APPLICATION NOTE

App. Note Code: 5-F
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Power Supplies

CAMPBELL SCIENTIFIC
WHEN MEASUREMENTS MATTER

Power Supplies

Batteries, Solar Panels, AC Chargers

This application note describes power supplies available from Campbell Scientific, provides procedures for analyzing the power requirements of data acquisition systems, and includes examples of power consumption calculations. Specific equipment described includes alkaline and rechargeable batteries, charging sources, and regulators. The interaction of these components are outlined in Figure 1. In most applications, power supplies offered by Campbell Scientific will power a standard system for months without recharge. This information is intended for users who need to understand the specifics of their system due to use of peripherals, adverse environmental conditions, or use in high latitudes.

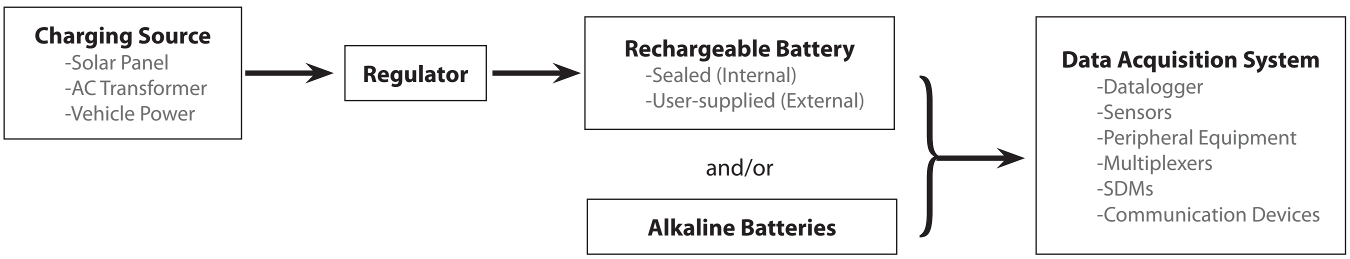

Figure 1. The interaction of a system's components.

1. 12 Vdc Batteries

Campbell Scientific's equipment is powered with 12 Vdc batteries (either alkaline or sealed rechargeable).

NOTE

The datalogger batteries should not drop below:

- ***7 Vdc for the CR200(X) series***
- ***9.6 Vdc for the CR800, CR850, CR1000, CR9000X, CR510, CR10(X), and CR7***
- ***10 Vdc for the CR3000***
- ***11 Vdc for the CR5000 and CR23X***

You should program the datalogger to periodically measure, record, and transmit the battery voltage. Storing a daily minimum battery voltage is an excellent method of monitoring battery health.

1.1 Alkaline

The availability of alkaline batteries makes them attractive for short-term applications where the batteries can be replaced quickly and easily.

The BPALK is an alkaline battery pack that can power a CR800, CR850, CR1000, CR510, or CR10(X) datalogger. It contains eight D cells that provide a nominal rating of 7.5 Ahr.

The CR3000 and CR23X dataloggers can have an alkaline battery base as part of their integrated package. A CR3000 or CR23X with the alkaline battery base is powered by 10 D cells that provide a nominal rating of 10 Ahr.

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An alkaline power supply option is not available for our CR200X-series, CR9000X(C), CR5000, and CR7 dataloggers. They use either sealed rechargeable batteries or ac power.

Alkaline batteries are NOT rechargeable. Back-up power can be provided by a user-supplied sealed rechargeable battery. A blocking diode prevents the user-supplied battery from charging the alkaline batteries.

The above amp hour ratings are at 20°C; the amp hour rating decreases with temperature. The table below depicts the relationship of temperature and battery service.

Typical Alkaline Battery Service and Temperature

Temperature (°C)	% of 20°C Service*
20 to 50	100
15	98
10	94
5	90
0	86
-10	70
-20	50
-30	30

**The table's data are based on one D cell battery with a current drain of 50 mA. As the current drain decreases, the service improves.*

CAUTION

Alkaline batteries may leak when used outside the temperature range of -25° to +50°C, or if you mix new and used batteries. Leakage can also occur if the battery voltage drops below 9.6 Vdc.

