Campbell Scientific

SunSentry™

A pragmatic solution for safeguarding meteorological data

renewable energy

Campbell Scientific's SunSentry

Campbell Scientific's SunSentry doesn't just solve the operational meteorological monitoring challenge—it advances a sustainable and effective paradigm. Through thoughtful engineering and an innovative design, Campbell Scientific created a system that delivers the reliability you need with the flexibility you want, using several different tactics to minimize the difficulties in system reliability:

- Commitment to industry-preferred sensors and signals
- Optimized network topology
- Strategic optical isolation to provide paramount signal exactitude
- Configurable RS-485 termination
- Industry-leading technical support and project management

Which sensors should be used?

Meteorological (met) sensors come in myriad output signal options. Many sensor manufacturers, including Campbell Scientific, have made digital versions of their most popular sensors. Some sensors can also support multiple protocols. The utility-scale segment of the solar energy industry has been trending for years toward Modbus RTU over RS-485 as the standard sensor output protocol.

Modbus RTU is a simple communications protocol that is ubiquitous across many industries. It is easy to decode and makes error interpretation straightforward. Campbell Scientific chose Modbus RTU over RS-485 as the primary sensor communications protocol for the SunSentry station. This commitment to Modbus RTU over RS-485 provides several advantages:

- A wide variety of compatible digital sensors and peripheral devices provides valuable metadata.
- Stations are not constrained by independent sensor outputs such as analog measurements (one input per sensor).
- Common and well-understood industrial protocol and multi-drop connections allow for easier troubleshooting.
- Device pairings are easily customizable within the same system architecture (repeatable configurations).

Sensor selection will remain an important consideration across the industry and in different regions. With 50 years developing and deploying weather stations across the globe, Campbell Scientific knows what sensors should be used for various meteorological parameters.

Back-of-Module Temperature Measurements

For back-of-module (BOM) temperature measurements, Campbell Scientific recommends the CS241DM. The CS241 was the first series of BOM temperature sensors using a Pt-1000, Class A sensing element. The Pt-1000 is less susceptible to lead loss resistance errors when four-wire measurements are not possible. The CS241DM is the digital version in the CS241 series. In another first, the CS241DM has programmable termination resistance, a feature not commonly seen on many sensors.

Photovoltaic Soiling Measurements

For photovoltaic (PV) soiling, Campbell Scientific recommends the DustVue™ sensor. The DustVue uses the tried-and-true short-circuit current (I_{sc}) and BOM temperature measurement method. This method follows IEC 60904 for measuring photovoltaic current-voltage characteristics and is critical to properly determine the soiling ratio and soiling loss index. The DustVue design is reliable, does not require long periods for calibrations, and has no dependency on deposited particle sizes or size distributions.

Meteorological Measurements

For meteorological measurements, Campbell Scientific has been at the forefront of leading sensor development for 50 years. The ClimaVue™40 provides industry-required performance at an unbeatable price. The ClimaVue 40 integrates all industry-required—and some additional—meteorological parameters including wind speed, wind direction, ambient air temperature, relative humidity, barometric pressure, tipping bucket precipitation, and lightning detection.

Irradiance Measurements

Lastly, but most important to solar energy success, Campbell Scientific has spent decades making irradiance measurements at the highest metrological levels. Campbell Scientific is a leading trusted advisor and has developed a concise preferred list of irradiance sensors. These sensors provide excellent performance at a reasonable price. Preferred irradiance sensors include less expensive reference cells all the way to high-quality, ISO 9060:2018 Class A, spectrally flat, and fast-response pyranometers with integrated dew and frost mitigation. Campbell Scientific is also an irradiance sensor calibration provider with a strong connection to national metrology labs.

RS-485 Network Topology

Like many decisions, there are some limitations to consider when using Modbus RTU over RS-485. Most of these limitations are related to the topology of the RS-485 network. RS-485 defines the electrical characteristics to drive specific signals for communications. When used incorrectly, a network of RS-485 sensors can become unreliable. Below is an example station with common measurements seen at a utility-scale solar-power-producing site.

