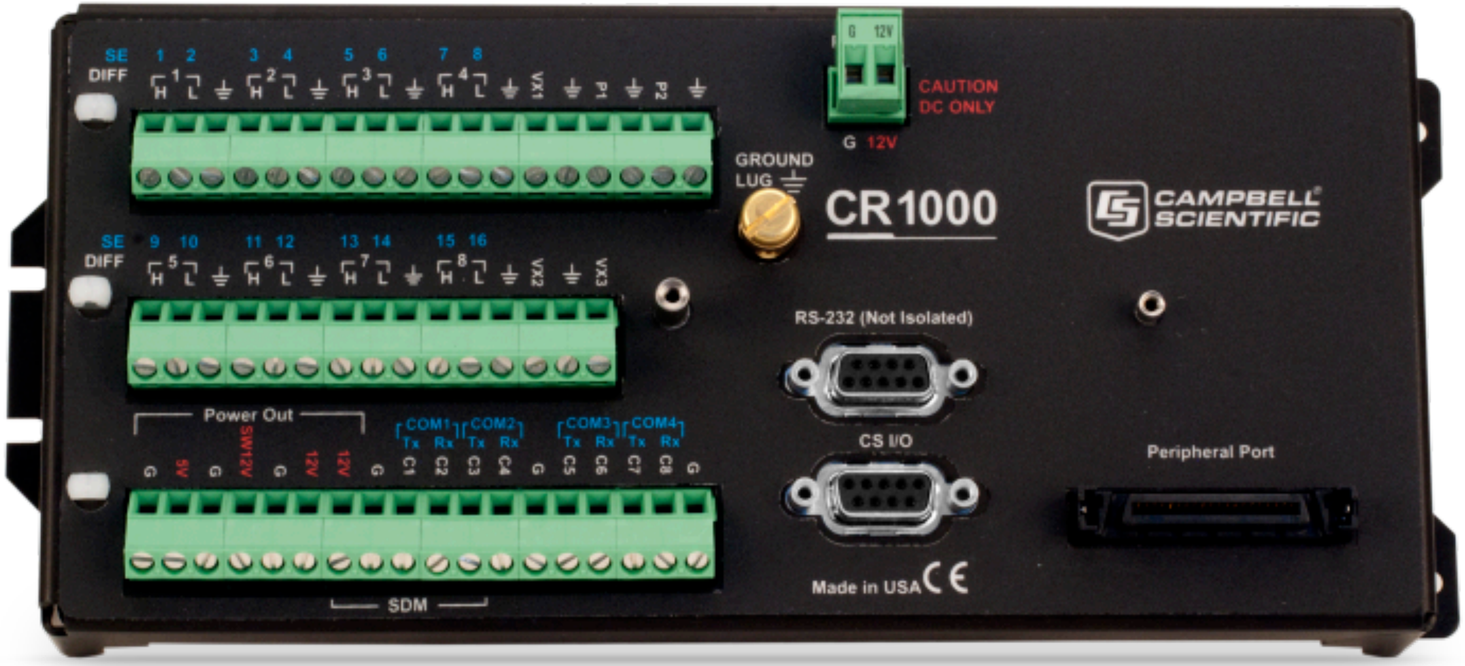
Introduction to the Campbell Scientific CR1000 Datalogger



Campbell Scientific CR1000 Datalogger

- a rugged “computer” mounted in a sealed can with integrated wiring panel
- runs an Operating System (OS) and compiler
  - **OS:** software that supports computer’s basic functions such as application execution, task scheduling, & peripheral control
  - **Compiler:** translates code from a high-level programming language to machine code (0’s & 1’s)
- OS is specific to datalogger model; version is updated regularly

Campbell Scientific CR1000 Datalogger

- a programmable **voltmeter** – an instrument used for measuring electrical potential difference between two points in an electric circuit
- measures almost any sensor with an electrical response
- converts electrical signals into engineering units
- performs calculations

CSI CR1000 Datalogger: Specifications

- Datalogger power supply: 9.6 – 16vdc
- Sensor input voltage ranges vary depending on sensor type
- Wide temperature range:
  - Standard: -25°C to +50°C
  - Extended: -55°C to +85°C
- Lithium battery-backed clock, program, & memory
- Clock accuracy: ±3 min/year

-25° to +50°C, non-condensing environment, unless otherwise specified. Recalibration recommended every three
em configuration should be confirmed with Campbell Scientific before purchase.

6 or DIFF1-DIFF8)
ended (SE) individually config-
expansion provided by optional

ION: Basic resolution (Basic Res)
a single A/D conversion. A DF mea-
versal has better (finer) resolution than

	DF Res (μV)[2]	Basic Res (μV)
	667	1333
	333	667
	33.3	66.7
	3.33	6.7
.5	1.0	2.0
±2.5	0.33	0.67

Range overhead of ~9% on all ranges guarantees that full-scale values will not cause over range.
[2]Resolution of DF measurements with input reversal.

URACY[3]:
0.06% of reading + offset), 0° to 40°C
0.12% of reading + offset), -25° to 50°C
0.18% of reading + offset), -55° to 85°C (-XT option only)
ccuracy does not include the sensor and measurement noise. Offsets are defined as:
Offset for DF w/input reversal = 1.5·Basic Res + 1.0 μV
Offset for DF w/o input reversal = 3·Basic Res + 2.0 μV
Offset for SE = 3·Basic Res + 3.0 μV

NALOG MEASUREMENT SPEED:

Integration Type/Code	Integration Time	Settling Time	Total Time[4] SE w/ No Rev	Total Time[4] DF w/ Input Rev
250	250 μs	3 ms	~1 ms	~12 ms
60 Hz[5]	16.67 ms	3 ms	~20 ms	~40 ms
50 Hz[5]	20.00 ms	3 ms	~25 ms	~50 ms

[4]Includes 250 μs for conversion to engineering units.
[5]AC line noise filter.

