www.albedotelecom.com

Testing with xGenius: Working with Clocks

xGenius generates different kinds of frequency and phase clock reference outputs that could be used for different purposes. Among the different options we can list the following:

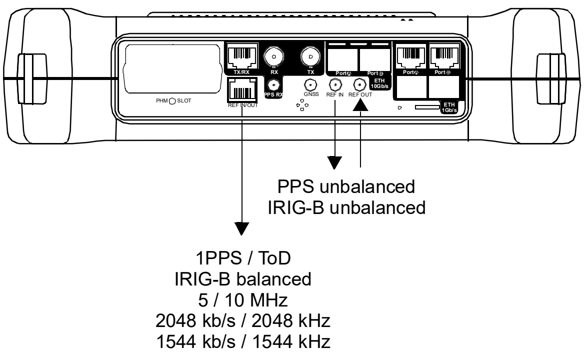

Figure 1 *Clock reference inputs and outputs available in xGenius units.*

- *1PPS / ToD outputs*, balanced or unbalanced: These outputs meet the ITU-T G.8271 specifications and may provide a performance level equivalent to a *Primary Reference Time Clock* (PRTC) as defined in ITU-T G.8272 when the test unit is properly configured.
- *Frequency outputs*, including 2048 kHz and 10 MHz interfaces. These outputs provide the same performance than a *Primary Reference Clock* as defined in ITU-T G.811 when the unit is properly configured.

Due to the high performance level provided by xGenius clock reference outputs, they are suitable to synchronize virtually any network. They have the advantage of being portable and battery operated. When the built in Rubidium oscillator is used they also provide good holdover performance. This function makes xGenius independent of GNSS when used as a portable synchronization source.

A typical application of clock reference outputs is to generate an stimulus to the device or network to be tested. This stimulus is propagated through the network and the result is analyzed in a second remote unit. Typical performance metrics are the *Time Error* (TE), *Time Interval Error* (TIE), *Maximum TIE* (MTIE) and *Time DEViation* (TDEV).

Clock reference outputs could also be used as a synchronization source for a second test equipment. This setup is typical of self-synchronized tests required for *Boundary Clock* (BC) or *Transparent Clock* (TC) benchmarking. The advantage of this setup is a very high accuracy level independent of any external element to the test system.

This document is mainly focused in phase and time applications delivered over packet switched networks and for this reason, only 1PPS / ToD and PTP tests are described in detail. However, frequency output clocks are still important in TDM applications and also in packet applications where only frequency distribution is relevant.

1. 1 PPS Tests

This section deals about two basic test setups related with 1PPS interface tests. In one of them 1PPS is used as an stimulus and GNSS provides time / phase reference. In the second configuration 1PPS is used as a clock reference. The GNSS-synchronized test is suitable when the excitation signal is to be transmitted to a location far from the analysis interface. The self-synchronized test is very accurate but it requires the generator and the analyzer to be physically connected by a short patch cable.

AN-OUTGEN 06/18

There is actually a third basic setup that is not described here but it also has several important applications. It is a configuration in which a single unit generates a 1PPS / ToD output and at the same time runs 1PPS / ToD analysis test. This test has the same accuracy level than the dual-unit self-synchronized test.

