ALL Power Labs
personal scale power

Chapter 10
Grid Tie Module

Featuring the DSE 8610 Grid Tie Auto-start Load Share Control Module

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Brief Explanation of the Grid Tie System

The Power Pallet Grid Tie module uses a Deep Sea 8610 controller to synchronize the Power Pallet with and export power to the grid. It is configurable through the *Deep Sea Configuration Suite Software* with many settings also accessible through the controller interface. ALL Power Labs ships the Power Pallet Grid Tie systems already configured. The settings should not be changed unless done so by a trained professional.

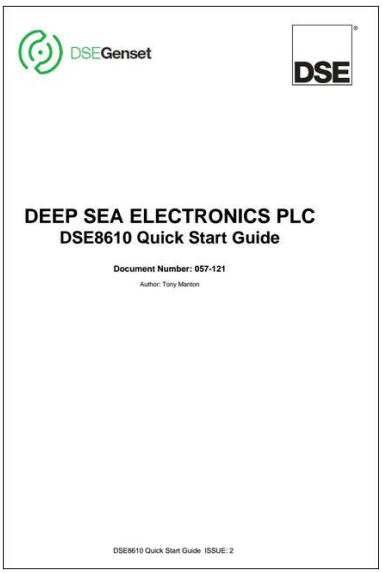
1. Warnings/Hazards

NOTE: Observe local regulations. Local codes may supersede these recommendations. Plan your system with your utility company and an electrical engineer before connecting to the grid. Be sure to read the DSE manuals and the manuals for the generator before attempting a grid tie installation.

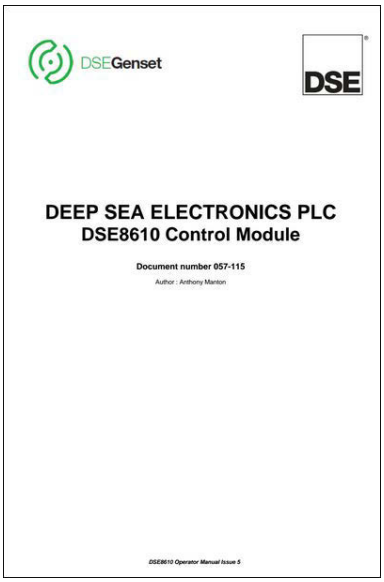
- Improperly connecting the Power Pallet to an electrical system can cause electrical current from the generator to backfeed into the utility grid or microgrid when it should be shut down. This backfed power could unexpectedly electrocute utility workers or other individuals who come into contact with wires or electrical equipment, or cause the generator to explode or catch fire. It is imperative that you consult the utility company or a qualified electrician in order to determine the additional equipment that will be required to safely interconnect to the utility grid or microgrid.
- Disconnect the electrical system from the grid before carrying out maintenance or repairs on the grid tie system.
- There is risk of danger to equipment if the equipment is in mains paralleling mode and ‘stand-alone mode’ is enabled. In this case, the system will close to dead bus and thus will energize the grid causing risk danger to equipment and operator or linemen.
- Improper connections to an electrical system can allow electrical current from the generator to backfeed into the utility lines. Such backfeed may electrocute utility company workers or others who contact the lines during a power outage, and the generator may explode, burn, or cause fires when utility power is restored. Consult the utility company or a qualified electrician.
- Always disconnect system from the grid before servicing. Do not work on equipment when powered.

III. Reference Materials

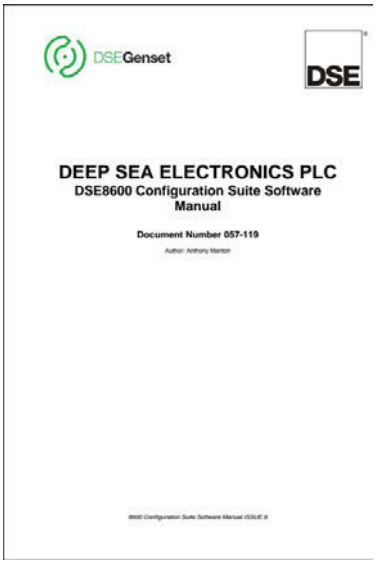
Deep Sea Electronics has a full listing of manuals and quick start guides available in several languages on their website available for download. Please visit:
http://www.deepseaplc.com/support/product-software/dse-genset/synchronising-load-sharing-controllers/dse8610.
This document may occasionally refer you to one of the following technical manuals.



