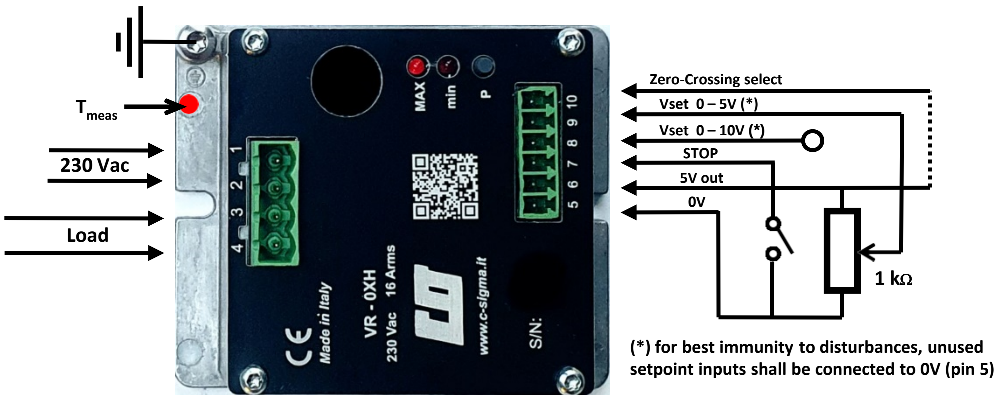
C-Sigma

Single Phase Voltage Regulator VR-0XH



Made in ITALY

Micro Controller Unit based TRIAC Conduction Angle Control Algorithm.
User selectable Zero-Crossing operation (by wiring to pin 10 the 5V available at pin 6) .
Zero-Crossing Half-periods Spreading Algorithm for balanced, minimal flicker driving of IR Quartz Tubes.
Rugged construction, fully encapsulated in electrically insulating protective resin (flammability rating UL94 V-0).
Short-circuit proof internal auxiliary transformer (to supply the internal control circuitry with SELV voltage).
For higher reliability and longer life, no electrolytic capacitors are used.
The package includes the cable-side connectors (4-pin 20A and 6-pin 10A), both UL94 V-0.

DESCRIPTION

The operation principle is based on controlling the conduction angle using a TRIAC. The VR-0XH is fully compatible with the previous generation VR-01A in terms of form, fit, and function. It can thus be used as a drop-in replacement for the VR-01A, while doubling to 16A the current handling capability (the VR-01A was capable of only 8A). The internal TRIAC's ratings feature 800V and 25A, allowing ample margins with respect to the nominal 16A, 230VAC. Generous margins result in good immunity to transient overcurrents and overvoltages, thus improving overall reliability. As a further protection against higher energy overvoltages, the regulator already includes a suitable varistor. The TRIAC's conduction angle is controlled by a microcontroller unit (MCU), whose control algorithm converts the value of the control voltage (0-10V, or 0-5V from a potentiometer) into a train of pulses, applied to the TRIAC's gate until the next zero crossing of the line voltage. This technique provides stable control even with loads characterised by a dominant inductive component. Thus, the VR-0XH regulator is ideally suited for controlling single-phase high-slip motors, which are typical in applications such as fans and roll winder machines. Furthermore, the algorithm implemented inside the MCU simplifies the calibration of the control characteristics (Fig. 2): it is sufficient to input the minimum and maximum points only once, and the MCU will then automatically compute both the slope and offset of the control characteristics. By wiring to pin 10 the 5V available at pin 6, it is now possible to select the Zero-Crossing mode of operation, an optimal control strategy for the heating elements used in a wide variety of industrial ovens. Our special Half-Periods Spreading Algorithm ensures that every half-period is always followed (or preceded) by one of opposite polarity within a time interval of no more than 10 periods of the mains AC voltage (a typical requirement imposed by utilities to prevent excessive imbalance).

