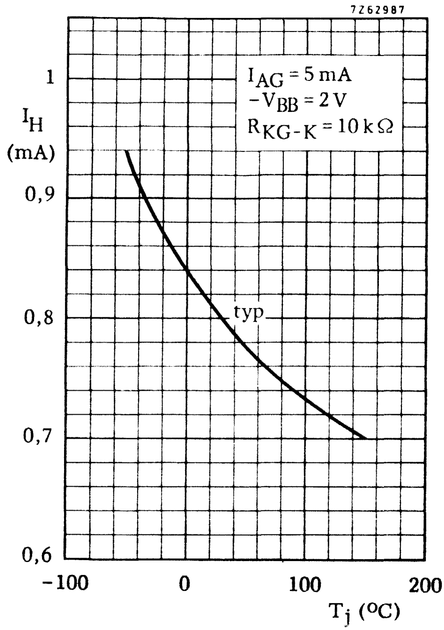

7Z62984
I_{AG} = 5 mA
T_{amb} = 25 °C
typical values
$-V_{BB}$ = 0 to 5 V
R_{KG-K} = 10 kΩ
$-V_{BB}$ =
5 V; R_{KG-K} = 1 kΩ
2 V; 1 kΩ
0; 1 kΩ
I_A (mA)
V_{KG-K} (mV)
TUT

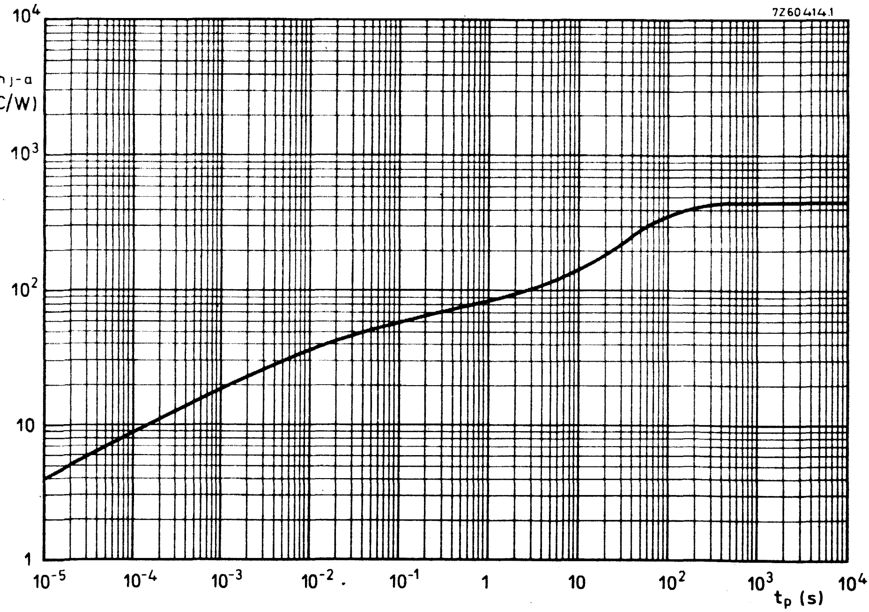

7Z62990
V_{KG-K} (mV)
I_A = 5 mA
10 mA
15 mA
50 mA
100 mA
$-V_{BB}$ = 0 to 5 V
R_{KG-K} = 10 kΩ
T_{amb} = 25 °C
typical values
I_{AG} (mA)
TUT

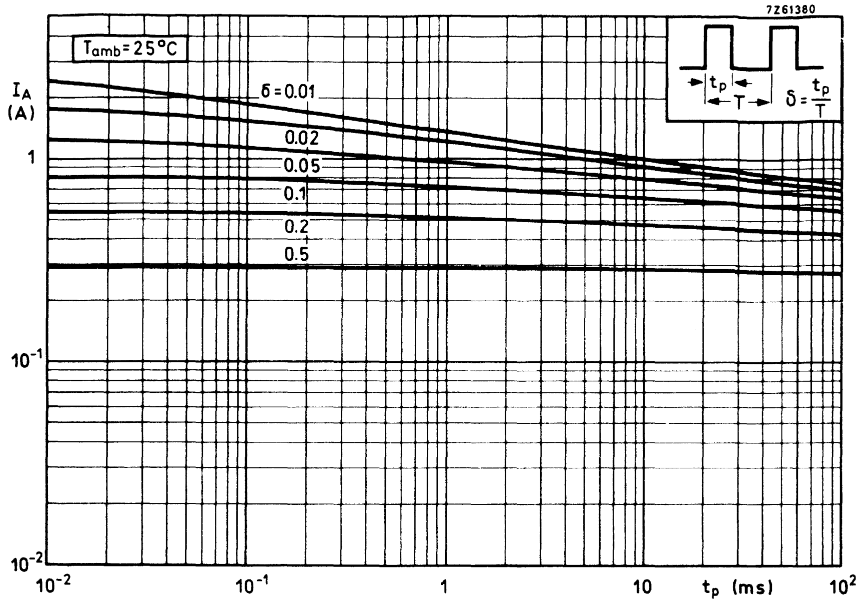

7Z62989
I_{AG} = 5 mA
T_{amb} = 25 °C
typical values
I_A (mA)
$-V_{BB}$ = 0 to 5 V
R_{KG-K} = 10 kΩ
$-V_{BB}$ = 5 V
R_{KG-K} = 1 kΩ
2 V; 1 kΩ
0; 1 kΩ
V_{KG-K} (V)
TUT

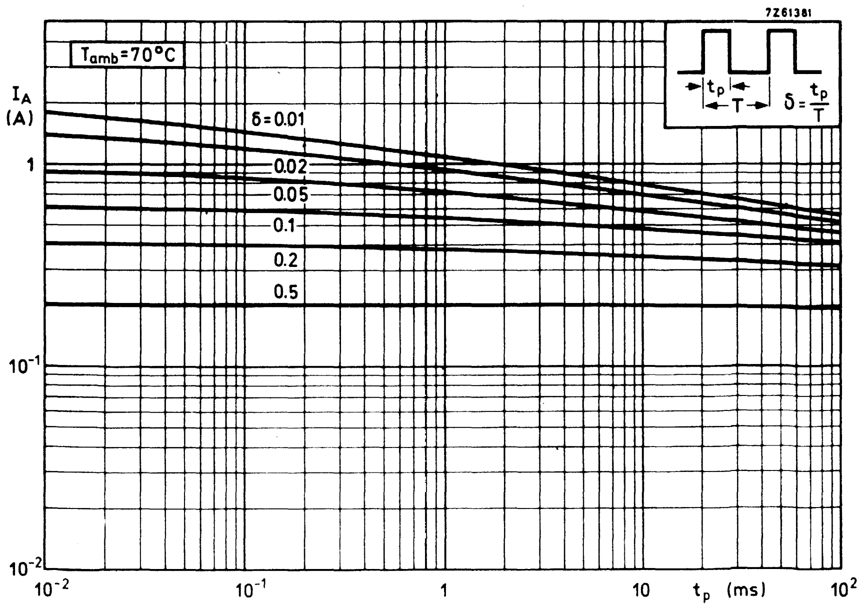

7Z62983
I_A = 100 mA
50 mA
20 mA
5 mA
V_{KG-K} (V)
$-V_{BB}$ = 0 to 5 V
R_{KG-K} = 10 kΩ
T_{amb} = 25 °C
typical values
I_{AG} (mA)
TUT


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)

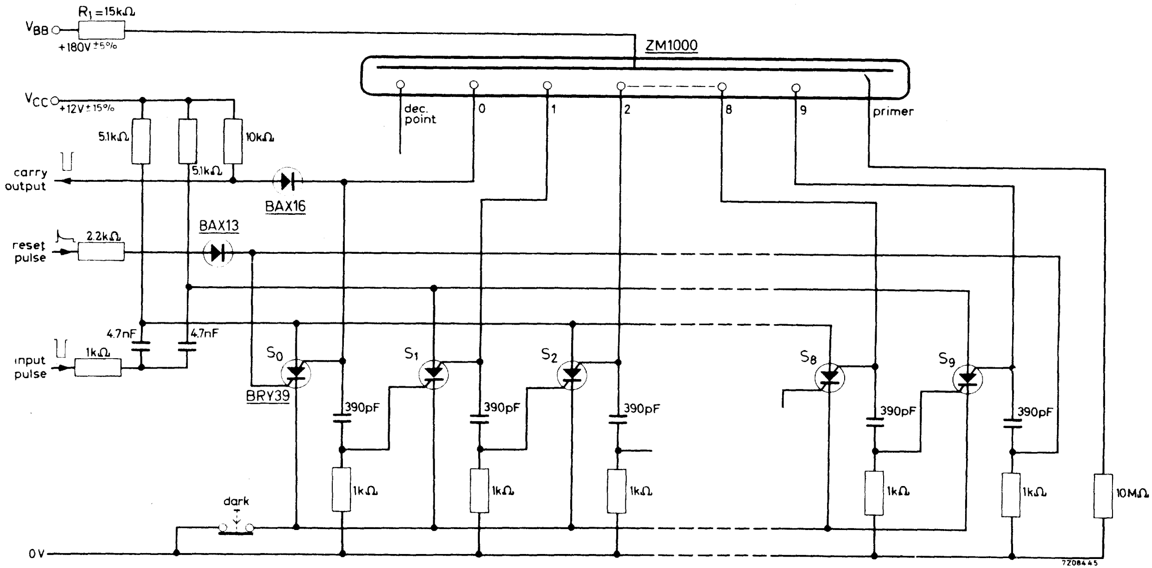

7Z61380
T_{amb} = 25 °C
I_A (A)
δ = 0.01
0.02
0.05
0.1
0.2
0.5
t_p (ms)
T
δ = $\frac{t_p}{T}$
1
10^{-1}
10^{-2}
10
10^2


7Z61381
T_{amb} = 70 °C
I_A (A)
δ = 0.01
0.02
0.05
0.1
0.2
0.5
t_p (ms)
T
δ = $\frac{t_p}{T}$
1
10^{-1}
10^{-2}
10
10^2

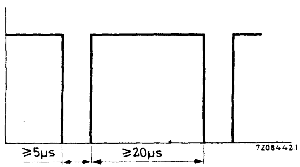
APPLICATION INFORMATION

Decade ring-counter circuit with display ($f \leq 40$ kHz)

Operating ambient temperature T_{amb} 0 to 70 °C



Input pulse:



All resistors 1/8 W; ±5%; except R_1: 3%

PROGRAMMABLE UNIJUNCTION TRANSISTOR

The BRY39 is a planar p-n-p-n trigger device in a TO-72 metal envelope, intended for use in switching applications such as motor control, oscillators, relay replacement, timers, pulse shaper, trigger device etc.
For the application of the BRY39 as SCS see Handbook Part 3, section SWITCHING TRANSISTORS and as THYRISTOR TETRODE see Handbook Part 1a, section THYRISTORS, DIACS, TRIACS. (For explanation of symbols see page 2). ←

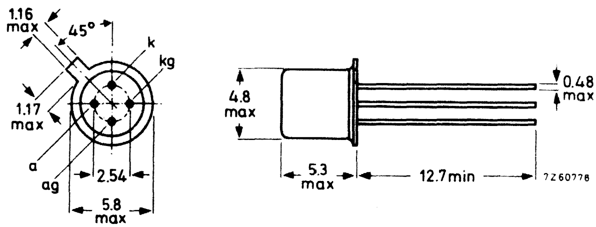
QUICK REFERENCE DATA				
Gate-anode voltage	V_{GA}	max.	70	V
Anode current (d.c.) up to T_{case} = 85 °C	I_A	max.	250	mA
Junction temperature	T_j	max.	150	°C
Peak point current V_S = 10 V; R_G = 10 kΩ	I_P	<	5	μA
Valley point current V_S = 10 V; R_G = 10 kΩ	I_V	>	50	μA

MECHANICAL DATA

Dimensions in mm

Anode gate connected to case

TO-72



Accessories supplied on request: 56246; 56263.

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

→ Voltage

Gate-anode voltage	V_{GA}	max.	70	V

Currents

Anode current (d.c.) up to T_{amb} = 25 °C	I_A	max.	175	mA
Anode current (d.c.) up to T_{case} = 85 °C	I_A	max.	250	mA
Repetitive peak anode current t = 10 μs; δ = 0.01	I_{ARM}	max.	2.5	A
Non-repetitive peak anode current t = 10 μs; T_j = 150 °C	I_{ASM}	max.	3	A
Rate of rise of anode current up to I_A = 2.5 A	$\frac{dI_A}{dt}$	max.	20	A/μs

Temperatures

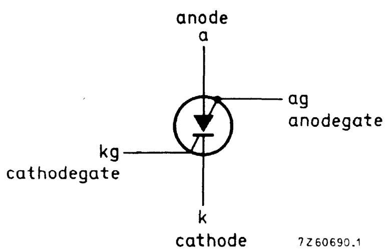
Storage temperature	T_{stg}	-65 to	+200	°C
Operating junction temperature	T_j	max.	150	°C

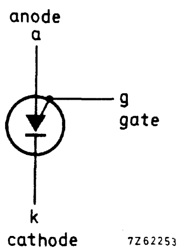
THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.45	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	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.



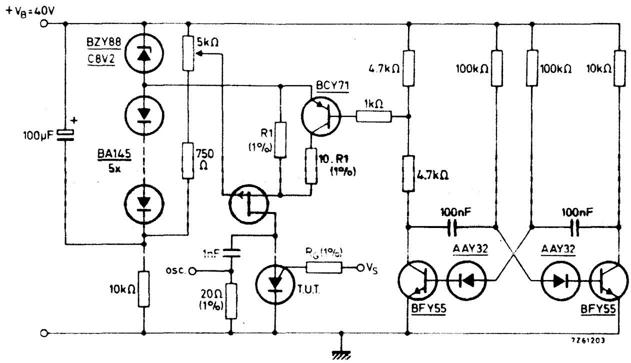


CHARACTERISTICS

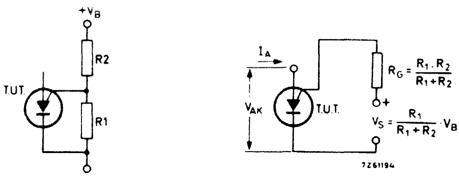
$T_{amb} = 25\ ^{o}C$ unless otherwise specified

Peak point current				
$V_S = 10\ V;\ R_G = 10\ k\Omega$	I_P	<	5	μA
$V_S = 10\ V;\ R_G = 1\ M\Omega$	I_P	<	1	μA
Valley point current				
$V_S = 10\ V;\ R_G = 10\ k\Omega$	I_V	>	50	μA
$V_S = 10\ V;\ R_G = 1\ M\Omega$	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

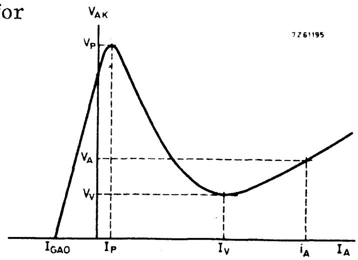


Equivalent test circuit



BRY39 with "program" resistors R_1 and R_2

Equivalent test circuit for characteristics testing



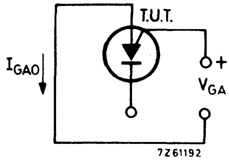
Offset voltage $V_{offset} = V_P - V_S\ (I_A = 0)$

See graph on page 6.

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

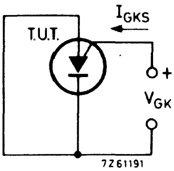
Gate-anode leakage current

$I_K = 0$; $V_{GA} = 70$ V	I_{GAO}	<	10	nA

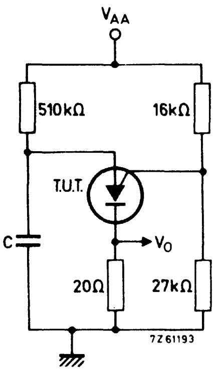


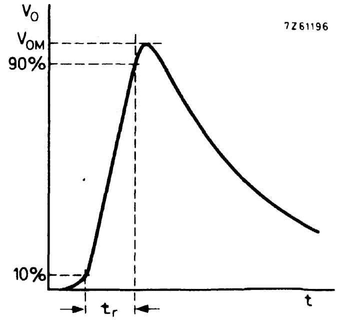
Gate-cathode leakage current

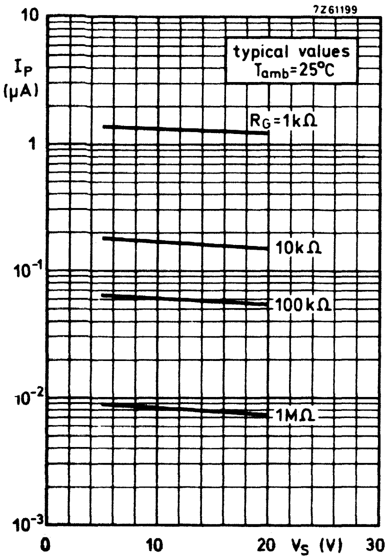
$V_{AK} = 0$; $V_{GK} = 70$ V	I_{GKS}	<	100	nA

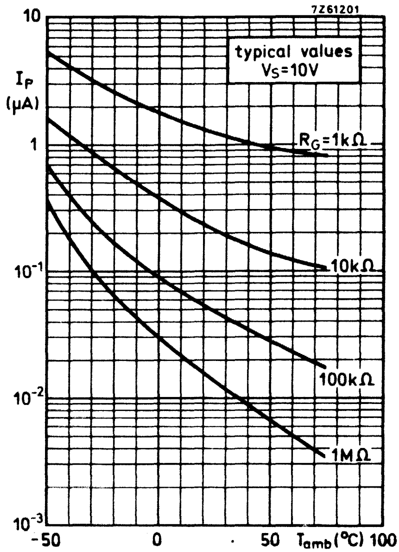


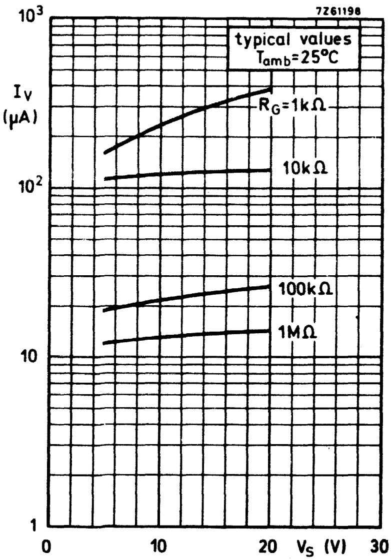
Anode voltage at I_A = 100 mA	V_A	<	1.4	V
Peak output voltage				
V_{AA} = 20 V; C = 0.2 μF	V_{OM}	>	6	V
Rise time				
V_{AA} = 20 V; C = 10 nF	t_r	<	80	ns

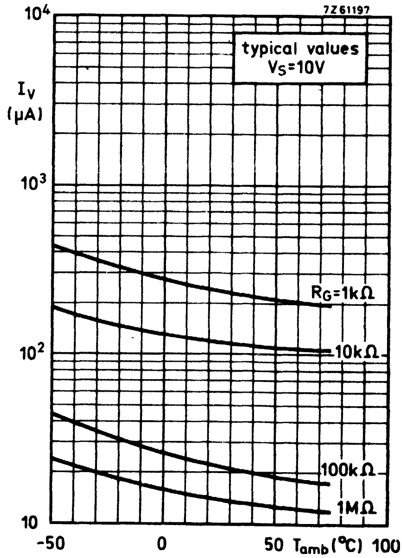


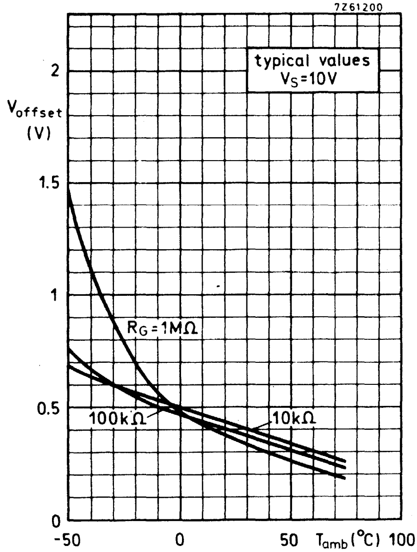


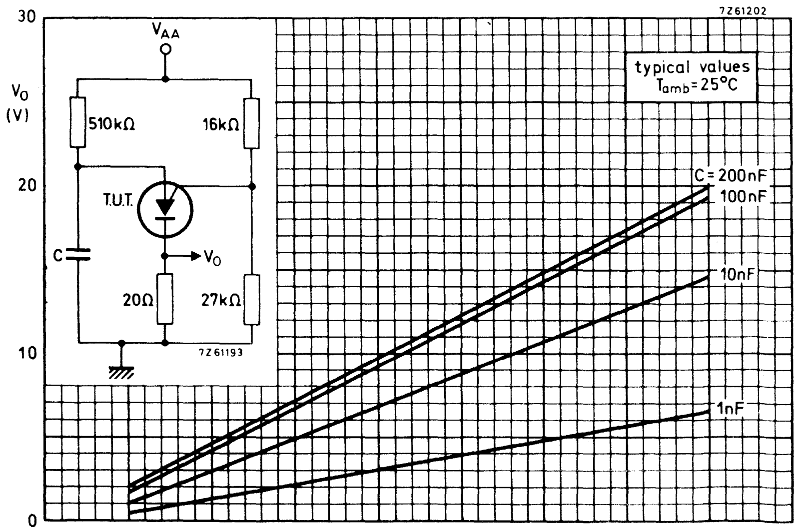

7Z61199
typical values
T_{amb}=25°C
I_P
(μA)
R_G=1kΩ
10kΩ
100kΩ
1MΩ
10
1
10^{-1}
10^{-2}
10^{-3}
0
10
20
V_S (V)
30


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
typical values
T_{amb} = 25°C
V_O
(V)
30
20
10
0
V_{AA}
510kΩ
16kΩ
T.U.T.
C
V_O
20Ω
27kΩ
7Z61193
C = 200nF
100nF
10nF
1nF
0
10
20
30
V_{AA} (V)
40

SWITCHING TRANSISTORS

N-P-N transistor in a TO-39 metal envelope with the collector connected to the case. It is primarily intended for core-driving in the 0.3 μs stores range.

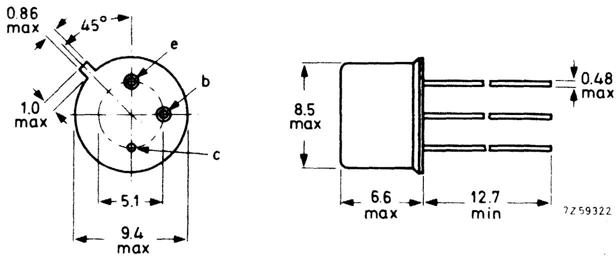
QUICK REFERENCE DATA

			BSS27	BSS28	BSS29	
Collector-emitter voltage (open base)	V_{CEO}	max.	45	30	30	V
Collector current (peak value)	I_{CM}	max.	1	1	1	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	800	800	800	mW
D.C. current gain I_C = 500 mA; V_{CE} = 1 V	h_{FE}	>	25	30	20	
Saturation voltage I_C = 500 mA; I_B = 35 mA	V_{CEsat}	<	0.4	0.4	0.5	V
Turn off time I_C = 500 mA; I_B = 50 mA; $-I_{BM}$ = 50 mA	t_{off}	<	40	45	50	ns

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-39



Accessories available: 56218; 56245; 56265

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

Voltages			BSS27	BSS28	BSS29	
Collector-base voltage (open emitter)	V_{CBO}	max.	70	50	50	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	30	30	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
Reverse base current (peak value)	$-I_{BM}$	max.	0.2	A

Power dissipation				
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	800	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	$R_{th\ j\text{-}a}$	=	225	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	35	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current			BSS27	BSS28	BSS29	
V_{CE} = 40 V; R_{BE} = 50 Ω	I_{CER}	<	1	–	–	μA
V_{CE} = 40 V; R_{BE} = 50 Ω; T_j = 150 °C	I_{CER}	<	1000	–	–	μA
V_{CE} = 25 V; R_{BE} = 50 Ω	I_{CER}	<	–	1	1	μA
V_{CE} = 25 V; R_{BE} = 50 Ω; T_j = 150 °C	I_{CER}	<	–	1000	1000	μA
Currents at reverse biased emitter junction						
$-V_{BE}$ = 4 V; V_{CE} = 40 V	$-I_{BEX}$	<	1	–	–	μA
$-V_{BE}$ = 4 V; V_{CE} = 25 V	$-I_{BEX}$	<	–	1	1	μA

CHARACTERISTICS (continued)

			BSS27	BSS28	BSS29	
Breakdown voltages						
Collector-base voltage; $I_E = 0$; $I_C = 10\,\mu A$	$V_{(BR)CBO}$	>	70	50	50	V
Collector-emitter voltage; $I_C = 1$ mA; $R_{BE} = 50\,\Omega$	$V_{(BR)CER}$	>	70	50	50	V
Collector-emitter voltage; $I_B = 0$; $I_C = 10$ mA	$V_{(BR)CEO}$	>	45	30	30	V
Emitter-base voltage; $I_C = 0$; $I_E = 10\,\mu A$	$V_{(BR)EBO}$	>	5	5	5	V
Saturation voltages [1]						
$I_C = 150$ mA; $I_B = 10$ mA	V_{CEsat}	<	0.3	0.3	0.4	V
	V_{BEsat}	<	1.0	1.0	1.0	V
$I_C = 500$ mA; $I_B = 35$ mA	V_{CEsat}	<	0.4	0.4	0.5	V
	V_{BEsat}	>	0.8	0.8	0.78	V
	V_{BEsat}	<	1.2	1.2	1.2	V
$I_C = 800$ mA; $I_B = 60$ mA	V_{CEsat}	<	0.75	–	–	V
	V_{BEsat}		0.82 to 1.3	–	–	V
$I_C = 1000$ mA; $I_B = 100$ mA	V_{CEsat}	<	0.8	–	–	V
	V_{BEsat}	<	1.5	–	–	V
D.C. current gain						
$I_C = 150$ mA; $V_{CE} = 1$ V	h_{FE}	>	30	40	25	
$I_C = 500$ mA; $V_{CE} = 1$ V	h_{FE}	>	25	30	20	
$I_C = 800$ mA; $V_{CE} = 1$ V	h_{FE}		18 to 60	–	–	
$I_C = 1000$ mA; $V_{CE} = 5$ V	h_{FE}	>	15	–	–	
Transition frequency at f = 100 MHz [1]						
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	typ.	400	400	400	MHz
$I_C = 500$ mA; $V_{CE} = 10$ V	f_T	typ.	300	300	300	MHz
Collector capacitance at f = 1 MHz						
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<		8		pF
Emitter capacitance at f = 1 MHz						
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	typ.		30		pF
		<		45		pF

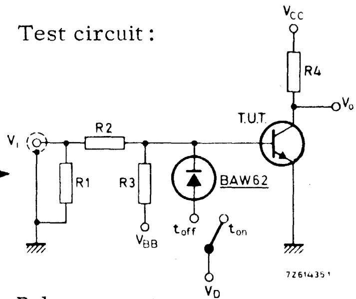
[1]) Measured under pulsed conditions: $t_p = 300\,\mu s$; $\delta = 0.01$

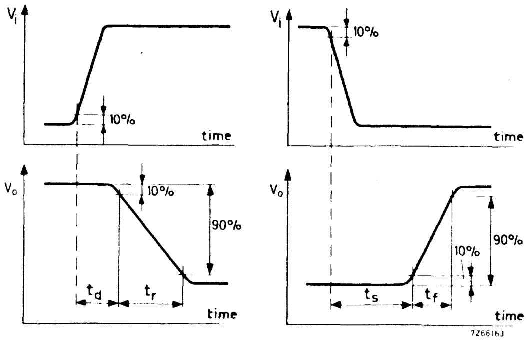
CHARACTERISTICS (continued)

Switching times

		BSS27	BSS28	BSS29	
Turn-on time when switched from					
→ $-V_{BE}$ = 2 V to I_C = 500 mA; I_B = 50 mA	t_{on}	> 5	–	–	ns
		< 25	25	30	ns
$-V_{BE}$ = 2 V to I_C = 1000 mA; I_B = 100 mA	t_{on}	5 to 20	–	–	ns
Turn-off time when switched from					
→ I_C = 500 mA; I_B = 50 mA to cut-off with $-I_{BM}$ = 1 mA	t_{off}	< 250	250	250	ns
I_C = 500 mA; I_B = 50 mA to cut-off with $-I_{BM}$ = 50 mA	t_{off}	> 15	–	–	ns
		< 40	45	50	ns
I_C = 1000 mA; I_B = 100 mA to cut-off with $-I_{BM}$ = 100 mA	t_{off}	10 to 40	–	–	ns
Storage time when switched from					
I_C = 500 mA; I_B = 50 mA to cut-off with $-I_{BM}$ = 50 mA	t_s	> 12	10	10	ns
I_C = 1000 mA; I_B = 100 mA to cut-off with $-I_{BM}$ = 100 mA	t_s	> 8	–	–	ns

Test circuit:

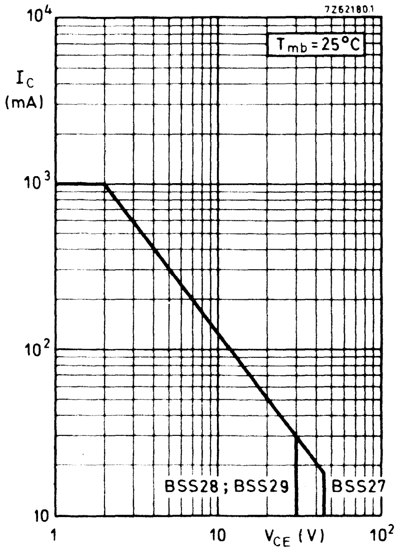


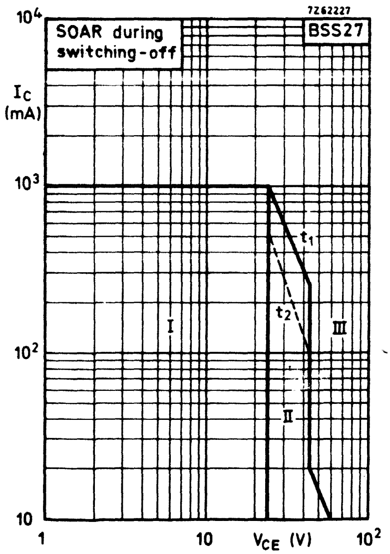


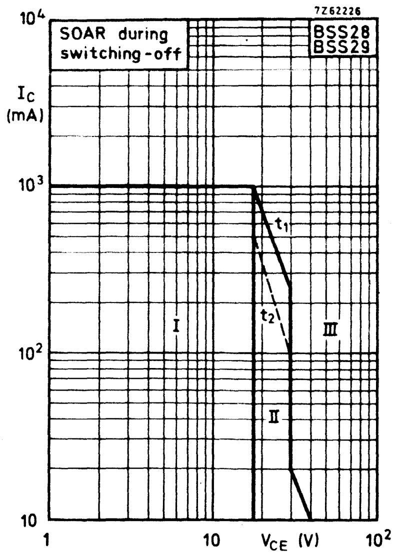
Pulse generator:

Pulse duration	$t_p \geq$	500 ns
Rise time	$t_r \leq$	5 ns
Fall time	$t_f \leq$	5 ns
Source impedance	R_S =	50 Ω

									turn-on time		turn-off time		
	I_C (mA)	I_B (mA)	$-I_{BM}$ (mA)	V_{CC} (V)	R1 (Ω)	R2 (Ω)	R3 (Ω)	R4 (Ω)	$-V_{BB}$ (V)	V_i (V)	V_{BB} (V)	V_i (V)	$-V_D$
BSS27	500	50	50	45	56	375	400	90	4.0	24.75	16.7	37.5	3
BSS27	1000	100	100	45	56	200	200	45	4.0	24.75	16.7	37.5	3
→ BSS27	500	50	1	45	56	750	∞	90	–	–	–	37.5	–
BSS28; BSS29	500	50	50	30	56	375	400	60	4.0	24.75	16.7	37.5	3
BSS28; BSS29	500	50	1	30	56	750	∞	60	–	–	–	37.5	–







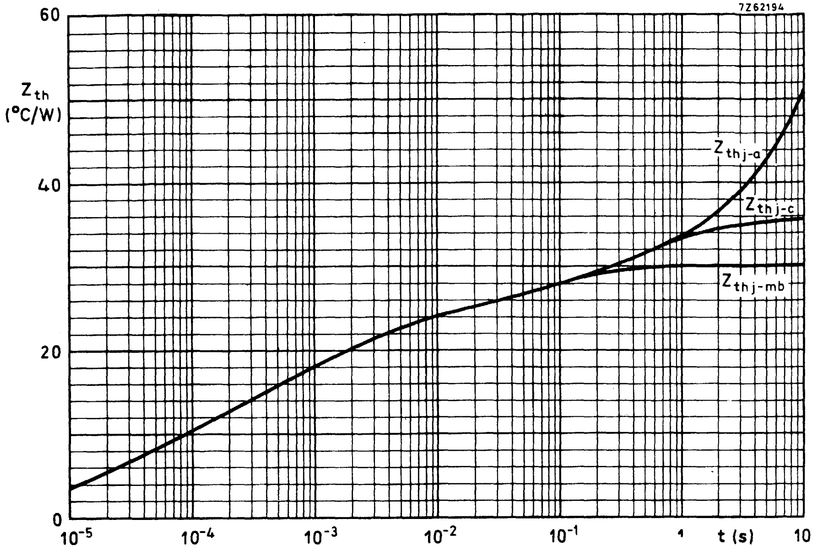
I Region of permissible operation during switching off with $-V_{BB} = 4$ V; $R_{BE} = 39\ \Omega$

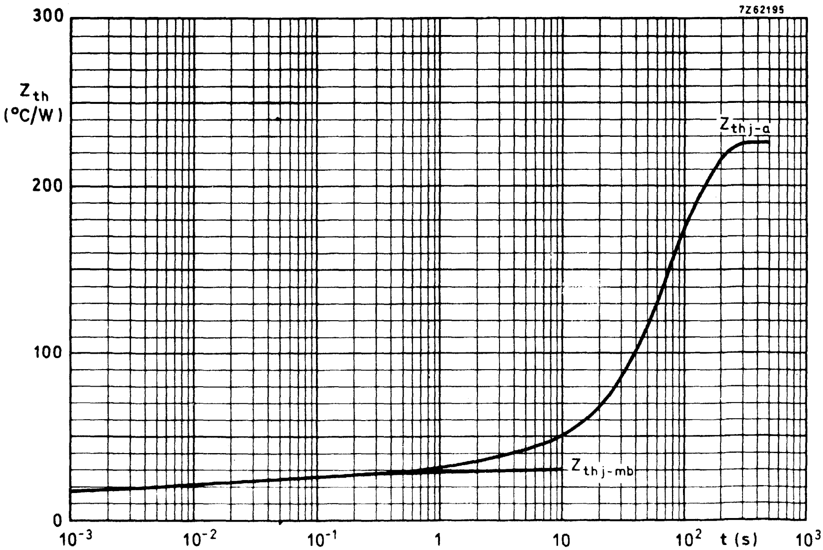
II Permissible extension for repetitive pulsed operation

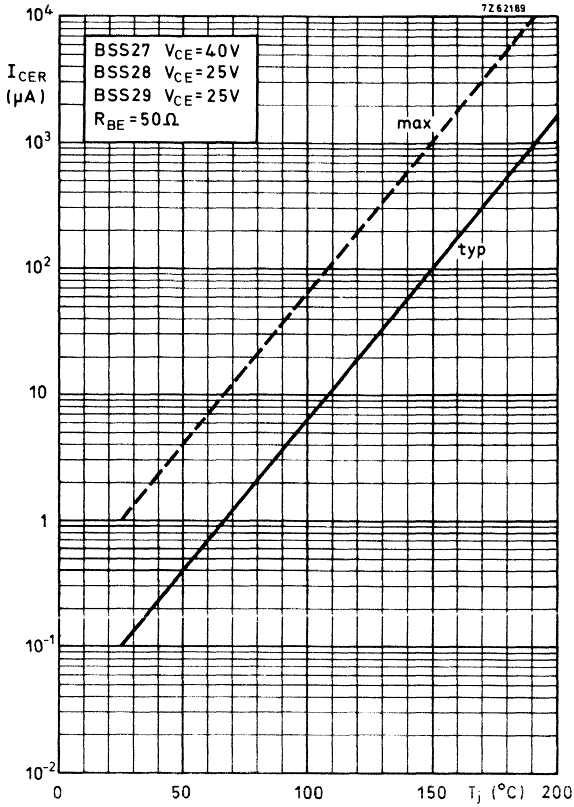
t_1 limits operations with $t_p \leq 0.1\ \mu s$; $\delta = 0.25$

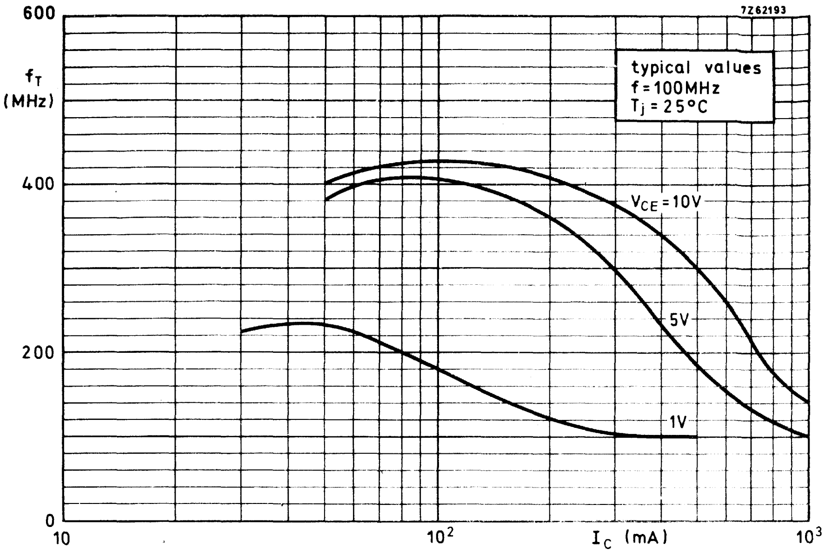
t_2 limits operations with $t_p \leq 1\ \mu s$; $\delta = 0.25$

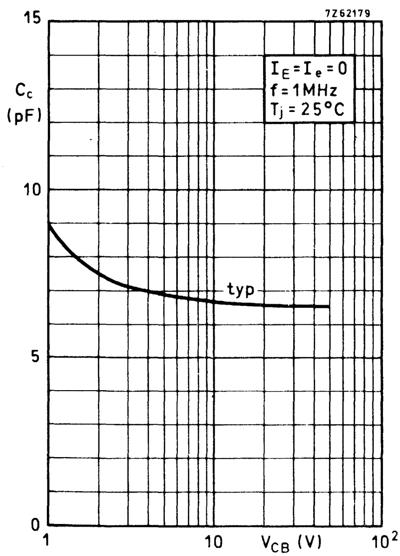
III Operation in this area is not allowed.

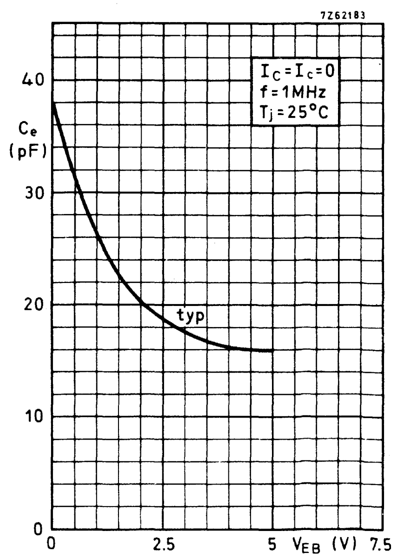

7Z62194
Z_{th} (°C/W)
60
40
20
0
$Z_{th\,j-a}$
$Z_{th\,j-c}$
$Z_{th\,j-mb}$
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1
t (s)
10

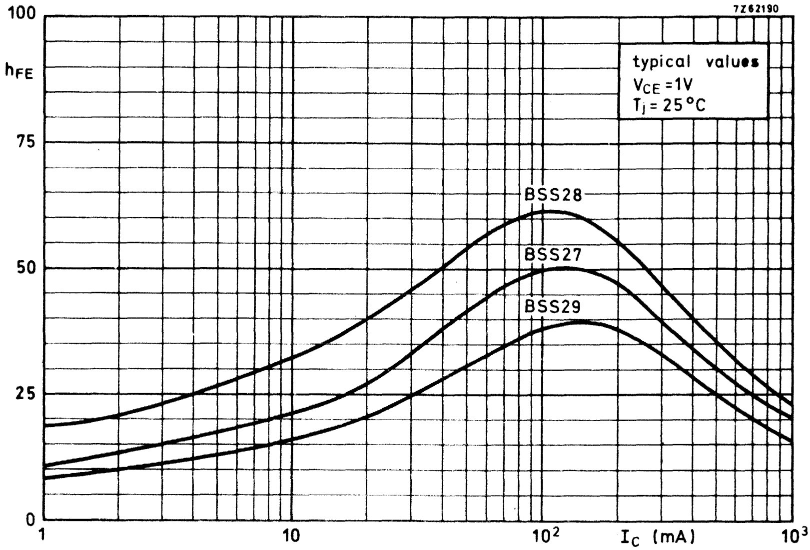

7Z62195
Z_{th} (°C/W)
300
200
100
0
$Z_{th\,j-a}$
$Z_{th\,j-mb}$
10^{-3}
10^{-2}
10^{-1}
1
10
10^{2}
t (s)
10^{3}

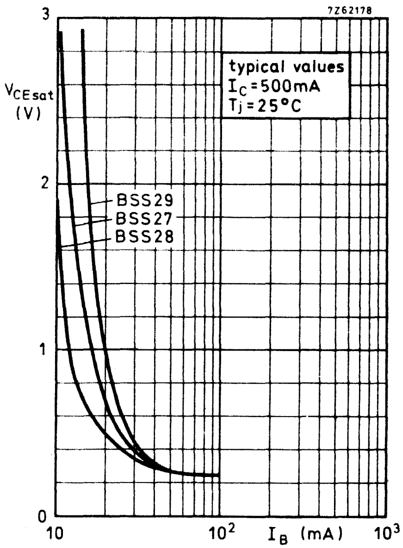

7Z62189
I_{CER} (μA)
BSS27 V_{CE}=40V
BSS28 V_{CE}=25V
BSS29 V_{CE}=25V
R_{BE}=50Ω
max
typ
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}
0
50
100
150
T_j (°C)
200

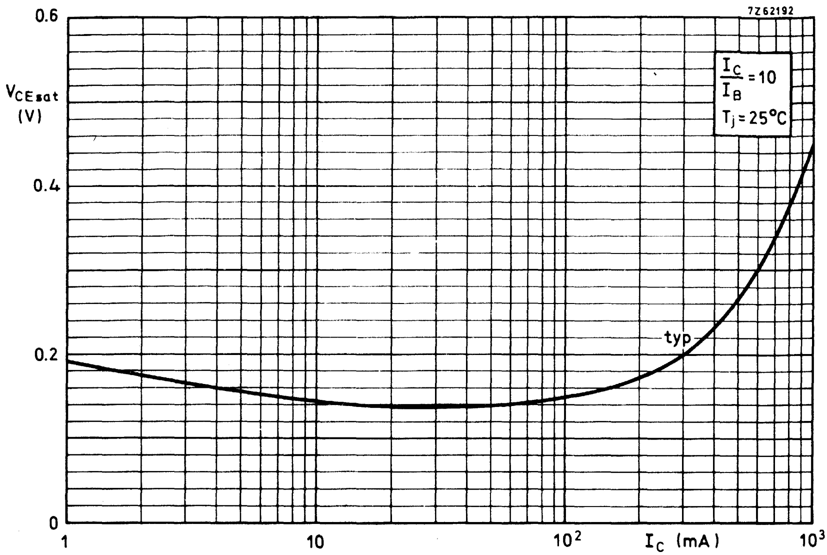

7Z62193
600
f_T
(MHz)
400
200
0
10
10^2
I_C (mA)
10^3
typical values
f = 100MHz
T_j = 25°C
V_{CE} = 10V
5V
1V

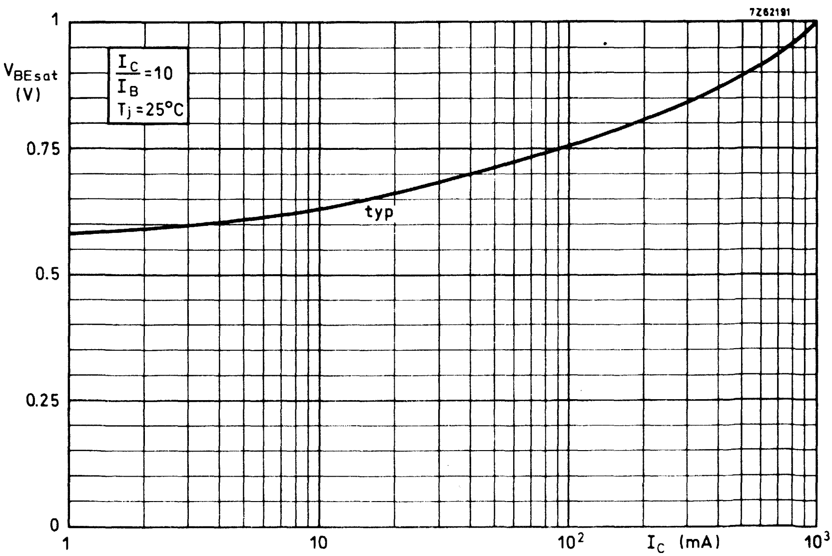

7Z62179
15
C_c
(pF)
10
5
0
1
10
V_{CB} (V)
10^2
$I_E = I_e = 0$
f = 1MHz
T_j = 25°C
typ

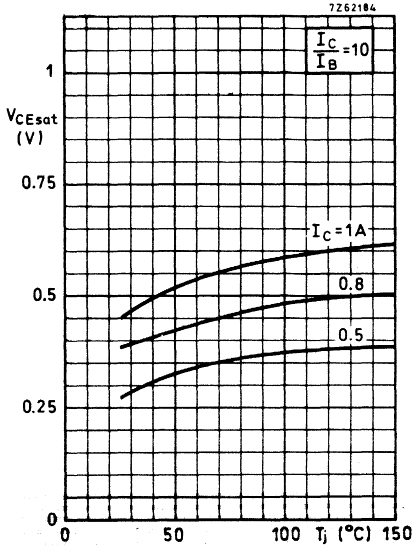

7Z62183
40
C_e
(pF)
30
20
10
0
0
2.5
5
V_{EB} (V)
7.5
$I_C = I_c = 0$
f = 1MHz
T_j = 25°C
typ

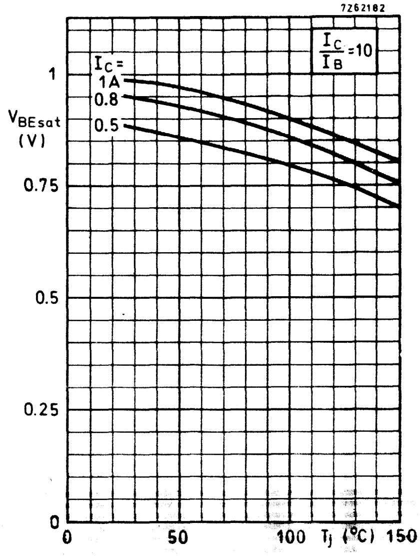

7Z62190
100
h_{FE}
75
50
25
0
1
10
10^2
I_C (mA)
10^3
typical values
V_{CE} = 1V
T_j = 25 °C
BSS28
BSS27
BSS29

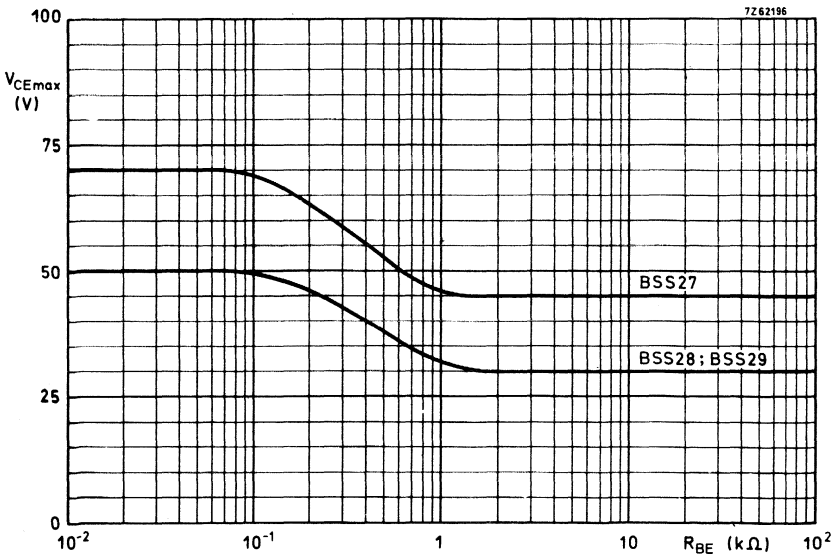

7Z62178
3
V_{CEsat}
(V)
2
1
0
10
10^2
I_B (mA)
10^3
typical values
I_C = 500mA
T_j = 25 °C
BSS29
BSS27
BSS28

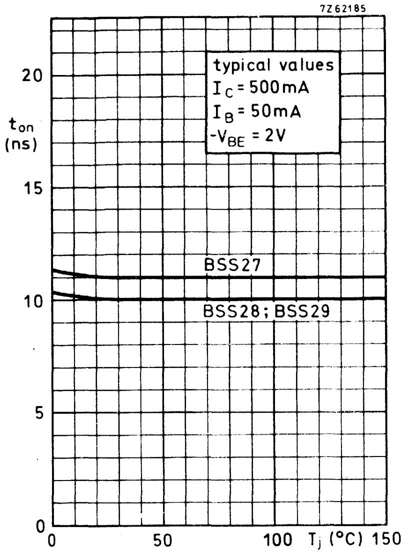

7Z62192
V_{CEsat} (V)
0.6
0.4
0.2
0
$\frac{I_C}{I_B} = 10$
$T_j = 25\,^{\circ}C$
typ
1
10
10^2
I_C (mA)
10^3

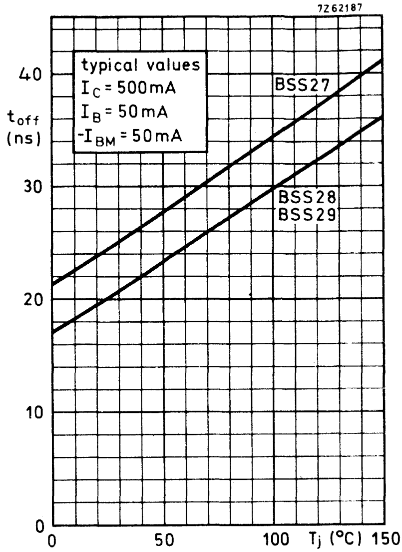

7Z62191
V_{BEsat} (V)
1
0.75
0.5
0.25
0
$\frac{I_C}{I_B} = 10$
$T_j = 25\,^{\circ}C$
typ
1
10
10^2
I_C (mA)
10^3

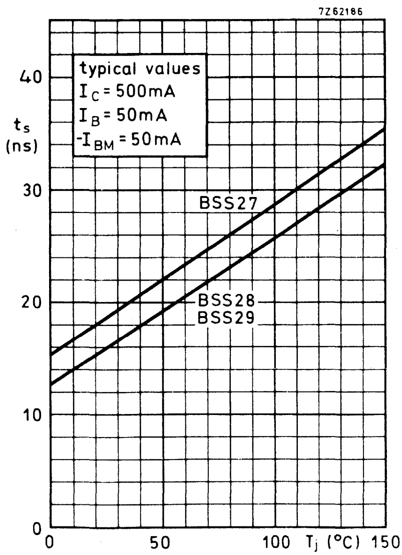

7Z62184
$\frac{I_C}{I_B}$ = 10
V_{CEsat} (V)
1
0.75
0.5
0.25
0
I_C = 1A
0.8
0.5
0
50
100
T_j (°C)
150

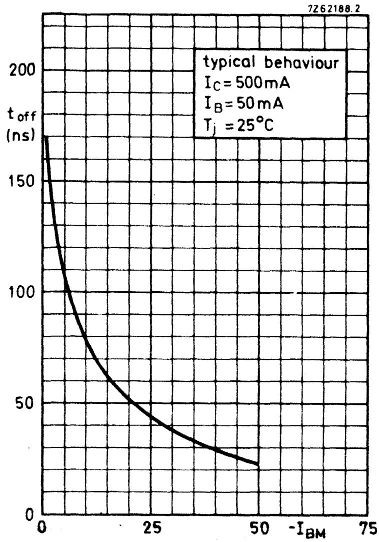

7Z62182
$\frac{I_C}{I_B}$ = 10
V_{BEsat} (V)
1
0.75
0.5
0.25
0
I_C =
1A
0.8
0.5
0
50
100
T_j (°C)
150

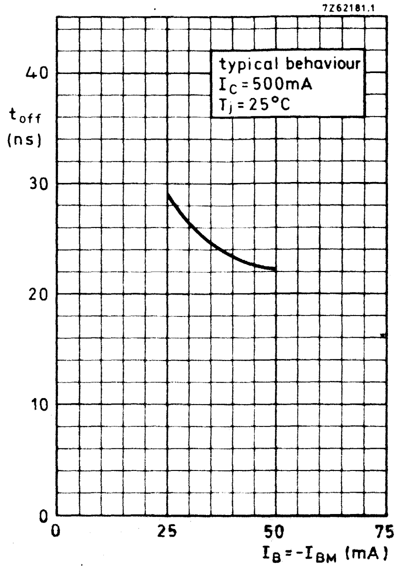

7Z62196
V_{CEmax} (V)
100
75
50
25
0
BSS27
BSS28; BSS29
10^{-2}
10^{-1}
1
10
R_{BE} (kΩ)
10^2


7Z62185
typical values
I_C = 500mA
I_B = 50mA
$-V_{BE}$ = 2V
t_{on} (ns)
BSS27
BSS28; BSS29
T_j (°C)
0
5
10
15
20
50
100
150


7Z62187
typical values
I_C = 500mA
I_B = 50mA
$-I_{BM}$ = 50mA
t_{off} (ns)
BSS27
BSS28
BSS29
T_j (°C)
0
10
20
30
40
50
100
150


7Z62186
typical values
I_C = 500mA
I_B = 50mA
$-I_{BM}$ = 50mA
t_s (ns)
BSS27
BSS28
BSS29
T_j (°C)
0
10
20
30
40
50
100
150


7Z62188.2
typical behaviour
I_C = 500mA
I_B = 50mA
T_j = 25°C
t_{off} (ns)
200
150
100
50
0
0
25
50
$-I_{BM}$
75


7Z62181.1
typical behaviour
I_C = 500mA
T_j = 25°C
t_{off} (ns)
40
30
20
10
0
0
25
50
75
$I_B = -I_{BM}$ (mA)

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 very high speed core-driving purposes.

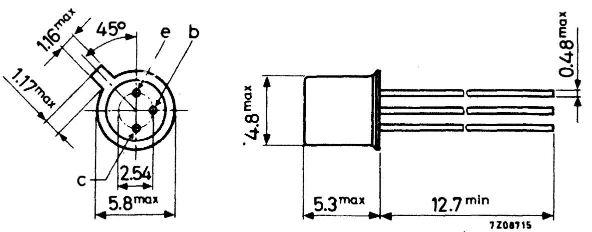
QUICK REFERENCE DATA

			BSS40	BSS41	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	60	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	30	V
Collector current (peak value)	I_{CM}	max.	1		A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360		mW
Junction temperature	T_j	max.	200		°C
D.C. current gain I_C = 500 mA; V_{CE} = 1 V	h_{FE}	>	25		
Saturation voltage I_C = 500 mA; I_B = 50 mA	V_{CEsat}	<	0.5		V
Turn-off time I_C = 500 mA; I_B = 50 mA; $-I_{BM}$ = 50 mA	t_{off}	<	45		ns

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-18



Accessories supplied on request: 56246; 56263.

