Breaking down the barriers

A3 ALPHA–The next generation in electricity metering

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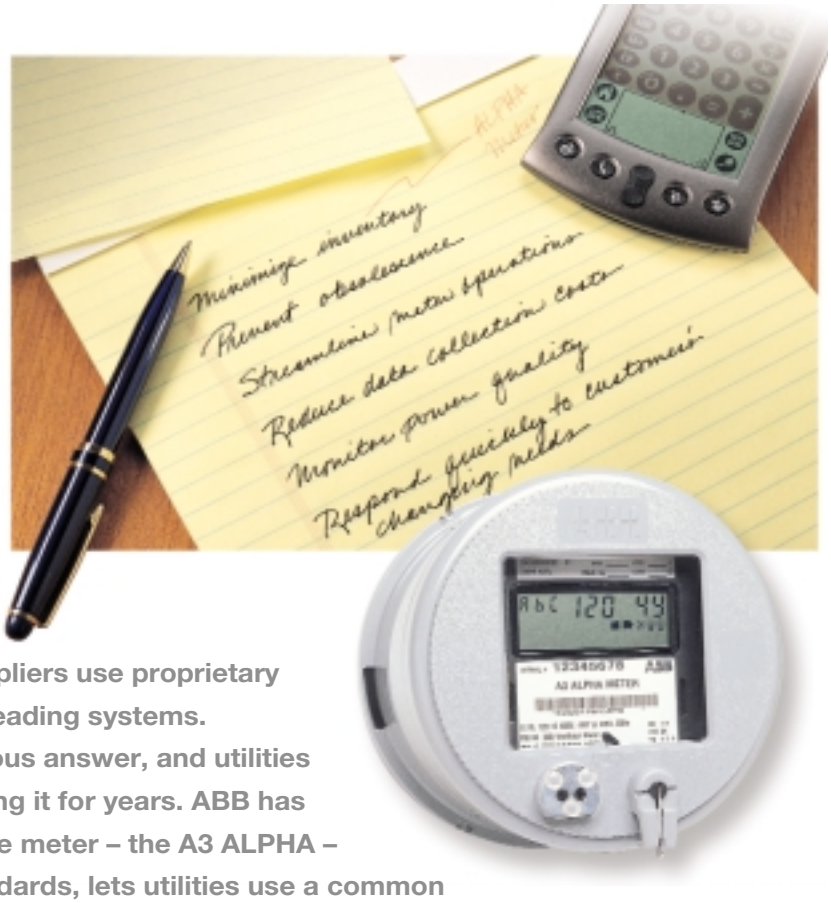


Imagine being a candy store owner and children from all over the world come into your shop, speaking in different languages and offering to pay in different currencies. The chances are that you will have difficulty making sure the children get what they want and that you get the right money. Electric utilities can find themselves in a similar situation when collecting meter readings. This is because meter suppliers use proprietary communications protocols in their reading systems. Protocol standardization is the obvious answer, and utilities the world over have been encouraging it for years. ABB has now developed an electronic revenue meter – the A3 ALPHA – which, by supporting new open standards, lets utilities use a common industry vocabulary for meter data communications.

Deregulation and privatization of the world's energy markets is forcing electric utilities to consider their options in key operational areas. The pressure is on to minimize inventories and prevent obsolescence, streamline meter operations and communications, and reduce data collection costs; at the same time, the utilities want to be able to monitor power quality and respond quickly to customers' changing needs.

ABB is helping utilities meet this challenge with the new A3 ALPHA electronic revenue meter, which builds on patented and proven ALPHA meter technology. Since the first units were introduced in 1992, more than 2 million ALPHA meters have been shipped to utilities around the world. Besides incorporating the high-function energy measurement capabilities of its

predecessors, the new A3 ALPHA meter offers increased data recording, profiling and power quality measurement (see *Table*). Just as importantly, it implements the new, standardized, ANSI open communications protocol for meter data communications.

The A3 ALPHA meter provides a meter design platform that supports a variety of utility metering requirements. The most basic A3 ALPHA meter can be factory-configured for simple single-rate measurement of total kWh and maximum kW demand. The most advanced A3 ALPHA can be configured as a multi-rate, real/reactive, bidirectional meter. Other standard features provide instrumentation readings of line voltage, current, phase angle and power. Every A3 ALPHA meter is equipped with capabilities that can automatically validate the meter service connections, assuring that the meter is properly connected into the power system. A3 ALPHA meters can also be configured for power quality monitoring, detecting and recording phase or total system outages, low and high voltage events and other system anomalies. These special events can be logged in memory along with load profile readings and the new capability of instrumentation profile readings.

