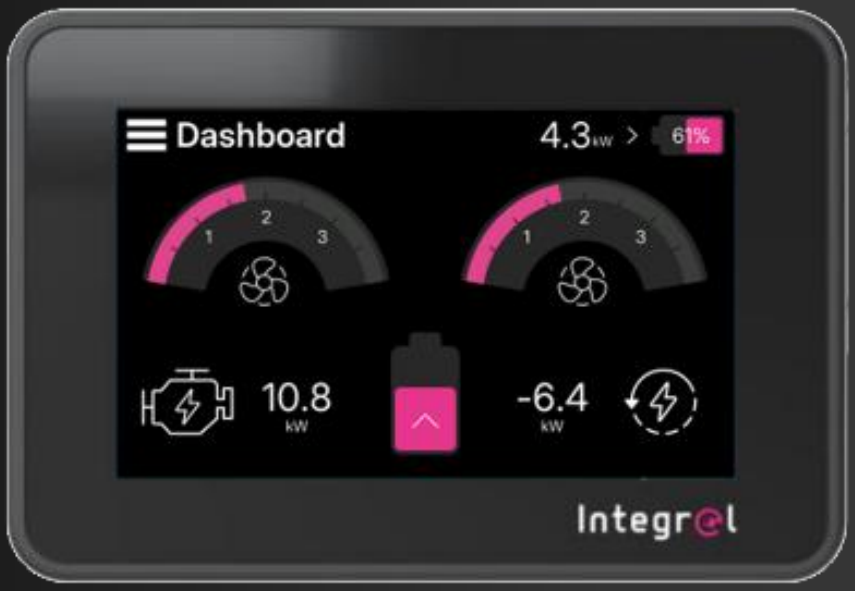
Integral

E-DRIVE

USER GUIDE



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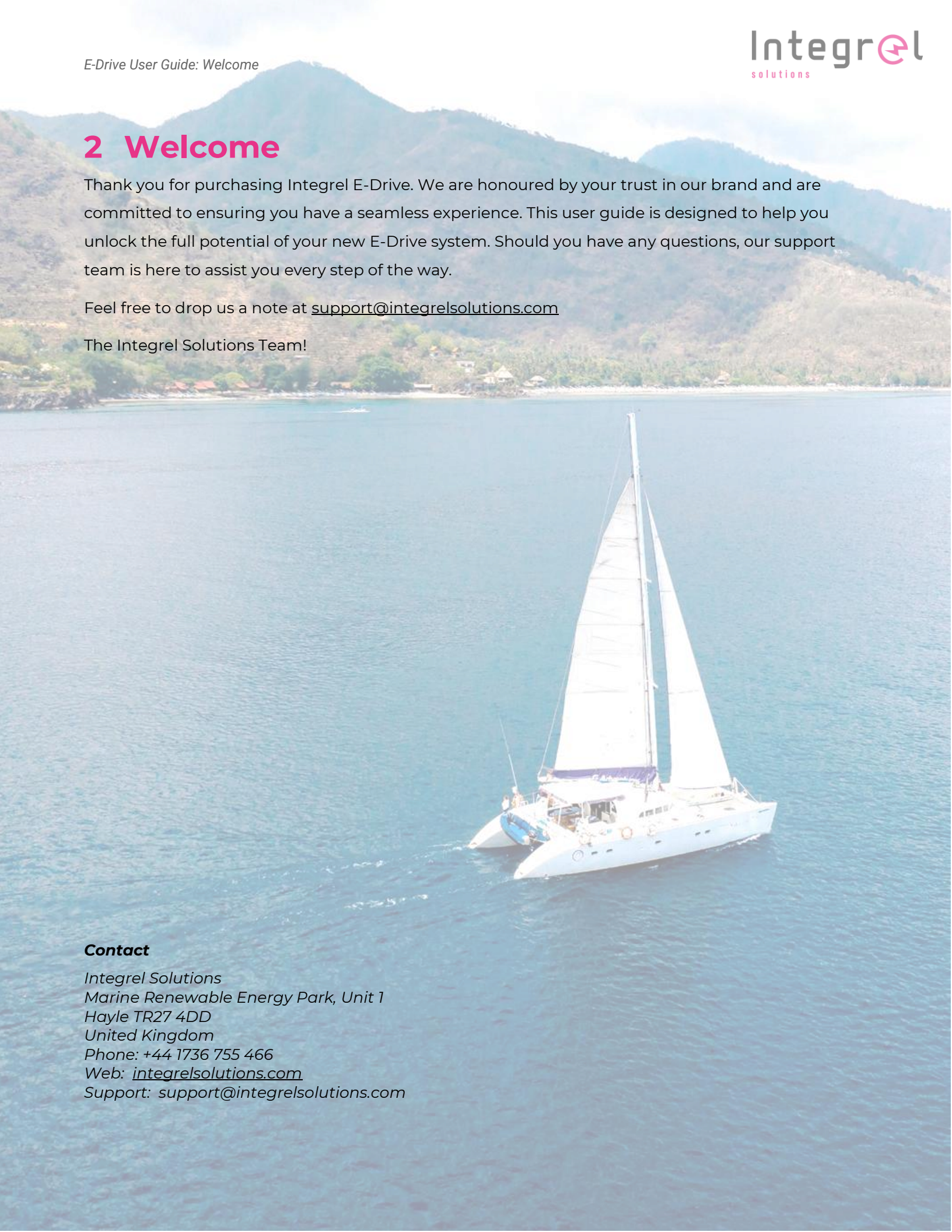
2 Welcome

Thank you for purchasing Integrel E-Drive. We are honoured by your trust in our brand and are committed to ensuring you have a seamless experience. This user guide is designed to help you unlock the full potential of your new E-Drive system. Should you have any questions, our support team is here to assist you every step of the way.

Feel free to drop us a note at support@integrelsolutions.com

The Integrel Solutions Team!



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3 Introduction

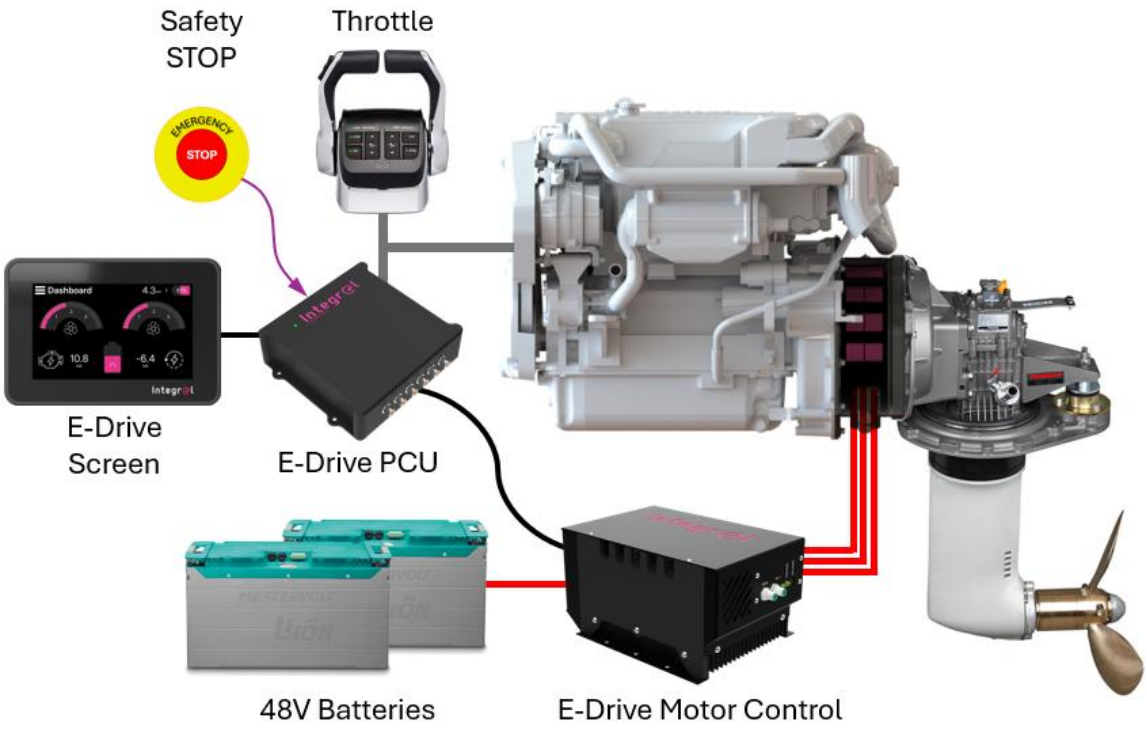
Integrel E-Drive is an innovative marine power generation and hybrid electric drive system that works together with traditional fossil-fuel powered propulsion engines. E-Drive seamlessly handles all your onboard power requirements and offers a tranquil electric drive cruising experience.

At the core of the system is a patent-pending custom-designed high-efficiency electric motor/generator capable of generating up to 15kW of electric power and up to 20hp of electric drive. The E-Drive motor and associated control system have been designed from the ground up to maximise power generation and drive efficiency while maintaining operational safety.

Boat propulsion is controlled with the throttle as usual. Additionally, mode selection on the E-Drive screen enables a choice between using the engine to generate power to charge the 48V batteries or silently driving the boat using the E-Drive motor (with the engine off).

Integrel E-Drive is designed with the utmost concern for safety and reliability. If there is ever a problem with E-Drive, the system can be immediately shut down using the safety stop switch installed next to the helm; the safety switch is shown in the following diagram.

To ensure safe operation at all times, Integrel strongly recommends familiarising yourself with the information provided in the E-Drive Safety section of this document.



Let's dive in to see how E-Drive works! Firstly, ensure the E-Drive system and 48V batteries are switched on, then follow the steps below. For the instructions below, choose E-Drive mode for the port hull using the lower-left icon on the main Dashboard of the E-Drive screen.

Generate Power

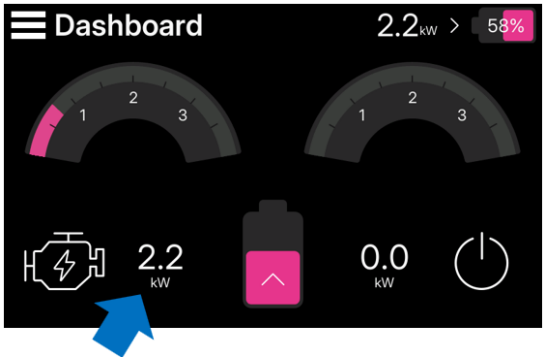
Engine Ignition → **ON**

Throttle Head → **NEUTRAL**

Engine → **START**

E-Drive Mode →

The E-Drive system immediately begins to generate power because the engine is not in gear. Power generation pauses after throttle movements when in-gear.