1.2 Sealed Rechargeable

All of our dataloggers can be powered by a rechargeable power supply that consists of a rechargeable battery, regulator, and charging source (typically an ac wall charger or solar panel). The charging source powers the datalogger system while float-charging the batteries. The batteries then provide back-up power if the charging source is interrupted.

The PS100 and PS200 are rechargeable power supplies for our CR800, CR850, CR1000, CR510, and CR10(X) dataloggers. They consist of a regulator and a sealed rechargeable battery that has a nominal rating of 7.0 Ahr. The PS100 is used for standard applications. The PS200 smart power supply optimizes battery charging and increases the battery's life by using two-step constant voltage charging and temperature compensation. A more detailed description and additional features of the PS200 are provided in Section 2.1.

Our CR3000, CR5000, CR7, CR9000X(C), and CR23X can have a rechargeable battery base as part of their integrated package. Battery nominal ratings are 7.0 Ahr for the CR3000, CR5000, and CR9000XC; 2.5 Ahr for the CR7; and 14 Ahr for the CR9000X.

Campbell Scientific offers the BP12, BP24, and BP84 battery packs for systems that have higher current drain equipment such as satellite transmitters. They consist of a rechargeable battery, enclosure mounting bracket, and cables. A regulator is required. The BP12 and BP24 can use either the CH100 or CH200 regulator, and the BP84 uses the #18529 Morningstar SunSaver regulator. The BP12, BP24, and BP84 provide a nominal rating of 12, 24, and 84 Ahr, respectively.

For polar applications, Campbell Scientific suggests using the Cyclon battery, manufactured by EnerSys. Testing has shown that these batteries have the best performance in extremely cold temperatures. Visit EnerSys' website at www.enersysreservepower.com for more information.

1.2.1 Cyclic Service Life of Rechargeable Batteries

The industry definition of the *cyclic service life* of a battery is the period until it drops to 60% of its rated capacity. For a 7 Ahr battery, this is when after repeated recharging, the battery can only deliver 4.2 Ahr. When choosing a battery, you should also consider the number of recharge cycles you can expect from the battery until it reaches the end of its cyclic service life.

Several factors affect the cyclic service life, including ambient temperature during charging and storage, number of discharge cycles, depth of discharge cycles, and charging voltage. Clearly, these are complex relationships.

The following may help you assess your batteries' service life:

(1) **Temperature**: warmer temperatures decrease life because heat hastens chemical reactions that cause corrosion of the internal electrodes. The temperature effects are shown on Figure 2 and described below.

- 100% of useful life at an optimal 20°C, decreasing to . . .
- 90% of useful life at 30°C, then decreasing approximately linearly to . . .
- 10% of useful life at 55°C.

