TPRO-cPCI/TSAT-cPCI
SYNCHRONIZABLE TIMECODE GENERATOR with COMPACT PCI BUS INTERFACE

User Manual

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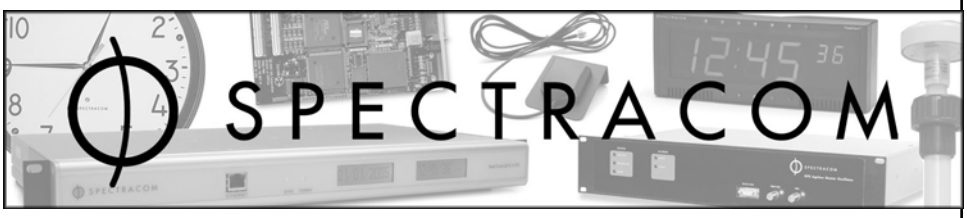

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Specifications subject to change or improvement without notice.

SPECTRACOM LIMITED WARRANTY

LIMITED WARRANTY

Spectracom warrants each new product manufactured and sold by it to be free from defects in software, material, workmanship, and construction, except for batteries, fuses, or other material normally consumed in operation that may be contained therein AND AS NOTED BELOW, for five years after shipment to the original purchaser (which period is referred to as the "warranty period"). This warranty shall not apply if the product is used contrary to the instructions in its manual or is otherwise subjected to misuse, abnormal operations, accident, lightning or transient surge, repairs or modifications not performed by Spectracom.

The GPS receiver is warranted for one year from date of shipment and subject to the exceptions listed above. The power adapter, if supplied, is warranted for one year from date of shipment and subject to the exceptions listed above.

THE ANALOG CLOCKS ARE WARRANTED FOR ONE YEAR FROM DATE OF SHIPMENT AND SUBJECT TO THE EXCEPTIONS LISTED ABOVE.

THE TIMECODE READER/GENERATORS ARE WARRANTED FOR ONE YEAR FROM DATE OF SHIPMENT AND SUBJECT TO THE EXCEPTIONS LISTED ABOVE.

The Rubidium oscillator, if supplied, is warranted for two years from date of shipment and subject to the exceptions listed above.

All other items and pieces of equipment not specified above, including the antenna unit, antenna surge suppressor and antenna pre-amplifier are warranted for 5 years, subject to the exceptions listed above.

WARRANTY CLAIMS

Spectracom's obligation under this warranty is limited to in-factory service and repair, at Spectracom's option, of the product or the component thereof, which is found to be defective. If in Spectracom's judgment the defective condition in a Spectracom product is for a cause listed above for which Spectracom is not responsible, Spectracom will make the repairs or replacement of components and charge its then current price, which buyer agrees to pay.

Spectracom shall not have any warranty obligations if the procedure for warranty claims is not followed. Users must notify Spectracom of the claim with full information as to the claimed defect. Spectracom products shall not be returned unless a return authorization number is issued by Spectracom.

Spectracom products must be returned with the description of the claimed defect and identification of the individual to be contacted if additional information is needed. Spectracom products must be returned properly packed with transportation charges prepaid.

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Spectracom highly recommends that prior to returning equipment for service work, our technical support department be contacted to provide trouble shooting assistance while the equipment is still installed. If equipment is returned without first contacting the support department and "no problems are found" during the repair work, an evaluation fee may be charged.

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EXTENDED WARRANTY COVERAGE

Extended warranties can be purchased for additional periods beyond the standard five-year warranty. Contact Spectracom no later than the last year of the standard five-year warranty for extended coverage.

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Table of Contents

1 Overview

This manual provides comprehensive information on the system architecture, specifications, and operation of the Spectracom TPRO-cPCI and TSAT-cPCI Synchronizable Time Code Generators with PCI Bus Interface.

The TPRO-cPCI and TSAT-cPCI provide high-accuracy timing functions on a plug-in board for the CompactPCI® computer bus. The board has an on-board clock, which is kept in sync to either an external time code input (TPRO-cPCI) or to time provided by GPS satellites (TSAT-cPCI). Several timing functions are derived from the on-board clock, including a programmable periodic pulse rate output ("Heartbeat"), a programmable start/stop output ("Match"), a selectable frequency output ("Oscillator Out", 1 kHz, 1, 5, or 10 MHz), and a time-stamping input ("Time Tag").

The TSAT-cPCI includes an externally-mounted GPS antenna and a 100-foot cable to connect the antenna to the board. The GPS satellites provide continuous time and position information, available anywhere in the world. It automatically syncs its on-board clock to the time transmitted by the GPS satellites and disciplines the onboard 10 MHz oscillator to maintain a 1 microsecond accuracy. The board outputs a time code signal, in IRIG-B format, which conveys the day, hour, minute, and second, and also has a 1 kHz carrier referenced to the on-board oscillator.

The TPRO-cPCI is similar to the TSAT-cPCI, with the exception that it obtains time from an input time code. The time code can be in IRIG-A, IRIG-B or NASA36 format; the board automatically detects which format is being used. The time code conveys the day, hour, minute, and second. The on-board 10 MHz oscillator is disciplined to maintain an accuracy of 10 microseconds for IRIG-A and 15 microseconds for IRIG-B and NASA36.

Either board may be used as a stand-alone time code generator. The computer programs the day, hour, minute, and second. The board then continues to count from that time, using the on-board oscillator as the time base reference. This is called *freewheeling*.

The host computer communicates to either board through a set of memory-mapped registers. When the computer boots up, the board identifies itself to the CompactPCI® bus by specifying the unique Subsystem Vendor ID and Subsystem Device ID. The host computer can then read the instantaneous time, and command the board to set time, and/or to provide an interrupt at a periodic rate, at a specified time, and/or when a time-tag event occurs.

Front panel indicator lights indicate when the board is in the process of synchronizing ("acquiring") the GPS or time code input signal, and when the board has established valid synchronization. The host computer can also interrogate the status register to determine these and other conditions.

1.1 General Information about GPS

NOTE: GPS applies only to the TSAT-cPCI board; the TPRO-cPCI is not equipped for GPS.

The United States government operates a set of approximately 32 satellites, collectively known as the "GPS Constellation" or "GPS Satellites." Each satellite has an internal atomic clock and

transmits a signal specifying the time and satellite position. On the ground, the GPS receiver determines its position (longitude, latitude, and elevation) and the time by decoding the signals simultaneously from at least four of the GPS satellites.

The satellite orbits are circular, inclined approximately 56 degrees from the equator, orbiting the Earth once every 11 hours. There are several different orbital planes, providing continuous coverage to all places on Earth. The GPS receiver uses an omni-directional antenna; the satellites move slowly across the sky (they are not at fixed locations).

Each satellite transmits a spread-spectrum signal, centered at 1575.42 MHz. When power is first applied, the GPS receiver begins searching for the satellites. It does this by searching for each satellite individually, listening for each satellite's distinct spread-spectrum hopping sequence. This process can take a few minutes, as the receiver iteratively locates satellites, refines its position, and determines for which satellites to search.

The GPS receiver retains the last known position when the power is switched off. This results in faster satellite acquisition the next time it is switched on. If the antenna has been moved more than a few miles, however, acquisition time will be slightly longer because it must first re-compute the position.

1.2 Your Spectracom GPS Receiver

Your board's GPS receiver is built into the antenna housing and communicates to the board via a serial (RS-422) interface. Power (+12V) is supplied from the board. The unit comes with a 100-foot cable. Extension cables are available in 100-foot lengths. The maximum total length is 500 feet. The connectors on the extension cables are not weatherproof; only the first 100-feet can be outdoors. The cable consists of several twisted pairs (not coaxial cable) and a foil shield.

