Integrel solutions

INSTALLATION GUIDE

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Software Version 2.1.80

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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 recharged. Simple busbar connections are provided for all AC and DC voltages, and no changes are required to the downstream electrical system of a vessel.

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

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Marine Renewable Energy Park, Unit 1
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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. The equipment operator must have an appropriate skill level to minimise the risk of injury or equipment damage during installation and operation.

It is the responsibility of the operator of the equipment and components detailed in this manual to ensure that the equipment and components are used in the manner intended, are correctly installed, and are suitable for end-user requirements.

Integrel Solutions does not provide 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

Be aware of signs or symbols when installing and operating the system. The following examples indicate common signage; study the documentation to learn and understand each.

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 temperature material that ***can cause severe personal injury, death, or substantial property damage.***

2.2 Health and Safety during Installation

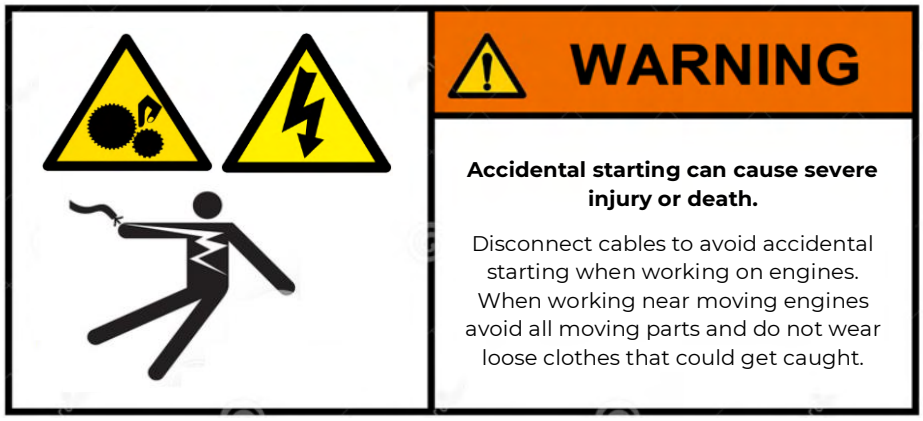
While installing this system, caution should be taken throughout the entire installation process. Installation of an Integrel system requires working with batteries, engines and some heavy lifting.

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.

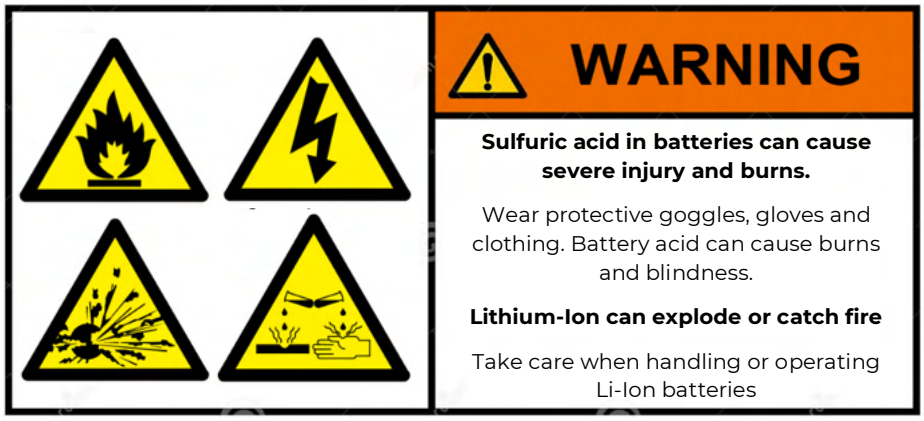
Utmost care must be taken when opening hatches and lockers. Make sure you remove or securely support hatches and lockers in a safe manner.

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.



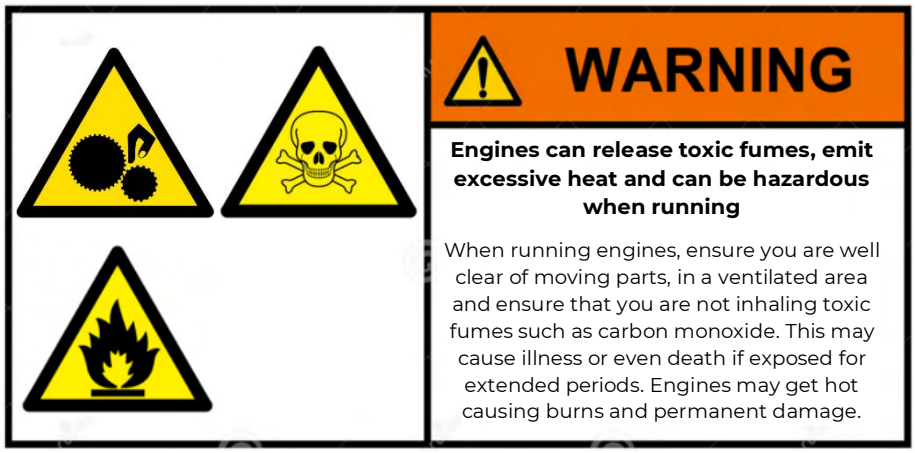
Explosive fuel vapours can cause severe injury or death. Take additional precautions when using petroleum gas, diesel, natural gas, butane, and propane.

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 belts and pulleys when the engine or generator is running. Replace guards, screens, and covers before operating the generator.

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. Plan ahead and 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 schematics in Section 5 provide examples of standard Integrel installations, please review them. Integrel provides a custom schematic for each installation; if you don't have a schematic for your system, please contact Integrel Solutions and we will create a schematic for you.

3.2 System Operation

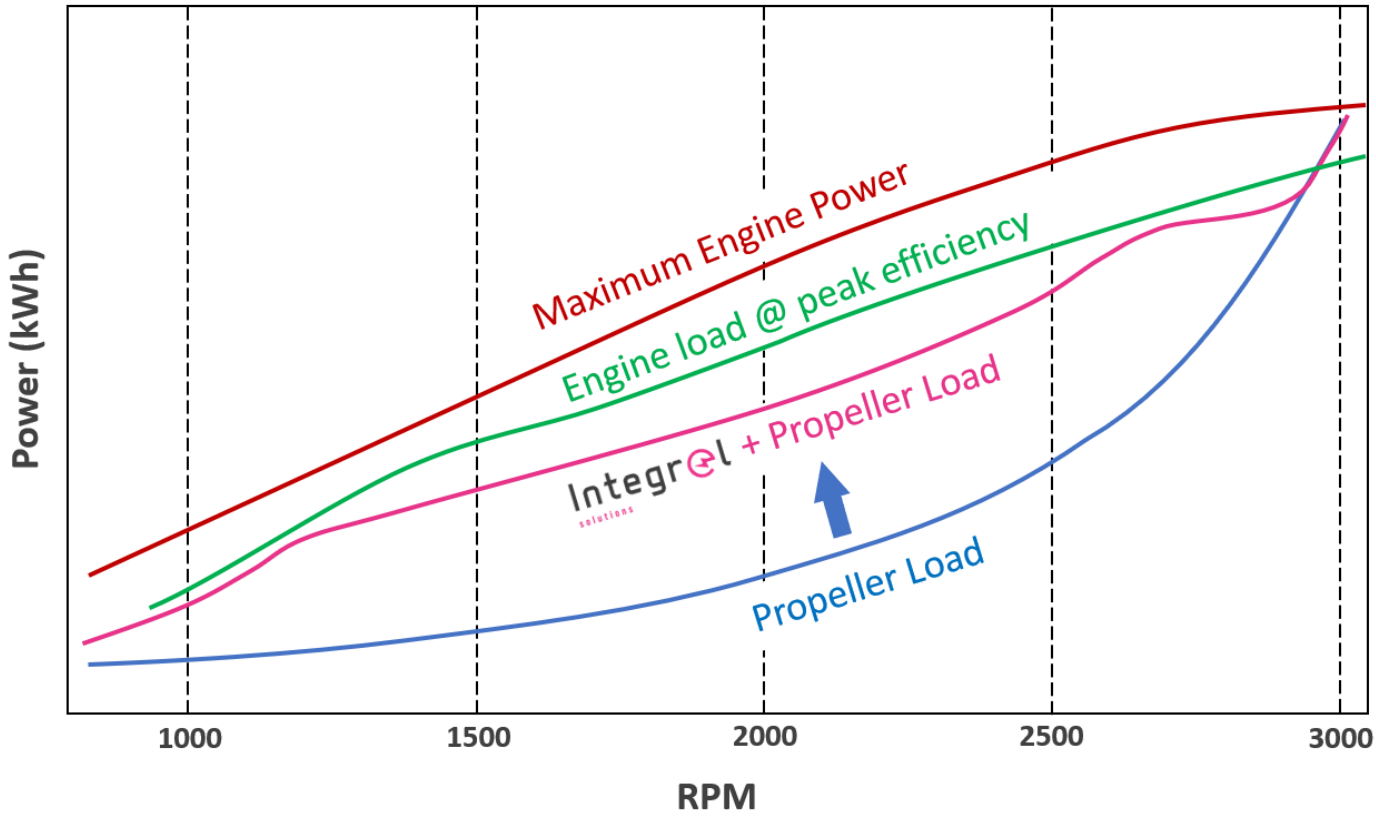
The information in this section is intended to help you understand how the system operates.

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 safety and redundancy as a priority. It is important to constantly manage and monitor the state of all batteries, including battery voltage, current and temperature.

3.2.1 Integrel makes the engine run more efficiently

The following graph shows how Integrel makes an engine run closer to optimal efficiency. Over nearly the entire RPM range, the propeller (blue line) uses much less power than the engine produces when running at optimal efficiency (green dashed line). When Integrel is generating, it adds a load to the engine in addition to the propeller load; the combined load (pink dashed line) is much closer to the optimal engine load. The result? The engine runs more efficiently AND generates large amounts of usable energy with closer to optimal fuel usage.



3.2.2 Power Control with PWM

Pulse Width Modulation (PWM) controls power (in kW) to charge the batteries. Typically, as the engine speed (RPM) increases, the PWM increases; although PWM also depends on various other factors including temperature, battery charge state, in-gear transitions, and rapid changes to engine speed.

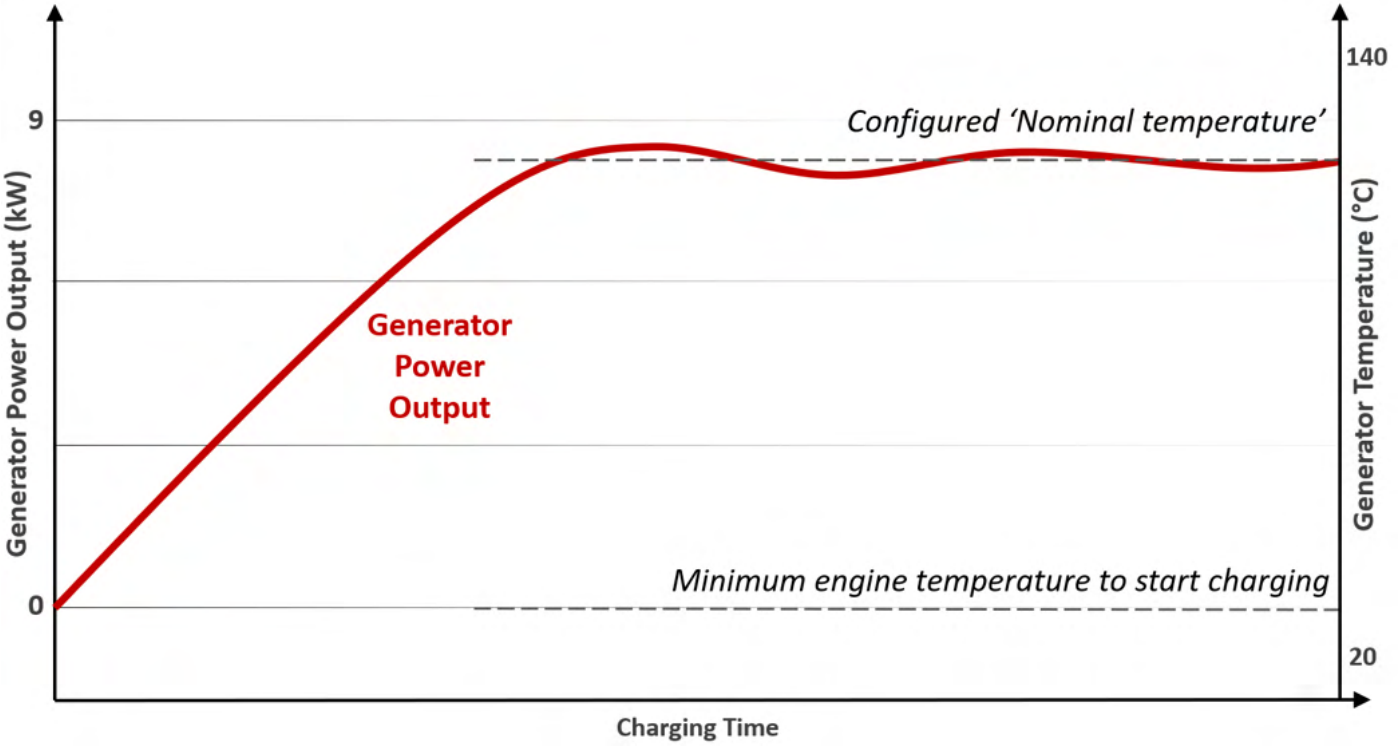
3.2.3 Power Generation vs. Engine Speed

As the engine speed (RPM) increases, the amount of charging power also increases. Under ideal conditions (low battery state of charge and cool temperatures) charging power peaks around 9 kW. At peak power output, the Integrel Generator starts to get hot.

3.2.4 Power Generation vs. Temperature

The Integrel Generator is air cooled and gets hotter as it generates more and more power. When the generator reaches about 110°C (230°F), the Integrel system reduces power output to limit the generator maximum temperature to 120-130°C (248-266°F).

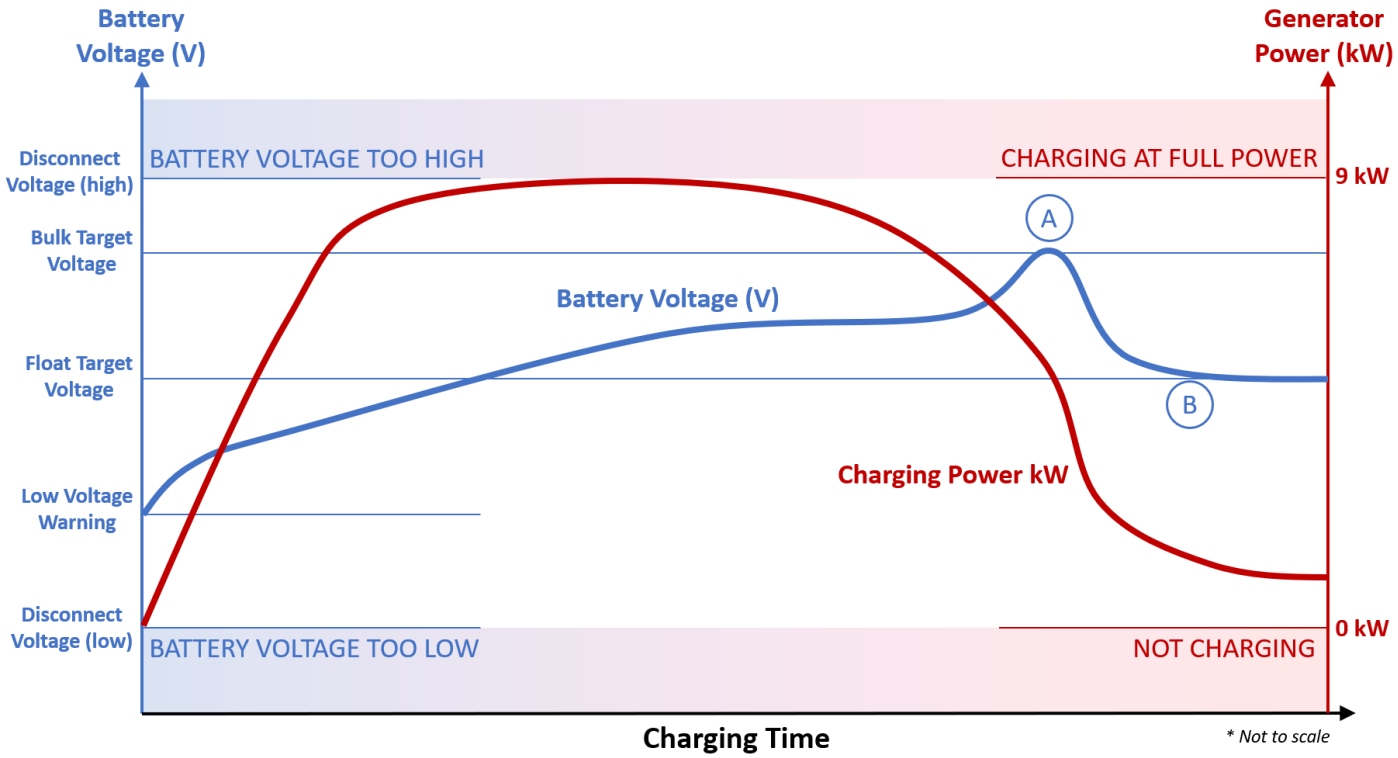
When the generator begins to cool, the charging power increases again. This cycle repeats until the batteries are fully charged.



3.2.5 Charging and Setpoints

The following graph illustrates 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, setpoints are marked corresponding to system parameters documented in Section 7 of this guide. Warning voltages display on the Integrel screen and disconnect voltages open the Integrel Smart Switch at these setpoints. This operation prevents the system over charging or discharging batteries which in turn avoids potential damage to the battery(s).



3.3 Integrel System Components

9kW On-Engine Generator (OEG)
The electrical power source of the Integrel System

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

Engine Mounting Kit
Each mounting 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 load if a safety or battery critical event occurs

Integrel Touchscreen
Monitors and controls the Integrel System, and allows viewing of engine and battery data

Integrel Junction Box
Provides a connection point for the Integrel (Argo) CAN bus network

Integrel Breaker Switch Panel
The panel switch is fitted with breaker switches to provide a way to power the system ON/OFF as well as act as a protection device

3.4 Third Party Equipment

On most systems, third-party equipment forms a significant part of the installation. It is advisable to follow the installation manuals and 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, Mastervolt and Lithionics.

3.4.2 External Battery Management System (BMS)

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

NOTE! Integrel strongly recommends the BMS is updated to use the latest software available from the manufacturer at the time of installation.

3.4.3 Battery Monitors / Displays

Most lithium battery brands supported by Integrel provide a dedicated display to indicate battery status including voltage, current and power status, warnings, errors, State of Charge (SoC) and more. Several examples are shown below.

Mastervolt EasyView 5

Victron Touch GX
(used with the Cerbo GX)

MG Energy Monitor

3.4.4 DC/DC Converters

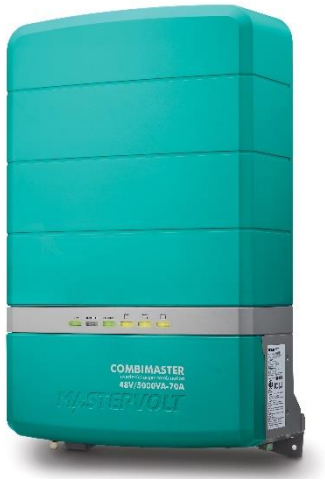
Most systems require one or more DC/DC converters to convert power from 48V to either 24V or 12V. Examples include Mastervolt and Victron DC/DC converters shown here.

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 configured with an appropriate lithium charge profile.

NOTE! Victron Orion DC/DC converters can **NOT** be used to charge Lithium batteries!

3.4.5 Inverter/Chargers

Inverter/Chargers manage the conversion of DC/AC power and distribution of shore power throughout the vessel; they 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(s) as well as other related system components. In nearly all 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 Power Distributors

Power distributors are modular DC busbars used to connect batteries and power management devices. They are typically connected with the larger power management system and can be remotely monitored. Some distributors include fuses, others do not.

3.4.8 Simple Busbar

Busbar(s) are often used to connect conductors to together. They are used for safety circuits as well as common grounds. Always label each busbar clearly to denote which circuit it belongs 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 third-party equipment. See Annex D – Guide to Fuses for information 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 usage.

Cable Lugs
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

Ferrule Crimps
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 CAN bus 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 the manufacturer's website.

NOTE!

All devices must be installed 500mm above the 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
- Auxiliary battery banks including 12V, 24V, house batteries, thruster batteries etc.
- Shore power supply systems
- Electrical thrusters, including power supply batteries
- DC/DC converters for 12V and/or 24V
- Any 110VAC and/or 230VAC supply systems
- Domestic systems
- Air conditioning systems
- Inverter chargers
- Wind turbines
- Multi-Functional Displays (MFD) such as B&G, Simrad, Garmin, etc.
- Any devices connected to the NMEA 2000 backbone

4.3 Batteries

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 with sufficient air circulation. Lithium-Ion batteries automatically disconnect if their internal temperature exceeds a safety threshold, which in some cases may be as low as 45°C (113°F). 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.

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 should 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 provided in Annex C – Conductor Guides. 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 conductors should be run separately (if possible) to minimise coupling of electrical 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. 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 mounting 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 during normal operation. If the Controller overheats, the system shuts 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 Touchscreen

The Integrel Touchscreen can be mounted remotely from other system components but should be positioned in a location where any alarms can be heard. If the Integrel system is connected to a third-party multi-function display (MFD) configured to display Integrel operational data including alarms and warnings, then the Touchscreen may be located in a more discrete location.

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 though the Smart Switch can be operated remotely with the Integrel Touchscreen, it is advisable to place the switch in a location where it can be easily accessed. 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 system should always remain on, therefore the panel switch 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 from the 12V power supply whilst generating. DC/DC converters should also be switched off using the panel switch should the boat be left for long periods 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 accumulation. 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 to power lower voltage appliances and/or charge 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 24V/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 D – Guide to Fuses 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

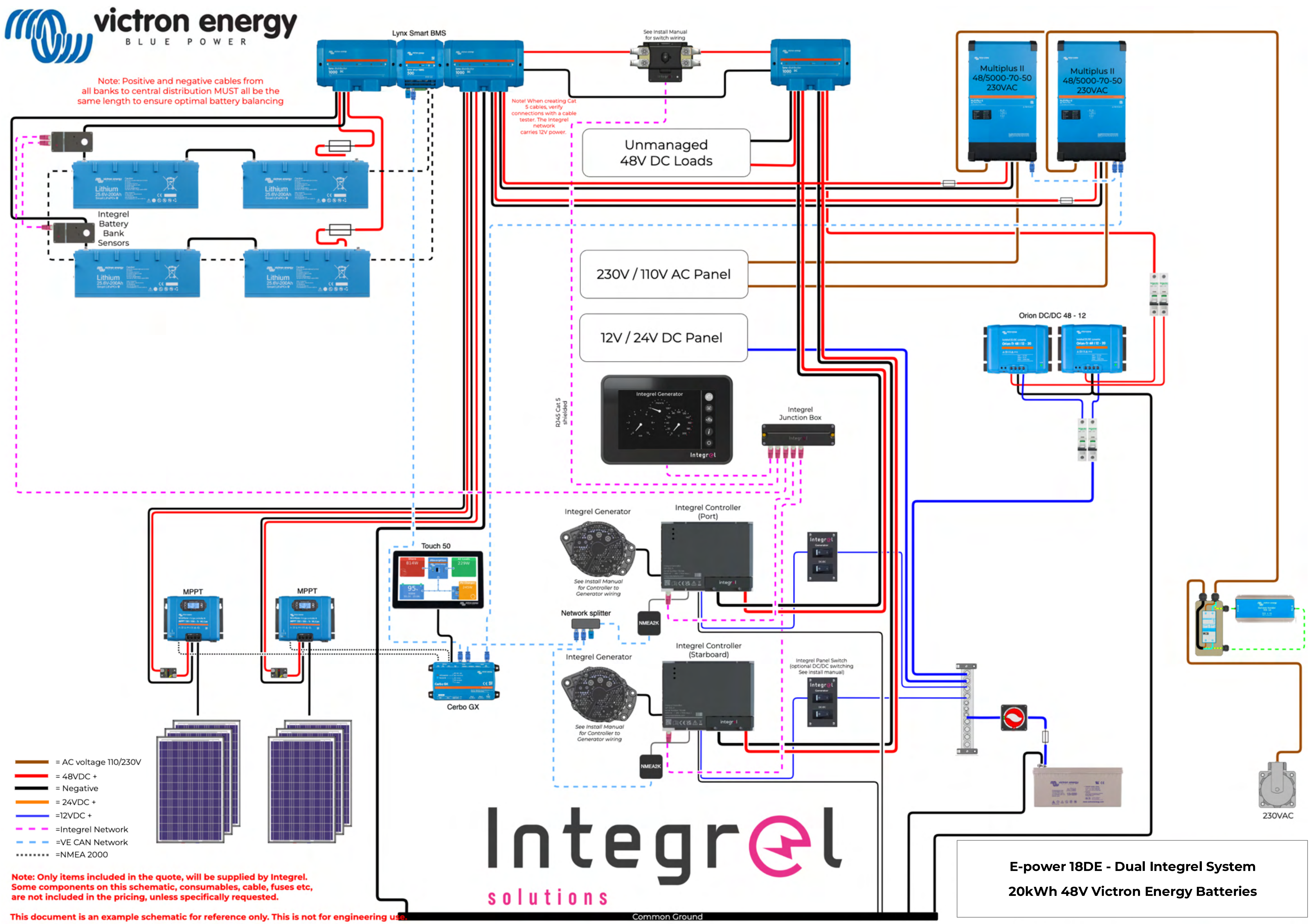
This chapter provides information to describe system wiring.