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

			BSS40	BSS41	
Voltages					
Collector-base voltage (open emitter)	V_{CBO}	max.	60	60	V
Collector-emitter voltage (open base)	V_{CEO}	max.	40	30	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	5	V
Currents					
Collector current (peak value)	I_{CM}	max.	1		A
Base current (peak value)	I_{BM}	max.	0.2		A
Power dissipation					
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360		mW
Temperatures					
Storage temperature	T_{stg}		−65 to +200		°C
Junction temperature	T_j	max.	200		°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	480	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	150	°C/W

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

			BSS40	BSS41	
Collector cut-off current					
$V_{CE} = 40$ V; $R_{BE} = 50\ \Omega$	I_{CER}	<	1		μA
$V_{CE} = 40$ V; $R_{BE} = 50\ \Omega$; $T_j = 150\ ^oC$	I_{CER}	<	1000		μA
Current at reverse biased emitter junction					
$-V_{BE} = 4$ V; $V_{CE} = 40$ V	$-I_{BEX}$	<	1	-	μA
$-V_{BE} = 4$ V; $V_{CE} = 30$ V	$-I_{BEX}$	<	-	1	μA
Breakdown voltages					
Collector-base voltage; $I_E = 0$; $I_C = 100$ μA	$V_{(BR)CBO}$	>	60	60	V
Collector-emitter voltage; $I_C = 1$ mA; $R_{BE} = 50\ \Omega$	$V_{(BR)CER}$	>	60	50	V
Collector-emitter voltage; $I_B = 0$; $I_C = 10$ mA	$V_{(BR)CEO}$	>	40	30	V
Emitter-base voltage; $I_C = 0$; $I_E = 100$ μA	$V_{(BR)EBO}$	>	5	5	V
Saturation voltages [1]					
$I_C = 150$ mA; $I_B = 10$ mA	V_{CEsat}	<	0.3		V
	V_{BEsat}	<	1.0		V
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	0.5		V
	V_{BEsat}	<	1.2		V
D.C. current gain					
$I_C = 150$ mA; $V_{CE} = 1$ V	h_{FE}	>	30		
$I_C = 500$ mA; $V_{CE} = 1$ V	h_{FE}	>	25		
Transition frequency at f = 100 MHz					
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	>	200		MHz
Collector capacitance at f = 1 MHz					
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	10		pF
Emitter capacitance at f = 1 MHz					
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	<	50		pF

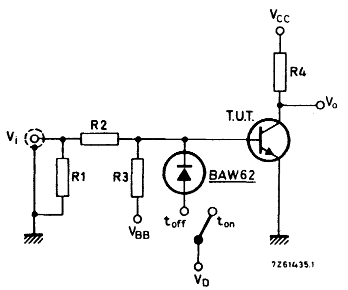
[1]) Measured under pulsed conditions: $t_p = 300\ \mu s$, $\delta = 0.01$

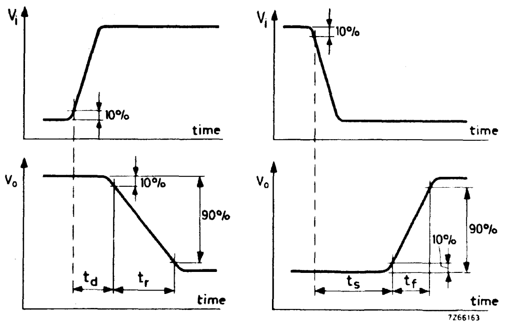
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Switching times

Turn-on time when switched from $-V_{BE}$ = 2 V to I_C = 500 mA; I_B = 50 mA	t_{on}	<	35	ns
Turn-off time when switched from I_C = 500 mA; I_B = 50 mA to cut-off with $-I_{BM}$ = 1 mA	t_{off}	<	250	ns
Turn-off time when switched from I_C = 500 mA; I_B = 50 mA to cut-off with $-I_{BM}$ = 50 mA	t_{off}	<	45	ns
Storage time when switched from I_C = 500 mA; I_B = 50 mA to cut-off with $-I_{BM}$ = 50 mA	t_s	>	10	ns

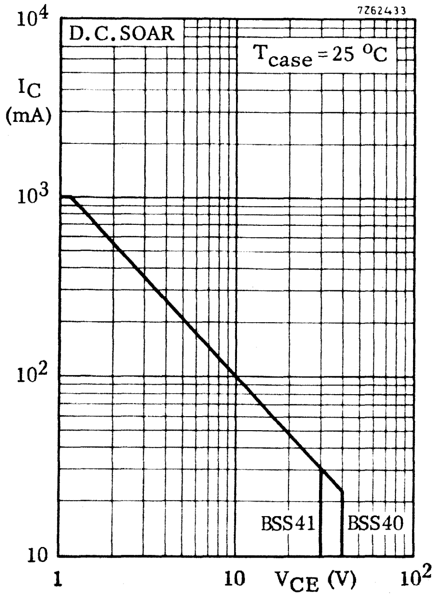
Test circuit:

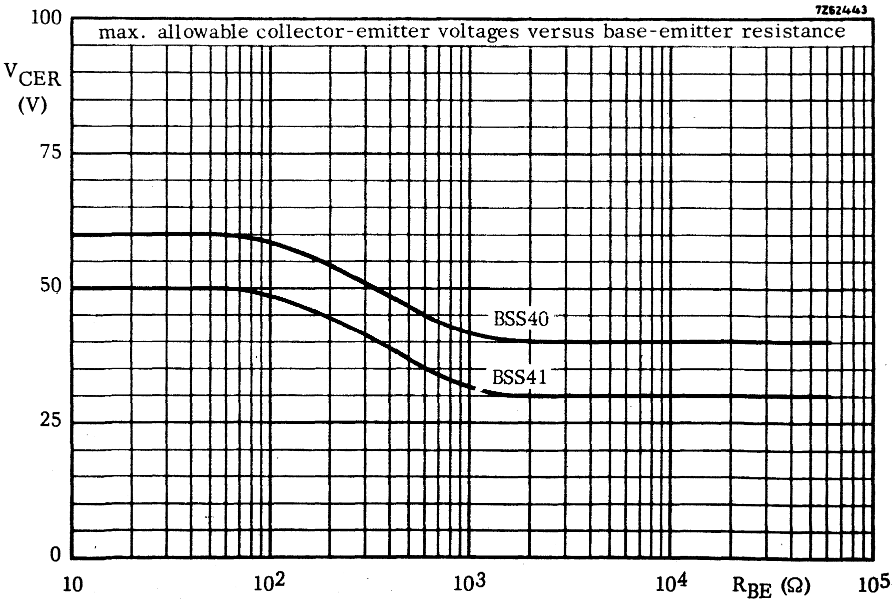


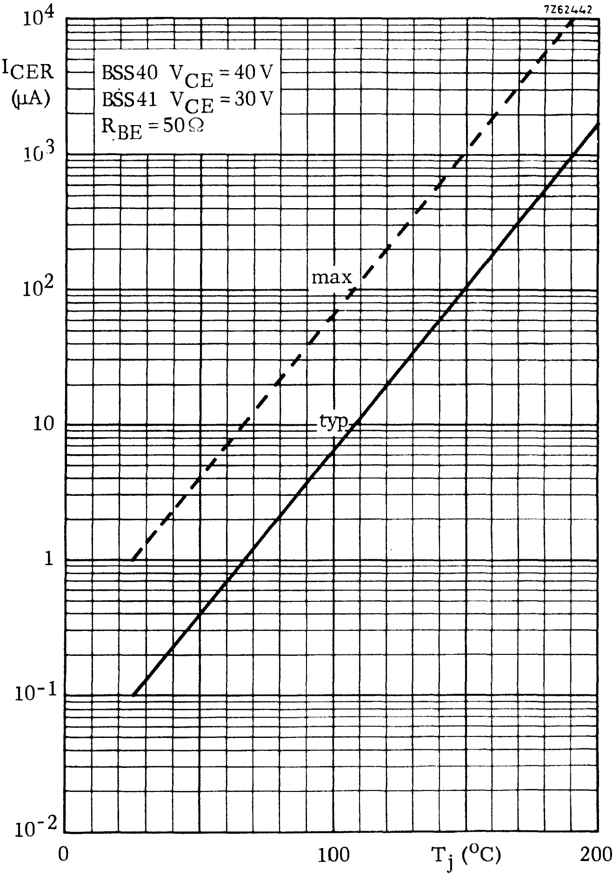


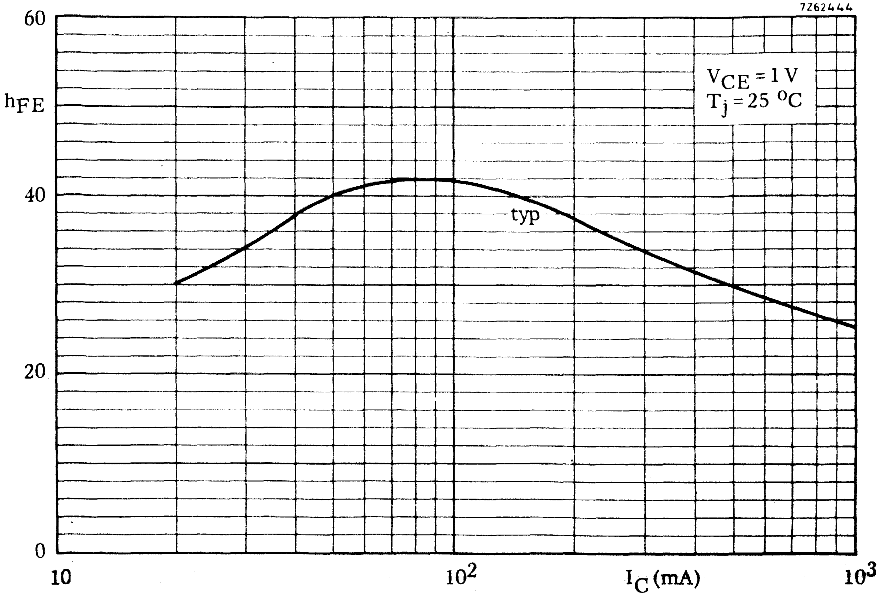
Pulse generator: Pulse duration $t_p \geq$ 500 ns
Rise time $t_r \leq$ 5 ns
Fall time $t_f \leq$ 5 ns
Source impedance R_S = 50 Ω

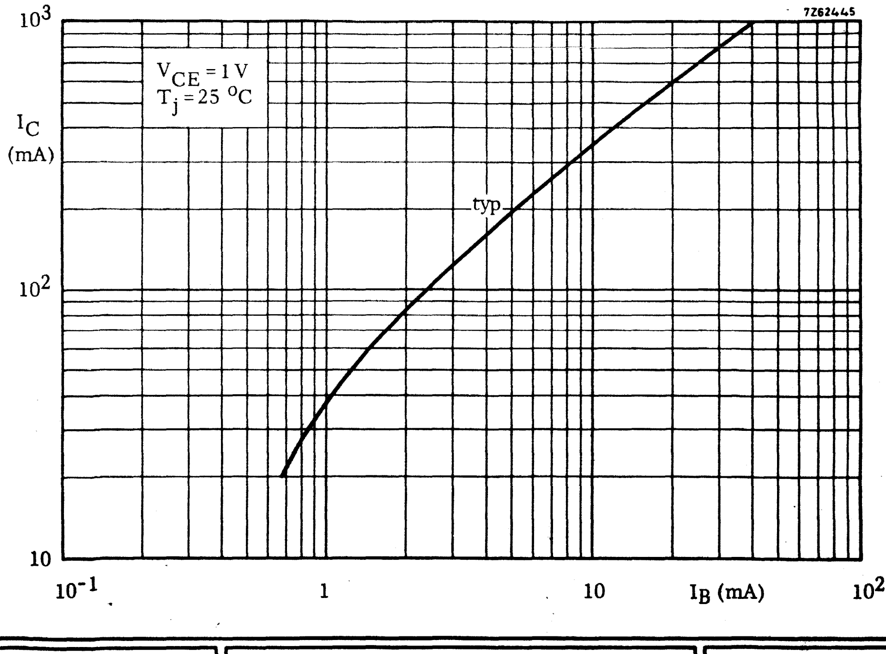
								turn-on time		turn-off time		
I_C (mA)	I_B (mA)	$-I_{BM}$ (mA)	V_{CC} (V)	R1 (Ω)	R2 (Ω)	R3 (Ω)	R4 (Ω)	$-V_{BB}$ (V)	V_i (V)	$+V_{BB}$ (V)	V_i (V)	$-V_D$ (V)
500	50	50	45	56	375	400	90	4	24.75	16.7	37.5	3
500	50	1	45	56	750	∞	90	–	–	–	37.5	–

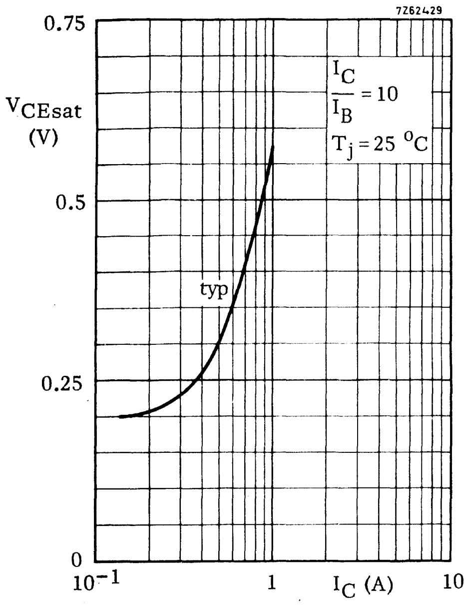

7Z62433
D.C.SOAR
T_{case} = 25 °C
I_C (mA)
10^4
10^3
10^2
10
1
10
V_{CE} (V)
10^2
BSS41
BSS40

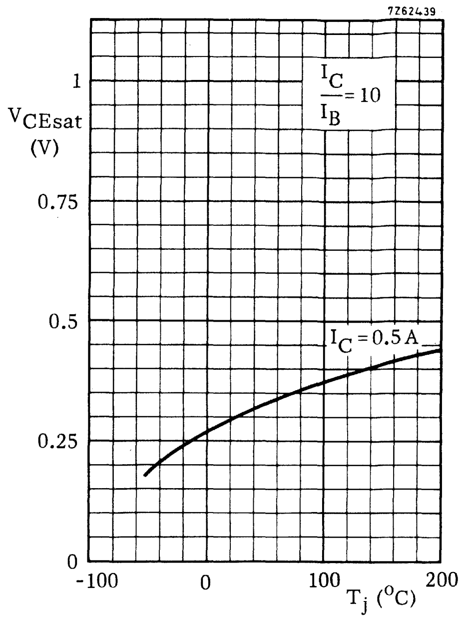

7Z62443
max. allowable collector-emitter voltages versus base-emitter resistance
V_{CER} (V)
100
75
50
25
0
10
10^2
10^3
10^4
R_{BE} (Ω)
10^5
BSS40
BSS41

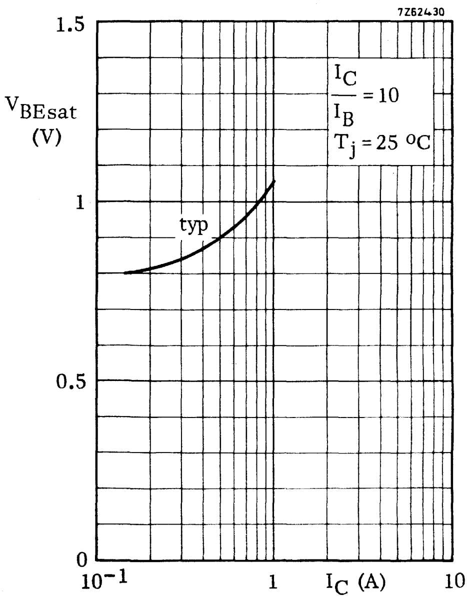

7Z62442
10^4
I_{CER} (μA)
BSS40 V_{CE} = 40 V
BSS41 V_{CE} = 30 V
R_{BE} = 50 Ω
10^3
max
10^2
10
typ
1
10^{-1}
10^{-2}
0
100
T_j (°C)
200

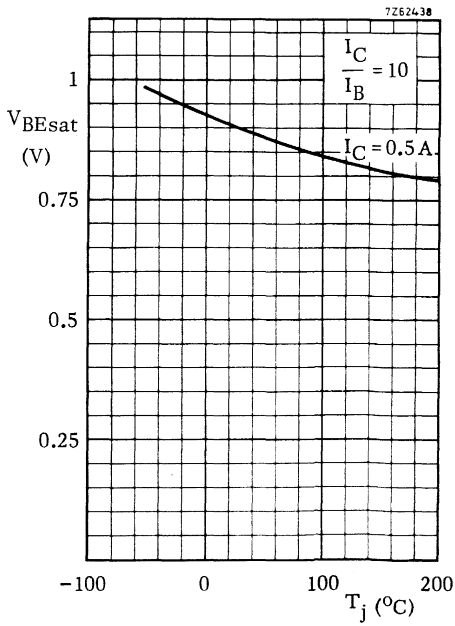

7Z62444
60
40
20
0
hFE
VCE = 1 V
Tj = 25 °C
typ
10
10^2
IC (mA)
10^3

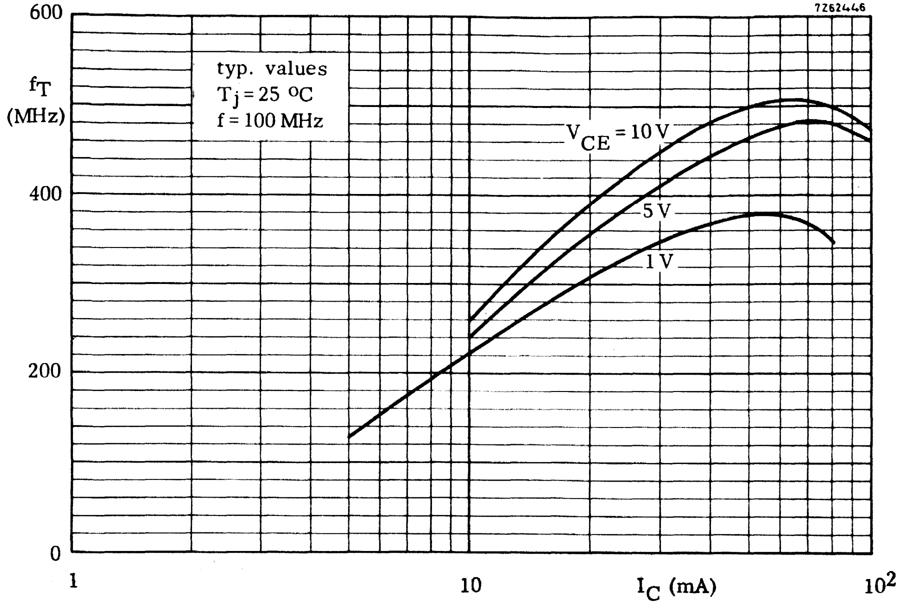

7Z62445
10^3
10^2
10
IC
(mA)
VCE = 1 V
Tj = 25 °C
typ
10^-1
1
10
IB (mA)
10^2

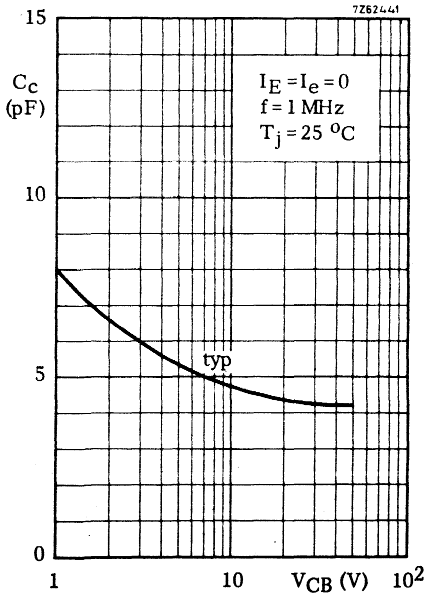

7Z62429
0.75
V_{CEsat}
(V)
0.5
0.25
0
10^{-1}
1
I_C (A)
10
$\frac{I_C}{I_B} = 10$
$T_j = 25\ ^oC$
typ

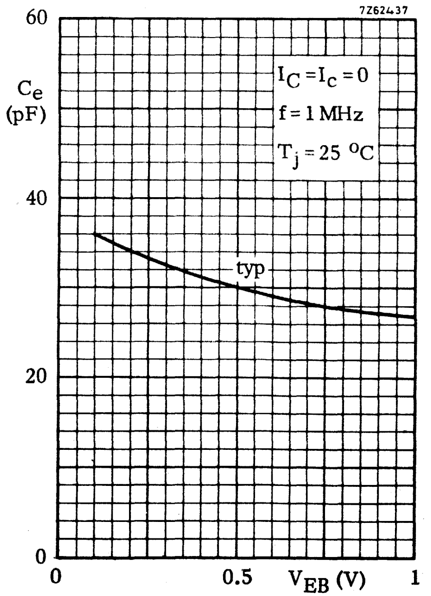

7Z62439
1
V_{CEsat}
(V)
0.75
0.5
0.25
0
-100
0
100
200
T_j (^oC)
$\frac{I_C}{I_B} = 10$
$I_C = 0.5$ A

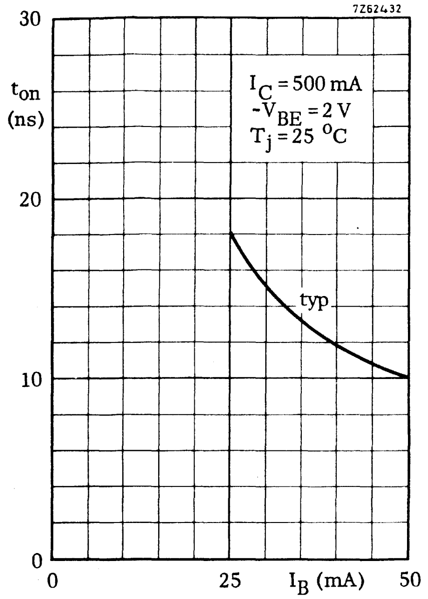

7Z62430
1.5
V_{BEsat}
(V)
1
0.5
0
10^{-1}
1
I_C (A)
10
$\frac{I_C}{I_B} = 10$
$T_j = 25\ ^oC$
typ

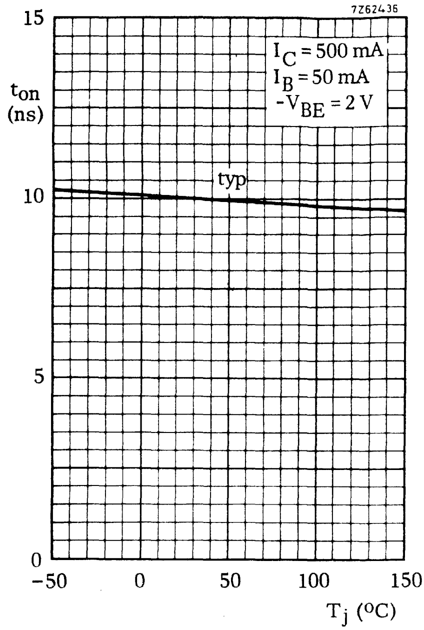

7Z62438
1
V_{BEsat}
(V)
0.75
0.5
0.25
-100
0
100
200
T_j (^oC)
$\frac{I_C}{I_B} = 10$
$I_C = 0.5$ A

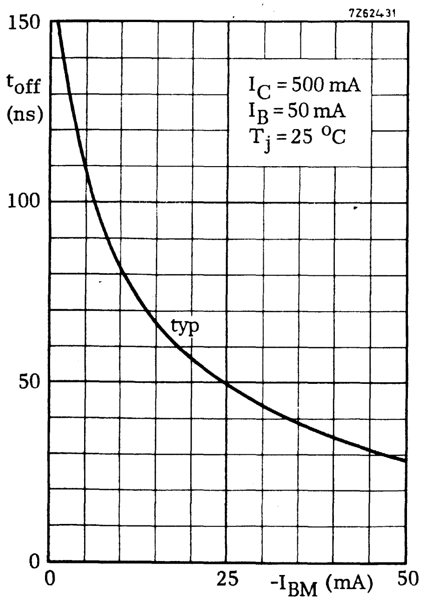

7Z62446
600
400
200
0
f_T
(MHz)
typ. values
$T_j = 25\ ^oC$
f = 100 MHz
$V_{CE} = 10\ V$
5 V
1 V
1
10
I_C (mA)
10^2

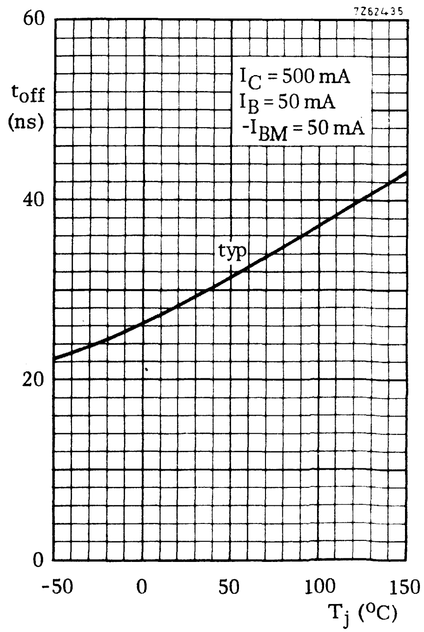

7Z62441
15
10
5
0
C_c
(pF)
$I_E = I_e = 0$
f = 1 MHz
$T_j = 25\ ^oC$
typ
1
10
V_{CB} (V)
10^2

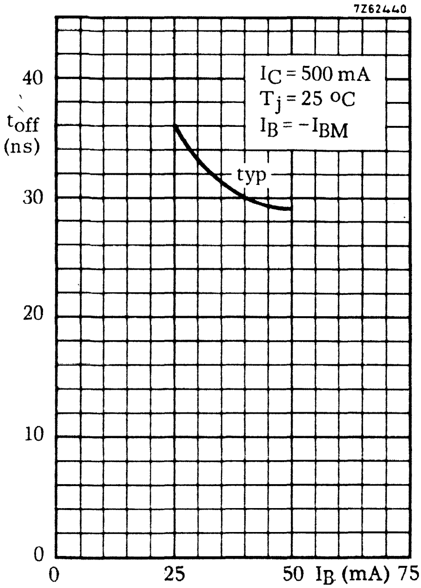

7Z62437
60
40
20
0
C_e
(pF)
$I_C = I_c = 0$
f = 1 MHz
$T_j = 25\ ^oC$
typ
0
0.5
V_{EB} (V)
1

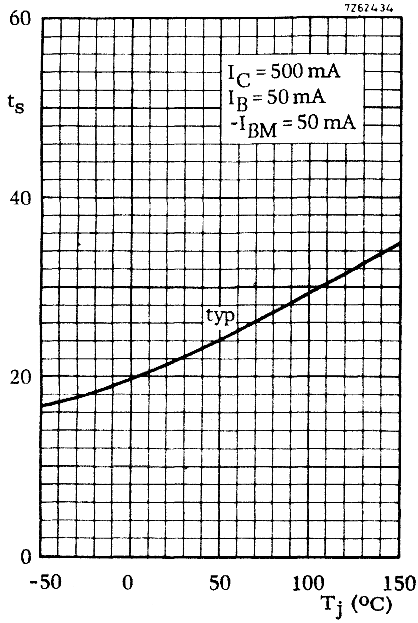

7Z62432
30
20
10
0
t_{on} (ns)
I_C = 500 mA
$-V_{BE}$ = 2 V
T_j = 25 °C
typ
0
25
I_B (mA)
50


7Z62436
15
10
5
0
t_{on} (ns)
I_C = 500 mA
I_B = 50 mA
$-V_{BE}$ = 2 V
typ
−50
0
50
100
150
T_j (°C)


7Z62431
150
100
50
0
t_{off} (ns)
I_C = 500 mA
I_B = 50 mA
T_j = 25 °C
typ
0
25
$-I_{BM}$ (mA)
50


7Z62435
60
40
20
0
t_{off} (ns)
I_C = 500 mA
I_B = 50 mA
$-I_{BM}$ = 50 mA
typ
-50
0
50
100
150
T_j (°C)


7Z62440
I_C = 500 mA
T_j = 25 °C
I_B = $-I_{BM}$
t_{off}
(ns)
typ
40
30
20
10
0
0
25
50
I_B (mA)
75


7Z62434
I_C = 500 mA
I_B = 50 mA
$-I_{BM}$ = 50 mA
t_s
typ
60
40
20
0
-50
0
50
100
150
T_j (°C)

SILICON PLANAR EPITAXIAL TRANSISTORS

P-N-P transistors in a TO-39 metal envelope with the collector connected to the case. These transistors are intended for general industrial applications.

QUICK REFERENCE DATA

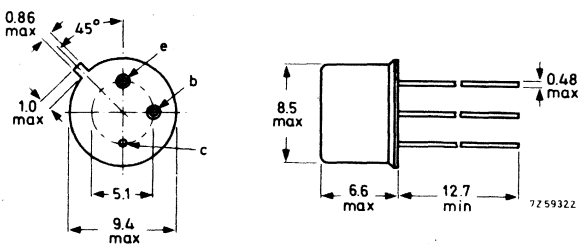
			BSV15	BSV16	BSV17	
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	40	60	80	V
Collector current (d.c.)	$-I_C$	max.		1.0		A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.		0.8		W
up to T_{case} = 25 °C	P_{tot}	max.		5.0		W
Junction temperature	T_j	max.		200		°C
Transition frequency at f = 20 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 10 V	f_T	>		50		MHz

		BSV15-6 BSV16-6 BSV17-6	BSV15-10 BSV16-10 BSV17-10	BSV15-16 BSV16-16
D.C. current gain $-I_C$ = 100 mA; $-V_{CE}$ = 1 V	h_{FE}	40 - 100	63 - 160	100 - 250

MECHANICAL DATA

Dimensions in mm

TO-39
Collector connected to case



max. lead diameter is guaranteed only for 12.7 mm

Accessories supplied on request: 56218, 56245, 56265.

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 ^oC	P_{tot}	max.	0.8	W
up to T_{case} = 25 ^oC	P_{tot}	max.	5.0	W
up to T_{mb} = 50 ^oC	P_{tot}	max.	5.0	W

Temperatures				
Storage temperature	T_{stg}		−65 to +200	^oC
Junction temperature	T_j	max.	200	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	220	$^oC/W$
From junction to case	$R_{th\ j-c}$	=	35	$^oC/W$
From junction to mounting base	$R_{th\ j-mb}$	=	30	$^oC/W$

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

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

D.C. current gain

			BSV15-6 BSV16-6 BSV17-6	BSV15-10 BSV16-10 BSV17-10	BSV15-16 BSV16-16
$-I_C$ = 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

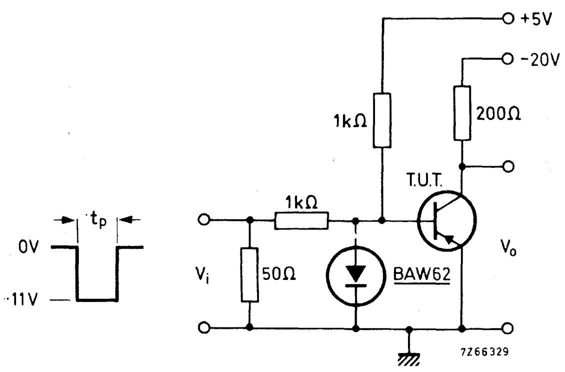
Turn-off time

$-I_C$ = 100 mA; $-I_B$ = $+I_{BM}$ = 5 mA

Storage time t_s < 500 ns

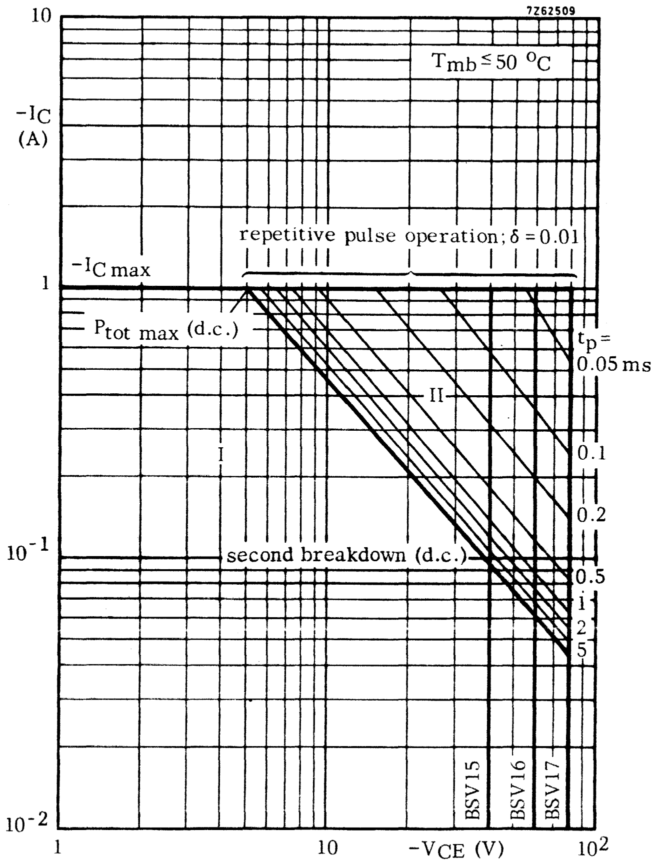
Fall time t_f < 150 ns

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

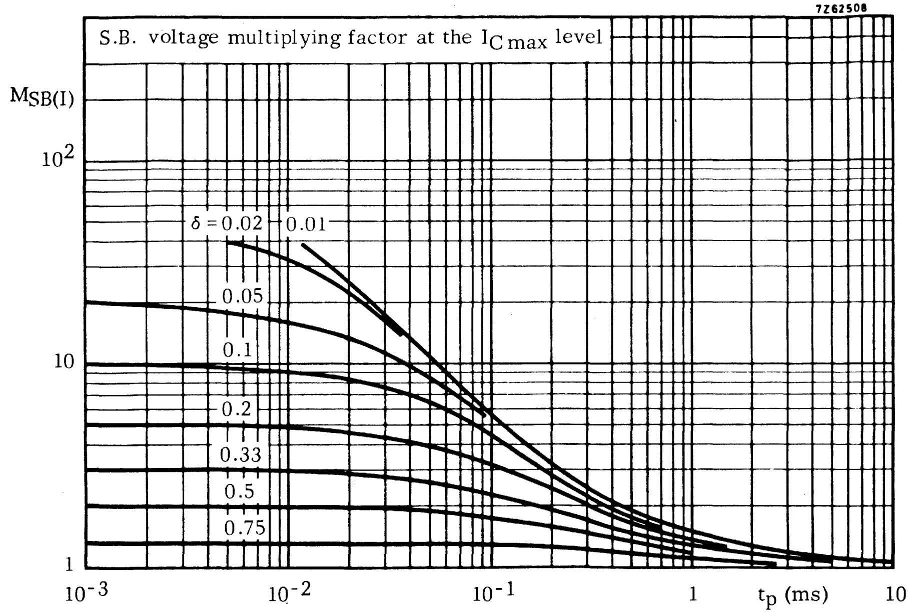
Oscilloscope:
Rise time ≤ 15 ns
Input impedance ≥ 100 kΩ

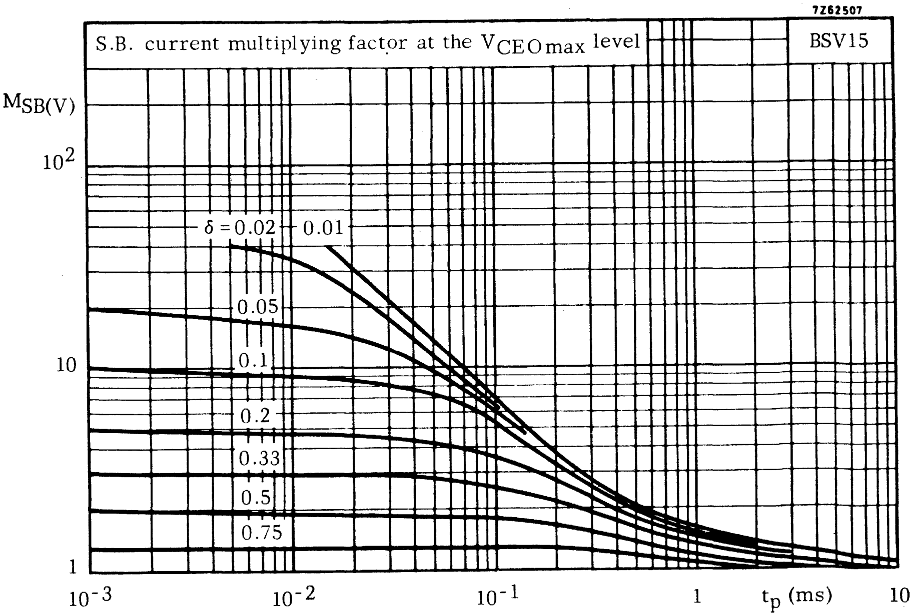


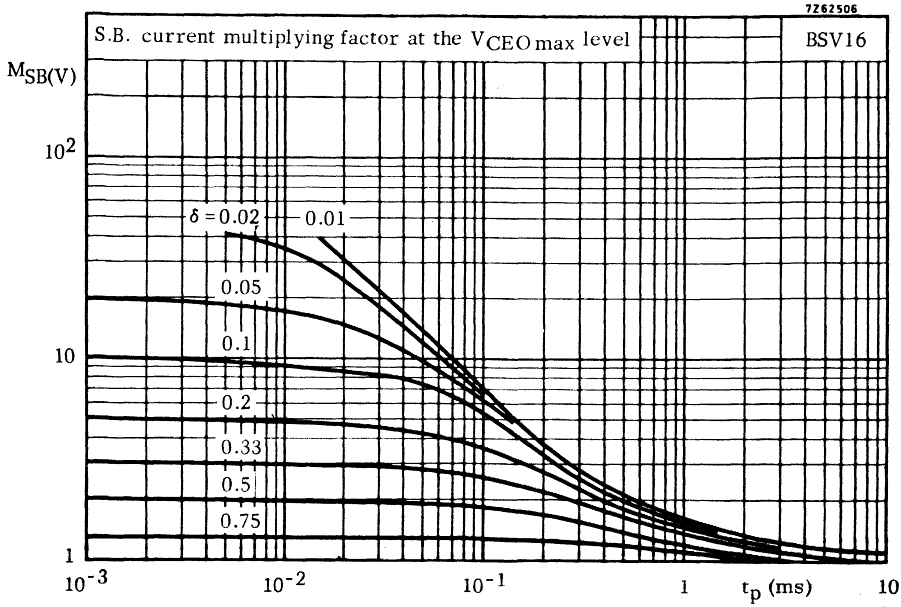
Safe Operating Area with the transistor forward biased

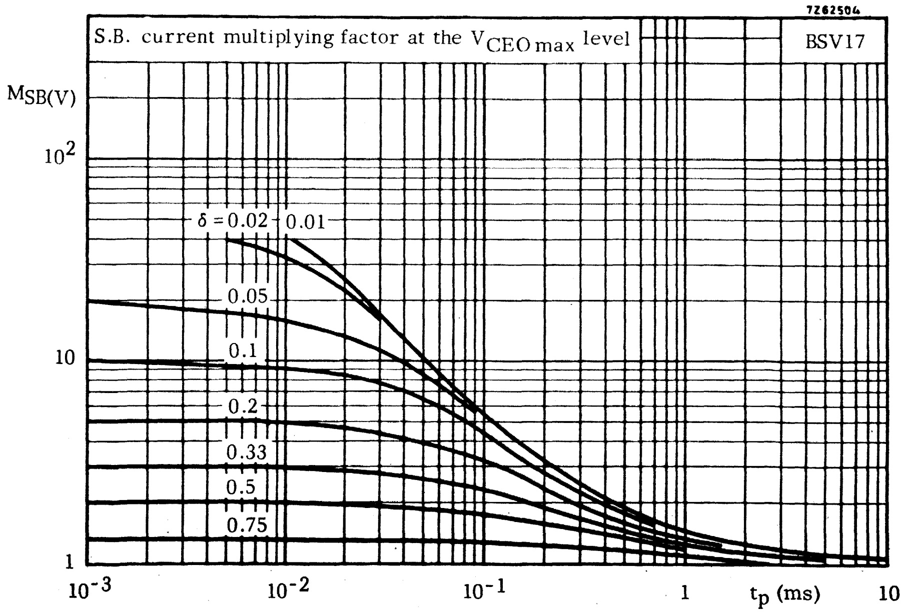
I Region of permissible d. c. operation

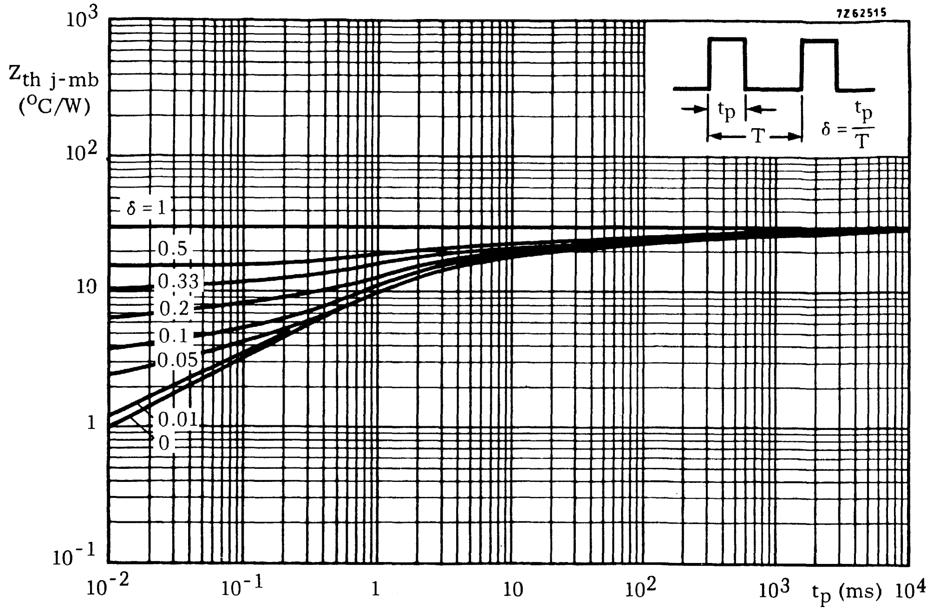
II Permissible extension for repetitive pulse operation

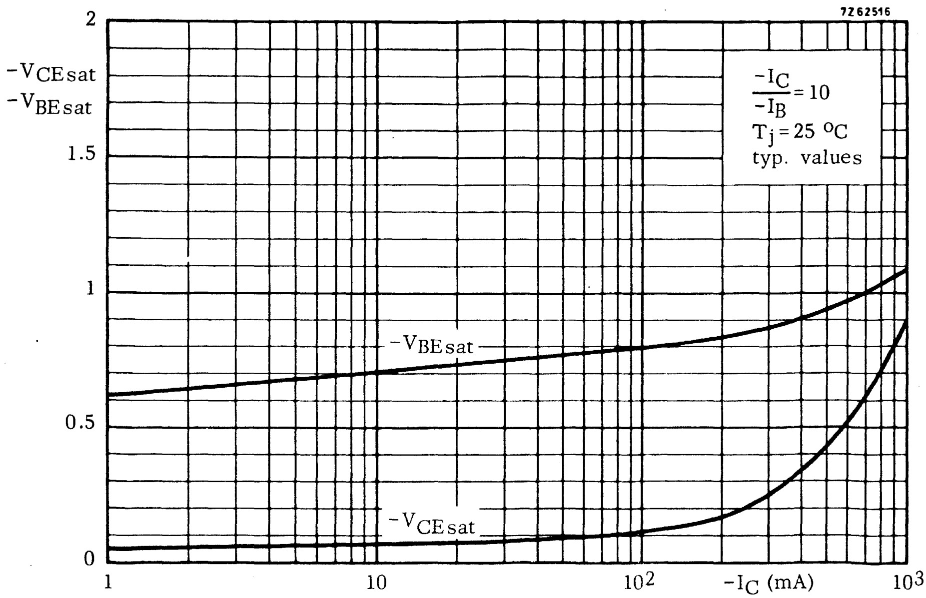

7Z62508
S.B. voltage multiplying factor at the $I_{C\,max}$ level
$M_{SB(I)}$
10^2
10
1
δ = 0.02
0.01
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

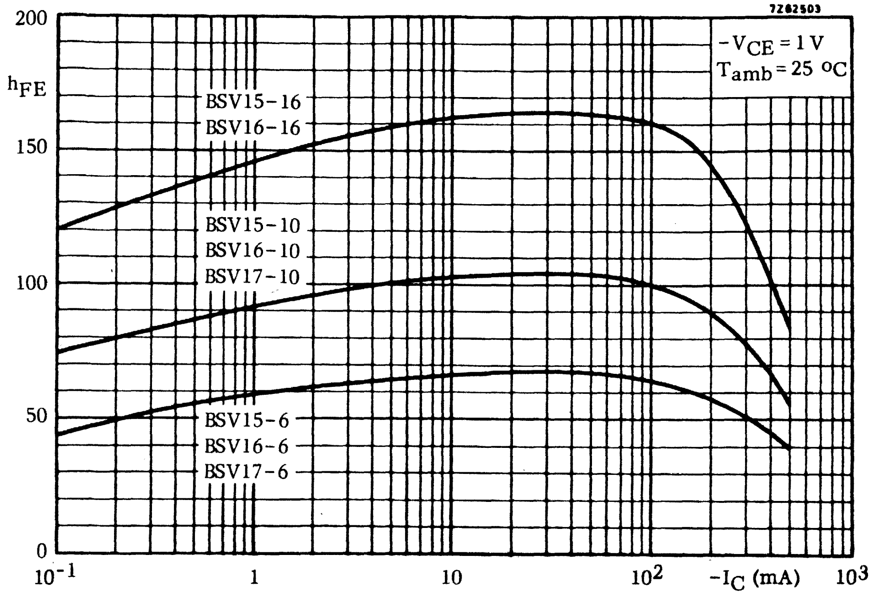

7Z62507
S.B. current multiplying factor at the $V_{CEO\,max}$ level
BSV15
$M_{SB(V)}$
10^2
10
1
δ = 0.02
0.01
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

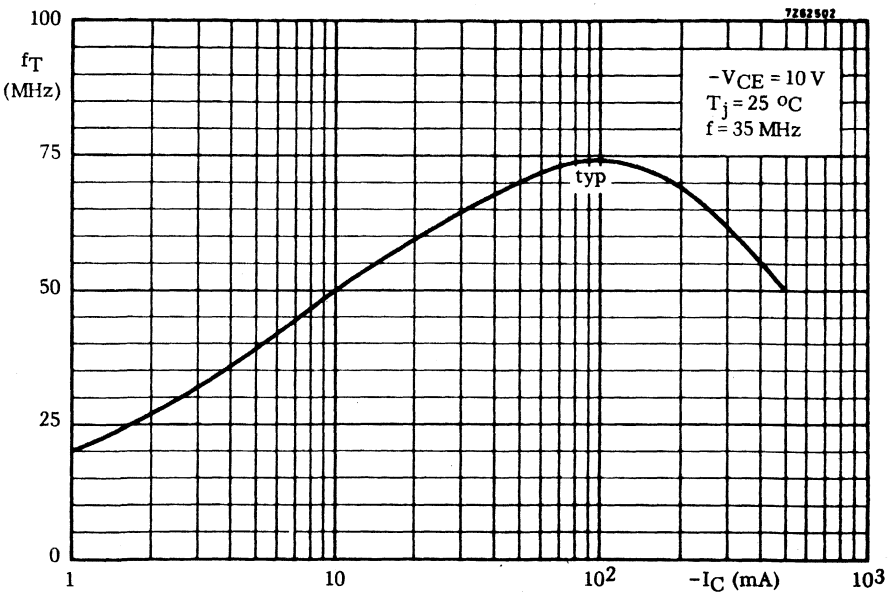

7Z62506
S.B. current multiplying factor at the $V_{CEO\,max}$ level
BSV16
$M_{SB(V)}$
10^2
10
1
$\delta = 0.02$
0.01
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10

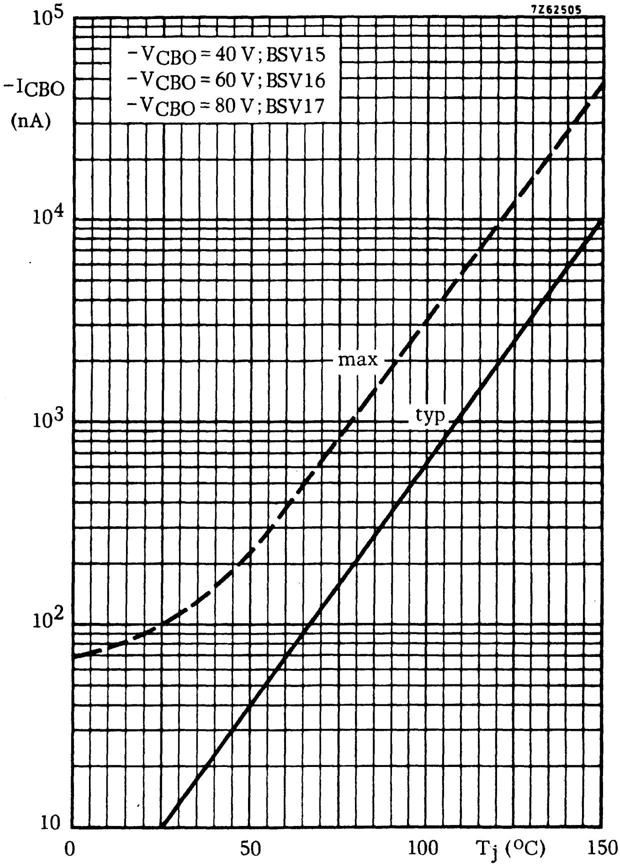

7Z62504
S.B. current multiplying factor at the $V_{CEO\,max}$ level
BSV17
$M_{SB(V)}$
10^2
10
1
$\delta = 0.02$
0.01
0.05
0.1
0.2
0.33
0.5
0.75
10^{-3}
10^{-2}
10^{-1}
1
t_p (ms)
10


7Z62515
10^3
$Z_{th\ j\text{-}mb}$ (°C/W)
10^2
$\delta = 1$
0.5
0.33
0.2
0.1
0.05
0.01
0
10
1
10^{-1}
10^{-2}
10^{-1}
1
10
10^2
10^3
t_p (ms)
10^4
t_p
T
$\delta = \frac{t_p}{T}$


7Z62516
2
$-V_{CEsat}$
$-V_{BEsat}$
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
150
100
50
0
h_{FE}
BSV15-16
BSV16-16
BSV15-10
BSV16-10
BSV17-10
BSV15-6
BSV16-6
BSV17-6
$-V_{CE}$ = 1 V
T_{amb} = 25 °C
10^{-1}
1
10
10^2
$-I_C$ (mA)
10^3


7Z62502
100
75
50
25
0
f_T
(MHz)
$-V_{CE}$ = 10 V
T_j = 25 °C
f = 35 MHz
typ
1
10
10^2
$-I_C$ (mA)
10^3


7Z62505
$-V_{CBO}$ = 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

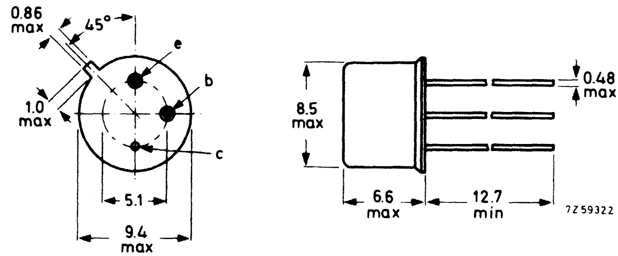
N-P-N transistor in a TO-39 metal envelope primarily intended for use as a print hammer drive. It has good high current saturation characteristics.

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



max. lead diameter is guaranteed only for 12.7 mm

Accessories supplied on request: 56218, 56245, 56265

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_C	max.	1.0	A

Power dissipation

Total power dissipation up to T_{case} = 50 °C	P_{tot}	max.	5.0	W

Temperatures

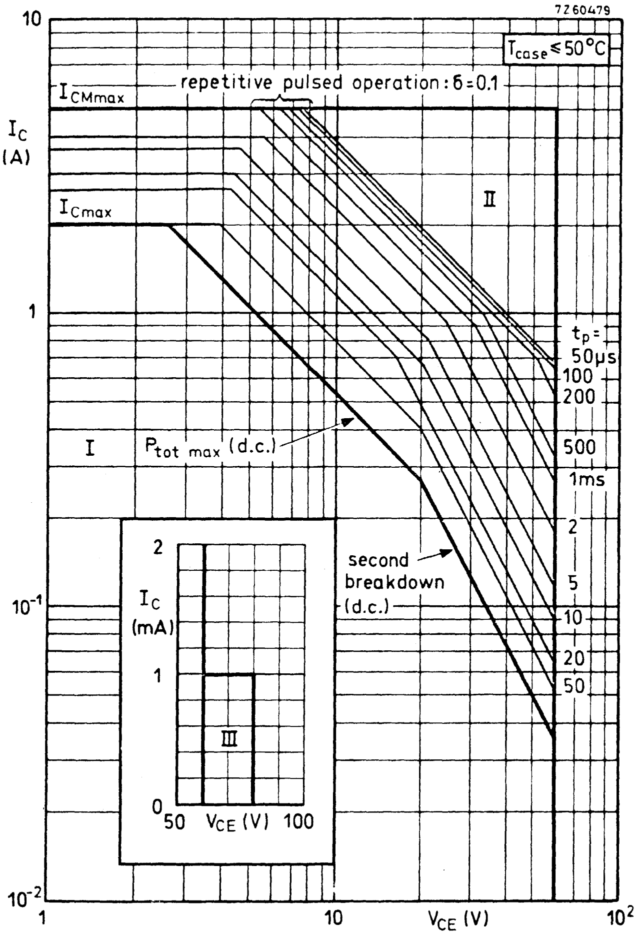
Storage temperature	T_{stg}		−55 to +175	°C
Junction temperature	T_j	max.	175	°C

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

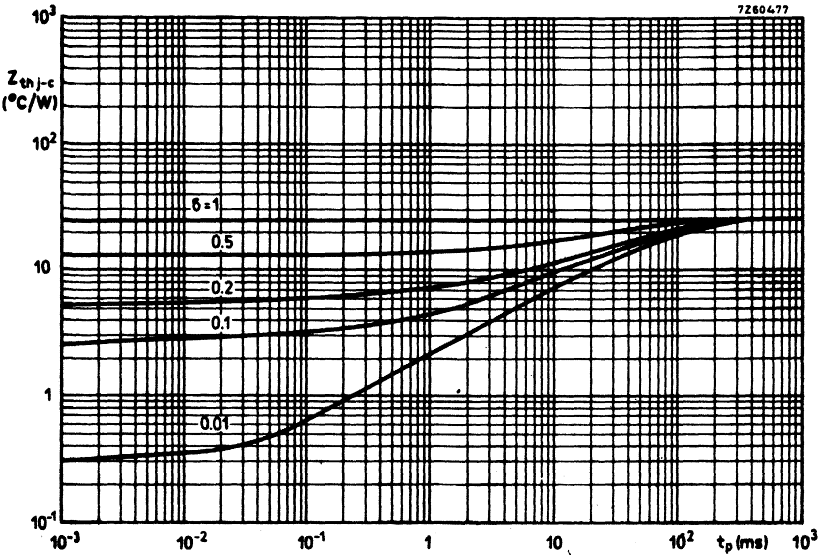


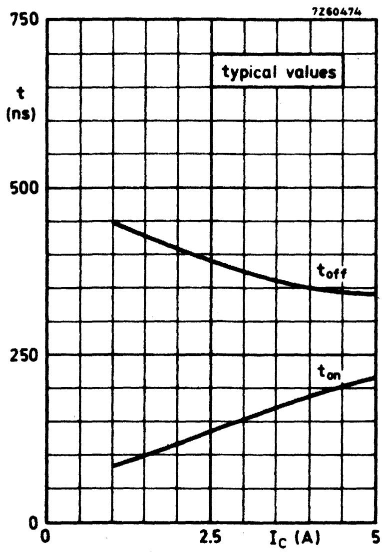
Safe Operating Area

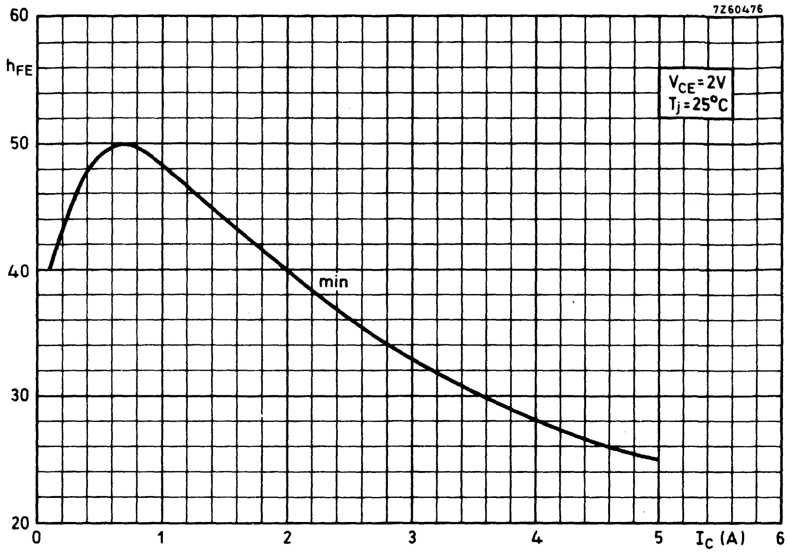
I Region of permissible d.c. operation

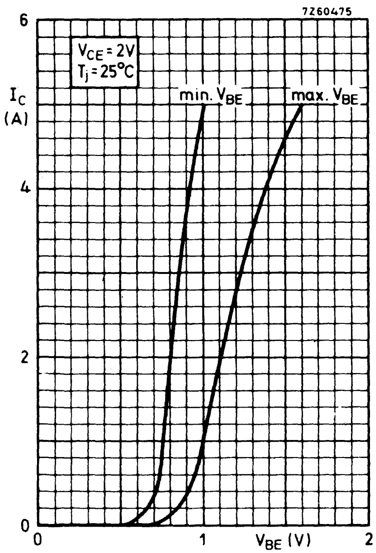
II Permissible extension for repetitive pulsed operation

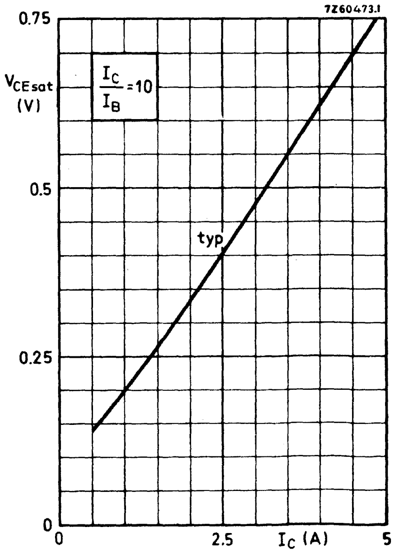
III D.C. operation in this region is allowable, provided $R_{BE} \leq 50\ \Omega$


7Z60477
$Z_{th\,j-c}$ (°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
$V_{CE} = 2V$
$T_j = 25^oC$
min


7Z60475
6
I_C
(A)
4
2
0
0
1
V_{BE} (V)
2
$V_{CE} = 2V$
$T_j = 25^oC$
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

HIGH VOLTAGE P-N-P TRANSISTOR

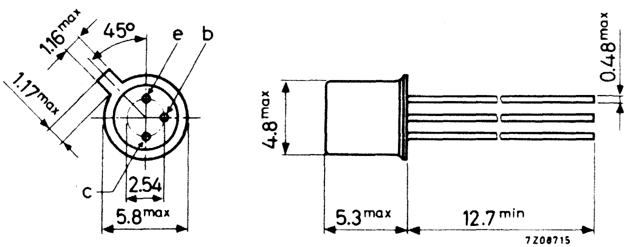
Silicon planar epitaxial transistor in a TO-18 metal envelope with the collector connected to the case. It is intended for anode switching in dynamically driven numerical indicator tubes.

