

# DATA SHEET

## **TDA8541** 1 W BTL audio amplifier

Product specification  
Supersedes data of 1997 Feb 19  
File under Integrated Circuits, IC01

1998 Apr 01

**1 W BTL audio amplifier****TDA8541****FEATURES**

- Flexibility in use
- Few external components
- Low saturation voltage of output stage
- Gain can be fixed with external resistors
- Standby mode controlled by CMOS compatible levels
- Low standby current
- No switch-on/switch-off plops
- High supply voltage ripple rejection
- Protected against electrostatic discharge
- Outputs short-circuit safe to ground,  $V_{CC}$  and across the load
- Thermally protected.

**GENERAL DESCRIPTION**

The TDA8541(T) is a one channel audio power amplifier for an output power of 1 W with an 8  $\Omega$  load at a 5 V supply. The circuit contains a BTL amplifier with a complementary PNP-NPN output stage and standby/mute logic. The TDA8541T comes in an 8 pin SO package and the TDA8541 in an 8 pin DIP package.

**APPLICATIONS**

- Portable consumer products
- Personal computers
- Telephony.

**QUICK REFERENCE DATA**

| SYMBOL    | PARAMETER                       | CONDITIONS                                           | MIN. | TYP. | MAX. | UNIT          |
|-----------|---------------------------------|------------------------------------------------------|------|------|------|---------------|
| $V_{CC}$  | supply voltage                  |                                                      | 2.2  | 5    | 18   | V             |
| $I_q$     | quiescent current               | $V_{CC} = 5\text{ V}$                                | –    | 8    | 12   | mA            |
| $I_{stb}$ | standby current                 |                                                      | –    | –    | 10   | $\mu\text{A}$ |
| $P_o$     | output power                    | THD = 10%; $R_L = 8\ \Omega$ ; $V_{CC} = 5\text{ V}$ | 1    | 1.2  | –    | W             |
| THD       | total harmonic distortion       | $P_o = 0.5\text{ W}$                                 | –    | 0.15 | –    | %             |
| SVRR      | supply voltage ripple rejection |                                                      | 50   | –    | –    | dB            |

**ORDERING INFORMATION**

| TYPE<br>NUMBER | PACKAGE |                                                           |         |
|----------------|---------|-----------------------------------------------------------|---------|
|                | NAME    | DESCRIPTION                                               | VERSION |
| TDA8541T       | SO8     | plastic small outline package; 8 leads; body width 3.9 mm | SOT96-1 |
| TDA8541        | DIP8    | plastic dual in-line package; 8 leads (300 mil)           | SOT97-1 |

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BLOCK DIAGRAM

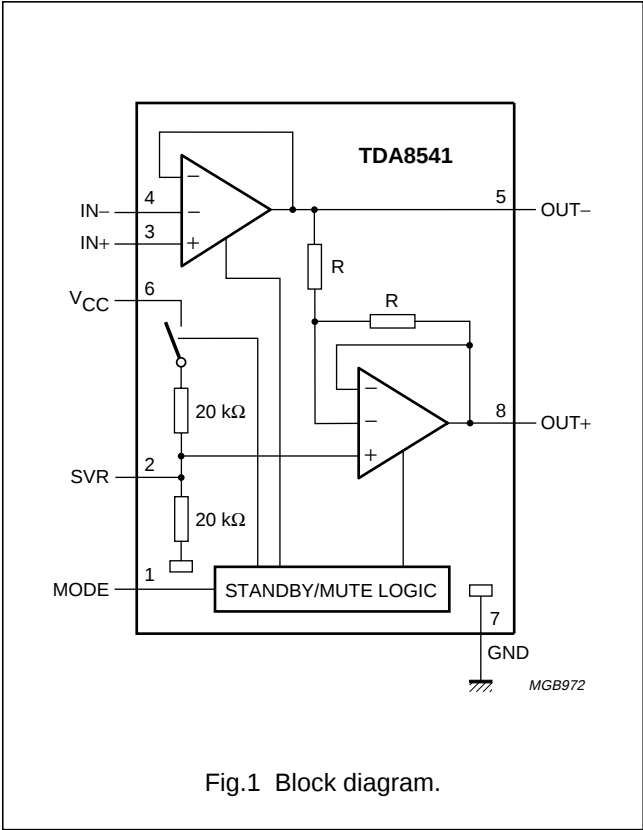


Fig.1 Block diagram.

PINNING

| SYMBOL          | PIN | DESCRIPTION                                      |
|-----------------|-----|--------------------------------------------------|
| MODE            | 1   | operating mode select (standby, mute, operating) |
| SVR             | 2   | half supply voltage, decoupling ripple rejection |
| IN+             | 3   | positive input                                   |
| IN-             | 4   | negative input                                   |
| OUT-            | 5   | negative loudspeaker terminal                    |
| V <sub>CC</sub> | 6   | supply voltage                                   |
| GND             | 7   | ground                                           |
| OUT+            | 8   | positive loudspeaker terminal                    |

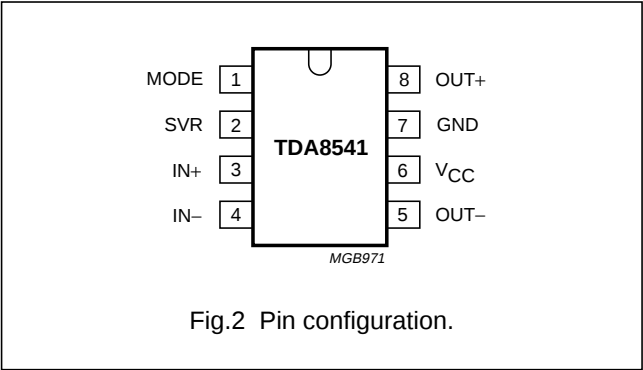


Fig.2 Pin configuration.

FUNCTIONAL DESCRIPTION

The TDA8541(T) is a BTL audio power amplifier capable of delivering 1 W output power to an 8 Ω load at THD = 10% using a 5 V power supply. Using the MODE pin the device can be switched to standby and mute condition. The device is protected by an internal thermal shutdown protection mechanism. The gain can be set within a range from 6 dB to 30 dB by external feedback resistors.

Power amplifier

The power amplifier is a Bridge Tied Load (BTL) amplifier with a complementary PNP-NPN output stage. The voltage loss on the positive supply line is the saturation voltage of a PNP power transistor, on the negative side the saturation voltage of an NPN power transistor. The total voltage loss is <1 V and with a 5 V supply voltage and an 8 Ω loudspeaker an output power of 1 W can be delivered.

Mode select pin

The device is in standby mode (with a very low current consumption) if the voltage at the MODE pin is >(V<sub>CC</sub> – 0.5 V), or if this pin is floating. At a MODE voltage level of less than 0.5 V the amplifier is fully operational. In the range between 1.5 V and V<sub>CC</sub> – 1.5 V the amplifier is in mute condition. The mute condition is useful to suppress plop noise at the output, caused by charging of the input capacitor.

