Product Specification
INTEGRATED CIRCUIT
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OM5428

Phase control and general purpose triac triggering circuit

INTEGRATED ELECTRONIC SOLUTIONS
1BUTLER DRIVE
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AUSTRALIA

IES

Phase control and general purpose triac triggering circuit

OM5428

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(1) The contents of this document are subject to the disclaimer on page 16

Phase control and general purpose triac triggering circuit

OM5428

1 FEATURES

- Design flexibility for phase control applications
- Adjustable proportional range
- Adjustable hysteresis
- Adjustable firing burst repetition time
- Adjustable pulse width
- Supplied from the mains
- Provides supply for external temperature bridge
- Low supply current, low dissipation

2 GENERAL DESCRIPTION

The OM5428 is a bipolar integrated circuit delivering negative pulses for triggering a triac. The flexibility of the circuit makes it suitable for a variety of applications, such as:

- Phase control
- Motor speed control
- Synchronous on/off switching
- Temperature control
- Time-proportional control

3 BLOCK DIAGRAM

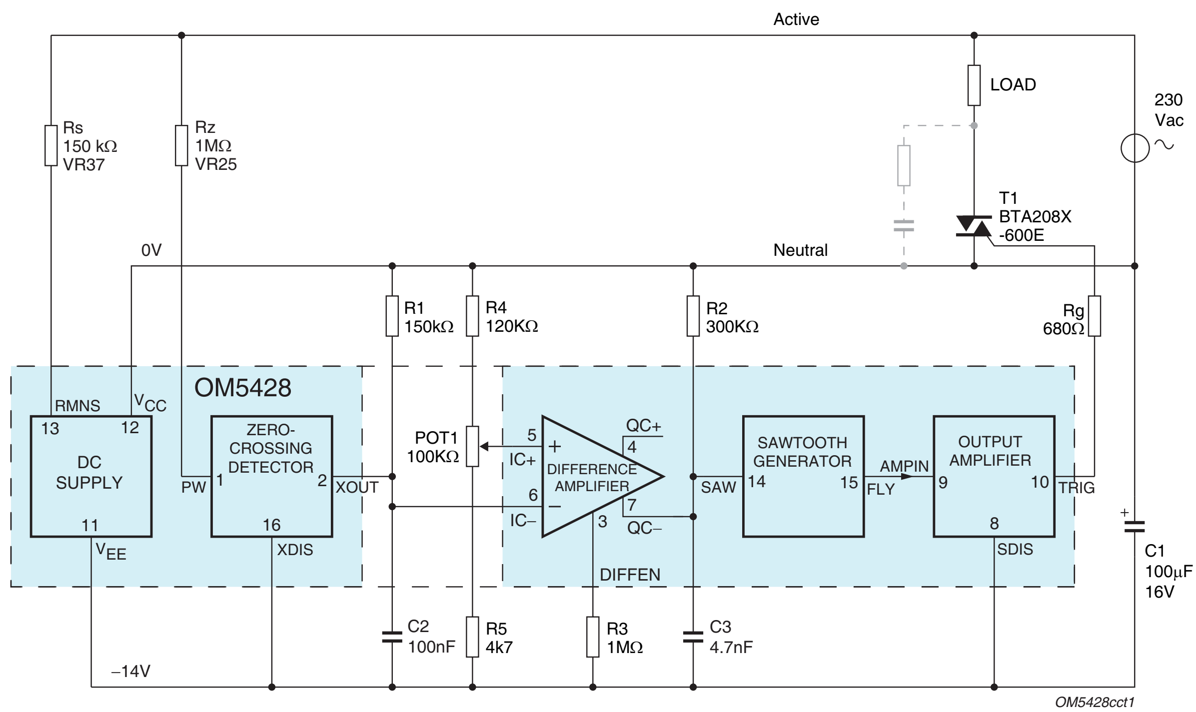


Fig.1 Block diagram of the OM5428

4 ORDERING INFORMATION

TYPE NUMBER	PACKAGE		
	NAME	DESCRIPTION	VERSION
OM5428 T	SO16	plastic small outline package; 16 leads; body width 3.9 mm	SOT109-1

Note: DIP16 version is also available on request.

5 PINNING INFORMATION

5.1 Pinning layout

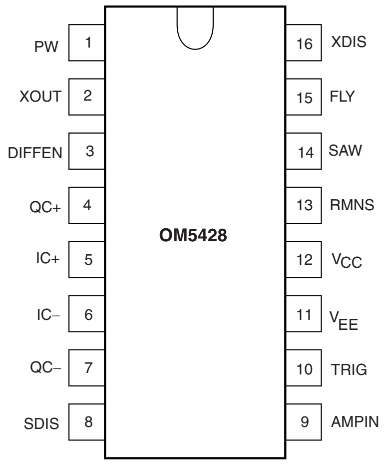


Fig.2 Pin configuration

5.2 Pin description

SYMBOL	PIN	DESCRIPTION
PW	1	pulse width control input
XOUT	2	zero-crossing detector output
DIFFEN	3	difference amplifier enable output
QC+	4	comparator non-inverting output
IC+	5	comparator non-inverting input
IC–	6	comparator inverting input
QC–	7	comparator inverting output
SDIS	8	triac gate sense disable input
AMPIN	9	output stage input
TRIG	10	output stage output
V_{EE}	11	negative supply
V_{CC}	12	positive supply
RMNS	13	external power resistor
SAW	14	sawtooth generator trigger input
FLY	15	sawtooth generator output
XDIS	16	zero crossing detector disable input

