ABB **Application Note**

Substation Automation and Protection Division

IRIG B Implementation in the DPU/TPU/GPU 2000/R and DPU1500R Units

Foreword

IRIG B is a time code, which allows devices across the world to synchronize with a common time source to a resolution of one millisecond. IRIG B allows each device to synchronize with the frame received by an IRIG B receiver. ABB's DPU/TPU/GPU 2000/R and DPU 1500R relays (herein referred to as an IED) offer IRIG B time synchronization capabilities.

Figure 1 illustrates a typical IRIG B installation. An IRIG B time receiver accepts the RF signal and transforms it into a one second time synch frame. IEDs in the substation use the one second time synch frame to govern their internal clocks and event recorders.
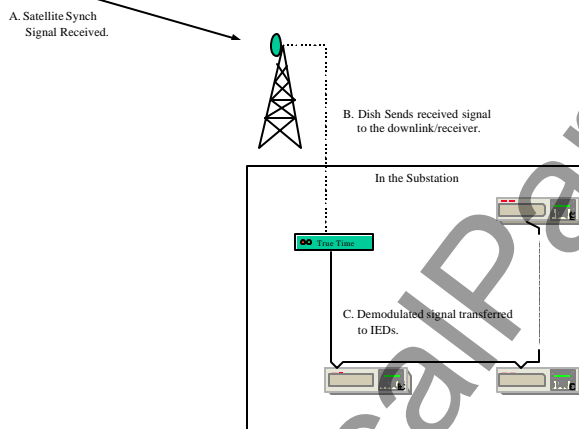

A. Satellite Synch Signal Received.

B. Dish Sends received signal to the downlink/receiver.

In the Substation

True Time

C. Demodulated signal transferred to IEDs.

Figure 1 - Typical IRIG B Architecture

IRIB B receivers/converters can format the IRIG B synchronization frames as a TTL-level pulse width, Manchester Encoded or Modulated Carrier Frequency signal. TTL-level signals are pulse DC with a voltage range of 0 to 5V. Modulated Carrier Frequency signals are pulse coded AM signals with modulation (tone bursts).

IRIG B is a general designation for time synchronization. There are many subsets to the IRIG B format. These were developed to provide functionality primarily for military applications dealing with missile and spacecraft tracking, telemetry systems, and data handling systems. IRIG B was embraced by the utility industry to answer a need to provide a sequence of events capability between a group of substations. Care must be exercised to match the device demodulating the signal from the satellite (downlink converter) with the IED's requiring specific IRIG B code formats.

DPU/TPU/GPU products support Pulse Width Code (X= 0), whereas, REL 3XX products having an IRIG B Poni Card support Pulse Width Code and Sine Wave Amplitude Modulated, and REL5XX products support Sine Wave Amplitude Modulated IRIG. If the IRIG signal supplied to the device is one in which the attached device cannot decode, the IED shall not synchronize with the signal and IED will not calculate time correctly.

The IRIG B time code has a one second time frame. Every frame contains 30 bits of Binary Coded Decimal time information representing seconds, minutes, hours, days and a second 17 bit straight binary time-of-day. The frame has internal time markers, which insure time-stamping accuracy to the millisecond. An eight millisecond frame reference marker appears during the first ten milliseconds of each frame. Another eight millisecond position identifier appears during the ninetieth millisecond of each one hundred millisecond period mark. The 30 bit Binary Coded Decimal time data occurs in the first one hundred millisecond of each 1 second frame. Optional control functions are sometimes encoded in the data stream. These functions control deletion commands and allow different data groupings within the synchronization strings. Decoding an IRIG B pulse is quite a complex undertaking. A typical 1 second time frame is illustrated in Figure 2. It is interesting to note that the year is not included within the IRIG B frame. If the Control Function frame (CF) or Straight Binary Time of Day frame (SBT) is not used , the bits defined within those fields are to be set as a string of zeroes and sent to the IED IRIG B receiver.
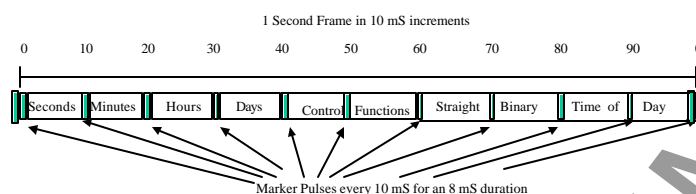

Figure 2 - IRIG B Frame Construction

IRIG B is defined for code format sets identified by a three digit format number. Permissible format numbers for the IRIG B subsets are:

IRIG B XYZ Where:
The first field "X" identifies the encoding type of the IRIG B signal. DPU/TPU/GPU products support Pulse Width Code (X= 0), whereas, REL 3XX products having an IRIG B PONI Card support Pulse Width Code and Sine Wave Amplitude Modulated, and REL5XX products support Sine Wave Amplitude Modulated IRIG. Manchester Modulated code was added in IRIG Standard 200-98 Dated May 1998. It is not supported in the ABB protective relay products which are IRIG B capable.

The second field "Y" determines if a carrier is included within IRIG B Data format.

