BACnet Protocol Guide
EM-RS485

Senva Sensors
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Beaverton, OR 97008

154-0022-0E

Rev.	Release Date	By	Description of Change	ECR
0A	11/22/2016	DLE	Initial Release	---
0B	4/11/2017	DLE	Updated for firmware v1.1.2	---
0C	3/21/2018	DLE	Updated for firmware v1.1.3	---
0D	5/29/2018	DLE	Updated RS485 terminal polarity, firmware v1.1.4	---
0E	7/17/19	DPK	Updated firmware for reduced point map	---

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See Also:

    152-0291   *EM-RS485 Installation Instructions*

    154-0023   *EM-RS485 Modbus Protocol Guide*

Protocol Implementation Conformance Statement

Date	Tuesday, May 29, 2018
Vendor Name	Senva Sensors
Product Name	EM
Product Model Number	EM-RS485
Firmware Revision	1.1.4
Application Software Version	May 29 2018, 07:52:59
BACnet Protocol Revision	14
Product Description	3 Phase Energy Meter
BACnet Standardized Device Profile	BACnet Application Specific Controller (B-ASC)
List of BACnet Interoperability Building Blocks Supported	DS-RP-B, DS-RPM-B, DS-WP-B, DS-WPM-B, DM-DDB-B, DM-DOB-B, DM-DCC-B, DM-TS-B, DM-RD-B
Segmentation Capability	No Support
Standard Object Types Supported	See following. Optional implementations are **marked**.
Data Link Layer Options	MS/TP Master, MS/TP Slave (9600 – 115200)
Device Address Binding	No Support
Networking Options	No Support
Character Sets Supported	ISO 10646 (UTF-8)
Communications Gateway	No Support
Network Security Options	Non-Secure Device

Configuration
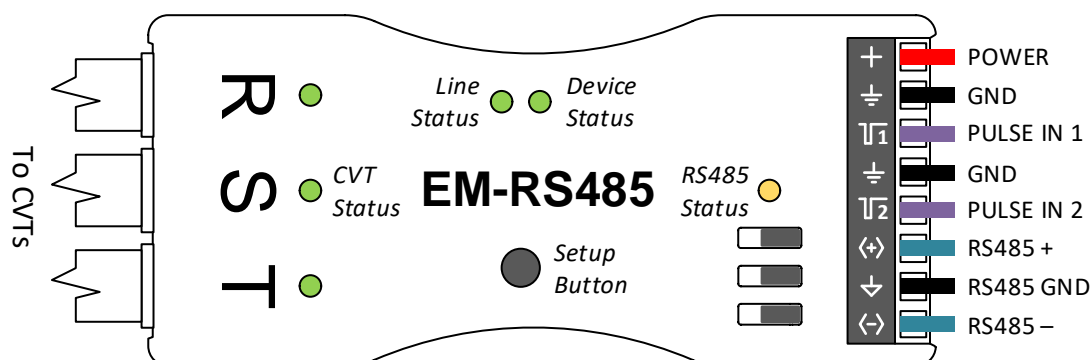
✓ Get In　　　✓ Get Out　　　→ **Get Data**

Congratulations on installing your new Senva EM-RS485 energy meter! This *BACnet Protocol Guide* assumes the first stage of installation is complete, with the meter and any CVTs connected and powered. A green *Device Status* indicates the meter is powered and ready. If not, refer to the separate *Installation Instructions* before continuing. Now, only the network configuration remains between you and the data.

Leave the meter in the default factory mode for automatic network configuration:

- Automatic *Baud Rate* detection (see BV114, AV124): 9600 – 115200 baud
- Automatic *Protocol* detection (see BV112, MSV122): BACnet
- Automatic *MAC Address* selection (see BV113, AV123): 0 – 127

To begin automatic configuration, simply connect the RS485 terminals to an active MS/TP network. An active MS/TP network consists of at least one MS/TP master device (typically a gateway or controller).

Once connected, the meter observes RS485 activity to learn *Baud Rate*, *Protocol*, and *MAC Address*. Without activity, the meter cannot learn! The meter will not interfere with existing network traffic during the observation phase. As configuration proceeds, the *RS485 Status* LED indicates progress with a combination of color and blinking activity patterns. Diagnostic mode conditions can help identify the current auto configuration step (see Figure 1, and also the *Installation Instructions*).
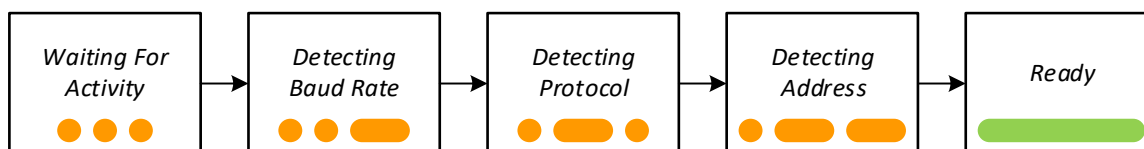
Figure 1: Automatic Configuration Conditions

In the *Detecting Protocol* phase of automatic configuration, the meter also detects serial format, comprising the number of *Data Bits*, *Parity*, and number of *Stop Bits*. The BACnet standard specifies a fixed format of 8 bits, no parity, and 1 bit respectively. The meter does not support configuration of *Data Bits* or *Stop Bits* as the nature of BACnet itself effectively precludes useful alternatives. However, for compatibility with non-conforming implementations the meter does support *Parity* configuration (see MSV126).

In the *Detecting Address* phase of automatic configuration, the meter selects a *MAC Address* from a pool of unused addresses detected on the MS/TP local network. Candidate addresses are added to the pool after two successive *Poll-For-Master* requests time out with no reply. A meter typically needs 15 – 30 seconds to identify candidates (somewhat longer if many new meters are connected at once).

To reduce collisions with other devices that may be also selecting an automatic *MAC Address*, the final address selection includes a small random component. However, the random component is strongly biased towards lower addresses (to keep the token ring efficiency high). Also, the meter makes two tests to confirm that the candidate address is really unused:

- The first test confirms that two devices have not simultaneously selected the same *MAC Address*.
- The second test confirms that there is no MS/TP slave device occupying the selected *MAC Address* . (A slave device would not naturally respond to the *Poll-For-Master* requests).

If either test fails, the meter abandons the selected address and resumes observation. If there appears to be no unused addresses, the meter will observe indefinitely. This may occur for a few reasons:

- There is no MS/TP master device generating *Poll-For-Master* requests.
- All MS/TP master addresses 0 – 127 are already assigned to other devices.
- The *Max Master* property has been set smaller than 127, and all MAC addresses from 0 – *Max Master* are already assigned to other devices.

The *RS485 Status* LED turns green after auto configuration completes. Assuming no conflicts, a BACnet controller can then discover the meter to query or configure the various objects. To differentiate between multiple discovered meters, check the last three digits of the unique serial number printed on the label. The meter sets the default *Device ID* by adding "665000" to the last three digits of the serial number.
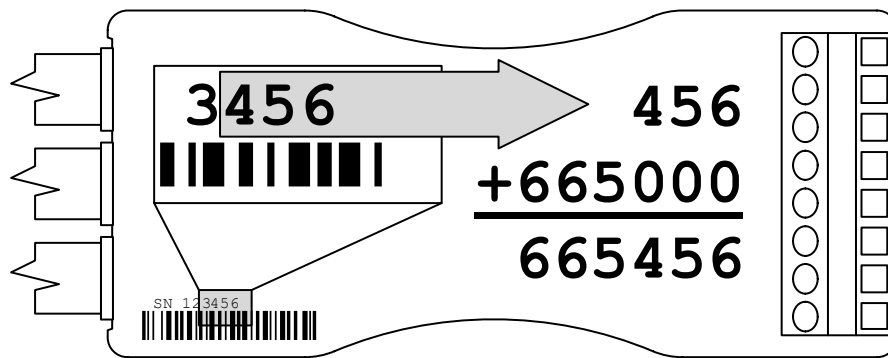
Figure 2: Default Device ID

The meter stores any discovered automatic configuration result in non-volatile memory and reloads them whenever the meter resets (e.g. after power loss). The automatic configuration (including *MAC Address*) can be cleared by pressing the *Setup Button* while resetting the meter (e.g. removing and reapplying power). User-configured parameters will not be affected, but the meter must redetect missing parameters before reestablishing communication with the controller.

WARNING: Before moving a meter with an automatically selected *MAC Address* to a new network, ensure there will be no conflicts! If necessary, reset the automatic configuration or set a new address manually.

For permanent installations, the protocol configuration parameters (see AV123, AV124, MSV126) may be set to lock the baud rate, serial format, and protocol. However, this will prevent the meter from adapting to future changes in the network environment.

Device

- Object Identifier   **W**   Default: 665XXX (see Configuration)
- Object Name   **W**   30 characters maximum
- Object Type   R
- System Status   R
- Vendor Name   R
- Vendor Identifier   R
- Model Name   R
- Firmware Revision   R
- Application Software Version   R
- **Location**   **W**   30 characters maximum
- **Description**   **W**   30 characters maximum
- Protocol Version   R
- Protocol Revision   R
- Protocol Services Supported   R
- Protocol Object Types Supported   R
- Object List   R   Too large to be read with a single *Read-Property* request; must be read element by element
- Max APDU Length Accepted   R
- Segmentation Supported   R
- APDU Timeout   R
- Number of APDU Retries   R
- **Max Master**   **W**   1 – 127; see AV123
- **Max Info Frames**   **W**   0 – 255; see AV123
- Device Address Binding   R
- Database Revision   R
- **Serial Number**   **R**   Matches the serial number printed on the label
- **Last Restart Reason**   **R**
- **Time of Device Restart**   **R**
- **Local Date**   **R**   Volatile; must be set via *Time-Synchronization*
- **Local Time**   **R**   Volatile; must be set via *Time-Synchronization*
- Property List   R
- **Device Features**   **R**   Proprietary property ID 6650

  This read-only property, of type *Bit String*, enumerates various the hardware features of a meter. Each '1' represents a feature that is present.

  1. *RS485* (always present)
  2. *Pulse Outputs*
  3. *Pulse Inputs*
  4. *Internal Thermistor*
  5. *Setup Button*

Accumulators (Pulse Input)

- Object Identifier   R
- Object Name   R
- Object Type   R
- Present Value   **W**   Only writable when *Out Of Service* is *True*
- Status Flags   R
- Event State   R   Always *Normal*
- **Reliability**   **W**   Only writable when *Out Of Service* is *True*
- Out of Service   **W**
- Units of Measure   **W**
- Maximum Present Value   **W**   Default 4294967295 ($2^{32} - 1$)
- Scale   **W**
- **Pre-Scale**   **W**
- **Value Change Time**   R   Only valid if the system time is valid
- **Value Before Change**   R
- **Value Set**   **W**
- Property List   R

ACC210	**Pulse Input 1**	**R/NV**
ACC220	**Pulse Input 2**	**R/NV**

Returns the count of pulses received at the respective pulse terminal (see *Installation Instructions*).

> **NOTE:** The corresponding *Binary Inputs* (BI201/BI202) track the instantaneous state of the terminal.

Each count in the *Present Value* represents a pair of input edges (active low), registered on the leading (falling) edge. At each transition, the input delays by the *Debounce Time* (see AV208).
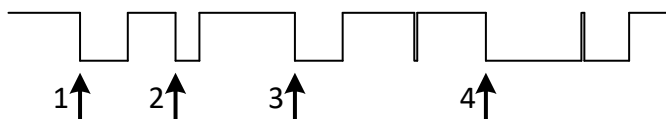
Figure 3: Pulse Input Counting

The *Present Value* will count to the *Maximum Present Value* before overflowing to 0. If setting the *Maximum Present Value* smaller than the *Present Value*, the *Present Value* does not update until the next pulse input event.

The *Pre-Scale* property may be configured to convert an input pulse stream to a suitable scale or engineering unit. The *Pre-Scale* factor consists of a pair of integer coefficients N and M:

$$C_{PV} = \frac{N}{M} \times C_{IN}$$

where:

C_{PV} =   final count stored in the *Present Value*
C_{IN} =   raw count detected at the pulse input terminal

Integer coefficients permit exact (lossless) conversion, following the algorithm prescribed in the BACnet standard. N and M must be positive integers less than or equal to 65535 ($2^{32} - 1$).

Many common floating point factors can be expressed as a ratio of two integers. For efficiency, consider reducing scaling factors to the lowest common denominator. For example:

0.1	=	1 / 10	
0.95	=	19 / 20	[95 / 100]
$1.33\overline{3}$	=	4 / 3	[($1.33\overline{3} \cdot 10 - 1.33\overline{3}$) / (10 − 1)]
1.5	=	3 / 2	[15 / 10]

The *Pre-Scale* conversion operates directly on a stream of input pulses. Changing coefficients does not alter the *Present Value*, but the effect of the transition on any internal remainder is undefined.

The *Scale* and *Units of Measure* properties store arbitrary values. These may be useful to attach relevant metadata directly to a pulse input object, but they do not directly affect the counting operation.

The *Value Set* property allows accumulator initialization. This may be useful for continuity when the EM-RS485 replaces an existing meter. When set, *Value Set* follows the defined BACnet procedure:

1. The current *Present Value* is preserved in *Value Before Change*.
2. The value is stored in both *Value Set* and *Present Value*.
3. If valid, the current date and time are stored in *Value Change Time*.

