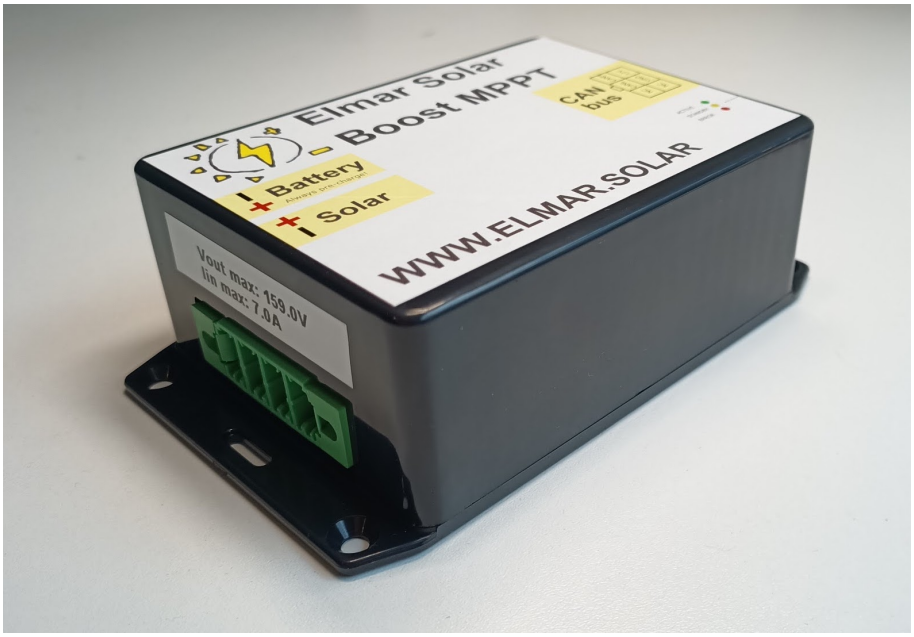
# Elmar Solar Race MPPT Datasheet

March 16, 2023



# 1 Introduction

This document describes the specifications, performance and properties of the Elmar Solar Race MPPT. This MPPT is designed with teams competing in the World Solar Challenge in mind. It boasts an impressive cost/efficiency profile while remaining extremely lightweight.

Different versions of the MPPT are available to accompany for lower current Multi-junction solar arrays and Lower/Higher voltage battery systems. This document describes the default configuration of the MPPT optimized for SunPower C60 silicon solar cells and a 35 series cell li-ion battery.

# 2 Features

- Very high electrical conversion efficiency up to 99.4%
- Tracking algorithm optimized for solar cars driving up to 130km/h
- Data transmission via CAN Bus
- End of charge current control for safe and optimal battery charging