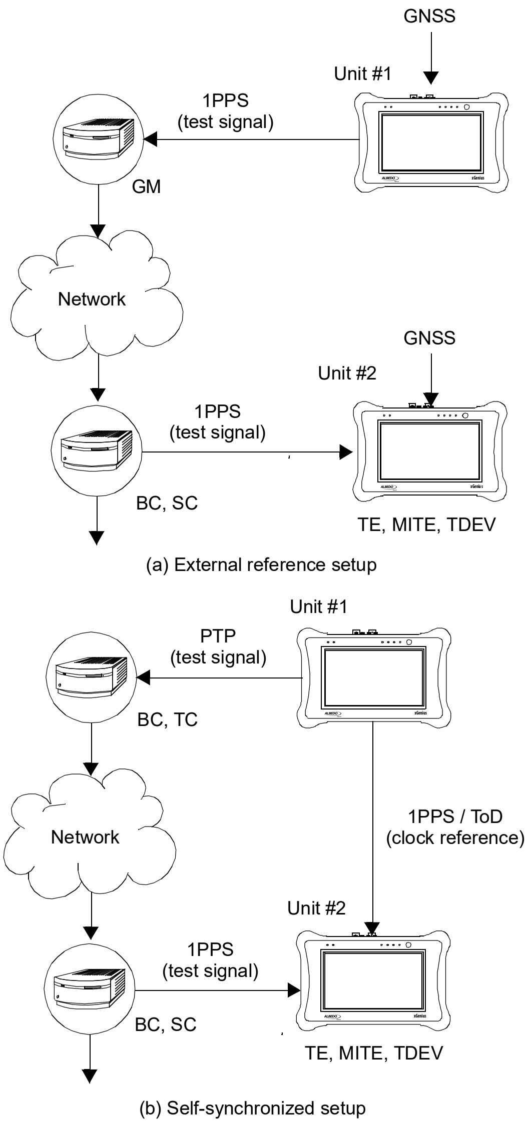

Figure 2 *Test configurations requiring 1PPS / ToD outputs: (a) GNSS-synchronized test (b) self-synchronized test.*

Case I: GNSS-synchronized Test

Two xGenius units are required for this test. It is assumed that these units are configured to the factory defaults. The units may be installed in different locations potentially a long distance away one each other.

Unit #1 generates a 1PPS stimulus signal that is transferred through a packet switched network. A second tester (unit #2) runs a TE / MTIE / TDEV test in some BC 1PPS monitoring output or at the 1PPS output provided by a PTP *Slave Clock* (SC).

Setting up the Reference

xGenius units 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 in test unit #1 (generator) and #2 (analyzer) separately:

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*.
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 do not have fine locking status and they go directly to the *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 being not mandatory, the increase in accuracy it could be obtained in this way is quite important. This is the required procedure to be followed separately in each unit:

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 be started when test unit geographical location changes. 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: 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.

Connecting the Units

It is assumed that the input and output physical network interfaces are 1PPS unbalanced as defined in ITU-T Recommendations G.703 and G.8271. For unit #1 the following configuration is required:

1. Connect the xGenius REF OUT port to the network input interface using a 50 Ω coaxial cable
2. From the *Home* panel, go to *Config*,
   The port configuration panel is displayed.
3. Go to *Reference clock*,
   The clock reference input and output configuration panel is displayed
4. Select *PPS (REF SMB)* in *Output clock* to start generating a 1 PPS output synchronized with the GNSS reference.

The configuration required in unit #2 is as follows:

1. Connect the xGenius PPS RX port to the network output interface using a 50 Ω coaxial cable.
2. From the *Home* panel, go to *Config*,
   The port configuration panel is displayed.
3. Select *Mode* to enter in the mode selection menu
4. Choose *Clock monitor*.

Configuring the Test Port

Follow these steps in test unit #2:

1. From the *Home* panel, go to *Config*,
   The port configuration panel is displayed.
2. Select *Port C* to enter in the port specific configuration menu.
3. Configure *Clock frequency* to *PPS (Port C)*.
4. Configure the Connector to *Unbalanced* and select the *1PP1S (Port C)* interface in *Clock frequency*.

Configuring the Test

Once the 1PPS clock interface is configured in unit #2, the user still has to configure the tests to be run. In this setup this is the TE / MTIE / TDEV test. To enable this test, 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 MTIE / TDEV test by setting the *Enable* control to *On*.

4. Configure *Standard mask* to *PTP G.8271.1 Reference Point C* if you are testing at the output of a PTP SC or to any other mask suitable to your test requirements.

