AN03 GPS Timing

Introduction

It is well known that GPS can be used as a source of highly accurate synchronisation and time transfer. The ability of the GPS system to achieve this is down to the fact that the GPS satellites themselves are synchronised with on-board Caesium or Rubidium atomic clocks that are in turn synchronised to GPS time (GPS time has a direct relationship to UTC).

In this way, it means that the GPS satellites are all phase coherent that allows the GPS system to be used as method of highly accurate synchronisation for systems that can be on opposite sides of the globe. Similarly, highly accurate time transfer can be achieved with the GPS system.

There are various forms of GPS based equipment on the market designed for synchronisation, but NavSync has a unique GPS receiver platform that allows the direct generation of a GPS steered output frequency and 1pps signal, with the ability of the receiver to maintain GPS lock even in extremely poor signal strength areas. This unique ability allows the GPS antenna used in the system to be sited in far more convenient locations (even inside buildings) with reduced cabling requirements and often the removal of any lightning strike protection.

NavSync CW25-TIM GPS Receiver

The CW25-TIM GPS receiver module is an extremely small surface mount module with dimensions of only 25mm x 27mm x 3mm which incorporates an internal Numerically Controlled Oscillator (NCO) that creates an output frequency that is GPS software steered by the baseband processor of the CW25-TIM. This NCO is user programmable to any frequency in the range of 10Hz to 10MHz, which can simplify any follow on Phase Locked Loop (PLL) design.

The CW25-TIM receiver uses specialised firmware that is designed specifically for GPS synchronisation, and will automatically enter a Self Survey mode of operation on power up. The Self Survey mode allows the receiver to continuously calculate its geographic position for a period of 20 minutes (the NCO frequency is valid during this period but the phase error will fluctuate relative to the positional error). After the 20 minute self survey period, the receiver will automatically calculate an average of the geographical position and fix this value in the receiver firmware, which allows the phase error of the NCO output frequency to be more accurately controlled.

More importantly, the receiver now no longer has to calculate a positional fix to update the NCO and this allows the receiver to maintain a highly accurate NCO output even down to one satellite being tracked. This feature means that the receiver would have to completely lose sight of all GPS satellites to stop the NCO being synchronised to GPS, which means that the CW25-TIM can be used as a highly reliable source of GPS synchronisation.

Another unique feature of the CW25-TIM is the ability to maintain a positional fix with extremely low signal strengths. A more detailed description of how this is achieved is explained in **AN01 Indoor GPS**, but effectively the CW25-TIM can track satellites down to levels of –155dBm which relates to signals typically seen deep inside buildings. Although at such signal levels the receiver would need network assistance to acquire new satellites and therefore maintain long term GPS synchronisation (see **AN02 Network Assistance**), it means that the CW25-TIM receiver can easily maintain reliable autonomous GPS synchronisation with the antenna placed in relatively poor signal strength areas such as inside buildings next to windows etc. This means that the antenna does not need to be located up a mast or on the rooftop as is the norm, which considerably reduces the cost and complexity of deployment in terms of antenna cabling and lightning strike protection.

CW25-TIM Performance

The following section describes the synchronisation performance of the CW25-TIM in terms of Maximum Time Interval Error (MTIE) which is an internationally recognised metric of any clock source. The definition of MTIE is as follows;

The maximum error for all possible measurement intervals within the measurement period.

Test Set Up

The MTIE measurements were conducted on the CW25-TIM with the test set up as shown in Figure 1

