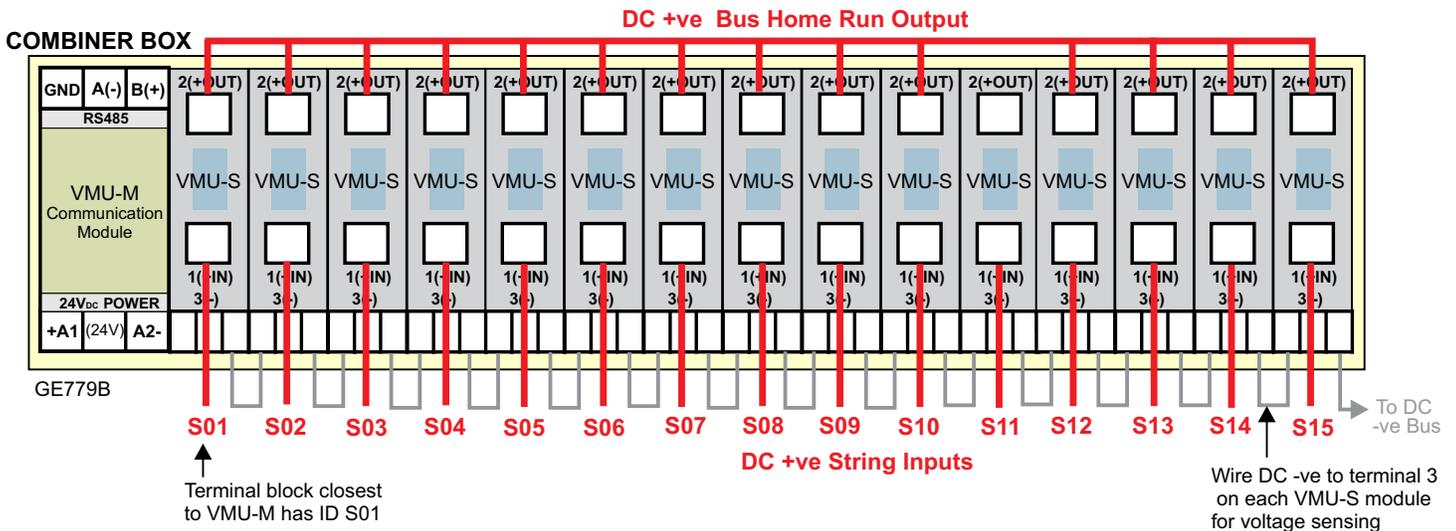


Fig 2 Smart combiner DC wiring with voltage sensing



RS485 Serial: Each combiner will need an RS485 serial connection and 24VDC control power for the current/voltage measurement as shown in figure 4. Combiners are daisy chained together and connected to the K135 gateway in the SolarVu enclosure. Typical layout for combiners that use the CG VMU-S current/voltage sensors is shown in fig 2 and 3.

Connect Cat5e outdoor grade CMX cable from the SolarVu enclosure to the smart combiners in a daisy chain sequence matching wire colors for D+, D- and GND/COM terminals as shown in Fig 4. Pay attention to the wire polarity of the D+ and D- RS485 connections to ensure successful communication. Each smart combiner VMU-M module must have a unique slave address which may be configured in the field to match the settings programmed into the SolarVu K135 gateway. These are shown on the SolarVu configuration form. If combiners have been pre-programmed and labelled at the factory, ensure the matching combiner box number and panel string wires are connected so the SolarVu strings are labelled correctly in the SolarVu online Combiner and Strings screens. Consult the Eos Array VMU-M instructions for field programming communications settings. A flashing green light on the VMU-M means communications on the RS485 is working. Solid green means power is OK but no communication. Red means alarm.

As shown in fig 2, the VMU-S terminal block closest to the VMU-M module will have a ID of C1-S01 (for combiner box 1). Each string can be named in SolarVu SETUP (see page 8) to match the designation used on the customer's panel layout drawings but the ID always matches the physical location of the terminal block.

