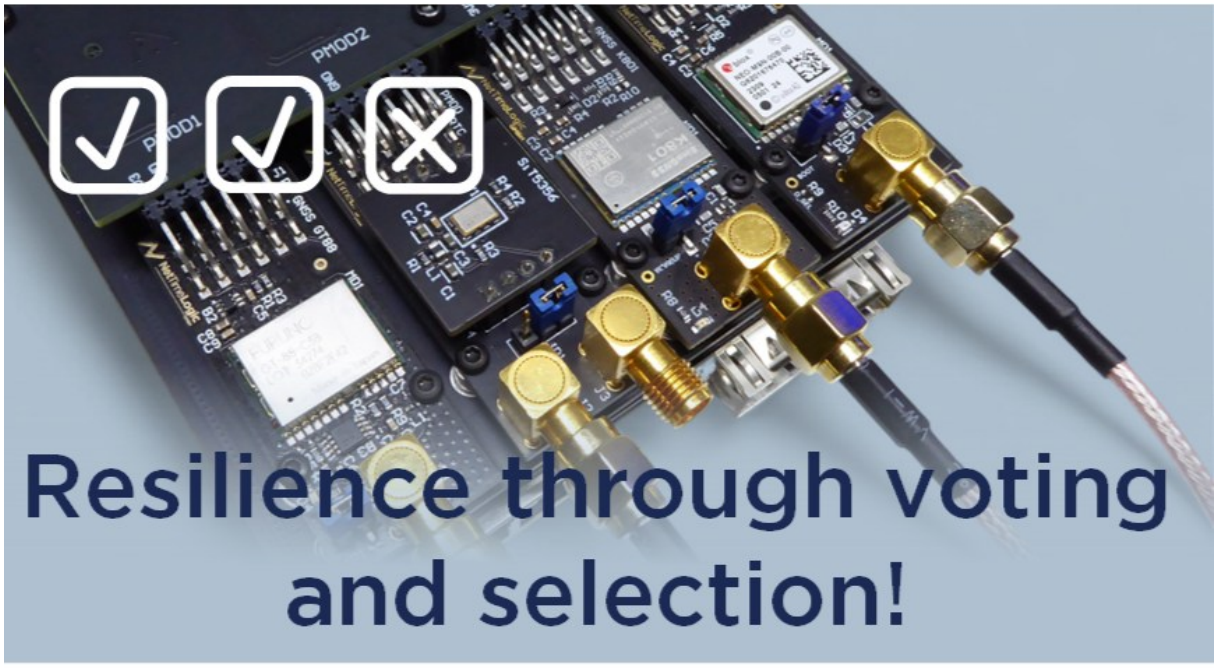



# Resiliency with majority voting and source selection

15. Juli 2025

NetTimeLogic is a leader in high performance, high accuracy and high resiliency time synchronization solutions.

In today's world where almost any critical infrastructure is relying on GNSS synchronization, GNSS jamming and spoofing are a major threat to national security.

Creating resilient timing synchronization solutions is key to overcoming these ever-increasing threads.

With NetTimeLogic's latest IP additions to its modular hardware platform AIONYX, resilient GNSS synchronization just got simpler. The next chapters will describe the countermeasure mechanisms that NetTimeLogic implemented to make NetTimeLogic's AIONYX platform the most robust synchronization solution on the market:

