



ITWatchDogs



RPM-X2

Remote Power Manager User Guide

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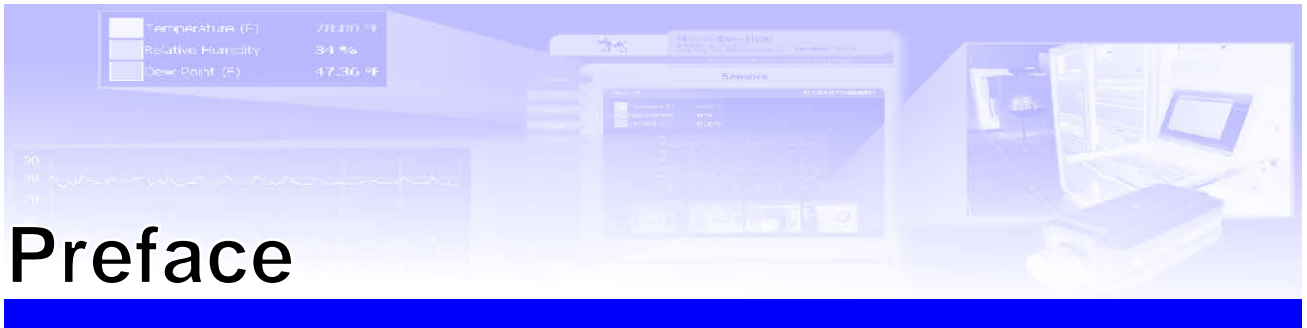
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Preface

About this Manual:

This manual is designed to help you set up and use your ITWatchDogs RPM-X2 Remote Power Manager. The first chapter will provide you with a basic introduction to the RPM-X2 itself, along with instructions on how to properly install and connect it; subsequent chapters will explain each of the RPM-X2's functions in detail. Note that this manual assumes that the user has at least some basic familiarity with configuring and using monitoring units from the ITWatchDogs *WeatherGoose Series-II* family, including how to connect external sensor devices via the Digital Sensor Bus and access the monitoring unit's configuration and control pages via a web browser.

Obtaining Related Documentation:

This manual is primarily concerned with the ITWatchDogs RPM-X2 Remote Power Manager, which is an optional accessory for the ITWatchDogs family of environment monitors. For more information or additional examples concerning the environment-monitor unit itself, refer to the appropriate manual for the specific model of ITWatchDogs environment monitor in question. These manuals can be downloaded from our web site, in the Support→Documentation section here:

<http://www.itwatchdogs.com/documentation.aspx>

Document Conventions:

This document uses some or all of the following conventions:

<i>system messages</i>	Messages which the unit displays to the user are shown in <i>monospaced italic "Courier"</i>
user-typed commands	Information you must enter is shown in monospaced "Courier"
[KEY]	Square brackets are used to indicate that the user should press a specific key or keys on the user's PC keyboard; i.e. [ENTER] means the user should hit the "Enter" key, as opposed to typing the word "enter". [CTRL][C] means to hit the "control" and "c" keys together.
web page controls	The names of buttons or control boxes on the unit's web page are shown in Arial italic .
<user setting>	Elements which the user must fill in with their own specific information are shown in <i>italics</i> between angle brackets; i.e. <ip address>, <account name>
Note:	Text highlighted in yellow means reader take note . Notes contain suggestions or cautions which the reader should keep in mind when trying to use a particular feature of the product.
Warning:	Text highlighted in red means reader be careful! Warnings indicate situations where equipment damage, malfunction, or data loss could result if the highlighted information or instructions are not followed by the user.
► Model-specific information	Information which only applies to one or more specific models will be highlighted in grey, with an ► arrow preceding the text.



Introducing your RPM-X2 Remote Power Manager

With many companies placing increased emphasis on energy efficiency and cutting operations costs, many IT-facility managers are finding it necessary to monitor the actual power draw of the equipment within their data-center racks. The ITWatchDogs' RPM-X2 Remote Power Manager allows users of the *WeatherGoose Series II*-family of monitoring equipment to add AC-power monitoring capabilities to their existing system; using the RPM-X2, you can keep a logged history of power usage over time, allowing you to spot trends in power usage, as well as setting alarm thresholds to give you early warning if the equipment connected to the RPM-X2 begins to draw too much current. (A good example of this would be keeping an eye on your ventilation fans; these often exhibit increased current draw when the bearings are starting to wear out and the motor has to work harder to keep the fan blades turning.)

The RPM-X2 also give you individual control over each of its two AC outlets, allowing you to selectively shut down or turn on any equipment connected to each outlet. This can allow you to remotely shut down overheating equipment, or to power-cycle and reboot a locked-up router, modem, or file server, without needing to physically visit the site to unplug and reconnect the balky device's power cord in person.

The RPM-X2 Remote Power Manager is compatible with any monitoring unit in the *WeatherGoose Series II*-family which has at least one available Digital Sensor Bus jack. (The *MicroGoose* is the only member of the *Series-II* family which is not compatible, as it does not have any connections for digital or analog sensors.) In general, the RPM-X2 will operate the same way regardless of which model it is connected to; therefore, in the majority of the instructions and diagrams on the following pages, we will simply illustrate the use of the RPM-X2 with a standard *SuperGoose-II* model, and will use the term "WeatherGoose" or "monitoring unit" to refer generically to the ITWatchDogs *WeatherGoose Series-II* family of monitoring units as a whole. If it is necessary to point out a particular behavior which only applies to a specific model, this behavior will be highlighted (as shown here), along with the specific model(s) to which the highlighted section applies.

Important Compatibility Information!

The RPM-X2 Remote Power Manager is a relatively new addition (as of the 2nd quarter of 2011) to our product line. If you purchased your *WeatherGoose Series-II* monitoring unit and additional sensors (if any) at the same time as your RPM-X2, your monitoring unit and sensors will have already shipped with the correct firmware revision and compatible hardware to support it. However, if you are attempting to use an RPM-X2 in combination with a monitoring unit and/or other external sensor devices which you may already have purchased and set up prior to the introduction of the RPM-X2, please read and be aware of the following compatibility requirements:

- **The RPM-X2 is only supported by the *WeatherGoose Series II*-family of monitoring devices.** *Series-I* models are not supported. If you are currently using a *Series-I* model, you will need to replace it with the equivalent *Series-II* model if you wish to add an RPM-X2 to your facility. If you are in doubt about which model you have, a visual guide to identifying your particular model can be found on our website here: <http://www.itwatchdogs.com/series.gif>
- **A firmware revision of v3.6.0 or higher is required.** If your monitoring unit is currently running a firmware revision prior to v3.6.0, you will need to visit the Support→Firmware area of our web site (<http://www.itwatchdogs.com/software-firmware-download.aspx>), to download and install the firmware upgrade for your monitoring unit prior to connecting the RPM-X2.
- **The RPM-X2 is not compatible with the older RTAF2 and RTAFH2 airflow sensors.** If you have an existing installation with one or more of these sensor devices attached, you will need to disconnect and remove them before you connect the RPM-X2, as these older sensor devices will cause data-communication errors if they are paired with an RPM-X2. (If the monitoring unit detects this conflict occurring on the sensor bus, it will display a warning message on its web page advising you which legacy sensor(s) are causing the conflict, and ask you to remove them.) This incompatibility between RTAF2 / RTAFH2 and the RPM-X2 applies to all WeatherGoose models and firmware revisions.
- Incompatibilities may also occur with certain versions of the RTHD2 (temperature / humidity / dewpoint) sensors, especially ones manufactured before the 4th quarter of 2010. Again, the unit will display a warning message if you have an incompatible RTHD2 connected alongside the RPM-X2.

