Want more longer-term data for multiple users from less equipment? The benefits are big. The payback is real.

In the never-ending drive to get more from less, electric utility engineers are continually looking for ways to obtain more information from fewer pieces of equipment. To support those needs, innovative vendors are providing utilities and electric power users with devices that have greater capabilities at lower cost than earlier generation equipment. Transient recorders are one way manufacturers have expanded functionality well beyond simple electronic oscillographs.

As shown in Fig. 1 , in addition to traditional sinusoid recording (for seconds of data), modern transient recorders provide long-term recording for power swings (for several minutes), continuous recording of minimal resolution of data (for days) power quality data, steady-state loggers (for weeks or months), power quality data, fault location and information for scheduling breaker maintenance.

Sinusoid data has been used for years as a tool for verifying the operation of the overall protection scheme from the PTs, CTs and relay to the breakers and carrier signals. Providing details on faults not only enables the protection engineers to detect faulty settings, relay algorithm problems, failed hardware and other issues to minimize time to investigate problems but also provide documented data for legal and regulatory requirements.

Demand for more data

Since the widespread power outages in the western United States in the midto-late-1990s, and, more recently, the August 2003 blackout in the Northeast, there has been an intense focus on the need for longer-term data. This has been reinforced with new requirements from NERC that calls for Dynamic Disturbance Recorders (DDRs) at select locations on the power system.

Since recording sinusoid data for multiple minutes would create files >10Mbytes, a method was needed to store power system data at reasonable speeds without sacrificing the information available from the data. Some systems limit the number of channels or calculated values that are stored for disturbance records. An excellent balance, however,

can be obtained by storing subcycle phasor data on every channel along with RMS (or DC for appropriate signals) and a frequency channel. By storing triggered data at a 100 or 120Hz rate, slower phenomena such as power and frequency swings in the 0.3–15Hz oscillation range, out-of-step conditions, generator start up and other slower, longer-term problems can be diagnosed.

This type of information also can be useful in analyzing issues associated with large motor starts and other large load changes. Moreover, it can be very useful at generating plants where problems can take several minutes to grow to the point of causing a plant trip or other serious issue. Recording a disturbance record with the faster transient record is a good compromise for less powerful systems. But, to get the most out of such recorders, it is best to have dedicated triggers that focus on these slower phenomena. By offering triggers over a variety of bands with dedicated time constants, the system is able to differentiate between a real problem and the normal oscillations that occur every day.

The more advanced systems also take this a step further by storing the phasor data at a 25- or 30-Hz data rate continuously. This provides lower resolution data for distant faults that don't trigger recorders or where triggers were misapplied. One possible drawback to this is the volume of memory needed at the recorder. In a 32-analog channel system, storing the RMS, phasor magnitude and angle and two frequency values requires 6Gb of storage for two weeks' worth of data. This is easily accomplished using modern hard drives integral to the recorder. However, streaming this type of data to an external device requires a dedicated, reliable communication link that typically cannot be used for other systems without compromising this primary function.

Expanding capabilities

Another function available in the new generation of recorders allows them to be used as circular chart recorder replacements. Most substations had the old pen-based circular recorders that required monthly paper replacement and annual pen replacement. Typically, these provided a 15-minute average value of bus voltages for regulatory compliance requirements, were very labor intensive and of little value beyond steady-state values.

Newer systems are able to compute and store RMS values for not only the bus voltages, but the line currents, too. With the large capacity memories available now, storing 52 weeks of a 1-minute minimum, maximum and average value is a simple process. This provides superior resolution, more details beyond just steady-state values (max and

min), and files can be analyzed via computer programs to compute the total time the system is operating within prescribed limits such as EN 61000-4-30.

In addition to computing steady-state RMS levels, the system frequency also can be recorded in the same type of long-term steady-state format. This can be used to replace strip chart recorders in control rooms at generating plants or control centers. Additionally, this information (frequency, Irms, Vrms, digital input status) is available on communication ports in industrystandard protocols such as DNP, reducing or eliminating the need for RTUs at some locations.