Accumulators (Energy)

- Object Identifier   R
- Object Name   R
- Object Type   R
- Present Value   **W**   Only writable when *Out Of Service* is *True*
- Status Flags   R
- Event State   R   Always *Normal*
- **Reliability**   **W**   Only writable when *Out Of Service* is *True*
- Out of Service   **W**
- Units of Measure   R
- Maximum Present Value   R   Always *999,999*
- Scale   R   Always *1.0*
- **Pre-scale**   **R**   Always { *1,1* }
- Property List   R

The meter provides two objects to access each energy measurement. Both objects access the same internal register, with a fixed capacity of ±1.0 TWh. Reading either *Present Value* always returns a value scaled to the system *Energy Units* (see MSV173).

1. The *Accumulators* return an unsigned integer, 0 – *Maximum Present Value*. When the energy exceeds the *Maximum Present Value*, the value wraps to 0 (modulo arithmetic). This view most closely corresponds to traditional analog meters, with the primary advantage that the energy resolution is fixed at 1 *Energy Unit*.

    If energy overflows, the overflow energy may still be read by setting the next larger *Energy Unit*. Negative power causes net accumulators (e.g. ACC1706) to run backwards; underflow causes the value to wrap from 0 backwards to *Maximum Present Value*.
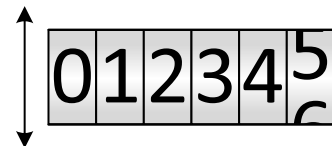
2. The *Analog Inputs* (see AI700, AI1700 ff.) return a floating point value that does not overflow (unless the internal 1.0 TWh register itself overflows). However, the resolution will gradually degrade as energy accumulates, making it harder to observe small changes in energy over short intervals.

Corresponding objects share *Out of Service* and *Reliability*. For example, setting the *Out of Service* of ACC700 sets *Out of Service* AI700 at the same time. Both properties automatically reset when the meter itself resets, to *False* and *No Fault Detected* respectively.

To initialize an accumulator, set *Out of Service* to *True,* and then write the desired energy to the *Present Value* of either object. This may be useful when the EM-RS485 replaces an existing meter. Set *Out of Service* to *False* to begin accumulating new energy again.

> **WARNING:** Energy accumulators left *Out of Service* will not accumulate new energy!

Reliability returns *Over Range* when any energy accumulates during *Over Voltage* (see AI1420) or *Over Current* (see AI1520) conditions. However, accumulators do not otherwise track reliability.

System

ACC700　Total Real Energy (ACC)　　　　　　　　　　　　　　　R/NV

Accumulator versions of AI700 – AI706. The default units are kWh (see MSV173).

Returns the combined energy of the system phases (see MSV161). For a *3 Phase* installation:

$$Total = ACC1700 + ACC2700 + ACC3700$$

$$Import = ACC1702 + ACC2702 + ACC3702$$

$$Export = ACC1704 + ACC2704 + ACC3704$$

$$Net = ACC1706 + ACC2706 + ACC3706$$

ACC702 Import ● ACC704 Export ● ACC706 Net

ACC720　System Real Energy (ACC)　　　　　　　　　　　　　R/NV

Accumulator versions of AI720 – AI726. The default units are kWh (see MSV173).

Returns the combined energy of the system phases (see MSV161). Unlike *Total Real Energy* (above), these accumulators derive from *Net Real Power* (see AI620). For a *3 Phase* installation,

$$System = \int |P_{NET}| \cdot dt = \int |P_R + P_S + P_T| \cdot dt$$

Compare the order of the absolute value operations in this example with the *Total Real Energy* derived from the *Total Real Power* (see AI600):

$$Total = \int \Sigma P \cdot dt = \int (|P_R| + |P_S| + |P_T|) \cdot dt$$

When the individual *Real Power* (see AI1600) of all system phases flows in the same direction (import or export), the *System* accumulators track the corresponding *Total* accumulations exactly. However, the *System* calculation allows opposite phase powers to cancel before accumulation.
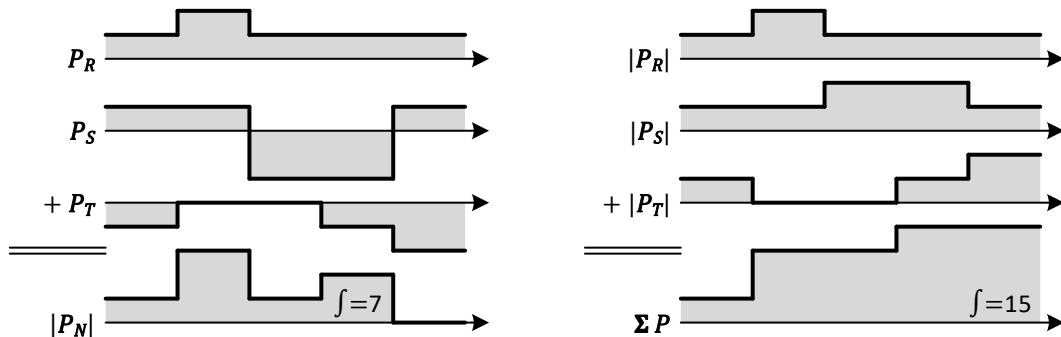
Figure 4: System vs. Total Energy

The *Import* and *Export* accumulations follow the sign of *Net Real Power*:

$$Import = \int \begin{cases} |P_{NET}| \cdot dt & if\ P_{NET} > 0 \\ 0 & otherwise \end{cases}$$

$$Export = \int \begin{cases} |P_{NET}| \cdot dt & if\ P_{NET} < 0 \\ 0 & otherwise \end{cases}$$

Net Real Energy (see ACC706) equals any possible *System Net* accumulator, as the calculation does not take absolute values.

ACC722 Import ● ACC724 Export

ACC740   Total Reactive Energy (ACC)   R/NV

Accumulator versions of AI740 – AI744. The default units are kVARh (see MSV173).

Returns the combined energy of the system phases (see MSV161). For a *3 Phase* installation:

$$Total = ACC1740 + ACC2740 + ACC3740$$

$$Import = ACC1742 + ACC2742 + ACC3742$$

$$Export = ACC1744 + ACC2744 + ACC3744$$

ACC742 Import ● ACC744 Export

ACC760   Total Apparent Energy (ACC)   R/NV

Accumulator versions of AI760 – AI764. The default units are kVAh (see MSV173).

Returns the combined energy of the system phases (see MSV161). For a *3 Phase* installation:

$$Total = ACC1760 + ACC2760 + ACC3760$$

$$Import = ACC1762 + ACC2762 + ACC3762$$

$$Export = ACC1764 + ACC2764 + ACC3764$$

ACC762 Import ● ACC764 Export

R Phase

ACC1700   Total R Phase Real Energy (ACC)   R/NV

Accumulator versions of AI1700 – AI1706. The default units are kWh (see MSV173).

Returns the accumulation of *Real Power* **P** (see AI1600). Note the absolute value operation in the accumulation of *Total* but not *Net*:

$$Total = \int |\boldsymbol{P}| \cdot dt$$

$$Net = \int \boldsymbol{P} \cdot dt$$
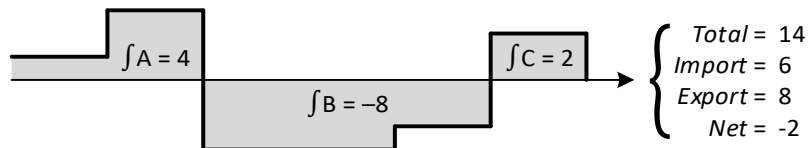
Figure 5: Real Energy

The *Import* and *Export* accumulations follow the sign of *Real Power*:

$$Import = \int \begin{cases} |\boldsymbol{P}| \cdot dt & if\ \boldsymbol{P} > 0 \\ 0 & otherwise \end{cases}$$

$$Export = \int \begin{cases} |\boldsymbol{P}| \cdot dt & if\ \boldsymbol{P} < 0 \\ 0 & otherwise \end{cases}$$

Accumulation stops during *Phase Loss* conditions (see AI1420).

ACC1702 Import ● ACC1704 Export ● ACC1706 Net

ACC1740   Total R Phase Reactive Energy (ACC)   R/NV

Accumulator versions of AI1740 – AI1744. The default units are kVARh (see MSV173).

Returns the accumulation of *Reactive Power Q* (see AI1640):

$$Total = \int |Q| \cdot dt$$

The *Import* and *Export* accumulations follow the sign of *Real Power P* (see AI1600):

$$Import = \int \begin{cases} |Q| \cdot dt & if\ P > 0 \\ 0 & otherwise \end{cases}$$

$$Export = \int \begin{cases} |Q| \cdot dt & if\ P < 0 \\ 0 & otherwise \end{cases}$$

Accumulation stops during *Phase Loss* conditions (see AI1420).

Although *Reactive Power* itself is signed, the accumulators capture only the magnitude without distinguishing between capacitive and inductive modes. Consider calculating this from average power (one of AI1648 – AI1652) over an interval instead:

$$Net = \overline{Q} \cdot \Delta t$$

ACC1742 Import • ACC1744 Export

ACC1760   Total R Phase Apparent Energy (ACC)   R/NV

Accumulator versions of AI1760 – AI1764. The default units are kVAh (see MSV173).

Returns the accumulation of *Apparent Power S* (see AI1660):

$$Total = \int S \cdot dt = \int V \cdot I \cdot dt$$

The *Import* and *Export* accumulations follow the sign of *Real Power P* (see AI1600):

$$Import = \int \begin{cases} S \cdot dt & if\ P > 0 \\ 0 & otherwise \end{cases}$$

$$Export = \int \begin{cases} S \cdot dt & if\ P < 0 \\ 0 & otherwise \end{cases}$$

Accumulation stops when the *RMS Voltage* becomes invalid (see AI1420).

ACC1762 Import • ACC1764 Export

S Phase

ACC2000 – ACC2999

S Phase *Accumulators* parallel the R Phase, offset +1000.

For example, read AI2700 for *Total S Phase Real Energy.*

T Phase

ACC3000 – ACC3999

T Phase *Accumulators* parallel the T Phase, offset +2000.

For example, read AI3700 for *Total T Phase Real Energy.*

Analog Inputs

- Object Identifier   R
- Object Name   R
- Object Type   R
- Present Value   **W**   Only writable when *Out Of Service* is TRUE
- Status Flags   R
- Event State   R   Always NORMAL
- **Reliability**   **W**   Only writable when *Out Of Service* is TRUE
- Out of Service   **W**
- Units of Measure   R
- **Update Interval**   **R**
- **Minimum Present Value**   **R**
- **Maximum Present Value**   **R**
- **Resolution**   **R**
- Property List   R

For statistical purposes, analog input values are organized into groups. By convention, the primary object leading each group provides the most accurate, up-to-date reading possible. Secondary objects within a group provide statistical measurements in time that may support some simple logging applications with less overhead for setup and bandwidth. Typical statistical values include:

- **Smoothed:** Returns the value after applying a first-order exponential filter (see AV134).
- **Minimum:** Returns the single lowest valid reading taken since last reset.
- **Maximum:** Returns the single highest valid reading taken since last reset.
- **Average:** Returns the average of all valid readings taken since last reset.

Except for the energy accumulators, each analog input group shares common *Out Of Service* and *Reliability* properties. Setting *Out Of Service* to *True* disables all statistical calculation, so that any group value may be arbitrarily set. Statistics will be reset after setting *Out Of Service* to *False* again.

Once recorded, there are a few methods to reset statistics records (*Minimum*, *Maximum*, *Average*):

- Manually for a single object, by writing 0 to the *Present Value* (**W0** in the Access Legend).
- Manually for an individual group, by setting *Out Of Service* to *True* and then *False* again.
- Manually for multiple objects, by writing one of the *Statistics Reset* keys (see AV192, AV1192).
- Automatically for single values, by configuring *Auto Reset Statistics* (see BV195).

Most statistical values reset with a value equal to the *Present Value* of the primary object (see Figure 6).

Demand statistical values reset to 0 until the end of the current demand window (see AI1800, AV186).
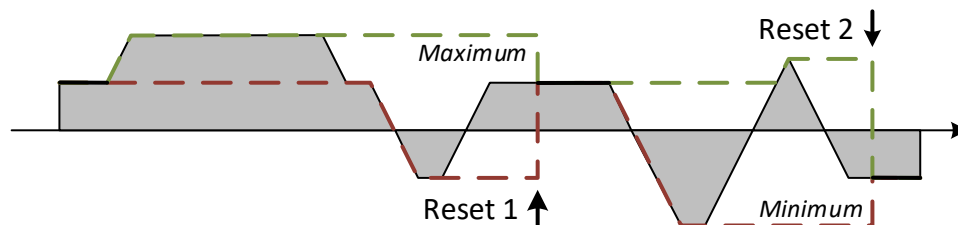
Figure 6: Reset Behavior

General

AI310   Temperature   R/W0

Returns the approximate ambient temperature at the meter's installed location. The default units are °F (see MSV133). The meter compensates small drifts in CVT voltage and current measurements (the meter assumes CVT temperature is similar to meter temperature, see *Installation Instructions*).

If the temperature is beyond the product specifications, the *Device Status* LED will indicate the corresponding *Temperature Limit* warning condition (see *Installation Instructions*).