CHARACTERISTICS

Mains voltage:	230 V ac @ 50/60 Hz	Maximum load current:	16 A_{rms}
Non repetitive peak current (20ms):	250 A	I^2t for fusing (10ms):	312 A^2s (*)
TRIAC's Power dissipation:	20W @ 16A_{rms}	TRIAC junction to VR-0XH case R_{th}:	3°C/W (**)
Case temperature (@ T_{meas} point):	50°C MAX (@16A load)	External Potentiometer:	1 KΩ
Mains – Case isolation:	2500 V_{rms}	Mains to Control section isolation:	3750 V_{rms}
W x L x H, weight:	72 x 86 x 30 mm, 250 gr	Power transfer efficiency @ 3kW:	>99%

(*) Thus, for adequate protection install only ultra rapid fuses (specific for semiconductors) with I^2t value < 100 A^2s
(**) For optimal dissipation, apply the provided thermal pad (WE-TGF 40101005) between the VR-0XH base and the mounting surface.

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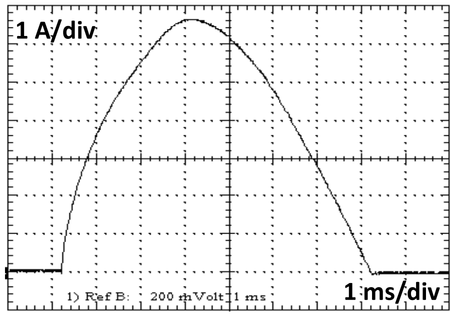
COMPLIANCE TO STANDARDS

VR-0XH is suited for applications in industrial machinery compliant with the requirements of the Low Voltage Directive (72/23/CEE) and Machinery Directive (89/392/CEE), as well as to the requirements of the Italian Norma Generale CEI EN 60204-1 1998-04. Referring to Electromagnetic Compatibility, the verification of the level of overall emissions from the end application machinery is the sole responsibility of the manufacturer of said machinery. However, when properly connected, conducted emissions from the VR-0XH itself are usually very small (see the example of fig. 1), and in most cases the conventional filters usually installed in industrial control cabinets would suffice to ensure compliance with applicable regulations.

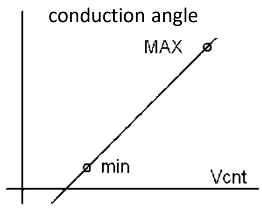


1 – Load current example (4 A_{rms}) while driving a high slip motor in a winder machine application

INSTALLATION

Installation of this equipment shall be performed only by qualified personnel. It is the users' responsibility to ensure that the installation of the VR-0XH in their machinery complies with the laws and regulations applicable in their countries.

IMPORTANT: *The following calibration procedure is not required and is not accessible when in Zero-Crossing mode. Any existing **min** and **MAX** parameters will hence be ignored.*



2 – control characteristics

The regulator control characteristics (conduction angle versus control voltage) is linear. When the control voltage is applied to pin 8 (input impedance = 20 KΩ) the allowed range is 0-10V, when applied to pin 9 (input impedance > 100 KΩ) the allowed range is 0-5V. Pin 9 can also be driven by the center tap of a potentiometer (1 KΩ) between the 5V output (pin 6) and the 0V reference (pin 5). When both pin 9 and pin 8 are wired, the MCU will read both setpoints and select the greater one. If one of the two setpoint inputs is not used, for best immunity to disturbances it shall be wired to 0V (pin 5). The MCU computes slope and offset of the control characteristics from two calibration measurements, ***min*** and ***MAX***, defined by means a simple procedure:

- Connect the VR-0XH to the load (example: a high slip motor), while measuring the load current (rms value).
- Power on while pressing the push button, and the ***min LED*** will start flashing.
- Release the button and then set the control voltage (or the potmeter) to the value desired for the "***min***" point (example: V_{cnt} = 1V). To enter the control voltage minimum value, press the button again until the ***min LED*** stops flashing and remains constantly ON, then release it.
- Now that the ***min LED*** is constantly ON progressively change the control voltage (or rotate the potmeter knob) until the ammeter reads the ***true rms load current value*** desired for the "***min***" point (example: I_{load} = 0.5 A_{rms}).
- Press again the button to enter the desired "***min***" point of the rms current value.
- Upon releasing the button, the ***min LED*** will turn off, and the ***MAX LED*** will instead start flashing.
- Set the control voltage (or the potmeter) to the value desired for the "***MAX***" point (ex. : V_{cnt} = 10V). To enter the control max value, press the button again until the ***MAX LED*** stops flashing and remains constantly ON, then release it.
- Now that the ***MAX LED*** is constantly ON, progressively change the control voltage (or rotate the potmeter knob) until the ammeter reads the ***true rms load current value*** desired for the "***MAX***" point (example: I_{load} = 8 A_{rms}).
- Press again the button to enter said desired "***MAX***" point rms current value.