NOTE: Spectracom recommends weatherproofing the cable connection at the GPS antenna in order to protect the connection from moisture. Contact Spectracom to order the appropriate weatherproofing kit.

1.3 Inventory

Before installing the board, please verify that all material ordered has been received. The TSAT-cPCI is delivered with a 100-foot cable with pre-installed connectors, a GPS receiver/antenna (housed together in a single enclosure), a breakout-cable (DB-15 to several BNC connectors), and a user manual. The TPRO-cPCI does not include those accessories specific to GPS functions. If there is a discrepancy, please contact Spectracom Customer Service at US +1.585.321.5800.

1.4 Inspection and Support

Unpack the equipment and inspect it for damage. If any equipment has been damaged in transit, please contact Spectracom Customer Service at US +1.585.321.5800.

If any problems occur during installation and configuration of your Spectracom product, please contact Spectracom Technical Support at US +1.585.321.5823 or US +1.585.321.5824.

CAUTION:  *Electronic equipment is sensitive to Electrostatic Discharge (ESD). Observe all ESD precautions and safeguards when handling the timecode generator.*

NOTE: If equipment is returned to Spectracom, it must be shipped in its original packing material. Save all packaging material for this purpose.

2 Settings, Connection, and Configuration

2.1 Jumper Settings

The board has three push-on configuration jumpers. Verify that these are installed as shown in Figure 2.1. (Certain custom options may call for these these jumpers to be arranged differently than shown in the example. Such options include supplemental instructions to explain the jumper settings).

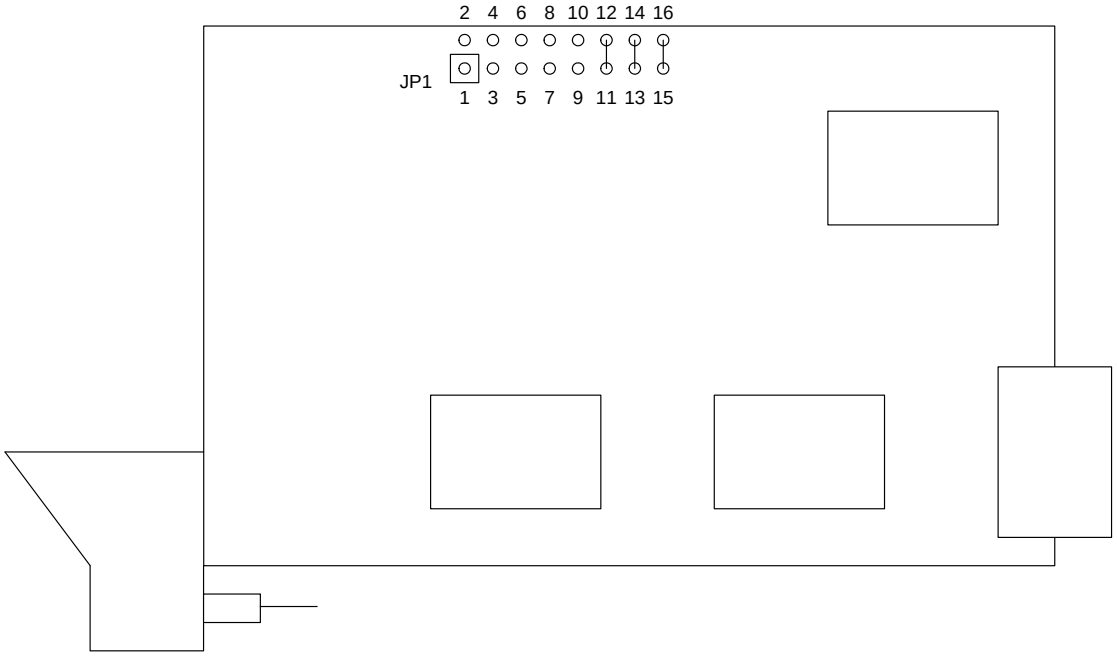

Figure 2.1– Jumper Settings

Jumper numbers are not printed on the board.

Jumper 11 to 12 connects the programmed Oscillator Output frequency to the RS-422 driver input.

Jumper 13 to 14 connects the **Heartbeat** output from the on-board circuitry to the **Timing** connector.

Jumper 15 to 16 connects the **Match** output from the on-board circuitry to the **Timing** connector.

The normal jumper setting consists of jumpers at locations 11 to 12, 13 to 14, and 15 to 16; and no jumpers at 1 to 2, 3 to 4, 5 to 6, 7 to 8, and 9 to 10, as shown above.

Jumpers 1-10 are reserved for custom options.

2.2 Bus Connector

The CompactPCI® bus connector (J1) is **not soldered** to the board. This is normal. The connector is designed to be press-fitted into the board.

2.3 External Connections

Only those functions that are actually used need to be connected. Always turn the computer's power off before connecting or disconnecting.

2.4 GPS Antenna Connector (TSAT-cPCI Only)

The TSAT-cPCI is equipped with a high-density, 15-pin plug connector, labeled "GPS ANTENNA", which connects to the GPS antenna via the supplied cable. Spectracom cables include shielding to meet EMI requirements. **Use of other cables is not recommended.**

When power is first applied, the board sends initialization commands to the receiver/antenna. For this reason, do not disconnect and reconnect the antenna while power is applied.

2.5 Timing Connector

Both versions of the board have a DB-15 socket connector, labeled "TIMING". The pinout for this connector is the same for both TPRO-cPCI and TSAT-cPCI, as follows:

Table 2.1—Timing Pinouts

Pin	Function	Type
1	Time Code Input+	Differential Analog
2	Timecode Input–	Differential Analog
3	Signal Ground	——
4	Time Code Output	Single-ended Analog
5	Signal Ground	——
6	Match Output	TTL Output
7	Signal Ground	——
8	Oscillator Output+	RS-422 Output
9	In-Sync Output Open	Open Collector
10	Time-Tag Input	TTL Input
11	1PPS Sync Input	TTL Input
12	1PPS Output+	RS-422 Output
13	1PPS Output+	RS-422 Output
14	Heartbeat Output	TTL Output
15	Oscillator Output-	RS-422 Output
This pinout is different than Spectracom's TPRO/TSAT-PCI series boards.		

2.6 Breakout Cable

A breakout cable assembly is supplied with each board to access the most commonly-used features. This cable consists of a 15-pin plug and five BNC sockets. Standard boards are supplied with breakout cable Number 0810545.

Because the Time Code Input is a differential signal, for standard boards the breakout cable uses a shorter cable for the Time Code Input than for the other signals; the shield (Time Code Input–) is not connected to Signal Ground on the board. The shorter cable prevents the shield from touching the other shields, thus preserving the isolation from Signal Ground. (In most applications, the Time Code Input– is connected to Signal Ground on the user's end.)

2.7 Time Code Input

This differential analog signal consists of an amplitude-modulated sine wave that can be of IRIG-A, IRIG-B, or NASA36 format. The board detects the format automatically and establishes synchronization. No commands need to be sent from the host computer in order to establish synchronization.

The carrier frequency depends on the code format (1 kHz for IRIG-B and NASA36, 10 kHz for IRIG-A). IRIG-B is by far the most popular format. The sine wave has two distinct amplitudes, known as "mark" and "space". The ratio of mark:space is 3:1. An AGC circuit accommodates a wide range of possible input amplitudes, as described in *Chapter Three—Specifications*.

