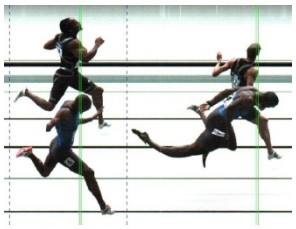
TECH NOTE :: QuantumX and IRIG-B Time Synchronization



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Abstract

This Tech Note describes how to time synchronize a QuantumX system to an IRIG-B time source. For this purpose you need minimum one MX840A/B or MX440A/B in your overall QuantumX system.

Intro

QuantumX is a modular distributable data acquisition solution from HBM for measurement and testing solving demanding engineering tasks for quicker innovation. The data acquisition modules offer highly accurate inputs acquiring physical quantities in the wide field of **mechanical, hydraulics, thermal** and **electrical or mixed systems** with data rates from 0.1 to 100 kS/sec and channel. QuantumX acquires sensor or transducer inputs measuring **force, strain, torque, pressure, temperature, displacement, speed, position, acceleration, flow, voltage, current and many more**. QuantumX offers superb A/D inputs supporting **voltage, current, bridge based inputs for strain gage or inductive transducers, LVDT, resistive, thermocouple, digital pulses** and signals from data busses like **CAN bus** parallel and time synchronous to all other inputs.

Some modules have output capability and work as signal converter (input to output), signal generator, real-time reaction (analog, digital) or gateway to other digital busses then Ethernet or FireWire like CAN bus or EtherCAT bus.

In general QuantumX can be time synchronized via FireWire, Ethernet NTP or PTPv2, IRIG-B or EtherCAT.

What is time?

We use clocks to be in time when meeting with other persons. In sport some fragments of a second can be decisive to win or lose a race. The necessary accuracy of the clock of course depends on the application.

In Test & Measurement applications high time accuracy between channels plays an important role in qualifying and analyzing measurement results. In the world-wide market and applications different timing mechanisms are established according to varying requirements on timing, latency and real-time ability.

When it comes to timing we have to differentiate between relative and absolute time.

An absolute time is needed when the acquired data for example a specific load in a monitored bridge construction shall be mapped to a certain real life event, impact or activity like the train crossing this bridge with an absolute time stamp like date-month-day-hour-second-millisecond.

An absolute time source can be:

- Terrestrial radio signal like DCF-77
- Satellite based GPS signal
- Other sources like dedicated internet located time server corresponding with clients over specific timing protocols like NTP (Network Time Protocol)

A relative system time is OK when a test is reproducible and the relative time of the signals to each other matters the most and no absolute time is needed. This is sufficient in most of the test & measurement applications.

The system time is explicitly available when it is represented by a clock. This is often necessary in complex systems. Now and again it has to be checked whether the deviation is tolerable and whether the clock needs to be corrected.

Two effects are in evidence when setting or synchronizing clocks: independent clocks initially run at an offset for one thing. To synchronize them, the more inaccurate clock is set to the more accurate one (offset correction). Another thing is that real clocks do not run at exactly the same speed. Therefore, the speed of the more inaccurate cock has to be regulated constantly (drift correction).

Time synchronization shall not be mixed up with real-time ability or time latency.

Real-time ability in a network with distributed modules or participants can be reached by a real-time bus like EtherCAT, ProfiNET, FlexRay, ARINC429. What does “real-time” mean? Real-time means deterministic behavior, so in general this means that a needed decision can be done with a time given (sensor -> control algorithm -> reaction / actuator).

Time latency is an aspect which has to be taken into account when it comes to design a control algorithm. For real-time control normally a fix and very low time latency from sensor to controller is needed. For non-deterministic protocols like Ethernet TCP/IP or CANbus time latency is variable.

QuantumX Time Synchronization Mechanisms – a comparison

Characteristic	Ethernet IEEE1588:2008 PTPv2	Ethernet NTP	EtherCAT	FireWire	IRIG-B
HBM DAQ product line	QuantumX B type modules, GENESIS GEN3i / GEN3t ...., SomatXR modules	QuantumX, MGCplus, Optical Interrogators	QuantumX	QuantumX	QuantumX, GENESIS
Important	Full network must work on PTPv2, even the switch but not the data sink (PC)	NTP master needed: light: PC / catmanEASY high quality: dedicated master	CX27B, support of distributed clocks	All modules: auto time sync, power, real-time mode	MX840A/B or MX440A/B any input necessary, FireWire inherits time stamp to other modules.
Max distance between participants	100 m electrical	100 m electrical, optical solutions, WLAN / WiFi available	100 m	5 m electrical 300 m optical	see FireWire
Sync Quality	100 ns to 1 µs	1 - 10 ms	< 1 µs	< 1 µs	< 1 µs
Sync Settling Time	Immediately	Up to 90 min first start up to 5 min standard	Immediately	Immediately	Immediately
Max Number of participants	PC and DAQ software is bottleneck	PC and DAQ software is bottleneck	See standard	12 in daisy chain 24 in star topology	see FireWire
Sync Master	Auto, best time	Dedicated master	EtherCAT master	Auto, lowest UUID	IRIG-B source
Special				Bus can work in real-time and power up to 1.5 A can be distributed	