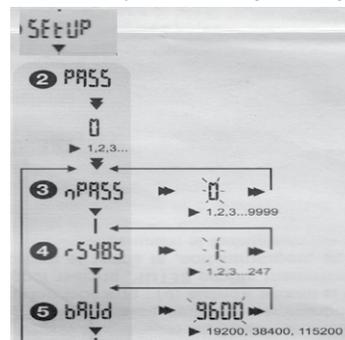
Power Supply: DC control power for each combiner can be provided from the 24VDC power supply in the SolarVu enclosure as shown in fig 4. This can be run in the same cat5e cable as the communication wire for short distances if the voltage drop from the #24 AWG pair is not excessive. Otherwise, use a separate #18AWG pair to supply power.

CHANGE VMU-M COMMS SETTINGS

Serial communications settings may be pre-configured at the factory. If they need to be entered in the field consult the VMU-M documentation for programming instructions. This is a summary example of the steps needed to program the VMU-M for settings RS485, 9600 baud, slave address 2

- Power on/off the VMU-M (24VDC) to initialize
- From the home screen push button multiple times until SETUP appears
- Hold (2 sec) button until PASS appears
- Hold (2 sec) button for 0 to appear
- Hold (2 sec) until nPASS appears
- Push then release once for rS485
- Hold (2 sec) button until slave address appears eg 1
- Push button multiple times until desired slave address appears eg 2
- Hold (2 sec) button to save slave address and return to rS485
- Push button once for baud to appear
- Hold (2 sec) button until baud rate appears eg 96 (96=9600)
- Push button for desired baud rate
- Hold (2sec) button to save baud rate

See Eos Array VMU-M Programming Guide for instructions



Web Portal

Once communication and control power to the combiners is connected, access the SolarVu energy portal online. Access the smart combiner screens by clicking ANALYZER --> Strings for graphical view and ANALYZER --> combiners for tabular data. Interpretation of each screen and alarm setup is described in the next few sections. If any combiners appear not to be communicating check the power indicator on the sensor module, communication connections and slave address settings. If assistance is needed contact Cachelan Technical Support.

Fig 3 Typical wiring showing DC strings, 24VDC control power and 485 serial communications

