

1. Scope

This functional specification guide describes the features of the Cooper Power Systems Form 4D microprocessor-based recloser control, which is part of a line of fully integrated controls. These controls feature a standard look and feel, and a universal platform that can be programmed for almost any protective application.

In addition to the flexible and user-friendly platform, the Form 4D control will utilize modern communications technology. With fully modular communications compatibility, the Form 4D control will support cellular and radio communications utilizing the Serial and Network DNP3, IEC 60870-5-101, IEC 60870-5-104, and IEC 61850 protocols. Side panel RS-232, fiber-optic, Ethernet, and RS-485 ports are available for connection to SCADA or other devices. These ports are accessed by swinging the control panel forward.

The Form 4D recloser control provides phase and ground current sensing, 6 voltage inputs, and three-phase voltage sensing. The Form 4D control can compute power, energy, power factor, and power flow direction from these current and voltage inputs.

The standardized front panel of the Form 4D control is used to program and interrogate the control, as well as to display metering and alarm information. Control parameters can also be programmed via personal computer using **ProView NXG** interface software. The **ProView NXG** interface software includes the functionality to create and modify time-current curves (TCCs), and provides diagnostic information. The Form 4D control analysis tools include event recording, data profiling, and various metering capabilities.

2. Applicable Standards

2.1. The Form 4D control has been designed and tested in accordance with the following standards as applicable:

2.1.1. IEEE C37.60-2003 (ANSI/IEEE). American National Standard Requirements for Overhead Pad-Mounted, Dry Vault and Submersible Automatic Circuit Reclosers and Fault Interrupters for Alternating Current Systems.

2.1.2. IEEE C37.90.1-2002. IEEE Standard for Surge Withstand Capabilities (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus.

2.1.3. IEEE C37.90.2-2004. IEEE Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers.

2.2. The recloser control shall be tested to the following normative test standards:

2.2.1. IEC 255-21-1: 1988, Vibration, Shock, Bump, and Seismic Tests in Measuring Relays and Protective Equipment; Vibration tests (sinusoidal), Class 1

2.2.2. IEC 255-21-2: 1988, Vibration, Shock, Bump, and Seismic Tests in Measuring Relays and Protective Equipment; Shock and bump tests, Class 2

2.2.3. IEC 60255-5: 2000. Insulation Coordination for Measuring Relays and Protection Equipment – Requirements & tests.

- Test 6.1.3, Impulse Voltage Withstand Test. Category III; 4 kV impulse

- Test 6.1.4, Dielectric Test. 3150 V dc on contact input and contact outputs for 1 minute.

2.2.4. IEC 60068-2-1, Environmental Tests; Test A: cold, Section 4, -40°C 16hrs

2.2.5. IEC 60068-2-2, Environmental Tests; Test B: dry heat Section 4, +85°C 16hrs

- 2.2.6. EN 55022: 1998, Information Technology Equipment – Radio disturbance characteristics – Limits & Methods of Measurement; Conducted & radiated emissions; (Class A, Industrial)
- 2.2.7. IEC 61000-4-2: 2008, Electromagnetic Compatibility, Part 4: Testing and Measurement Techniques; Section 2: Electrostatic Discharge Test, Level 4
- 2.2.8. IEC 61000-4-3: 2006, Electromagnetic Compatibility (EMC) - Part 4: Testing and Measurement Techniques, Section 3: Radiated Radio-Frequency, Electromagnetic Field Immunity Test, Open test level of 35 V/m, 80MHz to 2.7GHz
- 2.2.9. IEC 61000-4-4: 2004, Electromagnetic Compatibility, Part 4: Testing and Measurement Techniques; Section 4: Electrical Fast Transient /Burst Immunity Test, Level 4 (Severe industrial environment)
- 2.2.10. IEC 61000-4-6: 2003 with A1:2004 & A2:2006 Electromagnetic Compatibility (EMC), Part 4: Testing and Measurement Techniques, Section 6: Immunity to conducted disturbances, induced by radio-frequency fields; Level 3