QuantumX IRIG-B Support

The IRIG time codes were originally developed by the Inter-Range Instrumentation Group (IRIG) of the US Army. The standard was first published in 1960 and has been revised several times. The latest standardized version of IRIG is standard 200-04, “IRIG Serial Time Code Formats,” updated in September, 2004.

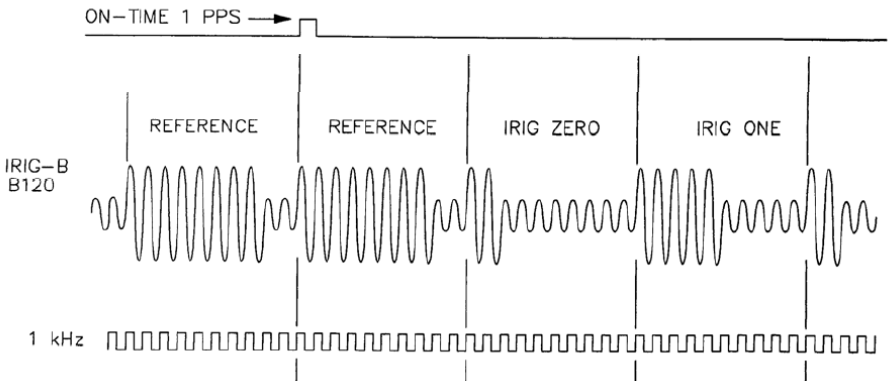
QuantumX can decode the IRIG-B types B000 through B007 and B120 through B127 on all inputs of the MX840B amplifier. The analog modulated IRIG signals needs to be connected to the 10 V analog input of the device (optional via

BNC: SUBHD15-BNC connector). The digital BCD modulated IRIG signals needs to be connected to digital frequency input without directional signal and is much more accurate. Wiring diagrams are part of the QuantumX operating manual.

IRIG-B time coded signals in general include time, year and optionally the seconds of the current day.

In case you parameterize a single input of MX840B working on IRIG-B this module will become the QuantumX time master and all other modules within the FireWire network are automatically time synchronized according to IRIG-B.

QuantumX does not support the Manchester coded version IRIG-B 2xx.

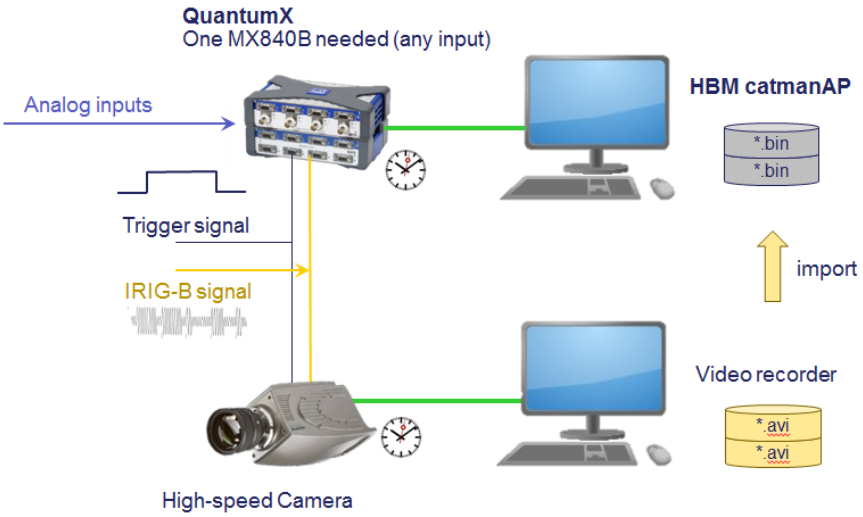


Coding: 1kHz amplitude-modulated. Source: IRIG standard 200-04

IRIG-B is dominantly used in aerospace and military applications and recently also together with high-speed cameras. Many of the testing labs in these industrial branches have an IRIG-B master installed somewhere and close to the test equipment you can find an IRIG-B port next to the Ethernet network. In general IRIG-B time sources are also available as box solutions with GPS sensor connection (i.e. Meinberg).

