

DATA SHEET

TDA1564J

Run-cool stereo power amplifier

Preliminary specification
File under Integrated Circuits, IC01

2002 Jan 14

Run-cool stereo power amplifier

TDA1564J

FEATURES

- Low dissipation due to switching from Single-Ended (SE) to Bridge-Tied Load (BTL) mode
- Differential inputs with high Common Mode Rejection Ratio (CMRR)
- Mute/standby/operating (mode select pin)
- Load dump protection circuit
- Short-circuit safe to ground, to supply voltage and across load
- Loudspeaker protection circuit
- Offset detection for each channel
- Device switches to single-ended operation at excessive junction temperatures
- Thermal protection at high junction temperature (170°C)
- Clip detection at THD = 2.5%
- Diagnostic information (clip/protection/prewarning/offset).

GENERAL DESCRIPTION

The TDA1564J is a monolithic power amplifier in a 17-lead single-in-line (SIL) plastic power package. It contains two identical 25 W amplifiers. The dissipation is minimized by switching from SE to BTL mode, only when a higher output voltage swing is needed. The device is primarily developed for car radio applications.

QUICK REFERENCE DATA

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|----------------|---------------------------------|--|------|------|------|------------|
| V_P | supply voltage | DC biased | 6.0 | 14.4 | 18 | V |
| | | non-operating | – | – | 30 | V |
| | | load dump | – | – | 45 | V |
| I_{ORM} | repetitive peak output current | | – | – | 4 | A |
| $I_{q(tot)}$ | total quiescent current | $R_L = \infty$ | – | 95 | 150 | mA |
| I_{stb} | standby current | | – | 1 | 50 | μ A |
| $ Z_i $ | input impedance | | 90 | 120 | 150 | k Ω |
| P_o | output power | $R_L = 4 \Omega$; EIAJ | – | 38 | – | W |
| | | $R_L = 4 \Omega$; THD = 10% | 23 | 25 | – | W |
| | | $R_L = 4 \Omega$; THD = 2.5% | 18 | 20 | – | W |
| G_v | voltage gain | | 25 | 26 | 27 | dB |
| CMRR | common mode rejection ratio | $f = 1 \text{ kHz}$; $R_s = 0 \Omega$ | – | 80 | – | dB |
| SVRR | supply voltage ripple rejection | $f = 1 \text{ kHz}$; $R_s = 0 \Omega$ | 45 | 65 | – | dB |
| $ \Delta V_O $ | DC output offset voltage | | – | – | 100 | mV |
| α_{cs} | channel separation | $R_s = 0 \Omega$ | 40 | 70 | – | dB |
| $ \Delta G_v $ | channel unbalance | | – | – | 1 | dB |

ORDERING INFORMATION

| TYPE NUMBER | PACKAGE | | |
|-------------|---------|--|----------|
| | NAME | DESCRIPTION | VERSION |
| TDA1564J | DBS17P | plastic DIL-bent-SIL power package; 17 leads (lead length 12 mm) | SOT243-1 |

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BLOCK DIAGRAM

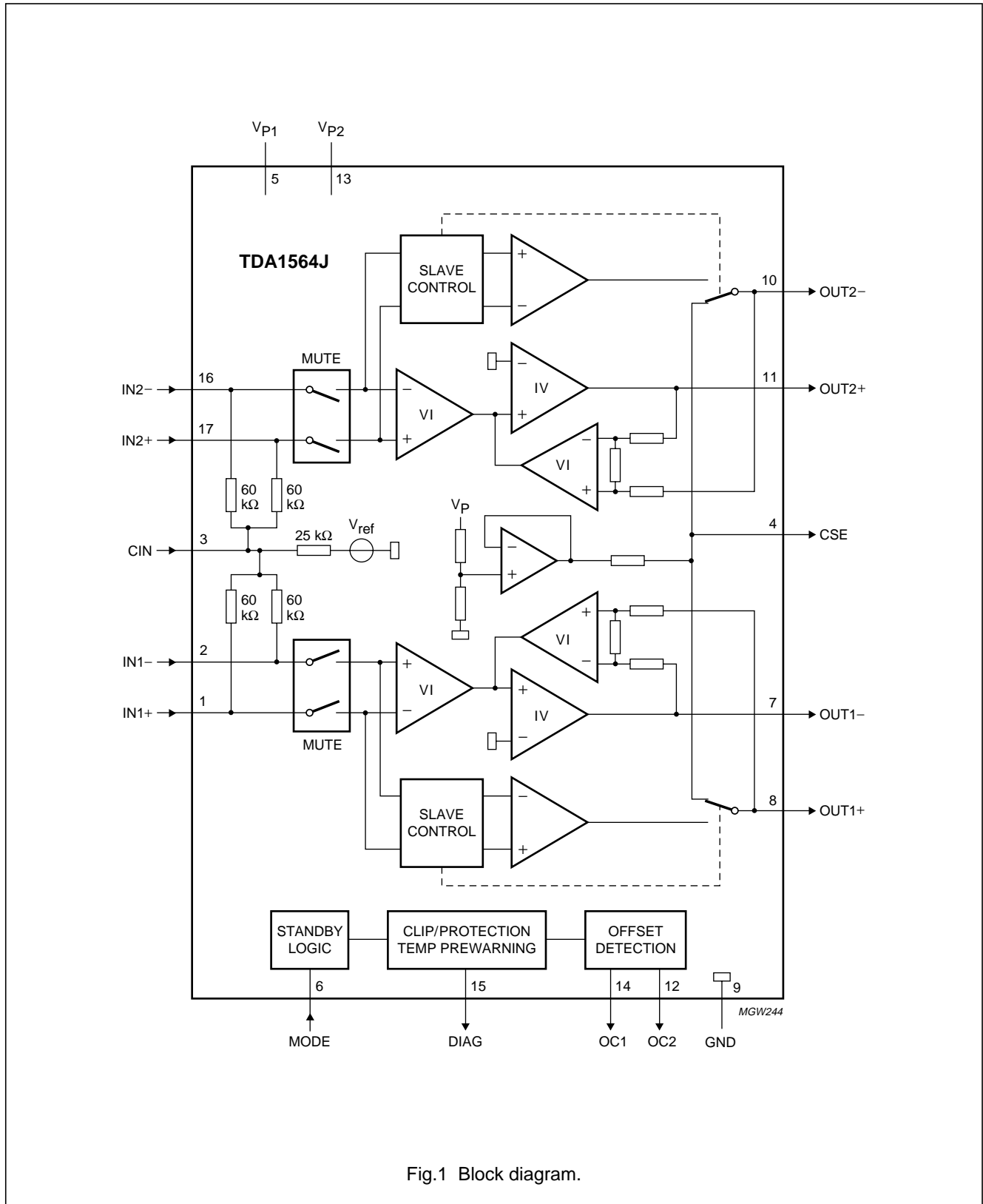


Fig.1 Block diagram.

Run-cool stereo power amplifier

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PINNING

| SYMBOL | PIN | DESCRIPTION |
|-----------------|-----|---|
| IN1+ | 1 | non-inverting input 1 |
| IN1- | 2 | inverting input 1 |
| CIN | 3 | common input |
| CSE | 4 | electrolytic capacitor for single-ended (SE) mode |
| V _{P1} | 5 | supply voltage 1 |
| MODE | 6 | mute/standby/operating |
| OUT1- | 7 | inverting output 1 |
| OUT1+ | 8 | non-inverting output 1 |
| GND | 9 | ground |
| OUT2- | 10 | inverting output 2 |
| OUT2+ | 11 | non-inverting output 2 |
| OC2 | 12 | offset capacitor 2 |
| V _{P2} | 13 | supply voltage 2 |
| OC1 | 14 | offset capacitor 1 |
| DIAG | 15 | diagnostic |
| IN2- | 16 | inverting input 2 |
| IN2+ | 17 | non-inverting input 2 |

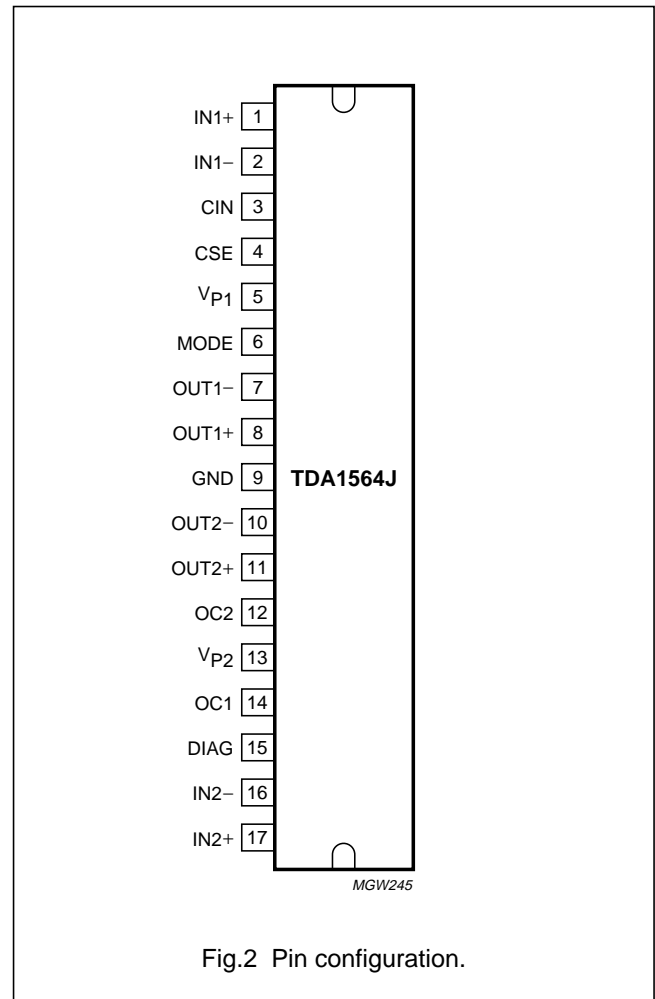


Fig.2 Pin configuration.

