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CONTENTS

50

65

76

84

Technology Special:

FEATURES

COLUMNS

DEPARTMENTS

An accurate computer clock is important for certain digital modes and for contest logging. How can you automatically keep it correct when you aren't connected to the internet? K5PA says the answer is over your head…

Using GPS to Set Your Computer Clock in the Field

BY GENE HINKLE,* K5PA

It is important to have time set correctly on computer platforms so that amateur radio digital mode applications such as WSJT-X are synchronized within a second or better of each other and to allow logging programs to save the correct UTC (Coordinated Universal Time) time for contacts. Many solutions exist when connected to network infrastructures. Indeed, Windows®-based platforms can use network time servers to gather and set the computer's time automatically.

When operating away from your shack, however, it is a different story. How can you automatically set time when your computer is not connected to the Internet? This is a situation commonly faced when operating ham radio in the field or on DXpeditions to remote areas where the internet time is unavailable or unreliable.

You can manually set the time using shortwave time broadcasts, such as WWV or CHU, where reception is available. However, there are few alternatives other than highly accurate clock standards. I was looking for a better solution that could be used at home, in the field, or during a DXpedition, and that would be automatic and foolproof.

The solution I found is to use the Global Positioning System, or GPS (Figure 1). There are readily available and inexpensive ($30 class) "hockey puck"-style GPS receivers with integrated L-band antennas available from Amazon, eBay, and other vendors on the internet. These GPS receivers have USB serial data interfaces and power is provided through the data cable. Just by adding the GPS receiver to the computer's USB port, it is possible to read

Figure 1. With a simple receiver and inexpensive software, you can use GPS satellites to keep your computer clock accurate from any place where you can see the sky.

Photo A. GlobalSat Model BU-353-S4 USB GPS receiver and Type A male-to-female extension cable (10 feet).

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What is GPS?

The NAVSTAR Global Positioning System (GPS) consists of a constellation of satellites that circle the Earth twice each day and include a precise set of clocks that are synchronized by a command and control center operated by the U.S. Air Force. Each GPS satellite transmits a unique pseudorandom code at UHF frequencies that allow receivers to measure precise distance and time. By using multiple satellites simultaneously, receivers can measure latitude, longitude, altitude, velocity, and time. Although these satellites are used by the military for precise navigation and timing, civilian use has grown exponentially since the first launch in 1978.

GPS technology is now fully integrated into our personal technology such as smartphones, personal mapping, automobiles, time-keeping, etc. The technology has advanced so much that the Federal Aviation Administration now allows GPS to be used in airplane navigation under certain circumstances.

The Russian GLONASS Constellation is an alternate Global Navigation Satellite Systems that provides end-users with additional space-based resources. Many GPS receivers today can use either GPS or GLONASS system based on signal availability to provide accurate and rapid location and time information.

There is also a European system known as EGNOS, the European Geostationary Navigation Overlay Service.

position and time information from the constellation of GPS satellites. An example of one GPS "hockey puck" style unit that I use is the GlobalSat BU-353-S4 USB GPS receiver (black) shown in Photo A (a full materials list is provided in Table 1 at the end of this article). This receiver has 48-channel all-in-view tracking, built-in L-band antenna, an SiRF Star IV GPS Chipset and WAAS/EGNOS support (see References). These features are simply phenomenal for the money.

The puck-style design has a magnet under the module, making it easy to stick to any ferromagnetic material. It needs to be mounted so that the magnet is at the bottom and the antenna is pointed upward. The GPS receiver must always have a view of the sky in order to see line-of-sight to the GPS constellation. The satellites are constantly moving so, as one or more leave

Table 1. Materials and Sources

Item	Brand / Description / Part No. / Model	Vendor URL	Price Class
1	GlobalSat / GPS Receiver Module / P/N BU-353-S4 USB GPS Receiver (Black) / Model # 05-BU-353-S4	<https://www.amazon.com/>	$30
2	Cable Matters / SuperSpeed USB 3.0 Type A Male to Female Extension Cable in Black 10 Feet / P/N 200008-BLACK-10	<https://www.amazon.com/>	$7
3	VisualGPS, LLC / NMEATime2 - PC Time Synchronization software / Version 1.3.5	<http://bit.ly/2wOrFZW>	$20

