

DATA SHEET

TDA1023/T

Proportional-control triac triggering circuit

Product specification
Supersedes data of August 1982
File under Integrated Circuits, IC02

May 1991

Proportional-control triac triggering circuit

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FEATURES

- Adjustable width of proportional range
- Adjustable hysteresis
- Adjustable width of trigger pulse
- Adjustable repetition timing of firing burst
- Control range translation facility
- Fail safe operation
- Supplied from the mains
- Provides supply for external temperature bridge

APPLICATIONS

- Panel heaters
- Temperature control

GENERAL DESCRIPTION

The TDA1023 is a bipolar integrated circuit for controlling triacs in a proportional time or burst firing mode. Permitting precise temperature control of heating equipment it is especially suited to the control of panel heaters. It generates positive-going trigger pulses but complies with regulations regarding mains waveform distortion and RF interference.

QUICK REFERENCE DATA

| SYMBOL | PARAMETER | MIN. | TYP. | MAX. | UNIT |
|-----------------|--|------|------|------|--------------|
| V_{CC} | supply voltage (derived from mains voltage) | – | 13.7 | – | V |
| V_Z | stabilized supply voltage for temperature bridge | – | 8 | – | V |
| $I_{16(AV)}$ | supply current (average value) | – | 10 | – | mA |
| t_w | trigger pulse width | – | 200 | – | μ s |
| T_b | firing burst repetition time at $C_T = 68 \mu$ F | – | 41 | – | s |
| $-I_{OH}^{(1)}$ | output current | – | – | 150 | mA |
| T_{amb} | operating ambient temperature range | –20 | – | +75 | $^{\circ}$ C |

Note

1. Negative current is defined as conventional current flow out of a device. A negative output current is suited for positive triac triggering.

ORDERING INFORMATION

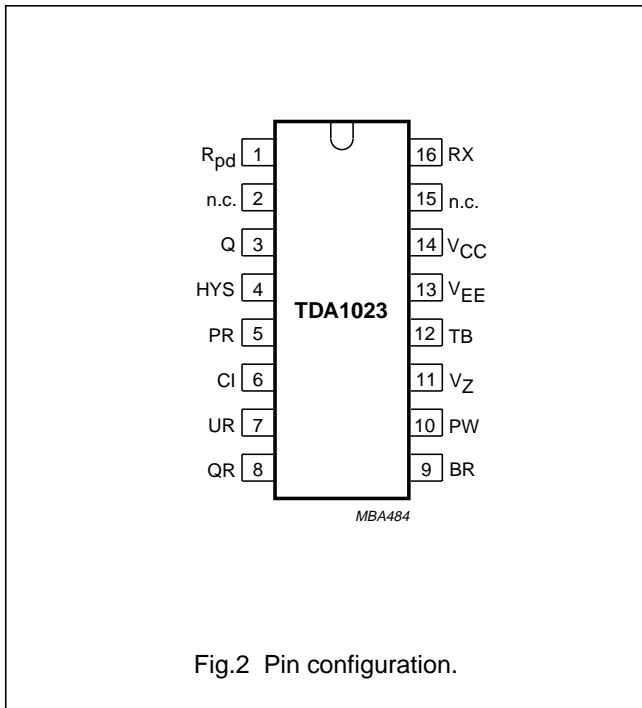
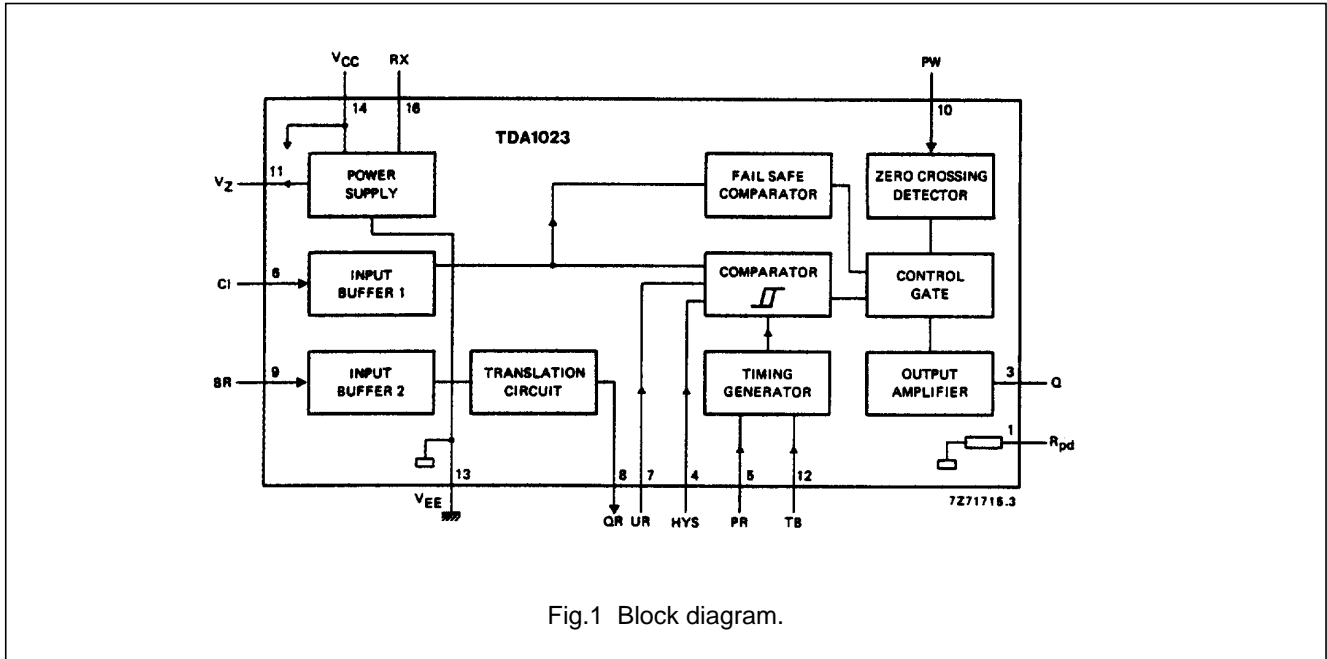
| EXTENDED TYPE NUMBER | PACKAGE | | | |
|-------------------------|---------|--------------|----------|------------------------------|
| | PINS | PIN POSITION | MATERIAL | CODE |
| TDA1023 | 16 | DIL | plastic | SOT38 ⁽¹⁾ |
| TDA1023T | 16 | mini-pack | plastic | SO16; SOT109A ⁽²⁾ |

Note

1. TDA1023: 16 DIL; plastic (SOT38); SOT38-1; 1996 November 27.
2. TDA1023T: 16 mini-pack; plastic (SO16; SOT109A); SOT109-1; 1996 November 27.

