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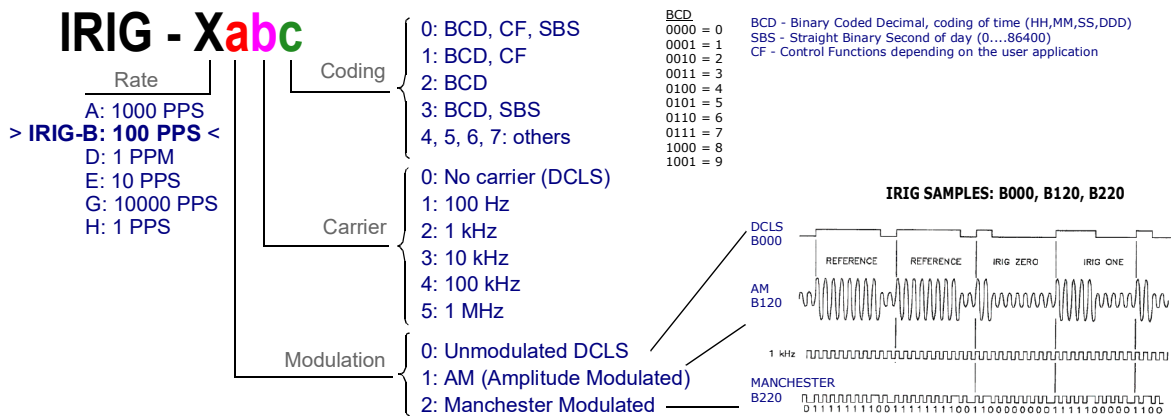# IRIG-B Testing with xGenius and Zeus

IRIG - X a b c

Rate
A: 1000 PPS
> IRIG-B: 100 PPS <
D: 1 PPM
E: 10 PPS
G: 10000 PPS
H: 1 PPS

Coding
0: BCD, CF, SBS
1: BCD, CF
2: BCD
3: BCD, SBS
4, 5, 6, 7: others

Carrier
0: No carrier (DCLS)
1: 100 Hz
2: 1 kHz
3: 10 kHz
4: 100 kHz
5: 1 MHz

Modulation
0: Unmodulated DCLS
1: AM (Amplitude Modulated)
2: Manchester Modulated

BCD
0000 = 0
0001 = 1
0010 = 2
0011 = 3
0100 = 4
0101 = 5
0110 = 6
0111 = 7
1000 = 8
1001 = 9

BCD - Binary Coded Decimal, coding of time (HH,MM,SS,DDD)
SBS - Straight Binary Second of day (0....86400)
CF - Control Functions depending on the user application

IRIG SAMPLES: B000, B120, B220

DCLS B000
AM B120
1 kHz
MANCHESTER B220

REFERENCE   REFERENCE   IRIG ZERO   IRIG ONE

0111111110011111110011000000001111100001100

Figure 1 *IRIG time codes. IRIG-B is the most important family member. IRIG-B time codes are defined with three digits to specify the encoding, carrier frequency and other information.*

IRIG-B (or *Inter-Range Instrumentation Group-B*) is a standard for time and frequency synchronization used in a variety of applications, including synchronizing substations and airports. The length of time that IRIG-B will be used for these purposes depends on several factors, including the specific requirements and needs of the systems being synchronized, as well as any potential advances or improvements in technology that may make other synchronization methods such as PTP more effective or efficient. In general, however, IRIG-B is a widely-used and well-established standard for time and frequency synchronization, and is likely to continue being used for these purposes for the foreseeable future.

IRIG-B is a standard for time and frequency synchronization that has evolved over time, and there are several different versions of the standard, including optical, electrical, and AM versions. The specific version of IRIG-B used in a given application will depend on the specific requirements and needs of the systems being synchronized, as well as the availability and compatibility of the different versions. For example, the optical version of IRIG-B is often used for long-distance synchronization, while the AM version

is commonly used for short-range synchronization. Overall, the various versions of IRIG-B are designed to provide reliable and accurate time and frequency synchronization for a wide range of applications.

