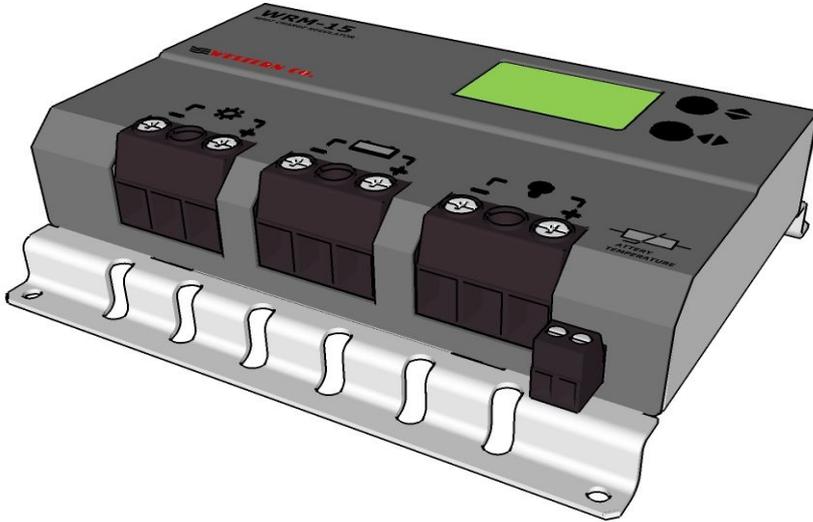


PHOTOVOLTAIC CHARGE REGULATOR

WRM-15

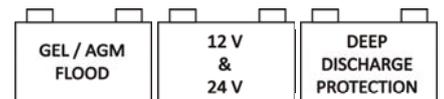


WRM-15 is a complete solution for the realization of off-grid PV systems to power supply road signs systems, lighting systems, small low voltage systems and for the recharge of batteries inside caravans. This model of charge regulator has got a circuit of search of the maximum PV module's power (MPPT) : regardless of battery voltage and its charge state, WRM-15 make always the PV module work in its point of maximum power maximizing the energy extracted from the module and loaded into the battery. PWM charge regulators want PV modules with No. 36 cells for the recharge of 12V batteries and PV modules with No. 72 cells for the recharge of 24V batteries. This planning obligation is no more necessary with MPPT circuit where you can use the cheaper PV modules used in grid connected systems (with a number of cells different from 36 or 72) also in PV off-grid systems. You can also use amorphous PV modules that normally are not suitable to PWM charge regulators.

The several programs of load management, selectable by the user, make WRM-15 the complete solution in several applications; i.e. to power supply video cameras that have to work only during the day, or to power supply flashing systems / road signs that have to work only during night, or to power supply lighting systems that have to work only for a certain number of hours during night. WRM-15 detects the day/night state according to the PV module's voltage; therefore it's not necessary to connect further sensors to the regulator. A wide display shows the working status of the regulator either through simple and intuitive icons either displaying the values of recharge current, battery voltage, energy produced by the PV module, load current and energy consumed by the load.



- **MPPT recharge**
- **Wide voltage range on PV module input**
 $V_{PAN} 0-100V$
- **Maximum PV module power 225W for 12V battery and 450W for 24V battery**
- **Integrated blocking diode**
- **For sealed, GEL and flooded lead acid batteries**
- **Recharge voltage compensated in temperature**
- **12V / 24V battery voltage auto-detect**
- **18 programs for load management**
- **48 LCD symbols for user interface**
- **Low battery protection**
- **Over-temperature protection**
- **Protection for battery polarity inversion**
- **Overload protection on output**
- **IP20 metal box**



General description

WRM-15 is a photovoltaic charge regulator for leaden electrochemical batteries either sealed (SEAL) or flooded lead acid (FLOOD). In fig. 1 there is a scheme of principle of WRM-15.