Collecting meter reading data is becoming increasingly complex, and the new electronic meters need to take full account of this trend. Even as ABB and others were introducing electronic meters for more complex tariffs, collecting electricity metering data was moving beyond the simple reading of 4 or 5 dials and manual recording of the kilowatt-hours consumed. Now, with customers wanting to measure more quantities, meters are more commonly read electronically. This is done locally using an optical probe and a computer, or remotely by an automatic meter reading (AMR) system. The A3 ALPHA meter supports a variety of remote communications options, including internal telephone modems that can initiate an alarm call to utility systems in the event of unusual events or even power outages.

Improved communications through open standards

ABB and other suppliers have introduced, over the years, a whole range of

Table: ABB A3 ALPHA meter — main characteristics

Property	Data	
Nameplate nominal voltage range	120 – 480 V	
Operating voltage range	96 – 528 V	
Current	0 to Class amperes	
Nominal frequency	50 or 60 Hz ±5%	
Temperature range	-40° to 85°C inside meter cover	
Humidity range	0 to 100% non–condensing	
ANSI applicable standards	C12.1, C12.10, C12.20, C12.18, C12.19, C12.21	
Absolute current	Continuous at 120% of meter's maximum current Temporary (1s) at 200% of meter's maximum current	
Surge voltage withstand	ANSI C37.90.1 oscillatory	2.5 kV, 2500 strikes
	IEC 801-4	4 kV, 2.5 kHz repetitive burst for 1 minute
Accuracy	With load = {0.2 + 0.001 (Class/I)(1 + tan θ)}%	
Accuracy variations	Voltage coefficient = ±0.01% change from nominal Temperature coefficient = ±0.01% per °C	

electronic electricity meters with different communications protocols. This has meant that electric utilities have had to support different communications protocols for the collection of data from these meters. And as suppliers launched ever-newer electronic meters, the variety of system requirements kept on growing. The result was that developing and using computer-based meter reading devices and software became more difficult and complex. Utilities therefore began to encourage standardization of systems, seeking more commonality in the hardware and software required to collect meter data. What was wanted were ways to reduce the initial and ongoing costs of their metering systems.

While some limited protocol standardization developed in Europe through the work of the IEC standards groups, it covered collection of only the most basic data. The IEC efforts did not yet address the growing variety of the more complex data that utilities required. At the same time, in North America, it was being recognized that standardizing communication processes for the more than 3000 US utilities was complex and would take longer than had been thought.

Beginning in 1996, the American National Standards Institute (ANSI), Automatic Meter Reading Association (AMRA), and Measurement Canada, joined forces to publish standards for meter data storage and communications protocols. [1] This collaboration resulted in the establishment of three significant standards for developing metering systems:

- *ANSI C12.18 (1996): Protocol Specification for ANSI Type 2 Optical Port:* A communication protocol for transport data structures as defined in C12.19 using an infrared optical port.
- *ANSI C12.19 (1997):* Utility Industry End Device Tables: The standard that defines the data structure for use in metering products.
- *ANSI C12.21 (1998):* Protocol Specification for Telephone Modem Communication: A communication standard designed to transport data structures as defined in C12.19 via telephone modems.

By supporting the new ANSI standards, the A3 ALPHA meter gives customers far more flexibility than is possible with other electricity meters in its class. Meters supporting the standard promise simpler interfaces, faster implementation of new features, and lower operational costs.

ANSI and A3 ALPHA communications help customers reduce costs

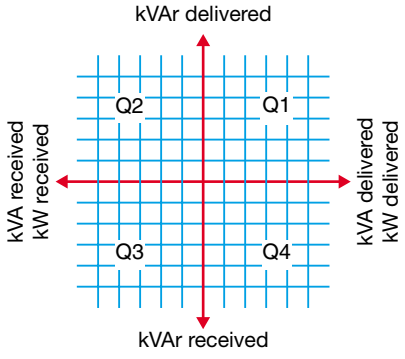
The A3 ALPHA was designed specifically to accommodate all of these new standards and offers a more complete implementation of the ANSI standards than any other meter currently available. Using open standards for meter data communications, utilities will be able to reduce their operating costs by removing the obstacles created by proprietary communications protocols. This standardization allows for quicker design and implementation of AMR systems and will provide more overall metering system options in the marketplace.

