SPECTRACOM

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APPLICATION NOTE REGARDING THE PENDING LEAP SECOND TO OCCUR IN DECEMBER 2005

As you may already know, the first leap second in seven years will be occurring on December 31st, 2005. (The last time that a leap second was added was Dec 31st, 1998.) This event will add one additional second to the Coordinated Universal Time (UTC) reference. This Application Note describes how this time event will affect Spectracom NetClocks and Ethernet Time Servers, as well as the external PCs and devices connected to these Spectracom Models.

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SECTION 1: WHAT IS A LEAP SECOND?

A leap second is an addition or a subtraction of one second at periodic intervals to keep UTC in sync with the earth's rotation. Leap seconds usually occur every few years.

According to the National Institute for Standards and Technology (NIST) website (http://tf.nist.gov/), a leap second "is a second added to Coordinated Universal Time (UTC) to make it agree with astronomical time to within 0.9 second. UTC is an atomic time scale, based on the performance of atomic clocks. Astronomical time is based on the rate of rotation of the earth. Since atomic clocks are more stable than the rate at which the earth rotates, leap seconds are needed to keep the two time scales in agreement.

"The first leap second was added on June 30, 1972, and they occur at a rate of slightly less than one per year, on average. Although it is possible to have a negative leap second (a second removed from UTC), so far, all leap seconds have been positive (a second has been added to UTC). Based on what we know about the earth's rotation, it is unlikely that we will ever have a negative leap second."

For additional information on leap seconds, visit websites such as the USNO (US Naval Observatory) site: http://tycho.usno.navy.mil/leapsec.html

SECTION 2: WHEN IS THE NEXT LEAP SECOND SCHEDULED TO OCCUR?

Historically, leap seconds have only been implemented on either June 30th or December 31st. This year, a leap Second is scheduled to be added (an addition is known as a *leap second positive*) on December 31st at UTC midnight (not local time midnight). Because this leap second correction occurs at UTC midnight instead of local time midnight, it will occur at exactly the same moment regardless of the time zone and geographic location in which you are located. In December, US residents will be following Standard Time (not Daylight Saving Time), so UTC midnight will occur at the following local times based on your location in the US (as shown in Table 1 below):

Time Zone	Local Time at UTC Midnight
Eastern	7:00 PM
Central	6:00 PM
Mountain	5:00 PM
Pacific	4:00 PM

Table 1: UTC Midnight to Local Time Conversion

SECTION 3: HOW IS THE LEAP SECOND ADDED TO THE UTC TIME?

Instead of the UTC time normally incrementing as **23:59:58, 23:59:59, 00:00:00, 00:00:01, etc**, on December 31st, UTC will increment as **23:59:58, 23:59:59, 23:59:60, 00:00:00, 00:00:01, etc**.

SECTION 4: DO THE IRIG, REMOTE, AND SERIAL OUTPUTS FROM THE NETCLOCKS, MODEL 9188 ETHERNET TIME SERVERS, AND TTS MODELS CONTAIN PENDING (UPCOMING) LEAP SECOND INFORMATION?

The IRIG output, available on the Models 9183, 8183, and TTS240 (IRIG B or IRIG E), does not contain pending leap second information. The external systems connected to the IRIG output will not incorporate the pending leap second until the leap second has actually been inserted. The next time these external systems process the signal to obtain the time, the time will have changed by one second and the systems should update accordingly to incorporate the leap second.

The RS-485 remote and RS-232 Serial ports on all model NetClocks, the Model 9188 Ethernet Time Servers, and the TTS models output selected Data Formats to the external devices. No matter how the NetClocks and the Model 9188 Ethernet Time Servers handle the pending leap second internally, whether the external devices are alerted ahead of time concerning the pending leap second is based on the selected Data Format output and the operation of the external devices' software. The Data Format selected for output depends on the requirements of the external device synchronization and the Model Number of the NetClock.

The following table depicts which Data Formats contain information about pending (upcoming) leap seconds and which ones do not. Not all Data Formats are available from all NetClocks, Ethernet Time Servers, and TTS models, as also shown in Table 2.

