

DATA SHEET

TDA8357J

Full bridge vertical deflection output
circuit in LVDMOS

Preliminary specification
File under Integrated Circuits, IC02

1999 Nov 10

Full bridge vertical deflection output circuit in LVDMOS

TDA8357J

FEATURES

- Few external components required
- High efficiency fully DC coupled vertical bridge output circuit
- Vertical flyback switch with short rise and fall times
- Built-in guard circuit
- Thermal protection circuit
- Improved EMC performance due to differential inputs.

GENERAL DESCRIPTION

The TDA8357J is a power circuit for use in 90° and 110° colour deflection systems for 25 to 200 Hz field frequencies, and for 4 : 3 and 16 : 9 picture tubes. The IC contains a vertical deflection output circuit, operating as a high efficiency class G system. The full bridge output circuit allows DC coupling of the deflection coil in combination with single positive supply voltages.

The IC is constructed in a Low Voltage DMOS (LVDMOS) process that combines bipolar, CMOS and DMOS devices. DMOS transistors are used in the output stage because of absence of second breakdown.

QUICK REFERENCE DATA

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|---|-------------------------|--------|------|-----------|------|
| Supplies | | | | | | |
| V_P | supply voltage | | 7.5 | 12 | 18 | V |
| V_{FB} | flyback supply voltage | | $2V_P$ | 45 | 66 | V |
| $I_{q(P)(av)}$ | average quiescent supply current | during scan | – | 10 | 15 | mA |
| $I_{q(FB)(av)}$ | average quiescent flyback supply current | during scan | – | – | 10 | mA |
| P_{tot} | total power dissipation | | – | – | 8 | W |
| Inputs and outputs | | | | | | |
| $V_{I(dif)(p-p)}$ | differential input voltage (peak-to-peak value) | | – | 1000 | 1500 | mV |
| $I_{o(p-p)}$ | output current (peak-to-peak value) | | – | – | 2.0 | A |
| Flyback switch | | | | | | |
| $I_{o(peak)}$ | maximum (peak) output current | $t \leq 1.5 \text{ ms}$ | – | – | ± 1.2 | A |
| Thermal data; in accordance with IEC 747-1 | | | | | | |
| T_{stg} | storage temperature | | –55 | – | +150 | °C |
| T_{amb} | ambient temperature | | –25 | – | +75 | °C |
| T_j | junction temperature | | – | – | 150 | °C |