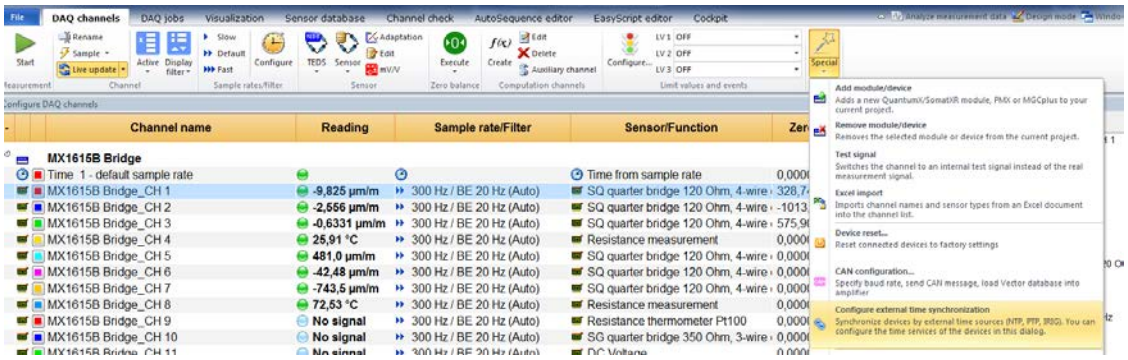
HBM GENESIS also supports IRIG-B as option to the mainframe. This IRIG option has an IRIG OUT, accessible with microdot connector on the front panel. If there is no IRIG IN signal source connected to GENESIS the IRIG-B OUT port will deliver the internal time as IRIG time code. Please set GEN DAQ time to RTC and GEN DAQ will just act as IRIG time source for QuantumX.