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PINNING

| SYMBOL | PIN | DESCRIPTION |
|-----------------|-----|--|
| R _{pd} | 1 | internal pull-down resistor |
| n.c. | 2 | not connected |
| Q | 3 | output |
| HYS | 4 | hysteresis control input |
| PR | 5 | proportional range control input |
| CI | 6 | control input |
| UR | 7 | unbuffered reference input |
| QR | 8 | output of reference buffer |
| BR | 9 | buffered reference input |
| PW | 10 | pulse width control input |
| V _Z | 11 | reference supply output |
| TB | 12 | firing burst repetition time control input |
| V _{EE} | 13 | ground |
| V _{CC} | 14 | positive supply |
| n.c. | 15 | not connected |
| RX | 16 | external resistor connection |

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FUNCTIONAL DESCRIPTION

The TDA1023 generates pulses to trigger a triac. These pulses coincide with the zero excursions of the mains voltage, thus minimizing RF interference and mains supply transients. In order to gate the load on and off, the trigger pulses occur in bursts thus further reducing mains supply pollution. The average power in the load is varied by modifying the duration of the trigger pulse burst in accordance with the voltage difference between the control input CI and the reference input, either UR or BR.

Power supply: V_{CC} , RX and V_Z (pins 14, 16 and 11)

The TDA1023 is supplied from the AC mains via a resistor R_D to the RX connection (pin 16); the V_{EE} connection (pin 13) is linked to the neutral line (see Fig.4a). A smoothing capacitor C_S should be coupled between the V_{CC} and V_{EE} connections.

A rectifier diode is included between the RX and V_{CC} connections whilst the DC supply voltage is limited by a chain of stabilizer diodes between the RX and V_{EE} connections (see Fig.3).

A stabilized reference voltage (V_Z) is available at pin 11 to power an external temperature sensing bridge.

Supply operation

During the positive mains half-cycles the current through the external voltage dropping resistor R_D charges the external smoothing capacitor C_S until RX attains the stabilizing potential of the internal stabilizing diodes. R_D should be selected to be capable of supplying the current I_{CC} for the TDA1023, the average output current $I_{3(AV)}$, recharge the smoothing capacitor C_S and provide the supply for an external temperature bridge. (see Figs 9 to 12). Any excess current is by-passed by the internal stabilizer diodes. The maximum rated supply current, however, must not be exceeded.

During the negative mains half-cycles external smoothing capacitor C_S supplies the sum of the current demand described above. Its capacitance must be sufficiently high to maintain the supply voltage above the specified minimum.

Dissipation in resistor R_D is halved by connecting a diode in series (see Fig.4b and 9 to 12). A further reduction in dissipation is possible by using a high quality dropping capacitor C_D in series with a resistor R_{SD} (see Figs 4c and 14). Protection of the TDA1023 and the triac against mains-borne transients can be provided by connecting a suitable VDR across the mains input.

Control and reference inputs CI, BR and UR (pins 6, 9 and 7)

For the control of room temperature (5 °C to 30 °C) optimum performance is obtained by using the translation circuit. The buffered reference input BR (pin 9) is used as a reference input whilst the output reference buffer QR (pin 8) is connected to the unbuffered reference input UR (pin 7). This ensures that the range of room temperature is encompassed in most of the rotation of the potentiometer to give a linear temperature scale with accurate setting.

Should the translation circuit not be required, the unbuffered reference input UR (pin 7) is used as a reference input. The buffered reference input BR (pin 9) must then be connected to the reference supply output V_Z (pin 11).

For proportional power control the unbuffered reference input UR (pin 7) must be connected to the firing burst repetition time control input TB (pin 12). The buffered reference input BR (pin 9), which is in this instance inactive, must then be connected to the reference supply output V_Z (pin 11).

Proportional range control input PR (pin 5)

The output duty factor changes from 0% to 100% by a variation of 80 mV at the control input CI (pin 6) with the proportional range control input PR open. For temperature control this corresponds to a temperature difference of 1 K.

By connecting the proportional range control input PR (pin 5) to ground the range may be increased to 400 mV, i.e. 5 K. Intermediate values may be obtained by connecting the PR input to ground via a resistor R5 (see Table 1).

Hysteresis control input HYS (pin 4)

With the hysteresis control input HYS (pin 4) open, the device has a built-in hysteresis of 20 mV. For temperature control this corresponds with 0.25 K.

Hysteresis is increased to 320 mV, corresponding to 4 K, by grounding HYS (pin 4). Intermediate values are obtained by connecting pin 4 via resistor R4 to ground. Table 1 provides a set of values for R4 and R5 giving a fixed ratio between hysteresis and proportional range.

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Trigger pulse width control input PW (pin 10)

The width of the trigger pulse may be adjusted to the value required for the triac by choosing the value of the external synchronization resistor R_S between the trigger pulse width control input PW (pin 10) and the AC mains. The pulse width is inversely proportional to the input current (see Fig.13).

Output Q (pin 3)

Since the circuit has an open-emitter output it is capable of sourcing current. It is thus suited for generating positive-going trigger pulses. The output is current-limited and short-circuit protected. The maximum output current is 150 mA and the output pulses are stabilized at 10 V for output currents up to that value.

To minimize the total supply current and power dissipation, a gate resistor R_G must be connected between the output Q and the triac gate to limit the output current to the minimum required by the triac (see Figs 5 to 8).

Pull-down resistor R_{pd} (pin 1)

The TDA1023 includes a 1.75 k Ω pull-down resistor R_{pd} between pins 1 and 13 (V_{EE} , ground connection) intended for use with sensitive triacs.

LIMITING VALUES

In accordance with the Absolute Maximum System (IEC 134)

| SYMBOL | PARAMETER | MIN. | MAX. | UNIT |
|-----------------------|--|------|------|-------------|
| V_{CC} | DC supply voltage | – | 16 | V |
| Supply current | | | | |
| $I_{16(AV)}$ | average | – | 30 | mA |
| $I_{16(RM)}$ | repetitive peak | – | 100 | mA |
| $I_{16(SM)}$ | non-repetitive peak ($t_p < 50 \mu s$) | – | 2 | A |
| V_I | input voltage, all inputs | – | 16 | V |
| $I_{6, 7, 9, 10}$ | input current | – | 10 | mA |
| V_1 | voltage on R_{pd} connection | – | 16 | V |
| $V_{3, 8, 11}$ | output voltage, Q, QR, V_Z | – | 16 | V |
| Output current | | | | |
| $-I_{OH(AV)}$ | average | – | 30 | mA |
| $-I_{OH(M)}$ | peak max. 300 μs | – | 700 | mA |
| P_{tot} | total power dissipation | – | 500 | mW |
| T_{stg} | storage temperature range | –55 | +150 | $^{\circ}C$ |
| T_{amb} | operating ambient temperature range | –20 | +75 | $^{\circ}C$ |