The default smoothed value response time is 30 seconds (see AV134).

AI312 Smoothed ● AI314 Minimum ● AI316 Maximum ● AI318 Average

AI380   Power Supply Voltage   R/W0

Returns the approximate working voltage provided to the meter's low voltage power supply, in V. The voltage reported is an internal voltage after rectification and input protection (typically 1.0 – 2.0 V less than the external supply).

The meter requires 12.0 VDC minimum for full operation. If the measured voltage drops below this threshold, the meter anticipates a power loss and saves the configuration and accumulated energy to non-volatile memory. However, if the power loss proves incomplete, the meter may continue to operate at the reduced supply voltage. In this state, accumulated energy may be lost if the meter has insufficient reserve power when (if) full power loss occurs. The *Device Status* LED will indicate the corresponding *Low Supply Voltage* warning condition (see *Installation Instructions*).

AI382 Smoothed ● AI384 Minimum ● AI386 Maximum ● AI388 Average

System

AI410   Line Frequency   R/W0

Returns the fundamental AC line frequency f, in Hz. If there are no CVTs connected, or all of the CVTs measure *Phase Loss* conditions (see AI1420), returns 0 Hz.

With a *PowerPrint Frequency* target set (see AV242), frequency variations may set the *Frequency Drift* condition (see AV400). If so, *Reliability* will also return *Over Range* or *Under Range*, as appropriate.

The default smoothed value response time is 60 seconds (see AV142).

AI412 Smoothed ● AI414 Minimum ● AI416 Maximum ● AI418 Average

AI420   Phase Average RMS Voltage   R/W0

Returns the average $\overline{V}$ of the *RMS Voltage* (see AI1420) of all valid system phases. If there are no valid phases, *Present Value* returns 0 V and *Reliability* returns an appropriate reason.

For average calculations in general, a valid system phase must:

- Be included in the *System Phase Selection* (see MSV161),
- Have a *CVT Status* of *No Error* (see MSV1103), and
- Not be detecting the *Phase Loss* condition (see AI1420).

The default smoothed value response time is 10 seconds (see AV144).

AI422 Smoothed ● AI424 Minimum ● AI426 Maximum ● AI428 Average

AI450   Phase to Phase Average RMS Voltage   R/W0

Returns the average $\overline{V_{PP}}$ of the *Phase to Phase RMS Voltage* (see AI1450) between valid system phases (as defined by AI420). If there are exactly two valid phases, the average collapses to the single reading between them. If there are less than two valid phases, *Present Value* returns 0 V and *Reliability* returns an appropriate reason.

As with individual phase to phase voltages measurements, the average is valid only when CVTs share a common neutral connection and all phases have the same frequency (the meter does not check either condition).

The default smoothed value response time is 10 seconds (see AV144).

AI452 Smoothed ● AI454 Minimum ● AI456 Maximum ● AI458 Average

AI520   Phase Average RMS Current   R/W0

Returns the average $\overline{I}$ of the *RMS Current* (see AI1520) of valid system phases (as defined by AI420). If there are no valid phases, *Present Value* returns 0 A and *Reliability* returns an appropriate reason.

The default smoothed value response time is 2 seconds (see AV154).

AI522 Smoothed ● AI524 Minimum ● AI526 Maximum ● AI528 Average

AI540   Phase Average Current Angle   R/W0

Returns the average $\overline{\varphi}$ of the *Current Angle* (see AI1540) of valid system phases. The default units are *Degrees* (see MSV153), normalized between −180 and +180°.

In addition to the standard criteria (as defined by AI420), valid system phases must have sufficient load power to give a stable measurement (see AI1600, *No Load* condition). If there are no valid phases, *Present Value* returns 0°, and *Reliability* returns an appropriate reason.

The average of angles with a total sweep approaching 180° or more (see Figure 7) is indeterminate. In such cases, *Present Value* returns 0°, and *Reliability* returns *Unreliable Other*.

An indeterminate average often indicates that the CVT voltage leads or current sensor loop were installed backwards. If so, a negative multiplier (see AV1142, AV1152) may restore the result.

A: Sweep = 60° ✓   *B: Sweep = 135° ✓*   *C: Sweep = 205° ✗*
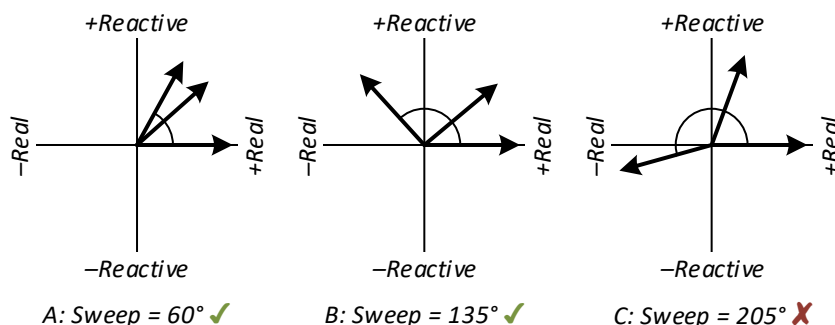
Figure 7: Swept Current Angle

The default smoothed value response time is 2 seconds (see AV154).

AI542 Smoothed ● AI544 Minimum ● AI546 Maximum ● AI548 Average

AI550 System Power Factor   R/W0

Returns the true (apparent) power factor $\widehat{pf}$ of the valid system phases (as defined by AI420).

Unlike an arithmetic average, the system power factor weights the *Real Power* (see AI620) and *Apparent Power* (see AI660) of each phase (see Figure 8). This definition keeps lightly loaded phases with relatively poor power factor from introducing excessive distortion in the result.

$$\widehat{pf} = \frac{P_{NET}}{\overline{S}}$$

If negative, the system export power exceeds the import power.

If the power in two phases flows in opposite directions, the real components cancel, reducing the overall power factor.

The default smoothed value response time is 2 seconds (see AV164).
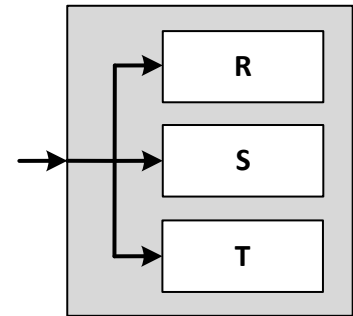
Figure 8: System Power Factor

AI552 Smoothed ● AI554 Minimum ● AI556 Maximum ● AI558 Average

AI600 Total Real Power   R/W0

Returns the absolute sum ΣP of the *Real Power* (see AI1600) of valid system phases (as defined by AI420). The default units are kW (see MSV163).

The default smoothed value response time is 2 seconds (see AV164).

AI602 Smoothed ● AI604 Minimum ● AI606 Maximum ● AI608 Average

AI610 Phase Average Real Power   R/W0

Returns the absolute average $\overline{P}$ of the *Real Power* (see AI1600) of valid system phases (as defined by AI420). The default units are kW (see MSV163).

The default smoothed value response time is 2 seconds (see AV164).

AI612 Smoothed ● AI614 Minimum ● AI616 Maximum ● AI618 Average

AI620 Net Real Power   R/W0

Returns the signed sum P_{NET} of the *Real Power* (see AI1600) of valid system phases (as defined by AI420). The default units are kW (see MSV163). Negative values indicate that overall export power exceeds import power.

The default smoothed value response time is 2 seconds (see AV164).

AI622 Smoothed ● AI624 Minimum ● AI626 Maximum
AI628 Overall Average ● AI630 Import Average ● AI632 Export Average

AI640 Total Reactive Power   R/W0

Returns the absolute sum ΣQ of the *Reactive Power* (see AI1640) of valid system phases (as defined by AI420). The default units are kVAR (see MSV163).

The default smoothed value response time is 2 seconds (see AV164).

AI642 Smoothed ● AI644 Minimum ● AI646 Maximum ● AI648 Average

AI650 Phase Average Reactive Power   **R/W0**

Returns the absolute average $\overline{Q}$ of the *Reactive Power* (see AI1640) of valid system phases (as defined by AI420). The default units are kVAR (see MSV163).

The default smoothed value response time is 2 seconds (see AV164).

AI652 Smoothed ● AI654 Minimum ● AI656 Maximum ● AI658 Average

AI660 Total Apparent Power   **R/W0**

Returns the absolute sum ΣS of the *Apparent Power* (see AI1660) of valid system phases (as defined by AI420). Always positive. The default units are kVA (see MSV163).

The default smoothed value response time is 2 seconds (see AV164).

AI662 Smoothed ● AI664 Minimum ● AI666 Maximum ● AI668 Average

AI670 Phase Average Apparent Power   **R/W0**

Returns the absolute average $\overline{S}$ of the *Apparent Power* (see AI1660) of valid system phases (as defined by AI420). The default units are kVA (see MSV163).

The default smoothed value response time is 2 seconds (see AV164).

AI672 Smoothed ● AI674 Minimum ● AI676 Maximum ● AI678 Average

AI700 Total Real Energy (AI)   **R/NV**

Full range versions of ACC700 – ACC706. The default units are kWh (see MSV173).

AI702 Import ● AI704 Export ● AI706 Net

AI720 System Real Energy (AI)   **R/NV**

Full range versions of ACC720 – ACC724. The default units are kWh (see MSV173).

AI722 Import ● AI724 Export

AI740 Total Reactive Energy (AI)   **R/NV**

Full range versions of ACC740 – ACC744. The default units are kVARh (see MSV173).

AI742 Import ● AI744 Export

AI760 Total Apparent Energy (AI)   **R/NV**

Full range versions of ACC760 – ACC764. The default units are kVAh (see MSV173).

AI762 Import ● AI764 Export

AI800 Demand Total Real Power   **R/W0/NV**

Returns the absolute sum ΣP_D of the *Demand Real Power* (see AI1800) of valid system phases (as defined by AI420). The default units are kW (see MSV163).

AI802 Previous ● AI804 Minimum ● AI806 Maximum

AI820 Demand Net Real Power   **R/W0/NV**

Returns the signed sum $\Sigma P_{D \cdot NET}$ of the *Demand Real Power* (see AI1800) of valid system phases (as defined by AI420). The default units are kW (see MSV163).

AI822 Previous ● AI824 Minimum ● AI826 Maximum

AI840   Demand Total Reactive Power   R/W0/NV

Returns the absolute sum ΣQ_D of the *Demand Reactive Power* (see AI1840) of valid system phases (as defined by AI420). The default units are kVAR (see MSV163).

AI842 Previous ● AI844 Minimum ● AI846 Maximum

AI860   Demand Total Apparent Power   R/W0/NV

Returns the absolute sum ΣS_D of the *Demand Apparent Power* (see AI1860) of valid system phases (as defined by AI420). The default units are kVA (see MSV163).

AI862 Previous ● AI864 Minimum ● AI866 Maximum

R Phase

AI1420   R Phase RMS Voltage   R/W0

Returns the effective line RMS voltage V measured between the CVT voltage leads and multiplied by the *Voltage Multiplier* (see AV1142), in V. Always positive, regardless of the sign of the multiplier.

When voltage exceeds the *Voltage Rating* (see AV1140), the measurement may have a reduced accuracy, and *Reliability* will return *Over Range*.

When the voltage drops below approximately 15% of the *Voltage Rating* (90 V for a 600 V rated CVT), the *Phase Loss* condition (see AV1400) may be set. Even at higher RMS voltages, *Phase Loss* may still occur if the frequency exceeds the system limits (see *Installation Instructions*).

In *Phase Loss* conditions, the *Real Power* (see AI1600), *Reactive Power* (see AI1640), and derived measurements become invalid. Also, *Reliability* will return *Under Range*. *Apparent Power* (see AI1660) remains valid down to approximately 2% of the *Voltage Rating* (12 V for a 600 V rated CVT), although measurements may have a reduced accuracy. Below 2%, returns 0 V.

Figure 9: Voltage Range

With a *PowerPrint Voltage* target set (see AV1144), voltage variations may set the *Brown Out Voltage* (too low) or *Surge Voltage* (too high) conditions (see AV400). If so, *Reliability* will return *Over Range* or *Under Range*, as appropriate.

The default smoothed value response time is 10 seconds (see AV144).

AI1422 Smoothed ● AI1424 Minimum ● AI1426 Maximum ● AI1428 Average

AI1440   R to S Phase Voltage Angle   R/W0

Returns the relative angle θ between the voltage of this phase and the "next" (definition below). The default units are *Degrees* (see MSV153), normalized between −180 and +180°.

IMPORTANT: Unlike most measurements (intra-phase and independent), the definition of phase to phase voltage depends on "next" phase. The complete progression:

- AI1440   R Phase to S Phase
- AI2440   S Phase to T Phase
- AI3440   T Phase to R Phase

Positive angles indicate that the "next" phase lags this phase (see Figure 10). A negative *Voltage Multiplier* (see AV1142) for one phase rotates the result by 180°, also normalized. (Negative multipliers on both phases cancel each other)

This measurement assumes that both phases have the same frequency (the meter does not check). If the voltage of either phase drops too low, this value returns 0 V.

Figure 10: Phase Progression

With a *PowerPrint Voltage Angle* target set (see AV1146), angle variations may set the *Phase Drift* condition (see AV400). If so, *Reliability* will return *Over Range* or *Under Range*, as appropriate. Otherwise, *Reliability* always returns some combination of the two phase reliabilities.