Running the Test

Te test is now ready to start. Press *RUN* in the test unit to do that. The TE / MTIE / TDEV results are computed by the test unit #2 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.
1. Select *Port C* to enter in the port specific results.
2. Go to *Wander test*.
3. Choose between *Wander analysis*, *MTIE* or *TDEV*
4. Check the *TE*, *Max. TE*, *Offset*, *Max. offset*, *Drift*, *Max. Drift* (*Wander analysis* results panel); *Time*, *TIE*, *MTIE* and *Mask* results (*MTIE* results panel) or *Time*, *TDEV* and *Mask* results (*TDEV* results panel).

To stop the test press *RUN* a second time at any moment.

Case II: Self-synchronized Test

Again, two units are required inthis test case. This time the stimulus is a PTP data flow transmitted through an Ethernet interface. The analysis signal is 1 PPS /ToD in the same way that in test case I.

It is assumed a simple configuration for PTP (1000BASE-T interface, no VLANs). The PTP profile is assumed to be the ITU-T G.8275.1 (L2 payload, multicast transmission...). The analysis interface is 1 PPS / ToD *balanced* as defined in ITU-T Recommendations G.703 and G.8271. The initial state for both test units is the factory default configuration.

This test could be used to verify the performance of a PTP slave clock with a 1 PPS / ToD output.

Setting up the Reference

The following procedure enables test unit #1 to supply a 1PPS / ToD timing signal to test unit #2 but nothing stops the user to do the opposite and let unit #2 to generate the timing for unit #1. The only requirement is that the unit with better performance should generate the reference signal. For example if a Rubidium and OCXO units are used, the Rubidium should provide the timing for the OCXO. The steps to follow are:

1. Connect the unit #1 REF IN / OUT port to the REF IN / OUT port in unit #2 using an straight RJ-45 to RJ-45 cable.
   Note: Non-ToD references are of limited use in tests requiring PTP master or slave emulation because they don't carry time information and they cannot be used to measure TE.
2. In unit #1, from the *Home* panel, go to *Config*, The port configuration panel is displayed.
3. Select *ToD (Port Ref. In / Out)* in *Output clock* to start generating a 1PPS / ToD output synchronized to the unit #2 local oscillator.
4. Go to *PPS / ToD output interfaces*.
5. Configure *Output ToD protocol* to *ITU-T G.8271*.
6. In unit #2, from the *Home* panel, go to *Config*, The port configuration panel is displayed.
7. Select *ToD (Port Ref. In / Out)* in *Input clock* to lock unit #2 with the 1PPS / ToD output generated by unit #1.
8. Go to *PPS / ToD input interfaces*.
9. Configure *Input reference delay* to compensate for the 1PPS cable delay. You should add 5 ns per meter of coaxial cable.
10. Press *LEDS* to display the test unit status.
11. 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 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 do not have fine locking status and they go directly to the *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.

Connecting the Units

For unit #1 the following configuration is required:

1. Connect the xGenius RJ-45 Port A to the network input interface using an Ethernet patch cable.

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 *Ethernet endpoint* and confirm by pressing ENTER.

Unit #2 is connected to the output interface exactly in the same way that in test case #1

Configuring PTP Master Emulation Mode

The following sequence is required in unit #1 to generate the PTP stimulus signal.

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

2. Go to *PTP (IEEE 1588)*.

3. Enable the PTP protocol in the unit by configuring *PTP mode* to *Emulation*.
A label with the text PTP is displayed in the top notification area.

4. Configure the equipment to become an IEEE 1588 master by configuring *Clock emulation* to *Master*.

5. Configure the timing of the different messages associated to PTP from the *Message timing* menu.

6. Configure the *Domain*, *Priority 1* and *Priority 2* to the right values for your network.

If the previous settings are correct the "M" indication ("Master") will be displayed close th the "PTP" label.

Configuring the Test

The test to be run is the same that in test case I and the test configuration procedure is therefore the same.

Running the Test

Follow the same procedure that in test case I to run the test.