3. Ratings

- 3.1. The recloser control shall have an operating range of -40°C to +65°C ambient.
- 3.2. The recloser control shall operate within specification and not be damaged by temperature rates-of-change up to 0.2°C per minute.
- 3.3. The recloser control (minus the battery) shall not be damaged by short-term storage at ambient temperatures from -40°C to +85°C. Battery(s) shall be stored at temperatures less than 47°C.
- 3.4. The recloser control shall operate from 120/240VAC and from 125/250VDC with a 65W peak input power.
- 3.5. The recloser control shall include a battery that shall provide sufficient power to run the control without AC power for 24 hours at 20°C.
- 3.6. The recloser control shall operate on 50 and 60 Hz systems.

4. Construction

- 4.1. The standard recloser control shall be housed in a mild steel, weather-proof outdoor cabinet with accessible entry through one door. A stainless steel control cabinet is available as an option.
- 4.2. The recloser control cabinet shall be of the following dimension:
 - 4.2.1. 15.07 in (382.8 mm) wide
 - 4.2.2. 18.00 in (457.2 mm) high
 - 4.2.3. 13.40 in (340.4 mm) deep
- 4.3. The recloser control cabinet door shall include gasketing to assure a weather-tight seal and include one locking provision for utility grade locks. The provision allows for a padlock with the shank size of 0.38 inches and 9.5 mm. The recloser control cabinet has a NEMA rating of 4 and an IP rating of 5X.
- 4.4. A minimum of two latch points shall be required for the cabinet door.
- 4.5. A nameplate shall be attached to the door.

- 4.6. Front door entry shall allow access to the operating panel without exposure to battery or primary power voltage.
- 4.7. The swing panel of the recloser control module shall allow direct access to all control wiring, including incoming voltage, communications ports, hardwired inputs and outputs, and battery.
- 4.8. As part of the housing, a factory-mounted and pre-wired control receptacle shall allow the user a quick disconnect from the recloser.
- 4.9. The recloser control housing shall have a provision for cable entry – up to six cable openings including the R1 receptacle to be connected to the high-voltage apparatus. Five circular openings 1.44 inch in diameter and one opening 1.0 inch square.
- 4.10. The recloser control housing shall have two vent holes to prevent moisture buildup. The control shall have a standard thermostatically-controlled heater for humidity control. The heater shall draw power from the power input.

5. Front Panel

- 5.1. The front panel shall be designed to minimize training costs and avoid potential misoperation.
- 5.2. The front panel shall be separated into two sections clearly identified by color-coding.
 - 5.2.1. The top portion of the control shall be used for programming the control.
 - 5.2.2. The lower portion of the control shall be used for operation.
- 5.3. The recloser control shall be integrated as a system to include proper status of the recloser on the front panel.
- 5.4. The control programming section shall provide the user LED status indication. Each LED shall be rated for visibility in bright sunlight.
- 5.5. The control shall have a total of twenty-one LEDs available for direct control and recloser status information. As a minimum, dedicated LEDs shall include status indication as follows:
 - A-Phase Fault
 - B-Phase Fault
 - C-Phase Fault
 - Ground Fault
 - Sensitive Ground
 - Frequency Trip
 - Voltage Trip
 - Above Minimum Trip
 - Recloser Lockout
 - Recloser Open
 - Recloser Closed
 - Alarm
 - Control OK
 - AC Power
 - Battery
 - A-Phase Voltage
 - B-Phase Voltage
 - C-Phase Voltage
 - X-Phase Voltage
 - Y-Phase Voltage

