APPLICATION GUIDE

How to Set Up Grid Code Compliance Features in the DECS-250 and DECS-250N

Purpose

This application guide provides information for implementing the Grid Code Compliance feature set of Basler's DECS-250 Digital Excitation Control System. The purpose of the grid code feature is to comply with the necessary functionality requirements of standard VDE-AR-N-4110, herein referred to as VDE 41110. In this guide, the most common grid code setup is covered plus the control actions of the reactive power control modes. This guide is not a substitute for the DECS-250 instruction manual. The DECS-250 instruction manual, available at www.basler.com, serves as the comprehensive source of information about DECS-250 features and functions.

About Basler

Basler Electric is a manufacturer of excitation systems, voltage regulators, genset controls, protective relays, and custom transformers. Basler also offers turnkey engineering services through their Basler Services, LLC subsidiary. Basler products control and manage the delivery of electricity and are commonly found in applications such as power plants, substations, hydro dams, agricultural facilities, airports, refineries, telecom facilities, factories, marine applications, and many others. Basler has been in business since 1942 and our products are in operation in over 145 countries around the world.

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Table of Contents

1. Settings Overview

All DECS-250 grid code settings are located in the Settings Explorer of BESTCOMS*Plus*®. Grid code settings are grouped into the following categories/tabs:

- *Configure:* enables and disables the grid code settings and provides the settings that govern the steady-state, disconnect, and reconnect operations.
- *Active Power Control:* feeds a governor bias signal through the DECS-250 and applies active power outer-loop control and a Limited Frequency Sensitivity Mode (LFSM) feature. Active Power Control functionality is outside the scope of this application guide.
- *Reactive Power Control:* changes the var control setpoint via one of five algorithms: Q(PF), Q(Voltage Limit), Q(U), Q(P), and Q(Third Party).
- *Grid Code Test:* enables fictitious biasing of signals to simplify testing of certain functions.

1.1 Configure

When configuring steady-state operation, pay attention to the measurement units as the frequency disconnect time delay is expressed in minutes and the voltage disconnect and grid disconnect time delays are expressed in seconds. The default DECS-250 setting values are taken from VDE 4110 but can be adjusted as requested by the grid operator. Grid code Configure tab settings are illustrated in Figure 1.