Some common examples of industries that use IRIG-B include:

- *Aerospace and defense*: IRIG-B is often used in aerospace and defense applications to synchronize systems and equipment, such as radar and navigation systems, missile guidance systems, and satellite communication systems.

- *Telecommunications*: IRIG-B is commonly used in telecommunications systems to synchronize clocks and timing signals, which is essential for ensuring the accurate transmission and reception of data.

- *Power and energy*: IRIG-B is frequently used in power and energy systems, such as electric power grids, to synchronize substations and other equipment, which is necessary for maintaining the stability and reliability of the power system.

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- *Transportation*: IRIG-B is also commonly used in transportation systems, such as railways and airports, to synchronize clocks and other systems, which is essential for ensuring the smooth and efficient operation of these systems.

Overall, IRIG-B is a widely-used and well-established standard for time and frequency synchronization, and it is used in many different industries and applications where accurate and reliable synchronization is required.

ALBEDO testers such as xGenius and Zeus have features to monitor frequency and time clock signals, including IRIG-B time codes, and runs synchronization tests on them.

1. TEST SUMMARY

Verification of IRIG-B signals with xGenius or Zeus requires configuration of both the clock reference and the test interface. Most results also require that a test is started with the *RUN* button. A high level description of the steps to follow to configure the test is given below:

1. Attach and configure the clock reference input. Any time reference can be used for this purpose. ALBEDO testers are compatible with GNSS, ToD and IRIG-B references. It is also possible to run IRIG-B synchronization tests in holdover mode. This document assumes that the clock reference is GNSS.

2. Attach the IRIG-B *Pluggable Hardware Module (PHM)* to the unit. The appropriate module is the PHM-25.

3. Attach and configure the test signal. The tester can partially detect the time code structure, but users must configure manually those parameters not automatically detected. Here, it is assumed that the analysis runs in an IRIG-B124 time code, which describes a 1 kHz AM modulated signal with the BCDToY -BCDYear-CF-SBS time code.

4. Start a new test with the help of the *RUN* button.

5. Check the test results browsing to the correct panels in the menu tree.

2. SETTING UP THE REFERENCE

xGenius and Zeus testers may be equipped with a built in GNSS receiver. These units have a SMA female connector suitable for connecting an antenna. Units with the built in GNSS receiver are also supplied with a compact antenna with 5 m of coaxial cable plus a 10 m extension cable. Using a different antenna is possible as long as the specifications of the GNSS module are taken into account. To use the built in GNSS module follow these steps:
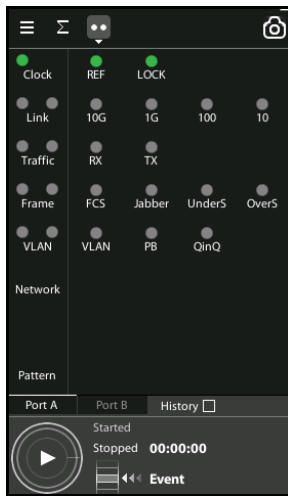
1. Attach the antenna to the unit. Make sure that the antenna sees as much of the sky as possible. The unit may fail to achieve synchronization if there are not enough satellites in sight. Some tests may loss accuracy if the number of satellites in sight is reduced.

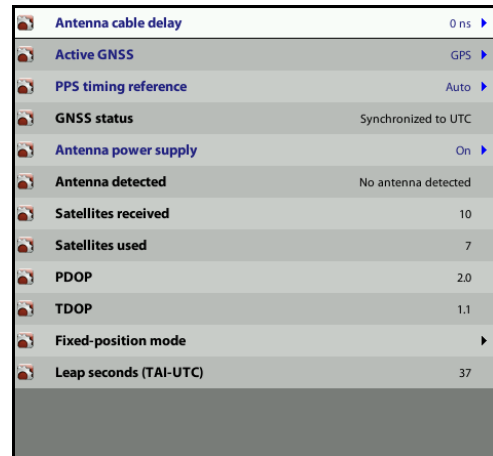2. From the *Home* panel, go to *Config*, The port setup panel is displayed.

