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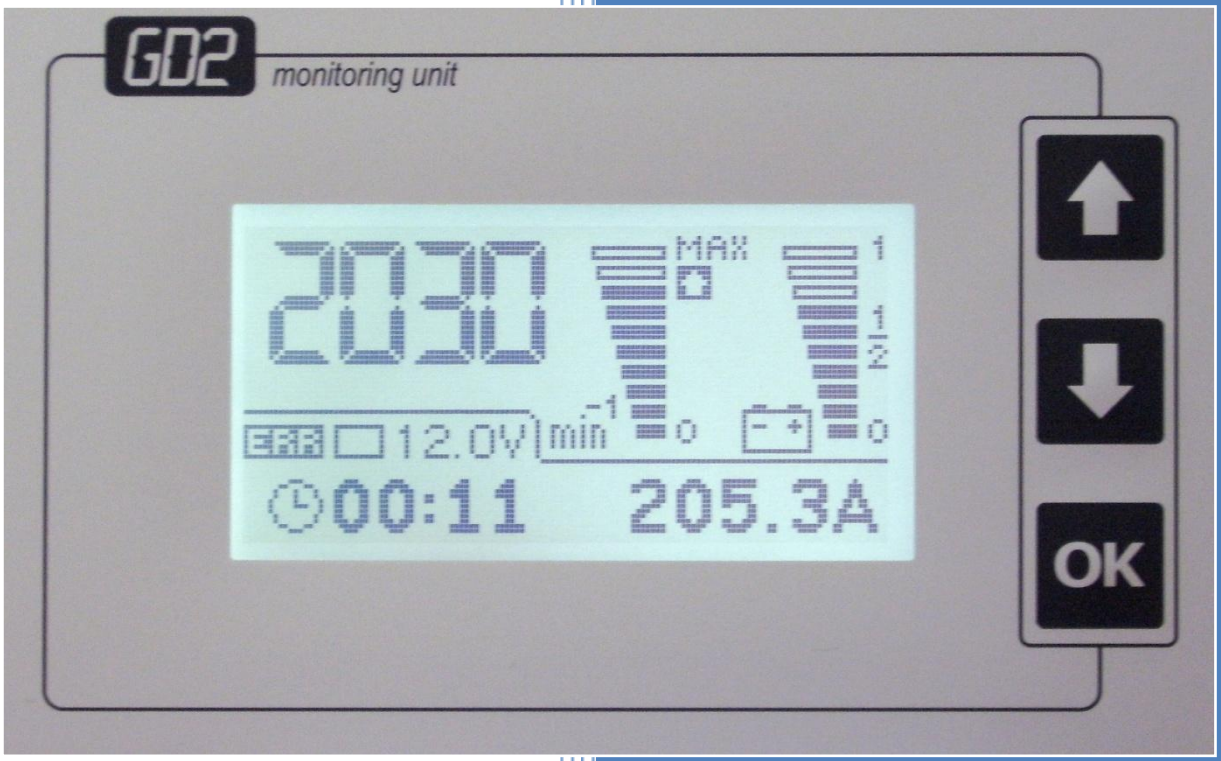
GD2/HV2 User Guide



Display, control and battery monitoring unit

Issue: 3(8)

General Information

The manufacturer accepts no liability for any consequences resulting from inappropriate, negligent or incorrect installation or adjustment of the optional operating parameters of the equipment or from mismatching the variable speed drive with the motor.

The contents of this guide are believed to be correct at the time of printing. In the interests of a commitment to the policy of continuous development and improvement, the manufacturer reserves the right to change the specification of the product or its performance, or the contents of the guide, without notice.

Display and drive software version

This product is supplied with the latest version of software. If this product is to be used in a new or existing system with other drives, there may be some differences between their software and the software in this product. These differences may cause this product to function differently.

The software version of the display can be checked by looking at the user menu by pressing [OK] button while turning on the display. SAC drive software version can be checked by connecting the drive to the PC and using SACTERM software. Please consult your SAC documentation for more information.

If there is any doubt, contact your dealer.

Issue Number: 3
Display software: 2.1.5 onwards
SAC software: 1.39 onwards

Contents

Introduction

GD2 is a display, control and battery monitoring unit. It is intended to be used in electrically propelled vehicles and boats as an add-on to one of Piktronik's CAN enabled AC motor controllers.

It serves as a graphical user interface between the user and the controller. User can set the speed or torque of the motor and see the current speed as well as a range of other quantities such as battery voltage, battery current, motor current, remaining time of driving at the current consumption etc. At the same time GD2 unit observes the state of charge of the battery, that is, how much charge there is left, how much was charged and how much discharged. It detects when the battery is being charged, sounds an alarm when the battery is low etc. GD2 is linked to one of Piktronik's motor controllers over the CAN bus. In addition of sending reference for motor RPM or torque to the controller, it also receives various data from CAN enabled controller. This data is then displayed on screen. GD2 also has extensive built-in safety systems that inform the user of an error in the form of an on-screen message. It also improves energy conservation on board with configurable sleep mode.

GD2 is available in two configurations; GD2-48 for low voltage (up to 75V maximum battery voltage) systems as shown in Figure 1 or GD2-12 for high voltage systems as shown in Figure 2.

GD2-48 can be directly powered from the main batteries but the maximum battery voltage must not exceed 75V. Battery voltage and current are measured directly. Optionally a backlight control input and an economy mode switch for motor speed limitation can be connected to the device.

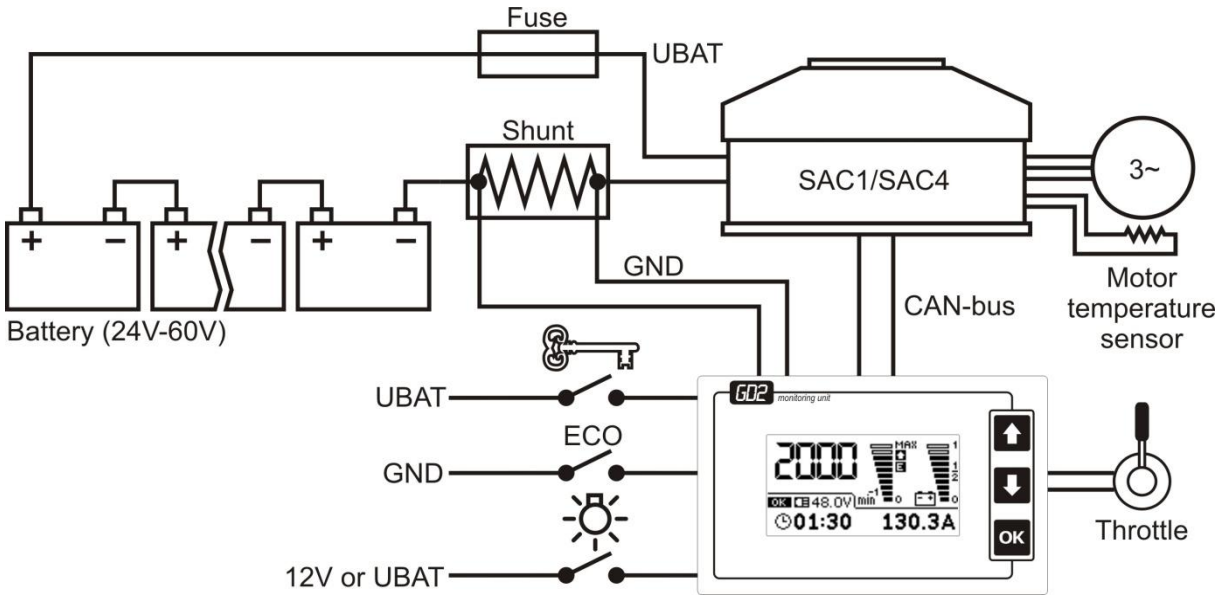


Figure 1: Integration of the GD2-48 unit in 24V - 60V systems (SAC1 or SAC4)

The GD2-12 version is intended for use with 96V - 300V batteries or battery systems.

The display unit (as well as the power supply of the AC motor controller) is usually supplied by a DC/DC converter with 12V output (such as KOP96-300). Maximum supply voltage is limited to 27V with the GD2-12 version. Battery voltage and current are measured indirectly through HV2 high-voltage galvanically isolated measurement adapter. The additions are direct motor temperature measurement, economy mode switch, and a controller power-on relay.