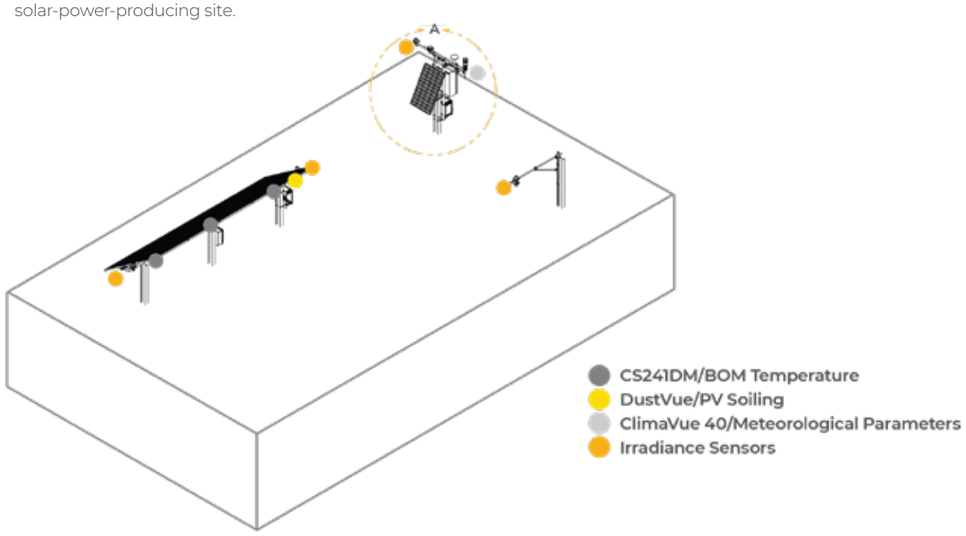


Figure 1. A simple drawing of common measurements on an operational monitoring station

From the drawing above, we can see some measurements are concentrated together while others are not. Is there an ideal topology or layout? Yes. However, in practice, it is difficult, if not impossible, to meet the ideal network topology. Poorly designed topologies can cause many different problems that can manifest themselves in complex ways and make troubleshooting in the field difficult. Campbell Scientific has taken steps within the SunSentry product design to minimize complications and ensure industry-leading data communications with maximum sensor uptime.

There are many resources available on RS-485 communications and network topology best practices. Anyone interested is encouraged to find, study, and be advised on their designs independently. Two of the first take-aways that you find in many RS-485 topology studies are: 1) daisy-chain topologies are good, and 2) star topologies are not good. Some documents will say star topologies are to be avoided at all costs.

The unfortunate reality when designing a system for meteorological monitoring is that star topologies are inevitable. In star topologies, sensors can be wired back to the main signal and power buses easily. A simple representation is below where servers (sensors) are responding to the client's (data logger) request.

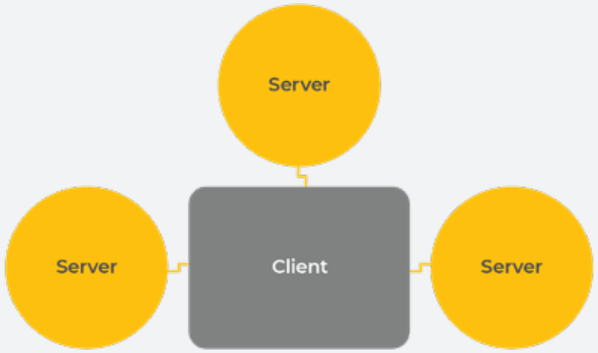


Figure 2. RS-485: Star Topology

This physical connection approach is very fast, simple, and easy to install in the field. Avoiding star topologies entirely would require harmonized sensor connector couplers or additional connection points, and—depending on the number of sensors—possibly more independent RS-485 channels. Below is a simple representation of a daisy-chain topology. Each server is connected to the server that follows. The SunSentry implements this with CS241DM sensors, which are easily and commonly daisy-chained.