Possible QuantumX System Topology time sync'd with IRIG-B using a camera

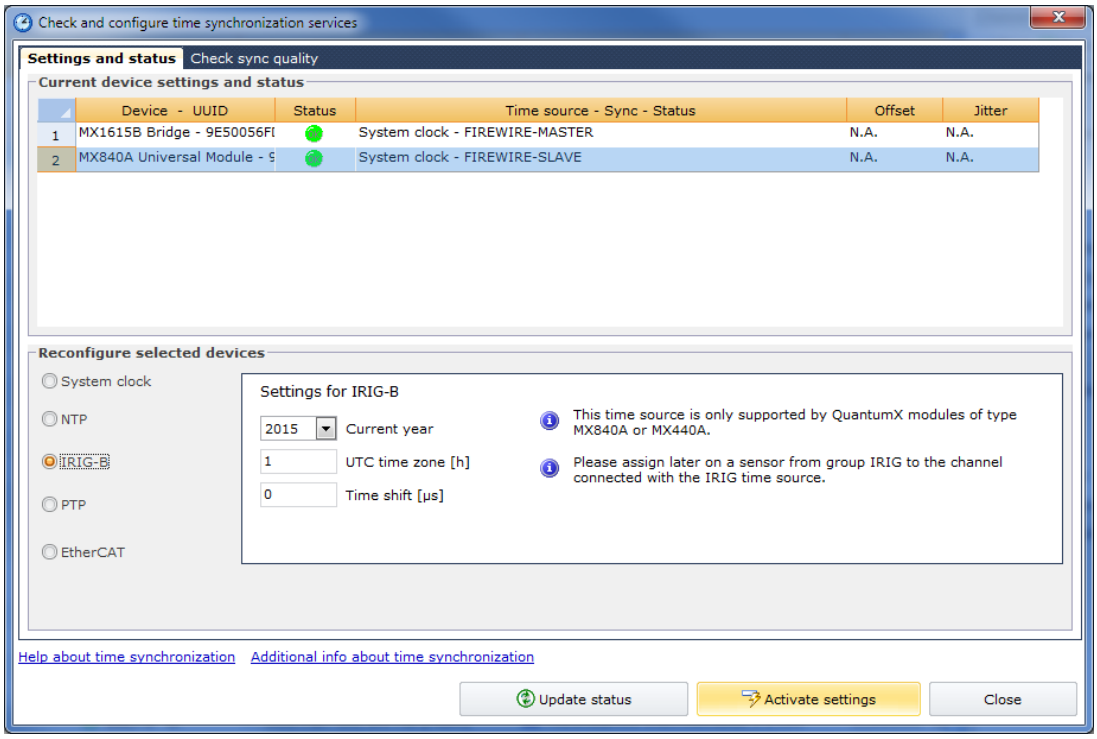


IRIG-B parameterization using the software catmanAP

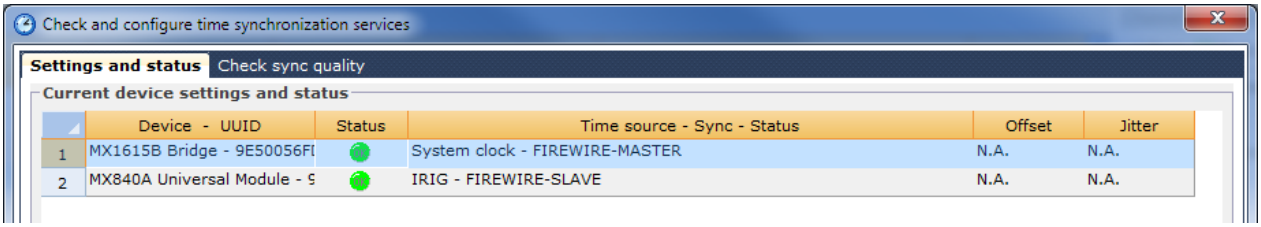
1. Special -> Configure external time snychronization:



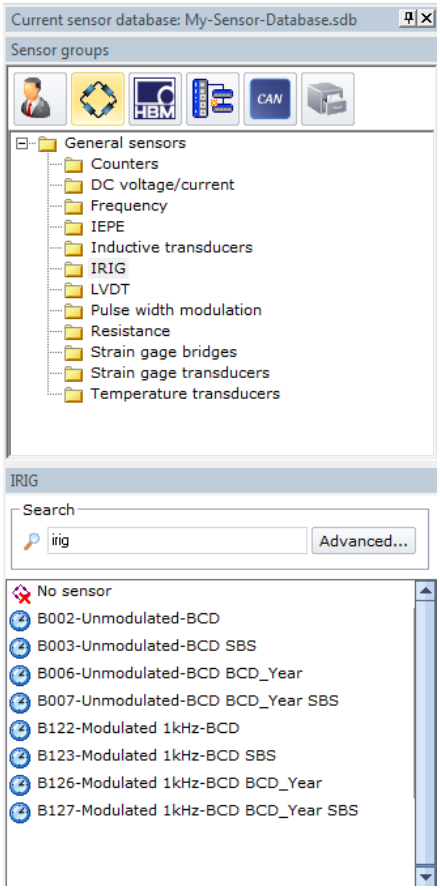
2.



Mark the MX840A/B in the list, set the time source to IRIG-B, enter year and your time zone to UTC (derived from Coordinated Universal Time, i.e. universal time, corresponding to Greenwich Mean Time or London time). Also take into account any difference due to summer or winter time. If you know the time delay between the IRIG-B time generator and your device, you can correct it using the entry for Time shift. Now activate the settings which transfers all the parameter to the device and then to all other connected modules via FireWire.



3. Now go to the channel list and assign the IRIG-B “sensor” to the channel where your IRIG-B time source is connected to.



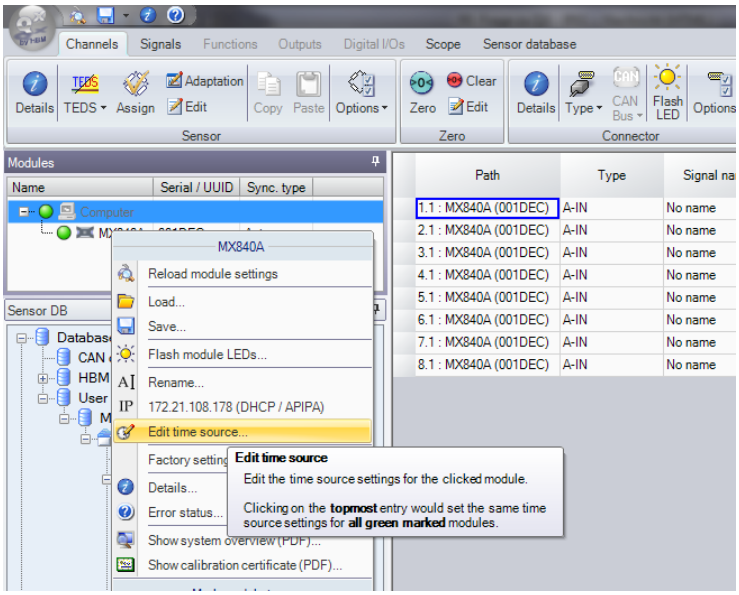
4. Check the data of the parameterized channel

After the first configuration, settling may be prolonged so therefore allow the devices need sufficient time to adapt.

