Integrel solutions

INSTALLATION GUIDE

VERSION 5.0 - MARCH 29, 2022

Software Version 1.6.11

Table of Contents

1 INTRODUCTION

Integrel is a modern, intelligent way of generating, storing and distributing electrical energy in off-grid applications such as recreational marine craft. Integrel is completely automatic, delivering significant amounts of energy seamlessly throughout the vessel without user input. It is fuel-efficient, reducing overall fuel consumption for propulsion and generation, and very cost-effective with virtually no maintenance costs. Integrel completely replaces a conventional generator (genset) and delivers all of the power needed to make living on board as comfortable as living at home. For the boat builder, the Integrel system simplifies the electrical energy system substantially.

An Integrel system provides all of a vessel's energy needs in one consolidated package. The system also provides additional safety, engine, and battery management tools for the end user to handle modern lithium-ion battery banks. The system automatically alerts the user when batteries need to be re-charged. Simple busbar connections are provided for all AC and DC voltages, and no changes are required to a vessels downstream electrical systems.

NOTE!

Integrel is classified as an 'extra low voltage DC system' and falls within the scope of the International Standard ISO 13297:2020 and ABYC E11 Standard. It is strongly recommended that a copy of these standards is studied before proceeding with the installation of the Integrel system. Nothing in this guide supersedes these two standards and if conflicting information is found, the standards will always prevail.

1.1 Target Audience Assumptions

It is assumed the reader of this installation guide is a trained electrical installer with adequate knowledge of marine electrical engineering terms, concepts, language and abbreviations.

1.2 Contact details

Integrel Solutions
Marine Renewable Energy Park, Unit 1
Hayle TR27 4DD
Phone: +44 1736 755 466
Web: www.integrelsolutions.com
Support: support@integrelsolutions.com

1.3 Limited Liability

1.3.1 Disclaimer

Integrel Solutions has taken great care in preparing the information contained in this manual and the information is believed to be accurate, comprehensive, and reliable at the time of publishing. However, it is up to the operator of the equipment and parts detailed in this manual to ensure that they are appropriately skilled to use such equipment and parts.

It is also the responsibility of the operator of the equipment and parts detailed in this manual to ensure that the equipment and parts are used in the manner they are supposed to be used, are correctly installed and are suitable for the customers' requirements.

Integrel Solutions does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of the information contained in this manual.

To the extent permitted by law, Integrel Solutions does not assume any responsibility or liability for any injury, loss or damage incurred as a result of any use or reliance upon the information contained within this manual other than for such injury, loss or damage which it would be unlawful for Integrel Solutions to attempt to exclude.

1.4 Acknowledgements

The Integrel team would like to offer a special thankyou to **Nigel Calder** for providing editorial and technical comments as well as a thorough review of this document. Thanks Nigel!

2 HEALTH AND SAFETY

IMPORTANT HEALTH AND SAFETY INSTRUCTIONS. Electromechanical equipment, including generator sets, transfer switches, switchgear, and accessories, can cause bodily harm and pose life-threatening danger when improperly installed, operated, or maintained. To prevent accidents be aware of potential dangers and act safely. Read and follow all safety precautions and instructions.

SAVE THESE INSTRUCTIONS!

This manual has several types of safety precautions and instructions: Danger, Warning, Caution, and Notice.

2.1 Health and safety notices

Please be aware of signs or symbols when installing and operating the system. Below are some examples of signage you may come across. Please learn and be aware of what these indicate.

Safety decals affixed to the equipment in prominent places alert the operator or service technician to potential hazards and explain how to act safely.

DANGER

Danger indicates the presence of a hazard that ***will cause severe personal injury, death, or substantial property damage.***

WARNING

Warning indicates the presence of a hazard that ***can cause severe personal injury, death, or substantial property damage.***

CAUTION

Caution indicates the presence of a hazard that ***will or can cause minor personal injury or property damage.***

HIGH VOLTAGE/ HIGH CURRENT

High voltage or high current indicates voltages or currents that ***can cause severe personal injury or death.***

EXPLOSIVE MATERIALS

Materials that may explode if mishandled or incorrectly used, this ***can cause severe personal injury, death, or substantial property damage.***

FLAMMABLE OR HIGH TEMPERATURE MATERIAL

Flammable or high fermeture material that ***can cause severe personal injury, death, or substantial property damage.***

2.2 Health and Safety when Installing

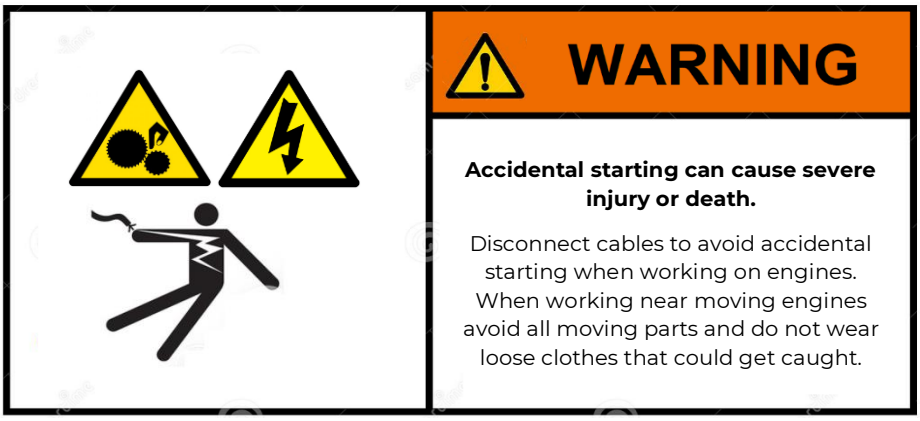
While installing this system, caution should be taken throughout the entire installation process. Installation of an Integrel system requires working with batteries, engines and some heavy lifting.

2.2.1 Accidental Starting and Moving Parts

Fitting the Integrel system involves the use of engines and other moving components such as hatch covers, and other associated parts used on leisure and sailing craft.

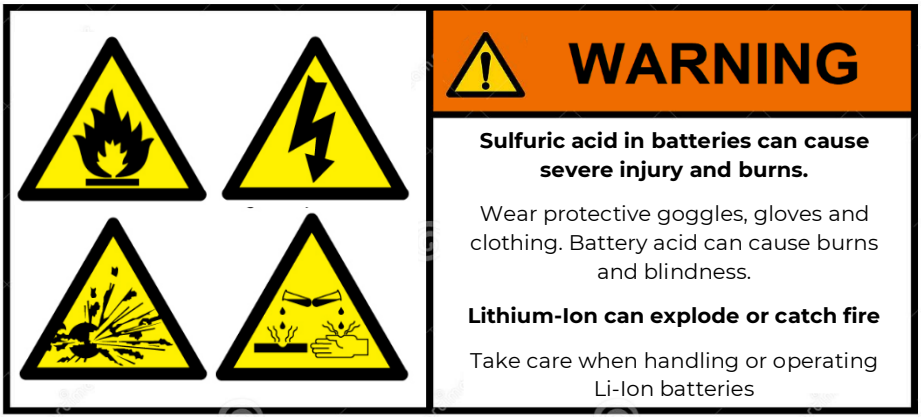
Utmost care must be taken when opening hatches and lockers. Make sure you remove or securely support hatches and lockers in a safe manner.

Lock off any engine start buttons to ensure against accidental starting.



2.2.2 Battery Safety

Use tools with insulated handles. Remove the negative (-) lead first when disconnecting the batteries. Reconnect negative (-) leads last when reconnecting the batteries. Never connect the negative (-) battery conductor to the positive (+) connection terminal of the starter solenoid. Do not test the battery condition by shorting the terminals together.



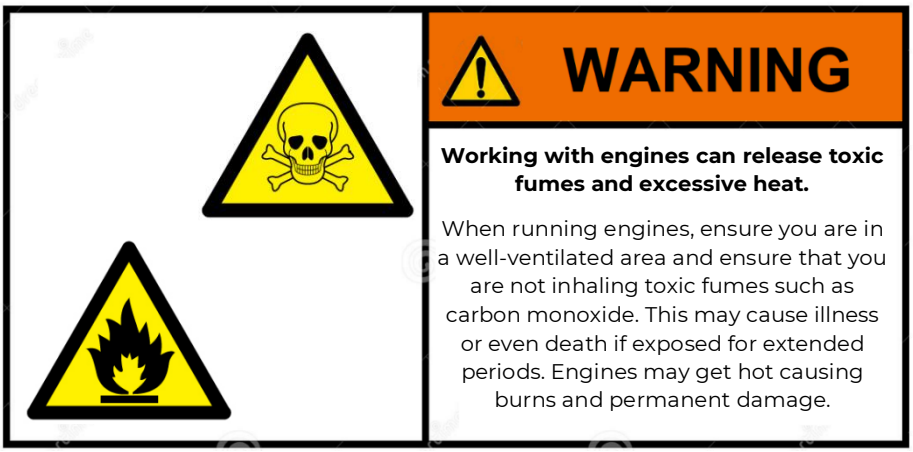
Explosive fuel vapours can cause severe injury or death. Take additional precautions when using petroleum gas, diesel, natural gas, butane, and propane.

2.2.3 Hazardous Noise

Engine noise and Hazardous noise can cause hearing loss. Generator sets not equipped with sound enclosures can produce noise levels greater than 105 dBA. Prolonged exposure to noise levels greater than 85 dBA can cause permanent hearing loss. Wear hearing protection when near an operating generator set or propulsion engine.

2.2.4 Working with Engines

Fitting the Integrel system involves running engines for long periods of time. Ensure the vessel is suitably configured to reduce inhalation of emissions while the system is running.



2.2.5 Hazardous Voltages

Short circuits - hazardous voltage/current can cause severe injury or death.

Short circuits can cause bodily injury and/or equipment damage. Do not contact electrical connections with tools or jewellery while adjusting or repairing equipment. Remove all jewellery before servicing equipment.

Grounding electrical equipment - hazardous voltage will cause severe injury or death.

Electrocution is possible whenever electricity is present. Ensure you comply with all applicable codes and standards. Electrically ground the equipment, transfer switch, and related equipment and electrical circuits. Turn off the main circuit breakers of all power sources before servicing the equipment. Never contact electrical leads or appliances when standing in water or on wet ground because these conditions increase the risk of electrocution.

Connecting the battery and the battery charger - hazardous voltage will cause severe injury or death.

Reconnect the battery correctly, positive to positive and negative to negative, to avoid damage to the battery charger and battery.

Servicing the generator set when operating - exposed moving parts will cause severe injury or death.

Keep hands, feet, hair, clothing, and test leads away from the belts and pulleys when the generator set is running. Replace guards, screens, and covers before operating the generator set.

2.2.6 Heavy lifting

Some of the equipment involved with the installation may be heavy. Where practical, use lifting equipment such as strops and lifting hoists. Some components, including batteries, may need to be lifted into tight and awkward locations. Ensure you plan how to move components into place in a safe and sensible manor to prevent damage to people, components, and equipment.

3 THE INTEGREL SYSTEM

3.1 General System Assembly

The schematic in Section 5 is an example of a standard Integrel installation. A schematic is produced for each installation; please refer to it and study it. The schematic provides details on how the system should be fitted. If you don't have a schematic, please contact Integrel Solutions for a schematic for your system.

3.2 System Operation

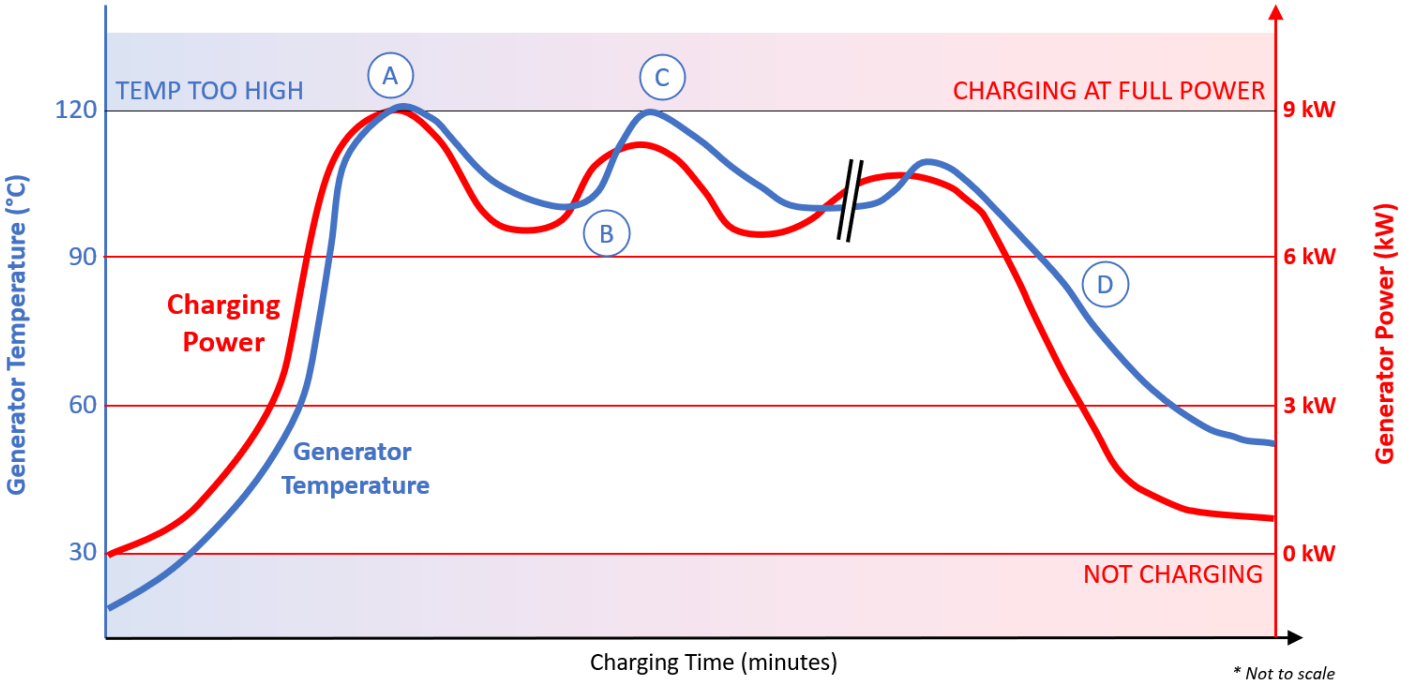
The information in this section is intended to help you understand how the system operates.

The Integrel System operates by following complex preconfigured algorithms to charge and monitor 48V, 24V and 12V battery banks as well as working with the engine to produce an efficient charge that does not cause excessive loads on the engine.

The system has been designed with 100% safety in mind. It is important to constantly manage and monitor the state of all batteries, including battery voltage, current and temperature.

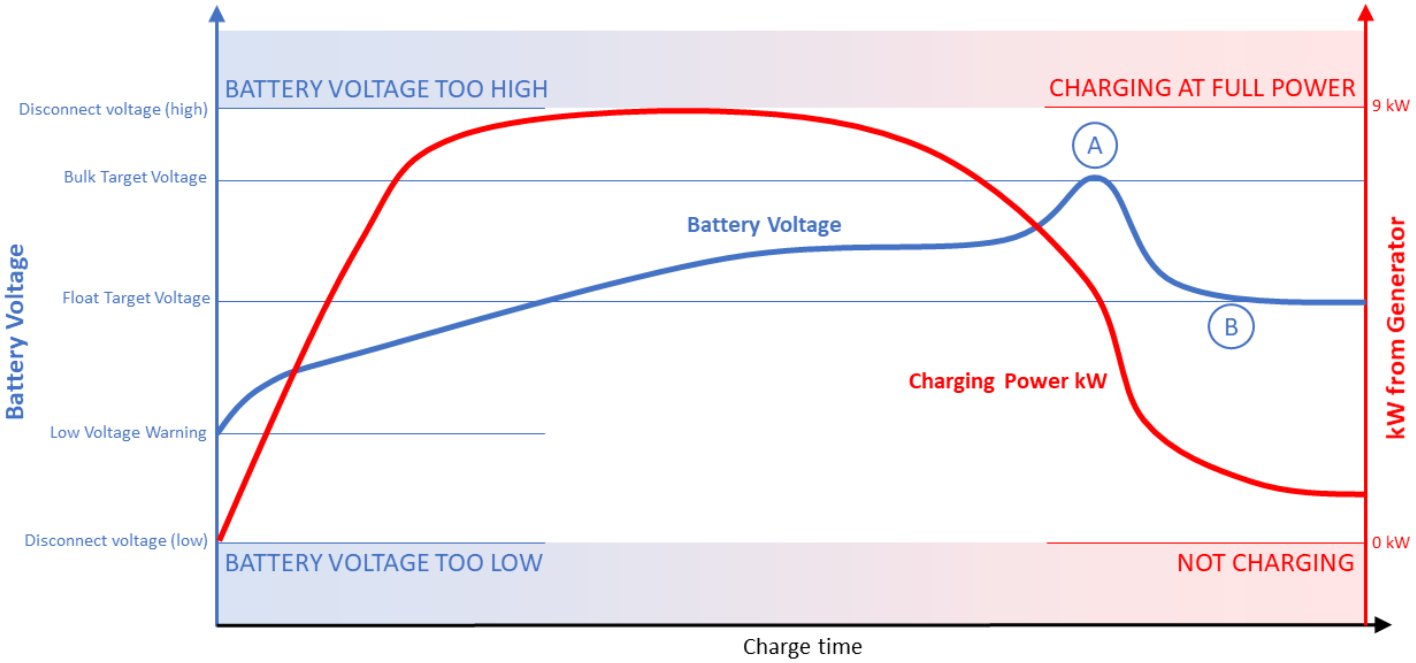
3.2.1 Temperature Control and Power Generation

The system uses temperature monitoring to ensure peak charging performance. The generator ramps to full charge power until the generator temperature reaches a (configurable) maximum, typically 120°C. At this temperature (A on the graph), the power output is reduced until the temperature drops to a pre-determined setpoint (B on the graph). The output power then ramps again until it reaches the configurable maximum (C on the graph). This process continues until the batteries approach full charge at which point the temperature naturally drops as the charging power reduces (D on the graph).



3.2.2 Charging and Set-points

The graph below shows how the Integrel System charges LiFePO4 Lithium batteries. This curve does not take temperature into consideration, real charge curves may exceed temperature limits and fail to reach the maximum 9 kW power output. In the graph below there are set points marked that are noted in the settings chapter of this manual. Warning voltages display on the screen and disconnect voltages open the smart switch at these set points. This prevents the system over charging or discharging batteries which in turn avoids potential damage to the battery(s).



** Not to scale*

3.3 Integrel System Components

9kW Engine Mounted Generator
The electrical power source of the Integrel System.

System Controller
The 'black box' that monitors and controls system components.

Engine Mounting Kit
Each kit is designed specifically to suit the make/model of the propulsion engine.

Battery Sensor(s)
Monitors the state of a battery bank (aka 'string' of batteries)

Integrel Smart Switch
Disconnects battery(s) if a safety or battery critical event occurs (48V and 24V)

Screen Interface
Converts Integrel CANbus data into a format compatible with the Integrel screen

Integrel Junction Box
Provides a connection point for the Integrel (Argo) CANbus system

Touch Screen User Interface
Displays live information of the Integrel System

Integrel Panel Switch
Turns the Integrel System and DC/DC Converters ON or OFF

3.4 Third Party Equipment

On most systems, third-party equipment forms a significant part of the installation. Installation manuals are provided with most third-party equipment. It is advisable to follow the installation requirements of third-party equipment in conjunction with this installation manual. Some of the following equipment may already be installed as part of an existing system.

3.4.1 Batteries

The Integrel system works with batteries from various manufacturers including Victron, MG Energy and Mastervolt, examples from each manufacturer are shown below. Batteries supported by Integrel are documented in Annex A - Battery Data.

3.4.2 Battery Management System (BMS)

The following pictures show examples of a Victron Lynx Smart BMS, Victron VE.Bus BMS and MG Master LV BMS. All batteries require a BMS; the BMS may be incorporated inside the battery for some models.

3.4.3 Battery Monitors / Displays

With most lithium batteries supported by Integrel, a screen is provided to show battery status including errors, voltages, State of Charge (SoC) and additional battery information.

Mastervolt EasyView 5

Victron Touch GX
(used with the Cerbo GX)

MG Energy Monitor

3.4.4 DC/DC Converters

Most systems require one or more DC/DC converters to convert power from 48V to either 24V or 12V. Examples include Mastervolt and Victron DC/DC converters shown here.

DC/DC converters vary by brand and model. If you plan to use a DC/DC converter to charge lithium batteries, ensure the DC/DC can be set up with an appropriate lithium charge profile.

Victron Orion DC/DC converters can NOT be used to charge Lithium batteries.

3.4.5 Inverter/Chargers

Inverter/Chargers manage the conversion and distribution of shore power throughout the vessel and are typically included with all systems. If supplied by Integrel, the inverter/charger comes with a manual from the manufacturer. If an inverter/charger has already been installed, we strongly recommend obtaining a manual to aid installation.

NOTE! Ensure you have the correct communication cables and configuration software for the inverter/charger, as well as other system components. In many installations, settings need to be changed to operate correctly with the battery system.

3.4.6 Galvanic Isolators

Used in conjunction with AC shore power systems, a galvanic isolator helps prevents galvanic corrosion of any submerged metal parts of the vessel. If the vessel uses an isolation transformer, a galvanic isolator is not needed.

3.4.7 Lynx Distributors/Power in

These are modular DC busbars, used to connect batteries or other devices. They come as monitored system with fuses (Lynx distributor) or as an unmonitored system with fuses (Lynx power in).

3.4.8 Simple Busbar

A busbar is often used to connect power sources and negative conductors together. These are used for safety circuits as well as common grounds. Always label each busbar to ensure it is clear which circuit it applies to.

3.4.9 Isolating Switches

Isolating switches are required in electrical systems and are used to isolate charging systems from batteries. Sometimes isolating switches are replaced with solenoid switches with remote operation.

3.4.10 Isolating Solenoids

Isolating solenoids are often used to isolate charging systems from batteries in place of an Isolating Switch. These are readily available up to 500 Amp in a remote configuration or with local operation.

3.4.11 Fuses

Fuses are critical and recommended for use wherever possible to prevent damage to Integrel and other third-party equipment. See Annex C for guides on fuse sizes, types and locations.

3.4.12 Crimps and Ferrules

To adhere to marine standards, all electrical system AC or DC conductors at any voltage must be terminated. The following images show common termination methods, including their uses

Heavy Duty Crimp Terminals

Used to crimp thick heavy gauge conductors; typically crimped using hydraulic or electric crimpers

Ring Crimp Terminals

Used to crimp any mounting type connections including groundings and voltage tap connections

Bootlace Ferrule Terminals

Used to crimp any conductor that fits into any screw or push fit terminal

RJ45 plugs

Terminates CAT 5 and CAT 6 cables; used with the Integrel (Argo) CANbus Network

4 PRE-FIT SURVEY

4.1 Introduction

Prior to starting the installation, it is beneficial to carry out a visual survey of the boat to identify where the individual components will be installed. This is particularly important for the batteries which are likely to be the largest and heaviest items. For specific sizes and weights, please refer to our website and Annex A - Battery Data.

NOTE!

All devices must be installed 500mm above bilge line.

Do not install batteries anywhere there is potential risk for water ingress presently or in the future. For example, do not install batteries directly below engine cover seals where seal deterioration may occur over time.

4.2 Existing Electrical Systems

A review of existing systems should be considered. This may impact the location of busbars, switches, and batteries. Care should be taken to ensure the system is installed without excessive runs of conductors or wiring.

