GALLEY POWER

Digital Battery Power

USER'S MANUAL

GP2 SERIES MPPT SOLAR CHARGER CONTROLLER

Galley Power LLC

www.galleypower.com

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About Galley Power LLC

Galley Power LLC is dedicated to provide cost-effective high performance battery management solutions. With extensive expertise on power electronics, batteries and renewable energy, Galley Power provides both standard and customized solutions with minimum time-to-market and maximum customer satisfaction.

Revision D, July 2016

Safety Instructions

This manual contains important instructions that should be followed during installation and maintenance of Galley Power LLC's GP2 series MPPT solar charge controller.

Consult your battery charging specifications to ensure that the GP2 series charge controller is compatible with your chosen batteries. Please follow all the applicable safety regulatory requirements.

WARNING Be very careful when working with batteries. Lead-acid batteries can generate explosive gases, and short-circuit can draw thousands of amps from the battery. Read all instructions provided with the battery.

WARNING Do not disconnect while the circuit is alive unless the area is known to be nonhazardous.

Voltage Rating Do not exceed the voltage ratings of the controller. The output voltage of the charger must match the voltage rating of the battery.

Sunlight For optimal power conversion, the controller should be protected from direct sunlight.

Airflow Ensure adequate ventilation and space for air flow around the controller.

Connection Copper wire with minimum 90°C insulation rating and between 12 AWG and 14 AWG gauge is recommended. Consult system requirements for wiring and connector selection.

Grounding Grounding is not required for operation. Grounding shall comply with the system requirements; GFDI devices and ground fault protection should be implemented at system level when necessary. Do not use positive grounding.

1. Introduction

The GP2 series MPPT solar charger controller is a photovoltaic (PV) charger controller for 12V and 24V DC battery systems. It harvests the maximum power available from the PV panel and charges the batteries with multi-stage charging profile.

GP2 charger has following standard features:

- PV panel voltage can be higher and lower than battery voltage during charging with buck-boost power train.
- Full range Maximum Power Point Tracking (MPPT) ensuring uninterrupted energy harvesting during normal operation, shading or over irradiance situations.
- Intelligent MPPT algorithm with fast responding speed and maximum power conversion. See Section 4.2 for details.
- Up to 99.7% MPPT efficiency.
- Three-stage charging profile. (More stages available as options.)
- Dual-color LED display for system monitoring.
- Up to 150W power capability with over 96% efficiency.
- 10A battery charging current capability for 12V model; 5A battery charging current capability for 24V model.
- Comprehensive protections including input over-voltage/under-voltage, output over-voltage/under-voltage, over load, shot circuit, back-fed current, reverse polarity and over-temperature.
- Two-year limited warranty.
- RoHS compliant

GP2 charger has following optional features:

- External temperature sensor support and charging temperature compensation.
- Output wire voltage drop compensation.
- RS232 communication port supporting user programming capability.
- Water-proof and water-tight versions.

2. Installation

This chapter contains the installation information and procedures.

2.1 Installation Information

The GP2 MPPT charger controller must be wired to its own PV panel. The PV panel shall have open circuit voltage less than 41V. The input voltage protection circuit on GP2 charger will clamp the input voltage to 45V (typical) during over-voltage event. If the PV panel operates with voltage over 41V and high output current for extended period of time, the input voltage protection might be damaged.

GP2 charger has a 7~41V MPPT range. However, it uses 10V (typical) to detect night-to-day transition and first-time power-on; therefore, the PV panel needs a nominal open circuit voltage over 10V to start up. Please contact Galley Power if a different detection point is required.

The GP2 MPPT charger controller must be mounted in a dry location protected from liquid, moisture, flammable materials. The location shall also be protected from rain, snow, dust, vibration and direct sunlight. The GP2 charger shall not be installed with vented batteries in a sealed enclosure, while it can be installed with sealed batteries in the same enclosure with adequate ventilation. Please also observe other applicable system and safety requirements during installation.

The GP2 MPPT charger controller can be used in ungrounded PV systems or negative-grounded systems. *The negative terminals (Batt- and Panel-) on the charger are common negative.*

The open-frame version connection is 4-pin plug-in 5mm terminal block with voltage rating of 300V and current rating of 20A. The plug can accommodate wire size AWG12~18; please choose wire size based on system requirements. The screw on the plug is M3, and the torque required is 0.56N.m typical.

