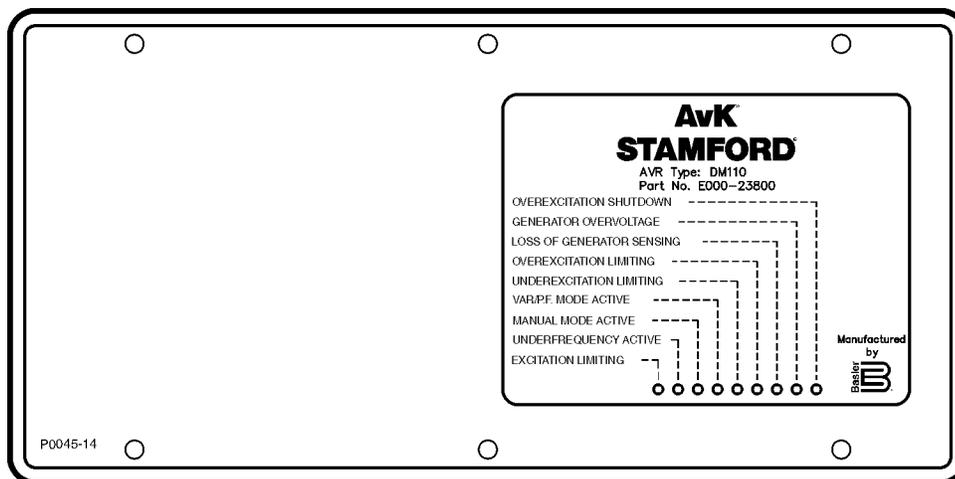


## Instruction Manual STAMFORD / AvK DM110 Digital Excitation Control System



<b>SECTION 1 GENERAL INFORMATION</b> .....	<b>1-1</b>
INTRODUCTION .....	1-1
FEATURES .....	1-1
SPECIFICATIONS .....	1-1
Operating Power .....	1-1
Generator Voltage Sensing .....	1-2
Generator Current Sensing .....	1-2
Bus Voltage Sensing .....	1-2
Accessory Input.....	1-2
Communication Port.....	1-2
Contact Input Circuits.....	1-3
Common Alarm Output.....	1-3
Field Output.....	1-3
AVR Operating Mode .....	1-3
FCR (Manual) Operating Mode.....	1-3
Var Operating Mode .....	1-3
PF Operating Mode .....	1-3
Parallel Compensation .....	1-4
Phase Compensation.....	1-4
Field Overvoltage Protection.....	1-4
Generator Overvoltage Protection.....	1-4
Overexcitation Limiter.....	1-4
Excitation Limiter .....	1-5
Underexcitation Limiter.....	1-5
Soft Start Function (AVR Mode Only).....	1-5
Voltage Matching.....	1-5
Metering (BESTCOMS).....	1-5
Environment .....	1-6
Type Tests .....	1-6
Physical .....	1-6
Agency Recognitions.....	1-6

## Figures

Figure 1-1. Typical V/Hz Curves.....	1-4
--------------------------------------	-----

## SECTION 2 HUMAN-MACHINE INTERFACE.....2-1

INTRODUCTION .....	2-1
FRONT PANEL INDICATORS .....	2-1
Overexcitation Shutdown .....	2-1
Generator Overvoltage.....	2-1
Loss of Generator Sensing.....	2-1
Overexcitation Limiting .....	2-1
Underexcitation Limiting.....	2-2
Var/P.F. Mode Active.....	2-2
Manual Mode Active .....	2-2
Underfrequency Active .....	2-2
Excitation Limiting .....	2-2
COMMUNICATION PORT .....	2-2

**Figures**

Figure 2-1. DM110 Front Panel Indicators, P/N E000-23800 .....2-1  
 Figure 2-2. DM110 Front Panel Indicators, P/N E000-23801 .....2-1  
 Figure 2-3. DM110 Communication Port Location.....2-2

**SECTION 3 • FUNCTIONAL DESCRIPTION .....3-1**

INTRODUCTION .....3-1  
 DM110 FUNCTION BLOCKS .....3-1  
     Analog Input Circuits .....3-1  
         Bus Voltage.....3-1  
         Generator Voltage.....3-1  
         B-Phase Line Current .....3-2  
         Accessory Input (Auxiliary Adjust) .....3-2  
         Field Voltage .....3-2  
         Field Current.....3-2  
     Contact Input Circuits .....3-2  
         Raise.....3-2  
         Lower .....3-2  
         Var/Power Factor Control/Excitation Limiter (52J/K) .....3-3  
         Parallel Generator Compensation (52L/M) .....3-3  
         Voltage Matching Control.....3-3  
     RS-232 Communication Port.....3-3  
     Microprocessor.....3-3  
     Power Input Stage.....3-3  
     Power Supply .....3-3  
     Power Amplifier Stage .....3-3  
     Front Panel Indicators .....3-4  
     Relay Output .....3-4  
 DM110 OPERATING FEATURES.....3-4  
     Operating Modes.....3-4  
         Automatic Voltage Regulation Mode.....3-4  
         Manual Mode .....3-4  
         Var Control Mode.....3-4  
         Power Factor Control Mode.....3-4  
     Reactive Droop Compensation .....3-5  
     Underfrequency.....3-5  
     Dwell.....3-5  
     Protection .....3-5  
         Generator Overvoltage .....3-5  
         Loss of Sensing Voltage .....3-5  
         Field Overvoltage (Overexcitation Shutdown) .....3-6  
     Limiters.....3-6  
         Overexcitation Limiting .....3-6  
         Underexcitation Limiting .....3-7  
     Soft Start .....3-7  
     Voltage Matching.....3-7

**Figures**

Figure 3-1. Simplified DM110 Block Diagram.....3-1

<b>SECTION 4 • INSTALLATION .....</b>	<b>4-1</b>
INTRODUCTION .....	4-1
MOUNTING .....	4-1
CONNECTIONS .....	4-5
DM110 Terminations.....	4-5
Bus Voltage Sensing Inputs .....	4-5
Generator Voltage Sensing Inputs .....	4-6
Phase B Line Current Sensing Input.....	4-6
Accessory Input.....	4-6
Raise and Lower Contact Inputs .....	4-6
Var/Power Factor Control/Second Overexcitation Limiter Contact Input.....	4-6
Parallel Generator Compensation.....	4-6
Parallel Control and Var/PF/Second OEL Control Inputs .....	4-6
Voltage Matching.....	4-7
Power Supply Inputs .....	4-7
Chassis Ground.....	4-7
Power (Field) Output .....	4-7
Relay Output (Alarm).....	4-7
Communication Port.....	4-8
DM110 Connections for Typical Applications .....	4-8
INSTALLATION FOR CE COMPLIANCE .....	4-14
Mounting.....	4-14
Wiring .....	4-14
PRELIMINARY SETUP.....	4-14
Operating Power Considerations During DM110 Programming.....	4-15
ADJUSTMENTS .....	4-15

### Figures

Figure 4-1. DM110 Dimensions .....	4-2
Figure 4-2. Cutout and Drilling Dimensions.....	4-3
Figure 4-3. DM110 Terminals .....	4-4
Figure 4-4. RS-232 Port Pin Assignments.....	4-4
Figure 4-5. Personal Computer to DM110 Connections.....	4-5
Figure 4-6. Typical Connections for PMG Application with ABC Rotation and Three-Phase Sensing .....	4-8
Figure 4-7. Typical Connections for PMG Application with ABC Rotation and Single-Phase Sensing.....	4-9
Figure 4-8. Typical Connections for Shunt Application with ABC Rotation and Three-Phase Sensing ...	4-10
Figure 4-9. Typical Connections for Shunt Application with ABC Rotation and Single-Phase Sensing...	4-11
Figure 4-10. Typical Connections for Station Power Application and Three-Phase Sensing .....	4-12
Figure 4-11. Cross-Current (Reactive Differential) Connections .....	4-13
Figure 4-12. Operating Power Connections for DM110 Programming (Input Voltage >120 Vac).....	4-14

### Tables

Table 4-1. Bus Voltage Sensing Terminals .....	4-4
Table 4-2. Generator Voltage Sensing Terminals .....	4-5
Table 4-3. 52L/M and 52J/K Control Modes .....	4-6
Table 4-4. Communication Port Pin Functions .....	4-7

## **SECTION 5 • BESTCOMS SOFTWARE .....**

INTRODUCTION .....	5-1
INSTALLATION.....	5-1

Installing BESTCOMS.....	5-1
Connecting the DM110 and PC.....	5-1
STARTING BESTCOMS.....	5-1
Establishing Communication.....	5-2
CHANGING SETTINGS.....	5-2
SENDING AND RECEIVING SETTINGS.....	5-2
Sending Settings.....	5-3
Receiving Settings.....	5-3
Saving Settings to DM110 Memory.....	5-3
SETTING DEFINITIONS.....	5-3
System Configuration.....	5-3
System Settings.....	5-3
Setting Adjustments.....	5-5
Setpoint Tab.....	5-5
Startup Tab.....	5-6
Control Gain.....	5-7
Control Gain Tab.....	5-7
Analysis.....	5-8
AVR Tab.....	5-10
FCR Tab.....	5-11
PF Tab.....	5-11
VAR Tab.....	5-13
Protection Settings.....	5-14
Protection Tab.....	5-14
Limiter Tab.....	5-15
Metering, Operation and Alarms.....	5-16
Operation Tab.....	5-16
Alarm/Status Tab.....	5-19
PID DATA.....	5-20
PID Calculation Based on Input Values.....	5-21
Adding to the PID List.....	5-21
Removing a PID List Record.....	5-21
Retrieving Existing Data from the PID List.....	5-21
SETTINGS FILES.....	5-22
Printing Settings Files.....	5-22
Saving Settings Files.....	5-22
Uploading Settings Files.....	5-22
PASSWORD PROTECTION.....	5-23
Changing the Password.....	5-23
TERMINATING COMMUNICATION.....	5-23
EMBEDDED FIRMWARE.....	5-23
Updating the Firmware.....	5-23

## Figures

Figure 5-1. Software Title and Version.....	5-1
Figure 5-2. Communication Port Menu Selection.....	5-2
Figure 5-3. Password Dialog Box.....	5-2
Figure 5-4. Communication Initiation Screen.....	5-2
Figure 5-5. Wait Dialog Box.....	5-2
Figure 5-6. System Configuration Screen.....	5-4
Figure 5-7. Setting Adjustments Screen, Setpoint Tab.....	5-6

Figure 5-8. Setting Adjustments Screen, Startup Tab.....5-7  
 Figure 5-9. Control Gain Screen.....5-8  
 Figure 5-10. Analysis Screen, AVR Tab.....5-10  
 Figure 5-11. Analysis Screen, FCR Tab.....5-11  
 Figure 5-12. Analysis Screen, PF Tab .....5-12  
 Figure 5-13. Analysis Screen, VAR Tab.....5-13  
 Figure 5-14. Protection Settings, Protection Tab .....5-15  
 Figure 5-15. Protection Settings Screen, Limiter Tab .....5-16  
 Figure 5-16. Metering, Operation, and Alarms Screen, Operation Tab .....5-17  
 Figure 5-17. Metering, Operation, and Alarms Screen, Alarm/Status Tab.....5-20  
 Figure 5-18. PID Window .....5-21  
 Figure 5-19. Settings Upload Dialog Box .....5-22  
 Figure 5-20. Password Dialog Box.....5-23  
 Figure 5-21. Software Uploading Advisory Dialog Box.....5-24  
 Figure 5-22. DM110 Embedded Program Loader .....5-24  
 Figure 5-23. Retrieved DM110 Information .....5-25  
 Figure 5-24. Settings File Reminder Dialog Box .....5-25  
 Figure 5-25. Open Dialog Box .....5-25  
 Figure 5-26. File Transfer Progress.....5-26  
 Figure 5-27. DM110 Information After Upload.....5-26

**Tables**

Table 5-1. DM110 Stability Range Settings .....5-9  
 Table 5-2. Analysis Screen Tab Combinations .....5-9

**SECTION 6 • MAINTENANCE AND TROUBLESHOOTING .....6-1**

PREVENTATIVE MAINTENANCE .....6-1  
 TROUBLESHOOTING.....6-1  
     Generator Voltage Does Not Build .....6-1  
     Low Generator Output Voltage.....6-2  
     High Generator Output Voltage.....6-3  
     Poor Voltage Regulation.....6-3  
     Generator Output Unstable (Hunting) .....6-3  
     Overexcitation Shutdown Indicator is Annunciating .....6-4  
     Loss of Generator Sensing Indicator is Annunciating.....6-4  
     Overexcitation Limiting Indicator is Annunciating.....6-4  
     Underexcitation Limiting Indicator is Annunciating.....6-4  
     Underfrequency Active Indicator is Annunciating .....6-5  
     No Droop .....6-5  
     No Voltage Matching .....6-6

# SECTION 1 • GENERAL INFORMATION

---

## INTRODUCTION

The STAMFORD | AvK Digital Excitation Control System (DM110) is an electronic, solid-state, microprocessor based control device. The DM110 regulates the output voltage of a brushless, ac generator by controlling the current into the generator exciter field. Input power to the DM110 can be from a multi-pole, high-frequency, permanent magnet generator (PMG) or from the generator output when used as a conventional, shunt-excited, excitation system.

The DM110 is supplied in an encapsulated package designed for behind-the-panel mounting. Two mounting configurations are available. Part number E000-23800 (Basler P/N 9287500138) has its LED indicators located on the bottom side of the unit. Part number E000-23801 (Basler P/N 9287500139) has its LED indicators located on the top side of the unit. The DM110 is held in place by thread-forming screws that thread into its plastic shell. Front panel indicators (LEDs) annunciate DM110 status and system conditions. DM110 connections are made through quarter-inch, quick-connect terminals on the rear panel. A 9-pin DB-9 type connector on the rear panel provides communication between the DM110 and an IBM compatible PC.

---

## FEATURES

DM110 units have the following features and capabilities:

Four control modes: automatic voltage regulation (AVR), manual or field current regulation (FCR), power factor (PF) regulation, and reactive power (var) regulation.

Programmable stability settings.

Soft start and voltage buildup control with an adjustable ramp in AVR control mode.

Excitation limiting, overexcitation limiting (OEL) and underexcitation limiting (UEL) in AVR, Var, and PF control modes.

Underfrequency (volts/hertz) regulation.

Dwell (% volts/second) regulation aids speed recovery of turbocharged engines.

Generator-to-bus voltage matching

Three-phase or single-phase generator voltage (rms) sensing/regulation in AVR mode.

Single-phase bus voltage (rms) sensing.

Single-phase generator current sensing for metering and regulation purposes.

Field current and field voltage sensing.

One analog input for proportional remote control of the setpoint.

Five contact sensing inputs for system interface.

One common output relay for alarm indication and trip functions.

Three protection functions: field overvoltage, generator overvoltage, and loss of sensing.

Generator paralleling with reactive droop compensation and reactive differential compensation.

Phase compensation accommodates various phase relationships between sensed voltage and sensed current

RS-232 communication port for personal computer communication using BESTCOMS Windows® based software for fast, user-friendly, setup and control.

---

## SPECIFICATIONS

DM110 specifications and qualifications are listed in the following paragraphs.

### Operating Power

Refer to Section 4, *Installation* for special requirements concerning the application of operating power during DM110 programming and the application of station power.

Voltage:	88 to 250 Vac, single-phase or three-phase (L-L)
Frequency:	50 to 400 Hz
Burden:	650 VA
Voltage Buildup:	6 Vac
Terminals:	3, 4, 5

**Generator Voltage Sensing**

Type: 1-Phase/3-Phase, 4 ranges  
 Burden: <1 VA per phase  
 Terminals: E1, E2, E3

50 Hertz Sensing

Range 1: 100 Vac (85 to 132 Vac)  
 Range 2: 200 Vac (190 to 220 Vac)  
 Range 3: 400 Vac (380 to 440 Vac)  
 Range 4: N/A

60 Hertz Sensing

Range 1: 120 Vac (85 to 132 Vac)  
 Range 2: 240 Vac (170 to 264 Vac)  
 Range 3: 480 Vac (340 to 528 Vac)  
 Range 4: 600 Vac (540 to 660 Vac)

**Generator Current Sensing**

Type: 1-phase (B-phase with angle compensation in BESTCOMS), 50/60 Hz  
 Continuous Rating: 1 Aac maximum  
 Burden: <0.1 VA  
 Terminals: CT1, CT2

**Bus Voltage Sensing**

Type: 1-phase, 4 ranges  
 Burden: <1 VA per phase  
 Terminals: B1, B3

50 Hertz Sensing

Range 1: 100 Vac (85 to 132 Vac)  
 Range 2: 200 Vac (190 to 220 Vac)  
 Range 3: 400 Vac (380 to 440 Vac)  
 Range 4: N/A

60 Hertz Sensing

Range 1: 120 Vac (85 to 132 Vac)  
 Range 2: 240 Vac (170 to 264 Vac)  
 Range 3: 480 Vac (340 to 528 Vac)  
 Range 4: 600 Vac (540 to 660 Vac)

**Accessory Input**

Voltage Range: 4 to 20 mAdc  
 Burden: 138  $\Omega$ ,  $\pm 10\%$   
 Terminals: A (+), B (-)

Setpoint Range

For all operating modes, 12 mA = setpoint. If the current decreases below approximately 2 mA, the accessory input is ignored.

AVR Operating Mode:  $\pm 15\%$  of setpoint: 20 mA = +15%, 4 mA = -15%  
 Var Operating Mode:  $\pm 50\%$  of setpoint: 20 mA = +50% (lagging), 4 mA = -50% (leading)  
 Power Factor Operating Mode:  $\pm 30\%$  of setpoint: 20 mA = +30%, 4 mA = -30%  
 FCR Operating Mode:  $\pm 30\%$  of setpoint: 20 mA = +30%, 4 mA = -30%

**Communication Port**

Interface: Full duplex RS-232  
 Connection: Rear panel DB-9 connector  
 Baud: 4800  
 Data Bits: 8  
 Parity: None  
 Stop Bit: 1

**Contact Input Circuits**

Type:	Dry contacts
Interrogation Voltage:	13 Vdc (supplied by DM110)
<u>Terminal Assignments for Standard Functions</u>	
Raise:	6U, 7
Lower:	6D, 7
Var/PF or 2 <sup>nd</sup> OEL Enable:	52J, 52K
Parallel Control:	52L, 52M
Voltage Matching:	VM, VMC

**Common Alarm Output**

Type:	Form A, closed during normal operation
Rated Load:	7 Aac/Adc continuous
Make:	30 Aac/Adc, carry for 0.2 sec
Break:	7 Aac/0.1 Adc
Operating Voltage:	240 Vac/250 Vdc maximum
Terminals:	AL1, AL2

**Field Output**

Continuous Rating:	63 Vdc, 7 Adc
Field Resistance:	5 $\Omega$ minimum
Terminals:	F+, F-

10 Second Forcing Rating

200 Vac Power Input:	135 Vdc, 15 Adc
110 Vac Power Input:	90 Vdc, 10 Adc (9 $\Omega$ field) 75 Vdc, 15 Adc (5 $\Omega$ field)

**FCR (Manual) Operating Mode**

Adjustment Range:	0 to 7 Adc
Increment:	0.1 Adc

**Var Operating Mode**

Adjustment Range:	-100 to 100%
Increment:	0.1%

**PF Operating Mode**

Adjustment Range:	0.6 lag to 0.6 lead
Increment:	0.001

**AVR (Auto) Operating Mode**

Adjustment Range:	See <i>Generator Voltage Sensing</i>
Voltage Regulation:	$\pm 0.25\%$ over load range at rated power factor and constant generator frequency. $\pm 0.5\%$ with 3-phase sensing and shunt power at 40% THD of the voltage waveform (due to a six SCR load).
Temperature Drift:	$\pm 0.5\%$ for a 40°C change
V/Hz Characteristic:	Slope from 0 to 3PU is adjustable in 0.01PU increments. Transition (Corner) frequency is adjustable from 40 to 65 Hz. See Figure 1-1 for the V/Hz curves.
Maximum Dwell:	20%V/s in six steps: Disabled, 4%V/s, 8%V/s, 12%V/s, 16%V/s, 20%V/s
Response Time:	Within 1 cycle

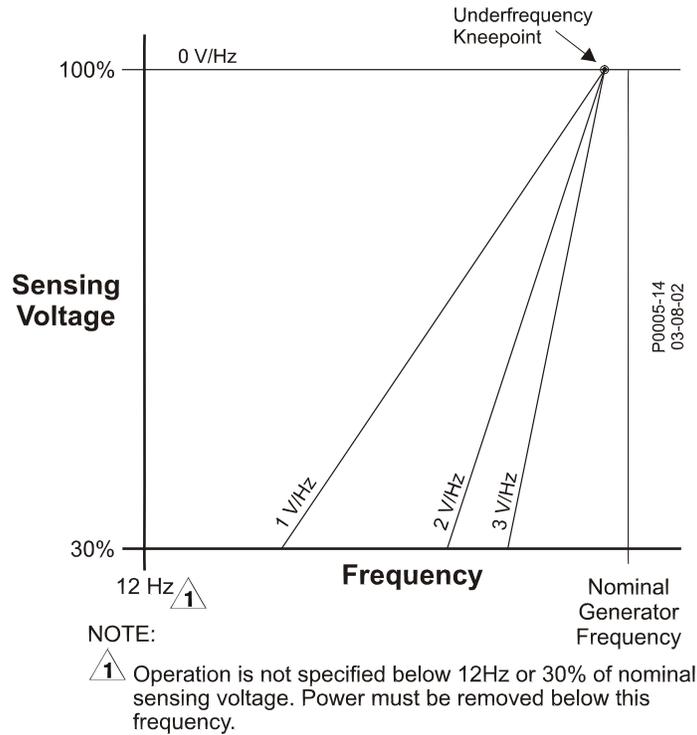


Figure 1-1. Typical V/Hz Curves

**Parallel Compensation**

Modes: Reactive Droop and Reactive Differential (cross-current)\*  
 Droop Adjust Range: 0 to 10%  
 Increment: 1%

\* Burden can exceed 1 VA if external resistors are added to the CT circuit.

**Phase Compensation**

Adjustment Range: -30 to +30°  
 Increment: 0.1°

**Field Overvoltage Protection**

Pickup Range: 0 to 250 Vdc  
 Time Delay: 10 s (fixed)

**Generator Overvoltage Protection**

Pickup  
 Range: 100 to 120% of system voltage setting  
 Increment: 1.0%  
Alarm Time Delay  
 Range: 0 to 10 s  
 Increment: 1 s

**Overexcitation Limiter**

Pickup  
 Range: 0 to 15 Adc  
 Increment: 0.01 Adc  
Alarm Time Delay  
 Range: 0 to 10 s  
 Increment: 1 s

**Excitation Limiter**Pickup

Range: 0 to 15 Adc

Increment: 0.01 Adc

**Underexcitation Limiter**Pickup

Range: 0 to 100% of rated vars

Increment: 1%

Alarm Time Delay

Range: 0 to 10 s

Increment: 1 s

**Soft Start Function (AVR Mode Only)**

Time Adjust Range: 1 to 7,200 s

Increment: 1 s

**Voltage Matching**Accuracy: Generator rms voltage is matched with the bus rms voltage to within  $\pm 0.5\%$  of the generator voltage.

Bus Secondary Input

Bias Range:  $\pm 0$  to 7 in 0.001 incrementsOperating Modes

Maintain or Revert

In Maintain mode the voltage setpoint shall be adjusted to the bus level during synchronism and stay at this level when the 52L/M or 52J/K contact inputs change state.

In Revert mode the DM110 operates as it did in Maintain mode except that the voltage setpoint reverts to its original value prior to synchronization, after the DM110 has detected (via the 52J/K contact input) that the generator has been on-line and is returning to its off-line state.

Time Adjustment

Range: 1 to 300 s

Increment: 0.01 s

**Metering (BESTCOMS)**Generator Voltage

Range: 10 V to 79 kV

Accuracy:  $\pm 0.5\%$  (at 25°C)Generator Current

Range: 0.04 to 3,000 Aac (Not to exceed nominal CT rating)

Accuracy:  $\pm 0.5\%$  (at 25°C)Frequency

Range: 40 to 65 Hz

Accuracy:  $\pm 0.2$  Hz (at 25°C)Field Voltage

Range: 0 to 200 Vdc

Accuracy:  $\pm 5.0\%$  (at 25°C)Field Current

Range: 0 to 20 A

Accuracy:  $\pm 0.5\%$  (at 25°C)Bus Voltage

Range: 10 V to 79 kV

Accuracy:  $\pm 0.5\%$  (at 25°C)Auxiliary DC Input

Range: 4 to 20 mAdc

Accuracy:  $\pm 0.5\%$  (at 25°C)Power (Apparent, Real, and Reactive)

Range: 0 to 99 MVA, MW, Mvar

Accuracy:	±3.0% (at 25°C)
<u>Power Factor</u>	
Range:	–1.0 to –0.6, +0.6 to +1.0
Accuracy:	±0.02 at rated current (25°C), CT input 10% nominal rating
<u>Phase Angle</u>	
Range:	0 to 360 degrees
Accuracy:	±2.0 degrees (at 25°C), CT input 10% nominal rating

**Environment**Operating Temperature

DM110: –40 to 70°C (–40 to 158°F)

Storage Temperature

DM110: –40 to 85°C (–40 to 185°F)

CD-ROM: 0 to 50°C (32 to 122°F)

**Type Tests**

Shock:	Withstands 20 G in three perpendicular planes
Vibration:	Withstands 1.2 G at 5 to 26 Hz Withstands 0.914 mm (0.036 in) double amplitude at 27 to 52 Hz Withstands 5 G at 53 to 500 Hz
Salt Fog:	Qualified per MIL-STD-810E

**Physical**Weight

Unit: 1.10 kg (2.42 lb)

Shipping: 1.31 kg (2.88 lb)

Shipping Carton Dimensions (W x H x D)

Single Unit: 299 x 79 x 146 mm (11.75 x 3.125 x 5.75 in)

48 Units: 841 x 653 x 352 mm (33.13 x 25.69 x 13.88 in)

**Agency Recognitions**cURus

cURus recognition per UL Standard 508 and CSA Standard C22.2 No. 14

CE

Emissions:	CISPR11/EN55011, Level A
Electrostatic Discharge (ESD):	IEC 1000-4-2/EN 61000-4-2, Level B
Radiated Susceptibility:	IEC 1000-4-3/EN 61000-4-3, Level A
Electrical Fast Transient:	IEC 1000-4-4/EN 61000-4-4, Level B
Radio Frequency–Conducted:	IEC 1000-4-6/EN 61000-4-6, Level A
Power Frequency–Magnetic:	IEC 1000-4-8/EN 61000-4-8, Level A
Dielectric:	IEC 255
Surge Immunity:	IEC 1000-4-5/EN 61000-4-5, Level B
Voltage Dips, Interruptions, and Variations Immunity:	IEC 1000-4-11/EN 61000-4-11, Level C

## SECTION 2 • HUMAN-MACHINE INTERFACE

### INTRODUCTION

The DM110 human-machine interface (HMI) consists of front panel indicators and a rear-panel communication port.