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 (peak value)	$-I_{CM}$	max.	100	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	250	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	typ.	95	MHz

MECHANICAL DATA — Dimensions in mm

TO-18

Collector connected to case



max. lead diameter is guaranteed only for 12.7 mm

Accessories supplied on request: 56246; 56263

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

Voltages

Collector-base voltage (open emitter) $-I_C = 10\ \mu A$	$-V_{CBO}$	max.	110	V
Collector-emitter voltage ($R_{BE} = 10\ k\Omega$) $-I_C = 10\ \mu A$	$-V_{CER}$	max.	110	V 1) 2)
Collector-emitter voltage (open base) $-I_C = 100\ \mu A$	$-V_{CEO}$	max.	100	V
Emitter-base voltage (open collector) $-I_E = 10\ \mu A$	$-V_{EBO}$	max.	6	V

Currents

Collector current (d.c.)	$-I_C$	max.	100	mA
Collector current (peak value)	$-I_{CM}$	max.	100	mA 3)
Base current (peak value)	$-I_{BM}$	max.	100	mA

Power dissipation

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

Temperatures

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

THERMAL RESISTANCE

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

1) The transistor may be operated in the breakdown region, provided the collector current does not exceed 10 μA at $T_{amb} = 70\ ^oC$

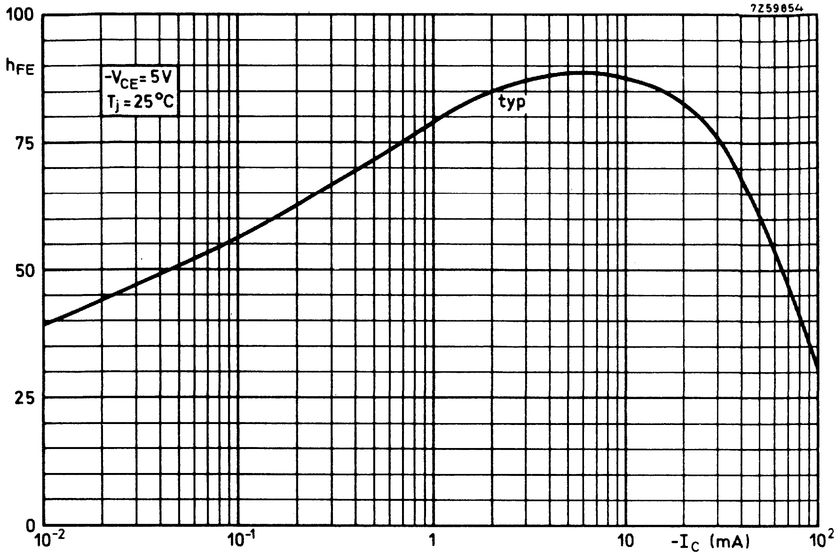
2) The transistor can withstand an inductive load of 4 mH in series with a resistance of 4 kΩ, combined with a collector current of 25 mA before switching-off

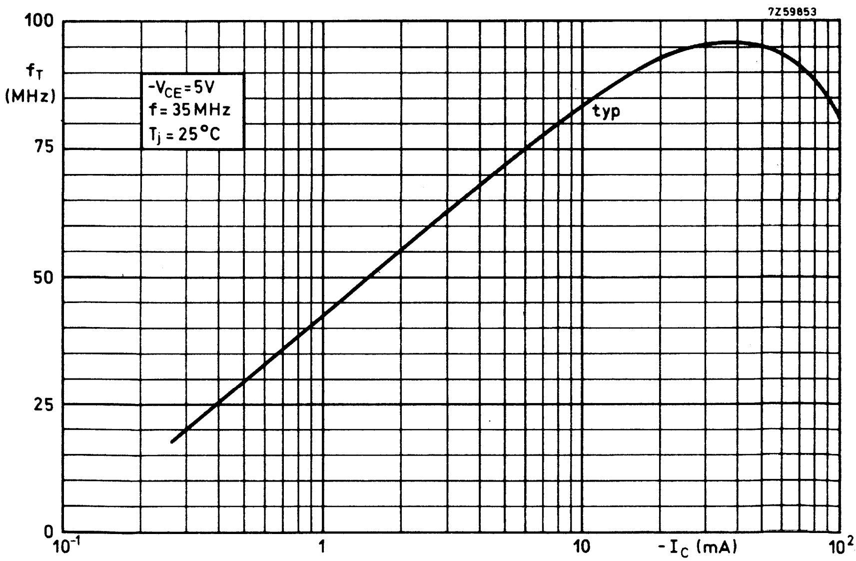
3) The transistor can withstand a capacitive load of 100 pF, combined with a collector voltage equal to $-V_{CER}$ before switching-on

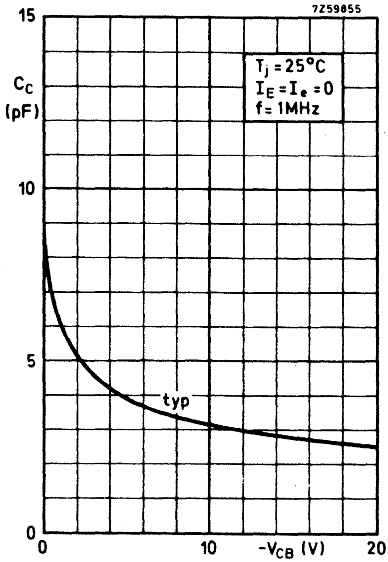
CHARACTERISTICS

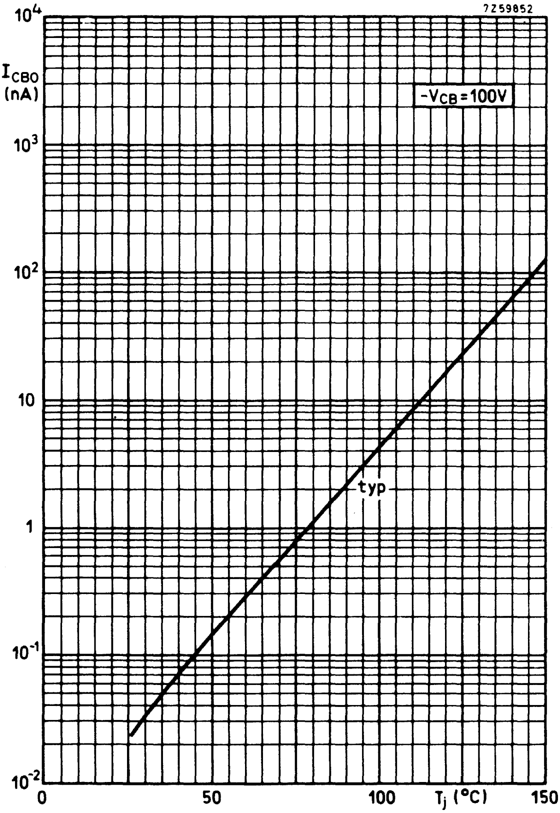
T_j = 25 °C unless otherwise specified

Collector cut-off current			
$I_E = 0$; $-V_{CB} = 100$ V; $T_j = 70$ °C	$-I_{CBO}$	<	5 μA ←
$-V_{CE} = 110$V; $R_{BE} = 10$ kΩ	$-I_{CER}$	<	10 μA
Emitter cut-off current			
$I_C = 0$; $-V_{EB} = 6$ V	$-I_{EBO}$	<	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
		typ.	95 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

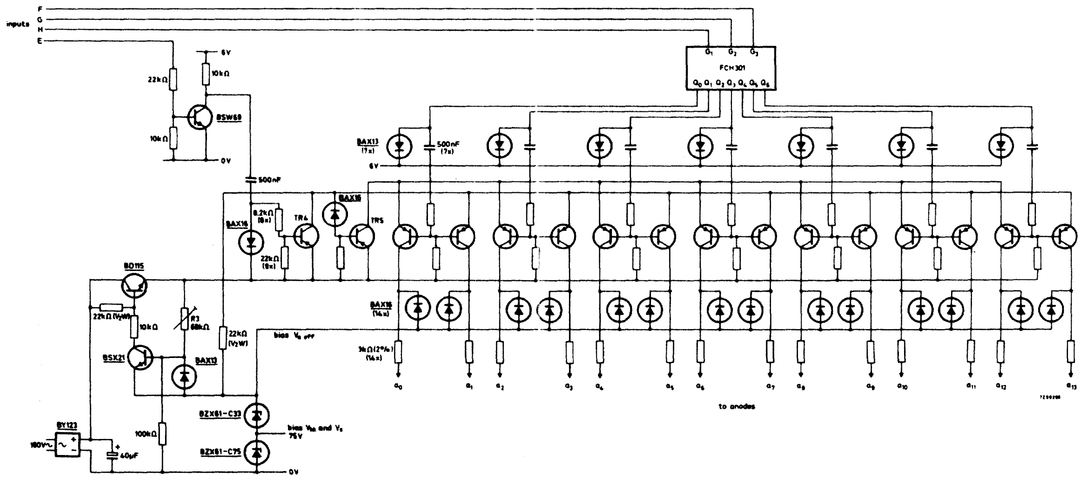

7Z59853
100
f_T (MHz)
$-V_{CE} = 5V$
f = 35 MHz
$T_j = 25°C$
typ
75
50
25
0
10^{-1}
1
10
$-I_C$ (mA)
10^2


7Z59055
15
10
5
0
C_C
(pF)
$T_j = 25°C$
$I_E = I_e = 0$
f = 1MHz
typ
0
10
$-V_{CB}$ (V)
20


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

APPLICATION INFORMATION

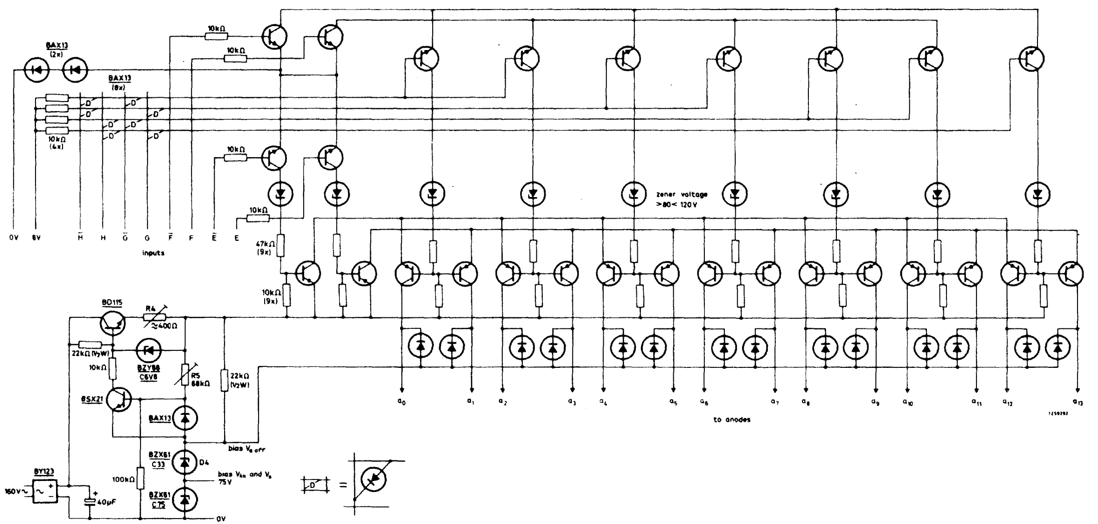
1. Practical circuit with BSV68 for dynamic operation of indicator tubes (e.g. pandicon)



Except where stated, all p-n-p transistors are BSV68

APPLICATION INFORMATION (continued)

2. Direcly coupled circuit for positive logic with BSV68



Except where stated, all p-n-p transistors are BSV68, n-p-n transistors BSW69 and clamping diodes BAX16

N-P-N SWITCHING TRANSISTORS

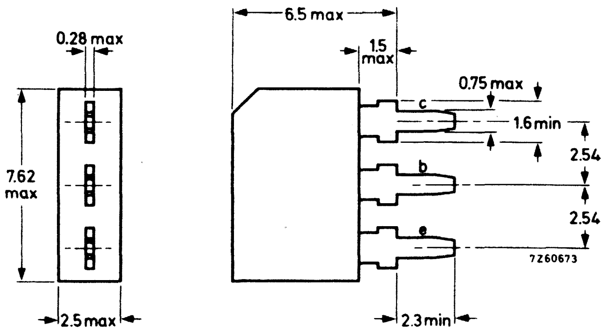
Planar epitaxial transistors for switching applications.

QUICK REFERENCE DATA

			BSV86	BSV87	BSV88	
Collector-base voltage (open emitter)	V_{CBO}	max.	75	75	60	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	30	25	V
Collector current (peak value)	I_{CM}	max.	1.0	1.0	1.0	A
Total power dissipation up to T_{amb} = 50 °C	P_{tot}	max.	220	220	220	mW
D.C. current gain						
I_C = 150 mA; V_{CE} = 10 V	h_{FE}	>	100	40	35	
		<	300	120	-	
Transition frequency at f = 100 MHz						
I_C = 50 mA; V_{CE} = 10 V	f_T	>	100	100	100	MHz

MECHANICAL DATA

Dimensions in mm



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

			BSV86 BSV87	BSV88	
Voltages					
Collector-base voltage (open emitter)	V_{CBO}	max.	75	60	V
Collector-emitter voltage (R_{BE} = 10 Ω)	V_{CER}	max.	50	35	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	25	V
Emitter-base voltage (open collector)	V_{EBO}	max.	7	5	V
Currents					
Collector current (d.c.)	I_C	max.		0.4	A
Collector current (peak value)	I_{CM}	max.		1.0	A
Emitter current (peak value)	$-I_{EM}$	max.		1.12	A
Base current (peak value)	I_{BM}	max.		0.12	A
Power dissipation					
Total power dissipation up to T_{amb} = 50 °C	P_{tot}	max.		220	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	$R_{th\ j\text{-}a}$	=	450	°C/W

CHARACTERISTICS

$T_j = 25\ ^oC$ unless otherwise specified

			BSV86	BSV87	BSV88	
Collector cut-off current						
$I_E = 0$; $V_{CB} = 60$ V	I_{CBO}	<	100	100		nA
$I_E = 0$; $V_{CB} = 30$ V	I_{CBO}	<			100	nA
$I_E = 0$; $V_{CB} = 60$ V; $T_j = 100\ ^oC$	I_{CBO}	<	10	10		μA
$I_E = 0$; $V_{CB} = 30$ V; $T_j = 100\ ^oC$	I_{CBO}	<			10	μA
Emitter cut-off current						
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	100	100		nA
$I_C = 0$; $V_{EB} = 3$ V	I_{EBO}	<			100	nA
Base-emitter voltage						
$I_C = 1$ mA; $V_{CE} = 5$ V	V_{BE}	<	0.9	0.9	0.9	V
Saturation voltages						
$I_C = 10$ mA; $I_B = 1$ mA	V_{CEsat}	<	80	80	80	mV
$I_C = 50$ mA; $I_B = 5$ mA	V_{CEsat}	<	120	120	120	mV
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	200	200	200	mV
	V_{BEsat}	<	1300	1300	1300	mV
$I_C = 400$ mA; $I_B = 40$ mA	V_{CEsat}	<	425	425	425	mV
	V_{BEsat}	<	1300	1300	1300	mV
D.C. current gain						
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	75	35	35	
$I_C = 150$ mA; $V_{CE} = 10$ V	h_{FE}	>	100	40	35	
		<	300	120	–	
$I_C = 500$ mA; $V_{CE} = 10$ V	h_{FE}	>	40	20	20	
Small signal current gain at f = 1 kHz						
$I_C = 1$ mA; $V_{CE} = 5$ V	h_{fe}	>	50	40	–	
		<	200	120	–	
$I_C = 5$ mA; $V_{CE} = 10$ V	h_{fe}	>	70	35	–	
		<	300	150	–	

CHARACTERISTICS (continued)

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

Transition frequency at f = 100 MHz

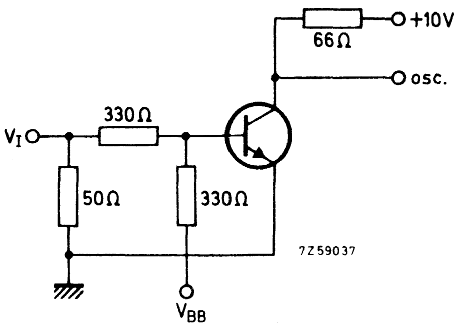
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	>	100	MHz

Switching times

$I_C = 150$ mA; $I_{B1} = -I_{B2} = 15$ mA

			BSV86 BSV87	BSV88	
Delay time	t_d	typ.	20	20	ns
Rise time	t_r	typ.	30	30	ns
Storage time	t_s	typ.	190	190	ns
		<	250	–	ns
Fall time	t_f	typ.	20	20	ns

Test circuit:



measuring t_d and t_r: $V_{BB} = -5$ V; $V_I = +12$ V with $t_r = 20$ ns
measuring t_s and t_f: $V_{BB} = +6$ V; $V_I = -11$ V with $t_f = 20$ ns

P-N-P SWITCHING TRANSISTORS

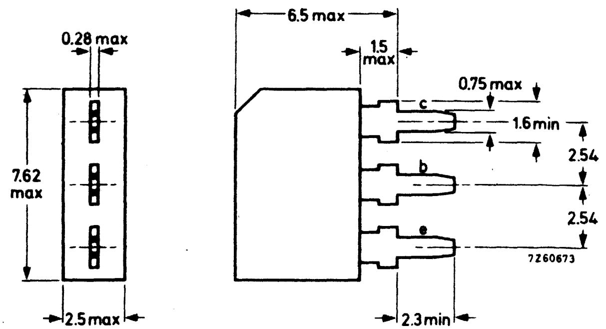
Planar epitaxial transistors for switching applications.

QUICK REFERENCE DATA

			BSV96	BSV97	BSV98	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30	30	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30	30	30	V
Collector current (peak value)	$-I_{CM}$	max.	800	800	800	mA
Total power dissipation up to T_{amb}=50 °C	P_{tot}	max.	220	220	220	mW
D.C. current gain $-I_C$ = 150 mA; $-V_{CE}$ = 2 V	h_{FE}	> <	100 250	40 120	30 –	
Transition frequency at f = 35 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 5 V	f_T	typ.	75	75	75	MHz

MECHANICAL DATA

Dimensions in mm



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.	5	V

Currents

Collector current (d.c. or average over any 20 ms period)	$-I_{C(AV)}$	max.	300	mA
Collector current (peak value)	$-I_{CM}$	max.	800	mA

Power dissipation

Total power dissipation up to T_{amb} = 50 ^{o}C	P_{tot}	max.	220	mW

Temperatures

Storage temperature	T_{stg}		-65 to +150	^{o}C
Junction temperature	T_{j}	max.	150	^{o}C

THERMLA RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	450	^{o}C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

			BSV96	BSV97	BSV98	
Collector cut-off current						
V_{BE} = 0; $-V_{CE}$ = 20 V	$-I_{CES}$	<	100	100	100	nA
V_{BE} = 0; $-V_{CE}$ = 20 V; T_j = 100 °C	$-I_{CES}$	<	10	10	10	μA
Saturation voltages						
$-I_C$ = 300 mA; $-I_B$ = 30 mA	$-V_{CEsat}$	<	0.5	0.5	0.5	V
	$-V_{BEsat}$	<	1.3	1.3	1.3	V
$-I_C$ = 800 mA; $-I_B$ = 30 mA	$-V_{CEsat}$	<	6	6	6	V
D.C. current gain						
$-I_C$ = 10 mA; $-V_{CE}$ = 2 V	h_{FE}	>	25	25	25	
$-I_C$ = 150 mA; $-V_{CE}$ = 2 V	h_{FE}	>	100	40	30	
		<	250	120	-	
$-I_C$ = 500 mA; $-V_{CE}$ = 2 V	h_{FE}	>	25	25	25	
Transition frequency at f = 35 MHz						
$-I_C$ = 50 mA; $-V_{CE}$ = 5 V	f_T	typ.	75	75	75	MHz
Collector capacitance at f = 1 MHz						
$I_E = I_e$ = 0; $-V_{CB}$ = 10 V	C_c	typ.	10	10	10	pF

SILICON PLANAR EPITAXIAL TRANSISTOR

N-P-N transistor in a TO-18 metal envelope intended for core driver applications in small memories.

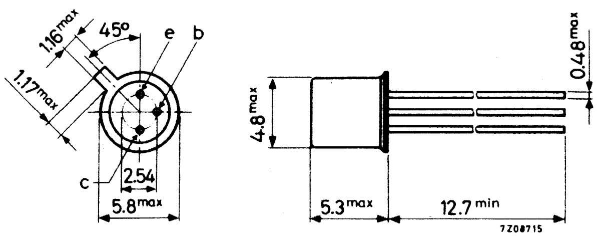
QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	V
Collector current (peak value)	I_{CM}	max.	500	mA
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	1,0	W
Junction temperature	T_j	max.	200	°C
D.C. current gain I_C = 500 mA; V_{CE} = 1 V	h_{FE}	>	15	
Transition frequency I_C = 50 mA; V_{CE} = 10 V; f = 100 MHz	f_T	>	250	MHz
Turn-off time when switched from I_C = 500 mA; I_B = 50 mA to cut-off with $-I_{BM}$ = 50 mA	t_{off}	<	60	ns

MECHANICAL DATA

Dimensions in mm

Collector connected to case

TO-18



Accessories supplied on request: 56246; 56263

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

Voltages

Collector-base voltage (open emitter) $I_C = 0,1$ mA	V_{CBO}	max.	40	V
Collector-emitter voltage (open base) $I_C = 30$ mA	V_{CEO}	max.	25	V
Emitter-base voltage (open collector) $I_E = 0,1$ mA	V_{EBO}	max.	5	V

Currents

Collector current (d.c.)	I_C	max.	300	mA
Collector current (peak value)	I_{CM}	max.	500	mA

Power dissipation

Total power dissipation up to $T_{case} = 25$ °C	P_{tot}	max.	1,0	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	$R_{th\ j\text{-}a}$	=	0,50	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0,175	°C/mW

CHARACTERISTICS T_j = 25 °C 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; $T_j = 100$ °C	I_{CBO}	<	50	μA
→ Breakdown voltages				
$I_C = 30$ mA; $R_{BE} = 100\ \Omega$	$V_{(BR)CER}$	>	40	V
$I_C = 30$ mA; $R_{BE} = 1\ k\Omega$	$V_{(BR)CER}$	>	30	V
Saturation voltages				
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0,5	V
	V_{BEsat}	<	1,3	V
$I_C = 500$ mA; $I_B = 35$ mA	V_{CEsat}	<	0,7	V
$I_C = 500$ mA; $I_B = 50$ mA	V_{BEsat}	<	1,8	V
D.C. current gain				
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	30	
→ $I_C = 150$ mA; $V_{CE} = 1$ V	h_{FE}	>	40	
→ $I_C = 500$ mA; $V_{CE} = 1$ V	h_{FE}	>	15	
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	8,0	pF
Transition frequency at f = 100 MHz				
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	>	250	MHz
Turn-on time when switched to				
a) $I_C = 150$ mA; $I_B = 15$ mA (Fig. 1 on page 4)	t_{on}	<	60	ns
b) $I_C = 300$ mA; $I_B = 40$ mA (Fig. 1 on page 4)	t_{on}	<	50	ns
Turn-off time when switched from				
c) $I_C = 150$ mA; $I_B = 15$ mA to → cut-off with $-I_{BM} = 15$ mA (Fig. 2 on page 4)	t_{off}	<	70	ns
d) $I_C = 300$ mA; $I_B = 40$ mA to → cut-off with $-I_{BM} = 20$ mA (Fig. 1 on page 4)	t_{off}	<	110	ns
e) $I_C = 400$ mA; $I_B = 50$ mA to cut-off with $-I_{BM} = 1$ mA (Fig. 1 on page 4)	t_{off}	<	300	ns
→ f) $I_C = 500$ mA; $I_B = 50$ mA to cut-off with $-I_{BM} = 50$ mA (Fig. 3 on page 4)	t_{off}	<	60	ns

CHARACTERISTICS (continued)

	I_C (mA)	I_B (mA)	I_{BM} (mA)	V_{CC} (V)	R1 (kΩ)	R2 (kΩ)	R3 (Ω)	R4 (Ω)	V_{BB} (V)	V_{BE} (V)	V_i (V)
a	150	15	–	10	1	∞	50	62	–	–	0 to +16
b	300	40	–	15, 5	0, 33	0, 33	56	50	−4, 5	−2, 25	0 to +20
c	150	15	−15	10	1	1	50	62	+16	–	0 to −30
d	300	40	−20	15, 5	0, 33	0, 33	56	50	+15, 3	–	0 to −20
e	400	50	− 1	12, 5	1	∞	50	30	–	–	+51 to 0
→ f	500	50	−50	21	0, 2	–	–	40	−3	–	+11, 3 to −8, 7

Test circuits:

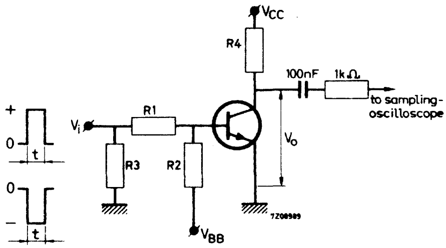


Fig. 1

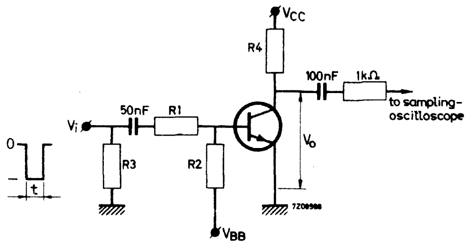


Fig. 2

Pulse generator:

Rise time t_r ≤ 2 ns
Pulse duration t = 200 ns
Fall time t_f ≤ 2 ns
Output resistance R_o = 50 Ω

Oscilloscope:

Input resistance R_i = 50 Ω

Equivalent test circuit:

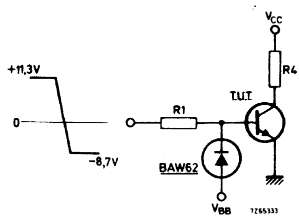
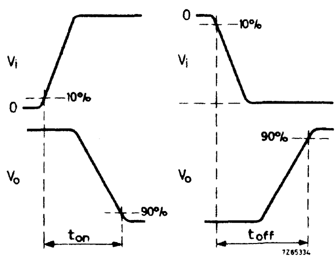
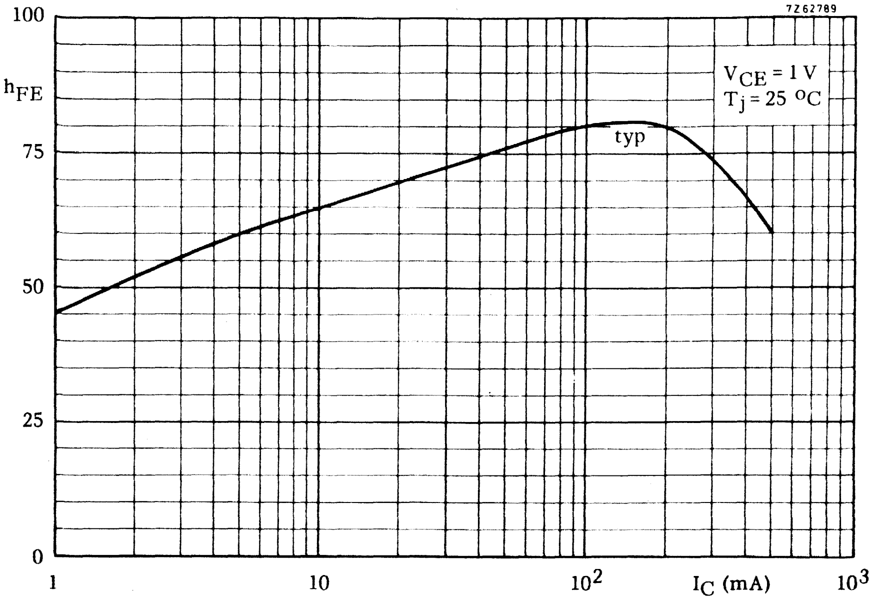
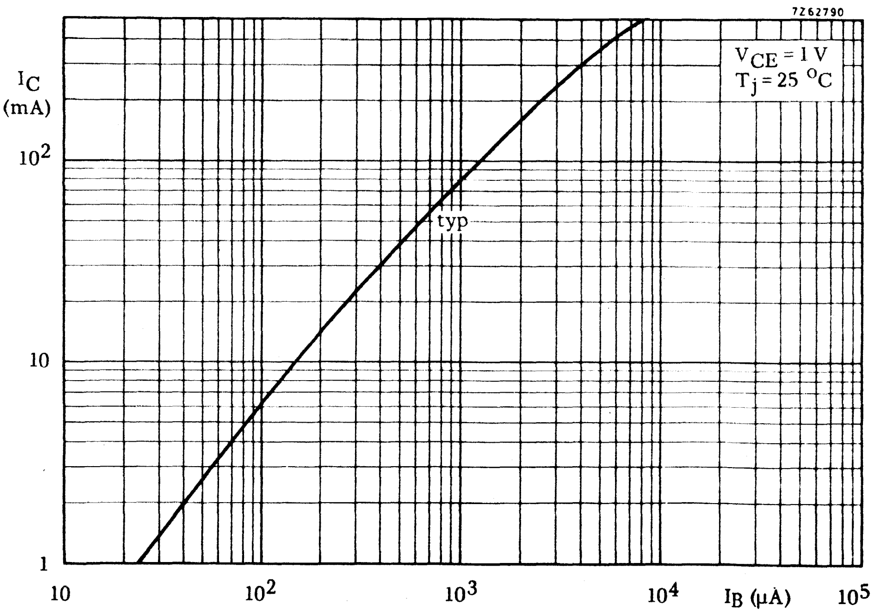
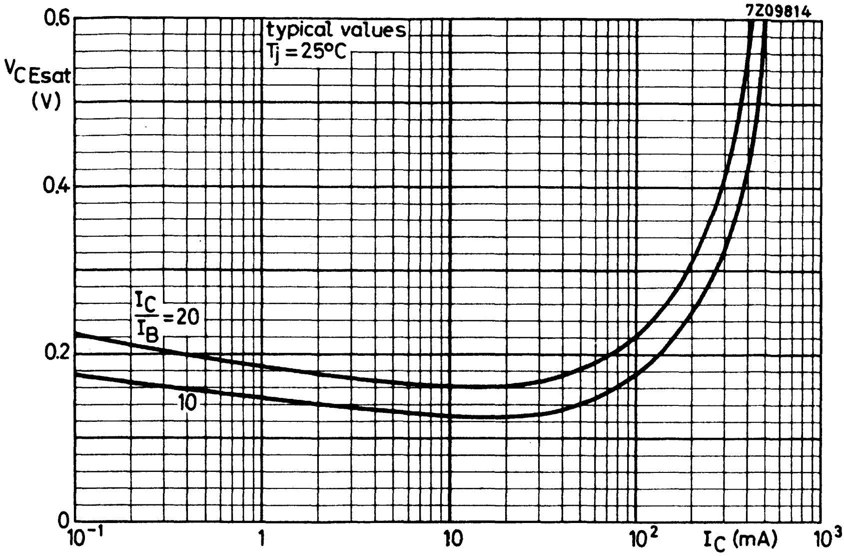


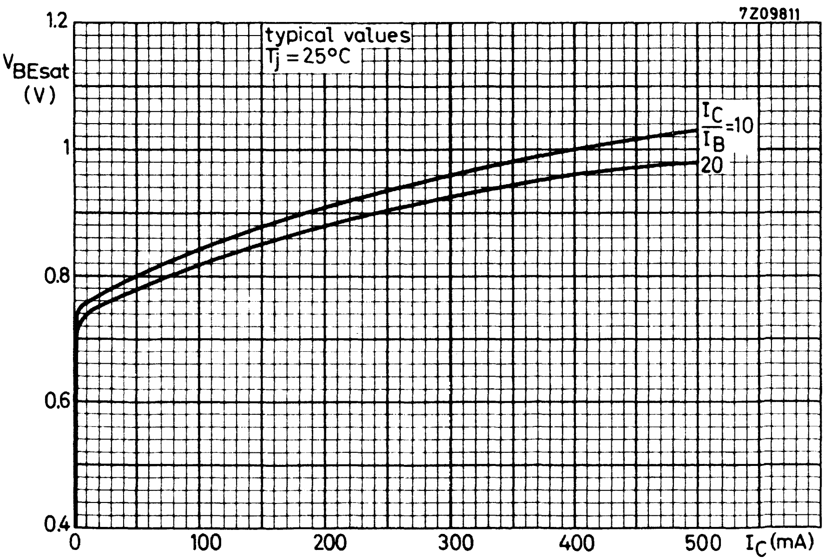
Fig. 3

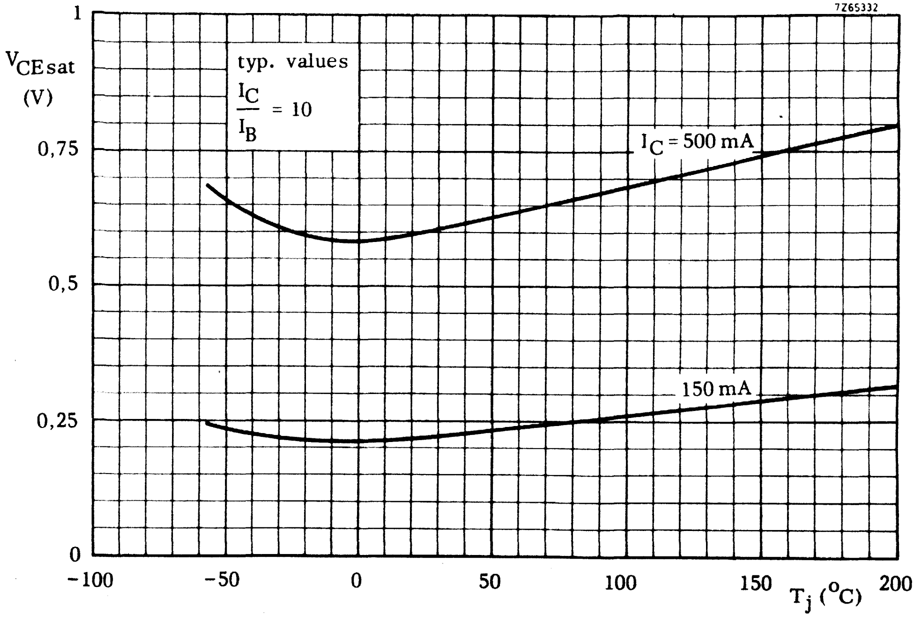


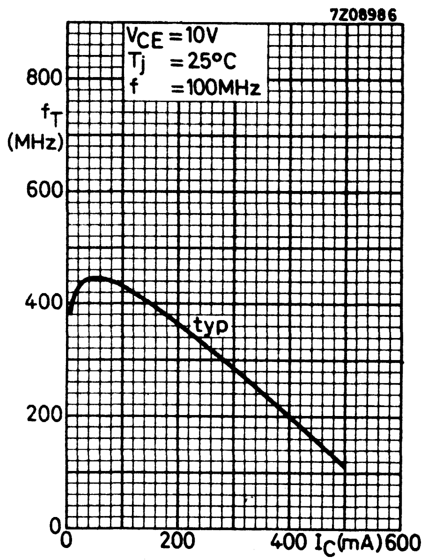

7Z62789
100
h_{FE}
75
50
25
0
1
10
10^2
I_C (mA)
10^3
V_{CE} = 1 V
T_j = 25 °C
typ

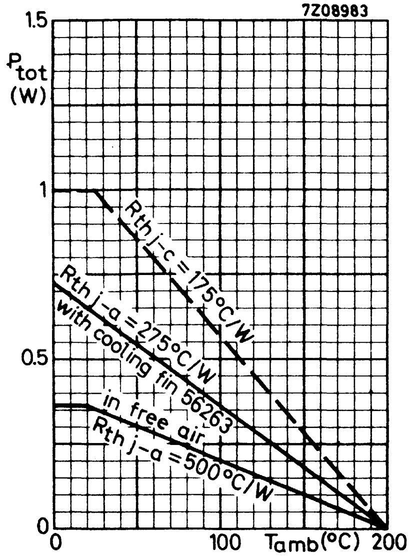

7Z62790
I_C
(mA)
10^2
10
1
10
10^2
10^3
10^4
I_B (μA)
10^5
V_{CE} = 1 V
T_j = 25 °C
typ

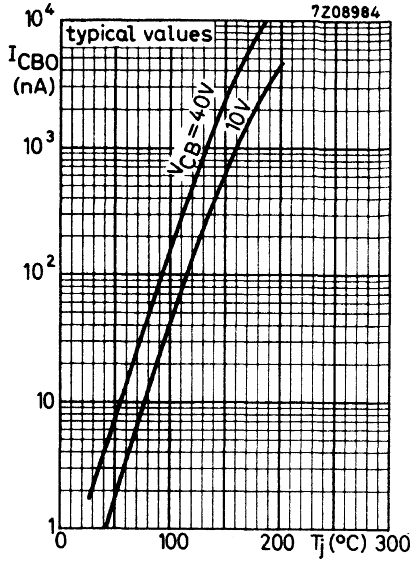

7Z09814
typical values
$T_j = 25°C$
V_{CEsat} (V)
0.6
0.4
0.2
0
$\frac{I_C}{I_B} = 20$
10
10^{-1}
1
10
10^2
I_C (mA)
10^3

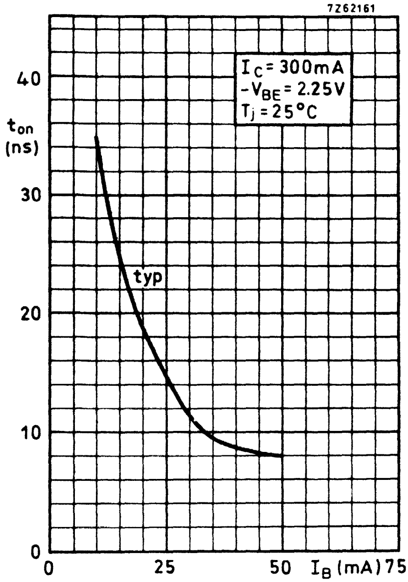

7Z09811
typical values
$T_j = 25°C$
V_{BEsat} (V)
1.2
1
0.8
0.6
0.4
$\frac{I_C}{I_B} = 10$
20
0
100
200
300
400
500
I_C (mA)

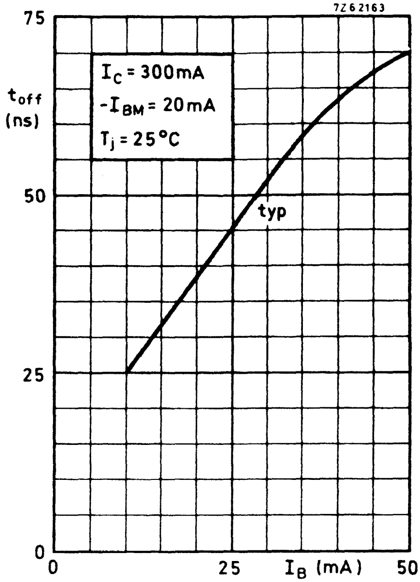

7Z65332
V_{CEsat}
(V)
typ. values
$\frac{I_C}{I_B} = 10$
$I_C = 500$ mA
150 mA
1
0,75
0,5
0,25
0
−100
−50
0
50
100
150
200
T_j (°C)

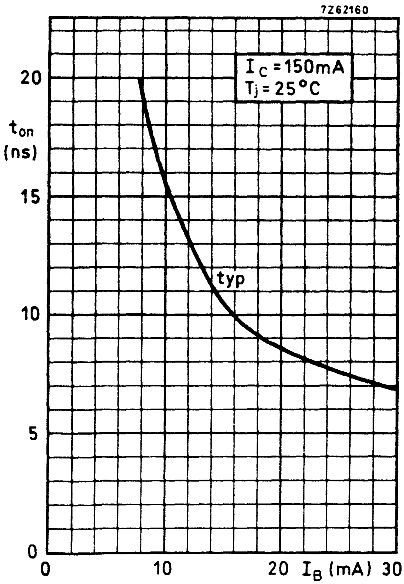

7Z08986
$V_{CE} = 10V$
$T_j = 25°C$
f = 100MHz
f_T
(MHz)
800
600
400
200
0
typ
0
200
400
I_C(mA)
600

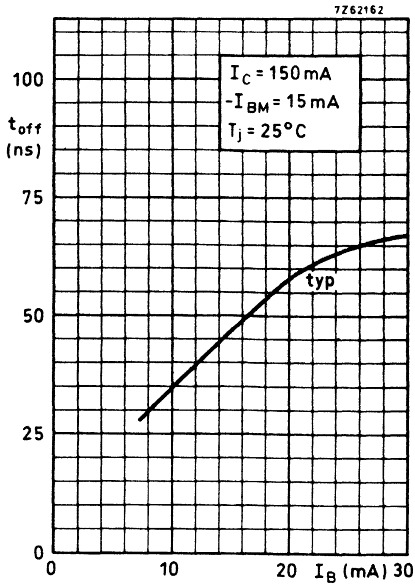

7Z08983
1.5
P_{tot} (W)
1
0.5
0
Rth j-c = 175°C/W
Rth j-a = 275°C/W with cooling fin 56263
in free air Rth j-a = 500°C/W
0
100
200
T_{amb} (°C)


7Z08984
10^4
typical values
I_{CBO} (nA)
10^3
10^2
10
1
V_{CB} = 40V
10V
0
100
200
300
T_j (°C)


7Z62161
I_C = 300mA
$-V_{BE}$ = 2.25V
T_j = 25°C
t_{on} (ns)
typ
0
10
20
30
40
0
25
50
I_B (mA) 75


7Z62163
I_C = 300mA
$-I_{BM}$ = 20mA
T_j = 25°C
t_{off} (ns)
typ
0
25
50
75
0
25
I_B (mA)
50


7Z62160
I_C = 150mA
T_j = 25°C
t_{on} (ns)
typ
0
5
10
15
20
0
10
20
I_B (mA) 30


7Z62162
I_C = 150mA
$-I_{BM}$ = 15mA
T_j = 25°C
t_{off} (ns)
typ
0
25
50
75
100
0
10
20
I_B (mA) 30

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a TO-39 metal envelope with the collector connected to the case. The transistors are intended for general purposes, especially for switching with inductive load.

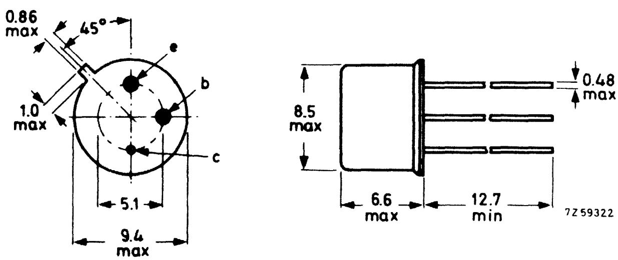
QUICK REFERENCE DATA

			BSW66	BSW67	BSW68	
Collector-base voltage (open emitter)	V_{CBO}	max.	100	120	150	V
Collector-emitter voltage (open base)	V_{CEO}	max.	100	120	150	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	6	6	V
Collector current (peak value)	I_{CM}	max.	2			A
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	5.0			W
Junction temperature	T_j	max.	200			°C
Transition frequency at f = 35 MHz I_C = 100 mA; V_{CE} = 20 V	f_T	typ.	80			MHz
D.C. current gain I_C = 10 mA; V_{CE} = 5 V	h_{FE}	>	30			
I_C = 500 mA; V_{CE} = 5 V	h_{FE}	>	30			

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-39



Accessories available: 56218, 56245, 56265

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 °C	P_{tot}	max.	0.8	W
T_{case} = 25 °C	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	°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

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $V_{CB} = V_{CBOmax}$	I_{CBO}	<	100	µA
$I_E = 0$; $V_{CB} = \frac{1}{2} V_{CBOmax}$	I_{CBO}	<	100	nA
$I_E = 0$; $V_{CB} = \frac{1}{2} V_{CBOmax}$; T_j = 150 °C	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

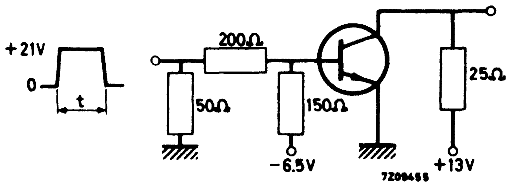
Turn on time when switched from

$-V_{BE}$ = 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:



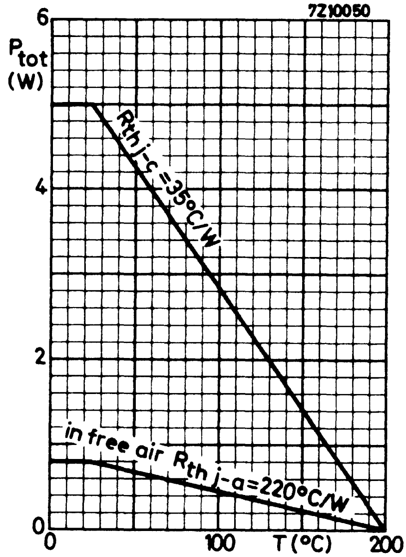
Pulse generator:

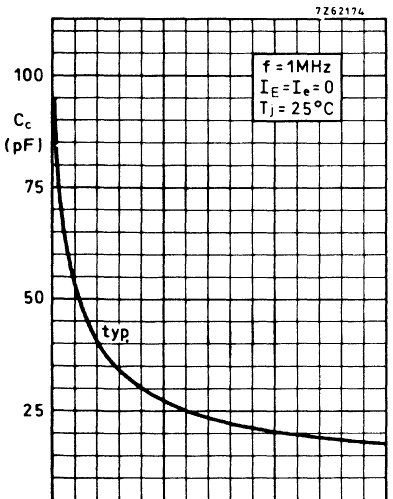
Pulse duration	t	> 5 μs
Rise time	t_r	< 10 ns
Fall time	t_f	< 10 ns

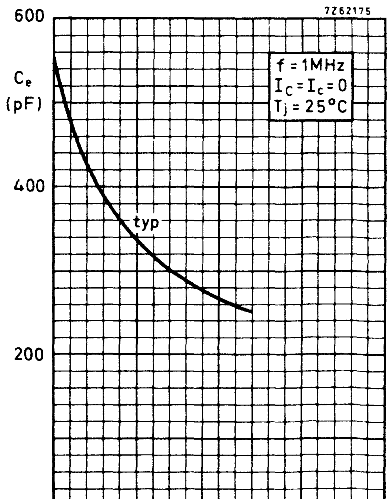
Note

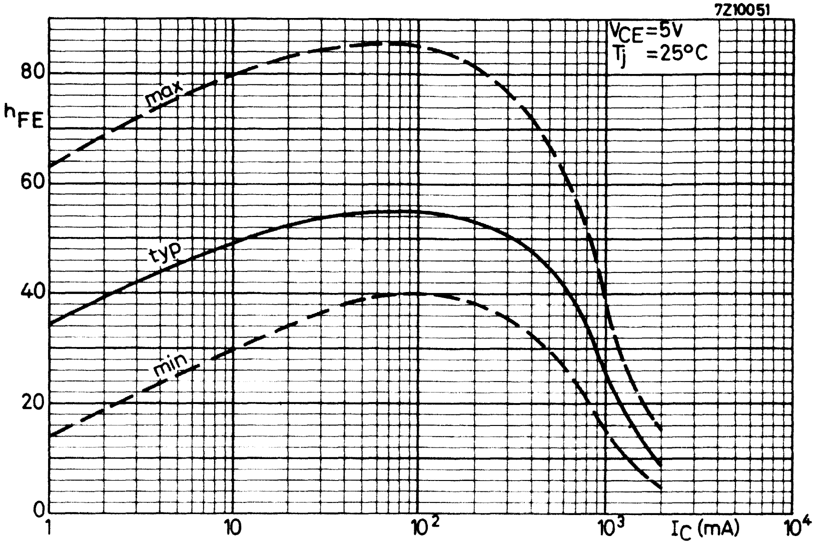
$-I_{BM}$ is the reverse current that can flow during switching off. The indicated $-I_{BM}$ is determined and limited by the applied cut-off voltage and series resistance.

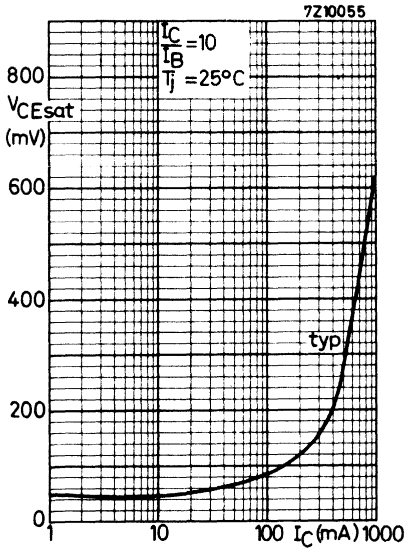
CHARACTERISTICS (continued)

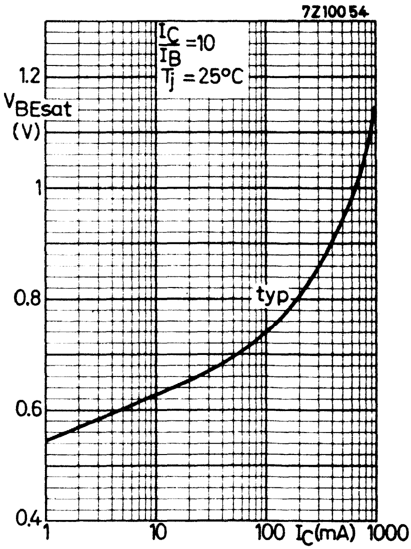


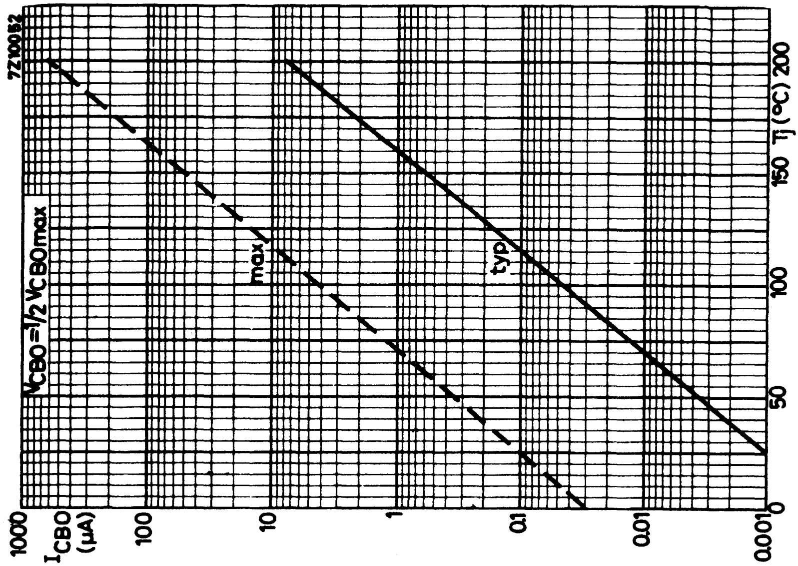


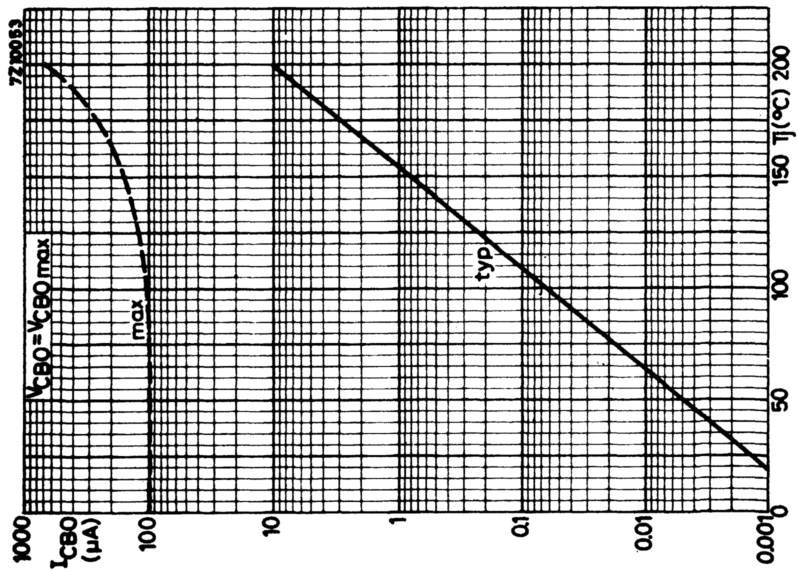



7Z10051
V_{CE} = 5V
T_j = 25°C
h_{FE}
max
typ
min
0
20
40
60
80
1
10
10^2
10^3
I_C (mA)
10^4


7Z10055
$\frac{I_C}{I_B}$ = 10
T_j = 25°C
V_{CEsat}
(mV)
0
200
400
600
800
typ
1
10
100
I_C (mA)
1000


7Z10054
$\frac{I_C}{I_B}$ = 10
T_j = 25°C
V_{BEsat}
(V)
0.4
0.6
0.8
1
1.2
typ
1
10
100
I_C (mA)
1000


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)

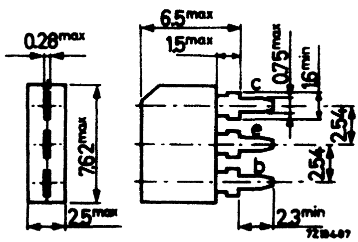

7Z10053
VCBO=VCBOmax
max
typ
ICBO
(μA)
1000
100
10
1
0.1
0.01
0.001
0
50
100
150
200
Tj (°C)

SILICON PLANAR SWITCHING TRANSISTOR

N-P-N transistor in a plastic envelope intended for driving numerical indicator tubes

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	150	V
Collector-emitter voltage with R_{BE} = 10 kΩ	V_{CER}	max.	150	V
Collector current (d.c.)	I_C	max.	50	mA
Total power dissipation up to T_{amb} = 50 °C	P_{tot}	max.	125	mW
D.C. current gain at T_j = 25 °C I_C = 4 mA; V_{CE} = 2 V	h_{FE}	>	30	
Transition frequency at f = 100 MHz I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	130	MHz

MECHANICAL DATA Dimensions in mm



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

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	150	V
Collector-emitter voltage with R_{BE} = 10 kΩ	V_{CER}	max.	150	V
Emitter-base voltage (open collector)	V_{EBO}	max.	6	V

Currents

Collector current (d.c.)	I_C	max.	50	mA
Emitter current (d.c.)	$-I_E$	max.	50	mA

Power dissipation

Total power dissipation up to T_{amb} = 50 °C	P_{tot}	max.	125	mW

Temperatures

Storage temperature	T_{stg}		−30 to +125	°C
Junction temperature	T_j	max.	125	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.6	°C/mW

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

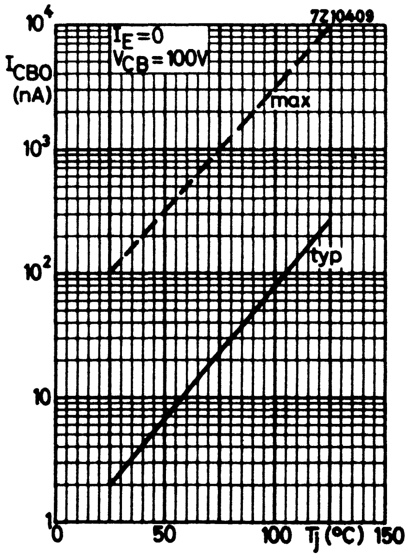
I_E = 0; V_{CB} = 100 V	I_{CBO}	<	100	nA
I_E = 0; V_{CB} = 150 V	I_{CBO}	<	10	µA
V_{BE} = 150 V; R_{BE} = 10 kΩ	I_{CER}	<	100	µA
V_{CE} = 100 V; V_{BE} = 0.4 V; T_j = 75 °C	I_{CEX}	<	100	µA

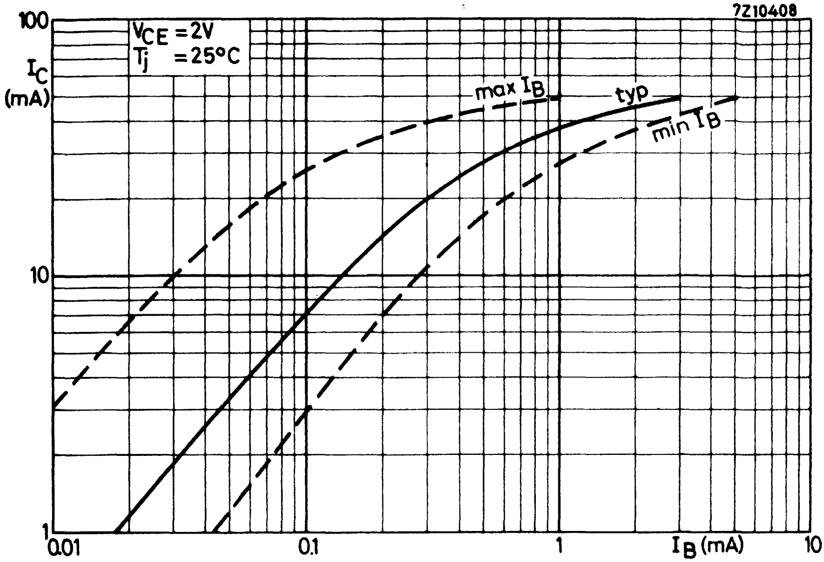
Emitter cut-off current

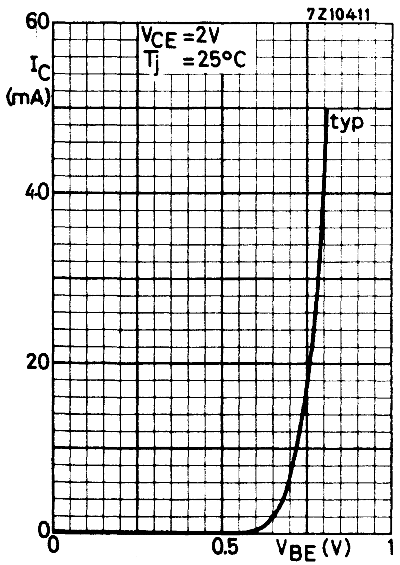
I_C = 0; V_{EB} = 4 V	I_{EBO}	<	100	nA
I_C = 0; V_{EB} = 6 V	I_{EBO}	<	10	µA

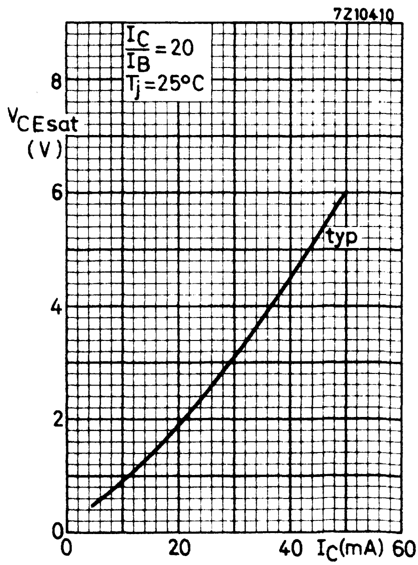
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Base-emitter voltage				
I_C = 4 mA; V_{CE} = 2 V	V_{BE}	<	0.75	V
Saturation voltage				
I_C = 20 mA; I_B = 1 mA	V_{CEsat}	<	4	V
D.C. current gain				
I_C = 4 mA; V_{CE} = 2 V	h_{FE}	>	30	
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; V_{CB} = 10 V	C_c	typ.	2	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; V_{EB} = 0.5 V	C_e	typ.	17	pF
Transition frequency at f = 100 MHz				
I_C = 10 mA; V_{CE} = 5 V	f_T	typ.	130	MHz




7Z10408
V_{CE} = 2V
T_j = 25°C
I_C (mA)
max I_B
typ
min I_B
I_B (mA)
100
10
1
0.01
0.1
1
10


7Z10411
V_{CE} = 2V
T_j = 25°C
I_C (mA)
typ
V_{BE} (V)
60
40
20
0
0
0.5
1


7Z10410
$\frac{I_C}{I_B}$ = 20
T_j = 25°C
V_{CEsat} (V)
typ
I_C (mA)
8
6
4
2
0
0
20
40
60

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a TO-39 (reduced height) metal envelope with the collector connected to the case. They are intended for very high speed switching capability in high current applications.