# 3 Specifications

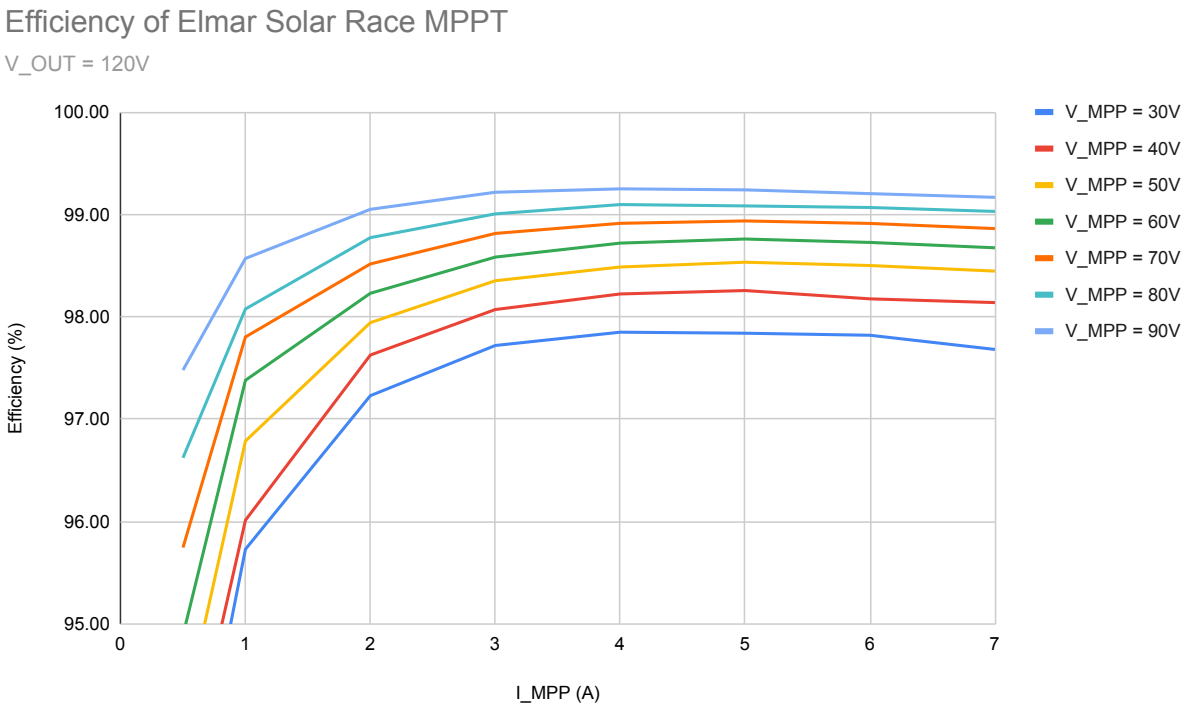
| **Parameter** | **Minimal** | **Nominal** | **Maximal** | **Unit** |
|---|---|---|---|---|
| Array Voltage *1 | 20 | | 150 | Volt |
| Array Current | | | 7.0 | Ampere |
| Output Voltage *1 *2 | 22 | 129.5 | 147.0 | Volt |
| Output shutdown voltage spike | | | 175 | Volt |
| Boost ratio | 1.1 | | 8 | |
| Efficiency | | 98.1 | 99.4 | % |
| Off state current draw ($V_{out} = 140V$) | | 84 | 100 | uA |
| Operating Temperature | 0 | | 55 | Celsius |
| | | | | |
| **CAN Interface Specification** | | | | |
| Supply Voltage | 10.8 | 12 | 13.2 | Volt |
| Supply Current | | 60 | | mA |
| Transmission rate *3 | 125 | 500 | 1000 | kB/s |
| | | | | |
| **Dimensions** | | | | |
| Length | | 136 | | mm |
| Width | | 82 | | mm |
| Height | | 44 | | mm |
| Weight incl. enclosure | | 395 | | gram |
| Weight excl. enclosure | | 285 | | gram |