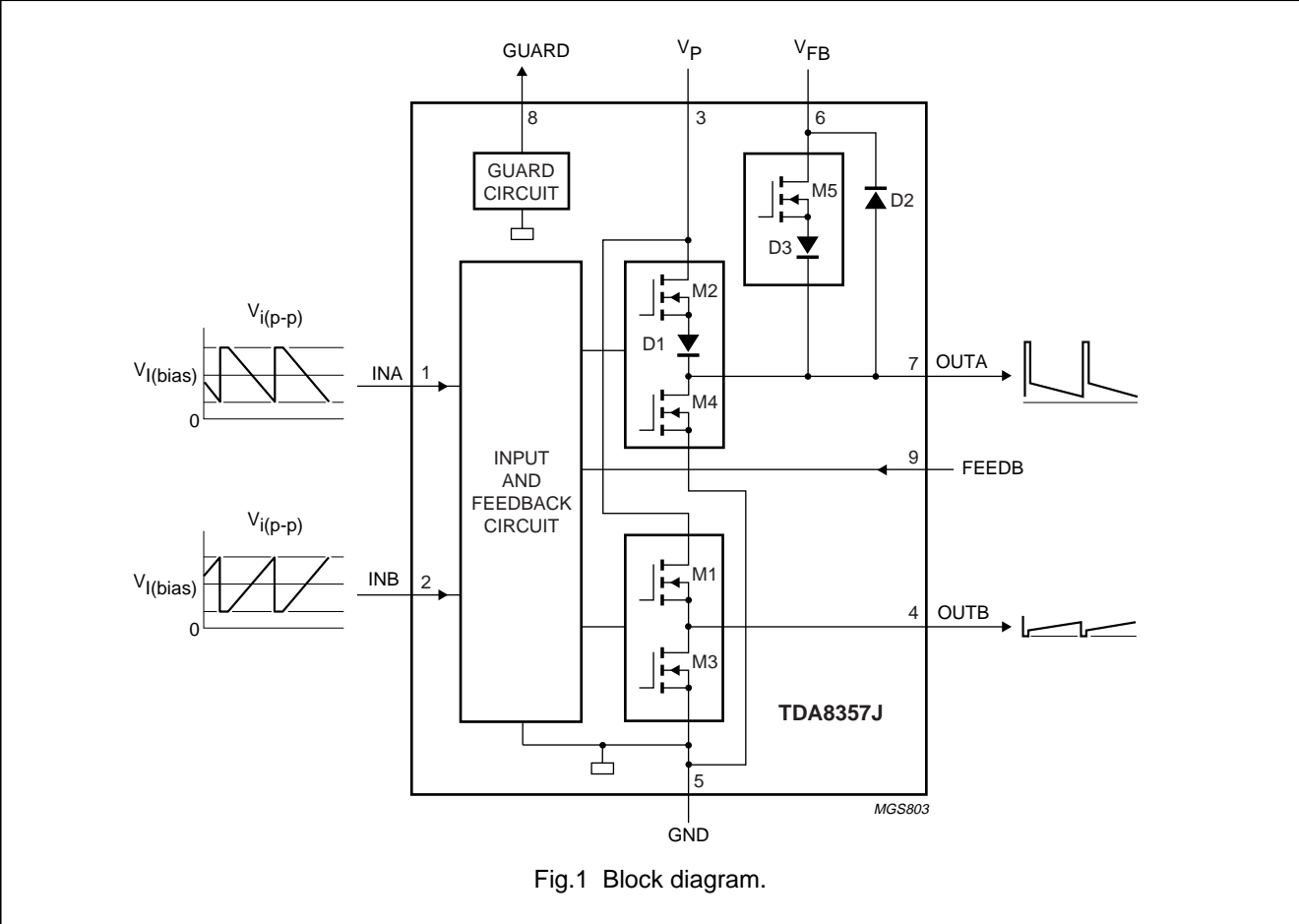
ORDERING INFORMATION

| TYPE NUMBER | PACKAGE | | |
|----------------|---------|---|----------|
| | NAME | DESCRIPTION | VERSION |
| TDA8357J | DBS9P | plastic DIL-bent-SIL power package; 9 leads (lead length 12/11 mm); exposed die pad | SOT523-1 |

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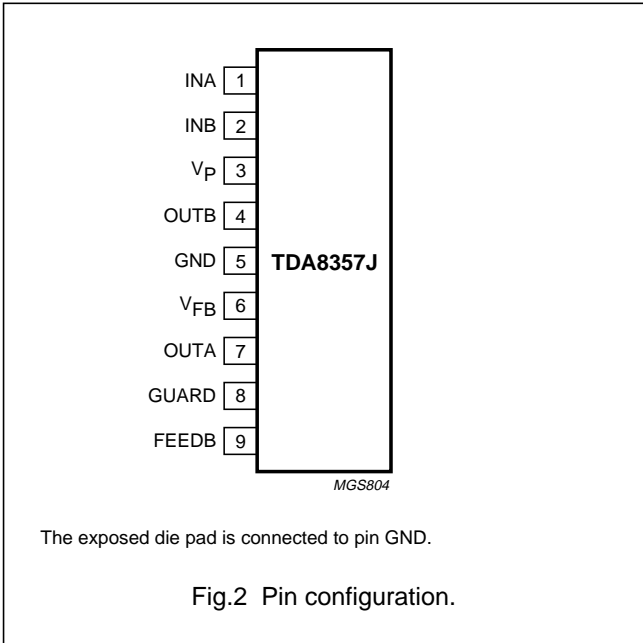
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BLOCK DIAGRAM



PINNING

| SYMBOL | PIN | DESCRIPTION |
|-----------------|-----|------------------------|
| INA | 1 | input A |
| INB | 2 | input B |
| V _P | 3 | supply voltage |
| OUTB | 4 | output B |
| GND | 5 | ground |
| V _{FB} | 6 | flyback supply voltage |
| OUTA | 7 | output A |
| GUARD | 8 | guard output |
| FEEDB | 9 | feedback input |



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FUNCTIONAL DESCRIPTION

Vertical output stage

The vertical driver circuit has a bridge configuration. The deflection coil is connected between the complimentary driven output amplifiers. The differential input circuit is voltage driven. The input circuit is specially designed for direct connection to driver circuits delivering a differential signal but it is also suitable for single-ended applications. The output currents of the driver device are converted to voltages by the conversion resistors R_{CV1} and R_{CV2} (see Fig.3) connected to pins INA and INB. The differential input voltage is compared with the voltage across the measuring resistor R_M , providing internal feedback information. The voltage across R_M is proportional with the output current. The relationship between the differential input current and the output current is defined by:

$$2 \times I_{I(dif)(p-p)} \times R_{CV} = I_{O(p-p)} \times R_M$$

The output current should measure 0.5 to 2.0 A (p-p) and is determined by the value of R_M and R_{CV} . The allowable input voltage range is 100 mV to 1.6 V for each input. The formula given does not include internal bondwire resistances. Depending on the values of R_M and the internal bondwire resistance (typical value of 50 mΩ) the actual value of the current in the deflection coil will be about 5% lower than calculated.

Flyback supply

The flyback voltage is determined by the flyback supply voltage V_{FB} . The principle of two supply voltages (class G) allows to use an optimum supply voltage V_P for scan and an optimum flyback supply voltage V_{FB} for flyback, thus very high efficiency is achieved. The available flyback output voltage across the coil is almost equal to V_{FB} , due to the absence of a coupling capacitor which is not required in a bridge configuration. The very short rise and fall times of the flyback switch are determined mainly by the slew-rate value of more than 300 V/μs.

Protection

The output circuit contains protection circuits for:

- Too high die temperature
- Overvoltage of output A.

