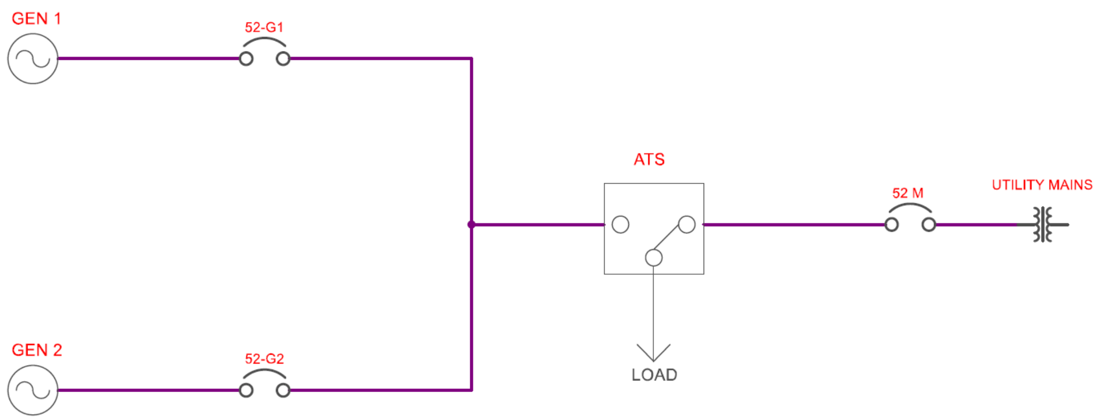
APPLICATION GUIDE

How to Set Up the DGC-2020HD for Paralleling in a Multiple Generator Setup

From a Single-Line Diagram:



To a Fully Functional System:

Purpose

This application guide is intended to be used as a quick start guide for implementing the use of the DGC-2020HD in a multiple generator paralleling application with a digitally controlled ATS. The purpose is to provide users with direction on the minimum settings that need to be configured, and logic that needs to be created to achieve genset control. This application guide is not a comprehensive instruction manual that covers all features and functions of the DGC-2020HD. Users should always refer to the DGC-2020HD instruction manuals available at www.basler.com for further details.

About the Author

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About Basler

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Application Overview

In this application, multiple generators are required for standby power. When the system is in emergency mode, two generators will be paralleled to a common bus. An Automatic Transfer Switch (ATS) is being used to switch between normal and emergency power sources. DGC-2020HD controllers are providing genset control, breaker control, synchronization, and load sharing for the two machines. A single-line diagram is shown in Figure 1.

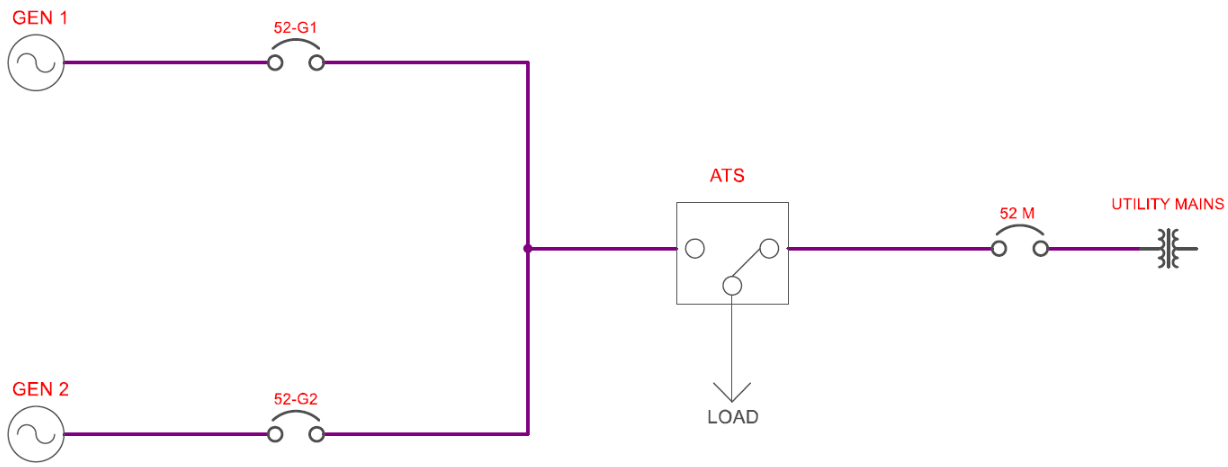

Figure 1. Single-Line Diagram

The ATS controller leads the sequence of operations. The ATS and the ATS controller are provided by other vendors. Some of the functions that are typically performed by the ATS controller include generator and mains sensing, sending start and stop requests to the genset controllers, and initiating load transfer. During each step of the sequence of operations, there are time delays that need to be observed, including a time delay before starting the generators when the utility power fails, and a time delay before transferring the loads back to the utility when power is restored. These time delays are typically programmed into the ATS controller.

In such applications, the genset controllers are simply responding to instructions from the ATS controller. For simplicity, we will assume that each genset controller will receive an ATS start request as a contact input closure. When the genset controllers receive a remote start request, the generators will start and reach rated speed and voltage as quickly as possible. We will also assume that the DGC-2020HDs are connected to each other on an Ethernet network. In this setup, the controllers perform distributed control by communicating with each other on a peer-to-peer network.

When multiple genset controllers are attempting to issue breaker close requests, they participate in dead bus breaker close arbitration. The controller with the lowest sequence ID closes to the dead bus. Then, the other controllers synchronize the remaining generators to the live bus and close their breakers. Once multiple generators are paralleled, the DGC-2020HDs handle KW and KVar sharing over the intergenset communications network. The two machines will run in isochronous at all times.

Figure 2 illustrates DGC-2020HD to generator wiring for generator breaker control.

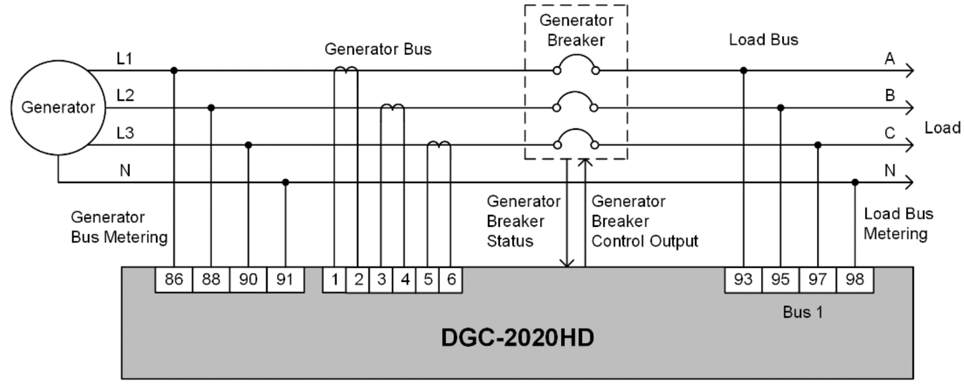

Figure 2. DGC-2020HD to Generator Wiring for Generator Breaker Control

Figure 3 illustrates DGC-2020HD to engine wiring.

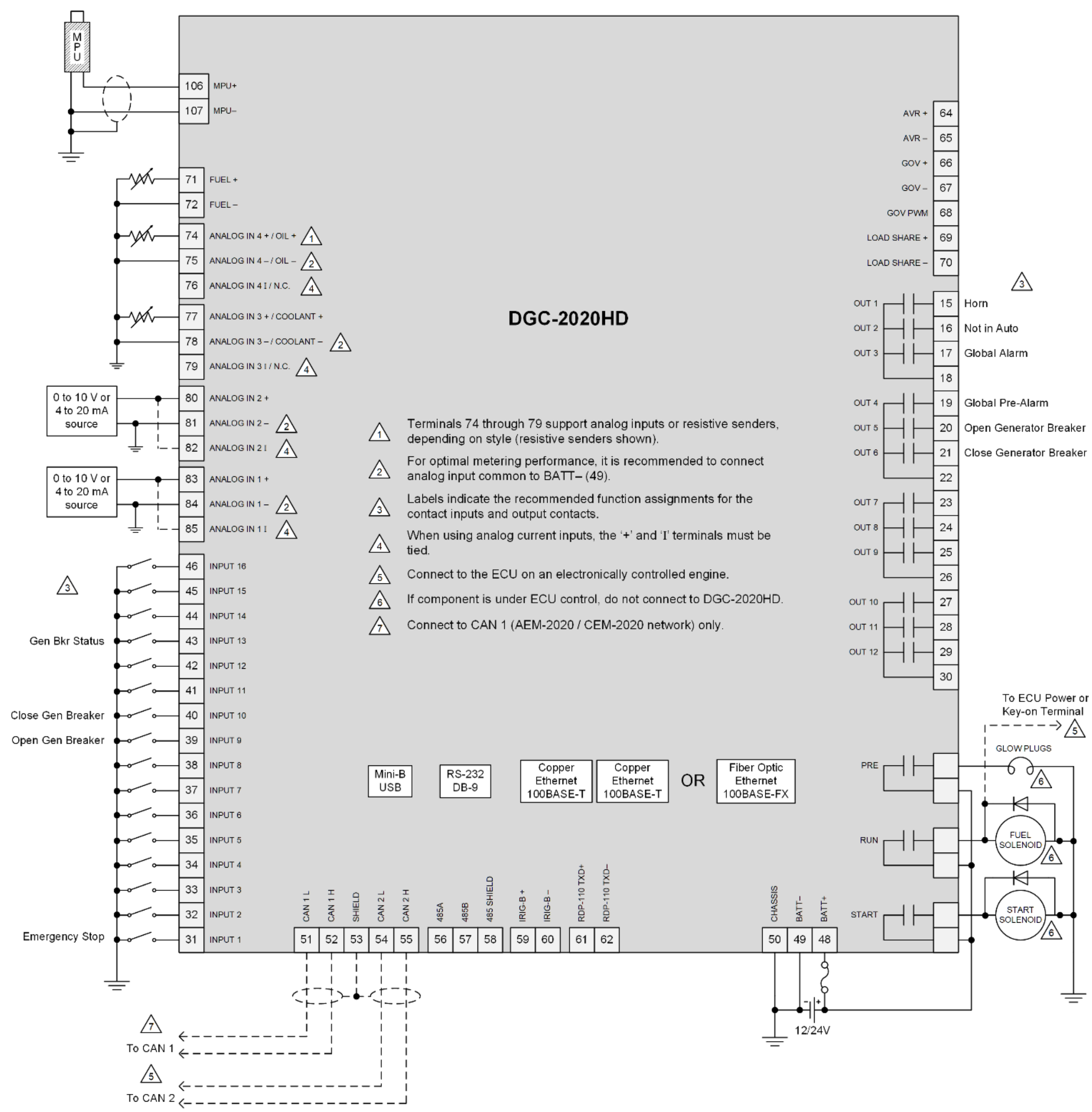

Figure 3. DGC-2020HD to Engine Wiring

Style Number

The Auto Sync option is needed for paralleling. Note that over current protection with inverse time curves is not available with the standard protection option. Figure 4 shows the DGC-2020HD Style Number Selection.