With no *PowerPrint Voltage Angle* target, the meter substitutes 120°, a standard angle for 3-phase services. Three angles of approximately –120° will set the *Reverse RST Order* condition. Three angles not approximately equal to either –120° or +120° will set the *Not Three Phase* condition. *Phase Loss* on either phase blocks both conditions from being set.

The default smoothed value response time is 60 seconds (see AV142).

AI1442 Smoothed ● AI1444 Minimum ● AI1446 Maximum ● AI1448 Average

AI1450   R to S Phase RMS Voltage   R/W0

Returns the RMS voltage V_{PP} between the "hot" leads of this phase and the next (as defined by AI1440), in V. This calculation assumes a common neutral connection (see Figure 11) between phases and that both phases have the same frequency (the meter does not check for either).
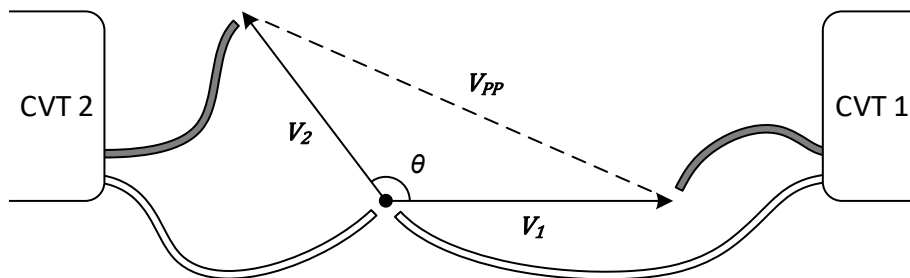
Figure 11: Phase to Phase Common Neutral

The following equation represents the basic phase to phase voltage calculation:

$$V_{PP} = \sqrt{(V_1 - V_2 \cos\theta)^2 + (V_2 \sin\theta)^2}$$

A negative *Voltage Multiplier* (see AV1142) for exactly one phase rotates the result by 180°, effectively reversing the polarity of the neutral and "hot" leads.

Reliability always returns some combination of the phase and angle reliabilities.

The default smoothed value response time is 10 seconds (see AV144).

AI1452 Smoothed ● AI1454 Minimum ● AI1456 Maximum ● AI1458 Average

AI1520   RMS Current   R/W0

Returns the effective line RMS current **I** measured with the CVT current sensing loop and multiplied by the *Current Multiplier* (see AV1152), in A. Always positive, regardless of the sign of the multiplier.

When the current exceeds the *Current Rating* (see AV1150) the measurement may have a reduced accuracy, and *Reliability* may return *Over Range*.

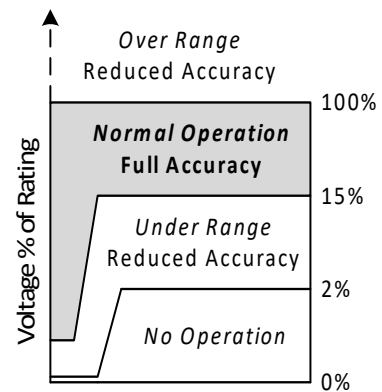Fundamentally, Rogowski coils measure <u>changes in current</u>, not current itself. This is why Rogowski coils are not well-suited for DC current measurements and also why they may be sensitive to high frequency harmonics.   Even though a particular RMS current may be within the CVT *Current Rating*, individual harmonic components may exceed the input range.

If the meter detects that current harmonics may lead to reduced accuracy, the *High Harmonics* condition (see AV1400) will be set. However, given the wide variation in harmonics between different loads, the meter cannot detect every possible scenario leading to reduced accuracy.

The default smoothed value response time is 2 seconds (see AV154).

AI1522 Smoothed ● AI1524 Minimum ● AI1526 Maximum ● AI1528 Average

AI1540   Current Angle   R/W0

Returns the four quadrant current angle **φ**. The default units are *Degrees* (see MSV153), normalized between −180 and +180°. A negative *Current Multiplier* (see AV1152) rotates the result by 180°, effectively reversing the orientation of the current sensor loop.

Current angle measures the angle of the phase current fundamental with respect to the voltage fundamental. Positive angles represent leading (capacitive) loads.

Internally, the meter calculates from the vector formed by *Real Power* (see AI1600) and *Reactive Power* (see AI1640). Note the negation required to maintain sign convention (see Figure 12):

$$\varphi = -\mathrm{atan}\frac{Q}{P}$$

Displacement power factor may be easily derived from current angle:

$$pf_D = \cos(\varphi) = \frac{1}{\sqrt{1+\left(\frac{Q}{P}\right)^2}}$$

Figure 12: Current Angle Quadrants

During *No Load* conditions the *Real Power* (see AI1600) becomes too small for reliable calculation. In this case *Present Value* returns 0° and *Reliability* returns *Under Range*. Otherwise, *Reliability* returns some combination of the *RMS Voltage* and *RMS Current* reliabilities.

The default smoothed value response time is 2 seconds (see AV154).

AI1542 Smoothed ● AI1544 Minimum ● AI1546 Maximum ● AI1548 Average

AI1550 Power Factor R/W0

Returns true (a.k.a. apparent) power factor pf. A negative value indicates export power.

$$pf = \frac{P}{S} = \frac{P}{V \cdot I}$$

Reliability follows *Current Angle* (see AI1540), including *No Load* conditions (see AI1600).

When power factor drops below 0.5 (absolute value), the *Low Power Factor* condition (see AV1400) is set. *Low Power Factor* may indicate an installation error (see *Installation Instructions*).

The default smoothed value response time is 2 seconds (see AV154).

AI1552 Smoothed ● AI1554 Minimum ● AI1556 Maximum ● AI1558 Average

AI1600 Real Power R/W0

Returns real power P, after multiplication by the *Power Multiplier* (see AV1162). The default units are kW (see MSV163). A negative value indicates export power.

When *Real Power* drops very low, the *No Load* condition (see AV1400) is set. During *No Load* conditions, *Current Angle* (see AI1540) and *Power Factor* (see AI1550) measurements become unreliable. The *No Load* condition is also set during *Phase Loss* conditions.

The *Import* and *Export Averages* only update during the respective intervals (see Figure 13). The *Import Average* is always positive, and the *Export Average* is always negative. When power flows exclusively in one direction, one of these will remain at 0 kW.
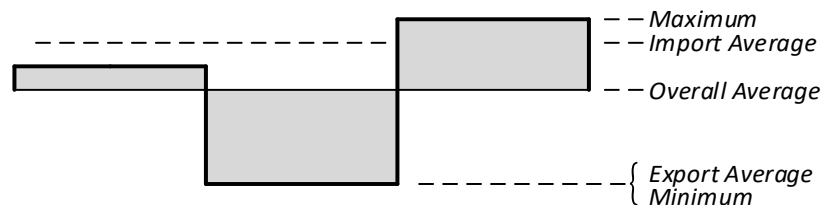
Figure 13: Real Power Averages

During *Phase Loss* conditions (see AI1420), returns 0 kW, all of the *Averages* stop updating, and *Reliability* returns *Under Range*. Otherwise, *Reliability* returns a combination of *RMS Voltage* and *RMS Current* reliabilities.

The default smoothed value response time is 2 seconds (see AV164).

AI1602 Smoothed ● AI1604 Minimum ● AI1606 Maximum
AI1608 Overall Average ● AI1610 Import Average ● AI1612 Export Average

AI1640 Reactive Power R/W0

Returns reactive power Q, after multiplication by the *Power Multiplier* (see AV1162). The default units are kVAR (see MSV163). A negative value indicates a capacitive load (leading power factor).

The *Import* and *Export Averages* only update during the respective *Real Power* (see AI1600) intervals. When *Real Power* flows exclusively in one direction, one of these will remain at 0 kW. All three averages may be positive or negative, depending on the mix of capacitive and inductive loads.

During *Phase Loss* conditions (see AI1420), returns 0 kVAR, all of the *Averages* stop updating, and *Reliability* returns *Under Range*. Otherwise, *Reliability* follows *Real Power*.

The default smoothed value response time is 2 seconds (see AV164).

AI1642 Smoothed ● AI1644 Minimum ● AI1646 Maximum
**AI1648 Overall Average ● AI1650 Import Average ● AI1652 Export Average**

AI1660   Apparent Power   R/W0

Returns apparent power S, after multiplication by the *Power Multiplier* (see AV1162). The default units are kVA (see MSV163). Apparent power is always positive:

$$S = V \cdot I$$

The *Import* and *Export Averages* only update during the respective *Real Power* (see AI1600) intervals. When *Real Power* flows exclusively in one direction, one of these will remain at 0 kW.

When the *RMS Voltage* becomes invalid (see AI1420), returns 0 kVA, all of the *Averages* stop updating, and *Reliability* returns *Under Range*. Otherwise, *Reliability* follows *Real Power*.

The default smoothed value response time is 2 seconds (see AV164).

AI1662 Smoothed ● AI1664 Minimum ● AI1666 Maximum
AI1668 Overall Average ● AI1670 Import Average ● AI1672 Export Average

AI1700   Total Real Energy (AI)   R/NV

Full range versions of ACC1700 – ACC1706. The default units are kWh (see MSV173).

AI1702 Import ● AI1704 Export ● AI1706 Net

AI1740   Total Reactive Energy (AI)   R/NV

Full range versions of ACC1740 – ACC1742. The default units are kVARh (see MSV173).

AI1742 Import ● AI1744 Export

AI1760   Total Apparent Energy (AI)   R/NV

Full range versions of ACC1760 – ACC1762. The default units are kVAh (see MSV173).

AI1762 Import ● AI1764 Export

AI1800   Demand Real Power   R/W0/NV

Returns the average P_D of *Real Power* (see AI1600) over a windowed interval. The default units are kW (see MSV163). Negative values indicate that export energy exceeded import energy over the course of the demand window.

Demand power bridges a gap between peak power and total energy accumulation. Many peak power measurements are short-lived and can be absorbed by an electrical utility with minimal side effects. However, sustained high power usage requires a fixed capacity investment regardless of the actual consumption (for example, transmission lines). Some utilities bill larger customers for both total energy consumption and peak demand power, although specific rules vary.

Internally, demand windows run for a fixed interval, with each new window marking the end of the previous window. The *Window Time* (see AV183) sets the maximum window length, and periodic *Synchronization* (see MSV181) can help align the start of a window with an external reference. All of the demand power objects follow the same common window schedule.
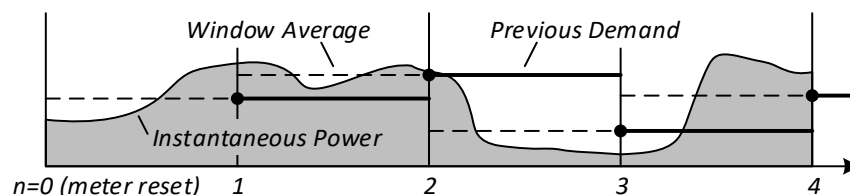
Figure 14: Fixed Demand Windows

During each window, demand continuously tracks the flow of energy in the line. When this value stops changing at the end of the window, it becomes *Previous Demand* (see Figure 14). At the same time, the *Minimum* and *Maximum Demand* statistics update with any new record(s). Finally, the demand tracker resets for the next window. The *Demand Window Count* (see AV186) increments exactly once for each demand window.

Formally, demand power may be defined as measured energy divided by the measurement time:

$$P_D = \frac{\Delta E}{\Delta t} = \frac{\int_{t_n}^{t_{n+1}} P \cdot dt}{t_{n+1} - t_n}$$

Notwithstanding previous language that describes a fixed window, the primary demand power object returns a continuously smoothed representation of *Current Demand*. This value smoothly transitions between the fixed demand levels as each window develops (see Figure 15). While not a substitute for a true sliding window calculation, this provides a more timely view of changing demand without waiting for the end of an interval. In *Full Synchronization* mode (see MSV181), the behavior of *Current Demand* is undefined.
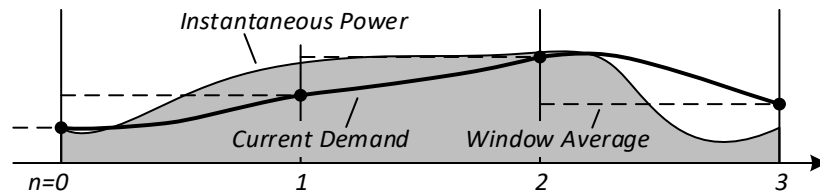
Figure 15: Current Demand Smoothing

Reliability returns *Over Range* if either the *Over Voltage* (see AI1420) or *Over Current* (see AI1520) conditions occur during the window. However, demand objects do not otherwise track reliability.

After every reset, the meter restores the non-volatile *Minimum* and *Maximum Demand* statistics. The *Current Demand* becomes available immediately, but the *Previous Demand* requires one full window interval to fully initialize.

> **WARNING:** Writing *Out Of Service* to *True* will interrupt the calculation of *Current Demand*. This preserves a constant value for inspection and modification during the *Out Of Service* interval. However, on writing *Out Of Service* to *False* again, the *Present Value* may become corrupt. Additionally, the corrupt value may be propagated to derived statistics at the end of the current window. Any demand statistics corrupted in this way should be reset (see AV192).