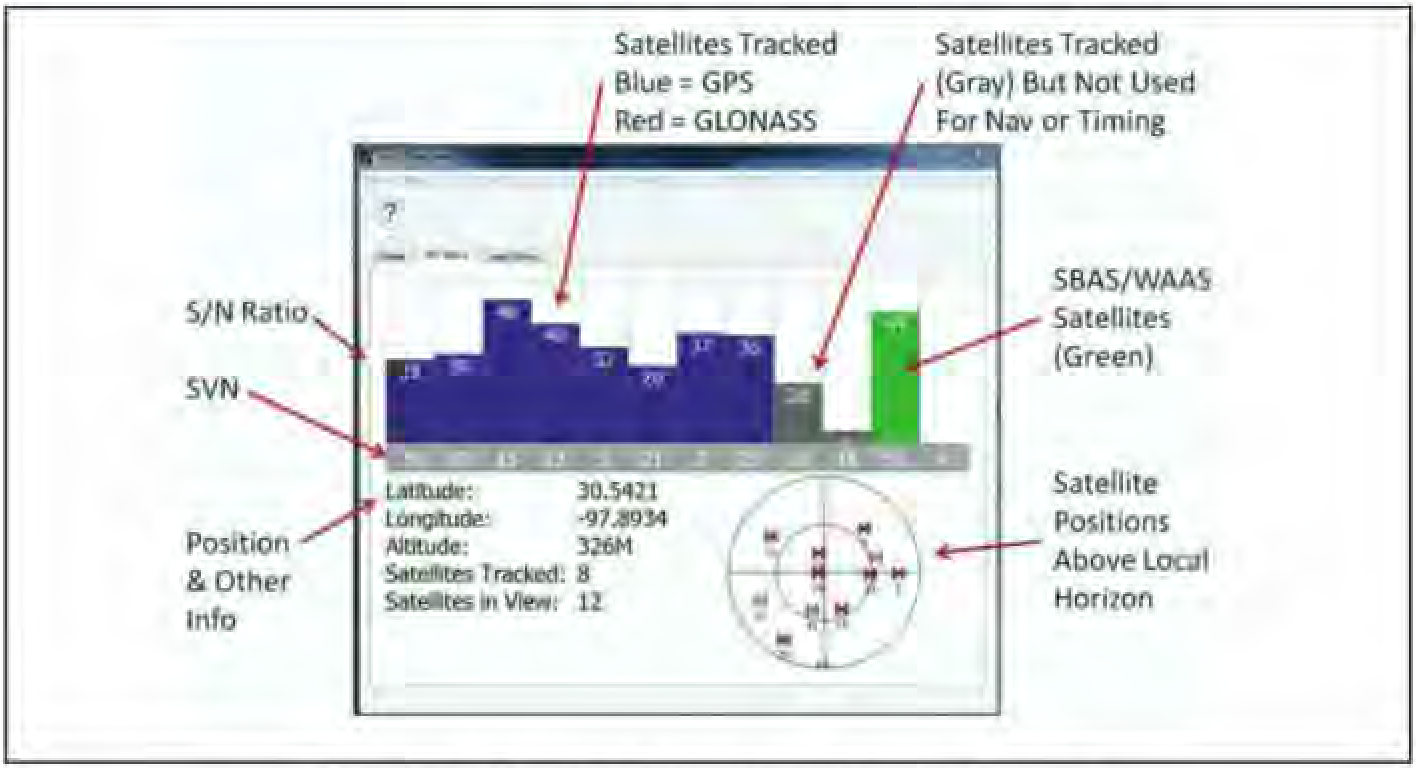

Figure 2. NMEATime panel showing satellite tracking information.

the field of view, others are emerging. Due to mounting restrictions at my home QTH, I only have a partial view of the sky but have found the GPS still performs adequately.

The USB connection on the GPS module can be extended with a USB port extension also shown Photo A. I have mounted the GPS modules outside my home, approximately 15 feet away from my computer's USB ports, without problems. [The maximum distance specification for the USB2 standard is 5 meters (16.4 feet), based on signal delay through the cable.] There are also longer extensions available with active electronics contained within the cable.

GPS Versus UTC Time

GPS receivers demodulate L-band microwave frequency radio signals from the constellation of satellites to calculate geo-location and time. The GPS receiver decodes these signals and uses them to create accurate time messages in the form of preformatted text strings. Each text string message serves a specific purpose, such as location information and time.

