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NOTICE

The OM5428 is now superseded by the IES5528.

The information below is provided for your convenience only.

Please refer to IES5528 for more details.

Nov 20 2009

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OM5428

Phase Controller and Triac Triggering IC

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 Phase Control and General Purpose Triac Triggering IC is a bipolar integrated circuit that delivers negative gate pulses for triggering a triac.

The OM5428 has numerous control options which, coupled with the external IC configurability makes the device suitable for a wide variety of applications in mains power control.

It is mains powered, not requiring an expensive DC supply, while also providing an external DC supply rail for powering sensors or low power ICs.

The OM5428 allows the engineer design flexibility when implementing a triac driven phase control or switching application. It provides a complete triac control solution.

3 APPLICATIONS

The flexibility of the OM5428 makes it suitable for a variety of applications, such as:

- Light Dimming
- Motor Control
- Zero Crossing on/off switching
- Temperature Control
- Time-proportional Control
- Home Heating and Cooling
- Ventilation Systems
- Soft Start Motor Control

4 BLOCK DIAGRAM

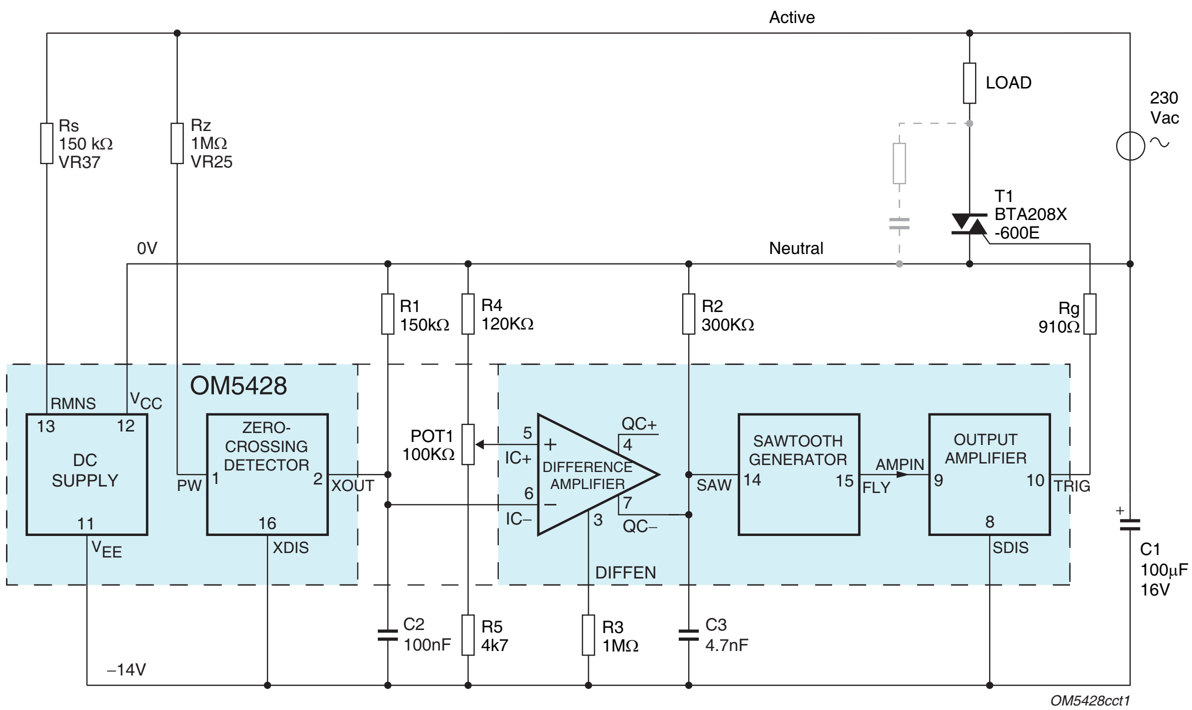

Fig.1 Block diagram of the OM5428

5 PINNING INFORMATION

5.1 Pinning Layout

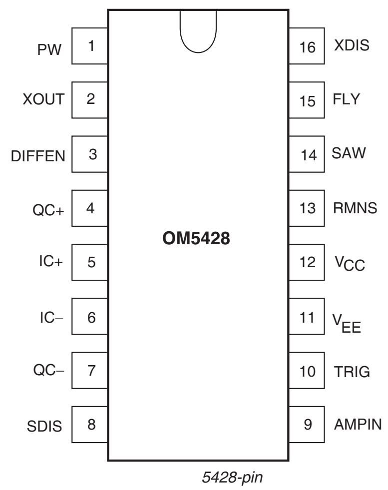

Fig.2 Pin configuration

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

The OM5428 comprises the following sections:

- supply derived from mains via dropping resistor (Rs);
- reset to ensure correct start-up;
- gate sense for reduction in the number of pulses produced when firing the triac;
- zero-crossing detector synchronizes triac gate pulses;
- difference amplifier passing a signal from a sensor, or indication of a potentiometer setting or switch position.
- ramp function generator operating as the saw-tooth oscillator in time proportional or phase control;
- output amplifier 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 saw-tooth 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.