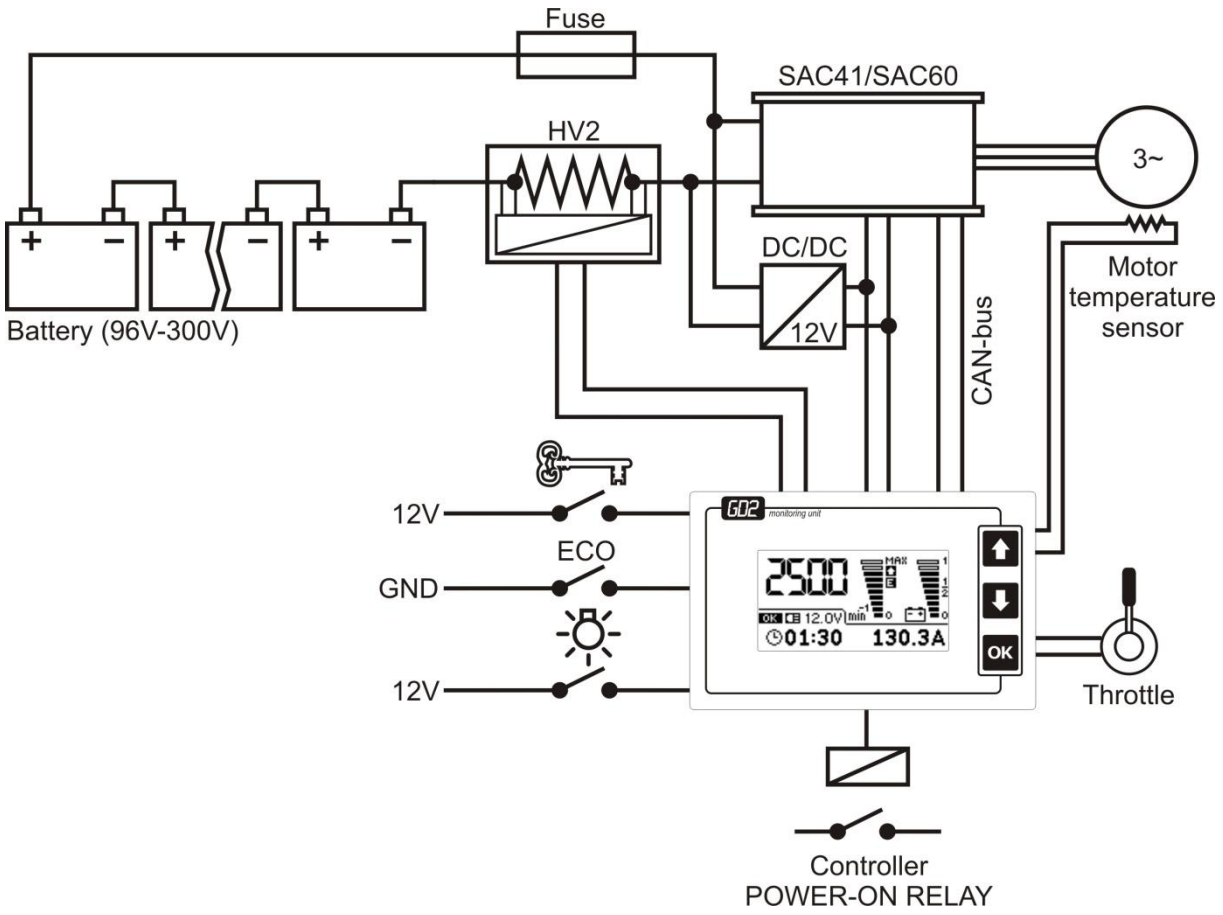


Figure 2: Integration of the GD2-12 unit in 96V - 300V systems (SAC41 or SAC60)

Technical specification

Electrical

	GD2-12	GD2-48
Operating voltage range	8.0 to 27.0 VDC	18.0 to 75.0 VDC
Maximum operating current	52 mA @ 12 V	26.5 mA @ 48 V
Standby current	4.5 mA @ 12 V	2.9 mA @ 48 V
Current measurement method	Shunt	HV2
Current measurement range	±20.0 to ±600.0 A (configurable)	

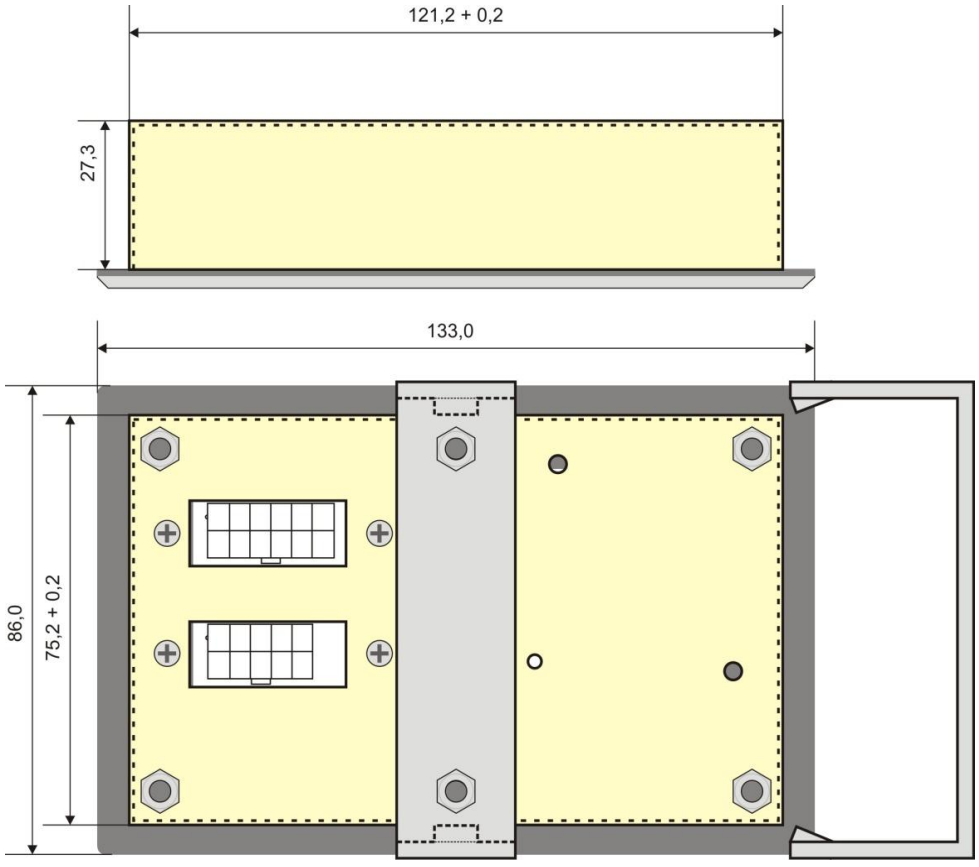
Mechanical

Display	Graphical LCD monochrome 128 x 64 pixels
Backlight	Low power white LED
Panel cutout	122mm x 76mm
Mating connector	Molex Mini Fit 12 pin, Female Crimp Terminals
	Molex Mini Fit 10 pin, Female Crimp Terminals

Environmental

Temperature range	-25°C to 60°C
Relative humidity	9% to 95% (vapor)
Enclosure protection	IP65 (face), IP40 (rear)

Dimensions



Installation

GD2 has two Molex connectors on the backside:

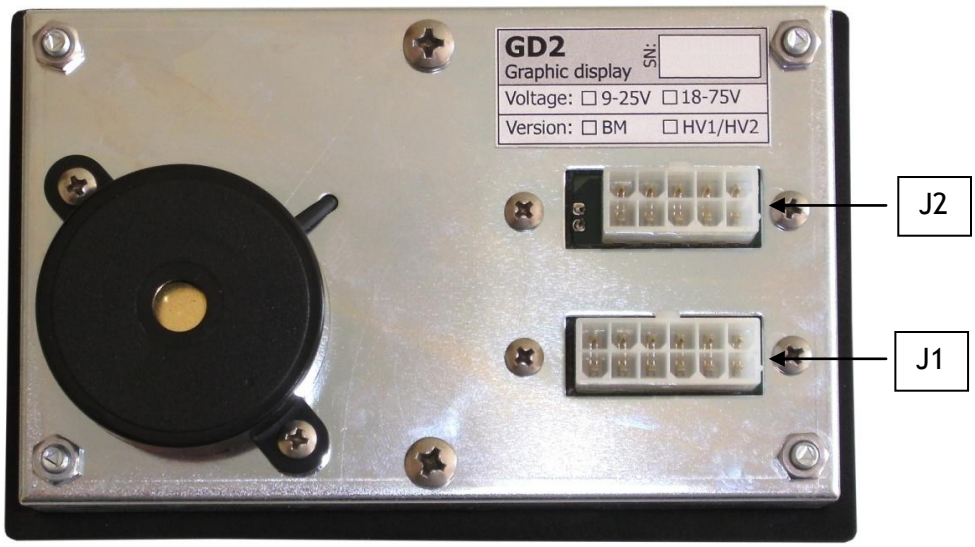
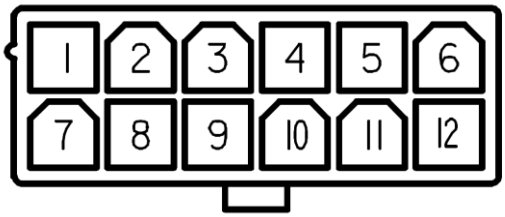


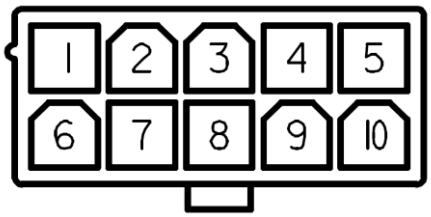
Figure 3: Backside of the GD2 unit

Terminal assignment



J1 - MOLEX 12-PIN

Pin	Abbr.	Function
1	SH+	Shunt +
2	SH-	Shunt -
3	TIN	Motor temperature sensor
4	ECO	Economy mode switch
5	GND	Ground
6	UIN	Continuous supply voltage
7	BL	Backlight switch
8	POT	Throttle input
9	AGND	Analog ground
10	NC	Reserved
11	EN	Enable / Start
12	RE1	Main relay



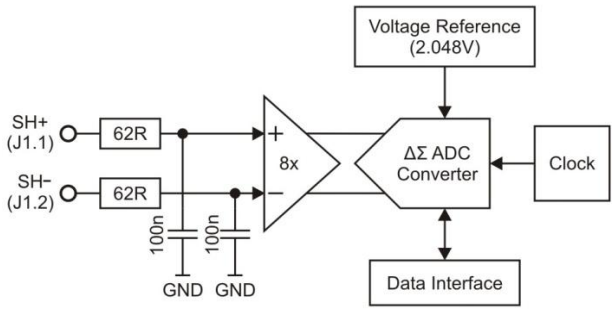
J2 - MOLEX 10-PIN

Pin	Abbr.	Function
1	CANH	CAN high
2	GND	Ground
3	NC	Reserved
4	PZ1	EXT. PIEZZO -
5	UEX	EXT. PIEZZO + (+26V)
6	CANL	CAN low
7	SER	Serial comm. input for HV1/HV2
8	RE2	Aux relay
9	NC	Reserved
10	NC	Reserved

It is recommended you use original set of cables.

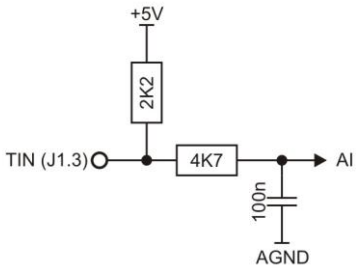
Description of the terminals

Shunt (SH+, SH-), Pins J1.1 – J1.2



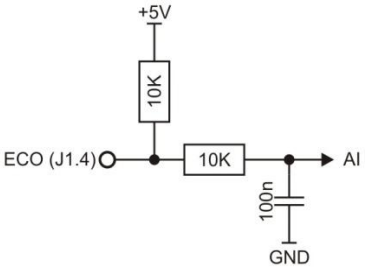
- Differential input for shunt voltage drop measurement.
- Shunt cable must be a shielded twisted pair.
- If you do not use shunt resistor, please short SH+ and SH- and connect them both to GND.
- Maximum input range ±256mV.

Motor temperature sensor (TIN), Pin J1.3



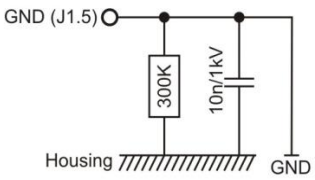
- For resistive temperature sensors.
- Voltage drop across temperature sensor is measured.
- Sensor ground must be connected to AGND (J1.9).
- Measured temperature value is available through CAN interface.
- Ex.: KTY83-110

Economy mode switch (ECO), Pin J1.4



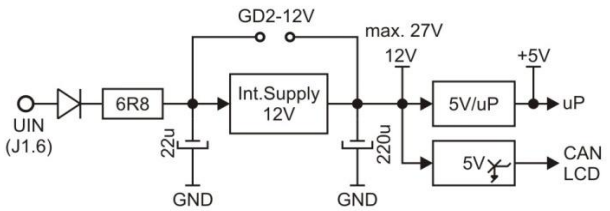
- Connect to ground when active.
- The purpose of this switch is the additional limitation of RPM and power as a consequence.
- It is useful for example as additional safeguard when navigating your boat in a port.
- With REGEN enabled devices (parameter P8.5) this input is used for REGEN mode activation.

Ground (GND), Pin J1.5



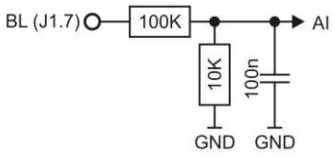
- Direct connection to device ground.
- Only capacitive coupling to device case.

Supply voltage (UIN), Pin J1.6



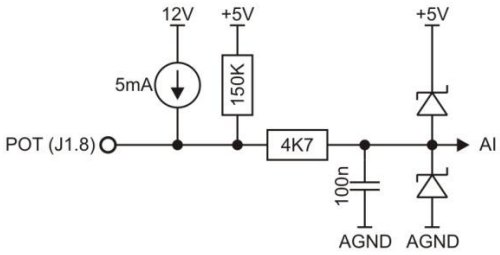
- Supply voltage for the device.
- 12V internal supply is bypassed with GD2-12V version.
- Max. supply voltage is 27V for GD2-12V and 75V for other versions.

Backlight switch (BL), Pin J1.7



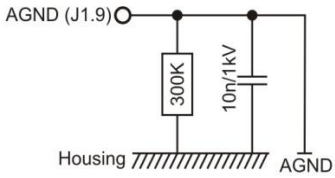
- External input to turn on the device backlight.
- Display backlight will turn on by setting BL = “high” (+5V…55V).

Throttle input (POT), Pin J1.8



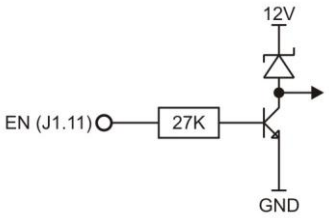
- Two wire interface.
- 5mA current source for potentiometer supply.
- Maximum input voltage: 5V
- Maximum resistance: 1kΩ @ 5mA
- Throttle ground must be connected to AGND (J1.9).
- Short and open circuit protection.
- Polarity of the potentiometer does not matter since the direction can be programmed in SETUP.

Analog ground (AGND), Pin J1.9



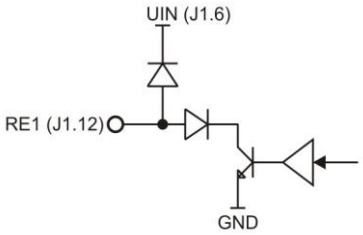
- Separate ground for temperature sensor and throttle.

Enable / Start (EN), Pin J1.11



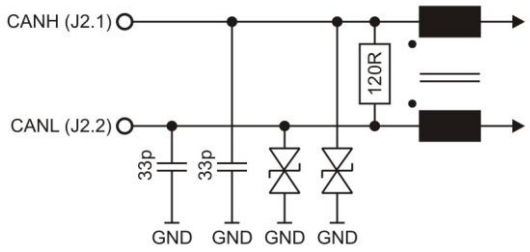
- By applying a voltage to UIN and by setting EN = “high” (+5V…75V) the device will turn on.
- Will wake the device from standby.

