iCON™APX

Technical Manual

iCon APX Advanced Functionality Meter

SENSUS METERING SYSTEMS

Technical Manual for the iCon APX Advanced Functionality Meter

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iCon APX Advanced Functionality Meter

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Chapter 1

The iCon™ APX Advanced Functionality Meter is a commercial-grade, electricity meter. By analyzing information from the metering industry, Sensus Metering Systems has developed a new, configurable meter designed to meet the demands of commercial metering.

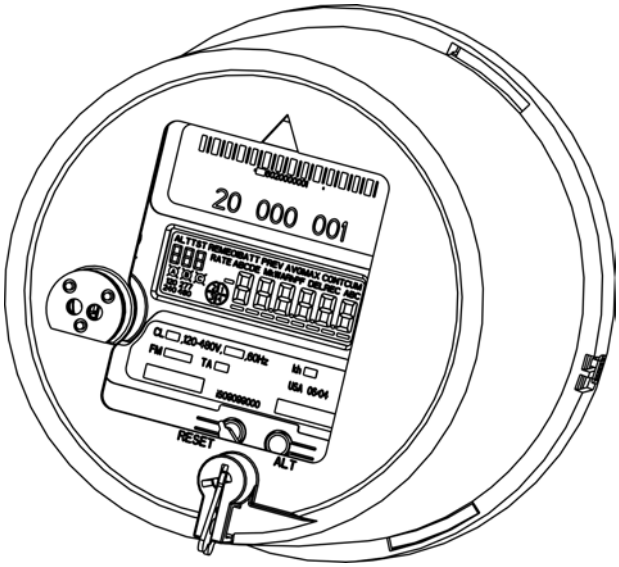


Figure 1-1: iCon APX Advanced Functionality Meter

Overview

This manual provides technical and support information for the iCon APX meter:

- Socket: Form 9S (8S) 20 Amp
- Socket: Form 16S (14S, 15S, 17S) 200 Amp

Purpose

The purpose of this manual is to provide:

- Physical descriptions of the APX meters.
- Descriptions of fixed and optional features.
- A reference for meter set up, operation, troubleshooting, and maintenance.

This document is intended for technically qualified personnel of energy supply companies and their contractors who are responsible for the system planning, installation, commissioning, operation, maintenance, decommissioning, and/or disposal of meters.

Safety

WARNING

Hazardous voltages are present while power is applied to meters, meter sockets, or other metering equipment. Any work on the energized equipment presents the danger of electrical shock and can result in death or serious injury. The information contained within this manual is intended to be an aid to qualified metering personnel. It is not intended to replace the extensive training necessary to handle metering equipment in a safe manner.
Use extreme care when servicing the meter while power is applied.

CAUTION

Qualified electricians and metering specialists, in accordance with local utility safety practices and utility requirements, should perform all work on this product with extreme care. Failure to comply with this caution can result in the destruction of or damage to the equipment and/or permanent loss of stored data..

All industry safety precautions must be observed during all phases of operation, service, and servicing of the meters. Failure to comply with these precautions or with specific warnings in this manual violates safety standards of design, manufacture, and the intended use of the metering instrument. Sensus Metering Systems assumes no liability for the customer's failure to comply with these requirements.

Manual Conventions

This section provides additional information that may be required for meter configuration and maintenance purposes.

Additional Information Sources

- Handbook for Electricity Metering, 10th Edition, Edison Electrical Institute
- Requirements for Watthour Meter Sockets, ANSI C12.7-1993

Notational Conventions

Hexadecimal Values

Hexadecimal values in this manual are expressed as follows:

- Values that are in hexadecimal notation are shown as two or four (4) characters followed by the letter "h." Each character can have a value from 0 through F. For example, 9C3Fh
- All other numbers are in decimal notation.

Ranges

Ranges, or parameters, expressed in this manual are expressed a pair of values separated by ellipses. For example, 0…5 include numbers 0 and 5 and all of the values in between.

Register Notation and Usage

Registers are a part of the meter memory that contains the addresses that are used to hold specific kinds of information. The following registers are contained in the APX meter. The information stored in these registers is usually configured using the *iConFig* application software.

Billing Registers

The APX meter contains two Billing Registers. The Billing Registers store:

- Selected consumption readings
- The associated Maximum Demand readings
- The associated Cumulative Demand or Continuously Cumulative Demand.

Previous Demand Registers

The Previous Demand registers contain a snapshot of the Billing Registers captured during the last Demand Reset. Any data in these registers is overwritten during the reset.

Status Register

The status register store meter dependent information (e.g., Low Battery, Meter errors, Demand overloads)

History Log Register

The History Log registers store data for selected events that may occur during meter operation. More than 40 different events can be recognized and the results stored in these registers.

Applicable Standards

The iCon APX meter meets or exceeds the ANSI standards for commercial and industrial electricity metering.

Table 1-1: Applicable Standards

ANSI C12.1 – 2001	American National Standard Code for Electricity Metering
ANSI C12.13-1991	American National Standard Code for Electronic Time-of-Use Registers for Electricity Meters
ANSI C12.18-1996	American National Standard Code for Protocol Specification for ANSI Type 2 Optical Port
*ANSI C12.19 - 1997	American National Standard Code for Utility Industry End Device Data Tables
*ANSI C12.20 – 2002	American National Standard Code for Electricity Meters 0.2 and 0.5 Accuracy Classes
ANSI C12.21-1999	American National Standard Code for Protocol Specification for Telephone Modem Communication
ANSI/IEEE C37.90 –1989	IEEE Standard Surge Withstand Capability (SWC) for Protective Relays and Relay Systems
* - The iCon™ APX conforms to the standards, however the meters are not governed by them.	

Chapter 2

iCon APX Meter

The iCon™ APX Advanced Functionality Meter continues to use same field-proven Sentec® sensor technology found in the other meters in the iCon family.

Accuracy

The APX meter is built with a backbone of precision that exceeds ANSI C12.20 standards for accuracy.

Reliability

The iCon APX meter uses a simple, unique modular design that meets the most stringent performance requirements for revenue billing applications. This construction reduces the number of connections thereby reducing the possibility of false data or metering related problems.

Expandability

Like the iCon meter, the APX meter employs an open architecture design that allows for easy and cost effective AMR integration. The APX meter was designed with this idea in mind.

Tamper Resistance

Since there are no moving parts, the APX meter is not vulnerable to the tampering methods (e.g., using magnets, inserting foreign objects into the gears, inverting the meter in the socket) used to affect electromechanical meters.

System Architecture

Figure 2-1 shows the APX meter with the Meter Cover and Register Cover removed.

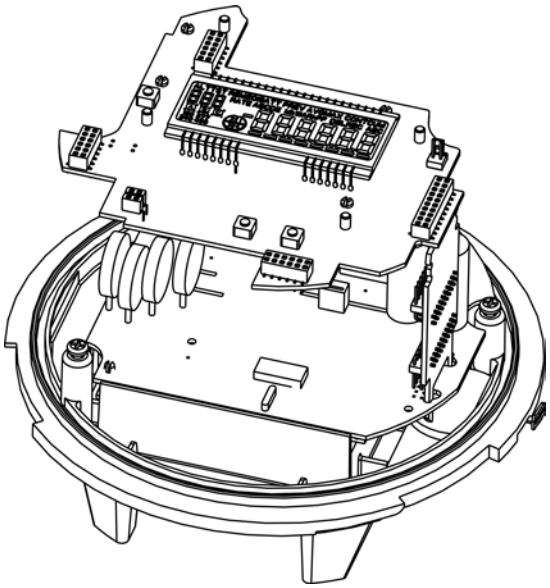


Figure 2-1: APX Meter Internal Components

APX meters:

- Display accumulated electricity usage data on an easy-to-read liquid crystal display (LCD).
- Are compatible with industry requirements for mounting and device profile features.
- Are compliant with all applicable ANSI standards.

NOTE:
This manual describes some of the features available in iCon APX meters. At the time of order, specific options are selected for each utility. Not all features may appear in all meters.

APX meters meet or surpass the needs for automated billing measurement, data collection, selected control and notification, and usage management for utilities, service providers, and end-users (business-owners). For more information, please email askicon@sensus.com.

Hardware

The basic components of the meter are shown in Figure 2-2.

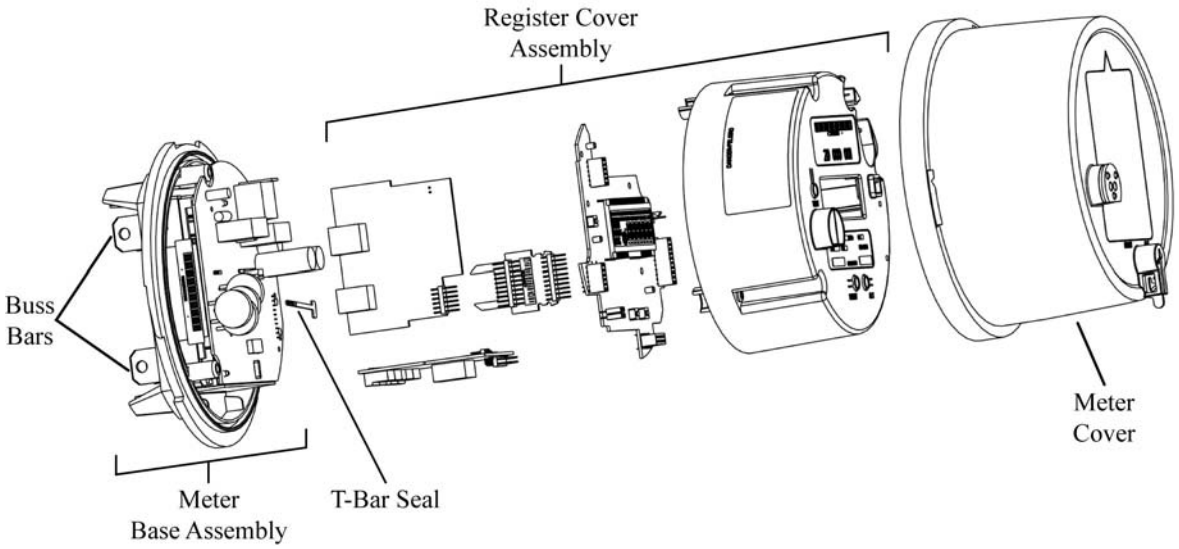


Figure 2-2: iCon APX Meter Components

Meter Base Assembly

The Meter Base Assembly consists of the Meter Base, the Sensor Board, and related hardware. Figure 2-4 shows the Sensor Board in the Meter Base.

There are no field-serviceable parts in the Meter Base Assembly.

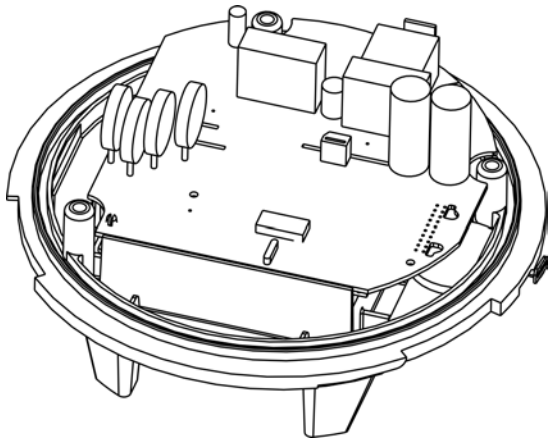


Figure 2-3: Meter Base Assembly

Meter Base

The Meter Base is molded from highly durable thermoplastics. It provides a stable platform for the Sensor Board. In addition to the components described in this section, it contains the hangar for mounting the meter, and the T-Bar for meter security.

Figure 2-4 through Figure 2-6 provide views of the available APX meter Forms.

Figure 2-4 shows a transformer rated Form 9S (8S) Meter Base.

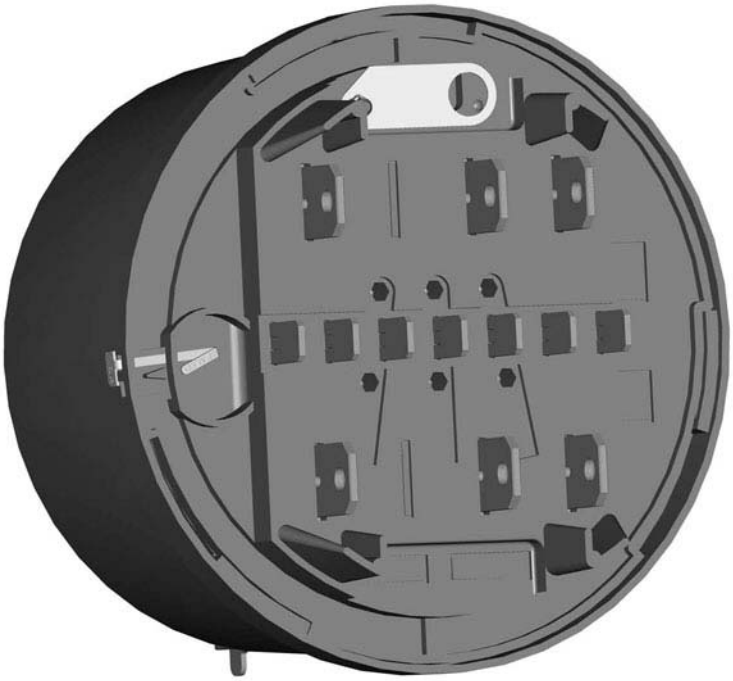


Figure 2-4: Form 9S (8S) Meter Base

Figure 2-4 shows a Form 16S (14S, 15S, 17S) Meter Base.

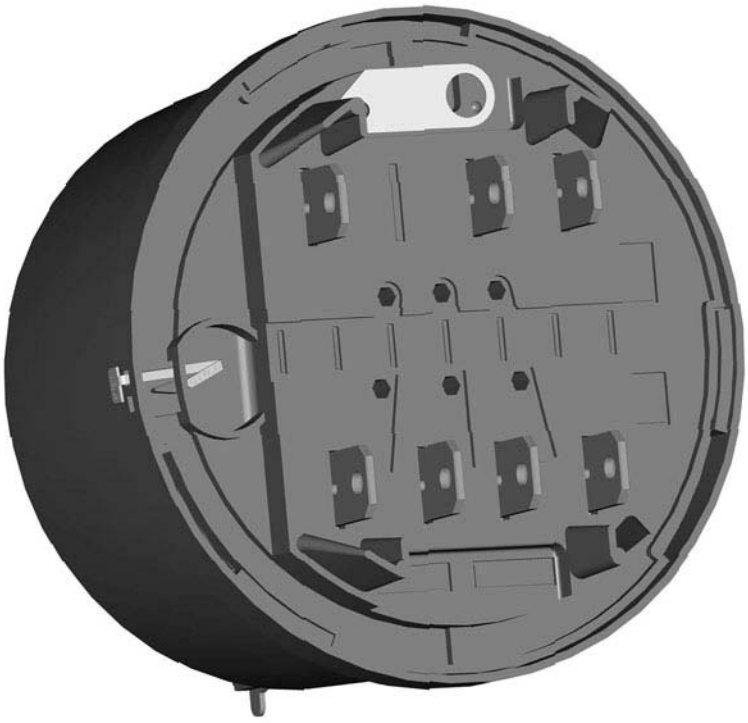


Figure 2-5: Form 16S (14S, 15S, 17S) Meter Base

For self-contained meters, there is an optional Phantom Load version of the Meter Base. Figure 2-6 shows a Form 15S/16S Meter Base with the Phantom Load (closed position).