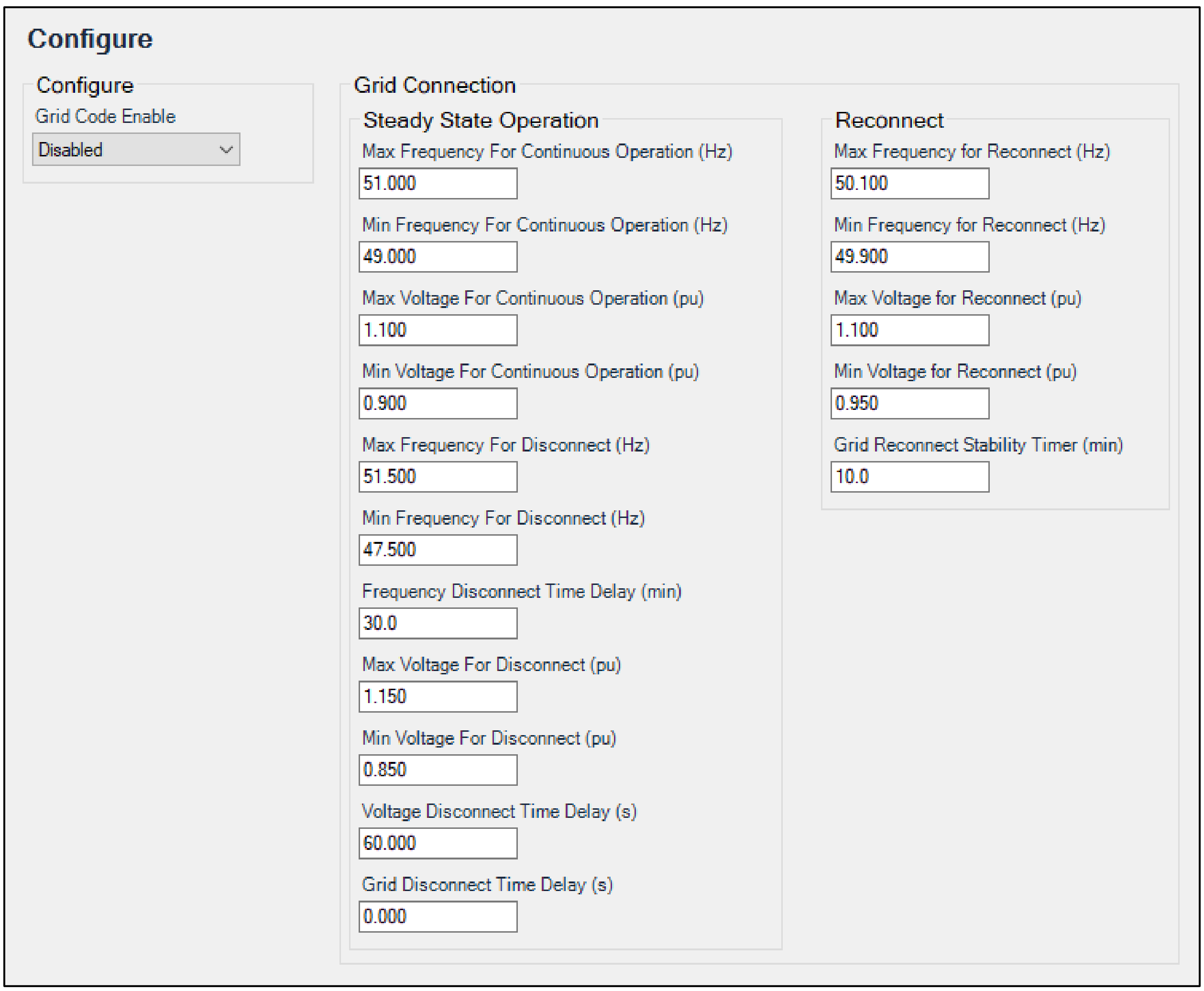

Figure 1. Configure Tab Settings

Continuous operation is the nominal state and is defined by the following settings:

- Max Frequency for Continuous Operation (Hz)
- Min Frequency for Continuous Operation (Hz)
- Max Voltage for Continuous Operation (pu)
- Min Voltage for Continuous Operation (pu)

When the generator frequency or voltage leaves these operating windows, a timer starts. These operating windows are illustrated in Figure 2.

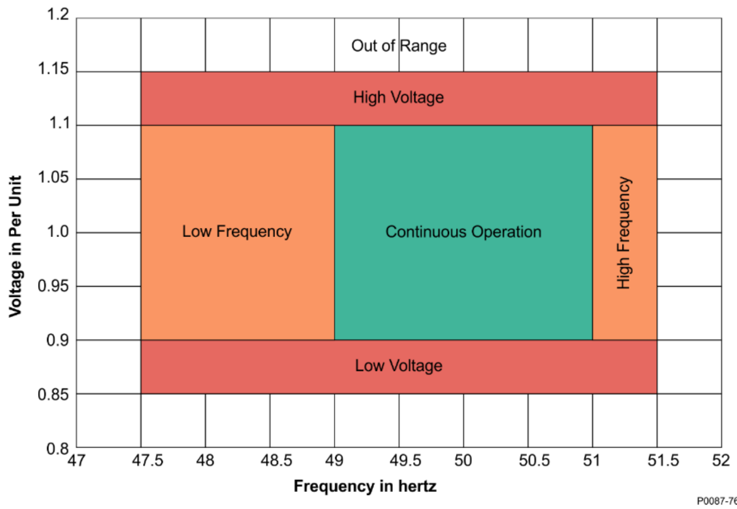

Figure 2. Frequency and Voltage Operating Windows

Being outside the defined frequency window will start an internal counter. If the counter is greater than the delay, the DECS-250 will set a flag for use with BESTlogic™*Plus*, external devices, and/or SCADA software to take the unit offline.