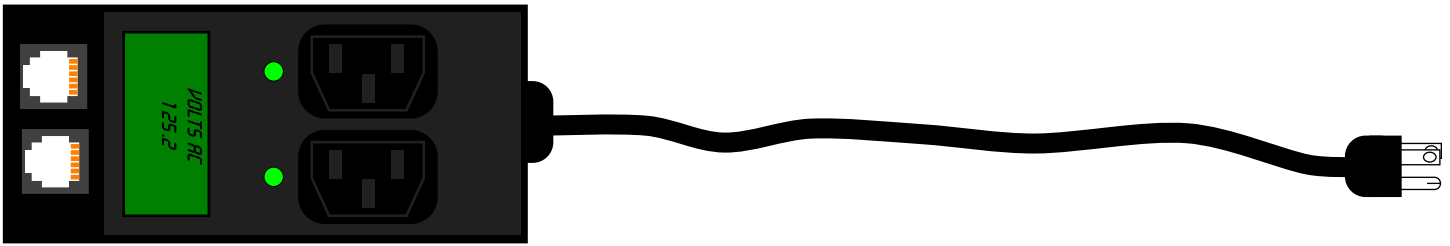
Other Digital Sensor Bus devices such as the RT-series temperature sensors, CCAT analog-to-digital converters, and the newer RTAFHD3 temperature/airflow/humidity “combo” sensors are not affected by this incompatibility. If you are not certain whether you currently have any of the older RTAF2 or RTAFH2 sensors in service, *Appendix A* of the “*RTAFHD3 Temperature / Airflow / Humidity / Dewpoint Sensor Installation & User Guide*” contains some diagrams to assist you in determining which type(s) of sensors you have installed.

ITWatchDogs apologizes for the inconvenience. Any customers who wish to add an RPM-X2 Remote Power Manager to an existing *WeatherGoose Series-II*-based monitoring system with RTAF2, RTAFH2, or RTHD2 sensors already attached are invited to contact our sales department, to discuss possible upgrade or replacement options for these devices.

Unpacking your RPM-X2 Remote Power Manager:

When you first open up the box your RPM-X2 came in, you should find the following items. (Note that the actual appearance of the devices you received may vary slightly from the sample illustrations shown here.)

RPM-X2 Remote Power Manager



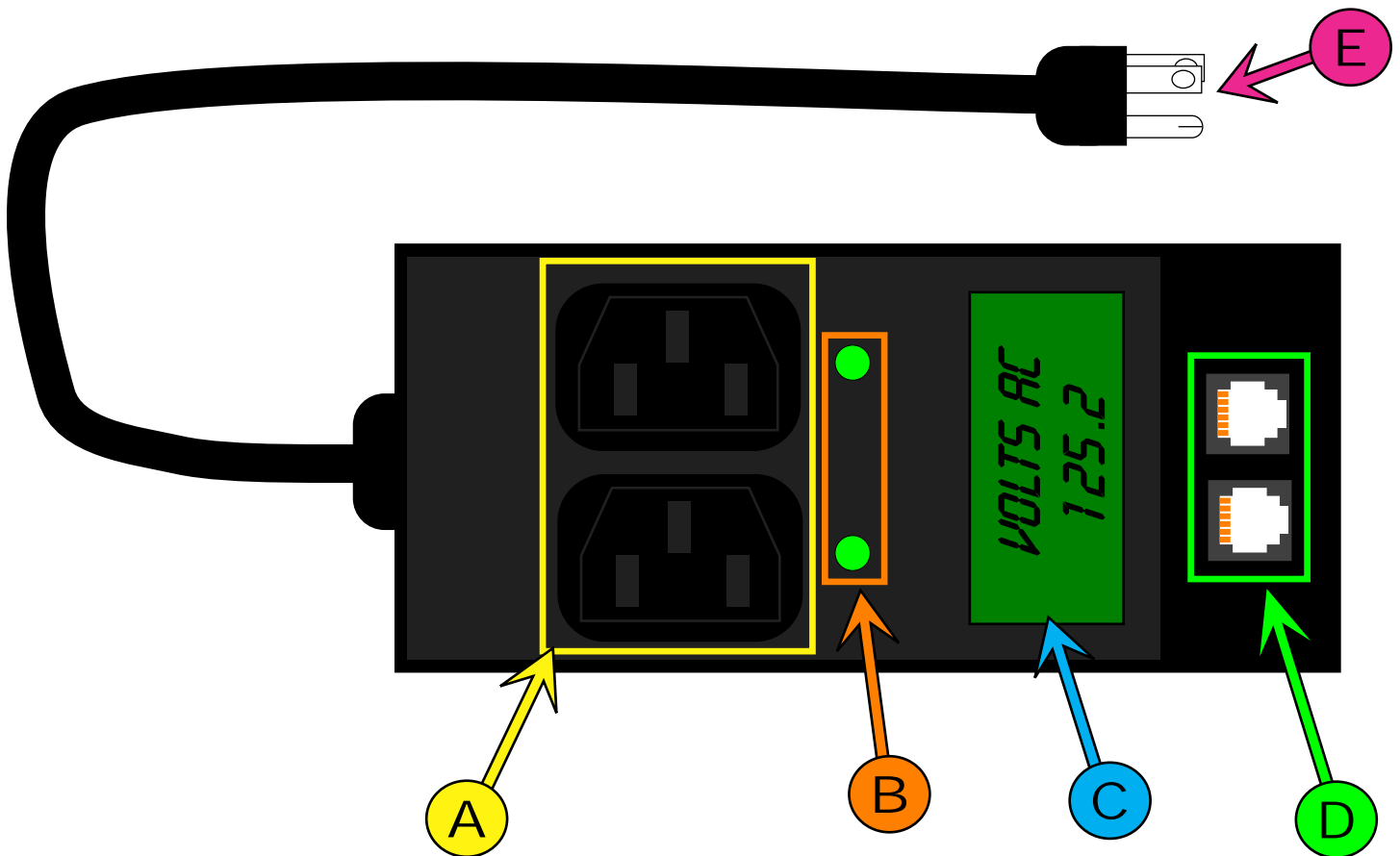
(This sample illustration shows an RPM-X2 equipped with a NEMA 5-15P power cord, and a pair of IEC C-13 sockets. The exact appearance of your model will vary, depending upon which combination of power-cord and socket options you specified when ordering.)

Uplink Cable



The standard Uplink Cable supplied with the I/O Expander is 10 ft. (3 m.) in length, with 6P6C modular connectors at each end. If your application requires a longer (or shorter) cable length, any suitable CAT3 or telephone-style patch cable can be used, as long as all six wires are connected “straight-through” from one end to the other; i.e. pin 1 to pin 1, pin 2 to pin 2, etc.

Below is a quick overview of the physical connections and indicators on the front and back of the RPM-X2 Remote Power Manager unit itself. (Note: the sample diagram shown below has been simplified for clarity; the actual physical appearance of the unit may vary slightly.)



A Relay-Controlled AC Power Sockets: The RPM-X2 Remote Power Manager provides two power sockets, either of which can be independently turned on or off via the web interface. (The illustration above shows an RPM-X2 equipped with a pair of IEC C13 sockets. Models with NEMA 5-15R or IEC C19 sockets are also available.)

Note that regardless of the socket type used, the maximum load that can be drawn on a single outlet is 12A, as this is the maximum current rating of the relay contacts. The maximum which can be drawn by both outlets together will depend on which power-cord option the unit is configured with; a NEMA 5-15P or IEC C-14 power cord will only permit a 15A combined load, while units equipped with a NEMA 5-20P or IEC C-20 cord can permit up to 20A.

B Power-Socket Status LEDs: Next to each AC power socket is an LED which indicates the outlet's status. If a socket's control relay is energized, the LED will illuminate to indicate that particular socket is "live" and that any equipment plugged into that socket is receiving AC power. Conversely, an unlit LED shows that the control relay is de-energized and that there is no AC power present at the socket.



LCD Status Display:

This status display provides a rotating display of the AC-power measurements being taken by the RPM-X2's metering circuitry. The display shows the current line voltage, power draw (both in amps and watts), power factor, along with historical statistics on the highest and lowest line voltages seen by the unit and the total number of kilowatt-hours metered by the unit. These measurements will be explained in more detail under *Configuring and Using the RPM-X2 Remote Power Manager*.



Digital Sensor Bus Jacks:

This pair of 6P6C modular jacks provides a connection between the RPM-X2 and the host monitoring unit, and from the RPM-X2 to another Digital Sensor Bus device. This allows you to “daisy-chain” several RPM-X2 units together, which can help reduce the aggregate cable-length totals and, in turn, simplify your cable management vs. having to run individual Uplink Cables back from multiple RPM-X2 units back to the host monitor.

Note that the maximum number of Digital Sensor Bus devices which can be attached to any one *WeatherGoose Series II*-family monitoring unit is 16. The “daisy-chain” jacks on the RPM-X2 do not increase this limit; i.e. if you have two RPM-X2's connected, they still count as two separate devices, regardless of whether one is daisy-chained to another or whether both are directly connected to the host monitoring unit.



AC Power Cord:

The RPM-X2 Remote Power Manager comes equipped with a 10ft (3m) power cord, equipped with either a NEMA 5-15P, NEMA 5-20P, or an IEC C-20 plug. Note that the plug and power cord are permanently attached, and are not interchangeable.



