

Appendix D

Electrical Metering Equipment and Sensors

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D.1 Controllable Electrical Panel

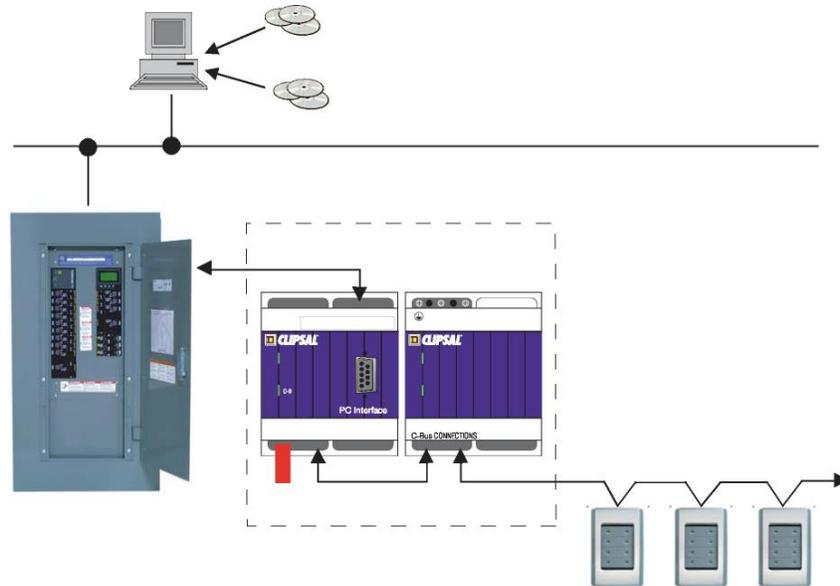


Figure D.1. Square D Power Link Electrical Panel

D.1.1 Schneider Electric/Square D Power Link G3 Control System

The Square D Powerlink G3 offers programmable and controllable breakers affording the ability to schedule on/off events at 1 minute resolution intervals.

D.1.1.1 Specifications

Square D Powerlink G3 Controllers accept commands from both dry-contact inputs and serial communications. Typical control devices include low-voltage pushbutton wall switches, occupancy sensors, photo sensors, card access, and building automation systems.

Terminals on the controller allow connection to external control devices. The 500-level controllers can accept up to eight separate control inputs, while the 1000-, 2000-, and 3000-level controllers can accommodate either eight 3-wire or sixteen 2-wire inputs. All controllers provide 24 Vdc control power [National Electric Code (NEC) Class 2] for sensing input contact status. Input types include:

- maintained NO (normally open with or without blink)
- maintained NC (normally closed with or without blink)
- momentary toggle/maintained toggle
- momentary on/momentary OFF
- dual momentary

Other features and specifications include:

- Controller inputs can be configured for status feedback to operate pilot lights or actuate other control equipment. A total maximum current of 60 mA at 24 Vdc is available to eight status outputs.
- Input timers, with settings from 1 second to 18 hours, can also be incorporated into the input configuration to provide timed override control
- Combines the control, input, and scheduling features of the other systems with the added benefit of embedded Ethernet connectivity.
- Provides control capabilities and communication with a true peer-to-peer (P2P) control network to allow different controllers to share input signals, schedules, and lighting zone states.
- Ethernet connectivity reduces network installation costs and enhances reliability by eliminating the need for a dedicated lighting control network.
- Ethernet infrastructure can also be more cost effective: it uses commonly available off-the-shelf components rather than manufacturer-specific proprietary components.
- Enhanced system reliability: local IT staff can quickly diagnose and resolve most problems associated with the network infrastructure.
- Web-enabled benefits include: ability to override zones, change schedules, and view system status from the convenience of a standard web-browser.