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CHARACTERISTICS

VCC = 11 to 16 V; T_{amb} = -20 to +75 °C unless otherwise specified

| SYMBOL | PARAMETER | CONDITIONS | MIN. | TYP. | MAX. | UNIT |
|---|--|--|------|------|------|-------|
| Supply | | | | | | |
| V _{CC} | internally stabilized supply voltage at I ₁₆ = 10 mA | | 12 | 13.7 | 15 | V |
| $\Delta V_{CC}/\Delta I_{16}$ | variation with I ₁₆ | | – | 30 | – | mV/mA |
| I ₁₆ | supply current at V ₁₆₋₁₃ = 11 to 16 V; I ₁₀ = 1 mA; f = 50 Hz; pin 11 open; V ₆₋₁₃ > V ₇₋₁₃ | pins 4 and 5 open | – | – | 6 | mA |
| | | pins 4 and 5 grounded | – | – | 7.1 | mA |
| Reference supply output V_Z (pin 11) for external temperature bridge | | | | | | |
| V ₁₁₋₁₃ | output voltage | | – | 8 | – | V |
| –I ₁₁ | output current | | – | – | 1 | mA |
| Control and reference inputs CI, BR and UR (pins 6, 9 and 7) | | | | | | |
| V ₆₋₁₃ | input voltage to inhibit the output | | – | 7.6 | – | V |
| I _{6, 7, 9} | input current | V ₁ = 4 V | – | – | 2 | μA |
| Hysteresis control input HYS (pin 4) | | | | | | |
| ΔV_6 | hysteresis | pin 4 open | 9 | 20 | 40 | mV |
| ΔV_6 | hysteresis | pin 4 grounded | – | 320 | – | mV |
| Proportional control range input PR (pin 5) | | | | | | |
| ΔV_6 | proportional range | pin 5 open | 50 | 80 | 130 | mV |
| ΔV_6 | proportional range | pin 5 grounded | – | 400 | – | mV |
| Pulse width control input PW (pin 10) | | | | | | |
| t _w | pulse width | I _{10(RMS)} = 1 mA; f = 50 Hz | 100 | 200 | 300 | μs |
| Firing burst repetition time control input TB (pin 12) | | | | | | |
| T _b C _T | firing burst repetition time, ratio to capacitor C _T | | 320 | 600 | 960 | ms/μF |
| Output of reference buffer QR (pin 8) | | | | | | |
| V ₈₋₁₃ | output voltage at input voltage: | V ₉₋₁₃ = 1.6 V | – | 3.2 | – | V |
| V ₈₋₁₃ | | V ₉₋₁₃ = 4.8 V | – | 4.8 | – | V |
| V ₈₋₁₃ | | V ₉₋₁₃ = 8 V | – | 6.4 | – | V |
| Output Q (pin 3) | | | | | | |
| V _{OH} | output voltage HIGH | –I _{OH} = 150 mA | 10 | – | – | V |
| –I _{OH} | output current HIGH | | – | – | 150 | mA |
| Internal pull-down resistor R_{pd} (pin 1) | | | | | | |
| R _{pd} | resistance to V _{EE} | | 1 | 1.75 | 3 | kΩ |

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Table 1 Adjustment of proportional range and hysteresis. Combinations of resistor values giving hysteresis > 1/4 proportional range.

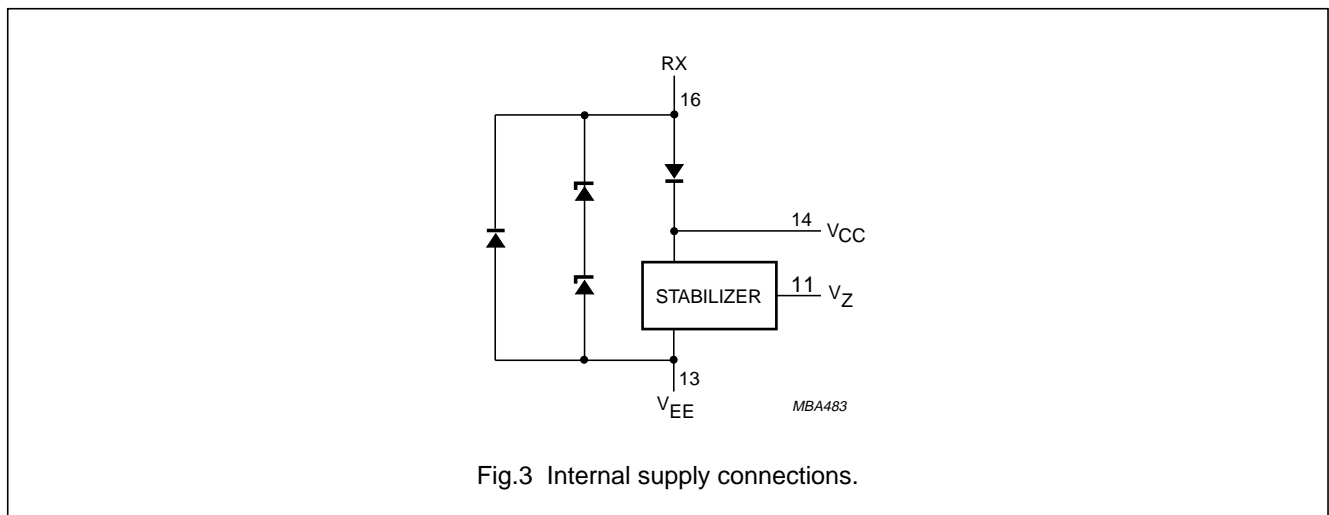
| Proportional range mV | Proportional range resistor R5 kΩ | Minimum hysteresis mV | Maximum hysteresis resistor R4 kΩ |
|--------------------------|---|--------------------------|---|
| 80 | open | 20 | open |
| 160 | 3.3 | 40 | 9.1 |
| 240 | 1.1 | 60 | 4.3 |
| 320 | 0.43 | 80 | 2.7 |
| 400 | 0 | 100 | 1.8 |

Table 2 Timing capacitor values C_T

| Effective DC value μF | Marked AC specification | | Catalogue number ⁽¹⁾ |
|--------------------------|-------------------------|----|---------------------------------|
| | μF | V | |
| 68 | 47 | 25 | 2222 016 90129 |
| 47 | 33 | 40 | -- 90131 |
| 33 | 22 | 25 | - 015 90102 |
| 22 | 15 | 40 | -- 90101 |
| 15 | 10 | 25 | -- 90099 |
| 10 | 6.8 | 40 | -- 90098 |