With the port engine running at engine idle, E-Drive generates around 2 kW of power as indicated by the blue arrow in the picture above.

Electric Drive

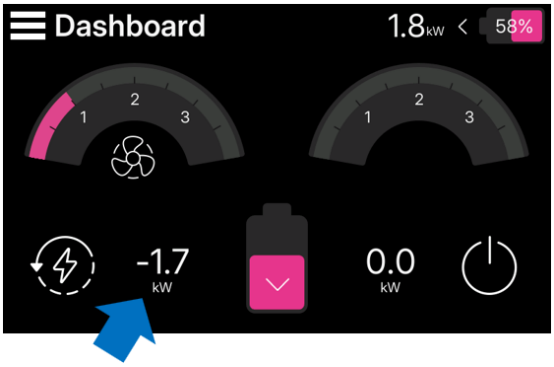
Engine Ignition → **ON**

Throttle Head → **NEUTRAL**

Engine → **OFF**

E-Drive Mode →

Ensure the boat is safely tied to the dock, then move the throttle into forward idle in-gear and slowly increase the throttle to around 1000 RPM.



With the port motor running at 1000 RPM, E-Drive consumes less than 2kW of power from the batteries as indicated by the blue arrow in the picture above.

Note! If the system flashes a **Paused** notification, tap the Paused button to learn why.

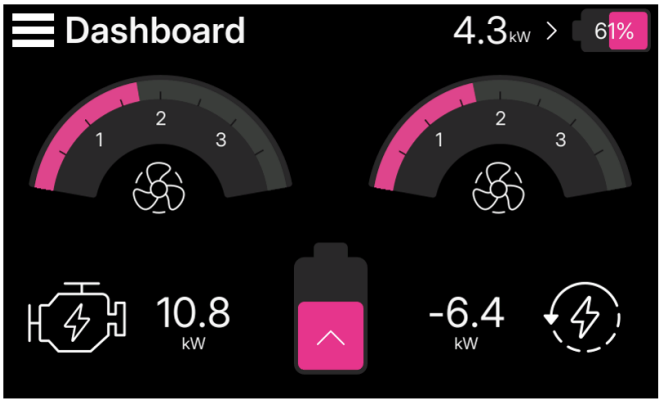
4 E-Drive User Interface

4.1 E-Drive Modes

E-Drive has three different modes.

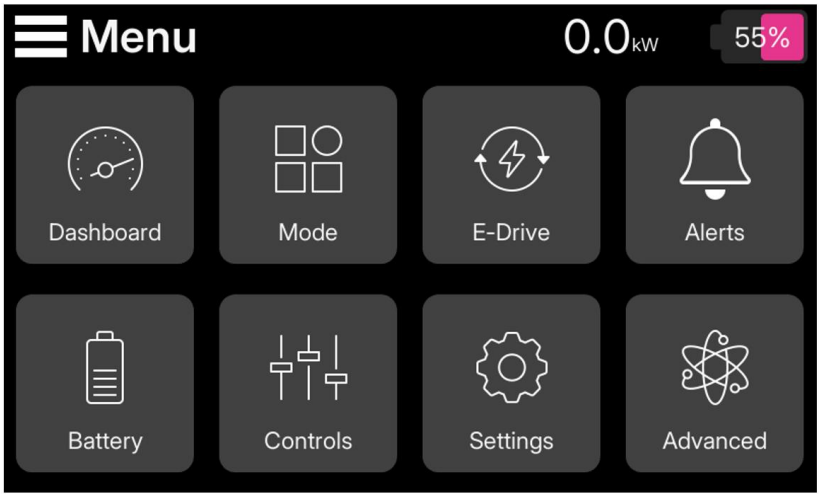
- **Standby Mode**. In standby mode, the system is not active.
- **Generate Mode**. In generation mode, the system generates power when the engine is running. The engine can be in neutral when generating, or it can be in gear driving the boat as well as generating power.
- **Drive Mode**. In drive mode, the system drives the propeller using the E-Drive motor powered by energy stored in the batteries. The engine does not need to be running in drive mode, but the engine ignition must remain on to supply power to the throttle system.

Propulsion and generation are controlled using the engine throttle together with modes/settings on one or more E-Drive screens. E-Drive provides two types of screens. The primary helm screen is a 5" rectangular screen that is typically installed at the indoor helm (or navigation) station. One or more secondary 3" round helm screens are installed at each outdoor helm station such as the flybridge.



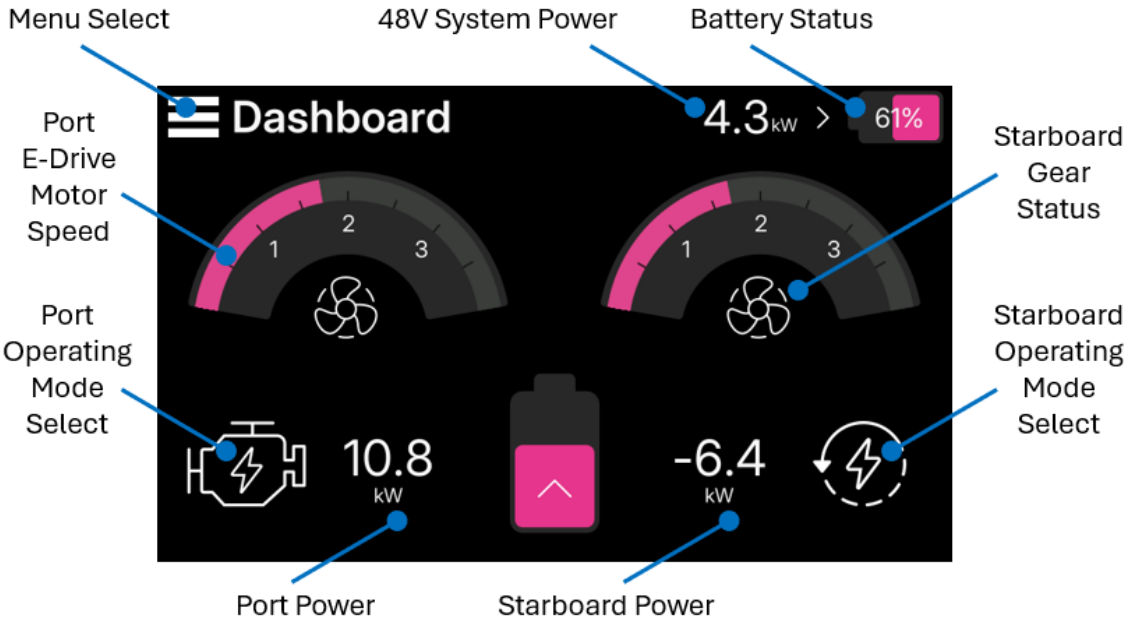
4.2 Primary Helm Screen

The primary helm screen provides full control of all E-Drive functions including mode selection, user configurable limits for power generation and consumption, and software updates. The menu provides access to a list of pages described in the following sections.



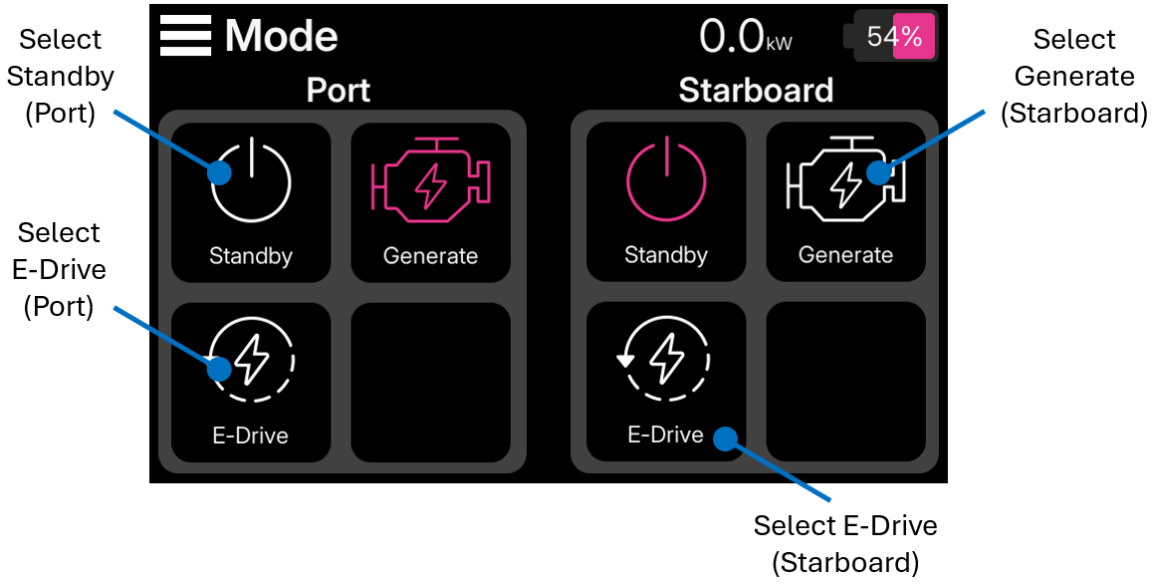
4.2.1 Main Dashboard

The main dashboard provides a summary view and control of the E-Drive system.



