ITT
Semiconductors

Discrete Semiconductors for Surface Mounting (SMD)

Transistors
Diodes
Tuner Diodes
Zener Diodes
Stabilizer Diodes
Schottky Diodes
Rectifiers

Manual 1991

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Cross-Reference SMD Type / Original Type

SMD Type	Case	Original Type	Case
BA682	MiniMELF	BA282	DO-35
BA683	MiniMELF	BB283	DO-35
BA782	60A2	BA282	DO-35
BA783	60A2	BA283	DO-35
BB404	TO-236	–	–
BB510	TO-236	–	–
BB701	60A2	–	–
BB721	60A2	BB521	DO-35
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BC817-16	TO-236	BC337-16	TO-92
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BC850C	TO-236	BC550C	TO-92
BC856A	TO-236	BC556A	TO-92
BC856B	TO-236	BC556B	TO-92
BC857A	TO-236	BC557A	TO-92
BC857B	TO-236	BC557B	TO-92
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BC858A	TO-236	BC558A	TO-92
BC858B	TO-236	BC558B	TO-92
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SMD Type	Case	Original Type	Case
BC859A	TO-236	BC559A	TO-92
BC859B	TO-236	BC559B	TO-92
BC859C	TO-236	BC559C	TO-92
BC859A	TO-236	BC559A	TO-92
BC859B	TO-236	BC559B	TO-92
BC859C	TO-236	BC559C	TO-92
BC860A	TO-236	BC560A	TO-92
BC860B	TO-236	BC560B	TO-92
BC860C	TO-236	BC560C	TO-92
BCW60A	TO-236	BC548A	TO-92
BCW60B	TO-236	BC548B	TO-92
BCW60C	TO-236	BC548C	TO-92
BCW60D	TO-236	BC548D	TO-92
BCW61A	TO-236	BC558A	TO-92
BCW61B	TO-236	BC558B	TO-92
BCW61C	TO-236	BC558C	TO-92
BCW61D	TO-236	BC558D	TO-92
BCX70G	TO-236	BC547A	TO-92
BCX70H	TO-236	BC547B	TO-92
BCX70J	TO-236	BC547C	TO-92
BCX70K	TO-236	BC547D	TO-92
BCX71G	TO-236	BC557A	TO-92
BCX71H	TO-236	BC557B	TO-92
BCX71J	TO-236	BC557C	TO-92
BCX71K	TO-236	BC557D	TO-92
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LL101B	MiniMELF	SD101B	DO-35
LL101C	MiniMELF	SD101C	DO-35
LL103A	MiniMELF	SD103A	DO-35
LL103B	MiniMELF	SD103B	DO-35
LL103C	MiniMELF	SD103C	DO-35
LL4148	MiniMELF	1N4148	DO-35
LL4149	MiniMELF	1N4149	DO-35
LL4150	MiniMELF	1N4150	DO-35
LL4151	MiniMELF	1N4151	DO-35
LL4152	MiniMELF	1N4152	DO-35
LL4153	MiniMELF	1N4153	DO-35
LL4154	MiniMELF	1N4154	DO-35
LL4446	MiniMELF	1N446	DO-35
LL4447	MiniMELF	1N4447	DO-35
LL4448	MiniMELF	1N4448	DO-35
LL4449	MiniMELF	1N4449	DO-35
LL4450	MiniMELF	1N4450	DO-35
LL4451	MiniMELF	1N4451	DO-35
LL4453	MiniMELF	1N4543	DO-35
LL4454	MiniMELF	1N4454	DO-35

SMD Type	Case	Original Type	Case
ZM4729 to ZM4764	MELF	1N4729 to 1N4764	DO-41
ZMM1 to ZMM51	MiniMELF	ZPD1 to ZPD51	DO-35
ZMM5225 to ZMM5262	MiniMELF	1N5225 to 1N5262	DO-35
ZMU100 to ZMU180	MELF	ZPU100 to ZPU180	DO-41
ZMY1 to ZMY100	MELF	ZPY1 to ZPY100	DO-41

Cross-Reference Original Type / SMD Type

Original Type	Case	SMD Type	Case
BA282	DO-35	BA682	MiniMELF
BA283	DO-35	BA683	MiniMELF
BA282	DO-35	BA782	60A2
BA283	DO-35	BA783	60A2
BB521	DO-35	BB721	60A2
BB523	DO-35	BB723	60A2
BB529	DO-35	BB729	60A2
BB531	DO-35	BB731	60A2
–	–	BB404	TO-236
–	–	BB510	TO-236
–	–	BB701	60A2
–	–	BB730	60A2
BC327-16	TO-92	BC807-16	TO-236
BC327-25	TO-92	BC807-25	TO-236
BC327-40	TO-92	BC807-40	TO-236
BC328-16	TO-92	BC808-16	TO-236
BC328-25	TO-92	BC808-25	TO-236
BC328-40	TO-92	BC808-40	TO-236
BC337-16	TO-92	BC817-16	TO-236
BC337-25	TO-92	BC817-25	TO-236
BC337-40	TO-92	BC817-40	TO-236
BC338-16	TO-92	BC818-16	TO-236
BC338-25	TO-92	BC818-25	TO-236
BC338-40	TO-92	BC818-40	TO-236
BC546A	TO-92	BC846A	TO-236
BC546B	TO-92	BC846B	TO-236
BC547A	TO-92	BC847A	TO-236
BC547B	TO-92	BC847B	TO-236
BC547C	TO-92	BC847C	TO-236
BC547A	TO-92	BCX70G	TO-236
BC547B	TO-92	BCX70H	TO-236
BC547B	TO-92	BCX70J	TO-236
BC547C	TO-92	BCX70K	TO-236
BC548A	TO-92	BC848A	TO-236
BC548B	TO-92	BC848B	TO-236
BC548C	TO-92	BC848C	TO-236
BC548A	TO-92	BCW60A	TO-236
BC548B	TO-92	BCW60B	TO-236
BC548B	TO-92	BCW60C	TO-236
BC548C	TO-92	BCW60D	TO-236
BC549A	TO-92	BC849A	TO-236
BC549B	TO-92	BC849B	TO-236
BC549C	TO-92	BC849C	TO-236
BC550B	TO-92	BC850B	TO-236
BC550C	TO-92	BC850C	TO-236
BC556A	TO-92	BC856A	TO-236

Original Type	Case	SMD Type	Case
BC556B	TO-92	BC856B	TO-236
BC557A	TO-92	BC857A	TO-236
BC557B	TO-92	BC857B	TO-236
BC557C	TO-92	BC857C	TO-236
BC557A	TO-92	BCX71G	TO-236
BC557B	TO-92	BCX71H	TO-236
BC557B	TO-92	BCX71J	TO-236
BC557C	TO-92	BCX71K	TO-236
BC558A	TO-92	BC858A	TO-236
BC558B	TO-92	BC858B	TO-236
BC558C	TO-92	BC858C	TO-236
BC558A	TO-92	BCW61A	TO-236
BC558B	TO-92	BCW61B	TO-236
BC558B	TO-92	BCW61C	TO-236
BC558C	TO-92	BCW61D	TO-236
BC559A	TO-92	BC859A	TO-236
BC559B	TO-92	BC859B	TO-236
BC559C	TO-92	BC859C	TO-236
BC560A	TO-92	BC860A	TO-236
BC560B	TO-92	BC860B	TO-236
BC560C	TO-92	BC860C	TO-236
SD101A	DO-35	LL101A	MiniMELF
SD101B	DO-35	LL101B	MiniMELF
SD101C	DO-35	LL101C	MiniMELF
SD103A	DO-35	LL103A	MiniMELF
SD103B	DO-35	LL103B	MiniMELF
SD103C	DO-35	LL103C	MiniMELF
ZPD1 to ZPD51	DO-35	ZMM1 to ZMM51	MiniMELF
ZPU100 to ZPU180	DO-41	ZMU100 to ZMU180	MELF
ZPY1 to ZPY100	DO-41	ZMY1 to ZMY100	MELF
ZTE1,5 to ZTE5,1	DO-35	LL1,5 to LL5,1	MiniMELF
1N4148	DO-35	LL4148	MiniMELF
1N4149	DO-35	LL4149	MiniMELF
1N4150	DO-35	LL4150	MiniMELF
1N4151	DO-35	LL4151	MiniMELF
1N4152	DO-35	LL4152	MiniMELF
1N4153	DO-35	LL4153	MiniMELF
1N4154	DO-35	LL4154	MiniMELF

Original Type	Case	SMD Type	Case
1N4446	DO-35	LL4446	MiniMELF
1N4447	DO-35	LL4447	MiniMELF
1N4448	DO-35	LL4448	MiniMELF
1N4449	DO-35	LL4449	MiniMELF
1N4450	DO-35	LL4450	MiniMELF
1N4451	DO-35	LL4451	MiniMELF
1N4453	DO-35	LL4453	MiniMELF
1N4454	DO-35	LL4454	MiniMELF
1N4729 to 1N4764	DO-41	ZM4729 to ZM4764	MELF
1N5225 to 1N5262	DO-35	ZMM5225 to ZMM5262	MiniMELF

Technical Information

Index of Symbols

B	Base connection
C	Capacitance, junction capacitance, collector connection
C_{CBO}	Collector base capacitance (open emitter)
C_{EBO}	Emitter base capacitance (open collector)
C_{tot}	Capacitance, diode capacitance
C_N	Nominal capacitance
ΔC	Capacity variation
E	Emitter connection
f	Frequency
f_p	Pulse frequency
f_T	Gain bandwidth product
f_{Q1}	Cutoff frequency for Q = 1
f_0	Series resonance frequency
F	Noise figure
h	Parameters of h-(hybrid)matrix
h_f	Small signal current gain
h_i	Input impedance
h_o	Output admittance
h_r	Reverse voltage transfer ratio
h_{FE}	DC current gain, common emitter
I	Current
I_B	Base current
I_{BM}	Peak base current
I_C	Collector current
I_{CBO}	Collector base cutoff current (open emitter)
I_{CEO}	Collector emitter cutoff current (open base)
I_{CER}	Colletor emitter cutoff current (specified resistance between base and emitter)
I_{CES}	Colletor emitter cutoff current (base short-circuited to emitter)
I_{CEV}	Collecotor emitter cutoff current (specified voltage between base and emitter)
I_{CM}	Peak collector current
I_E	Emitter current
I_{EBO}	Emitter base cutoff current (open collector)
I_F	Forward current
I_{FAV}	Average (rectified) forward current
I_{FRM}	Repetitive peak forward current
I_{FSM}	Surge forward current (non-repetitive)
I_R	Reverse (leakage) current
I_{RM}	Reverse pulse current
I_Z	Zener current (operating current)
I_{ZK}	Zener current at breakdown region
I_{ZM}	Maximum Zener current
I_{ZS}	Surge Zener current
I_{ZT}	Zener test current
I_{ZSM}	Surge Zener current (non-repetitive)
I_0	Average (rectified) forward current
L_S	Series inductance
P_{tot}	Total power dissipation
Q	Q-Factor, figure of merit
r_f	Dynamic forward resistance
r_s	Dynamic series resistance
r_{zj}	Dynamic resistance in the breakdown region
r_{zth}	Termal differential resistance in the breakdown region
r_{zu}	Static differential resistance in the breakdown region
R	Resistance
R_{BE}	Resistance between base and emitter
R_d	Damping resistance
R_G	Generator output resistance
R_L	Load resistance
R_S	Series resistance
R_{th}	Thermal resistance
R_{thA}	Thermal resistance junction to ambient air
R_{thC}	Thermal resistance junction to case
R_{thSB}	Thermal resistance junction to back of substrate
S	Stabilization factor; length of edge of a cooling fin
t	Time
$\tan \delta$	Loss factor
t_d	Delay time
t_f	Fall time
t_{fr}	Forward recovery time
t_{on}	Switching-on time
t_p	Pulse duration
t_r	Rise time
t_{rr}	Reverse recovery time
t_s	Storage time
t_{tot}	Total switching time
T	Temperature, duration of a full cycle
T_{amb}	Ambient temperature
T_C	Case temperature
T_{EL}	Temperature of electrodes
T_j	Junction temperature
T_L	Lead temperature
T_S	Storage temperature
T_{SB}	Temperature of back of substrate
τ	Time constant
V_F	Instantaneous forward voltage
V_R	Instantaneous reverse voltage
V	Voltage
V_{BE}	Base emitter voltage

V_{BEsat}	Base emitter saturation voltage
$V_{(BR)R}$	Reverse breakdown voltage
$V_{(BR)CBO}$	Collector base breakdown voltage (open emitter)
$V_{(BR)CEO}$	Collector emitter breakdown voltage (open base)
$V_{(BR)CER}$	Collector emitter breakdown voltage (specified resistance between base and emitter)
$V_{(BR)CES}$	Collector emitter breakdown voltage (emitter short-circuited to base)
$V_{(BR)EBO}$	Emitter base breakdown voltage (open collector)
V_{CB}	Collection base voltage
V_{CBO}	Collector base voltage (open emitter)
V_{CE}	Collector emitter voltage
V_{CEO}	Collector emitter voltage (open base)
V_{CER}	Collector emitter voltage (specified resistance between base and emitter)
V_{CES}	Collector emitter voltage (emitter shortcircuited to base)
V_{CEsat}	Collector emitter saturation voltage
V_{CEV}	Collector emitter voltage (specified voltage between base and emitter)
V_{EBO}	Emitter base voltage (open collector)
V_F	Forward voltage
V_N	Nominal voltage
V_R	Reverse voltage
V_{RF}	RF voltage
V_{RM}	Peak reverse voltage
V_{RMS}	RMS voltage
V_{RRM}	Repetitive peak reverse voltage
V_{RSM}	Surge peak reverse voltage (non-repetive)
V_Z	Zener voltage
V_O	DC voltage, half wave rectification
V_{fr}	Voltage rise when switching on (forward recovery)
V_{in}	Input voltage
V_{out}	Output voltage
Z_{ZK}	Zener impedance at I_{ZK}
Z_{ZT}	Zener impedance at I_{ZT}
α_{VZ}	Temperature coefficient of Zener voltage
η_V	Rectification efficiency (quotient of the mean value of the rectified voltage and the peak value of the RF signal voltage)
ν	Ratio of pulse duration to full cycle, duty cycle

Characteristics and Maximum Ratings

The electrical performance of a semiconductor device is usually expressed in terms of its characteristics and maximum ratings.

Characteristics are those which can be measured by use of suitable measuring instruments and circuits, and provide information on the performance of the device under specified operating conditions (at a given bias, for example). Depending on requirements, they are quoted either as typical values or guaranteed values.

Typical values are expressed as figures or as one or more curves, and are subject to spreads.

Guaranteed values are preceded either by the symbol > (greater than) or < (less than); sometimes the guaranteed spread limits are indicated by the numbers with three dots between them. Occasionally a typical curve is accompanied by another curve, this being a 95%, or, in a few cases, a maximum spread limit curve.

Maximum Ratings give the values which cannot be exceeded without risk of damage to the device. Changes in supply voltage and in the tolerances of other components in the circuit must also be taken into consideration. No single maximum rating should ever be exceeded, even when the device is operated well within the other maximum ratings. The inclusion of the word "admissible" in a title means that the associated curve defines the maximum ratings.

An exception to this rule are data on collector current. The collector current, quoted as one of the critical transistor values, is a maximum value recommended by the manufacturer which should be noted in connection with the other characteristics valid for this collector current (e. g. collector and saturation voltages, current gain etc.) when selecting a transistor. In certain cases, the quoted collector current may be exceeded without the transistor being destroyed. The absolute limit for the collector current is determined by the maximum admissible power dissipation of the transistor.

Silicon Diodes

Silicon is a particularly suitable material for the manufacture of diodes because of the small leakage currents, high breakdown voltages, and steep forward characteristics that may be attained. Admissible junction temperatures of up to $T_j = +200\,°C$ allow a relatively high level of power to be dissipated in a package of small dimensions. Silicon diodes are manufactured as junction diodes by a diffusion process, preferably using the epitaxial planar technique.

The admissible power dissipation P_{tot}, junction temperature T_j, and ambient temperature T_{amb} are related as follows:

$$P_{tot} = \frac{T_j - T_{amb}}{R_{thA}}$$

Since a certain amount of the generated heat must be conducted away from the junction via the connecting electrodes, the following proviso is often quoted in data sheets: Valid provided that electrodes are kept at ambient temperature.

Silicon Capacitance Diodes

Silicon capacitance diodes are used for electronic tuning purposes, automatic frequency control (AFC), frequency modulation, mixing, frequency multiplication, and for controlling the bandwidth of capacitively coupled bandpass filters; they also have applications in dielectric and parametric amplifiers. In all these applications, advantage is taken of the fact that the depletion layer capacitance is dependent on the applied reverse voltage.

Basically, a silicon capacitance diode has the same construction as any normal alloyed or diffused semiconductor diode: the depletion layer of the PN junction contains only very few free charge carriers and can be considered as the dielectric of a capacitor whose plates are formed by the high-conductivity regions. Silicon capacitance diodes are normally operated under reverse bias conditions. If the applied reverse voltage is increased, then the thickness of the depletion layer increases and the depletion layer capacitance consequently decreases. For example, referred to a reverse voltage of 3 V, depletion layer capacitance and reverse voltage are related by the following equation:

$$C = C_{3V} \cdot \left(\frac{3\,V + V_D}{V_R + V_D}\right)^n,$$

where V_D is the diffusion potential (0.7 V for silicon). The value of the exponent "n" depends on the manufacturing process, and is

0.33 for diffused diodes with a linear PN junction,
0.5 for alloyed diodes, or diodes with a steep diffusion profile, and can be
0.75 and more if a special diffusion technique involving several superimposed diffusion processes is used.

These so-called "large capacitance ratio" or tuner diodes have a hyperabrupt (retrograded) PN junction giving a steep capacitance characteristic. This makes it possible for the first time to cover the entire frequency range of a VHF or UHF television tuner, or that of an MW receiver, without any band switching. Because the exponent "n" in the capacitance formula is not a constant, but varies with reverse voltage, the capacitance variation of these tuner diodes does not follow a mathematically definable law. To ensure accurate tracking, therefore, diodes intended for incorporation into tuners are supplied in matched groups.

Another important parameter of a capacitance diode is the Q factor, which should be high. At high frequencies, the Q factor of a capacitance diode is

$$Q \approx \frac{1}{2 \pi f C_{tot} r_s}$$

where C_{tot} is the diode capacitance, r_s the series resistance of the diode. The series resistance r_s is virtually the same as the bulk resistance of the diode.

As can be deduced from the Q formula, the Q factor of a capacitance diode varies with reverse bias; this is because the diode capacitance decreases as the reverse voltage is increased; the Q factor is also dependent on frequency.

The "cut-off" frequency, f_{Q1}, of a capacitance diode is that frequency at which the Q factor is reduced to 1, i.e.

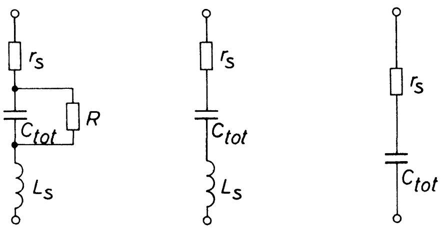
$$Q = \frac{f_{Q1}}{f}$$

Another important factor, which cannot be altogether ignored, is the series inductance L_s. This comprises the inductance of the connecting electrodes and the internal inductance of the diode. The inductance L_s together with the diode capacitance C_{tot} forms a series-tuned circuit which resonates at a frequency of:

$$f_0 = \frac{1}{2 \pi \sqrt{L_s \cdot C_{tot}}}$$

Depending on the application, a capacitance diode can be represented by the following equivalent circuits:

The complete equivalent circuit a) comprises, apart from the diode capacitance C_{tot}, a series resistance r_s, a series inductance L_s, and a reverse resistance $R = V_R/I_R$. Since the reverse resistance of a silicon diode is extremely high, it is usually ignored, and the circuit then reduces to circuit b). At low and medium frequencies the series inductance L_s can also be ignored; this results in the circuit shown in c).



a) b) c)

Junction capacitance, series resistance and reverse resistance are temperature dependent. The temperature coefficient of the junction capacitance is due to the effect of temperature on the diffusion voltage V_D, which is –2 mV/°C. This means that a reverse voltage reduction of approximately 2 mV has the same effect on the junction capacitance as a junction temperature increase of 1 °C. The temperature coefficient of the junction capacitance is therefore positive, and decreases as the reverse bias is increased. The reverse resistance decreases by about 6 % and the series resistance by about 1 % if the junction temperature is increased by 1 °C.

To ensure that the reverse bias does not vary appreciably with temperature, it is good practice to make the value of the diode series resistor through which the reverse bias is applied as low as practicable (approx. 30 to 100 kΩ).

In all tuning applications it is important that the AC signal amplitude is small in comparison with the lowest reverse bias voltage applied, as otherwise the non-linearity of the capacitance characteristic will cause signal distortion and an apparent change of capacitance. By the use of two diodes in a push-pull arrangement it is possible to obtain a considerable reduction in distortion, even at large signal amplitudes, because the diodes are then driven in antiphase and thus tend to cancel any distortion.

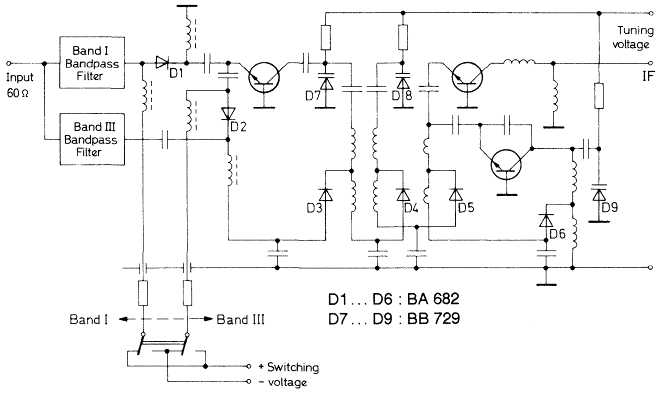
Silicon Diode Switches

These diodes were developed for electronic band switching in television and radio tuners operating at MW to UHF. Diode switches, unlike the switching diodes normally used for logic applications (for example, LL4148), are intended as an electronic equivalent to the contacts of mechanical range switches.

Diode switches exhibit either a very high reverse impedance (approx. 1 MΩ in parallel with approx. 1.3 pF) when they are non-conducting (switch open), or a very low dynamic forward impedance (approx. 0.5 Ω in series with approx. 2.5 nH) when they are conducting (switch closed).

The glass case MiniMELF of the diode switches ensures that full advantage can be taken of their inherently small series inductance, since connecting electrodes may be soldered directly to the case.

The following circuit diagram illustrates the use of type BA682 diode switches in an electronically tuned VHF television tuner.



Silicon Zener Diodes

Zener diodes are special silicon diodes which have a relatively low, defined breakdown voltage, called the Zener voltage.

At low reverse voltages a Zener diode behaves in a similar manner to an ordinary silicon diode, that is, it passes only a very small leakage current. If, however, the reverse bias is increased until it reaches the breakdown region, then a small reverse voltage increase causes a considerable increase in leakage current; the reverse current is then called the Zener current. The characteristics of a Zener diode operating under reverse breakdown conditions are similar to those of a struck glow discharge tube. Because of this, Zener diodes can be used in a similar way, i. e. as stabilizers, limiters, ripple reduction elements, reference voltage sources, and also as DC coupling elements with a constant voltage drop.

Characteristics

The slope of the reverse breakdown characteristic defines the static differential resistance $r_{zu} = dV_Z/dI_Z$, which, in turn, comprises a dynamic (or inherent differential) resistance r_{zj} and a thermal differential resistance r_{zth}.

Use of the dynamic resistance alone for characterizing the performance of a Zener diode is only satisfactory if the ambient temperature can be assumed to be constant, and the Zener current variations are so rapid that the junction temperature is unable to follow them. A generalized design approach requires that the effect of slow Zener current variations is also taken into consideration, in which case the design must be based on the static differential resistance valure r_{zu}, which is the sum of the dynamic and the thermal differential resistance:

$r_{zu} = r_{zj} + r_{zth}$

At T_{amb} = const.,

$V_Z = f(I_Z, T)$

so that

$$\frac{dV_Z}{dI_Z} = \left(\frac{\delta V_Z}{\delta I_Z}\right)_T + \left(\frac{\delta V_Z}{\delta T}\right)_{I_Z} \frac{dT}{dI_Z} \quad (1)$$

Setting

$$\frac{dV_Z}{V_Z \cdot dT} = \alpha_{VZ} \quad (2) \qquad \text{and} \quad \frac{dT}{V_Z \cdot dI_Z} = R_{thA} \quad (3)$$

yields

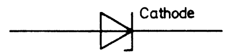
$$r_{zu} = r_{zj} + V_Z^2 \cdot \alpha_{VZ} \cdot R_{thA} = r_{zj} + r_{zth} \quad (4)$$

where α_{VZ} is the Zener voltage temperature coefficient, T the junction temperature, and R_{thA} the thermal resistance between the junction and the ambient air.

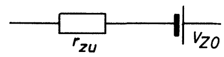
The dynamic resistance is largely dependent on current, and decreases as the Zener current increases. The temperature coefficient α_{VZ} is dependent on temperature, but only at Zener voltages below 7 V.

Circuit symbol for a Zener diode

or



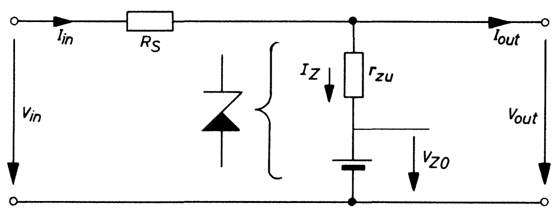
Simplified equivalent circuit diagram



V_{Z0} is the breakdown voltage, extrapolated for $I_Z = 0$.

Design of Stabilizer Circuits

To simplify the design procedure, a constant differential resistance r_z is assumed in the following expressions. Since this does not strictly apply (as has been pointed out previously), an r_z value which lies in the middle of the stabilization range should be used. It is also assumed that T_{amb} is constant.



In the above circuit, the Zener diode is replaced by an equivalent circuit comprising a constant voltage generator giving a DC voltage of V_{Z0} in series with a differential resistance r_{zu}. Other parameters in this circuit diagram are: V_{out} = output voltage, I_{out} = output current, V_{in} = input voltage, I_{in} = input current, I_Z = Zener current, and R_S = series resistance.

The following equations apply

$$V_{in} - V_{out} = (I_{out} + I_Z) \cdot R_S, \quad (5)$$

$$V_{out} - V_{Z0} = I_Z \cdot r_{zu} \quad (6)$$

If equation (6) is combined with equation (5) one obtains

$$V_{in} = V_{out} + I_{out} \cdot R_S + (V_{out} - V_{Z0}) \cdot \frac{R_S}{r_{zu}} \quad (7)$$

Differentiation yields the smoothing factor

$$G = \frac{dV_{in}}{dV_{out}} = 1 + \frac{R_S}{r_{zu}}, \quad (8)$$

where I_{out} is assumed to be constant.

Because R_S is, as a rule, very much larger than r_{zu}, the smoothing factor G can be taken as being approximately equal to the ratio R_S/r_{zu}. As can be deduced from equation (8), G increases linearly with R_S (provided that V_{in} is also increased), and, if V_{in} and R_S approach infinity, the G will also approach infinity.

More important than the smoothing factor is the stabilization factor S, i. e. the ratio of a relative input voltage change to a relative output voltage change:

$$S = \frac{\frac{dV_{in}}{V_{in}}}{\frac{dV_{out}}{V_{out}}} = \left(1 + \frac{R_S}{r_{zu}}\right) \cdot \frac{V_{out}}{V_{in}} \qquad (9)$$

The stabilization factor, unlike the smoothing factor, does not increase linearly with V_{in} and R_S, but approaches a finite limit value when V_{in} and $R_S \rightarrow \infty$. In order to determine this limit value, R_S is eliminated from equation (9) by the use of equation (5):

$$R_S = \frac{V_{in} - V_{out}}{I_{out} + I_Z} = \frac{V_{in} - V_{out}}{I_{in}}$$

with the result that

$$S = \frac{V_{out}}{V_{in}} + \frac{V_{out}}{I_{in} \cdot r_{zu}} \cdot \left(1 - \frac{V_{out}}{V_{in}}\right) \qquad (10)$$

If $V_{in} \rightarrow \infty$, then this reduces to

$$S_{max} = \frac{V_{out}}{I_{in} \cdot r_{zu}} \qquad (11)$$

It can be seen that for a given Zener diode and a given load, the stabilization improves as the input voltage is increased; it should be noted, however, that the power dissipated in the diode series resistor rises at a higher rate than that at which the stabilization factor is increased. As a sensible comprise between the requirements of good stabilization and acceptable power dissipation, it is suggested that the input voltage be made about 2 to 4 times the value of the output voltage.

The output resistance presented by the stabilizer is equal to the diode series resistance R_S in parallel with the differential resistance r_{zu} of the diode. Since R_S is usually very much larger than r_{zu}, the stabilizer output resistance is virtually equal to r_{zu}. It should be noted that in this calculation R_S includes the source resistance of the input supply so that V_{in} is the source EMF.

Other important factors which must be taken into consideration in the design of a shunt stabilizer are, apart from the stabilization factor and the output resistance, the maximum admissible power dissipation and the maximum admissible Zener current. These must not be exceeded under maximum input voltage and minimum load current conditions. The following conditions must be fulfilled:

$$V_{out}\left(\frac{V_{in\,max} - V_{out}}{R_S} - I_{out\,min}\right) < P_{tot}, \qquad (12)$$

$$R_s > \frac{V_{in\,max} - V_{out}}{I_{Z\,max} + I_{out\,min}} \qquad (13)$$

Finally, steps must be taken to ensure that the output current I_{out} does not become excessive. If the input voltage is constant, then the Zener current decreases in the same proportion as the output current increases. However, at very small Zener currents the dynamic resistance of the Zener diode rises sharply and the stabilization performance is correspondingly degraded.

Therefore, the following conditions must be fulfilled:

$$\left(\frac{V_{in\,min} - V_{out}}{R_S} - I_{out\,max}\right) > I_{Z\,min}, \qquad (14)$$

$$R_S < \frac{V_{in\,min} - V_{out}}{I_{Z\,min} + I_{out\,max}} \qquad (15)$$

$I_{Z\,min}$ should be 5 to 10% of $I_{Z\,max}$.

Breakdown Voltage (Zener Voltage) Measurements on Zener Diodes

If a Zener diode is connected to a constant current source, then at constant ambient temperature, the Zener voltage changes and approaches asymptotically a final value. This voltage change is due to the power dissipated in the junction which in turn causes a rise in junction temperature. Zener diodes with a negative temperature coefficient exhibit a Zener voltage reduction, whereas those with a positive temperature coefficient show a Zener voltage increase on application of current. The magnitude of this voltage change due to intrinsic heat generation can be derived from the relevant curves.

Because it is not practical to wait during tests until each device has reached its thermal equilibrium, it is common practice to measure the breakdown voltage of Zener diodes by application of a pulsating current of less than 1 sec duration. Under these conditions the junction temperature is the same as the ambient temperature. The magnitude of the test current used varies from type to type and is quoted in the relevant data sheets.

Therefore, designers, but especially customers carrying out acceptance tests, should allow for the fact that the Zener voltage of a device which is at thermal equilibrium will differ from that quoted in the data sheet. To arrive at an estimate of the equilibrium Zener voltage, a voltage equal to the product of Zener current and thermal differential resistance should be added to the voltage associated with the chosen current as derived from the published dynamically measured breakdown curves.

Silicon Schottky Barrier Diodes

Schottky diode current flow is due to majority carrier conduction. It is not affected by reverse recovery transients as are conventional PN diodes due to stored charge and minority carrier injection.

The low forward voltage drop and fast switching make the diodes ideal for protection of MOS devices, steering, biasing and coupling for fast switching and low logic level applications.

Silicon Rectifiers

The definitions of terms given below are, in the main, those used in the DIN Standards listed on page 23.

Electrical Data

The electrical data, especially the nominal values, apply, unless stated otherwise, to as half-wave rectifier circuit, a sinusoidal 50 Hz AC supply, a resistive load, and operation at altitudes not greater than 1000 m above sea level. In the following paragraphs the definitions of some of the more important electrical data (grouped according to bias conditions) are given.

Forward direction of current flow through a rectifier is that direction at which the rectifier exhibits its lower resistance.

Forward voltage V_F is the voltage drop across a rectifier due to a current in the forward direction (the "forward current"). The forward characteristic gives the relationship between instantaneous forward current and forward voltage.

Nominal current is the arithmetic mean value I_{FAV} of the rectified forward current recommended by the manufacturers; it applies to a half-wave rectifier circuit with resistive load.

Maximum admissible mean forward current is the arithmetic mean value of the maximum admissible continous forward current in a half-wave rectifier circuit with resistive load. It is usually quoted in conjunction with specified cooling conditions or a specified case temperature. Devices operating under maximum mean forward current conditions have no overload safety margin.

Repetitive peak forward current I_{FRM} is the peak value of any repetitive current (this could be non-sinusoidal, as may be the case with capacitive loads).

Overload mean forward current $I_{F(OV)}$ is any current whose mean value over one cycle exceeds the nominal current value. Devices should only be loaded up to the overcurrent limit if they are operated intermittently. The maximum admissible overload current depends on the duty factor (ED/SD) and the period time (SD). Period time = on time + off time.

The maximum current is that overload current which, if permitted to persist, would cause the destruction of the device. It can be derived from a maximum current curve in which the maximum current is plotted as a function of overload duration with the operational state of the device prior to the overload period as parameter. The maximum current curve is used to arrive at the correct fuse rating.

Rated overload factor is the ratio of maximum current to nominal current. If the maximum current is quoted following to nominal current, then it may be admissible to multiply the maximum current with the basic load factor, provided that the forward current prior to the overload condition was less than the nominal current. The basic load factor is given as a function of the ratio of basic load current to nominal current.

The surge (non-repetitive) forward current I_{FSM} is the maximum admissible instantaneous amplitude of a single current pulse of defined shape and duration produced under defined operational conditions. The time interval between any two such current pulses should be not less than 1 min.

Reverse direction of current flow through a rectifier is that direction at which the device exhibits its higher resistance.

Nominal operating voltage is the RMS value of the operational alternating voltage recommended by the manufacturers.

Maximum admissible repetitive peak reverse voltage V_{RRM} is the maximum admissible instantaneous value of any repetitive reverse voltage peaks.

Maximum admissible surge (non-repetitive) peak reverse voltage V_{RSM} is the maximum peak value of any non-repetitive reverse voltage. This must not be exceeded – however short in duration.

Thermal Characteristics

The heat generated in a silicon rectifier during operation must be removed, otherwise the maximum admissible junction temperature would be exceeded. This heat is almost entirely due to the forward losses, and the reverse losses can be ignored under normal working conditions. Since, for reasons of economy, rectifiers are designed to operate at high current density, and possess only a low thermal capacity, it is essential that special attention is paid to cooling problems if the destruction of the rectifiers by thermal overloads is to be avoided. In small rectifiers it is adequate that the heat is radiated from the surface of the case and conducted away via the connecting leads, but power rectifiers require additional cooling aids; they are, therefore, bolted to cooling fins or heat sinks which reduce the termal resistance between the junction and the surrounding air. In the following paragraphs the most important terms used in the thermal data are explained.

Operating temperature range T_{amb} is that range between two limits of the cooling agent temperature where the rectifier may be operated with its maximum admissible repetitive peak reverse voltage. The current load has to be determined from the graphs. Because of the lower air density and consequent reduction in cooling, the current load must be reduced at altitudes of more than 1000 m above sea level.

The storage temperature range T_S is the range of temperatures at which the device may be stored without being subjected to any electrical stresses.

The junction temperature T_j is the (spatial) average temperature of the depletion layer. Temperatures up to the maximum admissible junction temperature will not cause any irreversible changes in the performance of the device.

The case temperature T_C is the temperature on the surface of the case.

Handling Recommendations

Rectifiers are hermetically sealed against external influences, and any leak in the case could cause a reduction of their life. Protection against hard shocks is, therefore, essential.

The low thermal capacity of silicon rectifiers makes it essential that the devices are short-circuit protected by means of quick-blow fuses.

In circuits employing several parallel-connected rectifiers there is a distinct danger that, because of the spread in forward characteristics, at least one device may be overloaded. Therefore a series resistor should be connected in series with each rectifier to ensure that the total power is evenly distributed.

Silicon rectifiers have one characteristic in common with gas-filled rectifiers – they require a certain time to switch from the forward conducting to the reverse blocking state. This so-called reverse recovery time, during which charge carriers are removed from the depletion layer, is of the order of several microseconds and varies from device to device. If several rectifiers are connected in series without any precautions being taken, then the rectifier with the shortest reverse recovery time blocks first and thereby delays the removal of charge carriers in all the other devices, with the result that this rectifier is liable to be damaged. This disadvantage can be overcome by shunting each rectifier in the stack with a network consisting of a resistor connected in series with a capacitor. The time constant of this RC network should be at least 50 μsec, but should be considerably shorter than the duration of one half-cycle of the applied AC voltage (e. g. for f_{in} = 50 Hz; R = 1 kΩ, C = 50 nF). Use of these networks ensures that the total reverse voltage is evenly distributed over all the rectifier units in the stack.

Design Information for Rectifier Circuits

The following tables contain design information for most of the commonly employed rectifier circuits. The information is listed according to load conditions, i. e. for resistive, inductive and back EMF loads (back EMF loads include a source of back EMF, such as a capacitor, a battery, or a DC motor). The figures for resistive and inductive loads are, as a rule, identical; if they differ, then the inductive load figures are given in brackets.

The tables are arranged so that once the DC voltage, DC current and DC power requirements are known, all the more important design parameters can be quickly determined. It should be noted that a maximum overvoltage factor of 10% (permissible in industrial supplies) was taken into consideration when the tabulated figures were calculated.

No rectifier currents are given for circuits intended for back EMF load applications, because under these conditions the rectifier current depends largely on the magnitude of the back EMF. It is recommended that in this case the rectifiers be rated only for up to 70% of the current admissible with resistive loads.

If the circuit incorporates a "high-inductance" smoothing choke, then the figure in brackets should be used. High-inductance means in this context that

$$L > 0.2 \ \frac{V_{BR}}{I_{DC} \cdot f_{BR}}$$

where L is the chocke inductance in henry, V_{BR} the RMS value of the superimposed ripple voltage in volts, I_{DC} the direct current in amperes, and f_{BR} the ripple frequency in Hertz. The voltage dropped across the smoothing chocke must be taken into consideration in the calculation.

The necessary capacitance of the reservoir capacitor can be calculated by use of the following approximate formula:

For half-wave and voltage multiplier circuits:

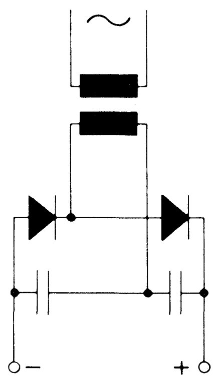
$$C = 250 \cdot \frac{I_{DC}}{V_{BR} \cdot f_{BR}}$$

For single-phase, full-wave circuits:

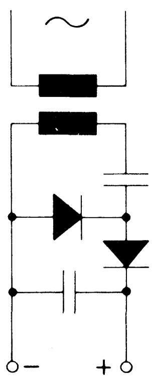
$$C = 200 \cdot \frac{I_{DC}}{V_{BR} \cdot f_{BR}}$$

where C is the capacitance of the reservoir capacitor in microfarad, I_{DC} the DC current in milliamperes, V_{BR} the RMS value of the superimposed ripple voltage in volts and f_{BR} the ripple frequency in Hertz.

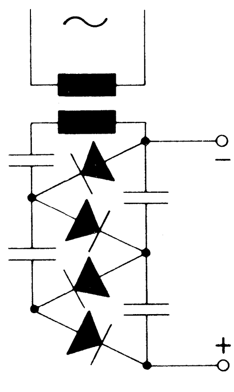
DC output voltages substantially higher than the applied RMS AC voltage can be obtained by the use of voltage doubler or voltage multiplier circuits, a circuit incorporating n rectifiers and n reservoir capacitors producing an open circuit output voltage of approximately n times the peak value of the applied AC voltage. In this case each rectifier should be rated for the same reverse voltage as that applicable to a half-wave rectifier circuit with back EMF load.



Series-connected voltage doubler



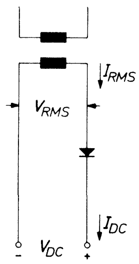
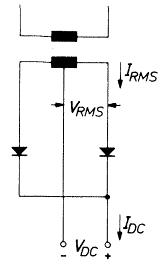
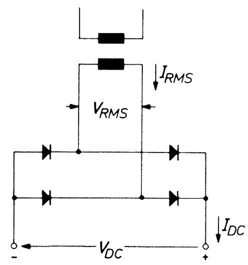
Shunt-connected voltage doubler



Voltage multiplier

Technical Information

Design Information for Single-Phase Circuits

	Halfe-wave	Full-wave	Bridge
Circuit Diagrams			

Resistive load

Characteristics (each diode):

	Halfe-wave	Full-wave	Bridge
$V_{RRM} >$	$3.45 \cdot V_{DC}$	$3.45 \cdot V_{DC}$	$1.73 \cdot V_{DC}$
$V_{RRM} >$	$1.56 \cdot V_{RMS}$	$3.12 \cdot V_{RMS}$	$1.56 \cdot V_{RMS}$
$I_{FAV} >$	$1.0 \cdot I_{DC}$	$0.5 \cdot I_{DC}$	$0.5 \cdot I_{DC}$

Circuit parameters:

	Halfe-wave	Full-wave	Bridge
V_{RMS}	$2.22 \cdot V_{DC}$	$1.11 \cdot V_{DC}$	$1.11 \cdot V_{DC}$
I_{RMS}	$1.57 \cdot I_{DC}$	$0.78\ (0.71) \cdot I_{DC}$	$1.11\ (1.0) \cdot I_{DC}$
P_t	$3.1 \cdot P_{DC}$	$1.48\ (1.34) \cdot P_{DC}$	$1.24\ (1.11) \cdot P_{DC}$
V_{BR}	$1.21 \cdot V_{DC}$	$0.48 \cdot V_{DC}$	$0.48 \cdot V_{DC}$
f_{BR}	$1 \cdot f_{in}$	$2 \cdot f_{in}$	$2 \cdot f_{in}$

Load with back EMF

Characteristics (each diode):

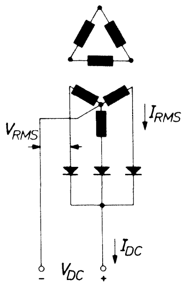
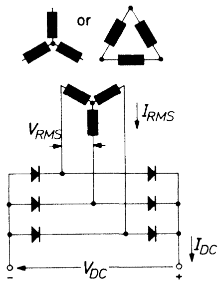
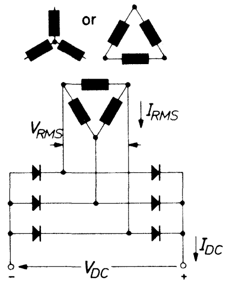
	Halfe-wave	Full-wave	Bridge
$V_{RRM} >$	$2.65 \cdot V_{DC}$	$2.5 \cdot V_{DC}$	$1.25 \cdot V_{DC}$
$V_{RRM} >$	$3.12 \cdot V_{RMS}$	$3.12 \cdot V_{RMS}$	$1.56 \cdot V_{RMS}$

Circuit parameters:

	Halfe-wave	Full-wave	Bridge
V_{RMS}	$0.85 \cdot V_{DC}$	$0.8 \cdot V_{DC}$	$0.8 \cdot V_{DC}$
I_{RMS}	$2.1 \cdot I_{DC}$	$1.1 \cdot I_{DC}$	$1.57 \cdot I_{DC}$
P_t	$1.73 \cdot P_{DC}$	$1.48 \cdot P_{DC}$	$1.24 \cdot P_{DC}$
V_{BR}	to $0.05 \cdot V_{DC}$	to $0.05 \cdot V_{DC}$	to $0.05 \cdot V_{DC}$
f_{BR}	$1 \cdot f_{in}$	$2 \cdot f_{in}$	$2 \cdot f_{in}$

Values in brackets apply to circuits with resistive loads and incorporating a high inductance chocke.

Design Information for Three-Phase Circuits

	Star	Three-phase bridge	Three-phase bridge
Circuit diagrams			

Resistive load

Characteristics (each diode):

	Star	Three-phase bridge	Three-phase bridge
$V_{RRM} >$	$2.3 \cdot V_{DC}$	$1.15 \cdot V_{DC}$	$1.15 \cdot V_{DC}$
$V_{RRM} >$	$2.7 \cdot V_{RMS}$	$1.56 \cdot V_{RMS}$	$1.56 \cdot V_{RMS}$
$I_{FAV} >$	$0.33 \cdot I_{DC}$	$0.33 \cdot I_{DC}$	$0.33 \cdot I_{DC}$

Circuit parameters:

	Star	Three-phase bridge	Three-phase bridge
V_{RMS}	$0.86 \cdot V_{DC}$	$0.74 \cdot V_{DC}$	$0.74 \cdot V_{DC}$
I_{RMS}	$0.58 \cdot I_{DC}$	$0.82 \cdot I_{DC}$	$0.82 \cdot I_{DC}$
P_t	$1.35 \cdot P_{DC}$	$1.05 \cdot P_{DC}$	$1.05 \cdot P_{DC}$
V_{BR}	$0.18 \cdot V_{DC}$	$0.042 \cdot V_{DC}$	$0.042 \cdot V_{DC}$
f_{BR}	$3 \cdot f_{in}$	$6 \cdot f_{in}$	$6 \cdot f_{in}$

Load with back EMF

Characteristics (each diode):

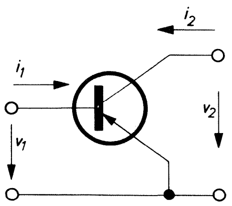
	Star	Three-phase bridge	Three-phase bridge
$V_{RRM} >$	$2.41 \cdot V_{DC}$	$1.15 \cdot V_{DC}$	$1.15 \cdot V_{DC}$
$V_{RRM} >$	$3.12 \cdot V_{RMS}$	$1.56 \cdot V_{RMS}$	$1.56 \cdot V_{RMS}$

Circuit parameters:

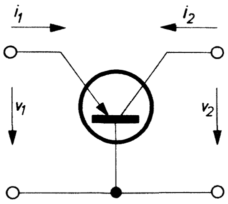
	Star	Three-phase bridge	Three-phase bridge
V_{RMS}	$0.77 \cdot V_{DC}$	$0.74 \cdot V_{DC}$	$0.74 \cdot V_{DC}$
I_{RMS}	$0.75 \cdot I_{DC}$	$0.82 \cdot I_{DC}$	$0.82 \cdot I_{DC}$
P_t	$1.57 \cdot P_{DC}$	$1.05 \cdot P_{DC}$	$1.05 \cdot P_{DC}$
f_{BR}	$3 \cdot f_{in}$	$6 \cdot f_{in}$	$6 \cdot f_{in}$

Basic Transistor Circuits

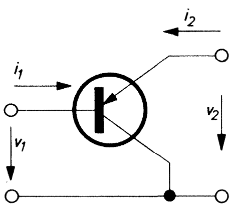
There are three basic transistor circuits. They are called according to that electrode (emitter, base, collector) which is common to both input and output circuit.



Common Emitter



Common Base



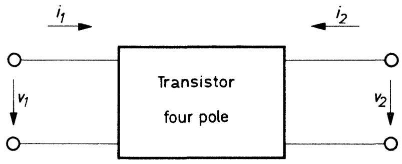
Common Collector

Properties of the three basic circuits:

	Common Emitter	Common Base	Common Collector
Input impedance	medium	small	high
Output impedance	medium	high	small
Current gain	high	less than 1	high
Upper frequency limit	low	high	low

Four-Pole-Symbols of h-Matrix

A transistor can be considered as an active four-pole network. When driven with small low-frequency signals its properties can be described by the four characteristic values of the h- (hybrid) matrix, which are assumed to be real.



$$v_1 = h_i \cdot i_1 + h_r \cdot v_2$$

$$i_2 = h_f \cdot i_1 + h_o \cdot v_2$$

If expressed this in matrix form we obtain:

$$\begin{pmatrix} v_1 \\ i_2 \end{pmatrix} = (h) \begin{pmatrix} i_1 \\ v_2 \end{pmatrix} \qquad (h) = \begin{pmatrix} h_i & h_r \\ h_f & h_o \end{pmatrix}$$

Explanation of h-Parameters

Input impedance (shorted output, $v_2 = 0$):

$$h_i = \frac{v_1}{i_1}$$

Reverse voltage transfer ratio (open input, $i_1 = 0$):

$$h_r = \frac{v_1}{v_2}$$

Small signal current gain (shorted output, $v_2 = 0$):

$$h_f = \frac{i_2}{i_1}$$

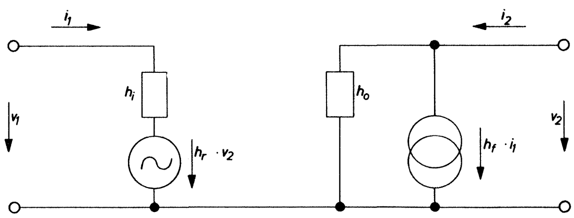
Output admittance (open input, $i_1 = 0$):

$$h_o = \frac{i_2}{v_2}$$

A frequently used abbreviation is the determinant:

$\triangle h = h_i \cdot h_o - h_r \cdot h_f$

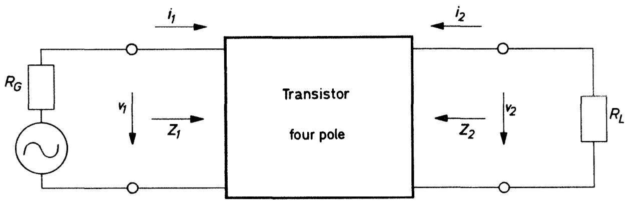
For all three basic circuit configurations the circuit illustrated below represents the equivalent four-pole circuit using h-parameters.



In the transistor data sheets the h-parameters are usually quoted for the common emitter configuration and for a given operating point (bias). The latter is determined by the collector voltage, the emitter or collector current and by the ambient temperature. For different operating points, correction factors are needed which can be gathered from the relevant curves. For common base or common collector transistor stage calculations, the appropriate h-parameters are ascertained from those of the common emitter configuration by using the following conversion formulas.

	Common Emitter	Common Base	Common Collector
Input impedance	h_{ie}	$h_{ib} = \frac{h_{ie}}{1 + h_{fe}}$	$h_{ic} = h_{ie}$
Reverse voltage transfer ratio	h_{re}	$h_{rb} = \frac{h_{ie} \cdot h_{oe}}{1 + h_{fe}} - h_{re}$	$h_{rc} = 1 - h_{re}$
Small signal current gain	h_{fe}	$h_{fb} = -\frac{h_{fe}}{1 + h_{fe}}$	$-h_{fc} = 1 + h_{fe}$
Output admittance	h_{oe}	$h_{ob} = \frac{h_{oe}}{1 + h_{fe}}$	$h_{oc} = h_{oe}$

Calculation of a Transistor Stage



Input impedance

$$Z_1 = \frac{v_1}{i_1} = \frac{h_i + R_L \cdot \Delta h}{1 + h_o \cdot R_L}$$

Output impedance

$$Z_2 = \frac{v_2}{i_2} = \frac{h_i + R_G}{\Delta h + h_o \cdot R_G}$$

Current gain

$$G_C = \frac{i_2}{i_1} = \frac{h_f}{1 + h_o \cdot R_L}$$

Voltage gain

$$G_V = \frac{v_2}{v_1} = \frac{-h_f \cdot R_L}{h_i + R_L \cdot \Delta h}$$

Power gain

$$G_P = \frac{v_2 \cdot i_2}{v_1 \cdot i_1} = \frac{h_f^2 \cdot R_L}{(1 + h_o \cdot R_L)\,(h_i + R_L \cdot \Delta h)}$$

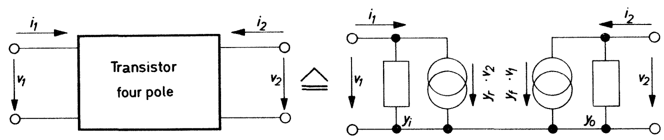
Max. available power gain, input and output matched with $R_{G\,opt}$ resp. $R_{L\,opt}$

$$G_{p\,max} = \left(\frac{h_f}{\sqrt{\Delta h} + \sqrt{h_i \cdot h_o}} \right)^2$$

$$R_{G\,opt} = \sqrt{\frac{h_i \cdot \Delta h}{h_o}} \qquad R_{L\,opt} = \sqrt{\frac{h_i}{h_o \cdot \Delta h}}$$

Four-Pole Symbols of y-Matrix

Whereas the network behaviour of low-frequency transistors could be described by using the h- (hybrid) matrix, the y- (admittance) matrix is usually employed for high frequency transistors.



$$i_1 = y_i \cdot v_1 + y_r \cdot v_2$$

$$i_2 = y_f \cdot v_1 + y_o \cdot v_2$$

In matrix form we obtain:

$$\begin{pmatrix} i_2 \\ i_1 \end{pmatrix} = (y) \begin{pmatrix} v_1 \\ v_2 \end{pmatrix} \qquad (y) = \begin{pmatrix} y_i & y_r \\ y_f & y_o \end{pmatrix}$$

The y-parameters are complex values which can be expressed as

$y_{ik} = g_{ik} + jb_{ik}$ with $b_{ik} = \omega C_{ik}$ or with $b_{ik} = -\frac{1}{\omega L_{ik}}$

Often, the following notation is expedient:

$y_{ik} = |\, y_{ik} \,| \exp j\varphi_{ik}$

By adding the suffix e, b, or c it is possible to indicate to which of the three basic circuit configurations the parameters are valid.