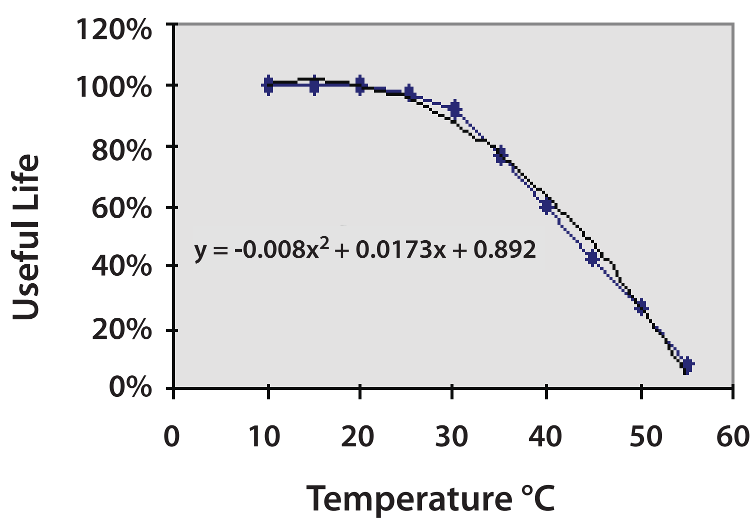

Figure 2: Useful Life of Yuasa NP Batteries versus Temperature

(2) **Depth of discharge:**

- If constantly trickle-charged at a voltage of 13.5 to 13.8 Vdc at an ambient temperature of 20°C (~68°F), such that the battery voltage never drops below ~12.2 V, expect 5 to 6 years of useful life.
- If cycled down to ~11.6 V, expect ~1200 cycles.
- If cycled down to ~11.2 V, expect ~600 cycles.
- If cycled down to ~10.5 V, expect ~500 cycles.

NOTE

Campbell Scientific suggests you store the minimum and maximum battery voltages in your daily data. You can program the datalogger to count the number of times the voltage dropped below certain values.

1.2.2 Solar Panels and Required Battery Capacity

When using a solar panel, the batteries must have the capacity to power the system during periods of low light. The battery capacity's requirements vary with the latitude of the site. Below lists the recommended reserve time based on latitude.

Latitude of Installation Site	Recommended Reserve Time
0° to 30° (N or S)	144 to 168 hr
30° to 50° (N or S)	288 to 336 hr
50° to 60° (N or S)	432 hr
Polar Regions	8,760 hr

NOTE

Polar reserve time assumes yearly site visits. Because of long polar nights, riming, and snowfall, for many polar sites, you cannot count on any charging from the solar panels. Therefore, the reserve time should equal the time between visits.

Assuming your site isn't located in the polar regions, the following equation allows you to calculate your system's required battery capacity:

Required battery capacity = (system's current drain)(reserve time)/(0.8)

The 0.8 value is to limit the battery depth of discharge to 80%. This assumes the worst case conditions. Refer to Sections 6 and 7 for examples.

The following equation can be used to calculate the required battery capacity if your site is located at a polar region:

Required battery capacity = 2 (system's current drain)(reserve time)

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2. Regulators

A regulator must be used to connect rechargeable batteries with a charging source. The regulator controls the current flowing to the battery and prevents the battery current from flowing to the charging source. Our regulators provide built-in temperature compensation to optimize battery performance.

An internal regulator is included with our PS100 and PS200 power supplies; SP10R and SP20R solar panels; and the rechargeable battery base of our CR3000, CR5000, CR7, CR9000X(C), and CR23X dataloggers.

Campbell Scientific also offers several stand-alone regulators. Either the CH100 or CH200 regulator is used with our BP12 and BP24 battery packs. Either the CH200 or #18529 Morningstar SunSaver regulator is used with our SP70 solar panel. The BP84 battery pack uses the #18529 regulator. Also available is the DCDC18R regulator that allows the batteries of a CR3000, CR5000, or CR23X to be recharged with vehicle power.

2.1 Smart Chargers (PS200 and CH200)

The PS200 and CH200 are micro-controller-based smart chargers with two-step constant voltage charging and temperature compensation that optimize battery charging and increases the battery's life.

The PS200 and CH200 have two input terminals that allow simultaneous connection of two charging sources. A maximum power point tracking algorithm for solar inputs is included that maximize available solar charging resources.

Onboard measurements, along with a serial communication interface, provide users with charge input voltage, battery voltage, onboard temperature, battery current, and load current measurements. These measured parameters can be used to compute net charging currents, battery health, and power budgets for improved site management.

The PS200 and CH200 have several safety features intended to protect the charging source, battery, charger, and load devices. Both the SOLAR – G and CHARGE – CHARGE input terminals incorporate hardware current limits and polarity-reversal protection. A fail-safe, self-resettable thermal fuse protects the CHARGE – CHARGE inputs in the event of a catastrophic AC/AC or AC/DC charging source failure. Another self-resettable thermal fuse protects the 12 V output terminals of the charger in the event of an output load fault. The PS200 and CH200 also have battery-reversal protection, and include ESD and surge protection on all of their inputs and outputs.