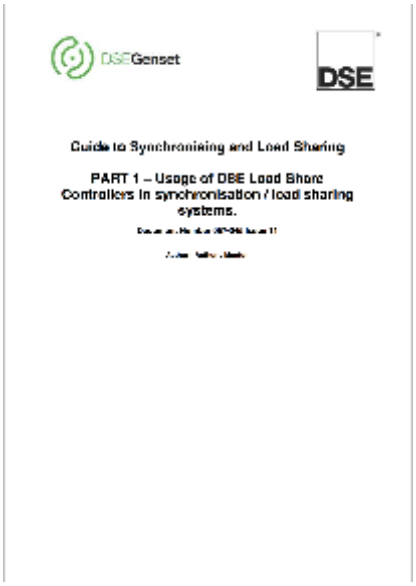
DSE8610 Quick Start Guide



DSE8610 Control Module (User Manual)



DSE Configuration Suite PC Software Installation & Operation Manual	DSE8600 Configuration Suite Software Manual
Load Share System Design and Commissioning	

	
Guide to Synchronising and Load Sharing Part 1	**Guide to Synchronising and Load Sharing Part 2**

IV. Use Cases

A. Use Cases and Available Features

The following features sets are available:

Feature	Mains Paralleling	Part of a Microgrid	Stand Alone Operation
Fixed export control	Yes	Yes	No
No Break transfer	N/A	No	N/A
Islanding	No	No	No
Load sharing	No	No	No
Close to dead bus	No	No	Yes
Earth fault detection	No	No	No
Mains decoupling	Yes*	No	N/A
Vector Shift	Yes	No	N/A

*Does not meet IEEE 1547, CEI not met (Mains Decoupling triggers)

a. Connection to a Utility for Mains Paralleling

In this case, a single Power Pallet is connected to a utility grid with fixed power export—i.e. a constant power level that does not vary with load. If multiple Power Pallets are onsite, each is independently tied to the grid with no load sharing between the units.

b. Part of a Microgrid

A microgrid is an independent electrical grid, typically small- or distributed-scale, that may connect to a larger utility grid, but can meet its power and control requirements within the microgrid system.. Because a grid-tied Power Pallet is configured for fixed export, the generator will not respond to match the load demand as a standalone Power Pallet will. Therefore, ensure that the microgrid includes another power source or storage ability. If the Power Pallet is exporting more power than there is load on the microgrid, excess power will be generated with no sink, leading to unstable operation, high reactive power, and potentially overcurrent electrical trips and shutdowns.

If there is more load on the microgrid than the Power Pallet is exporting and there is no other power source that can support excess load, the Power Pallet's generator will bog down and an underfrequency or under-voltage electrical trip alarm is likely to occur.
An example of this is a diesel generator and Power Pallet supplying load to the microgrid.

c. Stand-Alone Operation

Note: ALL Power Labs does not support stand-alone operation of the Power Pallet Grid-Tied models. However, instructions are provided for troubleshooting purposes only that are only to be done by an APL certified technician.

In order to enable this feature connect battery ground on main negative bus inside enclosure to digital input D (DSE pin 63). Contact APL support before carrying out any changes related to standalone operation.

V. Commissioning Procedure

Please note that the Grid Tie Power Pallets are already configured when shipped. The commissioning procedure listed here is offered for reference only.

1. PCU Configuration

Enable 'Grid Tie' mode on the PCU. Navigate to the view for this configuration setting by using the buttons on the control panel.

2. Deep Sea Configurations

The APL Grid Tie Configuration Worksheet is available in the Documentation and Resources package on the USB key that is sent with each system as a resource to calculate the configurations needed for site specific needs. Please contact support@allpowerlabs.com for this if needed.

