NERC PRC-002 Compliance Statement

Introduction

The NERC Reliability Standard PRC-018-1, *Disturbance Monitoring Equipment Installation and Data Reporting* is being retired due to its consolidation with Reliability Standard PRC-002-2, *Define Regional Disturbance Monitoring and Reporting Requirements*.

In accordance with Requirement R10 of NERC Standard PRC-002-2, utilities are required to maintain time accuracy of less than $\pm$ 2 milliseconds in all Disturbance Monitoring equipment (DME). Furthermore, as required in PRC-002-2, this time shall be in Coordinated Universal Time (UTC) format.

GNSS Clocks manufactured by Arbiter Systems, Inc. provide UTC time in accordance with this requirement. The accuracy of clock timecode outputs (IRIG-B, 1 PPS, and NTP) varies by model and choice of timecode, but always exceeds NERC requirements.

Unmodulated IRIG-B Time Code

Accuracy of the IRIG-B unmodulated or level shift format time code is identical to the specified accuracy of the 1PPS output of the same clock model. Generally, performance exceeds the product's specification by a significant margin. The 1PPS and IRIG-B unmodulated signals are generated internally using very similar hardware, and differ in accuracy only by slight variations in propagation delay. These are always less than $\pm$ 100 nanoseconds, and are generally a few tens of nanoseconds or less (output-to-output skew).

IED performance cannot be guaranteed by Arbiter; however as a guideline, well-implemented IEDs should be able to synchronize to the applied IRIG-B (or 1 PPS) signal to $\pm$ 100 nanoseconds or better. Typical IED IRIG inputs include an optocoupler, noise filtering, and Schmitt trigger. These components introduce a small fixed delay, which is easily compensated for in IED design. Even uncompensated, these delays should be no more than a few microseconds, and are inconsequential with respect to the requirements of PRC-002-2.

Modulated IRIG-B Time Code

Modulated IRIG-B is an audio band signal (300 Hz - 3 kHz), and while we generate this time code using accurate direct digital synthesis methods, it is impractical to measure the performance of this signal with an accuracy much better than $\pm$ 10 microseconds. This is because the slew rate of the signal is limited (a 1 kHz sine wave), and the location of the zero-crossing is quite challenging to determine with great precision. This is complicated by the fact that the on-time mark of the IRIG-B modulated signal is located at an inflection point in the signal, where the magnitude of the 1 kHz sine wave is changing from "space" or 30% of reference amplitude, to "mark" or 100% reference amplitude.

Likewise, IEDs using the modulated IRIG time code cannot determine the on-time mark with accuracy better than $\pm$ 10 microseconds, and in fact, performance of 50 to 100 microseconds is a reasonable expectation (see, for example, the above-referenced NERC CIPC Security Guideline, page 3.) However, this level of performance easily meets the requirements of PRC-002-2.

NTP Network Time Protocol

Some newer IEDs use NTP to synchronize to a master time source. Arbiter provides NTP time server options for this purpose. Performance of NTP implementations varies across the map depending on the care taken in the design of the NTP drivers. Historically, NTP has been viewed as a time transfer method with best accuracy of $\pm$ 1 millsecond to $\pm$ 10 milliseconds. However, this has recently been shown to be pessimistic. For example, Bruce Muschlitz of EnerNex Consulting presented a paper at the IEEE PES general meeting [ca. 2007], demonstrating time transfer between two garden-variety PCs running Microsoft Windows, to less than $\pm$ 10 microseconds. His implementation was highly optimized, but it did not use any custom drivers or other kernel-level modifications. All software used standard Windows API calls.

Arbiter's current NTP implementation, used with well-optimized NTP implementation in an IED, can easily synchronize the IED's internal clock to within $\pm$ 500 microseconds of UTC or better. This includes the effect of packet delays experienced in a typical substation network, such as store-and-forward delays and delays caused by network traffic. This performance meets the requirements of PRC-002-2.

UTC Time Scale

NERC's requirement that event data be time stamped in UTC time (PRC-002-2 R10) means that the IRIG outputs of all GNSS clocks, driving DME covered by PRC-002-2, should be operated in the UTC mode rather than local time zone mode. Alternatively, NERC might accept use of the IEEE Standard C37.118 extensions to the IRIG time code, which include the current local offset, and from which UTC time can be determined. However it is done, compliance with this NERC requirement implies that event records (COMTRADE files, for instance) should be time-tagged using UTC time, not local time.

Note that this requirement does not preclude local system operators from displaying or viewing event data using local time zones. COMTRADE viewers and other data presentation-layer tools can convert from UTC to local time, if desired. Our understanding of NERC's requirements is that all data, at the data management layer (i.e all data transmitted over a communications link, or stored in an electronic file format), should be in UTC time scale.

Arbiter's GNSS clocks automatically convert the time received from the GNS system (in "GNSS time scale") to UTC time, using data broadcast by the GNSS system. This data includes the current offset between UTC and GNSS time, and information about pending leap seconds. All GNSS clock outputs (when set to UTC, rather than local time) are compliant with the requirements of PRC-002-2 for UTC.

Cable Delays

In some installations, cable delays may affect performance. Time code signals, like any electrical signal, are delayed by passage through any transmission medium. In most installations, these delays are inconsequential when compared to the requirements of PRC-002-2. Specifically, typical media (coaxial cable, shielded twisted pairs, and fiber) have a delay of about 5 nanoseconds per meter (1.5 nanoseconds per foot).

If you are concerned about these delays, you should also be concerned about the delays in the wiring between the ITs in the yard and the IED electrical inputs. Since these runs are normally longer (than connections between the GNSS clock and IED), they will contribute more delay. However, even a 300-meter (or 1000-foot) run will only contribute a delay of about 1.5 microseconds - more than 1000 times less than the PRC-002-2 requirement.

IED Performance

Performance described in this document is guaranteed only for Arbiter's products. In particular, IED performance is the responsibility of the IED vendor. While we believe that modern IEDs will in most cases meet the requirements of PRC-002-2 when used with Arbiter's GNSS clocks, this must be verified with each IED maker. Each should be able to provide a statement regarding the performance of their products relative to the accuracy of the supplied time code signal, so that the performance of the two devices can be added together to demonstrate overall compliance with PRC-002-2.

Certification

A signed version of this document, on company letterhead, is available on request.

The statements in this document apply to current production versions of Arbiter's products, or any Arbiter GNSS clock (whenever manufactured), equipped with current firmware revisions.

Signed:

Signatory: Bruce H. Roeder, Chief Operating Officer