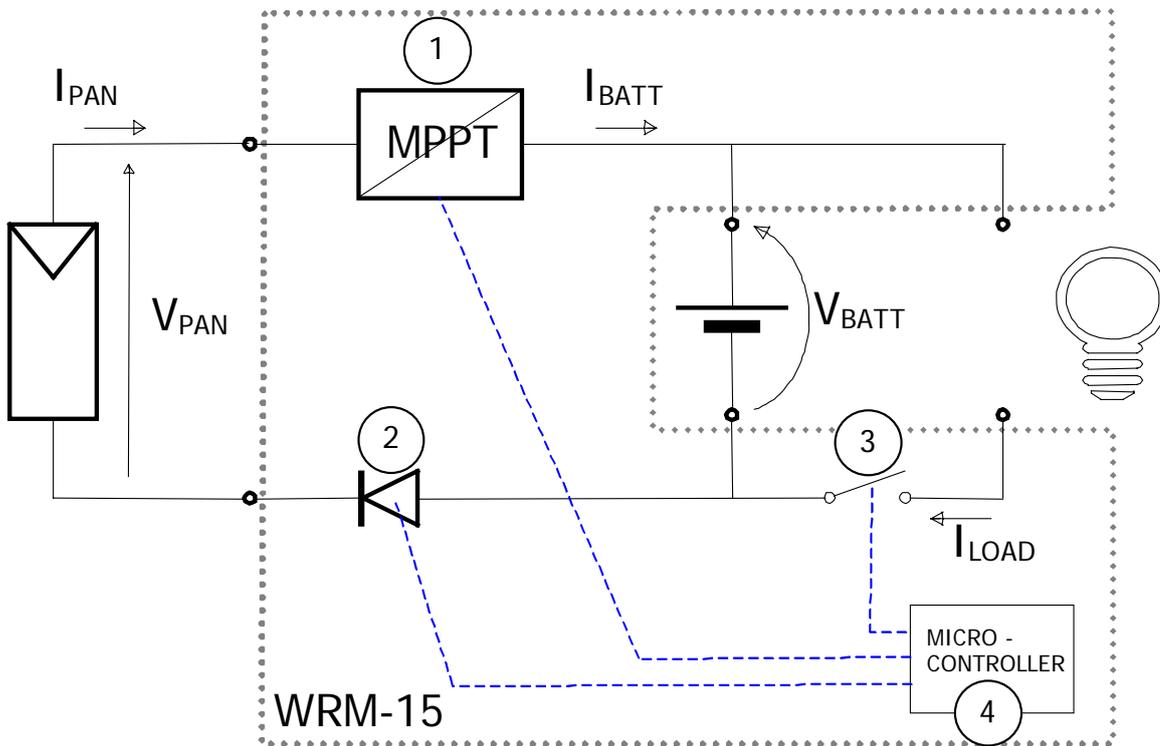


Fig. 1 Schema di principio

- 5- Recharge circuit: it adapts V_{PAN} and I_{PAN} (respectively voltage and current of the photovoltaic module) so to search the condition in which the power that is given by the PV module is maximum, thus realizing the MPPT (*Maximum Power Point Tracking*). In addition, it manages the battery recharge by reducing the current sent towards the battery when the voltage V_{BATT} exceeds its recharge voltage (V_{ch}).
- 6- Series diode: it serves to avoid that during night, when the PV module is not lighted, it cannot absorb current from the battery.
- 7- Circuit for the load control: it turns on/off the load according to the program that has been set from the user and it provides to the load detachment in case of low battery / overload / short-circuit on the load.
- 8- Microprocessor: it controls the whole circuit, it measures currents and voltages of PV module / battery / load and it shows them on the display.

Choice of the PV module

WRM-15 charge regulator, tank to the recharge circuit with MPPT, allows to use a wide range of photovoltaic modules ensuring the optimum exploitation of the power. The PV module has to be chosen according to the nominal voltage of battery and respecting the constraints of the panel input of WRM-15: maximum voltage 100V and maximum panel power 225W with 12V battery and 450W with 24V battery.

Battery nominal voltage		PV modules' features
<p>12V Battery nominal voltage</p>		V_{mp} : voltage at the maximum power at $T=25^{\circ}C > 15,0V$ V_{OC} : open circuit voltage at $T=-10^{\circ}C < 100V$ P_{MAX} : maximum power at $25^{\circ}C < 225W$ We recommend PV modules with mono or polycrystalline silicon with a number of cells from minimum 36 to maximum 144 cells.
<p>24V Battery nominal voltage</p>		V_{mp} : voltage at the maximum power at $T=25^{\circ}C > 30,0V$ V_{OC} : open circuit voltage at $T=-10^{\circ}C < 100V$ P_{MAX} : maximum power at $25^{\circ}C < 450W$ We recommend PV modules with mono or polycrystalline silicon with a number of cells from minimum 72 to maximum 144 cells.