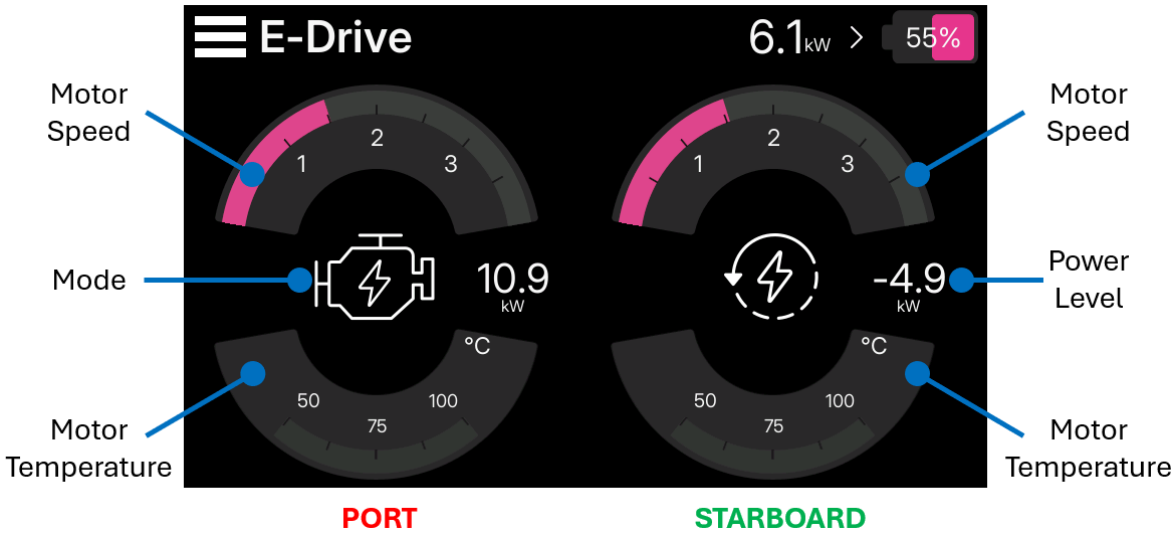
4.2.2 Mode Select

The Mode Select page enables E-Drive mode selection.



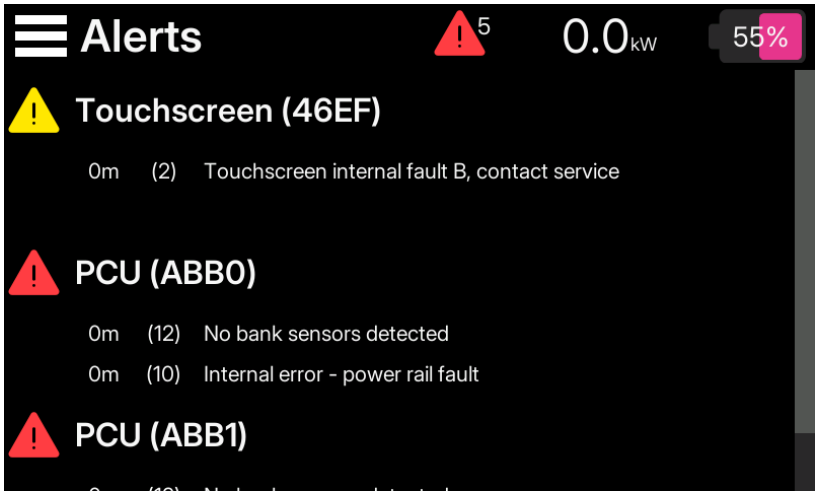
4.2.3 E-Drive Dashboard

The E-Drive dashboard shows a summary of E-Drive motor speeds and temperatures.



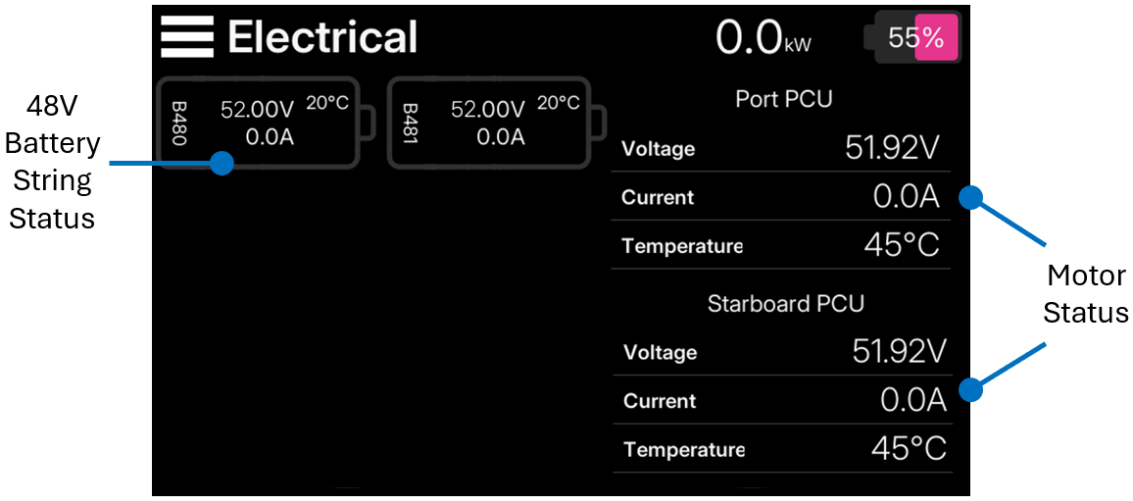
4.2.4 Alerts

The Alerts page shows a list of current and historical alerts. It may be necessary to scroll the page to access alerts that are not visible. See the Alerts and Notifications section of this document for a detailed list of alerts. To delete historical alerts, press and hold the alert, then select ‘Delete’.



4.2.5 Battery & Electrical Dashboard

The battery and electrical dashboard indicate the status of installed batteries and the voltage, current and temperature at the motor controller(s) as reported by the PCU(s).

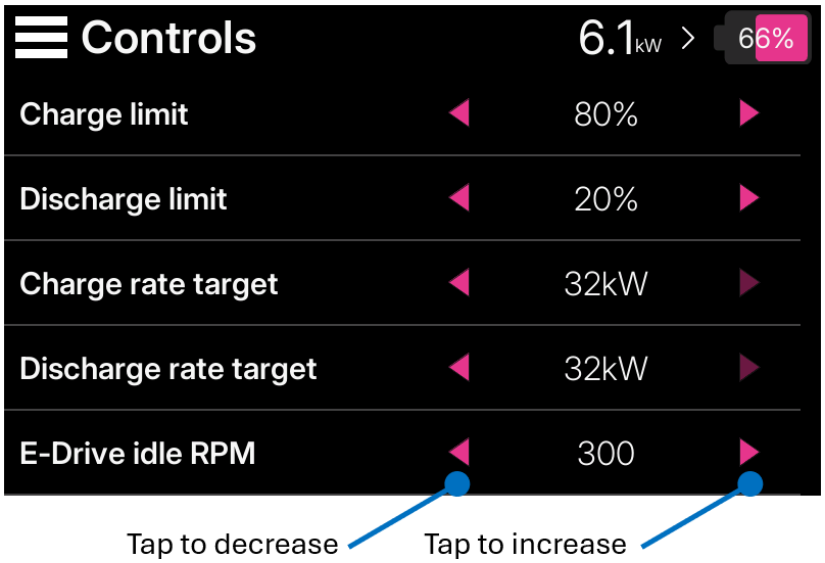


4.2.6 Controls

The Controls page provides a way to set E-Drive operational limits and targets including:

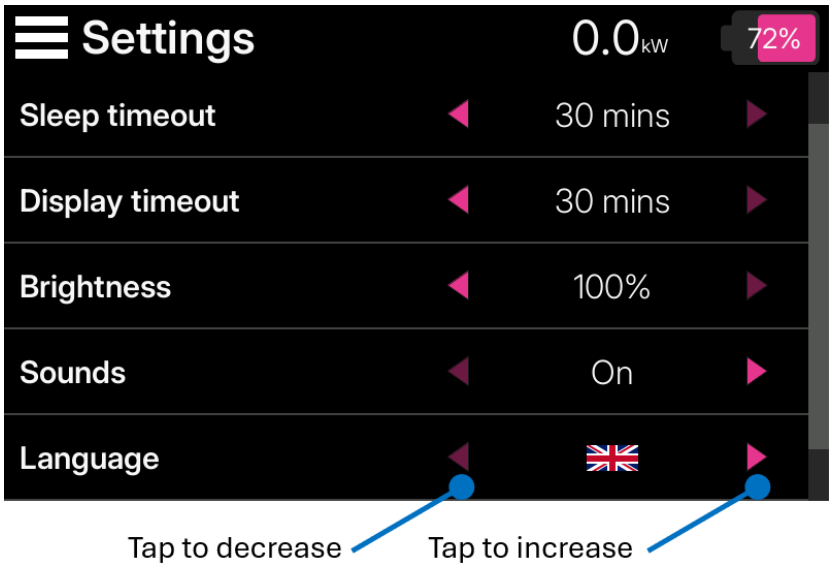
- **Charge limit**. Maximum generation charge limit (generation mode only).

- **Discharge limit**. Minimum electric drive discharge limit (drive mode only).
- **Charge rate target**. E-Drive attempts to charge the batteries at this charge rate (generation mode only).
- **Discharge rate target**. E-Drive attempts to discharge batteries at this rate (drive mode only).
- **E-Drive idle RPM**. The target idle speed of the drive shaft (drive mode only).



4.2.7 Settings

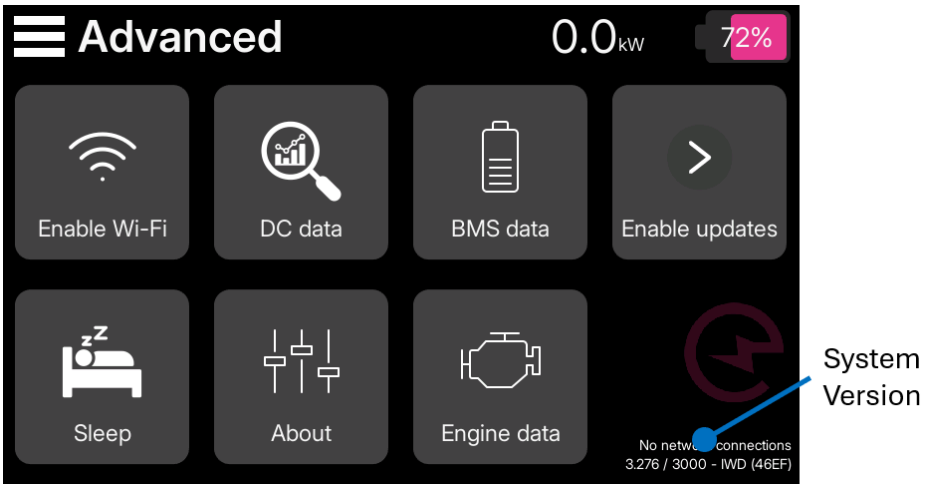
Provides a way to configure user settings and preferences.