Explanation of y-Parameters

Input admittance (shorted output, $v_2 = 0$)

$$y_i = \frac{i_1}{v_1}$$

Reverse transconductance (shorted input, $v_1 = 0$)

$$y_r = \frac{i_1}{v_2}$$

Forward transconductance (shorted output, $v_2 = 0$)

$$y_f = \frac{i_2}{v_1}$$

Output admittance (shorted input, $v_1 = 0$)

$$y_o = \frac{i_2}{v_2}$$

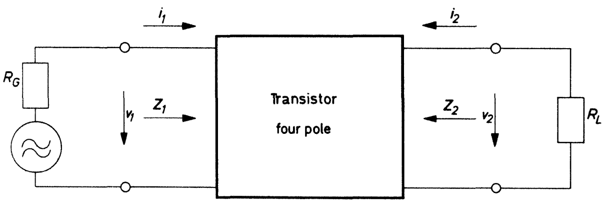
The determinant reads $\Delta y = y_i \cdot y_o - y_r \cdot y_f$

Conversion from y-Parameters to h-Parameters

$$h_i = \frac{1}{y_i} \qquad h_r = -\frac{y_r}{y_i} \qquad \Delta h = \frac{y_o}{y_i}$$

$$h_f = \frac{y_f}{y_i} \qquad h_o = \frac{\Delta y}{y_i}$$

Calculation of a Transistor Stage



Input impedance

$$Z_1 = \frac{v_1}{i_1} = \frac{1 + y_o \cdot R_L}{y_i + \Delta y \cdot R_L}$$

Output impedance

$$Z_2 = \frac{v_2}{i_2} = \frac{1 + y_i \cdot R_G}{y_o + \Delta y \cdot R_G}$$

Current gain

$$G_C = \frac{i_2}{i_1} = \frac{y_f}{y_i + \Delta y \cdot R_L}$$

Voltage gain

$$G_V = \frac{v_2}{v_1} = \frac{-y_f \cdot R_L}{1 + y_o \cdot R_L}$$

Power gain

$$G_P = \frac{v_2 \cdot i_2}{v_1 \cdot i_1} = \frac{|y_f|^2 \cdot R_L}{(1 + y_o \cdot R_L)\ (y_i + \Delta y \cdot R_L)}$$

Available power gain, input matched with $R_{G\,opt}$

$$G_{p\,av} = \frac{4 \cdot y_f^2 \cdot R_G \cdot R_L}{[(y_1 + \Delta y \cdot R_L) \cdot R_G + 1 + y_o \cdot R_L]^2}$$

Max. available power gain, input and output matched with $R_{G\,opt}$ resp. $R_{L\,opt}$

$$G_{P\,max} = \left(\frac{y_f}{\sqrt{\Delta y} + \sqrt{y_i \cdot y_o}} \right)^2$$

Max. available power gain will be attained if input and output are matched, where:

$$R_{L\,opt} = \sqrt{\frac{y_o}{y_i} \cdot \frac{1}{\Delta y}}$$

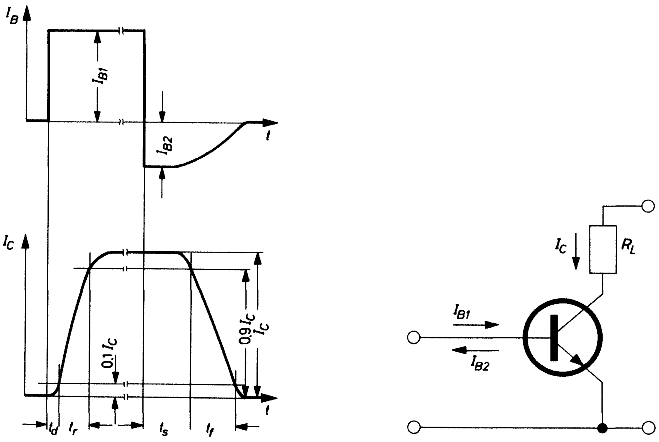
$$R_{G\,opt} = \sqrt{\frac{y_i}{y_o} \cdot \frac{1}{\Delta y}}$$

and:

$$\Delta y = y_i \cdot y_o - y_r \cdot y_f$$

Switching Times

Definitions for the various times which make up the total switching time can be gathered from the diagram below in which the switching characteristic of a transistor in common-emitter configuration is illustrated.

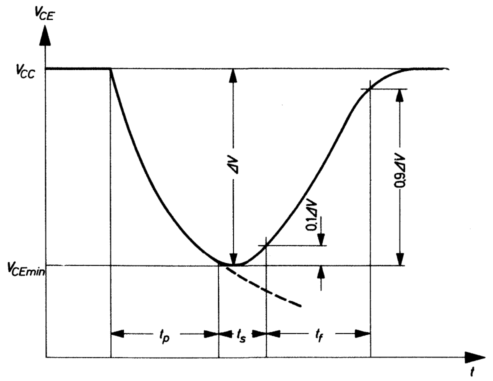


t_d	Delay time
t_r	Rise time
t_s	Storage time
t_f	Fall time
$t_{on} = t_d + t_r$	Turn-on time
$t_{off} = t_s + t_f$	Turn-off time

The duration of the switching times depends upon the transistor type and very much on the circuit arrangement.

With increasing saturation of the transistor the turn-on time decreases and the turn-off time increases. An increase of the turn-off current I_{B2} shortens the turn-off time.

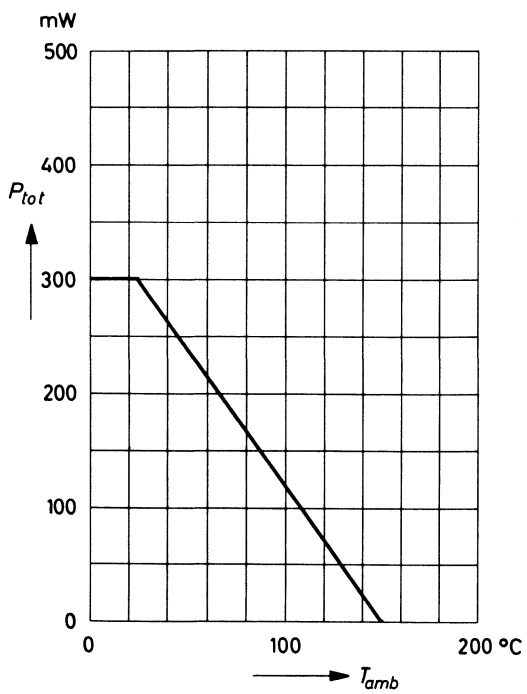
The switching times depend on the duration of the turn-on pulse. It is only when the duration of this pulse is a multiple of the switching times that the latter remain constant. If the pulse is shorter, especially the storage time decreases. With a pulse duration in the region of the turn-on time the transistor is no longer fully saturated. The collector voltage then exhibits a characteristic such as is qualitatively represented in the diagram below.



Admissible Power Dissipation

The indicated maximum admissible junction temperature must not be exceeded because this could damage or cause the destruction of the semiconductor crystal. Since the user cannot measure this temperature, data sheets also reveal the maximum admissible power dissipation P_{tot} usually in the form of a derating curve (see diagram).

Admissible power dissipation versus ambient temperature



If power dissipation is kept within these limits the maximum junction temperature will not be exceeded.This can easely be checked by using the equation

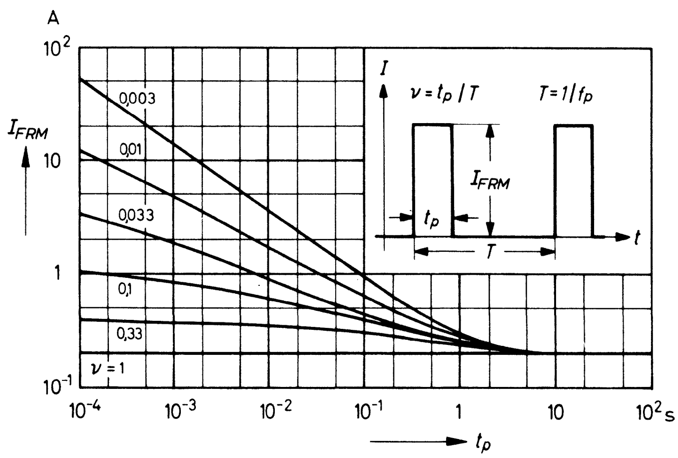
$$T_j = T_{amb} + P_{tot} \cdot R_{th}.$$

The admissible dissipation of semiconductor devices which operate from sinusoidal supplies is based on the arithmetic mean value of junction temperature and power dissipation.

Pulse power dissipation may usually exceed continuous power dissipation.

Some of the data sheets contain diagrams which allow the rating of a device operating under pulsed conditions to be determined.

In the diagram below, which applies to diodes and rectifiers, the maximum admissible pulse current amplitude is plotted as a function of pulse duration for an ambient (or case) temperature of + 25 °C. If the device is to operate at higher ambient temperatures, then it is necessary to derate the current values derived from this diagram in accordance with the "admissible dissipation versus temperature" curve.



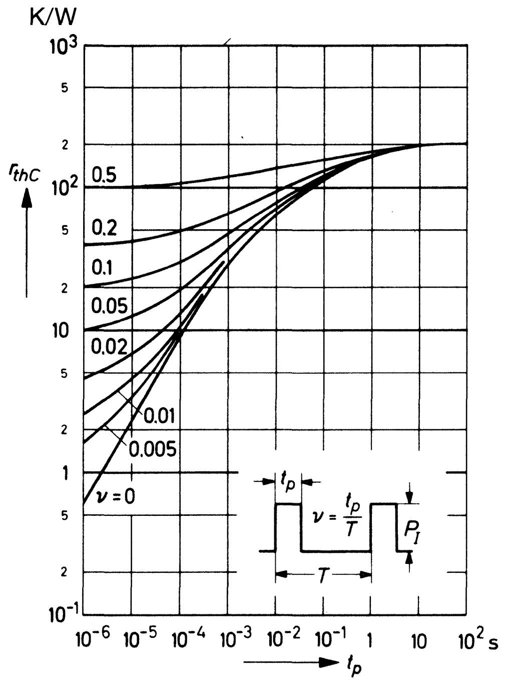
For Zener diodes and transistors it is preferable to provide a plot which gives the terminal pulse resistance rather than the admissible current amplitude as a function of t_p (the duration of the rectangular pulse which causes power to be dissipated) as shown in the diagram below. The operational junction temperature can then be calculated by use of the formula

$$T_j = T_{amb} + P_I \cdot r_{thA}$$

or, if additional power P_D is continuously dissipated, by use of the formula

$$T_j = T_{amb} + P_D \cdot R_{thA} + P_I \cdot r_{thA}.$$

Pulse thermal resistance versus pulse duration



Mounting Informations

Because semiconductor devices are sensitive to excessive junction temperature, designers should pay special attention to the lay-out of equipment and ensure that there is adequate space between heat-generating components and semiconductor devices.
Semiconductor devices can be fitted in any position.

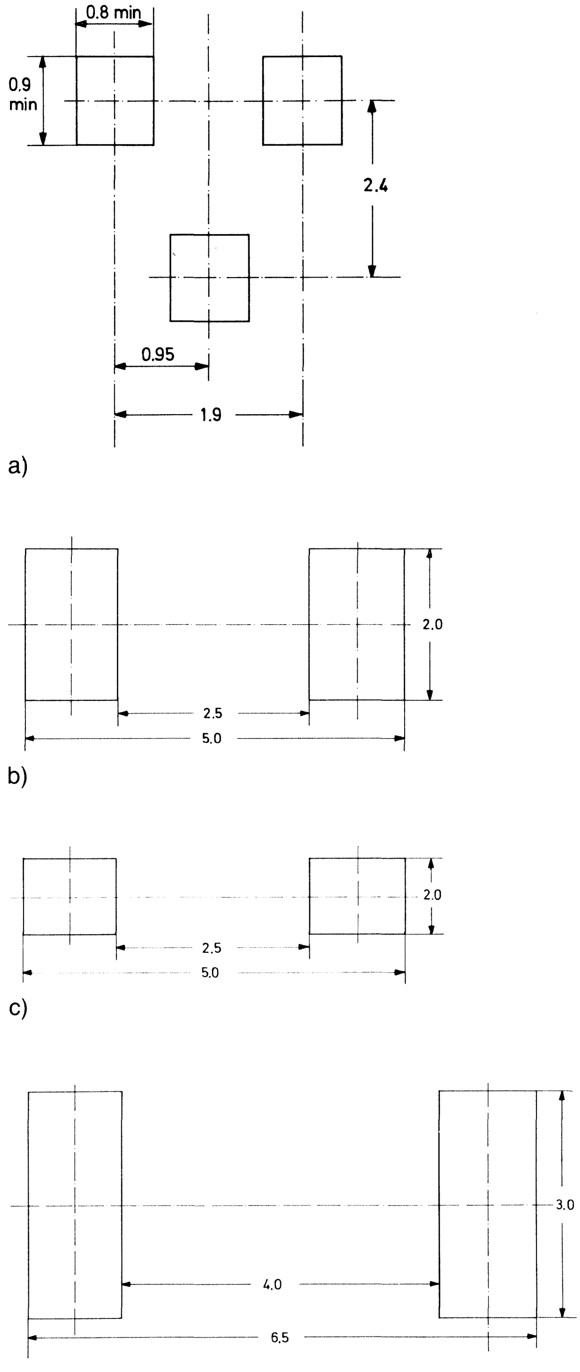
The following soldering methods are permitted:

soldering iron
dip soldering
wave soldering
reflow soldering
vapor phase soldering

With the first three methods a maximum solder temperature of 260 °C for a period of 10 seconds may not be exceeded.

With reflow and vapor phase soldering a maximum solder temperature of 235 °C for a period of 30 seconds may not be exceeded.

Suggestions for the soldering pads for mounting the devices are given in the following sketches.

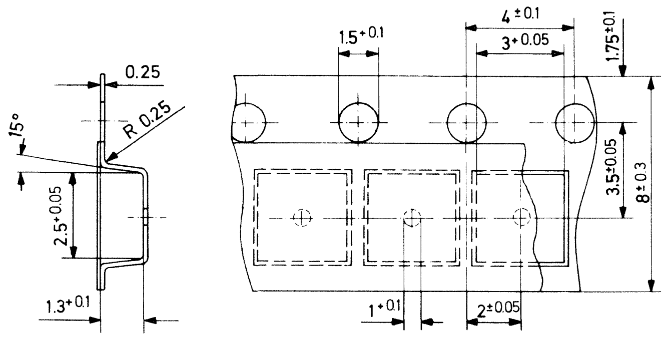


Metalization areas
dimensions in mm
a) for TO-236
b) for MiniMELF
c) for 60A2
d) for MELF

Packaging

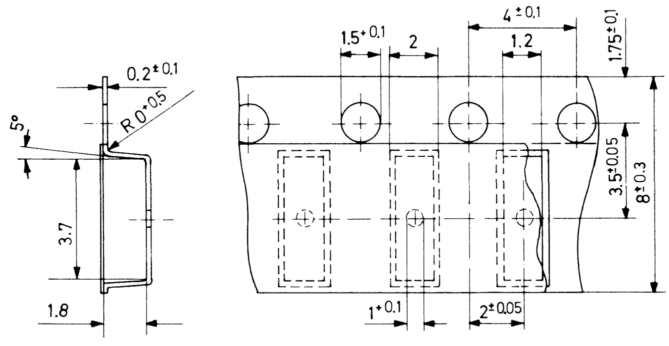
ITT Semiconductors supplies the SMD components either in bulk or in 8-mm or 12-mm blister tapes depending on type of case.

Both the tape dimensions for the cases TO-236, MiniMELF, 60A2 and MELF and the dimensions of the reels are shown in the following figures.



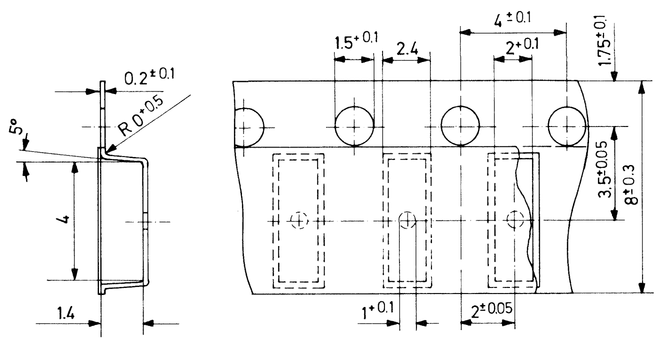
Accumulated pitch tolerance is ±0.2 mm over 10 pitches

8-mm carrier tape for case TO-236
dimensions in mm



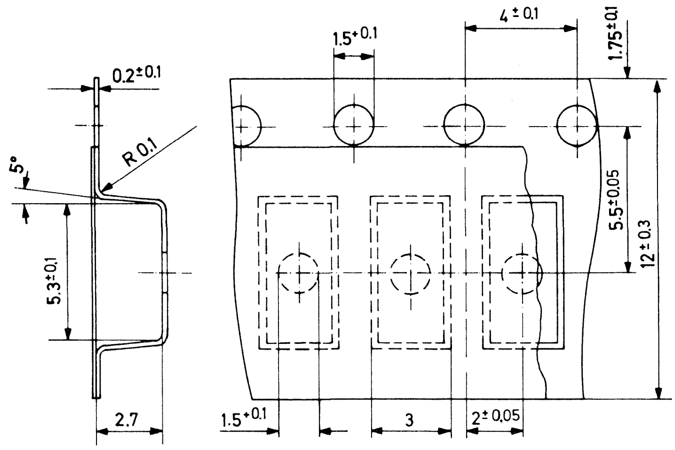
Accumulated pitch tolerance is ±0.2 mm over 10 pitches

8-mm carrier tape for MiniMELF package
dimensions in mm



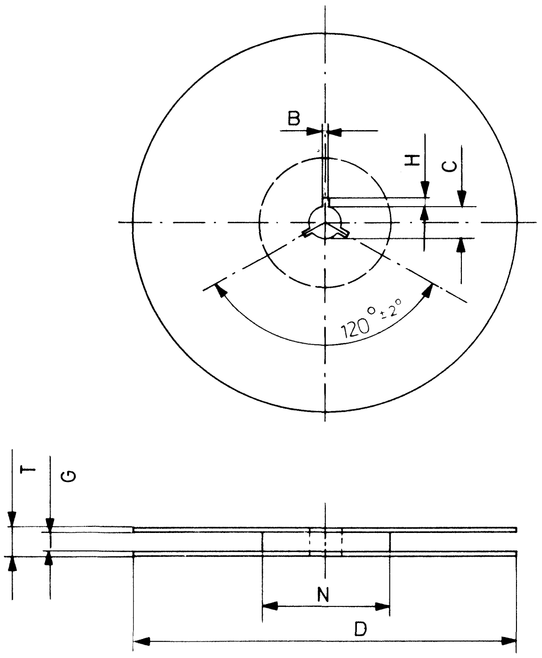
Accumulated pitch tolerance is ± 0.2 mm over 10 pitches

8-mm carrier tape for case 60A2
dimensions in mm



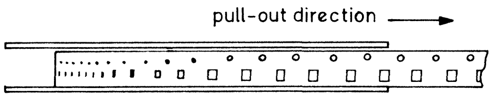
Accumulated pitch tolerance is ±0.2 mm over 10 pitches

12-mm carrier tape for MELF package
dimensions in mm



	8-mm-carrier tape	12-mm carrier tape
B	2 ± 0.5	2 ± 0.5
C	13 ± 0.5	13 ± 0.5
D	178 + 2 250 330	178 + 2 250 330
G	8.4 + 1.5	12.4 + 2
H	4 ± 0.5	4 ± 0.5
N	60	60
T	<14.9	<20

Dimensions in mm



Reel for 8-mm and 12-mm carrier tapes

The carrier tape consists of a plastic tape with "nests" having a size corresponding to the components requirements. The sprocket holes are on one side of the tape. The blister tapes are sealed with a cover tape.

The components in the TO-236 case are placed with the mounting side on the bottom of the nests which are on the underside of the tape. The single connection of the case is adjacent to the sprocked holes.

The cathode side of the components in MELF and Mini-MELF cases are adjacent to the sprocket holes.

Other orientation can be supplied on demand.

The beginning of the tape comprises a 200 mm long lead-in with vacant nests and unsealed cover foil, followed by a further 10 to 20 vacant, but this time sealed nests.

At the hub end of the tape there are 10 to 20 sealed nests containing no devices. This end of the tape automatically detaches from the hub of the reel at the end of the unreeling procedure (Draft DIN IEC 49 (CO) 564).

The reel labelling contains the following items.

Country of manufacture
Type designation
Code number
Quantity
Date

The packaging units for taped devices are

types of case	qty/reel	reel ∅
TO-236	3000	178 mm
MELF	5000	330 mm
MiniMELF	2500 5000 10000	178 mm 250 mm 330 mm
MiniMELF-Tuner-Diodes	2000	178 mm
60A2-Turner-Diodes	3000	178 mm

Specifications for Quality

1. General

The outgoing quality of ITT's semiconductor devices is determined by the 100% testing of the guaranteed parameters with the most modern equipment. It is assured by means of a sampling system based on the laws of statistics covering all electrical and mechanical limit values.

The Quality is described by AQL-values (AQL = Acceptable Quality Level), which define the percentage of defectives in a batch, at or below which there is at least a 90% probability of the batch being accepted.

2. Defectives

Defectives are defined in terms of the maximal ratings and guaranteed characteristics of electrical and mechanical parameters. A device is considered defective if any one parameter does not lie within the limits quoted in the data-sheet. If an item has more than one defect, the this is counted as one defect only, i.e. a batch is assessed on the number of defective items and not on the number of defects. Defects are classified according to type and degree.

Type of defects:
a) Mechanical defects (case and leads)
b) Electrical defects

Degree of defects:
a) Catastrophic defects are those which preclude any use of the item
b) Limit defects are those which allow restricted use of the item

3. AQL (Acceptable Quality Level) Values

The group AQL values for the stated failure groups are given below. The AQL values apply to the sum of all defectives within the group.

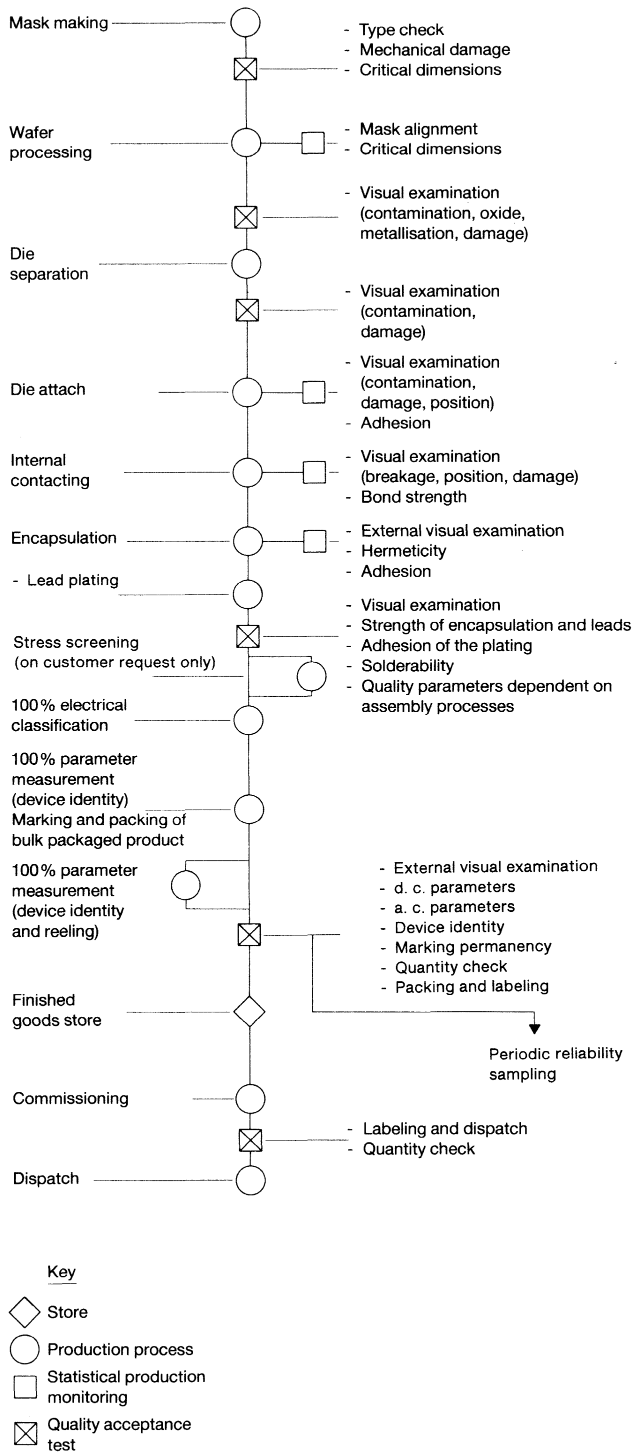
Defectives:

Mechanical:	Catastrophic defectives	0.065 %
	Limit defectives	0.25 %
Electrical:	Catastrophic defectives	0.025 %
	Limit defectives	0.065 %

4. Incoming Inspection

The tests carried out by the manufacturer are designed so as to obviate the need for any incoming inspection by the user. If, however, a user wishes to carry out an incoming inspection, then this should be done on a sample basis, as laid down in the internationally accepted MIL-STD 105 D (DIN 40080) specifications.

Quality control during manufacture Transistors and Diodes



DIN Standards (German)

The information contained in this book conforms, in the main, to the following German DIN Standards:

DIN IEC 286-1 (9.82)	Packaging of components for automatic handling; Tape packaging of components with leads on contiunous tapes
DIN IEC 286-2 (2.87)	Packaging of components for automatic handling; Tape packaging of components with unidirectional leads on contiunous tapes
DIN IEC 286-3 (9.87)	Packaging of components for automatic handling; Packaging of leadless components on contiunous tapes
DIN 41781 (7.72)	Rectifier diodes, definitions
DIN 41782 (6.69)	Mono-crystalline rectifier devices, guidelines for the presentation of published data
DIN 41785 Sheet 1 (10.69)	Semiconductor devices, letter symbols on data sheets, general
DIN 41785 Part 2 (6.76)	Semiconductor devices, letter symbols on data sheets for semiconductor devices for telecommunication
DIN 41785 Sheet 3 (2.75)	Semiconductor devices, letter symbols for data sheets for power semiconductor devices
DIN 41790 (1.69)	Semiconductor devices, recommendations for data sheets, voltage reference and voltage regulator diodes
DIN 41791 Sheet 1 (9.71)	Semiconductors for telecommunication, recommendations for data sheets, general
DIN 41791 Sheet 2 (10.72)	Semiconductor devices for telecommunication, recommendations for data sheets, low-power signal diodes and switching diodes
DIN 41791 Sheet 4 (3.74)	Semiconductor devices for telecommunication, recommendations for data sheets, low power signal transistors
DIN 41791 Sheet 6 (6.76)	Semiconductor devices for telecommunication, recommendations for data sheets, switching transistors
DIN 41791 Sheet 8 (9.71)	Low power semiconductor devices, recommendations for data sheets, variable capacitance diodes
DIN 41853 (12.75)	Semiconductor diodes, signal diodes and rectifier diodes for telecommunication, terms and definitions
DIN 41854 (4.79)	Transistors, terms and definitions
DIN 41855 (10.74)	Semiconductor devices and integrated circuits, kinds of devices and general terms
DIN 41869 Part 1 (7.73)	Case 23A3 for semiconductor devices; main dimensions
DIN 41870 Sheet 1 (4.69)	Cases for semiconductor devices and integrated circuits, short designations
DIN 41870 Part 2 (7.83)	Cases for semiconductor devices and integrated circuits, survey, terminal covering
DIN 41870 Part 3 (9.82)	Cases for semiconductor devices and integrated circuits Case 60A2 (IEC: A67)

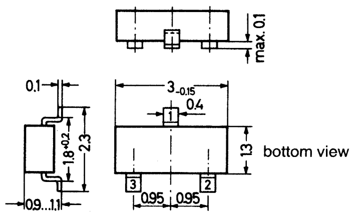
NPN Silicon Transistors

BC817, BC818

NPN Silicon Epitaxial Planar Transistors
for switching, AF driver and amplifier applications.

Especially suited for automatic insertion in thick- and thin-film circuits.

These transistors are subdivided into three groups -16, -25 and -40 according to their current gain.
As complementary types the PNP transistors BC807 and BC808 are recommended.
The pinconfiguration of these types is the following: 1 = Collector, 2 = Base, 3 = Emitter.



Plastic package 23A3
according to DIN 41869 (≈ TO-236)
The case is impervious to light.

Weight approximately 0.01 g
Dimensions in mm

Marking code

Type	Marking
BC817-16	6A
-25	6B
-40	6C
BC818-16	6E
-25	6F
-40	6G

Absolute Maximum Ratings

		Symbol	Value	Unit
Collector Emitter Voltage	**BC817**	V_{CES}	50	V
	BC818	V_{CES}	30	V
Collector Emitter Voltage	**BC817**	V_{CEO}	45	V
	BC818	V_{CEO}	25	V
Emitter Base Voltage		V_{EBO}	5	V
Collector Current		I_C	800	mA
Peak Collector Current		I_{CM}	1000	mA
Peak Base Current		I_{BM}	200	mA
Peak Emitter Current		$-I_{EM}$	1000	mA
Power Dissipation at T_{SB} = 50 °C		P_{tot}	310[1)]	mW
Junction Temperature		T_j	150	°C
Storage Temperature Range		T_S	−65 ... +150	°C

[1)] Ceramic Substrate 0.7 mm; 2.5 cm^2 area

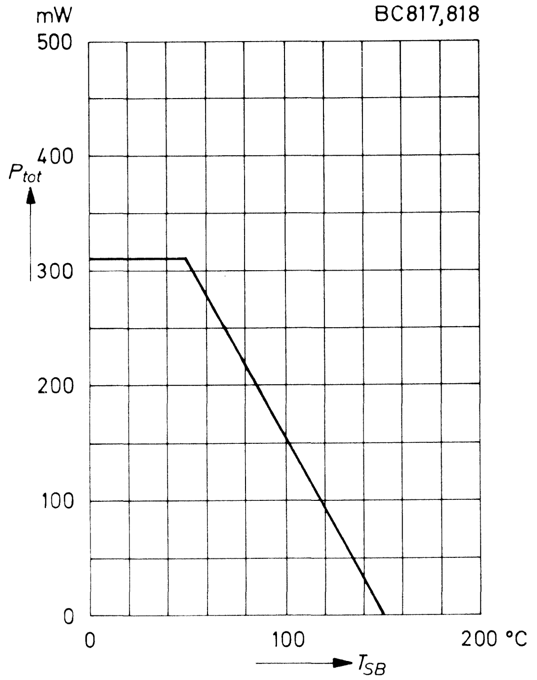
Characteristics at T_{amb} = 25 °C

	Symbol	Min.	Typ.	Max.	Unit
DC Current Gain at V_{CE} = 1 V, I_C = 100 mA **Current Gain Group-16** **-25** **-40** at V_{CE} = 1 V, I_C = 300 mA **-16** **-25** **-40**	 h_{FE} h_{FE} h_{FE} h_{FE} h_{FE} h_{FE}	 100 160 250 60 100 170	 – – – – – –	 250 400 600 – – –	 – – – – – –
Thermal Resistance Junction Substrate Backside	R_{thSB}	–	–	320[1)]	K/W
Thermal Resistance Junction to Ambient	R_{thA}	–	–	450	K/W
Collector Saturation Voltage at I_C = 500 mA, I_B = 50 mA	V_{CEsat}	–	–	0.7	V
Base Emitter Voltage at V_{CE} = 1 V, I_C = 300 mA	V_{BE}	–	–	1.2	V
Collector Cutoff Current at V_{CE} = 45 V **BC817** at V_{CE} = 25 V **BC818** at V_{CE} = 25 V, T_j = 150 °C	 I_{CES} I_{CES} I_{CES}	 – – –	 – – –	 100 100 5	 nA nA µA
Emitter Cutoff Current at V_{EB} = 4 V	I_{EBO}	–	–	100	nA
Gain Bandwidth Product at V_{CE} = 5 V, I_C = 10 mA, f = 50 MHz	f_T	–	100	–	MHz
Collector Base Capacitance at V_{CB} = 10 V, f = 1 MHz	C_{CBO}	–	12		pF

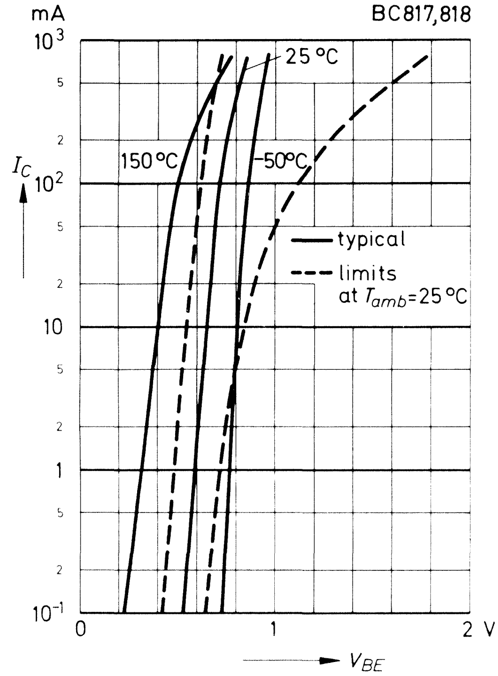
[1)] Ceramic Substrate 0.7 mm; 2.5 cm^2 area

Admissible power dissipation versus temperature of substrate backside

Ceramic Substrate 0.7 mm; 2.5 cm² area.

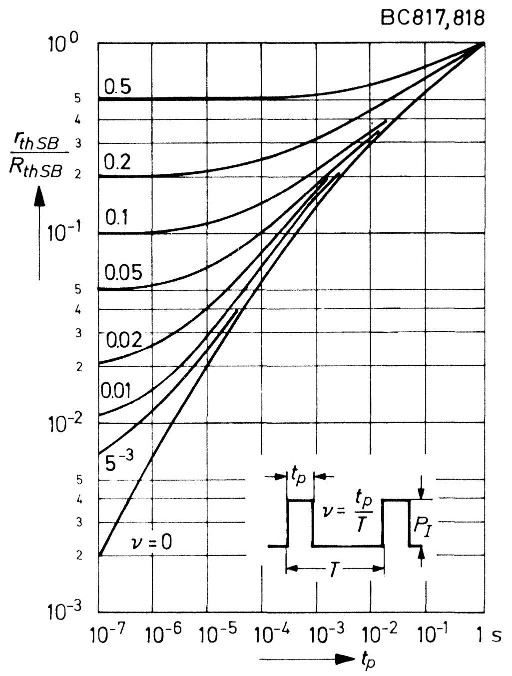


Collector current versus base emitter voltage

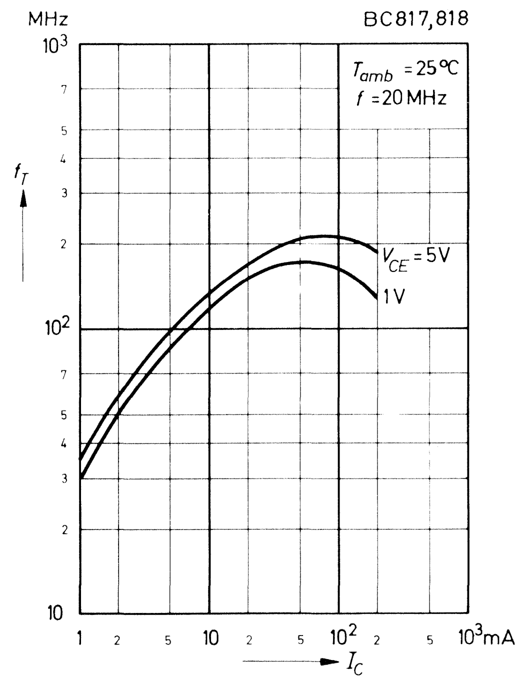


Pulse thermal resistance versus pulse duration (normalized)

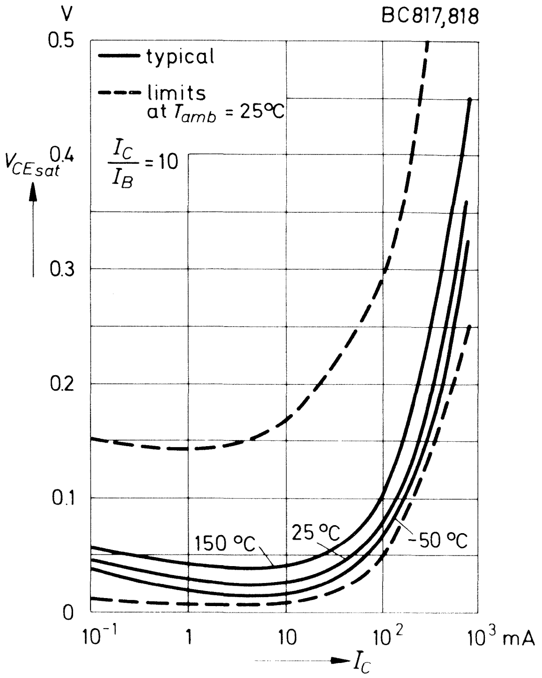
Ceramic Substrate 0.7 mm; 2.5 cm² area.



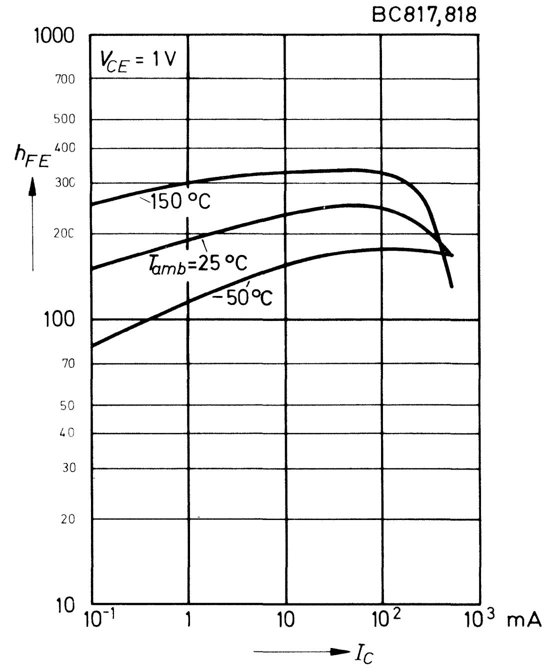
Gain bandwidth product versus collector current



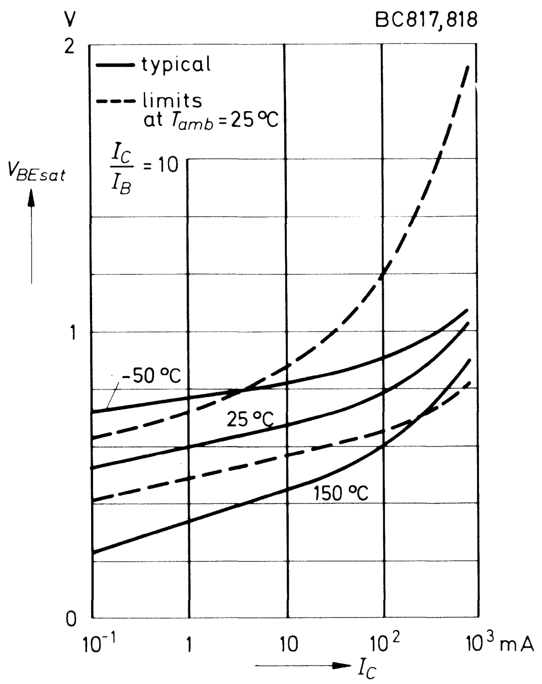
Collector saturation voltage versus collector current



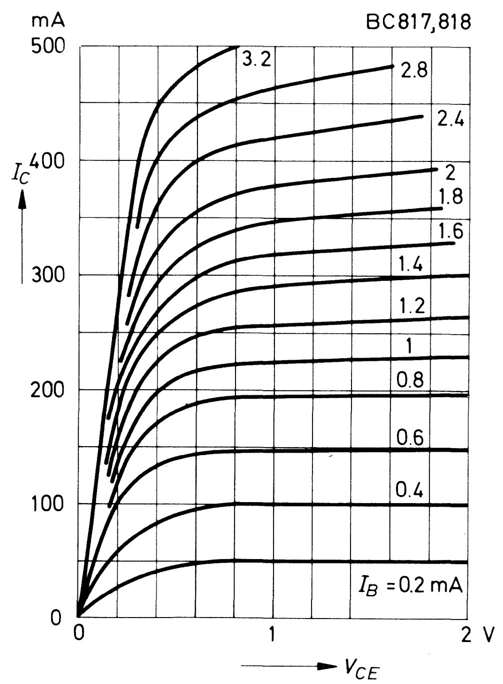
DC current gain versus collector current



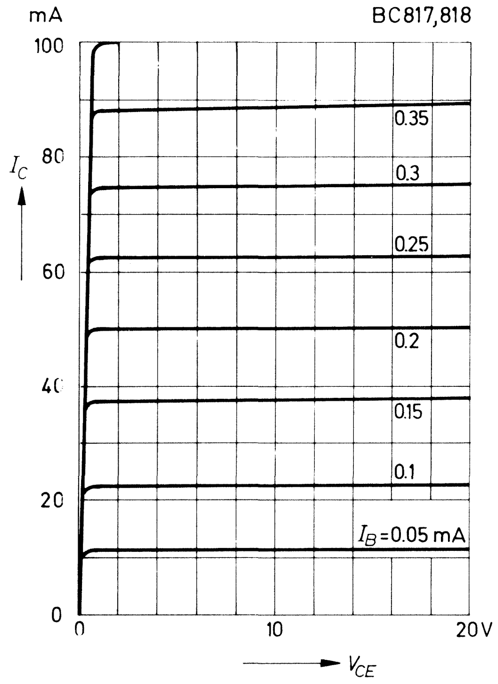
Base saturation voltage versus collector current



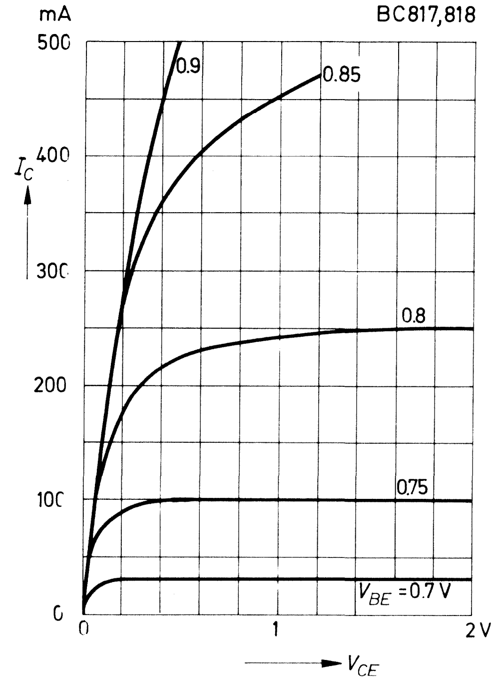
Common emitter collector characteristics



Common emitter collector characteristics



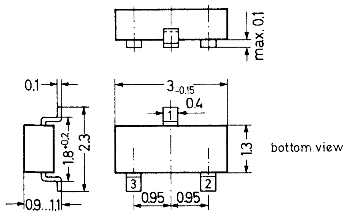
Common emitter collector characteristics



NPN Silicon Epitaxial Planar Transistors
for switching and AF amplifier applications.

Especially suited for automatic insertion in thick- and thin-film circuits.

These transistors are subdivided into three groups A, B and C according to their current gain. The types BC846 is available in groups A and B, however, the types BC847 and BC848 can be supplied in all three groups. The BC849 is a low noise type and the BC850 a extremely low noise type. Both are available in groups B and C. As complementary types the PNP transistors BC856...BC860 are recommended.
The pinconfiguration of these types is the following: 1 = Collector, 2 = Base, 3 = Emitter.



Plastic package 23A3
according to DIN 41869 (≈ TO-236)
The case is impervious to light

Weight approximately 0.01 g
Dimensions in mm

Marking code

Type	Marking
BC846A	1A
B	1B
BC847A	1E
B	1F
C	1G

Marking code

Type	Marking
BC848A	1J
B	1K
C	1L
BC849B	2B
C	2C
BC850B	2F
C	2G

Absolute Maximum Ratings

		Symbol	Value	Unit
Collector Base Voltage	**BC846**	V_{CBO}	80	V
	BC847, BC850	V_{CBO}	50	V
	BC848, BC849	V_{CBO}	30	V
Collector Emitter Voltage	**BC846**	V_{CES}	80	V
	BC847, BC850	V_{CES}	50	V
	BC848, BC849	V_{CES}	30	V
Collector Emitter Voltage	**BC846**	V_{CEO}	65	V
	BC847, BC850	V_{CEO}	45	V
	BC848, BC849	V_{CEO}	30	V
Emitter Base Voltage	**BC846, BC847**	V_{EBO}	6	V
	BC848, BC849, BC850	V_{EBO}	5	V
Collector Current		I_C	100	mA
Peak Collector Current		I_{CM}	200	mA
Peak Base Current		I_{BM}	200	mA
Peak Emitter Current		$-I_{EM}$	200	mA
Power Dissipation at T_{SB} = 50 °C		P_{tot}	310	mW
Junction Temperature		T_j	150	°C
Storage Temperature Range		T_S	−65 . . . +150	°C

Characteristics at T_{amb} = 25° C

		Symbol	Min.	Typ.	Max.	Unit
h-Parameters at V_{CE} = 5 V, I_C = 2 mA, f = 1kHz						
Small Signal Current Gain	**Current Gain Group A**	h_{fe}	–	220	–	–
	B	h_{fe}	–	330	–	–
	C	h_{fe}	–	600	–	–
Input Impedance	**Current Gain Group A**	h_{ie}	1.6	2.7	4.5	kΩ
	B	h_{ie}	3.2	4.5	8,5	kΩ
	C	h_{ie}	6	8.7	15	kΩ
Output Admittance	**Current Gain Group A**	h_{oe}	–	18	30	μS
	B	h_{oe}	–	30	60	μS
	C	h_{oe}	–	60	110	μS
Reverse Voltage Transfer Ratio	**Current Gain Group A**	h_{re}	–	$1.5 \cdot 10^{-4}$	–	–
	B	h_{re}	–	$2 \cdot 10^{-4}$	–	–
	C	h_{re}	–	$3 \cdot 10^{-4}$	–	–
DC Current Gain at V_{CE} = 5 V, I_C = 10 μA	**Current Gain Group A**	h_{FE}	–	90	–	–
	B	h_{FE}	–	150	–	–
	C	h_{FE}	–	270	–	–
at V_{CE} = 5 V, I_C = 2 mA	**Current Gain Group A**	h_{FE}	110	180	220	–
	B	h_{FE}	200	290	450	–
	C	h_{FE}	420	520	800	–
Thermal Resistance Junction to Substrate Backside		R_{thSB}	–	–	320[1)]	K/W
Thermal Resistance Junction to Ambient		R_{thA}	–	–	450	K/W
Collector Saturation Voltage at I_C = 10 mA, I_B = 0,5 mA		V_{CEsat}	–	90	250	mV
at I_C = 100 mA, I_B = 5 mA		V_{CEsat}	–	200	600	mV
Base Saturation Voltage at I_C = 10 mA, I_B = 0.5 mA		V_{BEsat}	–	700	–	mV
at I_C = 100 mA, I_B = 5 mA		V_{BEsat}	–	900	–	mV
Base Emitter Voltage at V_{CE} = 5 V, I_C = 2 mA		V_{BE}	580	660	700	mV
at V_{CE} = 5 V, I_C = 10 mA		V_{BE}	–	–	720	mV
Collector Cutoff Current at V_{CE} = 80 V	**BC846**	I_{CES}	–	0.2	15	nA
at V_{CE} = 50 V	**BC847, BC850**	I_{CES}	–	0.2	15	nA
at V_{CE} = 30 V	**BC848, BC849**	I_{CES}	–	0.2	15	nA
at V_{CE} = 80 V, T_j = 125 °C	**BC846**	I_{CES}	–	–	4	μA
at V_{CE} = 50 V, T_j = 125 °C	**BC847, BC850**	I_{CES}	–	–	4	μA
at V_{CE} = 30 V, T_j = 125 °C	**BC848, BC849**	I_{CES}	–	–	4	μA
at V_{CB} = 30 V		I_{CBO}	–	–	15	nA
at V_{CB} = 30 V, T_j = 150 °C		I_{CBO}	–	–	5	μA
Gain Bandwidth Product at V_{CE} = 5 V, I_C = 10 mA, f = 100 MHz		f_T	–	300	–	MHz
Collector Base Capacitance at V_{CB} = 10 V, f = 1 MHz		C_{CBO}	–	3.5	6	pF
Emitter Base Capacitance at V_{EB} = 0.5 V, f = 1 MHz		C_{EBO}	–	9	–	pF
Noise Figure at V_{CE} = 5 V, I_C = 200 μA, R_G = 2 kΩ f = 1 kHz, Δf = 200 Hz	**BC846, BC847, BC848**	F	–	2	10	dB
	BC849, BC850	F	–	1.2	4	dB
at V_{CE} = 5 V, I_C = 200 μA, R_G = 2 kΩ, f = 30...15000 Hz	**BC849**	F	–	1.4	4	dB
	BC850	F	–	1.4	3	dB

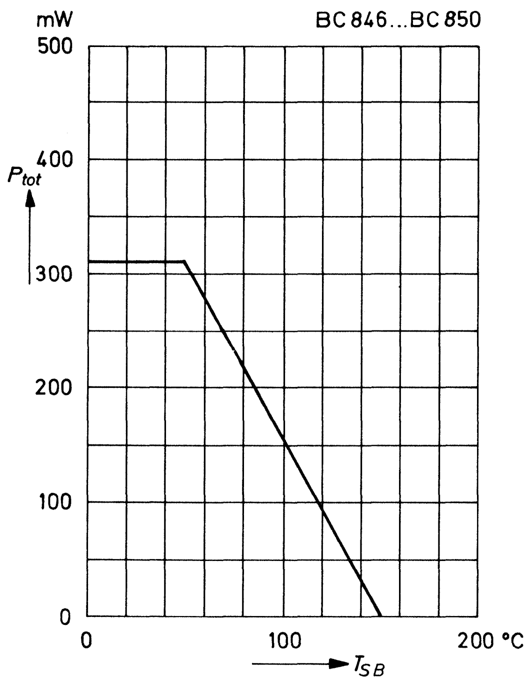
[1)] Ceramic Substrate 0.7 mm; 2.5 cm^2 area

Characteristics, continuation

	Symbol	Min.	Typ.	Max.	Unit
Equivalent Noise EMF at V_{CE} = 5 V, I_C = 200 μA, R_G = 2 kΩ, f = 10 . . . 50 Hz **BC850**	v_r	–	–	0.135	μV

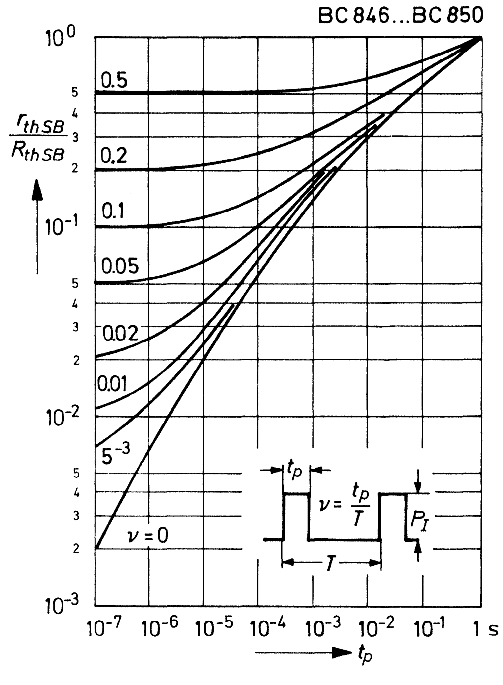
Admissible power dissipation versus temperature of substrate backside

Ceramic Substrate 0.7 mm; 2.5 cm² area.