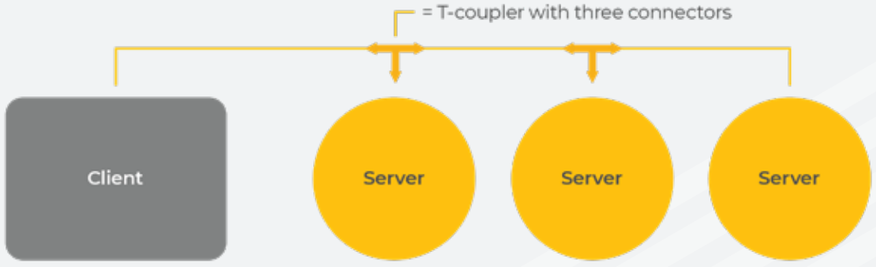


Figure 3. RS-485: Daisy-Chain Topology

The star topology can reduce signal quality, leading to an increase in missed or dropped Modbus responses. Star topologies are electrically parallel connections as opposed to the series connections of a daisy-chain. Instead of one branch for the signal to traverse, there are now multiple branches. These multiple branches can produce errant signal reflections or have signals attenuate incorrectly.

Another limitation to consider is that the total cable lengths of all sections/segments in the RS-485 network cannot exceed 1200 m. Take a simple example in which BOM temperature sensors are installed on solar modules 50 m, 100 m, and 150 m away from the end of an array or data logger. In a star configuration, each sensor would need to have the respective cable for the location of the measurement. In a daisy-chain configuration, shorter cable lengths can be used, helping save money while improving the network reliability.

With potentially 10–20 sensors on a single station, the total segments of cable could approach 1200 m. If an application required greater than 1200 m, then a separate/independent network would be needed.

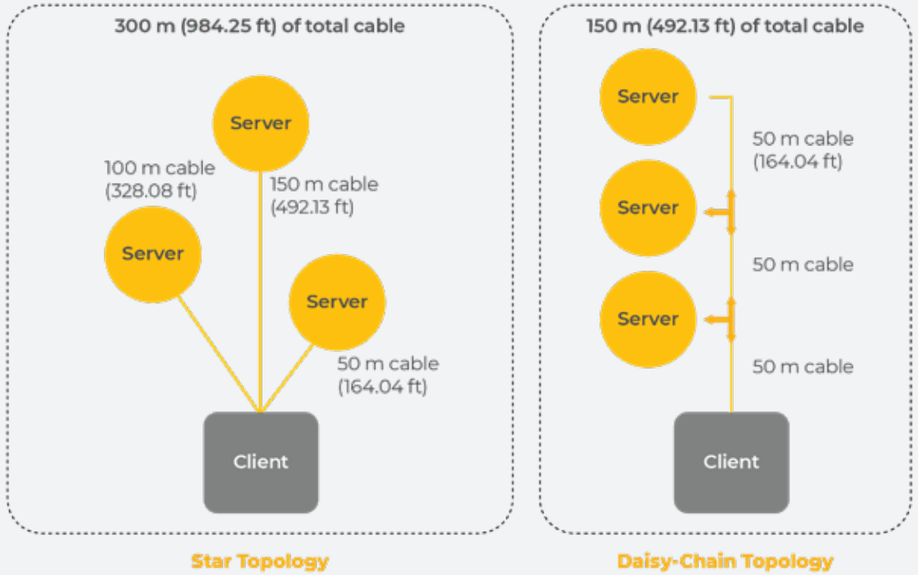
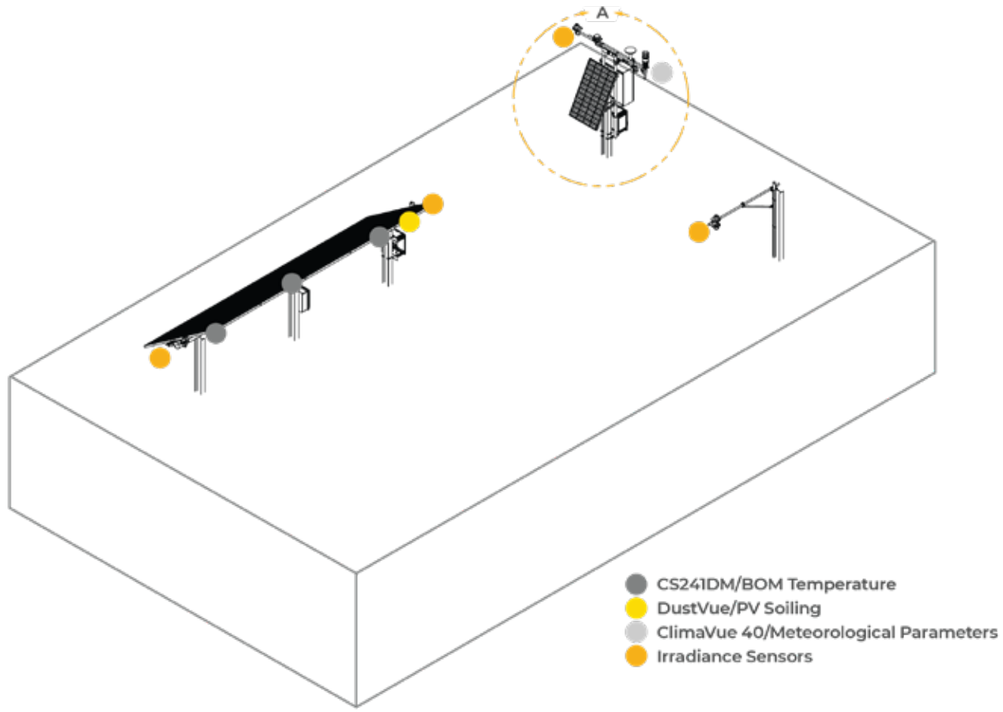