### FRONT PANEL INDICATORS

DM110 front panel indicators consist of nine red LEDs. The indicators of part number E000-23800 (Basler P/N 9287500138) are shown in Figure 2-1 and the indicators of part number E000-23801 (Basler P/N 9287500139) are shown in Figure 2-2. Each indicator is described in the following paragraphs.

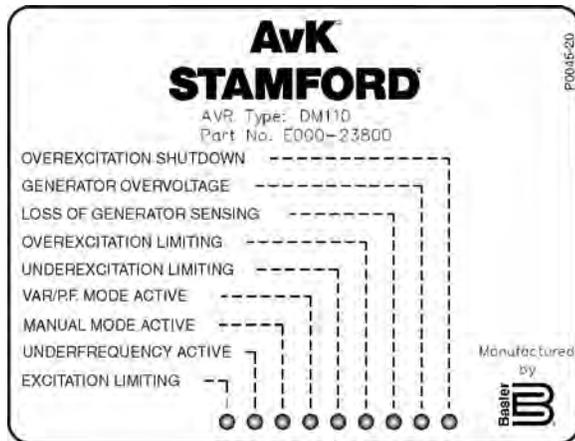


Figure 2-1. Front Panel Indicators, P/N E000-23800

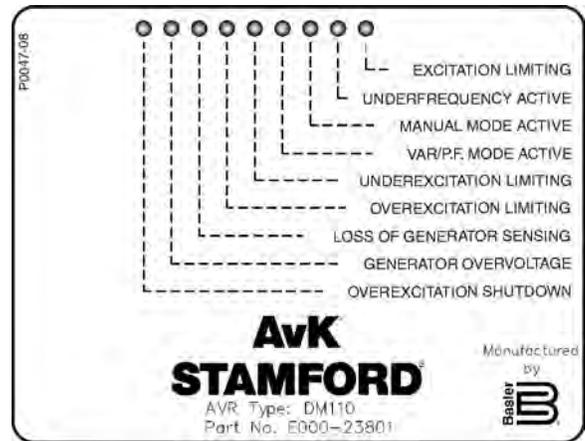


Figure 2-2. Front Panel Indicators, P/N E000-23801

#### Overexcitation Shutdown

This LED lights when the Overexcitation Protection feature is enabled and the field voltage exceeds the adjustable setpoint for 10 seconds. The DM110 will shutdown when an overexcitation condition is detected. The Overexcitation Shutdown LED will light for 5 seconds when the DM110 is powered up following an overexcitation shutdown.

#### Generator Overvoltage

This LED lights when generator output voltage exceeds the adjustable setpoint for 0.75 seconds. When a generator overvoltage condition exists, the DM110 output contacts close and the DM110 shuts down (if hardware shutdown is enabled). The Generator Overvoltage LED will light for 5 seconds when the DM110 is powered up following a generator overvoltage shutdown.

#### Loss of Generator Sensing

This LED lights when a loss of generator sensing voltage is detected. When a loss of sensing condition occurs, the DM110 output contacts close. Depending on the protective action selected, the DM110 will either shutdown or transfer to Manual mode. The Loss of Generator Sensing LED will flash for 5 seconds when the DM110 is powered up following a loss of generator sensing shutdown.

#### Overexcitation Limiting

This LED lights when the field current exceeds the programmed overexcitation limit. It stays lit until the condition ceases or the overexcitation time delay expires and the DM110 shuts down. The Overexcitation Limiting LED will flash for 5 seconds when the DM110 is powered up following an overexcitation limiting shutdown.



# SECTION 3 • FUNCTIONAL DESCRIPTION

## 1. INTRODUCTION

This section describes how the DM110 functions and explains its operating features. To ease understanding, DM110 functions are illustrated in the block diagram of Figure 3-1. A detailed description of each function block is provided in the paragraphs under the heading of *DM110 Function Blocks*.

DM110 operating features include four operating modes, four protective functions, startup provisions, reactive droop compensation, underfrequency compensation, and voltage matching. A detailed description of each operating feature is provided in the paragraphs under the heading of *DM110 Operating Features*.

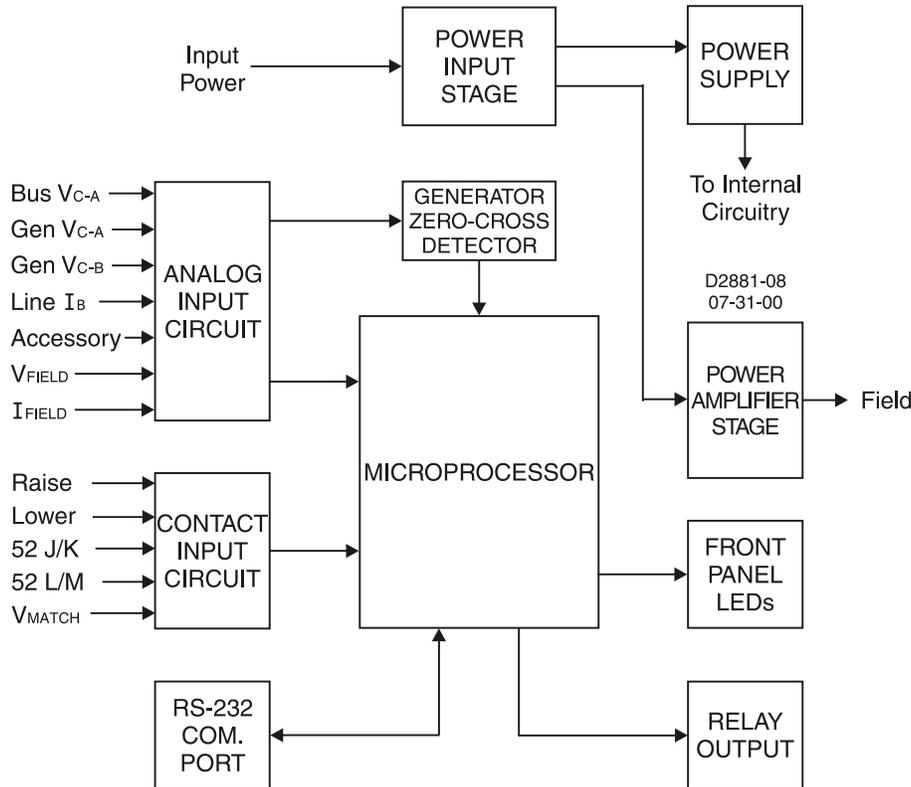


Figure 3-1. Simplified DM110 Block Diagram

## 2. DM110 FUNCTION BLOCKS

The following paragraphs describe each of the function blocks illustrated in Figure 3-1. The function of each block is explained along with the operation of all function block inputs and outputs.

### Analog Input Circuits

Seven analog voltages and current may be sensed and applied to the DM110.

#### Bus Voltage

C-phase and A-phase bus voltages are monitored at terminals B3 and B1 on units that include voltage matching. Nominal voltages of up to 600 Vac may be sensed at these terminals. Voltage monitored at this input is scaled and conditioned before being applied to the input of the analog-to-digital converter (ADC). This bus voltage signal applied to the ADC is used to calculate the rms value of the bus voltage across phases C and A (Bus V<sub>C-A</sub>).

#### Generator Voltage

Generator voltage is monitored at terminals E1 (A-phase), E2 (B-phase), and E3 (C-phase). Nominal voltages of up to 600 Vac may be sensed at these terminals. Voltage applied to these inputs is scaled and conditioned before being

applied to the input of the ADC. The voltage signal from phase C and A ( $V_{C-A}$ ) of the generator is used by the ADC to calculate the rms value of generator voltage across phases C and A. Likewise, the voltage signal from phase C and B ( $V_{C-B}$ ) of the generator is used by the ADC to calculate the rms value of generator voltage across phases C and B. The rms value of generator phase B to phase A voltage ( $V_{B-A}$ ) is calculated by the microprocessor from the phase C to phase A signal ( $V_{C-A}$ ) and the phase C to phase B ( $V_{C-B}$ ) signal.

Additionally, the generator phase C to phase A ( $V_{C-A}$ ) signal is applied to a filtered, zero-cross detector circuit. This signal is applied to the microprocessor and is used to calculate generator frequency.

#### B-Phase Line Current

The phase B line current (IB) signal is developed through a customer supplied current transformer (CT) and monitored through terminals CT1 and CT2. The current monitored at these terminals is scaled and conditioned by an internal current transformer and active circuitry for use by the ADC. The signal applied to the ADC is used to calculate the rms value of phase B line current.

Additionally, the phase angle between phase B line current and phase C to phase A generator voltage is calculated for use during droop and var/power factor operation.

Variations in the angle expected between the voltage and current (up to  $\pm 30^\circ$ ) can be accommodated with the phase compensation setting in BESTCOMS.

#### Accessory Input (Auxiliary Adjust)

This input allows adjustment of the DM110 regulation setpoint by the application of a 4 to 20 mA dc current through terminals A and B. The response of the regulation setpoint to the accessory input is dependent upon the operating mode of the DM110.

When operating in AVR mode, applying 20 mA dc of current from terminal A (+) to terminal B (-) will increase the regulation setpoint by 15%. Applying 4 mA dc of current from terminal A (+) to terminal B (-) decreases the regulation setpoint by 15%. Applying a value of 12 mA dc holds the setpoint at its present level.

When operating in Var mode, applying 20 mA dc of current from terminal A (+) to terminal B (-) will increase the var setpoint by 50% (lagging). Applying 4 mA dc of current from terminal A (+) to terminal B (-) decreases the var setpoint by 50% (leading). Applying a value of 12 mA dc holds the setpoint at its present level.

When operating in Manual (FCR) or Power Factor modes, applying 20 mA dc of current from terminal A (+) to terminal B (-) will increase the regulation setpoint by 30%. Applying 4 mA dc of current from terminal A (+) to terminal B (-) decreases the regulation setpoint by 30%. Applying a value of 12 mA dc holds the setpoint at its present level.

For all modes, if less than approximately 1.3 mA dc is applied or the Accessory input circuit is opened, the regulation setpoint will return to the nominal level.

The Accessory input introduces a 138  $\Omega$  burden on the dc source in series with a blocking diode voltage drop of approximately 0.7 V dc.

#### Field Voltage

Voltage ( $V_{FIELD}$ ) across the regulator field output terminals, F+ and F-, is monitored, scaled, and conditioned before being applied to the ADC. This signal is used to calculate the dc value of field voltage for use in system protection.

#### Field Current

Current ( $I_{FIELD}$ ) through the main power output switch is converted to a proportional voltage level. This voltage signal is scaled and conditioned before being applied to the input of the ADC. The result is used to calculate the dc value of field current for use in the Manual mode of operation as well as protection of the system.

### **Contact Input Circuits**

Five contact input circuits powered from an internal 13 V dc power supply provide input control from user-supplied, isolated, dry-type contacts.

#### Raise

Closing a contact across terminals 6U and 7 causes the active operating setpoint to increase. This function is active as long as the contact is closed. After the contact is open for 2 seconds, the new setpoint is saved and becomes the operating setpoint for future operation.

#### Lower

Closing a contact across terminals 6D and 7 causes the active operating setpoint to decrease. This function is active

as long as the contact is closed. After the contact is open for 2 seconds, the new setpoint is saved and becomes the operating setpoint for future operation.

#### Var/Power Factor Control/Excitation Limiter (52J/K)

Through BESTCOMS, the 52J/K contact input can be programmed to control either the var/power factor controller or the excitation limiter function. When the 52J/K contact input is programmed to control the var/PF controller, the excitation limiter is not available. Likewise, when the 52J/K contact input is programmed to control the excitation limiter, var/PF control is not available.

If the 52J/K contact input is configured to control the Var/Power Factor function:

- An open contact across terminals 52J and 52K enables Var/PF correction
- A closed contact across terminals 52J and 52K disables Var/PF correction

If the 52J/K contact input is configured to control the overexcitation limiter:

- An open contact across terminals 52J and 52K selects the setpoint of the OEL
- A closed contact across terminals 52J and 52K selects the setpoint of the excitation limiter

If neither var/power factor correction nor the excitation limiter is configured for control by the 52J/K contact input, then the open/closed state of the 52J/K contact input has no effect on DM110 operation.

#### Parallel Generator Compensation (52L/M)

Closing a contact across terminals 52L and 52M disables parallel operation. An open contact enables parallel operation and the DM110 operates in reactive droop compensation mode.

If the Var/Power Factor Control option is present and is enabled in the software, the 52J/K input has priority. Therefore, if the 52J/K and the 52L/M inputs are both open, the system operates in var/power factor mode. For more information, see *Voltage Matching Control Option*.

#### Voltage Matching Control

If the Voltage Matching option is enabled in the software, closing a contact across terminals VM and VMC causes the DM110 to operate in the voltage matching mode. An open contact disables voltage matching. Voltage matching is also disabled when either the 52J/K or 52L/M inputs are open.

### **RS-232 Communication Port**

The communication port provides the interface for user programming (setup) of the DM110. Connection is made to the female RS-232 (DB-9) connector with a user-supplied, standard 9-pin cable. The communication port is optically isolated and is powered from a transformer-isolated supply.

### **Microprocessor**

The microprocessor is the heart of the DM110 and performs measurement, computation, control, and communication functions by the use of its embedded programming and the nonvolatile settings stored in its memory.

### **Power Input Stage**

Input power applied to terminals 3, 4, and 5 is rectified and filtered before being applied to the power amplifier and the power supply. Input power may be single-phase or three-phase in the range of 88 to 250 Vac at a frequency of 50 to 400 hertz.

The input power source should be properly fused for the application.

### **Power Supply**

The internal switch-mode power supply receives power from the power input stage and supplies power at the required dc voltage levels to the internal circuitry of the DM110.

### **Power Amplifier Stage**

The power amplifier receives power from the power input stage and supplies a controlled amount of power to the exciter field via terminals F+ and F-. The amount of power supplied to the exciter field is based on gating pulses received from the microprocessor. The power amplifier uses a solid state power switch to provide the required power to the exciter field. Power amplifier output to the field is rated up to 63 Vdc at 7 Adc continuous and 135 Vdc at 15 Adc for 10 seconds.

## Front Panel Indicators

Nine front-panel LED indicators light to indicate various protective functions and operating modes. Section 2, *Human-Machine Interface* provides more information about the front panel indicators.

## Relay Output

A common alarm output contact is provided through terminals AL1 and AL2. During normal operating conditions, the contacts are closed. The contacts open to indicate an alarm condition, trip condition, or loss of operating power. The relay output is non-latching.

---

## DM110 OPERATING FEATURES

The following paragraphs describe the characteristics of each DM110 operating feature.

### Operating Modes

The DM110 provides up to four modes of operation selectable through BESTCOMS software. Automatic voltage regulation mode and Manual mode are standard features. Var and Power Factor modes are an option.

#### *Automatic Voltage Regulation Mode*

In Automatic Voltage Regulation (AVR) mode, the DM110 regulates rms generator output voltage. This is accomplished by sensing generator output voltage and adjusting dc output excitation current to maintain voltage at the regulation setpoint. The regulation setpoint is adjusted by the Raise and Lower contact inputs, the Accessory input, or through BESTCOMS software. The regulation point may also be modified by the Droop function or the Underfrequency function under certain conditions.

#### *Manual Mode*

In Manual mode, also known as Field Current Regulation (FCR) mode, the DM110 maintains dc excitation current at a set level. The current-level setpoint is adjustable from 0.03 to 7 Adc in 0.01 Adc increments by the Raise and Lower contact inputs, the Accessory input, or through BESTCOMS software. Var

 <b>CAUTION</b>
<b>The Manual mode excitation level must be evaluated prior to enabling this feature. If the level of excitation current is inappropriate for the generator, severe damage to the generator may occur.</b>

#### *Var Control Mode*

In Var Control mode, the DM110 maintains generator vars (volt-amperes, reactive) at a set level when paralleling with an infinite bus. The DM110 calculates generator vars by using the sensed generator output voltage and current quantities. It then adjusts the dc excitation current to maintain vars at the setpoint. Var control is enabled and disabled through BESTCOMS software. When the software is turned on, var control is enabled or disabled through the Var/Power Factor Control (52J/K) contact input circuit. The var setpoint is adjustable from 100 percent absorb to 100 percent generate through the Raise and Lower contact inputs, the optional Accessory input, or through BESTCOMS software. Var control mode is mutually exclusive with the second overexcitation limiter—when var correction is enabled, the second OEL is not available.

#### *Power Factor Control Mode*

In Power Factor Control mode, the DM110 maintains generator power factor at a set level when paralleling with an infinite bus. The DM110 calculates generator power factor using the sensed generator output voltage and current quantities and then adjusts the dc excitation current to maintain power factor at the setpoint. Power factor control is enabled or disabled through BESTCOMS software. When the software is turned on, it is enabled or disabled through the Var/Power Factor Control (52J/K) contact input circuit. The power factor setpoint is adjustable between 0.6 lag and 0.6 lead through the Raise and Lower contact inputs, the Accessory input, or through BESTCOMS software. Power Factor control mode is mutually exclusive with the excitation limiter—when power factor correction is enabled, the excitation limiter is not available.

## Reactive Droop Compensation

The DM110 provides a reactive droop compensation feature to assist in the sharing of reactive load during parallel generator operation. When this feature is enabled, the DM110 calculates the reactive portion of the generator load using the sensed generator output voltage and current quantities and then modifies the voltage regulation setpoint accordingly. A unity power factor generator load results in almost no change in generator output voltage. A lagging power factor generator load (inductive) results in a reduction of generator output voltage. A leading power factor generator load (capacitive) results in an increase of generator output voltage. Droop is adjustable up to 10 percent with rated, nominal B-phase line current (1 ampere or 5 amperes applied through terminals CT1 and CT2) and 0.8 power factor. The droop feature is enabled and disabled through the Parallel Generator Compensation contact input circuit (terminals 52L and 52M). Droop is also disabled when operating in var or power factor control modes.

## Underfrequency

When generator frequency drops below the selected knee frequency setpoint, the voltage setpoint is automatically adjusted by the DM110 so that generator voltage follows the selected PU (per unit) V/Hz curve. When operating on the selected PU V/Hz curve, the Underfrequency Active indicator lights on the front panel and in BESTCOMS. Underfrequency control is disabled below 12 hertz. The knee frequency is adjustable from 40 to 65 hertz in 0.1 hertz increments and the PU V/Hz curve may be set at a slope of 0 to 3 in 0.01 steps through BESTCOMS software. A slope of 0 effectively disables the underfrequency function. The DM110 has a minimum regulation point of approximately 30 percent of the nominal setpoint.

## Dwell

The dwell function introduces a time-based response to the recovery of the voltage based upon the recovery of the speed, magnitude of the voltage dip, and the dwell setting in BESTCOMS. The purpose of the delay is to reduce the generator kW below the available engine kW during the recovery period, thus allowing an improved speed recovery. This control is effective only during load switching when the speed decreases below the underfrequency knee setting. If the speed stays above the knee during a load transient, the dwell function will have no effect on the recovery. This feature is typically used with a generator coupled to a turbocharged engine with limited block load acceptance. With the dwell setting disabled, the response will follow the V/Hz curve selected. Increasing the dwell setting increases the delay time between speed recovery and voltage recovery. Higher settings result in a quicker voltage recovery for a given condition. Lower settings result in a slower recovery for a given condition.

## Protection

The DM110 includes three protective functions: generator overvoltage, loss of sensing voltage, and field overvoltage. Each protective function has a corresponding front panel indicator that lights when the function is active. An active protective function is also annunciated through BESTCOMS.

### Generator Overvoltage

A generator overvoltage condition can be configured (in BESTCOMS) to open the DM110 relay output, disable the DM110, initiate both actions, or initiate neither action. When the sensed generator voltage increases above the adjustable voltage level setpoint for the duration of the adjustable alarm time delay, the DM110 initiates the selected action.

If the DM110 is configured to open the relay output, a generator overvoltage condition will light the front panel and BESTCOMS Generator Overvoltage indicator and open the relay output at terminals AL1 and AL2.

If the DM110 is configured for hardware shutdown, a generator overvoltage condition will disable the DM110 after the alarm time delay expires. When the DM110 is powered up following a generator overvoltage shutdown, the Generator Overvoltage indicator will light for five seconds.

The voltage level setpoint is adjustable from 100 to 120 % of the system voltage setting. The alarm time delay is adjustable from 0 to 10 seconds.

### Loss of Sensing Voltage

The DM110 monitors the sensed generator output voltage and takes protective action if a loss of sensing voltage is detected. A loss of sensing voltage is detected during the following conditions.

- The sensed voltage is less than 50 percent of the rated voltage (one-phase or three-phase sensing).
- A total loss of any phase occurs (three-phase sensing).
- The voltage difference between any phase (line-to-line) and the three-phase average exceeds 20 percent of nominal (three-phase sensing).

A time delay of 0 to 25 seconds is adjustable through BESTCOMS software. This delays the protective action in order to allow field forcing in applications that do not sense B-phase generator current. The default time delay setting is 10 seconds.

BESTCOMS software allows the selection of one of two protective actions for a loss of sensing. Either a complete shutdown or a transfer to Manual mode may be selected.

If shutdown is selected and a loss of sensing occurs, the Loss of Generator Sensing indicator on the front panel and in BESTCOMS lights, the relay output opens, and the DM110 shuts down after the adjustable time delay expires. When the DM110 is powered up following a loss of generator sensing shutdown, the Loss of Generator Sensing indicator will light for five seconds. However, if the loss of sensing conditions still exists, the DM110 will not shut down due to loss of sensing until the soft-start time delay and the loss of sensing time delay expires.

If transfer to Manual is selected and a loss of sensing occurs, the relay output opens, the front panel and BESTCOMS Loss of Generator Sensing indicators latch on, and the DM110 transfers to the Manual mode of operation after the adjustable time delay expires. The loss of generator sensing indication is active until the DM110 detects the restoration of sensing or DM110 operating power is removed. If DM110 operating power is removed during a loss of sensing voltage, the loss of sensing voltage alarm is retained and re-activated for five seconds upon restoration of operating power (providing that the loss of sensing voltage was the last active alarm prior to DM110 power-up). The DM110 will remain in Manual operating mode until switched via BESTCOMS. Before selecting transfer to Manual on loss of sensing, it is necessary to determine an appropriate Manual (FCR) mode setpoint level to be transferred to. An inappropriate excitation level could result in severe damage to equipment.

This function is disabled when the frequency decreases below 12 hertz or when a generator short circuit condition is detected. A generator short-circuit is determined when the B-phase CT current exceeds three times the per unit value. Loss of sensing shutdown or transfer is not active during the soft-start time.

#### Field Overvoltage (Overexcitation Shutdown)

A field overvoltage condition can be configured (in BESTCOMS) to open the DM110 relay output, disable the DM110, initiate both actions, or initiate neither action. When the field voltage increases above the adjustable voltage level setpoint for the fixed duration of 10 seconds, the DM110 initiates the selected action.

If the DM110 is configured to open the relay output, a field overvoltage condition will light the front panel and BESTCOMS Overexcitation Shutdown indicator and open the relay output at terminals AL1 and AL2.

If the DM110 is configured for hardware shutdown, a field overvoltage condition will disable the DM110 after the 10 second time delay expires. When the DM110 is powered up following a field overvoltage shutdown, the Overexcitation Shutdown indicator will light for five seconds.

The voltage level setpoint is adjustable from 0 to 250 Vdc. The field overvoltage time delay is fixed at 10 seconds.

### **Limiters**

DM110 limiters consist of two field excitation limiters triggered by an increase in field current and an underexcitation limiter (UEL) triggered by excessive leading vars. The first field excitation limiter functions as an overexcitation limiter (OEL) that limits and protects against excessive field current. The second field excitation limiter limits the field current during normal operating conditions that are not indicative of a fault.

#### Overexcitation Limiting

The DM110 provides two types of overexcitation limiting: summing point and takeover. Both field excitation limiters use the same type of limiting.

*Summing Point Field Excitation Limiter.* When the level of field current increases above the adjustable current level setpoint, the front panel and BESTCOMS Overexcitation Limiting indicators light. If the overexcitation condition persists for the duration of the user-adjustable alarm time delay, the relay output at terminals AL1 and AL2 opens.

The advantage of a summing-point type of field excitation limiter is that it can provide a smooth transition into and out of the limit. Its drawback is that it does not control field current directly, but has to work through the normal voltage regulator, and may be influenced by changes in terminal voltage.

*Takeover Field Excitation Limiter.* When takeover-style overexcitation limiting is used, the level of field current at which limiting occurs is determined by an adjustable current level setpoint. If the field current increases above the adjustable current level setpoint, the front panel and BESTCOMS Overexcitation Limiting indicators light and the field current is limited and forced to follow the inverse time curve.

The advantage of a takeover type of field excitation limiter is that it provides direct control of the exciter field current without relying on the normal voltage regulator's control action. Its drawback is that it may not provide a smooth transition into and out of the limit.

If hardware shutdown is enabled, the DM110 will be disabled when the time delay expires. When the DM110 is powered up following a shutdown triggered by overexcitation limiting, the Overexcitation Limiting indicator will light for five seconds.

Separate current level setpoints are provided for the first and second excitation limiter. Each excitation limiter has a current level setpoint that is adjustable from 0 to 15 Adc. Both field excitation limiters share the same alarm time delay which is adjustable from 0 to 10 seconds. The type of field excitation limiter selected is used by both the OEL and excitation limiter. The excitation limiter cannot be set above the overexcitation limit.

