

# CH201

## 12V Charging Regulator



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# 1. Introduction

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The CH201 is a charging regulator for an external rechargeable 12V VRLA, valve-regulated lead-acid, battery, such as the BP12 or BP24 offered by Campbell Scientific. Charging power for this charging regulator is typically supplied by an unregulated solar panel or AC-to-DC converter.

The CH201 is a smart charger that provides a programmable low voltage disconnect and two-step constant voltage charging with temperature compensation for optimal charging and battery life. A maximum power point tracking algorithm is incorporated for solar inputs to maximize available solar charging resources.

The CH201 is a series regulator, which has the regulator placed, in series, between the charging source and the load. As batteries become closer to fully charged, series regulators reduce the current drawn from the charging source. The charging source may be completely unloaded if full charge is reached. Charging source unloading is acceptable for solar panels and AC-to-DC converters. For wind turbines, charging source unloading can cause free spinning. Consequently, do not use series charging regulators, such as the CH201, to regulate wind-turbine outputs without a method to load the turbine when the batteries require little or no charging current.

The CH201 has several safety features that protect the charging source, battery, charger, and load devices. Both the **DC In 1** and **DC In 2** input terminals have polarity reversal protection and programmable hardware current limits. The CH201 has a programmable maximum battery charging current limit. A self-resettable, thermal fuse is in-series with the 12 VDC output terminals to protect the charger from an output load fault. The CH201 includes battery reversal protection, and ESD and surge protection are incorporated on all inputs and outputs.

## 2. Precautions

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Only use the following battery cables with the CH201: pn 34029, pn 34031, pn 34040, and pn 36589.

Overcharging VRLA batteries can produce excess hydrogen and oxygen gases, and the accumulation of hydrogen gas can form an explosive mixture. Fortunately, hydrogen gas is difficult to contain in anything but a metal or glass enclosure.

**DANGER:**

Never house VRLA batteries in an enclosure that does not allow dispersion of emitted hydrogen gas.

When using a current limiting power supply such as a AC-to-DC converter, change the input current limit using the *Device Configuration Utility* to prevent the CH201 from pulling more current than what is available, thus tripping current limit protection of the converter.

VRLA batteries can provide high-surge currents. A 4.6 A solid-state circuit breaker protects the 12 VDC output terminals, but there is no fusing for inadvertent bridging of the battery terminals.

**DANGER:**

Accidental shorting of battery terminals is a fire hazard. Shorting the terminals with metallic objects, such as watchbands, can cause severe burns due to rapid heating.

VRLA battery manufacturers state that “Heat Kills Batteries.” While the operating temperature range is –40 to 60 °C, optimum battery life occurs in the 5 to 35 °C temperature range<sup>1</sup>. The CH201 offers temperature compensation of the battery charging voltage based on a temperature measurement inside the CH201 case. The CH201 internal temperature measurement only accurately represents battery temperature for charge voltage compensation if the battery is next to the CH201. To overcome temperature differences, use the CH201 serial interface to input an independently measured battery temperature for improved charging temperature compensation.

With rechargeable batteries, a charge → discharge → recharge event is termed a cycle. Depth of discharge can greatly affect the battery service life. For example, limiting the depth of discharge to 50% instead of 100% (complete discharge) will double the number of useful cycles available from the battery. VRLA batteries last longer with less (or more shallow) depth of discharge.

VRLA batteries self-discharge at approximately 3% of rated capacity per month at room temperature<sup>1</sup>. A 3% of rated capacity per month self-discharge results in 100% discharge in approximately 33 months for a battery stored at room temperature. The battery self-discharge rate increases with higher storage temperatures.

**WARNING:**

Leaving a lead-acid battery in a discharged state for prolonged periods causes large sulfate crystals (sulfation) that are detrimental to battery performance.

Every few months, recharge stored batteries to prevent irreversible sulfation due to prolonged time in a discharged state.

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<sup>1</sup>Genesis Application Manual – Genesis NP and NPX Series US-NP-AM-002, June 2006.

# 3. Initial inspection

Upon receipt of the CH201, inspect the packaging and contents for damage. File damage claims with the shipping company.

# 4. Overview

FIGURE 4-1 (p. 3) provides a simplified schematic of the CH201 charging regulator. See Table 5-1 (p. 7) for rechargeable batteries offered by Campbell Scientific.

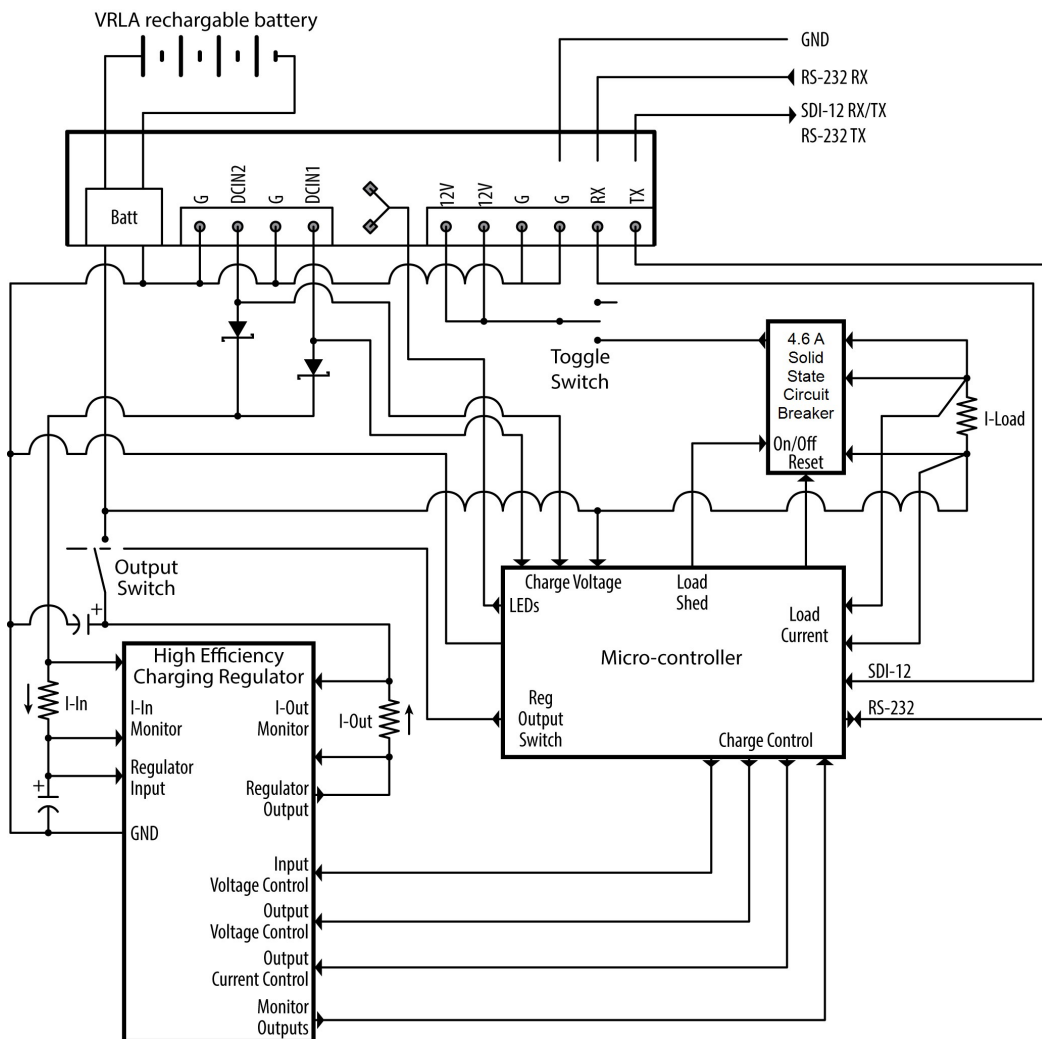


FIGURE 4-1. CH201 schematic

An unregulated solar panel or AC-to-DC converter typically supplies charging power to the CH201. As shown in [FIGURE 4-1](#) (p. 3), diodes connected to the two **DC In** terminals provide input reversal protection and isolation between power sources. **DC In** terminals have a polarity that must be followed. Connect the positive wires to the **DC In** terminals, and connect the negative wires to the **G** terminals. Reversed polarity inputs, however, will NOT damage the CH201. The **DC In** input terminals have an input current limit of approximately 10 amps, making the CH201 well suited for 170 watt or smaller solar panels. Higher powered solar panels may not damage the CH201, but the additional power likely won't be fully used. Additionally, each input has a programmable current limit. See [\(Optional\) Configure using Device Configuration Utility](#) (p. 12).