3. Go to *Reference clock*.

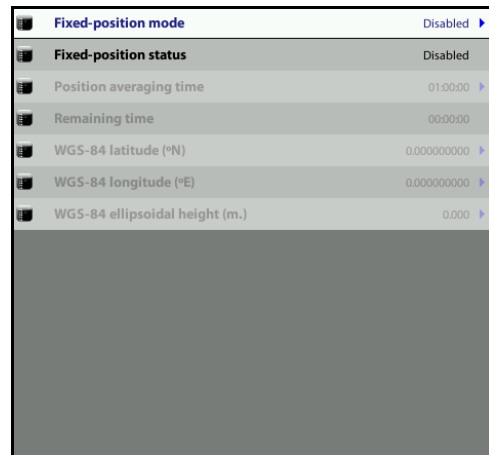4. Configure *Input clock* to *GNSS*.

A L B E D O - APPLICATION NOTE
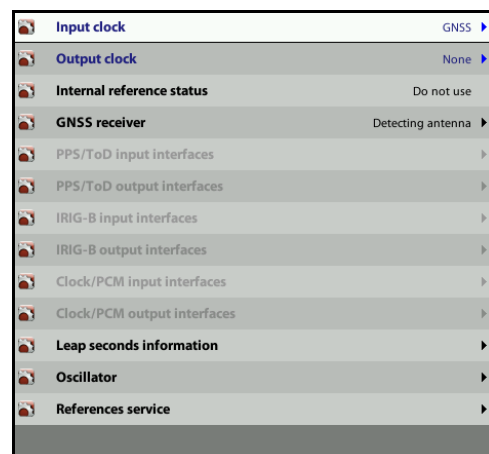
5. Press *LEDS* to display the test status.

6. Wait for the REF and LOCK LEDs to become green.
Note: The locking process for the OCXO version of xGenius may take around 10 minutes. The coarse locking process in Rubidium units requires around 20 minutes.
Note: Both Rubidium and OCXO versions of xGenius are ready for testing once the LOCK LED is green but Rubidium units are not yet prepared to supply their maximum accuracy. These units go to a *Fine locking* status before being fully *Locked* to the reference. The *Fine locking* status may last for around four hours in Rubidium units. OXCO units have a much shorter fine locking status and they go almost immediately to *Locked* when they finish the coarse locking procedure. The user could check the current locking status (*Locking*, *Fine locking*, *Locked*, *Holdover*, etc.) from the *Oscillator* menu in the *Reference clock* menu.

Configuring the GNSS Properties

The user could optionally configure the GNSS interface in the test unit. Despite not being mandatory, the increase in accuracy it could be obtained in this way is quite important. This is the required procedure:

1. From the *Home* panel, go to *Config*,
The port setup panel is displayed.

2. Go to *Reference clock*.

3. Go to *GNSS receiver*.

4. Configure a compensation for the antenna cable through the *Antenna delay correction* field.

5. Enable or disable any of the *GPS*, *GLONASS*, *Beidou* or *Galileo* constellations through the *Active GNSS* setting.

6. Go to *Fixed-position mode*.

7. Adjust the *Position averaging time* and enable position averaging by configuring *Fixed-position mode* to *Auto-average*.
The *Fixed-position status* field now displays *Averaging*
Note: At least one hour of position averaging is required for a reasonable accuracy.
Note: The position averaging procedure should run only once as long as the test unit geographical location is not changed. The unit checks any change in position (longitude,

latitude, altitude) every time it is connected to a GNSS antenna. If a change in the coordinates is detected, then an error message is displayed in the status field and the mode is disabled.