6 QUICK REFERENCE DATA

T_{amb} = 25°C

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
$-V_{EE}$	DC supply voltage	derived from mains voltage	–	14.7	–	V
$-I_{EE}$	supply current	quiescent current	–	180	–	µA
I_{TRIG}	output current	set via gate resistor (Rg)	–	–	80	mA
t_w	zero crossing pulse width sawtooth pulse width	Rz = 500KΩ RC (R = 300KΩ; C = 4.7nF)	– –	100 100	– –	µs µs
P_{tot}	total power dissipation	maximum	–	–	300	mW
T_{amb}	operating ambient temperature range		–40	–	+85	°C

7 FUNCTIONAL DESCRIPTION

Fig.1 shows the functional block diagram of the OM5428. It comprises the following sections:

- d.c. supply derived from the mains via a dropping resistor (Rs);
- reset to ensure correct startup;
- gate sense for reduction in the number of pulses produced when firing the triac;
- zero-crossing detector for synchronization of the trigger pulses;
- difference amplifier passing a signal from a sensor, or indication of a potentiometer setting or switch position, etc.;
- ramp function generator operating as the sawtooth oscillator in time proportional or phase control;
- output amplifier amplifying trigger pulses and driving the triac gate.

7.1 Supply

The OM5428 has been designed so that it is supplied directly from mains voltage via a dropping resistor. For this purpose a regulator circuit is included to limit the DC supply voltage. The external supply dropping resistor Rs (mains voltage rated) is connected between the mains active and pin RMNS; V_{CC} is connected to the neutral or common line. A smoothing capacitor C1 is connected between V_{CC} and V_{EE}. The circuit produces a negative supply voltage at V_{EE}, which may be used to supply an external circuit such as a temperature sensing bridge.

During the negative half of mains, current through the external voltage dropping resistor Rs charges the external smoothing capacitor C1 to the shunt voltage of the regulator. The value of Rs should be chosen such that it can supply the current for the OM5428, plus the charge required to drive the triac gate and any external (peripheral) circuits connected to V_{EE} by recharging the smoothing capacitor C1 on the mains negative half cycles. Any excess current is bypassed through the shunt transistor of the regulator. The maximum rated current must not be exceeded.

During the positive half of the mains cycle the external smoothing capacitor C1 supplies the circuit. Its capacitance must be large enough to maintain the supply voltage above the minimum specified limit.

A suitable VDR may be connected across the mains to provide protection for the OM5428 and the triac against mains-born transients.

7.2 Reset

A reset circuit providing four reset functions throughout the OM5428 has been included.

Initially the reset signal ensures that trigger pulses are not produced until V_{EE} has reached its minimum value and C1 is fully charged. The input SAW (pin14) to the sawtooth generator is also held at a low state until the reset threshold has been reached.

During start-up the reset is also responsible for holding the input pins to the difference amplifier, IC+ (pin 5) at a high state and IC- (pin 6) at a low state. As a result, functions such as soft and hard start while phase firing can be realised.

7.3 Zero-crossing detector

The OM5428 contains a zero-crossing detector to produce pulses that coincide with the zero crossings of the mains voltage to minimise RF interference and transients on the mains supply.

If the load to be driven is purely resistive, the synchronization voltage is obtained direct from the mains via a resistor. As a result trigger pulses start shortly before, and end shortly after, each zero-crossing of the mains voltage. In this manner radio interference is reduced to a minimum.

If the load contains an inductive component, the synchronization will be produced by the internal gate sense circuit rather than the zero-crossing detector. The trigger pulse is then produced at the earliest possible moment, i.e. immediately following zero-crossing of the phase-shifted load current.

During phase control the zero-crossing detector is used to generate a sawtooth voltage synchronous with the mains. As soon as the d.c. control voltage corresponding to a preset trigger angle is exceeded the output is pulsed.

The pulse width control input PW (pin 1) allows adjustment of the pulse width at output XOUT (pin 2), to the value required for the triac. This is done by choosing the value of external synchronization resistor Rz between PW and the AC mains. The pulse width is determined by the amount of current flowing to or from pin PW. Any current exceeding 9uA will result in the output of the zero-crossing detector being disabled. The zero-crossing detector output is also inhibited when the XDIS input (pin 16) is HIGH, and enabled when LOW, e.g. connected to V_{EE}.