- Z-Phase Voltage

- 5.6. A sharp, backlit 4-line x 20-character display shall be included in the programming section. The LCD panel contrast shall be field-adjustable to allow for various mounting heights and applications.
- 5.7. The LCD shall provide extensive status information regarding the distribution system, recloser, and control using a minimum of seven navigational keys in an organized menu structure. The navigational keys shall include direct scroll up, down, left and right keys, along with immediate enter, escape, and edit keys for direct operation.
- 5.8. The programming section shall include a USB connector for direct connection to a personal computer (PC). The interface shall be designated DCE to directly connect to the USB port of the PC without any special cables or connectors. (Refer to Section 10.4 for additional information.)
- 5.9. The operating section shall allow the user direct open and close operation of the recloser along with pre-defined and customized operating functions.
- 5.10. The TRIP and CLOSE buttons shall have a minimum surface area of one square inch (6.45 cm²) with a protective guard around the perimeter of each button to prevent accidental trip or close. No exceptions to the surface area standards shall be accepted.
- 5.11. The TRIP button shall be green and the CLOSE button shall be red. No exceptions to the color of the TRIP and CLOSE button standards shall be accepted.
- 5.12. The front operating panel shall include the following pushbuttons with LED indicators:
 - Ground Trip Blocked
 - Non-Reclosing
 - Supervisory OFF
 - Alternate Profile #1
- 5.13. The front operating panel shall include the following:
 - Hot Line Tag ON/OFF Toggle Switch
 - Hot Line Tag LED Indicator Ring
 - USB Data Ports

6. Software

- 6.1. The recloser control shall use Microsoft® Windows® operating system-based interface software. The software shall be separate from the recloser control.
- 6.2. The executable configuration interface software shall allow the user the ability to save and edit files based upon user requirements independent of connectivity to the control.
- 6.3. All settings, metering, and diagnostic tools shall use standard dialog boxes, including available minimum and maximum values, for each setting.
- 6.4. Firmware upgrades shall be available through direct connection to the dedicated USB port on the control front panel without any additional equipment required.
- 6.5. The executable configuration interface software shall allow for the following save and create options:
 - 6.5.1. Save only communication settings to files based upon user requirements, independent of connectivity to control.

- 6.5.2. Save only Configurable Logic settings to files based upon user requirements, independent of connectivity to control.
- 6.5.3. Save only protection profile settings to files based upon user requirements, independent of connectivity to control.
- 6.5.4. Save only system configuration settings to files based upon user requirements, independent of connectivity to control.
- 6.5.5. Create boolean logic, using system boolean values, Contact I/O module inputs, binary communication points, and front panel button presses as inputs, to drive Contact I/O module contacts.
- 6.5.6. Create boolean logic, using system boolean values, Contact I/O module inputs, and binary communication points, and front panel button presses as inputs, to drive SCADA readable, binary communication points.
- 6.5.7. Create boolean logic, using system boolean values, Contact I/O module inputs, binary communication points, and front panel button presses as inputs, to set boolean protection profile settings.
- 6.5.8. Create boolean logic, using system boolean values, Contact I/O module inputs, binary communication points, and front panel button presses as inputs, to change the default functionality of front panel LEDs.

7. Protection

- 7.1. **Protection Profiles:** Two protection profiles shall be provided, each capable of fully specifying the operation of the control.
 - 7.1.1. The protection profile shall be selectable from the front-panel push-button overlays, through the interface software, via the human-machine interface (HMI), through SCADA communications, or through configurable logic.
 - 7.1.2. Each protection profile shall include the following at a minimum:
 - Overcurrent protection
 - Over and Undervoltage protection
 - Over and Underfrequency protection
 - Sync Check
 - Sensitive Earth Fault Protection
 - Operation Settings
- 7.2. **Overcurrent Protection/Time-Current Curves (TCC):** The overcurrent protection feature shall allow the user to program the control with the settings associated with the phase and ground overcurrent elements that are common to all TCC elements (TCC1, TCC2, TCC3, TCC4).
 - 7.2.1. Time-current curves shall be available for fast and delayed operations.
 - 7.2.2. Each time-current curve shall be selectable from 54 standard curves and 5 user curves which can be further customized by the user.
 - 7.2.3. The time-current curves shall also be selectable from a graphical TCC editor to visualize any modifications prior to configuring the control (see Sec. 7.3 Time-Current Curve Editor).
 - 7.2.4. The time-current curves shall include the following modifications for phase and ground protection:
 - Time Multiplier with a range of 0.1 to 25.
 - Time Adder with a range of 0 to 30 seconds.