Run-cool stereo power amplifier

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FUNCTIONAL DESCRIPTION

The TDA1564J contains two identical amplifiers with differential inputs. At low output power [up to output amplitudes of 3 V (RMS) at $V_P = 14.4$ V], the device operates as a normal SE amplifier. When a larger output voltage swing is needed, the circuit switches internally to BTL operation.

With a sine wave input signal, the dissipation of a conventional BTL amplifier (up to 2 W output power) is more than twice the dissipation of the TDA1564J; see Fig.10.

In normal use, when the amplifier is driven with music-like signals, the high (BTL) output power is only needed for a small percentage of time. Assuming that a music signal has a normal (Gaussian) amplitude distribution, the dissipation of a conventional BTL amplifier with the same output power is approximately 70% higher (see Fig.11).

The heatsink has to be designed for use with music signals. With such a heatsink, the thermal protection will disable the BTL mode when the junction temperature exceeds 150 °C. In this case, the output power is limited to 5 W per amplifier.

The gain of each amplifier is internally fixed at 26 dB. The device can be switched to the following modes via the MODE pin:

- Standby with low standby current (<50 μ A)
- Mute condition, DC adjusted
- On, operation.

The device is fully protected against a short-circuit of the output pins to ground and to the supply voltage. It is also protected against a short-circuit of the loudspeaker and against high junction temperatures. In the event of a permanent short-circuit condition to ground or the supply voltage, the output stage will be switched off, causing low dissipation. With a permanent short-circuit of the loudspeaker, the output stage will be repeatedly switched on and off. The duty cycle in the 'on' condition is low enough to prevent excessive dissipation.

The device also has two independent DC offset detection circuits that can detect DC output voltages across the speakers. With a DC offset greater than 2 V, a warning is given on the diagnostic pin. There will be no internal shutdown with DC offsets.

When the supply voltage drops below 6 V (e.g. engine start), the circuit mutes immediately, avoiding clicks from the electronic circuit preceding the power amplifier.

The voltage of the SE electrolytic capacitor (pin 4) is kept at $0.5V_P$ by means of a voltage buffer (see Fig.1). The value of this capacitor has an important influence on the output power in SE mode, especially at low signal frequencies. A high value is recommended to minimize dissipation at low frequencies.

The diagnostic output is an open-collector output and requires a pull-up resistor. It gives the following outputs:

- Clip detection at THD = 2.5%
- Short-circuit protection:
 - When a short-circuit occurs (for at least 10 μ s) at the outputs to ground or the supply voltage, the output stages are switched off to prevent excessive dissipation; the outputs are switched on again approximately 500 ms after the short-circuit is removed, during this short-circuit condition the protection pin is LOW
 - When a short-circuit occurs across the load (for at least 10 μ s), the output stages are switched off for approximately 500 ms; after this time, a check is made to see whether the short-circuit is still present
 - The power dissipation in any short-circuit condition is very low.
- During start-up/shutdown, when the product is internally muted
- Temperature prewarning:
 - A prewarning (junction temperature > 145 °C) indicates that the temperature protection will become active. The prewarning can be used to reduce the input signal and thus reduce the power dissipation
- Offset detection:
 - One of the channels has a DC output voltage greater than 2 V.

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LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 60134).

| SYMBOL | PARAMETER | CONDITIONS | MIN. | MAX. | UNIT |
|--------------------|--------------------------------|------------------------------------|------|------|------|
| V _P | supply voltage | operating | – | 18 | V |
| | | non-operating | – | 30 | V |
| | | load dump; t _r > 2.5 ms | – | 45 | V |
| V _{P(sc)} | short-circuit safe voltage | | – | 18 | V |
| V _{rp} | reverse polarity voltage | | – | 6 | V |
| I _{ORM} | repetitive peak output current | | – | 4 | A |
| P _{tot} | total power dissipation | | – | 60 | W |
| T _{stg} | storage temperature | | –55 | +150 | °C |
| T _{vj} | virtual junction temperature | | – | 150 | °C |
| T _{amb} | ambient temperature | | –40 | – | °C |

THERMAL CHARACTERISTICS

| SYMBOL | PARAMETER | CONDITIONS | VALUE | UNIT |
|----------------------|---|-------------|-------|------|
| R _{th(j-c)} | thermal resistance from junction to case | note 1 | 1.3 | K/W |
| R _{th(j-a)} | thermal resistance from junction to ambient | in free air | 40 | K/W |

Note

- The value of R_{th(c-h)} depends on the application (see Fig.3).

Heatsink design

There are two parameters that determine the size of the heatsink. The first is the rating for the virtual junction temperature and the second is the ambient temperature at which the amplifier must still deliver its full power in the BTL mode.

With a conventional BTL amplifier, the maximum power dissipation with a music-like signal (at each amplifier) will be approximately two times 6.5 W. At a virtual junction temperature of 150 °C and a maximum ambient temperature of 65 °C, R_{th(vj-c)} = 1.3 K/W and R_{th(c-h)} = 0.2 K/W, the thermal resistance of the heatsink

$$\text{should be: } \frac{150 - 65}{2 \times 6.5} - 1.3 - 0.2 = 5 \text{ K/W}$$

Compared to a conventional BTL amplifier, the TDA1564J has a higher efficiency. The thermal resistance of the heatsink should be:

$$1.7 \left(\frac{145 - 65}{2 \times 6.5} \right) - 1.3 - 0.2 = 9 \text{ K/W}$$

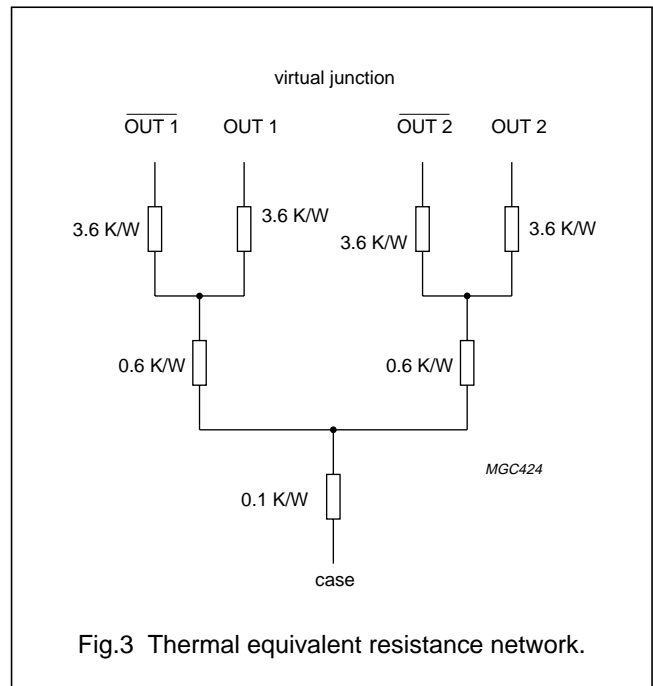


Fig.3 Thermal equivalent resistance network.

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DC CHARACTERISTICS $V_P = 14.4\text{ V}$; $T_{\text{amb}} = 25\text{ °C}$; measured in Fig.7; unless otherwise specified.