APL Configuration Worksheet inputs:

1. Configuration (generator)
    a. frequency
    b. generator wiring
2. Nominal voltage
3. Upper and Lower mains disconnect values (if different than IEEE 1547 defaults)
    a. frequency
    b. voltage

Once the input values have been entered into the worksheet, use the output values in the lowest section of the spreadsheet to configure your DSE controller. To do this, the "Deep Sea Configuration Suite PC Software" must be installed on your computer, which you can download from the Deep Sea Electronics website after creating a free user account (http://www.deepseaplc.com/home/). You should enter the worksheet's output values into the **base file*** (which is provided by APL and includes other base configurations for the Power Pallet) using the DSE Configuration Suite software. Upload the modified config file to DSE from the DSE configuration program over a USB connection. Please consult the DSE 8600 Configuration Suite Software Manual for upload instructions. Note: if the DSE 8610 module firmware version is different than the DSE base configuration file version, you must reconcile the two by upgrading or downgrading the configuration file or the module firmware.

If the configuration of the system is changed from its original configuration when shipped, APL customer service representative must be notified to ensure future service and warranty coverage.

If you are re-configuring your Power Pallet or grid tie system, you should download the original DSE configuration file from the Deep Sea module and save it on your computer, in addition to saving a version of the new DSE configuration file.

**Please contact APL Customer Service for the base file.*

3. AVR Tuning

a. Disconnect the two (orange and black) bias wires on the generator's AVR (automatic voltage regulator). See wiring diagram.
b. Make sure that the tiny arrow on the AVR VOLT potentiometer is centered within the tick marks.
c. The arrow on the STAB potentiometer should be set two marks clockwise from the, fully-counterclockwise position.
d. Start the engine. Wait until "Generator Available" appears on the DSE controller screen.
e. Adjust the VOLT potentiometer to change the phase to phase (Ph-Ph) voltage to the desired nominal voltage, as displayed on the DSE controller screen.

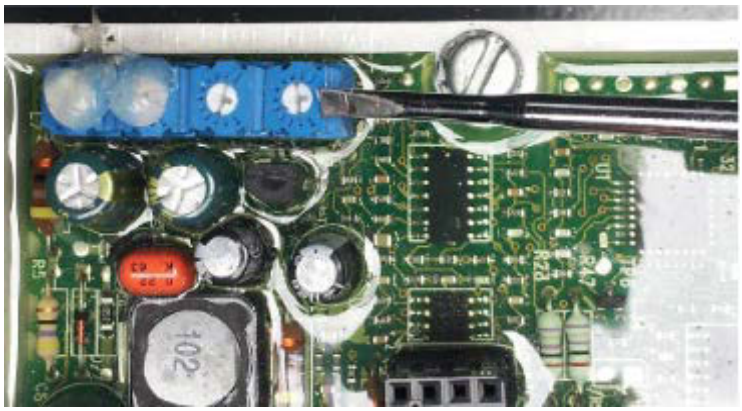


Figure x. Location of VOLT and STAB potentiometer on generator AVR.

4. Configure DSE SCADA Settings

The following procedure is designed to confirm that the DSE is able to accurately control genset output voltage (through the AVR) and the frequency (controlled by the governor) via the DSE program's supervisory control and data acquisition (SCADA) interface. To set the SCADA settings most easily, connect your computer to the USB port on the DSE controller and connect to the module using the Deep Sea 8600-series Configuration Suite. For further reading, please see page 15 in the *Deep Sea Commissioning Load Share System Design Manual.*

IMPORTANT: The SCADA settings must be set independently after the configuration file is uploaded to the DSE module because they are not stored as a part of the module configuration file. This feature also permits the DSE controller to carry out real-time monitoring and control through SCADA, without the need to re-upload configuration files. The Clone Module feature transfers both the configuration AND the settings of the Multiset, Governor/ AVR interface and the Sync page. For more information see DSE 8600 Config SW Manual.

The DSE module controls the governor and AVR on the genset through bias voltages, which command them to increase or decrease the output frequency and voltage, respectively. The bias voltages are configured through setting the bias "center" voltage (SW1), and range (SW2).