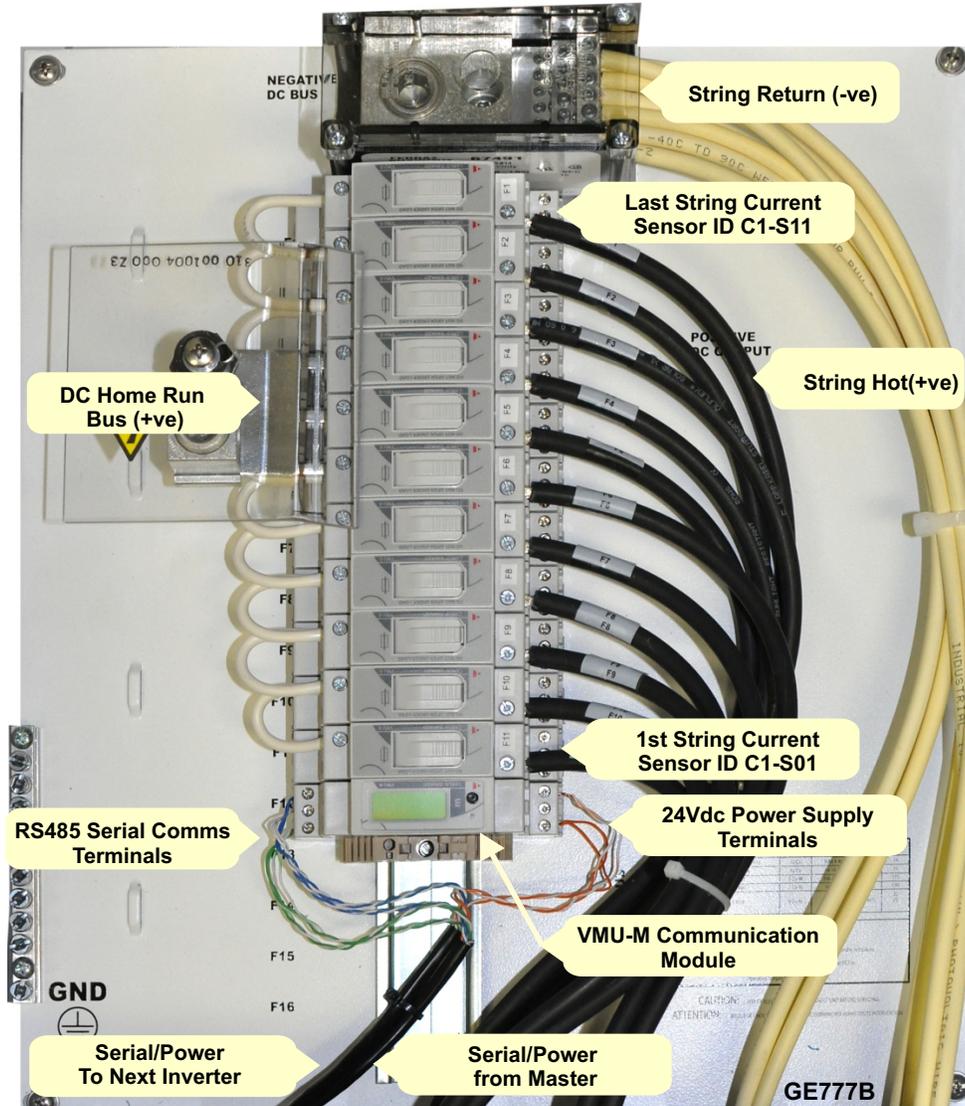
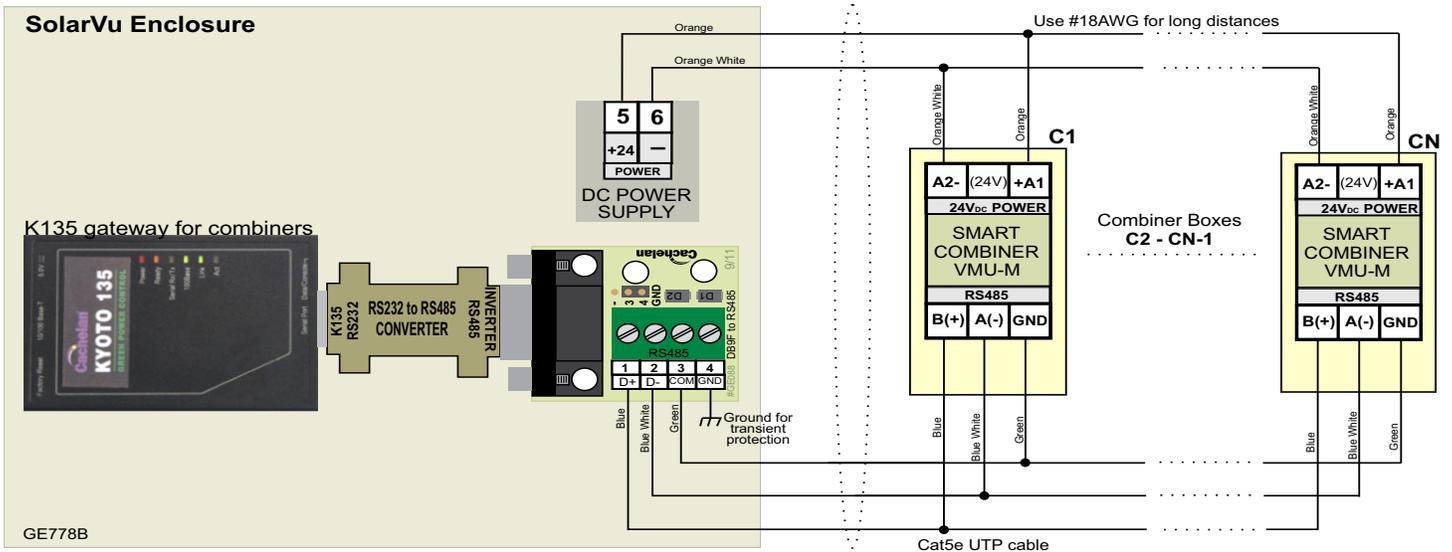


Fig 4 Smart combiner communication wiring using CG VMU-M communications module



ANALYZER

COMBINERS When a system is equipped with the smart combiners option, digital and graphical string current screens are available in the Analyzer pulldown menu. Use this feature to quickly identify under performing panels which are difficult to detect with only total system energy metering but if left unnoticed, could cost thousands of dollars in lost revenue over the system lifetime.