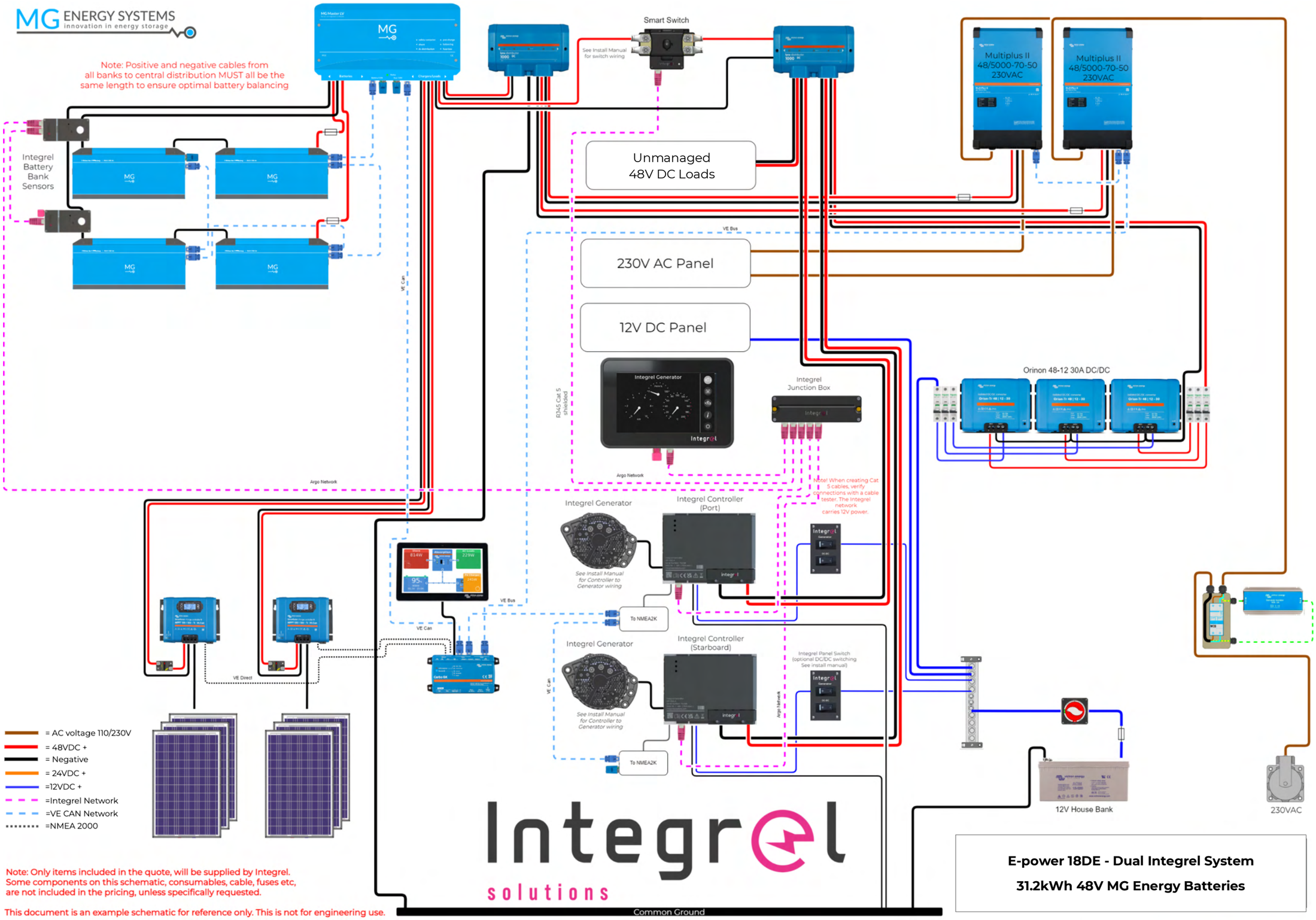
Integrel equipment is supplied with wiring looms that are labelled to aid installation. Loom pinouts are documented in Section 13.

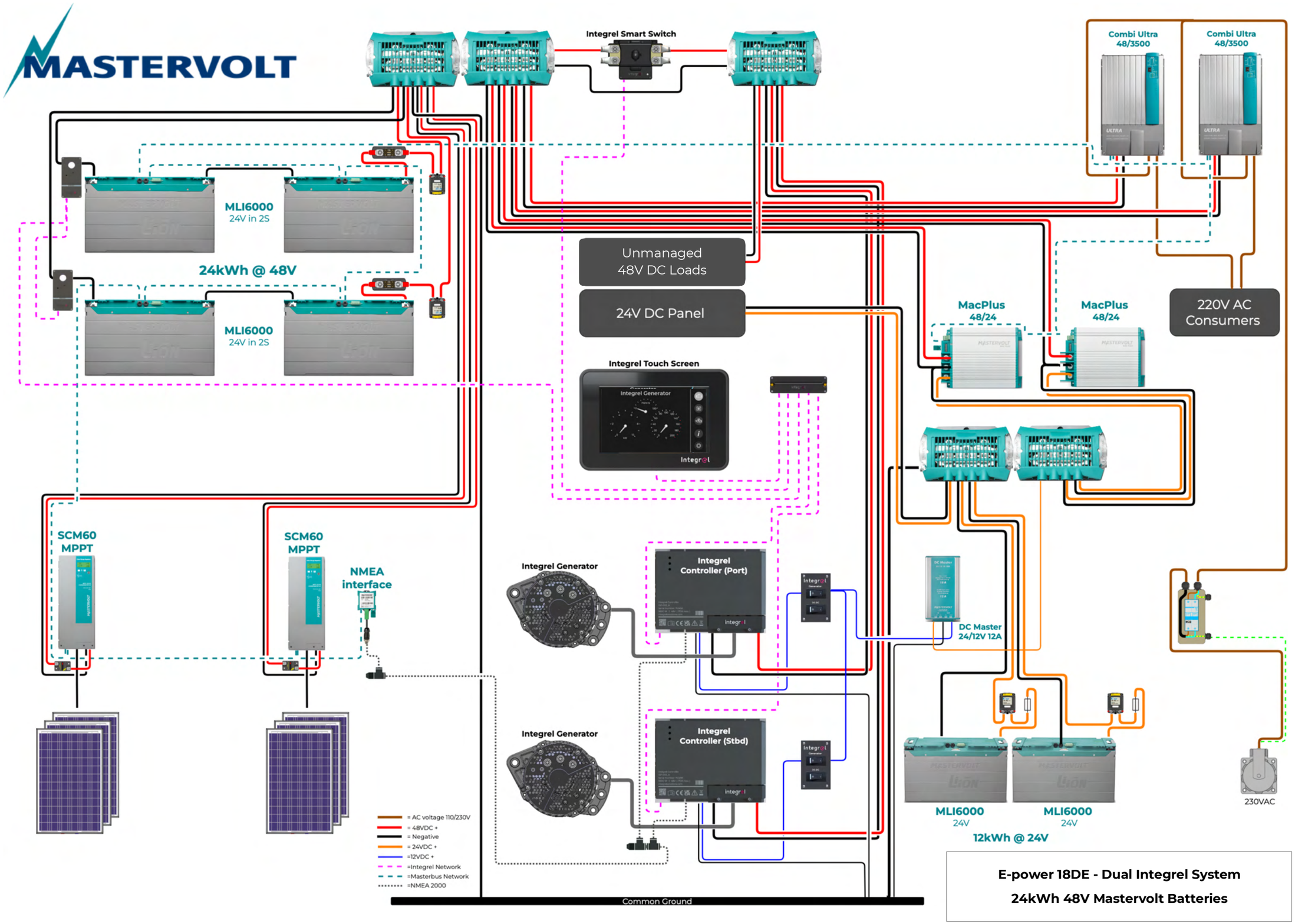
The schematics on the following pages provide several examples of typical Integrel system installations. The major system components shown in these example are:

- Dual Integrel system
- 48V battery banks
- Battery Bank Sensors to monitor 48V battery banks, but also 12V/24V Lithium or Gel/Flooded
- Inverters, used to convert 48V DC to mains to power domestic loads including air conditioning
- DC/DC converters for charging any auxiliary 12V/24V battery banks
- Solar panels and MPPT charge controllers
- MCBs (circuit breakers) and consumer units

NOTE!
The following schematics do not include fuse types, locations, and conductor diameters. Please see Annex D – Guide to Fuses for information on fuses and fuse locations.


victron energy
BLUE POWER
Note: Positive and negative cables from
all banks to central distribution MUST all be the
same length to ensure optimal battery balancing
Lynx Smart BMS
See Install Manual
for switch wiring
Note! When creating Cat 5 cables, verify connections with a cable tester. The Integrel network carries 12V power.
Unmanaged
48V DC Loads
Multiplus II
48/5000-70-50
230VAC
Multiplus II
48/5000-70-50
230VAC
Lithium
Integrel
Battery
Bank
Sensors
230V / 110V AC Panel
12V / 24V DC Panel
Orion DC/DC 48 - 12
RJ45 Cat 5 shielded
Integrel Generator
Integrel
Junction Box
Integrel Generator
Integrel Controller
(Port)
See Install Manual for Controller to Generator wiring
Network splitter
NMEA2K
Touch 50
MPPT
MPPT
Cerbo GX
Integrel Generator
Integrel Controller
(Starboard)
Integrel Panel Switch
(optional DC/DC switching
See install manual)
See Install Manual for Controller to Generator wiring
NMEA2K
230VAC
= AC voltage 110/230V
= 48VDC +
= Negative
= 24VDC +
=12VDC +
=Integrel Network
=VE CAN Network
=NMEA 2000
Integrel
solutions
E-power 18DE - Dual Integrel System
20kWh 48V Victron Energy Batteries
Note: Only items included in the quote, will be supplied by Integrel.
Some components on this schematic, consumables, cable, fuses etc,
are not included in the pricing, unless specifically requested.
This document is an example schematic for reference only. This is not for engineering use.
Common Ground

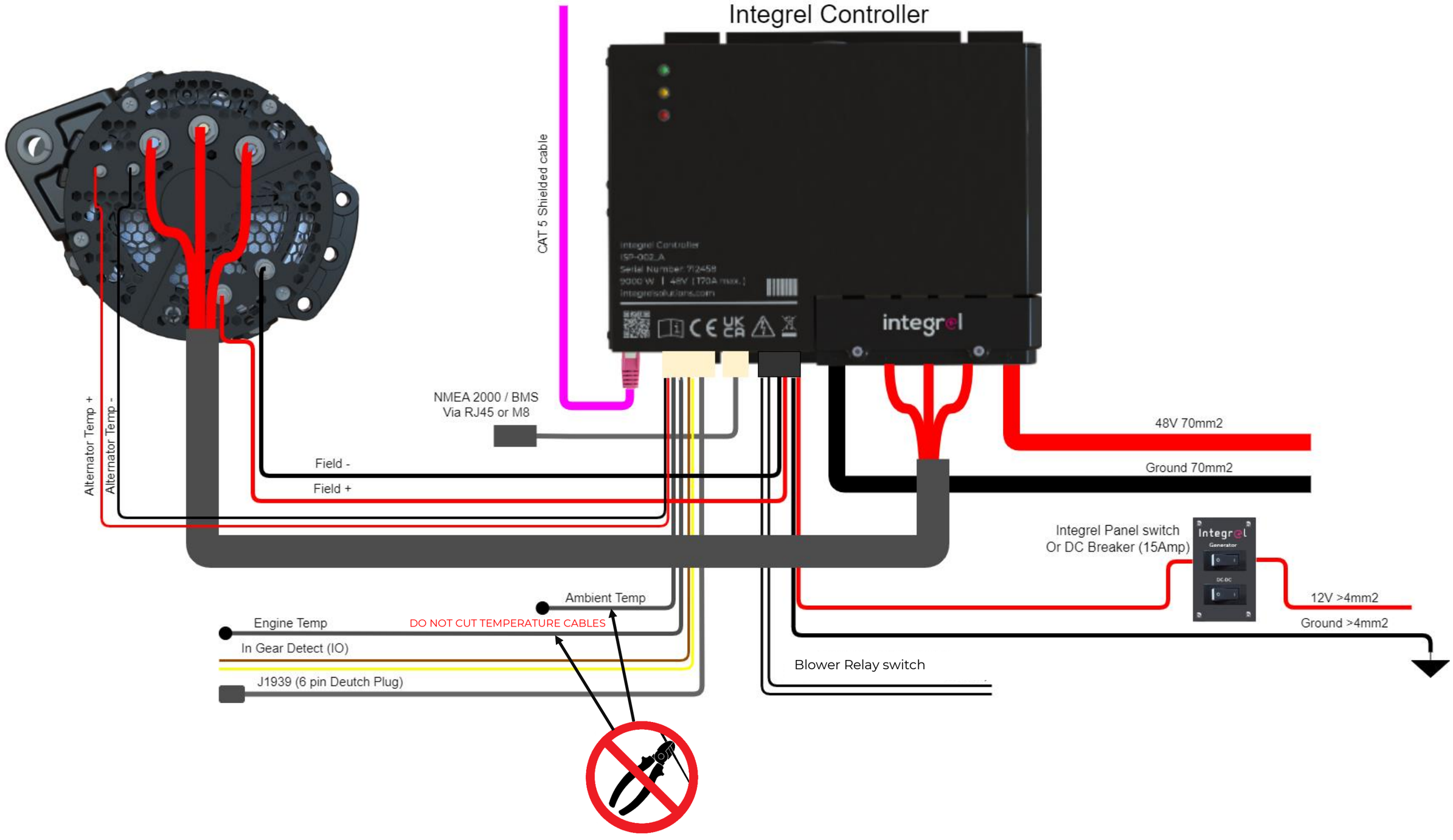

MG ENERGY SYSTEMS
innovation in energy storage
Note: Positive and negative cables from all banks to central distribution MUST all be the same length to ensure optimal battery balancing
Integrel Battery Bank Sensors
Smart Switch
See Install Manual for switch wiring
Unmanaged 48V DC Loads
Multiplus II 48/5000-70-50 230VAC
Multiplus II 48/5000-70-50 230VAC
VE Bus
230V AC Panel
12V DC Panel
Integrel Generator
Integrel Junction Box
Orinon 48-12 30A DC/DC
RJ45 Cat 5 shielded
Argo Network
Note! When creating Cat 5 cables, verify connections with a cable tester. The Integrel network carries 12V power.
Integrel Generator
Integrel Controller (Port)
See Install Manual for Controller to Generator wiring
To NMEA2K
VE Can
VE Bus
Integrel Generator
Integrel Controller (Starboard)
Integrel Panel Switch (optional DC/DC switching See install manual)
See Install Manual for Controller to Generator wiring
To NMEA2K
VE Direct
= AC voltage 110/230V
= 48VDC +
= Negative
= 24VDC +
=12VDC +
=Integrel Network
=VE CAN Network
=NMEA 2000
12V House Bank
230VAC
Common Ground
Integrel solutions
Note: Only items included in the quote, will be supplied by Integrel.
Some components on this schematic, consumables, cable, fuses etc, are not included in the pricing, unless specifically requested.
This document is an example schematic for reference only. This is not for engineering use.
E-power 18DE - Dual Integrel System
31.2kWh 48V MG Energy Batteries



E-power 18DE - Dual Integrel System

24kWh 48V Mastervolt Batteries

5.1 Wiring the Integrel Generator and Controller

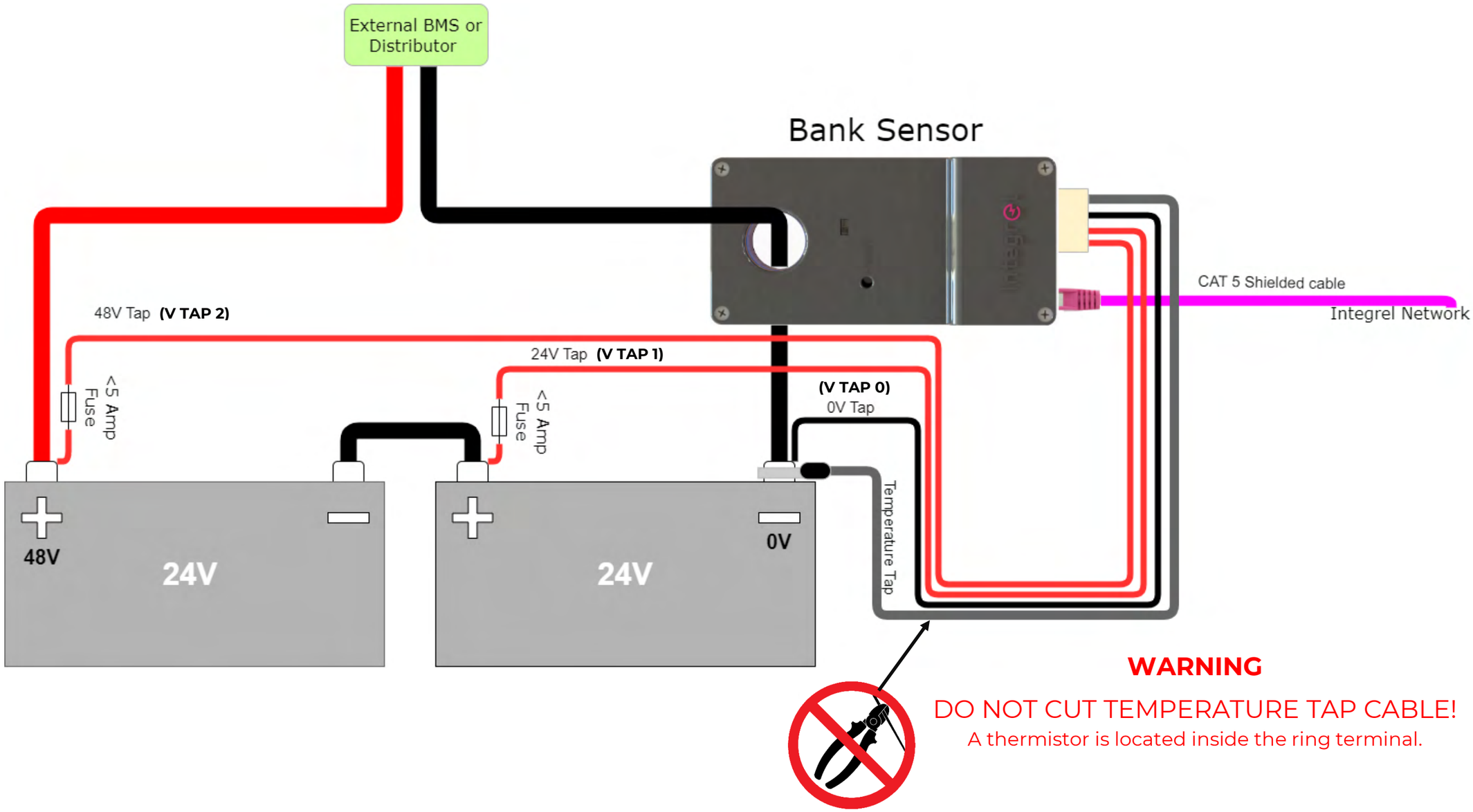


5.2 Wiring Integrel Bank Sensor(s) to Batteries

The following schematic illustrates Bank Sensor wiring. Note that fuses should **always** be installed on the positive voltage taps to protect conductors from accidental shorts to ground. Any fuse between 0.5A to 5A may be used.

When wiring voltage taps, the 0V tap is always connected to the **most negative** terminal, and the highest number voltage tap is always connected to the **most positive** terminal.

The example system shown below has 2 x 24V batteries in series to create a 48V bank. The 0V tap is connected to ground (0 volts), the 1V tap is connected to 24V (middle connection between the batteries) and the 2V tap is connected to 48 volts.



WARNING

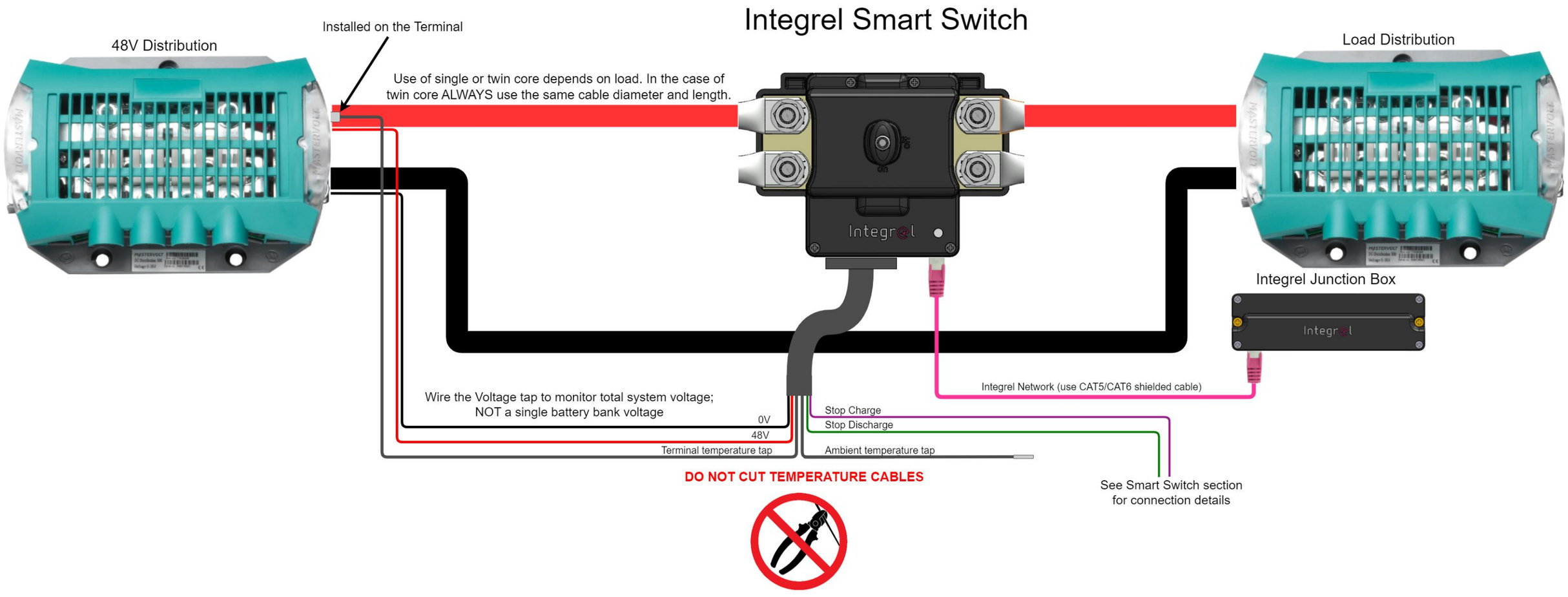
DO NOT CUT TEMPERATURE TAP CABLE!

A thermistor is located inside the ring terminal.

5.3 Wiring the Smart Switch to Batteries

The following diagram shows how the Smart Switch is connected to the 48V distribution system.

