

Distribution Protection M-7651A D-PAC

Application: DER Interconnection Protection



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BECKWITH ELECTRIC  CO. INC.

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Drew Welton is the Vice President of Sales & Creative Technical Solutions for Beckwith Electric and provides strategic leadership to the sales management team as well as creative technical solutions to our customers. Mr. Welton joined Beckwith Electric in 2016 as Director of Sales to provide strategic sales leadership and to further develop and execute sales channels.

- North American Regional Manager for OMICRON starting in 1997.
- Regional Sales Manager with Beckwith Electric. He also served as National Sales Director for Substation Automation with AREVA T&D.
- Written numerous articles on substation maintenance testing, and has conducted numerous training sessions for substation technicians and engineers at utilities and universities across North America.
- 20 year Senior Member of IEEE-PES, has been a contributor on a number of PSRC working groups, and presented at a number of industry conferences specific to power system protection and control.
- Graduate of Fort Lewis College, Durango, CO, with a Bachelor's degree in Business Administration.

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BECKWITH ELECTRIC  CO. INC.

Wayne Hartmann

Senior VP, Customer Excellence
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 904-238-3844



Wayne is Beckwith Electric's top strategist for delivering innovative technology messages to the Electric Power Industry through technical forums and industry standard development.

- Before joining Beckwith Electric, performed in Application, Sales and Marketing Management capacities at PowerSecure, General Electric, Siemens Power T&D and Alstom T&D.
- Provides training and mentoring to Beckwith Electric personnel in Sales, Marketing, Creative Technical Solutions and Engineering.
- Key contributor to product ideation and holds a leadership role in the development of course structure and presentation materials for annual and regional Protection & Control Seminars.
- Senior Member of IEEE, serving as a Main Committee Member of the Power System Relaying and Control Committee for over 25 years.
 - Chair Emeritus of the IEEE PSRCC Rotating Machinery Subcommittee ('07-'10).
 - Contributed to numerous IEEE Standards, Guides, Reports, Tutorials and Transactions, delivered Tutorials IEEE Conferences, and authored and presented numerous technical papers at key industry conferences.
- Contributed to McGraw-Hill's "Standard Handbook of Power Plant Engineering."

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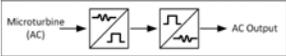
M-7651A D-PAC for DER Interconnection Protection

DER Interconnection Protection Overview

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Conventional DER

<p>Industrial Gas Turbine</p> 	<p>Reciprocating Diesel</p> 
<p>Microturbine Gaseous Fuel</p>  	<p>Reciprocating Gaseous Fuel</p> 

Reciprocating aka: Internal Combustion Engine (ICE)

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Conventional DER

Fuel Cell

The diagram shows a fuel cell with an anode on the left and a cathode on the right, separated by a polymer electrolyte. Hydrogen (H₂) enters the anode and oxygen (O₂) enters the cathode. Protons (H⁺) move from the anode to the cathode through the electrolyte. Electrons (e⁻) flow from the anode through a load to the cathode. Water (H₂O) is produced at the cathode. Depleted fuel and product gases exit from the anode side, and depleted oxidant and product gases exit from the cathode side.

Fuel Cell (DC) → [Inverter] → AC Output

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Renewable DER

Solar (Thermal)

The diagram illustrates the solar thermal cycle. Parabolic mirrors focus sunlight onto a receiver, heating oil. The hot oil flows through a heat exchanger to heat water, creating steam. The steam drives a turbine and generator. The steam is then condensed back into water by a condenser, which is cooled by another heat exchanger, and the cycle repeats.

Solar (PV)

Small Hydro

PV Array/ Battery (DC) → [Inverter] → AC Output

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Renewable DER

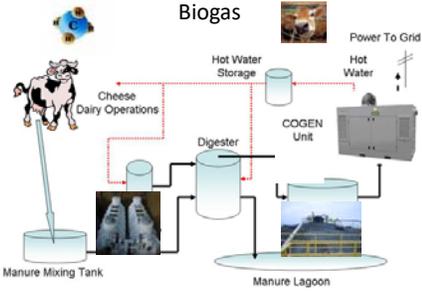


Wind

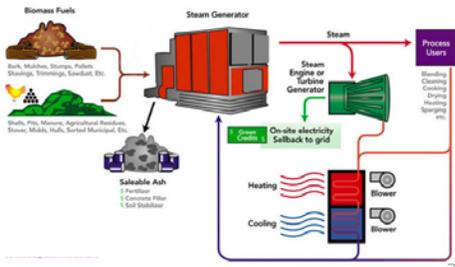
- May be induction or synchronous generator output
- May be mixture of generator and inverter output



Biogas



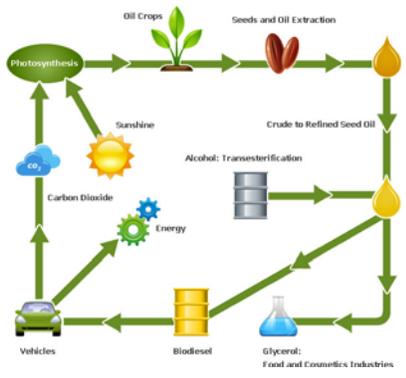
Biomass



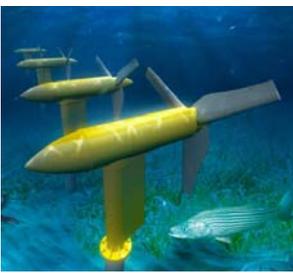
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Renewable DER

Biodiesel



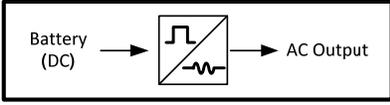
Tidal



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Renewable DER

Storage Battery



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Protection Elements and Use

- “The Five Food Groups”
 - Loss of Parallel Operation (utility disconnected)
 - Anti-Islanding
 - Abnormal Power Flow
 - Anti-Islanding
 - Fault Backfeed Removal
 - Detection of Damaging System Conditions
 - Restoration
- Impact on interconnection protection
 - Interconnection transformer configuration
 - Various types of DERs
 - Induction, Synchronous, Asynchronous (Inverters)



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Interconnection Protection

“The Five Food Groups”

- Loss of Utility Parallel (Anti-Islanding)
 - Voltage and frequency (27, 59, 81-U, 81-O)
 - Rate-of-change of frequency (81R, aka ROCOF)
 - Based on load (real and reactive) not equaling generation

- Abnormal Power Flow (Anti-Islanding)
 - Power (32F, 32R-U)
 - Based on power flow violations across the PCC

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Low Import Power: 32R-U

REVERSE UNDERPOWER (32R-U)

Load Following

- 32R-U Relay pickup set to at least 5% of total connected generator rated KVA
- 32R-U Relay programmed to trip when imported power falls below the pick-up level
- Switching off a large amount of facility load may cause nuisance tripping
- Generator Control should have proper bias power margin set

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Low Import Power: 32R-U

Utility Source

Circuit breaker closed

Feeder Loads

Low Import Power (32R-U)

Power Import 40 kVA

All circuit breakers closed

➤ Generation adjusted to match local load with bias equal to large switched motor load

➤ Import power is higher, but application secure

M 40 kVA

Local Load 360 kVA

DG 360 kVA

Gen = Load - Bias
360 = 400 - 40

- Bias is made in the genset controller to ensure import of 40kW when paralleled
- 32R-U is set lower with appropriate margin (trips if import goes below genset control setpoint)

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Interconnection Protection

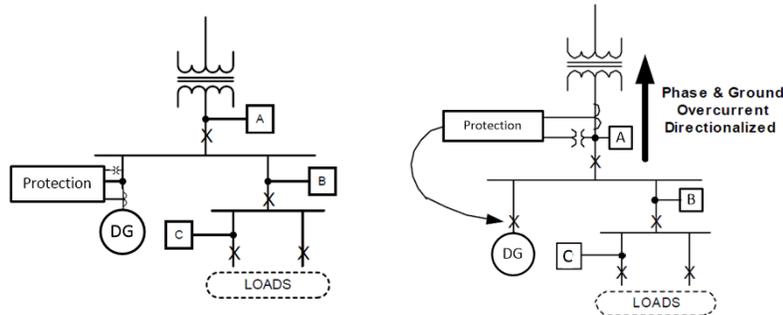
"The Five Food Groups"

- Fault Backfeed Detection
 - Phase and overcurrent (51V, 51), grounded systems
 - Directional overcurrent (67) or impedance (21) may be used
 - Ground overcurrent (50N/51N) for grounded systems
 - Directional ground overcurrent (67N) may be used
 - Ground over/under voltage (27N, 27N/59N) for ungrounded systems
 - Negative sequence overcurrent (46)
 - *Based on abnormally high current or abnormally low/high voltage as a result of faults*

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Direction vs. Non-Direction Elements at the PCC

- When applying non-directional phase or ground elements for fault backfeed protection (50P, 50N, 51P, 51N), they must be coordinated for faults in the facility and on the utility.
- This could lead to longer clearing times for utility faults.
- To speed up response of utility faults, use of directional elements (67, 67N, 21P), set to only trip in the utility's direction, will provide maximum trip speed.



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Issues with Inverter-Based DER Protection

- Inverter-based DER produces very little fault current
 - 1.0-1.3x rated current at full output
 - Fault current even less when output is lower than rated
 - Solar PV late in day; low irradiance = low output
- Fault backfeed protection (overcurrent) cannot be set below load for fear of nuisance tripping
- Resultant large NDZ (non-detection zone)
 - Transfer Trip anyone \$\$\$\$\$\$?????

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Focused Directional Overcurrent (FDO) Concept

- Use of focused directional overcurrent (FDO) elements (67P, 67Q, 67N) for Distributed Energy Resource (DER) Interconnection Protection (IP)
- Applicable at the PCC

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Traditional Directional Element

- For DER IP, directionalization is a reliability and security enhancement to control phase and ground overcurrent elements
- Used at the PCC, directionalization *to the EPS* blinds the overcurrent elements for load and faults *in the DER's facility*, thereby *increasing* the DER IP security
- In traditional 180° forward/reverse directional control, the overcurrent elements are subject to tripping on the DER's real power output.

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Traditional Directional Element

- Increasing the MTA from 15° to 115° so the forward real power load region is ignored exposes the overcurrent element to trip for load flow and faults in the facility (reverse load area).

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Inverter Fault Current Level

- Inverters typically develop fault current of 1.1-1.3x rated current
- To avoid tripping on normal power output, the overcurrent elements may be set above the DER's rated output current
- For an inverter-based DER, this overcurrent pickup value is typically 1.2–1.4x the DER's rated output current

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Inverter Fault Current Level

- This tactic decreases sensitivity to detect DER fault infeed into the EPS
- This current value is essentially the same as load with margin for overload
- If the inverter-based DER is supplied by some variable source, such as a PV array, and as the PV output decreases below rated, the output current for both load and faulted EPS conditions also decreases below rated, making fault detection even more difficult.

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Focused Directionality

- FDO allows the directional characteristic of overcurrent element to be tunable to other than the traditional 180° forward/reverse decision
- Ex., the overcurrent element response angle may be restricted to 45° forward, plus or minus 10°, for an effective response angle of 35° to 55°

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FDO and Current Setting

- FDO elements allow settings as low as 0.15A secondary which should greatly improve the sensitivity of the overcurrent elements
- The actual minimum primary current level detectable depends on the applied CT ratio
- Ex., DER IP using a 500:5 CT and by employing a setting of 0.15 secondary amps on the FDO element yields a sensitivity of 15A primary amps

0.15A sec. I

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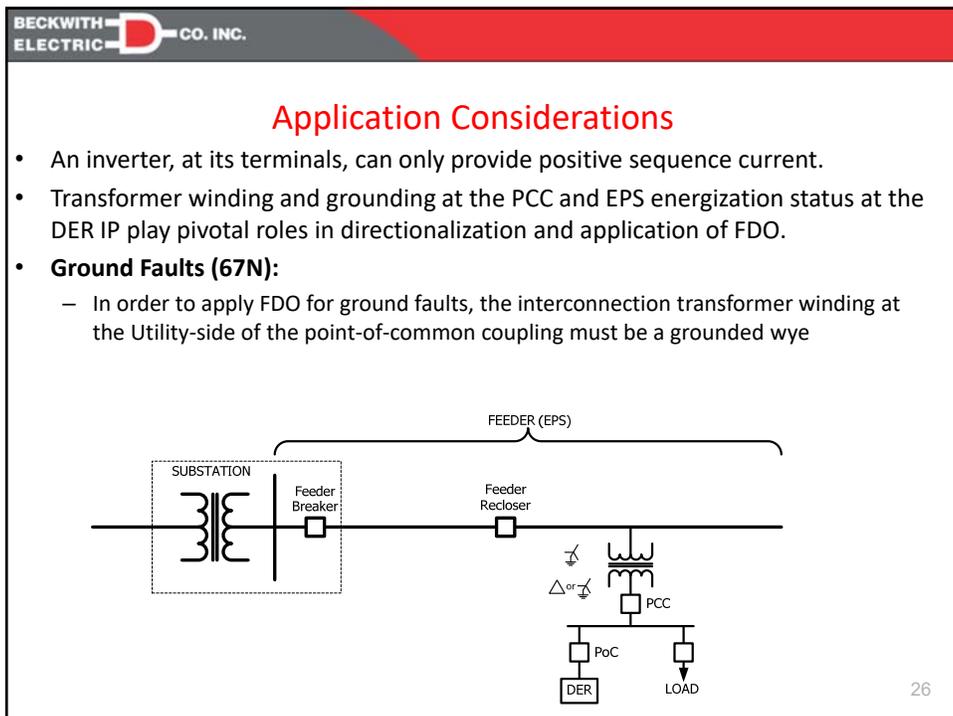
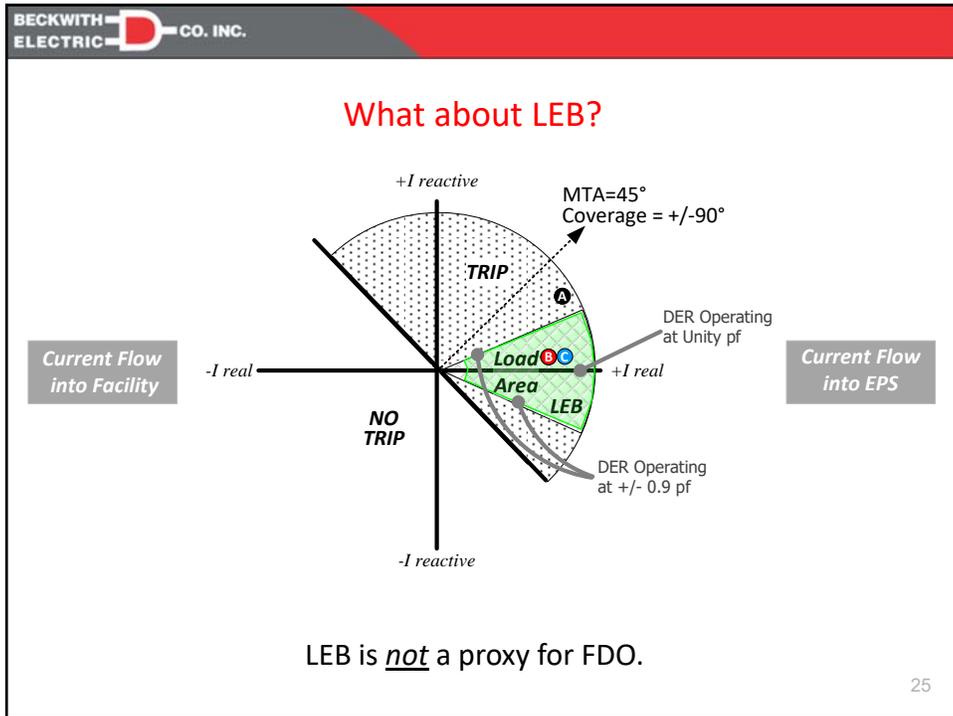
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FDO and Current Setting