Specifications

- **Operating Voltage range:** 90 ~ 275VAC, 50/60Hz
- **Max. allowed current draw (*per outlet*):** 12A (@120VAC)
(*regardless of outlet type*)
- **Max. allowed current draw (*both outlets, combined*):**
(*with NEMA 5-15P or IEC C14 power cord*) 15A
(*with NEMA 5-20P or IEC C20 power cord*) 20A
- **Max. kWh (kilowatt-hours) metered:** 9999 hrs.
- **Maximum Digital Sensor Bus cable length:** 600ft (182m)
(*total including Uplink Cable*)
- **Operating Temperature Range:** -30°C ~ +85°C (-22°F ~ +185°F)
- **Supplied Accessories:** (1) Uplink Cable, 10ft. (3m.)

IMPORTANT NOTE:

This device has not been tested or certified to comply with ANSI C12.20 or IEC 62053 standards for electric-meter accuracy, and is not intended for use in applications which require “billing-grade” accuracy.



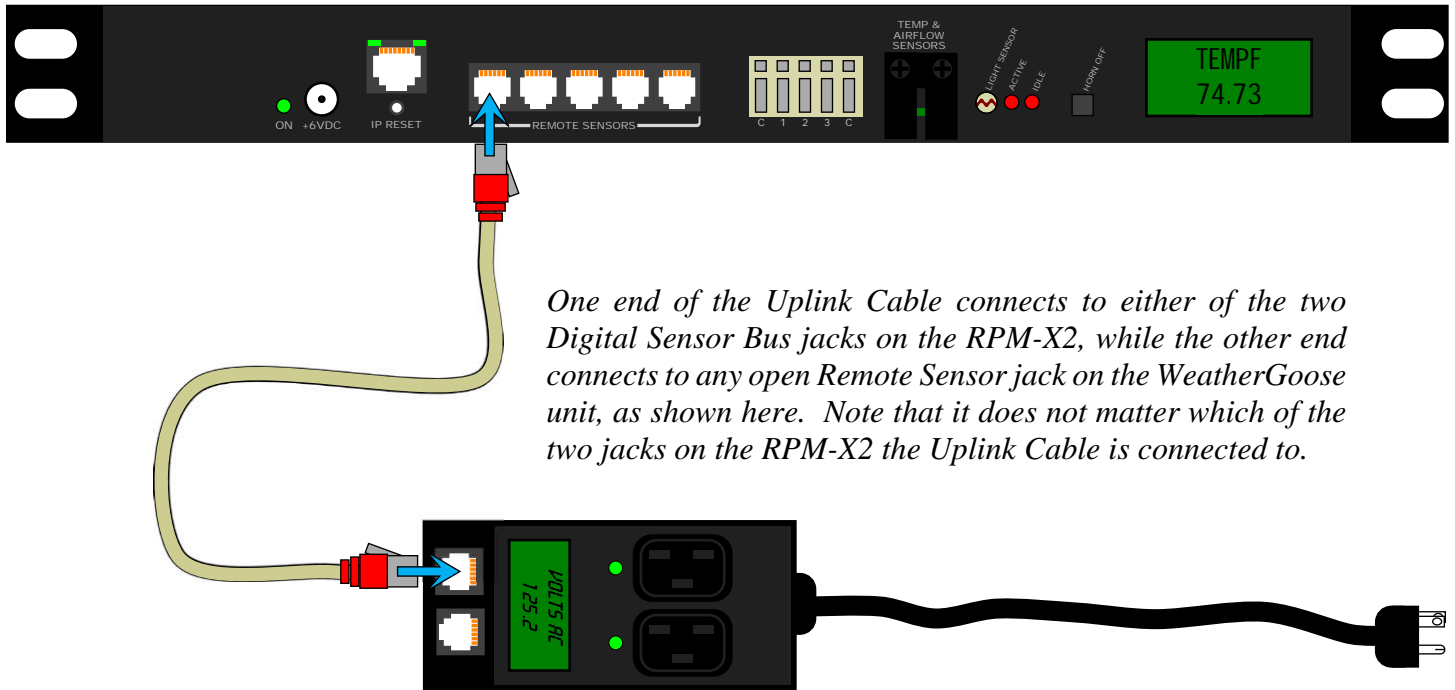
Hooking up the RPM-X2

Once you have mounted the RPM-X2 Remote Power Manager in the desired location in your equipment rack, the next step is to connect it to your monitoring unit, connect one or more loads to the relay-controlled power sockets, then plug the unit into AC power. The following sections will provide illustrated examples of how to:

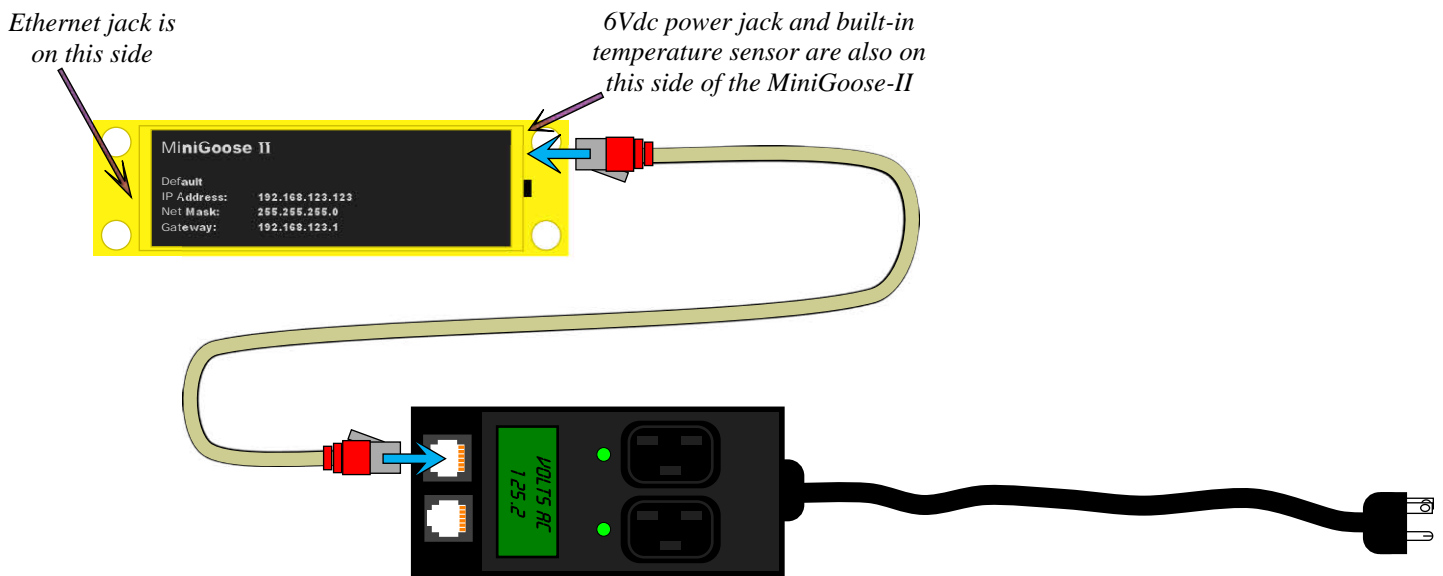
- Connect the Uplink Cable between the RPM-X2 and the host monitoring unit
- Daisy-chain additional Digital Sensor Bus devices to the RPM-X2
- Connect equipment to the relay-controlled power sockets
- Connect the RPM-X2 to AC line power

Connecting the Uplink Cable to the host monitoring unit:

The diagram below illustrates the connection to a standard SuperGoose-II monitoring unit as an example; other rack-mounted units, such as the RelayGoose-II, WeatherGoose-II, or MiniGoose/XP-II, will connect in a similar fashion.

