Application Note

Substation Automation and Protection Division

Time Synchronization Using ABB Relays

ABSTRACT: *ABB Relays offer unparalleled storage capabilities. The DPU/TPU/GPU 2000R IED's, as a stand alone device can archive and store up to 254 Events, 32 Faults, and numerous Oscillographic Records without any intermediate storage or conversion devices. The DPU/TPU/GPU 2000R also has SCADA protocols such as Modbus, DNP 3.0, and UCA as communication options. One common requirement of any archival system is the timestamp associated with each of the stored data elements. Within this document, the ABB method of ensuring the accurate timestamp of an event occurs independently of the SCADA protocol installed within the system. ABB has used the strengths of the protocol and the IED design to allow the maximum flexibility in selection of a time clock synchronization method regardless of the protocol selected in the IED. This paper will explain the Time Synchronization methods for the DPU/TPU/GPU IED's using Modbus or DNP 3.0 protocols.*

TIME SYNCRONIZATION METHODS

Inside of the ABB DPU/TPU/GPU 2000R is an internal time clock. The internal clock can operate be enabled or disabled for operation. As with any clock, there is a certain capability by which the clock may keep a timing accuracy. Some protocols such as DNP 3.0 and Ethernet Based SNTP (Simple network Time Protocol) have mechanisms within the protocol to synchronize the clock and keep it accurate to a certain accuracy. The protocol itself has the ability to send commands and re-synchronize the clock so that each attached IED using its synchronization capability on the network is accurate within a certain resolution (usually within an accuracy of +- milliseconds or tens of milliseconds) depending upon the protocol and the hardware design employed by the manufacturer of the IED.

Other protocols, such as Modbus do not have a time synchronization mechanism built into the protocol (such as Modbus or UCA). The manufacturer may or may not provide a mechanism for synchronization of the clocks for each IED on the network using that protocol. For Modbus protocol, some manufacturers use an external time synchronization technique to keep the internal IED clock in synch such as IRIG B or GPS), and then the protocol can imbed the time as part of response when querying the IED for the event. For UCA protocol, some manufactures use an external timing mechanism (such as IRIG B or SNTP).

As a general rule, using a dedicated synchronization channel (such as IRIG B) allows for greater accuracy of synchronization between IED's than if synchronization is performed using general protocol related synchronization techniques. This is due to the dedicated channel being deterministic in its update of each attached IED clock. When a communication channel is used to provide time synchronication, other factors such as network traffic, IED processing times, and host generation of time string generation to send to IED's can vary widely for each communication packet that the variance for the synchronization processing may be great for each IED.

Within this paper, only DNP 3.0 and Modbus time synchronization will be explained since to this date, the vast majority of IED's use these protocols and require accurate synchronization of clocks throughout the network.

DNP 3.0 TIME SYNCHRONIZATION

Within the DPU/TPU 2000R, three methods of time synchronization are possible:

1. No Time Synchronization
2. DNP 3.0 Protocol Time Synchronization
3. IRIG B Time Synchronization

Within the DPU/TPU, there is a time clock, which may be enabled or disabled. If the clock is disabled, then the relay will not time stamp each event in the relay. If the clock is enabled, then the user may select synchronization using the protocol or an external time source such as IRIG B.

Within DNP 3.0, one may configure the device to accept Time Synchronization via IRIG B or via the protocol. DNP 3.0 has specific objects (Range 50 through 59) allowing for Time Synchronization. Following the procedure compliant with the "Distributed Network Protocol DNP 3.0 Basic 4 Document Set 994-0007 Rev 0.3" manual and excepted from the ABB DPU 2000R Automation Guide, the procedure for Time Synchronization is as follows.

"Although, required for a Level 2 implementation, the DPU 2000 and DPU 2000R allow for Time Synchronization via the DNP 3.0 communication network. Time Synchronization must be enabled if the value in Parameter 9 is other than 0. The procedure for Time Synchronization is covered in the DNP Texts referenced within this document. The procedure to perform time synchronization is included here for the benefit of the reader.

1. The Master station sends a Delay Measurement Response request to the relay (Object 52 Variant 1 or 2 in reference to fine or coarse time). The Master records the time of the transmission of the first bit of the first byte of the request.
2. The relay receives the first bit of the first byte of the Delay Measurement Request at the time the RTU RECEIVE TIME (the local time in the relay).
3. The relay transmits the first bit of the first byte of the response to the Delay Measurement request at time RTU SEND TIME. The response contains the fine or coarse (as defined by Variant 1 or 2 of Object 52 as defined in the DNP 3.0 specification) TIME DELAY object, with the time in this object equal to the "turn around time [time of send/receive and relay response] of the host communicating to the relay.
4. The Master Station receives the first bit of the first byte of the relay's response at the time the Master Receive Time is recorded by the host as the response input.
5. The Master Station can now calculate the one way propagation delay

   delay = (Master Send Time - Master Receive Time - "turn around time")/2
6. The master now transmits the first bit of the first byte of a WRITE COMMAND at time of send. The Write request contains the calculated value of the actual host time plus the calculated delay time. This is the time the relay will be set to including delay. The Write command shall be Object 50 variant 2 as defined by the DNP 3.0 protocol.