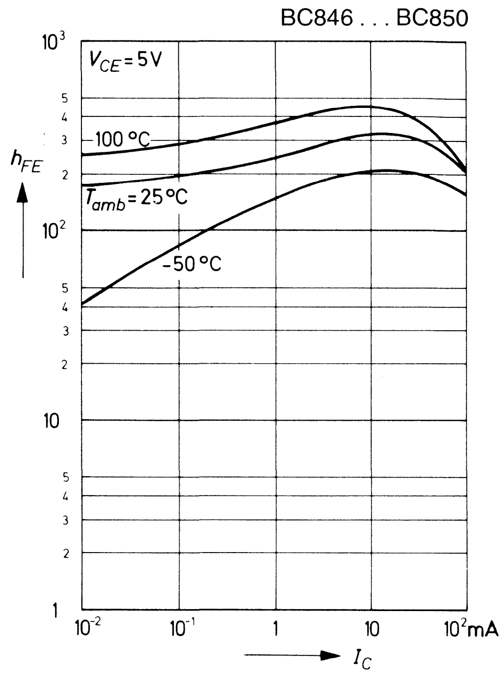


Pulse thermal resistance versus pulse duration (normalized)

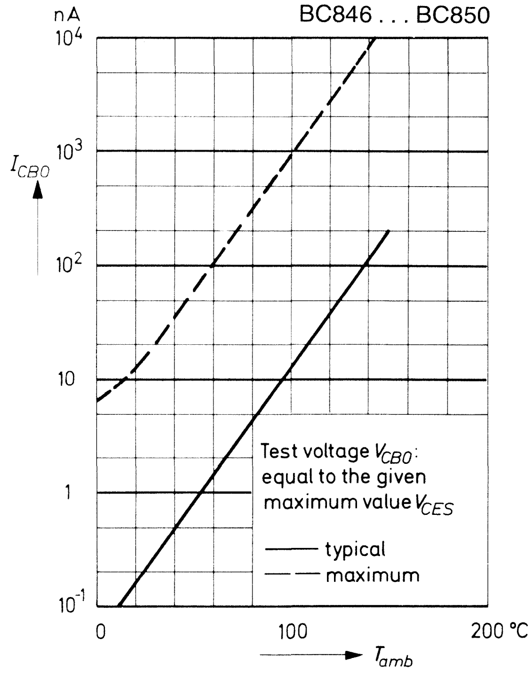
Ceramic Substrate 0.7 mm; 2.5 cm² area.



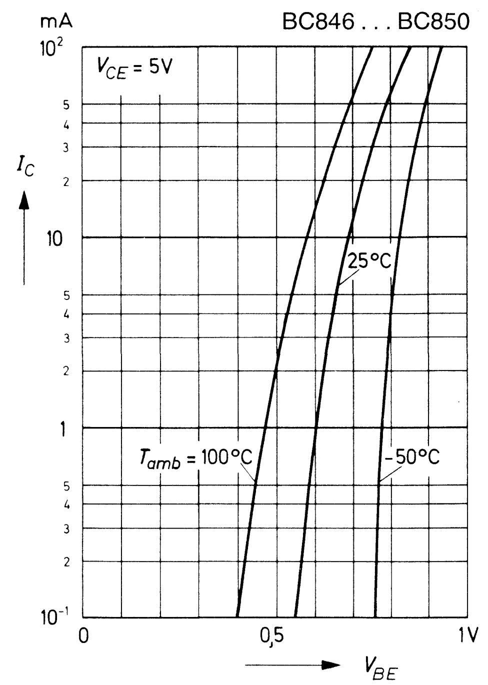
DC current gain versus collector current



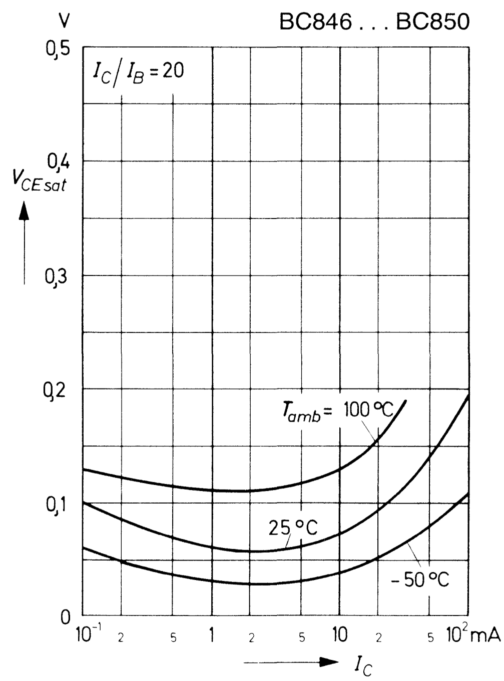
Collector cutoff current versus ambient temperature



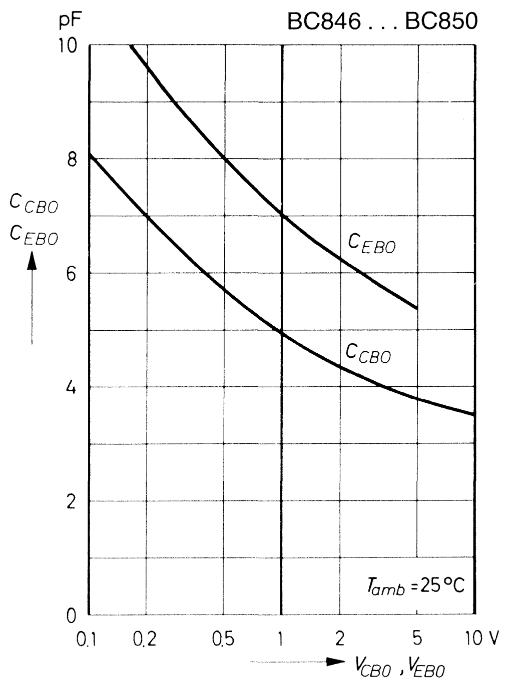
Collector current versus base emitter voltage



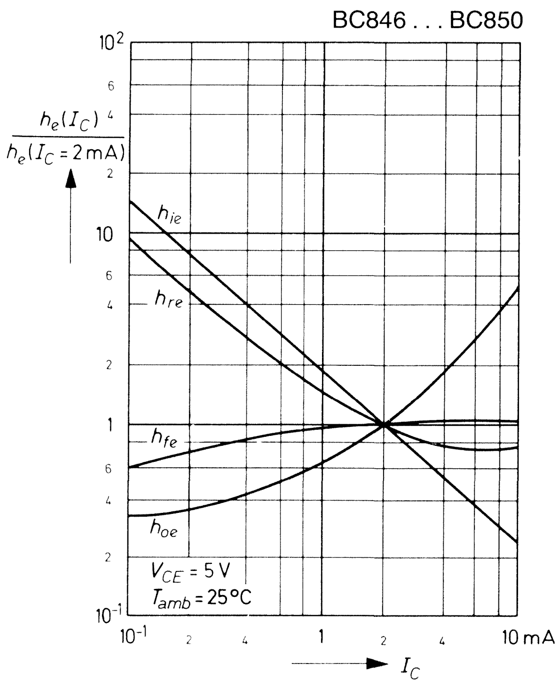
Collector saturation voltage versus collector current



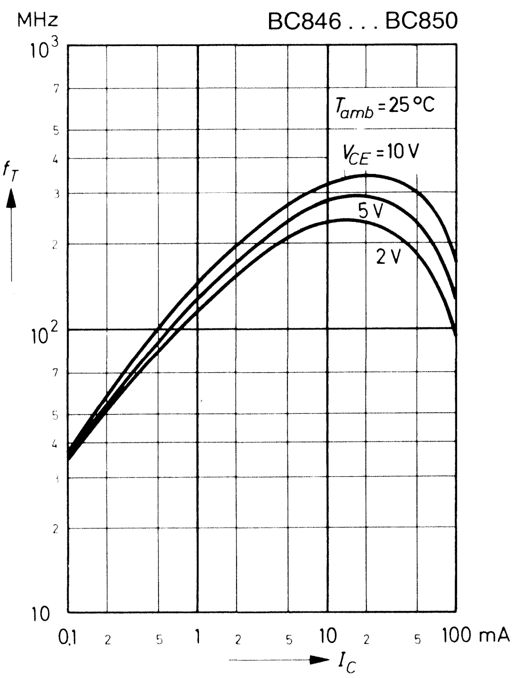
Collector base capacitance, Emitter base capacitance versus reverse bias voltage



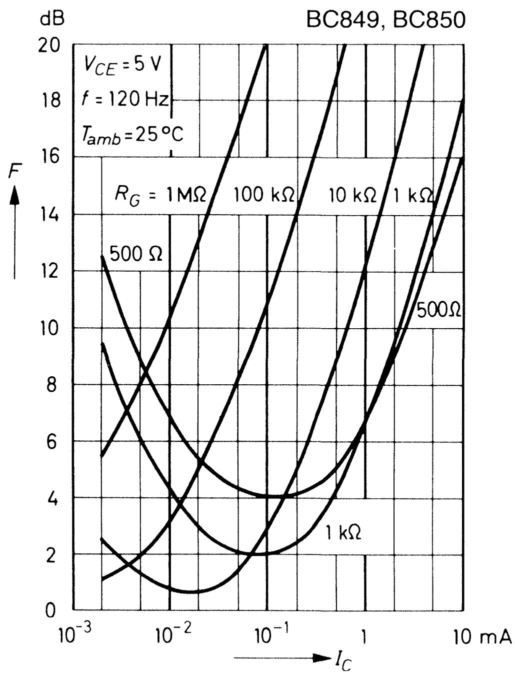
Relative h-parameters versus collector current



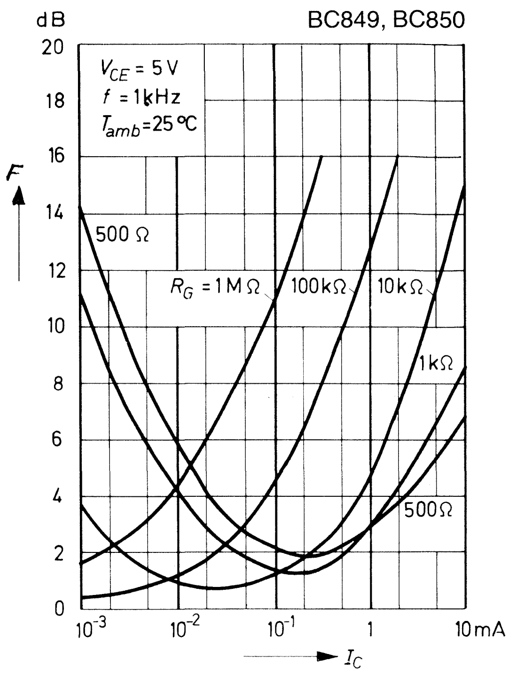
Gain bandwidth product versus collector current



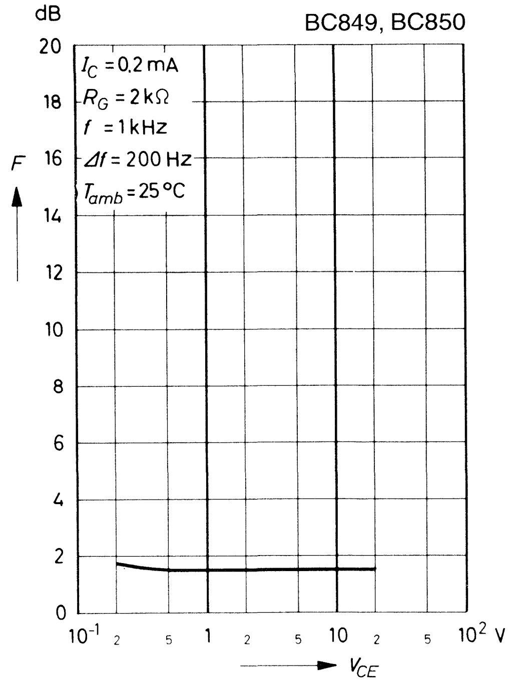
Noise figure versus collector current



Noise figure
versus collector current



Noise figure
versus collector emitter voltage

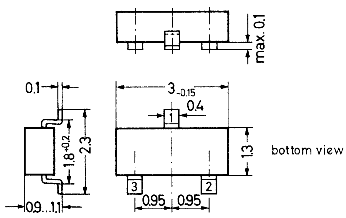


BCW60, BCX70

NPN Silicon Epitaxial Planar Transistors
for switching and AF amplifier applications.

Especially suited for automatic insertion in thick- and thin-film circuits.

These transistors BCW60 are subdivided into the groups A, B, C and D, the transistors BCX70 into the groups G, H, J and K according to their current gain. As complementary types the PNP transistors BCW61 and BCX71 are recommended.
The pinconfiguration of these types is the following:
1 = Collector, 2 = Base, 3 = Emitter.



Plastic package 23A3
according to DIN 41869 (≈ TO-236)
The case is impervious to light

Weight approximately 0.01 g
Dimensions in mm

Marking code

Type	Marking
BCW60A	AA
BCW60B	AB
BCW60C	AC
BCW60D	AD

Marking code

Type	Marking
BCX70G	AG
BCX70H	AH
BCX70J	AJ
BCX70K	AK

Absolute Maximum Ratings

		Symbol	Value	Unit
Collector Emitter Voltage	**BCW60**	V_{CES}	32	V
	BCX70	V_{CES}	45	V
Collector Emitter Voltage	**BCW60**	V_{CEO}	32	V
	BCX70	V_{CEO}	45	V
Emitter Base Voltage		V_{EBO}	5	V
Collector Current		I_C	200	mA
Base Current		I_B	50	mA
Power Dissipation at T_{SB} = 50 °C		P_{tot}	310[1)]	mW
Junction Temperature		T_j	150	°C
Storage Temperature Range		T_S	−65 to +150	°C

[1)] Ceramic Substrate 0.7 mm; 2.5 cm^2 area

Characteristics at T_{amb} = 25 °C

	Symbol	Min.	Typ.	Max.	Unit
h-Parameters at V_{CE} = 5 V, I_C = 2 mA, f = 1 kHz					
Small Signal Current Gain **Group A, G**	h_{fe}	–	200	–	–
B, H	h_{fe}	–	260	–	–
C, J	h_{fe}	–	330	–	–
D, K	h_{fe}	–	520	–	–
Input Impedance **Group A, G**	h_{ie}	1.6	2.7	4.5	kΩ
B, H	h_{ie}	2.5	3.6	6	kΩ
C, J	h_{ie}	3.2	4.5	8.5	kΩ
D, K	h_{ie}	4.5	7.5	12	kΩ
Output Admittance **Group A, G**	h_{oe}	–	18	30	μS
B, H	h_{oe}	–	24	50	μS
C, J	h_{oe}	–	30	60	μS
D, K	h_{oe}	–	50	100	μS
Reverse Voltage Transfer Ratio **Group A, G**	h_{re}	–	$1.5 \cdot 10^{-4}$	–	–
B, H	h_{re}	–	$2 \cdot 10^{-4}$	–	–
C, J	h_{re}	–	$2 \cdot 10^{-4}$	–	–
D, K	h_{re}	–	$3 \cdot 10^{-4}$	–	–
DC Current Gain					
at V_{CE} = 5 V, I_C = 10 μA **Group A, G**	h_{FE}	–	78	–	–
B, H	h_{FE}	20	145	–	–
C, J	h_{FE}	40	220	–	–
D, K	h_{FE}	100	300	–	–
at V_{CE} = 5 V, I_C = 2 mA **Group A, G**	h_{FE}	120	170	220	–
B, H	h_{FE}	180	250	310	–
C, J	h_{FE}	250	350	460	–
D, K	h_{FE}	380	500	630	–
at V_{CE} = 1 V, I_C = 50 mA **Group A, G**	h_{FE}	50	–	–	–
B, H	h_{FE}	70	–	–	–
C, J	h_{FE}	90	–	–	–
D, K	h_{FE}	100	–	–	–
Thermal Resistance Junction to Substrate Backside	R_{thSB}	–	–	320[1)]	K/W
Thermal Resistance Junction to Ambient	R_{thA}	–	–	450	K/W
Collector Saturation Voltage					
at I_C = 10 mA, I_B = 0.25 mA	V_{CEsat}	–	120	350	mV
at I_C = 50 mA, I_B = 1.25 mA	V_{CEsat}	–	200	550	mV
Base Saturation Voltage					
at I_C = 10 mA, I_B = 0.25 mA	V_{BEsat}	–	700	850	mV
at I_C = 50 mA, I_B = 1.25 mA	V_{BEsat}	–	830	1050	mV
Base Emitter Voltage					
at V_{CE} = 5 V, I_C = 10 μA	V_{BE}	–	520	–	mV
at V_{CE} = 5 V, I_C = 2 mA	V_{BE}	550	650	750	mV
at V_{CE} = 1 V, I_C = 50 mA	V_{BE}	–	780	–	mV
Collector Cutoff Current					
at V_{CE} = 32 V **BCW60**	I_{CES}	–	–	20	nA
at V_{CE} = 32 V, T_{amb} = 150 °C	I_{CES}	–	–	20	μA
at V_{CE} = 45 V **BCX70**	I_{CES}	–	–	20	nA
at V_{CE} = 45 V, T_{amb} = 150 °C	I_{CES}	–	–	20	μA
Emitter Cutoff Current at V_{EB} = 4 V	I_{EBO}	–	–	20	nA
Collector Emitter Breakdown Voltage					
at I_C = 2 mA **BCW60**	$V_{(BR)CEO}$	32	–	–	V
BCX70	$V_{(BR)CEO}$	45	–	–	V

1) Ceramic Substrate 0.7 mm; 2.5 cm^2 area

Characteristics, continuation

	Symbol	Min.	Typ.	Max.	Unit
Emitter Base Breakdown Voltage at $I_E = 1\ \mu A$	$V_{(BR)EBO}$	5	–	–	V
Gain Bandwidth Product at $V_{CE} = 5$ V, $I_C = 10$ mA, f = 100 MHz	f_T	125	250	–	MHz
Collector Base Capacitance at $V_{CEB} = 10$ V, f = 1 MHz	C_{CBO}	–	–	4.5	pF
Emitter Base Capacitance at $V_{EB} = 0.5$ V, f = 1 MHz	C_{EBO}	–	8	–	pF
Noise Figure at $V_{CE} = 5$ V, $I_C = 200\ \mu A$, $R_G = 2\ k\Omega$, f = 1 kHz, $\triangle f = 200$ Hz	F	–	2	6	dB
Switching Times (see Fig. 1) at $I_C = 10$ mA, $I_{B1} = -I_{B2} = 1$ mA, $R_1 = 5\ k\Omega$, $R_2 = 5\ k\Omega$, $-V_{BB} = 3.6$ V, $R_L = 990\ k\Omega$					
Delay Time	t_d	–	35	–	ns
Rise Time	t_r	–	50	–	ns
Turn-On Time	$t_d + t_r$	–	85	150	ns
Storage Time	t_s	–	400	–	ns
Fall Time	t_f	–	80	–	ns
Turn-Off Time	$t_s + t_f$	–	480	800	ns

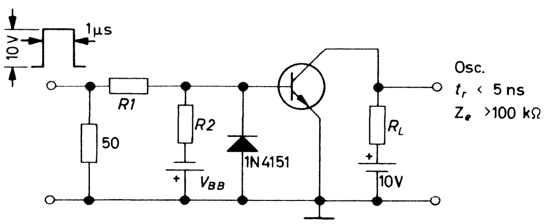
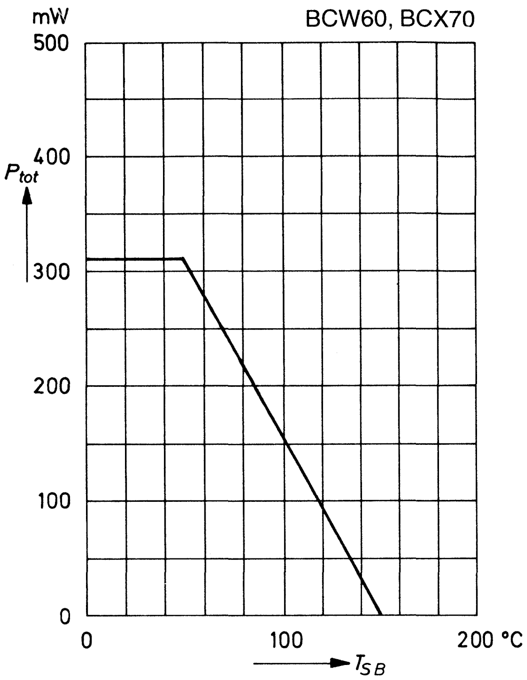
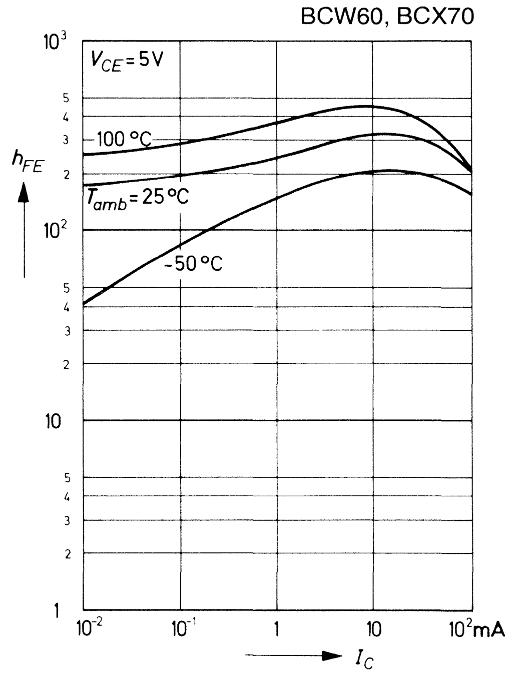


Fig. 1:
Test circuit for switching times

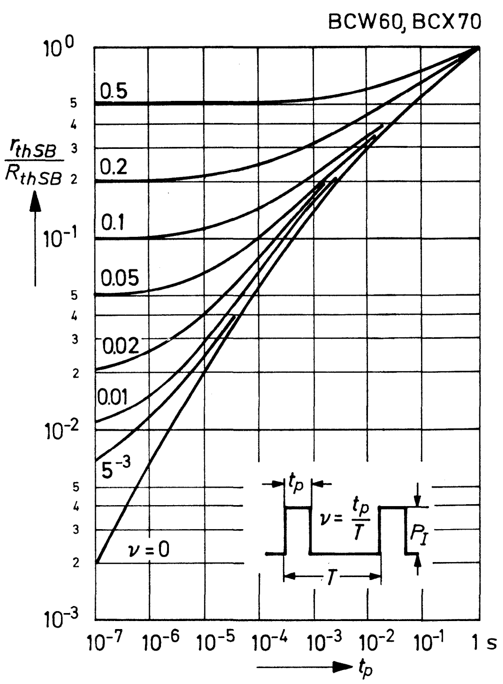
Admissible power dissipation versus temperature of substrate backside
Ceramic Substrate 0.7 mm; 2.5 cm² area.



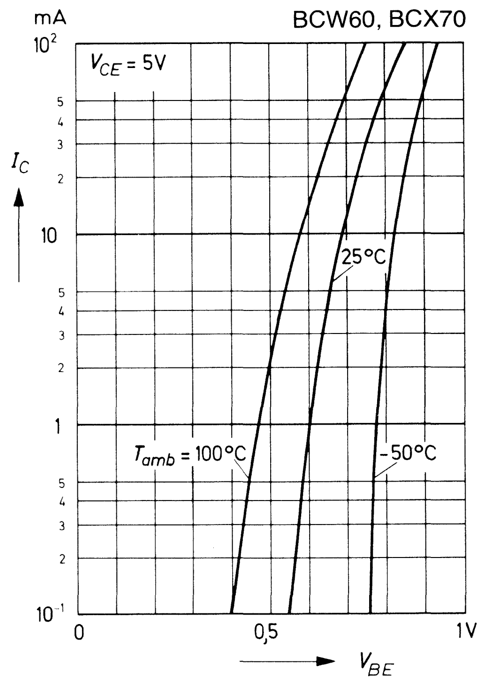
DC current gain versus collector current



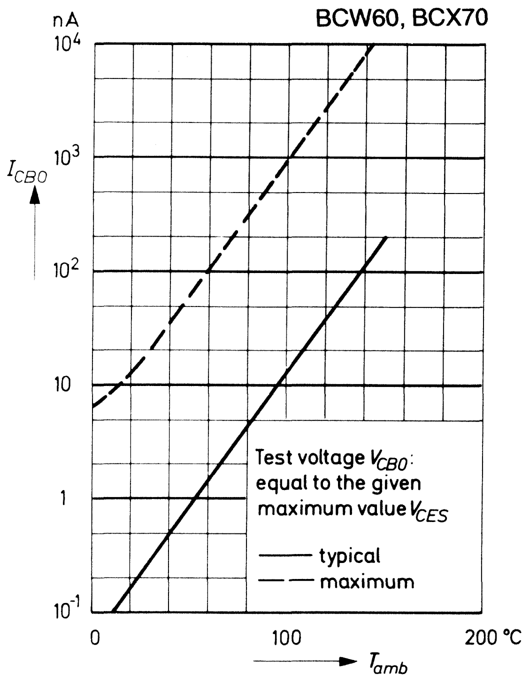
Pulse thermal resistance versus pulse duration (normalized)
Ceramic Substrate 0.7 mm; 2.5 cm² area.



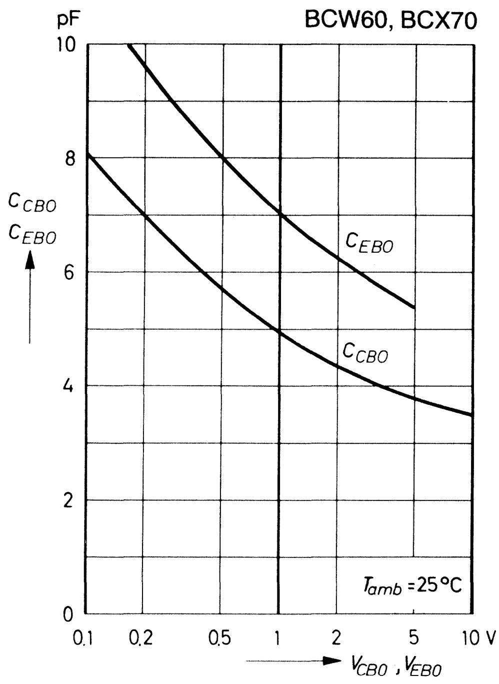
Collector current versus base emitter voltage



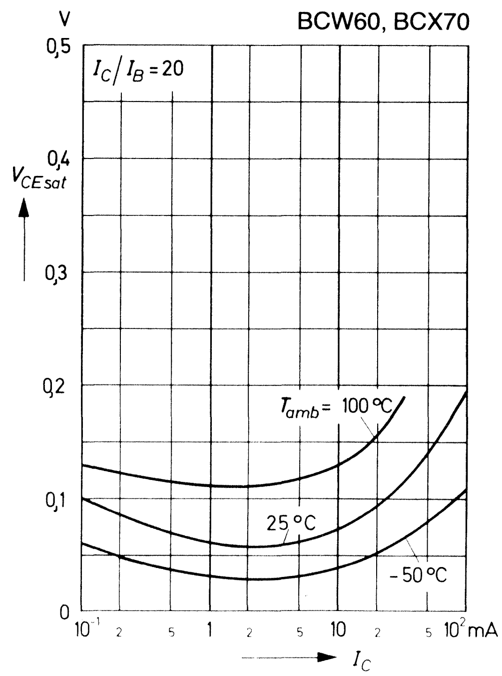
Collector cutoff current versus ambient temperature



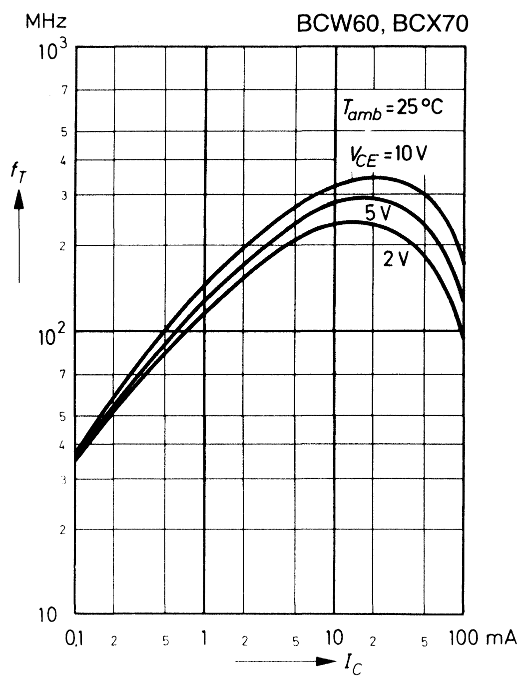
Collector base capacitance, Emitter base capacitance versus reverse bias voltage



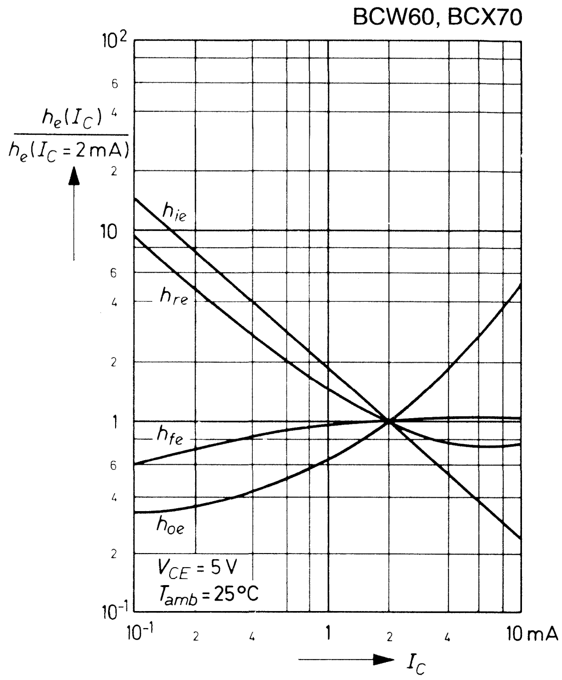
Collector saturation voltage versus collector current



Gain bandwidth product versus collector current



Relative h-**parameters versus collector current**



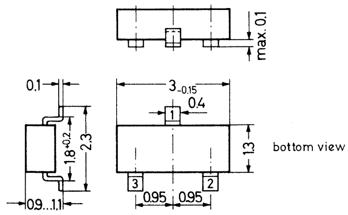
PNP Silicon Transistors

BC807, BC808

PNP Silicon Epitaxial Planar Transistors
for switching, AF driver and amplifier applications.

Especially suited for automatic insertion in thick- and thin-film circuits.

These transistors are subdivided into three groups -16, -25 and -40 according to their current gain.
As complementary types the NPN transistors BC817 and BC818 are recommended.
The pinconfiguration of these types is the following:
1 = Collector, 2 = Base, 3 = Emitter.



Plastic package 23A3
according to DIN 41869 (≈ TO-236)
The case is impervious to light

Weight approximately 0.01 g
Dimensions in mm

Marking code

Type	Marking
BC807-16	5A
-25	5B
-40	5C
BC808-16	5E
-25	5F
-40	5G

Absolute Maximum Ratings

		Symbol	Value	Unit
Collector Emitter Voltage	**BC807**	$-V_{CES}$	50	V
	BC808	$-V_{CES}$	30	V
Collector Emitter Voltage	**BC807**	$-V_{CEO}$	45	V
	BC808	$-V_{CEO}$	25	V
Emitter Base Voltage		$-V_{EBO}$	5	V
Collector Current		$-I_C$	500	mA
Peak Collector Current		$-I_{CM}$	1000	mA
Peak Base Current		$-I_{BM}$	200	mA
Peak Emitter Current		I_{EM}	1000	mA
Power Dissipation at $T_{SB} = 50$ °C		P_{tot}	310[1)]	mW
Junction Temperature		T_j	150	°C
Storage Temperature Range		T_S	−65 ... +150	°C

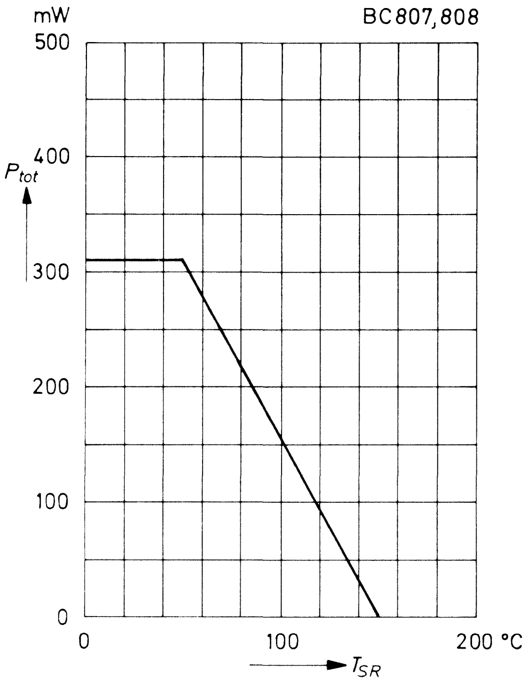
[1)] Ceramic Substrate 0.7 mm; 2.5 cm² area

Characteristics at T_{amb} = 25 °C

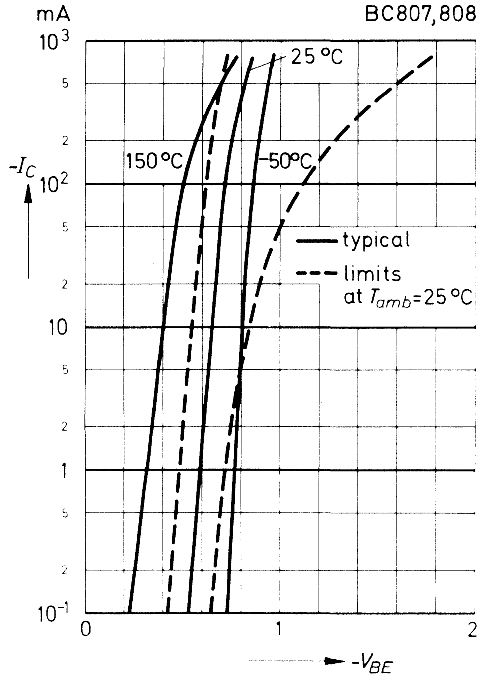
	Symbol	Min.	Typ.	Max.	Unit
DC Current Gain at $-V_{CE}$ = 1 V, $-I_C$ = 100 mA **Current Gain Group-16**	h_{FE}	100	–	250	–
-25	h_{FE}	160	–	400	–
-40	h_{FE}	250	–	600	–
at $-V_{CE}$ = 1 V, $-I_C$ = 300 mA **-16**	h_{FE}	60	–	–	–
-25	h_{FE}	100	–	–	–
-40	h_{FE}	170	–	–	–
Thermal Resistance Junction Substrate Backside	R_{thSB}	–	–	320[1)]	k/W
Thermal Resistance Junction to Ambient	R_{thA}	–	–	450	K/W
Collector Saturation Voltage at $-I_C$ = 500 mA, $-I_B$ = 50 mA	$-V_{CEsat}$	–	–	0.7	V
Base Emitter Voltage at $-V_{CE}$ = 1 V, $-I_C$ = 300 mA	$-V_{BE}$	–	–	1.2	V
Collector Cutoff Current at $-V_{CE}$ = 45 V **BC 807**	$-I_{CES}$	–	–	100	nA
at $-V_{CE}$ = 25 V **BC 808**	$-I_{CES}$	–	–	100	nA
at $-V_{CE}$ = 25 V, T_j = 150 °C	$-I_{CES}$	–	–	5	μA
Emitter Cutoff Current at $-V_{EB}$ = 4 V	$-I_{EBO}$	–	–	100	nA
Gain Bandwidth Product at $-V_{CE}$ = 5 V, $-I_C$ = 10 mA, f = 50 MHz	f_T	–	100	–	MHz
Collector Base Capacitance at $-V_{CB}$ = 10 V, f = 1 MHz	C_{CBO}		12		pF

[1)] Ceramic Substrate 0.7 mm; 2.5 cm^2 area

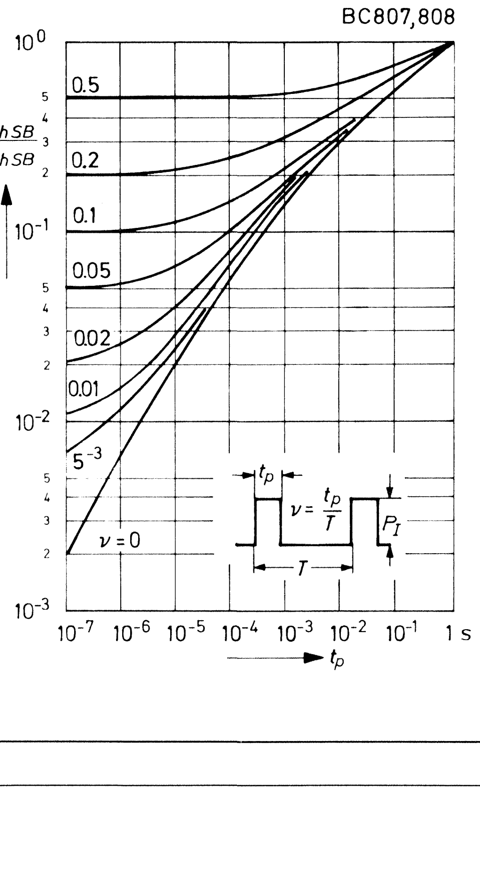
Admissible power dissipation versus temperature of substrate backside
Ceramic Substrate 0.7 mm; 2.5 cm² area.



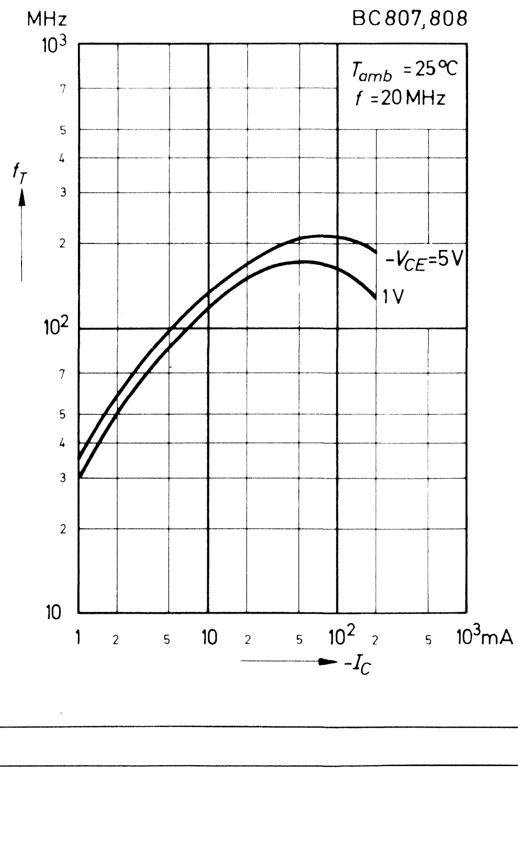
Collector current versus base emitter voltage



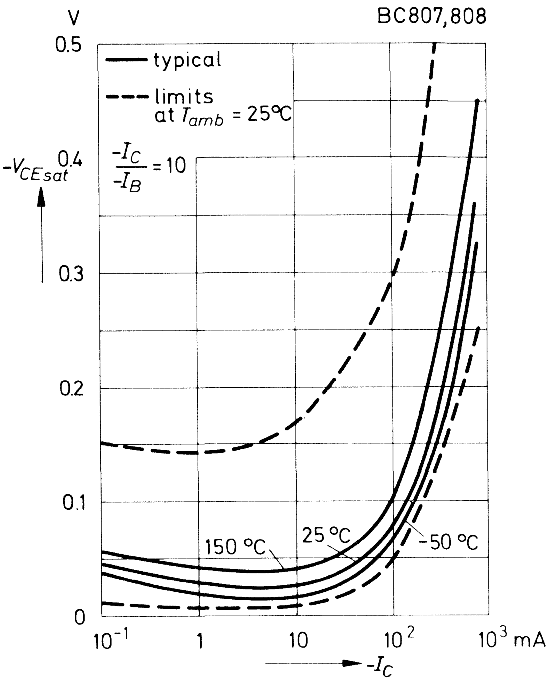
Pulse thermal resistance versus pulse duration (normalized)
Ceramic Substrate 0.7 mm; 2.5 cm² area.



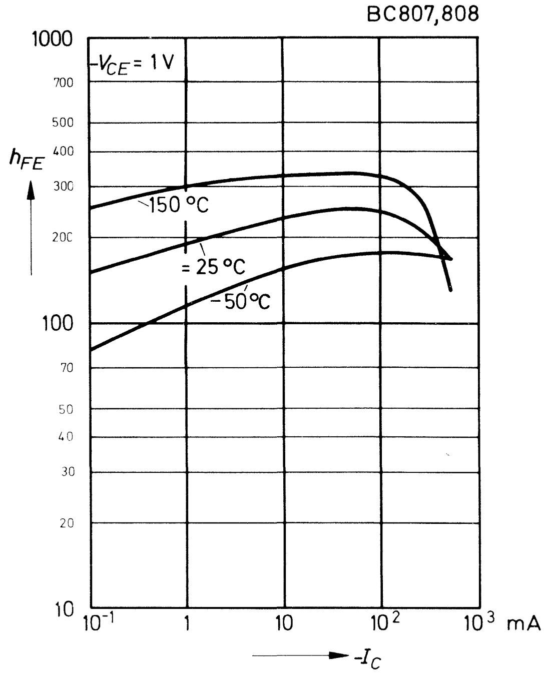
Gain bandwidth product versus collector current



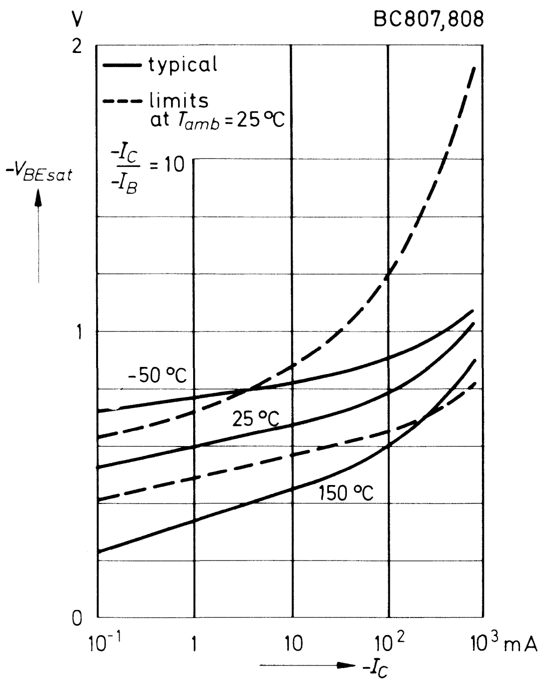
Collector saturation voltage versus collector current



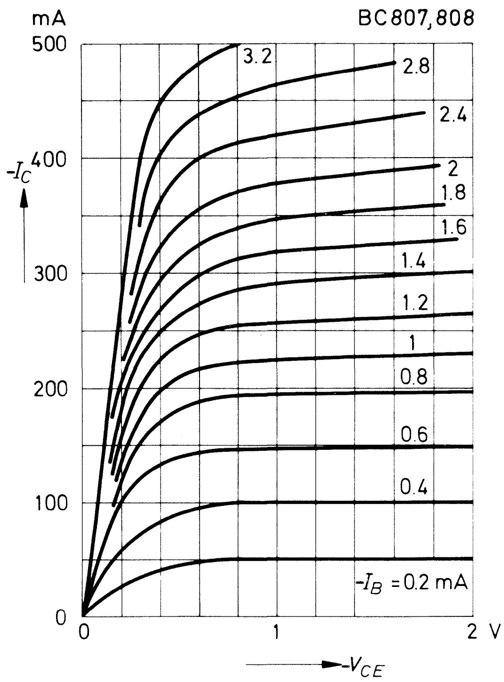
DC current gain versus collector current

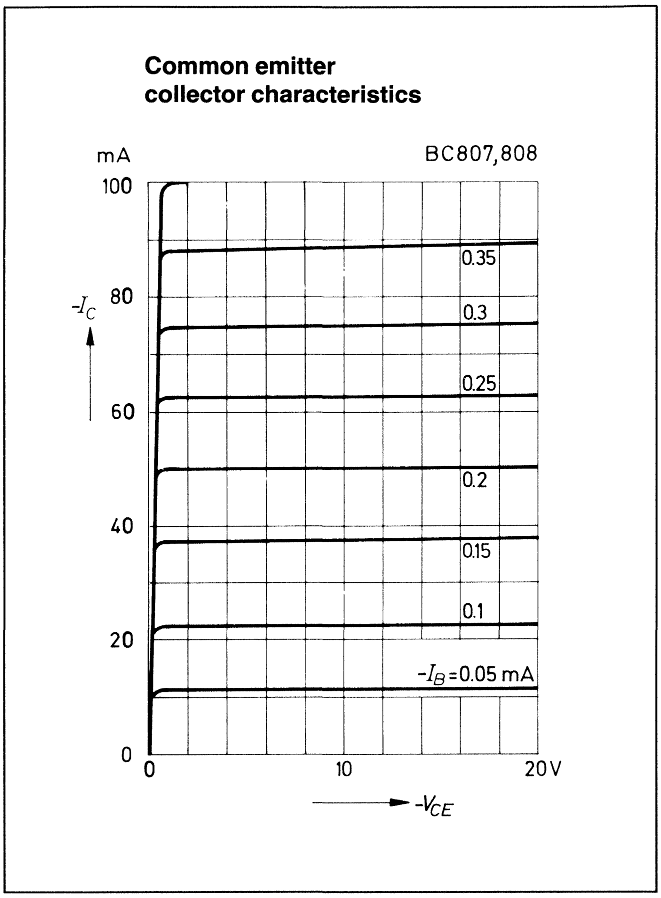


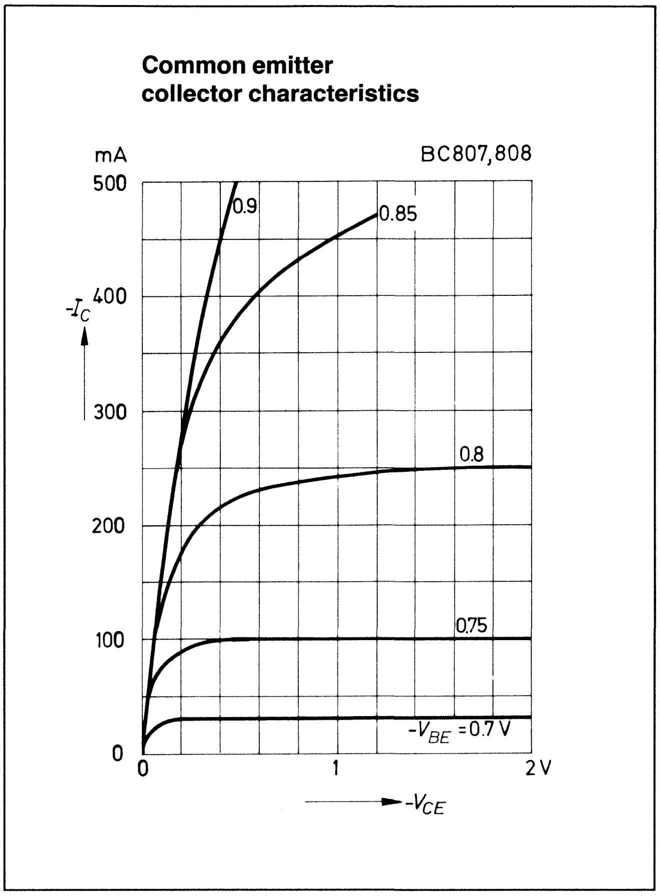
Base saturation voltage versus collector current



Common emitter collector characteristics



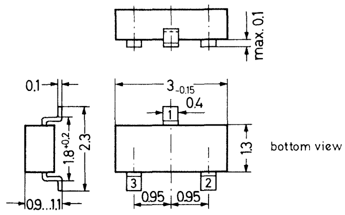

Common emitter
collector characteristics
BC807,808
mA
100
80
60
40
20
0
-I_C
0.35
0.3
0.25
0.2
0.15
0.1
-I_B=0.05 mA
0
10
20V
-V_{CE}


Common emitter
collector characteristics
BC807,808
mA
500
400
300
200
100
0
-I_C
0.9
0.85
0.8
0.75
-V_{BE} =0.7 V
0
1
2 V
-V_{CE}

BC856 . . . BC860

PNP Silicon Epitaxial Planar Transistors
for switching and AF amplifier applications.

Especially suited for automatic insertion in thick- and thin-film circuits.
These transistors are subdivided into three groups A, B and C according to their current gain. BC856 is available in groups A and B, however, the types BC857, BC858, BC859 and BC860 can be supplied in all three groups. The BC859 is a low noise type and the BC860 a extremely low noise type. As complementary types the NPN transistors BC846 ... BC850 are recommended.
The pinconfiguration of these types is the following: 1 = Collector, 2 = Base, 3 = Emitter.



Plastic package 23A3
according to DIN 41869 (≈ TO-236)
The case is impervious to light

Weight approximately 0.01 g
Dimensions in mm

Marking code

Type	Marking
BC856A	3A
B	3B
BC857A	3E
B	3F
C	3G
BC858A	3J
B	3K
C	3L

Marking code

Type	Marking
BC859A	4A
B	4B
C	4C
BC860A	4E
B	4F
C	4G

Absolute Maximum Ratings

		Symbol	Value	Unit
Collector Base Voltage	**BC856**	$-V_{CBO}$	80	V
	BC857, BC860	$-V_{CBO}$	50	V
	BC858, BC859	$-V_{CBO}$	30	V
Collector Emitter Voltage	**BC856**	$-V_{CES}$	80	V
	BC857, BC860	$-V_{CES}$	50	V
	BC858, BC859	$-V_{CES}$	30	V
Collector Emitter Voltage	**BC856**	$-V_{CEO}$	65	V
	BC857, BC860	$-V_{CEO}$	45	V
	BC858, BC859	$-V_{CEO}$	30	V
Emitter Base Voltage		$-V_{EBO}$	5	V
Collector Current		$-I_C$	100	mA
Peak Collector Current		$-I_{CM}$	200	mA
Peak Base Current		$-I_{BM}$	200	mA
Peak Emitter Current		I_{EM}	200	mA
Power Dissipation at T_{SB} = 50 °C		P_{tot}	310[1)]	mW
Junction Temperature		T_j	150	°C
Storage Temperature Range		T_S	–65 . . . +150	°C

Characteristics at T_{amb} = 25 °C

	Symbol	Min.	Typ.	Max.	Unit
h-Parameters at $-V_{CE}$ = 5 V, $-I_C$ = 2 mA, f = 1 kHz					
Current Gain **Current Gain Group A**	h_{fe}	–	220	–	–
B	h_{fe}	–	330	–	–
C	h_{fe}	–	600	–	–
Input Impedance **Current Gain Group A**	h_{ie}	1.6	2.7	4.5	kΩ
B	h_{ie}	3.2	4.5	8.5	kΩ
C	h_{ie}	.6	8.7	15	kΩ
Output Admittance **Current Gain Group A**	h_{oe}	–	18	30	µS
B	h_{oe}	–	30	60	µS
C	h_{oe}	–	60	110	µS
Reverse Voltage Transfer Ratio **Current Gain Group A**	h_{re}	–	$1.5 \cdot 10^{-4}$	–	–
B	h_{re}	–	$2 \cdot 10^{-4}$	–	–
C	h_{re}	–	$3 \cdot 10^{-4}$	–	–
DC Current Gain					
at $-V_{CE}$ = 5 V, $-I_C$ = 10 µA **Current Gain Group A**	h_{FE}	–	90	–	–
B	h_{FE}	–	150	–	–
C	h_{FE}	–	270	–	–
at $-V_{CE}$ = 5 V, $-I_C$ = 2 mA **Current Gain Group A**	h_{FE}	110	180	220	–
B	h_{FE}	200	290	450	–
C	h_{FE}	420	520	800	–
Thermal Resistance Junction Substrate Backside	R_{thSB}	–	–	320[1)]	K/W
Thermal Resistance Junction to Ambient	R_{thA}	–	–	450	K/W
Collector Saturation Voltage					
at $-I_C$ = 10 mA, $-I_B$ = 0.5 mA	$-V_{CEsat}$	–	90	300	mV
at $-I_C$ = 100 mA, $-I_B$ = 5 mA	$-V_{CEsat}$	–	250	650	mV
Base Saturation Voltage					
at $-I_C$ = 10 mA, $-I_B$ = 0.5 mA	$-V_{BEsat}$	–	700	–	mV
at $-I_C$ = 100 mA, $-I_B$ = 5 mA	$-V_{BEsat}$	–	900	–	mV
Base Emitter Voltage					
at $-V_{CE}$ = 5 V, $-I_C$ = 2 mA	$-V_{BE}$	600	660	750	mV
at $-V_{CE}$ = 5 V, $-I_C$ = 10 mA	$-V_{BE}$	–	–	800	mV
Collector Cutoff Current					
at $-V_{CE}$ = 80 V **BC846**	$-I_{CES}$	–	0.2	15	nA
at $-V_{CE}$ = 50 V **BC847, BC850**	$-I_{CES}$	–	0.2	15	nA
at $-V_{CE}$ = 30 V **BC848, BC849**	$-I_{CES}$	–	0.2	15	nA
at $-V_{CE}$ = 80 V, T_j = 125 °C **BC846**	$-I_{CES}$	–	–	4	µA
at $-V_{CE}$ = 50 V, T_j = 125 °C **BC847, BC850**	$-I_{CES}$	–	–	4	µA
at $-V_{CE}$ = 30 V, T_j = 125 °C **BC848, BC849**	$-I_{CES}$	–	–	4	µA
at $-V_{CB}$ = 30 V	$-I_{CBO}$	–	–	15	nA
at $-V_{CB}$ = 30 V, T_j = 150 °C	$-I_{CBO}$	–	–	5	µA
Gain Bandwidth Product at $-V_{CE}$ = 5 V, $-I_C$ = 10 mA, f = 100 MHz	f_T	–	150	–	MHz
Collector Base Capacitance at $-V_{CB}$ = 10 V, f = 1 MHz	C_{CBO}	–	–	6	pF
Noise Figure					
at $-V_{CE}$ = 5 V, $-I_C$ = 200 µA, R_G = 2 kΩ, f = 1 kHz,					
△f = 200Hz **BC856, BC857, BC858**	F	–	2	10	dB
BC859, BC860	F	–	1	4	dB

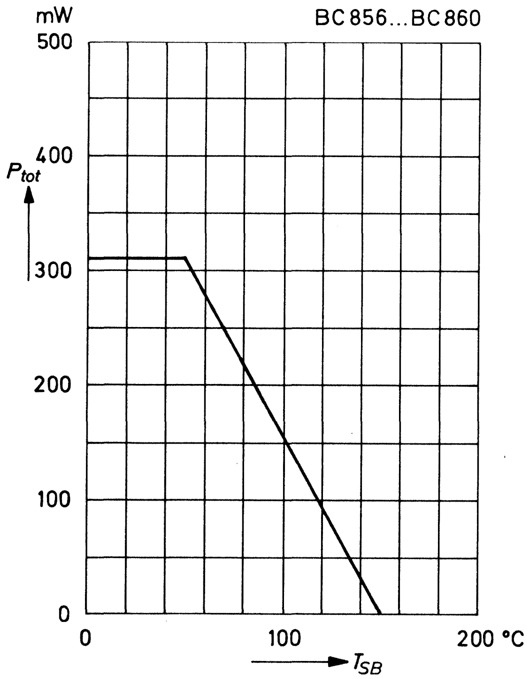
1) Ceramic Substrate 0.7 mm; 2.5 cm^2 area

Characteristics, continuation

		Symbol	Min.	Typ.	Max.	Unit
Noise Figure at $-V_{CE}$ = 5 V, $-I_C$ = 200 μA, R_G = 2 kΩ, f = 30 . . . 15000 Hz	**BC859** **BC860**	F F	– –	1.2 1.2	4 2	dB dB
Equivalent Noise EMF at $-V_{CE}$ = 5 V, $-I_C$ = 200 μA, R_G = 2 kΩ, f = 10 . . . 50 Hz	**BC860**	v_r	–	–	0.11	μV

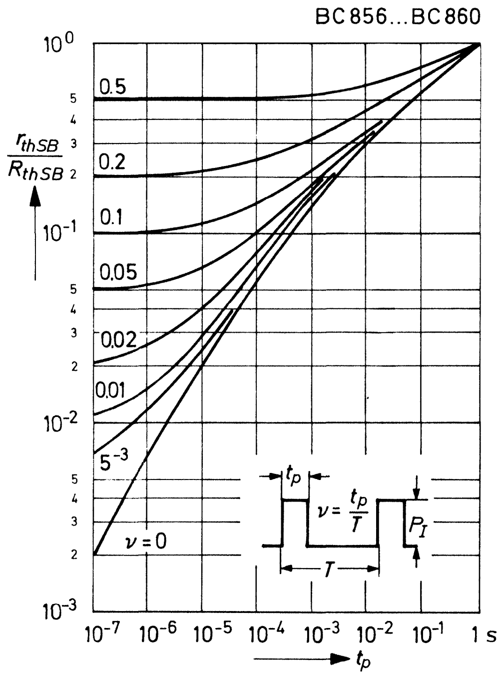
Admissible power dissipation versus temperature of substrate backside

Ceramic substrate 0.7 mm; 2.5 cm² area.