- Sensitive overcurrent element pickup setting with a definite time characteristic will coordinate with transmission protection and allow ride-through.
 - Transmission protection is typically definite time Z with transfer trip aided clearing times of 20-25 with 50BF margin

0.15A sec. I

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Interconnection Protection

"The Five Food Groups"

- Damaging System Conditions
 - Open phase condition or load imbalance (46, 47), negative sequence current and voltage
 - Phase sequence reversal (47), negative sequence voltage
 - Loss of synchronism (78)
 - Instantaneous overvoltage (59I)
 - *Based on current or voltage imbalance (including reverse phase rotation), power system and DER going out-of-step, or ferroresonance*
- Facilitate proper restoration
 - All elements reset, voltage and frequency within limits
 - Reconnect timer (79) (all DER)
 - Sync check (25)
 - Synchronous generators and some self-commutating inverters

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Conditions for Ferroresonance

- Feeder that DER is connected to must be isolated from the utility
 - (Islanded condition)
- KW load in the island must be less than 3 times DER rating
- Capacitance must be greater than 25% and less than 500% of DER rating
- There must be a transformer in the circuit to provide nonlinearity

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Ferroresonance: Test Circuit Setup

New York Field Tests- 1989
Field Test Circuit

Conditions:
Wye-Wye Transformers, 100kVAR capacitance, 60kW generator, 12kW load

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Advanced Convergent Protection Application

- Fault Backfeed Removal
- Damaging Conditions
- Loss of Utility Parallel (Anti-Islanding)
- Abnormal Power Flow
- Restoration

LOAD BUS
Protection Element Usage

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BECKWITH ELECTRIC CO. INC. **7651A D-PAC & 7679 Recloser Control**

- Usage:
 - Feeder/Switchgear Protection
 - Recloser Control
 - DER Interconnection Protection
- Protection Applications (example):
 - *Reverse Interlock* (Fast Bus Protection)
 - *Maintenance Mode* (fast, sensitive tripping of the Mains/Tie when personnel are working on the switchgear; decreases arc flash incident energy)
 - *Breaker Failure* (Trip Mains/Tie when Feeder CB fails)
 - *Breaker Circuit Monitoring* (Trip and Close Circuits)
 - *Alternate Settings* for Backfeeding
 - *Directional Protection* (Ph. & Gnd.) to prevent motor fault backfeed nuisance tripping

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BECKWITH ELECTRIC CO. INC. **7651A D-PAC & 7679 Recloser Control**

- Metering, PQ Monitoring & Protection Applications:
 - All measure quantities
 - Complex calculated quantities (W, VAR, kVA, kVAR)
 - Energy and Demands (+W/Hr, -W/Hr, Min., Max.)
 - Harmonic Spectra Recording to 63rd (Graphic and Tabular)
 - THD Alarm (%)
 - THD Trip (%)
 - TDD Alarm (%)
 - TDD Trip (%)
 - ITIC Curve Plotting for all Trips
- Communication Based Protection Solutions
 - Peer-to-Peer for Transfer Trip, Breaker Failure, Interlocking
 - DMS to Relay for Profile Changes, Setpoint Changes
 - IEC 61850, DNP, MODBUS

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BECKWITH ELECTRIC  CO. INC. **Why New Protection and Why Now?**

Key Reasons:

- 1. Information for Operations and Analysis** made possible thanks to technological advances in software microprocessors and memory.
 - Advanced Metering, PQ, DME DFR Records, High Visibility SOE, Data Storage, Data Filtering, Data Presentation, etc.
- 2. Demand for Advanced Communications**
 - True Ethernet, Dual MAC, IEC 61850, SD, USB
- 3. Regulatory Compliance**
 - NERC & IEEE Cyber Security Compliance
- 4. Simplicity to Execute Complex Applications**

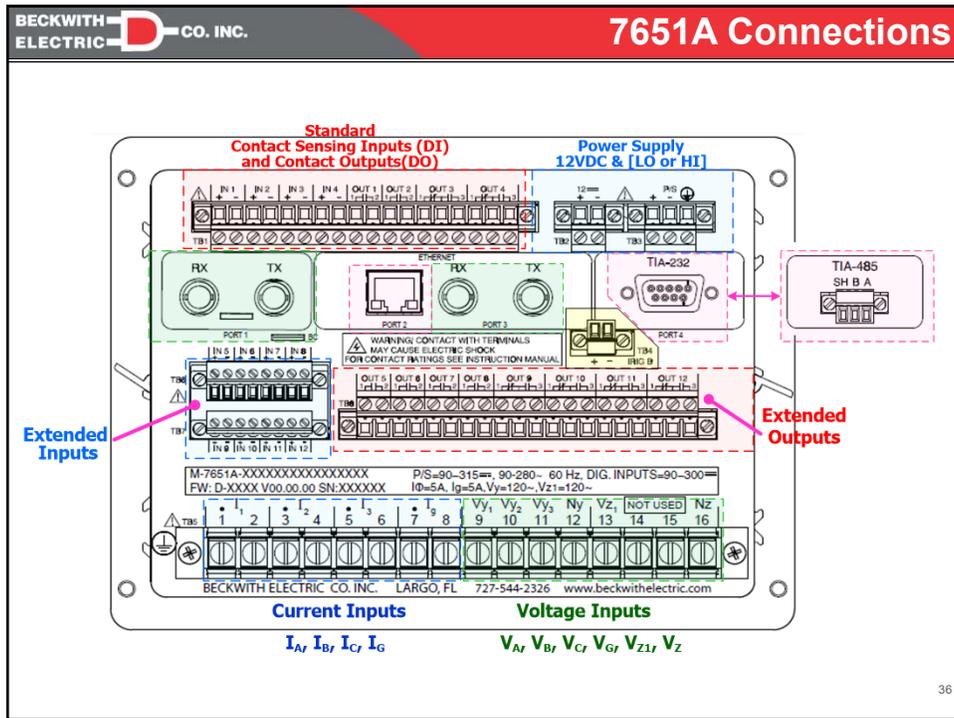
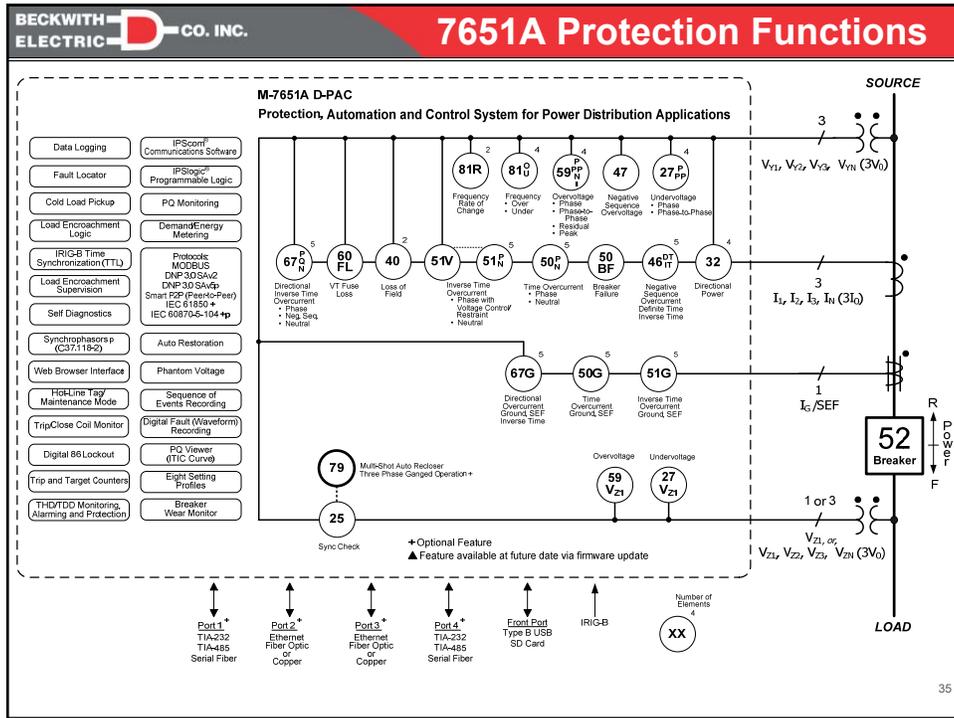
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BECKWITH ELECTRIC  CO. INC. **7651A D-PAC & 7679 Recloser Control**

Applications: Feeder, Switchgear, Recloser, DER

- Provide Full Suite of Voltage, Current, Directional Current, Directional Power, Load Shed and Restoration Elements
- Simple to Apply Preprogrammed Distribution Protection Schemes
- Complex Scheme Graphical Logic for Custom Applications
- Seamless Integration into Existing and Future Practices

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BECKWITH ELECTRIC CO. INC. 7651A CT/VT Inputs

- Voltage/Current Inputs available on the M-7651A:

SMART MODEL NUMBER: M.7651A - . . . - . . . - . . . - . . . - . . . - . . . - . . . - . . .

VOLTAGE INPUTS	
(4) LEA-High or VT Voltage Inputs (300 Vac Max)	H4
(4) LEA-Low Voltage Inputs (12 Vac Max)	L4
(3) LEA-Low Voltage Inputs (12 Vac Max) + (1) LEA-High or VT Voltage Input (300 Vac Max)	X4
(6) LEA-High or VT Voltage Inputs (300 Vac Max)	H6
(6) LEA-Low Voltage Inputs (12 Vac Max)	L6
(3) LEA-Low Voltage Inputs (12 Vac Max) + (3) LEA-High or VT Voltage Inputs (300 Vac Max)	X6

M-7651A-XXXXXXXXXXXXXXXXXXXX P/S=90-315~, 90-280~ 60 Hz, DIG. INPUTS=90-300~
 FW: D-XXXX V00.00.00 SN:XXXXXX IΦ=5A, Ig=5A, Vy=120~, Vz1=120~

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PHASE CURRENT INPUTS	
1A Current Inputs (3)	1
5A Current Inputs (3)	5

GROUND CURRENT INPUTS	
1A Ig Current Input	1
5A Ig Current Input	5
200mA SEF Ig Current Input *Note 1	H
50mA SEF Ig Current Input	M
10mA SEF Ig Current Input	L

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BECKWITH ELECTRIC CO. INC. Contact Sensing Inputs & Contact Outputs

- Four programmable inputs (DI) and four programmable outputs (DO) (2 Form "A" & 2 Form "C")
 - Inputs are externally wetted and can be individually configured for high or low voltage
 - Low Voltage, 18~60V, or, High Voltage, 80~300V
- Extended I/O (optional) adds additional 8 programmable inputs (DI) plus 8 programmable outputs (DO) (4 Form "A" & 4 Form "C")

SMART MODEL NUMBER: M.7651A - . . . - . . . - . . . - . . . - . . . - . . . - . . .

I/O OPTIONS	
Standard I/O - (4) LV (9-60 Vdc) Inputs and (4) Dry Type Outputs	SL
Standard I/O - (4) HV (90-300 Vdc) Inputs and (4) Dry Type Outputs	SH
Expanded I/O - Standard I/O plus additional (8) LV (9-60 Vdc) Inputs and (8) Dry Type Outputs	EL
Expanded I/O - Standard I/O plus additional (8) HV (90-300 Vdc) Inputs and (8) Dry Type Outputs	EH

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BECKWITH ELECTRIC CO. INC. **Advanced Communications**

- Up to 4 rear ports available:
 - Port1 Serial (Std)
 - RS-232 or RS-485 or Serial Fiber
 - Port2 Ethernet (Optional)
 - RJ-45 Ethernet (Copper) or FO
 - Port3 Ethernet (Optional)
 - RJ-45 Ethernet (Copper) or FO
 - Port4 Serial (Optional)
 - RS-232 or RS-485 or Serial Fiber or Bluetooth
- Protocols Supported:
 - Modbus, Modbus over TCP/IP
 - DNP3.0, DNP over TCP & UDP
 - IEC-61850 (Optional)
 - IEC-60870-5-104 (Optional)
 - 2179 (Optional)
- Dual MAC Ethernet port offers full auto-negotiable 10/100Mbps auto-detect communication with multi user and multi protocol support
- IRIG-B; Demodulated, TTL Level, Isolation 1,500V

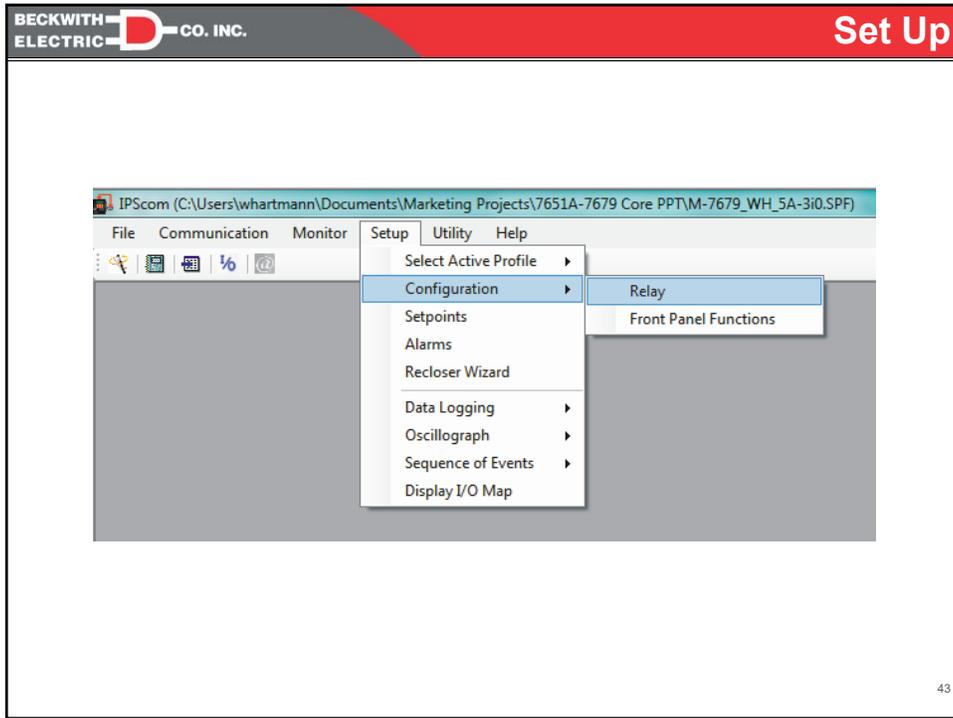
Protocols
 Serial Ports – MODBUS®, DNP3.0
 Ethernet Ports – MODBUS over TCP/IP and UDP, DNP3.0 over TCP/IP and UDP; IEC 61850, SmartP2P (Peer to Peer)▲, IEC 60870-5-104/101▲ (optional)