#### Underexcitation Limiting

When the level of leading vars increases above the adjustable var level setpoint, the front panel and BESTCOMS Underexcitation Limiting indicators light. If the underexcitation condition persists for the duration of the adjustable alarm time delay, the relay output at terminals AL1 and AL2 opens.

If hardware shutdown is enabled, the DM110 will be disabled when the time delay expires. When the DM110 is powered up following a shutdown triggered by underexcitation limiting, the Underexcitation Limiting indicator will light for five seconds.

The var level setpoint is adjustable from 0 to 100% of the rated vars. The rated var level is determined by the following equation:

$$\text{rated var level} = V_{AVG} \times I_B \times \sqrt{3}$$

where  $I_B$  is the DM110 nominal current sensing rating (1 Aac or 5 Aac)

The alarm time delay is adjustable from 0 to 10 seconds.

#### **Soft Start**

The DM110 also incorporates an adjustable soft start feature that controls the time for generator voltage or field current to ramp to the regulation setpoint. The ramp rate is adjustable from 1 to 7,200 seconds in 1 second increments through BESTCOMS. The underfrequency feature is also active during soft start and takes priority in control of the generator voltage in an effort to minimize voltage overshoot.

#### **Voltage Matching**

Voltage matching is useful when the PT ratios in an application are not matched exactly. Using BESTCOMS to enter the generator PT ratio and bus PT ratio will automatically compensate for the offset. The DM110 voltage matching option automatically matches the rms generator output with the rms bus voltage prior to synchronizing. The DM110 compares and matches the generator voltage with the bus voltage by adjusting the dc excitation current. Voltage matching is enabled when the bus voltage is within 10% of the nominal sensing range selected. As long as the values of generator and bus voltage (applies to the DM110 voltage sensing inputs) are within the acceptable range, voltage matching can be achieved.

The rate at which the DM110 matches the generator input level with the bus input level is controlled by a voltage matching speed setting. This setting is adjustable from 1 to 300 seconds in 0.01 second increments.

Voltage matching can be disabled by the state of the DM110 contact inputs. In BESTCOMS, the 52J/K contact input, 52L/M contact input, or both contact inputs can be configured to enable and disable voltage matching. To enable bus voltage matching, select 52J/K. This will allow droop to remain active. When the utility tie breaker closes, voltage matching will be disabled automatically (via the 52J/K contact input) and var/power factor control will be enabled.

Two voltage matching modes are available: Maintain and Revert. When Maintain mode is implemented, the DM110 setpoint is maintained at the bus voltage level even when the generator or utility breaker is open. When Revert mode is implemented, the DM110 setpoint reverts to its original level when the generator or utility breaker opens. Revert is the default voltage matching mode.

#### **NOTICE**

**The UEL function is active only during parallel operation when the 52J/K contact input or 52L/M contact input is open.**

## SECTION 4 • INSTALLATION

---

### INTRODUCTION

DM110 Digital Excitation Control Systems are delivered in sturdy cartons to prevent shipping damage. Upon receipt of a system, check the part number against the requisition and packaging list for agreement. Inspect for damage, and if there is evidence of such, immediately file a claim with the carrier and notify your sales representative.

If the unit is not installed immediately, store it in the original shipping package in a moisture- and dust-free environment.

---

### MOUNTING

The DM110 is normally located in the generator conduit box. It is designed for behind the panel mounting and requires a cutout for front panel viewing. Supplied mounting hardware consists of six #12 thread-forming screws that pass through mounting holes in the conduit box and thread into the plastic shell of the DM110. The recommended torque range for the steel mounting screws is 4.07 to 4.52 newton-meters (36 to 40 inch-pounds). The unit must be mounted where the ambient temperature does not exceed the allowable environmental conditions called out in Section 1, *General Information, Specifications*. DM110 package dimensions are shown in Figure 4-1. Cutout and drilling dimensions are shown in Figures 4-2 and 4-3. Figure 4-2 illustrates part number E000-23800 (Basler P/N 9287500138), which has its LED indicators located on the bottom side of the unit. Figure 4-3 illustrates part number E000-23801 (Basler P/N 9287500139), which has its LED indicators located on the top side of the unit. Drawing dimensions are shown in inches and millimeters (in parenthesis).

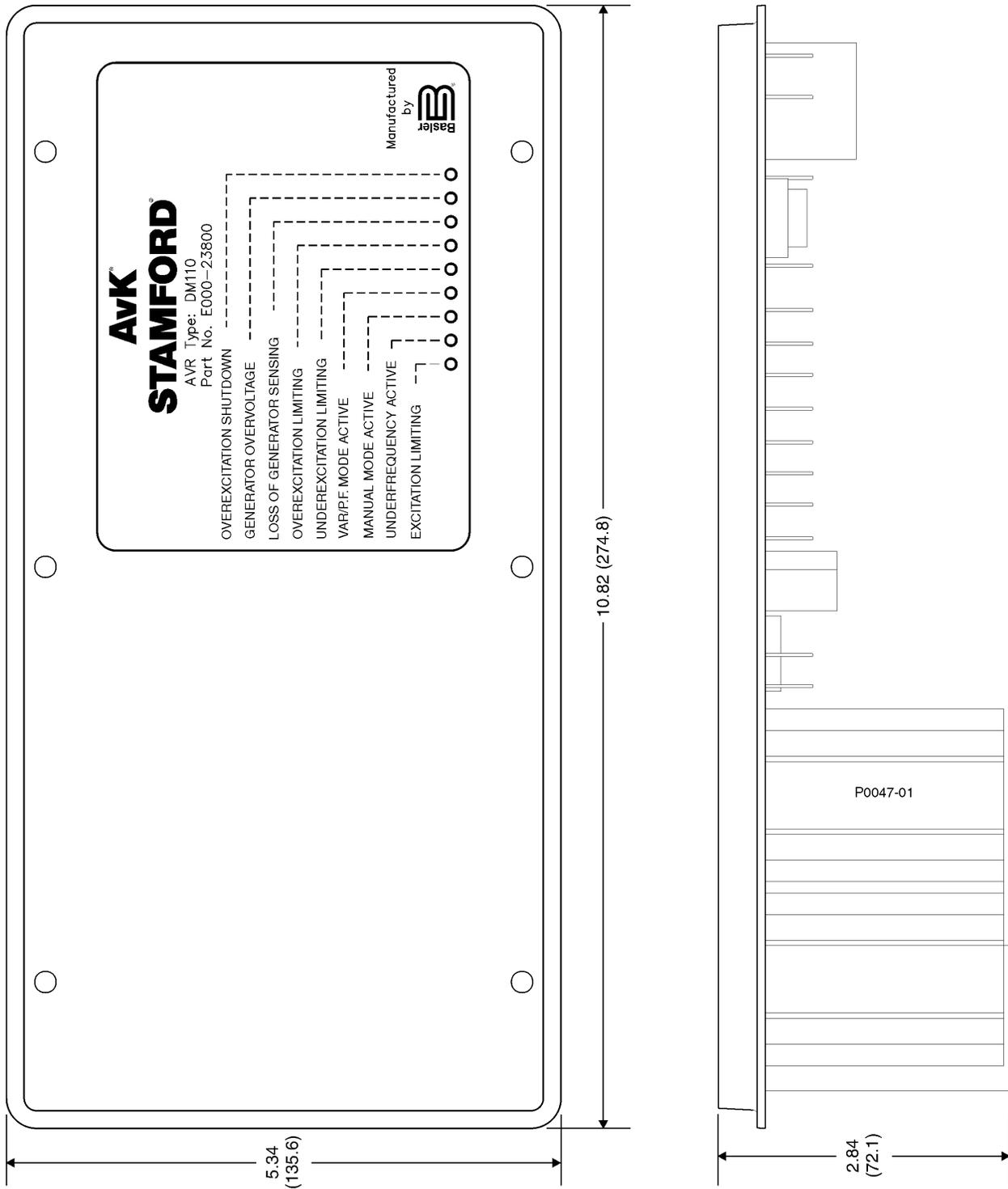


Figure 4-1. DM110 Dimensions

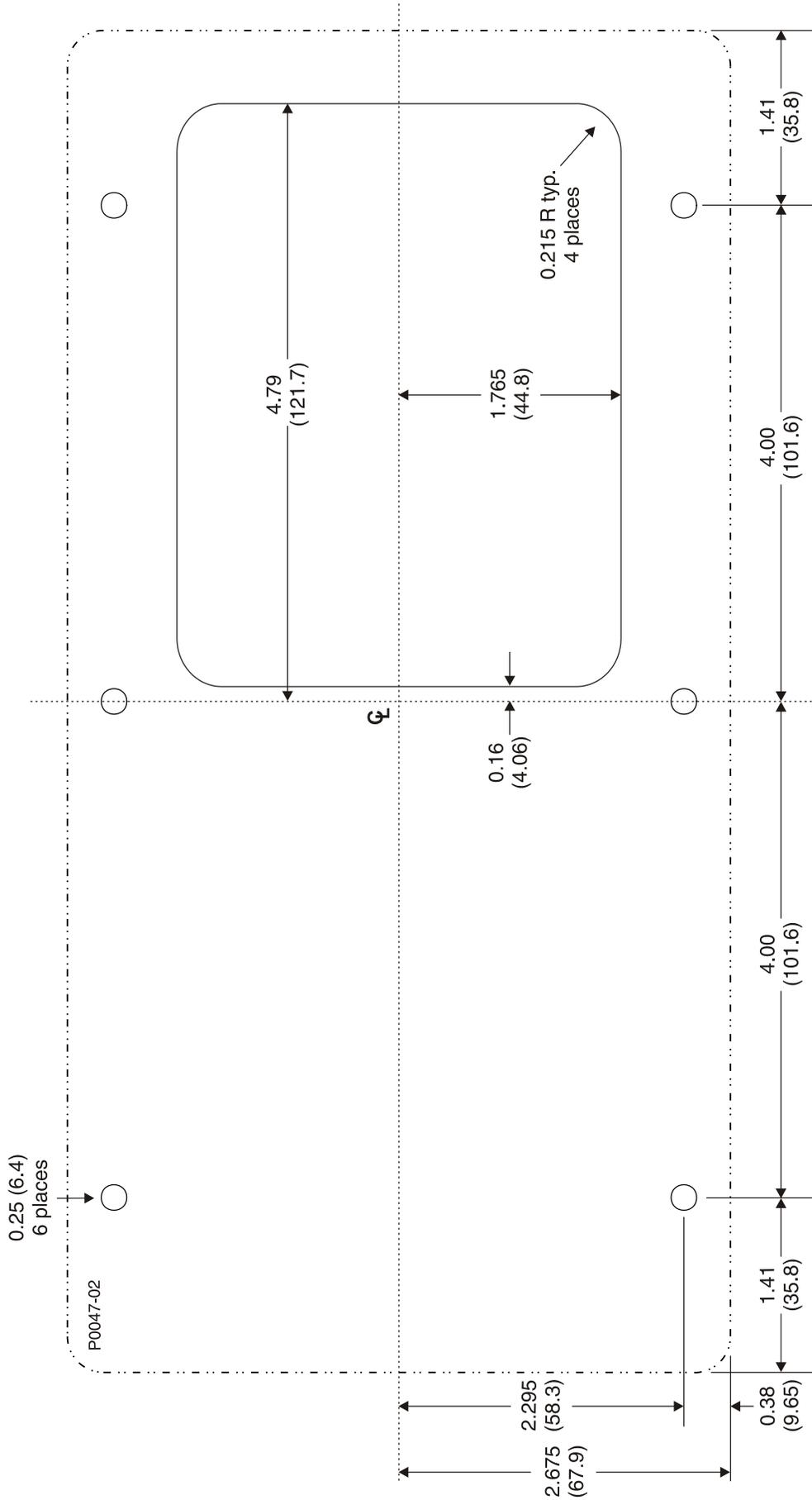


Figure 4-2. Cutout and Drilling Dimensions, P/N E000-23800

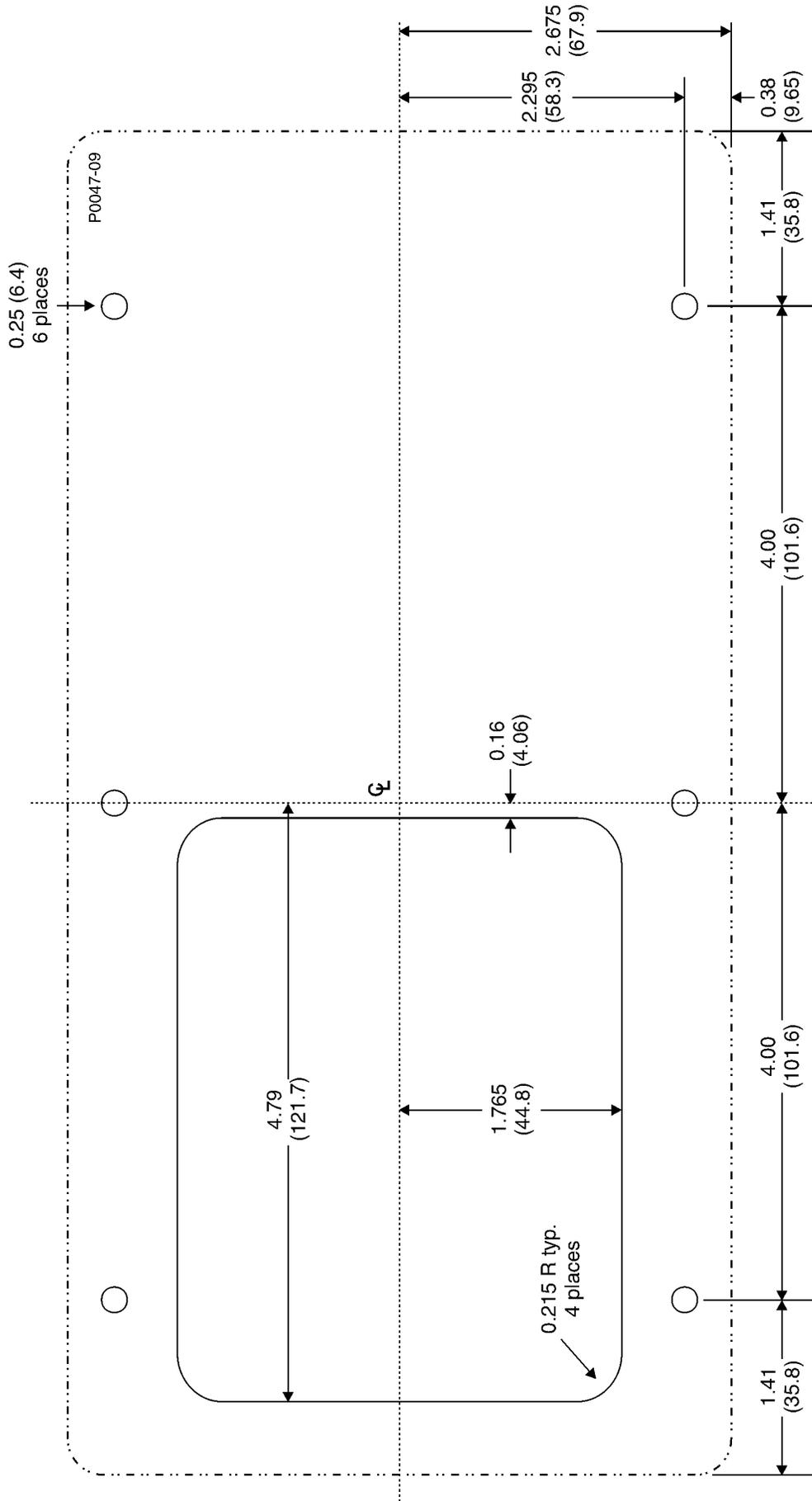


Figure 4-3. Cutting and Drilling Dimensions, P/N E000-23801

## CONNECTIONS

DM110 connections are dependent on the application and excitation scheme. Incorrect wiring may result in damage to the unit. Check the part number to ensure that you have the correct unit before connecting and applying power.

<b>NOTICE</b>
<p><b>Be sure that the DM110 is hard-wired to earth ground with no smaller than 12 AWG copper wire attached to the ground terminal on the rear of the unit case. When the unit is configured in a system with other devices, connect a separate lead from the ground bus to each DM110 unit.</b></p>

### DM110 Terminations

DM110 units have two types of interface terminals. One type is quarter-inch, quick-connect terminals and the other is a 9-pin DB9 connector. All terminals are located on the rear of the unit. The quarter-inch, quick-connect terminal labels are located on the rear of the case. Wires performing common functions, such as voltage sensing leads, should be grouped together. The 9-pin DB-9 type connector is used for temporary interface with both IBM compatible PCs and hand-held computers.

Figure 4-4 shows the terminal connections located on the rear panel of the DM110. Except as noted above, connections should be made with minimum wire size of 14 AWG.

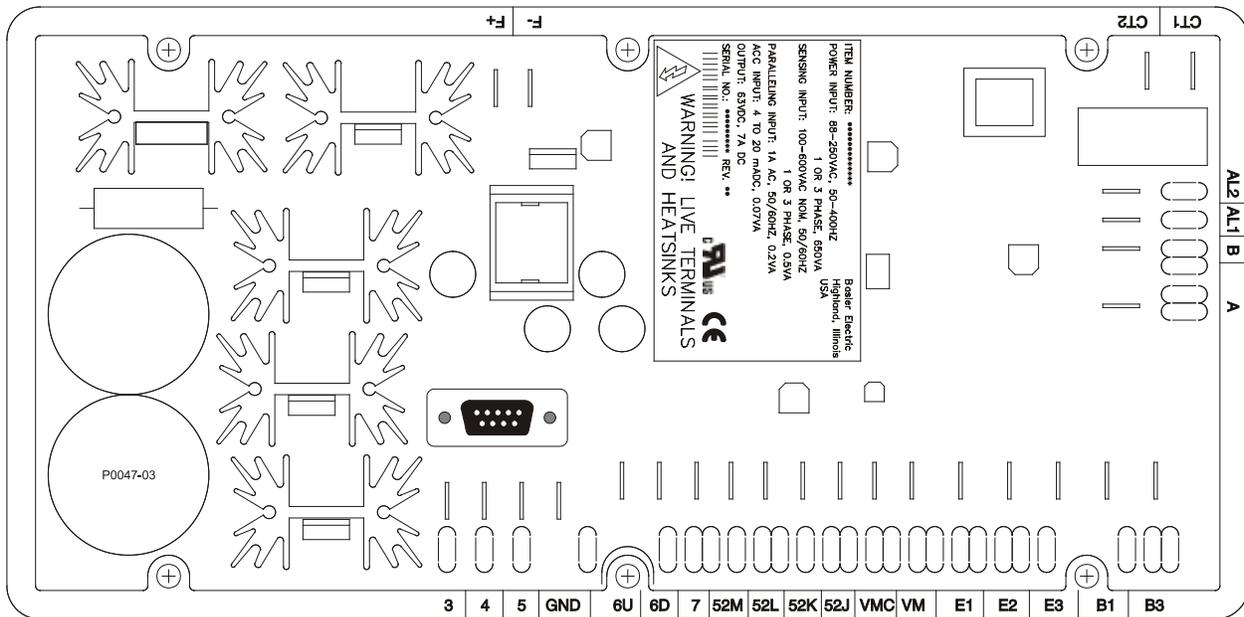


Figure 4-4. DM110 Terminals

### Bus Voltage Sensing Inputs

The bus voltage sensing terminals are labeled B1 and B3. These terminals are used only on units that include the Voltage Matching option. The bus input is not phase sensitive to generator sensing. Table 4-1 lists the terminal assignments for bus voltage sensing.

Table 4-1. Bus Voltage Sensing Terminals

Bus Voltage Phase	Terminal
A	B1
C	B3

## Generator Voltage Sensing Inputs

The generator voltage sensing terminals are labeled E1, E2, and E3. The DM110 comes equipped for three-phase sensing as standard. Single-phase sensing is obtained by connecting the C-phase sensing input to terminals E2 and E3. Table 4-2 lists the terminal assignments for three-phase and single-phase generator voltage sensing.

*Table 4-2. Generator Voltage Sensing Terminals*

Sensing	Generator Phase	Terminal
3-Phase	A	E1
	B	E2
	C	E3
1-Phase	A	E1
	C	E2, E3

## Phase B Line Current Sensing Input

Generator line current is stepped down through a user-supplied current transformer (CT). Secondary current from that transformer is applied to terminals labeled CT1 and CT2.

## Accessory Input

The accessory input terminals are labeled A and B and accept a control input of 4 to 20 mAdc. Applying 4 mAdc from terminal A (+) to terminal B (–) causes a –15% (AVR mode), –30% (FCR or Power Factor modes), or –50% (Var mode) change in the active mode setpoint. Applying 20 mAdc from terminal A (+) to terminal B (–) causes a +15% (AVR mode), +30% (FCR or Power Factor modes), or +50% (Var mode) change in the active mode setpoint. Applying a value of 12 mAdc holds the active mode setpoint at its present level. If less than approximately 1.3 mAdc is applied or the Accessory input circuit is opened, the regulation setpoint will return to the nominal level.

## Raise and Lower Contact Inputs

Remote setpoint adjustment may be accomplished by connecting a single-pole, double-throw (SPDT), spring return, center-off switch to the terminals labeled 6U, 7, and 6D. To connect this switch, the center pole, or common terminal, must be connected to terminal 7. The other two terminals are connected to terminals 6U and 6D.

This remote adjust switch may be mounted up to 150 feet away from the DM110 when using twisted, shielded cable. Only dry, ungrounded switching contacts should be applied to the Raise and Lower contact inputs.

## Var/Power Factor Control/Second Overexcitation Limiter Contact Input

A customer-supplied enable/disable contact for this function connects to the terminals labeled 52J and 52K.

Only dry, ungrounded switching contacts should be applied to terminals 52J and 52K.

## Parallel Generator Compensation

A customer-supplied enable/disable contact for this function connects to the terminals labeled 52L and 52M.

Only dry, ungrounded switching contacts should be applied to the Parallel Generator Compensation contact input.

## Parallel Control and Var/PF/OEL/Excitation Limiter Control Inputs

User-supplied contacts at terminals 52L and 52M determine whether AVR or Droop mode is active. Terminals 52L and 52M typically connect to a 52b auxiliary contact of the generator breaker. User-supplied contacts at terminals 52J and 52K control whether var/power factor correction or the second overexcitation limiter is active or disabled. Terminals 52J and 52K typically connect to the auxiliary contacts of the utility tie breaker. Table 4-3 lists the operating modes achieved for the different 52L/M and 52J/K contact states. A closed state indicates a continuous contact closure and an open state indicates a continuous open-circuit.

Table 4-3. 52L/M and 52J/K Control Modes

DM110 Operating Mode	52L/M	52J/K	Generator Operating Mode
AVR mode active, no droop, optional var/PF mode disabled	Closed	Closed	Single unit/stand-alone
Droop mode active, optional var/PF mode disabled	Open	Closed	Paralleled to the utility grid (droop) or two or more generators islanded (droop or CCC)
Var/PF mode active	Open	Open	Paralleled to utility grid
Excitation limiter mode active	N/A	Open	OEL setpoint enabled
Excitation limiter mode active	N/A	Closed	Excitation limiter setpoint enabled

### Voltage Matching

A customer-supplied enable/disable contact for this function connects to the terminals labeled VM and VMC. Only dry, ungrounded switching contacts should be applied to the Voltage Matching contact input.

Voltage matching is also enabled/disabled by the state of the 52J/K and/or 52L/M contact inputs. In BESTCOMS, voltage matching can be configured to be disabled when the 52J/K or 52L/M contact input is open or just the 52J/K contact input is open.

### Power Supply Inputs

Power input terminals are labeled 3, 4, and 5. Single-phase or three-phase power may be applied. Single-phase power may be applied to any two of the three terminals.

The DM110 can be powered directly from a variety of sources as long as the DM110 input power specifications are followed (see Section 1, General Information, Specifications).

Examples of DM110 operating power sources are:

- Generator (shunt fed)
- Permanent magnet generator (PMG)
- Auxiliary winding

When powering the DM110 from a low-impedance power source, special provisions must be made to avoid damage to the DM110. Examples of a low-impedance power source include a station service source or power outlet. An Inrush Current Reduction Module, ICRM-7, must be connected between the power source and DM110 input power terminals (see Figure 4-10). The ICRM-7 prevents DM110 damage by minimizing the level of inrush current. The ICRM-7 can also be used when programming the DM110. However, the Preliminary Setup paragraphs illustrate an alternate method for temporarily powering the DM110 for programming.

More details about the ICRM-7 are available in Basler Electric publication 9387900990.

### Chassis Ground

The chassis ground terminal is labeled GND.

### Power (Field) Output

The field output terminals for connection to the generator exciter field are labeled F+ and F–.

### Relay Output (Alarm)

The common alarm relay output contact may be accessed at the terminals labeled AL1 AND AL2.

**Communication Port**

The RS-232 port on the rear panel uses a DB-9 female connector. Figure 4-5 illustrates the pin assignments of the communication port and Table 4-4 identifies the RS-232 connector pin functions. A standard communication cable terminated with a DB-9 male connector is used for PC interface with the DM110 as shown in Figure 4-6.