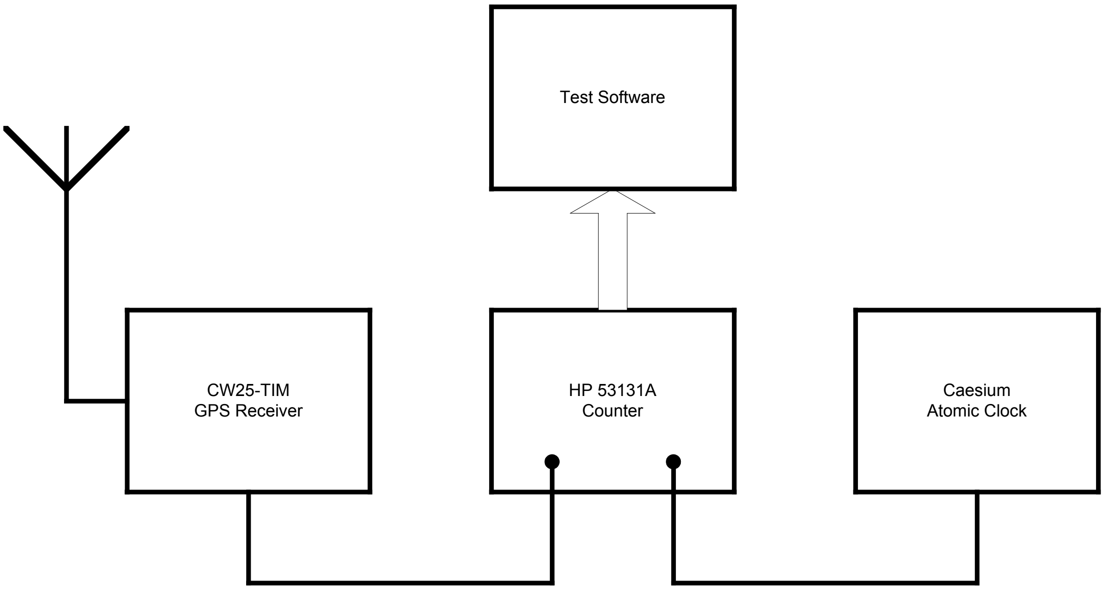


Figure 1

The HP53131A counter measures the time interval between the output frequency of the CW25-TIM relative to the highly stable and accurate reference provided by the Caesium source and provides the data over a GPIB interface to the measuring software located on the PC (the software used is the TimeMonitor software from Symmetricom).

The software logs the measured phase error over time and post processes the data to allow the creation of MTIE data for the CW25-TIM unit under test.

Test Results

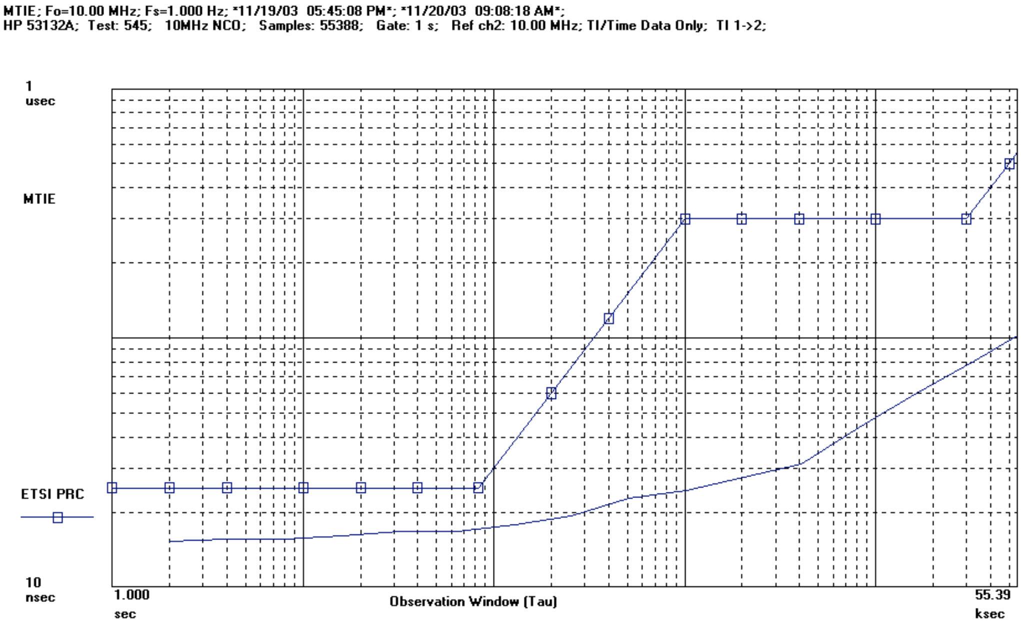
The test results achieved with the described test set up are outlined below for three different test scenarios;