A similar response occurs when outside the defined voltage window. Being outside the defined voltage window, the unit will also be governed by the grid disconnect time delay.

The counters decrement when the monitored parameters return to within their respective minimum and maximum settings. Figure 3 illustrates how a timer would decrement (green band) when the voltage is within the setting window and how it would increment (red area) when outside its setting window.

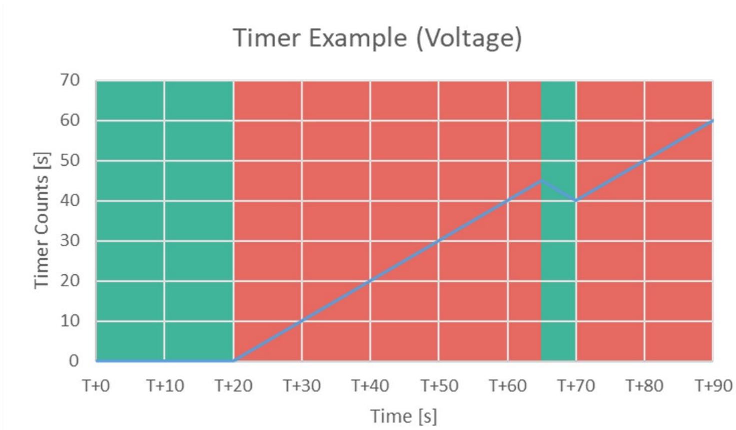

Figure 3. Timer Behavior

1.2 Reactive Power Control

For reactive power control, the selection of which control algorithm to use is entirely dependent upon the application and grid connection. As such, no advice will be provided in this application guide. Instead, an overview of all of the control modes will be presented. Math models and further details for the reactive power control modes are provided in Basler document 9440300091, *Mathematical Per-Unit Model of the DECS-250 Excitation System*.

1.2.1 LVRT Configure

The Low Voltage Ride Through configuration settings (Figure 4) serve as the master control for all reactive control modes as required by VDE 4110. When enabled and the DECS-250 is operating in var mode, the reactive power reference that var mode uses is replaced by the reactive power reference as calculated by the control mode selected.

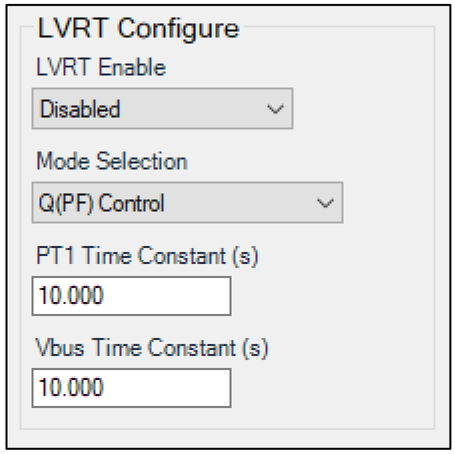

Figure 4. LVRT Configuration Settings

The PT1 and Vbus time constants should be selected according to the requirements of grid operator. The default setting of 10 seconds for each time constant may be sufficient for many applications. Responses to reactive power setpoint changes are determined by the PT1 time constant. The Vbus time constant establishes the time constant for the low-pass filter on bus voltage measurement.

1.2.2 Q(PF)

Q(PF) controls reactive power (Q) to maintain a constant ratio of active power (P) to apparent power (|**S**|). This differs from traditional power factor (PF) control in that PF is not measured or used as the error signal. P is calculated based on the measured voltage and current. The calculated value of P is used in combination with the power factor setting to calculate $Q(PF)_{REF}$ as seen in the following equation.

$$Q(PF)_{REF} = P\sqrt{\frac{1}{PF^2} - 1}$$

$Q(PF)_{REF}$ is used as the reference and is compared to the calculated reactive power, Q, to create the error signal. The setpoint may be set directly or through an auxiliary source by way of the DECS-250 auxiliary input.

Q(PF) aids grid stability by virtue of increasing the export of reactive power as active power increases. However, it will also decrease reactive power by the same fashion and potentially lead to a voltage sag on the grid.