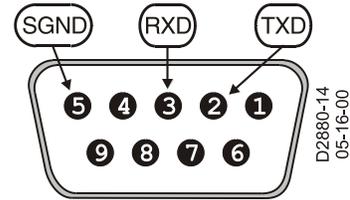


Figure 4-5. RS-232 Port Pin Assignments

Table 4-4. Communication Port Pin Functions

Pin	Function	Name	Direction
1	N/C	—	N/A
2	Transmit data	TXD	From DM110
3	Receive data	RXD	To DM110
4	N/C	—	N/A
5	Signal ground	GND	N/A
6	N/C	—	N/A
7	N/C	—	N/A
8	N/C	—	N/A
9	N/C	—	N/A

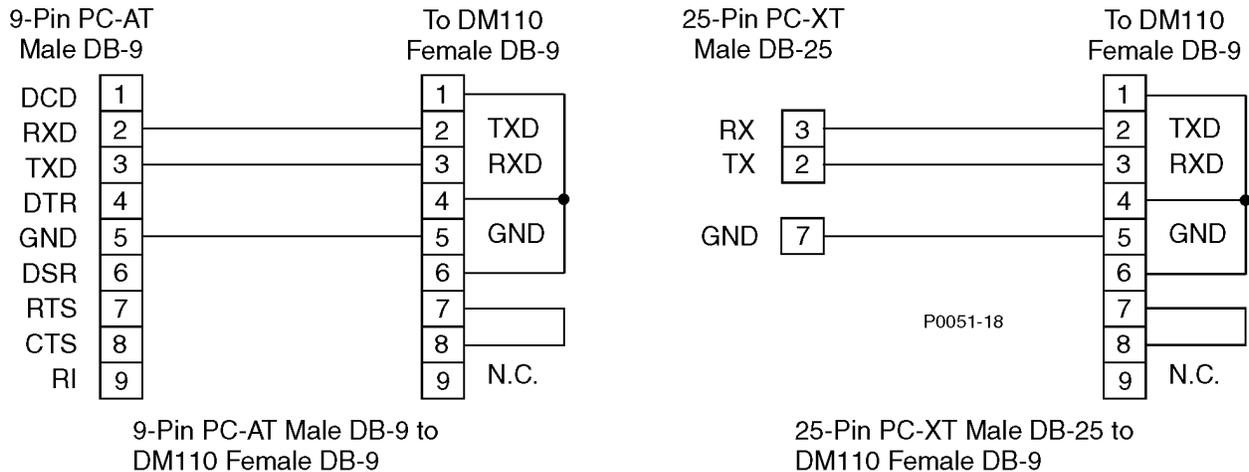


Figure 4-6. Personal Computer to DM110 Connections

**DM110 Connections for Typical Applications**

Figures 4-7 through 4-11 illustrate typical applications using the DM110. Figure 4-7 shows an application where DM110 operating power is derived from a permanent magnet generator (PMG) and three-phase voltage sensing is applied to the DM110. Figure 4-8 shows another PMG application but with single-phase voltage sensing. Figure 4-9 shows an application where DM110 operating power is derived from the generator output (shunt application) and three-phase voltage sensing is applied to the DM110. Figure 4-10 shows another shunt application but with single-phase sensing. Figure 4-11 shows a DM110 powered by single-phase station power in a three-phase sensing application.

Figure 4-12 shows a typical connection diagram for two paralleled generators operating in cross-current compensation (reactive differential) mode. The resistors shown have a value of 0.1 ohms. This is a typical value that can be used to set the burden. (Ensure that the resistor power rating is adequate for the installation.)

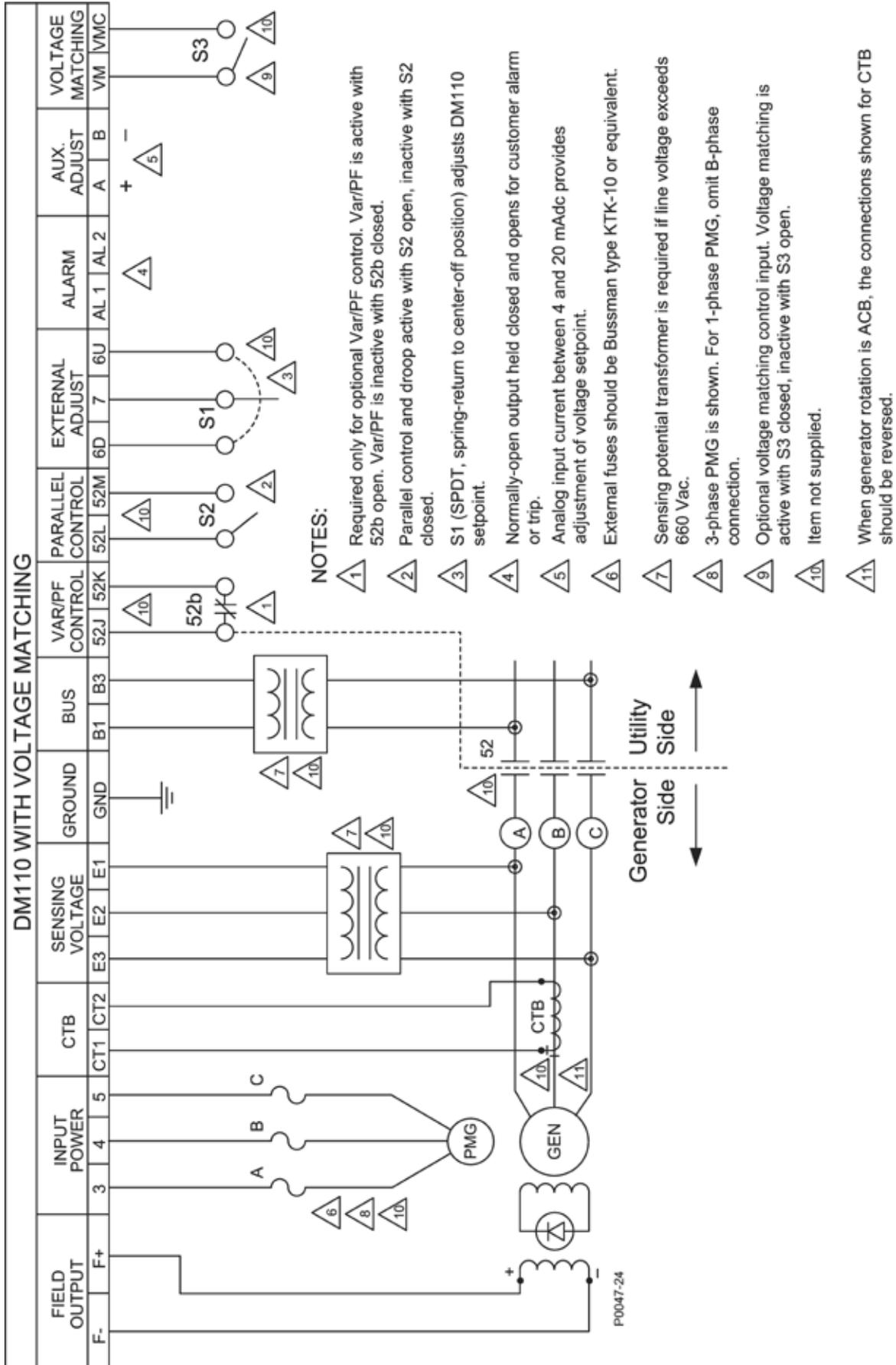


Figure 4-7. Typical Connections for PMG Application with ABC Rotation and Three-Phase Sensing

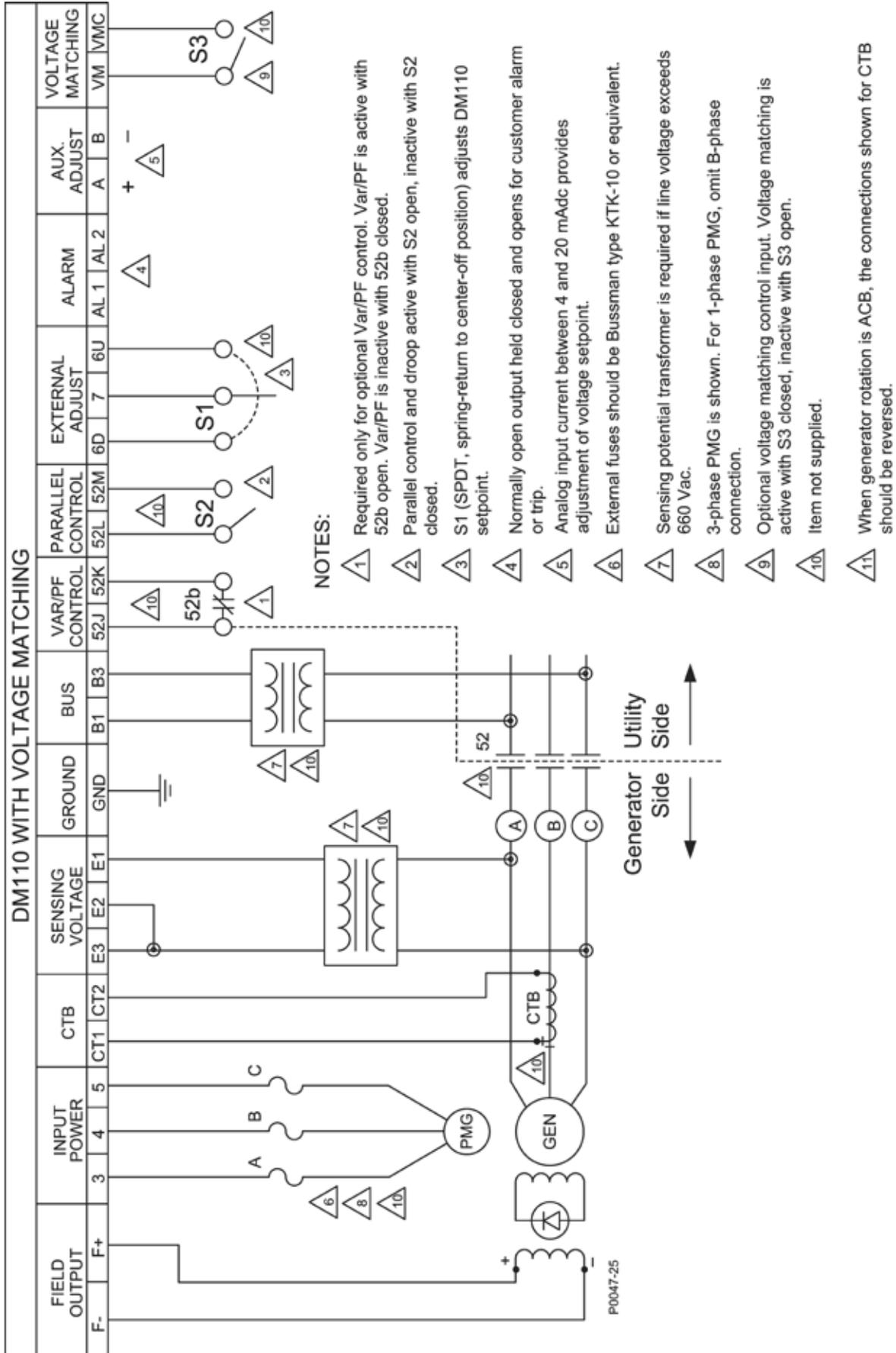
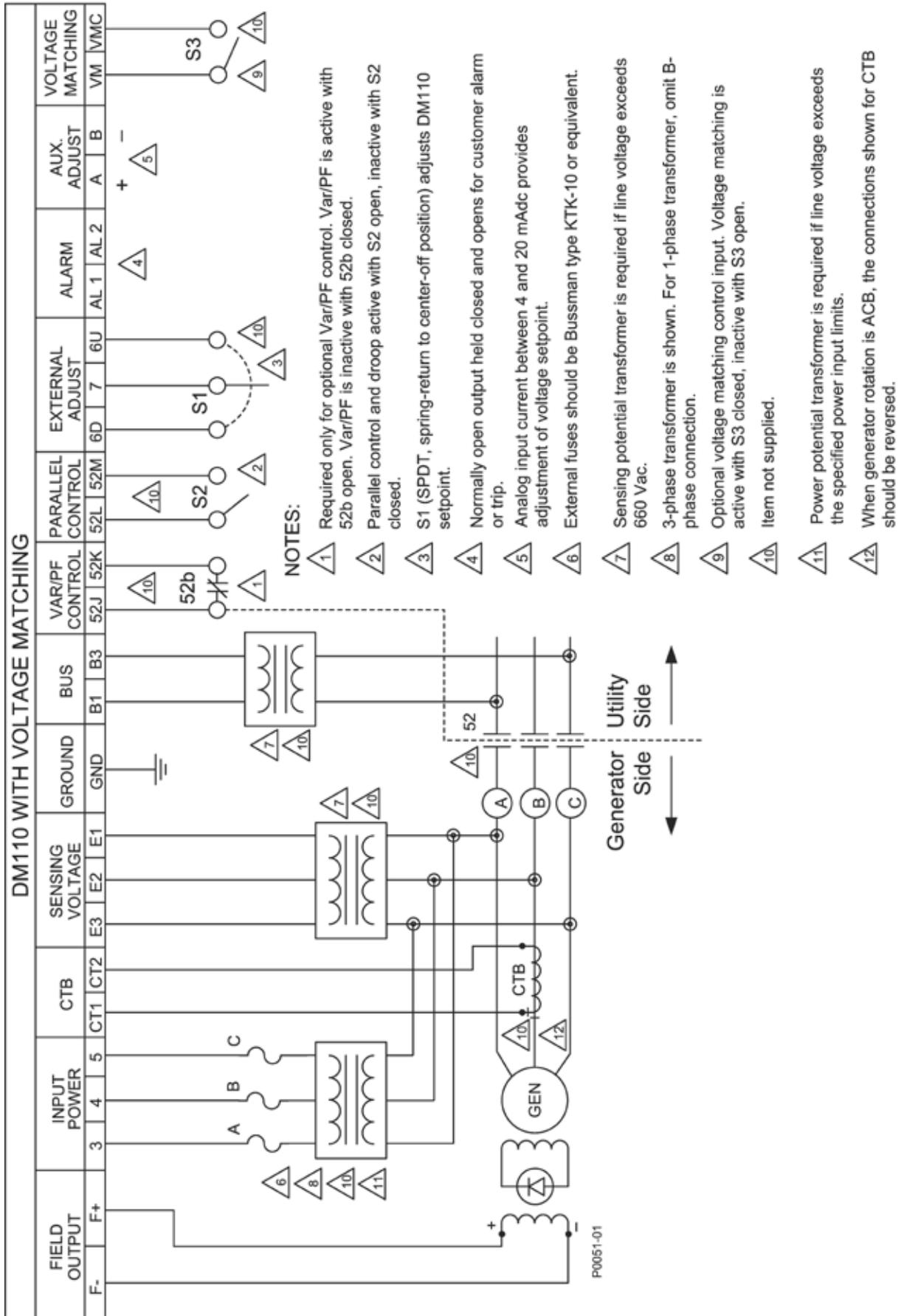


Figure 4-8. Typical Connections for PMG Application with ABC Rotation and Single-Phase Sensing



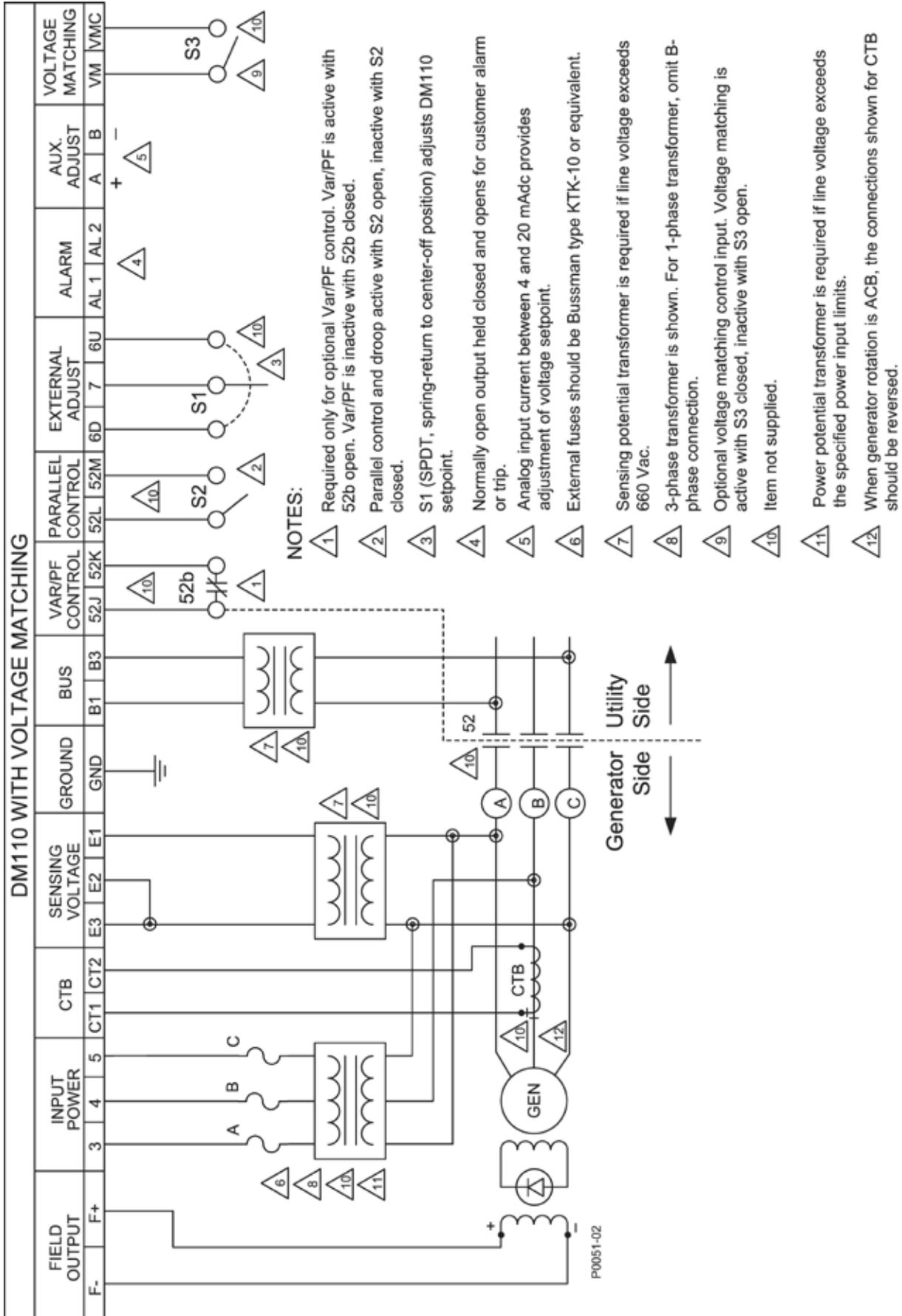


Figure 4-10. Typical Connections for Shunt Application with ABC Rotation and Single-Phase Sensing

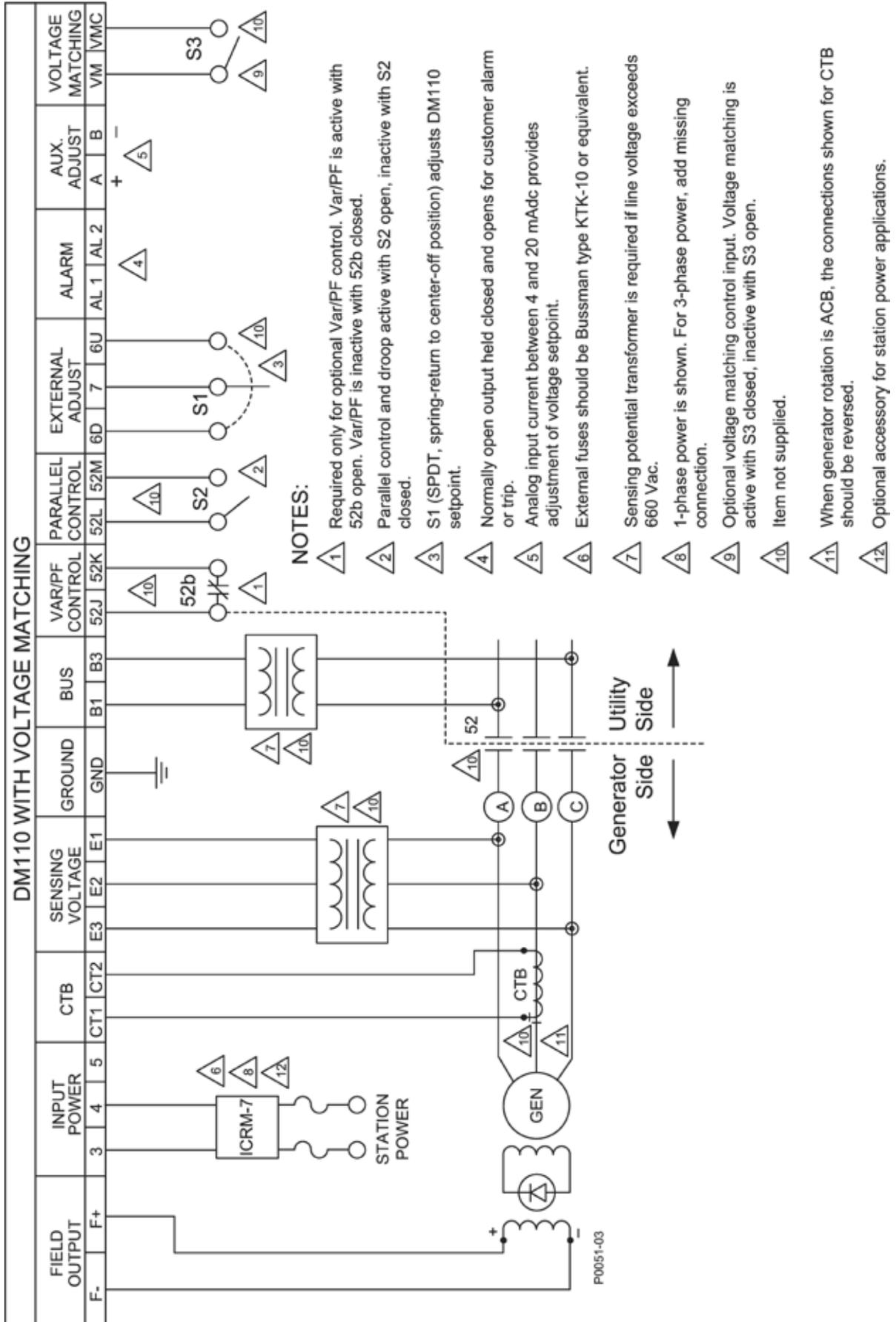


Figure 4-11. Typical Connections for Station Power Application and Three-Phase Sensing

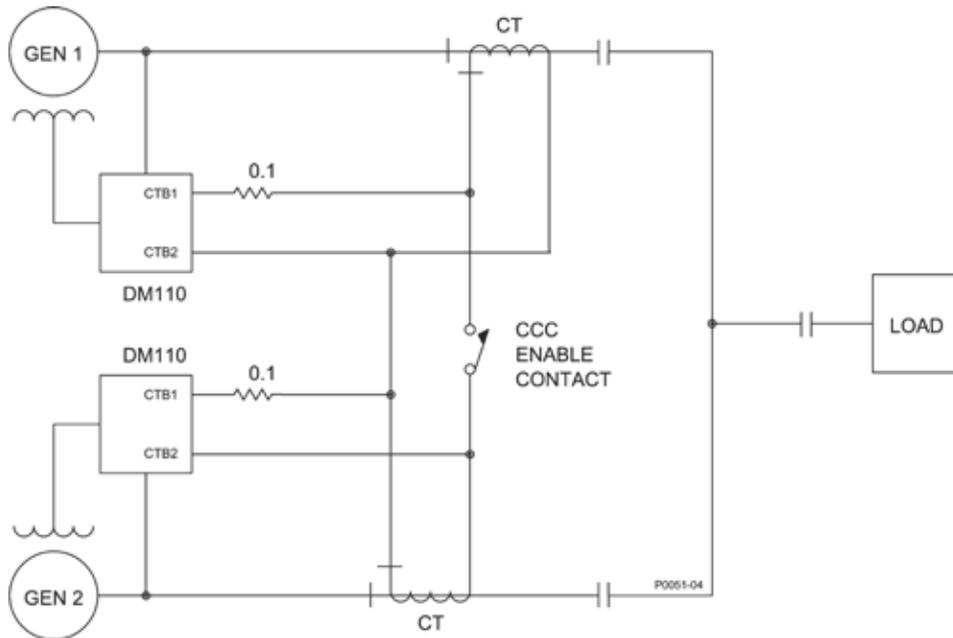


Figure 4-12. Cross-Current (Reactive Differential) Connections

## INSTALLATION FOR CE COMPLIANCE

The following paragraphs describe the mounting and wiring requirements for a CE (European Community) compliant installation.

### Mounting

The DM110 must be mounted inside a grounded, metal enclosure (conduit box). An access panel should cover the opening for the front panel display.

### Wiring

Wiring connected to the terminals listed below must be shielded. Each shield should be terminated to ground on the outside of the conduit box.

- Current sensing terminals CT1 and CT2
- Relay output terminals AL1 and AL2
- Var/Power Factor control/second OEL contact input terminals 52J and 52K
- Parallel generator compensation terminals 52L and 52M
- Raise and lower contact input terminals 6U, 6D, and 7
- Accessory input current terminals A and B
- Voltage matching contact input terminals VM and VMC

## PRELIMINARY SETUP

Before starting the generator and DM110 for the first time, proceed as follows.

### **WARNING**

**Lethal voltage is present at the rear panel when the unit is energized. Rear panel connections should be made only when the unit is de-energized.**

1. Tag and disconnect all wiring to the DM110. Be sure to insulate the wire terminals to prevent a short circuit.
2. Start the prime mover and perform all engine governor adjustments.

3. After all initial governor adjustments have been made, shut down the prime mover.
4. Connect only the DM110 power input terminals to an auxiliary power source. Before applying DM110 operating power, observe the precautions noted in Operating Power Considerations During DM110 Programming.
5. Perform all initial DM110 settings by connecting a PC operating with BESTCOMS to the rear communication port of the DM110 and save all new settings.
6. Remove power from the DM110.
7. Connect the rest of the DM110 leads using the tagged identification.
8. Start the prime mover/generator and perform the final adjustments at rated speed and load.
9. After the initial startup, the DM110 should not require any further adjustments unless there is a change in the system.

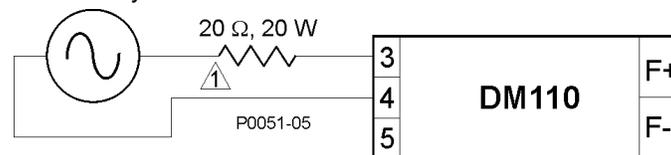
### Operating Power Considerations During DM110 Programming

Due to its pulse-width modulated (PWM) power stage, the DM110 operating power input has a substantial amount of capacitance. High inrush current can be experienced upon DM110 power-up when a “solid” power source is used. When powering the DM110 for programming with voltage greater than 120 Vac, high inrush current may damage the unit. Therefore, during programming, DM110 operating power should be within the range of 30 to 120 Vac (50/60 Hz).

