RT130 3.4.3 Firmware Update - PASSCAL User Notes

Eric Makarewicz and Brit O'Neill, 2013-05-07

Introduction

In this document are listed the firmware changes between version 3.0.0 and 3.4.3, from the Reftek 130-CPU Firmware Release Notes, along with comments on how usage or results are different for some of the changes.

We've organized the changes into the following categories:

- New Features,
- Continuous Trigger/Start Alignment,
- Disks,
- Error Handling,
- Files,
- GPS,
- Packets,
- Parameters,
- Telemetry,
- Miscellaneous Other,
- and finally, Not Applicable to PASSCAL RT130.

In each category, the firmware changes, from REF TEK 130-CPU Firmware Release Notes, are shown in gray boxes with any comments immediately below. Some changes will not noticeably affect the user experience with the RT130 and so may not have any comments, but all changes are listed. Firmware changes that users might readily notice or be interested in and may want or need instruction on are shown in gray boxes outlined in red. For questions, or further information, on any particular change, please contact passcal@passcal.nmt.edu.

General Comments

PASSCAL's current policy is to not make firmware changes in the field. This is particularly true in this case. For all firmware versions above 3.0.0 Reftek recommends upgrading the ATD and CPU board FPGAs as well. We will remove, reprogram, and reinstall these chips, and then re-test the units after reassembly, in our lab.

During our testing of the RT130 3.4.3 firmware, we observed some significant data loss (missing events) when using 4 GB CF cards and 1000 sps. We are conducting additional testing, but until that testing is completed, we will continue to support experiments using RT130 with 4 GB CF cards or with higher sample rates with 3.0.0 firmware.

Finally, please be aware that, despite updated firmware, these are not new RT130 and, because of older hardware, may not have all the capability that brand new units from Reftek might have. To minimize potential field issues and data loss, it is recommended that, for equipment from the PASSCAL Instrument Center, the

PASSCAL usage guidelines be followed at all times. Again, for questions, or further information, please contact passcal@passcal.nmt.edu.

New Features

3.4.0-3. Corrected Bit Weight Calculation When Using the Sensor Comment

The firmware has been changed to allow the bit weights for 2 different sensors to be entered and applied to their respective channels.

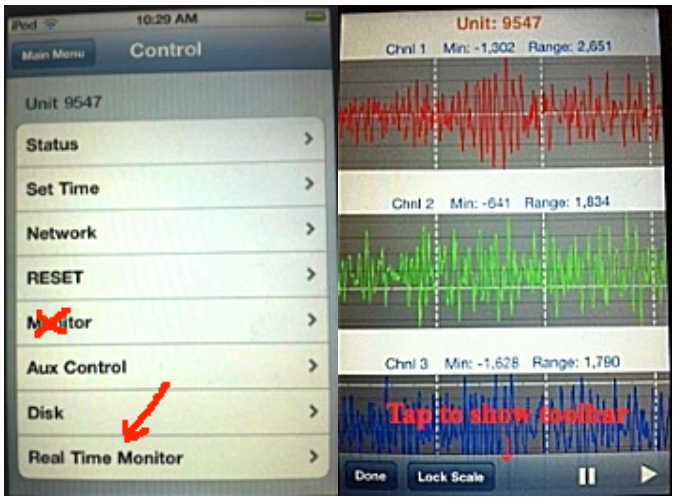
3.4.0-2. Correction to the EH/ET Packets Full Scale Analog Code

The firmware has been changed to add a code to allow a +/-20 V full scale analog sensor to be specified in the EH/ET packets.

3.4.0-7. Addition of New Command DD for Real Time Data Monitoring

A new command "DD" has be added to allow real time data monitoring using iFSC software running on a iPod touchTM (4th generation) or (iPhone 4S or iPhone 3GS).

As noted above, this feature is only available through the iFSC app running on a iPod Touch or iPhone, it is not available on a Clié.
From the main page of the iFSC application, tap on "Control" and then, at the bottom of that page, tap on "Real Time Monitor" (the original Monitor function is still available also). Select which "group" of sensor channels to monitor (typically "1-3" for PASSCAL 3-channel DAS) and the desired scaling, then press "Start" in the upper right corner. The data monitor shows in 'real time' a down-sampled stream of data from the channels. It has a slight lag, around half a second. Tap on the screen to pop up a toolbar at the bottom for pausing, restarting, or stopping.

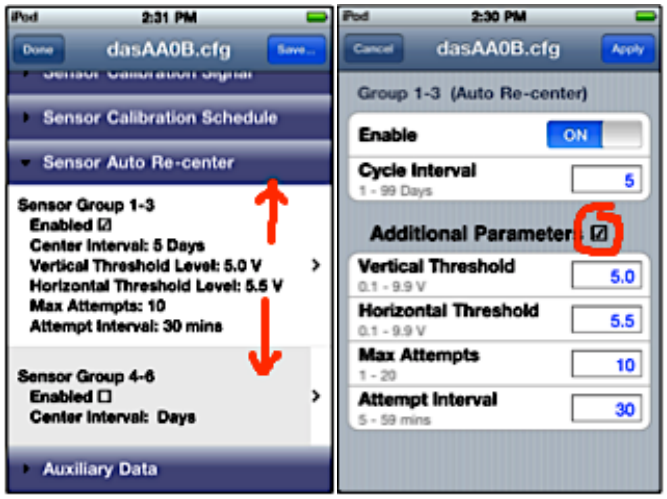


NOTE: This function only works with Group 2 sampling rates (see 3.4.3-5 below for list of sample rates in each group), except it does not work with the 50 sps rate newly added to Group 2.

3.4.0-8. Addition of Automatic Mass Re-centering

The existing "PQ" command has been expanded to provide greater control of the re-centering of the mass of a sensor.

Previously users have been able to "auto center" sensors, having the RT130 automatically send a centering command at specified intervals. With this firmware update, and using iFSC (iPod or iPhone app), there is now the option to set mass position thresholds for sensor centering. These options are accessed through the menus for editing a configuration. On the main Edit Configuration page in iFSC, to view the Sensor Auto Re-center parameters that have been set, use the "pinch-out" gesture (see below) to expand the display area. After enabling auto re-centering, tap the right hand arrow to get the edit screen and then tap the "Additional Parameters" checkbox:



The Additional Parameters work together as follows:

- The mass position is sampled once per minute for each channel and a running average of the last 16 samples is compared to the "Threshold Level" to determine when the sensor needs to be re-centered.
- When a re-center is issued, mass position sampling is suspended for the number of minutes specified in the "Attempt Interval". The Attempt Interval could be viewed as a time for the masses and sensor to settle, or stabilize, before sampling the mass positions again.
- When sampling resumes, 16 samples are collected before the running average calculation is performed and compared to the Threshold Level. Each time the first 16 samples produce an average greater than the Threshold Level, a re-center attempt is made and a re-center attempts counter is incremented.
- If the re-center attempts counter reaches the "Max Attempts" value, mass re-centering is suspended for "Cycle Interval" days. Thus if external conditions are variable and preventing the sensor from staying centered, this allows time for those conditions to settle before attempting centering again, and helps reduce the chance of burning out the centering motors.
- Whenever 17 or more readings are taken before the 16 sample running average is over the Threshold Level, the re-center attempts counter is set back to 0.

NOTE: When using iFSC with 3.0.0, the iFSC app will allow the user to set the Additional Parameters, however the 3.0.0 DAS is only aware of the Enable state and the Cycle Interval, the other parameters are ignored.

When the non-SOH messages are viewed in the log, the Auto-Center parameters are shown as:

```
130 Sensor Auto-Center Information
    Sensor = 1
        Enable = Enabled
        Reading Interval = 3.0
```

```
Cycle Interval = 1
Level = 3.0
Attempts = 5
Attempt Interval = 10
```

The "Level" value is the Horizontal Threshold, and the "Reading Interval" value is actually the Vertical Threshold.

3.4.3-4. Modification to the Channel Information to Retrieve the Sensor Type

The code has been modified to extract the Sensor Type from the Sensor Model field of the channel information. The sensor type determines the behavior of the sensor control lines on the channel connector.