1.2.3 Q(Voltage Limit)

Q(Voltage Limit) controls reactive power to stay on the segmented line as defined by the four points in the curve example of Figure 5.

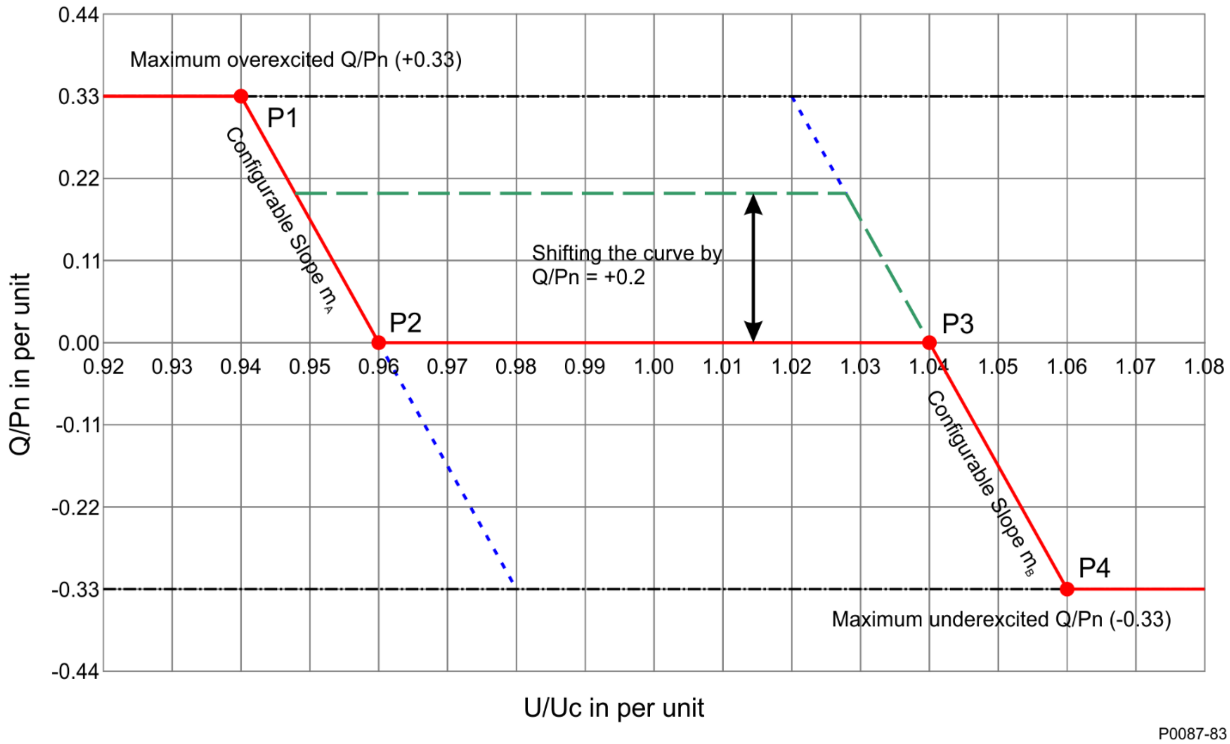

Figure 5. Q(Voltage Limit) Curve Example, Without Bus

A bias may be used to shift the midline (as defined as the segment between points 2 and 3) up and down. See Figure 6.