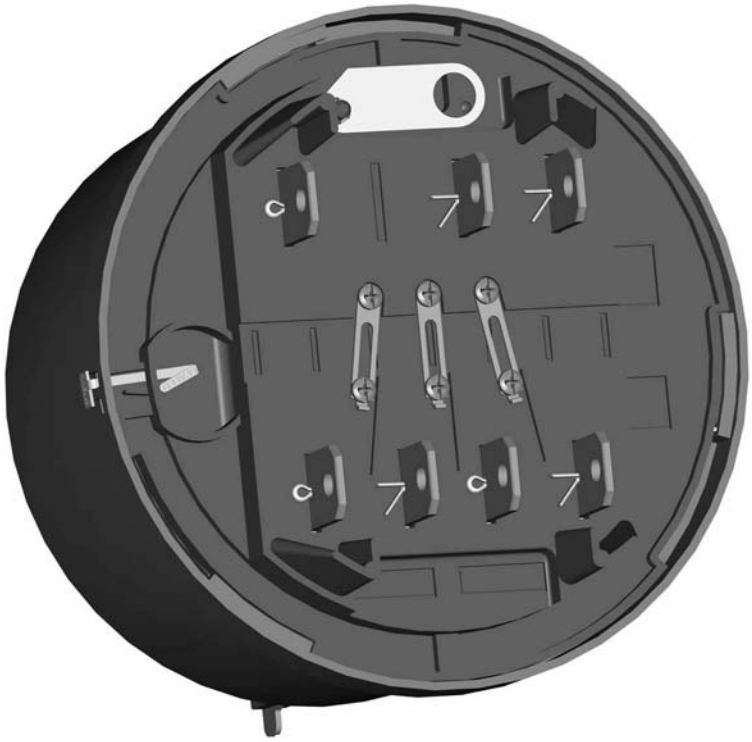


Figure 2-6: Form 15S/16S Meter Base - Optional Phantom Load

All meter bases provide knockouts for the option boards.

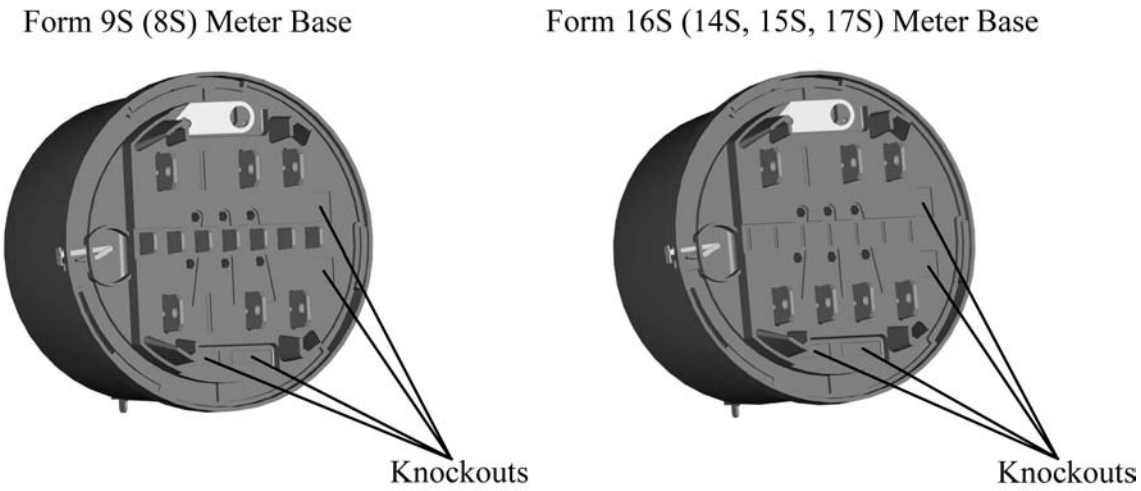


Figure 2-7: Meter Base – Option Board Knockouts

Sensor Board

The Sensor Board is a part of the Meter Base Assembly and consists of the sensing circuitry, buss bars, power supply, and connector ports. There are no field serviceable components in the base assembly.

The module:

- Senses all of the voltages and currents for all phases passing through the meter
- Provides the DC power for the rest of the meter
- Contains the data of all of the sampled energy and voltages
- Supports reading of the sampled data by the Register Display Board
- Holds the calibration information stored in EEPROM

Buss Bars — The buss bars are conducting blades that carry the load current from the service socket to the load. In self-contained meters, the buss bars provide the voltage inputs to the metrology and provide power to the meter's internal power supply.

Sensing Circuitry — The primary components include a patented linear current sensor and integrated circuitry specifically designed for poly-phase electricity metering. The ADE7758 is a 24-pin, poly-phase, energy measuring, integrated-circuit chip with a serial interface and pulse outputs. This chip measures/calculates the following values:

- Active Energy - Wh
- Reactive and Apparent Energy – VARh and VAh
- RMS Voltages
- RMS Currents
- Temperature

The chip is suitable for three-phase, three-wire and/or three-phase, four-wire Delta or Wye services. This chip stores the measurement samples of each quantity and supports read operations by the Register Display Board.

Switching Power Supply — The power supply is a true, three-phase, surge protected, auto-ranging (96 VAC to 576 VAC) power supply. It accepts voltages present at the service socket and provides DC power for the rest of the meter. The power supply functions even with power present on only one phase.

Connector Ports — The Connector Ports provide the physical links to the Sensor Board for the Interconnect Board and the Option Cards.

Register Cover Assembly

The Register Cover Assembly consists of:

- Register Cover
- Register Display Board
- Interconnect Board
- Option Boards

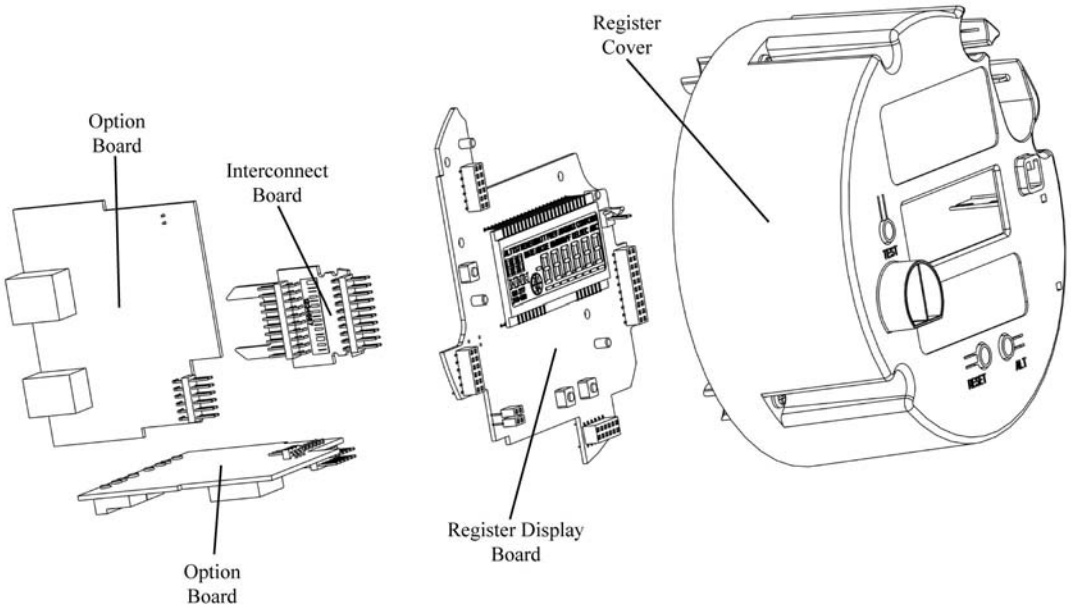


Figure 2-8: Register Cover Assembly – Exploded View

Register Cover

The Register Cover is an opaque shield that protects the meter's internal components from external tampering and serves as the mounting surface for the labels. The cover also contains 'pockets' to house batteries that maintain the DC voltage for circuitry required to function during an outage; such as the RTC. Except for the Optical Port Shield, LCD, TEST tab, RESET tab, and ALT tab, no internal components can be viewed through the Register Cover.

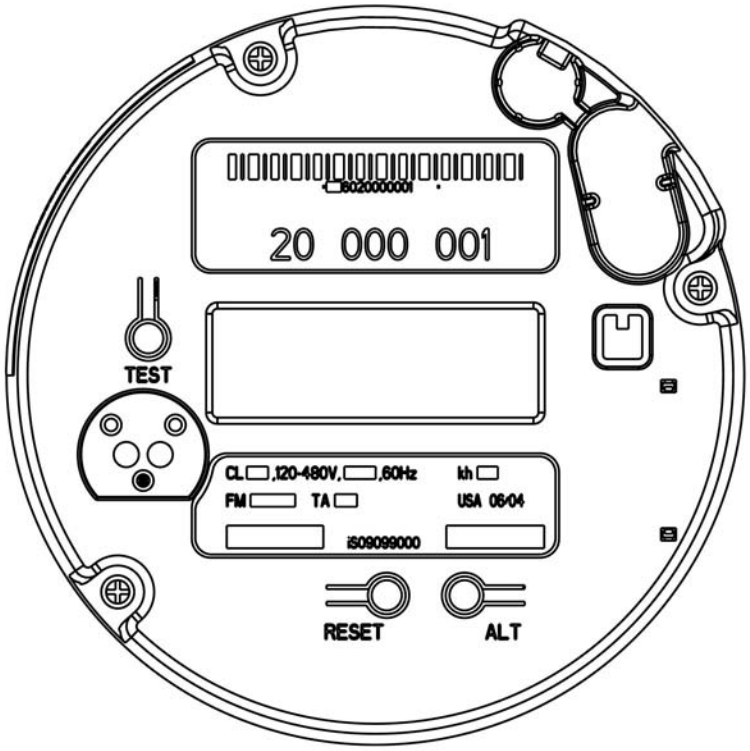


Figure 2-9: Register Cover

Labels

The meter has labels on the Register Cover. The Nameplate, and Warning Label are on all Register Covers. If an AMR module is installed, an FCC Label will be present.

Upper and Lower Nameplate Labels

The upper and lower labels are compliant with the ANSI C12.10 – 1997 standard and may include:

- Meter:
  - Style Number
  - Current class
  - Form
  - Service type
  - K_h value
  - Test Amps
  - Accuracy Class

- Operating:
  - Voltages
  - Frequencies
- A unique meter identifier
- Descriptive information

Meter information required by the utility

- Factory-generated bar code for the:
  - Meter ID
  - Test board

Warning Label

The Warning Label contains a multi-lingual message on the hazards and potential consequences of working on energized equipment.

FCC Label

The FCC Label is affixed to the Register Cover and may:

- Contain patent and part numbers
- Provide relevant FCC Part 15 compliance information
- Describe the operating conditions
- Provide additional compliance information pertaining to an optional RF AMR module installed in the meter

The following Note applies to iCon APX meters containing the Sensus MXU Model 530-T RF AMR module.

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.□□□□

□This device contains FCC ID: KCHMXU530T / IC: 2220A-MXU530T.□□□

□CAUTION: Changes or modifications not expressly approved by Sensus Metering Systems could void the user's authority to operate the equipment.□□

Register Display Board

The Register Display Board (display board) consists of a Liquid Crystal Display (LCD), **Alternate Mode** button, **Demand Reset** button, **Test Mode** button, three option-board connections, and an optical port consisting of one (1) infrared LED and one (1) infrared LED sensor.

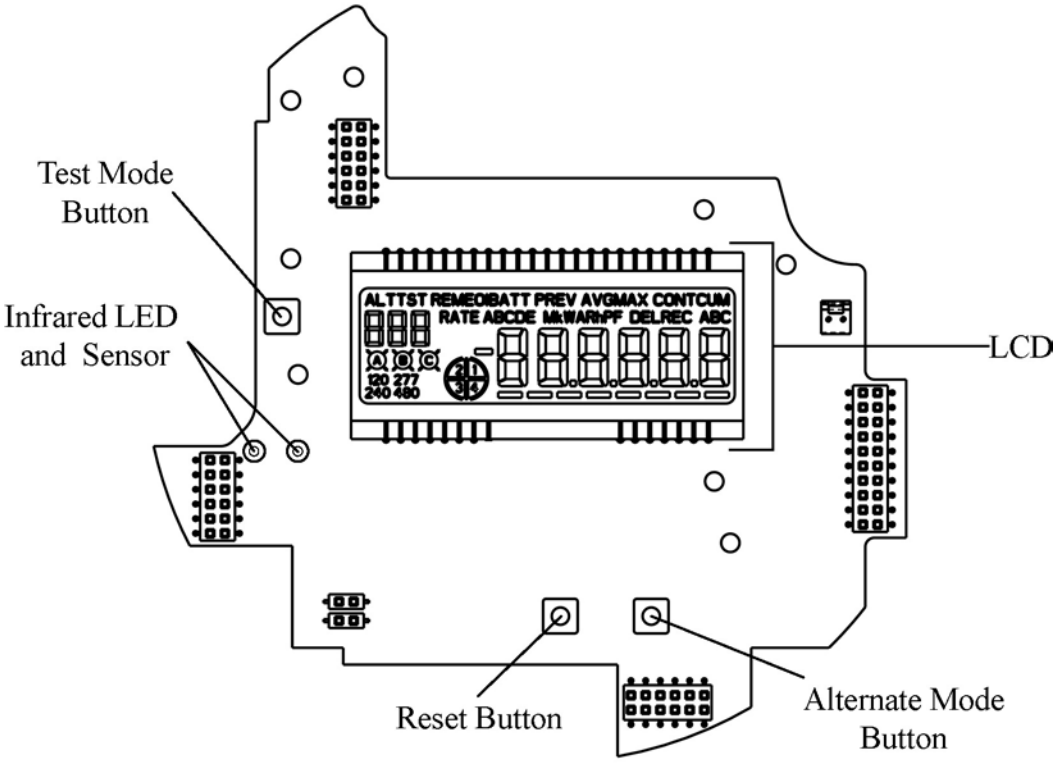


Figure 2-10: Register Display Board

The display board

- Includes connectors for plugging in the option boards and Interconnect Board
- Periodically reads data contained within the ADE7758 chip on the Sensor Board
- Parses the data into the different billing quantities
- Communicates the results of calculations by way of the LCD and/or remote communication ports
- Manages the remote communication ports:
  - ANSI C12-18, Type 2 compliant Optical Port
  - RS-232 or RS-485
  - Ethernet/Modem connection
  - Third-party communication boards
- Stores the following data in non-volatile, flash memory:
  - Meter firmware
  - Meter status
  - History Log
  - The configuration program created with *iConFig*™
  - Billing information

Liquid Crystal Display

The LCD provides meter reading and test information. The information on the LCD is visible in direct sunlight and can be read at angles of 15 degrees above and below the LCD centerline.

Figure 2-11 shows the LCD's Annunciators and Displays.