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## LIMITING VALUES

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

| SYMBOL    | PARAMETER                            | CONDITIONS    | MIN. | MAX.           | UNIT |
|-----------|--------------------------------------|---------------|------|----------------|------|
| $V_{CC}$  | supply voltage                       | operating     | -0.3 | +18            | V    |
| $V_I$     | input voltage                        |               | -0.3 | $V_{CC} + 0.3$ | V    |
| $I_{ORM}$ | repetitive peak output current       |               | –    | 1              | A    |
| $T_{stg}$ | storage temperature                  | non-operating | -55  | +150           | °C   |
| $T_{amb}$ | operating ambient temperature        |               | -40  | +85            | °C   |
| $V_{psc}$ | AC and DC short-circuit safe voltage |               | –    | 10             | V    |
| $P_{tot}$ | total power dissipation              | SO8           | –    | 0.8            | W    |
|           |                                      | DIP8          | –    | 1.2            | W    |

## QUALITY SPECIFICATION

In accordance with “SNW-FQ-611-E”. The number of the quality specification can be found in the “Quality Reference Handbook”. The handbook can be ordered using the code 9397 750 00192.

## THERMAL CHARACTERISTICS

| SYMBOL        | PARAMETER                                   | CONDITIONS  | VALUE | UNIT |
|---------------|---------------------------------------------|-------------|-------|------|
| $R_{th\ j-a}$ | thermal resistance from junction to ambient | in free air |       |      |
|               | TDA8541T (SO8)                              |             | 160   | K/W  |
|               | TDA8541 (DIP8)                              |             | 100   | K/W  |

## DC CHARACTERISTICS

$V_{CC} = 5\text{ V}$ ;  $T_{amb} = 25\text{ °C}$ ;  $R_L = 8\ \Omega$ ;  $V_{MODE} = 0\text{ V}$ ; measured in test circuit Fig.3; unless otherwise specified.

| SYMBOL                  | PARAMETER                          | CONDITIONS              | MIN.           | TYP. | MAX.           | UNIT          |
|-------------------------|------------------------------------|-------------------------|----------------|------|----------------|---------------|
| $V_{CC}$                | supply voltage                     | operating               | 2.2            | 5    | 18             | V             |
| $I_q$                   | quiescent current                  | $R_L = \infty$ ; note 1 | –              | 8    | 12             | mA            |
| $I_{stb}$               | standby current                    | $V_{MODE} = V_{CC}$     | –              | –    | 10             | $\mu\text{A}$ |
| $V_O$                   | DC output voltage                  | note 2                  | –              | 2.2  | –              | V             |
| $ V_{OUT+} - V_{OUT-} $ | differential output voltage offset |                         | –              | –    | 50             | mV            |
| $I_{IN+}, I_{IN-}$      | input bias current                 |                         | –              | –    | 500            | nA            |
| $V_{MODE}$              | input voltage mode select          | operating               | 0              | –    | 0.5            | V             |
|                         |                                    | mute                    | 1.5            | –    | $V_{CC} - 1.5$ | V             |
|                         |                                    | standby                 | $V_{CC} - 0.5$ | –    | $V_{CC}$       | V             |
| $I_{MODE}$              | input current mode select          | $0 < V_{MODE} < V_{CC}$ | –              | –    | 20             | $\mu\text{A}$ |

## Notes

- With a load connected at the outputs the quiescent current will increase, the maximum of this increase being equal to the DC output offset voltage divided by  $R_L$ .
- The DC output voltage with respect to ground is approximately  $0.5 \times V_{CC}$ .

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**AC CHARACTERISTICS**

$V_{CC} = 5\text{ V}$ ;  $T_{amb} = 25\text{ }^{\circ}\text{C}$ ;  $R_L = 8\text{ }\Omega$ ;  $f = 1\text{ kHz}$ ;  $V_{MODE} = 0\text{ V}$ ; measured in test circuit Fig.3; unless otherwise specified.

| SYMBOL   | PARAMETER                        | CONDITIONS           | MIN. | TYP. | MAX. | UNIT          |
|----------|----------------------------------|----------------------|------|------|------|---------------|
| $P_o$    | output power                     | THD = 10%            | 1    | 1.2  | –    | W             |
|          |                                  | THD = 0.5%           | 0.6  | 0.9  | –    | W             |
| THD      | total harmonic distortion        | $P_o = 0.5\text{ W}$ | –    | 0.15 | 0.3  | %             |
| $G_v$    | closed loop voltage gain         | note 1               | 6    | –    | 30   | dB            |
| $Z_i$    | differential input impedance     |                      | –    | 100  | –    | $k\Omega$     |
| $V_{no}$ | noise output voltage             | note 2               | –    | –    | 100  | $\mu\text{V}$ |
| SVRR     | supply voltage ripple rejection  | note 3               | 50   | –    | –    | dB            |
|          |                                  | note 4               | 40   | –    | –    | dB            |
| $V_o$    | output voltage in mute condition | note 5               | –    | –    | 200  | $\mu\text{V}$ |

**Notes**

- Gain of the amplifier is  $2 \times R_2/R_1$  in test circuit of Fig.3.
- The noise output voltage is measured at the output in a frequency range from 20 Hz to 20 kHz (unweighted), with a source impedance of  $R_S = 0\text{ }\Omega$  at the input.
- Supply voltage ripple rejection is measured at the output, with a source impedance of  $R_S = 0\text{ }\Omega$  at the input. The ripple voltage is a sine wave with a frequency of 1 kHz and an amplitude of 100 mV (RMS), which is applied to the positive supply rail.
- Supply voltage ripple rejection is measured at the output, with a source impedance of  $R_S = 0\text{ }\Omega$  at the input. The ripple voltage is a sine wave with a frequency between 100 Hz and 20 kHz and an amplitude of 100 mV (RMS), which is applied to the positive supply rail.
- Output voltage in mute position is measured with an input voltage of 1 V (RMS) in a bandwidth of 20 kHz, so including noise.

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**TEST AND APPLICATION INFORMATION****Test conditions**

Because the application can be either Bridge-Tied Load (BTL) or Single-Ended (SE), the curves of each application are shown separately.

The thermal resistance = 100 K/W for the DIP8 envelope; the maximum sine wave power dissipation for

$T_{amb} = 25\text{ °C}$  is:

$$\frac{150 - 25}{100} = 1.25\text{ W}.$$

For  $T_{amb} = 60\text{ °C}$  the maximum total power dissipation is:

$$\frac{150 - 60}{100} = 0.9\text{ W}.$$

**BTL application**

$T_{amb} = 25\text{ °C}$  if not specially mentioned,  $V_{CC} = 5\text{ V}$ ,  $f = 1\text{ kHz}$ ,  $R_L = 8\text{ }\Omega$ ,  $G_v = 20\text{ dB}$ , audio band-pass 22 Hz to 22 kHz.

The BTL application diagram is shown in Fig.3.

The quiescent current has been measured without any load impedance. The total harmonic distortion as a function of frequency was measured with a low-pass filter of 80 kHz. The value of capacitor C2 influences the behaviour of the SVRR at low frequencies, increasing the value of C2 increases the performance of the SVRR.

The figure of the mode select voltage ( $V_{ms}$ ) as a function of the supply voltage shows three areas; operating, mute and standby. It shows, that the DC-switching levels of the mute and standby respectively depends on the supply voltage level.