Guard circuit

A guard circuit with output pin GUARD is provided.

The guard circuit generates a HIGH-level during the flyback period. The guard circuit is also activated for one of the following conditions:

- During thermal protection ($T_j \approx 170^\circ\text{C}$)
- During an open-loop condition.

The guard signal can be used for blanking the picture tube and signalling fault conditions. The vertical synchronization pulses of the guard signal can be used by an On Screen Display (OSD) microcontroller.

Damping resistor compensation

HF loop stability is achieved by connecting a damping resistor R_{D1} across the deflection coil. The current values in R_{D1} during scan and flyback are significantly different. Both the resistor current and the deflection coil current flow into measuring resistor R_M , resulting in a too low deflection coil current at the start of the scan.

The difference in the damping resistor current values during scan and flyback have to be externally compensated in order to achieve a short settling time. For that purpose a compensation resistor R_{CMP} in series with a zener diode is connected between pins OUTA and INA (see Fig.4). The zener diode voltage value should be equal to V_P . The value of R_{CMP} is calculated by:

$$R_{CMP} = \frac{(V_{FB} - V_{loss(FB)} - V_Z) \times R_{D1} \times R_{CV1}}{(V_{FB} - V_{loss(FB)} - I_{coil(peak)} \times R_{coil}) \times R_M}$$

where:

- $V_{loss(FB)}$ is the voltage loss between pins V_{FB} and OUTA at flyback
- R_{coil} is the deflection coil resistance
- V_Z is the voltage of zener diode D5.

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LIMITING VALUES

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

| SYMBOL | PARAMETER | CONDITIONS | MIN. | MAX. | UNIT |
|-----------|--|---|----------------|-------------------------|--------------|
| V_P | supply voltage | | – | 18 | V |
| V_{FB} | flyback supply voltage | | – | 68 | V |
| V_n | DC voltage pin OUTA pin OUTB pins INA, INB, GUARD and FEEDB | note 1 | – – –0.5 | 68 V_P V_P | V V V |
| I_n | DC current pins OUTA and OUTB pins OUTA and OUTB pins INA, INB, GUARD and FEEDB | during scan (p-p) at flyback (peak); $t \leq 1.5$ ms | – – –20 | 2.0 ± 1.2 +20 | A A mA |
| I_{lu} | latch-up current | current into any pin; pin voltage is $1.5 \times V_P$; note 2 | – | +200 | mA |
| | | current out of any pin; pin voltage is $-1.5 \times V_P$; note 2 | –200 | – | mA |
| V_{es} | electrostatic handling voltage | machine model; note 3 | –300 | +300 | V |
| | | human body model; note 4 | –2000 | +2000 | V |
| P_{tot} | total power dissipation | | – | 8 | W |
| T_{stg} | storage temperature | | –55 | +150 | °C |
| T_{amb} | ambient temperature | | –25 | +75 | °C |
| T_j | junction temperature | note 5 | – | 150 | °C |

Notes

- When the voltage at pin OUTA supersedes 70 V the circuit will limit the voltage.
- At $T_{j(max)}$.
- Equivalent to 200 pF capacitance discharge through a 0 Ω resistor.
- Equivalent to 100 pF capacitance discharge through a 1.5 k Ω resistor.
- Internally limited by thermal protection at $T_j \approx 170$ °C.

THERMAL CHARACTERISTICS

In accordance with IEC 747-1.

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---------------|---|-------------|------|------|------|------|
| $R_{th(j-c)}$ | thermal resistance from junction to case | | – | – | 6 | K/W |
| $R_{th(j-a)}$ | thermal resistance from junction to ambient | in free air | – | – | 65 | K/W |

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CHARACTERISTICS

$V_P = 12\text{ V}$; $V_{FB} = 45\text{ V}$; $f_{\text{vert}} = 50\text{ Hz}$; $V_{I(\text{bias})} = 880\text{ mV}$; $T_{\text{amb}} = 25\text{ }^{\circ}\text{C}$; measured in test circuit of Fig.3; unless otherwise specified.