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---------------------------------------|---|---|------|------|-------|--------------------|
| Supplies | | | | | | |
| V_P | supply voltage | note 1 | 6.0 | 14.4 | 18.0 | V |
| $I_{q(\text{tot})}$ | total quiescent current | $R_L = \infty$ | – | 95 | 150 | mA |
| I_{stb} | standby current | | – | 1 | 50 | μA |
| V_{CSE} | average electrolytic capacitor voltage at pin 4 | | – | 7.1 | – | V |
| $ \Delta V_O $ | DC output offset voltage | on state | – | – | 100 | mV |
| | | mute state | – | – | 100 | mV |
| Mode select switch (see Fig.4) | | | | | | |
| V_{MODE} | voltage at mode select pin | standby condition | 0 | – | 1 | V |
| | | mute condition | 2 | – | 3 | V |
| | | on condition | 4 | 5 | V_P | V |
| $I_{\text{MODE}(\text{sw})}$ | switch current through pin 6 | $V_{\text{MODE}} = 5\text{ V}$ | – | 25 | 40 | μA |
| Diagnostic | | | | | | |
| V_{DIAG} | output voltage at the diagnostic output pin | $I_{\text{DIAG}} = 2\text{ mA}$; during any fault condition or clip detect | – | – | 0.5 | V |
| I_{DIAG} | current through the diagnostic pin | during any fault condition or clip detect | 2 | – | – | mA |
| $V_{O(\text{DC})}$ | DC output voltage detection levels | | 1.4 | 2 | 2.5 | V |
| Protection | | | | | | |
| T_{pre} | prewarning temperature | | – | 145 | – | $^{\circ}\text{C}$ |
| $T_{\text{dis}(\text{BTL})}$ | BTL disable temperature | note 2 | – | 150 | – | $^{\circ}\text{C}$ |

Notes

1. The circuit is DC biased at $V_P = 6$ to 18 V and AC operating at $V_P = 8$ to 18 V .
2. If the junction temperature exceeds 150°C , the output power is limited to 5 W per channel.

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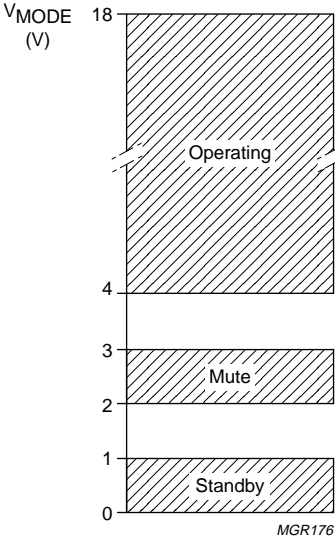


Fig.4 Switching levels of the mode select pin.

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AC CHARACTERISTICS

$V_P = 14.4$ V; $R_L = 4$ Ω ; $C_{CSE} = 1000$ μ F; $f = 1$ kHz; $T_{amb} = 25$ $^{\circ}$ C; measured in Fig.7; unless otherwise specified.

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|----------------|---------------------------------|---|--------------------|-------------|------|------------|
| P_o | output power | THD = 0.5% | 15 | 19 | – | W |
| | | THD = 10% | 23 | 25 | – | W |
| | | EIAJ | – | 38 | – | W |
| | | $V_P = 13.2$ V; THD = 0.5% | – | 16 | – | W |
| | | $V_P = 13.2$ V; THD = 10% | – | 20 | – | W |
| THD | total harmonic distortion | $P_o = 1$ W; note 1 | – | 0.1 | – | % |
| P | power dissipation | | see Figs 10 and 11 | | | W |
| B_p | power bandwidth | THD = 1%; $P_o = -1$ dB with respect to 15 W | – | 20 to 15000 | – | Hz |
| $f_{ro(l)}$ | low frequency roll-off | -1 dB; note 2 | – | 25 | – | Hz |
| $f_{ro(h)}$ | high frequency roll-off | -1 dB | 130 | – | – | kHz |
| G_v | closed-loop voltage gain | $P_o = 1$ W | 25 | 26 | 27 | dB |
| SVRR | supply voltage ripple rejection | $R_s = 0$ Ω ; $V_{ripple} = 2$ V (p-p) on/mute | 45 | 65 | – | dB |
| | | standby; $f = 100$ Hz to 10 kHz | 45 | – | – | dB |
| CMRR | common mode rejection ratio | $R_s = 0$ Ω | 70 | 90 | – | dB |
| $ Z_i $ | input impedance | | 90 | 120 | 150 | k Ω |
| $ \Delta Z_i $ | mismatch in input impedance | | – | 1 | – | % |
| V_{SE-BTL} | SE to BTL switch voltage level | note 3 | – | 3 | – | V |
| $ V_{out} $ | output voltage mute (RMS value) | $V_i = 1$ V (RMS) | – | 100 | 150 | μ V |
| $V_{n(o)}$ | noise output voltage | on; $R_s = 0$ Ω ; note 4 | – | 100 | 150 | μ V |
| | | on; $R_s = 10$ k Ω ; note 4 | – | 105 | – | μ V |
| | | mute; note 5 | – | 100 | 150 | μ V |
| α_{CS} | channel separation | $R_s = 0$ Ω ; $P_o = 15$ W | 40 | 70 | – | dB |
| $ \Delta G_v $ | channel unbalance | | – | – | 1 | dB |

Notes

1. The distortion is measured with a bandwidth of 10 Hz to 30 kHz.
2. Frequency response externally fixed (input capacitors determine the low frequency roll-off).
3. The SE to BTL switch voltage level depends on the value of V_P .
4. Noise output voltage measured with a bandwidth of 20 Hz to 20 kHz.
5. Noise output voltage is independent of R_s .

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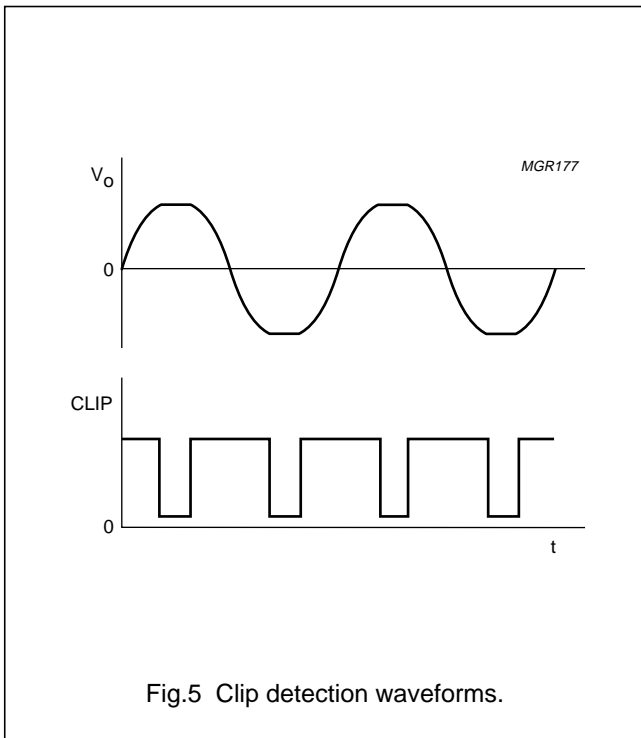


Fig.5 Clip detection waveforms.

