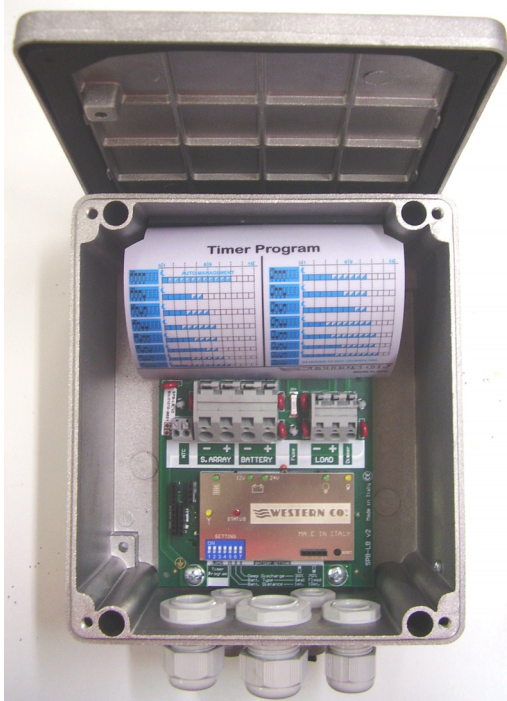**FEATURES OF SPB-LB_v2:**

- **MPPT** recharge.
- Wide voltage range on PV module input (up to 100V).
- Max power of PV module: 225W at 12V and 450W at 24V.
- Integrated blocking diode.
- Suitable for systems with battery bank at 12V or 24V.
- 12/24V auto detect.
- Switch for battery selection: sealed, GEL or flooded lead acid.
- Switch for selection of battery distance: 1meter or 10 meters (in case of batteries at the bottom of the pole).
- Switch for setting depth of discharge (DoD) 30% or 70%.
- Recharge of battery compensated in temperature.
- Integrated light sensor (through PV module).
- Possible load activation with flux reduction.
- Switch to program the hours of load activation.
- Auto management.
- Protection for battery polarity inversion.
- Over temperature protection.
- Overload protection.
- Low battery protection.
- LEDs for the following indications; 12/24V; on/off load; on/off flux reduction; current from PV; protections.
- SMT PCB with microcontroller.
- IP65 metal box for outdoor application.
- Easy installation.

General Description:

SPB-LB charge regulator has been planned to be used in off-grid PV lighting systems; in fact, thanks to its IP65 metal case, it is indicated for use in environments exposed to the elements. SPB-LB has got a very efficient recharge circuit with an algorithm of search of the maximum PV modules' power (MPPT); it has got a wide input range (up to 100V) so to adapt the different types of photovoltaic modules. It is suitable for 12V and 24V systems (auto detect) both for sealed and flooded lead acid batteries and it can manage a max PV power of respectively 225W and 450W. The recharge is compensated in temperature (external sensor). SPB-LB manages intelligently an installation with remote battery (at the bottom of the pole~10mt) without using additional connections and it has got many protections: battery polarity inversion, overload, overvoltage, over temperature, low battery. The latter threshold is selectable for a use of the battery bank with depth of discharge (DoD) of 30% or 70%.

SPB-LB manages an output for a load with currents up to 8A able to drive our SOX-E ballasts (for LPS lamps) and the drivers for LED lamps. Another output called DIMMER is also dedicated for our products in order to handle even the lamp flux reduction. This feature allows to reduce consumptions during the hours where there is not a need for maximum lighting. Load activation and flux reduction are programmable through dip-switches as shown in the table.

Day/night detection is executed according to the PV module voltage; therefore it is not necessary to connect further sensors to the regulator. The choice to use terminals for quick connection (no screws model "cage clamp") for connections is dictated by the simplicity and reliability of the contact that no longer depends on screw tightening. The wide box assures an easy cabling thanks also to the protective barriers for the most delicate electronic components.

Status LED, switches and screen printing indications facilitate the system configuration, the working analysis and diagnostics.

Working:

SPB-LB is a charge regulator from PV modules for sealed (SEAL) or flooded lead acid (FLOOD) electrochemical leaden batteries.

Fig. 1 shows a diagram of principle:

(1)-*Recharge circuit:* it adapts V_{PAN} and I_{PAN} (respectively PV module voltage and current) so to search the condition with the maximum power from the PV module (MPPT -Maximum Power Point Tracking). In addition it manages the battery recharge by reducing the output current to the battery when V_{BATT} exceeds the charging voltage (V_{ch}).