2.2 Installation Procedures

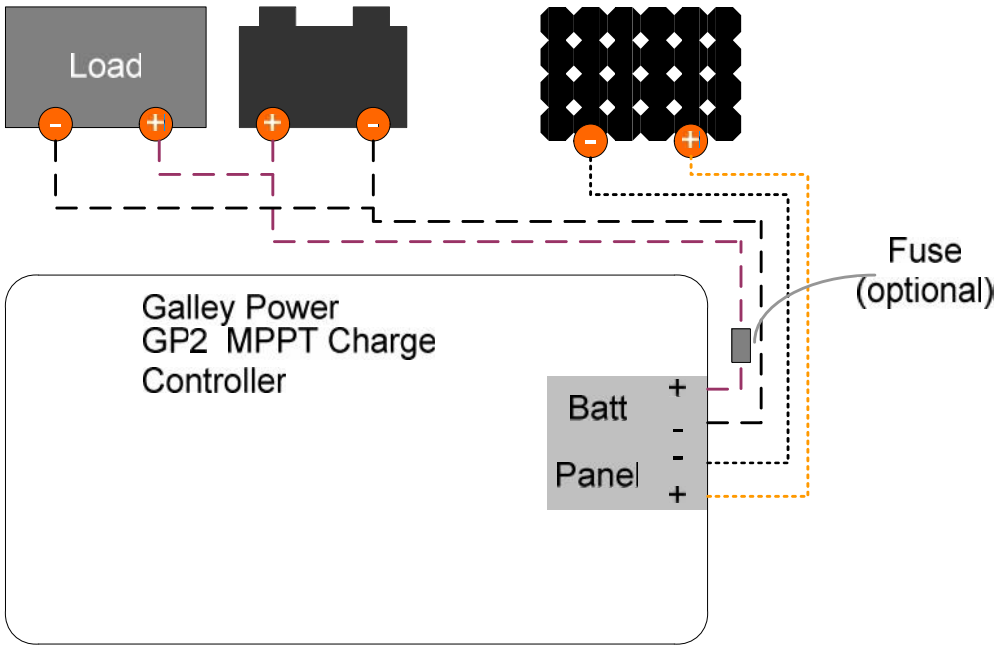

Fig. 1 GP2 charger controller wiring diagram

Step 1: MOUNTING the Charger Box

Mount the controller securely using the mounting holes provided on the enclosure's flanges or with a means appropriate to the application.

NOTES:

- If the cable between the charger and the battery is long, consider using GP2's dynamic cable voltage drop compensation feature (for applicable models).
- The GP2 series charger can be mounted in any orientation.
- Do not expose to water for open-frame models. The water-proof models with IP54 rating allow safe operation when exposed to moderate water exposure. For harsh environment, consider water-tight option with IP65 rating.
- Do not mount in direct sunlight or near a source of heat for optimal power conversion.
- Allow adequate airflow around the controller to achieve maximum output capability.
- For outdoor use, the open frame version must be housed in an NEMA Type 3 or higher enclosure for proper protection. Follow system requirements when applicable.

Step 2: Connect the Battery

Connect the battery to the BATT+ and BATT- terminals.

For the version with plug-in header, it is allowed to connect all wires (battery and PV panel) to the header first and plug the header in the module.

It is allowed to connect the PV panel first and connect the battery afterwards. The module might report battery voltage low error before the battery is connected.

NOTES:

- A small spark while connecting the battery is normal.

Step 3: Connect the PV panel

Connect the solar panel to the PANEL+ and PANEL- terminals.

For the version with plug-in header, it is allowed to connect all wires (battery and PV panel) to the header first and plug the header in the module.

NOTES:

- To qualify a night-to-day transition, the charger module will not start up until the input voltage rises over 10V.
- PV panel open circuit voltage rises in cold weather. The solar panel's open circuit voltage (Voc) shall remain below the maximum input voltage of the GP2 series charger at the coldest possible expected temperature.
- If multiple PV panels are used in parallel, blocking diodes are recommended for each panel, or please follow the panel manufacturer's recommendation.

Step 4: (optional) Connect the load

Connect the load(s) to the battery terminals or to the BATT+ and BATT- terminals.

NOTES:

- Heavy loads connected directly to the battery side would have low wiring voltage drop.
- The charge controller's available power depends on the solar input. Under heavy loading condition, the charger might not be able to provide protection against battery over-discharge (Battery Low fault).

3. LED Indicators

GP2 series charger controller has dual-color LED outputs for status indication. For open-frame option, the LED is on the top of the module; for water-tight and water-proof version, the LED is brought out of the module with wires.

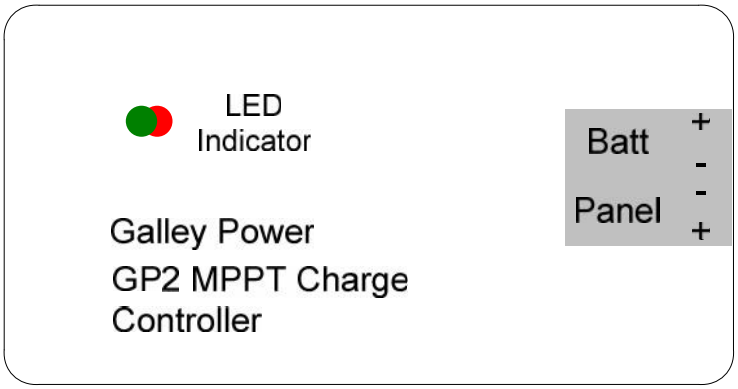

Fig. 2 GP2 charger controller LED display

3.1 GREEN LED

The green LED indicator will light whenever PV panel energy is available for battery charging. At night, the charger will goes into deep sleep and the green LED will turn off.