Figure 4. DGC-2020HD Style Number

The DGC-2020HD is capable of numerous functions through the configuration of several settings in BESTCOMS*Plus*® and implementation of logic in BESTlogic™*Plus* Programmable Logic. However, with only a few settings, and minimal logic, the DGC-2020HD can be programmed to achieve basic genset control in an emergency standby application.

Some of the key settings that need to be configured are described next.

CAN Bus Setup

In order to avoid communications errors, it is important to first ensure that CAN Bus network installations are done correctly. The following list summarizes the CAN Bus installation requirements for all DGC controllers:

- If the DGC is providing one end of the J1939 bus, a 120-ohm 1/2 watt terminating resistor should be installed across the CAN2 L and CAN2 H terminals. Refer to the appropriate DGC instruction manual for terminal numbering.
- If the DGC is not part of the J1939 bus, the stub connecting the DGC to the bus should not exceed 914 mm (3 ft) in length.
- The maximum bus length, not including stubs, is 40 m (131 ft).
- The J1939 drain (shield) should be grounded at one point only. If grounded elsewhere, do not connect the drain to the DGC.

On the CAN Bus Setup page, ECU support needs to be enabled if the DGC-2020HD will communicate with an engine ECU. DTC support must be enabled if the DGC-2020HD will receive DTCs sent to it from the engine ECU. 4 is the most common SPN conversion method, but it should be changed if necessary. Some engine manufacturers specify a J1939 ECU address for transmitting requests to the engine ECU. These include RPM requests to run the engine at a specific speed, engine start requests, and engine stop requests. Engine control parameter transmit needs to be enabled if the controller will send control requests to the engine ECU. On the list shown in Table 1, the CAN Bus address is user selectable for some ECUs. The standard ECU is listed for ECU types that are not included in Table 1.

Note that the ECU CAN Bus wires need to be terminated on the DGC-2020HD's CAN 2 terminals. CAN 1 is dedicated for Basler Electric's accessory modules: the AEM-2020, CEM-2020, and VRM-2020. On the CAN Bus Setup page shown in Figure 5, there are settings for ECU contact control, ECU related time values, coolant temperature source, and oil pressure source. The default settings are typical for an ECU controlled engine, but they can be changed if necessary.

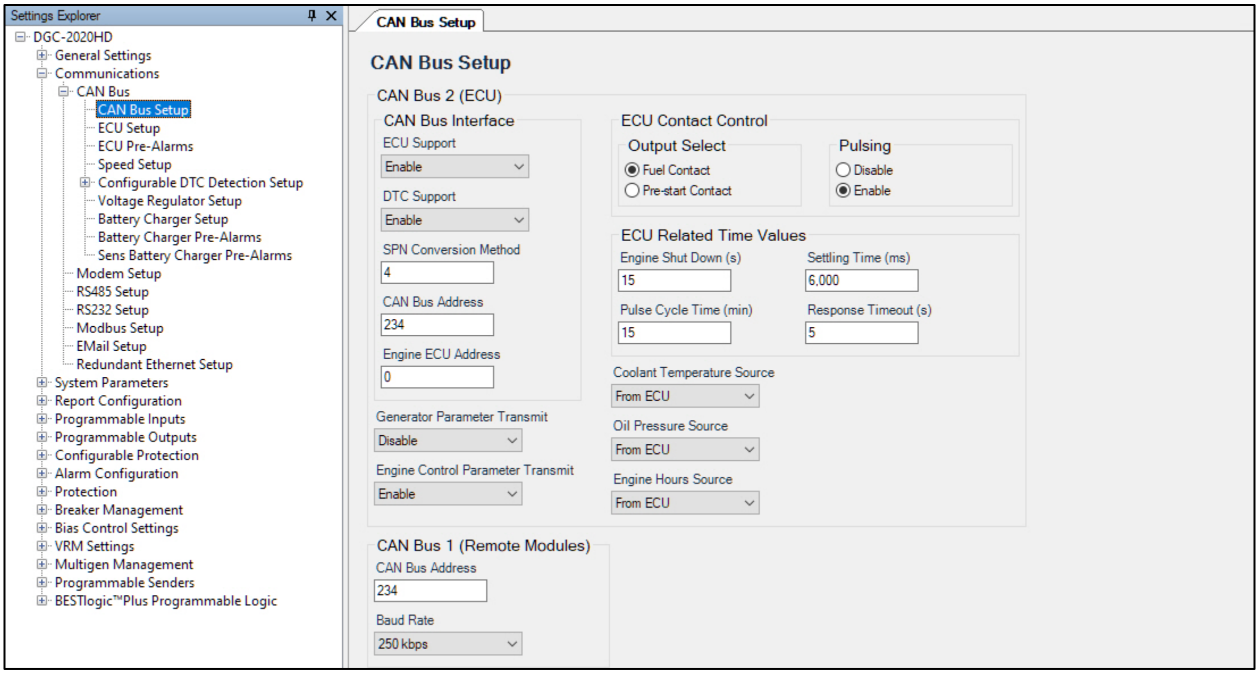

Figure 5. CAN Bus Setup

Table 1. CAN Bus Address per ECU Type

ECU Type	CAN Bus Address
Cummins	220
Daimler CPC4	User-selectable
GM/Doosan	User-selectable
Isuzu	User-selectable
John Deere	User-selectable
mtu ADEC	1
mtu ECU7/ECU8	6
mtu MDEC	6
mtu Smart Connect	234
Scania	39
Standard	User-selectable
Volvo Penta	User-selectable
Woodward PG Plus	230

ECU Setup

For ECU controlled engines only, there are settings to be selected on the ECU Setup page shown in Figure 6. The ECU type can be selected on this page. There are additional settings that apply to specific ECU types. Standard ECU is an available selection for ECU types that are not listed on the drop down list of ECU types.

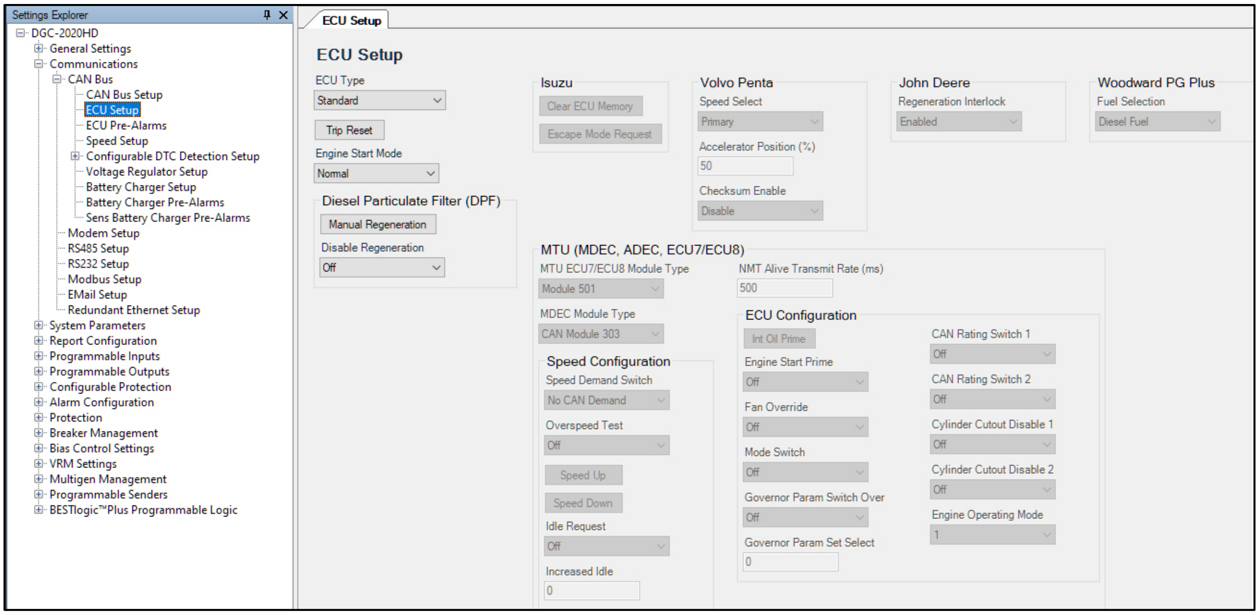

Figure 6. ECU Setup

Speed Setup

For J1939 controlled engines that are receiving RPM requests from the genset controller, CAN Bus RPM request must be enabled on the Speed Setup page shown in Figure 7. The remaining settings on this page can be adjusted as needed for the application.

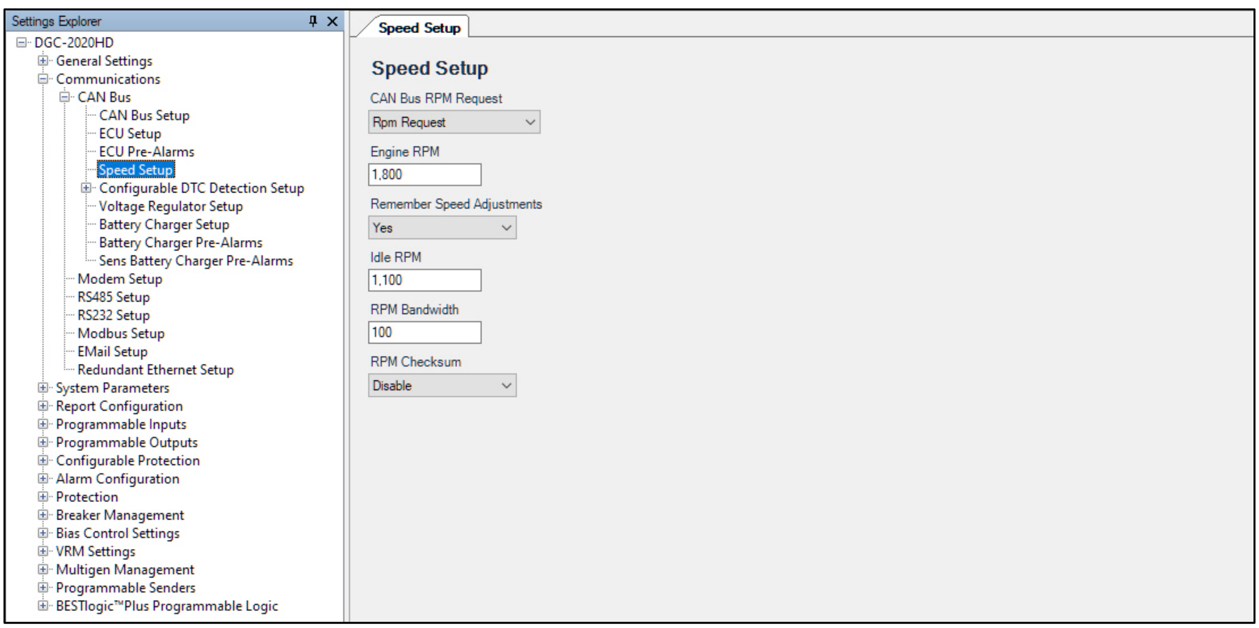

Figure 7. Speed Setup

System Settings

On the System Settings page shown in Figure 8, the System Type should be set to Multiple Generator. In systems with tie breakers controlled by DGC-2020HD controllers, the System Type should be set to Segmented Bus System. Segmented bus systems are beyond the scope of this application guide.

