# DATA SHEET

# BF904; BF904R
## N-channel dual gate MOS-FETs

Product specification
Supersedes data of 1997 Sep 05

1999 May 17





PHILIPS

# N-channel dual gate MOS-FETs BF904; BF904R

## FEATURES

- Specially designed for use at 5 V supply voltage
- Short channel transistor with high transfer admittance to input capacitance ratio
- Low noise gain controlled amplifier up to 1 GHz
- Superior cross-modulation performance during AGC.

## APPLICATIONS

- VHF and UHF applications with 3 to 7 V supply voltage such as television tuners and professional communications equipment.

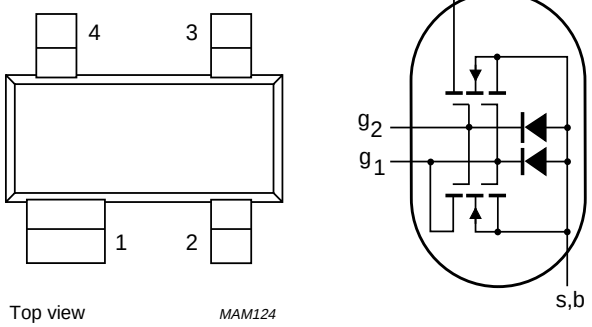
## DESCRIPTION

Enhancement type field-effect transistor in a plastic microminiature SOT143B and SOT143R package. The transistor consists of an amplifier MOS-FET with source and substrate interconnected and an internal bias circuit to ensure good cross-modulation performance during AGC.

| CAUTION |
|---|
| This product is supplied in anti-static packing to prevent damage caused by electrostatic discharge during transport and handling. For further information, refer to Philips specs.: SNW-EQ-608, SNW-FQ-302A and SNW-FQ-302B. |

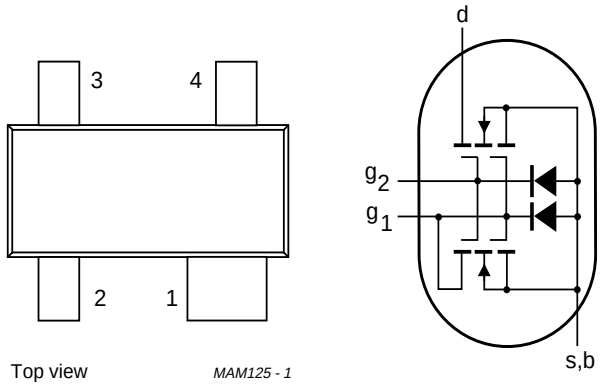
## PINNING

| PIN | SYMBOL | DESCRIPTION |
|---|---|---|
| 1 | s, b | source |
| 2 | d | drain |
| 3 | $g_2$ | gate 2 |
| 4 | $g_1$ | gate 1 |




**BF904 marking code:** M04.

Fig.1 Simplified outline (SOT143B) and symbol.




**BF904R marking code:** M06.

Fig.2 Simplified outline (SOT143R) and symbol.

## QUICK REFERENCE DATA

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| $V_{DS}$ | drain-source voltage | | – | – | 7 | V |
| $I_D$ | drain current | | – | – | 30 | mA |
| $P_{tot}$ | total power dissipation | | – | – | 200 | mW |
| $T_j$ | operating junction temperature | | – | – | 150 | °C |
| $\lvert y_{fs} \rvert$ | forward transfer admittance | | 22 | 25 | 30 | mS |
| $C_{ig1\text{-}s}$ | input capacitance at gate 1 | | – | 2.2 | 2.6 | pF |
| $C_{rs}$ | reverse transfer capacitance | f = 1 MHz | – | 25 | 35 | fF |
| F | noise figure | f = 800 MHz | – | 2 | – | dB |

**LIMITING VALUES**

In accordance with the Absolute Maximum Rating System (IEC 134).

| SYMBOL | PARAMETER | CONDITIONS | MIN. | MAX. | UNIT |
|---|---|---|---|---|---|
| $V_{DS}$ | drain-source voltage | | – | 7 | V |
| $I_D$ | drain current | | – | 30 | mA |
| $I_{G1}$ | gate 1 current | | – | ±10 | mA |
| $I_{G2}$ | gate 2 current | | – | ±10 | mA |
| $P_{tot}$ | total power dissipation | see Fig.3 | | | |
| | BF904 | $T_{amb} \leq 50$ °C; note 1 | – | 200 | mW |
| | BF904R | $T_{amb} \leq 40$ °C; note 1 | – | 200 | mW |
| $T_{stg}$ | storage temperature | | –65 | +150 | °C |
| $T_j$ | operating junction temperature | | – | 150 | °C |

**Note**

1. Device mounted on a printed-circuit board.

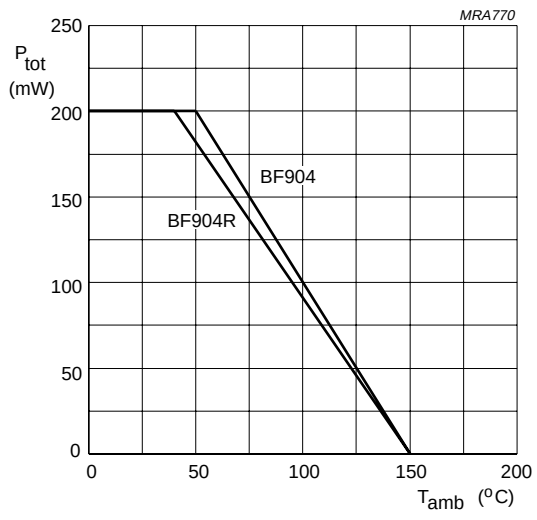



Fig.3 Power derating curves.