The pulse width can be determined using the following formula:

$$PW = 2\left(\frac{\mathrm{asin}\left(\frac{(9\times10^{-6}\cdot Rz)}{Vmains(pk)}rad\right)}{100\pi}\right) \quad s$$

Output XOUT, which produces negative-going output pulses, is an n-p-n open-collector output that for some applications may require an external pull-up resistor connected to V_{CC}.

7.4 Difference amplifier

7.4.1 IC+, IC-, QC+, QC-

IC+ and IC− (pins 5 and 6) are differential inputs of the comparator or differential amplifier, with QC+ and QC− (pins 4 and 7) as complementary outputs. QC+ and QC− are n-p-n open collector outputs requiring external collector resistors to V_{CC}. QC+ will be HIGH and QC− will be LOW when IC+ is higher than IC−.

IC+ and IC- are both the base drive of separate p-n-p transistors. In order for correct operation of the comparator, the input voltage on these pins should be set up such that current is able to be drawn from them. Such arrangements may involve a pot controlled voltage divider.

Complementary outputs QC+ and QC− are open collector n-p-n outputs, and therefore require external pull-ups to realise a “high” on the output. When not used these outputs can be left open circuit.

7.4.2 DIFFEN

The comparator contains a p-n-p current mirror source that is activated by a current out of DIFFEN (pin 3). The current drawn from pin 3 determines the drive for the comparator outputs.

7.5 Sawtooth generator

The sawtooth generator may be used to produce bursts of trigger pulses, with the net effect that the load is periodically switched on and off.

With a time-proportional switch, the ramp voltage produced by the sawtooth generator serves to provide the repetition frequency of load switching that can be adjusted with the control voltage.

In phase control, the flyback of the sawtooth is used as the drive signal for generating the trigger pulse.

7.5.1 SAW

The firing burst repetition time is usually determined by an external resistor and capacitor connected to the sawtooth generator trigger input SAW (pin 14). The repetition time is approximately 0.4 x RC.

7.5.2 FLY

The output FLY (pin 15) is an n-p-n open-collector output. During the flyback period of the sawtooth pulse the transistor is ON and is capable of sinking current.

7.6 Output Amplifier

The output stage is used to provide gate pulses of sufficient current to drive a triac.

The output has been designed to produce negative going pulses with respect to mains neutral. This allows a triac to be fired in its more sensitive regions, reducing the amount of gate current needed to latch the triac and hence reducing the overall current consumption.

Depending on the configuration of the drive circuit, the output can be used to provide single gate pulses, or a burst of pulses. This operating mode needs to be taken into account when calculating power supply requirements.

7.6.1 AMPIN

The output stage is driven via an internal pull-up and therefore may be inhibited by drawing current from input AMPIN (pin 9). In typical applications this can be driven by simple connection to the open collector FLY pin.

7.6.2 TRG

The output TRIG (pin 10) is an n-p-n open-collector output capable of sinking current i.e. conventional current flow into the circuit.

A gate resistor Rg should be connected between the output TRIG and the triac gate to limit the output current to the minimum required by the triac. By doing this, the total supply current and the power dissipation of the IC are minimised. Output TRIG is protected with a diode to V_{EE} (pin 11) against damage by undershoot of the output voltage, e.g. caused by an inductive load.

7.7 Gate sense

Included in the OM5428 is a function that is capable of determining the state of the triac. Used to inhibit the output amplifier, the gate sense circuit ensures that multiple gate pulses are not produced, hence reducing overall current consumption.

7.7.1 SDIS - GATE SENSE DISABLE

If multiple gate pulses are required, the gate sense circuit can be disable using the SDIS pin. The SDIS pin is connected to the base of an n-p-n transistor which controls an internal current mirror. A current can be injected into SDIS by connecting it to Vcc via a 1MOhm resistor.

When the disable function is not being used, SDIS should be connected to Vee. The SDIS pin should never be left unconnected.

8 LIMITING VALUES

In accordance with the Absolute Maximum Rating System (IEC 134).
All voltages specified with respect to V_{CC}, Common.

SYMBOL	PARAMETER	CONDITIONS	MIN.	MAX.	UNIT
$-V_{EE}$	supply voltage supply current		– –	18 15	V mA
V_I	input voltage, all inputs excluding pins RMNS and PW	I < 15mA	V_{EE} – 0.5	V_{EE} + 18	V
V_I	input voltage, pins RMNS and PW	I < 15mA	V_{EE} – 18	V_{EE} + 18	V
I_I	input current, all inputs excluding pin RMNS and TRIG		–1	1	mA
$I_{RMNS(AV)}$	rectified average		–	15	mA
$I_{RMNS(RM)}$	repetitive peak		–	50	mA
I_{TRIG}	output current	t < 300 µs	–	300	mA
P_{tot}	total power dissipation		–	300	mW
T_{stg}	storage temperature		–40	+150	°C
T_{amb}	operating ambient temperature		–40	+85	°C