In a static switch application (see figure 5) where 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 triac conduction is maintained through the mains voltage zero-crossing, reducing radio interference 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 saw-tooth 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.

7.3.1 PW

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 9µA 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:

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

7.3.2 XOUT

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}.

7.3.3 XDIS

Input XDIS can be used to disable the zero-crossing detector, to inhibit the synchronised pulses provided by XOUT. This is done by injecting a current into XDIS, typically by connecting it via a 1MΩ resistor to V_{CC}. Input XDIS is connected directly to the base on an n-p-n transistor referenced to V_{EE}, and when not used it should be connected directly to V_{EE}.
XDIS must never be left floating.

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 (referenced to V_{CC}) that is activated by a current out of DIFFEN (pin 3). The current drawn from pin 3 determines the drive for the comparator outputs. Typically this current is provided by a resistor connected between DIFFEN and the negative supply rail V_{EE}

7.5 Saw-tooth Generator

The saw-tooth 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 saw-tooth 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 saw-tooth 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 saw-tooth generator trigger input SAW (pin 14). The capacitor connected to SAW is charged via R2 connected to Vcc, and discharged via an internal 10k resistor. Provided the value of resistor R2 is much greater than the internal 10k resistor, the repetition time is approximately 0.43 x RC. R2 should not be less than 300kΩ. Repetition rate and gate pulse width can be set by selecting a suitable value for C3.

Typical gate pulse width is approximately.

$$t_g = R.C.(0.102)\ s$$

When not used, SAW can be left unconnected.

7.5.2 FLY

The output FLY (pin 15) is an n-p-n open-collector output. During the flyback period of the saw-tooth 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.

For “phase-control” applications, with gate-sense is normally enabled (i.e. SDIS connected to V_{EE}), such that when the triac is conducting after the application of a gate pulse, no further gate pulses are provided.

For “static switch” applications, where zero-crossing triggering of the triac is required, the gate-sense is normally disabled by injecting a current via a resistor connected to VCC.

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 V_{EE}. 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 with respect to V_{CC}, Common.

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Power Supply						
$-V_{EE}$	supply voltage (operating)	I_{CC} = 1 mA	14.3	14.7	15.3	V
$-I_{EE}$	quiescent current	All function pins open cct	–	160	250	μA
Pulse width control input PW (pin 1)						
V_{PW}	input voltage	I_{PW} = 100 μA I_{PW} = –100 μA	– –	1.35 –1.35	– –	V V
$I_{PW(Peak)}$	input current	peak value	–	–	1	mA
$I_{PW(+thresh)}$	Positive current threshold		–	+11	–	μA
$I_{PW(-thresh)}$	Negative current threshold		–	–9	–	μA
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} + 0.6V	–	–	V
I_{XDIS}	input current		–	–	30	μA
Zero-crossing detector output XOUT (pin 2) (Voltages with respect to V_{EE})						
V_{XOUT}	output voltage (pull-down)		V_{EE} + 0.6V	0.75	0.90	V
I_{XOUT}	max pull down current		–	–	40	mA
Comparator input IC+ and IC– (pins 5 and 6)						
V_{ID}	Input voltage range	note1	V_{EE}+1V	–	-1	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) (Voltages with respect to V_{EE})						
$V_{SAW(H)}$	input trigger voltage HIGH		4.5	5.1	5.8	V
$V_{SAW(L)}$	input trigger voltage LOW		1.15	1.30	1.45	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} + 1.2V	-	V
I_{AMPIN}	output drive enable (pull-down)	V_{AMPIN} = V_{EE}	3	–	–	μA

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNIT
Output stage output TRIG (pin 10) (Voltages with respect to V_{EE})						
V_{TRIG}	output voltage	(@ 100mA pulsed)	$V_{EE} + V_{SAT}$	530	750	mV
I_{TRIG}	output current (pull-down)	$V_{sat} < 1V$	-	–	80	mA

Note 1. Either IC- or IC+ may exceed Vcc-1V, but not both simultaneously.