3. Charging Sources

Charging circuitry, ac transformers, solar panels, and vehicle power are used in systems that have sealed rechargeable batteries. The charging sources must produce enough power to balance the power requirements of the system.

3.1 Charging Circuitry and AC Transformers

Charging circuitry and ac transformers charge sealed rechargeable batteries by using power from external ac power lines. Hardware for charging the batteries via ac power is included with the CR7's enclosures and the CR9000X(C) datalogger.

The 9591, 22110, 14014, and 22111 ac transformers are offered for our other sealed rechargeable batteries. The 9591 and 22110 transformers may be used in the United States and in other countries where the ac outlet sources 110 Vac. The 9591 connects directly to a regulator's terminals; the 22110 is fitted with a connector for attachment to a prewired enclosure.

The #14014 and 22111 are generally used when local ac power is provided at voltages other than 110 Vac; they accept ac power in the range of 90 to 264 Vac @ 47 to 63 Hz. The 14014 connects directly to a regulator's terminals; the 22111 is fitted with a connector for attachment to a prewired enclosure.

3.2 Solar Panels

Solar panels charge batteries by converting sunlight into direct current. Campbell Scientific's SP10 10-W and SP20 20-W solar panels can recharge the battery of a PS200, PS100, BP12 (requires CH100 or CH200), BP24 (requires CH100 or CH200), CR3000, CR5000, CR7, or CR9000X(C). The SP10R 10-W and SP20R 20-W solar panels include an internal regulator, and are intended for recharging a user-supplied, deep-cycle RV battery.

The SP70-L solar panel is used in CO_2 Bowen Ratio, CO_2 Eddy Covariance, or other systems that require high-power solar panels. This solar panel must be connected to a CH200 or 18529 Morningstar SunSaver regulator. Two SP70-L solar panels can be connected to one regulator to provide 140 W of power.

NOTE

The SP10R and SP20R regulated solar panels have a 2 mA continuous current drain. The 18529 Morningstar SunSaver Regulator draws 6 to 10 mA of continuous current. The CH200 has a quiescent current drain of ≤300 µA.

Solar Panel Specifications

	SP10/SP10R	SP20/SP20R	SP70
Voltage at Peak Power	16.8 V	16.8 V	17.1 V
Power	10 W maximum, 9 W guaranteed minimum	20 W maximum, 18 W guaranteed minimum	70 W* maximum, 66.5 W guaranteed minimum
Current at Peak	0.59 A	1.19 A	4.1 A
Dimensions	16.5 x 10.6 x 0.9 in. (41.9 x 26.9 x 2.3 cm)	19.7 x 16.6 x 2 in. (50 x 42.2 x 5.1 cm)	47.6 x 21.1 x 2 in. (120.9 x 53.7 x 5 cm)

**The 70 W peak power for the SP70 assumes one solar panel is used. When two SP70 solar panels are connected to one regulator, the peak power is 140 W.*

NOTE

Specifications assume a 1 kilowatt per square meter illumination and a solar panel temperature of 25°C (77°F). Individual panels may vary up to 10%. The output panel voltage increases as the panel temperature decreases.

You can determine the best solar panel model for applications not located in a polar region by using this equation:

Solar panel current > ((system Ahr/day) x 1.2)/(hrs of light)

Where: **1.2**—accounts for solar panel system loss
hrs of light — the number of hours in the day that the sky is clear enough for the solar panel to source current. To be safe, we suggest you use the worst case condition (i.e., winter).

See Sections 6 and 7 for examples.

Use the following equation to determine the best solar panel model for sites located in a polar region:

solar panel current > ((system Ahr/day) x 2)

NOTE

For polar sites, the solar panel must be mounted vertically to take advantage of the low sun angle in the winter as well as maintaining a charge in the summer when the sun is higher in the sky. The panel is also mounted vertically to reduce the tendency for the panel to collect snow or rime up.