D.2 Metering Data Logger



Figure D.2. Campbell CR 1000

D.2.1 Campbell CR 1000 Specifications and Features

- 4 Mbyte memory
- Program execution rate of up to 100 Hz
- CS input/output (I/O) and RS-232 serial ports
- 13-bit analog-to-digital conversions

- 16-bit H8S Renesas Microcontroller with 32-bit internal central processing unit (CPU) architecture
- Temperature-compensated real-time clock
- Background system calibration for accurate measurements over time and temperature changes
- Single DAC used for excitation and measurements to give ratio for metric measurements
- Gas discharge tube protected inputs
- Data values stored in tables with a time stamp and record number
- Battery-backed static random access memory (SRAM) and clock ensuring data, programs, and accurate time are maintained while the CR1000 is disconnected from its main power source
- Serial communications with serial sensors and devices supported via I/O port pairs
- PakBus®, Modbus, Distributed Network Protocol 3 (DNP3), Transmission Control Protocol/Internet Protocol (TCP/IP), FTP, and Simple Mail Transfer Protocol (SMTP) protocols supported

D.2.1.1 Communications Protocols

The CR1000 supports the PakBus, Modbus, DNP3, TCP/IP, FTP, and SMTP communication protocols. With the PakBus protocol, networks have the distributed routing intelligence to continually evaluate links. Continually evaluating links optimizes delivery times and, in the case of delivery failure, allows automatic switch over to a configured backup route.

The Modbus remote terminal unit (RTU) protocol supports both floating point and long formats. The data logger can act as a slave and/or master.

The DNP3 protocol supports only long data formats. The data loggers are level 2 slave compliant, with some of the operations found in a level 3 implementation.

The TCP/IP, FTP, and SMTP protocols provide TCP/IP functionality when the CR1000 is used in conjunction with an NL115, NL120, or third party serial internet protocol (IP) device.

D.3 Temperature Multiplexer



Figure D.3. Campbell AM25T/1632B Multiplexer

Multiplexers increase the number of sensors that can be measured by a CR1000 by sequentially connecting each sensor to the data logger. Several multiplexers can be controlled by a single CR1000.

Depending on sensor type, the AM16/32B can multiplex 16, 32, or 48 sensors. Up to six AM16/32Bs may be connected to the same datalogger, depending on the number of control ports and analog inputs available.

The AM16/32B either multiplexes 16 groups of four lines (a total of 64 lines) through four common (COM) terminals, or multiplexes 32 groups of two lines (also a total of 64 lines) through two COM terminals. A cable connects the common terminals to datalogger analog inputs, excitation channels, or ground as required by the sensor. The datalogger controls the multiplexer using two control ports or one control port and one excitation channel.

D.3.1 AM16/32B Specifications

- Power: 9.6 to 16 Vdc (under load)
- Scan Advance: Occurs on the leading edge of the clock pulse transition (from below 1.5 V to above 3.3 V)
- Minimum Clock Pulse Width: 1 ms
- Maximum Actuation Time for Relay: 20 ms
- Relay Operation: break before make
- Initial Relay Resistance, Closed: 0.1 Ohm
- Maximum Switching Voltage: 50 Vdc. *A voltage divider such as the VDIV10:1 may be needed between the AM16/32B and the datalogger to stay within the input limits of the datalogger channel.*
- Maximum Switching Current: 500 mA. *Switching currents greater than 30 mA (occasional 50 mA acceptable) degrade the suitability of that channel for switching low-voltage signals.*
- Minimum Contact Life: 10^7 closures
- CE Compliance: EN 61326: 1998 EN 55022: 1998 Class B
- Surge: Complies with IEC 61000-4-5, test level 3 (± 2 kV, 2 ohms coupling impedance)
- CE Compliant
- Weight: 680 g (1.5 lb)

D.4 Weather Station



Figure D.4. Campbell WXT520 Weather Station

The WXT520 is a solid-state, all-in-one weather instrument that measures wind speed and direction, precipitation, barometric pressure, temperature, and relative humidity. Its small size makes it ideal for quick, short-term deployments. However, the WXT520 is not intended for weather stations that require research-grade performance.