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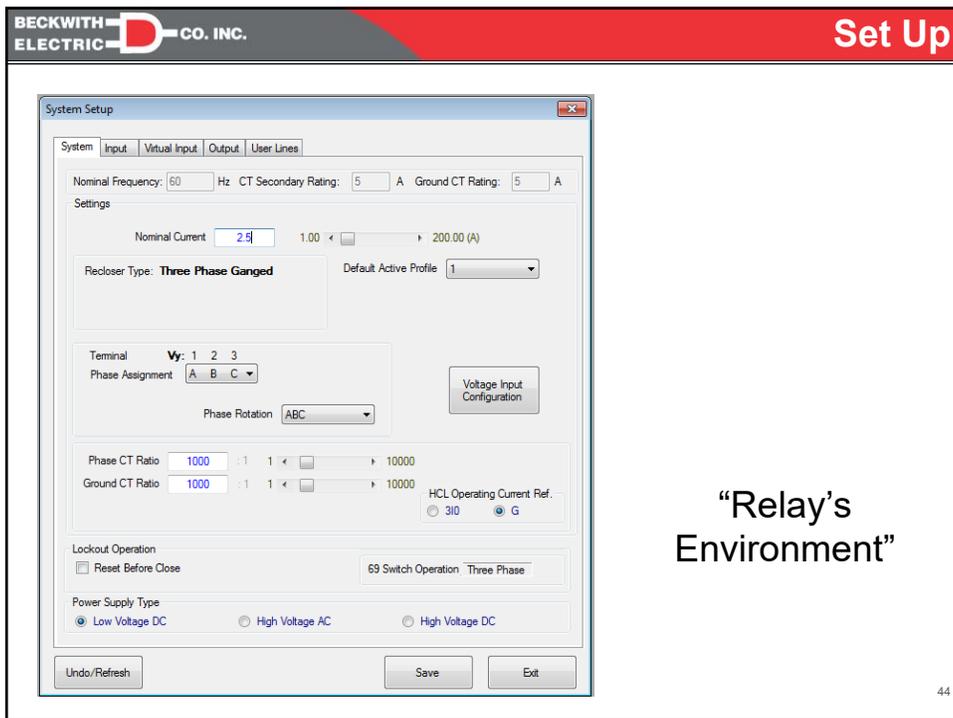
BECKWITH ELECTRIC CO. INC. **Overall Software Flow**

★ Show creating a file and connecting to the relay

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“Relay’s Environment”

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BECKWITH ELECTRIC CO. INC. **Set Up**

Voltage Input Configuration

LEA Hardware: H4 Secondary Nominal Voltage: 69.00 50.00 300.00 (V-I-g)

Vy side voltage transducers: VT LEA HIGH

Vy Side (VT) VT Configuration: WYE

Vy1 (A) PTR: 4.0 1.0 10000.0 Vy2 (B) PTR: 4.0 1.0 10000.0 Vy3 (C) PTR: 4.0 1.0 10000.0

Vz side voltage transducers: VT LEA HIGH

Vz Side (VT) VT Configuration: WYE

Vz1 (A) PTR: 4.0 1.0 10000.0

Undo/Refresh Save Exit

“Relay’s Environment”

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BECKWITH ELECTRIC CO. INC. **Contact (Voltage) Sensing Inputs**

System Setup

System Input Virtual Input Output User Lines

Input	Active State	Function	Debounce (0 - 5000 ms)	Input Wetting
	Close Open (Inverted)			DC AC
Input 1	<input checked="" type="radio"/> <input type="radio"/>	52a Phases ABC	10	<input checked="" type="radio"/> DC <input type="radio"/> AC
Input 2	<input checked="" type="radio"/> <input type="radio"/>	52b Phases ABC	10	<input checked="" type="radio"/> DC <input type="radio"/> AC
Input 3	<input checked="" type="radio"/> <input type="radio"/>	General	10	<input checked="" type="radio"/> DC <input type="radio"/> AC
Input 4	<input checked="" type="radio"/> <input type="radio"/>	General	10	<input checked="" type="radio"/> DC <input type="radio"/> AC
Input 5	<input checked="" type="radio"/> <input type="radio"/>	General	10	<input checked="" type="radio"/> DC <input type="radio"/> AC
Input 6	<input checked="" type="radio"/> <input type="radio"/>	General	10	<input checked="" type="radio"/> DC <input type="radio"/> AC
Input 7	<input checked="" type="radio"/> <input type="radio"/>	General	10	<input checked="" type="radio"/> DC <input type="radio"/> AC
Input 8	<input checked="" type="radio"/> <input type="radio"/>	General	10	<input checked="" type="radio"/> DC <input type="radio"/> AC
Input 9	<input checked="" type="radio"/> <input type="radio"/>	General	10	<input checked="" type="radio"/> DC <input type="radio"/> AC
Input 10	<input checked="" type="radio"/> <input type="radio"/>	General	10	<input checked="" type="radio"/> DC <input type="radio"/> AC
Input 11	<input checked="" type="radio"/> <input type="radio"/>	General	10	<input checked="" type="radio"/> DC <input type="radio"/> AC
Input 12	<input checked="" type="radio"/> <input type="radio"/>	General	10	<input checked="" type="radio"/> DC <input type="radio"/> AC

Can mix high and low voltages

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BECKWITH ELECTRIC CO. INC. **Outputs**

The screenshot shows the 'System Setup' dialog box with the 'Output' tab selected. It contains a table of 12 outputs. Each output row has three radio buttons for 'Direct', 'Latched', and 'Pulsed'. The 'Pulsed' radio button is selected for all outputs. To the right of the radio buttons is a 'Pulse Width/Seal-In Time' field, all set to '0.07 s'. Further right is a 'Function' dropdown menu, and to the far right is an 'Enable Remote Control' checkbox, all checked for every output. At the bottom, there is a 'Manual Close Delay' field set to '0' and a slider ranging from 0 to 90 (s). Buttons for 'Undo/Refresh', 'Save', and 'Exit' are at the bottom.

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BECKWITH ELECTRIC CO. INC. **Profiles**

The screenshot shows the 'Profile Manager' dialog box. It contains eight text input fields, each with a label above it: 'Profile 1 (Max 20 Characters)' containing 'RECLOSER MODE', 'Profile 2 (Max 20 Characters)' containing 'ALT_1 RECLOSER MODE', 'Profile 3 (Max 20 Characters)' containing 'ALT_2 RECLOSER MODE', 'Profile 4 (Max 20 Characters)' containing 'SWITCH MODE', 'Profile 5 (Max 20 Characters)' containing 'SECTIONALIZER MODE', 'Profile 6 (Max 20 Characters)' containing 'DG MODE', 'Profile 7 (Max 20 Characters)' containing 'Profile 7', and 'Profile 8 (Max 20 Characters)' containing 'Profile 8'. Below the text boxes is a 'Maximum Number of Profiles' dropdown menu set to '6'. Buttons for 'Undo/Refresh', 'Save', and 'Exit' are at the bottom.

User Profile Identification

Setting Profiles: 8

- These can be invoked by contact input, communication input, button input or measured parameter levels (ex., 32F vs. 32R)
- Each profile may be labeled for Operator and Technician use
- 7679 only; When role modes are changed, protection menus change to match the role
 - Recloser
 - Switch
 - Sectionalizer

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BECKWITH ELECTRIC CO. INC. **Elements in a Profile**

Profile and Elements 8 Profiles
User manes will be displayed here

Element Programming by Clicking Element Number

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BECKWITH ELECTRIC CO. INC. **Operating Modes**

7679 Profiles to Change Operating Modes 8 Profiles
User manes will be displayed here

Roles include Recloser, Switch, Sectionalizer
Elements available to match mode selected

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BECKWITH ELECTRIC CO. INC. **Common Settings**

Setpoints

View Style
 Beoview Explorer

Profile 1 | Profile 2 | Profile 3 | Profile 4 | Profile 5 | Profile 6 | Profile 7 | **Profile 8** | Other Setpoints

PSBC
Power Supply/Battery Charger Monitor

TCCM
Trip/Close Circuit Monitor

60FL
Fuse-Loss Detection

THD
Total Harmonic Distortion

Global Settings

Programming

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BECKWITH ELECTRIC CO. INC. **Element: 51P**

51P-Phase Inverse Time Overcurrent #1 | 51P-Phase Inverse Time Overcurrent #2 | 51P-Phase Inverse Time Overcurrent #3 | 51P-Phase Inverse Time Ov

Enable Individual Phase

Phase ABC
 Enable

Settings

Primary Value: 3.5 Pickup: 3.50 0.10 < > 16.00 (A)

Curve: IEEE Extremely Inverse [View Graph](#)

Time Multiplier (Dial): 1.00 0.10 < > 25.00

Time Adder: 0.00 0.00 < > 30.00 (s)

Min. Response Time Adder: 0.00 0.00 < > 1.00 (s)

Electromechanical Reset

Outputs: 1 2 3 4 5 6 7 8 9 10 11 12

Blocking Inputs: 1 2 3 4 5 6 7 8 9 10 11 12 FL

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BECKWITH ELECTRIC CO. INC. **51P TOC**

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BECKWITH ELECTRIC CO. INC. **TOC Curve Display**

Show setting 51P

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BECKWITH ELECTRIC CO. INC. **50P**

50P-Phase Instantaneous/Definite Time Overcurrent

50P-Phase Instantaneous/Definite Time Overcurrent #1 | 50P-Phase Instantaneous/Definite Time Overcurrent #2 | 50P-Phase Instantaneous/Definite Time Overcurrent #3

Enable Individual Phase

Phase ABC Enable

Settings
Primary Value 15 Pickup 15.00 0.10 ← → 100.00 (A)
Definite Time 0.35 0.00 ← → 600.00 (s)

Outputs: 1-12

Blocking Inputs: 1-12 FL

High Current Lockout

Phase Settings HCL Phase Enable

Ref. Current 17.70 0.50 ← → 500.00 (A)
Time Delay 0.05 0.00 ← → 600.00 (s)

55

BECKWITH ELECTRIC CO. INC. **Directional Overcurrent**

67P, 67Q, 67N (67P shown below)

67P-Phase Directional Overcurrent

#1 | #2 | #3 | #4 | #5

Phase ABC Enable

Polarization Voltage V1 Enabled Direction Directional

Min. Polarization Voltage 5.0 2.0 ← → 10.0 (% of Nominal Voltage)

Block # below Min. Polarization Voltage

Max Sensitivity Angle 45 0 ← → 359 (Degree)

Angle Band 90 5 ← → 90 (Degree) Directionality View

Definite Inverse

Definite Time
Primary Pickup 100 Pickup 0.30 0.25 ← → 100.00 (A)
Definite Time 10.00 0.00 ← → 600.00 (s)

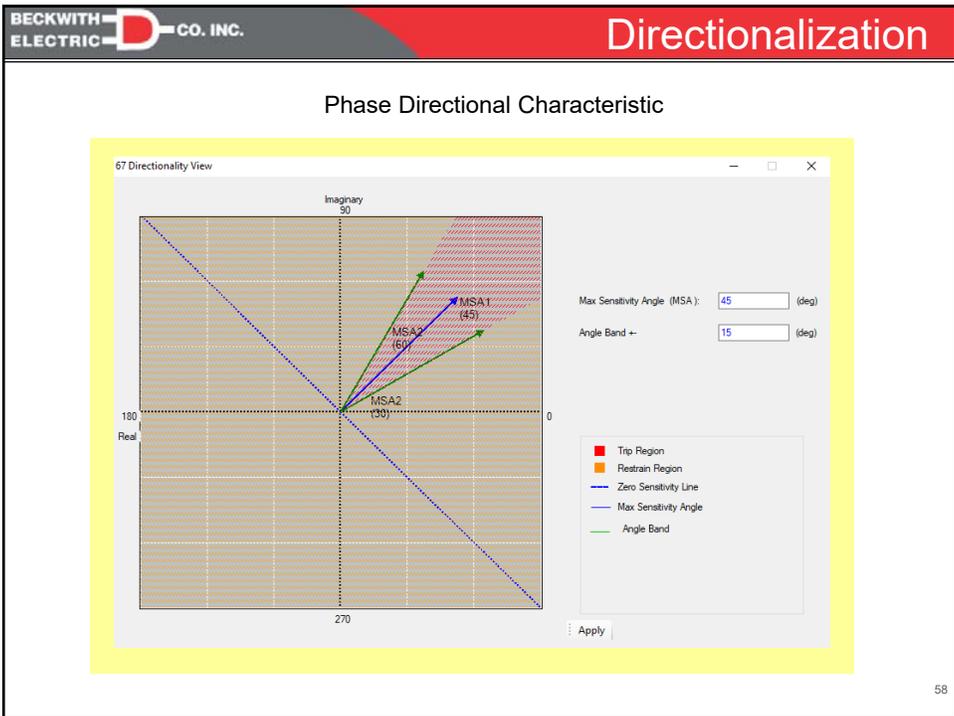
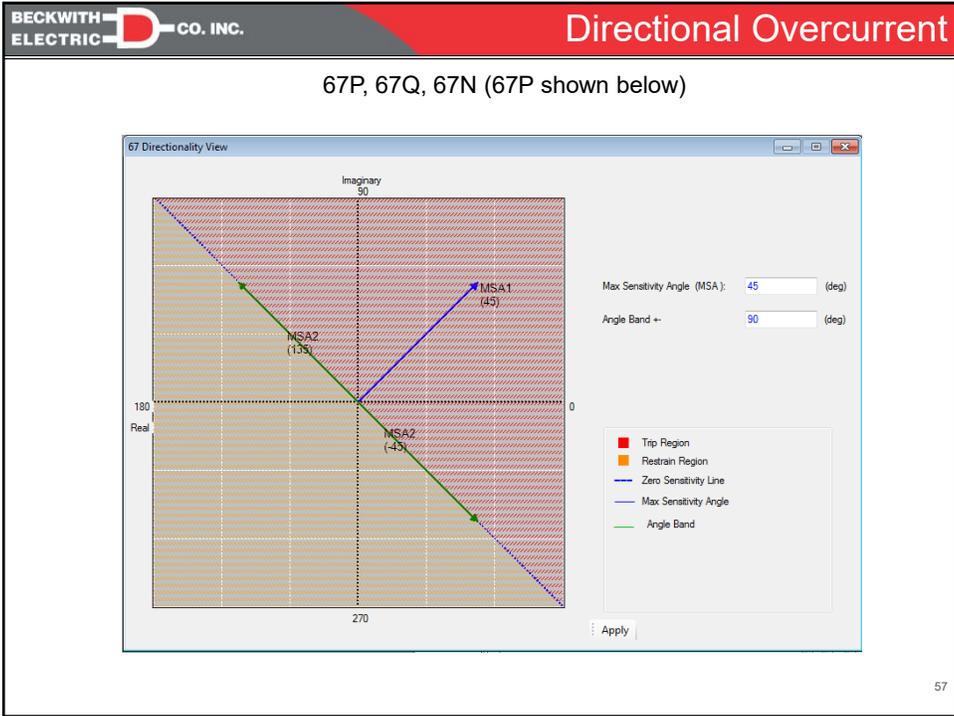
Outputs: 1-12