Selected Data Format Output	Contains Information About a Pending Leap Second	Applicable to Which Models
0	No	All
1	No	All
2	Yes	All
3	Yes	Models 8183, 8184, 8189, 918x, and TTSxxx only
4	Yes	Models 8183, 8184, 8189, 918x, and TTSxxx only
7	Yes	Models 918x (Version 2.3.0 or higher) only
8	No	Models 918x (Version 2.3.0 or higher) only
90	No	Models 8183, 8184, 8189, 918x, and TTSxxx only

Table 2: Data Formats that Contain Pending Leap Second Information

Depending on the received Data Format from the NetClock, Model 9188 Ethernet Time Server, or TTSxxx, the external devices that are connected to the Remote and Serial outputs (Such as 911 CAD Systems, consoles, voice loggers, and others) may not be alerted to the pending leap second before the leap second is inserted. If these devices are using a Data Format that contains leap second

information and the devices' software properly handles this information, the devices will automatically correct for the time change at or shortly after UTC midnight.

If the external device is receiving a Data Format that does not contain pending leap second information, at some point after the leap second has been added at UTC midnight, the devices will read the data streams, sense the changed time, and update accordingly. Some systems read and process the time data every second. These systems should update at or shortly after UTC midnight. **Other systems only read the input time at scheduled intervals. In this case, the system may not correct for the leap second occurrence at UTC midnight, instead correcting it at its next scheduled synchronization interval.** Contact the system manufacturer for more details on how the software in question handles a time correction from a NetClock or Model 9188 Ethernet Time Server.

SECTION 5: WILL THE NTP TIME STAMPS FROM NETCLOCKS WITH AN ETHERNET CONNECTOR (MODELS 9183, 9189, 8189, TTSXXX) AND THE ETHERNET TIME SERVERS (MODELS 9188 AND 8188) PROVIDE THE PCs WITH THE ALERT OF A PENDING LEAP SECOND?

The NTP/SNTP time stamp packets that are sent from NetClocks that have Ethernet ports (Models 9183, 9189, 8189, TTS200, TTS220 and TTS240), and the Ethernet Time Severs (Models 9188 and 8188) contain two status bits called the Leap Indicator (LI) bits. The LI bits, besides providing to the PCs time sync status of the NetClock or Ethernet Time Server, also provide indication of a pending leap second 24 hours prior to the addition of the second. During a leap second occurrence, these bits are both set to "on" 24 hours prior to the scheduled leap section correction.

The Models 9183, 9188, 9189, and TTSxxx (with Application software version 2.2.1 and below) as well as the Models 8188 and 8189 do not set the LI bits 24 hours prior to the leap second occurrence. As described herein, the LI bits are usually ignored by the client software, so this does not matter.

NOTE: The exception to this is the Model 9188 (Application software version 2.3.0 and above) when configured to receive Data Format 0 as the reference input from the NetClock. Because Data Format 0 does not contain pending leap second indication from the NetClock, these Ethernet Time Servers will not receive an indication of the pending leap second from the NetClock. They cannot set the LI bits in the NTP/SNTP outputs as a result.

The PCs that receive the NTP/SNTP are supposed to read the LI bits and determine how to handle a pending leap second change to the time without operator intervention. **Testing conducted at Spectracom, however, has shown that client programs such as the Microsoft Windows W32Time program and the UNIX NTP4 software appear to ignore the change in the LI bits. As a result,the unscheduled synchronization after the leap second is applied doesn't actually occur. The PCs instead wait until their next scheduled interval to correct the time as they normally would.**

The following is a detailed description of the leap second operation for the Windows W32Time program, Spectracom's PresenTense software for Windows, and the NTP4 (NTP daemon) software for UNIX. For any additional information regarding the Windows W32Time program, contact Microsoft. For NTP4 software programs, refer to http://www.ntp.org/.

A) WINDOWS PCs

Microsoft Windows 2000, XP, and 2003 have a built-in NTP time synchronization program called W32Time. This client program uses NTP packets from the Spectracom NetClocks and Ethernet Time Servers to derive the current UTC time.

There are a couple of different versions of the W32Time programs that are used in Windows (all called "W32Time" regardless of version). W32Time in Windows 2000 and older versions of Windows XP uses Simple Network Time Protocol (SNTP) to synchronize the time of the PC, while Windows 2003 and newer versions of Windows XP use Network Time Protocol (NTP) to synchronize.