Internal diodes route power from the source with the highest input voltage. An AC-mains-powered application can use a solar panel for back-up if the AC-to-DC source has a higher voltage than the solar panel. The solar power will be the primary supply and AC will be the secondary supply if the solar panel has a higher output voltage than the AC-to-DC source.

The **12V** output terminals are for powering a data logger and peripherals. A toggle switch controls power to these output terminals. The total output current is limited by a 4.6 A solid-state circuit breaker.

Each battery family uses a unique charging algorithm to calculate the best charging voltage for battery temperature. The algorithms use the charger temperature as the default temperature source. If the charger and battery are in the same enclosure, the two temperatures will be similar. If the battery will be in a separate enclosure, place a temperature sensor on or near the battery and use the appropriate SDI-12 or RS-232 command to send this temperature to the module (see [Table 7-4](#) (p. 25) and [Table 7-6](#) (p. 27)).

The CH201 has two LED indicators, the **CHG** (charge) LED and the **CK BAT** (check battery) LED. [Table 7-7](#) (p. 30) and [Table 7-8](#) (p. 30) list the conditions and associated colors for the **CHG** and **CK BAT** LEDs.

The CH201 communicates using a data logger or computer **COM** port. Data logger communications can be done using SDI-12 or RS-232 as indicated in [FIGURE 7-3](#) (p. 23) and [FIGURE 7-4](#) (p. 26). See [Communications](#) (p. 21) for details.

## 4.1 Communications interface

The CH201 can send data to the user to observe and manage power requirements and possible problems. It can also be configured to work with a wide range of batteries and input power supplies and test the existing battery system for possible shorting and sulfation problems.

The CH201 can be used without any configuration or communications. To take advantage of the additional features of the CH201, however, the CH201 supports three kinds of communications:

- Communications to a computer running *Device Configuration Utility*. This utility simplifies configuration of the CH201 and allows for operating system updates. *Device Configuration Utility* may be downloaded free of charge at [www.campbellsci.com/downloads](http://www.campbellsci.com/downloads). See (Optional) *Configure using Device Configuration Utility* (p. 12).
- SDI-12 communications as an SDI-12 sensor according to the SDI-12 standard ([www.SDI-12.org](http://www.SDI-12.org)). See *SDI-12 communications* (p. 23) for an in depth explanation.
- RS-232 communications to a data logger or computer. See *RS-232 communications* (p. 25) for an in-depth explanation.

SDI-12 data logger programming is usually simpler than RS-232 programming. Also, multiple SDI-12 sensors can share a single data logger control or universal terminal if they have unique SDI-12 addresses; RS-232 devices are limited to one device per terminal. The advantage of RS-232 is its speed can be faster than SDI-12.

All CH201 serial communications use three **COM** terminals, **TX**, **RX**, and **G**. The CH201 will detect the mode of communications and will reconfigure itself accordingly.




FIGURE 4-2. CH201 COM terminals



# 5. Specifications

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<b>Operational Temperature<sup>a</sup>:</b>	-40 to 60 °C
<b>Dimensions:</b>	11.40 x 10.08 x 3.38 cm (4.49 x 3.97 x 1.33 in)
<b>SOLAR Terminals (Solar Panel or Other DC Source)<sup>b</sup></b>	
<b>Input Voltage Range:</b>	15 to 50 VDC
<b>Maximum Charging Current:</b>	10 A
<b>Power Out (+12 terminals)</b>	
<b>Voltage:</b>	Unregulated 12 V from battery 4.6 A solid state circuit breaker. Self-resettable thermal.
<b>Battery Charging<sup>c</sup></b>	
<b>CYCLE Charging:</b>	$V_{\text{batt}}(T) = 14.70 \text{ V} - (24 \text{ mV}) \cdot (T - 25 \text{ }^\circ\text{C})$
<b>FLOAT Charging:</b>	$V_{\text{batt}}(T) = 13.65 \text{ V} - (18 \text{ mV}) \cdot (T - 25 \text{ }^\circ\text{C})$
<b>Measurements</b>	
<b>Input Voltage:</b>	$\pm(1\% \text{ of reading} + 15 \text{ mV})$
<b>Battery Voltage:</b>	$\pm(2\% \text{ of reading} + 15 \text{ mV})$
<b>Load Current<sup>d</sup>:</b>	$\pm(2\% \text{ of reading} + 2 \text{ mA})$
<b>Battery Current<sup>d</sup>:</b>	$\pm(2\% \text{ of reading} + 10 \text{ mA})$
<b>Charger Temperature:</b>	$\pm 2 \text{ }^\circ\text{C}$
<b>Quiescent Current</b>	
<b>No Charge Source Present:</b>	300 $\mu\text{A}$ maximum
<b>No Battery Connected:</b>	Typical 5 mA at 40 VDC
<b>Compliance:</b>	View the EU Declaration of Conformity at <a href="http://www.campbellsci.com/CH201">www.campbellsci.com/CH201</a> 

<sup>a</sup> VRLA battery manufacturers state that “heat kills batteries” and recommend operating batteries at temperatures below 50 °C.

<sup>b</sup> Battery voltages below 8.7 V may result in <3.0 A current limit because of fold-back current limit.

<sup>c</sup> Two-step temperature compensated constant-voltage charging for valve-regulated lead-acid batteries. Cycle and float charging voltage parameters are programmable with the default values listed.

<sup>d</sup> Impulse-type changes in current may have an average current measurement error of  $\pm(10\% \text{ of reading} + 2 \text{ mA})$ .

**Table 5-1: Available Campbell Scientific battery packs**

Battery Pack Model	Amp-Hour Capacity (Ah)	Operating Temperature Range <sup>1</sup> (°C)	Battery Family
BP7	7	Charge: -15 to 50 Discharge: -20 to 60	EnerSys/Genesis
BP12	12	Charge: -15 to 50 Discharge: -20 to 60	EnerSys/Genesis
BP24	24	Charge: -15 to 50 Discharge: -20 to 60	EnerSys/Genesis
BP84	84	-40 to 71	Concorde Sun Xtender

<sup>1</sup> Battery specifications are from the manufacturer. The CH201 contains charging algorithms that optimize battery charging over the range of -40 to 60 °C. Battery usage outside of manufacturer specifications could have unknown effects on the life of the battery.

**WARNING:**

Battery life is shortened if the battery is allowed to discharge below 11.5 VDC. Low voltage disconnect can be set in the CH201. Default low voltage disconnect is 6 VDC.

**Charging requirements and tips:**

Campbell Scientific offers a variety of solar panels and AC-to-DC transformers to meet the power requirements of a system installation.

- 10 A is the highest input current that the CH201 can fully use. Although a solar panel or transformer with a higher output current won't damage the CH201, its power will not be fully used. Peak voltage of the solar panel must be less than 50 VDC.
- Solar panel specifications assume a 1 kilowatt per square meter illumination and a solar panel temperature of 25 °C (77 °F).
- Individual solar panels may vary up to 10%.
- Solar panel output voltage increases as the panel temperature decreases. VRLA batteries also have increased output voltage as the battery temperature decreases.
- Higher latitudes and less sun hours during winter months might require a larger solar panel than what is required to keep the battery charged during the summer.
- Use the *Device Configuration Utility* to change the current limit settings of **DC In 1** or **DC In 2** to accommodate the current limit of a charging source. For example, set the current limit to

1.67 A to avoid tripping the power supply when using a wall charger with a 1.67 A current limit.

**DC In** terminals have a polarity that must be followed. Connect the positive wires to the **DC In** terminals, and connect the negative wires to the **G** terminals. Reversed polarity inputs, however, will NOT damage the CH201.