### THERMAL CHARACTERISTICS

| SYMBOL | PARAMETER | CONDITIONS | VALUE | UNIT |
|---|---|---|---|---|
| $R_{th\ j\text{-}a}$ | thermal resistance from junction to ambient | note 1 | | |
| | BF904 | | 500 | K/W |
| | BF904R | | 550 | K/W |
| $R_{th\ j\text{-}s}$ | thermal resistance from junction to soldering point | note 2 | | |
| | BF904 | $T_s$ = 92 °C | 290 | K/W |
| | BF904R | $T_s$ = 78 °C | 360 | K/W |

**Notes**

1. Device mounted on a printed-circuit board.
2. $T_s$ is the temperature at the soldering point of the source lead.

### STATIC CHARACTERISTICS

$T_j$ = 25 °C unless otherwise specified.

| SYMBOL | PARAMETER | CONDITIONS | MIN. | MAX. | UNIT |
|---|---|---|---|---|---|
| $V_{(BR)G1\text{-}SS}$ | gate 1-source breakdown voltage | $V_{G2\text{-}S}$ = $V_{DS}$ = 0; $I_{G1\text{-}S}$ = 10 mA | 6 | 15 | V |
| $V_{(BR)G2\text{-}SS}$ | gate 2-source breakdown voltage | $V_{G1\text{-}S}$ = $V_{DS}$ = 0; $I_{G2\text{-}S}$ = 10 mA | 6 | 15 | V |
| $V_{(F)S\text{-}G1}$ | forward source-gate 1 voltage | $V_{G2\text{-}S}$ = $V_{DS}$ = 0; $I_{S\text{-}G1}$ = 10 mA | 0.5 | 1.5 | V |
| $V_{(F)S\text{-}G2}$ | forward source-gate 2 voltage | $V_{G1\text{-}S}$ = $V_{DS}$ = 0; $I_{S\text{-}G2}$ = 10 mA | 0.5 | 1.5 | V |
| $V_{G1\text{-}S(th)}$ | gate 1-source threshold voltage | $V_{G2\text{-}S}$ = 4 V; $V_{DS}$ = 5 V; $I_D$ = 20 μA | 0.3 | 1 | V |
| $V_{G2\text{-}S(th)}$ | gate 2-source threshold voltage | $V_{G1\text{-}S}$ = $V_{DS}$ = 5 V; $I_D$ = 20 μA | 0.3 | 1.2 | V |
| $I_{DSX}$ | drain-source current | $V_{G2\text{-}S}$ = 4 V; $V_{DS}$ = 5 V; $R_{G1}$ = 120 kΩ; note 1 | 8 | 13 | mA |
| $I_{G1\text{-}SS}$ | gate 1 cut-off current | $V_{G2\text{-}S}$ = $V_{DS}$ = 0; $V_{G1\text{-}S}$ = 5 V | – | 50 | nA |
| $I_{G2\text{-}SS}$ | gate 2 cut-off current | $V_{G1\text{-}S}$ = $V_{DS}$ = 0; $V_{G2\text{-}S}$ = 5 V | – | 50 | nA |

**Note**

1. $R_{G1}$ connects gate 1 to $V_{GG}$ = 5 V; see Fig.20.

### DYNAMIC CHARACTERISTICS

Common source; $T_{amb}$ = 25 °C; $V_{DS}$ = 5 V; $V_{G2\text{-}S}$ = 4 V; $I_D$ = 10 mA; unless otherwise specified.

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| $\lvert y_{fs} \rvert$ | forward transfer admittance | pulsed; $T_j$ = 25 °C | 22 | 25 | 30 | mS |
| $C_{ig1\text{-}s}$ | input capacitance at gate 1 | f = 1 MHz | – | 2.2 | 2.6 | pF |
| $C_{ig2\text{-}s}$ | input capacitance at gate 2 | f = 1 MHz | 1 | 1.5 | 2 | pF |
| $C_{os}$ | drain-source capacitance | f = 1 MHz | 1 | 1.3 | 1.6 | pF |
| $C_{rs}$ | reverse transfer capacitance | f = 1 MHz | – | 25 | 35 | fF |
| F | noise figure | f = 200 MHz; $G_S$ = 2 mS; $B_S$ = $B_{Sopt}$ | – | 1 | 1.5 | dB |
| | | f = 800 MHz; $G_S$ = $G_{Sopt}$; $B_S$ = $B_{Sopt}$ | – | 2 | 2.8 | dB |