GREEN LED Indicator	Description	Status
	Fast blinking. The blinking rate increases with higher charging current	Bulk
	Slow blinking	Absorption
	Constant on	Float
	Blink once every 3 seconds	Idle
	Two fast green blinking	Trickle charging in low battery mode

Table 1. Green LED

NOTE:

- When the PV panel energy is low, the charger will also go into idle mode.

3.2 RED LED

RED LED indicates a charger fault condition. If the fault condition is cleared, the charger will automatically recovers and the red LED turns off. Only one fault condition displays when multiple faults are pending.

RED LED blink patterns indicate the fault source. A long blink is 1 second LED ON, and a short blink is 0.3 second ON. There is a 2-second interval between the LED patterns.

RED LED Indicator	Description	Error Status
	Single long blink	Input voltage too high
	Two consecutive long blinks	Battery voltage too high
	One long red – one short red blink	Battery voltage too low
	One short red – one long red blink	Over-load
	Single short blink	External temperature fault (when feature is available)
	Two consecutive short blink	Internal temperature fault
	Solid	System error (Contact Galley Power LLC)
	Two fast red blinking	Trickling charging off in low battery mode

Table 2. Red LED

3.3 RED/GREEN:

If RED/GREEN blinking appears upon power up, it indicates module parameter integrity error. For fixed version, contact Galley Power. For configurable version, reconfigure the parameters if the parameter was just configured; otherwise, contact Galley Power.

For configurable version, RED/GREEN also appears when the module is put into configuration mode; the module is in off mode at the same time.

4. Theory of Operation

This chapter describes the operation of GP2 MPPT charger controller on maximum power point tracking, battery charging, and fault handling.

4.1 Overview of Operations

When system is set up and the module is powered on first time, GP2 charger will not start up until both the input voltage is over 10V and battery terminal voltage is over the battery low threshold. If only the battery is connected, the charger will be off until a PV panel is connected. If only the PV panel is connected, the charger will stay off and report "low battery" until the battery is connected.

Above input and output qualification process also applies during night-to-day transition. At night, the charger will go into deep sleep and drain less than 100nA from the battery. After sunrise, the charger will not start until the PV output voltage is over 10V.

After night-to-day transition, the charger will start from the charging stage in the previous day. For example, if the battery was in absorption stage, the charger will continue the absorption operation instead of starting with bulk charging. This will reduce the stress on the battery and extend battery life.

During normal operation, the maximum power pointer tracking function will converter maximum PV power into the battery (see 4.2 for details). When the PV power available is more than what the charging limit allows, the charger will limit the charging power accordingly (see 3.3 for details).

Under faulty conditions, the charger will stay off until the fault is cleared, and the charger will drain minimum amount of power from the battery.

4.2 Maximum Power Point Tracking (MPPT)

GP2 Charger implements MPPT algorithm to deliver the maximum energy available from the PV panel to the batteries.

For a PV panel, its available power and optimal operating point is time varying and depends on factors such as cloud, irradiance, temperature, shading, sunlight angel, etc. The MPPT algorithm searches for this optimal operating point by applying variable load on the PV panel. Ideally, the charger will only conduct search when the operating point changes because the search means temporary sub-optimal energy harvesting; while in a stable environment (e.g. a cloudless sunny

day), it is preferred that charger dwells on a MPP for an extended period of time for maximum energy harvesting because the MPP does not change much or changes slowly.

GP2 charger's proprietary MPPT algorithm meets above requirements and has following features:

1) Dynamic dwelling time:

GP2 charger is continuously monitoring the energy harvested with its adaptive model. The model automatically tunes the dwelling time with longer dwelling time for steady environments and with shorter dwelling time for fast transient situations.

2) Adaptive MPP rate:

GP2 charger uses adaptive MPP rate to maintain accuracy under both high power and low power scenario.

3) Uninterrupted MPPT:

With 7~41V PV voltage tracking range, GP2 charger provides uninterrupted charging in both cases that the input is higher and lower than the battery voltage. This feature enables continuous energy harvesting in cases such as shading conditions (input might be lower than battery voltage) and over irradiance conditions (input voltage might be higher than battery voltage).

4) Hybrid MPPT scan:

GP2 charger searches both the global MPP and local MPP with balanced maximum power conversion and fast responding speed. The feature enables maximum energy harvesting for cases such as aging panels or unbalanced panels with multiple local maximum power points.

5) Intelligent re-try:

GP2 charger will go into idle state and consume power when the PV power is low. Its internal observer continually monitors the PV panel and resumes MPPT whenever PV power recovers.