The options that this modification affects, such as the "Lock" and "Unlock" buttons on the bottom of the "Sensor & Aux Control" page in iFSC, are not applicable to PASSCAL RT130. A different sensor control board is required. **The iFSC "Lock" and "Unlock" controls DO NOT WORK with PASSCAL equipment.**

3.4.3-5. Modification to Include 50 SPS as Part of Group Two

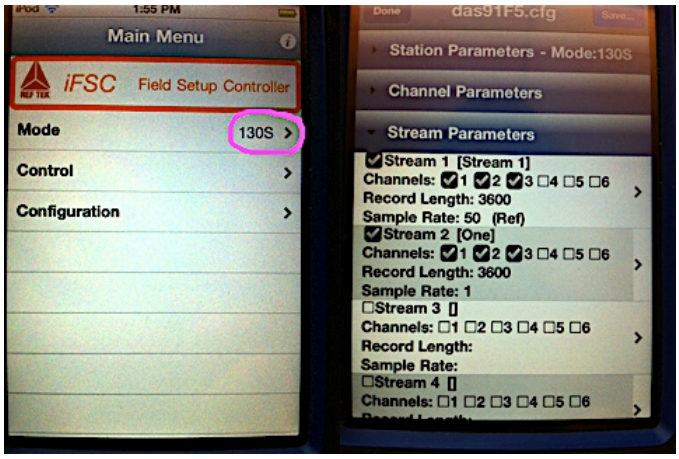
The code has been modified to move 50 sps from Group One to Group Two. This change will allow the user to record a stream at 50 sps and additional streams at any other Group Two rate simultaneously.

Group 1 sample rates are only available when recording a single, same, sample rate for all streams. Group 2 sample rates may be recorded in any combination within all streams.
The two groups now are:

One: 1000, 500, 250, 125, 25
Two: 200, 100, 50, 40, 20, 10, 5, 1, 0.1

If you try to program a PASSCAL RT-130 for this option (i.e. using 50 sps with another sample rate) using iFSC in the 130 mode, it will either not allow you to chose mismatched data streams or it will give an error like this:

However, if you switch to the 130S mode, then you can configure the RT130 with mixed data streams that include 50sps:



Mixed 50sps stream configuration of a PASSCAL RT-130 with the 3.4.3 FW using this method (using 130S Mode) is possible. Note that this sample rate is not compatible with the new real time data monitor function (see 3.4.0-7 above).

Continuous Trigger Start/Alignment

3.2.5-3. Modification to Continuous Trigger Event Time Alignment

Continuous trigger streams will now align the starting time of the event if the record length specified divides evenly into 86,400 seconds (24 hrs.). To perform this alignment the first events record length will be adjusted so that all subsequent events will be aligned and equal to the length specified. Time alignment will never occur for samples rates less than 1 sps or for stream 9 AUX channels events.
Example: A record length of 3600 seconds (1hr.) will produce events that start exactly on the hour after the first event is reduced to achieve the alignment.

With record lengths set to the norm of 3600 seconds (1hour), with the 3.4.3 firmware the first event ends at the start of the next real-world hour even if the event was not a full hour in length. The next event and all subsequent events start on the hour and end on the next hour. This aligns all the time streams in a very easy to analyze format.
With 3.0.0 firmware the first event measured one hour in length, ending one hour from its start time. Each event start time was one hour offset from the previous event start time.

3.2.8-3. Correction to Continuous Trigger Start Time After Year Roll

Corrected of the continuous trigger start time for events after the year roll. The continuous stream alignment was first introduced in version 3.2.5.

3.2.8-4. Correction to Continuous Trigger Alignment After Clock Adjustment

Correction of the continuous trigger event alignment after a clock has been adjusted by the user or by the GPS. When a clock change is detected all continuous stream events in progress are ended and new events started so time alignment can be performed. The continuous stream alignment was first introduced in version 3.2.5.

3.4.0-1. Correction to Continuous Stream Time Alignment

A correction was made to fix a possible error in the Start Time of the Event Header when the DAS clock is changed and new time alignment values are calculated.

Disks

3.2.2-5. Modification to the Disk LED Illumination during Boot-up

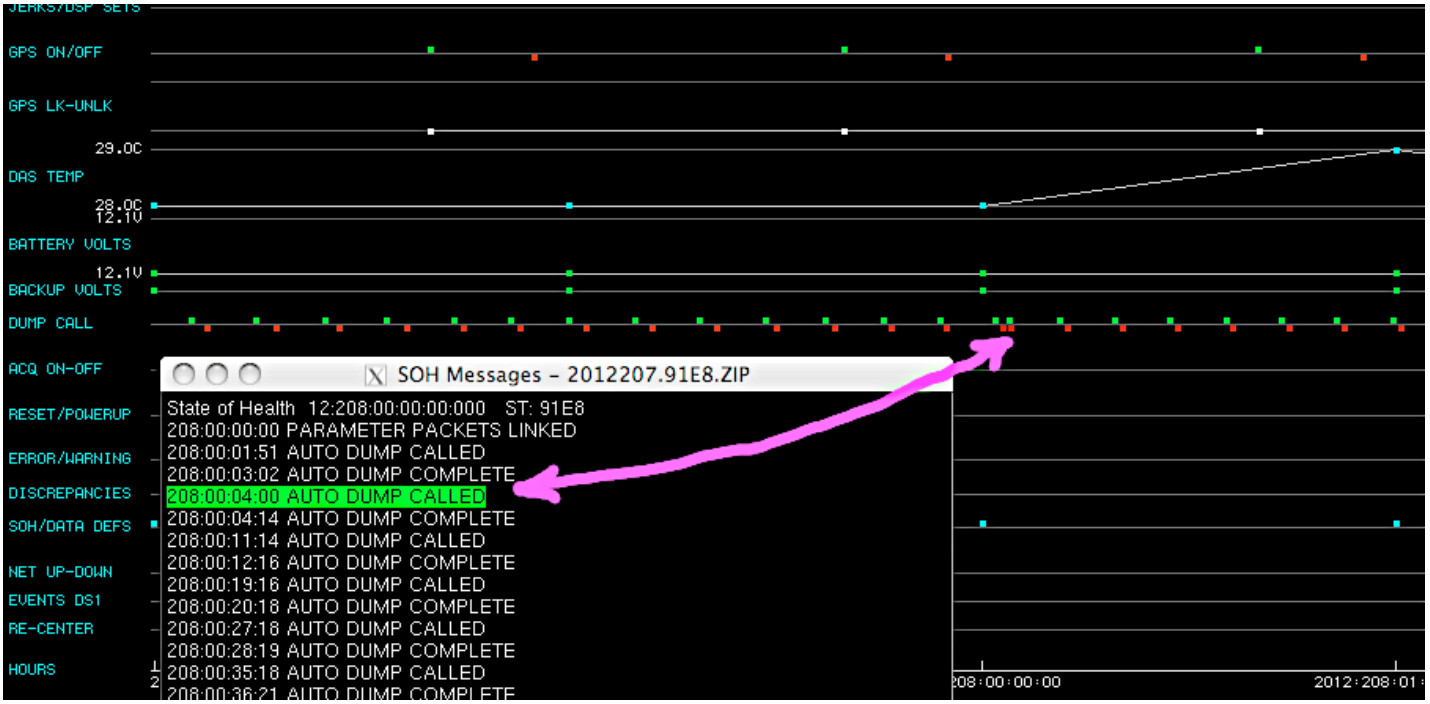
The LEDs will remain Red for all installed disks during the entire boot-up sequence. The LEDs will change to green when the DAS is fully operational and the disks can be removed. This change was made to clarify the DAS status, reducing the chance that a disk is removed during boot-up.

3.4.3 firmware, on startup, initially lights both disk RED LEDs simultaneously for 4-5 seconds, then briefly both GREEN LEDs light, followed by a short RED-GREEN sequence on one disk and then the other, then both GREEN.
3.0.0 firmware, on startup treats disks sequentially, with the RED LED for 1 second, followed by GREEN LED for 1-2 seconds, then RED LED for 3 seconds or until the first disk fully read, then the same sequence on the second disk.
The main point is to not remove either disk until the unit is fully booted up.

3.2.2-9. Addition of a Forced Disk Dump Once a Day

A forced dump to disk has been added at 4 minutes after midnight to ensure that the data is dumped once a day even if the amount of data collect has not reached the dump threshold.

Using normal PASSCAL disk setup (dump threshold at 66%, auto-wrap off, dump on ET off), with the 3.0.0 firmware the dumps to disk are done when RAM reaches 66%. However, with the 3.4.3 firmware there is an additional dump to disk done at 12:04 AM each night, even if a RAM dump occurred recently. This additional dump to disk is noticeable in the log and in logpeek, as highlighted with arrows in the figure below:



Additional daily dump to disk at 12:04 AM

3.2.8-7. Modification to Disk Operations When a New Disk is Installed

When the Das detects that a new disk is installed in the system the disk is examined to determine the total size and the size of the clusters. If the disk in question is larger than 2G and is not formatted with 32KB cluster, it will be formatted automatically and any data on the disk will be lost.

With 3.4.3, we verified that when the disk was formatted correctly, upon installation the disk was read and then the DAS returned to a waiting state. This was true whether the disk was named correctly for the particular DAS or not.