Figure 4. Star vs. daisy-chain topologies making measurements at 50 m, 100 m, and 150 m, respectively. Daisy-chained sensors can reduce the total cable segments in a network.



Let's consider Figure 1 (shown again above) as it is a typical solar energy operational monitoring case. This example follows Class A monitoring specified in IEC 61724-1:2021. Many contemporary projects use one-axis trackers and bifacial modules. One option in the IEC standard for bifacial monitoring would have at least one plane of array (POA) and three rear-side plane of array (RPOA) irradiance measurements. Add in the required three BOM temperature measurements and a soiling measurement or two, and you have eight or nine sensors needing connections and terminations.

In this example, a SunSentry station would use the required main met enclosure along with one junction box. The ClimaVue 40 and some irradiance sensors would be connected directly to the main met terminals while the CS241DM, DustVue, and additional irradiance sensors would land their wires in the junction box.

Independent and Isolated Networks

The SunSentry provides a hybrid approach to RS-485 network topologies by using a combination of daisy-chain and star branches, striking a perfect mix of performance and ease of use. A simplified wire diagram of the SunSentry is below.

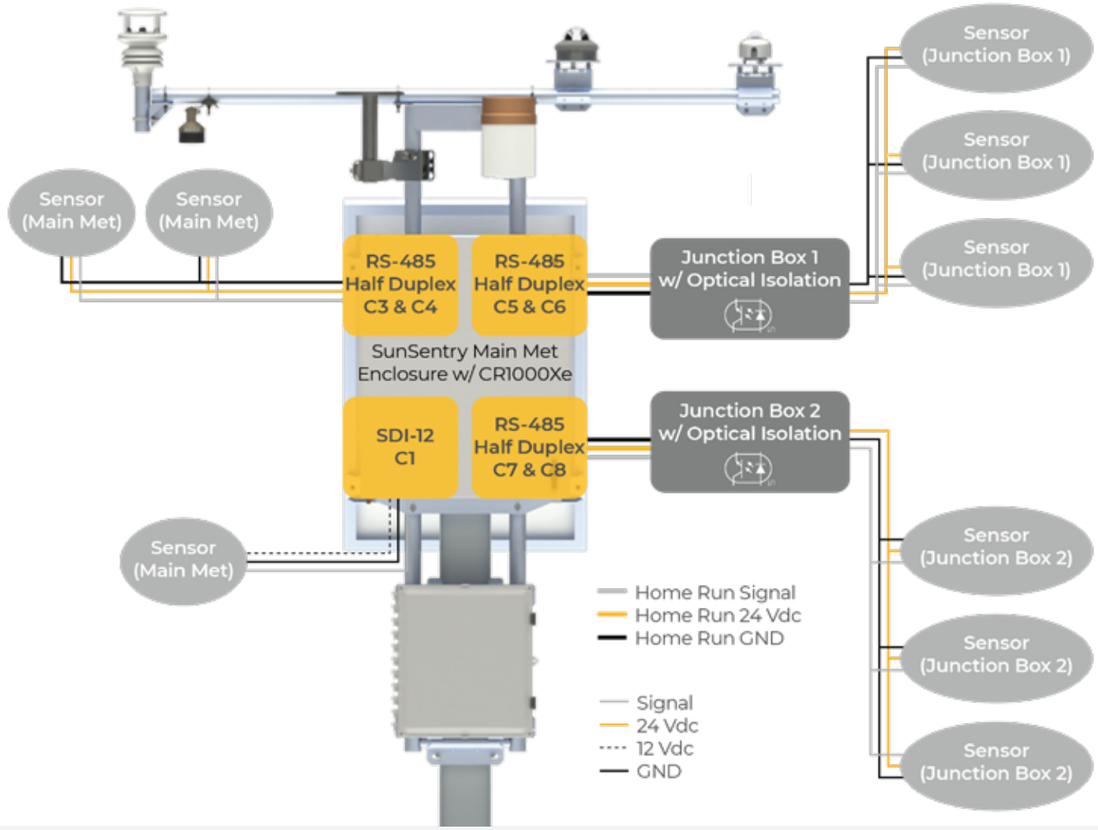