Main relay (RE1), Pin J1.12



- Open collector output can be used to drive the main relay.
- Main relay connection controls DC link charging (SAC40/SAC41/SAC60).
- Maximum permitted current is 0.3A.

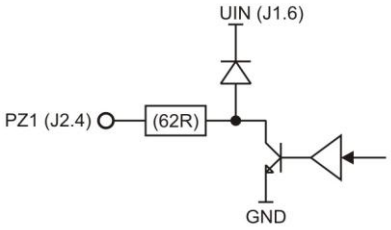
CAN interface (CANH, CANL), Pin J2.1 – Pin J2.6



The CAN interface has the following characteristics:

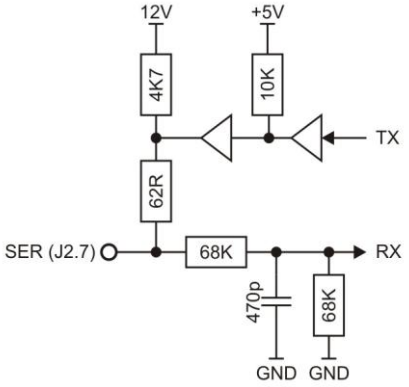
- CAN 1.2, 125 kBaud
- 120Ω termination resistor mounted.
- The CAN interface is compatible with CAN enabled Piktronik SAC controllers.
- CAN bus cable must be a shielded twisted pair with the impedance close to 120Ω.

*External Piezzo (PZ1), Pin J2.4 (*optional)*



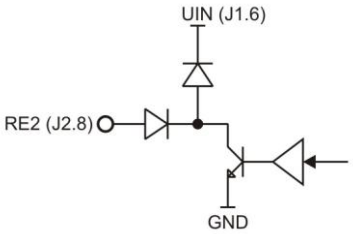
- Optional connection to the external piezzo buzzer.

Serial interface for HV1/HV2 (SER), Pin J2.7



- Serial communication is used to receive measurement data from galvanically isolated HV1/HV2 high voltage measurement unit.
- This pin is used only by the GD2-12V version (for use with SAC40/SAC41/SAC60 controller).

Auxiliary relay (RE2), Pin J2.8



- Open collector output can be used to drive auxiliary relay.
- Main relay connection controls DC link charging (SAC40/SAC41/SAC60).
- Maximum permitted current is 0.3A.

Accessories and Add-ons for GD2

Throttle (Single lever control)

Two throttle versions for side mounting in boats are available as shown in Figure 4. Figure 5 shows internal throttle wiring.

Figure 4: Throttle versions

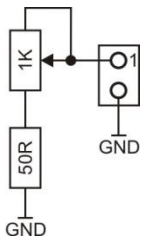


Figure 5: Internal throttle wiring

High voltage measurements module HV1/HV2[1]

HV1/HV2 provides galvanic isolation for high-voltage and current measurement. It is compatible with the GD2-12V version. Module with the accompanying shunt resistor is shown below:

Figure 6: HV1/HV2 with shunt resistors

GD2-J2 12-pin to J2 4-pin Adapter cable

Adapter is required when directly replacing GD1 with GD2 or when using 4-pin CAN connection.

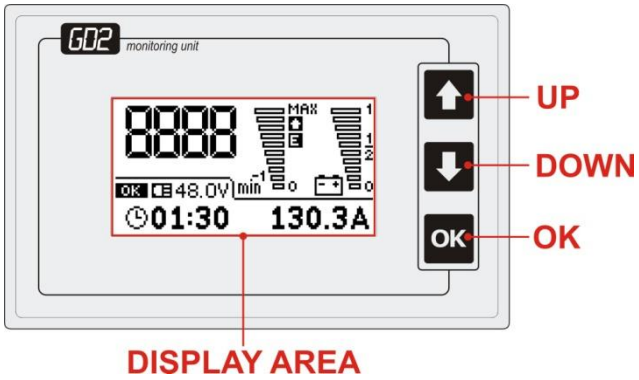
Figure 7: GD2-J2 Adapter

[1] The GD2-12V is compatible with both HV1 and HV2 module. The HV2 has better measurement accuracy than the HV1 and is therefore preffered over the HV1.

Handling and operation

GD2 is turned on with the START switch. User interface of the GD2 has the following elements:

- Display area, showing relevant data, device setup and error messages
- [UP], [DOWN] and [OK] keys for direct interaction with the GD2.



There are several operating modes when using GD2 as shown in Figure 8:

- Power-On initialization
- Setup
- Normal operation: standby mode, sleep mode, control mode

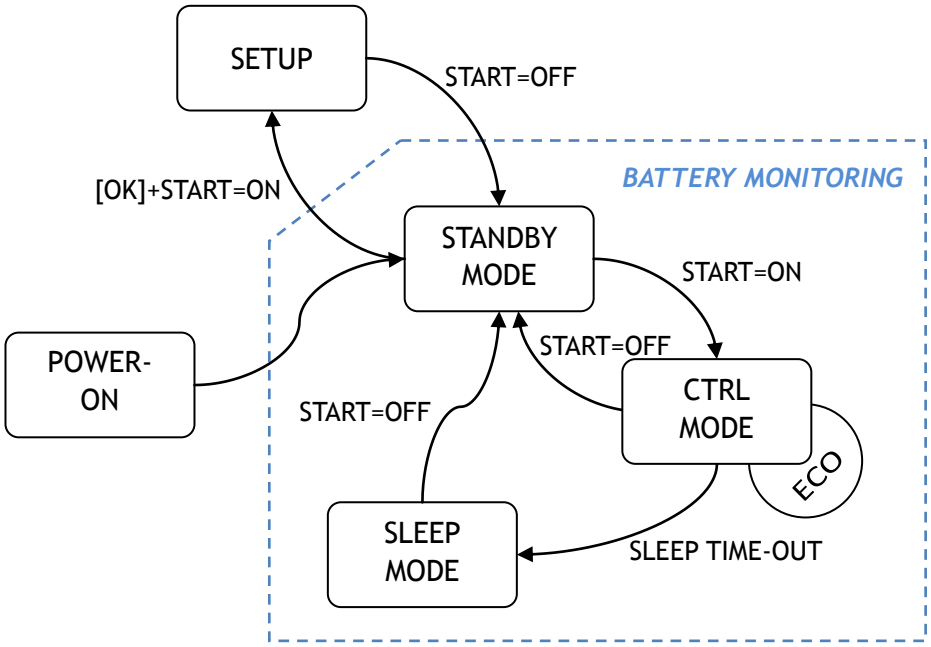
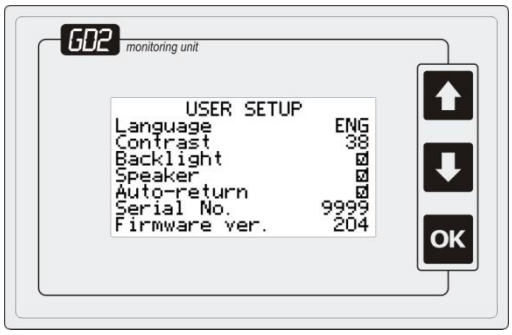


Figure 8: GD2 State diagram

Device Setup

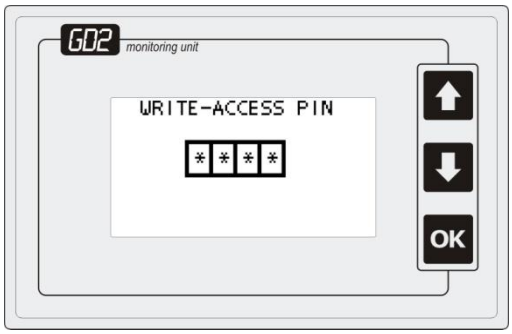
Before the GD2 unit can be used, it must be properly configured. To enter setup, while the GD2 is connected to the battery, hold [OK] while you restart GD2 with the [START] switch.