Wiring scheme

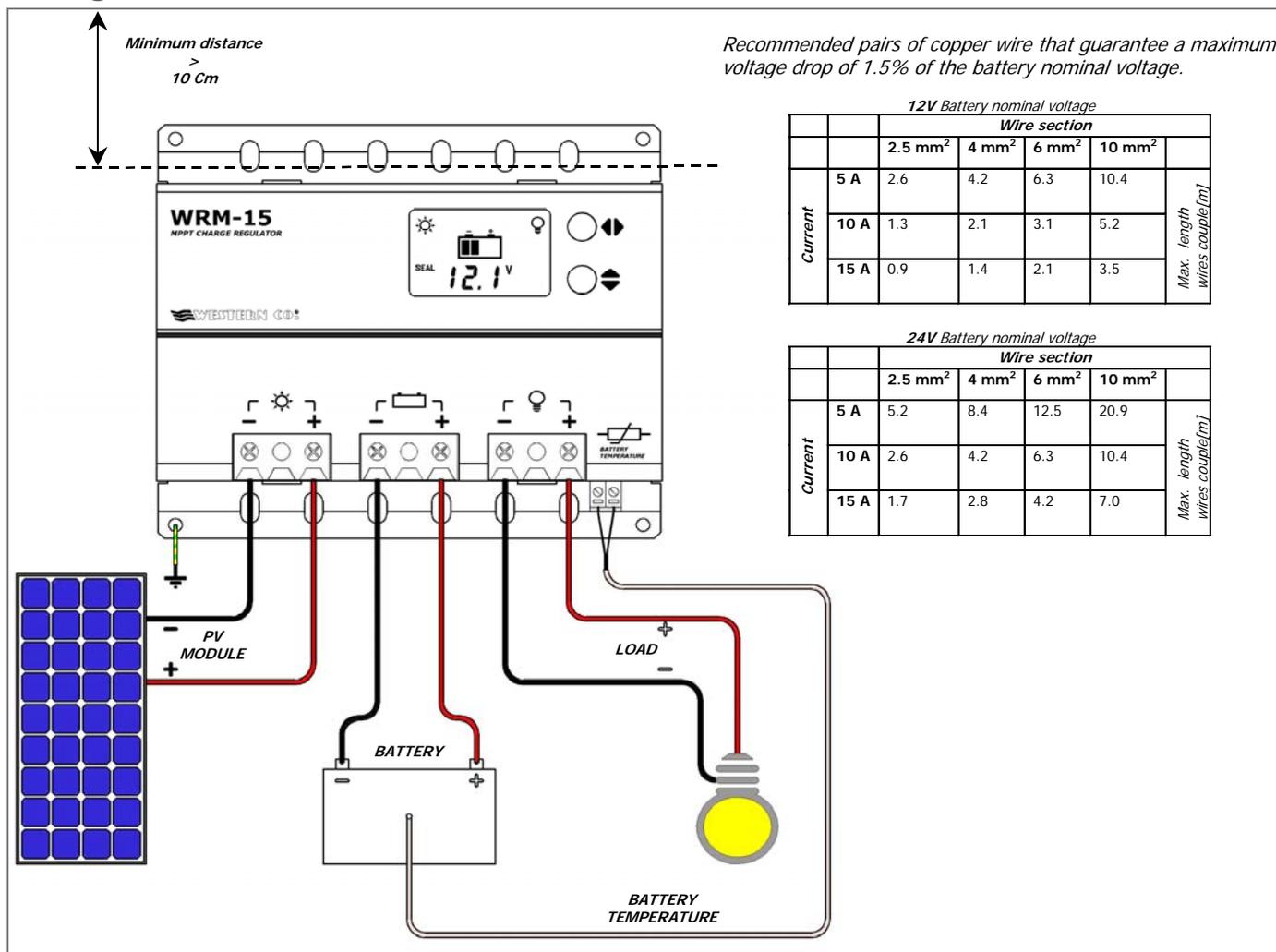


Fig. 2 Connection scheme

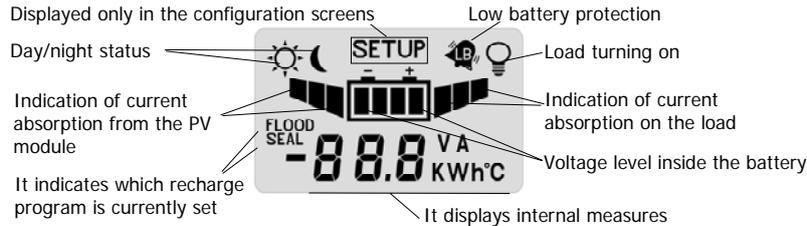
- 1) Install WRM-15 in a dry and adequately ventilated place; it has to be fixed on a non-flammable surface and placed so to leave unobstructed space of at least 10cm around the device that allows the cooling by natural air convection.
- 2) Connect respectively: load, sensor for battery temperature measure (supplied), PV module and, last, the battery as in the scheme fig. 2. When you connect the battery the regulator turns on and it begins to work. Use proper cable sections as indicated in fig. 2.
- 3) If WRM-15 recognizes automatically the battery nominal voltage and it adapts consequently its working thresholds. The user must configure the kind of used battery to adequate the right recharge voltage (V_{ch}). You have to set the SEAL configuration if you use VRLM or GEL sealed batteries, while you have to choose the FLOOD configuration if you use flooded lead acid batteries (fig. 4).
- 4) Set the proper load management program to your own application (fig. 4).

System testing

Once made the connections as in fig. 2 it is necessary to proceed with the testing of the system.

- 1) With the PV module exposed to sunrays, verify that WRM-15 is recharging the battery reading on the recharge current I_{PAN} e I_{BAT} (see fig. 3).
- 2) To verify that the battery temperature sensor has been properly connected check on the LCD that at the page "battery temperature" a reliable temperature value is displayed (fig. 3).
- 3) Verify the correct turning on of the load. If the load is ON only during night it is possible to simulate the night by disconnecting temporarily one of the wires of the PV module. With load ON check the absorbed current by reading in the proper page of the LCD (fig. 3).

Visualizations