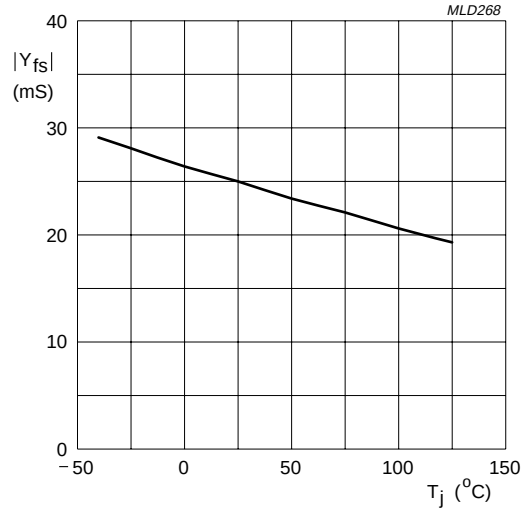
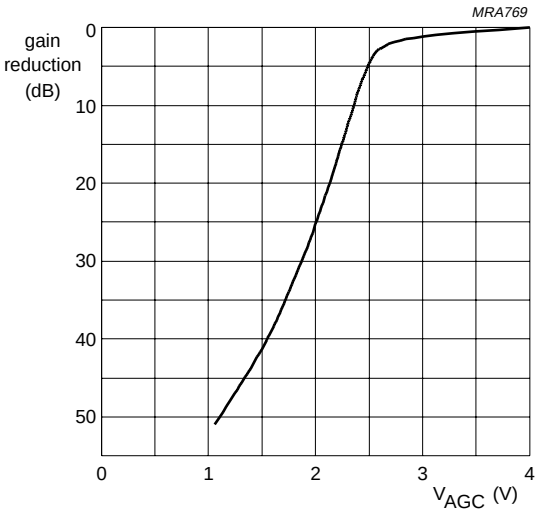
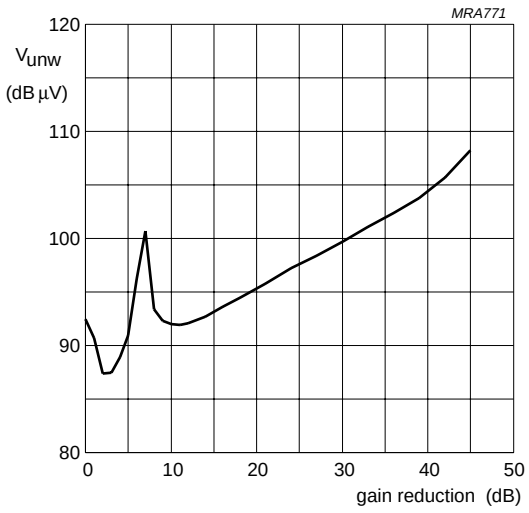



Fig.4 Transfer admittance as a function of the junction temperature; typical values.



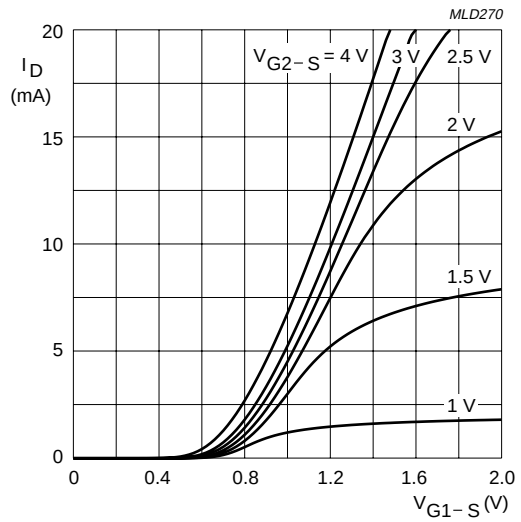

f = 50 MHz.

Fig.5 Typical gain reduction as a function of the AGC voltage.



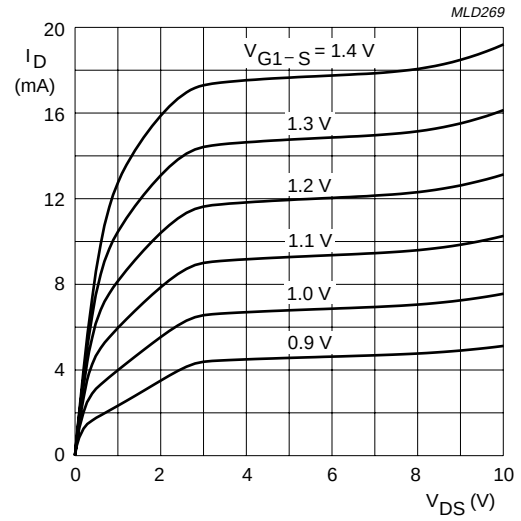

$V_{DS}$ = 5 V; $V_{GG}$ = 5 V; $f_w$ = 50 MHz.
$f_{unw}$ = 60 MHz; $T_{amb}$ = 25 °C; $R_{G1}$ = 120 kΩ.

Fig.6 Unwanted voltage for 1% cross-modulation as a function of gain reduction; typical values; see Fig.20.



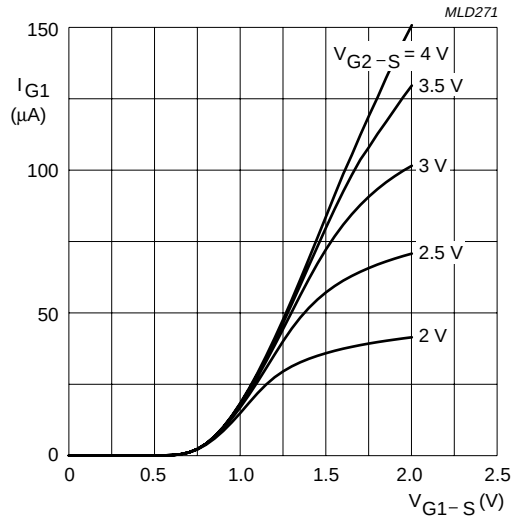

$V_{DS}$ = 5 V.
$T_j$ = 25 °C.