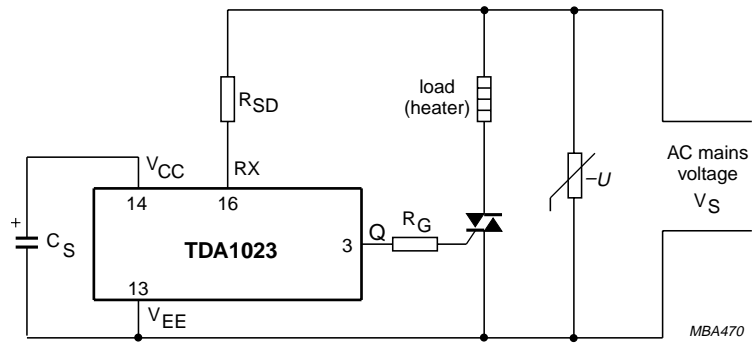
Note

1. Special electrolytic capacitors recommended for use with the TDA1023.

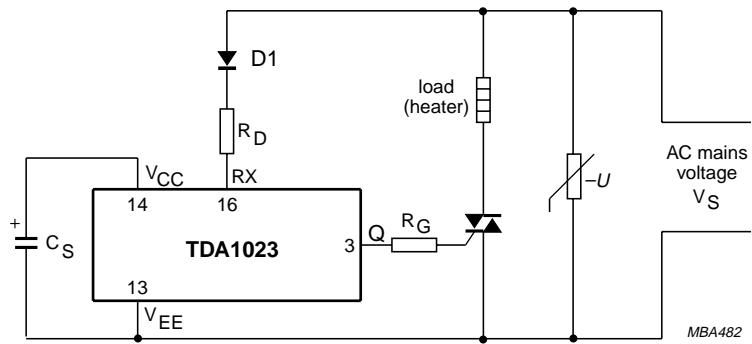


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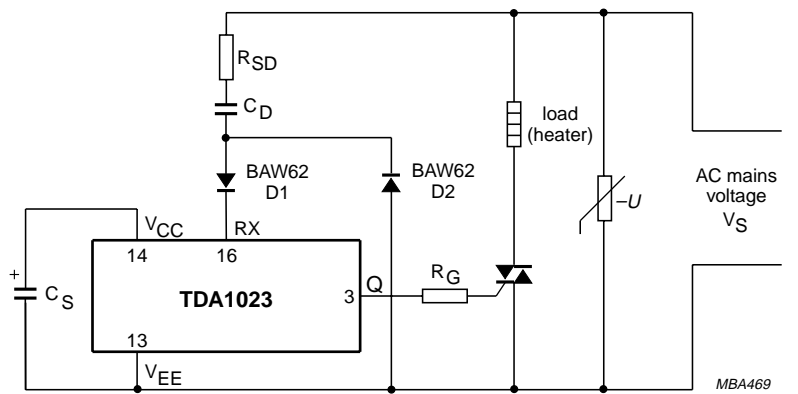
TDA1023/T



a.



b.

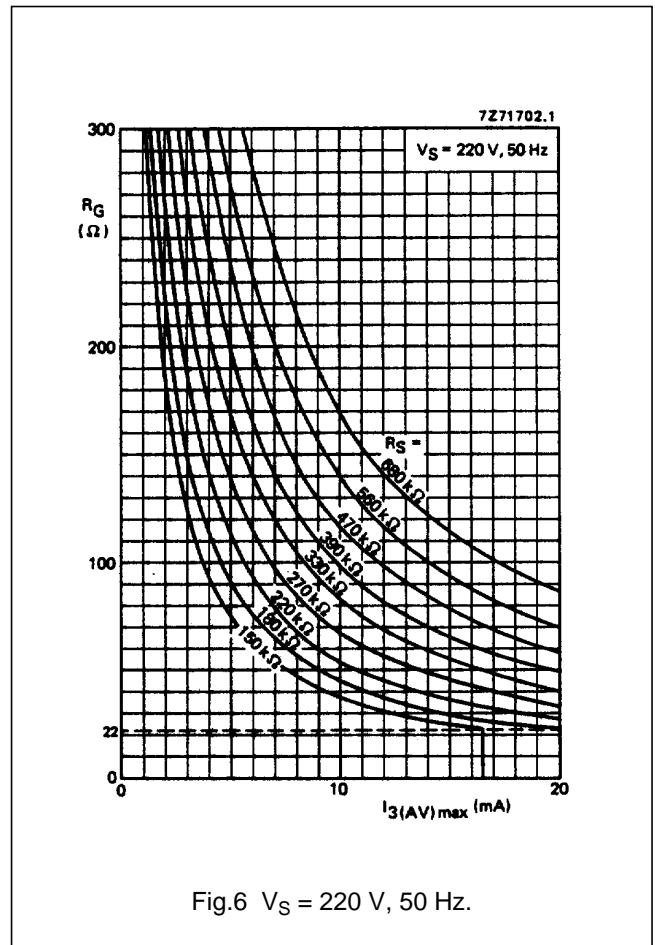
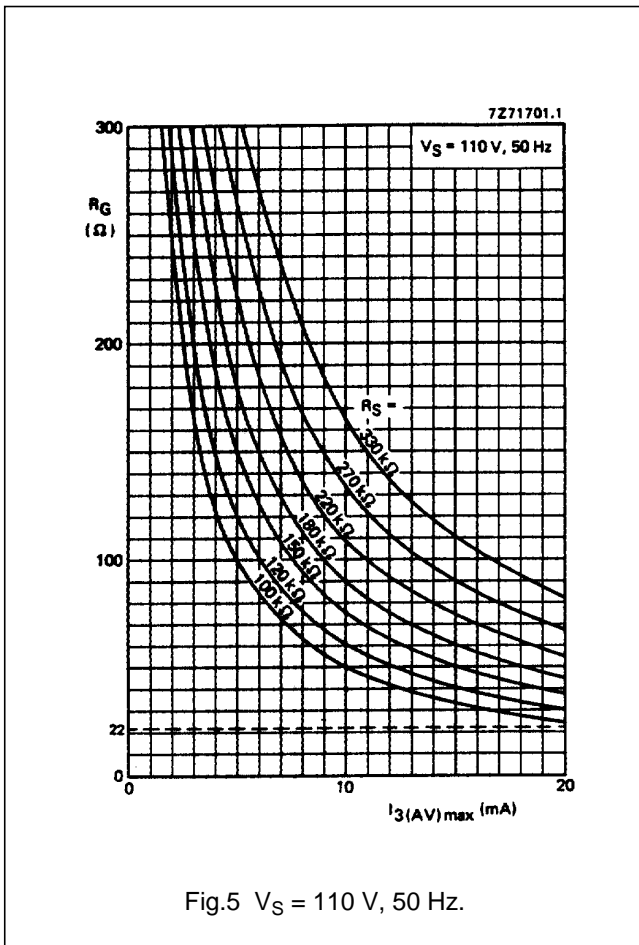


c.

Fig.4 Alternative supply arrangements.

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Proportional-control triac triggering circuit

TDA1023/T

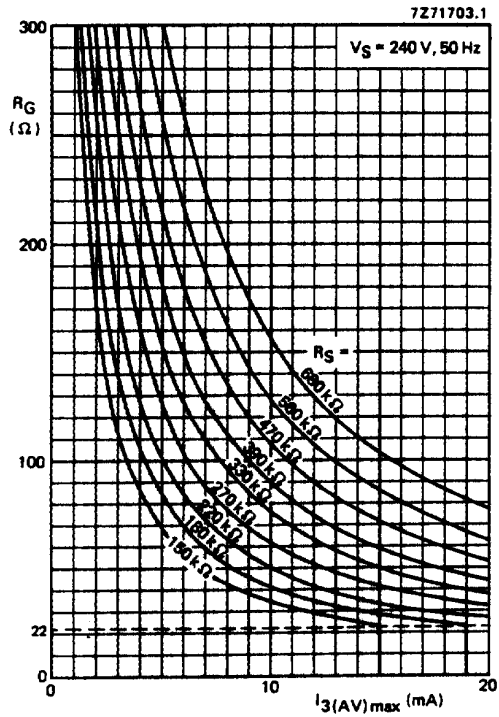


Fig.7 $V_S = 240 \text{ V}, 50\text{Hz}$.