Blocking Inputs: 1-12 FL

Virtual Input: 1 2 3

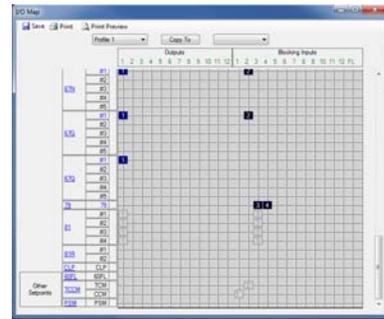
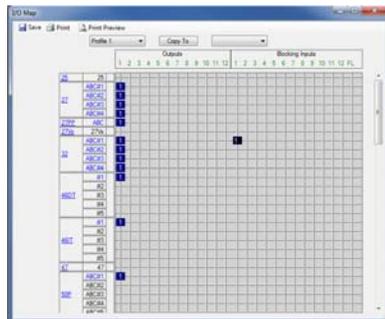
Undo/Refresh Save Exit

56



BECKWITH ELECTRIC CO. INC. **Output I/O Map**

- Output I/O Map helps minimize logic programming by visually displaying which function and which setpoints are programmed to each output and which inputs are programmed to block
- I/O Map tool allow copying of logics to other profiles
- For testing purposes individual protection elements can be disabled without deleting its programming. In this case the functions will be greyed out.
- Custom IPSlogics also appear here.



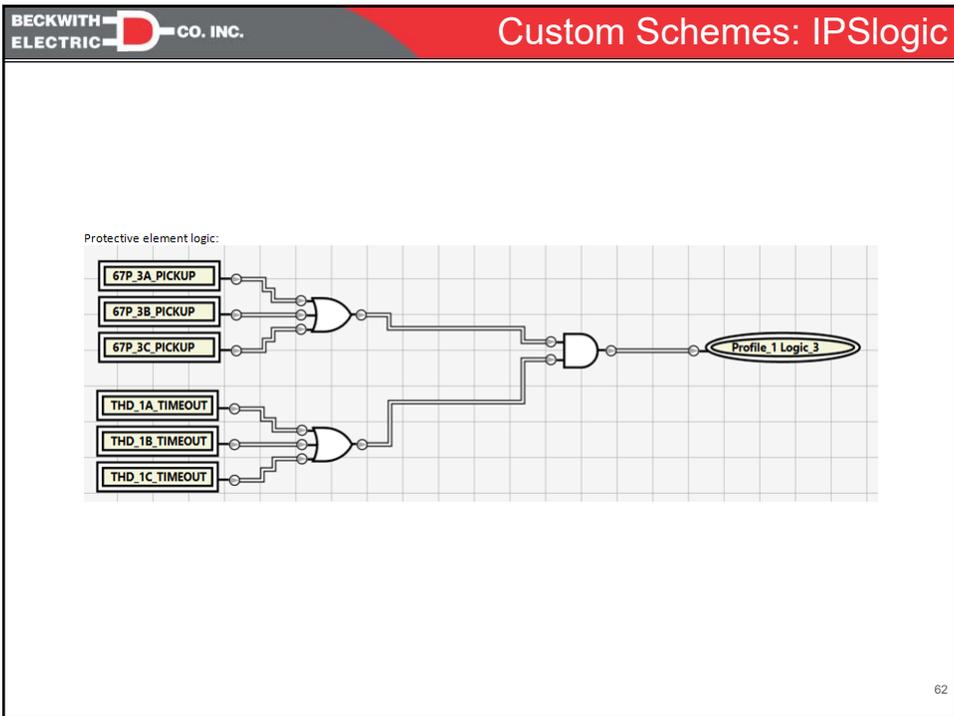
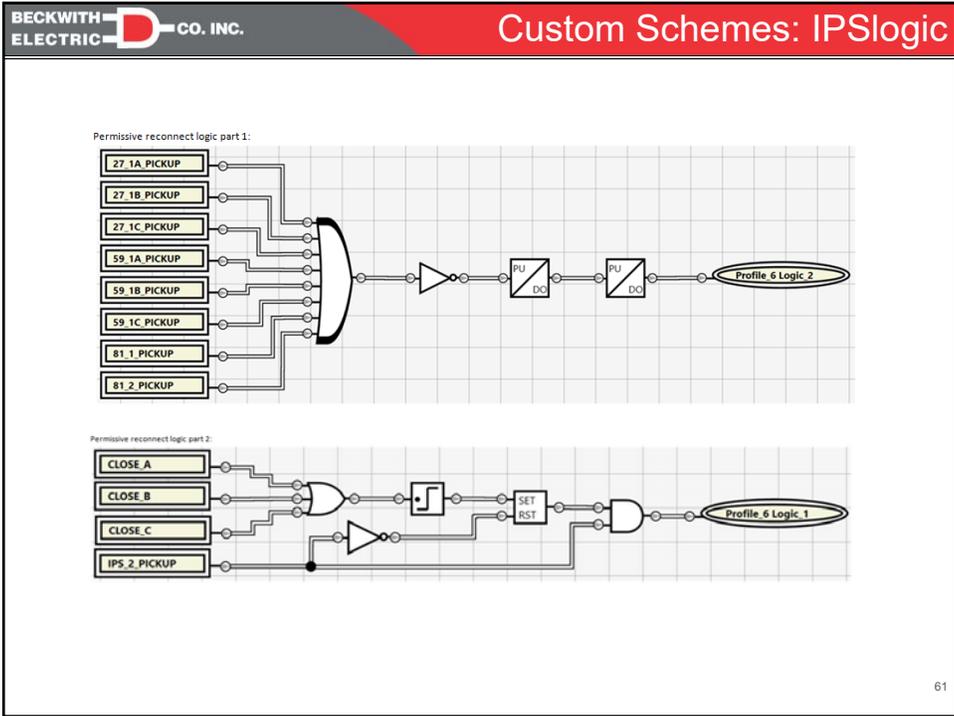
59

BECKWITH ELECTRIC CO. INC. **Custom Schemes: IPSLogic**

This screenshot shows the 'IPS Logic' configuration window. It has a 'Settings' section with a 'Time Delay' of 0.00. Below that is a 'Virtual IPSLogic Outputs' section with dropdowns for 'Profile Switching', 'Tip/Lockout', and 'Hot Line Tag'. At the bottom, there are 'Outputs' and 'Blocking Inputs' sections, each with a grid of checkboxes for connections. The 'Outputs' grid has columns 1-12 and rows 1-100. The 'Blocking Inputs' grid has columns 1-12 and rows 1-100. There are 'Undo/Refresh', 'Save', and 'Exit' buttons at the bottom.

This screenshot shows the 'IPS Logic Editor' window. It features a large grid for drawing logic diagrams. On the left side, there is a vertical toolbar containing various logic symbols: AND gates, OR gates, NOT gates, XOR gates, and a timer block labeled 'Timer 1 (ms)'. The main grid is currently empty, with a few faint lines and a single timer block placed on the right side.

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BECKWITH ELECTRIC CO. INC. Custom Schemes: IPSLogic

Close Supervision Logic:

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BECKWITH ELECTRIC CO. INC. Custom Schemes: IPSLogic

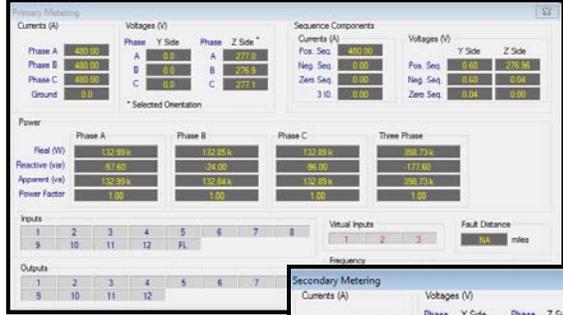
Beckwith TT CUT-IN / CUT-OUT Logic: DG MODE (PROFILE #6) - IPSLogic #3

Beckwith TT SEND Logic: DG MODE (PROFILE #6) - IPSLogic #4

★ Open IPSLogic, add gate, show state simulator

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BECKWITH ELECTRIC CO. INC.
Monitoring



Primary

Primary



Secondary

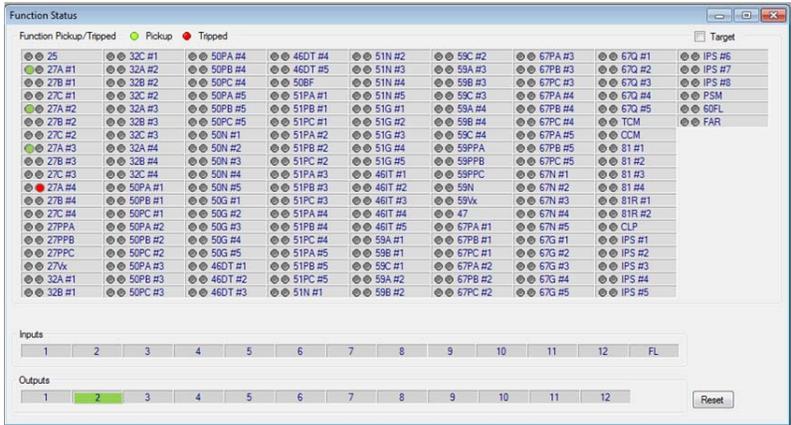
Secondary

★ Show loadflow metering

65

BECKWITH ELECTRIC CO. INC.
Monitor Pickups and Trips

Real-time for Testing/Commissioning



Backstory:

- Four 27 elements are set
- 27/4 is set at 0.7pu, 20 cycles
- 27/1, 2, 3 are set closer to nominal, but with longer time delays
- Voltage on Phase A is dropped to 0.5pu.
- 27/4 trips; all other 27s in pickup on Phase A as long as low voltage is present and CB status indicates closed

66

BECKWITH ELECTRIC CO. INC.
Demand & Energy Metering

The screenshot shows the 'Demand Metering' configuration window. It includes sections for 'Demand Interval' (set to 15 Minutes), 'Max Demand Load Current (IL)' for three phases (A, B, C) with values of 20.00, and 'Demand Present' and 'Demand History' tables. The 'Energy Metering' section lists various bidirectional registers like 'Watt Hrs Fwd A' and 'Rev Watt Hrs A'.

Set Rated Load for TDD Metering

Demand

- Demand and Energy
- Present
- Historical
- Min/Max
- All with date and time stamping

Energy (Bidirectional Registers)

67

BECKWITH ELECTRIC CO. INC.
Set Up Oscillography Triggers

The 'Setup Oscillograph Recorder' window shows settings for 'Samples/Cycle' (128), 'Post Trigger Delay' (45), and 'Length of OSC' (300). It includes 'Undo/Refresh', 'Save', and 'Exit' buttons.

The 'OSC Triggers' window displays two columns: 'Disable Trigger' and 'Enable Trigger'. The 'Disable Trigger' list includes items like 'IPS #4 Timeout Dropout' and 'Input Pickup 1'. The 'Enable Trigger' list includes 'Output Dropout 1' and '51PA #1 Timeout'. Buttons for 'Move All', 'Move Selected', 'Clear All', 'Save', and 'Exit' are at the bottom.

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BECKWITH ELECTRIC CO. INC. **Metering & Phasor Diagram**

Secondary Metering: Loadflow at 1.0pf

Secondary Metering

Currents (A)		Voltages (V)				Sequence Components				
Phase	Value	Phase	Y Side	Phase	Z Side	Currents (A)	Value	Phase	Y Side	Z Side
Phase A	4.000	A	0.00	A	69.72	Pos. Seq.	4.000	Pos. Seq.	0.010	69.250
Phase B	4.000	B	0.00	B	69.24	Neg. Seq.	0.000	Neg. Seq.	0.010	0.010
Phase C	4.000	C	0.00	C	69.25	Zero Seq.	0.000	Zero Seq.	0.010	0.000
Ground	0mA	* Selected Orientation				3 I0	0.000			

Power		Phase A	Phase B	Phase C	Three Phase
Real (W)		276.80	276.90	277.13	830.83
Reactive (var)		-0.33	-0.16	-0.58	-1.07
Apparent (va)		276.80	276.90	277.13	830.83
Power Factor		1.00	1.00	1.00	1.00

Inputs		Virtual Inputs		Fault Distance	
1	2	1	2	NA miles	
9	10	3			

Outputs		Frequency	
1	2	Y Side	Z Side
9	10	Frequency (Hz)	60.00
		ROCOF (Hz/s)	0.06

- Note V Sequence sets:
 - V1=Total Current
 - V2 = 0
 - V0 = 3
- Note I Sequence sets:
 - I1=Total Current
 - I2 = 0
 - I0 = 3
- Powers
 - Watts = KVA
 - VAR = 0

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BECKWITH ELECTRIC CO. INC. **Metering & Phasor Diagram**

Primary Metering: Loadflow at 1.0pf

Primary Metering

Currents (A)		Voltages (V)				Sequence Components				
Phase	Value	Phase	Y Side	Phase	Z Side	Currents (A)	Value	Phase	Y Side	Z Side
Phase A	480.00	A	0.0	A	277.0	Pos. Seq.	480.00	Pos. Seq.	0.60	276.96
Phase B	480.00	B	0.0	B	276.9	Neg. Seq.	0.00	Neg. Seq.	0.60	0.04
Phase C	480.00	C	0.0	C	277.1	Zero Seq.	0.00	Zero Seq.	0.04	0.00
Ground	0.0	* Selected Orientation				3 I0	0.00			