You will enter the first page of setup, which requires no PIN code to change parameters.



Without the PIN code you can still browse through the parameters on the following pages. However, you cannot change them. The navigation is done by using the [UP] and [DOWN] button. Press [UP] or [DOWN] to select the next parameter. The parameter with focus will have a browse sign (>) in front of the value. When you reach the last parameter on the page, press the [DOWN] button again to go to the next page. Or if you have reached the first parameter on the page, press [UP] to go to the previous screen. Holding [UP] or [DOWN] longer will let you jump to the next page directly without skipping through parameters.

To edit the parameters you have to enter Write-access PIN code on the second page:



When entering a PIN code, press [OK] to enter edit mode. Then select the first digit with [UP] / [DOWN] and press [OK] to proceed to the next digit. Repeat the procedure until all digits are entered. If you have entered a valid PIN code, you will be granted permission to change all parameters. If not, you will have to wait 30 seconds to try again. Once a valid PIN is entered, the field will show OK.

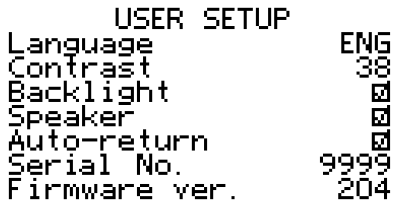
If you have permission to change the parameters, then the edit sign (➡) in front of the parameter value will be shown. To edit a parameter, press [OK]. Value to be edited will appear inverted. You can now change the value using [UP] / [DOWN] keys. If you hold the key for a longer time, you will notice that values change faster and faster - this will help you select the desired value faster. When you enter the desired value just press enter to store the value and proceed with other parameters.

Pressing the [OK] button when an ON-OFF parameter is selected will toggle the parameter value. Parameter value is [ON] when ☑ is shown.

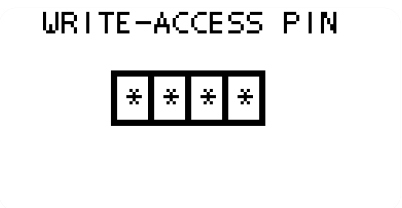
Not all parameters can be directly edited with [UP] / [DOWN] keys. A teach in sign (⇒) in front of the parameter value indicates to teach the value in.

Parameter page 1 – User setup

Parameters on this page can be changed by the user without entering PIN code.

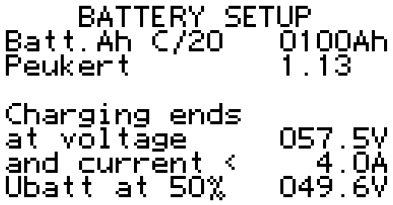


P1.1	Language Select the desired language. Currently, the English and German languages are supported Range: [ENG]/[DEU]
P1.2	Contrast Select contrast of LCD module. Range: 0 – 80
P1.3	Backlight (always on) Select this option if you want to always turn on the backlight for LCD module. When set to “off” the backlight will be controlled by using the backlight switch input (Pin J1.7). Range: [Off]/[On]
P1.4	Speaker Turn speaker on or off. Range: [Off]/[On]
P1.5	Auto-return Automatically return to the main screen when enabled. See chapter ‘Automatic scrolling to Screen1’ for more information. Range: [Off]/[On]
P1.6	Serial Number Read-only. Shows serial number of GD2 unit.
P1.7	Firmware version Read-only. Shown software version in your GD2 unit.



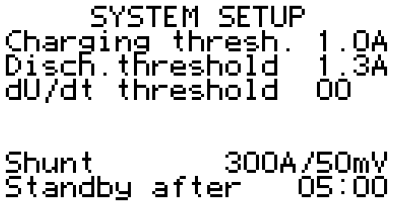
Write-access PIN	Enter PIN code if you want to edit the parameters on pages 2 to 8. If you do not enter the PIN code, you can still view the parameters, but you cannot change them (except on Page 1)

Parameter page 2 – Battery setup



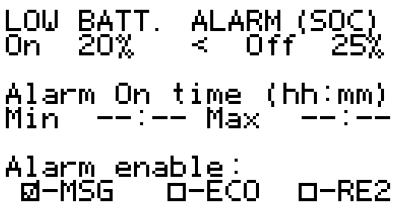
P2.1	Batt. Ah C/20 Total capacity of your battery pack, measured for 20h discharge rate. If your batteries are connected in series, enter the capacity of a single battery. If connected in parallel, enter the capacity of a single battery time's number of batteries. Range: 20Ah – 1999Ah.
P2.2	Peukert Peukert's exponent determines how the rate of discharge affects the remaining charge in the battery. For example: if you discharge your battery for a short time with a higher current, it will deliver less charge as if you discharge it over twice the period with only half the current. The lower the Peukert's exponent, the better your battery is at handling large currents. Typical value is 1.13 for Lead-Acid batteries and 1.04 for Lithium batteries. Range: 1.00 – 1.49
P2.3	Charging ends at voltage Voltage at which GD2 detects the end of charging when charging current is lower than at the end of charging current (P2.4) and sets the charging counter to 100%. Range: 1.0V – 340.0V.
P2.4	and current < Current threshold at which GD2 detects the end of charging when charging voltage is greater or equal to charging end voltage (P2.3) and restores charging counter to 100%. Range: 0.1A – 9.9A.
P2.5	Ubatt at 50% Battery voltage at which the remaining charge in your battery is at 50%. GD2 has a fixed programmed battery voltage to State-of-charge relation for initial SOC approximation. Range: 1.0 – 300.0V.

Parameter page 3 – System setup



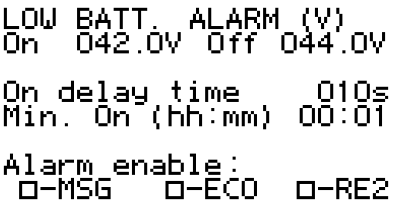
P3.1	Charging threshold Charging threshold current is a current at which the GD2 considers that the battery is being charged. Please see chapter 'Charging detection' for more information. Range: 0.1A – 9.9A.
P3.2	Discharging threshold Discharging threshold current is a current at which the GD2 considers that the battery is being discharged. Range: 0.1A – 9.9A.
P3.3	dU/dt threshold Reserved for future use.
P3.4	Shunt Current in amperes flowing through a shunt resistor that produces voltage drop of 50mV. This current is also about the maximum battery current allowed. You should never overload the shunt resistor. Please keep this in mind when selecting your shunt resistor. Range: 20 – 600A
P3.5	Standby after After this time the unit will go into sleep mode if the throttle is in the neutral position and there is no action from the user. LCD display and controller will be turned off to conserve battery power and you have to restart the system with the START button to wake it up. However, battery voltage and current will still be measured. Function units are mm:ss. Range: 00:01 – 59:59 (--:-- Off)

Parameter page 4 – Low battery SOC alarm



P4.1	SOC Alarm On The remaining percent of charge in the battery when the low-battery alarm should go on. The alarm is presented in one of the enabled ways (P4.5, P4.6, P4.7). Range: 00 – 90% (Set to 00 for Off)
P4.2	SOC Alarm Off The remaining percent of charge in the battery when the low-battery alarm should go off. When set lower than SOC Alarm On (P4.1), the parameter is ignored. Range: 00 – 90%
P4.3	Min On time The minimum 'Alarm On' time. The minimum time that the alarm stays activated even if the State-of-charge percentage has risen above the Low battery alarm Off setpoint (P4.2). Function units are hours:minutes. Range: --:-- / 00:01 – 12:00
P4.4	Max On time The maximum 'Alarm On' time. The maximum time that the alarm stays activated even if the State-of-charge percentage is still below the Low battery alarm Off setpoint (F2.2). The value “--:--“ indicates an unlimited time, and the relay will stay activated until the State-of-charge percentage has risen above the Low battery alarm Off setpoint (F2.2). Function units are hours:minutes. Range: --:-- / 00:01 – 12:00
P4.5	Enable MSG Enable low battery SOC alarm message display. Range: [Off]/[On]
P4.6	Enable ECO Enable ECO mode with low battery SOC alarm. In order to use this function torque control mode (P7.6) must be disabled. Range: [Off]/[On]
P4.7	Enable RE2 Enable low battery alarm RE2 output. Range: [Off]/[On]

