# DEEP SEA ELECTRONICS PLC

## DSEA106 MKII Operator Manual

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**DSEA106 MKII Operator Manual**



## Amendments Since Last Publication

| Amd. No. | Comments |
|---|---|
| 1 | First release |
| 2 | Added UL information |
| 3 | Updated Setup Procedure |

Typeface. The typeface used in this document is *Arial*. Care should be taken not to mistake the upper case letter I with the numeral 1. The numeral 1 has a top serif to avoid this confusion.

***Clarification of notation used within this publication.***

| | |
|---|---|
| **NOTE:** | Highlights an essential element of a procedure to ensure correctness. |
| **CAUTION!** | Indicates a procedure or practice, which, if not strictly observed, could result in damage or destruction of equipment. |
| **WARNING!** | Indicates a procedure or practice, which could result in injury to personnel or loss of life if not followed correctly. |

# Table of Contents

# 1 INTRODUCTION

**WARNING!: LIVE PARTS exist within the AVR. To avoid damage to persons and/or property, only qualified personnel, having full understanding of the application must install the product.**

This document details the installation requirements of the DSEA106 MKII Auxiliary / Shunt power Digital Automatic Voltage Regulator. The manual forms part of the product and should be kept for the entire life of the product. If the product is passed or supplied to another party, ensure that this document is passed to them for reference purposes.
This is not a *controlled document.* You will not be automatically informed of updates. Any future updates of this document will be included on the DSE website at www.deepseaplc.com

For details on configuring the DSEA106 MKII using a PC, refer to the relevant configuration software manual.

## 1.1 BIBLIOGRAPHY

This document refers to and is referred to by the following DSE publications which can be obtained from the DSE website www.deepseaplc.com

| DSE Part | Description |
|---|---|
| 053-226 | DSEA106 MKII Installation Instructions |
| 057-271 | DSEA106 MKII Configuration Suite PC Software Manual |

# 2 SPECIFICATIONS

## 2.1 REQUIREMENTS FOR UL CERTIFICATION

| Description | Specification |
|---|---|
| Conductors | **⚠CAUTION!: For applications in the US, the DSEA106 MKII is rated as PD3 for 0 V to 430 V and PD2 for 430 V to 600 V. For applications in Canada, the DSEA106 MKII is rated as PD3 for 0 V to 300 V and PD2 for 300 V to 600 V** |
| | • Conductor protection must be provided in accordance with NFPA 70, Article 240<br>• Low voltage circuits (35 V or less) must be supplied from the engine starting battery or an isolated secondary circuit.<br>• The communication, sensor, and/or battery derived circuit conductors shall be separated and secured to maintain at least ¼" (6 mm) separation from the generator and mains connected circuit conductors unless all conductors are rated 600 V or greater. |
| Current Inputs | • Must be connected through UL Listed or Recognized isolating current transformers with the secondary rating of 5 A max. |
| Communication Circuits | **⚠CAUTION!: The communication port is for temporary use and service access only by qualified service personnel only. Use appropriate Personal Protective Equipment (PPE) during connection as risk of potential shock hazard.** |
| | • Must be connected to communication circuits of UL Listed equipment. |
| Mounting | • Suitable for flat surface mounting in Open Type Device Enclosure Type rating with surrounding air temperature -22 ºF to +158 ºF (-30 ºC to +70 ºC)<br>• Suitable for pollution degree 3 environments when voltage sensing inputs do not exceed 300 V. When used to monitor voltages over 300 V device to be installed in an unventilated or filtered ventilation enclosure to maintain a pollution degree 2 environment. |
| Operating Temperature | • -22 ºF to +158 ºF (-30 ºC to +70 ºC) |

## 2.2 TERMINAL SPECIFICATION

| Parameter | Description |
|---|---|
| Connection Type | Spade terminals. |

## 2.3 AUXILIARY WINDING / SHUNT SUPPLY

**⚠NOTE: The DSEA106 MKII AVR is suitable for alternators with *Auxiliary Winding* or *Shunt* connections only. For alternators with *Permanent Magnet Generator (PMG)* connections, contact DSE Technical Support for more details: support@deepseaplc.com**

| Parameter | Description |
|---|---|
| Arrangement | Single phase or phase to phase voltage. |
| Voltage | 100 V AC to 300 V AC between terminals *Aux*– and *Aux*+. |
| Frequency | 40 Hz to 180 Hz. |
| Shunt Source Inductance | 40 mH to 1000 mH. |
| Auxiliary Source Inductance | 40 mH to 70 mH. |

## 2.4 GENERATOR VOLTAGE / FREQUENCY SENSING

| Parameter | Description |
|---|---|
| Arrangement | Single phase or phase to phase voltage. |
| Measurement Method | True RMS up to 11th harmonic. |
| Primary To Ground Resistance | >4 MΩ from each phase to *A-* and *P2* (internally connected). |
| Phase to Phase Resistance | 600 kΩ between terminals *L1* and *N (L2)*. |
| Voltage | 15 V AC to 600 V AC between terminals. |
| Voltage Accuracy | ±0.5 % of full scale. |
| Maximum Common Mode Voltage | 500 V. |
| Frequency | 40 Hz to 65 Hz. |
| Frequency Accuracy | ±0.2 Hz. |

## 2.5 GENERATOR CURRENT MEASUREMENT

The DSEA106 MKII measures current in a chosen phase for the purposes of quadrature droop using terminals *S1* and *S2*. For further details, refer to the section entitled *Quadrature Droop* elsewhere in this document.

| Parameter | Description |
|---|---|
| Arrangement | Single phase on any phase. |
| Measurement Method | True RMS up to 11th harmonic. |
| Maximum Continuous Current | 5 A |
| Burden on the CT | 0.25 VA |
| Common Mode Offset | ±1 V peak from *S2* terminal to *A-* and *P2* (internally connected). |
| Accuracy | ±1 % of Nominal (5 A) excluding CT error. |
| Droop Adjustment | 0% to 10% |

## 2.6 EXTERNAL AC VOLTAGE BIAS

External voltage bias inputs are provided to allow an external circuit to influence the output of the generator.

| Parameter | Description |
|---|---|
| Potentiometer Bias Input (terminals *P1* and *P2*) | 0 Ω to 5 kΩ |
| DC Voltage Bias Input Range (terminals *A1* and *A2*) | -10 V to 10 V |
| DC Voltage Bias Input Impedance | > 10 kΩ |
| Bias Range | ±1% to ±16% of Nominal Voltage set using PC software |

## 2.7 EXCITER FIELD OUTPUT

| Parameter | Description |
|---|---|
| Exciter Winding Impedance | 5 Ω to 50 Ω. |
| Exciter Winding Inductance | 0.3 H to 1.2 H |

### 2.7.1 CONTINUOUS

Continuous rating is subject to output power being 500 W or below.

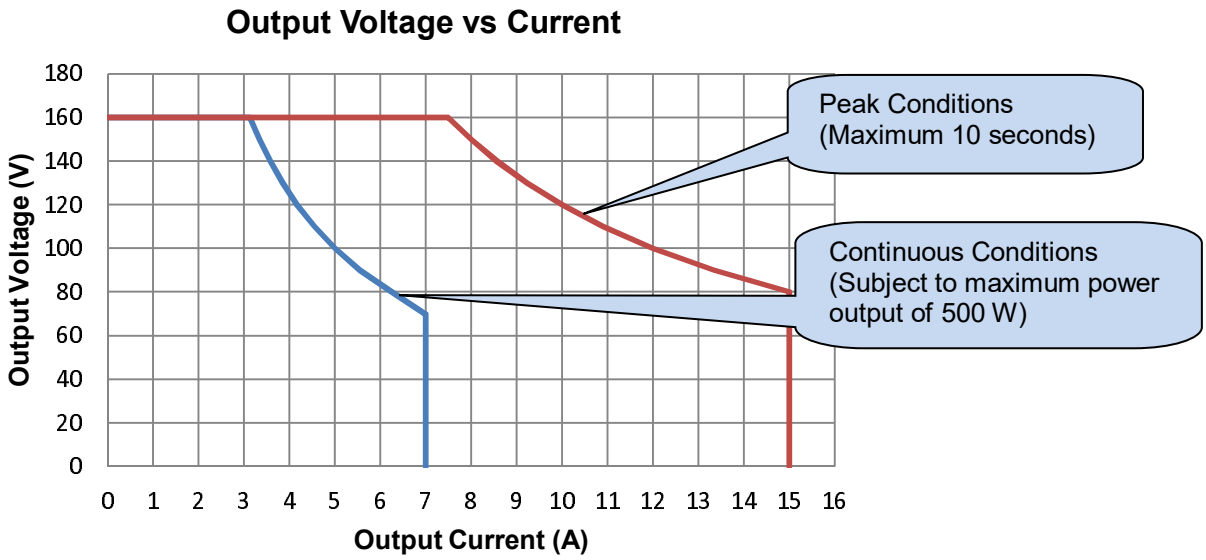
| Parameter | Description |
|---|---|
| Output Voltage | 0 V DC to 100 V DC. |
| Output Current | 0 A DC to 7 A DC. |

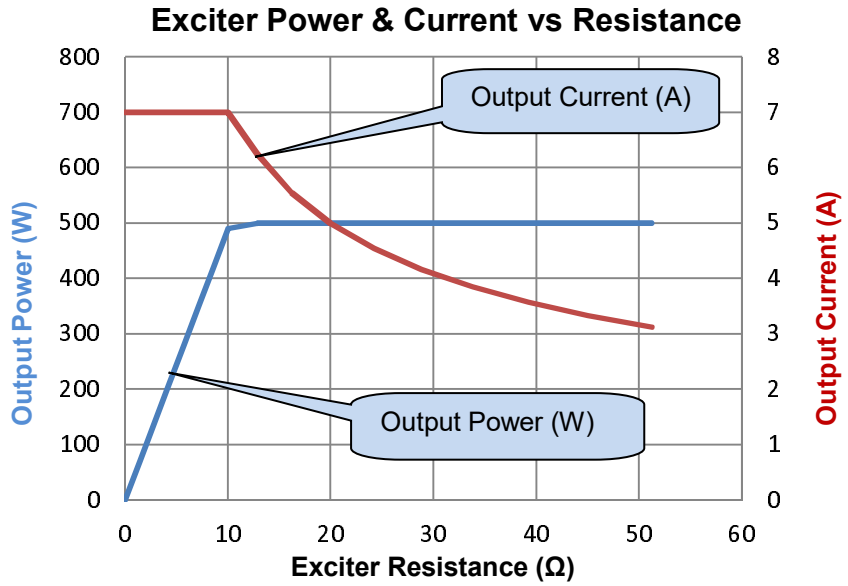
### 2.7.2 PEAK CONDITIONS

Peak conditions are for a maximum of 10 seconds.

| Parameter | Description |
|---|---|
| Output Voltage (Overload) | 150 V DC for 10 seconds. |
| Output Current (Overload) | 15 A DC for 10 seconds. |

## 2.8 OUTPUT POWER LIMITATION CURVES



## 2.9 DIMENSIONS

| Parameter | Description |
|---|---|
| Overall Size | 179 mm x 108 mm x 61 mm<br>(7.1 “ x 4.3 “ x 2.4 “) |
| Mounting Type | Screw Mounting to Chassis. |
| Mounting Holes | Suitable for M5 bolts/screws. Outside diameter 5.5 mm<br>(Outside diameter 0.2 “) |
| Mounting Hole Centres | 149 mm x 85 mm<br>(5.9 “ x 3.3 “) |

## 2.10 TEMPERATURE

| Parameter | Description |
|---|---|
| Operating Temperature | -40 ºC to +70 ºC<br>(-40 ºF to +158 ºF) |
| Storage Temperature | -40 ºC to +80 ºC<br>(-40 ºF to + 176 ºF) |

## 2.11 COMMUNICATION

**NOTE: For further details of module configuration, refer to DSE Publication: *057-271 DSEA106 MKII Configuration Suite PC Software Manual.***

In conjunction with the DSE815 Configuration Interface, the communication port is provided to give a simple means of connection between a PC and the controller.
Using the DSE Configuration Suite Software, the operator is then able to monitor the device and perform reset operations.

