Electronic Power Meters
Guide For Their Selection and Specification

Rick Schlobohm, P.E.,
GE Specification Engineer

Electronic power meters vary widely in features and this range of features determines the price level of the meter. The purpose of this article is to help the reader select the right meter from the vast number of choices for their customers, matching the function and need of the meter with the value to the customer.

Is a Meter Needed?

Every power distribution system that justifies the talent of a design professional should qualify for a meter. If the customer indicates that they do not want a meter of any kind, then they are admitting that they have no desire to know what is happening with their electrical system. Typically they are looking for guidance, and the proper guidance is that meters provide critical detail about the system that assists in its safe operation, maintainability, up-time, and economics.

The cost of the meter can appear to the inexperienced owner as an unnecessary or trivial expense. Basic single point metering, however, can be as low as 1% of the project cost and provide significant ongoing and long term benefits to the owner and user, and engineers when planning for modification or upgrade of the gear. A very sophisticated meter specified for every breaker could increase the cost of distribution equipment 50%. The specifying engineer should therefore consider the true needs of the customer when selecting and specifying meters.

Establishing the fact that the meter is needed is the easy first step. Determining the number of meters required, the style and functionality of the meter and the interface for the meters is the next more difficult step. The meter should match the project sophistication and the customer's expectations and budget. If there is any doubt, the owner should be consulted before specification so that the meter selected meets their expectations.

Functions and Features:

Parameters: Most basic meters today monitor and display a variety of voltage, current, power and energy parameters. These can extend to over 50 parameters, which include a variety of min/max, line-to-line, line-to-neutral, demand and power factor values. Simple readings can show the owner the voltage level at his facility so that corrective actions can be taken when harmful low or high levels occur. The simple verification of voltage present in the equipment is fundamental for the safety of the technicians to determine if de-energization procedures were effective. An indication of voltage is also required before manual re-transfer to utility power from a generator after an operating cycle. The min/max values for the different parameters are extremely valuable to determine spare or future capacity within the equipment, as is Demand. The difference between min/max and Demand values is that min/max are instantaneous values, whereas Demand is a short term average. Demand values are either fixed or sliding window averages where the power usage for a set time period (anywhere from 15 min to 1 hour) is monitored over the entire billing cycle to determine the short-term power usage. The metered demand values are useful to verify utility billing, especially since demand charges can represent 50% of the bill. The power factor values reflect the ratio of real (KW) to total (KVA) power used and could help determine the need for power factor correction capacitors, the capacity, and whether the capacitors installed (if any) are functioning as required. Most basic meters monitor the three phases for voltage and current and calculate the neutral current. If true verification of the neutral circuit is required, its actual measurement must be specified because it cannot be assumed that the simplest meters can accomplish this task.

Advanced Parameters: The next level of enhanced meters usually referred to as 'power quality,' incorporate the memory and high speed monitoring capability to capture and analyze unusual system anomalies such as harmonics. Harmonics are higher frequencies (multiples of the fundamental 60HZ) which are imposed on the system by pulsing devices such as variable frequency drives, electric welders, or ballasts, and can cause significant system heating and overvoltage. Individual and three phase average harmonic values can be obtained for both voltage and current values. This data is crucial when attempting to resolve otherwise unexplainable overloading conditions and the failure of sensitive electronic equipment. Application guidelines for harmonics are addressed in IEEE-519 and the IEEE Emerald Book. Additional values that utilize harmonic data, which may typically be displayed, include crest factor, TIF and K factor.

Waveform capture capability can be an important feature, but if the meter is only equipped with a simple numerical display and the meter is not connected to a network computer or portable computer with analysis software, this feature is not needed. The highest-level meters include data logging capabilities and ability to manually and/or automatically capture triggered waveforms of surges, spikes, swells, sags, or any desired event and can provide a time-stamp of its occurrence for analysis after the event. The high-end features of a premium meter should definitely be considered for a sophisticated facility such as a data center or hospital. If the meter is a stand-alone unit, not connected to a monitoring system and in a facility without an on-site technician, these features could possibly never be utilized. The more sophisticated meters also incorporate a higher sampling rate and more onboard memory to store the collected data.

Sampling Rate: The sampling rate of the meter is the number of data points that the meter gathers within a cycle of the waveform to calculate the measured values. 16 samples per cycle is considered the minimum sampling rate to calculate RMS values. A meter used to monitor THD (Total Harmonic Distortion) should be capable of taking a minimum of 64 samples per cycle, while 256 samples per cycle are required for harmonic spectrum analysis. Meters with up to 512 samples per cycle are available for more intensive waveform analysis and CBEMA plots. The greater the sampling rate of the meter and the degree of on-board logging of the sampled data will dictate the amount of memory required for the meter.