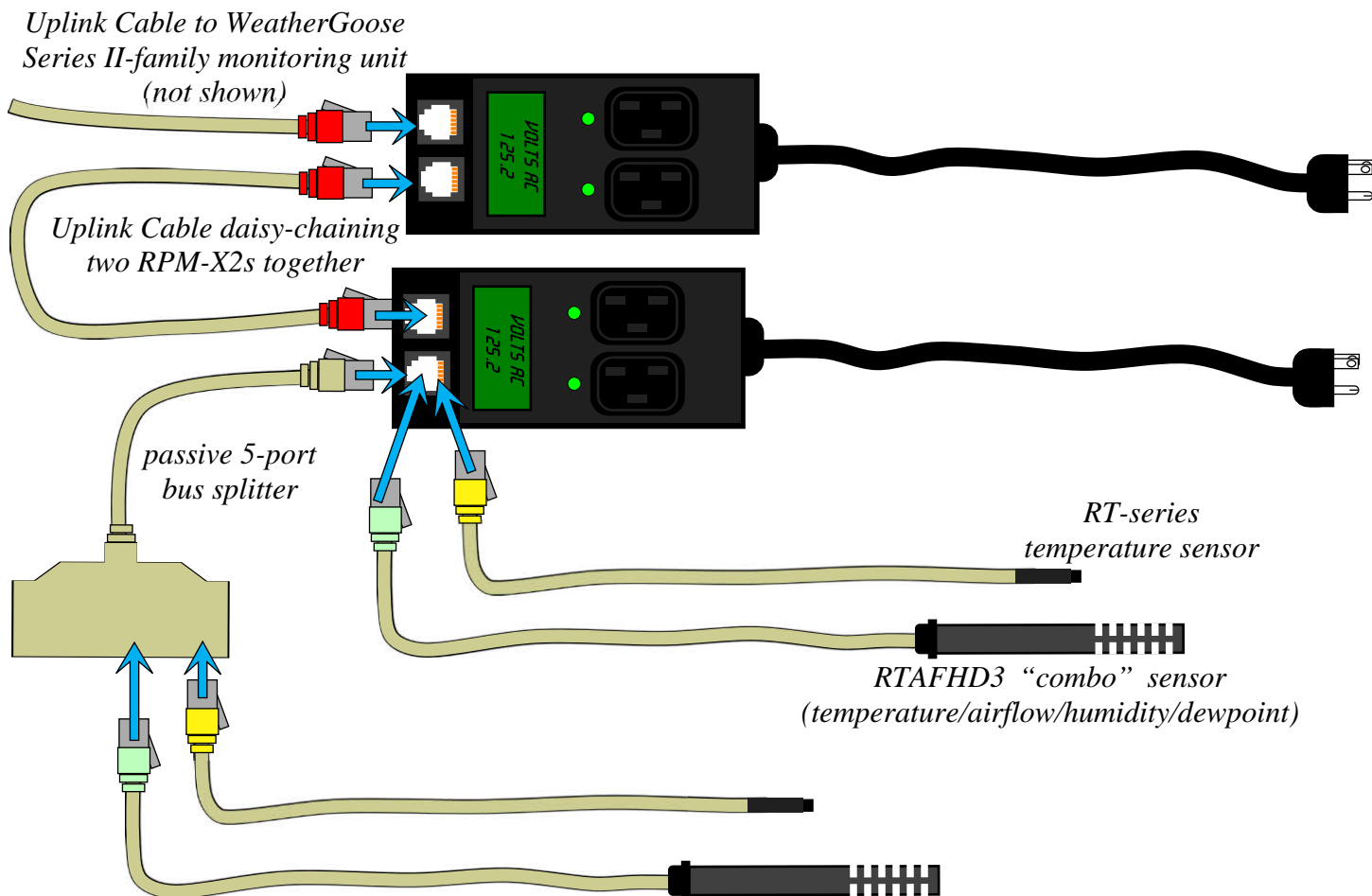


The RPM-X2 can also be connected to the single Digital Sensor jack of a MiniGoose-II, as shown here.



Daisy-chaining additional Digital Bus Sensors:

The RPM-X2 provides two Digital Sensor Bus jacks. This allows you to place additional sensors, including more RPM-X2 units, alongside the RPM-X2 without having to run all of those sensors' cabling back to the host monitoring unit individually. Connecting additional digital-sensor devices is as simple as plugging the sensor's 6P6C plug into the unoccupied Digital Sensor jack, as illustrated here. The RPM-X2's sensor jacks are compatible with all of ITWatchDogs' current digital-sensor products, and also supports most of our legacy products (such as previous versions of the CCAT) as well. (The only legacy sensors specifically not supported are the now-discontinued RTAF2 and RTAFH2 airflow sensors, as mentioned at the front of this manual.)

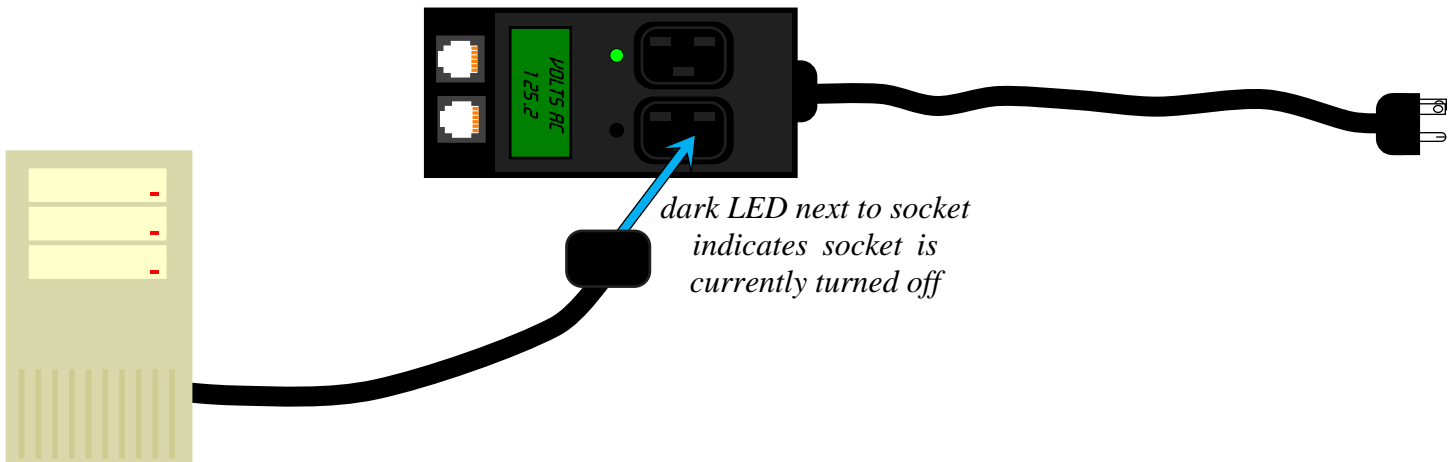


As demonstrated in the above diagram, you can also attach a passive splitter to one of the RPM-X2's Digital Sensor jacks, then attach multiple sensors to the splitter. However, as mentioned previously, the absolute maximum number of sensors which can be supported by any single WeatherGoose monitoring unit is 16, and the cable length of all sensors combined must not exceed 600 ft (200m). It is important to note that the RPM-X2 does not increase either of these limits, and neither will additional passive splitters, regardless of whether they are connected to the RPM-X2 or directly to the WeatherGoose monitoring unit.

A passive splitter can, however, help reduce the aggregate cable-length totals in a complex installation, since its cable length only counts once in the total. If, for example, you needed to place an RPM-X2 and three temperature sensors in an adjoining room 50 feet away from the rack the host monitor is in, running all four sensors back to the host itself would result in an aggregate cable length of 2×50 , or 200ft. On the other hand, running a single Uplink Cable to the adjoining room, then connecting a splitter and the three temperature sensors with shorter 12ft cables to the RPM-X2, would result in an aggregate length of only $50 + (3 \times 12)$, or 86ft.

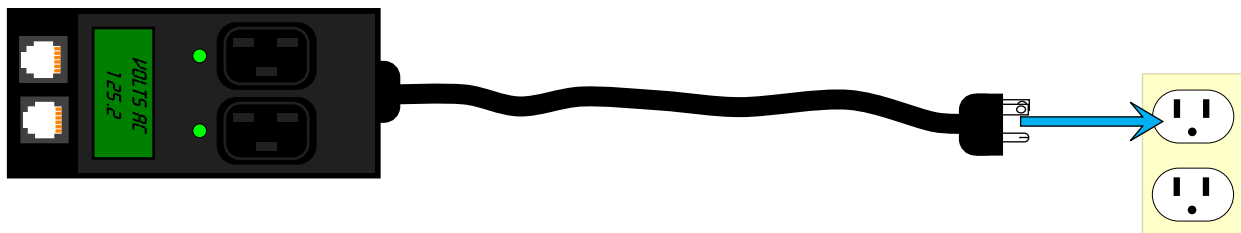
Connecting equipment to the relay-controlled power sockets:

The RPM-X2 Remote Power Manager provides two relay-controlled power sockets which can be individually turned on or off from the host monitoring unit's web page. No special procedure is required to connect equipment to the power sockets; however, it is generally considered good practice to only connect or disconnect equipment when the socket is turned off, as illustrated here by the dark LED indicator next to the socket which is about to have a file server connected to it. (Instructions on how to turn the relays on and off will be found in the following section, *Configuring and Using the RPM-X2 Remote Power Manager.*)



Connecting the RPM-X2 to AC line power:

The RPM-X2 Remote Power Manager includes a permanently-attached 10ft. (3m.) power cord and AC plug. Simply plug the RPM-X2 into a matching outlet on any nearby wall socket, power strip, or UPS (uninterruptible power supply).