PARAMETERS RESET

before starting any new ***min*** and ***MAX*** calibration procedure, the following reset is at first needed: with no load (thus, pin 4 NOT connected), proceed as above for the "***min***" point, but while constantly holding ***V_{cnt} = 0V*** (or potmeter at min), and then for the "***MAX***" point, but while constantly holding ***V_{cnt} = 10V*** (or potmeter at max).

LEDs CODE: ***min LED*** flashing = VR-0XH powered ON ***MAX LED*** flashing = VR-0XH switched to STOP

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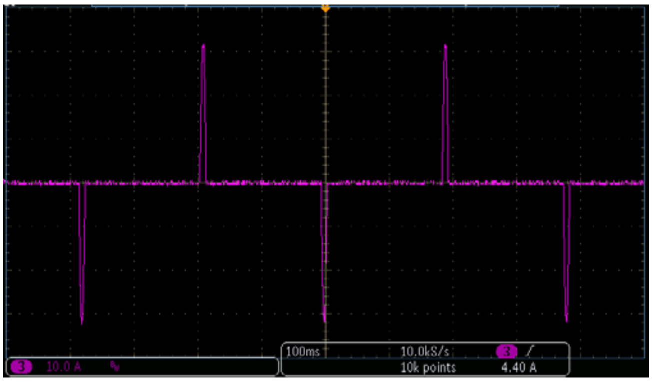
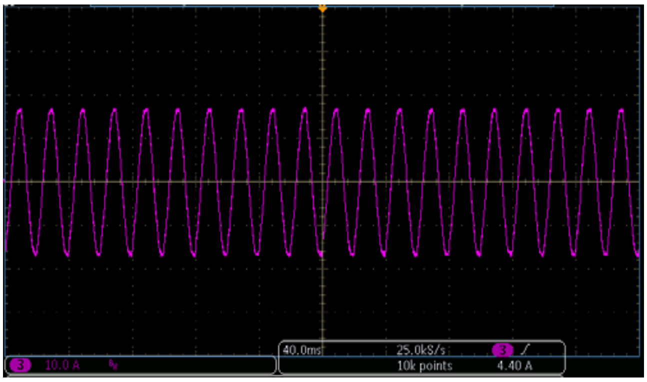
ZERO CROSSING HALF-PERIODS SPREADING FUNCTIONALITY

At power-up, the MCU checks whether 5V is present at pin 10 (e.g., by permanently wiring pin 10 to pin 6). If 5V is not present, the MCU switches to the conduction angle mode of operation described on page 2.

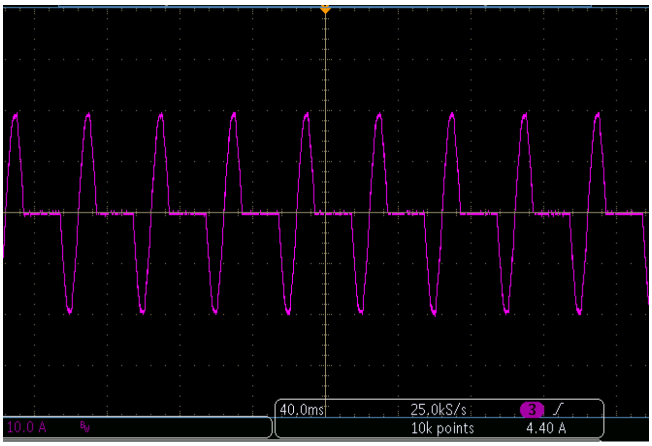
When 5V is instead detected, the MCU switches to the Zero-Crossing mode of operation. When in this mode, the average power transferred to the load is not controlled by adjusting the conduction angle during each single half-period (10ms at 50Hz, 8.3ms at 60Hz) of the mains voltage, but rather by controlling the number of full half-periods applied to the load according to a specific pattern. Said pattern is a function of the applied setpoint, and it is optimised for ensuring that the maximum time interval during which no current flows through the load is at most nine mains periods (180ms @50Hz, and corresponding to 5% setpoint), interval progressively decreasing at increasing setpoint, and always < 1 mains period (20ms @50Hz) for setpoint values > 25%. This special feature of our Half-Periods Spreading Algorithm allows us to drive very low thermal inertia loads, for example, IR quartz tubes, while minimizing the amount of residual flickering to a point that it can be considered negligible in a wide range of industrial applications (but, at first, always verify its suitability to your particular application).
Additionally, over a 10 periods time interval of the mains AC voltage, the number of positive half-periods always equals the number of negative half-periods, in compliance with utilities' requirements for balanced loads. When in Zero-Crossing mode, the range of regulation is 5% to 100%, with a 1% resolution, while achieving a 99% power transfer efficiency at a 3kW load. In the following examples, the oscilloscope purple trace (10A/div) corresponds to the current into three parallel connected 1kW IR quartz tubes (e.g. RS Pro 796-0176) as measured by a clamp-on current probe:



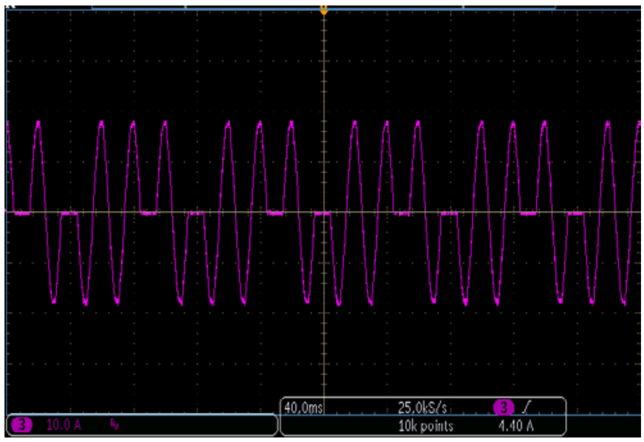
Min. driving is 5% of half-periods



100% of half-periods



50% of half-periods



75% of half-periods

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The zero-crossing mode of operation is optimal for controlling the power delivered to conventional InfraRed heating elements, such as those of the ceramic or quartz tube tungsten filament types, used in a variety of industrial IR ovens. Though it *shall **NOT** be used for driving electric motors* (for that use instead the mode of operation described at pg. 2). By ensuring that the TRIAC turns ON exactly at the zero-crossing of the ac line voltage, the load current will be switched at 0A. Such a condition minimises the harmonic content of the line current, as well as the generation of electromagnetic disturbances. In practice, in such mode of operation, it is no longer necessary to install filters and power factor correctors. Of course, this is so only for resistive loads. Note that although the pin 8 setpoint input voltage range is 0-10V, when in zero-crossing mode 100% driving is instead reached already at 8V. The 2V margin ensures that a fully ON condition can be guaranteed, even in installations characterised by a noisy EMC environment.

INRUSH CURRENT PEAK

When a heating element is activated, its filament's resistance increases significantly due to the filament heating up. When initially at room temperature the resistance is instead quite low. Therefore, suddenly applying the mains voltage to a much lower resistance value results in a peak of current far greater than the nominal value. Such peak then gradually decreases over subsequent half-periods, stabilising once the heating element reaches its operating temperature.

This phenomenon is especially noticeable in IR quartz tubes, for which the room-temperature resistance can be as little as one-tenth of the resistance when incandescent. Depending on the line impedance, this may easily lead to a current peak exceeding 100A at the first half-period (for a 16A nominal load). It then takes about 20 additional half-periods to settle to the nominal 23A peak (16A rms). Although such a high inrush peak can be handled without issues by the TRIAC mounted inside the VR-0XH, it is the user's responsibility to determine whether it might cause problems elsewhere, such as unwanted blowing of upstream fuses, triggering of circuit breakers, or the generation of excessive EMI disturbances. For applications where a large inrush current is indeed a concern, the following turn-on sequence may be implemented:

- Do not start with zero-crossing mode (i.e., leave open the connection between pins 6 and 10).
- During the first 20 periods of the mains voltage, progressively increase the setpoint from 0 to the desired value.
- Upon reaching the desired operating setpoint, close the connection between pins 6 and 10 (zero-crossing mode).

By following this sequence, the otherwise large inrush current peak will be effectively contained.