**SE application**

$T_{amb} = 25\text{ °C}$  if not specially mentioned,  $V_{CC} = 7.5\text{ V}$ ,  $f = 1\text{ kHz}$ ,  $R_L = 4\text{ }\Omega$ ,  $G_v = 20\text{ dB}$ , audio band-pass 22 Hz to 22 kHz.

The SE application diagram is shown in Fig.13.

The capacitor value of C3 in combination with the load impedance determines the low frequency behaviour. The total harmonic distortion as a function of frequency was measured with low-pass filter of 80 kHz. The value of capacitor C2 influences the behaviour of the SVRR at low frequencies, increasing the value of C2 increases the performance of the SVRR.

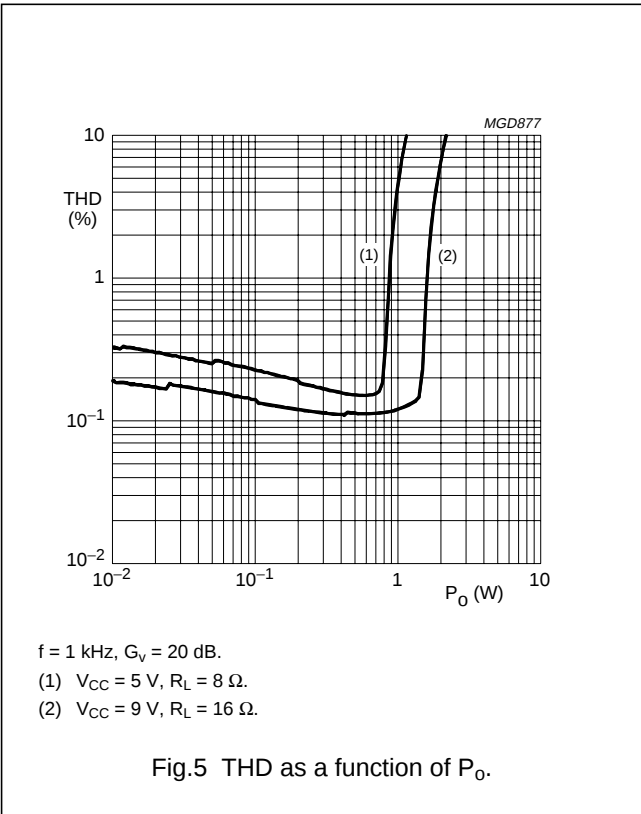
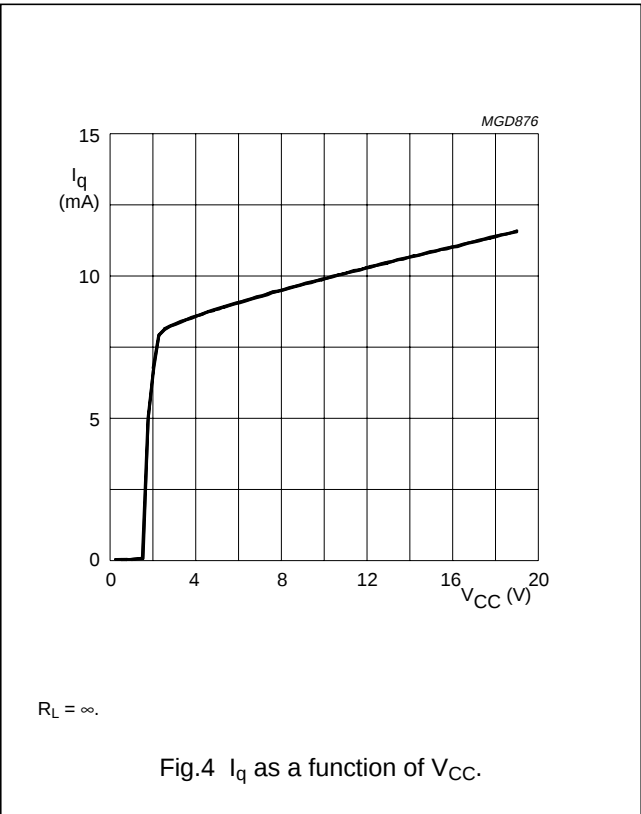
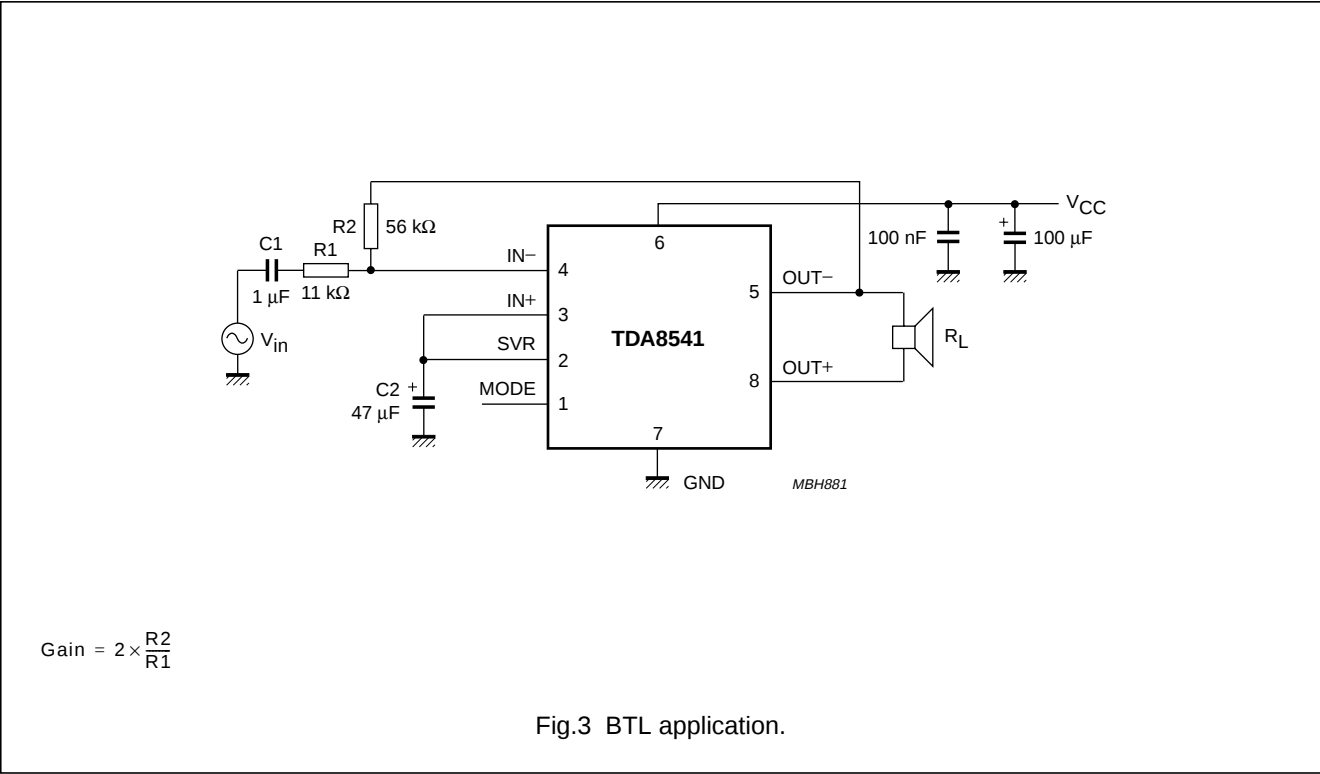
**General remark**

The frequency characteristic can be adapted by connecting a small capacitor across the feedback resistor. To improve the immunity of HF radiation in radio circuit applications, a small capacitor can be connected in parallel with the feedback resistor (56 k $\Omega$ ); this creates a low-pass filter.