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 it is 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.

5. Temperature dependent phase control for motor speed control.

   Full phase control is realised over a narrow temperature range of 25 degC or less using an NTC thermistor temperature sensor and low power Op-Amps. This configuration allows motor speed control from 0 to 100% over narrow temperature ranges by varying the triac conduction angle. Suitable for applications such as building ventilation, coolant pumping systems and wherever temperature is used to control motor speed.

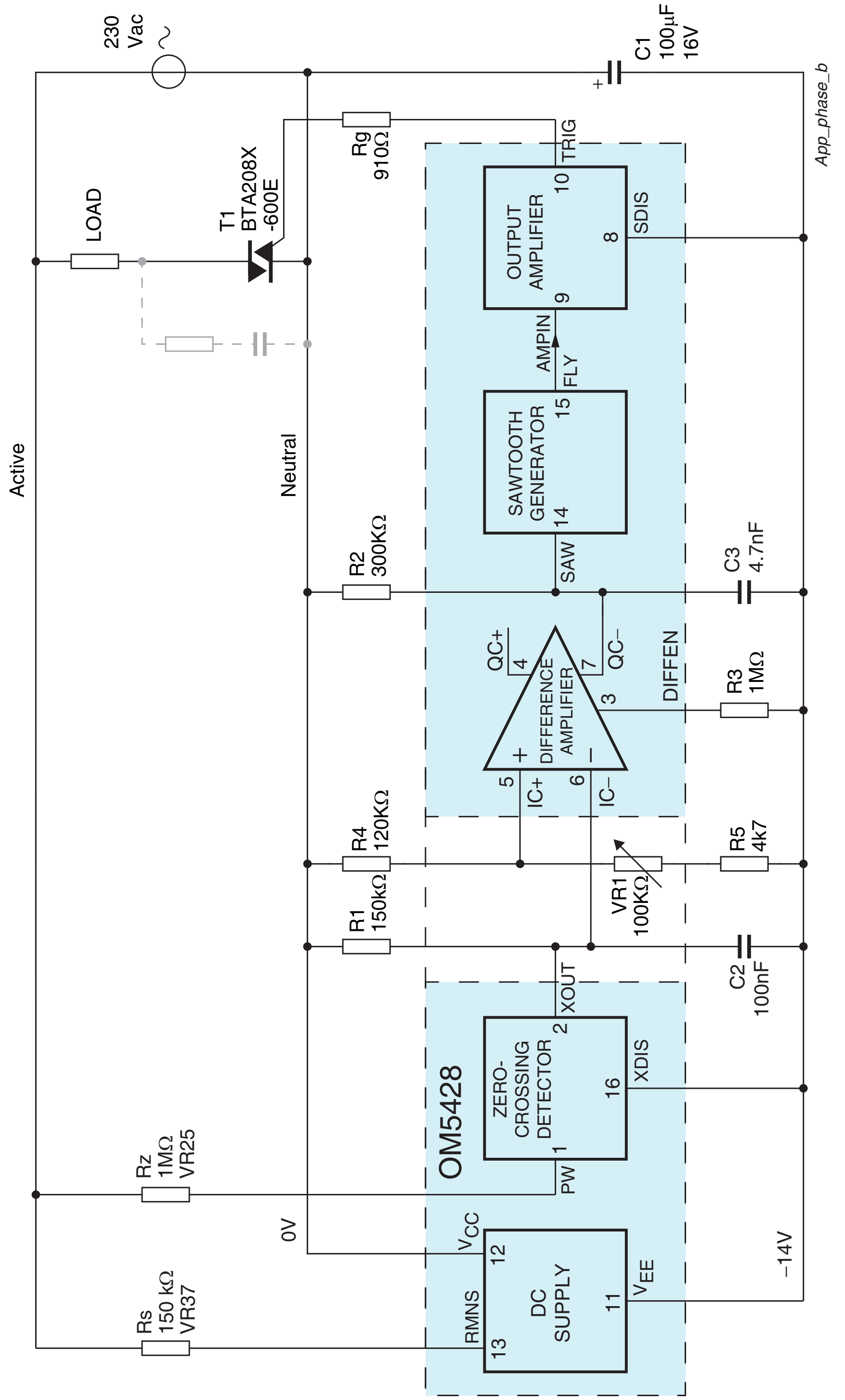

Fig.3 **Phase Controller**. Typical application of the OM5428 as a single-phase control circuit. The circuit produces a trigger pulse at the gate of the triac. The pulse is produced when the voltage on pin IC- (related to mains zero crossing) becomes greater than the voltage on pin IC+. The values shown for Rs, Rg, Rz and C3 give a gate current I_{GT} = 12 mA typical at V_{GT} = 1.5 V and a trigger pulse duration t_w = 140 µs typical.