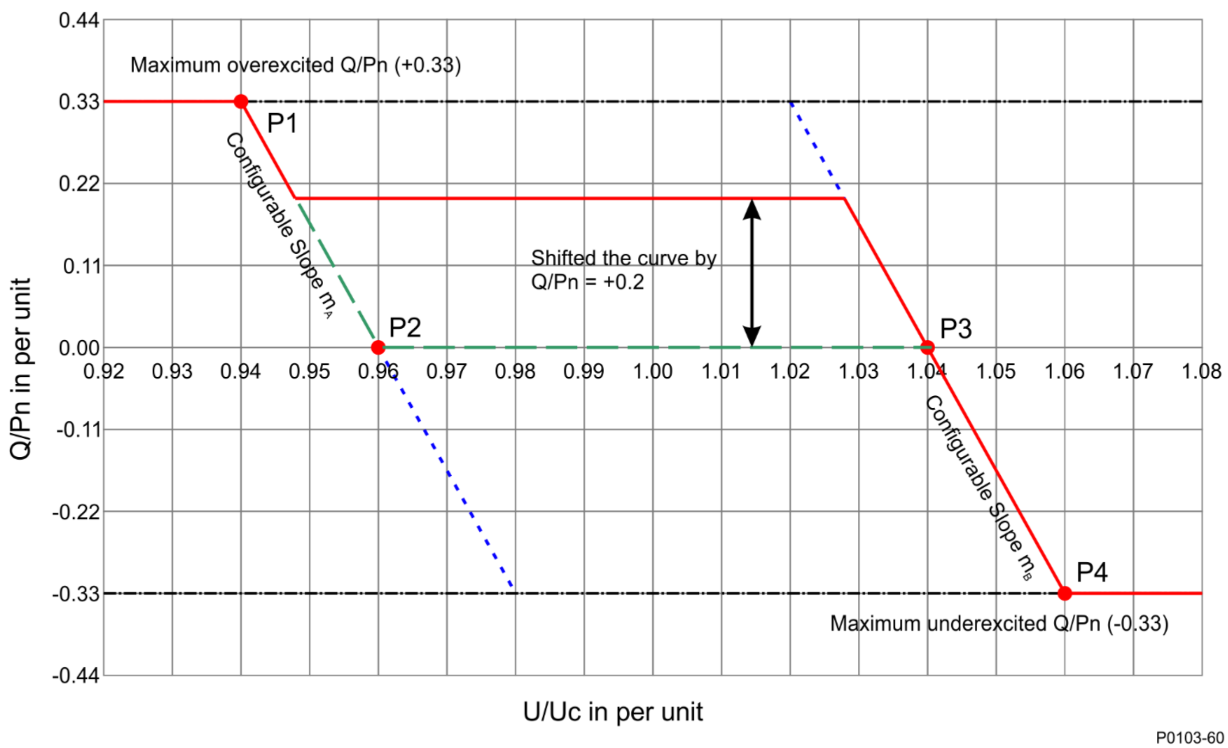

Figure 6. Q(Voltage Limit) Curve Example, With 0.2 Bias

Bus voltage is filtered per the time constant on the LVRT Configure tab. The default setting values are per VDE 4110 but can be adjusted as required by the grid operator. The bias may be set directly or through an auxiliary source applied to the DECS-250 auxiliary input. Q(Voltage Limit will attempt to improve voltage stability by decreasing reactive power when the bus voltage is high and increasing reactive power when the bus voltage is low.

1.2.4 Q(U)

Q(U) adjusts reactive power based on the bus voltage. A slope, illustrated in Figure 7, governs how reactive power will increase or decrease when the bus voltage deviates from nominal. A voltage dead band provides stability in the reactive power. When the dead band is active, Q(U) has an envelope where the reactive power setpoint does not change with respect to bus voltage. If the bus voltage strays outside the dead band, the reactive power will shift the minimum amount to establish a new dead band that includes the bus voltage level. A bias may be used to increase or decrease the reference voltage where the reactive power exchange is zero.