SNTP based client programs request the time from the Time Server at scheduled intervals and correct the PC's time after they calculate the correct time from that poll. NTP based client programs use polls of the time server for a side-by-side comparison of the time of the PC to the time of the Time Server. Based on the error between the two, they speed up or slow down the PC time so that, theoretically, both times match at the next scheduled poll of the Time Server (The PC time is jumped to the correct value only when starting the service).

The NTP/SNTP time stamps that are sent from NetClocks and the Ethernet Time Severs contain two status bits called the "LI" (Leap Indicator) bits. The LI bits, besides providing time sync status of the NetClock or Ethernet Time Server, also provide indication of a pending leap second 24 hours prior to the event occurring.

The W32Time program is supposed to read these bits and, when they indicate that a leap second is to be added or removed, the program is then flagged to generate an unscheduled poll of the NTP Server sometime between UTC midnight and 15 minutes after UTC midnight. These polls are to happen at random times for each PC so that all PCs on the network are not requesting the time from the NTP Server simultaneously. This poll is supposed to adjust the PC to the correct UTC time.

The testing Spectracom has performed on this program indicates that the change in the LI bits is ignored by the W32Time program. This means the PCs won't be alerted ahead of time to the pending leap second. At the next scheduled update interval (W32Time updates once every 24 hours, while XP updates once every 7 days), the program will note that the time is at least one second off and will synchronize the PC's time for the leap second as well as any drift that may have occurred since the previous scheduled update (normal operation). **What this means is that a system that updates only once every 7 days may not indicate the correct time after the leap second for the week between scheduled updates.**

B) PCs RUNNING SPECTRACOM'S PRESENTENSE SERVER AND CLIENT SOFTWARE

The PresenTense Server and client software have two modes of operation. They can operate in either SNTP mode ("Network") or in NTP PLUG-IN mode using the built-in NTP4 Module.

In the Network mode of operation, the clients receive the time stamps from the NTP Time Severs at scheduled intervals (**the default is every 15 minutes**). The program will correct the PC's time for a leap second at the next scheduled update. Setting the update interval for a lower update interval than 15 minutes will update the time even sooner after the leap second has been added.

In the NTP4 PLUG-IN mode of operation, the software polls the NTP Time Server at a periodic interval to determine the amount of error. It then adjusts the slew rate of the PC so that, at the next poll interval, the time will be correct. In this mode of operation, large corrections to the time are not desirable, so the time is adjusted by slewing the time for the leap second over a period of a few hours.

C) PCs RUNNING NTP4 SOFTWARE

NTP4 software uses the NTP4 daemon ("NTPD") to synchronize the time of the PC. NTPD uses complicated algorithms to determine a PC's drift rate and then slews this drift rate so the computer's time doesn't have to jump at a scheduled interval. It makes minor adjustments to the slew rate to keep the time accurate.

The NTPD program is supposed to utilize the LI Bits to determine if a leap second is pending and automatically correct the time at UTC midnight. Testing at Spectracom, however, indicates that the software doesn't detect the pending leap second to adjust for the time. The time change is detected and the PC time is slewed to the correct time over a period of roughly 30-50 minutes.

SECTION 6: HOW WILL SPECTRACOM NETCLOCKS, ETHERNET TIME SERVERS, WALL DISPLAY CLOCKS, AND MODEL 8185 TIMEBURST HANDLE THE CORRECTION TO UTC TIME?

The Spectracom NetClocks, Ethernet Time Servers, wall display clocks, and Model 8185 TimeBurst have all been tested for the upcoming leap second event. The specific handling of the leap second correction for each Model is listed below.

A) NETCLOCK/2 AND MODEL 8182

The WWVB-based NetClock/2 receives UTC time directly from the National Institute of Standards and Technology (NIST) WWVB transmitter. NIST will make a change to its bit stream for the entire month preceding the leap second event.

Bit number 56 in the pattern of 60 bits that are sent each minute (one bit is sent each second) is called the leap second bit. WWVB changes this bit to a binary “1” at the beginning of the month (they reset the bit to a binary “0” at the last second of the month). The NetClock/2 reads this bit pattern change, which flags the clock to add a second on the last minute of the current UTC month. This results in the last minute of the month containing 61 seconds instead of the normal 60.

For the NetClock/2 to read the bit pattern change, the clock must have at decent WWVB reception capability at some point during the month of December. To ensure the NetClock/2 has adequate reception capability, look at the three front panel status lamps and make sure they are all green. If any or all of these lights are red, please contact Spectracom Technical Support for assistance with troubleshooting the reception issue.