4.3 Lead-acid Battery Charging and Operation States

GP2 charger supports flood, AGM and Gel charging profiles. It has four charging stages: bulk, absorption, float and, optionally, equalization. It also has an idle state. GP2 charger will remember its charging status and resume the charging status after a night-to-day transition.

By default, GP2 charger enables bulk, absorption and float stages. Please refer to specifications for default parameters.

4.3.1 Bulk stage

During bulk stage, the charger delivers all PV power available into the battery, and the charger is operating in MPPT mode.

When the PV power available results in an output current higher than the output current limit (I_{ref}), the charger will output the maximum allowed current (I_{ref})and operate in constant output current mode.

When the battery voltage reaches the reference bulk voltage (V_{bulk}), the charger changes to absorption stage.

4.3.2 Absorption stage

During absorption stage, the charger will operate in constant voltage mode and keep the battery voltage at reference absorption voltage (V_{absorp}). In this stage, the charging current gradually reduces as the battery SOC (state of charge) increases.

To avoid over-gassing and over-heating, the charger will complement absorption and change to float stage if ***either*** of following conditions is met:

1) when the charger has stayed in the absorption stage over the absorption time limit ($T1_{absorp}$).
For example, if $T1_{absorp}$ is 150 minutes, the charger will always go to floating stage when the internal timer reaches 150 minutes. The timer will be reset to zero at night, and the charger will stay in absorption stage the next day but the timer will start from zero.

2) when the charging current is less than cut-off current (I_{absorp}) for a period of absorption cut-off time limit ($T2_{absorp}$).
For example, with I_{absorp} as 1A and $T2_{absorp}$ as 5 minutes, the charge will go to float stage when the charging current is less than 1A for 5 minutes. The timer pauses when the charging current falls under 1A due to low PV power. The timer will be reset to zero at night, and the charger will stay in absorption stage the next day but the timer will start from zero.

4.3.3 Float stage

During float stage, the GP2 charger will operate in constant voltage mode and keep the battery voltage at reference float voltage (V_{float}). Depending on the battery load condition and the available PV power, the charger might delivery maximum power to the batteries and operates in either constant output current or MPPT mode.

By default, the GP2 charger will stay in float stage until the ReBulk condition is met.

Optionally, the float stage can go to idle state by setting float stage time limit (T_{float}). For example, when T_{float} is 60 minutes, the charger will stay in float stage for an hour. The timer will be reset at night, and the charge will stay in float stage the next day but the timer will start from zero. The default value for T_{float} is infinity.

4.3.4 Idle state

During idle state, the charger stays off and consumes minimum power from the battery. The charger will remember its battery charging stages and resume the charging stage when the idle condition is cleared.

The charger might get into idle state in following cases:

1) Low PV power:
   When the PV power is low, the charger turns off to consume power. It will resume MPPT and go back to its active charging stage when PV power recovers.

2) Battery full:
   When float stage is completed, the charge might go to idle stage. This is optional, and please see float stage for details.

3) Faults:
   This is a special case. The charger is off during fault conditions. The LED will display fault source.

4.3.5 ReBulk

The GP2 charger will always go back to bulk stage when the battery voltage is lower than ReBulk voltage (V_{ReBulk}) for a period of T_{ReBulk}.

4.3.6 Equalization

Equalization is an optional stage and is disabled by default. The user can set the reference equalization voltage, equalization time, and cycle time. The requirements on equalization

depend on battery type and applications. Please contact Galley Power for more details.