3.3 Vehicle Power

Vehicle power can recharge the CR3000, CR5000, and CR23X's sealed rechargeable batteries if the DCDC18R Boost Regulator is used. Our DCDC18R increases the vehicle's supply voltage (11 to 16 Vdc) to charging levels required by the datalogger (18 Vdc).

4. Power Supply Adapters

Campbell Scientific offers two adapters that fasten onto our PS100 power supply, PS200 power supply, CH100 regulator, and CH200 regulator. The A100 is for powering peripherals and external devices at non-datalogger sites such as repeater stations. When the A100 adapter is connected to a PS100, PS200, CH100, or CH200, the power supply can source both 5 Vdc and 12 Vdc. When used with a CH100 or CH200, either a BP12 or BP24 battery pack is also required at the non-datalogger site.

The A105 adapter adds four 12 V terminals and four ground terminals to a CH100, CH200, PS100, or PS200. The extra terminals make it easier to wire multiple continuously powered 12 Vdc devices to the power supply. The A100 and A105 cannot be used at the same time.

5. Calculating Power Consumption of a System

The power consumption of a system is the sum of the datalogger, sensors, and peripheral equipment's (multiplexers, SDMs, and communication devices) average current drains. Examples of calculating a system's power consumption are provided in Sections 6 and 7.

5.1 Dataloggers

The average current drain can be calculated by determining the time spent in an active state (performing measurements, processing/ storing data) versus the time spent in a quiescent state. This relationship is primarily affected by the datalogger's scan rate (see Figure 3) and the length of the datalogger program. The current drains of Campbell Scientific's dataloggers in both active and quiescent states are listed below.

Datalogger	Quiescent Current Drain*	Active Current Drain*
CR200X	0.2 mA	3 mA
CR800	0.6 mA	10 mA
CR1000	0.6 mA	10 mA
CR3000	1 mA	15 mA
CR5000	1.5 mA	200 mA
CR9000X**	30 mA	750 to 1000 (processing), 750 to 4000 (analog meas.)

** The above current drains assume a temperature range of -25° to +50°C. Operation outside these limits increases the current drain.*

***The CR9000X datalogger's power consumption varies according to the combination of input modules. A list of the current drains for the modules is published in the CR9000X manual.*