After the bit pattern change has been read by the NetClock/2, causing the internal flag to be set to make the correction, the clock will automatically apply the leap second at the end of the month. During the last minute of the UTC month, the next second after 23:59:59 will be 23:59:60. This will be reflected on the front panel display as either UTC or local time hours displaying a value of “60” in the seconds portion of the display. Simultaneously, the seconds value of “60” will also be reflected in the time data streams available from the Remote, Serial, and IRIG output ports.

B) MODELS 8183, 8183A, 8184, AND 8189

GPS based NetClocks are alerted to a pending leap second via the GPS receiver at an arbitrary number of months before the pending leap second. This alert is provided to the NetClock at the beginning of the month in which the scheduled leap second is to occur. After the unit is alerted to the pending leap second, it will be flagged to apply automatically the correction at the last second of the UTC month.

IRIG and Front Panel Display (Models 8183 and 8183A only), RS-232 Serial, and RS-485 Remote Output Port Time Code Leap Second Notification:

The GPS based Models 8183, 8183A, 8184, and 8189 products provide a 1 month prior notification of leap seconds in the Remote and Serial Data Formats 2, 3, and 4. Data Formats 0, 1, and 90 and the IRIG output in the Model 8183 do not provide leap second information to external devices.

The RS-485 and RS-232 outputs available from the Remote and Serial ports and the front panel display (on select models) will add “60” to the seconds value at the top of the minute at UTC midnight. The next second will be “00”, with a normal count-up from that point forward (refer to Table 3).

Data Format 0 (Set to Eastern)	Data Format 1 (Set to Eastern)	Data Format 2 (always UTC)
365 18:59:56 STZ=05	SAT 31DEC05 18:59:56	D05 365 23:59:56.000 LS
365 18:59:57 STZ=05	SAT 31DEC05 18:59:57	D05 365 23:59:57.000 LS
365 18:59:58 STZ=05	SAT 31DEC05 18:59:58	D05 365 23:59:58.000 LS
365 18:59:59 STZ=05	SAT 31DEC05 18:59:59	D05 365 23:59:59.000 LS
365 18:59:60 STZ=05	**SAT 31DEC05 18:59:60**	**D05 365 23:59:60.000 LS**
365 19:00:00 STZ=05	SAT 31DEC05 19:00:00	D06 001 00:00:00.000 S
365 19:00:01 STZ=05	SAT 31DEC05 19:00:01	D06 001 00:00:01.000 S
365 19:00:02 STZ=05	SAT 31DEC05 19:00:02	D06 001 00:00:02.000 S
365 19:00:03 STZ=05	SAT 31DEC05 19:00:03	D06 001 00:00:03.000 S
365 19:00:04 STZ=05	SAT 31DEC05 19:00:04	D06 001 00:00:04.000 S
365 19:00:05 STZ=05	SAT 31DEC05 19:00:05	D06 001 00:00:05.000 S

Table 3: RS-485 Remote and RS-232 Serial Port Data from Models 8183, 8184, and 8189.

The connected devices (ANI/ALI, CAD Systems, radio consoles, voice loggers, and others) that interface to the NetClock through the Remote, Serial, and IRIG outputs may not immediately correct for this additional second, depending on how their software dictates operation. Instead of reading and processing the time data every second, some systems may elect to read the time only at scheduled intervals. In this case, that system will not correct for the leap second occurrence until its next scheduled synchronization interval. Contact the system manufacturer for more details on how the systems in question handle a time correction from the NetClock/2.

No internal log entries will be made indicating that the leap second was applied.

C) MODELS 9183, 9189, TTS200, TTS220, TTS240

GPS based NetClocks are alerted to a pending leap second via the GPS receiver at an arbitrary number of months before the pending leap second or from a phone call placed to NIST using the optional dial-out modem feature for that particular month (the dial-out option is not available for all models). This alert is provided to the NetClock or TTS unit at the beginning of the month in which the scheduled leap second is to occur. After the unit is alerted to the pending leap second, it will be flagged to apply automatically the correction at the last second of the UTC month.