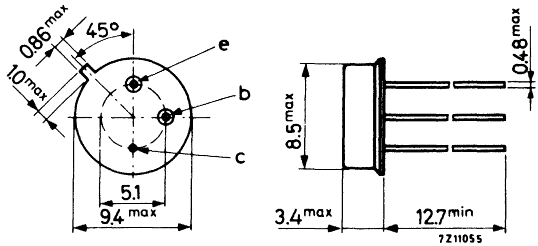
QUICK REFERENCE DATA

			BSX12	BSX12A	
Collector-base voltage (open emitter)	V_{CBO}	max.	25	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	12	15	V
Collector current (d.c.)	I_C	max.	1		A
Total power dissipation up to T_{mb} = 95 °C	P_{tot}	max.	3		W
Junction temperature	T_j	max.	200		°C
Collector-emitter saturation voltage I_C = 100 mA; I_B = 10 mA	V_{CEsat}	<	230		mV
D.C. current gain at T_j = 25 °C I_C = 300 mA; V_{CE} = 0.5 V	h_{FE}	typ. / 30 to	60 / 120		
Transition frequency I_C = 100 mA; V_{CE} = 5 V ; f = 100 MHz	f_T	typ.	620		MHz
Storage time when switched from I_C = 1 A; I_B = 100 mA to cut-off with $-I_{BM}$ = 100 mA	t_s	<	18		ns

MECHANICAL DATA see page 2

MECHANICAL DATA Dimensions in mm

TO-39 (reduced height)
Collector connected to case



max. lead diameter is guaranteed only for 12.7 mm

Accessories supplied on request: 56218

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

Voltages

			BSX12	BSX12A	
Collector-base voltage (open emitter)	V_{CBO}	max.	25	25	V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max.	25	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	12	15	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4	4	V

Currents

Collector current (d.c.)	I_C	max.	1	A
Collector current (peak value)	I_{CM}	max.	1	A
Base current (peak value)	I_{BM}	max.	0.2	A

Power dissipation

Total power dissipation up to T_{mb} = 95°C	P_{tot}	max.	3	W

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	300	°C/W
From junction to mounting base	$R_{th\ j\text{-}mb}$	=	35	°C/W

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

Collector cut-off currents				
$I_E = 0$; $V_{CB} = 25$ V	I_{CBO}	typ.	10	nA
		<	500	μA
$I_E = 0$; $V_{CB} = 25$ V; $T_j = 150\ ^oC$	I_{CBO}	typ.	7	μA
		<	1	mA
$V_{BE} = 0$; $V_{CE} = 15$ V	I_{CES}	typ.	10	nA
		<	100	μA
$V_{BE} = 0$; $V_{CE} = 15$ V; $T_j = 125\ ^oC$	I_{CES}	typ.	5	μA
		<	500	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 4$ V; $T_j = 150\ ^oC$	I_{EBO}	typ.	100	nA
		<	500	μA
Current at reverse biased emitter junction				
$V_{CE} = 15$ V; $-V_{BE} = 2$ V	$-I_{BEX}$	typ.	100	nA
		<	100	μA
Saturation voltages				
$I_C = 10$ mA; $I_B = 1$ mA	V_{CEsat}	<	0.25	V
	V_{BEsat}	typ.	0.72	V
		<	0.78	V
$I_C = 100$ mA; $I_B = 10$ mA	V_{CEsat}	<	0.23	V
	V_{BEsat}	typ.	0.8	V
		<	1.1	V
$I_C = 300$ mA; $I_B = 30$ mA	V_{CEsat}	<	0.33	V
	V_{BEsat}	typ.	0.9	V
		<	1.2	V
$I_C = 300$ mA; $I_B = 30$ mA; $T_j = 85\ ^oC$	V_{CEsat}	<	0.5	V
$I_C = 1$ A; $I_B = 0.1$ A	V_{CEsat}	<	0.7	V
	V_{BEsat}	typ.	1.1	V
		0.9 to	1.7	V

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

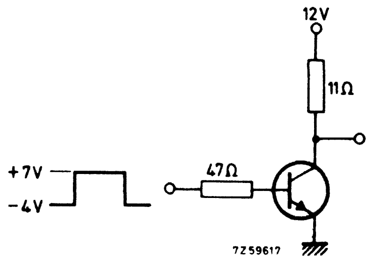
D.C. current gain				
$I_C = 10$ mA; $V_{CE} = 0.5$ V	h_{FE}	>	20	
		typ.	45	
$I_C = 100$ mA; $V_{CE} = 0.5$ V	h_{FE}	>	30	
		typ.	65	
$I_C = 300$ mA; $V_{CE} = 0.5$ V	h_{FE}	typ.	60	
		30 to	120	
$I_C = 1$ A ; $V_{CE} = 1$ V	h_{FE}	>	15	
		typ.	35	
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 0$	C_c	typ.	10	pF
		<	25	pF
$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	typ.	8	pF
		<	12	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	typ.	16.5	pF
		<	25	pF
Transition frequency at f = 100 MHz				
$I_C = 100$ mA; $V_{CE} = 5$ V	f_T	>	450	MHz
		typ.	620	MHz
$I_C = 500$ mA; $V_{CB} = 0$	f_T	>	200	MHz
		typ.	400	MHz

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

Switching times (see page 6)

Turn on time when switched from $-V_{BE}$ = 4 V to I_C = 1 A; I_B = 100 mA	t_{on}	typ.	11	ns
		<	15	ns
Turn off time when switched from I_C = 1 A; I_B = 0.1 A to cut off with $-I_{BM}$ = 0.1 A	t_s	typ.	13	ns
		<	18	ns
	t_{off}	typ.	19	ns
		<	25	ns

Test circuit:



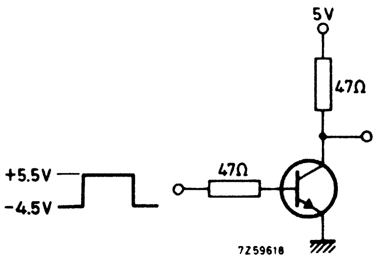
Pulse generator:

Pulse duration	t_p	=	100	ns
Rise time	t_r	<	1	ns
Duty cycle	δ	=	0.01	

Storage time

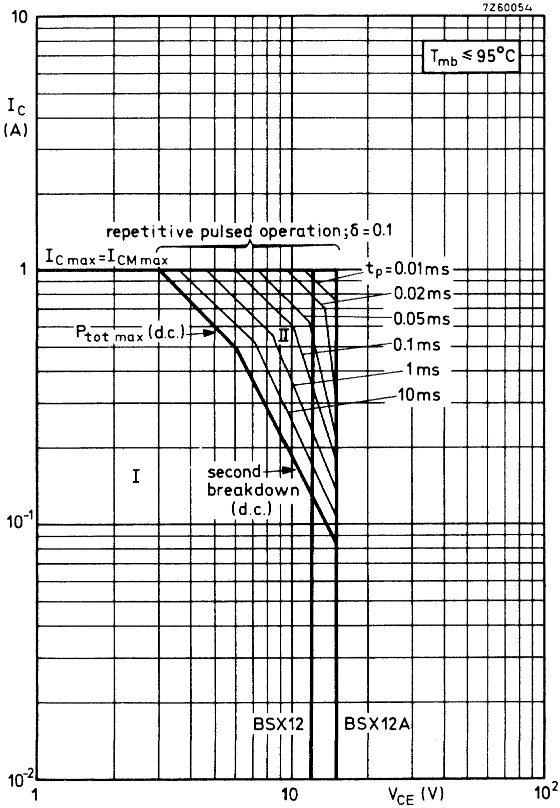
$I_C = I_{B1} = -I_{B2}$ = 0.1 A	τ_s	typ.	11	ns
		<	15	ns

Test circuit:



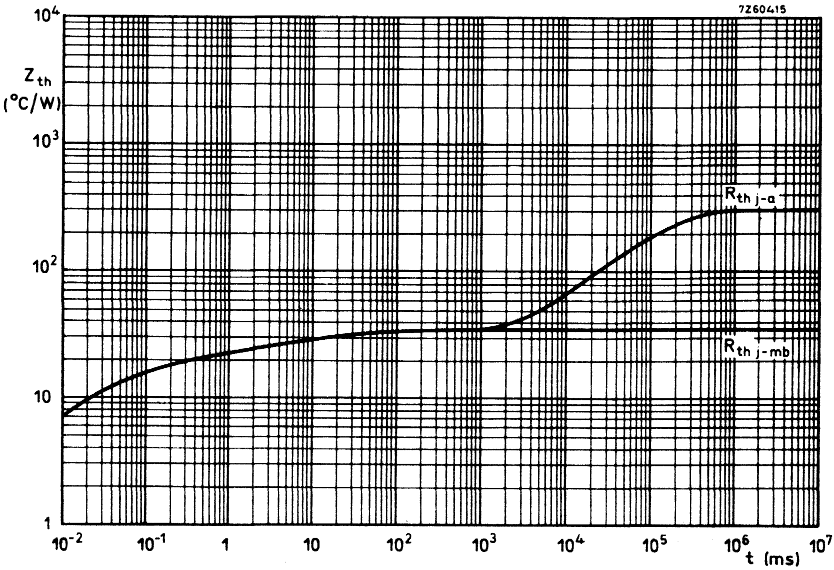
Pulse generator:

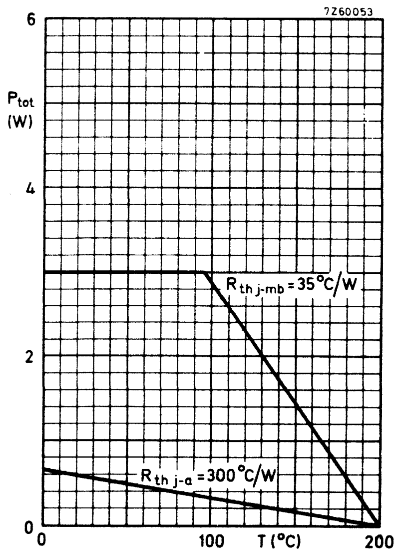
Pulse duration	t_p	=	100	ns
Rise time	t_r	<	1	ns
Duty cycle	δ	=	0.01	

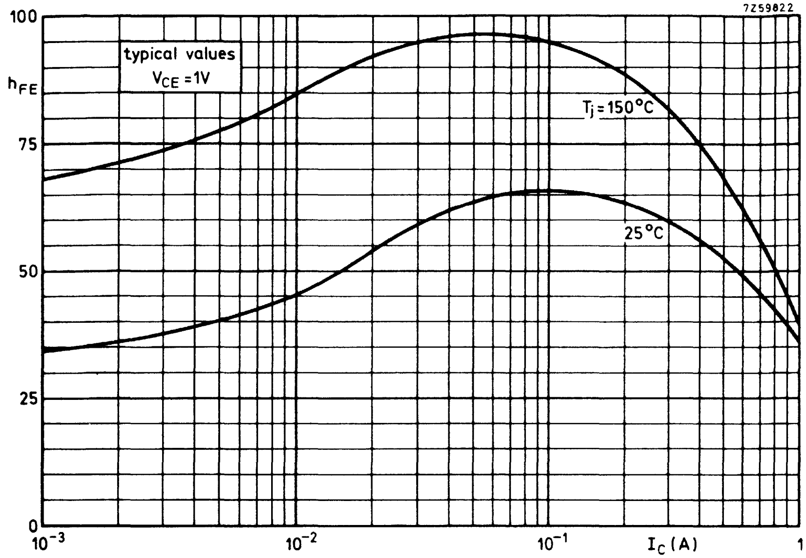


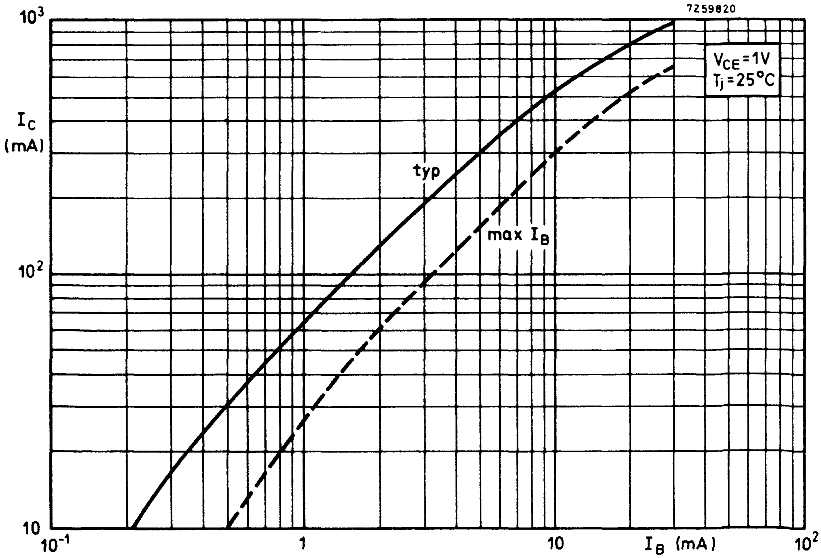
Safe Operating Area with the transistor forward biased

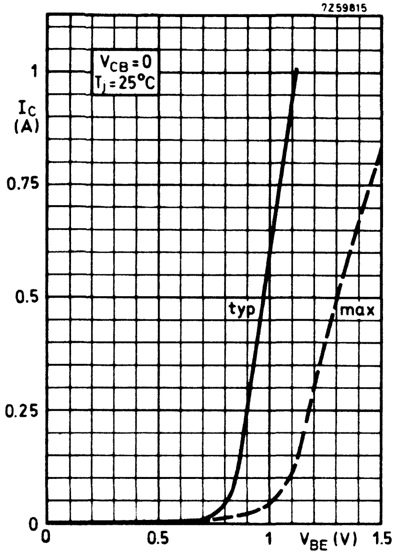
I Region of permissible d.c. operation
II Permissible extension for repetitive pulsed operation

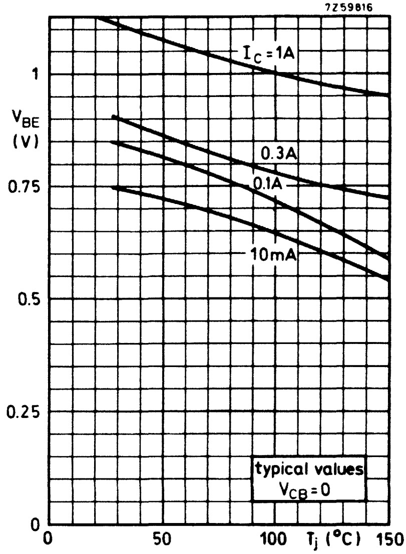

7Z60415
Z_{th} (°C/W)
10^4
10^3
10^2
10
1
$R_{th\ j-a}$
$R_{th\ j-mb}$
10^{-2}
10^{-1}
1
10
10^2
10^3
10^4
10^5
10^6
10^7
t (ms)

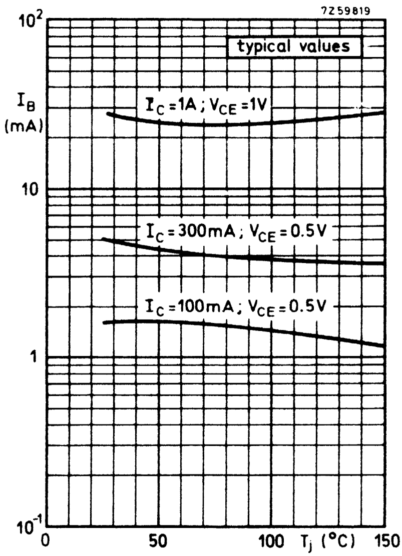

7Z60053
P_{tot} (W)
6
4
2
0
$R_{th\ j-mb} = 35\ °C/W$
$R_{th\ j-a} = 300\ °C/W$
0
100
T (°C)
200

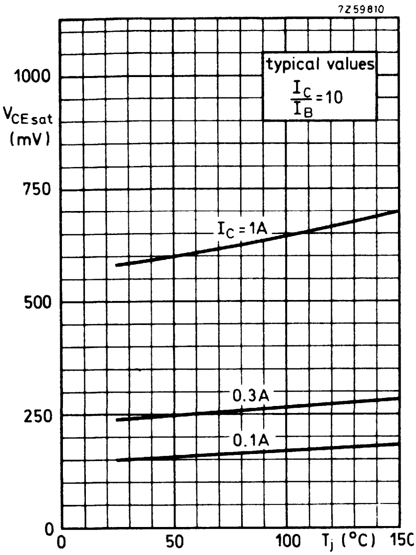

7Z59822
typical values
V_{CE} = 1V
h_{FE}
100
75
50
25
0
T_j = 150°C
25°C
10^{-3}
10^{-2}
10^{-1}
I_C (A)
1

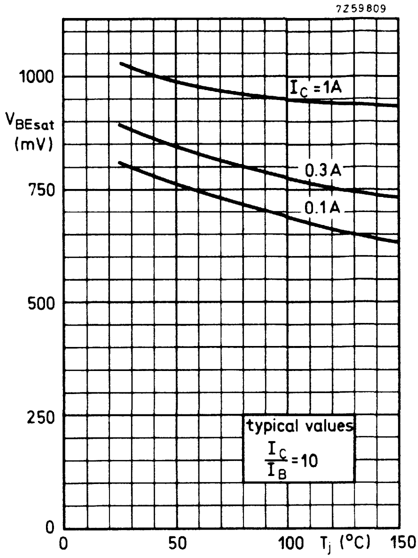

7Z59820
V_{CE} = 1V
T_j = 25°C
I_C
(mA)
10^3
10^2
10
typ
max I_B
10^{-1}
1
10
I_B (mA)
10^2

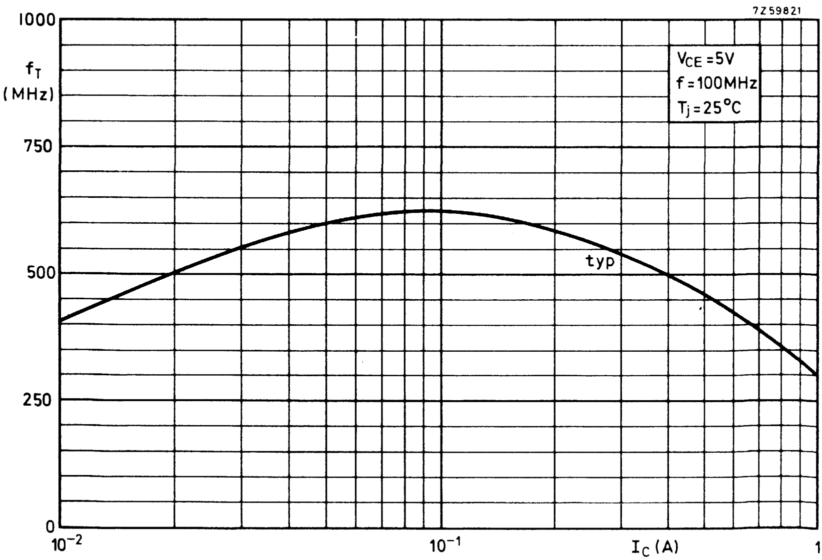

7Z59815
$V_{CB} = 0$
$T_j = 25°C$
I_C (A)
1
0.75
0.5
0.25
0
typ
max
0
0.5
1
V_{BE} (V)
1.5

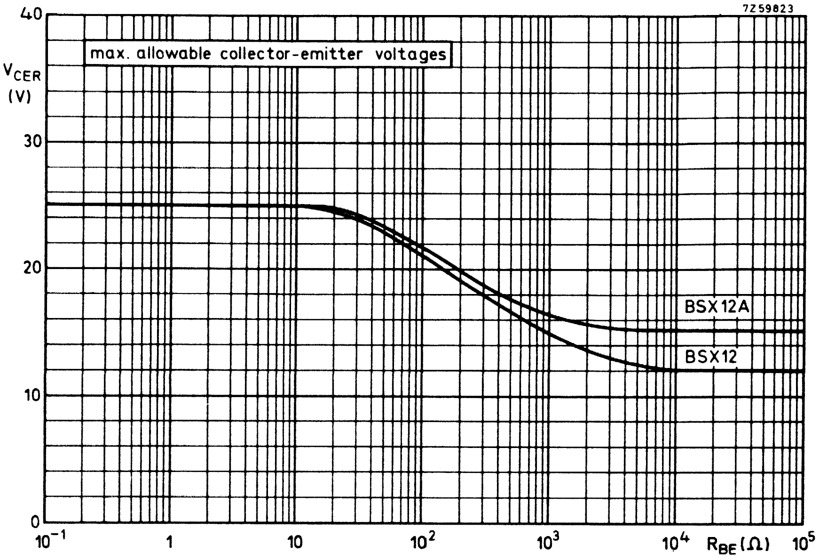

7Z59816
V_{BE} (V)
1
0.75
0.5
0.25
0
$I_C = 1A$
0.3A
0.1A
10mA
typical values
$V_{CB} = 0$
0
50
100
T_j (°C)
150

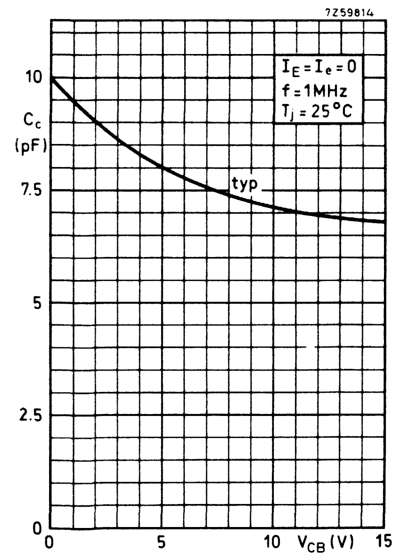

7Z59819
10^2
I_B (mA)
10
1
10^{-1}
typical values
$I_C = 1A$; $V_{CE} = 1V$
$I_C = 300mA$; $V_{CE} = 0.5V$
$I_C = 100mA$; $V_{CE} = 0.5V$
0
50
100
T_j (°C)
150

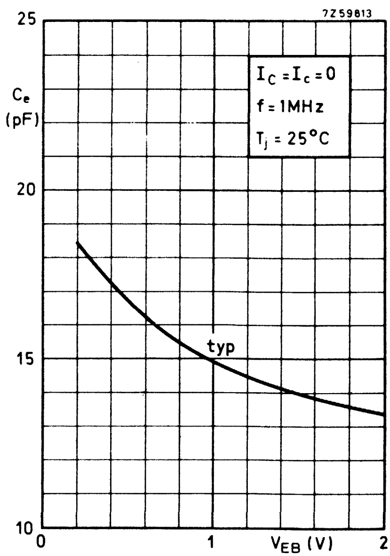

7Z59810
typical values
$\frac{I_C}{I_B}=10$
1000
V_{CEsat}
(mV)
750
500
250
0
$I_C = 1A$
0.3A
0.1A
0
50
100
T_j (°C)
150

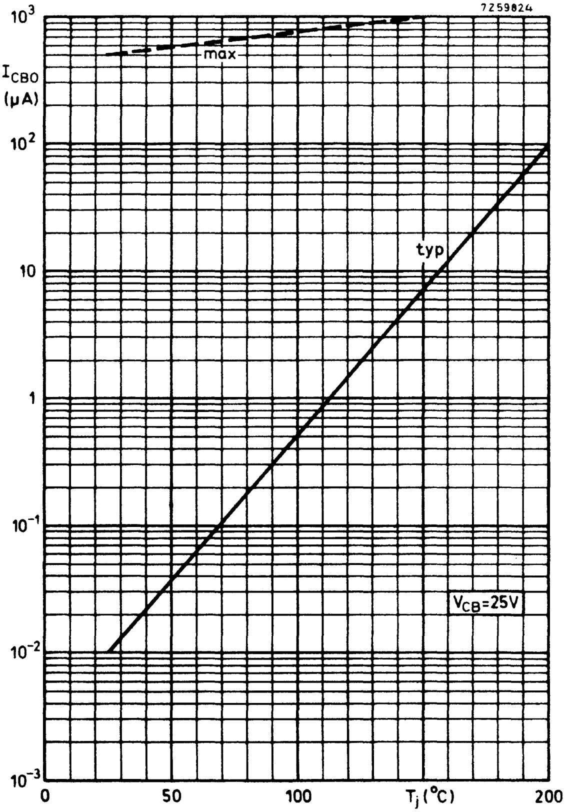

7Z59809
1000
V_{BEsat}
(mV)
750
500
250
0
$I_C = 1A$
0.3A
0.1A
typical values
$\frac{I_C}{I_B}=10$
0
50
100
T_j (°C)
150

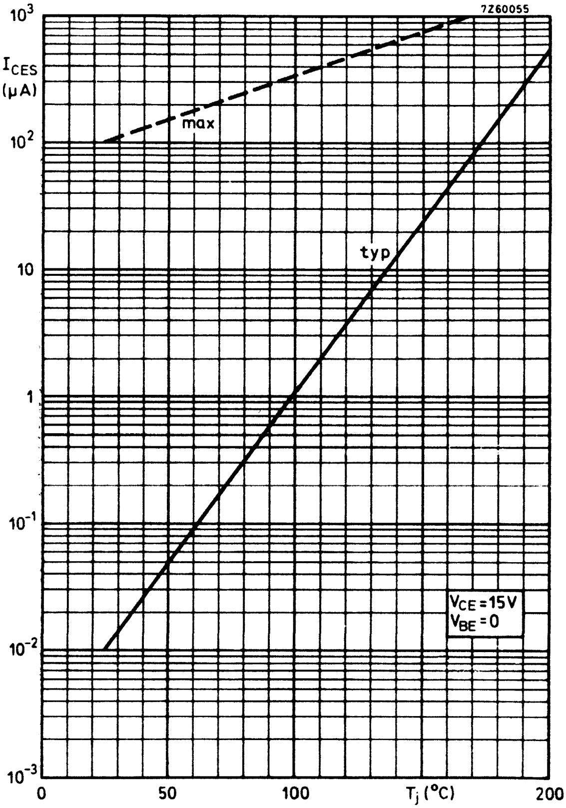

7Z59821
1000
f_T
(MHz)
750
500
250
0
$V_{CE} = 5V$
f = 100MHz
$T_j = 25°C$
typ
10^{-2}
10^{-1}
I_C (A)
1

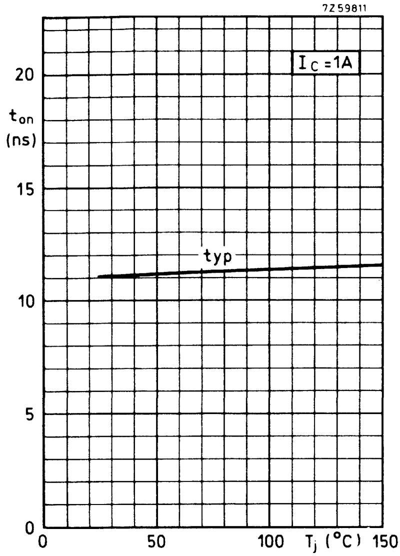

7Z59823
max. allowable collector-emitter voltages
V_CER (V)
40
30
20
10
0
BSX12A
BSX12
10^-1
1
10
10^2
10^3
10^4
R_BE (Ω)
10^5

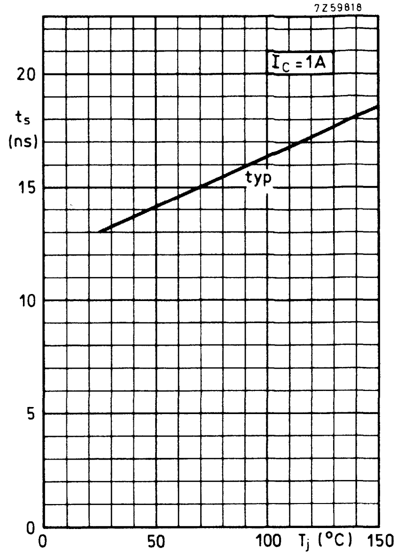

7Z59814
I_E = I_e = 0
f = 1MHz
T_j = 25°C
C_c (pF)
10
7.5
5
2.5
0
typ
0
5
10
V_CB (V)
15

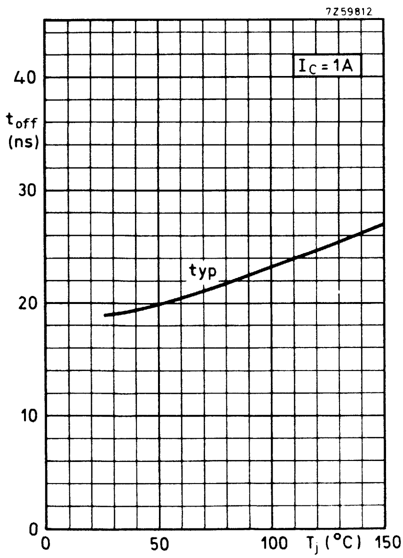

7Z59813
I_C = I_c = 0
f = 1MHz
T_j = 25°C
C_e (pF)
25
20
15
10
typ
0
1
V_EB (V)
2

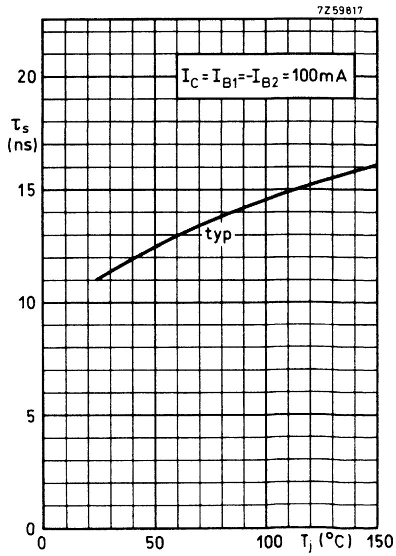

7Z59024
10^3
max
I_{CBO}
(μA)
10^2
typ
10
1
10^{-1}
V_{CB}=25V
10^{-2}
10^{-3}
0
50
100
T_j (°C)
200


7Z60055
I_{CES} (μA)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
max
typ
V_{CE} = 15 V
V_{BE} = 0
0
50
100
T_j (°C)
200


7Z59811
$I_C = 1A$
20
t_{on}
(ns)
15
typ
10
5
0
0
50
100
T_j (°C)
150


7Z59818
$I_C = 1A$
20
t_s
(ns)
15
typ
10
5
0
0
50
100
T_j (°C)
150


7Z59812
$I_C = 1A$
40
t_{off}
(ns)
30
typ
20
10
0
0
50
100
T_j (°C)
150


7Z59817
$I_C = I_{B1} = -I_{B2} = 100mA$
20
τ_s
(ns)
15
typ
10
5
0
0
50
100
T_j (°C)
150

VERY HIGH SPEED SWITCHING TRANSISTORS

N-P-N silicon planar epitaxial transistors in a TO-18 metal envelope with the collector connected to the case. The BSX19 and BSX20 are primarily intended for very high speed saturated switching.

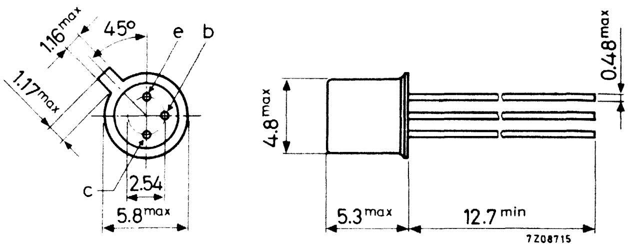
QUICK REFERENCE DATA

		BSX19	BSX20	
Collector-base voltage (open emitter)	V_{CBO}	max. 40	40	V
Collector-emitter voltage (open base)	V_{CEO}	max. 15	15	V
Collector-emitter voltage (V_{BE} = 0)	V_{CES}	max. 40	40	V
Collector current (peak value)	I_{CM}	max. 500	500	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max. 360	360	mW
D.C. current gain at T_j = 25 °C				
I_C = 10 mA; V_{CE} = 1 V	h_{FE}	20 to 60	40 to 120	
I_C = 100 mA; V_{CE} = 2 V	h_{FE}	> 10	20	
Transition frequency				
I_C = 10 mA; V_{CE} = 10 V	f_T	> 400	500	MHz
Storage time				
$I_C = I_B = -I_{BM}$ = 10 mA	t_s	< 10	13	ns

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-18



Accessories available: 56246, 56263

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector-emitter voltage with V_{BE} = 0	V_{CES}	max.	40	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4.5	V

Current

Collector current (peak value; t = 10 μs)	I_{CM}	max.	500	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360	mW

Temperatures

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

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.48	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0.15	°C/mW

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

CHARACTERISTICS

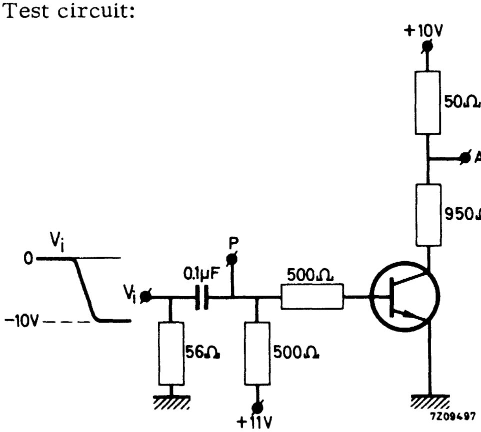
T_j = 25 °C unless otherwise specified

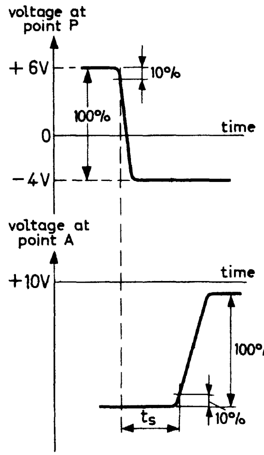
Collector cut-off current				
$I_E = 0$; $V_{CB} = 20$ V	I_{CBO}	<	400	nA
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 150$ °C	I_{CBO}	<	30	μA
$V_{BE} = 0$; $V_{CE} = 15$ V; $T_j = 55$ °C	I_{CES}	<	0.40	μA
$V_{BE} = 0$; $V_{CE} = 40$ V	I_{CES}	<	1.0	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 4.5$ V	I_{EBO}	<	10	μA
Currents at reverse biased emitter junction				
$V_{CE} = 15$ V; $-V_{BE} = 3$ V; $T_j = 55$ °C	I_{CEX}	<	0.60	μA
	$-I_{BEX}$	<	0.60	μA
Sustaining voltages				
$I_C = 10$ mA; $I_B = 0$	$V_{CEOsust}$	>	15	V
$I_C = 10$ mA; $R_{BE} = 10$ Ω	$V_{CERsust}$	>	20	V
Base-emitter voltage (see also page 8)				
$I_C = 30$ μA; $V_{CE} = 20$ V; $T_j = 100$ °C	V_{BE}	>	0.35	V
Saturation voltages				
$I_C = 10$ mA; BSX19: $I_B = 0.6$ mA; BSX20: $I_B = 0.3$ mA	V_{CEsat}	<	0.3	V
$I_C = 10$ mA; $I_B = 1$ mA	V_{CEsat}	<	0.25	V
	V_{BEsat}	0.70 to	0.85	V
$I_C = 100$ mA; $I_B = 10$ mA	V_{CEsat}	<	0.60	V
	V_{BEsat}	<	1.50	V
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	<	4	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 1$ V	C_e	<	4.5	pF

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

		BSX19	BSX20	
D.C. current gain				
I_C = 10 mA; V_{CE} = 1 V	h_{FE}	20 to 60	40 to 120	
I_C = 10 mA; V_{CE} = 1 V; T_j = −55 °C	h_{FE}	> 10	20	
I_C = 100 mA; V_{CE} = 2 V	h_{FE}	> 10	20	
Transition frequency				
I_C = 10 mA; V_{CE} = 10 V	f_T	> 400	500	MHz
		typ. 500	600	MHz
Switching times				
Storage time (see also pages 20 and 21)				
$I_C = I_B = -I_{BM}$ = 10 mA	t_s	typ. 5	6	ns
		< 10	13	ns

Test circuit:





Pulse generator:

Rise time	t_r	<	1	ns
Pulse duration	t	>	300	ns
Duty cycle	δ	<	0.02	
Source impedance	R_S	=	50	Ω

Oscilloscope:

Input impedance	R_i	=	50	Ω
Rise time	t_r	<	1	ns

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Switching times

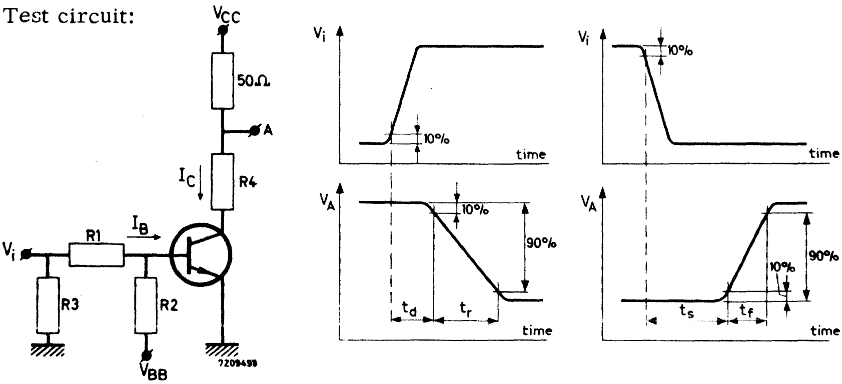
Turn on time (see also pages 14 and 15)

from $-V_{BE}$ = 1.5 V to I_C = 10 mA; I_B = 3 mA		t_{on}	<	12	ns
from $-V_{BE}$ = 2.25 V to I_C = 100 mA; I_B = 40 mA		t_{on}	<	7	ns

Turn off time (see also pages 16 to 19)

from I_C = 10 mA; I_B = 3 mA	BSX19	t_{off}	<	15	ns
to cut-off with $-I_{BM}$ = 1.5 mA	BSX20	t_{off}	<	18	ns
from I_C = 100 mA; I_B = 40 mA to cut-off	BSX19	t_{off}	<	18	ns
with $-I_{BM}$ = 20 mA	BSX20	t_{off}	<	21	ns

Test circuit:



Pulse generator:

Rise time	t_r	<	1	ns
Pulse duration	t	>	300	ns
Duty cycle	δ	<	0.02	
Source impedance	R_S	=	50	Ω

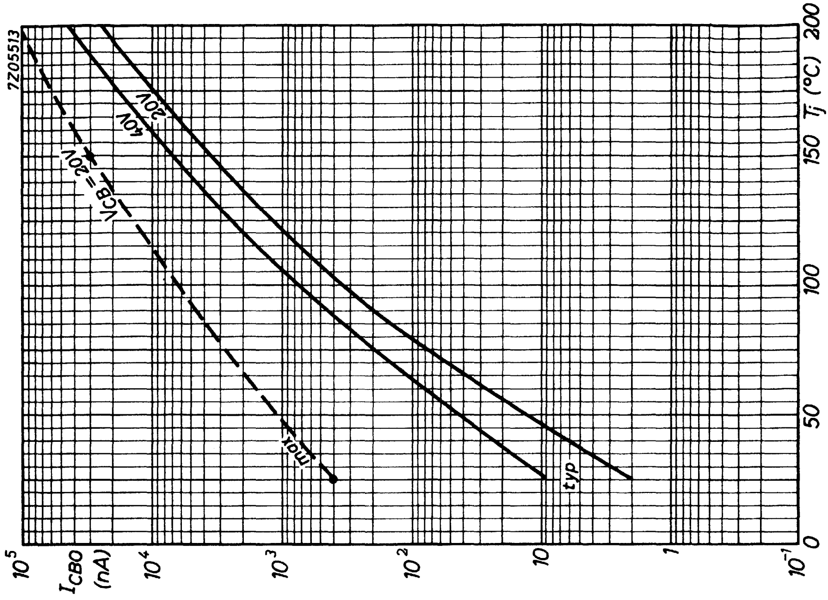
Oscilloscope:

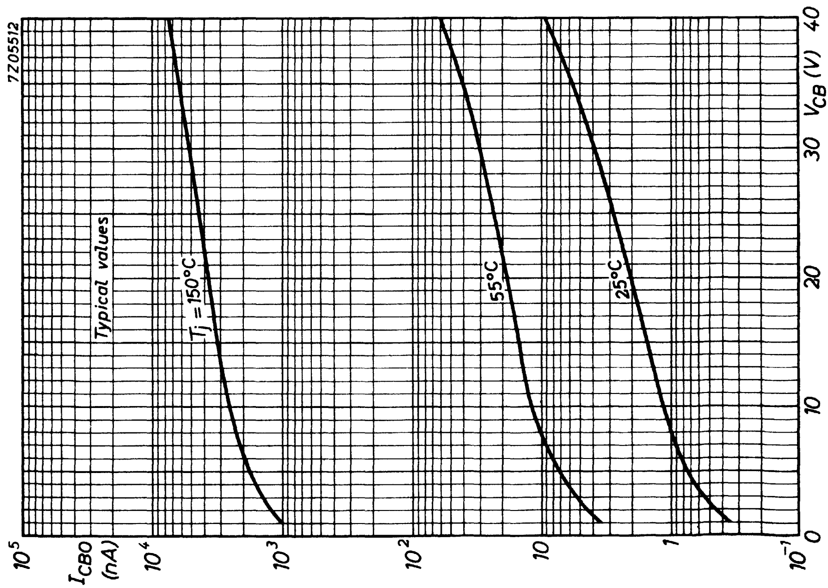
Input impedance	R_i	=	50	Ω
Rise time	t_r	<	1	ns

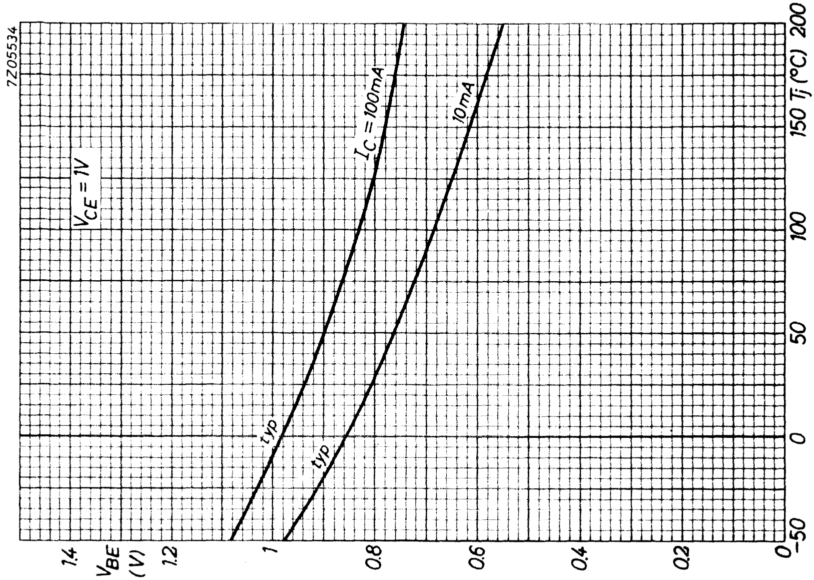
							turn on time			turn off time	
I_C (mA)	I_B (mA)	$-I_{BM}$ (mA)	V_{CC} (V)	R1;R2 (kΩ)	R3 (Ω)	R4 (Ω)	$-V_{BB}$ (V)	$-V_{BE}$ (V)	V_i (V)	V_{BB} (V)	$-V_i$ (V)
10	3	1.5	3	3.3	50	220	3.0	1.5	15	12.0	15
100	40	20	6	0.33	56	0	4.5	2.25	20	15.3	20

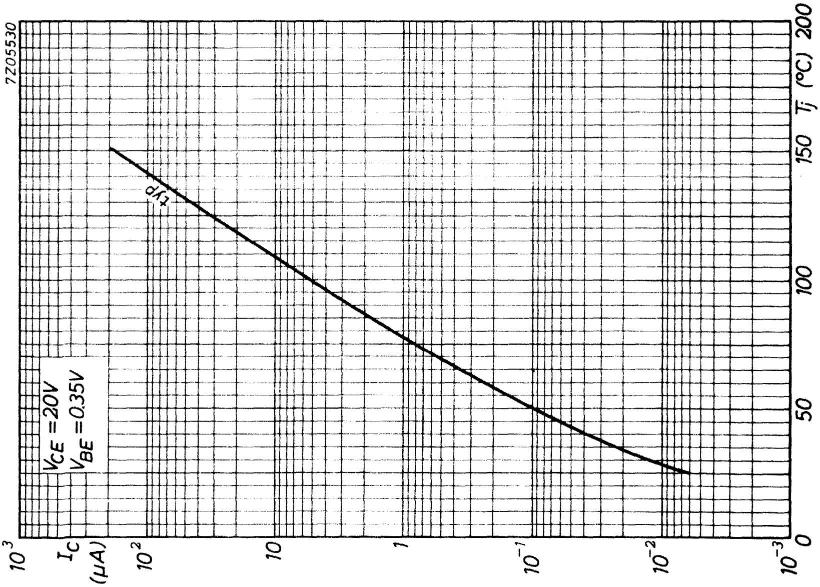
Note

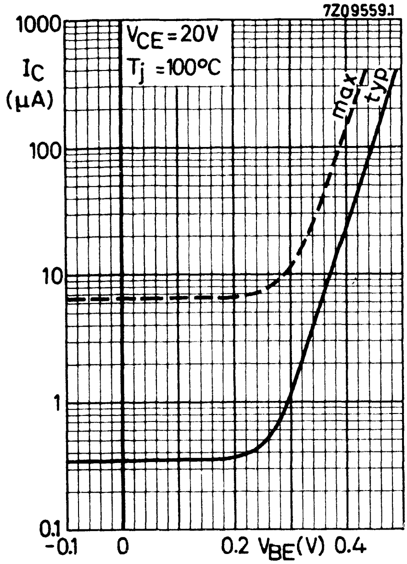
$-I_{BM}$ is the reverse current that can flow during switching off. The indicated $-I_{BM}$ is determined and limited by the applied cut-off voltage and series resistance.

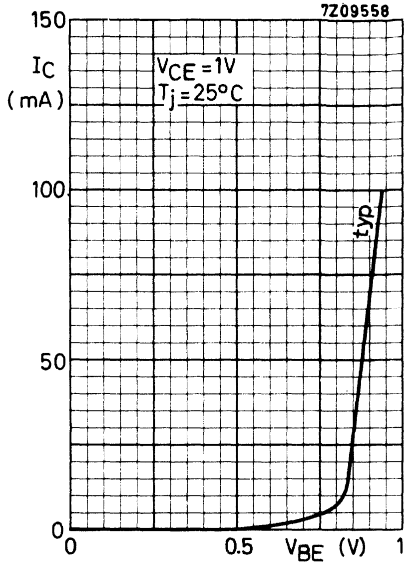

7Z05513
I_{CBO} (nA)
10^5
10^4
10^3
10^2
10
1
10^{-1}
T_j (°C)
0
50
100
150
200
V_{CB} = 20V
40V
20V
max
typ

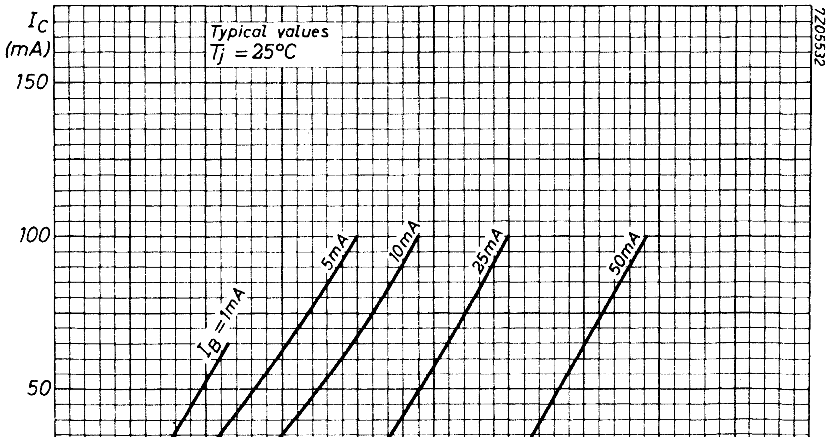

7Z05512
Typical values
I_{CBO} (nA)
10^5
10^4
10^3
10^2
10
1
10^{-1}
V_{CB} (V)
0
10
20
30
40
T_j = 150°C
55°C
25°C

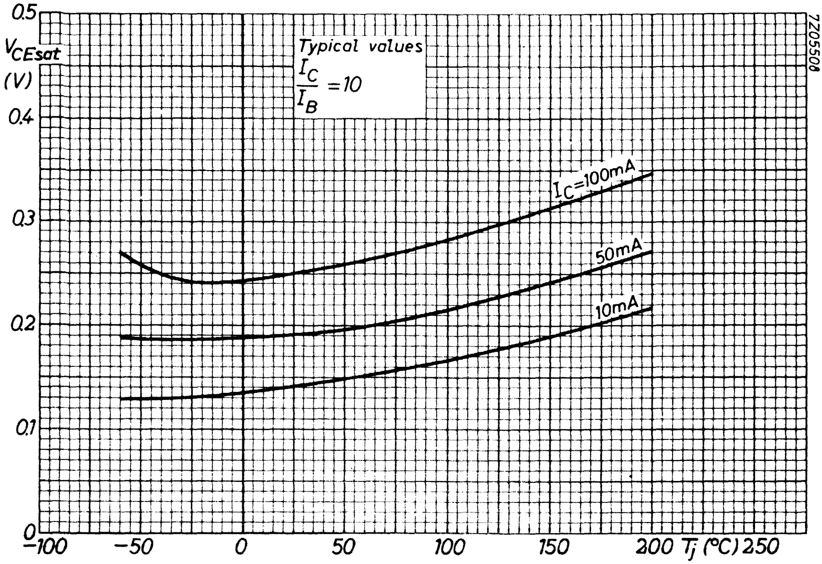

7Z05534
$V_{CE} = 1V$
$I_C = 100mA$
10mA
typ
typ
V_{BE} (V)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
T_j (°C)
−50
0
50
100
150
200

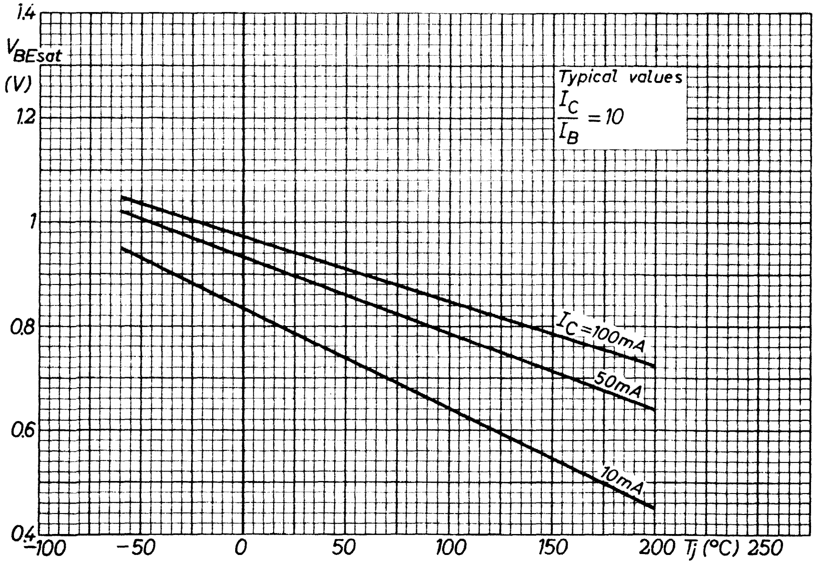

7Z05530
$V_{CE} = 20V$
$V_{BE} = 0.35V$
typ
I_C (μA)
10^3
10^2
10
1
10^{-1}
10^{-2}
10^{-3}
T_j (°C)
0
50
100
150
200

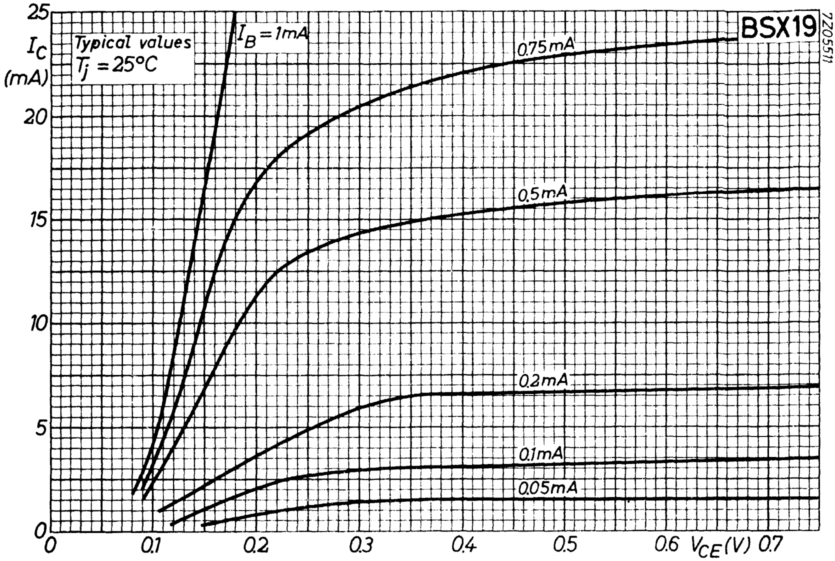

7Z09559.1
1000
I_C
(μA)
100
10
1
0.1
−0.1
0
0.2
V_{BE}(V)
0.4
V_{CE} = 20V
T_j = 100°C
max
typ

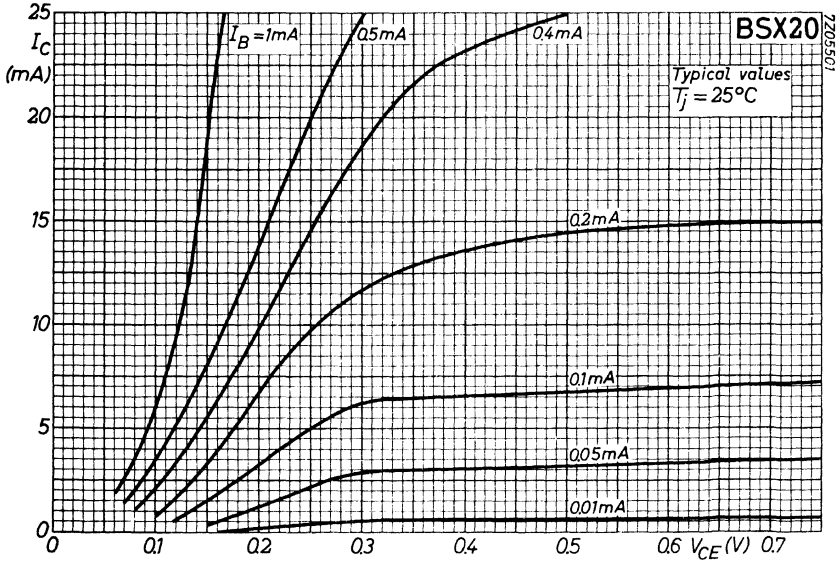

7Z09558
150
I_C
(mA)
100
50
0
0
0.5
V_{BE} (V)
1
V_{CE} = 1V
T_j = 25°C
typ

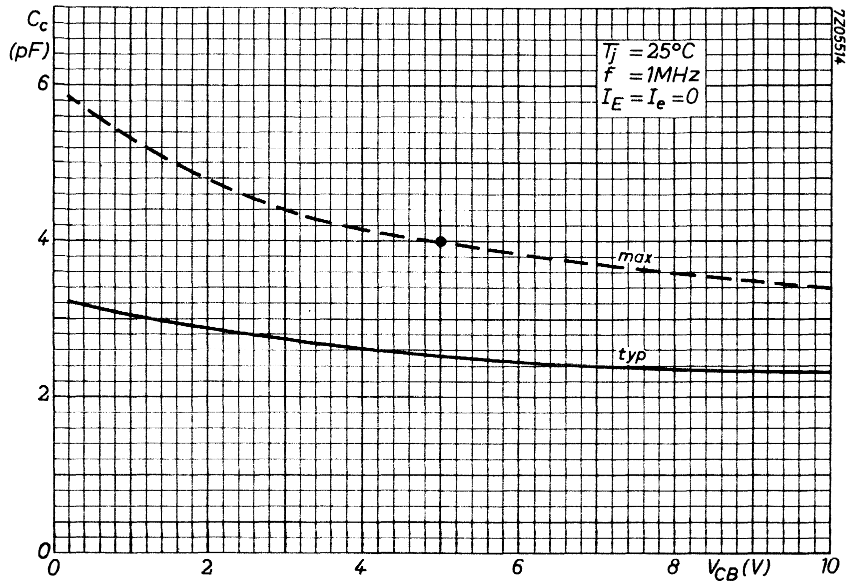

7Z05532
I_C
(mA)
150
100
50
0
0.7
0.8
0.9
1
1.1
V_{BE} (V)
1.2
Typical values
T_j = 25°C
I_B = 1mA
5mA
10mA
25mA
50mA

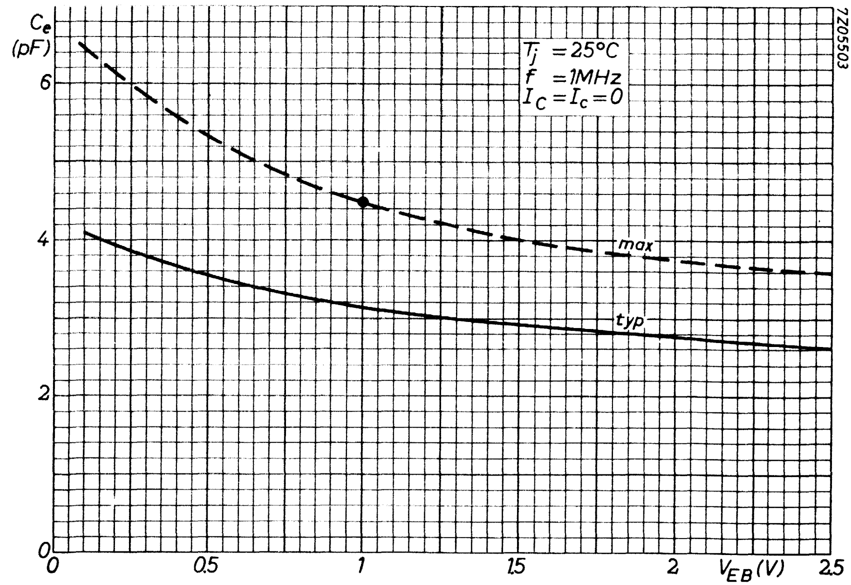

0.5
V_{CEsat}
(V)
0.4
0.3
0.2
0.1
0
Typical values
$\frac{I_C}{I_B} = 10$
I_C=100mA
50mA
10mA
7Z05506
−100
−50
0
50
100
150
200
T_j (°C)
250

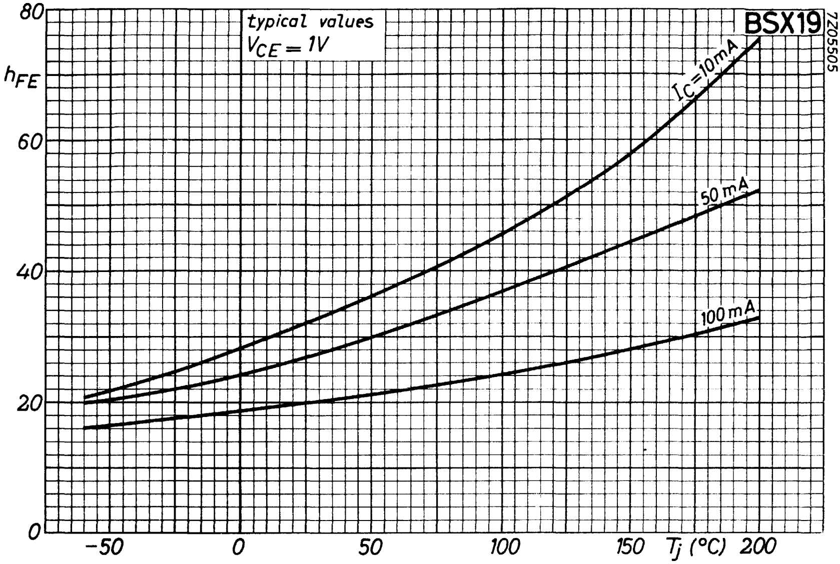

1.4
V_{BEsat}
(V)
1.2
1
0.8
0.6
0.4
Typical values
$\frac{I_C}{I_B} = 10$
I_C=100mA
50mA
10mA
−100
−50
0
50
100
150
200
T_j (°C)
250

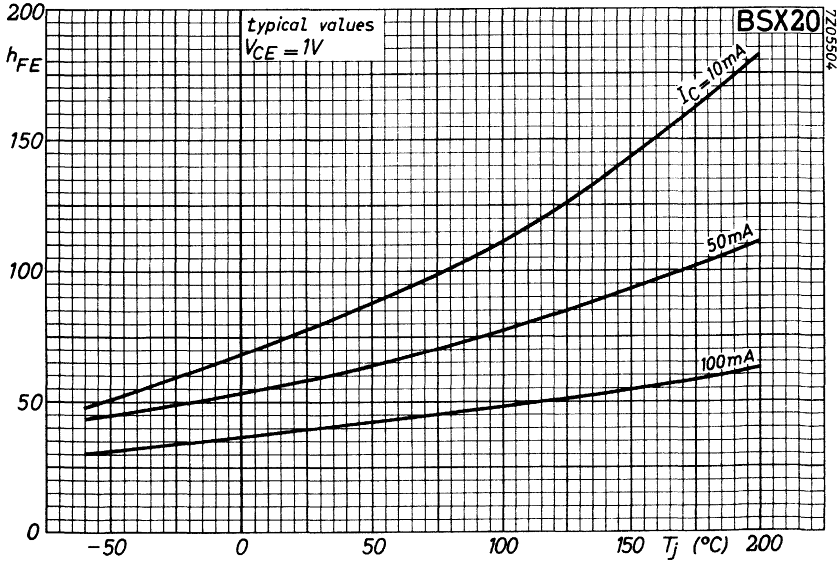

BSX19
7Z05511
Typical values
$T_j = 25°C$
I_C (mA)
$I_B = 1mA$
0.75mA
0.5mA
0.2mA
0.1mA
0.05mA
V_{CE} (V)
0
5
10
15
20
25
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7