The screenshot shows the 'ANALYZER' tab selected. A dropdown menu is open showing 'Combiners'. The main content area displays a table for 'C01: Combiner 1 - ID 150'. The table has columns for ID, String Name, DC Current, DC Voltage, DC Power, and % Rel. Below the table are sections for Alarm, Sensors, ID, and STATUS. Numbered callouts (1-13) point to various UI elements.

ID	String Name	DC Current	DC Voltage	DC Power	% Rel
C01-S01	String 1	6.14 A	336 V	2,063 W	100 %
C01-S02	String 2	5.98 A	336 V	2,009 W	97 %
C01-S03	String 3	6.07 A	336 V	2,040 W	99 %
C01-S04	String 4	5.94 A	336 V	1,996 W	97 %
C01-S05	String 5	5.95 A	336 V	1,999 W	97 %
C01-S06	String 6	5.90 A	336 V	1,982 W	96 %
C01-S07	String 7	5.84 A	336 V	1,962 W	95 %
C01-S08	String 8	5.72 A	336 V	1,922 W	93 %
C01-S09	String 9	5.77 A	336 V	1,939 W	94 %
C01-S10	String 10	5.65 A	336 V	1,898 W	92 %
C01-S11	String 11	5.43 A	336 V	1,824 W	88 %
Total		64.39 A		21.6 kW	
Average		5.85 A	336 V	1,967 W	

Below the table, the Alarm section shows a Threshold of > 4.00 A avg and a Trigger of < 90 % of Rel. The Sensors section shows Internal Temp. of 0.0°C. The ID section shows Modbus ID of 150. The STATUS section shows 1 low current alarm.

- COMBINERS** Use the Analyzer pulldown box and select Combiners to see digital string current, power and alarm status. For a graphical view select Strings in this box or go direct using the Strings button ① ③.
- COMBINER ID:** Combiner name and serial address ID as defined in SETUP are shown for identification. The physical combiner boxes can be labelled with these names for easy matching to this online view.
- DC CURRENT:** Actual DC string current measured in the combiner box. Total current of all strings feeding the combiner home run output to the inverter, also known as the zone current is shown in ⑥
- % RELATIVE** Normally under any combination of irradiance and temperature, all strings with the same number of panels and orientation will have the same current. To identify problem strings, the highest output string is assigned a % REL value of 100% and the other strings are shown as the variation % from the maximum string in the combiner box. An alarm threshold ⑨ is entered in SETUP to warn when one string is too low ⑦.
- DC VOLTS & DC POWER** Combiner bus DC voltage and string power (amps * volts). Total DC output power for the combiner box is shown at the bottom of the column ⑥
- TOTAL CURRENT & POWER** Total current from all strings and power (common DC bus voltage * total current). Average current and average string power are also shown.
- ALARM WARNING** If current in any string falls below the alarm trigger setting and the minimum threshold is exceeded ⑨ the string row will be highlighted in red for easy identification of a potential problem. This will also trigger an alarm email to be sent.
- ALARM SETTINGS** After observing the normal variation of string currents for a new system, the alarm trigger should be set to be outside this range to send a warning without causing nuisance alarms. A string current of less than 90% of the maximum string is a good starting point. To prevent spurious alarms at the beginning / end of the day or under low light conditions when large variations are expected, the maximum string current must exceed the alarm threshold setting or alarms are blocked. Typically this will be set to 50% or more of expected peak capacity. Click the EDIT button to adjust these values in SETUP if necessary.
- SENSORS** Available values measured by the combiner box such as internal temperature are shown in this panel. Parameters may vary with combiner boxes from different vendors.
- STATUS** If any alarms are detected for the combiner box, the number of alarms will be shown in red. Otherwise Combiner OK in blue indicates everything is normal. Scroll down to check the status of each combiner box separately.

