Spectrum INSTRUMENTS, INC.

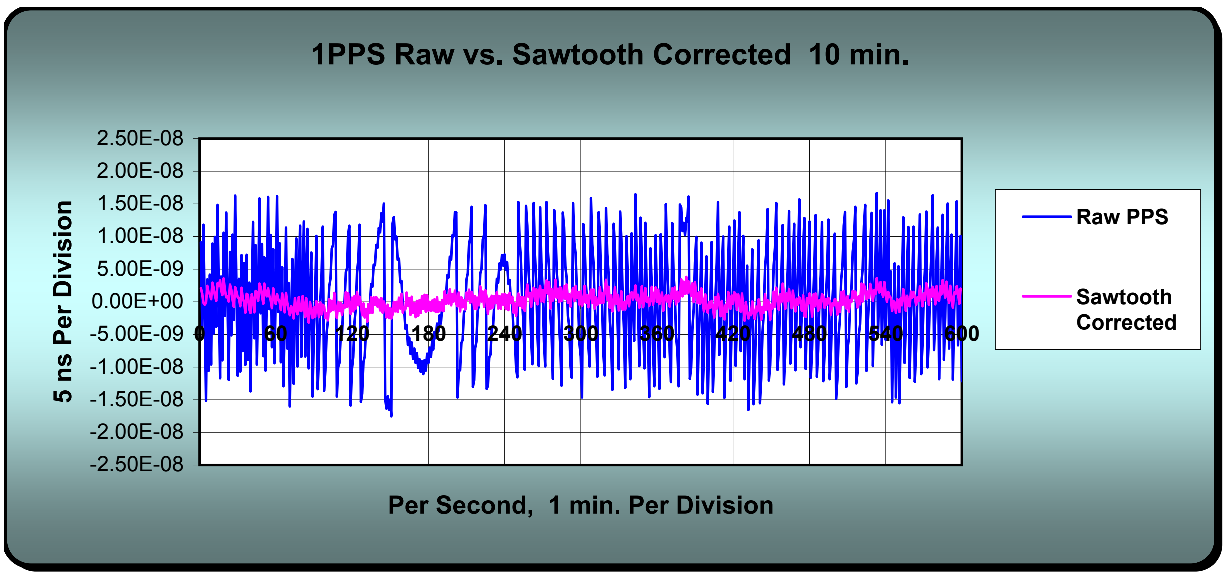
Developments in Accuracy & Phase Coherency

The most recent advancements in Spectrum's technology have been incorporated into the TM-4 platform, and are the result of breakthrough developments in both accuracy and phase coherency.

Real-time Sawtooth Correction

The TM-4 architecture removes the deterministic underlying noise (caused by granularity inherent in the GPS receiver's clock circuits) when generating the Pulse-Per-Second (PPS) signal. By applying negative sawtooth residual correction in real-time, the TM-4 compensates for error and reduces the pulse-to-pulse variability in the raw PPS from the ± 15 ns typically found in competing units to an unprecedented ± 5 ns.

Because the TM-4 applies the sawtooth correction in real-time, it can also use this lower-jitter signal to discipline its internal primary reference oscillator, making for an overall more stable and accurate system.



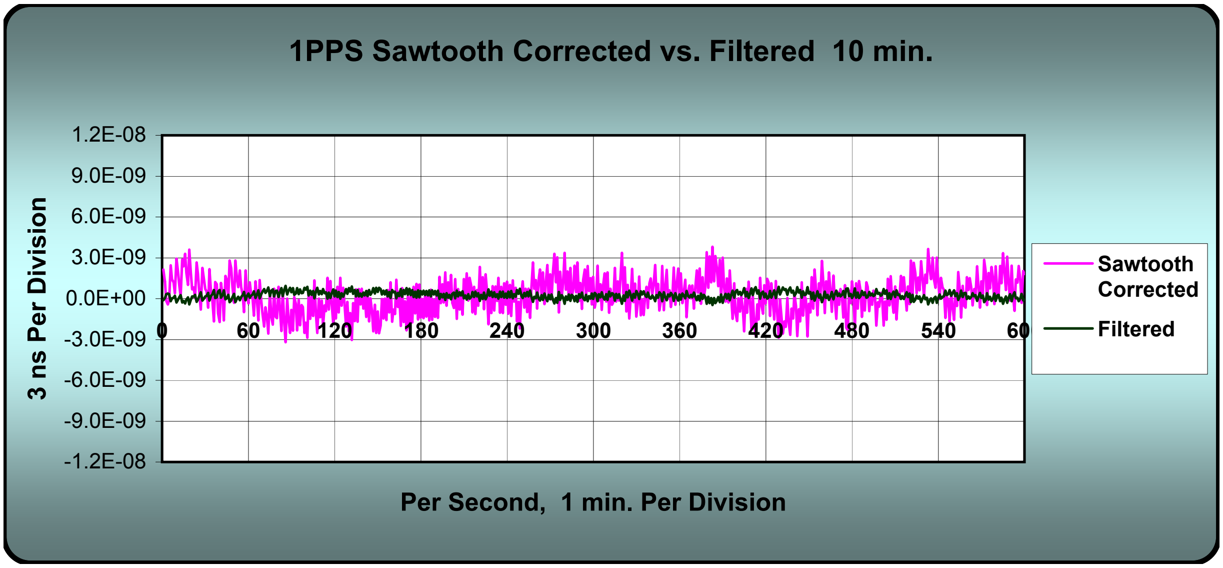
Time interval between PPS signals and Rubidium reference oscillator.
Raw PPS is from GPS receiver before sawtooth correction.