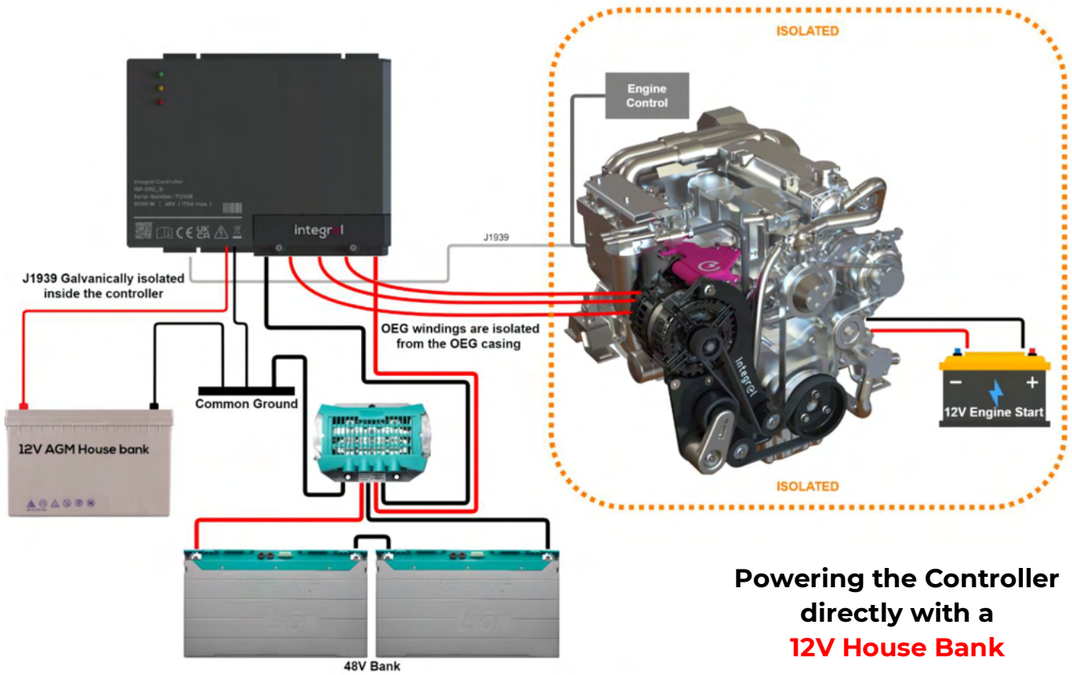
The Stop Charge (lilac colour) / Stop Discharge (green colour) wires are used on systems that do not communicate with the Integrel Controller via the NMEA2000 network.



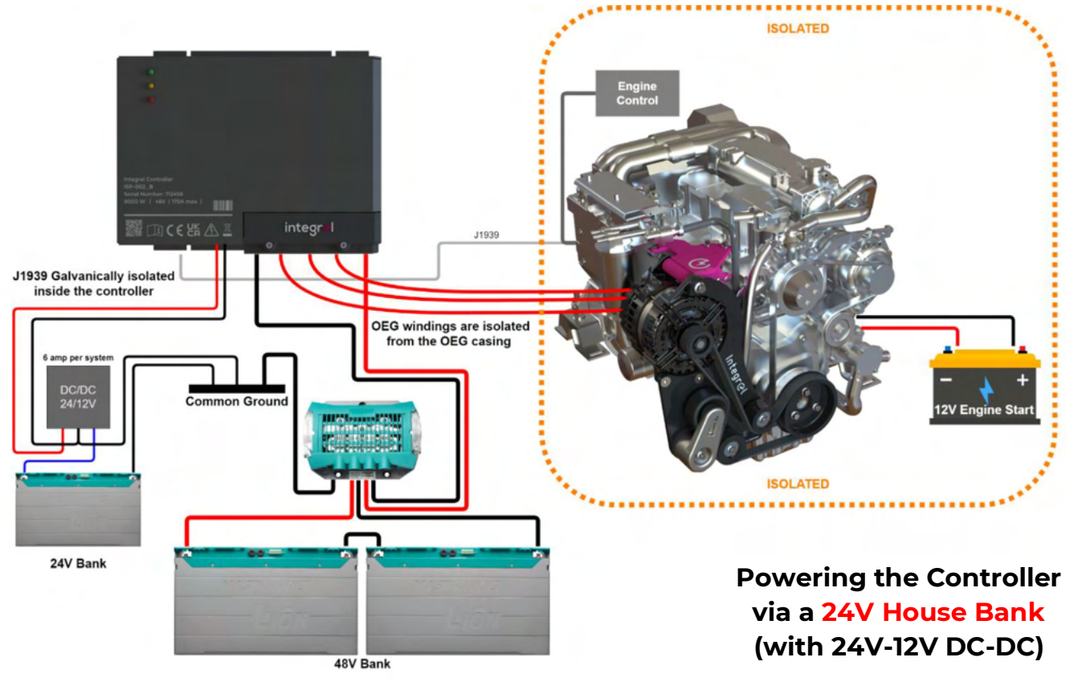
5.4 Powering the Controller

The Controller requires external 12V power to monitor all systems at all times, even when the 48V battery bank is disconnected. The Controller should be powered by a separate house battery bank. Powering the Controller from a house battery maintains complete isolation from the engine and avoids galvanic corrosion.

DO NOT use an engine start battery to power the Controller! The following example illustrates how to keep the Integrel system isolated from the engine.



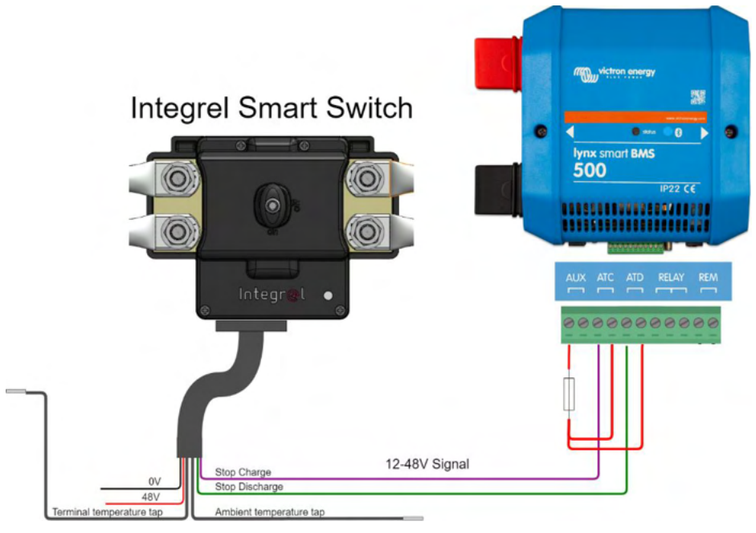
Powering the Controller directly with a 12V House Bank

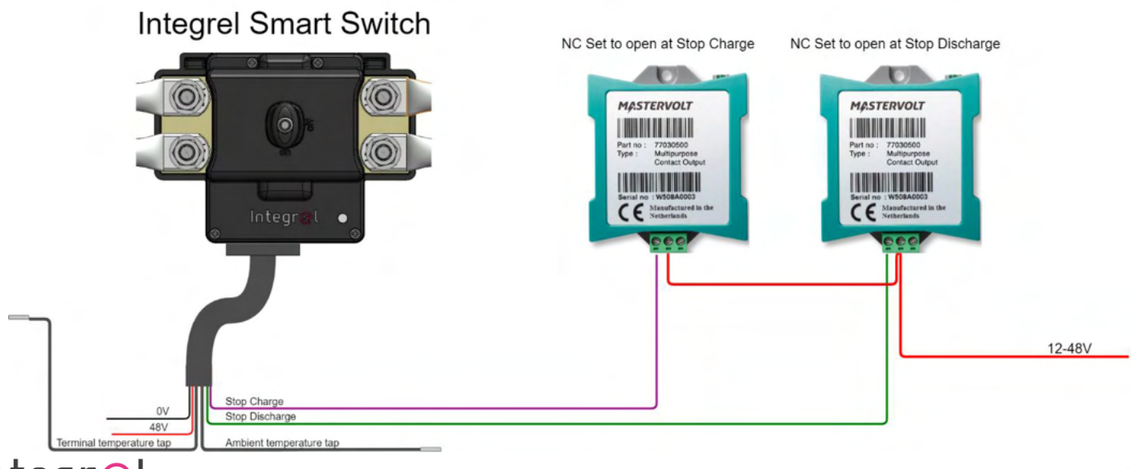


Powering the Controller via a 24V House Bank (with 24V-12V DC-DC)

5.5 Stop Charge / Stop Discharge

The following diagrams illustrate how to connect the Stop Charge and Stop Discharge conductors using the Smart Switch I/O signals. Integrel installations that include BMS integration over CAN or NMEA 2000 do not need the Stop Charge / Stop Discharge conductors to be connected; in these systems, the stop signals are sent over the integrated CAN data network.





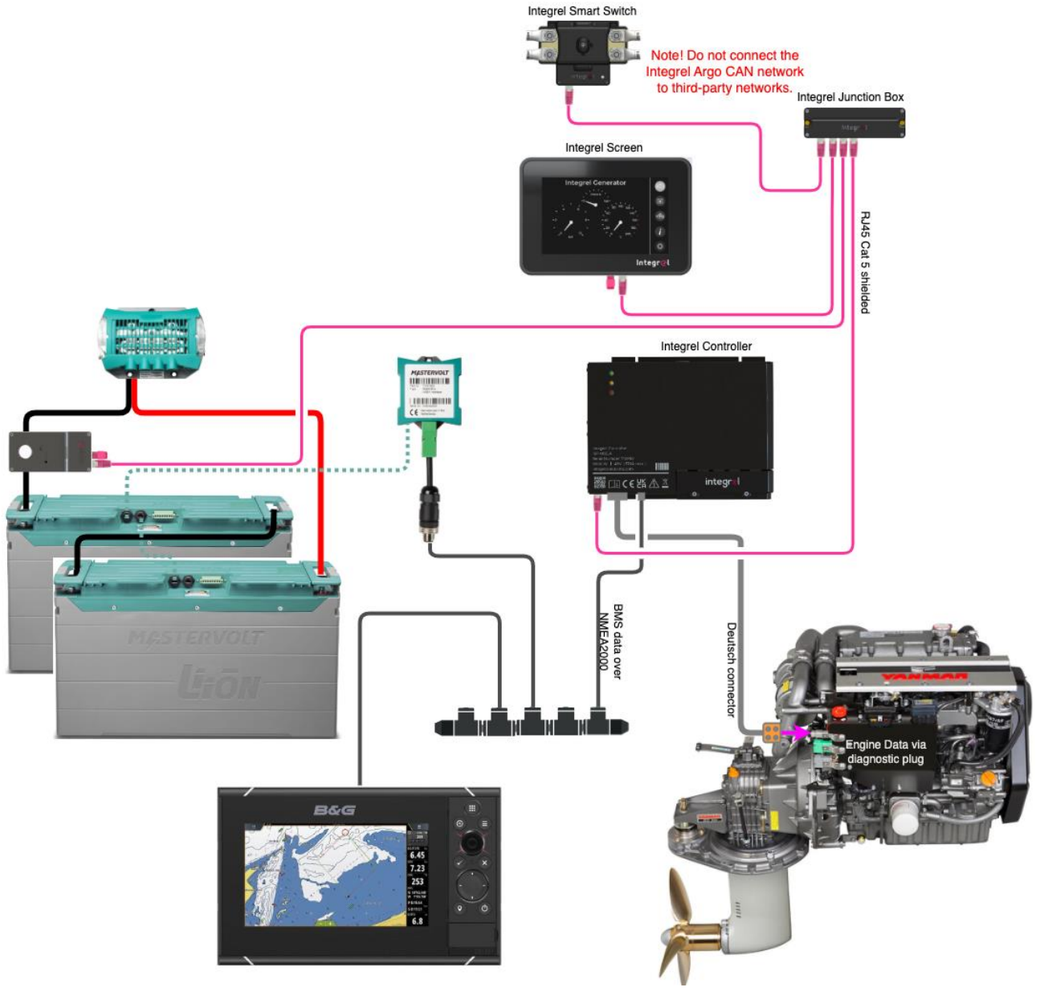
5.6 CAN bus Networks with NMEA2000

The following schematics provide a guide to typical CAN bus data network connections.

Pink lines indicate Integrel proprietary (Argo) CAN bus connections.

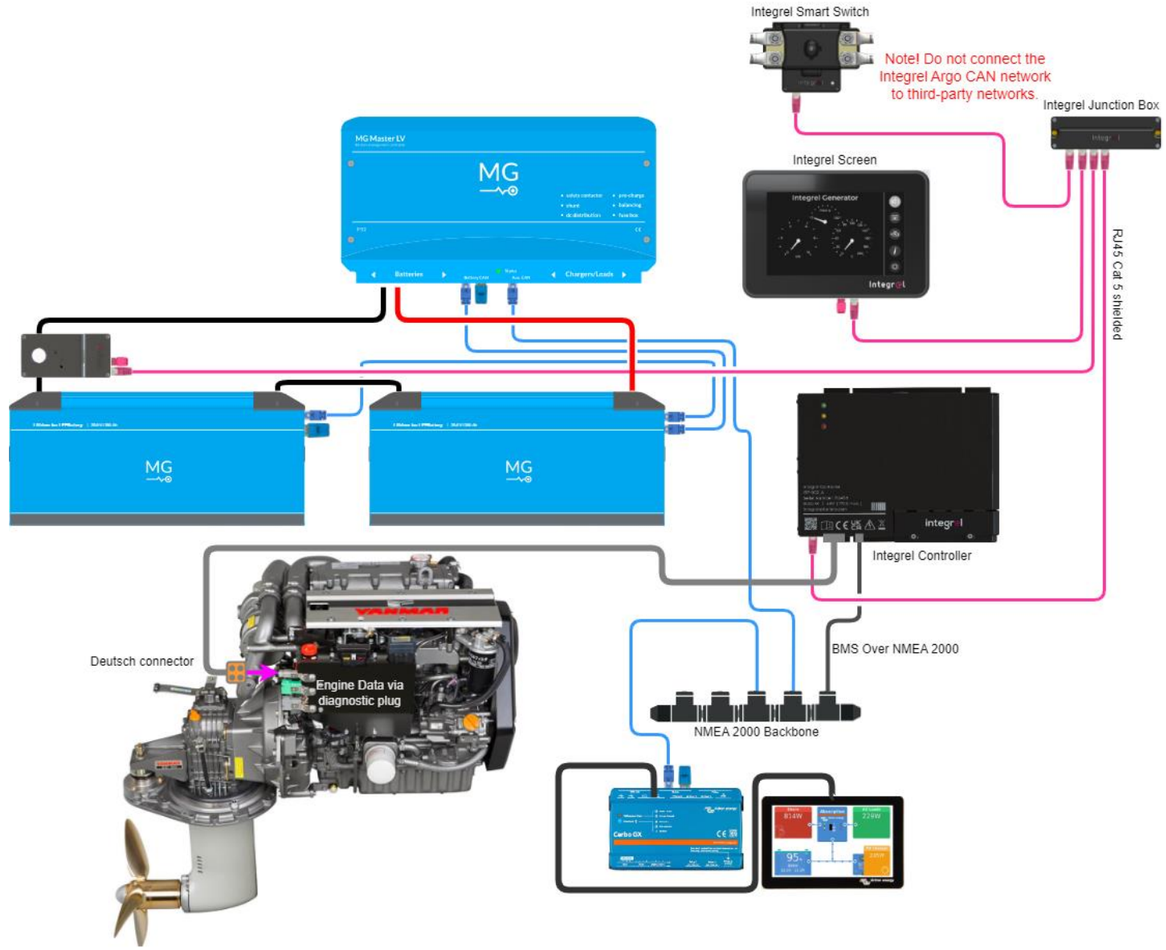
NMEA2000 and J1939 (engine) connections are labelled separately.

The diagram on the right illustrates an MG system, but the same configuration can also be used with a Victron Lynx Smart BMS.



Connection to a Mastervolt System

The Integrel Controller connects to Mastervolt batteries on the NMEA2000 backbone via a NMEA2000-Masterbus interface (available from Mastervolt). The batteries and NMEA2000-MasterBus interface must be programmed during installation. Contact support for setup supplement documentation.



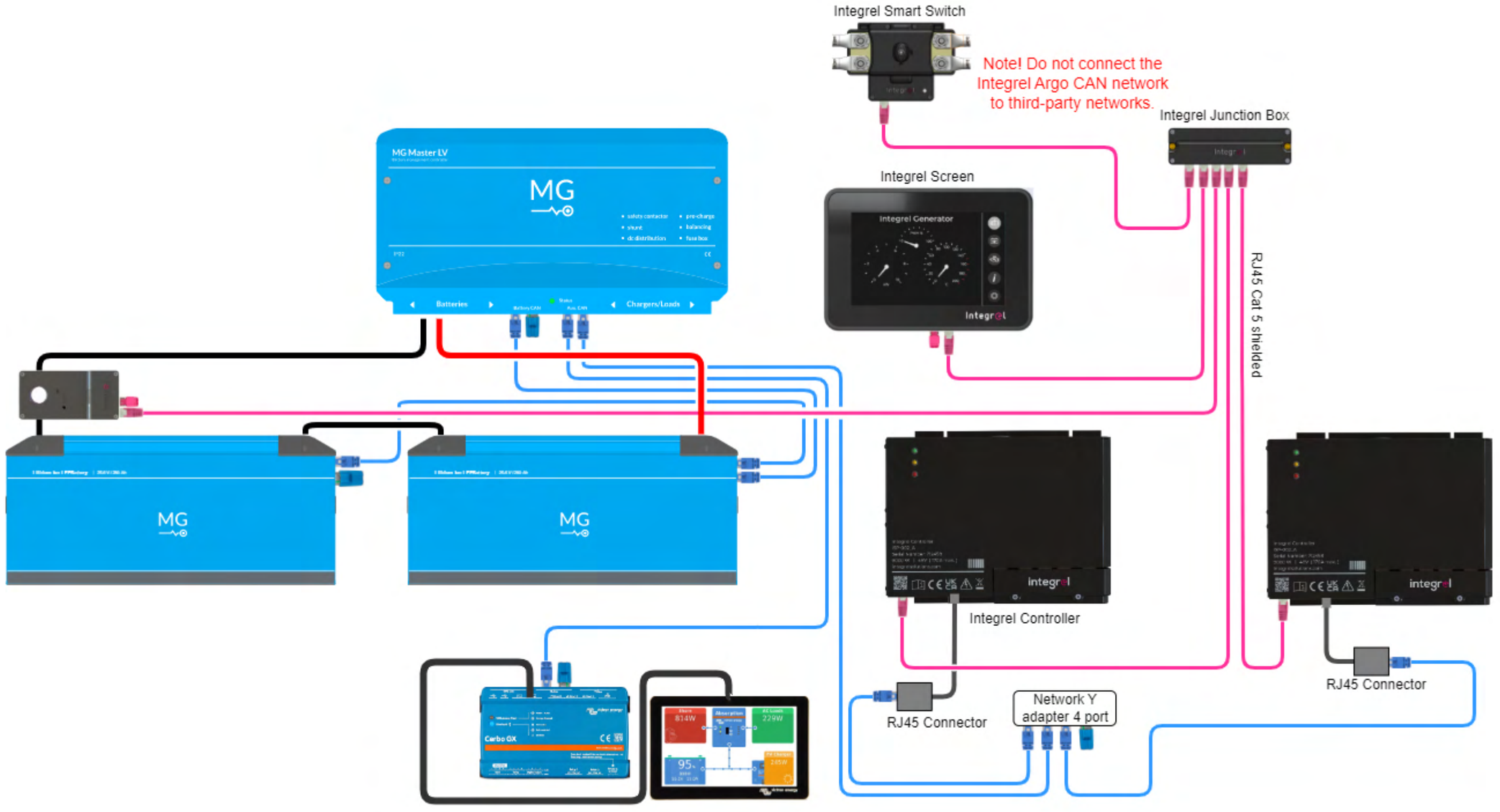
Connection to a MG Energy System

The Integrel Controller can connects to the MG Master LV BMS via the NMEA2000 backbone or VE CAN. The above highlights how to connect via the NMEA 200 Network.

5.7 CAN bus Networks with VE.Can

The following schematic depicts the connections for a dual Integrel system wired to a MG battery system.

For systems that use Victron, replace the MG Master LV with a Lynx Smart BMS.



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 configuration 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 routing 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 access holes in plywood	☐
Rags	Cleaning up spills or stains	☐

6.3 External Parts

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. These parts are NOT supplied by integrel.

Part	Use	Check
DC conductor high current (red and black tinned)	Battery conductor for connecting high current systems. Refer to Annex C – Conductor Guides for sizes	☐
DC conductor low current (red and black tinned)	Providing 12V and 24V power to devices. Refer to Annex C – Conductor Guides 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.	☐
Circuit Breakers	For use with DC/DC's and single-phase systems	☐

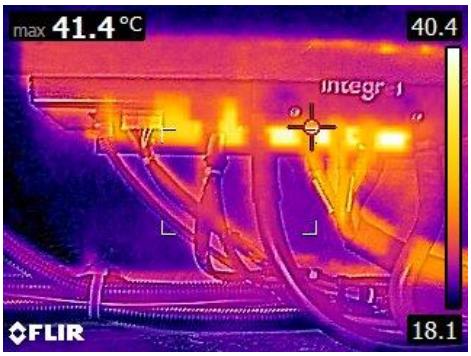
6.4 Preparation

Before starting the 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. Always test any custom-made network cables before installing.
4. After fitting is complete, use a quality thermal imaging camera (e.g., Flir, Fluke, etc.) to check all connections (see the following example images). Test the system with a moderate load to begin with to verify connections are tightened correctly.



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 negative 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 – Battery Installation 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	☐

Step	Operation	Check
16	Fit the negative battery cable to the negative busbar.	☐
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.

6.7.1 Charge and Balance all Batteries

All batteries must be fully charged and balanced before installation. Refer to the guide provided by the battery manufacturer for guidelines.

6.7.2 Conductor Lengths

It is VERY important to ensure that all positive and negative conductors from each battery bank to common busbars / BMS connections are equal lengths. This ensures even balancing throughout the battery system. If conductors are not the same length, varying conductor resistances impact how battery banks are charged and balanced.

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.

Key Points

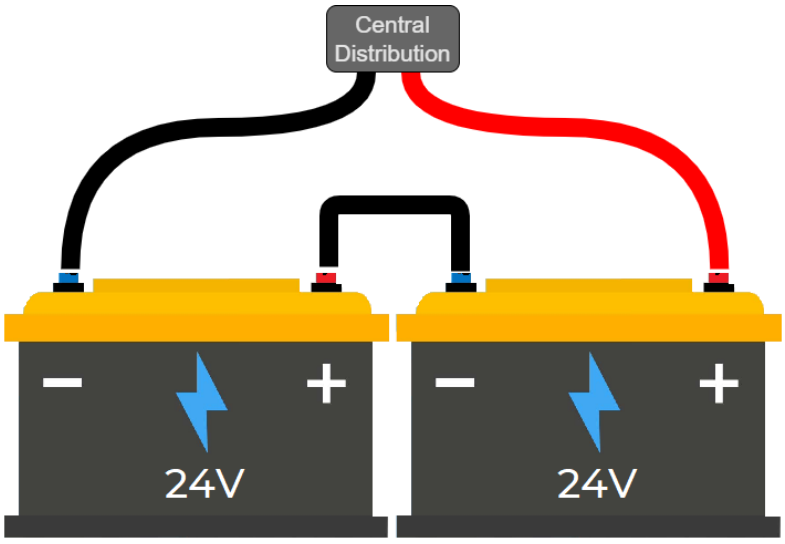
- Keep all conductors the same length.
- Run the negative through the bank sensors BEFORE final crimping.
- DO NOT coil any excess conductors; run them in lengths.
- Ensure the cable diameter is correct for the current rating of the battery

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 multiple single 48V batteries connected in parallel or (one or more) strings of 2 x 24V batteries in series, as shown to the right.

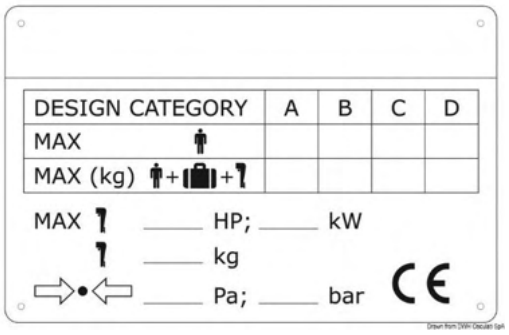
Each 48V battery bank (1 x 48V battery or 2 X 24V batteries in series), must be monitored by a single bank sensor.

Monitoring each bank separately provides the system with redundancy in case of a battery failure.



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.
3. Plan weight distribution if required, check the builders plate for maximums. Consideration should be taken to ensure the intended waterline of the vessel meets the recommended level.



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 Mastervolt DC distributor or Victron 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 C – Conductor Guides and Annex D – Guide to Fuses 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, Victron Energy and Mastervolt. 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	Victron Energy	Mastervolt
SCAN ME	SCAN ME	SCAN ME
MG LFP 24V Series Battery Manual	Lithium Battery 25.6V Smart Battery Manual	MLI Ultra 24/6000

NOTE

Always set up batteries according to the guidelines in the manual provided by the battery manufacturer. Check the manual refers to the batteries that are being 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 Mounting Direction

Integrel recommends installing the Bank Sensor in the orientation shown – with the Integrel logo facing **away from the battery**. If the sensor is installed backwards, the reported kW and Amps In/Out data will be incorrect; a software setting can be used to invert the data.