The System Breaker Configuration should be set to Generator Breaker Control. The other settings should be adjusted as needed.

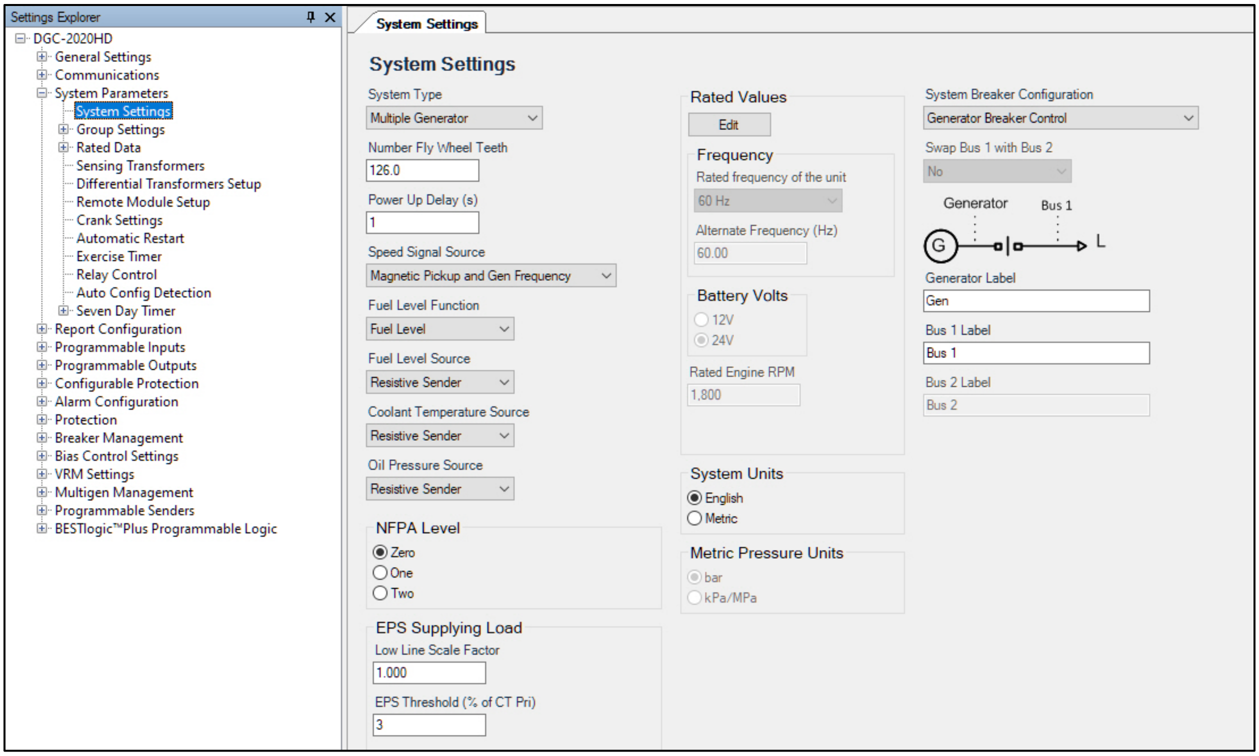

Figure 8. System Settings

Rated Data Settings

Rated data settings for the generator and the bus need to be entered on the Rated Data Settings page. In the example shown in Figure 9, the generator is rated for 100 KW, 0.8 pf, 208/120 Vac wye, 60 Hz. The current transformers (CTs) have a 400:5 turns ratio. Potential transformers (PTs) are not needed because the DGC-2020HD is capable of sensing up to 576 Vac directly.

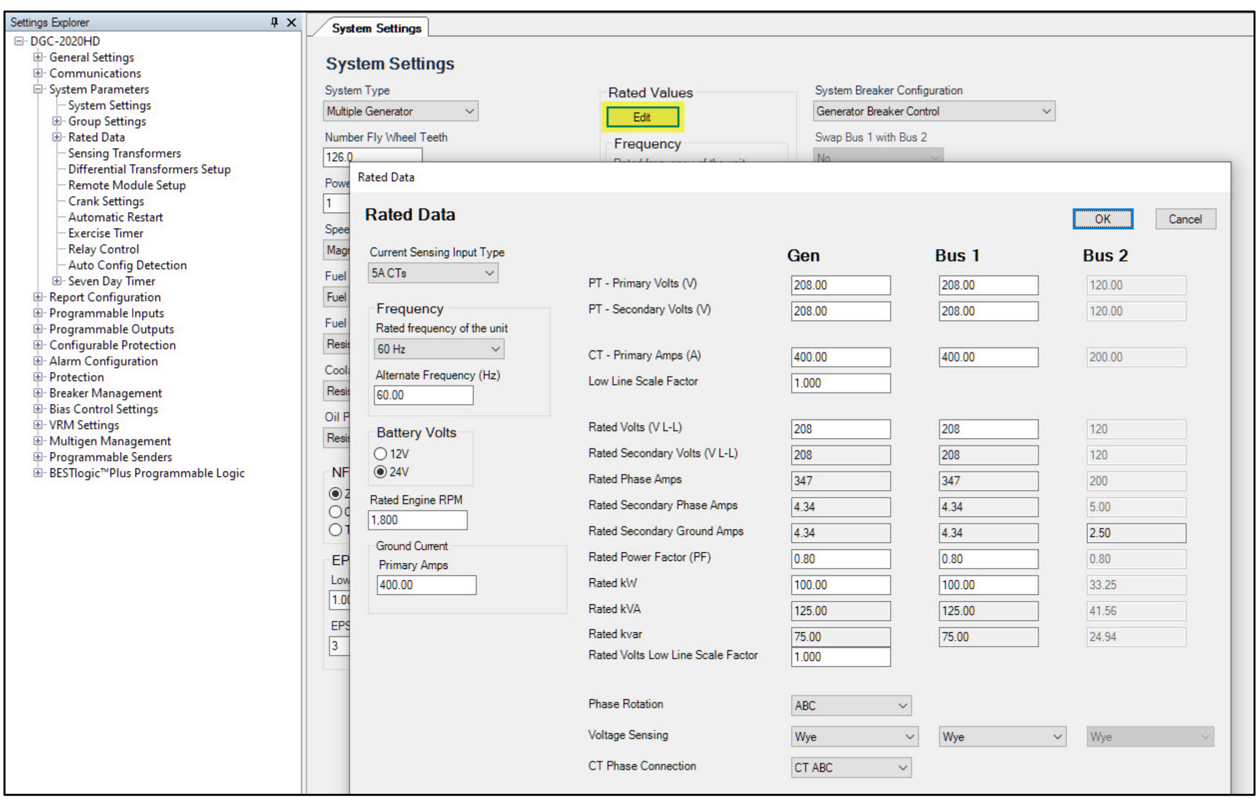

Figure 9. Rated Data Settings

Crank Settings

On the Crank Settings page shown in Figure 10, a time setting can be entered for a pre-crank delay. The pre-start relay can be used to control a circuit to power equipment that needs to be turned on before the engine cranks. Examples include glow plugs, coolant heaters, pre-lube pumps, etc.

The cranking style can be set to continuous or cycle. If cycle is chosen, the number of crank cycles, crank time, and the rest time can be changed. The crank disconnect limit can be set as a percentage of engine rated speed. Alternatively, the oil pressure crank disconnect setting can be enabled and an oil pressure threshold can be set for crank disconnect.

The DGC-2020HD can be configured to allow the genset to cooldown before shutting down. A time setting can be entered for the "No Load Cool Down Time" setting. During cooldown, the generator runs at rated speed, with no load.

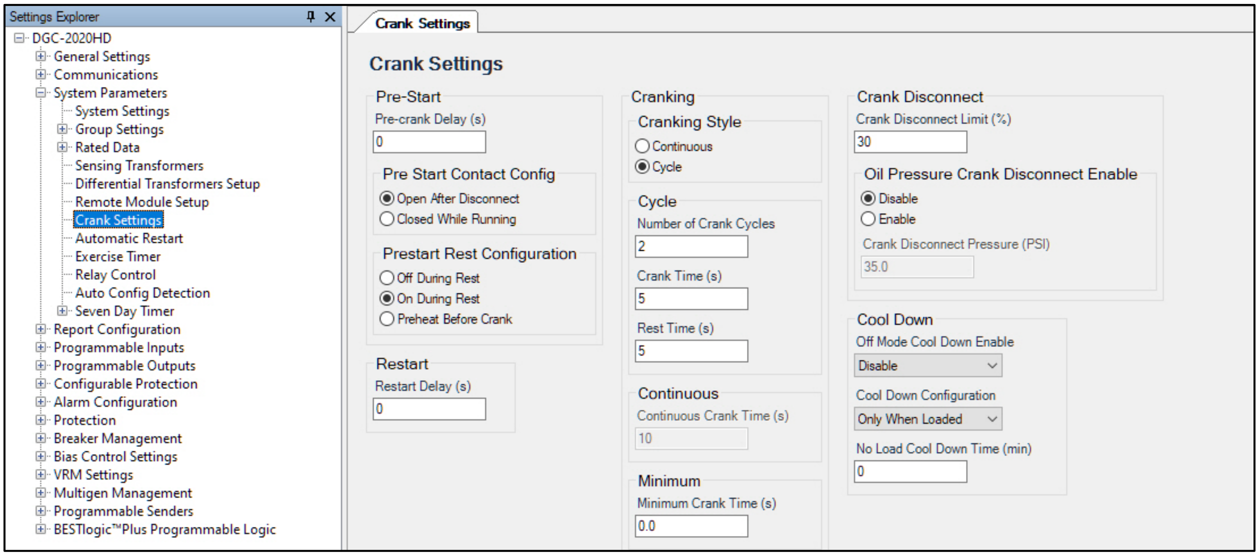

Figure 10. Crank Settings

Programmable Inputs

The 16 programmable inputs on the DGC-2020HD can be used in logic as desired. Inputs have been designated as follows, consistent with the interconnect diagram shown in Figure 3 and the logic diagram shown in Figure 29.

- Input 1 – Emergency stop
- Input 2 – Remote start
- Input 9 – Generator breaker open request
- Input 10 – Generator breaker close request
- Input 13 – Generator breaker status feedback

Programmable Outputs

The programmable outputs can be used in logic as desired. Outputs have been designated as shown in Figure 11 for consistency with the controller to engine interconnect diagram shown in Figure 3, and the logic diagram shown in Figure 29.