Items that may impact the system include:

- PV (photovoltaic/solar) systems
- Inverters
- Shore power supply systems
- Electrical thrusters, including power supply batteries
- DC/DC converters for 12V and/or 24V
- Any 110VAC and/or 240VAC supply systems
- Domestic systems
- Air conditioning systems
- Inverter chargers
- Wind turbines

4.3 Batteries

For specific sizes and weights, please refer to the battery guide in Annex A. Batteries must be installed in a **dry space** and well clear of any area where there might be water ingress or excessive moisture (see ISO 13297:2020, ABYC E-10 ANS (2021), and ABYC TE-13 2020 for further details).

All batteries, but particularly Lithium-Ion batteries, are sensitive to temperature. It is essential that batteries are positioned in the coolest possible location in the boat and there is plenty of air circulation around them. Lithium-Ion batteries will automatically disconnect if their internal temperature exceeds a safety threshold which in some cases may be as low as 45°C. If prolonged operation in high ambient temperatures is required, careful attention must be paid to the manufacturers safe operating limits, and battery choices should be made accordingly. In addition, some batteries may have low temperature usage limits.

If lead-acid batteries are used, the installation location must be vented to the exterior. If you have any doubt about the effect of battery weight on boat trim, consult a naval architect.

NOTE!

Wet and AGM batteries should not be installed in accommodation areas that are not well ventilated. Lithium batteries must be installed in a ventilated area. Refer to the latest ISO and ABYC standards for battery securing and mounting and locations.

Integrel Solutions only recommend and supply the most reliable and thoroughly tested batteries. Batteries contain large amounts of energy. Safety around batteries is of utmost importance! Standards must be followed for the purposes of warranty and insurance.

4.4 Conductor Routing

Routes for conductors need to be identified as part of the survey, bearing in mind that conductor lengths should be kept to a minimum to reduce weight and power losses. Details of recommended conductor sizes are given in Annex B. Most vessels have conduits for major conductor runs and these should be used where possible. Points to remember when running conductors include:

- Positive and negative power conductors should be run together to reduce stray magnetic fields.
- Conductors should always be kept clear of bilge areas.
- Data cables, AC power conductors and DC cables should be run separately (if possible) to minimise coupling of noise and interference.

4.5 Integrel Generator

The generator is mounted on the front end of the engine and is normally driven from an additional pulley bolted to the existing crank pulley. Depending on the make of engine, the Integrel generator may extend outside the normal envelope of the engine. Be sure to check there is sufficient room to accommodate any overhang. Installation instructions are provided with each specific engine bracket kit.

4.6 Integrel Controller

When mounting the controller, it is important to remember that while the system is in use, the controller produces a large amount of heat; internal fans are used to extract heat for normal operation. If the controller overheats, the system will shut down so it is important to ensure adequate ventilation is provided around the controller. For additional information, see the controller installation instructions taking specific care to note the ventilation direction.

4.7 Integrel Display

The display can be mounted remotely from the other system components and should be positioned where it is easy to see from the navigation station, or alternately the main saloon. The display has been designed to show the battery states and voltage at a glance and it is useful to view the display easily from all common spaces. The display also shows various alarms and alerts and must be readily accessible to acknowledge and clear alerts. A template for the display cut-out is provided in the Annex, or the screen mounting panel supplied with the kit may be used.

4.8 Smart Switches and Isolators

The system can be fitted with an Integrel Smart Switch and/or manual isolator switch(es). The location of these switches is important, even with the Smart Switch. Even though the Smart Switch can be operated remotely with the Integrel display, it is advisable to put the switch in a location where it can be easily reached. The same guidance applies to any third-party manual switches.

4.9 Battery Bank Sensor

The battery bank sensor measures battery parameters including individual battery voltage and battery bank temperature. The sensor communicates with the Integrel controller via a CAT 5 cable. Bank sensors should be placed on the most negative battery lead of each string of batteries closest to the battery. Bank sensors should be secured in place (typically with a cable tie) to avoid movement along the cable.

4.10 Integrel Panel Switch

[Except when the boat is in long term storage] the Integrel switch should always remain on, therefore it should be located in a position where it cannot be knocked. It must however still be readily accessible since it must be turned off when the boat is left for long periods of time as noted earlier.

The Integrel system uses a very small amount of power in sleep mode but can draw up to 6A whilst generating. There should also be a switch for the DC/DC converters to allow the owner to turn these off should the boat be left without shore power.

4.11 Busbars

Busbars are used as a primary means of connecting DC power conductors. Busbar(s) should be covered to prevent any accidental contact that may cause shorts.

4.12 Inverter/Charger

The inverter function converts 48VDC from the batteries into either 110VAC or 230VAC. Integrel recommends installation of an inverter/charger sized to provide the peak continuous AC power needed for mains AC house loads. The charger function charges the 48V batteries when shore power is available.

The location of the inverter/charger is less critical as it does not need much maintenance, however it does generate heat. It is important to install it in an area with sufficient ventilation that does not suffer from heat build-up. It must also be installed in a dry location free of moisture.

4.13 DC/DC Converter

DC/DC converters convert power from 48VDC batteries to 24VDC and/or 12VDC appliances and/or batteries. DC/DC converters generate a large amount of heat and need to be located in a place that has space to cool. Note that the 48V and 24/12V negative terminal are typically not connected internally and must be externally connected on a common negative busbar.

4.14 Fuses

Fuses are used throughout the system. Please ensure you follow the schematic, as this indicates where fuses are placed in the circuit. Refer to Annex C for typical locations and for a guide on fuse sizing. Always calculate the correct size based on the load and conductor within the circuit. Overcurrent protection sizing and location must comply with the requirements of ISO 13297 and ABYC E-11.

5 SCHEMATICS

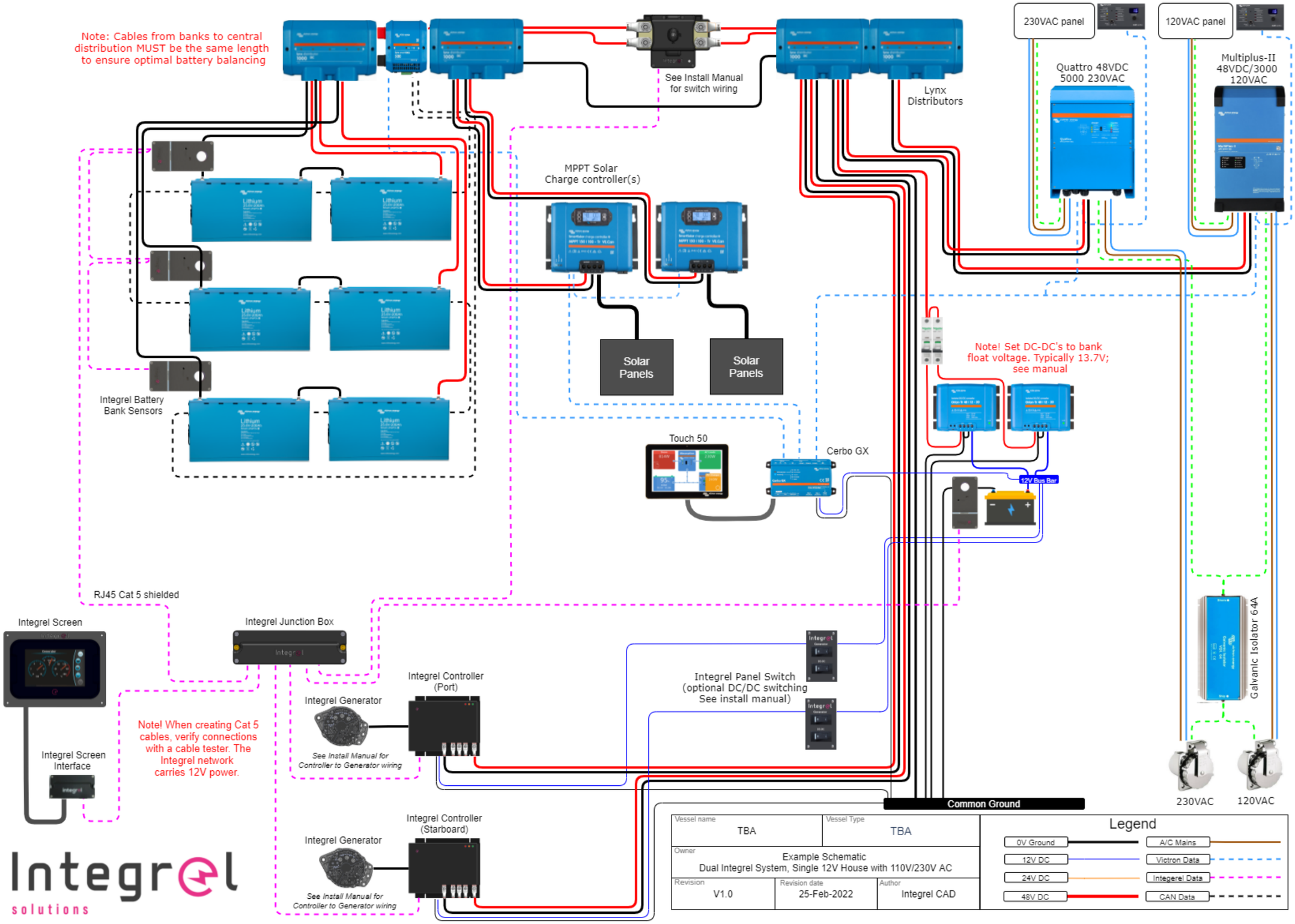
This chapter provides information to describe system wiring.

Integrel equipment is supplied with wiring looms that are labelled to aid installation. Loom pinouts are documented in Section 13.

The schematic on the following page is a representative example of a typical Integrel system installation. The major system components shown in the example are:

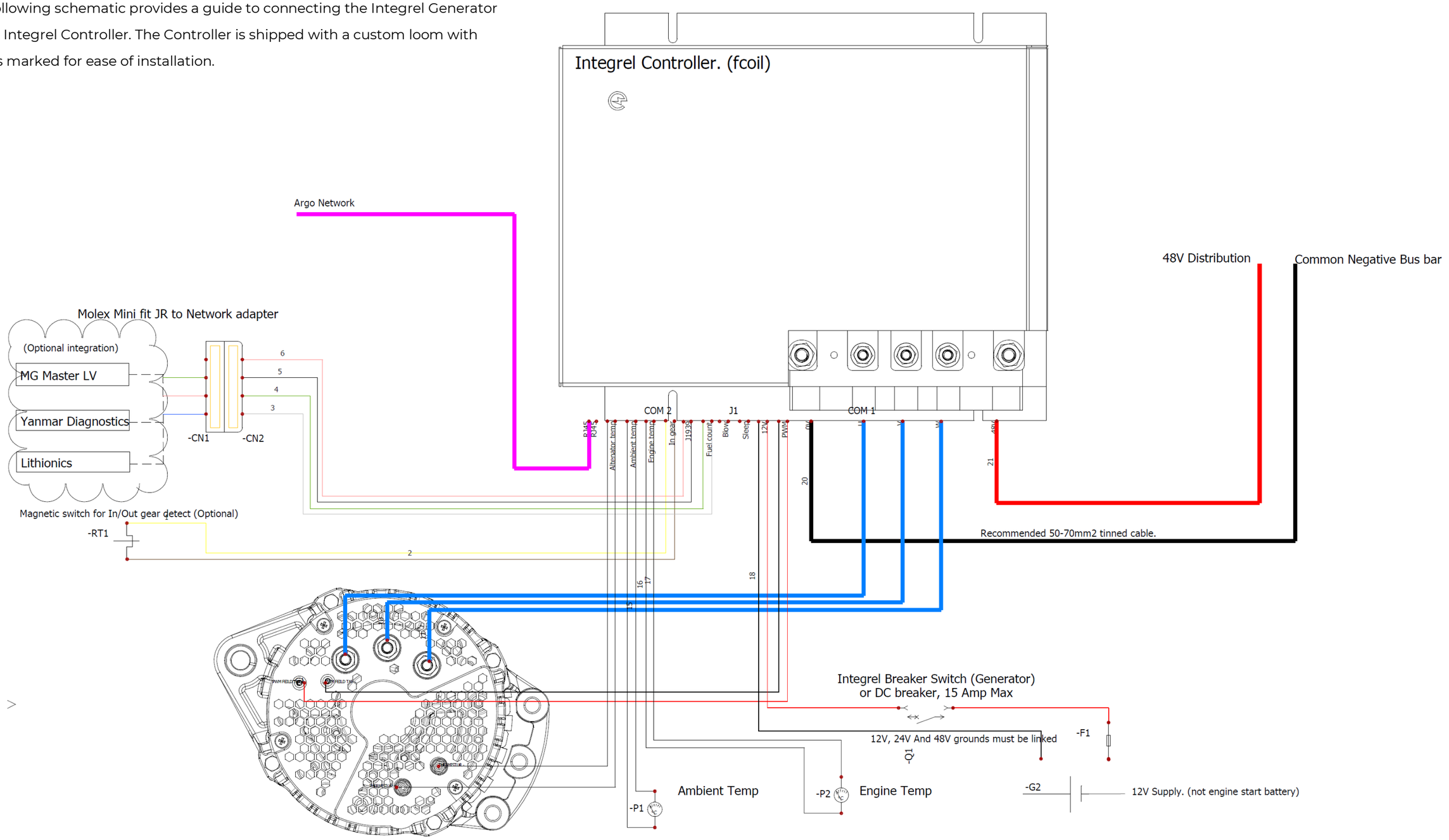
- A dual Integrel system which is typically of an installation on a catamaran
- A 30kWh Lithium battery bank comprising 6 x 24V 5kWh Victron batteries connected in 3 parallel banks, with each bank connected 2-in-series
- A 230VAC mains system with a maximum power capacity of 5kW supplied by a Victron 5kW Quattro inverter/charger.
- 2 x 48V-12V DC/DC converters used to charge the 12V house bank
- A 64A galvanic isolator to protect against galvanic corrosion when shore power is used
- A Victron CerboGX and Touch 50 display used to monitor and control the Victron power electronics
- (Optional) MPPT solar chargers used when solar cells are fitted
- (Optional) A 120VAC mains system with a maximum power capacity of 3kW supplied by a Victron 3kW Quattro inverter/charger. The 120VAC mains is primarily used to charge batteries when only 120VAC shore power is available.

NOTE!
The following schematics do not include fuse types, locations, and conductor diameters. Please see Annex C for information on fuses and fuse locations. When you receive your system, a custom schematic is provided. The schematic will also have any other auxiliary systems including solar, power inverters, shore power, etc.


Note: Cables from banks to central distribution MUST be the same length to ensure optimal battery balancing
See Install Manual for switch wiring
Lynx Distributors
230VAC panel
120VAC panel
Quattro 48VDC 5000 230VAC
Multiplus-II 48VDC/3000 120VAC
MPPT Solar Charge controller(s)
Solar Panels
Solar Panels
Integrel Battery Bank Sensors
Note! Set DC-DC's to bank float voltage. Typically 13.7V; see manual
Touch 50
Cerbo GX
12V Bus Bar
RJ45 Cat 5 shielded
Integrel Screen
Integrel Junction Box
Integrel Controller (Port)
Integrel Generator
See Install Manual for Controller to Generator wiring
Integrel Panel Switch (optional DC/DC switching See install manual)
Galvanic Isolator 64A
Integrel Screen Interface
Note! When creating Cat 5 cables, verify connections with a cable tester. The Integrel network carries 12V power.
Integrel Controller (Starboard)
Integrel Generator
See Install Manual for Controller to Generator wiring
Common Ground
230VAC
120VAC
Vessel name
TBA
Vessel Type
TBA
Owner
Example Schematic
Dual Integrel System, Single 12V House with 110V/230V AC
Revision
V1.0
Revision date
25-Feb-2022
Author
Integrel CAD
Legend
0V Ground
12V DC
24V DC
48V DC
A/C Mains
Victron Data
Integerel Data
CAN Data

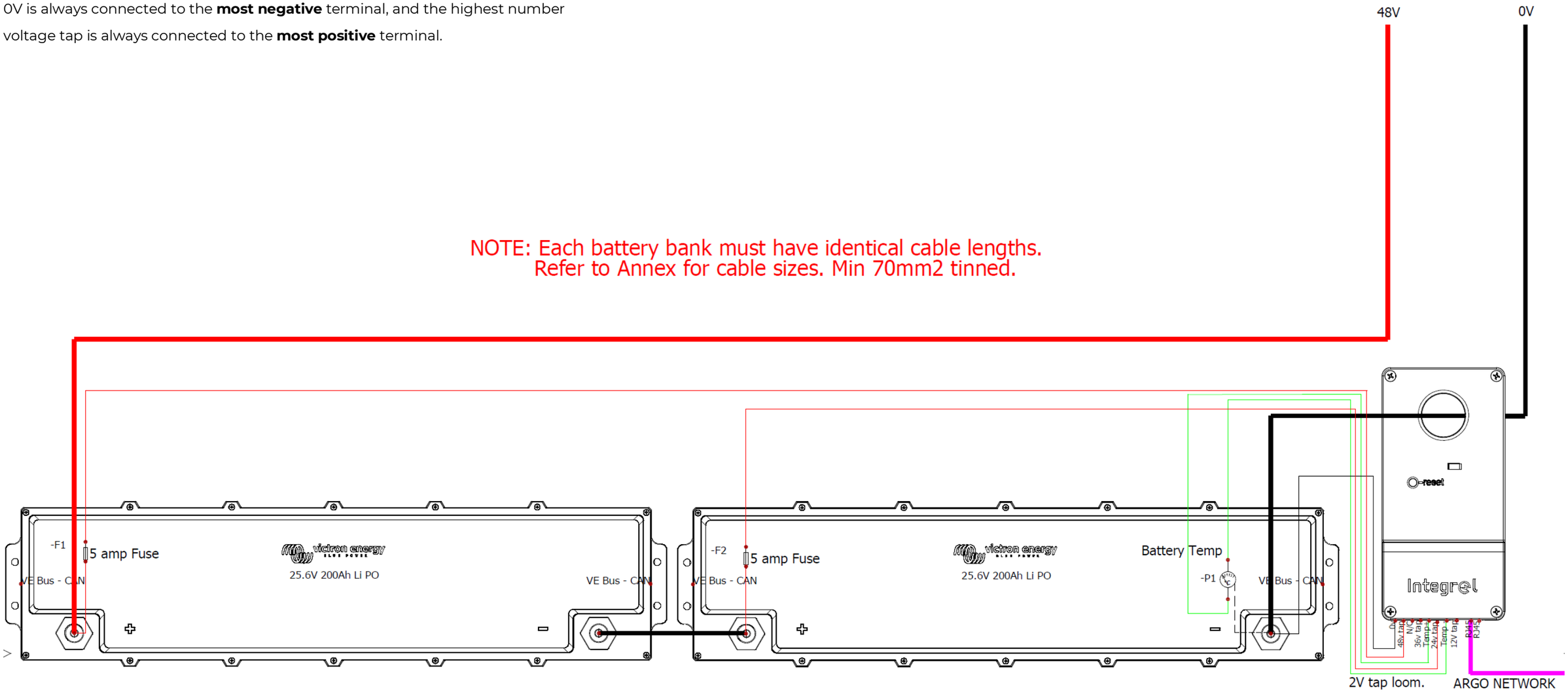
5.1 Wiring the Integrel Generator and Controller

The following schematic provides a guide to connecting the Integrel Generator to the Integrel Controller. The Controller is shipped with a custom loom with cables marked for ease of installation.



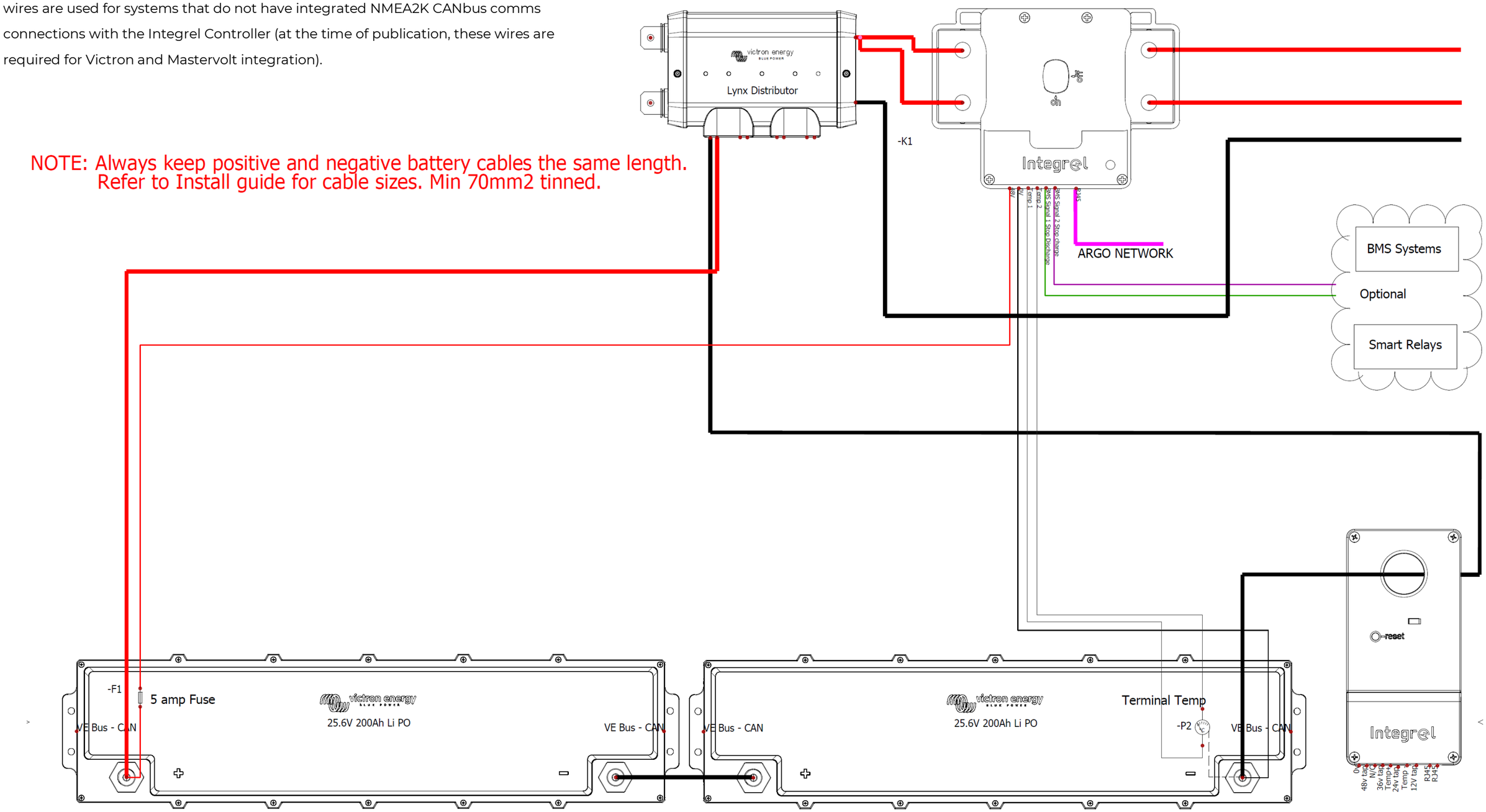
5.2 Wiring Integrel Bank Sensor(s) to Batteries

The following schematic illustrates bank sensor wiring. Note that fuses should **always** be installed on voltage taps, see Annex C. When wiring voltage taps, 0V is always connected to the **most negative** terminal, and the highest number voltage tap is always connected to the **most positive** terminal.



