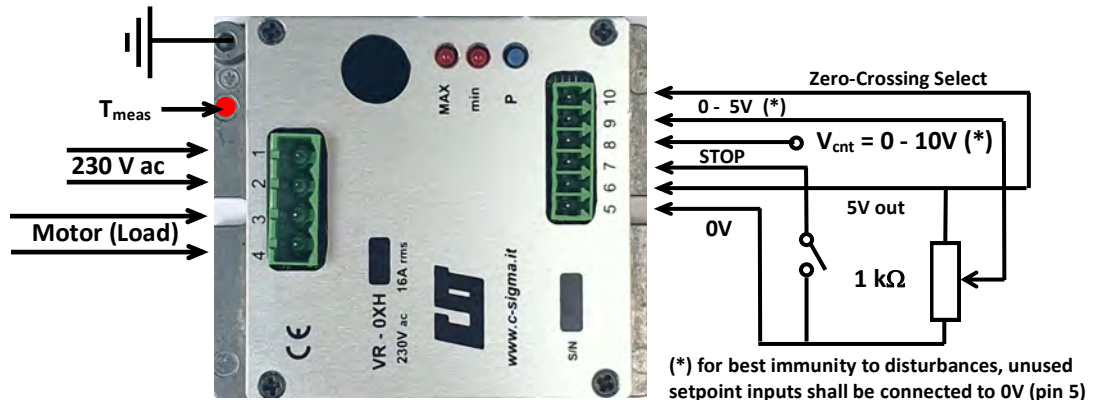




Single Phase Voltage Regulator VR-0XH



Made in Italy

SMD Technology.

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 protective epoxy and polyurethane resins.

Short-circuit proof internal auxiliary transformer (to supply the internal control circuitry with SELV voltage).

For higher reliability, only self-healing film capacitors are used (no electrolytics).

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 operating margins with respect to the nominal 16A, 230VAC. Generous margins result in good immunity to transient overcurrents and overvoltages, thus improving overall reliability. As further protection against higher energy over-voltages, 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 "pulse train", which is then applied to the TRIAC's gate until the next zero crossing of the line voltage. The "pulse train" 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 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 ² t for fusing (10ms):	312 A ² s (*)
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 I²t value < 100 A²s

(**) For optimal performance apply the provided thermal pad between the VR-0XH base and the mounting surface.

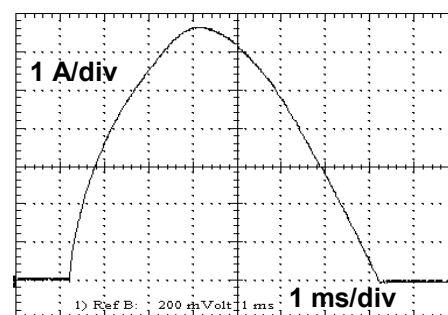


VR-0XH



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.

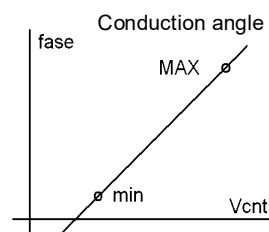


1 - Load current example (4 A_{rms}) while driving a high slip motor in a winder machine application.

INSTALLATION

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

The regulator control characteristics (conduction angle versus control voltage) is linear. When the control voltage is applied to pin 8 (input impedance = 20 K Ω) the allowed range is 0-10V, when applied to pin 9 (input impedance > 100 K Ω) the allowed range is 0-5V. Pin 9 can also be driven by the center tap of a potentiometer (1 K Ω) between the auxiliary 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, to then select the greater one. If one of the two setpoint inputs is unused, for best immunity to disturbances it shall be wired to 0V (pin 5). The MCU automatically computes slope and offset of the control characteristics from two calibration measurements, **min** and **MAX**, defined by means a simple procedure (**not available when in Zero-Crossing mode**):



2 - Control Characteristic.

- Connect the VR-0XH to the load (example: a high slip motor), while measuring the load current (rms value).
- Power On while pressing on 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: $V_{cnt} = 1V$). Press again the button, until the **min LED** stops flashing and is constantly ON, so as to enter said control voltage **min** value, and then release it.
- Now that the **min LED** is always 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 said desired **"min"** point rms current value.
- Upon releasing the button the **min LED** will now 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. : $V_{cnt} = 10V$). Press again the button until **MAX LED** stops flashing and stays ON, so as to enter said control voltage **MAX** value, and then release it.
- Now that the **MAX LED** is always 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.