NetClock Models 9183, 9188, and 9189 with Application software version of 2.3.0 or higher will also provide an indication of the upcoming leap second occurrence on the “System Status” page in the web browser user interface. To view this screen, log into the unit’s web browser user interface. Click on “Status and Logs” on the bottom menu and then on “System Status” on the left menu. The Dynamic System Information box will add a row to the end of the static box after it receives the indication (from either the GPS receiver or the dial-out modem) that a leap second will be added. Refer to Figure 1.

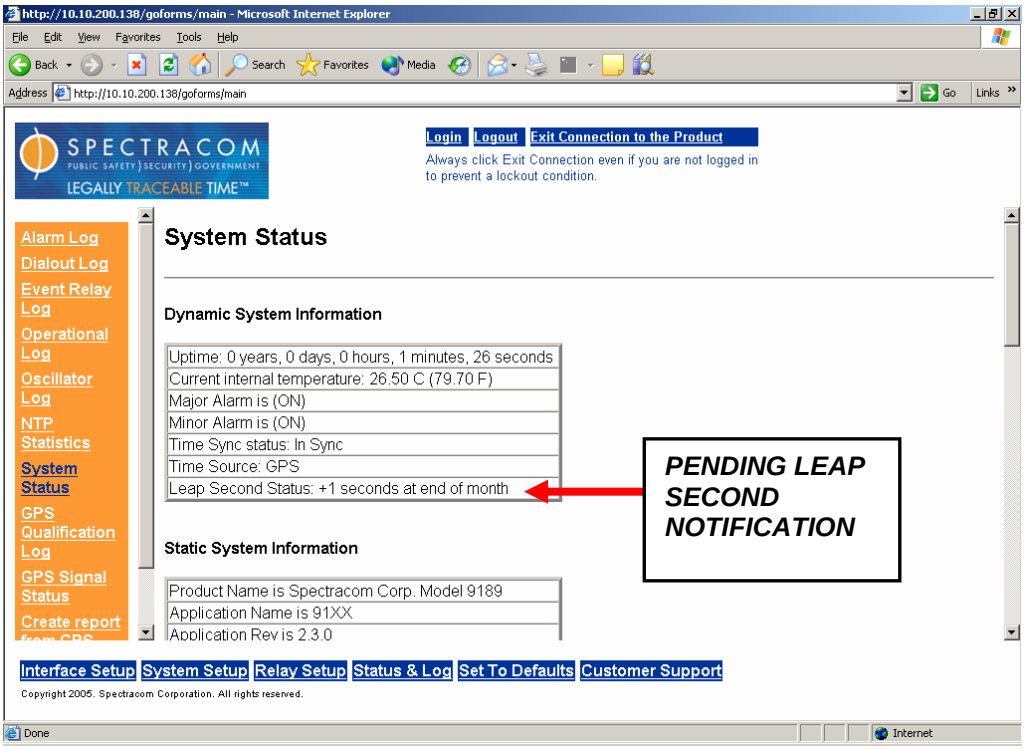

Figure 1: Example Pending Leap Second Notification in the Web browser User Interface

IRIG (Models 9183 and TTS240), Front Panel Display (Models 9189, TTS220 and TTS240), RS-232 Serial and RS-485 Remote output port time code Leap Second Notification

The following table displays the Remote and Serial port output data during the insertion of a leap second as seen on the Remote and Serial output ports. The NTP output, the front panel display, and the IRIG port on applicable units will provide the same time data as below (but in their standard formats).

NOTE: The hours displayed are from a port that is configured for Eastern Time Zone. The number "365" indicates the Day of Year followed by hour:minutes:seconds. STZ=05 is Standard Time with a 5 hour offset from UTC.

Data Format 0 (Set to Eastern)	Data Format 1 (Set to Eastern)	Data Format 2 (always UTC)
365 18:59:56 STZ=05	SAT31DEC05 18:59:56	D05 365 23:59:56.000 LS
365 18:59:57 STZ=05	SAT31DEC05 18:59:57	D05 365 23:59:57.000 LS
365 18:59:58 STZ=05	SAT31DEC05 18:59:58	D05 365 23:59:58.000 LS
365 18:59:59 STZ=05	SAT31DEC05 18:59:59	D05 365 23:59:59.000 LS
365 18:59:60 STZ=05	**SAT31DEC05 18:59:60**	**D05 365 23:59:60.000 LS**
365 19:00:00 STZ=05	SAT31DEC05 19:00:00	D06 001 00:00:00.000 S
365 19:00:01 STZ=05	SAT31DEC05 19:00:01	D06 001 00:00:01.000 S
365 19:00:02 STZ=05	SAT31DEC05 19:00:02	D06 001 00:00:02.000 S
365 19:00:03 STZ=05	SAT31DEC05 19:00:03	D06 001 00:00:03.000 S
365 19:00:04 STZ=05	SAT31DEC05 19:00:04	D06 001 00:00:04.000 S
365 19:00:05 STZ=05	SAT31DEC05 19:00:05	D06 001 00:00:05.000 S
365 19:00:06 STZ=05	SAT31DEC05 19:00:06	D06 001 00:00:06.000 S