Power		Phase A	Phase B	Phase C	Three Phase
Real (W)		132.99k	132.85k	132.89k	398.73k
Reactive (var)		-57.60	-24.00	-96.00	-177.60
Apparent (va)		132.99k	132.84k	132.89k	398.73k
Power Factor		1.00	1.00	1.00	1.00

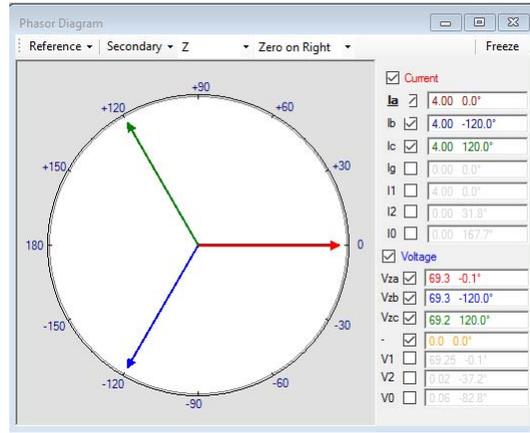
Inputs		Virtual Inputs		Fault Distance	
1	2	1	2	NA miles	
9	10	3			

Outputs		Frequency	
1	2	Y Side	Z Side
9	10	Frequency (Hz)	60.00
		ROCOF (Hz/s)	0.06

- Note V Sequence sets:
 - V1=Total Current
 - V2 = 0
 - V0 = 3
- Note I Sequence sets:
 - I1=Total Current
 - I2 = 0
 - I0 = 3
- Powers
 - Watts = KVA
 - VAR = 0

70

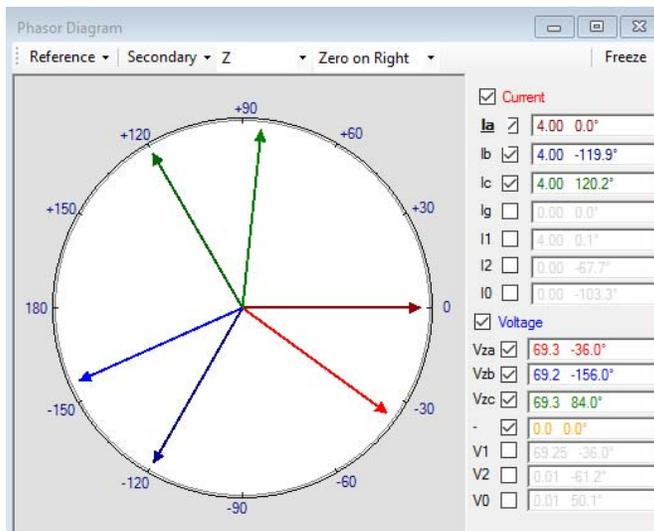
Vector Diagram: Loadflow at 1.0pf



Show loadflow vector diagram

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Vector Diagram: Loadflow at 0.8 pf lag



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BECKWITH ELECTRIC CO. INC. **Metering & Phasor Diagram**

- Vector Diagram: Loadflow at 1.0pf,
 - “C” Phase Current Rolled

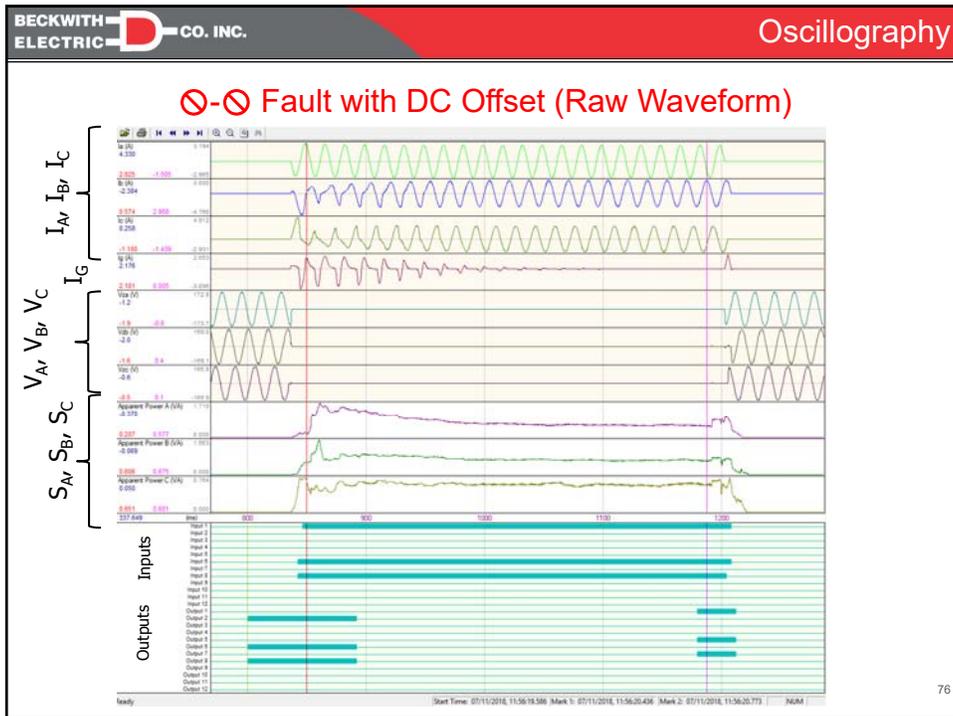
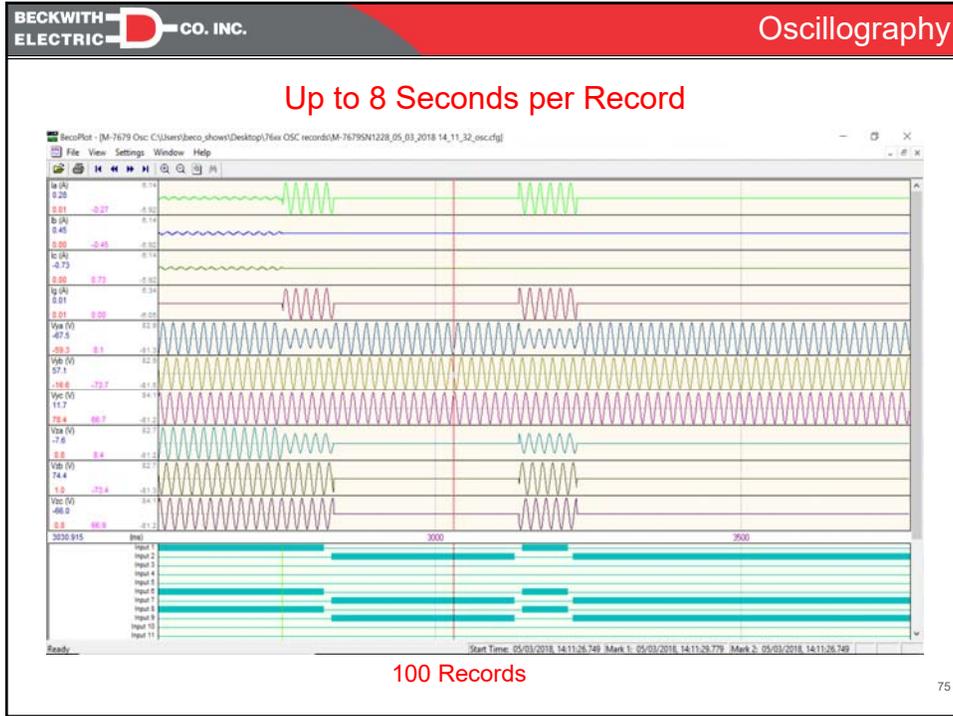
73

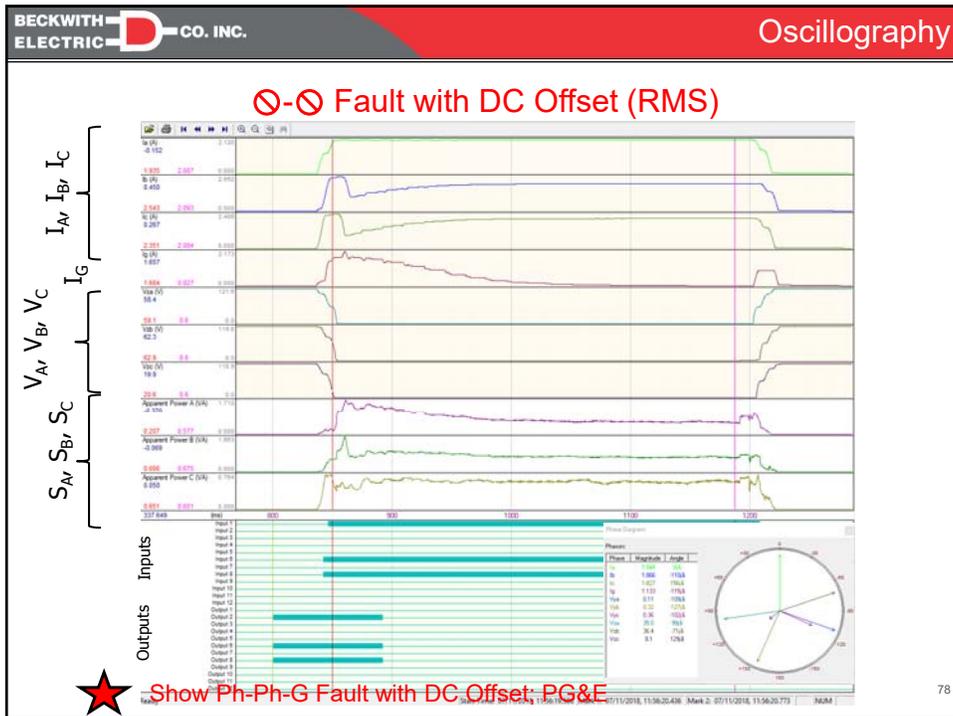
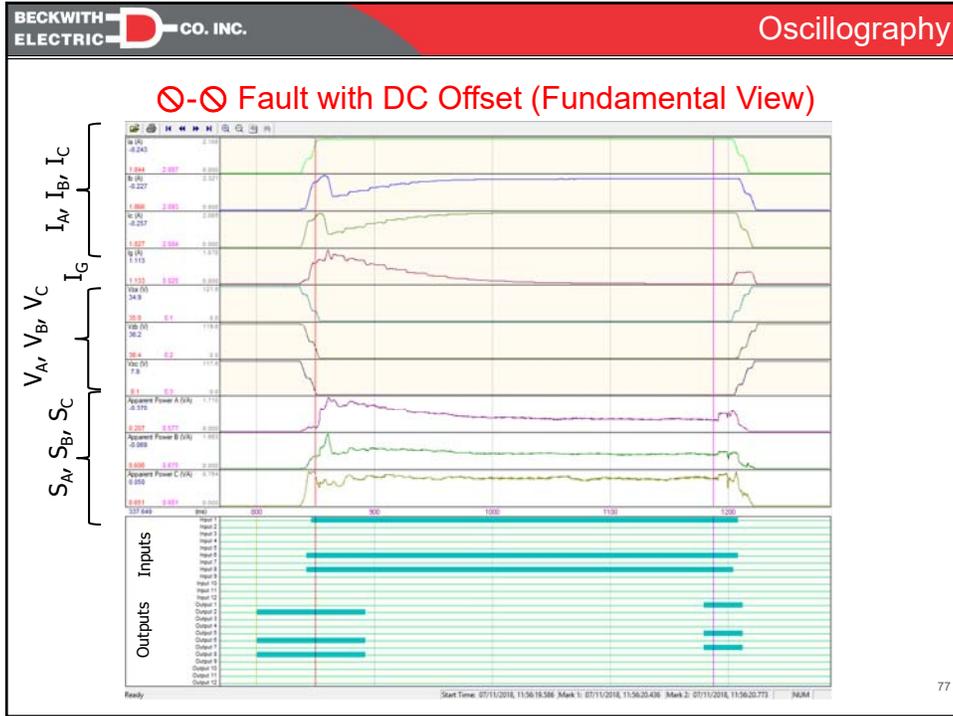
BECKWITH ELECTRIC CO. INC. **SOE**

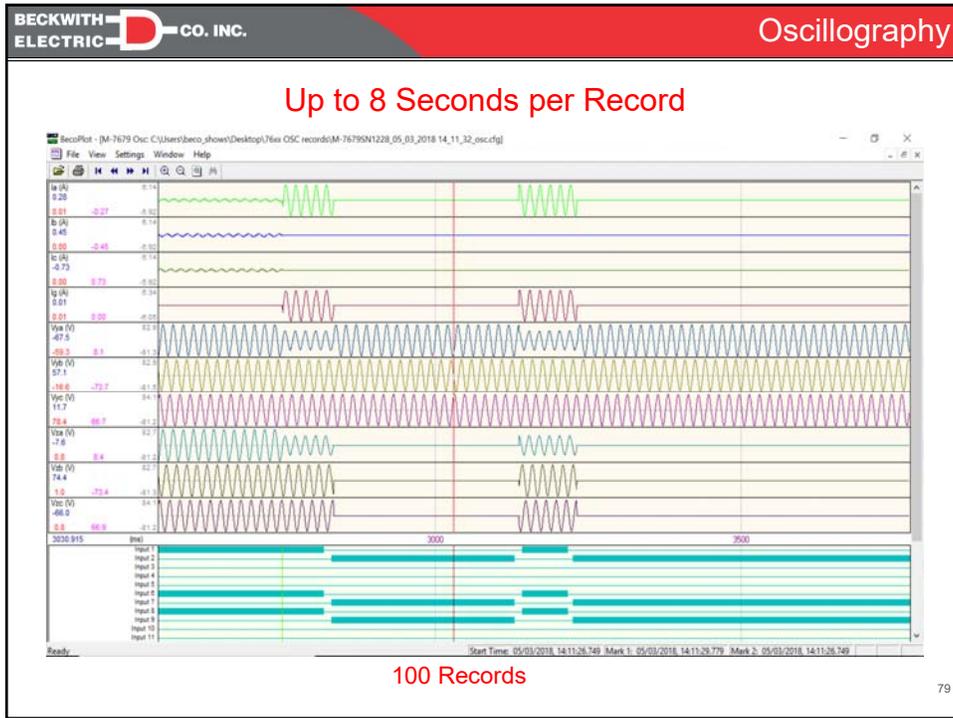
SOE Showing Trip

Voltage				Current			
Harmonics							
	A	B	C		A	B	C
1: 60Hz	120.22	119.15	120.37				
2: 120Hz	0.04	0.06	0.04				
3: 180Hz	0.24	0.39	0.07				
4: 240Hz	0.03	0.03	0.02				
5: 300Hz	0.08	0.04	0.03				
6: 360Hz	0.03	0.04	0.02				
7: 420Hz	0.03	0.02	0.04				
8: 480Hz	0.02	0.03	0.03				
9: 540Hz	0.02	0.02	0.02				
10: 600Hz	0.00	0.02	0.02				
11: 660Hz	0.04	0.02	0.02				
12: 720Hz	0.03	0.03	0.02				
13: 780Hz	0.04	0.02	0.02				
14: 840Hz	0.02	0.00	0.02				
15: 900Hz	0.02	0.04	0.02				
16: 960Hz	0.00	0.03	0.00				
17: 1020Hz	0.00	0.03	0.00				
18: 1080Hz	0.02	0.04	0.02				
19: 1140Hz	0.00	0.02	0.02				
20: 1200Hz	0.02	0.00	0.02				
21: 1260Hz	0.02	0.04	0.02				
22: 1320Hz	0.02	0.03	0.02				
23: 1380Hz	0.03	0.03	0.00				
24: 1440Hz	0.02	0.02	0.03				
25: 1500Hz	0.02	0.02	0.03				