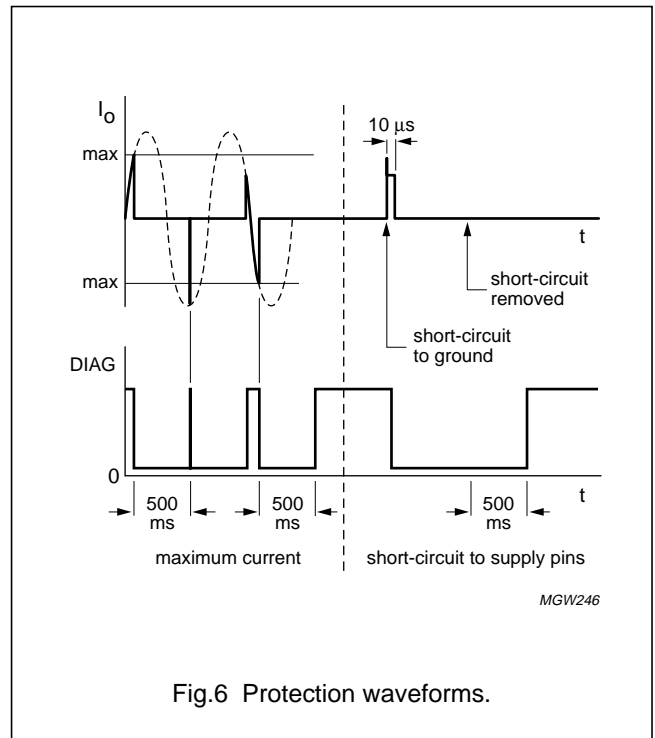
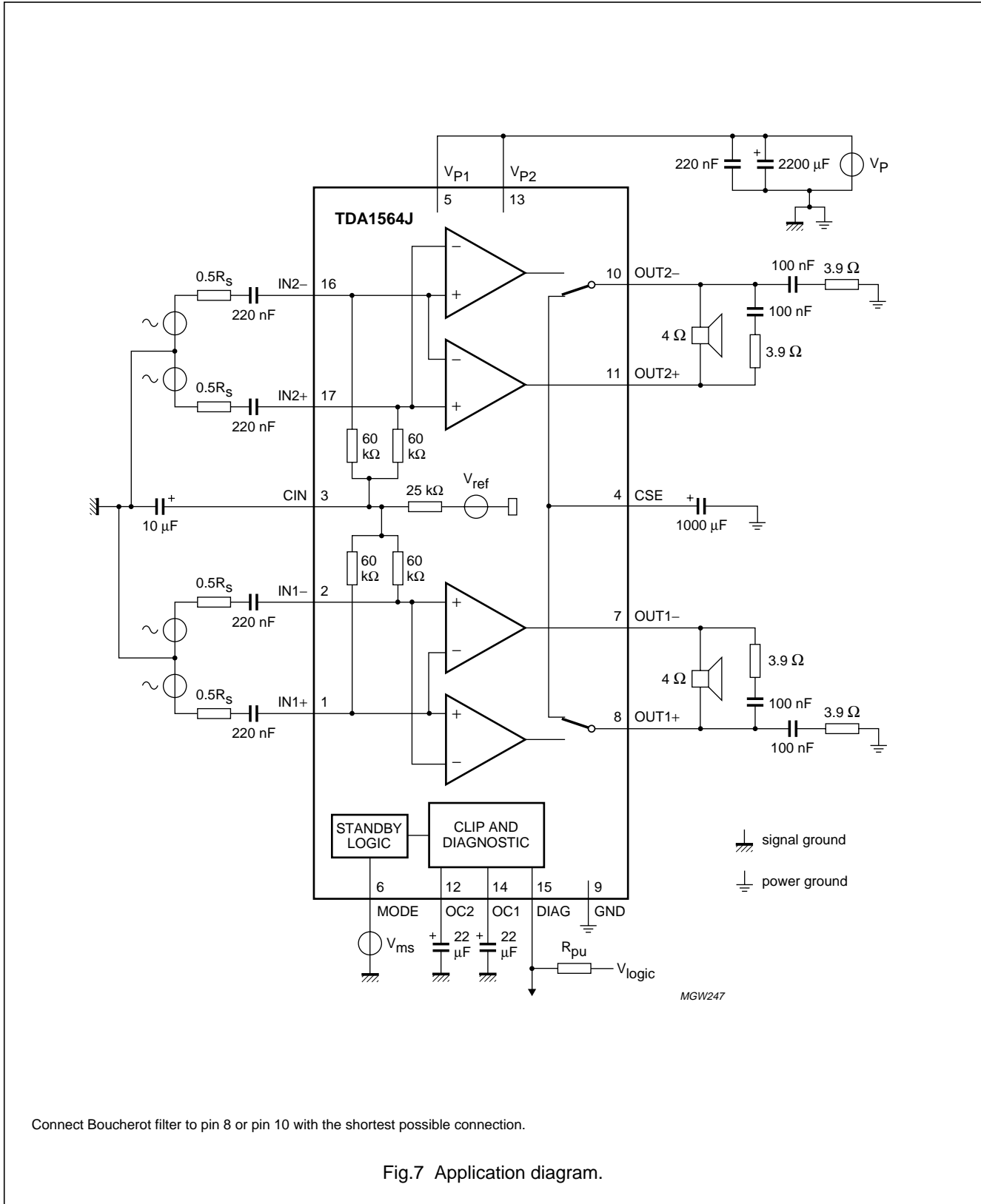


Fig.6 Protection waveforms.

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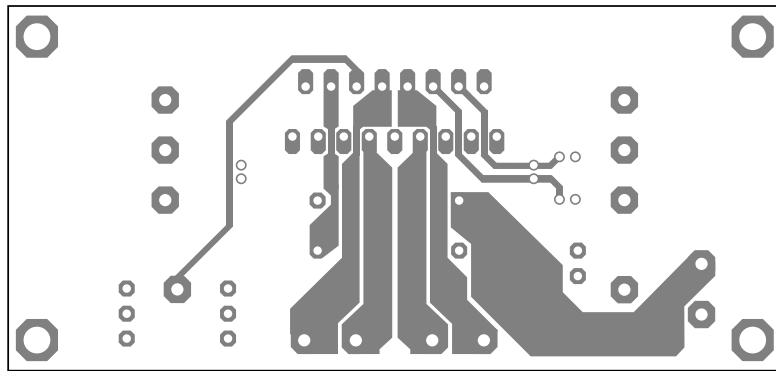
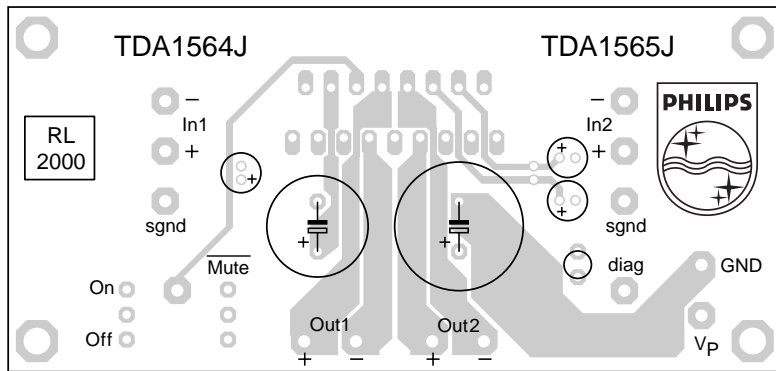
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TEST AND APPLICATION INFORMATION



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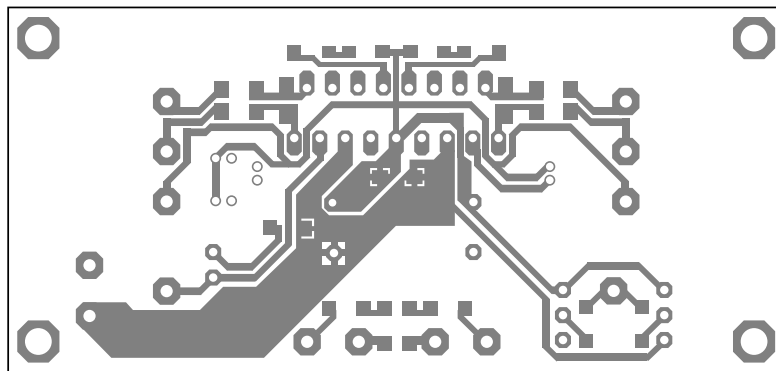
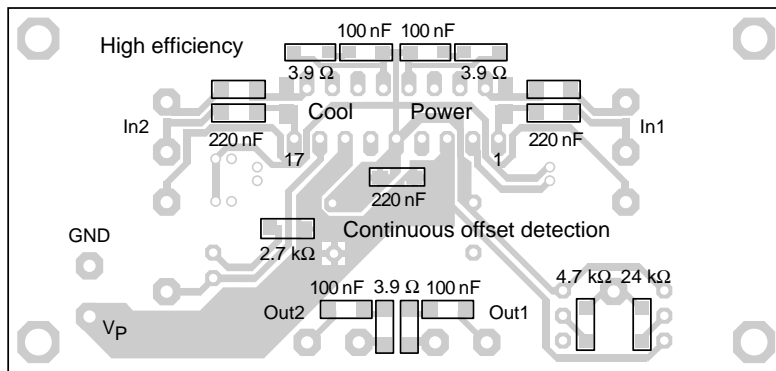
MGW248

Dimensions in mm.

Fig.8 PCB layout (component side) for the application of Fig.7.