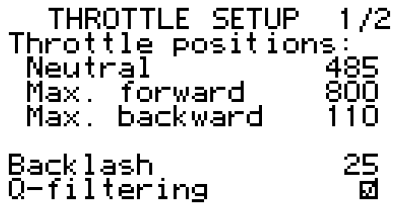
Parameter page 5 – Battery low voltage alarm

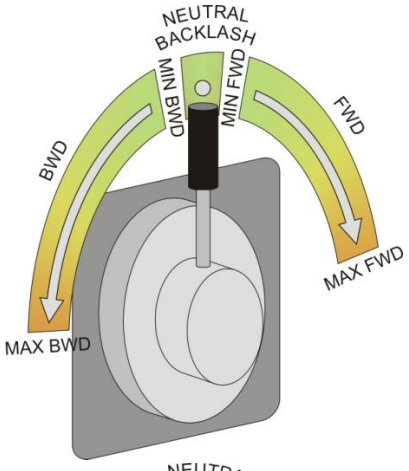


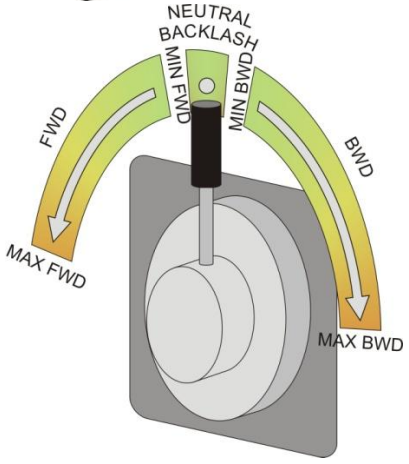
P5.1	Alarm On When the battery voltage has fallen below this value, the low-battery alarm will be activated. Alarm is presented in one of the enabled ways (P5.5, P5.6, P5.7). Range: 0.0 – 340.0V
P5.2	Alarm Off Battery voltage threshold when low-battery alarm is released. Range: 0.0 – 340.0V
P5.3	On delay time This is the time that the Low battery alarm On condition, P5.1, must reach before the alarm is activated. Range: 0 – 300sec
P5.4	Min On The minimum time that the alarm relay stays activated even if the battery voltage has risen above the Low battery alarm Off voltage (P5.2). Function units are hours:minutes. Range: --:--/00:01 – 12:00
P5.5	Enable MSG Enable low battery voltage alarm message display. Range: [Off]/[On]
P5.6	Enable ECO Enable ECO mode with low battery voltage alarm. In order to use this function the torque control mode (P7.6) must be disabled. Range: [Off]/[On]
P5.7	Enable RE2 Enable low battery alarm RE2 output. Range: [Off]/[On]

Parameter page 6 – Throttle setup 1 of 2

On this page you can calibrate your throttle. You can set where the neutral position of the throttle is (the motor is not running) and set how far you must move the throttle to reach the full RPM of the motor. Note that values on this page can only be changed by moving the throttle itself. They cannot be changed with UP / DOWN keys. Position of your throttle is measured in small steps, called quants. The throttle can occupy any of up to 1024 positions or quants, although only the range from 1 to 1023 is allowed for normal operation. When throttle measurement is out of range, the error condition will arise and the user will be presented with an error message (please see chapter 'Notification system' for more information).





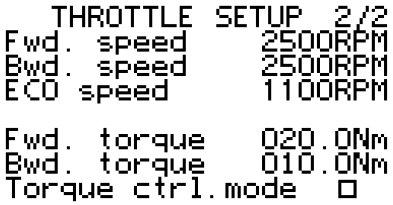


P6.1	Neutral First you must select the neutral throttle position. In this position the motor will be turned off. When set, proceed to (P6.2) to set the next position. Range: 1 – 1023
P6.2	Max. forward Throttle position where the motor should have the full RPM or torque in the forward direction. Note that you can select whatever physical direction of the throttle you desire. This means that you do not have to worry if the throttle is mounted on the right or left side of the cockpit. The GD2 will recognize this automatically. When set, proceed to (P6.3) to set the next position. Range: 1 – 1023
P6.3	Max. backward Throttle position where the motor should have the full RPM or torque in the backward direction. You will only be allowed to move the throttle in the opposite direction of the forward range, which makes perfect sense. You cannot overlap the forward and backward range. When set, press OK to finish the throttle calibration. Range: 1 – 1023
P6.4	Backlash Manual correction of the throttle backlash. Small area around the neutral position is called 'backlash'. While the throttle is positioned inside this range it is still considered as in neutral position. The motor will still be turned off. Purpose of this area is to compensate for mechanical tolerances and wear out of the throttle and also to allow the comfortable selection of the neutral position when driving. This parameter determines how wide the neutral area is. Range: 0 – 99
P6.5	Q-filtering When the enabled small changes of the throttle value are ignored due to electrical noise. Range: [Off]/[On]

Notes:

- Neutral position has a limited range.
- A part of the throttle measurement range is reserved to detect when the throttle is disconnected.

Parameter page 7 – Throttle setup 2 of 2

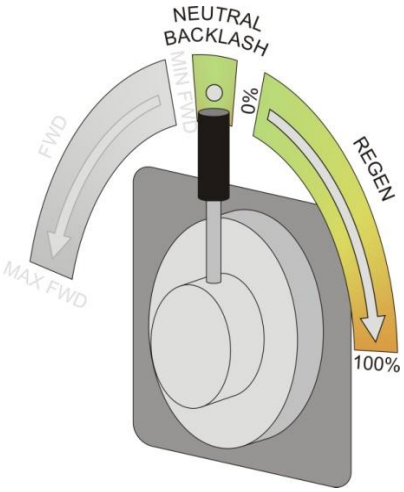


P7.1	Fwd. speed Speed of the motor when you select the full forward RPM with the throttle. Range: 1 – 9999 RPM
P7.2	Bwd. Speed Speed of the motor when you select the full backward RPM with the throttle. Range: 1 – 9999 RPM
P7.3	ECO speed When ECONOMY MODE is active then the max. motor RPM in the forward and backward direction is limited to this value. ECONOMY MODE is useful for example as an additional safeguard when navigating your boat in a port. It can also be used as an automatic battery power limitation when the battery low alarm is enabled (P4.7 and P5.7). ECO speed must always be lower than any other maximum speed value. ECO speed does not apply when driving in the Torque control mode. Range: 1 – 9999 RPM
P7.4	Fwd. torque Torque of the motor when you select full forward torque with the throttle. Only active when the parameter P7.6 is set. Range: 0.1 – 999.9 Nm
P7.5	Bwd. Torque Torque of the motor when you select full backward torque with the throttle. Only active when the parameter P7.6 is set. Range: 0.1 – 999.9 Nm
P7.6	Torque ctrl. Mode If you select this option then the throttle position will command the motor torque instead of the RPM. In other words, you can select whether you drive by torque or by RPM. If this option is turned off, make sure you have configured the parameters P7.1 and P7.2 correctly. If this option is turned on, make sure you have configured the parameters P7.4 and P7.5 correctly. Range: [Off]/[On]

Parameter page 8 – Regen setup

The generator principle allows recharging the batteries from the mechanical power obtained from motor shaft. The application is suited for boats with sailing capabilities. During the sailing periods the REGEN mode must be enabled on the GD2 display. The principle is only available with REGEN enabled motor controllers. When the generator mode is enabled (parameter P8.5 set to On), the economy mode input switch (Pin J1.4) becomes the Regen enable input. Economy mode cannot be manually enabled.