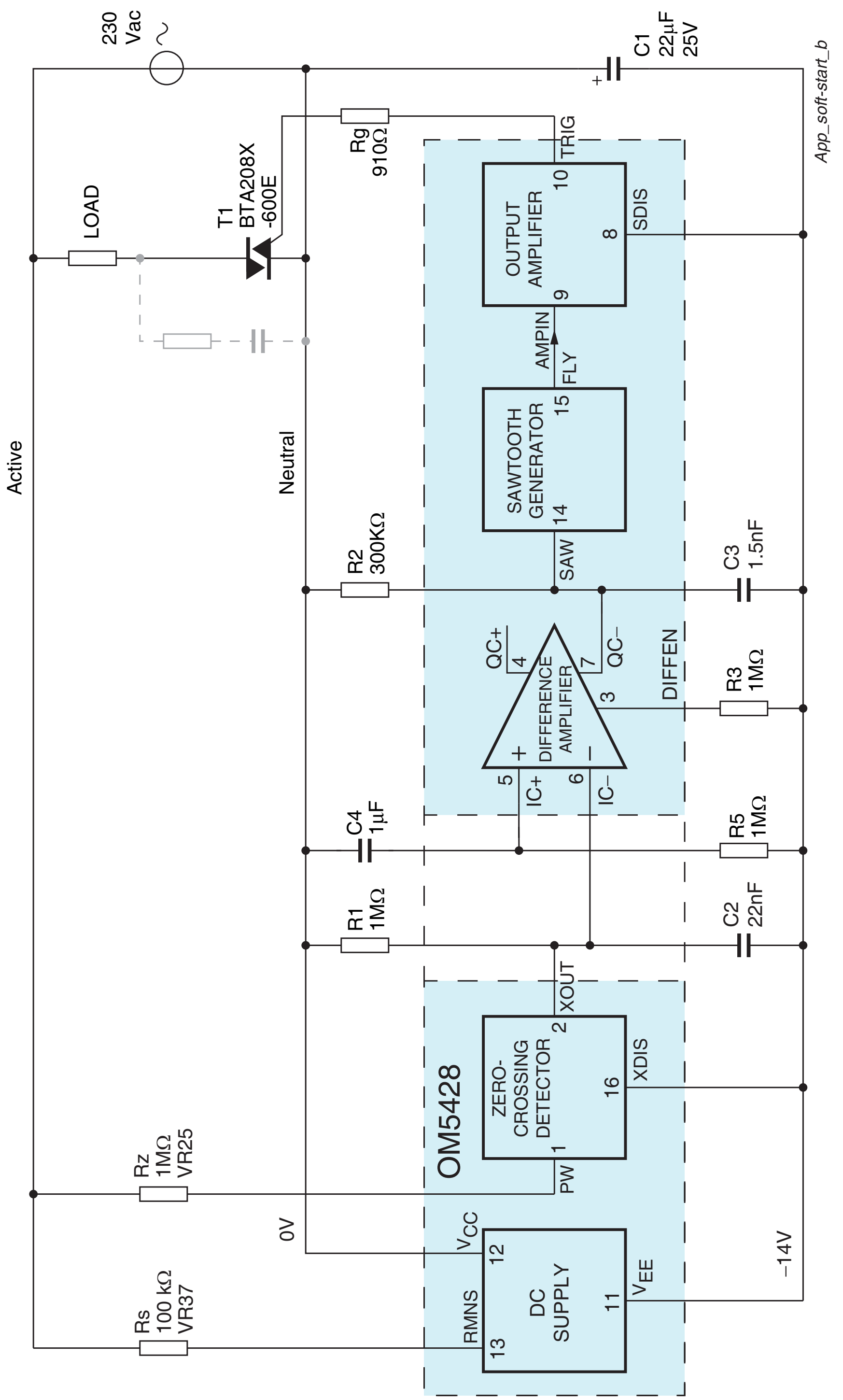

Fig.4 **Soft Start Controller**. Application of the OM5428 as a “Soft-start” motor controller. This is really a special case of phase control, whereby at initial power-on the load is ramped up from 0% to 100% of full power over approx. 1 second.