#### ⚠ CAUTION

**When programming the DM110 without the generator spinning, the connections to DM110 terminals F+ and F- should be removed.**

If it is necessary to perform programming with applied operating power over 120 Vac, a current-limiting resistor must be connected between the power source and DM110 (Figure 4-13). A resistor rated at 20 ohms and 20 watts may be used to limit the inrush current to a safe level. During the duration of the inrush current (about one cycle), the resistor power rating will be exceeded. Once the inrush has passed, the resistor power dissipation level will be minimal. If desired, a 10 ohm, 50 watt resistor may be used instead.



⚠ If desired, a 10 Ω, 50 W resistor may be substituted.

Figure 4-13. Operating Power Connections for DM110 Programming (Input Voltage >120 Vac)

These special operating considerations are to be observed only during DM110 programming. Applications where the DM110 is powered from the generator output (shunt powered) or a permanent magnet generator (PMG) are still valid within the constraints given in Section 1, General Information, Specifications. In applications where station power is used to power the DM110, the DM110 should be protected by an Inrush Current Reduction Module (ICRM-7). See *Power Supply Inputs* for more information.

## ADJUSTMENTS

All adjustments are made using external switching, or with BESTCOMS software via the rear panel communication port. See Sections 5 and 6 for more information regarding setting adjustments with BESTCOMS software.

## SECTION 5 • BESTCOMS SOFTWARE

### INTRODUCTION

BESTCOMS-DM110 software provides the communication link between the DM110 and the user. All DM110 settings are entered through BESTCOMS and all metering values (updated about once every second) are read through BESTCOMS. Software within BESTCOMS enables the user to establish proper PID (proportional + integral + derivative) parameters based on a specified generator and/or exciter time constants. Within BESTCOMS, DM110 settings can be saved in a computer file and used later to configure other units with the same settings.

### INSTALLATION

BESTCOMS software for the DM110 operates with IBM-compatible personal computers (PCs) operating with Microsoft® Windows® 2000, XP, and Vista®. The minimum recommended operating requirements are:

- IBM compatible PC, 486DX2 or faster (100 MHz or higher microprocessor is recommended)
- CD-ROM Drive
- One available serial port

#### Installing BESTCOMS

BESTCOMS software contains a setup utility that installs the program on your PC. An uninstall utility is loaded with the program that can be used to remove BESTCOMS from your PC if desired. Use the following procedure to install BESTCOMS.

1. Insert the CD-ROM into the PC CD-ROM drive.
2. When the DM110 Setup and Documentation CD menu appears, click the Install button for the BESTCOMS PC Program. The setup utility automatically installs BESTCOMS on your PC.

When BESTCOMS is installed, a STAMFORD | AvK folder is added to the Windows® program menu. This folder is accessed by clicking the Start button and pointing to Programs. The STAMFORD | AvK folder contains icons for the BESTCOMS-DM110 program and a utility to remove BESTCOMS.

#### Connecting the DM110 and PC

Connect a communication cable between the rear RS-232 connector of the DM110 and the appropriate communication port of the PC. Refer to Figure 2-2 for the location of the DM110 RS-232 connector and Figure 4-5 for the required connections between the DM110 and a PC.

#### **CAUTION**

**When applying operating power to the DM110 for programming purposes, observe the precautions called out in Section 4, Installation, Preliminary Setup.**

### STARTING BESTCOMS

BESTCOMS is started by clicking the Windows® Start button, pointing to Programs, the STAMFORD | AvK folder, and then clicking the BESTCOMS-DM110 icon. At startup, a dialog box with the program title and version number is displayed briefly (Figure 5-1). After this dialog box is displayed, the System Configuration screen is displayed.



Figure 5-1. Software Title and Version

### Establishing Communication

Communication between BESTCOMS and the DM110 must be established before viewing metering values or reading or changing settings. BESTCOMS screen settings are updated only after communication is opened or the communication settings have been changed.

Open the DM110 communication port by clicking on **Communications** on the menu bar, hovering the mouse pointer over **Open Comm Port**, and clicking **RS-232 Port**. Figure 5-2 illustrates the menu selections for opening the DM110 communication port.

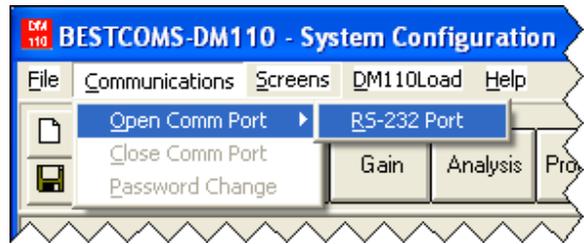


Figure 5-2. Communication Port Menu Selection

When **RS-232 Port** is selected, the Password dialog box of Figure 5-3 appears and prompts you to enter a password. Each DM110 is delivered with “decs” as the default password. See the Password Protection sub-section for information about changing the password.

After the correct password is entered, the Communication Initiation screen of Figure 5-4 is displayed. Select Comm 1, Comm 2, Comm 3, or Comm 4 as the active communication port on your PC and click the Initialize button. BESTCOMS initializes communication by obtaining the configuration settings from the DM110.



Figure 5-3. Password Dialog Box

**NOTICE**

BESTCOMS may display the dialog box of Figure 5-5 when initializing DM110 communication, obtaining DM110 configuration settings, or performing other tasks. It's important to wait until the box disappears before trying to execute communication commands. Issuing commands while the Wait dialog box is present may disrupt communication between the DM110 and BESTCOMS.



Figure 5-4. Communication Initiation Screen



Figure 5-5. Wait Dialog Box

## CHANGING SETTINGS

A setting is changed by clicking within the setting field and typing the new setting. The range limits of a setting can be viewed by double-clicking the setting. Once all desired setting changes have been made on a setting group screen, the settings must be sent to the DM110 before viewing other screens. Otherwise, the settings changes will be lost. Settings changes can be sent to the DM110 by clicking the **SendToDM110** button. Settings can also be sent to the DM110 by clicking **Communications** on the menu bar and clicking **Send To DM110**.

## SENDING AND RECEIVING SETTINGS

When communication is enabled, DM110 settings can be sent or received through BESTCOMS.

### Sending Settings to the DM110

Settings changes are sent to the DM110 by clicking the **SendToDM110** button. This causes the selected setting displayed on the current settings screen to become the DM110 setting. Settings can also be sent to the DM110 by clicking **Communications** on the menu bar and clicking **Send To DM110**. Additionally, a single setting can be

sent by pressing the **Enter** key after the new value is typed in. The **SendToDM110** button must be clicked or the Enter key must be pressed after each setting change to ensure that all settings are sent to the DM110. See *Saving Settings to DM110 Memory* for information about retaining DM110 settings after operating power is removed.

### Receiving Settings

DM110 settings are retrieved by clicking the **GetFromDM110** button. This causes the current settings of the DM110 to be displayed on the settings screen. Settings can also be received from the DM110 by clicking **Communications** on the menu bar and clicking **Get From DM110**.

### Saving Settings to DM110 Memory

Settings are saved in nonvolatile memory (EEPROM). In the event of a power loss, these are the settings that are active at power up. When setting changes are made and sent to the DM110, they are automatically saved to EEPROM (if the correct password is entered). When you close communication or exit BESTCOMS, you may be asked for a password. Enter the correct password to ensure that all setting changes are saved.

---

## SETTING DEFINITIONS

Settings, metering values, and data records are arranged into six groups within BESTCOMS:

- System Configuration
- Setting Adjustments
- Control Gain
- Analysis
- Protection/Relay
- Metering/Operation

Each group is contained on a BESTCOMS screen. Each BESTCOMS screen has a corresponding toolbar button that can be selected to access that screen. The six screens also can be accessed by clicking **Screens** on the menu bar and then selecting the desired setting group (screen) from the list. A screen's settings and parameters are further organized by labeled tabs with the screen. In the following paragraphs, settings are arranged and defined according to the organization of the BESTCOMS screens and tabs.

### System Configuration

The System Configuration screen consists of one tab labeled System Settings. Click the **Configure** button to access the System Configuration screen or click **Screens** on the menu bar and click **System Configuration**.

#### *System Settings*

System settings are shown in Figure 5-6 and described in the following paragraphs.

*Sensing Voltage.* This setting is used to configure the DM110 for either single-phase or three-phase sensing voltage.

*Limiter Mode.* This setting enables and disables the excitation limiters. Overexcitation limiting (OEL) or underexcitation limiting (UEL) can be enabled independently, both can be enabled, or neither limiter enabled.

*OEL Type.* This setting configures the overexcitation limiter as a summing point limiter or takeover-style limiter.

*52JK Mode.* This setting is used to configure the 52J/K contact input to control either the var/power factor controller or the excitation limiter function. When the 52J/K contact input is configured to control the var/PF controller, the excitation limiter is not available. Likewise, when the 52J/K contact input is programmed to control the excitation limiter, var/PF control is not available.

If the 52J/K contact input is configured to control the var/PF function:

- An open contact across terminals 52J and 52K enables var/PF correction
- A closed contact across terminals 52J and 52K disables var/PF correction

If the 52J/K contact input is configured to control the overexcitation limiter:

- An open contact across terminals 52J and 52K enables the setpoint of the OEL
- A closed contact across terminals 52J and 52K enables the setpoint of the excitation limiter

*Generator Frequency.* This setting is used to select a nominal system operating frequency of 50 hertz or 60 hertz.

*Regulator Sensing Voltage (V).* The nominal, ac generator voltage obtained from the generator sensing transformer is entered in this setting field. Voltages within the ranges of 100 to 140 Vac, 200 to 280 Vac, or 400 to 560 Vac may be entered in 0.1 Vac increments. A setting of 600 Vac is also possible.

*Regulator Sensing Current (A).* This field indicates the DM110 rated generator sensing value. The DM110 rated regulator sensing current is displayed only when communication between the DM110 and BESTCOMS is established.

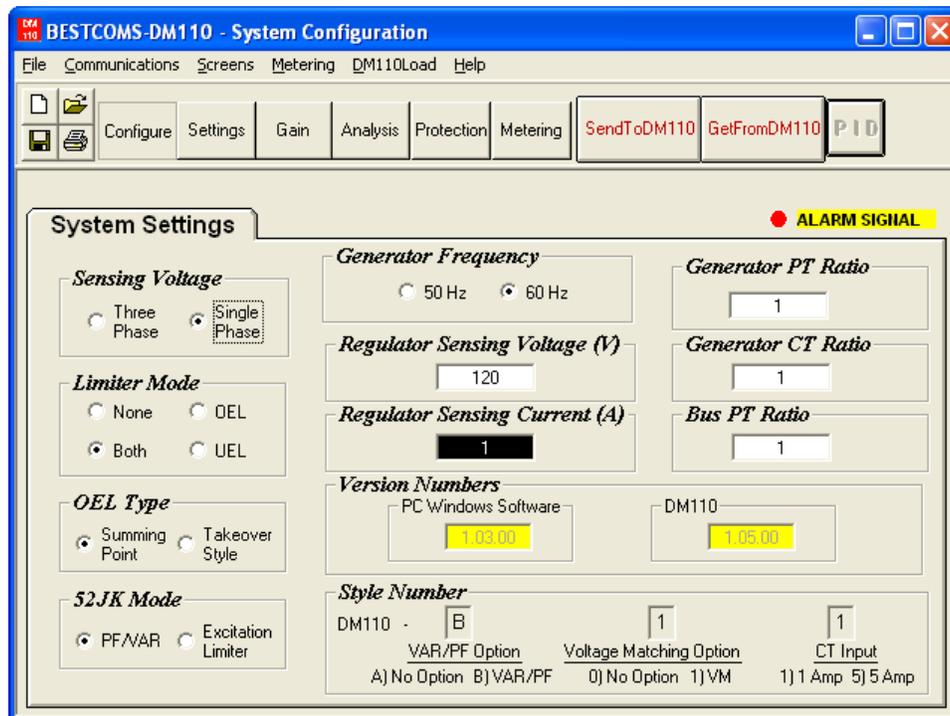


Figure 5-6. System Configuration Screen

*Version Numbers.* These two read-only version numbers indicate the BESTCOMS software version and the DM110 embedded software version. Version numbers are displayed only when communication between the DM110 and BESTCOMS is established.

*Style Number.* The three, read-only style number fields indicate the electrical characteristics and operational features of the DM110. The style number is displayed only when communication between the DM110 and BESTCOMS is established.

*Generator PT Ratio.* The ratio of the generator sensing transformer is entered in this setting field. This ratio allows the voltage displayed through BESTCOMS to match the actual generator output voltage. A ratio of 1 to 150 may be entered in increments of 0.01.

*Generator CT Ratio.* The ratio of the generator B-phase current transformer is entered in this setting field. This ratio allows the current displayed by the DM110 to match the actual B-phase generator output current. A ratio of 1 to 6,000 may be entered in increments of 0.1.

*Bus PT Ratio.* This setting field is used to enter the bus potential sensing transformer ratio. This ratio allows the bus voltage to be displayed through BESTCOMS. A ratio of 1 to 150 may be entered in 0.01 increments.

#### NOTICE

If the CT is positioned in part of a parallel circuit that does not carry full load current, then the ratio entered should be referenced to full line current. For example, if the full line current is 4000A and 1000:1 CT is positioned in quarter line current (4 parallel circuits), then the ratio entered should be 4000:1

## Setting Adjustments

The Setting Adjustments screen consists of two tabs: Setpoint and Startup.

### Setpoint Tab

The Setpoint tab settings of the Setting Adjustments screen are shown in Figure 5-7. Each setting of the Setpoint tab is described in the following paragraphs.

*Automatic Voltage Regulator (AVR) - AVR Setpoint (V).* This setting field is used to enter the desired generator output terminal voltage. The AVR setpoint value range depends on the regulator sensing voltage and band setting.

*Fine Voltage Adjustment - Band Setting (%).* The Band Setting determines the minimum and maximum adjustment allowed to the AVR Setpoint (as a percentage of the Regulator Sensing Voltage setting (see Figure 5-8)). Band Setting values are entered as a percentage of the regulator sensing voltage setting over a range of 0 to 15% in 0.1% increments.

*Drop - Setpoint (%).* This setting controls the reactive droop compensation feature of the DM110. The setpoint value determines the amount of change permitted in the generator voltage setpoint when the DM110 responds to a reactive load. The setpoint value is adjustable from 0 to 10% in increments of 0.01%. The setpoint is based on a 0.8 power factor load.

If the equivalent drooping characteristic is to be based on 0.0 power factor load and the generator line current rating, the droop setpoint should be scaled as follows:

**New Droop Setpoint % = Desired Droop Setpoint (@ 0.0 PF) % \* 0.6 \* (Gen CT Primary Rating / Gen Rated Line Current)**

Generator Rated Line Current: 1500 A

Example:

Generator Rated Line Voltage: 480 V

Generator Sensing CT: 2000:5

Desired Droop Setpoint at 0.0 PF: 5%

**New Droop Setpoint % = 5 \* 0.6 \* (2000/1500) = 4%**

In this example a droop setpoint of 4% equals 5% voltage droop at 0.0 power factor.

Note: The ratio used for the Gen CT Primary rating should be the same value as entered in "Generator Droop CT Ratio" in section 5-4

*Droop – Phase Compensation.* This setting compensates for generators that are wound in such a way that the sensing supplied to the regulator is not at 90° with respect to the output current that is sensed for droop. The phase compensation setting is used to add to or subtract from the phase angle between the sensed voltage and current. An angle of –30° to 30° may be entered in 0.1° increments. The default setting of 0° is suitable for applications where a 90° angle exists between the sensed voltage and current (unity power factor).

*Field Current Regulator (FCR) - FCR Setpoint (A).* This setting defines the field current setpoint when operating in Manual mode. The FCR Setpoint field accepts a value of 0.03 to 7 Adc in 0.01 Adc increments.

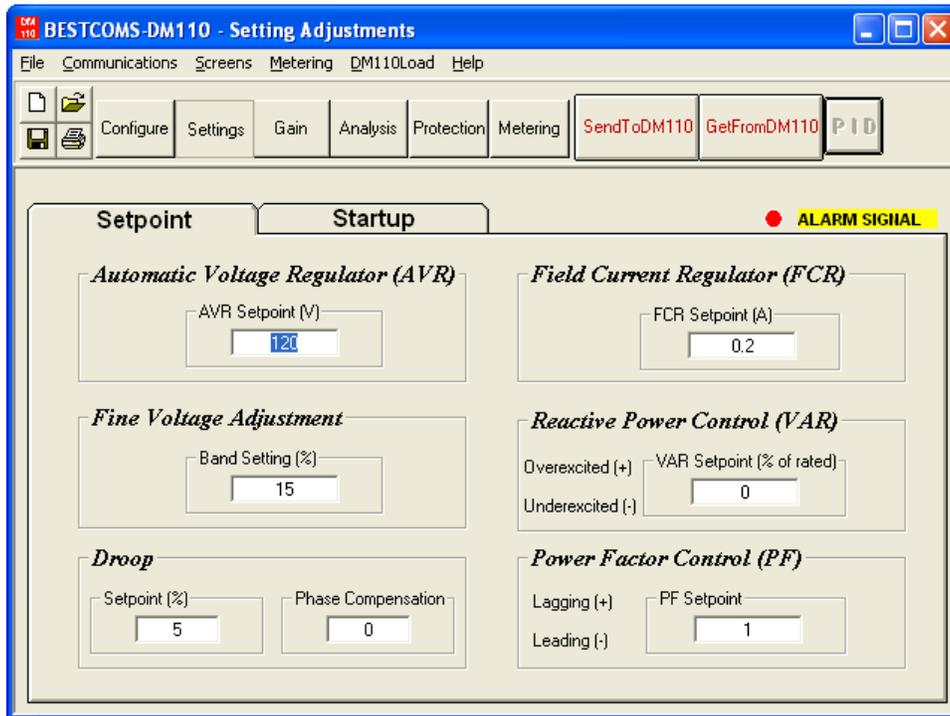


Figure 5-7. Setting Adjustments Screen, Setpoint Tab

**Reactive Power Control (VAR) - VAR Setpoint (% of rated).** The VAR Setpoint determines the level of generator vars maintained by the DM110 when operating in Var Control mode. Values from –100% (underexcited) to +100% (overexcited) in 1.0% increments may be entered in the VAR Setpoint field.

**Power Factor Control (PF) - PF Setpoint.** The PF Setpoint determines the level of generator power factor maintained by the DM110 when operating in Power Factor Control mode. PF Setpoint values are adjustable from -0.6 to -1 (1) or 0.6 to +1 in 0.001 increments. Negative values give a leading power factor and positive values give a lagging power factor.

#### Startup Tab

The Startup-tab settings of the Setting Adjustment screen are shown in Figure 5-8. Each setting of the Startup tab is described in the following paragraphs.

**Startup Control - Gen Soft Start Time (sec).** This setting defines the time limit for the generator soft-start voltage ramp time. The soft-start time minimizes generator voltage overshoot and can be set from 1 to 7,200 seconds in 1 second increments.

**Underfrequency Setting - Corner Frequency (Hz).** The Corner Frequency setting defines the value of frequency that causes the DM110 to adjust the voltage setpoint so that the generator voltage follows the selected volts per hertz slope. A value of 40 to 65 hertz can be entered in this setting field in 0.01 increments.

**Underfrequency Setting - Slope (Volts/Hz).** The slope for generator underfrequency protection is selected with this per-unit setting. A slope setting of 0 to 3.00 can be entered in increments of 0.01.

**Dwell Setting – Dwell (% Volts/sec).** This setting introduces a delay between generator speed recovery and voltage recovery. Settings of 4, 8, 12, 16, 20, and Disable are possible. Selecting Disable forces the generator voltage to follow the Underfrequency Slope (V/Hz) setting.

**Voltage Matching - Speed (sec).** This setting determines how quickly the generator voltage is adjusted by the DM110 to match the bus voltage. The Speed setting is adjustable from 1 to 300 seconds in 0.01 increments.

**Voltage Matching – Disable by Contact.** This setting selects the DM110 contact input used to disable voltage matching. Selecting “52JK or 52LM” allows either the 52JK or 52LM contact input to disable voltage matching. Selecting “52JK” allows only the 52JK contact input to disable voltage matching.

**Voltage Matching – Mode.** The voltage matching mode can be Maintain or Revert. When Maintain is selected, the DM110 setpoint is maintained at the bus voltage level even after the generator or utility breaker opens. When Revert

is selected, the DM110 setpoint reverts to its original level when the generator or utility breaker opens.

*Gen to Bus PT Match Level (%)*. Ensures accurate voltage matching by compensation for the error between the generator and bus voltage sensing transformers. The match level is expressed as the relationship of the generator voltage to the bus voltage (in percent). A setting of zero to 700% may be entered in 0.1% increments.

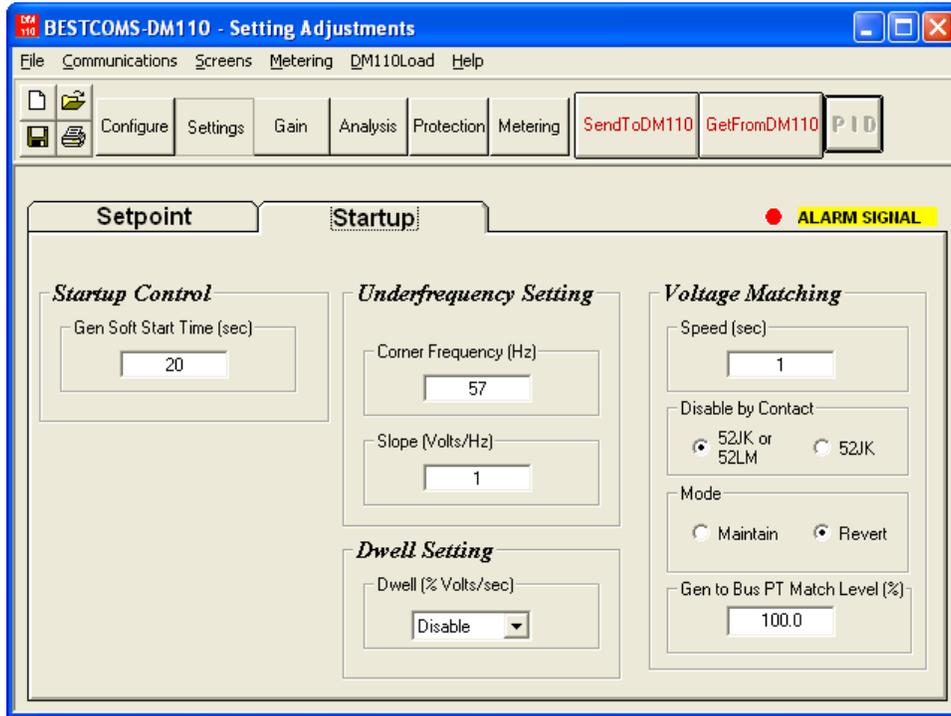


Figure 5-8. Setting Adjustments Screen, Startup Tab

**Control Gain**

The Control Gain screen consists of one tab labeled Control Gain. Click the Gain button to access the Control Gain screen or click Screens on the menu bar and click Control Gain.

Control Gain Tab

Control gain settings are shown in Figure 5-9 and are described in the following paragraphs.

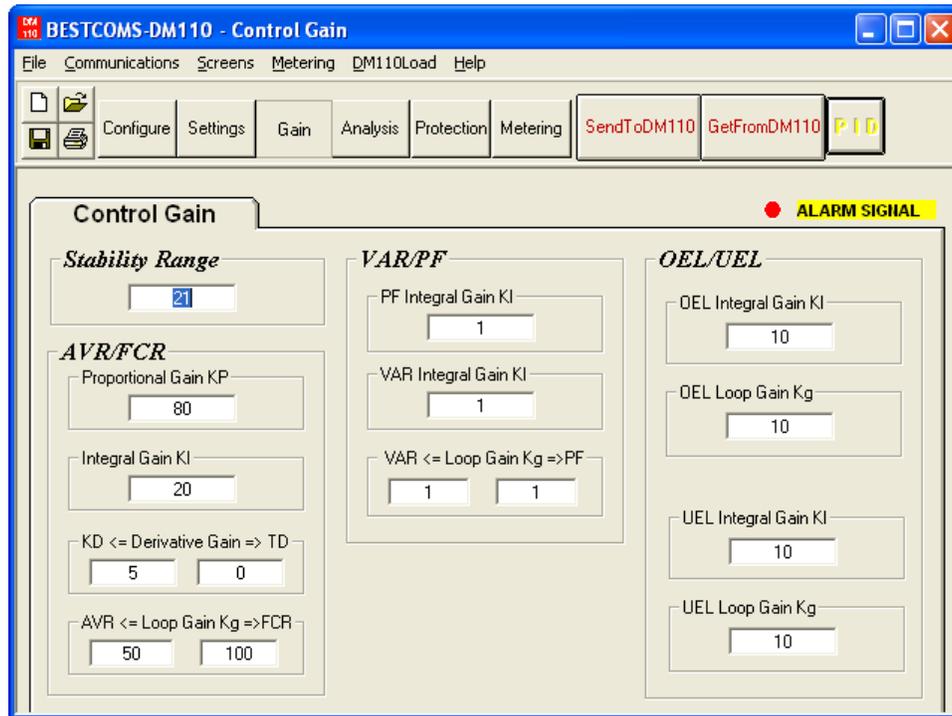


Figure 5-9. Control Gain Screen

**Stability Range.** This setting selects one of 20 preset stability ranges within the DM110. A guide for selecting the stability range is provided in Table 5-1. A setting of 21 enables the entry of custom stability settings through the BESTCOMS PID window. Information about the PID window is provided later under the heading of *PID Window*. When the Stability Range is set at 21, the PID button may be selected to access the PID window. A Stability Range setting of 1 through 20 disables the PID button and prevents access to the PID window.

**AVR/FCR - Proportional Gain KP.** This setting selects the proportional constant (KP) stability parameter. The DM110 supplies a value that is equivalent to KP multiplied by the error between the voltage setpoint and the actual generator output voltage. KP values of 0 to 1,000 may be entered in increments of 0.01.

Observe the following guidelines when tuning the KP value. If the transient response has too much overshoot, then KP should be decreased. If the transient response is too slow, then KP should be increased.

