Synchronizing End-to-End Relay Testing with the Model 1088B Satellite-Controlled Clock

Utility company engineers and managers are challenged to provide ever-increasing utilization of existing transmission lines. End-to-end relay testing, which tests a complete protection subsystem, including relays at different locations plus the communications link between them, is now practical with the advent of economical GPS clocks. The Arbiter Systems®, Inc. Model 1088B GPS Satellite-Controlled Clock provides the features needed to synchronize end-to-end relay tests.

Methods of Synchronization

At this time, end-to-end relay test sets are synchronized by one of two methods: (a) a trigger pulse, or (b) an internal trigger generated from a one pulse-per-second (1PPS) reference and a timecode such as IRIG-B or RS-232. The Model 1088B supports both methods.

Programmable Pulse Output

User-specified trigger pulses are generated using the Programmable Pulse output of the Model 1088B. This output is set to generate a pulse corresponding to a pre-entered time mark. The time mark may be either UTC or local time, and the trigger may be generated daily with a 24-hour period, or once, on a specified day. The resolution of the trigger command is 0.01 second. Accuracy is the same as for the 1 PPS output. This output may also be set to output a pulse at intervals of seconds (to 60,000) or minutes (to 1000). Pulse width is also selectable from 10 ms to 600 s.

One Pulse-Per-Second Output

The 1 PPS output is generated accurately, on-time, every second. When using this output for synchronization, some method must be provided to overcome the onesecond ambiguity of the 1 PPS signal. In other words, a means must be provided to identify the particular 1PPS pulse which is needed to trigger the test. This is generally provided with either IRIG-B or RS-232 signals. Either one of these signals provide a complete time message which identifies the time of occurence of each 1PPS pulse. All of these signals are standard in the Model 1088B.

Trigger and 1PPS Accuracy

The timing of the trigger output, relative to the 1PPS output, is guaranteed to be within 50 nS of the exact time specified (typically, within 5 nS). Including all offsets in the Model 1088B plus potential errors caused by USA Department of Defense-imposed Selective Availability (SA), which degrades accuracy, the timing error of two pulses, generated by two different clocks at different locations, in the position-hold mode, will be less than 200 ns with 99.99% confidence. This is true for all timecode outputs from the Model 1088B, that is, if one location is synchronized using 1 PPS and IRIG-B, and another is synchronized with the trigger output, or for any other combination, the total error will be less than 200 nS 99.99% of the time. The primary source of error is the presence of SA; this error is reduced substantially by using the position-hold mode. Without position hold, the error between two locations will still be less than 500 nS 99.5% of the time. The preceding statements about timing error are also true if an intentional offset is added to the trigger output. For example, if the trigger time is set to have a fractional seconds value of 0.56 second, the trigger output will occur exactly 560 milliseconds after the 1 PPS rising edge, plus or minus 50 nanoseconds. The error from 560 milliseconds, compared to a second clock, will still be less than 200 nanoseconds 99.99% of the time. For more detailed information about the accuracy of the Model 1088B GPS Satellite-Controlled Clock, refer to Application Note 108, "Timing Performance of the Model 1088B GPS Satellite-Controlled Clock."

Other Possibilities

It is possible to accurately trigger an event such as a relay test using the unmodulated (logic-level) IRIG-B output of the Model 1088B. While not all sources of unmodulated IRIG-B are particularly accurate, this signal is generated in the Model 1088B/BP with accuracy of 50 nS (5 nS typical), relative to the 1 PPS output. In addition to being a complete timecode in one signal, unmodulated IRIG-B provides accurate (+5 nS typical) on-time transitions every ten milliseconds. Because of the timing message content of this signal, each one of these transitions can be easily identified and an exact time assigned to it. We are not now aware of any end-to-end test sets which use this input signal to provide accurate timing. However, because of the excellent potential of this signal for end-to-end testing, we are providing this information and recommendation.