AI1802 Previous ● AI1804 Minimum ● AI1806 Maximum

AI1840 Demand Reactive Power   R/W0/NV
Returns the average Q_D of *Reactive Power* (see AI1640) over a windowed interval. The default units are kVAR (see MSV163). Negative values indicate a primarily capacitive load (leading power factor) over the course of the interval.

AI1842 Previous ● AI1844 Minimum ● AI1846 Maximum

AI1860 Demand Apparent Power   R/W0/NV
Returns the average S_D of *Apparent Power* (see AI1660) over a windowed interval. The default units are kVA (see MSV163).

AI1862 Previous ● AI1864 Minimum ● AI1866 Maximum

S Phase

AI2000 – AI2999

S Phase *Analog Inputs* parallel the R Phase, offset +1000.

For example, read AI2600 for the *S Phase Real Power*.

T Phase

AI3000 – AI3999

T Phase *Analog Inputs* parallel the R Phase, offset +2000.

For example, read AI3600 for the *T Phase Real Power*.

Analog Values

- Object Identifier   R
- Object Name   R
- Object Type   R
- Present Value   **W**   Writable unless indicated otherwise.
- Status Flags   R
- Event State   R   Always *Normal*
- **Reliability**   **R**   Always *No Fault Detected*
- Out of Service   R   Always *False*
- Units of Measure   R
- **Minimum Present Value**   **R**
- **Maximum Present Value**   **R**
- **Resolution**   **R**
- Property List   R

System

AV103   Reset Count   R/NV

Returns a lifetime count of firmware resets for any reason. The meter maintains this count in a protected section of non-volatile memory unaffected by *Configuration Reset* (see AV190).

At each reset, the meter restores accumulated energy, demand statistics, and pulse input counts from non-volatile memory. However, all the analog statistics reset, plus the *Up Time* (see AV104), *Energy Timestamp* (see AV174), and *Binary Inputs* (see BI201, BI202).

AV104   Up Time   R

Returns the time since the last meter reset, in seconds. To determine the cause, read the *Last Restart Reason* property of the *Device* object.

AV123   MAC Address   R/W/NV

Sets the MS/TP address, 0 – 254 (MS/TP reserves address 255 for broadcast).

When *Auto Address* is *Active* (see BV113), returns the auto-selected address (see Configuration). Otherwise, returns the user-configured address.

Setting any address also sets *Auto Address* to *Inactive*. When setting a new address, the meter acknowledges using the original address. Therefore, a client must temporarily remember the original address and only switch at the beginning of the next new transaction.

When *Max Info Frames* (see Device) is not equal to 0 and the *MAC Address* is smaller than or equal to the *Max Master* (see Device), the meter operates in MS/TP master mode. Otherwise, the meter operates in MS/TP slave mode (no token passing or polling, no initiation of *I-Am* or *I-Have* services).

> **NOTE:** Because *Max Master* must be 127 or less, addresses 128 – 254 are always MS/TP slaves.

Default: Varies

AV124   RS485 Baud Rate   R/W/NV

Sets the communication baud rate, 1200 – 460800.

When *Auto Baud Rate* is *Active* (see BV114), returns the auto-detected baud rate (see Configuration). Otherwise, returns the user-configured baud rate.

Almost by definition, successfully reading baud rate implies a correct value, with no further action required. However, when transitioning an MS/TP network to a new baud rate, it may be useful to remotely configure the new baud rate before transitioning the gateway/controller. Setting any user-configured baud rate also sets *Auto Baud Rate* to *Inactive*.

> **WARNING:** The meter provides no facility to revert the baud rate remotely. Once written, the meter will lose communication until the client baud rate matches the new configuration.

Default: *Varies*

0   AV134   Smoothed Temperature Response Time R/W/NV

Sets the step response time for smoothed temperature (see AI312), in seconds.

Across all groups, the various *Smoothed* values track the instantaneous measurement after the application of a first-order exponential function. This low pass filter attenuates fast changes, such as the inrush current of a large industrial motor. *Smoothed* values may provide a stable baseline measurement but will always lag the instantaneous measurement (see Figure 16A).

Formally, response time sets the time required for a *Smoothed* value to complete 90% of the transition after an ideal step between two stable values (see Figure 16B).

A: General Smoothing   *B: Ideal Step Response*
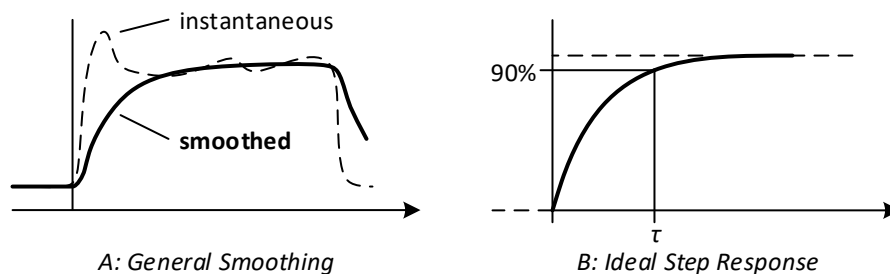
Figure 16: Smoothed Response Time

During periods of invalid measurement, *Smoothed* values return 0 (undefined). The resumption of valid measurements momentarily suppresses the smoothing function while the value stabilizes.

Default: 30 seconds

AV142   Smoothed Frequency Response Time   R/W/NV

Sets the step response time (see AV134) for smoothed *Frequency* (see AI412) and *Voltage Angle* (e.g. AI1442), in seconds.

Default: 60 seconds

AV144   Smoothed Voltage Response Time   R/W/NV

Sets the step response time (see AV134) for smoothed *RMS Voltage* (e.g. AI1422), in seconds.

Default: 10 seconds

AV154   Smoothed Current Response Time   R/W/NV

Sets the step response time (see AV134) for smoothed *RMS Current* (e.g. AI1522), *Current Angle* (e.g. AI1542), and *Power Factor* (e.g. AI1552), in seconds.

Default: 2 seconds

AV164   Smoothed Power Response Time   R/W/NV

Sets the step response time (see AV134) for smoothed *Power* (e.g. AI1602), in seconds.

Default: 2 seconds

AV174   Energy Timestamp   R

Returns a high resolution timestamp, 0 – 4194304 milliseconds (2^{22} – 1, about 1 hour).

The timestamp value updates atomically with the various energy accumulators. If read atomically with one or more energy measurements by a *Read-Multiple* query, this timestamp may be useful for calculating accurate average power from differential energy:

$$P_{AVG} = \frac{\Delta E}{\Delta t} = \frac{E_2 - E_1}{t_2 - t_1}$$

AV182   Demand Synchronization Hour   R/W/NV

Sets the hour of the day for demand window synchronization, 0 – 23 hours.

Only applies when the *Demand Window Synchronization* mode is *Every Day* (see MSV181). In this case, synchronization occurs at the top of the selected hour.

Default: 0 (midnight)

AV183   Demand Window Time   R/W/NV

Sets the maximum demand window time, 0 – 1440 minutes.

The demand measurements (see AI1800) measure average power within a windowed period.

Every time the *Elapsed Demand Window* time (see AV184) reaches this limit, the current window closes and a new window starts.

If set to 0 minutes, the window time is unlimited. In this case, new windows are only started by external synchronization (see MSV181) or software synchronization (see AV184).

Default: 15 minutes

AV184   Elapsed Demand Window   R/W0

Returns the time since the beginning of the current demand window, in minutes.

The demand measurements (see AI1800) measure average power within a windowed period.

This value resets to 0 at the beginning of each new demand window. Writing 0 at any time automatically starts a new window (software synchronization).

AV186   **Demand Window Count**   R/NV

Returns the number of completed demand windows. Any demand window at least 1 second long counts, regardless of whether the window was defined by external synchronization (see MSV181), software synchronization (see AV184), or elapsed time (see AV183). Resetting all or a portion of the demand statistics (see AV192, AV1192) does not automatically start a new demand window.

The system and all phase demand values update together (e.g. AI1800), so this count can serve as a unique key to identify each new batch of demand statistics (e.g. for logging).

Resets to 0 only when the system and all phase demand statistics are reset together (see AV192).

AV190   **Configuration Reset**   W

Always returns 0. Write the reset key to reset the meter to factory defaults.

> **WARNING:** The entire non-volatile configuration will be permanently lost; previous configurations cannot be recovered. This includes accumulated energy, demand statistics, and pulse input counts. This also includes the current RS485 serial format, *MAC Address*, and *Device ID*. The only parameters not affected are the *Reset Count* (see AV103) and the *Energy Reset Count* (see AV194).

After a configuration reset, the meter itself will reset and re-learn the current baud rate, serial format, protocol, and *MAC Address* (see Configuration). If the *Device ID* was previously changed, it may be necessary for the controller to rediscover the meter.

- Write 9699690 to reset the meter to factory defaults.

AV192   **Statistics Reset**   W

Always returns 0. Write one of the following keys to reset some or all of the phase statistics. Writing any other value results in an error response.

> **WARNING:** Selected statistics will be permanently lost; previous records cannot be recovered.

System statistics ONLY:

- Write 4765089 to reset analog statistics (AI410 – AI678: *Minimum, Maximum, Average*)
- Write 5338209 to reset demand statistics (AI800 – AI866: *Minimum, Maximum*)
- Write 6647201 to clear accumulated energy (ACC700 – ACC766: *All Objects*)
- Write 5811297 to reset all system statistics

System and all phases R/S/T:

- Write 7648701 to reset all analog statistics
- Write 7566461 to reset all demand statistics
- Write 6909373 to reset all accumulated energy
- Write 4762749 to reset all statistics

Phase R/S/T statistics may also be reset individually (see AV1192). Analog statistics automatically reset whenever the meter itself resets (see AV103). Individual analog and demand statistics may also be automatically reset when *Auto Reset Statistics* is *Active* (see BV195).

Resetting any subset of accumulated energy increments the *Energy Reset Count* (see AV194).

AV194   **Energy Reset Count**   R/NV

Returns the number of times accumulated energy has been reset. Counts "1" for every full or partial energy reset key written (see AV192, AV1192), regardless of the actual energy accumulation.

This value may be useful for auditing, since the meter maintains this count in a protected section of non-volatile memory unaffected by *Configuration Reset* (see AV190)

AV208   Pulse Input Debounce Time   R/W/NV

Sets the delay time for each input transition before registering a new state, 0 – 255 milliseconds.

This suppresses glitches in the input, such as might be generated by a mechanical relay or electrical interference (see Figure 17). Affects both the *Pulse Inputs* (see ACC210, ACC220) and corresponding *Binary Inputs* (see BI201, BI202).
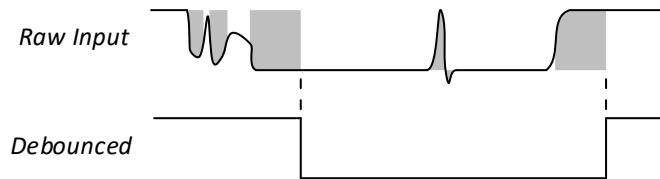
Figure 17: Debouncing Delay

If possible, set the debounce time to 50% of the expected minimum pulse time. Setting 0 disables debouncing: new input states register immediately, but the count may be noisy.

> **IMPORTANT:** Because each pulse must have both a high and low interval, the maximum pulse rate will be 1/2 the equivalent rate of a single debounce time. For example, a 1 millisecond debounce time permits a maximum pulse rate of 500 Hz. Reduce the maximum pulse rate further when the duty cycle of the input is not 50%.

Default: 10 milliseconds (50 Hz)

AV242   PowerPrint Frequency   R/W/NV

Sets the expected PowerPrint frequency. If set to any non-zero value, and the *Frequency* (see AI410) differs from expected by more than the *Frequency Tolerance* (see AV244), then the *Frequency Drift* condition (see AV400) will be set.

Set the expected frequency by writing this value directly, or by initializing *PowerPrint* (see BV241).

Default: 0 Hz (undefined)

AV244   PowerPrint Frequency Tolerance   R/W/NV

Sets the tolerance of the *PowerPrint Frequency* (see AV242), 0 – 10 Hz.

Default: 0.2 Hz

AV246   PowerPrint Voltage Tolerance   R/W/NV

Sets the tolerance of the *PowerPrint Voltage* (see AV1144) for all phases, 0 – 100% as a ratio of the target voltage. For example, given a target voltage of 240 V and a tolerance of 10%, PowerPrint expects voltages of 216 – 264 V.

Default: 10%

AV248   PowerPrint Voltage Angle Tolerance   R/W/NV

Sets the tolerance of the *PowerPrint Voltage Angle* (see AV1146) for all pairs of phases, 0– 180°. The default units are *Degrees* (see MSV153).

Default: 30°

AV400   Active Conditions   R

Returns an encoded set of flags representing active system conditions:

•	*Mismatched Voltage* (see AI1450)	BIT [5]	32
•	*Reverse RST Order* (see AI1440)*	BIT [6]	64
•	*Not 3-Phase* (see AI1440)*	BIT [7]	128
•	*Frequency Drift* (see AI420)**	BIT [12]	4096
•	*Phase Drift* (see AI1440)**	BIT [15]	32768

The conditions reflect the near-real-time system status observed over the previous 1 – 2 seconds. The *Line Status* LED also indicates the active conditions (see *Installation Instructions*).

If no CVTs are installed, always returns "0". To decode a set of condition flags, see Appendix A.

