A Smart Power Measuring Sensor

by

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July 27, 1999

A sensor with an integrated microprocessor — a smart sensor — can simplify and thus reduce cost in installations for management of electrical power in buildings. Using a common bus, hundreds of smart sensors can communicate with a host computer over a simple twisted pair connection. The smart sensor takes advantage of the periodic nature of power waveforms and uses intelligent compression of voltage and current data to reduce the storage and bandwidth requirement for the host while retaining all significant information. No analog to digital conversion is required in the host. Galvanic isolation to 4000 volts is provided. Operating power is derived from the voltage being measured, but it can also be provided over the data bus.

Complex harmonic amplitudes are computed within each smart sensor for voltage and current. Corrections for temperature and phase shift are applied and the results are transmitted to the host. Transient amplitudes and waveforms can also be stored and reported. The storage time is limited by available memory within the smart sensors and the programmed time increment.

Each sensor is fully programmable by users. A unique identifier, communication, and calibration software are included in permanent memory. Other code is downloaded by the host computer over the data connections and can be completely rewritten in a matter of seconds.

Power measurement, true and reactive, is the usual request from users. A smart sensor used in a single phase system where the voltage connected is directly associated with the current passing through its hole can determine true power, reactive power in the fundamental, and harmonic power by itself. In more complex installations, e.g. three phase delta, sensors must work together using communication over the data path to calculate power.

All channels are amplified with programmable gain and digitized with an 8 bit converter. The combination of 8 bits of gain and 8 bits of digitized data can be thought of as a floating point number with one part in 256 resolution regardless of the amplitude. Each smart sensor has a low gain voltage channel which is digitized and can be compared to programmable thresholds for analysis of transients.

Sensors can have 8 or 32kBytes of memory which must hold downloaded software suitable for the task assigned. Any extra is available for storage of data, such as waveforms or history of energy usage. All memory is retained in the event of loss of power. When power is restored events leading up to the time of shutdown can be read out by the host.

This package is made possible due to the low dissipation Patented transducer technology incorporated in this product.

Specifications: All are preliminary and subject to change

Parameters measured:

- RMS AC volts and amperes
- Complex harmonic amplitudes to 31st or more with special software
- Power factor
- Energy consumption (watt-hours)
- Real (true) and Imaginary (reactive) power components
- Current or voltage waveforms sampled up to 20 kHz .
- Instantaneous peak voltage to 20 times full scale.
- Sensor temperature.

Accuracy:

- 5 percent of full scale without correction over the environmental range.
- Instrument errors corrected to 1 percent by software using stored calibration data and internal thermometer.
- Long term averaged data can be more precise.
- Resolution 0.5 percent of full scale.
- Measurements can be decimated for higher resolution in voltage or current at the expense of resolution in time.
- More precision and NIST traceability in specialized units.

Memory:

- Stored program downloaded by host will use some of the 32kBytes of random access storage:
- Remainder can be used to save measurements such as:
- Time history of power usage.
- Peak instantaneous voltage, current or power and its time of occurrence.
- Host must request and receive information stored in the instrument often enough to prevent overflow of local memory.
- Memory will survive loss of power and be available for readout when power is restored. Estimated retention is 10 years.

Communication:

- Two wire bi-directional bus uses radio frequency carrier with an RS485 protocol. Conversion to standard bus is by means of an inexpensive module which can support hundreds of sensors.
- Up to 100kBits/sec depending on distance and number of other instruments connected in parallel.
- Galvanically isolated from the mains to 4500 volts peak.
- Shielded twisted pair interconnects do not require termination.
- Smart Sensors are slaves, responding to requests from the host.
- Data transfer in decimal (ASCII) or binary depending on capability of the host and software in the sensor.
- Sensors can be reprogrammed over the bus for different tasks.
- Two light emitting diodes are provided on each sensor for maintenance. One indicates transmitter active, the other is programmable.

Descriptors produced by analysis in the host computer.

Harmonic content of the current or voltage as THD or individual values.

Long term monitoring of power usage.

Long term history of power quality including transients.

Comparison of measured to expected currents as an aid to early identification of failures such as in motor bearings.

Control of low priority power usage to minimize peak demand.

Identification of noise sources by time coincidence of transients.

Power requirement:

Derives operating power from voltage being measured. A few watts, No cooling required. As an option, power can be provided over the data bus.

Timing: Synch signal must be provided and can be derived from the data bus, the voltage being measured, or an independent source.

Environment:

The instrument is intended for installation in remote locations such as transformer cabinets and power distribution boxes.

Temperature: -40 to +80 degC

Humidity: 0-100% non-condensing.

Altitude: 25000 feet, limited by connection to high voltage terminals.

Magnetic fields: 200 gauss maximum DC field. Some sensitivity to incidental AC fields at power line frequency can be expected.

Sensors will meet FCC specifications for a class B device.

Package:

Potted module. 3 X 4.5 X .866 inches.

Accomodates current carrying conductors to 1 inch diameter.

Connections fully insulated for installation with wire nuts or other standard "in the power box" techniques.

Voltage measurement by safety leads of fused resistance wire connected to the distribution terminals. No other breaker or fuse is required, wires are factory replaceable.

Current measurement by inductive coupling to the insulated current carrying conductor.

Blind tapped holes provided for mounting when support cannot be provided by the current carrying conductor.