Configuring and Using the RPM-X2 Remote Power Manager

Once you have connected the RPM-X2 Remote Power Manager to your *WeatherGoose Series II*-family monitoring unit, and have connected it to AC power and plugged in the equipment to be monitored according to the preceding pages, the next step is to configure the unit by setting the desired alarm thresholds and actions via the host monitoring unit's **Alarm**, **Control**, **Display** and **Logging** pages. You can also assign names to each power socket, and selectively determine which of its readings are to be graphed and logged. The following sections will describe how to:

- Assign meaningful names to the RPM-X2 itself via the **Display** page
- Assign meaningful names to the control relays, and turn the equipment connected to them on or off via the **Control** page
- Determine which power-measurement readings are graphed and logged via the **Logging** page
- Read and understand the statistics presented on both the host monitoring unit's web pages, and on the RPM-X2's internal LCD display.

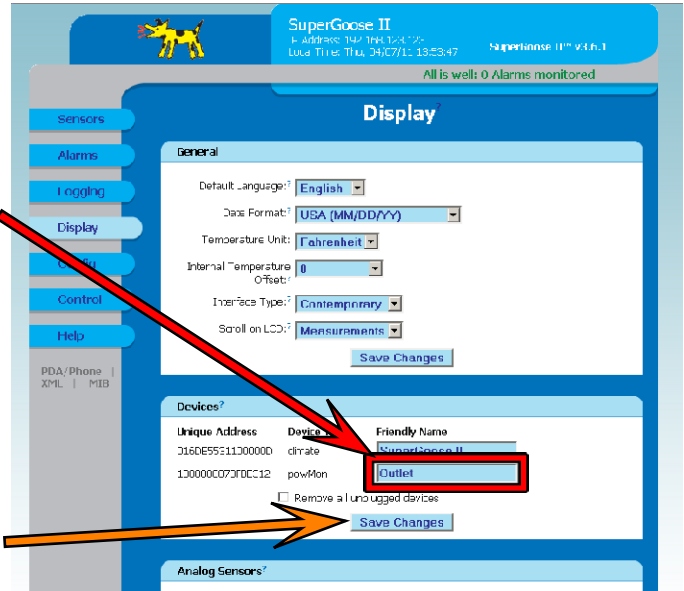
Assigning a “friendly” name to the RPM-X2 Remote Power Manager:

Once you have connected the RPM-X2 Remote Power Manager to the host monitoring unit, as detailed in the previous chapter, open your PC’s web browser and type `http://<ip address>` in the browser’s address bar to bring up the unit’s web page. (If you have not yet changed the monitoring unit’s configuration from the factory default, `<ip address>` would be 192.168.123.123; otherwise, type in the IP address you’ve assigned it to on your network.) Then, click on the **Display** tab to bring up the “Display” page, where you can configure the “friendly names” assigned to the RPM-X2.

Scroll down to the “Devices” section, and you will see the RPM-X2 has appeared as a new entry in the list, with a Device Type of “powMon” and a unique 16-digit address which corresponds to the unit’s ID code on the Digital Sensor Bus. The “Friendly Names” of the attached sensor devices (and the host monitoring unit itself) are to the right of the device types, as shown here.

By default, the RPM-X2 names itself “Outlet”; however, you can change it to any name you prefer. You might, for example, name it after a particular rack or server to be monitored; i.e. “Rack 2-14 AC Power”, or “Filesrv14”. The only limit is that the name you choose can only be 31 characters long.

After typing in the name you wish to give the RPM-X2, click the “Device” section’s **Save Changes** button to make the change.



Note that if more than one RPM-X2 is connected, they will all start out calling themselves “Outlet”, so the only way to distinguish one from another is by their device ID numbers. If you intend to connect more than one of these, make sure that you make a note of the device IDs printed on the side or bottom of the unit before installation, so that you can identify them on the host monitoring unit’s web page and re-name them appropriately.

(Alternatively, if you have already installed the RPM-X2s into their permanent locations and it would be difficult to remove them again to find the device-ID numbers, you can identify them by connecting only one unit at a time to the host monitor, waiting a minute or so for that unit to appear in the device list, re-naming it, then connecting the next RPM-X2 in turn.)

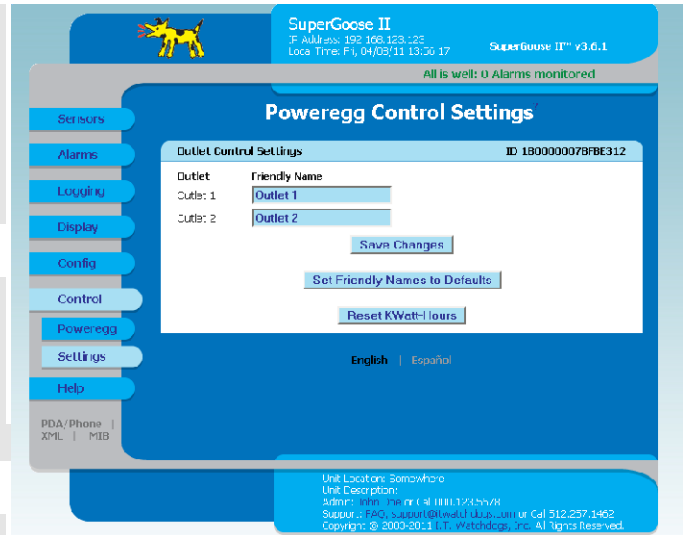
► *Note for users of the IOE I/O Expander:* If you have an IOE installed, the **Display** tab will divide itself into two secondary tabs – a **Main** tab, and a tab for the I/O Expander. Friendly-name settings for the RPM-X2 will be found on the **Display** → **Main** tab.

Assigning “friendly” names to the relay-controlled power outlets:

► If you have connected the RPM-X2 to a monitoring unit that does not have built-in control relays of its own, such as a SuperGoose-II (shown here), you will notice that the web interface has acquired a new tab, named **Control**, with two secondary tabs named **RPM-X2** and **Settings**. This tab is where you configure the RPM-X2’s control relays. The unit will default to the **RPM-X2** tab when **Control** is selected.

► If you have connected the RPM-X2 to a monitoring unit that does have built-in control relays of its own, such as a RelayGoose-II, you will notice that the **Control** tab has now split itself into three secondary tabs, named **Main**, **RPM-X2** and **Settings**. The unit will default to the **Main** tab when **Control** is selected.

► On units running v3.6.x firmware revisions, as shown here, the tab and its control settings will be named **Poweregg** rather than **RPM-X2**. This is merely a cosmetic difference; “PowerEgg” was the name of an older, now-discontinued version of the RPM-X2 device. The **Poweregg** tab and its control functions in v3.6.x are identical to the **RPM-X2** tab in later versions.



The **Settings** tab is where you can assign “friendly” names to each of the RPM-X2’s relay-controlled AC outlets, and also reset the KiloWatt-Hour meter in each RPM-X2. If you have more than one RPM-X2 connected, they will all be displayed on this page, each with its own section and set of control buttons. Each section will be identified by the “friendly name” you assigned it on the “Display” page, to help you distinguish them.

Note also that the control buttons are not “global”; i.e. each button will only save the changes made to its own associated RPM-X2. (For example, if you have three RPM-X2s attached, and you click the Set Friendly Names to Defaults button for RPM-X2 unit #2, it will only reset the names for that particular unit, not for all three of them.)

Relay Settings:

Here, you can change the **Friendly Name** of each outlet on the RPM-X2. By default, these will be named “Outlet 1” and “Outlet 2”; however, you can change them to any name you prefer, up to 31 characters for each name

After you have set your preferred friendly names, click the **Save Changes** button to make them take effect.

Set Friendly Names to Defaults:

Clicking this button will reset the “friendly names” of the outlets to the factory defaults of “Outlet 1” and “Outlet 2”.