Additionally, the various operating parameters are available to be viewed or changed.

To connect a module to a PC by USB, the following items are required:

- DSEA106 MKII

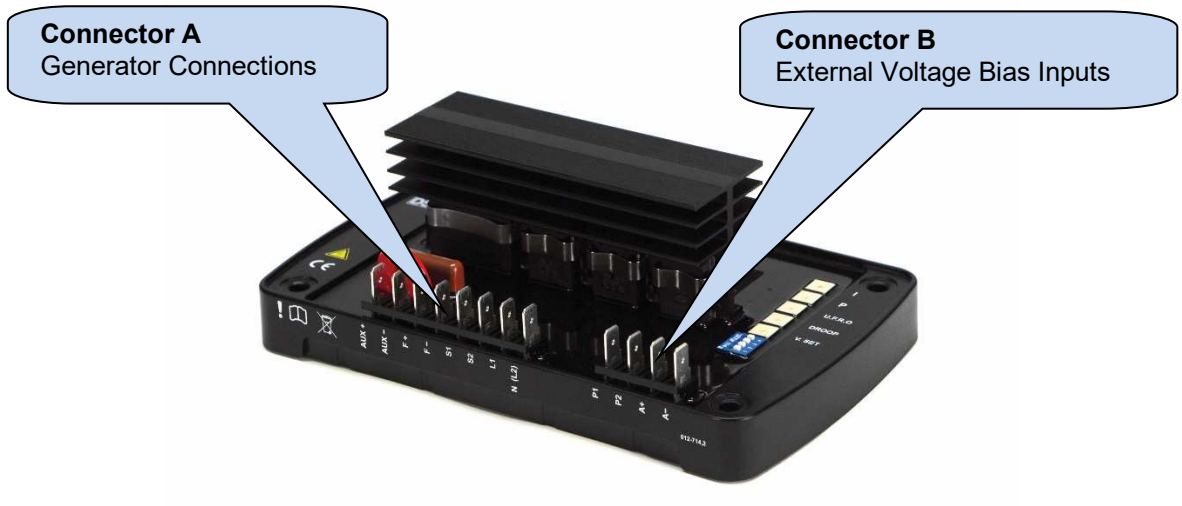
- DSE815 Configuration Interface

- DSE Configuration Suite PC Software (available from www.deepseaplc.com).

# 3 INSTALLATION

**WARNING!: LIVE PARTS exist within the AVR. To avoid damage to persons and/or property, only qualified personnel, having full understanding of the application must install the product.**

The DSEA106 MKII is designed to be mounted on the control panel chassis or within the alternator housing utilising the integral mounting holes. For dimension and mounting details, see the section entitled *Specifications, Dimensions* elsewhere in this document.




## 3.1 USER CONNECTIONS

### 3.1.1 CONNECTOR A – GENERATOR CONNECTIONS

| Terminal | Function | Recommended Size |
|---|---|---|
| AUX + | Connection to the positive terminal of the generator Auxiliary Winding. | 2.5 mm² (AWG13) |
| AUX - | Connection to the negative terminal of the generator Auxiliary Winding. | 2.5 mm² (AWG13) |
| F+ | Connection to the positive terminal of the generator Exciter Field Winding. | 2.5 mm² (AWG13) |
| F- | Connection to the negative terminal of the generator Exciter Field Winding. | 2.5 mm² (AWG13) |
| S1 | Connection to the Droop CT S1 terminal. | 1.5 mm² (AWG17) |
| S2 | Connection to the Droop CT S2 terminal. | 1.5 mm² (AWG17) |
| L1 | Connection to any of the generator AC output phases | 1.0 mm² (AWG18) |
| N (L2) | Connection to generator AC output neutral or additional phase | 1.0 mm² (AWG18) |

### 3.1.2 CONNECTOR B – EXTERNAL AC VOLTAGE BIAS INPUT

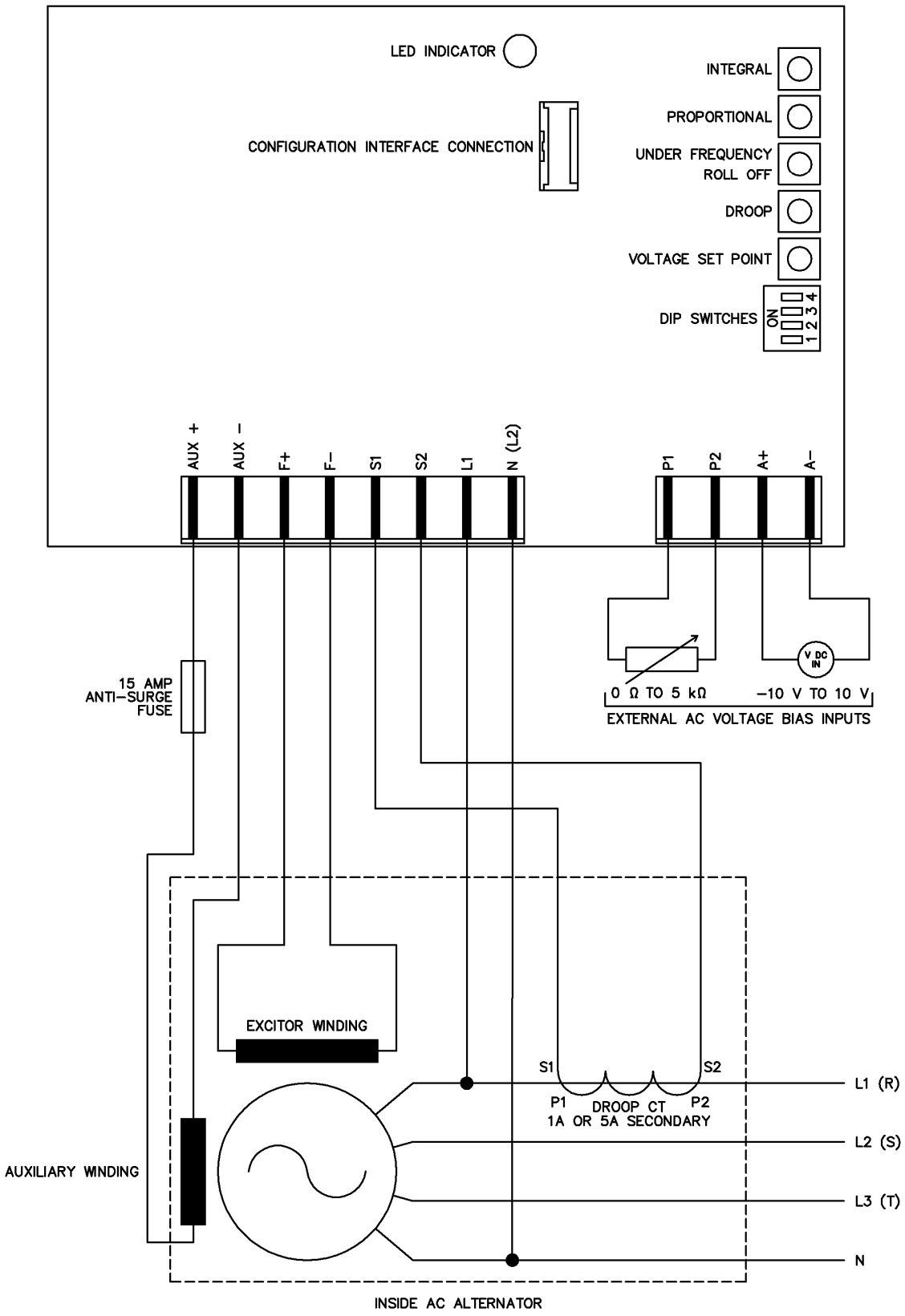
| Terminal | Function | Recommended Size |
|---|---|---|
| P1 | Connection to one side of a remote 5 kΩ adjustment potentiometer. | 1.0 mm² (AWG18) |
| P2 | Connection to one side of a remote 5 kΩ adjustment potentiometer. | 1.0 mm² (AWG18) |
| A+ | -10 V to 10 V remote adjustment input positive terminal. | 1.0 mm² (AWG18) |
| A- | -10 V to 10 V remote adjustment input negative terminal. | 1.0 mm² (AWG18) |