9 CHARACTERISTICS

At T_{amb} = 25°C; Voltages are specified with respect to V_{CC}, Common.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Power Supply						
$-V_{EE}$	supply voltage (operating)	I_{CC} = 1 mA	14.1	14.7	15.3	V
$-I_{EE}$	quiescent current	All function pins open cct	–	180	300	µA
Pulse width control input PW (pin 1)						
V_{PW}	input voltage	I_{PW} = 100 µA I_{PW} = –100 µA	– –1.2	– –	1.2 –	V V
$I_{PW(Peak)}$	input current	peak value	–	–	1	mA
t_w	pulse width	V = 230Vac, Rz = 500KΩ	–	100	–	µs
Zero-crossing detector disable input XDIS (pin 16)						
V_{XDIS}	input voltage	inhibit	$V_{EE} + V_{BE}$	–	–	V
I_{XDIS}	input current		–	–	30	µA
Zero-crossing detector output XOUT (pin 2)						
V_{XOUT}	output voltage (pull-down)		$V_{EE} + V_{BE}$	–	–	V
I_{XOUT}	max pull down current		–	–	40	mA
Comparator input IC+ and IC– (pins 5 and 6)						
$\pm V_{ID}$	differential input voltage		–	–	7	V
I_{IC+}	input bias current	$v_{IC+} > v_{IC-} + 1V$	–	–	–10	µA
I_{IC-}	input bias current	$v_{IC-} > v_{IC+} + 1V$	–	–	–10	µA
Comparator outputs QC+ and QC– (pins 4 and 7)						
V_{QC}	output voltage	I_{DIFFEN} = 15 µA	V_{EE}	–	–	V
I_{QC}	output current (pull-down)	I_{DIFFEN} = 15 µA	–	1	–	mA
Comparator enable DIFFEN (pin 3)						
I_{DIFFEN}	enable current (pull-down)	R_{DIFFEN} = 1MΩ	–	15	–	µA
Sawtooth generator trigger input SAW (pin 14)						
$V_{SAW(H)}$	input trigger voltage HIGH		–	–9.7	–	V
$V_{SAW(L)}$	input trigger voltage LOW		–	–13.5	–	V
$I_{SAW(L)}$	max pull-down @ low voltage		–	50	60	µA
Sawtooth generator output FLY (pin 15)						
I_{FLY}	output current (pull-down)		–	500	–	µA
Gate sense inhibiting input SDIS (pin 8)						
I_{SDIS}	input current (pull-up)		3.0	6.0	–	µA
Output stage input AMPIN (pin 9)						
V_{AMPIN}	output drive disable (internal pull-up)	AMPIN pin open cct	–	V_{EE} + $2V_{BE}$	–	V
I_{AMPIN}	output drive enable (pull-down)	$V_{AMPIN} = V_{EE}$	3	–	–	µA
Output stage output TRIG (pin 10)						
V_{TRIG}	output voltage		$V_{EE} + V_{SAT}$	–	–	V
I_{TRIG}	output current (pull-down)	V_{sat} < 1V	–	–	80	mA

10 IMPORTANT: ELECTRICAL SAFETY WARNING

OM5428 circuit is connected to the mains electrical supply and operates at voltages which need to be protected by proper enclosure and protective covering. Application circuits for OM5428 should be designed to conform to relevant standards (such as IEC 65, or Australian Standards AS3100, AS3250 and AS3300), it should only be used in a manner that ensures the appliance in which they are used complies with all relevant national safety and other Standards.

It is recommended that a printed circuit board using this integrated circuit be mounted with non-conductive clips, and positioned such that the minimum creepage distances from the assembly to accessible metal parts, and between high voltage points cannot be transgressed.

It should be noted that as there are Mains Voltages on the circuit board adequate labelling should be attached to warn service personnel, and others, that this danger exists.

A control board assembly should be mounted, preferably vertically, with sufficient free air flow across its surface to prevent the heat dissipated in various components from causing an unacceptable rise in the ambient temperature. The triac also needs to have an adequate heatsink, as exceeding its rated maximum junction temperature can result in loss of control, unpredictable behaviour, and possible dangerous conditions.

The board should be mounted in a place that is clean and dry at all times, not subject to condensation or the accumulation of dust and other contaminants.

11 APPLICATION INFORMATION

The reliability of modern triacs has given a strong impetus to the introduction of electronic power control in industrial as well as non-industrial areas. Because of the low cost of these devices and simplification in trigger circuitry, electronic power control now enjoys a host of applications such as electronic household cookers, panel radiators, fans, hobby tools, and even vacuum cleaners.

The general purpose trigger circuit OM5428, referred to as a trigger module, supplies the pulses for gate triggering triacs. This module is connected to the mains via a dropping resistor hence removing the need for an expensive external supply.

The OM5428 is an inexpensive, versatile trigger module and, being a monolithic IC in 16-pin dual in-line package, it takes up hardly any space at all. It is ideally suited for applications such as:

1. Phase control: single phase control (full cycle).

   Phase control is stepless control of output power by varying the conduction angle of the triac, 180 degree conduction corresponding to full output power. Step changes in triac voltage and current during turn-on give rise to RF interference. Appropriate RF interference suppression methods need to be applied for all phase triggered loads.

   It should be noted that phase control is not permitted for heating purposes.