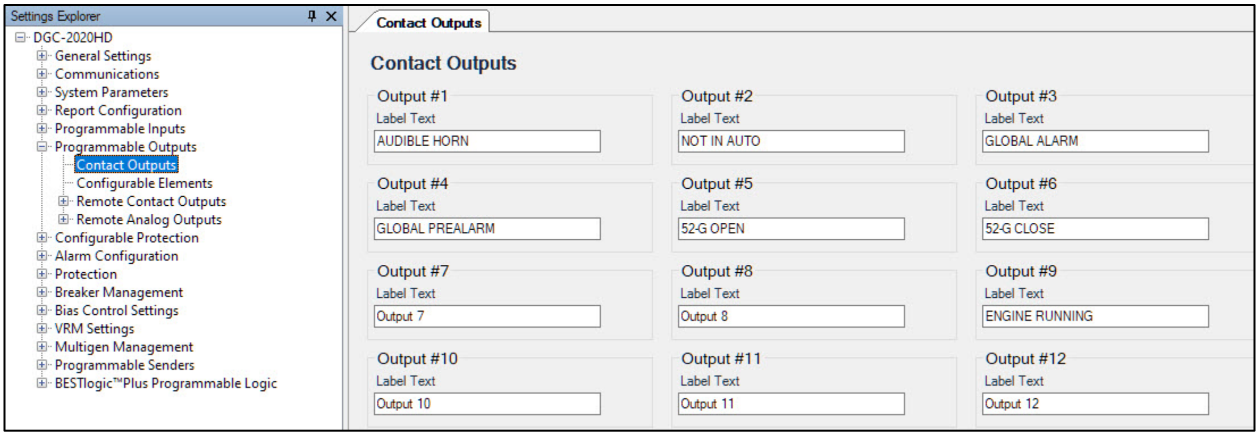

Figure 11. Programmable Outputs

Multiple protection elements are available for protecting the generator against fault conditions, depending on the style number of the controller. All protection elements are disabled by default. If the DGC-2020HD controller is the device that is responsible for protecting the generator, appropriate protection settings should be selected for the application. Refer to Chapter 17 of the *DGC-2020HD Configuration Instruction Manual* for descriptions of each protection element and associated settings. **It is the responsibility of the person(s) commissioning the generator to ensure that it is adequately protected before running it.**

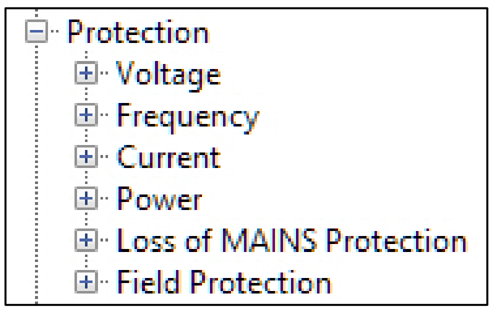

Figure 12. Protection Elements

Generator Breaker Settings

In an islanded multiple generator application, the first generator breaker to close will close to a dead bus. Hence, the Dead Bus Close Enable setting must be enabled under Breaker Hardware, on the Gen Breaker settings page shown in Figure 13. The other settings on this page should be adjusted if necessary.

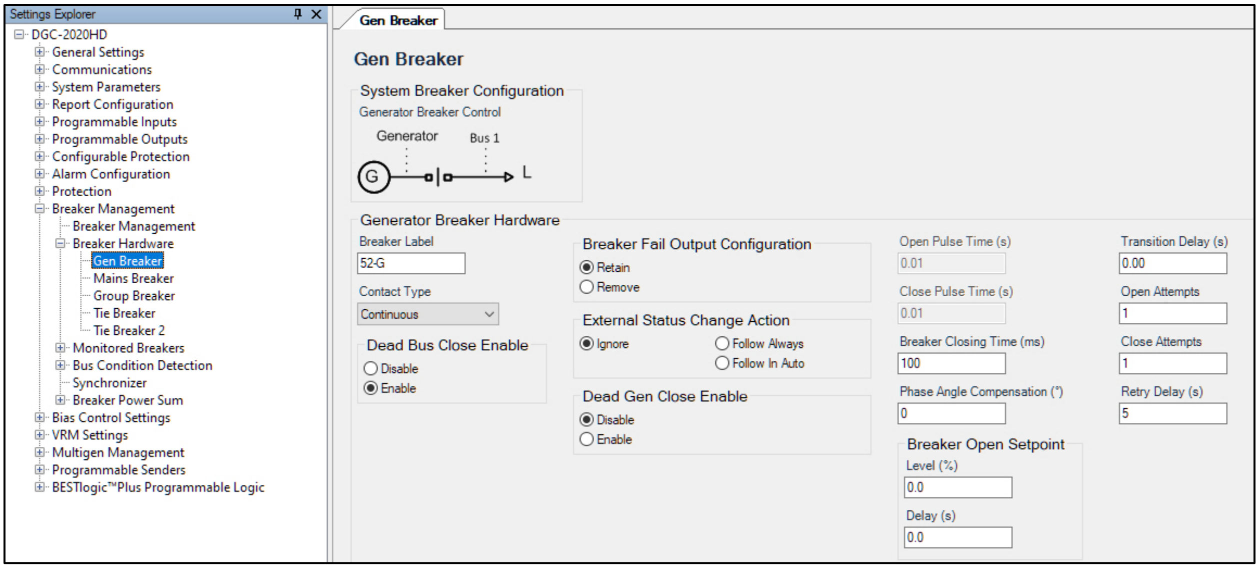

Figure 13. Generator Breaker Settings

Generator and Bus Condition Detection

The generator and bus condition detection settings are automatically updated when the rated data settings are updated. However, it is important to check these settings to ensure that they meet the application. The genset controller will receive a gen stable status only when the generator voltage and frequency are within the ranges shown in Figure 14.

The controller will not send a generator breaker close request until it receives a generator stable status. The auto synchronizer will not become active until the DGC-2020HD determines that both the generator and load bus are stable.

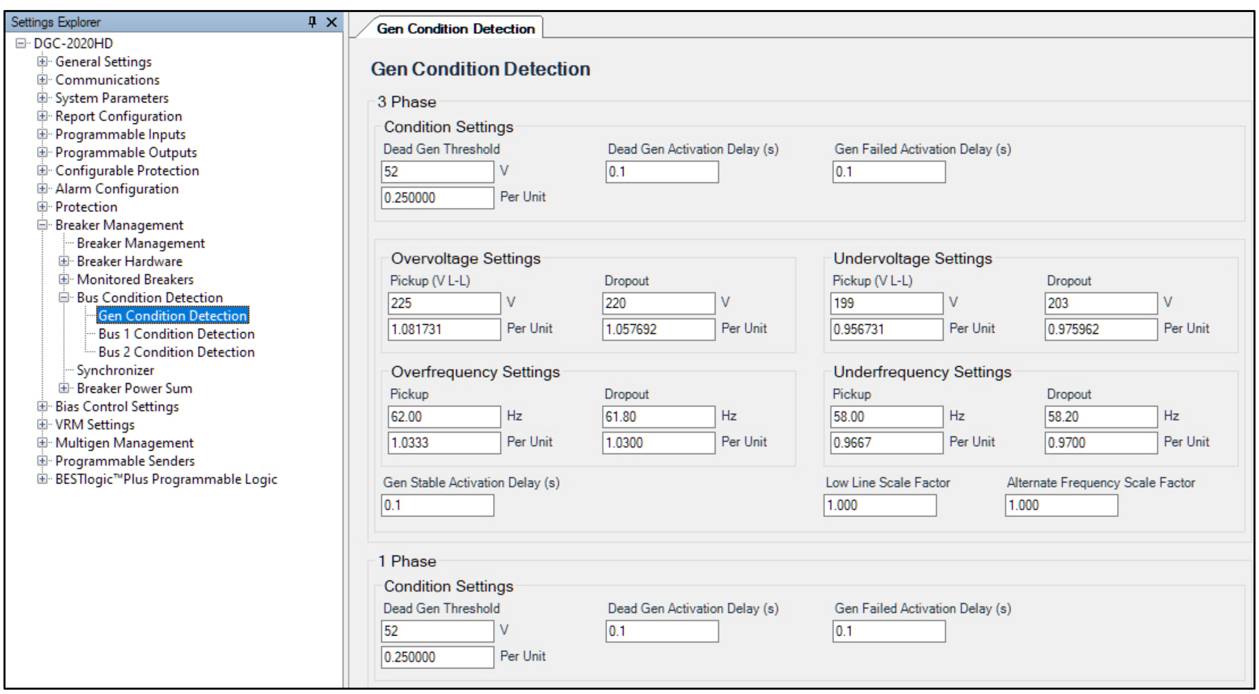

Figure 14. Generator Condition Detection Settings

Bias Control Settings

During synchronization and paralleling operations, the DGC-2020HD needs to bias the speed and voltage of the generators in the system. The bias control settings are found on the settings page shown in Figure 15.

We will assume that the voltage bias is being sent as an analog signal, and the speed bias is sent over CAN Bus communications since most new internal combustion engines are controlled by an electronic control unit (ECU). The DGC-2020HD has provisions for providing an analog speed bias signal to an electronic speed governor via the GOV output terminals if needed.

AVR Bias Control Settings

On the Output Configuration page shown in Figure 15, the bias control output type should be set to analog.

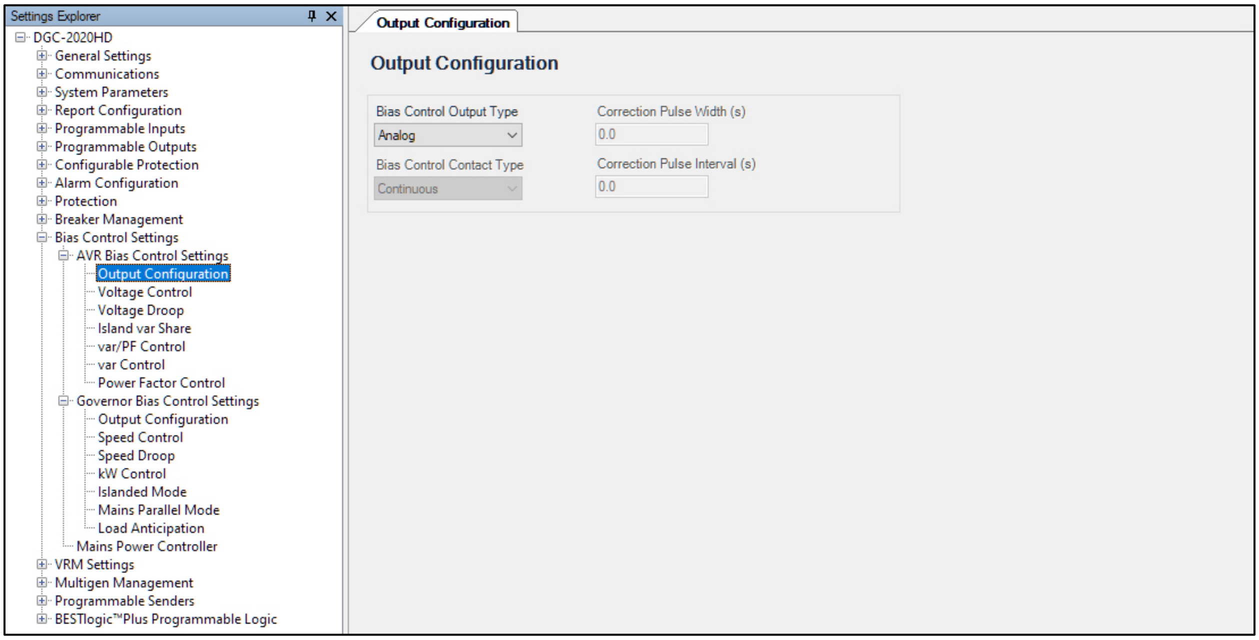

Figure 15. AVR Bias Output Control Type

On the Voltage Control page shown in Figure 16, the Trim Enable setting should be set to either Enable When Gen Breaker Is Closed or Enable Always. The gain settings need to be adjusted in order to get a fast, but stable response for kvar sharing. Note that if the trim enable setting is set to “Enabled Always”, the breaker does not need to be closed to tune the voltage controller. Refer to the **Voltage Controller Tuning Procedure** in Chapter 22 of the *DGC-2020HD Configuration Instruction Manual*.