Time codes, regardless of format, convey the Julian day (001-366), hour, minute, and second. Precise frequency is also conveyed. The year and date are not conveyed. The board phase-locks and disciplines its on-board oscillator to the time code carrier. This allows the board's timing functions to have an accuracy of ten microseconds for IRIG-A and fifteen microseconds for IRIG-B and NASA36. IRIG-A accuracy is slightly better than that of IRIG-B and NASA36, because IRIG-A has a faster/higher carrier frequency.

Essentially, time codes are audio signals. They can be distributed, without degradation, for long distances (several hundred feet) using co-axial or twisted-pair cables. Cable and termination impedance is not critical, since the signal consists of a low-frequency sine wave. A single output can drive many (>10) inputs.

The time code can be recorded on tape in order to time-stamp data, but there are several drawbacks to this. For example, due to time-base flutter, precision boards like the TPRO-cPCI will not synchronize to a time code that is being played back from tape. Also, when recording, it is often necessary to reduce the amplitude of the signal; otherwise the recorder's AGC will compress the high and low parts to the same amplitude, thus losing the timing information.

Digitizing the time code is not recommended because the precise frequency information, which is contained in the carrier frequency, is lost. In all probability, the board will not synchronize to a digitized reproduction of a time code because of the time base errors involved.

2.8 Time Code Output

The board outputs an IRIG-B time code signal, capable of driving many (>10) boards.

The on-board clock generates the time code output. It is always present. When the board is powered-up it begins counting from Day 001, hour 00, minute 00, second 00 (001:00:00:00). Valid Julian days range from 001 to 366. The invalid Julian day number (000) signifies that the clock has not been set. The time code output jumps to the correct time when the clock is set (via the computer bus), or when synchronization is established with the time code input (for TPRO-cPCI) or to GPS (for TSAT-cPCI).

There are two methods for using the time code output to drive inputs for multiple boards. The "T" method connects the output of the master to each slave's input. The advantage of this method is that, if any board loses the incoming signal, it will report a loss of sync and will not affect the other slaves; however, it does require an additional connector (usually a BNC "T") at all but the master and the last slave boards.

The second method is known as a "loop-through." The output of the master is connected to the input of the first slave. The output of the first slave is connected to the input of the second slave, and so on. The advantage is that no additional connectors are needed; but, if the signal is lost at a given board, all of the boards that are "downstream" from that board will have lost sync with the master. While they will be in sync with each other (this is usually an advantage), they can neither recognize nor indicate loss of master sync (a disadvantage).

The user must determine which method is most suitable for the application, although most applications use the "T" method.

2.9 Time Tag Input

The board latches the on-board clock time into a holding register on the rising edge of this signal. The user's software is responsible for ensuring that each event is read before the next occurs.

This is a TTL input with an on-board 10K pull-up resistor to +5V.

2.10 1 PPS Output

This one pulse per second output comes from the on-board clock. It is present regardless of whether the board is synchronized or freewheeling. An RS-422 driver and series 10-ohm resistors in each line are on-board. The recommended termination is 120-ohms, ½ watt, line-to-line (not to ground). The 1PPS Output can be used as a single-ended TTL signal.

2.11 Oscillator Output

Software selects whether this signal is 10 MHz, 5 MHz, 1 MHz, 1 kHz, or Off. It is an RS-422 signal with 10-ohm resistors in each line on the board. The recommended termination is 120-ohms, ½ watt, line-to-line (not to ground). The driver is enabled (not tri-stated), held in the "zero" condition, when in the Off mode.

2.12 Heartbeat Output

This is a programmable, periodic pulse with a TTL driver. It is present regardless of whether the board is synchronized or freewheeling. Power on default state is **off** for heartbeat output.

2.13 Match Output

The Match Output is a TTL output. It goes high at a pre-set time and low at another pre-set time, much like an alarm clock.

2.14 In-Sync Output

This is the same signal that lights the **green** SYNC light on the front panel and drives the Flag–Sync bit in the Status Register. It is an open-collector output, suitable for driving an LED or a

small relay. It can also be used to drive TTL logic by connecting an external 4.7K pull-up resistor to +5V. Use of a Schmitt Trigger input (e.g., 74HCT14) is recommended, as the rise time is relatively slow. The external pull-up resistor and the distributed cable capacitance determine the rise time.

The In-Sync output conducts current to ground when the board is in sync with GPS or the time code input. It also pulses low briefly during power-on reset, or when a “Forced Reset” or “Lamp Test” command is issued. This provides a means for testing the external relay or LED.

2.15 Indicator Lights

The front panel has two indicator lights.

2.15.1 ACQ Indicator Light

The **yellow** ACQ indicator lights when the board is in the process of acquiring either the GPS satellite signals or the incoming time code. When the indicator is not lit, there is no time code input, there are errors in the serial communication to the GPS receiver, or the board is in-sync.

The ACQ indicator also lights momentarily during power-on reset, when a Forced Reset or Lamp Test command is issued, or when any command is sent to the board when the Blink Yellow Mode is enabled.

2.15.2 SYNC Indicator Light

The **green** SYNC indicator lights when the board has established synchronization with the GPS satellite signal or the input time code.

The SYNC indicator also lights momentarily during power-on reset, or when a Forced Reset or Lamp Test command is issued.

3 Specifications

NOTE: Specifications apply to both the TPRO-cPCI and the TSAT-cPCI unless otherwise indicated.

Table 3.1—General Specifications	
Size (board)	100mm, 160 mm, 1.6mm (H, D, T) (3.94 inch, 6.30 inch, 0.063 inch) (H, D, T)
Size (front panel)	3U x 4HP 128.7 mm, 20.32 mm (H, W) (5.07 inch, 0.80 inch) (H, W)
Circuit Board Material	UL 94V-0 FR-4
Power (TSAT-cPCI)	+5V ± 5%: 425 mA max +12V ± 5%: 425 mA max –12V ± 5%: 50 mA max
Power (TPRO-cPCI)	+5V ± 5%: 425 mA max +12V ± 5%: 225 mA max –12V ± 5%: 50 mA max
Operating Temperature	TSAT-cPCI: 0 to 70 C (32 to 158 F) TPRO-cPCI: 0 to 70 C (32 to 158 F)
Storage Temperature	–40C to +85C (–40F to +185F)
Humidity	0 to 95%, non-condensing
TIMING Connector	DB-15 socket, 15 pins
GPS ANTENNA Connector	High-density, D-type plug, 15 pins

Table 3.2—CompactPCI® Interface	
CompactPCI® Interface	Standard 32-bit (J1 only)
CompactPCI® Spec	2.0 Compliant
Memory Map	64 consecutive 32-bit words (256 bytes)
I/O Map	(None)
Chipset Vendor ID (PLX Technology, Inc.)	0x10b5
Chipset Device ID (PLX 9050 Chip)	0x9050
Subsystem Vendor ID (Spectracom)	0x1347
Subsystem Device ID (TPRO-cPCI)	0x7000
Subsystem Device ID (TSAT-cPCI)	0x7100

Table 3.3—On-board Clock	
Synchronization to GPS (TSAT–cPCI)	±1 µS max
Synchronization to Time Code Input (TPRO-cPCI)	±10 µS max (IRIG-A) ±15 µS max (IRIG-B, NASA36)
Time base (freewheeling) TSAT-cPCI	±25 ppm (±25 µS per Sec)
Time base (freewheeling) TPRO-cPCI	±100 ppm (±100 µS per Sec)
Time base (freewheeling) TSAT-cPCI	±1 PPM in one minute
Time base (freewheeling) TPRO-cPCI–05	±10 PPM in one minute
Range	366:23:59:59.999999
Resolution	1 µS