D.4.1 Specifications

- Electromagnetic Compatibility (EMC): Complies with EMC standard EN61326-1
- International Electrotechnical Commission (IEC) Standards: IEC 60945/61000-4-4, IEC 60945/61000-4-2
- Input Voltage: 5 to 30 Vdc (below 5.3 V the measurement performance for high wind speeds may be degraded)
- Typical Current Drain @ 12 Vdc: 0.1 mA [Serial Data Interface at 1200 Baud (SDI-12) standby]; 3 mA (Default Measuring Intervals)
- Output: SDI-12
- Operating Temperature: -52° to $+60^{\circ}\text{C}$
- Storage Temperature: -60° to $+70^{\circ}\text{C}$
- Operating Relative Humidity: 0 to 100% RH
- Height: 23.8 cm (9.38 in)
- Diameter: 11.5 cm (4.52 in)
- Weight: 650 g (1.43 lb)

D.4.2 Air Temperature

Measurement Range: -52° to $+60^{\circ}\text{C}$

Accuracy: $\pm 0.3^{\circ}\text{C}$ @ $+20^{\circ}\text{C}$

Output Resolution: 0.1°C

D.4.3 Barometric Pressure

Measurement Range: 600 to 1100 hPa

Accuracy:

± 0.5 hPa @ 0° to 30°C ;

± 1 hPa @ -52° to $+60^{\circ}\text{C}$

Output Resolution: 0.1 hPa

D.4.4 Relative Humidity

Measurement Range: 0 to 100% RH

Accuracy:

$\pm 3\%$ RH @ 0 to 90% RH;

$\pm 5\%$ RH @ 90 to 100% RH

Output Resolution: 0.1% RH

D.4.5 Wind Speed

Measurement Range:

0 to 60 m s^{-1}

Response Time: 0.25 s

Accuracy: $\pm 0.3\text{ m s}^{-1}$ or $\pm 3\%$, whichever is greater (0 to 35 m s^{-1});

$\pm 5\%$ (36 to 60 m s^{-1})

D.4.6 Wind Direction

Measurement Range: 0° to 360°

Response Time: 0.25 s

Accuracy: $\pm 3^{\circ}$

Output Resolution: 1°

D.4.7 Precipitation

Rainfall Measurement: cumulative accumulation after latest automatic or manual reset

Collecting Area: 60 cm^2

Output Resolution: 0.01 mm (0.001 in)

Field Accuracy for Daily Accumulation: better than 5% (weather dependent; does not include possible wind induced error)

Rain Duration: Counting each 10-s increment whenever droplet detected

Rain Intensity: 1-min. running average in 10-s steps

Rain Intensity Range: 0 to 200 mm hr⁻¹ (broader range possible with reduced accuracy)

D.5 Pyranometer



Figure D.5. Campbell Scientific LP02 Blackened Thermopile Pyranometer

D.5.1 Technical Description

The LP02 measures solar radiation with a high-quality blackened thermopile protected by a dome. The blackened thermopile provides a flat spectral response for the full solar spectrum range, which enables the LP02 to be used under plant canopies or lamps, when the sky is cloudy, and for reflected radiation measurements.

The LP02 includes a bubble level, three adjusting screws, and a cable gland. The bubble level and adjusting screws allow the sensor to be leveled without using a leveling base. The gland facilitates cable replacement.

The LP02 produces a millivolt signal that is measured directly by a Campbell Scientific datalogger.

Two LP02 pyranometers can be mounted back-to-back to make a low-cost albedometer; contact Campbell Scientific for more information.