2. Soft-start power controller.

   Soft-start is a means of providing a controlled turn-on of an electric motor, to eliminate the effect of high starting torque. It is particularly useful in industrial vacuum cleaner applications.

3. On/off control: static switch.

   On/off control is a method of power control where triggering should preferably occur symmetrically with respect to the zero crossing of the triac current to avoid RF interference. That is, triggering must start before the current has dropped to the holding value, and must continue until the current has risen again above the latching level. Under these conditions radio interference is kept at a minimum.

4. Time proportional control: temperature and motor speed control.

   Time proportional control is on/off control with a fixed repetition rate of load switching. The system is called time proportional because the power in the load averaged over the repetition period is varied. This system provides more accurate temperature control, avoiding the overshoot which is inherent in on/off control. Triggering conditions are the same as for on/off control.

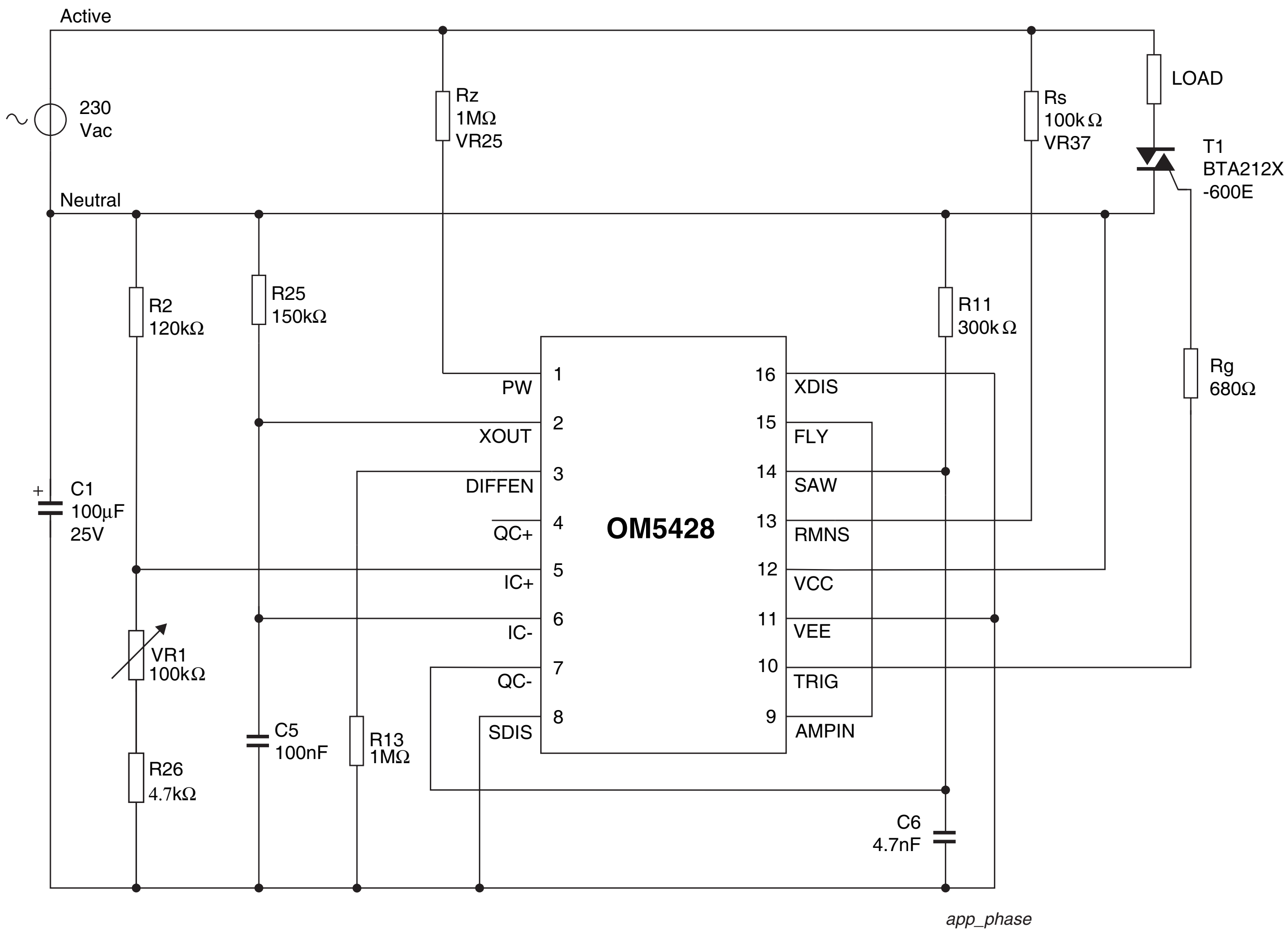


Fig.3 Typical application of the OM5428 as a single-phase control circuit. The circuit produces a trigger pulse at the gate of the triac. The pulse is produced when the voltage on pin IC- (related to mains zero crossing) becomes greater than the voltage on pin IC+. The arrangement forms a full-wave AC controller. The values shown for Rg, R4 and C3 give a gate current I_{GT} = 20 mA typical at V_{GT} = 1.5 V and a trigger pulse duration t_w = 140 µs typical.