## 6. Installation

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The CH201 module is designed to handle extreme conditions and to transmit charging, load, and battery voltage and current information directly to a data logger by using SDI-12 or RS-232 commands. The data logger program can use the CH201 data to calculate a power budget for the system and remotely pinpoint power problems. SDI-12 or RS-232 connections are not required for normal operation, and the module is ready to use out of the box.

The CH201 has mounting holes on one-inch centers for mounting to a standard Campbell Scientific enclosure backplate—see the enclosure manual for mounting suggestions. See [FIGURE 6-1](#) (p. 9) for a typical enclosure installation using a CH201.

### NOTE:

By default, the CH201 module is programmed with a battery capacity of zero amp-hours (Ah). This sets the charger to charge at a lower current rate. A battery capacity must be configured into the CH201 to enable the more aggressive two-step constant voltage charging scheme. See [Battery families and capacity](#) (p. 15) for making changes by using *Device Configuration Utility*. A downloadable example program using SDI-12 to set the battery capacity is available at [www.campbellsci.com/downloads/ch201-program-examples](http://www.campbellsci.com/downloads/ch201-program-examples) .

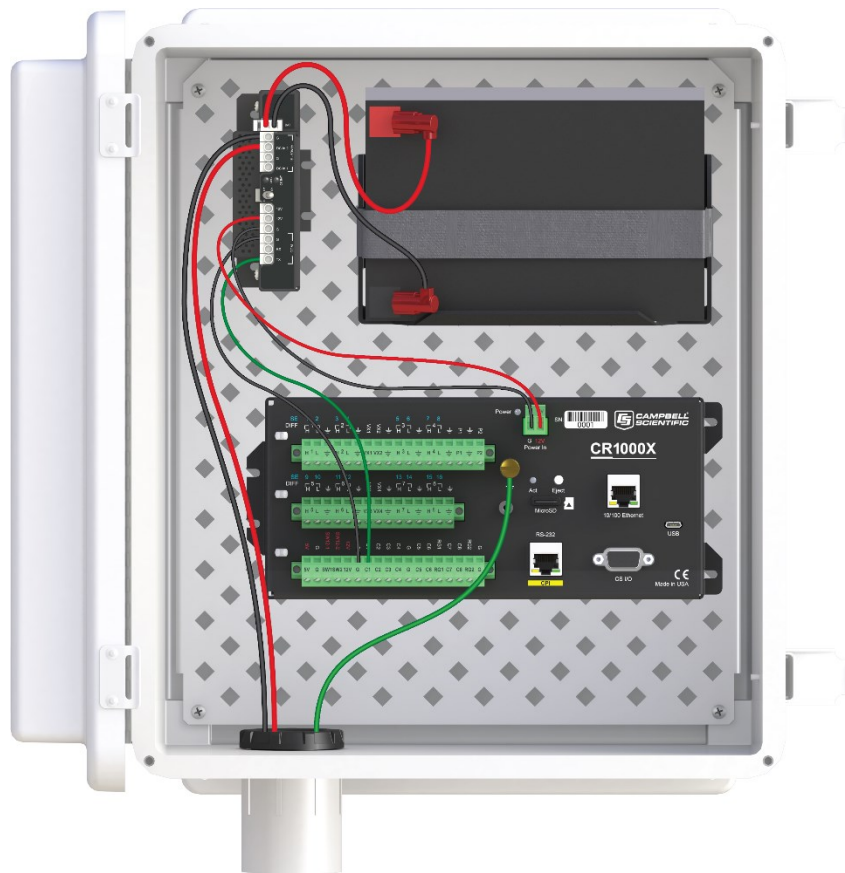


FIGURE 6-1. CH201 configured for SDI-12 communications

The installation section discusses the following:

6.1 Connect to power source .....	10
6.2 Connect to battery .....	11
6.3 Connect to data logger .....	11
6.4 (Optional) Connect to data logger for SDI-12 or RS-232 communications ..	11
6.5 Turn on power source .....	12
6.6 Turn on CH201 .....	12
6.7 (Optional) Configure using Device Configuration Utility .....	12

## 6.1 Connect to power source

### DANGER:

Although the power supply and battery are low voltage, they can heat a metal ring, watchband, or bracelet enough to burn skin or melt metal when shorted. Remove rings, watches, or bracelets before hooking up power and connecting a battery.

Unlike the CH200, the CH201 has two DC inputs instead of one AC and one DC input. A solar panel or AC-to-DC converter can connect to either input terminal. If both CH201 inputs are connected to power sources, the power source with the highest voltage will supply power to the CH201. Therefore, two solar panels can face different directions to allow the solar panel facing the most direct sunlight to power the CH201.

Toggle the power supply switch to **Off** before connecting power to the CH201.

### NOTE:

The switch on the CH201 only controls power going to the **12V** terminals. The battery is continuously charged regardless of the switch position when charging voltage is present.

### 6.1.1 Solar panel

### WARNING:

To prevent sparking while wiring the solar panel, lay the solar panel face down on its packing box or cover it with something to block the sunlight while wiring up the panel.

Connect the black (negative) wire from the solar panel to the G terminal that is adjacent to the **DC In 1** or **DC In 2** terminal. Connect the red (positive) wire from an unregulated solar panel to the **DC In 1** or **DC In 2** terminal. See [FIGURE 6-2](#) (p. 10).



FIGURE 6-2. Voltage input connections on the CH201

## 6.1.2 DC power

Double-check the input voltages coming in to the charger/regulator with a volt meter.

**DC In 1** Input Voltage: 15 to 50 VDC

**DC In 2** Input Voltage: 15 to 50 VDC

### **WARNING:**

Exceeding the maximum voltage will damage the CH201. Only one input is used at a time, whichever has a higher voltage.

## 6.2 Connect to battery

Only use the following battery cables with the CH201: pn 34029, pn 34031, pn 34040, and pn 36589. Connect the red wire to the positive battery post and the black wire to the negative battery post. Inset the connector into the CH201 **BAT** port.

## 6.3 Connect to data logger

The CH201 comes with a 1-foot black wire attached to a **G** terminal block and a 1-foot red wire attached to a **12V** terminal block. The data logger includes a voltage input terminal connector. The wires from the CH201 attach to this connector, which plugs into the **Power In** terminal on the data logger. Attach the red wire from the CH201 to the **12V** terminal on the connector; attach the black wire to the **G** terminal, then plug the connector into the data logger.

## 6.4 (Optional) Connect to data logger for SDI-12 or RS-232 communications

The **TX**, **RX**, and **G** terminals are used for communications. [FIGURE 7-3](#) (p. 23) shows example SDI-12 wiring and [FIGURE 7-4](#) (p. 26) shows example RS-232 wiring.

### **NOTE:**

Communications with the CH201 is required if the data logger is programmed to collect information from the power supply. See [Communications](#) (p. 21) for more information.

## 6.5 Turn on power source

Turn on the charging source power or uncover the solar panel. The green **CHG** LED should flash every 4 to 5 seconds, which indicates correct incoming connections and adequate charging voltage.