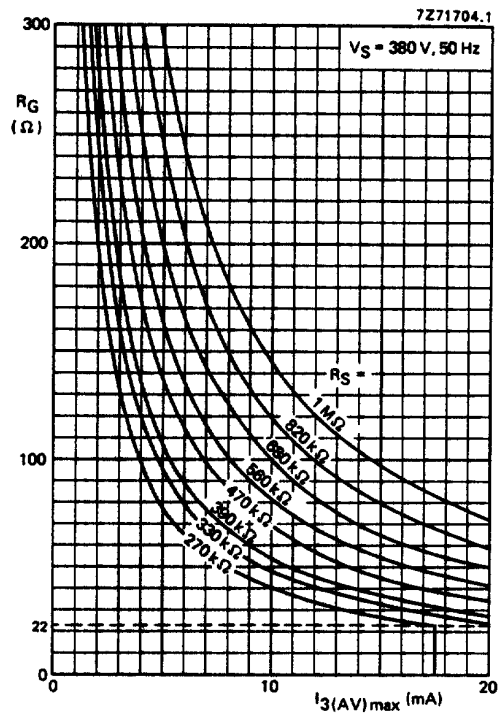


Fig.8 $V_S = 380 \text{ V}, 50 \text{ Hz}$.

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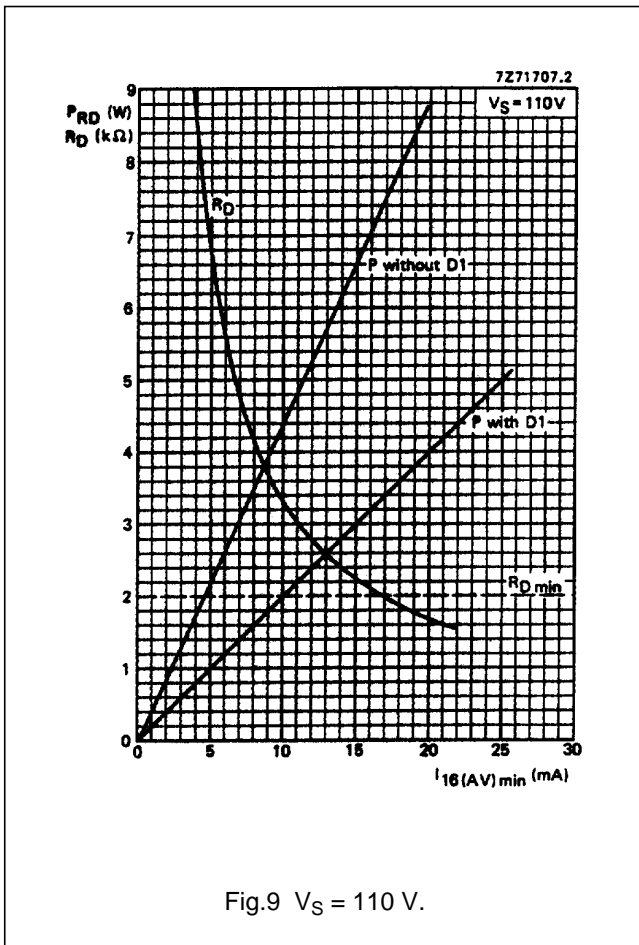


Fig.9 $V_S = 110 V$.

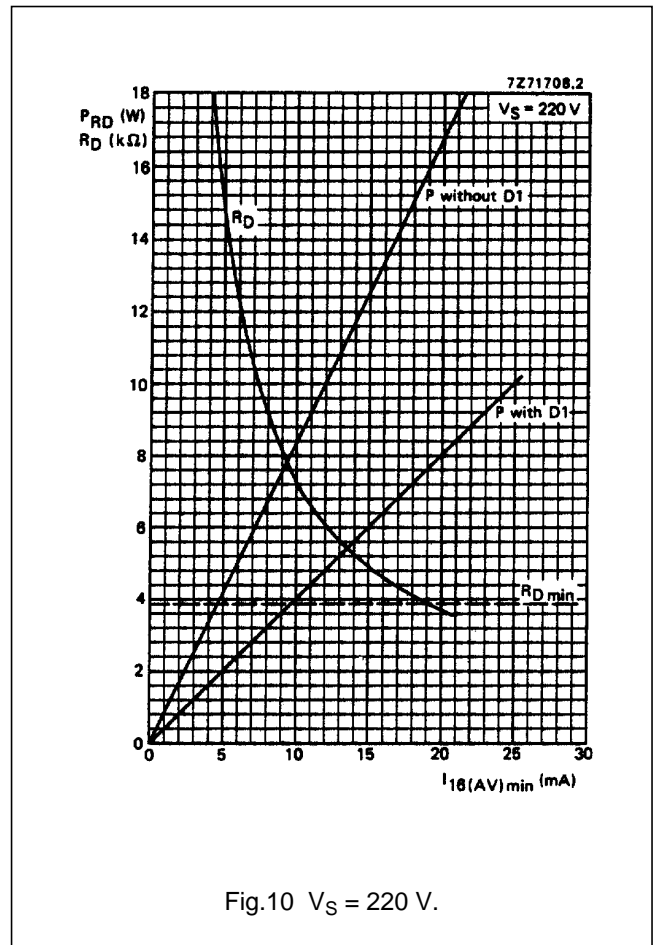


Fig.10 $V_S = 220 V$.

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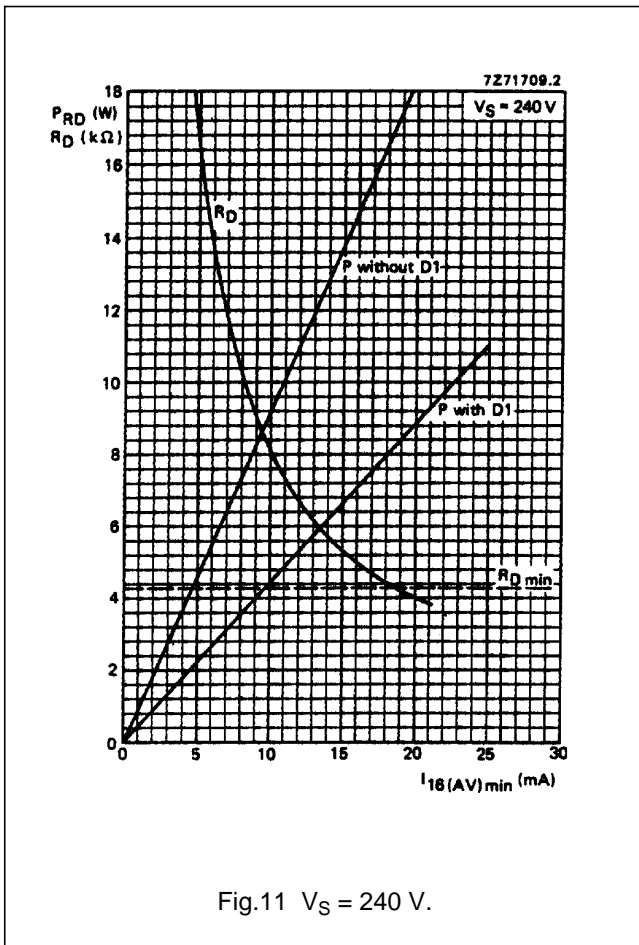


Fig.11 $V_S = 240\text{ V}$.

