N-P-N 1 GHz WIDEBAND TRANSISTOR

N-P-N transistor in a TO-72 metal envelope, with insulated electrodes and a shield lead connected to the case. The transistor has a low noise, a very high power gain and good intermodulation properties. It is primarily intended for:
- Channel aerial amplifiers for bands I, II, III and IV/V (40–860 MHz).
- Wideband aerial amplifiers (40–860 MHz).

QUICK REFERENCE DATA

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<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Unit</th>
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<td>V_{CBOM}</td>
<td>max. 30 V</td>
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<tr>
<td>Collector-emitter voltage</td>
<td>V_{CEO}</td>
<td>max. 15 V</td>
</tr>
<tr>
<td>Collector current</td>
<td>I_{CM}</td>
<td>max. 50 mA</td>
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<td>P_{tot}</td>
<td>max. 200 mW</td>
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<td>Junction temperature</td>
<td>T_{j}</td>
<td>max. 200 °C</td>
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<td>C_{fe}</td>
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MECHANICAL DATA

Fig. 1 TO-72.

Dimensions in mm

(1) = shield lead (connected to case).
Accessories: 56246 (distance disc).
RATINGS
Limiting values in accordance with the Absolute Maximum System (IEC 134)

Collector-base voltage (open emitter; peak value) \( V_{CBOM} \) max. 30 V
Collector-emitter voltage (peak value) \( R_{BE} \leq 50 \, \Omega \) \( V_{CERM} \) max. 30 V
Collector-emitter voltage (open base) \( V_{CEO} \) max. 15 V
Emitter-base voltage (open collector) \( V_{EBO} \) max. 2.5 V
Collector current (DC) \( I_C \) max. 25 mA
Collector current (peak value; \( f > 1 \, \text{MHz} \)) \( I_{CM} \) max. 50 mA
Total power dissipation up to \( T_{amb} = 25 \, \text{°C} \) \( P_{tot} \) max. 200 mW
Storage temperature \( T_{stg} \) -65 to +200 °C
Junction temperature \( T_j \) max. 200 °C

THERMAL RESISTANCE
From junction to ambient in free air
From junction to case

\[ R_{th\,ja} = 880 \, \text{K/W} \]
\[ R_{th\,jc} = 580 \, \text{K/W} \]
CHARACTERISTICS

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

Collector cut-off current

$I_C = 20 \, mA$; $I_B =$ value for which $I_C = 22 \, mA$ at $V_{CE} = 1 \, V$

$I_{CB0}$ max. 10 nA

$V_{CEK}$ max. 0.75 V

![IC vs VCE](image)

DC current gain

$|I_C| = 2 \, mA$; $V_{CE} = 1 \, V$

$|I_C| = 25 \, mA$; $V_{CE} = 1 \, V$

$f_T$ typ. 1.0 GHz

$h_{FE}$ 20 to 150

$f_T$ typ. 1.2 GHz

$h_{FE}$ 20 to 125

Transition frequency*

$I_C = 2 \, mA$; $V_{CE} = 5 \, V$; $f = 500 \, MHz$

$I_C = 25 \, mA$; $V_{CE} = 5 \, V$; $f = 500 \, MHz$

$C_C$ max. 1.7 pF

$C_{re}$ typ. 0.6 pF

Collector capacitance at $f = 1 \, MHz^{**}$

$|I_E| = I_e = 0$; $V_{CB} = 10 \, V$

Feedback capacitance at $f = 1 \, MHz^{*}$

$I_C = 2 \, mA$; $V_{CE} = 5 \, V$; $T_{amb} = 25 \, ^\circ C$

Noise figure*

$I_C = 2 \, mA$; $V_{CE} = 5 \, V$; $T_{amb} = 25 \, ^\circ C$

$f = 200 \, MHz$; optimum source impedance

$f = 500 \, MHz$; $Z_S = 50 \, \Omega$

$f = 800 \, MHz$; optimum source impedance

$F_{max}$ 4.0 dB

$F_{max}$ 6.5 dB

$F_{max}$ 7.0 dB

Power gain (not neutralized)*

$I_C = 8 \, mA$; $V_{CE} = 10 \, V$; $T_{amb} = 25 \, ^\circ C$

$G_p$ min. 19 dB

$G_p$ typ. 22 dB

$G_p$ 7.0 dB

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* Shield lead grounded.

** Shield lead not connected.
CHARACTERISTICS (continued)

Intermodulation characteristics

1. Output power at $f = 200$ MHz; $T_{amb} = 25$ °C
   $I_C = 8$ mA; $V_{CE} = 10$ V; V.S.W.R. at output $< 2$
   $f_p = 202$ MHz; $f_q = 205$ MHz; $d_{im} = -30$ dB
   measured at $f(2q-p) = 208$ MHz (Channel 9)

\[ P_o \text{ typ. } 6 \text{ mW} \]

![Test circuit diagram]

Fig. 3 Test circuit.

Coil data:

L1 = 3 turns silver plated Cu wire (1.4 mm); winding pitch 2.7 mm; int. diam. 8 mm; 
taps at 0.5 turn and 1.5 turns from earth.

L2 = 5.5 turns silver plated Cu wire (1.4 mm); winding pitch 2.2 mm; int. diam. 8 mm.

L3 = 3 turns silver plated Cu wire (1.4 mm); winding pitch 3.3 mm; int. diam. 8 mm.