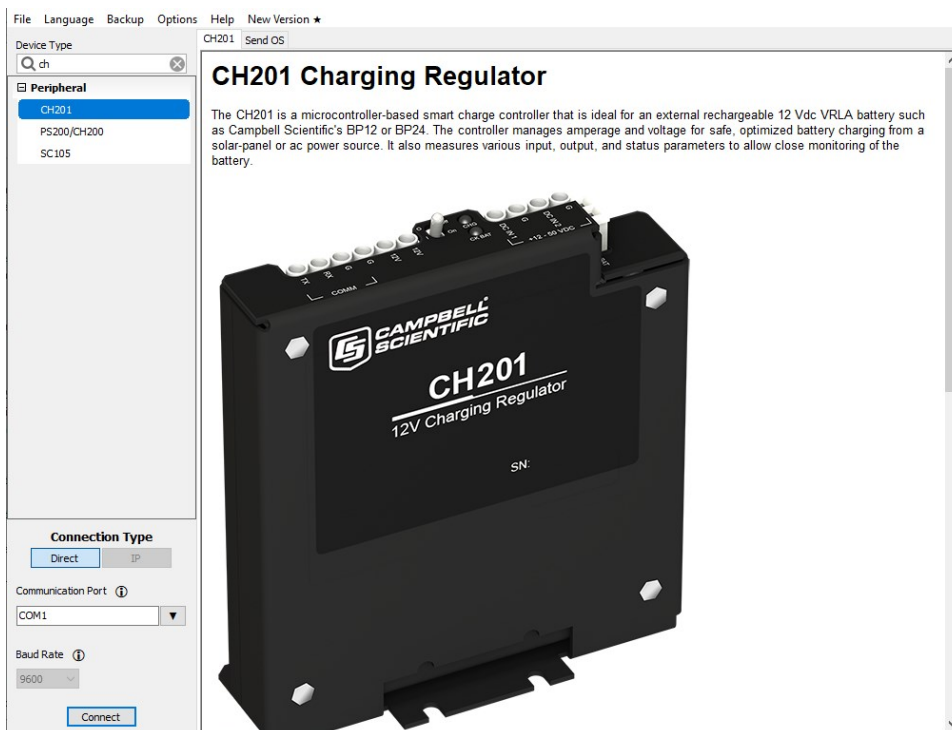
## 6.6 Turn on CH201

Toggle the switch on the CH201 supply to **On**. Check the voltage of the attached devices by using a volt meter.

## 6.7 (Optional) Configure using *Device Configuration Utility*

Using Campbell Scientific *Device Configuration Utility* is the easiest method to configure the CH201 and the only method to update the operating system. If updating an operating system, refer to [Downloading an operating system](#) (p. 31)

1. Select **CH201** in the **Device Type** list on the left of the *Device Configuration Utility* window.



2. Connect to the computer using an A200 device (see [FIGURE 6-3](#) (p. 13)). [Table 7-5](#) (p. 26) and the bottom of the CH201 *Device Configuration Utility* screen show wiring to an A200.

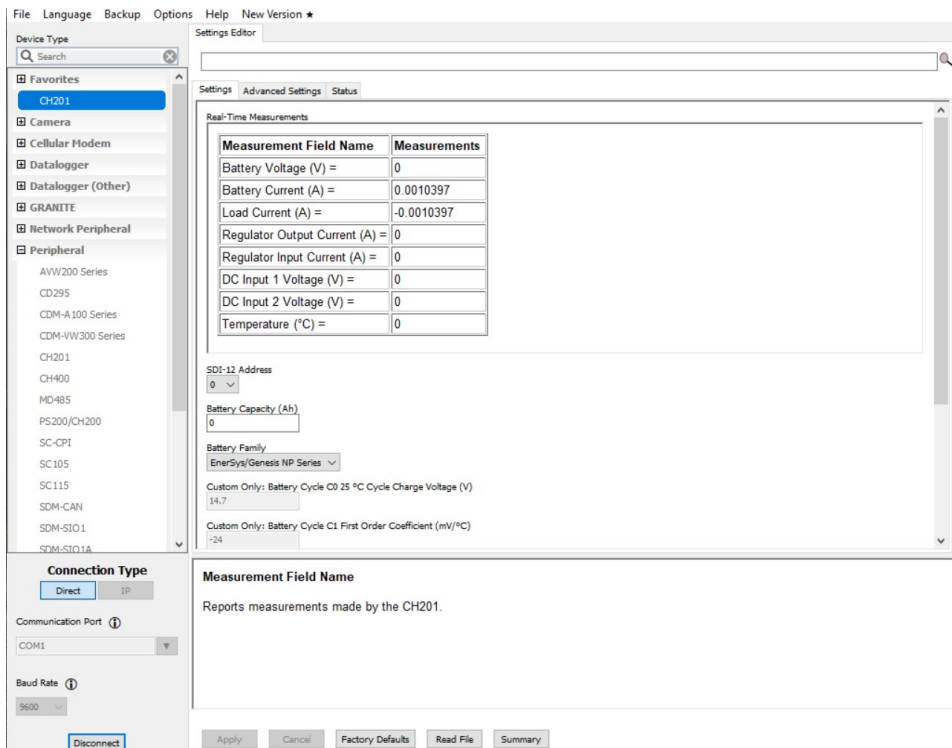


*FIGURE 6-3. Connecting the CH201 to a computer by using an A200*

3. Select the appropriate **Com Port**.
4. Power the CH201 from the A200, battery, or DC power source on the **DC In 1** or **DC In 2** terminals.



- Click **Connect** to access the **Settings Editor**. The **Settings Editor** displays real-time values (updated every second) and allows some settings to be changed.

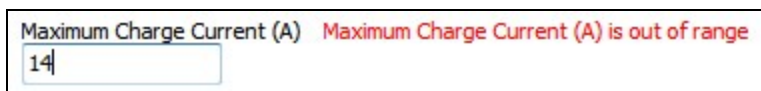


- To change a setting, select the field to be changed.

**NOTE:**

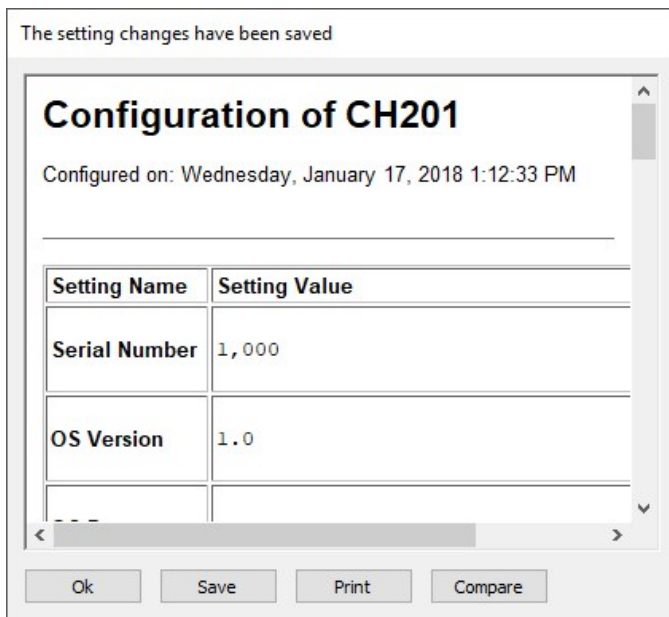
Although shown, the custom battery settings can only be changed if **Custom** is selected for **Battery Family**.

- Type a new value and press **Enter**. If the new value is not within an acceptable range, a red message will appear to the right of the new value as shown in the following image. Grayed-out fields cannot be changed. The bottom of the **Settings Editor** displays a description of and information for the selected setting.



- After changing settings, click **Apply**. If the CH201 accepts the settings, a configuration summary will appear.

- Click **Save** to use the **Read File** option in the future to check settings or apply settings to other CH201 regulators.



**TIP:**

Click the **Factory Defaults** button to revert to the factory default settings (read-only values are not affected).

**TIP:**

Click the **Read File** button to restore settings based on a file that was created earlier.

## 6.7.1 Battery families and capacity

The CH201 has built-in charging algorithms for the EnerSys/Genesis NP series of batteries (Campbell Scientific models BP7, BP12, and BP24), EnerSys/Cyclon Series, Concorde Sun Xtender (BP84), or it can use custom algorithms entered by the user. The CH201 uses a second order polynomial to make the correct battery charging adjustments for known battery families and charging cycles. See [FIGURE 6-4](#) (p. 16).

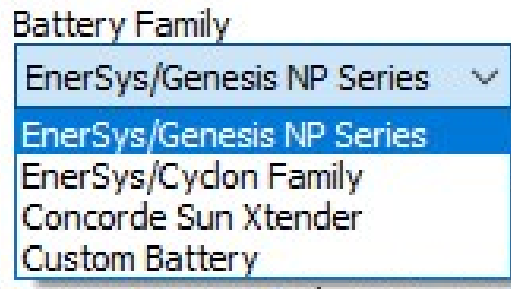


FIGURE 6-4. Battery family list

Set the **Battery Family** to match the battery family being used. The default settings are **Battery Capacity** of zero (0) and **Battery Family** of **EnerSys/Genesis NP Series**. Setting the **Battery Capacity** to zero (0) forces the charger to only float charge the battery. **Battery Capacity** must be changed to allow cycle charging. [Table 6-1](#) (p. 17) shows the default settings for each battery family. The settings are based on the following equation:

$$V_{\text{charge}}(T) = C_0 + C_1(T-25^{\circ}\text{C}) + C_2(T-25^{\circ}\text{C})^2$$

Where:

T = Battery temperature in ° C.