NOISE VOLTAGE: For DF measurements with input rsal on ±2.5 mV input range (digital resolution dominates gher ranges).
s Integration: 0.34 μV RMS
Hz Integration: 0.19 μV RMS
LIMITS: ±5 Vdc
MMON MODE REJECTION: >100 dB
L MODE REJECTION: 70 dB @ 60 Hz when using rejection
OLTAGE RANGE W/O MEASUREMENT
PTION: ±8.6 Vdc max.
D INPUT VOLTAGE W/O DAMAGE: ±16 Vdc max.
±6 nA max. @ 50°C;
JUNCTION
asurements):

VX FREQUENCY SWEEP FUNCTION: Switched outputs provide a programmable swept frequency, 0 to 2500 mv square waves for exciting vibrating wire transducers.

PERIOD AVERAGE
Any of the 16 SE analog inputs can be used for period averaging. Accuracy is ±(0.01% of reading + resolution), where resolution is 136 ns divided by the specified number of cycles to be measured.
INPUT AMPLITUDE AND FREQUENCY:

Voltage Gain	Input Range (±mV)	Signal (peak to peak) Min. (mV)[6]	Signal (peak to peak) Max (V)[7]	Min Pulse Width (μV)	Max[8] Freq (kHz)
1	250	500	10	2.5	200
10	25	10	2	10	50
33	7.5	5	2	62	8
100	2.5	2	2	100	5

[6]Signal centered around Threshold (see PeriodAvg() instruction).
[7]With signal centered at the datalogger ground.
[8]The maximum frequency = 1/(twice minimum pulse width) for 50% of duty cycle signals.

RATIOMETRIC MEASUREMENTS
MEASUREMENT TYPES: Provides ratiometric resistance measurements using voltage excitation. 3 switched voltage excitation outputs are available for measurement of 4- and 6-wire full bridges, and 2-, 3-, and 4-wire half bridges. Optional excitation polarity reversal minimizes dc errors.
RATIOMETRIC MEASUREMENT ACCURACY:[9,10,11]
±(0.04% of Voltage Measurement + Offset)
[9]Accuracy specification assumes excitation reversal for excitation voltages < 1000 mV. Assumption does not include bridge resistor errors and sensor and measurement noise.
[10]Estimated accuracy, ΔX (where X is value returned from the measurement with Multiplier = 1, Offset = 0):
BrHalf() instruction: $\Delta X = \Delta V_1/V_X$
BrFull() instruction $\Delta X = 1000 \cdot \Delta V_1/V_X$, expressed as $mV \cdot V^{-1}$.
ΔV^{-1} is calculated from the ratiometric measurement accuracy. See Resistance Measurements Section in the manual for more information.
[11]Offsets are defined as:
Offset for DIFF w/input reversal = 1.5·Basic Res + 1.0 μV
Offset for DIFF w/o input reversal = 3·Basic Res + 2.0 μV
Offset for SE = 3·Basic Res + 3.0 μV
Excitation reversal reduces offsets by a factor of two.

PULSE COUNTERS (P1-P2)
2 inputs individually selectable for switch closure, high frequency pulse, or low-level ac. Independent 24-bit counters for each input.
MAXIMUM COUNTS PER SCAN: 16.7×10^6
SWITCH CLOSURE MODE:
Minimum Switch Closed Time: 5 ms
Minimum Switch Open Time: 6 ms
Max. Bounce Time: 1 ms open w/o being counted
HIGH-FREQUENCY PULSE MODE:
Maximum Input Frequency: 250 kHz
Maximum Input Voltage: ±20 V
Voltage Thresholds: Count upon transition from below 0.9 V to above 2.2 V after input filter with 1.2 μs time constant.
LOW-LEVEL AC MODE: Internal ac coupling removes ac offsets up to ±0.5 Vdc.
Input Hysteresis: 12 mV RMS @ 1 Hz
Maximum ac Input Voltage: ±20 V
Minimum ac Input Voltage:

Sine Wave (mV RMS)	Range(Hz)
20	1.0 to 20
200	0.5 to 200
2000	0.3 to 10,000
5000	0.3 to 20,000

LOW FREQUENCY MODE MAX: <1 kHz
HIGH-FREQUENCY MODE MAX: 400 kHz
SWITCH-CLOSURE FREQUENCY MAX: 150 Hz
EDGE TIMING RESOLUTION: 540 ns
OUTPUT VOLTAGES (no load): high 5.0 V ±0.1 V; low <0.1
OUTPUT RESISTANCE: 330 Ω
INPUT STATE: high 3.8 to 16 V; low -8.0 to 1.2 V
INPUT HYSTERESIS: 1.4 V
INPUT RESISTANCE: 100 kΩ with inputs <6.2 Vdc
0.220 kΩ with inputs ≥6.2 Vdc
SERIAL DEVICE/RS-232 SUPPORT: 0 TO 5 Vdc UART

SWITCHED 12 VDC (SW-12)
1 independent 12 Vdc unregulated source is switched on and off under program control. Thermal fuse hold current = 900 mA at 20°C, 650 mA at 50°C, 360 mA at 85°C.