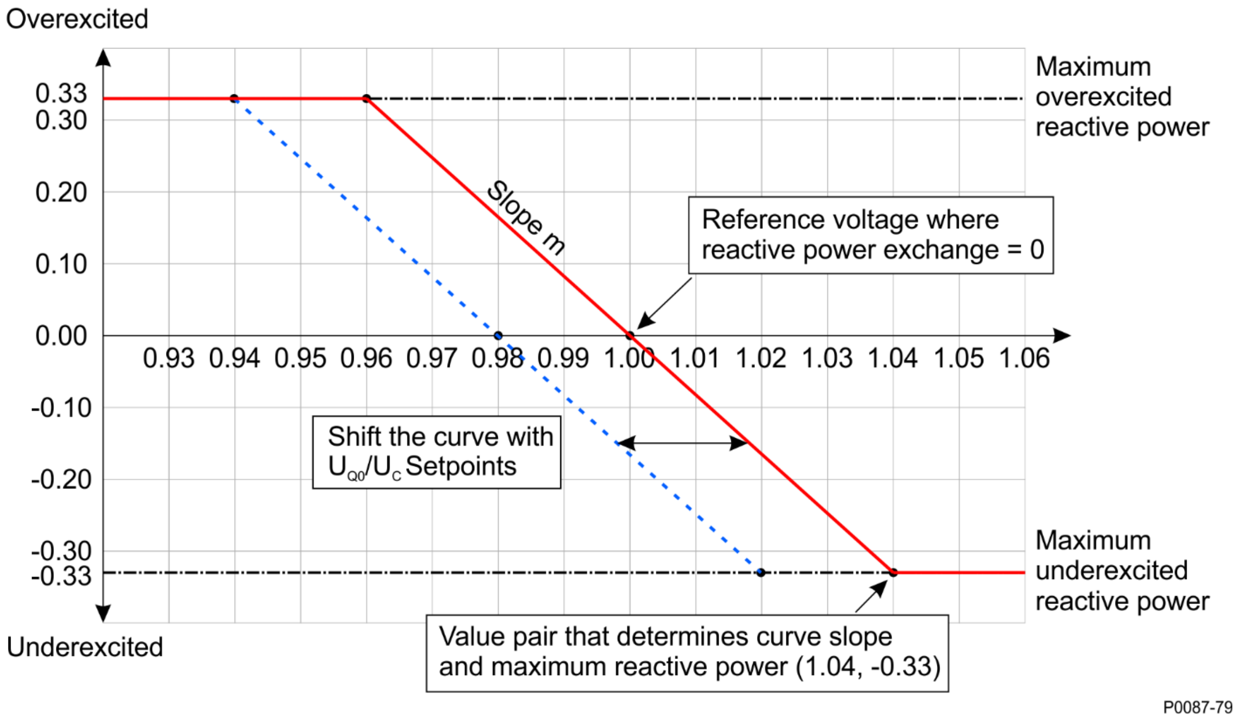

Figure 7. Q(U) Control Diagram

1.2.5 Q(P)

Q(P) controls reactive power to stay on a segmented line defined by a 10-point graph where the x axis is real power (P) and the y axis is reactive power (Q). The example of Figure 8 shows only five points for clarity. This control algorithm does not support biasing.