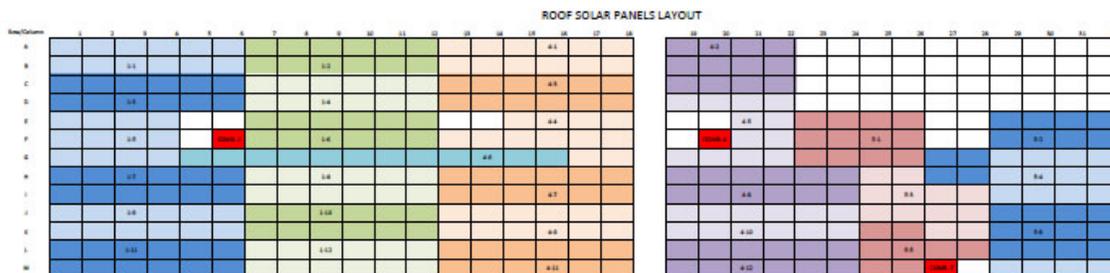
11 LAST UPDATE INDICATORS

Last Communication - Shows the last time a data message was received from the combiner boxes gateway. If the gateway has successfully established an internet connection this indicator will be green even if there is no connection to the combiners. If flashing red, check ethernet connection, IP settings and ensure the gateway is powered on. A single gateway is typically shared by all combiner boxes. Click the LISTEN button to determine cause.

Last Data Update - Once the gateway is successfully communicating to the combiner and sending data, this indicator will show if the data is valid. For normal operation, both indicators are green. If this indicator is red, check the connection between the combiner box and the gateway, that the combiner box is powered on and that the correct serial ID has been entered into each combiner box. A separate status indicator is provided for each combiner box for quickly identifying connection issues to any device. See SolarVu installation instructions for further details.

COMBINER/STRING LAYOUT

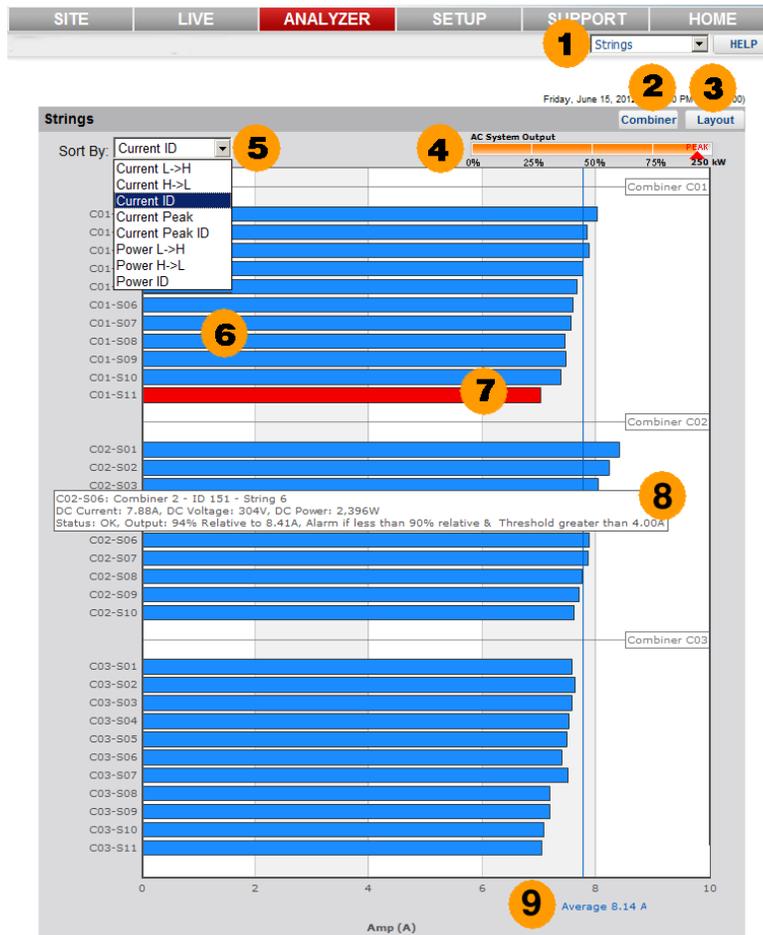
Combiner # - Serial #	1 - 11606		2 - 11607		3 - 11608		4 - 11609		5 - 11610		6 - 11611	
	109	111	13	17	15	18	19	20	14	16	108	110
Strings	1.1	1.9	2.1	2.9	3.1	3.9	4.1	4.9	5.1	5.9	6.1	6.9
	1.2	1.10	2.2	2.10	3.2	3.10	4.2	4.10	5.2	5.10	6.2	6.10
	1.3	1.11	2.3	2.11	3.3	3.11	4.3	4.11	5.3	5.11	6.3	6.11
	1.4	1.12	2.4	2.12	3.4	3.12	4.4	4.12	5.4	5.12	6.4	6.12
	1.5		2.5		3.5	3.13	4.5		5.5		6.5	6.13
	1.6		2.6		3.6		4.6		5.6		6.6	
	1.7		2.7		3.7		4.7		5.7		6.7	
	1.8		2.8		3.8		4.8		5.8		6.8	