4.4 Lithium-ion Battery Charging and Operation States

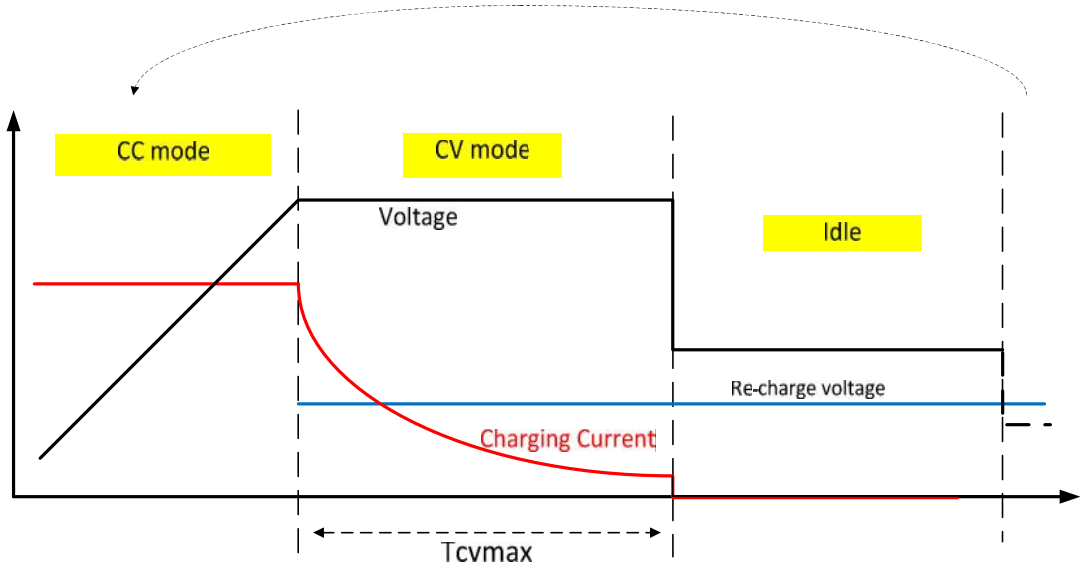

Fig. 3 Lithium-ion Battery Charging Profile

GP2 charger supports LIB and LiFePO4 battery charging profile. Its 12V version can work with 3S LIB, 4S LIB, 4S LiFePO4, and the 24V version 6SLIB, 8S LiFePO4.

GP2 charger has three charging stages: CC mode, CV mode and Idle. It also has a recharge condition to go back to CC mode.

4.4.1 Constant Current (CC) mode

In constant current (CC) mode, the battery state-of-charge (SOC) is low, and all available PV energy is delivered to the battery. Specifically,

1. When the PV energy is too high, the charger will limit the charging current to the battery to Imax (default value, 10A).

2. If the PV energy is lower, the MPPT will converter the maximum available energy to the battery. The battery voltage will be lower than the charger voltage (Vref). The charger will continue charging until the battery voltage reach Vref.

3. After battery voltage reaches Vref, the SOC is high, and the battery goes into CV mode.

4.4.2 Constant Voltage (CC) mode

In constant voltage (CV) mode, the battery SOC is high, and the charger continues charge the battery until the end-of-charge current is met. Specifically,

1. When the PV energy is high, the charger will keep the battery voltage at Vref, and only converter PV energy necessary to maintain Vref.

2. The charger will terminate charging and go into Idle mode when the charging current is less than end-of-charge current (Iedc) (default, 0.5A) for a time duration of T1 (default, 30 sec).

3. However, if a low charging current (less than Iedc) is due to low PV energy, the charger will ignore this condition, and the T1 timer pauses.

4. The elapse timer (Tcvmax) sets the maximum allowed time in CV mode for safety protection. This time is defaulted as 4 hours, and it is only active when in CV mode.

4.4.3 Idle State

During idle state, the charger stays off and consumes minimum power from the battery. The charger will remember its battery charging stages and resume the charging stage when the idle condition is cleared.

The charger might get into idle state in following cases:

1. Low PV power:
   When the PV power is low, the charger turns off to consume power. It will resume MPPT and go back to its active charging stage when PV power recovers.

2. Battery full:
   When float stage is completed, the charge might go to idle stage. This is optional, and please see float stage for details.

3. Faults:
   This is a special case. The charger is off during fault conditions. The LED will display fault source.

4.4.4 Recharge Condition

When the charge is CV mode or in Idle mode, if the battery voltage is lower than recharge voltage (Vrecharge) for a period of T3, the charger will go back to CC mode and converter maximum allowed PV energy to the battery through MPPT. All timer counts are reset.

4.5 Low battery and dead battery condition

4.5.1 Low battery condition

When the battery voltage is less than the Low-battery voltage, the charger goes into trickle charging mode and charges the battery with a typical current of 0.2A. The charger controls its exact charging current (between 50mA and 0.5A) depending on the battery and PV panel conditions.

Two fast green LED blinks indicate active trickle charging in low battery condition; if the PV energy could not sustain a trickle charging, two fast red blink indicate the low battery condition with charger off.

After the battery voltage is brought over the Low-battery voltage level, normal operation resumes.

4.5.2 Dead battery condition

When the battery voltage is less than Dead-battery condition, the charger will goes into battery output low protection.
This prevents the charger from charging a potentially damaged battery.

4.6 Fault and Protection

GP2 charger has comprehensive protections to fault conditions. During a pending fault, the charger will be off with LED reporting fault source. The charger will restart and resume its charging stage when the fault is cleared.

For input, GP2 charger has input over-voltage and under-voltage protection. As an exception, when under-voltage happens, the LED will not report fault source because this under-voltage might due to normal conditions such as cloud and shading; instead, the green LED reports idle status.

At input, GP2 charger also has reverse polarity protection and over voltage clamping. It will clamp the input voltage to 45V (typical) during over-voltage event. Care should be taken so that the voltage clamping does not last extended period with high current, or the clamping circuit might fail.

At output, GP2 charger has over-voltage (battery high) and under-voltage (battery low) protection. GP2 charger also has battery reverse battery protection; with its built-in transient voltage suppressors (TVS), GP2 charger is designed for ISO-7637-2.

GP2 charger also has over current, short circuit and back-fed current protection.

GP2 charger has internal temperature protection. The default over-temperature threshold is 70C and, when triggered, the charger will restart after the temperature falls under 55C. The default under-temperature threshold is -35C, and, when triggered, the charger will restart after the temperature goes over -25C. When an external temperature sensor is connected (applicable models), the charger has external temperature protection.