(2)-*Blocking diode:* it is necessary to avoid that during night, when the PV module is not lighted, it can absorb current from the battery.
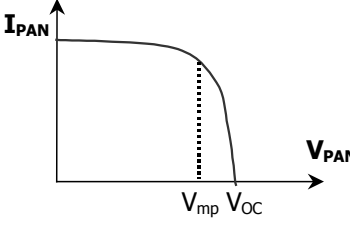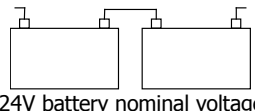
(3)-*Circuit for load control:* it turns ON / OFF the load according to the program set by the user, it commands Dimmer signalling, and makes the load to detach in case of low battery or overload.

(4)-*Microcontroller:* it controls the whole circuit, it measures currents and voltages of PV module, battery and load, it executes MPPT algorithm.

Fig. 1 Basic diagram
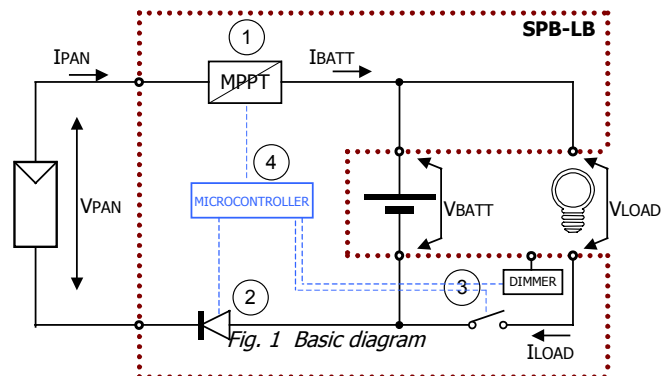
Choice of the PV module:

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

Battery nominal voltage		PV modules features
12V battery nominal voltage		V_{mp}: voltage at max power at T=25°C > 15,0V V_{OC}: open circuit voltage at T=-10°C <100V P_{MAX}: max power at 25°C < 225W We recommend mono or polycrystalline PV modules with a number of cells from minimum 36 to max 144.
24V battery nominal voltage		V_{mp}: voltage at max power at T=25°C > 30,0V V_{OC}: open circuit voltage at T=-10°C <100V P_{MAX}: max power at 25°C < 450W We recommend mono or polycrystalline PV modules with a number of cells from minimum 72 to max 144.

Installation:

The product installation must be performed very carefully in all its phases since from it depends the long term reliability of the system; the major cause of the malfunctions is due to a lack of thoroughness during installation (ex. inappropriate cable section or cabling mistakes can generate overheating, imperfect closures create water infiltrations that damage electronics, and so on). Here below the steps to follow:

- Fix the SPB-LB on an adequate surface not exposed to sunrays by using the 4 holes of the box (WESTERN CO. PV street-lamps have got some holes on the top-of-pole mounting structure). The side with cable-glands is always downward in order to facilitate water drainage. The cover has a gasket that ensures the IP protection degree; therefore be sure to place it perfectly and then gradually tighten the 4 closing screws. Always recheck that the cable-glands are properly tightened.
- Following the diagram in Fig. 2, connect with the right polarities respectively: load; sensor for battery temperature measure (supplied); PV module and lastly the battery. When connecting the battery the charge regulator turns on and starts working (it is normal that normale with the contact of the last pole there is a spark of light, it is due to charge of the internal capacitor). Use the appropriate sections of the cable as shown in Fig. 2.
- SPB-LB automatically recognizes the nominal voltage battery and accordingly adapt its operating thresholds. When starting on immediately check that the LED lightens - 12V o 24V according to the nominal voltage of the battery bank.
- You must set the configuration for batteries:
- move switch n°5 to ON position if batteries are near the regulator, while move switch n°5 to OFF position if the batteries are far from the regulator (batteries at the bottom of the pole and charge regulator on the top of the pole).
- move switch n°6 selecting the kind of battery in use to adjust the proper charging voltage (V_{ch}). Set the SEAL configuration if you use VRLM or GEL sealed batteries, set the FLOOD configuration if you use flooded lead acid batteries.
- move switch n°7 selecting the depth of discharge of battery between 30% and 70%. This leads to the autonomy of the system in case of sun absence - with 70% we will have more autonomy but the expected life of battery is reduced. We generally recommend a DoD of 30%.
- Set through the switches n°1-2-3-4 the right load management program according to the requested application.