The A3 ALPHA meter fully supports ANSI C12.18, C12.19, and C12.21. As the electricity industry continues to adopt these standards, more systems and communications options will become available, and the users of the A3 ALPHA meter will benefit from a more competitive tool for data collection and analysis systems.

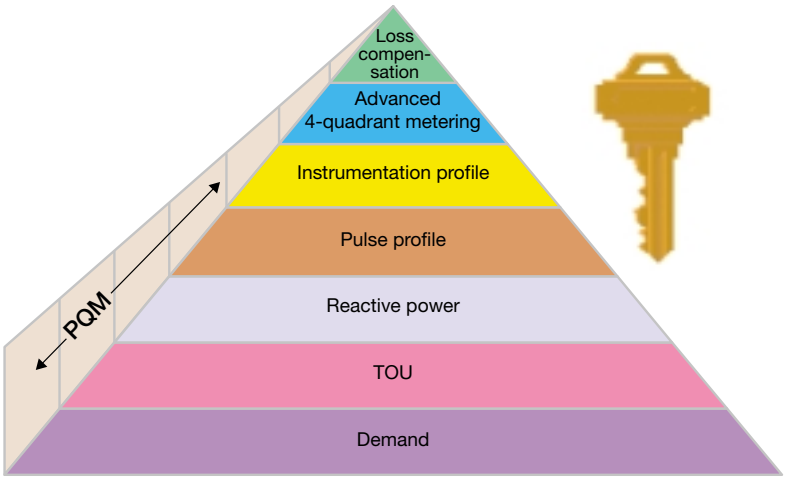
Advanced four–quadrant metering

Four-quadrant metering 1 allows measurement of real, reactive, and apparent energy in both the delivered and received directions. A3 ALPHA meters with reactive metering or apparent metering capabilities can measure two quantities, one average

1 Advanced four–quadrant metering allows measurement of real, reactive, and apparent energy in both the delivered and received directions.



2 Alpha Keys software allows easy reconfiguration of the A3 ALPHA, for example to change it from a simple kW-hour meter into a sophisticated, multi-functional meter.



power factor and two coincident values. When enabled with advanced four-quadrant metering, these meters offer six measured quantities, two average power factors and four coincident values.

Alpha Keys for flexible meter configuration

Using software called Alpha Keys 2, the A3 ALPHA meter can easily be reconfigured to convert a simple, kilowatt-hour meter into a sophisticated meter reporting:

- Time of use (TOU)
- kVA
- kVAr
- Load profiling
- Power quality
- Instrumentation profiling
- Transformer and line loss compensation
- Advanced four–quadrant metering

A meter with this feature saves valuable time and resources as it does not have to be removed from service or sent to the factory for reconfiguration. The Alpha Keys provide a hedge against potential hardware costs should rates or customer service requirements change. Alpha Keys can also be used to drive a utility's meter inventory to very low levels without reducing its ability to respond to new customer needs.

The meter engine – driving a more efficient operation

The power supply used for the A3 ALPHA accepts a wide range of voltages – from 96 to 528 VAC – allowing a single meter to be used for multiple applications. Its 12-V output is fed to a linear regulator to obtain the logic level voltage needed by the meter.

Power is measured by two integrated circuits: the *meter engine* and the *microcontroller* 3. These serve as the control center for all the metering components.

The meter engine receives current through a precision–wound current sensor. This reduces the current proportionally, so that the meter engine can measure it accurately without becoming overloaded. A digital signal processor converts the analog current inputs into digital pulses.