Memory: Most meters utilize non-volatile memory for the storage of the setup parameters and historical data. If the end user is expecting the meter to continuously log data, or to capture waveforms after an event, then a greater amount of on-board memory is required. Historical logs can be set up to record data in intervals. A typical meter when set to record 8 values every 15 minutes will have a 58 day capacity with 512k of memory, but this can increase to 602 days with a 4 meg memory. Utilizing the same 15 minute interval, if the user decides to monitor all parameters typically available they will only have a 66 day capacity with the 4 Meg memory. Similar limitations exist for waveform recording. If a meter has limited memory, all parameters can be sampled for all inputs at 64 samples per cycle for 2 cycles, but if the sampling rate is increased to 256 samples per cycle, only a single parameter can be sampled for 1 cycle. Samplings rates are available to 512 samples per cycle for intensive analysis.

Display: The display is typically the first item to be noticed by the end user. The display should be bright and easy to read. It rarely matters whether the display utilizes plasma technology, LED, fluorescent or LCD panels, but it should be clearly visible where mounted in the equipment. There are meters available with numerical characters as small as 1/8" to larger than ½". Some displays will only indicate a single parameter while many will display three parameters simultaneously. Many high-end meters are available with large screens, which will even display waveforms. The higher the functionality of the display, the more room the meter requires in the face of the equipment and the higher the cost to the owner.

Accuracy: The accuracy is probably one of the most often specified features for a meter. The capability of the meter to display the measured parameter can range from 1% to better than .01%. The minimum accuracy required for revenue billing is generally considered 0.5%. If the meter is to be utilized for sub-billing or cost allocation, the 0.5% accuracy should be specified. Though the meter may have the capability for accurate measurements, the overall accuracy depends on the meter and the current transformers sending the signal. Meter grade instrument transformers should always be specified in lieu of relay grade to obtain the best accuracy possible.

Time: A clock within the meter is not an often specified item, but can provide useful information. If the meter is equipped with an internal clock and time-stamping capability, the time and day of minimum or maximum values or a triggered event can be known.

Interface:

Hardwire: Many meters are installed for stand-alone applications for local access of the data only. There is a growing trend to monitor this information remotely. In the by-gone days of electro-mechanical watt-hour meters (rotating disc) the only remote accessible interface was a pulsed output. The meter was mechanically geared to change the state of a set of contacts for each pre-determined amount of energy usage. This feature has been designed into many electronic meters in order to interface with existing BAS (building automation system) and demand control equipment to monitor energy usage. Another traditional method of monitoring values is from voltage or current transducers. The transducer converts the measured parameter to a scaled value typically between 4-20 mA, which is then monitored by another system, typically the BAS. This feature is still popular and is available on many electronic meters today with a typical of analog outputs which can be assigned to any measured parameter, with an output of either 4-20mA or 0-1mA being a standard offering. However, some meters have only a single analog output while others have as many as 8 or more, so it is important that the specification be clear on the project needs. Analog inputs are used to monitor external parameters by the meter, such as a temperature transducer, and then have the value displayed by the meter or networked to the power monitoring system. Relay outputs are useful for alarm conditions. These can typically be programmed to operate on a parameter limit and then be wired into a control or monitoring system for subsequent actions. The relay outputs on most modern meters can also be programmed to function as a pulsed output, described above.

Serial Communications: Serial communications are composed of two basic parameters, the hardware and the protocol. The design engineer should always specify an open protocol so that interface with third party systems is possible. If the protocol is proprietary, then the remote monitoring package can only be obtained from the vendor supplying the meter. The designer should always verify that a register map for the parameters is readily available from the vendor. The most popular open protocols for power management system serial interface are DNP and Modbus RTU on a RS-485 or Ethernet TCP/IP network. The speed of the transfer of data will vary from 19.2 kBaud for the Modbus networks to 115kBaud and faster with the Ethernet connection. Meters with an open protocol will be capable of being easily integrated into any network system, otherwise incompatibility and miscommunication will likely occur.

Many of the high-end meters which communicate on an Ethernet network can act as hubs for other meters which communicate on Modbus. This is an extremely useful feature when a lower end meter is desired for branch monitoring and a high-end meter is desired for main monitoring. Many of the high-end meters with Ethernet capability can also be assigned an IP address for direct web access and communications.