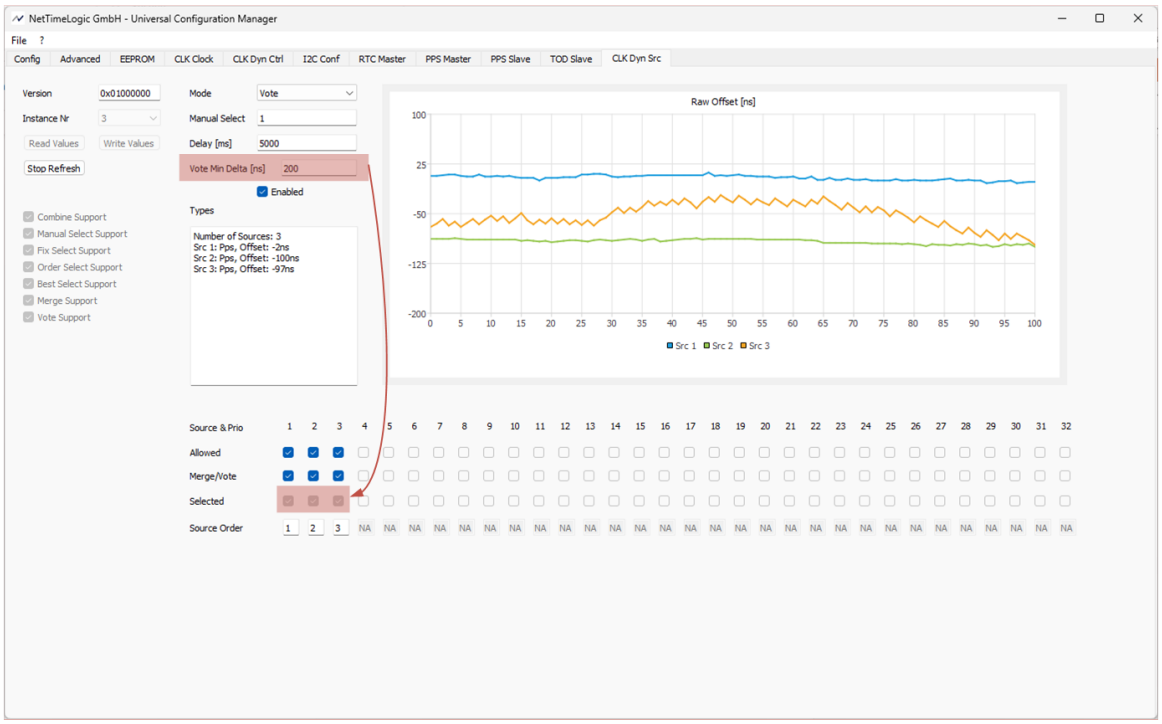
## Multi-Source Majority Voting and Merging

NetTimeLogic added an advanced voting and merging mechanism to its GNSS synchronized PTP Grandmaster and NTP Server configuration of the AIONYX platform.

The AIONYX platform allows to connect 3 GNSS receivers (same or multi-vendor) and a high stability oscillator within one AIONYX-S or AIONYX-M hardware configuration.

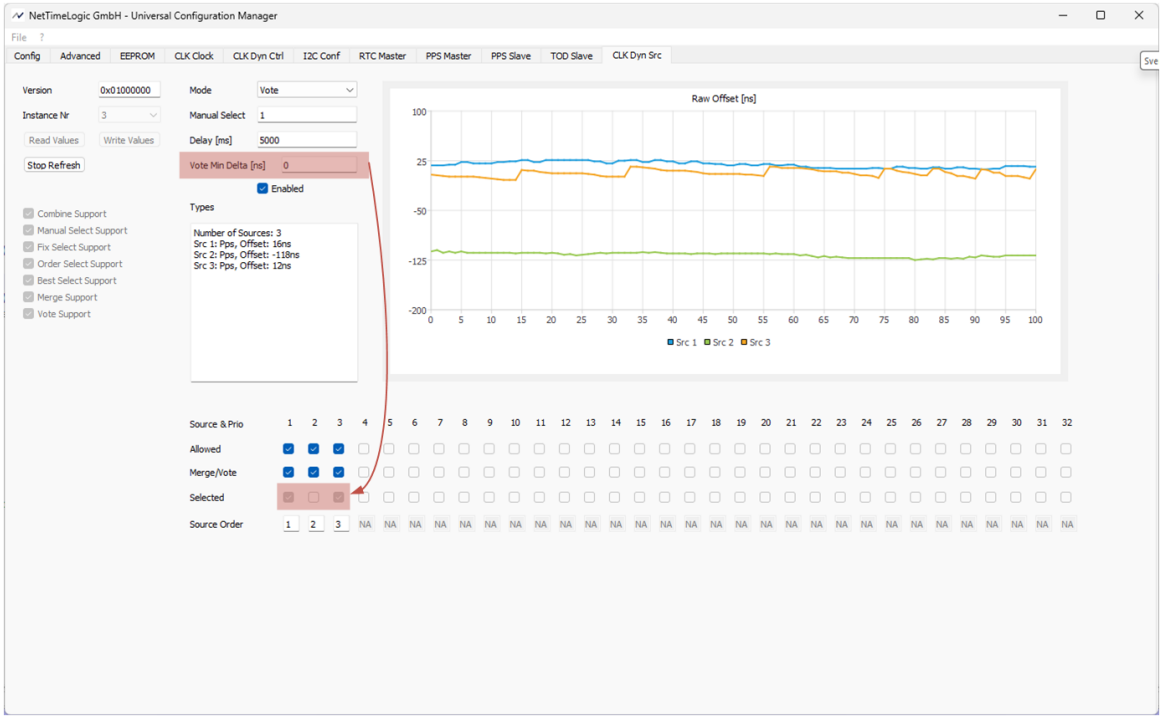
Having 3 GNSS receivers allows us to make a majority vote over these three time sources. Each of the receivers is connected to an individual PPS Slave and TOD Slave IP. The PPS Slave IP uses the PPS signal from the receiver to calculate the frequency and phase difference of the local oscillator whereas the TOD Slave IP extracts and calculates the time of day from the NMEA/UBX/ESIP/TSIP messages received via the serial interface from the receiver.