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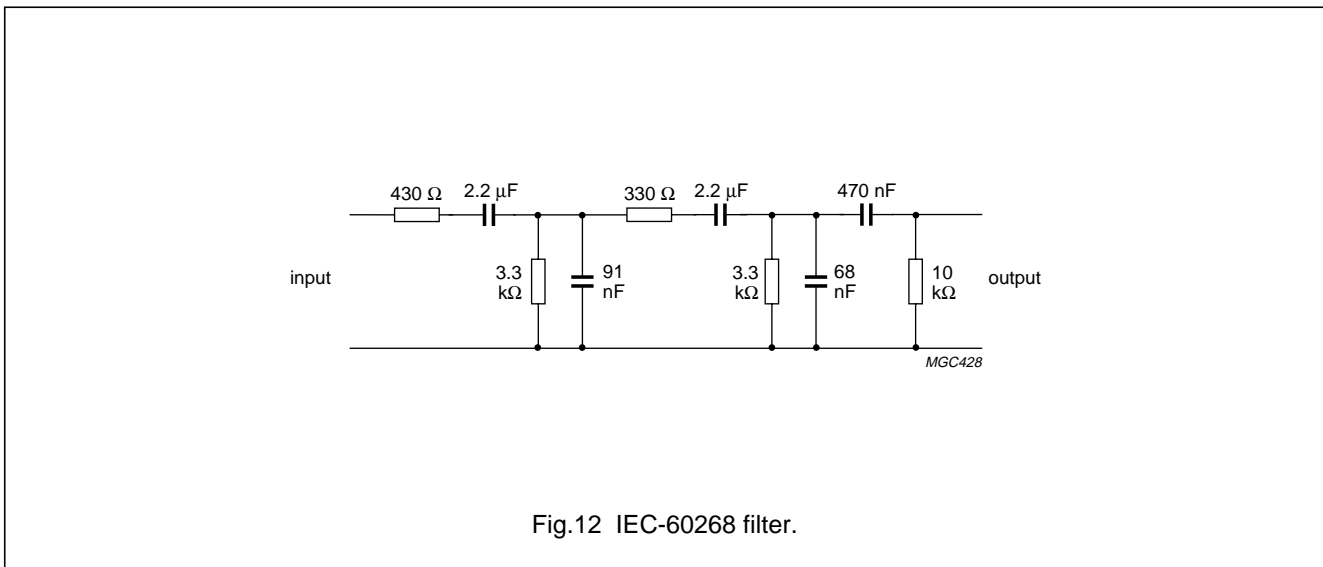
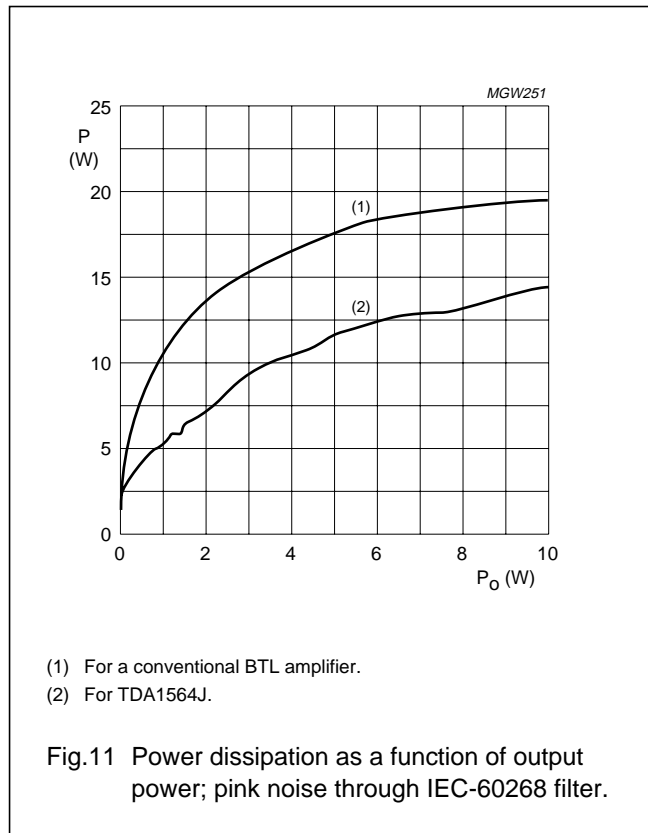
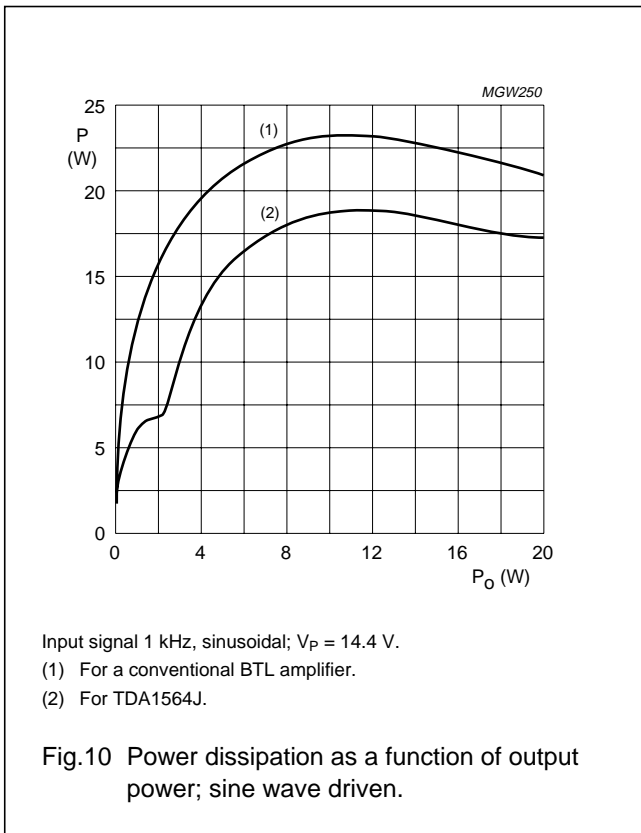
MGW249

Dimensions in mm.

Fig.9 PCB layout (soldering side) for the application of Fig.7.