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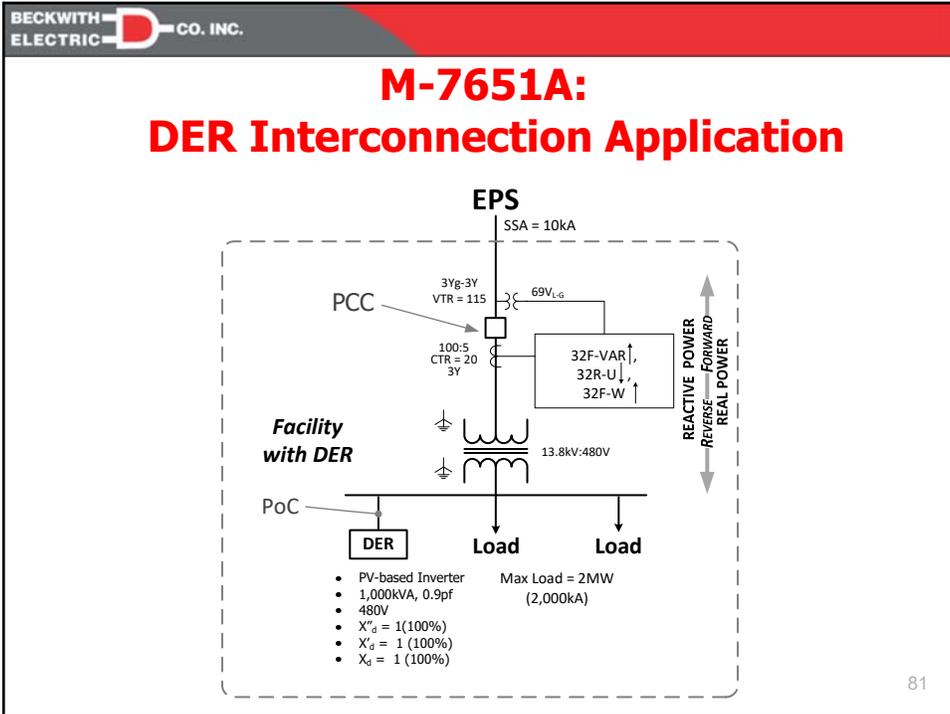


BECKWITH ELECTRIC  CO. INC.

M-7651A for DER

Element Testing

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- BECKWITH ELECTRIC CO. INC.
- ## M-7651A: DER Interconnection Application
- "Elements of Distinction"*
- 32F-VAR: Inadvertent VAR Export for Exporting DER
 - 32R-U: Minimal Import Power for Non-Exporting DER
 - 32F-Watt: Inadvertent Forward Overpower
- 82

M-7651A Settings: DER Interconnection Application

- VTR = 115:1
- VT Type: 3Y-3Y
- Rated Secondary Voltage = $69V_{LG}$
- CTR = 100:5 = 20 (3Y)
- Inverter Power = 1,000kVA
- Inverter FRA = $I = \text{kVA}/1.73 \cdot \text{kV}$
 $= I = 1,000/1.73 \cdot 13.8$
 $= I = 41.88A = 42A$

Note: "FRA" = Full Rated Amps

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M-7651A Settings: 32F-VAR DER Interconnection Application

- $I_{FRA} = 42A$
- $I_{NOM} = I_{FRA} / CTR$
- $= 42 / 20$
- $= 2.1A$
- $V_{NOM} = 69V$

Line-to-Ground Voltage:

$$P_{NOM} = 3 \cdot V_{NOM} \cdot I_{NOM} \text{ (Secondary Nominal Power)}$$

$$\text{Pickup} = \pm \frac{\text{Primary Power (Three-Phase)}}{P_{NOM} \cdot VTR \cdot CTR}$$

- Formula for "Relay P_{NOM} "
 - $3 * 69 * 2.1 = 434.7W_R = 435W_R = 1pu$

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M-7651A Settings: 32F-VAR DER Interconnection Application

Relay W=	435Wr	1pu	2.1 A
INV "S" Out	pu	Secondary Current @ pu	
1000	1.00	2.1	
900	0.90	1.89	
800	0.80	1.68	
700	0.70	1.47	
600	0.60	1.26	
500	0.50	1.05	
400	0.40	0.84	
300	0.30	0.63	
200	0.20	0.42	
100	0.10	0.21	
0	0.00	0	

- Minimum sensitivity of relay is 0.01A
- We are good to 15% of inverter power

85

M-7651A: CT Dimensioning

- CT Limitations

Device Number	Function	Setpoint Ranges	Increment	Accuracy†
Directional Instantaneous/Definite Time Overcurrent (Cont'd.)				
<i>Inverse Time:</i>				
	Pickup			
	1 A CT/Gnd CT	0.02 to 3.20 A	0.01 A	±0.02 A or ±3%
	5 A CT/Gnd CT	0.10 to 16.00 A	0.01 A	±0.1 A or ±3%

- Minimum Sensitivity of Inverse Time Element: 67Q, N, P
- 5A CT, 0.1A_{sec}
- The relay in this application can detect faults to 10% of inverter rating (10% rating = 0.21A_{sec})

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M-7651A: CT Dimensioning

- CT Limitations

AC Current Inputs

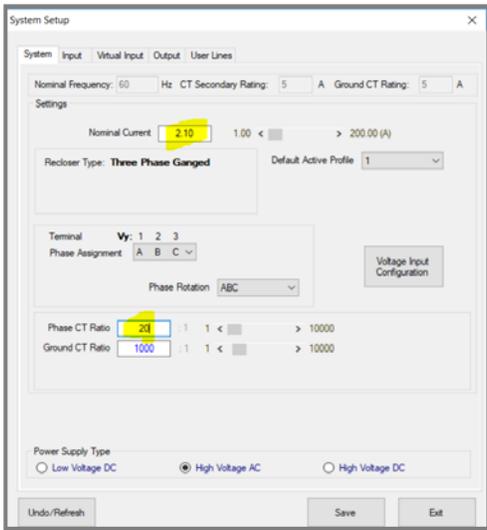
AC Current	I Nominal	I Continuous	I Short duration	Burden
Phase Current	1 A 5 A	3 A 15 A	100 A for 1 second 500 A for 1 second	< 0.021 VA < 0.20 VA
Ground Current	1 A 5 A	3 A 15 A	100 A for 1 second 500 A for 1 second	< 0.021 VA < 0.20 VA

- SSA = 10kA (10,000A)
 - System SSA contribution is greater than Facility with DER
 - $10,000/40 = 250$; <500A; OK
- Max. Load of Facility with DER (DER off) = 2MW
 - $2MW = kVA / (1.73 * kV) = 2,000 / (1.73 * 13.8) = 83.8$
 - $83.8 / 100 = 0.83A$; OK

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System Setup



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BECKWITH ELECTRIC CO. INC.

System Setup

Voltage Input Configuration

LEA Hardware: H4 Secondary Nominal Voltage: 69 50.00 < > 300.00 (V_{lg})

Vy side voltage transducers: VT LEA HIGH

Vy Side (VT): VT Configuration: WYE

 Vy1(A) PTR: 115.0 1.0 < > 10000.0 Vy2 (B) PTR: 115.0 1.0 < > 10000.0 Vy3 (C) PTR: 115.0 1.0 < > 10000.0

Vz side voltage transducers: VT LEA HIGH

Vz Side (VT): VT Configuration: WYE

 Vz1 (A) PTR: 60.0 1.0 < > 10000.0

Undo/Refresh Save Exit

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BECKWITH ELECTRIC CO. INC.

M-7651A Test Connections

For both connections,
 $V_A@0^\circ$ with $I_A@0^\circ$ & $V_B@-120^\circ$ with $I_B@-120^\circ$ & $V_C@-240^\circ$ with $I_C@-240^\circ$
 = 100% forward real power flow

TEST SET Notes:

- Each phase's neutral connected together internally.
- One common neutral for all phases available for external connection

TEST SET Notes:

- Each phase's neutral available for connection.
- Neutrals should be externally commoned together.

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BECKWITH ELECTRIC  CO. INC.

M-7651A D-PAC for DER Interconnection Protection

32F-VAR Element Application

91

BECKWITH ELECTRIC  CO. INC.

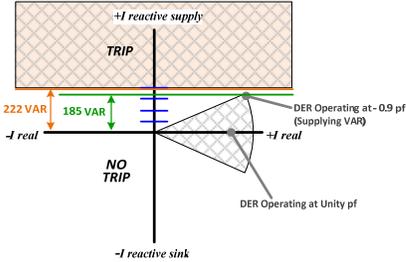
M-7651A Settings: 32F-VAR DER Interconnection Application

RELAY POWER

- $P_{NOM} = 3 * 69 * 2.10 = 438 \text{ VA} = 1\text{pu}$
- Normal pf = +/- 0.9 (25 degrees)
 - $\sin 25^\circ = 0.4226$
 - $\cos 25^\circ = 0.9$
- kW at 0.9 = $438 * \cos 25 = 394\text{W}$
- VARs at 0.9 = $438 * \sin 25 = 185 \text{ VAR}$
- Normal VAR Export Max. = 185 VAR
- 20% Margin = $185 * 1.2 = 222 \text{ VAR}$
- Setting = VAR / 1pu VA = $222 / 438 = 0.5077 = 0.51 \text{ pu}$

Line-to-Ground Voltage:
 $P_{NOM} = 3 * V_{NOM} * I_{NOM}$ (Secondary Nominal Power)

Pickup = $\pm \frac{\text{Primary Power (Three-Phase)}}{P_{NOM} * V_{TR} * CTR}$



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M-7651A Settings: 32F-VAR DER Interconnection Application

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BECKWITH ELECTRIC CO. INC.

32F-VAR Setpoints

32-Directional Power

Phase ABC Enable

Settings Pickup: 0.51 -3.00 < > 3.00 (pu)

Definite Time: 2.00 0.00 < > 500.00 (s)

Operating Power: Real Reactive

Blocking Inputs: Under power Over power

Outputs: 1-12, FL, 1-3

EPS
SSA = 10kA

- PV-based Inverter
- 1,000kVA, 0.9pf
- 480V
- $X'_s = 1$ (100%)
- $X'_r = 1$ (100%)
- $X'_0 = 1$ (100%)

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BECKWITH ELECTRIC  CO. INC.

Testing the 32F-VAR Element

Inom (2.1) X Vnom (69) = 144.9W
 144.9 X .51 (PU) Pick up = 73.9W

Phase A		Analog Outputs		
Real (W)	124.48	Set Mode	Direct	
Reactive (var)	74.04	V A-N	69.00 V	0.00 °
Apparent (va)	144.83	V B-N	69.00 V	-120.00 °
Power Factor	0.86 LAG	V C-N	69.00 V	120.00 °
		I A	2.100 A	-31.00 °
		I B	2.100 A	-151.00 °
		I C	2.100 A	89.00 °

Rotate 3-ph currents
 Meter reactive VAR's in Secondary Metering
 Check pick up and trip time
 Output 1 will pulse

Trip1	<input type="checkbox"/>	<input checked="" type="checkbox"/>		2.021 s
-------	--------------------------	-------------------------------------	--	---------

BECKWITH ELECTRIC  CO. INC.

M-7651A D-PAC for DER Interconnection Protection

32R-U Element Application

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BECKWITH ELECTRIC CO. INC.

M-7651A Settings: 32R-U DER Interconnection Application

RELAY POWER

- $P_{NOM} = 3 * 69 * 2.1$
= 438 VA = 1pu
- $W_{NOM} = 3 * 69 * 2.1 * (\text{Cos } 0^\circ)$
= 438 VA = 1pu
- $W_{NOM10\%} = 3 * 69 * 2.1 * (\text{Cos } 0^\circ) * (0.1)$
= 43.5W
- $I_{(W10\%)} \text{ at } 1.0\text{pf} = 43.5 / (3 * 69 * \text{Cos } 0^\circ)$
= 0.21A

- Desire to trip if real power imported into the Facility with DER is less than 10% of the DER's rated output
- At unity pf, minimal amps coming into facility with DER must be equal or greater than 0.21A, or 21mA

Line-to-Ground Voltage:

$P_{NOM} = 3 * V_{NOM} * I_{NOM}$ (Secondary Nominal Power)

Pickup = $\pm \frac{\text{Primary Power (Three-Phase)}}{P_{NOM} * V_{TR} * CTR}$

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BECKWITH ELECTRIC CO. INC.

M-7651A Settings: 32R-U DER Interconnection Application

REVERSE UNDERPOWER

Reverse --- Relay --- Forward

- Negative Pickup
- Underpower

EPS

Facility with DER

- PV-based Inverter
- 1,000kVA, 0.9pf
- 480V
- $X'_s = 1$ (100%)
- $X'_d = 1$ (100%)
- $X'_c = 1$ (100%)

Max Load = 2MW (2,000kA)

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BECKWITH ELECTRIC CO. INC.

32R-U Setpoints

Note:
Blocking Inputs 1 and 2 are used to block the 32R-U element if either the PPC CB or DER CBs are opened. Do not select blocking for "element only" testing.

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BECKWITH ELECTRIC CO. INC.

M-7651A Settings: 32R-U Test Procedure

Set Mode	Direct		
V A-N	69.00 V	0.00 °	60.000 Hz
V B-N	69.00 V	-120.00 °	60.000 Hz
V C-N	69.00 V	120.00 °	60.000 Hz
I A	250.0 mA	-180.00 °	60.000 Hz
I B	250.0 mA	-300.00 °	60.000 Hz
I C	250.0 mA	-60.00 °	60.000 Hz

Set Mode	Direct		
V A-N	69.00 V	0.00 °	60.000 Hz
V B-N	69.00 V	-120.00 °	60.000 Hz
V C-N	69.00 V	120.00 °	60.000 Hz
I A	210.0 mA	-180.00 °	60.000 Hz
I B	210.0 mA	-300.00 °	60.000 Hz
I C	210.0 mA	-60.00 °	60.000 Hz

- 1) Pre-fault, Clears the Target
- 2) Ramp 3 ph. Currents down on 10mA steps
- 3) Verify trip time and function status

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BECKWITH ELECTRIC  CO. INC.