The new systems even provide the capability to create and use phase groups and line groups to compute a variety of parameters internal to the recorder. From phase groups, positive, zero and negative sequence values are computed, and voltage unbalance obtained. Combining a current phase group and a voltage phase group then provides the capability to compute Watts, VARs, Volt- Amps and power factor. These values are then used for triggering and logging steady-state values. This provides an overall measure of system loading and capacity for growth.

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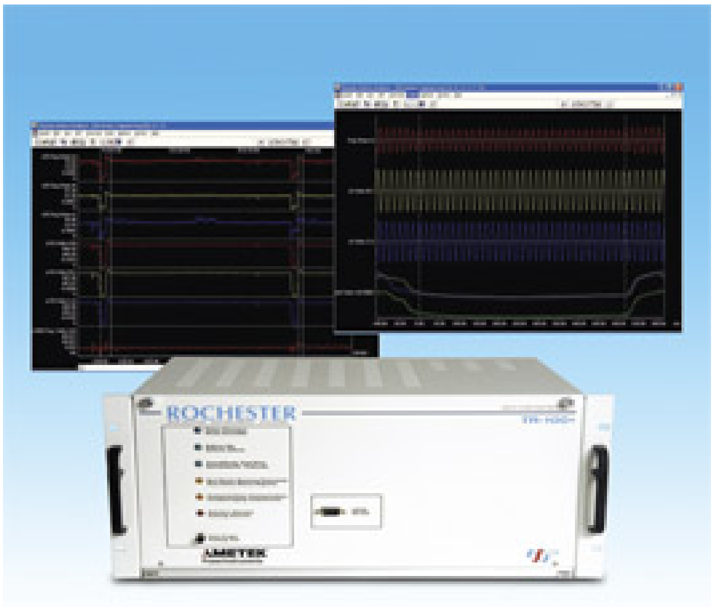
Driving forces
Over the past 15 years, there has been an explosion in the use of switch-mode power supplies in everything from PC and consumer electronics to PLCs and other types of industrial controllers. These, along with adjustable speed drives and many other devices, are creating an amount of harmonic pollution on the power system never before seen. To counter this problem, IEEE and EN have implemented limits on harmonic magnitudes at the point of common coupling (PCC). Some countries have taken this a step further and placed regulatory limits on harmonics at different voltage levels. Consequently, utilities need to know the level of harmonics present on the power system and where they are coming from.

“Flicker” is another phenomenon that has resurfaced after many decades of limited concern. This term originated from the way incandescent lights would “flicker” in

intensity due to a modulation in the magnitude of the voltage. Human perception of flicker possibly could lead to headaches, reduced productivity and other personnel problems.

Caused by rapidly fluctuating loads, flicker is measured as an instantaneous, perceived short-term (Pst) and perceived long-term value (Plt). The Pst is a 10- minute value and the Pst is a 120-minute value that can be calculated from the Pst. As with other parameters noted above, some advanced fault recorders have the ability to compute and store a flicker value. Most use the IEC definition, which is based on 230V/50Hz and then interpolate the data to 115V/60Hz if necessary. Typically storing this on one set of voltages at a location is sufficient since this will propagate through transformers and affect an entire location.

Voltage unbalance is another parameter that can be computed and stored by advanced transient data recorders. Two different parameters can be calculated and stored—negative sequence unbalance and zero sequence unbalance. As the name would indicate, these are the ratio of the negative or zero sequence voltages to the positive sequence voltage measured as a percent (or fraction). These are excellent measures of the overall efficiency of the power system. Too high a value and there will be too many losses, costing the utility or consumer money.



Extended data reach
As with many IEDs in a substation, the modern oscillograph is monitoring a variety of signals that can be used for several different applications. An example of extending the digital transient recorder data to newer applications is breaker maintenance scheduling.

By monitoring all 3-phase currents through the breaker and the A or B contact on the breaker, three critical parameters can be tracked in a database—total number of operations, duty and total current. Additionally, data can be presented to maintenance personnel showing the duration of fault current for each individual operation. This capability clearly can flag a problem, if there is fault current present for a longer time on 1 or 2 phases, indicating a stuck pole (or an evolving fault). By using an additional analog channel, the trip coil current also can be monitored for every operation. This gives an excellent indication of the travel-curve and acceleration within the breaker so deteriorating trends in the mechanical portion of the breaker can be acted upon before a catastrophic failure occurs.