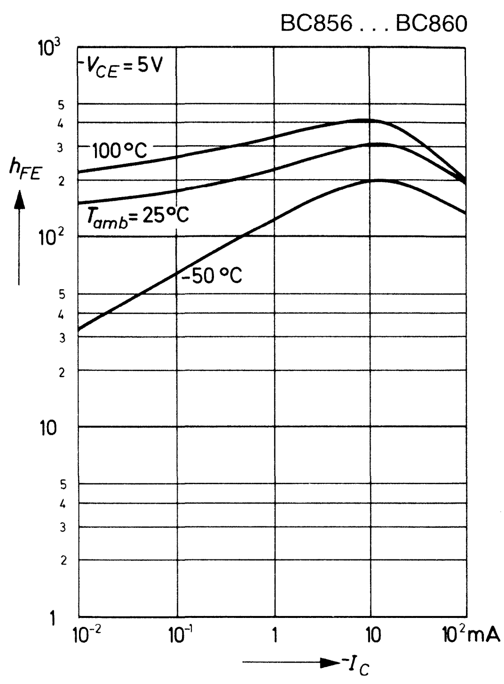


Pulse thermal resistance versus pulse duration (normalized)

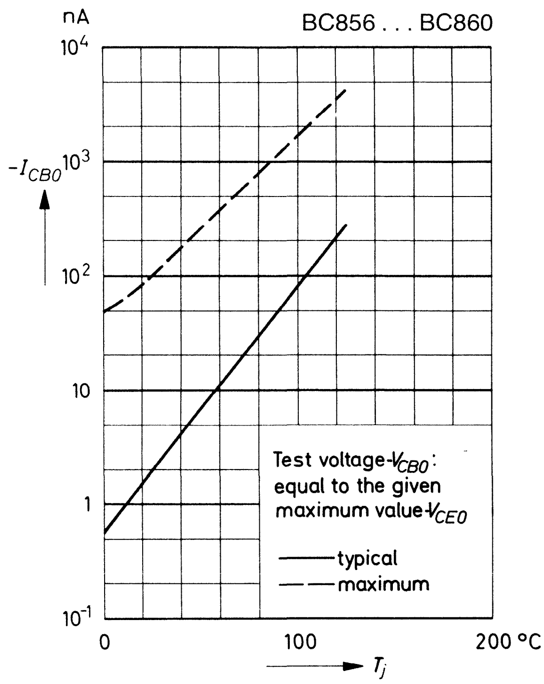
Ceramic substrate 0.7 mm; 2.5 cm² area.



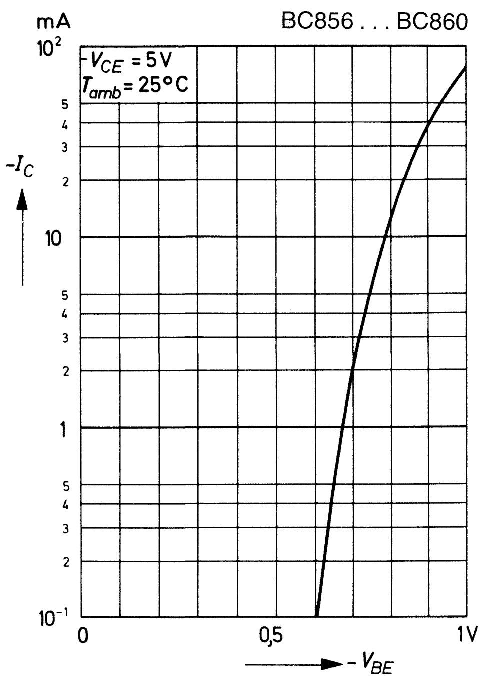
DC current gain versus collector current



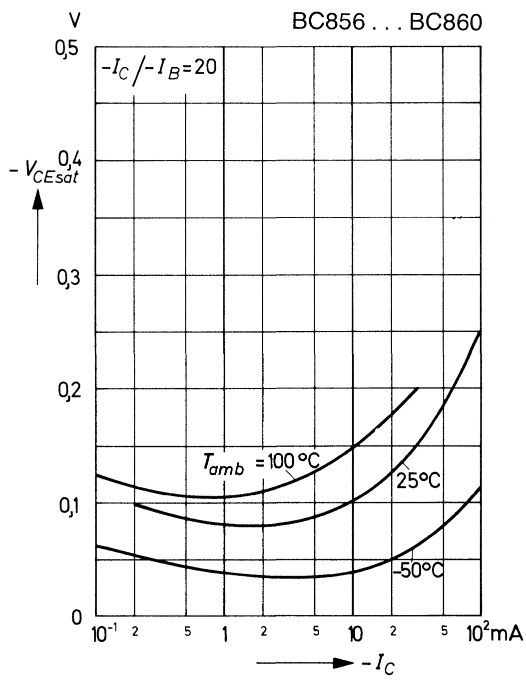
Collector cutoff current versus junction temperature



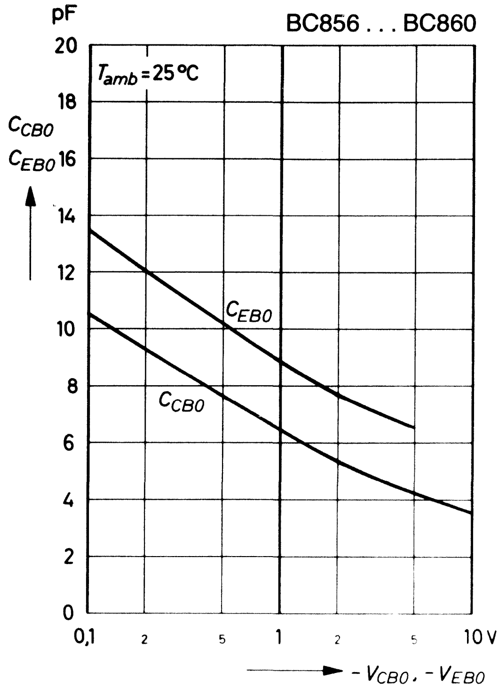
Collector current versus base emitter voltage



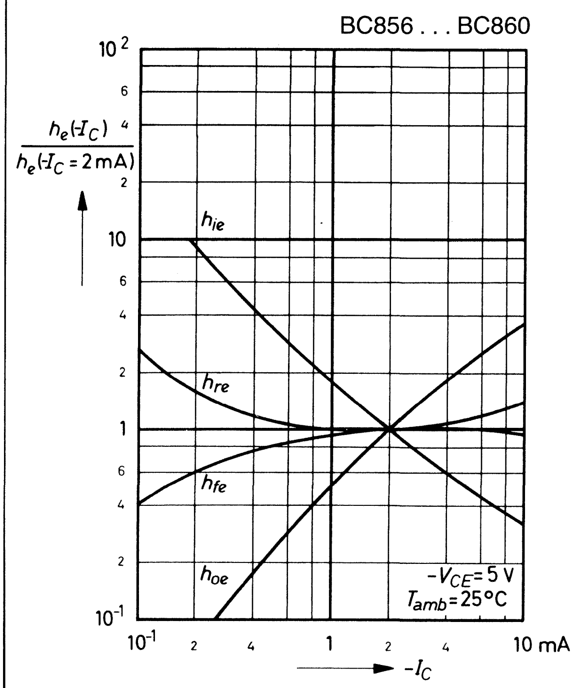
Collector saturation voltage versus collector current



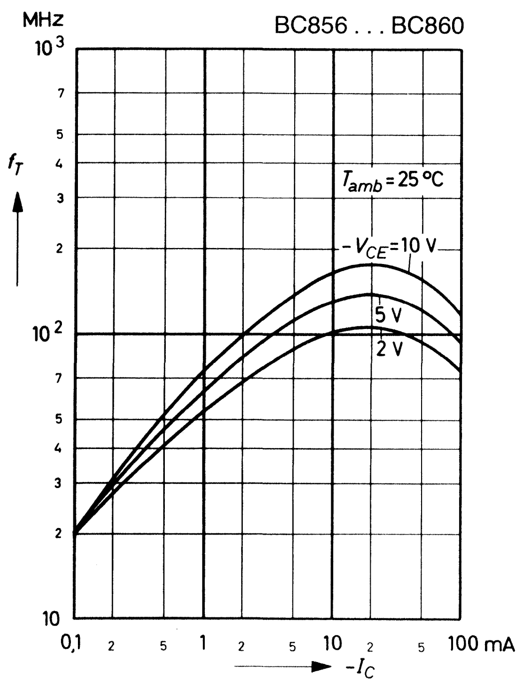
Collector base capacitance, Emitter base capacitance versus reverse bias voltage



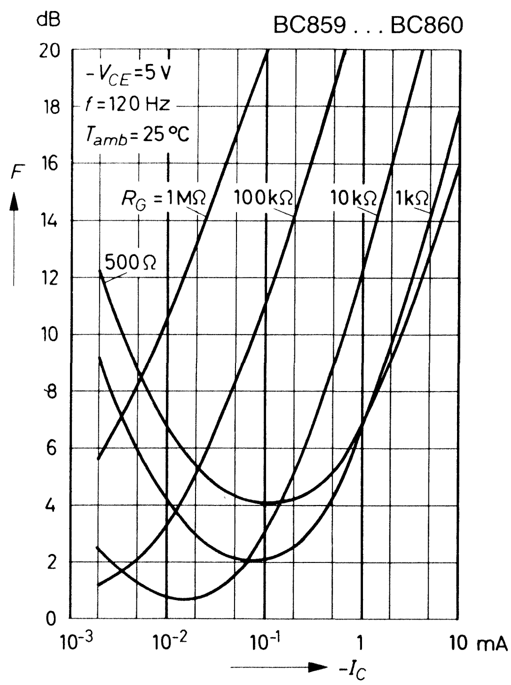
Relative h-parameters versus collector current



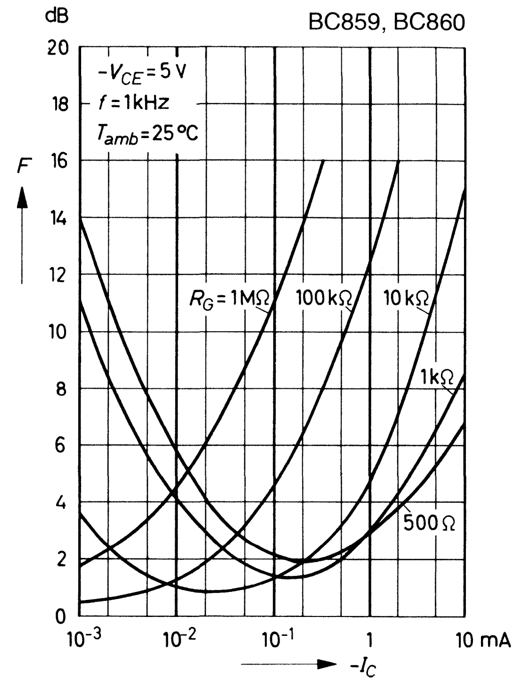
Gain bandwidth product versus collector current



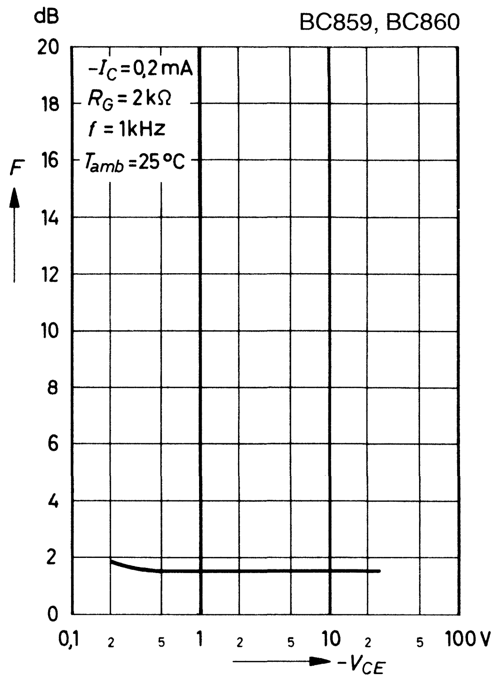
Noise figure versus collector current



Noise figure
versus collector current



Noise figure
versus collector emitter voltage

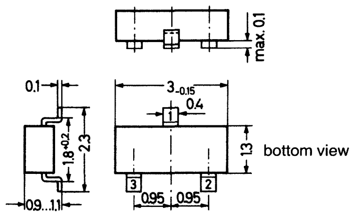


BCW61, BCX71

PNP Silicon Epitaxial Planar Transistors
for switching and AF amplifier applications.

Especially suited for automatic insertion in thick- and thin-film circuits.

These transistors BCW61 are subdivided into the groups A, B, C and D, the transistors BCX71 into the groups G, H, J and K according to their current gain. As complementary types the NPN transistors BCW60 and BCX70 are recommended.
The pinconfiguration of these types is the following: 1 = Collector, 2 = Base, 3 = Emitter.



Plastic package 23A3
according to DIN 41869 (≈ TO-236)
The case is impervious to light

Weight approximately 0.01 g
Dimensions in mm

Marking code

Type	Marking
BCW61A	BA
BCW61B	BB
BCW61C	BC
BCW61D	BD

Marking code

Type	Marking
BCX71G	BG
BCX71H	BH
BCX71J	BJ
BCX71K	BK

Absolute Maximum Ratings

		Symbol	Value	Unit
Collector Emitter Voltage	**BCW61** **BCX71**	$-V_{CES}$ $-V_{CES}$	32 45	V V
Collector Emitter Voltage	**BCW61** **BCX71**	$-V_{CEO}$ $-V_{CEO}$	32 45	V V
Emitter Base Voltage		$-V_{EBO}$	5	V
Collector Current		$-I_C$	200	mA
Base Current		$-I_B$	50	mA
Power Dissipation at T_{SB} = 50 °C		P_{tot}	310[1)]	mW
Junction Temperature		T_j	150	°C
Storage Temperature Range		T_S	−65 to +150	°C

[1)] Ceramic Substrate 0.7 mm; 2.5 cm^2 area

Characteristics at T_{amb} = 25 °C

		Symbol	Min.	Typ.	Max.	Unit
h-Parameters at $-V_{CE}$ = 5 V, $-I_C$ = 2 mA, f = 1 kHz						
Current Gain	**Group A, G**	h_{fe}	–	200	–	–
	B, H	h_{fe}	–	260	–	–
	C, J	h_{fe}	–	330	–	–
	D, K	h_{fe}	–	520	–	–
Input Impedance	**Group A, G**	h_{ie}	1.6	2.7	4.5	kΩ
	B, H	h_{ie}	2.5	3.6	6	kΩ
	C, J	h_{ie}	3.2	4.5	8.5	kΩ
	D, K	h_{ie}	4.5	7.5	12	kΩ
Output Admittance	**Group A, G**	h_{oe}	–	18	30	μS
	B, H	h_{oe}	–	24	50	μS
	C, J	h_{oe}	–	30	60	μS
	D, K	h_{oe}	–	50	100	μS
Reverse Voltage Transfer Ratio	**Group A, G**	h_{re}	–	$1.5 \cdot 10^{-4}$	–	–
	B, H	h_{re}	–	$2 \cdot 10^{-4}$	–	–
	C, J	h_{re}	–	$2 \cdot 10^{-4}$	–	–
	D, K	h_{re}	–	$3 \cdot 10^{-4}$	–	–
DC Current Gain						
at $-V_{CE}$ = 5 V, $-I_C$ = 10 μA	**Group A, G**	h_{FE}	–	140	–	–
	B, H	h_{FE}	30	200	–	–
	C, J	h_{FE}	40	270	–	–
	D, K	h_{FE}	100	340	–	–
at $-V_{CE}$ = 5 V, $-I_C$ = 2 mA	**Group A, G**	h_{FE}	120	170	220	–
	B, H	h_{FE}	180	250	310	–
	C, J	h_{FE}	250	350	460	–
	D, K	h_{FE}	380	500	630	–
at $-V_{CE}$ = 1 V, $-I_C$ = 50 mA	**Group A, G**	h_{FE}	60	–	–	–
	B, H	h_{FE}	80	–	–	–
	C, J	h_{FE}	100	–	–	–
	D, K	h_{FE}	110	–	–	–
Thermal Resistance Junction to Substrate Backside		R_{thSB}	–	–	320[1]	K/W
Thermal Resistance Junction to Ambient		R_{thA}	–	–	450	K/W
Collector Saturation Voltage						
at $-I_C$ = 10 mA, $-I_B$ = 0.25 mA		$-V_{CEsat}$	–	120	250	mV
at $-I_C$ = 50 mA, $-I_B$ = 1.25 mA		$-V_{CEsat}$	–	250	500	mV
Base Saturation Voltage						
at $-I_C$ = 10 mA, $-I_B$ = 0.25 mA		$-V_{BEsat}$	–	700	850	mV
at $-I_C$ = 50 mA, $-I_B$ = 1.25 mA		$-V_{BEsat}$	–	800	1050	mV
Base Emitter Voltage						
at $-V_{CE}$ = 5 V, $-I_C$ = 10 μA		$-V_{BE}$	–	550	–	mV
at $-V_{CE}$ = 5 V, $-I_C$ = 2 mA		$-V_{BE}$	600	650	750	mV
at $-V_{CE}$ = 1 V, $-I_C$ = 50 mA		$-V_{BE}$	–	720	–	mV
Collector Cutoff Current						
at $-V_{CE}$ = 32 V	**BCW61**	$-I_{CES}$	–	–	20	nA
at $-V_{CE}$ = 32 V, T_{amb} = 150 °C		$-I_{CES}$	–	–	20	μA
at $-V_{CE}$ = 45 V	**BCX71**	$-I_{CES}$	–	–	20	nA
at $-V_{CE}$ = 45 V, T_{amb} = 150 °C		$-I_{CES}$	–	–	20	μA
Emitter Cutoff Current at $-V_{EB}$ = 4 V		$-I_{EBO}$	–	–	20	nA
Collector Emitter Breakdown Voltage						
at $-I_C$ = 2 mA	**BCW61**	$-U_{(BR)CEO}$	32	–	–	V
	BCX71	$-U_{(BR)CEO}$	45	–	–	V

[1] Ceramic Substrate 0.7 mm; 2.5 cm² area

Characteristics, continuation

	Symbol	Min.	Typ.	Max.	Unit
Emitter Base Breakdown Voltage at $-I_E = 1\ \mu A$	$-U_{(BR)EBO}$	5	–	–	V
Gain Bandwidth Product at $-V_{CE} = 5$ V, $-I_C = 10$ mA, f = 100 MHz	f_T	–	180	–	MHz
Collector Base Capacitance at $-V_{CB} = 10$ V, f = 1 MHz	C_{CBO}	–	–	6	pF
Emitter Base Capacitance at $-V_{EB} = 0.5$ V, f = 1 MHz	C_{EBO}	–	11	–	pF
Noise Figure at $-V_{CE} = 5$ V, $-I_C = 200\ \mu A$, $R_G = 2\ k\Omega$, f = 1 kHz, $\triangle f = 200$ Hz	F	–	2	6	dB
Switching Times (see Fig. 1) at $-I_C = 10$ mA, $-I_{B1} = I_{B2} = 1$ mA					
Delay Time	t_d	–	35	–	ns
Rise Time	t_r	–	50	–	ns
Turn-On Time	$t_d + t_r$	–	85	150	ns
Storage Time	t_s	–	400	–	ns
Fall Time	t_f	–	80	–	ns
Turn-Off Time	$t_s + t_f$	–	480	800	ns

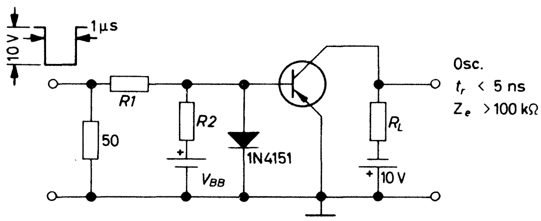
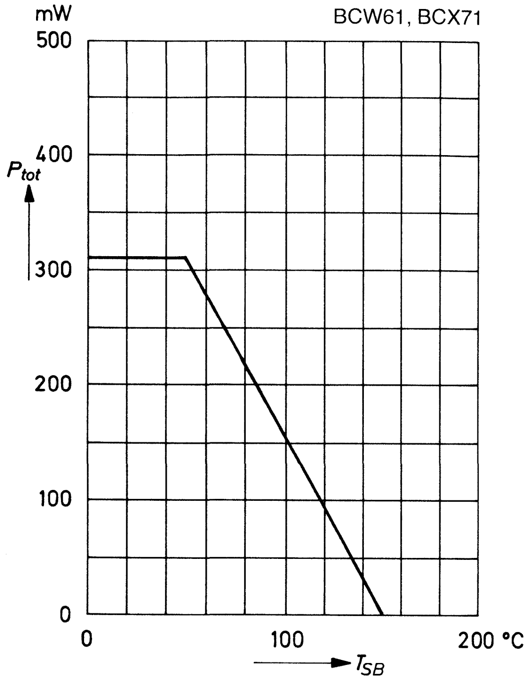


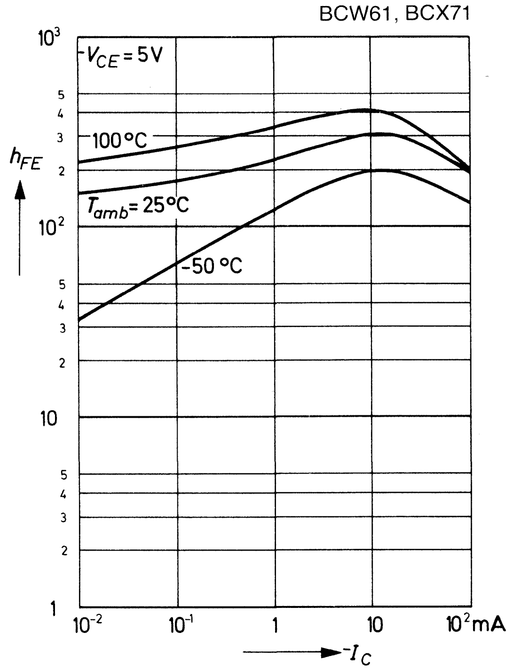
Fig. 1:
Test circuit for switching times

Admissible power dissipation versus temperature of substrate backside

Ceramic substrate 0.7 mm; 2.5 cm² area.

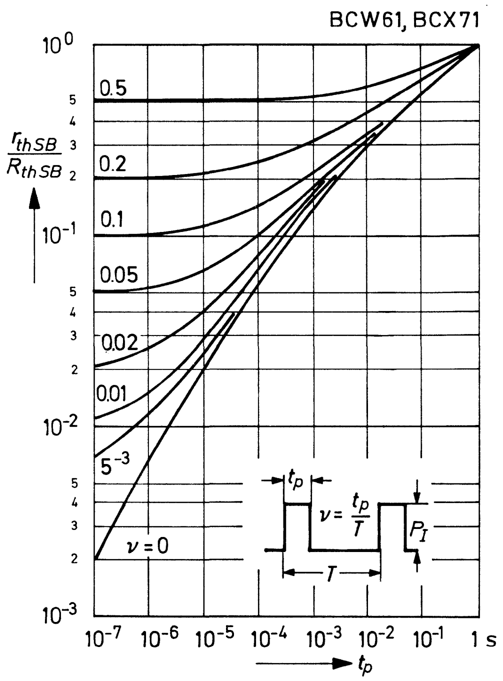


DC current gain versus collector current

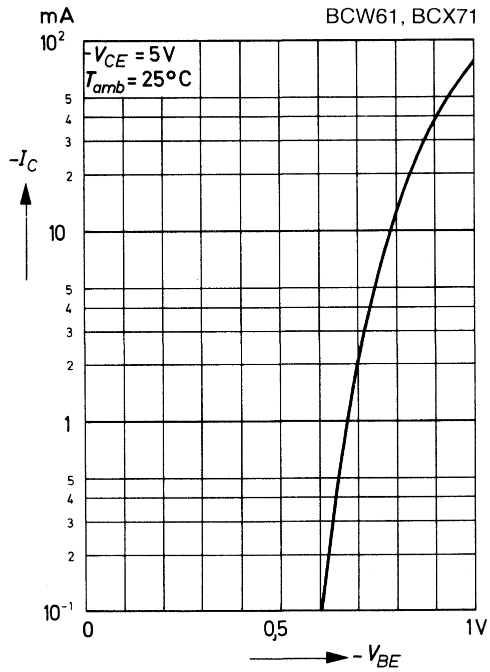


Pulse thermal resistance versus pulse duration (normalized)

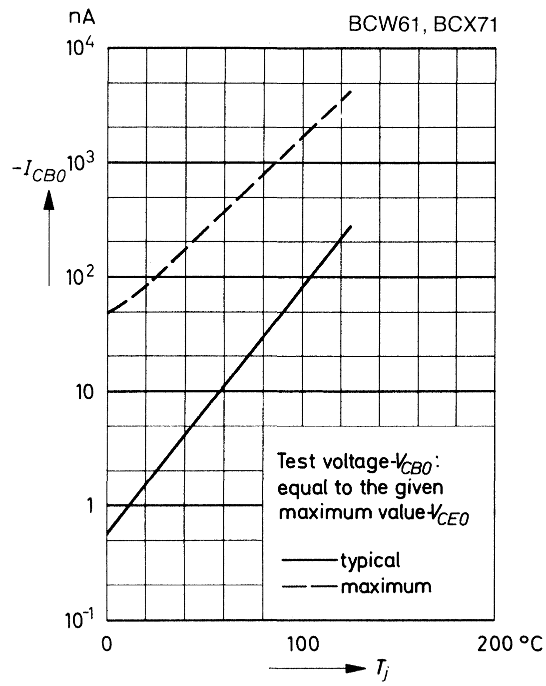
Ceramic Substrate 0.7 mm; 2.5 cm² area.



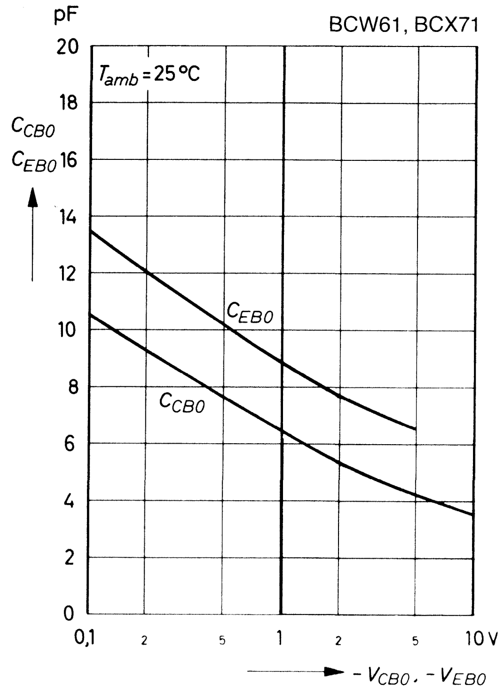
Collector current versus base emitter voltage



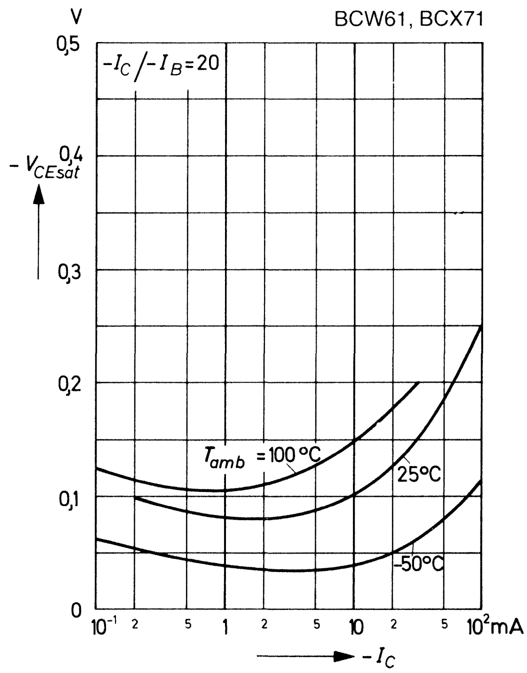
Collector cutoff current versus junction temperature



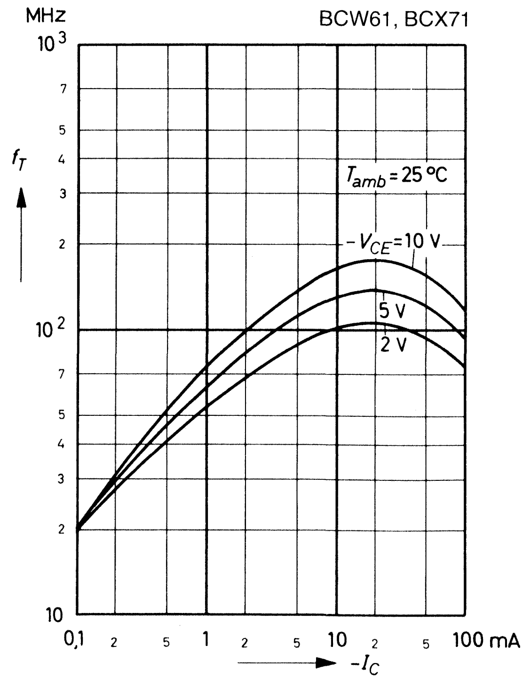
Collector base capacitance, Emitter base capacitance versus reverse bias voltage



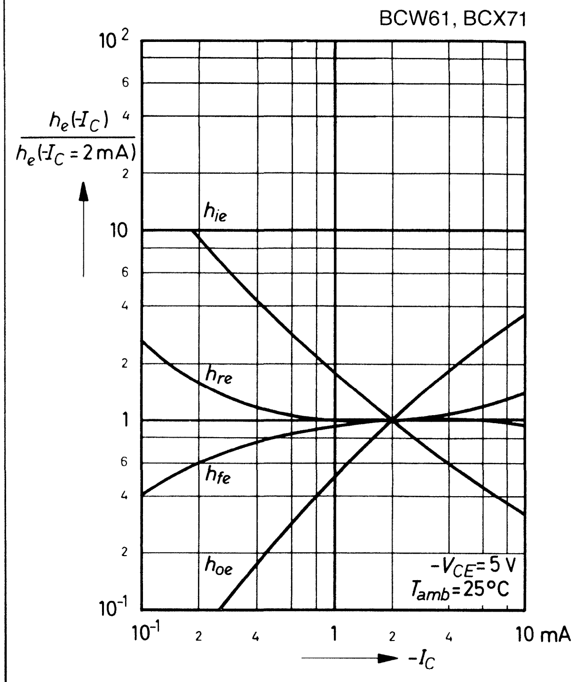
Collector saturation voltage versus collector current



Gain bandwidth product versus collector current



Relative h-**parameters**
versus collector current



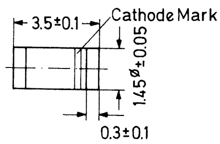
Silicon Diodes

BAV100 . . . BAV103

Silicon Epitaxial Planar Diodes
for general purpose

These diodes are also available in DO-35 case with the type designations BAV18 . . . BAV21.

These diodes are delivered taped.
Details see "Taping"



Glass case MiniMELF

Weight approx. 0.05 g
Dimensions in mm

Absolute Maximum Ratings

		Symbol	Value	Unit
Reverse Voltage	**BAV100**	V_R	60	V
	BAV101	V_R	120	V
	BAV102	V_R	200	V
	BAV103	V_R	250	V
Forward DC Current at T_{amb} = 25 °C		I_F	250[1]	mA
Rectified Current (Average) Half Wave Rectification with Resist. Load at T_{amb} = 25 °C and f ≥50 Hz		I_0	200[1]	mA
Repetitive Peak Forward Current at f ≥50 Hz, Θ = 180 °C, T_{amb} = 25 °C		I_{FRM}	625[1]	mA
Surge Forward Current at t<1 s, T_j = 25 °C		I_{FSM}	1	A
Power Dissipation at T_{amb} = 25 °C		P_{tot}	400[1]	mW
Junction Temperature		T_j	175	°C
Storage Temperature Range		T_S	−65 to +175	°C

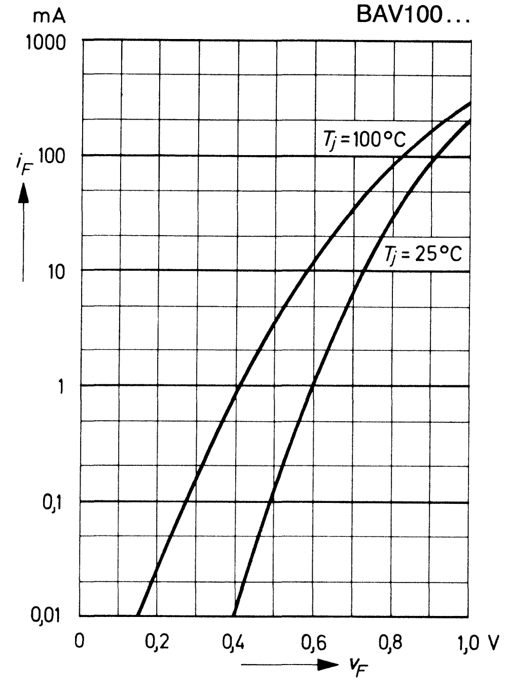
[1] Valid provided that electrodes are kept at ambient temperature.

Characteristics at $T_j = 25\ °C$

	Symbol	Min.	Typ.	Max.	Unit
Forward voltage at $I_F = 100$ mA	V_F	–	–	1	V
Leakage Current					
at $V_R = 50$ V **BAV100**	I_R	–	–	100	nA
at $V_R = 50$ V, $T_j = 100\ °C$ **BAV100**	I_R	–	–	15	µA
at $V_R = 100$ V **BAV101**	I_R	–	–	100	nA
at $V_R = 100$ V, $T_j = 100\ °C$ **BAV101**	I_R	–	–	15	µA
at $V_R = 150$ V **BAV102**	I_R	–	–	100	nA
at $V_R = 150$ V, $T_j = 100\ °C$ **BAV102**	I_R	–	–	15	µA
at $V_R = 200$ V **BAV103**	I_R	–	–	100	nA
at $V_R = 200$ V, $T_j = 100\ °C$ **BAV103**	I_R	–	–	15	µA
Dynamic Forward Resistance at $I_F = 10$ mA	r_f	–	5	–	Ω
Capacitance at $V_R = 0$, f = 1 MHz	C_{tot}	–	1.5	–	pF
Reverse Recovery Time from $I_F = 30$ mA through $I_R = 30$ mA to $I_R = 3$ mA; $R_L = 100\ \Omega$	t_{rr}	–	–	50	ns
Thermal Resistance Junction to Ambient Air	R_{thA}	–	–	0.375[1)]	K/mW

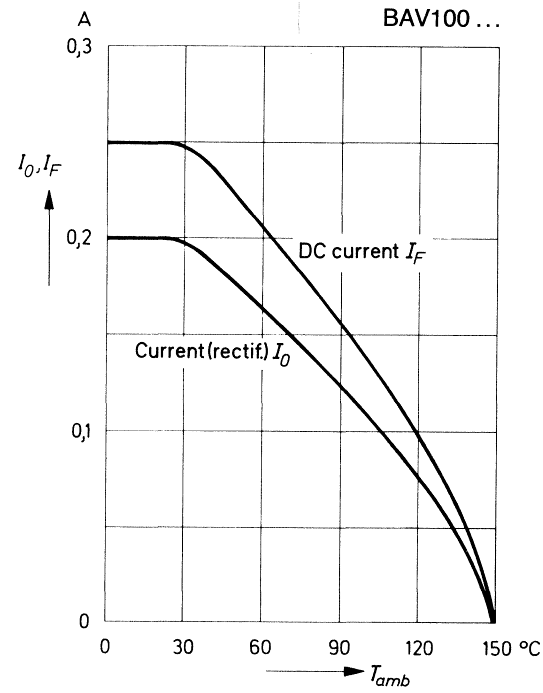
[1)] Valid provided that electrodes are kept at ambient temperature.

Forward characteristics



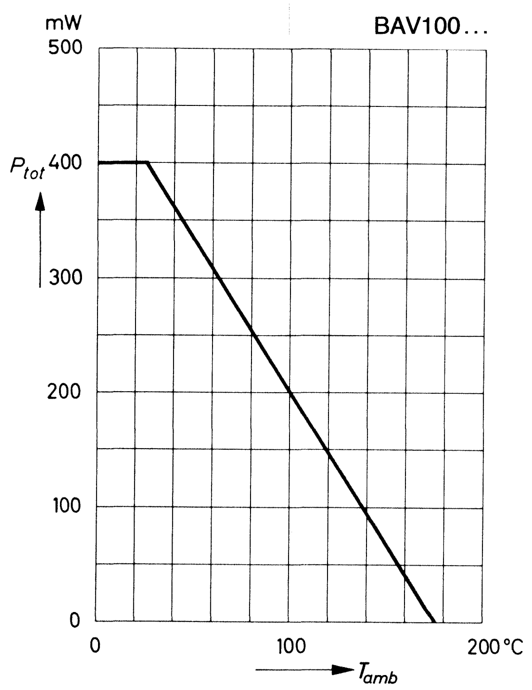
Admissible forward current versus ambient temperature

Valid provided that electrodes are kept at ambient temperature

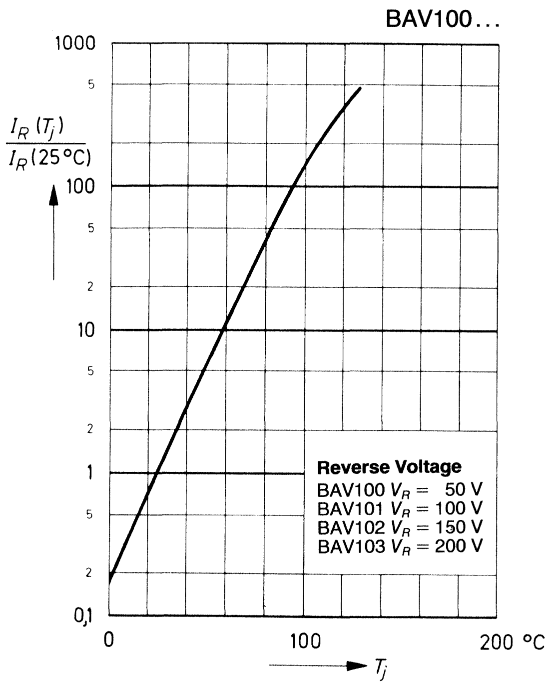


Admissible power dissipation versus ambient temperature

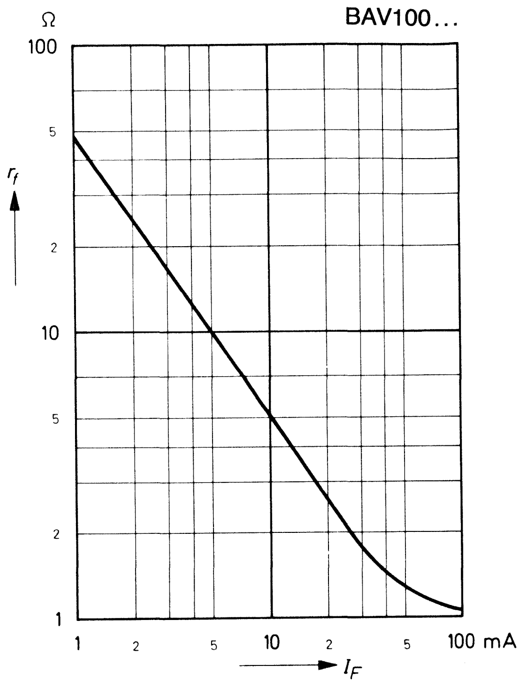
Valid provided that electrodes are kept at ambient temperature



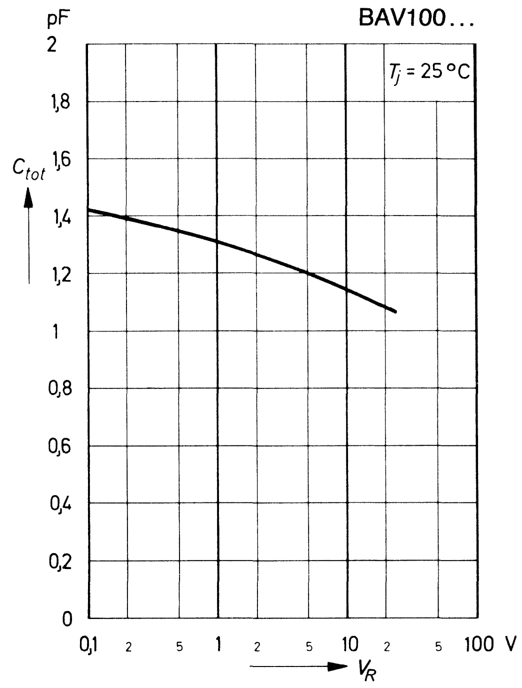
Leakage current versus junction temperature



Dynamic forward resistance versus forward current

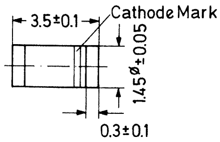


Capacitance versus reverse voltage



LL4148

Silicon Epitaxial Planar Diode
fast switching diode in MiniMELF case especially suited for automatic insertion.
Identical electrically to standard JEDEC 1N4148



Glass case MiniMELF

These diodes are delivered taped.
Details see “Taping”.

Weight approx. 0.05 g
Dimensions in mm

Absolute Maximum Ratings

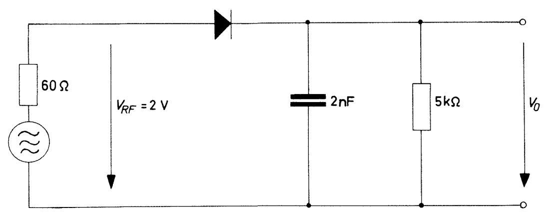
	Symbol	Value	Unit
Reverse Voltage	V_R	75	V
Peak Reverse Voltage	V_{RM}	100	V
Rectified Current (Average) Half Wave Rectification with Resist. Load at T_{amb} = 25 °C and f ≥ 50 Hz	I_0	150[1]	mA
Surge Forward Current at t < 1 s and T_j = 25 °C	I_{FSM}	500	mA
Power Dissipation at T_{amb} = 25 °C	P_{tot}	500[1]	mW
Junction Temperature	T_j	175	°C
Storage Temperature Range	T_S	−65 to +175	°C

[1] Valid provided that electrodes are kept at ambient temperature.

Characteristics at $T_j = 25\ °C$

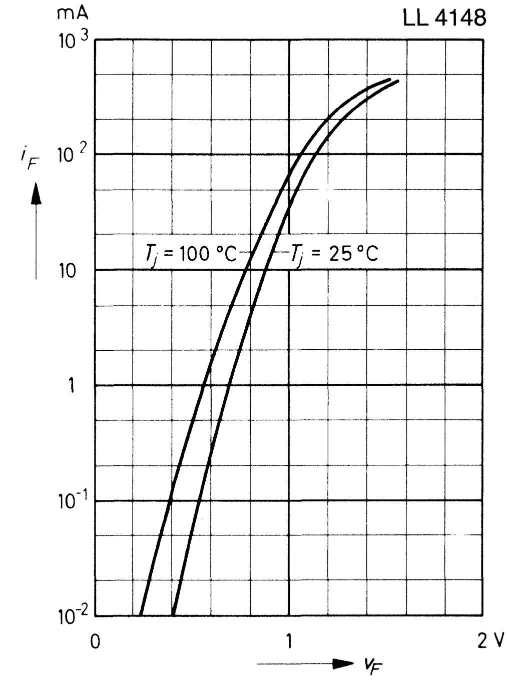
	Symbol	Min.	Typ.	Max.	Unit
Forward Voltage at $I_F = 10$ mA	V_F	–	–	1	V
Leakage Current at $V_R = 20$ V at $V_R = 75$ V at $V_R = 20$ V, $T_j = 150\ °C$	 I_R I_R I_R	 – – –	 – – –	 25 5 50	 nA µA µA
Reverse Breakdown Voltage tested with 100 µA Pulses	$V_{(BR)R}$	100	–	–	V
Capacitance at $V_F = V_R = 0$	C_{tot}	–	–	4	pF
Voltage Rise when Switching ON tested with 50 mA Forward Pulses $t_p = 0.1\ \mu s$, Rise Time < 30 ns, $f_p = 5$ to 100 kHz	V_{fr}	–	–	2.5	V
Reverse Recovery Time from $I_F = 10$ mA to $I_R = 1$ mA, $V_R = 6$ V, $R_L = 100\ \Omega$	t_{rr}	–	–	4	ns
Thermal Resistance Junction to Ambient Air	R_{thA}	–	–	0.35[1]	K/mW
Rectification Efficiency at f = 100 MHz, $V_{RF} = 2$ V	η_V	0.45	–	–	–

[1] Valid provided that electrodes are kept at ambient temperature.

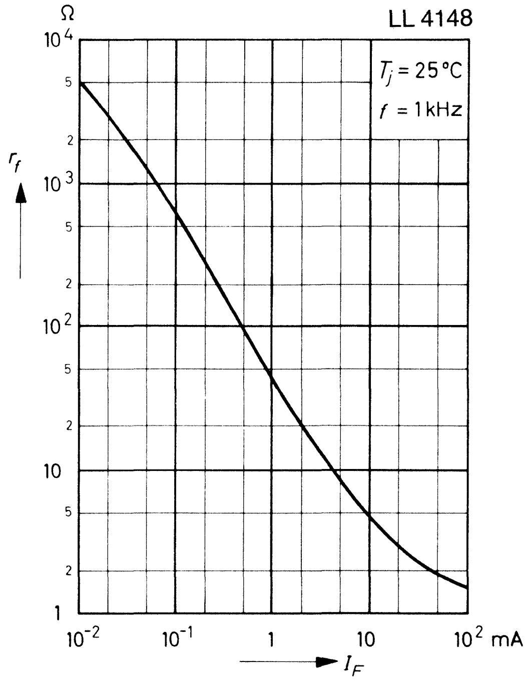


Rectification Efficiency Measurement Circuit

Forward characteristics

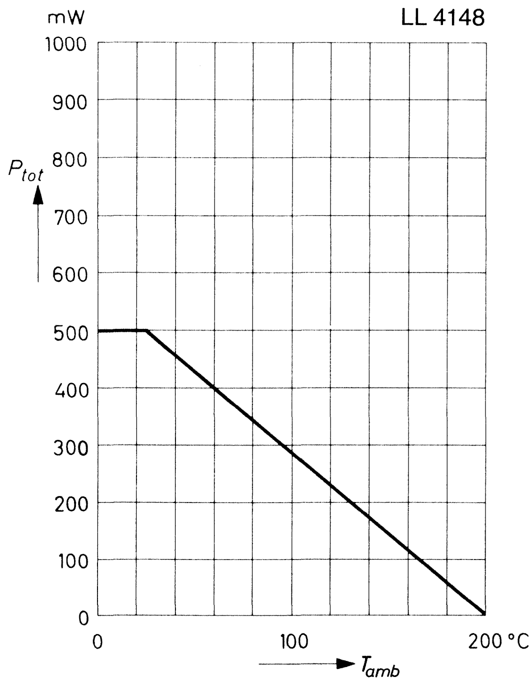


Dynamic forward resistance versus forward current

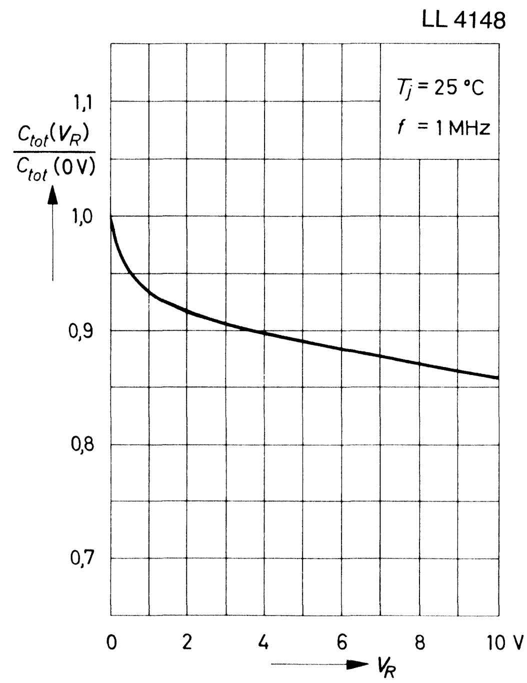


Admissible power dissipation versus ambient temperature

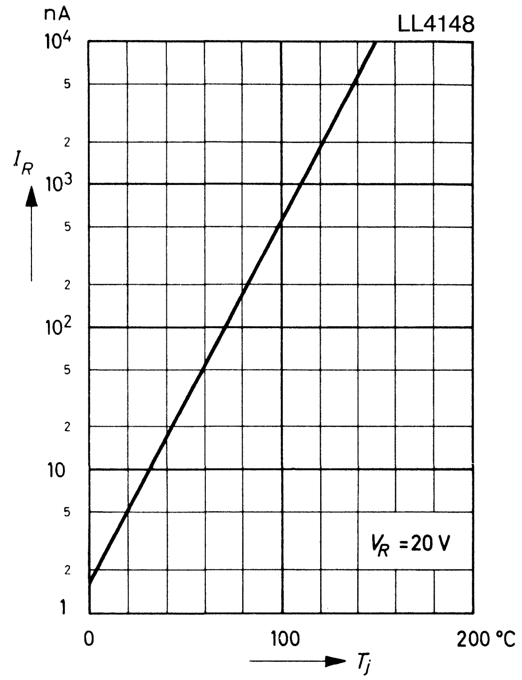
Valid provided that electrodes are kept at ambient temperature



Relative capacitance versus reverse voltage

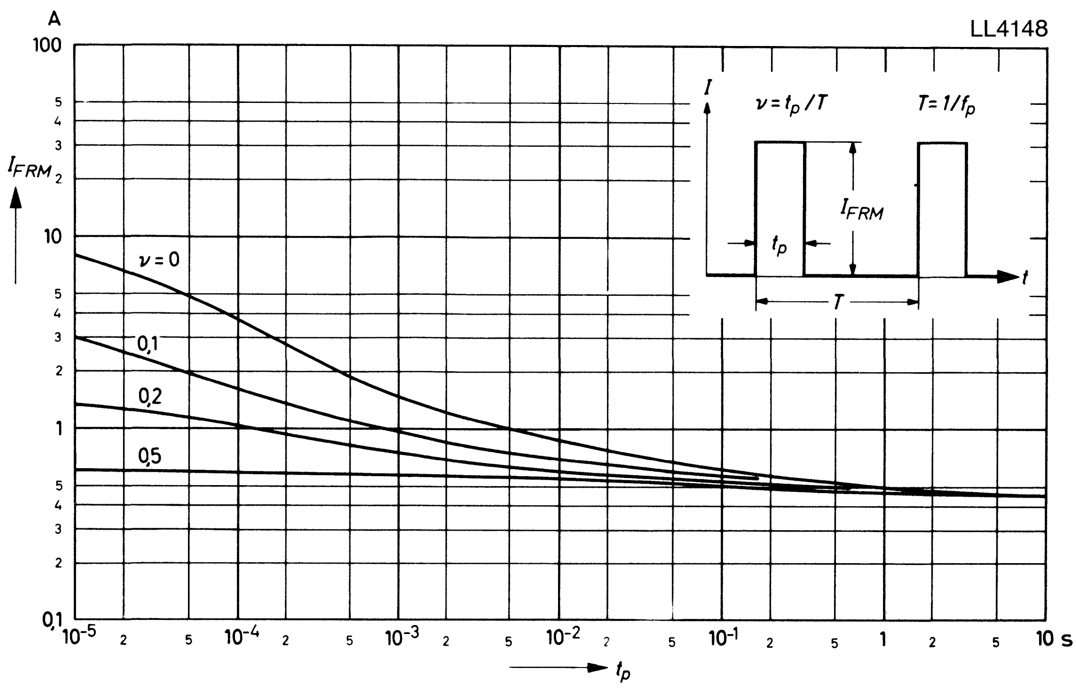


Leakage current versus junction temperature



Admissible repetitive peak forward current versus pulse duration

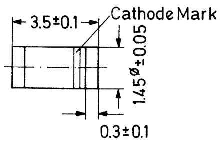
Valid provided that electrodes are kept at ambient temperature



LL4151

Silicon Epitaxial Planar Diode
fast switching diode in MiniMELF case especially suited for automatic insertion.
Identical electrically to standard JEDEC 1N4151

These diodes are delivered taped.
Details see "Taping".