M-7651A D-PAC for DER Interconnection Protection

32F-Watt Element Application

101

BECKWITH ELECTRIC  CO. INC.

M-7651A Settings: 32F-W DER Interconnection Application

RELAY POWER

- $P_{NOM} = 3 * 69 * 2.1$
= 438 VA = 1pu
- $W_{NOM} = 3 * 69 * 2.1 * (\text{Cos } 0^\circ)$
= 438 VA = 1pu
- $W_{NOM25\%} = 3 * 69 * 2.1 * (\text{Cos } 0^\circ) * (0.25)$
= 108.6W
- $I_{(W25\%)} \text{ at } 1.0\text{pf} = 108.6 / (3 * 69 * \text{Cos } 0^\circ)$
= 0.525A

Line-to-Ground Voltage:
 $P_{NOM} = 3 * V_{NOM} * I_{NOM}$ (Secondary Nominal Power)
 $\text{Pickup} = \pm \frac{\text{Primary Power (Three-Phase)}}{P_{NOM} * V_{TR} * CTR}$

- Desire to trip if real power exported out of the Facility with DER is greater than 25% of the DER's rated output
- At unity pf, maximum amps flowing into the EPS at unity pf must be equal or greater than 0.525A, or 525mA

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M-7651A Settings: 32F-W DER Interconnection Application

FORWARD OVERPOWER

Pick up →

Reverse --- Relay --- Forward

- Positive Pickup
- Overpower

EPS

SSA = 10kA

Facility with DER

- PV-based Inverter
- 1,000kVA, 0.9pf
- 480V
- $X'_s = 1$ (100%)
- $X'_r = 1$ (100%)
- $X'_t = 1$ (100%)

Max Load = 2MW
(2,000kA)

REACTIVE POWER
Reverse — Forward
REAL POWER

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32F-W Setpoints

32-Directional Power

#1	#2	#3	#4
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Phase ABC Enable

Settings

Pickup: -3.00 < > 3.00 (pu)

Definite Time: 0.00 < > 600.00 (s)

Operating Power: Real Under power Reactive Over power

Outputs: 1-12 (checkboxes) | Blocking Inputs: 1-12 (checkboxes) | Virtual Input: 1-3 (checkboxes)

Setting is 25% of I_n (2.1)

EPS

SSA = 10kA

Facility with DER

- PV-based Inverter
- 1,000kVA, 0.9PF
- 480V
- $X'_s = 1$ (100%)
- $X'_r = 1$ (100%)
- $X'_t = 1$ (100%)

Max Load = 2MW
(2,000kA)

REACTIVE POWER
Reverse — Forward
REAL POWER

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32F-W

Test

Analog Outputs			
Set Mode	Direct ▼		
V A-N	69.00 V	0.00 °	60.000 Hz
V B-N	69.00 V	-120.00 °	60.000 Hz
V C-N	69.00 V	120.00 °	60.000 Hz
I A	500.0 mA	0.00 °	60.000 Hz
I B	500.0 mA	-120.00 °	60.000 Hz
I C	500.0 mA	120.00 °	60.000 Hz

Pre-fault values

In (2.1) x .25 = .525mA

Ramp up in 50mA steps, . > 2 sec. per step
Verify trip time and pick-up

Analog Outputs			
Set Mode	Direct ▼		
V A-N	69.00 V	0.00 °	60.000 Hz
V B-N	69.00 V	-120.00 °	60.000 Hz
V C-N	69.00 V	120.00 °	60.000 Hz
I A	525.0 mA	0.00 °	60.000 Hz
I B	525.0 mA	-120.00 °	60.000 Hz
I C	525.0 mA	120.00 °	60.000 Hz

Trip 4
●


1.009 s

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Annex.

Software Navigation Overview

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Creating NEW File

The screenshot shows the IPSCOM application interface. The 'File' menu is open, and the 'New' option is selected, which has opened a sub-menu. In this sub-menu, 'M-7651A D-PAC System' is highlighted. A red arrow points from this menu item to the 'M-7651A' configuration dialog box. The dialog box contains various settings for the system type, including Firmware Version (01.06.05), Nominal Frequency (60 Hz), Secondary CT Rating (5 A), Extended ID (Disable), Ground CT Rating (5 A), Autoreclose (3 phase Operation) (Disable), Voltage Input Option (H4), and Communication Purchase Option (IEC61850 Disable). The file name 'M7651A_6_5_5_H4_Sk_0_CC_010605_file' is entered in the bottom field.

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Opening EXISTING File

The screenshot shows the IPSCOM application interface. The 'File' menu is open, and the 'Open' option is selected. A red arrow points from the 'Open' menu item to a file explorer window. The file explorer window shows the 'Documents' folder, and the file 'M7651A_Sk238' is selected. The file details show it is a .sup file, 821 KB in size, and was last modified on 3/7/2017 at 8:02 AM. The file name 'M7651A_Sk238' is entered in the 'File name' field, and the file type is set to 'M-7600 File (*.sup)'. The 'Open' button is highlighted.

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Display I/O Map

The 'I/O Map' window displays a grid with 'Outputs' (1-12) and 'Blocking Inputs' (1-12). The grid contains various I/O points such as 480T, 480L, 480N, 480P, 480Q, 480R, 480S, 480T, 480U, 480V, 480W, 480X, 480Y, 480Z, 480AA, 480AB, 480AC, 480AD, 480AE, 480AF, 480AG, 480AH, 480AI, 480AJ, 480AK, 480AL, 480AM, 480AN, 480AO, 480AP, 480AQ, 480AR, 480AS, 480AT, 480AU, 480AV, 480AW, 480AX, 480AY, 480AZ, 480BA, 480BB, 480BC, 480BD, 480BE, 480BF, 480BG, 480BH, 480BI, 480BJ, 480BK, 480BL, 480BM, 480BN, 480BO, 480BP, 480BQ, 480BR, 480BS, 480BT, 480BU, 480BV, 480BW, 480BX, 480BY, 480BZ, 480CA, 480CB, 480CC, 480CD, 480CE, 480CF, 480CG, 480CH, 480CI, 480CJ, 480CK, 480CL, 480CM, 480CN, 480CO, 480CP, 480CQ, 480CR, 480CS, 480CT, 480CU, 480CV, 480CW, 480CX, 480CY, 480CZ, 480DA, 480DB, 480DC, 480DD, 480DE, 480DF, 480DG, 480DH, 480DI, 480DJ, 480DK, 480DL, 480DM, 480DN, 480DO, 480DP, 480DQ, 480DR, 480DS, 480DT, 480DU, 480DV, 480DW, 480DX, 480DY, 480DZ, 480EA, 480EB, 480EC, 480ED, 480EE, 480EF, 480EG, 480EH, 480EI, 480EJ, 480EK, 480EL, 480EM, 480EN, 480EO, 480EP, 480EQ, 480ER, 480ES, 480ET, 480EU, 480EV, 480EW, 480EX, 480EY, 480EZ, 480FA, 480FB, 480FC, 480FD, 480FE, 480FF, 480FG, 480FH, 480FI, 480FJ, 480FK, 480FL, 480FM, 480FN, 480FO, 480FP, 480FQ, 480FR, 480FS, 480FT, 480FU, 480FV, 480FW, 480FX, 480FY, 480FZ, 480GA, 480GB, 480GC, 480GD, 480GE, 480GF, 480GG, 480GH, 480GI, 480GJ, 480GK, 480GL, 480GM, 480GN, 480GO, 480GP, 480GQ, 480GR, 480GS, 480GT, 480GU, 480GV, 480GW, 480GX, 480GY, 480GZ, 480HA, 480HB, 480HC, 480HD, 480HE, 480HF, 480HG, 480HH, 480HI, 480HJ, 480HK, 480HL, 480HM, 480HN, 480HO, 480HP, 480HQ, 480HR, 480HS, 480HT, 480HU, 480HV, 480HW, 480HX, 480HY, 480HZ, 480IA, 480IB, 480IC, 480ID, 480IE, 480IF, 480IG, 480IH, 480II, 480IJ, 480IK, 480IL, 480IM, 480IN, 480IO, 480IP, 480IQ, 480IR, 480IS, 480IT, 480IU, 480IV, 480IW, 480IX, 480IY, 480IZ, 480JA, 480JB, 480JC, 480JD, 480JE, 480JF, 480JG, 480JH, 480JI, 480JJ, 480JK, 480JL, 480JM, 480JN, 480JO, 480JP, 480JQ, 480JR, 480JS, 480JT, 480JU, 480JV, 480JW, 480JX, 480JY, 480JZ, 480KA, 480KB, 480KC, 480KD, 480KE, 480KF, 480KG, 480KH, 480KI, 480KJ, 480KK, 480KL, 480KM, 480KN, 480KO, 480KP, 480KQ, 480KR, 480KS, 480KT, 480KU, 480KV, 480KW, 480KX, 480KY, 480KZ, 480LA, 480LB, 480LC, 480LD, 480LE, 480LF, 480LG, 480LH, 480LI, 480LJ, 480LK, 480LL, 480LM, 480LN, 480LO, 480LP, 480LQ, 480LR, 480LS, 480LT, 480LU, 480LV, 480LW, 480LX, 480LY, 480LZ, 480MA, 480MB, 480MC, 480MD, 480ME, 480MF, 480MG, 480MH, 480MI, 480MJ, 480MK, 480ML, 480MM, 480MN, 480MO, 480MP, 480MQ, 480MR, 480MS, 480MT, 480MU, 480MV, 480MW, 480MX, 480MY, 480MZ, 480NA, 480NB, 480NC, 480ND, 480NE, 480NF, 480NG, 480NH, 480NI, 480NJ, 480NK, 480NL, 480NM, 480NN, 480NO, 480NP, 480NQ, 480NR, 480NS, 480NT, 480NU, 480NV, 480NW, 480NX, 480NY, 480NZ, 480OA, 480OB, 480OC, 480OD, 480OE, 480OF, 480OG, 480OH, 480OI, 480OJ, 480OK, 480OL, 480OM, 480ON, 480OO, 480OP, 480OQ, 480OR, 480OS, 480OT, 480OU, 480OV, 480OW, 480OX, 480OY, 480OZ, 480PA, 480PB, 480PC, 480PD, 480PE, 480PF, 480PG, 480PH, 480PI, 480PJ, 480PK, 480PL, 480PM, 480PN, 480PO, 480PP, 480PQ, 480PR, 480PS, 480PT, 480PU, 480PV, 480PW, 480PX, 480PY, 480PZ, 480QA, 480QB, 480QC, 480QD, 480QE, 480QF, 480QG, 480QH, 480QI, 480QJ, 480QK, 480QL, 480QM, 480QN, 480QO, 480QP, 480QQ, 480QR, 480QS, 480QT, 480QU, 480QV, 480QW, 480QX, 480QY, 480QZ, 480RA, 480RB, 480RC, 480RD, 480RE, 480RF, 480RG, 480RH, 480RI, 480RJ, 480RK, 480RL, 480RM, 480RN, 480RO, 480RP, 480RQ, 480RR, 480RS, 480RT, 480RU, 480RV, 480RW, 480RX, 480RY, 480RZ, 480SA, 480SB, 480SC, 480SD, 480SE, 480SF, 480SG, 480SH, 480SI, 480SJ, 480SK, 480SL, 480SM, 480SN, 480SO, 480SP, 480SQ, 480SR, 480SS, 480ST, 480SU, 480SV, 480SW, 480SX, 480SY, 480SZ, 480TA, 480TB, 480TC, 480TD, 480TE, 480TF, 480TG, 480TH, 480TI, 480TJ, 480TK, 480TL, 480TM, 480TN, 480TO, 480TP, 480TQ, 480TR, 480TS, 480TT, 480TU, 480TV, 480TW, 480TX, 480TY, 480TZ, 480UA, 480UB, 480UC, 480UD, 480UE, 480UF, 480UG, 480UH, 480UI, 480UJ, 480UK, 480UL, 480UM, 480UN, 480UO, 480UP, 480UQ, 480UR, 480US, 480UT, 480UU, 480UV, 480UW, 480UX, 480UY, 480UZ, 480VA, 480VB, 480VC, 480VD, 480VE, 480VF, 480VG, 480VH, 480VI, 480VJ, 480VK, 480VL, 480VM, 480VN, 480VO, 480VP, 480VQ, 480VR, 480VS, 480VT, 480VU, 480VV, 480VW, 480VX, 480VY, 480VZ, 480WA, 480WB, 480WC, 480WD, 480WE, 480WF, 480WG, 480WH, 480WI, 480WJ, 480WK, 480WL, 480WM, 480WN, 480WO, 480WP, 480WQ, 480WR, 480WS, 480WT, 480WU, 480WV, 480WW, 480WX, 480WY, 480WZ, 480XA, 480XB, 480XC, 480XD, 480XE, 480XF, 480XG, 480XH, 480XI, 480XJ, 480XK, 480XL, 480XM, 480XN, 480XO, 480XP, 480XQ, 480XR, 480XS, 480XT, 480XU, 480XV, 480XW, 480XX, 480XY, 480XZ, 480YA, 480YB, 480YC, 480YD, 480YE, 480YF, 480YG, 480YH, 480YI, 480YJ, 480YK, 480YL, 480YM, 480YN, 480YO, 480YP, 480YQ, 480YR, 480YS, 480YT, 480YU, 480YV, 480YW, 480YX, 480YY, 480YZ, 480ZA, 480ZB, 480ZC, 480ZD, 480ZE, 480ZF, 480ZG, 480ZH, 480ZI, 480ZJ, 480ZK, 480ZL, 480ZM, 480ZN, 480ZO, 480ZP, 480ZQ, 480ZR, 480ZS, 480ZT, 480ZU, 480ZV, 480ZW, 480ZX, 480ZY, 480ZZ.

The 'Setup' window shows a 'Blocking' checkbox circled in red.