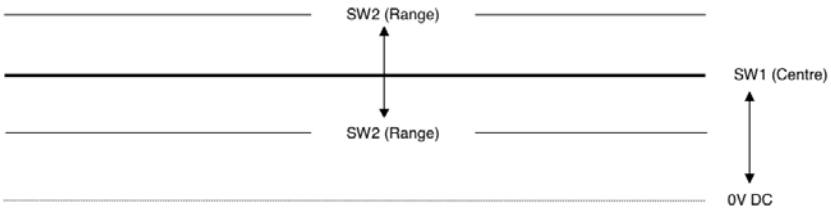


Figure 1. Illustration of the center and range of the bias voltages for the AVR and governor.

The following procedures confirm that the Deep Sea has control of the genset voltage and frequency.

A. AVR Bias Tuning Procedure

> **CAUTION:** For bias voltages exceeding 2.5V, the AVR's default behavior is to reject the bias input. This can lead to unexpected behavior of the generator. For more information, consult the AVR manual.
>
> **CAUTION:** Bias voltages outside the range of -5V to +5V may damage the AVR. The Deep Sea can output voltages from 0-10V.

- Initial AVR SW1 = See Value In Configurations Table
- Initial AVR SW2 = See Value In Configurations Table
- Record initial SW1 value (SW1i)
- With genset running - Adjust SW1 to raise the output frequency 15% over nominal voltage.
    - For example: 230V Ph-Ph * 115% = 265V (230V + 35V) (see Table 1)
- The generator should be kept running without load
- Record the value of SW1 (SW1f)
- Set SW2 to the difference between SW1f - SW1i
- Set SW1 to the initial value (SW1i)

Table 1. Nominal and Upper phase-to-phase voltage examples

Nom. V Ph-Ph	Upper V Span (115% of Nom.)
190	219
200	230
208	239
220	253
230	265
240	276
254	292
266	306
277	319
380	437
400	460
415	477
440	506
460	529
480	552

B. Governor Bias Tuning Procedure

- Disconnect governor bias wires from back of DSE controller
- Initial Governor SW1 = See Value In Configurations Table
- Initial Governor SW2 = See Value In Configurations Table
- The generator should be kept running without load
- Record initial SW1 value (SW1i)
- With genset running - Adjust SW1 to raise the output frequency by 2.5Hz (SW1f)
- Record the final value of SW1 (SW1f)
- Set SW2 to the difference between SW1f-SW1i
- Set SW1 to the initial value (SW1i)

Editing Parameters:

All settings can be configured using the Configuration Suite software. Do not alter these settings unless recommended by a trained APL certified technician. Most settings can also be configured through the DSE control panel: Press and hold the (√) button for basic settings. For advanced settings press and hold (√) and (STOP) buttons.

For more information see: ***DSE8610 Control & Instrumentation System Operators Manual - 9. FRONT PANEL CONFIGURATION***

VI. Dynamic Tuning for Grid Tie Operation

Each utility grid or microgrid has unique dynamics and the Power Pallet's generator must be "tuned" to properly synchronize and maintain stable power export.
The figure below shows the hardware configuration of the Deep Sea Module and the Power Pallet:

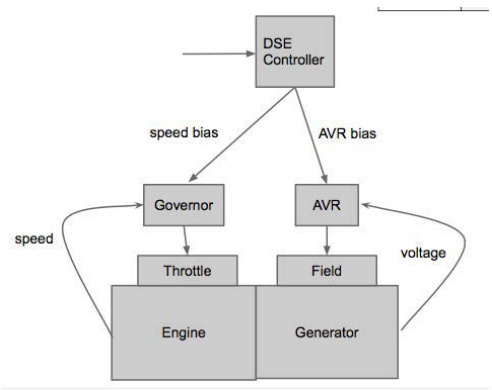


Figure x. Control Scheme of the Power Pallet and Deep Sea Module

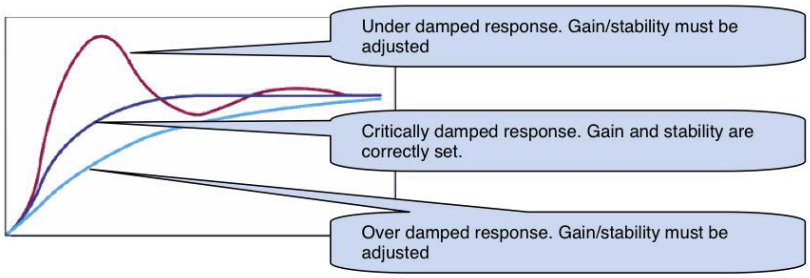


Figure x. Control dynamic response in relation to gain and stability values

Figure 3. Dynamic system responses according to gain/stability parameters.