## 3.2 TYPICAL WIRING DIAGRAMS

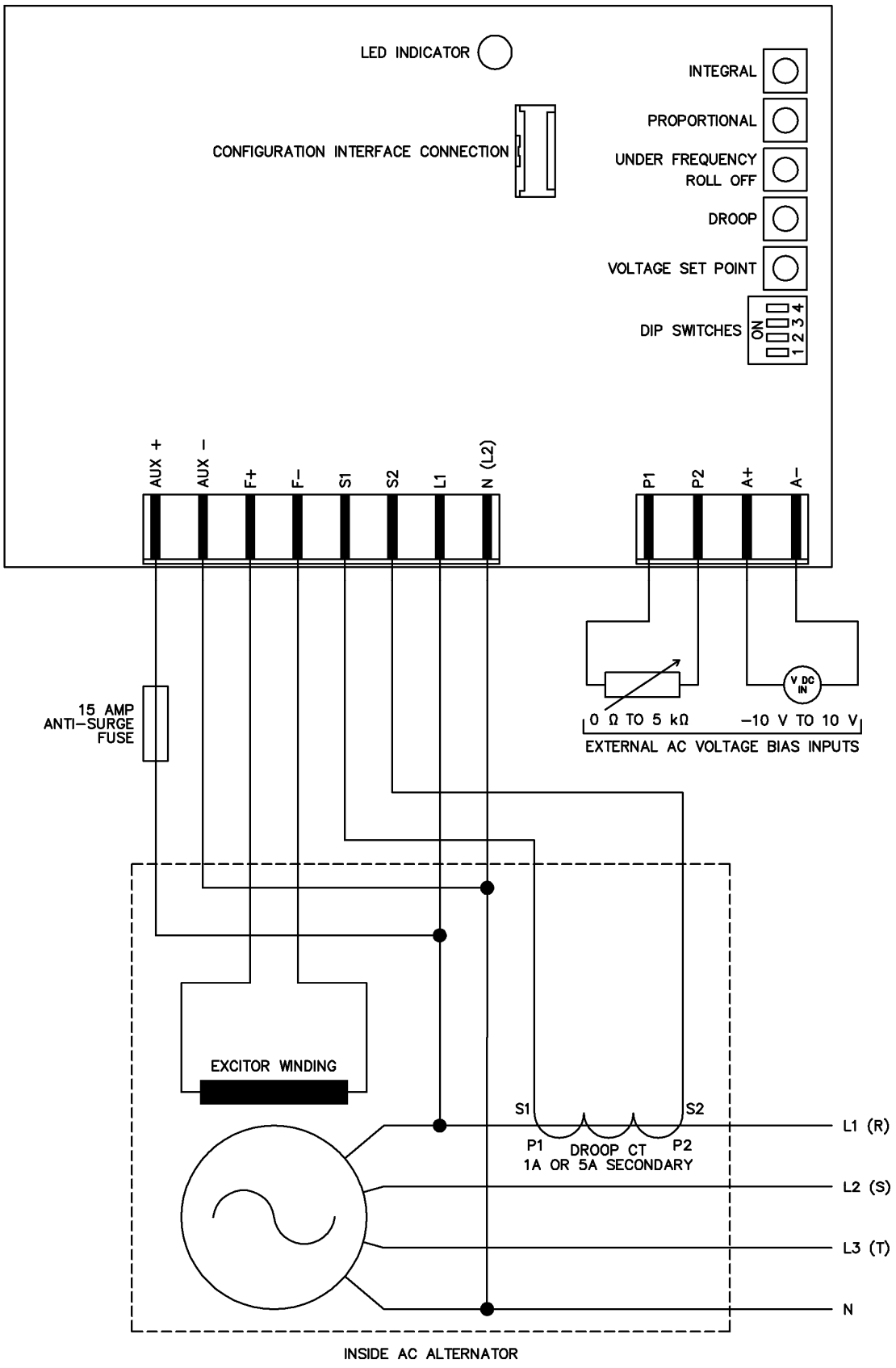
**WARNING!: LIVE PARTS exist within the AVR. To avoid damage to persons and/or property, only qualified personnel, having full understanding of the application must install the product.**

**NOTE: The DSEA106 MKII AVR is only suitable for alternators with *Auxiliary Winding* or *Shunt* connections. For alternators with *Permanent Magnet Generator (PMG)* connections, contact DSE Technical Support for more details: support@deepseaplc.com**

### 3.2.1 AUXILIARY WINDING CONNECTION



### 3.2.2 SHUNT CONNECTION



# 4 SETUP PROCEDURE

**WARNING!: To protect the alternator, 'De-excite' the alternator as described by the alternator manufacturer before commisioning the engine governor. Only re-enable the alternator after successful governor comissioning.**

**WARNING!: LIVE PARTS exist within the AVR. To avoid damage to persons and/or property, only qualified personnel, having full understanding of the application must install the product.**

**NOTE: For further details of module configuration, refer to DSE Publication: *057-271 DSEA106 MKII Configuration Suite PC Software Manual.***

The engine must be commissioned as far as possible before this procedure is carried out, in particular the governor must be setup to produce stable speed control at 1500 RPM / 1800 RPM.

Use DSE Configuration Suite PC Software to upload the factory default configuration to the AVR if required.

## 4.1 AVR INITIAL SETTINGS

Determine from the alternator sensing connections what level of voltage feedback the AVR receives from the alternator.

Set the AVR DIP Switches as required to match the AVR sensing voltage and frequency. This setting must be suitable fro the voltage applied across the *L1* and *N (L2)* terminals.

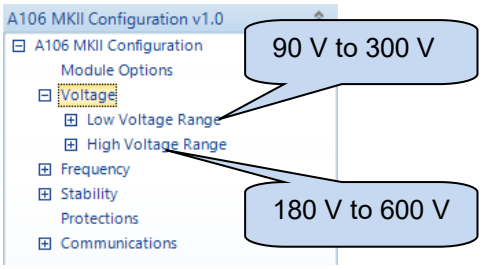
| DIP Switch | Function | Off | On |
|---|---|---|---|
| 1 | Voltage Sensing Range | 90 V to 300 V (Low Voltage Range) | 180 V to 600 V (High Voltage Range) |
| 2 | Frequency Range | 50 Hz | 60 Hz |

Set the AVR DIP Switches to the following positions. This selects one of the four alternative *Stability* settings of the AVR. Settings values for each of the Stability options are factory set but adjustable using the DSE Configuration Suite PC Software.

| DIP Switch 3 | DIP Switch 4 | Function |
|---|---|---|
| Off | Off | Stability Range 1 |
| On | Off | Stability Range 2 |
| Off | On | Stability Range 3 |
| On | On | Stability Range 4 |

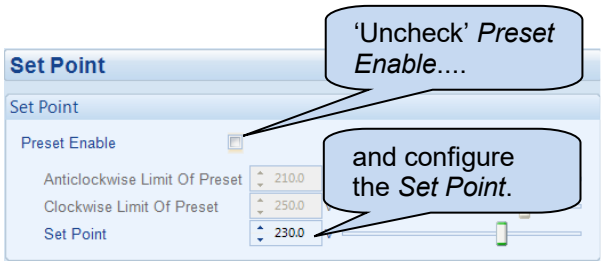
Using DSE Configuration Suite PC Software, select the appropriate voltage menu *Low Voltage Range* (for 90 V to 300 V systems) or *High Voltage Range* (for 180 V to 600 V systems).

This voltage refers to the voltage applied to the AVR *L* and *N (L2)* terminals (the sensing voltage).




Now select the *Set Point* menu and 'uncheck' the *Preset Enable* option.

This allows the *Set Point* parameter to be configured.



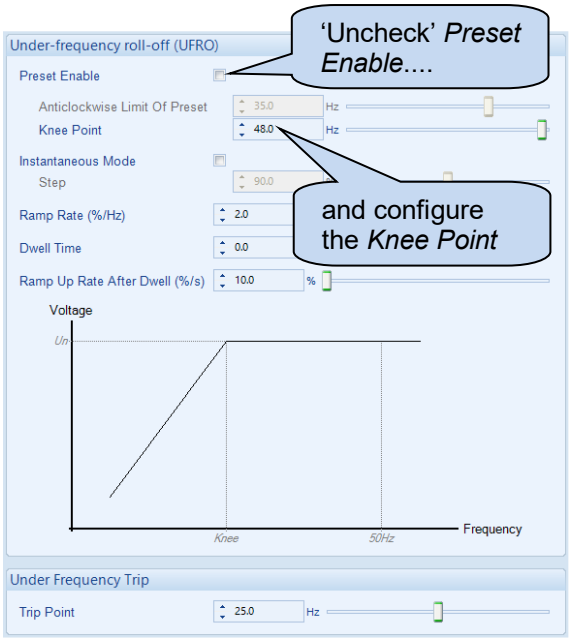

Leave the *Droop* and *External Bias* settings in their default states initially, these are to be addressed later.

Using DSE Configuration Suite PC Software, ensure that the *Auto Frequency Detection* is disabled and select the appropriate frequency menu (50 Hz or 60 Hz).


Uncheck the *Preset Enable* option.
This allows *Under Frequency Roll Off Knee Point* to be adjusted if required.

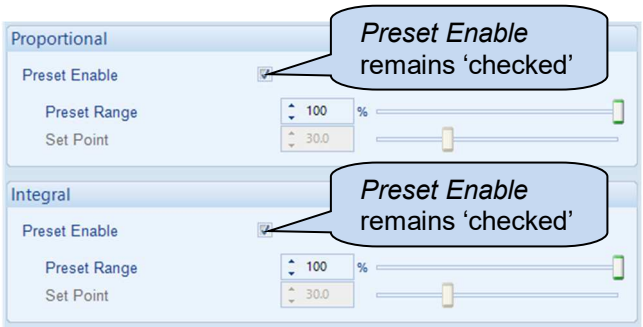
To ease setup, adjust *Knee Point* to a low value to prevent *Under Frequency Roll Off* from activating during the setup procedure.

Set the *Under Frequency Trip Point* as required.

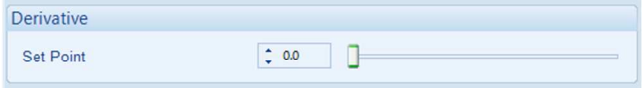


Open the selected *Stability Configuration* page.

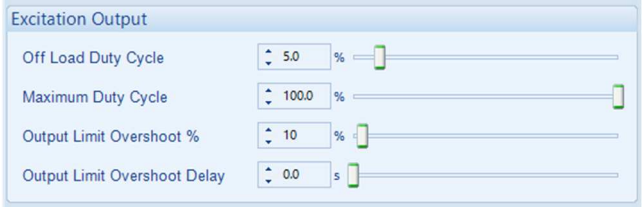

Ensure the *Proportional* and *Integral Preset Enable* options are checked, and set the *Preset Range* of both to 100 %.



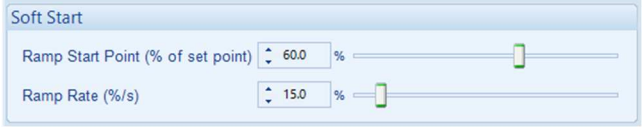

Set the *Derivative Set Point* to 0.




Set the *Maximum Duty Cycle* to 100 %. Leave all other *Excitation Output* values at default.

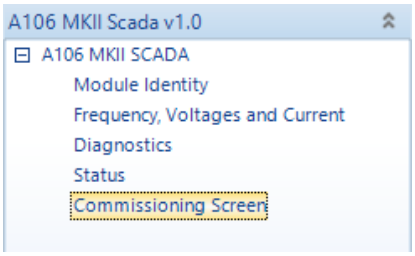



Leave the *Soft Start* values at default for the first start. If an excessive voltage spike occurs on start up, reduce the *Ramp Start Point*.