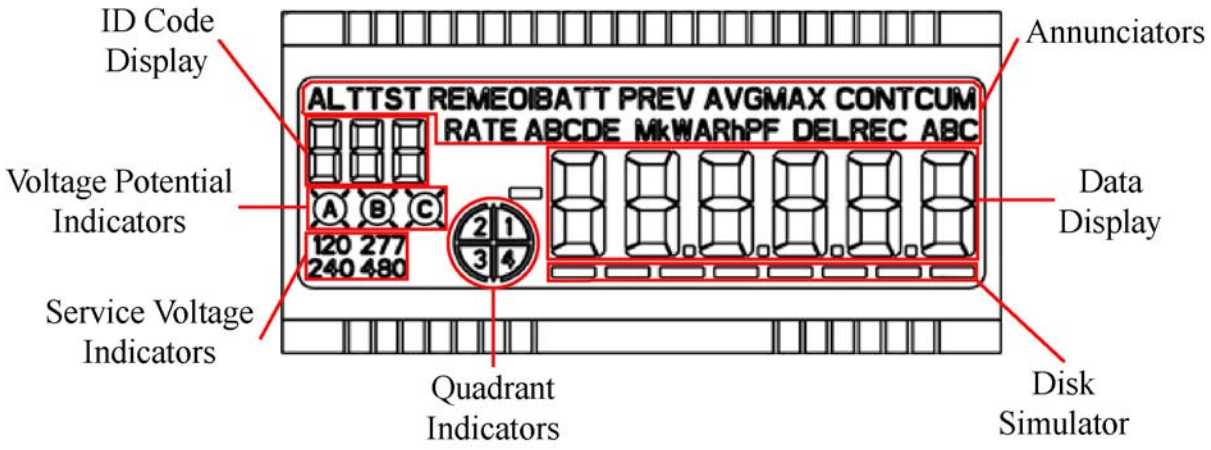


Figure 2-11: LCD Annunciators, Displays, and Indicators

Annunciators

Annunciators are composed of LCD segments that can be enabled/disabled to display the following meter conditions and measurements.

ALT (Alternate List) — This Annunciator illuminates when the meter shows the values from the Alternate Display List. No measurements are affected while in this display mode.

TST (Test List) — This Annunciator illuminates when the meter is in Test Mode.

REM (Remote Communications) — This Annunciator illuminates when the meter detects outside connections to the meter on any of its communication ports.

EOI (End of Interval) — This Annunciator illuminates at the end of every Demand Interval. The Annunciator remains illuminated for four (4) seconds and then extinguishes.

BATT (Battery) — When the meter contains a Real-Time-Clock (RTC) battery, this Annunciator illuminates when the meter detects the installed battery's useful life is at or below 15 percent.

PREV (Previous) — When configured and the meter contains previously stored billing data, this Annunciator illuminates when the Data Display is showing previous billing data.

AVG (Average) — When configured, this Annunciator illuminates when the LCD is showing the average system voltage or current.

MAX (Maximum), **CONT** (Continuously), **CUM** (Cumulative) — These Annunciators illuminate when the LCD shows Peak Demand quantities. When configured, the MAX (Peak Demand), the MAX and CUM (Cumulative Peak Demand), or MAX, CONT, and CUM (Continuously Cumulative Peak Demand) Annunciators illuminate.

RATE A, B, C, D, E — When configured for Time-of-Use (TOU), the RATE Annunciator and one of the alphabetic Annunciators illuminate when the Data Display shows the applicable rate information. The displayed information is configured from the Switch Times tab of the TOU / Calendar module of *iConFig*.

M (Mega) — This Annunciator illuminates when the value shown by the Data Display is one million of a specified unit.

k (kilo) — This Annunciator illuminates when the value shown by the Data Display is one thousand of a specified unit.

V (Volts), **W** (Watts) — The W consists of two V-shaped Annunciators. When one Annunciator is illuminated, it appears as the letter V. When both Annunciators are illuminated, they appear as the letter W. These Annunciators illuminate when the value shown by the Data Display is either Volts or Watts.

A (Amperes)**, R (**Reactive) — These Annunciators can be used in conjunction with the V Annunciators. They illuminate when the value shown by the Data Display is as follows:

- VA = Voltamperes
- VAR - The product of the total Voltamperes and the sine of the angle between current and voltage.

h (Energy) — This Annunciators illuminates when the Data Display is showing an integrated quantity.

PF (Power Factor) — This Annunciator illuminates when the value in the Data Display shows a power factor value. Power factor values are calculated based upon the integrated quantities the meter is configured (either factory default or with the *iConFig* application) to accumulate.

DEL (Delivered), **REC** (Received) — These Annunciators illuminate when the value in the Data Display shows the contents of the related Delivered or Received billing registers. These Annunciators do not indicate whether the actual power flowing through the meter is delivered or received.

A, B, C (Per Phase Quantity) — These Annunciators illuminate when the value in the Data Display is for the detected phase. When all Annunciators are extinguished, the quantity is for all three phases.

Displays and Indicators

ID Code Display — When configured, this three-digit identifying code is displayed simultaneously with an item shown in the Data Display area. (typically, a unique code is configured for each Data Display item).

120, 277, 240, 480 (Service Voltage Indicators) — The meter detects the nominal service voltage during power up and illuminates the display of the detected voltage. If the nominal service voltage cannot be determined (as a result of an incorrectly wired socket, for example), all Service Voltage Indicators are illuminated.

Voltage Potential Indicators — Illuminate when voltage is present in those phases

Quadrant Indicators — Illuminate to show the direction of the power presently flowing through the meter and whether the power factors are leading or lagging. The quadrants are defined as follows:

- Quadrant 1 (lagging) – Wh and VARh delivered to the customer.
- Quadrant 2 (lagging) – Wh received from the customer and VARh delivered to the customer.
- Quadrant 3 (leading) – Wh and VARh received from the customer.
- Quadrant 4 (leading) – Wh delivered to the customer and VARh received from the customer.

Meters that do not have Reactive or Apparent energy measurements enabled will only be able to indicate the direction of the kWh energy. These meters will illuminate Quadrant 1 and Quadrant 4 to indicate energy flowing to a customer and Quadrant 2 and Quadrant 3 to indicate energy received from a customer.

Data Display — The Data Display is composed of LCD segments that can display letters, digits, and symbols. The values can be configured as follows:

- Energy, Demand and Power Factor Values:
  - Display formats: kilo (10^3), Mega (10^6), or unity (10^0)
  - Display values of up to five (5) digits
  - Display up to three (3) decimal places
- Date Format
  - MM-DD-YY
  - DD-MM-YY
  - YY-MM-DD
- Time can be displayed in either 12-hour or 24-hour formats as hh:mm:ss
- A minus (-) sign can be displayed for negative net values

Disk Simulator —The Disk Simulator is an eight-segment bar that is under the Data Display. In normal operating conditions, the Disk Simulator appears to move from left to right (delivered power) and increments once depending upon the K_h value. In reverse power conditions, it appears to move from right to left.

Buttons

Alternate Mode

Activating this button manually changes the meter from its present mode to display and scroll through the Alternate Display Register List that was configured through *iConFig*. Also, while in Test Mode, this button allows you to scroll through the Test Mode Display List items.

Demand Reset

Activating this button causes the meter to:

- Store a copy of all billing register data to the Previous Demand register.
- Add the present Peak Demand values to their associated Cumulative Demand values.
- Resets the Peak Demand value to zero (0).

Test

Activating this button manually changes the meter from its present mode to Test Mode. Pressing and holding this button for three seconds causes the meter to enter ‘Test Lock’. See “Test Mode Lock” below.

Infrared LED and Sensor

The infrared LED, sensor, and supporting circuitry combine to make up the electronics of an ANSI Type 2 optical port. The signal levels conform to the ANSI C12.18-1996 Protocol Specification for ANSI Type 2 Optical Port.

Connector Ports

The Register Display Board contains connector ports for option boards and the Interconnect Board. Figure 2-12 shows the locations of the connector ports.

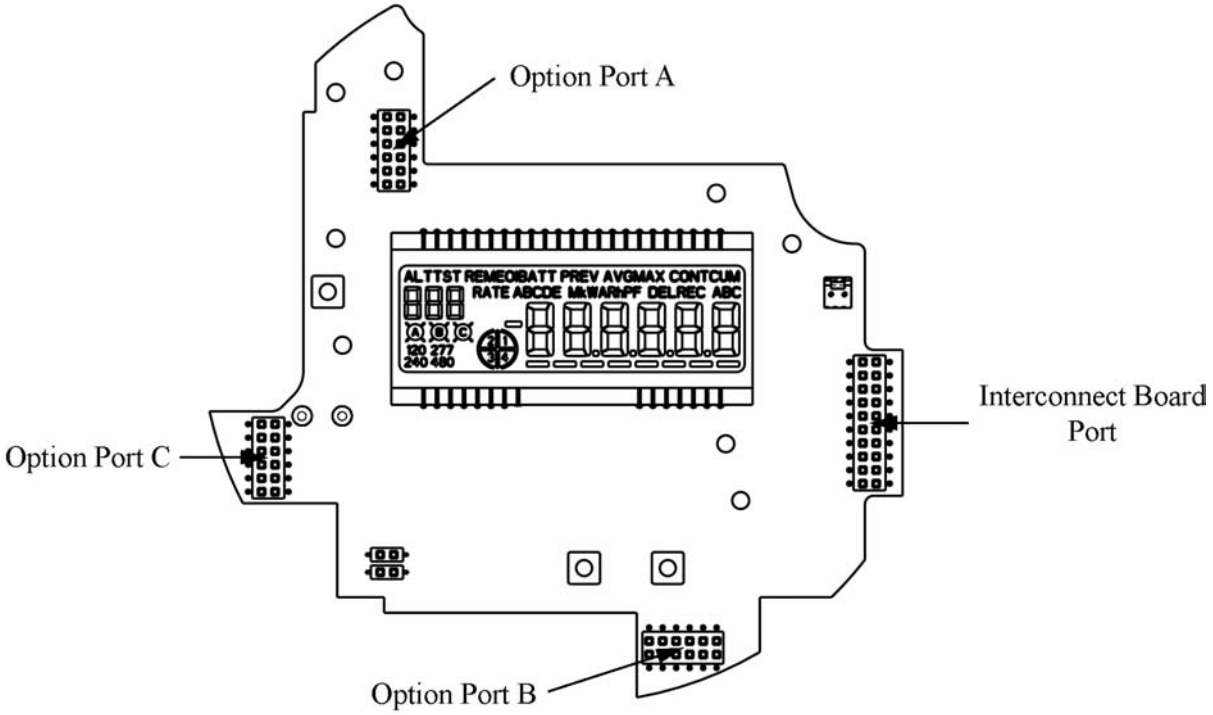


Figure 2-12: Register Display Board Connector Ports

Interconnect Board

The interconnect board provides a physical path for data and power supply signals from the Sensor Board in the Meter Base Assembly to the Register Display Board.

Option Boards

To ensure client satisfaction, the APX meter is designed to support additional features and upgrades through the incorporation of option boards which connect to Option Ports A, B, and C. Visit to the Sensus website for more information on these boards as more become available.

Meter Cover

The Meter Cover:

- Provides:
  - Protection from the weather and other contaminants
  - A clear view of the LCD and Labels located under the cover
  - An integrated ANSI Type 2 Optical port
  - Access to the RESET and ALT switches by way of a sealable RESET/ALT Lever
- Limits unauthorized access to the internal switches, components, and buttons.

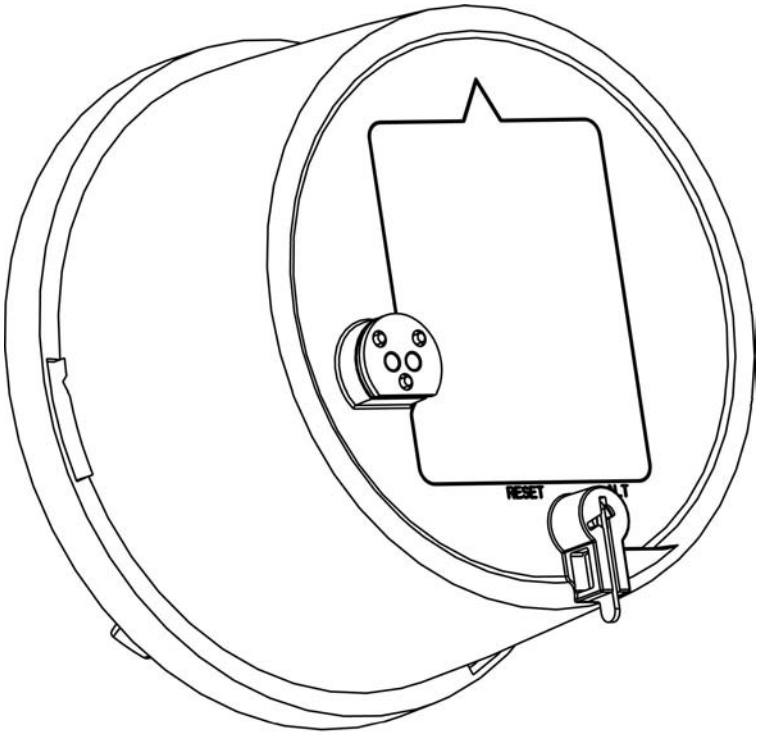


Figure 2-13: Meter Cover

After final set-up and calibration of the meter at the factory, the Meter Cover and Meter Base Assembly are sealed with a T-Bar. The RESET/ALT Lever can also be sealed using an industry-standard Demand Reset Seal. Broken or missing seals provide evidence of possible tampering.

Metering Capabilities

The APX meter is capable of a wide range of measurements and calculations based on the needs of the customer. This section provides some descriptions of the configurable settings in the APX meter.

The APX meter can be configured to provide the average value of power, or related quantity, over a specified period of time (Demand metering). The LCD displays the results in the form of kW, kVAR, or kVA.

Demand parameters are stored in the meter and control events such as:

- The length of the:
  - Demand Interval
  - Demand Subinterval
  - Test Mode Demand Interval
  - Test Mode Demand Subinterval
- Whether or not to use:
  - Demand Forgiveness
  - Outage Recognition time
  - Demand Reset Lockout Period

Display Lists

The meter maintains up to four (4) display lists. The contents of each list and the order in which items appear is configured using *iConFig*. Each list item is displayed as the meter scrolls through the list depending upon the meter's operating Mode.

Normal Display List

When the meter is in Normal Mode, the *Normal Display List* is displayed. This list usually contains quantities and data used for customer billing and is the default list displayed when power is restored (unless the *Test Lock* feature has been activated – see "Test Mode Lock" below). This list is displayed after exiting any of the other modes.

In this mode, the meter automatically scrolls through the configured List Items at the configured rate.

Alternate Display List

When the meter is in Alternate Mode, the *Alternate Display List* is displayed. This list usually contains information that is not normally used for customer billing (e.g., site surveys, debugging the meter, marketing information, future equipment planning). This list is displayed when the meter is in Normal Mode and the **ALT** button is pressed or by way of remote commands from *iConFig*.

In this mode, the meter automatically scrolls through the configured List Items at the configured rate. The meter automatically exits Alternate Mode after the configured timeout expires. When the timeout is set to zero (0), it will remain in Alternate Mode until the power is removed.

To exit Alternate Mode, press the **ALT** button again or by way of remote commands using *iConFig*.

Test Display List

When the meter is in Test Mode, the *Test Display List* is displayed. This list usually contains the quantities and data that can be used to verify meter calibration. This list is displayed when the meter is in Normal Mode or Alternate Mode and the **TEST** button is pressed or using remote commands from *iConFig*.

Upon entering Test Mode, the TST Annunciator on the LCD illuminates, and the meter:

- Suspends regular metering
- Stores all of the billing data into non-volatile memory
- Resets all of the Energy and Demand values to zero (0)

In Test Mode, the measured quantities are stored in the Test Mode registers and not in the customer-billing registers. Use the **RESET** button to set all of the metering and demand quantities in the Test Mode registers back to zero (0) and the **ALT** button to manually scroll through the items in the *Test Display List*. The meter automatically exits Test Mode after the configured timeout expires. When the timeout is set to zero (0), it will remain in Test Mode until the power is removed.