**AVR/FCR - Integral Gain KI.** This setting selects the integral constant (KI) stability parameter. The DM110 supplies a value that is equivalent to KI multiplied by the integral of the error between the voltage setpoint and the actual generator output voltage. KI values of 0.01 to 1,000 may be entered in increments of 0.01.

Increasing the value of KI decreases the time required to reach steady state.

**AVR/FCR - Derivative Gain KD.** This setting selects the derivative constant (KD) stability parameter. The DM110 provides an output value that is equivalent to KD multiplied by the derivative of the error between the voltage setpoint and the actual generator output voltage. KD values of 0 to 1,000 may be entered in increments of 0.01.

Increasing the value of KD reduces transient response ringing.

**AVR/FCR – Derivative Gain TD.** This setting removes the effect of noise on numerical differentiation. A setting of 0 to 1 may be entered in 0.01 increments.

**AVR/FCR - AVR<=Loop Gain Kg=>FCR.** This setting adjusts the loop-gain level of the PID algorithm. Loop Gain values of 0 to 1,000 may be entered for AVR and FCR operation in increments of 0.01.



Control mode and operating status selections are made at the Operation tab of the BESTCOMS Metering screen and are discussed later in this section.

### AVR Tab

Figure 5-10 illustrates the settings, sensing values, and alarm signal indicators of the AVR tab. The settings of the AVR tab make it possible to increment and decrement the AVR setpoint of the DM110. The sensing values and alarm signal indicators of the AVR tab are also displayed by the other tabs of the Analysis screen.

**Voltage Step Response - AVR Setpoint (V) (Nominal).** This read-only field indicates the AVR setpoint. (The AVR setpoint is set by using the Setpoint tab of the Setting Adjustments screen). The voltage displayed in the AVR Setpoint field is selected by clicking the adjacent button. Clicking this button sends the AVR Setpoint value to the DM110 and changes the color of the button from gray to red.

**Voltage Step Response - Increment of AVR Setpoint (V).** These two fields indicate the increase that occurs to the AVR setpoint when the corresponding Increment button is clicked. The “% increase” field is used to set and indicate the percentage that the AVR setpoint is increased when the Increment button is clicked. The “AVR Setpoint =” field indicates the value of voltage that corresponds to the “% increase” field. Any setpoint value within range or higher than the setpoint value can be typed into the “AVR Setpoint =” field, which updates the “% increase” field. The AVR setpoint changes to this value when the adjacent button is clicked. When clicked, the Increment button changes from gray to red to indicate that the AVR setpoint has increased to the value in the “AVR Setpoint =” field.

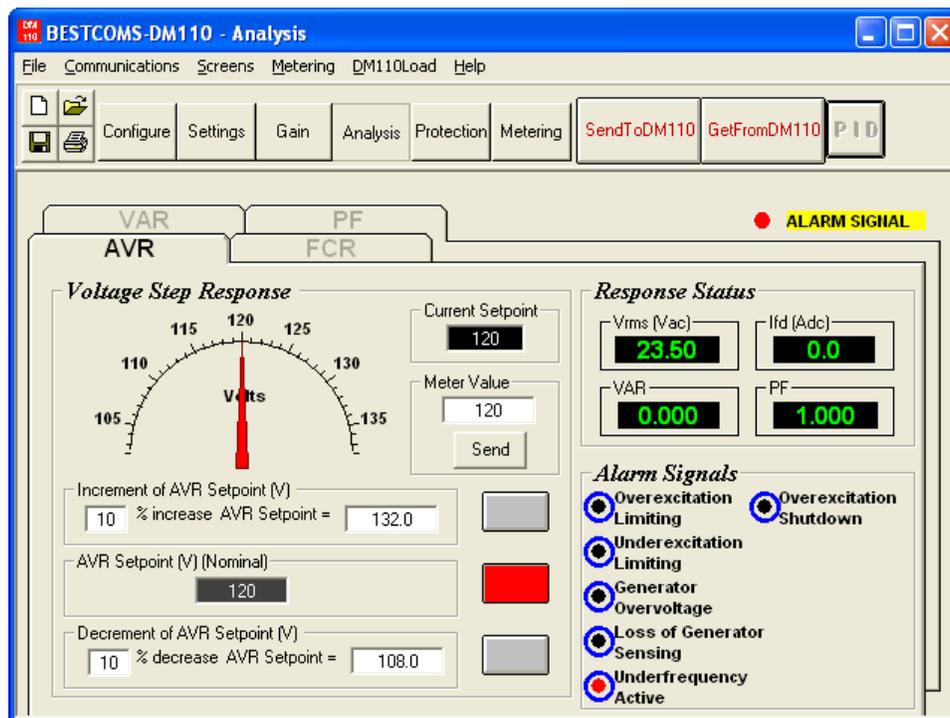


Figure 5-10. Analysis Screen, AVR Tab

**Voltage Step Response - Decrement of AVR Setpoint (V).** These two fields indicate the change that will occur to the AVR setpoint when the corresponding Decrement button is clicked. The “% decrease” field is used to set and indicate the percentage (0 to 10%) that the AVR setpoint is decreased when the Decrement button is clicked. The “AVR Setpoint =” field indicates the value of voltage that corresponds to the “% decrease” field. Any setpoint value within range or lower than the setpoint value can be typed into the “AVR Setpoint =” field, which updates the “% decrease” field. The AVR setpoint changes to this value when the adjacent button is clicked. When clicked, the Decrement button changes from gray to red to indicate that the AVR setpoint has decreased to the value in the “AVR Setpoint =” field.

**Voltage Step Response - Meter Value.** This field and the dial pointer indicate the value of the selected AVR setpoint. When the AVR setpoint is changed by clicking the increment, decrement, or setpoint button, the meter value field and dial pointer indicate the new setpoint value. A new AVR setpoint can be typed directly into the Meter Value field or selected by dragging the dial pointer to the desired value. The new value is sent to the DM110 by clicking the Send button.

*Voltage Step Response - Current Setpoint.* The active DM110 setpoint (adjusted by using any of the previously mentioned methods) is displayed in this field. To return the AVR setpoint to the nominal setting, the button adjacent to the “AVR Setpoint (V) (Nominal)” field should be clicked. If the AVR tab is left to view other tabs or screens without returning the AVR setpoint to nominal, an AVR dialog box appears. Clicking the Yes button returns the AVR setpoint to nominal. Clicking No maintains the AVR setpoint at the current value.

**FCR Tab**

Figure 5-11 illustrates the settings, sensing values, and alarm signal indicators of the FCR tab. The settings of the FCR tab make it possible to increment and decrement the FCR setpoint of the DM110. The sensing values and alarm signal indicators of the FCR tab are also displayed by the other tabs of the Analysis screen.

*Field Current Step Response - FCR Setpoint (A).* This read-only field indicates the FCR setpoint. (The FCR setpoint is set by using the Setpoint tab of the Setting Adjustments screen). The current displayed in the FCR Setpoint field is selected by clicking the adjacent pushbutton. Clicking this button sends the FCR Setpoint value to the DM110 and changes the color of the pushbutton from gray to red.

*Field Current Step Response - Increment of FCR Setpoint (A).* These two fields indicate the increase that occurs to the FCR setpoint when the corresponding Increment button is clicked. The “% increase” field is used to set and indicate the percentage (0 to 10%) that the FCR setpoint is increased when the Increment button is clicked. The “FCR Setpoint =” field indicates the value of current that corresponds to the “% increase” field. Any setpoint value within range or higher than the setpoint value can be typed into the “FCR Setpoint =” field, which updates the “% increase” field. The FCR setpoint changes to this value when the adjacent button is clicked. When clicked, the Increment button changes from gray to red to indicate that the FCR setpoint has increased to the value in the “FCR Setpoint =” field.

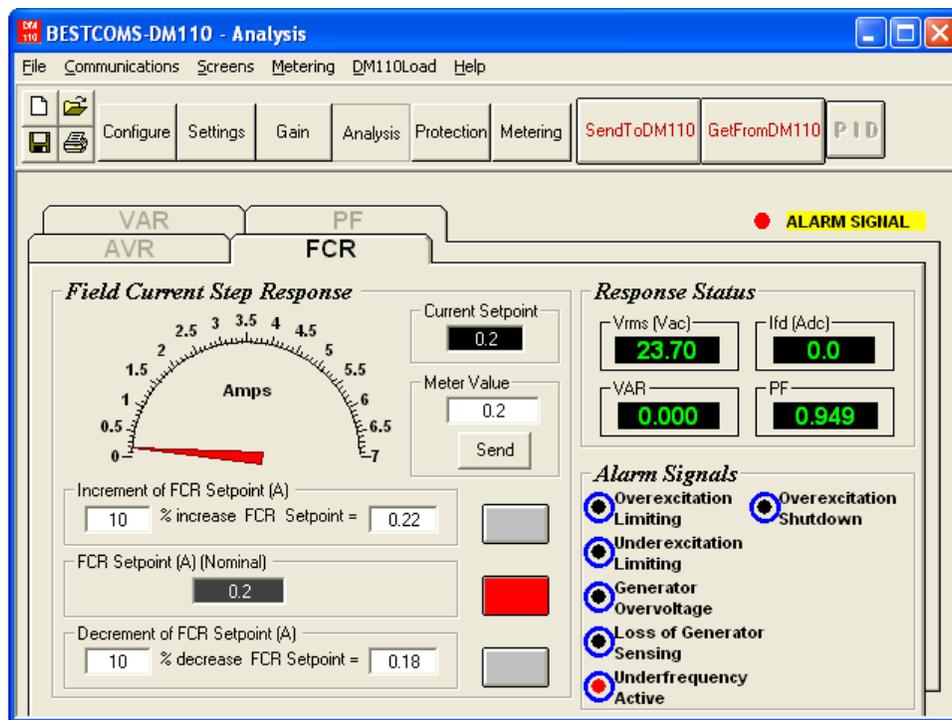


Figure 5-11. Analysis Screen, FCR Tab

*Field Current Step Response - Decrement of FCR Setpoint (A).* These two fields indicate the change that will occur to the FCR setpoint when the corresponding Decrement button is clicked. The “% decrease” field is used to set and indicate the percentage that the FCR setpoint is decreased when the Decrement button is clicked. The “FCR Setpoint =” field indicates the value of current that corresponds to the “% decrease” field. The FCR setpoint changes to this value when the adjacent button is clicked. When clicked, the Decrement button changes from gray to red to indicate that the FCR setpoint has decreased to the value in the “FCR Setpoint =” field.

*Field Current Step Response - Meter Value.* This field and the dial pointer indicate the value of the selected FCR setpoint. When the AVR setpoint is changed by clicking the increment, decrement, or setpoint button, the meter value field and dial pointer indicate the new setpoint value. A new FCR setpoint can be typed directly into the “Meter Value” field or selected by dragging the dial pointer to the desired value. The new value is sent to the DM110 by clicking the Send button.

*Field Current Step Response - Current Setpoint.* The active DM110 setpoint (adjusted by using any of the previously mentioned methods) is displayed in this field. To return the FCR setpoint to the nominal setting, the button adjacent to the “FCR Setpoint (A) (Nominal)” field should be clicked. If the FCR tab is left to view other tabs or screens without returning the FCR setpoint to nominal, an FCR setpoint dialog box appears. Clicking the Yes button returns the AVR setpoint to nominal. Clicking No maintains the AVR setpoint at the current level.

PF Tab

Figure 5-12 illustrates the settings, sensing values, and alarm signal indicators of the PF tab. Each setting of the PF tab is described in the following paragraphs.

*Power Factor Step Response - Power Factor Setpoint (Nominal).* This read-only field indicates the PF setpoint. (The PF setpoint is set by using the Setpoint tab of the Setting Adjustments screen.) The value displayed in the FCR Setpoint field is selected by clicking the adjacent pushbutton. Clicking this button sends the PF setpoint value to the DM110 and changes the color of the pushbutton from gray to red.

*Power Factor Step Response - Increment of PF Setpoint.* This field indicates the new PF setpoint that is established when the corresponding increment button is clicked. Any setpoint value within range or higher than the existing setpoint value can be typed into the “Increase PF Setpoint =” field. The PF setpoint changes to this value when the adjacent button is clicked. When clicked, the Increment button changes from gray to red to indicate that the PF setpoint has increased to the value in the “Increase PF Setpoint =” field.

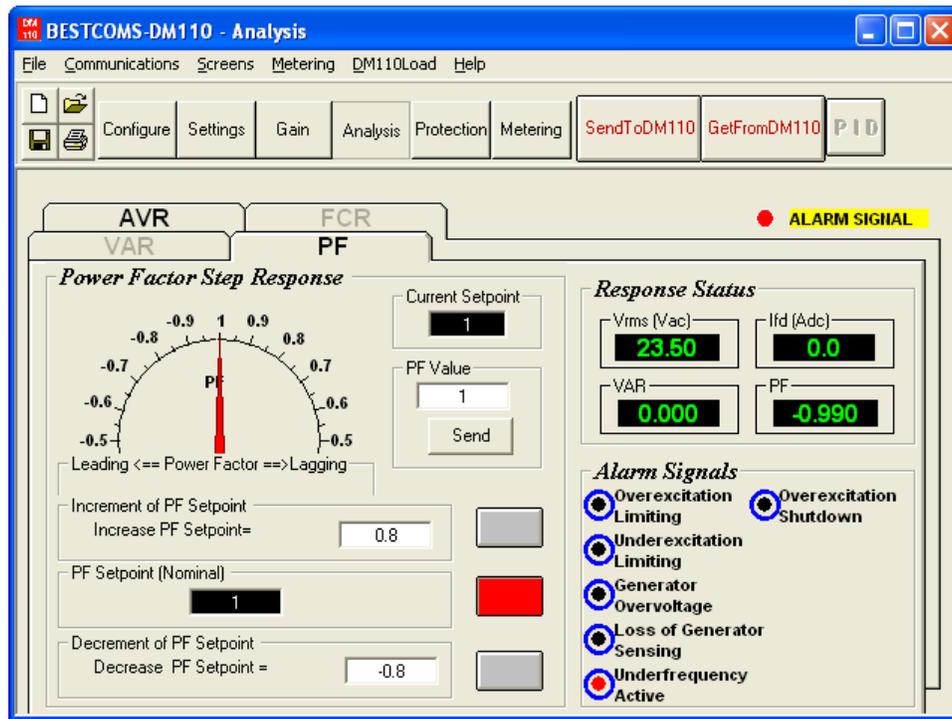


Figure 5-12. Analysis Screen, PF Tab

**Power Factor Step Response - Decrement of PF Setpoint.** This field indicates the new PF setpoint that is established when the corresponding decrement button is clicked. Any setpoint value within range or lower than the existing setpoint value can be typed into the “Decrease PF Setpoint =” field. The PF setpoint changes to this value when the adjacent button is clicked. When clicked, the Decrement button changes from gray to red to indicate that the PF setpoint has decreased to the value in the “Decrease PF Setpoint =” field.

**Power Factor Step Response - PF Value.** This field and the dial pointer indicate the value of the selected PF setpoint. When the PF setpoint is changed by clicking the increment, decrement, or setpoint button, the meter value field and dial pointer indicate the new setpoint value. A new PF setpoint can be typed directly into the “PF Value” field or selected by dragging the dial pointer to the desired value. The new value is sent to the DM110 by clicking the Send button.

**Power Factor Step Response - Current Setpoint.** The active DM110 setpoint (adjusted by using any of the previously mentioned methods) is displayed in this field. To return the PF setpoint to the nominal setting, the button adjacent to the PF Setpoint (Nominal) field should be clicked. If the PF tab is left to view other tabs or screens without returning the PF setpoint to nominal, a PF setpoint dialog box appears. Clicking the Yes button returns the AVR setpoint to nominal. Clicking No maintains the AVR setpoint at the current value.

### VAR Tab

Figure 5-13 illustrates the settings, sensing values, and alarm signal indicators of the VAR tab. Each setting of the VAR tab is described in the following paragraphs.

**Reactive Power Step Response - VAR Setpoint (%) (Nominal).** This read-only field indicates the var setpoint. (The var setpoint is set by using the Setpoint tab of the Setting Adjustments screen.) The value displayed in the “VAR Setpoint” field is selected by clicking the adjacent button. Clicking this button sends the var setpoint value to the DM110 and changes the color of the pushbutton from gray to red.

**Reactive Power Step Response - Increment of VAR Setpoint (%).** This field indicates the increase that occurs to the FCR setpoint when the corresponding Increment button is clicked. The “Increase VAR Setpoint =” field is used to set and indicate the percentage that the var setpoint is increased to when the Increment button is clicked. Any setpoint value (expressed as a percent of nominal) within range or higher than the existing setpoint value can be typed into the “Increase VAR Setpoint =” field. The var setpoint changes to the new value when the adjacent button is clicked. Clicking this button sends the var setpoint value to the DM110 and changes the color of the pushbutton from gray to red.

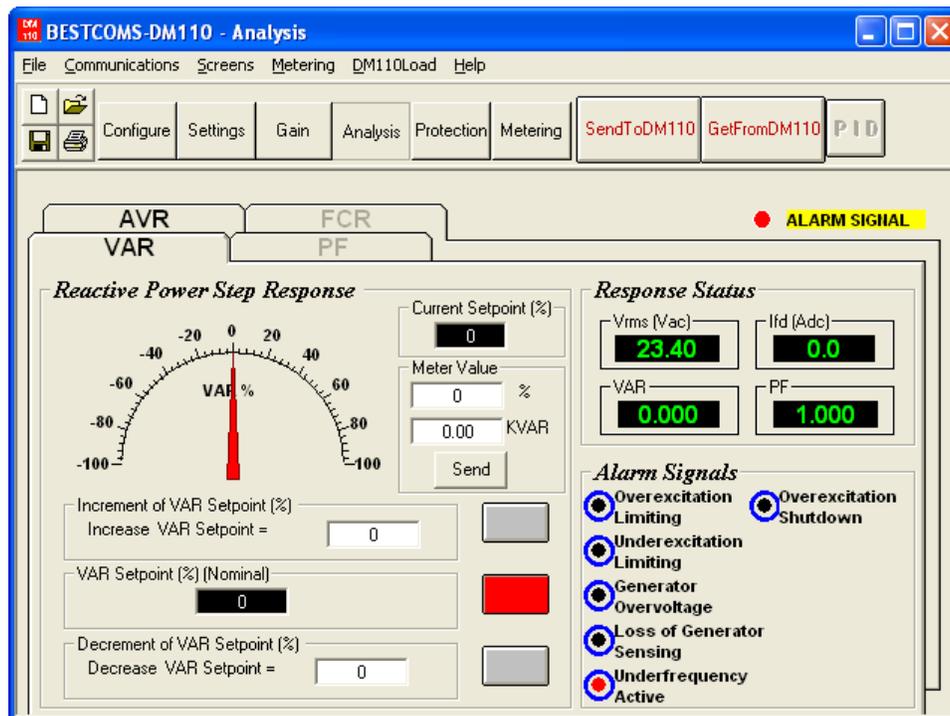


Figure 5-13. Analysis Screen, VAR Tab

*Reactive Power Step Response - Decrement of VAR Setpoint (%)*. This field indicates the decrease that occurs to the FCR setpoint when the corresponding Decrement button is clicked. The “Decrease VAR Setpoint =” field is used to set and indicate the percentage that the var setpoint is decreased to when the Decrement button is clicked. Any setpoint value (expressed as a percent of nominal) within range or lower than the existing setpoint value can be typed into the “Decrease VAR Setpoint =” field. The var setpoint changes to the new value when the adjacent button is clicked. Clicking this button sends the var setpoint value to the DM110 and changes the color of the pushbutton from gray to red.

*Reactive Power Step Response - Meter Value*. These fields and the dial pointer indicate the value of the selected var setpoint. When the var setpoint is changed by clicking the increment, decrement, or setpoint button, the meter value fields and dial pointer indicate the setpoint value. A new var setpoint, expressed as a kvar value or a percentage of nominal, can be typed directly into either Meter Value field or selected by dragging the dial pointer to the desired value. The new value is sent to the DM110 by clicking the Send button.

*Reactive Power Step Response - Current Setpoint (%)*. The active var setpoint (adjusted by using any of the previously mentioned methods) is displayed in this field. To return the var setpoint to the nominal setting, the button adjacent to the “VAR Setpoint (%) (Nominal)” field should be clicked. If the VAR tab is left to view other tabs or screens without returning the VAR setpoint to nominal, a var setpoint dialog box appears. Clicking the Yes button returns the var setpoint to nominal. Clicking No maintains the var setpoint at the current value.

## Protection Settings

The Protection Settings screen consists of two tabs: Protection and Limiter. Click the Protection button to access the Protection Settings screen or click Screens on the menu bar and click Protection Settings.

### Protection Tab

Protection settings are shown in Figure 5-14 and are described in the following paragraphs.

*Generator Overvoltage - Voltage Level (%)*. The value of this field is expressed as a percentage of the nominal generator voltage and determines the level of generator voltage required to initiate a generator overvoltage condition. An overvoltage percentage value of 100 to 120 percent may be entered in 1 percent increments. A generator overvoltage condition lights the Generator Overvoltage LED on the front panel.

*Generator Overvoltage – Alarm Time Delay (sec)*. This setting establishes the length of time that a generator overvoltage condition must exist before the DM110 annunciates the condition. An alarm time delay of 0 to 10 seconds may be entered in 1 second increments.

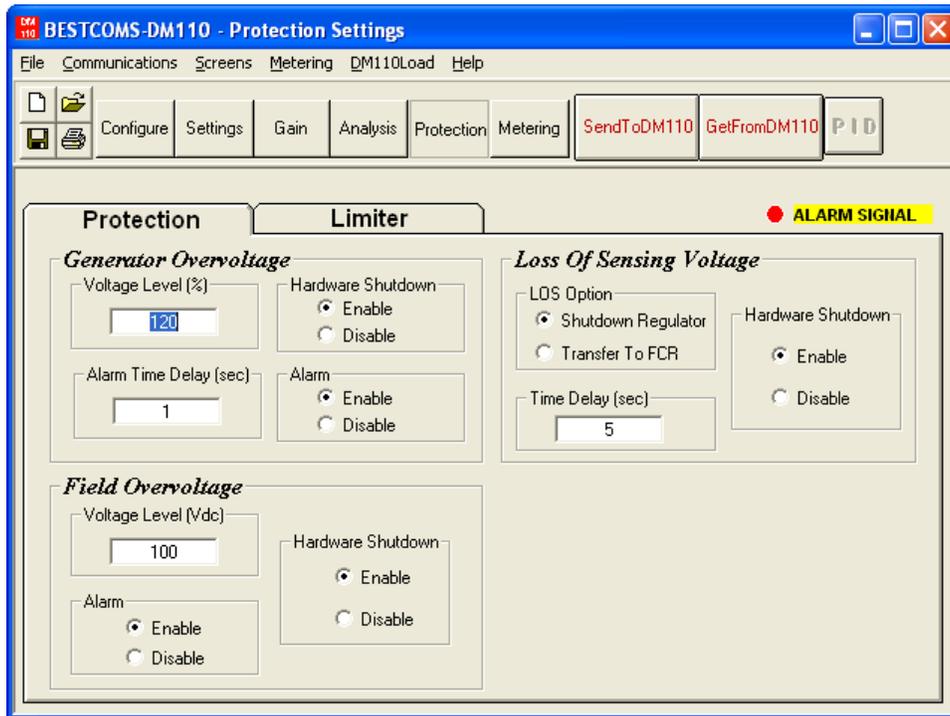


Figure 5-14. Protection Settings, Protection Tab

**Generator Overvoltage - Hardware Shutdown.** Enabling Hardware Shutdown will cause the DM110 to remove field excitation when the generator overvoltage setting is exceeded. Disabling Hardware Shutdown prevents the DM110 from removing excitation during a generator overvoltage condition.

**Generator Overvoltage – Alarm.** This setting enables and disables closure of the DM110 Alarm output (terminals AL1 and AL2) during generator overvoltage. Disabling the alarm also disables hardware shutdown.

**Field Overvoltage - Voltage Level (Vdc).** The value in this field is adjustable from 0 to 250 Vdc and determines the field voltage level that will cause the DM110 to issue an overexcitation limit alarm. When the field voltage increases above the value of this field for 10 seconds, the Overexcitation Shutdown LED on the front panel lights.

**Field Overvoltage - Alarm.** If the Alarm is enabled and a field overvoltage condition exists for 10 seconds, the DM110 Alarm output (terminals AL1, AL2) will close. Disabling the Alarm prevents the Alarm output from closing when a field overvoltage condition exists. Disabling the alarm also disables hardware shutdown.

**Field Overvoltage - Hardware Shutdown.** When Hardware Shutdown is enabled, the DM110 will remove field excitation when a field overvoltage condition exists for 10 seconds.

**Loss of Sensing Voltage - LOS Option.** One of two DM110 responses can be selected for a loss of sensing voltage condition. Selecting Shutdown Regulator will cause the DM110 to remove field excitation when loss of sensing voltage occurs. Selecting Transfer To FCR will cause the DM110 to transfer to FCR mode when a loss of sensing voltage occurs.

**Loss of Sensing Voltage - Time Delay (sec).** The value of this field determines the time delay between when a loss of sensing voltage is recognized and the DM110 responds according to the Hardware Shutdown and LOS Option options selected. A time delay of 0 to 25 seconds may be entered in 1 second increments.

**Loss of Sensing Voltage - Hardware Shutdown.** Enabling Hardware Shutdown will cause the DM110 to remove field excitation when a loss of sensing voltage occurs. Disabling Hardware Shutdown prevents the DM110 from removing excitation during a loss of sensing voltage.

#### Limiters Tab

Limiters tab settings are shown in Figure 5-15 and described in the following paragraphs.