N.B. 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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VR-0XH



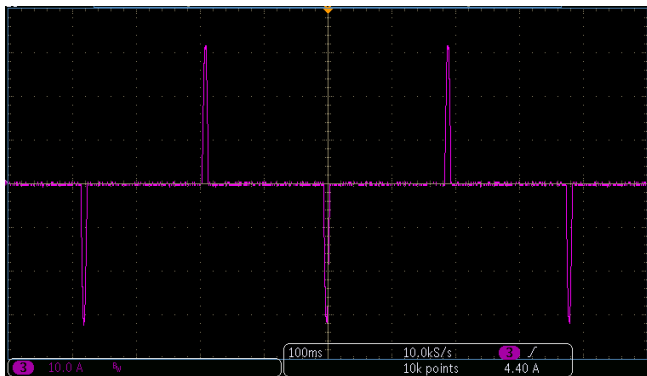
C-Sigma

ZERO CROSSING HALF-PERIODS SPREADING FUNCTIONALITY

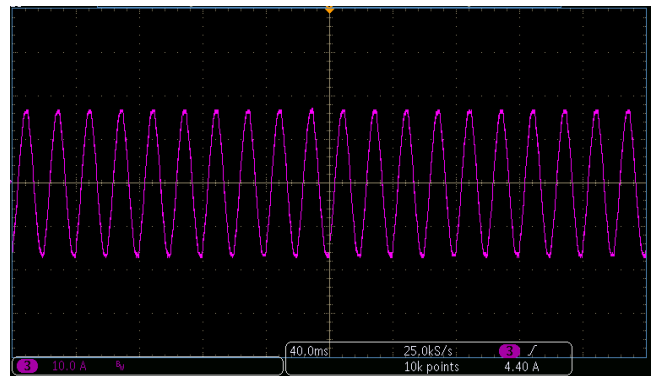
At power-up, the MCU checks whether 5V is present at pin 10 (obtained, for example, by permanently wiring pin 10 to pin 6). If 5V is not present, the MCU switches to the conduction angle mode of operation described on page 2.

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. The said pattern is a function of the applied setpoint. 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), 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, minimising 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).

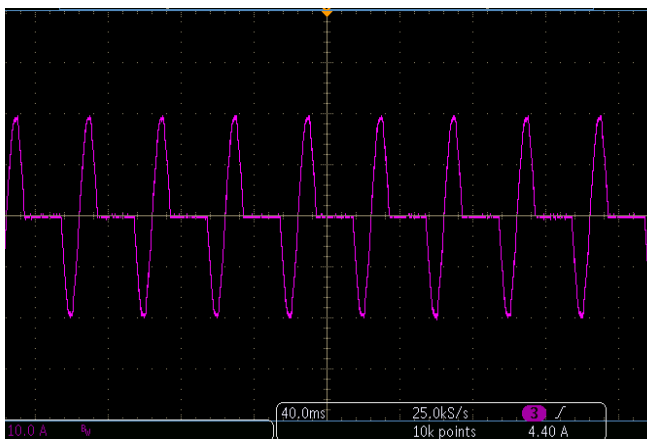
Additionally, over a 10-period time interval of the mains AC voltage, the number of positive half-periods always equals the number of negative half-periods, in compliance with utilities' requirements for balanced loads. When in Zero-Crossing mode, the range of regulation is 5% to 100%, with a 1% resolution, while achieving a 99% power transfer efficiency at a 3kW load. In the following examples, the oscilloscope purple trace 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:



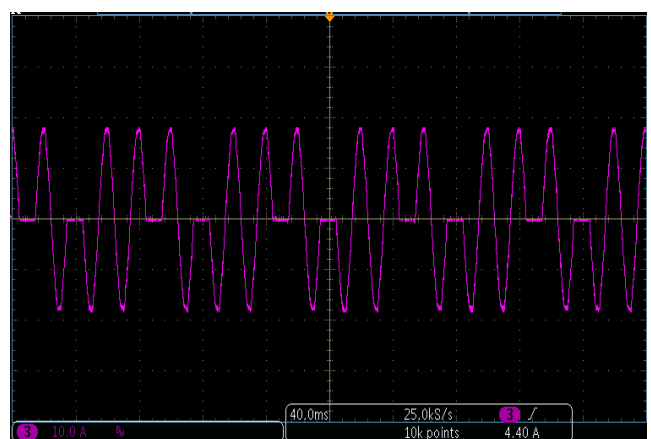
Min. driving is 5% of half-periods



100% of half-periods



50% of half-periods



75% of half-periods





VR-0XH



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 the control of 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 a mode, it is no longer necessary to install filters and power factor correctors. Of course, this is so only for restive loads. Note that although the pin 8 setpoint input voltage range is 0-10V, 100% driving is reached already at 8V (when in zero-crossing mode). 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. At room temperature, the resistance is low, allowing a large initial current to flow. Therefore, suddenly applying the mains voltage to a much lower resistance causes a peak current far higher than the nominal rms current. This peak then gradually decreases over subsequent half-periods, stabilising once the heating element reaches its operating temperature. This phenomenon is especially notable for IR quartz tubes, where the cold resistance can be as little as one-tenth of the resistance when incandescent. Depending on the line impedance, this may easily lead to a peak of current exceeding 100A at the first half-period (referring to 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 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 circuit breakers, or generating EMI disturbances. For applications where a large inrush current is a concern, the following turn-on sequence may be employed.

- 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 peak current at inrush will be effectively contained.