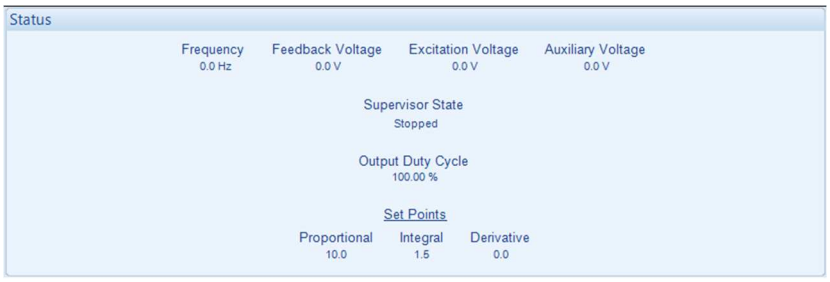



Choose the *Protections* tab and set *Start-up Fail Delay* to its maximum value. This prevents it interfering with the setup process.

Using DSE Configuration Suite PC Software, connect SCADA and select the Commissioning Screen display.




Set the *Proportional* preset on the AVR to approximately 10. Set the *Integral* preset on the AVR between 1 and 2. Ensure the derivative value is 0, and the *Output Duty Cycle* is 100 % with the engine not running.




Connect a voltmeter to the alternator output, preferably connected 'phase to neutral'

**NOTE: If an oscilloscope is not available, the voltmeter and SCADA screen are used solely. This does not show rapid oscillation of the voltage output and hence does not provide the optimum setup environment.**

If available, connect an oscilloscope to the alternator output, preferably connected 'phase to neutral', and set it to a slow time-base so that the spot takes about 4 seconds to traverse the screen. Set it to 'auto-trigger' so that it keeps rolling continuously. It is the variation in the peak voltage that is of interest as it shows instability and settling time very clearly.

## 4.2 FIRST START

**NOTE: It is impossible to predict exactly what happens when the set is first started! Observe carefully and be prepared to stop the generator. Test Emergency Stop operation prior to starting. Ensure you have completed the previous section fully.**

**NOTE: Do not apply load to the set until instructed during the following procedure.**

**NOTE: For further details of module configuration, refer to DSE Publication: *057-271 DSEA106 MKII Configuration Suite PC Software Manual.***

Start the generating set and observe the feedback voltage using the SCADA screen and the voltmeter.

### 4.2.1 AVR TRIPS AFTER FIRST START

If the AVR trips, the LED flashes. Immediately stop the generating set and then count the flashes.

Take the following action:

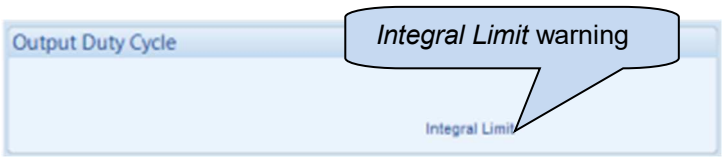
| LED state | Cause | Action |
|---|---|---|
| Rapid Continuous Flashing | Corrupt configuration | Write the configuration to the AVR again, if this reoccurs the AVR is faulty and should be returned. |
| Single Flash | Start-up Failed Trip (Voltage Feedback Failed to Reach 70% of *Set Point*) | Delayed by 10 seconds if the setup instructions were correctly followed.<br>Go to the next stability range using the DIP switches to increase the *Maximum Duty Cycle*.<br>This may require repeating depending on the duty cycle the alternator needs. |
| Two Flashes | Over Excite Trip | Increase the *Over Excite Trip* on the Protections menu by 50%.<br>This may require repeating depending on the excitation voltage the alternator needs. |
| Three Flashes | Loss of Sensing | Check the feedback wiring as this indicates a loose connection. |
| Four Flashes | Under Frequency Trip | Indicates the engine is not up to speed, check the governor. |
| Five Flashes | Potentiometer Fault | Indicates that the potentiometer connected to terminals P1 and P2 has become open circuit. |
| Steady | UFRO Active | Indicates the engine is not up to speed, check the governor. |

### 4.2.2 LOW OUTPUT VOLTAGE AFTER FIRST START

If the generator output voltage is not reaching the configured *Set Point*, check that the voltmeter reading is consistent with the *Feedback Voltage* on the Commissioning Screen display. If there is a difference in the reading, this indicates a mistake in the alternator sensing wires or configuration.

For example, if a 440 V (phase to phase) alternator is connected 'half phase', this results in 220 V (phase to phase) being connected to the AVR *L* and *N* terminals. The *Feedback Voltage* shows 220 V, the voltage measured by the AVR. The AVR *Set Point* must be configured to match the sensing voltage as the AVR works to adjust the excitation to achieve and maintain the sensed voltage to match the configured set point.

If the voltmeter and SCADA display are consistent, but not reaching the full feedback voltage, then check if an *Integral Limit* warning is active. The *Integral Limit* warning is viewed in either the 'Output Duty Cycle' box on the Diagnostic Screen, or in the 'Status' box on the Commissioning Screen. This indicates that the *Maximum Duty Cycle* is set too low in the configuration. Stop the set and increase the value to 100 %, then repeat the test.



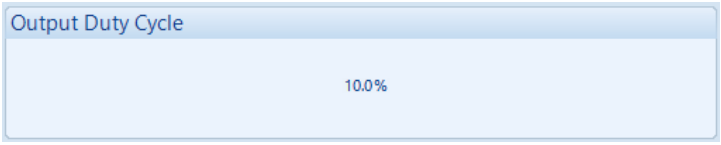

## 4.3 AFTER A SUCCESSFUL START

**NOTE: Proceed below only when the generating set runs without the AVR tripping and when the feedback voltage reaches the set point and remains stable.**

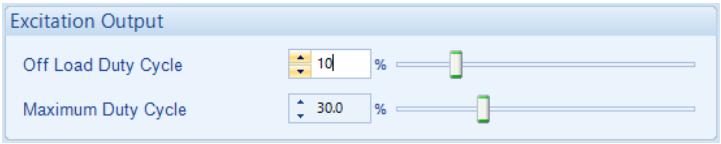
**NOTE: For further details of module configuration, refer to DSE Publication: *057-271 DSEA106 MKII Configuration Suite PC Software Manual.***

### 4.3.1 OFF LOAD DUTY CYCLE SETTING

With the set running **off load**, take note of the *Output Duty Cycle* being displayed on the Diagnostic or Commissioning Screen in SCADA.




Stop the set and configure the *Off Load Duty Cycle* to this value, i.e. *Off Load Duty Cycle* is the normal 'off load' operating point.



### 4.3.2 STABILITY SETTINGS

The following subsections detail the procedure for setting up the *Proportional*, *Integral*, and *Derivative* stability settings for optimal AVR load acceptance and operation.

#### 4.3.2.1 PROPORTIONAL

**NOTE: If an oscilloscope is not available, the voltmeter and SCADA screen are used solely. This does not show rapid oscillation of the voltage output and hence does not provide the optimum setup environment.**

**WARNING!: Use only a suitable insulated preset adjustment tool.**

Start the set and wait for the voltage to reach the *Set Point*. Allow a little time for the voltage to stabilise

Gradually increase the *Proportional* setting, by turning the *Proportional* preset clockwise, until the generator output voltage becomes unstable. Very slowly decrease the *Proportional* setting, until the voltage stabilises. Make a note of the *Proportional* setting value, on the Commissioning Screen, and reduce the setting by approximately 20 %.

#### 4.3.2.2 INTEGRAL

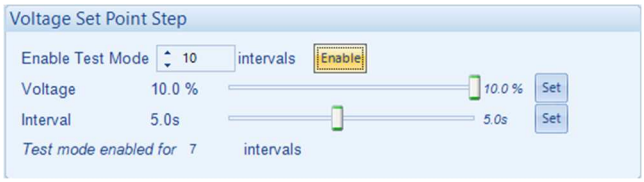
**NOTE: Proceed below only after setting *Proportional.***

**NOTE: If an oscilloscope is not available, the voltmeter and SCADA screen are used solely. This does not show rapid oscillation of the voltage output and hence does not provide the optimum setup environment.**

**WARNING!: Use only a suitable insulated preset adjustment tool.**

Gradually increase the *Integral* setting by turning the *Integral* preset clockwise, until the generator output voltage becomes unstable. Very slowly decrease the *Integral* setting, until the voltage stabilises.

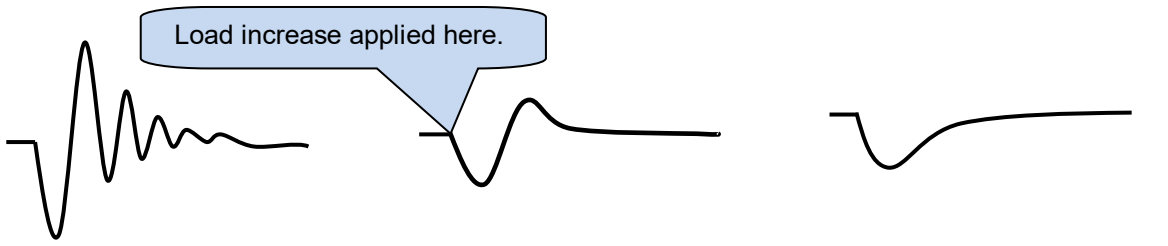
#### 4.3.2.3 VOLTAGE SET POINT STEP




The *Voltage Set Point Step* feature allows the configured stability settings to be tested, without the use of a load bank. The voltage *Set Point* is increased and decreased by a pre-defined percentage, at the set interval for a set number of cycles. For commissioning the default values of 10 intervals, voltage steps of 10 % and interval delay of 5 seconds should be used.

When the *Voltage Set Point Step* is activated the AVR first increases the excitation output voltage to increase generator output voltage. If this increase is too large, the set point is surpassed, requiring a decrease in excitation. The inverse of this process then occurs; the AVR decreases the excitation output voltage to decrease generator output voltage. As with the step-up, if the decrease is too large, the set point is surpassed, requiring an increase in excitation.

The AVR's response to these *Voltage Set Point Step* changes indicate how well the current stability settings handle load changes, and what further adjustments may be required. Example oscilloscope traces of the AVR's 'transient response' to *Voltage Set Point Step* changes are shown below:




Too much oscillation

Good response
No change required

Response too small resulting in

With the *Proportional* and *Integral* presets set as described in the procedure above, the initial response to the *Voltage Set Point Step* changes is likely to have been unstable. The next step to improve this response is to increase the *Derivative* preset.