One signal message from the GPS satellite includes the difference between true GPS time and UTC time. GPS time was purposely synchronized to UTC time on January 6, 1980. Leap seconds are added to UTC time to account for the Earth's rotation period variations over time. But leap second adjustments are never added to the GPS system. Since 1980, the leap seconds create a time offset between the two systems. For example, after the 2016 UTC leap second adjustment, GPS time was 18 seconds ahead of UTC. (See Q&A sidebar for more on this)

GPS receivers use the correction signal message to calculate UTC time from the GPS time. Local time can also be displayed by offsetting the UTC time based on the local time zone. When GPS receivers are initially turned on, they may not indicate the corrected time because the UTC correction signal message has not yet been decoded from the satellite. On a new GPS receiver, it may require up to 12 minutes to receive the correction messages before UTC time is accurately calculated. Afterwards, synchronization can appear within a minute or two.

Figure 3. NMEATime panel status tab showing time synchronization information.

Software to Auto-Set Computer Time

With the addition of the GPS receiver to a computer system, a method to read the GPS time information and automatically set the computer clock is needed. This can be accomplished using readily available computer applications such as i h, available from VisualGPS, LLC. There is other software available, such as BktTimeSyn, but I have focused on NMEATime2, based on my experiences using these applications.

NMEATime2 implements a different approach for GPS time synchronization. The program's creator, Monte Variakojis (KE6GQO), informed me that he takes the GPS serial data message string, characterizes it, and uses it as a short-term timing reference. He does this by time-tagging the incoming message to the PC clock. He then uses digital filters and his software algorithms to create an error signal to discipline the PC clock to the incoming filtered signal. His approach gives a long-term computer clock accuracy of about 1mS.

The download path to the program is at <http://bit.ly/2wOrFZW>. The pro-

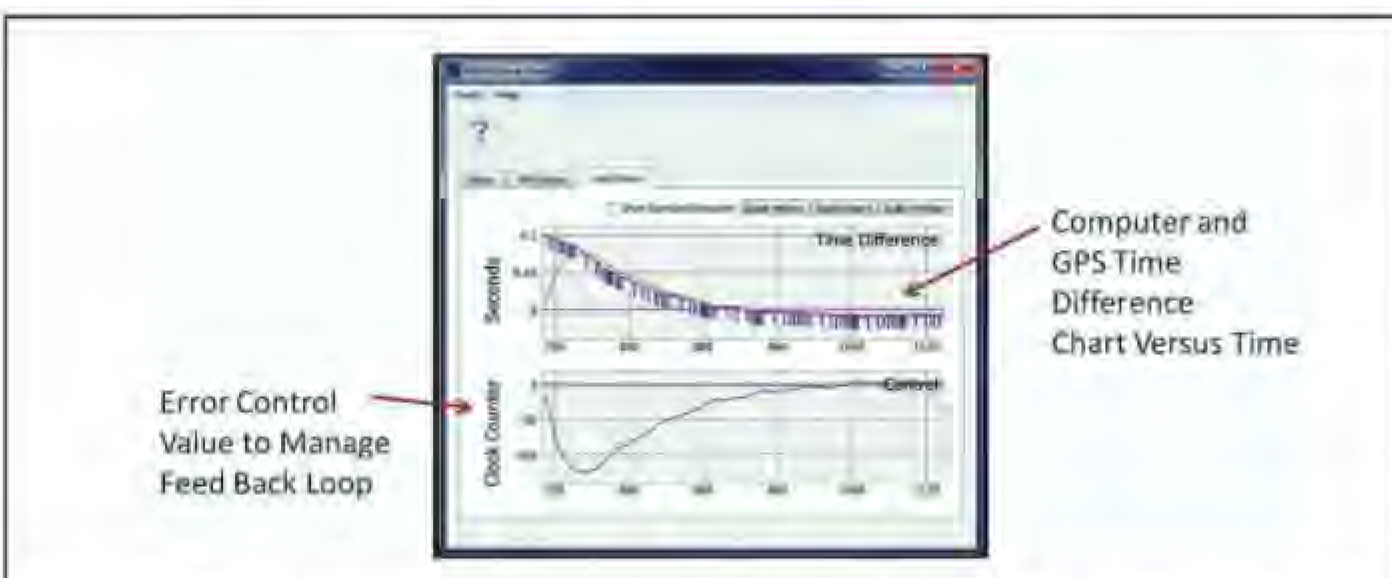

Figure 4. NMEATime panel status tab showing feedback loop information.

gram can be evaluated free of charge for 30 days after installation. This allows enough time to evaluate the capabilities and suitability to your application prior to purchase.