6.8.2 Installation Guidelines

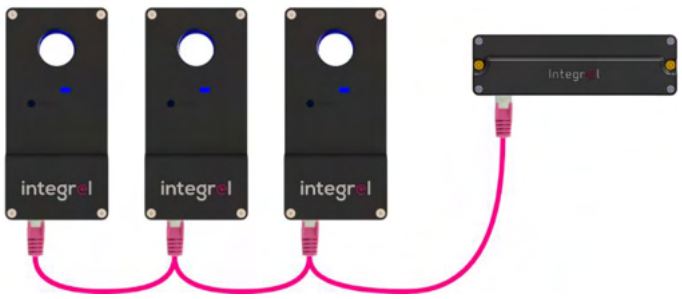
1. Battery lugs (terminals) larger than 70-10 are too large to fit through the hole in the Bank Sensor. Feed the battery conductor through the hole in the Bank Sensor **THEN** terminate the conductor!
2. Ensure the Bank Sensor is installed as close as possible to the negative battery terminal with the Integrel logo facing **away from the battery**; installation examples are shown in the following images.

3. Ensure the Bank Sensor is secured with a cable tie to avoid movement which may otherwise disturb sensor measurements.
4. After the Bank Sensor is attached, terminate the loom provided. Wire the Bank Sensor loom to the batteries as shown in Section 5.2. For 12V and 24V note the Voltage tap connections outlined in Section 6.8.3 on the following page. Integrel recommends all Vtaps are fused to protect the conductors from snagging and accidental shorting. Use inline fuses or blade fuse holders as shown to the right.

The description in the following table applies to systems with 2 x 24V batteries connected in series to create a 48V battery bank.

Label	Connection
V tap 2	48V – The most positive connection (add an inline fuse)
V tap 1	24V – The series connection between the banks (add in inline fuse)
0V	0V – The most negative connection.
Battery Temp	The battery temperature conductor may be connected to the most positive or most negative connection. The ring terminal contains a thermistor used to monitor the temperature of a battery terminal. **WARNING**: DO NOT CUT THE TEMPERATURE TAP CONDUCTOR!

5. After the loom has been wired in, plug the CAT 5 cable between the Bank Sensor and the next Bank Sensor (or junction box) if the sensor is the last in the chain; each Bank Sensor has two RJ45 ports to daisy-chaining.



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.

6.8.3 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 (circled in red in the following table).

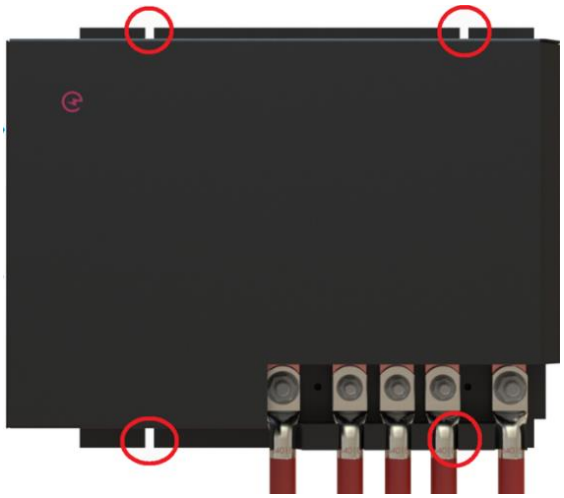
Vtap Loom Connection	1 x Vtap 12V batteries	1 x Vtap 24V batteries	2 x Vtap 12V batteries	1 x Vtap 48V batteries	2 x Vtap 24V batteries	4 x Vtap 12V batteries
Vtap 0 →	0V	0V	0V	0V	0V	0V
Vtap 1 →	12V	24V	12V	48V	24V	12V
Vtap 2 →	-	-	24V	-	48V	24V
Vtap 3 →	-	-	-	-	-	36V
Vtap 4 →	-	-	-	-	-	48V
Bank Voltage	**12V**	**24V**	**24V**	**48V**	**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.

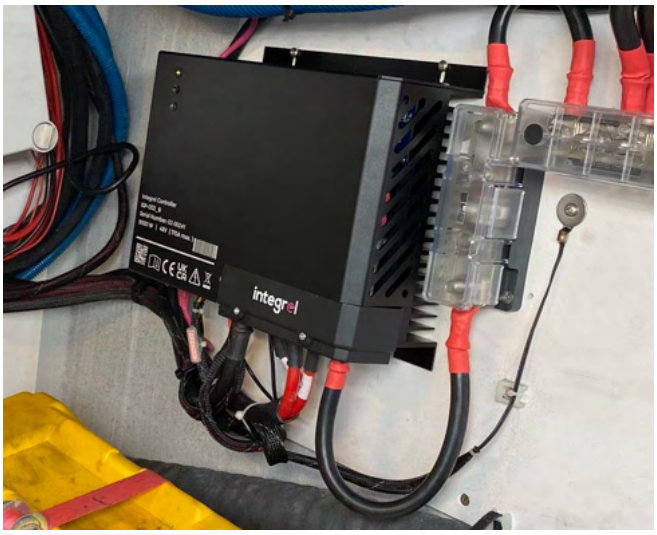
6.9 Integrel Controller

Use the four mounting slots (highlighted in the 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.



6.9.1 Controller Location

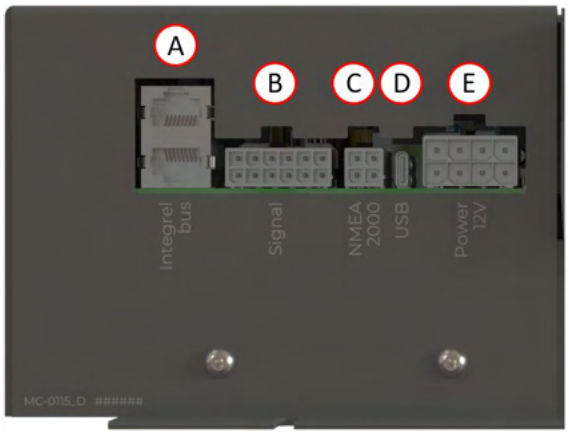
The Integrel Controller should be installed in a well-ventilated location. Air flows through the Controller from left to right as shown in the image below. An ideal installation location is high on the wall of the engine bay away from any hatch openings (to minimise the chance of water ingress).



NOTE!

The Controller must be installed away from any sine wave inverters. Noise from the inverters may cause disruption to RPM readings and may disturb system operation.

6.9.2 Controller Connections



Controller ID	Description
A	Integrel (Argo) CAN Network (RJ45)
B	Multi-signal Loom Connector
C	NMEA2000 / BMS Connection
D	USB C (used with Integrel Configurator)
E	Power Loom Connector
F	Status Indicator LEDs
G	Cooling Fan Inlets
H	48V DC Negative Connection
I	3 x AC Phase Connections (to Generator)
J	48V DC Positive Connection

Insert the Multisignal (B) and Power (E) Loom plugs, then connect the three AC phase connections (I).

Once the looms and phases 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.

6.9.3 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.

6.9.4 Ambient Temperature Sensor

The ambient temperature sensor is used to monitor the temperature of the engine bay. The sensor should be installed near the Controller. Do not mount the sensor onto metal or other objects that conduct heat (from the engine or other electrically powered devices).

6.9.5 Gear Detect Switch

The Integrel system uses a physical I/O switch to determine if the gearbox (transmission) is in-gear, see the Controller schematic. The gear detect conductors are brown and yellow and the pinout is shown in Section 13 - Connectors and Fuses. The gear detect switch must be wired as follows:

In-gear	Switch =	
Out-of-gear	Switch =	

Popular switches include:

- MCS-137 from COMUS Group (magnetic proximity switch).
- CE10.00.AM from CamdenBoss (mechanical limit switch).

When commissioning, a symbol appears in the corner of the Integrel Touchscreen to indicate whether the engine is in-gear or out-of-gear. If a switch is not fitted, connect the wires together to cause the Integrel system to treat the propeller as permanently engaged thus preventing excess load on the engine. Integrel recommends the use of a gear detect switch on engines smaller than 50 hp.

Note! For some engines, it is possible to obtain in-gear status information from the J1939 engine interface, see *Section 6.9.6 - J1939 Engine Integration* for details.

6.9.6 J1939 Engine Integration

The Integrel system can be connected to the J1939 ECU interface of an engine which provides real-time engine data including engine speed (RPM), engine temperature, and more.

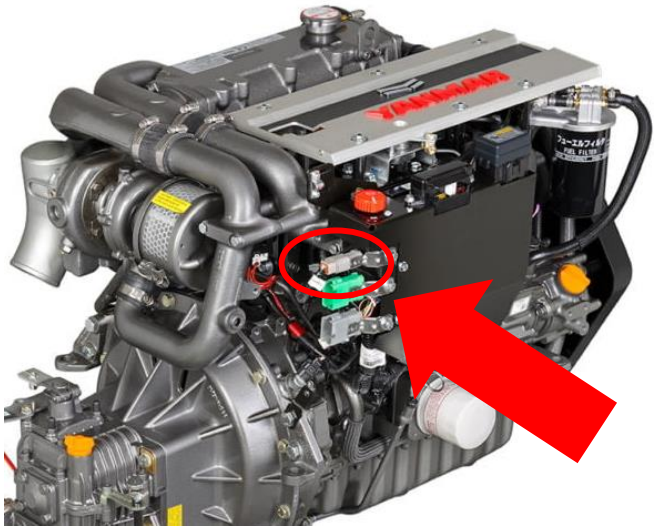
When J1939 is connected, Integrel obtains engine speed directly from the engine in addition to the default measurement technique where engine speed is estimated from the speed of the Integrel generator. If the Integrel belt slips, differing speed readings cause Integrel to report a belt slip alert.

For some engines, Integrel can also use the J1939 connection to determine whether the engine is in-gear or out-of-gear. This feature is currently supported for Yanmar engines ONLY.

The Integrel Controller loom contains a plug that connects directly to the engine diagnostic J1939 socket on a Yanmar engine. A separate adapter is provided for use with Volvo and other engine types.

Yanmar Connection on the Controller Loom

J1939 is labelled as Diagnostic on a Yanmar Engine



J1939 Connection location on a Yanmar Engine

The Integrel Controller has several configuration settings to control operation of J1939 functionality.

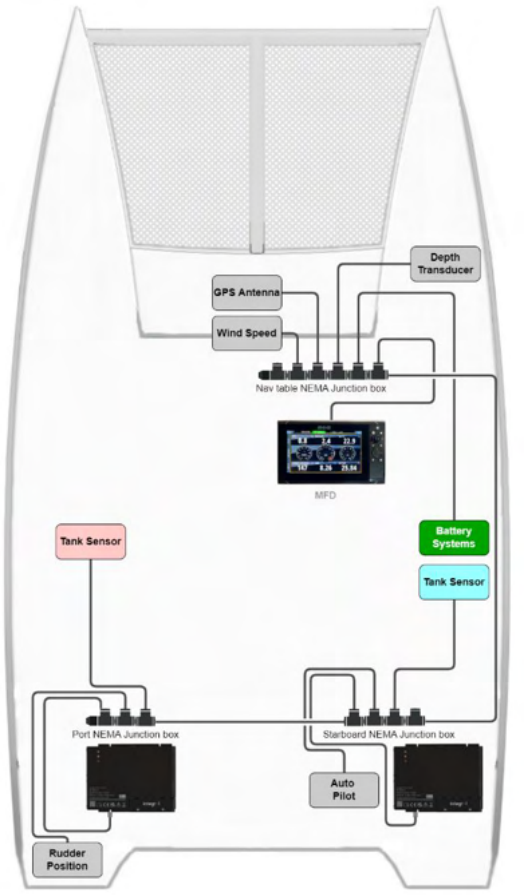
Setting	Description
`j1939_enabled`	Enable or Disable use of the J1939 interface. • 0 = Disabled • 1 = Enabled
`j1939_engine_address`	Selects which J1939 source address to read engine data from. For multi-engine installs, there are two cases to consider: • Engines with **SEPARATE** J1939 connections (TYPICAL installs) o 0 = for both Port and Starboard Controllers • Engines with **JOINED** J1939 connections (ADVANCED installs only) o 0 = for the Port Controller o 1 = for the Starboard Controller
`use_j1939_gear_detect`	Use J1939 data to determine if the engine is in gear or out of gear • 0 = Do NOT use J1939 for gear detection • 1 = Use J1939 for gear detection ***Note!*** *Supported for Yanmar engines ONLY*

6.9.7 NMEA2000 Integration

NMEA2000 is used as a common network on boats to distribute information and data between various onboard devices. The Integrel system provides the following functionality when connected to a NMEA2000 network.

- Integrel system data is sent to NMEA2000 including system voltage, charge current and OEG temperature.
- Engine data is sent to NMEA2000 including engine RPM, temperature, oil pressure and fuel rate. Integrel reads engine data from the engine J1939 interface and sends the data to NMEA2000 (ONLY if Integrel is also connected to the engine J1939 interface; see *Section 6.9.6 - J1939 Engine Integration* for details).
- Battery system data is received from NMEA2000 such as battery state-of-charge, temperature, allow-to-charge/discharge status, and battery warnings (ONLY if the battery system is also connected to NMEA2000). The type of battery data received is dependent on the battery system.

The picture (to the right) illustrates an example of how to physically connect Integrel to the NMEA2000 network; if more than one Integrel Controller is present in the system, both Controllers must be connected.



The Integrel Controller has several configuration settings to control operation of NMEA2000 functionality.

Setting	Description
`n2k_data_select`	Selects which data is published on the NMEA2000 network. • 0 = No data published • 1 = Integrel data (Voltage, Current, OEG Temperature) • 2 = Engine data (RPM, Temperature, Oil Pressure, Fuel Rate) • 3 = Integrel data and Engine data

`n2k_engine_instance`	Selects which NMEA engine instance to output engine data to the NMEA network.
	• For a single Integrel system, set to 0
	• For a dual Integrel system
	  ○ 0 = for the Port Controller
	  ○ 1 = for the Starboard Controller
	Note! If other devices output engine data to the NMEA2000 network, they may conflict with Integrel. Use Integrel OR the other device BUT NOT BOTH! In advanced use cases, port and starboard Integrel Controllers could be set to 3 and 4, and an MFD (or other NMEA display device) could be configured to use either Integrel or the J1939 gateway to receive and display engine data.

6.9.8 BMS and Battery Integration

Integrel recommends connecting all Integrel Controller(s) in the system to the BMS via a NMEA2000 network. Alternately for direct connections, VE.Can may be used for MG or Victron systems with a RJ45 connector or M8 5-pin connector, and RV-C should be used for Lithionics systems.

The following table contains a description of the integration support available for each BMS and battery system supported by Integrel.

BMS System	Connection	Integration Support
Mastervolt	NMEA2000 (using MasterBus-to-NMEA200 Interface)	SoC, Battery safety, Stop Charge,
MG Master LV	NMEA 2000 (or VE.Can)	Full integration including faults, cell data, dynamic current management, SoC, stop charge and full flags.
Victron Lynx BMS	NMEA 2000 (or VE.Can)	SoC, warning flags and cell data
Lithionics	RV-C	Full integration including faults, cell data, dynamic current management, SoC, stop charge and all flags.

Dynamic current management (DCM) refers to the ability to split battery charging current between two or more Controllers, and to compensate for other charging sources (such as solar and wind) to ensure that charging current does not exceed the maximum battery charging limit.

The Integrel Controller has several configuration settings to control operation of BMS and DCM functionality.

Setting	Description
`bms_identifier`	Selects the BMS data instance to be used. • `0` = MG or Victron SmartBMS • `X` = Mastervolt MasterBus-to-N2K interface DC address (typically 0) • `9` = Lithionics IonGate
`bms_config_id`	• `0` = Default (not Mastervolt) • `X` = Number of physical Mastervolt batteries (not the number of strings)
`use_dcm`	Configure the behaviour of Dynamic Current Management • `0` = Disable DCM. Integrel does NOT attempt to adjust output power to control the current within BMS or Bank Sensor limits. If a Bank Sensor limit is exceeded, charging is stopped. • `1` = Use BMS current limit and Bank Sensor current limit. Integrel automatically balances the available current limit between Controllers to ensure that neither the BMS current limit (via CAN) or the Bank Sensor limit (according to configuration) are exceeded. The lowest of these two always applies. • `2` = Use BMS current limit ONLY. Same functionality as `1`, however only the BMS current limit is used (provided the BMS provides a current limit)

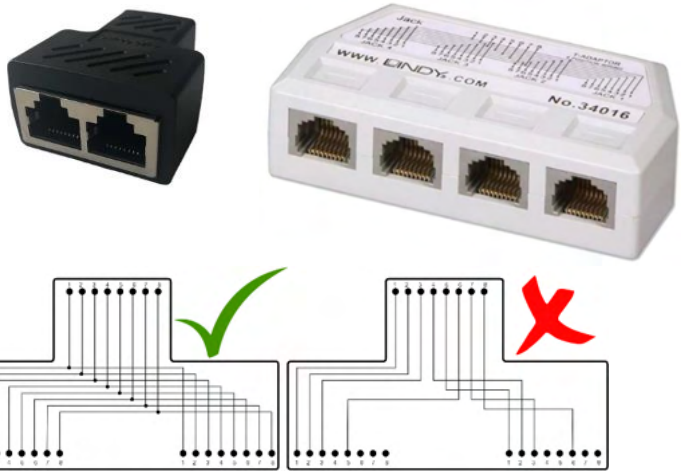
NMEA 2000 Usage

The Controller can be connected directly to the NMEA 2000 backbone. With a dual system, both Controllers must connect to the NMEA2000 backbone to ensure correct operation if one of the Controllers is powered off. See *Section 6.9.7 – NMEA2000 Integration* for details.

RJ45 (VE.Can) Usage

VE.Can networks can be used to connect systems using equipment from MG Energy and Victron.

The system can be wired directly to a VE.Can network as noted above. For dual systems and systems with longer conductor runs, Y adapters can be used to fit termination resistors. Single systems that have shorter networks can plug directly into a Controller. With only one termination resistor required in the CAN network.



NOTE!

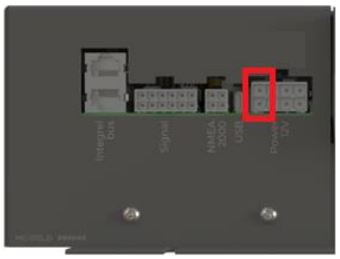
If an RJ45 adapter is used, be sure to use a straight through adapter, not a splitter type adapter. If you are unsure, use a network tester to test connections.

MG Master LV BMS (Aux.CAN)

Victron Lynx BMS (VE.CAN)

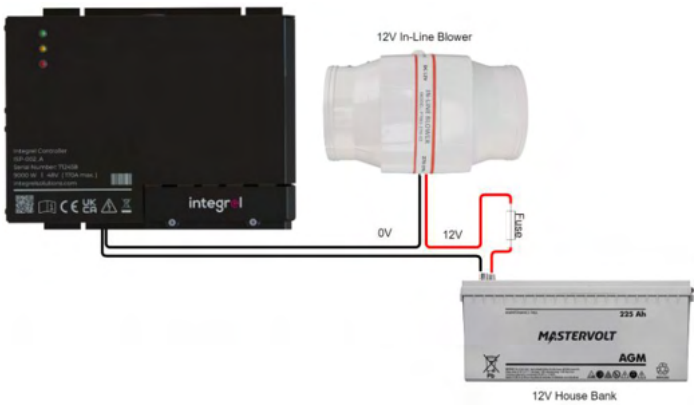
6.9.9 Blower Fan Auxiliary Relay

The Controller incorporates a software configurable auxiliary relay that may be used to switch a blower fan. The fan is used to increase OEG cooling which helps to increase the sustained power output of the Integrel system. The relay can switch a **MAXIMUM 10A current** and a 10A fuse MUST be installed in-line with the blower fan as illustrated in the following schematic.



The relay is enabled using the Integrel Configurator with the Controller setting:

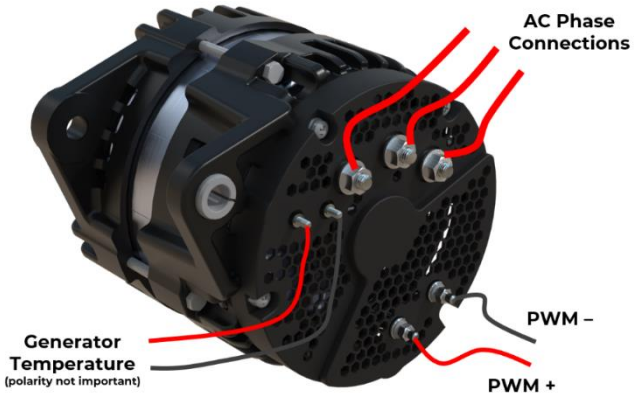
`blower_fan_activate_temperature`

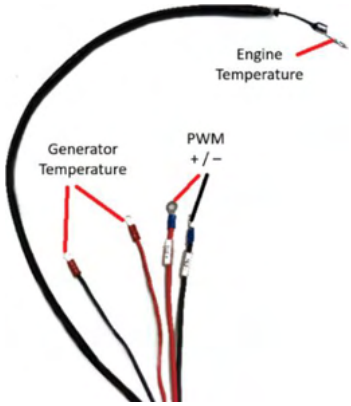


6.10 Connecting the Integrel Generator to the Controller

The Integrel Generator is installed onto an engine mounting bracket kit 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.

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

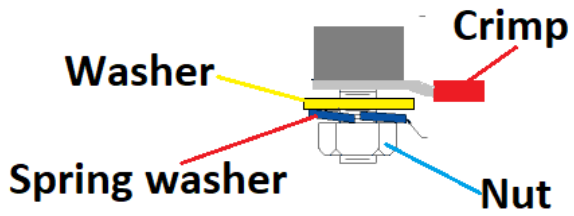




Generator Marking	Connection Description
P1	AC Phase 1 (order not important)
P2	AC Phase 2 (order not important)
P3	AC Phase 3 (order not important)
T1	Generator temperature
T2	Generator temperature
P –	PWM wire (black)
P +	PWM wire (red)

Important!

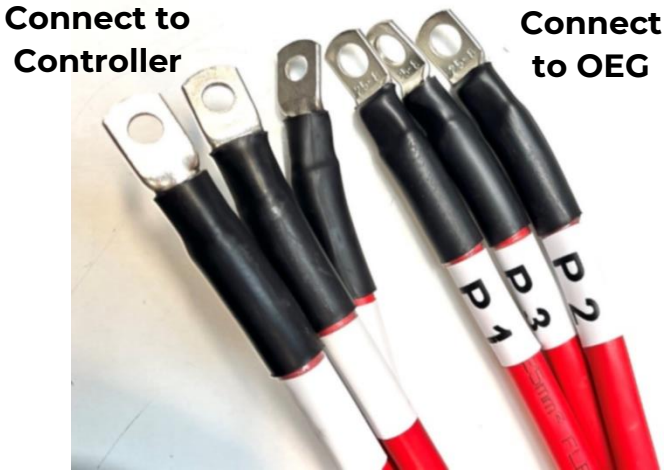
Ensure each connection has a washer and spring washer as shown.
The Integrel system will not work properly if connections become loose.

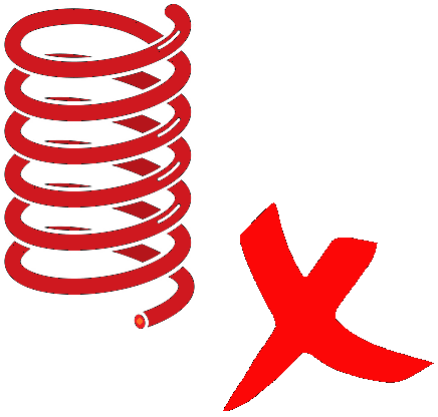


DO NOT COIL PHASE OR POWER CONDUCTORS

All power and phase conductors should be cut to length. Coiling conductors may cause excessive heating resulting in a fire hazard. Excess lengths of conductor should be laid in straight runs.