5.3 Wiring the Smart Switch to Batteries

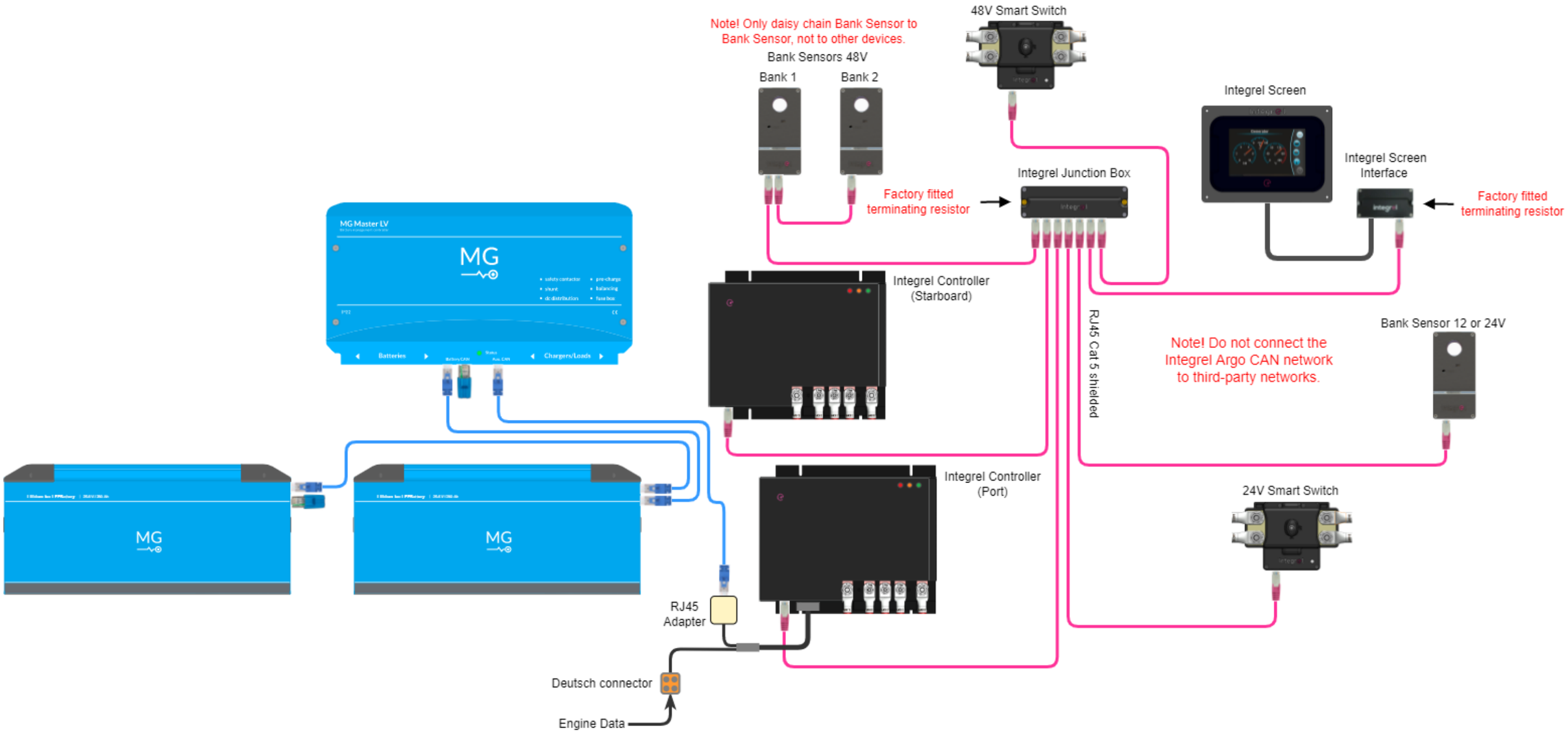
The following diagram shows how the smart switch is connected to the batteries and the rest of the Integrel system. The (lilac and green) stop discharge / charge wires are used for systems that do not have integrated NMEA2K CANbus comms connections with the Integrel Controller (at the time of publication, these wires are required for Victron and Mastervolt integration).



5.4 CAN bus Networks

The following schematic provides a guide to typical CAN network connections.

Pink lines indicate Integrel (Argo) CANbus connections, and blue lines indicate Victron NMEA2K CANbus connections.



6 INSTALLATION

6.1 Skills Required

Installing an Integrel system is less complex and time consuming than installing a traditional generator, but it still requires experience and guidance from Integrel Solutions. Installation must be performed by a qualified installer, with online access to Integrel setup software and other Integrel resources.

So far as possible, the Integrel system is preconfigured, including wiring harnesses.

6.2 Tools Required

Hand Tools	Use	Check
Head torch	Visibility in tight spaces	☐
Rechargeable light	Visibility in tight spaces	☐
Extension lead	Powering tools or bringing power to the boat	☐
Infrared camera (Thermal Imaging)	Check all components and connections to ensure heat is not being generated from bad connections or components	☐
Clamp meters / Multimeter	Confirm and check system power/voltage/current	☐
Socket drive set: 1/2", 1/4"	General assembly	☐
Screwdrivers: PH no2, PZ no2, PZ no1 Slotted screwdriver: Small (3mm), Slot medium (4, 5mm)	General assembly	☐
Side cutters	General assembly	☐
Metric spanner set (mm): 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19	General assembly	☐
Hammer	Remember, not everything is a nail!	☐
Ratchet crimpers (for insulated terminals red, blue, yellow)	Crimping conductors for voltage taps or where looms may need to be lengthened or shortened	☐
Ferrule crimpers and ferrules	Used to fit bootlace ferrules to wires.	☐
Hydraulic or electric crimpers for non-insulated copper tube terminals, including up to at least 90mm^2 conductor crimp tool	Crimping heavy conductors	☐
Large cable cutters	Cutting heavy conductors	☐
Knife, Stanley blade, Boxcutter	General assembly	☐
Power Tools (battery preferred) Drill, hole saws, drill bits (various)	Creating conductor routes and mounting components	☐
Jig saw (vibrating saw)	Cutting holes in panels with narrow blade	☐
Vacuum cleaner	Cleaning	☐

Hand Tools	Use	Check
Hot air gun for heat shrink	Applying heat shrink on terminals	☐
Tape measure	General assembly	☐
Marker pens	General assembly	☐
RJ45 crimper	Making custom length CAT5 cables	☐
CAT5 Tester	Testing CAT5 cables	☐
Electrical tape / self-amalgamating tape	Insulating and taping cuts	☐
Cable feeders and pullers	Pulling conductors through tight spaces	☐
Right angle driver	Accessing hard-to-reach screws and terminals	☐
Hole saws	Cutting conductor route access holes in plywood	☐
Rags	Cleaning up spills or stains	☐

6.3 External Parts (not supplied by Integrel)

During an install you will need other equipment that is not always supplied by Integrel. The following table provides a list of parts that may be required.

Part	Use	Check
DC conductor high current (red and black tinned)	Battery conductor for connecting high current systems. Refer to Annex B for sizes	☐
DC conductor low current (red and black tinned)	Providing 12V and 24V power to devices. Refer to Annex B for sizes	☐
Shielded CAT-5 cable and RJ45 plugs	Connecting Integrel components together	
Zip ties of varying sizes and thickness	Used for tidying conductors	☐
Screw on cable tie mounts	Aids mounting conductors for tidiness	☐
Cable spiral wrap or flexible conduit	Tidying loose conductors	☐
Hydraulic/electric crimp terminals (depends on conductor/batteries used)	Terminating battery conductors	☐
Ferrule and ring terminals	Terminating loose wires	☐
Heat shrink (red and black)	For heat shrinking crimped terminals and colour coding positive and negative conductors if using just black tinned.	☐

6.4 Preparation

Before starting any installation, clear a space and remove any panels to obtain access to areas that you will need for routing conductors and installing components. The following sections provide guidelines for installing each component.

6.5 Key Points to Remember

Take note of the following key points during fitting and testing.

1. Always torque terminals for batteries, switches, busbars, and any other terminals to avoid over-tightening. For all Integrel terminals, torque to **15 Nm**; for third party equipment, consult relevant data sheets.
2. Ensure 48V, 24V and 12V DC system grounds are connected.
3. After fitting is complete, use a quality thermal imaging camera (from Flir, Fluke or others, see images) to inspect:
    a. 12V and CANbus connections on power up. If any RJ45 cables have bad terminations, shorts may cause cables/connectors to melt or fuses to blow.
    b. All terminals and connections to check for high resistance caused by loose or damaged connections. Check on power-up and after the system has been running for at least 15 minutes.
4. Always have an Integrel engineer check and confirm settings before testing and sign off.

6.6 Fitting Order

The following instructions provide a guide to the order in which the system should be fitted to the boat. Integrel strongly recommends fitting components in this order to avoid damage to the system.

NOTE!
To avoid damaging the Integrel Controller: Ensure 48V DC and 12V DC negative conductors are connected **BEFORE** power is applied to the Integrel system.

Step	Operation	Check
1	Install all batteries into the final location and secure each battery to the vessel, see Section 6.7 for further details. All batteries should be fully charged prior to installation. DO NOT FIT ANY CONDUCTORS YET.	☐
2	Install the battery management system (BMS). DO NOT FIT ANY CONDUCTORS YET.	☐
3	Install the Smart Switch (if provided), isolator switches and busbars. DO NOT FIT ANY CONDUCTORS YET.	☐
4	Fit the Integrel bracket kit to the engine including the Integrel Generator.	☐
5	Fit the Integrel Controller in place, run the Controller loom to ensure there is enough slack in the cable to reach the Generator. DO NOT FIT THE CABLE YET.	☐
6	Fit the Integrel Smart Switch in place ensuring it can be easily reached	☐
7	Install the Integrel Screen into the cabin	☐
8	Install the Integrel Panel Switch, or 12V miniature circuit breaker (MCB) instead	☐
9	Install the Integrel Junction Box	☐
10	Install all DC/DC converters and inverter / chargers	☐
12	Wire the Generator to the Controller including: • 3 x phase conductors • PWM positive / PWM negative • Temperature positive / Temperature negative	☐
13	Fit the engine temperature sensor to the engine	☐
14	Fit the Bank Sensor loom to the Bank Sensor (do not connect the RJ45 yet)	☐
15	Fit negative conductor to the battery • Run the most negative cable of the battery bank through the Bank Sensor and secure the Bank Sensor to the cable to avoid movement along the cable. • Fit the 0V tap of the bank sensor loom to the most negative terminal of the battery bank	☐
16	Fit the negative battery cable to the negative busbar.	☐

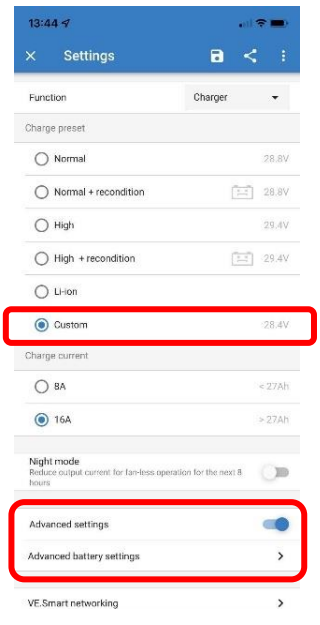
Step	Operation	Check
17	Fit the Smart Switch loom. DO NOT FIT THE RJ45 CABLE YET.	☐
18	Fit the negative (0V tap) of the smart switch loom to either the most negative terminal or the negative busbar.	☐
19	Fit all of the remaining negative conductors: DC/DCs, inverters, solar charge controllers, 12V house batteries, 12V engine start batteries, 24V battery banks etc. IMPORTANT: Ensure all DC negative connections are made before continuing.	☐
20	Prepare all the positive voltage taps by installing in-line fuse holders onto the wires. DO NOT INSTALL FUSES YET.	☐
21	Fit all the positive conductors from the batteries to the busbar, including series connections, T Class/MRBF fuses and the voltage taps. DO NOT INSTALL FUSES YET.	☐
22	Connect the positives of the DC/DC converters, inverters, solar charge controllers, 12V house, 12V engine start, 24V banks, etc.	☐
23	Fit the controller 48V DC connections, negative first to the relevant fuses and busbars.	☐
24	Install voltage tap fuses into their holders	☐
25	Fit all CAN network cables (RJ45) from equipment including Controller(s), Screen, Bank Sensors, and Smart Switches to the Integrel Junction Box	☐
26	Connect the +12V supply to the Controller	☐
27	Double check all connections. Ensure +12V is connected to the Controller and that all negatives are shared. After completing checks, switch the system on and begin setting up and testing. Refer to commissioning in Chapter 8 - COMMISSIONING AND TESTING once these steps and set up are complete.	☐

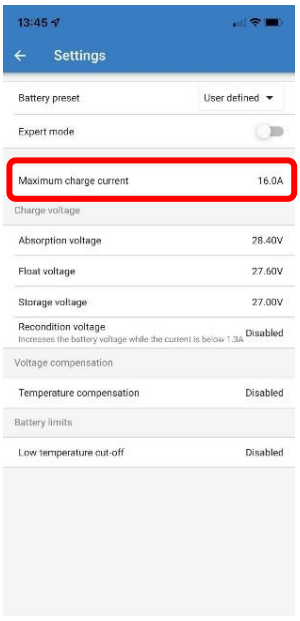
6.7 Battery Installation

This section covers battery installation for batteries from MG Energy and Victron. It provides instructions up to the point of connecting all batteries together. Connection to the Integrel Controller is covered in a later section.

6.7.1 Fully Charge all Batteries

Before installation, always charge batteries to the recommended float voltage. Connect each battery using a Victron (or other) smart charger, then use the Victron Connect App to connect to the charger and set the bulk and float voltages to match the battery.

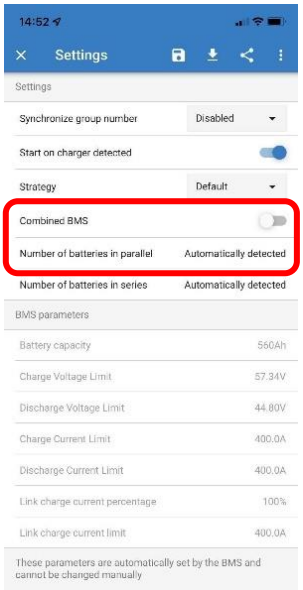


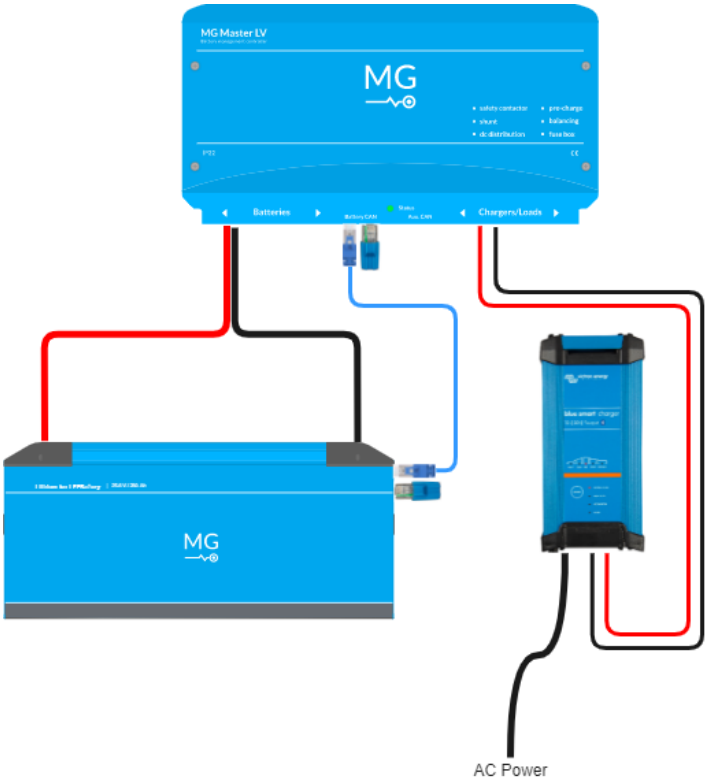


When charging MG batteries, always charge through the MG Master LV BMS. Follow the configuration shown.

Using the Victron Connect App, connect to the MG master LV listed as Lynx ION BMS.

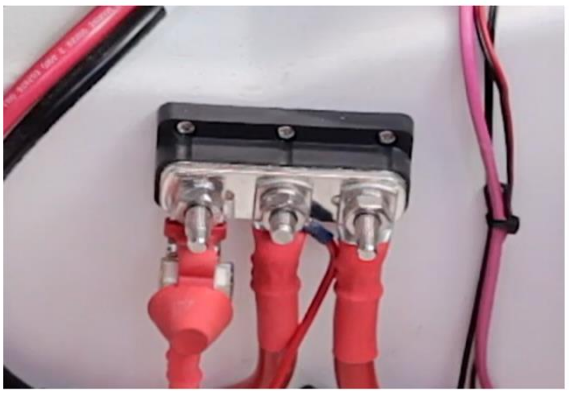
Configure the *'Number of batteries in parallel'* and *'Number of batteries in series'* settings to *'Automatically detected'*.





6.7.2 Conductor Lengths

It is VERY important to ensure that all conductors between batteries and battery banks are equal lengths. This ensures even balancing throughout the battery system. If conductors are not the same length, varying conductor resistances will impact how battery banks are charged and balanced.



48V Busbar

First, assemble conductors for the battery bank furthest away from the location where all banks meet (typically at a common busbar or distributor), then assemble remaining conductors to match. You may need to run conductors back and forth to the banks to take up any additional slack.

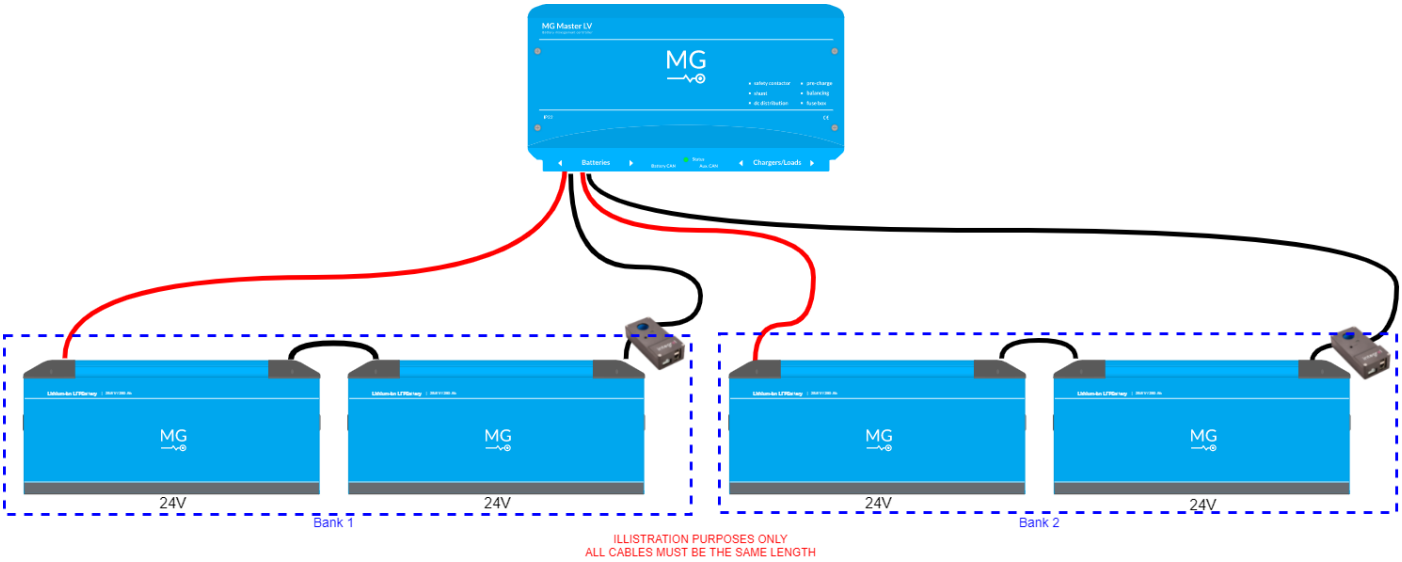
DO NOT COIL CONDUCTORS!

Don't forget to run the most negative battery conductor of each bank through a bank sensor prior to terminating the conductor, the terminators may not fit through the hole in the bank sensor!

6.7.3 Battery Configuration

The Integrel system is designed to charge a bank of batteries at a nominal 48V. The battery bank may comprise multiples of a single 48V battery, 2 x 24V batteries, or even 4 x 12V batteries. For larger capacity installations, Integrel recommends batteries are connected in parallel banks, with each bank totalling 48V.

As an example, the configuration shown in the following diagram consists of 4 x 24V batteries. The batteries are configured in two 48V banks connected in parallel, with each individual bank consisting of 2 x 24V batteries connected in series to make 48V. This is a common configuration. However some installations may only have a single bank of 2 x 24V batteries, while others may have 2, 3, or even more banks. As a reminder, it is **VERY IMPORTANT** that all conductors are the same length when wiring batteries!



6.7.4 Planning and Preparation

1. Ensure the space where battery(s) are to be installed meets the temperature, ventilation, and safety requirements specific to the battery type.
2. Ensure all batteries are secured to the vessel. Rachet straps are often used for this purpose, however it is up to the installer to decide what is best for the space where the batteries are installed.

6.7.5 Conductor and Wiring Guidelines

1. When fitting batteries, connect the negative terminal first. This is important to avoid damage to components and other systems.
2. All battery banks should be connected together using a fused Master LV for MG or a fused distributor such as Lynx distributor.
3. Do NOT fit the final negative connection to the negative busbar until you have installed the Bank Sensors. See Section 4.9, Battery Bank Sensors.
4. Minimise the length of all conductor connections between individual batteries in each battery bank.
5. Ensure the length of conductors from each battery bank to the 48V busbar are identical.
6. When connecting batteries to the BMS (Battery Management System), follow the guidelines provided by the battery manufacturer.
7. Ensure the ground connection of all DC voltage systems are connected together including 12V, 24V and 48V.

See Annex B and C for additional information related to wiring batteries. Ensure you follow the schematic, and the correct fuses are installed throughout the system.

6.7.6 Battery Vendors

The Integrel System has been qualified for use with Lithium-Ion batteries from multiple vendors including MG Energy Systems and Victron Energy. Using a smartphone camera and/or QR reader app, the manual for batteries from these vendors is available online by scanning the respective QR code.

MG Energy Systems

MG LFP 24V Series Battery Manual

Victron Energy

Lithium Battery 25.6V Smart Battery Manual

NOTE

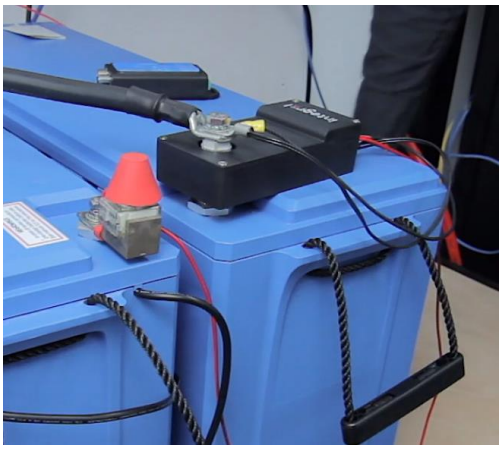
Always set up batteries according to the guidelines in the manual provided by the battery manufacturer. Check the manual you have refers to the battery you have installed.
If you need help finding the correct manual, contact Integrel support.