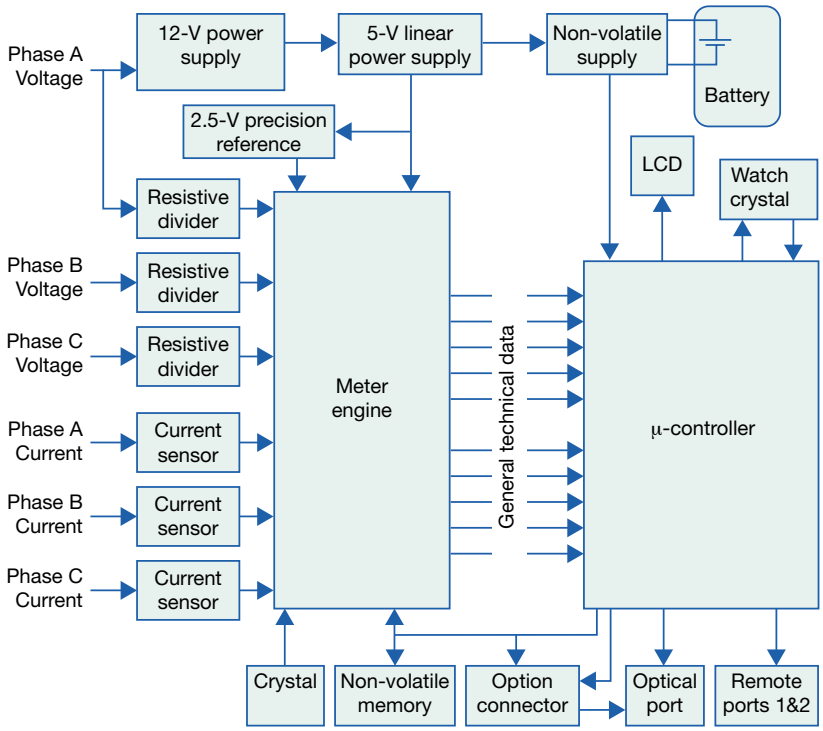
Voltage is measured with the help of scaled inputs from resistive dividers. These dividers maintain the logic voltage at the level necessary to ensure the engine's efficient operation and to minimize the phase shifts, which occur over a wide dynamic range. The meter engine communicates continuously with the microcontroller in order to process pulses into metered quantities (eg, watts, VA, and VAr).

The microcontroller performs many different functions needed for metering communications and efficient operation, for example:

- Processing of raw meter data from the meter engine
- Storage of processed data (also called *billing data*)
- Communication with the meter engine and non-volatile memory
- Provision of communications over optical and remote ports
- Operation of the display (LCD)
- Control of installed option boards

The microcontroller is also responsible for shutting down the meter safely in the event of a power failure. To prevent any loss of revenue due to power failure, the billing data are stored in a non-volatile memory. When power is restored, the meter returns to its operational state

3 Block diagram of the A3 ALPHA meter



immediately prior to the failure before resuming normal operation.

Advanced meter tools minimize uncertainties

The A3 ALPHA meter can perform a series of tests to verify and analyze the electrical service and check for power quality. System service tests validate the electrical service the A3 ALPHA is metering and provide a near instantaneous analysis of the conditions at the meter's location. Power quality monitors constantly review the circuit parameters.

Power quality monitoring

Deregulation is forcing electric utilities to face the prospect of their best customers leaving for 'a better deal'. Many utilities are therefore drawing up new service contracts to entice their key industrial clients to sign up for long-term partnerships. Advanced power monitoring plays an important part in contracts of this kind.

The A3 ALPHA meter, combined with ABB software, can help identify power distortion problems and their source. By fully deploying power quality monitoring (PQM), utilities can proactively enhance customer service. The A3 ALPHA meter looks for exceptions to user-defined thresholds for items such as voltage, current, total harmonic distortion, and total demand distortion. Through a variety of tests, the new meter can measure and collect power quality data 24 hours a day. In response to customer input, the meter is designed to:

- Continuously monitor over 10 different power quality conditions
- Record 32 channels of instrumentation data
- Display over 50 different instrumentation quantities
- Perform site diagnostics and verify service
- Generate real-time alarms when violations occur

System service tests

Two tests – the *service voltage test* and the *system current test* – are all that are needed to verify the service type, phase rotation and validity of the phase voltage and phase current.

Service voltage test

This test checks the voltage and service type to determine if voltage transformers are wrongly wired or line fuses are missing. When the meter determines the service voltage to be correct, it stores this information as a basis for additional power quality tests.

System current test

This test checks the current to determine if current transformers or installation sockets are wrongly wired, or if load–side fuses are missing.

System instrumentation

System instrumentation measurements can provide a near instantaneous analysis of the electrical service. Examples of these measurements are

per-phase voltage, per-phase kW, and per-phase total harmonic distortion of voltage or current. These measurements are not used for billing; instrumentation quantities are instantaneous whereas billing is measured or averaged over time. (Billing quantities measure all the phases. Instrumentation quantities can measure each phase individually.)