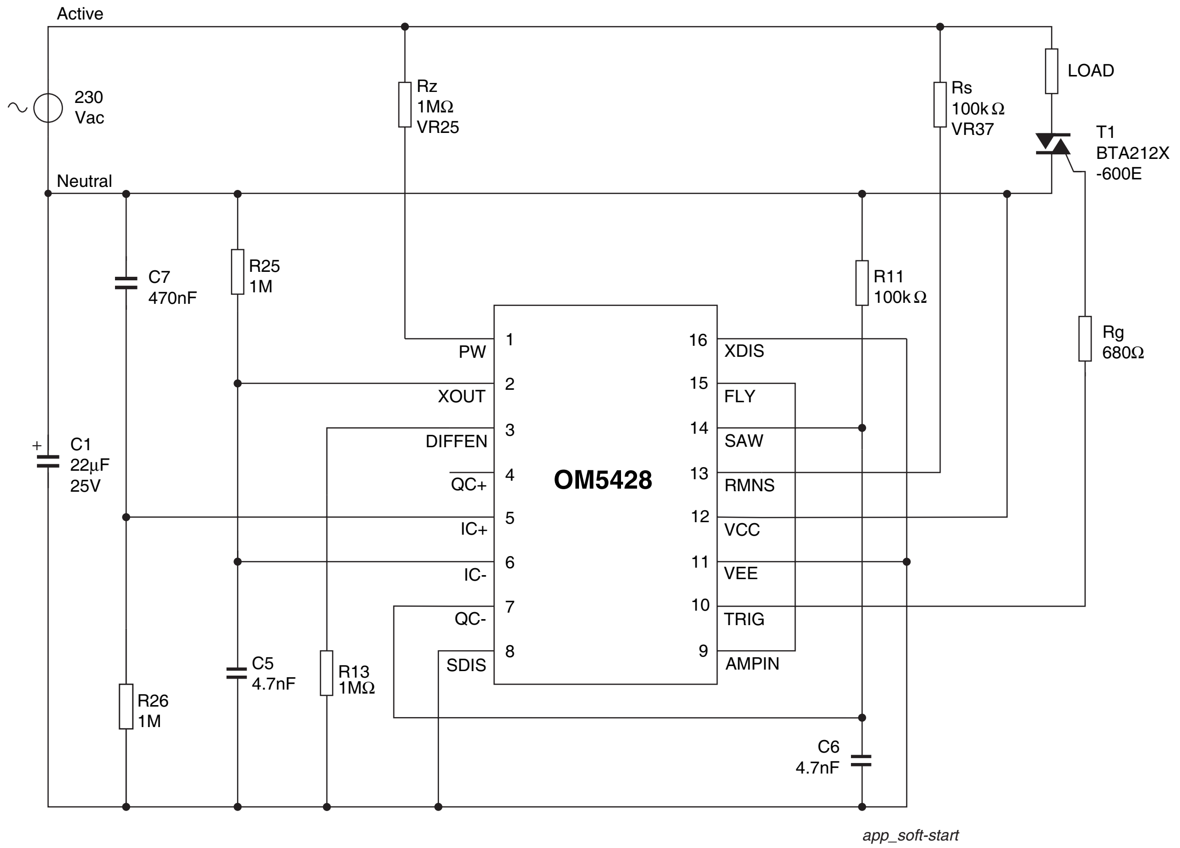


Fig.4 Application of the OM5428 as a “Soft-start” motor controller.
This is really a special case of phase control, whereby at initial power-on the load is ramped up from 0% to 100% of full power over approx. 1 second.