4.2.8 Advanced

Provides access to advanced settings, including:

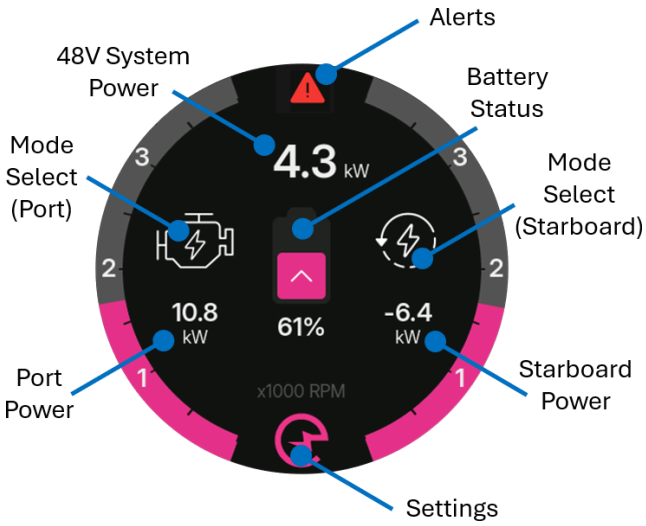
- Wi-Fi and software updates
- Detailed battery information including current BMS status and battery configuration
- Detailed engine information including speed, load, temperature, fuel rate, and more.
- Detailed system information including device IDs, hardware versions, and software versions.
- Direct control of E-Drive sleep mode



4.3 Secondary Helm Screen

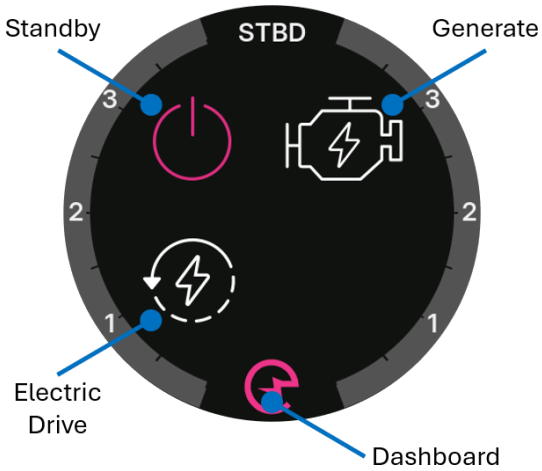
Dashboard

The secondary helm dashboard is similar to the primary helm dashboard, however the menu system is not available on the secondary helm.



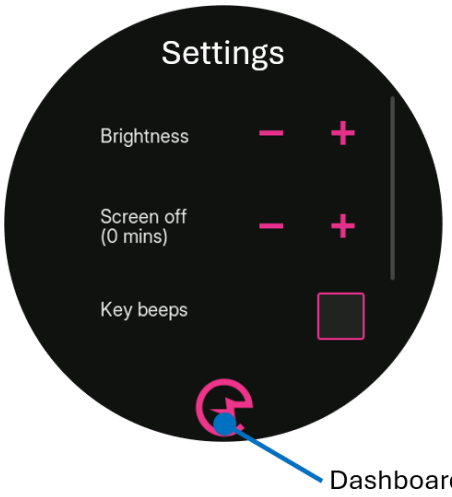
Mode Select

To change E-Drive mode, tap the port or starboard mode icon on the main dashboard, then tap the desired mode for the hull.



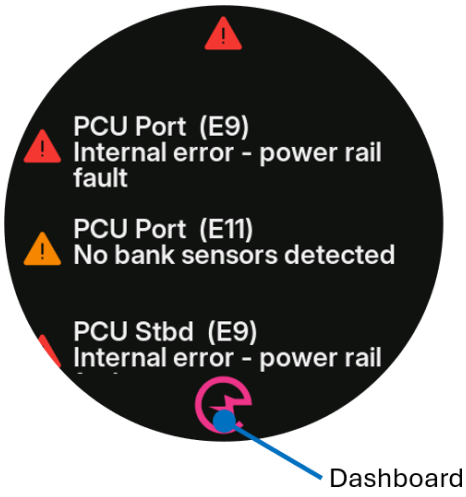
Settings

From the main dashboard, tap the Integrel logo at the bottom of the screen to access user settings. Tap the Integrel icon at the bottom of the screen to return to the dashboard.



Alerts

Tap the Alert triangle at the top of the screen to see active alerts; scroll to see alerts off-screen. Tap the Integrel icon at the bottom of the screen to return to the dashboard.



5 Operating E-Drive

5.1 How to generate power?

Power can be generated when the engine is running with the gearbox in neutral, or when the engine is in-gear driving the boat. If the engine is in neutral, all of the engine power is available to generate power, but if the engine is in-gear, available engine power is reduced because some of the engine power is used by the propeller to drive the boat.

To generate power:

- Turn the engine ignition on.
- Move the throttle to the neutral position.
- Select Generation Mode on the E-Drive screen.
- Start the engine.
- Move the throttle into forward (or reverse) idle, then increase the throttle demand as required. Note that E-Drive generates power whether the engine is in neutral or in-gear, however when the engine is in-gear, generation starts after a short delay as explained in the section titled 'Prioritising Propulsion'.

After throttle demand stabilizes, power generation ramps up to:

- The maximum power charging limit of the batteries, or
- The maximum power generation limit set on the E-Drive screen, or
- The maximum power generation capability of the E-Drive motor.

Generation continues until:

- The battery state of charge reaches the maximum charge limit set on the E-Drive screen, or
- The battery indicates it is unable to continue charging; typically because the battery has reached a maximum charge limit.

5.2 What limits power generation?

The power generation output level depends on a number of factors, including:

- **Throttle demand**. E-Drive generally produces higher power output as throttle demand is increased. Generation is most efficient with the engine running in the range 1900 - 2200 RPM. As

throttle demand approaches wide open throttle, power generation is reduced so that all engine power is given to the propeller for propulsion.

- **Available engine power**. The engine produces more power at higher speeds, but the propeller load increases at higher speeds also; so the available power from the engine varies with speed. This behaviour is shown by the graph in the section titled 'How does E-Drive Work?'.
- **Battery charge capability**. E-Drive limits generation power to the maximum charging limit recommended by the battery manufacturer. If for example, four batteries are connected in parallel (not in series!), the charge rate is increased by a factor of four.
- **Screen setting**. Maximum power generation can be limited with a setting on the E-Drive screen Control menu.
- **Temperature**. The E-Drive motor is air-cooled and heats up with time as it generates power. When the motor reaches maximum operating temperature, power generation output is reduced to avoid overheating.

5.3 How to drive with the E-Drive motor?

The engine ignition must be turned on, but the engine does NOT need to be running while using electric drive. To drive with the E-Drive motor:

- Turn the engine ignition on.
- Move the throttle to the neutral position.
- Select Drive Mode on the E-Drive screen.
- Ensure the engine is turned OFF.
- Move the throttle into forward (or reverse) idle in-gear, then increase the throttle demand as required. Note that the E-Drive motor does not operate with the gearbox out of gear!

Electric drive continues until:

- The battery state of charge reaches the minimum charge limit set on the E-Drive screen, or
- The battery indicates it is unable to continue discharging; typically because the battery has reached a minimum charge limit.

5.4 What limits drive speed?

Drive speed and the amount of battery power used when driving depends on several factors, including:

- **Throttle demand**. Low throttle demand uses minimal power, wide open throttle uses maximum power.
- **Battery discharge capability**. The power discharge capability of the battery bank.
- **Screen setting**. The drive power limit set on the E-Drive screen.
- **Temperature**. The E-Drive motor is air-cooled and heats up with time as it drives. When the motor reaches maximum operating temperature, drive speed is reduced to avoid overheating.
- **Propeller load**. As the propeller speed increases, the mechanical load on the E-Drive motor increases. Maximum speed is reached when the propeller load increases to the point that it consumes all of the power available from the motor. To learn more, read the section 'How does E-Drive Work?'.

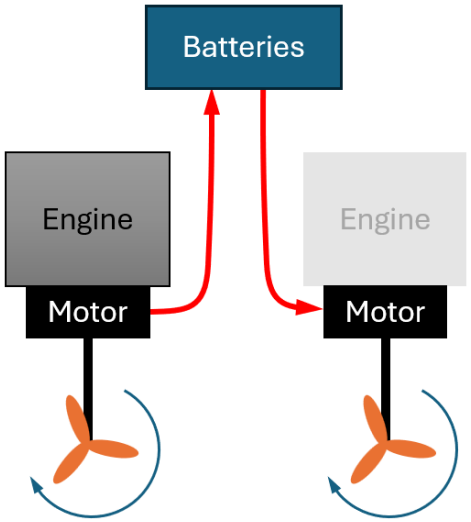
5.5 Using One Engine to Drive both Hulls

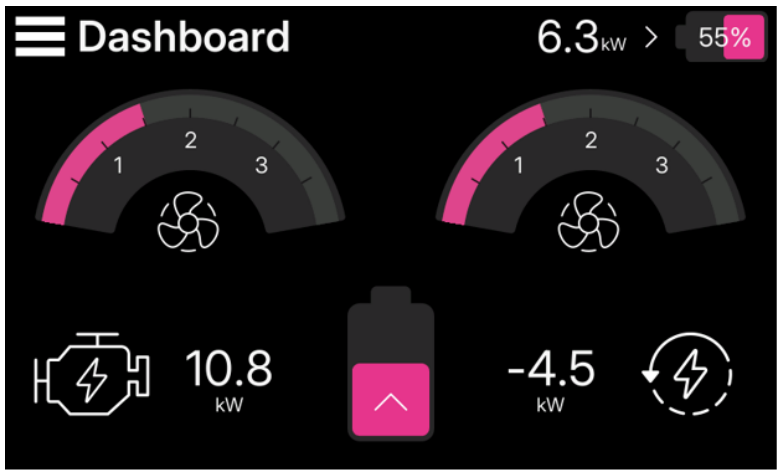
A dual E-Drive system installed on a catamaran can use the engine in one hull to generate power and drive, and with the power generated, drive the other hull with the E-Drive motor; and as an added bonus, charge the batteries with any surplus power!

Let's look at an example to illustrate how this works. The example below shows:

- the port engine running at 1500 RPM in-gear with E-Drive generating 10.8kW, and
- the starboard E-Drive motor driving at 1500 RPM (with the starboard engine turned off).