State	Available	Sync	On Grid
Governor	No Bias	Frequency Match	Load Share Control
Generator Field	No Bias	Voltage Match	Reactive Power Control

The Deep Sea control module has SCADA settings that determine how the AVR and governor bias control loops react dynamically to fluctuations in the grid in an effort to maintain a stable, synchronized connection between the Power Pallet and the grid. These settings are called gain and stability and, during synchronization, the frequency synchronizer and voltage matcher are controlled by their gain, while, when the Power Pallet is exporting power, gain and stability control load share and reactive power control.

Gain

The gain determines how rapidly the control module bias can respond to instantaneous changes in the grid or generator's dynamics. In general, a lower gain setting results in a slow frequency or voltage matching process, but too high a setting may cause instability (hunting).

Stability

The stability determines how the control module bias responds to the longer-term relationship between the nominal and actual voltage. In general, a higher stability setting will cause the actual frequency or voltage to come very close to the nominal values, but may reduce the control module's ability to respond quickly when there is a disturbance in the grid or generator.

Note: The pre-set gain and stability settings will be acceptable in some, but not all, use cases. Please contact APL customer support if it is necessary to adjust these values to tune your Power Pallet to the grid. Changing these values without an APL-certified technician may void the warranty.

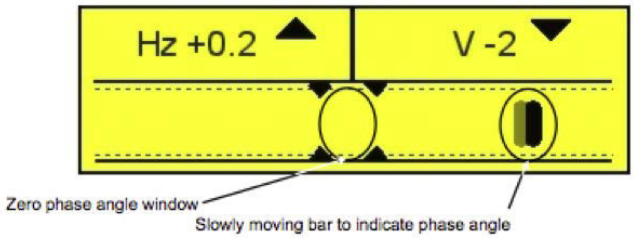


Figure 4. Deep Sea synchronizer screen

1. Frequency Synchronizer

The frequency synchronizer adjusts governor bias to bring the generator's frequency into sync with the grid during the synchronization process. This is displayed on the upper left side of the synchronization screen as a +/-Hz reading when out of synchronization range, or with a check mark if the voltage is within bounds.

- **Slip Frequency**

  The difference between the Power Pallet's generator frequency and the bus/mains frequency of the grid. For example, with a slip frequency of 0.2 Hz, the two power sources will be in phase (zero phase angle) once every five seconds. With stable

generator frequency, the bar will consistently move to the right across the screen, while frequency variation will show as inconsistent movement back and forth across the screen.

2. Voltage Matcher

During the synchronization process,the voltage matcher adjusts the AVR bias in order to synchronize the generator's voltage to that of the grid. This is displayed on the upper right side of the synchronization screen as a +/-V reading when out of synchronization range, or with a check mark if the voltage is within bounds.

When both the frequency and voltage of the Power Pallet's generator are synchronized with those of the grid, the bar will move into the zero phase angle window and be bounded by vertical bars. At this time, you should hear a loud click, which is the contactor closing the circuit and creating a connection between the generator and the grid.

3. Load Share

When the Power Pallet is connected to the grid, the load share control adjusts the governor bias. Because the generator is locked in synchronization with the grid when the contactor is closed, the speed change request effectively is a request to open or close the governor throttle. Thus, the load share effectively controls the amount of real power export from the system based on the configurable target power setpoint.

4. Reactive Load Control

When the Power Pallet is connected to the grid,the reactive load control controls the AVR bias . Since the generator voltage is locked in synchronization with the grid when the contactor is closed, the voltage change request effectively is a request to increase or decrease the generator field, adjusting the ratio between reactive power for the amount of real power.

Note: Reactive load control is typically unstable under 5 kW of real power.

