Guideline for Time Synchronization of Protection, Control and Monitoring

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GUIDELINE FOR TIME SYNCHRONIZATION OF PROTECTION, CONTROL AND MONITORING

June 6, 2006

Introduction

This guideline applies to protection, control and monitoring devices and systems at all transmission stations 100kV and above, at associated generating units 30MVA and above and at control centers. The goal is to provide one millisecond time synchronization for power system disturbance and event analysis for all major stations in the WECC.

This guideline complies with Recommendation 12 of the 'August 14, 2003 Blackout: NERC Actions to Prevent and Mitigate the Impacts of Future Cascading Blackouts'[1]

Power system disturbance analysis requires accurate time tagging (synonymous with time stamping) of power system quantities and events. Modern digital devices such as digital fault recorders, digital protective relays, event recorders, dynamic disturbance (power swing) monitors and SCADA (supervisory control and data acquisition) systems typically contain internal real-time clocks for time tagging recorded data. Many of these devices are capable of receiving an external time code for synchronizing their internal clocks to a common source providing a practical time synchronization method. Properly time-synchronized data facilitates the identification and understanding of the sequence of events prior to, during and after the disturbance and is particularly valuable when analyzing data supplied from neighboring utilities for wide area disturbances.

The preferred method to obtain synchronization of digital substation, generation and control center devices is to use a time dissemination system that is traceable to a recognized standard such as the one maintained by the U.S. National Institute of Standards and Technology (NIST). By obtaining a suitable time code receiver, the user can receive the time signals traceable to the NIST standard free of charge. Global Positioning System (GPS) precise time code receivers provide this traceable standard and can now facilitate an economical implementation of one millisecond resolution time tagging on a station by station basis throughout the WECC.

[1] ftp://www.nerc.com/pub/sys/all_updl/docs/blackout/BOARD_APPROVED_BLACKOUT_RECOMMENDATIONS_021004.pdf

Global Positioning System

The Global Positioning System (GPS) is a constellation of 24 or more earth orbiting satellites that provide a world-wide radio-navigation signal. GPS signals are derived from atomic frequency standards on board each satellite which are traceable to NIST. These signals are widely used as a reference for time synchronization and frequency calibration. GPS provides exceptional timing accuracy and exceeds the time synchronization requirements for electric system station devices.

The GPS system is operated by the U.S. military but the signal can be obtained without charge using a GPS receiver. The GPS signal is capable of being intentionally degraded in a process called Selective Availability (SA). However, on May 2, 2000 the US Military deactivated SA and now most GPS timing receivers can produce a time reference with a standard deviation of 10 nanoseconds or less.

For general station time synchronization applications requiring one millisecond accuracy, the GPS system exceeds the requirements. In addition, GPS can also meet the requirements for specialized real-time measuring systems such as dynamic disturbance monitors using synchronized phasor measurements where the time accuracy required is better than 50 microseconds.

Power System Disturbance Analysis and SCADA

The majority of power system disturbance analysis to confirm the correct operation of protective relaying systems and associated station equipment is provided by station based devices such as digital fault recorders, digital protective relays and event recorders. For special cases, such as wide area disturbances, where information is not adequately available from station based devices, SCADA system data records will need to be analyzed. This creates the requirement for applying a GPS receiver input into the master SCADA computer to provide time tagging of station sequence of events. However, many existing station supervisory control systems do not accept precise time inputs for event recording except those with the most modern RTUs (remote terminal units). As such, SCADA master event recording will have inaccurate time tagging of events due to the polling interval required for the controlled stations. As modern RTUs and SCADA systems are installed, SCADA master event recording will improve in accuracy. This guideline is not meant to directly drive the upgrade of RTUs but should be considered to include time synchronization as part of any RTU modernization strategy. Similarly, this guideline is not meant to directly drive the upgrade of master SCADA systems. It is meant only to utilize GPS time synchronization into existing master SCADA systems to the degree that its incorporation incrementally improves sequence of events recording. As SCADA systems are modernized, it is expected that one millisecond event time capture from RTUs will be incorporated.

Operation in Electric System Stations

GPS receivers designed for operation in electric system stations are available from a number of manufacturers. These devices should be confirmed to be hardened against the electrical surges normally found in this environment.