For the PPS Slave adjustments, the individually calculated offsets are then averaged. The absolute difference from the average for each offset is then used for voting. The N/2+1 (e.g. 2 out of 3) sources with the smallest difference are selected for merging. If the difference is less than a configurable threshold the source is selected for merging even if the voting would not select this source (this avoids switching sources and allows averaging over more sources if all sources are close to each other). If only one or two time sources are available no voting can take place and the available sources are selected for merging.




Voting with minimum Delta

For the TOD Slave time adjustments, the voting works the same way but based on the delta to the absolute time to be set and the threshold mechanism does not exist since adjustments will be done in second steps and are absolute times.




Voting without minimum Delta

The same scheme will be used also for setups where there are more than 3 sources available. The more sources the more resilient the voting: e.g. 3 out of 5 voting allows for two erroneous sources. The additional sources do not have to be GNSS, it could also be PTP, NTP, IRIG, PPS etc. basically any primary reference that you have available. This also reduces the dependency on GNSS.

After the voting comes the merging. As for now the merging is a simple averaging over the voted sources. Note: for the future it will be analyzed if a weighted voting and merging will provide even better results.

The voting and merging will not only be useful for the case where a GNSS source fails e.g. due to jamming but also for the case where a GNSS source gets actively manipulated e.g. by undetected spoofing. To get the maximum resistance to GNSS manipulation, it is desirable to use three different receivers from three different vendors with three individual GNSS antennas located as far as possible apart from each other as possible. Unlike other players which need three dedicated devices to achieve this (if possible after all), with NetTimeLogic's AIONYX platform you can do all this easily within one device - just choose your favorite three PM GNSS modules, take a PM CLK RTC and you are ready to go. Of course, you can also have multiple AIONYX platforms to increase the resiliency even more, but this is not a requirement.

Sourcing from the same antenna and using of identical receivers will reduce the resiliency since only a single antenna needs to be spoofed or jammed and it is much easier to get around the spoofing detection built into the GNSS receiver when they all use the same mechanism.

When jamming is detected the specific time source is simply not available anymore, when all sources are jammed the device goes into holdover.

In the case of spoofing the scheme is different. When spoofing is detected the time source is marked as unavailable, however if the spoofing is not detected by the receiver the voting mechanism will take over and if it differs from the majority it will ignore the source. Undetected spoofing can be worked around if the majority of receivers are still ok. Additional spoofing detection can also be integrated after the receiver, to get an even higher chance of spoofing detection and not purely rely on the spoofing detection in the GNSS receivers. Similar to jamming if all sources are detected to be spoofed, the device goes into holdover.