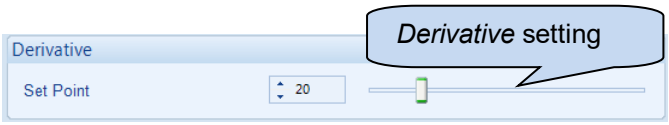
#### 4.3.2.4 DERIVATIVE

**NOTE: Proceed below only after setting both *Proportional* and *Integral.***

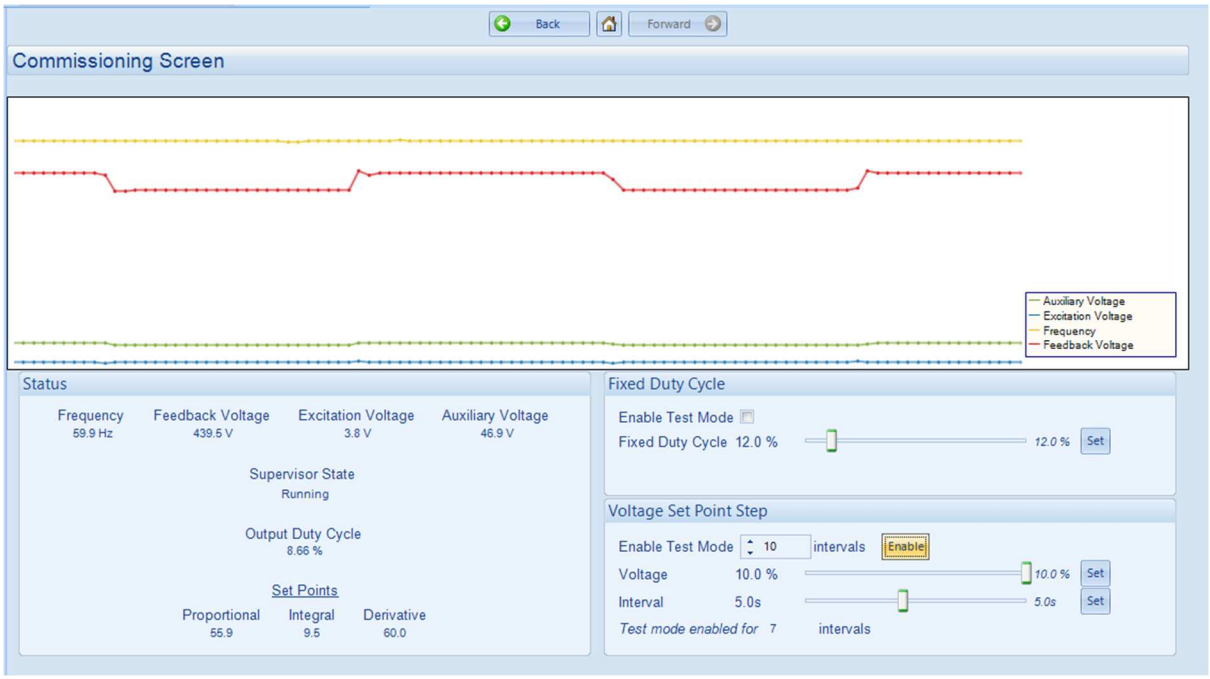
**NOTE: If an oscilloscope is not available, the voltmeter and SCADA screen are used solely. This does not show rapid oscillation of the voltage output and hence does not provide the optimum setup environment.**

**NOTE: If the genset is intended for dual frequency operation, the *Voltage Set Point Step* test must be completed at both frequencies. If the response is stable at one frequency, but unstable at the other, adjust the *Derivative Set Point* and repeat the test.**

**WARNING!: Use only a suitable insulated preset adjustment tool.**



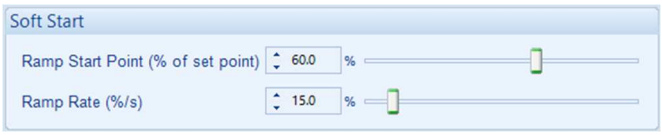

The *Derivative* preset can only be adjusted by changing the AVR's configuration file. The settings is found on the selected *Stability Configuration* page. To begin testing, increment the *Derivative Set Point* in steps of 20. After making each adjustment, write the configuration to the AVR, and then start the generator. Once this is done repeat the *Voltage Set Point Step* test, and check the response. A good response should match the middle oscilloscope trace, shown above. Once this has been achieved, all the stability settings of the AVR have been satisfactorily set up and do not require further adjustment. Further load acceptance tests can be performed with a load bank, if deemed necessary.
The below image illustrates the Commissioning Screen from a correctly configured AVR during *Voltage Set Point Step* testing:



#### 4.3.2.5 SOFT START RAMP

Once the stability settings have been completed, the *Soft Start Ramp* values can be set.

The *Ramp Start Point* value determines the percentage of the configured voltage *Set Point* at which the *Soft Start Ramp* takes effect. If a voltage spike at a value below the voltage *Set Point* is shown on start up, decrease this value. The settings should then be adjusted to allow for the smoothest start up in the optimum time for your application.




The *Ramp Rate* value determines how fast the voltage ramps up from the *Ramp Start Point* to the *Set Point* on start up. If excessive overshoot past the *Set Point* is seen, decrease this value. The settings should then be adjusted to allow for the smoothest start up in the optimum time for your application.

### 4.3.3 DROOP SETTING

**NOTE: Proceed with *Droop* setting only after the AVR has been correctly stabilised by following the *Stability Settings* section first.**

Quadrature Droop monitors the reactive power provided by the generator to the load and is used to provide kvar sharing (reactive load sharing) between generators.

Droop is optional. If required, a Current Transformer (CT) must be fitted in one of the alternator phases. The AVR must be configured correctly to match which phase the CT is fitted to, relative to the voltage settings. This is performed in the DSE Configuration Suite PC Software.

For example:

- If the CT and voltage setting are the same phase, select an *Offset Angle* of 0º (zero).
- If the CT is on phase 2 and the voltage sensing on phase 1, select an *Offset Angle* of 120º

#### 4.3.3.1 INITIAL DROOP SETUP

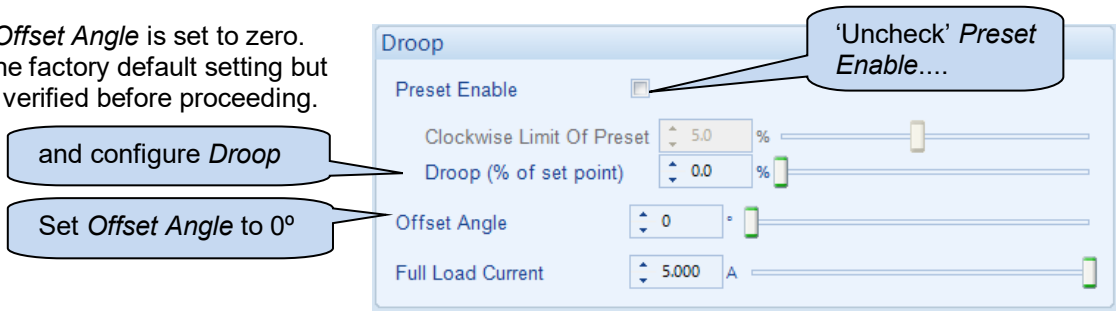
Set *Droop (% of set point)* to the desired level. This is defined as the percentage by which the output voltage will fall when the measured kvar corresponds to full load at 0.8 power factor.

For example: For a generator rated at 230 V and 100 kVA, with droop set to 10%.
When the load reaches 80 kW at 0.8 pf (60 kvar) lagging, the output voltage will fall by 10% to 207 V.
It is the **reactive** power that is measured and acted upon by the AVR.

Since there is only provision for one CT the AVR assumes that the load is balanced between the phases.

**NOTE: It is very important that *Offset Angle* is set to 0 before proceeding.**

Ensure *Offset Angle* is set to zero. This is the factory default setting but must be verified before proceeding.




Set *Full Load Current* to match the CT secondary current when the generator is at full load.

For example: For a set rated at 230 V and 100 kVA, three phase, with a 200:5 CT:

- The full load current is (100000/230)/3 = 145 A per phase.
- Applying the CT ratio to find the secondary current 145 x (5 /200) = 3.625 A
- *Full Load Current* should be set to 3.625 A

Write the configuration to the AVR.

#### 4.3.3.2 OBTAINING AND CONFIGURING THE CT PHASE SHIFT

**NOTE: It is very important that Droop *Initial Setup* procedure is followed before continuing.**

To account for the choices made for the CT, its location and which phases are used for voltage sensing, *Offset Angle* must be configured correctly. This is performed as follows:

Start the generator set and apply a purely resistive load of at least 25% of the generator capacity, it **must** be resistive only load, with no reactive element.

Using SCADA *Frequency, Voltage and Current*, note the current lag angle. This shows the phase shift caused by the Droop CT, its location and the AVR voltage sensing connections.

Remove the load, stop the generator and change *Offset Angle* to this noted angle and write the configuration to the AVR.

The AVR is now compensated for the choice of phase for the CT and voltage sensing.

Droop is now set, if required it can be tested using an inductive load bank.

### 4.3.4 EXTERNAL BIAS SETTING

**NOTE: Proceed with *External Bias Setting* only after the AVR has been correctly stabilised by following the *Stability Settings* section first.**

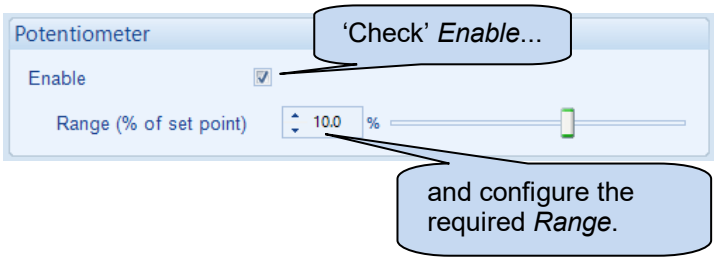
#### 4.3.4.1 EXTERNAL POTENTIOMETER

**NOTE: The external potentiometer is designed for manual adjustment of the output voltage. Where automatic voltage matching or kvar sharing is required, use the DC Voltage Input instead.**

**NOTE: Where both (External Potentiometer and DC Voltage Input) are used simultaneously, both inputs are summed to determine the output voltage.**

Connect a 5 kΩ linear potentiometer (pot) to the AVR input terminals such that a clockwise rotation increases its resistance. The pot must be 'volt free' i.e. electrically isolated from all other potentials.

Check the 'Enable' check box and enter the desired control range of the pot. For example a setting of 10% allows adjustment of a set point of 230 V over the range 207 V to 253 V. (230 V +/- 10% )




An open circuit (disconnected or damaged) potentiometer is automatically detected by the AVR and the output returns to the set point.