To exit Test Mode, press the **TEST** button or use remote commands from *iConFig*. Upon exiting Test Mode, the customer-billing data is restored.

Test Mode Lock

This feature allows a utility to run special tests that require the meter to remain in Test Mode even after temporary interruptions in power.

When the Test Mode Lock feature has been activated, the meter starts back up (i.e., after power is restored after an outage) in Test Mode provided it is still within its configured timeout period. To activate Test Mode Lock:

1. Ensure the meter is in Normal Mode. Depending on the mode, refer to the appropriate display list paragraph above.
2. Press and hold the **TEST** button for three (3) seconds. The TST Annunciator will flash On and Off to indicate that the Test Mode Lock feature is active.
3. To exit Test Mode while in Test Mode Lock, press the **TEST** button again.

NOTE:
If the Test Lock feature is activated and the timeout period is set to zero (0), the meter will start up and remain in Test Mode indefinitely.

Diagnostic Display List

When the meter is in Diagnostic Mode, the Diagnostic display list will be presented. This list usually contains per phase instantaneous measurements and information (such as volts, amperes, watts, volt-amperes, volt-amperes reactive, etc.). This information may be useful in troubleshooting wiring problems or verifying that the wiring is correct.

While in Diagnostic Mode, the meter continues to measure and store usage data in the billing registers.

To enter Diagnostic Mode, pass a magnet over the side of the meter as shown in Figure 2-14.. Each subsequent swipe of the magnet will advance the display to the next item in the list. It is possible to use the magnet in the Optical Probe.

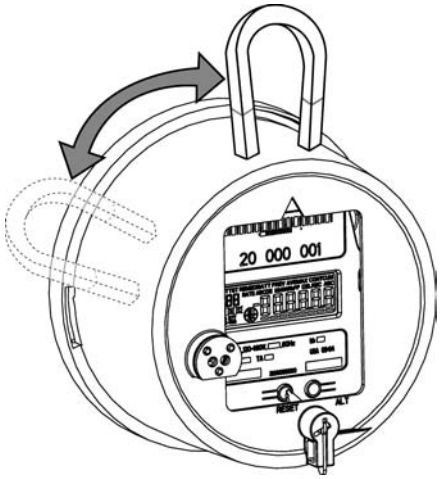


Figure 2-14: Scrolling Through Display List

While in Diagnostic Mode, the meter continues to measure and store usage data in the billing registers.

After the configurable timeout period has expired, the meter automatically reverts back to the *Normal Display List*. To manually exit Diagnostic Mode, use the RESET/ALT Lever to press the **ALT** button. Alternatively, this mode can be entered and exited by way of remote commands using *iConFig*.

The meter automatically exits Diagnostic Mode after the configured timeout expires. When the timeout is set to zero (0), the meter will remain in Diagnostic Mode until the power is removed.

Security

The meter is capable of storing up to eight separate passwords, each with its own set of access permissions. *Read*, *Write*, and *No Access* permission settings can be applied to the following categories for each password:

- Identification/Status
- Procedures
- Billing
- Security
- Schedule
- Load Profile
- History Events
- Thresholds/Alarms
- User Defined (ANSI C12.19 User Defined Tables)
- Option Boards
- Misc - Manufacturer Defined Tables

Chapter 3

The iCon™ APX Advanced Functionality Meter is configured using the *iConFig*™ application. This chapter provides brief descriptions of the Modules used to configure the meter.

Refer to *iConFig Start-up and User's Guide* for instructions on configuring the meter.

Hardware Setup

The information in this section is not intended to provide instructions to unqualified personnel nor replace the extensive training needed to safely handle the metering equipment. The set-up of all meters shall be accomplished by qualified electricians and metering specialists.

The procedures described in this section are recommended for new or upgraded meters. After setting up the meters, it may be necessary to program/reprogram and/or calibrate the meter.

The set-up of all meters shall be accomplished by qualified electricians and metering specialists.

All Meters

In order to insure security, the meters are protected by two seals.

- A T-Bar Seal that goes on the back of the meter
- Demand Reset Seal that secures the RESET/ALT Lever.

After set-up is complete, seal the meters.

Self-Contained Meters

Some self-contained meters have Phantom Load links on the bottom of the Meter Base Assembly. Ensure the links are all up and secured with the screws.

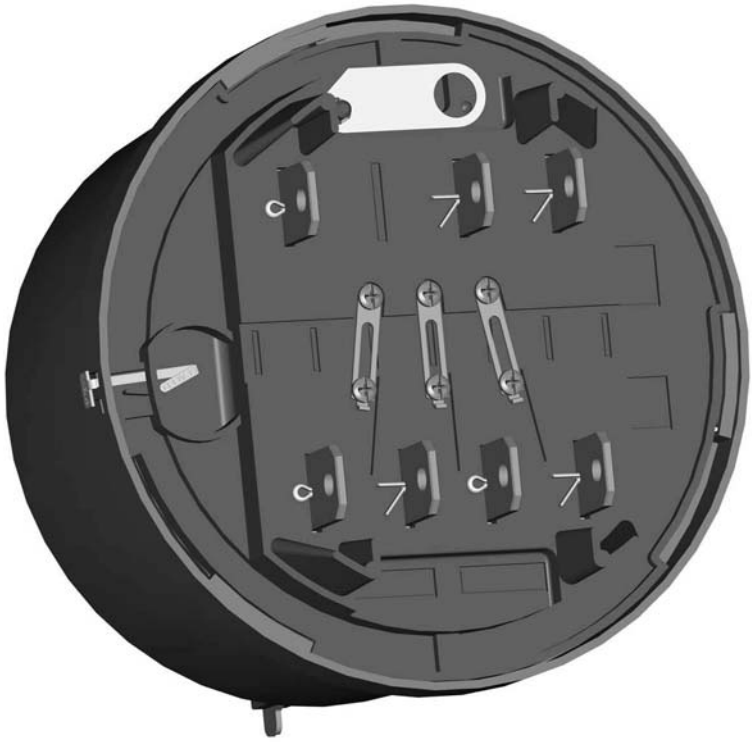


Figure 3-1: Phantom Load Links (closed)

Calibration Check

⚠ WARNING ⚠

Do not permit unauthorized personnel to operate meter-testing equipment or to test meters. Hazardous voltages can be present, exposing personnel to the risk of death or serious injury, and exposing equipment to the risk of damage. Only authorized, trained personnel may operate the meter-testing equipment, using approved test procedures and safety precautions.

Depending on the meter form and the particular requirements of the test board, you may have to first 'open' the Phantom Load Links.

To perform a calibration check:

1. Loosen the two screws on each link.
2. Open the Phantom load links by:
   a. Loosening all of the screws on each link
   b. Sliding the links down until they stop
3. Re-tighten the lower screws enough to prevent any link from moving.
4. Install the meter into your test board.
5. In the controlling software for your test board, choose the appropriate meter form (Form 9 or Form 16).
6. Perform the calibration check.

After completing the calibration check:

1. Remove the meter from the test board.
2. Close the Phantom Load links by:
   a. Loosening the lower screws on each link
   b. Sliding the links up until they stop
3. Securely tighten all of the screws to prevent the slides from moving.

Testing

To interface with test equipment, the meter generates test pulses. The energy value assigned to each test pulse is defined as the meter K_h and can be configured to value that is a multiple of 0.2.

Meter	**Default K_h**	**Range (Wh/Pulse)**
Form 9	1.8 Wh/pulse	0.2 to 40.8
Form 16	21.6 Wh/pulse	0.2 to 99.8

The test pulse output is compatible with all ANSI-rated laboratory and field test equipment and is transmitted through the Infrared (IR) Test Pulse LED. When aligning the optical pick-up in front of the IR Test Pulse LED. Position the pick-up so that it is perpendicular to the IR Test Pulse LED. See Figure 3-2.

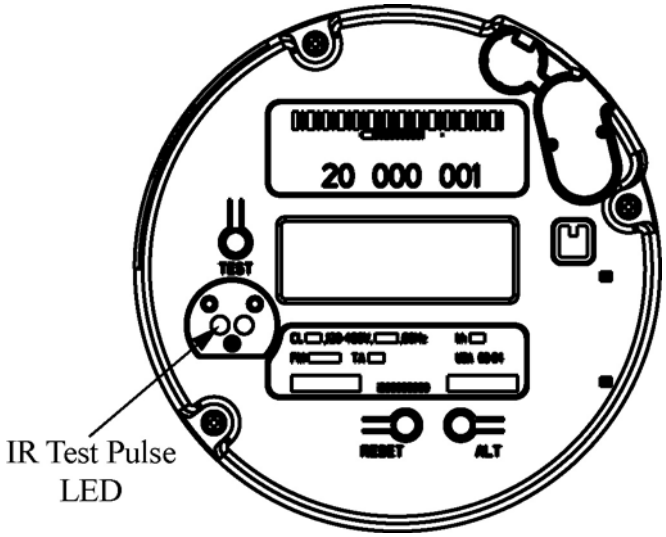


Figure 3-2: Location of the Infrared Test Pulse LED

IR Test Pulse LED Background

The iCon APX meter contains a Metering Chip that is used for the measurement of energy

(voltage ∗ current). The test pulse signal is based on an output from this chip. This signal is routed up through the display board to the Infrared (IR) LED in the optical port on the face of the meter. The meter controls the function of the IR LED. When the meter detects communication activity on the sensor portion of the optical port, it stops the IR LED from sending test pulses and switches it for use as a transmitter. Once communication has ended, the meter reverts the IR LED back to a test-pulse output.

To allow the meter to properly detect the service and restore all its billing and status registers, a start-up delay of seven (7) seconds is required at the beginning of each meter test operation.

Setting the Start-up Delay

Below are instructions on how to set the start-up delay on the following test boards:

- WECO
- UTEC/RFL

If you are using a test board not identified above, please contact Sensus Metering Systems to have it added to this document for other's benefit.

WECO – Windows software

1. Execute the **Winboard** software.
2. Close the **Winboard** – **Meter Testing** window if open.
3. Enter the **Winboard**-**Administration** window.
4. Select the **Administration** menu.
5. Select **Workstation Settings**.
6. Select the **Station 1** tab.
7. Set the **Standard Settling Time** to 7 seconds (with other settling times, this will result in a delay time of approximately 10 seconds overall).
8. Select **Save** then **Close**.
9. If you have problems changing this in the WECO software, call 601-933-0900.

WECO – DOS software

1. Execute the DOS software.
2. Press the **F8** function key for the Setup menu.
3. Set the **KWH Test Dwell Time** field to 7 seconds (with other settling times, this will result in a delay time of approximately 10 seconds overall).
4. Press the **F1** function key to save and return.
5. If you have problems changing this in the WECO software, call 601-933-0900.

UTEC/RFL – Windows software

1. Enter Syslink DB Maintenance.
2. Enter **Meter Test** under **Testset Group**.
3. Select **Testset**.
4. Edit **SubTest**.
5. Enter **Testpoint** screen.
6. Select **Testpoint** to edit.
7. Change **Stabilization Delay** to 10 seconds.
8. Save changes.
9. If you have problems changing this in the UTEC software, call 800-952-8832.

UTEC/RFL – DOS software

The UTEC/RFL DOS software does not have a provision for a delay time. The test starts with the first test pulse the test board receives after voltage and current are applied to the meter. As a result, spurious results may occur when using this test board to test the iCon 12S meter.

Display Board Check

After applying power to the meter, ensure the LCD is active and displaying meter information based upon the configured display modes.

Test Mode

The purpose of Test Mode is to allow you to verification the calibration of the meter without losing any customer billing data. Also, the Demand Interval for Test Mode can be shorter than for other modes allowing you to check the Demand measurement within the meter much faster.

Refer to the *iConFig Start-up and User's Guide* for information on configuring Display Modules and Demand Modules.

To put the meter in Test Mode using the **TEST** button:

1. Remove the Meter Cover. Refer to "Removing the Meter Cover" in Chapter 4.
2. Press the **TEST** button.

It is also possible to put the meter into Test Mode using *iConFig*.

Upon entering Test Mode:

- A "snapshot" of all of the customer-billing data is taken and stored in separate locations. Test billing data and test data are not applied to the customer's billing data while the meter is in Test Mode.
- The TST Annunciator illuminates.
- The first item in the Test Mode Display List is shown on the LCD.

To scroll through the items in the Display List, press and release the **ALT** button. When you reach the last item and press the **ALT** button, the meter will recycle to first item in the Display List.

Test Mode Operation

While the meter is in Display Mode, the Test Pulse correlates to the energy value that is visible on the LCD.

NOTE:
If the Display List item does not have an energy reading, the Test Pulse will correlate to the kWh present at the meter.

Example:

If the item on the Display List is kWh delivered, the Test Pulse will correspond to the kWh presently going through the meter.

When you press and release the ALT button and the next item on the Display List is kVAR hours, the Test Pulse will correspond to the kVAR hours.

The Test Pulse constant (K_t) in Test Mode can be different than the constant (K_h) that is used in Normal, Alternate, and Site Diagnostic Modes.

Test Lock

To put the meter into Test Lock from Normal Mode, press and hold the **TEST** button [approximately three (3) seconds] until the TST Annunciator flashes. While in Test Lock, the **TST** Annunciator will flash.

In Test Lock the meter remains in Test Mode for the amount of time configured in the Test Mode Timeout period, even if power is cycled during that time. If the Test Mode Timeout period is set to zero (0), the meter will remain in Test Lock indefinitely. Regardless of whether the meter is in Test Mode or Test Lock, pressing the Test button a second time causes the meter to revert back to Normal Mode.

When exiting Test Mode, all previously stored customer-billing data from the “snapshot” is restored to the billing registers and the meter returns to Normal Mode.

Reset Button

It is possible to reset the energy and Demand values in the Test Mode registers without having to cycle the meter through different modes. While in Test Mode, press and release the **RESET** button to reset the Test Mode registers.

Installation

The APX meter is designed to be compatible with the mechanical form factor of existing electromechanical, commercial meters. This design allows technicians and trained meter personnel to perform meter installations easily and without the use of specialized tools.

To install the meter, follow the procedures established by your company for standard commercial meters.

Should the meter be configured to monitor for diagnostic errors, it may be necessary for the technician to observe the meter for several minutes to ensure no error messages appear. Refer to “

Diagnostics and Alarms" below.

Meter Power-Up

NOTE:
If the meter was in Test Lock or the Test Mode timeout period had not expired, the LCD will display the last item that was shown on the LCD at the time power was removed.

After installing the meter into a socket and applying power, the meter should boot up and start cycling through the Normal Display List unless:

- The meter was powered down while in Test Lock
- The Test Mode Timeout Period has not expired.

In addition to the boot-up items discussed in this section, additional settings can be configured using *iConFig*.

NOTE:
If the meter was in service prior to powering down, meter and billing data is automatically stored. During power-up, the meter retrieves the stored data.

After power is applied to the meter, the meter:

- Determines the service type
  - Wye
  - Delta
- Determines the phase rotation
  - A, B, C
  - C, B, A
- Detects any missing voltages
- Verifies the service voltages
  - Phase-to-Neutral
    - 120
    - 240
    - 277
  - Phase-to-Phase
    - 208
    - 480

NOTE:
If the meter detects phase angle errors, the meter runs industry-standard diagnostics (see "Diagnostics and Alarms" below)

- Verifies the phase angles are correct for the service type (variances can be configured with *iConFig*).