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---------------------------------|--|--|--------|----------|-----------|-----------------|
| Supplies | | | | | | |
| V_P | operating supply voltage | | 7.5 | 12 | 18 | V |
| V_{FB} | flyback supply voltage | note 1 | $2V_P$ | 45 | 66 | V |
| $I_{q(P)(\text{av})}$ | average quiescent supply current | during scan | – | 10 | 15 | mA |
| $I_{q(P)}$ | quiescent supply current | no signal; no load | – | 55 | 75 | mA |
| $I_{q(FB)(\text{av})}$ | average quiescent flyback supply current | during scan | – | – | 10 | mA |
| Inputs A and B | | | | | | |
| $V_{i(\text{dif})(\text{p-p})}$ | differential input voltage (peak-to-peak value) | note 2 | – | 1000 | 1500 | mV |
| $V_{I(\text{bias})}$ | input bias voltage | note 2 | 100 | 880 | 1600 | mV |
| $I_{I(\text{bias})}$ | input bias current | | – | 25 | 35 | μA |
| Outputs A and B | | | | | | |
| $V_{\text{loss}(1)}$ | voltage loss first scan part | note 3 $I_o = 0.7\text{ A}$ | – | – | 3.9 | V |
| | | $I_o = 1.0\text{ A}$ | – | – | 5.5 | V |
| $V_{\text{loss}(2)}$ | voltage loss second scan part | note 4 $I_o = -0.7\text{ A}$ | – | – | 2.8 | V |
| | | $I_o = -1.0\text{ A}$ | – | – | 4.0 | V |
| $I_{o(\text{p-p})}$ | output current (peak-to-peak value) | | – | – | 2.0 | A |
| LE | linearity error | $I_{o(\text{p-p})} = 2.0\text{ A}$; notes 5 and 6 | | | | |
| | | adjacent blocks | – | 1 | 2 | % |
| | | non adjacent blocks | – | 1 | 3 | % |
| V_{offset} | offset voltage | across R_M ; $V_{i(\text{dif})} = 0\text{ V}$ | | | | |
| | | $V_{I(\text{bias})} = 200\text{ mV}$ | – | – | ± 15 | mV |
| | | $V_{I(\text{bias})} = 1\text{ V}$ | – | – | ± 25 | mV |
| $\Delta V_{\text{offset}(T)}$ | offset voltage variation with temperature | across R_M ; $V_{i(\text{dif})} = 0\text{ V}$ | – | – | 40 | $\mu\text{V/K}$ |
| V_O | DC output voltage | $V_{i(\text{dif})} = 0\text{ V}$ | – | $0.5V_P$ | – | V |
| $G_{V(\text{ol})}$ | open-loop voltage gain | notes 7 and 8 | – | 60 | – | dB |
| $f_{-3\text{dB}(h)}$ | high –3 dB cut-off frequency | open-loop | – | 1 | – | kHz |
| G_V | voltage gain | note 9 | – | 1 | – | |
| $\Delta G_{V(T)}$ | voltage gain variation with the temperature | | – | – | 10^{-4} | K^{-1} |
| PSRR | power supply rejection ratio | note 10 | 80 | 90 | – | dB |

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| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---------------------------------|-------------------------------|---|--------|----------|-----------|---------------|
| Flyback switch | | | | | | |
| $I_{O(\text{peak})}$ | maximum (peak) output current | $t \leq 1.5 \text{ ms}$ | – | – | ± 1.2 | A |
| $V_{\text{loss(FB)}}$ | voltage loss at flyback | note 11 $I_o = 0.7 \text{ A}$ $I_o = 1.0 \text{ A}$ | – – | 7.5 8 | 8.5 9 | V V |
| Guard circuit | | | | | | |
| $V_{O(\text{grd})}$ | guard output voltage | $I_{O(\text{grd})} = 100 \mu\text{A}$ | 5 | 6 | 7 | V |
| $V_{O(\text{grd})(\text{max})}$ | allowable guard voltage | maximum leakage current $I_{L(\text{max})} = 10 \mu\text{A}$ | – | – | 18 | V |
| $I_{O(\text{grd})}$ | output current | $V_{O(\text{grd})} = 0 \text{ V}$; not active | – | – | 10 | μA |
| | | $V_{O(\text{grd})} = 4.5 \text{ V}$; active | 1 | – | 2.5 | mA |

Notes

- To limit V_{OUTA} to 68 V, V_{FB} must be 66 V due to the voltage drop of the internal flyback diode between pins OUTA and V_{FB} at the first part of the flyback.
- Allowable input range: $V_{I(\text{bias})} + V_{I(\text{dif})} < 1600 \text{ mV}$ and $V_{I(\text{bias})} - V_{I(\text{dif})} > 100 \text{ mV}$ for each input.
- This value specifies the sum of the voltage losses of the internal current paths between pins V_P and OUTA, and between pins OUTB and GND. Specified for $T_j = 125^\circ\text{C}$. The temperature coefficient for $V_{\text{loss}(1)}$ is a positive value.
- This value specifies the sum of the voltage losses of the internal current paths between pins V_P and OUTB, and between pins OUTA and GND. Specified for $T_j = 125^\circ\text{C}$. The temperature coefficient for $V_{\text{loss}(2)}$ is a positive value.
- The linearity error is measured for a linear input signal without S-correction and is based on the 'on screen' measurement principle. This method is defined as follows. The output signal is divided in 22 successive equal time blocks k. The 1st and 22nd blocks are ignored, while the voltage amplitudes are measured across R_M , starting at $k = 2$ and ending at $k = 21$, where V_k and V_{k+1} are the measured voltages of two successive blocks. V_{min} , V_{max} and V_{avg} are the minimum, maximum and average voltages respectively. The linearity errors are defined as:

$$\text{a) } LE = \frac{V_k - V_{k+1}}{V_{\text{avg}}} \text{ (adjacent blocks)}$$

$$\text{b) } LE = \frac{V_{\text{max}} - V_{\text{min}}}{V_{\text{avg}}} \text{ (non adjacent blocks)}$$

- The linearity errors are specified for a minimum input voltage of 300 mV (p-p). Lower input voltages lead to voltage dependent S-distortion in the input stage.

$$7. \quad G_{V(\text{ol})} = \frac{V_{\text{OUTA}} - V_{\text{OUTB}}}{V_{\text{FEEDB}} - V_{\text{OUTB}}}$$

- Pin FEEDB not connected.

$$9. \quad G_V = \frac{V_{\text{FEEDB}} - V_{\text{OUTB}}}{V_{\text{INA}} - V_{\text{INB}}}$$

- $V_{P(\text{ripple})} = 500 \text{ mV}$ (RMS value); $50 \text{ Hz} < f_{P(\text{ripple})} < 1 \text{ kHz}$; measured across R_M .