- Minimum Response Time with a range of 0.01 to 1.0 seconds.
 - High Current Trip (HCT) with a range of 1 to 32 multiples of minimum trip.
 - HCT Time Delay with a range of 0.01 to 0.150 seconds.
 - Reset coefficient with a range of 0.000001 to 30.0.
- 7.3. **Time-Current Curve Editor:** Coordination and actual time-current modifications shall be available with a graphic interactive Time-Current Curve Editor.
- 7.3.1. The Time-Current Curve Editor shall include a complete database of standard industry recloser time-current curves (TCC), both ANSI and IEC types, along with the ability to customize the TCCs with multipliers, constant time adders, or minimum response time adders.
- 7.3.2. The user shall be able to derive their own specific TCC through data point entry. Five custom curves shall be programmable.
- 7.3.3. Each modified time-current curve shall be able to be identified with a user-customized name and shall be selectable for configuring the control.
- 7.3.4. The grid and format for presenting TCCs shall have a user-adjustable scale, including the option of presenting multiple TCCs in various user-configured colors.
- 7.4. **Sensitive Earth Fault Protection:** The control shall include a Sensitive Earth Fault (SEF) Trip feature that will provide tripping of the recloser for ground currents below normal ground minimum trip levels.
- 7.4.1. The SEF feature shall have programmable operations to lockout and reclose intervals independent of the ground settings.
- 7.4.2. The SEF feature shall be independently selectable for each protection profile.
- 7.5. **High Current Lockout:** The control shall include a High Current Lockout (HCL) feature that will automatically lockout the control when current exceeds a programmable level.
- 7.5.1. The active shot numbers for the lockout shall be selectable for phase and ground.
- 7.5.2. Direct Current values, not multiples of minimum trip, shall be provided.
- 7.5.3. The HCL feature shall be independently selectable for each protection profile.
- 7.6. **Cold Load Pickup:** The control shall include a Cold Load Pickup (CLPU) feature to prevent the control from tripping due to short-term increases in current caused by loss of normal load diversity or feeder inrush.
- 7.6.1. The CLPU settings shall be active for a specific time as determined by the Activation Time setting, after both of the following have occurred:
- 7.6.1.1. The recloser was open and locked out longer than a user-defined period of time (CLPU minimum recloser open time).
- 7.6.1.2. One of the following Close conditions:
- Manual Close initiated via the front panel Close pushbutton
 - Assertion of a Close contact input
 - Supervisory Close command (SCADA or Remote)
- 7.6.2. The CLPU feature shall inhibit 'normal' overcurrent protection during the CLPU active time.
- 7.6.3. The CLPU feature shall have a separate, group-independent Phase and Ground minimum trip, reclose interval, and number of operations to lockout elements.