Reset KWatt-Hours:

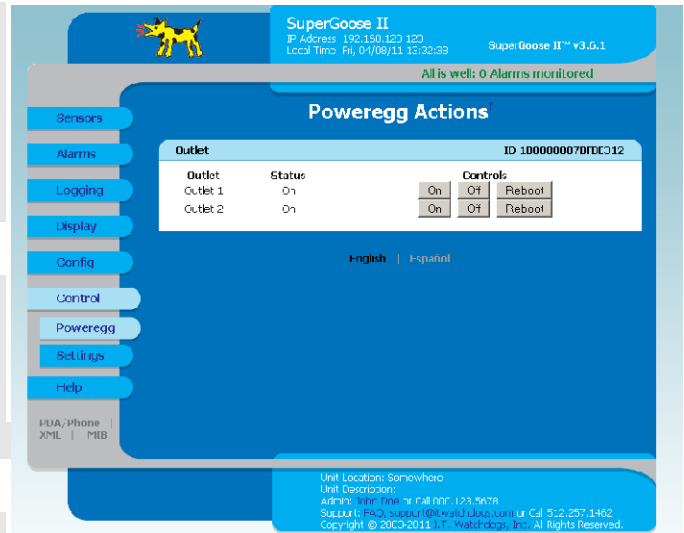
This button resets the kilowatt-hour meter inside the RPM-X2 to zero.

Operating the power-outlets' control relays:

► If you have connected the RPM-X2 to a monitoring unit that does not have built-in control relays of its own, such as a SuperGoose-II (shown here), you will notice that the web interface has acquired a new tab, named **Control**, with two secondary tabs named **RPM-X2** and **Settings**. This tab is where you configure the RPM-X2's control relays. The unit will default to the **RPM-X2** tab when **Control** is selected.

► If you have connected the RPM-X2 to a monitoring unit that does have built-in control relays of its own, such as a RelayGoose-II, you will notice that the **Control** tab has now split itself into three secondary tabs, named **Main**, **RPM-X2** and **Settings**. The unit will default to the **Main** tab when **Control** is selected.

► On units running v3.6.x firmware revisions, as shown here, the tab and its control settings will be named **Poweregg** rather than **RPM-X2**. This is merely a cosmetic difference; “PowerEgg” was the name of an older, now-discontinued version of the RPM-X2 device. The **Poweregg** tab and its control functions in v3.6.x are identical to the **RPM-X2** tab in later versions.



The **RPM-X2** (or **Poweregg**) tab is where you can turn either of the RPM-X2's relay-controlled AC outlets on or off. If you have more than one RPM-X2 connected, they will all be displayed on this page, each with its own section and set of control buttons. Each section will be identified by the “friendly name” you assigned it on the “Display” page, to help you distinguish them. The name of each outlet, along with its current status, will be displayed here, and each outlet will have three control buttons: **On**, **Off**, and **Reboot**.

“On” and “Off” are, of course, fairly self-explanatory; clicking an outlet's **On** button will turn on AC power to that outlet, while clicking the **Off** button will turn off power to the outlet. The default state of the outlets is “on” when the RPM-X2 is first powered up, so you will not need to manually turn the outlets back on after a power failure or shutdown.

The **Reboot** button, on the other hand, combines both of these actions: when an outlet's **Reboot** button is clicked, that outlet will be turned off for a period of 12 seconds, then turned back on again. This function can be useful for remotely rebooting a piece of equipment, such as a router, which has locked up and is no longer responding to commands.

Choosing which measurement(s) to log and graph:

From the **Logging** page, you can selectively determine which of the RPM-X2's measurements should be shown in the unified graph at the top of the page, in the same fashion as any other sensor measurement.

The RPM-X2 will appear as its own block of measurements and settings, beneath the host monitoring unit's own internal sensors. These settings are explained in more detail in the user guides for the monitoring units themselves, but in brief, you can set the following parameters for each measurement:

LCD: this checkbox determines whether this measurement appears in rotation on the front-panel LCD, if your monitoring unit is equipped with one. Note that this setting does not control the RPM-X2's LCD display; it only affects the LCD display on the host monitoring unit itself.

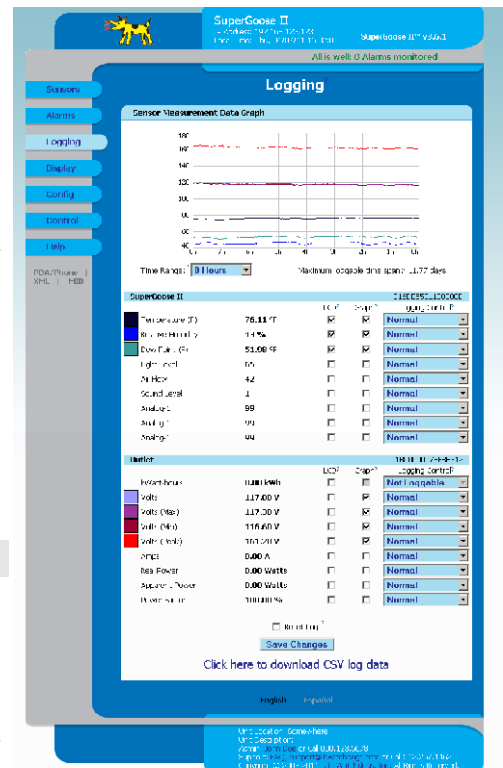
► (If your particular model of monitoring unit doesn't have a built-in LCD display, this column of checkboxes will not be shown.)

Graph: this checkbox determines whether a measurement is shown in the merged graph at the top of the “Logging” page. Note that this does not affect the individual graphs on the “Sensors” page; these will always be shown, unless logging is turned off for all of the measurements in a particular sensor device. (Also note that the “Kilowatt-Hours” (kWh) measurement is not loggable or graphable, since this is a running tally maintained internally by the RPM-X2 itself.)

Logging Control: this drop-down box allows you to control how (or if) the data is logged for each particular measurement. There are four possible options:

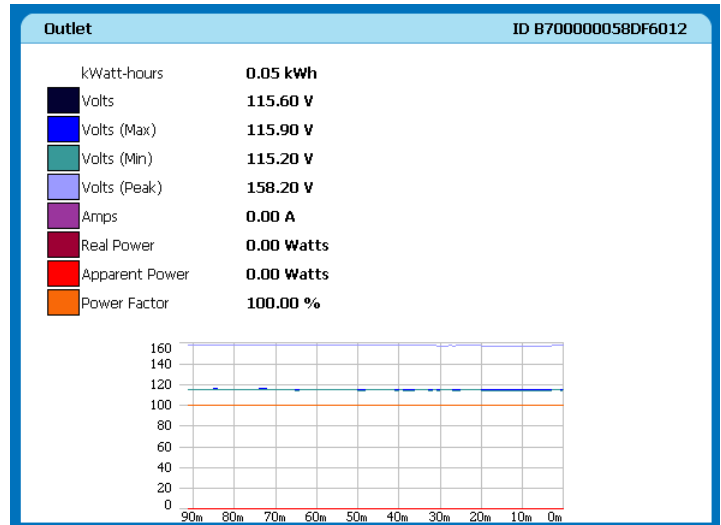
- **Normal:**
All measurements will be logged.
- **High-Water Mark:**
Each new measurement sample is compared to the previous one. If the new measurement is higher than the previous one, it will be logged and become the new “high-water mark”; if it is lower, it is discarded and the previous measurement will persist until a higher measurement is seen by the sensor.
- **Low-Water Mark:**
Each new measurement sample is compared to the previous one. If the new measurement is lower than the previous one, it will be logged and become the new “low-water mark”; if it is higher, it is discarded and the previous measurement will persist until a lower measurement is seen by the sensor.
- **Logging Off:**
No measurements will be logged. Note that if this option is selected, the **Graph** checkbox for that sensor will be greyed out, since it is not possible to graph that sensor if its data is not logged.

Note that these logging options do not affect the alarm system; the monitoring unit will continue to check each sensor's incoming measurement sample against any alarm thresholds you may have set for that sensor, and will trip the alarm if the measurement exceeds the thresholds. These options only affect whether or not the sample is then recorded into the logging system, which operates independently of the alarm system. After you have set your preferred logging options, click the **Save Changes** button to make them take effect.