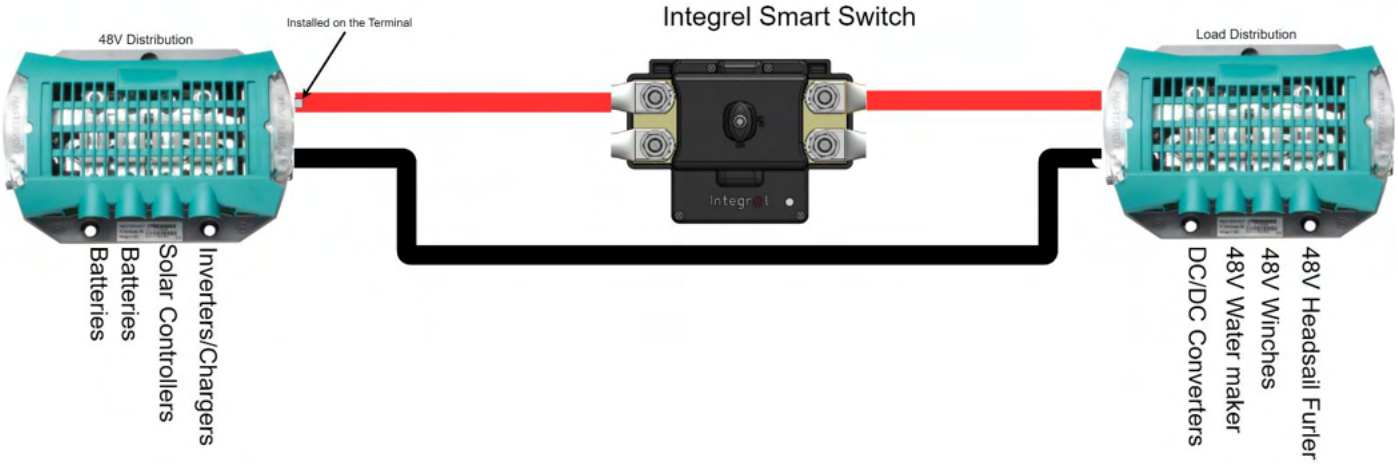
Note that the holes in the ends of the phase conductor terminals that connect to the Controller are **smaller** than the holes of the terminals that connect to the OEG.





6.11 Integrel Smart Switch

The Smart Switch is usually connected after the batteries, solar charger and inverters as these components are usually controlled by the BMS system. The Switch protects the battery bank from damage by disconnecting the bank from the load if the bank is discharged to a critically low SoC level. The following diagram provides an example of the correct installation location for the smart switch.



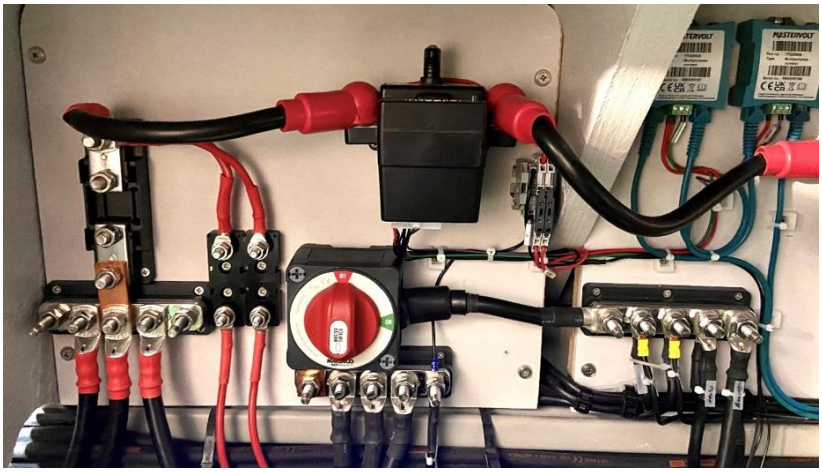
NOTE!

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 following 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 schematic in Section 5. Note the Smart Switch is also available in a 24V configuration. The guide below also applies, however the voltage taps are connected to a 24V source (not 48V).

6.11.1 Integrel Smart Switch Connections

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

Ambient Temperature Tap

The Ambient temperature tap monitors the ambient air temperature of the battery bay.

Battery Terminal Temperature Tap

The Battery Terminal temperature tap monitors the temperature of one of the battery terminals; the tap must be connected to one of the main 48V battery terminals. Battery terminals may overheat due to excessively high current, electrical shorts or a loose terminal.

48V Tap (Ground and 48V)

Connect the 48V tap to a point where the battery connections converge on the battery side of the switch.

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.

6.11.2 Wiring Stop Charge/Discharge

Stop Charge / Stop Discharge connections are wired with systems that do not use BMS integration over CAN. If you are unsure whether to wire these connections, contact Integrel.

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 Integrel equipment such as chargers and solar systems.

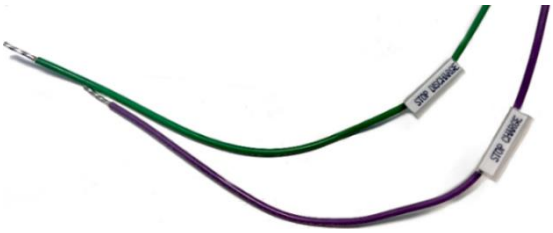
Victron VE.Bus BMS

Mastervolt Multipurpose Contact

Lynx Smart BMS

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

See the examples in Section 5.5 – Stop Charge / Stop Discharge.



Victron

The stop signal is controlled automatically to observe Stop Charge / Stop Discharge.

Mastervolt Masterbus

The Multipurpose contact should be set to trigger at Stop Discharge and Stop Charge.

Signal	Voltage Above 10V	Voltage Below 10V	Action
Signal 1 Stop Charge	Signal NOT active	Signal active	System stops charging. Switch stays closed
Signal 2 Stop Discharge			Switch Opens

6.11.3 Operating the Smart Switch

Manually Activating the Switch

To manually open or close the switch, pull the knob up or push the knob down as shown.

- Pull up to Open (OFF)
- Push down to Close (ON)

Locking the Switch OFF

The switch can be locked in the OFF position which is useful during maintenance or wintering. Locking the switch OFF ensures the 48V supply is not accidently reconnected.

To lock the switch in the off position, pull up and rotate the knob ninety degrees in a clockwise direction as shown.

6.12 Integrel Junction Box

The Integrel Junction Box provides a common connection point for the Integrel proprietary Argo CAN bus 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.

6.13 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.

6.14 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

6.15 DC/DC Converters

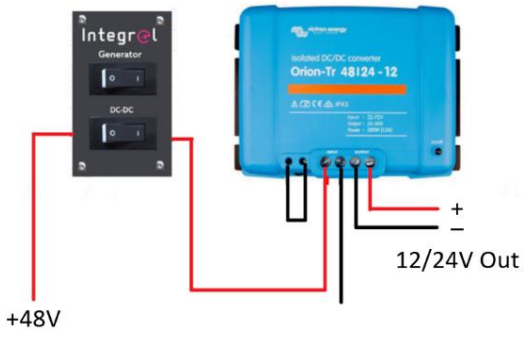
The instructions in this section refer specifically to Victron Orion DC-DC converters. DC-DC converters from other manufacturers may also be used.

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

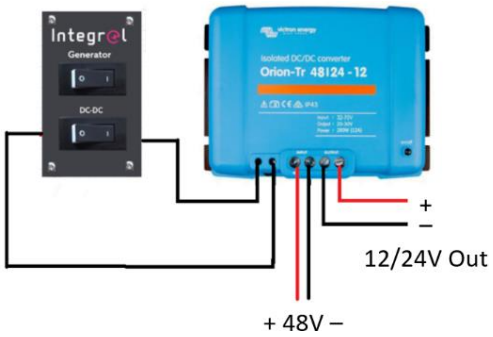
The Integrel Panel Switch can be used to control the operation of the DC/DC converter(s). If Victron DC/DC converters are used, there are two connection methods depending on the current drawn from the 48V supply.

Method 1 can be used if current draw from the 48V supply is **less than 16 amps**. If the current sourced is **greater than 16A**, Method 2 must be used. Connections for both methods are shown in the following diagram.

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.

NOTE!

Always remember to join the ground connection from the DC/DC converters to the negative busbar. Ground connections on DC/DC converters are internally isolated and need to be externally joined. Failure to externally join ground connections may cause equipment damage.

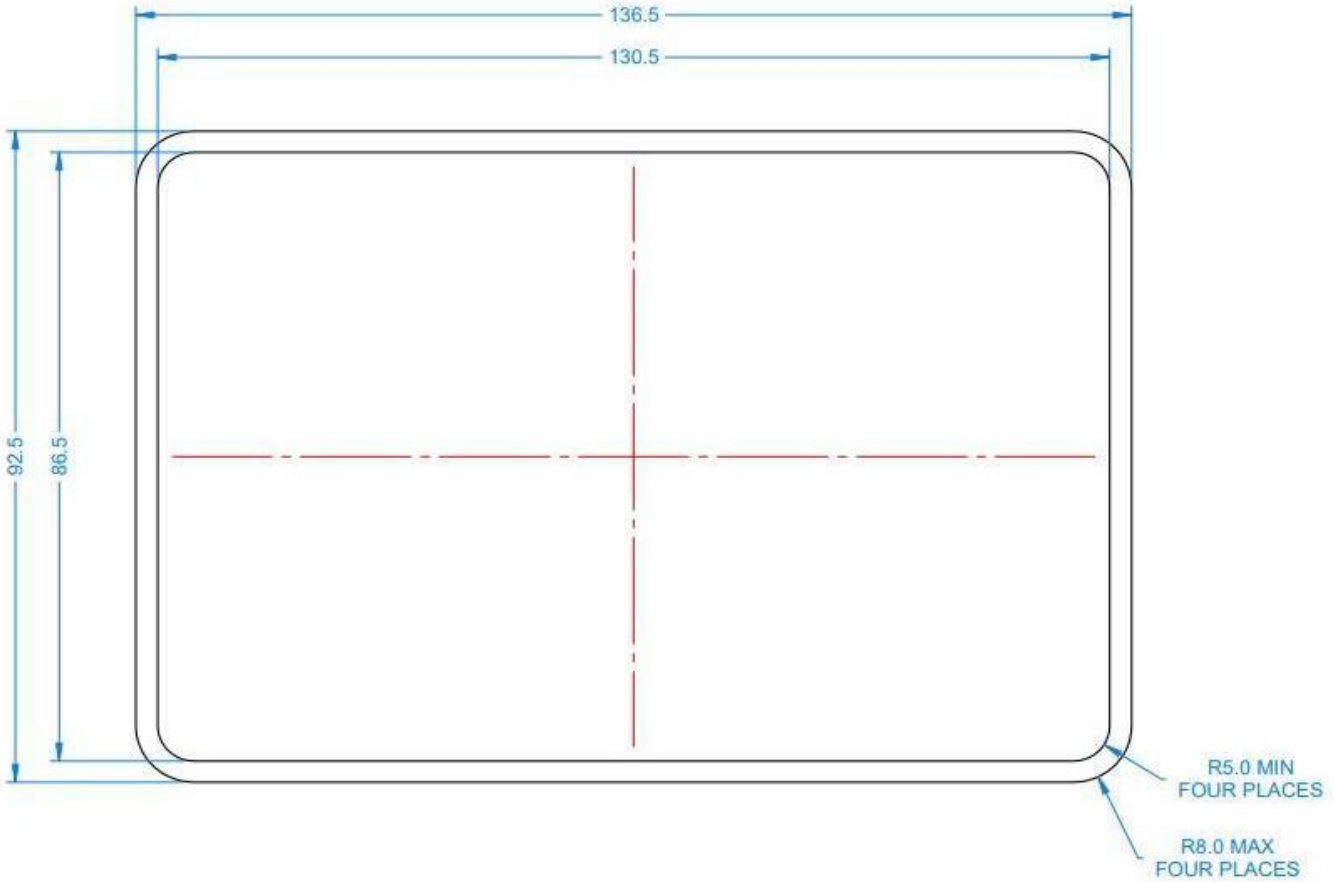
Orion-Tr voltage adjustment screw

6.16 Integrel Touchscreen

Prior to mounting the Touchscreen, connect the screen to the Integrel Argo CAN bus network via one of the RJ45 connectors and insert an Integrel termination resistor (if the Touchscreen is located at the end of a long CAT5 conductor run).

The Touchscreen must be mounted in a location that is easily visible and audible; the Touchscreen contains a buzzer to provide alerts and warnings. It is also used to perform updates to Integrel system components via Wi-Fi or USB.

To mount the Touchscreen, use the template shown below to cut a hole in the mounting panel then simply push the screen into place.



Cut out dimensions for the Integrel Touchscreen

(the Touchscreen is designed to be installed into panels with a thickness of at least 6mm)

6.17 Final Connections

6.17.1 Connecting the 48V system to the Controller

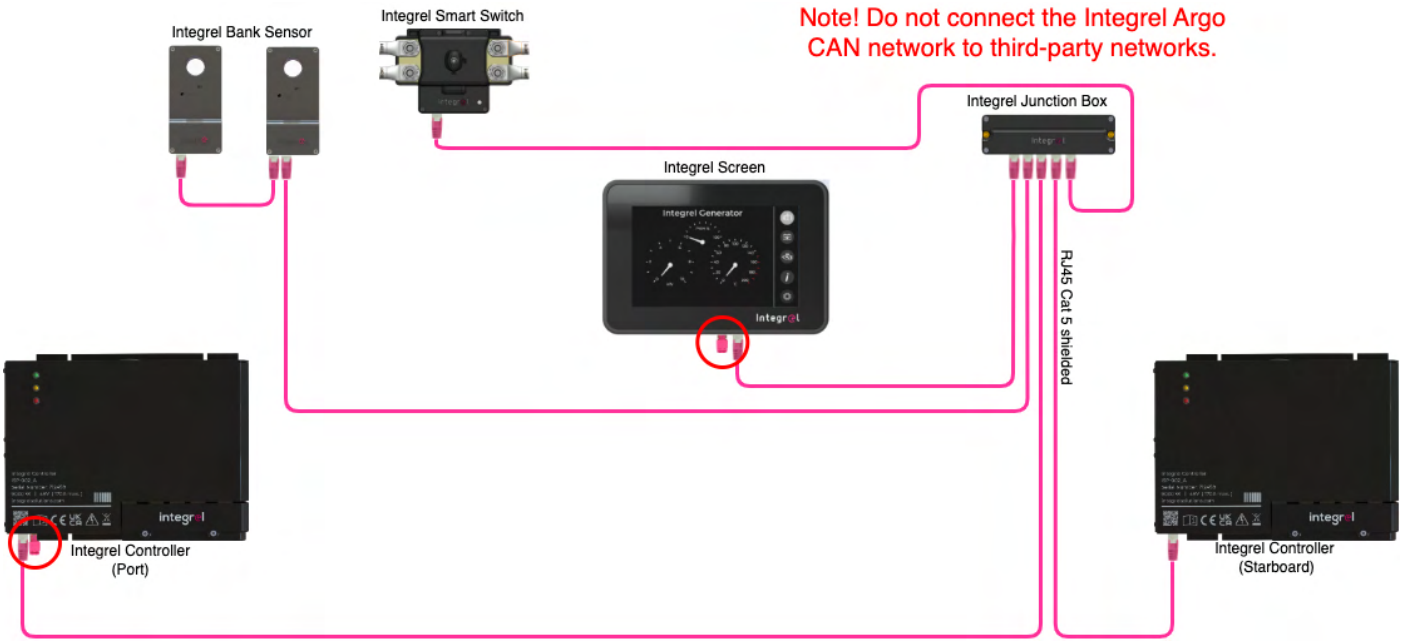
Before connecting the 48V battery supply to the Controller, it is critical to ensure that all connections are tightened correctly. High amperage runs through the 48V battery supply. Loose connections can quickly become hot and generate excessive amounts of heat that may cause damage to systems and the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

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

6.17.2 Integrel Argo CAN bus Network

Typical 2-wire CAN bus networks require terminating resistors at each end of the network. Terminations are essential for error free communication.

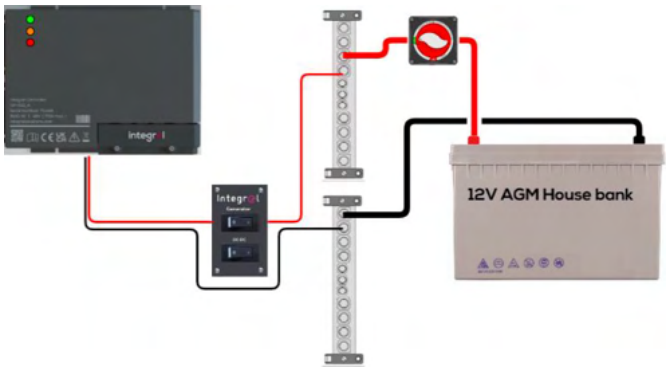
When connecting the Integrel network, ensure there are **ALWAYS TWO** termination resistors in the system installed at the end of the two longest conductor runs. The following diagram shows an example of CAN bus connections for an Integrel system.



Integrel CAN bus Network Physical Wiring with CAT5 Cables

6.17.3 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 CAN bus 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. Each Integrel system is pre-configured at the factory, however we recommend reviewing all relevant settings BEFORE making any changes. If your system needs to be set up, a list of settings will be provided by Integrel to help guide you through the process.

7.1 Prerequisites

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

1. A Windows© PC or Mac with USB connection
2. Integrel Serial Configuration Software Application
   a. Available from support@integrelsolutions.com
3. A USB DATA cable to connect your computer to the Integrel Controller (with a USB-C connector)

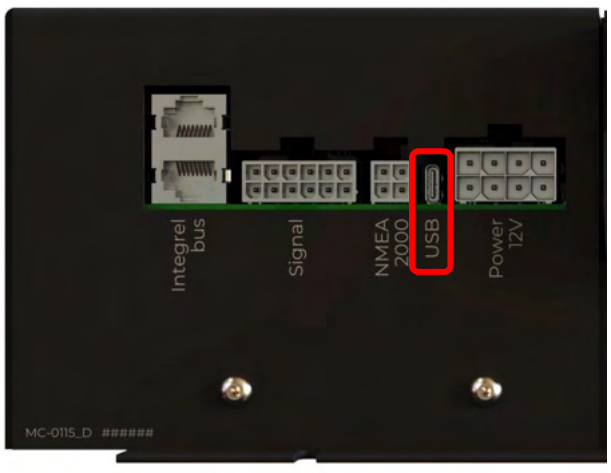
USB C Connector

7.2 Connecting 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. Access to the system is via the Integrel Controller.

The Controller USB interface connector is shown below (circled in red). Use a suitable USB C cable to plug from your computer to the Controller. The cable must be a **USB DATA cable**; some cables are used for charging only.

Once the Controller is connected to the computer, open the Integrel Configurator App.



NOTE!

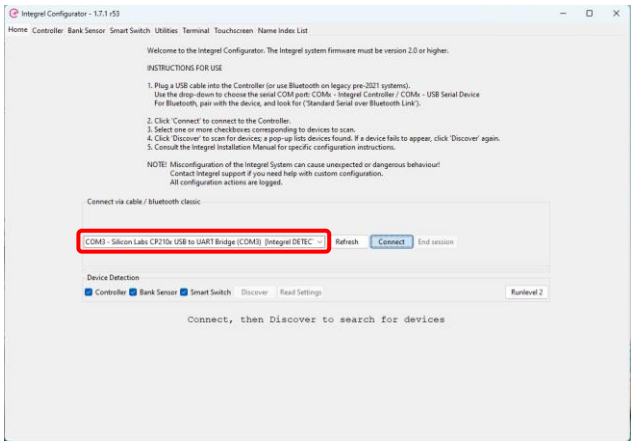
Configurator **version 1.7** or later is required to configure systems with software **version 2.1.x** or later.

The Serial Configurator maintains a logfile (in the same folder as the application).
If problems are encountered while using the Configurator, the logfile can be used to help diagnose the issue.

7.3 Integrel Configurator Application

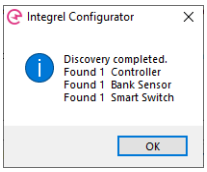
The Configurator provides a way to interact with the Integrel system as follows:

- Scan for hardware components on the Integrel network
- Read hardware versions
- Read and write settings for each hardware component
- Update Integrel software via Wi-Fi or USB



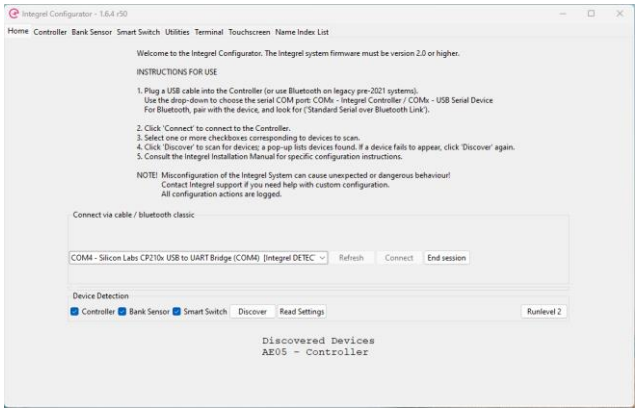
Connect to Devices

- Launch the Configurator
- The Integrel system appears automatically in the 'Connect via …' drop-down (outlined in red).
    - Click '**Refresh**' to scan for new connections if required.
- Click '**Connect**'
- Select the type of Integrel devices to be discovered using checkboxes in the 'Device Detection' section.
- Click '**Discover**' to discover devices on the Integrel network
- The following pop-up appears



- Click 'OK' to dismiss

A list of devices discovered appear at the bottom of the window.

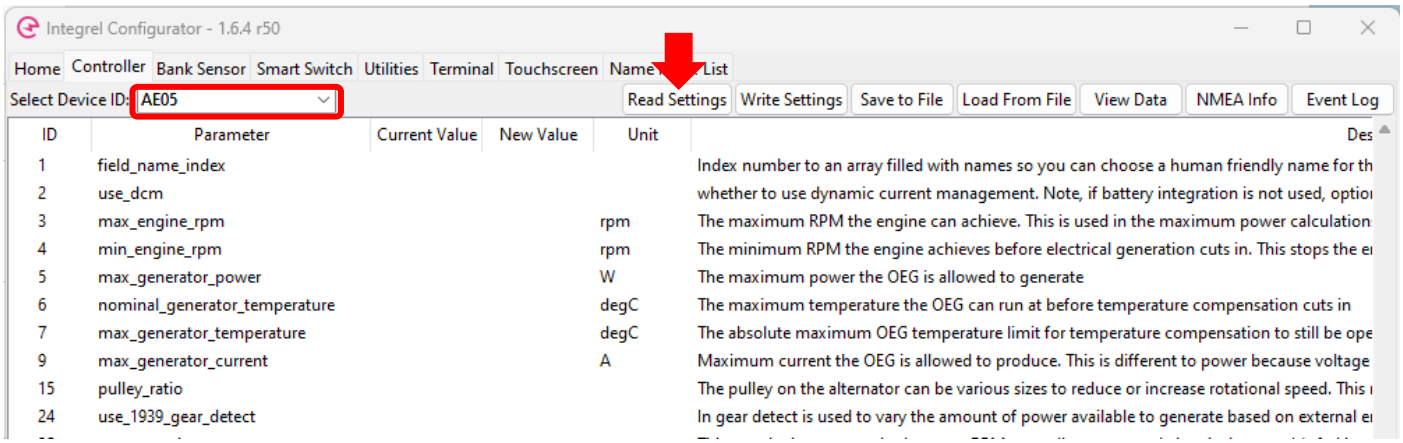


Once connected, use the tabs at the top of the window to access Configurator functionality.

Configurator Tab	Function
Home	• Discover and connect to devices or end a session.
Controller	• Read, write, load, and save Controller settings. • View system data. *Note! This data is not a live feed, but a snapshot taken when a connection to the Controller was established.* • Access NMEA2000 network diagnostics. • View event logs to diagnose system faults.
Bank Sensor	• Read, write, load, and save Bank Sensor settings. • View system data. *Note! This data is not a live feed, but a snapshot taken when a connection to the Controller was established.*
Smart Switch	• Read, write, load, and save Smart Switch settings. • View system data. *Note! This data is not a live feed, but a snapshot taken when a connection to the Controller was established.*
Utilities	• Synchronise/set the system clock.
Terminal	• Access system data logging (diagnostic purposes only).
Touchscreen	• Provide system software updates via Wi-Fi.
Name Index List	• Number index used to label devices on the Touchscreen; provided for reference only.

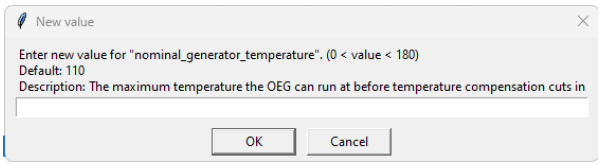
7.3.1 Choose Devices and Read Settings

To access device settings, select the relevant device tab, then choose the device ID using the drop-down (circled in red below). Once a device has been selected, select **Read Settings** (red arrow); settings appear in the 'Current Value' column.