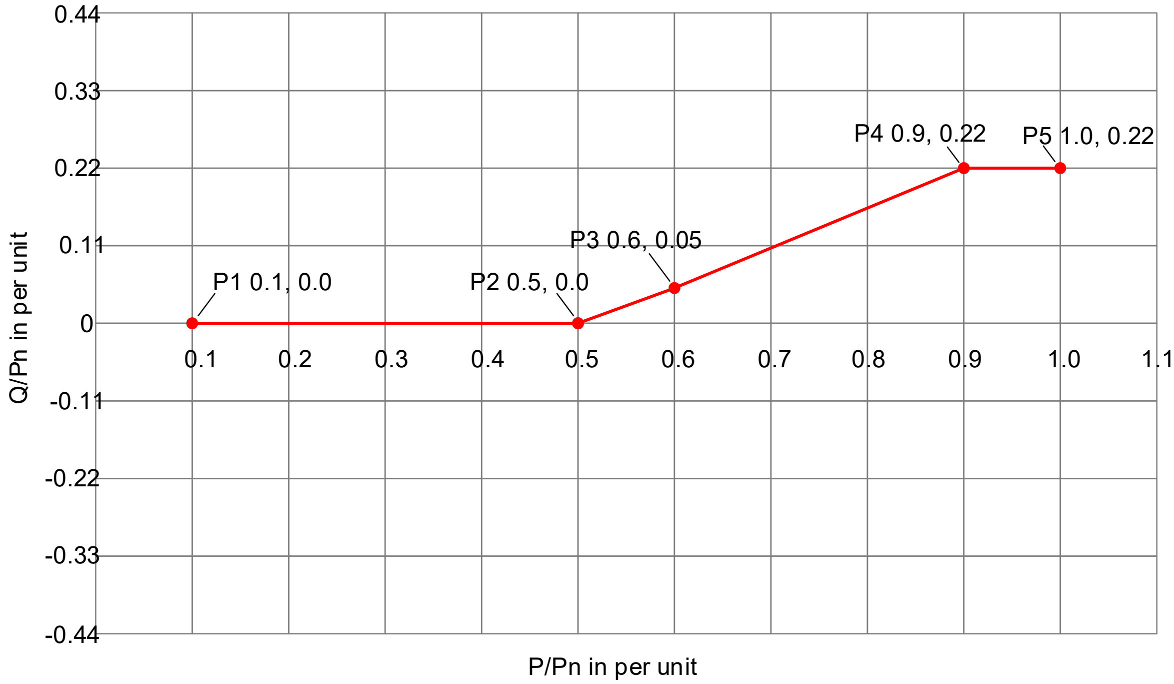

Figure 8. Q(P) Segmented Functions

1.2.6 Q(Third Party)

When the DECS-250 is embedded in a complex SCADA network, Q(Third Party) enables direct setting of the reactive power setpoint. A base reference point is provided for the third party to operate around, if desired.

Bridge mode, enabled and disabled on the Q(Third Party) tab, is outside the scope of this application guide.

1.3 Grid Code Test

Not all scenarios where grid code would be applied are easily replicated in a lab. To assist with testing, the BESTCOMS*Plus* Grid Code Test tab (Figure 9) provides the ability to create simulated biases in the metered inputs of bus voltage and bus frequency. To prevent introduction of a permanent bias, a maximum test duration must be established when sending the biases. A Test Meter setting selects what signal will be represented by the Grid Code Test Signal on the real-time analysis screen.

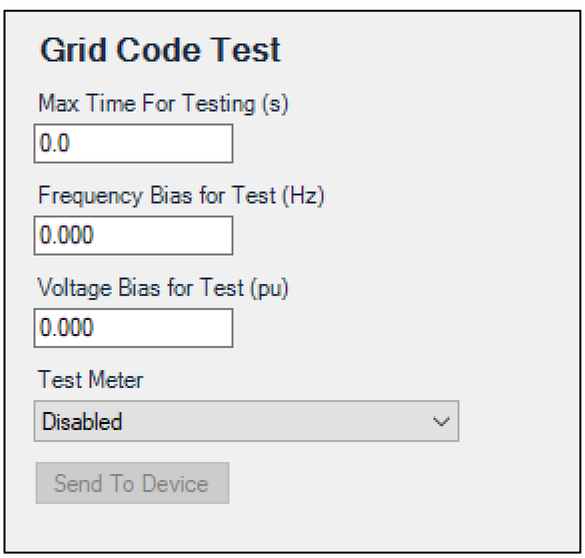

Figure 9. Grid Code Test Settings

2. Onlining Procedure

If the var controller is using a control algorithm as detailed above, the DECS-250 will annunciate this by showing the unit mode as LVRT on the BESTCOMS*Plus* Metering Summary tab. To achieve that control, a custom BESTlogic™*Plus* scheme is recommended where Grid Code and LVRT are enabled while offline so that the reconnect timing flags may be of use. Use the VAR/PF enable block to control the change from voltage matching or AVR mode to LVRT mode.

As shown in Figure 10, two changes to the standard BESTlogic™*Plus* scheme are recommended. The first is that the GCC_DISCONNECTED should be connected to a contact input. This contact output should wire into either opening the 52 breaker or be used for signaling to the SCADA system that the DECS-250 has timed out and has met the conditions that allow it to break offline. The second change is that the GCC_DISABLED status should be used as a block for going offline.

Using those two flags as described will ensure compliance with VDE 4110 by commanding the DECS-250 to go offline and remain offline for the entirety of reconnect timing.