Note: The internal power-up reset holds IC+ (pin 5) high and IC- (pin 6) low until the power supply is established.

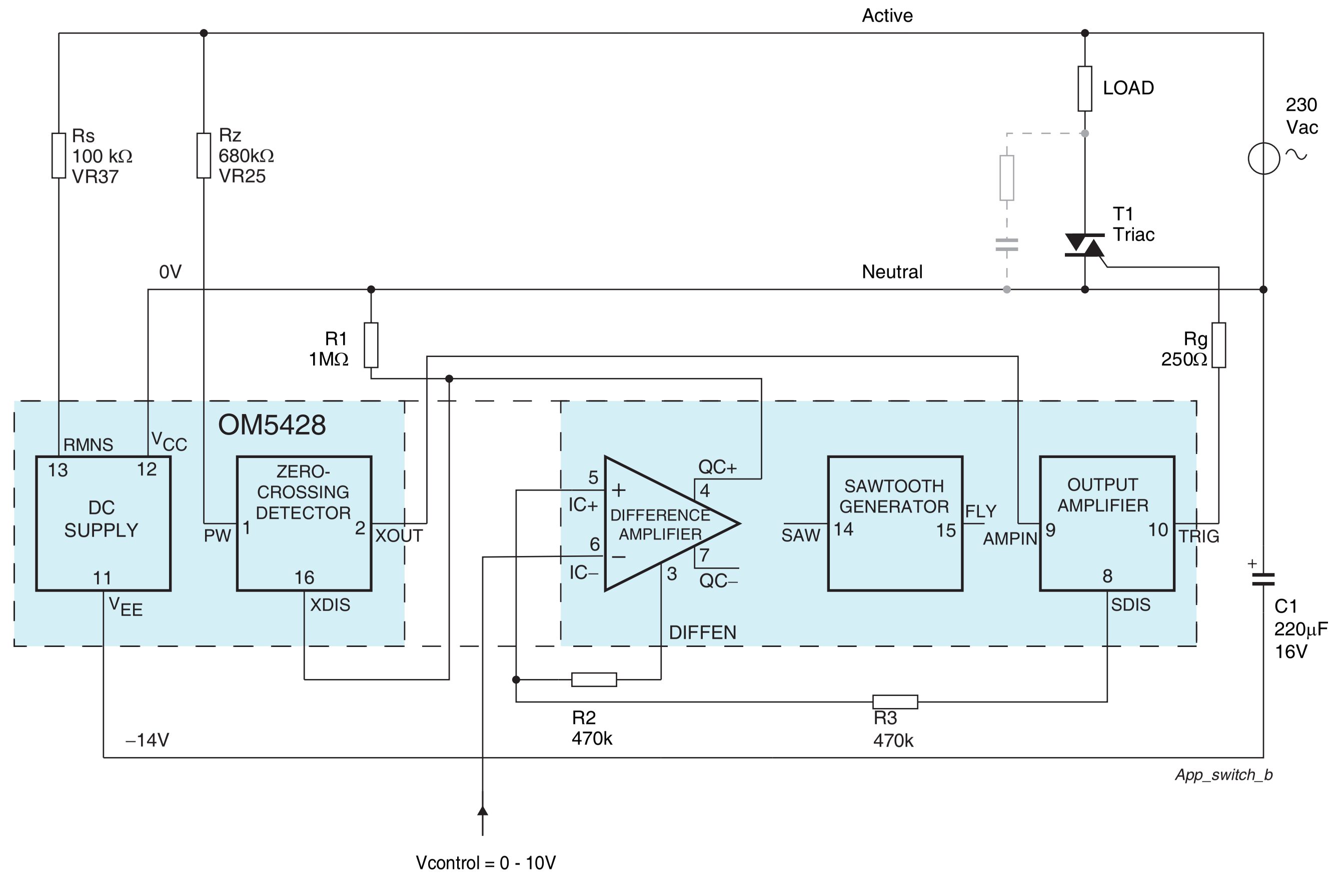

Fig.5 **Static Switch**. Typical application of the OM5428 as a static switch for resistive loads. The arrangement gives triggering around the zero crossings of the mains voltage. The values shown for Rs, Rg, Rz and C1 give a gate current I_{GT} = 50 mA typical at V_{GT} = 1.5 V and a trigger pulse duration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

Note: R2 and R3 sink current from DIFFEN, source current into SDIS, and provide a half-rail voltage divider for IC+.