- This value specifies the internal voltage loss of the current path between pins V_{FB} and OUTA.

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APPLICATION INFORMATION

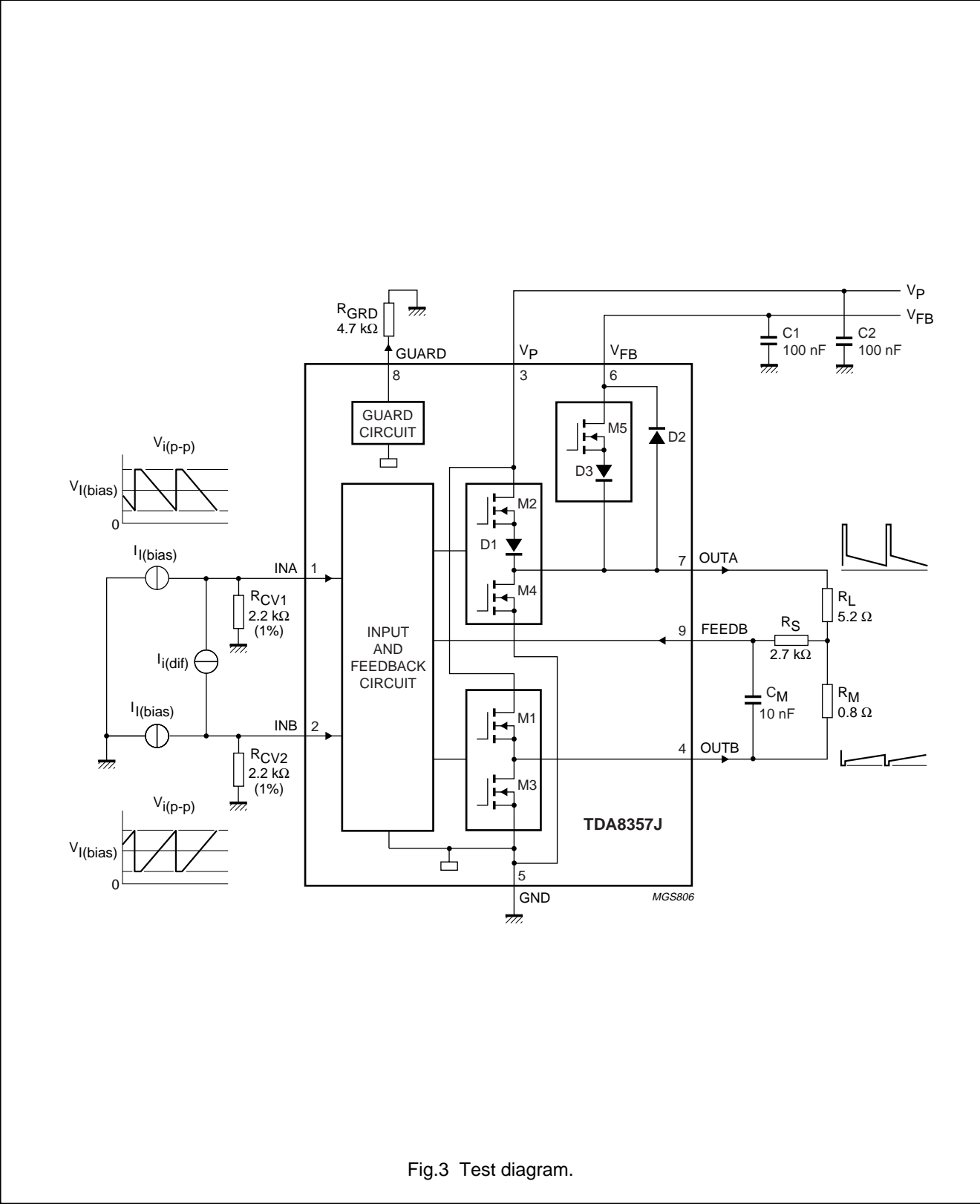
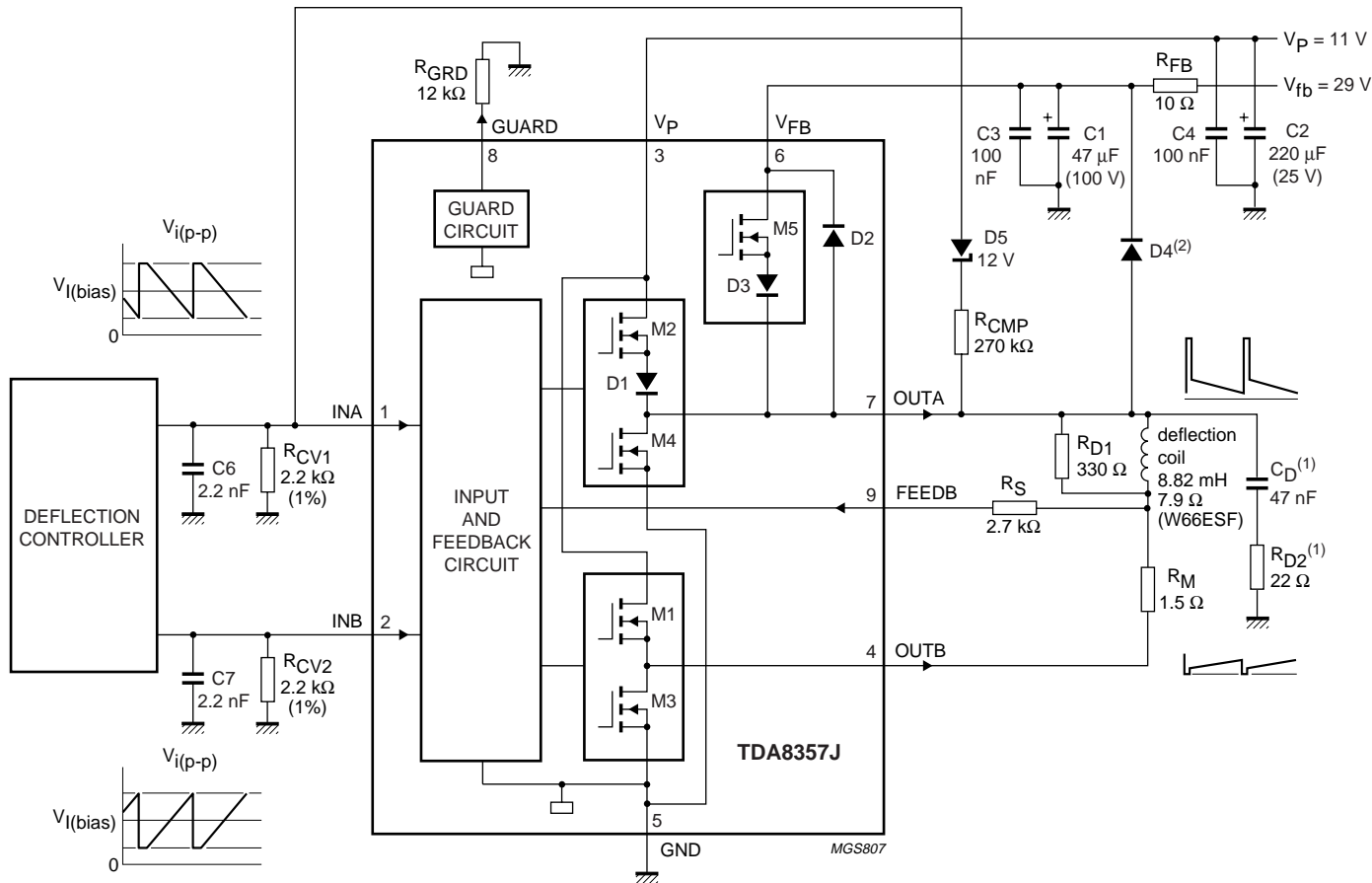