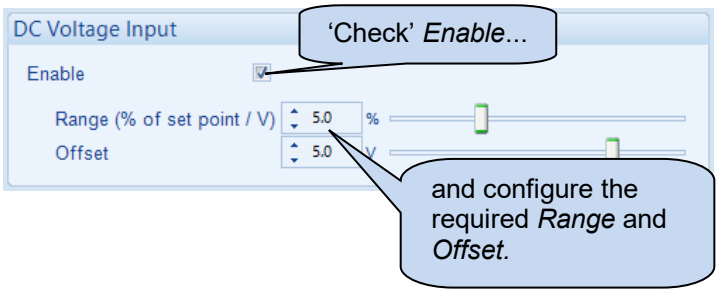
#### 4.3.4.2 DC VOLTAGE INPUT

**NOTE: The DC Voltage Input is designed for automatic voltage matching or kvar sharing. For manual adjustment, use the External Potentiometer input instead.**

**NOTE: Where both (External Potentiometer and DC Voltage Input) are used simultaneously, both inputs are summed to determine the output voltage.**

Connect an external DC voltage to the input terminals. The source must be electrically isolated from all other potentials.

Check the 'Enable' check box and enter the desired control range of the pot. For example with settings of *Offset* at 5 V and Range (% of set point / V) of 2% / V, this means at 5 V the generator runs at nominal (230 V) and is adjustable by +10% (+5V from *Offset*) and -30% (-15 V from *Offset).* This results in an adjustable range from 161 V to 253 V (230 V -30% to +10%).




An open circuit input is treated as a 0 V input and so reduces the output voltage to the appropriate percentage of the set point. Using the above example, an open circuit input would reduce the output voltage to 207 V.

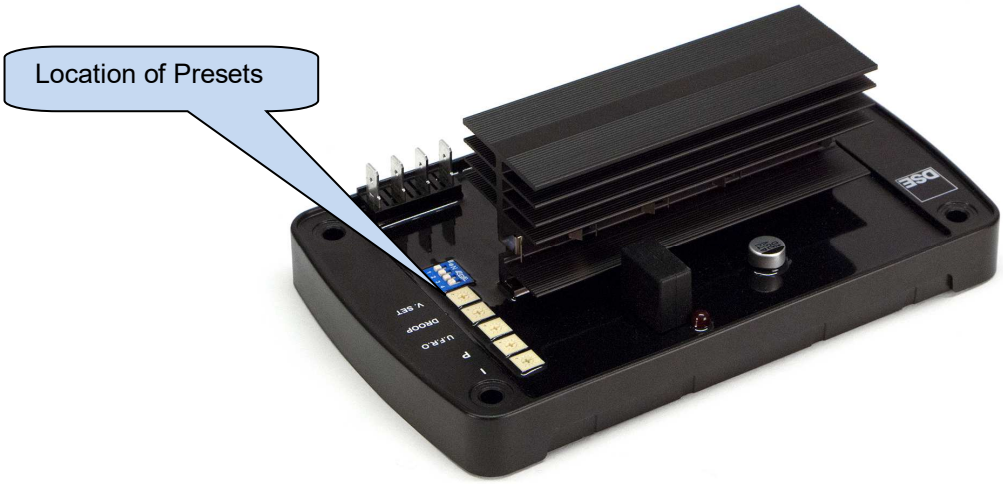
## 4.4 FINALISING SETUP

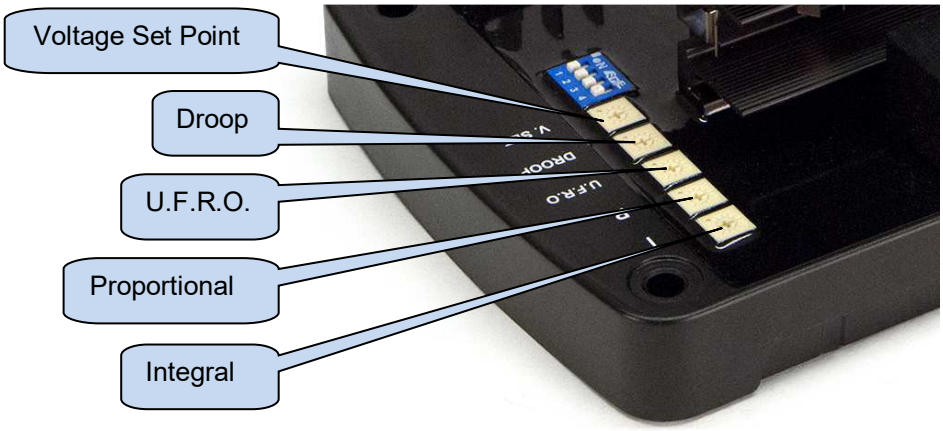
**NOTE: For further details of module configuration, refer to DSE Publication: *057-271 DSEA106 MKII Configuration Suite PC Software Manual.***

### 4.4.1 PRESETS

**WARNING!: Use only a suitable insulated potentiometer (preset) adjustment tool.**

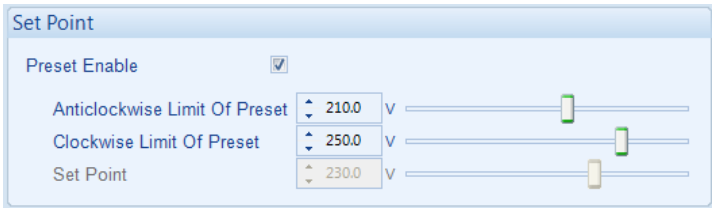
Presets are the adjusters fitted on the AVR and may be disabled if end user adjustment is not required.
When enabled, the range of the presets is configurable using the DSE Configuration Suite PC Software to enable the generator assembler to limit user adjustment within a range suitable for the completed generator.



#### 4.4.1.1 VOLTAGE PRESET

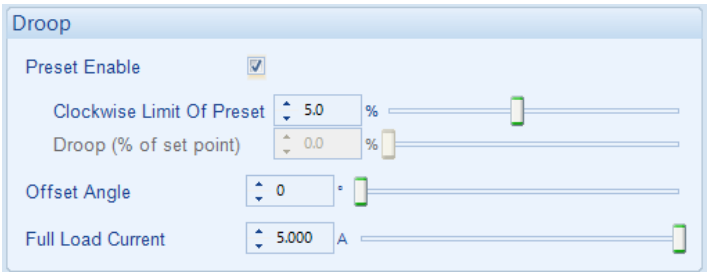
If the voltage preset is required to be active, check the *Preset Enable* parameter in the configuration and set the *Anticlockwise Limit of Preset* and *Clockwise Limit of Preset* to give the desired control span.
Write the configuration to the AVR.
With the generator set stopped, observe the setting on the SCADA *Diagnostic* display and turn the preset to the desired voltage set point.




#### 4.4.1.2 DROOP PRESET

**NOTE: The droop function is described in the section entitled *Operation* elsewhere in this document.**

If the droop preset is required to be active, check the *Preset Enable* parameter in the configuration and set the *Clockwise Limit of Preset* to give the desired control span for the preset.
Write the configuration to the AVR.
With the generator set stopped, observe the setting on the SCADA *Diagnostic* display and turn the preset to the desired droop set point.

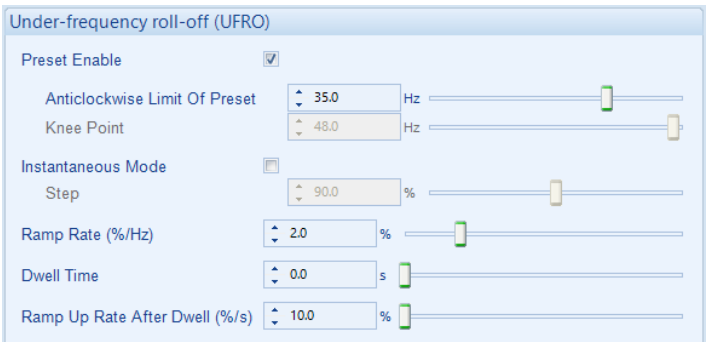



#### 4.4.1.3 UNDER FREQUENCY ROLL OFF (UFRO) PRESET

**NOTE: The UFRO function is described in the section entitled *Operation* elsewhere in this document.**

**NOTE: To disable the UFRO function, disable the Preset and adjust *Knee Point* to minimum value.**

If the UFRO preset is required to be active, check the *Preset Enable* parameter in the configuration and set the *Anticlockwise Limit Of Preset* to give the desired control span for the preset.
Write the configuration to the AVR.
With the generator set stopped, observe the setting on the SCADA *Diagnostic* display and turn the preset to the desired UFRO set point.




Consult the alternator manufacturer's documentation in order to determine suitable settings for the UFRO function.

### 4.4.2 ALTERNATE VOLTAGE RANGE

| DIP Switch | Function | Off | On |
|---|---|---|---|
| 1 | Voltage Sensing Range | 90 V to 300 V | 180 V to 600 V |

DIP Switch 1 selects the Voltage Sensing Range. Any adjustments to the presets affect the selected range. To adjust the alternative range, first change the DIP switch position.

With the generator set stopped, observe the settings on the SCADA *Diagnostic* display and turn the presets to the desired positions.

### 4.4.3 ALTERNATE FREQUENCY RANGE

**NOTE: The Alternate Frequency Range DIP switch is not functional when the *Auto Frequency Detection* function is enabled. For further details of module configuration, refer to DSE Publication: *057-271 DSEA106 MKII Configuration Suite PC Software Manual.***

| DIP Switch | Function | Off | On |
|---|---|---|---|
| 2 | Frequency Range | 50 Hz | 60 Hz |

DIP Switch 2 selects the Frequency Range. Any adjustments to the presets affect the selected range. To adjust the alternative range, first change the DIP switch position.

With the generator set stopped, observe the settings on the SCADA *Diagnostic* display and turn the presets to the desired positions.

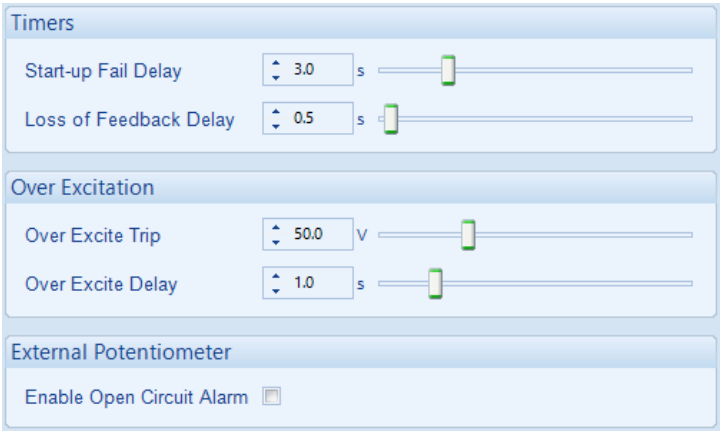
### 4.4.4 ALTERNATE STABILITIES

While the AVR is provided with four alternative *Alternator Stability* configurations, it is not intended that an AVR is switched between them after setup as this would require the entire stabilisation procedure to be carried out again for the new selection.