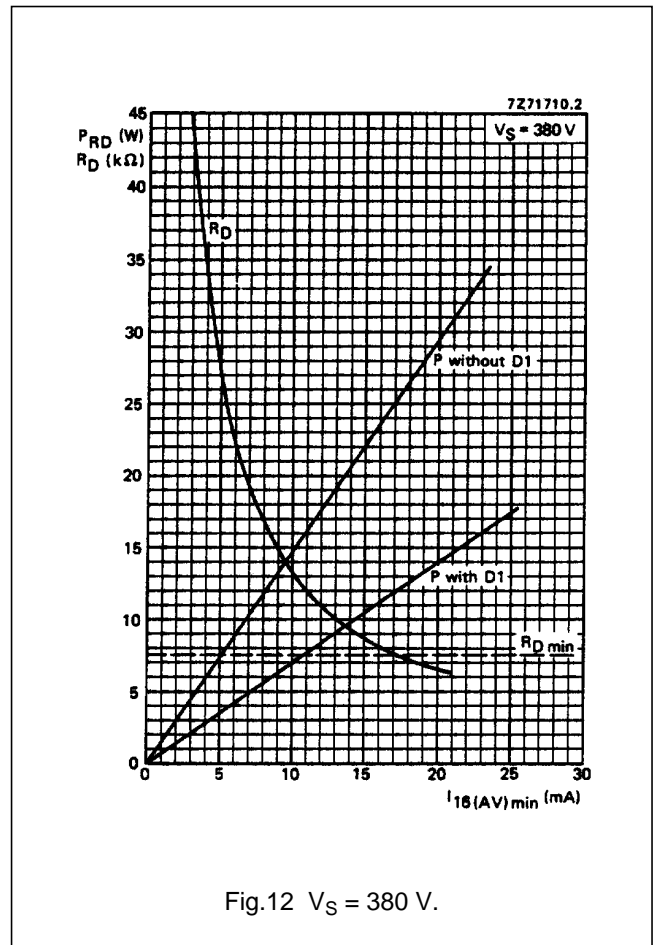


Fig.12 $V_S = 380\text{ V}$.

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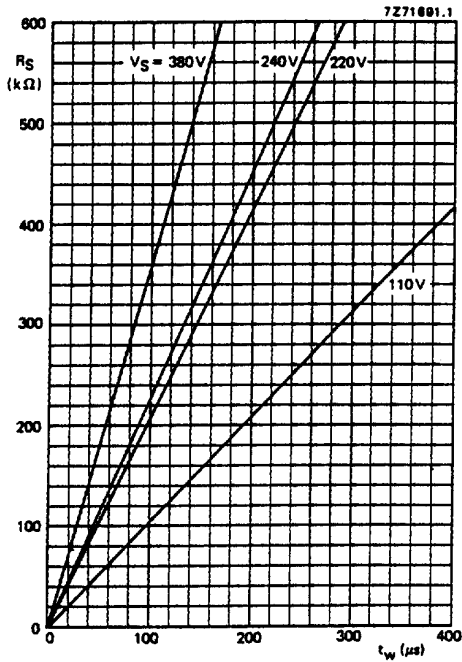


Fig.13 Synchronization resistor R_S as a function of required trigger pulse width t_w with a mains voltage V_S as a parameter.

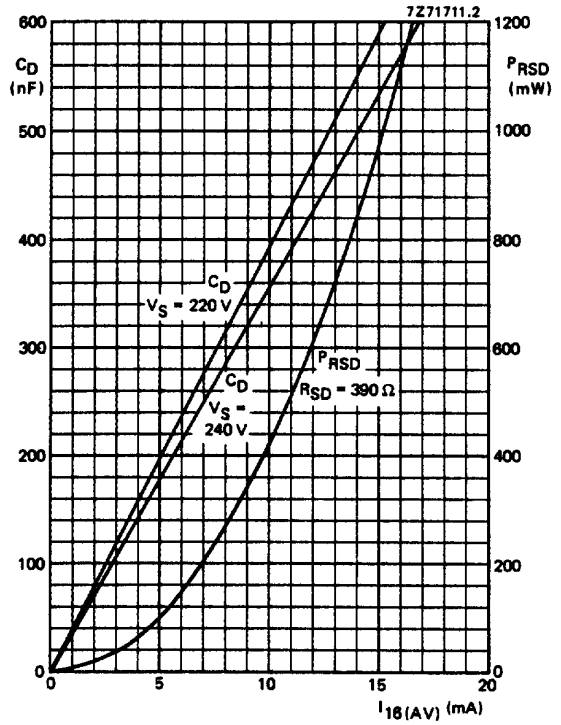
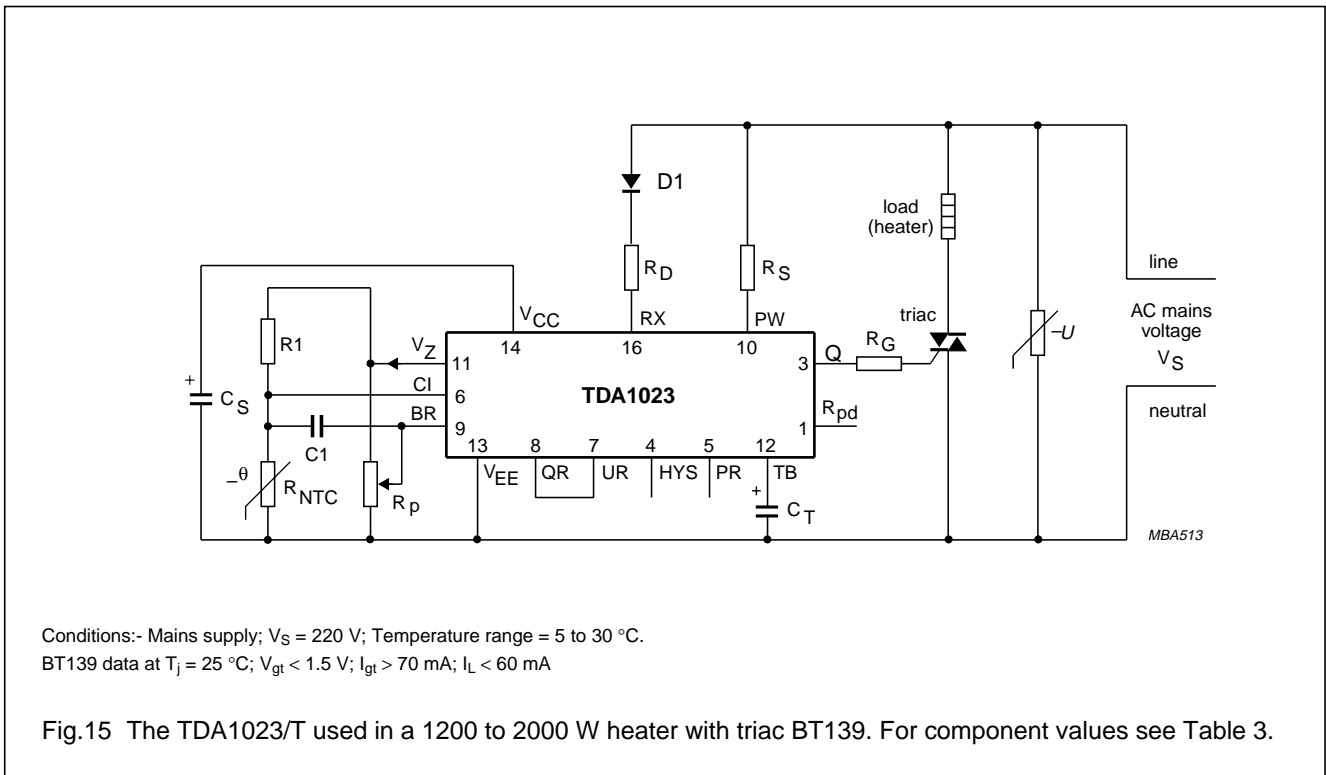