Power-measurement readings and statistics:

Each RPM-X2 connected to a WeatherGoose II-series monitoring unit will have its own block on the **Sensors** page, similar to the example shown here. In this block, you will find the most recent measurement sample for all of the parameters monitored by the RPM-X2, along with a graph illustrating the full history of the RPM-X2's readings since the device was connected (up to the limits of the monitoring unit's internal memory).



The measurements shown and logged on the host monitoring unit's web pages are as follows:

- **kWatt-hours:**

This is a running tally of the total kilowatt-hours (kWh) consumed by any equipment connected to the RPM-X2's power sockets. This number is saved internally by the RPM-X2, and will persist even across a power failure or disconnection. It can only be reset from the **Control** → **RPM-X2** tab.

- **Volts:**

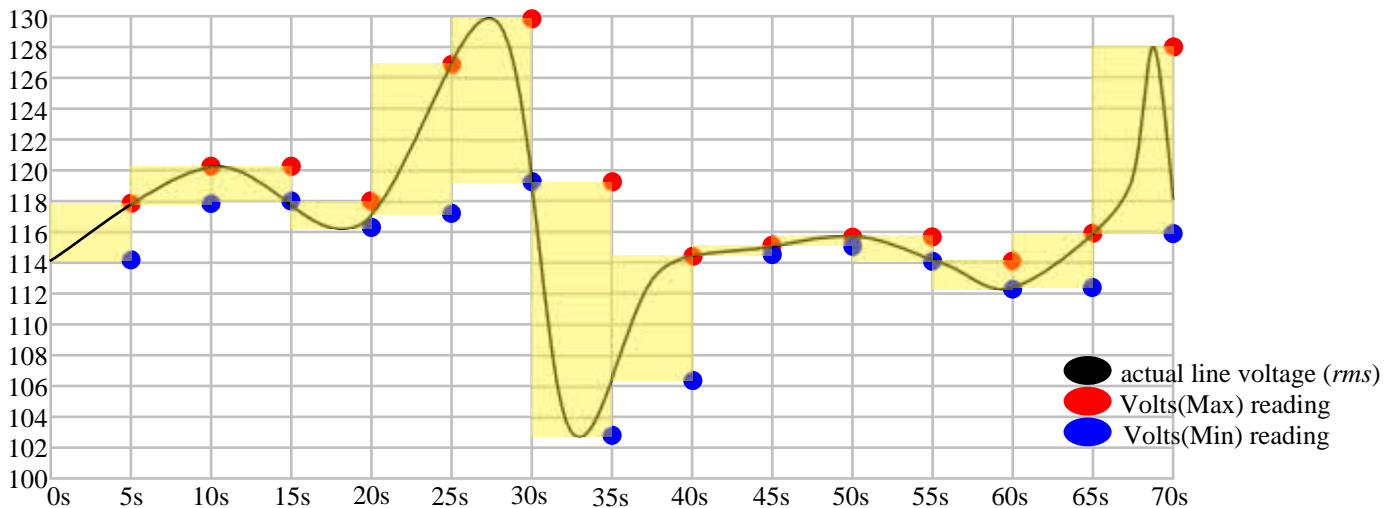
The current AC line voltage, displayed as VAC(rms). Since AC line voltage is a sine wave of alternating polarity rather than a continuous voltage, the *rms* (Root-Mean-Square) method is used to give the average electrical power of a cycle.

- **Volts (Max):**

The highest AC line voltage seen by the RPM-X2 since power-on, displayed as VAC(rms). This statistic, along with Volts(min) and Volts(peak), resets after the RPM-X2 is polled by the host monitoring unit; i.e. they report the max, min, and peak voltages seen since the last time the readings were recorded by the host. (The illustration shown below gives an example of this behavior.)

- **Volts (Min):**

The lowest AC line voltage seen by the RPM-X2 since power-on, displayed as VAC(rms).



This graph illustrates how the Volts(min) and Volts(max) readings follows the fluctuations in actual line voltage while the RPM-X2 is connected to a host monitoring unit, which is polling the device at 5-second intervals. Each time the unit is polled, Volts(min), Volts(max), and Volts(peak) are reset, and follow the voltages changes from that point until the next polling interval. (Note that the Volts(peak) reading is not shown on this graphic for clarity, but it follows the same behavior as Volts(max).)

- **Volts (Peak):**
The highest AC line voltage seen by the RPM-X2 since power-on, displayed as VAC(*pk*). This reading shows the “true” peak voltage, as opposed to the RMS voltage. (see **Appendix A** for more information on peak vs. RMS voltage measurements.)
- **Amps:**
The total current draw, in Amps, of any equipment connected to the RPM-X2’s power sockets. (Assuming, of course, that at least one of the sockets is energized. If both sockets are off, this measurement will be zero.)
- **Real Power:**
The amount of power, in Watts, being consumed by any equipment connected to the RPM-X2’s power sockets.
- **Apparent Power:**
The amount of power, in Watts, being delivered to any equipment connected to the RPM-X2. This may be different from the Real power when the equipment is a highly inductive (i.e. a motor) or capacitive (such as a switching power supply) load, rather than a purely resistive load such as a heating element. (See **Appendix A** for more detailed information on Real vs. Apparent power, and the significance of the Power Factor measurement.)
- **Power Factor:**
The ratio of Real vs. Apparent power as measured above, expressed as a percentage ratio from 0~100%.

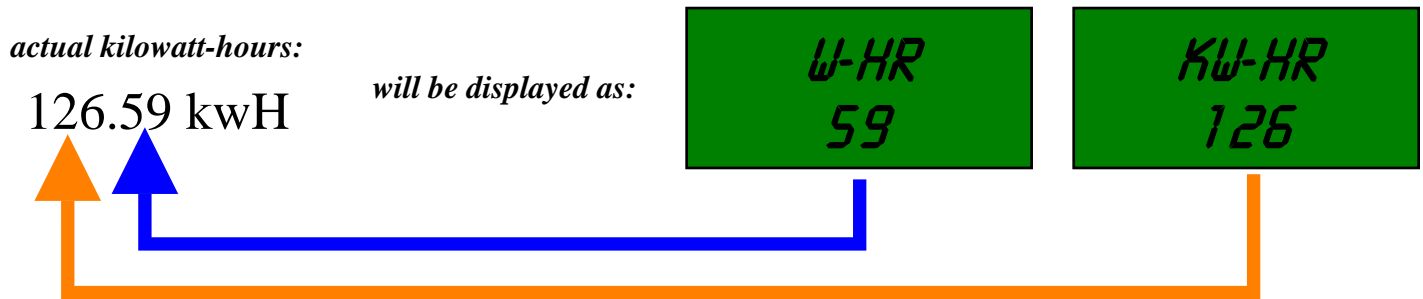
These measurements are also displayed on the RPM-X2’s built-in LCD display, allowing the device to be used for “spot check” or temporary installations even while not connected to a host monitoring unit. However, due to the limits of the LCD display, the names of the measurements are different than those shown on the monitoring unit’s web page. The names of the measurements, in the order they’re displayed on the LCD, are as follows:

- **Volts:**
The current AC line voltage, displayed as VAC(*rms*). Since AC line voltage is a sine wave of alternating polarity rather than a continuous voltage, the *rms* (Root-Mean-Square) method is used to give the average electrical power of a cycle.
- **Amps:**
The total current draw, in Amps, of any equipment connected to the RPM-X2’s power sockets. (Assuming, of course, that at least one of the sockets is energized. If both sockets are off, this measurement will be zero.)
- **Watts:**
The amount of power, in Watts, being consumed by any equipment connected to the RPM-X2’s power sockets. Corresponds to the **Real Power** measurement on the web page.
- **Volt-Amp:**
The amount of power, in Watts, being delivered to any equipment connected to the RPM-X2. Corresponds to the **Apparent Power** measurement on the web page.
- **Pwr-Fctr:**
The ratio of Real vs. Apparent power as measured above, expressed as a percentage ratio from 0~100%. Corresponds to the **Power Factor** measurement on the web page. (See **Appendix A** for more detailed information on Real vs. Apparent power, and the significance of the Power Factor measurement.)

- **W-hr and KW-hr :**

These measurements, together, give a running tally of the total kilowatt-hours (kWh) consumed by any equipment connected to the RPM-X2's power sockets. This number is saved internally by the RPM-X2, and will persist even across a power failure or disconnection. It can only be reset from the **Control** → **RPM-X2** tab when the RPM-X2 is connected to a host monitoring unit. Together, these readings correspond to the **kWh-hours** measurement on the web page.