Configuring APX Meters

With *iConFig*, users can create or edit configuration programs that can be downloaded into APX meters. *iConFig* is a user-friendly software package that has been developed to configure, troubleshoot, and read the APX meter. *iConFig* is designed to be a flexible, Microsoft® Windows-based application that runs on:

Windows:

- 98SE
- NT 4.0
- 2000 (any version)
- Millennium Edition (Me)
- XP (any version)

iConFig is used to perform the following functions:

- Configure the meter using “Programs”
- Read the meter
- Generate reports
- Upgrade/Downgrade meter capabilities
- Update the firmware

The meter may be preprogrammed at the factory for basic commercial metering. Although certain parameters are customizable when ordering the meters, additional configurations are accomplished through *iConFig*. Refer to the online tutorials and the *iConFig Start-up and User’s Guide*

iConFig configures the meter by converting the desired settings into hexadecimal code and then downloads those settings to the tables within the meter (in accordance with ANSI 12.19).

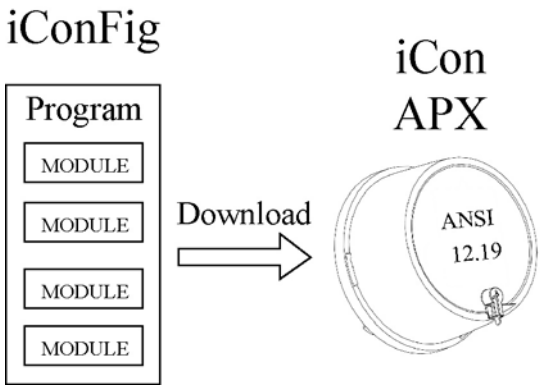


Figure 3-3: *iConFig* Application

Identification

The Identification data contains information about the utility, the configuration program, vendor, and other meter data. The data in this Module is for informational purposes and has no effect on the operation of the meter.

The following identification data are permanently stored in meter memory. The data is stored at the factory and no changes are allowed.

- Manufacturer's serial number
- Firmware version
- Nameplate information

The APX meter can store additional, customer required identification data:

- Utility meter ID
- Account number
- Miscellaneous ID
- Program vendor
- Program
  - Version number
  - Revision number
- Owner
- Utility division
- Service point
- Customer ID
- X, Y, and Z coordinates
- Tariff ID

All of these data are for informational/identification purposes only and have no effect on the operation of the meter. The meter provides the utilities a place to store additional information that is important to their billing or tracking system.

Metering Constants

The APX meter allows the following Metering Constants to be configured by users.

- K_h and K_t values - typically set at the factory using *iConFig*, but may be changed by the user
- Meter multiplier:
  - Stored but not used by the meter
  - Used by the billing systems when reading data from the meter
- Time BaseTime Base selection (internal crystal or line frequency synchronization)
- CT and PT ratios (for transformer rated meters)

Diagnostics and Alarms

The meter can be configured to monitor or ignore certain internal conditions and to display alarm codes should any of those condition be detected. The following items can be configured:

- The conditions to monitor
- The threshold levels
- How long a condition must exist before the meter issues an alarm
- To perform any of the following actions should a monitored condition occur:
  - Lock the display with the error code, or add the code to the Normal Display List
  - Add an entry to the History Log
  - Send a message through a communications module (if installed)
  - Close a relay (if installed)

NOTE:
Any time changes are made to the alarm settings, use *iConFig* to clear all alarms and status bits.

Industry Standard Diagnostics

This section discusses the standard diagnostics that, when configured, are tested by the meter every ten (10) seconds. If any one diagnostic fails six (6) consecutive times, the meter considers the diagnostic to have failed. Refer to *iConFig Set-up and User's Guide* for more information.

A failed diagnostic must pass six (6) consecutive times before the meter considers the diagnostic to have passed.

Diagnostic 1

Polarity and Cross Phase Check tests for the proper phase relationships of each of the voltages with respect to phase A voltage. This diagnostic checks for faulty site wiring. The nominal values are based on the "type" of meter, and can be overridden.

Diagnostic 2

Phase Voltage Deviation Check compares each phase against the "nominal" phase voltage.

Diagnostic 3

Inactive Phase Current Check checks the current amplitudes against a configured.

Diagnostic 4

Phase Angle Displacement Check verifies that the power factor for each phase is within the limits (measured in degrees) for each phase for maximum lag and maximum lead. This diagnostic is not performed if a phase voltage is missing or Diagnostic 3 fails.

Diagnostic 6

Current Magnitude Imbalance Check checks for the relative amplitude of the phase currents and compares each current to the average of all enabled currents.

Diagnostic 7

Energy Direction Check fails if any enabled, phase energy flow is negative (received power).

History Logs

In addition to recording *Diagnostic and Alarm* events, the meter can record other events (e.g., outages, downloading configuration program, entering/exiting Test Mode). For Time-of-Use and Load Profile meters that have the *Calendar* function enabled, the time and date each event occurs is also stored.

History Logs allow the meter to record Events that occur during the normal operation of the meter. You can configure the meter to:

- Record up to 250 History Log entries
- Select what Events to record
- Overwrite old entries or stop recording after the maximum number of entries has been recorded
- Record or not record Table Writes (ANSI C12.19)

Special Features

The APX meter contains a list of billing quantities, instantaneous measurements, and special values that can be selected and assigned to up to six (6) User Defined Tables. Specific data stored in each of the tables identified by the values will be inserted into the User Defined Table. Using the *Read User Defined Data* Function in *iConFig*, you can perform a single table-read instead of downloading from the individual tables.

Chapter 4

This section provides brief descriptions and procedures for:

- Communicating with the meter
- Programming the meter (firmware)
- Resetting the meter
- Replacing meter components

Meter Communication

Linking with meter is accomplished by various means. This section provides brief descriptions of the means to communicate with APX meters for data transfer, programming and configuring, and meter updates.

To communicate with APX meters, use an ANSI Type 2 optical probe with any of the equipment listed below.

- Laptop or Work Station with a Microsoft Windows operating system and loaded with *iConFig* or some other software for communicating with electricity meters
- A supported hand-held device used to read billing information from meters.

Infrared Port

The infrared port was designed to accept an ANSI C12.18 Type 2 optical probe. The port can communicate up to speeds of 19200 bps, and complies with the protocol specified in the ANSI C12.18-1996 standard.

Remote Communications

Installing an optional AMR Module enables remote meter communications. For more information, refer to the documentation that came with the AMR Module.

Updating the Firmware

The firmware is stored in flash memory and can be easily loaded into the meter through its optical port. If it becomes necessary to update the meter's firmware, Sensus Metering strongly recommends that all billing and meter data be backed up prior to the installation process.

To update the meter's firmware, an Action can be created and executed using *iConFig*. Refer to *iConFig Start-up and User's Guide* for instructions on performing a firmware upgrade.

Resetting the Meter

It may be necessary to reset the meter:

- In the event that a meter is malfunctioning or fails to perform as programmed and/or configured
- After removing a meter from service (depending on the standard procedures of the utility)

NOTE:
Performing a Cold Start clears all of the customer data registers. Ensure all customer data is downloaded and stored prior to performing a Cold Start. Failure to observe this note will result in permanent data loss.

A Cold Start restores the meter to factory default settings. All configuration settings as well as billing, status, and history data will be lost.

Some meters come from the factory pre-programmed and performing a Cold Start is not required. Should your company policy require it, perform a Cold Start prior to configuring and installation.

A Cold Start can be performed in either of the following ways:

- Press and hold the three buttons on the face of the meter (**TEST**, **RESET**, and **ALT**), and then apply power to the socket.
- Use *iConFig* to perform a Cold Start. Refer to *iConFig Start-up and User's Guide* for instructions on performing a Cold Start.

Upon recognizing a 'Cold Start', the meter will commence erasing all data. During this process, the LCD will display **ErASE** and a series of incrementing numbers. At the end of the process, the meter will restore the factory default settings and automatically perform a 'Warm Start'.

Troubleshooting

Troubleshooting iCon™ APX meters can consist of performing a visual check, installation check, shop testing, and display board checks.

Visual Check

WARNING
Do not apply power to a meter that may have been damaged or may otherwise be defective. Arcing, fire, or explosion may occur, and noxious gases can be generated. Failure to observe this warning exposes personnel to the risk of death or serious injury, and can destroy or cause additional damage to the unit.

Check for missing seals, tampering, or any physical damage to the outside of the unit before applying power to the socket. If any damage is visible, perform a more detailed inspection by partially disassembling the meter (refer to "Removing the Register Cover"). Carefully inspect the internal components for:

- Signs of excessive heat or burning
- Hardware that appears to be missing or damaged

Contact your sales representative to report meters that are damaged or that you suspect may be defective. Otherwise re-assemble the meter before proceeding with any tests.

Installation Check

The most common cause of incorrect data registration is incorrect installation or the installation of the meter in an application other than its intended application. Other areas to check are as follows:

- Is the meter installed in a poly-phase, Form 8 or 9 socket (transformer rated models) or a Form 14, 15, 16, or 17 socket (self contained models)?
- Does the service voltage fall within the voltage range listed on the nameplate?
- Is the T-Bar Seal and/or Demand Reset Seal broken or missing? This indicates possible tampering; report the incident in accordance with your company's reporting procedures.
- Is there evidence of mechanical or electrical damage?
- Where fitted, check the phantom load slides to ensure:
  - The slides are all in the closed position.
  - The hold-down screws are all securely tightened.

Shop Testing

The meter does not require adjustments outside of the factory. To verify the meter is operating within factory specifications, verify its calibration using your meter shop's procedures for testing poly-phase meters.

WARNING

Do not permit unauthorized personnel to operate meter-testing equipment or to test meters. Hazardous voltages are present, exposing personnel to the risk of death or serious injury, and exposing equipment to the risk of damage. Only authorized, trained personnel may operate the meter-testing equipment, using approved test procedures and safety precautions.

For information on using an optical pick-up to monitor test pulses, refer to "Test Pulse K_h Outputs" in *Configuration* (Chapter 3).

Diagnostic Checks

The meter can run Diagnostic Checks as follows:

- Every 10 seconds (except during a power outage)
- Advanced Diagnostic Alarms depend on the Minimum Service Duration setting and are monitored constantly

The specific items that are tested are described below. Before the meter indicates a Diagnostic Check failure, it must fail for one minute (six consecutive tests). Likewise, once a Diagnostic Check has failed, the meter must pass for one minute for a failure to clear. This process prevents erroneous failures based on short-term load fluctuations.

A unique error code can be displayed on the LCD for each Diagnostic Check failure. Refer to *Appendix C: Alarms, Diagnostics, and Errors* for more information on specific error codes and corrective measures. The meter can be configured to do any one of the following options:

- Append the alarm code on the LCD's display list
- Lock the LCD with the alarm code on the LCD

Configurable tables within the meter contain the necessary values to monitor and regulate the diagnostics described in this section. A separate data table contains a counter for each diagnostic and increments when each enabled diagnostic goes from PASSED to FAILED.

Each diagnostic check can:

- Be enabled
- Be disabled
- Cause a history message/dial out to be performed
- Operate an alarm relay
- Cause an error message display

In the event the meter senses a condition that generates an alarm code, the code is sent to the LCD and displayed based upon the configuration of the Display Module. Refer to *Appendix C: Alarms, Diagnostics, and Errors* for more information.

The meter can be configured to display alarm codes. The codes can be cleared by pressing the **RESET** button, by a remote command using *iConFig*, or other software used for communicating with meters. Alternatively, the meter can be configured to only display alarm codes for as long as the condition that caused the failure exists.

NOTE:

When **Lock display on alarms** is selected (Diagnostic and Alarms Module), only the first detected alarm is displayed. In case there may be more than one alarm, Sensus recommends that, prior to clearing the alarms, you use *iConFig* to read the meter's status information The status information will indicate all of the alarms that are present.

Replacement – Basic Components

This section provides the necessary instructions for removal and replacement of defective components. In addition to meter repair, the replacement instructions can be used for upgrading the meter.

If you upgrade the meter with supported option boards, it may be necessary to recalibrate the meter. Refer to the option board's accompanying documentation for more information.

Replacement of the Meter Cover

It is strongly recommended that all replacement procedures for component-level repairs be done in the shop. Removal of the Meter Cover in the field may allow debris or other contaminants into the meter, damaging the meter or causing further damage to a malfunctioning meter.

CAUTION

Removal of the Meter Cover in the field may allow debris or other contaminants into the meter, further damaging the meter or causing the meter to malfunction.

Removing the Meter Cover

WARNING

Hazardous voltages are present when power is applied to the meter. Do not remove the Meter Cover or attempt to disassemble the metering equipment while power is applied. Failure to observe this warning exposes personnel to the risk of death or serious injury and risks damage to the equipment.

1. If the APX meter is in a test socket, ensure the power has been removed from the socket.
2. Remove the meter from the test socket.
3. Remove the T-Bar Seal from the meter.
4. Grasp the Meter Cover, and turn it counter-clockwise until it reaches a positive stop.

Figure 4-1: Removing the Meter Cover

5. Remove the Meter Cover from the Meter Base Assembly.

Installing the Meter Cover

1. Reseat the Meter Cover into the Meter Base Assembly
2. Turn the Meter Cover clockwise until it reaches a positive stop.

Figure 4-2: Installing the Meter Cover

3. Install a new T-Bar Seal.
4. Install a new Demand Reset Seal.

Replacement of the Register Cover

The instructions in this section provide the necessary steps required to replace the Register Cover.

Removing the Register Cover

1. Remove the Meter Cover. Refer to "Removing the Meter Cover" above.
2. Loosen the three (3) captive screws that secure the Register Cover to the Meter Base Assembly so they are no longer engaged in the Base Assembly.

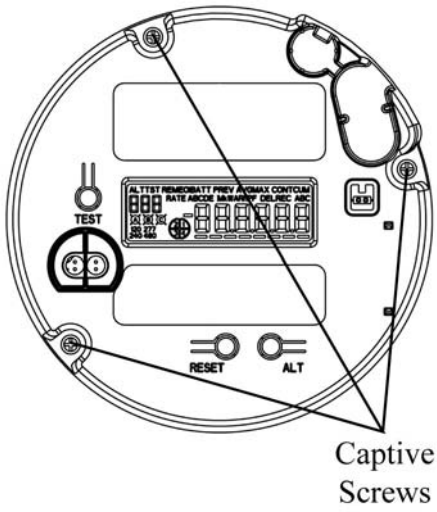


Figure 4-3: Register Cover – Captive Screws

⚠ CAUTION ⚠

⚠ The APX meter design provides a secure fit of the Interconnect Board into the Sensor Board connector port. When removing the Register Cover, it may be necessary to gently rock the Register Cover from top to bottom to extract the Interconnect Board pins from the Sensor Board connector port. Use care not to over-extend the pins. Failure to observe this caution may result in damage to the meter.

3. Carefully remove the Register Cover from the Meter Base Assembly to expose the internal components.

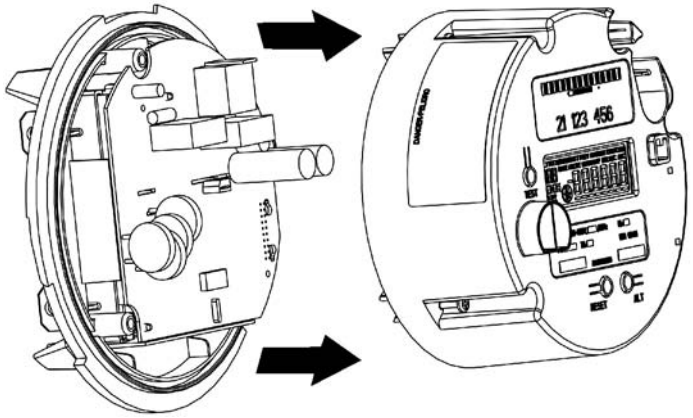


Figure 4-4: Register Cover – Removal

Installing the Register Cover

1. Hold the Register Cover at a slight angle as shown in Figure 4-5.
2. Align the Interconnect Board with the associated connector on the Sensor Board.
3. Align the Captive Screw Slot with the opening in the Sensor Board.