   When the relay receives the time synchronize write command, the relay is Synchronized.

According to the specification of DNP 3.0, if all delay times for all devices receiving commands on the network are the same, the host may send a broadcast command which is address FFFF hexadecimal"

Additionally, The DPU 2000R may be parameterized to request Time Synchronization via the protocol's IIN bits. The parameter may be set to request "NEED TIME" in one minute increments from a value of 1 to 255 minutes. Without any parameterization, the relay requests time synchronization every 60 minutes.
The DPU/TPU also may be configured to accept time synchronization using IRIG B. Each card has a two wire Unmodulated (0XX Format) input in which a time synchronization signal is received. The input is fully compliant with the IRIG B standard and is accurate to 1 mS.
Figure 1 illustrates the connection of the source to the DPU/TPU. Figure 2 illustrates a system with IRIG B wired to each of the multi-dropped IED's on the time synchronization channel.

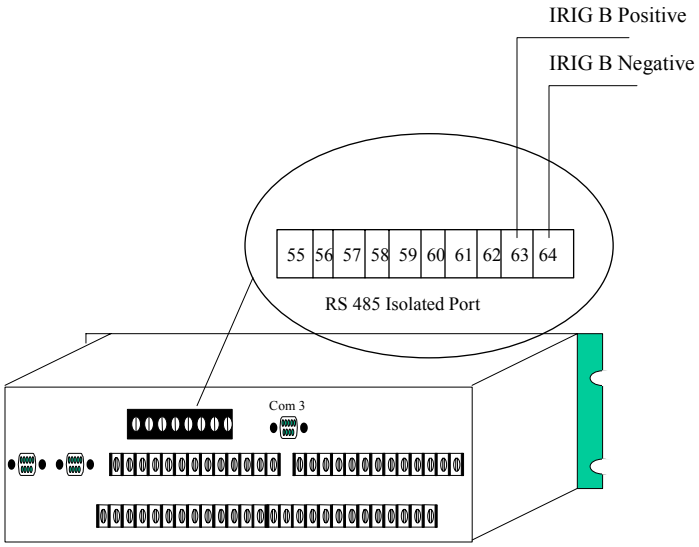

FIGURE 1: TIME SYNCHRONIZATION INPUT

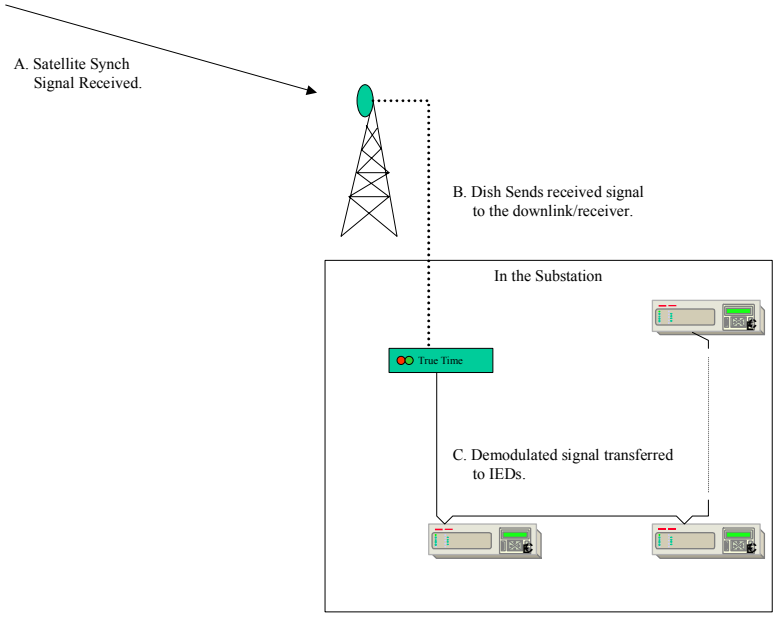

FIGURE 2: SYSTEM TIME SYNCRHONIZATION ARCHITECTURE EXAMPLE

Within the DPU/TPU, the DNP 3.0 Protocol timestamps events requested when change event objects are requested. Examples of change event objects include Object 2, Object 32, and Object 60. Each event reports the time in the standard 64 bit format accepted in the DNP 3.0 protocol format. Additionally, the ABB protective relays serve as a data concentrator and have large buffering capabilities built within the DPU/TPU which allow storage of multiple events for each data class so that the host device can poll the IED at any time and obtain each event. No intermediate devices (such as hubs, data concentrators, or bay controllers) are required since the capability is built into the DPU/TPU communication card.

MODBUS TIME SYNCHRONIZATION

Unlike DNP 3.0, Modbus does not have imbedded time synchronization. However, ABB DPU/TPU/GPU relays have incorporated advanced time synchronization features within the protocol. Each event, as in the case for DNP 3.0 is stored in an internal buffer within the DPU/TPU/GPU. The communication card takes the event and places it in a format compliant with the protocol. A DPU/TPU/GPU using Modbus may be configured to:

1. Disable the Internal Clock.
2. Timestamp the Event using the internal clock.
3. Timestamp the Event using the IRIG B synchronized clock.