*Conditions only reported when the *PowerPrint Voltage* (see AV1144) is undefined.
**Conditions only reported after activating the corresponding PowerPrint feature(s).

AV401   Previous Conditions   R/W0

Returns an encoded set of flags representing all active and historical system conditions. Equivalent to *Active Conditions* (see AV400), except that conditions remain in the set until manually cleared.

Write "0" to clear historical flags (set in AV401 but no longer set in AV400). Flags are also cleared when the meter resets. Active flags (still set in AV400) cannot be effectively cleared, since they will be immediately re-set.

R Phase

AV1140   Voltage Rating   R

Returns the CVT's maximum rated RMS voltage. This always applies to the raw input voltage, measured between the CVT voltage leads without considering the *Voltage Multiplier* (see AV1142).

If the direct input voltage exceeds this rating, the *Over Voltage* condition (see AV1400) will be set. In *Over Voltage* conditions voltage, power, and energy measurements may have reduced accuracy.

> **WARNING:** Exceeding the rated RMS voltage may result in hazardous operating conditions.

AV1142   Voltage Multiplier   R/W/NV

Sets a multiplier to scale from raw input voltage to effective line voltage. Set equal to the ratio of any potential transformer used to step down voltages higher than the maximum rating.   For example, set 35.0 when using a 4200:120 V potential transformer.

The *RMS Voltage* (see AI1420) always returns the effective line voltage including the multiplier. Power and energy measurements scale by the same factor.

Negative multipliers can correct installations where CVT voltage leads are installed backwards:

- Has no effect on *RMS Voltage* (see AI1420), which is always positive.
- Reverses the direction (import/export) of *Power Factor* (see AI1550), *Real Power* (see AI1600), and *Reactive Power* (see AI1640).
- Adds 180° to *Current Angle* (see AI1540), unless the *Current Multiplier* (see AV1152) is also negative, in which case the signs cancel.
- Adds 180° to both *Phase to Phase Voltage Angles* (see AI1440) that include this phase, unless the other phase *Voltage Multiplier* (see AV2142, AV3142) in the pair is also negative.

Default: 1.0

AV1144 PowerPrint Voltage   R/W/NV

Sets the expected PowerPrint voltage. If set to any non-zero value, and *RMS Voltage* (see AI1420) differs from expected by more than the *PowerPrint Voltage Tolerance* (see AV246), then either the *Brown Out Voltage* or *Surge Voltage* conditions (see AV1400) will be set.

Set the expected voltage by writing this value directly, or by initializing *PowerPrint* (see BV241).

Default: 0 (undefined)

AV1146 PowerPrint Voltage Angle   R/W/NV

Sets the expected PowerPrint relative voltage angle between this phase and the "next" (as defined for *Voltage Angle,* see AI1440). If both phases have a non-zero *PowerPrint Voltage* (see AV1144), and the relative *Voltage Angle* differs from the expected angle by more than the *Voltage Angle Tolerance* (see AV248), then the *Phase Drift* condition (see AV1400) will be set.

Set the expected angle by writing this value directly, or by initializing *PowerPrint* (see BV241).

Default: 0 (undefined)

AV1150 Current Rating   R

Returns the CVT's rated RMS current. This always applies to the raw input current measured in the Rogowski Coil loop without considering the *Current Multiplier* (see AV1152). The rating applies only at 60 Hz; ratings at other frequencies are inversely proportional (see AI1520).

If the raw input current exceeds this rating, the *Over Current* condition (see AV1400) may be set. However, this condition reflects the technology capability of the current sensing loop, which may be higher than rating in some cases.   In *Over Current* conditions the current, power, and energy measurements may have reduced accuracy.

AV1152 Current Multiplier   R/W/NV

Sets a multiplier to scale from raw input current to effective line current. Set the inverse of the number of times the conductor passes through the current sensor loop.   For example, set 0.2 when the conductor wraps 5 times.

> **WARNING:** Never deform the Rogowski Coil! Wrapping a conductor may increase accuracy when measuring very low currents, but may also reduce accuracy by deviating from the recommended installation procedure (see *Installation Instructions*). Performance specifications not guaranteed.

The *RMS Current* (see AI1520) always returns the effective line current including the multiplier. Power and energy measurements scale by the same factor.

Negative multipliers can correct installations where a current transducer is installed backwards:

- Has no effect on *RMS Current* (see AI1420), which is always positive.
- Reverses the direction (import/export) of *Power Factor* (see AI1550), *Real Power* (see AI1600), and *Reactive Power* (see AI1660).
- Adds 180° to *Current Angle* (see AI1540), unless the *Voltage Multiplier* (see AV1142) is also negative, in which case the signs cancel.

Default: 1.0

AV1162   Power Multiplier   R/W/NV

Sets a multiplier to scale from raw input power to reported power. For example, set 3.0 to infer the other power and energy of all three phases of a balanced load while measuring just one. This way, the reported measurements have the correct magnitude and scale without any post-calculation.

> **WARNING:** The less balanced the phases, the more this technique reduces measurement accuracy, especially for reactive power. However, the equipment and installation savings may be worthwhile when the primary objective is a relative/trend type measurement.

Negative multipliers reverse the direction (import/export) of *Power Factor* (see AI1550), *Real Power* (see AI1600), and *Reactive Power* (see AI1640).

Setting this value also sets the *Power Multiplier Override* (BV1161) to *Active*. To restore the default, set the *Power Multiplier Override* to *Inactive*.

Default: 1.0

AV1192   Statistics Reset   W

Always returns 0. Write one of the following keys to reset some or all of the phase statistics. Writing any other value results in an error response.

> **WARNING:** Selected statistics will be permanently lost; previous records cannot be recovered.
>
> **NOTE:** Each phase has different keys, which are also different from the system reset keys. This guarantees that statistics cannot be accidentally reset by writing a key to the wrong object.

R Phase (AV1192):

- Write 7779749 to reset analog statistics (AI1420 – AI1672: *Minimum, Maximum, Average*)
- Write 5207141 to reset demand statistics (AI1800 – AI1866: *Minimum, Maximum*)
- Write 7564709 to clear accumulated energy (ACC1700 – ACC1766: *All Objects*)
- Write 6204517 to reset all R Phase statistics

S Phase (AV2192):

- Write 6600105 to reset analog statistics (AI2420 – AI2672: *Minimum, Maximum, Average*)
- Write 7173225 to reset demand statistics (AI2800 – AI2866: *Minimum, Maximum*)
- Write 4287913 to clear accumulated energy (ACC2700 – ACC2766: *All Objects*)
- Write 6073449 to reset all S Phase statistics

T Phase (AV3192):

- Write 4240817 to reset analog statistics (AI3420 – AI3672: *Minimum, Maximum, Average*)
- Write 4813937 to reset demand statistics (AI3800 – AI3866: *Minimum, Maximum*)
- Write 6516145 to clear accumulated energy (ACC3700 – ACC3766: *All Objects*)
- Write 4369521 to reset all T Phase statistics

Phase statistics may also be reset by a *System Statistics Reset* (see AV192). Analog statistics are automatically reset whenever the meter itself resets (see AV103). Individual analog and demand statistics may also be automatically reset when *Auto Reset Statistics* is *Active* (see BV195).

Resetting any subset of accumulated energy increments the *Energy Reset Count* (see AV194).

AV1400   Active Conditions R

Returns an encoded set of flags representing active phase conditions:

- *Sensor Fault* (see MSV1103)   BIT [0]   1
- *No Load* (see AI1600)   BIT [1]   2
- *Negative Power* (see AI1600)   BIT [2]   4
- *Phase Loss* (see AI1420)   BIT [3]   8
- *Bad Frequency* (see AI1420)   BIT [4]   16
- *Low Power Factor* (see AI1550)   BIT [5]   32
- *Over Current* (see AV1150)   BIT [6]   64
- *Over Voltage* (see AV1140)   BIT [7]   128
- *High Harmonics* (see AI1520)   BIT [8]   256
- *Unexpected Sensor* (see MSV1104)*   BIT [9]   512
- *Missing Sensor* (see MSV1104)*   BIT [10]   1024
- *Surge Voltage* (see AV1144)*   BIT [11]   2048
- *Brown Out Voltage* (see AV1144)*   BIT [13]   8192

The conditions reflect the near-real-time phase status observed over the previous 1 – 2 seconds. The *CVT Status* LED also indicates the active conditions (see *Installation Instructions*).

If no CVT is installed, always returns "0". To decode a set of condition flags, see Appendix A.

*Conditions only reported after activating the corresponding PowerPrint feature(s).

AV1401   Previous Conditions R/W0

Returns an encoded set of flags representing all active and historical phase conditions. Equivalent to *Active Conditions* (see AV1400), except that conditions remain in the set until manually cleared.

Write "0" to clear historical flags (set in AV1401 but no longer set in AV1400). Flags are also cleared when the meter resets. Active flags (still set in AV1400) cannot be effectively cleared, since they will be immediately re-set.

S Phase

AV2000 – AV2999

S Phase *Analog Values* parallel the R Phase, offset +1000.

For example, read AV2140 for the *S Phase Voltage Rating*.

T Phase

AV3000 – AV3999

T Phase *Analog Values* parallel the R Phase, offset +2000.

For example, read AV3140 for the *T Phase Voltage Rating*.

Binary Inputs

- Object Identifier   R
- Object Name   R
- Object Type   R
- Present Value   **W**   Only writable when *Out Of Service* is *True*
- Status Flags   R
- Event State   R   Always *Normal*
- **Reliability**   **W**   Only writable when *Out Of Service* is *True*
- Out of Service   **W**
- Polarity   R
- **Inactive Text**   **R**
- **Active Text**   **R**
- **Change of State Time**   **R**   Only valid if the system time is valid
- **Change of State Count**   **W**   Write 0 to reset
- **Time of State Count Reset**   **R**   Only valid if the system time is valid
- **Elapsed Active Time**   **W**   Write 0 to reset
- **Time of Active Time Reset**   **R**   Only valid if the system time is valid
- Property List   R

BI200   Setup Button   R

Returns *Active* when the *Setup Button* (see *Installation Instructions*) is pressed.

This value may be useful for protocol testing. Regardless of the value returned, the *Setup Button* always performs its normal function for diagnostics and configuration.

BI201   Binary Input 1   R
BI202   Binary Input 2   R

Returns the current stable state of the corresponding pulse input (active low; see *Installation Instructions*). The *Pulse Input Debounce Time* (see AV208) sets the minimum stability requirement for each transition.

This value may be useful if the pulse input is connected to a discrete contact, such as an alarm, to trigger additional controller actions. If so, the corresponding *Pulse Input* count (see ACC210, ACC220) may be ignored.

One of the binary inputs may be selected as the source for *Demand Window Synchronization* (see MSV181).
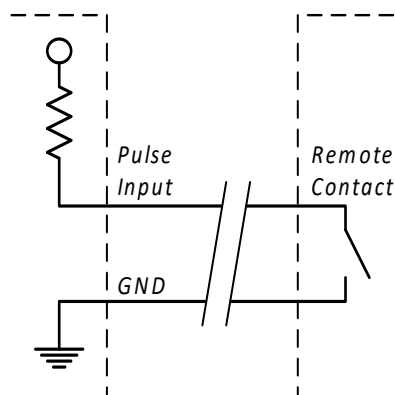
Figure 18: Binary Input Wiring

Binary Values

- Object Identifier   R
- Object Name   R
- Object Type   R
- Present Value   W
- Status Flags   R
- Event State   R   Always *Normal*
- **Reliability**   **R**   Always *No Fault Detected*
- Out of Service   R   Always *False*
- **Inactive Text**   **R**
- **Active Text**   **R**
- Property List   R

System

BV111   Identify Meter   R/W

Sets the LED status interface into a visually identifiable mode. When set to *Active*, all status LEDs (see *Installation Guide*) begin slowly blinking green together.   This pattern is distinct from any other interface pattern the meter may display during normal operation. The LEDs will remain in identify mode until reset to *Inactive* or the *Setup Button* is pressed.

This feature may be useful if several meters are connected on a single network and the association between discovered device IDs and physical meters is uncertain (also see the Device *Serial Number*).

Default: *Inactive* (normal LEDs)

BV112   Auto Protocol   R/W/NV

Sets the state of automatic protocol detection. When *Active*, the RS485 receiver initially allows frames of any supported protocol. On establishing confidence in a particular protocol (about 10 consecutive frames of the same type), this becomes the preferred *RS485 Protocol* (see MSV122).

Generally, having a preferred protocol disallows other protocols. This reduces uncertainty in the unlikely event that a particular frame or sequence could be interpreted as more than one protocol. However, should the protocol really change (e.g. by moving the meter to a different network), the meter will eventually lose confidence in the preferred protocol. After temporarily allowing all protocols, automatic protocol detection will establish a new preference. To avoid the delays associated with changing protocol, set the *RS485 Protocol* to some option that permanently allows multiple protocols.

When changing this value, the meter keeps the current *RS485 Protocol* to avoid communication loss. Setting *Inactive* disables further automatic protocol changes and only allows the protocol(s) specifically set in *RS485 Protocol*.

Default: *Active*

BV113   Auto MAC Address   R/W/NV

Sets the state of the automatic address selection. When *Active*, the *MAC Address* (see AV123) has been automatically selected from a pool of unused MS/TP master addresses (see Configuration). When changing this value, the meter keeps the current *MAC Address* to avoid communication loss.