	Main page. It displays the battery voltage (V_{BAT}), the recharge program currently selected (either SEAL or FLOOD), the day/night status detected by the PV module. The load icon, if ON, indicates that the load is power supplied.
button	
	It displays the current (I_{PAN}) of the PV module. We remember that the current delivered by the PV module depends on its state of sun-lighting and on battery charge status. With charged battery ($V_{batt} > 14.4V @ 12V$ or $V_{batt} > 28.8V @ 24V$) and even with a good lighting of the PV module, you have low recharge currents since the regulator limits such current so to avoid the battery overcharge.
button	
	PV module voltage (V_{PAN}).
button	
	It displays the power in watt actually delivered by the PV module.
button	
	It displays the counter of energy that is delivered by the PV module in kWh. It is possible to reset this measure pressing simultaneously the buttons $\blacktriangleleft \blacktriangleright$ for 2 seconds.
button	
	It displays the recharge current inside the battery (I_{BAT}).
button	
	It displays the battery temperature that is currently measured by the temperature sensor connected to WRM-15.
button	
	It displays the current that is currently delivered to the load; even if in this screen the load icon is on, this does not mean that it is effectively power supplied; in fact the load is controlled according to the management load program that is currently set.
button	
	It displays the power that is currently delivered to the load in watt.
button	
	It displays the Energy counter in kWh consumed by the load. It is possible to reset this counter pressing simultaneously the buttons $\blacktriangleleft \blacktriangleright$ for 2 seconds.
button	Pressing the button you go back to the main page.

Fig. 3 Display pages of measures

System configuration

You can go to the configuration pages of WRM-15 pressing simultaneously for at least 2 seconds the buttons $\blacktriangleleft \blacktriangleright$.