$C_2 = 0$  for linear charge voltage vs. temperature relation.

**Table 6-1: Battery specifications**

Battery family	Cycle C <sub>0</sub> (V) <sup>1</sup>	Cycle C <sub>1</sub> (mV/°C)	Cycle C <sub>2</sub> (mV/°C) <sup>2</sup>	Float C <sub>0</sub> <sup>1</sup> (V)	Float C <sub>1</sub> (mV/°C)	Float C <sub>2</sub> (mV/°C) <sup>2</sup>	Minimum Voltage (V)
EnerSys/ Genesis							
NP Series	14.70	-24	0	13.65	-18	0	12.5
EnerSys/ Cyclon Family							
Cyclon Series	14.70	-24	0.24	13.65	-24	0.24	13.2
Concorde Sun Xtender	14.31	-24	0.24	13.29	-24	0.24	13.0
Custom	User set	User set	User set	User set	User set	User set	User set
User Settable	Default = 14.70	Default = -24	Default = 0	Default = 13.65	Default = -18	Default = 0	Default = 12.5

<sup>1</sup> C<sub>0</sub> values are at 25 °C

**NOTE:**

Consider changing the **Custom Battery** default settings. See your battery manufacturer specifications for correct charging information.

The CH201 is designed to charge lead-acid batteries only. Lead-acid batteries come in three styles. The first two styles are valve-regulated lead-acid (VRLA) batteries. VRLA batteries are considered maintenance free because they do not require the addition of water to the cells. They also vent less gas than flooded lead-acid batteries.

- Absorbed Glass Mat (AGM) maintenance-free battery. This style of battery has the electrolyte (acid) absorbed and trapped in a glass fiber mat, which is sandwiched between lead plates. This battery is sealed. No water or acid can be added and the design allows the battery to be mounted in any position. This style battery is also called starved-electrolyte.
- Gel Cell maintenance-free battery. This battery has the electrolyte (acid) mixed with silica dust to form an immobilized gel, which is sandwiched between lead plates. This battery is sealed. No water or acid can be added. This type of battery can be sensitive to how it is mounted. See manufacturer for details.

- Flooded-Cell batteries. These are commonly used in automobiles. Deep-cycle marine batteries are usually flooded-cell batteries. These batteries use a liquid electrolyte and require the addition of water over time. They can only be mounted upright.

Different battery families and sometimes different manufacturers of the same battery style require different charging algorithms. For example, Campbell Scientific sells VRLA AGM style batteries from two different manufacturers — EnerSys/Genesis (BP7, BP12, and BP24) and Concorde (BP84) — yet both batteries require a different charging algorithm. The charging algorithm applied depends on the battery temperature and whether the battery is cycle charged (fast charged) or float charged. Each manufacturer has a recommended charging algorithm for cycle charging or float charging the battery. Cycle charging puts a higher voltage across the battery for a short time, forcing the battery to take in more current and charge faster. Cycle charging is recommended for systems running on solar panels so the maximum amount of current is moved into the battery as quickly as possible. Battery amp-hour capacity must be known when cycle charging to switch over to float charging at the correct point in the charging cycle, eliminating overcharging and damaging the battery. Float charging puts a lower voltage across the battery and is amp-hour independent.

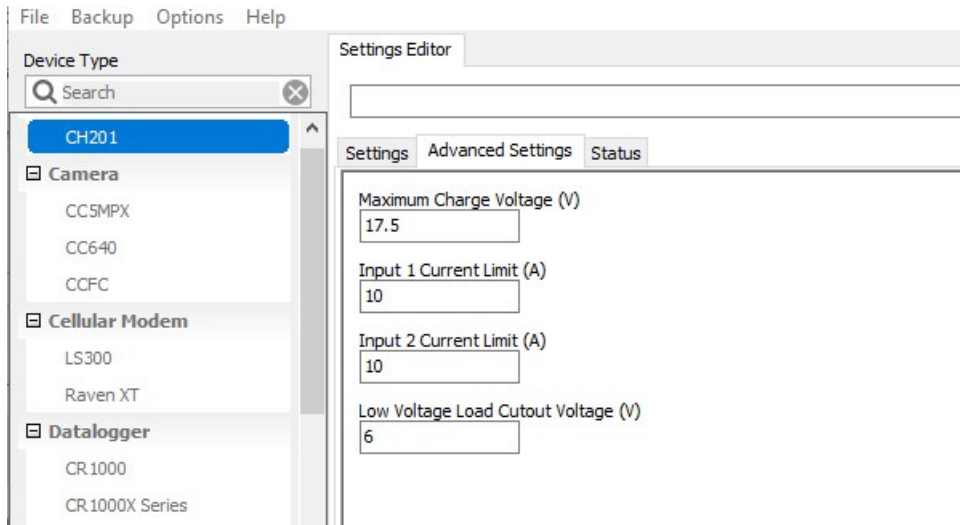


FIGURE 6-5. *Device Configuration Utility* Advanced Settings tab

When using a charger with current limiting feature, use the *Device Configuration Utility* to change the current limit in the CH201 to be slightly lower so that it doesn't trip the current limit feature of the charge source (see [FIGURE 6-5](#) (p. 18)).

# 7. Operation

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This section covers the following:

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## 7.1 Charging algorithm

The CH201 uses a two-step constant voltage charging algorithm, which is the preferred method for rapidly charging VRLA batteries<sup>1</sup> from a solar panel. If the CH201 is powered solely from a continuous power supply, bypass the two-step charging and use continuous, unaggressive charging by using the battery capacity setting of zero (default value). When powered from a solar panel, the battery charge deficit (Qloss) is compared to the specified battery capacity to determine if aggressive cycle charging is necessary. Cycle charging is used if Qloss is determined to be greater than 20% of the battery capacity. Upon detection that the battery is near full charge, the constant voltage charging level is reduced from the aggressive cycle charging voltage to the non-aggressive float-charge voltage to prevent overcharging and unwanted gassing of the battery.

If the battery capacity is left at the default value of zero, Qloss always equals 0, which disables cycle charging. Consequently, CH201 users must enter the battery capacity in the **Device Configuration Utility** to enable the aggressive cycle charging capability of the two-step constant voltage charging algorithm that is optimal for charging from solar panels.

Discharged VRLA batteries can initially accept large charging currents, often resulting in the charger being unable to initially maintain a constant voltage because of current limiting by the charge source or the charger itself. As a result, a typical two-step constant voltage charging cycle usually consists of three distinct stages; a current limited charge stage, a constant cycle voltage charge stage, and a constant float voltage charge stage (see [FIGURE 7-1](#) (p. 20)). The current limited stage and/or the constant cycle charge voltage stage may not occur if the battery size is

small relative to the current capability of the charge source, or if the battery is near full charge at the beginning of a charge cycle.

Normally, cycle charging terminates and float charging begins when  $Q_{loss}$  has been reduced to zero. An exception occurs if, during cycle charging the battery, charge current is reduced to below  $C/100$ , where  $C$  is the user-entered battery capacity. This condition indicates the charger is trying to aggressively cycle charge a fully charged battery, perhaps because a new fully charged battery was swapped in to replace an old battery that suffered from a significant  $Q_{loss}$ . During cycle charging, if the battery charge current falls below  $C/100$ , cycle charging is terminated and  $Q_{loss}$  is zeroed.