2. IEEE 1588 / PTP Tests

This section describes three more test cases where generation of an output reference or test signal is necessary. Test case III describes a test that is closely related with test case I but both the 1PPS / ToD excitation and result signals are replaced by PTP flows transmitted over Ethernet interfaces.

Test case IV describes a self-synchronized test where the reference is transmitted over the same physical interface that the signal under test using Synchronous Ethernet. The advantage of this configuration is that the clock reference is readily available even if GNSS cannot be used and if the test units are far away one each other. The drawback is that requires support of Synchronous Ethernet in the test network. Moreover, Synchronous Ethernet is a frequency technology. It is not designed to distribute time and phase information. The result is that the analyzer is not able to generate the same results than if a time clock reference (GNSS, 1PPS /ToD) is used.

Test case V, a PTP self-synchronized test with 1PP / ToD reference, has many points in common with test case II but it replaces the 1 PPS analysis interface by PTP. This configuration is ideally suited for BC and TC testing because it combines the high accuracy provided by the ToD reference with a packet test interface. It has the inconvenience that a 1 PSS / ToD link is necessary between test units

ALBEDO Telecom - Registered in Barcelona, Book 41613, Page 155, Sheet B-390886 - VAT : ESB6523022

#1 and #2 but on the other hand this test is able to measure all the available performance parameters, including TE.

In all three cases units are restored to the factory defaults before starting configuration. PTP profile is assumed to be the ITU-T G.8275.1 (L2 payload, multicast transmission...). A simple configuration for all Ethernet test ports is also assumed (1000BASE-T, no VLANs).

Case III: Externally Synchronized Test

In this test case, unit #1 is configured to emulate a PTP master clock. The test signal is transmitted through a chain of network elements such as BCs or TCs. The output is the PTP data flow resulting from transmission of the original sequence over the test network. This is therefore a pure PTP test. Clock references are GNSS both in unit #1 and #2.

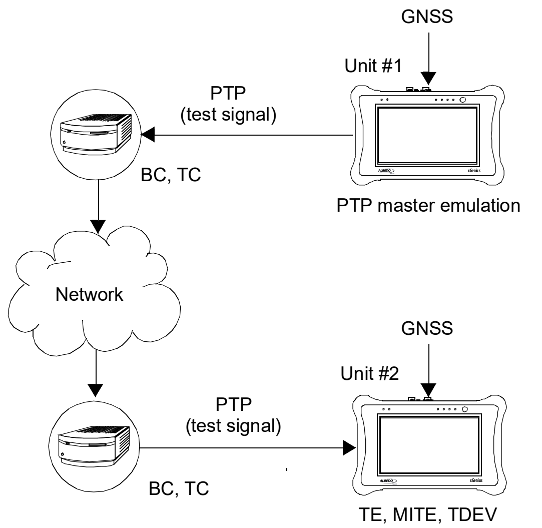

Figure 3 *GNSS-synchronized test for PTP BCs and TCs.*

Setting up the Reference

Proceed in the same way that in test case I to configure the GNSS references in unit #1 and #2.

Configuring the GNSS Properties

Proceed in the same way that in test case I to configure the GNSS properties in unit #1 and #2.

Connecting the Unit

Unit #1 and unit #2 are connected to the input and output interfaces in the test network in the same way:

1. Connect the xGenius RJ-45 Port A to the network input interface using an Ethernet patch cable.

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 *Ethernet endpoint* and confirm by pressing ENTER.

Configuring PTP Master Emulation Mode

Proceed with unit #1 in the same way that described in test case II to configure the equipment in PTP master emulation mode.

Configuring the PTP Pseudo-slave Mode

In the pseudo-slave emulation mode unit #2 behaves as a PTP slave but keeping an independent synchronization source (GNSS, in this setup) that enables the unit to compute MTIE, TDEV, TE and other performance metrics based on the comparison of the test signal phase and frequency with the clock reference input (GNSS):

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

2. Go to *PTP (IEEE 1588)*.

3. Configure the equipment to become an IEEE 1588 pseudo-slave by configuring *PTP mode* to *Test*.
A label with the text PTP is displayed in the top notification area.