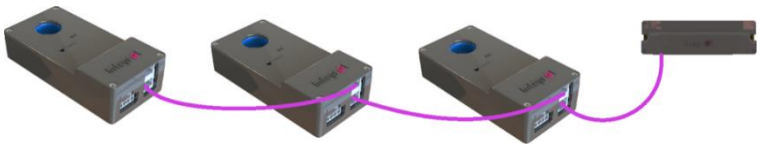
6.8 Battery Bank Sensors

Battery Bank Sensors are fitted to the most negative conductor of each battery bank and can be fitted to 12V, 24V or 48V banks.

6.8.1 Installation Guidelines

1. Battery terminals greater than 70mm are too large to fit through the hole in the Bank Sensor. Feed the battery conductor through the hole in the Bank Sensor **THEN** terminate the conductor!
2. Ensure the Bank Sensor is installed as close as possible to the negative battery terminal.
3. Ensure the Bank Sensor is secured with a cable tie to avoid movement which will otherwise disturb sensor measurements. The pictures to the right provide alternate options for securing a bank sensor.
4. After the Bank Sensor is attached, terminate the loom provided.
5. Wire the Bank Sensor loom to the batteries as shown in Section 5.2. Refer also to the following wiring diagram that demonstrates how to connect Bank Sensors. It is advisable to terminate with minimal slack on all cables; this keeps the system tidy.
6. After the loom has been wired in, plug the CAT 5 cable between the Bank Sensor and the next Bank Sensor, or the communication module (or junction box) if the sensor is the last in the chain. See the following picture for an example.





Bank Sensor daisy chain

A FINAL REMINDER!

Run the negative conductor through the hole in the Bank Sensor **BEFORE** terminating the conductor. The termination connector may not fit through the hole in the Bank Sensor.

6.8.2 Voltage Taps

Voltage taps can be connected in varying configurations to suit the battery configuration. The following table outlines which voltage tap loom to use for each configuration option. A common configuration is use of the 2 x Vtap loom with 2 x 24V batteries for a total bank voltage of 48V (outlined in red in the following table); also shown generically in the image at the bottom of this section.

V tap Loom Connection	1 x Vtap 12V Batteries	1 x Vtap 24V batteries	2 x Vtap 12V batteries	2 x Vtap 24V batteries	4 x Vtap 12V batteries
Vtap 1 →	12V	24V	12V	24V	12V
Vtap 2 →	-	-	12V	24V	12V
Vtap 3 →	-	-	-	-	12V
Vtap 4 →	-	-	-	-	12V
Total Bank Voltage	**12V**	**24V**	**24V**	**48V**	**48V**

NOTE!

- When connecting voltage taps, always attach the 0V ground BEFORE any of the positive taps.
- Always put fuses on positive voltage taps.
- Always connect the highest number voltage tap to the most positive conductor.

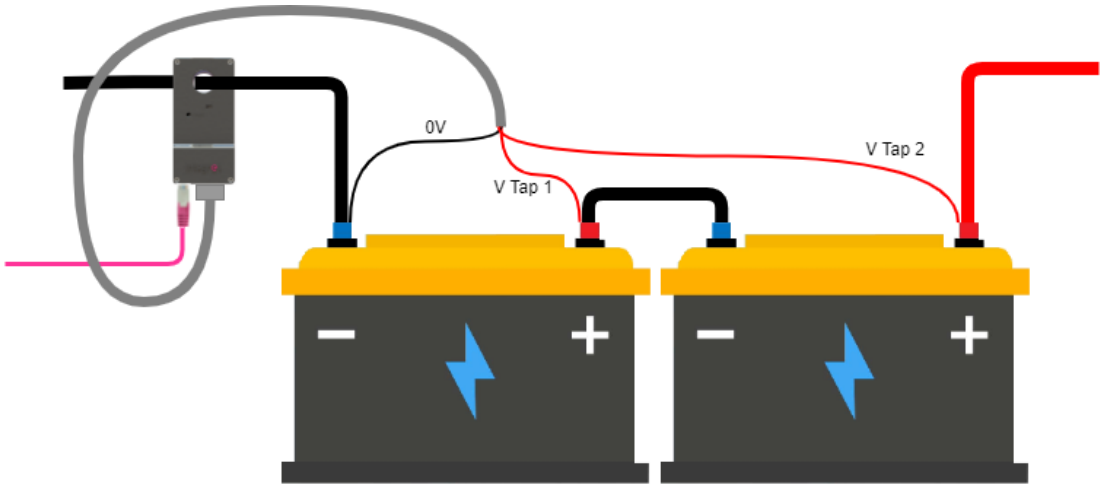
Some of the most common problems with Integrel system installations are related to voltage taps, including:

- A missing voltage tap, or a voltage tap that is not installed.
- A voltage tap connected to the wrong battery in the bank or string. This causes issues such as failure to generate power. It may also result in battery display problems.

Always wire the 0V Ground voltage tap to the most negative battery connection and the highest number voltage tap to the most positive battery connection as shown in the following image.

Always fit fuses to positive voltage taps.

The following image shows an example of a 2 x Vtap loom configuration (with arbitrary battery voltage). The 0V Ground tap connects to the most negative connection, Vtap 1 connects to the positive terminal of the first battery, and Vtap 2 connect to the positive terminal of the second battery.



6.8.3 Bank Sensor Reset Procedure

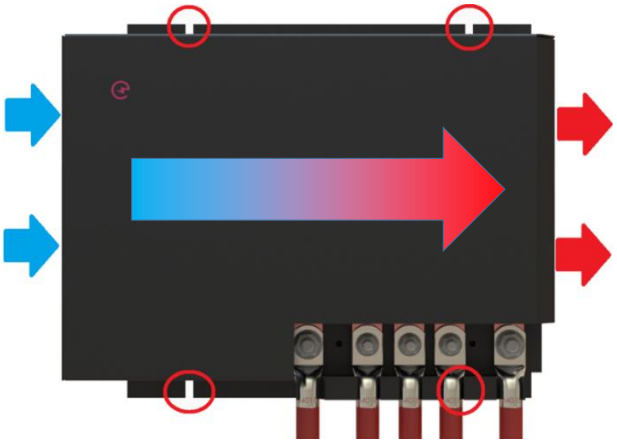
After the system is initially powered, the Bank Sensor may need to be reset. To reset the Bank Sensor, use a pointed tool such as a small screwdriver. Press and hold the reset button (shown by the red arrow in the image) according to the following table to select the desired reset operation.

The SoC reset operation should only be performed AFTER batteries have been fully charged to a 100% State of Charge.

Hold Time in seconds	LED Indication	Function
0 - 3	Solid ON	Reverses the current measurement polarity. This is very if the Bank Sensor has been installed backwards and you have already terminated the conductor!
3 - 6	Flashes ON/OFF	Forces system State of Charge (SoC) to reset to 100% on all bank sensors configured to monitor batteries with the same voltage
6 +	Solid ON	Factory reset

6.9 Integrel Controller

Use the 4 mounting slots (circled in the following diagram) to fasten the Controller. Screw the enclosure to a suitable horizontal or vertical location. To avoid overheating, ensure the Controller is properly ventilated and the fans on the left side of the enclosure are not obstructed.



Mounting Locations and Airflow

Vertically Installed Controller

6.10 Connecting the Integrel Generator to the Controller

The Integrel Generator is installed onto an engine mounting bracket kit that is designed specifically to suit each engine model. Follow the installation guide provided with the bracket kit to install the bracket on the engine. After the bracket kit is installed and the Generator is in place, use the following instructions to connect and wire the Generator to the Controller.

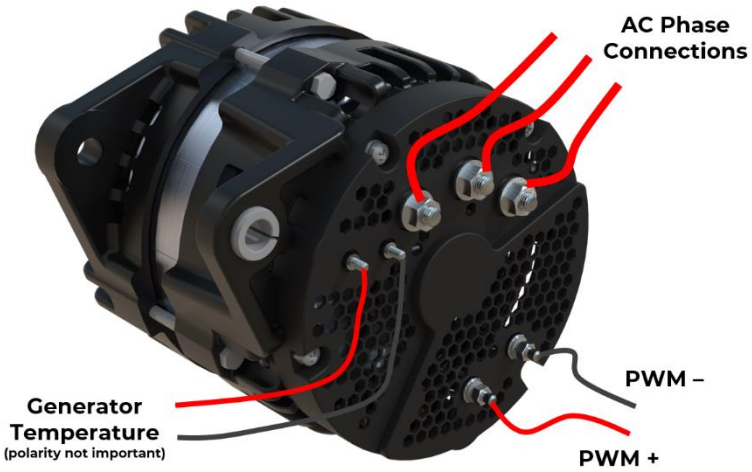
6.11 Generator and Controller Connections

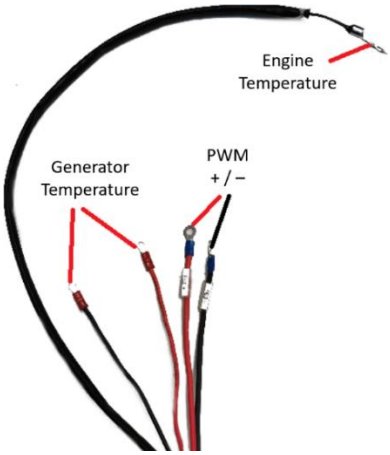
Connections for the Generator and Controller are shown in the following pictures.

6.11.1 Generator Connections

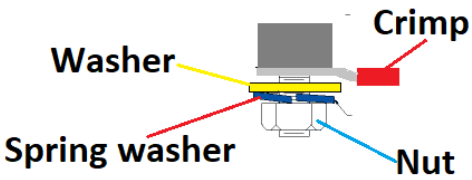
The Generator case is marked with letters to indicate the connections, the following table and images document the connections.

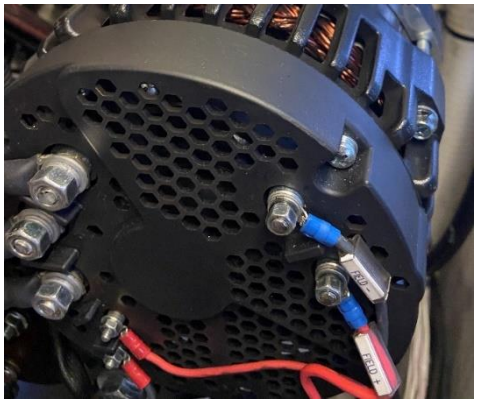
Generator Marking	Connection
P1	AC Phase 1 (order not relevant)
P2	AC Phase 2 (order not relevant)
P3	AC Phase 3 (order not relevant)
T1	Generator temperature
T2	Generator temperature
P –	PWM wire (black)
P +	PWM wire (red)





To connect the phase conductors, remove the nut washer and spring washer from the Generator then attach the relevant connections. Once the phase conductors are connected, refit the nut washer and spring washer in the order shown in the following diagram.





6.11.2 Controller Connections

A. Red, Amber and Green indicator LED's
B. Cooling fans
C. Argo CAN network (RJ45)
D. Signal Loom Connector
E. Power Loom Connector
F. 48V Negative (Ground) Connection
G. 3 x AC Phase Connections
H. 48V Positive Connection

Plug the Generator loom plugs into the Controller, then connect the three AC phase connections.

Once the Generator loom and phase connections are connected, clip the cables with cable ties and screw on mounts. Ensure there is acceptable slack on the conductor route from the solid mounting on the boat and the Generator; this allows for movement of the engine during normal operation.

6.11.3 Engine Temperature Sensor

To attach the engine temperature sensor, find a suitable point on the engine that heats up when the engine is running. Do not mount the temperature sensor connection near cooling devices such as fans. An example connection is shown in the picture to the right.

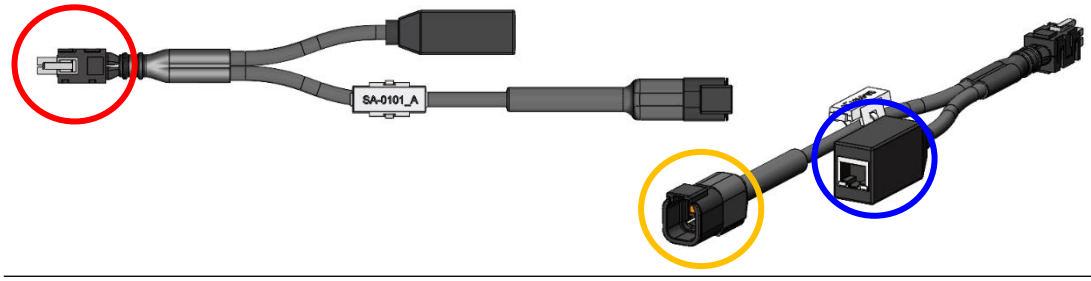
Controller connections to the 12V supply and RJ45 plugs for the display and junction box are covered in a later section.

6.11.4 Yanmar Engine Data

The Integrel system can be configured to estimate/obtain engine speed from either of two sources: by counting electrical pulses on one of the Generator conductors or by reading RPM from the engine J1939 ECN interface. The latter method is configured by default for Yanmar engines. Integrel provides a custom loom adapter for Yanmar engines.

Connect one end of the loom adapter to the Controller loom (red circle), and the plug (orange circle) to the Yanmar plug labelled Diagnostics. The adapter supplied may or may not include a BMS RJ45 connector option (blue circle).

The Integrel Controller setting used to configure use of J1939 is: `j1939_enabled`



6.11.5 In-Gear Detect

The Integrel system uses a physical I/O switch to determine if the gearbox (transmission) is in-gear, see the Controller schematic. The connections are denoted by a brown and yellow conductor and the pinout is shown in Section 11 - Wiring Pinouts. The in-gear detect switch must be wired as follows:

In-gear	Switch = OPEN
Out-of-gear	Switch = CLOSED

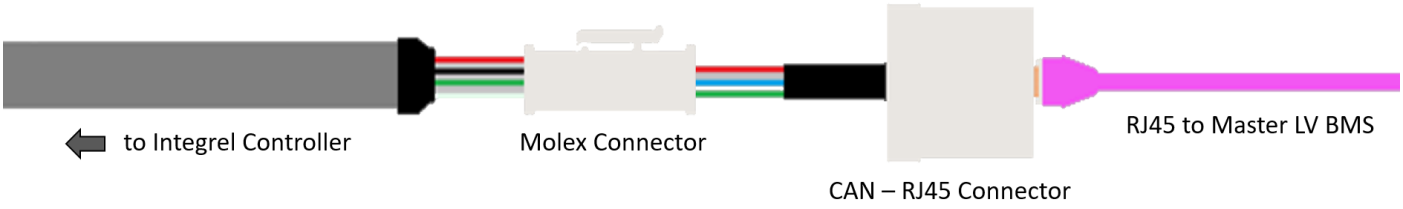
Popular switches include:

- MCS-137 from COMUS Group. This is a magnetic proximity switch.
- CE10.00.AM from CamdenBoss. This is a mechanical limit switch.

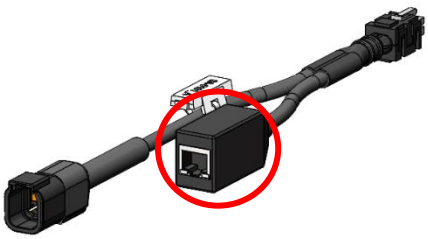
When commissioning, a symbol appears in the corner of the screen showing whether the system is in-gear or out-of-gear. If a switch is not fitted, these wires can be joined together. This causes the Integrel system to treat the propeller as permanently engaged, preventing excess load on the engine.

6.11.6 MG Master LV BMS Integration

When using MG batteries and a Master LV BMS, the Integrel system must be connected to the MG BMS. The Integrel system reads data from the MG BMS and adjusts the charge profile to better suit the battery requirements. Setup the looms for the CANbus network of the BMS as shown in the following diagrams. Connection looms are included with the installation kit. The RJ45 connection (red circle, below) to the BMS may be either via a single adapter cable, or combined in a 'splitter' loom to enable concurrent connection with the J1939 engine ECN interface.



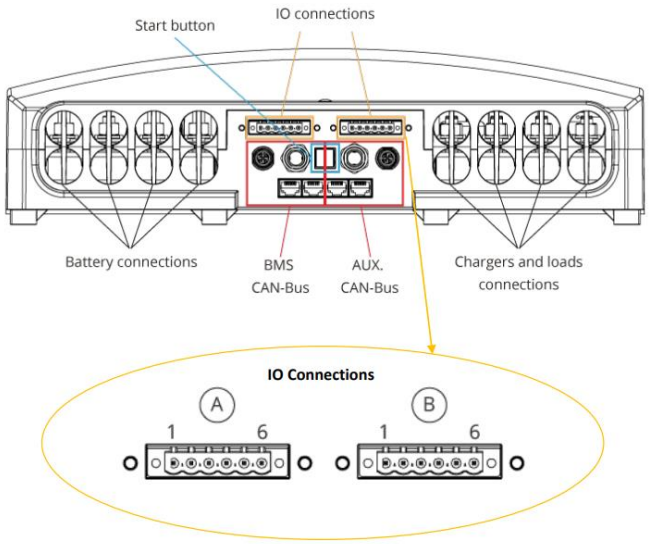
Connect the assembled loom to the Controller and to the AUX RJ45 port on the MG BMS. When adjusting Controller settings, configure the setting: `use_mg_controller = 1`



For dual Integrel installations, **only connect ONE of the Controllers to the MG BMS**, however both Controllers must be configured with the setting: `use_mg_controller = 1`

Use the BMS CANbus to connect the MG batteries to the MG BMS and the AUX CANbus to connect to the Controller. The following image of the underside of the MG BMS shows the location of the CANbus and the AUX CANbus connections. The Aux CANbus can also be used to connect Victron inverters such as a Quattro or Multiplus.

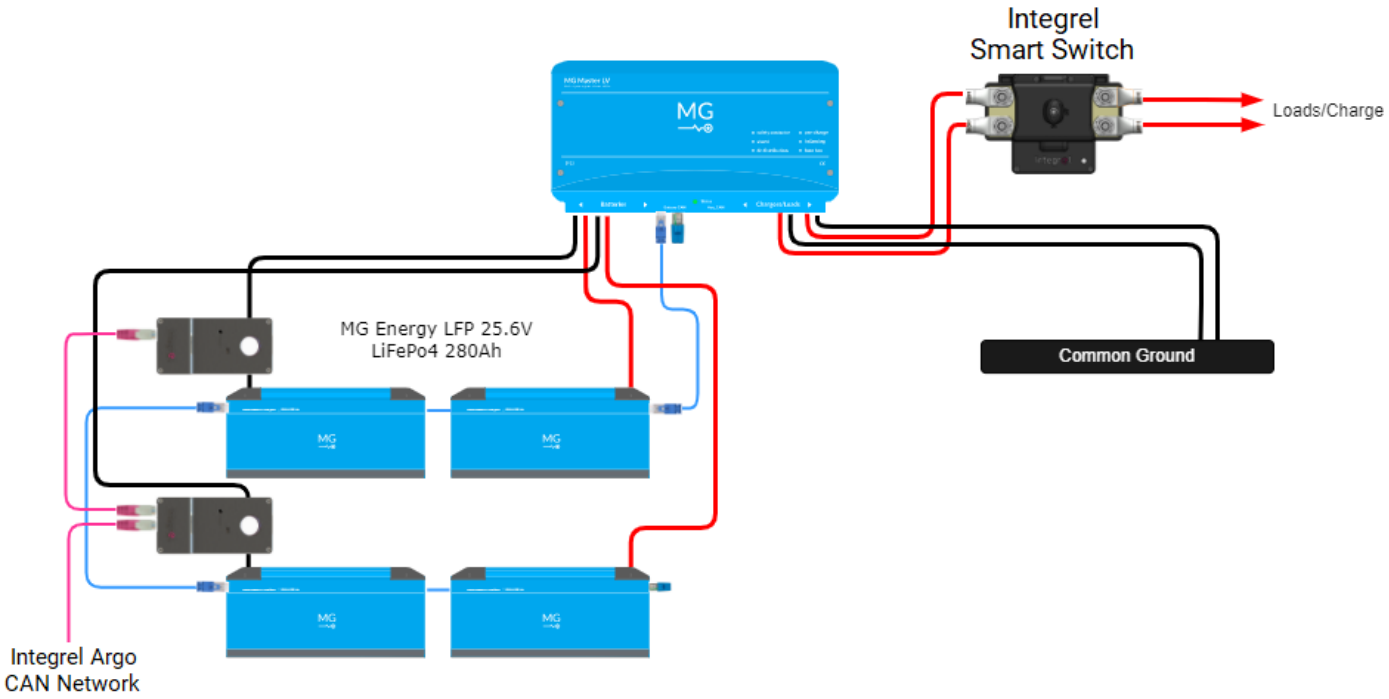
The Integrel system should be powered on permanently EXCEPT when laying up the boat for long periods of time. When power is restored to the boat after a lay up, a warning may appear on the Integrel display indicating that the system lost connection to the MG BMS. This is normal operation during the power up sequence. The warning automatically clears when a connection with the MG BMS is established.



MG master LV BMS Connections

6.12 Integrel Smart Switch

The Smart Switch is connected before the busbar and after the point at which all battery banks are wired together as shown in the following illustration. The switch is rated to a maximum of 400 amps, please note this when installing devices that load and charge the batteries. If the switch exceeds the maximum configured current setting, it automatically disconnects the batteries.



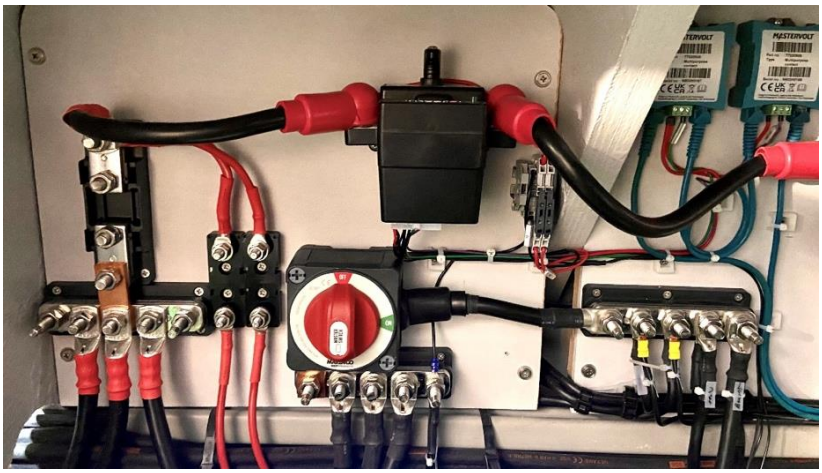
NOTE!

The Smart Switch is intended as a safety device to prevent overcharging or excessive discharging. Some systems have a disconnect switch AND a (remotely operated) Integrel Smart Switch to disconnect the batteries when leaving the boat.

Do NOT install load devices or unregulated charging-devices between the Smart Switch and the batteries as this configuration has the potential to cause damage to the batteries. This warning excludes the connection of an approved solar (or other) charger to charge batteries when the boat is unattended.