VII. Configuration Screens

[image of configuration screen]

The DSE control module has a series of monitoring and configuration screens. In order to switch between different information topics in the monitoring screens, use the left and right arrow buttons. In order to see different status screens within each topic area, use the up and down arrow buttons. The "Status" screen is important, as it displays the status of the generator, such as "Generator at Rest", "Generator Available", and "On Load". Once the Power Pallet is on load, the most useful monitoring screens are under the "Generator" heading. Simply press up once

to see the targets for various critical variables, such as load level, reactive power, power factor, and biases displayed as percentages and up once more to see their absolute values.

- ***Target Power***

The Power Pallet target power output for fixed export can be adjusted through the SCADA settings in the DSE Configuration Suite software, under Multiset ->Load Levels ->Maximum.
It can also be adjusted on the Deep Sea control module interface by adjusting “Load Parallel Power” - see “editing parameters”

(Note: Minimum load level is the point at which the contactor will open when ramping off load. We recommend maintaining the preset value in order to prevent contactor arcing)

Other important values, such as the power factor, can also be adjusted in the Configuration Suite under Multiset within SCADA settings or through the DSE control module interface. For complete instructions, please see_____(manuals).

VIII. Diagnostics

A. CT Polarity Diagnostics

See 8610 User Manual sections 3.5.2 and 3.5.3 for more information on the CT Polarity Diagnostics method.

B. Load Acceptance Test

- Load acceptance test - load system to 50% of power rating and confirm stable operation.
- During this load test, confirm current transformers are reading correct power [kW] and PF (e.g. ~1 for resistive loads)
- Engine should accept and shed load with stable recovery to nominal speed and voltage (e.g. within a maximum of 10 seconds)

C. Test PCU Shutdown Command

- Enter PCU Test menu
- Scroll to FET3 Starter
- Turn on
- The DSE control module should raise an alarm that says “PCU Commanded Shutdown”

IX. Troubleshooting

The troubleshooting provided in this table is only for a trained APL technician only or if directed by a trained APL technician or APL support team. Please do not conduct any troubleshooting below before contacting APL support.

Symptom	Possible Root Cause	Solution
System Does not Parallel to Bus/Grid	Miswiring or loose wiring.	Check that the DSE Input/Output pins and the enclosure's internal wiring are correct
PCU shutdown alarm not shutting down Deep Sea	DSE Input/Output pins may not be properly configured	Test PCU Shutdown Command. Check that wiring from PCU, inside enclosure, and at DSE controller is correct and connected.
Synchronizing system does not export power and causes "Reverse Power" alarm	Mains Paralleling mode may not be enabled.	Check that Mains Paralleling mode is enabled. Shipped configuration: Input D is left "open" = Mains Paralleling active
AVR bias rapidly fluctuating while on grid	Incorrect reactive power control tunings	Adjust reactive power control after consulting APL support
Symptom?	AVR bias out of range	Adjust AVR SW1/2
Fluctuating amperage or power factor despite stable governor	Poor reactive power control	Adjust reactive power control settings
Unstable power export	Poor load share control	Adjust load share settings
"Fail to sync" alarm	Unstable frequency	Check gas quality, governor stability, clean governor
Contactor not operating correctly	Possible miswire of solenoid voltage wiring	Check wiring
Negative power values reported.	CT(s) reversed polarity	Flip CTs to correct polarity

Over-voltage	Incorrect DSE wire-topology settings	Incorrect AVR potentiometer setting or bias
Under-voltage	Incorrect DSE wire-topology settings	
“E-stop alarm”	Ignition circuit fuse blown	Replace fuse (#3?)
“E-stop alarm”	Bad wiring	Confirm wiring
Unexpected engine shutdown	Outside pre-set parameters	Operate with in pre-set parameters or change parameters.
Unexpected engine shutdown	E-stop pressed	Reset E-stop button
Unexpected engine shutdown	PCU commanded shutdown	Check PCU alarm and refer to Automation Assembly section of APL Technician’s Handbook

*See provided DSE 8610 User Manual Section 11 and the DSE 8600 Series Configuration Suite Software Manual Section 4.5.3 for expanded troubleshooting