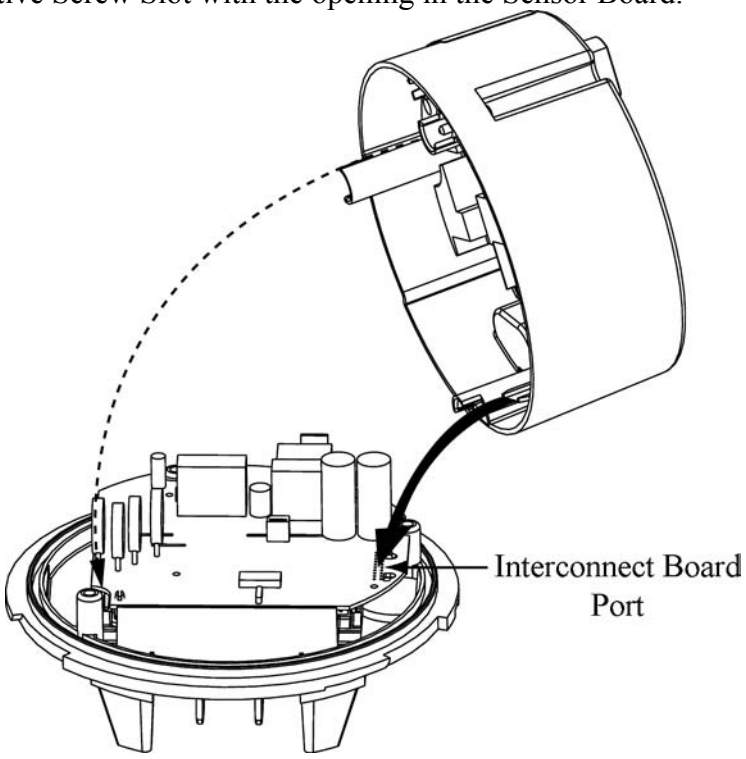


Figure 4-5: Installing the Register Cover

4. Tip the Register Cover down onto the Meter Base Assembly
5. Press the Register Cover firmly into the Meter Base Assembly until the Interconnect Board is firmly seated on the Sensor Board.

> **CAUTION**
>
> Use care not to over-tighten the captive screws. Failure to observe this Caution may result in damage to the bosses in the Meter Base.

6. Securely tighten the Captive Screws to five (5) in-lb of torque.
7. Install the Meter Cover. Refer to "Installing the Meter Cover" above.

Replacing the Interconnect Board

This section provides the instructions necessary to replace the Interconnect Board.

Removing the Interconnect Board

1. Remove the Register Cover. Refer to "Removing the Register Cover" above.

WARNING

The Register Display Board and Register Cover may contain sharp edges. Exercise care while removing the Interconnect Board. Do not overextend the Integrated Alignment Ribs. Failure to observe this warning may result in minor injury to personnel and damage to equipment.

2. Gently push the top of the left Integrated Alignment Rib to the left and pull the Interconnect Board up and to the right.
3. Gently push the top of the right Integrated Alignment Rib to the right and pull the Interconnect Board up and to the left.

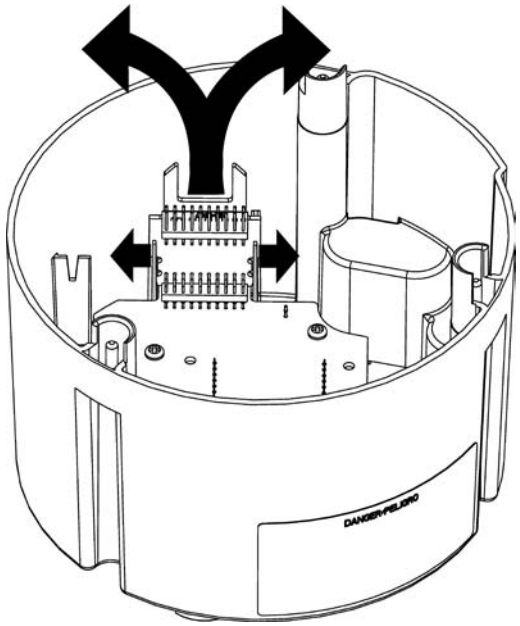


Figure 4-6: Removing the Interconnect Board

4. Repeat Step 2 and Step 3, slowly working the Interconnect Board from side to side until it is free of the Register Display Board connector.

Installing the Interconnect Board

1. Slide the Interconnect Board into the Integrated Alignment Ribs.

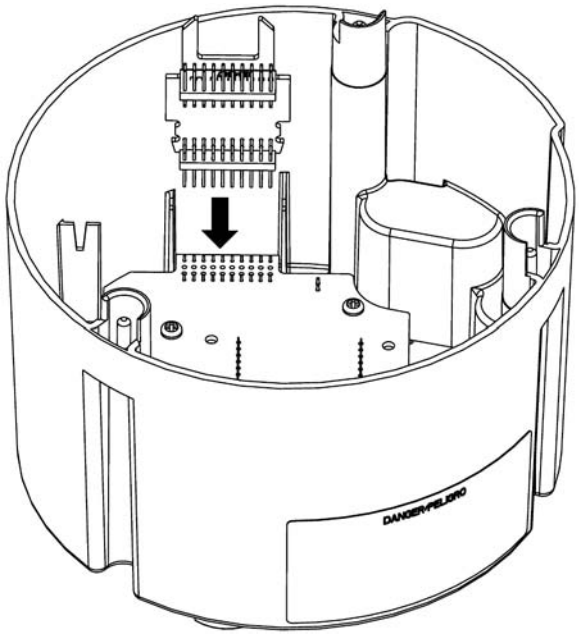


Figure 4-7: Installing the Interconnect Board

2. Align the Header Pins on the Interconnect Board with the connector on the Register Display Board.

> **⚠ WARNING ⚠**
>
> The Register Display Board, Register Cover, and Interconnect Board may contain sharp edges. Exercise care while installing the Interconnect Board. Failure to observe this warning may result in minor injury to personnel.

3. Gently press the Interconnect Board into the connector on The Register Display Board until the board clicks into place.
4. Install the Register Cover. Refer to “Installing the Register Cover” above.

Replacing the Register Display Board

This section contains instructions for replacing the Register Display Board.

Removing the Register Display Board

1. Remove the Interconnect Board. Refer to "Removing the Interconnect Board" above.
2. Remove the screws securing the Register Display Board to the Register Cover.

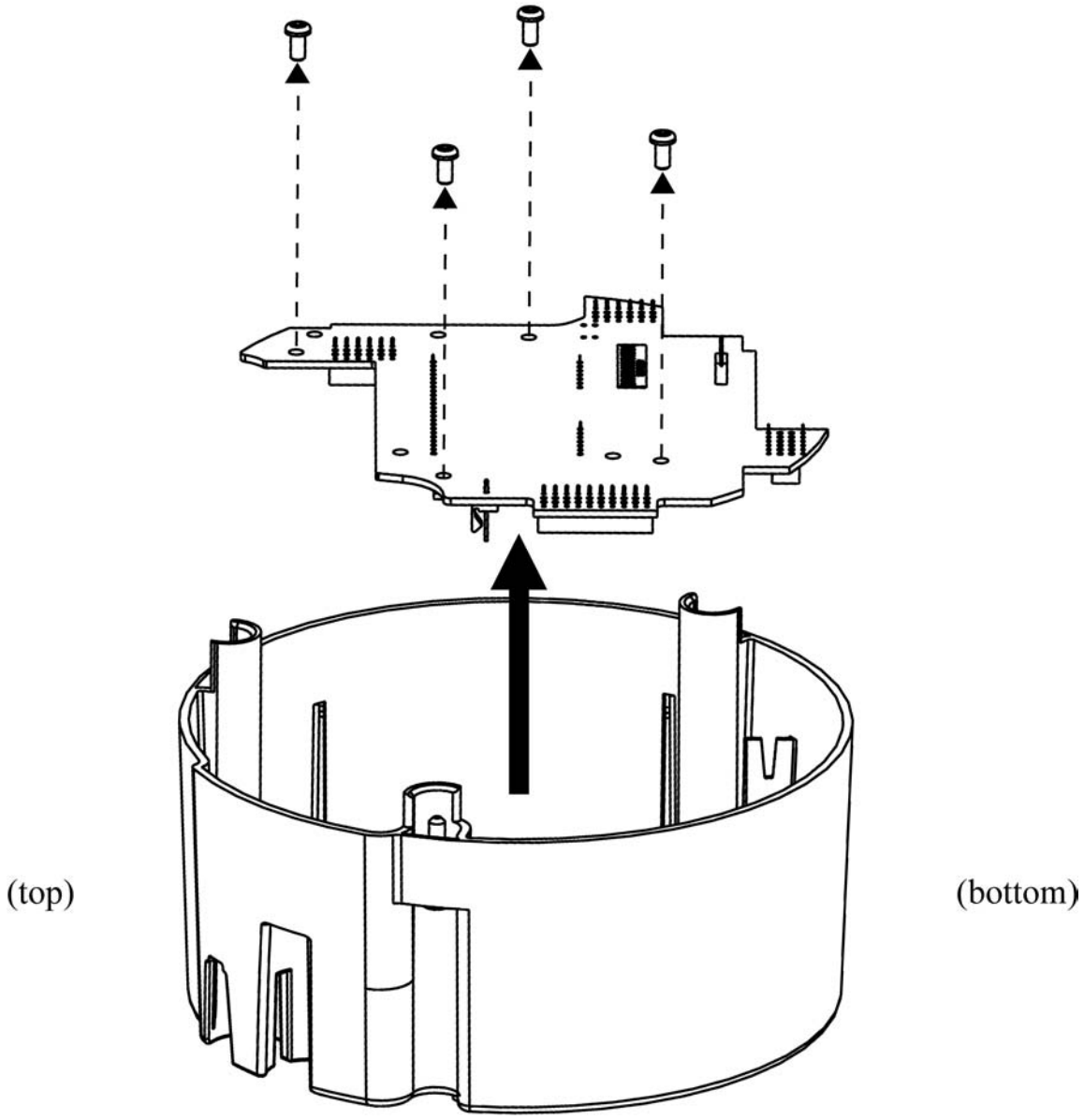


Figure 4-8: Removing the Register Display Board

3. Carefully lift the display board out of the Register Cover.

Installing the Register Display Board

1. Align the LCD with the rectangular opening in the Register Cover.
2. Insert the Register Display Board into the Meter Base Assembly as shown in Figure 4-9.

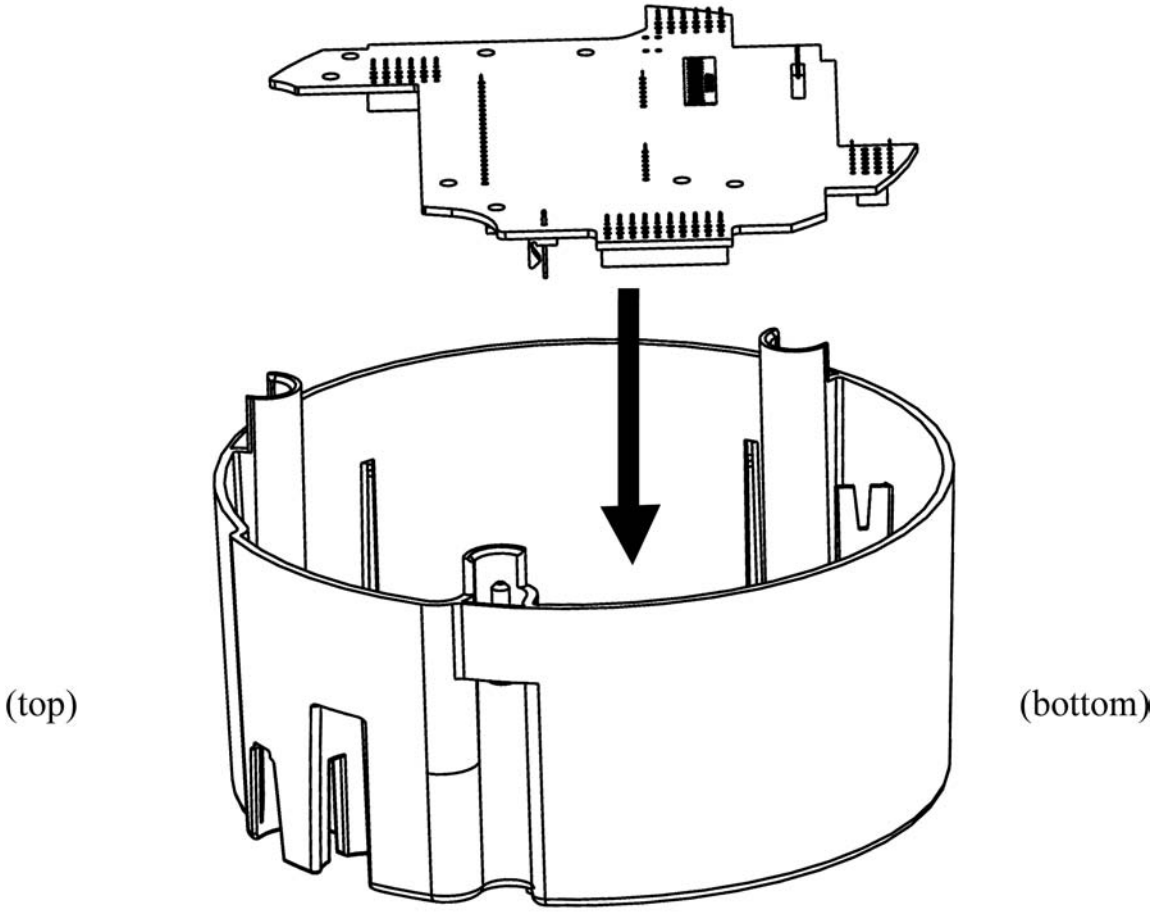


Figure 4-9: Installing the Register Display Board

3. Locate the four (4) holes for the screws.
4. Secure the display board to the Register Cover using the four (4) screws.

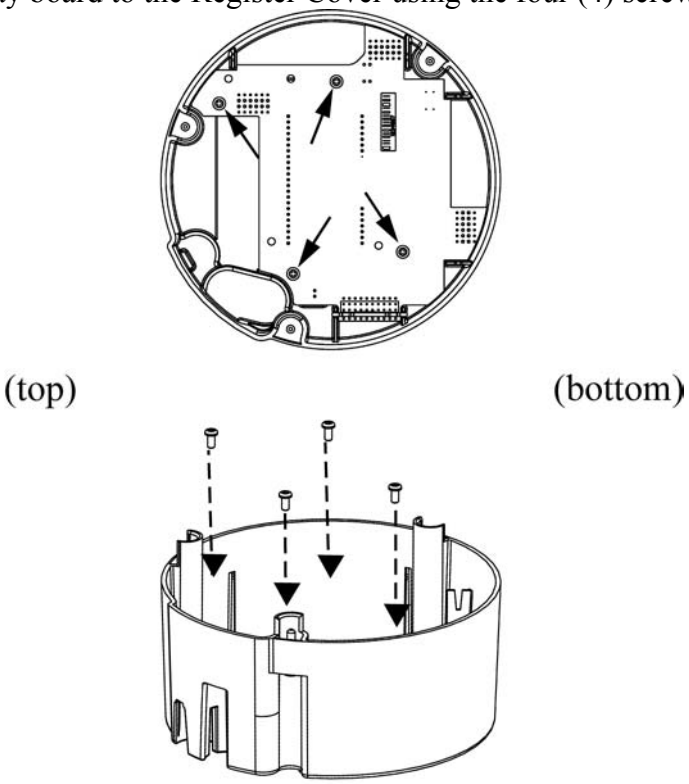


Figure 4-10: Installing the Register Display Board Screws

5. Install the Interconnect Board. Refer to "Installing the Interconnect Board" above.
6. Install the Register Cover. Refer to "Installing the Register Cover" above.