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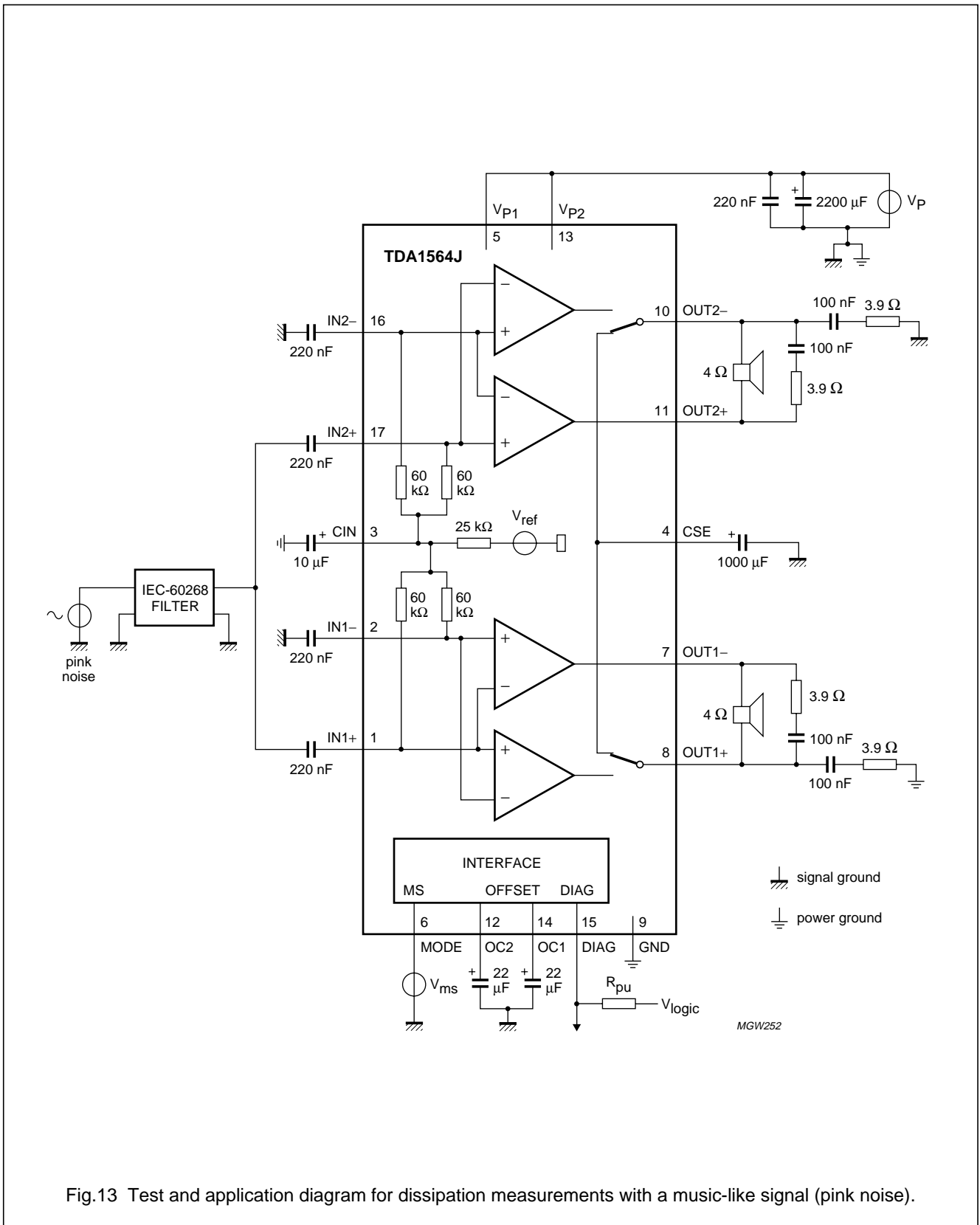
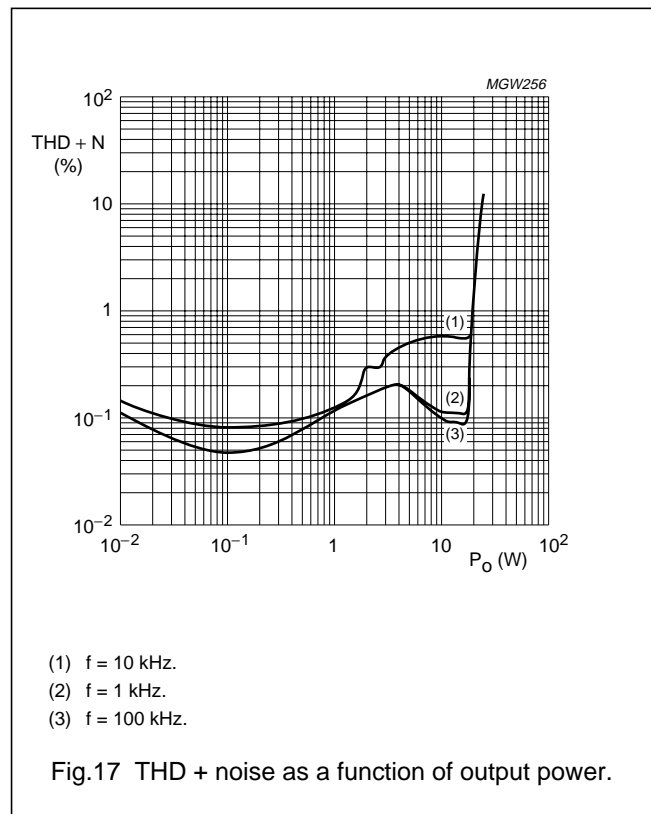
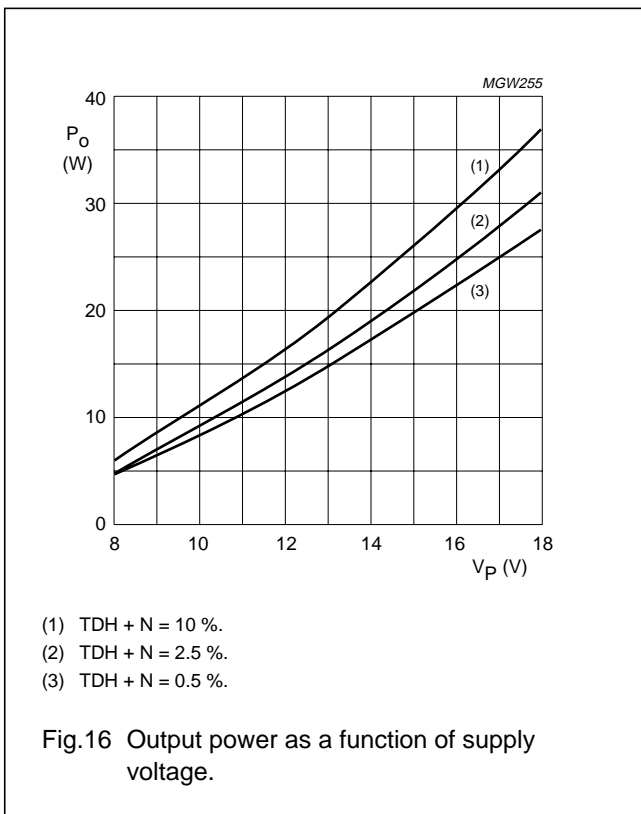
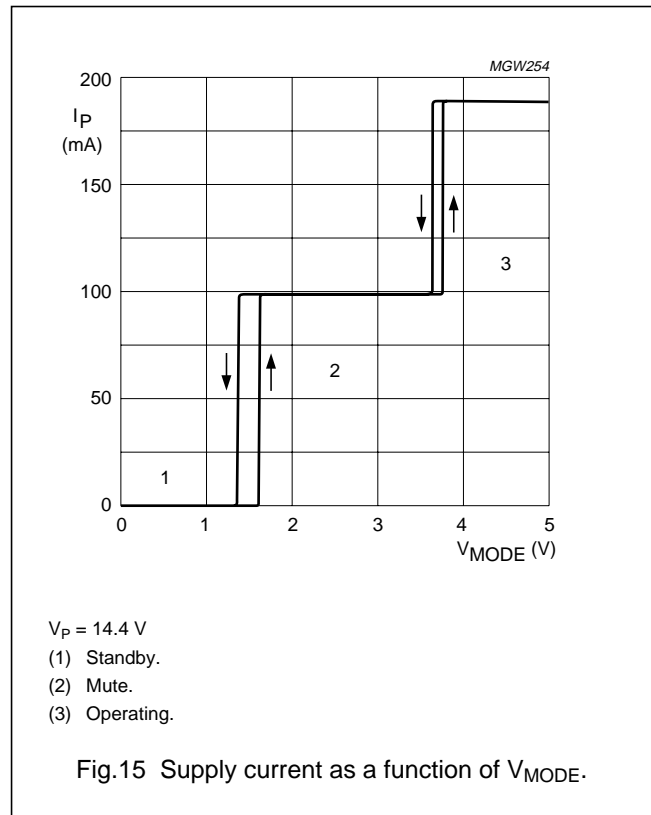
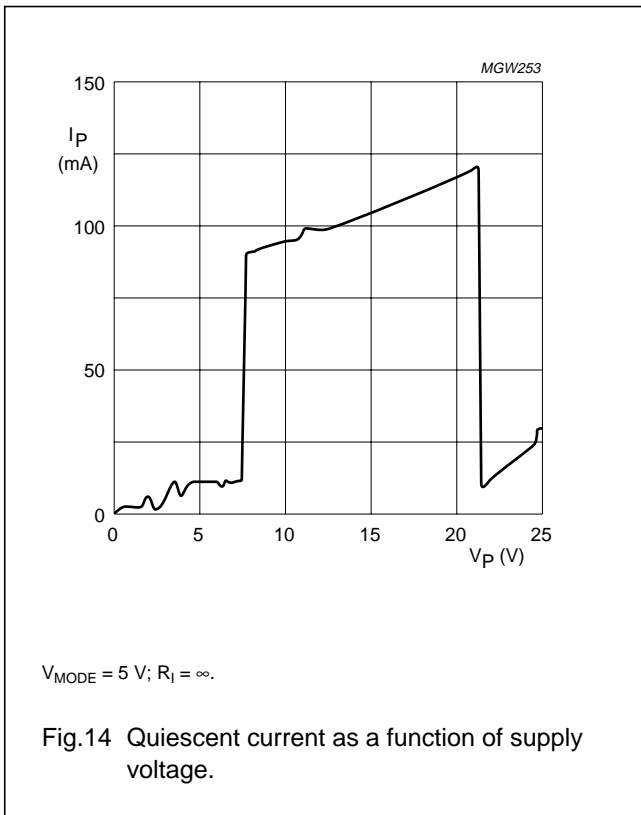


Fig.13 Test and application diagram for dissipation measurements with a music-like signal (pink noise).