Default: *Active*

BV114   Auto Baud Rate   R/W/NV

Sets the state of automatic baud rate detection. When *Active*, the meter may automatically change the *Baud Rate* (see AV124) in response to RS485 communication errors. When changing this value, the meter keeps the current *Baud Rate* to avoid communication loss.

> **IMPORTANT:** If *Active*, the meter will not create an MS/TP token on an idle line. Typically, an MS/TP master (see AV123) with the smallest *MAC Address* creates a token after about 500 milliseconds to build an orderly token ring. However, allowing the meter to create a token on an idle line could obstruct a controller attempting to force a switch to a new baud rate.
>
> In all other cases, the meter follows standard BACnet token passing rules. To also force standard behavior on an idle line, set *Auto Baud Rate* to *Inactive*.

Default: *Active*

BV116   Auto Parity   R/W/NV

Sets the state of automatic parity detection. When *Active*, the meter may automatically change the *Parity* (see MSV126) in response to RS485 communication errors. When changing this value, the meter keeps the current *Parity* to avoid communication loss.

Default: *Active*

BV195   Auto Reset Statistics   R/W/NV

Sets the reset mode for statistical measurements (*Minimum, Maximum, Average*). When *Active*, reading an individual statistical measurement also resets it, as if it had been followed by a write of 0 (see Analog Inputs).

Auto reset mode may be useful in some low-overhead remote logging installations.

> **WARNING:** When using *Auto Reset Statistics* as part of a periodic process, ensure there are no extra reads generated between logging intervals. Otherwise, the resulting records may reflect only a portion of the intended interval.

Default: *Inactive*

BV197   Simple Mode   R/W/NV

Sets the number of points available for discovery. When *Active* the device will be in Simple Mode, which is an abbreviated list of the most commonly used points (see Appendix B). When *Inactive* the device is in Advanced Mode which allows ALL points to be available for discovery.

Default: *Model Dependent, RPM Models = Simple Mode, All Other Models = Advanced Mode*

BV240   PowerPrint Alarm   R

Returns *Active* when any of the PowerPrint conditions are active:

- *Frequency Drift* (see AV242, AV400)
- *Phase Angle Drift* (see AV1146, AV400)
- *Brown Out Voltage* (see AV1144, AV1400)
- *Surge Voltage* (see AV1144, AV1400)
- *Unexpected Sensor* (see MSV1104, AV1400)

Review associated conditions and measurements to determine the source of any anomaly and appropriate actions. Once triggered, the *Alarm* remains *Active* for as long as any PowerPrint condition remains active, plus an additional 10 seconds.

BV241   PowerPrint   R/W/NV

Returns *Active* if at least one of the PowerPrint reference parameters has been set.

- *Frequency* (see AV242)
- *Voltage* (see AV1144)
- *Voltage Angle* (see AV1146)
- *Identity* (see MSV1104)

Setting *Inactive* clears all of the reference parameters at once. Setting *Active* while *Inactive* initializes PowerPrint (if already *Active*, setting *Active* has no effect).   When activated this way, PowerPrint initializes all of the reference parameters at once:

- Sets the expected frequency to exactly 50 Hz or 60 Hz if the measured *Frequency* (see AI410) is within the *Frequency Tolerance* (see AV244); otherwise leaves expected frequency undefined.
- Sets the expected voltage for each phase equal to the measured *RMS Voltage* (see AI1420) if the measured voltage is not detecting the *Phase Loss* condition.
- Sets the expected voltage angle between each phase and the next equal to the measured angle (see AI1440) if neither phase is detecting the *Phase Loss* condition.
- Sets the reference identity for each phase CVT if the *Status* (see MSV1103) is *No Fault Detected*.

May return a BACnet *Internal Error* if no PowerPrint parameters could be set (e.g. no CVTs installed).

Default: *Inactive*

R Phase

BV1102   CVT Present   R

Returns *Active* when the meter detects a connected CVT. For more detailed diagnostic information, read the *CVT Status* (see MSV1103). If *Inactive*, *Status* returns *No Sensor*.

BV1161   Power Multiplier Override   R/W/NV

Returns the status of the phase *Power Multiplier* (see AV1162). *Inactive* indicates the default multiplier; *Active* indicates an override. Setting *Inactive* resets the *Power Multiplier* to default.

Default: *Inactive*

S Phase

BV2000 – BV2999

S Phase *Binary Values* parallel the R Phase, offset +1000.

For example, read BV2102 for *S Phase Present*.

T Phase

BV3000 – BV3999

T Phase *Binary Values* parallel the R Phase, offset +2000.

For example, read BV3102 for *T Phase Present*.

Multi State Values

- Object Identifier   R
- Object Name   R
- Object Type   R
- Present Value   **W**
- Status Flags   R
- Event State   R   Always *Normal*
- **Reliability**   **R**   Always *No Fault Detected*
- Out of Service   R   Always *False*
- Number of States   R
- **State Text**   **R**
- Property List   R

Unless otherwise specified, changes to RS485 parameters are effective after the response (i.e. a client must maintain the original parameters for the remainder of the current transaction).

System

MSV122   RS485 Protocol   R/W/NV

Sets the communication protocol(s):

1. *Auto*   5. *BACnet and Modbus RTU*
2. *BACnet*   6. *BACnet and Modbus ASCII*
3. *Modbus RTU*   7. *Modbus RTU and ASCII*
4. *Modbus ASCII*   8. *Any Protocol*

If *Auto Protocol* is *Active* (see BV112), returns the auto-detected protocol (typically *BACnet*). Otherwise, returns the user-configured protocol option.

Setting any value other than *Auto* also sets *Auto Protocol* to *Inactive*. Setting *Auto* copies any previously set protocol option to the automatic protocol detector and sets *Auto Protocol* to *Active*. Setting an option with multiple protocols (5 – 8) reduces the *Auto Protocol* re-detection delay.

Default: *Auto*

MSV126   RS485 Parity   R/W/NV

Sets the communication parity:

1. *Auto*
2. *No Parity*
3. *Odd Parity*
4. *Even Parity*

If *Auto Parity* is *Active* (see BV116), returns the auto-detected parity (typically *No Parity* for BACnet). Otherwise, returns the user-configured parity option.

Setting any value other than *Auto* sets *Auto Parity* to *Inactive*. Setting *Auto* sets *Auto Parity* to *Active*, but keeps the current parity option to avoid loss of communication.

Default: *Auto*

MSV133   Temperature Units   R/W/NV

Sets the preferred units for temperature values:

1. *Degrees Fahrenheit* (°F)
2. *Degrees Celsius* (°C)

Verify the setting by reading the *Units of Measure* of the temperature object (see AI310). Saved statistical values automatically convert when the selected unit changes.

Default: *Degrees Fahrenheit*

MSV152   System Current Sensor Technology   R

Returns the overall current sensor technology of the CVT(s) installed with a meter. This value is provided in anticipation of future CVT technology upgrades:

1. *Unknown Technology*
2. *Conflicted Technology*
3. *Multiple Technology*
4. *Rogowski Coil*
5. *Current Transformer*

This value derives from the combination of the *Current Sensor Technology* (see MSV1.154) of each CVT. All CVTs installed with a single meter must be compatible for proper operation.

Read only. At EM-RS485 launch, all Senva CVTs are based on *Rogowski Coil* technology. If no CVTs are installed, returns *Unknown Technology*.

MSV153   Angle Units   R/W/NV

Sets the preferred units for angle values:

1. *Degrees*
2. *Radians*

Verify the setting by reading the *Units of Measure* of any angle object (e.g. AI540). Saved statistical values automatically convert when the selected unit changes.

Default: *Degrees*

MSV161   System Phase Selection   R/W/NV

Sets the phase selection mask for system measurements:

1. *3 Phase*
2. *R Phase and S Phase*
3. *S Phase and T Phase*
4. *R Phase and T Phase*

System measurements, including phase averages (e.g. AI420) and accumulations (e.g. ACC700), are based on the selected phases only. Set this value in case of a split system (e.g. 2 CVTs measuring a 2-phase system input with a third CVT measuring a separate branch load). There are no equivalent options for single phase, as individual phase measurements are always accessible.

For consistency, consider resetting the system statistics (see AV192) after changing this setting.

Default: *3 Phase*

MSV162   Power Spectrum   R/W/NV

Sets the bandwidth of real and reactive power and energy measurements:

1. *Wideband*
2. *Fundamental*

Generally, harmonic components are the result of non-linear distortions in the generator or the load. In *Wideband* mode, measurements include power of all harmonic components (e.g. 3rd, 5th), up to the cutoff frequency (see *Installation Instructions*). In *Fundamental* mode, measurements include only power in the fundamental *Frequency* (see AI410).

> **NOTE:** Harmonic power requires matched frequency components in the spectrum of both voltage and current. For example, given a 5th harmonic of current, there must be a corresponding 5th harmonic of voltage. Otherwise, even though distortion power increases, the real and reactive components of power cancel leaving only the power in the fundamental.

For consistency, consider resetting accumulated energy (see AV192) after changing this setting.

Default: *Wideband*

MSV163   Power Units   R/W/NV

Sets the preferred units for power and demand power values:

1. *Kilowatts*
2. *Watts*
3. *Megawatts*

Verify the setting by reading the *Units of Measure* of any power object (e.g. AI600). Saved statistical values, included maximum demand power, automatically convert when the selected unit changes.

The options specify real power only. Reactive and apparent power always follow the real power scale, as shown in each column:

	Relative Scale = 1.0	1,000	1,000,000
Real Power	W (Watts)	kW	MW
Reactive Power	VAR (Volt-Amps Reactive)	kVAR	MVAR
Apparent Power	VA (Volt-Amps)	kVA	MVA

Default: *Kilowatts*

MSV173   Energy Units   R/W/NV

Sets the preferred units for accumulated energy values:

1. *Kilowatt Hours*
2. *Watt Hours*
3. *Megawatt Hours*

Verify the setting by reading the *Units of Measure* of any energy object (e.g. ACC700). Accumulated energy automatically converts with no loss when the selected unit changes.

The options specify real energy units only. Reactive and apparent energy always follow the real energy scale, as shown in each column:

	Relative Scale = 1.0	1,000	1,000,000
Real Energy	Wh (Watt hours)	kWh	MWh
Reactive Energy	VARh (Volt-Amp Reactive hours)	kVARh	MVARh
Apparent Energy	VAh (Volt-Amp hours)	kVAh	MVAh

Default: *Kilowatt Hours*

MSV181 Demand Synchronization Mode   R/W/NV

Sets the synchronization mode for the demand window:

1. *No Synchronization*
2. *Setup Button*
3. *Binary Input 1 (falling)*
4. *Binary Input 1 (rising)*
5. *Binary Input 2 (falling)*
6. *Binary Input 2 (rising)*
7. *Every Hour*
8. *Every Day*

Selecting any of the synchronization sources allows the internal window to be aligned to some external reference (Figure 19B). When a synchronization event is detected, the current window ends immediately and a new window begins. Synchronization events occur exactly once when the selected condition is detected. Synchronization cannot re-occur until the condition is removed and redetected, no matter how long it may be maintained.

In *No Synchronization* mode, the *Elapsed Demand Window* (see AV184) counts time continuously, only restarting if the meter itself restarts (Figure 19A). When the counter reaches the full *Demand Window Time* (see AV183), the current demand window ends and a new window begins.

In *Setup Button* (see BI200) mode, synchronization occurs as soon as the button is pressed. The *Setup Button* always performs its normal function.   If there are any active diagnostic conditions, it may be necessary to exit diagnostic mode after pressing the button (see *Installation Instructions*). To avoid a second synchronization, wait for diagnostic mode to time out (about 60 seconds).

In *Binary Input* (see BI201, BI202) mode, *Falling Edge* synchronization occurs when an external contact pulls the pulse input to GND (active low, see Figure 18). *Rising Edge* synchronization occurs in the opposite condition, when an external contact opens. The *Debounce Time* (see AV208) may delay the synchronization up to 250 milliseconds after the transition. This mode may be useful to align demand windows with a utility meter that provides a regular synchronization pulse.

In *Every Hour* or *Every Day* mode, synchronization requires an initial BACnet *Time Synchronization* set the internal clock, and periodic broadcasts to correct small clock drift. If the *Time Synchronization* broadcasts are not maintained, performance will eventually be equivalent to *No Synchronization*. Also in *Every Day* mode, a specific hour of the day may be selected (see AV182).

For *Full Synchronization*, relying exclusively on an external trigger, disable the internal window time by setting the *Demand Window Time* to 0 minutes (Figure 19C).

A: No Synchronization   B: Basic Synchronization   C: Full Synchronization

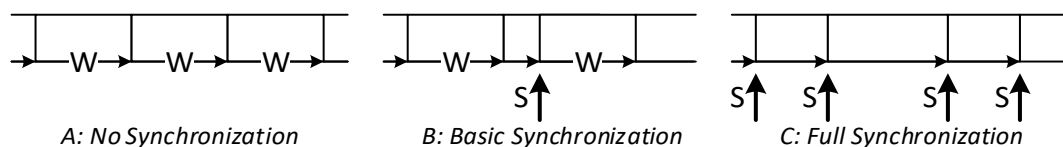*Figure 19: Synchronization Modes*

> **NOTE:** Consider synchronizing when the average power is typically light (e.g. midnight). When a synchronization event is detected, it makes no difference how much or little time has elapsed in the current window. Average power may be more volatile if the window has only just started, being measured over a shorter period of time.