8. Wait to the *Fixed position status* to become *Active*. The unit is now ready for testing.
   Note: Theoretically, testing could start before the end of the position averaging process. The improved time estimation due to this function would be automatically applied starting from the end of the auto-averaging process.

3. CONFIGURING THE TEST PORT

Once the reference is ready, it is time to configure the test port. IRIG-B analysis requires an special PHM, the PHM-25. This module must be attached to the unit for testing but since PHMs are hot-pluggable, there is no need to shut the unit down to activate the module. In the following description, it is assumed that the test interface is a 50 Ω coaxial cable carrying an IRIG-B124 time code.
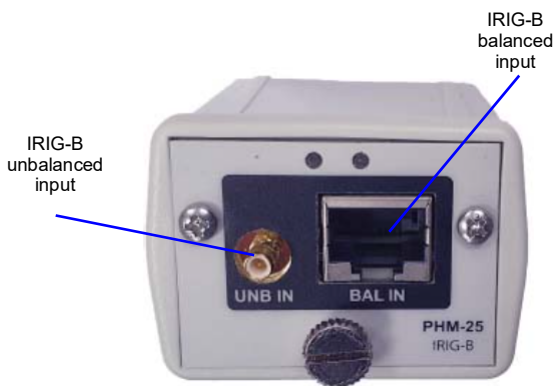

Figure 2 *PHM-25 for IRIG-B decoding and analysis applications*

Connecting the Unit

Connect the PHM25 SMB port to the coaxial input before starting the configuration. It may be necessary to use an adapter to change the IRIG-B outputt to the xGenius / Zeus SMB input. Once the transmission medium is physically connected to the unit follow these steps:

1. From the *Home* panel, go to *Config*,
   The port configuration panel is displayed.

2. Select *Mode* to enter in the mode selection menu

3. Choose *Clock monitor*.
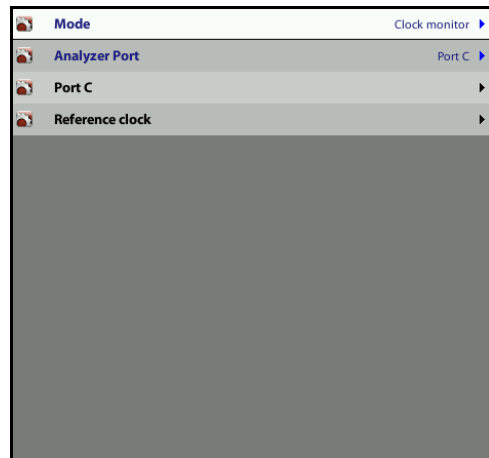
Configuring the Receiver

1. From the *Home* panel, go to *Config*,
   The *Setup* configuration panel is displayed.

2. Configure *Analyzer port* to *IRIG-B (PHM-25)*.

3. Select *IRIB-B* to enter in the port specific configuration menu.

4. Go to *Line*.
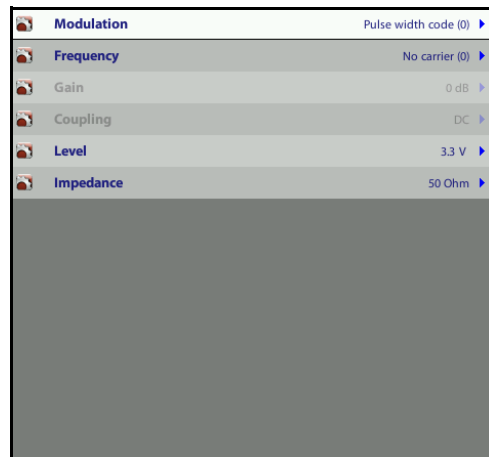
5. Configure *Modulation* to *Sine wave, AM (1)*.

6. Configure *Frequency* to *1kHz (2)*.

7. If necessary, configure *Impedance* to *50 Ohm*.

At this point, the unit should be receiving and decoding the IRIG-B124 time code.Make sure that everything is correct by checking the LED. All them should be displaying the green color. If the LVL (level) LED is red you may need to increase or decrease the the *Gain* value.