No configuration is required to synchronize the clock. The clock must only be enabled and IRIG B must be attached to the relay as illustrated in FIGURES 1 and 2. Once IRIG B is received by the DPU/TPU/GPU, the internal ABB DPU/TPU/GPU will be synchronized with the 1mS source.

Since Modbus does not have a time “Object” imbedded in the protocol, the relay must store it for interpretation by the host device.

Within the DPU/TPU/GPU, data is stored in specific buffers as illustrated in Figure 3 (the DPU is used as an example).

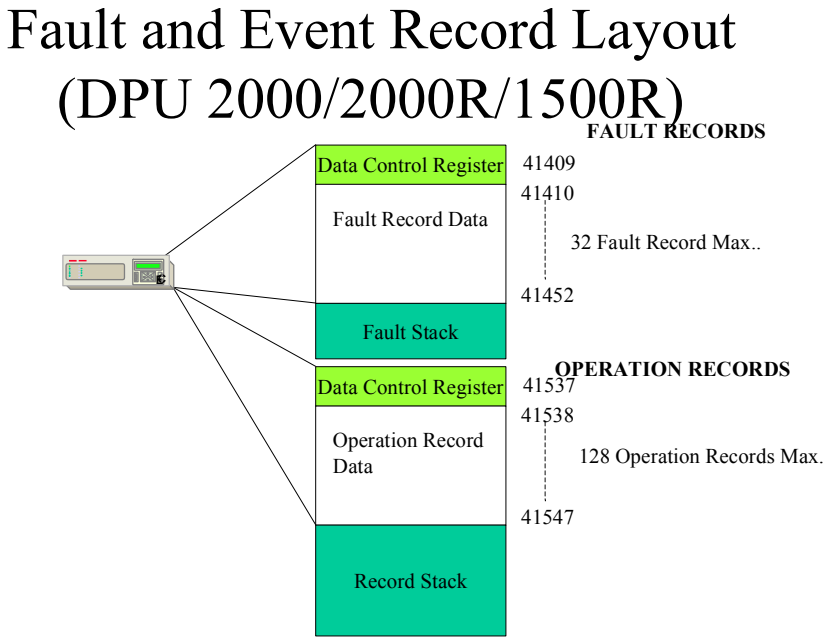

FIGURE 3: FAULT AND EVENT RECORD DATA

As illustrated in Figure 3, each Fault and Event record has viewable data and non-viewable Stack Data. The host device writes a value to a data control register and the non-viewable data is transferred to the viewable memory area. This write causes a pointer to “point and load” the archived data from the stack area to the viewable register area. The host device can then view the Fault or Operation record. The data within the record includes the time of the event or operation. The time included in the record is the time reported on the clock at the instant of the event.

The method to obtain the information is illustrated in FIGURE 4. The data may be obtained using a variety of Modbus commands:

- Issue a Modbus Command 06 (Write Single Register) and Modbus Command 03 (Read Single Register)
- Issue a Modbus Command 16 (Write Multiple Registers) and Modbus Command 03 (Read Single Register)
- Issue a Modbus Command 23 (Write /Read Multiple Registers)

The host can then interpret the fault/event data and the associated time registers included with the data.

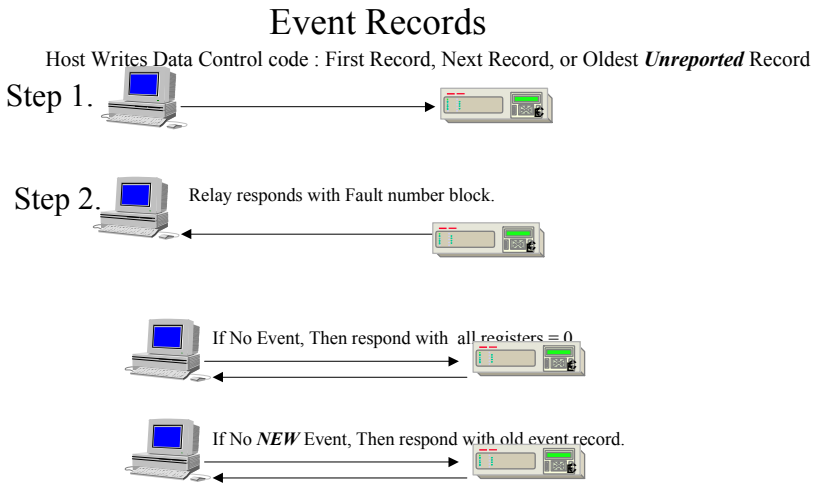

FIGURE 4: EVENT RECORD RETRIVAL USING MODBUS.

IN SUMMARY

The DPU/TPU/GPU is a versatile IED with protection, communication and automation features included in the standard product. The IED's have time synchronization capabilities included within the base product transcending protocol implementation. Time synchronization is included and compliant with the protocol selected. In cases where time synchronization is not part of the protocol, the ABB has included innovative and industry standard methods of obtaining the time synchronized data using standard data access packages.

Additional information is included in ABB's Automation Technical Guides available on the web at www.abb.com/substationautomation