The third field "Z" determines if a combination of the BCD time / Control Function/ Straight Binary Time is included within the IRIG B time frame. The inclusion or exclusion of any of the fields may cause errors in receivers not designed for the field's inclusion/ exclusion.

The following combinations may seem daunting, but only a subset of the listed formats are actually defined within the specification.

IF X =
0   = Pulse Width Code
1   = Sine Wave Amplitude Modulated
2   = Manchester Modulated Code

IF Y =
0   = No Carrier
2   =1Khz , 1mS
3   =10Khz, 0.1 mS
4   =100 Khz, 10 mS

2

5   =1Mhz, 1mS

IF Z=
0   =BCD Time,Control Function, Straight Binary Seconds
1   =Binary Coded Decimal Time, Control Function
2   =Binary Coded Decimal Time
3   =Binary Coded Decimal Time, Straight Binary Seconds

For the TPU/GPU/DPU 2000/2000R products, IRIG B 000 and 002 formats are supported. Consult the IRIG B generator manufacturer so that the correct IRIG B code format is supplied to the receiving devices.

Hardware Configuration

IRIG B time synchronization is available for the products listed in Table 1. Generally, three types of protective relays do not offer IRIG B, units without a communication card, units with Modbus Plus communication cards, and units with DNP 3.0 communication cards.

Table 1 - IRIG B Inclusion listed by product part number.

DPU 2000	
	48 X X X X X X 2 – X XXX
	48 X X X X X X 3 – X XXX
	48 X X X X X X 4 – X XXX
TPU 2000	
	488 X X X X X 2 –X XXX
	488 X X X X X 3 –X XXX
	488 X X X X X 4 –X XXX
DPU 2000R	
	587 X X X X 2 – X X X X 0
	587 X X X X 2 – X X X X 2
	587 X X X X 2 – X X X X 3
	587 X X X X 2 – X X X X 4
	587 X X X X 3 – X X X X 0
	587 X X X X 4 – X X X X 0
	587 X X X X 4 – X X X X 2
	587 X X X X 4 – X X X X 4
	587 X X X X 8 – X X X X 0
	587 X X X X 8 – X X X X 1
	587 X X X X 8 – X X X X 2
	587 X X X X 8 – X X X X 4
TPU 2000R	
	588 X X X X 2 – X X X X 0
	588 X X X X 2 – X X X X 2
	588 X X X X 2 – X X X X 4
	588 X X X X 3 – X X X X 0
	588 X X X X 4 – X X X X 0
	588 X X X X 4 – X X X X 2
	588 X X X X 4 – X X X X 4
	588 X X X X 8 – X X X X 0

	588 X X X X 8 – X X X X 2
	588 X X X X 8 – X X X X 4
GPU 2000R	
	589 X X X X 2 – X X X X 0
	589 X X X X 2 – X X X X 4
	589 X X X X 3 – X X X X 0
	589 X X X X 4 – X X X X 0
	589 X X X X 8 – X X X X 0
	589 X X X X 8 – X X X X 4
	X = Don't Care

Each of these units uses the AUX COM port located at the rear of the relay to accept the TTL IRIG B signal. The DPU/TPU/GPU 2000R and DPU 1500R use Pins 63 and 64 to accept the IRIG B negative polarity and IRIG B positive polarity signals respectively, as illustrated in Figure 3. The DPU/TPU 2000 use pins 65 and 66 as illustrated in Figure 4.
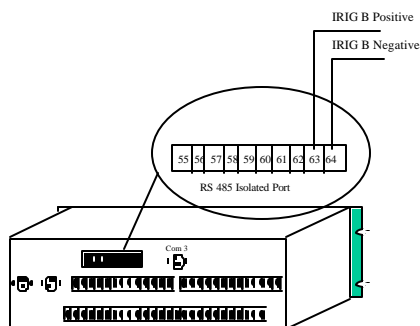

Figure 3 - DPU/TPU/GPU 2000R and DPU 1500R IRIG B Connector Placement
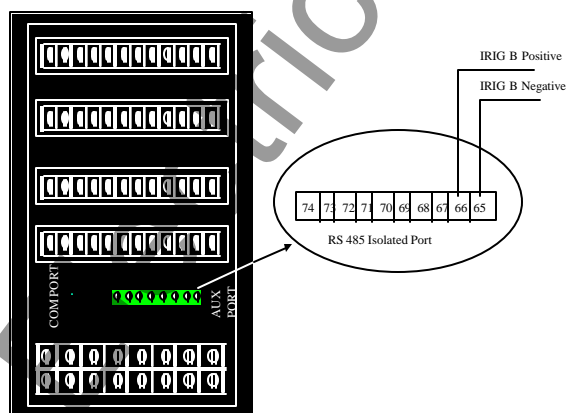

Figure 4 - DPU/TPU 2000 IRIG B Connector Placement

ABB's implementation of IRIB B requires that the signal be daisy-chained to each device. Each device in the IRIG B network presents a load to the IRIG B receiver/converter. Daisy-chained inputs are simple parallel circuits. A sample calculation is shown for the example illustrated in Figure 5.