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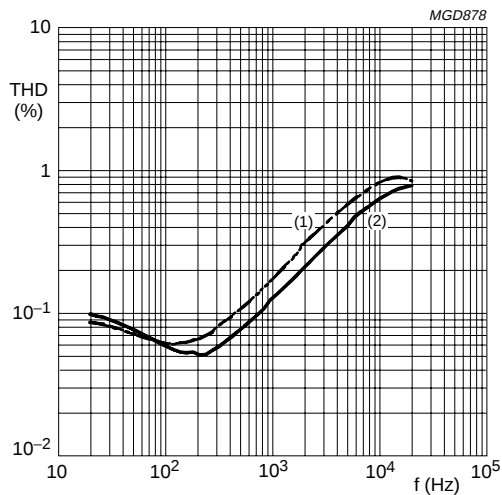
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BTL APPLICATION



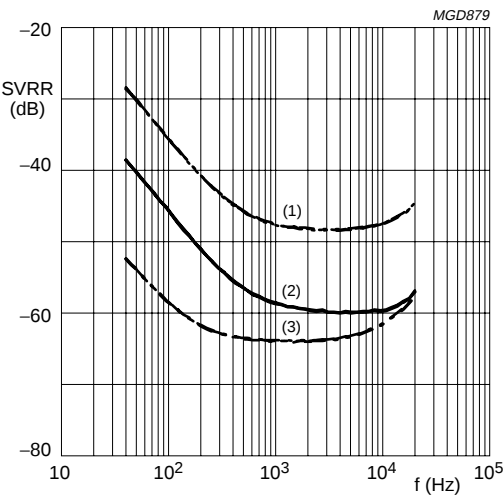
1 W BTL audio amplifier

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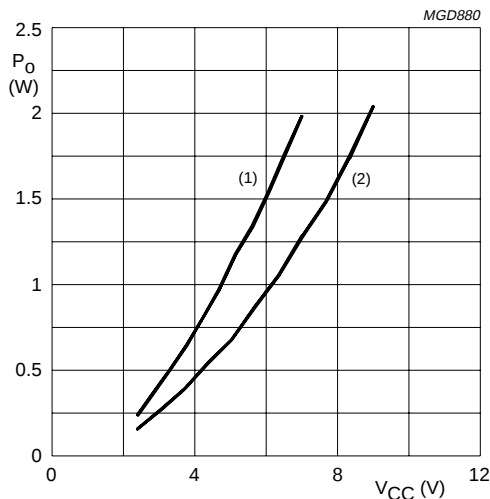
$P_o = 0.5 \text{ W}$ ,  $G_v = 20 \text{ dB}$ .  
(1)  $V_{CC} = 5 \text{ V}$ ,  $R_L = 8 \Omega$ .  
(2)  $V_{CC} = 9 \text{ V}$ ,  $R_L = 16 \Omega$ .

Fig.6 THD as a function of frequency.



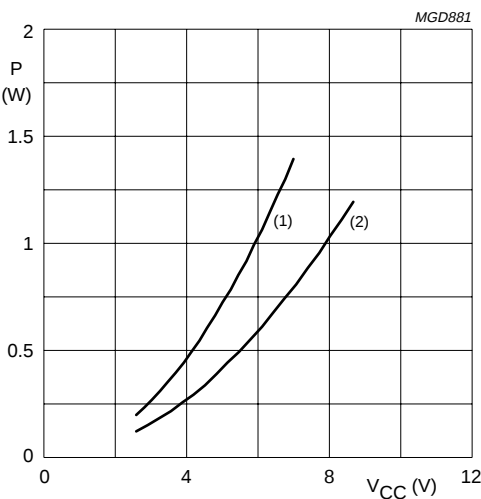
$V_{CC} = 5 \text{ V}$ ,  $8 \Omega$ ,  $R_s = 0 \Omega$ ,  $V_i = 100 \text{ mV}$ .  
(1)  $G_v = 30 \text{ dB}$ .  
(2)  $G_v = 20 \text{ dB}$ .  
(3)  $G_v = 6 \text{ dB}$ .

Fig.7 SVRR as a function of frequency.



THD = 10%.  
(1)  $R_L = 8 \Omega$ .  
(2)  $R_L = 16 \Omega$ .

Fig.8  $P_o$  as a function of  $V_{CC}$ .

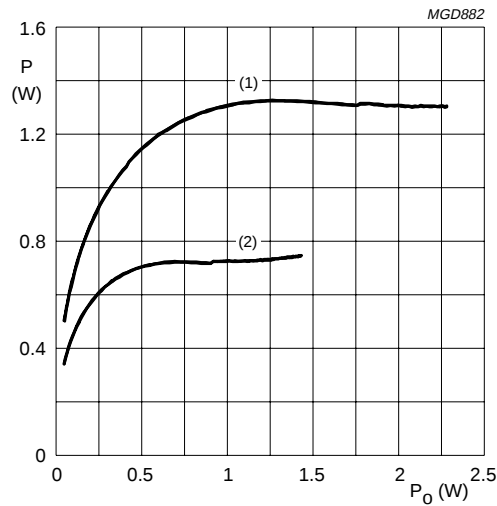


(1)  $R_L = 8 \Omega$ .  
(2)  $R_L = 16 \Omega$ .

Fig.9 Worst case power dissipation as a function of  $V_{CC}$ .

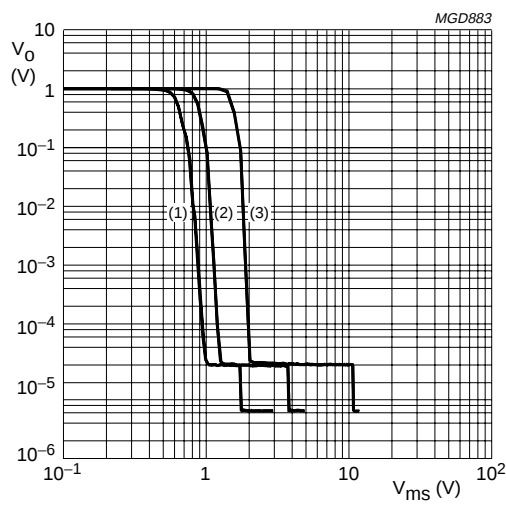
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Sine wave of 1 kHz.  
(1)  $V_{CC} = 9\text{ V}$ ,  $R_L = 16\ \Omega$ .  
(2)  $V_{CC} = 5\text{ V}$ ,  $R_L = 8\ \Omega$ .

Fig.10  $P$  as a function of  $P_O$ .