Glass case MiniMELF

Weight approx. 0.05 g
Dimensions in mm

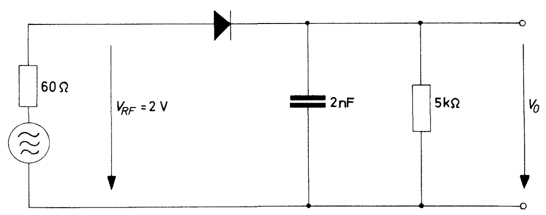
Absolute Maximum Ratings

	Symbol	Value	Unit
Reverse Voltage	V_R	50	V
Peak Reverse Voltage	V_{RM}	75	V
Rectified Current (Average) Half Wave Rectification with Resist. Load at T_{amb} = 25 °C and f ≥ 50 Hz	I_0	150[1]	mA
Surge Forward Current at t < 1 s and T_j = 25 °C	I_{FSM}	500	mA
Power Dissipation at T_{amb} = 25 °C	P_{tot}	500[1]	mW
Junction Temperature	T_j	175	°C
Storage Temperature Range	T_S	−65 to +175	°C
[1] Valid provided that electrodes are kept at ambient temperature.			

Characteristics at $T_j = 25\ °C$

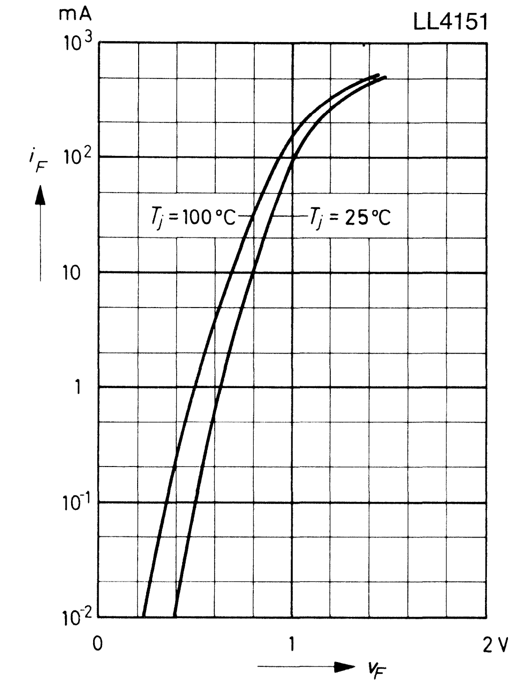
	Symbol	Min.	Typ.	Max.	Unit
Forward Voltage at $I_F = 50$ mA	V_F	–	–	1	V
Leakage Current at $V_R = 50$ V at $V_R = 50$ V, $T_j = 150\ °C$	 I_R I_R	 – –	 – –	 50 50	 nA μA
Reverse Breakdown Voltage tested with 5 μA Pulses	$V_{(BR)R}$	75	–	–	V
Capacitance at $V_F = V_R = 0$	C_{tot}	–	–	2	pF
Reverse Recovery Time from $I_F = 10$ mA through $I_R = 10$ mA to $I_R = 1$ mA from $I_F = 10$ mA to $I_R = 1$ mA, $V_R = 6$ V, $R_L = 100\ \Omega$	 t_{rr} t_{rr}	 – –	 – –	 4 2	 ns ns
Thermal Resistance Junction to Ambient Air	R_{thA}	–	–	0.35[1)]	K/mW
Rectification Efficiency at f = 100 MHz, $V_{RF} = 2$ V	η_V	0.45	–	–	–

[1)] Valid provided that electrodes are kept at ambient temperature.

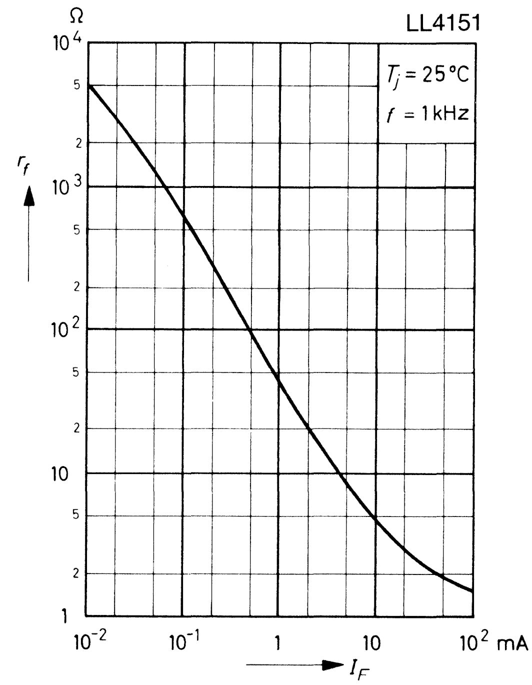


Rectification Efficiency Measurement Circuit

Forward characteristics

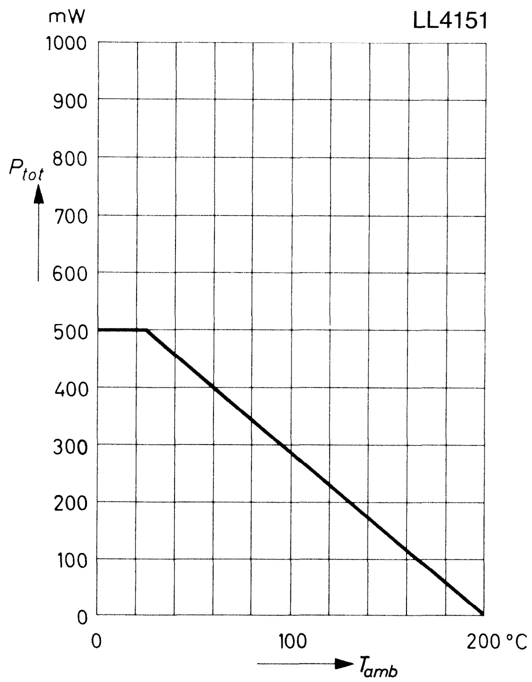


Dynamic forward resistance versus forward current

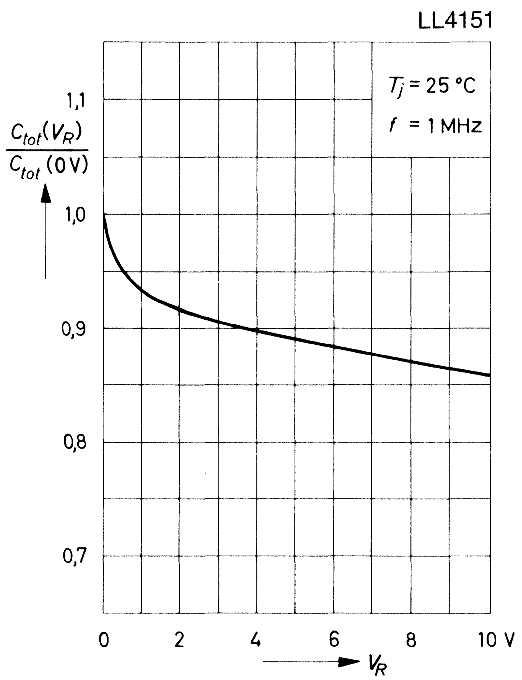


Admissible power dissipation versus ambient temperature

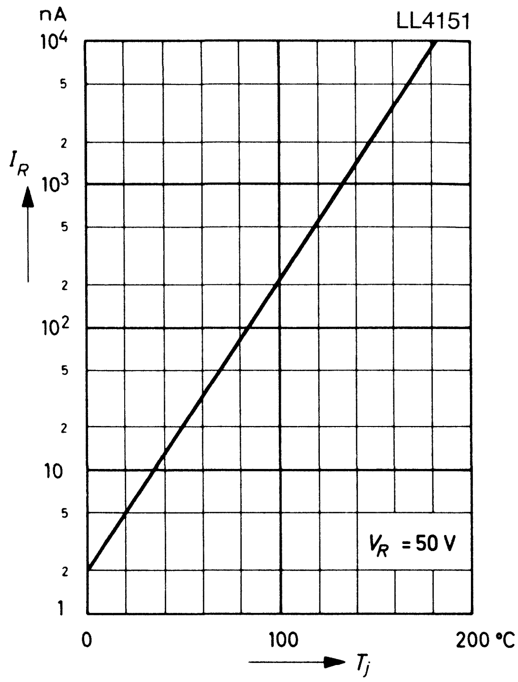
Valid provided that electrodes are kept at ambient temperature



Relative capacitance versus reverse voltage

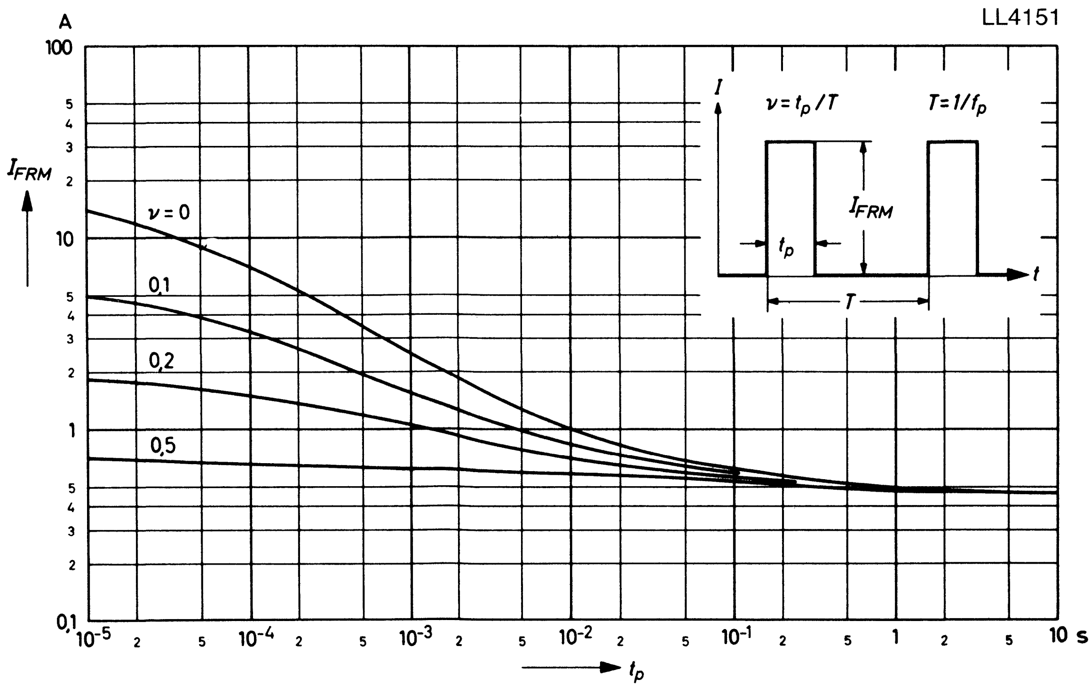


Leakage current versus junction temperature



Admissible repetitive peak forward current versus pulse duration

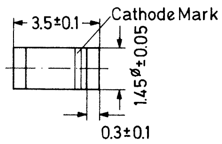
Valid provided that electrodes are kept at ambient temperature



LL4154

Silicon Epitaxial Planar Diode
fast switching diode in MiniMELF case especially suited for automatic insertion.
Identical electrically to standard JEDEC 1N4154

These diodes are delivered taped.
Details see "Taping".



Glass case MiniMELF

Weight approx. 0.05 g
Dimensions in mm

Absolute Maximum Ratings

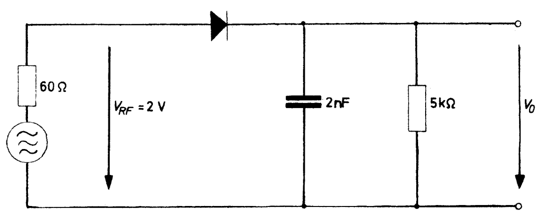
	Symbol	Value	Unit
Reverse Voltage	V_R	25	V
Peak Reverse Voltage	V_{RM}	35	V
Rectified Current (Average) Half Wave Rectification with Resist. Load at $T_{amb} = 25$ °C and $f \geqslant 50$ Hz	I_0	150[1)]	mA
Surge Forward Current at $t < 1$ s and $T_j = 25$ °C	I_{FSM}	500	mA
Power Dissipation at $T_{amb} = 25$ °C	P_{tot}	500[1)]	mW
Junction Temperature	T_j	175	°C
Storage Temperature Range	T_S	−65 to +175	°C

[1)] Valid provided that electrodes are kept at ambient temperature.

Characteristics at $T_j = 25\ °C$

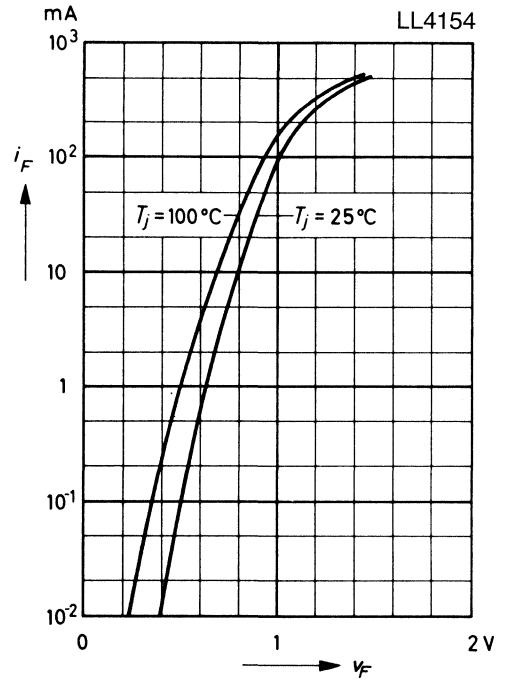
	Symbol	Min.	Typ.	Max.	Unit
Forward Voltage at $I_F = 30$ mA	V_F	–	–	1	V
Leakage Current at $V_R = 25$ V at $V_R = 25$ V, $T_j = 150\ °C$	 I_R I_R	 – –	 – –	 100 100	 nA μA
Reverse Breakdown Voltage tested with 5 μA Pulses	$V_{(BR)R}$	35	–	–	V
Capacitance at $V_F = V_R = 0$	C_{tot}	–	–	4	pF
Voltage Rise when Switching ON tested with 50 mA Forward Pulses $t_p = 0.1\ \mu s$, Rise Time < 30 ns, $f_p = 5$ to 100 kHz	V_{fr}	–	–	2.5	V
Reverse Recovery Time from $I_F = 10$ mA through $I_R = 10$ mA to $I_R = 1$ mA from $I_F = 10$ mA to $I_R = 1$ mA, $V_R = 6$ V, $R_L = 100\ \Omega$	 t_{rr} t_{rr}	 – –	 – –	 4 2	 ns ns
Thermal Resistance Junction to Ambient Air	R_{thA}	–	–	0.35[1]	K/mW
Rectification Efficiency at f = 100 MHz, $V_{RF} = 2$ V	η_V	0.45	–	–	–

[1] Valid provided that electrodes are kept at ambient temperature.

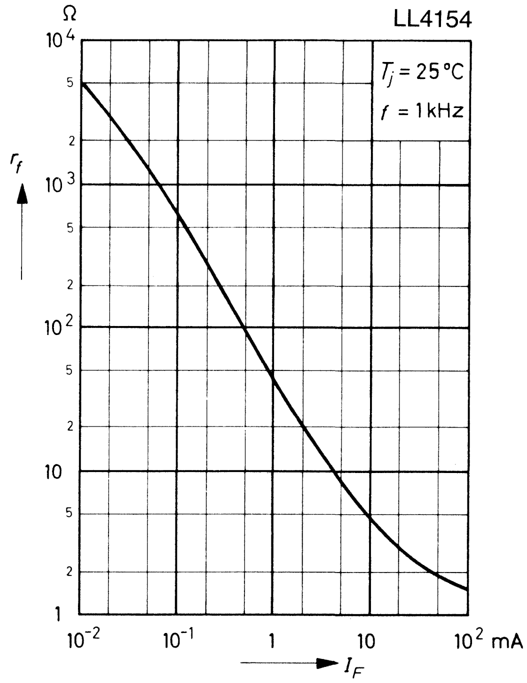


Rectification Efficiency Measurement Circuit

Forward characteristics

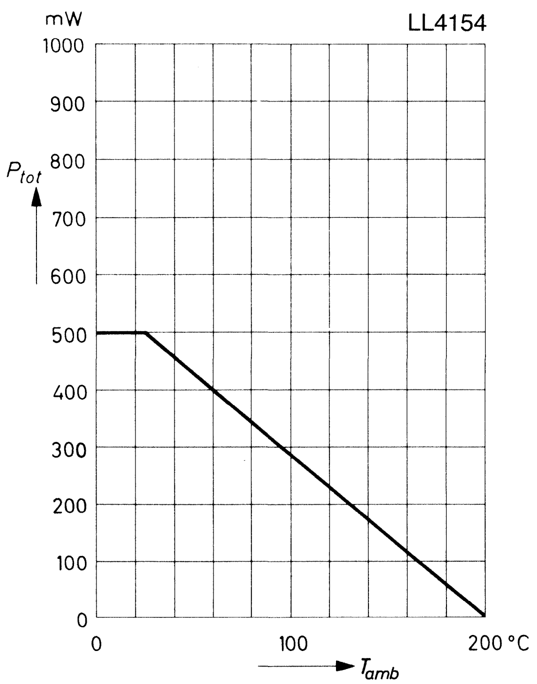


Dynamic forward resistance versus forward current

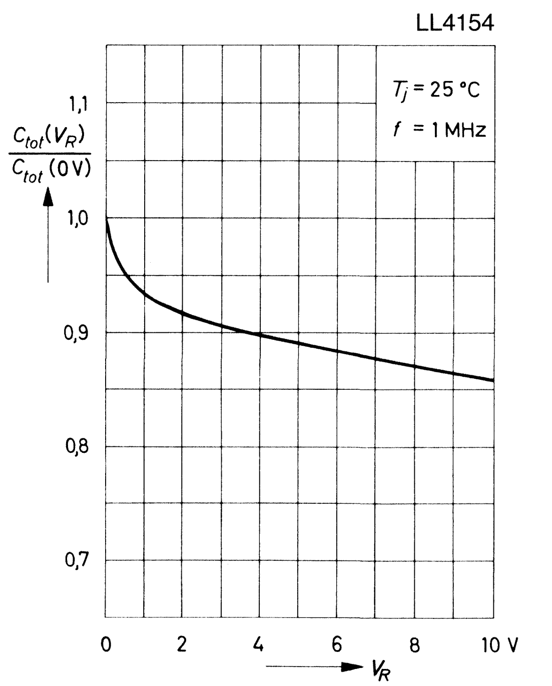


Admissible power dissipation versus ambient temperature

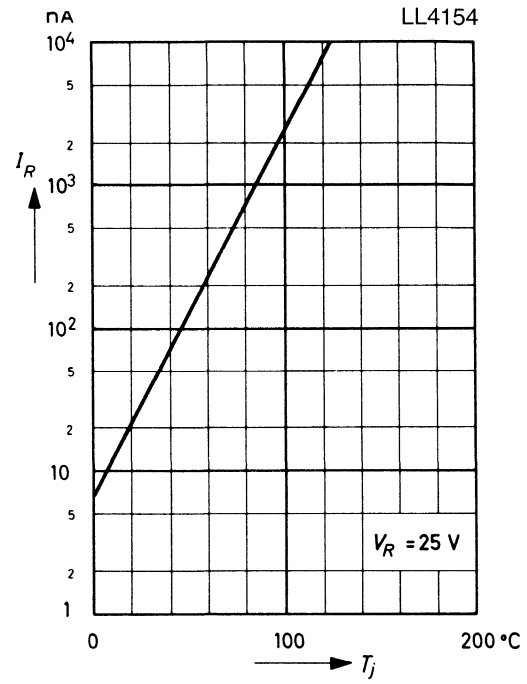
Valid provided that electrodes are kept at ambient temperature



Relative capacitance versus reverse voltage

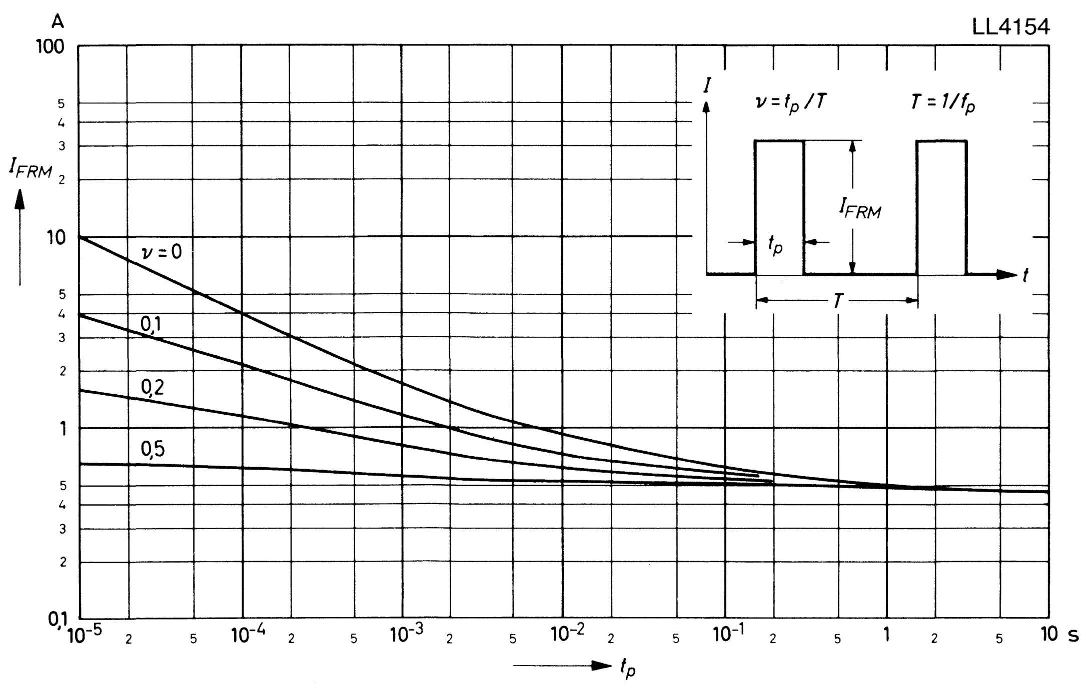


Leakage current versus junction temperature



Admissible repetitive peak forward current versus pulse duration

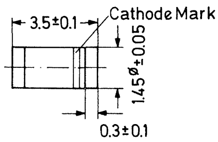
Valid provided that leads at a distance of 8 mm from case resp. electrodes of the MiniMELF case are kept at ambient temperature



LL4446

Silicon Epitaxial Planar Diode
fast switching diode in MiniMELF case especially suited for automatic insertion.
Identical electrically to standard JEDEC 1N4446

These diodes are delivered taped.
Details see "Taping".



Glass case MiniMELF

Weight approx. 0.05 g
Dimensions in mm

Absolute Maximum Ratings

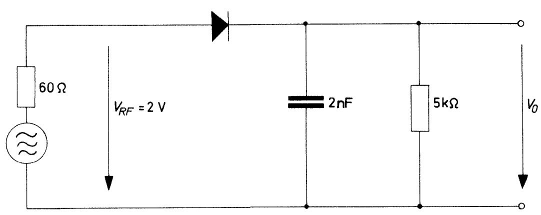
	Symbol	Value	Unit
Reverse Voltage	V_R	75	V
Peak Reverse Voltage	V_{RM}	100	V
Rectified Current (Average) Half Wave Rectification with Resist. Load at T_{amb} = 25 °C and f ≥ 50 Hz	I_0	150[1)]	mA
Surge Forward Current at t < 1 s and T_j = 25 °C	I_{FSM}	500	mA
Power Dissipation at T_{amb} = 25 °C	P_{tot}	500[1)]	mW
Junction Temperature	T_j	175	°C
Storage Temperature Range	T_S	–65 to +175	°C

[1)] Valid provided that electrodes are kept at ambient temperature.

Characteristics at $T_j = 25\ °C$

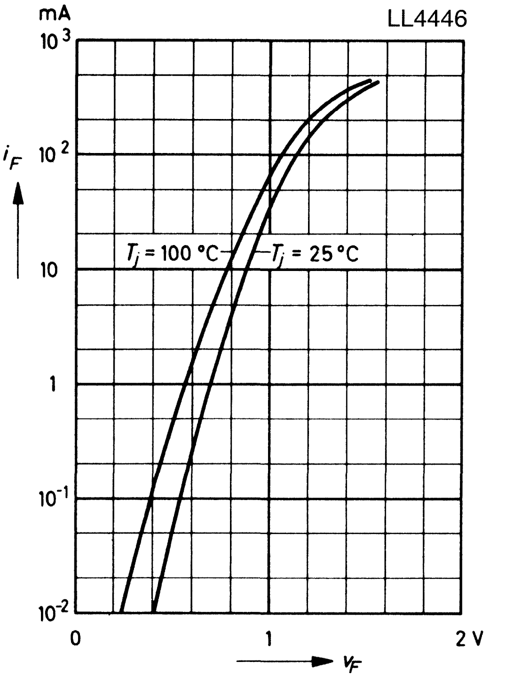
	Symbol	Min.	Typ.	Max.	Unit
Forward Voltage at $I_F = 20$ mA	V_F	–	–	1	V
Leakage Current at $V_R = 20$ V at $V_R = 75$ V at $V_R = 20$ V, $T_j = 150\ °C$	 I_R I_R I_R	 – – –	 – – –	 25 5 50	 nA μA μA
Reverse Breakdown Voltage tested with 100 μA Pulses	$V_{(BR)R}$	100	–	–	V
Capacitance at $V_F = V_R = 0$	C_{tot}	–	–	4	pF
Voltage Rise when Switching ON tested with 50 mA Forward Pulses $t_p = 0.1\ \mu s$, Rise Time < 30 ns, $f_p = 5$ to 100 kHz	V_{fr}	–	–	2.5	V
Reverse Recovery Time from $I_F = 10$ mA to $I_R = 1$ mA, $V_R = 6$ V, $R_L = 100\ \Omega$	t_{rr}	–	–	4	ns
Thermal Resistance Junction to Ambient Air	R_{thA}	–	–	0.35[1]	K/mW
Rectification Efficiency at f = 100 MHz, $V_{RF} = 2$ V	η_V	0.45	–	–	–

[1] Valid provided that electrodes are kept at ambient temperature.

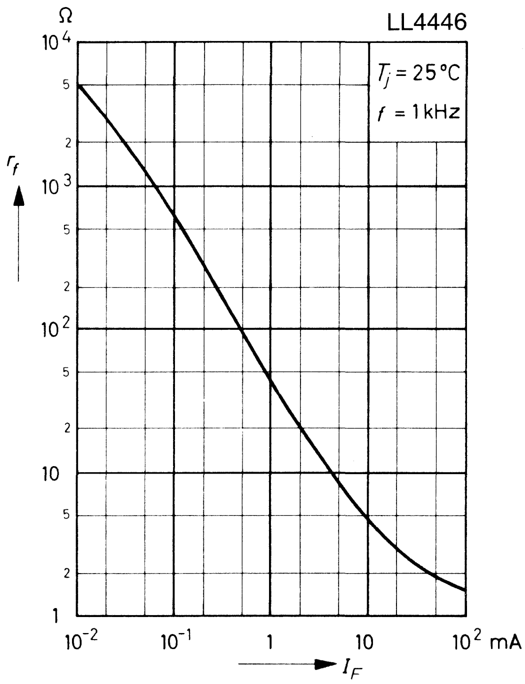


Rectification Efficiency Measurement Circuit

Forward characteristics

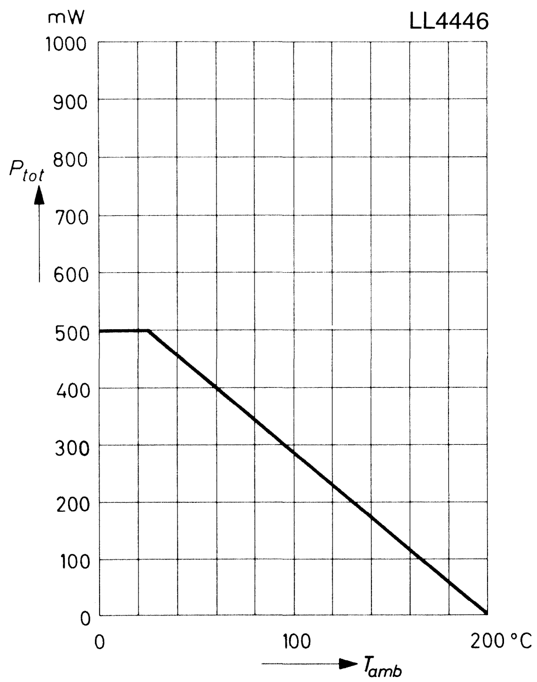


Dynamic forward resistance versus forward current

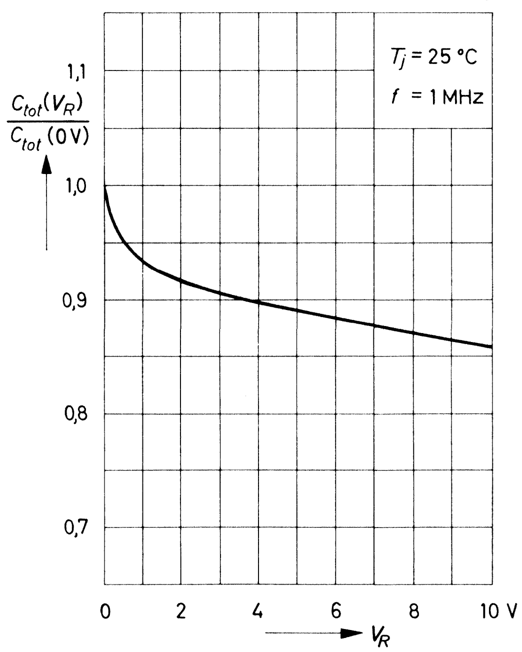


Admissible power dissipation versus ambient temperature

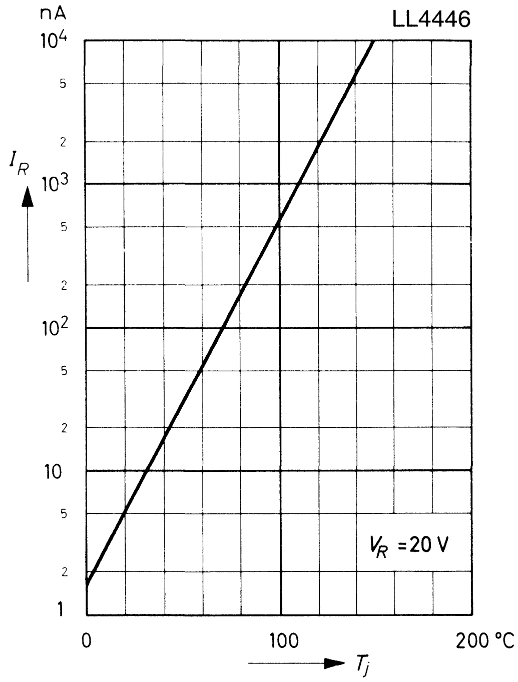
Valid provided that electrodes are kept at ambient temperature



Relative capacitance versus reverse voltage

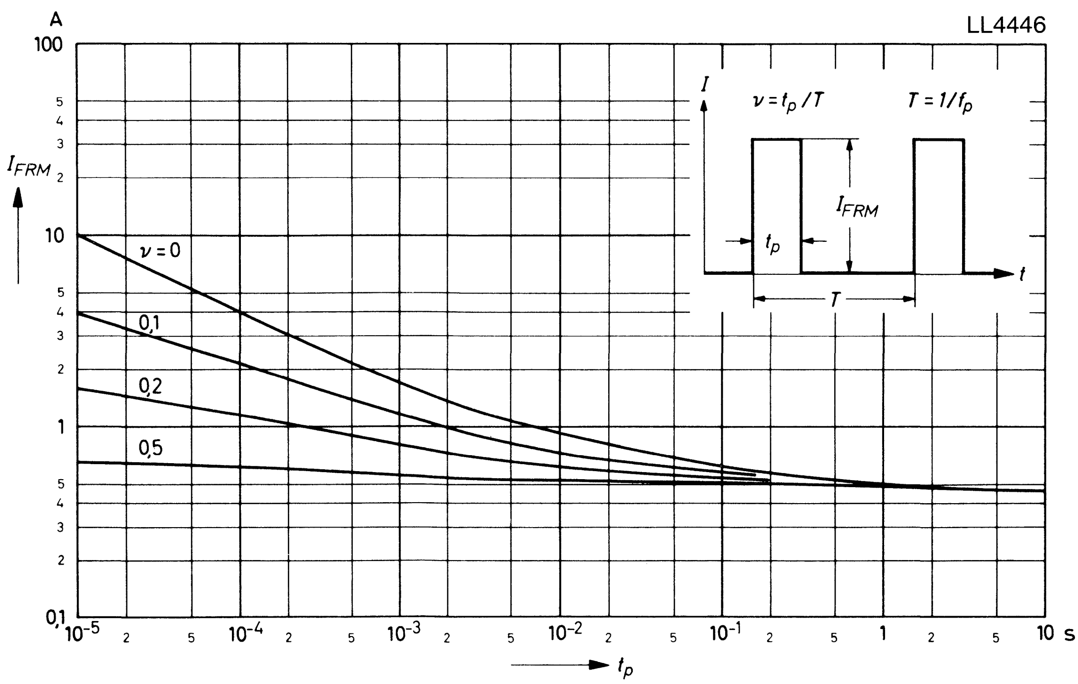


Leakage current versus junction temperature



Admissible repetitive peak forward current versus pulse duration

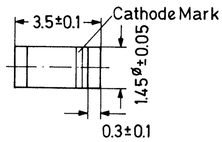
Valid provided that leads at a distance of 8 mm from case resp. electrodes of the MiniMELF case are kept at ambient temperature



LL4448

Silicon Epitaxial Planar Diode
fast switching diode in MiniMELF case especially suited for automatic insertion.
Identical electrically to standard JEDEC 1N4448

These diodes are delivered taped.
Details see "Taping".



Glass case MiniMELF

Weight approx. 0.05 g
Dimensions in mm

Absolute Maximum Ratings

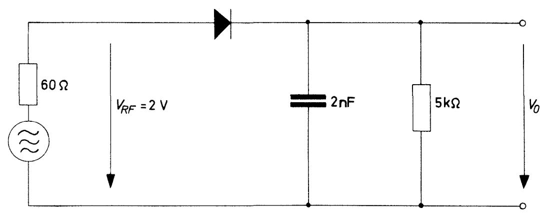
	Symbol	Value	Unit
Reverse Voltage	V_R	75	V
Peak Reverse Voltage	V_{RM}	100	V
Rectified Current (Average) Half Wave Rectification with Resist. Load at T_{amb} = 25 °C and f ≥ 50 Hz	I_0	150[1)]	mA
Surge Forward Current at t < 1 s and T_j = 25 °C	I_{FSM}	500	mA
Power Dissipation at T_{amb} = 25 °C	P_{tot}	500[1)]	mW
Junction Temperature	T_j	175	°C
Storage Temperature Range	T_S	−65 to +175	°C

[1)] Valid provided that electrodes are kept at ambient temperature.

Characteristics at $T_j = 25\ °C$

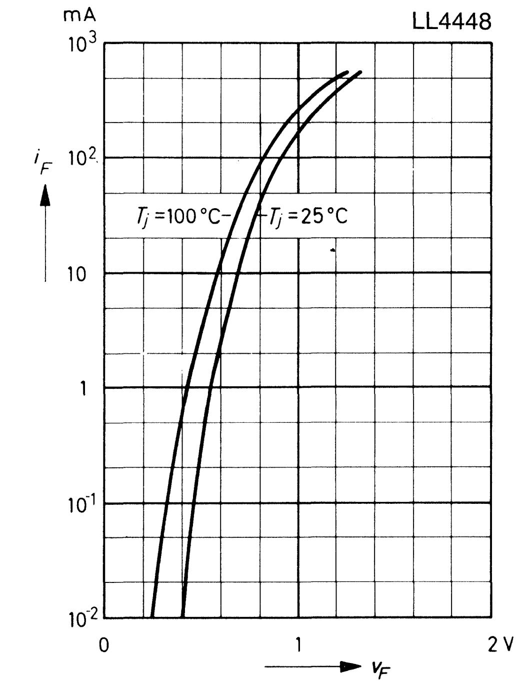
	Symbol	Min.	Typ.	Max.	Unit
Forward Voltage at $I_F = 5$ mA at $I_F = 100$ mA	 V_F V_F	 0.62 –	 – –	 0.72 1	 V V
Leakage Current at $V_R = 20$ V at $V_R = 75$ V at $V_R = 20$ V, $T_j = 150\ °C$	 I_R I_R I_R	 – – –	 – – –	 25 5 50	 nA μA μA
Reverse Breakdown Voltage tested with 100 μA Pulses	$V_{(BR)R}$	100	–	–	V
Capacitance at $V_F = V_R = 0$	C_{tot}	–	–	4	pF
Reverse Recovery Time from $I_F = 10$ mA to $I_R = 1$ mA, $V_R = 6$ V, $R_L = 100\ \Omega$	t_{rr}	–	–	4	ns
Thermal Resistance Junction to Ambient Air	R_{thA}	–	–	0.35[1]	K/mW
Rectification Efficiency at f = 100 MHz, $V_{RF} = 2$ V	η_V	0.45	–	–	–

[1] Valid provided that electrodes are kept at ambient temperature.

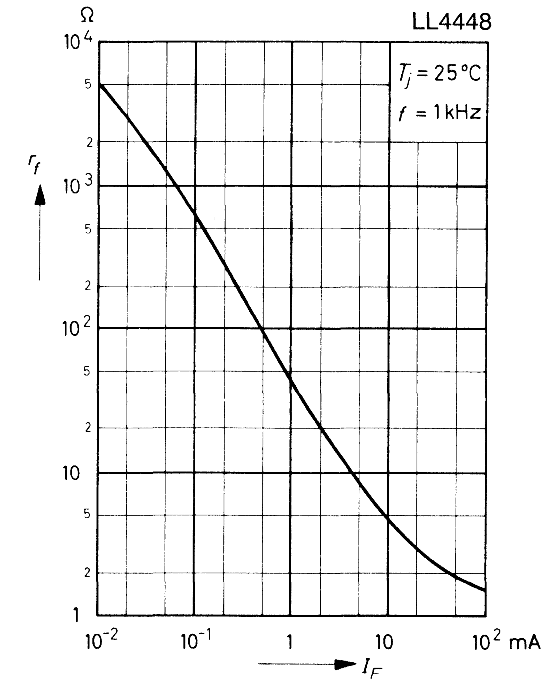


Rectification Efficiency Measurement Circuit

Forward characteristics

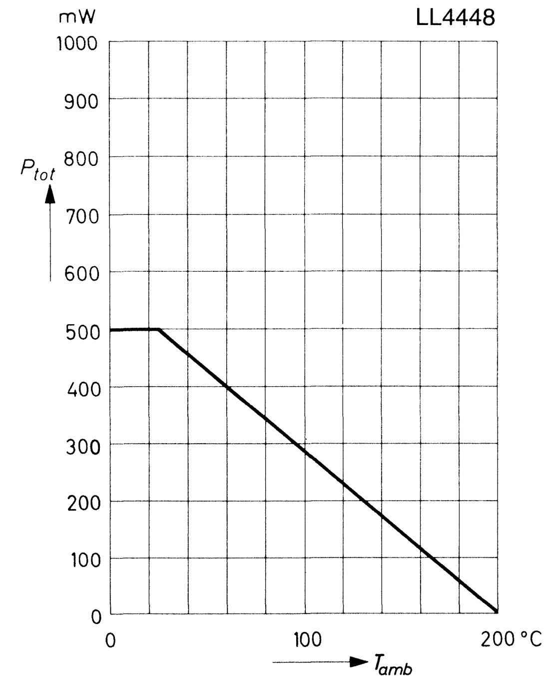


Dynamic forward resistance versus forward current

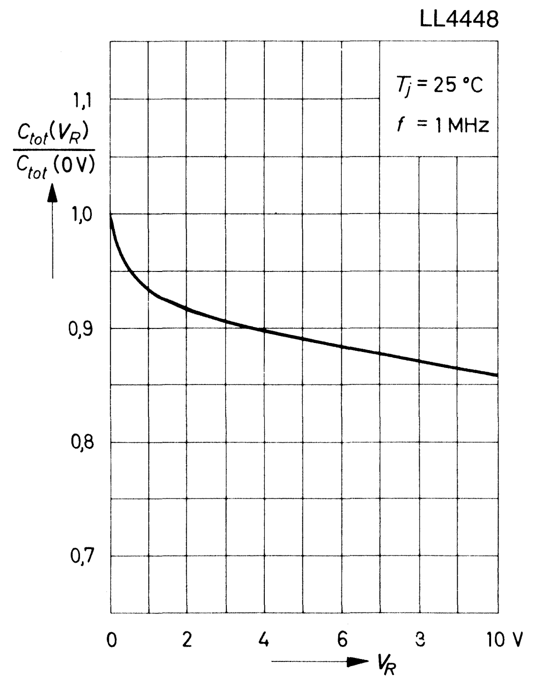


Admissible power dissipation versus ambient temperature

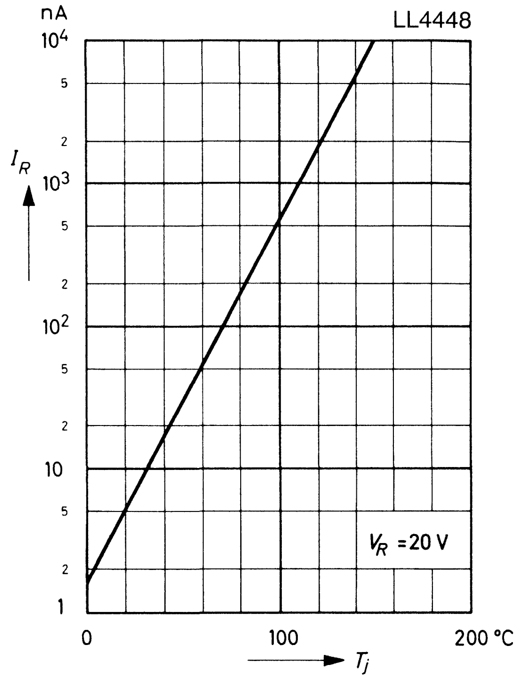
Valid provided that electrodes are kept at ambient temperature



Relative capacitance versus reverse voltage

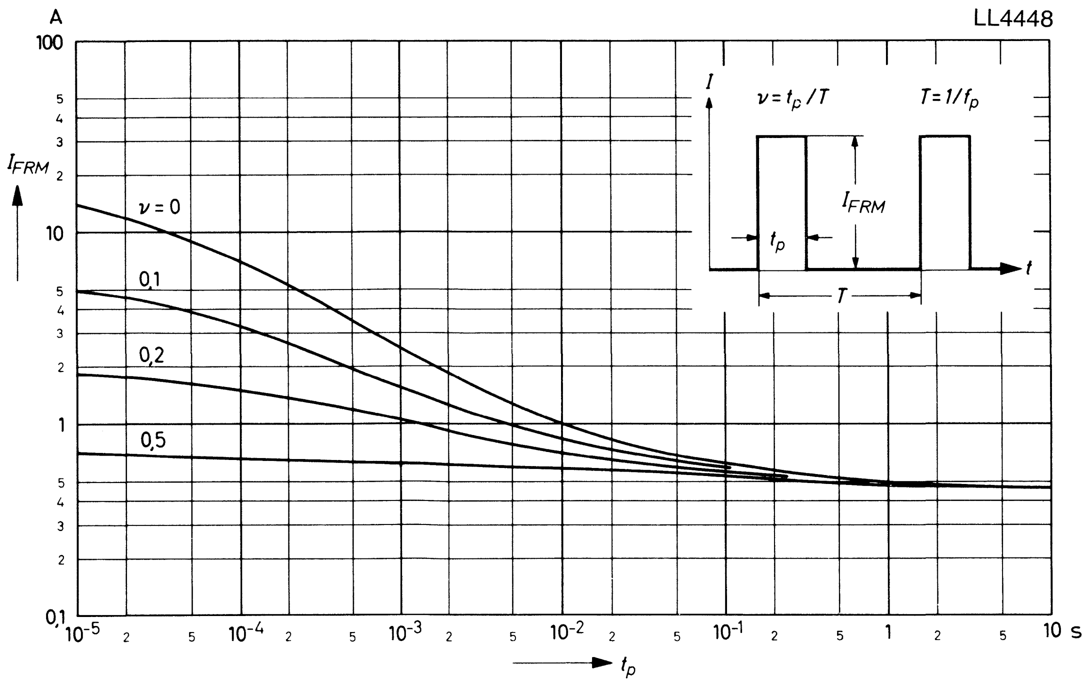


Leakage current versus junction temperature



Admissible repetitive peak forward current versus pulse duration

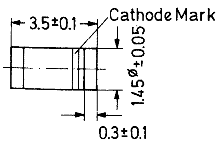
Valid provided that electrodes are kept at ambient temperature



Silicon Diodes

Silicon Diodes
for general purpose and switching

These diodes are identical electrically to the corresponding JEDEC 1N . . . types.



Glass case MiniMELF

Weight approx. 0.05 g
Dimensions in mm

These diodes are delivered taped.
Details see "Taping".

Type	Peak reverse voltage	Max. aver. rectified current	Max. power dissip. at 25 °C	Max. junction temperature	Max. forward voltage drop	at	Max. reverse current	at	Max. reverse recovery time	
	V_{RM} V	I_0 mA	P_{tot} mW	T_j °C	V_F V	I_F mA	I_R nA	V_R V	t_{rr} ns	Conditions
LL4149	100	150	500	175	1.0	10	25	20	max. 4.0	I_F = 10 mA, V_R = 6 V, R_L = 100 Ω, to I_R = 1 mA
LL4150	50	200	500	175	1.0	200	100	50	max. 4.0	I_F = I_R = 10 to 200 mA, to 0.1 I_F
LL4152	40	150	400	175	0.55	0.10	50	30	max. 2.0	I_F = 10 mA, V_R = 6 V, R_L = 100 Ω, to I_R = 1 mA
LL4153	75	150	400	175	0.55	0.10	50	50	max. 2.0	I_F = 10 mA, V_R = 6 V, R_L = 100 Ω, to I_R = 1 mA
LL4447	100	150	500	175	1.0	20	25	20	max. 4.0	I_F = 10 mA, V_R = 6 V, R_L = 100 Ω, to I_R = 1 mA
LL4449	100	150	500	175	1.0	100	25	20	max. 4.0	I_F = 10 mA, V_R = 6 V, R_L = 100 Ω, to I_R = 1 mA
LL4450	40	150	400	175	0.54	0.50	50	30	max. 4.0	I_F = I_R = 10 mA, to I_R = 1 mA
LL4451	40	150	400	175	0.50	0.10	50	30	max. 10	I_F = I_R = 10 mA, to I_R = 1 mA
LL4453	30	150	400	175	0.55	0.01	50	20	–	–
LL4454	75	150	400	175	1.0	10	100	50	max. 4.0	I_F = I_R = 10 mA, to I_R = 1 mA

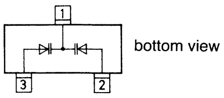
Silicon Diodes

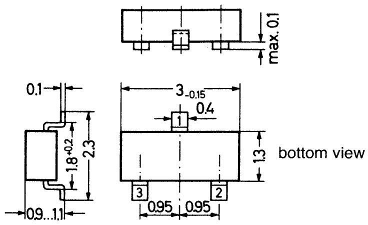
Tuner Diodes

BB404

Tuner Diode
Si Epitaxial Planar Dual Capacitance Diode for tuning in the VHF range, especially in car receivers.

These diodes are delivered taped.
Details see "Taping".





Plastic Package JEDEC TO-236
23 A 3 acording to DIN 41869

Weight approx. 0.01 g
Dimension in mm

Marking code

Type	Marking
BB404A	A4
BB404B	B4
BB404C	C4
BB404D	D4
BB404E	E4

Absolute Maximum Ratings

	Symbol	Value	Unit
Reverse Voltage	V_R	15	V
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_S	−55 to +125	°C

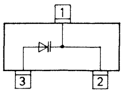
Characteristics at T_j = 25 °C

	Symbol	Min.	Typ.	Max.	Unit
Capacitance at f = 1 MHz, V_R = 2 V	C_{tot}	42	–	47.5	pF
Group A	C_{tot}	42	–	43.5	pF
B	C_{tot}	43	–	44.5	pF
C	C_{tot}	44	–	45.5	pF
D	C_{tot}	45	–	46.5	pF
E	C_{tot}	46	–	47.5	pF
Effective Capacitance Ratio at V_R = 2 to 8 V	$\frac{C_{tot}\,(2\ V)}{C_{tot}\,(8\ V)}$	1.65	–	1.75	–
Series Resistance at f = 100 MHz, C_{tot} = 38 pF	r_S	–	–	0.4	Ω
Leakage Current at V_R = 10 V	I_R	–	–	20	nA
Basic Tolerance[1] at V_R = 2 V	$\|K\|$	–	–	1	%

[1] Difference of capacitance values of the individual diodes in one package.

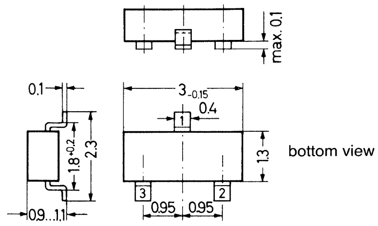
BB510

Tuner Diode
Si Epitaxial Planar Capacitance Diode with very high effective capacitance ratio for tuning the whole MW range, especially in car receivers.



Marking: CA

These diodes are delivered taped.
Details see "Taping".