NOTE

If the meter continues to malfunction, the error may be in the Sensor Board or other meter component. Do not replace the Sensor Board. Contact your sales representative and Customer Service at Sensus Metering Systems. Refer to Sensus Metering Systems.

Chapter 5

This chapter describes the theory of operation for the iCon™ APX Advanced Functionality meter. Figure 5-1 supplements the information contained in this section.

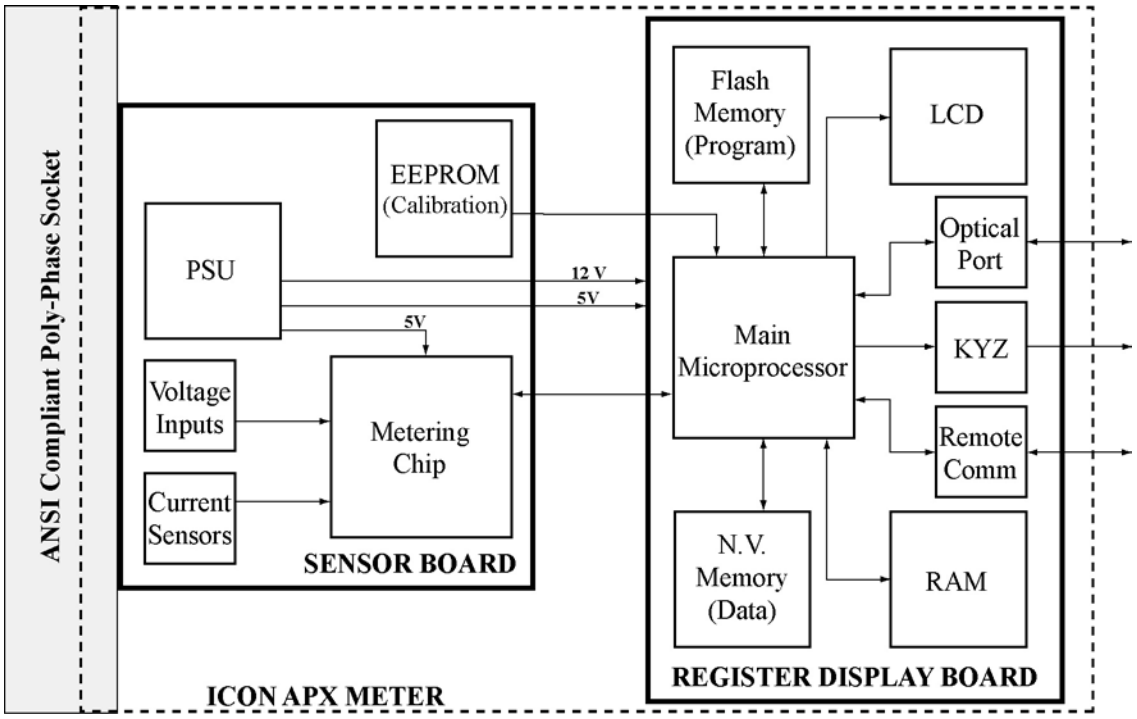


Figure 5-1: APX Meter Operational Overview

Metrology

The APX meter performs certain operations on the power present at the socket to provide accurate measurements. Metrology for power consumption consists of:

- Sensors
- Input
- Power Calculations
- Data Transfer

Sensors

The APX meter contains a current and voltage sensors for power measurement.

Current Sensor

Current is measured using proprietary Sentec® technology. There is one sensor for each phase, and these sensors interface with the Metering Chip by means of three precision amplifiers.

Voltage Sensor

Voltage on each phase is measured using a precision-resistive-divider that is designed to maintain a highly stable division ratio over temperature, humidity, and time. The signals from the divider feed into the Metering Chip.

Inputs

The two types of meter data are:

- Real-time values (instantaneous), such as per-phase voltages and currents
- Accumulated values, such as kWh

Depending on meter form, up to six inputs (Va, Vb, Vc, Ia, Ib, and Ic) are simultaneously sampled at a rate of 26k samples/second at 24-bit resolution. The sample streams:

- Are filtered
- Corrected for gain and offset
- Serve as the real-time values for the calculations of per-phase and poly-phase energy (Wh, VARh, and VAh)

The calculated energy values are accumulated in the designated energy registers, and are used to generate the test pulse signals. The K_h (configured through *iConFig*) setting controls the weight of each pulse. The test pulse signals are routed to the IR Test Pulse LED under the control of the main microprocessor.

Power Calculations

The real-time and accumulated values are used in the calculations to determine:

- Watts and Watt-hours
- kVA and kVAR

Watts and Watt-Hours

The Metering Chip multiplies the real-time values of current and voltage to calculate power (kW), and accumulates kW over time as energy (kWh). This calculation includes digital calibration factors to ensure that the registration of the meter is kept within specified tolerances.

The raw energy values for each individual phase are transmitted by digital serial interface to the Register Display Board. The interface also carries information on the RMS current and voltage for each phase. The values are interrogated by the Register Display Board at least once per line cycle.

kVA/kVAR Calculations

The Metering Chip calculates a +90 degree, phase-shifted current signal. The result is multiplied by the voltage signal to calculate reactive power (kVAR). The accumulation of reactive power over time provides the reactive energy (kVARh) measurement.

The Metering Chip measures the instantaneous RMS current and voltage signals and multiplies them together to create apparent power (arithmetic) samples. These samples are then accumulated over time to provide the apparent energy (kVAh) measurement (arithmetic).

The meter's main processor on the Register Display Board calculates vectorial kVAh using a vector calculation based on kWh and kVAR values.

Data Transfer

Twice per line cycle, the meter's main processor reads the data from all of the metrology energy registers. This data is parsed, distributed, and accumulated in registers located on the Register Display Board.

Once per second, the parsed data stored on the Register Display Board is transferred to high-level tasks running on the processor's real-time operating system. This parsed data is used to:

- Calculate demands
- Update total billing, Time-of-Use registers (when enabled), and Load Profile
- Determine if alarm thresholds, such as Demand Thresholds and/or Reverse Power Thresholds, have been exceeded

Calibration

The Sensor Board contains a serial EEPROM that stores the calibration constants of the sensors. These constants are determined during the initial calibration of the meter.

Register Display Board

Main Microprocessor

Firmware running in flash memory on a 32-bit, ARM7 (RISC) processor performs the advanced, high-level functions within the meter. The functions include:

- Processing and storage of data from metrology
- Displaying data on the LCD
- Communicating:
  - Internally with metrology
  - Externally by way of optional AMR modules
  - Externally by way of the integral optical port
- Monitoring and acting on activations of switches on the face of the meter
- Maintaining time and calendar functions
- Keeping status information updated
- Maintaining a historical log of events

Non-Volatile Memory

Special algorithms have been employed to ensure the long-term validity of the data stored in 256 KB of flash memory. This memory is used to store all non-volatile data such as:

- Meter configuration (*iConFig* created meter Program)
- Billing data
- Load Profile data
- Status data

Power Supply

The power supply is a wide-range, switch-mode supply that is designed to operate from a poly-phase supply. However, in the event of an outage on one or two phases, the power supply continues operating. Some functionality may be inhibited under these circumstances, depending on the option boards fitted to the meter and the service type/voltage. Refer to *Appendix B: Specifications* for details of operating voltage ranges.

Demand Metering

Demand

Demand is calculated over an interval of time. Intervals can be configured but must be factors of 60 minutes (1, 2, 3, 5, 6, 10, 12, 15, 30, and 60). The Demand interval and subinterval lengths (See "Sliding" below.) are configured using *iConFig*.

A new demand interval begins when the demand interval is changed or when entering or exiting Test Mode. The number of minutes remaining in the current subinterval is available for display. The EOI Annunciator temporarily illuminates at the end of each subinterval.

The meter calculates and stores the peak Demand for each energy value (kWh, kVARh, kVAh). The meter also stores either the Cumulative or Continuously Cumulative Demand.

The meter can calculate Block Demand and Sliding (Rolling) Demand (kW, kVA, kVAR).

Block

NOTE:
To configure the meter for Block Demand, the subinterval is set to the same length of time as the interval length.

Block Interval Demand is where the interval and subinterval are the same value. Dividing 60 by the interval length and then multiplying the quotient by the measured Demand gives you Block Demand.

EXAMPLE: If the interval length is 30 minutes and the measured energy is 100 kWh, then:

60 / Interval Length * Measured Energy = Block Demand

60 / 30 * 100 kWh = 200 kWh

Sliding

Sliding (Rolling) Demand is where intervals are divided into a fixed number of subintervals. Demand calculations are performed at the end of each subinterval instead of at the end of each interval.

As in Block Demand, the interval length must be a factor of 60. The subinterval length must be a factor of the interval. Figure 5-2 is an example of an interval of 30 minutes with 10-minute subintervals. Demand is calculated every 10 minutes based upon the three previous subintervals.

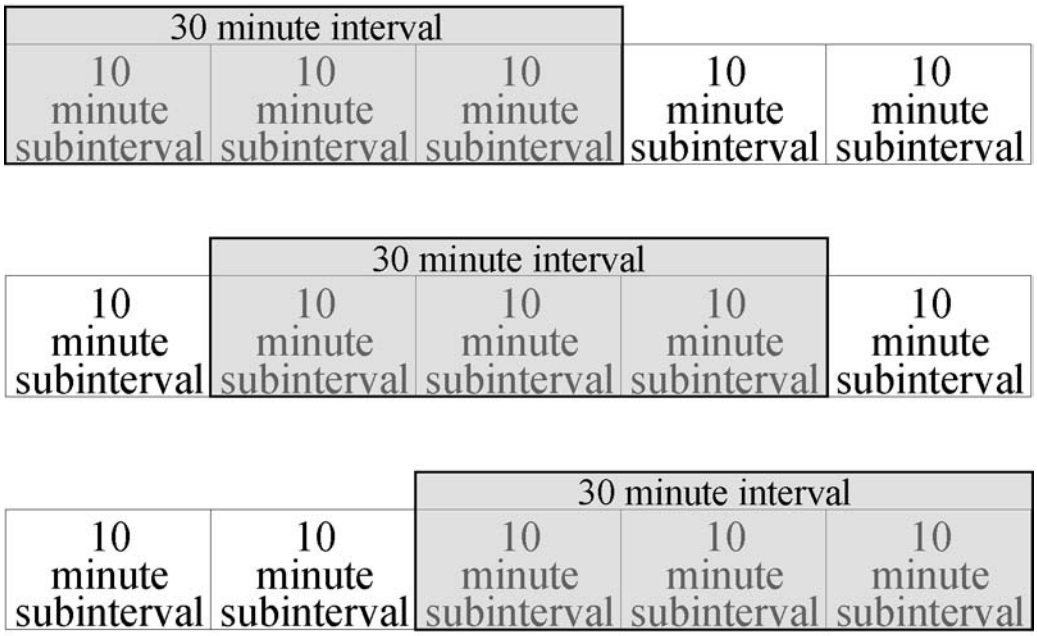


Figure 5-2: Sliding Demand Interval

Peak

Peak Demand is stored as part of the billing quantities in the billing registers. It is the maximum calculated Demand since the last Demand Reset.

Cumulative

Cumulative Demand is stored as part of the billing quantities in the billing registers. It is the sum of the previous billing period peak Demand readings. At the time of a Demand Reset, the maximum Demand for the most recent billing period is added to the previously accumulated total of all maximum Demands.

Continuous Cumulative

Continuous Cumulative Demand is stored as part of the billing quantities in the billing registers. It is the sum of the previous billing period peak Demands and the present period peak Demand.

Demand Reset

When the meter performs a Demand Reset, the meter:

- Adds the present Demand values to the Previous Demand register
- Resets the intervals back to the beginning
- Resets the Demand registers to zero (0)

Outage Recognition

The meter can detect temporary interruptions in service. For Demand calculations, meters without Real-Time-Clocks (RTCs) "recognize" all interruptions in service as outages. Meters with RTCs can be configured to only "recognize" outages if they last more than the configured number of seconds. The Outage Recognition Time is configurable using *iConFig*.

Demand Forgiveness Time

Demand Forgiveness Time is the configured amount of time immediately following a recognized power outage that Demand calculations are suspended. The Demand Forgiveness Time is configurable using *iConFig*.

Self Read

During a Self Read, the meter captures the current billing data and then stores it in the associated Self Read registers.

Self Reads are events that can be configured to be:

- Scheduled to occur at specific times or intervals
- Performed when other events occur (i.e., during a Demand Reset)
- Performed when triggered by an external command

Coincident Values

Coincident demand refers to a demand value that occurs at the same time as another demand reaches its peak value. For example, an electric utility may want to record the kVAR demand at the time of a maximum kW demand. This requires that kVAR demand be stored and reported during the same interval as the maximum kW demand. Similarly, coincident power factor refers to a power factor that occurs at the same time as a demand value reaches its peak value. For example, an electric utility may want to record the average power actor at the time of a maximum kVAR demand. This requires the average power factor be stored and reported during the same interval as the maximum kVAR demand.

Primary/Secondary Metering

Primary Metering applies to transformer rated meters. Measured energy values are scaled according to the current transformer (CT) and primary transformer (PT) ratios of the current and/or voltage transformers connected to the meter. The resultant values reflect the energy as if the meter was on the primary side of the transformers.

With Secondary Metering, the energy values are not scaled (i.e., the actual energy flowing through the meter is measured).

Appendix A

This appendix provides meter and ANSI compliant socket specifications.

Form 8S

The standard connections for the iCon™ APX Advanced Functionality Meter are made with blades that pass through the Meter Base into ANSI compliant sockets.

Figure A-1 shows the socket wiring for a two-element, transformer-rated, three-phase, four-wire socket for Delta service connections.

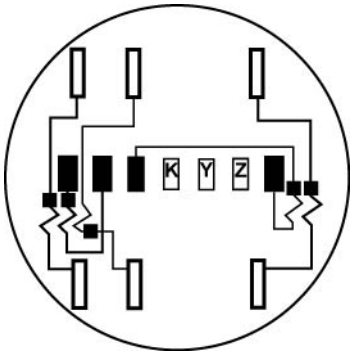


Figure A-1: Socket Wiring - Form 8S

Form 9S

Figure A-2 shows the socket wiring for a three-element, transformer-rated, three-phase, four-wire socket for Wye service connections.