Filtered PPS

The TM-4 architecture provides the user with the choice of the raw, sawtooth-corrected PPS from the GPS receiver (GPS PPS), or a smoothed (Filtered) PPS derived from the internal primary reference oscillator. The resulting Filtered PPS is essentially free of jitter and is as stable as the reference frequency. The primary reference oscillator is phase-locked to GPS PPS, and the Filtered PPS is more accurate in relation to UTC than even the sawtooth-corrected GPS PPS because of the elimination of jitter.

The TM-4 default setting is to supply GPS PPS before the primary reference oscillator is locked, and then automatically switch to Filtered PPS when phase lock is achieved. This way, the PPS output is always assured to be the most accurate possible at any givern moment in time. For specific application requirements, the PPS output can also be programmed to provide either source and not switch.

The comparison of Filtered PPS to sawtooth-corrected GPS PPS is shown on page 2.



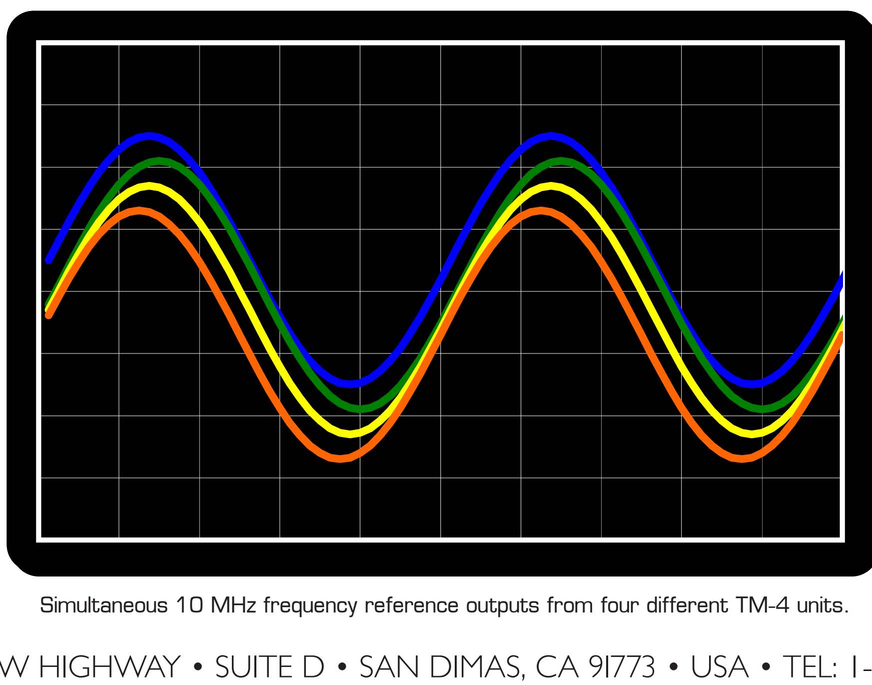
Time interval between PPS signals and Rubidium reference oscillator. Both signals simultaneous from same TM-4 unit

Phase Coherency

Time Difference of Arrival and other phase coherent radio applications need frequency references that are phase coherent from unit-to-unit. A variant of the TM-4 architecture originally developed to optimize for phase coherency has proven superior for most applications and has now been incorporated into all of the products in the TM-4 family.

The previous architecture had a long, fixed time-constant so that the impact of any disturbance to the oscillator (change in temperature, vibration, aging, etc.) would be spread over a long period. Over a period of time, the zero crossing of the primary frequency reference would converge on the rising edge of PPS, and units would become phase coherent. This architecture maintained steady frequency, but due to the tuning action of each unit and individual oscillator, it was possible for unrelated units to be out of phase from each other for periods of time.

The new phase-coherent architecture has an adaptive time constant. If the oscillator is disturbed or drifts out of phase, the TM-4 will apply a shorter time constant to more quickly bring the oscillator back into phase with PPS. When the unit returns to stable conditions and is holding the oscillator in phase, the control loop time constant will then extend to achieve the highest level of stability. By maintaining a tighter phase lock to PPS, each separate TM-4 unit is maintained in tighter phase coherency with every other unrelated unit.



Simultaneous 10 MHz frequency reference outputs from four different TM-4 units.