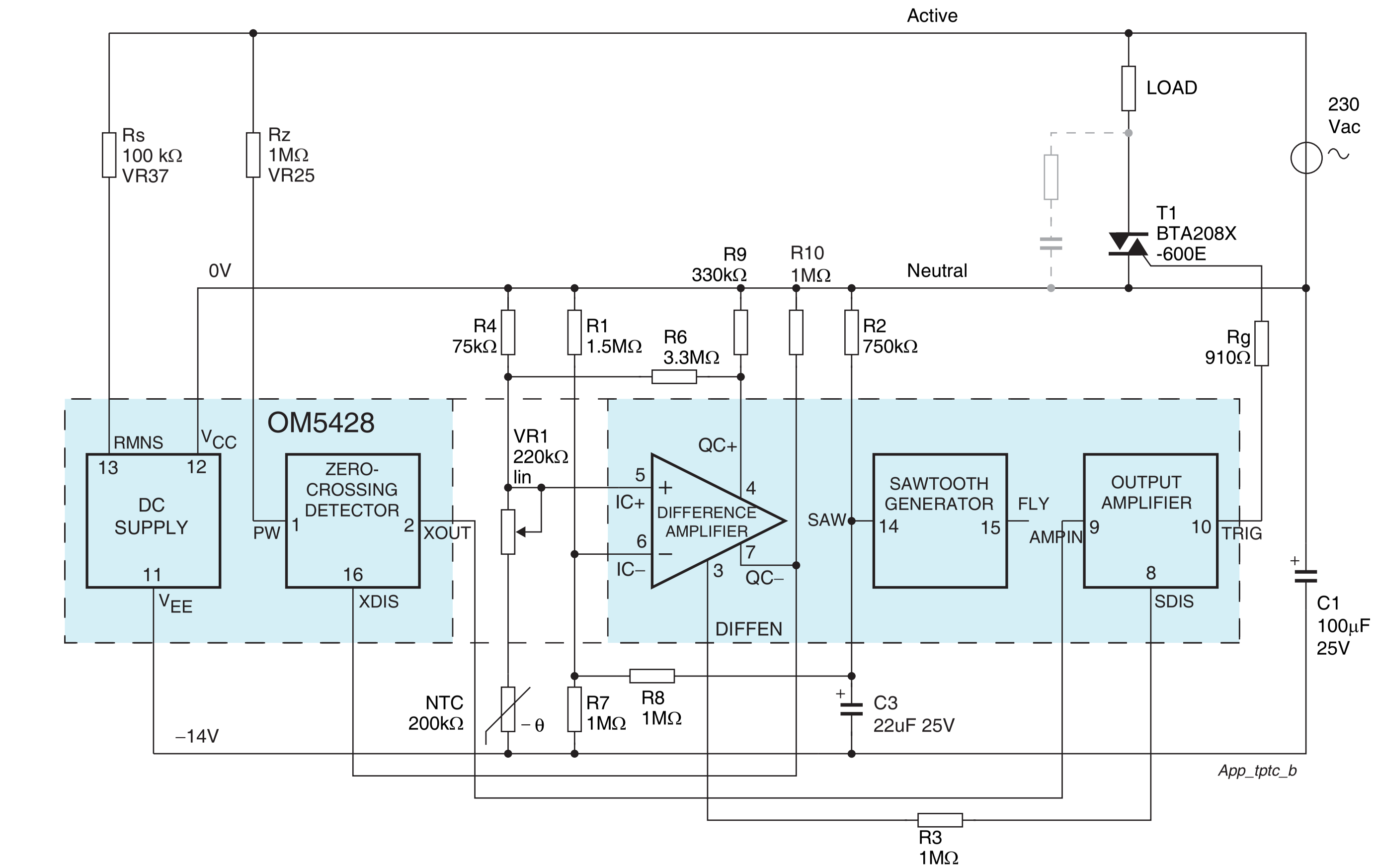

Fig.6 **Time Proportional Temperature Controller**. Typical application of the OM5428 as a time proportional temperature controller. The arrangement gives triggering around the zero crossings of the mains voltage as long as the voltage produced by the temperature bridge connected to IC+ (pin 5) is higher than the voltage on IC− (pin 6). The voltage on IC− is a saw-tooth with a repetition time of approximately 30 s; this time is determined by the RC network formed by R2 and C3. The values shown for Rs, Rg, and Rz give a gate current of approx I_{GT} = 12 mA typical at V_{GT} = 1.5 V and a trigger pulse duration t_w = 100 µs typical.