Band-pass = 22 Hz to 22 kHz.  
(1)  $V_{CC} = 3\text{ V}$ .  
(2)  $V_{CC} = 5\text{ V}$ .  
(3)  $V_{CC} = 12\text{ V}$ .

Fig.11  $V_O$  as a function of  $V_{ms}$ .

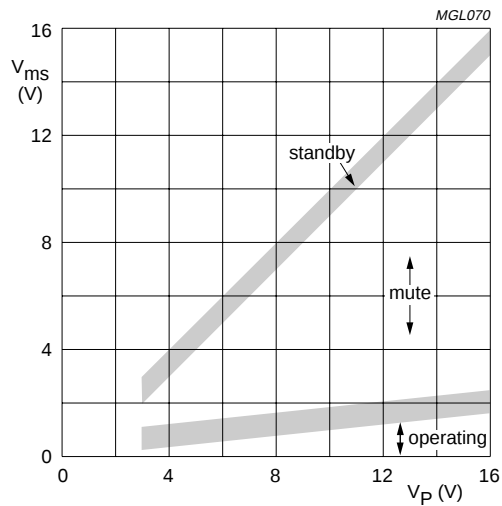
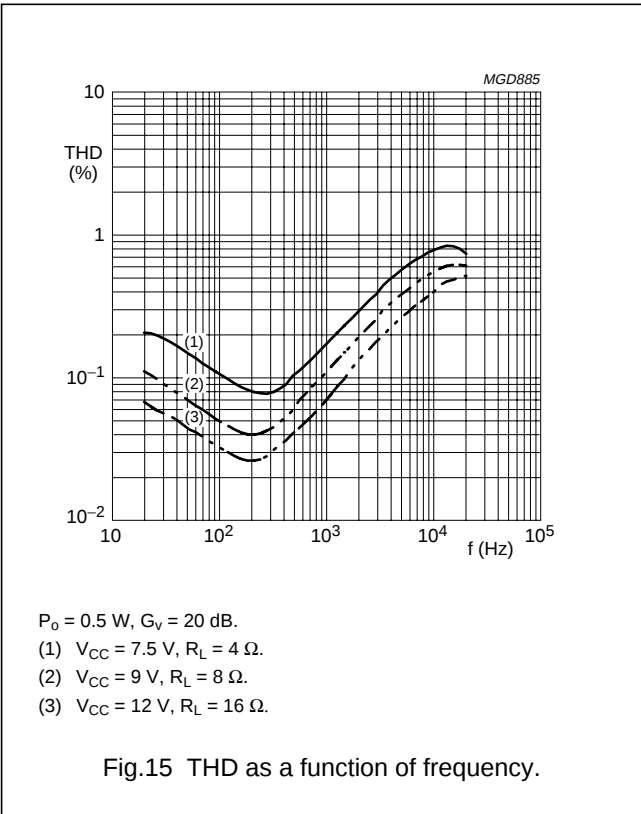
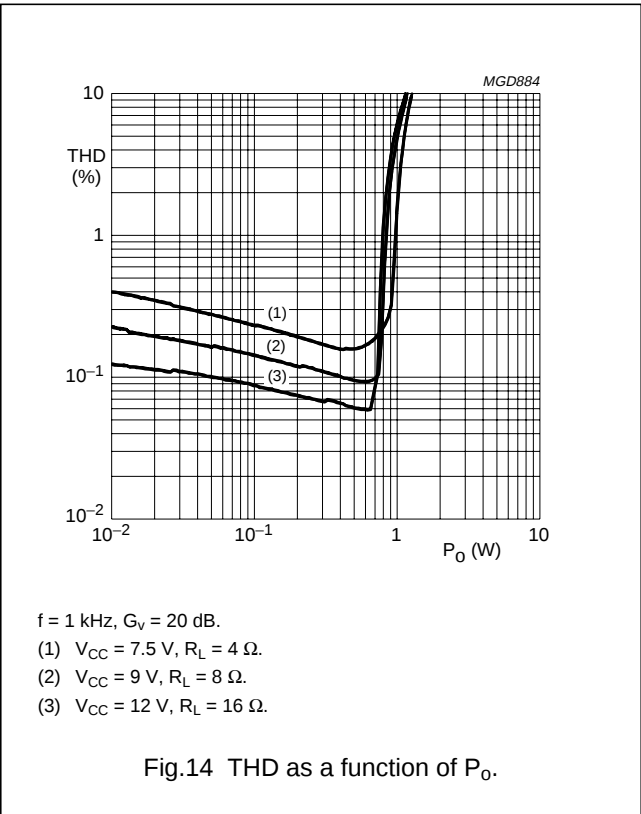
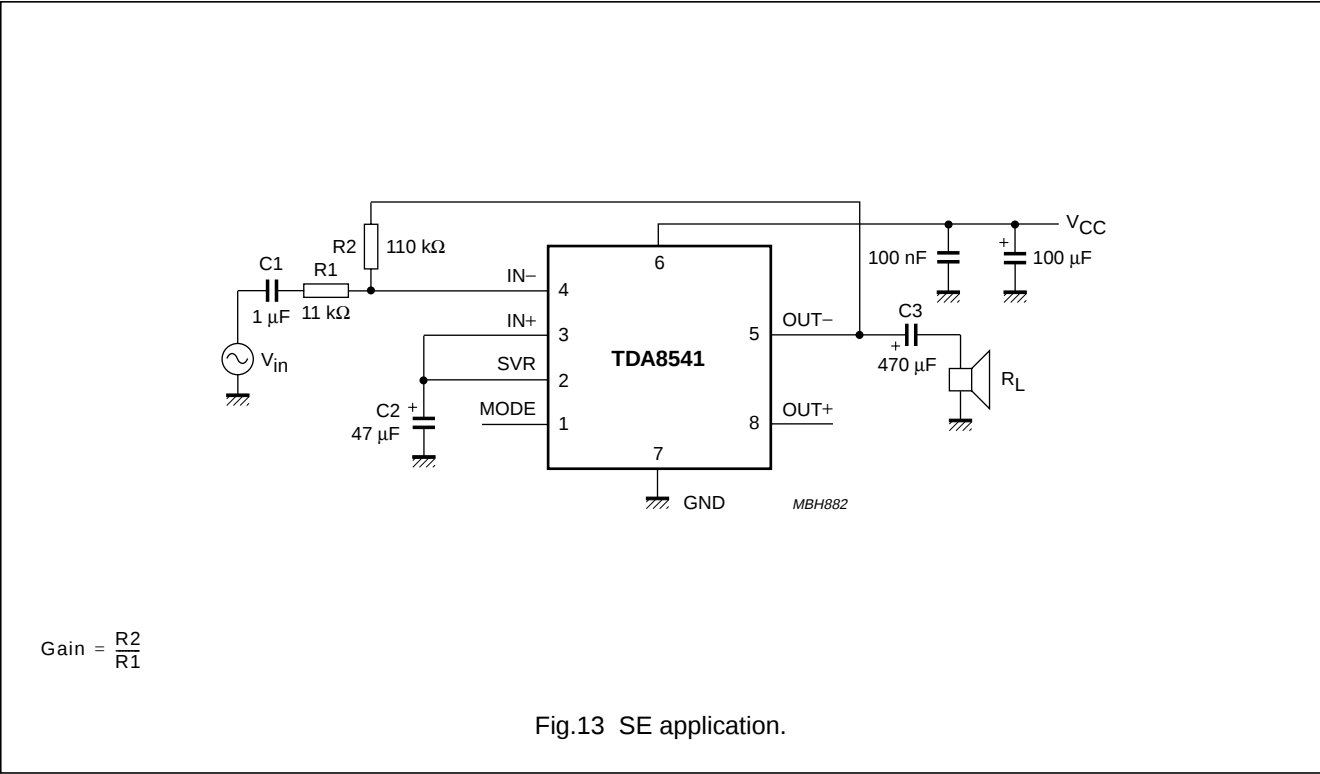


Fig.12  $V_{ms}$  as a function of  $V_P$ .