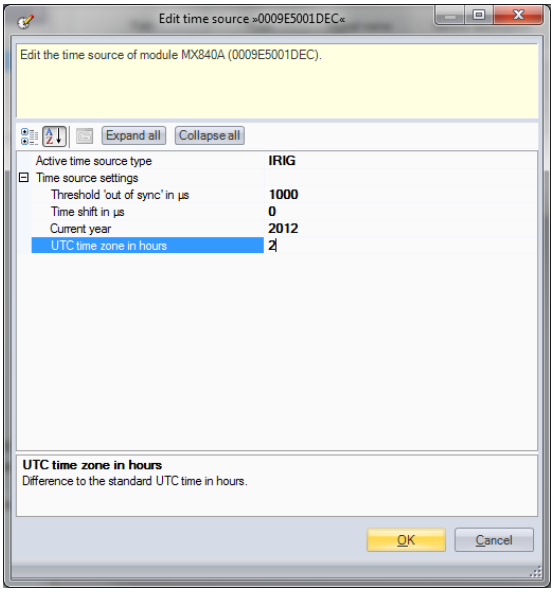
IRIG-B parameterization using the software MX Assistant

The following workflow shows the parameterization for IRIG-B.

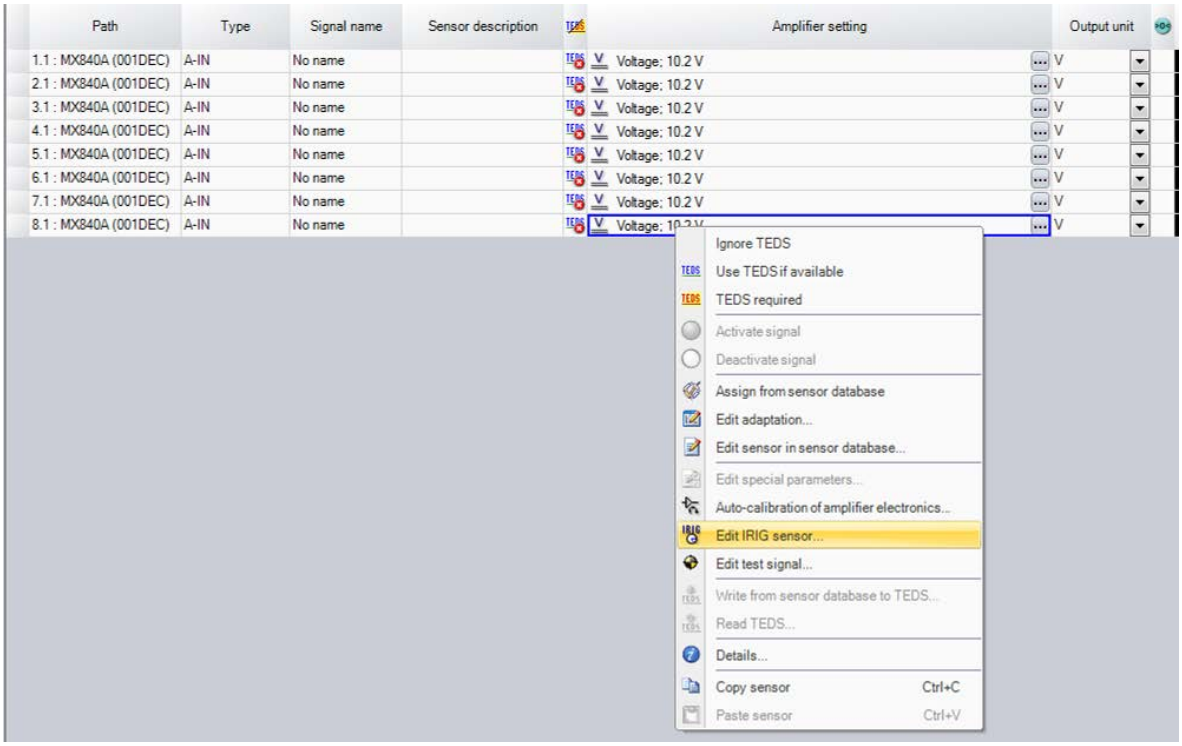
1. Right mouse click on your MX840A and enter the dialogue “Edit time source…”