Table 3.4—External GPS Receiver/Antenna	
TSAT-cPCI Only	
Number of Satellites Tracked	12 max
Acquisition Time (Warm Start)	45 seconds (typical)
Acquisition Time (Cold Start)	2 minutes (typ), 15 minutes (max)
Frequency	1575.42 MHz (Receive Only, L1 Band, C/A Code, SPS)
Sync to UTC	±130 nS (1 sigma, stationary location)
Altitude	–400 m to +8,000 m (–1,312 ft to +25,000 ft)
Position Accuracy	40 meters (135 ft) 2dRMS
Datum	WGS-84
Operating Temperature	–30C to +75C (–20F to +165F)
Storage Temperature	–55C to +90C (–65F to +195F)
Humidity	MIL STD 810E, Method 507.3, Procedure I, II, III (95%)
Weatherproof	MIL STD 810E, Method 512.3
Salt Fog	MIL STD 810E, Method 509.3 (48 hours)
Ultraviolet Protection	ASTM G53-88
Transient Protection	600 Watts, 1 mS (data and power lines)
ESD	IEC 1000-4-2 Level 4 (–8 KV to +8 KV)
EMI	FCC Part 15 Class B, European CE
Size	115 mm, 90 mm (4.5 inch, 3.6 inch) (Diam., H)
Mass	475 g (16.8 oz.)
Mounting	1–14 UNS threads x 1 inch deep
Mating Connector	Deutsch MMP26C-2212S1 Plug Housing
	with Deutsch 6862-201-22278 Contact Sockets

Table 3.5—Supplied GPS Antenna Cable	
TSAT-cPCI Only	
Length	30.5 m ± 0.3 m (100 ft ± 1 ft)
Cable Size	9 mm (0.4 inch) O.D.
Antenna Connector Size	20 mm (0.8 inch) O.D.
Board Connector Size	34 mm X 16 mm (1.4 inch x 0.6 inch)
Outer Jacket	Black PVC with U/V Stabilizer/Inhibitor
Internal Wires	5 Twisted Pairs, 22 AWG, stranded, insulated wire
EMI Shield	Foil (100% Coverage) and drain wire

Table 3.6—Optional Extension Cable for TSAT-cPCI	
Length	30.3 m ± 0.3 m (99.5 ft ± 1 ft)
Cable Size	9 mm (0.4 inch) O.D.
Connector Size (both ends)	34 mm X 16 mm (1.4 inch x 0.6 inch)

Table 3.7—Time Code Input	
TPRO-cPCI Only	
Connector	DB-15 TIMING, Pins 1(+) and 2(–)
Format (detected automatically)	IRIG-B(122) or IRIG-A(132)
Amplitude (mark) IRIG-A Amplitude (mark) IRIG-B	1.2 Vp-p (min), 8.0 Vp-p (max) 1.2 Vp-p (min), 8.0 Vp-p (max)
Modulation Ratio	2:1 min, 3:1 typical, 4:1 max
Time Base Error	±25 ppm max
Input Impedance	10K ohm
Common-Mode Voltage (relative to signal ground)	±100 V max
Acquisition Time	15 seconds max

Table 3.8—Time Code Output	
Connector	DB-15 TIMING, pin 4
Format	IRIG-B(122)(CF and SBS fields not used)
Amplitude (mark)	3.0 Vp-p min, 4.0 Vp-p typical, 6.5 Vp-p max; into 50 ohms
Modulation Ratio	3:1 (typical)
Time base Error	same as specified for the on-board clock

Table 3.9—Time Tag Input	
Connector	DB-15 TIMING, pin 5
Tagged Edge	Rising
Input Voltage (high)	+2.2 V min, +5.1 V max
Input Voltage (low)	–0.1 V min, +0.4 V max
Input Current (high)	100 uA max
Input Current (low)	–600 uA max
Input Termination (on-board)	10.7K ohms to +5 Volts
Rise/Fall Time	150 nS max
Pulse Width (time high)	1 uS min, 999.999 mS max

Table 3.9—Time Tag Input	
Time Between Each Rising Edge	500 uS min
Repetition Rate	2000 events/second max
Time Tag Accuracy	± 1 uS

Table 3.10—1PPS Output	
Connector	DB-15 TIMING, pins 13(+) and 12(–)
Output Type	Differential RS-422
Recommended Termination	120 ohms, ½ watt, line-to-line
On-Time Edge	Rising
Time base Error	Same as on-board clock
Differential Output Voltage	3.0 Vp-p typical into 120 ohms
Output Skew (pin 13 to pin 12)	5 nS typical
Pulse Width	4 uS typical

Table 3.11—Oscillator Output	
Connector	DB-15 TIMING, pins 8(+) and 15(–)
Output	Off, 1 kHz, 1 MHz, 5 MHz, or 10 MHz (programmable)
Power-on Default Frequency	Off
Output Type	Differential RS-422
Wave Shape	Square wave, 40%/60% duty cycle
Recommended Termination	120 ohms, ½ Watt, line-to-line
Differential Output (into 120 ohms)	2.5 Vp-p (1 kHz or 1 MHz) 2.0 Vp-p (5 MHz) 1.7 Vp-p (10 MHz)
Output Skew (pin 8 to pin 15)	5 nS typical
Cable Length* (1 kHz or 1 MHz)	76 m (250 ft) max
Cable Length* (5 MHz)	23 m (75 ft) max
Cable Length* (10 MHz)	3 m (10 ft) max
Spectracom recommends a 22 AWG twisted, shielded pair cable. Connect shield to connector shell.	

Table 3.12—Heartbeat Output	
Connector	DB-15 TIMING, pin 14
Wave Shape	Pulse
Pulse Polarity	Programmable
Pulse Width	100 nS, 333 nS, 1 uS, or 1 mS (Programmable)
Output Voltage (high)	2.4 V min at 2.5 mA
Output Voltage (low)	0.4 V max at –2.5 mA
Output Current (high or low)	2.5 mA max
Range	200 nS to 65.5 Seconds
Power-on Default	Disabled

Table 3.13—Match Output	
Connector	DB-15 TIMING, pin 6
Output Voltage (high)	3.8 V at 4 mA
Output Voltage (low)	0.3 V at –4 mA
Output Current (high or low)	±6 mA max
Setability	1 uS
Time base Error	Same as on-board clock

Table 3.14—In Sync Output	
Connector	DB-15 TIMING, pin 9
Output Type	Open Collector
External Pull-up Voltage	+27 VDC max
Output Voltage (low)	+0.5 V max at –20 mA
Output Current (low)	–20 mA max

CAUTION:

Electronic equipment is sensitive to Electrostatic Discharge (ESD). Observe all ESD precautions and safeguards when handling the timecode generator.

CAUTION:

It is necessary to use an external diode when driving inductive loads (e.g., relays). The diode should be situated as close to the load as possible, and connected across the load so that it is reverse-biased when the output is low. The user is responsible for choosing the proper diode. It should be capable of suppressing the induced energy from the collapsing magnetic field.

4 Register Level Description

NOTE: In this manual, the prefix "0x" indicates that the number is in hexadecimal (Base 16) format. The descriptor “\0” denotes a single ASCII “null” character, which as a value of zero (0x00). It indicates the end of an ASCII string.

4.1 Base Address

All accesses to the board consist of reading or writing 32-bit word values. The base address is assigned at power-on by the BIOS software. The absolute memory address is computed as the Base Address plus a constant Offset. Addresses count bytes (8 bits), but data is transferred as words (32 bits). Thus, the offset for each register is a number evenly divisible by four.

NOTE: Some of the registers use less than 32-bits. For the sake of clarity, only those bits actually used are described in this manual. All unused bits must be ignored in order to maintain compatibility with future revisions.