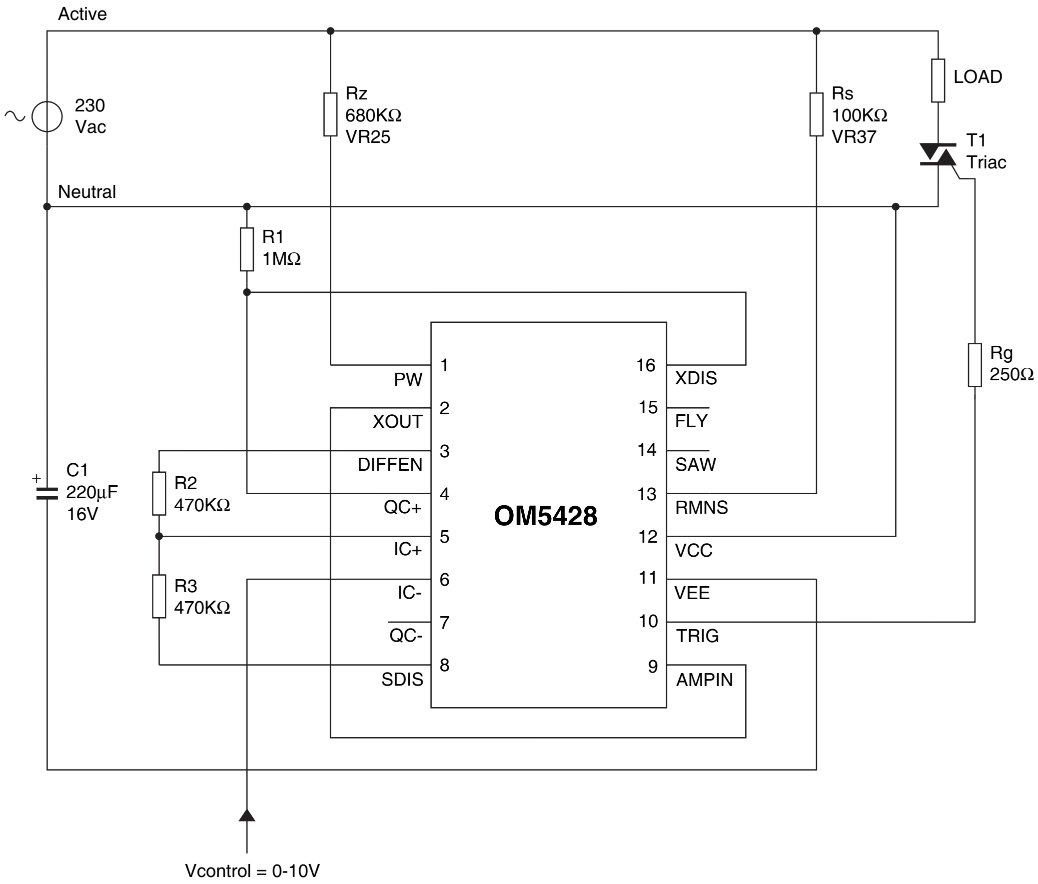


Fig.5 Typical application of the OM5428 as a static switch for resistive loads. The arrangement gives triggering around the zero crossings of the mains voltage. The values shown for Rs, Rg, Rz and C1 give a gate current I_{GT} = 50 mA typical at V_{GT} = 1.5 V and a trigger pulse duration t_w = 100 µs typical. The switching point for the output on IC- will be at $1/2V_{EE}$.