L4 = 5.5 turns silver plated Cu wire (1.4 mm); winding pitch 2.2 mm; int. diam. 11 mm.

* Shield lead grounded.
CHARACTERISTICS

Basis of adjustment

The intermodulation at an intermodulation distortion of $-30$ dB is caused by h.f. output current — voltage clipping.

The maximum undistorted output power is realised, if

a. Current and voltage clipping take place concurrently.

This occurs if

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

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

b. The h.f. collector current is as small as possible.

This is so if $-C_L = +C_{OE}$,

in which $C_{OE}$ is the output capacitance of the transistor at short circuited input.

For maximum output power at an intermodulation distortion of $-30$ dB, the (experimentally found) values of $R_L$ and $C_L$ are:

$R_L = 1$ k$\Omega$; $C_L = -1.8$ p$F$

Adjustment procedure

1. Remove the transistor and connect a dummy consisting of a 1 k$\Omega$ resistor in parallel with a 1.8 p$F$ capacitor between the collector and emitter connections of the output circuit.

2. Tune and match the output circuit for zero reflection at 205 MHz (V.S.W.R. = 1). After this adjustment, no further change may be made in the output circuit.

3. Replace the dummy by the transistor. Tune and match the input circuit for maximum power gain and good band pass curve.

The V.S.W.R. of the output will then, in most cases, be $\leq 2$ over the whole channel.

Corrections can be made by tuning L2; this will not disturb the band pass curve.
CHARACTERISTICS (continued)

Intermodulation characteristics*

2. Output power at $f = 800 \text{ MHz}$; $T_{\text{amb}} = 25 \degree \text{C}$

$I_C = 8 \text{ mA}; V_{CE} = 10 \text{ V}; \text{V.S.W.R. at output} < 2$

$f_p = 798 \text{ MHz}; f_q = 802 \text{ MHz}; d_{\text{im}} = -30 \text{ dB}$

measured at $f(2q-p) = 806 \text{ MHz}$ (Channel 62)

$$P_o \quad \text{typ.} \quad 6 \text{ mW}$$

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Coil data:

$L_1 = 24 \text{ mm} \times 6 \text{ mm} \times 0.5 \text{ mm silver plated Cu strip.}$

Tap of the input at 5 mm from earth.

$L_2 = 15 \text{ mm} \times 6 \text{ mm} \times 0.5 \text{ mm silver plated Cu strip.}$

$L_3 = 20 \text{ mm} \times 8 \text{ mm} \times 0.5 \text{ mm silver plated Cu strip.}$

$L_4 = 4 \text{ turns enameled Cu wire (0.5 mm); winding pitch 1.5 mm; int. diam. 4 mm.}$

Coupling link: 42 mm silver plated Cu wire (1 mm).

Basis of adjustment

At 800 MHz no dummy can be used to adjust for optimum collector load because at these frequencies the impedance transformations of a dummy are too high. A small signal at the mid-channel frequency of 802 MHz is fed to the input and increased until clipping occurs; that is, until the output power no longer increases linearly with the input signal. This clipping can be eliminated by tuning the output circuit, thereby making the output power equal to

$$P_o = \frac{I_C (V_{CE} - V_{CEK})}{2} = 35 \text{ mW}$$

The output circuit is adjusted for minimum intermodulation if the input signal is as small as possible at $P_o = 35 \text{ mW}$.

After this adjustment has been made no further change may be made in the output circuit.

Adjust the input circuit for maximum power gain and good band pass curve.

The V.S.W.R. of the output is then $\leq 2$ over the whole channel.

* Shield lead grounded.
CHARACTERISTICS

Intermodulation characteristics*

3. Intermodulation distortion

\( I_C = 8 \text{ mA}; \ V_{CE} = 6 \text{ V}; \ R_L = 37.5 \Omega; \ T_{amb} = 25 \text{ °C} \)

\( V_O = 100 \text{ mV} \) at \( f_p = 183 \text{ MHz} \)

\( V_O = 100 \text{ mV} \) at \( f_q = 200 \text{ MHz} \)

measured at \( f_{(2q-p)} = 217 \text{ MHz} \)

\( d_{im} \) typ. \(-40 \text{ dB}\)

![Circuit Diagram]

Fig. 5 Test circuit.

* Shield lead grounded.
Fig. 6 $T_j = 25^\circ$C; typical values.

Fig. 7 $T_j = 25^\circ$C; typical values.
Fig. 8 $V_{CE} = 1\, V; T_j = 25\, ^\circ C$.

Fig. 9 $V_{CE} = 1\, V; T_j = 25\, ^\circ C$. 
Fig. 10 \( f = 500 \text{ MHz}; T_j = 25 \degree \text{C}; \) typical values.

Fig. 11 \( I_E = i_e = 0; f = 1 \text{ MHz}; T_j = 25 \degree \text{C}; \) typical values.

Fig. 12 \( V_{CE} = 5 \text{ V}; T_j = 25 \degree \text{C}; \) typical values.
Fig. 13  $V_{CE} = 5\, V$; $f = 500\, \text{MHz}$; $Z_S = 50\, \Omega$; $T_{amb} = 25\, ^\circ\text{C}$; typical values.

Fig. 14  $V_{CE} = 5\, V$; $I_C = 2\, \text{mA}$; $Z_S = \text{optimum}$; $T_{amb} = 25\, ^\circ\text{C}$; typical values.