D.5.2 LP02-L Specifications

- Light Spectrum Waveband: 305 to 2800 nm
- Maximum Irradiance: 2000 W/m²
- Sensitivity: 15 μ V/W/m²
- Operating Temperature: -40° to +80°C
- Temperature Dependence: < 0.15%/°C

- International Standards Organization (ISO) Classification: Second Class
- Width: 7.8 cm (3.1 in.)
- Height: 5.9 cm (2.3 in.)
- Dome Diameter: 3.0 cm (1.2 in.)
- Weight with 15 ft cable: 363 g (0.8 lb)

D.6 Mean Radiant Temperature (Black Globe) Sensor



Figure D.1. Campbell Scientific Black Globe Temperature Sensor

The Black Globe temperature sensor uses a thermistor inside a 6-in. hollow black copper sphere to measure radiant temperature.

D.6.1 Specifications:

Temperature measurement range:	-5° to +95°C
Temperature Survival Range:	-50° to +100°C
Thermistor Interchangeability Error:	Typically $<\pm 0.2^{\circ}\text{C}$ over 0°C to 70°C and ± 0.3 @ 95°C
Polynomial Linearization Error:	$\pm 0.5^{\circ}\text{C}$ over -7°C to +90°C

D.7 Thermocouples

D.7.1 Space Temperature: Omega TMQSS-062U-2 Copper-[Constantan](#) (Type T) Thermocouple



Figure D.2. Space Temperature: Omega TMQSS-062U-2 Copper-[Constantan](#) (Type T) Thermocouple

D.7.1.1 Specifications:

- Maximum temperature range:
 - Thermocouple Grade
 - – 328 to 662°F
 - – 200 to 350°C
 - Extension Grade
 - – 76 to 212°F
 - – 60 to 100°C
 - Limits of error
 - Standard: 1.0°C or 0.75% above 0°C, 1.0°C or 1.5% Below 0°C
 - Special: 0.5°C or 0.4%

D.7.2 Surface Temperature: Omega S2C-T-120 Copper-[Constantan](#) (Type T) Thermocouple

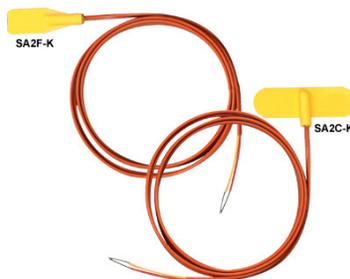


Figure D.3. Surface Temperature: Omega S2C-T-120 Copper-Constantan (Type T) Thermocouple

D.7.2.1 Specifications:

- Ultra-Slim Silicone Rubber for Maximum Flexibility
- Self-Adhesive Foil Backing for Faster Response Time
- Two Styles Available for Flat or Curved Surfaces
- Resistant to a Variety of Chemicals and Oils
- Temperature Range: -50 to 200°C (-58 to 392°F)
- Available in J, K, T and E—Color Coded for Instant Thermocouple Recognition
- 24 American wire gauge (AWG) Stranded Thermocouple-Grade Lead Wire
- Limits of error
 - Standard: 1.0°C or 0.75% above 0°C 1.0°C or 1.5% Below 0°C
 - Special: 0.5°C or 0.4%

D.8 Relative Humidity Sensors



Figure D.4. Campbell Scientific Relative Humidity Sensor

D.8.1 Specifications:

Campbell Scientific Europe's CS215 temp & RH sensor uses a Swiss manufactured digital humidity and temperature element which provides excellent measurement accuracy and reliability.

- Relative Humidity
 - Measurement Range: 0 to 100% RH (-20° to $+60^{\circ}\text{C}$)
 - Accuracy (at 25°C): $\pm 2\%$ (10–90% range), $\pm 4\%$ (0–100% range)
- Temperature
 - Measurement Range: -40°C to $+70^{\circ}\text{C}$
 - Accuracy: $\pm 0.4^{\circ}\text{C}$ ($+5^{\circ}$ to $+40^{\circ}\text{C}$), $\pm 0.9^{\circ}\text{C}$ (-40°C to $+70^{\circ}\text{C}$)
- General
 - Weight: 150 g (w/3 m cable); 5.3 oz (w/10 ft cable)
 - Diameter: 1.2cm (0.5") at sensor tip, 1.8cm (0.7") at cable end