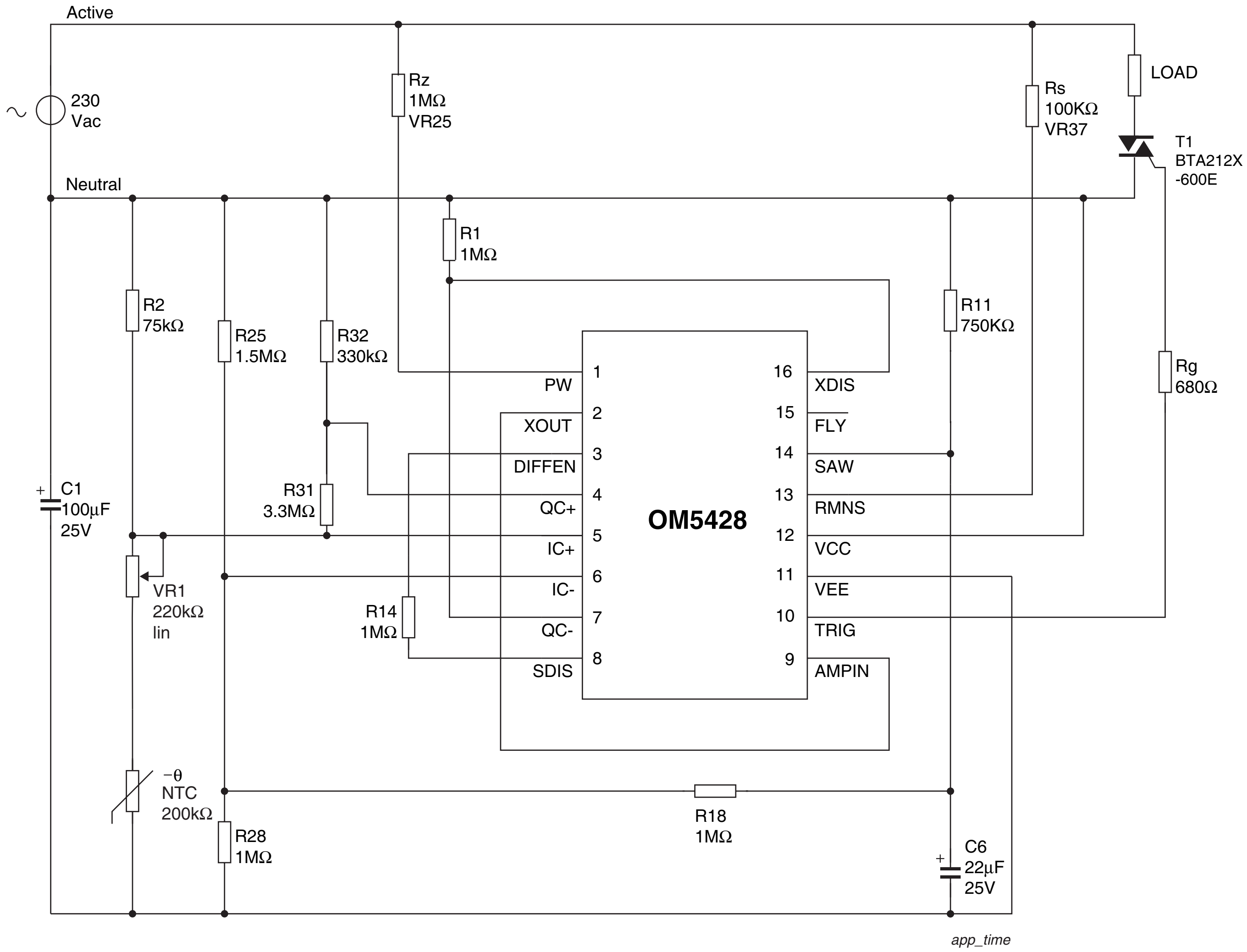
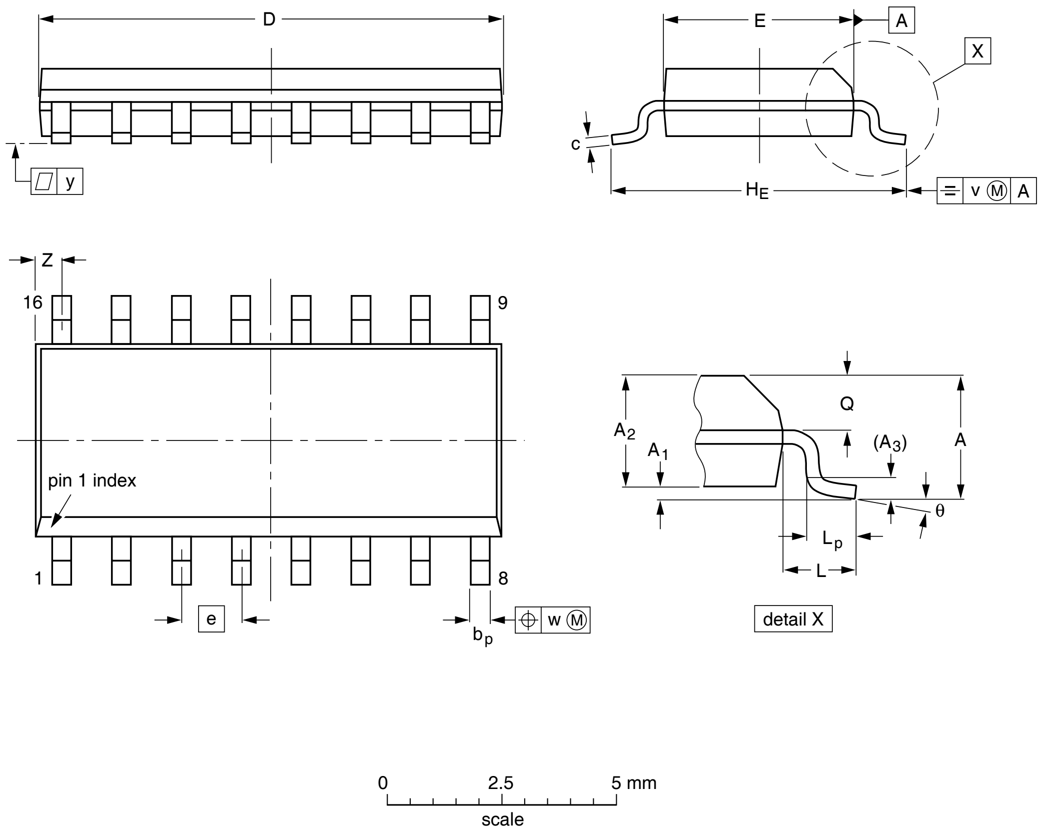


Fig.6 Typical application of the OM5428 as a time proportional temperature controller. The arrangement gives triggering around the zero crossings of the mains voltage as long as the voltage produced by the temperature bridge connected to IC+ (pin 5) is higher than the voltage on IC– (pin 6). The voltage on IC– is a sawtooth with a repetition time of approximately 30 s; this time is determined by the RC network formed by R3 and C2. The values shown for Rs, Rg, Rz and C2 give a gate current I_{GT} = 50 mA typical at V_{GT} = 1.5 V and a trigger pulse duration t_w = 100 µs typical.

12 PACKAGE OUTLINES

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

13 DEFINITIONS

Data sheet status	
Engineering sample information	This contains draft information describing an engineering sample provided to demonstrate possible function and feasibility. Engineering samples have no guarantee that they will perform as described in all details.
Objective specification	This data sheet contains target or goal specifications for product development. Engineering samples have no guarantee that they will function as described in all details.
Preliminary specification	This data sheet contains preliminary data; supplementary data may be published later. Products to this data may not yet have been fully tested, and their performance fully documented.
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.	

14 IES INFORMATION

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