Recharge program configuration page	
	It sets the recharge voltage for the battery. We recommend to set the SEAL program for GEL or sealed batteries and the FLOOD program for the recharge of flooded lead acid batteries. Recharge voltages relating to each one of the programs are indicated in the following fig. 6/8 and must be chosen in accordance with the battery manufacturer indications.
Page change	
Low Battery voltage configuration page	
	It sets the intervention voltage of Low Battery protection (load detachment in case of low battery). When pressing the button $\blacktriangleleft \blacktriangleright$ you change the setting from 10.8V to 12.2V for 12V systems and from 21.6V to 24.4V for 24V systems.
Page change	
Load management program configuration page	
	Load always ON during day or during night. Load only during day. Load ON during night. Load only during night. Load during night for 1 hour. Load ON during night for 16 hours.
Page change	
Voltage Configuration Page - Vday	
	WRM-15 detects the day when the voltage of PV module (V_{PAN}) is $>$ than the V_{DAY} threshold; it detects the night when V_{PAN} is $<$ than V_{NIGHT} threshold. In this page it is possible to change V_{DAY} threshold. V_{NIGHT} threshold = $V_{DAY} - 0.8V$
Page change	
Software version display page	
	It displays the software version in use on WRM-15.
Pressing the left button you go back to the configuration page of the recharge program.	

Fig. 4 Setting pages

Once modified the settings of WRM-15 these become operative only after the exiting from the configuration pages pressing simultaneously for at least 2 seconds the buttons $\blacktriangleleft \blacktriangleright$.

Error Codes

With the intervention of the internal protection of WRM-15 there are the error codes here below reported.

Error Code Table			
	<p>When the symbol <i>low battery</i> is flashing this indicates that there is the low battery protection (to preserve the battery life, the load has been disconnected). This protection intervenes when the battery voltage goes under the threshold V_{LB} that can be set by the user (fig. 4). WRM-15 leaves this protection when the battery will be recharged by the PV module at V_{OUT-LB} voltage (see Fig.8 "Table of electrical features").</p>		<p>There is the overload protection. The load current exceeded the maximum allowed limit for WRM-15 (Iload in the "Table of electrical features") and the regulator detached the load to prevent internal damages. If there is such a signaling, it is necessary to check if the current absorbed by the load is < of the allowed limit. After 1 minute WRM-15 try to power supply again the load and it exits from this state if the cause that generated the overload has been eliminated.</p>
	<p>The battery was connected with inverted polarities. Check the electrical connection of the battery.</p>		<p>You have this error when battery voltage goes under the threshold of 9.0V. When WRM-15 signaling this error it disable the charging circuit.</p>
	<p>You have this error when WRM-15 internal temperature exceeds 80°C and deactivates the recharge. You exit automatically from this protection when the internal temperature goes below the threshold 50°C. (note: the internal temperature of the regulator is not displayed). If you see often this protection we advise to place the regulator in a fresher place.</p>		

Fig. 5 Error Code Table

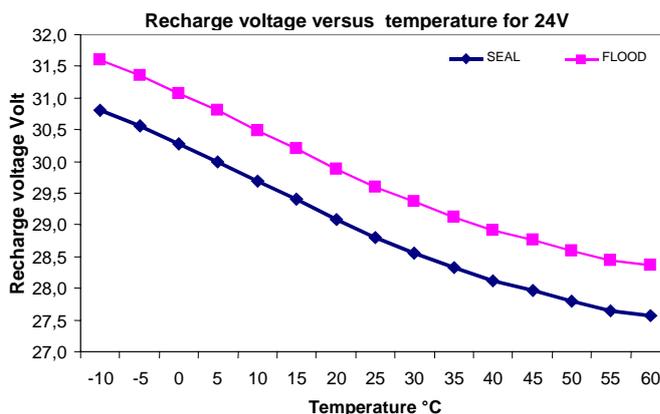
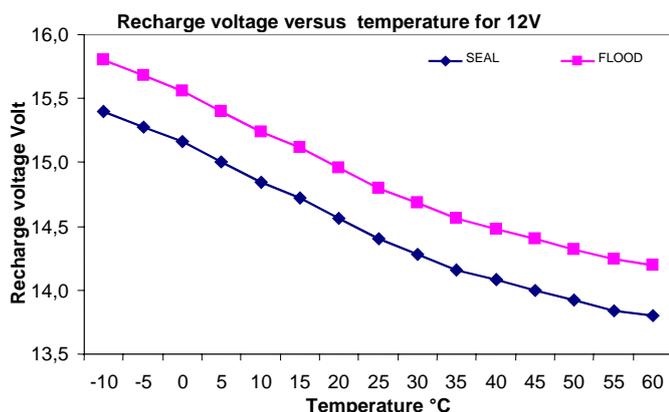