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Setpoint Summary

The 'Display All Settings' window shows the following information:

M-7651A Display All Setpoints

Serial Number: file
 Device: M-7651A
 Firmware Version: V01.06.05
 Company Info: Beckwith Electric Co., Inc.
 Location:
 Relay Manufacturer:
 System Information:
 Date/Time when SLP file was last SAVED: D:04/10/15 16
 Additional Info:

Factory

Factory:
 Secondary CT Rating: 5A
 Nominal CT Rating: 1A
 Nominal Frequency (Hz): 60
 Voltage Input Option: VT

System Setup

Setup:
 Nominal Voltage (V_{lg}): 48.00
 Nominal Current (A): 5.00
 Relays Type: Three Phase Opened
 No Reset Before Close: Disabled
 Lockout Operation: No Reset Before Close
 #9 Switch Operation: Three Phase
 VT Config: Low-To-Ground
 Default Active Profile: 1
 Phase Rotation: ABC

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IPScm 5-7631A (C:\Users\jgroover\Documents\M7631A_SQ238.scp)

SOE Set Up

3500 SOE stored in nonvolatile memory

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IPScm 5-7631A (C:\Users\jgroover\Documents\M7631A_SQ238.scp)

Oscillography Set Up

100 OSC files stored in nonvolatile memory

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IPScm 5-7651A - 10.0.0.188 (Modbus Ethernet Ch1)

File Communication Monitor Setup Utility Help

Primary Metering

Secondary Metering

Phasor Diagram

Function Status

Recloser Status Monitoring

Demand Metering

Harmonics

Sync Scope

Counters

Live Oscillograph

Battery Charger Monitoring

Breaker Accumulator Status

Primary Metering And Component Metering

Currents (A)		Voltages (V)		Sequence Components	
Phase A	500.40	Phase A	4199.8	Pos. Seq	500.40
Phase B	501.80	Phase B	4199.2	Neg. Seq	0.00
Phase C	500.40	Phase C	4215.0	Zero Seq	0.00
Ground	0	V1	1.2	3 I0	0.00

Power			
Phase A	Phase B	Phase C	Three Phase
Real (W)	2.10 M	2.10 M	6.30 M
Reactive (var)	16.70k	-8.50k	-6.70k
Apparent (va)	2.10 M	2.10 M	6.30 M
Power Factor	1.00	1.00	1.00

Inputs							
1	2	3	4	5	6	7	8
9	10	11	12	FL			

Frequency		
Frequency (Hz)	60.00	
ROCOF (Hz/s)	0.08	

Virtual Inputs		
1	2	3

Frequency: 60.00 Hz
ROCOF: 0.08 Hz/s
Virtual Inputs: 1, 2, 3
Fault Distance: NA miles

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BECKWITH ELECTRIC CO. INC.

IPScm 5-7651A - 10.0.0.188 (Modbus Ethernet Ch1)

File Communication Monitor Setup Utility Help

Primary Metering

Secondary Metering

Phasor Diagram

Function Status

Recloser Status Monitoring

Demand Metering

Harmonics

Sync Scope

Counters

Live Oscillograph

Battery Charger Monitoring

Breaker Accumulator Status

Secondary Metering, Components Metering, and Status

Currents (A)		Voltages (V)		Sequence Component	
Phase A	4.10	Phase A	69.85	Pos. Seq	4.10
Phase B	4.17	Phase B	69.68	Neg. Seq	0.00
Phase C	4.17	Phase C	70.25	Zero Seq	0.000
Ground	0.000	V1	0.03	3 I0	0.000

Power			
Phase A	Phase B	Phase C	Three Phase
Real (W)	291.75	290.81	875.55
Reactive (var)	2.22	-1.18	0.32
Apparent (va)	291.75	290.81	875.55
Power Factor	1.00	1.00	1.00

Inputs							
1	2	3	4	5	6	7	8
9	10	11	12	FL			

Frequency		
Frequency (Hz)	60.00	
ROCOF (Hz/s)	0.07	

Virtual Inputs		
1	2	3

Frequency: 60.00 Hz
ROCOF: 0.07 Hz/s
Virtual Inputs: 1, 2, 3
Fault Distance: 0.03 miles

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IPScm S-7651A - 10.0.0.188 (Modbus Ethernet Ch1)

File Communication Monitor Setup Utility Help

- Primary Metering
- Secondary Metering
- Phasor Diagram
- Function Status
- Recloser Status Monitoring
- Demand Metering
- Harmonics
- Sync Scope
- Counters
- Live Oscillograph
- Battery Charger Monitoring
- Breaker Accumulator Status

Phasor Diagram

All corresponding voltages and currents in phase (loadflow at unity pf)

Current	Value	Angle
Ia	4.17	-0.4°
Ib	4.17	-120.3°
Ic	4.17	119.7°
I0	0.00	0.0°

Voltage	Value	Angle
Va	69.9	0.0°
Vb	69.7	-120.5°
Vc	70.3	119.6°
V0	0.00	101.5°

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IPScm S-7651A - 10.0.0.188 (Modbus Ethernet Ch1)

File Communication Monitor Setup Utility Help

- Primary Metering
- Secondary Metering
- Phasor Diagram
- Function Status
- Recloser Status Monitoring
- Demand Metering
- Harmonics
- Sync Scope
- Counters
- Live Oscillograph
- Battery Charger Monitoring
- Breaker Accumulator Status

Phasor Diagram

- All corresponding voltages and currents in phase (loadflow at unity pf)
- Phase A current wired 180° from Phase A voltage

Current	Value	Angle
Ia	1.04	179.7°
Ib	1.04	119.8°
Ic	1.04	120.1°
I0	0.00	0.0°

Voltage	Value	Angle
Va	68.8	0.0°
Vb	69.7	120.7°
Vc	70.4	119.5°
V0	0.00	108.2°

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IPScm S-7651A - 10.0.0.188 (Modbus Ethernet Ch1)

File Communication Monitor Setup Utility Help

- Primary Metering
- Secondary Metering
- Phasor Diagram**
- Function Status
- Recloser Status Monitoring
- Demand Metering
- Harmonics
- Sync Scope
- Counters
- Live Oscillograph
- Battery Charger Monitoring
- Breaker Accumulator Status

Phasor Diagram

Parameter	Value	Angle
Ia	1.04	-10.0°
Ib	1.04	-129.9°
Ic	1.04	110.2°
Va	69.9	0.0°
Vb	69.9	-120.7°
Vc	70.4	119.5°

- All currents lag corresponding voltage by 10°
- Loadflow with lagging power factor

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IPScm S-7651A - 10.0.0.188 (Modbus Ethernet Ch1)

File Communication Monitor Setup Utility Help

- Primary Metering
- Secondary Metering
- Phasor Diagram**
- Function Status
- Recloser Status Monitoring
- Demand Metering
- Harmonics
- Sync Scope
- Counters
- Live Oscillograph
- Battery Charger Monitoring
- Breaker Accumulator Status

Phasor Diagram

Parameter	Value	Angle
Ia	1.05	169.0°
Ib	1.04	-129.0°
Ic	1.04	119.0°
Va	69.9	0.0°
Vb	69.9	-120.7°
Vc	70.4	119.5°

- All currents lag corresponding voltages by 10°
- Phase A current is wired 180° out-of-phase with Phase A voltage
- Representative of balanced load at lagging pf

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Function Status (Targets)

The screenshot shows the 'Function Status' window with a table of monitored items. The table has columns for 'Function Pickup/Tripped', 'Pickup', and 'Tripped'. A 'Target' column is also visible on the right. Below the table are sections for 'Inputs' and 'Outputs'.

Function Pickup/Tripped	Pickup	Tripped	Target				
25	32A R2	4EOT R3	51N R2	55A R3	57C R2	57G R1	60FL
27A R1	32B R2	50PC R3	4EOT R4	51N R3	55B R3	57A R3	57G R2
27B R1	32C R2	50PA R4	4EOT R5	51N R4	55C R3	57B R3	57G R3
27C R1	32A R3	50FB R4	50FB	51N R5	55A R4	57C R3	57G R4
27A R2	32B R3	50PC R4	51PA R1	51G R1	55B R4	57A R4	57G R5
27B R2	32C R3	50PA R5	51PB R1	51G R2	55C R4	57B R4	57G R1
27C R2	32A R4	50FB R5	51PC R1	51G R3	55PA	57C R4	57G R2
27A R3	32B R4	50PC R5	51PA R2	51G R4	55PB	57A R5	57G R3
27B R3	32C R4	50N R1	51PB R2	51G R5	55PC	57B R5	57G R4
27C R3	43 R1	50N R2	51PC R2	4EOT R1	55R	57C R5	57G R1
27A R4	43 R2	50N R3	51PA R3	4EOT R2	55A1	57N R1	57G R2
27B R4	43 R1	50N R4	51PB R3	4EOT R3	55A	57N R2	57G R3
27C R4	43 R2	50N R5	51PC R3	4EOT R4	55B	57N R3	57G R4
27PA	50PA R1	50G R1	51PA R4	4EOT R5	55C	57N R4	57G R5
27PB	50PB R1	50G R2	51PB R4	55A R1	47	57N R5	57G R1
27PC	50PC R1	50G R3	51PC R4	55B R1	57PA R1	57G R1	57G R2
27v1	50PA R2	50G R4	51PA R5	55C R1	57B R1	57G R2	57G R3
32A R1	50PB R2	50G R5	51PB R5	55A R2	57PC R1	57G R3	57G R4
32B R1	50PC R2	4EOT R1	51PC R5	55B R2	57PA R2	57G R4	57G R5
32C R1	50PA R3	4EOT R2	51N R1	55C R2	57B R2	57G R5	57G R6

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Reclose Status Monitor

The screenshot shows the 'Reclose Status Monitoring' window. It includes a 'Breaker Status' section with 'Phase A', 'Phase B', and 'Phase C' indicators. A 'Status Lockout' graph plots 'Close' and 'Trip' over 'Time (s)'. The graph shows a 'Trip' event at 170.8 ms, followed by a 'Lockout' period. The 'Legend' at the bottom indicates 'Control Reclose Time (Blue)' and 'Reclose Time (Red)'.

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IPScm 5-7651A - 10.0.0.188 (Modbus Ethernet Ch1)

File Communication Monitor Setup Utility Help

Primary Metering
Secondary Metering
Phasor Diagram
Function Status
Recloser Status Monitoring
Demand Metering
Harmonics
Sync Scope
Counters
Live Oscillograph
Battery Charger Monitoring
Breaker Accumulator Status

Harmonics Monitoring

Item	Voltage	Current
THD	13.3 %	2.8 %
TDO	-	0.6 %

Harmonic	Voltage	Current
0.0Hz	0.0 %	0.0 %
1.60Hz	100.0 %	99.7 %
2.120Hz	0.3 %	0.4 %
3.187Hz	13.3 %	0.4 %
4.243Hz	0.1 %	0.4 %
5.300Hz	0.2 %	0.6 %
6.357Hz	0.0 %	0.4 %
7.414Hz	0.0 %	0.4 %
8.471Hz	0.0 %	0.0 %
9.528Hz	0.1 %	0.6 %
10.585Hz	0.0 %	0.4 %
11.642Hz	0.0 %	0.4 %
12.700Hz	0.0 %	0.0 %
13.757Hz	0.0 %	0.4 %
14.814Hz	0.0 %	0.4 %
15.871Hz	0.0 %	0.4 %
16.928Hz	0.0 %	0.0 %
17.985Hz	0.0 %	0.4 %
19.042Hz	0.0 %	0.0 %
20.100Hz	0.0 %	0.6 %
21.157Hz	0.0 %	0.4 %
22.214Hz	0.0 %	0.4 %
23.271Hz	0.0 %	0.4 %
24.328Hz	0.0 %	0.4 %
25.385Hz	0.0 %	0.4 %

Waveform: Phase A, Phase B, Phase C. Demand Interval: 15 (sec). Demand max: 4.450 A. 03/07/17 09:53:57

Voltage Mag [V]
Current Mag [A]

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IPScm 5-7651A - 10.0.0.188 (Modbus Ethernet Ch1)

File Communication Monitor Setup Utility Help

Select Active Profile
Configuration
Setpoints
Alarms
Recloser Wizard
Data Logging
Oscillograph
Sequence of Events
Display I/O Map
Retrieve
Custom Curve Editor
Display All Settings

Retrieve SOE Record

Records retrieved: 40.2 of 202 (19.5 %)

Would you like to open the record?

Item	Value	Unit	L/O Status	Voltage	Current
Active Profile	1		No	Harmonics	A
Current A Max	5.22	A	No	1.00Hz	66.02
Current A Inst	4.17	A	No	2.120Hz	6.43
Current A Avg	1.82	A	No	3.187Hz	6.72
Current A Min	0	A	No	4.243Hz	0.54
Current B Max	4.12	A	No	5.300Hz	0.28
Current B Inst	4.17	A	No	6.357Hz	0.26
Current B Avg	1.17	A	No	7.414Hz	0.09
Current B Min	0	A	No	8.471Hz	0.06
Current C Max	4.17	A	No	9.528Hz	0.12
Current C Inst	4.17	A	No	10.585Hz	0.00
Current C Avg	1.48	A	No	11.642Hz	0.02
Current C Min	0	A	No	12.700Hz	0.02
Current G Max	0	A	No	13.757Hz	0.02
Current G Inst	0	A	No	14.814Hz	0.02
Current G Avg	0	A	No	15.871Hz	0.02
Current G Min	0	A	No	16.928Hz	0.02
Voltage A Max	69.87	V	No	17.985Hz	0.00
Voltage A Inst	69.84	V	No	18.000Hz	0.00
Voltage A Avg	19.6	V	No	19.114Hz	0.02
Voltage A Min	0	V	No	20.129Hz	0.02
Voltage B Max	77.32	V	No	21.143Hz	0.02
Voltage B Inst	75.95	V	No	22.158Hz	0.02
Voltage B Avg	19.53	V	No	23.173Hz	0.02
Voltage B Min	0	V	No	24.188Hz	0.02
Voltage C Max	77.27	V	No	25.203Hz	0.02

Sequence of Events Opened Record #1 0/0/2017 10:04:53 AM

Project Name: 0-02-001-00-00 Downloaded from IPScm Version 3.0 (04/16/16)

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Retrieve Oscillography Record

Record	Triggered Date/Time
<input checked="" type="checkbox"/> 60	03/07/2017 10:02:59
<input type="checkbox"/> 59	03/07/2017 09:58:09
<input type="checkbox"/> 58	03/07/2017 09:57:35
<input type="checkbox"/> 57	03/07/2017 09:57:31
<input type="checkbox"/> 56	03/07/2017 09:57:21
<input type="checkbox"/> 55	03/07/2017 09:56:36
<input type="checkbox"/> 54	02/17/2017 10:01:38
<input type="checkbox"/> 53	02/15/2017 17:12:15
<input type="checkbox"/> 52	02/15/2017 17:12:11
<input type="checkbox"/> 51	02/15/2017 17:12:06
<input type="checkbox"/> 50	02/15/2017 17:12:03
<input type="checkbox"/> 49	02/15/2017 17:12:01
<input type="checkbox"/> 48	02/15/2017 17:11:52
<input type="checkbox"/> 47	02/15/2017 17:11:50
<input type="checkbox"/> 46	02/15/2017 17:05:04
<input type="checkbox"/> 45	02/15/2017 17:05:00

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Retrieve Trip Sequence Events

No.	Date & Time	Events Sequence Reported
27	2/16/2017 17:12:14.999	SPG Step 10
28	2/16/2017 17:12:14.991	SPG Step 9
29	2/16/2017 17:12:14.877	SPG Step 7
30	2/16/2017 17:12:8.877	SPG Step 6

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