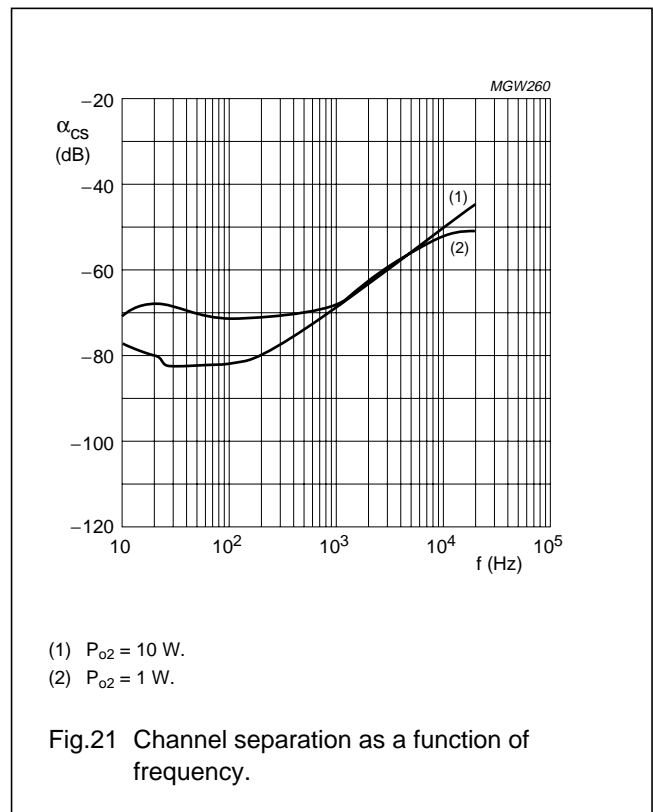
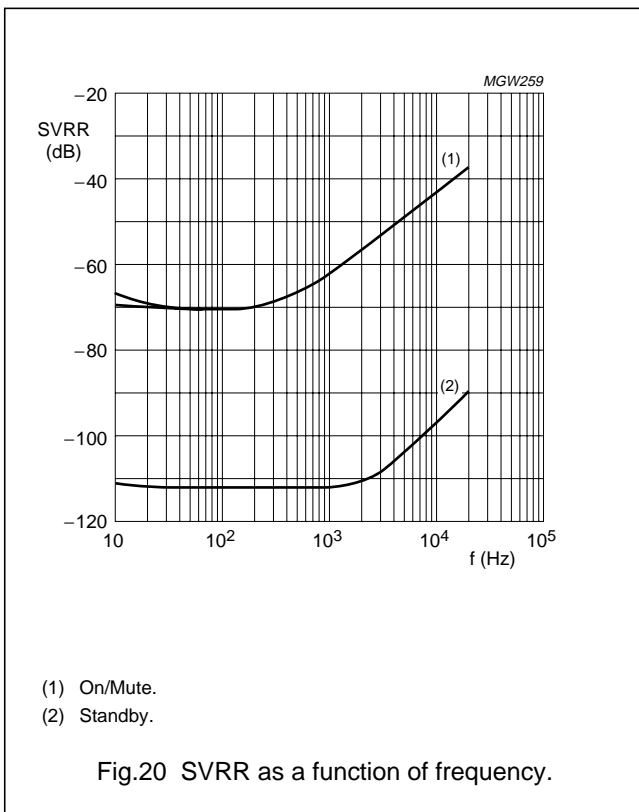
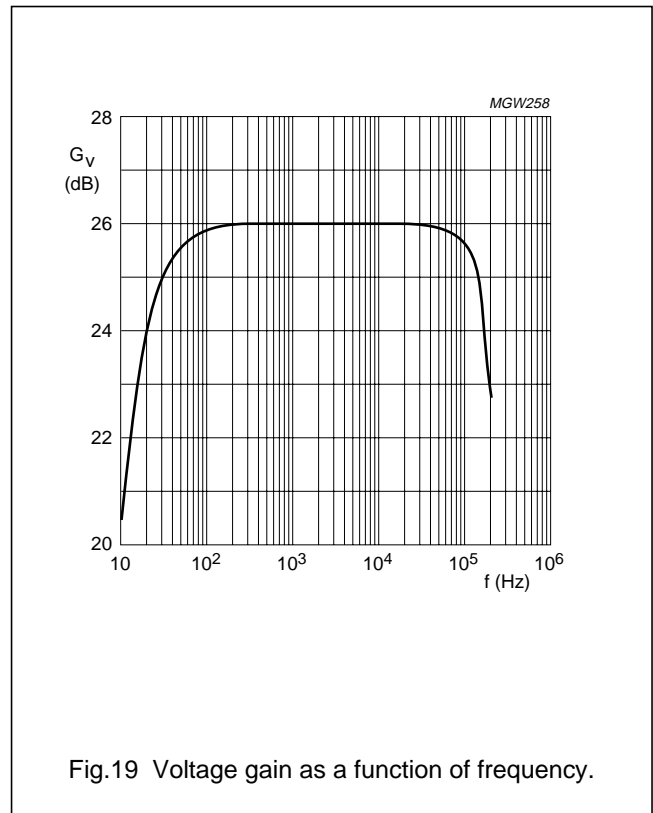
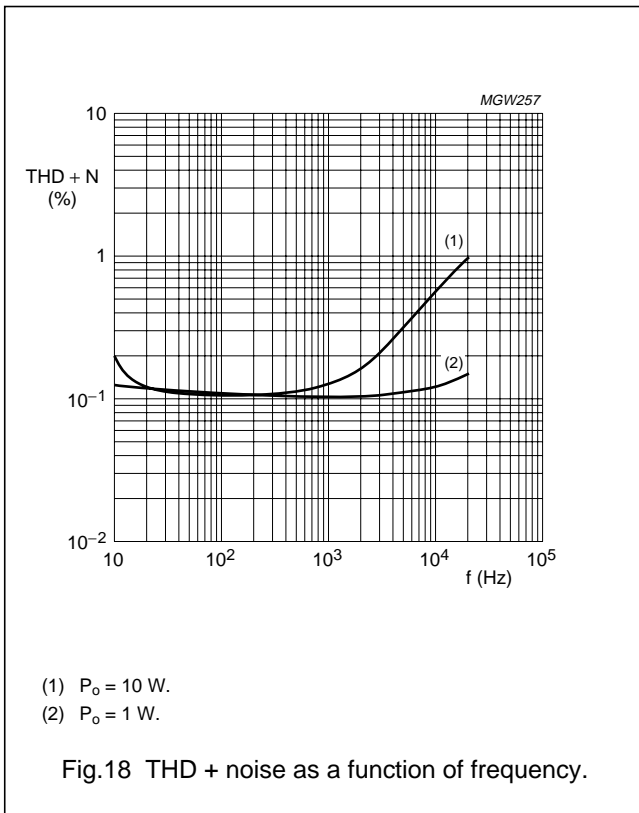
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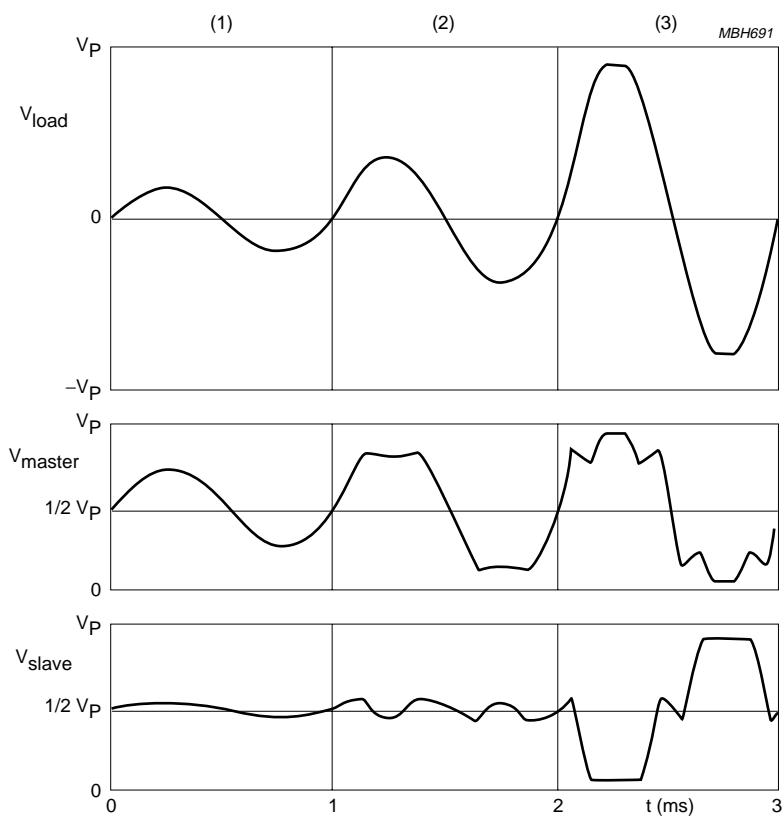
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See Fig.7:

$$V_{load} = V_7 - V_8 \text{ or } V_{11} - V_{10}$$

$$V_{master} = V_7 \text{ or } V_{11}$$

$$V_{slave} = V_8 \text{ or } V_{10}$$

Fig.22 Output waveforms.

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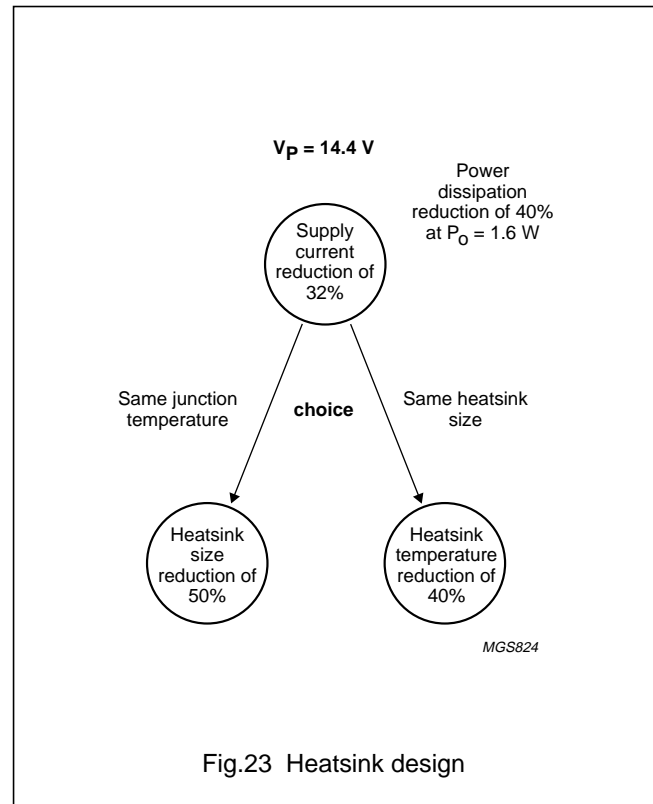
APPLICATION NOTES

Advantages of high efficiency

1. Power conversion improvement (power supply): Usually, the fact that the reduction of dissipation is directly related to supply current reduction, is neglected. One advantage is less voltage drop in the whole supply chain. Another advantage is less stress for the coil in the supply line. Even the adapter or supply circuit remains cooler than before due to the reduced heat dissipation in the whole chain because more supply current will be converted into output power.
2. Power dissipation reduction: This is the best known advantage of high efficiency amplifiers.
3. Heatsink size reduction: The heatsink size of a conventional amplifier may be reduced with approximately 50% at $V_p=14.4V$ when the TDA1564J will be used. In that case, the maximum heatsink temperature will remain the same.
4. Heatsink temperature reduction: The power dissipation and the thermal resistance of the heatsink determine the heatsink temperature rise.