### 4.4.5 PROTECTIONS

Verify the setting on the *Protections* menu.
Change *Start-up Fail Delay* to the desired time (this was changed earlier in the setup procedure to ease the setup process), the factory default 3.0 seconds is suitable for most generator sets.

Use the SCADA section of the Configuration Suite PC Software to check the *Excitation Voltage* during normal operation, at a high load (var) level. Set the *Over Excite Trip* slightly above this level.



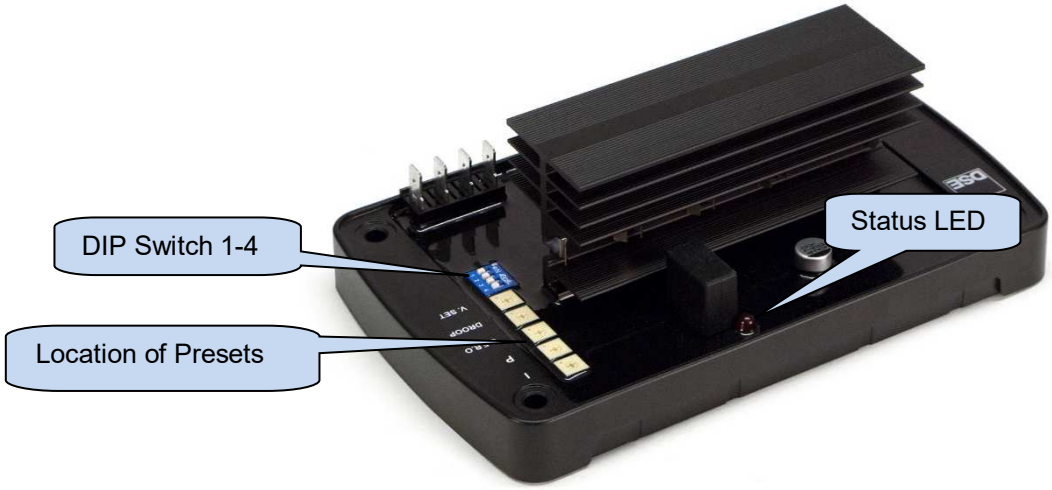
## 4.5 FINAL CHECK

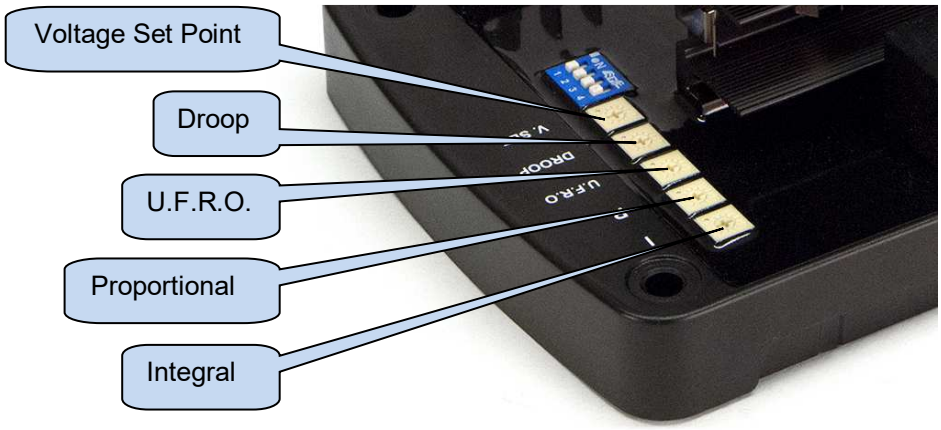
Start the generator set and check that it reaches the set voltage and is stable.
Test with various step loads within the limits of the generator and check that the voltage is stable with good transient response.
Increase to full load and check that the alternator output remains at the set voltage and is stable.
Check the droop, UFRO and external bias inputs as appropriate.
Remove the load and stop the set.

# 5 OPERATION

**NOTE: For further details of module configuration, refer to DSE Publication: *057-271 DSEA106 MKII Configuration Suite PC Software Manual.***

## 5.1 CONTROLS AND INDICATIONS



### 5.1.1 PRESETS

It is possible to disable the operation of the preset using DSE Configuration Suite PC Software in conjunction with DSE815 Interface. In this instance, the value of the disabled preset is fixed by the PC Software.

#### 5.1.1.1 VOLTAGE SET POINT

The Setting for the alternators output voltage. Turning the preset clockwise raises the output voltage.

#### 5.1.1.2 DROOP

**NOTE: Use of the Droop functions requires a droop CT to be fitted. See the section entitled *Setup Procedure* elsewhere in this document.**

Setting for the Quadrature Droop function. Turning the preset clockwise increases the amount of Quadrature Droop.

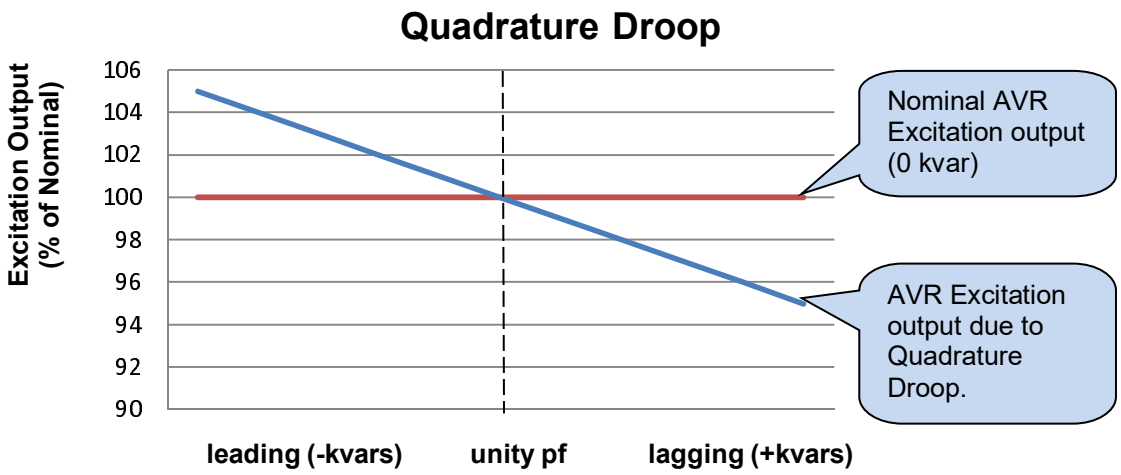
Quadrature Droop monitors the reactive power provided by the generator to the load and is to provide kvar sharing (reactive load sharing) between generator or to limit kvar output when paralleling a generator with the mains supply.

Reactive Power is the power used to supply the capacitive and inductive elements of the load.
Power supplied to a load that is more capacitive than inductive has a leading power factor.
Power supplied to a load that is more inductive than capacitive has a lagging power factor.

| Lagging Power Factor | Leading Power Factor |
|---|---|
| Lagging pf | Leading pf |
| +kvar | -kvar |
| Inductive | Capacitive |

As the AVR monitors the reactive power from the generator, its measurements are used to control the excitation output:

- Lagging reactive power (+kvars) causes a decrease in AVR excitation output to provide more “leading” power to the load.
- Leading reactive power (-kvars) causes an increase in AVR excitation output to provide more “lagging” power to the load.



## Multiple Generators

In a multiple generator system, the droop on the AVR is working to minimise the alternators kvar production. If the droop on each AVR is set identically, it balances the kvars between all the alternators as they each try to produce the minimum reactive power.

This enables a basic form of reactive power (kvar) sharing between connected generators, providing each AVR is configured to provide the same amount of droop.
However this has the effect on the alternator output voltage as it varies depending upon the changing nature of the reactive load.
Where a continuous voltage is required, the use of a generator load share controller with active kvar sharing and voltage compensation is recommended. Such controllers include the DSE8xxx series of load share controllers. Contact DSE Technical Support for more information.

To set the droop function for paralleling multiple generators:

**NOTE: If it is required that the generator output voltage droops to the nominal voltage, ensure that *Voltage Setpoint* is set higher then the nominal by the appropriate amount.**

1. With the generator running off load, adjust the *Voltage Setpoint* so that the generator is providing the desired voltage.
2. Put the generator to the 'typical' reactive load level that the set is to be connected to.
3. Increase the *Droop* setting until the generator output voltage drops by the required amount (typically 3% to 5%).
4. Ensure all generators in the system are set with exactly the same nominal voltage and droop setting.

For example:

The generator *off load* is producing 230 V.
Place the generator *on load* at typical load levels and adjust the *Droop* until the output voltage is 218 V. (this is 5% below nominal voltage).
When reactive power is zero (pf 1.0 or unity), the generator output voltage is 230 V.
When reactive power is negative (capacitive or leading pf) the output voltage is raised to increase inductive current from the generator.
When reactive power is positive (inductive of lagging pf) the output voltage is lowered to decrease inductive current from the generator.

## Mains Parallel

When paralleling with mains supply, the use of a generator load share controller with active kvar sharing and voltage compensation is recommended. Such controllers include the DSE8xxx series of load share controllers. Contact DSE Technical Support for more information.

Where such a mains controller does not exist, the droop setting is used to provide stabilisation to the output of kvar when in parallel with the mains.

To set the droop function when paralleling with mains and no other form of kvar control exists:

1. With the generator running off load, adjust the *Voltage Setpoint* so that the generator is providing the desired voltage.
2. Adjust the *Droop* setting as required (typically 2.5%).
3. When in parallel with the mains, adjust the *Voltage Setpoint* while monitoring the kvar output from the alternator to set the amount of kvar desired from the alternator. Increase the *Voltage Setpoint* to increase the kvar.