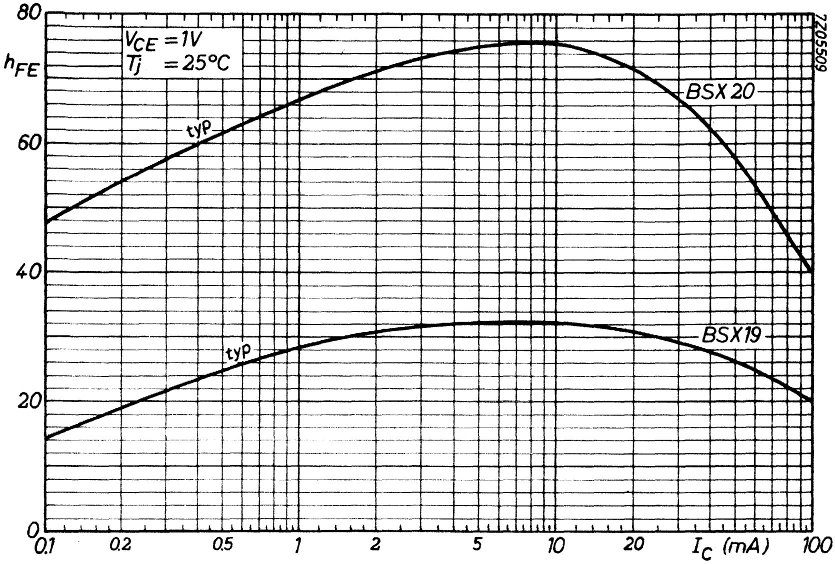

BSX20
7Z05501
Typical values
$T_j = 25°C$
I_C (mA)
$I_B = 1mA$
0.5mA
0.4mA
0.2mA
0.1mA
0.05mA
0.01mA
V_{CE} (V)
0
5
10
15
20
25
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7

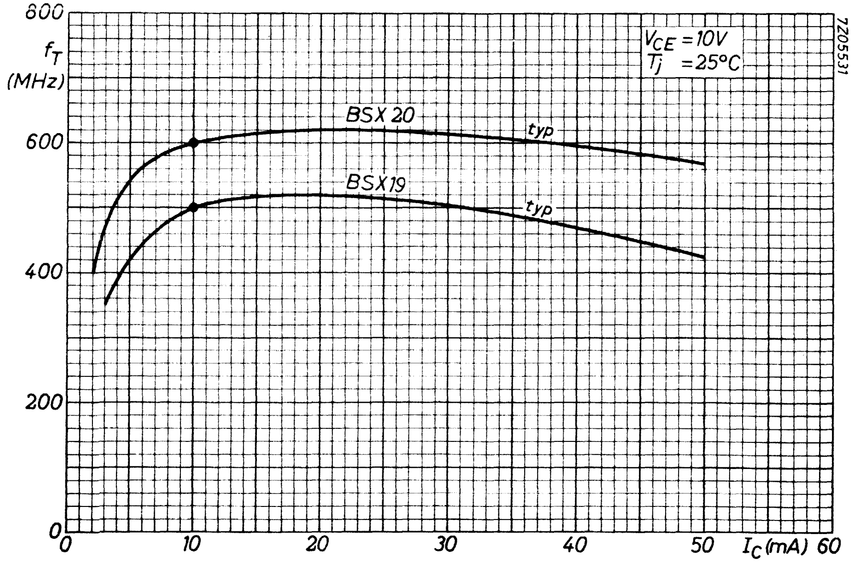

C_c
(pF)
6
4
2
0
0
2
4
6
8
10
V_{CB} (V)
T_j = 25°C
f = 1MHz
$I_E = I_e = 0$
max
typ
7Z05514

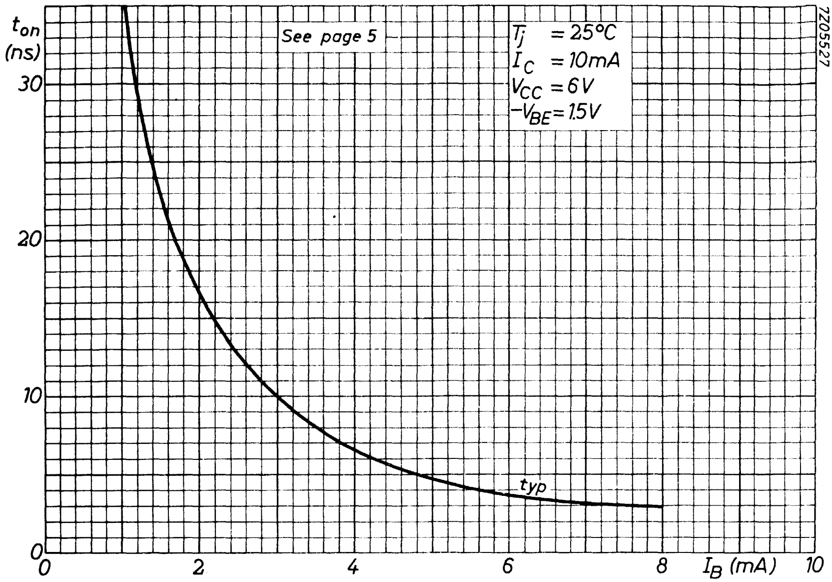

C_e
(pF)
6
4
2
0
0
0.5
1
1.5
2
2.5
V_{EB} (V)
T_j = 25°C
f = 1MHz
$I_C = I_c = 0$
max
typ
7Z05503

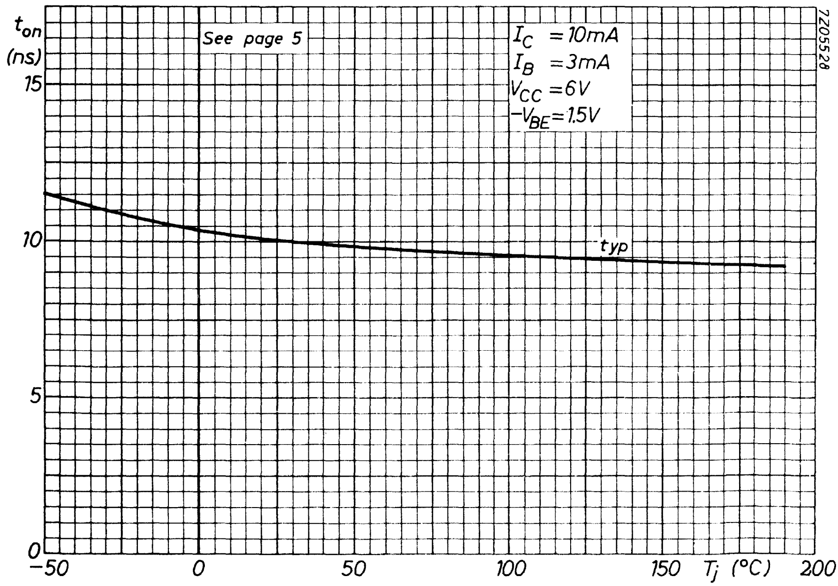

typical values
$V_{CE} = 1V$
BSX19
7Z05505
h_{FE}
80
60
40
20
0
$I_C = 10mA$
50 mA
100 mA
−50
0
50
100
150
T_j (°C)
200

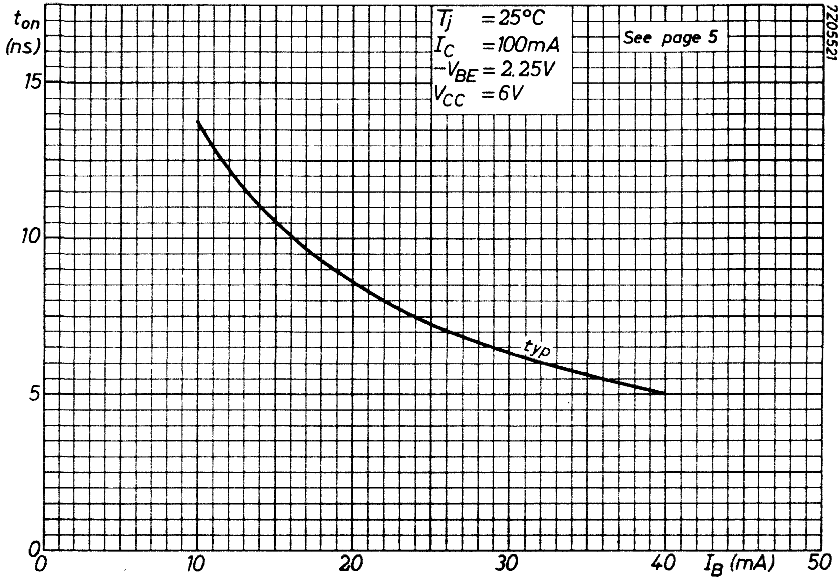

typical values
$V_{CE} = 1V$
BSX20
7Z05504
h_{FE}
200
150
100
50
0
$I_C = 10mA$
50mA
100mA
−50
0
50
100
150
T_j (°C)
200

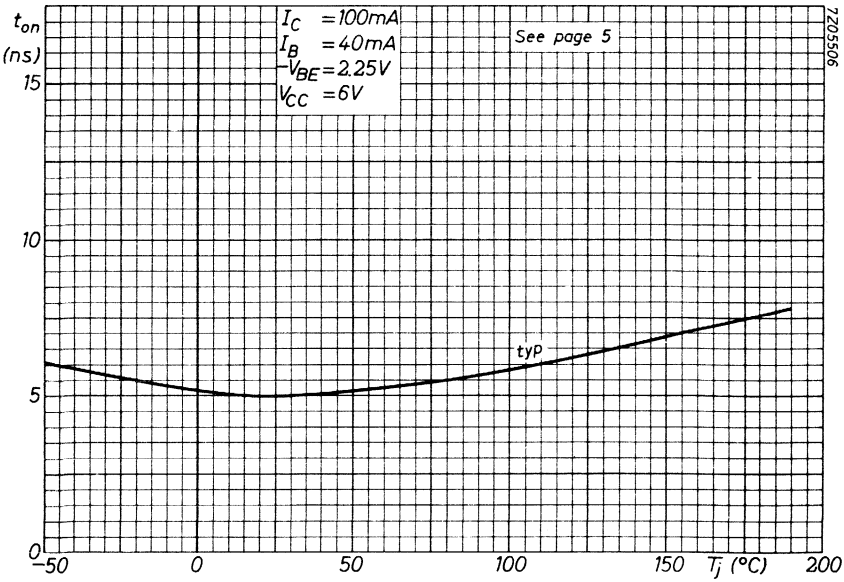

80
60
40
20
0
h_{FE}
V_{CE} = 1V
T_j = 25°C
typ
typ
BSX 20
BSX19
7Z05509
0.1
0.2
0.5
1
2
5
10
20
100
I_C (mA)

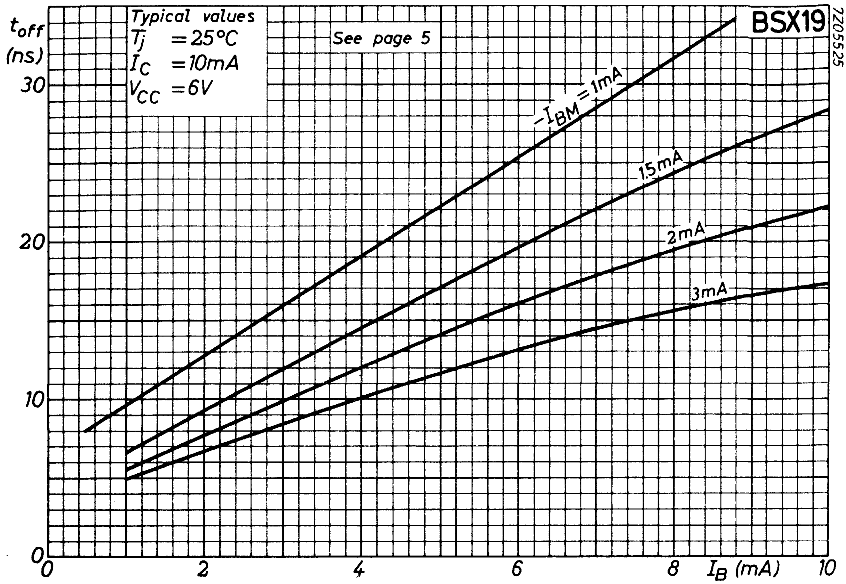

800
600
400
200
0
f_T
(MHz)
V_{CE} = 10V
T_j = 25°C
7Z05531
BSX 20
BSX19
typ
typ
0
10
20
30
40
50
60
I_C (mA)

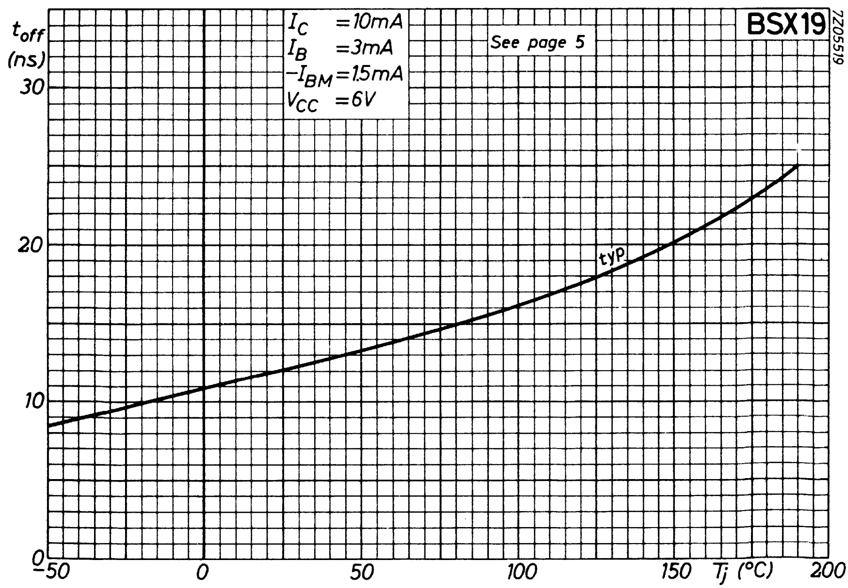

t_{on}
(ns)
30
20
10
0
See page 5
T_j = 25°C
I_C = 10mA
V_{CC} = 6V
$-V_{BE}$ = 1.5V
typ
0
2
4
6
8
I_B (mA)
10
7Z05527

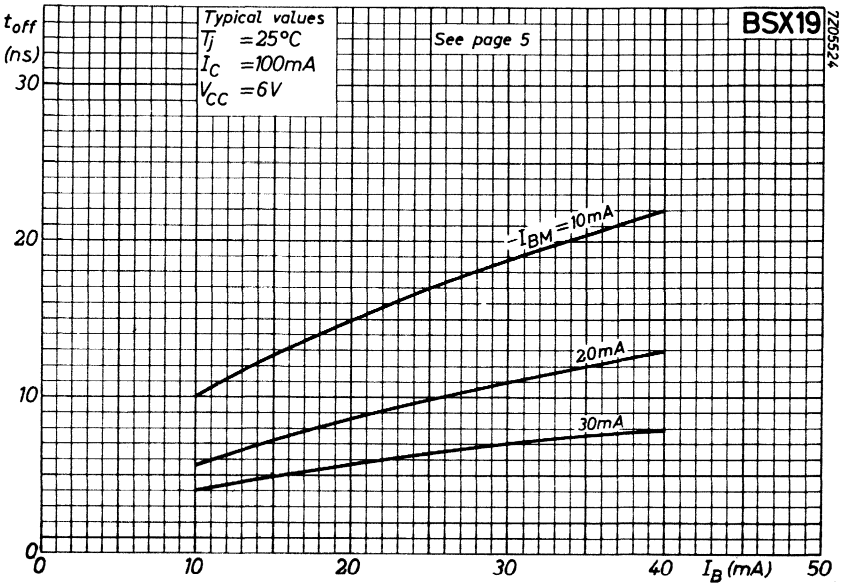

t_{on}
(ns)
15
10
5
0
See page 5
I_C = 10mA
I_B = 3mA
V_{CC} = 6V
$-V_{BE}$ = 1.5V
typ
−50
0
50
100
150
T_j (°C)
200
7Z05528

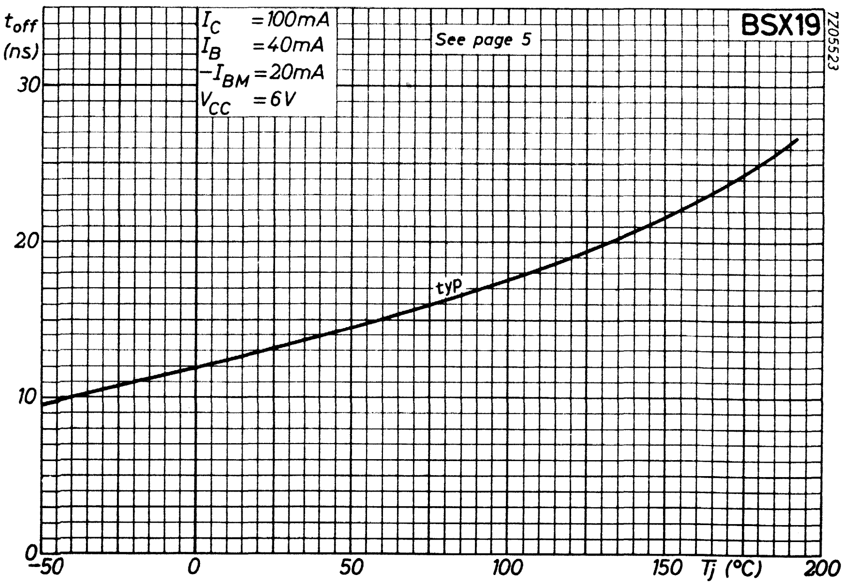

t_{on} (ns)
T_j = 25°C
I_C = 100mA
$-V_{BE}$ = 2.25V
V_{CC} = 6V
See page 5
7Z05521
typ
I_B (mA)
0
10
20
30
40
50
5
15

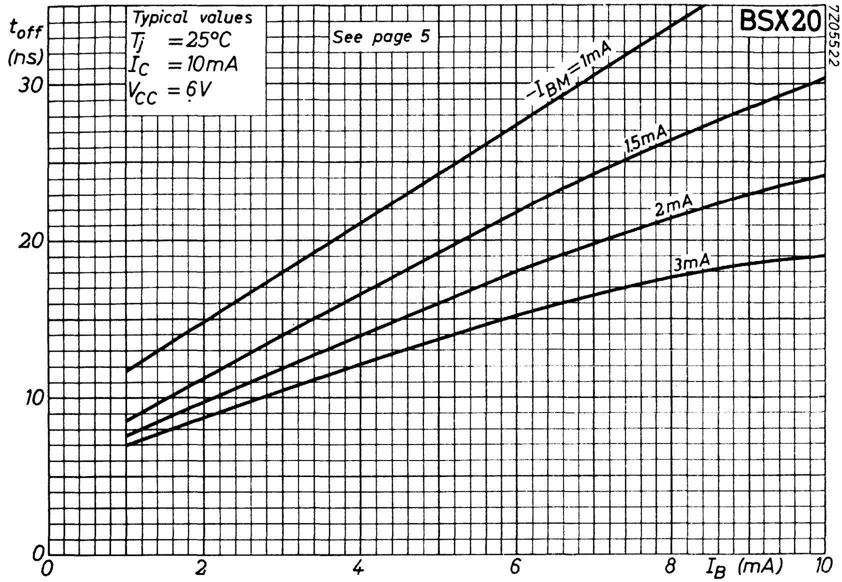

t_{on} (ns)
I_C = 100mA
I_B = 40mA
$-V_{BE}$ = 2.25V
V_{CC} = 6V
See page 5
7Z05506
typ
T_j (°C)
−50
0
50
100
150
200
5
10
15

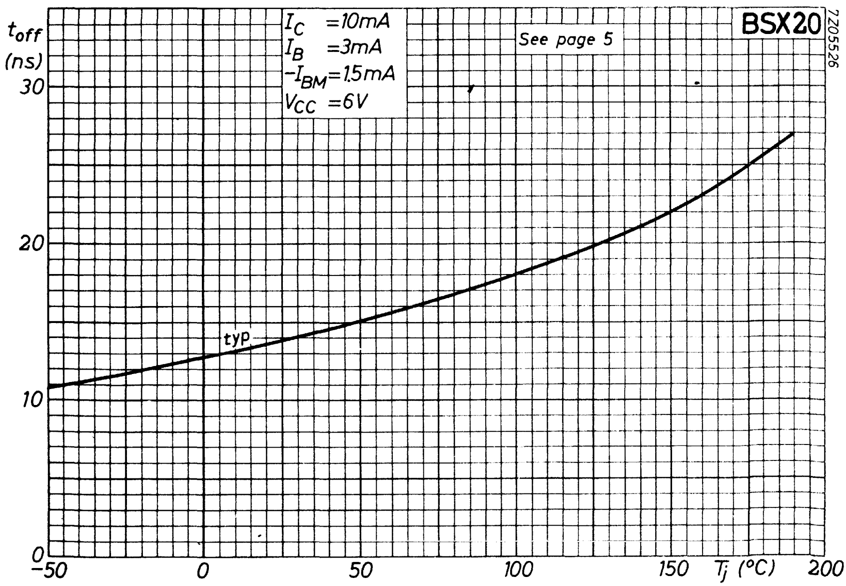

Typical values
T_j = 25°C
I_C = 10mA
V_{CC} = 6V
See page 5
BSX19
7Z05525
t_{off} (ns)
$-I_{BM}$ = 1mA
1.5mA
2mA
3mA
I_B (mA)

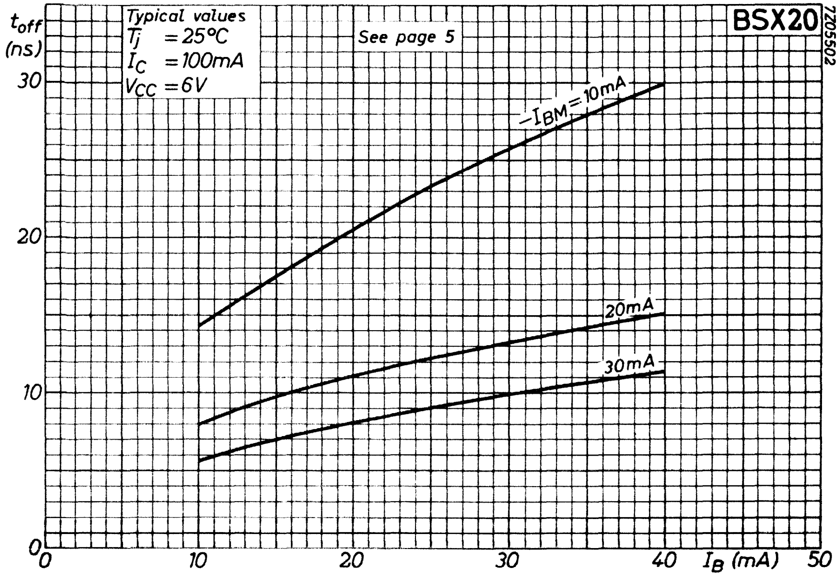

I_C = 10mA
I_B = 3mA
$-I_{BM}$ = 1.5mA
V_{CC} = 6V
See page 5
BSX19
7Z05519
t_{off} (ns)
typ
T_j (°C)

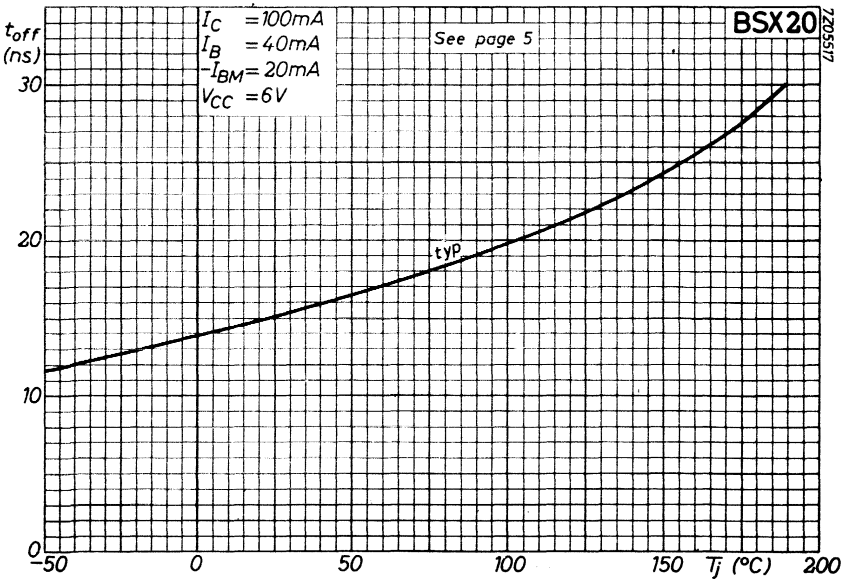

t_{off} (ns)
Typical values
T_j = 25°C
I_C = 100mA
V_{CC} = 6V
See page 5
BSX19
7Z05524
$-I_{BM}$ = 10mA
20mA
30mA
0
10
20
30
0
10
20
30
40
50
I_B (mA)

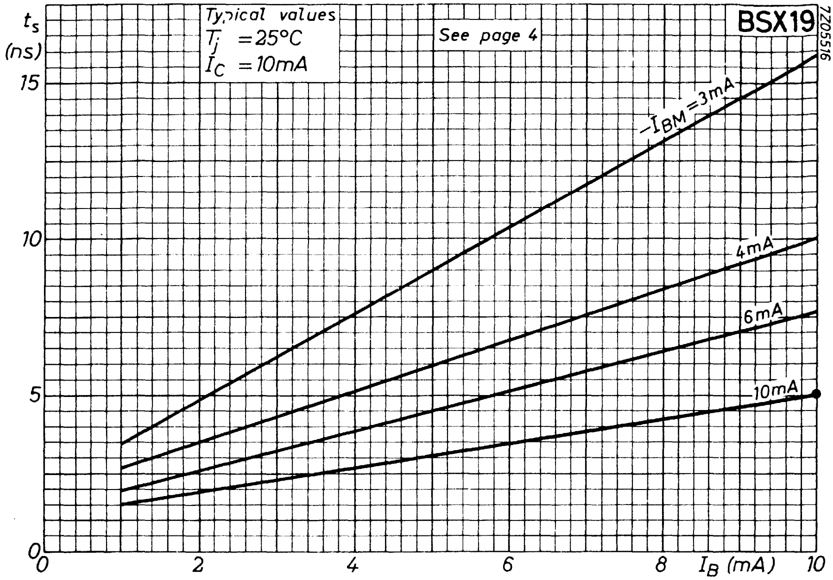

t_{off} (ns)
I_C = 100mA
I_B = 40mA
$-I_{BM}$ = 20mA
V_{CC} = 6V
See page 5
BSX19
7Z05523
typ
0
10
20
30
−50
0
50
100
150
200
T_j (°C)

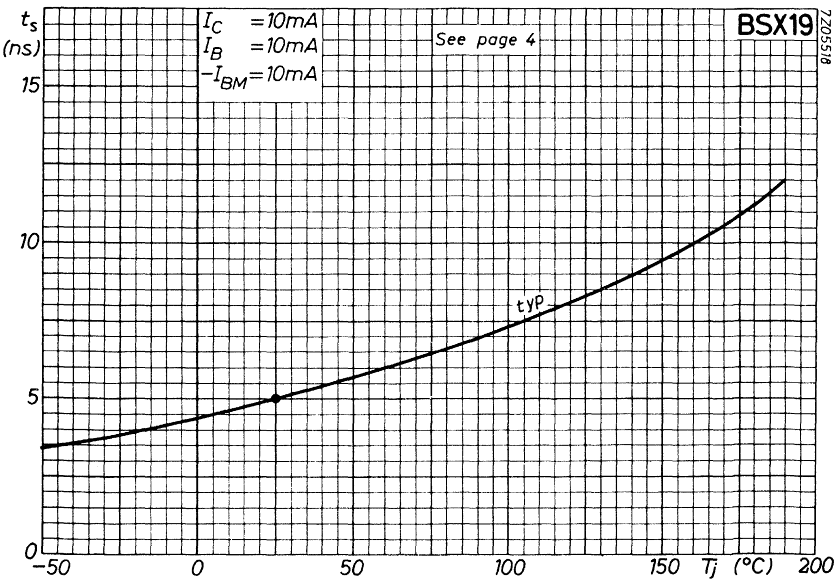

Typical values
T_j = 25°C
I_C = 10mA
V_{CC} = 6V
See page 5
BSX20
7Z05522
t_{off} (ns)
$-I_{BM}$=1mA
1.5mA
2mA
3mA
I_B (mA)
0
2
4
6
8
10
10
20
30

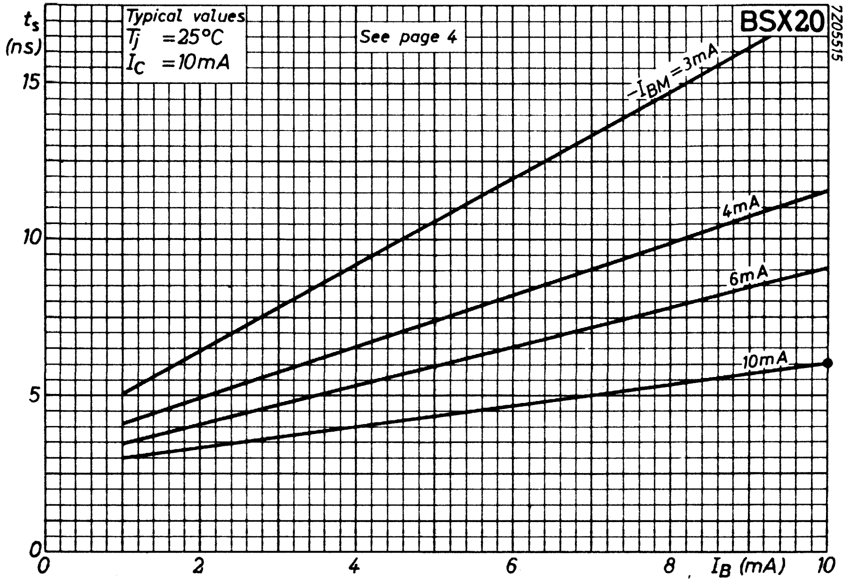

I_C = 10mA
I_B = 3mA
$-I_{BM}$=1.5mA
V_{CC} = 6V
See page 5
BSX20
7Z05526
t_{off} (ns)
typ
T_j (°C)
−50
0
50
100
150
200
10
20
30

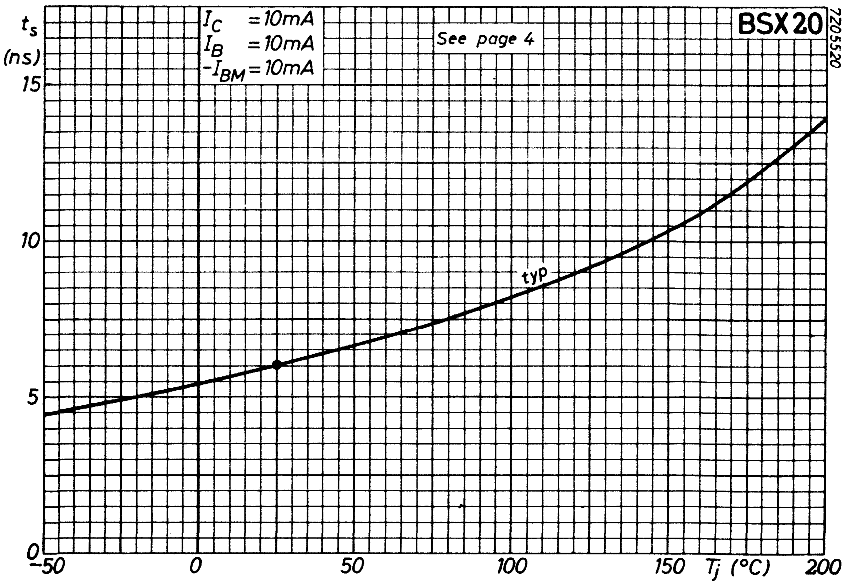

t_{off} (ns)
Typical values
T_j = 25°C
I_C = 100mA
V_{CC} = 6V
See page 5
BSX20
7205502
$-I_{BM}$ = 10mA
20mA
30mA
0
10
20
30
0
10
20
30
40
I_B (mA)
50


t_{off} (ns)
I_C = 100mA
I_B = 40mA
$-I_{BM}$ = 20mA
V_{CC} = 6V
See page 5
BSX20
7205517
typ
0
10
20
30
−50
0
50
100
150
T_j (°C)
200


t_s (ns)
Typical values
T_j = 25°C
I_C = 10mA
See page 4
BSX19
7Z05516
$-I_{BM}$=3mA
4mA
6mA
10mA
I_B (mA)
0
2
4
6
8
10
5
10
15

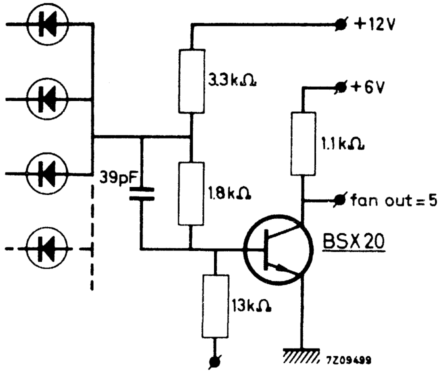

t_s (ns)
I_C = 10mA
I_B = 10mA
$-I_{BM}$= 10mA
See page 4
BSX19
7Z05518
typ
T_j (°C)
−50
0
50
100
150
200
5
10
15


t_s (ns)
Typical values
T_j = 25°C
I_C = 10mA
See page 4
BSX20
7Z05515
$-I_{BM}$ = 3mA
4mA
6mA
10mA
15
10
5
0
0
2
4
6
8
I_B (mA)
10


t_s (ns)
I_C = 10mA
I_B = 10mA
$-I_{BM}$ = 10mA
See page 4
BSX20
7Z05520
typ
15
10
5
0
−50
0
50
100
150
T_j (°C)
200

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

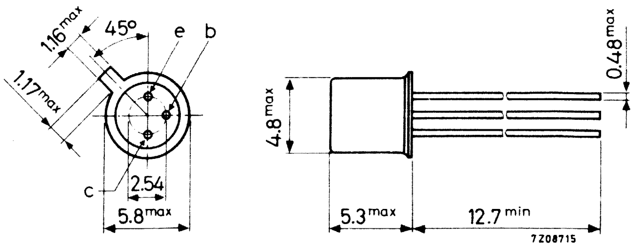
NOTE: The BSX21 may be operated in the breakdown region up to V_{CE} = 160 V, provided P_{tot} at T_{amb} = 85 °C does not exceed 100 mW.

MECHANICAL DATA

Dimensions in mm

Collector connected to case

TO-18



Accessories available: 56246, 56263

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

Collector-base voltage (open emitter) I_C = 100 μA	V_{CBO}	max.	120	V [1]
Collector-emitter voltage (open base) I_C = 4 mA	V_{CEO}	max.	80	V [1]
Emitter-base boltage (open collector) I_E = 100 μA	V_{EBO}	max.	5	V

Currents

Collector current (d.c. or average over any 20 ms period)	I_C	max.	100	mA
Collector current (peak value)	I_{CM}	max.	250	mA [2]
Emitter current (d.c. or average over any 20 ms period)	$-I_E$	max.	100	mA
Emitter current (peak value)	$-I_{EM}$	max.	250	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	mW

Temperatures

Storage temperature	T_{stg}		-65 to +175	°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.5	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0.15	°C/mW

[1] The BSX21 may be operated in the breakdown region up to V_{CE} = 160 V, provided P_{tot} at T_{amb} = 85 °C does not exceed 100 mW.

[2] The transistor can withstand a capacitive load of 500 pF, combined with a collector-base voltage of max. 150 V before switching on.

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $V_{CB} = 90$ V	I_{CBO}	typ.	1	nA
		<	200	nA
$I_E = 0$; $V_{CB} = 90$ V; $T_j = 150$ °C	I_{CBO}	typ.	0.25	μA
		<	50	μA
$V_{BE} = 0$; $V_{CE} = 80$ V; $T_j = 85$ °C	I_{CES}	typ.	0.01	μA
		<	20	μA

Emitter cut-off current

$I_C = 0$; $V_{EB} = 4$ V	I_{EBO}	typ.	0.5	nA
		<	200	nA
$I_C = 0$; $V_{EB} = 4$ V; $T_j = 150$ °C	I_{EBO}	typ.	0.05	μA
		<	50	μA

Saturation voltages

$I_C = 4$ mA; $I_B = 400$ μA	V_{CEsat}	<	0.7	V
	V_{BEsat}	<	1.2	V

D.C. current gain

$I_C = 1$ mA; $V_{CE} = 1$ V	h_{FE}	typ.	60
$I_C = 4$ mA; $V_{CE} = 1$ V	h_{FE}	>	20
		typ.	80
$I_C = 10$ mA; $V_{CE} = 1$ V	h_{FE}	typ.	82
$I_C = 20$ mA; $V_{CE} = 1$ V	h_{FE}	typ.	55

Collector capacitance at f = 1 MHz

$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	3.4	pF
		<	4.5	pF

Emitter capacitance at f = 1 MHz

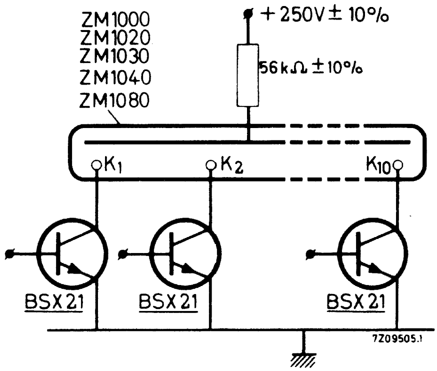
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	typ.	12	pF
		<	17	pF

Transition frequency at f = 35 MHz

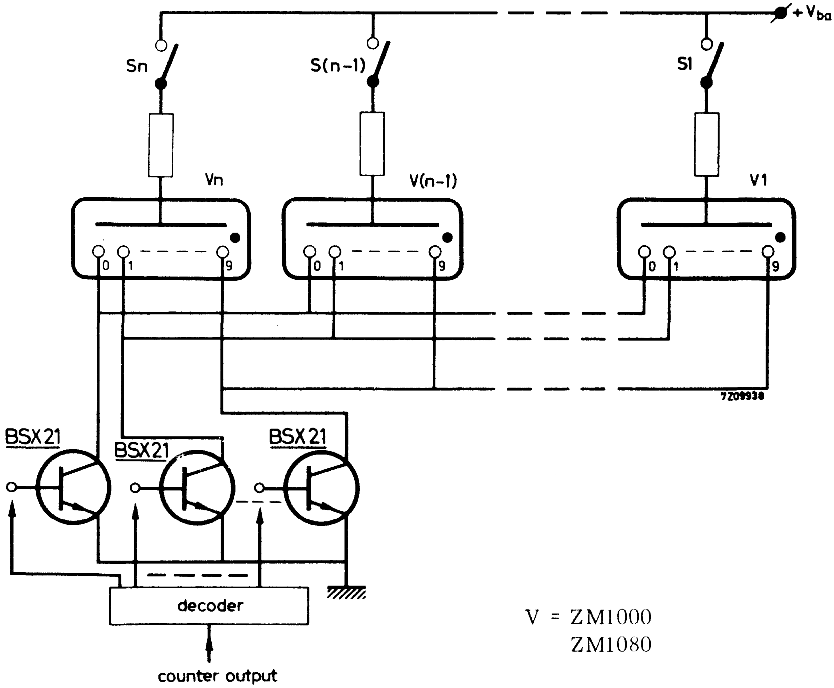
$I_C = 4$ mA; $V_{CE} = 10$ V	f_T	>	60	MHz
		typ.	160	MHz

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Practical circuit for static operation

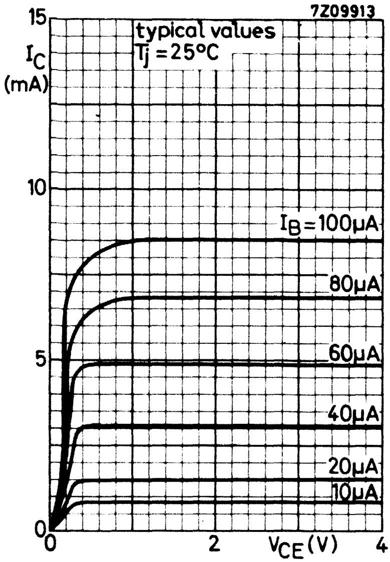


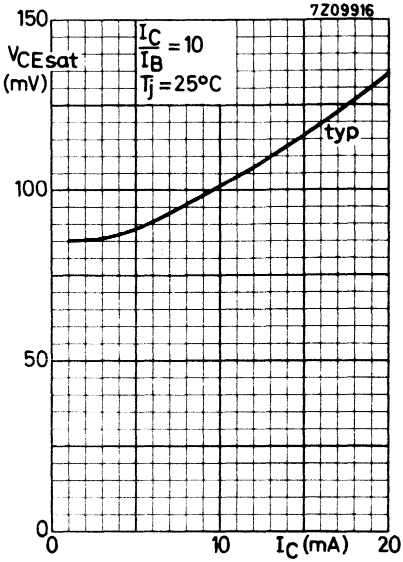
Practical circuit for dynamic operation

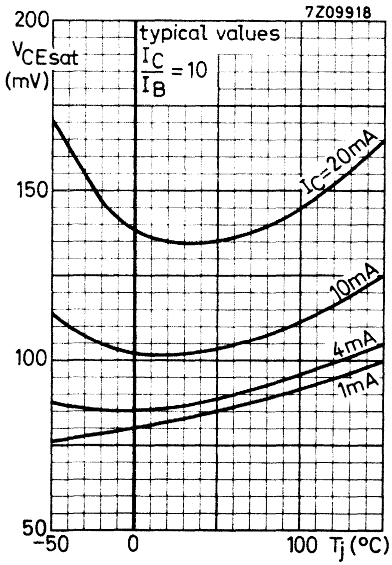


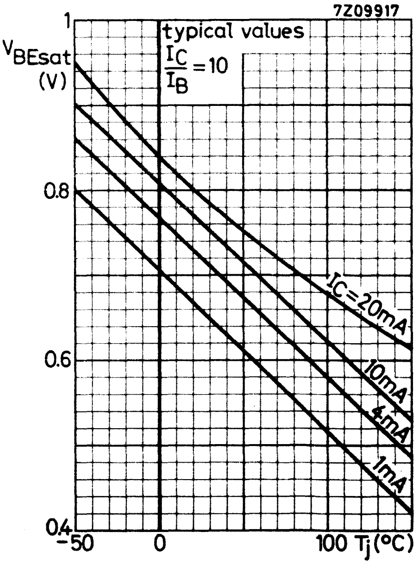
V = ZM1000
ZM1080

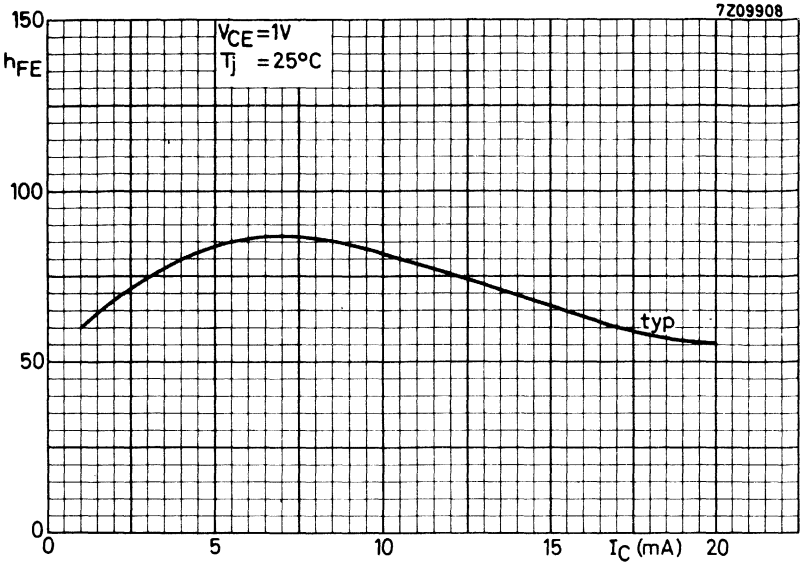
APPLICATION INFORMATION bulletins available on request

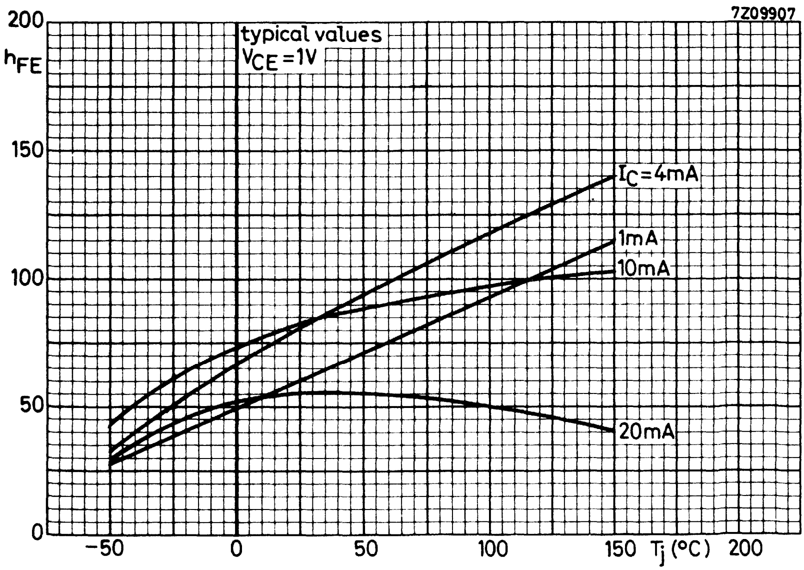

7Z09913
typical values
$T_j = 25°C$
I_C (mA)
15
10
5
0
$I_B = 100\mu A$
80μA
60μA
40μA
20μA
10μA
0
2
V_{CE} (V)
4

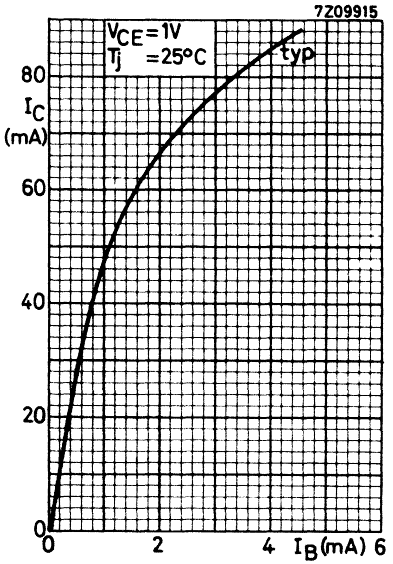

7Z09916
$\frac{I_C}{I_B} = 10$
$T_j = 25°C$
V_{CEsat} (mV)
150
100
50
0
typ
0
10
I_C (mA)
20

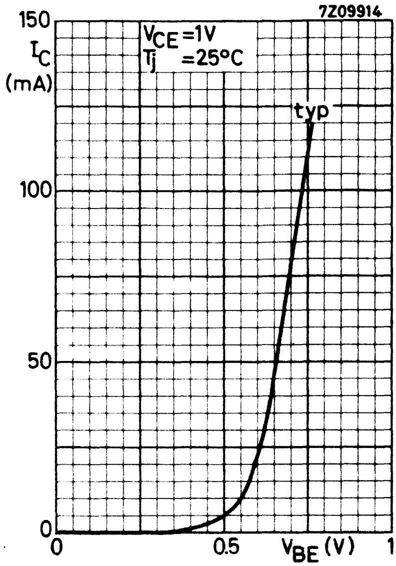

7Z09918
typical values
$\frac{I_C}{I_B} = 10$
V_{CEsat} (mV)
200
150
100
50
$I_C = 20mA$
10mA
4mA
1mA
−50
0
100
T_j (°C)

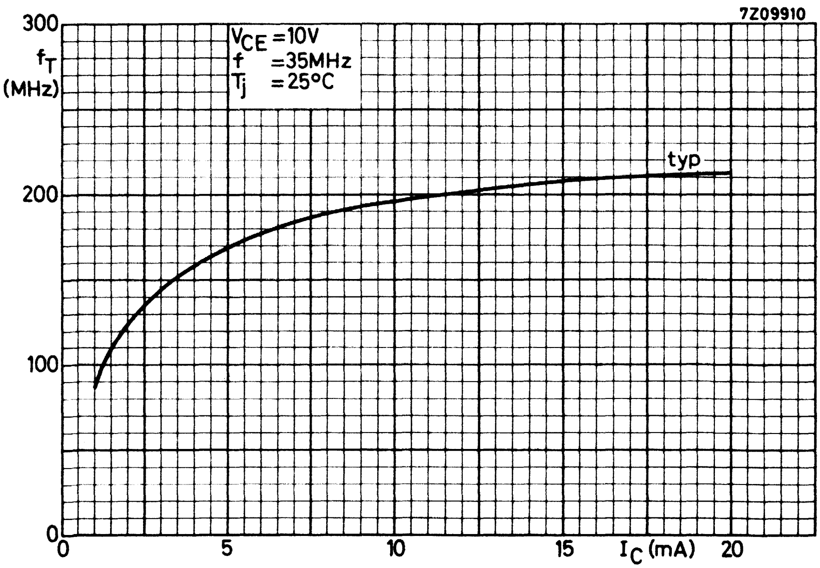

7Z09917
typical values
$\frac{I_C}{I_B} = 10$
V_{BEsat} (V)
1
0.8
0.6
0.4
$I_C = 20mA$
10mA
4mA
1mA
−50
0
100
T_j (°C)

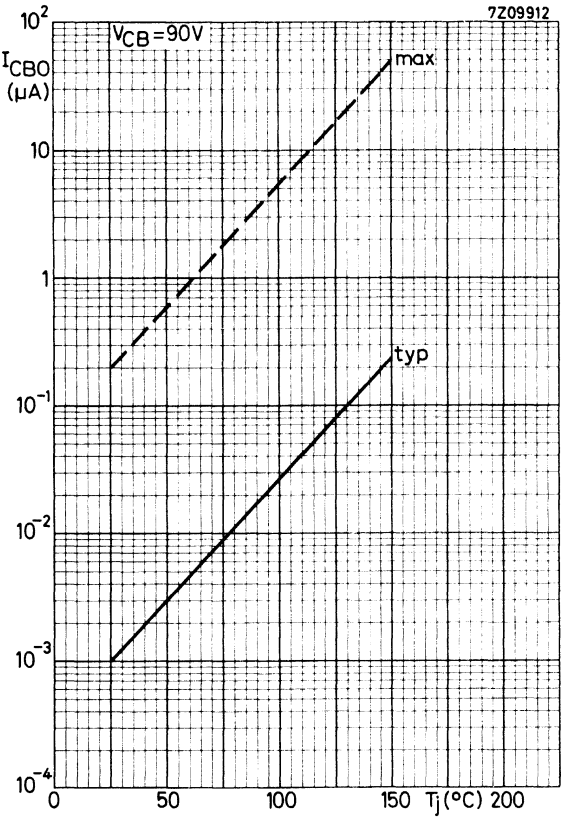

7Z09908
150
hFE
VCE=1V
Tj =25°C
100
50
0
typ
0
5
10
15
IC (mA)
20


7Z09907
200
hFE
typical values
VCE=1V
150
100
50
0
IC=4mA
1mA
10mA
20mA
−50
0
50
100
150
Tj (°C)
200

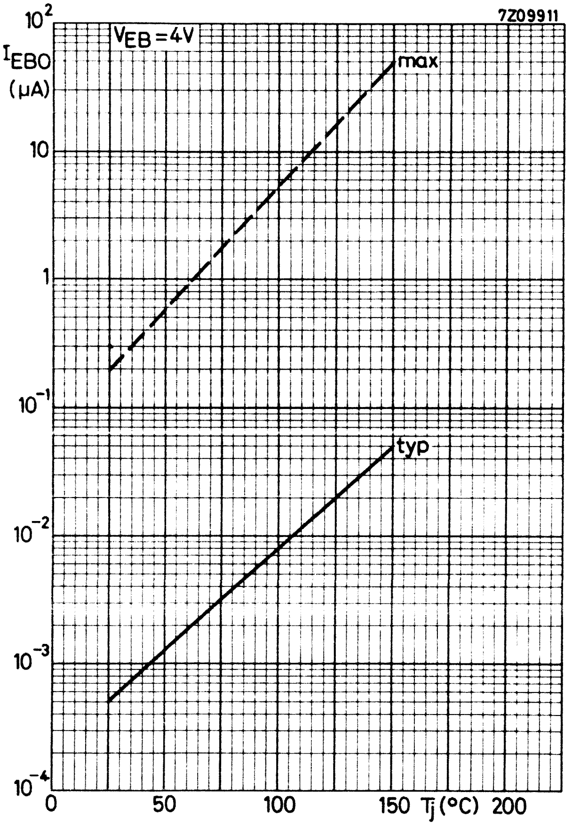

7Z09915
V_{CE} = 1V
T_j = 25°C
typ
I_C (mA)
80
60
40
20
0
0
2
4
I_B (mA)
6

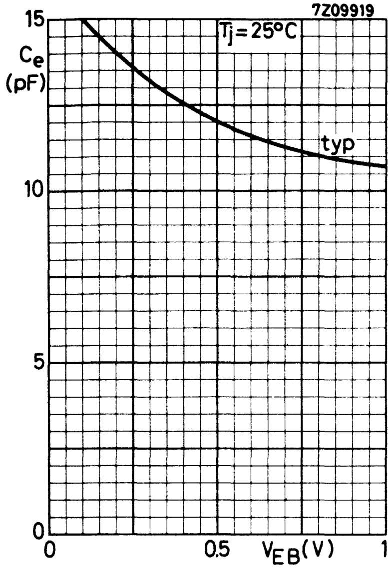

7Z09914
V_{CE} = 1V
T_j = 25°C
typ
150
I_C (mA)
100
50
0
0
0.5
V_{BE} (V)
1

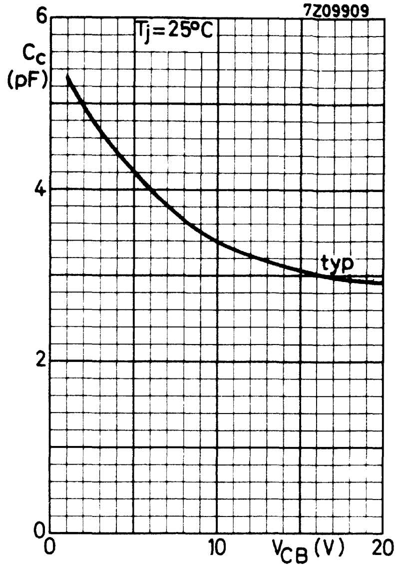

7Z09910
V_{CE} = 10V
f = 35MHz
T_j = 25°C
typ
300
f_T (MHz)
200
100
0
0
5
10
15
I_C (mA)
20



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
C_e
(pF)
10
5
0
0
0.5
V_{EB} (V)
1
$T_j = 25°C$
typ


7Z09909
6
C_c
(pF)
4
2
0
0
10
V_{CB} (V)
20
$T_j = 25°C$
typ

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a TO-39 metal envelope with the collector connected to the case. The BSX59, BSX60 and BSX61 are primarily intended for very high speed core-driving purposes.

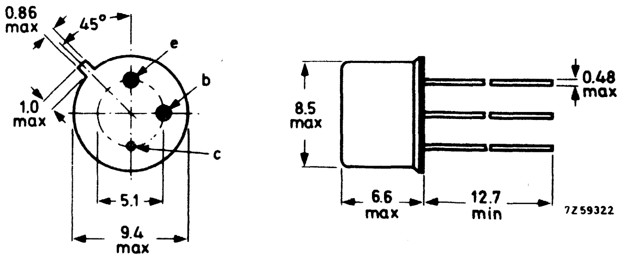
QUICK REFERENCE DATA

			BSX59	BSX60	BSX61	
Collector-base voltage (open emitter)	V_{CBO}	max.	70	70	70	V
Collector-emitter voltage (open base)	V_{CEO}	max.	45	30	45	V
Collector current (peak value)	I_{CM}	max.	1	1	1	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.8	0.8	0.8	W
Junction temperature	T_j	max.	200	200	200	°C
D.C. current gain I_C = 500 mA; V_{CE} = 1 V	h_{FE}	>	30	30	30	
Saturation voltage I_C = 500 mA; I_B = 50 mA	V_{CEsat}	<	0.5	0.5	0.7	V
Transition frequency I_C = 50 mA; V_{CE} = 10 V	f_T	typ.	450	475	475	MHz
Turn off time I_C = 500 mA; I_B = 50 mA	t_{off}	<	60	70	100	ns

MECHANICAL DATA

Dimensions in mm

Collector connected to case.
TO-39



max. lead diameter is guaranteed only for 12.7 mm

Accessories available: 56218; 56245; 56265.