When the same heatsink size is used from a conventional amplifier, the maximum heatsink temperature decreases and also the maximum junction temperature, which extends the life of this semiconductor device. The maximum dissipation with music-like input signals decreases by 40%.

It is clear that the use of the TDA1564J saves a significant amount of energy. The maximum supply current decreases by approximately 32%, that reduces the dissipation in the amplifier as well as in the whole supply chain. The TDA1564J allows a heatsink size reduction of approximately 50% or the heatsink temperature decreases by 40% when the heatsink size hasn't been changed.



Advantage of the concept used by TDA1564J

The TDA1564J is highly efficient under all conditions, because it uses a single-ended capacitor to create a non-dissipating half supply voltage. Other concepts rely on the fact that both input signals are the same in amplitude and phase. With the concept of a SE capacitor it means that it doesn't matter what kind of signal processing is done on the input signals. For example, amplitude difference, phase shift or delays between both input signals, or other DSP processing, have no impact on the efficiency.

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INTERNAL PIN CONFIGURATIONS

| PIN | NAME | EQUIVALENT CIRCUIT |
|--------------------|--------------------------------|--------------------|
| 1, 2, 16, 17 and 3 | IN1+, IN1-, IN2-, IN2+ and CIN | |
| 4 | CSE | |
| 6 | MODE | |
| 7, 11 | OUT1-, OUT2+ | |

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| PIN | NAME | EQUIVALENT CIRCUIT |
|--------|--------------|--------------------|
| 8, 10 | OUT1+, OUT2- | |
| 12, 14 | OC1, OC2 | |
| 15 | DIAG | |

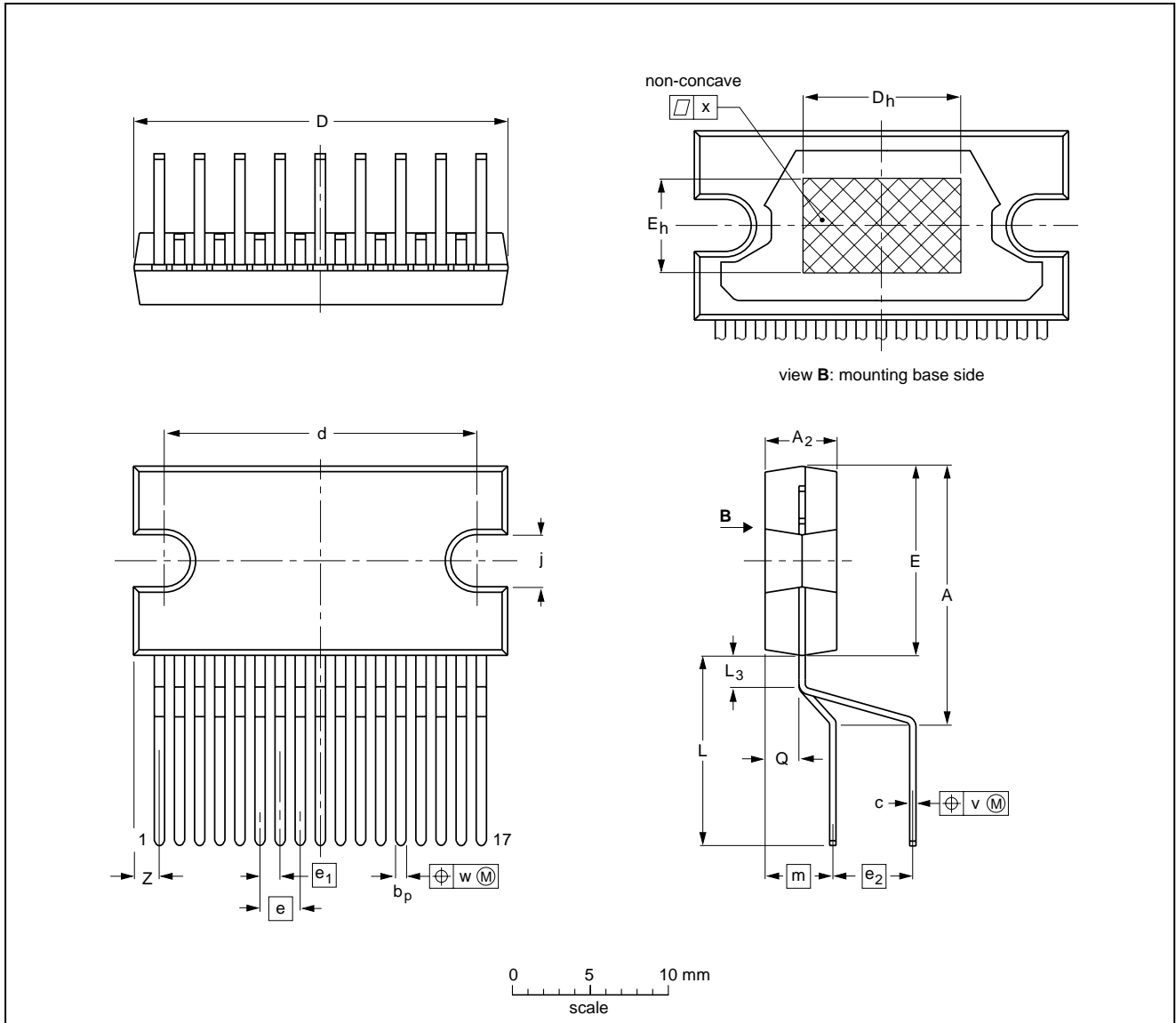
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PACKAGE OUTLINE

DBS17P: plastic DIL-bent-SIL power package; 17 leads (lead length 12 mm)

SOT243-1



DIMENSIONS (mm are the original dimensions)

| UNIT | A | A ₂ | b _p | c | D ⁽¹⁾ | d | D _h | E ⁽¹⁾ | e | e ₁ | e ₂ | E _h | j | L | L ₃ | m | Q | v | w | x | z ⁽¹⁾ |
|------|--------------|----------------|----------------|--------------|------------------|--------------|----------------|------------------|------|----------------|----------------|----------------|------------|--------------|----------------|-----|------------|-----|-----|------|------------------|
| mm | 17.0 15.5 | 4.6 4.4 | 0.75 0.60 | 0.48 0.38 | 24.0 23.6 | 20.0 19.6 | 10 | 12.2 11.8 | 2.54 | 1.27 | 5.08 | 6 | 3.4 3.1 | 12.4 11.0 | 2.4 1.6 | 4.3 | 2.1 1.8 | 0.8 | 0.4 | 0.03 | 2.00 1.45 |

Note

1. Plastic or metal protrusions of 0.25 mm maximum per side are not included.

| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|-----------------|------------|-------|------|--|---------------------|----------------------|
| | IEC | JEDEC | EIAJ | | | |
| SOT243-1 | | | | | | 97-12-16 99-12-17 |

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SOLDERING**Introduction to soldering through-hole mount packages**

This text gives a brief insight to wave, dip and manual soldering. A more in-depth account of soldering ICs can be found in our *"Data Handbook IC26; Integrated Circuit Packages"* (document order number 9398 652 90011).

Wave soldering is the preferred method for mounting of through-hole mount IC packages on a printed-circuit board.

Soldering by dipping or by solder wave

The maximum permissible temperature of the solder is 260 °C; solder at this temperature must not be in contact with the joints 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.

Manual soldering

Apply the soldering iron (24 V or less) to the lead(s) of the package, either 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.

Suitability of through-hole mount IC packages for dipping and wave soldering methods

| PACKAGE | SOLDERING METHOD | |
|---------------------------|------------------|-------------------------|
| | DIPPING | WAVE |
| DBS, DIP, HDIP, SDIP, SIL | suitable | suitable ⁽¹⁾ |

Note

- For SDIP packages, the longitudinal axis must be parallel to the transport direction of the printed-circuit board.

Run-cool stereo power amplifier

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DATA SHEET STATUS

| DATA SHEET STATUS ⁽¹⁾ | PRODUCT STATUS ⁽²⁾ | DEFINITIONS |
|----------------------------------|-------------------------------|--|
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