4.7 Optional Features

4.7.1 Temperature Compensation

(For models supporting external temperature sensor.)
When an external temperature sensor is attached, the charger will automatically adjust charging voltage based on the temperature measurement and preset compensation factor. This can extend battery life and improve overall charging performance.

4.7.2 Output Wire Compensation

When enabled, the output wire compensation allows the charger to increase its output voltage based on output current and preset compensation factor. This additional voltage will compensate the voltage drop on the wires from the charger to the battery and maintain the reference charge voltage at the battery side. Output wire compensation could reduce the battery charging time and improve charging efficiency.

4.7.3 RS232 Control Interface

(For models supporting user configuration.)
GP2 charger configurable version allows customers to change charging profile parameters and protection thresholds. Please contact Galley Power LLC for communication protocols.

5 Specifications

GP2 series MPPT solar charger controller has following standard specifications to cover most common usages. Configurable versions are also available so the user can customize following parameters to meet unique application needs.

5.1 Charger specifications

Parameter	12V Version	24V version
Standard Version		
Nominal Battery Voltage	12VDC	24VDC
Maximum Charging Current (I_{ref})	10A	5A
Maximum Panel Voltage (Voc)	41VDC	
MPP tracking range	7~41VDC	
Minimum Battery Voltage for Operation	8.5V	17V
Charge Profile	Bulk, Absorption, Float	
Charging Output Voltage Range	8 ~ 15.5VDC	16~31VDC
Operating Temperature	-40 ℃ ~ 70 ℃	
Charger Efficiency	96% - 98.5% typical	
MPPT Tracking Efficiency	99.5% typical	
Idle Consumption, typical	80uA	
Night Consumption, typical	80uA	
Connection	Terminal block w/plug	
Weight	12.5oz(non-potted)	
Dimensions	4.8"x2.6"x1.6"	
Warranty	2 years	
Optional Features		
Battery Temperature Compensation	0 ~ -100mV/℃, configurable	
Other form-factor	IP54 (water-proof version) / IP65 (water-tight version)	

5.2 Lead-acid Battery Charging Profile

12V Version Charge Profile Configurations

Parameters	12-V type Lead-acid battery		
	Flooded	**AGM**	**Gel**
Bulk/absorption voltage ($\mathbf{V_{bulk}}$/$\mathbf{V_{absorp}}$)	14.4V	14.3V	14.2V
Floating voltage ($\mathbf{V_{float}}$)	13.5V	13.4V	13.8V
Re-bulk voltage ($\mathbf{V_{ReBulk}}$)	12.5V	12.5V	12.5V
Absorption time ($\mathbf{T1_{absorp}}$)	180 min	180 min	180 min
Absorption cut-off current ($\mathbf{I_{absorp}}$)	1A	1A	1A
Absorption cut-off time ($\mathbf{T2_{absorp}}$)	10 min	10 min	10 min
Low/dead battery condition			
Low-battery voltage	10V	10V	10V
Dead-battery voltage	8.3V	8.3V	8.3V
Optional Features			
Temperature compensation	-27mV/C	-21mV/C	-27mV/C
Equalization voltage	16.0V	---	---

24V Version Charge Profile Configurations

Parameters	24-V type Lead-acid battery		
	Flooded	**AGM**	**Gel**
Bulk/absorption voltage ($\mathbf{V_{bulk}}$/$\mathbf{V_{absorp}}$)	28.8V	28.6V	28.4V
Floating voltage ($\mathbf{V_{float}}$)	27.0V	26.8V	27.6V
Re-bulk voltage ($\mathbf{V_{ReBulk}}$)	25V	25V	25V
Absorption time ($\mathbf{T1_{absorp}}$)	180 min	180 min	180 min
Absorption cut-off current ($\mathbf{I_{absorp}}$)	1A	1A	1A
Absorption cut-off time ($\mathbf{T2_{absorp}}$)	10 min	10 min	10 min
Low/dead battery condition			
Low-battery voltage	20V	20V	20V
Dead-battery voltage	16.6V	16.6V	16.6V
Optional Features			
Temperature compensation	-54mV/C	-42mV/C	-54mV/C
Equalization voltage	32.0V	---	---

5.3 LIB/LiFePO4 Charging Profile

12V Version Charge Profile Configurations

Parameters	12-V type lithium-ion battery		
	3S LIB	**4S LIB**	**4S LiFePO4**
Charge voltage (**V_{ref}**)	12.6V	16.8V	14.4V
End-of-charge current (**I_{eoc}**)	0.5A	0.5A	0.5A
I_{eoc} timer (T_1)	30sec	30sec	30sec
CV mode elapse timer(T_{cvmax})	4hr	4hr	4hr
Recharge voltage (**$V_{recharge}$**)	12.24V	16.32V	13.68V
Recharge delay (**T_3**)	3Sec	3Sec	3Sec
Low/dead battery condition			
Low-battery voltage	9.4V	12V	9.4V
Dead-battery voltage	7.5V	10V	8V