This is according to the following scheme: Better no source, than a wrong source.

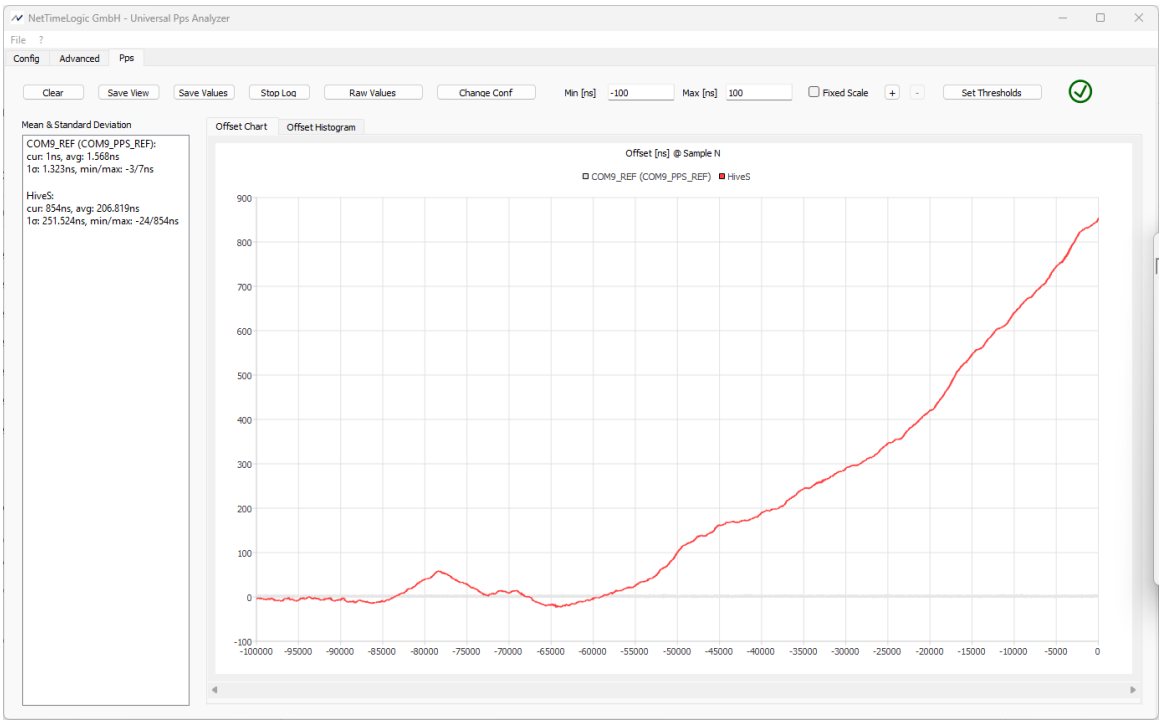
But if GNSS is not the only time source you have connected (e.g. PTP, NTP, IRIG or PPS) to the AIONYX platform the voting of course will simply just switch to this backup time source if GNSS fails, which brings us to the next mechanism which was implemented: Source Selection.

### Source Selection

This mechanism runs on top of the voting and merging mechanism of the individual time source types and can run in multiple modes: Manual Selection, Fix Order Selection, Dynamic Order Selection, and Best Selection. This allows us to select the best possible time source for the system in different ways. The Best Selection mechanism is for sure the most advanced mode and takes multiple parameters into account to automatically select the best time source for the system without the need of any user interaction.

## Advanced Holdover

As you can see having a very good holdover is key to withstand also longer periods of spoofing and jamming. Check out how great our holdover already is even with a comparably cheap (compared to a Miniature Atomic Clock or DOCXO) MEMS oscillator and no aging and temperature compensation.
Our advanced holdover scheme includes rate limiting, outlier filtering, long-term disciplining, averaging and with our latest addition also aging compensation (and in the future also temperature compensation).




24h holdover< 1us with aging compensation

More on the latest added aging compensation we will talk about in a separate post.