Fig.7 Transfer characteristics; typical values.



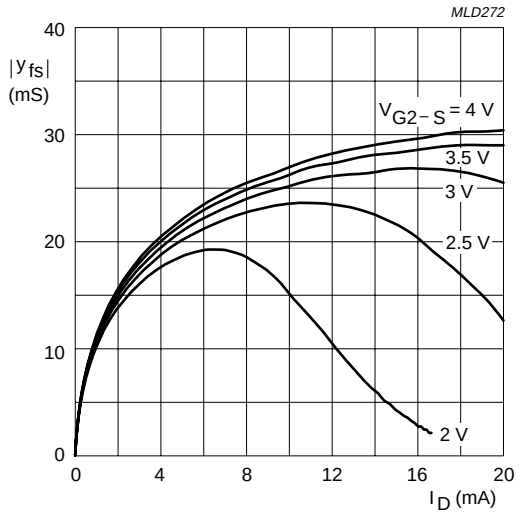

$V_{G2\text{-}S}$ = 4 V.
$T_j$ = 25 °C.

Fig.8 Output characteristics; typical values.



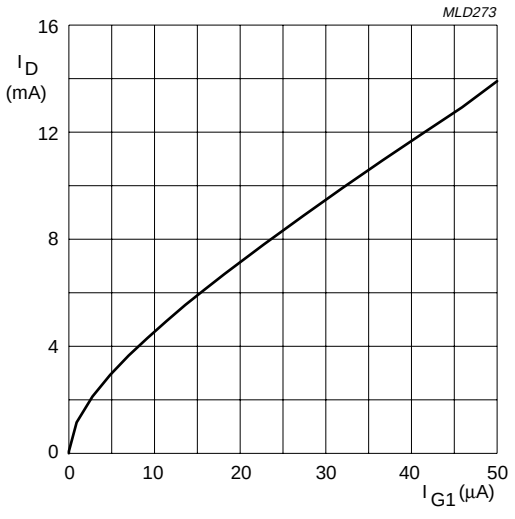

$V_{DS}$ = 5 V.
$T_j$ = 25 °C.

Fig.9 Gate 1 current as a function of gate 1 voltage; typical values.



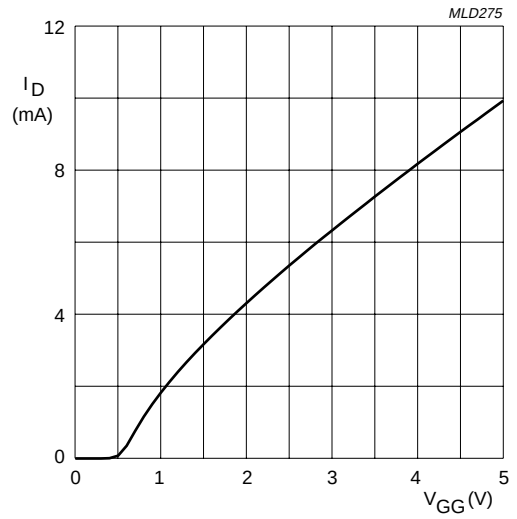

$V_{DS}$ = 5 V.
$T_j$ = 25 °C.

Fig.10 Forward transfer admittance as a function of drain current; typical values.



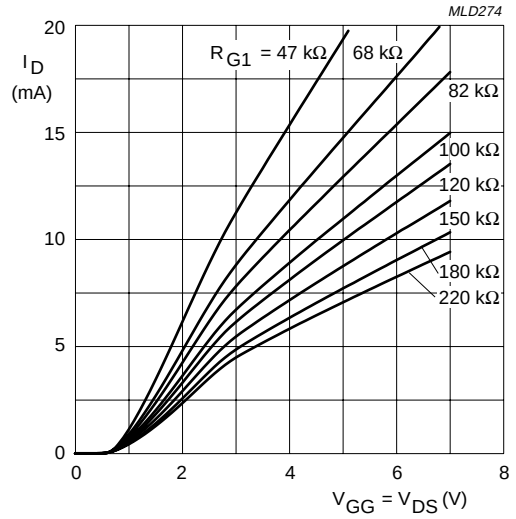

$V_{DS}$ = 5 V.
$V_{G2\text{-}S}$ = 4 V.
$T_j$ = 25 °C.

Fig.11 Drain current as a function of gate 1 current; typical values.