Since the starboard E-Drive motor only consumes 4.5kW power, the surplus 6.3kW power generated by the port E-Drive system is used to charge the batteries.





6 How does E-Drive Work?

6.1 Power Generation

E-Drive generates power in a carefully controlled manner, it constantly monitors system and battery voltages, current, temperature and engine state to efficiently generate power suited to the conditions.

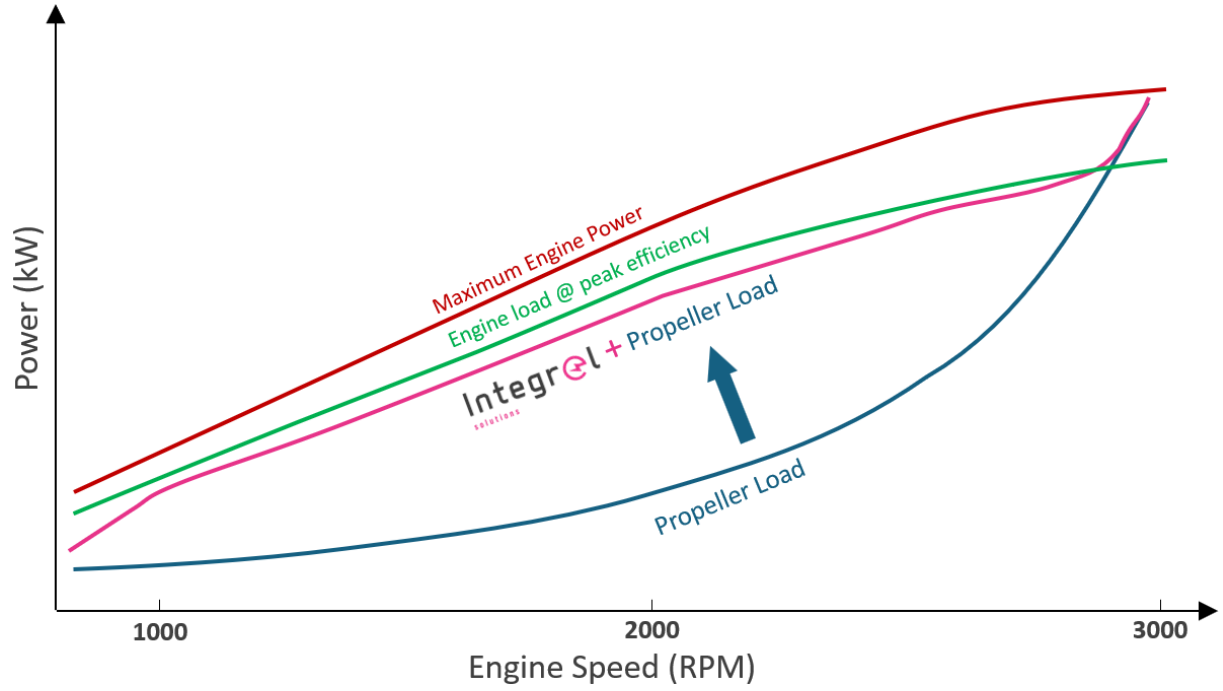
6.1.1 A Healthy and Efficient Engine

E-Drive makes an engine run more efficiently which keeps it healthy. Consider the graph below which shows engine output power and engine loads over the full engine RPM range.

Without E-Drive, the propeller (blue line) uses much less power than the engine (red line) is capable of producing over nearly the entire range of engine speeds. Engines have poor fuel efficiency with low loads.

Using Integrel E-Drive, the combined propeller and E-Drive generation load brings the overall load on the engine much closer to peak fuel efficiency.

The result? The engine runs more efficiently, is healthier AND generates large amounts of energy with near optimal fuel usage!



6.1.2 Power Generation vs. Engine Speed

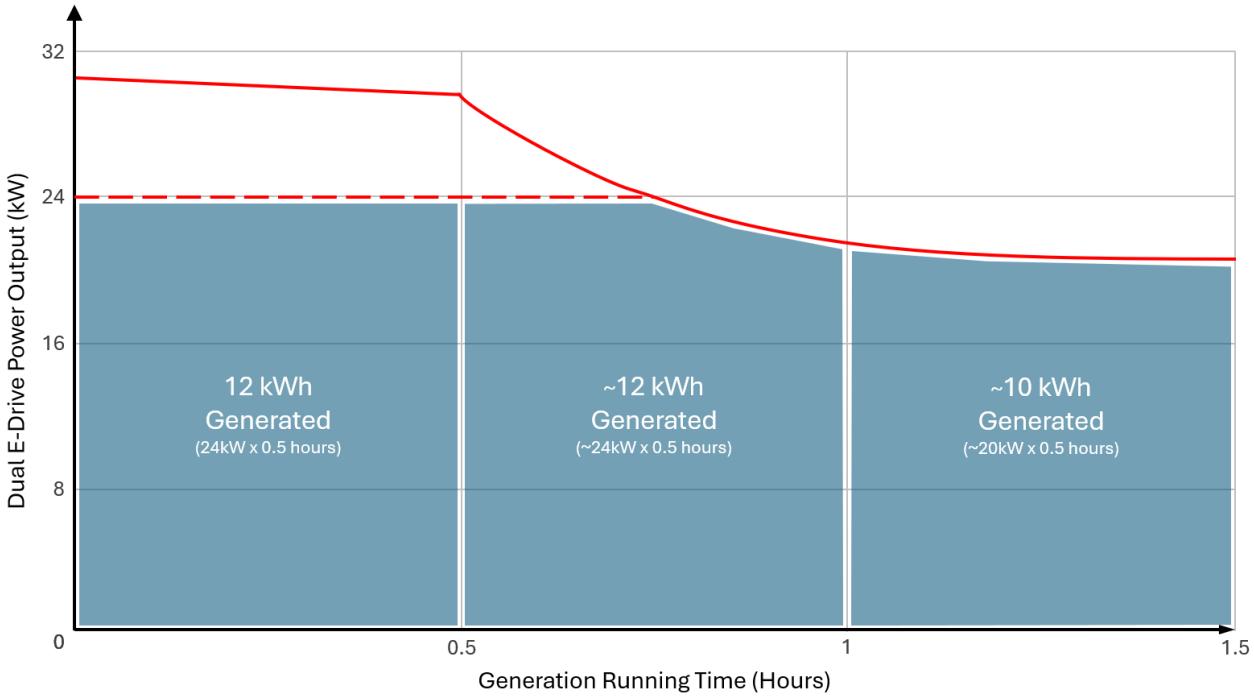
The amount of engine power available for charging increases as the engine speed is increased. Depending on the capacity and configuration of the 48V battery bank, charging power for a dual E-Drive system can be as high as 30 kW. E-Drive generates power most efficiently when the engine speed is in the range 1900 – 2200 RPM.

6.1.3 Power Generation vs. Temperature

The E-Drive motor is air-cooled and heats up with time as it generates power. When the motor reaches maximum operating temperature, power generation output is reduced to avoid overheating.

If the maximum power generation is limited to 24 kW as shown by the dotted line in the following graph, the system generates power at 24 kW for the first 45 minutes (0.75 hours), and the power output then reduces to around 20 kW thereafter.

In this example, the system produces a total of 34 kWh in under 90 minutes; enough to boost the charge of a 48kWh battery bank from 15% to 85%!



6.1.4 Prioritising Propulsion

E-Drive can generate up to 15 kW of electrical power from the engine, as a result, it is critical that the additional load on the engine is carefully managed to ensure propulsion is always prioritized. The E-Drive control system automatically adjusts the engine load which may sometimes result in a slight change in the sound of the engine. The additional load makes no difference to the boat speed on a modern engine with electronic governing. On older engines with a mechanical governor, the engine RPM may drop slightly.

The E-Drive system cuts generation immediately when a gear shift is detected or there is a rapid change in engine speed (RPM). This behavior ensures that when the boat is manoeuvering, or in circumstances where propulsion is required immediately, the entire engine power is available to drive the propeller.

Generation is also prohibited when the engine is below minimum operating temperature and as the throttle approaches full-ahead / full-astern. When the system senses the engine is in a steady state, or the engine speed is changing slowly, power generation resumes.

The E-Drive system never allows the generation load to push the total engine load (propulsion and generation) above 80-85% of the total engine power at any speed. This operation is handled automatically.

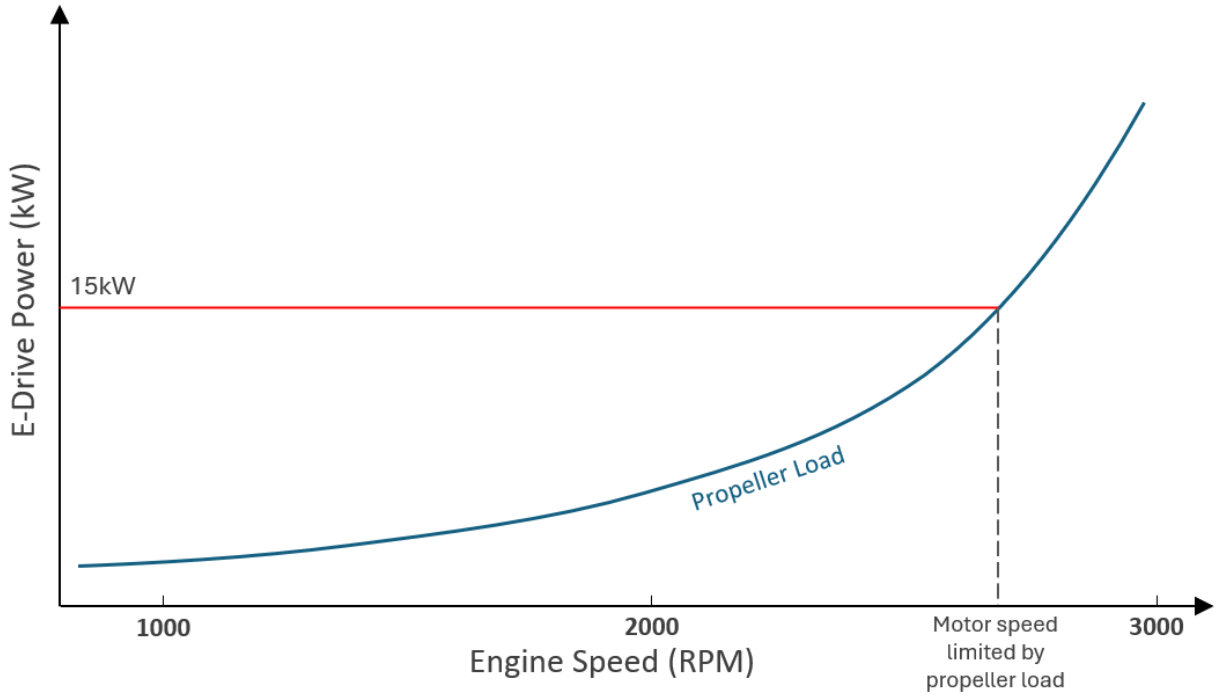
In summary, E-Drive automatically generates power while simultaneously ensuring that full engine power is instantly provided to the propeller when required.