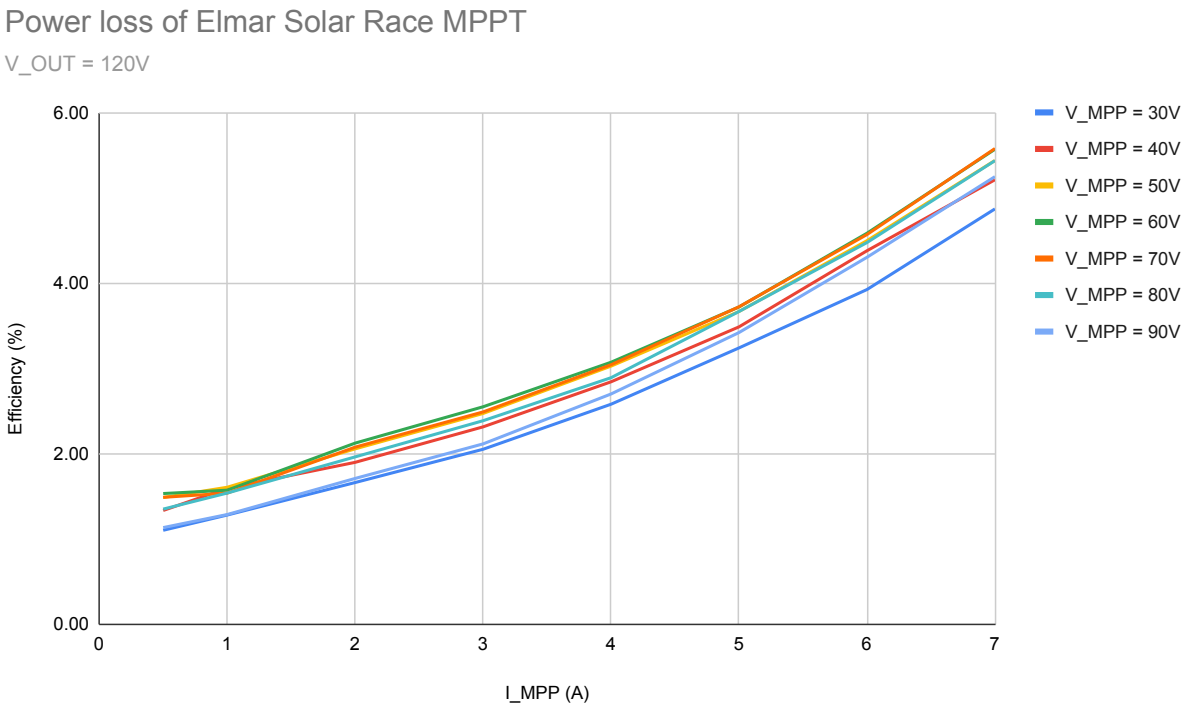
*1 The output voltage must be higher than 1.1x the input voltage for the MPPT to track the maximum power point correctly

*2 The output voltage can be factory configured to any value lower than 165.0V

*3 Transmission rate can be factory configured to the rate required by the customer.

# 4 Electrical conversion



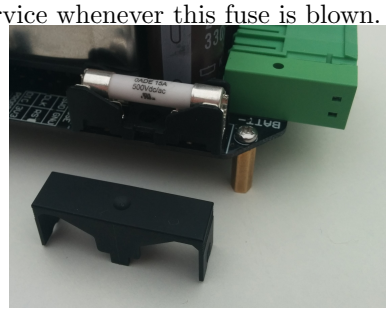
# 5 Fusing

## 5.1 CAN

The 12V Can supply voltage rail is protected with a resettable 200mA PTC fuse of the type Bourns MF-MSMF020-2 mounted on the PCB of the MPPT.

## 5.2 Power

The $V_{out}+$ voltage rail is protected with a fuse of the type Bel Fuse 0ADEC9150-BE mounted mounted on the PCB of the MPPT. This fuse is user replaceable, however it is recommended to send in the MPPT for service whenever this fuse is blown.



# 6 Precharge

## 6.1 Output

The Elmar Solar MPPT has 660uF of low-impedance capacitance across the DC bus output connections. Destructive high currents can flow when connecting capacitors or low impedance sources like a battery with a different voltage in parallel. An external precharge circuit is mandatory when connecting the MPPT output to a battery.

When the MPPT is in off state there is still a diode from the $V_{in}+$ to $V_{out}+$, allowing the array to charge the output capacitors of the MPPT. Whenever connecting the output of MPPT's in parallel or paralleling the MPPT output to other devices such as a motor controller special care has to be taken to discharge all capacitors prior to making connections to avoid damage.

## 6.2 Input

The Elmar Solar MPPT has 330uF of low-impedance capacitance across the $V_{IN}$ connections. A solar array is current limited and thereby a precharge circuit on the input is not necessary when connecting solar arrays that have a short circuit current of less than 8A.

# 7 Led signaling

A single LED indicator is available next to the canbus connectors. Use CAN to get more detailed information about the MPPT state.

| **Led color** | **state** |
|---|---|
| Off | off-state |
| orange | standby-state |
| green | active-state |
| red | error-state |

# 8 Can Bus Interface

The canbus van be used to monitor the operation of the MPPT and to limit the input current of the MPPT. The use of CAN communication is recommended but optional, the 12V can supply is required for the MPPT to turn on.