Since the LCD display is not large enough to show the full reading all at once, the measurement is shown in two parts, with the W-hr reading being the fractional value after the decimal point and KW-hr being the number of "whole" kilowatt-hours, as illustrated here:



- **Volt-Hi:**

The highest AC line voltage seen by the RPM-X2 since power-on, displayed as $VAC(rms)$. This statistic, along with Volt-Lo and Volt-Pk, resets whenever the RPM-X2 is polled by the host monitoring unit; if the RPM-X2 is not connected to a host monitoring unit, these readings will persist until the unit is powered down or disconnected from the voltage source. Corresponds to the **Volts (Max)** measurement on the web page.

- **Volt-Lo:**

The lowest AC line voltage seen by the RPM-X2 since power-on, displayed as $VAC(rms)$. Corresponds to the **Volts (Min)** measurement on the web page.

- **Volt-Pk:**

The highest AC line voltage seen by the RPM-X2 since power-on, displayed as $VAC(pk)$. This reading shows the "true" peak (*pk*) voltage, which may be higher than the (*rms*) voltage, seen by any connected equipment during a power surge. Corresponds to the **Volts (Peak)** measurement on the web page.

Appendix A: Understanding AC power measurements

Peak vs. RMS voltage:

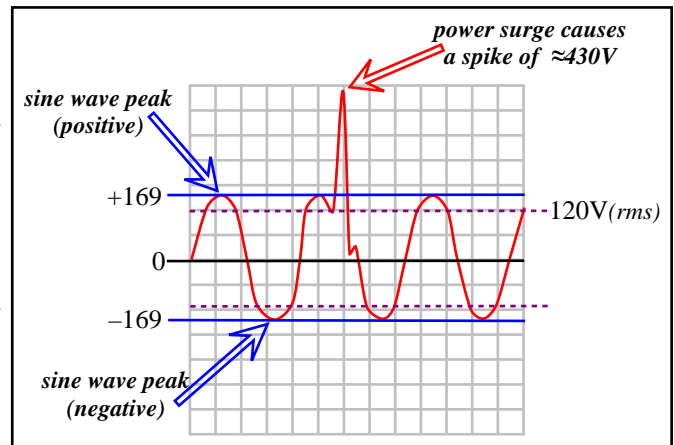
Since line voltage is AC, or alternating current, the voltage across the load is not constant. Rather, the voltage continuously varies from zero to peak and back to zero again as a sinusoidal waveform. RMS, or Root-Mean-Square, is a method of calculating the statistical, time-averaged magnitude of this continuously-varying voltage, which can then be used to calculate the actual power being delivered to the load over the complete AC voltage cycle.

Because using the RMS value for power calculations provides a more accurate picture of what's happening in the circuit, power-outlet voltages are almost always quoted in RMS values rather than peak values. However, the peak value can also be useful in determining whether you have “noisy” electrical power; typically, the RMS voltage should be approximately:

$$V_{rms} = V_{pk} \times 0.707$$

i.e. 0.707 times the peak voltage. (Or, conversely, $V_{pk} = V_{rms} \times 1.414$). If you notice that your RPM-X2 is frequently reporting peak voltages considerably higher than these calculations would suggest, you may have “noisy” power which is causing the voltage spikes to appear at various points during the sine wave, as illustrated here.

In this example, the RMS line voltage is 120VAC, so the RPM-X2 should normally report a **Volts(peak)** reading of 120×1.414 , or approximately 169V. However, as shown here, a power surge occurred which briefly spiked the voltage to 430V during part of the AC cycle, so when the unit is next polled by the monitoring unit, it reports a **Volts(peak)** of 430V instead. Frequent incidents of **Volts(peak)** being excessively high can give you early warning of power problems in your facility.



Real power vs. Apparent power:

As mentioned above, in an AC circuit the voltage is continuously varying in magnitude and polarity. As a consequence of this, the current flowing through the load also varies in magnitude and polarity.

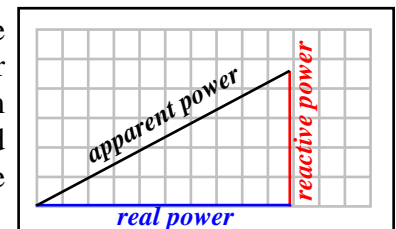
In a purely resistive-load AC circuit, such as a toaster or an incandescent light bulb, the voltage and current waveforms are in step (or in phase) with each other at all points of the AC power cycle, and all of the power transferred from the generating source performs work in the load. This work-performing power is known as the “real power” in the circuit.

However, when there are reactive loads (such as motors or switching-mode power supplies) present, voltage and current are no longer in phase. Instead, a portion of the energy flowing through the circuit ends up getting temporarily stored in the loads as an electric or magnetic field, and these electromagnetic fields tend to “push back” against the changes in voltage and current during the AC power cycle rather than doing actual work in the load. If the load is purely reactive, voltage and current are 90° out of phase; in this case, the product of (current X voltage) will be positive for one half of the AC cycle, but negative for the other half, resulting in a net power delivery of 0 for the full AC cycle.

As an analogy to help illustrate the concept, imagine the load as a merry-go-round, or roundabout, on a children’s playground, and the AC power coming from the generating source as the children pushing the merry-go-round to make it spin in a particular direction. Once a minute, a whistle blows to signal the kids to push the merry-go-round in the opposite direction – but each time the children try to do so, the mass and inertia of the merry-go-round resists their effort to change its direction, so it takes greater effort for them to overcome that stored energy before they can reverse the merry-go-round’s direction than it would if the merry-go-round had no mass (and thus, no inertia and no stored energy). “Reactance” and “reactive power” can be thought of as roughly equivalent to the inertia of the merry-go-round, and the extra effort required to overcome this inertia.

Reactive power is non-productive power; i.e. it does no actual work at the load. However, it still flows through the wires between the generator and the load, so the “ebb and flow” of this non-productive power still increases the overall current in the line, heating the wires and wasting energy. Thus, a circuit with a low power factor will require a higher current to transfer a given quantity of real power than will a circuit with a high power factor, just as a larger and heavier merry-go-round will require a greater amount of physical effort to reverse its direction than a smaller and lighter one. Also, a circuit with a low power factor will require heavier conductors and transformers to carry the current, and a more powerful generating source to drive it, since all of these have to be capable of delivering the total amount of real and reactive power to the load, not just the amount that does useful work.

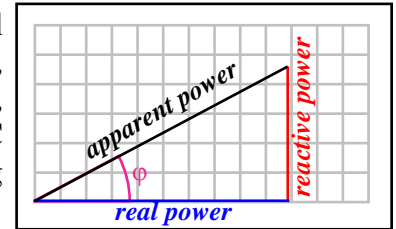
“Apparent power” is the combination of Real and Reactive powers which the electric circuit is required to deliver from generator to load, expressed as a vector sum of the two components, as illustrated here. (Note that the actual vector sum can be either positive or negative, depending on whether the reactance of the load is capacitive or inductive; however, Apparent Power is always expressed as the absolute value.)



Power Factor:

The ratio between the Real Power and Apparent Power, called the Power Factor, serves as a practical measure of the efficiency of an AC power distribution system. If you compare two (hypothetical) systems transmitting the same amount of real power, the system with the lower power factor will be the less efficient of the two, due to the reactive effects described above causing energy to be “stored” as electric or magnetic fields during part of the AC cycle and then returned to the source without actually doing useful work at the load.

The power factor is expressed as the cosine of the phase angle (ϕ) of the real vs. reactive-power components, as illustrated here. If the reactive power is zero, as it would be with a purely resistive load, then the phase angle will also be zero, and the power factor will be $\cos(0)$, or 1. This is the ideal situation for an AC power circuit; with a power factor of 1, all of the delivered power is performing useful work at the load.



If, on the other hand, the load is purely inductive or capacitive, then the Real Power component will be zero; in this case, the phase angle (ϕ) will be 90 degrees, and the power factor will be zero, indicating that none of the power flowing through the circuit is actually performing useful work at the load; it is simply being lost as heat in the wiring and in the reactance of the circuit.

In real-world applications, almost all AC circuits consist of some combination of resistive, capacitive, and inductive loads, so in practice the power factor will be somewhere between 1.0 and 0.0. The power factor may be either a positive or negative value, depending on the proportion of inductive vs. capacitive reactance in the circuit. (By convention, inductive reactances are considered to be “positive” values, while capacitive reactances are “negative”.) A mix of inductive and capacitive loads on an AC circuit will tend to cancel out each other’s reactive-power effects, bringing the circuit’s power factor closer to the ideal of 1.0.