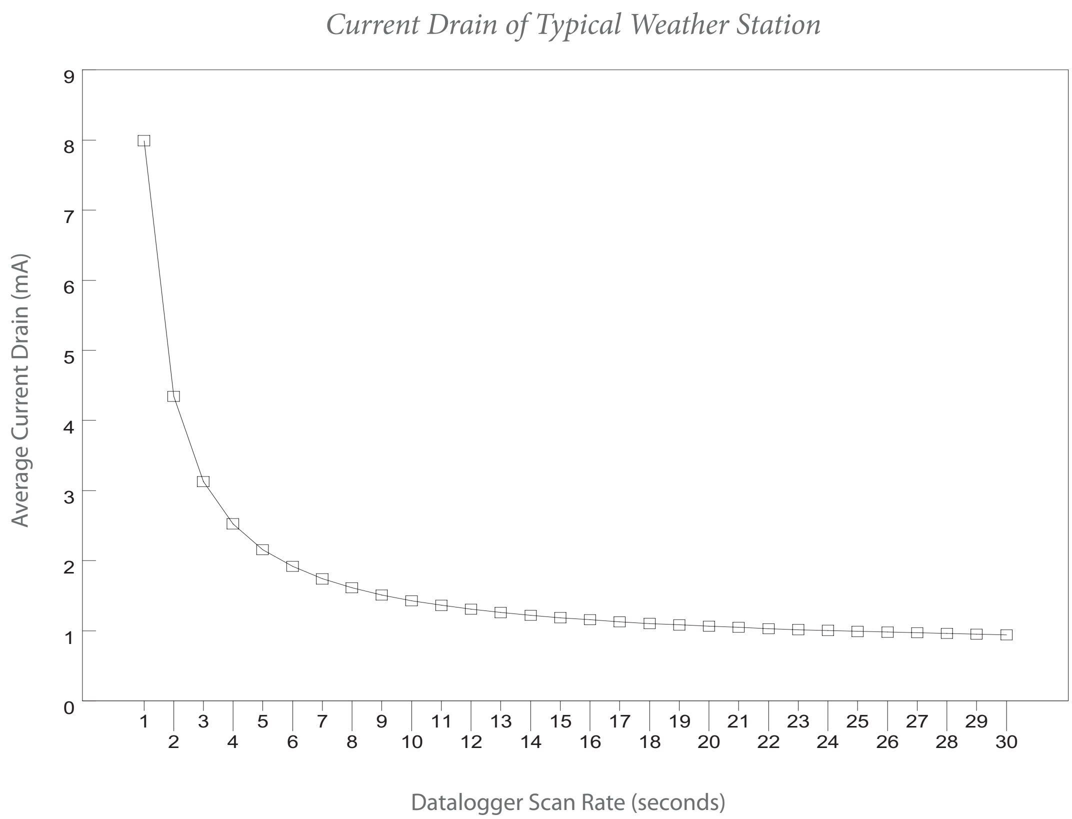

Figure 3: Short scan rates dramatically affect the current drain of a system.

5.2 Sensors

The current drain of a sensor is determined by its current drain during quiescent and active states, which is affected by the datalogger's scan rate. Most Campbell Scientific sensors have negligible power consumption. Sensors with negligible power consumption include our thermistors, fine-wire thermocouples, rain gages, wind vanes, cup anemometers, and pyranometers. Typical current drains for some sensors that have significant power consumption are shown below. Further information is available in the sensor operator's manuals and brochures.

Sensor Typical Current Drains

Sensor	Quiescent Current Drain*	Active Current Drain*
Fan-Aspirated Thermocouple		
ASPTC	negligible	260 mA
Temperature and Relative Humidity Probes		
CS215	120 µA	1.7 mA
HMP60	negligible	1 mA
HMP45C	negligible	4 mA
HMP155A	negligible	≤3 mA
Barometric Pressure Sensors		
CS100	<1 µA	<3 mA
CS106	<1 µA	<4 mA
Global Positioning Sensor		
GPS16X-HVS	negligible	65 mA
Pressure Transducers		
CS450	< 80 µA	8 mA
CS455	< 80 µA	8 mA
CS460	N/A	3 mA continuous
Turbidity Probes		
OBS-3+	negligible	15 mA
OBS300	negligible	15 mA
Ultrasonic and Radar Sensors		
SR50A	<1.0 mA (SDI-12 mode)	250 mA
CS475	4.7 mA	14 mA
CS476	4.7 mA	14 mA
CS477	4.7 mA	14 mA

Sensor Typical Current Drains Continued

Sensor	Quiescent Current Drain*	Active Current Drain*
Sonic Anemometers		
WindSonic1	N/A	~15 mA continuous
WindSonic4	N/A	~23 mA continuous
CSAT3	negligible	200 mA @ 60 Hz measurement 100 mA @ 20 Hz measurement
** Current drains assume a temperature range of -25° to +50°C. Operation outside these limits increases the current drain.*		

5.3 Peripheral Equipment

Peripheral equipment includes communication devices, multiplexers, and synchronous devices for measurement (SDMs). As with the datalogger, power consumption of multiplexers is determined by the percentage of time in active and quiescent states. This percentage is calculated from the datalogger's scan rate and program.

SDMs are generally in an active rather than a quiescent state and typically require an external rechargeable power supply.