System Test:

Once activated the system, it is necessary to proceed with the testing:
- With the PV module exposed to sunrays, verify that SPB-LB is charging the battery by observing the LED (1) that indicates the current intensity from the PV module. It will make some flashes as reported in the table.
- Verify the 12/24V LED does not indicate the NTC probe disconnetion (see following table).
- Verify the right load activation (moving temporarily all 4-5-6-7 switches in OFF position: load always ON); otherwise it is possible to simulate the night by disconnecting temporarily one of the wires of the PV module or even obscuring the PV module with an opaque panel.

Displayings and protections:

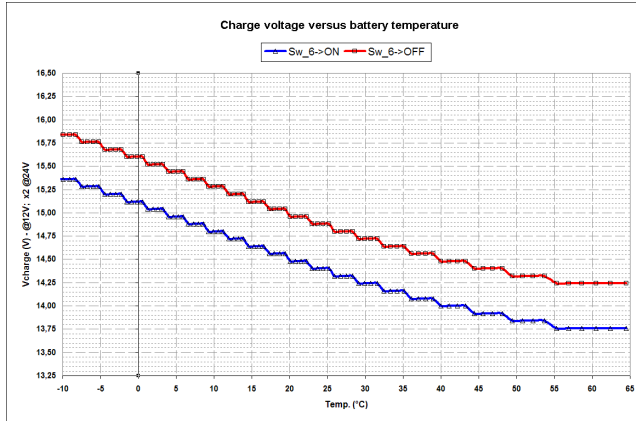| PV LED: Green	Functionality	The number of flashes indicates the intensity of current from the PV module
	1 — 4,3sec. —	1 flash with a pause of 4,3 sec.: 0,5A < PV current < 1,5A
	1 2 — 4,3sec. —	2 flashes with a pause of 4,3 sec.: 1,5A < PV current < 2,5A and so on …
		… intermediate values …
	1 13 — 4,3sec. —	13 flashes with a pause of 4,3 sec.: 12,5A < PV current < 13,5A
Status LED: Red	Functionality	It indicates the system status
STATUS		If always ON it indicates a system anomaly – a reset is needed.
	1 — 2.2sec. —	1 flash every 2,2 seconds: the Low-Battery protection is ON; the load is deactivated; you have to wait that the PV module recharges the battery and, after that, the protections deactivates (condition of normal working)
	1 2 — 2.2sec. —	2 flashes every 2,2 seconds: the overload protection is ON; the load is deactivated; after about 2 minutes the load is resetting, it makes 3 attempts in sequence , then it will wait the following night to try again.
	1 3 — 2.2sec. —	3 flashes every 2,2 seconds: over temperature protection; load OFF and deactivated recharge circuit; wait that the temperature inside the box decreases, then the protection will deactivate.
	1 4 — 2.2sec. —	4 flashes every 2,2 seconds: overvoltage protection; deactivated recharge circuit; the protection deactivates when the battery voltage goes back within the operative range.
Led 12/24 Green	Functionality	It indicates the working nominal voltage of the system
12U 24U	— 4,3sec. —	Besides the indication of the working nominal voltage of the system, if every 4,3sec the LED turns OFF for a moment, this means that NTC probe is disconnected. Vch becomes the same of Vch at 60°C

Timer Program
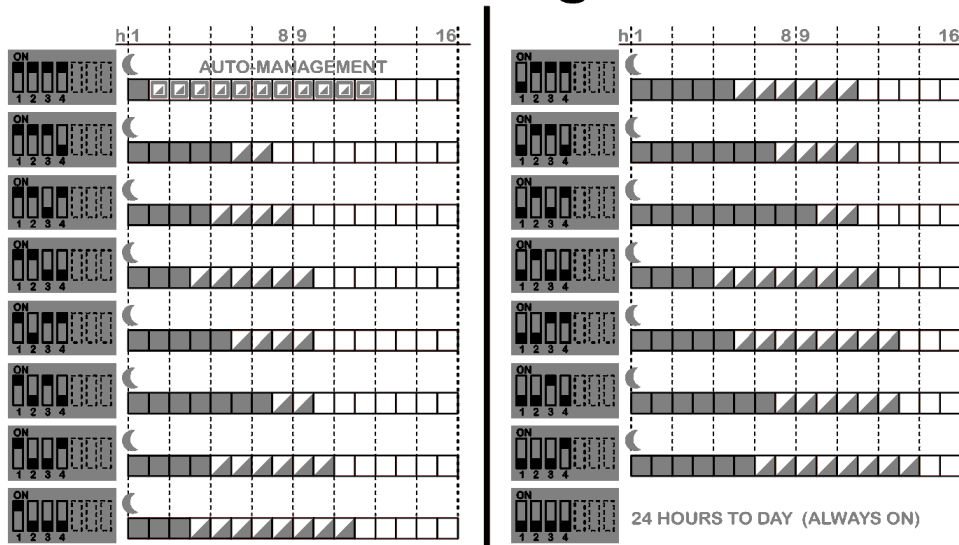
LOAD Programmation:

The load programming can be obtained from this table (also inside the case of SPB-LB). The "moon" symbol in correspondence of the first hour indicates the nightfall. Each small box represents an hour (from 1 to 16): if fully or partially coloured the "LOAD" output is active; the "Dimmer" output is active only if the small box is partially coloured (to represent flux reduction). The first configuration "AUTOMANAGEMENT" shall automatically vary the reduced hours according to the available energy inside the battery. The last configuration always activates the LOAD independently from the nightfall.

Fig. 2 Wiring scheme

LEGENDA:

	(1)	Current intensity from PV module
12V 24V	(2)	System working at 12V or 24V
	(3)	Load activation
	(4)	Flux reduction
STATUS	(5)	Eventual occurred protections
	(6)	Not used in this model
SETTING	(7)	Configuration Switch: 1234 as in "Timer program" table; 567 as in "Battery Setting" table
RESET	(8)	System Reset button

Graph 1

Graph 2
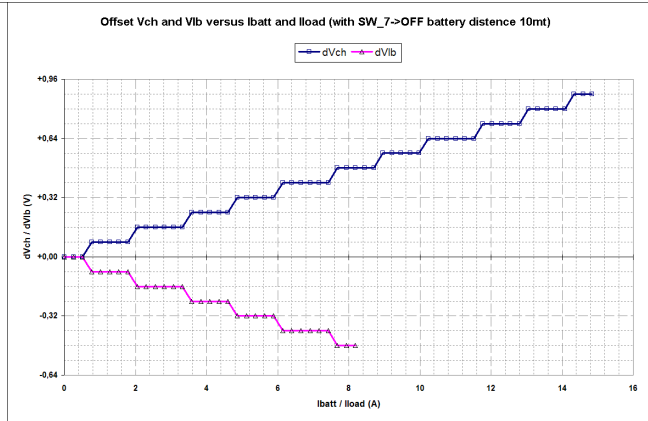
Electric features:

		12V battery nominal voltage			24V battery nominal voltage		
		Min	*Typ*	*Max*	*Min*	*Typ*	*Max*
Battery voltage	**Vbatt**	10V	12V	17V	20V	24V	34V
Open circuit voltage	**Vpan**	20V		100V	40V		100V
Panel Current	**Ipan**			13,5A			13,5A
Max panel current	**Pmax**			225W			450W
Load output voltage	**Vload**	-	Vbatt	-	-	Vbatt	**-**
Load current	**Iload**	-	-	8A	-	-	8A
Recharge voltage at 25°C SW_6->SEAL SW_6->FLOOD	**Vch**		14.44V 14.88V			28.88V 29.76V	
Vch compensation according to battery temperature (Tbatt) (see Graph 1)	**Vtadj**	-	24mV/°C	-	-	48mV/°C	-
Low battery voltage SW_5->ON SW_7->ON SW_7->OFF	**Vlb**	- -	12.00V 11.52V	- -	- -	24.00V 23.04V	- -
Vch compensation with SW_5->OFF (see Graph 2)	**Vremch**		+58mV/A			+58mV/A	
Low battery output voltage at 25°C	**Vout_lb**	-	Vch-0,24V	-	-	Vch-0,48V	-
Vlb compensation with SW_5->OFF (see Graph 2)	**Vremlb**		-58mV/A			-58mV/A	
Voltage detection of day (settable)	**Vday**	-	6.88V	-	-	11.36V	-
Voltage detection of night: Vnight = Vday −0.8V	**Vnight**	-	4.48V		-	8.96V	-
Auto -consumption	**Iqsc**		12.7mA			17,7mA	
Ambient Operating Temperature	**Tamb**	-10°C		40°C	-10°C		40°C
Protection degree			IP65			IP65	
Weight		-	1500 g	-	-	1500 g	-
Case/box dimensions (mm)		190x165 H100					
Dimensions with cables (mm)		250x165 H100					