(1) MTIE with outdoor antenna

(2) MTIE with indoor antenna

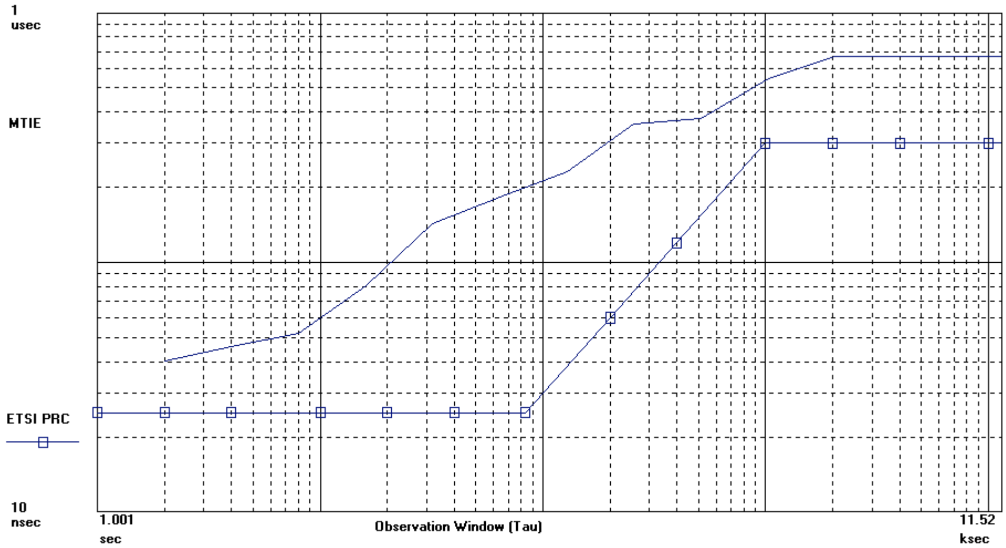
(3) MTIE with window antenna

MTIE with outdoor antenna



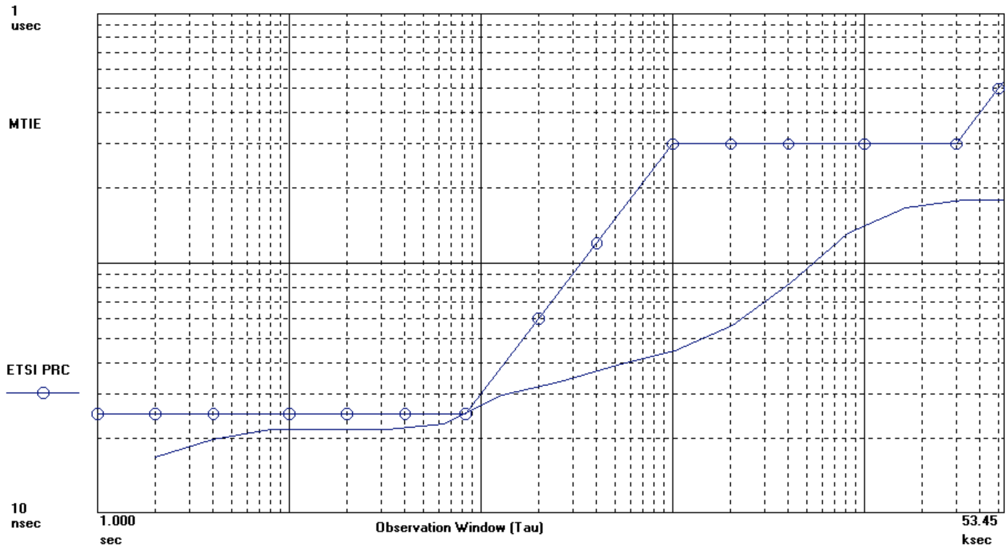
MTIE with indoor antenna

MTIE; Fo=10.00 MHz; Fs=999.0 mHz; "2/12/04 02:38:18 PM"; "2/12/04 05:50:27 PM";
HP 53132A; Test: 589; cw25_indoor_tim; Samples: 11506; Gate: 1 s; Ref ch2: 10.00 MHz; TI/Time Data Only; TI 1->2;



MTIE with window antenna

MTIE; Fo=10.00 MHz; Fs=1.000 Hz; "9/6/04 12:57:36"; "9/7/04 03:48:22";
HP 53132A; Test: 662; Window antenna; Samples: 53446; Gate: 1 s; Ref ch2: 10.00 MHz; TI/Time Data Only; TI 1->2;