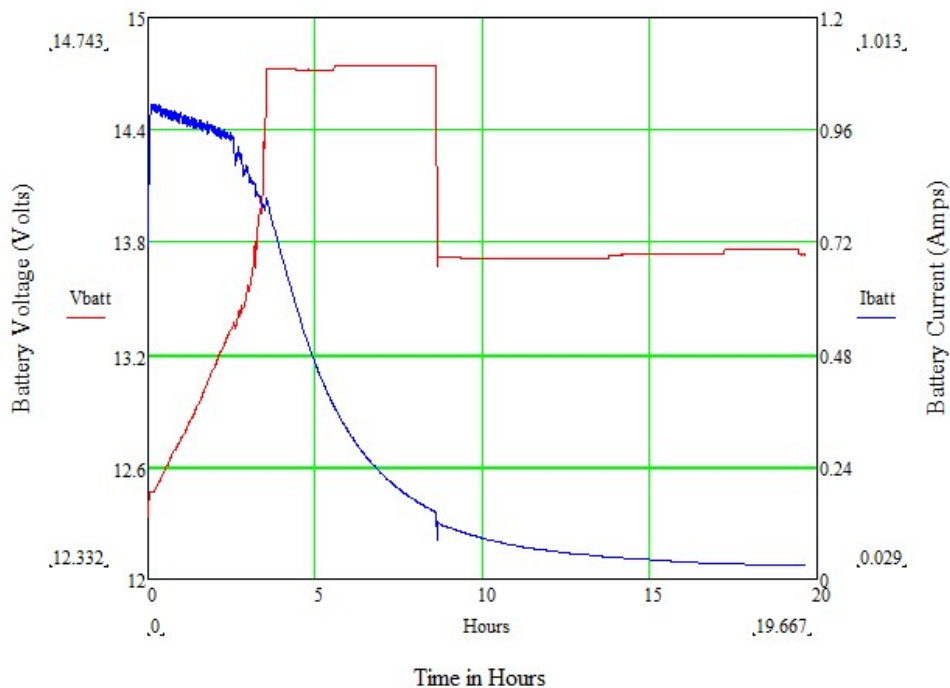


FIGURE 7-1. Two-step constant voltage battery charging

## 7.2 Maximum power point tracking

FIGURE 7-2 (p. 21) shows the current and power versus voltage for a 70 W solar panel. The graph shows the maximum power point of operation for the solar panel. Adjusting the load on the solar panel so it operates at this maximum power point is referred to as maximum power point tracking (MPPT). MPPT is beneficial when insufficient power is available from the charge source, which is the case during current limited charging. The noisy charging current and voltage observed in FIGURE 7-1 (p. 20) during the initial current limited charging stage is due to the MPPT algorithm of the CH201 searching for the maximum power point of the associated solar panel.

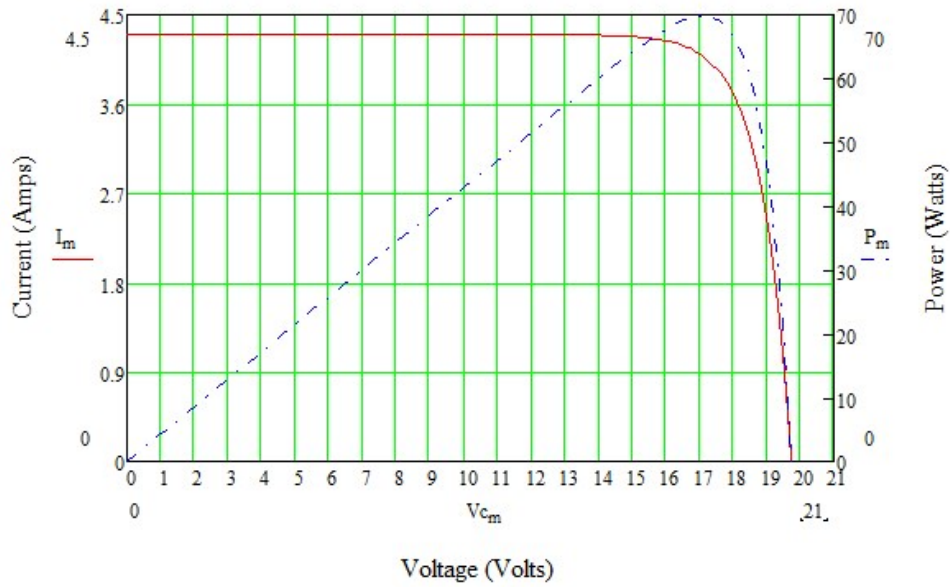


FIGURE 7-2. 70 W solar panel I – V and power characteristics

## 7.3 Communications

SDI-12 or RS-232 communications can be used to monitor the status of the battery, charging source, and charging regulator. [Table 7-1](#) (p. 22) lists the measurements available for both communications modes.



Measurement	Units	
Battery voltage	V	
Battery current	A	
Load current	A	
DC In 1 voltage	V	
DC In 2 voltage	V	
Temperature	°C	
Charge state	<i>SDI-12 Response</i>	<i>RS-232 Response/ DI-12 Meaning</i>
	-1	"REGULATOR FAULT"
	0	"NO CHARGE"
	1	"CURRENT LIMITED"
	2	"CYCLE CHARGING"
	3	"FLOAT CHARGING"
Charge source	<i>SDI-12 Response</i>	<i>RS-232 Response/ SDI-12 Meaning</i>
	0	"NONE"
	1	"DC In 1"
	2	"DC In 2"
Check battery	0 = normal 1 = check battery (battery voltage less than 10.5 V or battery is open circuit)	
Target battery voltage	V	
Input voltage at maximum power	V	
Battery capacity	Ah	
Qloss	Ah	

The information from the regulator can also be used to calculate power usage by the battery and the system. Measuring and storing power usage is useful to determine system power requirements (power budget) and to help identify devices using too much power. A

downloadable example program that monitors power usage is available at [www.campbellsci.com/downloads/ch201-program-examples](http://www.campbellsci.com/downloads/ch201-program-examples).

### 7.3.1 SDI-12 communications

SDI-12 is a serial communications standard specifically designed for reading measurements from multiple measurement sensors to data recorders, including Campbell Scientific data loggers.

Additional information about the SDI-12 protocol is available at [www.SDI-12.org](http://www.SDI-12.org) website and the [SDI-12 Sensors | Transparent Mode](#) and [SDI-12 Sensors | Watch or Sniffer Mode](#) videos.

To communicate with the CH201 using SDI-12, connect the CH201 to the data logger as shown in [Table 7-2](#) (p. 23).

Table 7-2: Wiring for SDI-12 communications		
CH201 connection	CH201 terminal function	Data logger connection
TX	SDI-12 transmit and receive	C or U <sup>1</sup> configured for SDI-12
G	Ground	⏏ (analog ground)
<sup>1</sup> U and C terminals are automatically configured by the measurement instruction.		

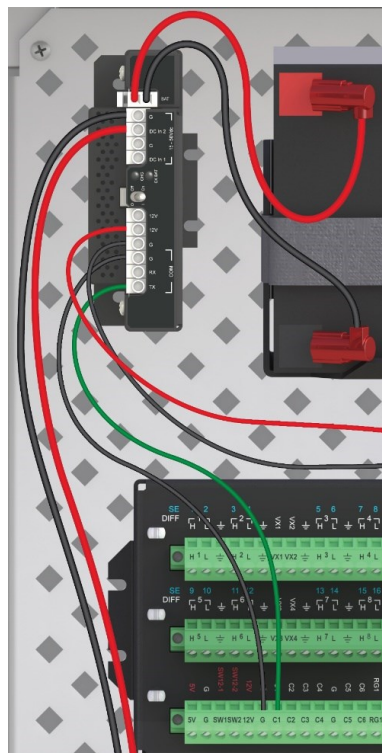


FIGURE 7-3. CH201 connected to a CR1000X via SDI-12

If multiple SDI-12 devices are connected to a data logger, Campbell Scientific recommends using separate terminals when possible. However, multiple SDI-12 devices can connect to the same data logger control or **U** terminal. Each must have a unique SDI-12 address. Valid addresses are 0 through 9, a through z, and A through Z. The CH201 has a default SDI-12 address of 0. The SDI-12 address can be changed by using *Device Configuration Utility* or an SDI-12 command (**aAb!**).