Fig. 6 Compensation curve of V_{ch} recharge voltage according to the battery temperature

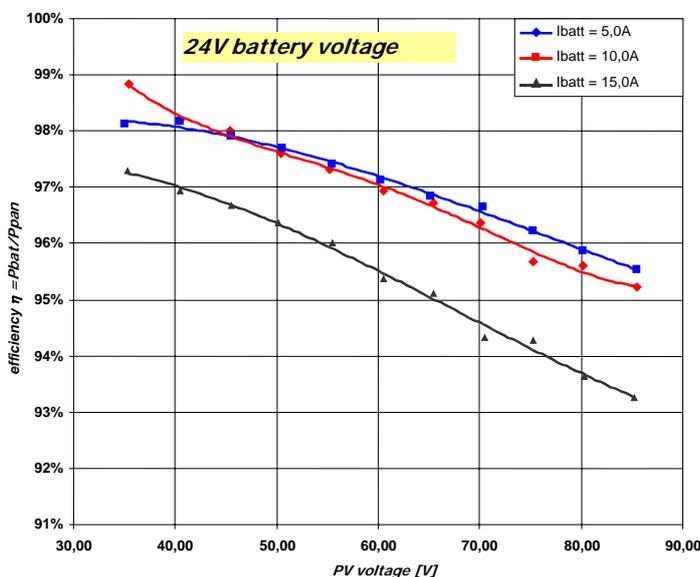
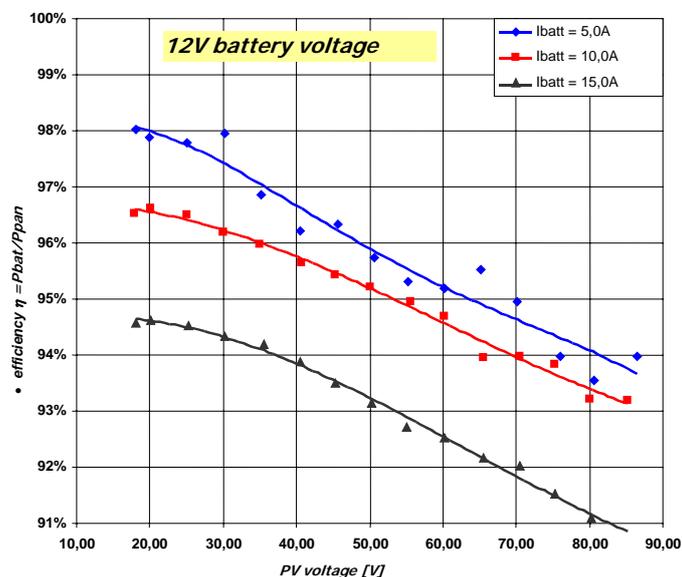


Fig. 7 WRM-15 efficiency versus voltage panel for 12V e 24V battery.

ELECTRICAL FEATURES

		12V battery nominal voltage			24V battery nominal voltage		
		Min	Tip	Max	Min	Tip	Max
Battery voltage	Vbatt	10V		17V	20V		34V
Open circuit panel voltage	Vpan	20V	-	100V	40V	-	100V
Panel current	Ipan	-	-	15A	-	-	15A
Maximum panel power	Pmax	-	-	225W	-	-	450W
Load output voltage	Vload	-	Battery voltage	-	-	Battery voltage	-
Load current	Iload	-	-	15A	-	-	15A
Recharge voltage at 25°C – SEAL program (default)	Vch		14.4V			28.8V	
Recharge voltage at 25°C – FLOOD program	Vch		14.8V			29.6V	
Compensation of Vch function of battery temperature (Tbatt)	Vtadj	-	-24mV/°C	-	-	-48mV/°C	-
Low battery voltage (settable)	Vlb	10.8V	11.4V (default)	12.2V	21.6V	22.8V (default)	24.4V
Low battery output voltage at 25°C - SEAL program	Vout_lb	-	13.4V	-	-	27.8V	-
Low battery output voltage at 25°C – FLOOD program	Vout_lb	-	13.8V	-	-	28.6V	-
Detection voltage of the day (settable)	Vday	2.4V	4.8V (default)	9.6V	4.8V	9.6V (default)	19.2V
Detection voltage of the night: Vnight = Vday –0.8V	Vnight	1.6V	-	8.8V	4.0V	-	18.4V
Auto consumption	Isleep		12.7mA (Vbat 14,0V)			17,7mA (Vbat 28,0V)	
Working temperature	Tamb	-10°C		40°C	-10°C		40°C
Dissipated power	Pdiss			20 W			29 W
Wire gauge		1mm ²		10mm ²	1mm ²		10mm ²
Protection degree			IP20			IP20	
Weight		-	515 g	-	-	515 g	-