- 12 LAYOUT DOCUMENTATION** To expedite commissioning for faster payment and to assist in identifying a bad panel when a string alarm is received, it is helpful to have design documents handy showing combiner ID / string # and the physical location of the associated panels. This documentation, typically a PDF file created from original design drawings, can be uploaded in SETUP to be available anytime for download by clicking the Layout button. Multiple pages can include other useful references like warranties, contacts etc.
- 13 STRINGS** Click the Strings button for a graphical view of string currents. These can be sorted by combiner, the entire roof, actual current, peak current and power. Alarms are displayed in red for a quick visual analysis of the entire system.

ANALYZER

COMBINERS When a system is equipped with the smart combiners option, digital and graphical string current screens are available in the Analyzer pulldown menu. Use this feature to quickly identify under performing panels which are difficult to detect with only total system energy metering but if left unnoticed, could cost thousands of dollars in lost revenue over the system lifetime. The strings screen is graphical for comparing relative panel output while the Combiners screen **1** is in text format for detailed analysis.



- 1 ANALYZER - STRINGS:** Select Strings in the ANALYZER tab selection menu, for a graphical view of string currents and power.
- 2 COMBINERS:** Alternate between graphical and text screens to view the information in different formats. Select Combiners in the Analyzer pulldown box or go directly from this screen using the Combiners **2** button to see digital string current, power and alarm status.
- 3 LAYOUT:** In SETUP upload a diagram of the panel locations by string and combiner on the roof for easy identification. Click the Layout button to view or print the saved drawing when doing commissioning or troubleshooting. The physical combiner boxes can be labelled at the site for easy matching to the online view.
- 4 AC SYSTEM OUTPUT:** Total AC system output similar to the LIVE screen is shown. When system output is very low, the individual strings may vary significantly but when running near capacity, the individual strings will normally closely match unless there is a problem.
- 5 SORT BY** Compare strings in different ways for a better understanding of performance. Strings are sorted relative to the largest string in the group to provide a meaningful comparison under any combination of irradiance and temperature.
 - Current L-->H:** All strings in the system are sorted from lowest to highest. Alarms will normally show up as a low relative value and hence appear at the top of the screen.
 - Current H-->L:** Similar to CURRENT L-->H except the order is reversed sorting from high to low with the largest current at the top.
 - Current ID:** Panels of different ratings or in different areas of the roof may be connected to separate combiner boxes for better matching. This view compares relative string values within each separate combiner box. Although the string current values may be quite different between combiner boxes, within the same combiner box they should be similar.

Current Peak: To analyze trends over time, the peak value since reset for all strings is continuously recorded and displayed. This selection sorts peak current values by all strings on the roof from highest to lowest. Reset the peak value in SETUP-->Equipment-->Combiners-->System to start a new measurement period. Hold the mouse over the peak area of the string bar for a popup showing the peak value and date when it last occurred.

Current Peak ID: Similar to current peak, but this screen sorts peaks by individual combiner boxes for easier comparison due to panel matching or different areas of the roof.

Power L-->H: If bus voltage is available from the combiner box home run output to the inverter then power can be displayed instead of current. When sorted from low to high for the entire roof, the strings with alarm conditions will usually appear at the top of the screen if enabled in SETUP.

Power H-->L: Similar to Power L-->H except sorted from highest to lowest with the highest output string appearing at the top. Scroll over with the mouse for details.

Power ID: When panels are arranged in strings with different ratings or on parts of the roof with different slopes then comparing string power by combiner box ID is a better than arranging them into a single group.