3.4.3-1. Correction to Last Disk Used after a Das Reset

A correction was made to retain the last disk used information while the disk voltage is below the minimum threshold and the DAS goes through a reset. The information is now retained for the DAS to continue writing to the last disk used when the voltage returns to a level that is high enough to continue disk operations.

With older firmware than 3.4.3, when disk wrap was ON (normally we use disk wrap OFF), after a low voltage occurrence, approximately half the time (apparently randomly) the DAS would reformat the active disk when the voltage returned to normal. This has not been observed with the 3.4.3 firmware. Again, this was only an issue when disk wrap was ON, which is not a typical PASSCAL configuration.

3.4.3-2. Correction to Disk Usage Information

A correction was made to fix the disk usage information being reported after the disk is formatted and the DAS switches disks. A timing issue was found which caused the wrong amount of space available to be reported. This timing condition was introduced in version 3.4.0 when the disk and Ethernet data dumping operations were separated to increase data throughput. In addition, the disk is now power cycled as part of the power down process. This causes the FAT table to be reread so the current disk usage information is used to update the disk statistics.

During testing of the 3.4.0 firmware we found a seemingly randomly occurring issue where, upon filling one disk so that the unit switched active disks, ~20% of the DAS would report only 0.063MB written to the first disk (although when disks were offloaded, all the data was there). We reported this bug to RefTek, and this issue is fixed in version 3.4.3.

Additionally, with this fix, when a unit is on low power, such that disk operations have been disabled and a reset is forced at 95% full RAM, the unit now rereads the FAT table during the power down process so the DAS is able to report the currently active disk (indicated by *) and the disk usage upon reboot:

```
209:17:28:38 DISK 1* USED:   478904  AVAIL:   520000  TOTAL:   998904  CL:  8K
```

Previously, with 3.0.0 since the unit was unable to access the disks during the low power condition the DAS could not report disk usage information upon reboot:

```
209:17:27:06 DISK 1: USED:        0  AVAIL:        0  TOTAL:        0  CL:  0K
```

Error Handling

These are lower level modifications that should not cause any changes that users would notice.

3.2.2-3. Modification to Low Level Disk Functions to Return Errors

The low level disk functions now return errors to the upper level functions improving error recovery.

3.2.2-11. Addition of an Software Watchdog
A software watchdog has been implemented to monitor code execution.

3.2.5-4. Modification to Disk Error Messages to Include "Formatting Error" Added
Formatting Error message to provide more information regarding the cause of a disk error due to a formatting issue.

3.2.9-1. 1. Modification to Handling of A/D Interrupt Errors
The code has been modified to reapply the A/D parameters if A/D synchronization errors are detected.

Files

3.2.2-7. Modification to the Naming of Incomplete Events Written to Disk
Events that are incomplete at the time they are dumped to disk will now have an approximate length value appended to the name each time a disk dump occurs. Previously the length value was always written as zero until the event was complete. Some utility programs use the length value for processing the data.

3.2.6-1 and 3.2.8-1. Correction to File Names for Events Written to Disk
Corrected the file name of the events written to disk. The name was created using the first sample time of each event. The millisecond portion of the file name generation was not correcting for 1000 millisecond values.

3.4.0-4. Modified the Way Files are Split When Disk Wrap is Enabled
The firmware has been modified to switch disks before the current disk is completely full splitting files for event in progress as necessary.

This is relevant when disk wrap is ON, which is not a typical PASSCAL operating mode. When disk wrap was ON the new 3.4.3 firmware, when switching to the next disk, would leave an amount of free space on the disk usually slightly larger than the RAM on the DAS.

GPS

3.2.2-6. Modification to the GPS Messages Written to the SOH File
The number of GPS SOH messages has been reduced by eliminating the redundant "INTERNAL CLOCK PHASE ERROR OF 0 USECONDS" messages. This message will now only be written once to the SOH file during each GPS Power-up sequence unless the phase error changes by more than 10 useconds from the last message output to the SOH file. The messages "EXTERNAL CLOCK TYPE: NMEA-GARMIN" and "EXTERNAL CLOCK WAKEUP " have been removed. The clock type message will only be written if it is not a "NMEA- GARMIN".

3.2.5-5. Modification to the Frequency of "External Clock Type:" SOH Message
The clock type SOH message use to be reported every 80 seconds while clock power was on. The message frequency has been change to report once per day, after a power-up and when acquisition is turned on.

In reference to both 3.2.2-6 and 3.2.5-5 above:
With 3.0.0 firmware, the 'External Clock Wakeup' messages were seen at the start of the clock cycle, as well as

'External Clock Type' and 'Internal Clock Phase Error' messages every 60-80 seconds while the GPS was locked, ~14 times in each clock lock cycle (20 minutes each hour) or ~168 messages in a 12 hour period. The messages for a normal clock cycle with 3.0.0 firmware are shown below with these messages highlighted in yellow:

```
194:00:40:00 EXTERNAL CLOCK POWER IS TURNED ON
194:00:40:05 EXTERNAL CLOCK WAKEUP
194:00:40:05 EXTERNAL CLOCK IS UNLOCKED
194:00:40:10 EXTERNAL CLOCK TYPE: NMEA-GARMIN
194:00:41:55 EXTERNAL CLOCK IS LOCKED
194:00:42:47 INTERNAL CLOCK PHASE ERROR OF -3 USECONDS
194:00:43:17 EXTERNAL CLOCK TYPE: NMEA-GARMIN
194:00:44:09 INTERNAL CLOCK PHASE ERROR OF 0 USECONDS
194:00:44:39 EXTERNAL CLOCK TYPE: NMEA-GARMIN
194:00:45:31 INTERNAL CLOCK PHASE ERROR OF 0 USECONDS
194:00:46:01 EXTERNAL CLOCK TYPE: NMEA-GARMIN
194:00:46:53 INTERNAL CLOCK PHASE ERROR OF -1 USECONDS
194:00:47:23 EXTERNAL CLOCK TYPE: NMEA-GARMIN
194:00:48:15 INTERNAL CLOCK PHASE ERROR OF -1 USECONDS
194:00:48:45 EXTERNAL CLOCK TYPE: NMEA-GARMIN
194:00:49:37 INTERNAL CLOCK PHASE ERROR OF 0 USECONDS
194:00:50:07 EXTERNAL CLOCK TYPE: NMEA-GARMIN
194:00:50:59 INTERNAL CLOCK PHASE ERROR OF 0 USECONDS
194:00:51:29 EXTERNAL CLOCK TYPE: NMEA-GARMIN
194:00:52:21 INTERNAL CLOCK PHASE ERROR OF 0 USECONDS
194:00:52:51 EXTERNAL CLOCK TYPE: NMEA-GARMIN
194:00:53:43 INTERNAL CLOCK PHASE ERROR OF 0 USECONDS
194:00:54:13 EXTERNAL CLOCK TYPE: NMEA-GARMIN
194:00:55:05 INTERNAL CLOCK PHASE ERROR OF 0 USECONDS
194:00:55:35 EXTERNAL CLOCK TYPE: NMEA-GARMIN
194:00:56:27 INTERNAL CLOCK PHASE ERROR OF 0 USECONDS
194:00:56:57 EXTERNAL CLOCK TYPE: NMEA-GARMIN
194:00:57:49 INTERNAL CLOCK PHASE ERROR OF 0 USECONDS
194:00:58:19 EXTERNAL CLOCK TYPE: NMEA-GARMIN
194:00:59:11 INTERNAL CLOCK PHASE ERROR OF 0 USECONDS
194:00:59:41 EXTERNAL CLOCK TYPE: NMEA-GARMIN
194:01:00:33 INTERNAL CLOCK PHASE ERROR OF 0 USECONDS
194:01:00:33 EXTERNAL CLOCK IS UNLOCKED
194:01:00:33 EXTERNAL CLOCK POWER IS TURNED OFF
```