6.2 Electric Drive

The E-Drive system uses the E-Drive motor in a carefully controlled manner, constantly monitoring system and battery voltages, current, and temperature to efficiently drive the boat based on throttle demand and battery state.

In general, the load of a propeller increases exponentially with propeller speed as shown by the following graph. It is much more energy efficient to use electric drive at low to mid-range propeller speeds, and indeed greater ranges are achieved when E-Drive is operated in this manner.

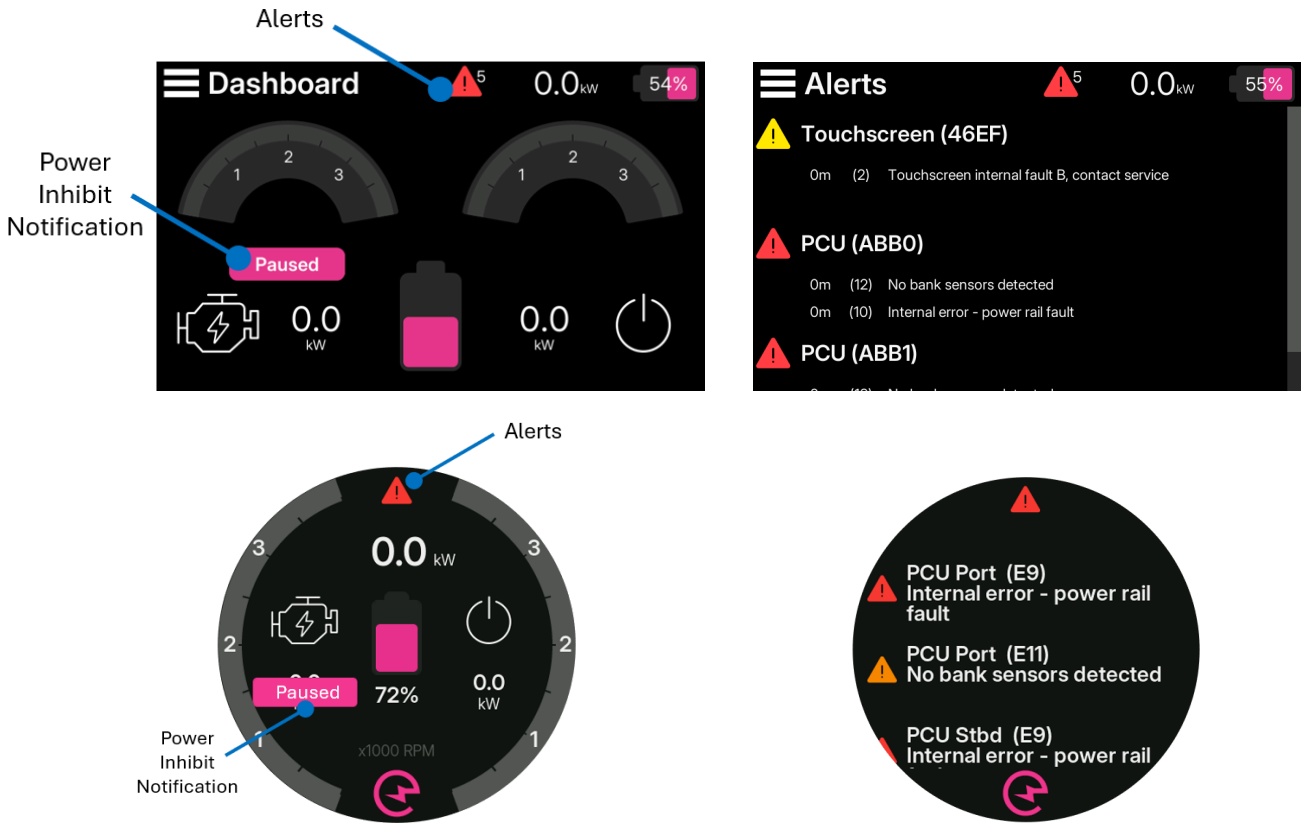
E-Drive speed and thus propeller speed, is limited by the propeller load at wide open throttle. The maximum achievable speed depends on the type of propeller used, together with the shape of the hull and weight of the boat.



7 Alerts and Notifications

E-Drive provides varying notifications and alerts to indicate current and historical system status. Power inhibit notifications indicate why generation or drive is temporarily paused; inhibit notifications are accessed by pressing the flashing **Paused** button when present.

Alerts vary in severity, from indication of minor issues that may (or may not) impact operation of the E-Drive system, through to indication of critical errors that prohibit system operation. Alerts are accessible by pressing the alert triangle located at the top of the E-Drive screen; or alternately by accessing the Alert page available in the primary helm screen menu.



7.1 Power Inhibit Notifications

If a condition prohibits generation or drive, a flashing **Paused** button is shown on the E-Drive screen to indicate E-Drive operation is inhibited. The following table provides a list of all conditions that can cause a power inhibit notification.

Notification	Description
Batteries Offline	All detected battery sensors report battery contactors are open resulting in a battery capacity of zero.
BMS (IO)	The system detected a stop charge/discharge signal from the physical inputs to the PCU.
BMS Stop Charge	The BMS indicates battery charging is currently prohibited.
BMS Stop Discharge	The BMS indicates battery discharging is currently prohibited.
Data Missing	Information necessary for safe operation of the system is unavailable or out of specification; review the Alerts screen for additional information.
Diagnostic Mode Active	Operation is limited because the system is in diagnostic mode.
Engine Warming Up	The engine temperature is below the configured by user settings.
Ignition OFF	The engine ignition (for the specified hull) needs to be powered on for the system to operate.
Manoeuver	Throttle changes indicate manoeuvring is in progress (only applicable when generating).
Motor Disabled	The motor controller is not able to function correctly; review the Alerts screen for additional information.
RPM High	The engine RPM is too high for the system to operate. In some systems, the E-Drive motor may be unable to generate useful power over the entire engine RPM range.
RPM Low	The engine RPM is too low for the system to generate power. This notification shows if the engine is not running, or if the engine RPM is below the minimum allowed RPM to generate power (which may be above the engine idle speed).
SoC Above Threshold	The battery state of charge is above the configured maximum charge limit (see the Controls screen; only applicable when generating)
SoC Below Threshold	The battery state of charge is below the configured maximum charge limit (see the Controls screen; only applicable when generating).

Notification	Description
System Error	One or more alerts prevent system operation; review the Alerts screen for additional information.
Temp. too High	One or more temperature sensors indicate the system is operating above a safe operating temperature limit.
Temp. too Low	One or more temperature sensors indicate the system is operating below a safe operating temperature limit.
Voltage too High	The voltage measured by the motor controller is above the minimum allowed threshold.
Voltage too Low	The voltage measured by the motor controller is below the minimum allowed threshold.

7.2 Alerts

A full list of alerts is provided in the following table. Alert severity is characterised according to level, with alert level 5 the most critical and alert level 1 the least critical.

Device	ID	Alert	Level	Cause	Actions
PCU	0	Configuration integrity error	4	Corrupted settings	The system runs with factory defaults
PCU	1	Startup self-check failed	4	Hardware fault on PCB or software glitch	
PCU	2	Internal software error	4	A software guardrail outside of normal operating limits was breached	Affected module(s) stops operating, the system may or may not continue operating
PCU	3	System voltage too high	4	Voltage on the EM 48V terminals or reported by the BMS exceeds the maximum voltage setting	
PCU	4	System voltage too low	3	Voltage on the EM 48V terminals or reported by the BMS is lower than the minimum voltage setting	
PCU	5	Output current too high	4	The EM output current is higher than the maximum setting	
PCU	6	RPM invalid	4	Invalid RPM (negative) reported by the motor controller	The motor is disabled until the system is power cycled
PCU	7	RPM divergence detected	2	Difference between Controller and engine RPM readings	None, alert only
PCU	8	Unassigned - 8	-		
PCU	9	Internal error - power rail fault	4	One or more internal supply rails are faulty (PCB)	None, alert only

Device	ID	Alert	Level	Cause	Actions
PCU	10	Generator control operation not correct	4		
PCU	11	No bank sensors detected	3	No bank sensor devices found on the Integrel network	System runs with BMS data only, or in fallback mode
PCU	12	BMS contactor open	2	The BMS reports a contactor is open, or is about to open	The system stops charging/discharging accordingly
PCU	13	BMS communication unavailable	2	No BMS is detected on the N2K network, or there is a conflict or other N2K issue	System runs with bank sensor data only, or in fallback mode
PCU	14	N2K BMS configuration incorrect	2	Multiple BMS devices matching the configured battery system type were found, or the Mastervolt battery count in the configuration does not match the number of batteries configured in the gateway	System runs with bank sensor data only, or in fallback mode
PCU	15	N2K protocol error	2	Too many devices on the network, or another devices is conflicting with the source address	System runs with bank sensor data only, or in fallback mode
PCU	16	Unassigned – 16	-		
PCU	17	Unassigned – 17	-		
PCU	18	Supply voltage too low	2	The supply voltage to the system (12V) is below 9V	None, alert only
PCU	19	CAN error - Integrel network	2	Bus errors on the CAN physical layer	
PCU	20	CAN error - Engine	2	Bus errors on the CAN physical layer	
PCU	21	CAN error - N2K	2	Bus errors on the CAN physical layer	