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	$R_{th\ j-a}$	=	220	°C/W
From junction to case	$R_{th\ j-c}$	=	43	°C/W
From junction to mounting base	$R_{th\ j-mb}$	=	35	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

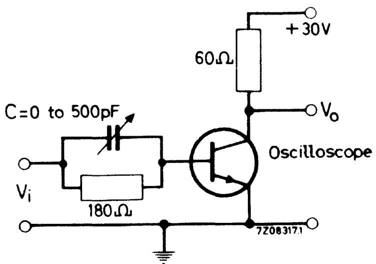
			BSX59	BSX60	BSX61	
Collector cut-off current						
$I_E = 0$; $V_{CB} = 40$ V	I_{CBO}	<	500	500	500	nA
$I_E = 0$; $V_{CB} = 40$ V; $T_j = 150$ °C	I_{CBO}	<	300	300	300	μA
Emitter cut-off current						
$I_C = 0$; $V_{EB} = 4$ V	I_{EBO}	<	300	300	500	nA
$I_C = 0$; $V_{EB} = 4$ V; $T_j = 150$ °C	I_{EBO}	<	50	50	50	μA
Currents at reverse biased emitter junction						
$-V_{BE} = 4$ V; $V_{CE} = 40$ V	$+I_{CEX}$	<	500	500	1000	nA
	$-I_{BEX}$	<	500	500	1000	nA
$-V_{BE} = 4$ V; $V_{CE} = 40$ V; $T_j = 150$ °C	$+I_{CEX}$	<	300	300	500	μA
	$-I_{BEX}$	<	300	300	500	μA
Saturation voltages						
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0.3	0.3	0.5	V
	V_{BEsat}	<	1.0	1.0	1.0	V
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	0.5	0.5	0.7	V
	V_{BEsat}	>	0.85	0.7	0.7	V
		<	1.2	1.3	1.3	V
$I_C = 1$ A; $I_B = 100$ mA	V_{CEsat}	<	1.0	1.0	1.3	V
	V_{BEsat}	<	1.8	1.8	1.8	V
D.C. current gain						
$I_C = 150$ mA; $V_{CE} = 1$ V	h_{FE}	>	30	30	30	
		typ.	70	90	105	
$I_C = 500$ mA; $V_{CE} = 1$ V	h_{FE}	>	30	30	30	
		<	90	90	90	
$I_C = 1$ A; $V_{CE} = 5$ V	h_{FE}	>	20	25	20	
		typ.	40	50	55	
Transition frequency						
$I_C = 50$ mA; $V_{CE} = 10$ V	f_T	>	250	250	250	MHz
		typ.	450	475	475	MHz
Collector capacitance at f = 1 MHz						
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	typ.	6	6	6	pF
		<	10	10	10	pF
Emitter capacitance at f = 1 MHz						
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	typ.	36	36	36	pF
		<	50	50	50	pF

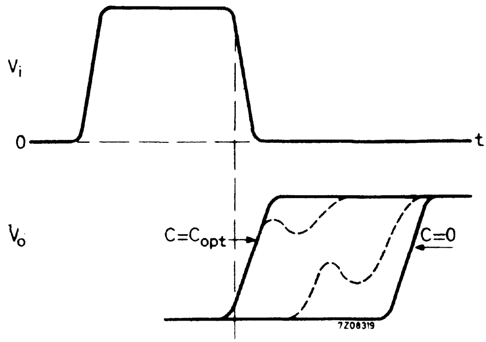
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Recovered charge

I_C = 500 mA; I_B = 50 mA | BSX60 | Q_s < 5 nC

Test circuit:





Adjust C from zero to C_{opt}

$Q_s = C_{opt} \cdot V_i$

Pulse generator:

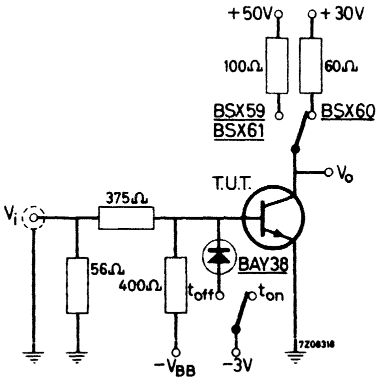
Pulse duration	t_p =	10 μs
Duty cycle	δ =	0.02

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Switching times (see also page 10)

			BSX59	BSX60	BSX61	
Turn on time when switched from $-V_{BE}$ = 2 V to I_C = 500 mA; I_B = 50 mA	t_{on}	typ.	17	17	18	ns
		<	35	40	50	ns
Turn off time when switched from I_C = 500 mA; I_B = 50 mA to cut-off with $-I_{BM}$ = 50 mA [1])	t_{off}	typ.	45	58	70	ns
		<	60	70	100	ns

Test circuit:



	t_{on}	t_{off}	
V_{BB}	4	16.7	V
V_i	24.75	37.5	V

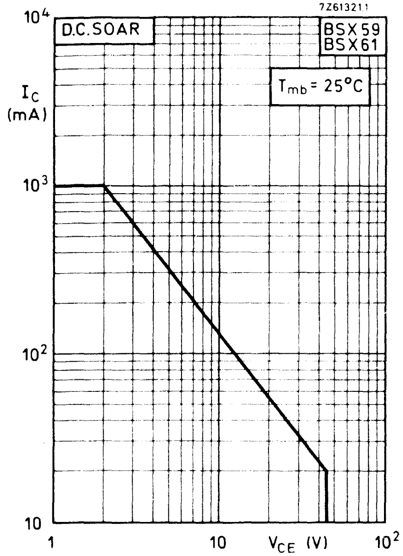
Pulse generator: Pulse duration t_p $\geq$ 500 ns

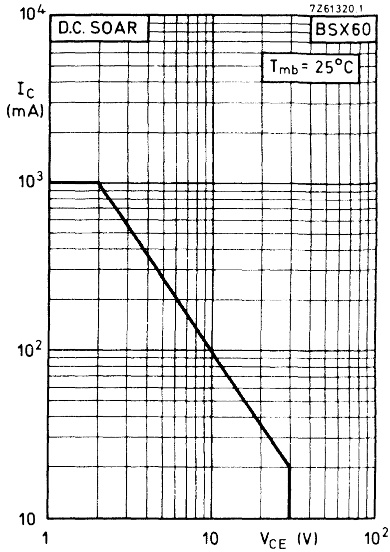
Rise time t_r $\leq$ 5 ns

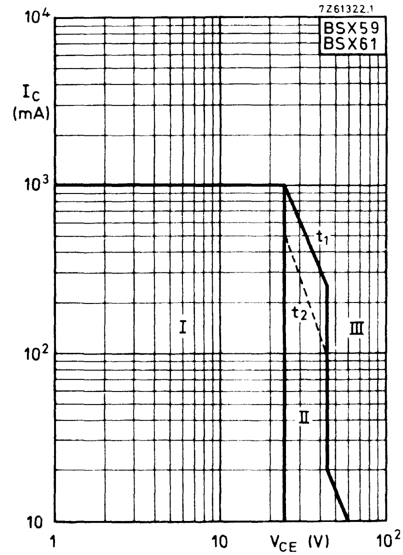
Fall time t_f $\leq$ 5 ns

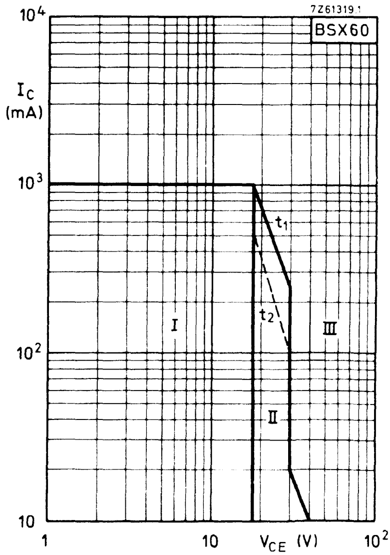
Output resistance R_o = 50 Ω (during pulse, otherwise infinite)

[1]) $-I_{BM}$ is the reverse current that can flow during switching off. The indicated $-I_{BM}$ is determined and limited by the applied cut-off voltage and the series resistance.



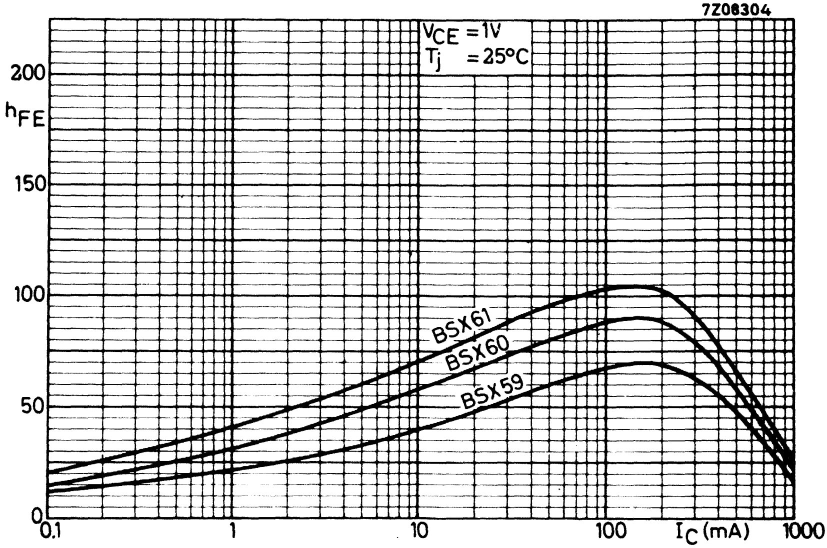


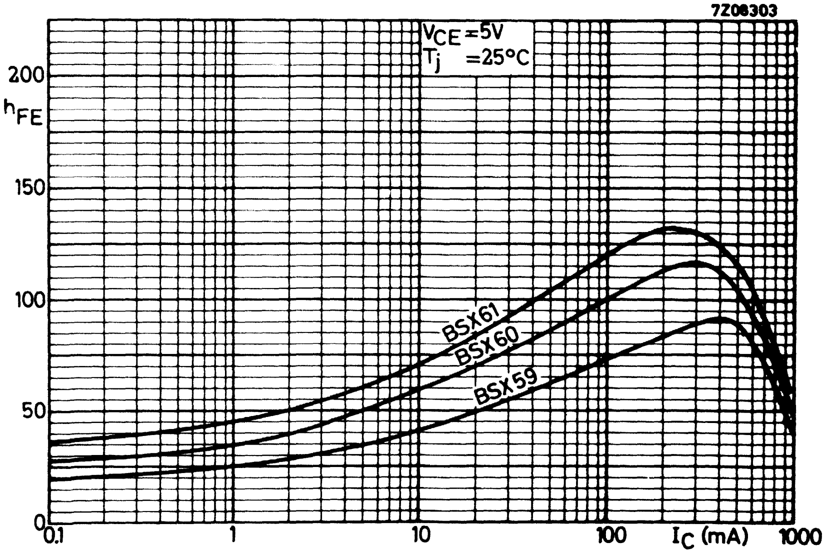


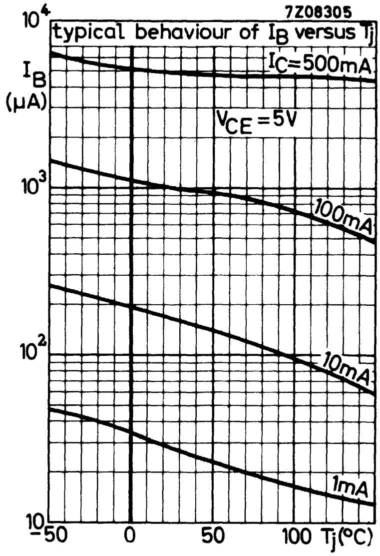


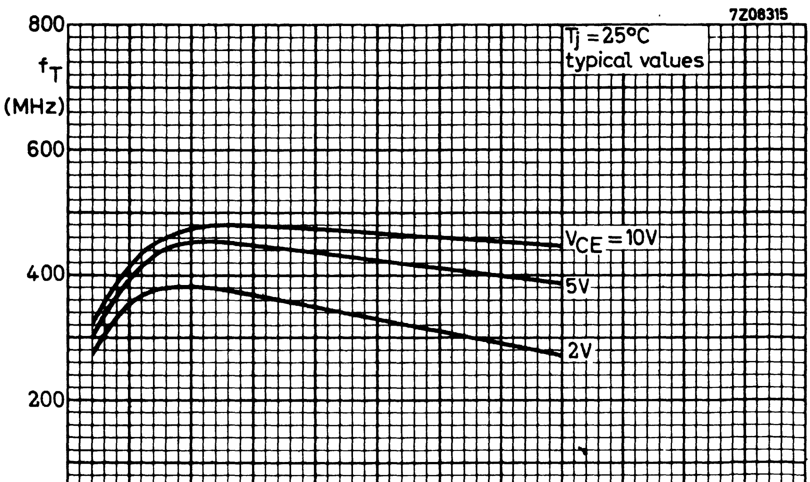
I Region of permissible operation during switching off with $-V_{BB} = 4$ V; $R_{BE} = 39\ \Omega$
II Permissible extension for repetitive pulsed operation.
t_1 limits operations with $t_p \leq 0.1\ \mu s$; $\delta = 0.25$
t_2 limits operations with $t_p \leq 1\ \mu s$; $\delta = 0.25$
III Operation in this area is not allowed.

Typical behaviour of d.c. current gain versus I_C

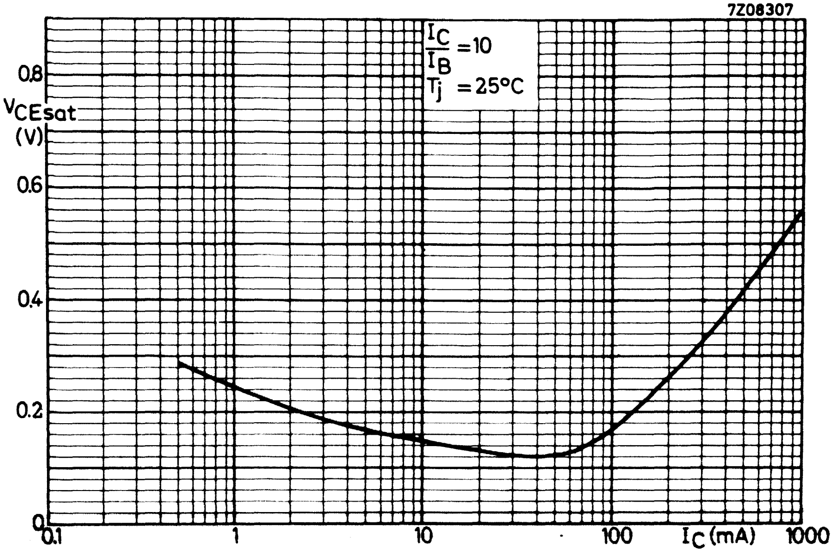


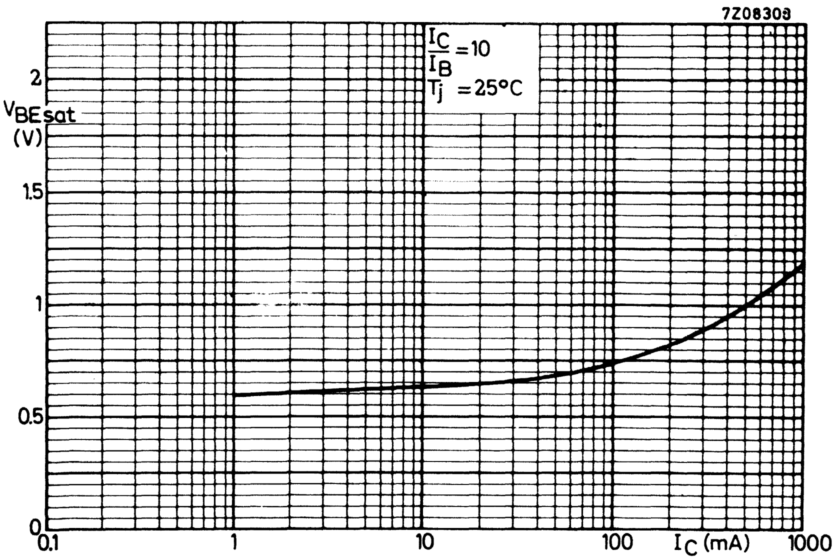



7Z08305
typical behaviour of I_B versus T_j
I_B (μA)
I_C=500mA
V_{CE}=5V
100mA
10mA
1mA
10^4
10^3
10^2
10
−50
0
50
100
T_j(°C)

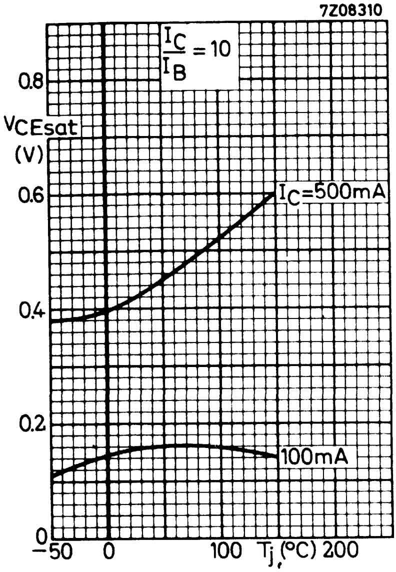

7Z08315
f_T (MHz)
T_j = 25°C
typical values
V_{CE} = 10V
5V
2V
800
600
400
200
0
0
50
100
150
200
250
I_C (mA)

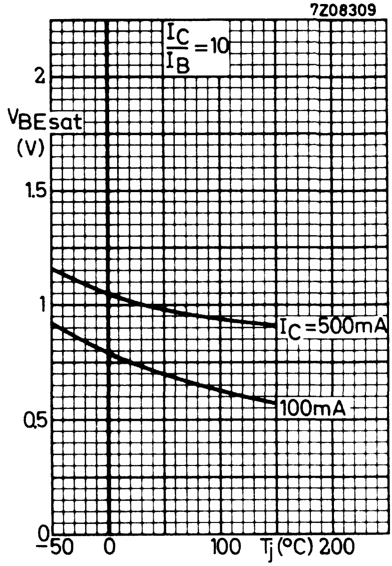
Typical behaviour of saturation voltages versus I_C

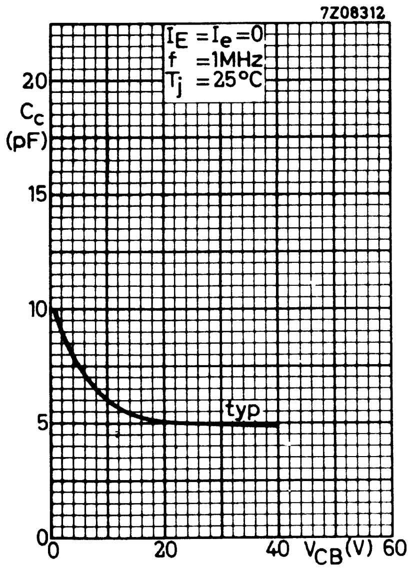


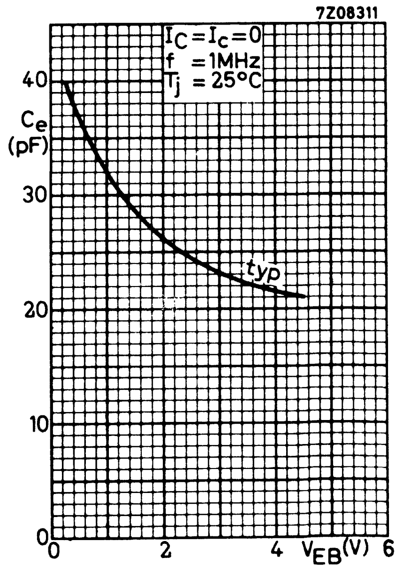


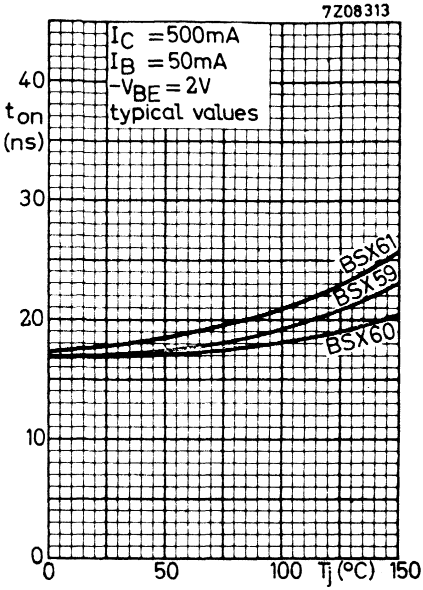
Typical behaviour of saturation voltages versus T_j

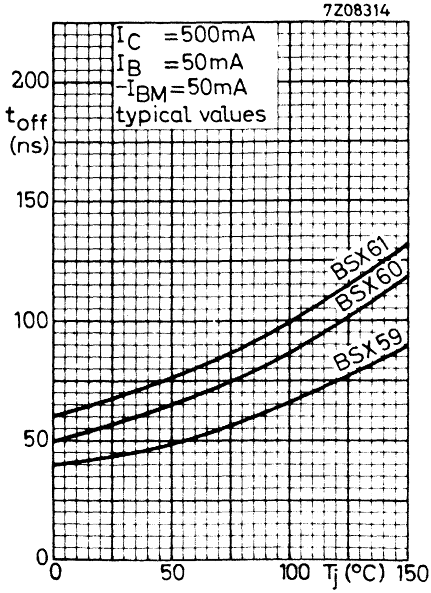


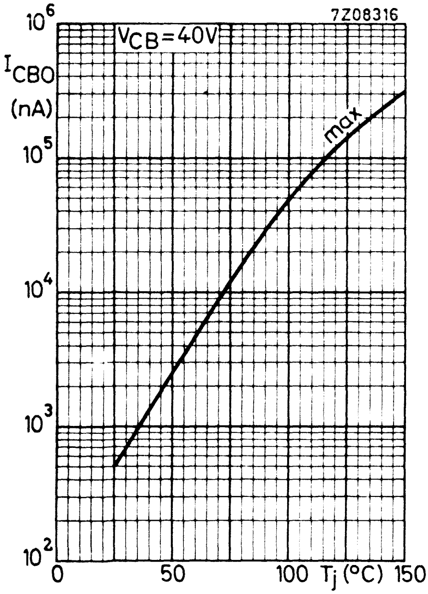


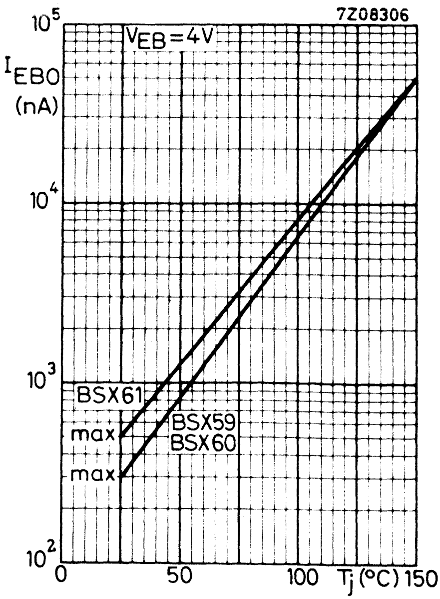





7Z08313
I_C =500mA
I_B =50mA
$-V_{BE}$=2V
typical values
40
t_{on}
(ns)
30
20
10
0
BSX61
BSX59
BSX60
0
50
100
T_j (°C)
150


7Z08314
I_C =500mA
I_B =50mA
$-I_{BM}$=50mA
typical values
200
t_{off}
(ns)
150
100
50
0
BSX61
BSX60
BSX59
0
50
100
T_j (°C)
150


7Z08316
V_{CB}=40V
10^6
I_{CBO}
(nA)
10^5
10^4
10^3
10^2
max
0
50
100
T_j (°C)
150


7Z08306
V_{EB}=4V
10^5
I_{EBO}
(nA)
10^4
10^3
10^2
BSX61
max
BSX59
BSX60
max
0
50
100
T_j (°C)
150

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 BSY38 and BSY39 are primarily intended for very high speed saturated switching and general purposes.

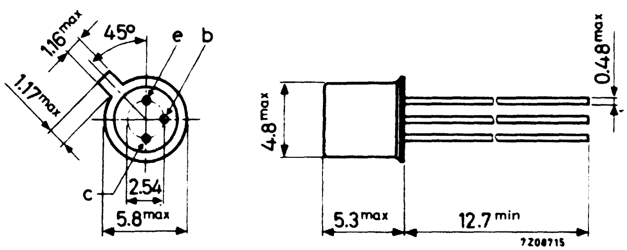
QUICK REFERENCE DATA

			BSY38	BSY39	
Collector-base voltage (open emitter)	V_{CBO}	max.	20	20	V
Collector-emitter voltage ($V_{BE} \leq 0$)	V_{CEX}	max.	15	15	V
Collector current (peak value)	I_{CM}	max.	200	200	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	300	mW
D.C. current gain at T_j = 25 °C					
I_C = 10 mA; V_{CE} = 0.35 V	h_{FE}		30 to 60	40 to 120	
I_C = 100 mA; V_{CE} = 1 V	h_{FE}		15 to 45	20 to 70	
Transition frequency					
I_C = 10 mA; V_{CE} = 2 V	f_T	typ.	350	350	MHz
Storage time					
$I_C = I_B = -I_{BM}$ = 10 mA	t_s	typ.	8	8	ns

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-18



Accessories available: 56246, 56263.

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	20	V
Collector-emitter voltage ($V_{BE} \leq 0$)	V_{CEX}	max.	15	V
Emitter-base voltage (open collector)	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.	200	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	300	mW

Temperatures

Storage temperature	T_{stg}		-65 to +175	°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.50	°C/mW
From junction to case	$R_{th\ j-c}$	=	0.15	°C/mW

1) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

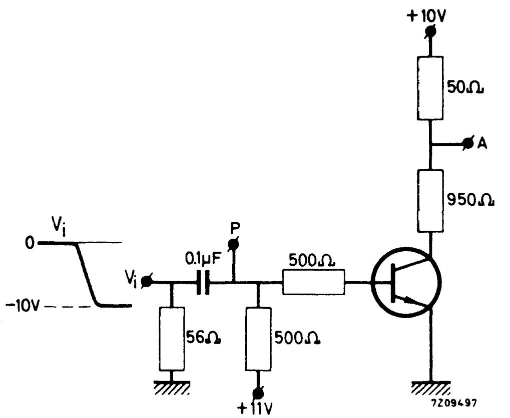
CHARACTERISTICS T_j = 25 °C unless otherwise specified

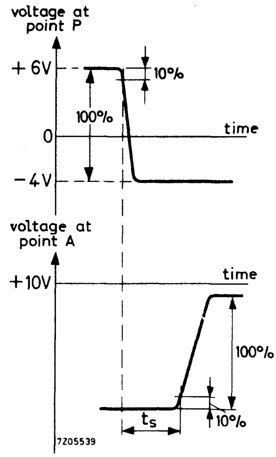
Collector cut-off current				
$I_E = 0$; $V_{CB} = 20$ V	I_{CBO}	<	100	nA
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 150$ °C	I_{CBO}	<	10	μA
$V_{BE} = 0$; $V_{CE} = 15$ V; $T_j = 55$ °C	I_{CES}	<	0.40	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	500	nA
$I_C = 0$; $V_{EB} = 5$ V; $T_j = 150$ °C	I_{EBO}	<	10	μA
Currents at reverse biased emitter junction				
$V_{CE} = 15$ V; $-V_{BE} = 3$ V; $T_j = 55$ °C	$-I_{BEX}$	<	0.60	μA
Sustaining voltages				
$I_C = 10$ mA; $I_B = 0$	$V_{CEOsust}$	>	12	V
Base-emitter voltage (see also page 9)				
$I_C = 30$ μA; $V_{CE} = 10$ V; $T_j = 100$ °C	V_{BE}	>	0.35	V
Saturation voltages				
$I_C = 10$ 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	<	5	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 1$ V	C_e	<	6	pF

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

		BSY38	BSY39	
D.C. current gain				
I_C = 10 mA; V_{CE} = 0.35 V	h_{FE}	30 to 60	40 to 120	
I_C = 100 mA; V_{CE} = 1 V	h_{FE}	15 to 45	20 to 70	
Transition frequency				
I_C 10 mA; V_{CE} = 2 V	f_T	> 200 typ. 350		MHz MHz
Switching times				
Storage time (see also page 12)				
I_C = I_B = $-I_{BM}$ = 10 mA	t_s	typ. 8 < 16		ns ns

Test circuit:





Note

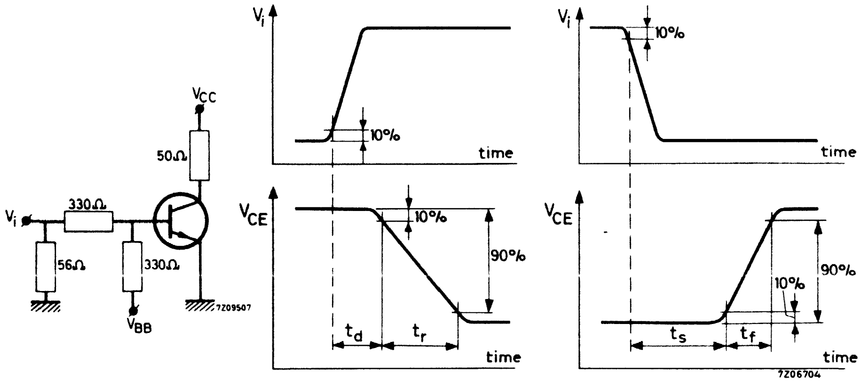
$-I_{BM}$ is the reverse current that can flow during switching off. The indicated $-I_{BM}$ is determined and limited by the applied cut-off voltage and series resistance.

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Switching times

Turn on time (see also page 13) when switched from $-V_{BE}$ = 2.25 V to I_C = 100 mA; I_B = 40 mA with $-I_{BM}$ = 20 mA $-V_{BB}$ = 4.5 V; V_{CC} = 6 V; V_i = 20 V	t_{on}	typ.	9	ns
		<	14	ns
Turn off time (see also page 13) when switched from I_C = 100 mA; I_B = 40 mA to cut-off with $-I_{BM}$ = 20 mA V_{BB} = 15.3 V; V_{CC} = 6 V; $-V_i$ = 20 V	t_{off}	typ.	25	ns
		<	45	ns

Test circuit:



Pulse generator:

Rise time	t_r	<	1	ns
Pulse duration	t	>	60	ns
Duty cycle	δ	<	0.02	

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.

SILICON PLANAR EPITAXIAL TRANSISTORS

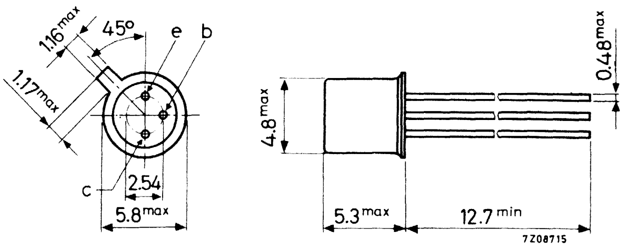
N-P-N transistors in a TO-18 metal envelope with the collector connected to the case. The 2N706A and 2N753 are primarily intended for low-power high-speed saturated switching application in industrial service.

QUICK REFERENCE DATA					
Collector-base voltage (open emitter)		V_{CBO}	max.	25	V
Collector-emitter voltage (open base)		V_{CEO}	max.	15	V
Collector current (d.c.)		I_C	max.	50	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 = 10 mA; V_{CE} = 1 V	2N706A	h_{FE}	20 to	60	
	2N753	h_{FE}	40 to	120	
Transition frequency					
I_C = 10 mA; V_{CE} = 10 V		f_T	>	200	MHz
Storage time					
I_C = I_B = $-I_{BM}$ = 10 mA	2N706A	t_s	<	25	ns
	2N753	t_s	<	35	ns

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-18



Accessories available: 56246, 56263

RATINGS (Limiting values) [1]

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector-emitter voltage at $R_{BE} \leqq 10\,\Omega$	V_{CER}	max.	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Current

Collector current (d.c. or average over any 20 ms period)	I_C	max.	50	mA

Power dissipation

Total power dissipation up to $T_{amb} = 25\,^oC$	P_{tot}	max.	300	mW

Temperatures

Storage temperature	T_{stg}	-65 to +175		^oC
Junction temperature	T_j	max.	175	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.5	$^oC/mW$
From junction to case	$R_{th\ j\text{-}c}$	=	0.15	$^oC/mW$

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current					
$I_E = 0$; $V_{CB} = 15$ V		I_{CBO}	<	0.5	μA
$I_E = 0$; $V_{CB} = 25$ V		I_{CBO}	<	10	μA
$I_E = 0$; $V_{CB} = 15$ V; $T_j = 150$ °C		I_{CBO}	<	30	μA
$V_{CE} = 20$ V; $R_{BE} = 100$ kΩ		I_{CER}	<	10	μA
Emitter cut-off current					
$I_C = 0$; $V_{EB} = 5$ V		I_{EBO}	<	10	μA
Sustaining voltages [1]					
$I_C = 10$ mA; $I_B = 0$		$V_{CEOsust}$	>	15	V
$I_C = 10$ mA; $R_{BE} = 10$ Ω		$V_{CERsust}$	>	20	V
Saturation voltages					
$I_C = 10$ mA; $I_B = 1$ mA		V_{CEsat}	<	0.6	V
		V_{BEsat}		0.7 to 0.9	V
D.C. current gain					
$I_C = 10$ mA; $V_{CE} = 1$ V	2N706A	h_{FE}		20 to 60	
	2N753	h_{FE}		40 to 120	
Collector capacitance at f = 1 MHz					
$I_E = I_e = 0$; $V_{CB} = 5$ V		C_c	<	5	pF
Transition frequency					
$I_C = 10$ mA; $V_{CE} = 10$ V		f_T	>	200	MHz

[1]) Measured under pulsed conditions to avoid excessive dissipation
Pulse duration t = 300 μs; duty cycle $\delta \leq 0.02$

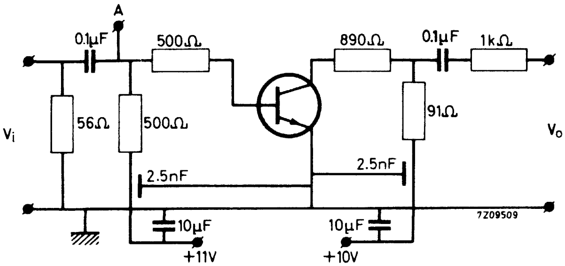
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

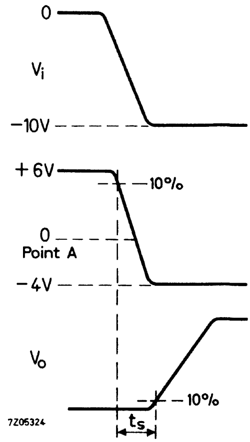
Storage time

$I_C = I_B = -I_{BM} = 10$ mA

2N706A	t_s	<	25	ns
2N753	t_s	<	35	ns

Test circuit: 1)





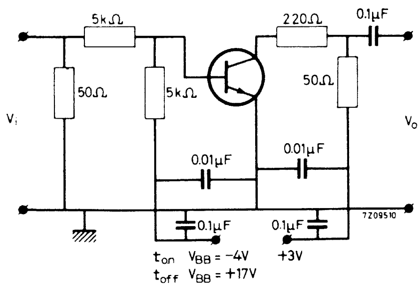
Turn on time

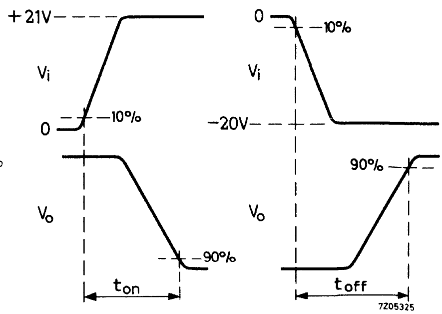
I_C = 10 mA; I_B = 3 mA; $-V_{BE}$ = 2 V t_{on} < 40 ns

Turn off time

I_C = 10 mA; I_B = 3 mA; $-I_{BM}$ = 1 mA t_{off} < 75 ns

Test circuit: 1)





1) Pulse generator:

Pulse duration	t	>	400	ns
Duty cycle	δ	<	0.02	
Rise time	t_r	<	1	ns
Source impedance	R_S	=	50	Ω

Oscilloscope:

Rise time	t_r	<	1	ns
Probe impedance		=	2	kΩ

SILICON PLANAR EPITAXIAL TRANSISTOR

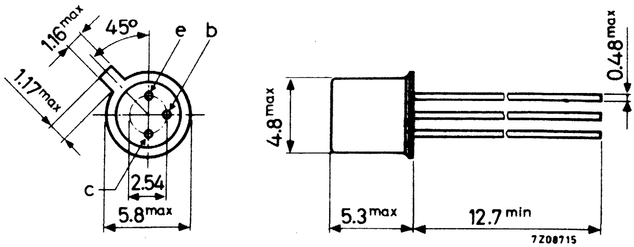
N-P-N transistor in a TO-18 metal envelope with the collector connected to the case. The 2N708 is primarily intended for use in very high-speed saturated switching and v.h.f. amplification.

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	h_{FE}	30 to 120		
Transition frequency				
I_C = 10 mA; V_{CE} = 10 V	f_T	>	300	MHz
Storage time				
I_C = I_B = $-I_{BM}$ = 10 mA	t_s	<	25	ns

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-18



Accessories available: 56246, 56263

RATINGS (Limiting values) [1]

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector-emitter voltage with $R_{BE} < 10\ \Omega$	V_{CER}	max.	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Current

Collector current (peak value; t = 10 μs)	I_{CM}	max.	500	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360	mW

Temperatures

Storage temperature	T_{stg}		−65 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.48	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0.145	°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}	<	25	nA
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 150$ °C	I_{CBO}	<	15	μA
$V_{CE} = 20$ V; $V_{BE} = 0.25$ V; $T_j = 125$ °C	I_{CEX}	<	10	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 4$ V	I_{EBO}	<	0.1	μA
Sustaining voltages [1]				
$I_C = 30$ mA; $I_B = 0$	$V_{CEOsust}$	>	15	V
$I_C = 30$ mA; $R_B \leq 10\ \Omega$	$V_{CERsust}$	>	20	V
Saturation voltages				
$I_C = 10$ mA; $I_B = 1$ mA	V_{CEsat}	<	0.4	V
	V_{BEsat}	0.72 to	0.80	V
$I_C = 7$ mA; $I_B = 0.7$ mA; $T_j = -55$ to $+125$ °C	V_{CEsat}	<	0.4	V
$I_C = 7$ mA; $I_B = 0.7$ mA; $T_j = -55$ °C	V_{BEsat}	<	0.9	V
D.C. current gain				
$I_C = 0.5$ mA; $V_{CE} = 1$ V	h_{FE}	>	15	
$I_C = 10$ mA; $V_{CE} = 1$ V	h_{FE}	30 to	120	
$I_C = 10$ mA; $V_{CE} = 1$ V; $T_j = -55$ °C	h_{FE}	>	15	
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	6	pF
Transition frequency				
$I_C = 10$ mA; $V_{CE} = 10$ V	f_T	>	300	MHz
Real part of small signal input impedance				
$I_C = 10$ mA; $V_{CE} = 10$ V; f = 300 MHz	$R_e(h_{ie})$	<	50	Ω

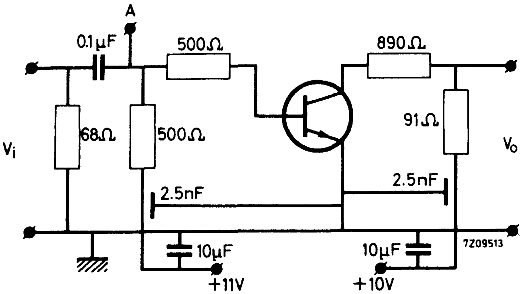
[1] Measured under pulsed conditions to avoid excessive dissipation. Pulse duration t = 300 μs; duty cycle $\delta < 0.01$

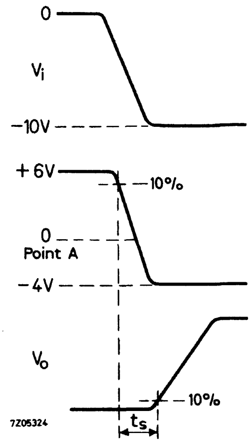
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Storage time

$I_C = I_B = -I_{BM} = 10$ mA t_s < 25 ns

Test circuit:





Pulse generator:

Pulse duration	t	≥	400	ns
Duty cycle	δ	≤	0.02	
Rise time	t_r	≤	1	ns
Source impedance	R_S	=	50	Ω

Oscilloscope:

Rise time t_r < 1 ns

High impedance probe

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a TO-18 metal envelope with the collector connected to the case. The 2N743 and 2N744 are primarily intended for low-power very high-speed saturated switching applications in industrial service.

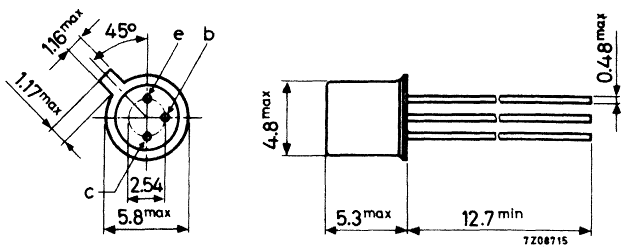
QUICK REFERENCE DATA

Collector-base voltage (open emitter)		V_{CBO}	max.	20	V
Collector-emitter voltage (open base)		V_{CEO}	max.	12	V
Collector current (d.c.)		I_C	max.	200	mA
Total power dissipation up to $T_{amb} = 25\,^oC$		P_{tot}	max.	300	mW
Junction temperature		T_j	max.	175	^oC
D.C. current gain at $T_j = 25\,^oC$					
$I_C = 10$ mA; $V_{CE} = 0.35$ V	2N743	h_{FE}	20 to	60	
	2N744	h_{FE}	40 to	120	
Transition frequency					
$I_C = 10$ mA; $V_{CE} = 10$ V		f_T	>	300	MHz
Storage time					
$I_C = I_B = -I_{BM} = 10$ mA	2N743	t_s	<	14	ns
	2N744	t_s	<	18	ns

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-18



Accessories available: 56246, 56263

RATINGS (Limiting values) [1]

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	20	V
Collector-emitter voltage (open base)	V_{CEO}	max.	12	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Current

Collector current (d.c. or average over any 20 ms period)	I_C	max.	200	mA

Power dissipation

Total power dissipation up to $T_{amb} = 25\ ^oC$	P_{tot}	max.	300	mW

Temperatures

Storage temperature	T_{stg}		-65 to +175	^oC
Junction temperature	T_j	max.	175	^oC

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.5	$^oC/mW$
From junction to case	$R_{th\ j-c}$	=	0.15	$^oC/mW$

[1] Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $V_{CB} = 20$ V	I_{CBO}	<	1	μA
$V_{BE} = 0$; $V_{CE} = 20$ V	I_{CES}	<	1	μA
$V_{BE} = 0$; $V_{CE} = 20$ V; $T_j = 170$ °C	I_{CES}	<	100	μA
$V_{BE} = 0.35$ V; $V_{CE} = 10$ V; $T_j = 100$ °C	I_{CEX}	<	30	μA

Emitter cut-off current

$I_C = 0$; $V_{EB} = 5$ V	I_{EBO}	<	10	μA

Sustaining voltage

$I_C = 10$ mA; $I_B = 0$	$V_{CEOsust}$	>	12	V [1]

Saturation voltages

$I_C = 10$ mA; $I_B = 1$ mA; $T_j = 170$ °C	V_{CEsat}	<	0.35	V
$I_C = 100$ mA; $I_B = 10$ mA; $T_j = 170$ °C	V_{CEsat}	<	1	V [1]
$I_C = 10$ mA; $I_B = 1$ mA	V_{BEsat}		0.65 to 0.85	V
$I_C = 10$ mA; $I_B = 1$ mA; $T_j = -55$ °C	V_{BEsat}	<	1.1	V
$I_C = 100$ mA; $I_B = 10$ mA	V_{BEsat}	<	1.5	V [1]
$I_C = 100$ mA; $I_B = 10$ mA; $T_j = -55$ °C	V_{BEsat}	<	1.6	V [1]

Collector capacitance at f = 1 MHz

$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	<	5	pF

Transition frequency

$I_C = 10$ mA; $V_{CE} = 10$ V	f_T	>	300	MHz

D.C. current gain

		2N743	2N744
$I_C = 1$ mA; $V_{CE} = 0.25$ V	h_{FE}	> 10	20
$I_C = 10$ mA; $V_{CE} = 0.35$ V	h_{FE}	20 to 60	40 to 120
$I_C = 10$ mA; $V_{CE} = 0.35$ V; $T_j = -55$ °C	h_{FE}	> 10	20
$I_C = 100$ mA; $V_{CE} = 1$ V	h_{FE}	> 10	20 [1]

[1] Measured under pulsed conditions to avoid excessive dissipation
Pulse duration t = 300 μs; duty cycle $\delta \leq 0.02$

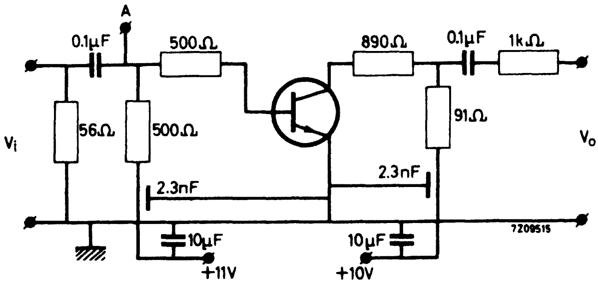
CHARACTERISTICS (continued) $T_j = 25\ ^{o}C$ unless otherwise specified

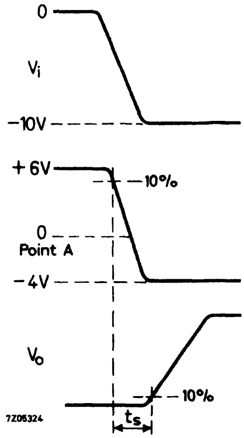
Storage time

$I_C = I_B = -I_{BM} = 10$ mA

2N743	t_s	<	14	ns
2N744	t_s	<	18	ns

Test circuit:





Pulse generator:

Pulse duration	t	≥	300	ns
Duty cycle	δ	≤	0.02	
Rise time	t_r	≤	1	ns
Source impedance	R_S	=	50	Ω

Oscilloscope:

Rise time	t_r	≤	1	ns
Input impedance	R_i	=	50	Ω

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Turn on time

I_C = 10 mA; I_B = 3 mA; $-V_{BE}$ = 1.5 V — t_{on} < 16 ns

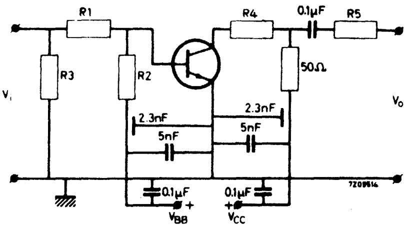
I_C = 100 mA; I_B = 40 mA; $-V_{BE}$ = 2.4 V — t_{on} < 12 ns

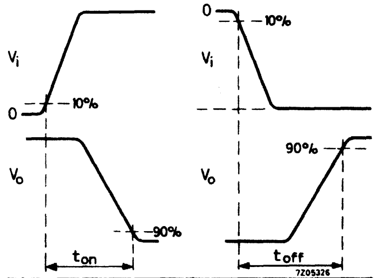
Turn off time

I_C = 10 mA; I_B = 3 mA; $-I_{BM}$ = 1.5 mA — t_{off} < 24 ns

I_C = 100 mA; I_B = 40 mA; $-I_{BM}$ = 20 mA — 2N743 t_{off} < 40 ns; 2N744 t_{off} < 45 ns

Test circuit:





I_C (mA)	I_B (mA)	V_{CC} (V)	R_1 (kΩ)	R_2 (kΩ)	R_3 (Ω)	R_4 (Ω)	R_5 (kΩ)	turn on $-V_{BB}$ (V)	turn on $-V_{BE}$ (V)	turn on V_i (V)	turn off V_{BB} (V)	turn off $-I_{BM}$ (mA)	turn off $-V_i$ (V)
10	3	3	3.3	3.3	50	220	0	3	1.5	15	12	1.5	15
100	40	6	0.33	0.33	56	0	1	4.5	2.4	20	15.3	20	20

Pulse generator:

Pulse duration	t	≥	400 ns
Duty cycle	δ	≤	0.02
Rise time	t_r	≤	1 ns
Source impedance	R_S	=	50 Ω

Oscilloscope:

Rise time	t_r	≤	1 ns
Input impedance	R_i	=	50 Ω

SILICON PLANAR EPITAXIAL TRANSISTOR

For data of this transistor please refer to the 2N706A.

SILICON PLANAR EPITAXIAL TRANSISTOR

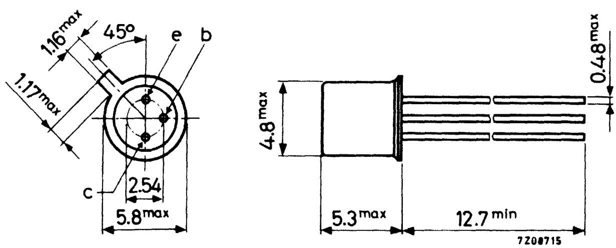
N-P-N transistor in a TO-18 metal envelope with the collector connected to the case. The 2N914 is primarily intended for use in very high-speed saturated switching and v.h.f. amplification.

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	h_{FE}	30 to	120	
Transition frequency				
I_C = 20 mA; V_{CE} = 10 V	f_T	>	300	MHz
Storage time				
$I_C = I_B = -I_{BM}$ = 20 mA	t_s	<	20	ns

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-18



Accessories available: 56246, 56263

RATINGS (Limiting values) [1]

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector-emitter voltage with $R_{BE} \leq 10\ \Omega$	V_{CER}	max.	20	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	V

Current

Collector current (peak value; t = 10 μs)	I_{CM}	max.	500	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360	mW

Temperatures

Storage temperature	T_{stg}	-65 to +200		°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.48	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0.145	°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}	<	25	nA
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 150$ °C	I_{CBO}	<	15	μA
$V_{CE} = 20$ V; $V_{BE} = 0.25$ V; $T_j = 125$ °C	I_{CEX}	<	10	μA
Emitter cut-off current				
$I_C = 0$; $V_{EB} = 4$ V	I_{EBO}	<	0.1	μA
Sustaining voltages [1]				
$I_C = 30$ mA; $I_B = 0$	$V_{CEOsust}$	>	15	V
$I_C = 30$ mA; $R_B \leq 10\ \Omega$	$V_{CERsust}$	>	20	V
Saturation voltages				
$I_C = 200$ mA; $I_B = 20$ mA	V_{CEsat}	<	0.7	V
$I_C = 10\ I_B$; $I_B = 0.1$ to 2 mA; $T_j = -55$ to +125 °C	V_{CEsat}	<	0.25	V
$I_C = 10$ mA; $I_B = 1$ mA	V_{BEsat}		0.7 to 0.8	V
D.C. current gain [1]				
$I_C = 500$ mA; $V_{CE} = 5$ V	h_{FE}	>	10	
$I_C = 10$ mA; $V_{CE} = 1$ V	h_{FE}		30 to 120	
$I_C = 10$ mA; $V_{CE} = 1$ V; $T_j = -55$ °C	h_{FE}	>	12	
Collector capacitance at f = 1 MHz				
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	6	pF
Emitter capacitance at f = 1 MHz				
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	<	9	pF
Transition frequency				
$I_C = 20$ mA; $V_{CE} = 10$ V	f_T	>	300	MHz

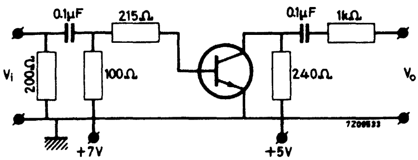
[1]) Measured under pulsed conditions to avoid excessive dissipation
Pulse duration t = 300 μs; duty cycle $\delta \leq 0.01$

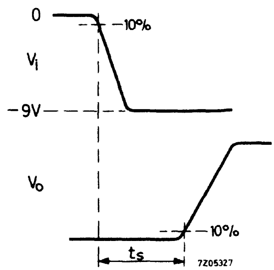
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

<u>Storage time</u>

$I_C = I_B = -I_{BM}$ = 20 mA | t_s < 20 ns

Test circuit: [1]





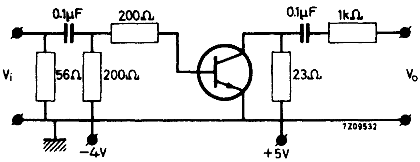
<u>Turn on time</u>

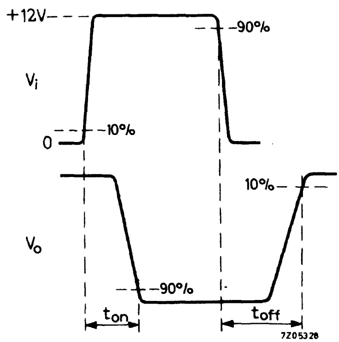
I_C = 200 mA; I_B = 35 mA; $-V_{BE}$ = 4 V | t_{on} < 40 ns

<u>Turn off time</u>

I_C = 200 mA; I_B = 35 mA; $-I_{BM}$ = 25 mA | t_{off} < 40 ns

Test circuit: [1]





[1]) Pulse generator:

Pulse duration	t	=	100 ns
Duty cycle	δ	≤	0.02
Source impedance	R_S	=	50 Ω

Rise and fall time sufficiently fast so that doubling their values does not affect the measured results within the required accuracy.

Oscilloscope:

Rise time	t_r	<	1 ns
Input impedance	R_i	=	50 Ω

GERMANIUM ALLOYED TRANSISTORS

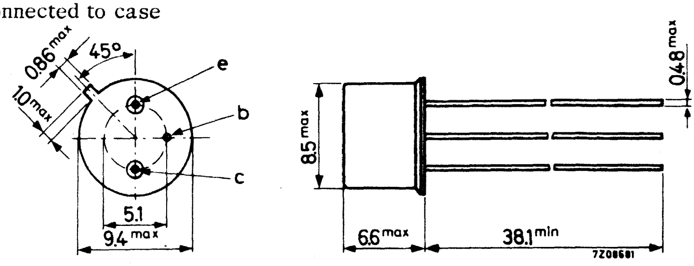
N-P-N transistors in a TO-5 metal envelope with the base connected to the case. These general purpose transistors are primarily intended for medium current medium speed computer logic applications.

QUICK REFERENCE DATA

			2N1302	1304	1306	1308	
Collector-base voltage (open emitter)	V_{CBO}	max.	25	25	25	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	20	15	15	V
Collector current (peak value)	I_{CM}	max.	300	300	300	300	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	150	150	150	mW
Junction temperature	T_j	max.	85	85	85	85	°C
D.C. current gain at T_j = 25 °C; I_C = 10 mA; V_{CE} = 1 V	h_{FE}	>	20	40	60	80	
Saturation voltage I_C = 10 mA; $I_B = \frac{I_C}{h_{FEmin}}$	V_{CEsat}	<	0.2	0.2	0.2	0.2	V
Transition frequency I_C = 1 mA; V_{CE} = 5 V	f_T	typ.	10	15	20	30	MHz
Turn on time ($t_d + t_r$)	t_{on}	typ.	285	270	225	220	ns
Turn off time ($t_s + t_f$)	t_{off}	typ.	865	850	815	790	ns

MECHANICAL DATA Dimensions in mm

TO-5
Base connected to case



Accessories available: 56218, 56245, 56265

RATINGS (Limiting values) [1]

Voltages			2N1302	1304	1306	1308	
Collector-base voltage (open emitter)	V_{CBO}	max.	25	25	25	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	25	20	15	15	V
Emitter-base voltage (open collector)	V_{EBO}	max.	25	25	25	25	V

Currents

Collector current (d.c. or average over any 20 ms period)	I_C	max.	200	mA
Collector current (peak value)	I_{CM}	max.	300	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	mW

Temperatures

Storage temperature	T_{stg}		-65 to +100	°C
Junction temperature	T_j	max.	85	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\,j\text{-}a}$	=	0.4	°C/mW
From junction to case	$R_{th\,j\text{-}c}$	=	0.2	°C/mW

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

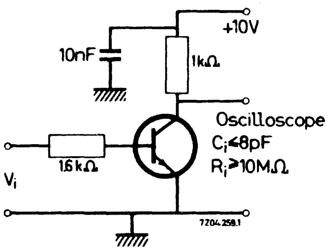
CHARACTERISTICS

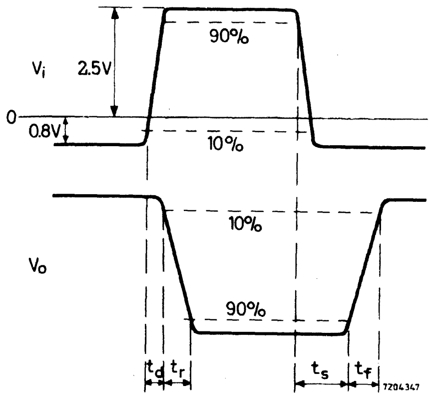
T_j = 25 °C unless otherwise specified

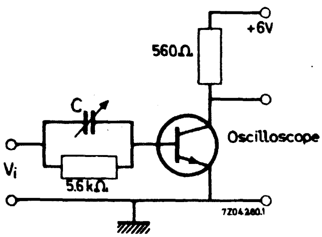
			2N1302	1304	1306	1308	
Collector cut-off current							
$I_E = 0$; $V_{CB} = 25$ V	I_{CBO}	typ.	3	3	3	3	μA
		<	6	6	6	6	μA
Emitter cut-off current							
$I_C = 0$; $V_{EB} = 25$ V	I_{EBO}	typ.	2.2	2.2	2.2	2.2	μA
		<	6	6	6	6	μA
Collector current at reverse biased emitter junction							
$-V_{BE} = 0.2$ V; $T_j = 55$ °C							
$V_{CE} = 20$ V	I_{CEX}	<	50	50			μA
$V_{CE} = 15$ V	I_{CEX}	<			50	50	μA
Saturation voltages							
$I_C = 10$ mA; $I_B = 0.5$ mA	V_{BEsat}	>	0.15	0.15	0.15	0.15	V
		typ.	0.30	0.25	0.24	0.23	V
		<	0.40	0.35	0.35	0.35	V
	V_{CEsat}	typ.	0.1				V
		<	0.2				V
$I_C = 10$ mA; $I_B = 0.25$ mA	V_{CEsat}	typ.		0.1			V
		<		0.2			V
$I_C = 10$ mA; $I_B = 0.17$ mA	V_{CEsat}	typ.			0.1		V
		<			0.2		V
$I_C = 10$ mA; $I_B = 0.13$ mA	V_{CEsat}	typ.				0.1	V
		<				0.2	V
Punch through voltage	V_{pt}	>	25	20	15	15	V
D.C. current gain							
$I_C = 10$ mA; $V_{CE} = 1$ V	h_{FE}	>	20	40	60	80	
		typ.	50	70	100	150	
		<		100	200	300	
$I_C = 200$ mA; $V_{CE} = 0.35$ V	h_{FE}	>	10	15	20	20	
		typ.	48	65	95	145	
Collector capacitance at f = 1 MHz							
$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	typ.	12	12	12	12	pF
		<	20	20	20	20	pF
Emitter capacitance at f = 1 MHz							
$I_C = I_c = 0$; $V_{EB} = 5$ V	C_e	typ.	8	8	8	8	pF
Transition frequency							
$I_C = 1$ mA; $V_{CE} = 5$ V	f_T	>	3	5	10	15	MHz
		typ.	10	15	20	30	MHz

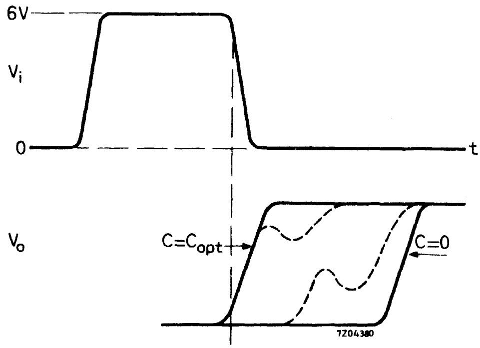
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

			2N1302	1304	1306	1308	
Switching times							
delay time	t_d	typ.	65	60	55	55	ns
rise time	t_r	typ.	220	210	170	165	ns
storage time	t_s	typ.	500	500	500	500	ns
fall time	t_f	typ.	365	350	315	290	ns
Recovered charge	Q_s	typ.	800	700	650	600	pC









Adjust C from zero to C_{opt}

$Q_s = C_{opt} \cdot V_i$

GERMANIUM ALLOYED TRANSISTORS

P-N-P transistors in a TO-5 metal envelope with the base connected to the case. These general purpose transistors are primarily intended for medium current medium speed computer logic applications.