#### 5.1.1.3 UNDER FREQUENCY ROLL OFF (UFRO)

**NOTE: For further details of module configuration, refer to DSE Publication: *057-271 DSEA106 MKII Configuration Suite PC Software Manual.***

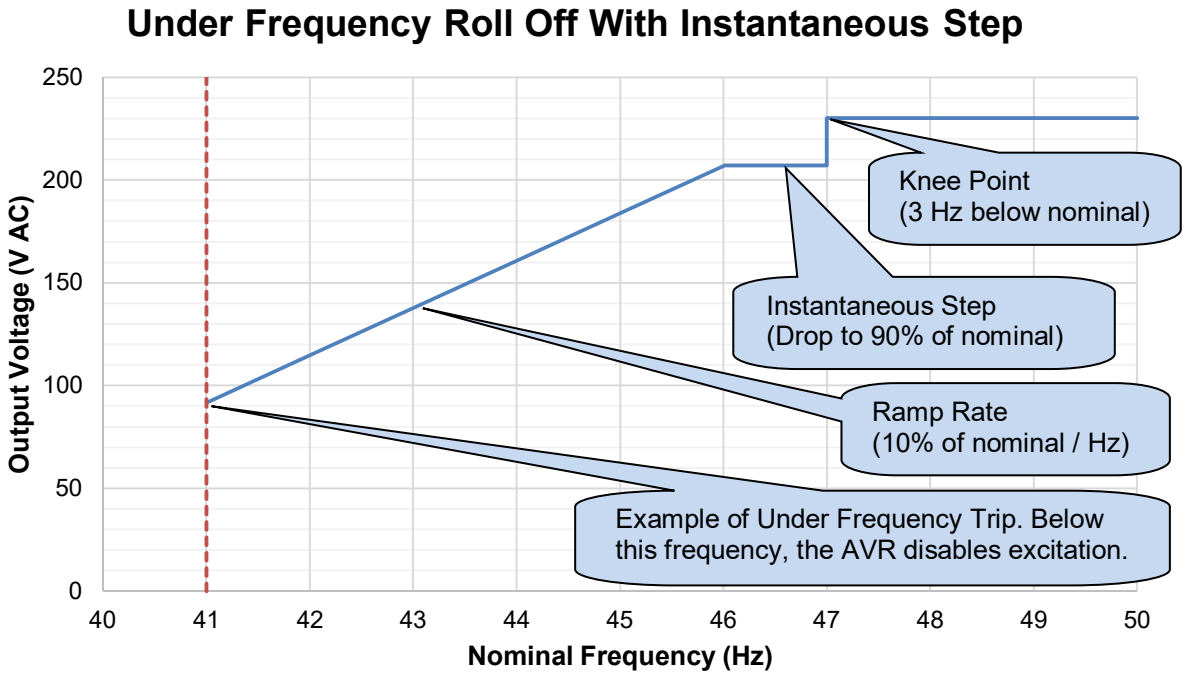
To help protect the alternator, output excitation is limited when generator output frequency is low, this is known as Under Frequency Roll Off. This reduces the alternator output voltage which in turn, reduces the load on the generator. This can help to improve the generator's reaction to step load changes.

Turning the potentiometer clockwise increases the *Knee Point* frequency. Below this frequency, the generator output voltage is reduced. An *Instantaneous Step* can be enabled to reduce the voltage to a percentage of the nominal frequency as soon as the frequency falls below the *Knee Point* setting. After which the rate of reduction is configurable using DSE Configuration Suite PC Software between 0 % / Hz and 10% / Hz.

A typical setting to start the *Under Frequency Roll Off* function is 3 Hz below nominal frequency.

As the frequency falls, the lower level is protected by the *Under Frequency* trip. Should the frequency fall below the trip level, the AVR excitation is disabled.

Example.
The following chart demonstrates Under Frequency Roll Off on a 50 Hz nominal system. The *Knee Point* is set to 47 Hz, *Instantaneous Drop* is set to 90% and *Ramp Rate* is set to 10% / Hz.



#### 5.1.1.4 PROPORTIONAL

**NOTE: For more detailed information on the set up procedure for *Proportional*, see the section entitled *Setup Procedure* elsewhere in this document.**

Adjusts the *Proportional* gain of the AVR output control. Turning the preset clockwise raises the Proportional gain.

Should the generator output be different from the DSEA106 MKII *Voltage Set Point*, a jump in Excitation Output is made to correct the error. The amplitude of this jump is governed by the Proportional Gain.
Too high a proportional gain setting results in an unstable output voltage, typically characterised by a fast changing, fast oscillating alternator output.
Too low a proportional gain setting may result in the *Voltage Set Point* not being reached or being reached a long time after a system disturbance such as the generator starting, or a change in load levels.

#### 5.1.1.5 INTEGRAL

**NOTE: For more detailed information on the set up procedure for *Integral*, see the section entitled *Setup Procedure* elsewhere in this document.**

Adjusts the *Integral* gain of the AVR output control. Turning the preset clockwise increases the Integral gain.

Should the generator output differ from the DSEA106 MKII *Voltage Set Point*, the difference is summed over time and the Excitation Output ramps to correct the accumulated error. The speed of this change is governed by the Integral Gain.
Too high an integral gain setting results in an unstable output voltage, typically characterised by a slow changing, slow oscillating alternator output.
Too low an integral setting may result in the *Voltage Set Point* not being reached or being reached a long time after a system disturbance such as the generator starting, or a change in load levels.

### 5.1.2 DIP SWITCH ADJUSTMENT

DIP switches are used to select the operating range of the A.V.R. Switch locations are shown in the section entitled *Controls and* Indications elsewhere in this document.

| DIP Switch 1 and 2 Functionality | | | |
|---|---|---|---|
| **DIP Switch** | **Function** | **Off** | **On** |
| 1 | Voltage Sensing Range | 90 V to 300 V | 180 V to 600 V |
| 2 | Frequency Range | 50 Hz | 60 Hz |
| **DIP Switch 3 and 4 Functionality** | | | |
| **DIP Switch 3** | **DIP Switch 4** | **Function** | |
| Off | Off | Stability Range 1 | |
| On | Off | Stability Range 2 | |
| Off | On | Stability Range 3 | |
| On | On | Stability Range 4 | |

### 5.1.3 STATUS LED

An LED shows operating status of the A.V.R.

| LED state | Cause | Possible Solution |
|---|---|---|
| Off | Running, or stationary but powered by U.S.B. | N/A |
| Rapid Continuous Flashing | Corrupt configuration | Write the configuration to the AVR again, if this reoccurs the AVR is faulty and should be returned. |
| Single Flash | Start-up Failed Trip (Voltage Feedback Failed to Reach 70% of *Set Point*) | Delayed by 10 seconds if the setup instructions were correctly followed.<br>Increase *Maximum Duty Cycle* on the appropriate stability menu by 50%.<br>This may require repeating depending on the duty cycle the alternator needs. |
| Two Flashes | Over Excite Trip | Increase the *Over Excite Trip* on the Protections menu by 50%.<br>This may require repeating depending on the excitation voltage the alternator needs. |
| Three Flashes | Loss of Sensing | Check the feedback wiring as this indicates a loose connection. |
| Four Flashes | Under Frequency Trip | Indicates the engine is not up to speed, check the governor. |
| Five Flashes | Potentiometer Fault | Indicates that the potentiometer connected to terminals P1 and P2 has become open circuit. |
| Steady | UFRO Active | Indicates the engine is not up to speed, check the governor. |

## 5.2 EXTERNAL AC VOLTAGE BIAS

**NOTE: Voltage adjust range is configured using DSE Configuration Suite PC Software. For further details, refer to DSE Publication: *057-271 DSEA106 MKII Configuration Suite PC Software Manual.***

Two external bias inputs are provided to allow remote adjustment of the alternator output.

| Input type | Description |
|---|---|
| DC Voltage Level (A+, A-) | -10 V DC to 10 V DC to provide voltage adjustment from the *Voltage Set Point.* The range and centre voltage are configurable using the DSE Configuration Suite PC Software.<br><br>Typically this input is provided by external Synchroniser / Load Share devices. |
| Potentiometer input (P1,P2) | 0 Ω to 5 kΩ (centre 2.5 kΩ) to provide voltage adjustment from the *Voltage Set Point.*<br><br>Typically this input is provided by a hand or automatically operated potentiometer. |

# 6 ALARMS

Activation of the following alarms disable the AVR excitation and flash the Status LED accordingly. For further information, see the section entitled *Status LED* elsewhere in this document.

## 6.1 START-UP TRIP

During start-up, the main generator output is monitored. If it fails to reach 70% of the *Voltage Set Point*, the *Startup Trip* alarm occurs.

## 6.2 LOSS OF FEEDBACK

**NOTE: Loss of Feedback Delay is configured using DSE Configuration Suite PC Software. For further details, refer to DSE Publication: *057-271 DSEA106 MKII Configuration Suite PC Software Manual.***

During normal running operation the main generator output is monitored. If this drops below 5% of the *Voltage Set Point* for the duration of the *Loss of Feedback Delay* time, the *Loss of Feedback* alarm occurs.

## 6.3 OVER EXCITATION

**NOTE: Over Excitation trip level is configured using DSE Configuration Suite PC Software. For further details, refer to DSE Publication: *057-271 DSEA106 MKII Configuration Suite PC Software Manual.***

The excitation of the alternator is monitored and an alarm triggered when the excitation level exceeds the adjustable trip point. This inhibits further excitation of the alternator.

## 6.4 UNDER FREQUENCY

**NOTE: Under Frequency trip level is configured using DSE Configuration Suite PC Software. For further details, refer to DSE Publication: *057-271 DSEA106 MKII Configuration Suite PC Software Manual.***

Indicates that the alternator output has fallen below the setting of the *Under Frequency* alarm. This inhibits further excitation of the alternator.

## 6.5 POTENTIOMETER FAULT

**NOTE: External Potentiometer Open Circuit Fault is configured using DSE Configuration Suite PC Software. For further details, refer to DSE Publication: *057-271 DSEA106 MKII Configuration Suite PC Software Manual.***

Indicates that the potentiometer connected to terminals P1 and P2 has become open circuit.

# 7 FAULT DIAGNOSIS

| Nature of Problem | Suggestion |
|---|---|
| The Status LED is flashing. | See section entitled *Status LED* elsewhere in this document. |
| The Status LED is not lit. | The generator may be stopped and the communication lead (DSE815 interface is not connected).<br>See section entitled *Status LED* elsewhere in this document. |
| The Status LED is lit, but the generator is stopped. | The AVR is powered by the DSE815 interface. This allows configuration of the AVR when the generator is not running. |
| Loss of Feedback alarm. | Check Voltage sensing connections on L1 and N(L2) terminals. |
| Startup Trip alarm. | Check Voltage sensing connections on L1 and N(L2) terminals. |
| Unstable voltage levels. | Check *Integral* and *Proportional* settings. |
| Voltage drops when load is applied. | This may be normal depending upon the settings of the *Droop* function and/or *Under Frequency Roll Off* function. |
| Voltage fails when load is applied. | This may be normal depending upon the settings of the *Under Frequency* alarm. |
| Voltage fails to reach set point. | Follow the Setup Procedure elsewhere in this manual. |
| Instability occurs in the voltage output. | Follow the Setup Procedure elsewhere in this manual. |

# 8 MAINTENANCE, SPARES, REPAIR AND SERVICING

The module is designed to be *Fit and Forget*. As such, there are no user serviceable parts. In the case of malfunction you should contact your original equipment supplier (OEM).

| Connection | Description | Part No. |
|---|---|---|
| USB | Requires DSE815 interface and connection lead. | 0815-01 |

## 8.1 WARRANTY

DSE provides limited warranty to the equipment purchaser at the point of sale. For full details of any applicable warranty, you are referred to your original equipment supplier (OEM).

## 8.2 DISPOSAL

If you use electrical and electronic equipment you must store, collect, treat, recycle and dispose of WEEE separately from your other waste.

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