## 8.1 Galvanic isolation

A galvanic isolation barrier is present between the CAN circuitry and the power circuit.

| **Parameter** | **Value** |
|---|---|
| Isolation Voltage | 1kVDC |
| Isolation Resistance | 10GOhm |
| Isolation Capacitance | 20-75pF |
| Insulation Grade | Basic |

## 8.2 CAN Bus Speed

The CAN Bus speed setting is hard coded into the device and can be specified when ordering the MPPT. Available options are 125kB/s, 250kB/s, 500kB/s and 1Mbit/s, by default it is set to 125 kB/s.

## 8.3 Identifier

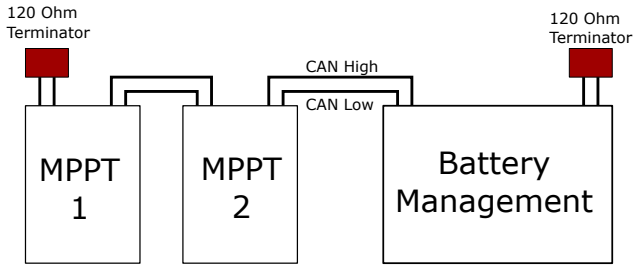
The identifier field has been split in three sections for Elmar Solar MPPT's. Bits 10-8 contain the general device identifier, bits 7-4 contain the specific device identifier and bits 3-0 contain the message identifier.

The general device identifier is hard coded into the device and can be specified when ordering the MPPT, by default it is set to 0x600. The specific device identifier can be selected using the rotary encoder on the MPPT and is equal to the number displayed on the rotary switch multiplied by 0x010.

With the default setting for the general device identifier of 0x600, and the rotary switch on position A, the MPPT base address becomes 0x6A0, with the rotary switch positioned on 3 the MPPT base address becomes 0x630.

## 8.4 CAN Termination

The CAN bus is structured as a linear network. The CAN bus data lines must be terminated at each end of the main bus with 120 ohm resistors between the CAN-H and CAN-L signals.



## 8.5 CAN broadcast Messages

### 8.5.1 Input measurements

ID: MPPT base Address + 0

| Variable | Byte | Type | Unit |
|---|---|---|---|
| Input Voltage | 0-3 | FLOAT | Volt |
| Input Current | 4-7 | FLOAT | Ampere |

### 8.5.2 Output measurements

ID: MPPT base Address + 1

| Variable | Byte | Type | Unit |
|---|---|---|---|
| Output Voltage | 0-3 | FLOAT | Volt |
| Output Current | 4-7 | FLOAT | Ampere |

### 8.5.3 Temperature

ID: MPPT base Address + 2

| Variable | Byte | Type | Unit |
|---|---|---|---|
| Mosfet Temperature | 0-3 | FLOAT | Degree Celsius |
| Controller Temperature | 4-7 | FLOAT | Degree Celsius |

### 8.5.4 Auxiliary power supply

ID: MPPT base Address + 3

| Variable | Byte | Type | Unit |
|---|---|---|---|
| 12V | 0-3 | FLOAT | Volt |
| 3V | 4-7 | FLOAT | Volt |

### 8.5.5 Limits

ID: MPPT base Address + 4

| Variable | Byte | Type | Unit |
|---|---|---|---|
| Max. Output Voltage | 0-3 | FLOAT | Volt |
| Max. Input Current | 4-7 | FLOAT | Ampere |