4.2 ASCII Strings

Some of the commands and responses consist of ASCII strings. Four ASCII bytes are grouped together in a single 32-bit word. The first character in the string is in the lowermost part of the word (bits 07:00), the next character byte is in bits 15:08, the next is in bits 23:16, and the fourth character in the string is in bits 31:24. For responses, which use more than four characters, the fifth character is in bits 07:00 of the word located at the next (higher) address, etc.

The “null” character denotes the end of an ASCII string. This is a single 8-bit number, value 0x00, and is written as "\0" in this manual. For example, the string "TEST12.3456\0" stored in the Response Register (tbreg_response[0] through tbreg_response[3]) would appear in memory as:

Offset	***Contents***	***Description***			
0x30	0x54534554	'T'	'S'	'E'	'T'
0x34	0x332e3231	'3'	'.'	'2'	'1'
0x38	0x00363534	'\0'	'6'	'5'	'4'
0x3c	0x????1234 [H]	Echo of command 0x1234			

[H] Denotes an undefined value

Not all commands and responses are ASCII strings. Some use straight binary format, and others use Binary Coded Decimal (BCD) format.

4.3 Register Map

The registers are mapped into 64 words (256 bytes) of consecutive memory space as shown below. The absolute memory address is computed as Base+Offset.

"tbreg_" denotes "timing board register."

For some registers, the content of the data written is irrelevant; the act of writing (any value) to the register triggers an event.

Offset	*Name (read)*	*Name (write)*
0x00	tbreg_status	tbreg_irq_enable
0x04	tbreg_clk_uppe	tbreg_clrflag_m
0x08	tbreg_clk_lowe	tbreg_clrflag_hb
0x0c	tbreg_clk_date	tbreg_clrflag_cmov
0x10	tbreg_ttag_status	tbreg_sim_ttag
0x14	tbreg_ttag_upper	tbreg_clrflag_sc
0x18	tbreg_ttag_lower	
0x1c	tbreg_ttag_date	
0x20		tbreg_cmd[0]
0x24		tbreg_cmd[1]
0x28		tbreg_cmd[2]
0x2c		tbreg_cmd[3]
0x30	tbreg_response[0]	
0x34	tbreg_response[1]	
0x38	tbreg_response[2]	
0x3c	tbreg_response[3]	
0x40		tbreg_reset

(0x44 through 0xfc are reserved for future use.)

4.3.1 Forced Reset (tbreg_reset)

Writing (any value) causes the board's embedded microprocessor to be reset. The board's bus interface logic is not reset. The user must wait for eight seconds after issuing this command before attempting to access the board.

4.3.2 Command Register (tbreg_cmd[3:0])

Commands are sent to the board by writing parameters (if any) to tbreg_cmd[2:0], then writing the command code to tbreg_cmd[3]. Commands are described in detail in *Chapter Five—Commands and Responses*.

4.3.3 Response Register (tbreg_response[3:0])

Responses to commands are placed in the response register. Responses are described in detail in *Chapter Five—Commands and Responses*.

4.3.4 Interrupt Enable Register (tbreg_irq_en)

The user can specify which of several possible conditions will generate an interrupt. The individual bits correspond to the IRQ Enable bits in the Status Register.

4.3.5 Clear Flag–Match Register (tbreg_clrflag_m)

Writing (any value) clears Flag–Match.

4.3.6 Clear Flag–Heartbeat Register (tbreg_clrflag_hb)

Writing (any value) clears Flag–Heartbeat.

4.3.7 Clear Flag–Command Overflow (tbreg_clrflag_cmov)

Writing (any value) clears Flag–Command Overflow.

4.3.8 Clear Flag–Sync Change (tbreg_clrflag_sc)

Writing (any value) clears Flag–Sync Change.

4.3.9 Status Register (tbreg_status)

The Status Register is defined as shown below. Reading the Status Register also loads the instantaneous Clock Time and Clock Date Registers.

Bit	*Name*	*Definition (1=asserted)*
31:30	——	*(reserved for future use)*
29	tbstat_f_cmov	Flag–Command Overflow
28	tbstat_tp_int	Testpoint–Interrupt
27:24	tbstat_ttec[3:0]	Time Tag Event Counter
23:21	——	*(reserved for future use)*
20	tbstat_tp_gps	Testpoint–GPS Antenna
19	——	*(reserved for future use)*
18:16	tbstat_ssi[2:0]	Synchronization Source Indicator
15	——	*(reserved for future use)*
14	tbstat_ttenable	Enable/disable Time Tag input
13	tbstat_irq_sc	IRQ Enable–Sync Change
12	tbstat_irq_cc	IRQ Enable -Command Complete
11	——	*(reserved for future use)*
10	tbstat_irq_tt	IRQ Enable–Time Tag
09	tbstat_irq_hb	IRQ Enable–Heartbeat
08	tbstat_irq_m	IRQ Enable–Match
07	tbstat_f_sc	Flag–Sync Change
06	tbstat_f_cc	Flag–Command Complete
05	——	*(reserved for future use)*
04	tbstat_f_tt	Flag–Time Tag
03	tbstat_f_hb	Flag–Heartbeat
02	tbstat_f_m	Flag–Match
01	tbstat_f_sync	Flag–Sync
00	tbstat_f_acq	Flag–Acquire

4.3.9.1 Flag–Acquire

This status bit is asserted when the board detects that a time code is present (before synchronization is established), or when the GPS receiver is connected, but is not tracking satellites. It is not asserted if no time code is connected to the input.

This bit corresponds to the yellow ACQ panel indicator, except this bit is not asserted during the lamp test or in response to a command while in Blink Yellow Mode.

4.3.9.2 Flag–Sync

This is the only bit to examine when determining whether or not the board has established synchronization. It is asserted when the board is properly synchronized to the incoming time code, or to the GPS satellites. It also indicates that the computed longitude, latitude, and altitude are valid (TSAT-PMC).

This bit corresponds to the green SYNC panel indicator, except this bit is not asserted during the lamp test.

4.3.9.3 Flag–Command Overflow

This bit is intended as a tool for debugging user-written software. It is asserted if the user's software sends a command (writes to tbreg_cmd[3]) when the board is not ready to accept a new command. It is de-asserted by writing (any value) to tbreg_clrflag_cmov.

4.3.9.4 Flag–Match

This bit is asserted when the Match Start time occurs. Reset it by writing (any value) to the tbreg_clrflag_m register. The Match Stop time does not affect it. This bit might be set at power-on reset; the user must clear this bit before setting the Match Start time.

4.3.9.5 Flag–Heartbeat

This flag is set by each Heartbeat pulse; the user clears it by writing (any value) to tbreg_clrflag_hb. The user's software must be fast enough to clear each Heartbeat before the next one occurs. This bit might be set at power-on reset; the user must clear this bit before using it.

The next Heartbeat output pulse will happen regardless of whether the user has cleared this flag. The user's software does not need to clear the Heartbeat Flag if the user's software does not interrogate this flag.

4.3.9.6 Flag–Time Tag

This bit is asserted when a Time Tag event occurs. The user acknowledges the Time Tag event, and de-asserts this bit, by reading the tbreg_ttag_date. This bit might be set at power-on reset; the user must clear this bit before using it.

4.3.9.7 Flag–Command Complete

This bit indicates that the board is ready to accept a new command in the tbreg_cmd[3:0] register. Writing to tbreg_cmd[0] clears this bit. The board will assert it after processing the command. The user must always check that this bit is asserted before sending a command.

4.3.9.8 Flag–Sync Change

This bit is asserted when Flag–Sync changes state, either from **not in sync** to **in sync**, or vice versa. Writing (any value) resets it to tbreg_clrflag_sc.