24V Version Charge Profile Configurations

Parameters	24-V type lithium-ion battery		
	6S LIB	**8S LiFePO4**	**8S LIB**
Charge voltage (**V_{ref}**)	25.2V	28.8V	Contact Galley Power LLC
End-of-charge current (**I_{eoc}**)	0.5A	0.5A	
I_{eoc} timer (T_1)	30sec	30sec	
CV mode elapse timer(T_{cvmax})	4hr	4hr	
Recharge voltage (**$V_{recharge}$**)	24.48V	27.36V	
Recharge delay (**T_3**)	3Sec	3Sec	
Low/dead battery condition			
Low-battery voltage	18.8V	18.8V	--
Dead-battery voltage	15.0V	16V	--

5.4 Mechanical Information

5.4.1 Mechanical dimensions with terminal block

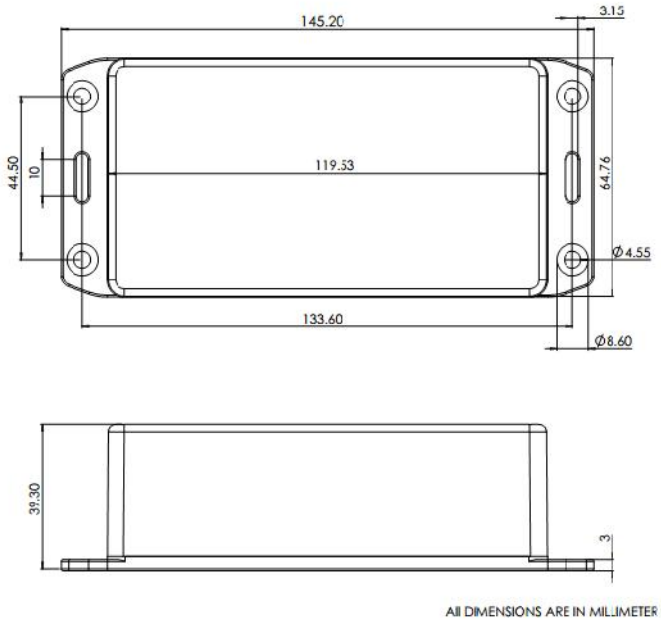

Fig I. Dimensions with terminal block unplugged

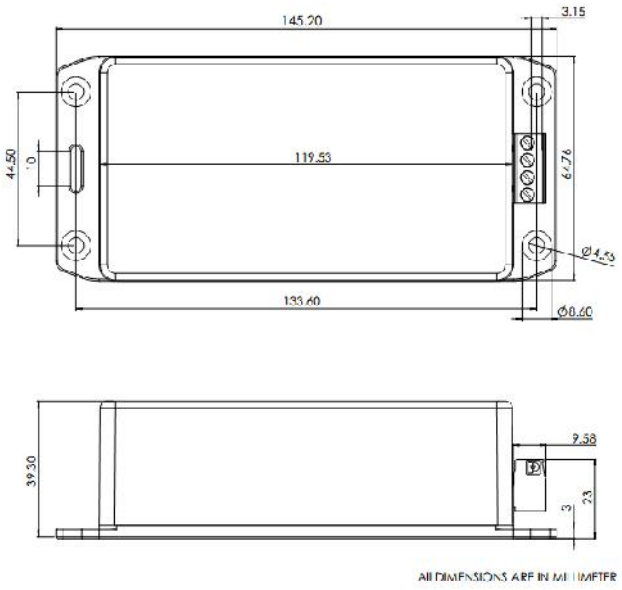

Fig II. Dimensions with terminal block plugged

5.4.2 Mechanical dimensions for water-proof version

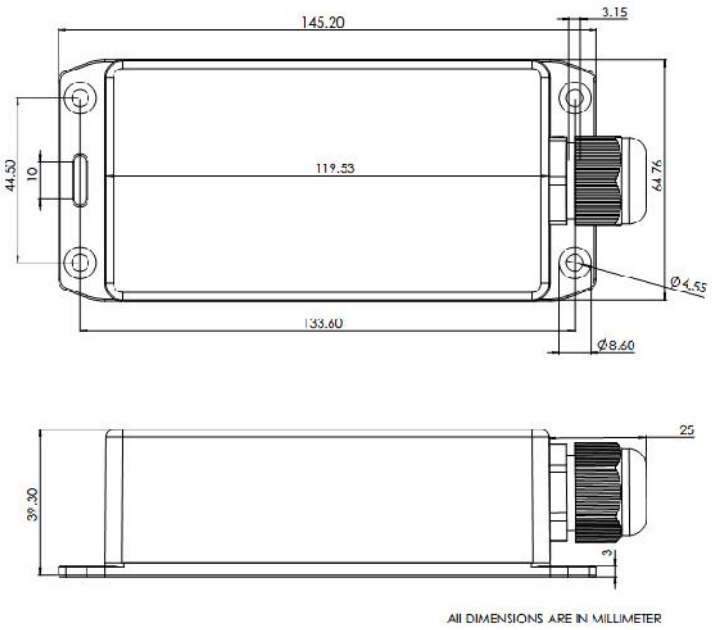

Fig III. Dimensions for water-proof version

5.5 Typical Power Efficiency

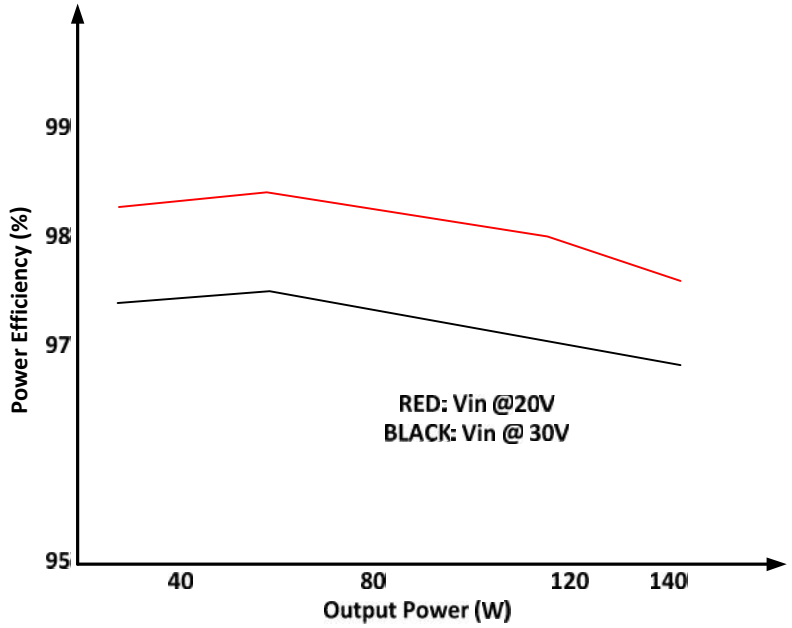

Fig IV. Typical 12V Version Power Efficiency

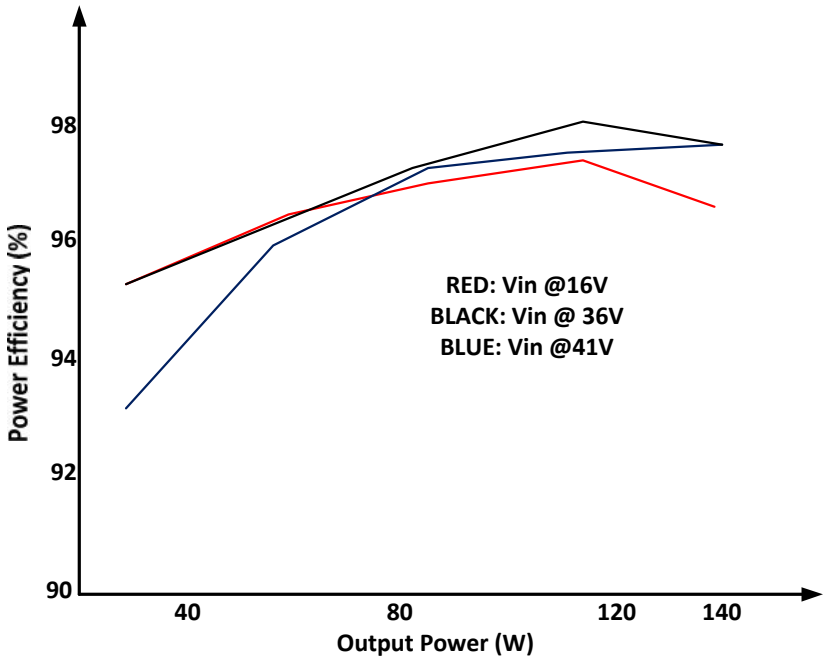

Fig V. Typical 24V Version Power Efficiency

LIMITED WARRANTY

Galley Power LCC warrants this GP2 series charger controller to be free from defects in material and workmanship for a period of Two (2) years from the date of shipment to the original end user, and, at its option, repair or replace, free of charge, any such defective products. This limited warranty shall only apply if this product has been operated in accordance with the User's Manual. This limited warranty does not apply when this product is damaged by accident, negligence, abuse or improper use or is subjected to unauthorized product modification or attempted repair.

To obtain warranty service

For warranty service, please contact, with proof of purchase, Galley Power LLC at info@galleypower.com

For rapid disposition of your warranty claim, please include the model, serial number and detailed reason for the failure, the panel type/size, type of batteries, system loads and any other related information. Galley Power will cover the return shipping charges if the claims are covered by the warranty.

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