If the input impedance of each DPU/TPU/GPU 2000R is measured at its IRIG B connection, the impedance would be 1000 ohms. Each IRIG B input requires at least 6 mA/per IED to drive the internal circuitry. A typical IRIG B source generates a voltage of 5V as per definition. One should perform a load calculation and a current budget to match the source capability with the loading of the IEDs attached to the IRIG B cicuit.

Calculating the load impedance presented to the IRIG B source generator is illustrated in Figure 5. Each IED load on the IRIG B link presents a parallel impedance to the source. The general equation for parallel impedance is:

$$\frac{1}{Z_{Total}} = \frac{1}{Z_1} + \frac{1}{Z_2} + \frac{1}{Z_3} + \ldots$$

$$I_{Total} = I_1 + I_2 + I_3 + \ldots$$

This impedance equation simplifies to the form in Figure 5 when all IED loads are identical. If the loads are not identical, the general equation listed above must be used to calculate the load.
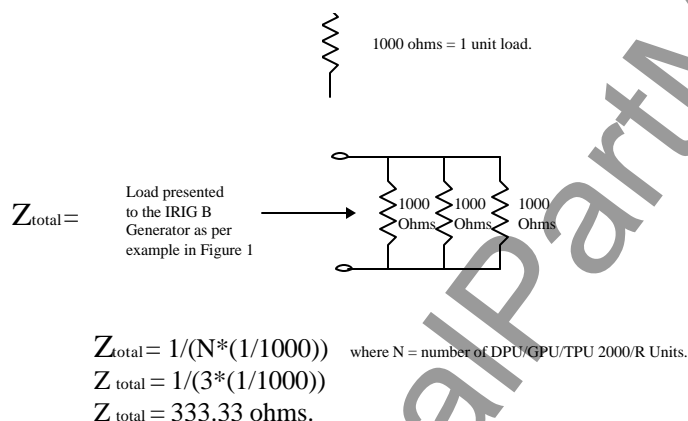

$$Z_{total} = 1/(N*(1/1000)) \quad \text{where N = number of DPU/GPU/TPU 2000/R Units.}$$
$$Z_{total} = 1/(3*(1/1000))$$
$$Z_{total} = 333.33 \text{ ohms.}$$

Figure 5 - Load Impedance Calculation

The calculated load impedance for the architecture presented in Figure 5 is 333.33 ohms. In this example the IRIG B receiver/converter must be capable of sending a three milli-amp TTL-level signal to a 333.33 ohm load. If the source is not matched with the load impedance, IRIG B will not operate correctly.

The cable recommended to connect the IRIG B devices shall have the following characteristics:

Capacitance: less than 40 pF per foot line to shield
Construction: 2-wire twisted pair shielded with PVC jacket

The maximum lead length of the entire relay is to be no more than 1000 feet. Cable types and vendors recommended and supported by ABB to interconnect the IRIG B devices are:

BELDEN 9841, BELDEN YM29560, or equivalent
An example of the terminal to terminal daisy-chain interconnection of three units is illustrated in Figure 6.
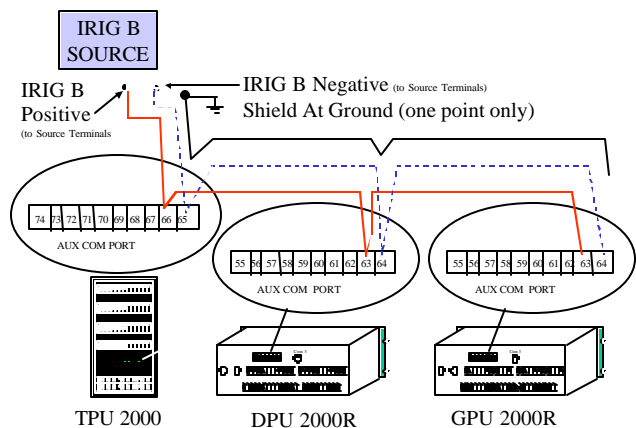
Figure 6 - Pin to Pin illustration of ABB Protective Daisy-chain link for IRIG B

Software Configuration

Physical interconnection of the devices is only one part of the procedure to allow IRIG B time stamp. The ABB protective relays must be configured to allow for IRIG B to be enabled. The procedure follows:

1. Start ECP from the DOS operating system for the appropriate device being configured.
2. Highlight the Change Settings Menu
3. Highlight and Select the Communications Menu
4. Scroll down to the field " IRIG B"
5. Depress the enter key and select the "ENABLE" selection Two selections are displayed, ENABLE-mmm or ENABLE-cc. ENABLE-mmm will timestamp events and display the millisecond time as a number from 1 to 999. ENABLE-cc will timestamp events and display the millisecond time as a decimal fraction of a second from 1 to 99.
6. Return from the menu item.
7. Download the changed selections to the attached unit.

The unit is now synchronized to the IRIG B time source. All events shall be time stamped to the common IRIG B time source. The protective relays may also be configured for IRIG B timestamping from the front panel MMI of units which are equipped with a front panel interface.

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