Figure 2 shows the NMEATime Properties Panel that is used to monitor the constellation of satellites during operation. The blue columns show the signal-to-noise (S/N) ratio (at the top of the blue column) for the numbered GPS Space Vehicle Number (**SVN** at the bottom of the column), the gray columns are satellites tracked but not used for navigation or timing and the green column shows SBAS/WAAS satellites. Sometimes the blue columns are red, indicating they are Russian GLONASS satellites. There is also information on the **Lat/Long/Alt** of the GPS receiver and, at the lower right, a local overhead view of where each **SVN** is located in the sky. These **SVN** locations will move over time as the satellites move in their orbits and eventually move below the horizon and disappear from the chart.

Figure 3 shows the NMEATime Panel Status tab that provides time of day (LOCAL or UTC based on the GPS receiver) that is used to monitor time synchronization status including the estimated time error each second (lower portion of green area).

Figure 4 shows the NMEATime Properties Panel that is used to monitor Loop Status for the Time Difference and the feedback Control Counter values. Ideally, the Time Difference is driven to zero over the course of time, typically to within milliseconds.

Figure 5 shows the NMEATime status panel that is used to display the time,

Q&A

Q1. How much time error can the digital modes, such as WSJT-X modes, tolerate?

A1. This is a good question. Joe Taylor, K1JT, the creator of the various modes used in WSJT-X suite of digital mode software, has stated in the WSJT-X User Manual (Section 2.0, System Requirements) that the computer time should synchronized within ± 1 second of UTC. Practically speaking, using GPS for time synchronization provides more than enough accuracy (less than ±1 second) and convenience to the radio operator.

Note about DT: There is a differential time (DT) heading in the WSJT-X message window showing the difference time error between your station and your QSO partner's station. The error measured is the propagation delay between stations, transmit delay (Tx Delay setting in the WSJT-X program setup), and equipment delays. Radio waves travel in free space at the speed of light ($3x10^5$ km/S, so 1,000 miles is equivalent to 5.3 mS). It is not uncommon to see DT values in the tens of milliseconds to several seconds depending on where on Earth (or the Moon for the case of EME) you are located and your equipment configuration. The moon bounce, 2-way delay is about 2.56 seconds, on average.

Q2. What is the difference between GPS time and UTC time?

A2. The GPS navigation message includes the difference between GPS time and UTC. As of December 2016, GPS time is 18 seconds ahead of UTC because of leap-second adjustments made to UTC but not to GPS time. GPS receivers subtract (or add as appropriate) this offset from GPS time to calculate UTC and local time based on specific time zone values. New GPS units may not show the correct UTC time until after receiving the UTC offset message. The GPS-UTC offset field (8 bits) can accommodate 255 leap seconds. GPS time is theoretically accurate to about 14 nS. However, most receivers lose accuracy in the interpretation of the signals and are only accurate to 100 nS. The Global Positioning System (GPS) epoch was set on January 6, 1980 and was then synchronized to UTC. True GPS Time is NOT adjusted for leap-seconds.

Q3. Does using a USB port GPS interface affect time accuracy?

A3. A serial port and USB port are both serial device interfaces with a difference in hardware implementation. The bit rate is still set by the driver software and is more than accurate enough for logging purposes. If you were trying to get down to sub-microsecond accuracy, then you would need to use a GPS with 1 pulse per second (pps) output and synchronize to it. But for time synchronization, the GPS messages contain the time-of-day information that is used to set the clocks. This is adequate for logging programs. The NMEATime2 software provides additional accuracy by providing a closed loop-tracking algorithm to force the error towards zero. Practically speaking, the time error is about a millisecond and that is more than adequate.

Morse Express 2017 Christmas Key

Continuing a tradition that spans the millennium so far, Morse Express has introduced The Morse Express 2017 Christmas Key, which is the seventeenth in the series. This year's key combines a traditional camelback lever with a translucent red knob and a walnut base.