Table 4: RS-485 and RS-232 Time Code Outputs During a Leap Second Insertion (Eastern Time Zone Offset [TZO])

D) MODEL 9188 ETHERNET TIME SERVER

The Model 9188 Ethernet Time Server is connected to the Remote port of any Spectracom NetClock. The Ethernet Time Server accepts the RS-485 data stream from the NetClock and converts it to an NTP data stream using an Ethernet connection. The Model 9188 also has available Remote and Serial output ports to send Data Formats to external devices for synchronization.

The Ethernet Time Server receives the RS-485 time code data from the NetClock once per second. After the NetClock has adjusted for the leap second as described previously, the Ethernet Time Server will note that the input data stream has changed by one second. It will add one second to its NTP, Remote, and Serial outputs. If the Ethernet Time Sever is receiving Data Format 0 as the input, it will not provide advance notice of the leap second occurrence to the external devices connected to its outputs. The time in the data streams, however, will reflect the new UTC time.

The actual operation and outputs of the Model 9188 depend on the current application software installed in the unit and the Data Format selected as the RS-485 input from the NetClock. Following are some details of operation for the NTP, Remote, and Serial ports for the Model 9188:

Model 9188s with Application software version of 2.3.0 can provide an indication of the upcoming leap second occurrence on the “System Status” page in the web browser user interface. For the Model 9188 to show the pending leap second in the web browser, it must be synchronized to the NetClock using Data Format 2 or 7 (not available in all versions). Data Format 0 does not provide the Model 9188 with information on a pending leap second. It only indicates that the leap second has occurred – not that one is pending.

To view this screen, log into the unit’s web browser user interface. Click on “Status and Logs” on the bottom menu and then on “System Status” on the left menu. The Dynamic System Information box will add a row to the end of the static box after it receives the indication (from either the GPS receiver or the dial-out modem) that a leap second will be added. Refer to Figure 2.

