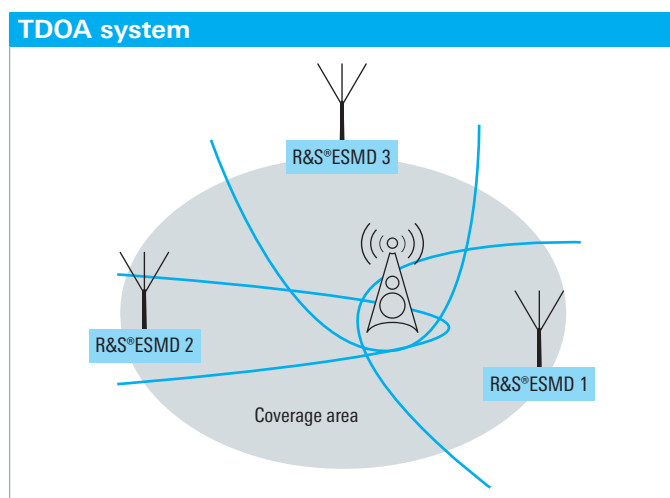# Increasing timestamp accuracy in TDOA applications

Using the internal R&S®ESMD-IGT GPS module and external GPS antenna in the R&S®ESMD wideband monitoring receiver

TDOA system

Coverage area

Your requirements

In a time difference of arrival (TDOA) network, the time difference of a signal's arrival at three or more receiver locations is measured. The measured time differences make it possible to determine the signal's geographical origin. Due to the high propagation speed of electromagnetic waves, the receivers' biggest challenge is to insert the high-precision timestamp in the I/Q data stream. This requires a suitable method for synchronizing the time in the receivers. Absolute timestamps that are independent of the receiver settings are necessary for maximum system flexibility.

Monitoring solution

The R&S®ESMD-IGT option adds an internal GPS module to the R&S®ESMD. When a GPS antenna is connected, the module delivers the GPS time and position to the R&S®ESMD.

The GPS pulse per second (PPS) signal is used to synchronize the internal 10 MHz reference frequency in the R&S®ESMD. A software-controlled loop minimizes the influence of the PPS signal's usual jitter, considerably increasing the frequency stability and time accuracy of the R&S®ESMD.

This Rohde & Schwarz solution provides a high-precision, absolute timestamp in the baseband data stream with no additional effort (for detailed values see R&S®ESMD data sheet, PD 5213.9863.22).

In TDOA applications, the smallest mistakes when inserting the timestamp can lead to incorrectly calculated positions. Changes in various settings (e.g. center frequency, bandwidth, span) influence the signal delay in the receiver. Ignoring this fact can lead to significant positioning errors caused by inaccurate timestamps. The R&S®ESMD exactly takes into account the temporal influence of all elements in the processing chain. The timestamp inserted in the I/Q data stream corresponds to the exact instant when the signal reaches the antenna input of the R&S®ESMD. It is therefore possible to set up a heterogeneous TDOA network, which includes various receivers for different site requirements (large-signal immunity, sensitivity, realtime bandwidth, etc.). Conventional TDOA systems have to be set up with identical receivers that have the same settings at the time of measurement. This considerably complicates implementation and the actual measurement, and significantly limits flexibility.

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Application

If an R&S®ESMD equipped with the R&S®ESMD-IGT option is brought to a new site within clear sight of at least four GPS satellites, it takes about 26 s for the GPS module to determine the current position. After about 20 min of operation, the synthesizer's heated crystal oscillator (OCXO) reaches its optimum operating temperature. The PPS provided by the GPS module additionally increases the accuracy of the internal reference frequency. The R&S®ESMD continually monitors the accuracy during operation. When the synchronization of the internal reference frequency with the PPS has been completed, the user receives a message on the GUI.

Depending on the requirements, the internal GPS module can be used in three different operating modes:

Free run mode

In free run mode, time accuracy is the lowest. The position determined by the GPS module is subject to considerable jitter, which also affects the time behavior. An averaging time is not necessary, however, and the position does not need to be known.

Averaging mode

In averaging mode, the R&S®ESMD averages the position data until a user-defined minimum positioning accuracy and the minimum averaging time have been reached. As soon as the averaging position data is as accurate as required, the receiver automatically switches to fixed mode.

Fixed mode

In fixed mode, the R&S®ESMD uses a static position as a reference, which means that the time behavior also reaches maximum accuracy. If a receiver is brought to a location with exactly known coordinates, these can be preset in fixed mode. If the position data does not comply with the actual location, the R&S®ESMD switches to free run mode. In all cases, good satellite reception is required for accurate position data and precise timestamps.

R&S®ESMD user interface with R&S®ESMD-IGT GPS module and external GPS antenna

Graphical indicator
Use of internal reference frequency (synchronized with the PPS), synchronization completed.
This indicator is displayed after the OCXO has warmed up and the PPS control loop has settled. Once synchronization has been completed, the maximum time-stamp accuracy is reached at a fixed GPS position (fixed mode).

Designation	Type	Order No.
Wideband Monitoring Receiver, without front panel control	R&S®ESMD	4066.0004.02
Wideband Monitoring Receiver, with front panel control	R&S®ESMD	4066.0004.03
Internal GPS Module and External GPS Antenna	R&S®ESMD-IGT	4079.8009.02

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