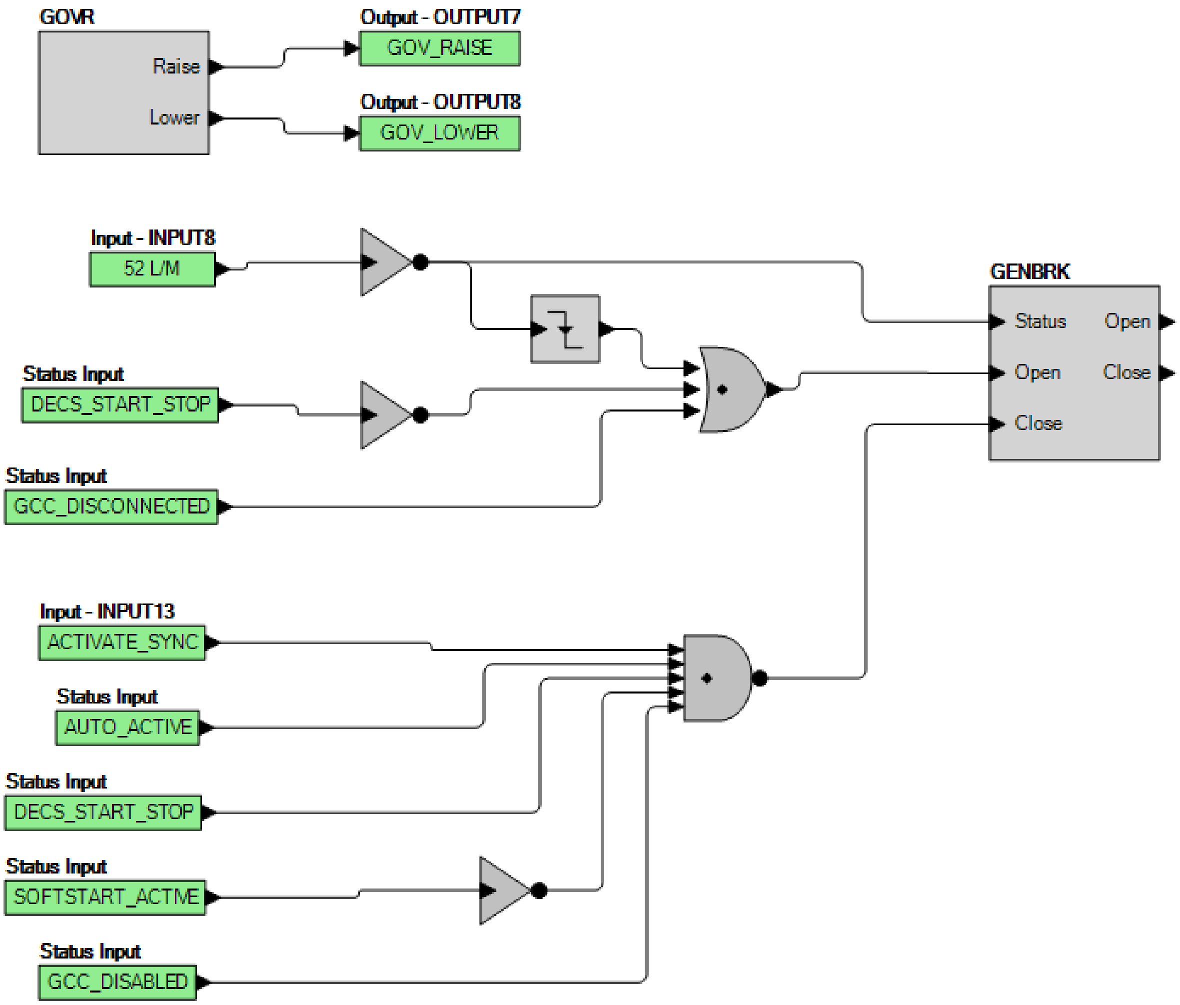

Figure 10. BESTlogic™*Plus* Scheme Example

To Learn More

To learn more, please email usatechsupport@basler.com or call 618.654.2341 to speak with a Basler representative.

References

1. 9440300091, *Mathematical Per-Unit Model of the DECS-250 Excitation System*, Revision E, October 2021
2. VDE-AR-N-4110, *Technical requirements for the connection and operation of customer installations to the medium voltage network (TCR medium voltage)*, November 2018