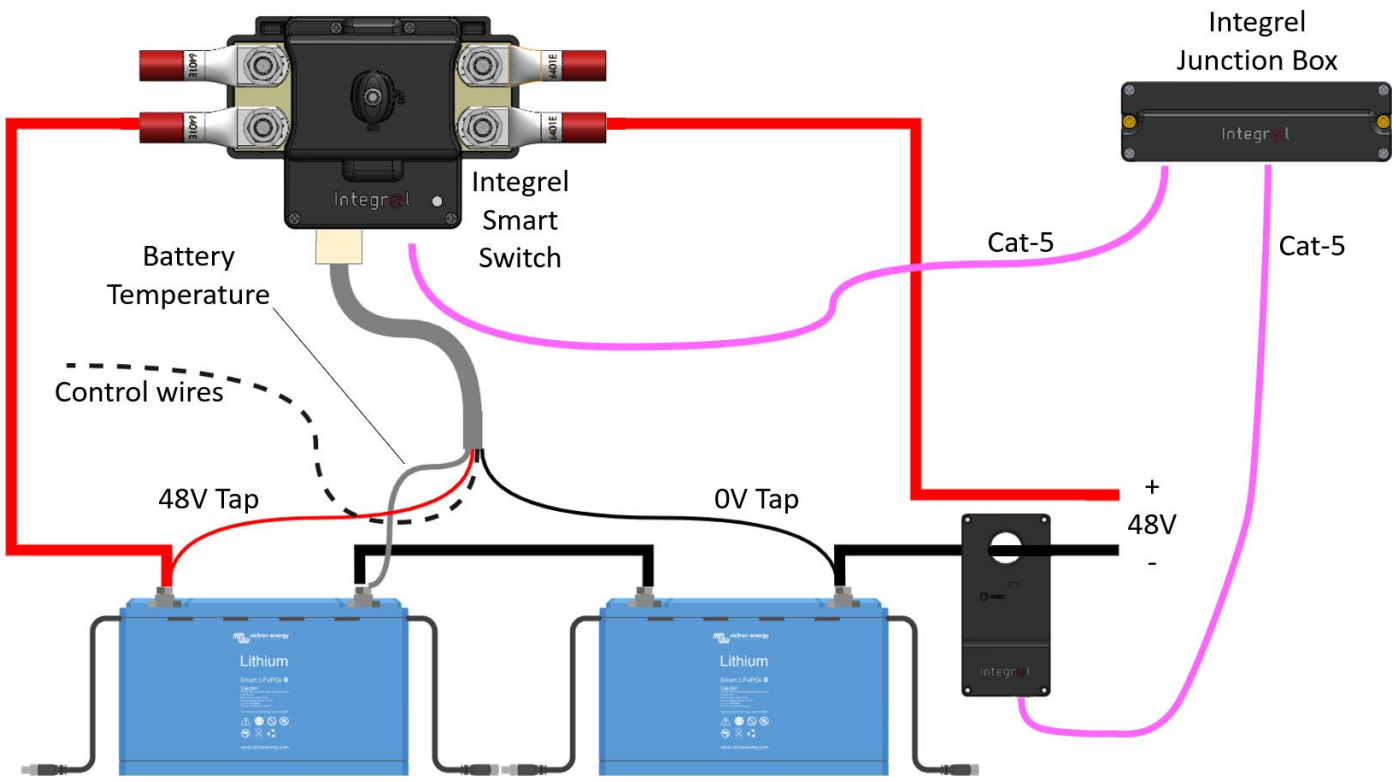
To install the Smart Switch, start by mounting the Switch in a suitable location using the mounting holes as shown in the illustrations.

Integrel Smart Switch Mount Points



Example Smart Switch Installation

Once the switch is mounted, connect the switch loom and terminate the wires to the correct locations as shown in the following illustration. When using two or more 48V battery banks, the voltage tap can be connected directly to the 48V positive and negative busbar.



Integrel Smart Switch Connections

Connect the temperature tap directly to any battery terminal to ensure a correct temperature reading.

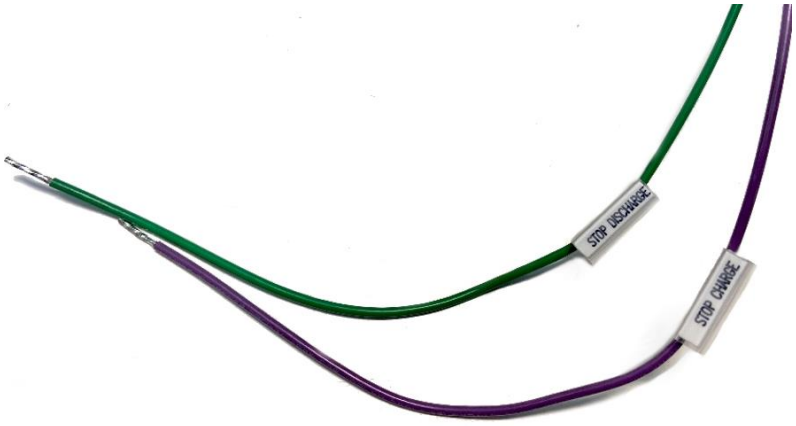
The Smart Switch is also available in a 24V configuration. The guide above also applies.

The dashed line in the illustration above represents any differences that might be present in various wiring looms. The most common variation is 2 wires named 'Stop Charge' and 'Stop Discharge'. These wires are plugged into the Victron BMS or a remote relay.

NOTE!

When connecting voltage taps, connect negatives first, and remove fuses during initial installation. Installation of fuses should follow the wiring and connection order instructions.

6.12.1 Wiring Stop Charge/Discharge



A separate stop charge / stop discharge loom may be used to warn if the system is being overcharged or discharged by any system external to the Integrel equipment such as chargers and solar systems.

This loom can be used with Mastervolt Multipurpose Contact Output, Victron VE Bus BMS, and some smart relays. These devices need to be programmed when to send a warning signal.

The 'rule of thumb' is to set any BMS stop charge signal higher than the recommended battery bulk voltage by at least 1 volt, and any BMS stop discharge signal at least 1 volt lower than the recommended battery disconnect voltage.

For 48V batteries, the typical voltage range for the stop charge signal is 58-60V, and the stop discharge signal is 48-44V.

Victron VE.Bus BMS

Mastervolt Multipurpose Contact

6.13 Integrel Junction Box

The Integrel Junction Box provides a common connection point for the Integrel proprietary Argo CANbus data network. The ideal location for the junction box is in a dry place away from dust. Devices can be networked into chains to expand a network if the installation does not have enough ports. Use the 2 screw holes to mount the junction box to a hard surface.

Take care when inserting RJ45 cables into the Junction Box sockets. If the plug is forced into the socket at an angle, several pins may be forced together which can cause electrical shorts.

When making RJ45 cables, use shielded CAT5 cable and ALWAYS test the cables before installation.

6.14 Integrel Panel Switch

The Integrel panel switch controls the 12V power supply to the Integrel system. The switch must be mounted in a location that is easy to access, but will not be accidentally knocked.

For wiring instructions, refer to schematics.

6.15 MCB (Switch Panel)

A DIN rail mounted Miniature Circuit Breaker (MCB) can also be used for switching power to the Controller and any DC/DC converters, MPPT solar controllers and PV panels. For the Controller, use a MCB with a DC rating of 10 amps.

Suitable DC MCBs are listed and shown below.

- Gewiss 10A breaker MTC 45, P/N GW90006
- Schneider Electric Acti 9 10A MCB, P/N A9F53110

6.16 DC/DC Converters

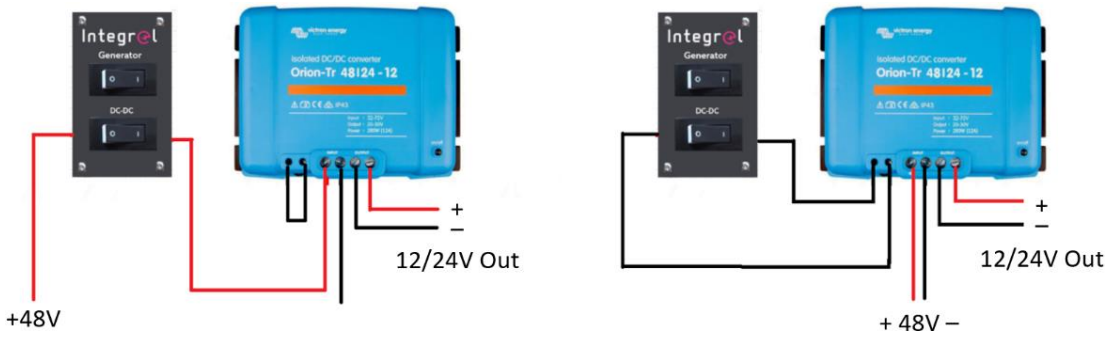
The instructions in this section refer specifically to Victron Orion DC-DC converters. DC-DC converters from other manufacturers may also be used.

Find a suitable location that is clean, dry, and well ventilated. Mount the DC/DC converter with suitable fastenings.

The Integrel Panel Switch can be used to control the operation of the DC/DC converter(s). If Victron DC/DC converters are used, there are two connection methods depending on the current drawn from the 48V supply.

Method 1 (shown to the left in the following diagram) can be used if current draw from the 48V supply is less than 16 amps. If the current sourced is higher than 16A, Method 2 (shown to the right) must be used. Connections for both methods are shown in the following diagram on the right.

Method 1 – In-line Switch **Method 2 – Switched Relay**



DC/DC Converter Wiring Configuration with Integrel Panel Switch

If Victron Orion 48V-12V or 48V-24V DC/DC converters are used, the DC/DC output voltage needs to be adjusted to match the batteries. Adjust the voltage to match the battery float voltage using the adjustment screw located on the underside of the Orion hardware (red circle in the following image); be

sure to disconnect batteries before making the adjustment! Note that Orion-Tr DC/DC converters can NOT be used to charge lithium batteries.

Orion-Tr voltage adjustment screw

NOTE!

Always remember to connect the grounds from the DC/DC converters to the negative busbar. The grounds on DC/DC converters are internally isolated and need to be externally connected. Failure to externally connect grounds may cause equipment damage.

6.17 Integrel Display Interface

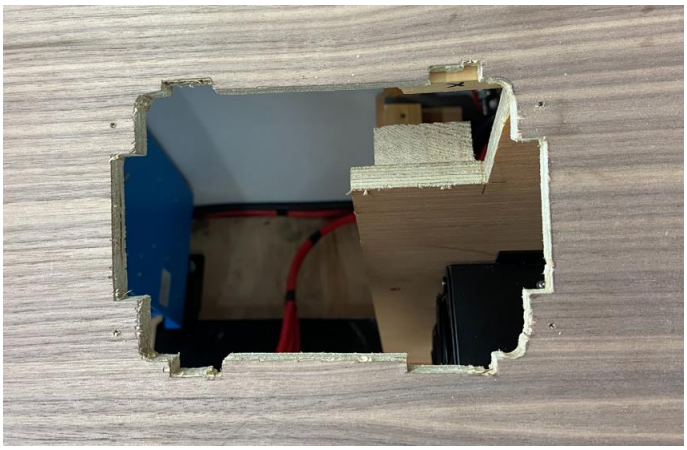
The Integrel display interface is mounted using two screws. It connects to the Integrel Argo CANbus network via an RJ45 connector.

The Interface must be mounted somewhere that is easily visible and audible; the display contains a buzzer to provide alerts and warnings. It is also used to perform updates to Integrel system components via USB.

6.18 Integrel Display

The Integrel Display connects via a loom to the Display Interface. Ensure the loom reaches between the Display and Display Interface BEFORE cutting a hole in the mounting panel.

Step 1
Use the acrylic panel as a cut out template



Step 2
Using a router, cut a hole for the screen in the panel

Step 3 (optional)
Mount the acrylic panel using the 4 outer holes

Step 4
Mount the screen using the 4 holes on the screen

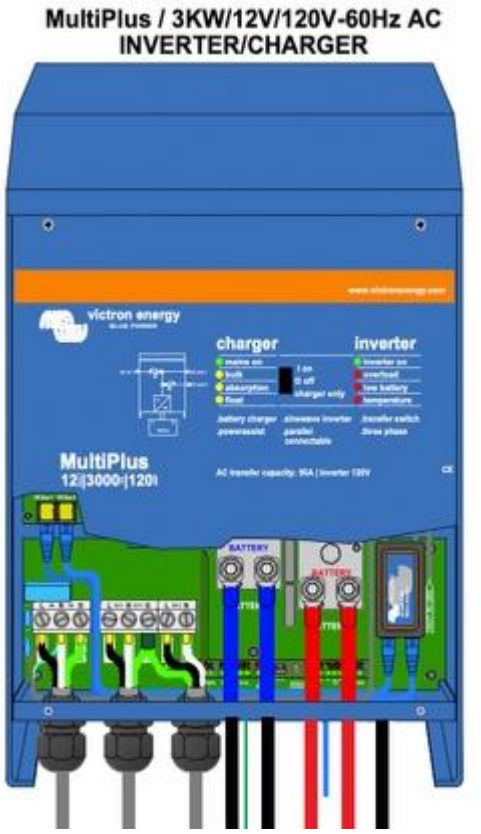
Step 5

Clip the outer bezel into place

Step 6

Plug the screen loom into the screen interface box.

6.19 Shore power and DC to AC Conversion



Integrel typically recommends use of Victron Multiplus II or Quattro inverter/chargers for all AC to DC and DC to AC conversion. When installing inverter/charger(s), ensure the area is accessible to enable future servicing and diagnostic fault finding.

Ensure you have the inverter/charger manual on hand during the installation.

The following suggestions relate to Victron Multiplus connections; however you will need to adjust the instructions to match a different inverter/charger installed on the boat. Make sure you follow the manual correctly or employ a Victron engineer to set up the system correctly

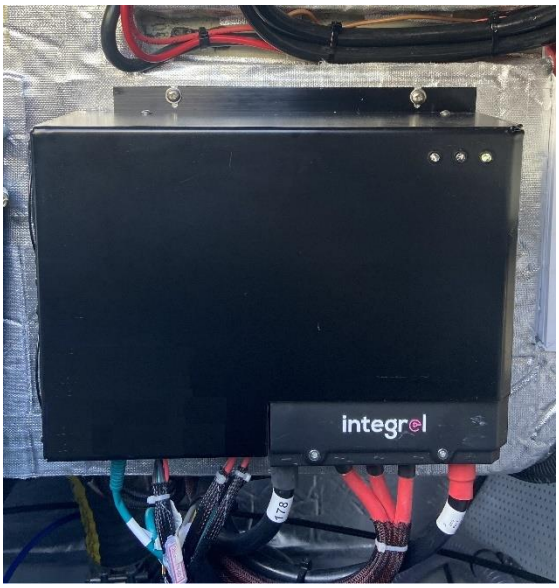
In the picture to the right, there are 2 x RJ45 connections. The connections can be connected to the Victron BMS, MG BMS and a Victron interface. These are also used to configure the device.

The picture also shows connections to the battery, AC supply and output (black and red). Ensure you calculate and use the correct diameter conductor to suit the power requirements.

When connecting shore power to a Multiplus or Quattro, always implement isolation transformers or galvanic isolators, if they are not used, damage can be caused to the vessel and systems over time.

6.20 Final Connections

6.20.1 Connecting 48V Battery(s) to the Controller

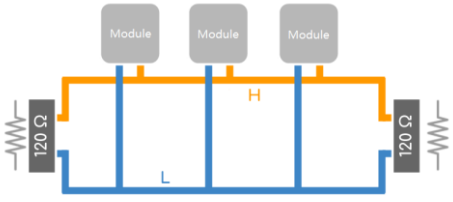


Before connecting the 48V battery supply to the Controller, it is critical to ensure that all connections are tightened correctly. High amperage runs through the 48V battery supply. Loose connections can quickly become hot and generate excessive amounts of heat that may cause damage to systems and the vessel if left unchecked.

Ensure all DC supplies share a common ground, especially the 12V DC supply that powers the Controller and the 48V DC supply to the main batteries.

When connecting the Controller, ensure the negative terminal is connected BEFORE the positive terminal.

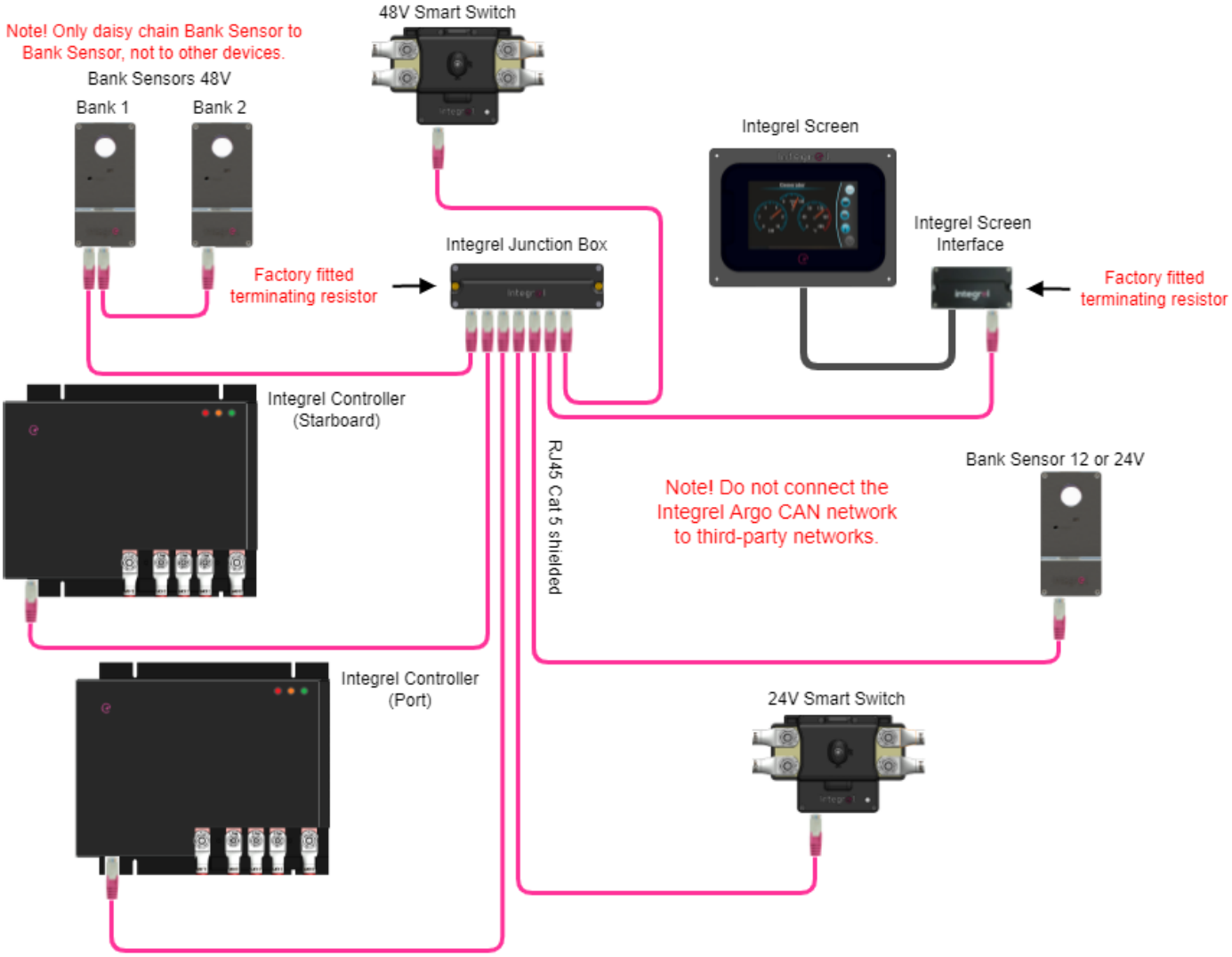
6.20.2 Integrel Argo CANbus Network



All 2-wire CANbus networks require terminating resistors at each end of the network. Terminations are essential for error free communication. An example of a CANbus network with termination resistors is shown to the right.

When connecting Integrel and other CANbus networks (including MG and Victron), ensure there are **ALWAYS TWO** termination resistors in the system. The following diagram shows an example of CANbus connections for an Integrel

system. The Smart Switch can be connected to either the Integrel Junction Box, or to one of the Integrel Bank Sensors.



Integrel CANbus Network Physical Wiring with CAT5 Cables

Integrel CANbus termination resistors are located inside the Integrel Junction Box, Integrel Smart Switch and Integrel Screen Interface as shown in the following printed circuit board pictures. A PCB jumper (circled in **yellow** in each picture) is used to connect or disconnect the termination resistor.

Junction Box

Smart Switch

Screen Interface

By default, the Screen Interface and Junction Box each have a jumper installed to connect the terminating resistor to the network. A small system may not need a junction box. In which case, a jumper must be installed in the Smart Switch to connect the termination resistor instead. In a larger system, two junction boxes may be needed, the terminating resistor from one of the junction boxes **must be disconnected** by removing a jumper from one of the junction boxes.

6.20.3 Connecting 12V to the Controller

The 12V power supply for the Controller is dependent on the equipment fitted to the system. The supply should be connected to a 12V house bank. Do NOT connect the Controller to a 12V engine starter battery bank since the Controller may, over long periods of time, drain the starter battery. Also, the voltage of an engine starter battery can briefly drop below the required Controller supply voltage when starting the engine. The resulting voltage drop may cause the Controller to reset. Double check the voltage level before plugging the system in.

NOTE!

The 12V supply to the Controller is usually wired through an Integrel Panel Switch or MCB located in a switch board. Check the voltage level and check the 12V ground reference is connected to the 48V system ground reference BEFORE applying power!

When the system is initially powered, check the CANbus network connections and other power connections for signs of overheating using a thermal imaging camera.

7 CONFIGURATION

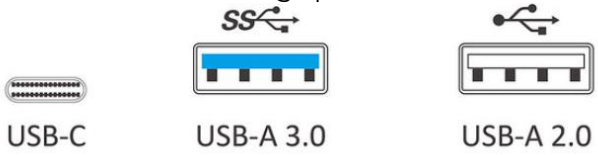
The following chapter explains how to configure Integrel system settings. Your system is pre-configured at the factory, however we recommend reviewing all relevant settings BEFORE making any changes. If your system needs set up, a list of settings will be provided by Integrel to help guide you through the process.

7.1 Connecting to the Integrel System

7.1.1 Pre-requisites

To connect to the Integrel system, you will need a computer with the following specifications

1. A windows PC with USB
2. Integrel Configuration Software
3. USB-A to USB-C Cable



7.2 Connect to the Integrel System

The following step-by-step instructions guide you through the process of connecting your computer to the Integrel system via USB.

Firstly, plug the USB cable (USB-C plug) to the socket at the top of the Controller and plug the other end (USB A plug) into your computer.

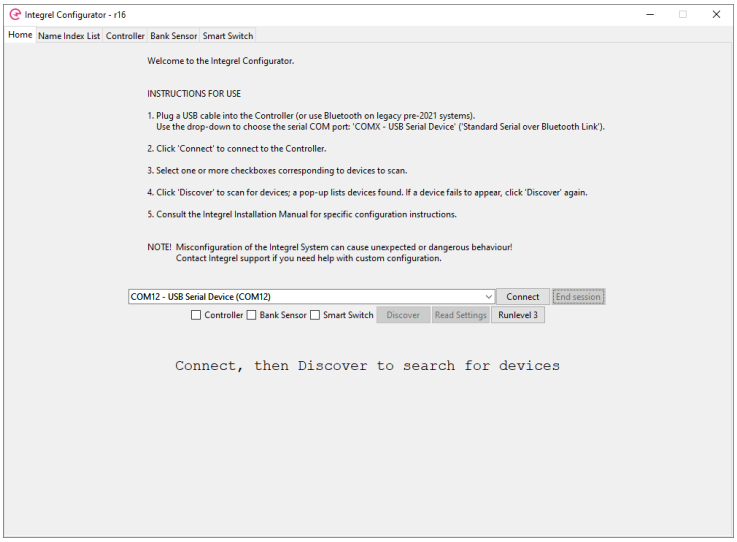
Once connected, use the Windows Device Manager to check you have a connection to the controller.