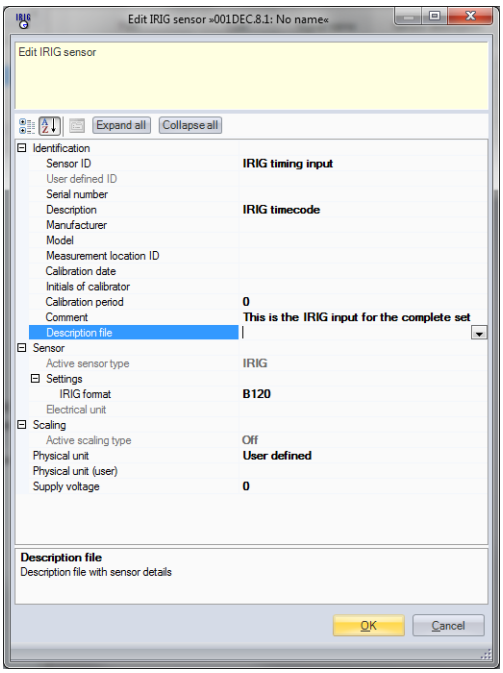
2. Select the time source to IRIG. All other modules connected to this master module over FireWire are then automatically time synchronized!



3. Now go to the channel list and open up the amplifier setting on the channel where your IRIG-B time source is connected to.



4. Now parameterize this IRIG channel:



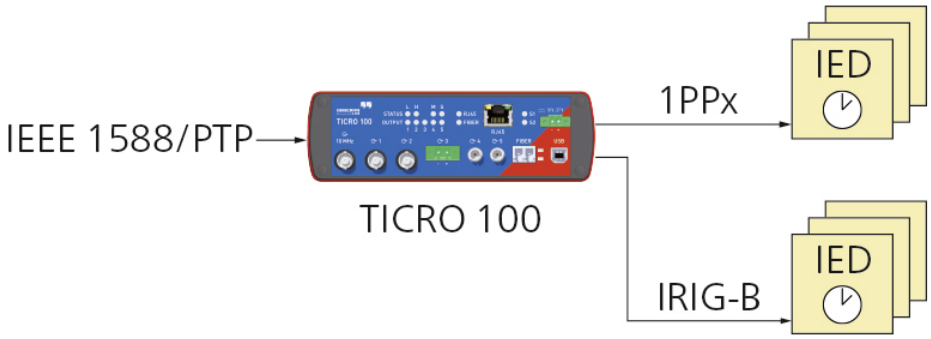
IRIG-B Camera

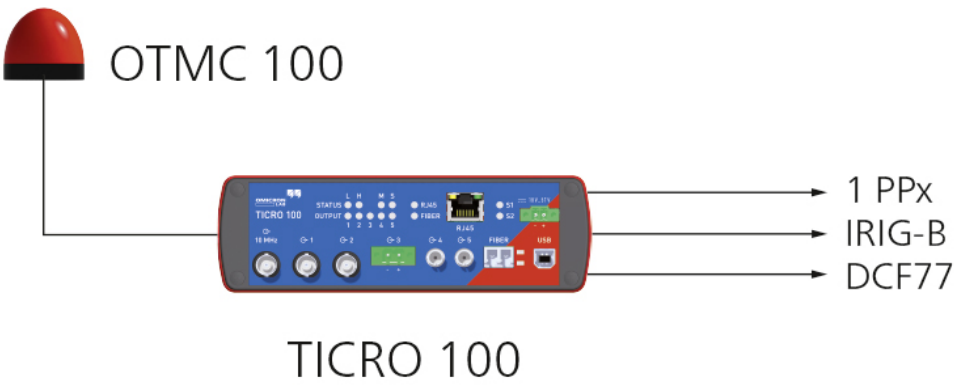
Photron FASTCAM-ultima APX

IRIG-B Time Sources

1. Build up your own IRIG-B time server or generator. There are many solutions available on the market. One supplier we tested and can recommend is the company Meinberg.
   https://www.meinbergglobal.com/english/products/irig-pci-usb-clocks.htm

2. Another supplier of time sources is Omicron and their product TICRO 100. The unit is a time converter which allows synchronizing several devices via PTPv2 and IRIG-B. OTMC is a GPS based time source.





3. GENESIS can host an IRIG-B board via an open XMC option slot. This unit can also generate a IRIG based signal to sync QuantumX with.

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