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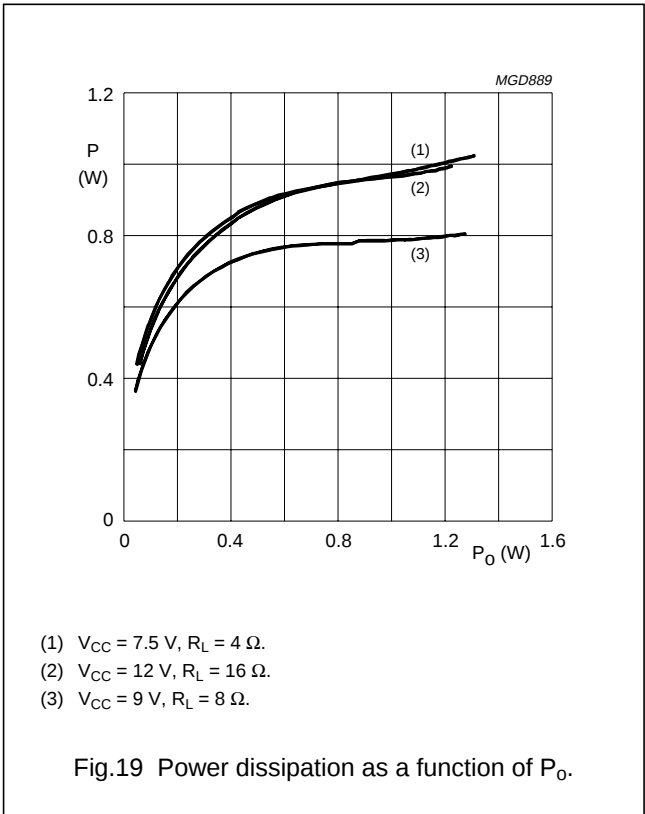
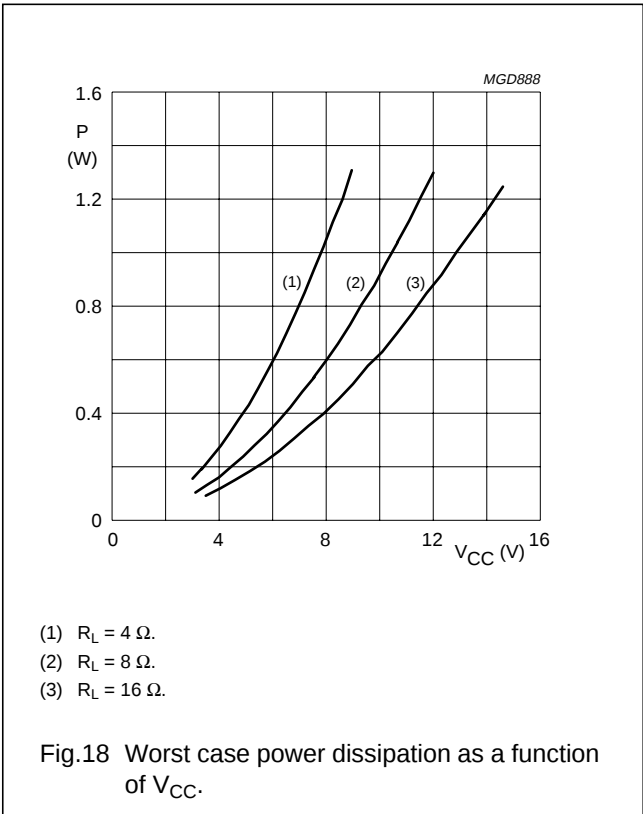
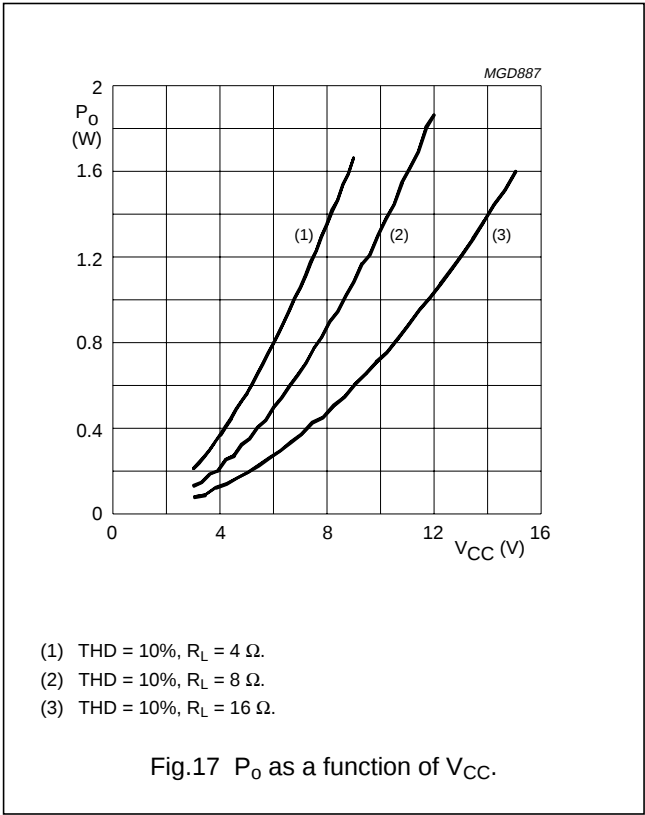
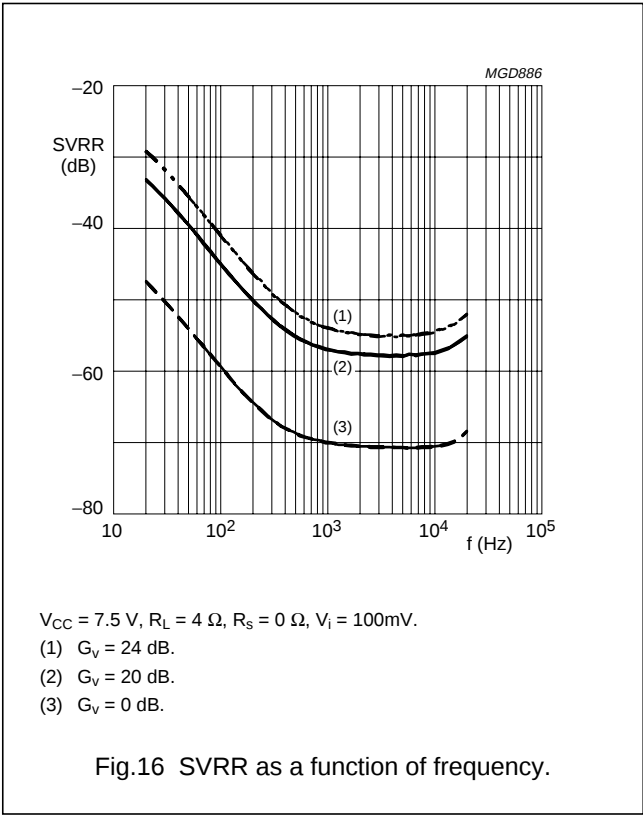
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SE APPLICATION