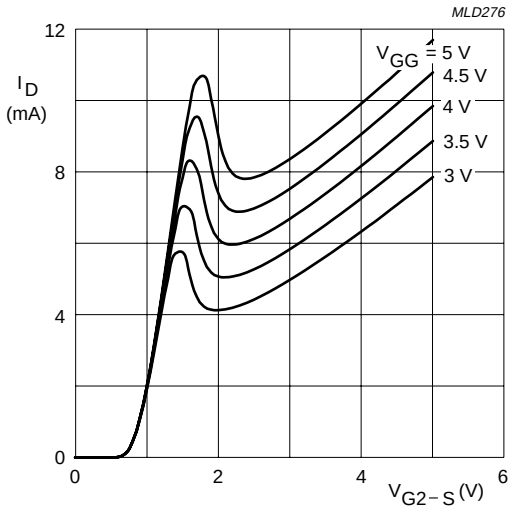

$V_{DS}$ = 5 V; $V_{G2\text{-}S}$ = 4 V.
$R_{G1}$ = 120 kΩ (connected to $V_{GG}$); $T_j$ = 25 °C.

Fig.12 Drain current as a function of gate 1 supply voltage (= $V_{GG}$); typical values; see Fig.20.



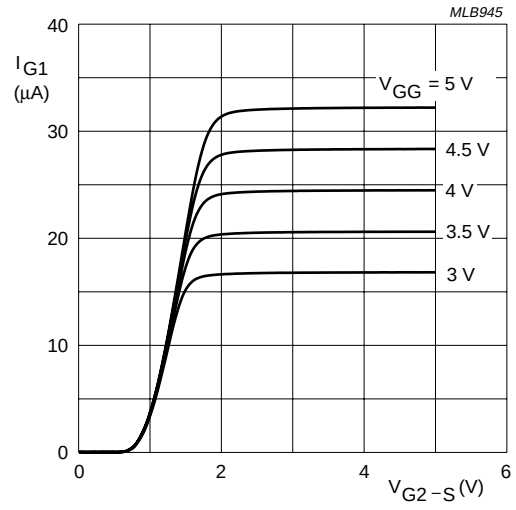

$V_{G2\text{-}S}$ = 4 V.
$R_{G1}$ connected to $V_{GG}$; $T_j$ = 25 °C.

Fig.13 Drain current as a function of gate 1 (= $V_{GG}$) and drain supply voltage; typical values; see Fig.20.



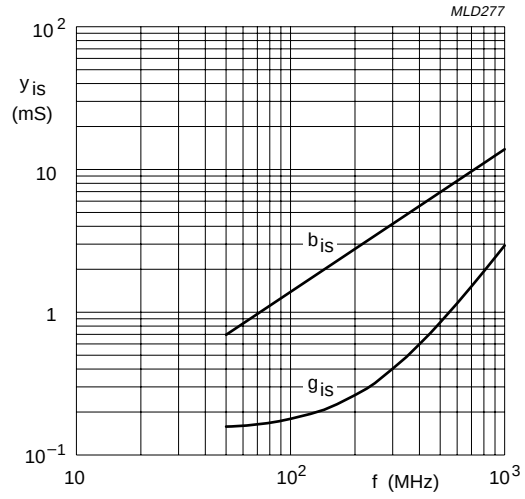

$V_{DS}$ = 5 V; $T_j$ = 25 °C.
$R_{G1}$ = 120 kΩ (connected to $V_{GG}$).

Fig.14 Drain current as a function of gate 2 voltage; typical values; see Fig.20.



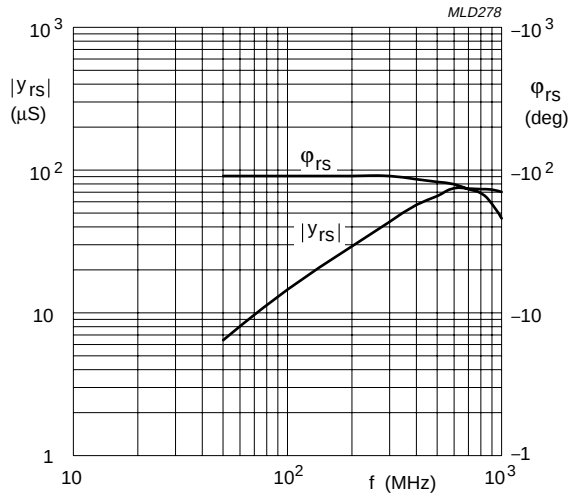

$V_{DS}$ = 5 V; $T_j$ = 25 °C.
$R_{G1}$ = 120 kΩ (connected to $V_{GG}$).

Fig.15 Gate 1 current as a function of gate 2 voltage; typical values; see Fig.20.



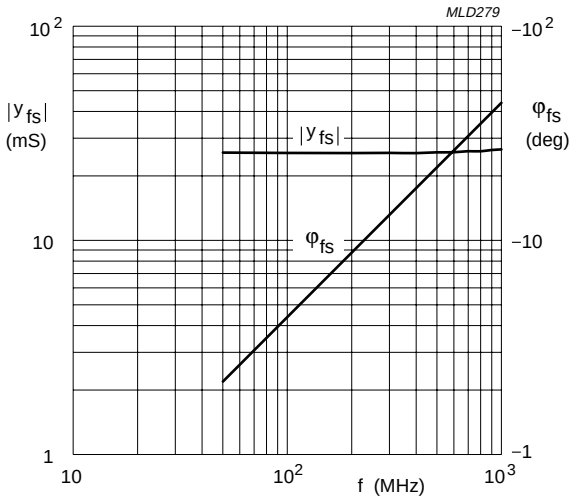

$V_{DS}$ = 5 V; $V_{G2}$ = 4 V.
$I_D$ = 15 mA; $T_{amb}$ = 25 °C.