7.3.2 Change and Write Settings

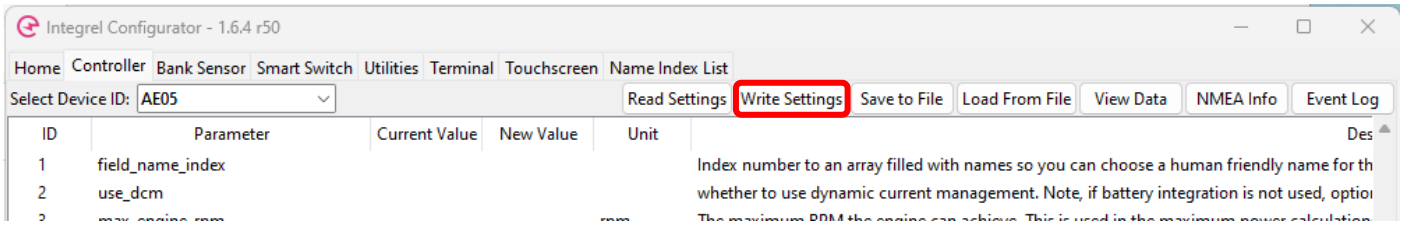
To change a setting, double-click the setting (Parameter) to change e.g. `nominal_generator_temperature`; a pop-up appears (see the following image). The pop-up provides information showing minimum, maximum and default values for the setting.



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

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

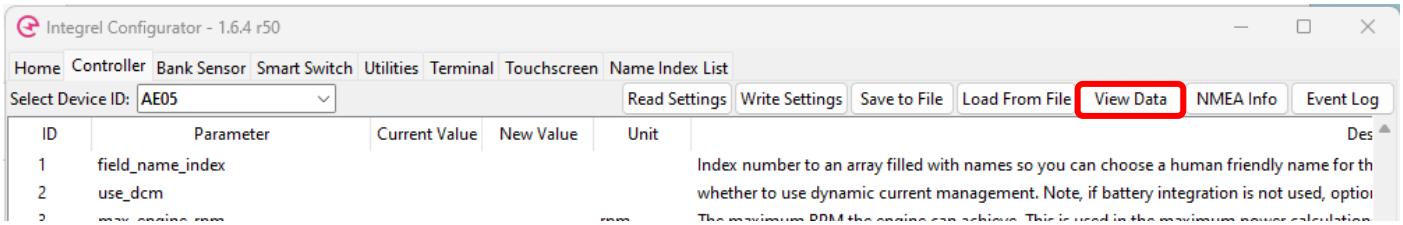
After you have finished making changes, select **Write Settings** (circled in red below). When you have finished making changes to device settings, return to the home page and select **End Session**.



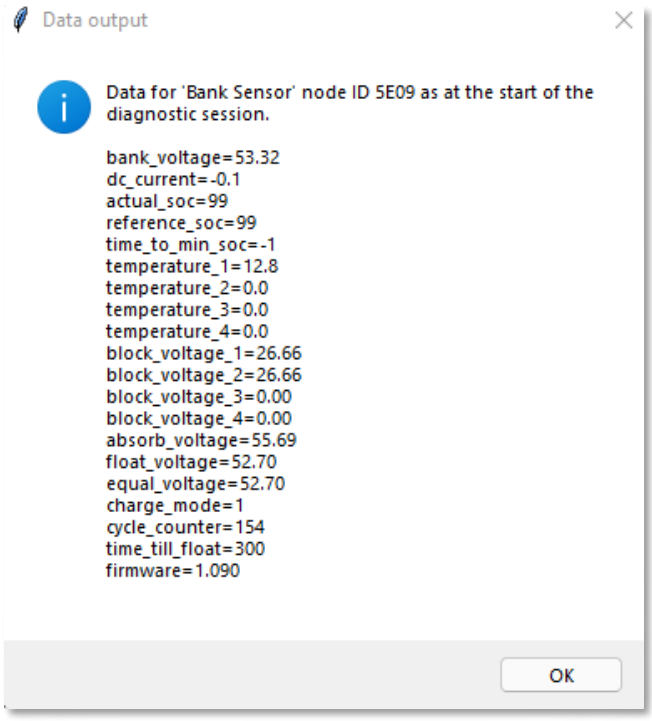
NOTE! To avoid accidental misconfiguration, the Write Settings function is disabled on some versions of the Integrel Configurator. If you are unable to write settings, contact support@integrelsolutions.com

7.3.3 Read Device Data

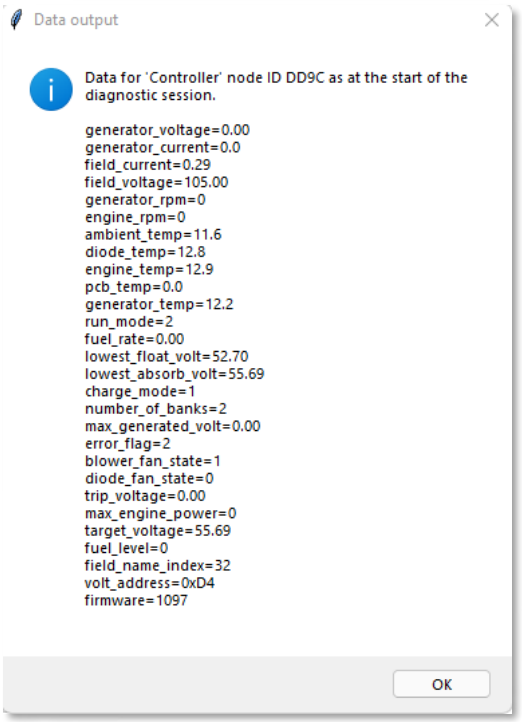
To read data captured by a device at the beginning of the session, first select the device, then select the **View Data** button as shown below (circled in red).



A dialogue box opens showing a data snapshot. Examples for a Bank Sensor and Controller are shown in the following screen captures.



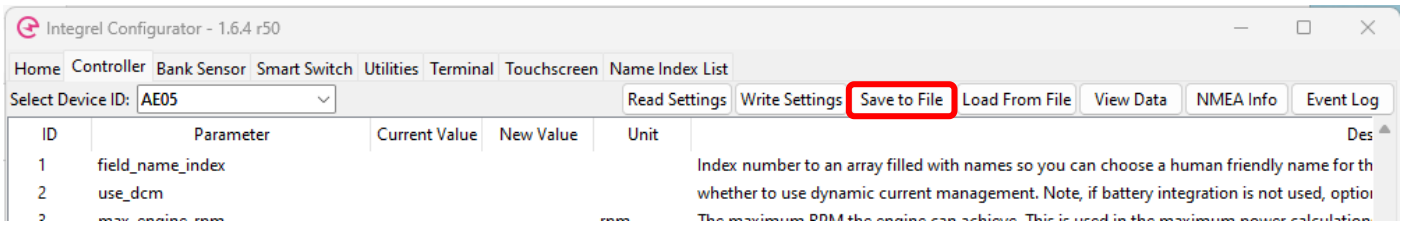
Data Snapshot : Bank Sensor



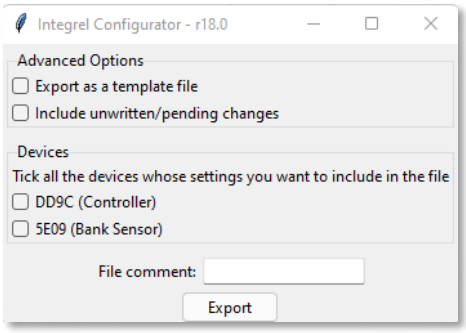
Data Snapshot : Controller

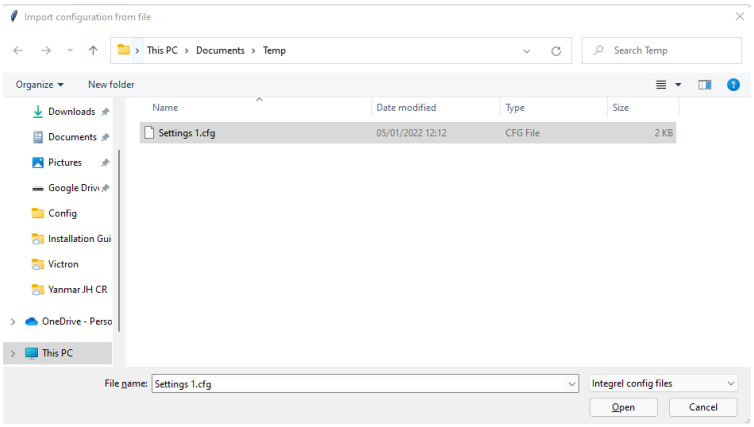
7.3.4 Save and Load Settings

Configuration settings can be saved to a file on your computer. 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 (circled in red below).



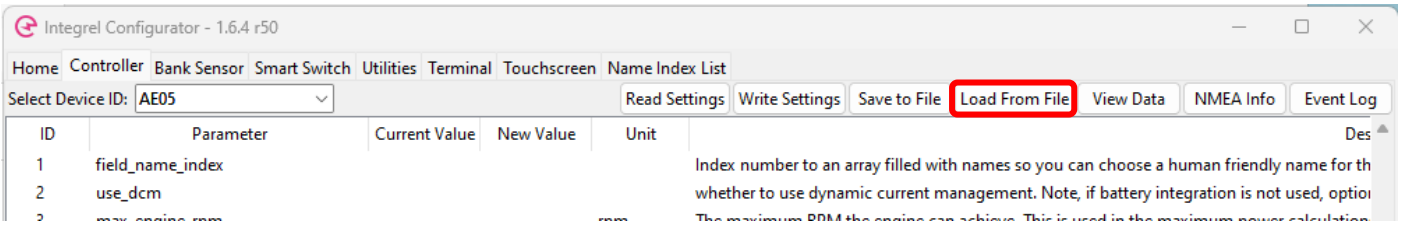
A pop-up appears as shown below (left). Select the devices you want to save by checking the relevant device IDs, then select **Export**. A file manager dialog appears (below, right). Enter a filename, and choose a relevant location to save the file, then select **Save**.





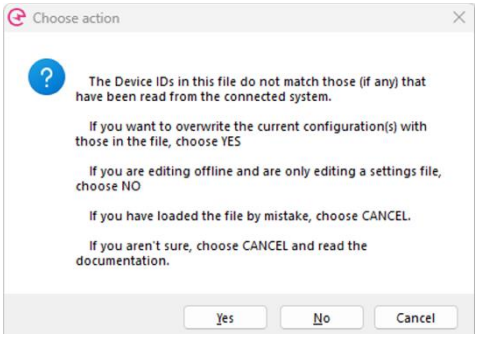
To load settings from a previously saved file, select the **Load from File** tab (circled in red below), a file manager dialog appears. Select the relevant configuration file to load, then select **Open**.

Settings read from the file appear in the 'New Value' column. Select **Write Settings** to write the settings to the device.



7.3.5 Read a Settings File

To read a settings file while not connected to a system, select the **Load from file** tab, then select the file you want to read. When the dialog box (right) shows; select **No**.



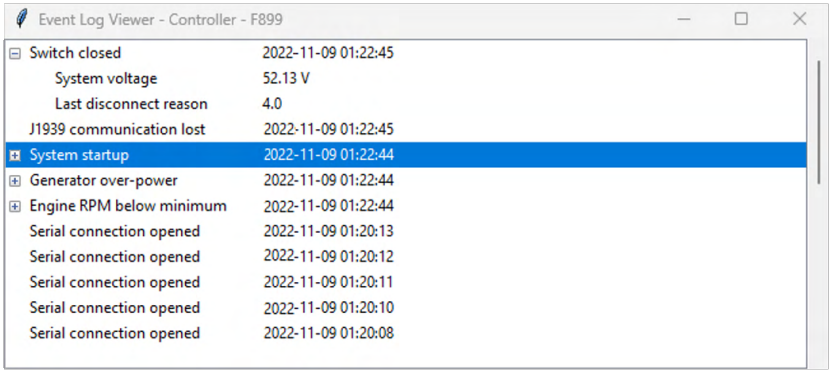
After the Configurator reads the file, use the 'Select Device ID' drop down to select offline devices. Change settings (if required), then select the tab **Save to File** to save the modified settings.

7.3.6 Event Logs

Event logs can be used to diagnose system problems and review system behaviour.

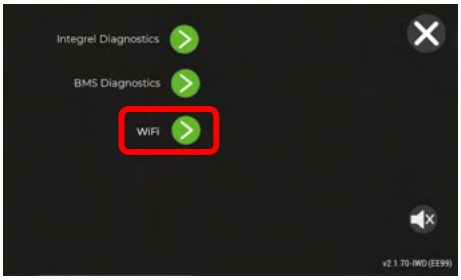
Event logs are only available on the Controller tab. To view the Event log, click the **Controller** tab then click the **Event Log** button.

The following screen capture shows an example of an event log.



7.3.7 Touchscreen Tab (Software Updates)

The Touchscreen tab can be used to update the system via Wi-Fi, contact Integrel to obtain the latest software update package.

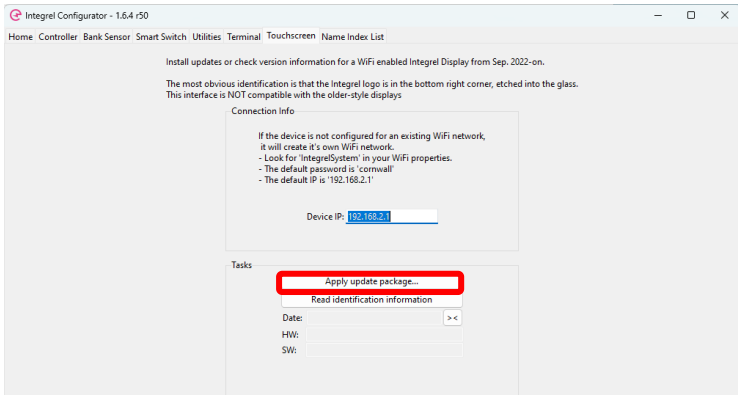


To update software via Wi-Fi, your computer must be connected to the Integrel Touchscreen Wi-Fi hotspot. To enable the Touchscreen Wi-Fi hotspot

1. Navigate to the Settings → Advanced menu on the Touchscreen (circled in red, right) and press the Wi-Fi button.
2. Connect your computer to the Wi-Fi network called 'Integrel-XXXX'.

Once your computer is connected to the Integrel Touchscreen Wi-Fi network, return to the Configurator Touchscreen tab.

1. Press **Apply update package**; a dialogue window opens.
2. Find and select the update package file, then select **Open**. The update package automatically uploads to the Touchscreen.



The Touchscreen prompts for manual confirmation to update each of the devices on the Integrel network in turn. A video tutorial is available to guide you through the software update process if required.

7.3.8 Utilities and Terminal Tab

Setting the Clock

To set/synchronise the system clock to the current time, select the **Utilities** tab. Select a controller ID and press **Read**, then **Sync Clock**.

Terminal

The Terminal is used for diagnostic purposes, an Integrel support engineer will provide instructions to use the terminal if required.

7.4 Controller Settings

This section contains information and guidance related to critical 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 Section 7.4.3	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.	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	Used to scale back the maximum current produced. Often 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.	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		Used to modify RPM calculations; do not change without advice from Integrel.	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	Restricts OEG power to a maximum torque load; set to 0 to disable.	0 – 255
j1939_enabled	1	-	Enables use of J1939 engine interface. See Section 6.9.6	0 / 1
j1939_engine_address	0	-	Selects which J1939 source address to read engine data from. See Section 6.9.6	0 – 255
n2k_data_select	3	-	Selects which data is published on the NMEA2000 interface, see Section 6.9.7	0/1/2/3
n2k_engine_instance	0	-	Selects which engine instance to output data for. See Section 6.9.7	0 – 255
bms_identifier	0	-	Select BMS type, see Section 6.9.8	0 – 255

7.4.1 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.

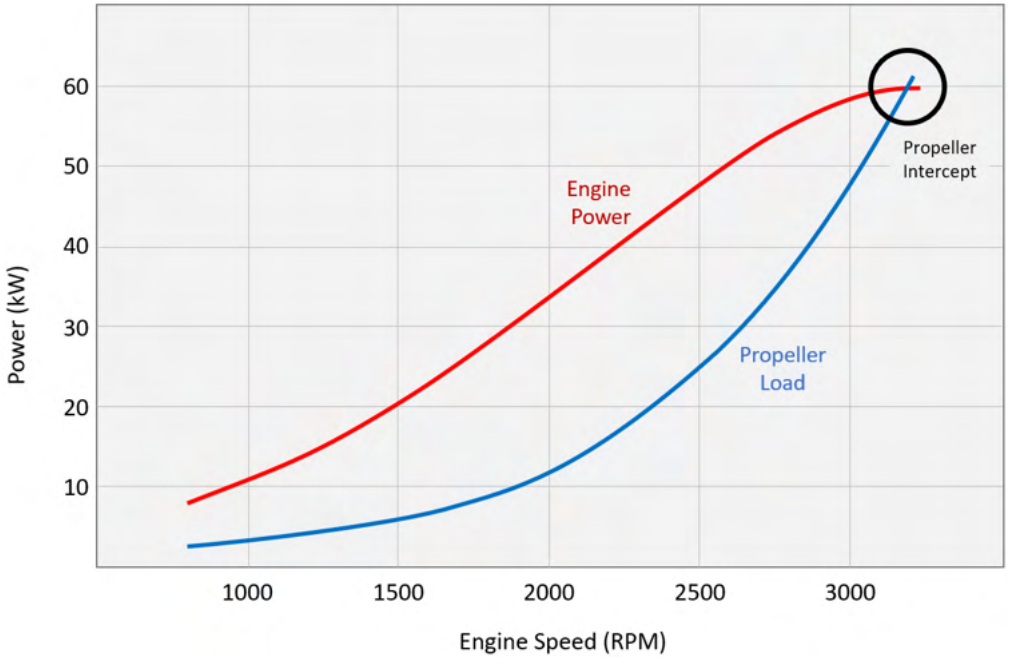
Compact – Poor ventilation

Spacious – Well ventilated

Setting	Poor Cooling (°C)	Moderate Cooling (°C)	Good Cooling (°C)
nominal_generator_temperature	100	115	120
maximum_generator_temperature	150	160	180

7.4.2 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 a number of 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.

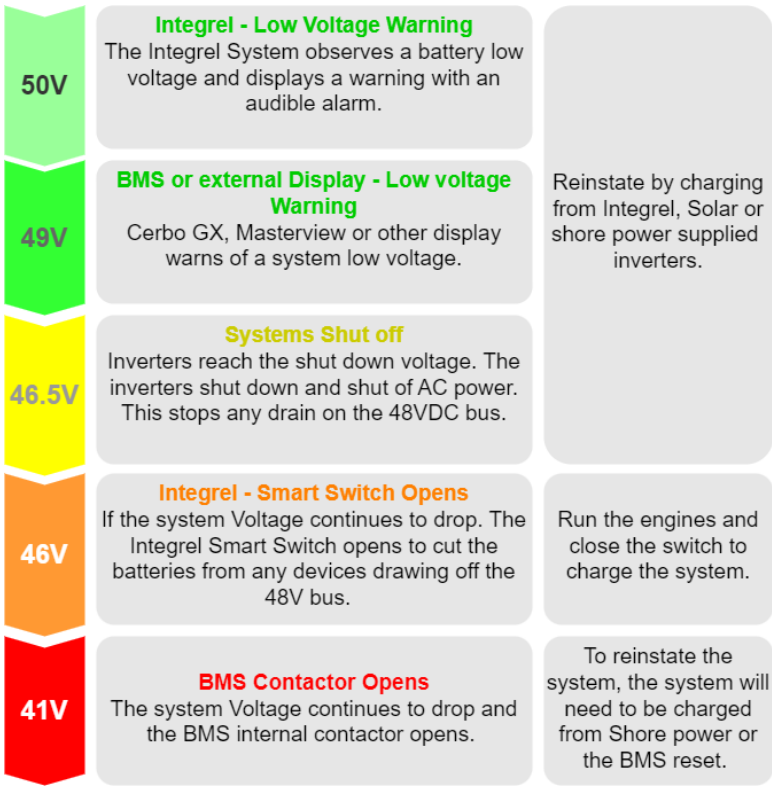
7.4.3 Engine Settings

Manu-facturer	Engine Model	Minimum RPM	Maximum 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	82
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 150/170/195	700	3500/3500/3500/3800/3800	110/125/143
Volvo	D2 40	700	3200	29
Volvo	D2 60	700	3000	44
Volvo	D2 75	700	3000	55
Volvo	D3 110/150/170/200/220	700	3000/3000/4000/4000/4000	81/110/125/147/162
Volvo	D4 300	850	3500	221
Volvo	TMD22	700	3500	57
Vetus	VETUS M40	700	3000	30
Beta	BETA 75	700	2600	56
Beta	BETA 90	700	2600	67
Nanni	N4.65	850	2700	48

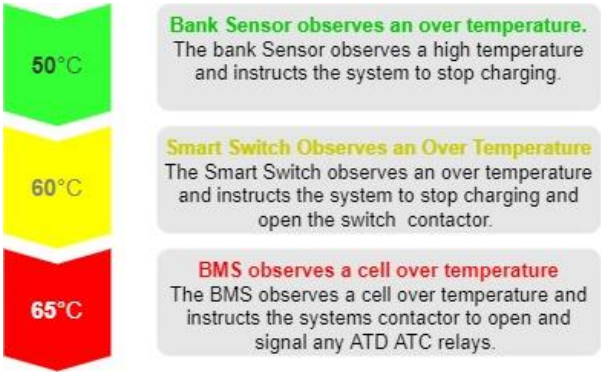
7.5 System Settings

The following flow diagrams demonstrate how the system operates as the battery voltage drops or the battery temperature increases. The system is designed (and can be configured) to provide multiple checkpoints or gates to maximise operational safety and minimise any chance of damage to batteries.

Low Voltage



High Temperature



The following tables provide a list of recommended settings for battery types warranted to work with the Integrel System. If the battery type you are planning to use is not listed in the table, operation of the Integrel system is not warranted to work your battery. Contact support@integrelsolutions.com if you are unsure.

The settings in these tables are **critical to ensure a safe working system!**

Integrel Device	Setting	MG Energy 24V (280Ah)	Victron LFP 25.6 (200Ah)	Mastervolt MLI 24 5000/6000	Lithionics 48V (315Ah)
Bank Sensor	bank_ah_rate (Ah)	280	200	200/230	315
Bank Sensor	Li_bulk_target (V)	55.2	56.8	57	57.6
Bank Sensor	Li_bulk_float (V)	53.2	54.0	54.0	55.2
Bank Sensor	Li_min_charge_temp (°C)	0	5	0	0
Bank Sensor	Li_max_charge_temp (°C)	57	50	50	52
Bank Sensor	Li_min_discharge_temp (°C)	-20	-20	-25	-20
Bank Sensor	Li_max_discharge_temp (°C)	57	50	50	52
Bank Sensor	Li_min_voltage (V)	44.0	43.0	44.0	46.6
Bank Sensor	Li_max_voltage (V)	57.0	58.0	58.5	58.4
Bank Sensor	Li_max_discharge_current (amp)	280	200	200/230	160
Bank Sensor	Li_max_charge_current (amp)	160	170	160/184	150
Bank Sensor	warning_voltage[1] (V)	48-50	48-50	48-50	48-50
Smart Switch	low_voltage_disconnect (V)	46	46	46	46
Smart Switch	high_voltage_disconnect (V)	58	59.5	59	59
Smart Switch	low_temp_disconnect (°C)	-10	-10	-10	-10
Smart Switch	high_temp_disconnect (°C)	65	60	55	54.5

Inverter/Charger Settings				
Bulk/Absorption Voltage	55.2	56.8	57	57.6
Float Voltage	53.2	54	54	55.2
Inverter cut-off Voltage[2]	47	47	47	47
Inverter Pre-Alarm[1]	48-50	48-50	48-50	48-50

NOTE!

1. *The voltage at which the alarm sounds to charge the system may be configured as required.*
2. *This is the recommended value; some inverters may not be configurable.*

7.6 Inverter/Charger Configuration

7.6.1 General

The following table describes key Inverter settings and recommended configurations for use with Integrel. Refer to the table in Section 7.5 together with the manufacturer's installation guide for additional guidance.

Setting Name	Value	Description
Bulk Voltage	Match the Bank Sensor settings	Target voltage for the batteries to be charged to 100% of capacity
Float Voltage	Match the Bank 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. See Examples in the table in Section 7.5.	The Inverter/charger shuts down when the voltage drops below this voltage.
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

7.6.1 Victron Quattro / Multiplus II

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

7.6.2 Mastervolt

Integrel supports Mastervolt batteries using a Masterbus to NMEA2000 interface as described in the supplementary Integrel document ***Mastervolt Battery Integration Guide***. The Integrel system reads battery data from the NMEA2000 network.

Mastervolt CZone operation is NOT supported with OEG Software v2.1.x; CZone support will be added in a future software release.

7.7 Battery (BMS) Configuration

All battery(s) / battery manufacturers supported by Integrel provide battery BMS data on proprietary CAN and/or NMEA 2000 networks. Integrel recommends all systems are configured to read BMS data directly from the BMS via NMEA2000 (MG, Victron, Mastervolt) or a VE.Can network (MG, Victron only).

The level of NMEA2000 support varies depending on the manufacturer. Diagnostic data is available by pressing **ADVANCED** on the Integrel Touchscreen, then **BMS Diagnostics**. Available data varies depending on the manufacturer.