COMPLIANCE INFORMATION
VIEW EU DECLARATION OF CONFORMITY AT:
www.campbellsci.com/cr1000
www.campbellsci.com/cr1000kd

COMMUNICATIONS
RS-232 PORTS:
DCE 9-pin: (not electrically isolated) for computer connection or connection of modems not manufactured by Campbell Scientific.
COM1 to COM4: 4 independent Tx/Rx pairs on control ports (non-isolated); 0 to 5 Vdc UART
Baud Rates: selectable from 300 bps to 115.2 kbps.
Default Format: 8 data bits; 1 stop bits; no parity
Optional Formats: 7 data bits; 2 stop bits; odd, even parity
CS I/O PORT: Interface with telecommunications peripherals manufactured by Campbell Scientific.
SDI-12: Digital control ports C1, C3, C5, and C7 are individually configured and meet SDI-12 Standard v 1.3 for datalogger mode. Up to 10 SDI-12 sensors are supported per port.
PERIPHERAL PORT: 40-pin interface for attaching CompactFlash or Ethernet peripherals
PROTOCOLS SUPPORTED: PakBus, AES-128 Encrypted PakBus, Modbus, DNP3, FTP, HTTP, HTML, POP3, PPP, SMTP, Telnet, NTCIP, NTP, SDI-12, SDM, TLS.

SYSTEM
PROCESSOR: Renesas H8S 2322 (16-bit CPU with 32-bit internal core running at 7.3 MHz)
MEMORY: 2 MB of flash for operating system; 4 MB of battery-backed SRAM for CPU usage and final data storage; 512 kB flash disk (CPU) for program files.
REAL-TIME CLOCK ACCURACY: ±3 min. per year. Correction via GPS optional.
REAL-TIME CLOCK RESOLUTION: 10 ms

SYSTEM POWER REQUIREMENTS
VOLTAGE: 9.6 to 16 Vdc
INTERNAL BATTERIES: 1200 mAh lithium battery for clock and SRAM backup that typically provides three years of backup
EXTERNAL BATTERIES: Optional 12 Vdc nominal alkaline and rechargeable available. Power connection is reverse polarity protected.
TYPICAL CURRENT DRAIN at 12 Vdc:
Sleep Mode: < 1 mA
1 Hz Sample Rate (1 fast SE measurement): 1 mA
100 Hz Sample Rate (1 fast SE measurement): 16 mA
100 Hz Sample Rate (1 fast SE measurement w/RS-232 communication): 28 mA
Active external keyboard display adds 7 mA (100 mA with backlight on).

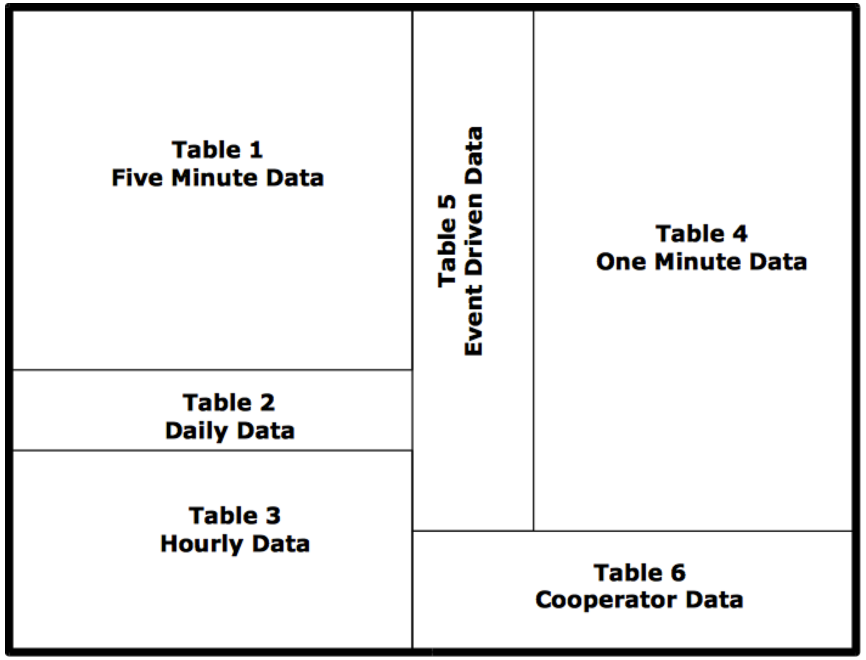
PHYSICAL
DIMENSIONS: 23.9 x 10.2 x 6.1 cm (9.4 x 4 x 2.4 in); additional clearance required for cables and leads.
MASS/WEIGHT: 1 kg / 2.1 lb

WARRANTY
3 years against defects in materials and

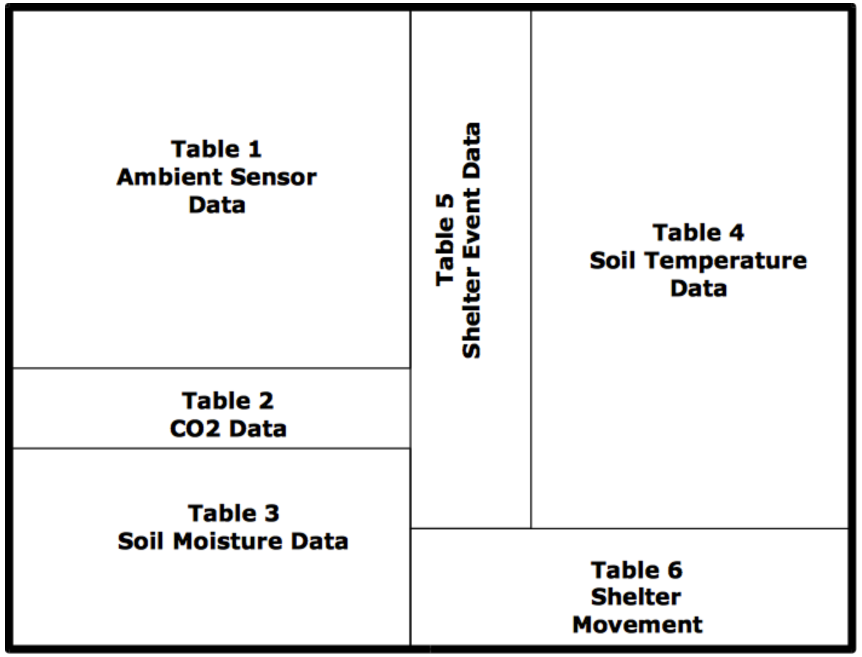
CSI CR1000 Datalogger: Memory

- Data stored in “table format”
- ~3.7 Mb available for data table storage

Example 1:



Example 2:

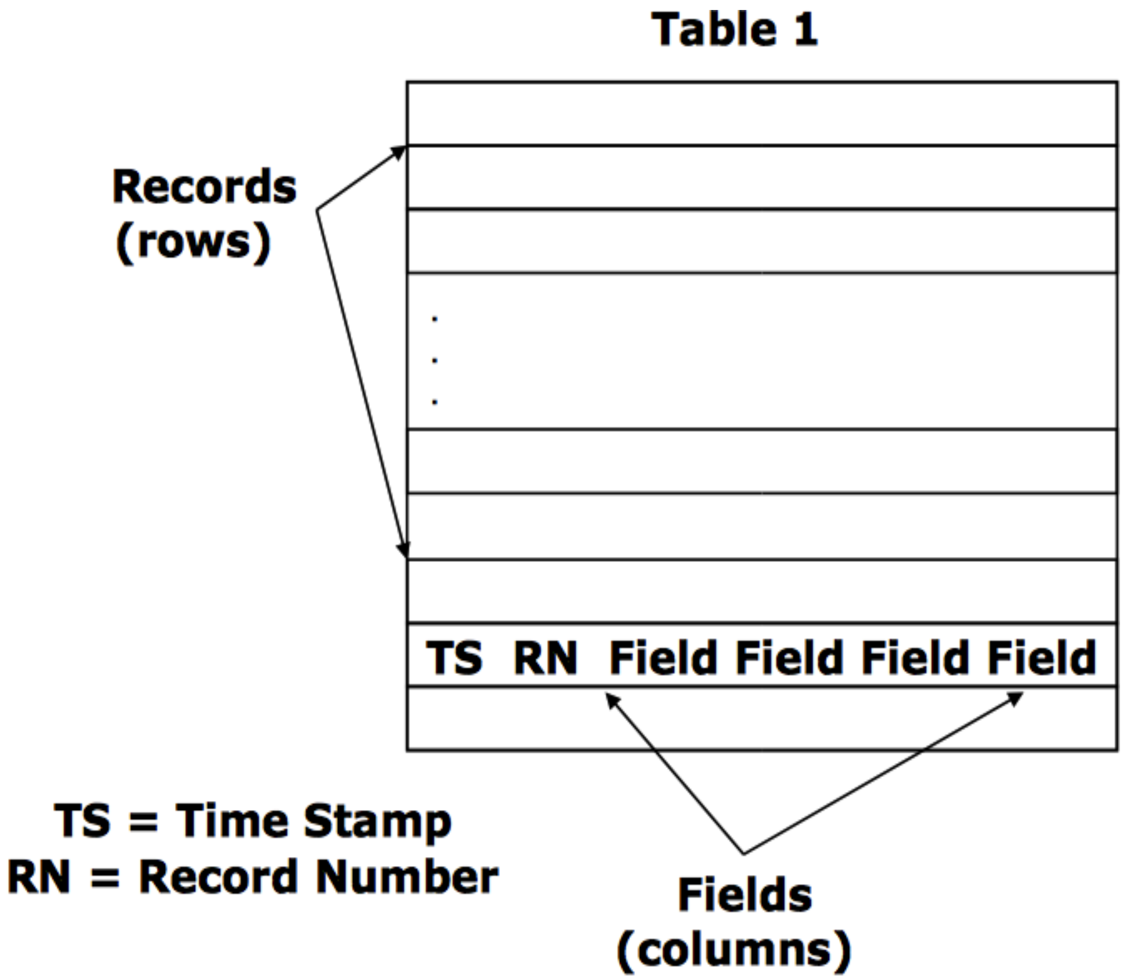


Data Tables

- Number, size, and update frequency of data tables defined by program
- Data tables can include fixed or averaged sensor values
  - Fixed: point-in-time (e.g. RH); total (e.g., rain gage)
- Table size can be auto allocated or fixed
- Data tables are erased when a new program is loaded
- ALWAYS DOWNLOAD DATA BEFORE LOADING A NEW PROGRAM!!

Data Table Structure

- Output formats
  - Ascii (*default*)
  - Binary (*often used with high frequency measurements, e.g., eddy covariance flux towers*)
- Comma separated values (csv)



Data File: <filename>.dat

- Hint: rename ".dat" files to ".csv" to open in Excel

```
"TOA5","CR1000_on_desk","CR1000","-1","0.0.15","CPU:EX2.CR1","29702","OneMin"
"TIMESTAMP","RECORD","AirTemp_C_Avg","AirTemp_C_Max","AirTemp_C_Min","Batt_Volt_Min"
"TS","RN","deg C","deg C","deg C","volts"
"","","Avg","Max","Min","Min"
"2004-05-04 07:28:00",0,24.01,24.02,24.01,13.19
"2004-05-04 07:29:00",1,23.99,24.01,23.97,13.19
"2004-05-04 07:30:00",2,23.96,23.97,23.95,13.19
```

The following is an example of how the above data might look when imported into a spreadsheet:

TOA5	CR1000_on desk	CR1000	1022	CR1000.Std .01	CPU:EX2.CR 1	27664	OneMin
TIMESTAMP	RECORD	AirTemp_C_ Avg	AirTemp_C_ Max	AirTemp_C_ Min	Batt_Volt_ Min		
TS	RN	deg C	deg C	deg C	volts		
		Avg	Max	Min	Min		
2004-05-04 07:28:00	0	24.01	24.02	24.01	13.19		
2004-05-04 07:29:00	1	23.99	24.01	23.97	13.19		
2004-05-04 07:30:00	2	23.96	23.97	23.95	13.19		

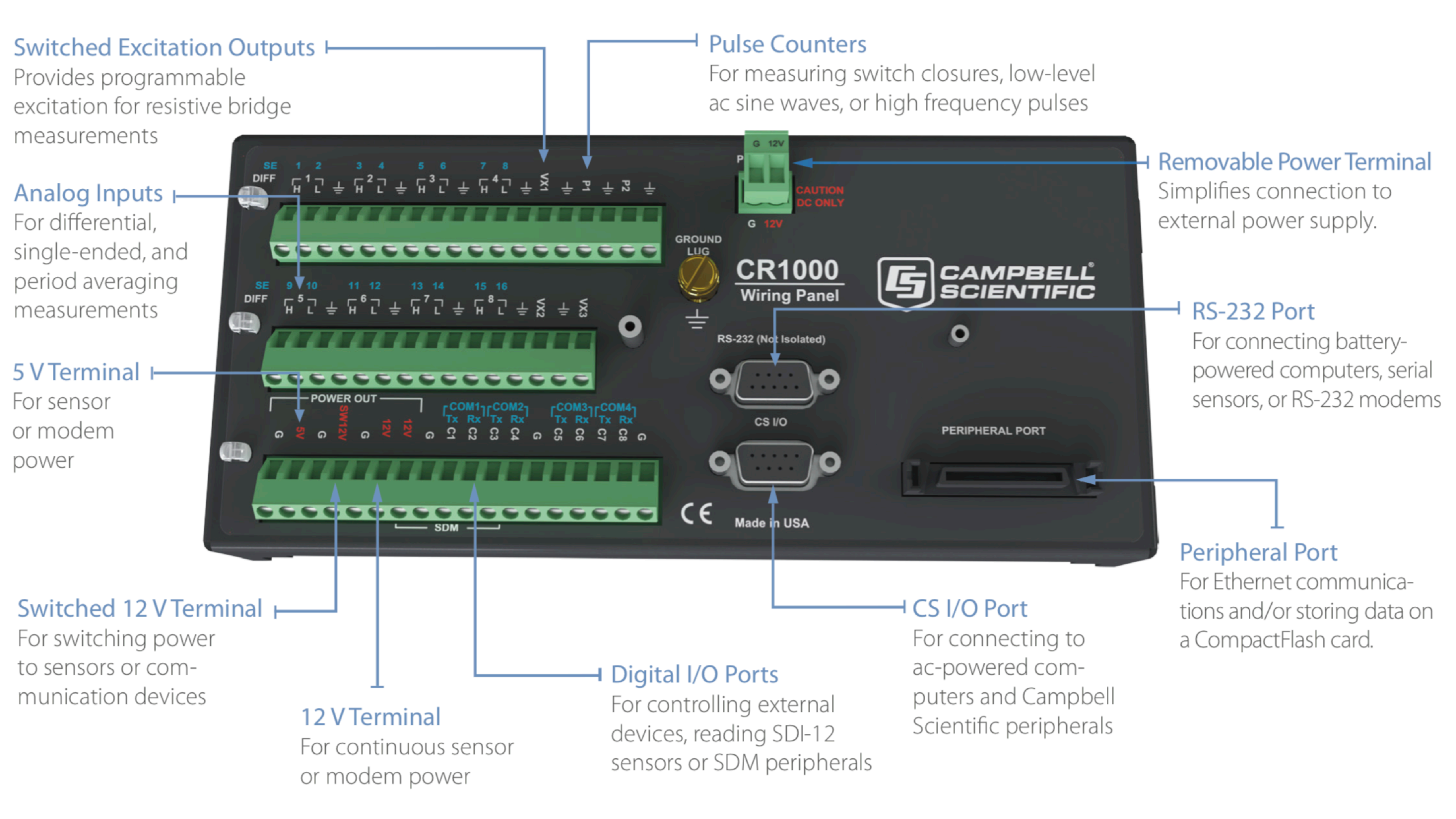
Default Data Tables

- **Status Table**: current system operating status information

- **Public Table**: current values for each public variable, updated at every program scan. *Good for troubleshooting!*

CR200X Numeric Display 1: Real Time Monitoring (Connected)

Public Table		Programmed Output	
RecNum	4288	RecNum	8668
TimeStamp	2019 18:09:18	TimeStamp	9/23/2019 18:00:00
batt	12.80144	batt_Min	12.80648
sondeDate	240919	sondeDate	240919
sondeTime	5718	sondeTime	5718
TempC	6.02	TempC	6.02
SpCond_uScm	15.78	SpCond_uScm	15.78
ODO_mgL	51.6	ODO_mgL	51.6
pH	20.7	pH	20.7
Turbidity	245.76	Turbidity	245.76
sondeVoltage	267.74	sondeVoltage	267.74
fDOM_RFU	0.13	fDOM_RFU	0.13
fDOM_QSU	7.38	fDOM_QSU	7.38
ODO_pctSat	82.35	ODO_pctSat	82.35
cond_uScm	-149.98	cond_uScm	-149.98
pH_mV	8.12	pH_mV	8.12
TDS_gL	0	TDS_gL	0