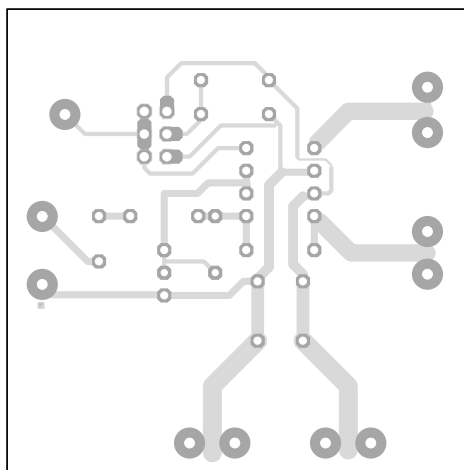
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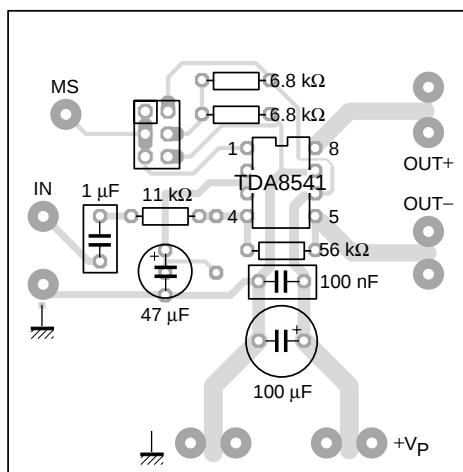


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a. Top view.



MBH920

b. Component side.

Fig.20 Printed-circuit board layout (BTL and SE).

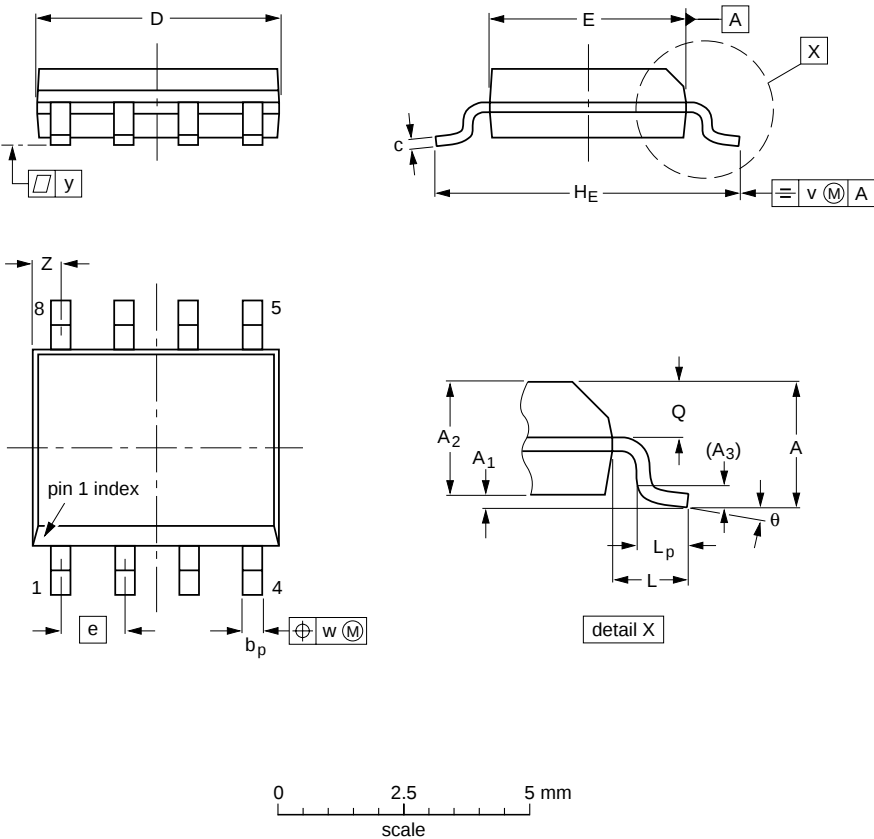
1 W BTL audio amplifier

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PACKAGE OUTLINES

SO8: plastic small outline package; 8 leads; body width 3.9 mm

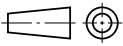
SOT96-1



DIMENSIONS (inch dimensions are derived from the original mm dimensions)

| UNIT   | A<br>max. | A <sub>1</sub> | A <sub>2</sub> | A <sub>3</sub> | b <sub>p</sub> | c                | D <sup>(1)</sup> | E <sup>(2)</sup> | e     | H <sub>E</sub> | L     | L <sub>p</sub> | Q              | v    | w    | y     | z <sup>(1)</sup> | θ        |
|--------|-----------|----------------|----------------|----------------|----------------|------------------|------------------|------------------|-------|----------------|-------|----------------|----------------|------|------|-------|------------------|----------|
| mm     | 1.75      | 0.25<br>0.10   | 1.45<br>1.25   | 0.25           | 0.49<br>0.36   | 0.25<br>0.19     | 5.0<br>4.8       | 4.0<br>3.8       | 1.27  | 6.2<br>5.8     | 1.05  | 1.0<br>0.4     | 0.7<br>0.6     | 0.25 | 0.25 | 0.1   | 0.7<br>0.3       | 8°<br>0° |
| inches | 0.069     | 0.010<br>0.004 | 0.057<br>0.049 | 0.01           | 0.019<br>0.014 | 0.0100<br>0.0075 | 0.20<br>0.19     | 0.16<br>0.15     | 0.050 | 0.244<br>0.228 | 0.041 | 0.039<br>0.016 | 0.028<br>0.024 | 0.01 | 0.01 | 0.004 | 0.028<br>0.012   |          |

- Notes
1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.
  2. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