7.7.1 MG Energy Systems Diagnostics

BMS data	Description
BMS Error	Shows BMS errors in numerical value.
Warning Flags	Warning flags reported by the BMS in numerical value.
Cell Voltage	Min. and max. cell voltage. Highest cell voltage and lowest.
Cell Temperature	Min. and max. cell temperature. Highest cell temperature and lowest.
Status Flags	BMS system status in numerical value e.g. balancing, charging, etc.
Unfiltered state	State of Charge
Target Voltage	BMS reported Target Voltage.
Target Current	BMS reported current limit

7.7.2 Mastervolt Diagnostics

BMS data	Description
Warning flags	Warning flags reported by the BMS in numerical value.
Status Flags	BMS system status in numerical value e.g. balancing, charging, etc.
SoC	State of Charge
ID SA	Used for diagnostic purposes
Status	Used for diagnostic purposes

7.7.3 Victron Diagnostics

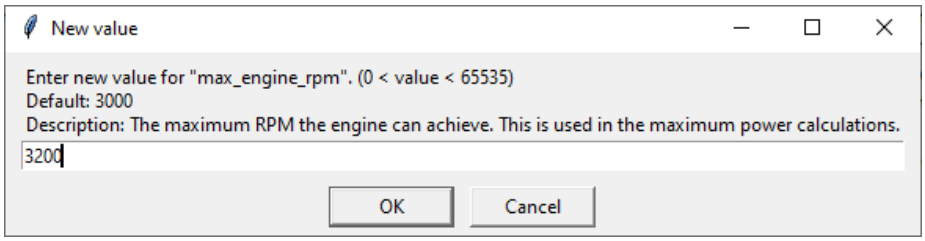
BMS data	Description
Warning flags	Warning flags reported by the BMS in numerical value.
Status Flags	BMS system status in numerical value e.g. balancing, charging, etc.
SoC	State of Charge
ID SA	Used for diagnostic purposes
Status	Used for diagnostic purposes

7.7.4 Lithionics

BMS data	Description
Fault present	Shows any BMS warnings in numerical value
Warning reference	Warning flags reported by the BMS in numerical value.
Cell Temperature	Min. and max. cell temperature. Highest cell temperature and lowest.
Current Limit	BMS reported current limitation
Target Voltage	Target voltage
Integrel Flags	Used for diagnostic purposes

7.8 Default Settings

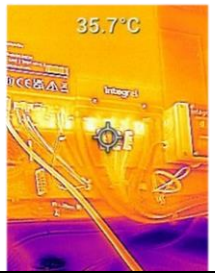
Use the Integrel Configurator to view defaults and limits for any setting. When a setting is selected, the 'New Value' dialog box shows the default, minimum and maximum values for the setting.



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 ensures a safe reliable system is delivered to the end-user.

#	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 touchscreen 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 Touchscreen 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 and power cycle the system before proceeding.	☐
6	**Connect Batteries** Switch the batteries ON via the switch/isolator.	☐
7	**Check Battery Current** Using the Integrel Touchscreen, 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 e.g. –2.123kW when charging means the polarity is incorrect and 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** Cross-check 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 Bank Sensor 'reset' button until the blue LED illuminates. See Annex B – Bank Sensor Calibration & Reset for instructions to calibrate and 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** After the engine mounting kit has been installed, it is important to check belt alignment. Ensure belt alignment has been checked BEFORE running the engine. If the belt creates dust or frays excessively, then recheck belt alignment and retest. A new belt always creates a minor amount of belt dust that subsides once the belt is worn in. 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. Using a thermal camera, check the temperature of all terminals carrying high current. 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 Touchscreen.	☐
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
Integrity check failed	1	2	Configuration settings may be corrupt.	Contact support.
System voltage (48V) too high	2	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	3	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	4	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	5	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	6	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	7	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	8	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	9	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	10	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	11	1	As above-- but this sensor is on the controller PCB	Check as above.
Engine temperature too low	12	2	The engine temperature is too low	Check the Controller setting: `engine_start_temperature`
Ambient temperature too high	13	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	14	2	Ambient temperature too low	If the temperature is not below 0°C then there could be a temperature sensor fault
Generator RPM out of range	15	2	Estimated RPM calculated from generator pulses is higher than maximum engine RPM	This could be a problem with the RPM circuit in the Controller or a generator fault. Contact support.
RPM divergence detected, check belt	16	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	17	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	18	1	Generator temperature sensor fault	Contact support
Diode temperature sensor fault	19	1	Diode temperature sensor fault	Contact support
DC/DC field voltage incorrect	20	2		Contact support
Startup self-check failed.	21	2		Contact support
Field coil fault	22	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	23	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	24	2	The BMS has reported a warning code	Provide the BMS warning code to support.
BMS reported an error	25	1	The BMS has reported an error code	Provide the BMS error code to support.
BMS Contactor Open	26	1	One or more contactors in the BMS are open	The BMS has opened the contactor. Check BMS for additional information.
BMS Comms Lost	27	1	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: `battery_integration_type`
J1939 Comms Lost	28	2	Communication with the Engine ECU interrupted	Check the connection to the engine J1939 diagnostic port.
BMS not detected on NMEA2000 network	29	2	The BMS was not found on the NMEA200 network	Check the Controller connection to the NMEA2000 network.
BMS not detected	30	2	The BMS was not detected on the BMS connection.	Check the Controller connection to the BMS network.
RPM too high, generation disabled	31	2	Generator RPM is too high	This could be a problem with the RPM circuit in the Controller or a generator fault. Contact support.
Check NMEA configuration	32	2	NMEA2000 configuration may be incorrect	Check NMEA2000 related settings. Check NMEA2000 compatible BMS/batteries are correctly configured.
12V power supply low, check batteries	33	2	12V battery is low	Check Controller 12V battery supply. The battery(s) may cause a Controller brownout under heavy load if the voltage drops below 12V.

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`
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`

Message Displayed	#	Warning Level	Description	Solution
Battery voltage imbalance	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.
Integrity check failed	27	2	Configuration settings may be corrupted.	Contact Integrel support.

9.3 Smart Switch Warning Messages

Message Displayed	#	Warning Level	Description	Solution
BMS signal 1 triggered (stop discharge)	1	2	'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.
BMS signal 2 triggered (stop charge)	2	2	'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 voltage threshold exceeded	3	2	The high voltage threshold configuration has been exceeded	
Low voltage threshold exceeded	4	2	The low voltage threshold configuration has been exceeded	
High current threshold exceeded	5	2	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	2	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	2	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	2	A device on the Integrel Argo CAN bus issued a PANIC disconnect message	
High battery temperature exceeded	10	2	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.

Message Displayed	#	Warning Level	Description	Solution
Low battery temperature exceeded	11	2	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	2	The battery sensor is faulty or missing	Check the wiring loom for faults
Switch solenoid stuck ON	13	2	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 screwdriver. Apply a small dab of copper slip to the contacts to avoid this happening again.
Switch solenoid stuck OFF	14	2	The switch contactor is stuck in the open position	Try to close the switch manually.
Battery voltage missing	15	2	The switch is not connected to the battery	Check the connection between the switch and the battery.
Discharge not allowed (MG)	21	2	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 TOUCHSCREEN

The Integrel Touchscreen 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 generating, 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 Information

System Summary and Warnings

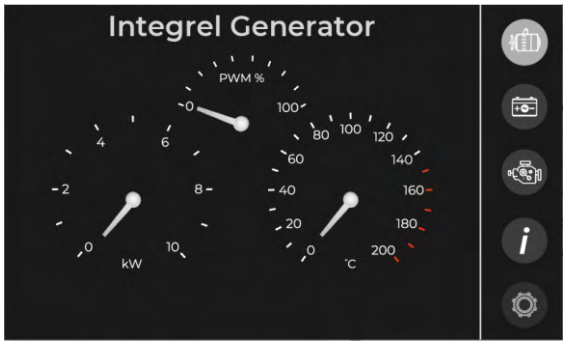
Battery Status Information

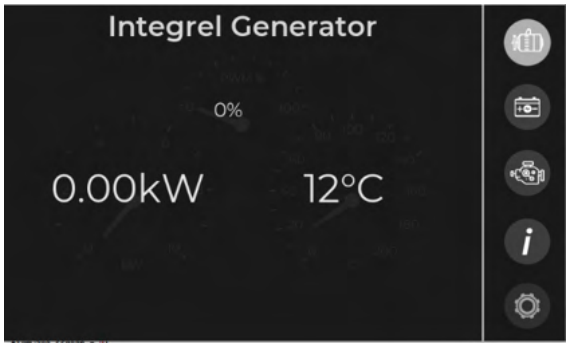
System Settings

Engine Status Information

10.2 Generator Status

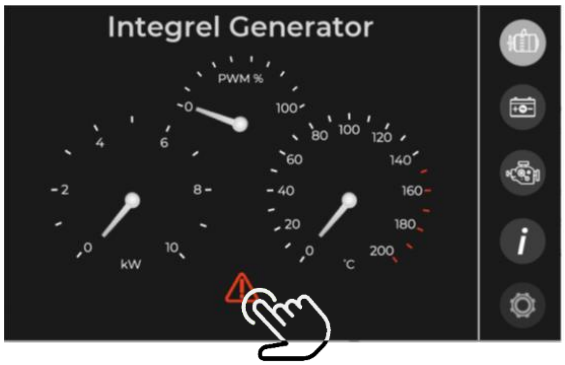
The following images show an example of the Generator Status and Information page. This page shows the power output in kW of each individual Generator. In a dual system, arrows at the bottom of the screen are available to select between the port and starboard Generator. Tap the screen to toggle the display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

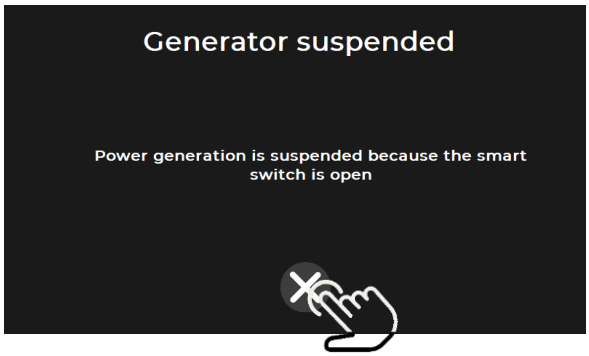




10.3 Warning Symbols

If a warning occurs during generation, a warning icon is shown at the bottom of the generator page. To learn more about the warning, tap the icon.

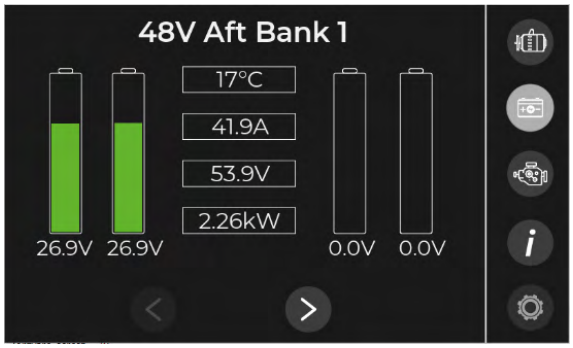




10.4 Battery Status Page

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).

The main page displays battery temperature, battery current (or SoC), battery voltage and power into or out of the battery. When the battery is discharging, power reads negative, and positive when charging.

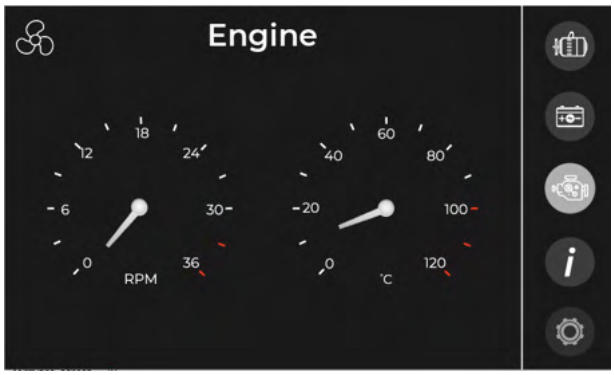


On the battery data page, the following information is shown:

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 (if configured).
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.

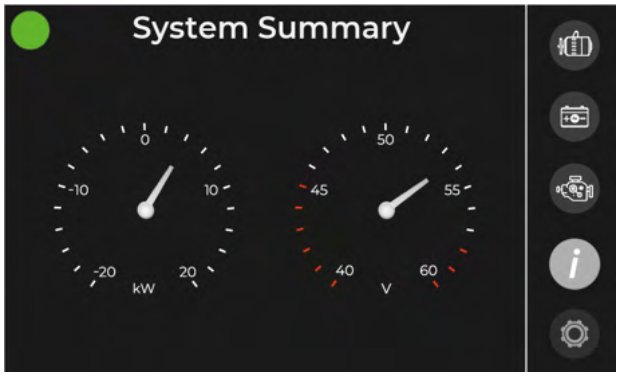
10.5 Engine Status

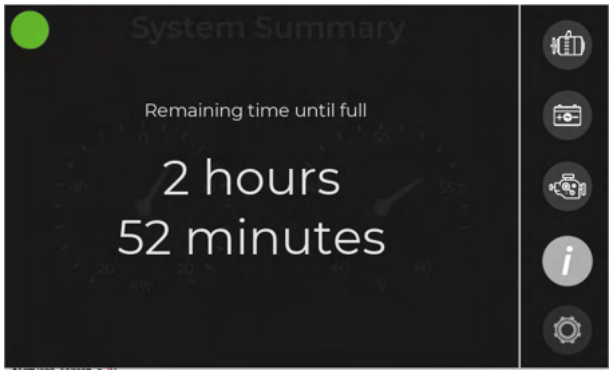
The Engine Status page shows the speed of the engine in RPM (revolutions per minute) and the temperature of the engine.



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

10.6 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.

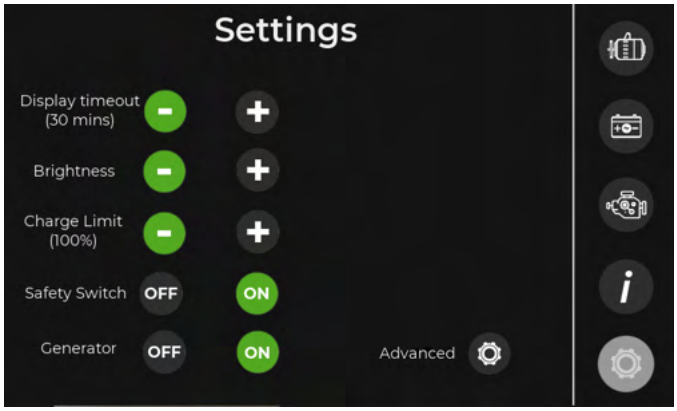
The System Summary page shows:

- Power being produced (or consumed) in kilowatts (kW)
- Voltage of the 48V battery banks
- Estimate of battery State of Charge (when connected to a BMS)

Tap the center of 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 instantaneous level of power flowing into or out of the battery banks; tap again to return to the analogue display.

10.7 Settings Page

Press the Settings icon to open the Settings page.



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

Time to Sleep. Activity timeout until the screen sleeps.

Brightness. Adjusts the screen brightness.

Charge Limit. Configures the maximum (State of Charge) charge limit.

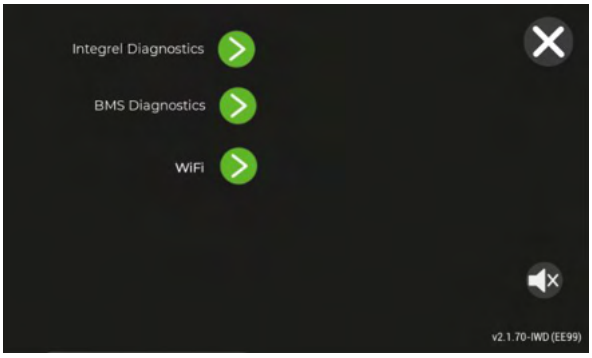
Safety Switch (and 24V Safety Switch). Controls the Integrel Smart Switch

- ON = Switch Closed (load connected)
- OFF = Switch Open (load disconnected)

Generator. Turns the Integrel Generator ON or OFF. If 'Safety Switch' is not shown, your boat does not have a switch installed.

Advanced. Access to System Diagnostics, BMS Diagnostics and Wi-Fi.

10.7.1 ADVANCED



Integrel Diagnostics

The diagnostics page can be used by the Integrel support team or an Installer to diagnose any issues with the Integrel system if required. See Section 10.8 for additional information.

BMS Diagnostics

The BMS page displays information and diagnostic data from the battery BMS; Integrel supports BMS systems from manufacturers including Mastervolt, Victron, MG Energy and Lithionics.

Wi-Fi

Wi-Fi is used to update Integrel software (available only on Integrel Touchscreen models from 2023 onwards).

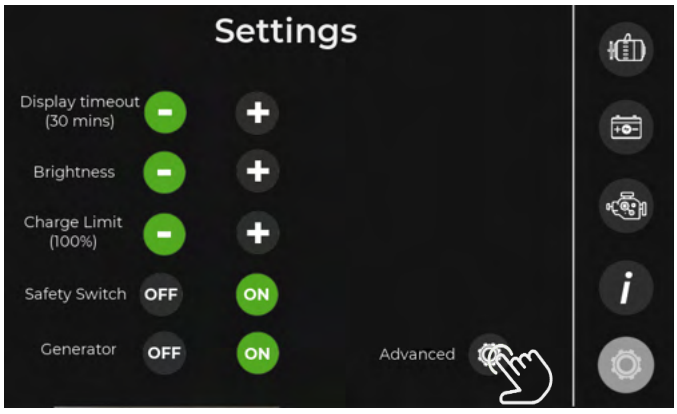
Speaker Mute

The mute button can be used to mute error and warning alerts.

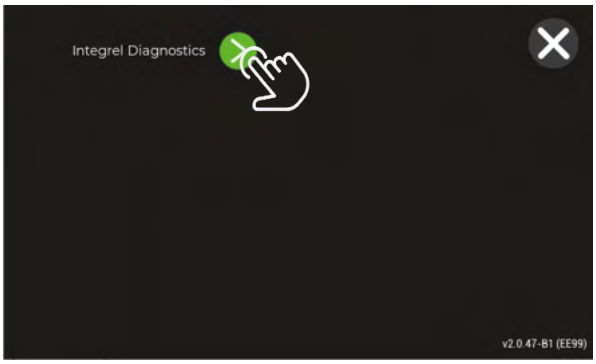
10.8 Diagnostic Information

Use the following instructions to access the Integrel diagnostic page.

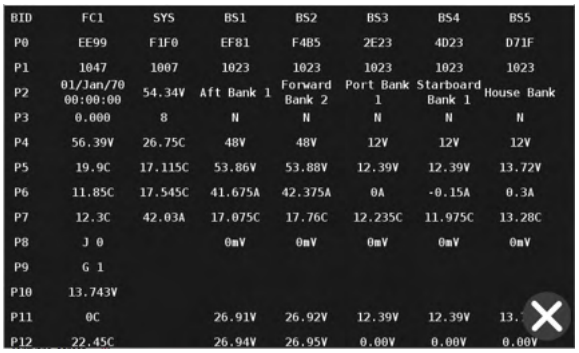
1. Navigate to the Settings page by selecting the settings (cog) icon in the bottom right corner of the screen. See Section 10.8.1 – Diagnostic Page Parameter Summary for more information.
2. Select the Advanced icon



3. Select Integrel Diagnostics



The Integrel Diagnostic Page is displayed. An example page is shown in the following image.



10.8.1 Diagnostic Page Parameter Summary

The Diagnostic Page is divided into columns. Each column displays information (parameters) related to individual Integrel system components such as the Integrel Controller, Bank Sensor or Smart Switch. Parameters are numbered sequentially and provide varying information depending on component. The following table provides a decoder for each parameter and for each component. Further explanation of each parameter is provided in following tables.

Parameter	Controller (FC)	System/Switch (SYS)	Bank Sensor (BS)
P0	EUID	EUID	EUID
P1	Firmware version	Firmware version	Firmware version
P2	Manufacture Date	Manufacture Date	Manufacture Date
P3	Hardware Revision	Hardware Revision	Hardware Revision
P4	Target Voltage	Switch Voltage 48V	Bank name
P5	Ambient Temperature	Last disconnect reason	Charge Mode (N/B/F/E)
P6	OEG Temperature	Ambient Temperature	Bank Sensor Type (12V/24V/48V)
P7	Engine Temperature	Battery Temperature 1	Battery Voltage
P8	J1939 Interface Status	Battery Temperature 2	Battery Current
P9	Engine Gear Status	Total system current	Battery Temperature

Parameter	Controller (FC)	System/Switch (SYS)	Bank Sensor (BS)
P10	12V supply voltage	Allow updates config	Voltage Offset
P11	NMEA fault flags	Screen Faults	Bank Actual SoC
P12	Diode Temperature	Buzzer Enabled	Bank Reference SoC
P13	Field Coil Voltage	DCM Current Limit	Block Voltage 1
P14	Field Coil Current		Block Voltage 2
P15	Generation Inhibit Reason		Block Voltage 3
P16	Last Generation Inhibit Reason		Block Voltage 4
P17	Last Zero PWM Reason		
P18	Alert Status		
P19	48V System Voltage		
P20	48V System Current		
P21	CAN Error Statistics 1: Argo/J1939		
P22	CAN Error Statistics 2: N2K		
P23	System Voltage Sample Quality		

10.8.2 Controller Parameters

Parameter	Controller (FC)	Description
P0	EUID	The four-digit ARGO CAN bus ID of the Controller e.g. `D14E`
P1	Firmware version	The firmware version running on the Controller
P2	Manufacture Date	Manufacturing date of the Controller
P3	Hardware Revision	Hardware revision of the circuit board
P4	Target Voltage	The target voltage the system will charge up to. This may be the Bulk, Float or another voltage requested by the BMS.
P5	Ambient Temperature	The temperature measured by the ambient temperature sensor.
P6	OEG Temperature	The temperature measured by the OEG internal temperature sensor (this is the same as the measurement shown on the Generator page).
P7	Engine Temperature	The temperature measured by the engine temperature sensor; or reported by J1939 data if the J1939 interface is connected to the engine.
P8	J1939 Interface Status Engine RPM Generator RPM	JX : J1939 is (1) / is not (0) being received on the J1939 interface EX : Engine RPM received from J1939 interface GX : OEG Generator RPM (estimated from Controller)
P9	Engine Gear Status	G0 : Engine is out of gear G1 : Engine is in gear
P10	Supply voltage	The Controller 12V (nominal) power supply voltage. **NOTE! The Integrel system may not operate correctly if the power supply voltage falls below 12V.**
P11	NMEA Faults	NMEA fault indicator
P12	Diode Temperature	The temperature of the Controller rectifying diode
P13	Field Coil Voltage	The Controller field coil driver voltage (57.6V nominal)
P14	Field Coil Current	The Controller field coil driver current
P15	Generation Inhibit Reason	The reason why the OEG is not charging (see the following P15/P16 table decoder for details).
P16	Last Generation Inhibit Reason	The reason why the OEG stopped charging last time (see the following P15/P16 table decoder for details).
P17	Last Zero PWM Reason	The reason why the PWM output is zero (see the following P17 table decoder for details).
P18	Alert Status	CAN bus alert status (see the following P18 table decoder for details).

Parameter	Controller (FC)	Description
P19	48V System Voltage	System voltage at the 48V output of the rectifying diode
P20	48V System Current	System current measured by the hall effect sensor
P21	CAN Error Statistics 1	ARGO TEC/REC error count, J1939 TEC/REC error count
P22	CAN Error Statistics 2	NMEA2000 TEC/REC error count

NMEA Faults (P11)

NMEA Faults is an integer in the range 1-8; values are shown in the following table.

#	NMEA Fault
1	BMS Inconclusive (more than one BMS found)
2	NMEA address conflict (badly behaving device on N2K)
3	BMS missing (BMS not found)
4	Masterbus battery configuration is incorrect
5	Internal software string error (internal use)
6	NMEA device list is full (network has too many devices)
7	Reserved
8	Reserved

Generation Inhibit Reason (P15/P16)

The Generation Inhibit reason is an integer in the range 1 – 9; values are shown in the following table.

#	Reason
1	Switch is Open
2	System paused due to Configuration / Debug
3	Memory integrity check failure
4	System voltage is too high / too low
5	Engine is too cold
6	Generation manually turned off (using Integrel Touchscreen)
7	The Controller has overheated
8	The BMS has instructed the system to stop charging
9	Maximum engine RPM exceeded

Last PWM Zero Reason (P17)

The Last PWM Zero reason is an integer in the range 1 – 13; values are shown in the following table.