Built-in security reduces system support costs

The A3 ALPHA meter also incorporates high-level security functions to prevent tampering. Three passwords prevent unauthorized access to the meter data. One password grants 'read only' access to the meter data and prevents programming changes. A second password allows the tasks necessary for billing data collection, such as adjusting the date and time, performing demand resets, and clearing any warnings or errors. A third password allows full programming, eg for changing meter constants or PQM test parameters.

All A3 ALPHA meter configurations provide an audit trail for detecting potential incidents of tampering. Such incidents can be reported as:

- Programming changes
- The ID number of the user making the programming change
- Power outages
- The number of manually initiated demand resets
- Reverse energy flow
- The number of failed password attempts

Logs and data sets

In addition to the anti–tampering tools, the A3 ALPHA meter records logs and data sets for different activities. They can be used to determine the quality of service or to investigate possible tampering with the meter.

Event log: All A3 ALPHA configurations can record the date and time of meter events, such as power failures, demand resets, test mode activities and time changes.

History log: All A3 ALPHA configurations record changes to meter programming. The history log records the date and time, the ANSI C12.19 table or procedure ID, and the ID of the user who edited the table or performed the procedure.

Self-reads: All A3 ALPHA meters support self-reads. A self-read records and stores current billing data. Self-reads can be triggered by a scheduled calendar event or every demand reset. The data can be retrieved later for analysis or billing.

Load profiling: A3 ALPHA meters with load profiling capability can record up to 8 channels of information. Load profiling has its own, independent interval length, which can be configured separately from the demand interval length.

Instrumentation profiling: A3 ALPHA meters with instrumentation profiling have two sets of instrumentation recorders. Each set can record up to 16 channels of information about the conditions at the meter's place of installation. Instrumentation profiling is typically used for analysis and not for billing purposes. Each set has its own, independent interval length, configured separately from the demand interval length or the load profiling interval length.

PQM log: A3 ALPHA meters with power quality monitoring capabilities have a log that records PQM test failures. The PQM log records the time of the PQM test failure and reports the identity of the failed test. After the condition that caused the PQM test failure has disappeared, the meter records the time the test is passed and reports its identity.

Voltage sag log: Meters with PQM capability also feature a voltage sag log. This log records the date, time and phases of any detected voltage sags. The meter recognizes sags lasting as little as 2 line cycles on any phase.

Options for maximizing metering flexibility

Option boards

Extra functions can be added to the A3 ALPHA meter by means of option boards 4. These are mounted on the main circuit board of the meter using a 20-pin connector.

The A3 ALPHA meter currently supports five communication options:

- Relay outputs
- Internal telephone modem
- RS232 serial interface
- RS485 serial interface
- 20-mA current loop

ABB Electricity Metering is evaluating new communication options and is

4 Extra functions can be added to the A3 ALPHA meter by mounting option boards on its main circuit board.

1 *A3 ALPHA meter*
2 *Internal telephone modem*
3 *Extended memory*
4 *20-mA current loop (6 output relays)*
5 *RS232 (4 output relays)*

working with companies outside ABB to make even more options available. Since the A3 ALPHA meter supports the ANSI protocol and communication standards, it will be easier for new software applications and communication options to be interfaced with the A3 ALPHA meter.

Programmable relays

An A3 ALPHA meter equipped with an option board to which relays have been fitted to generate echo pulses or provide other control signals, can also control external devices. For example, if a meter relay signals the start of a high-tariff period or violation of the maximum demand threshold, an external device can be made to turn off equipment until the condition returns to normal. Or when specific PQ conditions are essential to a consumer, a relay can be programmed to signal a PQM test failure to indicate conditions that affect, for example, a machine's operation.

The meter supports up to six different relays, depending on the set of option boards installed. All the relays are fully programmable. Users can select a different control source for each individual relay. Possible sources are:

- Energy pulse for any basic metered quantity
- End of demand interval signal
- Load control signal
- Specific TOU rate active signal
- Error or warning signal
- PQM test failure signal
- Alarm condition signal

Designed with an eye to the future

Accurate revenue and power quality metering with the A3 ALPHA gives utilities new options and allows them to provide better service for customers while minimizing hardware investments and costly obsolescence. The A3 ALPHA meter represents the next generation in metering. With its many advanced features, it is designed to help utilities not only today but also well into the future.

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Reference

[1] **T. York:** Exploring ANSI Standards in Meter Communications. PowerValue September/October 2000, 16-17.