#### 8.5.6 Status

ID: MPPT base Address + 5

| Variable | Byte | Type | Unit |
|---|---|---|---|
| CAN RX error counter | 0 | UINT8 | |
| CAN TX error counter | 1 | UINT8 | |
| CAN TX overfow counter | 2 | UINT8 | |
| error flags | 3 | 8 bits | bit7 (LSB): low array power<br>bit6: mosfet overheat<br>bit5: battery low<br>bit4: battery full<br>bit3: 12V undervoltage<br>bit2: reserved<br>bit1: HW overcurrent<br>bit0 (MSB): HW overvoltage |
| limit flags | 4 | 8 bits | bit7 (LSB): Input current min.<br>bit6: Input current max.<br>bit5: Output voltage max<br>bit4: Mosfet temperature<br>bit3: Duty cycle min.<br>bit2: Duty cycle max.<br>bit1: Local MPPT<br>bit0 (MSB): Global MPPT |
| mode | 5 | UINT8 | 0 = standby<br>1 = on |
| reserved | 6 | UINT8 | |
| test counter | 7 | UINT8 | +1 every second |

#### 8.5.7 Power connector

ID: MPPT base Address + 6

| Variable | Byte | Type | Unit |
|---|---|---|---|
| Output Voltage (Battery side of fuse) | 0-3 | FLOAT | Volt |
| Power connector Temperature | 4-7 | FLOAT | Degree Celsius |

## 8.6 CAN receive Messages

### 8.6.1 Mode

ID: MPPT base Address + 8

| Variable | Byte | Type | Unit |
|---|---|---|---|
| mode | 0 | UINT8 | 0 = standby<br>1 = on |

### 8.6.2 Maximum output voltage

ID: MPPT base Address + A

| Variable | Byte | Type | Unit |
|---|---|---|---|
| Max. Output Voltage | 0-3 | FLOAT | Volt |

### 8.6.3 Maximum input current

ID: MPPT base Address + B

| Variable | Byte | Type | Unit |
|---|---|---|---|
| Max. Input Current | 0-3 | FLOAT | Ampere |

### 8.6.4 reserved

ID: MPPT base Address + 9
ID: MPPT base Address + C..F

# 9 Connectors

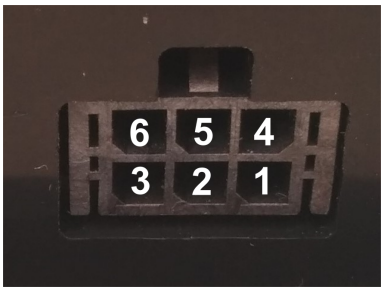
## 9.1 Can Bus

All 6 pins on the two canbus connectors are interconnected, pin 1 is connected to pin 1, pin 2 is connected to pin 2 etc. The connector used for the canbus on the MPPT is Wurth Electronics 66200621022.

Mating parts for this connector can be either:

- Wurth Electronics 662006113322
- Micro-Fit 3.0 430250600 / 430250608 / 430250610

| | | |
|---|---|---|
| 1 | +12V | Can Supply voltage, 10.8-13.2V |
| 2 | GND | Can Ground |
| 3 | NC | Not connected |
| 4 | CAN-H | Can High |
| 5 | CAN-L | Can Low |
| 6 | NC | Not connected |