#	Reason
1	Low RPM
2	Over voltage
3	OEG exceeded emergency temperature
4	OEG over current
5	OEG exceeded available engine power

#	Reason
6	PWM Negative (not used)
7	PWM RPM Delta (not used)
8	Low voltage detected by Controller
9	The system detected a gear change event
10	Engine too cold to begin charging
11	MG cutoff (not used)
12	Stopped to receive new parameter settings
13	Maximum engine RPM exceeded

Alert Status (P18)

Alert status is an integer in the range 1 – 8; values are shown in the following table.

#	Reason
1	ARGO – No CAN data received
2	J1939 – No CAN data received
3	NMEA2K – No CAN data received
4	J1939 Comms Lost
5	Slave Controller Flag
6	BMS CAN data recognised
7	Limp mode active
8	Not charging due to SoC limit

10.8.3 Smart Switch Parameters

Parameter	System/Switch (SYS)	Description
P0	EUID	The four-digit ARGO CAN bus ID of the Controller e.g. `D14E`
P1	Firmware version	The firmware versionS running on the Controller
P2	Manufacture Date	Manufacture date of the Switch hardware
P3	Hardware Revision	Hardware revision of the circuit board
P4	Switch Voltage (48V nominal)	The battery voltage measured by the Switch
P5	Last disconnect reason	The reason that caused the Switch contactor to last open (see the following P5 table decoder for details).
P6	Internal Temperature	The temperature measured by the ambient temperature sensor.
P7	Battery Temperature	The temperature measured by the battery terminal sensor
P8	Ambient Temperature	The temperature measured by the ambient air sensor
P9	Total system current	The total current flowing into/out of the battery bank (the total of current measured by all bank sensors)
P10	Allow Updates Config	
P11	Screen Faults	
P12	Buzzer Enabled	
P13	DCM Current Limit	

Last Disconnect Reason Decoder (P5)

The last disconnect reason is an integer in the range 1 – 26; values are shown in the following table.

#	Description
1	SIGNAL1_NO_DISCHARGE (Green/Purple IO wire)
2	SIGNAL2_NO_CHARGE (Green/Purple IO wire)
3	High Voltage (Switch V Tap)
4	Low Voltage (Switch V Tap)
5	High Current (total current measured by all 48V bank sensors)
6	High Temperature Disconnect (Ambient sensor)
7	Low Temperature Disconnect (Ambient sensor)
8	User Disconnect
9	Panic Disconnect
10	High Temperature Disconnect (Battery sensor)
11	Low Temperature Disconnect (Battery sensor)
12	Missing temperature
13	Switch Stuck on – contactor fused or switch held closed

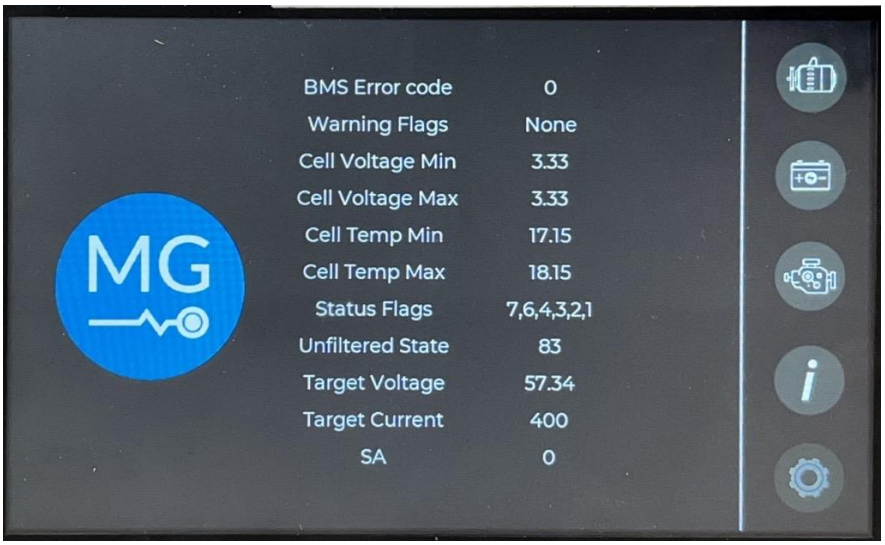
#	Description
14	Switch Stuck off – locked in the off position or solenoid failure.
15	Battery missing
16	BMS Error (Torqeedo)
17	BMS Block missing (Torqeedo)
18	BMS enumeration failed (Torqeedo)
19	BMS enumeration time out (Torqeedo)
20	BMS warning (Torqeedo)
21	BMS Discharge (All BMS systems)
22	Device Class Corrupt
23	Reserved
24	Reserved
25	Reserved
26	Reserved

10.9 Bank Sensor

Parameter	Bank Sensor (BS)	Description
P0	EUID	The four-digit ARGO Canbus ID of the Controller e.g. D14E
P1	Firmware version	The firmware version running on the Controller
P2	Manufacture Date	Manufacturing date of the Bank Sensor hardware
P3	Hardware Revision	The hardware revision of the board
P4	Bank name	The human friendly name for the Bank Sensor
P5	Mode (N/B/F/E)	Charging mode N – Not charging B – Charging to Bulk F – Charging to Float E – Equalising
P6	Bank Sensor Type (12V/24V/48V)	The battery type being monitored (classified by voltage)
P7	Battery Voltage	The measured voltage of the battery bank
P8	Battery Current	The measured current of the battery bank
P9	Battery Temperature	The measured temperature of the battery bank terminal
P10	Voltage Offset	The offset between the system voltage measured by the Controller and the voltage reading of the bank sensor.
P11	Bank Actual SoC	TBD
P12	Bank Reference SoC	TBD
P13	Block voltage 1	Measured voltage of Tap 1
P14	Block voltage 2	Measured voltage of Tap 2
P15	Block voltage 3	Measured voltage of Tap 3
P16	Block voltage 4	Measured voltage of Tap 4

10.9.1 BMS Diagnostics

The BMS diagnostic page contains BMS status and BMS warnings. The following sections provide information about BMS diagnostics for batteries supported by Integrel.



All BMS error codes are passed transparently from the BMS.

BMS Status Flags	
1	Contactor closed (charge)
2	Allow to Charge
3	Allow to Discharge
4	Is alive
5	Is charging
6	Is discharging
7	Contactor closed (load)
8	Charged

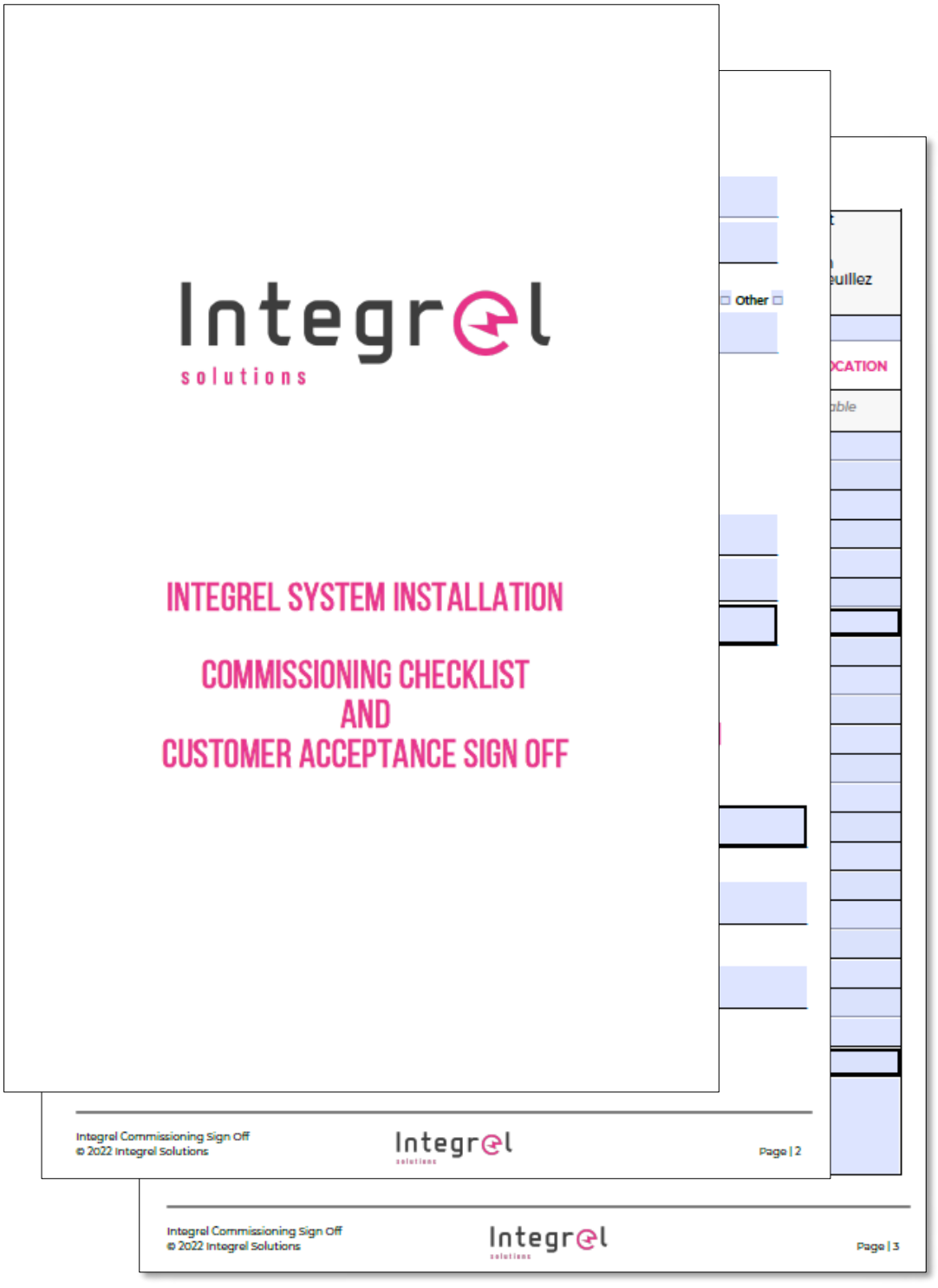
BMS Warning Flags	
1	Over Voltage
2	Under Voltage
3	High charge Current
4	High Discharge Current
5	Charging Suspended (By Integrel, due to BMS)
6	Balancing in progress
7	DCL enabled (Dynamic Current Limiting, Lithionics only)
8	Reserved

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.

This document is issued as an easy to complete fillable PDF document. A completed copy should be provided to each of the following parties:

- Installer
- Customer
- Integrel Solutions



12 TROUBLESHOOTING

The following table contains a list of potential issues that may occur during installation, testing and commissioning together with suggested solutions.

Issue	Possible Cause	Solution
Battery page: No battery data	No CAN bus connection to Bank Sensor	Check the RJ45 cable is properly connected between the battery bank sensor(s) and the Integrel Argo CAN bus network
Smart Switch not connecting	No CAN bus 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 Integrel 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
	OEG phase cable(s) damaged	Check OEG phase cables are connected and not damaged
Engine RPM is incorrect	Pulley ratio set incorrectly	Set the pulley ratio correctly
RPM not showing on the touchscreen	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	Check J1939 connection (if enabled). Contact Integrel Support otherwise.
Touchscreen 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
	In-gear detection failing	For engines<50hp, check in-gear cable/switch is connected and working. Check J1939 in-gear configuration is correctly (Yanmar only)
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.
Message: Battery missing (Smart Switch)	Smart Switch internal fuse	Check the internal fuse in the Smart Switch
	48V V tap missing	The 48V V tap for the switch is missing.
Controller has 12V but not powering	Internal CAN or 12V fuse.	Check the CAN and 12V fuse.
Generator temperature reads -77C	Connection is ‘open circuit’ or temperature sensor is damaged.	Check the connection between the controller and the OEG temperature pins. This may also mean a failed sensor. See Annex for testing.

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.

Controller LED Status Indicators

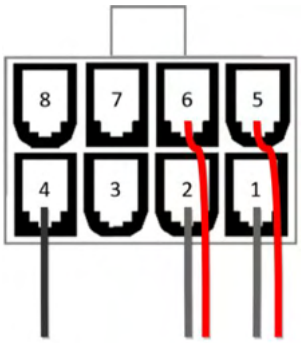
LED	State	Indication
	Green solid	Master Controller
	Green flash	Slave Controller
	Orange solid	A warning is active
	Orange flash	More than one warning is active
	Red solid	An error has occurred
	Red flash	More than one error has occurred

13 CONNECTORS AND FUSES

All pin numbers in this section correspond to looking directly at the connector socket on the relevant Integrel hardware (Bank Sensor, Smart Switch and Controller).

13.1 Bank Sensor Socket

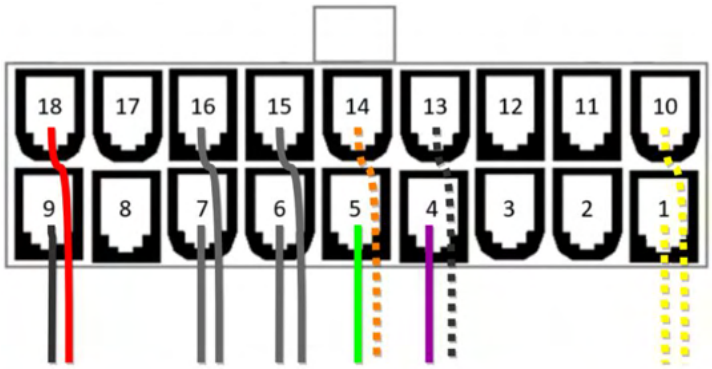
View looking at the Bank Sensor hardware.



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

13.2 Smart Switch Socket

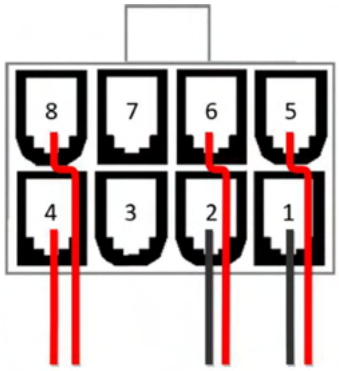
View looking at the Smart Switch hardware.



Pin #	Description
1	Switch Remote trigger (optional)
2	-
3	-
4	Allow-to-charge (Stop charge)
5	Allow-to-discharge (Stop discharge)
6	Temperature 2 0V (Battery Terminal)
7	Temperature 1 0V (Ambient)
8	-
9	0V
10	Switch Remote trigger (optional)
11	-
12	-
13	Switch Remote LED – (optional)
14	Switch Remote LED + (optional)
15	Battery Terminal Temperature
16	Ambient Temperature
17	-
18	48V/24V/12V In

13.4 Controller Power Socket

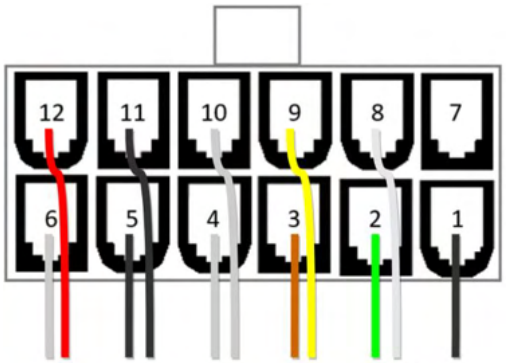
View looking at the Controller hardware.



Pin #	Description
1	Field Coil (PWM) –
2	0V Ground
3	0V Ground
4	Aux Relay Blower Switch
5	Field Coil (PWM) +
6	+12V In
7	-
8	Aux Relay Blower Switch

13.3 Controller Signal Socket

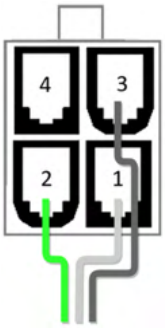
View looking at the Controller hardware.



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

13.5 NMEA 2000 Socket

View looking at the Controller hardware.



Pin #	Description
1	Ground
2	NMEA 2000 CAN Low
3	NMEA 2000 CAN High
4	Not Used

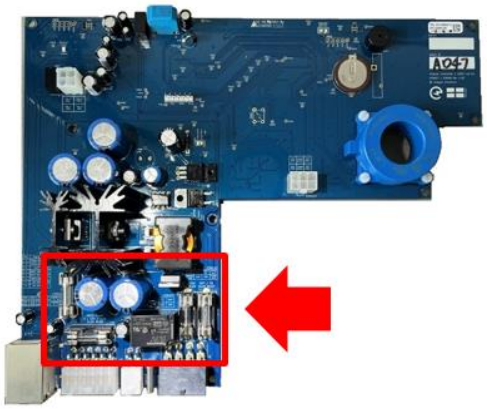
13.6 Fuse Locations

13.6.1 Controller

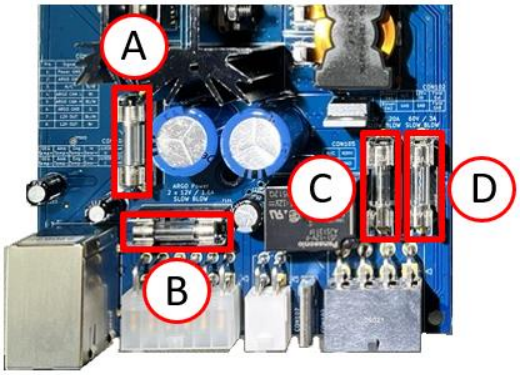
To access fuses inside the Controller, remove the plastic 48V / three phase conductor cover, disconnect all plugs and cables (including the 48V Positive, 48V Ground, 3 x phase cables) and open the case using the four screws shown below (red arrows).

Bottom view

Top view



Fuse Location



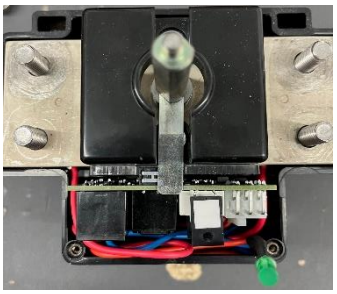
Fuse Identification

	A & B	C	D	Main 48V Fuse
Description	CAN Power	Main Power	DC/DC (PWM)	Main 48V fuse (not shown)
Size	5 x 20	5 x 20	5 X 20	MEGA Fuse
Type	12V 1.6A Slow Blow	12V 20A Slow Blow	57.6V @ 3A Medium Acting	58V @ 250 Amp

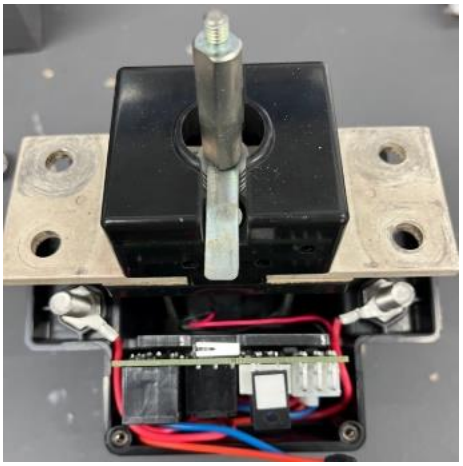
13.6.2 Smart Switch

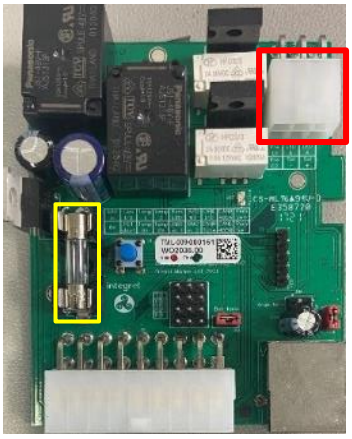
To access the Smart Switch fuse, remove the smart switch from its location and open the top casing. Do this by removing the ON/OFF knob. The knob unscrews anti-clockwise.

Once the knob is off, remove the 4 x screws and the 4 x cable securing nuts as shown to the right.



Once the top cover has been removed, pull the contactor partly out of the casing and move it to the back as shown in the image to the left, below. This helps to remove the PCB enough to access the fuse.

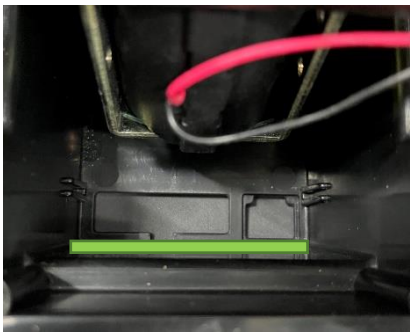




Pull the PCB partly out and disconnect the 6 Pin molex (outlined in RED, see image above to the right). Once the PCB is removed, the fuse (outlined in YELLOW) is easily accessible.

Fuse Type

Use	48V supply
Size	5 x 20
Type	57.6V 5A Slow



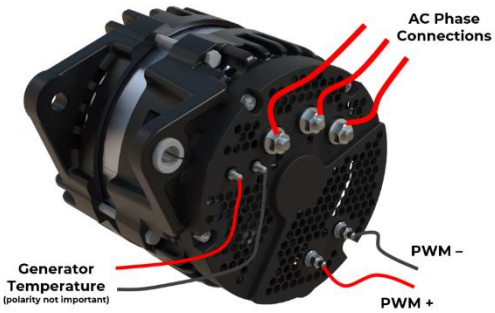
Check and replace the fuse if required. When reseating the PCB, ensure it is seated in the two grooves in the casing shown to the right highlighted in GREEN.

14 ANNEX

14.1 Annex A – OEG (Generator) Testing

To test the OEG (generator), refer to the resistance values in the following table. Disconnect the terminal before testing and use a high quality calibrated, auto-ranging multimeter or ohmmeter.

Resistance Test	Acceptable Range
Measure resistance between P1 and P2 (phases)	0.2 Ω
Measure resistance between P1 and P3 (phases)	0.2 Ω
Measure resistance between P2 and P3 (phases)	0.2 Ω
Measure resistance between F+ and F- (PWM)	22 - 23 Ω
Measure resistance between T1 and T2 (Temp)	11 - 17.5 kΩ



14.2 Annex B – Bank Sensor Calibration & Reset

In some instances, the bank sensor may need recalibration. The following text describes the recalibration process.

The reset button is accessible via a hole in the bank sensor case as shown. Use a non-conductive straight tool to access the reset button using the required process outlined in the following table.

Task	Reset Process
Reset internal SoC calculation (legacy software only)	Press the button for **ONE** second.
Reset power/current readings from the hall effect	Ensure there is nothing loading or draining the batteries, then press the button for **FOUR** seconds.
Factory reset the sensor	Press the button for **SEVEN** seconds.

14.3 Annex C – Conductor Guides

The following table contains a list of conductor recommendations for each part of the system where looms are not provided. If 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 minimum (must be SHIELDED!)** **Note!** Maximum length of 20 metres per connection	N/A

Integrel
ADVANCED POWER GENERATION & CONTROL

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	35mm²	50mm²		70mm²	95mm²
12m		6mm²	10mm²		16mm²	16mm²	25mm²	35mm²	35mm²	50mm²	50mm²	50mm²	50mm²	70mm²	70mm²	95mm²	120mm²
16m				16mm²	25mm²	25mm²	35mm²	50mm²	50mm²	70mm²	70mm²	95mm²	95mm²	120mm²	120mm²	150mm²	185mm²
20m		10mm²	16mm²	25mm²	25mm²	35mm²	50mm²	50mm²	70mm²	95mm²	95mm²	120mm²	120mm²	150mm²	150mm²	185mm²	240mm²
24m			25mm²	35mm²	35mm²	50mm²	70mm²	70mm²	95mm²	120mm²	120mm²	150mm²	150mm²	185mm²	185mm²	240mm²	300mm²
30m	6mm²		16mm²	25mm²	25mm²	35mm²	50mm²	50mm²	70mm²	95mm²	95mm²	120mm²	120mm²	150mm²	150mm²	185mm²	240mm²

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ADVANCED POWER GENERATION & CONTROL

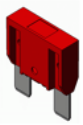
24V CABLE CALCULATION CHART (ALLOWANCE FOR 3% VOLTAGE DROP)

	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	6mm²	10mm²	10mm²		16mm²	25mm²	25mm²		35mm²	50mm²		120mm²
8m						10mm²		16mm²	16mm²	25mm²		35mm²	35mm²	50mm²	70mm²	95mm²	
12m		6mm²	6mm²	10mm²	10mm²		16mm²	25mm²	25mm²	35mm²	35mm²	50mm²	70mm²	70mm²	95mm²	120mm²	
16m					16mm²	16mm²	25mm²	25mm²	35mm²		50mm²	70mm²		95mm²			150mm²
20m		6mm²	10mm²	16mm²		25mm²		35mm²		50mm²	70mm²		95mm²		120mm²	150mm²	185mm²
24m		10mm²			25mm²		35mm²		50mm²	70mm²		95mm²		120mm²	150mm²	185mm²	240mm²
30m	6mm²		16mm²	25mm²		35mm²	50mm²	50mm²			95mm²		120mm²			240mm²	300mm²

14.4 Annex D – 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

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