Figure 5. The SunSentry (simplified)

The SunSentry uses three independent RS-485 buses from the Campbell Scientific CR1000Xe datalogger. Each bus acts as an independent network providing the following benefits:

- Reduces or eliminates the requirements of long cables
  - Makes use of daisy-chains along the longest branches and with repeated sensor or measurement types
- Cleans up the entire monitoring platform
  - Reduces the number of sensors in a large star topology
  - Reduces the potential for data collisions
  - Enables better time usage due to multiple buffers managing sensor reporting delays
  - Provides independent signal protection for each channel

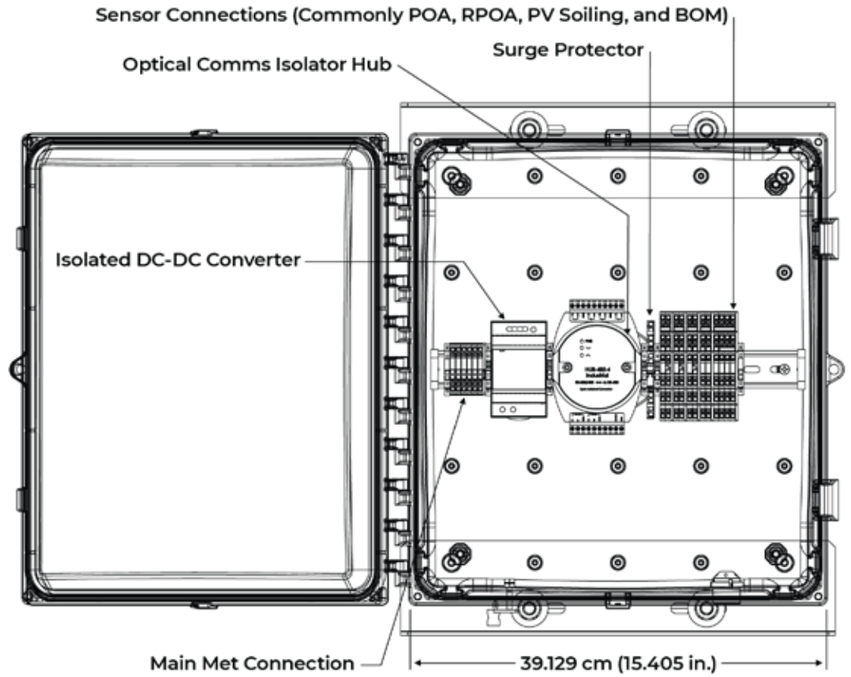


Figure 6. SunSentry junction box with optical isolation and surge protection

SunSentry junction boxes provide easy sensor landing in labeled terminal strips. Power to the associated sensors is handled by an isolated power converter/regulator with separate surge protection. Sensor signals are combined in an optical isolating hub. Optical isolation further liberates the networks, allowing for improved communication while also providing additional surge protection on the communications lines. All power and signals from the junction box return to the main met enclosure via home run cables. SunSentry stations follow industry best practices in surge protection selection and provisioning.