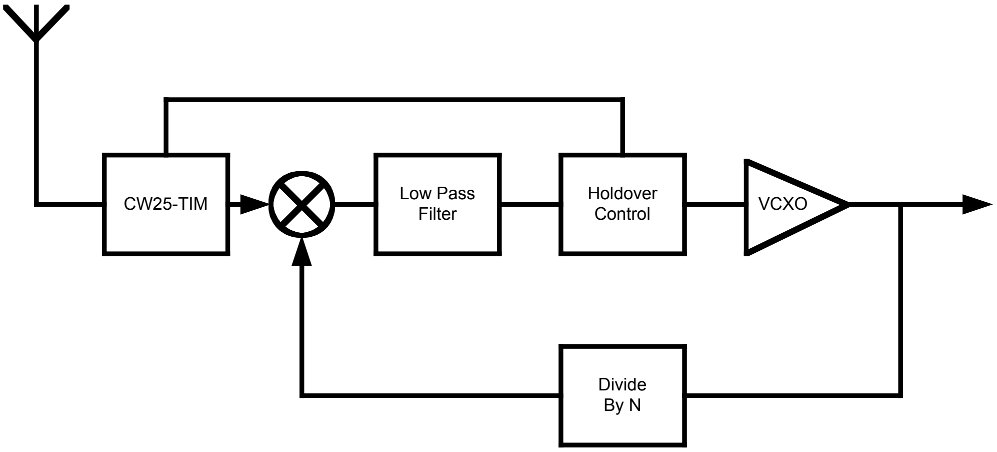
The test data shows that the CW25-TIM can be used as a highly reliable source of GPS synchronisation even with an antenna located in a poor signal strength area. However, the CW25-TIM does not have the capability of outputting a GPS steered frequency when there are no GPS signals at all – in other words, the receiver has no holdover capability.

Furthermore, because the NCO is a digital synthesiser it suffers from relatively poor jitter and phase noise. Whilst this may not be an issue in certain applications, it would create issues in a telecom or RF application.

To overcome this, NavSync can in conjunction with its parent company Connor Winfield (who are recognised experts in Telecom grade synchronisation modules), produce complete synchronisation modules that include the CW25-TIM receiver.

These modules typically use one of the following architectures;

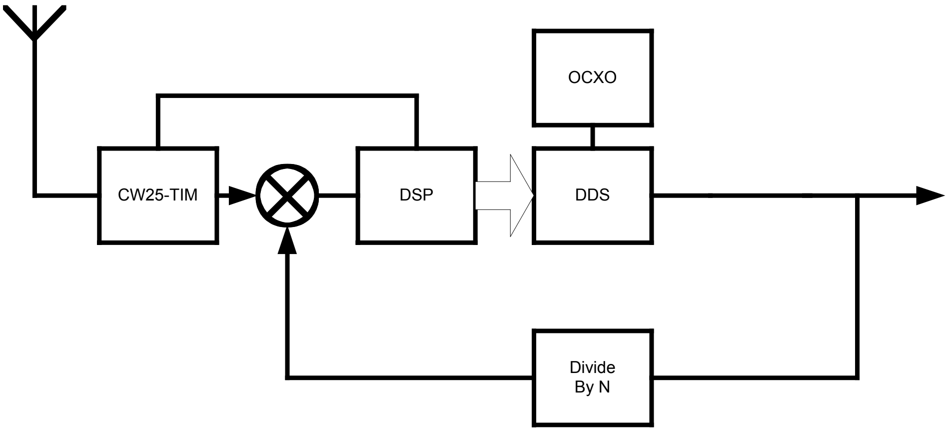
Crystal Oscillator Based



This architecture allows the addition of a PLL based around a crystal oscillator. This means that the PLL de-jitters the NCO frequency and the PLL output will have the phase noise performance of the specific crystal oscillator used in the PLL design. Furthermore, the architecture will allow holdover during loss of the GPS reference frequency by allowing the crystal oscillator to free run (in this way the holdover performance of the design is defined by the frequency stability of the crystal oscillator and Stratum 3 and Stratum 3E holdover performance can be achieved using OCXO oscillators).

What this architecture cannot do is achieve “hitless” switching between input references or achieve smooth MTIE transitions in and out of holdover as required by the various telecom standards.

Direct Digital Synthesis Based



When highly accurate control of the PLL during entry in an out of holdover is required, as well as “hitless” switching between input references, NavSync can also provide an architecture based around Direct Digital Synthesis (DDS). This architecture uses a DSP processor to control the DDS to allow very fine control of the DDS output which allows the system to limit the rate of change of the DDS frequency relative to system changes (such as the requirement to enter holdover). This allows the synchronisation module to achieve full telecom standards such as GR1244, G812 etc.

Conclusion

From the descriptions and data presented in this application note it can be seen that the CW25-TIM receiver can provide a highly accurate and reliable source of GPS synchronisation. The CW25-TIM receiver is intended to be embedded within OEM equipment that requires such a source of GPS synchronisation.

For applications where the OEM equipment requires a complete GPS synchronisation module, such architectures can be realised either as modules with a small footprint that are intended to be embedded within the OEM system, or as stand alone units. For further details of either the CW25-TIM or any of the synchronisation modules, please contact NavSync (contact details are available on www.navsync.com).