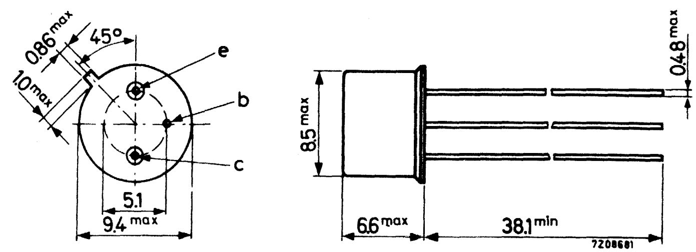
QUICK REFERENCE DATA

			2N1303	1305	1307	1309	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30	30	30	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	25	20	15	15	V
Collector current (peak value)	$-I_{CM}$	max.	300	300	300	300	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	150	150	150	mW
Junction temperature	T_j	max.	85	85	85	85	°C
D.C. current gain at T_j = 25°C; $-I_C$ = 10 mA; $-V_{CE}$ = 1 V	h_{FE}	>	20	40	60	80	
Saturation voltage $-I_C$ = 10 mA; $-I_B = \frac{-I_C}{h_{FEmin}}$	$-V_{CEsat}$	<	0.2	0.2	0.2	0.2	V
Transition frequency $-I_C$ = 1 mA; $-V_{CE}$ = 5 V	f_T	typ.	5	10	15	20	MHz
Turn on time ($t_d + t_r$)	t_{on}	typ.	360	255	230	200	ns
Turn off time ($t_s + t_f$)	t_{off}	typ.	1300	1150	1050	1050	ns

MECHANICAL DATA Dimensions in mm

TO-5

Base connected to case



Accessories available: 56218, 56245, 56265

RATINGS (Limiting values) [1]

Voltages

			2N1303	1305	1307	1309	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	30	30	30	30	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	25	20	15	15	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	25	25	25	25	V

Currents

Collector current (d.c. or average over any 20 ms period)	$-I_C$	max.	200	mA
Collector current (peak value)	$-I_{CM}$	max.	300	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	150	mW

Temperatures

Storage temperature	T_{stg}		−65 to +100	°C
Junction temperature	T_j	max.	85	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.4	°C/mW
From junction to case	$R_{th\ j-c}$	=	0.2	°C/mW

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

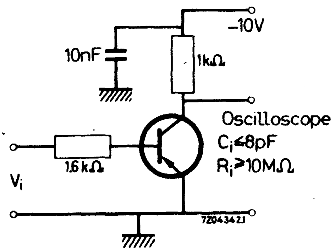
CHARACTERISTICS

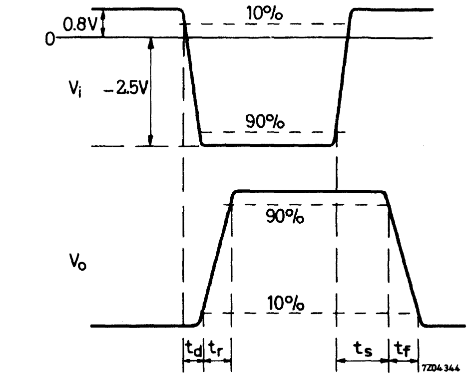
T_j = 25 °C unless otherwise specified

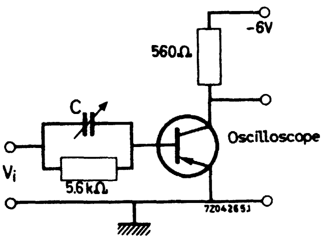
			2N1303	1305	1307	1309	
Collector cut-off current							
I_E = 0; $-V_{CB}$ = 25 V	$-I_{CBO}$	typ.	3	3	3	3	μA
		<	6	6	6	6	μA
Emitter cut-off current							
I_C = 0; $-V_{EB}$ = 25 V	$-I_{EBO}$	typ.	1.7	1.7	1.7	1.7	μA
		<	6	6	6	6	μA
Collector current at reverse biased emitter junction							
$-V_{CE}$ = 15 V; $+V_{BE}$ = 0.2 V; T_j = 55 °C	$-I_{CEX}$	<	50	50	50	50	μA
Saturation voltages		>	0.15	0.15	0.15	0.15	V
$-I_C$ = 10 mA; $-I_B$ = 0.5 mA	$-V_{BEsat}$	typ.	0.30	0.25	0.24	0.23	V
		<	0.40	0.35	0.35	0.35	V
	$-V_{CEsat}$	typ.	0.1				V
		<	0.2				V
$-I_C$ = 10 mA; $-I_B$ = 0.25 mA	$-V_{CEsat}$	typ.		0.1			V
		<		0.2			V
$-I_C$ = 10 mA; $-I_B$ = 0.17 mA	$-V_{CEsat}$	typ.			0.1		V
		<			0.2		V
$-I_C$ = 10 mA; $-I_B$ = 0.13 mA	$-V_{CEsat}$	typ.				0.1	V
		<				0.2	V
Punch through voltage	V_{pt}	>	25	20	15	15	V
D.C. current gain		>	20	40	60	80	
$-I_C$ = 10 mA; $-V_{CE}$ = 1 V	h_{FE}	typ.	50	70	100	150	
		<		100	200	300	
$-I_C$ = 200 mA; $-V_{CE}$ = 0.35 V	h_{FE}	>	10	15	20	20	
		typ.	35	55	90	130	
Collector capacitance at f = 1 MHz							
$I_E = I_e$ = 0; $-V_{CB}$ = 5 V	C_c	typ.	10	10	10	10	pF
		<	20	20	20	20	pF
Emitter capacitance at f = 1 MHz							
$I_C = I_c$ = 0; $-V_{EB}$ = 5 V	C_e	typ.	7	7	7	7	pF
Transition frequency							
$-I_C$ = 1 mA; $-V_{CE}$ = 5 V	f_T	>	3	5	10	15	MHz
		typ.	5	10	15	20	MHz

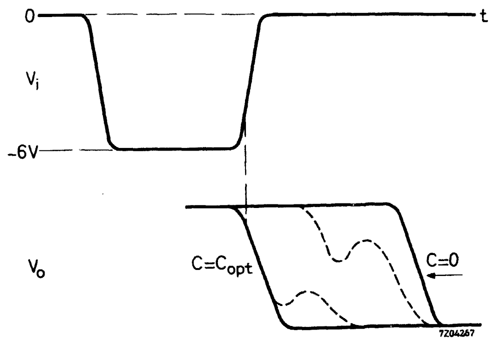
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

			2N1303	1305	1307	1309	
Switching times							
delay time	t_d	typ.	60	55	50	45	ns
rise time	t_r	typ.	300	200	180	155	ns
storage time	t_s	typ.	700	700	700	700	ns
fall time	t_f	typ.	600	450	350	350	ns
Recovered charge	Q_s	typ.	1000	1000	1000	1000	pC









Adjust C from zero to C_{opt}
$Q_s = C_{opt} \cdot V_i$

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a TO-39 metal envelope with the collector connected to the case. They are primarily intended for high speed switching.
The 2N2218 is also suitable for d.c. and v.h.f.-u.h.f. amplifiers.

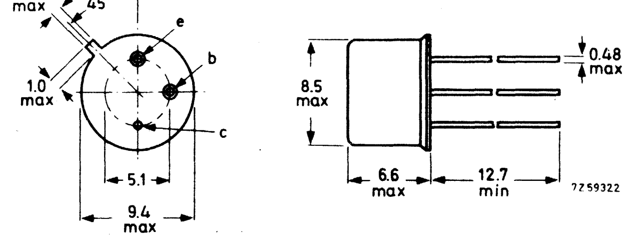
QUICK REFERENCE DATA

			2N2218	2N2218A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40	V
Collector current (d.c.)	I_C	max.	800	800	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.8	0.8	W
Junction temperature	T_j	max.	175	175	°C
D.C. current gain at T_j = 25 °C I_C = 10 mA; V_{CE} = 10 V	h_{FE}	>	35	35	
Transition frequency at f = 100 MHz I_C = 20 mA; V_{CE} = 20 V	f_T	>	250	250	MHz
Storage time I_C = 150 mA; I_B = $-I_{BM}$ = 15 mA	t_s	<	-	225	ns

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-39



max. lead diameter is guaranteed only for 12.7 mm

Accessories available: 56218; 56245; 56265.

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 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}	>	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 °C unless otherwise specified

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

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	$\mu\Omega^{-1}$

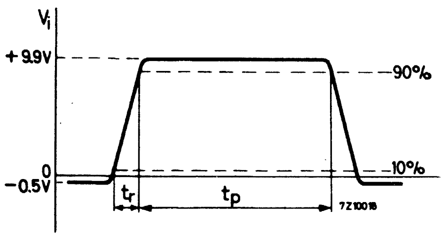
		2N2218	2N2218A	
I_C = 20 mA; V_{CE} = 20 V; f = 100 MHz				
Small signal current gain	h_{fe}	> 2.5	2.5	
I_C = 20 mA; V_{CE} = 20 V; f = 300 MHz				
Real part of input impedance	$Re(h_{ie})$	< 60	60	Ω

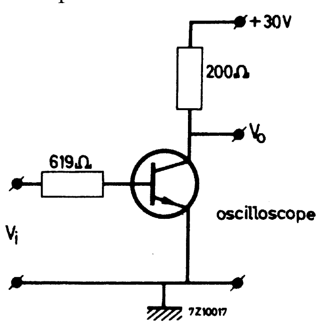
Switching times for 2N2218A

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 ≤ 200 ns
rise time t_r ≤ 2 ns

Oscilloscope:
input resistance R_i > 100 kΩ
input capacitance C_i < 12 pF
rise time t_r < 5 ns

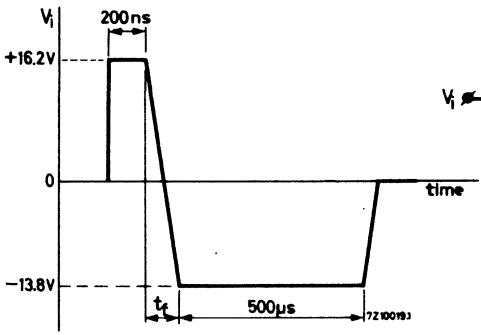
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

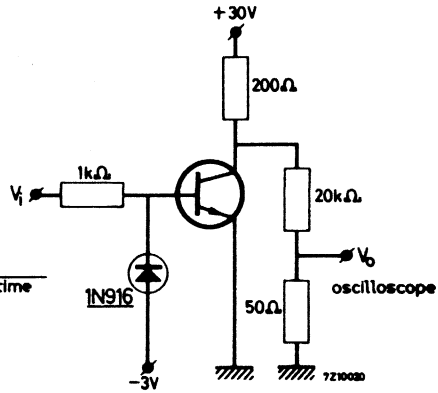
Switching times for 2N2218A

Turn off time
I_C = 150 mA; I_B = $-I_{BM}$ = 15 mA

Storage time	t_s	<	225	ns
Fall time	t_f	<	60	ns

Test circuit:





Pulse generator:
fall time t_f < 5 ns

Oscilloscope:

input impedance	R_i	>	100 kΩ
input capacitance	C_i	<	12 pF
rise time	t_r	<	5 ns

SILICON PLANAR EPITAXIAL TRANSISTORS

N-P-N transistors in a TO-39 metal envelope with the collector connected to the case. They are primarily intended for high speed switching.
The 2N2219 is also suitable for d.c. and v.h.f.-u.h.f. amplifiers.

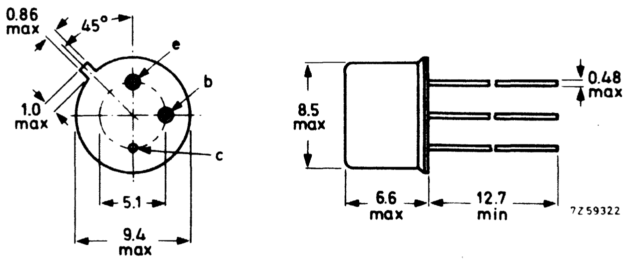
QUICK REFERENCE DATA

			2N2219	2N2219A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40	V
Collector current (d.c.)	I_C	max.	800	800	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.8	0.8	W
Junction temperature	T_j	max.	175	175	°C
D.C. current gain at T_j = 25 °C I_C = 10 mA; V_{CE} = 10 V	h_{FE}	>	75	75	
Transition frequency at f = 100 MHz I_C = 20 mA; V_{CE} = 20 V	f_T	>	250	300	MHz
Storage time I_C = 150 mA; I_B = $-I_{BM}$ = 15 mA	t_s	>	-	225	ns

MECHANICAL DATA Dimensions in mm

Collecter connected to case

TO-39



max. lead diameter is guaranteed only for 12.7 mm

Accessories available: 56218, 56245, 56265

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

			2N2219	2N2219A	
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.	0.8	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

			2N2219	2N2219A	
Collector cut-off current					
I_E = 0; V_{CB} = 50 V	I_{CBO}	<	10	–	nA
I_E = 0; V_{CB} = 50 V; T_{amb} = 150 °C	I_{CBO}	<	10	–	μA
I_E = 0; V_{CB} = 60 V	I_{CBO}	<	–	10	nA
I_E = 0; V_{CB} = 60 V; T_{amb} = 150 °C	I_{CBO}	<	–	10	μA
Emitter cut-off current					
I_C = 0; V_{EB} = 3 V	I_{EBO}	<	10	10	nA
Currents at reverse biased emitter junction					
V_{CE} = 60 V; $-V_{BE}$ = 3 V	I_{CEX}	<	–	10	nA
	$-I_{BEX}$	<	–	20	nA

1) Applicable up to I_C = 500 mA

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

			2N2219	2N2219A	
Breakdown voltages					
$I_E = 0$; $I_C = 10\ \mu A$	$V_{(BR)CBO}$	>	60	75	V
$I_B = 0$; $I_C = 10$ mA	$V_{(BR)CEO}$	>	30	40	V
$I_C = 0$; $I_E = 10\ \mu A$	$V_{(BR)EBO}$	>	5	6	V
Saturation voltages [1]					
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0.4	0.3	V
	V_{BEsat}	>	–	0.6	V
	V_{BEsat}	<	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; $T_{amb} = -55\,^{\circ}C$	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 unless otherwise specified

h parameters (common emitter)

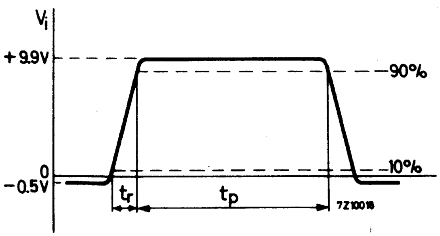
		2N2219	2N2219A	
I_C = 1 mA; V_{CE} = 10 V; f = 1 kHz				
Input impedance	h_{ie}		2 to 8	kΩ
Reverse voltage transfer ratio	h_{re}		< 8	10^{-4}
Small signal current gain	h_{fe}		50 to 300	
Output admittance	h_{oe}		5 to 35	$\mu\Omega^{-1}$
I_C = 10 mA; V_{CE} = 10 V; f = 1 kHz				
Input impedance	h_{ie}		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				
I_C = 0.1 mA; V_{CE} = 10 V; R_G = 1 kΩ; B = 1 Hz	F	< –	4	dB

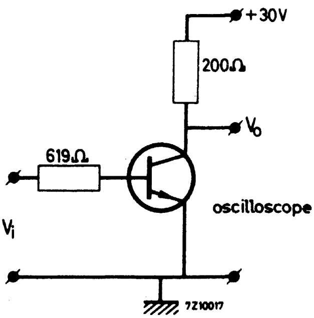
Switching times for 2N2219A

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

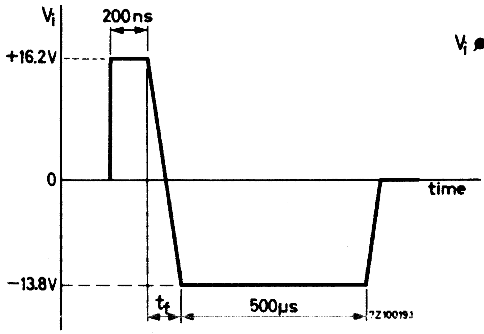
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

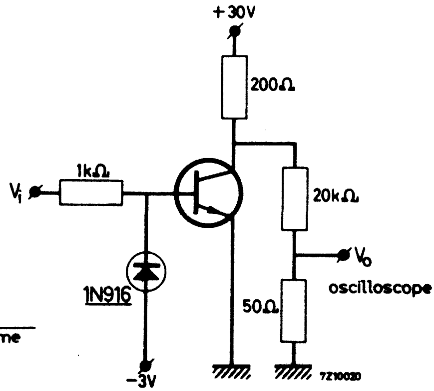
Switching times for 2N2219A

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

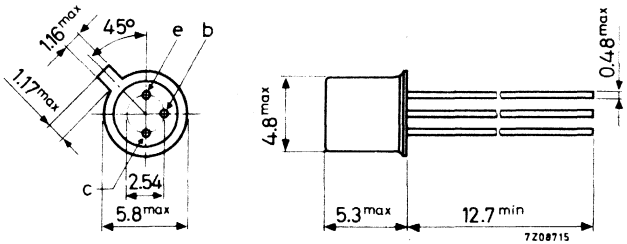
N-P-N transistors in a TO-18 metal envelope with the collector connected to the case. They are primarily intended for high speed switching.
The 2N2221 is also suitable for d.c. and v.h.f.-u.h.f. amplifiers.

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 $T_{amb} = 25\,^oC$	P_{tot}	max.	0.5	0.5	W
Junction temperature	T_j	max.	175	175	^oC
D.C. current gain at $T_j = 25\,^oC$ $I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	35	35	
Transition frequency at f = 100 MHz $I_C = 20$ mA; $V_{CE} = 20$ V	f_T	>	250	250	MHz
Storage time $I_C = 150$ mA; $I_B = -I_{BM} = 15$ mA	t_s	<	–	225	ns

MECHANICAL DATA Dimensions in mm

Collector connected to case
TO-18



Accessories available: 56246, 56263

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages			2N2221	2N2221A	
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40[1]	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	6	V

Current				
Collector current (d.c.)	I_C	max.	800	mA
Power dissipation				
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.5	W
up to T_{case} = 25 °C	P_{tot}	max.	1.8	W
Temperatures				
Storage temperature	T_{stg}		−65 to +200	°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	300	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	83	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current			2N2221	2N2221A	
$I_E = 0$; $V_{CB} = 50$ 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; $T_{amb} = -55\,^oC$	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 unless otherwise specified

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	$\mu\Omega^{-1}$

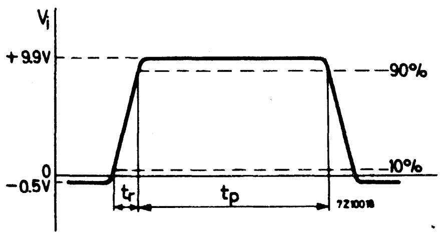
		2N2221	2N2221A	
I_C = 20 mA; V_{CE} = 20 V; f = 100 MHz				
Small signal current gain	h_{fe}	> 2.5	2.5	
I_C = 20 mA; V_{CE} = 20 V; f = 300 MHz				
Real part of input impedance	$Re(h_{ie})$	< 60	60	Ω

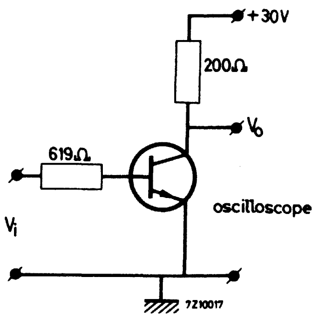
Switching times for 2N2221A

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	≤ 200 ns
rise time	t_r	≤ 2 ns

Oscilloscope:

input resistance	R_i	> 100 kΩ
input capacitance	C_i	< 12 pF
rise time	t_r	< 5 ns

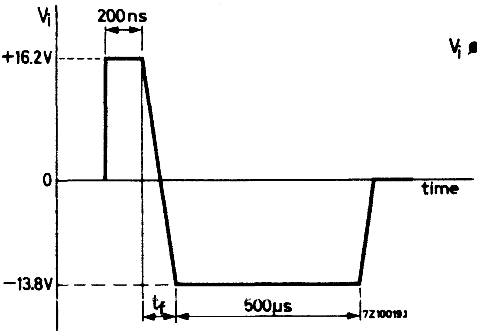
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

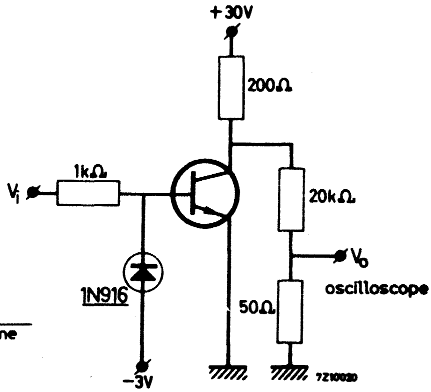
Switching times for 2N2221A

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

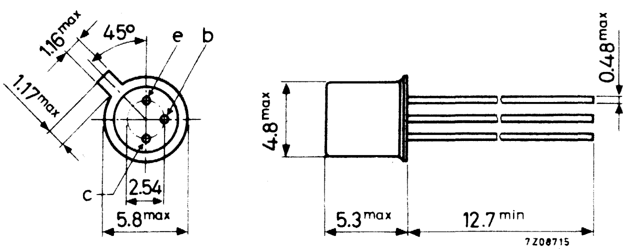
N-P-N transistors in a TO-18 metal envelope with the collector connected to the case. They are primarily intended for high speed switching.
The 2N2222 is also suitable for d.c. and v.h.f.-u.h.f. amplifiers.

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 available: 56246, 56263

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

			2N2222	2N2222A	
Voltages					
Collector-base voltage (open emitter)	V_{CBO}	max.	60	75	V
Collector-emitter voltage (open base)	V_{CEO}	max.	30	40[1]	V
Emitter-base voltage (open collector)	V_{EBO}	max.	5	6	V

Current				
Collector current (d.c.)	I_C	max.	800	mA
Power dissipation				
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.5	W
up to T_{case} = 25 °C	P_{tot}	max.	1.8	W
Temperatures				
Storage temperature	T_{stg}		-65 to + 200	°C
Junction temperature	T_j	max.	175	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	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					
$I_E = 0$; $I_C = 10\ \mu A$	$V_{(BR)CBO}$	>	60	75	V
$I_B = 0$; $I_C = 10$ mA	$V_{(BR)CEO}$	>	30	40	V
$I_C = 0$; $I_E = 10\ \mu A$	$V_{(BR)EBO}$	>	5	6	V
Saturation voltages [1]					
$I_C = 150$ mA; $I_B = 15$ mA	V_{CEsat}	<	0.4	0.3	V
	V_{BEsat}	>	–	0.6	V
		<	1.3	1.2	V
$I_C = 500$ mA; $I_B = 50$ mA	V_{CEsat}	<	1.6	1.0	V
	V_{BEsat}	<	2.6	2.0	V
D.C. current gain					
$I_C = 0.1$ mA; $V_{CE} = 10$ V	h_{FE}	>	35	35	
$I_C = 1$ mA; $V_{CE} = 10$ V	h_{FE}	>	50	50	
$I_C = 10$ mA; $V_{CE} = 10$ V	h_{FE}	>	75	75	
$I_C = 10$ mA; $V_{CE} = 10$ V; $T_{amb} = -55$ °C	h_{FE}	>	–	35	
$I_C = 150$ mA; $V_{CE} = 1$ V [1]	h_{FE}	>	50	50	
$I_C = 150$ mA; $V_{CE} = 10$ V [1]	h_{FE}		100 to 300	100 to 300	
$I_C = 500$ mA; $V_{CE} = 10$ V [1]	h_{FE}	>	30	40	
Transition frequency at f = 100 MHz					
$I_C = 20$ mA; $V_{CE} = 20$ V	f_T	>	250	300	MHz
Collector capacitance at f = 100 kHz					
$I_E = I_e = 0$; $V_{CB} = 10$ V	C_c	<	8	8	pF
Emitter capacitance at f = 100 kHz					
$I_C = I_c = 0$; $V_{EB} = 0.5$ V	C_e	<	–	25	pF
Feedback time constant at f = 31.8 MHz					
$I_C = 20$ mA; $V_{CE} = 20$ V	$r_b\ C_c$	<	–	150	ps

[1]) Pulse duration ≤ 300 μs; duty cycle ≤ 2%.

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

h parameters (common emitter)

		2N2222A	
I_C = 1 mA; V_{CE} = 10 V; f = 1 kHz			
Input impedance	h_{ie}	2 to 8	kΩ
Reverse voltage transfer ratio	h_{re}	< 8	10^{-4}
Small signal current	h_{fe}	50 to 300	
Output admittance	h_{oe}	5 to 35	$\mu\Omega^{-1}$
I_C = 10 mA; V_{CE} = 10 V; f = 1 kHz			
Input impedance	h_{ie}	0.25 to 1.25	kΩ
Reverse voltage transfer ratio	h_{re}	< 4	10^{-4}
Small signal current gain	h_{fe}	75 to 375	
Output admittance	h_{oe}	25 to 200	$\mu\Omega^{-1}$

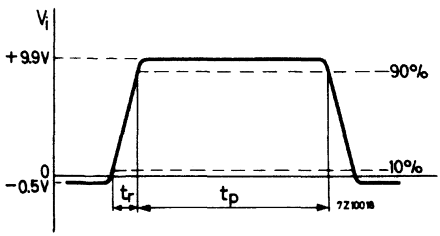
		2N2222	2N2222A	
I_C = 20 mA; V_{CE} = 20 V; f = 100 MHz				
Small signal current gain	h_{fe}	> 2.5	3.0	
I_C = 20 mA; V_{CE} = 20 V; f = 300 MHz				
Real part of input impedance	$Re(h_{ie})$	< 60	60	Ω
Noise figure at f = 1 kHz				
I_C = 0.1 mA; V_{CE} = 10 V; R_G = 1 kΩ; B = 1 Hz	F	< –	4	dB

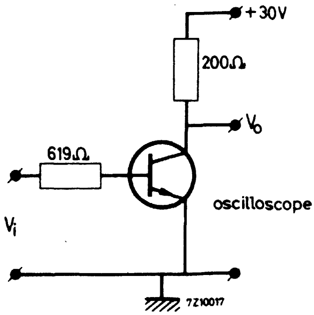
Switching times for 2N2222A

Turn on time when switched from
$-V_{BE}$ = 0.5 V to I_C = 150 mA; I_B = 15 mA

Delay time	t_d	< 10	ns
Rise time	t_r	< 25	ns

Test circuit:





Pulse generator:

pulse duration	t_p	≤ 200	ns
rise time	t_r	≤ 2	ns

Oscilloscope:

input resistance	R_i	> 100	kΩ
input capacitance	C_i	< 12	pF
rise time	t_r	< 5	ns

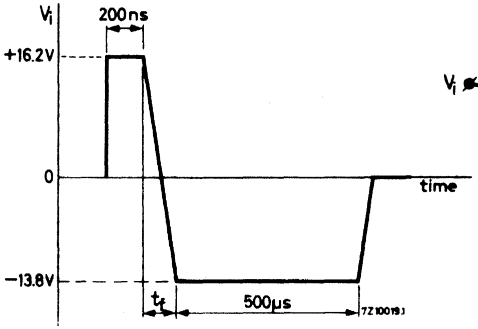
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

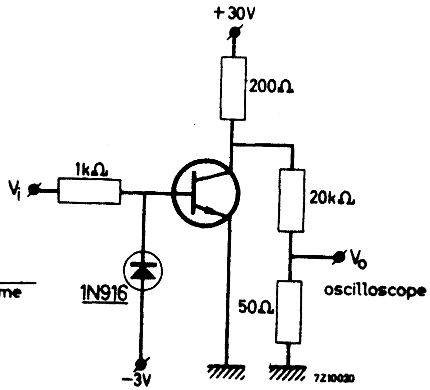
Switching times for 2N2222A

Turn off time
I_C = 150 mA; I_B = $-I_{BM}$ = 15 mA

Storage time	t_s	<	225	ns
Fall time	t_f	<	60	ns

Test circuit:





Pulse generator:
fall time t_f < 5 ns

Oscilloscope:

input impedance	R_i	>	100 kΩ
input capacitance	C_i	<	12 pF
rise time	t_r	<	5 ns

SILICON PLANAR EPITAXIAL TRANSISTORS

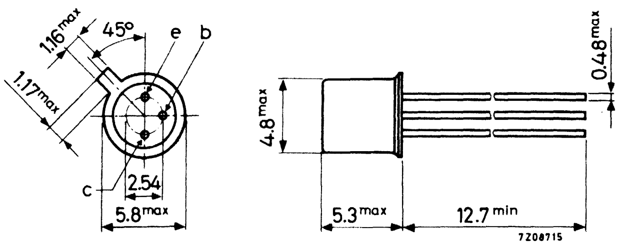
N-P-N transistors in a TO-18 metal envelope with the collector connected to the case. The 2N2368 and 2N2369 are primarily intended for use in very high-speed saturated switching and v.h.f. amplification.

QUICK REFERENCE DATA					
Collector-base voltage (open emitter)		V_{CBO}	max.	40	V
Collector-emitter voltage (open base)		V_{CEO}	max.	15	V
Collector current (peak value)		I_{CM}	max.	500	mA
Total power dissipation up to $T_{amb} = 25\ ^{o}C$		P_{tot}	max.	360	mW
Junction temperature		T_j	max.	200	^{o}C
D.C. current gain at $T_j = 25\ ^{o}C$					
$I_C = 10$ mA; $V_{CE} = 1$ V	2N2368	h_{FE}	20 to	60	
	2N2369	h_{FE}	40 to	120	
Transition frequency					
$I_C = 10$ mA; $V_{CE} = 10$ V	2N2368	f_T	>	400	MHz
	2N2369	f_T	>	500	MHz
Storage time					
$I_C = I_B = -I_{BM} = 10$ mA	2N2368	t_s	<	10	ns
	2N2369	t_s	<	13	ns

MECHANICAL DATA Dimensions in mm

Collector connected to case

TO-18



Accessories available: 56246, 56263

RATINGS (Limiting values) [1]

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector-emitter voltage with V_{BE} = 0	V_{CES}	max.	40	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4.5	V

Current

Collector current (peak value; t = 10 μs)	I_{CM}	max.	500	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360	mW

Temperatures

Storage temperature	T_{stg}	-65 to +200		°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	0.48	°C/mW
From junction to case	$R_{th\ j-c}$	=	0.145	°C/mW

1) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

$I_E = 0$; $V_{CB} = 20$ V	I_{CBO}	<	0.4	µA
$I_E = 0$; $V_{CB} = 20$ V; $T_j = 150$ °C	I_{CBO}	<	30	µA

Sustaining voltage [1]

$I_C = 10$ mA; $I_B = 0$	$V_{CEOsust}$	>	15	V [1]

Saturation voltages

$I_C = 10$ mA; $I_B = 1$ mA	V_{CEsat}	<	0.25	V
	V_{BEsat}		0.7 to 0.85	V

Collector capacitance at f = 140 kHz

$I_E = I_e = 0$; $V_{CB} = 5$ V	C_c	<	4	pF

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

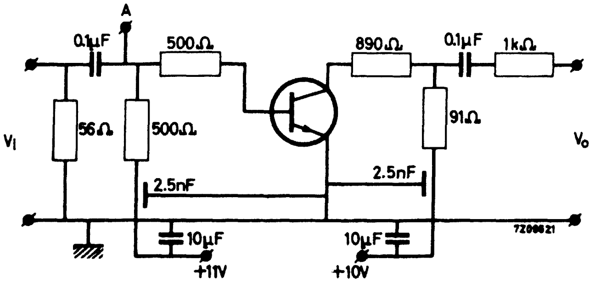
CHARACTERISTICS (continued) $T_j = 25\ ^oC$ unless otherwise specified

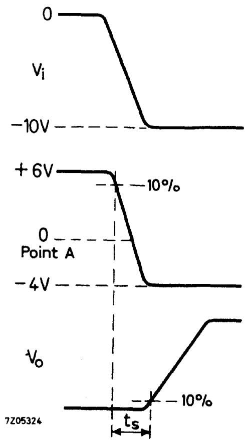
Storage time

$I_C = I_B = -I_{BM} = 10$ mA

2N2368	t_s	<	10	ns
2N2369	t_s	<	13	ns

Test circuit: [1])





Turn on time

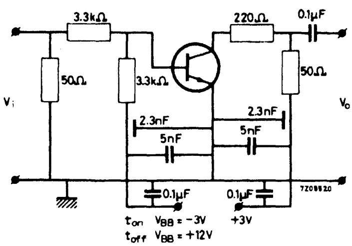
$I_C = 10$ mA; $I_B = 3$ mA; $-V_{BE} = 1.5$ V — t_{on} < 12 ns

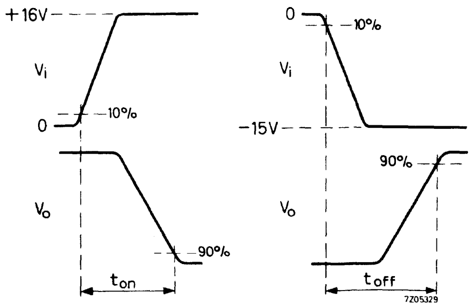
Turn off time

$I_C = 10$ mA; $I_B = 3$ mA; $-I_{BM} = 1.5$ mA

2N2368	t_{off}	<	15	ns
2N2369	t_{off}	<	18	ns

Test circuit: [1])





1) Pulse generator:

Pulse duration	t	≥	300	ns
Duty cycle	δ	≤	0.02	
Rise time	t_r	≤	1	ns
Source impedance	R_S	=	50	Ω

Oscilloscope:

Rise time	t_r	≤	1	ns
Input impedance	R_i	=	50	Ω

SILICON PLANAR EPITAXIAL TRANSISTOR

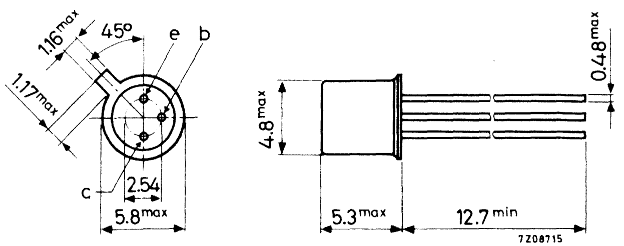
N-P-N transistor in a TO-18 metal envelope with the collector connected to the case. The 2N2369A is primarily intended for low-power very high-speed saturated switching applications in industrial service.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base)	V_{CEO}	max.	15	V
Collector current (peak value)	I_{CM}	max.	500	mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360	mW
Junction temperature	T_j	max.	200	°C
D.C. current gain at T_j = 25 °C				
I_C = 10 mA; V_{CE} = 1 V	h_{FE}		40 to 120	
Transition frequency				
I_C = 10 mA; V_{CE} = 10 V	f_T	>	500	MHz
Storage time				
I_C = I_B = $-I_{BM}$ = 10 mA	t_s	<	13	ns

MECHANICAL DATA Dimensions in mm

Collector connected to the case

TO-18



Accessories available: 56246, 56263

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	40	V
Collector-emitter voltage (open base) I_C = 0.01 to 10 mA	V_{CEO}	max.	15	V
Collector-emitter voltage with V_{BE} = 0	V_{CES}	max.	40	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4.5	V

Currents

Collector currents (d.c. or average over any 20 ms period)	I_C	max.	200	mA
Collector current (peak value; t = 10 μs)	I_{CM}	max.	500	mA

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360	mW

Temperatures

Storage temperature	T_{stg}		-65 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	0.48	°C/mW
From junction to case	$R_{th\ j\text{-}c}$	=	0.145	°C/mW

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current				
V_{BE} = 0; V_{CE} = 20 V	I_{CES}	<	0.4	μA
I_E = 0; V_{CB} = 20 V; T_j = 150 °C	I_{CBO}	<	30	μA
Base current				
V_{BE} = 0; V_{CE} = 20 V	$-I_{BEX}$	<	0.4	μA
Sustaining voltage [1]				
I_C = 10 mA; I_B = 0	$V_{CEOsust}$	>	15	V
Saturation voltages				
I_C = 10 mA; I_B = 1 mA	V_{CEsat}	<	0.2	V
	V_{BEsat}	0.7 to	0.85	V
I_C = 30 mA; I_B = 3 mA	V_{CEsat}	<	0.25	V
	V_{BEsat}	<	1.15	V
I_C = 100 mA; I_B = 10 mA	V_{CEsat}	<	0.5	V
	V_{BEsat}	<	1.6	V
I_C = 10 mA; I_B = 1 mA; T_j = 125 °C	V_{CEsat}	<	0.3	V
	V_{BEsat}	>	0.59	V
I_C = 10 mA; I_B = 1 mA; T_j = −55 °C	V_{BEsat}	<	1.02	V
D.C. current gain [1]				
I_C = 10 mA; V_{CE} = 1 V	h_{FE}	40 to	120	
I_C = 30 mA; V_{CE} = 0.4 V	h_{FE}	>	30	
I_C = 100 mA; V_{CE} = 1 V	h_{FE}	>	20	
I_C = 10 mA; V_{CE} = 1 V; T_j = −55 °C	h_{FE}	>	20	
Collector capacitance at f = 140 kHz				
I_E = I_e = 0; V_{CB} = 5 V	C_c	<	4	pF
Transition frequency				
I_C = 10 mA; V_{CE} = 10 V	f_T	>	500	MHz

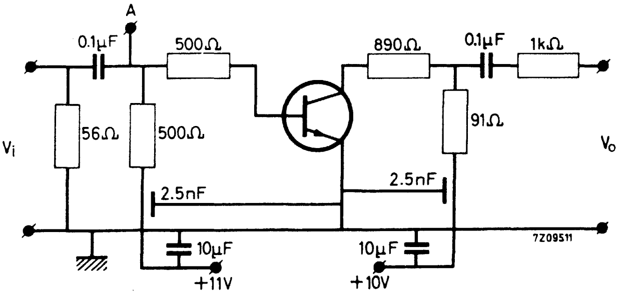
[1]) Measured under pulsed conditions to avoid excessive dissipation
Pulse duration t = 300 μs; duty cycle $\delta < 0.01$

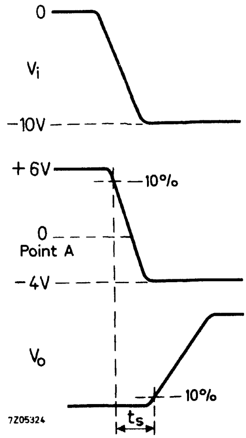
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Storage time

$I_C = I_B = -I_{BM} = 10$ mA t_s < 13 ns

Test circuit: 1)





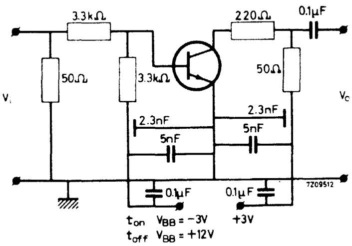
Turn on time

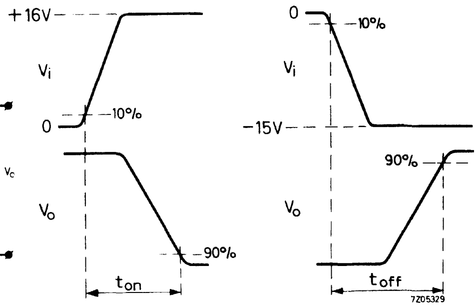
$I_C = 10$ mA; $I_B = 3$ mA; $-V_{BE} = 1.5$ V t_{on} < 12 ns

Turn off time

$I_C = 10$ mA; $I_B = 3$ mA; $-I_{BM} = 1.5$ mA t_{off} < 18 ns

Test circuit: 1)





1) Pulse generator:

Pulse duration	t	≥	300	ns
Duty cycle	δ	≤	0.02	
Rise time	t_r	≤	1	ns
Source impedance	R_S	=	50	Ω

Oscilloscope:

Rise time	t_r	≤	1	ns
Input impedance	R_i	=	50	Ω

SILICON LOW POWER SWITCHING TRANSISTORS

P-N-P transistors in a TO-18 metal envelope with the collector connected to the case. The 2N2894 is intended for medium speed, while the 2N2894A is intended for high speed, saturated switching applications for industrial service.

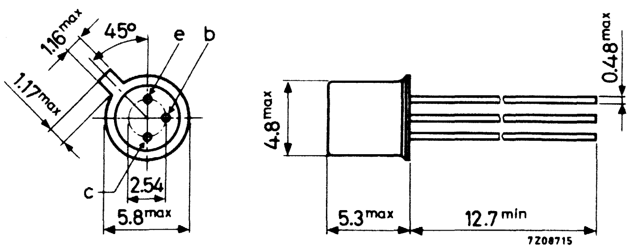
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	12		V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	12		V
Collector current (d.c.)	$-I_C$	max.	200		mA
Total power dissipation up to $T_{amb} = 25\,^oC$	P_{tot}	max.	360		mW
Junction temperature	T_j	max.	200		^oC
D.C. current gain at $T_{amb} = 25\,^oC$ $-I_C = 30$ mA; $-V_{CE} = 0.5$ V	h_{FE}	>	40		
			2N2894	2N2894A	
Turn-off time $-I_C = 30$ mA; $-I_{B1} = +I_{B2} = 1.5$ mA	t_{off}	<	90	35	ns

MECHANICAL DATA

Dimensions in mm

Collector connected to case
TO-18



Accessories supplied on request: 56246, 56263

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134)

Voltages			2N2894	2N2894A	
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	12	12	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	12	12	V [1]
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	4.0	4.5	V

Current				
Collector current (d.c.)	$-I_C$	max.	200	mA

Power dissipation				
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.36	W
up to T_{case} = 25 °C	P_{tot}	max.	1.2	W

Temperatures				
Storage temperature	T_{stg}	−65 to	+200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	486	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	146	°C/W

CHARACTERISTICS T_{amb} = 25 °C unless otherwise specified

Collector cut-off current			2N2894	2N2894A	
I_E = 0; $-V_{CB}$ = 6.0 V; T_{amb} = 125 °C	$-I_{CBO}$	<	10	–	μA
I_E = 0; $-V_{CB}$ = 10 V; T_{amb} = 125 °C	$-I_{CBO}$	<	–	10	μA
V_{BE} = 0; $-V_{CE}$ = 6.0 V	$-I_{CES}$	<	80	–	nA
V_{BE} = 0; $-V_{CE}$ = 10 V	$-I_{CES}$	<	–	50	nA
Breakdown voltages					
I_E = 0; $-I_C$ = 10 μA	$-V_{(BR)CBO}$	>	12	12	V
V_{BE} = 0; $-I_C$ = 10 μA	$-V_{(BR)CES}$	>	12	12	V
I_C = 0; $-I_E$ = 100 μA	$-V_{(BR)EBO}$	>	4.0	4.5	V

[1]) Applicable up to $-I_C$ = 10 mA

CHARACTERISTICS (continued) T_{amb} = 25 °C unless otherwise specified

			2N2894	2N2894A	
Sustaining voltage [1]					
$I_B = 0$; $-I_C = 10$ mA	$-V_{CEOsust}$	>	12	12	V
Saturation voltages [1]					
$-I_C = 10$ mA; $-I_B = 1.0$ mA	$-V_{CEsat}$	<	0.15	0.13	V
	$-V_{BEsat}$		0.78 to 0.98	0.78 to 0.92	V
$-I_C = 30$ mA; $-I_B = 3.0$ mA	$-V_{CEsat}$	<	0.2	0.19	V
	$-V_{BEsat}$		0.85 to 1.2	0.85 to 1.15	V
$-I_C = 100$ mA; $-I_B = 10$ mA	$-V_{CEsat}$	<	0.5	0.45	V
	$-V_{BEsat}$	>	–	1.0	V
		<	1.7	1.5	V
D.C. current gain [1]					
$-I_C = 1.0$ mA; $-V_{CE} = 0.5$ V	h_{FE}	>	–	20	
$-I_C = 10$ mA; $-V_{CE} = 0.3$ V	h_{FE}	>	30	30	
$-I_C = 30$ mA; $-V_{CE} = 0.5$ V	h_{FE}		40 to 150	40 to 120	
$-I_C = 30$ mA; $-V_{CE} = 0.5$ V; $T_{amb} = -55$ °C	h_{FE}	>	17	20	
$-I_C = 100$ mA; $-V_{CE} = 1.0$ V	h_{FE}	>	25	30	
Collector capacitance at f = 140 kHz					
$I_E = I_e = 0$; $-V_{CB} = 5.0$ V	C_c	<	6.0	4.5	pF
Emitter capacitance at f = 140 kHz					
$I_C = I_c = 0$; $-V_{EB} = 0.5$ V	C_e	<	6.0	6.0	pF
h parameter at f = 100 MHz (common emitter)					
$-I_C = 30$ mA; $-V_{CE} = 10$ V	h_{fe}	>	4.0	8.0	

[1] Pulse duration = 300 μs; duty cycle = 0.01

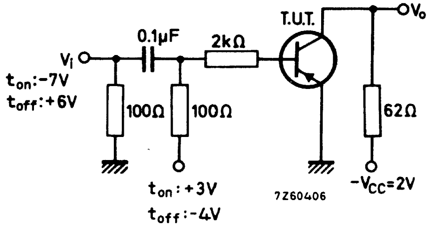
Switching times

T_{amb} = 25 °C unless otherwise specified

$-I_C$ = 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

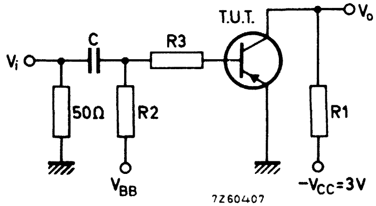
Sampling scope:

Rise time	t_r	<	1 ns
Input impedance	Z_i	=	100 kΩ

Switching times (continued) T_{amb} = 25 °C unless otherwise specified

Turn-on time	2N2894A	t_{on}	<	20	ns
Turn-off time	2N2894A	t_{off}	<	25	ns
Storage time	2N2894A	τ_s	<	20	ns

Test circuit:



Pulse generator:

Pulse duration = 400 ns
Rise time < 1 ns
Output impedance = 50 Ω

Sampling scope:

Rise time < 1 ns
Input impedance = 100 kΩ

	V_i (V)	V_{BB} (V)	R_1 (Ω)	R_2 (kΩ)	R_3 (kΩ)	$-I_C$ (mA)	$-I_{B1}$ (mA)	I_{B2} (mA)	C (μF)
t_{on}	-6.85	0	94	1.0	2.0	30	3.0	-	0.1
t_{off}	11.7	-9.85	94	1.0	2.0	30	3.0	3.0	0.1
τ_s	10	-11	270	0.5	0.5	10	10	10	0.33

P-N-P MEDIUM POWER GENERAL PURPOSE TRANSISTORS

P-N-P silicon planar epitaxial transistors in a TO-39 metal envelope with the collector connected to the case. These transistors are primarily intended for saturated switching and driver applications for industrial service.

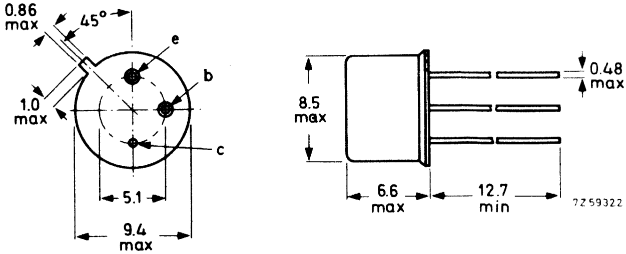
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60		V
Collector-emitter voltage (open base)					
2N2904	$-V_{CEO}$	max.	40		V
2N2904A	$-V_{CEO}$	max.	60		V
Collector current (d.c.)	$-I_C$	max.	0.6		A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.6		W
Junction temperature	T_j	max.	200		°C
Transition frequency					
$-I_C$ = 50 mA; $-V_{CE}$ = 20 V	f_T	>	200		MHz
D.C. current gain at T_j = 25 °C			2N2904	2N2904A	
$-I_C$ = 0.1 mA; $-V_{CE}$ = 10 V	h_{FE}	>	20	40	
$-I_C$ = 10 mA; $-V_{CE}$ = 10 V	h_{FE}	>	35	40	
$-I_C$ = 500 mA; $-V_{CE}$ = 10 V	h_{FE}	>	20	40	

MECHANICAL DATA

Dimensions in mm

Collecter connected to case
TO-39



max.lead diameter is guaranteed only for 12.7 mm

Accessories available: 56218, 56245, 56265

RATINGS (Limiting values) [1])

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base) $-I_C < 100$ mA — 2N2904	$-V_{CEO}$	max.	40	V
2N2904A	$-V_{CEO}$	max.	60	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	V

Current

Collector current (d.c.)	$-I_C$	max.	0.6	A

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.6	W
up to T_{case} = 25 °C	P_{tot}	max.	3	W

Temperatures

Storage temperature	T_{stg}		-65 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	290	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	58	°C/W

[1]) Limiting values according to the Absolute Maximum System as defined in IEC publication 134.

CHARACTERISTICS T_j = 25 °C unless otherwise specified

			2N2904	2N2904A	
Collector cut-off current					
I_E = 0; $-V_{CB}$ = 50 V	$-I_{CBO}$	<	20	10	nA
I_E = 0; $-V_{CB}$ = 50 V; T_j = 150 °C	$-I_{CBO}$	<	20	10	μA
$+V_{BE}$ = 0.5 V; $-V_{CE}$ = 30 V	$-I_{CEX}$	<	50		nA
Breakdown voltages					
I_E = 0; $-I_C$ = 10 μA	$-V_{(BR)CBO}$	>	60		V
I_B = 0; $-I_C$ = 10 mA 2N2904	$-V_{(BR)CEO}$	>	40		V
2N2904A	$-V_{(BR)CEO}$	>	60		V
I_C = 0; $-I_E$ = 10 μA	$-V_{(BR)EBO}$	>	5		V
Saturation voltages [1]					
$-I_C$ = 150 mA; $-I_B$ = 15 mA	$-V_{CEsat}$	<	0.4		V
	$-V_{BEsat}$	<	1.3		V
$-I_C$ = 500 mA; $-I_B$ = 50 mA	$-V_{CEsat}$	<	1.6		V
	$-V_{BEsat}$	<	2.6		V
D.C. current gain			2N2904	2N2904A	
$-I_C$ = 0.1 mA; $-V_{CE}$ = 10 V	h_{FE}	>	20	40	
$-I_C$ = 1 mA; $-V_{CE}$ = 10 V	h_{FE}	>	25	40	
$-I_C$ = 10 mA; $-V_{CE}$ = 10 V	h_{FE}	>	35	40	
$-I_C$ = 150 mA; $-V_{CE}$ = 10 V [1]	h_{FE}	>	40	40	
		<	120	120	
$-I_C$ = 500 mA; $-V_{CE}$ = 10 V [1]	h_{FE}	>	20	40	
Collector capacitance at f = 100 kHz					
I_E = I_e = 0; $-V_{CB}$ = 10 V	C_c	<	8		pF
Emitter capacitance at f = 100 kHz					
I_C = I_c = 0; $-V_{EB}$ = 2 V	C_e	<	30		pF
Transition frequency					
$-I_C$ = 50 mA; $-V_{CE}$ = 20 V	f_T	>	200		MHz

[1]) Measured under pulsed conditions to avoid excessive dissipation.
Pulse duration t ≤ 300 μs; duty cycle δ ≤ 0.02.

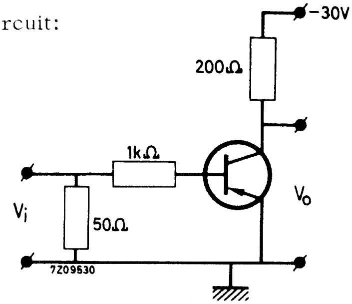
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

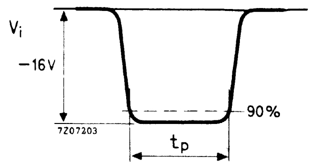
Switching times

Turn on time when switched to $-I_C$ = 150 mA; $-I_B$ = 15 mA

delay time	t_d	<	10	ns
rise time	t_r	<	40	ns
turn on time	t_{on}	<	45	ns

Test circuit:





Oscilloscope:

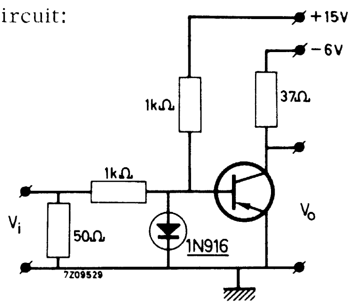
Rise time	t_r	≤	5 ns
Input impedance	Z_i	=	10 MΩ

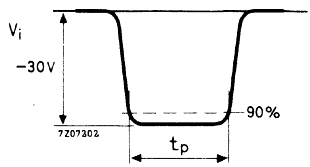
Pulse generator:	Frequency	f	=	150 Hz
	Pulse duration	t_p	=	200 ns
	Rise time	t_r	≤	2 ns
	Output impedance	Z_o	=	50 Ω

Turn off time when switched from
$-I_C$ = 150 mA; $-I_B$ = 15 mA to cut-off with $+I_{BM}$ = 15 mA

storage time	t_s	<	80	ns
fall time	t_f	<	30	ns
turn off time	t_{off}	<	100	ns

Test circuit:





Oscilloscope:

Rise time	t_r	≤	5 ns
Input impedance	Z_i	=	10 MΩ

Pulse generator:	Frequency	f	=	150 Hz
	Pulse duration	t_p	=	200 ns
	Rise time	t_r	≤	2 ns
	Output impedance	Z_o	=	50 Ω

P-N-P MEDIUM POWER GENERAL PURPOSE TRANSISTORS

P-N-P silicon planar epitaxial transistors in a TO-39 metal envelope with the collector connected to the case. These transistors are primarily intended for saturated switching and driver applications for industrial service.

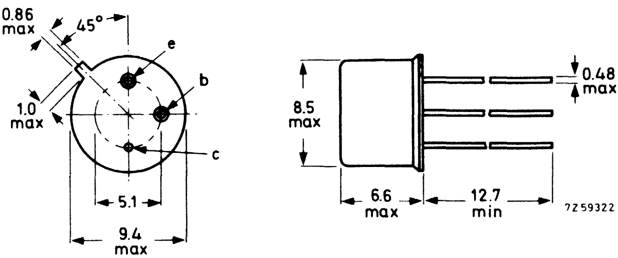
QUICK REFERENCE DATA

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base)				
2N2905	$-V_{CEO}$	max.	40	V
2N2905A	$-V_{CEO}$	max.	60	V
Collector current (d.c.)	$-I_C$	max.	0.6	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.6	W
Junction temperature	T_j	max.	200	°C
Transition frequency				
$-I_C$ = 50 mA; $-V_{CE}$ = 20 V	f_T	>	200	MHz
D.C. current gain at T_j = 25 °C			2N2905	2N2905A
$-I_C$ = 0.1 mA; $-V_{CE}$ = 10 V	h_{FE}	>	35	75
$-I_C$ = 10 mA; $-V_{CE}$ = 10 V	h_{FE}	>	75	100
$-I_C$ = 500 mA; $-V_{CE}$ = 10 V	h_{FE}	>	30	50

MECHANICAL DATA

Dimensions in mm

Collecter connected to case
TO-39



max. lead diameter is guaranteed only for 12.7 mm

Accessories available: 56218, 56245, 56265

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		nA
Breakdown voltages						
$I_E = 0$; $-I_C = 10$ μA		$-V_{(BR)CBO}$	>	60		V
$I_B = 0$; $-I_C = 10$ mA	2N2905	$-V_{(BR)CEO}$	>	40		V
	2N2905A	$-V_{(BR)CEO}$	>	60		V
$I_C = 0$; $-I_E = 10$ μA		$-V_{(BR)EBO}$	>	5		V
Saturation voltages [1]						
$-I_C = 150$ mA; $-I_B = 15$ mA		$-V_{CEsat}$	<	0.4		V
		$-V_{BEsat}$	<	1.3		V
$-I_C = 500$ mA; $-I_B = 50$ mA		$-V_{CEsat}$	<	1.6		V
		$-V_{BEsat}$	<	2.6		V

D.C. current gain			2N2905	2N2905A
$-I_C = 0.1$ mA; $-V_{CE} = 10$ V	h_{FE}	>	35	75
$-I_C = 1$ mA; $-V_{CE} = 10$ V	h_{FE}	>	50	100
$-I_C = 10$ mA; $-V_{CE} = 10$ V	h_{FE}	>	75	100
$-I_C = 150$ mA; $-V_{CE} = 10$ V [1]	h_{FE}	>	100	100
		<	300	300
$-I_C = 500$ mA; $-V_{CE} = 10$ V [1]	h_{FE}	>	30	50

Collector capacitance at f = 100 kHz				
$I_E = I_e = 0$; $-V_{CB} = 10$ V	C_c	<	8	pF
Emitter capacitance at f = 100 kHz				
$I_C = I_c = 0$; $-V_{EB} = 2$ V	C_e	<	30	pF
Transition frequency				
$-I_C = 50$ mA; $-V_{CE} = 20$ V	f_T	>	200	MHz

[1]) Measured under pulsed conditions to avoid excessive dissipation.
Pulse duration $t \leq 300$ μs; duty cycle $\delta \leq 0.02$.

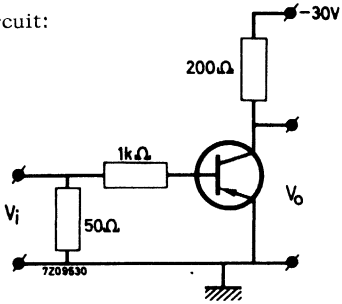
CHARACTERISTICS (continued) $T_j = 25\ ^oC$ unless otherwise specified

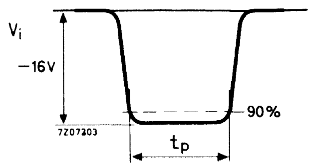
Switching times

Turn on time when switched to $-I_C = 150$ mA; $-I_B = 15$ mA

delay time	t_d	<	10	ns
rise time	t_r	<	40	ns
turn on time	t_{on}	<	45	ns

Test circuit:





Oscilloscope:

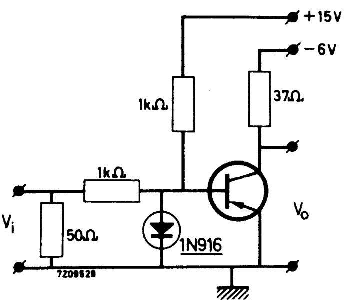
Rise time	t_r	≤	5	ns
Input impedance	Z_i	=	10	MΩ

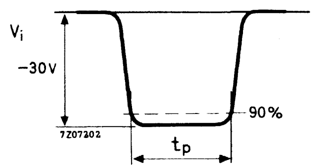
Pulse generator:	Frequency	f	=	150 Hz
	Pulse duration	t_p	=	200 ns
	Rise time	t_r	≤	2 ns
	Output impedance	Z_o	=	50 Ω

Turn off time when switched from
$-I_C = 150$ mA; $-I_B = 15$ mA to cut-off with $+I_{BM} = 15$ mA

storage time	t_s	<	80	ns
fall time	t_f	<	30	ns
turn off time	t_{off}	<	100	ns

Test circuit:





Oscilloscope:

Rise time	t_r	≤	5	ns
Input impedance	Z_i	=	10	MΩ

Pulse generator:	Frequency	f	=	150 Hz
	Pulse duration	t_p	=	200 ns
	Rise time	t_r	≤	2 ns
	Output impedance	Z_o	=	50 Ω

P-N-P MEDIUM POWER
GENERAL PURPOSE TRANSISTORS

P-N-P silicon planar epitaxial transistors in a TO-18 metal envelope with the collector connected to the case. These transistors are primarily intended for saturated switching and driver applications for industrial service.

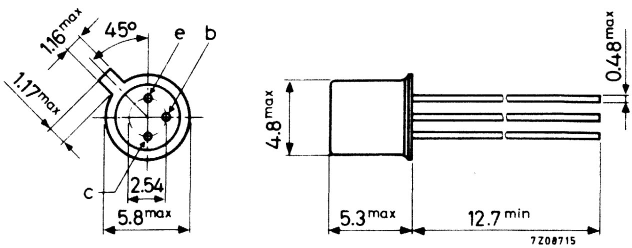
QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base)				
2N2906	$-V_{CEO}$	max.	40	V
2N2906A	$-V_{CEO}$	max.	60	V
Collector current (d.c.)	$-I_C$	max.	0.6	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.4	W
Junction temperature	T_j	max.	200	°C
Transition frequency at f = 100 MHz				
$-I_C$ = 50 mA; $-V_{CE}$ = 20 V; T_{amb} = 25 °C	f_T	>	200	MHz
D.C. current gain at T_j = 25 °C			2N2906	2N2906A
$-I_C$ = 0.1 mA; $-V_{CE}$ = 10 V	h_{FE}		> 20	40
$-I_C$ = 10 mA; $-V_{CE}$ = 10 V	h_{FE}		> 35	40
$-I_C$ = 500 mA; $-V_{CE}$ = 10 V	h_{FE}		> 20	40

MECHANICAL DATA

Dimensions in mm

Collector connected to case

TO-18



Accessories available: 56246, 56263

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base) $-I_C < 100$ mA — 2N2906	$-V_{CEO}$	max.	40	V
2N2906A	$-V_{CEO}$	max.	60	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	V

Current

Collector current (d.c.)	$-I_C$	max.	0.6	A

Power dissipation

Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.4	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.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	438	°C/W
From junction to case	$R_{th\ j-a}$	=	97	°C/W

CHARACTERISTICS

T_j = 25 °C unless otherwise specified

Collector cut-off current		2N2906	2N2906A	
$I_E = 0$; $-V_{CB} = 50$ 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 ≤ 300 μs; duty cycle δ ≤ 0.02.