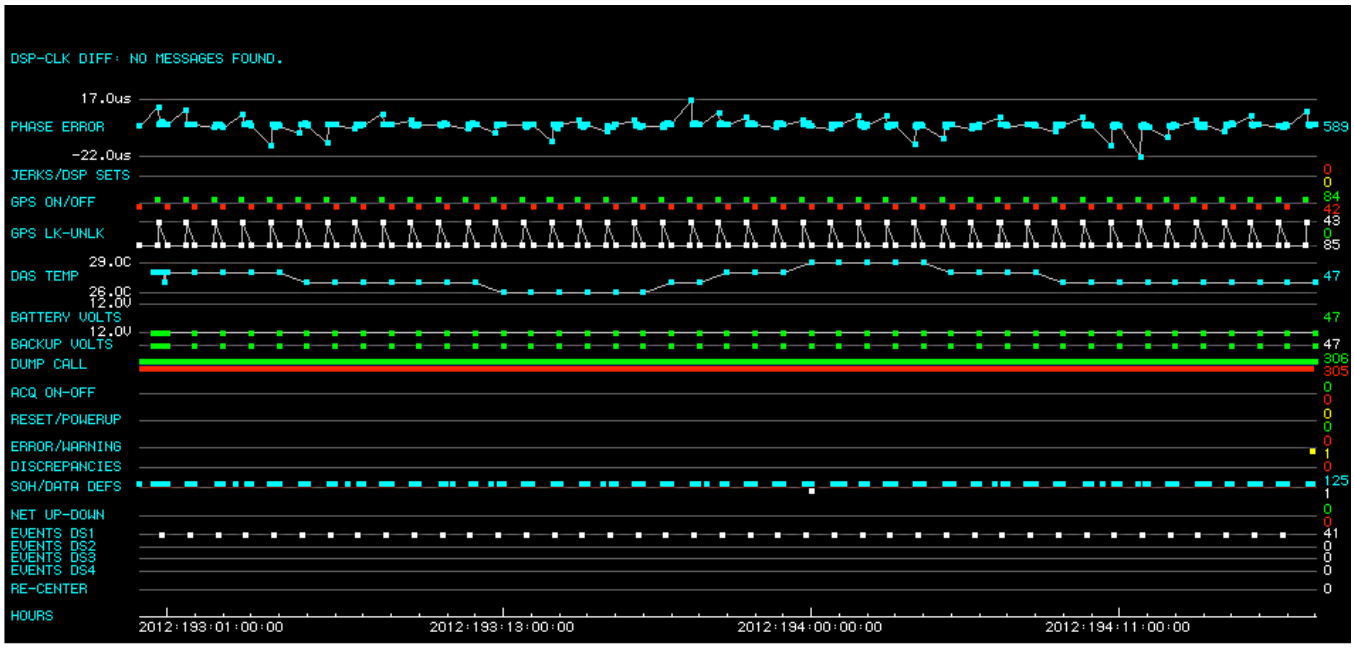
With 3.4.3 firmware, the 'External Clock Type' message is only seen: in the first clock cycle after Aquisition is turned On, the first clock cycle after the day rollover, and in the messages during powerup. The messages from a clock cycle that was the first one after the day rollover, with 3.4.3 firmware are shown below, with the reduction in messages highlighted:

```
194:00:40:00 EXTERNAL CLOCK POWER IS TURNED ON
194:00:40:05 EXTERNAL CLOCK IS LOCKED
194:00:40:10 EXTERNAL CLOCK TYPE: NMEA-GARMIN
194:00:41:02 INTERNAL CLOCK PHASE ERROR OF 9 USECONDS
194:00:58:48 EXTERNAL CLOCK IS UNLOCKED
194:00:58:48 EXTERNAL CLOCK POWER IS TURNED OFF
```

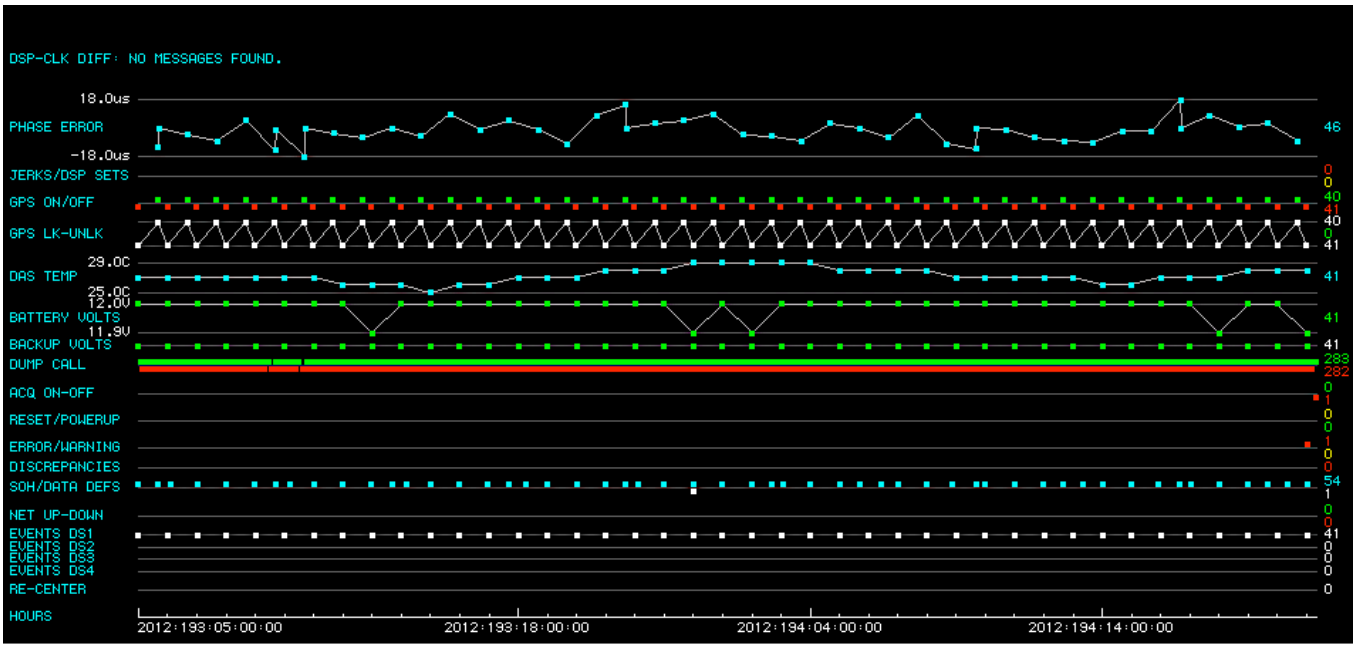
Additionally, as seen in the example directly above, no 'External Clock Wakeup' messages are written with 3.4.3 firmware. Also, SOH files show 'Internal Clock Phase Error' messages only once per lock cycle, unless the phase error changes more than 10 useconds. This amounted to ~14-16 messages total within a 12 hour period - once each hour when the clock locked and then during a few lock cycles when the phase error changed enough to generate an additional message.

The difference in the Phase Error message output is seen dramatically in logpeek. The first logpeek screen

below is from 3.0.0FW while the second screen capture is from a DAS with 3.4.3FW. Note the significantly different pattern in the phase error traces:



3.0.0FW



3.4.3FW

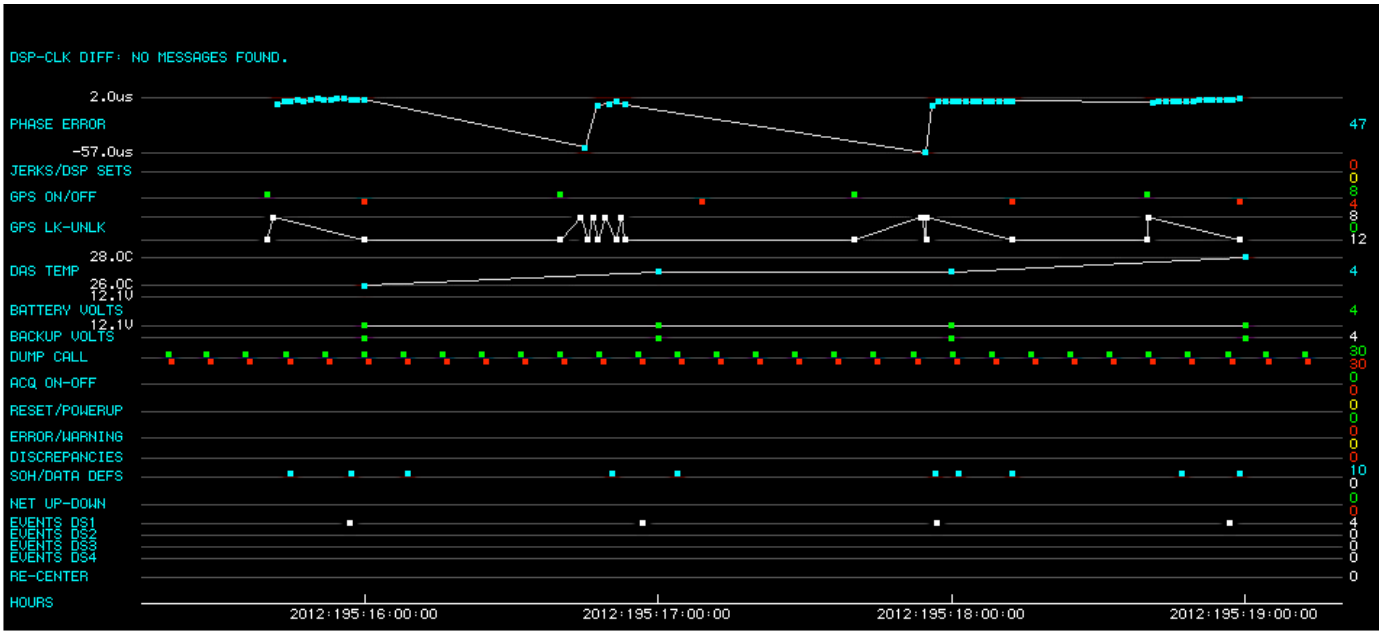
Another point of interest that is illustrated in the two logpeek screen captures above is the additional difference in the GPS LK-UNLK traces. The difference can be seen in the SOH log text examples above as well. In the 3.0.0 example at the start of the clock cycle, the first poll of the clock finds it's status unlocked and then in the second poll 15 seconds later the clock is locked. Finding the clock initially unlocked generates the sawtooth LK-UNLK trace in the upper screen capture. On the 3.4.3 example, the initial poll of the GPS finds it locked,