Most utilities have used some form of fault location tied to the data from their oscillographs. Early methods consisted of using the current and voltage magnitudes from the recorded data and correlating those numbers to specific locations from their fault studies. The new systems provide distance-to-fault data automatically. By using line models and impedance-based algorithms, an actual fault resistance is calculated and distance computed. Now, without ever having to look at waveforms, this distance value can be obtained by the personnel who need it, but who may not be experts in analyzing oscillographs.

Enhancing competitiveness

In this era of deregulation, re-regulation and competition, having a variety of data collected for different reports is critical to efficiently operate the overall T&D system to attract and keep customers. By tracking voltage dips and surges over time, it is possible to identify circuits to invest in to improve performance and to show a before-and-after quality. One of the newest applications for power system data is recording or transmitting Synchrophasor data. This consists of using the 3-phase voltages and computing and precisely time-tagging the positive sequence phasor data. Using this data over a wide area, utilities are able to detect instabilities before they become a serious problem.

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In conjunction with the Synchrophasor capability, the system must have the ability to accurately time tag this data to better than 30µsec. However, to decrease error due to

time tagging, it is better to minimize this. The more advanced systems have time-synchronization accuracy in the range of 50–100 nanoseconds.

Independent of the Synchrophasor capability, the need to analyze data from a wide geographic area—as witnessed by the Northeast blackout—it is critical that all recording and reporting devices be synchronized. This requires some source of UTC (Coordinated Universal Time) for all these distributed devices. Most common today is the GPS clock. These clocks typically output an IRIGB or a pulse-per-second signal. With this technology, it is easy to ensure that all devices are synchronized to +/-1msec. Additional considerations are UTC, local time and daylight savings time. With the merger of utilities there are many systems that now span several time zones and it is best to keep all devices on the same time. Using UTC (formerly GMT) is an easy way to do this, but isn't instantly intuitive to operators and other personnel as they look at the time tags. Typical practice at most utilities has been to settle on leaving all devices on standard time—no adjustments for daylight savings time—and if across multiple time zones, they will choose one and keep it there.

For unmanned substations, the need for panel meters has been minimized. By taking advantage of the new technology in fault recorders and many other IEDs, they can be completely eliminated. With a laptop or PC, any analog input and many computed values can be displayed in real time either locally in the substation or remotely via modem or TCP/IP. RMS current and voltage, Watts, VARs and Volt-Amps and THD are just some of these parameters.

Not only do modern transient recorders communicate to vendor-specific software for traditional date transfers, they now can interface to SCADA systems using DNP3.0 or other standard protocols. Once again, this saves on space, equipment, installation and wiring costs, not to mention engineering and drafting time when designing a new substation. With such a powerful interface, analog values, digital status and frequency magnitudes are available in real time, eliminating the need for analog transducers and reducing channel counts on the RTU.

Capture the benefits

When all is said and done, a modern transient recorder not only complies with the latest requirements from NERC, it also provides data for a variety of functions that, in the past, were generally available only with discrete devices. For example, sales and marketing organizations can benefit from power quality and historical data to provide high levels of customer service and attract new businesses. Maintenance departments can use the

data for optimizing breaker maintenance schedules, tree trimming or line upgrades and other regular tasks. Protection and relay engineers can use the traditional oscillograms to analyze faults and verify operations and line models, and use the newer disturbance data for stability analysis. Planning can use the data for load growth and equipment sizing. Additionally, the system can be an interface for SCADA personnel.

In summary, a modern transient recorder is a valuable tool that can replace several discrete devices. Its advanced support software provides answers, not just raw data. These systems, when tied to expert systems, provide a quick summary of all faults detailing the faulted circuit and phase(s), magnitude and duration of fault and what protection equipment operated. Location of faults, voltage quality information and data for optimally scheduling breaker maintenance are additional types of answers that are giving utility engineers more for less.

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