Plastic Package JEDEC TO-236
23 A 3 according to DIN 41869

Weight approx. 0.01 g
Dimensions in mm

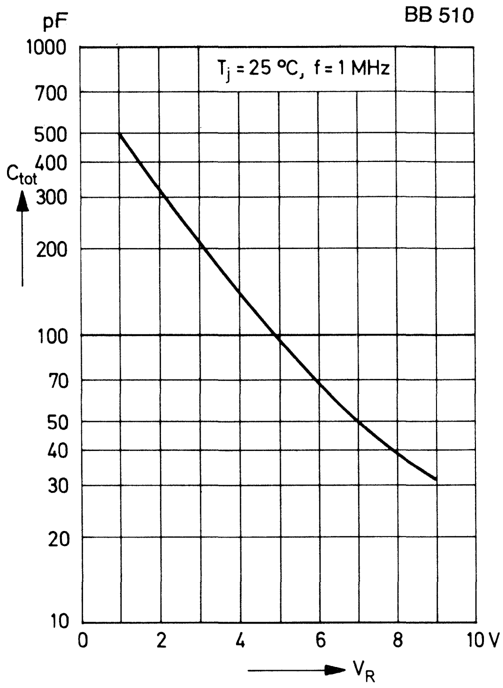
Absolute Maximum Ratings

	Symbol	Value	Unit
Reverse Voltage	V_R	12	V
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_S	– 55 to + 150	°C

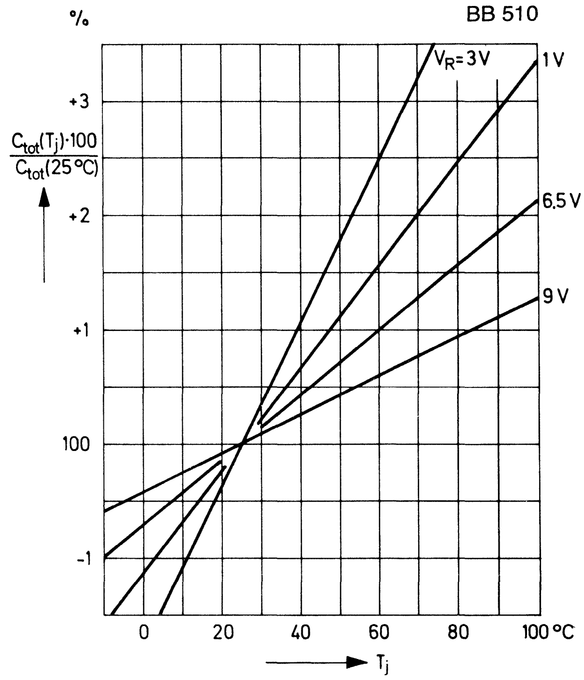
Characteristics at $T_j = 25$ °C

	Symbol	Min.	Typ.	Max.	Unit
Capacitance at f = 1 MHz at $V_R = 1$ V at $V_R = 9$ V	 C_{tot} C_{tot}	 440 20	 – –	 600 40	 pF pF
Effective Capacitance Ratio at $V_R = 1$ to 9 V	$\frac{C_{tot}\,(1\,V)}{C_{tot}\,(9\,V)}$	15	–	–	–
Q-Factor at $V_R = 1$ V, f = 1 MHz	Q	–	200	–	–
Leakage Current at $V_R = 10$ V	I_R	–	–	30	nA
Reverse Breakdown Voltage at $I_R = 100\ \mu A$	$V_{(BR)R}$	12	–	–	V

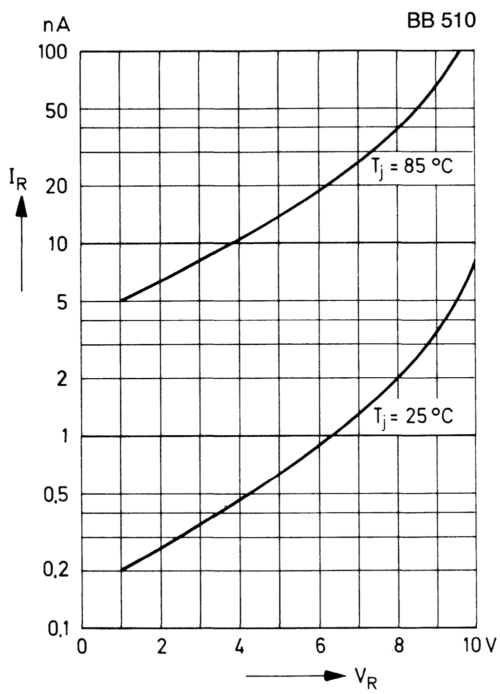
Capacitance versus reverse voltage



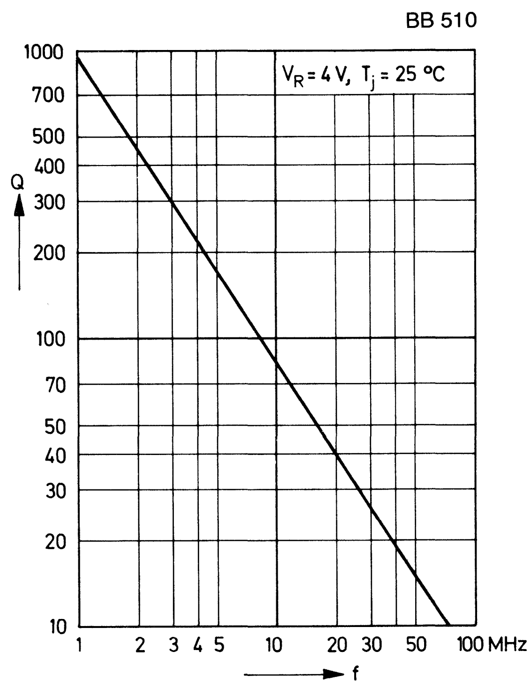
Capacitance versus junction temperature (relative values)



Leakage current versus reverse voltage



Q-Factor versus frequency



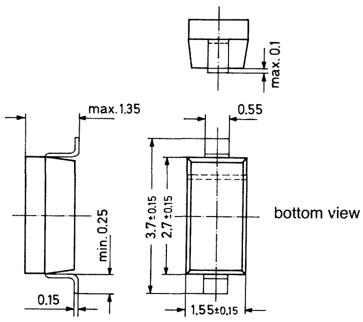
BB701

Tuner Diode
Si Epitaxial Planar Capacitance Diode for tuning the frequency range of 950 MHz to 1750 MHz, especially for satellite TV tuner.

These diodes are available as singles or as matched sets of two or more units according to the tracking condition described below.

These diodes are delivered taped.
Details see "Taping".

These diodes are also available with straight leads. Overall length 14 mm (only bulk packaging).



Plastic Package ≈ 60 A2
according to DIN 41870

Weight approx. 0.013 g
Dimension in mm

Absolute Maximum Ratings

	Symbol	Value	Unit
Reverse Voltage	V_R	32	V
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_S	−55 to +125	°C

Characteristics at T_j = 25 °C

	Symbol	Min.	Typ.	Max.	Unit
Capacitance at f = 1 MHz at V_R = 1 V at V_R = 28 V	 C_{tot} C_{tot}	 8 0.9	 – –	 9 1.2	 pF pF
Effective Capacitance Ratio at V_R = 1 to 28 V	$\frac{C_{tot}\ (1\ V)}{C_{tot}\ (28\ V)}$	8	–	9	–
Series Resistance at f = 470 MHz, C_{tot} = 9 pF	r_s	–	–	1.2	Ω
Leakage Current at V_R = 30 V	I_R	–	–	30	nA

For any two of six consecutive diodes in the carrier tape the maximum capacitance deviation in the reverse bias voltage range of V_R = 1 V to V_R = 28 V is 2.5 %.

BB721

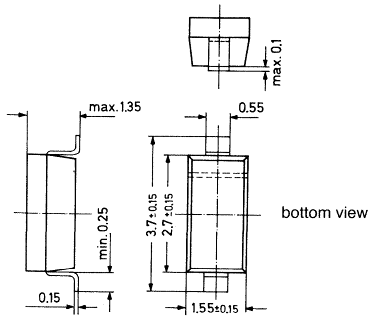
Tuner Diode
Silicon Epitaxial Planar Capacitance Diode with very wide effective capacitance variation for tuning the whole range of UHF television bands.

Two BB 721 in series are used for direct satellite receiving.

These diodes are available as singles or as matched sets of two or more units according to the tracking condition described below.

These diodes are delivered taped.
Details see "Taping".

These diodes are also available with straight leads. Overall length 14 mm (only bulk packaging).



Plastic Package ≈ 60 A2
according to DIN IEC 47(CO)718

Weight approx. 0.013 g
Dimension in mm

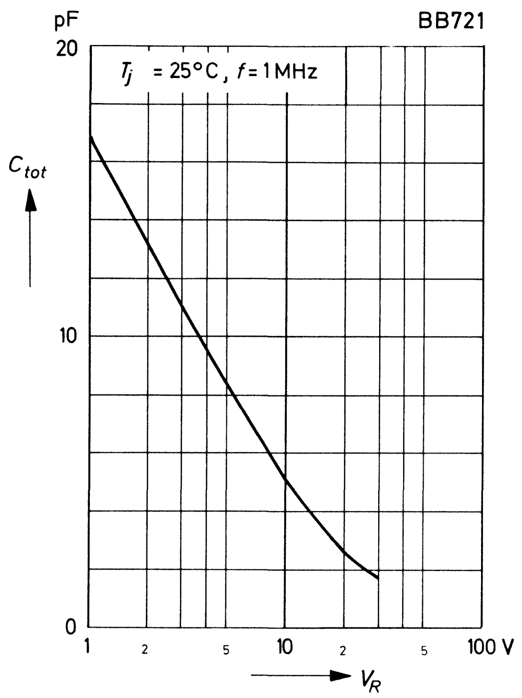
Absolute Maximum Ratings

	Symbol	Value	Unit
Reverse Voltage	V_R	32	V
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_S	−55 to +125	°C

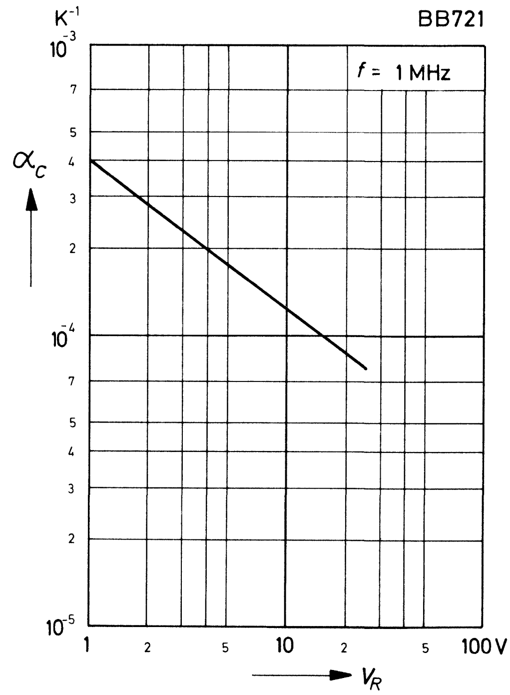
Characteristics at T_j = 25 °C

	Symbol	Min.	Typ.	Max.	Unit
Capacitance at V_R = 28 V at V_R = 25 V at V_R = 2 V	 C_{tot} C_{tot} C_{tot}	 2 2.1 14.01	 – – –	 2.29 2.39 16.33	 pF pF pF
Effective Capacitance Ratio at V_R = 1 to 28 V at V_R = 2 to 25 V	 $\frac{C_{tot}(1\,V)}{C_{tot}(28\,V)}$ $\frac{C_{tot}(2\,V)}{C_{tot}(25\,V)}$	 8 5.86	 – –	 – 7.78	 – –
Series Resistance at f = 470 MHz, C_{tot} = 14 pF	r_s	–	–	0.5	Ω
Series Inductance	L_s	–	2.5	–	nH
Leakage Current at V_R = 30 V	I_R	–	–	10	nA
Reverse Breakdown Voltage at I_R = 100 µA	$V_{(BR)R}$	32	–	–	V
For any two of six consecutive diodes in the carrier tape the maximum capacitance deviation in the reverse bias voltage range of V_R = 0.5 V to V_R = 28 V is 2.5 %.					

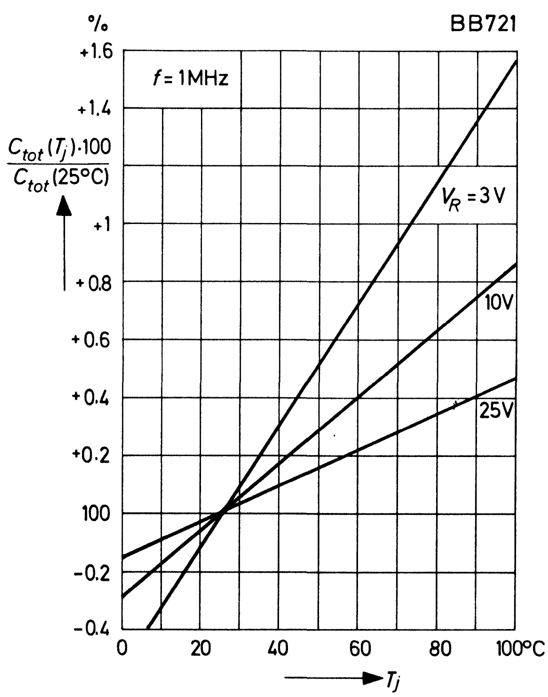
Capacitance versus reverse voltage



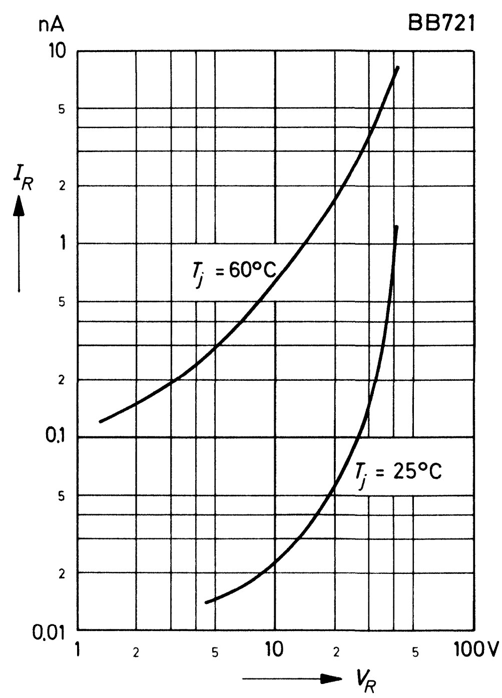
Temperature coefficient of capacitance versus reverse voltage

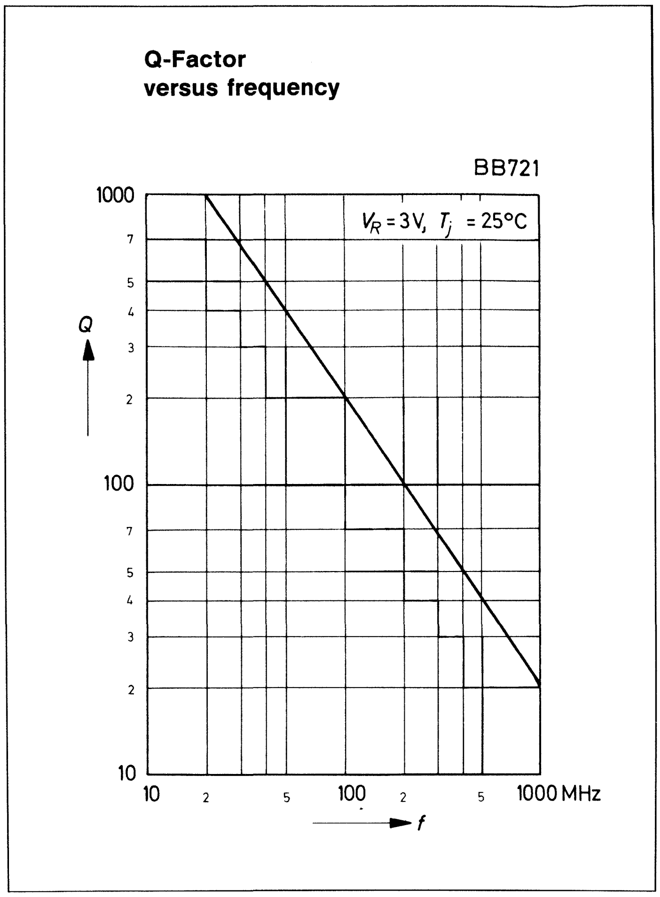


Relative capacitance versus junction temperature



Leakage current versus reverse voltage




Q-Factor
versus frequency
BB721
V_R = 3 V, T_j = 25°C
1000
7
5
4
3
2
100
7
5
4
3
2
10
Q
10
2
5
100
2
5
1000 MHz
f

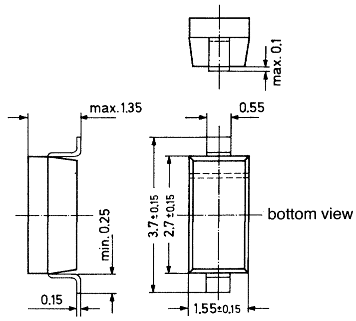
BB723

Tuner Diode
Silicon Epitaxial Planar Capacitance Diode with very wide effective capacitance variation for tuning the VHF range 170 to 303 MHz and the hyperband range 303 to 463 MHz without switching.

These diodes are available as singles or as matched sets of two or more units according to the tracking condition described below.

These diodes are delivered taped.
Details see "Taping".

The diodes BB 723 are also available with straight leads. Overall length 14 mm (only bulk packaging).



Plastic Package ≈ 60 A2
according to DIN IEC 47(CO)718

Weight approx. 0.013 g
Dimension in mm

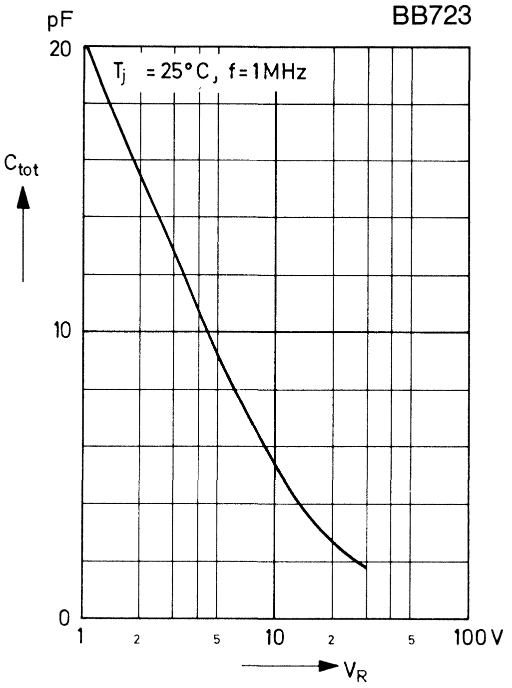
Absolute Maximum Ratings

	Symbol	Value	Unit
Reverse Voltage	V_R	32	V
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_S	−55 to +125	°C

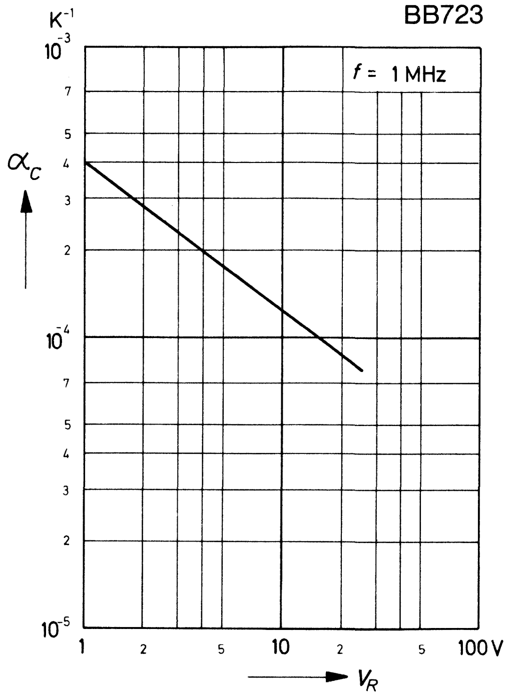
Characteristics at T_j = 25 °C

	Symbol	Min.	Typ.	Max.	Unit
Capacitance at V_R = 28 V at V_R = 25 V at V_R = 1 V	 C_{tot} C_{tot} C_{tot}	 3.15 – –	 – 3.5 50	 3.55 – –	 pF pF pF
Effective Capacitance Ratio at V_R = 1 to 28 V	$\frac{C_{tot}\ (1\ V)}{C_{tot}\ (28\ V)}$	19.5	–	25	–
at V_R = 3 to 25 V	$\frac{C_{tot}\ (3\ V)}{C_{tot}\ (25\ V)}$	–	14	–	–
Series Resistance at f = 300 MHz, C_{tot} = 25 pF	r_s	–	0.9	1.0	Ω
Series Inductance	L_s	–	2.5	–	nH
Leakage Current at V_R = 30 V	I_R	–	–	30	nA
Reverse Breakdown Voltage at I_R = 100 µA	$V_{(BR)R}$	32	–	–	V
For any two of six consecutive diodes in the carrier tape the maximum capacitance deviation in the reverse bias voltage range of V_R = 0.5 V to V_R = 28 V is 2.5 %.					

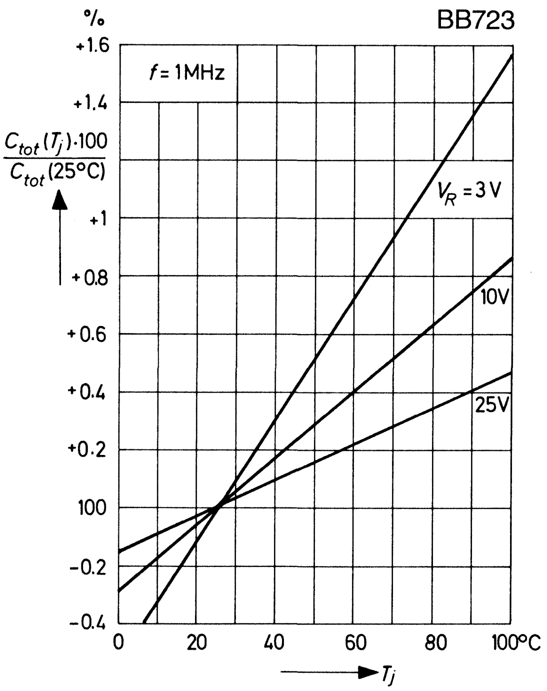
Capacitance versus reverse voltage



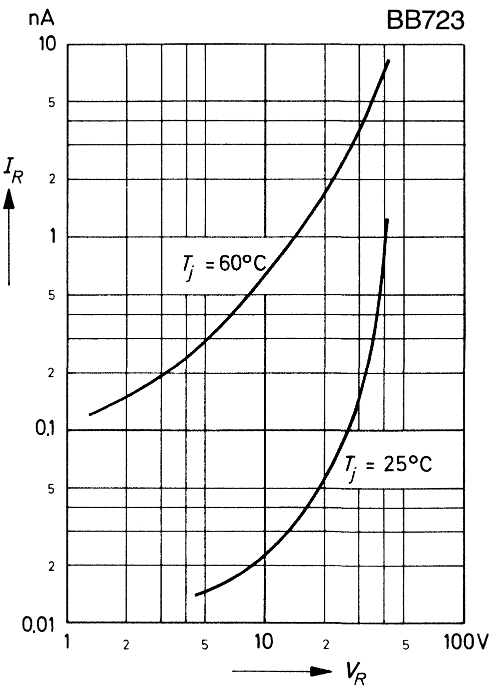
Temperature coefficient of capacitance versus reverse voltage



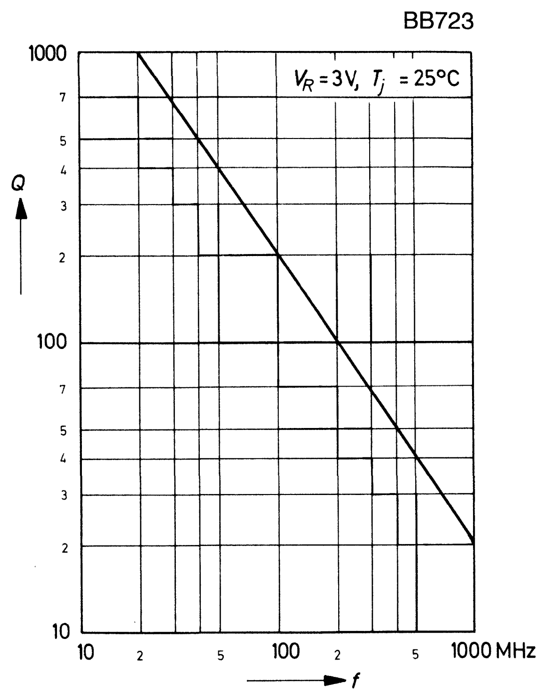
Relative capacitance versus junction temperature



Leakage current versus reverse voltage



Q-Factor versus frequency

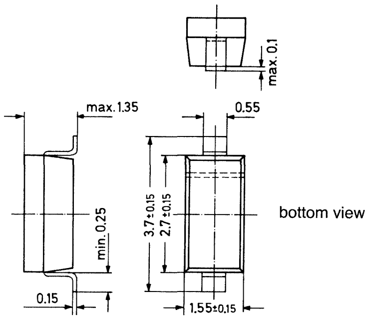


Tuner Diode
Silicon Epitaxial Planar Capacitance Diode with very wide effective capacitance variation for tuning the whole range of VHF CTV tuners.

These diodes are available as singles or as matched sets of two or more units according to the tracking condition described below.

These diodes are delivered taped.
Details see "Taping".

These diodes are also available with straight leads. Overall length 14 mm (only bulk packaging).



Plastic Package ≈ 60 A2
according to DIN IEC 47(CO)718

Weight approx. 0.013 g
Dimension in mm

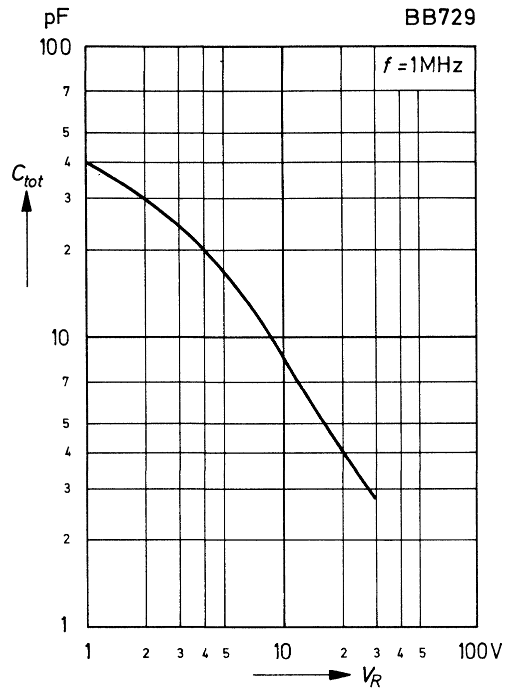
Absolute Maximum Ratings

	Symbol	Value	Unit
Reverse Voltage	V_R	32	V
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_S	−55 to +125	°C

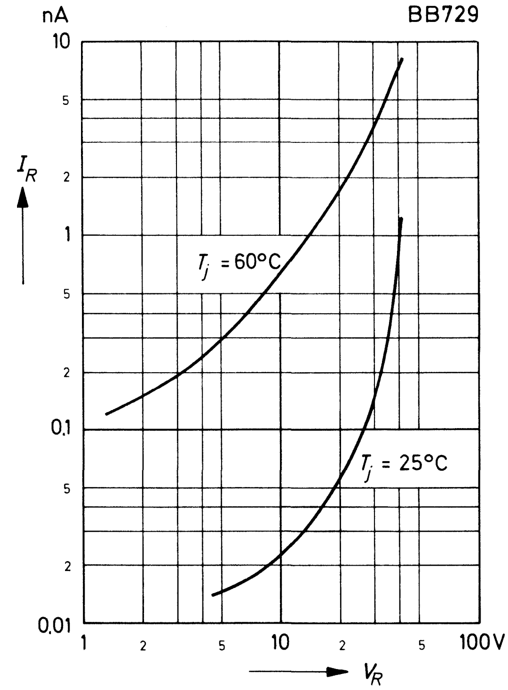
Characteristics at $T_j = 25$ °C

	Symbol	Min.	Typ.	Max.	Unit
Capacitance at $V_R = 28$ V at $V_R = 25$ V at $V_R = 2$ V	 C_{tot} C_{tot} C_{tot}	 2.38 2.68 26.9	 – – –	 2.93 3.12 33.1	 pF pF pF
Effective Capacitance Ratio at $V_R = 1$ to 28 V	$\frac{C_{tot}\ (1\ V)}{C_{tot}\ (28\ V)}$	12	–	–	–
at $V_R = 2$ to 25 V	$\frac{C_{tot}\ (2\ V)}{C_{tot}\ (25\ V)}$	10	–	11	–
Series Resistance at f = 470 MHz, $C_{tot} = 25$ pF	r_s	–	–	0.8	Ω
Series Inductance	L_s	–	2.5	–	nH
Leakage Current at $V_R = 30$ V	I_R	–	–	10	nA
Reverse Breakdown Voltage at $I_R = 100$ µA	$V_{(BR)R}$	32	–	–	V
For any two of six consecutive diodes in the carrier tape the maximum capacitance deviation in the reverse bias voltage range of $V_R = 0.5$ V to $V_R = 28$ V is 2.5 %.					

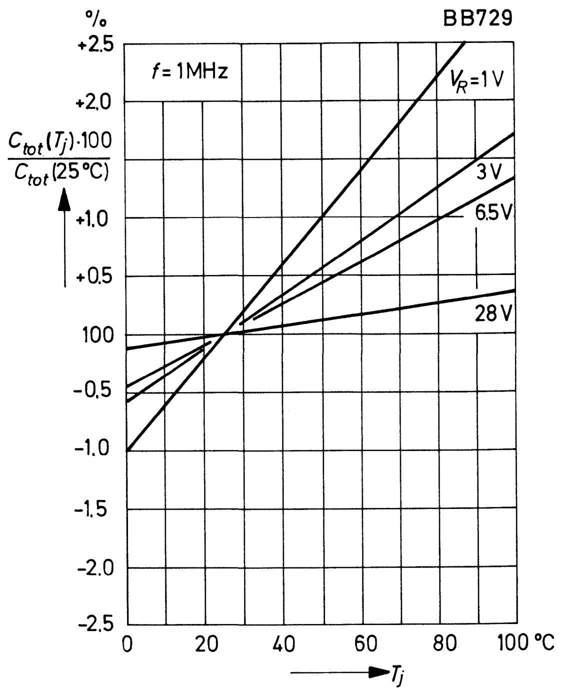
Capacitance versus reverse voltage



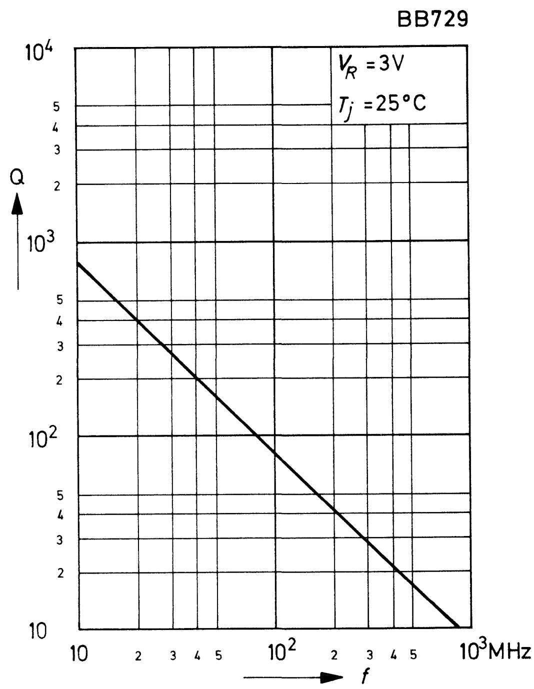
Leakage current versus reverse voltage



Relative capacitance versus junction temperature



Q-Factor versus frequency



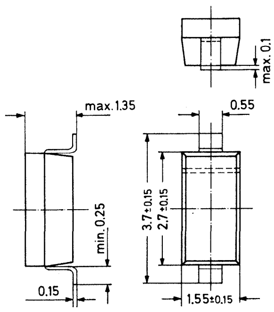
BB730

Tuner Diode
Silicon Epitaxial Planar Capacitance Diode with very wide effective capacitance variation for tuning the whole range of VHF or UHF television bands.

These diodes are available as singles or as matched sets of two or more units according to the tracking condition described below.

These diodes are delivered taped.
Details see "Taping".

These diodes are also available with straight leads. Overall length 14 mm (only bulk packaging).



BB730
Plastic Package ≈ 60 A2
according to DIN IEC 47(CO)718

Weight approx. 0.013 g
Dimensions in mm

Absolute Maximum Ratings

	Symbol	Value	Unit
Reverse Voltage	V_R	30	V
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_S	−55 to +125	°C

Characteristics at T_j = 25 °C

	Symbol	Min.	Typ.	Max.	Unit
Capacitance at V_R = 1 V at V_R = 28 V	 C_{tot} C_{tot}	 – 2.7	 42 –	 – 2.9	 pF pF
Effective Capacitance Ratio at V_R = 1 to 28 V	$\frac{C_{tot}\ (1\ V)}{C_{tot}\ (28\ V)}$	14.8	–	16.8	–
Series Resistance at f = 330 MHz, C_{tot} = 25 pF	r_s	–	–	0.9	Ω
Series Inductance	L_s	–	2.5	–	nH
Leakage Current at V_R = 28 V	I_R	–	–	10	nA
Reverse Breakdown Voltage at I_R = 100 µA	$V_{(BR)R}$	30	–	–	V
For any two of six consecutive diodes in the carrier tape the maximum capacitance deviation in the reverse bias voltage range of V_R = 0.5 V to V_R = 28 V is 2.5 %.					

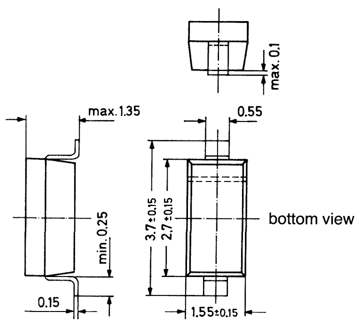
BB731

Tuner Diode
Silicon Epitaxial Planar Capacitance Diodes with very wide effective capacitance variation for tuning the VHF range 41 to 170 MHz in hyperband television tuners.

These diodes are available as singles or as matched sets of two or more units according to the tracking condition described below.

These diodes are delivered taped.
Details see "Taping".

The diodes BB 731 are also available with straight leads. Overall length 14 mm (only bulk packaging).



Plastic Package ≈ 60 A2
according to DIN IEC 47(CO)718

Weight approx. 0.013 g
Dimension in mm

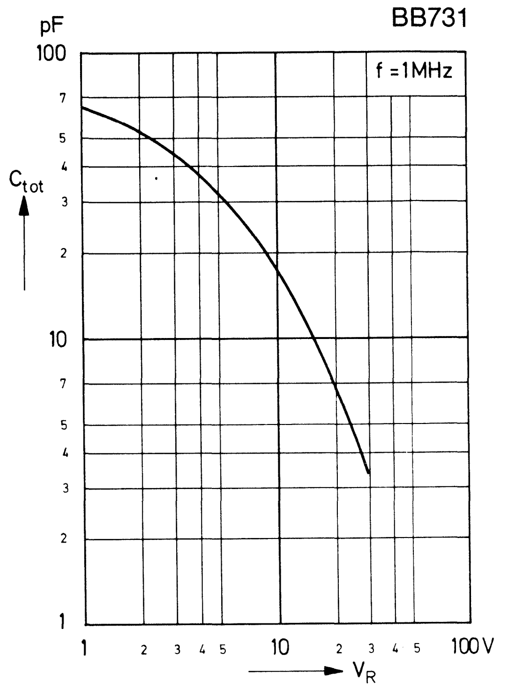
Absolute Maximum Ratings

	Symbol	Value	Unit
Reverse Voltage	V_R	32	V
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_S	−55 to +150	°C

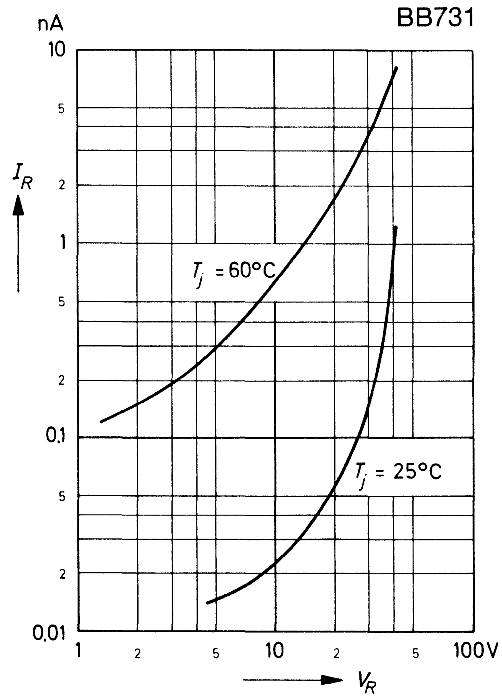
Characteristics at T_j = 25 °C

	Symbol	Min.	Typ.	Max.	Unit
Capacitance at V_R = 28 V at V_R = 25 V at V_R = 1 V	 C_{tot} C_{tot} C_{tot}	 3.15 – –	 – 3.5 50	 3.55 – –	 pF pF pF
Effective Capacitance Ratio at V_R = 1 to 28 V	$\frac{C_{tot}(1\,V)}{C_{tot}(28\,V)}$	19.5	–	25	–
at V_R = 3 to 25 V	$\frac{C_{tot}(3\,V)}{C_{tot}(25\,V)}$	–	14	–	–
Series Resistance at f = 300 MHz, C_{tot} = 25 pF	r_s	–	0.9	1.0	Ω
Series Inductance	L_s	–	2.5	–	nH
Leakage Current at V_R = 30 V	I_R	–	–	30	nA
Reverse Breakdown Voltage at I_R = 100 µA	$V_{(BR)R}$	32	–	–	V
For any two of six consecutive diodes in the carrier tape the maximum capacitance deviation in the reverse bias voltage range of V_R = 0.5 V to V_R = 28 V is 2.5 %.					

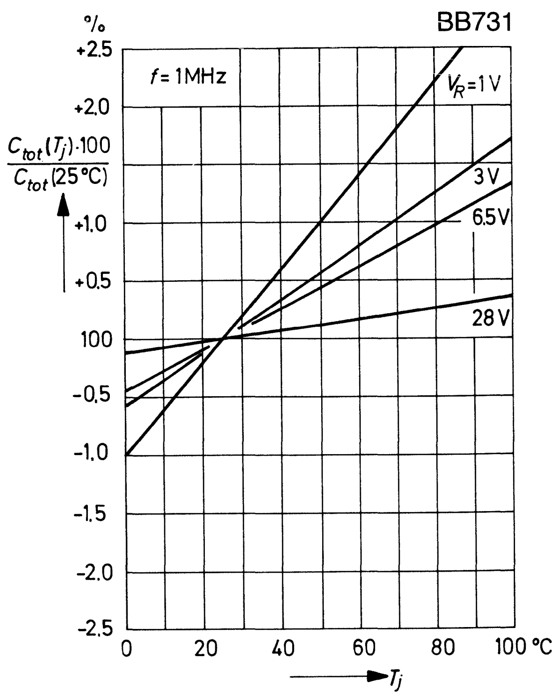
Capacitance versus reverse voltage



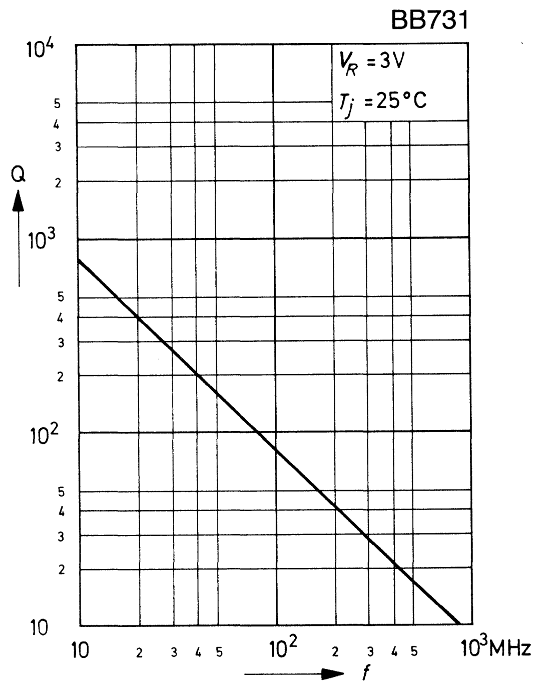
Leakage current versus reverse voltage



Relative capacitance versus junction temperature



Q-Factor versus frequency

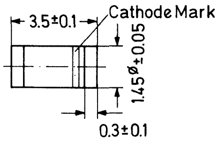


Diode Switches

BA682, BA683

Silicon Epitaxial Planar Diode Switches
In MiniMELF case (MELF = **M**etal **EL**ectrodes **Face**-bonding) especially suited for automatic insertion for electronic band-switching in radio and TV tuners in the frequency range of 50 ... 1000 MHz. The dynamic forward restistance is constant and very small over a wide range of frequency and forward current. The reverse capacitance is also small and largely independent of the reverse voltage.

These diodes are delivered taped.
Details see "Taping".



Glass case MiniMELF

Weight approx. 0.05 g
Dimensions in mm

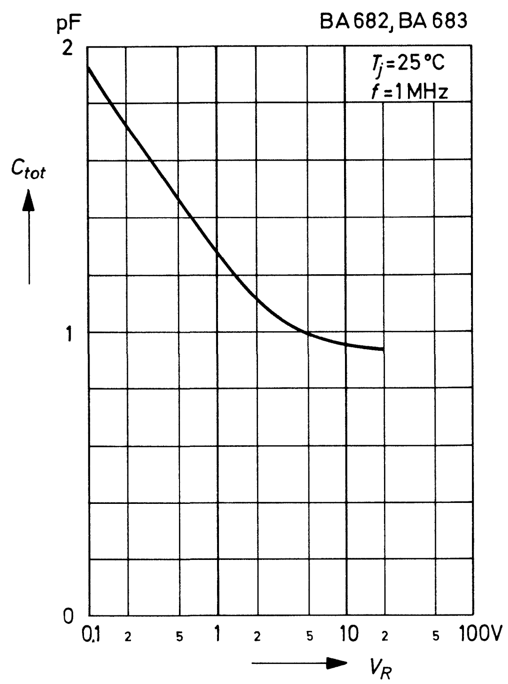
Absolute Maximum Ratings

	Symbol	Value	Unit
Reverse Voltage	V_R	35	V
Forward Current at T_{amb} = 25 °C	I_F	100	mA
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_S	– 55 to +150	°C

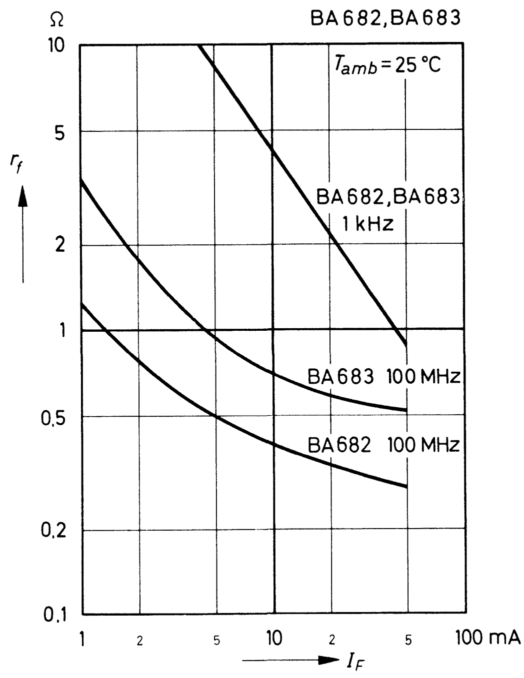
Characteristics at T_{amb} = 25 °C

		Symbol	Min.	Typ.	Max.	Unit
Forward Voltage at I_F = 100 mA		V_F	–	–	1	V
Leakage Current at V_R = 20 V		I_R	–	–	50	nA
Dynamic Forward Resistance at f = 50 to 1000 MHz, I_F = 3 mA	**BA682**	r_f	–	–	0.7	Ω
	BA683	r_f	–	–	1.2	Ω
at f = 50 to 1000 MHz, I_F = 10 mA	**BA682**	r_f	–	–	0.5	Ω
	BA683	r_f	–	–	0.9	Ω
Capacitance at V_R = 1 V, f = 1 MHz		C_{tot}	–	–	1.5	pF
at V_R = 3 V, f = 1 MHz	**BA682**	C_{tot}	–	–	1.25	pF
	BA683	C_{tot}	–	–	1.2	pF
Series Inductance		L_s	–	2	–	nH

Capacitance versus reverse voltage



Dynamic forward resistance versus forward current

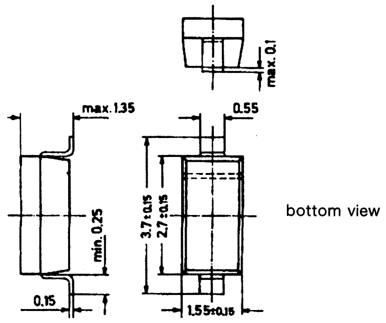


BA782, BA783

Silicon Epitaxial Planar Diode Switches
for electronic bandswitching in radio and TV tuners in the frequency range of 50 ... 1000 MHz. The dynamic forward resistance is constant and very small over a wide range of frequency and forward current. The reverse capacitance is also small and largely independent of the reverse voltage.

The diodes are delivered taped.

These diodes are also available with straight leads. Overall length 14 mm (only bulk packaging).



Plastic package ≈ 60 A2
according to DIN IEC 47(CO)718

Weight approximately 0.013 g
Dimensions in mm

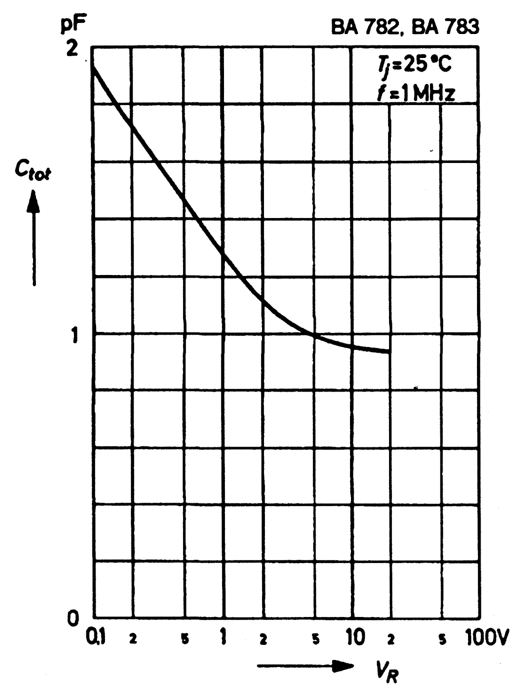
Absolute Maximum Ratings

	Symbol	Value	Unit
Reverse Voltage	V_R	35	V
Forward Current at T_{amb} = 25 °C	I_F	100	mA
Junction Temperature	T_j	125	°C
Storage Temperature Range	T_S	−55 to +125	°C

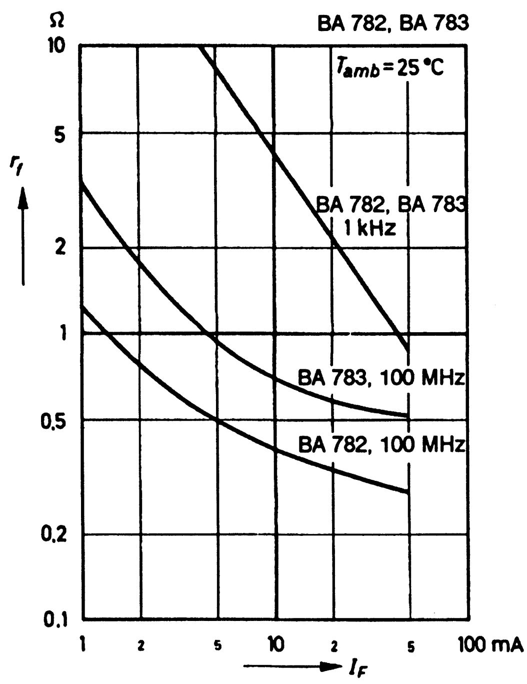
Characteristics at T_{amb} = 25 °C

		Symbol	Min.	Typ.	Max.	Unit
Forward Voltage at $I_F = 100$ mA		V_F	–	–	1	V
Leakage Current at $V_R = 20$ V		I_R	–	–	50	nA
Dynamic Forward Resistance at f = 50 to 1000 MHz, $I_F = 3$ mA	**BA782**	r_f	–	–	0.7	Ω
	BA783	r_f	–	–	1.2	Ω
at f = 50 to 1000 MHz, $I_F = 10$ mA	**BA782**	r_f	–	–	0.5	Ω
	BA783	r_f	–	–	0.9	Ω
Capacitance at $V_R = 1$ V, f = 1 MHz		C_{tot}	–	–	1.5	pF
at $V_R = 3$ V, f = 1 MHz	**BA782**	C_{tot}	–	–	1.25	pF
	BA783	C_{tot}	–	–	1.2	pF
Series Inductance across Case		L_S	–	2.5	–	nH

Capacitance versus reverse voltage



Dynamic forward resistance versus forward current



Schottky Diodes

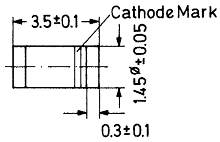
LL101A . . . LL101C

Silicon Schottky Barrier Diodes
for general purpose applications

The LL101 Series is a metal on silicon Schottky barrier device which is protected by a PN junction guard ring. The low forward voltage drop and fast switching make it ideal for protection of MOS devices, steering, biasing and coupling diodes for fast switching and low logic level applications.

This diode is also available in DO-35 case with the type designation SD101A, B, C.

These diodes are delivered taped.
Details see "Taping".



Glass case MiniMELF

Weight approx. 0.05 g
Dimensions in mm

Absolute Maximum Ratings

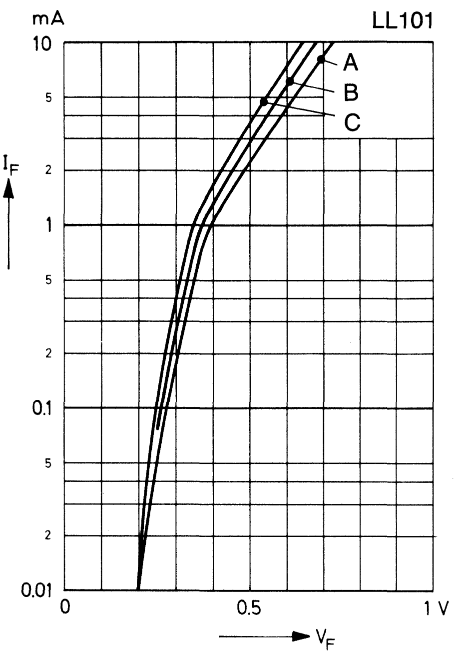
		Symbol	Value	Unit
Peak Inverse Voltage	**LL101A**	V_{RRM}	60	V
	LL101B	V_{RRM}	50	V
	LL101C	V_{RRM}	40	V
Power Dissipation (Infinite Heatsink)		P_{tot}	400[1]	mW
Max. Single Cycle Surge 10 µs Squarewave		I_{FSM}	2	A
Junction Temperature		T_j	175	°C
Storage Temperature Range		T_S	–55 to +175	°C

[1] Valid provided that electrodes are kept at ambient temperature.

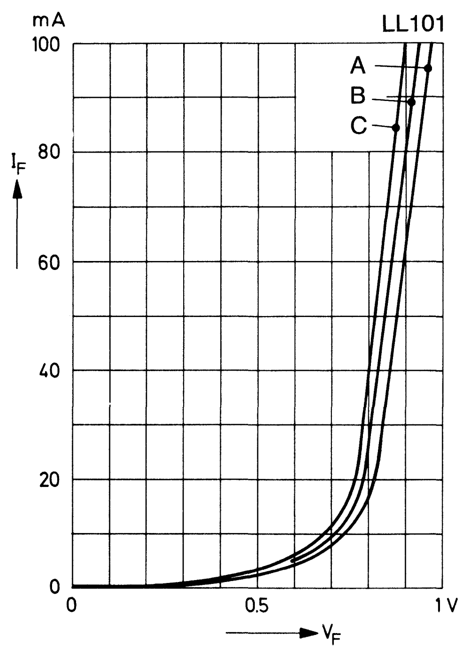
Characteristics at $T_j = 25\ °C$

		Symbol	Min.	Typ.	Max.	Unit
Reverse Breakdown Voltage						
at $I_R = 10\ \mu A$	**LL101A**	$V_{(BR)R}$	60	–	–	V
	LL101B	$V_{(BR)R}$	50	–	–	V
	LL101C	$V_{(BR)R}$	40	–	–	V
Leakage Current						
at $V_R = 50$ V	**LL101A**	I_R	–	–	200	nA
at $V_R = 40$ V	**LL101B**	I_R	–	–	200	nA
at $V_R = 30$ V	**LL101C**	I_R	–	–	200	nA
Forward Voltage Drop						
at $I_F = 1$ mA	**LL101A**	V_F	–	–	0.41	V
	LL101B	V_F	–	–	0.4	V
	LL101C	V_F	–	–	0.39	V
at $I_F = 15$ mA	**LL101A**	V_F	–	–	1	V
	LL101B	V_F	–	–	0.95	V
	LL101C	V_F	–	–	0.9	V
Junction Capacitance						
at $V_R = 0$ V, f = 1 MHz	**LL101A**	C_{tot}	–	–	2.0	pF
	LL101B	C_{tot}	–	–	2.1	pF
	LL101C	C_{tot}	–	–	2.2	pF
Reverse Recovery Time at $I_F = I_R = 5$ mA, recover to 0.1 I_R		t_{rr}	–	–	1	ns

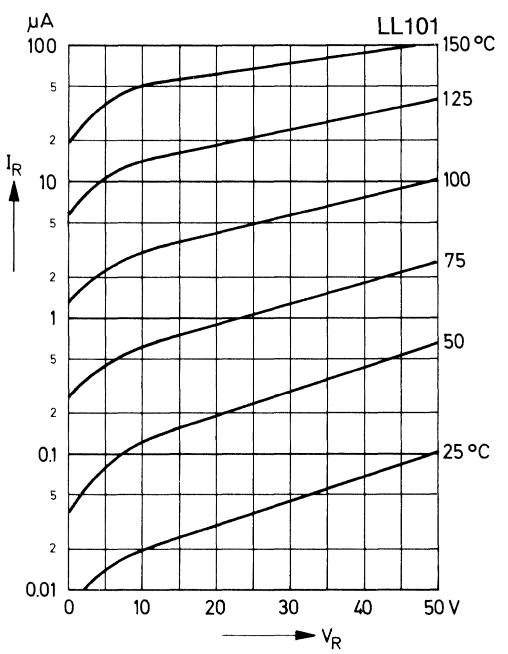
Typical variation of fwd. current vs. fwd. voltage for primary conduction through the Schottky barrier



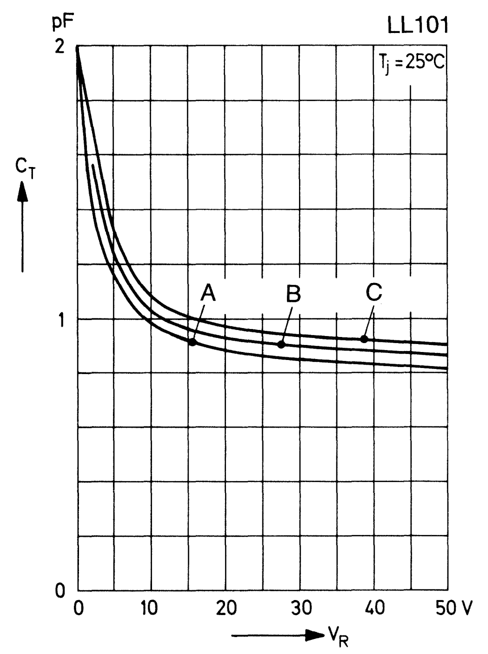
Typical forward conduction curve of combination Schottky barrier and PN junction guard ring



Typical variation of reverse current at various temperatures



Typical capacitance curve as a function of reverse voltage



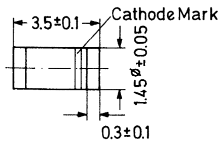
LL103A . . . LL103C

Silicon Schottky Barrier Diodes
for general purpose applications

The LL103A, B, C is a metal on silicon Schottky barrier device which is protected by a PN junction guard ring. The low forward voltage drop and fast switching make it ideal for protection of MOS devices, steering, biasing and coupling diodes for fast switching and low logic level applications. Other uses are for click suppression, efficient full wave bridges in telephone sub-sets, and as blocking diodes in rechargeable low voltage battery systems.