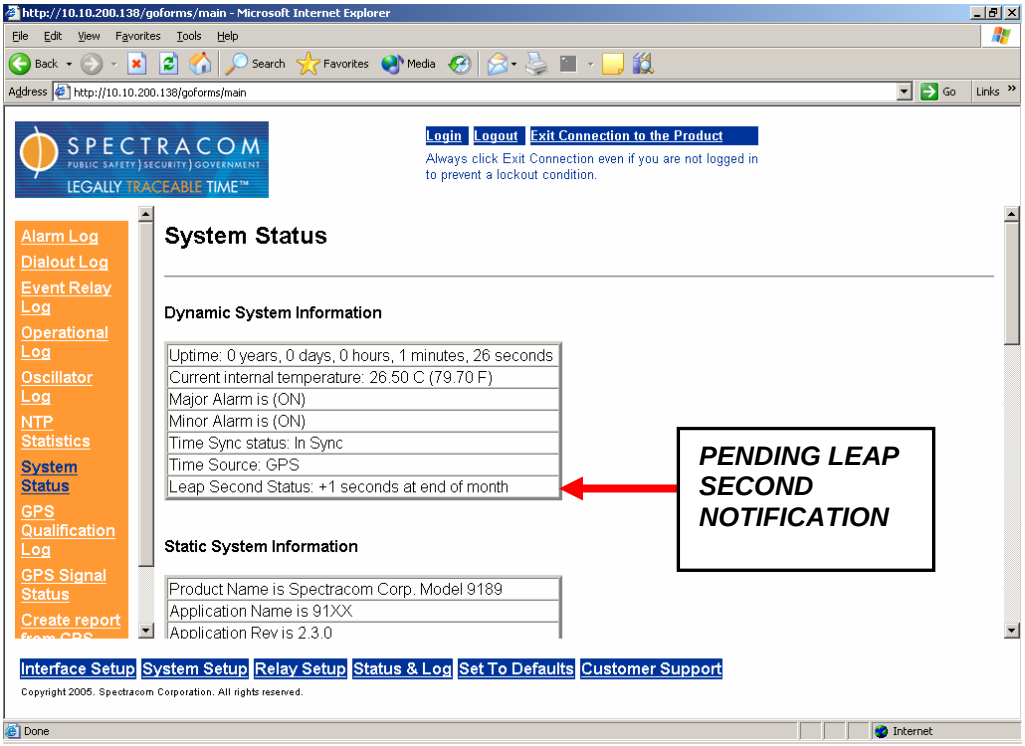

Figure 2: Pending Leap Second Displayed on the System Status Page

Application Software Version 2.3.0 or Higher:

Data Format 0 as the selected Data Format input (Data Format 0 does not contains a leap second indicator): On a positive leap second, the seconds will output as :59, :00, :01, :02, :02, 03, etc. On a negative leap second, the seconds will count as :58, :59, :00, :02, :03, etc.

Data Format 2 as the selected Data Format input (Data Format 2 contains a leap second indicator): A Model 9188 will follow the input seconds exactly when a leap second is added. Refer to the appropriate Model NetClock in Section 5 of this document for the operation of the Remote port during and after a leap second correction.

Application Software Version 2.0.0 Through 2.2.1:

Data Format 0 as the selected Data Format input: On a positive leap second, the seconds count as :59, :00, :01, :02, :02, 03, etc. On a negative leap second, the seconds count as :58, :59, :00, :02, :03, etc.

Data Format 2 as the selected Data Format input: On a positive leap second, the seconds count as :59, :00, :01, :02, :02, etc. On a negative leap second, the seconds count as :58, :59, :00, :02, etc.

Application software version 1.0.0 through 1.2.1

Data Format 2 as the selected Data Format input: On a positive leap second, the seconds count as :59, :00, :01, :02, :02, etc. On a negative leap second, the seconds count as :58, :59, :00, :02, etc.

Data Format 0 as the selected Data Format input: On a positive leap second, the seconds count as: 59, :00, :01, :02, :03, :03, etc. On a negative leap second, the seconds count as 58, :59, :00, :01, :03, etc.

No internal log entries will be made indicating that the leap second was applied.

E) DISPLAY CLOCK MODELS TV210, TV400, TV312, 8175, 8177, AND MODEL 8185 TIMEBURST

There are several different models of Spectracom wall display clocks. These wall display clocks accept the RS-485 Data Formats 0 or 1 from the RS-485 Remote ports. The clocks read the RS-485 data provided by the NetClock and synchronize to it. Some Models have a wired connection to the NetClock, while others have a wireless connection via a VHF or UHF radio.

Because Data Formats 0 and 1 do not provide an indication of a pending leap second, the display clocks will not receive prior notification that a leap second correction will occur. After the leap second has been inserted at the top of the minute, the wall clocks will read the time code data and make the correction to their displays.

The wired versions of the digital display clocks (Models TV210W, TV400W, 8175, and 8177) will update to the correct time a couple of seconds after UTC midnight. They receive the time every second from the NetClock. After the NetClock makes the correction for the leap second, the wall clocks will adjust accordingly within a couple of seconds.

The Model 8185 TimeBurst, used in conjunction with the wireless versions of the display clocks, will perform an unscheduled burst as soon as it reads the time change from the NetClock. This unscheduled burst is called a “data continuity” burst because the input time does not match the TimeBurst software’s expected time.

The wireless digital display clocks (Models TV210U/V and TV400U/V) will update after they “hear” the TimeBurst key the radio for the unscheduled burst. If, for any reason, the TimeView display clocks do not receive this message, they will update to the correct time after they receive a normally scheduled burst.

The Model TV312W wired analog wall clock will not adjust for the leap second immediately at UTC midnight. These clocks synchronize only at the top of each minute. They will adjust for the extra second within a couple of minutes of the leap second insertion. The Model TV312U/V wireless wall clocks will receive the update time from the TimeBurst and radio transmitter through the unscheduled data continuity burst or during one of the normally scheduled intervals thereafter.

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