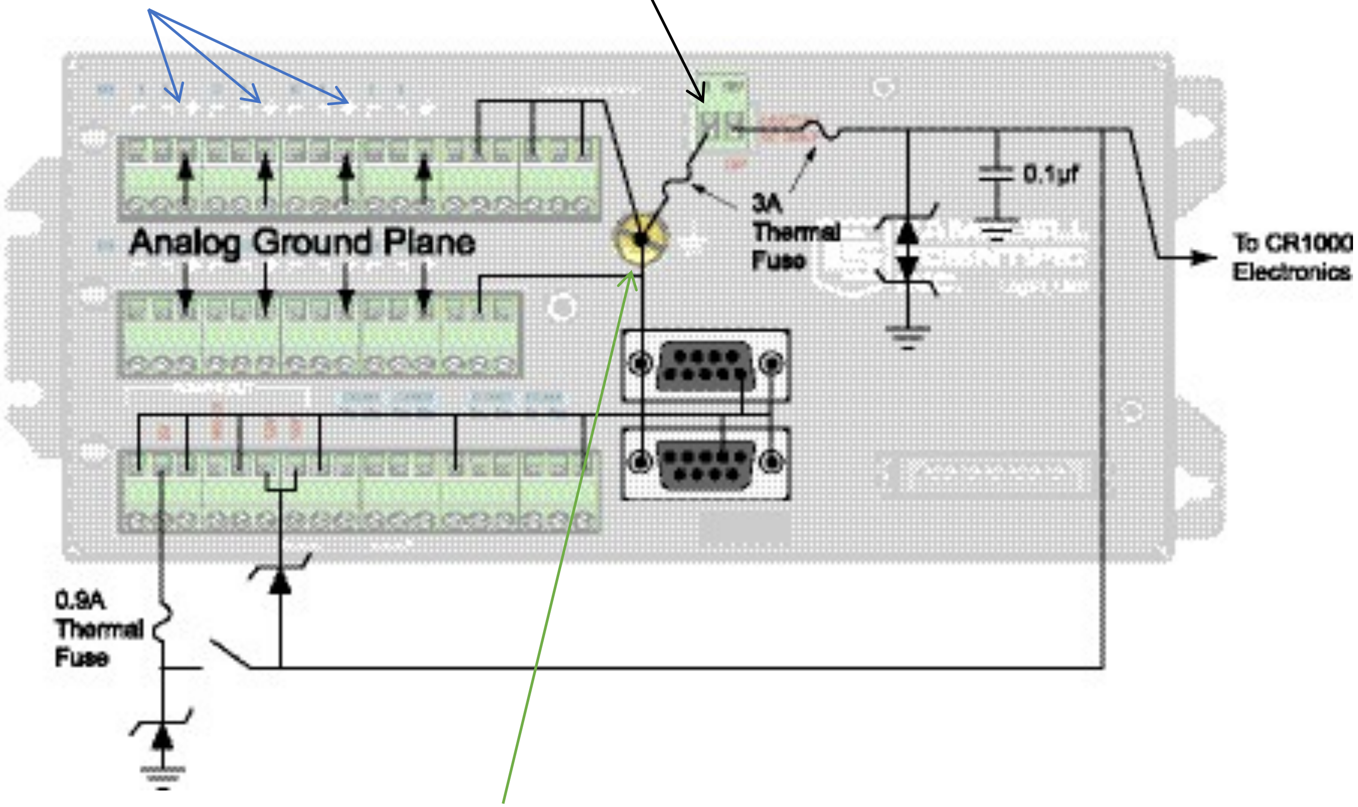


Switched Excitation Outputs
Provides programmable excitation for resistive bridge measurements
Pulse Counters
For measuring switch closures, low-level ac sine waves, or high frequency pulses
Removable Power Terminal
Simplifies connection to external power supply.
Analog Inputs
For differential, single-ended, and period averaging measurements
5 V Terminal
For sensor or modem power
RS-232 Port
For connecting battery-powered computers, serial sensors, or RS-232 modems
Peripheral Port
For Ethernet communications and/or storing data on a CompactFlash card.
Switched 12 V Terminal
For switching power to sensors or communication devices
12 V Terminal
For continuous sensor or modem power
Digital I/O Ports
For controlling external devices, reading SDI-12 sensors or SDM peripherals
CS I/O Port
For connecting to ac-powered computers and Campbell Scientific peripherals
CR1000
Wiring Panel
CAMPBELL SCIENTIFIC
GROUND LUG
CAUTION DC ONLY
RS-232 (Not Isolated)
CS I/O
PERIPHERAL PORT
POWER OUT
SDM
Made in USA

CR1000 Wiring Panel: “Grounds”

Power System Ground (i.e., black wire from photovoltaic system)