4. MEASURING INPUT LEVEL

xGenius and Zeus measure the input level of AM modulated IRIG-B signals in terms of two parameters: *Amplitude (Vpp)* and *DC offset*. Te latter is relevant in DC coupled interfaces only. To display these results follow the steps described below:

1. From the *Home* panel, go to *Results*,
   The test port results panel is displayed.

2. Press the *RUN* button to start a new test.

3. Select *IRIG-B* to enter in the port specific results.

4. Go to *Line*.
   Current, Minimum and Maximum values of the *Amplitude (Vpp)* and *DC offset* are displayed.

Line				Input level OK
	Current	Minimum	Maximum	Units
Amplitude (Vpp)	3.96	3.96	3.96	V
DC offset	37	37	37	mV

To display information about input level, configuration of an external clock reference is not strictly necessary.

5. TIME CODE INSPECTION

The IRIG-B frame has a complex structure including information not only about the time but also related with time scales, time zones, leap seconds and others. The xGenius and Zeus testers decode the IRIG-B time code and display the information carried in the frame. In case of any issue an alarm is raised and reported. To display the time code analysis results follow these steps:

1. From the *Home* panel, go to *Results*,
   The test port results panel is displayed.

2. Press the *RUN* button to start a new test.

3. Select *IRIG-B* to enter in the port specific results.

4. Go to *Line*.
   Information about the time code detected by the tester is displayed (*IRIG-standard*, *Coded expression*). If the time code changes during the test, the *Code changes* counter will be increased. The number of encoded frames is reported by *Analyzed frames*. In time codes with *BCDToy*, the number of seconds, minutes, days from the beginning of the year together with information about the current year is also displayed. If the time code has support for *SBS*, the seconds from the beginning of the day are displayed too. Finally, if the time code includes the *CF extension*, details related with leap seconds, daylight saving time, time zone, time code accuracy and other miscellaneous information are also shown.

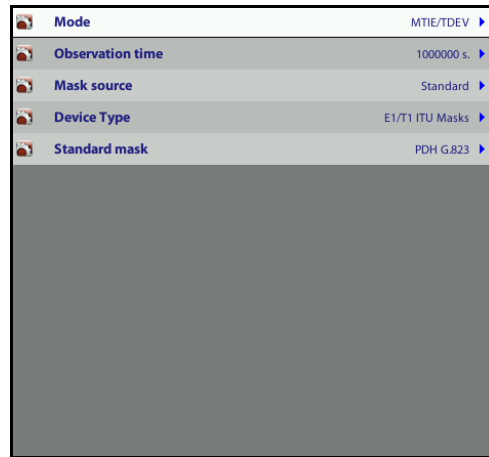| Frame	Synchronized to IRIG
	Results
IRIG standard	B124
Coded expression	BCDtoy, BCDyear, CF, SBS (4)
Code changes	0
Analyzed frames	110
BCDtoy seconds	36
BCDtoy minutes	59
BCDtoy hours	4
BCDtoy days	13
BCDyear	23
SBS (s)	17976
CF leap second event	No pending event
CF daylight saving time	Standard time
CF time zone offset (h)	-5.0
CF parity bit	0
CF time quality	Locked to a UTC source

5. Leave the *Line* panel and go to *Events*.
   Events related *Leap seconds* and *Daylight saving time* transitions are displayed.