Fig.16 Input admittance as a function of frequency; typical values.



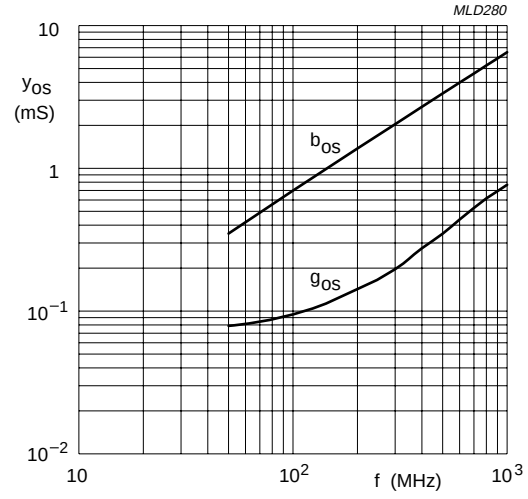

$V_{DS}$ = 5 V; $V_{G2}$ = 4 V.
$I_D$ = 15 mA; $T_{amb}$ = 25 °C.

Fig.17 Reverse transfer admittance and phase as a function of frequency; typical values.




$V_{DS}$ = 5 V; $V_{G2}$ = 4 V.
$I_D$ = 15 mA; $T_{amb}$ = 25 °C.

Fig.18 Forward transfer admittance and phase as a function of frequency; typical values.




$V_{DS}$ = 5 V; $V_{G2}$ = 4 V.
$I_D$ = 15 mA; $T_{amb}$ = 25 °C.

Fig.19 Output admittance as a function of frequency; typical values.

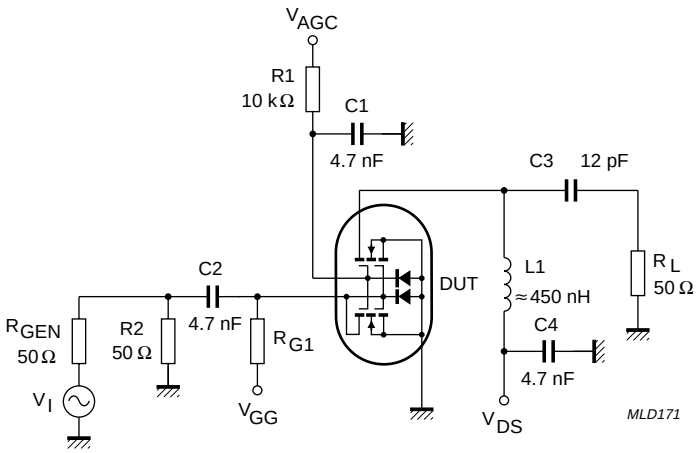



Fig.20 Cross-modulation test set-up.