(Analog) ***Signal*** Ground



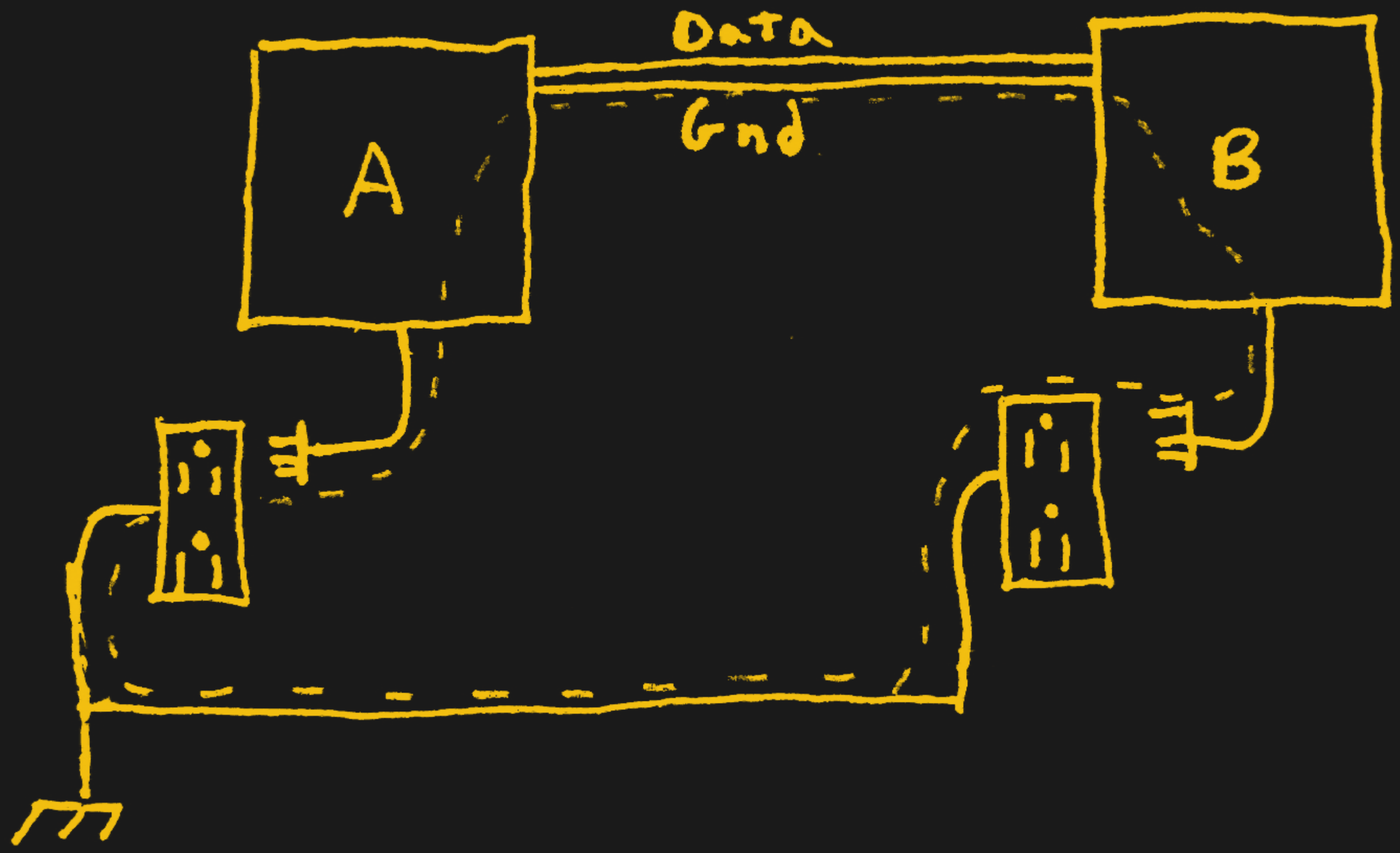
Earth Ground (i.e., copper wire to copper earth grounding rod)

CR1000 Grounding Rules

- Connect ground lug to earth ground
  - Provides low resistance path to earth ground
  - 6-8’ copper sheathed grounding rod
  - 12 AWG copper wire
  - Single ground rod may not be sufficient in low conductive substrates (e.g. sand, very dry soil, ice, rock)
  - Buoy Platforms: Grounding achieved by connecting a copper cable from the datalogger to the metallic part of the buoy hull part of which is submerged in water.
- If the sensor or wire has a shield wire, connect it to signal ground symbol
- *When connecting to a multiplexer using a shielded cable, <u>ground shield/drain wire on both ends</u>*
- Avoid ground loops!

Ground Loops

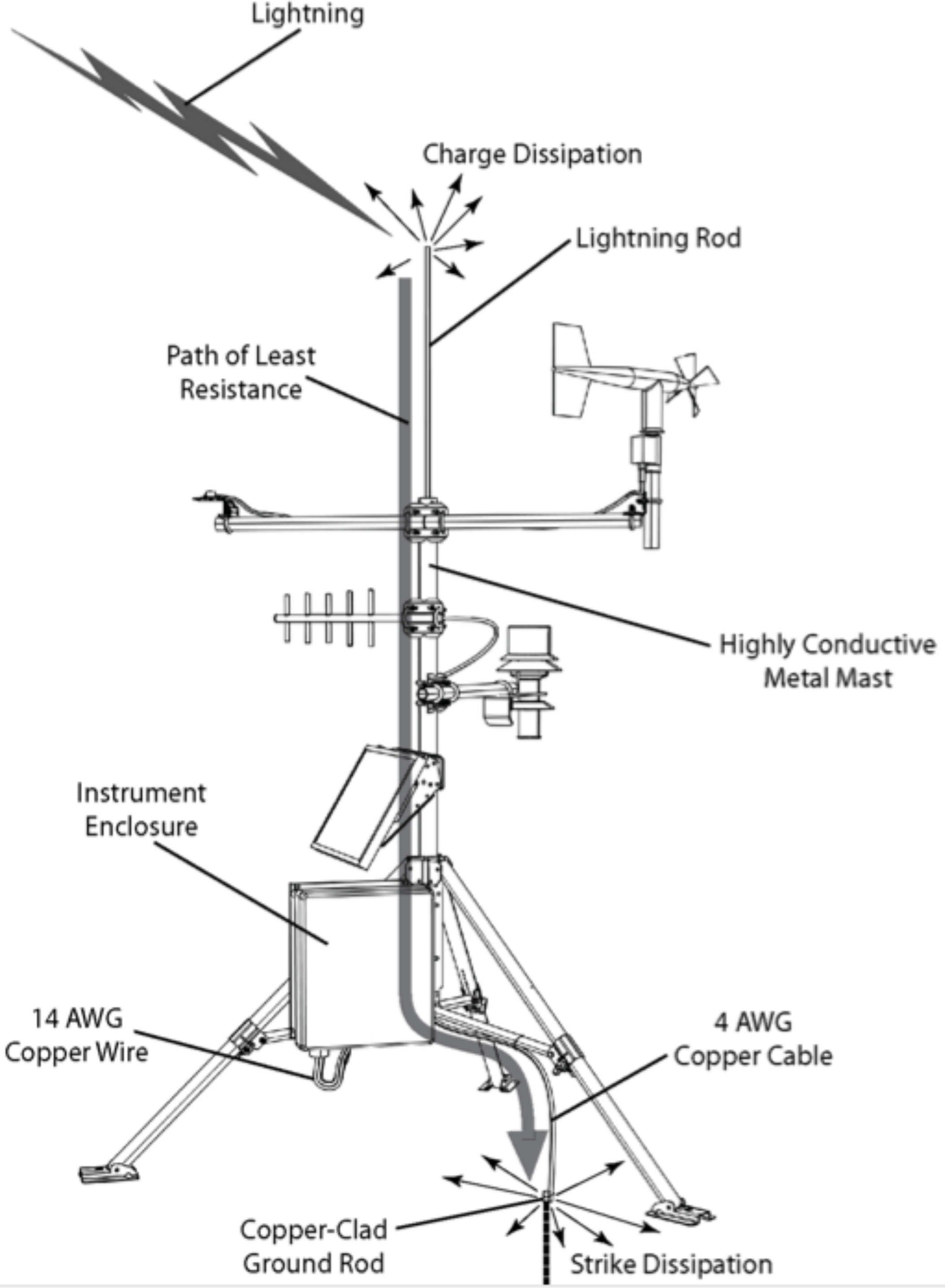
- **Ground Loop** - When two separate devices (A & B) are connected to ground separately, and then also connected to each via cable with a ground, creating a loop.
- This provides two separate paths to ground (B can go through its own connection to ground or it can go through the ground of the cable to A and then to A's ground), and means that current may start flowing in unanticipated ways.
- This is particularly noticeable in analog AV setups, where the result is audio hum or visible bars in a picture, but is also sometimes the cause of unexplained equipment failures.