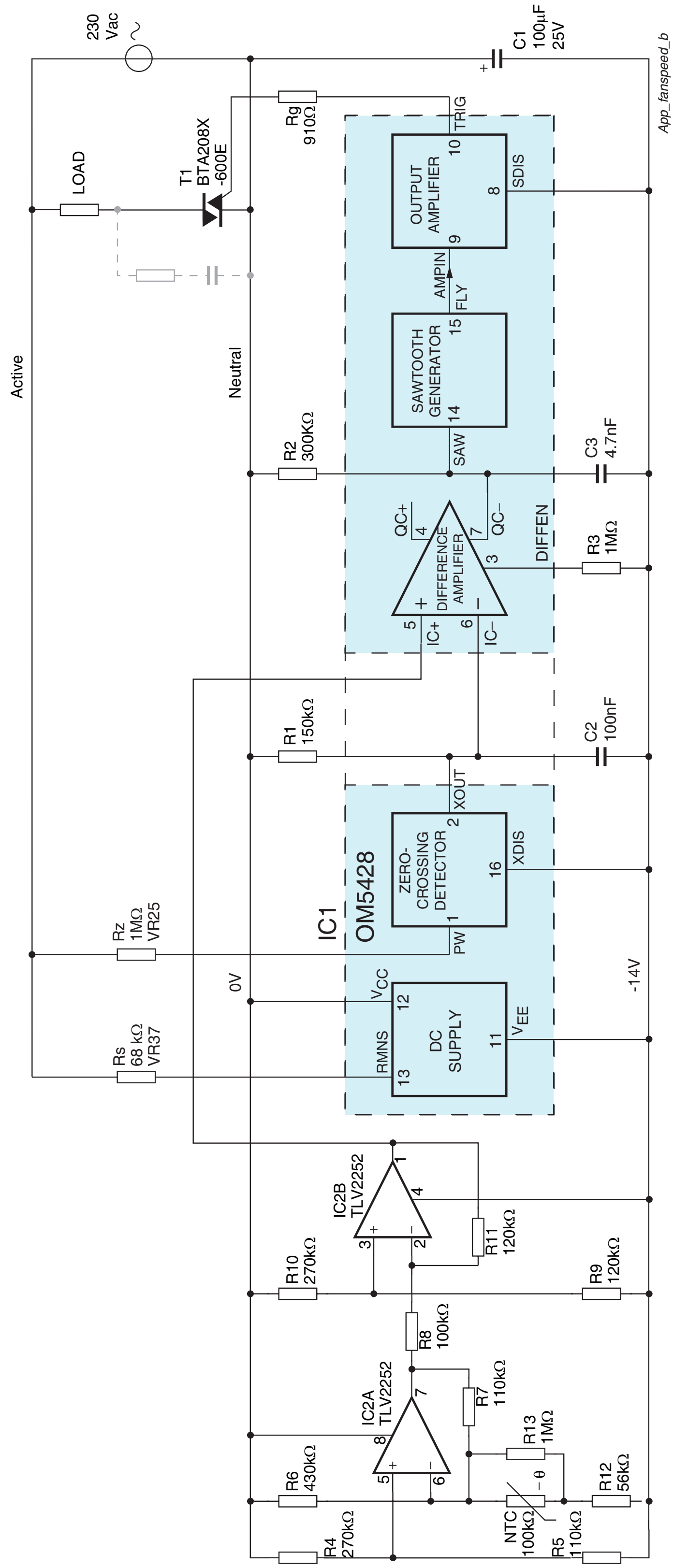

Fig.7 **Temperature Dependent Phase Controller**. This is a dedicated application of the phase control circuit of Figure 3, and shows an application of the OM5428 as a narrow-temperature-range single-phase control circuit. The conduction angle is controlled from 0 to 180 degrees over a temperature range of approx. 25°C.

The values shown for Rs, Rg, Rz and C3 give a gate current I_{GT} = 12 mA typical at V_{GT} = 1.5 V and a trigger pulse duration t_W = 140 µs typical.

Note: A spreadsheet calculator is available which can be used to determine the triac firing angle as a function of temperature. Contact Hendon for more information.