Device	ID	Alert	Level	Cause	Actions
PCU	22	CAN error - Throttle	2	Bus errors on the CAN physical layer	
PCU	23	Engine temperature too high	4	The engine temperature is higher than the maximum setting	None, alert only
PCU	24	Engine temperature sensor fault	3	Sensor is disconnected or faulty (short circuit to high/low)	None, alert only
PCU	25	Ambient temperature too high	2	The ambient temperature is higher than the maximum setting	None, alert only
PCU	26	Ambient temperature sensor fault	3	Sensor is disconnected or faulty (short circuit to high/low)	None, alert only
PCU	27	EM temperature too high	4	One or more of the phase/bearing temperatures is higher than the maximum setting	The motor is disabled until it cools down
PCU	28	Motor phase temperature sensor fault	2	Sensor is disconnected or faulty (short circuit to high/low)	Alert only, unless all are faulty, in which case the system runs in fallback temperature mode
PCU	29	Bearing temperature sensor fault	2	Sensor is disconnected or faulty (short circuit to high/low)	Alert only, unless all are faulty, in which case the system runs in fallback temperature mode
PCU	30	Throttle communication issue, engine side	3	Unexpected/inconsistent signal values on digital throttle network	System does not operate, and the bypass relay is opened to return control to the digital throttle system directly
PCU	31	No communication with throttle system	2	No data received on the throttle CAN network	System does not operate, and the bypass relay is opened to return control to the digital throttle system directly

Device	ID	Alert	Level	Cause	Actions
PCU	32	Throttle signal incoherent, check cables	3	Analog throttle signal is mismatched or faulty	System does not operate, and the bypass relay is opened to return control to the analog throttle directly
PCU	33	Throttle control hardware fault	3	Faulty analog throttle ADC or DAC	System does not operate, and the bypass relay is opened to return control to the analog throttle directly
PCU	34	Controller temperature too high	4	PCU temperature (PCB)	None, alert only
PCU	35	Motor controller temperature too high	3	EM Controller	The motor controller will stop operating until it cools down
PCU	36	Controller temperature sensor fault	3	Hardware fault on PCB – PCU	None, alert only
PCU	37	Motor controller communication error	4	Error on EM_CAN / unexpected loss of data	The motor is disabled until the issue clears
PCU	38	Motor controller direct fault	4	Fault reported by EM controller directly	The motor controller acts according to the fault
PCU	39	Internal hardware fault	4	reserved	
PCU	40	Throttle bypass relay opened	4	The throttle bypass relay is opened (not shown until it has closed once after power on)	None, alert only
PCU	41	CAN error - Motor	4	Bus errors on the CAN physical layer	
PCU	42	Motor controller initialisation failed	4	Error from the motor controller during initialisation	The motor is disabled until the system is power cycled

Device	ID	Alert	Level	Cause	Actions
PCU	43	Throttle control cannot communicate with engine	4	No throttle data received on the engine CAN network	System does not operate, and the bypass relay is opened to return control to the digital throttle system directly
PCU	44	Phase short - system disabled, contact service	4	The EM phase short detection triggered	
PCU	45	EM power overload, reduce throttle	4	The EM power exceeded the allowed demand	None, alert only
PCU	46	Temperature derate mode is active due to faulty sensors	3	All bearing or all phase temps are broken	The system runs in fallback temperature mode
PCU	47	Gearbox actuator error - E-Drive is not available	4	missing or “not-ready” from gear actuator	The system does not operate
Primary Touchscreen	0	Primary Touchscreen internal fault A, contact service	2	A software error has occurred, contact support	None, alert only
Primary Touchscreen	1	Primary Touchscreen internal fault B, contact service	2	A software error has occurred, contact support	None, alert only
Primary Touchscreen	2	Primary Touchscreen temperature too high	2	The onboard temperature exceeds 80C	None, alert only
Primary Touchscreen	3	Integrel CAN data network fault, check cables	2	Bus errors on the CAN physical layer	

Device	ID	Alert	Level	Cause	Actions
Primary Touchscreen	4	Primary Touchscreen supply voltage too low	2		
Primary Touchscreen	5	Primary Touchscreen internal fault C, contact service	2	A software error has occurred, contact support	
Primary Touchscreen	6	System fault in device, contact service	3	A device connected to the Integrel network is in failsafe mode	
Primary Touchscreen	7	Incompatible device detected, please update immediately	3	A device with a different Integrel protocol revision is connected	
Primary Touchscreen	8	Battery charge is low, start engine and switch to Generate mode!	3		
Primary Touchscreen	9	Battery charge very low, Drive will be disabled soon	3		
Battery sensor	0	Configuration integrity error	4	Corrupted settings	The system runs with factory defaults
Battery sensor	1	Startup self-check failed	4	Hardware fault on PCB or software glitch	
Battery sensor	2	Internal software error	4	A software guardrail outside of normal operating limits was breached	Affected module(s) stops operating, the system may or may not continue operating
Battery sensor	3	Temperature too high to charge	4	The temperature is higher than the maximum charge setting	Bank sensor reports bank not allowed to charge

Device	ID	Alert	Level	Cause	Actions
Battery sensor	4	Temperature too high to discharge	3	The temperature is higher than the maximum discharge setting	Bank sensor reports bank not allowed to discharge
Battery sensor	5	Temperature too low to charge	4	The temperature is lower than the minimum charge setting	Bank sensor reports bank not allowed to charge
Battery sensor	6	Temperature too low to discharge	3	The temperature is lower than the minimum discharge setting	Bank sensor reports bank not allowed to discharge
Battery sensor	7	Voltage too high	4	The voltage is higher than the maximum setting	Bank sensor reports bank not allowed to charge
Battery sensor	8	Voltage low - charge batteries	2	The voltage is lower than the warning setting	None, alert only
Battery sensor	9	Voltage too low - charge immediately	3	The voltage is lower than the minimum setting	Bank sensor reports bank not allowed to discharge
Battery sensor	10	Battery voltage imbalance	3	The difference in voltage between blocks of the string exceeds the configured allowable maximum	None, alert only
Battery sensor	11	Unassigned – 11	-		
Battery sensor	12	Temperature sensor fault	3	Sensor is disconnected or faulty (short circuit to high/low)	Temperature limits/warnings/protections are disabled
Battery sensor	13	Missing voltage tap	3	Voltage taps are backwards or wrongly configured	Bank sensor cannot report data, bank appears offline
Battery sensor	14	Internal error - power rail fault	4	One or more internal supply rails are faulty (PCB)	
Battery sensor	15	Voltage measurement fault	4	Voltage reading is outside the coherence limits	Bank sensor cannot report data, bank appears offline
Battery sensor	16	Battery contactor is open	2	The contactor IO input indicates the contactor is open	Bank sensor reports battery is offline

Device	ID	Alert	Level	Cause	Actions
Smart Switch	0	Integrel CAN data network fault, check cables	2		
Secondary Screen	0	Supply voltage too low	2		
Secondary Screen	1	Integrel CAN network fault, check cables	2		

8 Support & Maintenance

8.1 Maintenance

Unlike a standalone generator, Integrel E-Drive requires virtually no maintenance. The E-Drive motor is designed to operate for thousands of hours without service.

The primary battery bank requires no maintenance other than to ensure it is charged and powered off for storage during extended idle periods.

Under normal usage and operating conditions, the E-Drive system should remain on to enable it to monitor battery status, system voltage and temperature.

8.2 Storage

If the boat will not be used for extended periods, it is CRITICAL that the 48V battery system is disconnected, or alternately fitted with a reliable charging source that can maintain the battery with at least 80% state of charge and a safe minimum voltage.

We strongly recommend reading the Hibernation & Battery Care Guide to assist with preparation for boat for storage. We also recommend reading the battery manufacturer's documentation regarding storage of the batteries.

Failure to follow these instructions may result in full battery discharge and may result in PERMANENT DAMAGE TO THE BATTERIES. The Integrel Solutions Warranty Policy does NOT cover replacement of batteries damaged in this manner. If in doubt, consult a marine electrician.

If your system has a remote monitoring option, we recommend intermittently checking the state of the battery bank during long idle periods.

Return After Storage

After a long period of storage, it is important to reverse the storage procedure to correctly re-start the system.

Prior to switching the system on, carefully check the voltage of each battery with a voltmeter or multimeter. Ensure the voltage of each battery in the system is greater than the minimum voltage recommended by the battery manufacturer.

If one or more batteries are below the minimum recommended voltage, do NOT turn the system on. Contact a marine electrician for advice before proceeding.

8.3 Software Updates

The Integrel Solutions engineering and support teams are constantly working to improve our products. We intermittently offer software updates as and when required to improve system operation and provide new features such as integration with the latest battery brands.

The Integrel Configurator application is required to update software via Wi-Fi. For further information, see the resources section of the Integrel website.

8.4 Support

Integrel provides premium customer service and support. If you need help with your Integrel E-Drive system, we are ready and available to help.

Consult the Integrel website for an extensive list of frequently asked questions.

General support is available by opening a support ticket or sending an email. The entire support team are notified when a ticket is created ensuring a swift response.

Web: integrelsolutions.com/support/

Email: support@integrelsolutions.com

For urgent help, please call the support number shown below. Phone support is generally limited to business hours in the United Kingdom.

Technical Support: +44 7830 479 089

9 E-Drive Safety

E-Drive works together with a bank of 48V batteries that contain a large amount of energy. Voltage at 48V is not considered dangerous to humans, however if the positive and negative terminals of the 48V batteries are shorted or touched together with a wire, the resulting inrush of power can instantly melt the wire coating and even the wire itself! Very thick wires can become extremely hot very quickly and may cause a fire.

Consider the E-Drive system shown below. **Diagram A** on the left shows the E-Drive motor connected with three cables to the motor controller which is in turn connected to the batteries. During normal operation, power safely travels back and forth between the motor, the motor controller and the batteries.

Notice the connection between the engine chassis and the 48V negative? This connection is typically used to mitigate the effects of galvanic corrosion. Notice also the safety fuse in series with the connection? The safety fuse **must be installed** when E-Drive is fitted to the boat!