and this generates the zig-zag LK-UNLK trace in the lower screen. This difference at the start of the clock cycle is not due to DAS firmware. It is due to the receivers in these particular clocks. In both instances the clocks are the older "white-ring" Garmins. However, the receiver clock shown in the lower panel was a 15X-HVS rather than the older 15-HVS. Likewise in the "puck" style of GPS clocks, some are a 16-HVS and some have a 16X-HVS. The "X" versions of receivers lock faster than the older versions. (We've tried to note in inventory which are 15X and 16X.)
However, the zig-zag pattern of the newer receivers may also be seen sometimes with an older receiver - and in that case it indicates a problem. The component on the LID board which switches the GPS power on and off can sometimes become stuck in the power ON position thus keeping the GPS continually locked and then the "External Clock Is Unlocked" message will not be seen at the start of the clock cycle. (We have been testing the GPS power switch as part of the routine bench tests since mid 2011 when this issue was discovered.)

3.3.0-1. Modification to CLK Phase Error Correction when GPS Lock is Lost

The code has been modified to properly handle clock phase error correction cycle when the GPS losses lock.

With 3.0.0 firmware, during the GPS power On cycle, when the lock was lost during phase error calculations, larger errors could be calculated. In the logpeek capture below, the lock was lost near the start of two GPS cycles (as seen in the GPS LK-UNLK trace) and >50 µsecond errors were calculated (shown in the light blue PHASE ERROR trace). This is also detailed, and highlighted, in the log messages below the screen capture:

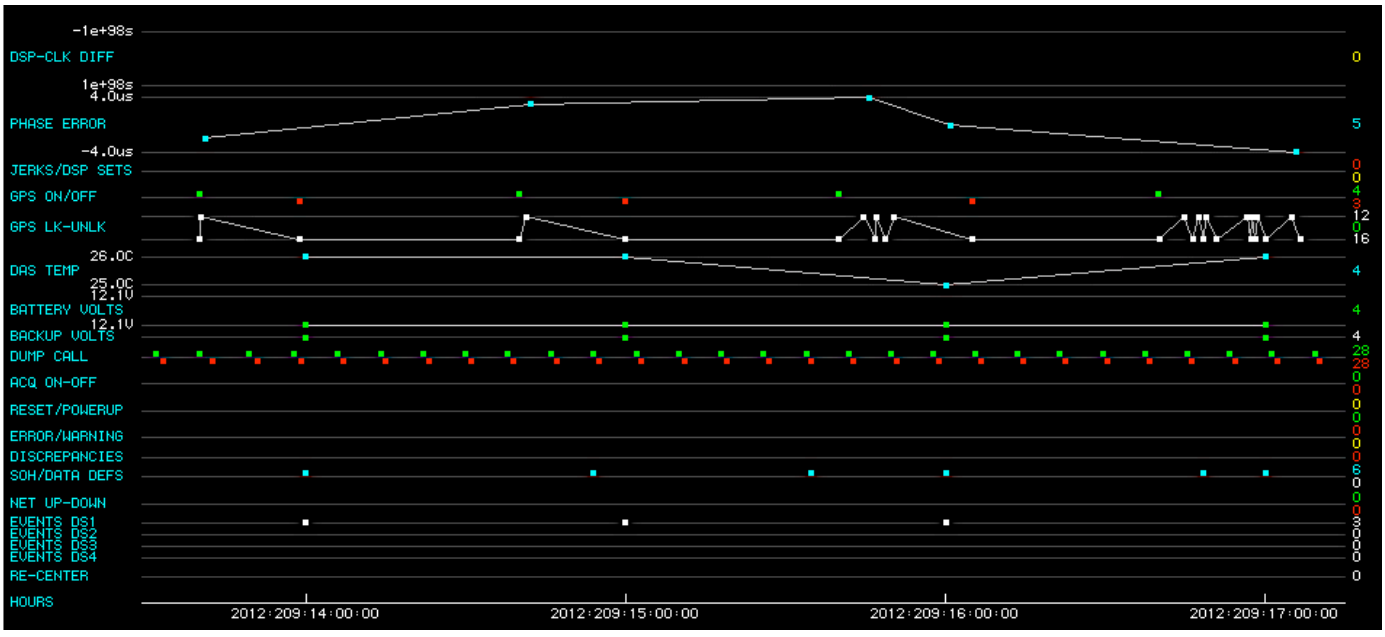


(19 'External Clock Type' messages have been removed from the log messages below.)

```
195:16:40:00 EXTERNAL CLOCK POWER IS TURNED ON
195:16:40:05 EXTERNAL CLOCK WAKEUP
195:16:40:05 EXTERNAL CLOCK IS UNLOCKED
195:16:44:14 EXTERNAL CLOCK IS LOCKED
195:16:45:06 INTERNAL CLOCK PHASE ERROR OF -51 USECONDS
195:16:45:38 EXTERNAL CLOCK IS UNLOCKED
195:16:46:41 EXTERNAL CLOCK IS LOCKED
195:16:47:33 INTERNAL CLOCK PHASE ERROR OF -6 USECONDS
195:16:47:46 EXTERNAL CLOCK IS UNLOCKED
195:16:49:12 EXTERNAL CLOCK IS LOCKED
195:16:50:04 INTERNAL CLOCK PHASE ERROR OF -4 USECONDS
```

```
195:16:51:26 INTERNAL CLOCK PHASE ERROR OF -2 USECONDS
195:16:51:28 EXTERNAL CLOCK IS UNLOCKED
195:16:52:29 EXTERNAL CLOCK IS LOCKED
195:16:53:17 EXTERNAL CLOCK IS UNLOCKED
195:16:53:21 INTERNAL CLOCK PHASE ERROR OF -5 USECONDS
195:17:08:51 EXTERNAL CLOCK FAILED TO LOCK
195:17:08:51 EXTERNAL CLOCK POWER IS TURNED OFF
195:17:40:00 EXTERNAL CLOCK POWER IS TURNED ON
195:17:40:05 EXTERNAL CLOCK WAKEUP
195:17:40:05 EXTERNAL CLOCK IS UNLOCKED
195:17:53:49 EXTERNAL CLOCK IS LOCKED
195:17:54:41 INTERNAL CLOCK PHASE ERROR OF -57 USECONDS
195:17:54:47 EXTERNAL CLOCK IS UNLOCKED
195:17:54:48 EXTERNAL CLOCK IS LOCKED
195:17:56:03 INTERNAL CLOCK PHASE ERROR OF -6 USECONDS
195:17:57:25 INTERNAL CLOCK PHASE ERROR OF -1 USECONDS
195:17:58:47 INTERNAL CLOCK PHASE ERROR OF -2 USECONDS
195:18:00:09 INTERNAL CLOCK PHASE ERROR OF -2 USECONDS
195:18:01:31 INTERNAL CLOCK PHASE ERROR OF -1 USECONDS
195:18:02:53 INTERNAL CLOCK PHASE ERROR OF -1 USECONDS
195:18:04:15 INTERNAL CLOCK PHASE ERROR OF -2 USECONDS
195:18:05:37 INTERNAL CLOCK PHASE ERROR OF -2 USECONDS
195:18:06:59 INTERNAL CLOCK PHASE ERROR OF -1 USECONDS
195:18:08:21 INTERNAL CLOCK PHASE ERROR OF -1 USECONDS
195:18:09:43 INTERNAL CLOCK PHASE ERROR OF -1 USECONDS
195:18:11:05 INTERNAL CLOCK PHASE ERROR OF -1 USECONDS
195:18:12:27 INTERNAL CLOCK PHASE ERROR OF -1 USECONDS
195:18:12:27 EXTERNAL CLOCK IS UNLOCKED
195:18:12:27 EXTERNAL CLOCK POWER IS TURNED OFF
```