Fig.3 Test diagram.

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$f_{\text{vert}} = 50 \text{ Hz}$; $t_{\text{FB}} = 640 \mu\text{s}$; $I_{\text{I(bias)}} = 400 \mu\text{A}$; $I_{\text{I(dif)(peak)}} = 494 \mu\text{A}$; $I_{\text{O(p-p)}} = 1.45 \text{ A}$.

(1) Optional, depending on the deflection coil impedance.

(2) Optional extended flash over protection; BYD33D or equivalent.

Fig.4 Application diagram.

Full bridge vertical deflection output circuit in LVDMOS

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Supply voltage calculation

For calculating the minimum required supply voltage, several specific application parameter values have to be known. These parameters are the required maximum (peak) deflection coil current $I_{\text{coil(peak)}}$, the coil parameters R_{coil} and L_{coil} , and the measuring resistance of R_M . The required maximum (peak) deflection coil current should also include the overscan.

The deflection coil resistance has to be multiplied with 1.2 in order to take account of hot conditions.

Chapter "Characteristics" supplies values for the voltage losses of the vertical output stage. For the first part of the scan the voltage loss is given by $V_{\text{loss(1)}}$. For the second part of the scan the voltage loss is given by $V_{\text{loss(2)}}$.

The voltage drop across the deflection coil during scan is determined by the coil impedance. For the first part of the scan the inductive contribution and the ohmic contribution to the total coil voltage drop are of opposite sign, while for the second part of the scan the inductive part and the ohmic part have the same sign.

For the vertical frequency the maximum frequency occurring must be applied to the calculations.