Diagram A

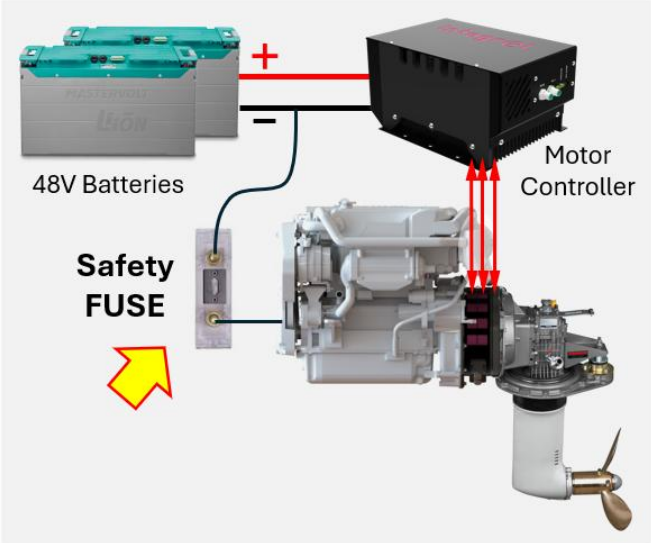
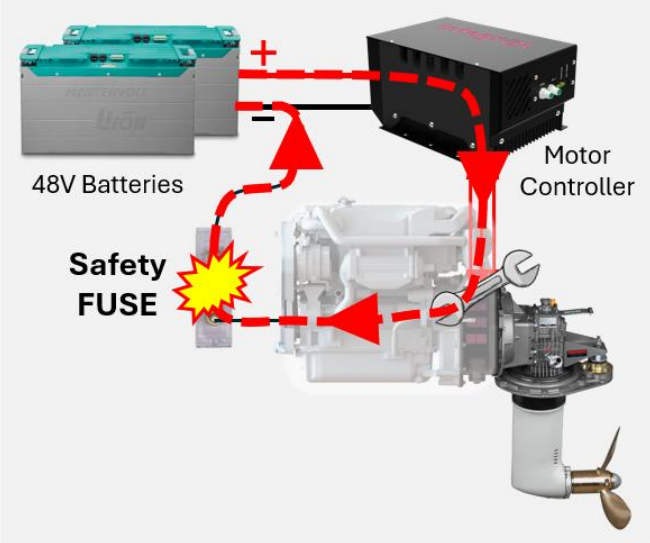


Diagram B



Now consider the situation in **Diagram B**, a misplaced wrench is accidentally shorting one of the motor cable connectors to the engine chassis. If the safety fuse was not present to break the short circuit, large amounts of energy from the 48V batteries would travel through the cables making them very hot and creating the potential to cause a fire.

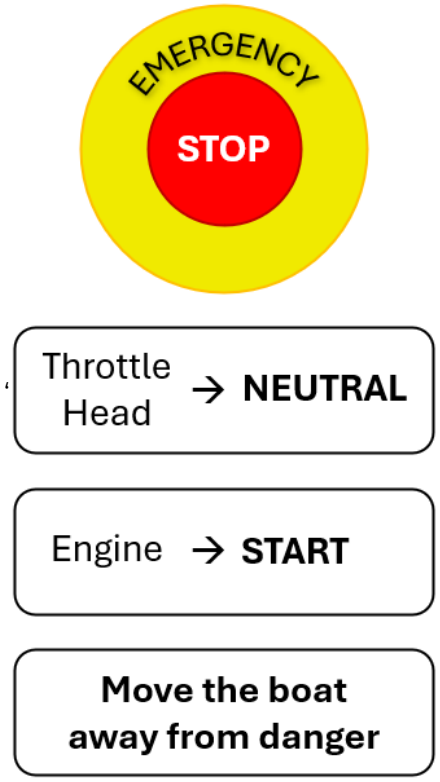
!! IMPORTANT !!

All connections between the engine chassis and 48V battery negative must be fused

9.1 Emergency Override Procedure

Should the E-Drive or battery system fail for any reason, use the following procedure to immediately switch to using the engines for propulsion:

1. Hit the E-Drive Emergency STOP button (located next to the helm).
2. Move the throttle(s) to neutral.
3. Start the engine(s).
4. Use the throttle and engines to moves the boat away from danger.



E-Drive Emergency Override Procedure

10 Certification

The E-Drive system is currently being tested to comply with the following international certifications and standards.

10.1 Europe

- **Recreational Craft Directive (RCD) (2013/53/EU)**
  - **EN ISO 16315**: Electrical propulsion systems for small craft
  - **EN ISO 25197**: Electrical/electronic control systems for steering, propulsion, or auxiliaries.
- **Electromagnetic Compatibility (EMC) Directive (2014/30/EU)**
  - **EN 60945**: Maritime navigation and radiocommunication equipment – EMC requirements
  - **EN ISO 16315**: EMC aspects of electrical propulsion systems for small craft
  - **EN 61000-6-2**: Immunity standard for industrial environments
- **Restriction of Hazardous Substances (RoHS) Directive (2011/65/EU, amended by 2015/863)**
  - **EN IEC 63000**: Technical documentation for RoHS compliance
- **Waste Electrical and Electronic Equipment (WEEE) Directive (2012/19/EU)**
  - **EN 50419**: Guidelines for WEEE marking.
- **Ecodesign Directive (2009/125/EC) and Energy Labelling Regulation (EU) 2017/1369**
  - **EN 50581**: Technical documentation for environmental impact assessment.

10.2 United States

- **ABYC E-11**: AC and DC Electrical System on boats
- **ABYC-E13**: Lithium-Ion Batteries
- **FCC Subpart 15**: Unintentional and Intentional Radiators

10.3 Other Standards

- IEC 60034 – Rotating Electrical Machines

11 Warranty

Triskel Marine (trading as Integrel Solutions Ltd) warrants its products to be free from defects in workmanship and materials for a period of 2 years from the date of purchase by the end-user, with a maximum of 36 months from the Integrel Solutions Limited invoice date.

11.1 Integrel Product Warranty Statement

Integrel Solutions provides comprehensive Product Liability cover for the Integrel System. In the event of any warranty-covered issue with an engine where Integrel has been fitted, Integrel Solutions will cover the repair or replacement of damaged parts in line with your existing engine warranty. This cover is not in addition to any engine warranty but supplements where a warranty is void because of the fitting of an Integrel System. It has identical terms and conditions as the manufacturer's warranty and the cover is like-for-like including the requirements around servicing, length of warranty and identifies how Integrel Solutions, in lieu of the engine manufacturer, will deal with an issue. In the highly unlikely event of any warranty issue arising, you will need to contact Integrel Solutions who will take lead responsibility on dealing with a claim. Integrel Solutions will manage any claim directly and will liaise directly with the client to ensure a single point of contact to minimise any delays. The full policy schedule for the Product Liability cover is available upon request covering damage attributed to Integrel beyond the engine manufacturers warranty.

Warranty for 3rd party products such as Power Electronics and Batteries are the responsibility of the manufacturer. The owner is responsible for registering these products and for contacting the manufacturer in case of a warranty claim. The manufacturer is solely responsible for the repair or replacement of the faulty product unless the damage is proven to be a direct result of a fault in the Integrel System, as diagnosed by an authorised representative of the manufacturer agreed by Integrel solutions.

Lithium-ion batteries supplied by Integrel Solutions are subject to the manufacturer's warranty or 3 years from date of purchase by the end-user. In addition, a demonstration of correct battery usage is required when making a battery warranty claim. During this period, the manufacturer will, at its discretion, repair or replace the defective product free of charge. The warranty does not include performing or reimbursing de-installation, transportation and re-installation.

11.2 Warranty Exclusions

This warranty will be considered void if the unit has suffered any physical damage or alteration, either internally or externally, and does not cover damages arising from improper use or incorrect user installation, or unauthorised modifications to an installation like:

- Reverse of battery polarity.
- Inadequate connection.
- Mechanical shock or deformation.
- Contact with liquid or oxidation by condensation.
- Use in an inappropriate environment that includes, but is not limited to, dust, corrosive vapor, humidity, high temperature, biological infestation.
- Breakage or damage due to lightning.
- Connection terminals and screws destroyed or damaged due to insufficient tightening.

This warranty will not apply where the product has been misused, neglected, improperly installed, or repaired by anyone other than Integrel Solutions Engineers or one of its authorized Certified Installers. In order to qualify for the warranty, the product must not be disassembled or modified.

11.3 Warranty Remedies

Repair or replacement are our sole remedies and Integrel Solutions shall not be liable for damages, whether direct, incidental, special, or consequential, even caused by negligence or fault. Integrel Solutions owns all parts removed from repaired products. Integrel Solutions uses new or reconditioned parts made by various manufacturers in performing warranty repairs and building replacement products. If Integrel Solutions repairs or replaces a part of a product, its warranty term is not extended. In the case of replacement, the new component has a warranty of 6 months, without effect on the initial warranty period. All remedies and the measure for damages are limited to the above. Integrel Solutions shall in no event be liable for consequential, incidental, contingent, or special damages, even if having been advised of the probability of such damages. All other warranties expressed or implied arising by law, course of dealing, course of performance, usage of trade or otherwise, including but not limited to implied warranties of merchantability and fitness for a particular purpose, are limited in duration to a period of two (2) years from the date of purchase.

11.4 Severability

If a part of the terms and conditions set out above is held invalid, void or unenforceable due to any particular national or international legislation, it shall not affect other parts of the terms and conditions remaining.

11.5 Consumer Law

The relevant consumer law for the country the goods are sold in will apply. You are also entitled to have the goods repaired or replaced if the goods fail to be of acceptable quality and the failure does not amount to a major failure

11.6 EXCLUSIONS OF LIABILITY

TO THE FULLEST EXTENT PERMITTED BY APPLICABLE LAWS, WE ON BEHALF OF OUR DIRECTORS, OFFICERS, EMPLOYEES, AGENTS, SUPPLIERS, LICENSOR AND SERVICE PROVIDERS EXCLUDE AND DISCLAIM LIABILITY FOR ANY LOSSES AND EXPENSES OF WHATEVER NATURE AND HOWSOEVER ARISING INCLUDING, WITHOUT LIMITATION, ANY DIRECT, INDIRECT, GENERAL, SPECIAL, PUNITIVE, INCIDENTAL OR CONSEQUENTIAL DAMAGES; LOSS OF USE; LOSS OF DATA; LOSS OF INCOME; LOSS OF PROFIT OR LOSSES OF ANY KIND OR CHARACTER, EVEN IF WE HAVE BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES OR LOSSES, ARISING OUT OF/OR IN CONNECTION WITH OUR PRODUCTS OR 3RD PARTY PRODUCTS SOLD BY US.

11.7 Third Party Warranties

We partner with selected brands and have tried and tested their products to ensure they work with our system. Each partner provides their own warranty that can be found via contacting the partner directly.

Integrel solutions

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