- 6 **STRING:** String name is entered in SETUP with the format C01-S02 where C01 is the prefix for combiner box 01 and the name, shown here as S02, can be entered by the user for easier identification. Blue indicates current, orange indicates power and red indicates an alarm condition for quickly identifying which strings need attention. By physically labelling the combiner boxes and strings at the site, this online identification will assist in quickly locating the panel or combiner that needs to be checked.
- 7 **ALARM:** Separate alarm trigger levels and holdoff thresholds can be set for each combiner box in SETUP --> Equipment -->Combiners. Alarms are set relative to the maximum string for valid comparisons under any combination of sunlight and temperature. Quickly scan for red alarm bars and scroll over the bar with the mouse for more details. Change the alarm trigger level in SETUP if normal variations are generating false alarms.
- 8 **DETAILS POPUP:** Hold the mouse pointer over any string for details of current measured values, alarm settings and status. This is useful for analyzing individual strings. Click the Combiner button  for a text screen of similar information.
- 9 **SCALE:** Scroll to the bottom of the screen to view the horizontal axis units if there are too many strings for the graph to completely fit on one screen. For easy readout, alternating gray and white vertical bands are used. A vertical colored line shows the average value for all strings.

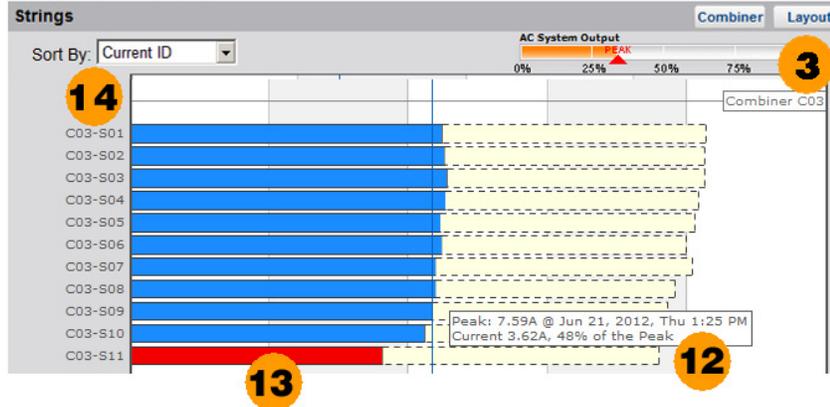
SETUP

Equipment - Combiners When a system is equipped with the smart combiners option, digital and graphical string current screens are available in the Analyzer pull down menu. Use this feature to quickly identify under performing panels which are difficult to detect with only total system energy metering but if left unnoticed, could cost thousands of dollars in lost revenue over the system lifetime. Enter parameters to display on the screens here including combiner and string names. Upload a file showing string layouts for easy retrieval to locate bad strings and combiners. Set alarms to warn of under performing strings for early detection. Reset the peak current recorder to start a new measurement period.

- 1 **SETUP - Equipment - Combiners:** Access the setup panels for all combiners by selecting this tab sequence. At the top are settings for the site. Scroll down to access each separate combiner box.
- 2 **BUTTON CAPTION:** A button with the default name Layout is provided on the string and combiner screens for downloading a layout drawing that has been previously uploaded ⑤. If desired, change the name to something else here.
- 3 **UPLOADED FILE / ALBUM:** Combine string layout drawings into a single PDF file and upload them for access from the String and Combiner screens for troubleshooting ⑤. Multiple files such as wiring diagrams can instead be grouped together into an album using WebFilm (SETUP -->Site-->Site Appearance-->WebFilm). Download the stored file or album using the Layout button.
- 4 **PEAK RECORDER:** SolarVu saves the peak current on each string and the date when the peak log was started. Click Reset to start a new Peak recording period. The old peak values will be erased. This is useful for observing maximum output during different seasons or to observe if the system is no longer producing the same output as previously. SolarVu also records the lifetime maximum current which displays when scrolling over the peak bar in the Strings screens. ①② Compare lifetime maximum to current peak to determine degradation over the life of the system due to aging. Lifetime maximum can only be factory reset.
- 5 **SAVE:** Periodically click the Save button to store entered values in the SolarVu server.
- 6 **COMBINER ID:** Each combiner has a default name of C01, C02... and a string default name S01, S02... For example C03-S12 is combiner #3 string #12. This name is shown on the string and combiner screens. ①④ The type and slave address of each combiner is factory programmed and shown here for reference but cannot be changed.