7.3 Integrel Configurator Application

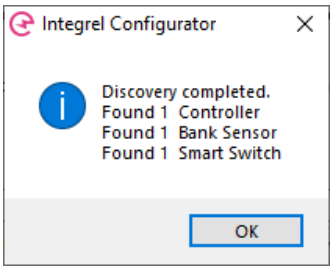
Download the Integrel Configurator Application from Integrel, install and run the application.

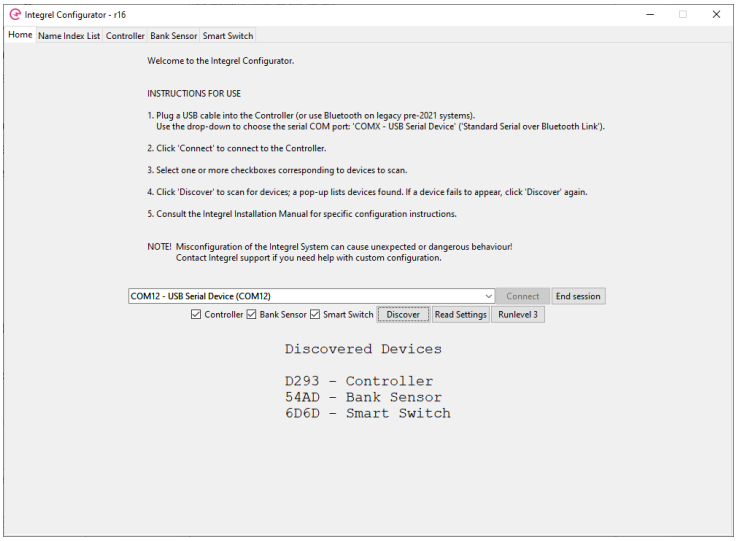
In the screen shown to the right:

- The USB Serial Device COM port may appear automatically. If not, use the drop-down box to select the correct USB COM port.
- Click connect. Once connected, the 'Discover' and 'Read Settings' boxes change from greyed out to active.
- Runlevel 3 provides access to configuration of standard settings.



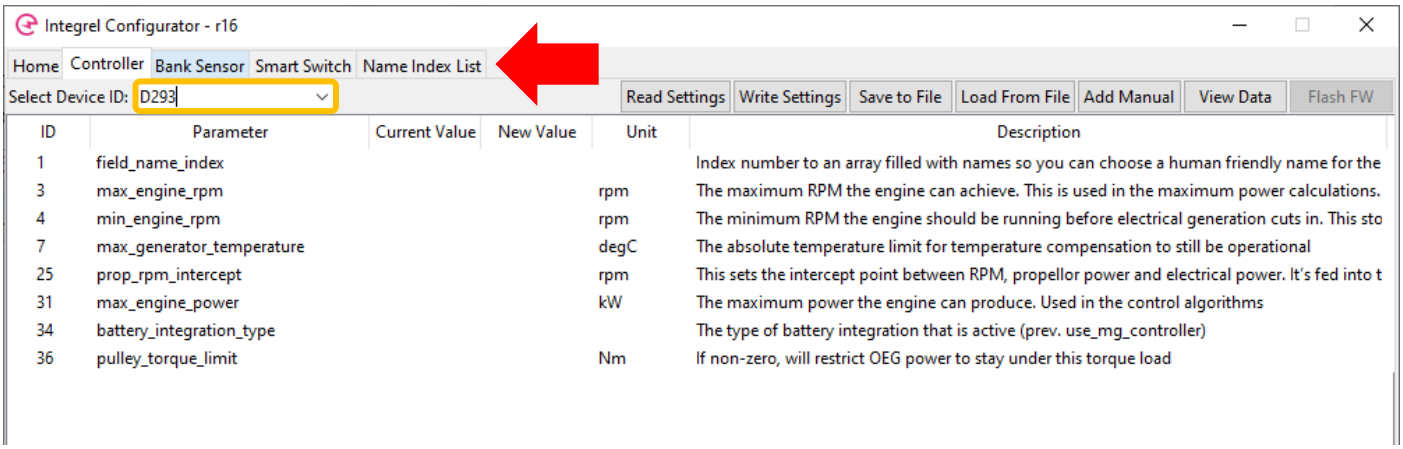
- Select devices to discover using the check boxes.
- Click 'Discover' to discover devices on the Integrel Argo network.
- The following pop-up appears





7.4 Choose Devices and Read Settings

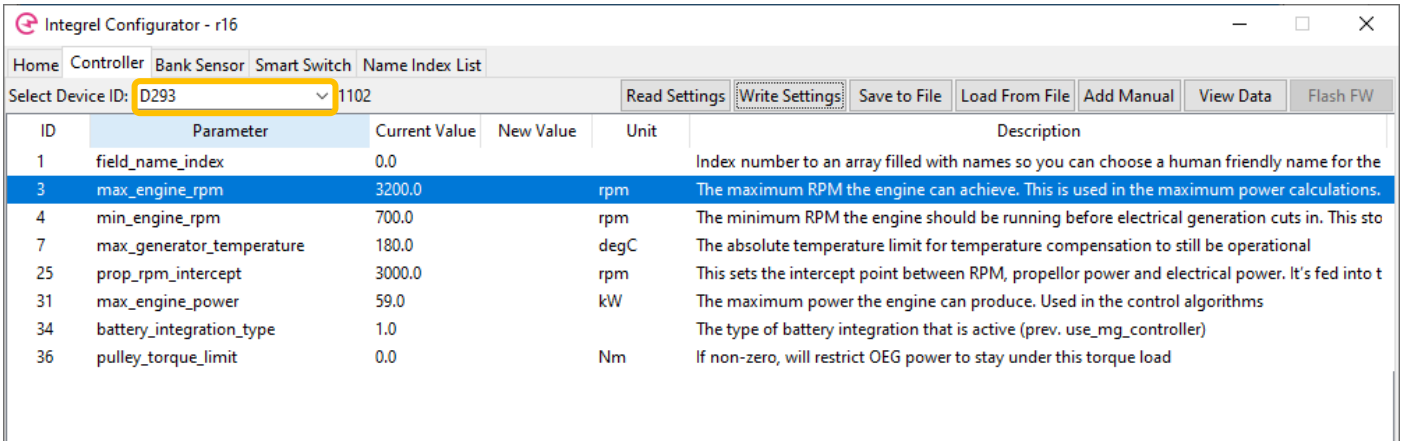
To configure devices, use the tabs along the top of the window to select devices as shown in the following screen capture (red arrow).



1. Select the Integrel device using the tabs: Controller, Bank Sensor or Smart Switch (marked with a red arrow in the screen capture)
2. Once the tab has been selected, choose the device ID using the drop-down box (outlined in in orange).
3. Once a device has been selected, select 'Read Settings'.
4. After settings are read, they appear in the 'Current Value' column

Note that 'Name Index List' tab displays an index of pre-defined and ID numbers used to configure device names (for reference only).

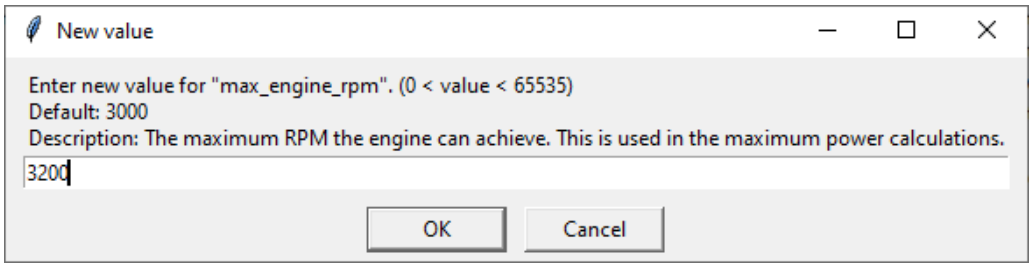
7.5 Write Settings



To write settings, select the relevant device in the 'node ID' box (outlined in orange).

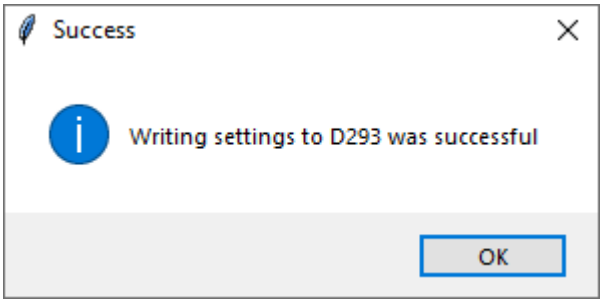
Double-click the setting (Parameter) that you want to change (e.g. max_engine_rpm); a pop up appears, see the following image. The popup provides information showing minimum, maximum and default values for the setting.

Enter the new setting in the entry field and select 'OK'.



Once accepted, the setting appears in the column marked 'New Value'.

To write the new setting to the device, select the 'Write Settings' button.



After the settings are successfully uploaded to the device, a pop-up appears and the new value moves to the 'Current Value' column.

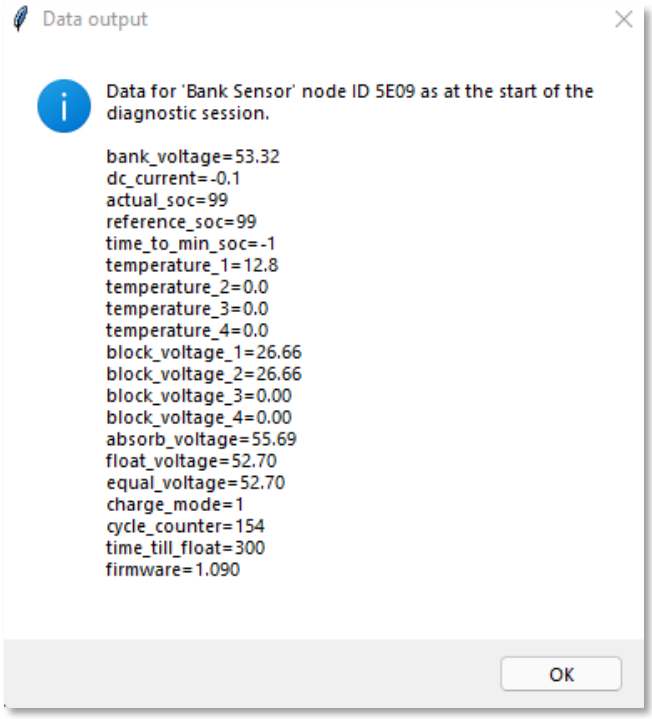
NOTE!

To ensure that settings are installed correctly, and the system runs properly:

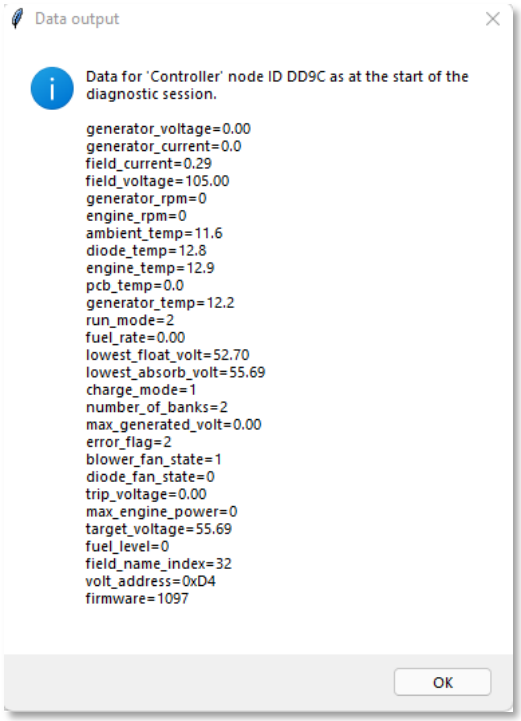
- Don't forget to select the 'Write settings' button, then check settings have uploaded properly
- Ensure all settings are cross-checked with battery and engine data from manufacturers

7.6 Read Device Data

To read data captured by a device at the beginning of the session, first select the device, then select the 'View Data' button; a dialogue box opens showing a data snapshot. Examples for a Bank Sensor and Controller are shown in the following screen captures.



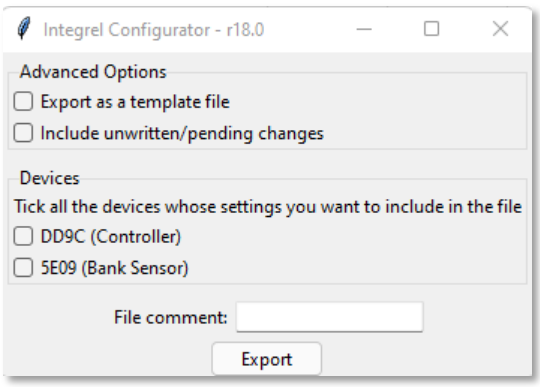
Data Snapshot : Bank Sensor



Data Snapshot : Controller

7.7 Save and Load Settings

Configuration settings can be saved to file on your computer for use in a later session. This is useful for configuration of additional systems with identical settings in the future. To save settings to a file, use the 'Save to File' button to save a copy of the current settings configuration; a pop-up appears as shown to the right .

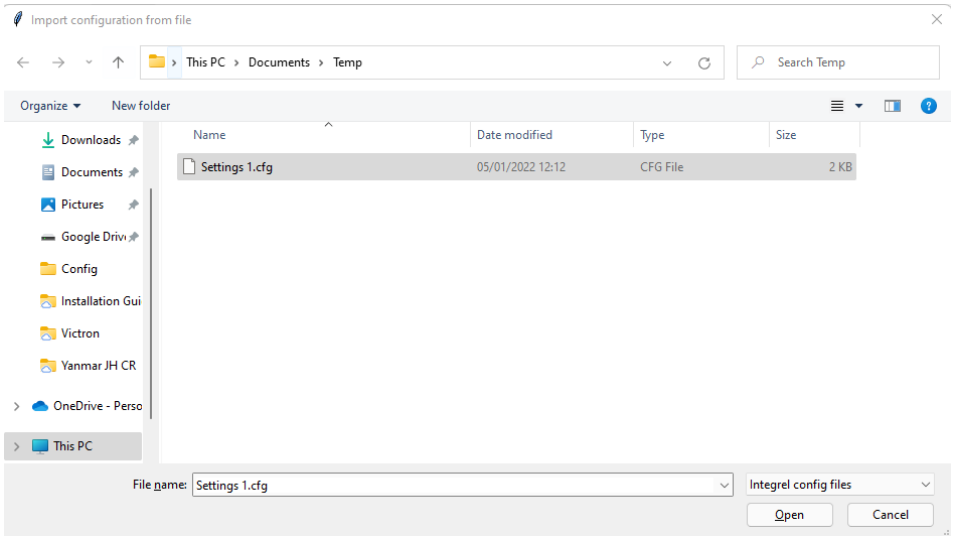


Select the devices you want to save by checking the relevant device IDs, then select the 'Export' button.

A file manager dialog appears.

Enter a filename and select a relevant location to save the file, then select 'Save'.

To load settings from a previously saved file, select the ‘Load from File’ button, a file manager dialog appears.



Select the relevant configuration file to load and then select ‘Open’.

Settings that are read from the file appear in the ‘New Value’ column.

Select ‘Write Settings” to write the settings to the system connected to the computer.

7.8 Controller Settings

This section contains specific information and guidance related to key Controller settings.

Setting	Default	Units	Description	Range
field_name_index	0	-	Number corresponding to a human friendly name for the Generator connected to a Controller. 31 = Integrel Generator 32 = Port Integrel Generator 33 = Starboard Integrel Generator	31 - 33
maximum_engine_RPM	3000	RPM	Sets the maximum RPM of the Generator See engine data at the end of this chapter.	0 - 65535
minimum_engine_RPM	700	RPM	Sets the minimum RPM of the engine before electrical generation starts. This avoids the Generator loading the engine at low RPMs which could cause the engine to stall. Lower kW means higher cut in.	0 - 65535
maximum_generator_power	9000	W	Sets the maximum Generator power output. May need to be lowered due to engine type and loading.	0 - 9000
nominal_generator_temperature	100	°C	The nominal temperature limit for the generator. This value may need to be reduced if there is poor ventilation around the engine.	0 - 180
maximum_generator_temperature	180	°C	The maximum temperature limit for the generator. This value may need to be reduced if there is poor ventilation around the engine.	0 - 200
max_generator_current	170	AMP	This is used to scale back the max current produced. Sometimes used with smaller battery banks with low capacity or to safe charge ultra-low capacity battery banks.	0 - 170
prop_RPM_intercept	3000	RPM	Sets the intercept point between RPM, propeller power and electrical power. See section below for info.	0 - 4000
maximum_engine_power	38	kW	The maximum power produced by the engine. Used to optimise power generation.	0 - 655
pulse_to_rpm_ratio	7.700		Can be tweaked if required, this setting rarely needs to be changed.	0-65
use_mg_controller	0	-	Used for MG batteries only; controls whether to respect the MG BMS charge limits. 0 = Not used / 1 = MG BMS used	0 / 1
pulley_torque_limit	0	Nm	If not Zero, restricts OEG power to stay under this torque load	0.0-255.0
j1939_enabled	1	-	Enables communication using J1939. J1939 adapter must be installed to use this setting. 0 = Not enabled / 1 = Enabled	0 / 1

7.8.1 Cooling Settings

Generator temperature settings need to be adjusted to suit nominal and maximum temperature depending on engine space, cooling, and ventilation. Installations with poor ventilation need lower temperature settings, well ventilated installations can be configured with higher temperature settings; see the following examples.

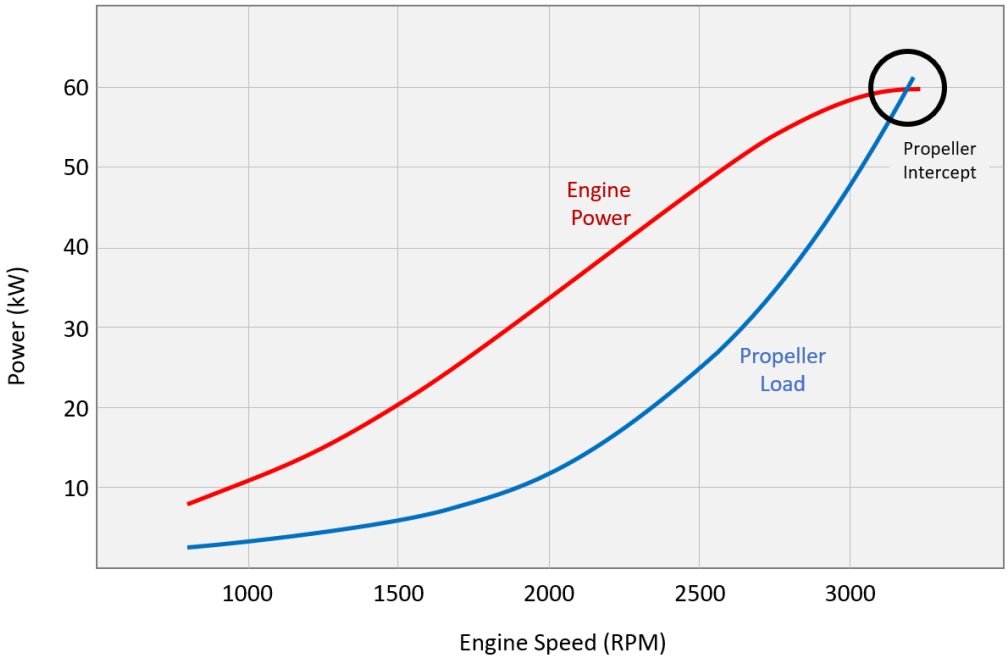
Compact – Poor ventilation

Spacious – Well ventilated

Setting	Poor Cooling (°C)	Moderate Cooling (°C)	Good Cooling (°C)
nominal_generator_temperature	100	120	120
maximum_generator_temperature	150	160	180

7.8.2 Propeller Intercept

The 'propeller intercept' occurs when the power output by the engine equals the load placed on the engine by the propeller. The concept of propeller intercept is shown in the following graph.



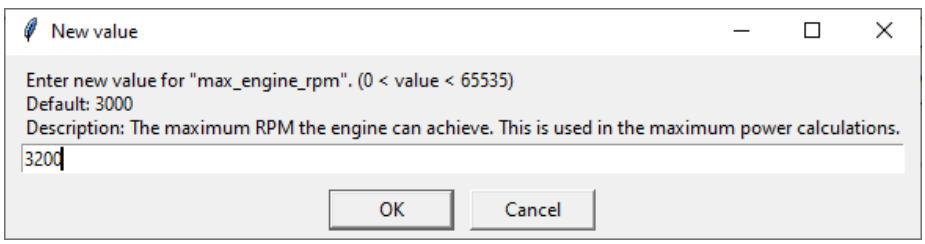
This calculation is made for each boat. The calculation depends on variables including engine power, hull shape, propeller pitch, drag and wind speed. An estimate of 3000 RPM is typically used, however the propeller intercept figure should be obtained from the boat manufacturer where possible.

7.8.3 Engine Settings

Manu-facturer	Engine Model	Min RPM	Max RPM	Max Engine Power (kw)
Yanmar	4JH45 CR	700	3000	33
Yanmar	4JH57 CR	700	3000	42
Yanmar	4JH80 CR	700	3200	59
Yanmar	4JH110 CR	700	3200	81
Yanmar	3JH40 CR	700	3000	29
Yanmar	4JH5E	700	3000	40
Yanmar	3JH5E	700	3000	29
Yanmar	6LY400	700	3300	294
Yanmar	6LY440	700	3300	324
Yanmar	8LV	700	3800	272
Yanmar	4LV	700	3500/3500/3500/3800/3800	150/170/195/230/250
Volvo	D2 40	700	3200	28
Volvo	D2 60	700	3000	44
Volvo	D2 75	700	3000	75
Volvo	D3 110/150/170/200/220	700	3000/3000/4000/4000/4000	81/110/125/147/162
Volvo	TMD22	700	3500	57
Vetus	VETUS M40	700	3000	30
Beta	BETA 75	700	2600	56
Beta	BETA 90	700	2600	67

7.9 Default Settings

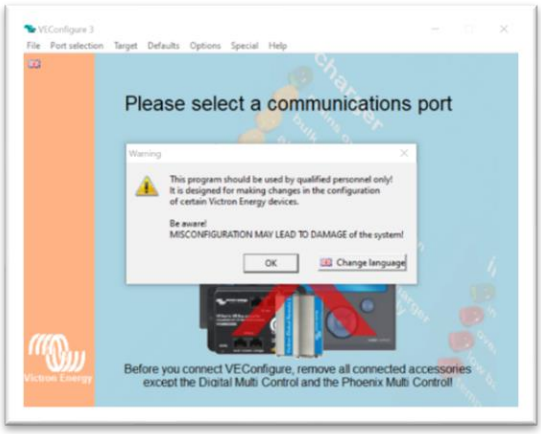
Use the Integrel Configurator to view defaults and limits for any setting. When a setting is selected, the ‘New Value’ dialog box shows the default, minimum and maximum values for the setting.



7.10 Settings for Victron Quattro / Multiplus II

To setup a Victron Quattro or Multiplus II inverter/charger, obtain and read the respective installation manual provided by Victron. Victron provides the MK3 USB serial tool (hardware) and VE config tool (software) to facilitate setup.