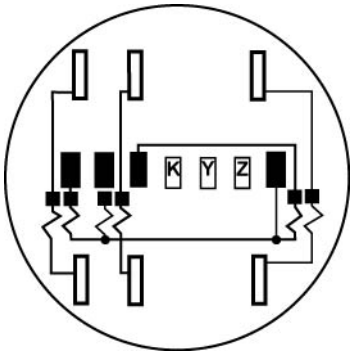


Figure A-2: Socket Wiring - Form 9S

Form 14S

Figure A-3 shows the socket wiring for a two-element, self-contained, three-phase, four-wire socket for Wye service connections.

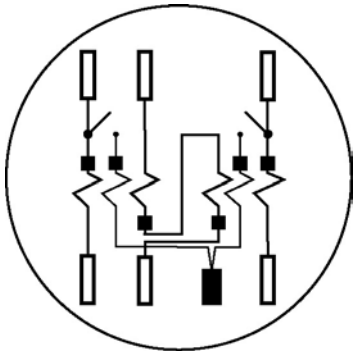


Figure A-3: Socket Wiring - Form 14S

Form 15S

Figure A-4 shows the socket wiring for a two-element, self-contained, three-phase, four-wire socket for Delta service connections.

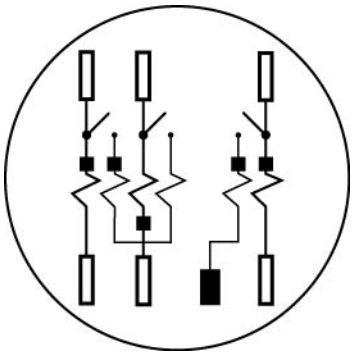


Figure A-4: Socket Wiring - Form 15S

Form 16S

Figure A-5 shows the socket wiring for a three-element, self-contained, three-phase, four-wire socket for Wye service connections.

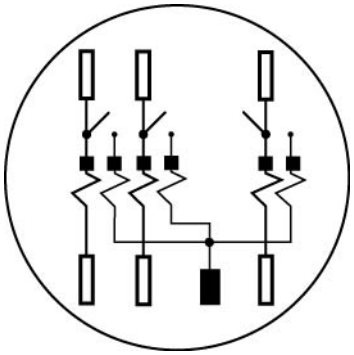


Figure A-5: Socket Wiring - Form 16S

Form 17S

Figure A-6 shows the socket wiring for a three-element, self-contained, three-phase, four-wire socket for Delta service connections.

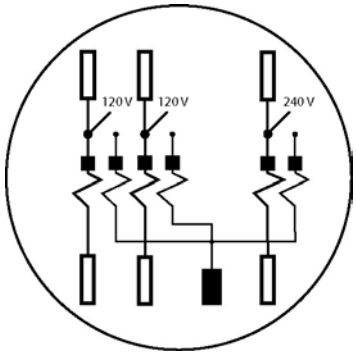


Figure A-6: Socket Wiring - Form 17S

Appendix B

This appendix provides meter and ANSI compliant socket specifications.

Meter Specifications

Operating

Table B-1: Operating Conditions

Voltage	120 – 480 (96 – 576) VAC
Current	0 to Class Amperes
Rated Frequency	45 – 65 Hz
Ambient Temperature	25°C ± 5°C (77°F ± 9°F)

Environmental

Table B-2: Environmental Conditions:

Temperature **Storage** **Operating**	 -40°C to +85°C (-40°F to 185°F) -30°C to +55°C (-22°F to 131°F)
Humidity	0 to 95% RH (non-condensing)

Maximums

Table B-3: Maximums

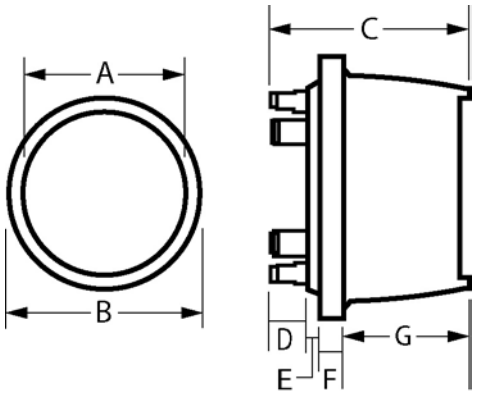
ANSI C37.90.1	2.5kV, 2500 strikes (Oscillatory)
ANSI/IEEE 62.41	6kV, @1.2/50µs, 10 strikes (High Voltage Line Surge
IEC 61000-4-4	4kV, 2.5kHz repetitive burst for 1 minute (Burst)
ANSI C12.1-2001 sec 4.7.3.1	2.5kV, 60Hz, for 1 minute (Insulation)
Current	120% Class Amperes Continuous 200% Class Amperes 1 Second
Voltage	576 VAC (Phase-to-Phase)

Input

Table B-4: Input Specifications

Starting Current	5mA for Class 20 50mA for Class 200
***Power Supply Burden**	120V 2.2W 3.5VA 240V 2.8W 6.6VA 277V 2.4W 6.8VA
Current Circuit Burden	< 0.25 VA per phase at Test Amperes
* - Input voltage measured phase to Neutral.	

Physical Dimensions



Dimensions

	A	B	C	D	E	F	G
in	6.45	6.95	5.0	0.91	0.27	0.55	3.31
cm	16.38	17.65	12.80	2.31	0.69	1.40	8.41

Shipping Weight

1 Meter Carton	2.6 lbs	1.2 kg
4 Meter Cartons	10.1 lbs	4.6 kg
96 Meter Pallet	278.4 lbs	126.3 kg

Appendix C

The tables in this appendix outline the codes for alarms and errors within the meter. Many of the codes can be configured by *iConFig*™ to be displayed on the meter's LCD should certain conditions or events occur. Refer to iConFig Set-up and User's Guide for configurable alarms and thresholds.

Certain conditions are detected by the meter and may be accompanied by one or more codes that aid the technician in troubleshooting the situation. In the event the meter detects an alarm condition, a code similar to the one shown in. Figure C-1 is displayed.

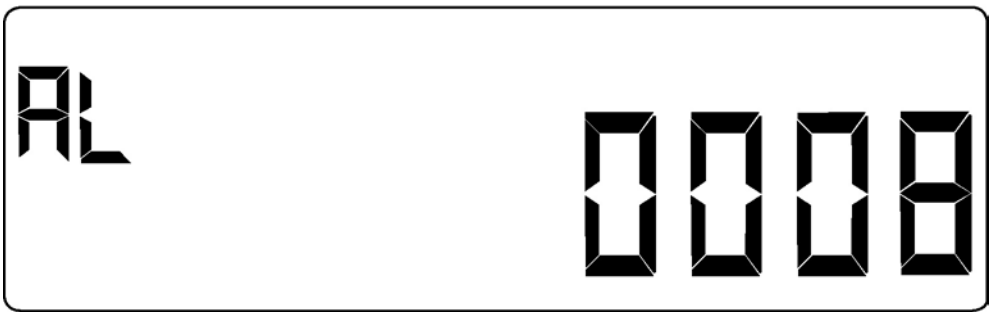


Figure C-1: Alarm Code Example

In the event the meter detects an alarm condition, a code similar to the one in Figure C-2 is displayed.

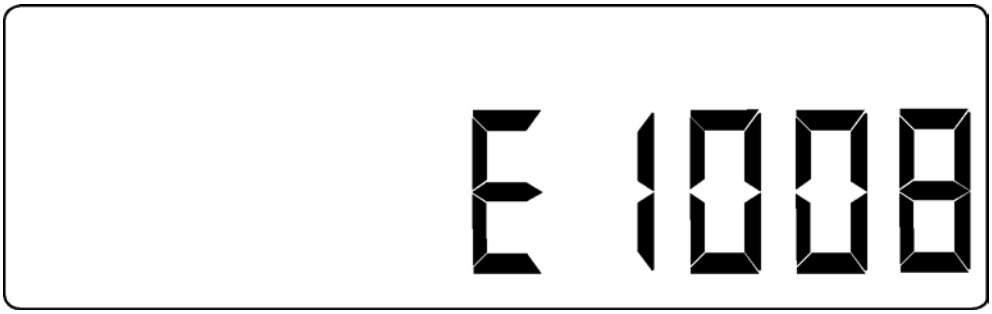


Figure C-2: Error Code Example

Codes

The following tables provide the code numbers, descriptions, notes, and corrective actions (if any)

Alarm

Codes	Description	Notes/Corrective Action
0008	Unprogrammed	No Program is present in the meter. Download a Program into the meter.
0013	Non-Volatile Memory Error	Meter memory is corrupted. Contact technical support.
0014	RTC Error	Real-Time-Clock (RTC) is malfunctioning. Backup all of the meter data and contact technical support.
0016	Low Battery	The battery is not working properly. Replace the battery.
0021	Reverse Rotation Detected (poly-phase)	Energy was received from the load side of the meter. No corrective action required.
0072	Register Overflow	Power down, and then power up the meter. If the error message remains, contact technical support.
0073	Last Demand Interval Restore Failed	The meter was unable to resume calculating Demand with the interval data that was saved during shutdown. A new interval was started. No corrective action required, If the condition persists, contact technical support.
0074	Last Load Profile Interval Restore Failed	The meter was unable to resume calculating Load Profile with the interval data that was saved during shutdown. A new interval was started. No corrective action required, If the condition persists, contact technical support.
0075	Modem Error	Modem may be malfunctioning. Contact technical support.
0080	Calibration Error – E^2 Corrupt	The meter detected an anomaly with the calibration constants. Return the meter to the vendor.
0088	Demand Overload Tier A	The user configures the meter to monitor these thresholds. Corrective actions are determined by the utility's standard procedures.
0089	Demand Overload Tier B	
0090	Demand Overload Tier C	
0091	Demand Overload Tier D	
0092	Demand Overload Tier E	
0093	Demand Overload Total	
0096	Phase A Missing Volts	The user configures the meter to monitor these thresholds. Corrective actions are determined by the utility's standard procedures.
0097	Phase B Missing Volts	
0098	Phase C Missing Volts	
0099	Phase A Missing Current	The user configures the meter to monitor these thresholds. Corrective actions are determined by the utility's standard procedures.
0100	Phase B Missing Current	
0101	Phase C Missing Current	
0104	Neutral Current Overload	
0106	Bad Element Detected	If the meter connections are good, contact technical support.
0107	Reverse Rotation Phase A Detected	The user configures the meter to monitor these thresholds. Corrective actions are determined by the utility's standard procedures.
0108	Reverse Rotation Phase B Detected	
0109	Reverse Rotation Phase C Detected	

Alarm Codes - *continued*

Codes	Description	Notes/Corrective Action
0112	Low Current Phase A	The user configures the meter to monitor these thresholds. Corrective actions are determined by the utility's standard procedures.
0113	Low Current Phase B	
0114	Low Current Phase C	
0115	Low Current (System)	
0116	High Current Phase A	The user configures the meter to monitor these thresholds. Corrective actions are determined by the utility's standard procedures.
0117	High Current Phase B	
0118	High Current Phase C	
0119	High Current (System)	
0120	Low Voltage Phase A	The user configures the meter to monitor these thresholds. Corrective actions are determined by the utility's standard procedures.
0121	Low Voltage Phase B	
0122	Low Voltage Phase C	
0123	Low Voltage (System)	
0124	High Current Phase A	The user configures the meter to monitor these thresholds. Corrective actions are determined by the utility's standard procedures.
0125	High Voltage Phase B	
0126	High Voltage Phase C	
0127	High Voltage (System)	
0128	Low Leading PF Phase A	The user configures the meter to monitor these thresholds. Corrective actions are determined by the utility's standard procedures.
0129	Low Leading PF Phase B	
0130	Low Leading PF Phase C	
0131	Low Leading PF (System)	
0132	High Leading PF Phase A	The user configures the meter to monitor these thresholds. Corrective actions are determined by the utility's standard procedures.
0133	High Leading PF Phase B	
0134	High Leading PF Phase C	
0135	High Leading PF (System)	
0136	Voltage Sag Phase A	The user configures the meter to monitor these thresholds. Corrective actions are determined by the utility's standard procedures.
0137	Voltage Sag Phase B	
0138	Voltage Sag Phase C	
0139	Voltage Sag (System)	
0140	Voltage Swell Phase A	The user configures the meter to monitor these thresholds. Corrective actions are determined by the utility's standard procedures.
0141	Voltage Swell Phase B	
0142	Voltage Swell Phase C	
0143	Voltage Swell (System)	
0144	AMR Module Error	The AMR module has reported an error to the meter. Refer to the documentation that accompanied the module.
0145	AMR Communication Error	The AMR module is no longer communicating with the meter. Reseat the module. If the condition persists, contact technical support.

Diagnostic

These diagnostics can turned On or Off with *iConFig*. The diagnostics are designed to assist the technicians and installers in diagnosing any error conditions within the meter and the service at the socket.

Codes	Description	Notes/Corrective Action
0001	Diagnostic 1 (Polarity/Cross Phase)	The meter has detected a connection that is reversed. Check the socket wiring at the meter and/or transformer.
0002	Diagnostic 2 (Phase Voltage Deviation)	The meter has detected one or more service voltages outside of the configured nominal percentage. Check the socket wiring at the meter and CT/PT ratios.
0003	Diagnostic 3 (Inactive Phase Current)	Current on one or more of the phases is missing. Check the socket wiring at the meter for each phase.
0004	Diagnostic 4 (Phase Angle Displacement)	The power factor of one or more of the phases is out of tolerance. Check the socket wiring at the meter for each phase.
0006	Diagnostic 6 (Current Magnitude/Imbalance)	Too much load current flowing to the meter and/or one or more of the phase currents are out of tolerance relative to the other phases. Check the connections to the load and load-side wiring.
0007	Diagnostic 7 (Energy Direction)	The power flowing through the meter is reversed. Check the socket wiring at the meter or for a generator on the load side of the meter.

Error

The following error codes indicate that the meter is not functioning improperly. Contact technical support to report the error code.

Codes	Description
1001	RAM Failure
1002	Flash Checksum
1003	Flash Empty
8841	Metrology Error
8904	Metrology Error
8905	Metrology Error
8C04	Metrology Error
8C05	Metrology Error
9001	RTC Error
9002	RTC Error
9003	RTC Error
9004	RTC Error
9005	RTC Error
9006	RTC Error
9007	RTC Error
9011	RTC Error
9012	RTC Error
9013	RTC Error
9014	RTC Error
9021	RTC Error
9022	RTC Error
9023	RTC Error

Error Codes - *continued*

Codes	Description
9101	RTC Error
9102	RTC Error
9103	RTC Error
9104	RTC Error
9111	RTC Error
9201	RTC Error
9202	RTC Error
9203	RTC Error
9306	Invalid NVRAM Version
9307	NVRAM Data Restore Error
930A	NVRAM firmware version upgrade
9601	Outage Interrupt Error
9602	Outage Interrupt Error
9603	Outage Interrupt Error
9604	Outage Reset Exception
9605	Undefined Instruction
9606	Software Interrupt Exception
9607	Pre-fetch Data Exception
9608	Data Exception
9609	Data Exception
960A	Operating System Error
960B	Run Time Error
960C	Assert Error
960D	Warm Start Error
960E	Cold Start Error
960F	Watchdog Error
9640	First Critical Section Error
9641	Calendar Error
9642	Summation Error
9643	Primary Value Error
9644	Demand Error
9645	Load Profile 1 Error
9646	Load Profile 2 Error
9647	Core Metering Error
9648	Display Error
9649	Data Error
964A	Relay Error
964B	Communication Error
964C	Startup Error
964D	Last Critical Section Error
964E	Calculation Error
9650	Overrun Error
9651	Low Power Mode Error
9652	Sleep Timer Error
9653	Reset Error
9655	Configuration Error
9656	Configuration Error

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