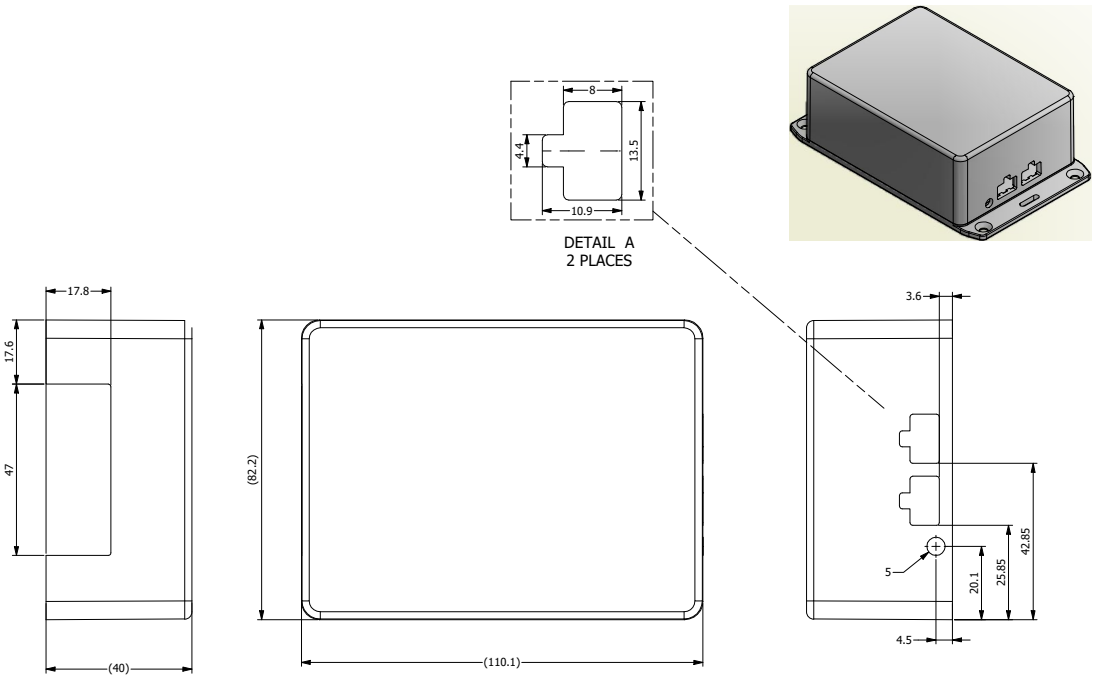

## 9.2 Power

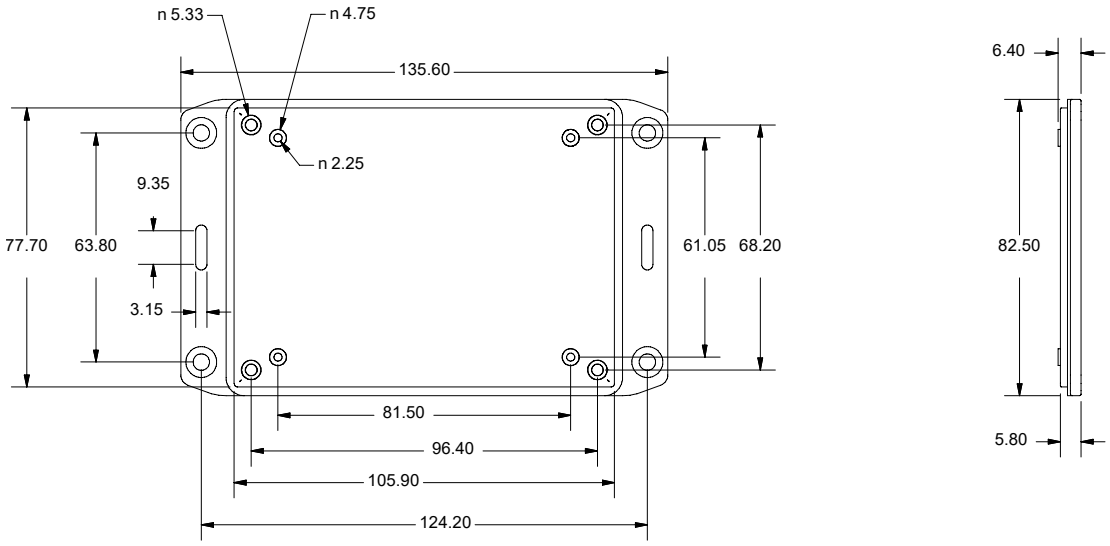
The Power connector used on the MPPT is Phoenix 1720819 (PC 5/4-GF-7,62). The recommended mating part for this connector is Phoenix contact 1777859 (PC 5/ 4-STF1-7,62). The connector is also backwards compatible with the older PC 4 counterparts.

| | | |
|---|---|---|
| 1 | $V_{in}-$ | Array - |
| 2 | $V_{in}+$ | Array + |
| 3 | $V_{out}+$ | Battery + |
| 4 | $V_{out}-$ | Battery - |

# 10 Dimensions

## 10.1 Top cover




## 10.2 Base plate