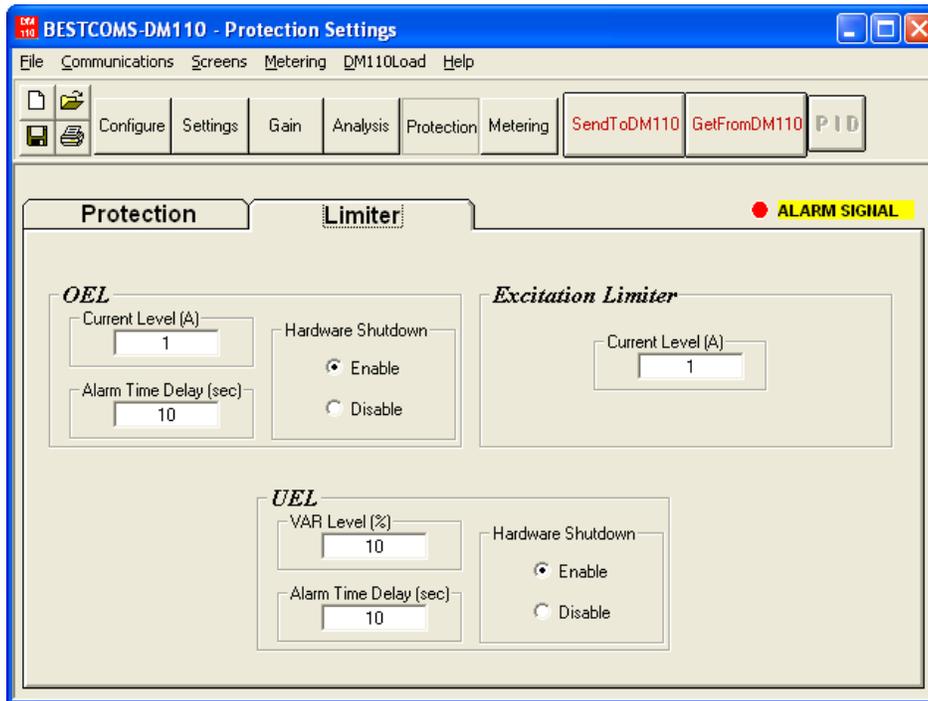


Figure 5-15. Protection Settings Screen, Limiter Tab

**OEL - Current Level (A).** The value of current in this field determines the excitation level that will cause the DM110 to issue an overexcitation limit alarm. A current level of 0 to 15 A may be entered in 0.01 increments. When the level of field current increases above the value of this field, the Overexcitation Shutdown LED on the front panel lights and the OEL time delay starts timing down.

**OEL - Alarm Time Delay (sec).** The value of this field determines the time delay between when the DM110 recognizes an overexcitation condition and the DM110 Alarm output (terminals AL1, AL2) closes. A time delay of 0 to 10 seconds may be entered in 1 second increments.

**OEL - Hardware Shutdown.** If the hardware shutdown feature is enabled and an overexcitation condition exists for the duration of the Alarm Time Delay, the DM110 will stop excitation when the Alarm output closes.

**Excitation Limiter – Current Level (A).** This setting establishes the level of field current where the DM110 starts limiting excitation during normal operating conditions that are not indicative of a fault. The setting range varies according to the setting of the OEL current level. For example, an OEL current level setting of 4 Adc gives an excitation limiter current level setting range of 0 to 4 Adc, and an OEL current level setting of 6 Adc gives an excitation limiter current level setting range of 0 to 6 Adc. A maximum setting range of 0 to 15 Adc is possible. The setting increment is 0.01 Adc.

**UEL – VAR Level (%).** This setting, expressed as a percentage of the leading var setpoint, determines the excitation level that will cause the DM110 to issue an underexcitation limit alarm. A setting of 0 to 100% may be entered in 1% increments. When the var level decreases below this setting, the Underexcitation Limiting LED on the front panel lights and the UEL time delay starts timing down.

**UEL – Alarm Time Delay (sec).** The value of this field determines the time delay between when the DM110 recognizes an underexcitation condition and the DM110 Alarm output (terminals AL1, AL2) closes. A time delay of 0 to 10 seconds may be entered in 1 second increments.

**UEL – Hardware Shutdown.** If the hardware shutdown feature is enabled and an underexcitation condition exists for the duration of the Alarm Time Delay, the DM110 will stop excitation when the Alarm output closes.

## Metering, Operation and Alarms

The Metering, Operation and Alarms screen is viewed by clicking the Metering button or by clicking Screens on the Menu bar and clicking Metering/Operation. Information displayed on the Metering, Operation and Alarms screen can be frozen by clicking the Metering button while viewing the screen or by clicking Metering on the Menu bar and clicking Disable Metering. Metering can be resumed by clicking the Metering button or by clicking Metering on the Menu bar and clicking Enable Metering. The Metering, Operation and Alarms screen consists of

two tabs: Operation and Alarm/Status.

### Operation Tab

Operation tab metering values, setpoint values, and control functions are illustrated in Figure 5-16.

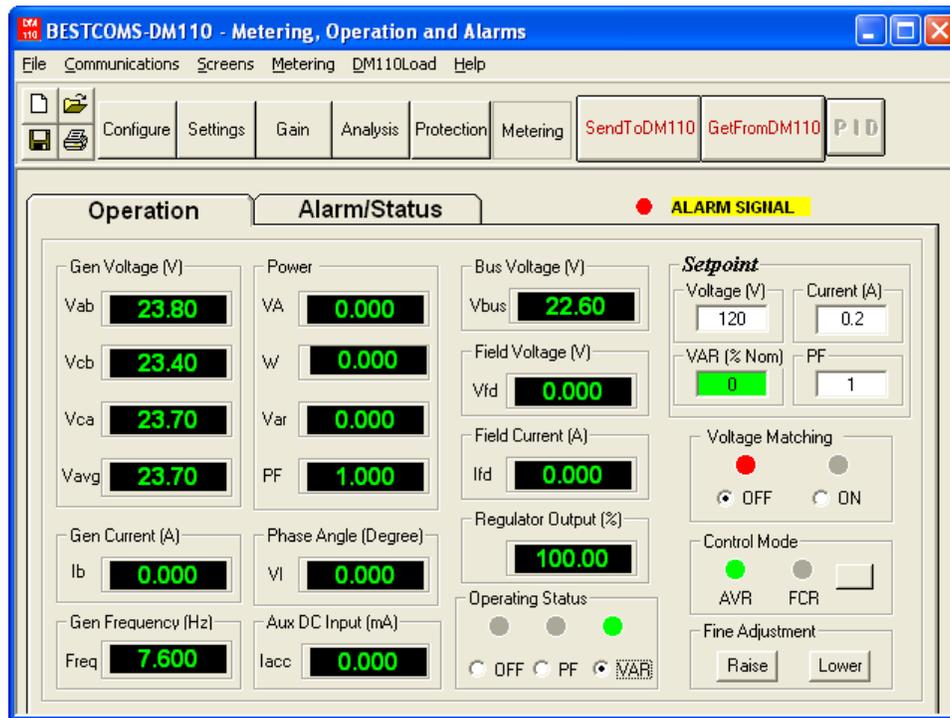


Figure 5-16. Metering, Operation, and Alarms Screen, Operation Tab

**Gen Voltage (V).** These metering values report the status of the  $V_{A-B}$ ,  $V_{C-B}$ ,  $V_{C-A}$ , and  $V_{AVG}$  generator voltages. The reported values are the product of the voltage sensed at terminals E1, E2, and E3 and the generator PT ratio. All metering values are updated once each second. When single-phase sensing is used (System Configuration screen, Sensing Voltage) and the DM110 sensing voltage terminals (E1, E2, and E3) are connected as shown in Figures 4-7 or 4-9, all of the generator voltage metering values will be identical.

**Gen Current (A).** This metering value indicates the level of the B-phase generator current. This value is the product of the current input to CT1 and CT2 and the CT ratio. Generator current is monitored through DM110 terminals CT1 and CT2.

**Gen Frequency (Hz).** This metering value indicates the frequency of the monitored generator voltage.

**Power - VA.** This metering value indicates apparent power and is the calculated product of the metered generator voltage ( $V_{AVG}$ ), PT ratio (entered at the System Configuration screen), metered generator current ( $I_b$ ), CT ratio (entered at the System Configuration screen), and the square root of 3. See Equation 5-1.

$$VA = V_{AVG} \times I_B \times \sqrt{3}$$

Equation 5-1

**Power - W.** This metering value indicates real power and is the calculated product of the metered generator voltage ( $V_{AVG}$ ), PT ratio (entered at the System Configuration screen), metered generator current ( $I_b$ ) CT ratio (entered at the System Configuration screen), square root of 3, and the cosine of the metered phase angle. See Equation 5-2.

$$W = V_{AVG} \times I_B \times \sqrt{3} \times \cos \phi$$

Equation 5-2

**Power - Var.** This metering value indicates reactive power and is the calculated product of the metered generator voltage ( $V_{AVG}$ ), PT ratio (entered at the System Configuration screen), metered generator current ( $I_b$ ) CT ratio

(entered at the System Configuration screen), square root of 3, and the sine of the metered phase angle. See Equation 5-3.

$$\text{var} = V_{AVG} \times I_B \times \sqrt{3} \times \sin \phi$$

*Equation 5-3*

*Power – PF.* This metering value indicates the power factor and is the calculated result of dividing the Real Power (W) value by the Apparent Power (VA) value. See Equation 5-4.

$$PF = W \div VA$$

*Equation 5-4*

*Phase Angle (Degree).* This metering value indicates the phase angle difference (in degrees) between the generator voltage and the generator current.

*Aux DC Input (V).* This metering value indicates the level of dc control current applied from a remote device to DM110 terminals A and B. The displayed value correlates to the generator voltage setpoint.

*Bus Voltage (V).* This metering value indicates the amount of bus voltage present at the utility side of the tie circuit breaker. The displayed value is the product of the voltage sensed at terminals B1 and B3 and the bus PT ratio.

*Field Voltage (V).* This metering value indicates the value of voltage being supplied from the DM110 output (terminals F+ and F-) to the generator field.

*Field Current (A).* This metering value indicates the amount of current flowing from the DM110 output (terminals F+ and F-) to the generator field.

*Regulator Output (%).* This metering value indicates the level of the field output, expressed as a percentage of the maximum rated output.

*Operating Status.* The Operating Status controls and indicators include three buttons and three corresponding indicators. Operating Status buttons are labeled PF, VAR, and OFF. Clicking the PF button changes the color of the adjacent PF indicator to green and causes the DM110 to maintain the desired power factor regulation point. The power factor regulation point can be set within the range of 0.6 lead to 0.6 lag. Clicking the VAR button changes the color of the adjacent VAR indicator to green and causes the DM110 to maintain the desired var regulation point. The var regulation point can be set within the range of 100 percent absorb to 100 percent generate. Clicking the OFF button changes the color of the adjacent OFF indicator to red and disables power factor and var regulation.

Operation of the Operating Status controls is determined by the status of the contacts connected across the DM110 Var/PF Control terminals (52J, 52K). When these contacts are open, the Operating Status controls are enabled. Closing the contacts at terminals 52J and 52K disables the Operating Status controls and interrupts regulation of vars or power factor until the contacts are opened again.

*Setpoint - Voltage (V).* This setting field can be used to enter the desired generator output terminal voltage. The voltage setpoint can also be entered at the Setting Adjustments screen, Setpoint tab, Automatic Voltage Regulator (AVR) - AVR Setpoint (V). The background color of this field is green when operating in AVR mode and power factor and var regulation is disabled.

*Setpoint - Current (A).* This setting defines the field current setpoint when operating in FCR mode. The current setpoint can also be entered at the Setting Adjustments screen, Setpoint tab, Field Current Regulator (FCR) - FCR Setpoint. Current values from 0 to 7 Adc may be entered in increments of 0.01 Adc. The background color of this field is green when operating in FCR mode.

*Setpoint - Var (% of nom.).* This setting determines the level of generator vars maintained by the DM110 when operating in var mode. The var setpoint can also be entered at the Setting Adjustments screen, Setpoint tab, Reactive Power Control (VAR) - VAR Setpoint (% of nom.). The background color of this field is green when the DM110 is operating in AVR mode and is regulating the var setpoint.

*Setpoint - Power Factor.* This setting determines the level of power factor regulation maintained by the DM110. The power factor setpoint can also be entered at the Setting Adjustments screen, Setpoint tab, Power Factor Control (PF) - PF Setpoint. Power Factor setpoint values are adjustable from -0.6 to -1 (1) or 0.6 to +1 in 0.001 increments. The background color of this field is green when the DM110 is operating in AVR mode and is regulating the power factor setpoint.

*Voltage Matching.* The Voltage Matching controls and indicators consist of two buttons and two adjacent indicators. Clicking the ON button changes the color of the adjacent ON indicator to green and enables voltage matching by the DM110. When Voltage Matching is enabled, the DM110 automatically adjusts the field current to match the generator output voltage with the bus voltage prior to synchronizing. In order for Voltage Matching to be enabled, the following conditions must be met.

- The Parallel Generator Compensation Contacts (terminals 52L and 52M) must be shorted.
- The DM110 Voltage Matching input must be shorted (terminals VM and VMC).
- Var/PF control must be disabled by shorting terminals 52J and 52K (open breaker).
- The DM110 must be operating in AVR mode.

Clicking the OFF button changes the color of the adjacent OFF indicator to red and disables the voltage matching function.

*Control Mode.* Clicking the AVR button changes the color of the adjacent AVR indicator to green and enables the AVR operating mode. When operating in AVR mode, the DM110 regulates the generator output voltage at the AVR setpoint. Clicking the FCR button changes the color of the adjacent FCR indicator to green and enables the FCR operating mode. When operating in FCR mode, the DM110 maintains the field current at the FCR setpoint. Enabling the FCR mode turns off Voltage Matching.

*Fine Adjustment.* Raise and Lower buttons control the fine adjustment of the operating setpoint. These buttons perform the same function as closing the appropriate set of contacts connected to the External Adjust terminals (6D and 7 to decrease, 6U and 7 to increase) of the DM110. For AVR mode, each click of the Raise button increases the voltage setpoint 0.01 volts; each click of the Lower button decreases the voltage setpoint 0.01 volts. The minimum and maximum limits for fine adjustment of the voltage setpoint are controlled by the Regulator Sensing Voltage setting (System Configuration screen) and the Fine Voltage Adjustment - Band setting (Setting Adjustments screen). Fine adjustment of the voltage setpoint can be increased/decreased no higher/lower than the Regulator Sensing Voltage setting plus/minus the Band setting. For example, a Regulator Sensing Voltage setting of 100 volts and a Band setting of 10 percent allows the Fine Adjustment function to increase the voltage setpoint to a maximum of 110 volts and decrease the voltage setpoint to a minimum of 90 volts. For Var, PF, or FCR modes, the Raise and Lower buttons provide fine adjustment over the entire adjustment range.

#### Alarm/Status Tab

The Alarm/Status tab indicators provide the status of DM110 protection functions, control modes, and contact inputs. Alarm/Status tab indicators are illustrated in Figure 5-17 and are described in the following paragraphs.

*Protection Alarms.* Six protection alarm indicators provide the status of DM110 protection functions. Alarm indicators include Overexcitation Shutdown, Overexcitation Limiting, Underexcitation Limiting, Generator Overvoltage, Loss of Generator Sensing, and Underfrequency. When a DM110 protection function detects an alarm condition, the appropriate indicator changes from black to red.

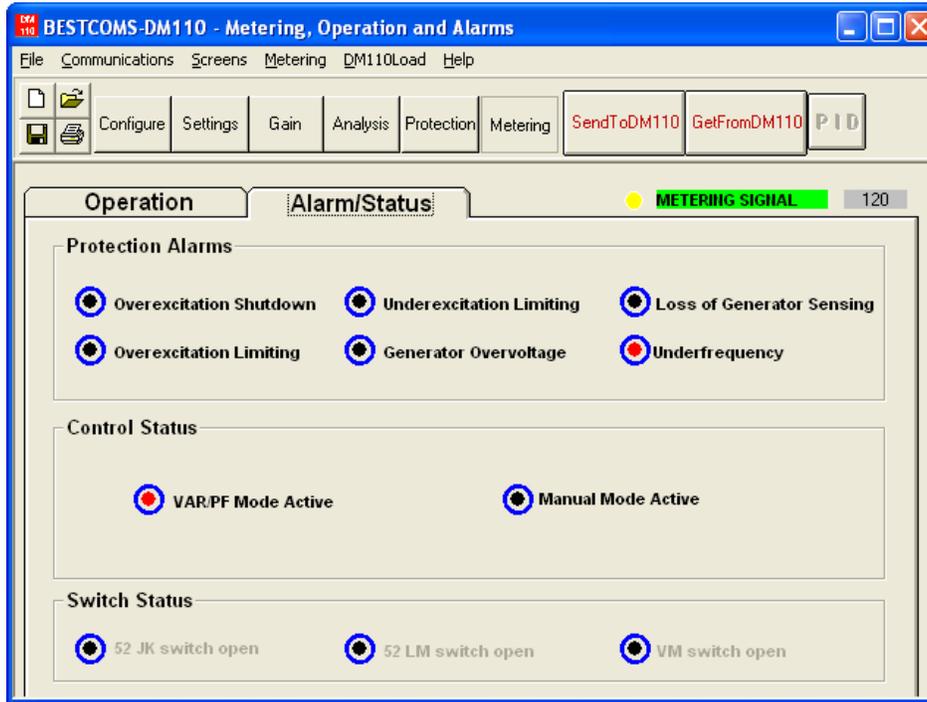


Figure 5-17. Metering, Operation, and Alarms Screen, Alarm/Status Tab

**Control Status.** Two Control Status indicators indicate when the VAR/PF and Manual modes are active. The Manual Mode Active indicator changes from black to red when the FCR control mode is active. The VAR/PF Mode Active indicator changes from black to red when the DM110 is operating in AVR mode and correction of power factor or vars is selected.

**Switch Status.** The Switch Status indicators annunciate the open/closed status of three DM110 contact inputs: 52J/K, 52L/M, and VM. Contact closure across an input is annunciated by the indicator color changing from black to red and the indicator label text changing from “switch open” to “switch closed”. When the 52J/K contact input is open, selection of PF or Var mode can be made on the Operation tab of the Metering, Operation, and Alarms screen. Closed contacts across the 52L/M input disable parallel control and droop. Closed contacts across the VM input enable the voltage matching function.

**Metering Signal.** The Metering Signal indicator flashes to indicate when metering is active. A number beside the indicator tracks how many times the metering and status indicators have been updated. When the Metering button is clicked or Metering on the Menu bar is clicked followed by Disable Metering, the Metering Signal indicator stops flashing, the metering update counter stops incrementing, and the metering functions stop being updated.

## PID DATA

BESTCOMS enables generator stability to be set through the automatic calculation of PID parameters. PID stands for Proportional, Integral, Derivative. The word proportional means that the response of the DM110 output is proportional or relative to the amount of change that is observed. Integral means that the DM110 output is proportional to the amount of time that a change is observed. Integral action eliminates offset. Derivative means that the DM110 output is proportional to the required rate of excitation change. Derivative action avoids excitation overshoot.

BESTCOMS automatically calculates PID values after the user selects the generator frequency, generator time constant (T'do), and exciter time constant (Texc). With BESTCOMS, the user may generate new PID numbers, add to a PID list file, and update the AVR gain settings in the Control Gain or Step Response screens.

The PID window (Figure 5-18) is accessed by clicking the PID button. The PID button can be clicked only when the Stability Range setting of the Control Gain screen is set at a value of 21. (A setting of 21 enables the entry of custom stability settings through the PID window.) Then, when a field of the Control Gain screen is changed or selected, the PID button changes from gray to yellow and the button can be clicked to view the PID window. After the PID numbers are modified, calculated, and updated, the PID window is closed by clicking the Update Setting Screen button. The modified PID values are then shown on the Control Gain screen.

Figure 5-18. PID Window

### PID Calculation Based on Input Values

The available range for the exciter time constant depends on the value entered for the generator time constant. (The default value for the exciter time constant is the generator time constant divided by 6.) The generator time constant value selected must be in the range of 1.00 to 15.00 seconds and in 0.05 increments. When the generator time constant value is 1.00, the available exciter time constant range is 0.03 to 0.50 in 0.01 second increments. When the generator time constant value is 15.00, the available exciter time constant range is 0.30 to 3.00 in 0.01 second increments.

For example, when T'do is set at 2.0 seconds, Texc is 0.33. After specifying the input values, a set of PID parameters (output data) is generated automatically. If T'do is set at 5.00 seconds, then Texc is 0.83 seconds. The calculated KP is 155.47, KI is 138.72, KD is 48, and Kg is 1.

PID parameters can be directly removed from, added to, or modified in the PID List Data. PID parameters may also be saved into a file (pidlist.dat).

### Adding to the PID List

 <b>CAUTION</b>
<b>Improper PID numbers will result in poor system performance or system damage.</b>

PID parameters can be added to a list and recalled for operation and comparison. To add to the list, type a name for the generator (or other appropriate information) in the generator information box. Select the generator time constant. Observe the PID gain parameters in the Field Output Data fields. If these gain parameters are appropriate, click the Add to PID List button. Check for the new parameters by pulling down the PID List (click the down arrow). The new gain and time constant parameters should be displayed.

### Removing a PID List Record

PID parameters can also be removed from the list. To remove a list (record), pull down the PID List and select the record or list so that the gain and time constant parameters are displayed. Click the Remove Record button and the listed record is deleted.

### Retrieving Existing Data from the PID List

To retrieve existing data, pull down the PID List and select the record or list so that the gain and time constant parameters are displayed and highlighted. Click the Get from a List button and the listed record input and output

data displays in the boxes.

## SETTINGS FILES

BESTCOMS software enables you to print a list of DM110 settings, save DM110 settings to a file, and open a settings file and upload those settings to a DM110.

### Printing Settings Files

A printout of DM110 settings can be useful for record keeping or comparison purposes. DM110 settings are printed by clicking the print icon or clicking **F**ile on the Menu bar and then clicking **P**rint. When the print command is given, a dialog box provides the opportunity to add a title, unit information, and comments to the settings list. Each entry is limited to a maximum of 54 characters. When **O**K is clicked, a print dialog box prompts you to select a printer. Once the printer is selected, the report is printed.

### Saving Settings Files

Saving DM110 settings to a file for uploading to other DM110 units saves setup time when configuring multiple units to the same configuration. A settings file can also be created in BESTCOMS without being connected to a DM110. The settings of the desired screens can be changed and these settings can then be saved to a file. Once a settings file is created, it can be edited using any text editing software, and then saved for uploading.

A settings file is created by clicking the save icon or by clicking **F**ile on the Menu bar and then clicking **S**ave. When the save command is given, a dialog box provides a choice of saving the settings in a DM110 file or text file.

If “DM110 File” is selected, a Save As dialog box appears and enables you to save the settings file. The file is automatically given a .de1 extension.

If “Text File” is selected, a dialog box provides the opportunity to add a title, unit information, and comments to the settings. Each entry is limited to a maximum of 54 characters. When **O**K is clicked, a Save As dialog box appears and enables you to save the settings file. The file is automatically given a .txt file extension.

### Uploading Settings Files

A DM110 settings file downloaded from a DM110 or created within BESTCOMS can be uploaded to multiple DM110 units. Only a DM110 settings file with a .de1 extension can be uploaded to a DM110 unit. Before uploading a file, communication must be initiated with the DM110 that is to receive the settings. Refer to the paragraphs labeled *Starting BESTCOMS*, *Establishing Communication*.



The upload process is started by clicking the open icon or clicking **F**ile on the menu bar and then clicking **O**pen. A dialog box is then displayed (Figure 5-19) reminding you that the DM110 should be off-line before uploading settings. Clicking **Y**es loads the settings into DM110 memory.

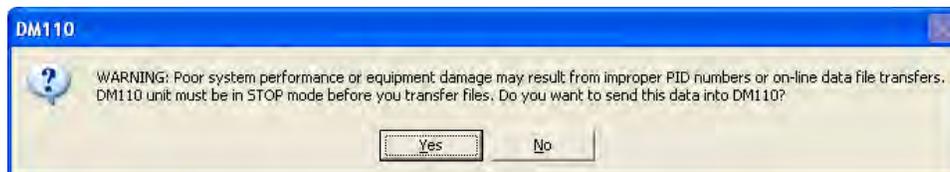


Figure 5-19. Settings Upload Dialog Box

## PASSWORD PROTECTION

Password protection guards against unauthorized changing or viewing of DM110 settings. A single password protects all DM110 settings. The DM110 is delivered with a default password of *decs*. Once the password is changed, it should be stored in a secure location. If the user-defined password is lost or forgotten, BESTCOMS must be reloaded to restore the default password.

### Changing the Password

#### NOTICE

**A password change can be made only after communication between BESTCOMS and the DM110 is established.**

A new password can be programmed by performing the following steps.

1. Click **C**ommunications on the menu bar and click **P**assword Change on the drop-down menu. The Change Password dialog box of Figure 5-20 appears.
2. Type the current password in the “Enter your access password” field of the Change Password dialog box and press the Enter key on your keyboard.
3. Another dialog box will appear with instructions for making the password change. Click the OK button and type a new password (8 alphanumeric characters, maximum) in the “Enter your new password” field.
4. Press the Enter or Tab key on your keyboard to advance the cursor into the field labeled “Re-enter your new password”. Type the new password again to confirm the changed password and press the Enter key. When the Enter key is pressed, the new password is enabled and a dialog box appears to remind you to keep your password in a secure location.



Figure 5-20. Password Dialog Box

## TERMINATING COMMUNICATION

DM110 communication is terminated by clicking on **C**ommunications on the menu bar, and clicking **C**lose **C**omm Port. You are asked if you want to save the settings to EEPROM. This question is asked even if no changes were made to the DM110 settings. When you execute the Close command (with a Yes or No to save settings to EEPROM), communication with the DM110 is terminated. If you choose to exit BESTCOMS (by clicking **F**ile on the menu bar and then **E**xit) without first closing communication, you are still given the opportunity to save the settings to EEPROM.

## EMBEDDED FIRMWARE

Embedded firmware is the operating program that controls the actions of the DM110. The DM110 stores firmware in nonvolatile flash memory that can be reprogrammed through the RS-232 communication port. It is not necessary to replace EPROM chips when replacing the firmware with a newer version.

### Updating the Firmware

Future enhancements to DM110 functionality may make a firmware update desirable. DM110 embedded firmware can be updated by performing the following steps.