- 7.6.4. The CLPU TCC curve collection shall be the same as the Overcurrent TCC curves.
- 7.7. **Hot Line Tag:** The control shall include a Hot Line Tag (HLT) feature to block all electronic Close operations (local or remote) for live-line work.
- 7.7.1. When activated the HLT feature shall only be capable of being deactivated from the source that activated HLT. Multiple sources may activate HLT. Each source that activates HLT must individually disable HLT.
- 7.7.2. The control shall trip on one operation-to-lockout on the composite curve of the HLT definite time and the TCC1 curve (whichever is faster) when HLT is active.
- 7.7.3. The HLT time delay shall be independently selectable for each protection profile.
- 7.8. **Fast Trips Disabled:** The control shall include a Fast Trips Disabled (FTD) feature to ignore the normal TCCs and number of trips and instead use the FTD settings when FTD is active.
- 7.8.1. FTD shall have its own set of TCCs and number of trips.
- 7.8.2. There shall be separate FTD settings for phase and ground.
- 7.8.3. The FTD feature shall be independently selectable for each protection profile.
- 7.9. **Sequence Precedence:** The control shall include a selection for phase or ground precedence.
- 7.9.1. When the control is set for phase precedence and the fault current is above both phase and ground pickup levels with both phase and ground tripping enabled, the sequence will use the phase shots-to-lockout setting.
- 7.9.2. When the control is set for ground precedence and the fault current is above both phase and ground pickup levels with both phase and ground tripping enabled, the sequence will use the ground shots-to-lockout setting.
- 7.10. **Over/Undervoltage Protection:** The control shall include three levels each of over- and undervoltage protection and shall include single-phase and three-phase tripping for both over- and undervoltage conditions.
- 7.10.1. A fixed time delay ranging from 0 to 3600 seconds shall be available for both over- and undervoltage protection.
- 7.10.2. Both the over- and undervoltage functions shall include a voltage pickup and time delay.
- 7.10.3. One level of overvoltage alarm and one level of undervoltage alarm shall be provided for each bushing.
- 7.10.4. Voltage protection shall be included as part of each protection profile.
- 7.10.5. A voltage restoration function, enabled or disabled by the user, shall be provided to allow the recloser to automatically close should voltage return to within configured settings for a user-settable time.
- 7.11. **Over/Underfrequency Protection:** The control shall include six levels of frequency protection. Each level shall be configurable as either overfrequency or underfrequency.
- 7.11.1. A fixed time delay ranging from 0 to 3600 seconds shall be available for both over- and underfrequency protection.

7.11.2. A frequency restoration function, enabled or disabled by the user, shall be provided to allow the recloser to automatically close should frequency return to within configured settings for a user-settable time.

7.11.3. Over- and underfrequency protection shall be included as part of each protection profile.

7.12. **Sync Check:** The control shall include sync check functionality.

7.12.1. Sync Check functionality shall include the following applications:

- Hot Line/Hot Bus Closing
- Dead Line/Hot Bus Closing
- Hot Line/Dead Bus Closing
- Dead Line/Dead Bus Closing

7.12.2. Sync Check parameters shall include the following configurable settings:

- Voltage Angle
- Mechanism Operating Delay
- Static Angle Delay
- Dead Threshold
- Live Threshold
- Upper Voltage Limit
- Lower Voltage Limit
- Upper Frequency Limit
- Lower Frequency Limit
- Fail-to-Close Timer

7.13. **Sequence Coordination:** The control shall include a Sequence Coordination feature which will allow the control to step through selected operations in the operating sequence without tripping.

7.13.1. The number of Sequence Coordination advances is programmable from one to three operations to provide trip coordination with a downline recloser.

7.13.2. The Sequence Coordination feature shall be independently selectable for each protection profile.

8. Metering

8.1. The control shall provide instantaneous, demand and energy metering.

8.2. The control shall provide the following metering values:

- Real and reactive power for each phase and total, including directional, on an individual basis.
- Demand currents on a per phase basis.
- Instantaneous currents, including ground current.
- Instantaneous voltage on a per phase basis.
- Instantaneous frequency.
- Positive, negative, and zero sequence voltages.
- Harmonics on a per phase basis for voltage and current.
- Instantaneous power factor on a per phase basis.
- Metering settings to include demand interval, and alarm thresholds for current, single-phase kW, three-phase kW, single-phase kVAR, and three-phase kVAR.
- Sync Phase Angle Difference.