This diode is also available in DO-35 case with the type designation SD103A, B, C.

These diodes are delivered taped.
Details see "Taping".



Glass case MiniMELF

Weight approx. 0.05 g
Dimensions in mm

Absolute Maximum Ratings

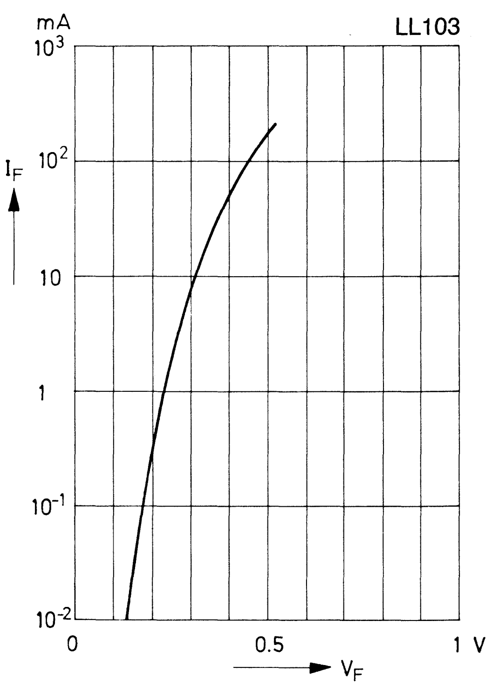
		Symbol	Value	Unit
Peak Inverse Voltage	**LL103A** **LL103B** **LL103C**	V_{RRM} V_{RRM} V_{RRM}	40 30 20	V V V
Power Dissipation (Infinite Heatsink) T_c = ⅜″ from dody derates at 4 mW/°C to 0 at 125 °C		P_{tot}	400[1)]	mW
Junction Temperature		T_j	125	°C
Storage Temperature Range		T_S	−55 to +125	°C
Single Cycle Surge 60 Hz sine wave		I_{FSM}	15	A

1) Valid provided that electrodes are kept at ambient temperature.

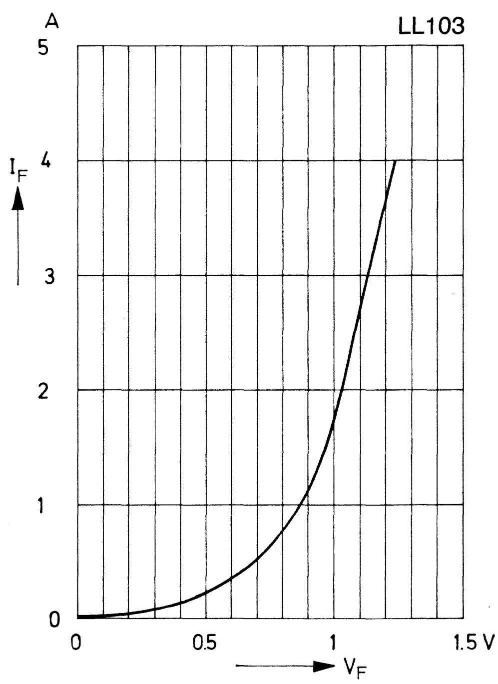
Characteristics at $T_j = 25\ °C$

	Symbol	Min.	Typ.	Max.	Unit
Leakage Current					
at $V_R = 30\ V$ **LL103A**	I_R	–	–	5	μA
at $V_R = 20\ V$ **LL103B**	I_R	–	–	5	μA
at $V_R = 10\ V$ **LL103C**	I_R	–	–	5	μA
Forward Voltage Drop					
at $I_F = 20\ mA$	V_F	–	–	0.37	V
at $I_F = 200\ mA$	V_F	–	–	0.6	V
Junction Capacitance at $V_R = 0\ V$, f = 1 MHz	C_{tot}	–	50	–	pF
Reverse Recovery Time at $I_F = I_R = 50\ mA$ to 200 mA, recover to 0.1 I_R	t_{rr}	–	10	–	ns

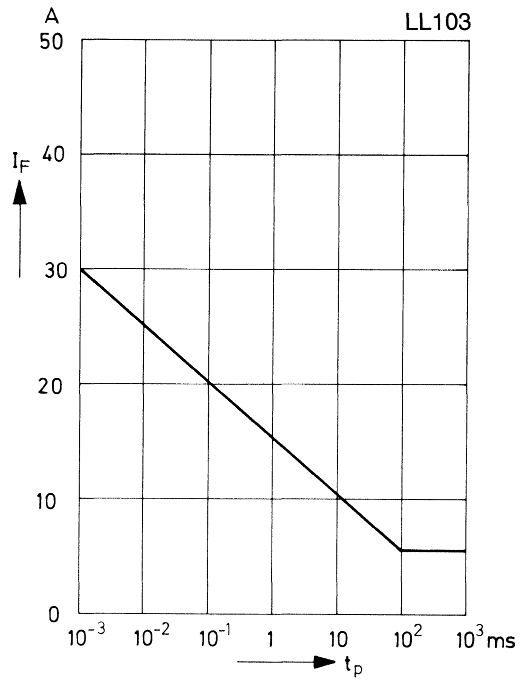
Typical variation of fwd. current vs. fwd. voltage for primary conduction through the Schottky barrier



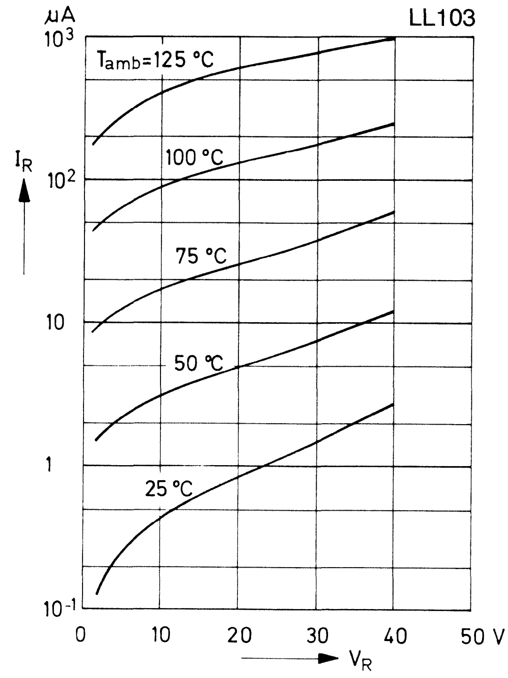
Typical high current forward conduction curve
$t_p = 300\ \mu s$, duty cycle = 2%



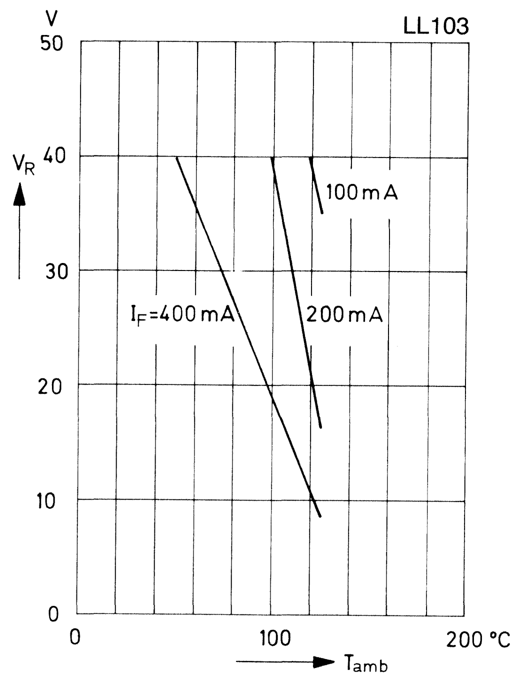
Typical non repetitive forward surge current versus pulse width
Rectangular pulse



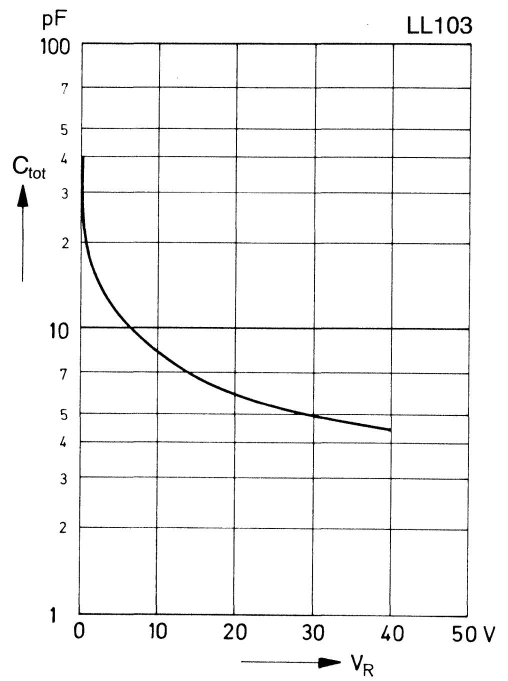
Typical variation of reverse current at various temperatures



Blocking voltage deration versus temperature at various average forward currents



Typical capacitance versus reverse voltage

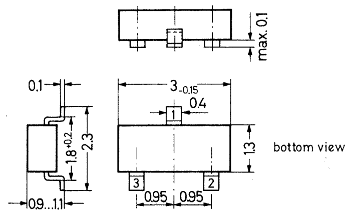


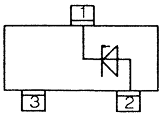
Zener Diodes

BZX84 . . .

Silicon Planar Zener Diodes
The Zener voltages are graded according to the international E 24 standard.

These diodes are delivered taped.





bottom view

Plastic Package JEDEC TO–236
23 A 3 according to DIN 41869

Weight approx. 0.01 g
Dimensions in mm

Absolute Maximum Ratings

	Symbol	Value	Unit
Zener Current	I_{ZM}	250	mA
Power Dissipation at T_{amb} = 25 °C	P_{tot}	350[1)]	mW
Junction Temperature	T_j	175	°C
Storage Temperature Range	T_S	−65 to +175	°C

[1)] Diode on Ceramic Substrate 10 mm × 8 mm × 0.7 mm.

Characteristics at T_{amb} = 25 °C

	Symbol	Min.	Typ.	Max.	Unit
Thermal Resistance Junction to Ambient Air	R_{thA}	–	–	420[1)]	K/W
Forward Voltage at I_F = 10 mA	–	–	–	0.9	V

[1)] Diode on Ceramic Substrate 10 mm × 8 mm × 0.7 mm.

Type	Marking	Zener Voltage [1] at I_{ZT} V_Z V	Dynamic resistance at I_{ZT} r_{zj} Ω	Temp. coefficient of Zener Voltage at I_{ZT} α_{VZ} 10^{-4}/K	Test current I_{ZT} mA	Reverse leakage current I_R µA	at V_R V
BZX84–C2V7	Z12	2.5 . . . 2.9	75 (≤100)	−9 . . . −4	5	20	1
BZX84–C3	Z13	2.8 . . . 3.2	80 (≤95)	−9 . . . −3	5	10	1
BZX84–C3V3	Z14	3.1 . . . 3.5	85 (≤95)	−8 . . . −3	5	5	1
BZX84–C3V6	Z15	3.4 . . . 3.8	85 (≤90)	−8 . . . −3	5	5	1
BZX84–C3V9	Z16	3.7 . . . 4.1	85 (≤90)	−7 . . . −3	5	3	1
BZX84–C4V3	Z17	4.0 . . . 4.6	80 (≤90)	−6 . . . −1	5	3	1
BZX84–C4V7	Z1	4.4 . . . 5.0	50 (≤80)	−5 . . . +2	5	3	2
BZX84–C5V1	Z2	4.8 . . . 5.4	40 (≤60)	−3 . . . +4	5	2	2
BZX84–C5V6	Z3	5.2 . . . 6.0	15 (≤40)	−2 . . . +6	5	1	2
BZX84–C6V2	Z4	5.8 . . . 6.6	6 (≤10)	−1 . . . +7	5	3	4
BZX84–C6V8	Z5	6.4 . . . 7.2	6 (≤15)	+2 . . . +7	5	2	4
BZX84–C7V5	Z6	7.0 . . . 7.9	6 (≤15)	+3 . . . +7	5	1	5
BZX84–C8V2	Z7	7.7 . . . 8.7	6 (≤15)	+4 . . . +7	5	0.7	5
BZX84–C9V1	Z8	8.5 . . . 9.6	6 (≤15)	+5 . . . +8	5	0.5	6
BZX84–C10	Z9	9.4 . . . 10.6	8 (≤20)	+5 . . . +8	5	0.2	7
BZX84–C11	Y1	10.4 . . . 11.6	10 (≤20)	+5 . . . +9	5	0.1	8
BZX84–C12	Y2	11.4 . . . 12.7	10 (≤25)	+6 . . . +9	5	0.1	8
BZX84–C13	Y3	12.4 . . . 14.1	10 (≤30)	+7 . . . +9	5	0.1	8
BZX84–C15	Y4	13.8 . . . 15.6	10 (≤30)	+7 . . . +9	5	0.05	0.7 $V_{Z\,nom.}$
BZX84–C16	Y5	15.3 . . . 17.1	10 (≤40)	+8 . . . +9.5	5	0.05	0.7 $V_{Z\,nom.}$
BZX84–C18	Y6	16.8 . . . 19.1	10 (≤45)	+8 . . . +9.5	5	0.05	0.7 $V_{Z\,nom.}$
BZX84–C20	Y7	18.8 . . . 21.2	15 (≤55)	+8 . . . +10	5	0.05	0.7 $V_{Z\,nom.}$
BZX84–C22	Y8	20.8 . . . 23.3	20 (≤55)	+8 . . . +10	5	0.05	0.7 $V_{Z\,nom.}$
BZX84–C24	Y9	22.8 . . . 25.6	25 (≤70)	+8 . . . +10	5	0.05	0.7 $V_{Z\,nom.}$
BZX84–C27	Y10	25.1 . . . 28.9	25 (≤80)	+8 . . . +10	2	0.05	0.7 $V_{Z\,nom.}$
BZX84–C30	Y11	28 . . . 32	30 (≤80)	+8 . . . +10	2	0.05	0.7 $V_{Z\,nom.}$
BZX84–C33	Y12	31 . . . 35	35 (≤80)	+8 . . . +10	2	0.05	0.7 $V_{Z\,nom.}$
BZX84–C36	Y13	34 . . . 38	35 (≤90)	+8 . . . +10	2	0.05	0.7 $V_{Z\,nom.}$
BZX84–C39	Y14	37 . . . 41	40 (≤130)	+10 . . . +12	2	0.05	0.7 $V_{Z\,nom.}$
BZX84–C43	Y15	40 . . . 46	45 (≤150)	+10 . . . +12	2	0.05	0.7 $V_{Z\,nom.}$
BZX84–C47	Y16	44 . . . 50	50 (≤170)	+10 . . . +12	2	0.05	0.7 $V_{Z\,nom.}$
BZX84–C51	Y17	48 . . . 54	60 (≤180)	+10 . . . +12	2	0.05	0.7 $V_{Z\,nom.}$

[1] Measured with pulses tp = 20 ms.

Type	Zener Voltage[1] at I_{ZT} V_Z V	Dynamic resistance at I_{ZT} r_{zj} Ω	Test current I_{ZT} mA	Zener Voltage[1] at I_{ZT} V_Z V	Dynamic resistance at I_{ZT} r_{zj} Ω	Test current I_{ZT} mA
BZX84–C2V7	3.3 (3.0 . . . 3.6)	25 (≤ 50)	20	2.2 (1.9 . . . 2.4)	300 (≤ 600)	1
BZX84–C3	3.6 (3.3 . . . 3.9)	25 (≤ 50)	20	2.4 (2.1 . . . 2.7)	325 (≤ 600)	1
BZX84–C3V3	3.9 (3.6 . . . 4.2)	20 (≤ 40)	20	2.6 (2.3 . . . 2.9)	350 (≤ 600)	1
BZX84–C3V6	4.2 (3.9 . . . 4.5)	20 (≤ 40)	20	3.0 (2.7 . . . 3.3)	375 (≤ 600)	1
BZX84–C3V9	4.4 (4.1 . . . 4.7)	15 (≤ 30)	20	3.2 (2.9 . . . 3.5)	400 (≤ 600)	1
BZX84–C4V3	4.7 (4.4 . . . 5.1)	15 (≤ 30)	20	3.6 (3.3 . . . 4.0)	410 (≤ 600)	1
BZX84–C4V7	5.0 (4.5 . . . 5.4)	8 (≤ 15)	20	4.2 (3.7 . . . 4.7)	425 (≤ 500)	1
BZX84–C5V1	5.4 (5.0 . . . 5.9)	6 (≤ 15)	20	4.7 (4.2 . . . 5.3)	400 (≤ 480)	1
BZX84–C5V6	5.7 (5.2 . . . 6.3)	4 (≤ 10)	20	5.4 (4.8 . . . 6.0)	80 (≤ 400)	1
BZX84–C6V2	6.3 (5.8 . . . 6.8)	3 (≤ 6)	20	6.1 (5.6 . . . 6.6)	40 (≤ 150)	1
BZX84–C6V8	6.9 (6.4 . . . 7.4)	2.5 (≤ 6)	20	6.7 (6.3 . . . 7.2)	30 (≤ 80)	1
BZX84–C7V5	7.6 (7.0 . . . 8.0)	2.5 (≤ 6)	20	7.4 (6.9 . . . 7.9)	30 (≤ 80)	1
BZX84–C8V2	8.3 (7.7 . . . 8.8)	3 (≤ 6)	20	8.1 (7.6 . . . 8.7)	40 (≤ 80)	1
BZX84–C9V1	9.2 (8.5 . . . 9.7)	4 (≤ 8)	20	9.0 (8.4 . . . 9.6)	40 (≤ 100)	1
BZX84–C10	10.1 (9.4 . . . 10.7)	4 (≤ 10)	20	9.9 (9.3 . . . 10.6)	50 (≤ 150)	1
BZX84–C11	11.1 (10.4 . . . 11.8)	5 (≤ 10)	20	10.6 (10.2 . . . 11.6)	50 (≤ 150)	1
BZX84–C12	12.1 (11.4 . . . 12.9)	5 (≤ 10)	20	11.9 (11.2 . . . 12.7)	50 (≤ 150)	1
BZX84–C13	13.1 (12.5 . . . 14.2)	5 (≤ 15)	20	12.9 (12.3 . . . 14.0)	50 (≤ 170)	1
BZX84–C15	15.1 (13.9 . . . 15.7)	6 (≤ 20)	20	14.9 (13.7 . . . 15.5)	50 (≤ 200)	1
BZX84–C16	16.1 (15.4 . . . 17.2)	6 (≤ 20)	20	15.9 (15.2 . . . 17.0)	50 (≤ 200)	1
BZX84–C18	18.1 (16.9 . . . 19.2)	6 (≤ 20)	20	17.9 (16.7 . . . 19.0)	50 (≤ 225)	1
BZX84–C20	20.1 (18.9 . . . 21.4)	7 (≤ 20)	20	19.9 (18.7 . . . 21.1)	60 (≤ 225)	1
BZX84–C22	22.1 (20.9 . . . 23.4)	7 (≤ 25)	20	21.9 (20.7 . . . 23.2)	60 (≤ 250)	1
BZX84–C24	24.1 (22.9 . . . 25.7)	7 (≤ 25)	20	23.9 (22.7 . . . 25.5)	60 (≤ 250)	1
BZX84–C27	27.1 (25.2 . . . 29.3)	10 (≤ 45)	10	26.9 (25.0 . . . 28.9)	65 (≤ 300)[2]	0.1
BZX84–C30	30.1 (28.1 . . . 32.4)	15 (≤ 50)	10	29.9 (27.8 . . . 32.0)	70 (≤ 300)[2]	0.1
BZX84–C33	33.1 (31.1 . . . 35.4)	20 (≤ 55)	10	32.9 (30.8 . . . 35.0)	75 (≤ 325)[2]	0.1
BZX84–C36	36.1 (34.1 . . . 38.4)	25 (≤ 60)	10	35.9 (33.8 . . . 38.0)	80 (≤ 350)[2]	0.1
BZX84–C39	39.1 (37.1 . . . 41.5)	25 (≤ 70)	10	38.9 (36.7 . . . 41.0)	80 (≤ 350)[2]	0.1
BZX84–C43	43.1 (40.1 . . . 46.5)	25 (≤ 80)	10	42.9 (39.7 . . . 46.0)	85 (≤ 375)[2]	0.1
BZX84–C47	47.1 (44.1 . . . 50.5)	30 (≤ 90)	10	46.8 (43.7 . . . 50.0)	85 (≤ 375)[2]	0.1
BZX84–C51	51.1 (48.1 . . . 54.6)	35 (≤ 100)	10	50.8 (47.6 . . . 54.0)	85 (≤ 400)[2]	0.1

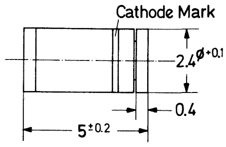
[1] Measured with pulses tp = 20 ms.
[2] Test current 0.5 mA.

ZM4729 . . . ZM4764

Silicon Planar Power Zener Diodes
for use in stabilizing and clipping circuits with high power rating. Standard Zener voltage tolerance is ±10 %. Add suffix "A" for ±5 % tolerance. Other tolerances available upon request.

These diodes are also available in DO-41 case with the type designation 1N4729 ... 1N4764.

These diodes are delivered taped.
Details see "Taping".



Glass case MELF

Weight approx. 0.25 g
Dimensions in mm

Absolute Maximum Ratings

	Symbol	Value	Unit
Zener Current see Table "Characteristics"			
Power Dissipation at T_{amb} = 25 °C	P_{tot}	1[1]	W
Junction Temperature	T_j	175	°C
Storage Temperature Range	T_S	−65 to +175	°C

[1] Valid provided that electrodes are kept at ambient temperature.

Characteristics at T_{amb} = 25 °C

	Symbol	Min.	Typ.	Max.	Unit
Thermal Resistance Junction to Ambient Air	R_{thA}	–	–	170[1]	K/W
Forward Voltage at I_F = 200 mA	V_F	–	–	1.2	V

[1] Valid provided that electrodes are kept at ambient temperature.

Type	Nominal Zener voltage[3] at I_{ZT} V_Z V	Test current I_{ZT} mA	Maximum Zener impedance[1] at I_{ZT} Z_{ZT} Ω	Z_{ZK} Ω	at I_{ZK} mA	Maximum reverse leakage current I_R μA	at V_R V	Surge current at $T_A = 25\ °C$ I_R mA	Maximum regulator current[2] I_{ZM} mA
ZM4729	3.6	69	10	400	1.0	100	1	1260	252
ZM4730	3.9	64	9	400	1.0	100	1	1190	234
ZM4731	4.3	58	9	400	1.0	50	1	1070	217
ZM4732	4.7	53	8	500	1.0	10	1	970	193
ZM4733	5.1	49	7	550	1.0	10	1	890	178
ZM4734	5.6	45	5	600	1.0	10	2	810	162
ZM4735	6.2	41	2	700	1.0	10	3	730	146
ZM4736	6.8	37	3.5	700	1.0	10	4	660	133
ZM4737	7.5	34	4.0	700	0.5	10	5	605	121
ZM4738	8.2	31	4.5	700	0.5	10	6	550	110
ZM4739	9.1	28	5.0	700	0.5	10	7	500	100
ZM4740	10	25	7	700	0.25	10	7.6	454	91
ZM4741	11	23	8	700	0.25	5	8.4	414	83
ZM4742	12	21	9	700	0.25	5	9.1	380	76
ZM4743	13	19	10	700	0.25	5	9.9	344	69
ZM4744	15	17	14	700	0.25	5	11.4	304	61
ZM4745	16	15.5	16	700	0.25	5	12.2	285	57
ZM4746	18	14	20	750	0.25	5	13.7	250	50
ZM4747	20	12.5	22	750	0.25	5	15.2	225	45
ZM4748	22	11.5	23	750	0.25	5	16.7	205	41
ZM4749	24	10.5	25	750	0.25	5	18.2	190	38
ZM4750	27	9.5	35	750	0.25	5	20.6	170	34
ZM4751	30	8.5	40	1000	0.25	5	22.8	150	30
ZM4752	33	7.5	45	1000	0.25	5	25.1	135	27
ZM4753	36	7.0	50	1000	0.25	5	27.4	125	25
ZM4754	39	6.5	60	1000	0.25	5	29.7	115	23
ZM4755	43	6.0	70	1500	0.25	5	32.7	110	22
ZM4756	47	5.5	80	1500	0.25	5	35.8	95	19
ZM4757	51	5.0	95	1500	0.25	5	38.8	90	18
ZM4758	56	4.5	110	2000	0.25	5	42.6	80	16
ZM4759	62	4.0	125	2000	0.25	5	47.1	70	14
ZM4760	68	3.7	150	2000	0.25	5	51.7	65	13
ZM4761	75	3.3	175	2000	0.25	5	56.0	60	12
ZM4762	82	3.0	200	3000	0.25	5	62.2	55	11
ZM4763	91	2.8	250	3000	0.25	5	69.2	50	10
ZM4764	100	2.5	350	3000	0.25	5	76.0	45	9

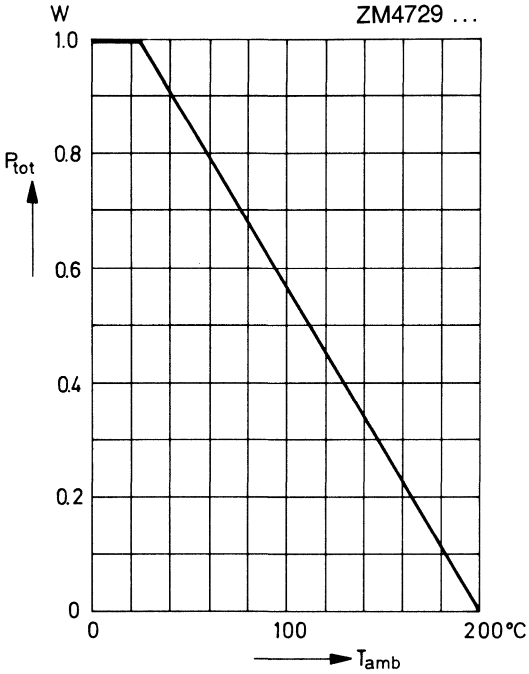
[1] The Zener Impedance is derived from the 60 Hz AC voltage which results when an AC current having an RMS value equal to 10% of the Zener current (I_{ZT} or I_{ZK}) is superimposed on I_{ZT} or I_{ZK}. Zener Impedance is measured at two points to insure a sharp knee on the breakdown curve and to eliminate unstable units.

[2] Valid provided that electrodes are kept at ambient temperature.

[3] Measured under thermal equilibrium and DC test conditions.

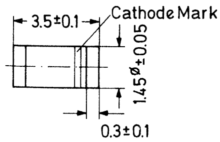
Admissible power dissipation versus ambient temperature

Valid provided that electrodes are kept at ambient temperature



ZMM1 . . . ZMM51

Silicon Planar Zener Diodes
in MiniMELF case especially for automatic insertion. The Zener voltages are graded according to the international E 24 standard. Smaller voltage tolerances and higher Zener voltages on request.



These diodes are also available in DO-35 case with the type designation ZPD1 . . . ZPD51.

These diodes are delivered taped.
Details see "Taping".

Glass case MiniMELF

Weight approx. 0.05 g
Dimensions in mm

Absolute Maximum Ratings

	Symbol	Value	Unit
Zener Current see Table "Characteristics"			
Power Dissipation at T_{amb} = 25 °C	P_{tot}	500[1]	mW
Junction Temperature	T_j	175	°C
Storage Temperature Range	T_S	– 55 to + 175	°C
[1] Valid provided that electrodes are kept at ambient temperature.			

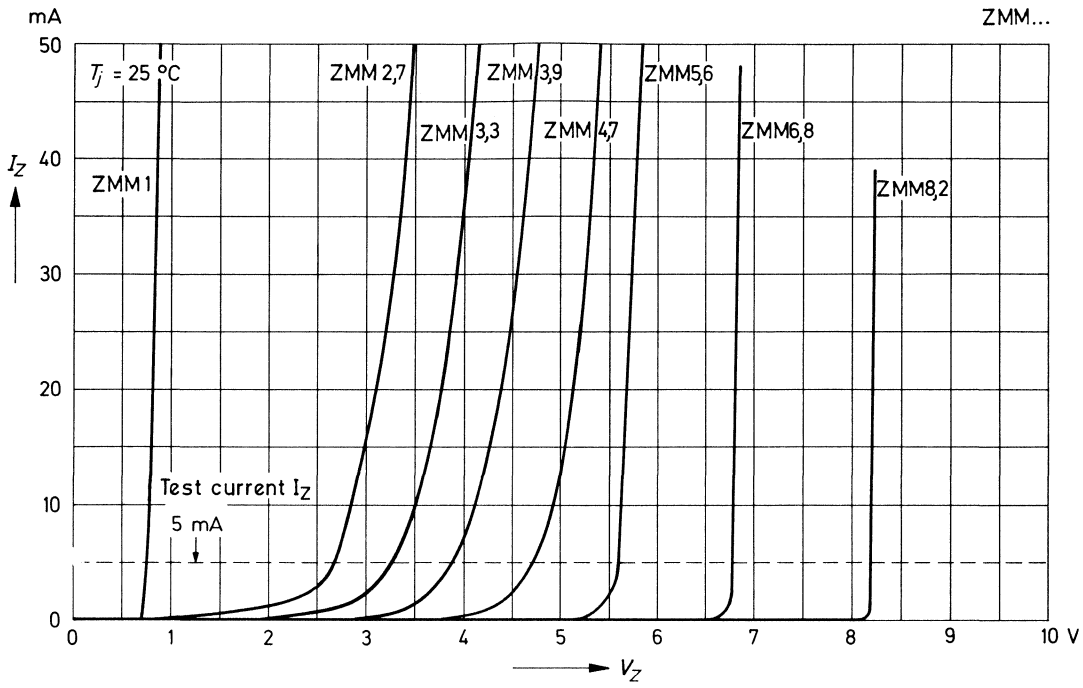
Characteristics at T_{amb} = 25 °C

	Symbol	Min.	Typ.	Max.	Unit
Thermal Resistance Junction to Ambient Air	R_{thA}	–	–	0.3[1]	K/mW
[1] Valid provided that electrodes are kept at ambient temperature.					

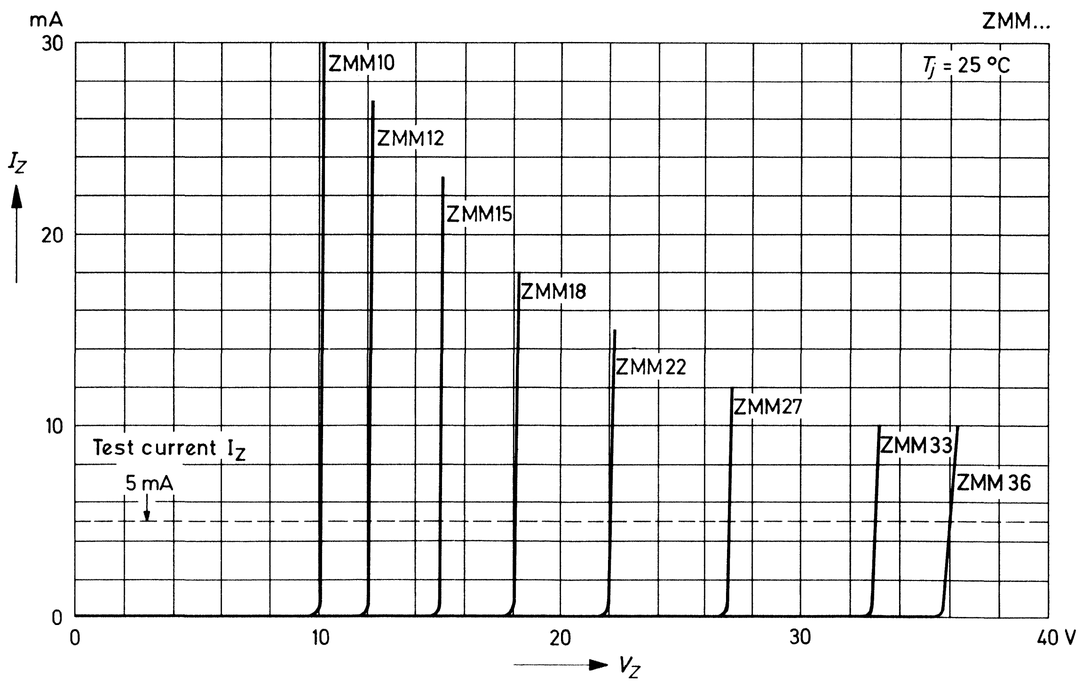
Type	Zener voltage[1] at I_Z = 5 mA V_Z V	Dynamic resistance at I_Z = 5 mA f = 1 kHz r_{zj} Ω	at I_Z = 1 mA f = 1 kHz r_{zj} Ω	Temp. coeff. of Zener volt. at I_Z = 5 mA α_{VZ} 10^{-4}/K	Reverse voltage at I_R = 100 nA V_R V	Admissible Zener current[2] at T_{amb} = 45 °C I_Z mA	at T_{amb} = 25 °C I_Z mA
ZMM1[3]	0.7 ... 0.8	6.5 (<8)	<50	−26 ... −23	–	280	340
ZMM2,7	2.5 ... 2.9	75 (<83)	<500	−9 ... −4	–	135	160
ZMM3	2.8 ... 3.2	80 (<95)	<500	−9 ... −3	–	117	140
ZMM3,3	3.1 ... 3.5	80 (<95)	<500	−8 ... −3	–	109	130
ZMM3,6	3.4 ... 3.8	80 (<95)	<500	−8 ... −3	–	101	120
ZMM3,9	3.7 ... 4.1	80 (<95)	<500	−7 ... −3	–	92	110
ZMM4,3	4.0 ... 4.6	80 (<95)	<500	−6 ... −1	–	85	100
ZMM4,7	4.4 ... 5.0	70 (<78)	<500	−5 ... +2	–	76	90
ZMM5,1	4.8 ... 5.4	30 (<60)	<480	−3 ... +4	>0.8	67	80
ZMM5,6	5.2 ... 6.0	10 (<40)	<400	−2 ... +6	>1	59	70
ZMM6,2	5.8 ... 6.6	4.8 (<10)	<200	−1 ... +7	>2	54	64
ZMM6,8	6.4 ... 7.2	4.5 (<8)	<150	+2 ... +7	>3	49	58
ZMM7,5	7.0 ... 7.9	4 (<7)	<50	+3 ... +7	>5	44	53
ZMM8,2	7.7 ... 8.7	4.5 (<7)	<50	+4 ... +7	>6	40	47
ZMM9,1	8.5 ... 9.6	4.8 (<10)	<50	+5 ... +8	>7	36	43
ZMM10	9.4 ... 10.6	5.2 (<15)	<70	+5 ... +8	>7.5	33	40
ZMM11	10.4 ... 11.6	6 (<20)	<70	+5 ... +9	>8.5	30	36
ZMM12	11.4 ... 12.7	7 (<20)	<90	+6 ... +9	>9	28	32
ZMM13	12.4 ... 14.1	9 (<25)	<110	+7 ... +9	>10	25	29
ZMM15	13.8 ... 15.6	11 (<30)	<110	+7 ... +9	>11	23	27
ZMM16	15.3 ... 17.1	13 (<40)	<170	+8 ... +9.5	>12	20	24
ZMM18	16.8 ... 19.1	18 (<50)	<170	+8 ... +9.5	>14	18	21
ZMM20	18.8 ... 21.2	20 (<50)	<220	+8 ... +10	>15	17	20
ZMM22	20.8 ... 23.3	25 (<55)	<220	+8 ... +10	>17	16	18
ZMM24	22.8 ... 25.6	28 (<80)	<220	+8 ... +10	>18	13	16
ZMM27	25.1 ... 28.9	30 (<80)	<250	+8 ... +10	>20	12	14
ZMM30	28 ... 32	35 (<80)	<250	+8 ... +10	>22.5	10	13
ZMM33	31 ... 35	40 (<80)	<250	+8 ... +10	>25	9	12
ZMM36	34 ... 38	40 (<90)	<250	+8 ... +10	>27	9	11
ZMM39	37 ... 41	50 (<90)	<300	+10 ... +12	>29	8	10
ZMM43	40 ... 46	60 (<100)	<700	+10 ... +12	>32	7	9.2
ZMM47	44 ... 50	70 (<100)	<750	+10 ... +12	>35	6	8.5
ZMM51	48 ... 54	70 (<100)	<750	+10 ... +12	>38	6	7.8

1) Tested with pulses t_p = 20 ms.
2) Valid provided that electrodes are kept at ambient temperature.
3) The ZMM1 is a silicon diode with operation in forward direction. Hence, the index of all parameters should be "F" instead of "Z". Connect the cathode electrode to the negative pole.

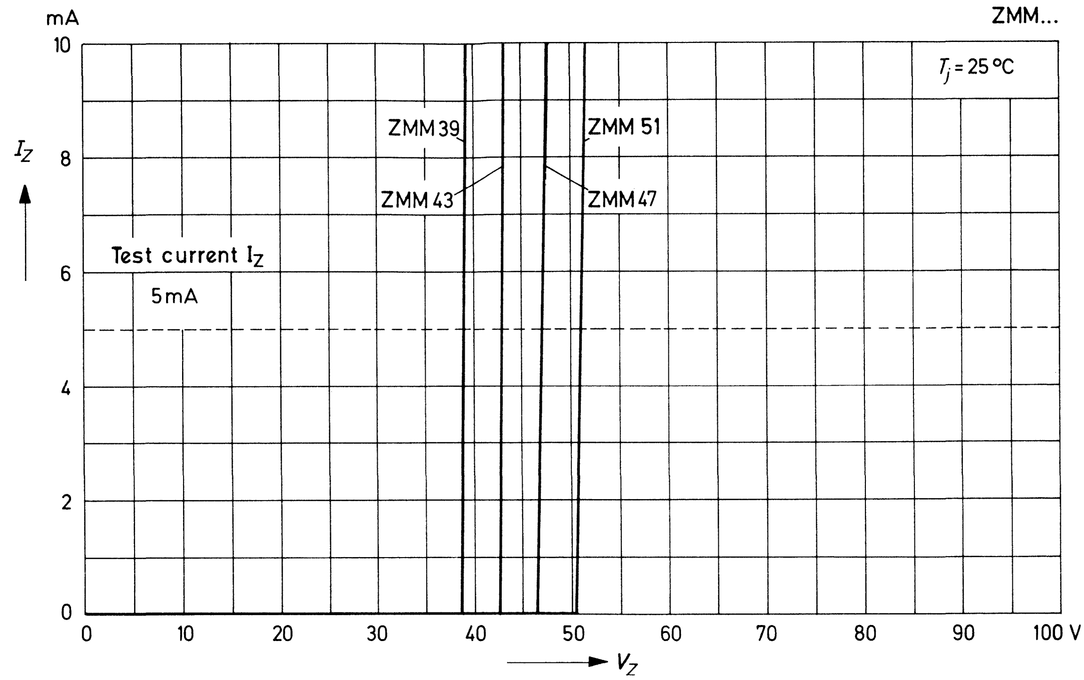
Breakdown characteristics
T_j = constant (pulsed)



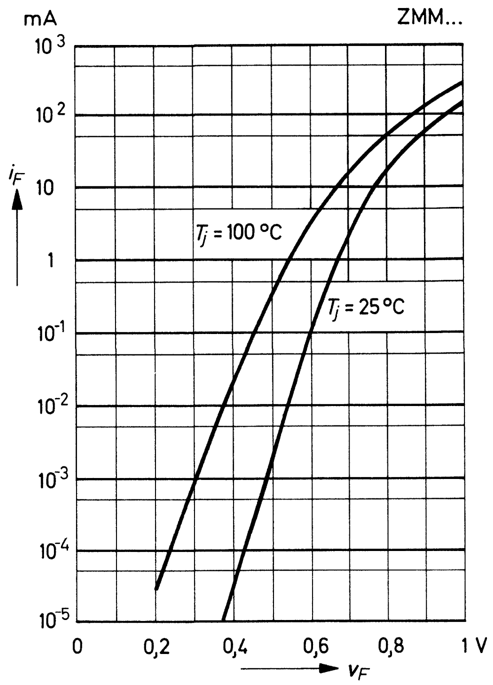
Breakdown characteristics
T_j = constant (pulsed)



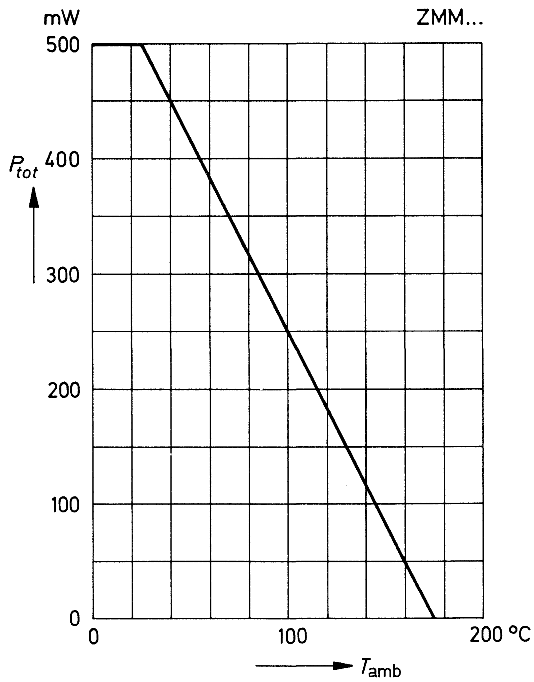
Breakdown characteristics
T_j = constant (pulsed)



Forward characteristics

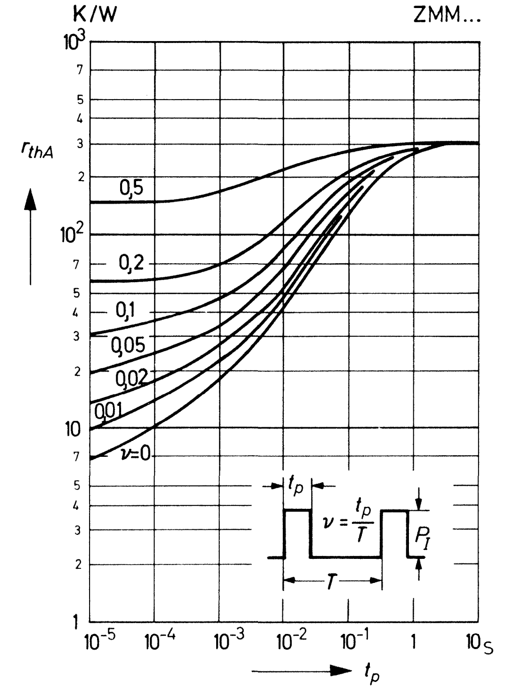


Admissible power dissipation versus ambient temperature
Valid provided that electrodes are kept at ambient temperature.

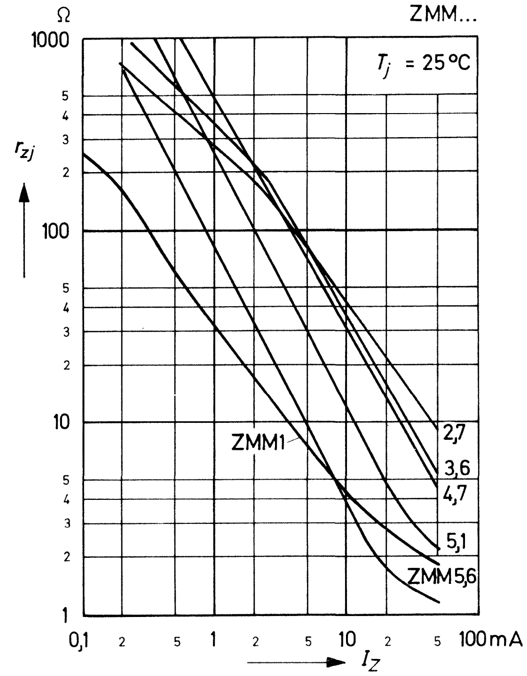


Pulse thermal resistance versus pulse duration

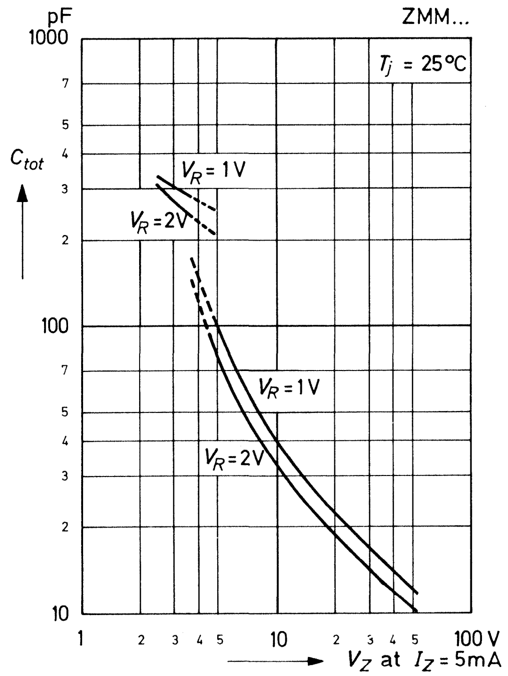
Valid provided that the electrodes are kept at ambient temperature.



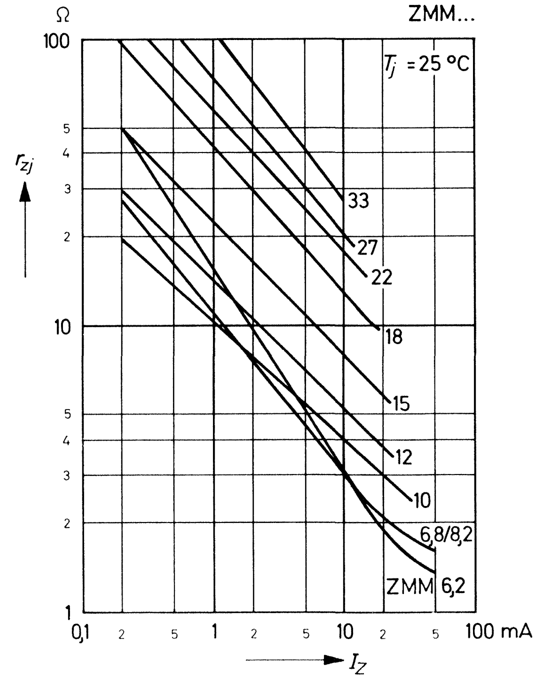
Dynamic resistance versus Zener current



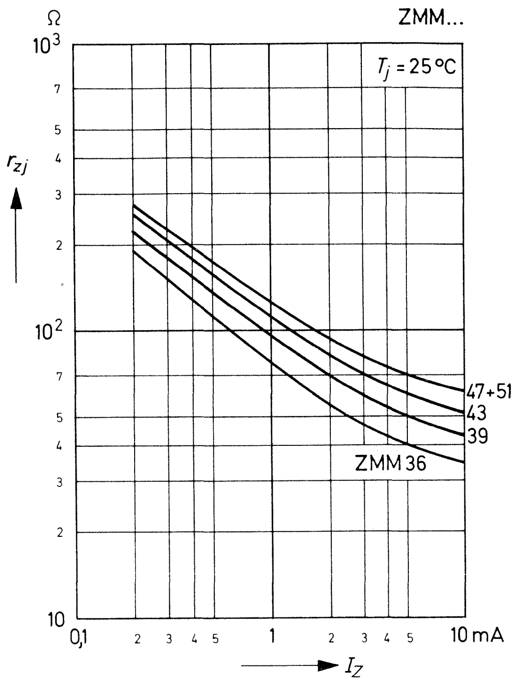
Capacitance versus Zener voltage



Dynamic resistance versus Zener current

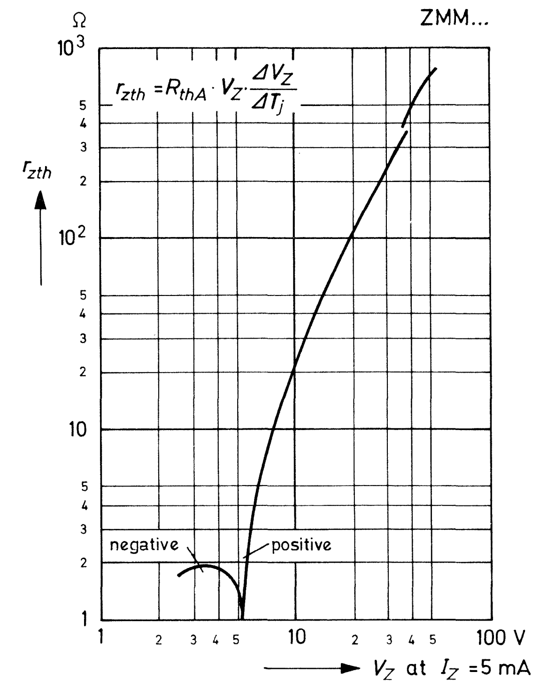


Dynamic resistance versus Zener current

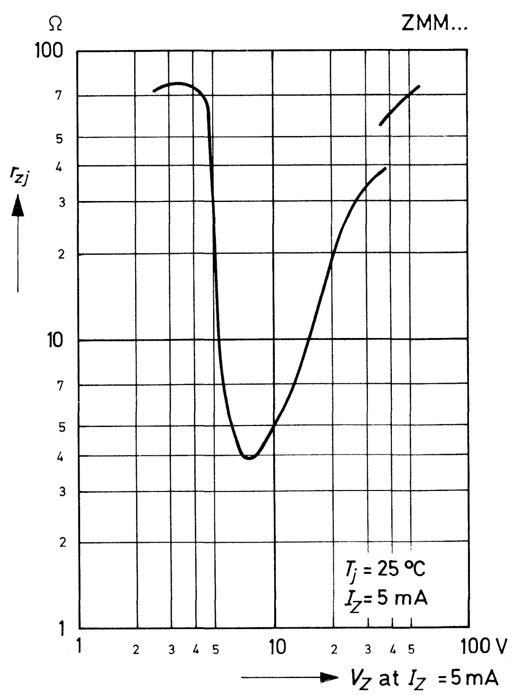


Thermal differential resistance versus Zener voltage

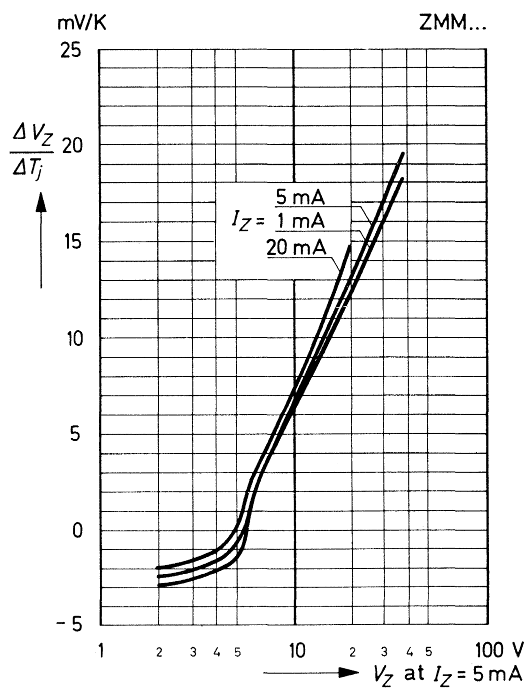
Valid provided that electrodes are kept at ambient temperature.