Fig.14 Nominal value of voltage dropping capacitor C_D and power P_{RSD} dissipated in a voltage dropping resistor R_{SD} as a function of average supply current $I_{16(AV)}$ with the mains supply voltage V_S as a parameter.

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Proportional-control triac triggering circuit

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Table 3 Temperature controller component values (see Fig.15). Notes 1, 2

| SYMBOL | PARAMETER | REMARKS | VALUE |
|--|--------------------------------|-----------------------------------|-------------------|
| t_w | trigger pulse width | see <i>BT139 data sheet</i> | 75 μ s |
| R_S | synchronization resistor | see Fig.13 | 180 k Ω |
| R_G | gate resistor | see Fig.6 | 110 Ω |
| $I_{3(AV)}$ | max. average gate current | see Fig.8 | 4.1 mA |
| R_4 | hysteresis resistor | see Table 1 | n.c. |
| R_5 | proportional band resistor | see Table 1 | n.c. |
| $I_{16(AV)}$ | min. required supply current | | 11.1 mA |
| R_D | mains dropping resistor | see Fig.10 | 6.2 k Ω |
| P_{RD} | power dissipated in R_D | see Fig.10 | 4.6 W |
| C_T | timing capacitor (eff. value) | see Table 2 | 68 μ F |
| VDR | voltage dependent resistor | cat. no. 2322 593 62512 | 250 V AC |
| D1 | rectifier diode | | BYW56 |
| R_1 | resistor to pin 11 | 1% tolerance | 18.7 k Ω |
| R_{NTC} | NTC thermistor (at 25 °C) | B = 4200 K cat no. 2322 642 12223 | 22 k Ω |
| R_p | potentiometer | | 22 k Ω |
| C_1 | capacitor between pins 6 and 9 | | 47 nF |
| C_S | smoothing capacitor | | 220 μ F; 16 V |
| If R_D and D1 are replaced by C_D and R_{SD} | | | |
| C_D | mains dropping capacitor | | 470 nF |
| R_{SD} | series dropping resistor | | 390 Ω |
| P_{RSD} | power dissipated in R_{SD} | see Fig.14 | 0.6 W |
| VDR | voltage dependent resistor | cat. no. 2322 594 62512 | 250 V AC |

Notes

- ON/OFF control: pin 12 connected to pin 13.
- If translation circuit is not required: slider of R_p to pin 7; pin 8 open; pin 9 connected to pin 11.

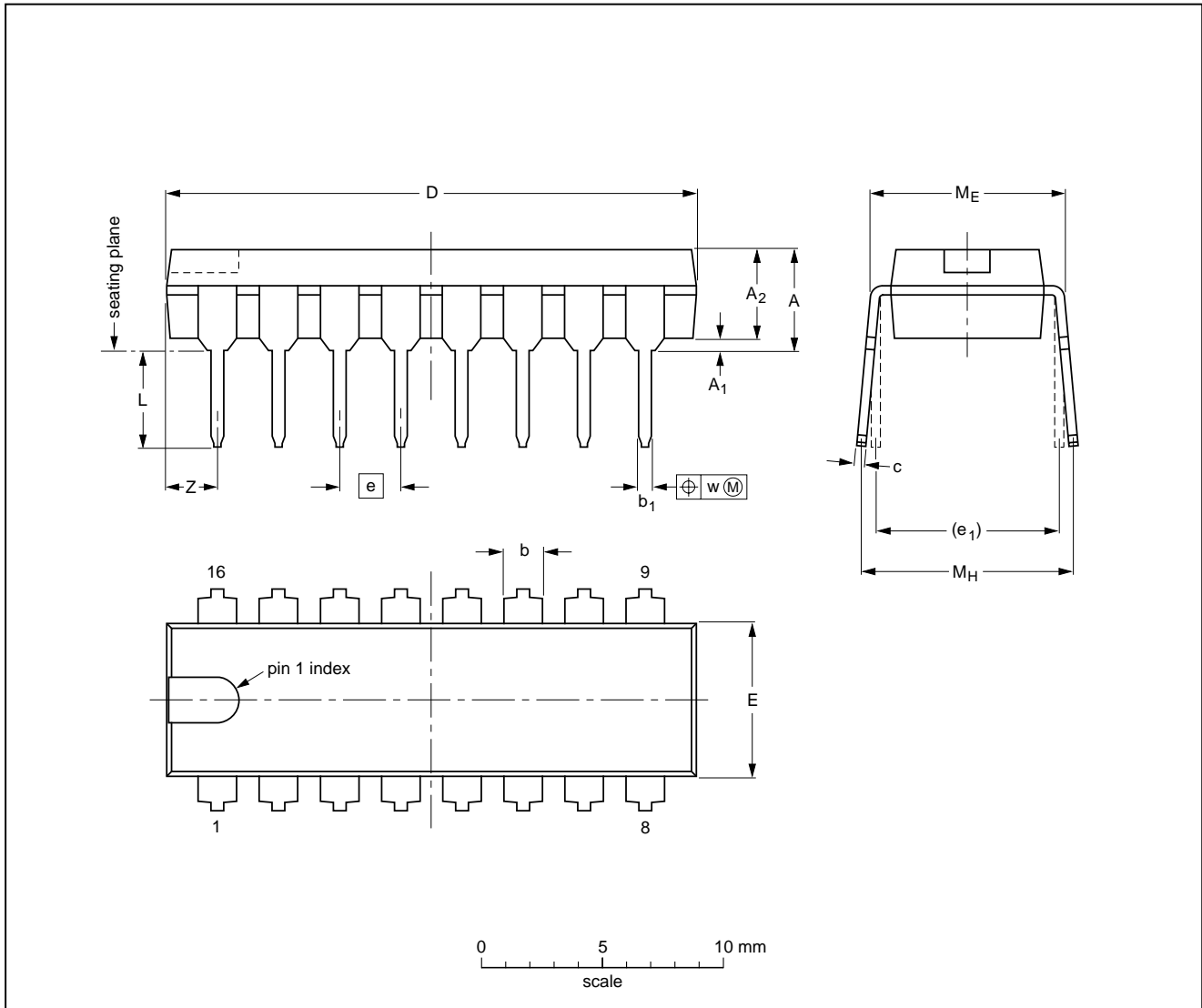
Proportional-control triac triggering circuit