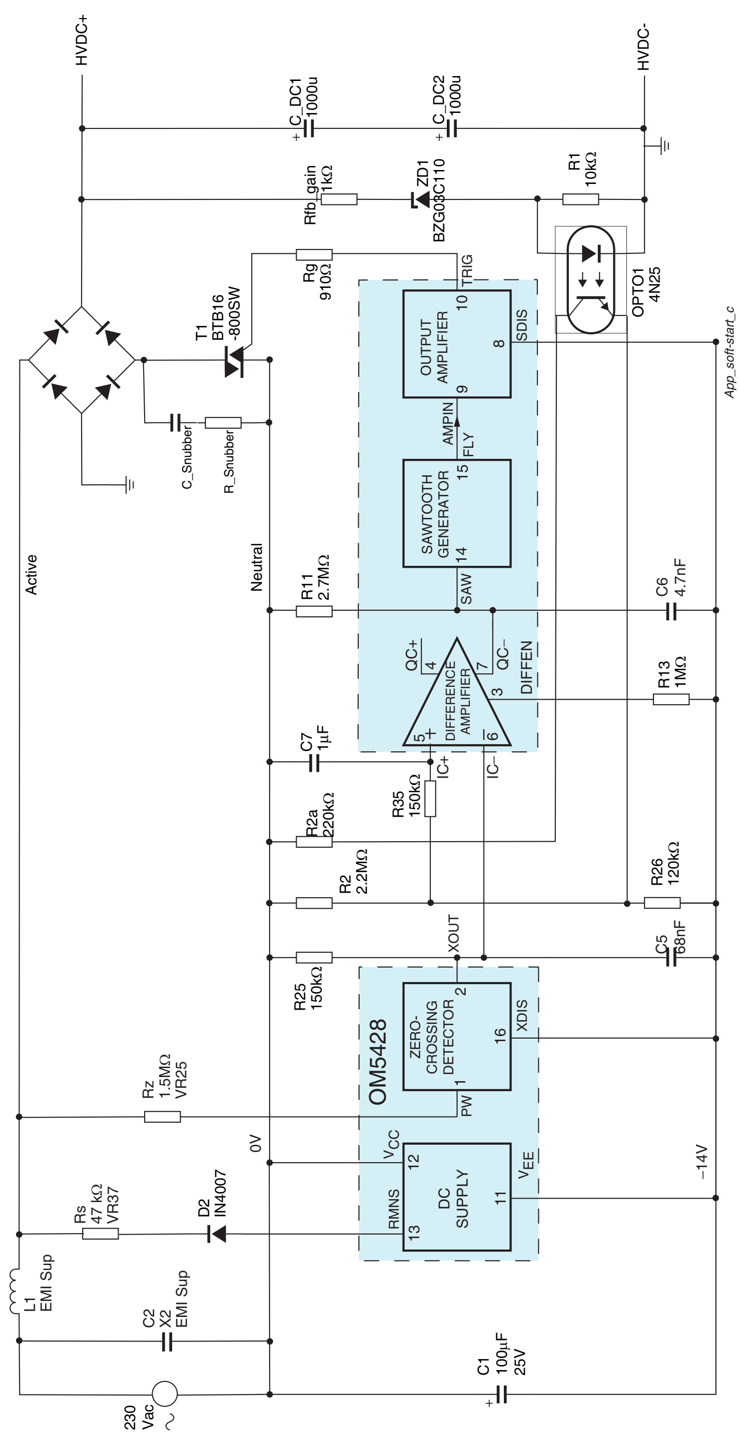

Fig.8 **0° to 60° Phase Controller with Soft Start and Feedback Control**. The values of R25, C5, R26, R2 and R2a plus R11 and C6 have been set to provide a 6ms to 10ms delay and a single trigger gate pulse duration t_W = 100us

12 ORDERING INFORMATION

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

Note: DIP16 versions are available- contact Hendon Semiconductors for details. For more information on packages, please refer to the document “Integrated Circuit Packaging and Soldering Information” on the Hendon web site.

13 ESD CAUTION

Electrostatic Discharge (ESD) sensitive device. ESD can cause permanent damage or degradation in the performance of this device. This device contains ESD protection structures aimed at minimising the impact of ESD. However, it is the users responsibility to ensure that proper ESD precautions are observed during the handling, placement and operation of this device.

14 DOCUMENT HISTORY

REVISION	DATE	DESCRIPTION
1.0	20041216	First Release
2.0	20050315	Second issue
3.0	20050805	Update internal block diagram detail
4.0	20060424	Add temperature dependent phase control application, package info removed
5.0	20060914	Update to HS format
5.1	20060921	Figure 4 Soft Start, R11 corrected 100k to 300k
5.2	20061106	Figure 4 Soft Start, Values for C7 and C5 corrected
6.0	20080616	Characteristics table updated, Figure component references rationalised. Calculation for gate pulse timing added to Saw-tooth generator description.

15 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.	

16 COMPANY INFORMATION

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