#### CAUTION

**If power is lost or communication is interrupted during file transfer, the DM110 will not recover and will cease to be operational.**

**NOTICE**

**Communication must be closed prior to uploading embedded firmware to the DM110. Refer to the Terminating Communication subsection for information about closing DM110 communication.**

1. Connect a communication cable between the rear RS-232 connector of the DM110 and the appropriate communication port of your PC.
2. Click **DM110Load** on the BESTCOMS menu bar and click **Uploading Embedded Software**. If this menu selection is grayed out, you'll need to close DM110 communication. Refer to the *Terminating Communication* subsection for information about closing DM110 communication.

When **Uploading Embedded Software** is clicked, a dialog box (Figure 5-21) is displayed that advises you to disconnect the DM110 generator and bus connections and save the DM110 settings in a file before proceeding with firmware uploading. Firmware uploading may replace some user-adjusted settings with factory-default settings.

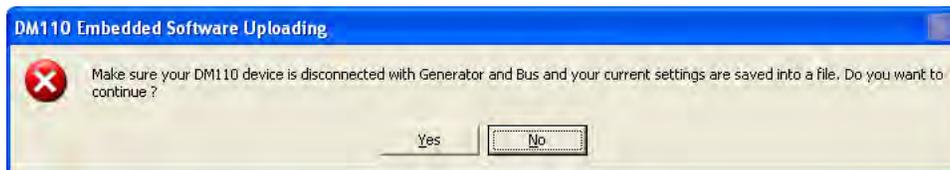


Figure 5-21. Software Uploading Advisory Dialog Box

3. Click **Yes** to proceed with software uploading. When **Yes** is clicked, the Communication Initiation screen (Figure 5-4) appears. Select the active communication port for your PC and click the **Initialize** button. BESTCOMS obtains the configuration settings from the DM110 and saves all settings. When the saving of settings is complete, the DM110 Embedded Program Loader of Figure 5-22 appears.

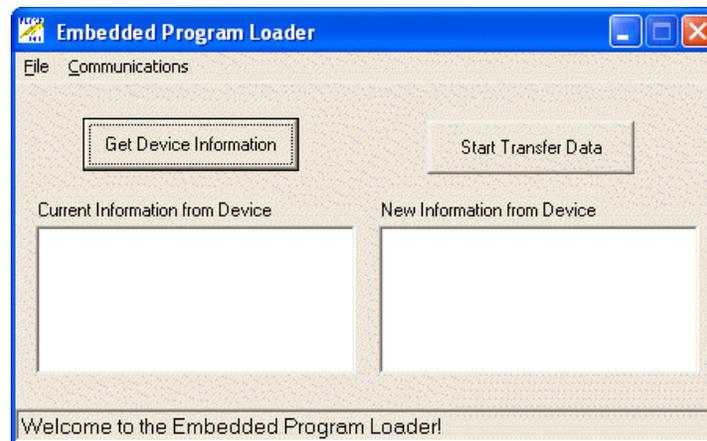


Figure 5-22. DM110 Embedded Program Loader

4. Click the **Get Device Information** button. The DM110 Embedded Program Loader retrieves and displays the DM110 model number, style number, serial number, and application program version number in the left-hand column (Figure 5-23).



Figure 5-23. Retrieved DM110 Information

- Click the **Start Transfer Data** button to proceed with software uploading. The dialog box of Figure 5-24 appears and recommends that your DM110 settings be saved in a file that can be uploaded to the DM110 after the embedded firmware is updated.



Figure 5-24. Settings File Reminder Dialog Box

Clicking **No** allows you to exit the upload process so that a DM110 settings file can be created. Refer to the Settings Files subsection for information about creating a settings file.

Clicking **Yes** continues with the upload process and displays the Open dialog box of Figure 5-25. The Open dialog box is used to locate and select the appropriate file for uploading to the DM110. Only files with a .S19 extension are displayed in the Open dialog box.

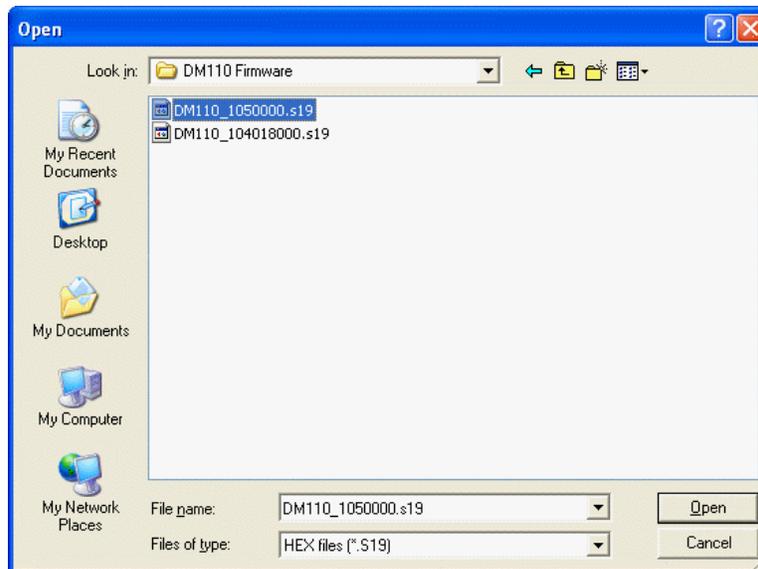


Figure 5-25. Open Dialog Box

- Select the appropriate file for uploading and click the **Open** button to start the file transfer. A dialog box (Figure 5-26) indicating the progress of the file transfer is displayed.

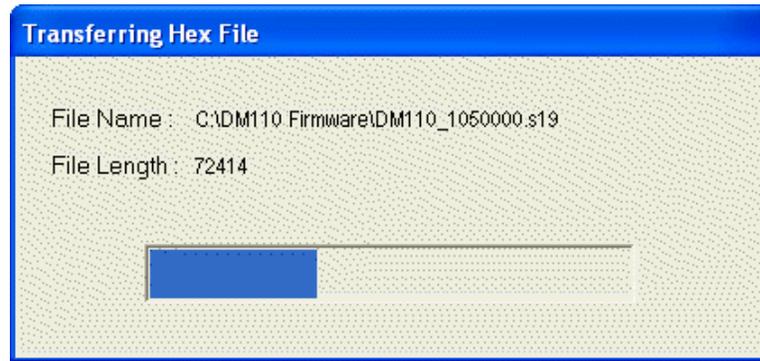


Figure 5-26. File Transfer Progress

Once the transfer is complete, the device information is displayed in the right-hand column of the DM110 Embedded Program Loader (Figure 5-27). The displayed program version number indicates the version and date of the firmware just loaded.

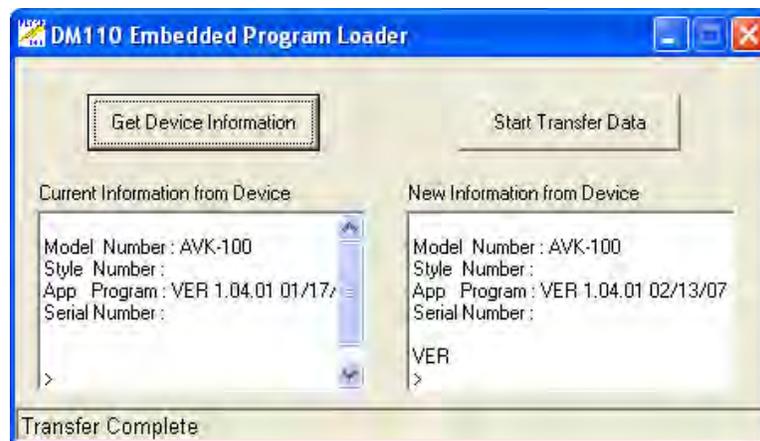


Figure 5-27. DM110 Information After Upload

7. Close the DM110 Embedded Program Loader. BESTCOMS loads the default settings, loads the saved settings, and checks the settings.

## SECTION 6 • MAINTENANCE AND TROUBLE-SHOOTING

---

### PREVENTATIVE MAINTENANCE

The only preventive maintenance required on the DM110 is to periodically check that the connections between the DM110 and the system are clean and tight. DM110 units are manufactured using state-of-the-art, surface-mount technology. As such, DM110 units are not field serviceable.

---

### TROUBLESHOOTING

If you do not get the results that you expect from the DM110, first check the programmable settings for the appropriate function. Use the following troubleshooting procedures when difficulties are encountered in the operation of your excitation system.

#### Generator Voltage Does Not Build

Step 1. Verify that all wiring is properly connected. Refer to Figures 4-6 through 4-10.

If wiring is improperly connected or loose, reconnect wiring properly.

If wiring connections are correct, proceed to Step 2.

Step 2. Verify that the generator is spinning at rated speed.

If the generator is not up to rated speed, increase generator speed to the rated value.

If the generator is spinning at rated speed, proceed to Step 3.

Step 3. For PMG power, check for correct input power to the DM110. Refer to Section 1, General Information, Specifications for input power requirements.

If voltage is not present, refer to the generator manual for repair procedures (PMG system only).

If voltage is present, proceed to Step 4.

Step 3a. If the DM110 is being shunt powered (non-PMG) mode, verify that the residual voltage applied to the power input is at least 6 Vac.

If the applied voltage is less than 6 Vac, refer to the generator manual and flash the generator field.

If the applied voltage is 6 Vac or greater, proceed to Step 4.

Step 4. Verify that no fuses are open.

Replace any open fuses.

If no fuses are open, proceed to Step 4.

Step 5. Verify that the front panel Overexcitation Shutdown indicator is not lit.

If the front panel Overexcitation Shutdown indicator (field voltage) is lit, check the generator and/or load conditions. Interrupt input power or shut down the generator for a minimum of one minute.

If the front panel Overexcitation Shutdown indicator is not lit, proceed to Step 6.

Step 6. Verify that the front panel Overexcitation Limiting indicator is not lit.

If the front panel Overexcitation Limiting indicator is lit, check the generator and load conditions. Also check the field current limit setpoint for the correct level. Interrupt input power or shut down the generator for a minimum of 1 minute.

If the front panel Overexcitation Limiting indicator is not lit, proceed to Step 7.

Step 7. Verify that the DM110 soft start settings are correct. Too long of a soft start setting may give the appearance of no buildup.

If the soft start settings are incorrect, adjust the settings.

If the soft start settings have no effect, proceed to Step 8.

A043Y695 (Issue 1)

Step 8. Replace the DM110 unit.

If replacing the DM110 unit does not correct the malfunction, then the generator is defective. Consult with the generator manufacturer.

### Low Generator Output Voltage

Step 1. Verify that the voltage adjustment is not set too low.

If the voltage adjustment is too low, adjust it to the correct setpoint.

If the voltage adjustment is correct, proceed to Step 2.

Step 2. Verify that the underfrequency knee setpoint is not greater than the generator frequency.

If the underfrequency setpoint is too high, adjust the setpoint below the rated generator frequency.

If the underfrequency setpoint is correct, proceed to Step 3.

Step 3. Verify that the generator is spinning at rated speed.

If the generator is not up to rated speed, increase the generator speed to the rated level.

If the generator is spinning at rated speed, proceed to Step 4.

Step 4. For PMG power, check for correct input power to the DM110. Refer to Section 1, General Information, Specifications for input power requirements.

If the DM110 input voltage is low, refer to the PMG manual for PMG repair (PMG system only).

If the voltage is at the required level, proceed to Step 5.

Step 4a. If the DM110 is being shunt powered (non-PMG), verify that the power potential transformer (if used) has the correct turns ratio, is sized properly, and is supplying the correct voltage level to the power input.

If the turns ratio of the power potential transformer is incorrect, is sized too small, or is not supplying the correct input power, replace the power potential transformer.

If the power potential transformer is correct, proceed to Step 5.

Step 5. Verify that the sensing potential transformer (if used) has the correct turns ratio and is operating correctly.

If the turns ratio of the sensing potential transformer is incorrect, replace the sensing potential transformer.

If the sensing potential transformer is operating correctly, proceed to Step 6.

Step 6. Verify that the front panel Overexcitation Limiting indicator is not lit.

If the front panel Overexcitation Limiting indicator is lit, check the generator and/or load conditions. Also check the field-current limit setpoint for the correct level. Interrupt input power or shut down the generator for a minimum of one minute.

If the front panel Overexcitation Limiting indicator is not lit, proceed to Step 7.

Step 7. Verify that the front panel Excitation Limiting indicator is not lit.

If the front panel Excitation Limiting indicator is lit, check the generator and/or load conditions. Also check the field current limiting setpoint for the correct excitation limiting level. Interrupt the input power or shut down the generator for a minimum of one minute.

If the front panel Overexcitation Limiting indicator is not lit, proceed to Step 8.

Step 8. Low generator output voltage may occur when operating in droop mode with an inductive load.

If the low voltage condition is not caused by the droop function, proceed to Step 8.

Step 9. Verify that the voltage setpoint is not being modified by application of voltage to the optional Accessory Input.

If the low voltage condition is not caused by voltage applied to the Accessory Input, proceed to Step 9.

Step 10. Replace the DM110 unit.

**High Generator Output Voltage**

- Step 1. Verify that the voltage adjustment is not set too high.  
If the voltage adjustment is too high, adjust it to the correct setpoint.  
If the voltage adjustment is correct, proceed to Step 2.
- Step 2. Verify that the sensing potential transformer (if used) has the correct turns ratio.  
If the turns ratio of the sensing potential transformer is incorrect, replace the sensing potential transformer with the correct one.  
If the sensing potential transformer is correct, proceed to Step 3.
- Step 3. High generator output voltage may occur when operating in droop mode with a capacitive load.  
If the high voltage condition is not caused by the droop function, proceed to Step 4.
- Step 4. Verify that the voltage setpoint is not being modified by application of voltage to the optional Accessory Input.  
If the high voltage condition is not caused by voltage applied to the Accessory Input, proceed to Step 5.
- Step 5. Replace the DM110 unit.

**Poor Voltage Regulation**

- Step 1. Verify that the case of the DM110 is properly grounded.  
If the DM110 is not properly grounded, connect a dedicated ground wire to the quarter-inch fast-on connector labeled GND on the rear of the DM110 case.  
If the DM110 is properly grounded, proceed to Step 2.
- Step 2. Check for grounded field leads.  
If the field leads are grounded, isolate them from ground.  
If the field leads are not grounded, proceed to Step 3.
- Step 3. If the DM110 is powered from a PMG, check for grounded PMG leads.  
If the PMG leads are grounded, isolate them from ground.  
If the PMG leads are not grounded, proceed to Step 4.
- Step 4. Verify that the generator frequency is not dropping below the DM110 underfrequency setpoint when load is applied to the generator.  
If the generator frequency is dropping below the underfrequency setpoint, reduce the setpoint if possible. Also check the prime mover and generator for proper sizing in relation to the applied load.  
If poor regulation is not related to DM110 underfrequency operation, proceed to Step 5.
- Step 5. Verify that regulation is not being affected by normal droop operation.  
If droop operation is not affecting regulation, proceed to Step 6.
- Step 6. Replace the DM110 unit.

**Generator Output Unstable (Hunting)**

- Step 1. Verify that the governor for the prime mover is operating properly.  
If the governor is not operating properly, troubleshoot using the manufacturer's suggested procedures.  
If the governor is operating properly, proceed to Step 2.
- Step 2. Verify that the sensing and input power leads are connected securely.  
If the sensing or input power leads are not connected securely, tighten the connections.

If the sensing or input power lead connections are secure, proceed to Step 3.

Step 3. Verify that the DM110 Stability Range is set to the proper range.

If the Stability Range setting is incorrect, reset the Stability Range.

If the Stability Range setting is correct, proceed to Step 4.

Step 4. Verify that the Stability Level is properly set.

If the Stability Level is not properly set, reset the Stability Level.

#### **Overexcitation Shutdown Indicator is Annunciating**

Step 1. Check for generator overloading.

If the generator is operating with a larger than rated load, shed load.

If the generator is operating with a rated or less than rated load, proceed to Step 2.

Step 2. Verify that the generator exciter field voltage requirements are compatible with the DM110.

If the exciter field voltage requirements are compatible with the DM110, proceed to Step 3.

Step 3. Replace the DM110.

If replacing the DM110 does not correct the malfunction, proceed to Step 4.

Step 4. Refer to the generator manual. Generator is defective.

#### **Loss of Generator Sensing Indicator is Annunciating**

Step 1. Verify that the voltage sensing leads are properly connected.

If the sensing leads are not properly connected, correct the connections.

If the sensing lead connections are correct, proceed to Step 2.

Step 2. For single-phase sensing, verify that E2 and E3 are connected.

If E2 and E3 are not connected, connect them both to phase C sensing voltage.

If E2 and E3 are properly connected, proceed to Step 3.

Step 3. Verify that the sensing potential transformer (if used) has the correct turns ratio and is functioning properly.

If the sensing potential transformer has the wrong turns ratio or is malfunctioning, replace it.

If the sensing potential transformer is correct and functioning properly, proceed to Step 4.

Step 4. Verify that the generator output voltage is present on all phases.

If the generator is missing a phase, refer to the generator manual. Generator is defective.

If generator output voltage is balanced on all phases, proceed to Step 5.

Step 5. Replace the DM110.

#### **Overexcitation Limiting Indicator is Annunciating**

Step 1. Check for generator overloading.

If the generator is operating with a larger than rated load, shed load.

If the generator is operating with a rated or less than rated load, proceed to Step 2.

Step 2. Verify that the DM110 output (field) current limit is not set too low.

If the output current limit setpoint is too low, adjust for the proper setting.

If the output current limit is set properly, proceed to Step 3.

Step 3. Verify that the generator exciter field current requirements are compatible with the DM110.

If the generator exciter field current requirements are compatible with the DM110, proceed to Step 4.

Step 4. Replace the DM110.

If replacing the DM110 does not correct the malfunction, proceed to Step 5.

Step 5. Refer to the generator manual. Generator is defective.

#### **Underexcitation Limiting Indicator is Annunciating**

Step 1. Verify that the DM110 generator voltage setpoint is not being driven to a lower level.

The setpoint can be affected by the Raise/Lower contact inputs or by the Auxiliary input.

Step 2. Verify that the DM110 output (field) current limit is not set too low.

Adjust the field current limit as needed.

Step 3. Use the connection diagrams of Section 4, *Installation* to verify that the sensing voltage and current connections to the DM110 provide the proper phasing.

Correct the sensing voltage and current connections as needed.

Step 4. Verify that the generator exciter field current requirements are compatible with the DM110.

If the generator exciter field current requirements are compatible with the DM110, proceed to Step 5.

Step 5. Replace the DM110.

If replacing the DM110 does not correct the malfunction, proceed to Step 6.

Step 6. Refer to the generator manual or contact the generator manufacturer.

#### **Underfrequency Active Indicator is Annunciating**

Step 1. Verify that the generator is operating at rated speed.

If the generator is not operating at rated speed, adjust the generator speed.

If the generator is operating at the rated speed, proceed to Step 2.

Step 2. Verify that the underfrequency setpoint is correct.

If the underfrequency setpoint is incorrect, adjust it to the correct value.

#### **No Droop**

Step 1. Verify that the DM110 52L/M contact input is open.

If the 52L/M contact input is not open, it must be opened to enable the droop function.

If the 52L/M contact input is open, proceed to Step 2.

Step 2. Verify that the DM110 52J/K contact input (if present) is closed or the Var/PF function is disabled via BESTCOMS. Var/PF operation must be disabled for droop operation. If var/PF operation is disabled, proceed to Step 3.

Step 3. Verify that the DM110 droop setting is not adjusted to 0% droop.

If the droop setting is adjusted to 0% droop, increase the setpoint above 0%.

If the droop setting is adjusted to above 0%, proceed to Step 4.

Step 4. Check for an open in the circuit connected to DM110 CT1 and CT2.

If there is an open circuit, repair as necessary.

If there is no open circuit, proceed to Step 5.

- Step 5. Verify that all connections are correct according to Figures 4-6 through 4-9.  
If connections are incorrect, correct the problem.  
If connections are correct, proceed to Step 6.
- Step 6. Verify that the load being applied to the generator for droop testing is not purely resistive.  
If only a resistive load is being applied to the generator, apply an inductive load and retest.  
If the load being applied to the generator is inductive, proceed to Step 7.
- Step 7. Verify that your DM110 is compatible with the current sensing transformer (1 A or 5 A secondary) being used. For example, a current sensing transformer with a 1 ampere output rating would produce very little droop if your DM110 has a 5 ampere current transformer input. Refer to Figure 1-1 to check the current transformer input of your DM110.  
If the current transformer input is incorrect, replace the current sensing transformer or the DM110 for compatibility.  
If the current transformer input is correct, proceed to Step 8.
- Step 8. If the above steps fail to correct the malfunction, replace the DM110 unit.

### No Voltage Matching

- Step 1. Verify that the Voltage Matching option was purchased and is enabled in the software.  
If not enabled, use the BESTCOMS software to turn on voltage matching.  
If voltage matching is enabled, proceed to Step 2.
- Step 2. Verify that all connections are correct according to Figures 4-6 through 4-9 as required for the Voltage Matching option of the DM110.  
If the interconnection is incorrect, reconnect according to the appropriate interconnect diagram.  
If the interconnection is correct, proceed to Step 3.
- Step 3. Verify that the DM110 VM/VMC contact input is closed.  
If the VM/VMC contact input is open, it must be closed to enable voltage matching.  
If the VM/VMC contact input is closed, proceed to Step 2.
- Step 4. Check for correct utility reference voltage on DM110 terminals B1 and B3.  
If the interconnection is incorrect, reconnect according to the appropriate interconnect diagram.  
If the interconnection is correct, check for open system fuses.  
Verify that the potential sensing transformer, if used, is connected to DM110 terminals B1 and B3.  
If potential sensing transformer connections are correct, proceed to Step 5.
- Step 5. Verify that the generator output voltage setpoint is within 10 percent of the measured utility bus voltage.  
If the setpoint is too low or too high, adjust the setpoint to the appropriate level.  
If the setpoint is correct, proceed to Step 6.
- Step 6. If the above steps fail to correct the Voltage Matching malfunction, replace the DM110.

## APPENDIX A • DEFAULT SETTINGS

## INTRODUCTION

The following default settings are saved in the DM110 prior to shipment.

### System Configuration

Control Mode: ..... AVR (Auto)  
 Operating Status: ..... Droop (VAR/PF Off)  
 Voltage Matching: ..... Off  
 Sensing Voltage Type: ..... Three Phase  
 Limiter Mode: ..... BOTH  
 OEL Type: ..... Summing Point  
 52JK Mode: ..... PF/VAR  
 Generator Frequency: ..... 50 Hz  
 Regulator Sensing Voltage: ..... 110 V  
 Regulator Sensing Current: ..... 1 A  
 Generator PT Ratio: ..... 1  
 Generator CT Ratio: ..... 1  
 Bus PT Ratio: ..... 1

### Setting Adjustments

AVR Setpoint: ..... 110 V  
 AVR Minimum Setpoint: ..... 99 V  
 AVR Maximum Setpoint: ..... 121 V  
 Fine Voltage Adjustment Band: ..... 10%  
 Droop Setting: ..... 3%  
 Phase Compensation: ..... 0 degrees  
 FCR Setpoint: ..... 0.03 A  
 FCR Minimum Setpoint: ..... 0 A  
 FCR Maximum Setpoint: ..... 7 A  
 VAR Setpoint: ..... 0%  
 Maximum Underexcited Setpoint: ..... -100%  
 Maximum Overexcited Setpoint: ..... 100%  
 PF Setpoint: ..... 1  
 Maximum Leading PF Setpoint: ..... -0.6  
 Maximum Lagging PF Setpoint: ..... 0.6  
 Generator Voltage Soft Start Time: ..... 20 sec  
 Dwell: ..... Disabled  
 Voltage Matching Speed: ..... 10 sec  
 Voltage Matching Disable: ..... 52JK  
 Voltage Matching Mode: ..... Revert  
 Generator to Bus Ratio: ..... 100%  
 Underfrequency Setting - Corner Frequency: ..... 47.5 Hz  
 Underfrequency Setting - Slope: ..... 1 V/Hz

### Control Gains

Stability Range: ..... 10  
 AVR/FCR - Proportional Gain KP: ..... 165.7  
 AVR/FCR - Integral Gain KI: ..... 158.7  
 AVR/FCR - Derivative Gain KD: ..... 54.08  
 AVR/FCR - Gain TD: ..... 0

### STAMFORD I AvK DM110 Default Settings 9287500992 Rev G

AVR - Loop Gain Kg: ..... 10  
 FCR - Loop Gain Kg: ..... 10  
 PF - Integral Gain KI: ..... 3  
 VAR - Integral Gain KI: ..... 3  
 VAR - Loop Gain Kg: ..... 3  
 PF - Loop Gain Kg: ..... 3  
 OEL - Integral Gain KI: ..... 10  
 OEL - Loop Gain Kg: ..... 10

UEL - Integral Gain KI:..... 10

UEL - Loop Gain Kg:..... 10

**Protection Settings**

OEL Current Level: ..... 10 A

Excitation Limiter: ..... 1 A

OEL Alarm Time Delay: ..... 10 sec

OEL Shutdown: ..... Enabled

UEL Var Level: ..... 20 %

UEL Alarm Time Delay: ..... 10 sec

UEL Shutdown: ..... Disabled

Field Overvoltage Level: ..... 100 Vdc

Field Overvoltage Alarm: ..... Enabled

Field Overvoltage Shutdown: ..... Enabled

Loss of Sensing Voltage Option: ..... Shutdown Regulator

Loss of Sensing Time Delay: ..... 5 sec

Loss of Sensing Hardware Shutdown: ..... Disabled

Generator Overvoltage Level: ..... 120%

Generator Overvoltage Shutdown: ..... Enabled

Generator Overvoltage Alarm Time Delay: ..... 1 sec

Generator Overvoltage Alarm: ..... Enabled



Head Office:  
Barnack Road  
Stamford  
Lincolnshire  
PE9 2NB  
United Kingdom  
Tel: +44 1780 484000  
Fax: +44 1780 484100

[www.cumminsgeneratortechnologies.com](http://www.cumminsgeneratortechnologies.com)

Copyright 2009, Cummins Generator Technologies Ltd. All Rights Reserved.  
Stamford and AvK are registered trademarks of Cummins Generator Technologies Ltd  
Cummins and the Cummins logo are registered trademarks of Cummins Inc.  
**A043Y695 (Issue 1)** Part Number: TD\_DM110\_11\_09\_G JS/AM