With 3.4.3, when the GPS lock was lost during phase error calculations, drift corrections were suspended. The logpeek screen capture below shows a similar example to that above, of the GPS lock being lost, but the suspension of drift corrections prevents the larger phase errors (the scale on the Phase Error trace is +4.0 to -4.0 μseconds). The log messages for this example, showing the suspension of drift correction, are listed below the screen capture:




```
209:15:40:00 EXTERNAL CLOCK POWER IS TURNED ON
209:15:40:05 EXTERNAL CLOCK IS UNLOCKED
209:15:44:42 EXTERNAL CLOCK IS LOCKED
209:15:45:34 INTERNAL CLOCK PHASE ERROR OF 4 USECONDS
209:15:46:49 EXTERNAL CLOCK IS UNLOCKED
```

```
209:15:46:49 EXTERNAL CLOCK ERROR - SUSPENDING DRIFT CORRECTION
209:15:46:57 EXTERNAL CLOCK IS LOCKED
209:15:48:45 EXTERNAL CLOCK IS UNLOCKED
209:15:50:26 EXTERNAL CLOCK IS LOCKED
209:16:00:52 INTERNAL CLOCK PHASE ERROR OF 0 USECONDS
209:16:04:58 EXTERNAL CLOCK IS UNLOCKED
209:16:04:58 EXTERNAL CLOCK POWER IS TURNED OFF
209:16:40:00 EXTERNAL CLOCK POWER IS TURNED ON
209:16:40:05 EXTERNAL CLOCK IS UNLOCKED
209:16:44:43 EXTERNAL CLOCK IS LOCKED
209:16:46:25 EXTERNAL CLOCK IS UNLOCKED
209:16:46:25 EXTERNAL CLOCK ERROR - SUSPENDING DRIFT CORRECTION
209:16:47:26 EXTERNAL CLOCK IS LOCKED
209:16:48:23 EXTERNAL CLOCK IS UNLOCKED
209:16:48:51 EXTERNAL CLOCK IS LOCKED
209:16:50:57 EXTERNAL CLOCK IS UNLOCKED
209:16:50:57 EXTERNAL CLOCK ERROR - SUSPENDING DRIFT CORRECTION
209:16:56:36 EXTERNAL CLOCK IS LOCKED
209:16:57:19 EXTERNAL CLOCK IS UNLOCKED
209:16:57:19 EXTERNAL CLOCK ERROR - SUSPENDING DRIFT CORRECTION
209:16:57:30 EXTERNAL CLOCK IS LOCKED
209:16:58:10 EXTERNAL CLOCK IS UNLOCKED
209:16:58:10 EXTERNAL CLOCK ERROR - SUSPENDING DRIFT CORRECTION
209:16:58:28 EXTERNAL CLOCK IS LOCKED
209:17:00:08 EXTERNAL CLOCK IS UNLOCKED
209:17:04:52 EXTERNAL CLOCK IS LOCKED
209:17:05:44 INTERNAL CLOCK PHASE ERROR OF -4 USECONDS
209:17:06:35 EXTERNAL CLOCK IS UNLOCKED
209:17:06:35 EXTERNAL CLOCK ERROR - SUSPENDING DRIFT CORRECTION
209:17:20:51 EXTERNAL CLOCK IS LOCKED
209:17:25:09 EXTERNAL CLOCK IS UNLOCKED
209:17:25:37 EXTERNAL CLOCK IS LOCKED
209:17:26:29 EXTERNAL CLOCK IS UNLOCKED
209:17:26:29 EXTERNAL CLOCK POWER IS TURNED OFF
```

3.4.3-11. Addition of GPS Firmware Information Once per day to SOH File

The GPS firmware version information is now written to the SOH file once per day.

With 3.4.3FW, during initial bootup and on the day roll, after the messages giving the CPU version and before the messages with the GPS location, there is now a string reporting “GPS Firmware Version: ...”
Example:

```
291:19:54:29 REF TEK 130
291:19:54:29 CPU SOFTWARE V 3.4.3    (2012:121)
291:19:54:29 GPS FIRMWARE VERSION: GPS 16-HVS VER. 3.20
291:19:54:29 GPS: POSITION: N34:04:25.32 W106:55:08.28 +01439M
```

Note that not all GPS report the firmware version, in which case the message is still present but says "GPS Firmware Version: Not Reported".

Packets

These changes should not generate any significant differences for users.

3.2.2-4. Modification to the Order that Data Packets are Sent

The trigger type of each stream is now used to determine the order that data packets are sent. Trigger data will now be sent before Continuous data.

3.2.8-2. Correction to Continuous Trigger DT Packet Time Stamp After Year Roll

Corrected the time stamp of the first data packet after year roll for continuous trigger events. The continuous stream alignment was first introduced in version 3.2.5.

3.4.3-9. Addition of Digital Filter Information in the EH/ET Packets

The EH/ET packets now contain the filter information used to derive the sample rate requested for that stream.

Parameters

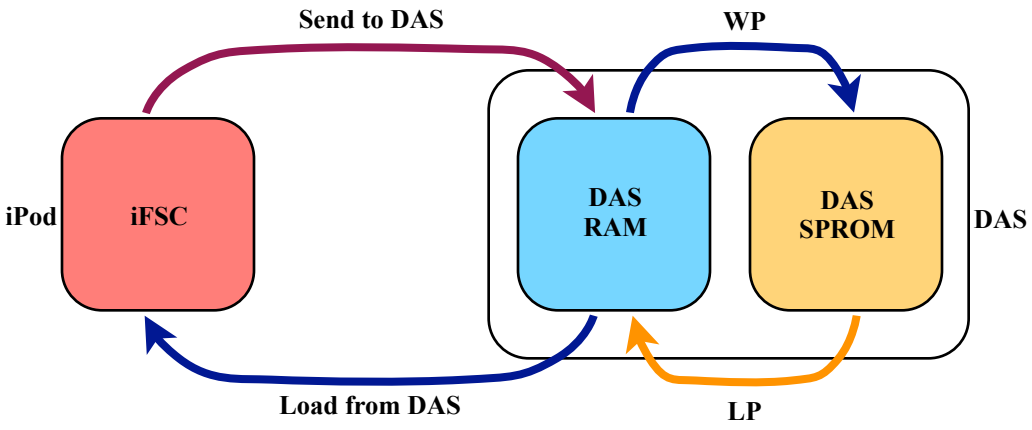
3.2.2-8. Modification to the LP and WP, Data Moved from Disk to SPROMS

The recording parameters are now stored in the SPROMS on the LID and CPU boards instead of being written to the disks installed in the unit at the time that the WP command is issued.

With 3.0.0 firmware, when the WP command was given, the parameters were written to disk and the amount of data stored on the disk could be seen to increase very slightly (using the Clié or iPod).

Using 3.4.3 is very different. When the WP command is given, the parameters are written to the SPROMS located inside the unit. There is no noticeable change in disk usage or anything else, only the interface software states that it has been done. The only way to verify the storage is to use the LP command to load parameters to the RAM, and then "Load from DAS" to the hand control interface (such as iFSC running on an iPod) and check some configuration parameters (such as experiment name) through the interface configuration menus.

The following illustration shows the path of configuration parameters when using the "Send to DAS", "Load from DAS", "WP" and "LP" commands:



The configuration parameters are still included daily in SOH.

NOTE/CAUTION: Changing the firmware clears recording parameters stored on SPROMS (see 3.2.5-2 and 3.2.8-5 below). If the parameters have been cleared through loading the firmware, and new parameters have not been sent, the DAS will not record data. There are a few default parameters but they do not include any channel or stream definitions. The only fields filled out are 'Station: STATION NAME' and 'Experiment: DEFAULT'. Starting acquisition, after clearing parameters by swapping firmware, does very little. On Start Acq the DAS is set to 'Start On' state but data is not recorded. RAM does not increase past its initial value. The DAS does not

dump when acquisition is stopped. A forced disk dump does nothing. No data was written to disk at all. A meaningful parameter set must be resent to the DAS after loading firmware.

3.2.5-2. Modification to the Stored Parameter Set when Firmware is Updated

Changes effecting the parameter set as part of a firmware update, could cause a compatibility issue, therefore the stored parameter set is now deleted whenever the firmware is updated

3.2.8-5. Modification to Erase Store Configuration Parameters

When the DAS detects that the firmware version has changed the configuration parameters stored in SPROM are erased. The configuration parameters were first stored in SPROM starting with version 3.2.2.

See Caution Note above 3.2.5-2.