Data
Gnd
A
B

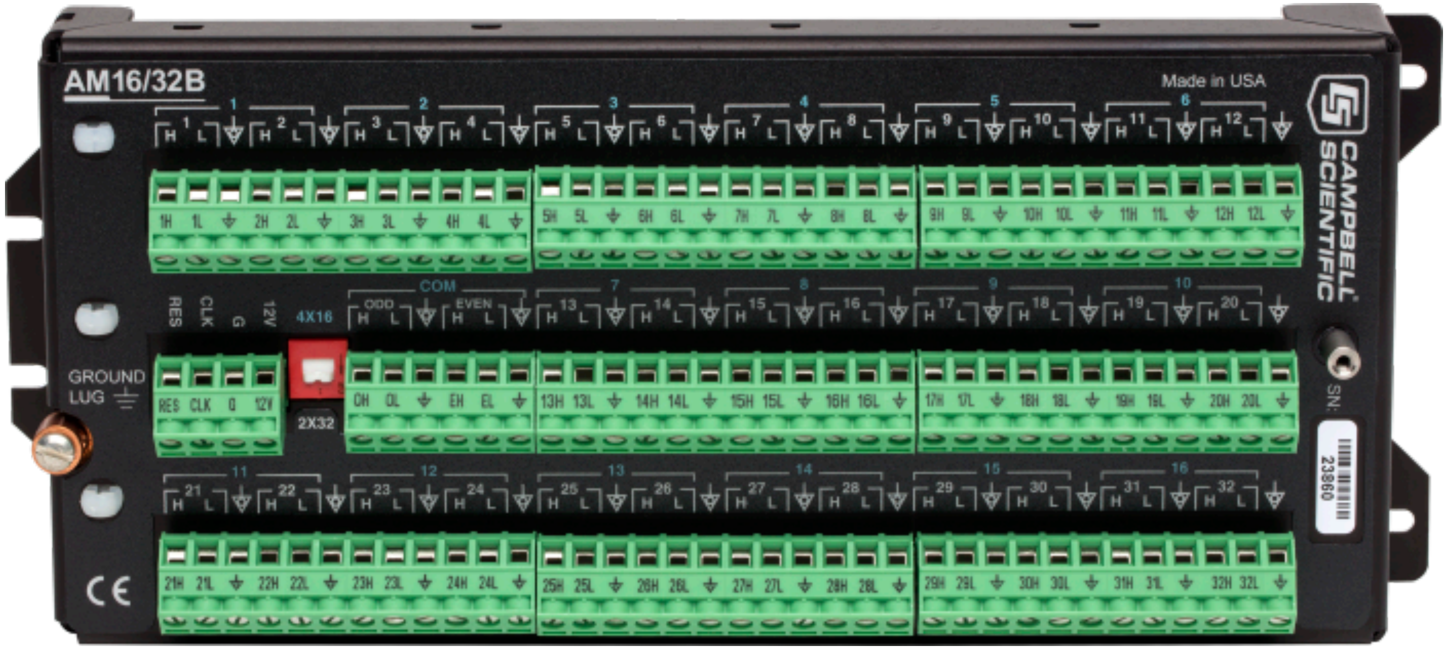
Lightning Protection

- Lightning Rod
  - Provides preferred strike point
  - Dissipates charge, reducing chance of strike
- Heavy gauge ground wire
- Ground Rod



AM16/32 Multiplexer

- Extension of datalogger wiring panel
- "Dumb": no OS, no CPU, no memory, etc..
- Powered from datalogger
- 16 DIFF channels
- 32 SE channels
- Can measure same types of sensors that datalogger can measure



Other Campbell Scientific Dataloggers

https://www.campbellsci.com/data-loggers