For the CR6 and CR1000X data loggers, triggering conflicts may occur when a companion terminal is used for a triggering instruction such as **TimerInput()**, **PulseCount()**, or **WaitDigTrig()**. For example, if the CH201 is connected to **C3** on a CR1000X, **C4** cannot be used in the **TimerInput()**, **PulseCount()**, or **WaitDigTrig()** instructions.

### 7.3.1.1 SDI-12 commands


SDI-12 command <sup>1</sup>	Values returned
aM!, aMC!	<ol style="list-style-type: none"> <li>1. Battery voltage</li> <li>2. Battery current</li> <li>3. Load current</li> <li>4. DC In 1 voltage</li> <li>5. DC In 2 voltage</li> <li>6. Temperature</li> <li>7. Charge state</li> <li>8. Charge source</li> <li>9. Check battery</li> </ol>
aM1!, aMC1!	<ol style="list-style-type: none"> <li>1. Charge state</li> <li>2. Charge source</li> <li>3. Check battery</li> </ol>
aM2!, aMC2!	<ol style="list-style-type: none"> <li>1. Target battery voltage</li> <li>2. Input voltage at maximum</li> <li>3. Battery capacity</li> <li>4. Qloss</li> </ol>

<sup>1</sup>a is the sensor address.

SDI-12 Command	Description	Response
<p><i>aXTnn.nn!</i></p> <p>Where:  <i>a</i> = CH201 SDI-12 address  <i>nn.nn</i> = temperature in °C</p>	<p>Overrides the internal temperature measurement for 15 minutes (or until canceled by a temperature restore command). Useful for entering the temperature of a remote battery. Temperature range is –40.00 to 100.00 °C.</p>	<i>aOK</i>
<p><i>aXTR!</i></p> <p>Where:  <i>a</i> = CH201 SDI-12 address</p>	<p>Restore temperature measurement to internal CH201 measurement.</p>	<i>aOK</i>
<p><i>aXCnn.n!</i></p> <p>Where:  <i>a</i> = CH201 SDI-12 address  <i>nn.n</i> = battery capacity in Ah</p>	<p>Enter battery capacity in Ah. Used to charge the battery correctly. Must be non-zero to use the quicker dual-rate charging scheme.</p>	<i>aOK</i>
<p><i>aXRQ!</i></p> <p>Where:  <i>a</i> = CH201 SDI-12 address</p>	<p>Sets Qloss to zero. If not used, the CH201 will automatically set Qloss to zero after trying to cycle charge a battery for eight hours or more.</p>	<i>aOK</i>

Downloadable example programs using these extended commands are available at [www.campbellsci.com/downloads/ch201-program-examples](http://www.campbellsci.com/downloads/ch201-program-examples) .

### 7.3.1.2 CRBasic programming

The CRBasic instruction **SDI12Recorder()** is used to program a data logger to communicate with the CH201 using SDI-12. Refer to the **CRBasic Editor** help for information about this instruction. Downloadable SDI-12 example programs are available at [www.campbellsci.com/downloads/ch201-program-examples](http://www.campbellsci.com/downloads/ch201-program-examples) .

## 7.3.2 RS-232 communications

The CH201 can use RS-232 to communicate directly with a Campbell Scientific data logger, or it can communicate with a computer through an A200 module. The following table shows the wiring for both connections.

Table 7-5: Wiring for RS-232 communications			
CH201 connection	CH201 terminal function	Data logger connection	A200 connection
TX	Transmit	C (even) (RX terminal of a COM port pair)	RX
RX	Receive	C (odd) (TX terminal of a COM port pair)	TX
COM G	Ground	G	G
DC In 1 or DC In 2	12 VDC	No connection	+12Vdc

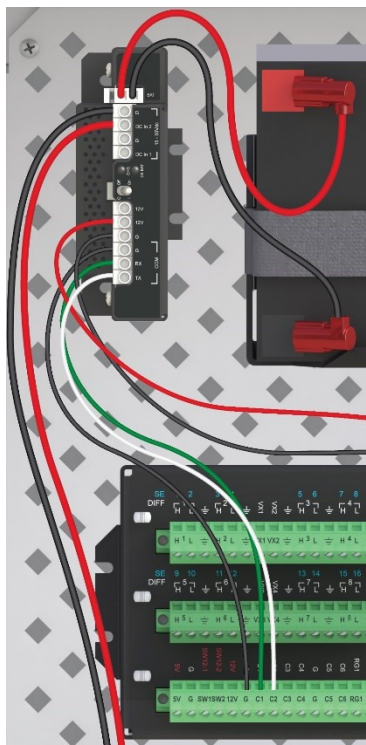


FIGURE 7-4. CH201 connected to a CR1000X via RS-232

RS-232 settings are as follows:

Bits per second: 9600

Data bits: 8

Parity: None

Stop bits: 1

Flow control: None

### 7.3.2.1 RS-232 commands

An RS-232 host initiates communication by sending an ASCII command string **CH201(n)x** terminated with <CR> (carriage return, 0x0D in hexadecimal format), where n = command number and x = command value.

The CH201 response string begins with an asterisk (\*), followed by the comma-delimited data strings and a checksum <CRC>. The string is terminated with <CR> <LF> (carriage return 0x13, line feed 0x10). Responses are numerical values with decimal points except for **Charge State** and **Charge Source**, which appear as ASCII strings.

Table 7-6: RS-232 commands and responses	
RS-232 command and response	Description
<p><b>Command:</b> CH201(0)0&lt;CR&gt;</p> <p><b>Response:</b> *, nnnn, nnnn, ..., &lt;CRC&gt;&lt;CR&gt;&lt;LF&gt;</p> <p><b>Where</b> nnnn = comma-delimited values and strings</p>	<p>Read CH201 status.</p> <p><b>Values Returned:</b> Battery voltage, battery current, load current, DC In 1 voltage, DC In 2 voltage, temperature, target battery voltage, maximum power input voltage setting, battery capacity, Qloss, charge state, charge source, check battery</p>
<p><b>Command:</b> CH201(1)nn.nn&lt;CR&gt;</p> <p><b>Where</b> nn.nn = temperature in °C</p> <p><b>Response:</b> *Battery Temperature = nnnn, &lt;CRC&gt;&lt;CR&gt;&lt;LF&gt;</p> <p><b>Where</b> nnnn = set temperature</p>	<p>Overrides the internal temperature measurement for 15 minutes (or until canceled by a temperature restore command). Useful for entering the temperature of a remote battery. Temperature range is -40.00 to 100.00 °C.</p>
<p><b>Command:</b> CH201(2)0&lt;CR&gt;</p> <p><b>Response:</b> *OK&lt;CRC&gt;&lt;CR&gt;&lt;LF&gt;</p>	<p>Restore temperature measurement to internal CH201 measurement.</p>

Table 7-6: RS-232 commands and responses	
RS-232 command and response	Description
<b>Command:</b> CH201(3) <i>nnn.nn</i> <CR>  <b>Where</b> <i>nnn.nn</i> = battery capacity in Ah  <b>Response:</b> *Battery capacity = <i>nnn.nn</i> <CRC> <CR> <LF>	Enter battery capacity in Ah. Used to charge the battery correctly. Must be non-zero to use the quicker dual-rate charging scheme.
<b>Command:</b> CH201(4) <i>nnn.nn</i> <CR>  <b>Where</b> <i>nnn.nn</i> = battery charge deficit in Ah  <b>Response:</b> *Qloss = <i>nnn.nn</i> <CRC> <CR> <LF>	Sets Qloss to zero. If not used, the CH201 will automatically set Qloss to zero after trying to cycle charge a battery for eight hours or more.

RS-232 command and response example:

Transmit: CH201(0)0<CR>

Receive:

\*, 14.726, 0.0514, 0.0017, 23.045, 0.2922, 25.03, 14.699, 18.45, 7.00, 2.99126, CYCLE CHARGING, DC In 1, 0, <CRC> <CR> <LF>

These values indicate the following:

Battery Voltage (V) = 14.726

Battery Current (A) = 0.0514

Load Current (A) = 0.0017

DC In 1 Voltage (V) = 23.045

DC In 2 Voltage (V) = 0.2922

Temperature (°C) = 25.03

Target Battery Voltage (V) = 14.699

Maximum Power Input Voltage (V) = 18.45

Battery Capacity (Ah) = 7.00

Qloss (Ah) = 2.99126

Charge State = CYCLE CHARGING

Charge Source = DC In 1

Check Battery = 0


### 7.3.2.2 CRBasic programming

Use the `SerialOut()` and `SerialInRecord()` CRBasic instructions to program a data logger to communicate with the CH201 using RS-232. To separate the numerical values, use `SplitStr()`.