4.3.9.9 Interrupt Enables

These six bits are asserted or de-asserted by writing to the corresponding bits in the Interrupt Enable Register. The user can read-back these bits by reading the Status Register. Writing "1" enables the interrupt. The power-on default is "0".

The interrupt will be asserted as long as the Interrupt Enable and Flag bits are both "1". Be sure that the corresponding flag bit is not asserted before setting the Interrupt Enable bit; otherwise, an unexpected interrupt will occur. The user's interrupt handler software acknowledges the interrupt by clearing the corresponding flag bit.

4.3.9.10 IRQ Enable–Match

This bit enables an interrupt when Flag–Match is asserted.

4.3.9.11 IRQ Enable–Heartbeat

This bit enables an interrupt when Flag–Heartbeat is asserted.

4.3.9.12 IRQ Enable–Time Tag

This bit enables an interrupt when Flag–Time Tag is asserted.

4.3.9.13 IRQ Enable–Command Complete

This bit enables an interrupt when Flag–Command Complete is asserted.

NOTE: Use this interrupt carefully. The only way to clear Flag-Command Complete is to send another command. This interrupt might be useful if a series of commands is to be sent, but most applications will not use this feature.

4.3.9.14 IRQ Enable–Sync Change

This bit enables an interrupt when Flag–Sync Change is asserted. This is useful for determining that synchronization has been established or lost.

4.3.9.15 Enable/Disable Time Tag Input

This bit enables (1) or disables (0) the Time Tag Input on the TIMING connector. Write "1" or "0" to the corresponding bit in the Interrupt Enable Register. The user can read-back this bit by reading the Status Register. The power-on default is "0" (disabled).

4.3.9.16 Synchronization Source Indicator

These three bits indicate which input time source is being used. This is intended for diagnostic purposes only.

tbstat_ssi[2:0]	**Input Time Source**
000	Searching for time code input (TPRO-cPCI) Acquiring GPS satellites (TSAT-cPCI)
001	Time Code Input (IRIG-A autodetected)
010	Time Code Input (IRIG-B autodetected)
011	Time Code Input (NASA36 autodetected)
100	GPS Satellites
Others	*(reserved for future use)*

4.3.9.17 Time Tag Event Counter

This is intended for diagnostic purposes only. It counts the number of time tag events that have occurred since the time tag registers were read. If it reaches maximum count (0xf), it will remain at maximum count.

The board latches only one time tag event. If another event occurs before the user reads the time tag registers, the second event is lost (not latched). This counter can be used to determine whether time tag events are being lost. Read this counter immediately prior to reading the time tag registers. If the count is **zero**, no events have occurred. If it is **one**, the time tag registers contain the latest event time, and no events have been lost. If it is greater than one, some time tag events have been lost.

The user's software must be able to read the time tag register faster than the event repetition rate. External hardware can be used to divide the time tag signal so that only every fifth event is tagged (for example). Such hardware is the user's responsibility.

4.3.9.18 Testpoint–Interrupt

This status bit is asserted when the board is asserting an interrupt. **It is used for diagnostic purposes only.** The user should examine the Flag bits, in conjunction with the IRQ Enable bits, only when determining which interrupt to service.

4.3.9.19 Testpoint–GPS Antenna

The board receives various messages from the GPS receiver/antenna. This bit is asserted when the board determines that the received messages are in the proper format. This does not indicate that it is tracking satellites; it means only that the communication between the board and the receiver/antenna is functioning properly.

If this bit is not asserted, the most likely problem is that the antenna cable is disconnected.

This bit will not be asserted during the first few seconds after a power-on reset or forced reset command.

The TPRO-PMC will always de-assert this bit. For this reason, do not use this bit to disqualify the board's data. Instead, **use this bit only as a troubleshooting tool**.

4.3.10 Clock Time Registers

(tbreg_clk_upper, tbreg_clk_lower, and tbreg_clk_date)

To read the Clock Time, first read the Status Register as described above, then read the two Clock Time registers and the Clock Date register. These registers consist of groups of four bits, each of which represents a digit in the time (i.e., it is in Binary Coded Decimal [BCD] format).

Bits	***tbreg_clk_upper***	***tbreg_clk_lower***
31:28	(reserved)	10s of seconds
27:24	100s of days	1s of seconds
23:20	10s of days	100s of mS
19:16	1s of days	10s of mS
15:12	10s of hours	1s of mS
11:08	1s of hours	100s of µS
07:04	10s of minutes	10s of µS
03:00	1s of minutes	1s of µS

For example, the time day 123, hour 09, minute 41, second 36.456789 would be represented as:

tbreg_clk_upper = 0x?1230941[H]
tbreg_clk_lower = 0x36456789

[H] Denotes an undefined value

5 Commands and Responses

5.1 Introduction

To send a command:

1. Read the Status Register, do not proceed until:
   Flag–Command Complete = 1.
2. Write the command to tbreg_cmd[3:0].
   ***Important**:* Write to tbreg_cmd[3] last.
3. If a response is expected, read the Status Register until
   Flag–Command Complete = 1, then read the response from tbreg_response[3:0].

Bits 15:00 of tbreg_cmd[3] specify the command operand. To maintain compatibility with future products, write zeroes to fields listed as "(unused)".

Writing to tbreg_cmd[3] causes the *Flag–Command Complete* status bit to be de-asserted, and signals the board to begin processing the command. This status bit is asserted *after* the board finishes processing the command. Only one command can be processed at a time.

5.2 Set Time

0 x 0010

When not synced to GPS or incoming time code, the host computer can set the time. The time then continues to increment from the set value (freewheel). However, if the GPS receiver begins to track satellites, or if a time code input is applied, time jumps to the GPS or time code time (unless synchronization has been disabled by the *Disable Sync* command).

Set Time values are specified from days through seconds. The milliseconds and microseconds are reset to zero when the command is processed. The time is formatted as Binary Coded Decimal (BCD).

Bits	**tbreg_cmd[0]**	**Bits**	**tbreg_cmd[1]**
31:28	(unused)	31:28	10s of seconds
27:24	100s of days	27:24	1s of seconds
23:20	10s of days	23:00	(unused)
19:16	1s of days		
15:12	10s of hours		
11:08	1s of hours		
07:04	10s of minutes		
03:00	1s of minutes		

Bits	**tbreg_cmd[2]**	**Bits**	**tbreg_cmd[3]**
31:16	(unused)	31:16	(unused)
15:12	1000s of Year	15:00	0x0010
11:08	100s of Year		
07:04	10s of Year		
03:00	1s of Year		

For example, to set the board to year 2001, day 345, hour 12, minute 56, second 29, write the following values:

tbreg_cmd[0] = 0x03451256
tbreg_cmd[1] = 0x29000000
tbreg_cmd[2] = 0x00002001
tbreg_cmd[3] = 0x00000010

The board will compute the Gregorian date (December 11) from the Julian day (345) and the year. Leap years are taken into account.

The year is used to determine whether the board should count to day 365 (non-leap year) or 366 (leap year) before rolling back to 001. The year **is not transmitted in the time code output**, so each board in a system must be commanded separately. The year *is not* used in the Match Time comparison. The power-on default is the special year 0001, a non-leap year. TSAT-PMC boards obtain the year from the GPS satellites, or it can be set manually, as described above. The year is incremented at the end of day 365 or 366.

A leap year is any year that is evenly divisible by four, except century years. A century year (2000, 2100, etc.) is a leap year only if it is evenly divisible by 400 (e.g., 2000, 2400, etc.).

The response in tbreg_response[3] is 0x????0010.

The user's software must ensure that only valid values are sent to the board. Also, the year must be set before the day. Otherwise, invalid Gregorian dates may result.