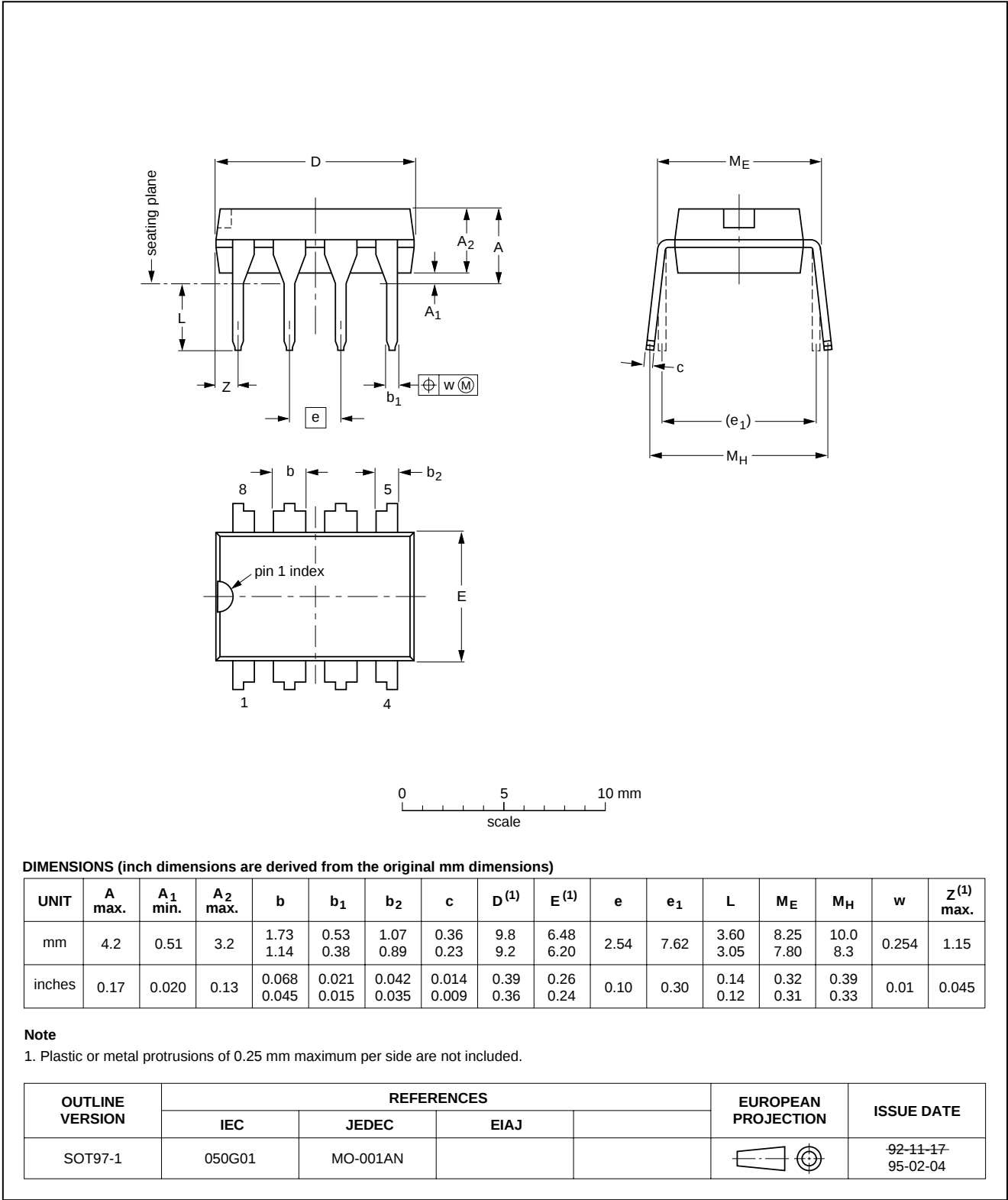
| OUTLINE<br>VERSION | REFERENCES |          |      |  | EUROPEAN<br>PROJECTION                                                                | ISSUE DATE           |
|--------------------|------------|----------|------|--|---------------------------------------------------------------------------------------|----------------------|
|                    | IEC        | JEDEC    | EIAJ |  |                                                                                       |                      |
| SOT96-1            | 076E03S    | MS-012AA |      |  |  | 95-02-04<br>97-05-22 |

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DIP8: plastic dual in-line package; 8 leads (300 mil)

SOT97-1



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## SOLDERING

### Introduction

There is no soldering method that is ideal for all IC packages. Wave soldering is often preferred when through-hole and surface mounted components are mixed on one printed-circuit board. However, wave soldering is not always suitable for surface mounted ICs, or for printed-circuits with high population densities. In these situations reflow soldering is often used.

This text gives a very brief insight to a complex technology. A more in-depth account of soldering ICs can be found in our *"IC Package Databook"* (order code 9398 652 90011).

### DIP

#### SOLDERING BY DIPPING OR BY WAVE

The maximum permissible temperature of the solder is 260 °C; solder at this temperature must not be in contact with the joint for more than 5 seconds. The total contact time of successive solder waves must not exceed 5 seconds.

The device may be mounted up to the seating plane, but the temperature of the plastic body must not exceed the specified maximum storage temperature ( $T_{stg\ max}$ ). If the printed-circuit board has been pre-heated, forced cooling may be necessary immediately after soldering to keep the temperature within the permissible limit.

#### REPAIRING SOLDERED JOINTS

Apply a low voltage soldering iron (less than 24 V) to the lead(s) of the package, below the seating plane or not more than 2 mm above it. If the temperature of the soldering iron bit is less than 300 °C it may remain in contact for up to 10 seconds. If the bit temperature is between 300 and 400 °C, contact may be up to 5 seconds.

### SO

#### REFLOW SOLDERING

Reflow soldering techniques are suitable for all SO packages.

Reflow soldering requires solder paste (a suspension of fine solder particles, flux and binding agent) to be applied to the printed-circuit board by screen printing, stencilling or pressure-syringe dispensing before package placement.

Several techniques exist for reflowing; for example, thermal conduction by heated belt. Dwell times vary between 50 and 300 seconds depending on heating method. Typical reflow temperatures range from 215 to 250 °C.

Preheating is necessary to dry the paste and evaporate the binding agent. Preheating duration: 45 minutes at 45 °C.

#### WAVE SOLDERING

Wave soldering techniques can be used for all SO packages if the following conditions are observed:

- A double-wave (a turbulent wave with high upward pressure followed by a smooth laminar wave) soldering technique should be used.
- The longitudinal axis of the package footprint must be parallel to the solder flow.
- The package footprint must incorporate solder thieves at the downstream end.

During placement and before soldering, the package must be fixed with a droplet of adhesive. The adhesive can be applied by screen printing, pin transfer or syringe dispensing. The package can be soldered after the adhesive is cured.

Maximum permissible solder temperature is 260 °C, and maximum duration of package immersion in solder is 10 seconds, if cooled to less than 150 °C within 6 seconds. Typical dwell time is 4 seconds at 250 °C.

A mildly-activated flux will eliminate the need for removal of corrosive residues in most applications.

#### REPAIRING SOLDERED JOINTS

Fix the component by first soldering two diagonally-opposite end leads. Use only a low voltage soldering iron (less than 24 V) applied to the flat part of the lead. Contact time must be limited to 10 seconds at up to 300 °C. When using a dedicated tool, all other leads can be soldered in one operation within 2 to 5 seconds between 270 and 320 °C.

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**DEFINITIONS**

| <b>Data sheet status</b>                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                                                       |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| 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.                                |
| <b>Limiting values</b>                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                                                       |
| 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. |                                                                                       |
| <b>Application information</b>                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                       |
| 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.

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1 W BTL audio amplifier

TDA8541

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**NOTES**

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1 W BTL audio amplifier

TDA8541

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1 W BTL audio amplifier

TDA8541

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**NOTES**

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