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PACKAGE OUTLINES

DIP16: plastic dual in-line package; 16 leads (300 mil); long body

SOT38-1



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

| UNIT | A max. | A ₁ min. | A ₂ max. | b | b ₁ | c | D ⁽¹⁾ | E ⁽¹⁾ | e | e ₁ | L | M _E | M _H | w | Z ⁽¹⁾ max. |
|--------|--------|---------------------|---------------------|----------------|----------------|----------------|------------------|------------------|------|----------------|--------------|----------------|----------------|-------|-----------------------|
| mm | 4.7 | 0.51 | 3.7 | 1.40 1.14 | 0.53 0.38 | 0.32 0.23 | 21.8 21.4 | 6.48 6.20 | 2.54 | 7.62 | 3.9 3.4 | 8.25 7.80 | 9.5 8.3 | 0.254 | 2.2 |
| inches | 0.19 | 0.020 | 0.15 | 0.055 0.045 | 0.021 0.015 | 0.013 0.009 | 0.86 0.84 | 0.26 0.24 | 0.10 | 0.30 | 0.15 0.13 | 0.32 0.31 | 0.37 0.33 | 0.01 | 0.087 |

Note

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

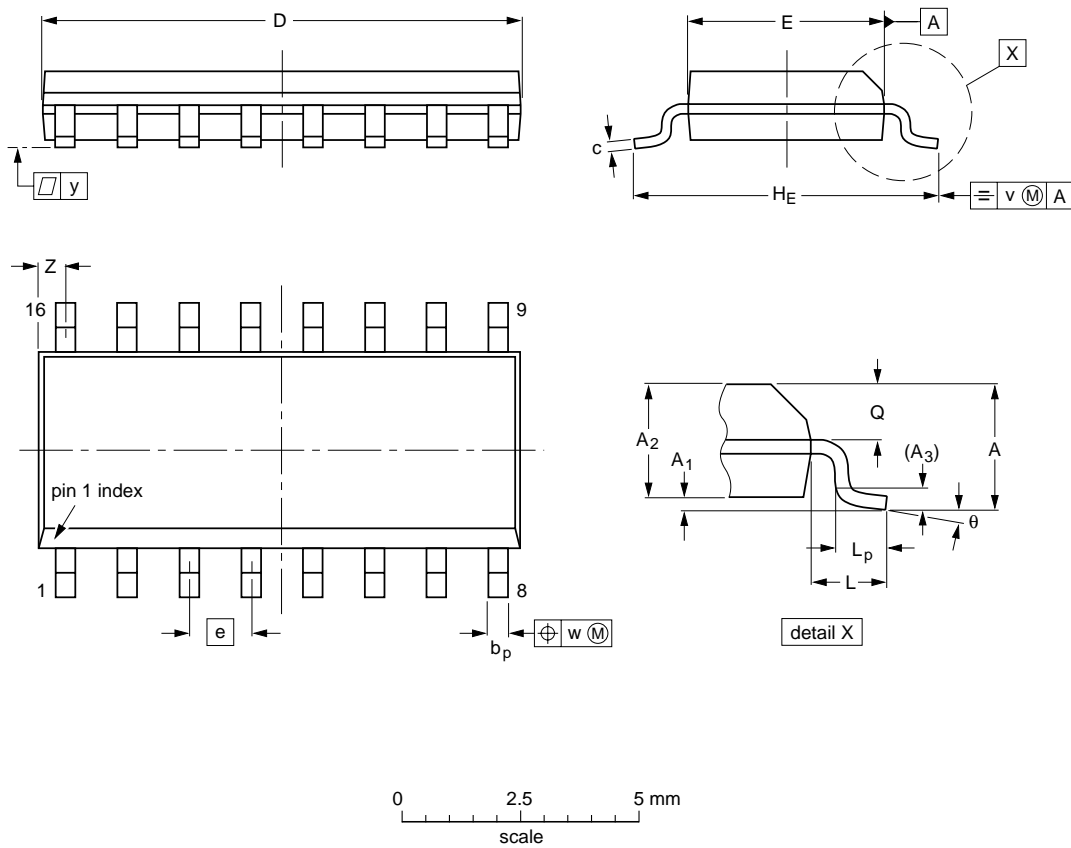
| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|-----------------|------------|----------|------|--|---------------------|----------------------|
| | IEC | JEDEC | EIAJ | | | |
| SOT38-1 | 050G09 | MO-001AE | | | | 92-10-02 95-01-19 |

Proportional-control triac triggering circuit

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SO16: plastic small outline package; 16 leads; body width 3.9 mm

SOT109-1



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

| UNIT | A max. | A ₁ | A ₂ | A ₃ | b _p | c | D ⁽¹⁾ | E ⁽¹⁾ | e | H _E | L | L _p | Q | v | w | y | Z ⁽¹⁾ | θ |
|--------|--------|----------------|----------------|----------------|----------------|------------------|------------------|------------------|-------|----------------|-------|----------------|----------------|------|------|-------|------------------|----------|
| mm | 1.75 | 0.25 0.10 | 1.45 1.25 | 0.25 | 0.49 0.36 | 0.25 0.19 | 10.0 9.8 | 4.0 3.8 | 1.27 | 6.2 5.8 | 1.05 | 1.0 0.4 | 0.7 0.6 | 0.25 | 0.25 | 0.1 | 0.7 0.3 | 8° 0° |
| inches | 0.069 | 0.010 0.004 | 0.057 0.049 | 0.01 | 0.019 0.014 | 0.0100 0.0075 | 0.39 0.38 | 0.16 0.15 | 0.050 | 0.244 0.228 | 0.041 | 0.039 0.016 | 0.028 0.020 | 0.01 | 0.01 | 0.004 | 0.028 0.012 | |

Note

1. Plastic or metal protrusions of 0.15 mm maximum per side are not included.

| OUTLINE VERSION | REFERENCES | | | | EUROPEAN PROJECTION | ISSUE DATE |
|-----------------|------------|----------|------|--|---------------------|----------------------|
| | IEC | JEDEC | EIAJ | | | |
| SOT109-1 | 076E07S | MS-012AC | | | | 95-01-23 97-05-22 |

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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.

Proportional-control triac triggering circuit

TDA1023/T

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.