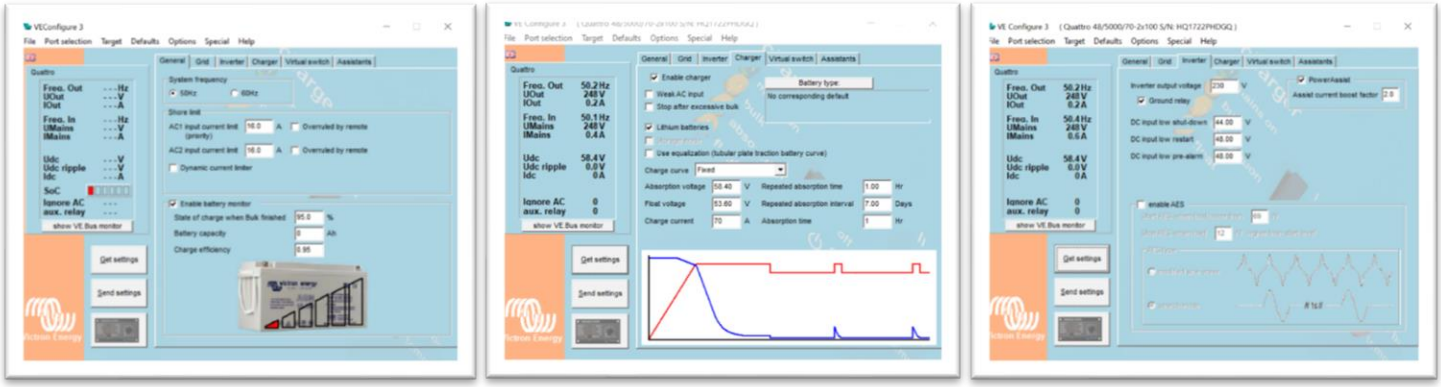
7.10.1 Using the Victron VE Config Tool



STEP 1. Run the VE Config tool; if a warning appears, press OK (see the following screengrab)

STEP 2. Select the menu item:
Port Selection | Com port | Auto detect

STEP 3. After auto connection completes, the following screens appear. Note the different tabs for settings.



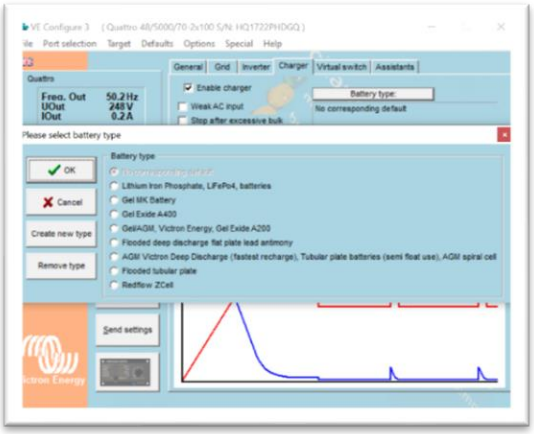
STEP 4. Change the settings in the inverter and charger tabs as described in the following table.

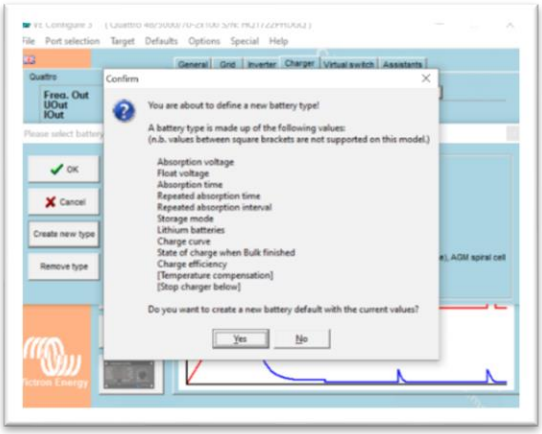
Setting Name	Value	Description
Bulk Voltage	Match the Banks Sensor settings	Target voltage for the batteries to be charged to 100% of capacity
Float Voltage	Match the Banks Sensor settings	Target voltage for the batteries to maintain charge

DC input low shut-down	Set higher than the Smart Switch to prevent the switch disconnecting before the Inverter disconnects. For example:
	`Quattro → 44.5V`
	`Smart Switch → 44.0V`
		The inverter/charger shuts down when the voltage drops below this voltage.

Setting Name	Value	Description
DC input low restart	`48V` (typical)	When the battery voltage rises above this voltage, the inverter starts to operate
DC input low pre-alarm	Match the Integrel low-voltage alarm (but may be set at a slightly higher voltage if desired)	When the battery voltage drops to this value, the Victron screen displays an alarm

STEP 5. Finally, the battery type needs to be configured as shown in the following screen captures.



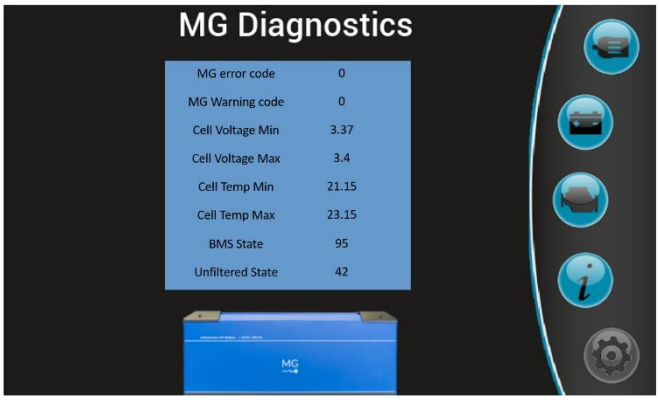


7.11 MG Energy Systems Integration

When using a MG master LV BMS, you will need to set up the wiring per the description in the MG Master LV integration section of the Installation section.

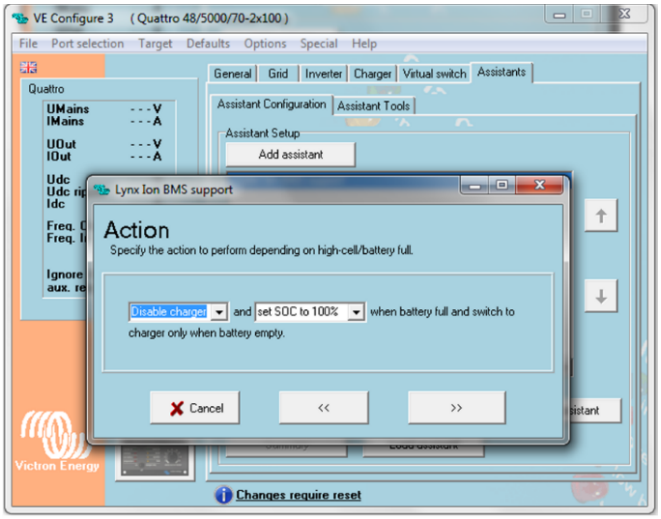
When inputting settings, be sure to configure the setting `use_mg_controller = 1`

Once confirmed, the system automatically connects to the MG system.



7.11.1 MG settings for the Quattro

Go to the charger tab and change the settings to the following: Set the absorption (bulk) voltage and float voltage to the value's specified in the table in Section 7.10.



7.11.2 MG CHARGER SETTINGS

The following table provides voltage settings for MG LFP 24 batteries.

Battery Type	Absorption Voltage (Volts)	Float Voltage (Volts)
Lithium-Ion LFP – MGLFP24XXX	55.2	53.2

8 COMMISSIONING AND TESTING

After the system has been installed and configured, a full review and test of the system must be performed. The following checklist provides a list of critical items that must be reviewed and tested. Follow the check list and review if necessary. This will ensure a safe reliable system is provided.

#	Item to Check	Check
1	**Check Connections & Wiring** Check that all 48V connections are correctly wired and tightened and confirm that all 12V, 24V and 48V grounds are tightened as well.	☐
2	**Disconnect Batteries** Ensure the batteries are turned OFF via a manual isolator switch (or the Smart Switch)	☐
3	**System Power-up** Turn the Integrel system on using the Integrel panel switch labelled 'Generator' or MCB depending on which method is used on the system. Using thermal imaging check the CAN (RJ45) network and 12V supply.	☐
4	**Review Power-up Issues** If there are any issues with the installation, the display may beep and display one or more errors. Common installation errors include incorrect or missing voltage or temperature sensors and cabling issues. Errors on the display will pinpoint as closely as possible the source of the fault; fix any faults before proceeding. 'Low system voltage' is an acceptable error, as this message means that all sensors are functioning correctly, but the main battery switches are open. This message will clear after Step 7.	☐
5	**Configure the System** Review all configuration items for the Controller(s), Battery Bank Sensor(s) and Smart Switch(es) and ensure the system is correctly configured. Disconnect the setup computer from the Integrel system interface before proceeding.	☐
6	**Connect Batteries** Turn the batteries ON via switch or isolator.	☐
7	**Check Battery Current** Using the Integrel display, review the current reading for each battery bank. For each bank in turn, apply a load (or charge input) to ensure the charge polarity is correct. When **discharging**, power displayed should be a **negative** kW number. When **charging**, power displayed should be a **positive** kW number.	☐
8	**Bank Sensor Polarity** If the current flow reads incorrectly on the screen (-2.123kW when charging would mean the polarity is wrong) the Bank Sensor is installed backwards. This can be corrected in Bank Sensor settings. To do this refer to the set-up guide and change the setting "polarity" to 1	☐
9	**Bank Sensor Current** Crosscheck the current with either a current meter or another display, like a Victron Cerbo GX If the current flow on the Bank Sensor(s) is incorrect, stop any charge or discharge going in or out of the relevant bank then press and hold the 'reset' button until the blue LED lights up. See Bank Sensor chapter on how to reset the sensor.	☐

#	Item to Check	Check
10	**DC/DC Converter Power-up** Switch the DC/DC converters on using the switch marked DC/DC on the Integrel panel switch.	☐
11	**Engine Start-up** Note that after brackets have been installed, it is important to check alignment. If this hasn't been done, then ensure you do this before running the engine. If the belt gives off dust or frays excessively then recheck alignment and retest. There is always a minor amount of dust given off at the beginning; this will subside once the belt has bedded into the pulleys. Start the engine. The engine page shows an RPM output, check this against the actual engine RPM. If it is not correct the pulley ratio may need to be tweaked, see Controller settings: pulse_to_rpm_ratio. **NOTE!** After the engine has warmed up, it is important to **retorque ALL bolts** used to fasten the Generator to the engine.	☐
12	**Charge Batteries** Charge the 48V batteries on shore power for at least 24 hours. This ensures the State of Charge (SoC) figures are correctly setup. Make sure the shore power charger takes the batteries into their float state. If they do not reach float, check the settings.	☐
13	**Disconnect Shore Power** Unplug the boat from shore power and leave unplugged for testing.	☐
14	**Load Test** Power on appliances to consume large amounts of power from the batteries. Thermal check terminals. Allow the battery State of Charge (SoC) to drop to around 70-80%.	☐
15	**Generator Charge Test** With the batteries still under load, start the engine and run at 1/3 to 1/2 throttle. The generated power output should peak between 8-9 kW. As the Generator heats up, the power output should drop slightly to 6-8 kW. If the engine compartment has poor ventilation, the generator may continue to run at a reduced power output to avoid overheating. In this case, additional ventilation in the engine compartment may be needed. Note that due to the manufacturing process you may see a slight difference in Generator ramp up. This is normal; there are a lot of factors that can affect the ramp up, including conductor lengths and cooling differences.	☐
16	**Thermal Connection Test** With the batteries under maximum load, check all 48V connections with a thermal imaging camera.	☐
17	**Perform Full-charge Cycle** Turn off all non-essential appliances and allow the system to complete a charge cycle. This may take an hour or more for a large bank of batteries. It is important to observe the system tripping to the float voltage shown on the battery page on the Integrel Display.	☐
18	**Perform Sea Trials** Use the engines to move the boat around the marina or take the boat for a short trip. Ensure the Integrel system cuts power generation each time engine speed (RPM) changes significantly; ensure there are no signs of engine overloading. After the system has been soak tested, recheck belts and **retorque ALL bolts**.	☐

9 ALARMS AND MESSAGES

Below is a list of alarms, warnings and error messages that may appear if there is a problem with the installation or system. Red (level 1) messages are higher priority critical messages, orange (level 2) messages are medium level warning messages.

9.1 Controller (Field Coil) Warning Messages

Message Displayed	#	Warning Level	Description	Solution
System voltage (48V) too high	1	1	48V supply on the controller/diode connections is above maximum.	Cross check the voltage using a multimeter. Check the circuit.
System voltage (48V) too low	2	1	48V supply on the controller/diode connections is below minimum.	Cross check the voltage using a multimeter. Check the circuit, check the batteries are switched on.
Generator output voltage too high	3	1	Voltage being produced by the Integrel generator is too high.	Cross check the voltage using a multimeter. Also check the settings are set correctly. Including the Controller setting: max_charge_voltage,
Generator output voltage too low	4	1	Voltage being produced by the Integrel generator is too low.	Cross check the voltage using a multimeter. Also check the settings are set correctly.
Safety voltage is being used	5	2	Controller has lost communication with bank sensors and so falls back to the 'safety_voltage'.	Check the bank sensor connection and that the internal LED is illuminated. Check the Bank sensor can be seen on the network by using, bank_sensor_detect.
			In earlier firmware versions <1.6 this could appear in rare cases when target_voltage briefly equalled safety_voltage	Change the Controller setting: default_float_safety_voltage Avoid changes larger than 0.3V
Output current too high	6	1	Generator output current above maximum	This is likely to be a Generator or PWM fault. Confirm by checking with a current meter.
Generator temperature too high	7	1	The temperature of the Generator is too high to produce power	This could be a sensor fault. Also check the Controller setting: max_generator_temperature
Generator temperature too low	8	2	The temperature of the Generator is too low to start to produce power	This could be a generator sensor fault. Also check the Controller setting: min_generator_temperature
Diode temperature too high	9	1	The Controller diode rectifier temperature is above maximum. Charging is suspended whilst this error is present.	Check the Controller fans are operating and can spin without obstruction. Ensure sufficient airflow around Controller. Check the setting max_diode_temperature
Controller temperature too high	10	1	As above - but this sensor is on the controller PCB	Check as above.
Engine temperature too low	11	2	The engine temperature is too low	Check the Controller setting: engine_start_temperature
Ambient temperature too high	12	2	Ambient temperature too high	If the temperature is not above 80°C, there could be a temperature sensor fault

Message Displayed	#	Warning Level	Description	Solution
Ambient temperature too low	13	2	Ambient temperature too low	If the temperature is not below 0°C then there could be a temperature sensor fault
Generator RPM not plausible	14	2	Estimated RPM calculated from generator pulses is higher than maximum engine RPM	This could be a problem with the RPM circuit on the PCB or a generator fault. Contact support.
ECU RPM Mismatch (check belt)	15	2	J1939 and engine RPM signal do not provide similar readings (only shows if J1939 engine RPM is used)	The serpentine belt may have snapped or is slipping,
Generator over power	16	1	Generator producing more power than maximum setting	May be a problem with the Controller RPM circuit or a generator fault.
Generator temperature sensor fault	17	1	Generator temperature sensor fault	Contact support
Diode temperature sensor fault	18	1	Diode temperature sensor fault	Contact support
Field coil fault	21	1	PWM has been requested/output by the Controller, but the generator is not producing power.	Check wiring, and generator for a plausible voltage on the field coil output pins. Check field coil fuse inside the Controller.
Bank sensor missing	22	2	The system has lost connection with the bank sensor(s)	Check the bank sensor connection and that the internal LED is illuminated. Check the Bank sensor can be seen on the network using the Integrel Configurator Tool.
BMS reported a warning	23	2	Battery integration – The BMS has reported a warning code	Provide the BMS warning code to support.
BMS reported an error	24	1	Battery integration – The BMS has reported an error code	Provide the BMS error code to support.
BMS Contactor Open	25	1	Battery integration - One or more contactors in the BMS are open	The BMS has opened the contactor. Check BMS for additional information.
BMS Comms Lost	26	1	Battery integration - communication with the BMS interrupted	Check connection to the BMS. Or check settings if no connection to a BMS is being used. Check the Controller setting: use_mg_controller

9.2 Bank Sensor Warning Messages

Message Displayed	#	Warning Level	Description	Solution
Missing voltage tap	1	2	There is a missing Vtap connection or the device class has been incorrectly set	The device class may be set incorrectly (14 = 48V, 17 = 24V, 18 = 12V) or a Vtap connection is in the wrong place. Use the Integrel Configurator Tool, select the Bank Sensor and View Data tab to check the Vtap voltage(s).
Missing temperature sensor	2	2	The battery temperature sensor is not connected	Check bank sensor loom wiring
Voltage tap backwards	3	2	A voltage tap connection is backwards	The device class may be set wrong (14 = 48V, 17 = 24V, 18 = 12V) or a Vtap connection is in the wrong place. Use the Integrel Configurator Tool, select the Bank Sensor and View Data tab to check the Vtap voltage(s).
Low battery voltage, please charge batteries	13	2	Bank voltage below configured minimum	If you believe this to be incorrect cross check with a multimeter. Check bank setting: warning_voltage

Message Displayed	#	Warning Level	Description	Solution
Disconnect voltage reached, please charge batteries	14	1	Bank voltage below configured disconnect	If you believe this to be incorrect cross check with a multimeter. Check bank setting: disconnect_voltage
Low battery state, please charge batteries / Low state of charge	15	2	Bank SoC below configured minimum (shown only if SoC display is enabled in this screen build)	Check the SoC setting: warning_soc
Disconnect charge level reached / Disconnect state of charge reached	16	1	Bank SoC is less than configured disconnect minimum (shown only if SoC is enabled in the screen build)	Check the SoC setting: disconnect_soc
Lithium max voltage exceeded	17	1	The battery bank voltage is above the configured maximum voltage.	If you believe this to be incorrect cross check with a multimeter. Check setting: li_max_voltage
Lithium min voltage reached, please charge batteries	18	1	The battery bank voltage is below the configured minimum voltage.	If you believe this to be incorrect cross check with a multimeter. Check setting: li_min_voltage
Lithium max discharge current exceeded	19	1	The discharge current is above the maximum setting for the battery bank	If you believe this to be incorrect cross check with a current meter. Check setting: li_max_discharge_current
Lithium max charge current exceeded	20	1	The charge current is above the maximum setting for the battery bank	If you believe this to be incorrect cross check with a current meter. Check setting: li_max_charge_current
Lithium max discharge temperature exceeded	21	1	The battery temperature sensor reported a temperature above the maximum discharge temperature setting	If you believe this to be incorrect cross check with a thermal imaging camera. Check setting: li_max_discharge_temperature
Lithium min discharge temperature exceeded	22	1	The battery temperature sensor reported a temperature below the minimum discharge temperature setting	If you believe this to be incorrect cross check with a thermal imaging camera. Check setting: li_min_discharge_temperature
Lithium max charge temperature exceeded	23	1	The battery temperature sensor reported a temperature above the maximum charge temperature setting	If you believe this to be incorrect cross check with a thermal imaging camera. Check setting: li_max_charge_temperature
Lithium min charge temperature exceeded	24	1	The battery temperature sensor reported a temperature below the minimum charge temperature setting	If you believe this to be incorrect cross check with a thermal imaging camera. Check setting: li_min_charge_temperature
Unknown battery type - check configuration	25	1	Battery manufacturer/model have not been set correctly	Check the bank sensor settings: battery_manufacturer, battery_model
High block divergence	26	1	Voltage difference between batteries in a series string exceeds 3 volts.	Cross check with a multimeter for a potential battery balancing issue. Re-balance the batteries by removing them and charging individually to float, then re-install.

9.3 Smart Switch Warning Messages

Message Displayed	#	Warning Level	Description	Solution
BMS signal 1 triggered (stop discharge)	1	1	'Stop discharge' signal transitioned from high to low	Check the device driving the stop discharge signal. If this signal is not in use, connect the input wire to DC ground. Unplug the Molex connector and RJ45. power the system down, reconnect the switch then power up the system.

Message Displayed	#	Warning Level	Description	Solution
BMS signal 2 triggered (stop charge)	2	1	'Stop charge' signal transitioned from high to low	Check the device driving the stop discharge signal. If this signal is not in use, connect the input wire to DC ground. Unplug the Molex connector and RJ45. power the system down, reconnect the switch then power up the system.
High current threshold exceeded	5	1	The high current threshold configuration has been exceeded	If triggered falsely, cross-check with a current meter then check the Smart Switch setting: high_current_disconnect
High ambient temperature exceeded	6	1	The high ambient threshold has been exceeded	If the temperature is not above 80°C, there could be a temperature sensor fault
Low ambient temperature exceeded	7	1	The low ambient threshold has been exceeded.	If the temperature is not below 0°C, there could be a temperature sensor fault
User has remotely disconnected switch	8	0	This is a signal from an IO.	
PANIC / Internal emergency disconnect received	9	1	A device on the Integrel Argo CANbus issued a PANIC disconnect message	
High battery temperature exceeded	10	1	The high ambient threshold configuration has been exceeded	If this has been triggered falsely, cross check with a thermal imaging camera, then check the Smart Switch setting: high_temperature_disconnect. Note this sensor should be connected to the battery terminal. During periods of high-power charge/discharge, terminals may heat up. Check terminal connections are not under- or over-tightened.
Low battery temperature exceeded	11	1	The low voltage threshold configuration has been exceeded	If this has been triggered falsely, cross check with a thermal imaging camera, then check the Smart Switch setting: low_temperature_disconnect.
Battery thermistor missing	12	1	The battery sensor is faulty or missing	Check the wiring loom for faults
Switch solenoid stuck on	13	1	The switch contactor is stuck in the closed position	During periods of high-power charge/discharge, switch contacts may fuse together. If the switch contactor will not open under manual control: disconnect the switch from power, remove the top and gently open the contactor with a flat screw driver. Apply a small dab of copper slip to the contacts to avoid this happening again.
Switch solenoid stuck off	14	1	The switch contactor is stuck in the open position	Try to close the switch manually
Discharge not allowed (MG)	21	1	MG LV Master BMS reported that discharge is not allowed. May only show when battery_integration_type is set to MG	Check MG Master LV BMS settings

10 INTEGREL SCREEN

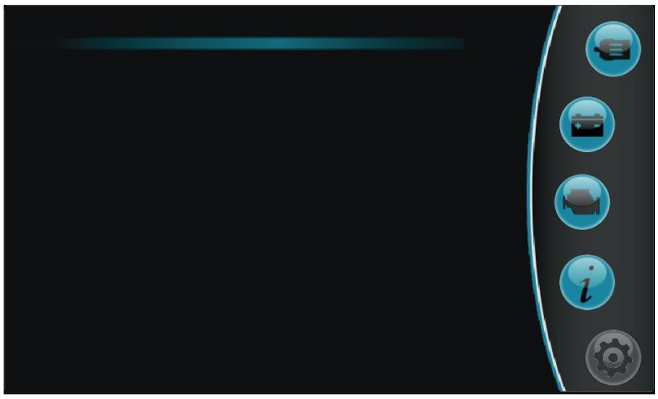
The Integrel screen provides a convenient way to view the state of the electrical power on the boat. It shows information about the main storage batteries, as well as other battery systems that are connected to the Integrel System including house banks and engine start batteries (if configured).

Various pages indicate how much power the Integrel Generator is producing, together with engine speed, energy usage by other systems as well as energy cycled into and out of the batteries.

In addition, the screen advises when it is time to recharge the main batteries by sounding an alarm and showing a warning icon. When the warning appears, connect to shore power or start the engine(s) to charge the batteries.

10.1 Menu System

The Integrel user interface is designed to be simple and easy to understand. Menu buttons are available to the right of the screen to provide access to each page of information. The menu button associated with a page is greyed out when the page corresponding to the button is displayed. Each menu button, together with a description of the corresponding page is shown below.