**Table 1** Scattering parameters: $V_{DS}$ =5 V; $V_{G2\text{-}S}$ = 4 V; $I_D$ = 10 mA

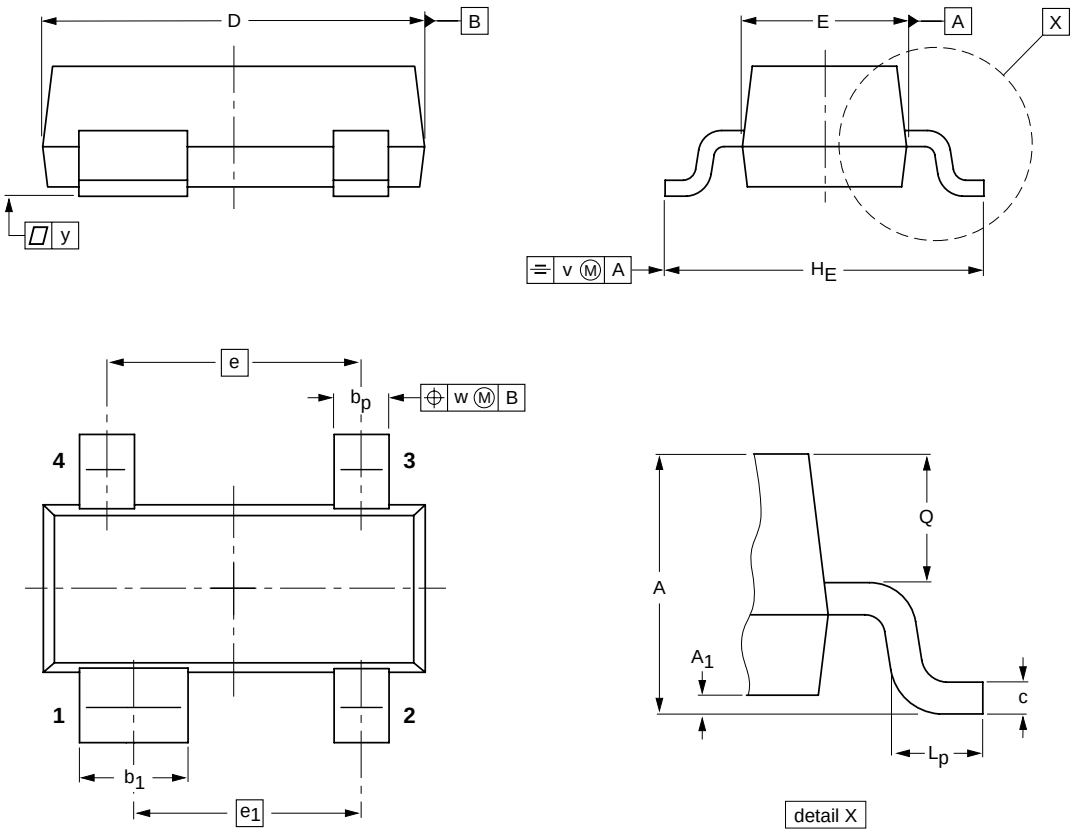
| f (MHz) | $S_{11}$ | | $S_{21}$ | | $S_{12}$ | | $S_{22}$ | |
|---|---|---|---|---|---|---|---|---|
| | MAGNITUDE (ratio) | ANGLE (deg) | MAGNITUDE (ratio) | ANGLE (deg) | MAGNITUDE (ratio) | ANGLE (deg) | MAGNITUDE (ratio) | ANGLE (deg) |
| 40 | 0.989 | –3.4 | 2.420 | 175.7 | 0.000 | 79.9 | 0.993 | –1.6 |
| 100 | 0.985 | –8.3 | 2.414 | 169.1 | 0.001 | 78.3 | 0.992 | –3.9 |
| 200 | 0.976 | –16.4 | 2.368 | 158.8 | 0.003 | 80.3 | 0.987 | –7.8 |
| 300 | 0.958 | –24.1 | 2.301 | 148.5 | 0.004 | 73.7 | 0.980 | –11.4 |
| 400 | 0.942 | –32.0 | 2.251 | 138.8 | 0.005 | 70.7 | 0.974 | –15.2 |
| 500 | 0.918 | –39.3 | 2.170 | 129.5 | 0.005 | 67.2 | 0.966 | –18.7 |
| 600 | 0.899 | –46.0 | 2.080 | 120.7 | 0.005 | 67.8 | 0.958 | –22.2 |
| 700 | 0.876 | –52.6 | 2.001 | 112.1 | 0.005 | 68.6 | 0.951 | –25.5 |
| 800 | 0.852 | –58.8 | 1.924 | 103.2 | 0.005 | 72.9 | 0.944 | –28.9 |
| 900 | 0.823 | –64.9 | 1.829 | 94.7 | 0.005 | 78.7 | 0.937 | –32.1 |
| 1000 | 0.800 | –70.9 | 1.747 | 86.5 | 0.005 | 88.3 | 0.933 | –35.2 |
| 1200 | 0.750 | –82.4 | 1.621 | 70.7 | 0.005 | 120.5 | 0.928 | –41.7 |
| 1400 | 0.719 | –92.7 | 1.535 | 54.6 | 0.008 | 139.8 | 0.930 | –48.4 |
| 1600 | 0.682 | –102.5 | 1.424 | 39.4 | 0.010 | 137.8 | 0.924 | –54.9 |
| 1800 | 0.642 | –109.8 | 1.349 | 22.5 | 0.013 | 156.8 | 0.928 | –62.9 |
| 2000 | 0.602 | –116.5 | 1.283 | 1.1 | 0.018 | 175.1 | 0.928 | –73.1 |
| 2200 | 0.547 | –124.9 | 1.130 | –15.1 | 0.014 | 172.6 | 0.887 | –81.0 |
| 2400 | 0.596 | –128.7 | 1.018 | –49.1 | 0.040 | –163.9 | 0.837 | –95.8 |
| 2600 | 0.682 | –132.6 | 0.979 | –79.4 | 0.077 | –164.0 | 0.778 | –109.6 |
| 2800 | 0.771 | –142.5 | 0.804 | –116.2 | 0.120 | 178.8 | 0.629 | –119.5 |
| 3000 | 0.793 | –157.5 | 0.541 | –153.5 | 0.149 | 158.3 | 0.479 | –119.9 |

**Table 2** Noise data: $V_{DS}$ = 5 V; $V_{G2\text{-}S}$ = 4 V; $I_D$ = 10 mA

| f (MHz) | $F_{min}$ (dB) | $\Gamma_{opt}$ | | $r_n$ |
|---|---|---|---|---|
| | | (ratio) | (deg) | |
| 800 | 2.00 | 0.686 | 49.6 | 50.40 |