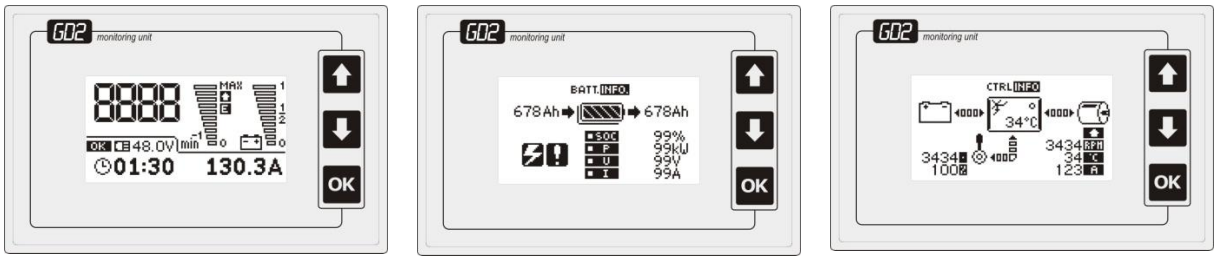
```
REGEN SETUP
Ov.speed trip 1500RPM

Regen torque  020.0Nm
Max.batt.volt 056.0V

Gain              016
Generator mode     □
```



P8.1	Ov. Speed trip Maximum allowable motor speed during the generator mode. When the motor speed is higher than this, the trip condition will occur. Range: 1 – 9999 RPM
P8.2	Regen torque Maximum braking torque during REGEN mode. Usually it is safe to use the following equation to obtain an approximate value for maximum braking torque: $T_{Regen} = \frac{10 \cdot U_{batMax} \cdot C}{\pi \cdot N}$, where U_{batMax} is the maximum battery voltage during charging (P2.3) in V, C is the battery capacity (P2.1) in Ah and N is nominal motor speed. Regen torque should be lower than the nominal motor torque to prevent motor damage. Range: 0.1 – 999.9 Nm
P8.3	Max. batt. volt. When battery voltage is higher than set value, the braking torque applied to the motor shaft will be gradually reduced. This is to prevent batteries from being overcharged. Range: 0.1 – 399.9 V
P8.4	Gain Determines the rate at which the applied braking torque to the motor is reduced, when the battery voltage is higher than the maximum battery voltage (P8.3). The default value is 16. Set this higher for nominal battery voltages above 75V if needed. You should normally not lower this value below 16. Range: 1 – 255
P8.5	Generator mode Enables REGEN mode. Range: [Off]/[On]

Normal operation

When you turn the [START] switch on, you will see startup logo on the screen for a few seconds. If there are no errors, you will see the main screen (Screen 1). There is a total of 3 screens and you can scroll between them with [UP] / [DOWN] keys.



Screen 1 – Main

Screen 2 – Battery info

Screen 3 – Controller info

Figure 9: GD2 Overview of displayed information

Operating GD2

Turning off the [START] switch will put the unit into sleep mode. If the throttle is in neutral and there was no action from the user then the GD2 will go into standby mode after the set amount of time. This time has to be configured in the Setup with the parameter (P3.5). In sleep mode the LCD display is turned off, but the GD2 still remains active and monitors the battery voltage and current. Before it goes into sleep mode, it also disables the controller and so saves energy.

Before you turn the unit on with the [START] switch, you must make sure that the throttle is in the neutral position. If not, then the unit will inform you of that with an error message. This function makes sure that the boat does not start moving if you have forgotten to move the throttle to the neutral position and turned the [START] switch on.

Detailed description about the information shown on a particular screen can be found in the following chapter.

Notification system

The notification system informs you if there is something wrong with any part of the system. When such an error occurs, a message will appear on the screen, titled "NEW MESSAGE". When the error is related to the functionality of the GD2 unit then an error number will be displayed, as well as the message itself. For example "ERR 001: Move throttle to neutral position". When the error is related to the controller then the controller error will be displayed followed by the message. For example "CONTROLLER ERR 004: Voltage low at start".

When you have read the new message, confirm this with the [OK] button. If there are any other messages then they will also be displayed and you will have to press the [OK] button to confirm them, until you will finally return to one of the three screens. If you wish to see if errors are still present, press the [OK] button on any of the screens. You will now be able to read the message and the screen will be titled "MESSAGE LIST". Press [UP] / [DOWN] to scroll between the messages.

If there are no messages in the list then you will read "NO MESSAGES". Press [OK] to exit browsing messages and to return to the main screen. Note that when the cause of the error is removed, the message will automatically be deleted from the list.

There are various error messages for different problems - from problems with the CAN bus, disconnection of the throttle, voltage problems, etc. For the list of all messages please see the chapter "Error messages and error codes".

If the CAN bus gets disconnected then all the values that depend on the successful CAN communication with the controller will be masked with the '-' signs. For example - on the main screen (Screen 1) you will see the '----' where the RPM value should be displayed.

Automatic scrolling to Screen 1

If you are viewing the Screen 2 or the Screen 3 without pressing any buttons for more than 30 seconds then you will automatically be scrolled to the Screen 1. That is the main screen and the data presented there are the most important and of most interest. If such behavior is not to your liking, it can be prevented by clearing the parameter (P1.5).

Power-on initialization

When GD2 unit is connected to the battery for the first time, the battery voltage is measured. State-of-charge (SOC, percentage of remaining charge, displayed on Screen 2) is then estimated according to the battery voltage. This estimation also depends on the parameter (P2.5) 'Ubat at 50%' (see Setup chapter for details). Therefore, if possible, try to connect the GD2 to the battery only after the battery has rested for a couple of hours without any load. Otherwise, the SOC value will be correct only after the first full charge.

Charging detection

When the conditions for charging are met then the GD2 detects charging. If enabled, two confirmation beeps will follow and the Battery monitoring screen will be displayed as shown on the Figure 10. There the arrow that symbolizes the charged Ah will start blinking. It keeps blinking until charging takes place. After that the GD2 returns to the sleep mode.

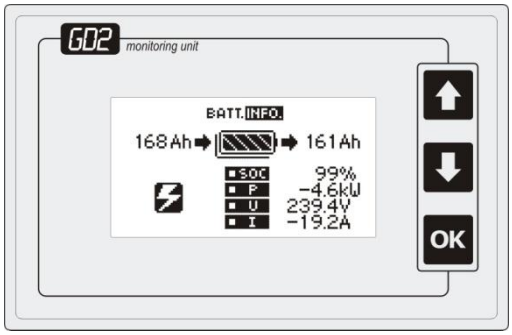


Figure 10: Battery monitoring screen during charging

Because the GD2 must detect various types of charging, regardless of whether the battery is full or empty or if different types of chargers are used, there exists a set of rules that describes charging.

Charging detection conditions:

The [START] switch is turned off. Negative (charging) current is equal to or greater than the current charging threshold set with the parameter (P3.1). The battery voltage is greater than the voltage set with the parameter (P2.3) in the Setup for more than 6 seconds. This ensures that the charging will still be detected in case the battery is already full and there flows almost no current.

Synchronisation

In order to keep your battery monitor delivering accurate status information about your battery, it is important to regularly synchronize your battery monitor with your battery.

A synchronization step means nothing more than performing a complete charge cycle on your battery. A charge cycle will be considered complete when the charging current drops bellow the

value set with the parameter (P2.4) and the battery voltage is higher than the value set with the parameter (P2.3). This typically means: when the battery charger switches to the float mode. By meeting these conditions, the battery is considered full, which will be indicated by the State-of-charge readout will be set to 100% (see description of Screen 1 - Battery monitoring screen).

Performing synchronizations regularly is also important to keep your battery healthy and to increase its lifetime.

Generator principle (REGEN)

The generator principle allows recharging the batteries from mechanical power obtained from the motor shaft. The application is suited for boats with sailing capabilities. During the sailing periods the REGEN mode must be enabled on GD2 display (see chapter “Enabling generator mode” bellow).

The principle is only available with regen enabled SAC controllers with integrated phase voltage measurement and relay Rele1. The operation is enabled for CAN MODE only.

Enabling generator mode (REGEN mode)

In order to allow generator operation, the GD2 display must be set into the REGEN mode. This is achieved by tying the pin (J1.4) to the GND (J1.5) for at least 2 seconds. REGEN mode can only be enabled with the potentiometer set to the neutral position. Successful setting of the generator mode is acknowledged with 1 beep and the status line on GD2 will indicate “REG” as shown in Figure 11.