Events		
Event	Count	Seconds
Leap second pending	0	0
Leap second	0	0
Daylight saving time pending	0	0
Daylight saving time	0	0

6. Leave the *Events* panel and go to Anomalies. A list with different anomalies related with time code integrity and others is displayed. The events listed in the table are: *Rx timestamp, Parity, Time, Discontinuity, SBS, Accuracy, Leap second, Daylight saving time.*

Anomalies		
Event	Count	Rate
Rx timestamp	0	0.000e+00
Parity	0	0.000e+00
Time	0	0.000e+00
Discontinuity	0	0.000e+00
SBS	0	0.000e+00
Accuracy	0	0.000e+00
Leap second	0	-
Daylight saving time	0	-

To run the IRIG-B frame decoding and analysis test, configuration of an external clock reference is not strictly necessary.

6. TIMING ANALYSIS

The purpose of IRIG-B is distribution of accurate time to devices compatible with this interface. For this reason, an important *xGenius* and *Zeus* function is to measure the accuracy level of the IRIG-B time. This is done by comparing the test signal with a supposedly perfect clock reference. The result of the analysis is the *Time Error* (TE) between test signal and reference. The steps to follow to check the IRIG-B accuracy level are described in the following sections.
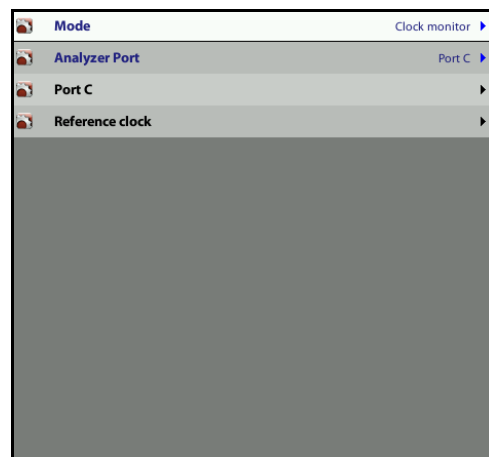
Configuring the Test

Once the IRIG-B test interface interface is configured, the user must still enable the timing analysis. The correct procedure is as follows:

1. From the *Home* panel, go to *Test*, The test configuration panel is displayed.

2. Go to *Wander test.*

3. Enable the test by setting Mode to the *Enable* control to MTIE/TDEV.

Note: Even if the test is referred as *MTIE/TDEV* in this scenario we are mainly interested in the *TE*. The MTIE and TDEV are usually ignored in IRIG-B applications.

Mode		MTIE/TDEV ▶
Observation time		1000000 s. ▶
Mask source		Standard ▶
Device Type		E1/T1 ITU Masks ▶
Standard mask		PDH G.823 ▶

Configuring the UTC Offset

This section is optional for the IRIG-B124 time code but it is mandatory if the time code works with local times and does not carry information about the UTC offset in the frame.

1. From the *Home* panel, go to *Config*, The *Setup* configuration panel is displayed.

2. Go to *Frame*.

3. Set the *Time mode* to *Manual*.

4. Set *Timescale* to *Local*.

1. Configure *Time zone offset (h)* and *Time zone offset (min)* to achieve the UTC-5 time offset.

Mode		Clock monitor ▶
Analyzer Port		Port C ▶
Port C		▶
Reference clock		▶

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Running the Test

Te test is now ready to start. The TE results are computed by the test unit in real time and they can be checked at any moment in the following way:

1. From the *Home* panel, go to *Results*,
The test port results panel is displayed.

2. Press the *RUN* button to start a new test.

3. Select *IRIG-B* to enter in the port specific results.

4. Go to *Wander test*.

5. Go to *Wander analysis.*

6. Make sure that you are getting a reasonable time in *RX IRIG timestamp*.

7. Check the *TE*, *Offset* and *Drift* results.

Wander analysis		Measuring
Results	Value	Units
TE	-8.041	µs
Min. TE	-8.041	µs
Max. TE	-8.041	µs
Offset	0	ppb
Max. offset	0	ppb
Drift	0	ppb/s
Max. drift	0	ppb/s
Rx IRIG timestamp	05:07:40	Local

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