As mentioned earlier, CS241DM sensors follow a daisy-chain approach. We expect the BOM temperature measurements and RPOA measurements to be furthest from the junction box on the arrays. A daisy-chain branch for the irradiance sensors on an array is preferred, but this is a challenge with projects mixing vendors and models as sensor pin-out is not an industry standard. If possible, combining irradiance sensors in a daisy-chain topology is preferred via appropriate connectors and couplers.

Termination Resistors

While this topic can become complex quickly, Campbell Scientific sought to simplify the matter. One rule the stations follow is to terminate the longest branches in the network. As mentioned earlier, the CS241DM has selectable termination resistors. We expect the BOM temperature measurements to be some of the farthest measurements (longest cables) from the junction boxes or data loggers. Some but not all sensors on the market can apply termination resistors in a similar manner to the CS241DM. In the case that additional physical termination resistors are needed on a long branch of the network, Campbell Scientific can supply the needed items.

Data Acquisition and Communications

The CR1000Xe datalogger is a measurement and data powerhouse, an unmatched platform within the renewable energy market! With the CR1000Xe, SunSentry stations can accommodate up to 32 different RS-485 sensors. This is up to three times the scalability of competitive products. CR1000Xe dataloggers also have both common ground and resistive ground (RG) terminals for dialing in challenging installations and configurations.

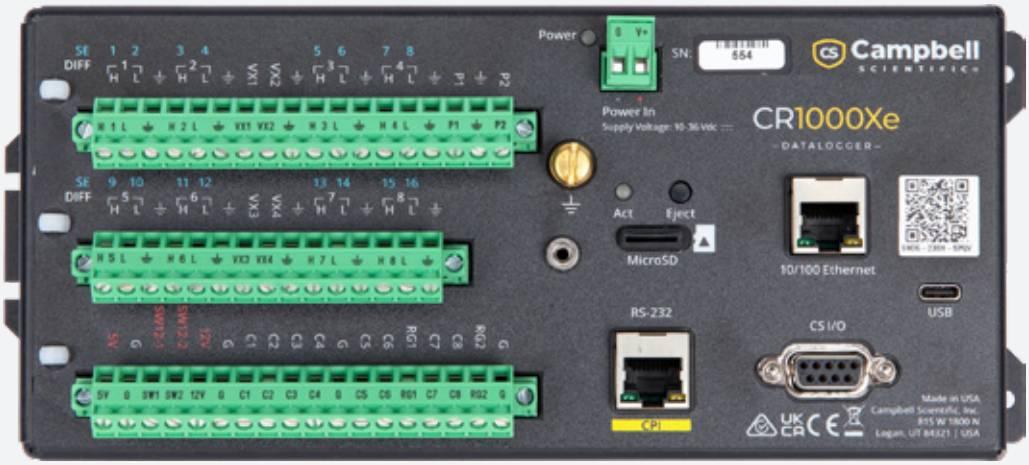


Figure 7. Campbell Scientific CR1000Xe Datalogger

The CR1000Xe retains all the industry-leading analog measurement channels while also sourcing more current to power sensors. The station is ready to handle whatever challenge is thrown at it. While not specific to RS-485 networks, the SunSentry provides all data via Modbus TCP, DNP3, FTP/S, and other common data-retrieval methods. The product meets ISO 27001:2022 for Information Security Management and will likely outlast the power purchase agreement at the site it monitors.

Altogether, Campbell Scientific has developed a robust measurement platform, ensuring the highest possible data availability. The hybrid network topologies retain ease-of-use while addressing critical points. Stations can be procured as stand-alone components or as turn-key stations with on-site installation and commissioning services provided by Campbell Scientific field services.

For more information about the SunSentry and how Campbell Scientific can help effectively execute your project, please contact **re.sales.na@campbellsci.com**.