4. Configure the timing of the different messages associated to PTP from the *Message timing* menu.

5. Configure the *Domain* to the right value for your network.

If the previous settings are correct, the PTP indication in the top of the screen will change from yellow to green and the “S” indication will be displayed close th the “PTP” label.

Configuring the Test

Once the PTP is active the user still has to configure the tests to be run. In this setup these are the TE and MTIE / TDEV tests. No specific action is required to enable the TE test. To enable the MTIE and TDEV test follow these steps:

1. From the *Home* panel, go to *Test*, The test configuration panel is displayed.
2. Go to *PTP wander test.*
3. Enable the MTIE / TDEV test by setting the *Enable* control to *On*.
4. Configure *Standard mask* to the mask suitable to your test requirements.

Running the Test

Te test is now ready to start. Press *RUN* in the test unit to do that. Now the TE and MTIE / TDEV are computed in real time. To check the TE results follow these steps:

1. From the *Home* panel, go to *Results*, The test port results panel is displayed.
2. Select *Port A* to enter in the port specific results.
3. Enter in *PTP* to display results about the PTP protocol.
4. Go to *Time Error statistics* to get the TE results.
5. Check the maximum and minimum values of *Total*, *Constant* and *Dynamic* TE and check that these are under the limits defined in ITU-T G.8271.1.

The MTIE / TDEV test is executed at the same time that the TE test. Real time results can be checked in the following way:

1. From the *Home* panel, go to *Results*, The test port results panel is displayed.
1. Select *Port A* to enter in the port specific results.
2. Enter in *PTP* to display results about the PTP protocol.
3. Go to *PTP wander test*.
4. Choose between MTIE or TDEV
5. Check the *Time*, *TIE*, *MTIE* and *Mask* results (*MTIE* results panel) or *Time*, *TDEV* and *Mask* results (*TDEV* results panel).
   Note: The TIE, MTIE and TDEV values must be understood as pktfilteredTIE, pktfilteredMTIE, and pktfilteredTDEV respectively.
   Note: The amount of time to wait before the first results are displayed depends of the filter settings.

To stop the TE and MTIE / TDEV tests press *RUN* a second time at any moment.

Case IV: SyncE Self-synchronized Test

Test case IV describes a test where the reference shares the same interface that the test signal. This reference travels from a unit configured in PTP master emulation mode to a unit configured in pseudo-slave mode but propagating the reference in the opposite direction is also possible as long as the network supports this setup.

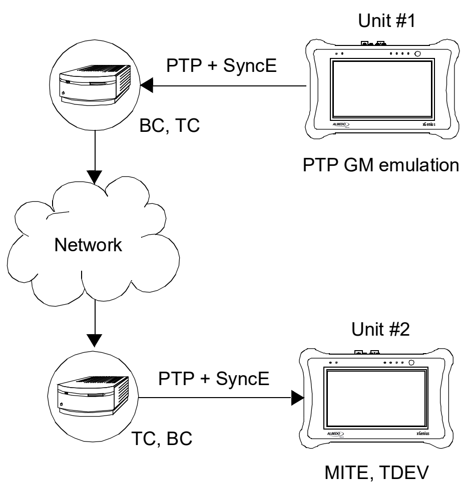

Figure 4 *SyncE self-synchronized test*

The test itself is similar to the test described in case III. What it makes different this setup is the way the clock reference is generated and distributed.

Connecting the Unit

Units #1 and #2 are connected to the test network in the same way that in test case III.

Setting up the Reference

Test unit #1has to be configured as a Synchronous Ethernet master. The procedure to do that is as follows:

1. From the *Home* panel, go to *Config*, The port setup panel is displayed.
2. Enter in *Port A* to display this port specific settings.
3. Go to *Physical layer*.
4. Go to *Autonegotiation.*
5. Configure *Clock role* to *Master*.