The data logger can decipher the two-character checksum by using the CRBasic instruction `Checksum()`. Set the `ChkSumType` parameter to 5. A correct checksum will produce a result of zero. A non-zero result indicates a transmission error(s) occurred.

The normal communication mode is SDI-12. Therefore, when the host first sends RS-232 characters, the first character might be missed. Avoid this by initiating RS-232 communication with two backspace characters `<BS>` (`0x08`) as shown in the following example subroutine:

```
'Subroutine sends two backspace characters to the CH201 to  
'wake it up and switch over to RS-232 mode.  
Sub WAKEUP  
  SerialOut (COMPRT,CHR(&H08),"",1,3)  
  SerialOut (COMPRT,CHR(&H08),"",1,3)  
EndSub
```

Downloadable example programs are available at [www.campbellsci.com/downloads/ch201-program-examples](http://www.campbellsci.com/downloads/ch201-program-examples) .

## 7.4 LED indicators

The CH201 has two LED indicators, the **CHG** (charge) LED and the **CK BAT** (check battery) LED. [Table 7-7](#) (p. 30) and [Table 7-8](#) (p. 30) list the conditions and associated colors for the **CHG** and **CK BAT** LEDs.



Condition	Color/state
No valid charge source	Off
Valid charge source and charging battery	Flashing green
Valid charge source but battery discharging	Flashing orange
Regulator fault detected	Flashing red
Waiting for new operating system ( <a href="#">Downloading an operating system</a> (p. 31))	Solid red
Transferring operating system	Solid green

Condition	Color/state
Battery voltage > 11.5 V	Off
$10.5 \text{ V} \leq \text{battery voltage} \leq 11.5 \text{ V}$	Flashing orange
Battery fault detected OR battery voltage < 10.5 V	Flashing red

## 8. References

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1 – Genesis Application Manual – Genesis NP and NPX Series US-NP-AM-002, June 2006.

# Appendix A. Downloading an operating system

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Although rarely needed, the operating system is easily updated by using the *Device Configuration Utility* and the RS-232 interface cable (sold separately).

1. Download the latest CH201 operating system from [www.campbellsci.com/ch201](http://www.campbellsci.com/ch201) to your computer. This download is an executable file that automatically installs itself into the correct folders. Run the file on the computer that will be used to connect to the CH201.
2. Connect the CH201 to power then connect it to the computer.
3. Open *Device Configuration Utility*.
4. Select **CH201** from the **Device Type** list on the left of the *Device Configuration Utility* window.
5. Select the **Send OS** tab.
6. Click **Start** and the **Select the operating system to send** dialog window appears.
7. Navigate to the **CH201\_[version number].a43** operating system file and click **Open**.
8. The **CHG** LED changes from red to green, indicating the module is receiving a new operating system. The process will take a few minutes.

**CAUTION:**

DO NOT disconnect from the CH201 during this process.

9. When the operating system has been successfully sent, the green LED turns off and *Device Configuration Utility* will bring up a window showing the new operating system was successfully sent.

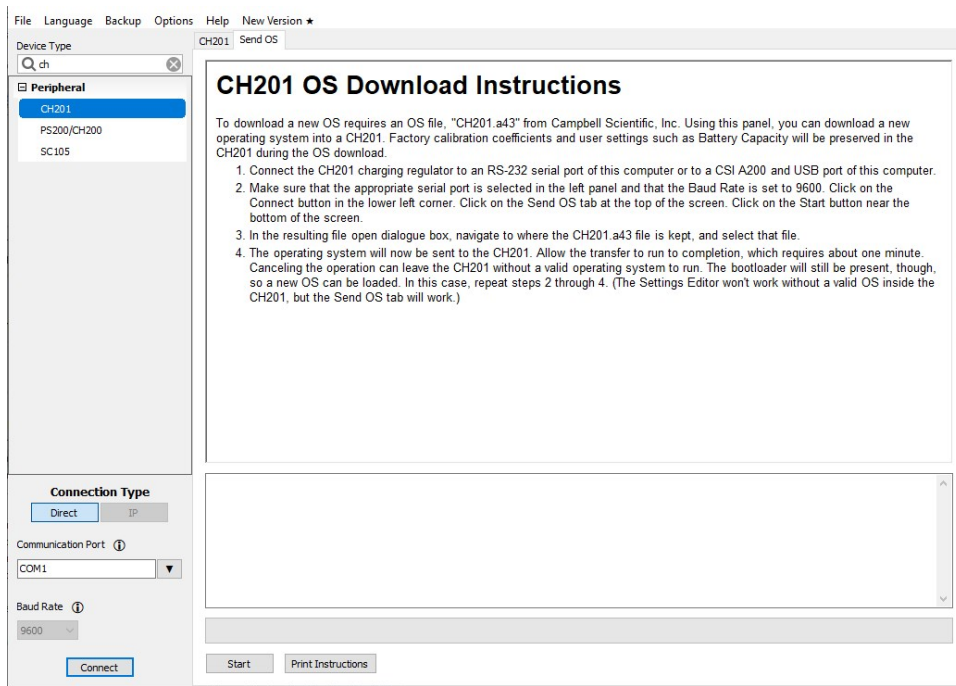


FIGURE A-1. Downloading a new operating system

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## General

- Protect from over-voltage.
- Protect electrical equipment from water.
- Protect from electrostatic discharge (ESD).
- Protect from lightning.
- Prior to performing site or installation work, obtain required approvals and permits. Comply with all governing structure-height regulations.
- Use only qualified personnel for installation, use, and maintenance of tripods and towers, and any attachments to tripods and towers. The use of licensed and qualified contractors is highly recommended.
- Read all applicable instructions carefully and understand procedures thoroughly before beginning work.
- Wear a **hardhat** and **eye protection**, and take **other appropriate safety precautions** while working on or around tripods and towers.
- **Do not climb** tripods or towers at any time, and prohibit climbing by other persons. Take reasonable precautions to secure tripod and tower sites from trespassers.
- Use only manufacturer recommended parts, materials, and tools.

## Utility and Electrical

- **You can be killed** or sustain serious bodily injury if the tripod, tower, or attachments you are installing, constructing, using, or maintaining, or a tool, stake, or anchor, come in **contact with overhead or underground utility lines**.
- Maintain a distance of at least one-and-one-half times structure height, 6 meters (20 feet), or the distance required by applicable law, **whichever is greater**, between overhead utility lines and the structure (tripod, tower, attachments, or tools).
- Prior to performing site or installation work, inform all utility companies and have all underground utilities marked.
- Comply with all electrical codes. Electrical equipment and related grounding devices should be installed by a licensed and qualified electrician.
- Only use power sources approved for use in the country of installation to power Campbell Scientific devices.

## Elevated Work and Weather

- Exercise extreme caution when performing elevated work.
- Use appropriate equipment and safety practices.
- During installation and maintenance, keep tower and tripod sites clear of un-trained or non-essential personnel. Take precautions to prevent elevated tools and objects from dropping.
- Do not perform any work in inclement weather, including wind, rain, snow, lightning, etc.

## Maintenance

- Periodically (at least yearly) check for wear and damage, including corrosion, stress cracks, frayed cables, loose cable clamps, cable tightness, etc. and take necessary corrective actions.
- Periodically (at least yearly) check electrical ground connections.

## Internal Battery

- Be aware of fire, explosion, and severe-burn hazards.
- Misuse or improper installation of the internal lithium battery can cause severe injury.
- Do not recharge, disassemble, heat above 100 °C (212 °F), solder directly to the cell, incinerate, or expose contents to water. Dispose of spent batteries properly.

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