Communication peripherals are typically active only during data transfer or while being interrogated by the base station computer. When a communication device is transmitting, the datalogger goes into a processing state. You should account for this when calculating your system's power consumption. Below is a list of some peripheral equipment's current drains. A more complete list is available in Campbell Scientific operator's manuals and brochures.

Peripheral Typical Current Drains

Peripheral	Quiescent Current Drain*	Active Current Drain*
Multidrop Modem		
MD485	1.2 mA	2 to 7 mA
Phone Modems (land line, voice synthesized, and digital cellular)		
COM220	~12 µA	~30 mA
COM320	~100 µA	~35 mA
RavenXTG	50 mA	120 mA transmit/receive
RavenXTV	50 mA	120 mA transmit/receive
Satellite Transceivers		
TX320	5 mA	2.6 A during transmission
ST-21	1.12 mA	375 mA transmitting

Peripheral Typical Current Drains Continued

Peripheral	Quiescent Current Drain*	Active Current Drain*
Radio Transmitters/Modems (spread spectrum and narrow band)		
RF401	<1 mA (power-saving options used)	24 mA (receiving); <75 mA (transmitting)
RF411	<1 mA (power-saving options used)	24 mA (receiving); <75 mA (transmitting)
RF416	<1 mA (power-saving options used)	36 mA (receiving); 75 mA (transmitting)
RF450	7 mA (sleep); 22 mA (idle)	76 mA (receiving); 500 mA (transmitting)
RF310-series	<65 mA	<2000 (transmit 5 WRF power); <1000 (transmit 12 WRF power) <80 mA (receiver)
RF500M	<350 µA	<15 mA
Multiplexers		
AM16/32B	<210 µA	6 mA
AM25T	0.5 mA	1 mA
Synchronous Devices for Measurement (SDMs)		
SDM-CD16AC	6 mA	45 mA per active LED (switch on or auto active)
SDM-CD8S	15 mA	45 mA per active LED (switch on or auto active)
SDM-CAN	<1 mA	70 mA (self-powered, isolated mode, recessive state); 120 mA (isolated mode, dominant state); 30 mA (non-isolated mode, recessive state); 70 mA (non-isolated mode, dominant state)
SDM-INT8	400 µA	13 to 20 mA
SDM-IO16	0.6 mA	3 mA
SDM-SIO1	70 µA	5 to 13 mA depending on transmit mode and connections made
SDM-SW8A	3 mA	6 mA

** Current drains assume a temperature range of -25° to +50°C. Operation outside these limits increases the current drain.*

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6. Typical Weather Station Example

6.1 System's Current Drain

Suppose a CR1000-based weather station measuring standard meteorological sensors at a thirty second (30 s) scan rate has an average current drain of:

State	Duration (seconds)	Current Drain (mA)
Active	0.2	10
Quiescent	29.8	0.6

$$\text{CR1000 Average Current Drain} = \frac{(0.2\text{ s})(10\text{ mA}) + (29.8\text{ s})(0.6\text{ mA})}{30\text{ s}}$$

$$= 0.66\text{ mA}$$

Communication with the station for data retrieval, monitoring, or program transfer also consumes power as the datalogger goes into a processing state, and activates the communication device. To conserve power, Campbell Scientific's modem devices are active only during communication.

For example, if the station is called once a day (1440 min) for 5 minutes via telephone (COM220 modem), the current drain is:

State	Duration (minutes)	Current Drain (mA)
Active	5	30 (COM220) + 10 (CR1000) = 40
Quiescent	1435	0.012

$$\text{Current Drain} = \frac{(5\text{ min})(40\text{ mA}) + (1435\text{ min})(0.012\text{ mA})}{1440\text{ min.}}$$

$$= 0.15\text{ mA}$$

Assuming negligible power consumption by the meteorological sensors, the system's average current drain is:

$$0.66\text{ mA} + 0.15\text{ mA} = 0.81\text{ mA or } 0.00081\text{ A}$$

6.2 Theoretical Alkaline Battery Life

This weather station can be powered with the BPALK power supply which has an amp hour rating of 7.5. The alkaline batteries will theoretically last:

$$(7.5\text{ Ahr})/(0.00081\text{ A}) = 9259\text{ hrs or about 385 days}$$

NOTE

Because temperature and other factors can affect battery service, you should monitor the battery voltage to determine the actual battery replacement schedule.