Telemetry

Significant firmware changes were made to telemetry. Initially we tested simply to verify that telemetry still worked at least as well as when running 3.0.0 firmware. We found that when transmitting 200 sps, plus 1 sps, 3-channel data, over an eight hour period we began to get a few brief gaps (~20 seconds total) in the 3.4.3 high sample rate data. But over the same period, from the 3.0.0 telemetered data ~3 hours of high sample rate data, and ~50% of the low sample rate data, was lost. At 250 sps there were several gaps of a few minutes in the 3.4.3 data, but more than 50% data loss with 3.0.0.

At 500 sps, 3.4.3 could not keep up with the throughput either. The DAS reboots when the RAM fills to 95%, and then tosses the ethernet queue at 97% RAM. So considerable telemetry data was lost due to tosses, but only minimal data was lost from disks (during the reboots). With 3.0.0, the DAS reboots at 95% RAM, but does not go to TOSS mode at 97% full. As long as the ethernet connection was up, the ethernet queue continued to fill RAM all the way to 100% at which point acquisition stopped. Therefore more than 50% of disk data was lost as well as the telemetered data.

In general, the telemetry throughput for the units running 3.4.3 was found to be better than the RT130 running 3.0.0. The sample rate and number of streams telemetered still need to be considered though.

3.2.2-1. Correction to the Ram Percent Full Checking and Forced Toss

The checks performed on ram usage did not change the telemetry data to the toss mode (if selected) when ram filled to 97% even if the toss delay had not been satisfied.

This is a correction that prevents the RAM from reaching 100% full and stopping acquisition when the throughput of the telemetry network cannot keep up with the rate at which data is recorded - if TOSS mode is selected. When the RAM fills to 97%, now the DAS tosses the data in the ethernet queue regardless of whatever Toss Delay has been selected. Previously, with Toss Mode selected on a DAS running 3.0.0, the DAS would only switch to Toss Mode after the network was down long enough to satisfy the Toss Delay. If the

network was frequently intermittant, or the sample rate was too high, the Toss Delay might never be met. The DAS would fill RAM to 100% and stop acquisition. Below is a side by side of log messages of an example:

3.0.0

```
101:19:35:50 MQCHK: MEMORY USED ABOVE 75%
101:19:35:50 MQCHK: MEMORY USED=03264,
AVAILABLE=01088, TOTAL=04352, (0->1)
101:19:35:50 MQCHK: DISKQ=01936, ENETQ=03226,
SERQ=00000
101:19:43:33 MQCHK: MEMORY USED ABOVE 85%
101:19:43:33 MQCHK: MEMORY USED=03700,
AVAILABLE=00652, TOTAL=04352, (1->2)
101:19:43:33 MQCHK: DISKQ=02724, ENETQ=03659,
SERQ=00000
```

RAM reaches 95% full and system goes through a reset:

```
101:19:52:14 MQCHK: MEMORY USED ABOVE 95%
101:19:52:14 MQCHK: MEMORY USED=04135,
AVAILABLE=00217, TOTAL=04352, (2->R)
101:19:52:14 MQCHK: DISKQ=03601, ENETQ=04091,
SERQ=00000
101:19:52:14 MQCHK: DISK POWER 12.38V  - VOLTAGE
OK
101:19:52:15 MQCHK: DATA DESTINATIONS HUNG -
FORCE RESET
101:19:52:22 SYSTEM POWERUP 00040: UNIT 9576,
CPU VER 3.0.0
101:19:52:22 MEMORY USED=04141, AVAILABLE=00211,
TOTAL=04352
101:19:52:27 UNCONFIGURE ETHERNET PORT
101:19:52:27 CONFIGURE ETHERNET PORT TO
192.168.033.002 (255.255.255.000)
101:19:52:27 CREATE ETHERNET ROUTE TO
129.138.026.000 THRU 192.168.033.001
101:19:52:27 POWERUP COMPLETE
101:19:52:27 RTP: NETWORK LAYER IS UP!
101:19:52:27 RTP: STOPPED BY EVENT OPEN
```

Memory still 95% full after reset, continues to increase:

```
101:19:52:27 MQCHK: STATUS AFTER RESET
101:19:52:27 MQCHK: MEMORY USED ABOVE 95%
101:19:52:27 MQCHK: MEMORY USED=04142,
AVAILABLE=00210, TOTAL=04352,(0->3)
101:19:52:27 MQCHK: DISKQ=03607, ENETQ=04114,
SERQ=00000
101:19:52:28 ACQUISITION ENABLED WITH DELAY OF
00:00
101:19:52:28 ACQUISITION STARTED
101:19:52:28 MEMORY USED=04154, AVAILABLE=00198,
TOTAL=04352
101:19:52:30 RTP: OPENED
101:19:54:53 MEMORY USED=04301, AVAILABLE=00051,
TOTAL=04352
```

Disk dump call at 99% RAM (dump threshold for this example):

```
101:19:54:54 AUTO DUMP CALLED
```

Despite dump call RAM reaches 100% full and ACQUISITION STOPS:

```
101:19:55:34 ACQUISITION STOPPED - RAM FULL
```

3.4.3

```
101:20:36:26 MQCHK: MEMORY USED ABOVE 75%
101:20:36:26 MQCHK: MEMORY USED=03264,
AVAILABLE=01088, TOTAL=04352, (0->1)
101:20:36:26 MQCHK: DISKQ=03241, ENETQ=00006,
SERQ=00000
101:20:40:43 MQCHK: MEMORY USED ABOVE 85%
101:20:40:43 MQCHK: MEMORY USED=03700,
AVAILABLE=00652, TOTAL=04352, (1->2)
101:20:40:43 MQCHK: DISKQ=03674, ENETQ=00007,
SERQ=00000
```

RAM reaches 95% full and system goes through a reset:

```
101:20:45:02 MQCHK: MEMORY USED ABOVE 95%
101:20:45:02 MQCHK: MEMORY USED=04135,
AVAILABLE=00217, TOTAL=04352, (2->R)
101:20:45:02 MQCHK: DISKQ=04109, ENETQ=00007,
SERQ=00000
101:20:45:02 MQCHK: DISK POWER 12.33V  - VOLTAGE
OK
101:20:45:02 MQCHK: DATA DESTINATIONS HUNG -
FORCE RESET
101:20:45:09 SYSTEM POWERUP 00047: UNIT 9547,
CPU VER 3.4.3
101:20:45:09 MEMORY USED=04140, AVAILABLE=00212,
TOTAL=04352
101:20:45:14 UNCONFIGURE ETHERNET PORT
101:20:45:14 CONFIGURE ETHERNET PORT TO
192.168.033.002 (255.255.255.000)
101:20:45:14 CREATE ETHERNET ROUTE TO
129.138.026.000 THRU 192.168.033.001
101:20:45:14 POWERUP COMPLETE
101:20:45:14 RTP: NETWORK LAYER IS UP!
```

Memory usage increases to 97% after reset so unit switches to TOSS:

```
101:20:45:14 RTP: DISC CHANGE ETHERNET LINK FROM
KEEP TO TOSS
101:20:45:14 RTP: STOPPED BY EVENT OPEN
101:20:45:19 MQCHK: STATUS AFTER RESET
101:20:45:19 MQCHK: MEMORY USED ABOVE 95%
101:20:45:19 MQCHK: MEMORY USED=04141,
AVAILABLE=00211, TOTAL=04352,(0->3)
101:20:45:19 MQCHK: DISKQ=04113, ENETQ=00006,
SERQ=00000
```

Disk dump call at 99% RAM (Acquisition Start is still part of reset):

```
101:20:45:20 AUTO DUMP CALLED
101:20:45:21 ACQUISITION ENABLED WITH DELAY OF
00:00
101:20:45:21 ACQUISITION STARTED
101:20:45:21 MEMORY USED=04158, AVAILABLE=00194,
TOTAL=04352
101:20:45:30 MQCHK: MEMORY USED BELOW 85%
101:20:45:42 MQCHK: MEMORY USED BELOW 75%
```

When RAM usage decreases enough the unit switches back to KEEP:

```
101:20:45:56 RTP: OPENED
```

(Continued on next page...)

(3.0.0 Continued)

```
101:19:55:34 ACQUISITION STOPPED
101:19:55:46 AUTO DUMP CALLED
101:19:55:49 AUTO DUMP COMPLETE
101:20:00:00 MEMORY USED=04140, AVAILABLE=00212,
TOTAL=04352
```

With acquisition stopped, telemetry transmission makes headway and is able to decrease RAM usage to the point that acquisition restarts again:

```
101:20:08:23 MQCHK: MEMORY USED BELOW 85%
101:20:40:18 ACQUISITION RESTARTED
101:20:40:18 ACQUISITION STARTED
101:20:40:18 MEMORY USED=02168, AVAILABLE=02184,
TOTAL=04352
```

(3.4.3 Continued)

```
101:20:45:56 RTP: APP CHANGE ETHERNET LINK FROM
TOSS TO KEEP
101:20:46:50 AUTO DUMP COMPLETE
```

Acquisition never stopped.