The camelback provides for an elegant level transition down to the contacts but it also adds mass to the lever, giving it a smoother "feel." That and the added leverage that you get with the trunnion at the rear of the key make it excellent for sending code.

The wires from the miniature binding posts are traced into the base and covered with a felt pad so the key will be less likely to slip, and won't mar the table. The hardware is solid brass, highly polished and, gold plated so that it will not tarnish or corrode. Contact spacing and spring tension are both controlled by the single adjusting screw just forward of the trunnion. The 2017 Christmas key weighs 2.25 ounces (60g) and measures 2-3/8 x 1-5/8 inches (60 x 40 millimeters) at the base.

The Morse Express 2017 Christmas Key is a limited edition, with a retail price of $89.95 plus shipping and handling. Each key has a label with "Christmas 2017" and a unique serial number. For more information, visit the Morse Express website <www.morseexpress.com> or call (800) 238-8205 or (303) 752-3382.

date, locked status, and the 1 sigma error estimate based on the time error tracking graph in the NMEATime Panel. The significance of the 1 sigma error is that this defines the one standard deviation for the cumulative errors over time. This provides a quality metric of how well the program is controlling the PC time clock (e.g., the smaller the better).

Monte Variakojis explains the significance of the 1 sigma value as follows:

The 1 sigma value only starts to calculate after 7200 consecutive seconds of time lock and it's there to show the long term accuracy average (one sigma). The time synchronization will be within this value (±) about 95% of the time.
The Estimated Time Error is the red line on the Time Difference plot. This is the actual filtered value that NMEATime uses as an input to the control loop. The blue line on the Time Difference plot is the actual unfiltered time difference between the GPS NMEA string and the PC clock.

NMEATime2 Setup Procedures

The software program is extremely easy to set up once the USB com port number is known and entered. A step-by-step procedure follows:

1. When the program first starts, the USB port used by the GPS is probably not set for the program to communicate with the attached GPS receiver. Therefore, the Tools - GPS - Setup Communications tab should be selected so you can enter the com port assigned to the GPS receiver.

Figure 5. NMEATime calculated 1 sigma time error (see text for discussion).

Figure 6. Dialog for Com port settings of the GPS receiver.

2. From the dialog box, select the Port number for the GPS connected to the computer. In my case, the port number was identified as COM6 - Prolific USB-to-Serial Comm Port.

3. Next select the Baud for the GPS receiver. All receivers I have used have a communication speed of 4800. My settings are shown in Figure 6. I selected Port to COM6 and set the Baud to 4800.

4. If all goes as planned, the Status screen should indicate either searching for the satellites or time lock as shown in Figure 7.

5. The status of the program can be followed by mouse clicking on your computer tray located at the lower right portion of your computer's screen and looking for the satellite icon image. The color of the image gives the program status as listed in Figure 8. The black area with computer icons is dependent on other programs your computer is running and your operating system. By using the color-coded icons, you can determine the program's status.

Summary

If your hamming takes you out of internet range and you use modes or take part in activities that require a very accurate computer clock, the GPS satellite system and about $60 in hardware and software can keep your clock updated almost anywhere you go.

Figure 8. System tray program status indication using color-coded satellite icons.

SPURIOUS SIGNALS By Jason Togyer KB3CNM

Figure 7. NMEATime panel status tab showing a locked condition.

Internet Link References

GlobalSat GPS receiver (price class $30 online): < http://www.globalsat.com.tw/>

NMEATime2 software, sets time on PC from GPS receiver (price class $20 online with a free 30-day trial period): < http://bit.ly/2yej0S2>

NMEATime2 tested GPS receivers that have been tested with the program: <http://bit.ly/2gvV1q2>

Leap Second Time Information: <http://bit.ly/2g3p1IV>

Time Systems and Dates - GPS Time: <http://bit.ly/2gctUDw>

BKtTimeSyn Software - Another application for setting time from GPS receivers: <http://bit.ly/2xzALcF>

Wide Area Augmentation System (WAAS) Information: <http://bit.ly/2yghXmS>

Space Based Augmentation System (SBAS) Information: <http://bit.ly/2g3pLOn>

European Geostationary Navigation Overlay Service (EGNOS) information: <http://bit.ly/2gcAAkM>