## PACKAGE OUTLINES

**Plastic surface mounted package; 4 leads** **SOT143B**

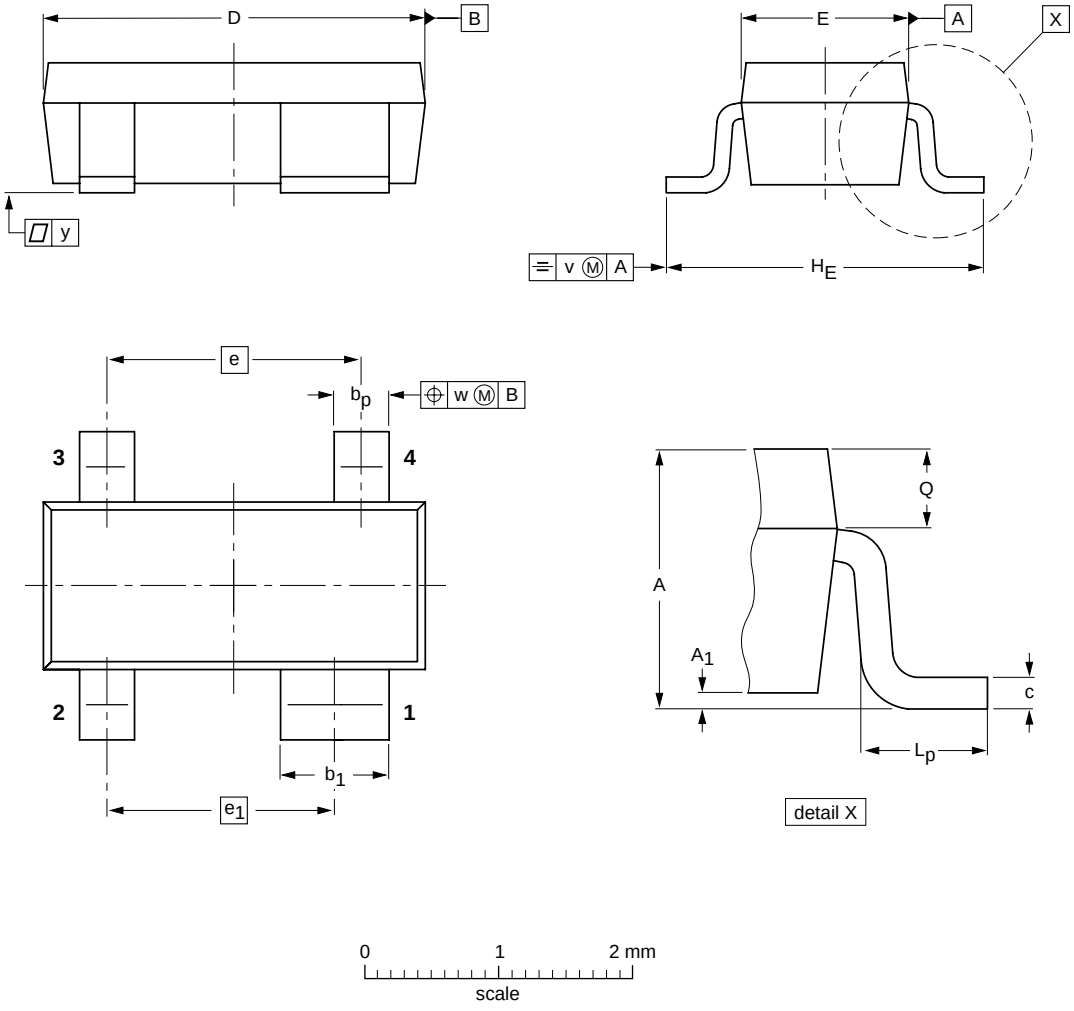



**DIMENSIONS (mm are the original dimensions)**

| UNIT | A | $A_1$ max | $b_p$ | $b_1$ | c | D | E | e | $e_1$ | $H_E$ | $L_p$ | Q | v | w | y |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 1.1<br>0.9 | 0.1 | 0.48<br>0.38 | 0.88<br>0.78 | 0.15<br>0.09 | 3.0<br>2.8 | 1.4<br>1.2 | 1.9 | 1.7 | 2.5<br>2.1 | 0.45<br>0.15 | 0.55<br>0.45 | 0.2 | 0.1 | 0.1 |

| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|---|---|---|---|---|---|---|
| | IEC | JEDEC | EIAJ | | | |
| SOT143B | | | | | | 97-02-28 |

**Plastic surface mounted package; reverse pinning; 4 leads** **SOT143R**




**DIMENSIONS (mm are the original dimensions)**

| UNIT | A | $A_1$ max | $b_p$ | $b_1$ | c | D | E | e | $e_1$ | $H_E$ | $L_p$ | Q | v | w | y |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mm | 1.1<br>0.9 | 0.1 | 0.48<br>0.38 | 0.88<br>0.78 | 0.15<br>0.09 | 3.0<br>2.8 | 1.4<br>1.2 | 1.9 | 1.7 | 2.5<br>2.1 | 0.55<br>0.25 | 0.45<br>0.25 | 0.2 | 0.1 | 0.1 |

| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|---|---|---|---|---|---|---|
| | IEC | JEDEC | EIAJ | | | |
| SOT143R | | | | | | 97-03-10 |

**DEFINITIONS**

| **Data Sheet Status** | |
|---|---|
| Objective specification | This data sheet contains target or goal specifications for product development. |
| Preliminary specification | This data sheet contains preliminary data; supplementary data may be published later. |
| Product specification | This data sheet contains final product specifications. |
| **Limiting values** | |
| Limiting values given are in accordance with the Absolute Maximum Rating System (IEC 134). Stress above one or more of the limiting values may cause permanent damage to the device. These are stress ratings only and operation of the device at these or at any other conditions above those given in the Characteristics sections of the specification is not implied. Exposure to limiting values for extended periods may affect device reliability. | |
| **Application information** | |
| Where application information is given, it is advisory and does not form part of the specification. | |

**LIFE SUPPORT APPLICATIONS**

These products are not designed for use in life support appliances, devices, or systems where malfunction of these products can reasonably be expected to result in personal injury. Philips customers using or selling these products for use in such applications do so at their own risk and agree to fully indemnify Philips for any damages resulting from such improper use or sale.

**NOTES**

**NOTES**

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