3.2.2-2. Modification to Interleave Telemetry Data During Disk Writes

Telemetry data is now periodically sent during the disk write operations to reduce the latency caused by suspending telemetry data transmission during disk dumps.

3.2.2-10. Addition of an Adaptive Telemetry Re-transmit Algorithm

The RTP re-transmit interval has been modified to adjust the re-transmit interval based on the round trip time of the previously transmitted packets. The maximum RTP re-transmit interval is 10 seconds.

With this change, and 3.2.2-2 above, there was a significant difference between the 3.0.0 DAS and the 3.4.3 DAS in how well the ethernet queues were emptied. This can be seen in the MQCHK messages in the logs of our example above (running a high sample rate and setting a high dump threshold):

With 3.0.0, when the RAM filled to 75% or more, all of the data in memory was still in the ethernet queue (ENETQ), with less in the disk queue (DISKQ). Although telemetry was transmitting, the ethernet queue backed up more than the disk queue. The following is after there had been one disk dump and the RAM filled again to 75%, 85% and 95%:

```
101:19:35:50 MQCHK: DISKQ=01936, ENETQ=03226, SERQ=00000
101:19:43:33 MQCHK: DISKQ=02724, ENETQ=03659, SERQ=00000
101:19:52:14 MQCHK: DISKQ=03601, ENETQ=04091, SERQ=00000
```

With 3.4.3, when the RAM filled to 75% or more, the data in memory was primarily in the disk queue and the ethernet queue remained nearly empty. Again, below are the queue statuses after one disk dump and RAM had again reached 75%, 85% and 95%:

```
101:20:36:26 MQCHK: DISKQ=03241, ENETQ=00006, SERQ=00000
101:20:40:43 MQCHK: DISKQ=03674, ENETQ=00007, SERQ=00000
101:20:45:02 MQCHK: DISKQ=04109, ENETQ=00007, SERQ=00000
```

3.2.2-12. Addition to the Behavior when Telemetry Connection is Lost

When the telemetry connection is lost, the DAS sends out Server Discoveries. After 5 minutes of sending Server Discoveries, the DAS will stop sending Server Discoveries for 2 minutes. This process is repeated until the connection is re-established. In addition the DAS will display the message "RTP SLEEPING" on the LCD during the 2 minutes that Server Discoveries are suspended.

Reftek has explained that this addition was made to improve reconnections, mapping the correct IP address of the server rather than the first address picked up from the carrier, when telemetry is over a VPN network.

Below are example log messages, from a DAS running 3.0.0 and one running 3.4.3, when the RTP link to the server was severed:

With 3.0.0, the unit switches from keep to toss, and messages showing attempts to unconfigure and reconfigure the ethernet port and create an ethernet route recurred approximately every 16 minutes:

```
099:19:29:21 RTP: NETWORK LAYER IS DOWN!
099:19:32:23 RTP: DISC CHANGE ETHERNET LINK FROM KEEP TO TOSS
099:19:45:39 UNCONFIGURE ETHERNET PORT
099:19:45:39 CONFIGURE ETHERNET PORT TO 192.168.033.002 (255.255.255.000)
099:19:45:39 CREATE ETHERNET ROUTE TO  129.138.026.000 THRU 192.168.033.001
099:20:02:15 UNCONFIGURE ETHERNET PORT
099:20:02:15 CONFIGURE ETHERNET PORT TO 192.168.033.002 (255.255.255.000)
099:20:02:15 CREATE ETHERNET ROUTE TO  129.138.026.000 THRU 192.168.033.001
```

Additionally, the LCD screen continues to show the RTP network info.

With a 3.4.3 DAS, the LCD screen shows 'RTP SLEEPING' instead of listing the network settings. The logfile shows the network down and the unit switching from keep to toss similarly to the 3.0.0 RT130. The log additionally shows the forced sleeps from the discovery mode, i.e. 'RTP: FORCING DISCOVERY SLEEP FOR: 120sec'. The first instance is five minutes after the time the network went down and then subsequently every 7 minutes (the unit sends discoveries for 5 minutes, then sleeps for 2, for a 7 minute cycle). The addition of the sleep periods increases the interval between ethernet port reconfigurations to about 22 minutes:

```
099:19:28:51 RTP: NETWORK LAYER IS DOWN!
099:19:28:53 RTP: DISC CHANGE ETHERNET LINK FROM KEEP TO TOSS
099:19:33:42 RTP: FORCING DISCOVERY SLEEP FOR:120 SECONDS
099:19:40:30 RTP: FORCING DISCOVERY SLEEP FOR:120 SECONDS
099:19:47:18 RTP: FORCING DISCOVERY SLEEP FOR:120 SECONDS
099:19:50:37 UNCONFIGURE ETHERNET PORT
099:19:50:37 CONFIGURE ETHERNET PORT TO 192.168.033.002 (255.255.255.000)
099:19:50:37 CREATE ETHERNET ROUTE TO   129.138.026.000 THRU 192.168.033.001
099:19:54:06 RTP: FORCING DISCOVERY SLEEP FOR:120 SECONDS
099:20:00:54 RTP: FORCING DISCOVERY SLEEP FOR:120 SECONDS
099:20:07:42 RTP: FORCING DISCOVERY SLEEP FOR:120 SECONDS
099:20:12:40 UNCONFIGURE ETHERNET PORT
099:20:12:40 CONFIGURE ETHERNET PORT TO 192.168.033.002 (255.255.255.000)
099:20:12:41 CREATE ETHERNET ROUTE TO   129.138.026.000 THRU 192.168.033.001
```

3.2.2-13. Addition to Cycle Ethernet Power Output

The Ethernet power output line (pin M - Net Connector) will now be powered off for 10 seconds if the RTP connection is down for approximately 80 minutes. This can be used to power cycle any radios that are powered by the 130. The 10 seconds power off will occur every 80 minutes until the RTP connection is re-established.

This functionality was tested and confirmed to work as described. When cycling the radio power, the message to the log is: 'RTP: DISCOVERY_CTR: 360 CYCLING RADIO POWER'. However, in a typical PASSCAL setup, the modem would not be powered through the DAS, but via a specific port on the power distribution box.

Miscellaneous Other

3.2.5-1. Correction to Aux EH/ET Bit Weight Information

Corrected the Bit Weight information in the EH/ET headers for Stream 9 Aux data. The 130 reported the wrong Bit Weight information for Channels 7-12 when a RT527 and a RT570 board were installed in the DAS.

3.4.0-5. Modification to the Das Temperature Reporting
The code has been modified to ensure that the calibration value used to calculate the bit weight for the temperature is valid. Otherwise the default bit weight value is used to determine the current temperature.

3.4.3-3. Modification to the Das Input and Charger Voltage Reporting
The code has been modified to ensure that the values used to calculate the bit weight used to improve the accuracy of the Input and Charger voltages are valid. If these values are outside the proper range then the default bit weight values are used.

Not Applicable

3.2.5-6. Addition of Code to Control LID Board Relay 1 During Trigger Events
Code was added to activate Relay 1 on the LID board for 15 seconds when a triggered event is detected. This is only done when special modifications are made to enable this feature.

3.2.5-7. Addition of Support for RT663 LID Board
Code was added for new RT663 LID Board. This Board is used in the 130-SMA/6E. This LID contains special channel routing.

3.2.5-8. Addition of Support for RT649 ATD Board
Code was added for new RT649 ATD Board..

3.2.5-9. Addition of Support for RT650 ATD Board
Code was added for new RT650 ATD Board.

3.2.8-6. Addition of Support for RT649 B05/B06 ATD Board
Code was added for new RT649 FPGA version 2_04 ATD Board

3.3.1-1. Modification to SOH Message "PLL Phase Shift Detected" RT649 Only.
The code has been modified to refine the detection of PLL phase shifts for the RT649 ATD board. Phase shifts greater than 61 nsec will be logged to the SOH. This only applies to a DAS with RT649 ATD boards.

3.4.0-9. Addition of Method to Stop DAS from Reporting Location and Altitude
The DAS can now be set-up to stop reporting the location and altitude information.

3.4.3-6. Addition of Support for Broadband Sensor Lock/UnLock
Code was added for locking and unlocking certain broadband sensors. This feature is only available on units that contain the new RT527 Rev D SCB Board.

3.4.3-7. Addition of Support for RT527 Rev D SCB Board
Code was added for new RT527 Rev D SCB Board.

3.4.3-8. Addition of Support for RT680 LID Board
Code was added for new RT680 LID Board.

3.4.3-10. Addition of Filter Description Packets for the TI 1281/1282 A/D
FD packets have been added for the TI 1281/1282 A/D used on RT608 and RT649 A/D boards.