The required power supply voltage V_P for the first part of the scan is given by:

$$V_{P(1)} = I_{\text{coil(peak)}} \times (R_{\text{coil}} + R_M) - L_{\text{coil}} \times 2I_{\text{coil(peak)}} \times f_{\text{vert(max)}} + V_{\text{loss(1)}}$$

The required power supply voltage V_P for the second part of the scan is given by:

$$V_{P(2)} = I_{\text{coil(peak)}} \times (R_{\text{coil}} + R_M) + L_{\text{coil}} \times 2I_{\text{coil(peak)}} \times f_{\text{vert(max)}} + V_{\text{loss(2)}}$$

The minimum required supply voltage V_P shall be the highest of the two values $V_{P(1)}$ and $V_{P(2)}$. Spread in supply voltage and component values also has to be taken into account.

Flyback supply voltage calculation

If the flyback time is known, the required flyback supply voltage can be calculated by the simplified formula:

$$V_{\text{FB}} = I_{\text{coil(p-p)}} \times \frac{R_{\text{coil}} + R_M}{1 - e^{-t_{\text{FB}}/x}}$$

where:

$$x = \frac{L_{\text{coil}}}{R_{\text{coil}} + R_M}$$

The flyback supply voltage calculated this way is about 5% to 10% higher than required.

Calculation of the power dissipation of the vertical output stage

The IC total power dissipation is given by the formula:

$$P_{\text{tot}} = P_{\text{sup}} - P_L$$

The power to be supplied is given by the formula:

$$P_{\text{sup}} = V_P \times \frac{I_{\text{coil(peak)}}}{2} + V_P \times 0.015 [\text{A}] + 0.3 [\text{W}]$$

In this formula 0.3 [W] represents the average value of the losses in the flyback supply.

The average external load power dissipation in the deflection coil and the measuring resistor is given by the formula:

$$P_L = \frac{(I_{\text{coil(peak)}})^2}{3} \times (R_{\text{coil}} + R_M)$$

Example

Table 1 Application values

| SYMBOL | VALUE | UNIT |
|-------------------------|-------|---------------|
| $I_{\text{coil(peak)}}$ | 0.725 | A |
| $I_{\text{coil(p-p)}}$ | 1.45 | A |
| L_{coil} | 8.82 | mH |
| R_{coil} | 7.9 | Ω |
| R_M | 1.5 | Ω |
| f_{vert} | 50 | Hz |
| t_{FB} | 640 | μs |

Table 2 Calculated values

| SYMBOL | VALUE | UNIT |
|--------------------------------------|----------|----------|
| V_P | 11 | V |
| $R_M + R_{\text{coil}} (\text{hot})$ | 11 | Ω |
| t_{vert} | 0.02 | s |
| x | 0.000802 | |
| V_{FB} | 29 | V |
| P_{sup} | 4.45 | W |
| P_L | 1.93 | W |
| P_{tot} | 2.52 | W |

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Heatsink calculation

The value of the heatsink can be calculated in a standard way with a method based on average temperatures.

The required thermal resistance of the heatsink is determined by the maximum die temperature of 150 °C.

In general we recommend to design for an average die temperature not exceeding 130 °C.

EXAMPLE

Measured or given values: $P_{\text{tot}} = 3 \text{ W}$; $T_{\text{amb}} = 40 \text{ °C}$;
 $T_j = 110 \text{ °C}$; $R_{\text{th}(j-c)} = 5 \text{ K/W}$; $R_{\text{th}(c-h)} = 2 \text{ K/W}$.

The required heatsink thermal resistance is given by:

$$R_{\text{th}(h-a)} = \frac{T_j - T_{\text{amb}}}{P_{\text{tot}}} - (R_{\text{th}(j-c)} + R_{\text{th}(c-h)})$$

When we use the values given we find:

$$R_{\text{th}(h-a)} = \frac{110 - 40}{3.0} - (5 + 2) = 16 \text{ K/W}$$

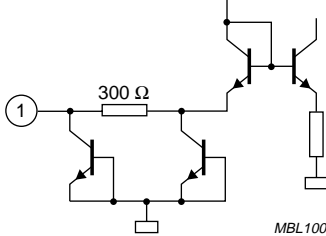
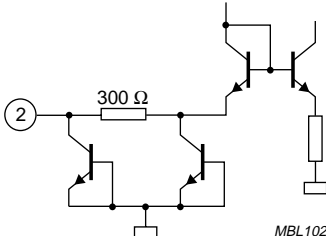
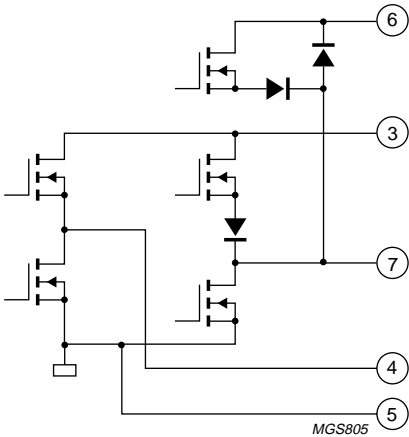
The heatsink temperature will be:

$$T_h = T_{\text{amb}} + (R_{\text{th}(h-a)} \times P_{\text{tot}}) = 40 + (3 \times 16) = 90 \text{ °C}$$