Now, unit #2 has to be configured to use the Synchronous Ethernet network clock as a reference clock. This is the procedure required to do that is described below:

1. From the *Home* panel, go to *Config*, The port setup panel is displayed.
2. Enter in *Port A* to display this port specific settings.
3. Go to *Physical layer*.
4. Go to *Autonegotiation.*
5. Configure *Clock role* to *Slave*.
6. Go back to the main *Config* menu.
7. Go to *Reference clock*.
8. Configure *Input clock* to *Ethernet (Port A)*.
9. Press *LEDS* to display the test unit status.
10. Wait for the REF and LOCK LEDs to become green.

Configuring PTP Master Emulation Mode

Proceed with unit #1 in the same way that described in test case II to configure the equipment in PTP master emulation mode.

Configuring the PTP Pseudo-slave Mode

Proceed with unit #2 in the same way that described in test case III to configure the equipment in PTP slave emulation mode.

Configuring the Test

Proceed with unit #2 in the same way that described in test case III to configure a MTIE / TDEV test.

Running the Test

Te test is now ready to start. Press *RUN* in the test unit to do that. Now MTIE / TDEV is computed in real time. To check the results follow these steps:

1. From the *Home* panel, go to *Results*, The test port results panel is displayed.
2. Select *Port A* to enter in the port specific results.
3. Enter in *PTP* to display results about the PTP protocol.
4. Go to *PTP wander test*.
5. Choose between MTIE or TDEV
6. Check the *Time*, *TIE*, *MTIE* and *Mask* results (*MTIE* results panel) or *Time*, *TDEV* and *Mask* results (*TDEV* results panel).
   Note: The TIE, MTIE and TDEV values must be understood as pktfilteredTIE, pktfilteredMTIE, and pktfilteredTDEV respectively.
   Note: The amount of time to wait before the first results are displayed depends of the filter settings.

To stop the MTIE / TDEV tests press *RUN* a second time at any moment.

Case V: ToD Self-synchronized Test

In this test case, there are two xGenius units running the master emulation mode and the pseudo-slave mode just as in test cases III and IV. Again, what it makes this test different is the way the reference is generated and distributed. Specifically this test case follows the same mechanism that test case II: one unit is locked to the ToD reference generated from the second unit.

Connecting the Unit

Units #1 and #2 are connected to the test network in the same way that in test case III.

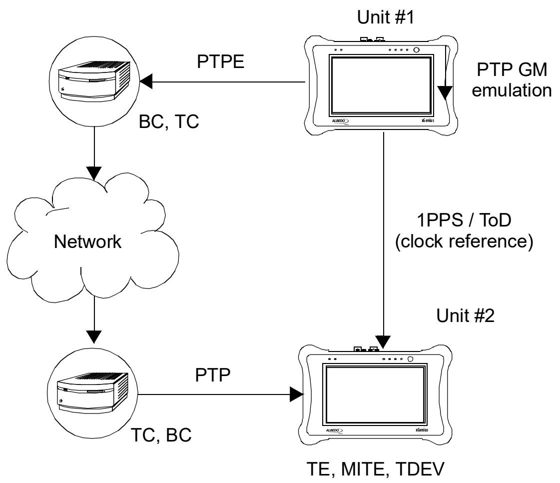

Figure 5 *ToD self-synchronized test*

Setting up the Reference

Proceed in the same way that in test case II to configure the ToD clock reference input and output in unit #1 and #2.

Configuring PTP Master Emulation Mode

Proceed with unit #1 in the same way that described in test case II to configure the equipment in PTP master emulation mode.

Configuring the PTP Pseudo-slave Mode

Proceed with unit #2 in the same way that described in test case III to configure the equipment in PTP slave emulation mode.

Configuring the Test

Proceed with unit #2 in the same way that described in test case III to configure a MTIE / TDEV test.

Running the Test

Follow the same procedure that in test case I to run the test.