6.3 Using Rechargeable Battery and Solar Panel

If we choose to use a solar panel and rechargeable battery to power the station, the rechargeable battery must be able to power the weather station during periods of low light. If the weather station is at a latitude of 40° North, the recommended reserve time listed in Section 1.2.2. is 336 hours. According to the equation listed in Section 1.2.2., the required battery capacity is:

$$\text{Required battery capacity} = (0.00081\ \text{A})(336\ \text{hr})/(0.8) = 0.34\ \text{Ahr}$$

Because the PS100's rechargeable battery has a 7.0 Ahr capacity, it sources sufficient current for this weather station.

We can determine the best solar panel model for the weather station by using the equation provided in Section 3.2.

First we need to calculate the station's average amp hours per day:

$$\text{Ahr/day} = (0.00081\ \text{A}) \times (24\ \text{hr/day}) = 0.0194\ \text{Ahr/day}$$

Assuming the solar panels source current for five hours per day, the panels must produce:

$$((0.0194\ \text{Ahr/day}) \times 1.2)/5\ \text{hr} = 0.0047\ \text{A}$$

Because the SP10 and SP10R's current at peak is 0.59 A, they can easily provide sufficient current for this system.

7. Example of a Weather Station Using RF Telemetry

7.1 System's Current Drain

An example of a high current drain system is when the previous weather station is called every five minutes (300 seconds) using an RF310 radio and RF500M modem. The RF's average current drain is:

State	Duration (seconds)	Current Drain (mA)
Active	10	2000 (RF310) + 15 (RF500M) + 10 (CR1000) = 2025
Quiescent	290	65(RF310) + 0.35 (RF500M) = 65.35

$$\text{RF System's Average Current Drain} = \frac{(10\ \text{s})(2025\ \text{mA}) + (290\ \text{s})(65.35\ \text{mA})}{300\ \text{s}}$$

$$= 130.67\ \text{mA}$$

Since the datalogger has a current drain of 0.66 mA, the average current drain of the system is:

$$0.66\ \text{mA} + 130.67\ \text{mA} = 131.33\ \text{mA or } 0.1313\ \text{A}$$

7.2 Using Rechargeable Battery and Solar Panel

The current drain of the RF system requires the use of a rechargeable battery instead of alkaline batteries. If you choose a solar panel for the charging source, the rechargeable battery must be able to power the station during periods of low light. If the station is at a latitude of 40° North, the recommended reserve time listed in Section 1.2.2. is 336 hours. According to the equation listed in Section 1.2.2., the required battery capacity is:

$$\text{Required battery capacity} = (0.1313\ \text{A})(336\ \text{hr})/(0.8) = 55\ \text{Ahr}$$

Therefore this station requires more battery capacity than what the PS100, PS200, BP12, or BP24 can source. In this situation, the BP84, a user-supplied marine or RV battery, or ac power should be used.

CAUTION

When using an external battery, disconnect the batteries included with the CR3000, CR5000, CR7, and CR23X. Two rechargeable batteries that have different amp hour ratings should not be connected in parallel.

The best solar panel model for this example can be calculated using the equation in Section 3.2. First we need to calculate the station's average amp hours per day:

$$\text{Ahr/day} = (0.1313\ \text{A}) \times (24\ \text{hr/day}) = 3.1512\ \text{Ahr/day}$$

Assuming the solar panel sources current for five hours per day, the panel must produce:

$$((3.1512\ \text{Ahr/day}) \times 1.2)/(5\ \text{hr}) = 0.7563\ \text{A}$$

Because the SP20 and SP20R current at peak is 1.19 A, they can easily provide sufficient current for this system.