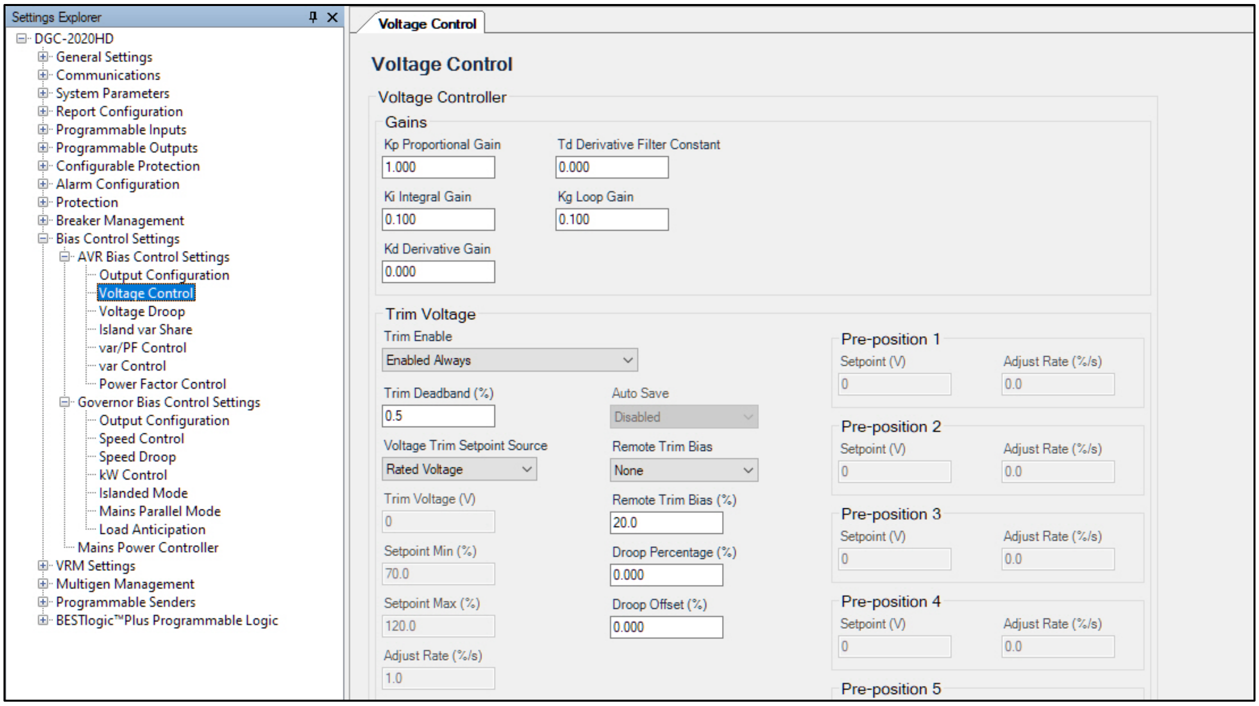

Figure 16. Voltage Trim Settings

Since the machines operate at a constant voltage setpoint, no voltage droop settings need to be entered. However, voltage droop settings can be entered on the Voltage Droop settings page shown in Figure 17, and droop override mode can be activated by logic conditions if desired. Droop override logic needs to be programmed in BESTlogic*Plus* Programmable Logic to use this feature.

On the Var/PF Control page, the Control Enable setting should be set to Enable. The Control Mode setting does not affect generator operation in an islanded system. It only pertains to grid-paralleled operations.

The var gain settings need to be adjusted to achieve stable var sharing between machines when paralleled. Refer to the **Var/PF Controller Tuning Procedure Using Multiple Machines in Island Parallel Operation** section in Chapter 22 of the *DGC-2020HD Configuration Instruction Manual*.

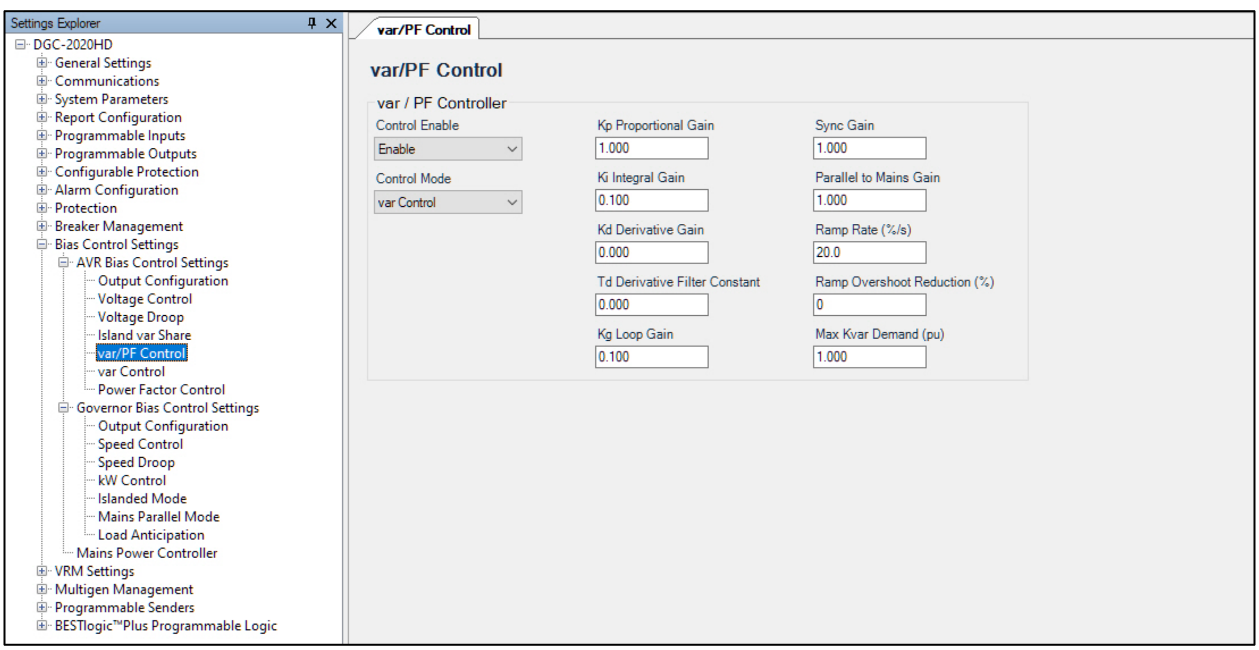

Figure 17. Var Tuning Settings

Governor Bias Control Settings

For CAN Bus speed control as well as analog speed controlled machines, the Bias Control Output Type should be set to Analog on the Output Configuration page (Figure 18).

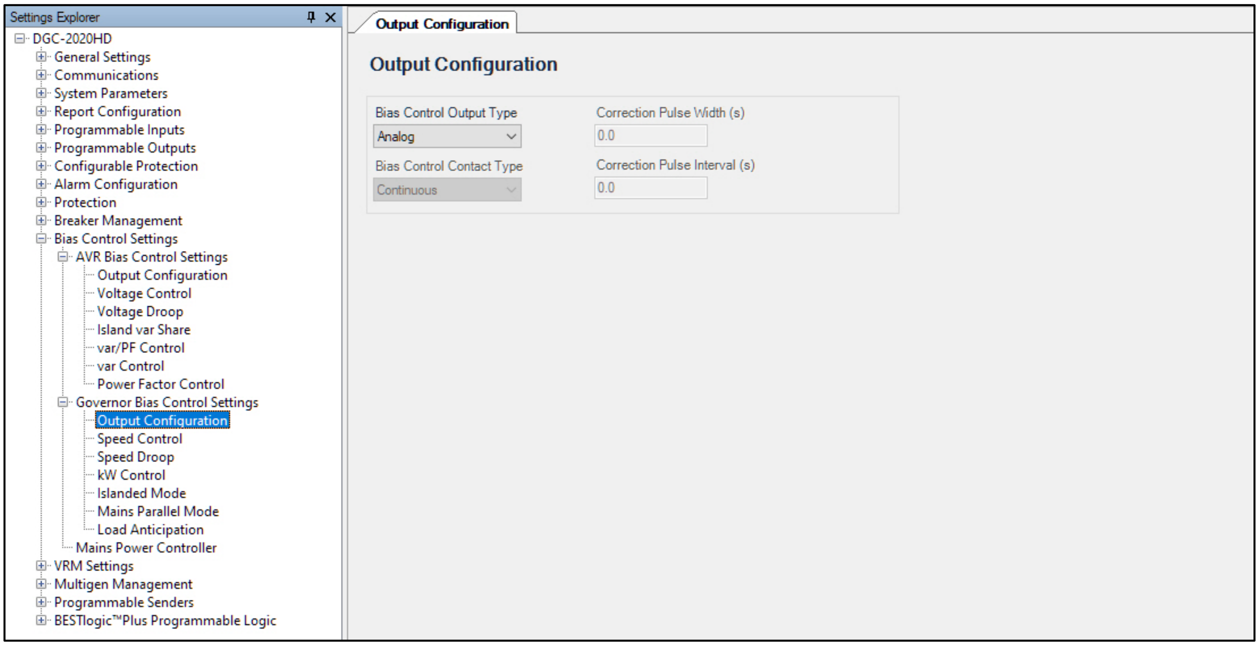

Figure 18. Speed Output Configuration

On the Speed Control Page shown in Figure 19, the Speed Trim should be set to either Enable When Gen Breaker Is Closed or Enable Always. The gain settings need to be adjusted in order to get a fast, yet stable response when tuning the speed response. Refer to the **Speed Controller Tuning Procedure** in Chapter 22 of the *DGC-2020HD Configuration Instruction Manual*.