- 7) **COMBINER NAME:** For easier identification, each combiner box can be assigned a user name. Label the physical combiner box with the name entered here that shows on SolarVu screens ❶❷ to assist the maintenance electrician in identifying each combiner box and strings inside when locating bad panels.
- 8) **SHOW STRINGS:** Not all strings in a combiner box may be used. To prevent nuisance alarms for unused strings and a misleading graphical display in the strings screen, uncheck any strings that are not connected.
- 9) **STRING NAME:** String ID is in the format C01-S02 where C01 is the prefix for combiner box 01 and S02 is string position 2 within the combiner box. A user string name can be assigned to each string for matching to the assignments in the site layout drawing for easier identification. This name will appear in the Combiner and String Analyzer screens. ❶❷
- 10) **ALARMS:** With hundreds of panels operating over many years under varying weather conditions, a visual using the graphical strings screen with alarms highlighted will quickly identify strings needing attention. This also reduces the need for expensive annual maintenance checks of the entire system. If automatic alarms are desired, adjust the settings here after commissioning. Each combiner box has individual settings to allow for differences such as number of panels per string, location and panels installed with different ratings. Some experimentation with settings may be required to eliminate false alarms while still detecting real faults. Simulate a fault by temporarily covering one or more panels and check that the settings pick up the reduced output or removing a string fuse to verify an alarm is received. Strings with an alarm condition are highlighted in red on the Strings screen ❶❷ and pink ❶❷ on the Combiners screen.
Alarm Trigger: Since the output current will vary from 0-100% of rated capacity under different irradiance and temperature conditions, all strings within the combiner are compared as a percentage of the maximum string output. Assuming identical panels, equal panel count per string and similar orientation then theoretically all strings would be the same or 100% Rel (relative) to the maximum. In practice, due to manufacturing tolerances, aging and other factors expect a normal variation of 10-15% under varying conditions. Set the Alarm Trigger to be less than this value to prevent nuisance alarms but high enough to detect a significant deviation such as a faulty panel or blown fuse. To disable alarms completely, set the alarm trigger to 0% Rel on each combiner box. On a large system, if one combiner is not responding and requires maintenance or is waiting to be commissioned, temporarily uncheck the Show box ❶❷ so it will not continuously report alarms.
Alarm Threshold: At the beginning and end of the day or during overcast conditions when the system is operating at very low output, the strings will show large variations relative to each other. To prevent nuisance alarms under these conditions, the alarm threshold is used to block alarms until the system is operating at normal levels. Enter a typical value of 50% of system capacity eg 4 amps for strings with 8 amps maximum output.
- 11) **Actual Output:** To assist in selecting suitable alarm settings for each separate combiner box, the actual values under current conditions are displayed. If the system is operating normally with no faults, then set the Alarm Trigger outside this value. For example if the range is 90%-100% a setting of 85% might be low enough to prevent nuisance alarms but still detect if a panel has failed or is shaded by debris, dust or snow.

ANALYZER --> Strings



ANALYZER --> Combiners

C01: Combiner 1 - ID 151

ID	String Name	DC Current	DC Voltage	DC Power	Rel
C01-S01	String 1	4.29 A	355 V	1,523 W	99 %
C01-S02	String 2	4.14 A	355 V	1,470 W	97 %
C01-S03	String 3	4.05 A	355 V	1,438 W	94 %
C01-S04	String 4	4.09 A	355 V	1,452 W	95 %
C01-S05	String 5	4.03 A	355 V	1,431 W	94 %
C01-S06	String 6	4.00 A	355 V	1,420 W	93 %
C01-S07	String 7	3.98 A	355 V	1,413 W	93 %
C01-S08	String 8	3.91 A	355 V	1,388 W	91 %
C01-S09	String 9	3.85 A	355 V	1,367 W	90 %
C01-S10	String 10	3.81 A	355 V	1,353 W	89 %
Total		40.15 A		14.3 kW	
Average		4.02 A	355 V	1,425 W	

Alarm Threshold > 4.00 A AVG Trigger < 90 % of Rel Edit

Sensors Internal Temp. 22.7°C

ID Modbus Address 151 Serial Number 07333

STATUS 1 low current alarm

Listen Last Data Updated: Jun 22, 2012, Fri 9:05 AM (GMT -5:00)

Listen Last Communication: Jun 22, 2012, Fri 9:05 AM (GMT -5:00)

Cachelan Technical Support
contactus@cachelan.com
905.470.8400 x228