Default: *No Synchronization*

R Phase

MSV1103 **CVT Status**   **R**

Returns general CVT status:

1. *No CVT*
2. *No Error*
3. *Detection Error*
4. *Communication Error*
5. *Configuration Error*
6. *Version Error*
7. *Technology Error*

Any *Error* status causes the *Sensor Fault* (see AV1400) condition to be set. In this case, all of the individual phase measurements (see AI1420 ff.) are marked invalid. In addition, the phase carries no weight in the system average calculations (see AI420 ff.). Previous phase statistics and energy accumulations are preserved.

Typically, errors result from an unreliable cable connection between the EM-RS485 and a CVT. Disconnect the CVT from the meter and inspect the cable and connector for damage. If an error persists when the CVT is reconnected, please contact technical support.

At EM-RS485 launch, all Senva CVTs are based on *Rogowski Coil* technology; *Technology Error* is provided in anticipation of future CVT technology upgrades.

MSV1104 **PowerPrint Identity Status**   **R/W/NV**

Sets the status of the CVT's PowerPrint identity:

1. *No Identity*
2. *Identity Saved*
3. *Identity Error*

The PowerPrint identity captures the digital identity of the installed CVT for reference. To initialize or update the PowerPrint identity, activate *PowerPrint* (see BV241) or write *Identity Saved*. To clear any saved identity, write *No Identity* or disable *PowerPrint*.

Returns *Identity Saved* when the CVT identity matches the reference identity. Returns *Identity Error* when it appears that the CVT has been removed or swapped with a different one. In the latter case, PowerPrint also sets the *Unexpected Sensor* and/or the *Missing Sensor* conditions (see AV1400).

Default: *No Identity*

MSV1154 **Current Sensor Technology**   **R**

Returns the current sensor technology of the CVT:

1. *Unknown Technology*
2. *Rogowski Coil*
3. *Current Transformer*

Read only. If no CVT is installed, returns *Unknown Technology*.

At EM-RS485 launch, all Senva CVTs are based on *Rogowski Coil* technology. The combination of the technology of all installed CVTs gives the *System Current Sensor Technology* (MSV152).

S Phase

MSV2000 – MSV2999

S Phase *Multi State Values* parallel the R Phase, offset +1000.

For example, read MSV2103 for the *S Phase Status*.

T Phase

MSV3000 – MSV3999

T Phase *Multi State Values* parallel the R Phase, offset +2000.

For example, read MSV3103 for the *T Phase Status*.

Character String Values

- Object Identifier   R
- Object Name   R
- Object Type   R
- Present Value   R
- Status Flags   R
- **Event State**   **R**   Always *Normal*
- **Reliability**   **R**   Always *No Fault Detected*
- **Out of Service**   **R**   Always *False*
- Property List   R

R Phase

CH1010   CVT Serial Number   **R**
Returns the unique serial number of the CVT. With no CVT installed, returns "000000".

CH1020   CVT Model   **R**
Returns the full model of the CVT. With no CVT installed, returns "NO SENSOR".

S Phase

CH2000 – CH2999
S Phase *Character String Values* parallel the R Phase, offset +1000.

For example, read CH2020 for the *S Phase Model*.

T Phase

CH3000 – CH3999
T Phase *Character String Values* parallel the R Phase, offset +2000.

For example, read CH3020 for the *T Phase Model*.

Files

- Object Identifier   R
- Object Name   R
- Object Type   R
- File Type   R
- File Size   R
- Modification Date   R
- Archive   W
- Read Only   R   Always *True*
- File Access Method   R   Always *Stream Access*
- Property List   R

F25000   User Configuration   R

Returns a copy of the non-volatile configuration (read only). Senva technical support may request a copy of the file contents to diagnose field installation problems.

Appendix A: Condition Flags Decoding

Reading the condition flag objects (see AV400, AV1400) always returns some positive integer R encoding a set C of one or more conditions. Conditions are encoded in binary form, with the interpretation of bits varying between objects. Undefined bits are reserved.

Follow this iterative procedure to find C given any value R:

1. Initialize $C = \{ \}$ (the empty set)
2. Initialize $X = 2^{15} = 32768$
3. If ($R < X$), skip to step 6
4. Subtract X from R
5. If the object defines condition X, add that to C. Otherwise, skip.
6. Divide X by 2 (move to the next smaller bit)
7. If ($X > 1$), repeat steps 3

For example, if AV1400 $R = 3108$, then $C = \{$ Negative Power, Low Power Factor, Surge Voltage $\}$:

Repetition		Step 3	Step 4	Step 5
1. $R = 3108$	$X = 32768$	TRUE		
2. $R = 3108$	$X = 16384$	TRUE		
3. $R = 3108$	$X = 8192$	TRUE		
4. $R = 3108$	$X = 4096$	TRUE		
5. $R = 3108$	$X = 2048$	FALSE	$R = 1060$	$C = C \cup \{$ Surge Voltage $\}$
6. $R = 1060$	$X = 1024$	FALSE	$R = 36$	skip $\{$ Reserved Condition $\}$
7. $R = 36$	$X = 512$	TRUE		
8. $R = 36$	$X = 256$	TRUE		
9. $R = 36$	$X = 128$	TRUE		
10. $R = 36$	$X = 64$	TRUE		
11. $R = 36$	$X = 32$	FALSE	$R = 4$	$C = C \cup \{$ Low Power Factor $\}$
12. $R = 4$	$X = 16$	TRUE		
13. $R = 4$	$X = 8$	TRUE		
14. $R = 4$	$X = 4$	FALSE	$R = 0$	$C = C \cup \{$ Negative Power $\}$
15. $R = 0$	$X = 2$	TRUE		
16. $R = 0$	$X = 1$	TRUE		

An uncompensated PV array may explain this particular set of conditions:

- The *Negative Power* condition may indicate that real power generation exceeds consumption, at least momentarily.
- The *Low Power Factor* condition may indicate a large reactive power, at least when compared to the net real power (assuming that the PV array does not generate reactive power).
- The *Surge Voltage* condition may indicate a too-small *PowerPrint Voltage Tolerance* (see AV246), not accounting for the voltage boost required to return power back to the grid.

Appendix B: Simple Mode Point List

Type	Point	Description/Object Identifier	R/W	Units	Range
AV	1	Configuration	R/W	n/a	0 to 4.294967e9
AV	3	R Phase Current Rating	R/W	Amps	0 to 1000000
AV	4	CT Ratio Secondary	R/W	1/Volts	0 to 4.294967e9
AV	5	R Phase Voltage Multiplier	R/W	Value	-1000000 to 1000000
AV	6	System Voltage	R/W	v	90 to 32000
AV	8	Power Print Voltage Tolerance	R/W	Percent	0 to 100
AI	1	Total Real Energy (AI)	R	kWh	0 to 1e9
AI	2	Total Real Power	R	kW	-180 to 180
AI	3	Total Reactive Power	R	kVAR	-180 to 180
AI	4	Total Apparent Power	R	kVA	0 to 180
AI	5	System Power Factor	R	pf	0 to 1
AI	6	Phase to Phase Average RMS Voltage	R	V	0 to 600
AI	7	Phase Average RMS Voltage	R	V	0 to 600
AI	8	Phase Average RMS Current	R	amps	0 to 300
AI	9	R Phase Real Power	R	kW	-System Max Power to System Max Power (AI45)
AI	10	S Phase Real Power	R	kW	-System Max Power to System Max Power (AI45)
AI	11	T Phase Real Power	R	kW	-System Max Power to System Max Power (AI45)
AI	12	R Phase Power Factor	R	pf	0 to 1
AI	13	S Phase Power Factor	R	pf	0 to 1
AI	14	T Phase Power Factor	R	pf	0 to 1
AI	15	R to S Phase RMS Voltage	R	V	0 to 600
AI	16	S to T Phase RMS Voltage	R	V	0 to 600
AI	17	T to R phase RMS Voltage	R	V	0 to 600
AI	18	R Phase RMS Voltage	R	V	0 to 600
AI	19	S Phase RMS Voltage	R	V	0 to 600
AI	20	T Phase RMS Voltage	R	V	0 to 600
AI	21	R Phase RMS Current	R	Amps	0 to 300
AI	22	S Phase RMS Current	R	Amps	0 to 300

AI	23	T Phase RMS Current	R	Amps	0 to 300
AI	25	Line Frequency	R	Hz	38 to 150
AI	26	Total Apparent Energy (AI)	R	240	0 to 1e9
AI	27	Total Reactive Energy (AI)	R	243	0 to 1e9
AI	28	R Phase Apparent Power	R	kVA	0 to 180
AI	29	S Phase Apparent Power	R	kVA	0 to 180
AI	30	T Phase Apparent Power	R	kVA	0 to 180
AI	31	R Phase Reactive Power	R	kVAR	-System Max Power to System Max Power (AI45)
AI	32	S Phase Reactive Power	R	kVAR	-System Max Power to System Max Power (AI45)
AI	33	T Phase Reactive Powre	R	kVAR	-System Max Power to System Max Power (AI45)
AI	34	Demand Total Real Power	R	kW	-System Max Power to System Max Power (AI45)
AI	35	Demand Total Reactive Power	R	kVAR	-System Max Power to System Max Power (AI45)
AI	36	Demand Total Apparent Power	R	kVA	-System Max Power to System Max Power (AI45)
AI	37	Maximum Demand Total Real Power	R	kW	-System Max Power to System Max Power (AI45)
AI	38	Maximum Demand Total Reactive Power	R	kVAR	-System Max Power to System Max Power (AI45)
AI	39	Maximum Demand Total Apparent Power	R	kVA	-System Max Power to System Max Power (AI45)
AI	40	Pulse Input 1	R	#	0 to 3000
AI	41	Pulse Input 2	R	#	0 to 3000
AI	42	Total R Phase Real Energy (AI)	R	kWh	0 to 1e9
AI	43	Total S Phase Real Energy (AI)	R	kWh	0 to 1e9
AI	44	Total T Phase Real Energy (AI)	R	kWh	0 to 1e9
AI	45	Theoretical System Maximum Power	R	kW	CVT Dependent
AI	47	Energy Reset Count	R	0 to 32700	
AI	50	Reset Count	R	0 to 32700	
AI	52	Alarm Bitmap	R	0 to 32700	
BI	1	R Phase Voltage Out of Range	R		0=Inactive, 1=Active

BI	2	S Phase Voltage Out of Range	R		0=Inactive, 1=Active
BI	3	T Phase Voltage Out of Range	R		0=Inactive, 1=Active
BI	4	R Phase Current Out of Range	R		0=Inactive, 1=Active
BI	5	S Phase Current Out of Range	R		0=Inactive, 1=Active
BI	6	T Phase Current Out of Range	R		0=Inactive, 1=Active
BI	7	Frequency Out of Range	R		0=Inactive, 1=Active
BI	9	R Phase Phase Loss	R		0=Inactive, 1=Active
BI	10	S Phase Phase Loss	R		0=Inactive, 1=Active
BI	11	T Phase Phase Loss	R		0=Inactive, 1=Active
BI	12	R Phase Low Power Factor	R		0=Inactive, 1=Active
BI	13	S Phase Low Power Factor	R		0=Inactive, 1=Active
BI	14	T Phase Low Power Factor	R		0=Inactive, 1=Active
BV	197	Simple/Advanced Mode	R/W		0 = Advanced, 1 = Simple

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AV	1	Configuration	R/W	n/a	0 to 4.294967e9
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AV	8	Power Print Voltage Tolerance	R/W	Percent	0 to 100
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AI	4	Total Apparent Power	R	kVA	0 to 180
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AI	14	T Phase Power Factor	R	pf	0 to 1
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AI	16	S to T Phase RMS Voltage	R	V	0 to 600
AI	17	T to R phase RMS Voltage	R	V	0 to 600

AI	18	R Phase RMS Voltage	R	V	0 to 600
AI	19	S Phase RMS Voltage	R	V	0 to 600
AI	20	T Phase RMS Voltage	R	V	0 to 600
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AI	22	S Phase RMS Current	R	Amps	0 to 300
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AI	30	T Phase Apparent Power	R	kVA	0 to 180
AI	31	R Phase Reactive Power	R	kVAR	-System Max Power to System Max Pow
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BI	4	R Phase Current Out of Range	R		0=Inactive, 1=Active
BI	5	S Phase Current Out of Range	R		0=Inactive, 1=Active
BI	6	T Phase Current Out of Range	R		0=Inactive, 1=Active
BI	7	Frequency Out of Range	R		0=Inactive, 1=Active
BI	9	R Phase Phase Loss	R		0=Inactive, 1=Active

BI	10	S Phase Phase Loss	R		0=Inactive, 1=Active
BI	11	T Phase Phase Loss	R		0=Inactive, 1=Active
BI	12	R Phase Low Power Factor	R		0=Inactive, 1=Active
BI	13	S Phase Low Power Factor	R		0=Inactive, 1=Active
BI	14	T Phase Low Power Factor	R		0=Inactive, 1=Active
BV	197	Simple/Advanced Mode	R/W		0 = Advanced, 1 = Simple