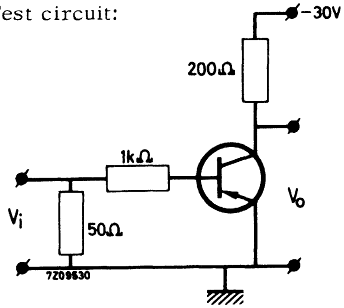
CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

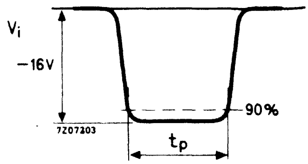
Switching times

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:





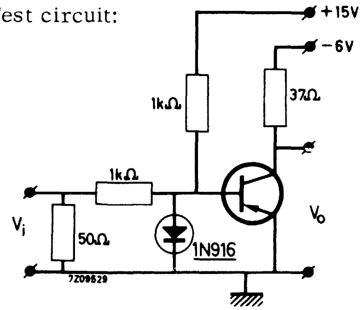
Oscilloscope:
Rise time $t_r \leq$ 5 ns
Input impedance Z_i = 10 MΩ

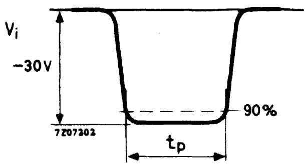
Pulse generator:			
Frequency	f	=	150 Hz
Pulse duration	t_p	=	200 ns
Rise time	t_r	≤	2 ns
Output impedance	Z_o	=	50 Ω

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

P-N-P MEDIUM POWER GENERAL PURPOSE TRANSISTORS

P-N-P silicon planar epitaxial transistors in a TO-18 metal envelope with the collector connected to the case. These transistors are primarily intended for saturated switching and driver applications for industrial service.

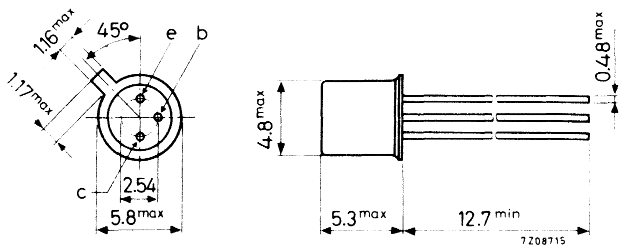
QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base)				
2N2907	$-V_{CEO}$	max.	40	V
2N2907A	$-V_{CEO}$	max.	60	V
Collector current (d.c.)	$-I_C$	max.	0.6	A
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.4	W
Junction temperature	$-T_j$	max.	200	°C
Transition frequency at f = 100 MHz				
$-I_C$ = 50 mA; $-V_{CE}$ = 20 V; T_{amb} = 25 °C	f_T	>	200	MHz
D.C. current gain at T_j = 25 °C			2N2907	2N2907A
$-I_C$ = 0.1 mA; $-V_{CE}$ = 10 V	h_{FE}	>	35	75
$-I_C$ = 10 mA; $-V_{CE}$ = 10 V	h_{FE}	>	75	100
$-I_C$ = 500 mA; $-V_{CE}$ = 10 V	h_{FE}	>	30	50

MECHANICAL DATA

Dimensions in mm

Collector connected to case

TO-18



Accessories available: 56246, 56263

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC134).

Voltages				
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	60	V
Collector-emitter voltage (open base) $-I_C < 100$ mA — 2N2907	$-V_{CEO}$	max.	40	V
2N2907A	$-V_{CEO}$	max.	60	V
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	5	V
Current				
Collector current (d.c.)	$-I_C$	max.	0.6	A
Power dissipation				
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	0.4	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.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j-a}$	=	438	°C/W
From junction to case	$R_{th\ j-c}$	=	97	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off current

			2N2907	2N2907A	
$I_E = 0$; $-V_{CB} = 50$ V	$-I_{CBO}$	<	20	10	nA
$I_E = 0$; $-V_{CB} = 50$ V; $T_j = 150$ °C	$-I_{CBO}$	<	20	10	μA
$+V_{BE} = 0.5$ V; $-V_{CE} = 30$ V	$-I_{CEX}$	<	50		nA

Breakdown voltages

$I_E = 0$; $-I_C = 10$ μA		$-V_{(BR)CBO}$	>	60	V
$I_B = 0$; $-I_C = 10$ mA	2N2907	$-V_{(BR)CEO}$	>	40	V
	2N2907A	$-V_{(BR)CEO}$	>	60	V
$I_C = 0$; $-I_E = 10$ μA		$-V_{(BR)EBO}$	>	5	V

Saturation voltages [1]

$-I_C = 150$ mA; $-I_B = 15$ mA	$-V_{CEsat}$	<	0.4	V
	$-V_{BEsat}$	<	1.3	V
$-I_C = 500$ mA; $-I_B = 50$ mA	$-V_{CEsat}$	<	1.6	V
	$-V_{BEsat}$	<	2.6	V

D.C. current gain

			2N2907	2N2907A
$-I_C = 0.1$ mA; $-V_{CE} = 10$ V	h_{FE}	>	35	75
$-I_C = 1$ mA; $-V_{CE} = 10$ V	h_{FE}	>	50	100
$-I_C = 10$ mA; $-V_{CE} = 10$ V	h_{FE}	>	75	100
$-I_C = 150$ mA; $-V_{CE} = 10$ V [1]	h_{FE}	>	100	100
		<	300	300
$-I_C = 500$ mA; $-V_{CE} = 10$ V [1]	h_{FE}	>	30	50

Collector capacitance at f = 100 kHz

$I_E = I_e = 0$; $-V_{CB} = 10$ V	C_c	<	8	pF

Emitter capacitance at f = 100 kHz

$I_C = I_c = 0$; $-V_{EB} = 2$ V	C_e	<	30	pF

Transition frequency at f = 100 MHz

$-I_C = 50$ mA; $-V_{CE} = 20$ V; $T_{amb} = 25$ °C	f_T	>	200	MHz

[1]) Measured under pulsed conditions to avoid excessive dissipation.
Pulsed duration $t \leq 300$ μs; duty cycle $\delta \leq 0.02$.

CHARACTERISTICS (continued)

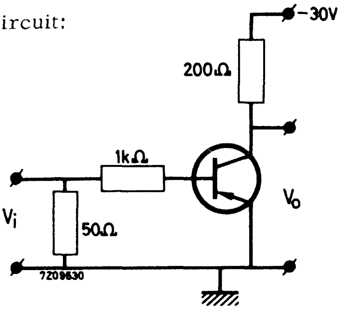
T_j = 25 °C unless otherwise specified

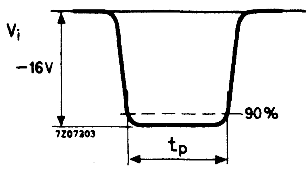
Switching times

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:

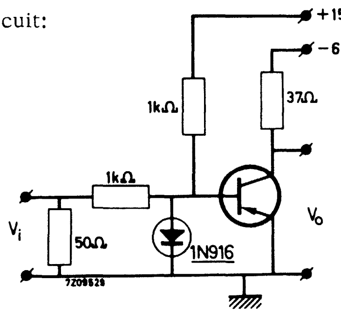
Rise time	t_r	≤	5	ns
Input impedance	Z_i	=	10	MΩ

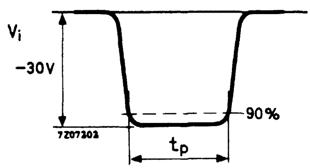
Pulse generator:	Frequency	f	=	150 Hz
	Pulse duration	t_p	=	200 ns
	Rise time	t_r	≤	2 ns
	Output impedance	Z_o	=	50 Ω

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

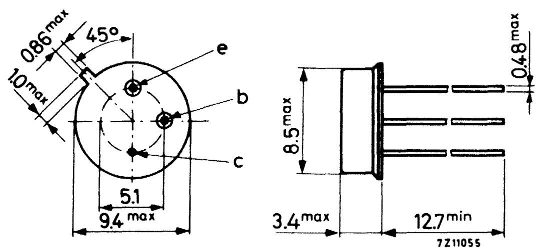
N-P-N transistors in a TO-39 (reduced height) metal envelope with the collector connected to the case. They are intended for very high speed switching capability in high current applications.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	V_{CBO}	max.	25	V
Collector-emitter voltage (open base)	V_{CEO}	max.	12	V
Collector current (d.c.)	I_C	max.	1	A
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	3	W
Junction temperature	T_j	max.	200	°C
Collector-emitter saturation voltage I_C = 100 mA; I_B = 10 mA	V_{CEsat}	<	230	mV
D.C. current gain at T_j = 25 °C I_C = 300 mA; V_{CE} = 0.5 V	h_{FE}		30 to 120	
Transition frequency I_C = 100 mA; V_{CE} = 5 V; f = 100 MHz	f_T	>	450	MHz
Storage time when switched from $I_C = I_{B1} = -I_{B2}$ = 100 mA	τ_s	<	15	ns

MECHANICAL DATA Dimensions in mm

TO-39 (reduced height)

Collector connected to case



max. lead diameter is guaranteed only for 12.7 mm

Accessories supplied on request: 56218

RATINGS Limiting values in accordance with the Absolute Maximum System (IEC 134)

Voltages

Collector-base voltage (open emitter)	V_{CBO}	max.	25	V
Collector-emitter voltage (open base) I_C = 0.1 to 30 mA	V_{CEO}	max.	12	V
Emitter-base voltage (open collector)	V_{EBO}	max.	4	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.	0.6	W
up to T_{case} = 25 °C	P_{tot}	max.	3	W

Temperatures

Storage temperature	T_{stg}		−65 to +200	°C
Junction temperature	T_j	max.	200	°C

THERMAL RESISTANCE

From junction to ambient in free air	$R_{th\ j\text{-}a}$	=	290	°C/W
From junction to case	$R_{th\ j\text{-}c}$	=	58	°C/W

CHARACTERISTICS T_j = 25 °C unless otherwise specified

Collector cut-off currents				
$V_{BE} = 0$; $V_{CE} = 15$ V	I_{CES}	<	100	µA
Base current				
$V_{BE} = 0$; $V_{CE} = 15$ V	$-I_B$	<	100	µA
Breakdown voltages				
$I_E = 0$; $I_C = 0.5$ mA	$V_{(BR)CBO}$	>	25	V
$I_C = 0$; $I_E = 0.1$ mA	$V_{(BR)EBO}$	>	4	V
Sustaining voltage [1]				
$I_B = 0$; $I_C = 30$ mA	$V_{CEOsust}$	>	12	V
Saturation voltages				
I_C = 10 mA; I_B = 1 mA	V_{CEsat}	<	0.25	V
	V_{BEsat}	<	0.78	V
I_C = 100 mA; I_B = 10 mA [1]	V_{CEsat}	<	0.23	V
	V_{BEsat}	<	1.10	V
I_C = 300 mA; I_B = 30 mA [1]	V_{CEsat}	<	0.33	V
	V_{BEsat}	<	1.30	V

			2N3303	2N3426	
I_C = 300 mA; I_B = 30 mA; T_{amb} = 125 °C [1]	V_{CEsat}	<	0.5	–	V
I_C = 300 mA; I_B = 30 mA; T_{amb} = 85 °C [1]	V_{CEsat}	<	–	0.5	V
I_C = 1000 mA; I_B = 100 mA [1]	V_{CEsat}	<	0.7	0.7	V
	V_{BEsat}	<	2.1	0.9 to 2.1	V

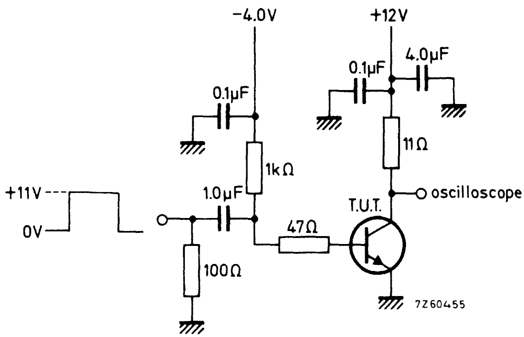
D.C. current gain				
I_C = 10 mA; V_{CE} = 0.5 V		h_{FE}	>	20
I_C = 100 mA; V_{CE} = 0.5 V [1]		h_{FE}	>	30
I_C = 300 mA; V_{CE} = 0.5 V [1]		h_{FE}		30 to 120
I_C = 300 mA; V_{CE} = 0.5 V; T_{amb} = −55 °C [1]	2N3303	h_{FE}	>	10

[1]) Measured under pulsed conditions to avoid excessive dissipation.
Pulse duration t = 300 µs; 2N3303: $\delta \leq 0.02$
2N3426: $\delta = 0.01$

CHARACTERISTICS (continued) T_j = 25 °C unless otherwise specified

Collector capacitance at f = 140 kHz					
$I_E = I_e = 0$; $V_{CB} = 0$	2N3426	C_c	<	25	pF
$I_E = I_e = 0$; $V_{CB} = 5$ V		C_c	<	15	pF
Emitter capacitance at f = 140 kHz					
$I_C = I_c = 0$; $V_{EB} = 0.5$ V		C_e	<	25	pF
Transition frequency at f = 100 MHz					
I_C = 100 mA; V_{CE} = 5 V		f_T	>	450	MHz
I_C = 500 mA; V_{CB} = 0	2N3426	f_T	>	200	MHz
Switching times					
Turn on time when switched from					
$-V_{BE}$ = 4 V to I_C = 1 A; I_B = 100 mA		turn on time t_{on}	<	15	ns
	2N3426	delay time t_d	<	5	ns
	2N3426	rise time t_r	<	15	ns
Turn off time when switched from					
I_C = 1 A; I_B = 0.1 A					
to cut off with $-I_{BM}$ = 0.1 A		turn off time t_{off}	<	25	ns
	2N3426	storage time t_s	<	20	ns
	2N3426	fall time t_f	<	15	ns

Test circuit:



Pulse generator:

t_p = 100 ns
t_r < 1 ns
t_f < 1 ns
Z_o = 50 Ω

Oscilloscope:

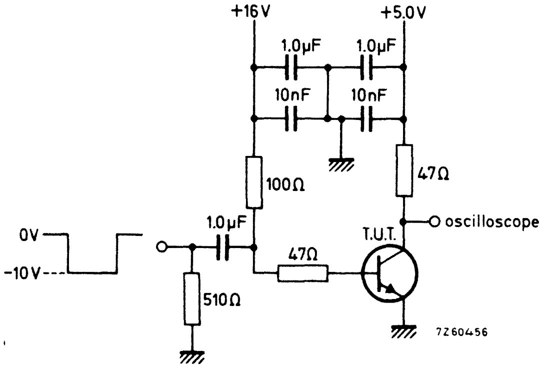
Z_i = 100 kΩ
t_r < 1 ns

CHARACTERISTICS (continued) $T_j = 25\ ^oC$ unless otherwise specified

Storage time

$I_C = I_{B1} = -I_{B2} = 0.1$ A	τ_s	<	15	ns

Test circuit:



Pulse generator:

$t_p = 100$ ns
$t_r < 1$ ns
$Z_o = 50\ \Omega$

Oscilloscope:

$Z_i = 100\ k\Omega$
$t_r < 1$ ns

SILICON EPITAXIAL TRANSISTOR

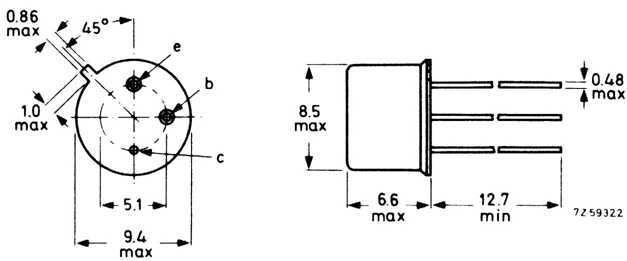
P-N-P transistor in a TO-39 metal envelope with the collector connected to the case. The transistor is intended for general industrial applications.

QUICK REFERENCE DATA				
Collector-base voltage (open emitter)	$-V_{CBO}$	max.	90	V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	65	V
Collector current (d.c.)	$-I_C$	max.	1.0	A
Total power dissipation up to T_{case} = 25 °C	P_{tot}	max.	5	W
Junction temperature	T_j	max.	200	°C
Collector-emitter saturation voltage $-I_C$ = 150 mA; $-I_B$ = 15 mA	$-V_{CEsat}$	<	0.65	V
D.C. current gain $-I_C$ = 150 mA; $-V_{CE}$ = 10 V	h_{FE}		40 to 140	
Transition frequency at f = 20 MHz $-I_C$ = 50 mA; $-V_{CE}$ = 10 V	f_T	>	60	MHz

MECHANICAL DATA

Dimensions in mm

TO-39
Collector connected
to case



max. lead diameter is guaranteed only for 12.7 mm.

Accessories supplied on request: 56218, 56245, 56265.

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 °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; $T_{case} = 150$ °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

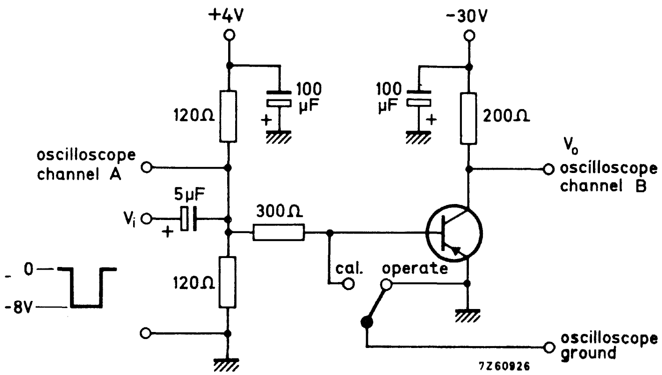
Turn on time
$-I_C$ = 150 mA; $-I_B$ = $+I_{BM}$ = 15 mA

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:

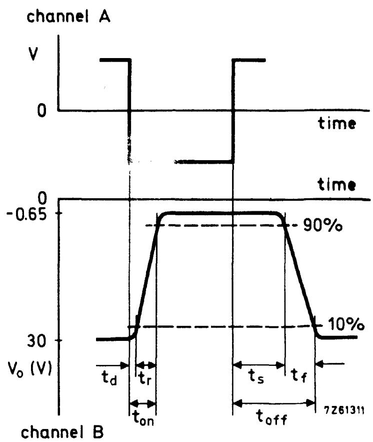


Pulse generator:

f = 10 kHz
t_r < 10 ns
t_p = 20 µs

Oscilloscope:

Z_i = 10 MΩ
C_i = 20 pF
t_r < 15 ns



Accessories

Introduction

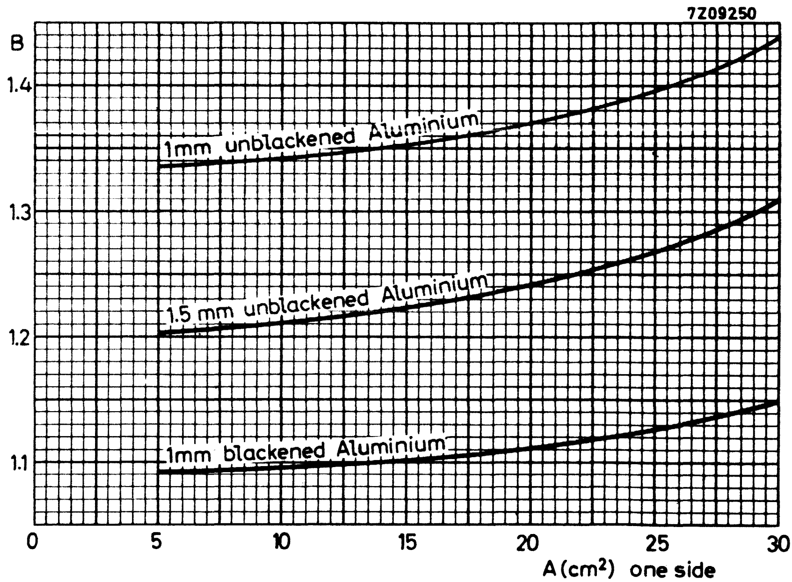
All information on thermal resistances of the accessories combined with flat heatsinks is valid for square heatsinks of 1.5 mm blackened aluminium.
For a few variations the thermal resistance may be derived as follows:

a. Rectangular heatsinks (sides a and 2a)

When mounted with long side horizontal, multiply by 0.95.
When mounted with short side horizontal, multiply by 1.10.

b. Unblackened or thinner heatsinks

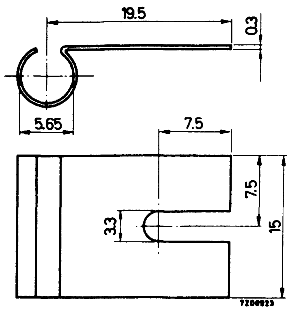
Multiply by the factor B given below as a function of the heatsink size A.



COOLING FIN

MECHANICAL DATA

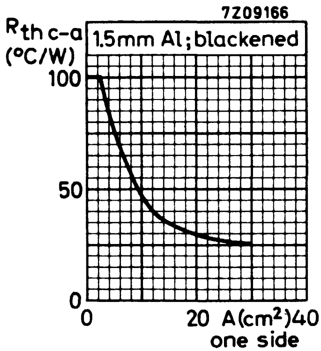
Dimensions in mm



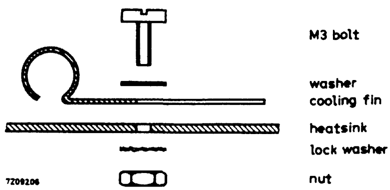
Fin material: brass, nickel plated

THERMAL RESISTANCE

From case to ambient with cooling fin only $R_{th\ c-a}$ = 100 °C/W
with heatsink see graph



MOUNTING INSTRUCTIONS

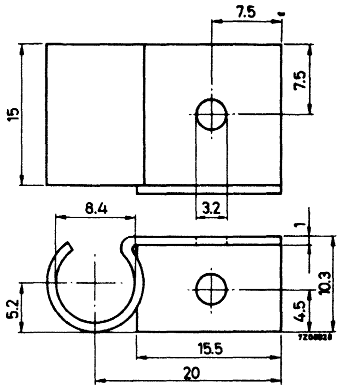


Torque on nut for good heat transfer: 5 cm kg

COOLING FIN

MECHANICAL DATA

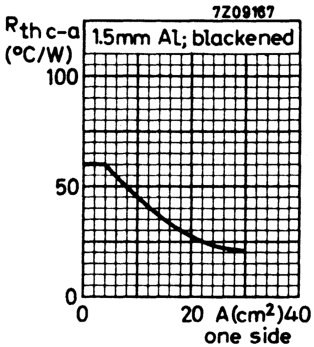
Dimensions in mm



Fin material: aluminium, blackened

THERMAL RESISTANCE

From case to ambient with cooling fin only — $R_{th\ c\text{-}a}$ = 60 °C/W
with heatsink — see graph



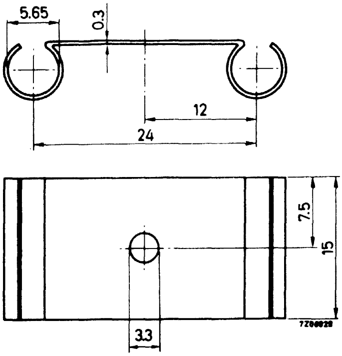
MOUNTING INSTRUCTIONS

Torque on M3 bolts for good heat transfer: 5 cmkg

COOLING FIN

MECHANICAL DATA

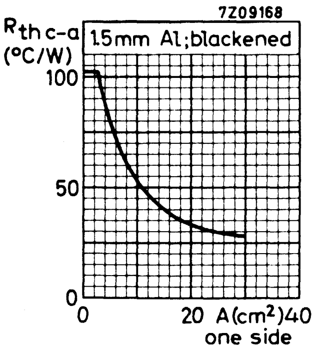
Dimensions in mm



Fin material: brass, nickel plated

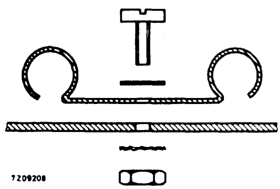
THERMAL RESISTANCE

From case to ambient with cooling fin only — $R_{th\ c-a}$ = 102 °C/W
with heatsink — see graph



R_{th} values apply to each transistor, provided the two transistors have been mounted so that the heat flow from each is equal.

MOUNTING INSTRUCTIONS

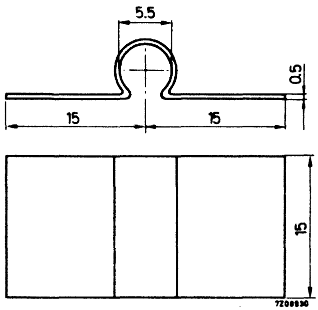


Torque on nut for good heat transfer: 5 cmkg

COOLING FIN

MECHANICAL DATA

Dimensions in mm



Fin material: brass, nickel plated

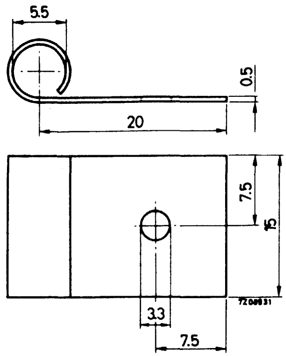
THERMAL RESISTANCE

From case to ambient with cooling fin only $R_{th\ c-a}$ = 75 °C/W

COOLING FIN

MECHANICAL DATA

Dimensions in mm

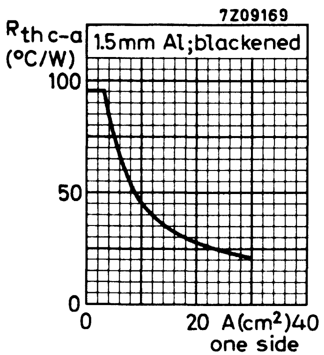


Fin material: brass, nickel plated

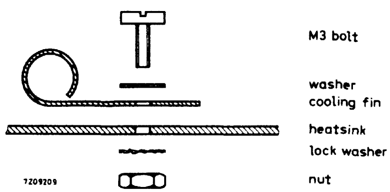
THERMAL RESISTANCE

From case to ambient with cooling fin only — $R_{th\ c\text{-}a}$ = 95 °C/W

with heatsink — see graph



MOUNTING INSTRUCTIONS

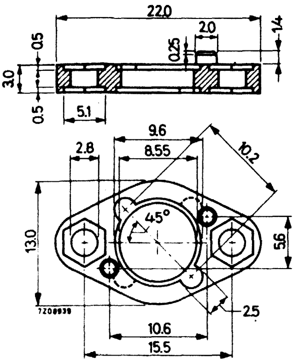


Torque on nut for good heat transfer: 5 cmkg

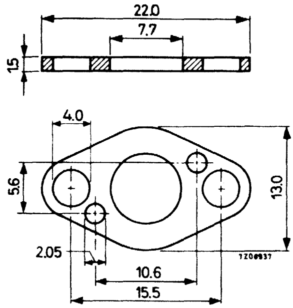
MOUNTING ACCESSORIES

MECHANICAL DATA

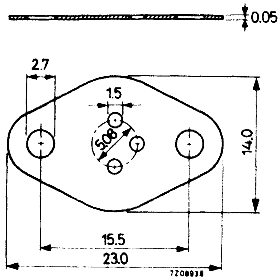
Dimensions in mm



top clamping washer
of insulating material



bottom clamping washer
material: brass, tin plated



mylar washer

THERMAL RESISTANCE

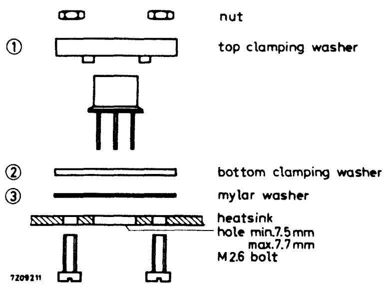
From mounting base to heatsink non insulated mounting $R_{th\ mb-h}$ = 3 °C/W

insulated mounting $R_{th\ mb-h}$ = 6 °C/W

TEMPERATURE

Maximum allowable temperature T_{max} = 100 °C

MOUNTING INSTRUCTIONS

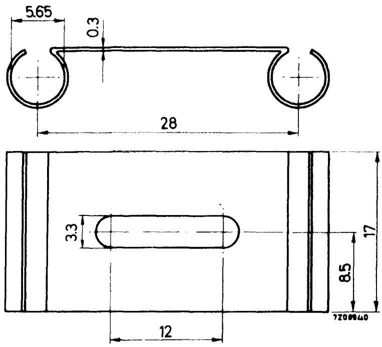


Non insulated mounting; without items 2 and 3. (Note: item 1 must than be mounted up-side down)

COOLING FIN

MECHANICAL DATA

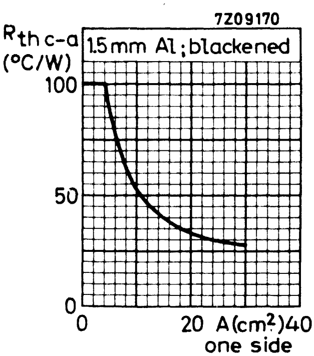
Dimensions in mm



Fin material: brass, nickel plated

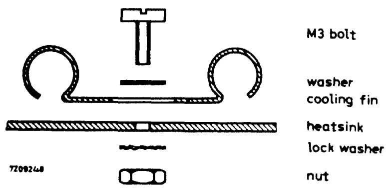
THERMAL RESISTANCE

From case to ambient with cooling fin only — $R_{th\ c-a}$ = 100 °C/W
with heatsink — see graph



R_{th} values apply to each transistor, provided the two transistors have been mounted so that the heat flow from each is equal.

MOUNTING INSTRUCTIONS

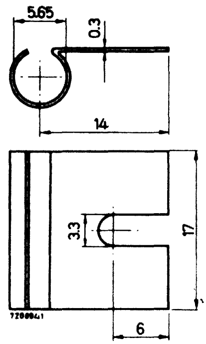


Torque on nut for good heat transfer: 5 cm kg

COOLING FIN

MECHANICAL DATA

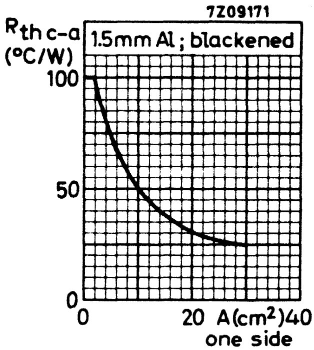
Dimensions in mm



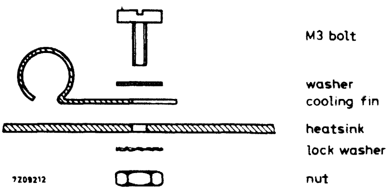
Fin material: brass, nickel plated

THERMAL RESISTANCE

From case to ambient with cooling fin only	$R_{th\ c\text{-}a}$	= 100 °C/W
with heatsink		see graph



MOUNTING INSTRUCTIONS

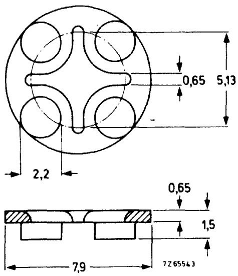


Torque on nut for good heat transfer: 5 cm kg

DISTANCE DISCS

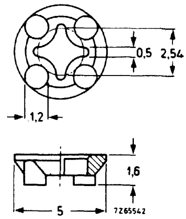
MECHANICAL DATA Dimensions in mm

56245



Insulating material

56246



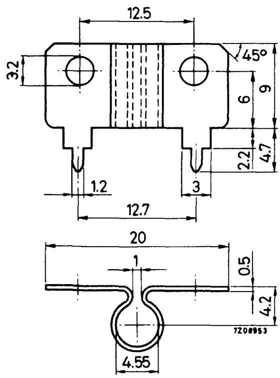
Insulating material

TEMPERATURE

Maximum allowable temperature T_{max} = 100 °C

56263 COOLING FIN

MECHANICAL DATA Dimensions in mm



Fin material: copper, tin plated

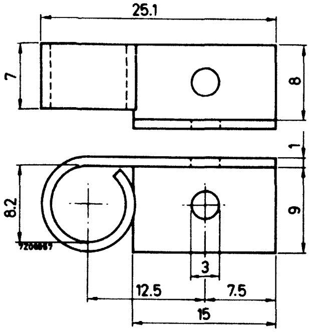
THERMAL RESISTANCE

From case to ambient $R_{th\ c-a}$ = 100 °C/W

COOLING FIN

MECHANICAL DATA

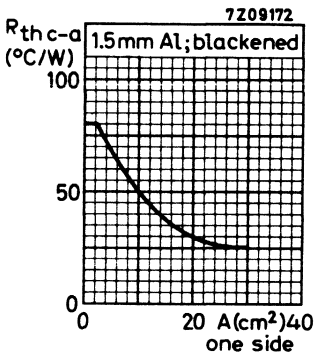
Dimensions in mm



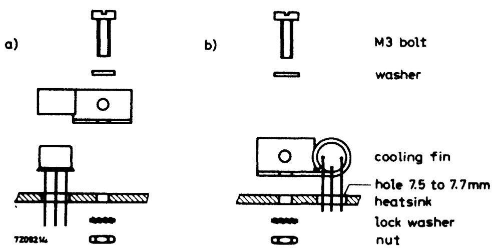
Fin material: aluminium, blackened

THERMAL RESISTANCE

From case to ambient with cooling fin only	$R_{th\ c\text{-}a}$	= 80 °C/W
with heatsink		see graph



MOUNTING INSTRUCTIONS



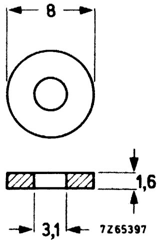
Torque on nut for good heat transfer: 5 cm kg

WASHER

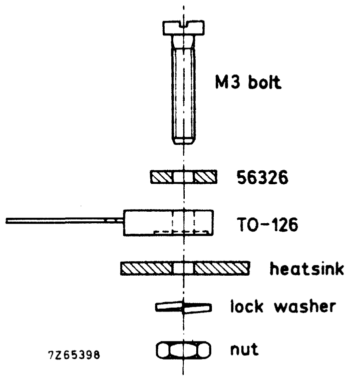
Flat metal washer for non-insulated mounting of envelope SOT-32 (TO-126).

MECHANICAL DATA

Dimensions in mm



MOUNTING INSTRUCTIONS



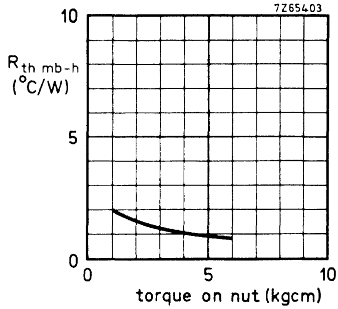
Minimum torque on nut for good heat transfer	4 kgcm (0, 4 Nm)
Maximum torque on nut	6 kgcm (0, 6 Nm)
Minimum thickness of heatsink	2 mm

The heatsink surface must appear flat and smooth, without burrs or scratches. If the hole in the heatsink is threaded, it should be countersunk and free of burrs; the hole should also be perpendicular to the plane of the heatsink, within 2^o tolerance (for M3 thread).
For mounting on a heatsink the use of a heat conducting compound is recommended.

THERMAL RESISTANCE

From mounting base to heatsink $R_{th\ mb\text{-}h}$ = 1 $^oC/W$

See also the graph.

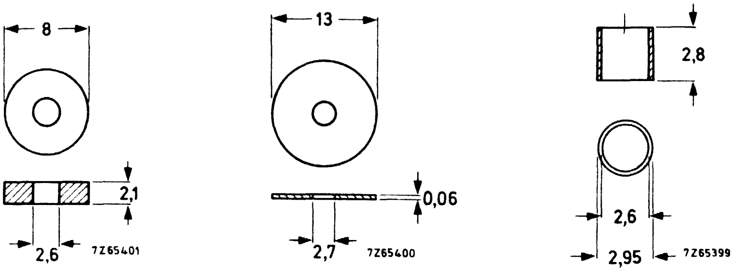


MOUNTING ACCESSORIES

Mounting accessories for insulated mounting of envelope SOT-32 (TO-126); the set con-consists of a metal washer, a mica washer and an insulating bush.

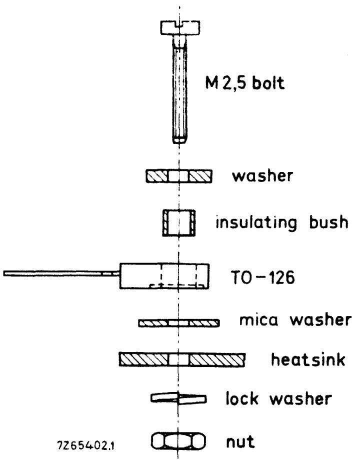
MECHANICAL DATA

Dimensions in mm



Metal washer   Mica washer   Insulating bush

MOUNTING INSTRUCTIONS



Minimum torque on nut for good heat transfer	4 kgcm (0, 4 Nm)
Maximum torque on nut	6 kgcm (0, 6 Nm)
Minimum thickness of heatsink	2 mm

MOUNTING INSTRUCTIONS (continued)

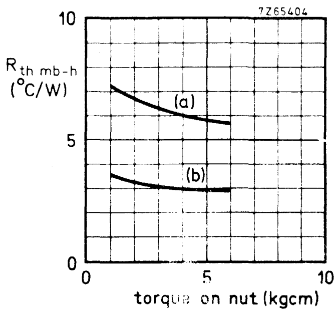
The heatsink surface must appear flat and smooth, without burrs or scratches. If the hole in the heatsink is threaded, it should be countersunk and free of burrs; the hole should also be perpendicular to the plane of the heatsink, within 10^{0} tolerance (for M2,5 thread). For good heat transfer the use of a heat conducting compound is recommended.

THERMAL RESISTANCE

From mounting base to heatsink

(a) without heat conducting compound	$R_{th\ mb\text{-}h}$	=	6	$^{o}C/W$
(b) with heat conducting compound	$R_{th\ mb\text{-}h}$	=	3	$^{o}C/W$

See also the graph.



INDEX OF TYPE NUMBERS

The inclusion of a type number in this publication does not necessarily imply its availability.

Type No.	Part	Section	Type No.	Part	Section	Type No.	Part	Section
AA119	1b	GePC	AF239	3	HF	BA222	1b	SiW
AAY21	1b	GePC	AF239S	3	HF	BA314	1b	SiW
AAY30	1b	GeGB	AF267	3	HF	BA315	1b	SiW
AAY32	1b	GeGB	ASY26	3	Sw	BA316	1b	SiW
AAY39	4	Mw	ASY27	3	Sw	BA317	1b	SiW
AAY39A	4	Mw	ASY28	3	Sw	BA318	1b	SiW
AAY59	4	Mw	ASY29	3	Sw	BAV10	1b	SiW
AAZ13	1b	GeGB	ASY73	3	Sw	BAV18	1b	SiW
AAZ15	1b	GeGB	ASY74	3	Sw	BAV19	1b	SiW
AAZ17	1b	GeGB	ASY75	3	Sw	BAV20	1b	SiW
AAZ18	1b	GeGB	ASY76	3	Sw	BAV21	1b	SiW
AC125	2	LF	ASY77	3	Sw	BAV40	1b	Sp
AC126	2	LF	ASY80	3	Sw	BAV41	1b	Sp
AC127	2	LF	ASZ15	2	P	BAV42	1b	Sp
AC127/01	2	LF	ASZ16	2	P	BAV43	1b	Sp
AC128	2	LF	ASZ17	2	P	BAV45	1b	Sp
AC128/01	2	LF	ASZ18	2	P	BAW56	4	Mm
AC132	2	LF	ASZ21	3	Sw	BAW62	1b	SiW
AC132/01	2	LF	BA100	1b	SiA	BAW95D	4	Mw
AC187	2	LF	BA102	1b	T	BAW95E	4	Mw
AC187/01	2	LF	BA114	1b	SiA	BAW95F	4	Mw
AC188	2	LF	BA145	1a	R	BAX12	1b	SiW
AC188/01	2	LF	BA148	1a	R	BAX13	1b	SiW
AD161	2	P	BA182	1b	T	BAX14	1b	SiW
AD162	2	P	BA216	1b	SiW	BAX15	1b	SiW
AF124	3	HF	BA217	1b	SiW	BAX16	1b	SiW
AF125	3	HF	BA218	1b	SiW	BAX17	1b	SiW
AF126	3	HF	BA219	1b	SiW	BAX18	1b	SiW
AF127	3	HF	BA220	1b	SiW	BAY96	4	Mw
AF139	3	HF	BA221	1b	SiW	BB104B	1b	T

GeGB = Germanium gold bonded diodes
GePC = Germanium point contact diodes
HF = High frequency transistors
LF = Low frequency transistors
Mm = Microminiature devices for thick- and thin-film circuits
Mw = Microwave devices
P = Low frequency power transistors
R = Rectifier diodes
SiA = Silicon alloyed diodes
SiW = Silicon whiskerless diodes
Sp = Special diodes
Sw = Switching transistors
T = Tuner diodes

Type No.	Part	Section	Type No.	Part	Section	Type No.	Part	Section
BB104C	1b	T	BC548	2	LF	BCY56	2	LF
12-BB105A	1b	T	BC549	2	LF	BCY57	2	LF
12-BB105B	1b	T	BC557	2	LF	BCY58	2	LF
12-BB105G	1b	T	BC558	2	LF	BCY59	2	LF
3-BB106	1b	T	BC559	2	LF	BCY70	2	LF
4-BB106	1b	T	BCW29	4	Mm	BCY71	2	LF
BB110B	1b	T	BCW30	4	Mm	BCY72	2	LF
BB110G	1b	T	BCW31	4	Mm	BCY87	4	Dual
BB113	1b	T	BCW32	4	Mm	BCY88	4	Dual
BB117	1b	T	BCW33	4	Mm	BCY89	4	Dual
BC107	2	LF	BCW46	2	LF	BCZ10	2	LF
BC108	2	LF	BCW47	2	LF	BCZ11	2	LF
BC109	2	LF	BCW48	2	LF	BCZ12	2	LF
BC146	2	LF	BCW49	2	LF	BD115	2	P
BC147	2	LF	BCW56	2	LF	BD131	2	P
BC148	2	LF	BCW57	2	LF	BD132	2	P
BC149	2	LF	BCW58	2	LF	BD133	2	P
BC157	2	LF	BCW59	2	LF	BD135	2	P
BC158	2	LF	BCW69	4	Mm	BD136	2	P
BC159	2	LF	BCW70	4	Mm	BD137	2	P
BC177	2	LF	BCW71	4	Mm	BD138	2	P
BC178	2	LF	BCW72	4	Mm	BD139	2	P
BC179	2	LF	BCY10	2	LF	BD140	2	P
BC200	2	LF	BCY11	2	LF	BD181	2	P
BC237	2	LF	BCY12	2	LF	BD182	2	P
BC238	2	LF	BCY30	2	LF	BD183	2	P
BC239	2	LF	BCY31	2	LF	BD201	2	P
BC307	2	LF	BCY32	2	LF	BD202	2	P
BC308	2	LF	BCY33	2	LF	BD203	2	P
BC309	2	LF	BCY34	2	LF	BD204	2	P
BC327	2	LF	BCY38	2	LF	BD226	2	P
BC328	2	LF	BCY39	2	LF	BD227	2	P
BC337	2	LF	BCY40	2	LF	BD228	2	P
BC338	2	LF	BCY54	2	LF	BD229	2	P
BC547	2	LF	BCY55	4	Dual	BD230	2	P

Dual = Dual transistors
LF = Low frequency transistors
Mm = Microminiature devices for thick- and thin-film circuits
P = Low frequency power transistors
T = Tuner diodes

Type No.	Part	Section	Type No.	Part	Section	Type No.	Part	Section
BD231	2	P	BF183	3	HF	BFR91	3	HF
BD232	2	P	BF184	3	HF	BFS17	4	Mm
BD234	2	P	BF185	3	HF	BFS18	4	Mm
BD235	2	P	BF194	3	HF	BFS19	4	Mm
BD236	2	P	BF195	3	HF	BFS20	4	Mm
BD237	2	P	BF196	3	HF	BFS21	4	FET
BD238	2	P	BF197	3	HF	BFS21A	4	FET
BD433	2	P	BF198	3	HF	BFS22A	4	Tr
BD434	2	P	BF199	3	HF	BFS23A	4	Tr
BD435	2	P	BF200	3	HF	BFS28	4	FET
BD436	2	P	BF240	3	HF	BFS92	3	HF
BD437	2	P	BF241	3	HF	BFS93	3	HF
BD438	2	P	BF254	3	HF	BFS94	3	HF
BDY20	2	P	BF255	3	HF	BFS95	3	HF
BDY38	2	P	BF257	3	HF	BFW10	4	FET
BDY60	2	P	BF258	3	HF	BFW11	4	FET
BDY61	2	P	BF259	3	HF	BFW12	4	FET
BDY90	2	P	BF324	3	HF	BFW13	4	FET
BDY91	2	P	BF336	3	HF	BFW16A	3	HF
BDY92	2	P	BF337	3	HF	BFW17A	3	HF
BDY93	2	P	BF338	3	HF	BFW30	3	HF
BDY94	2	P	BF450	3	HF	BFW45	2	Defl
BDY95	2	P	BF451	3	HF	BFW61	4	FET
BDY96	2	P	BF457	3	HF	BFW92	3	HF
BDY97	2	P	BF458	3	HF	BFW93	3	HF
BDY98	2	P	BF459	3	HF	BFX34	3	Sw
BF115	3	HF	BF494	3	HF	BFX44	3	HF
BF167	3	HF	BF495	3	HF	BFX89	3	HF
BF173	3	HF	BFR29	3	FET	BFY44	4	Tr
BF177	3	HF	BFR30	4	Mm	BFY50	3	HF
BF178	3	HF	BFR31	4	Mm	BFY51	3	HF
BF179	3	HF	BFR63	3	HF	BFY52	3	HF
BF180	3	HF	BFR64	3	HF	BFY55	3	HF
BF181	3	HF	BFR65	3	HF	BFY70	4	Tr
BF182	3	HF	BFR90	3	HF	BFY90	3	HF

Defl = Deflection transistors
FET = Field effect transistors
HF = High frequency transistors
Mm = Microminiature devices for thick- and thin-film circuits
P = Low frequency power transistors
Sw = Switching transistors
Tr = Transmitting transistors

Type No.	Part	Section	Type No.	Part	Section	Type No.	Part	Section
BLX13	4	Tr	BSV17	3	Sw	BTW33series	1a	Thyr
BLX14	4	Tr	BSV52	4	Mm	BTW34series	1a	Thyr
BLX69	4	Tr	BSV64	3	Sw	BTW47series	1a	Thyr
BLY83	4	Tr	BSV68	3	Sw	BTW92series	1a	Thyr
BLY84	4	Tr	BSV78	4	FET	BTX18series	1a	Thyr
BLY87A	4	Tr	BSV79	4	FET	BTX41series	1a	Thyr
BLY88A	4	Tr	BSV80	4	FET	BTX94series	1a	Thyr
BLY89A	4	Tr	BSV81	4	FET	BTX95series	1a	Thyr
BLY90	4	Tr	BSV86	3	Sw	BTY79series	1a	Thy
BLY91A	4	Tr	BSV87	3	Sw	BTY87series	1a	Thyr
BLY92A	4	Tr	BSV88	3	Sw	BTY91series	1a	Thyr
BLY93A	4	Tr	BSV96	3	Sw	BU105	2	Defl
BLY94	4	Tr	BSV97	3	Sw	BU108	2	Defl
BPX25	4	PhDT	BSV98	3	Sw	BU126	2	Defl
BPX29	4	PhDT	BSW41	3	Sw	BU132	2	Defl
BPX40	4	PhDT	BSW66	3	Sw	BU133	2	P
BPX41	4	PhDT	BSW67	3	Sw	BU204	2	Defl
BPX42	4	PhDT	BSW68	3	Sw	BU205	2	Defl
BPX66P	4	PhDT	BSW69	3	Sw	BU206	2	Defl
BPX71	4	PhDT	BSX12	3	Sw	BU207	2	Defl
BPY10	4	PhDT	BSX12A	3	Sw	BU208	2	Defl
BPY68	4	PhDT	BSX19	3	Sw	BU209	2	Defl
BPY69	4	PhDT	BSX20	3	Sw	BXY27	4	Mw
BPY76	4	PhDT	BSX21	3	Sw	BXY28	4	Mw
BPY77	4	PhDT	BSX59	3	Sw	BXY29	4	Mw
BR100	1a	Thyr	BSX60	3	Sw	BXY32	4	Mw
BR101	3	Sw	BSX61	3	Sw	BY126	1a	R
BRY39	1a	Thyr	BSY38	3	Sw	BY127	1a	R
BRY39 (SCS)	3	Sw	BSY39	3	Sw	BY164	1a	R
BRY39 (PUT)	3	Sw	BT100Aseries	1a	Thyr	BY176	1a	R
BSS27	3	Sw	BT101series	1a	Thyr	BY179	1a	R
BSS28	3	Sw	BT102series	1a	Thyr	BY184	1a	R
BSS29	3	Sw	BTW23series	1a	Thyr	BY185	1a	R
BSS40	3	Sw	BTW24series	1a	Thyr	BY187	1a	R
BSS41	3	Sw	BTW30series	1a	Thyr	BY188	1a	R
BSV15	3	Sw	BTW31series	1a	Thyr	BY206	1a	R
BSV16	3	Sw	BTW32series	1a	Thyr	BYX10	1a	R

Defl = Deflection transistors
FET = Field-effect transistors
PhDT = Photodiodes and transistors
Mm = Microminiature devices for thick- and thin-film circuits
Mw = Microwave devices
P = Low frequency power transistors
R = Rectifier diodes
Sw = Switching transistors
Thyr = Thyristors, diacs, triacs
Tr = Transmitting transistors

Type No.	Part	Section	Type No.	Part	Section	Type No.	Part	Section
BYX13series	1a	R	BZX92	1b	Vref	OA200	1b	SiA
BYX22series	1a	R	BZX93	1b	Vref	OA202	1b	SiA
BYX25series	1a	R	BZY78	1b	Vref	OAP12	4	PhDT
BYX29series	1a	R	BZY88series	1b	Vref	OC122	3	Sw
BYX30series	1a	R	BZY91series	1a	Vreg	OC123	3	Sw
BYX32series	1a	R	BZY93series	1a	Vreg	OCP70	4	PhDT
BYX35	1a	R	BZY95series	1a	Vreg	ORP10	4	I
BYX36series	1a	R	BZY96series	1a	Vreg	ORP13	4	I
BYX38series	1a	R	BZZ14	1a	Vreg	ORP30N	4	PhC
BYX39series	1a	R	BZZ15	1a	Vreg	ORP50	4	PhC
BYX40series	1a	R	BZZ16	1a	Vreg	ORP52	4	PhC
BYX42series	1a	R	BZZ17	1a	Vreg	ORP60	4	PhC
BYX45series	1a	R	BZZ18	1a	Vreg	ORP61	4	PhC
BYX46series	1a	R	BZZ19	1a	Vreg	ORP62	4	PhC
BYX48series	1a	R	BZZ20	1a	Vreg	ORP63	4	PhC
BYX49series	1a	R	BZZ21	1a	Vreg	ORP69	4	PhC
BYX50series	1a	R	BZZ22	1a	Vreg	ORP90	4	PhC
BYX52series	1a	R	BZZ23	1a	Vreg	OSB9110	1a	St
BYX55series	1a	R	BZZ24	1a	Vreg	OSB9210	1a	St
BYX56series	1a	R	BZZ25	1a	Vreg	OSB9310	1a	St
BYX59series	1a	R	BZZ26	1a	Vreg	OSB9410	1a	St
BYX71series	1a	R	BZZ27	1a	Vreg	OSM9110	1a	St
BZW86series	1a	TS	BZZ28	1a	Vreg	OSM9210	1a	St
BZW91series	1a	TS	BZZ29	1a	Vreg	OSM9310	1a	St
BZW93series	1a	TS	CAY10	4	Mw	OSM9410	1a	St
BZX48	1b	Vref	CQY11B	4	L	OSS9110	1a	St
BZX49	1b	Vref	CXY10	4	Mw	OSS9210	1a	St
BZX50	1b	Vref	CXY11A	4	Mw	OSS9310	1a	St
BZX61series	1b	Vreg	CXY11B	4	Mw	OSS9410	1a	St
BZX70series	1a	Vreg	CXY11C	4	Mw	OTH1200	1a	Ign
BZX75series	1b	Vreg	CXY12	4	Mw	RPY13	4	PhC
BZX79series	1b	Vreg	OA47	1b	GeGB	RPY18	4	PhC
BZX84series	4	Mm	OA90	1b	GePC	RPY19	4	PhC
BZX90	1b	Vref	OA91	1b	GePC	RPY20	4	PhC
BZX91	1b	Vref	OA95	1b	GePC	RPY27	4	PhC

GeGB = Germanium gold bonded diodes
GePC = Germanium point contact diodes
I = Infrared devices
Ign = Ignistors
L = Light emitting devices
Mm = Microminiature devices for thick- and thin-fim circuits
Mw = Microwave devices
PhC = Photoconductive devices
PhDT = Photodiodes and phototransistors
R = Rectifier diodes
SiA = Silicon alloyed diodes
SiW = Silicon whiskerless diodes
St = Rectifier stacks
Sw = Switching transistors
TS = Transient suppressor diodes
Vref = Voltage reference diodes
Vreg = Voltage regulator diodes

Type No.	Part	Section	Type No.	Part	Section	Type No.	Part	Section
RPY33	4	PhC	1N4448	1b	SiW	2N708	3	Sw
RPY41	4	PhC	1N5152	4	Mw	2N743	3	Sw
RPY43	4	PhC	1N5153	4	Mw	2N744	3	Sw
RPY55	4	PhC	1N5155	4	Mw	2N753	3	Sw
RPY58	4	PhC	1N5157	4	Mw	2N914	3	Sw
RPY71	4	PhC	1N5729B	1b	Vreg	2N918	3	HF
RPY76A	4	I	1N5730B	1b	Vreg	2N929	2	LF
1N748A	1b	Vreg	1N5731B	1b	Vreg	2N930	2	LF
1N749A	1b	Vreg	1N5732B	1b	Vreg	2N1302	3	Sw
1N750A	1b	Vreg	1N5733B	1b	Vreg	2N1303	3	Sw
1N751A	1b	Vreg	1N5734B	1b	Vreg	2N1304	3	Sw
1N752A	1b	Vreg	1N5735B	1b	Vreg	2N1305	3	Sw
1N753A	1b	Vreg	1N5736B	1b	Vreg	2N1306	3	Sw
1N754A	1b	Vreg	1N5737B	1b	Vreg	2N1307	3	Sw
1N755A	1b	Vreg	1N5738B	1b	Vreg	2N1308	3	Sw
1N756A	1b	Vreg	1N5739B	1b	Vreg	2N1309	3	Sw
1N757A	1b	Vreg	1N5740B	1b	Vreg	2N1613	3	HF
1N758A	1b	Vreg	1N5741B	1b	Vreg	2N1711	3	HF
1N759A	1b	Vreg	1N5742B	1b	Vreg	2N1893	3	HF
1N821	1b	Vref	1N5743B	1b	Vreg	2N2218	3	Sw
1N823	1b	Vref	1N5744B	1b	Vreg	2N2218A	3	Sw
1N825	1b	Vref	1N5745B	1b	Vreg	2N2219	3	Sw
1N827	1b	Vref	1N5746B	1b	Vreg	2N2219A	3	Sw
1N829	1b	Vref	1N5747B	1b	Vreg	2N2221	3	Sw
1N914	1b	SiW	1N5748B	1b	Vreg	2N2221A	3	Sw
1N914A	1b	SiW	1N5749B	1b	Vreg	2N2222	3	Sw
1N916	1b	SiW	1N5750B	1b	Vreg	2N2222A	3	Sw
1N916A	1b	SiW	1N5751B	1b	Vreg	2N2297	3	HF
1N916B	1b	SiW	1N5752B	1b	Vreg	2N2368	3	Sw
1N4009	1b	SiW	1N5753B	1b	Vreg	2N2369	3	Sw
1N4148	1b	SiW	1N5754B	1b	Vreg	2N2369A	3	Sw
1N4150	1b	SiW	1N5755B	1b	Vreg	2N2483	3	HF
1N4151	1b	SiW	1N5756B	1b	Vreg	2N2484	3	HF
1N4154	1b	SiW	1N5757B	1b	Vreg	2N2894	3	Sw
1N4446	1b	SiW	2N706A	3	Sw	2N2894A	3	Sw

HF = High frequency transistors
I = Infrared devices
LF = Low frequency transistors
Mw = Microwave devices
PhC = Photoconductive devices
SiW = Silicon whiskerless diodes
Sw = Switching transistors
Vref = Voltage reference diodes
Vreg = Voltage regulator diodes

Type No.	Part	Section	Type No.	Part	Section	Type No.	Part	Section
2N2904	3	Sw	2N4856	4	FET	56261	2, 3, 4	A
2N2904A	3	Sw	2N4857	4	FET	56262A	1a	A
2N2905	3	Sw	2N4858	4	FET	56263	1a to 4	A
2N2905A	3	Sw	2N4859	4	FET	56264A	1a	A
2N2906	3	Sw	2N4860	4	FET	56265	2, 3, 4	A
2N2906A	3	Sw	2N4861	4	FET	56268	1a	DH
2N2907	3	Sw	61SV	4	I	56271	1a	DH
2N2907A	3	Sw	40809	2	LF	56278	1a	DH
2N3055	2	P	40819	2	LF	56280	1a	DH
2N3303	3	Sw	40820	3	HF	56284	1a	DH
2N3375	4	Tr	40829	3	HF	56290	1a	HE
2N3426	3	Sw	40835	3	HF	56293	1a	HE
2N3442	2	P	56200	2, 3, 4	A	56295	1a	A
2N3553	4	Tr	56201	2, 3, 4	A	56299	1a	A
2N3570	3	HF	56201a	2, 3, 4	A	56302	2, 3, 4	A
2N3571	3	HF	56201b	2, 3, 4	A	56303	2, 3 4	A
2N3572	3	HF	56201c	2, 3, 4	A	56309B	1a	A
2N3632	4	Tr	56201d	2, 3, 4	A	56309R	1a	A
2N3771	2	P	56201e	2, 3, 4	A	56311	1a	WH
2N3772	2	P	56203	2, 3, 4	A	56312	1a	DH
2N3823	4	FET	56208	2, 3, 4	A	56313	1a	DH
2N3866	4	Tr	56209	2, 3, 4	A	56314	1a	DH
2N3924	4	Tr	56210	2, 3, 4	A	56315	1a	DH
2N3926	4	Tr	56218	2, 3, 4	A	56316	1a	A
2N3927	4	Tr	56226	2, 3, 4	A	56318	1a	DH
2N3966	4	FET	56227	2, 3, 4	A	56319	1a	DH
2N4036	3	Sw	56230	1a	HE	56324	2	A
2N4091	4	FET	56231	1a	HE	56325	2	A
2N4092	4	FET	56233	1a	A	56326	2, 3	A
2N4093	4	FET	56234	1a	A	56333	2, 3	A
2N4347	2	P	56239	2	A	56334	1a	DH
2N4391	4	FET	56245	2, 3, 4	A			
2N4392	4	FET	56246	1a to 4	A			
2N4393	4	FET	56253	1a	DH			
2N4427	4	Tr	56256	1a	DH			

A = Accessories
DH = Diecast heatsinks
FET = Field effect transistors
HE = Heatsink extrusions
HF = High frequency transistors
I = Infrared devices
LF = Low frequency transistors
P = Low frequency power transistors
Sw = Switching transistors
Tr = Transmitting transistors
WH = Water cooled heatsinks

MAINTENANCE TYPE LIST

The type numbers listed below are not included in this handbook except for those marked with an asterisk.

Detailed information will be supplied on request.

AF121
AF240
AFY16
AFZ12
*ASZ21
*BF177
*BF178
*BF179
BF334
BF335
*BSY38
*BSY39
OC139
OC140
OC141

General

High frequency transistors

Switching transistors

Accessories

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