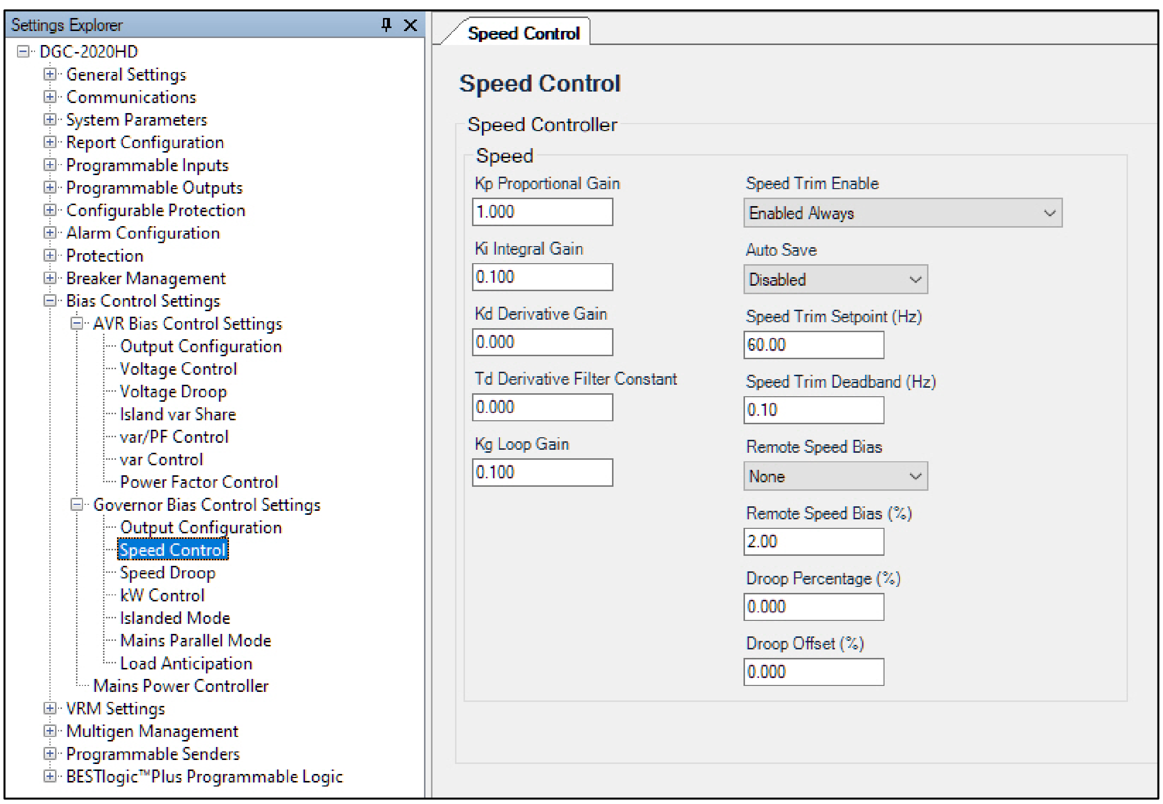

Figure 19. Speed Controller Settings

Since the machines operate at a constant speed setpoint, speed droop settings are not necessary. However, speed droop settings can be entered on the Speed Droop Settings page and droop override mode can be activated by logic conditions if desired. Droop override logic needs to be programmed in BESTlogic*Plus* Programmable Logic to use this feature.

On the kW Control settings page shown in Figure 20, the Load Control Enabled setting must be set to Enable. To achieve stable load sharing, the kW gain settings need to be adjusted. Refer to the **kW Load Controller Tuning Procedure Using Multiple Machines in Island Parallel Operation** section in Chapter 22 of the *DGC-2020HD Configuration Instruction Manual*.

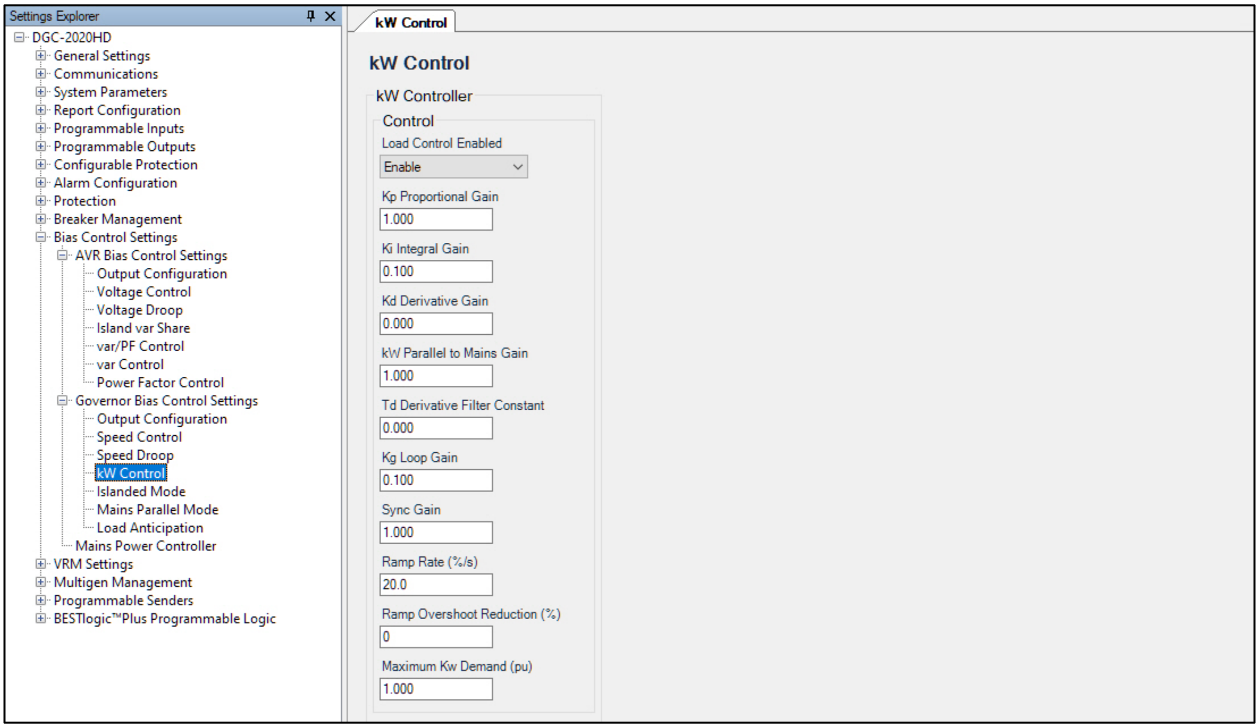

Figure 20. KW Controller Settings

On the Islanded Mode Settings Page shown in Figure 21, the Load Share Interface must be set to Ethernet to enable load sharing via Ethernet. Otherwise, the Load Share Interface must be set to Analog to enable analog load sharing.

To learn how to configure an Ethernet port for load sharing, refer to section titled **Ethernet Setup through BESTCOMS*Plus*** in Chapter 5 of the *DGC2020-HD Configuration Instruction Manual*.

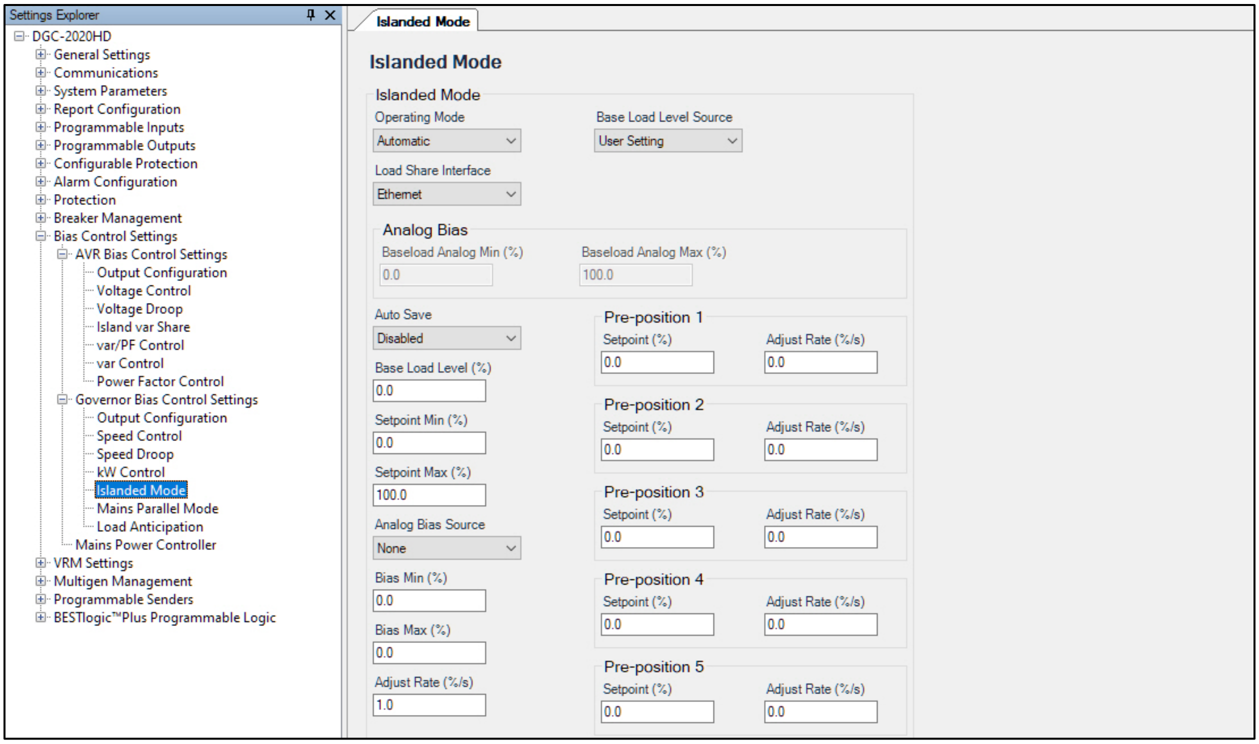

Figure 21. Load Share Interface Setting

Multi Generator Management

The AVR output voltage type can be set to voltage or current. The signal range can be set to increasing or decreasing. The signal range can be adjusted. Refer to Figure 22.

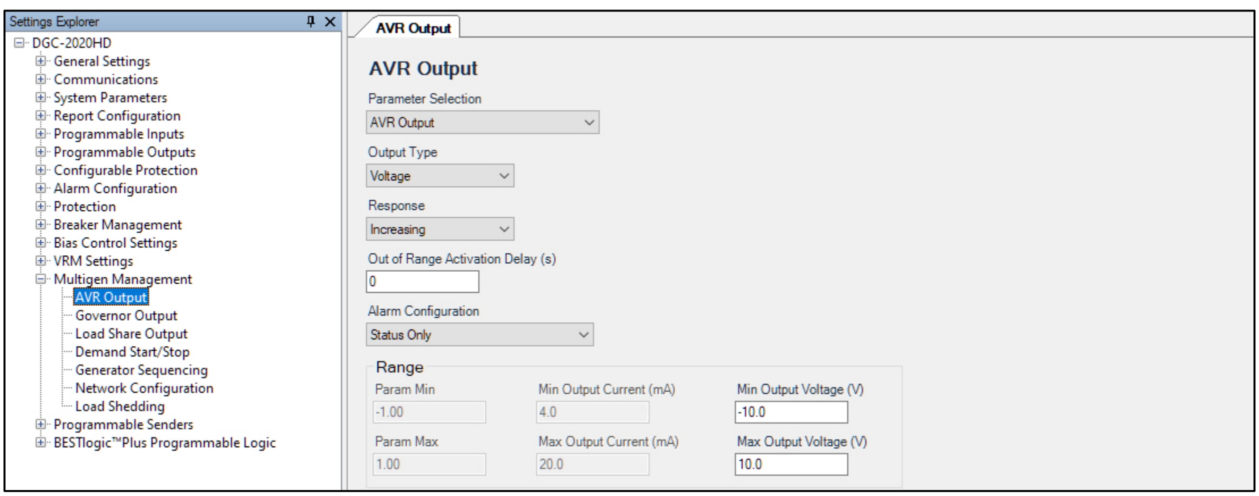

Figure 22. AVR Analog Bias Output Settings

The governor output voltage type can be set to voltage or current. The signal range can be set to increasing or decreasing. The signal range can be adjusted as needed. Refer to Figure 23.