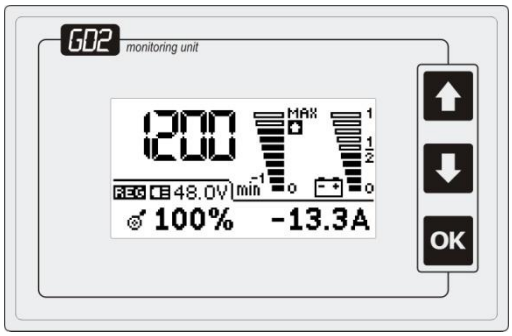


Figure 11: GD2 Main screen in REGEN mode

Operation

The power obtained from motor shaft is limited with motor speed / maximum power production characteristics of the propeller. The characteristics and its maximum power point depends of the boat speed. The speed of the shaft decreases with load torque in generator mode, while power increases with increasing of the speed at given torque.

Maximum amount of torque that can be used to recharge batteries, can be adjusted with potentiometer as percentage of maximum torque at maximum speed. Torque limit is proportional with speed.

When propeller is unable to deliver required torque, the speed decreases and the operation point is not optimal. Maximum peak power tracking algorithm (MPPT) tries to adjust the torque to obtain maximum available power. The MPPT algorithm stability depends of the electro-mechanical dynamics of the system and can be stabilized with the parameter in controller „1.24 BREAKING TORQUE“ used normally in EV operation. The value, set higher produces better dynamics and tracking but more torque variation resulting to speed variation. Setting this value too low can produce non optimal power point. Default value of „0.3 Nm“ is obtained experimentally.

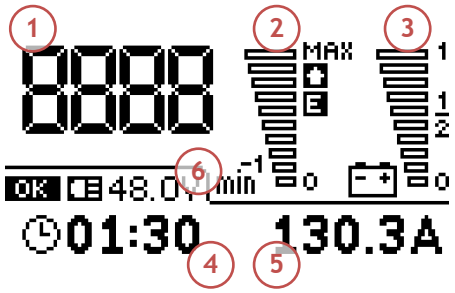
Operation safety:

- Checking motor speed at the start. At start the motor voltage range is checked from the measured controller branch voltages. The start condition is limited with the parameter in controller „1.26 MAX START SPEED“. The controller will only start when detected speed is lower.
- For correct motor relay operation controller the parameter „9.03 RELAY1_CONTROL“ must be set to mode 5.
- Controller over voltage prevention – external 3 phase motor relay disconnects the controller from the motor in case of over voltage or any of the controller errors. Additionally the maximum speed is limited in the display with parameter (P8.1). Status line on GD2 will be showing “TRIP” when this condition occurs.
- Battery overcharging limitation will reduce the torque in the generator mode and therefore the charging current. The limit is adjusted with an additional parameter (P8.3) and controller power.

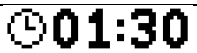
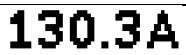
Disabling generator mode

To disable generator mode [START] switch must be turned off.

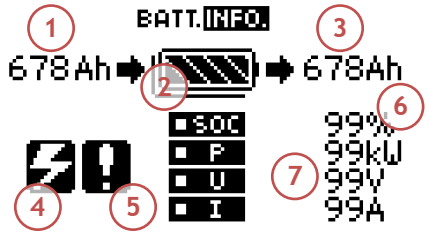
Screen 0 - Main screen



1 Speed value (RPM)
2 Speed, direction and economy mode indicator (RPM)
3 Remaining battery charge (State-of-charge)
4 Estimated remaining time of driving
5 Battery current
6 Status line

1		The motor speed value in RPM rounded to 5 RPM.
2		10-segment speed (RPM) indicator. Gives you visual feedback of your current motor speed. Direction indicator. When arrow symbol in status line is pointing up then the motor is spinning forward. When it is pointing down then the motor is spinning backward. Presence of ECONOMY MODE is shown with the [E] symbol. When you are driving in economy mode, you have additional limitation of RPM. This lower limit is configured in setup and is the same for forward and backward speed (see setup section of this document). Economy mode is activated using the ECO switch, but it can also be activated as a low battery alarm measure when activated in setup.
3		10-segment remaining battery charge (State-of-charge) indicator.
4		Estimated remaining time of driving at this current consumption. After this time battery will probably be empty. This value is masked with '--:--' if the motor has less than 50 RPM, no current flows from the battery or current flows into the battery or the remaining time is greater than 10 hours.
5		Battery current. The current is positive when it is flowing from the battery to the load.
6		Status line • OK, REG, TRIP, LOW • Lights indicator • Display supply voltage

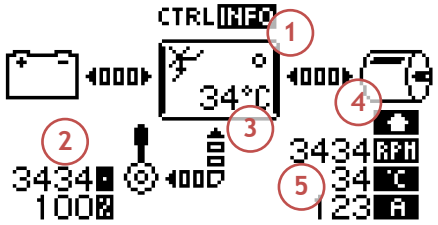
Screen 1- Battery monitoring screen



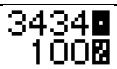
1 Charge charged
2 Remaining charge indicator
3 Charge used
4 Charging indicator
5 Low battery indicator
6 Amount of remaining charge
7 Battery measurements

1	678Ah	Displays the amount of charge that was charged into the battery and is obtained using the simple integral of current. It can only be increased or reset to zero. Ah charged gets reset at the beginning of charging. By partial charges, when the battery was not fully charged, this counter only gets incremented up to max. value.
2		Remaining charge indicator. Gives you quick visual feedback of the remaining battery charge.
3	678Ah	Displays the amount of charge that was extracted from the battery. And is obtained using the simple integral of current. It can only be increased or reset to zero. Ah used gets reset at the beginning of discharging.
4		Charging indicator.
5		Low battery indicator.
6	SOC 99%	Amount of remaining charge expressed in percent. This value is also referred to as a State-of-charge (SOC) and is calculated using Peukert's equation.
7	P 99kW U 99V I 99A	Battery measurement values: • Power (kW) • Voltage (V) • Current (A). Current is positive when it is flowing from the battery to the load.

Screen 2 - Controller and motor monitoring screen



1 Controller bridge-on indicator
2 Throttle position
3 Controller temperature
4 Motor direction
5 Motor measurements

1		Controller active - status indicator.
2		Throttle position. The upper number represents the position in quants, the lower number represents the position as a percentage range forward (positive sign) or backward (negative sign).
3		Controller temperature
4		Motor RPM direction. When the arrow symbol in the status line is pointing up then the motor is spinning forward. When it is pointing down then the motor is spinning backward.
5		Motor measurements: • RPM • Temperature • RMS current (A)

Error messages and error codes

List of all messages and error codes is provided below:

ERR 001: Move throttle to neutral position
ERR 002: Throttle error/disconnected
ERR 003: CAN bus timeout
ERR 004: Battery low
ERR 005: Motor temperature high. Reducing power.
ERR 006: High Voltage PCB timeout/no link
CONTROLLER ERR 001: Over current
CONTROLLER ERR 002: Over voltage
CONTROLLER ERR 003: Under voltage
CONTROLLER ERR 004: Voltage low at start
CONTROLLER ERR 005: Potentiometer error during operation
CONTROLLER ERR 006: Potentiometer not zero at start
CONTROLLER ERR 007: Controller over-temperature
CONTROLLER ERR 008: Controller under-temperature
CONTROLLER ERR 009: Controller temperature sensor error
CONTROLLER ERR 010: Current offset error
CONTROLLER ERR 011: DC link charging error
CONTROLLER ERR 012: Relay error
CONTROLLER ERR 013: PDPINTA (shortcut or mosfet/driver error)
CONTROLLER ERR 014: Bad user parameter CRC
CONTROLLER ERR 015: Bad system parameter CRC
CONTROLLER ERR 016: Bad flash CRC
CONTROLLER ERR 017: Wrong parameter version
CONTROLLER ERR 018: Invalid motor type
CONTROLLER ERR 019: Auto tuning error
CONTROLLER ERR 020: Boost error
CONTROLLER ERR 021: Motor over-temperature
CONTROLLER ERR 022: Motor temperature sensor failure
CONTROLLER ERR 023: Internal error
BMS WARN 01: Cell voltage high
BMS WARN 02: Cell voltage low
BMS WARN 03: Temperature high
BMS WARN 04: Temperature low
BMS WARN 05: Battery warning
BMS ERR 64: Cell over voltage
BMS ERR 65: Cell under voltage
BMS ERR 66: Temperature high
BMS ERR 67: Temperature low
BMS ERR 68: Over current
BMS ERR: Battery error

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