Fig. 8 Table of electrical features

Dimensions

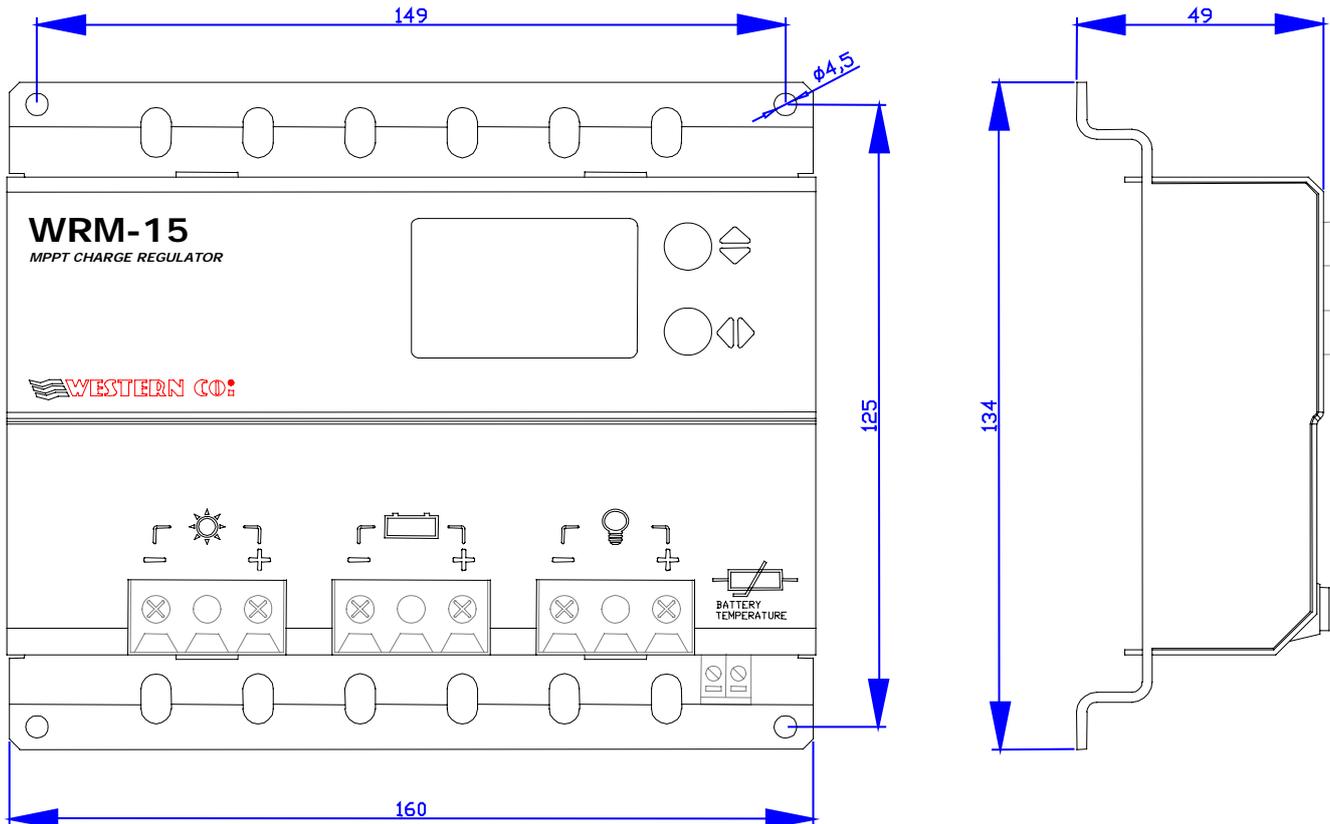


Fig. 8 Dimensions



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