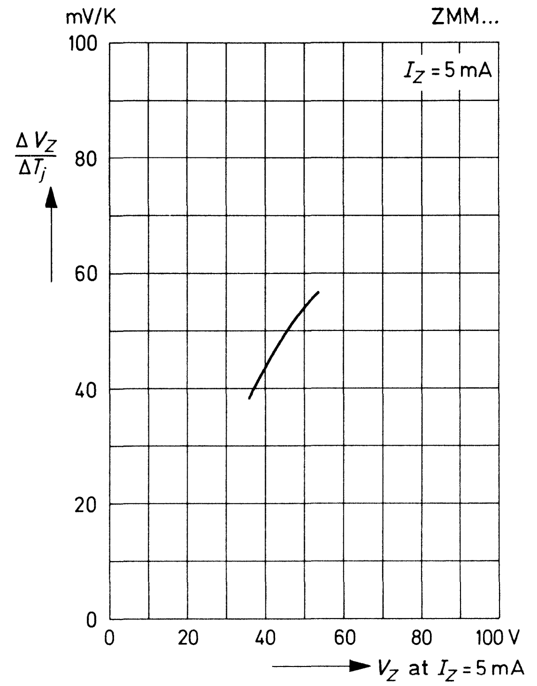
Dynamic resistance versus Zener voltage



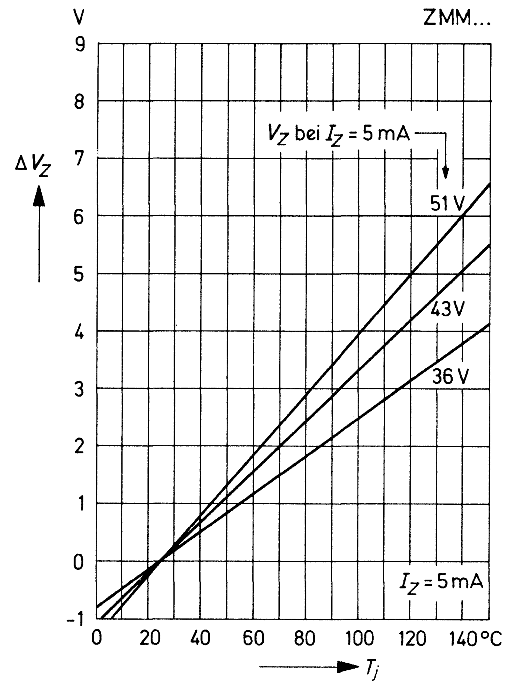
Temperature dependence of Zener voltage versus Zener voltage



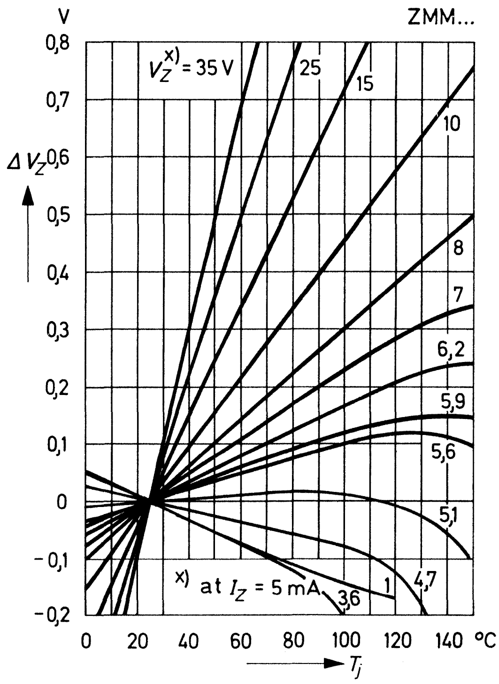
Temperature dependence of Zener voltage versus Zener voltage



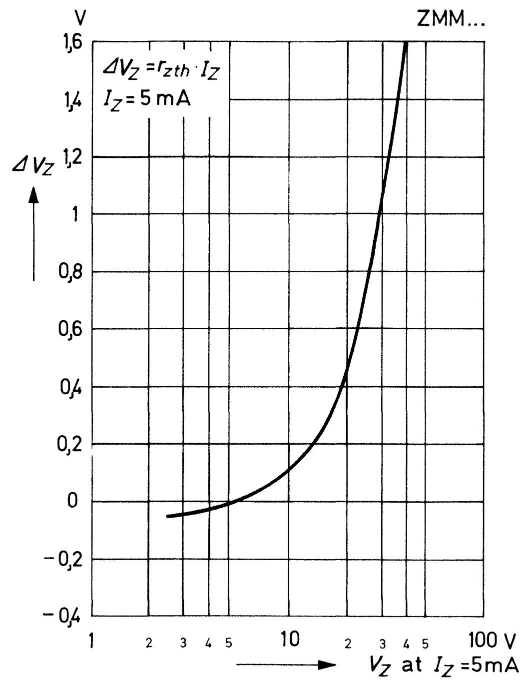
Change of Zener voltage versus junction temperature



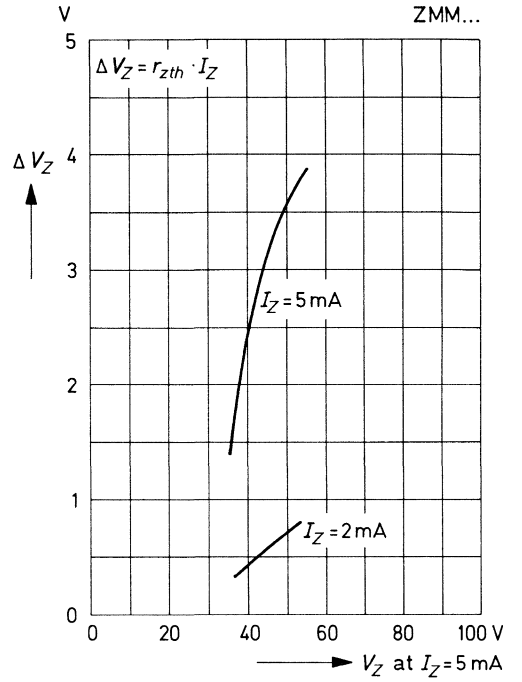
Change of Zener voltage versus junction temperature



Change of Zener voltage from turn-on up to the point of thermal equilibrium versus Zener voltage

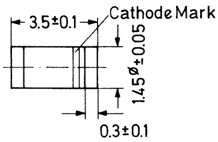


Change of Zener voltage from turn-on up to the point of thermal equilibrium versus Zener voltage



ZMM5225 . . . ZMM5262

Silicon Planar Zener Diodes
Standard Zener voltage tolerance is ±20 %. Add suffix "A" for ±10 % tolerance and suffix "B" for ±5 % tolerance. Other tolerances, non standard and higher Zener voltages upon request.



These diodes are also available in DO-35 case with te type designation 1N5225 . . . 1N5262.

These diodes are delivered taped.
Details see "Taping".

Glass case MiniMELF

Weight approx. 0.13 g
Dimensions in mm

Absolute Maximum Ratings

	Symbol	Value	Unit
Zener Current see Table "Characteristics"			
Power Dissipation at T_{amb} = 75 °C	P_{tot}	500[1)]	mW
Junction Temperature	T_j	175	°C
Storage Temperature Range	T_S	−65 to +175	°C
[1)] Valid provided that electrodes are kept at ambient temperature.			

Characteristics at T_{amb} = 25 °C

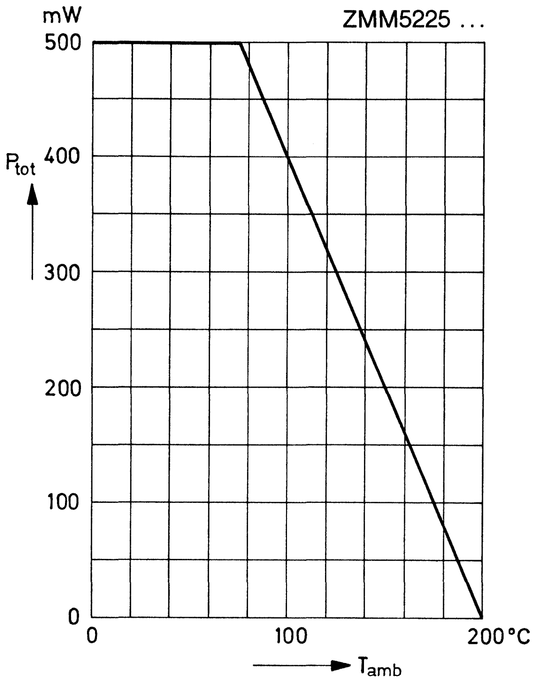
	Symbol	Min.	Typ.	Max.	Unit
Thermal Resistance Junction to Ambient Air	R_{thA}	–	–	0.3[1)]	K/mW
Forward Voltage at I_F = 200 mA	V_F	–	–	1.1	V
[1)] Valid provided that electrodes are kept at ambient temperature.					

Type	Nominal Zener voltage[3] at I_{ZT} V_Z V	Test current I_{ZT} mA	Maximum Zener impedance[1] at I_{ZT} Z_{ZT} Ω	at I_{ZK} = 0.25 mA Z_{ZK} Ω	Typical temperature coefficient α_{VZ} %/K	Maximum reverse leakage current I_R μA	Test voltage Suffix A V_R V	Suffix B V_R V	Maximum regulator current[2] I_{ZM} mA
ZMM5225	3.0	20	29	1600	−0.075	50	0.95	1.0	152
ZMM5226	3.3	20	28	1600	−0.070	25	0.95	1.0	138
ZMM5227	3.6	20	24	1700	−0.065	15	0.95	1.0	126
ZMM5228	3.9	20	23	1900	−0.060	10	0.95	1.0	115
ZMM5229	4.3	20	22	2000	−0.055	5	0.95	1.0	106
ZMM5230	4.7	20	19	1900	±0.030	5	1.9	2.0	97
ZMM5231	5.1	20	17	1600	±0.030	5	1.9	2.0	89
ZMM5232	5.6	20	11	1600	+0.038	5	2.9	3.0	81
ZMM5233	6.0	20	7	1600	+0.038	5	3.3	3.5	76
ZMM5234	6.2	20	7	1000	+0.045	5	3.8	4.0	73
ZMM5235	6.8	20	5	750	+0.050	3	4.8	5.0	67
ZMM5236	7.5	20	6	500	+0.058	3	5.7	6.0	61
ZMM5237	8.2	20	8	500	+0.062	3	6.2	6.5	55
ZMM5238	8.7	20	8	600	+0.065	3	6.2	6.5	52
ZMM5239	9.1	20	10	600	+0.068	3	6.7	7.0	50
ZMM5240	10	20	17	600	+0.075	3	7.6	8.0	45
ZMM5241	11	20	22	600	+0.076	2	8.0	8.4	41
ZMM5242	12	20	30	600	+0.077	1	8.7	9.1	38
ZMM5243	13	9.5	13	600	+0.079	0.5	9.4	9.9	35
ZMM5244	14	9.0	15	600	+0.082	0.1	9.5	10	32
ZMM5245	15	8.5	16	600	+0.082	0.1	10.5	11	30
ZMM5246	16	7.8	17	600	+0.083	0.1	11.4	12	28
ZMM5247	17	7.4	19	600	+0.084	0.1	12.4	13	27
ZMM5248	18	7.0	21	600	+0.085	0.1	13.3	14	25
ZMM5249	19	6.6	23	600	+0.086	0.1	13.3	14	24
ZMM5250	20	6.2	25	600	+0.086	0.1	14.3	15	23
ZMM5251	22	5.6	29	600	+0.087	0.1	16.2	17	21
ZMM5252	24	5.2	33	600	+0.087	0.1	17.1	18	19.1
ZMM5253	25	5.0	35	600	+0.089	0.1	18.1	19	18.2
ZMM5254	27	4.6	41	600	+0.090	0.1	20	21	16.8
ZMM5255	28	4.5	44	600	+0.091	0.1	20	21	16.2
ZMM5256	30	4.2	49	600	+0.091	0.1	22	23	15.1
ZMM5257	33	3.8	58	700	+0.092	0.1	24	25	13.8
ZMM5258	36	3.4	70	700	+0.093	0.1	26	27	12.6
ZMM5259	39	3.2	80	800	+0.094	0.1	29	30	11.6
ZMM5260	43	3.0	93	900	+0.095	0.1	31	33	10.6
ZMM5261	47	2.7	105	1000	+0.095	0.1	34	36	9.7
ZMM5262	51	2.5	125	1100	+0.096	0.1	37	39	8.9

[1] The Zener Impedance is derived from the 60 Hz AC voltage which results when an AC current having an RMS value equal to 10 % of the Zener current (I_{ZT} or I_{ZK}) is superimposed on I_{ZT} or I_{ZK}. Zener Impedance is measured at two points to insure a sharp knee on the breakdown curve and to eliminate unstable units.
[2] Valid provided that electrodes are kept at ambient temperature.
[3] Measured under thermal equilibrium and DC test conditions.

Admissible power dissipation versus ambient temperature

Valid provided that electrodes are kept at ambient temperature

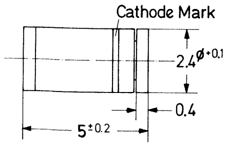


ZMU100 . . . ZMU180 (1W)

Silicon Planar Power Zener Diodes
for use in stabilizing and clipping circuits with higher power rating. The Zener voltage are graded according to the international E 12 standard. Smaller voltage tolerances on request.

These diodes are also available in DO-41 case with the type designation ZPU100 . . . ZPU180.

These diodes are delivered taped.
Details see "Taping".



Glass case MELF

Weight approx. 0.25 g
Dimensions in mm

Absolute Maximum Ratings

	Symbol	Value	Unit
Zener Current see Table "Characteristics"			
Power Dissipation at $T_{amb} = 25$ °C	P_{tot}	1[1)]	W
Junction Temperature	T_j	175	°C
Storage Temperature Range	T_S	−55 to +175	°C

1) Valid provided that electrodes are kept at ambient temperature.

Characteristics at T_{amb} = 25 °C

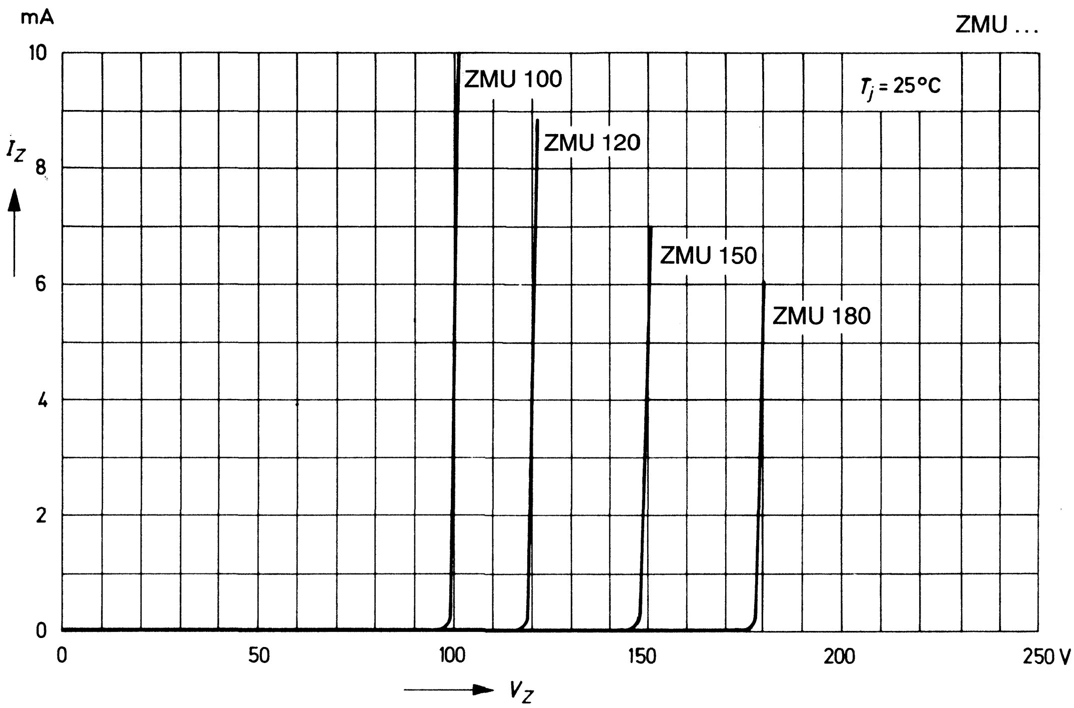
	Symbol	Min.	Typ.	Max.	Unit
Thermal Resistance Junction to Ambient Air	R_{thA}	–	–	170 [1]	K/W

[1] Valid provided that electrodes are kept at ambient temperature

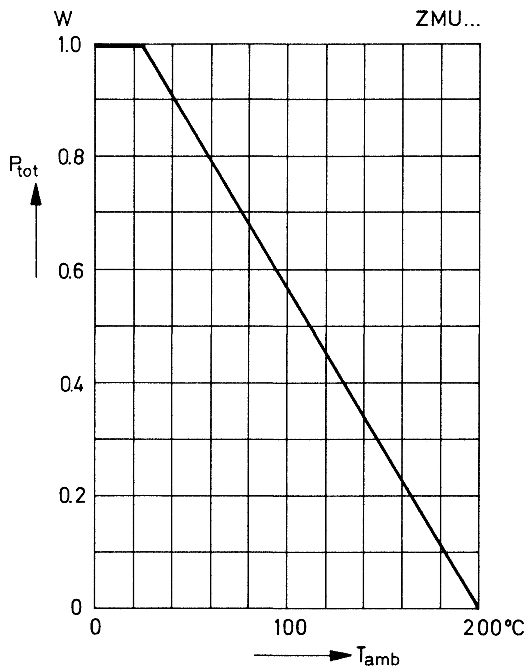
Type	Zener voltage [2] at I_{ZT} V_Z V	Dynamic resistance at I_{ZT} f = 1 kHz r_{zj} Ω	Temp. coeff. of Zener volt. at I_{ZT} $\alpha_{VZ} 10^{-4}$/K	Test current I_{ZT} mA	Reverse voltage at I_R = 0.5 µA V_R V	Admissible Zener current [1] at T_{amb} = 25 °C I_Z mA
ZMU100	88 ... 110	140 (<300)	+9 ... +13	5	>75	7
ZMU120	107 ... 134	170 (<330)	+9 ... +13	5	>90	6
ZMU150	130 ... 165	200 (<360)	+9 ... +13	5	>112	5
ZMU180	160 ... 200	220 (<380)	+9 ... +13	5	>134	4

[1] Valid provided that electrodes are kept at ambient temperature.
[2] Tested with pulses tp = 20 ms.

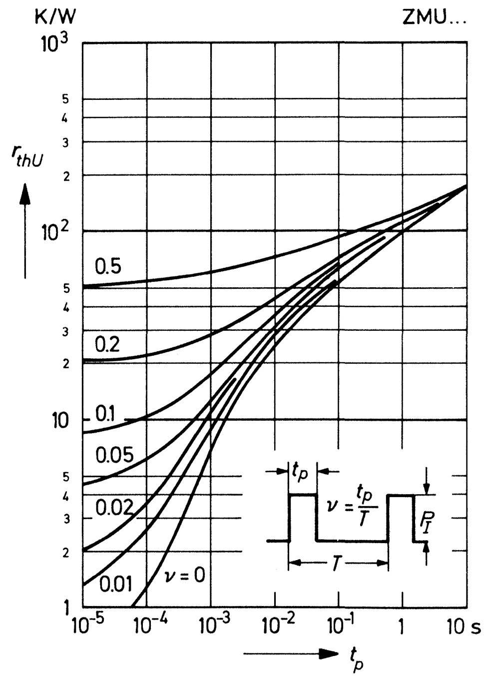
Breakdown characteristics
T_j = constant (pulsed)



Admissible power dissipation versus ambient temperature
Valid provided that electrodes are kept at ambient temperature

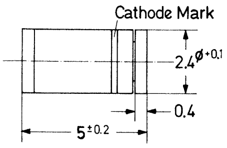


Pulse thermal resistance versus pulse duration
Valid provided that electrodes are kept at ambient temperature



ZMY1 . . . ZMY100 (1W)

Silicon Planar Power Zener Diodes
for use in stabilizing and clipping circuits with high power rating. The Zener voltages are graded according to the international E 24 standard. Smaller voltage tolerances on request.



Glass case MELF

Weight approx. 0.25 g
Dimensions in mm

These diodes are also available in DO-41 case with the type designation ZPY1 . . . ZPY100.

These diodes are delivered taped.
Details see "Taping".

Absolute Maximum Ratings

	Symbol	Value	Unit
Zener Current see Table "Characteristics"			
Power Dissipation at $T_{amb} = 25$ °C	P_{tot}	1[1]	W
Junction Temperature	T_j	175	°C
Storage Temperature Range	T_S	−55 to +175	°C

[1] Valid provided that electrodes are kept at ambient temperature.

Characteristics at $T_{amb} = 25$ °C

	Symbol	Min.	Typ.	Max.	Unit
Thermal Resistance Junction to Ambient Air	R_{thA}	–	–	170[1]	K/W

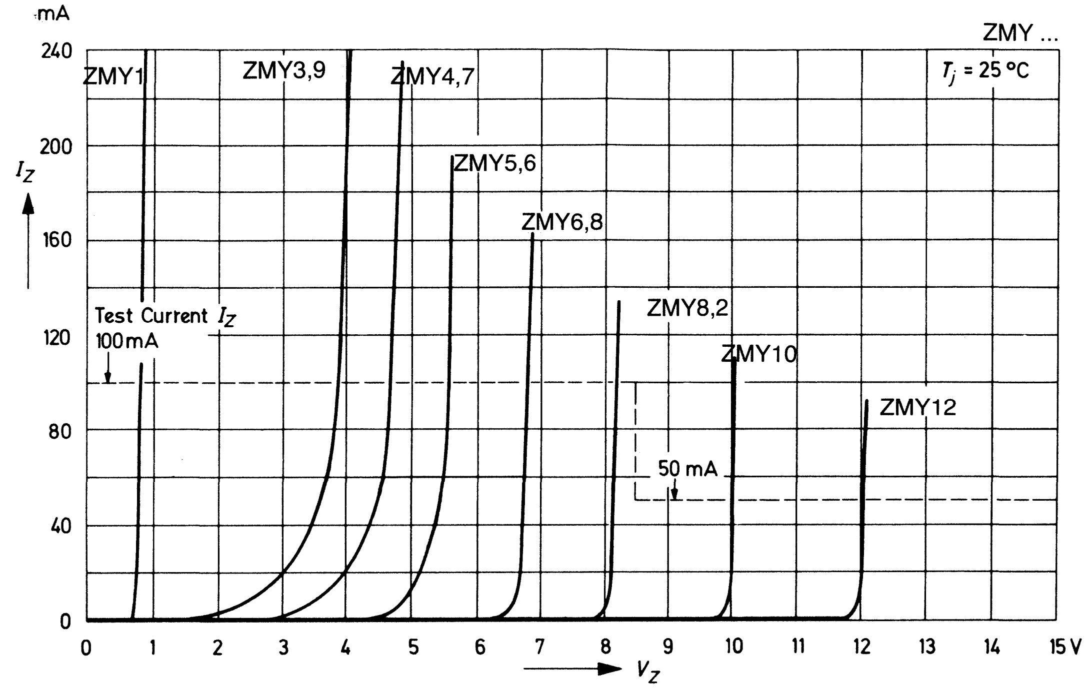
[1] Valid provided that electrodes are kept at ambient temperature.

Type	Zener voltage [2] at I_Z test V_Z V	Dynamic resistance at I_Z test f = 1 kHz r_{zj} Ω	Temp. coeff. of Zener volt. at I_Z test α_{VZ} 10^{-4}/K	Test current I_Z test mA	Reverse voltage at $I_R = 0.5\ \mu A$ V_R V	Admissible Zener current [1] at $T_{amb} = 25\ °C$ I_Z mA
ZMY1 [3]	0.65 ... 0.75	6.5 (<8)	−26 ... −23	5	–	406
ZMY3,9	3.7 ... 4.1	4 (<7)	−7 ... +2	100	–	203
ZMY4,3	4.0 ... 4.6	4 (<7)	−7 ... +3	100	–	182
ZMY4,7	4.4 ... 5.0	4 (<7)	−7 ... +4	100	–	165
ZMY5,1	4.8 ... 5.4	2 (<5)	−6 ... +5	100	>0.7	150
ZMY5,6	5.2 ... 6.0	1 (<2)	−3 ... +5	100	>1.5	135
ZMY6,2	5.8 ... 6.6	1 (<2)	−1 ... +6	100	>2.0	128
ZMY6,8	6.4 ... 7.2	1 (<2)	0 ... +7	100	>3.0	110
ZMY7,5	7.0 ... 7.9	1 (<2)	0 ... +7	100	>5.0	100
ZMY8,2	7.7 ... 8.7	1 (<2)	+3 ... +8	100	>6.0	89
ZMY9,1	8.5 ... 9.6	2 (<4)	+3 ... +8	50	>7.0	82
ZMY10	9.4 ... 10.6	2 (<4)	+5 ... +9	50	>7.5	74
ZMY11	10.4 ... 11.6	3 (<7)	+5 ... +10	50	>8.5	66
ZMY12	11.4 ... 12.7	3 (<7)	+5 ... +10	50	>9.0	60
ZMY13	12.4 ... 14.1	4 (<9)	+5 ... +10	50	>10	55
ZMY15	13.8 ... 15.8	4 (<9)	+5 ... +10	50	>11	49
ZMY16	15.3 ... 17.1	5 (<10)	+7 ... +11	25	>12	44
ZMY18	16.8 ... 19.1	5 (<11)	+7 ... +11	25	>14	40
ZMY20	18.8 ... 21.2	6 (<12)	+7 ... +11	25	>15	36
ZMY22	20.8 ... 23.3	7 (<13)	+7 ... +11	25	>17	34
ZMY24	22.8 ... 25.6	8 (<14)	+7 ... +12	25	>18	29
ZMY27	25.1 ... 28.9	9 (<15)	+7 ... +12	25	>20	27
ZMY30	28 ... 32	10 (<20)	+7 ... +12	25	>22.5	25
ZMY33	31 ... 35	11 (<20)	+7 ... +12	25	>25	22
ZMY36	34 ... 38	25 (<60)	+7 ... +12	10	>27	20
ZMY39	37 ... 41	30 (<60)	+8 ... +12	10	>29	18
ZMY43	40 ... 46	35 (<80)	+8 ... +13	10	>32	17
ZMY47	44 ... 50	40 (<80)	+8 ... +13	10	>35	15
ZMY51	48 ... 54	45 (<100)	+8 ... +13	10	>38	14
ZMY56	52 ... 60	50 (<100)	+8 ... +13	10	>42	13
ZMY62	58 ... 66	60 (<130)	+8 ... +13	10	>47	11
ZMY68	64 ... 72	65 (<130)	+8 ... +13	10	>51	10
ZMY75	70 ... 79	70 (<160)	+8 ... +13	10	>56	9
ZMY82	77 ... 88	80 (<160)	+8 ... +13	10	>61	8
ZMY91	85 ... 96	120 (<250)	+9 ... +13	5	>68	7.5
ZMY100	94 ... 106	130 (<250)	+9 ... +13	5	>75	7

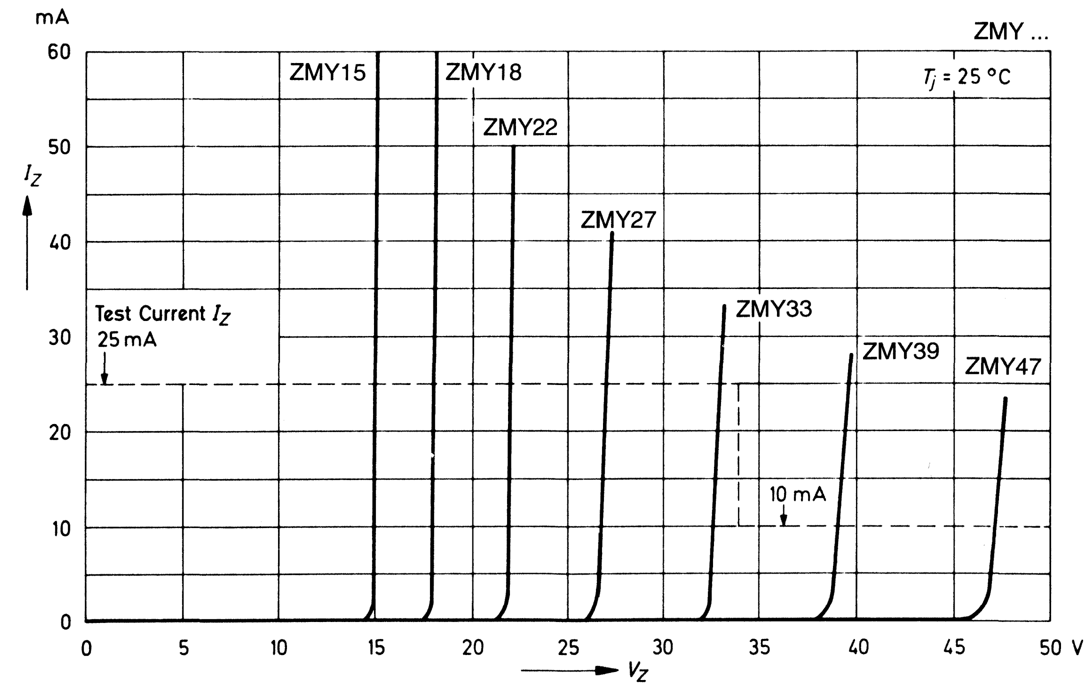
[1] Valid provided that electrodes are kept at ambient temperature.
[2] Tested with pulses tp = 20 ms.
[3] The ZMY1 is a silicon diode operated in forward direction. Hence, the index of all characteristics and maximum ratings should be "F" instead of "Z". Connect the cathode terminal to the negative pole.

For devices in glass case MELF with higher Zener voltage but same power dissipation see types ZMU100 ... ZMU180.

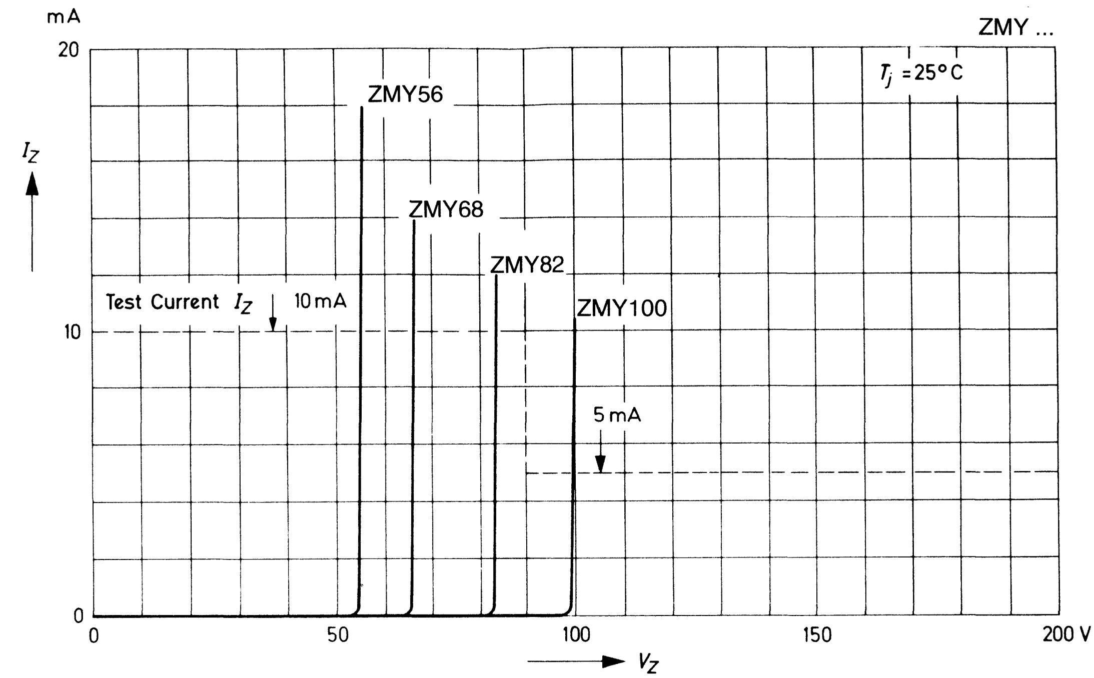
Breakdown characteristics
T_j = constant (pulsed)



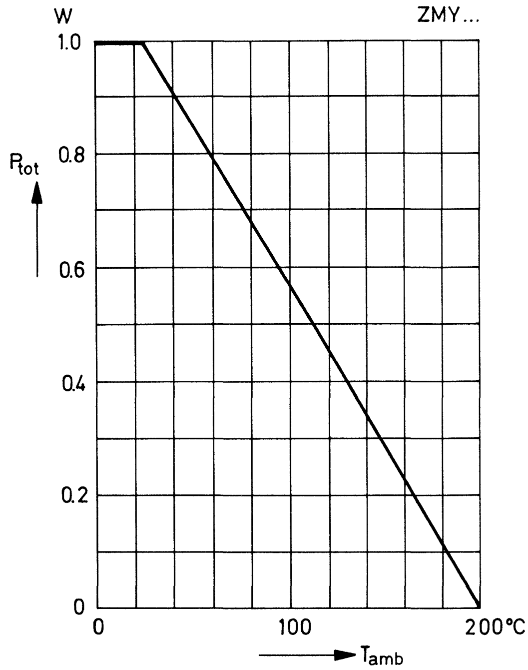
Breakdown characteristics
T_j = constant (pulsed)



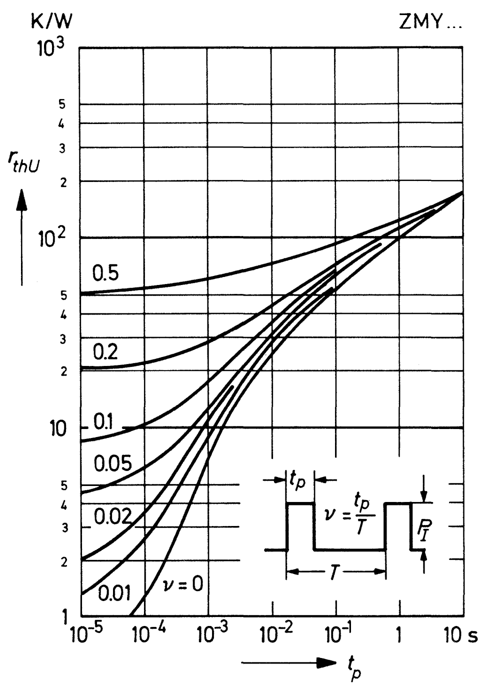
Breakdown characteristics
T_j = constant (pulsed)

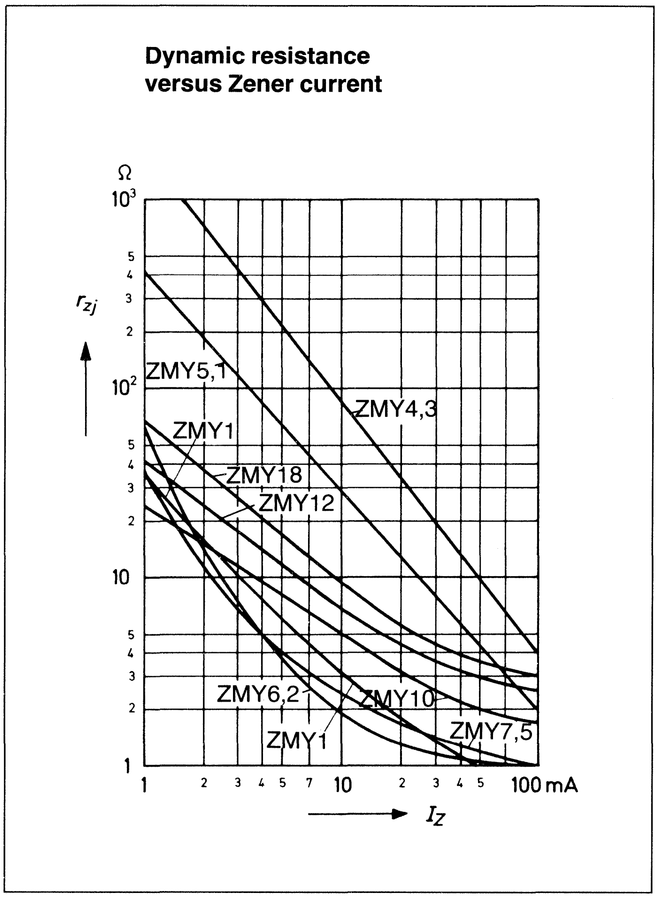


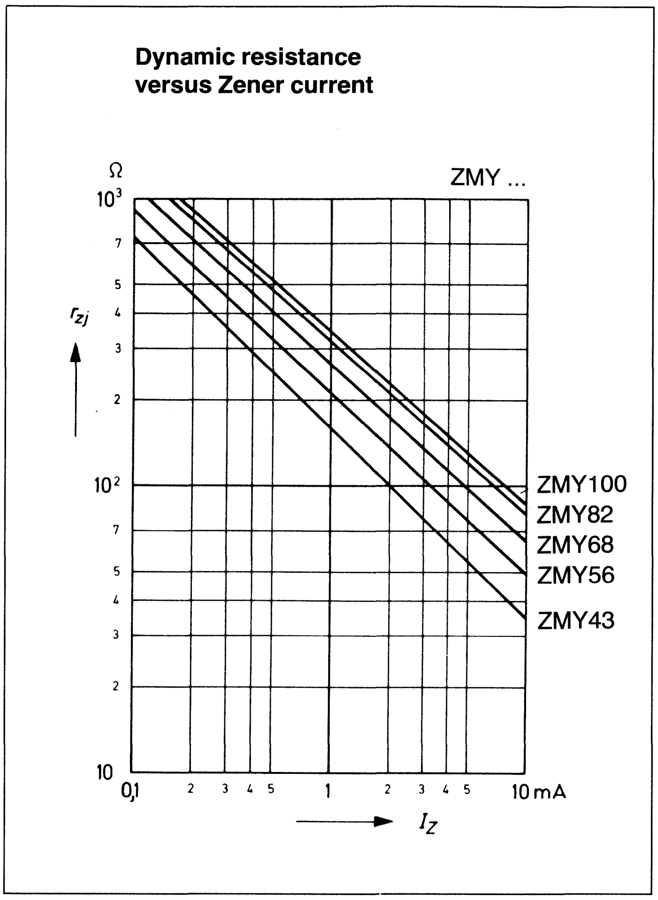
Admissible power dissipation versus ambient temperature
Valid provided that electrodes are kept at ambient temperature

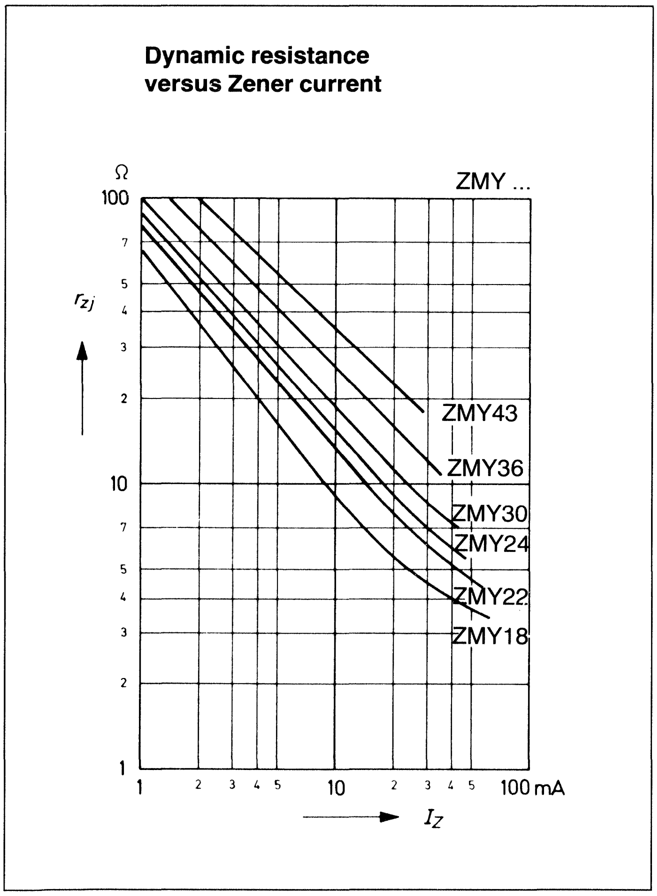


Pulse thermal resistance versus pulse duration
Valid provided that electrodes are kept at ambient temperature




Dynamic resistance
versus Zener current
Ω
r_{zj}
ZMY5,1
ZMY4,3
ZMY1
ZMY18
ZMY12
ZMY6,2
ZMY10
ZMY1
ZMY7,5
100 mA
I_Z


Dynamic resistance
versus Zener current
Ω
ZMY ...
r_{zj}
ZMY100
ZMY82
ZMY68
ZMY56
ZMY43
10 mA
I_Z

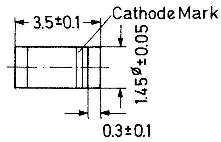

Dynamic resistance
versus Zener current
Ω
ZMY ...
r_{zj}
ZMY43
ZMY36
ZMY30
ZMY24
ZMY22
ZMY18
100 mA
I_Z

Stabilizer Diodes

LL1,5 . . . LL5,1

Silicon Stabilizer Diodes
Monolithic integrated analog circuits in MiniMELF case, designed for small power stabilizer and limitation circuits, providing low dynamic resistance and high-quality stabilization performance as well as low noise. In the reverse direction, these devices show the behavior of forward-biased silicon diodes.

The end of the device marked with the cathode ring is to be connected:
LL1,5 and LL2 to the negative pole of the supply voltage
LL2,4 ... LL5,1 to the positive pole of the supply voltage



Glass case MiniMELF

Weight approx. 0.05 g
Dimensions in mm

These diodes are also available in DO-35 case with the type designation ZTE1,5 . . . ZTE5,1.

These diodes are delivered taped.
Details see "Taping".

Absolute Maximum Ratings

	Symbol	Value	Unit
Operating Current see Table "Characteristics"			
Inverse Current	I_F	100	mA
Power Dissipation at T_{amb} = 25 °C	P_{tot}	300[1]	mW
Junction Temperature	T_j	150	°C
Storage Temperature Range	T_S	−55 to +150	°C

[1] Valid provided that electrodes are kept at ambient temperature.

Characteristics at T_{amb} = 25 °C

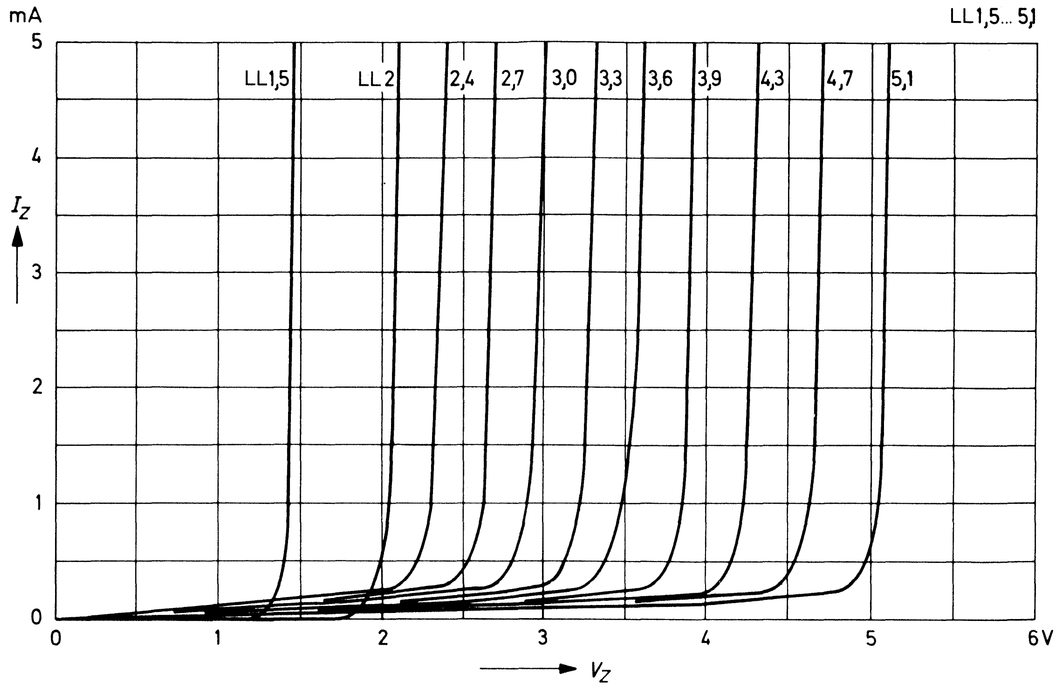
	Symbol	Min.	Typ.	Max.	Unit
Forward Voltage at I_F = 10 mA	V_F	–	–	1.1	V
Temperature Coefficient of the stabilized voltage at I_Z = 5 mA **LL1,5, LL2**	α_{VZ}	–	–26	–	10^{-4}/K
LL2,4, LL5,1	α_{VZ}	–	–34	–	10^{-4}/K
Thermal Resistance Junction to Ambient Air	R_{thA}	–	–	0.4[1)]	K/mW

1) Valid provided that electrodes are kept at ambient temperature.

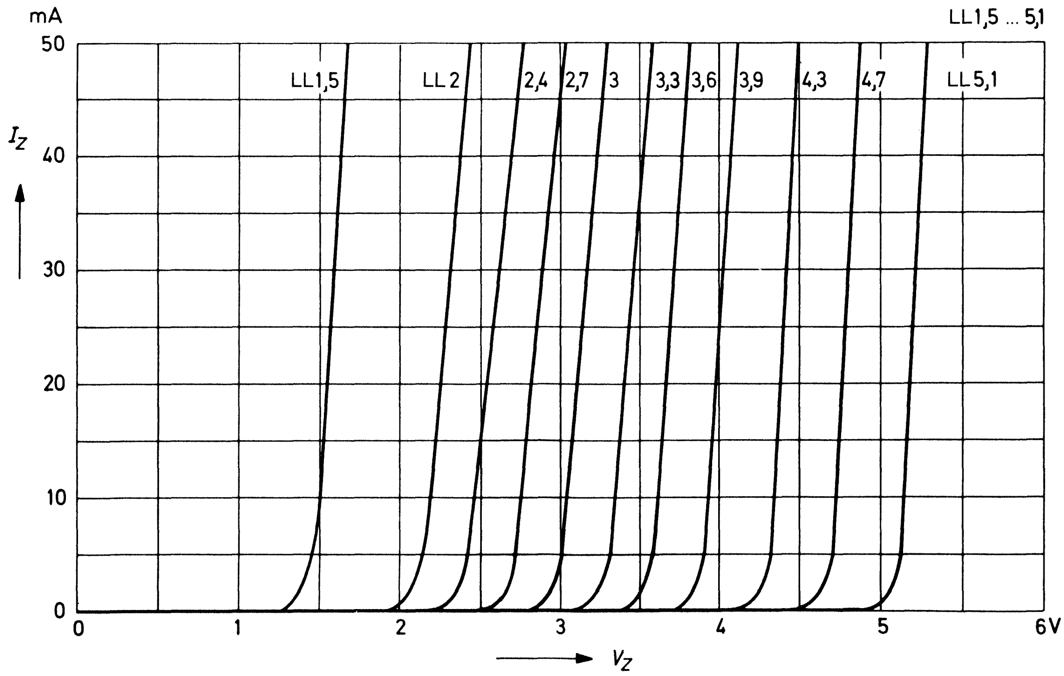
Type	Operating voltage at I_Z = mA V_Z V	Dynamic resistance at I_Z = mA r_{zj} Ω	Permissable operating current at T_{amb} = 25 °C[1)] I_Z max. mA
LL1,5	1.35 ... 1.55	13 (<20)	120
LL2	2.0 ... 2.3	18 (<30)	120
LL2,4	2.2 ... 2.56	14 (<20)	120
LL2,7	2.5 ... 2.9	15 (<20)	105
LL3	2.8 ... 3.2	15 (<20)	95
LL3,3	3.1 ... 3.5	16 (<20)	90
LL3,6	3.4 ... 3.8	16 (<25)	80
LL3,9	3.7 ... 4.1	17 (<25)	75
LL4,3	4.0 ... 4.6	17 (<25)	65
LL4,7	4.4 ... 5.0	18 (<25)	60
LL5,1	4.8 ... 5.4	18 (<25)	55

1) Valid provided that electrodes are kept at ambient temperature.

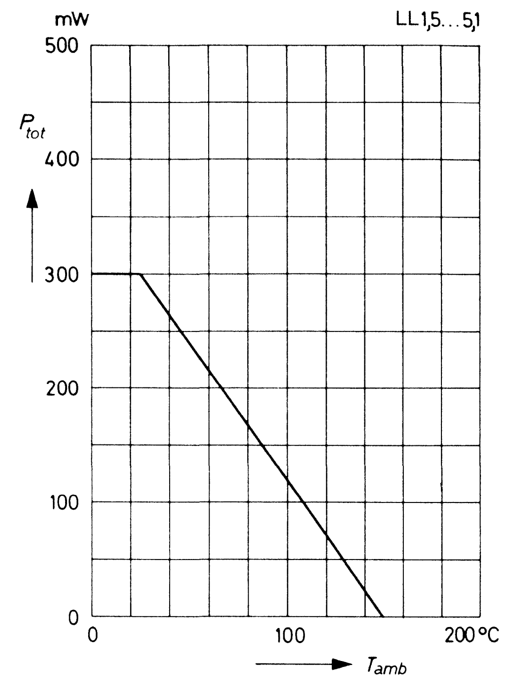
Breakdown characteristics
T_j = constant (pulsed)



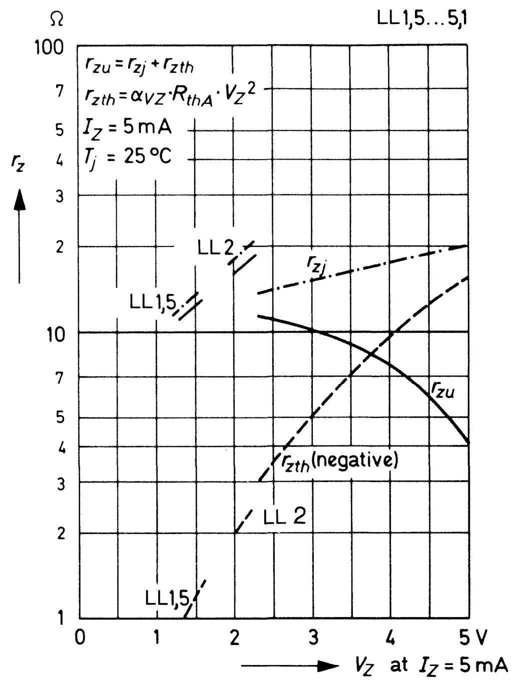
Breakdown characteristics
T_j = constant (pulsed)



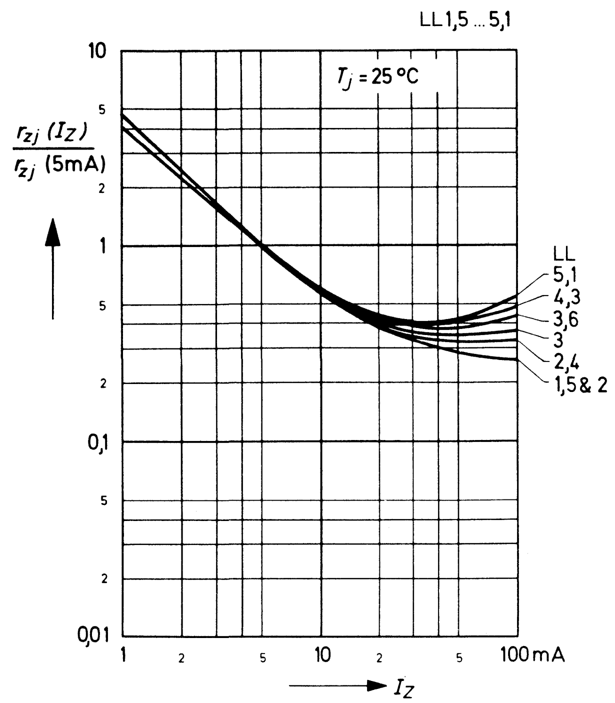
Admissible power dissipation versus ambient temperature
Valid provided that electrodes are kept at ambient temperature.



Dynamic resistance versus operating voltage



Dynamic resistance versus operating current, normalized



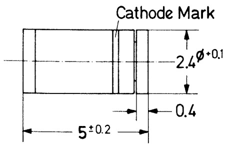
Rectifiers

LZ4001...LZ4003

Silicon Rectifiers

Nominal current 1 A
Repetitive peak reverse voltage 50...200 V

These rectifiers are delivered taped.



Glass case MELF

Weight approximately 0.25 g
Dimensions in mm

Absolute Maximum Ratings

		Symbol	Value	Unit
Repetitive Peak Reverse Voltage	**LZ4001**	V_{RRM}	50	V
	LZ4002	V_{RRM}	100	V
	LZ4003	V_{RRM}	200	V
Nominal Current with Resistive Load at T_{amb} = 25 °C		I_{FAV}	1	A
Surge Forward Current, Half Cycle 50 Hz, starting from T_j = 25 °C		I_{FSM}	15	A
Ambient Operating Temperature Range		T_{amb}	−65 to +175	°C
Storage Temperature Range		T_S	−65 to +175	°C

Characteristics

	Symbol	Min.	Typ.	Max.	Unit
Forward Voltage at I_F = 2 A, T_j = 25 °C	V_F	–	–	1.75	V
Leakage Current at V_{RRM}, T_j = 25 °C	I_R	–	–	5	µA

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