Modem interface is also available for many meters. These are typically 56kbaud modems for communication of data and alarms. Call-out features for notification of alarms via email or pagers are available for some advanced meters, and many meters with Ethernet capability have the ability to be addressed for remote access over the internet.

Front Panel Interface: The front panel interface can come in many forms, including RS-232 serial, infrared, or optical ports. The purpose of the front panel ports is to provide an easily accessible connection between the meter and a laptop for programming and setup. With some meters the port can also be used to download data for monitoring or logging. Many meters can be easily programmed from the front panel display, but most of the high-end meters require software to program the advanced features. The designer should consider the availability and cost of the software when selecting a meter. The software for some meters must be purchased, but other vendors make it readily available from their Internet site (example: http://www.geindustrial.com/multilin/software/index.htm).

Installation:

The actual installation of the meter should always be considered. The meter takes up space within the equipment. For most switchgear and switchboard applications, there is generally ample space for a meter to monitor the main device. However, if metering is required for each feeder breaker, then the designer should verify the space requirements with the equipment vendor to ensure that adequate area is available. The physical size of the meter can play a role in the overall equipment size though there are low impact options. For example, a number of small meters can be mounted in the same front panel space that a single high-end meter would occupy. Proper planning is required to make certain adequate space is available for the meter(s) specified.

Every meter mounted in electrical equipment will require CTs (current transformers) to drop the current to a level that can be monitored by the meter. Room for mounting the CTs is generally not an issue in large equipment such as switchboards or switchgear, but it becomes a major issue when the meters are added to panelboards or a general feeder location. A larger or additional enclosure is sometimes required to accommodate the CTs. Many meters and some applications require the use of VTs (voltage transformers) to reduce the measured voltage from a high level to 120V for monitoring by the meter. For switchboard or panelboard applications, the VTs are not required by equipment standards as they are for ANSI switchgear applications. For switchboard, panelboard or stand-alone applications, specifying a meter that will accept voltage inputs directly from the system (e.g.: 277/480V) can reduce the installed cost for the meter for many applications.

The communication interface is part of the installation. If the meter in the equipment is provided with a serial interface and is monitored by the meter vendor's software package, then the total responsibility for the installation is with the electrical contractor. If the meter is to be monitored by the BAS system, either through a hard-wired or software package the temperature control subcontractor will typically be involved, so care must be taken in preparation of the contract documents. The division of labor for the purchase and routing of communication cables and termination of the conductors must be clearly identified. There should be a clear point of execution, which includes the programming of the meters as well as the termination of the conductors within the electrical equipment. This will help ensure a smooth installation and minimize disagreements between the contractors during construction

Special Considerations:

Cost Allocation - Designs utilizing a meter on every circuit for cost allocation would only need to provide revenue accurate energy or demand values for monitoring. There are individual meters available that can monitor up to 12 single phase or 8 three-phase circuits. Using such devices reduces the cost of the metering equipment and the space required for mounting.

Setup Requirements – Today's electronic meters provide us with many enhancements unavailable in the past. However, these functions must be activated and set-up, including the internal clock. This requirement is often overlooked. To avoid underutilizing this important tool, the specifications should detail which function to activate, what their settings should be, and whose responsibility it is to program the meter.

Power Source – Most electronic meters are not self-powering. Most installations utilize a CPT (control power transformer) within the equipment for power. If the power is lost to the equipment, the meter will not function. If premium power quality meters are selected for a project, it would be desirable for them to capture critical data even during periods of system disturbance or voltage loss. In order to do so, a good source of reliable power such as a UPS (or battery system) is recommended. In this way the meter's monitoring capabilities are assured under all circumstances.

Conclusion:

There are many items to consider when selecting and specifying a meter. The most critical of these are outlined above and include in part: Determine the needs of the project and desires of the owner and user to most effectively satisfy their objectives; Clearly detail and focus these needs in the specification to stay on budget and within size limitations; Clearly specify the parameters which are required to be monitored by the meter and any special interface hardware required; Specify only open architecture protocols such as Modbus RTU to assure proper interfacing between components; Confirm the total accuracy and memory needs of the system in order to effectively accomplish billing and/or data gathering objectives of the project; Make the division of labor requirements clear for effective installation and communication needs; Specify an appropriate source of reliable control power for the meter in order to permit the meter's operation even under adverse operating conditions; Specify responsibility for programming and start-up of the meter. By following these considerations, the specifying engineer can feel confident that a system, which meets the owner's criteria, has been installed in the most cost effective method possible.

Additional meter product application information can be obtained at the following link: http://www.geindustrial.com/cwc/products?pnlid=5&id=epmfamily&catid=57