Field..... **Range**
Day..... 000–366
Hour 00–23
Minute 00–59
Second..... 00–59
Year 1990–2999

NOTE: The board does not check the range on these parameters. Sending out-of-range values will cause an error. This applies to all commands.

5.3 Set Year

0 x 0015

Time codes (IRIG-A, IRIG-B and NASA36) do not convey the year. Use this command to set the year. This is the same as setting the year using the 0x0010 command, except that this command does not change the Julian day or time. The year can be specified regardless of whether the board is in sync or not, and the year is retained if the board loses/acquires sync.

The valid range is 1990–2999. Values outside this range will result in the year being set to 0001.

Bits	tbreg_cmd[0]	Bits	tbreg_cmd[1]
31:00	(unused)	31:00	(unused)

Bits	tbreg_cmd[2]	Bits	tbreg_cmd[3]
31:16	(unused)	31:16	(unused)
15:12	1000s of Year	15:00	0x0015
11:08	100s of Year		
07:04	10s of Year		
03:00	1s of Year		

For example, to set the year to 2003, write the following commands:

tbreg_cmd[2] = 0x00002003
tbreg_cmd[3] = 0x00000015

The response indicates that the year has been set, or indicates year 0001 if an invalid year was commanded. The response is:

Bits	tbreg_response[0]	Bits	tbreg_response[1]
31:00	(unused)	31:00	(unused)

Bits	tbreg_response[2]	Bits	tbreg_response[3]
31:16	(unused)	31:16	(unused)
15:12	1000s of Year	15:00	0x0015
11:08	100s of Year		
07:04	10s of Year		
03:00	1s of Year		

5.4 Set Match Start Time

0 x 0020
Set the Match Start time by writing the following values:

Bits	tbreg_cmd[0]	Bits	tbreg_cmd[1]
31:28	(unused)	31:28	10s of seconds
27:24	100s of days	27:24	1s of seconds
23:20	10s of days	23:20	0.1s of seconds
19:16	1s of days	19:16	0.01s of seconds
15:12	10s of hours	15:12	0.001s of seconds
11:08	1s of hours	11:08	0.0001s of seconds
07:04	10s of minutes	07:04	0.00001s of seconds
03:00	1s of minutes	03:00	0.000001s of seconds

Bits	tbreg_cmd[2]	Bits	tbreg_cmd[3]
31:00	(unused)	31:16	(unused)
		15:00	0x0020

For example, to specify a Match Start time of day 345, hour 12, minute 56, second 29.123456, write the following values:

tbreg_cmd[0] = 0x03451256
tbreg_cmd[1] = 0x29123456
tbreg_cmd[3] = 0x00000020

The MATCH output and *Flag–Match* will be asserted when the clock time equals the Match Start time. The year is not used in the comparison. This command must be sent at least 50 mS prior to this.

The response in tbreg_response[3] is 0x00010020 if all fields are valid, or 0x00000020 if any field was out of range, specifically:

Field..... **Range**
Day..... 000–366
Hour 00–23
Minute 00–59
Second..... 00–59
Year 1990–2999

5.5 Set Match Stop Time

0 x 0030
Set the Match Stop Time as described above, except write tbreg_cmd[3] = 0x00000030. The response in tbreg_response[3] is 0x00010030 if all fields are valid, or 0x00000030 if any field was out of range.

5.6 Set Heartbeat Divider

0 x 0040

The Heartbeat is the output of a programmable divider. This command selects the clock frequency and the counter preset number.

The counter counts from the counter preset number up to maximum count (0xffff). When maximum count is reached, one Heartbeat pulse is output, and the counter re-loads the counter preset number. Compute the counter preset number N as follows:

N = 65536 – (F * t)

F is the frequency chosen; **t** is the Heartbeat interval in seconds.

The permissible range of values for N depends on the clock select. For clock selects 0x0, 0x2, and 0x3, the permissible range for N is 0x0000 through 0xfffe, inclusive. However, for clock select 0x1, the permissible range is 0x0003 through 0xfffc, with the further restriction that N must be evenly divisible by 3.

Set the Heartbeat period as follows. The counter is forced to maximum count each time synchronization is established. This causes the Heartbeat output to be in sync with the absolute time.

Bits	**tbreg_cmd[0]**	**Bits**	**tbreg_cmd[1]**
31:16	(unused)	31:04	(unused)
15:00	N	03	Invert(1)/Normal (0)
		02	Enable(1)/Disable (0)
		01:00	Clock Select

Bits	**tbreg_cmd[2]**	**Bits**	**tbreg_cmd[3]**
31:00	(unused)	31:16	(unused)
		15:00	0x0040

The Clock Select field selects F, as follows:

		Programmable Range		
Clock Sel	**F**	**Pulse Width**	***Minimum***	***Maximum***
0x0	$1 * 10^7$	100 nS	200 nS	6.55 mS
0x1	$3 * 10^6$	333 nS	666 nS	21.84 mS
0x2	$1 * 10^6$	1 µuS	2 µS	65.5 mS
0x3	$1 * 10^3$	1 mS	2 mS	65.5 seconds

Step size is the same as the Pulse Width.

5.6.1 Examples for Setting the Heartbeat

If the desired Heartbeat interval is 750 uS between pulses, choose ($1 * 10^6$) for the Clock Select, and compute N = 0xfd12:

$N = 65536 – (1 * 10^6)*(750 * 10^{–6})$
N = 64786 (base 10) convert to hex: 64786 = 0xfd12

Other examples:

Desired Pulse Rate	Chosen Clock Select	N
1.25 MPPS	0x0 ($1 * 10^7$)	0xfff8
120 PPS	0x1 ($3 * 10^6$)	0x9e58
100 PPS	0x2 ($1 * 10^6$)	0xd8f0
0.1 PPS	0x3 ($1 * 10^3$)	0xd8f0

Notice that, although 120 PPS and 100 PPS are in the range of clock selects 0x2 and 0x3, the clock select must be chosen to divide evenly.

5.7 Select Oscillator Output Frequency

0 x 0 n 45

Select the frequency for the Oscillator Output. Write one of the following commands to tbreg_cmd[3] to specify the frequency. The power-on default is OFF. Read tbreg_response[3] after sending the command to verify that it has been accepted.

Frequency	Command	Response
Off	0x00000045	0x????0045
1 kHz	0x00000145	0x????0145
1 MHz	0x00000245	0x????0245
5 MHz	0x00000345	0x????0345
10 MHz	0x00000445	0x????0445

If invalid data is commanded in bits 15:08, the response will be 0x????ff45, and the output will be OFF.

5.8 Set Offset Time

0 x 0060

This command is used to introduce deliberate offsets into the time. Most applications use the power-on default (zero delay). Setting a deliberate offset is useful for providing a pre-trigger. For example, the board's 1PPS output could be used to trigger an instrument at a known time *before* an event.

Offset times range from –999 to +999 µS in 1 µS steps. Negative numbers move the board's time earlier relative to actual time. The offset is coded in BCD format. There is no response.

The board implements the offset by varying the oscillator frequency until the board's time is changed by the commanded offset. Thus, it may take up to 5 minutes for an offset to take effect.

Bits	tbreg_cmd[0]	Bits	tbreg_cmd[1]
31:16	*(unused)*	*31:00*	*(unused)*
15:0	*N*		

Bits	tbreg_cmd[2]	Bits	tbreg_cmd[3]
31:00	(unused)	31:16	(unused)
		15:00	0x0060

Compute N as follows:

For negative offsets:
N = offset (range 0x0000 through 0x0999)

For positive offsets:
N = 0x1000 + offset (range 0x1000 through 0x1999)

NOTE: Be careful when writing software to increment or decrement this value. Only BCD values are acceptable. For example, 0x0019 and 0x0020 are valid, but 0x001A is not. Invalid values are ignored.