Generator Status and Information

Battery Status and Information

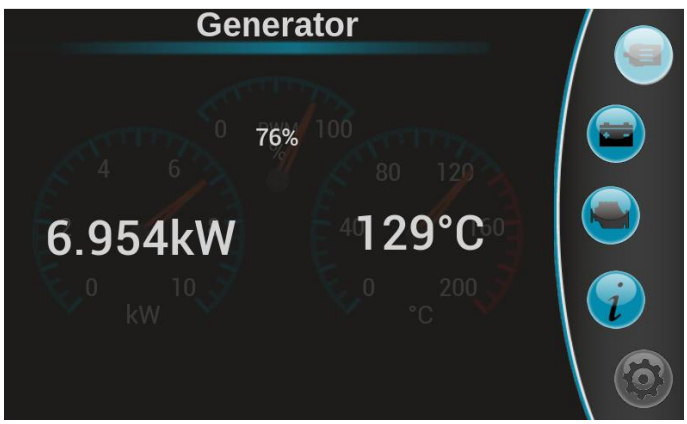
Engine Status and Information

System Summary

System Settings

10.2 Generator Status

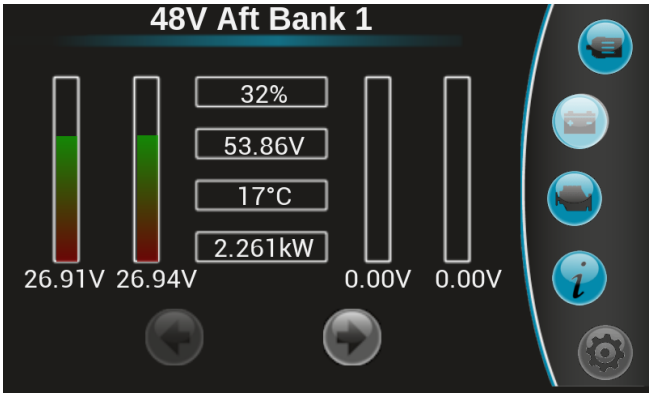
The following images show an example of the Generator Status and Information page. This page shows the power output in kW of each individual Generator. In a dual system, arrows at the bottom of the screen are available to select between the port and starboard Generator. Tap the screen to toggle the display format between analogue and digital.

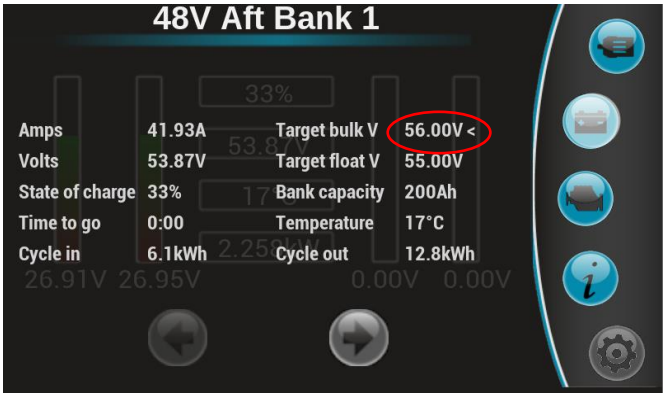


10.3 Battery Status Page

The following images show an example of the Battery Status page. Arrows at the bottom of the screen are used to scroll between banks. The display shows 12V, 24V and 48V banks. Tap the screen to toggle between a summary and detailed format. The detailed format indicates whether the system is charging to the bulk voltage or the float voltage by displaying an arrow (circled in red, below).

From top to bottom on the main page you will see SoC (State of Charge), Bank voltage, Battery temperature and power (in kW) in or out. Discharge will read -2.261kW and charging will read 2.261kW.



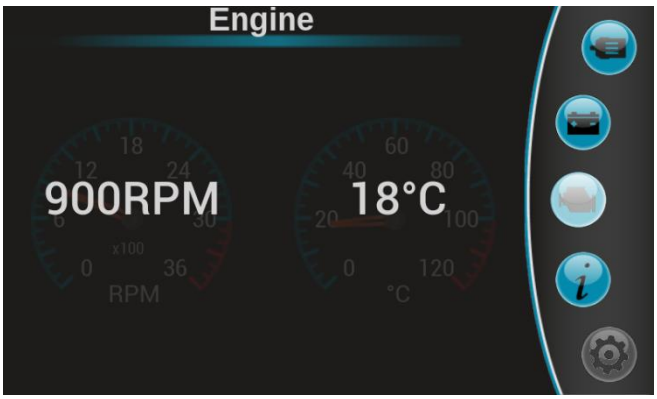


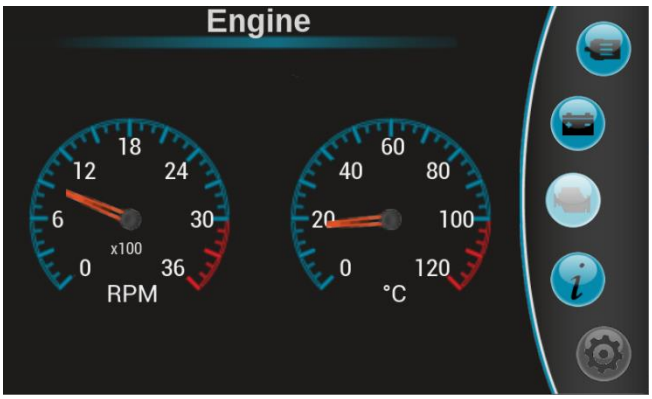
On the data page, the following information is shown:

1. **Amps**. The instantaneous current flowing into/out of the bank; a negative number means current is flowing out of the bank.
2. **Volts**. Voltage of the battery bank.
3. **State of Charge**. The state of charge of the battery bank (SoC display is firmware dependent).
4. **Time to go**. The time remaining until the battery bank is empty or charged; see the System Summary page for more information.
5. **Cycle in / Cycle out**. Energy the battery bank has received (Cycle in) or provided (Cycle out).
6. **Target Bulk / Target Float**. The target bulk voltage and target float voltage.
7. **Bank Capacity**. - The battery bank capacity in Amp-hours (Ah).
8. **Temperature**. – The temperature of the battery bank.

10.4 Engine Status

The Engine Status page shows the speed of the engine in RPM (revolutions per minute) and the temperature of the engine. On older engines, RPM is estimated using electronics connected to one of the Generator AC phase cables together with a pulley_ratio setting. On modern, electronically controlled engines, RPM is read directly from the engine electronics via the J1939 CANbus interface (if installed).

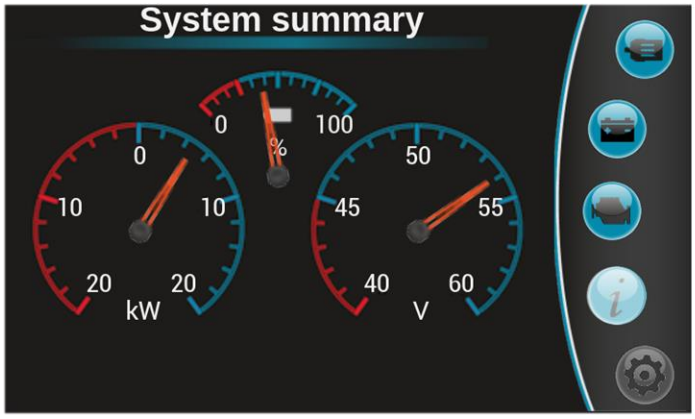




Tap the centre of the screen to show a digital version of the same information; tap again to return to the analog display.

10.5 System Summary

The System Summary page is displayed by default on power-up, however the System Summary page can be accessed at any time by pressing the 'Info' menu button.



The System Summary page shows:

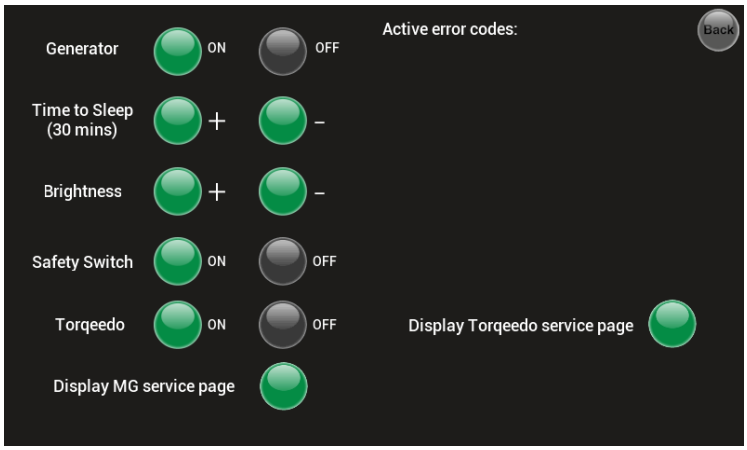
- Power being produced (or consumed) in kW
- Voltage of the 48V battery banks
- Estimate of battery State of Charge

The right-hand page will show a calculation of how long the batteries will take to reach full charge if charging and to reach disconnect voltage if discharging. This is calculated on the level of current being drawn or feeding into the battery banks.

Tap the screen to show 'Remaining time until full', which is an estimate of how long the batteries will take to reach 'full charge' if charging, or to reach the 'disconnect voltage' if discharging. The estimate is calculated based on the level of power flowing into or out of the battery banks; tap again to return to the analogue display.

10.6 Settings Page

Press the Cog menu item to open the Settings page. When the Settings page is displayed, the menu items are hidden to provide additional space to show settings. To return to the main menu, press the 'Back' button in the top right-hand corner of the page.



The Settings page can be used to change settings, read status and activate/and deactivate the Smart Switch. T also displays any warnings or alarms.

The information on the Settings page varies to match the installed hardware.

1. **Generator**. Turn the Generator ON or OFF. When ON, the Generator charges the batteries when the engine is on and only when needed.
2. **Time to sleep**. Activity timeout until the screen sleeps.
3. **Brightness**. Adjusts the screen brightness.
4. **Safety Switch**. Turn the safety switch on or off to connect or disconnect batteries (48V)
    a. **ON** = Switch closed (batteries connected)
    b. **OFF** = Switch open (batteries disconnected)
5. **Display MG Service Page**. Displays info from the MG Battery Management System (BMS)
6. **Display Torqeedo* service page**. Displays information about Torqeedo batteries.
7. **Torqeedo**. Switch Torqeedo batteries on or off.
8. **24V Switch**. Turn the 24V Safety Switch ON or OFF to disconnect/reconnect 24V batteries (if installed)

The Settings page displays buttons relevant to the components connected/configured. For example, if MG or Torqeedo are not connected, it will not display buttons related to either.

11 HANDOVER DOCUMENTATION

After installation is complete and the system has been fully tested, it is critical to schedule a customer acceptance handover and training session with the client. As part of the installation kit, Integrel provides a handover document to assist with this process.

Once handover and sign-off is complete, ask the client to add any personal comments and sign the document. It is important that a copy of all handover documentation is sent to Integrel to establish the end-user Warranty.

12 TROUBLESHOOTING

The following table contains a list of potential issues that may occur during fitting, testing and commissioning.

Issue	Possible Cause	Solution
Battery page: No battery data	No CANbus connection to Bank Sensor	Check the RJ45 cable is properly connected between the battery bank sensor(s) and the Integrel Argo CANbus network
Smart Switch not connecting	No CANbus connection to Smart Switch	Check the RJ45 cable is properly connected between the Smart Switch and the Integrel Argo CAN network
Battery page: Battery showing 0V	Battery voltage tap on backwards	Check the voltage taps are wired correctly. If backwards, voltages may be incorrect or zeroed out. See Bank Sensor set up for details.
Battery page: kW reading is backwards: negative (-) when charging positive (+) when discharging	The Bank Sensor is installed backwards	This can be reversed in settings to avoid the need to physically turn the Bank Sensor around on the conductor.
PWM at 100% but no power generation	Field coil fuse blown	Replace field coil fuse
	Generator failure	Contact Tech Support
PWM at 99% but low power generation	12V supply to the controller may be low.	Check 12V supply voltage of the house bank. If you have a 12V Bank Sensor monitoring the house bank, check it is showing >12.0
Engine RPM is incorrect	Pulley ratio set wrong	Set the pulley ratio correctly
RPM not showing on the screen	Phase connections	Check phase connections
	Loom fault	Check loom is not damaged. Check noise is not coupling into the loom from nearby cables.
	System in diagnostic mode	Disconnect USB or Bluetooth, cycle system power.
	Controller board failure	Contact Support
Screen shows "Max voltage exceeded"	Li-ion setting wrong	Check Li-ion settings

Issue	Possible Cause	Solution
Battery voltage dropping below cut out voltage.	A load device may have been connected between the Smart Switch and the battery bank.	Check the switch settings are correct and check wiring configuration. A single 24V nominal Lithium battery should never drop below 20V to avoid potential damage to the battery.
Engine seems to be overloaded	Pulley ratio incorrectly set	Set the pulley ratio correctly.
	Prop intercept incorrectly set	Set prop intercept correctly
	Max engine power set too high	Set maximum engine power correctly
	Min engine power set too low	Set minimum engine power correctly
Integrel Panel Switch keeps tripping	Faulty switch	Try a higher current rated switch, no more than 10 amps.
	Controller fault	Check the voltage to the Controller and that the PWM is wired correctly.

12.1 Controller LED Status

Three LEDs on the Controller indicate various operational states, warnings or error conditions. The following table documents the meaning of Controller LED indicator patterns. In most cases, status indicated by LEDS correspond with a warning displayed on the Integrel screen.

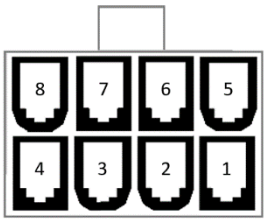
	Self check
	Normal Operation (Master)
	Normal Operation (Slave)
	Safety voltage active Bank Sensor missing BMS communications lost
	Generator temperature exceeded limit Ambient temperature exceeded limit Controller diode temperature exceeded limit Controller board temperature exceeded limit
	Generator RPM fault Engine communications lost Belt snapped
	System voltage exceeded maximum limit
	System voltage exceeded minimim limit Output voltage exceeded minimum/maximum limit Output current exceeded maximum limit Controller DC-DC fault
	Generator temperature fault Diode temperature fault
	Controller field coil circuit fault
	BMS contactor open

Controller LED Status Indicators

13 WIRING LOOMS AND PINOUTS

13.1 Bank Sensor

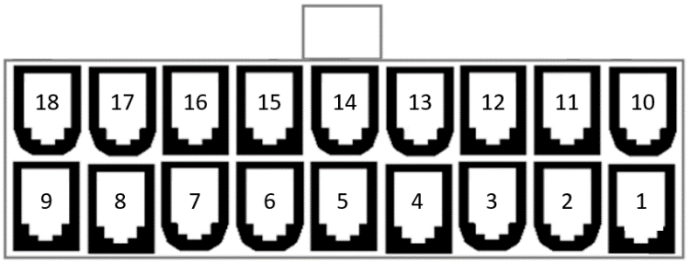
Front View



Pin #	Description
1	Battery Temperature –
2	Battery Temperature +
3	-
4	Voltage tap 0V
5	Voltage tap 12V
6	Voltage tap 24V
7	Voltage tap 36V
8	Voltage tap 48V

13.2 Smart Switch

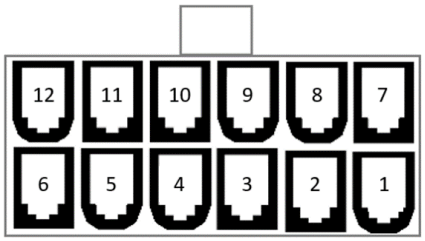
Front View



Pin #	Description
1	-
2	-
3	-
4	BMS 2 In
5	BMS 1 In
6	Temperature 2 0V
7	Temperature 1 0V
8	-
9	0V
10	-
11	-
12	-
13	-
14	-
15	Temperature 2
16	Temperature 1
17	-
18	48V/24V/12V In

13.3 Controller Signal (Field Coil)

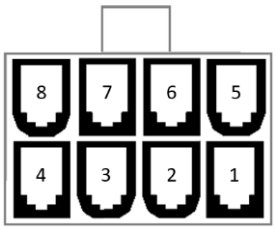
Front View



Pin no	Description
1	0V (Ground)
2	J1939 L / NMEA2K CAN L
3	In gear –
4	Engine Temp –
5	Ambient Temp –
6	Alternator Temp –
7	-
8	J1939 H / NMEA2K CAN H
9	In gear +
10	Engine Temperature +
11	Ambient Temperature +
12	Alternator Temperature +

13.4 Controller Power (Field Coil)

Front View



Pin #	Description
1	Field Coil (PWM) –
2	0V Ground
3	Sleep Sense –
4	Fan Switch 1
5	Field Coil (PWM) +
6	+12V In
7	Sleep Sense +
8	Fan Switch 2

14 ANNEX

14.1 Annex A – Battery Data

Battery Comparison														
Brand	Model	Capacity	Nominal Voltage	Bulk Voltage	Float Voltage	End of Discharge voltage	Disconnect Voltage	AH	Weight	Dimensions	Continuous Discharge	Continuous Charge	Cycles
MG Energy Solutions	LFP 25.6. 7.2kWh	7.2 kWh	25.60 V	28.2V	26.6V	22.4V	21.5V	280 Ah	53.0 Kg	652L x 294H x 193W mm	280.00 A	280.00 A	3,000
Victron	LiFePO4 Battery 25,6V/200Ah	5.1 kWh	25.60 V	28.4V	27V	22.4V	22.5V	200 Ah	53.0 Kg	317 x 631x 208 mm	200.00 A	100.00 A	3,000
Victron	LiFePO4 Battery 25,6V/200Ah	5.1 kWh	25.60 V	28.4V	27V	22.4V	22.5V	200 Ah	39.0 Kg	237 x650x163 mm	200.00 A	100.00 A	3,000
Mastervolt	MLI Ultra 24/5500	5.1 kWh	26.40 V	28.5V	27V	21V	21.5V	200 Ah	57.0 Kg	622x197x355 mm	500.00 A	60.00 A	3,500

14.2 Annex B – Conductor Guides

The following table contains a list of conductor recommendations for each part of the system where looms are not provided. In the event that a loom needs to be extended, always use like for like conductor material, thickness and colour.

All conductors must be sized in accordance with ISO 13297 or ABYC E-11 with appropriate ampacity de-rating for installation in engine compartments and bundling. Conductors must be sized for a maximum 10% voltage drop.

Usage	Type	Gauge
Battery conductor	Marine Tinned Battery Cable	Minimum 50 mm^2
All other DC power conductors including: 12V / 24V / 48V or other	Marine Tinned Cable	Minimum 4 mm^2
CAN bus cables RJ45	CAT 5 **FTP min or SHIELDED.** **Note!** Maximum length of 20 metres per connection	N/A

48V CABLE CALCULATION CHART (ALLOWANCE FOR 3% VOLTAGE DROP)

CURRENT FLOW

CABLE LENGTH	5A	10A	15A	20A	25A	30A	40A	50A	60A	70A	80A	90A	100A	120A	150A	200A	250A
0-2m	4mm²	4mm²	4mm²	4mm²	4mm²	4mm²	4mm²	6mm²	10mm²	10mm²	16mm²	16mm²	25mm²	25mm²	35mm²	50mm²	70mm²
3m						6mm²	6mm²	10mm²		16mm²		25mm²					
5m				6mm²	6mm²	10mm²	10mm²	16mm²	16mm²	25mm²	25mm²			35mm²	50mm²		
8m			6mm²	10mm²	10mm²		16mm²	25mm²	25mm²		35mm²	35mm²	35mm²	50mm²		70mm²	95mm²
12m		6mm²	10mm²		16mm²	16mm²	25mm²	35mm²	35mm²	35mm²	50mm²	50mm²	50mm²	70mm²	70mm²	95mm²	120mm²
16m				16mm²	16mm²	25mm²	35mm²	50mm²	50mm²	50mm²	70mm²	70mm²	70mm²	95mm²	95mm²	120mm²	150mm²
20m		10mm²	16mm²	25mm²	25mm²	35mm²	50mm²	70mm²	70mm²	95mm²	95mm²	120mm²	120mm²	150mm²	150mm²	185mm²	240mm²
24m	6mm²		16mm²														
30m																	

24V CABLE CALCULATION CHART (ALLOWANCE FOR 3% VOLTAGE DROP)

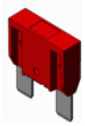
CURRENT FLOW

CABLE LENGTH	5A	10A	15A	20A	25A	30A	40A	50A	60A	70A	80A	90A	100A	120A	150A	200A	250A
0-2m	4mm²	4mm²	4mm²	4mm²	4mm²	4mm²	4mm²	6mm²	10mm²	10mm²	10mm²	16mm²	25mm²	25mm²	35mm²	50mm²	95mm²
3m							6mm²				16mm²					70mm²	
5m					6mm²	6mm²	10mm²	10mm²		16mm²	25mm²	25mm²		35mm²	50mm²		120mm²
8m				6mm²		10mm²		16mm²	16mm²	25mm²		35mm²	35mm²	50mm²	70mm²	95mm²	
12m			6mm²	10mm²	10mm²		16mm²	25mm²	25mm²	35mm²	35mm²	50mm²	70mm²	70mm²	95mm²	120mm²	
16m		6mm²	10mm²		16mm²	16mm²	25mm²	25mm²	35mm²		50mm²	70mm²		95mm²			150mm²
20m				16mm²	25mm²	25mm²		35mm²		50mm²	70mm²		95mm²		120mm²	150mm²	185mm²
24m		10mm²	10mm²	25mm²			35mm²		50mm²	70mm²		95mm²		120mm²	150mm²	185mm²	240mm²
30m	6mm²		16mm²		25mm²	35mm²	50mm²	50mm²			95mm²		120mm²			240mm²	300mm²

14.3 Annex C – Guide to Fuses

When installing fuses, ensure the correct fuse types are used for the circuit being fused. The following tables provide examples of fuse types and usage locations.

Note that the main fuse, closest to a battery or battery bank, must have an AIC rating in accordance with ABYC E-11; with lithium-ion batteries, this typically requires a Class-T fuse.

Based on 105°C wire Integrel ADVANCED POWER GENERATION & CONTROL	ATO	MAXI	MRBF	LINK	Class T
					
Wire gauge	2-30A	20-120A	30-300A	100-500A	110-400A
4mm²	25-30A	30-40A			
6mm²		40A	60A	60A	
10mm²		70-80A	80A	70-80A	
16mm²		70A	100A	100-125A	125A
25mm²			150A	125-150A	175A
35mm²			200A	175-200A	200A
50mm²			300A	250-300A	300A
70mm²				300A	350A
95mm²					400A

Fuse Locations and Types

Location	Types	Rating (Amps)
Battery to Busbar	MRBF / Link / Class T	200 – 400
Integrel Controller to Busbar	MRBF / Link / Class T	200 – 400
Busbar to DC/DC	MRBF / Link / Class T	30 – 400
Busbar to Inverter/Charger	MRBF / Link / Class T	30 – 400
24V and 12V Supply Systems	MAXI / MRBF / Class T	30 – 400
Positive voltage taps on Bank Sensor and Smart Switch positive taps.	ATO / MAXI	5
Busbar to Chargers	MAXI / MRBF	30 – 250

Integrel Solutions
Unit 1, Marine Renewable Energy Park
Hayle, Cornwall
UK
TR27 4DD
Phone: +44(0) 1736 755466
Web: www.integrelsolutions.com