A station alarm should be provided for any failure of the GPS receiver to maintain the required time synchronization.

UTC Time Standard and Local Time

The GPS time code receiver must be equipped with and selected to receive the Universal Coordinated Time (UTC) standard with automatic leap second corrections. Use of a local time zone hour offset in order to establish Pacific Standard Time or Mountain Standard Time as a local reference, as well as the application of a Daylight Saving Time adjustment, is left to the discretion of the individual utility since for disturbance analysis it is the minutes, seconds and milliseconds which are of greatest importance.

The IRIG-B Time Code Format

Various data formats exist for encoding the timing information for use as input to electronic devices. For the electric utility industry, the universally adopted data format for externally synchronizing substation devices is the IRIG-B time code. IRIG stands for Inter-Range Instrumentation Group. This standard is maintained by the Range Commanders Council
(RCC) which is a U.S. military organization serving the technical and operational needs of
U.S. test, training, and operational ranges.

The IRIG-B time code format provides day, month, hour, and second information to a resolution of one millisecond. The time code is repeated every second and can be amplitude modulated onto a 1 kHz carrier. More information on the IRIG-B time code format can be obtained from the RCC website at: http://jcs.mil/RCC/.

Distribution of Timing Signals in Electric System Stations

The IRIG-B time code signal can be transmitted as digital level-shift pulses or amplitude modulated onto a 1 Khz carrier. Unfortunately, there are no fully defined standards for the electrical specification of the signal or the mechanical interconnections. Unmodulated IRIG-B pulses are typically TTL logic level signals and modulated analog IRIG-B signals commonly span an amplitude range of 1Vp-p to 10Vp-p.

The IRIG-B transmitter/receivers are commonly interconnected using shielded twisted pair for the unmodulated signals and using coaxial cable terminated using BNC-type connectors with 600ohms impedance for the modulated signal.
The IRIG-B time code format does not include any error-checking capabilities. The integrity of the time transfer is dependent on internal error-handling algorithms of the receiving unit. It is important, therefore, to ensure that the signal is not compromised or degraded when distributed within the station.

Optical distribution of the signal is the preferred choice for ensuring signal integrity and is recommended whenever the signal must be transmitted between different control buildings within a station. Within the same building or control room, optical distribution is recommended whenever the signal is transmitted over distances greater than 15m (50ft) which, as a rule of thumb, is typically the maximum length for metallic inter-instrument laboratory signal cabling.

Proprietary time distribution systems exist which include cabling, termination and data format definitions but they are used specifically to interconnect devices from the same manufacturer. Precise time distribution between receivers and devices of different manufacturers will require more thorough review of interface requirements.

Intra-Utility and Inter-Utility Time Synchronization and Accuracy Confirmation

The preferred time synchronization method throughout the WECC is a dedicated GPS receiver for each applicable station.

Previous methods of using a central time source along with re-transmission to stations using telecommunications is no longer recommended due to the added inaccuracies in measuring propagation delays.

Routine investigations of transmission line faults within utilities and on inter-utility inter-tie paths should be used to confirm the accuracy of overall time synchronization at the connected stations.

Summary

The importance of providing time information on records of power system disturbances is generally recognized. Equally important is the ability to relate the time on any one recording device to the time on other recording devices from within a system and with those of neighboring systems. For this reason, it is the goal of the WECC to have time synchronization of power system disturbance data at control centers, major bulk power substations, and generating plants. Time synchronization should be provided to one millisecond accuracy at all times across a single utility and given a common GPS source this will provide one millisecond accuracy across the WECC.

The time source used must be traceable to the NIST standard and receive UTC with automatic leap second corrections to assure a common time source throughout WECC. Local time zone offsets for Pacific Standard Time or Mountain Standard Time or adjustments for Daylight Saving Time may be applied at the discretion of the utility.

The Global Positioning System is the recommended source for obtaining a time reference. It is exceptionally accurate, traceable to the NIST standard, receives UTC and is cost effective.

This guideline complies with Recommendation 12 of the 'August 14, 2003 Blackout: NERC Actions to Prevent and Mitigate the Impacts of Future Cascading Blackouts'[1]

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