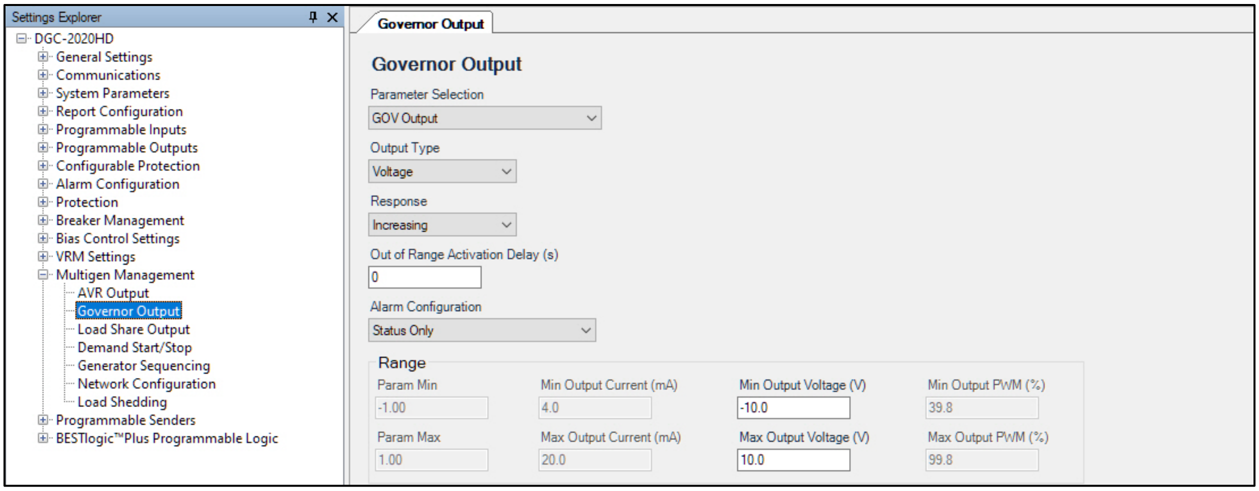

Figure 23. Governor Bias Output Settings

The Load Share Output settings only apply to installations where multiple DGC-2020HDs are interconnected via analog load share lines for load sharing. Hence, load share output settings do not apply to installations where load sharing is done through Ethernet communications. Note that when using analog lines for load sharing, KW is shared proportionally among machines over the analog lines. Voltage droop must be implemented for KVar sharing. When using Ethernet communications for load sharing, KW and KVar are shared proportionally among machines through Ethernet communications.

Demand start/stop and generator sequencing ID settings are not necessary for KW and KVar sharing. However, using these settings is beneficial for sequencing of generators for automatic dispatch based on load demand. For an islanded system, only the “Islanded” settings are applicable. Per Unit Load settings represent a fraction of the rated capacity of the generator.

In the example shown in Figure 24, when the generator load is at or above 80% of its rated capacity for a period of 60 seconds, the next generator in the sequence will automatically start and come online. The Delayed Start Level 1 settings will result in this outcome. Delayed Start Level 2 settings are used for a more rapid response to changes in load. When the generator load is at or above 90% of its rated capacity for a period of 5 seconds, the next generator in the sequence will come online. The Delayed Stop Level setting determines when generators need to go offline. In the example below, when the load on the generators that are online at or below 35% of rated capacity or for a period of 60 seconds, the lowest priority generator in the sequence will go offline, causing the loading on the remaining generators to increase.

For more information on how to automate generation dispatch, refer to the Demand Start / Stop, Generator Sequencing, and Network Configuration sections of Chapter 15 of the *DGC-2020HD Configuration Instruction Manual* and the application note: *Demand Start/Stop Setup with the DGC-2020HD*. Application notes are available from the DGC-2020HD Product Page on Basler Electric’s website.

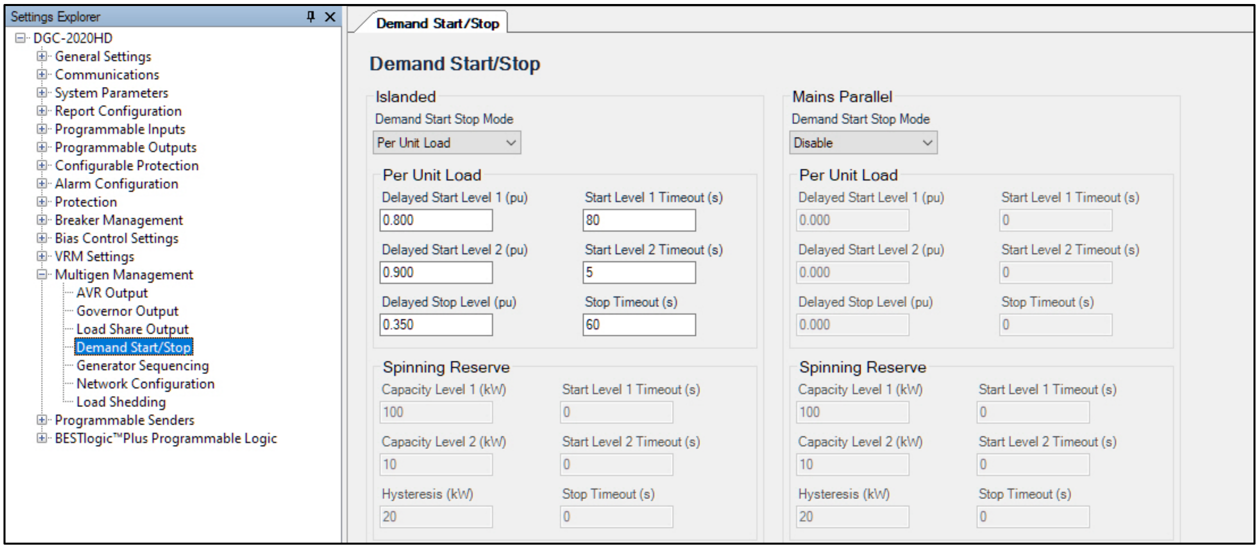

Figure 24. Demand Start/Stop Settings

Each controller in the system should be given a unique non-zero sequencing ID. If multiple units are given identical sequencing IDs, the DGC-2020HD network will use device MAC addresses for generator sequencing. Refer to Figure 25.

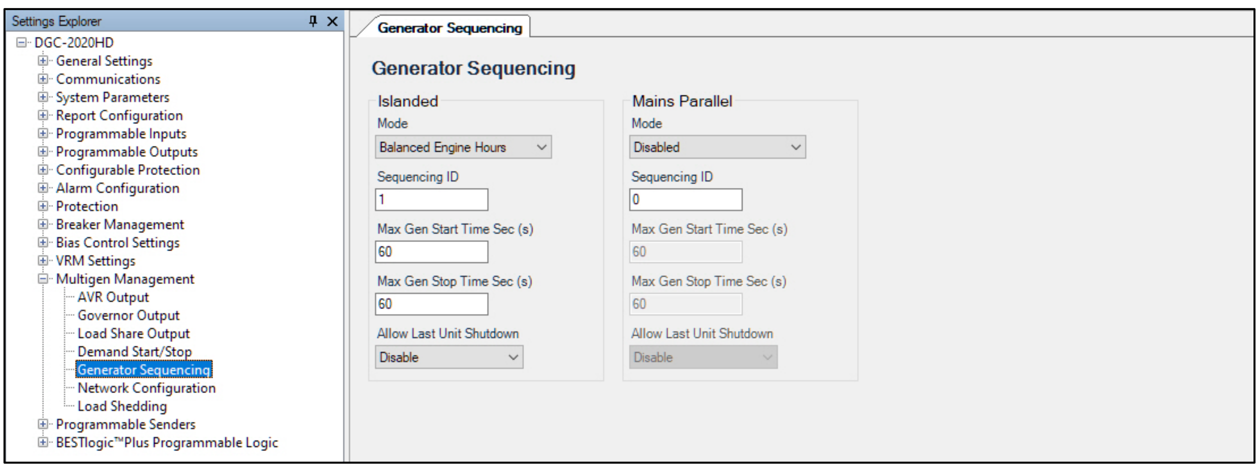

Figure 25. Generator Sequencing Settings

The sequence IDs of all the genset controllers in the system needs to be entered on the Network Configuration settings page of each DGC-2020HD as shown in Figure 26.

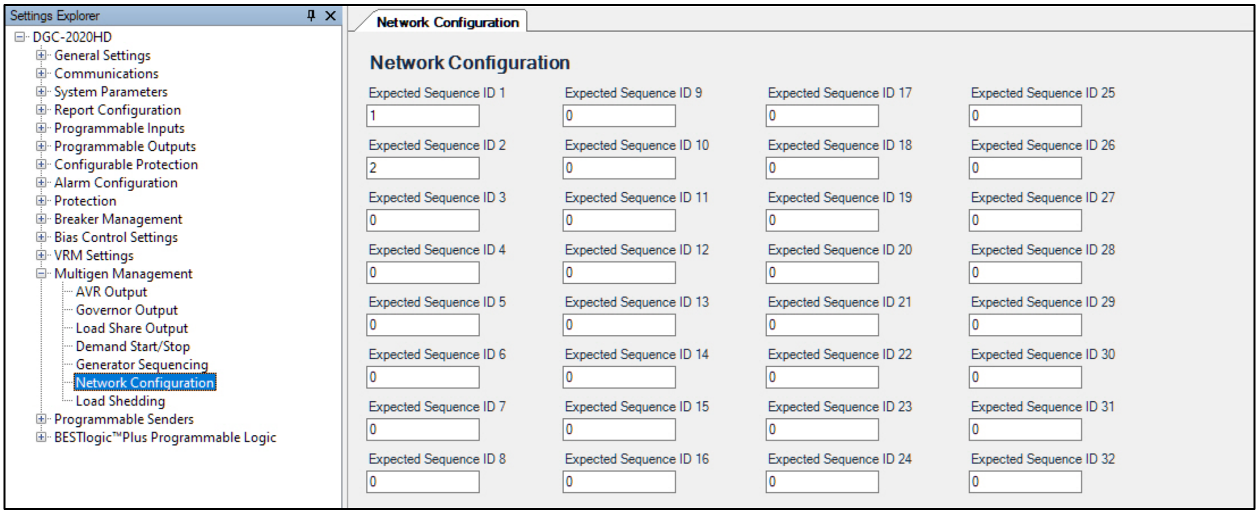

Figure 26. Network Configuration Settings

Programmable Senders

A DGC-2020HD with a style number ending in “R” has resistive inputs for coolant temperature and oil pressure senders. For coolant level senders from the list shown in Figure 27, the sender curve can be selected by clicking the “Load Cool. Settings File” button. Curves for oil pressure and fuel level can be loaded in a similar manner. If the sender curve is not loaded in BESTCOMS*Plus*, a custom curve can be created by entering values for the 11 points in the table. The sender slope can be changed. DGC-2020HDs with a style number ending in “R” have two resistive inputs and two analog inputs. The analog inputs can receive signals in the -10 Vdc to +10 Vdc range, or as a 4 to 20 mA current signal. DGC-2020HDs with a style number ending in "A" have four analog inputs and no resistive inputs. DGC-2020HD controllers with style numbers ending in “R” or “A” have a resistive input for a fuel level sender.