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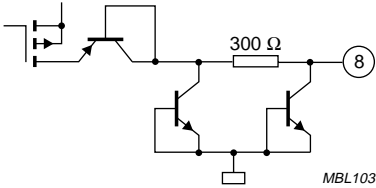
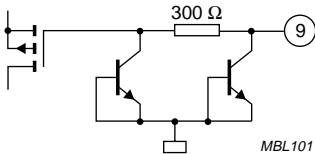
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INTERNAL PIN CONFIGURATION

| PIN | SYMBOL | EQUIVALENT CIRCUIT |
|-----|-----------------|--|
| 1 | INA |  |
| 2 | INB |  |
| 3 | V _P |  |
| 4 | OUTB | |
| 5 | GND | |
| 6 | V _{FB} | |
| 7 | OUTA | |

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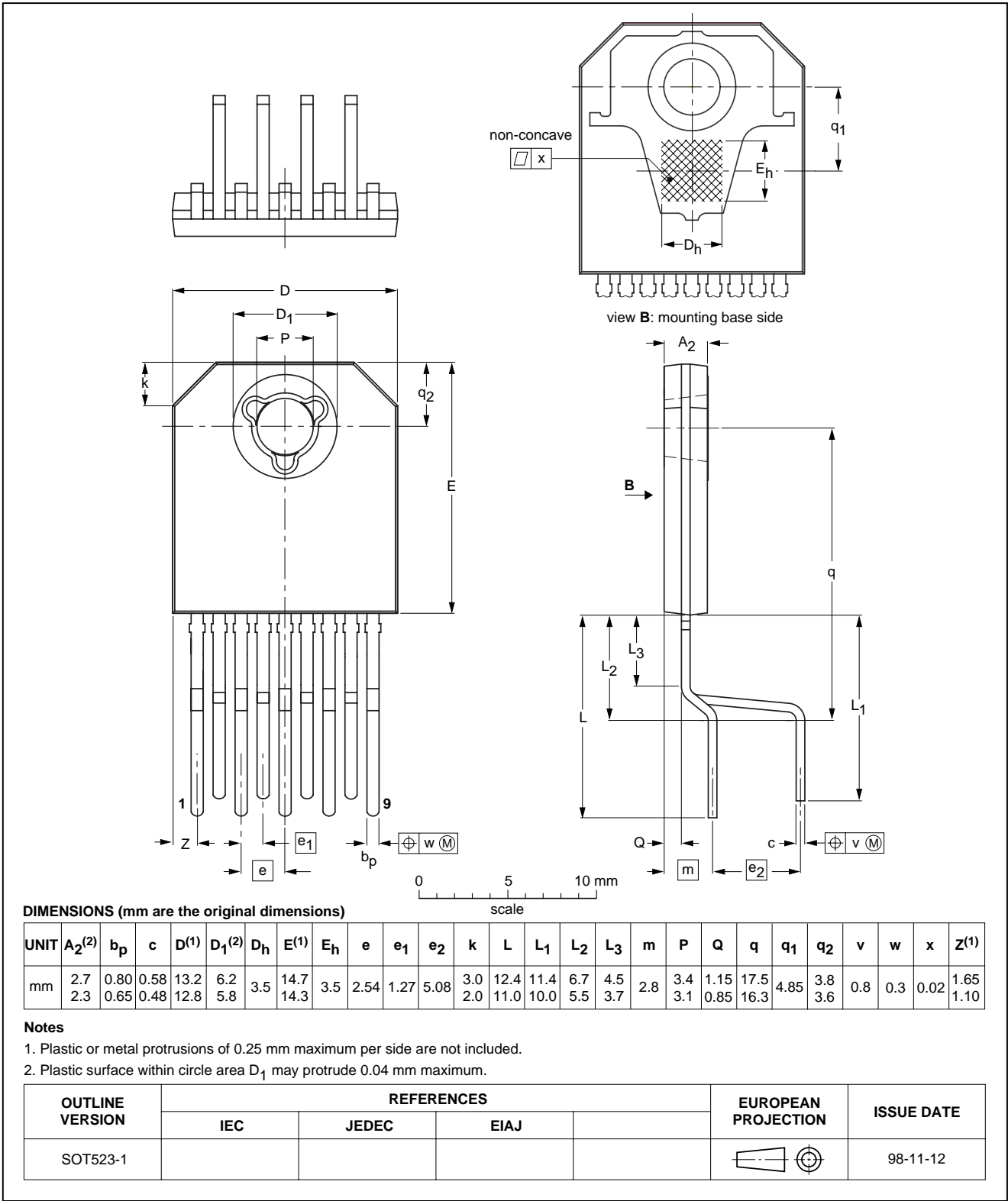
| PIN | SYMBOL | EQUIVALENT CIRCUIT |
|-----|--------|--|
| 8 | GUARD |  |
| 9 | FEEDB |  |

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PACKAGE OUTLINE

DBS9P: plastic DIL-bent-SIL power package; 9 leads (lead length 12/11 mm); exposed die padSOT523-1



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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.

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 this 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

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