8.3. An on-board Data Profiler shall be provided to record user-configured values (see Sect. 9.4).

9. Diagnostics

- 9.1. The control shall have Diagnostic information stored in non-volatile memory and shall be available from the front panel or remotely.
- 9.2. **Apparatus Wear Monitor:** The control shall be equipped with an Apparatus wear Monitor system to monitor the lifetime of the recloser mechanism.
 - 9.2.1. The Apparatus Wear Monitor will record how many times the recloser has been opened as well as keep track of the current interrupted in percentage compared to preset total Duty Cycle Factor.
 - 9.2.2. The Apparatus Wear Monitor shall permit programmable entries to preset the duty of an existing recloser.
- 9.3. **Sequence of Events Recorder:** The control shall be equipped with a Sequence of Events (SOE) recorder that will capture discrete events such as recloser Open/Close status changes, faults, mechanism failures, and system-oriented events, such as setting the control time.
 - 9.3.1. The SOE recorder shall place an accurate time stamp and analog information on events and store them in non-volatile memory.
 - 9.3.2. The SOE recorder shall maintain a minimum of 1000 events.
 - 9.3.3. The SOE recorder shall be capable of recording up to 116 event types, some of which shall include:
 - Overcurrent trip
 - Control trip
 - Non-reclose ON/OFF
 - External Alarm
 - Control Lockout
 - Sequence Reset
 - 9.3.4. The SOE recorder information shall allow for exporting to a CSV file by **ProView NXG** software.
- 9.4. **Data Profiler:** The control shall include a Data Profiler that shall record configurable analog data for a specific period of time and store them in volatile memory.
 - 9.4.1. The Data Profiler shall be configured to allow periodic recording with ranges from 1 minute to 24 hours for all selected parameters.
 - 9.4.2. The number of data samples that can be retained shall be dependent upon the number of profile data selected, the sample rate, and duration.
 - 9.4.3. At least 60 days of data shall be saved if 10 analog data points are selected and being continuously recorded with an interval of 15 minutes.
 - 9.4.4. The Data Profiler shall present the data in table form and allow exporting to a CSV file.

10. Communications

- 10.1. The control shall support the following digital communications protocols options in the control to interface with locally connected and remote systems:
 - Serial DNP3
 - Serial IEC 60870-5-101
 - Network DNP3
 - Network IEC 60870-5-104
- 10.2. The control shall support up to four optional Contact I/O modules.

- 10.2.1 Each Contact I/O Module shall contain four voltage driven inputs and four relay contact outputs.
- 10.2.2 The functionality of this I/O shall be assigned via configurable logic.
- 10.3 The control shall support the following communications protocols via add-on modules:
- IEC 61850
 - Modbus
 - 2179
- 10.4 The front panel shall include two (2) USB 2.0-compatible ports for local connection to the control.
- 10.4.1 One USB 2.0-compatible Device port shall be used for communications to a laptop or a PC.
- 10.4.2 One USB 2.0-compatible Host port shall be used to accommodate USB thumb drives and other USB-compatible hard drives that allow the user to upload settings directly to the control from the storage device.
- 10.4.3 All settings, real-time data, and archived data may be saved to a USB Flash drive via a front panel USB host connector.
- 10.4.4 All settings may be loaded from a USB Flash drive via a front panel USB host connector.
- 10.4.5 Communication settings (only) may be loaded from a USB Flash drive via a front panel USB host connector without affecting other settings.
- 10.4.6 Configurable Logic settings (only) may be loaded from a USB Flash drive via a front panel USB host connector without affecting other settings.
- 10.4.7 Protection Profile settings (only) may be loaded from a USB Flash drive via a front panel USB host connector without affecting other settings.
- 10.4.8 System Configuration settings (only) may be loaded from a USB Flash drive via a front panel USB host connector without affecting other settings.
- 10.5 The control shall provide for up to two remote communications interface cards that have a combination of the following media connections:
- RS-232
 - RS-485
 - Serial fiber optic with ST connectors
 - 10/100BASE T Ethernet with RJ45 connector
 - 10/100BASE F Single mode fiber Ethernet with dual LC connectors
 - 100BASE F fiber Ethernet with ST connectors
 - 100BASE F fiber Ethernet with SC connectors
 - Short-range wireless (802.11)
 - GSM Modem
- 10.6 The communications interface cards shall be accessible through the module side cover when the swing panel is open and have provisions to accept an add-on module to support communication features that are not provided natively by the control.

11 Control Security

- 11.1 The control shall have a customer-programmable security code to limit access of control programming and viewing functions to authorized personnel.

11.2 There shall be a connection password when communicating between the control and a computer.