The resistance ranges of the following senders are compatible with the DGC-2020HD. A compatible Fuel Level sender is the Isspro model R8925. Oil pressure senders compatible with the DGC-2020HD include Datcon model 02505-00, Isspro model R8919, Stewart-Warner models 279BF, 279C, 411K and 411M, and VDO models 360025 and 360811. Compatible Coolant Temperature senders include Datcon model 02019-00, Faria model TS4042, Isspro model, R8959, and Stewart-Warner model 334P. Other senders with matching resistance ranges may also be used.

Figure 27. Plug-and-Play Programmable Senders.

(From Chapter 8 of the *DGC-2020HD Configuration Instruction Manual*.)

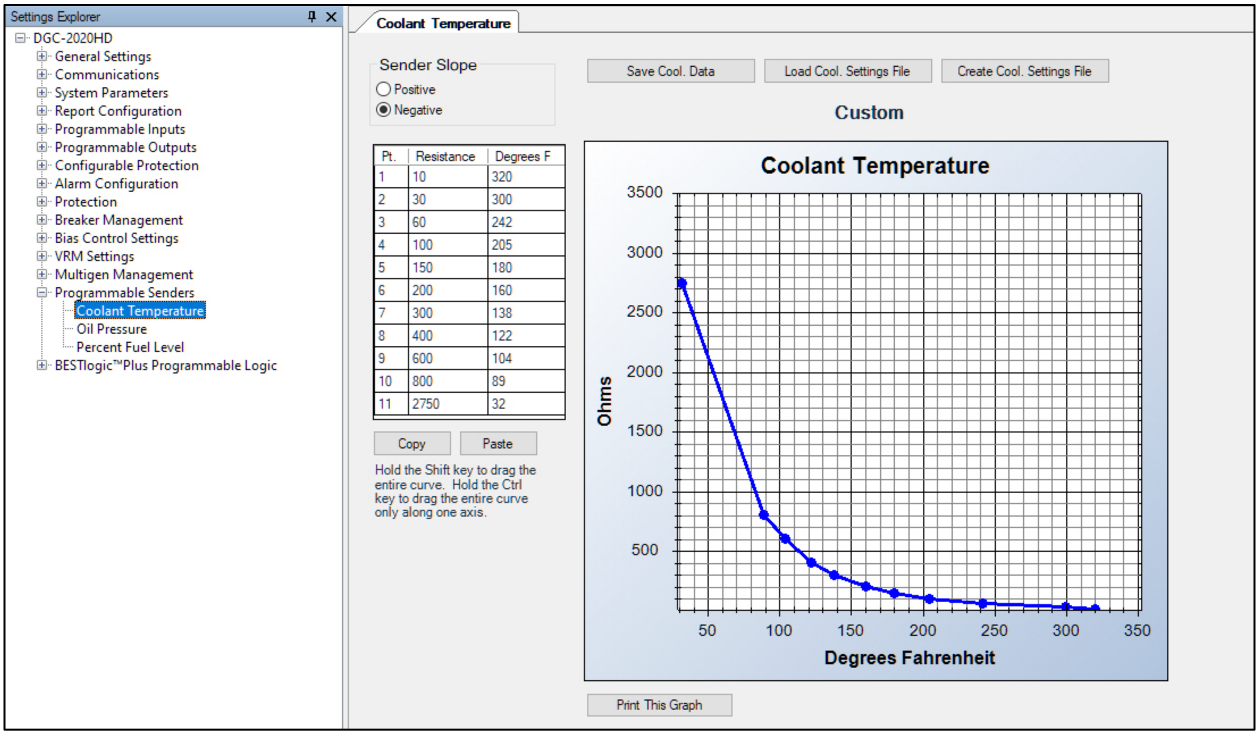

Figure 28. Programmable Sender Settings

So far, in this application guide, we have discussed the minimal settings that are needed for a DGC-2020HD to interface with single genset in a multiple generator setup where all generators are paralleled to a common bus. Now, an example will be provided illustrating a logic scheme implemented to achieve a typical paralleling sequence of operations.

Sequence of Operations

The remote start signal may be received by a specific genset controller initially, and then by other genset controllers subsequently. The first generator to receive the start signal will come online and the other generators will be synchronized to it. Alternatively, the remote start signal may be received by multiple genset controllers simultaneously, resulting in multiple generators attempting to have their breakers closed to the dead bus. In this scenario, the controllers participate in dead bus breaker close arbitration via peer-to-peer intergenset communications. The controller with the lowest sequence ID closes to the dead bus. Then, the remaining generators are synchronized and closed onto the live bus.

If an ATS is included in the system as shown in Figure 1, the ATS controller will lead the sequence of operations. Refer to the **DGC-2020HD Single Generator with ATS Application Guide** for a description of a typical ATS controlled sequence of operations.

In the logic scheme shown in Figure 29, the RUNWITHLOAD logic element is being used to start each generator and send a breaker close request once the generator is stable. The DGC-2020HD senses the load bus to determine whether it is dead or live. If the load bus is dead, the DGC-2020HD sends a dead bus breaker close request. If the DGC-2020HD determines that the bus is live and stable, the synchronizer becomes active. The breaker close request is only sent after the DGC-2020HD receives a “Synch Breaker Close OK” status.

The breaker closure sequence of operations described above works similarly when a generator start is initiated by the generator sequencer based on load demand.

Once the two generators are paralleled, the DGC-2020HDs handle kW and kvar sharing over the intergenset communications network if Ethernet load sharing is implemented. This setup allows multiple machines to share kW and kvar proportionally on a percentage capacity basis, while maintaining the rated frequency and voltage of the system throughout the load profile.

Implementing the logic scheme shown in Figure 29 will allow multiple DGC-2020HDs to control a system of gensets paralleled to a common bus as described above.

If transfer switches are incorporated into the paralleling scheme, multiple generators can receive the ATS start request to bring them online in close succession. Alternatively, one generator can come online via an ATS start request, and allow the other generators to cycle on and off as determined by the DGC-2020HD's demand start and stop settings.

Once the installation of all equipment and the setup of the genset controller is complete, the controller should be placed in AUTO mode to respond to run with load requests as well as demand based starts and stops.

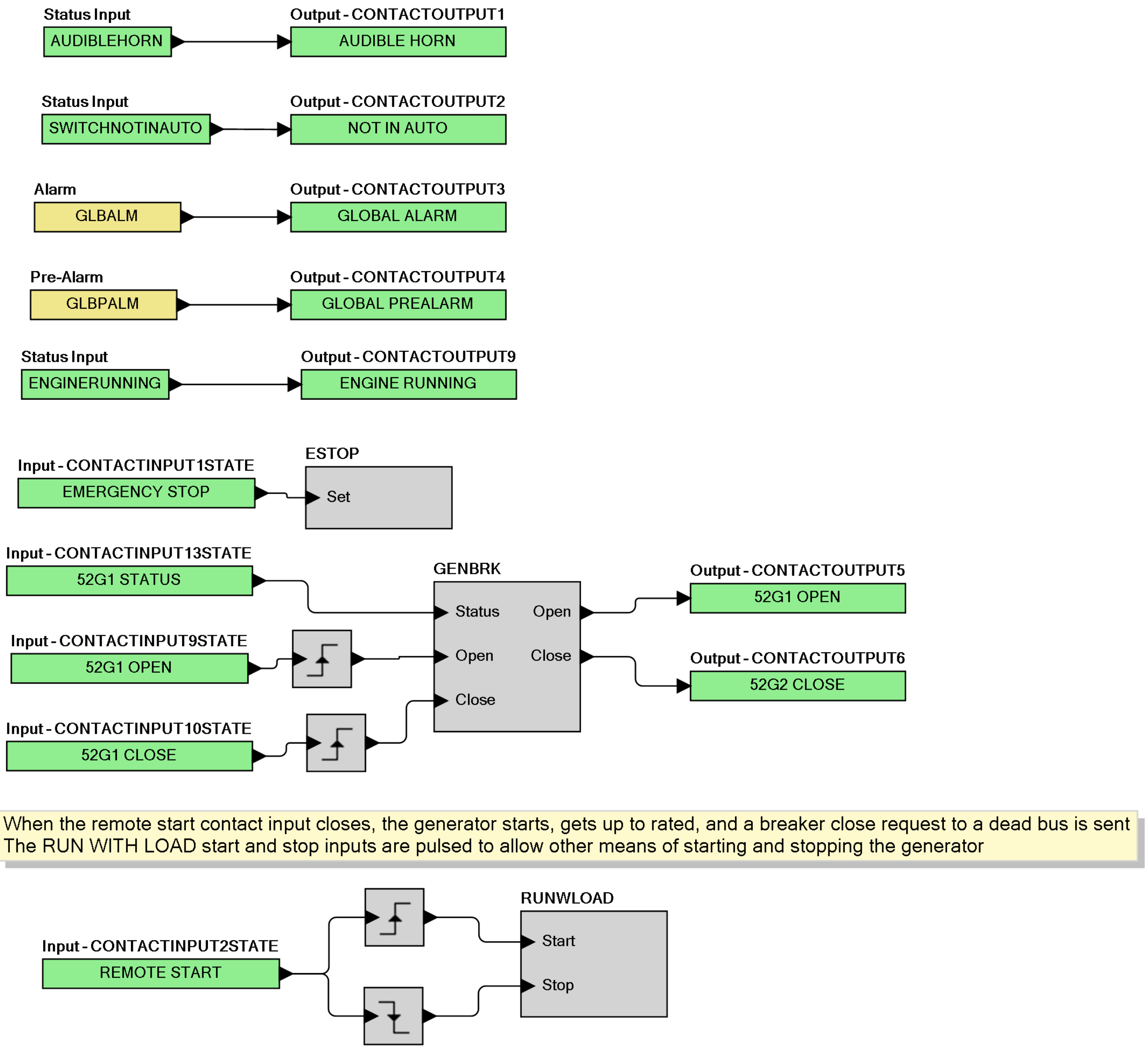

Figure 29. Logic Scheme

To Learn More

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