5.9 Read Number of Satellites Tracked and Altitude

0 x 0070 (TSAT-PMC Only)
Write command 0x00000070 to tbreg_cmd[3] to determine how many GPS satellites are being tracked, and the computed altitude (elevation). Altitude units are "meters above mean sea level." An ASCII string is returned. This contains the number (quantity) of satellites being tracked and the altitude.

Bits	**tbreg_response[0]**	**Bits**	**tbreg_response[1]**
31:24	fourth character	31:24	eight character
23:16	third character	23:16	seventh character
15:08	second character	15:08	sixth character
07:00	first character	07:00	fifth character

Bits	**tbreg_response[2]**	**Bits**	**tbreg_response[3]**
31:24	twelfth character	31:16	(unused)
23:16	eleventh character	15:00	0x0070
15:08	tenth character		
07:00	ninth character		

The response string is formatted as **AAAA.A,M,SS\0** where “AAAA.A” is the altitude and “SS” is the number of satellites tracked. The fields are delimited by commas, may (or may not) include leading zeroes, and could vary in length. Altitudes below mean sea level begin with "**–**". The "**–**" can appear in any of the “A” fields. Therefore, the following combinations could result: (–999.9), (0–99.9), (00–9.9), (000–.9), but altitudes above mean sea level do *not* begin with "+". Some antennas may not support below-sea-level conditions.

For example, "235.0,07\0" means that the TSAT-PMC is tracking 7 satellites, and the computed altitude is 235.0 meters above mean sea level. The resolution of the altitude field may exceed the accuracy of the altitude computation. Empty fields may be present when the TSAT-PMC is not tracking satellites (e.g., "\0").

5.10 Read Longitude

0 x 0071 (TSAT-cPCI Only)
Write command 0x00000071 to tbreg_cmd[3] to read the computed longitude. Units are degrees, minutes, and fractional minutes, **not** degrees, minutes, and seconds. An ASCII string is returned.

Bits	tbreg_response[0]	tbreg_response[1]
31:24	fourth character	31:24 eight character
23:16	third character	23:16 seventh character
15:08	second character	15:08 sixth character
07:00	first character	07:00 fifth character

Bits	tbreg_response[2]	tbreg_response[3]
31:24	twelfth character	31:16 (unused)
23:16	eleventh character	15:00 0x0071
15:08	tenth character	
07:00	ninth character	

The response format is "DDDMM.FFFFZ\0" where DDD is degrees, MM is minutes, FFFF is fractional minutes, and Z is either “E” or “W” (East or West). For example, "07123.4561W\0" represents 71 degrees, 23.4561 minutes, West. Empty fields may be present when it is not tracking satellites (e.g., "\0"). While tracking satellites, leading zeroes are present, if necessary, in the DDD, MM, and FFFF fields in order to maintain constant field size.

5.11 Read Latitude

0 x 0072 (TSAT-cPCI Only)
Write command 0x00000072 to tbreg_cmd[3] to read the computed latitude. Units are degrees, minutes, and fractional minutes, **not** degrees, minutes, and seconds. An ASCII string is returned.

Bits	tbreg_response[0]	tbreg_response[1]
31:24	fourth character	31:24 eight character
23:16	third character	23:16 seventh character
15:08	second character	15:08 sixth character
07:00	first character	07:00 fifth character

Bits	tbreg_response[2]	tbreg_response[3]
31:24	twelfth character	31:16 (unused)
23:16	eleventh character	15:00 0x0072
15:08	tenth character	
07:00	ninth character	

The response format is "DDMM.FFFFZ\0" where DD is degrees, MM is minutes, FFFF is fractional minutes, and Z is “N” or “S” (North or South). Empty fields may be returned when it is not tracking satellites (e.g., "\0"). While tracking satellites, leading zeroes will be present in the DD, MM, and FFFF fields, if necessary to maintain constant field size.

5.12 Enable/Disable Synchronization Flat

0 x 00c0 and 0 x 00c1
To disable synchronization to GPS, time code input, or 1PPS input, write command 0x000000c0 to tbreg_cmd[3].

To re-enable synchronization, send command 0x000000c1. The power-on default is to enable synchronization. There is no response.

5.13 Read Synchronization Enable Flag

0 x 00c2
To read the synchronization enable status, send command 0x000000c2 to tbreg_cmd[3]. The response in tbreg_response[3] will be 0x000001c2 if synchronization is enabled, or 0x000000c2 if disabled.

5.14 Factory Test Messages

0 x 00eb, 0 x 01eb, ...
The Factory Test Messages provide a means of diagnosing problems. There are 16 different possible messages, each of which is 128 bits (4 words) long. **Spectracom recommends that the user include the ability to read these messages.** Specifically, the user's software should include a function (subroutine) to read and display them (or log them to the disk). Normally, this function (subroutine) is not called.

The exact meaning of these messages is proprietary, and is not disclosed in this manual. Each response consists of data in tbreg_response[3:0]. As with other commands, the command is echoed in tbreg_response[3], bits 15:00.

To read one of the messages, send the appropriate command to tbreg_cmd[3], then read tbreg_response[0], tbreg_response[1], tbreg_response[2], and tbreg_response[3]. The commands are as follows:

Command	Response
0x000000eb	Factory Test Message 00
0x000001eb	Factory Test Message 01
0x000002eb	Factory Test Message 02
...	...
0x00000feb	Factory Test Message 15

NOTE: Spectracom may ask for the firmware and FPGA versions during troubleshooting. The function (subroutine) for reading the Factory Test Messages should also read these.

5.15 Read Version

0 x 00ec
This allows the user to read the version numbers of the FPGA (field-programmable gate array) and the embedded firmware. It is *not possible* to determine what options are present, or which version is more recent, from this number. It is is for diagnostic purposes only. **Spectracom suggests that the user's software include a means of reading and displaying these numbers.**

Send command 0x000000ec to tbreg_cmd[3]. The FPGA version is reported in bits 23:00 of tbreg_response[0]. The embedded firmware version is reported in bits 23:00 of tbreg_response[2]. These are in hexadecimal format.

For example, if the FPGA version is 033000 and the firmware version is 032900, the response is:

tbreg_response[0] = 0x??033000
tbreg_response[1] = 0x????????
tbreg_response[2] = 0x??032900
tbreg_response[3] = 0x????00ec

5.16 Lamp Test

0 x 00ee
This diagnostic command initiates the same lamp test sequence that occurs during power-on reset. There is no response. The yellow *ACQ* and green *SYNC* panel lights are illuminated briefly, one at a time. The In-Sync output on the *TIMING* connector will be asserted while the green *SYNC* panel light is illuminated. Write command 0x000000ee to tbreg_cmd[3].

5.17 Blink Yellow Mode

0 x 00b0 and 0 x 00b1
This diagnostic command blinks the yellow *ACQ* panel light briefly each time the board *finishes* processing *any* command. If the *ACQ* indicator is already lit, it will extinguish briefly when a command is processed. This can be helpful during software debugging. This mode is disabled when a power-on reset or Forced Reset occurs. There is no response.

Write 0x000000b1 (enable) or 0x000000b0 (disable) to tbreg_cmd[3].

NOTE: This command can also be used to provide a visual cue. For example, the user software can be written to send the enable command, immediately followed by a disable command, when a time tag event is detected, when the interrupt handler routine is entered, or when an external device is ready.

6 Options and Accessories

The following options and accessories are available:

6.1 Accessories

6.1.1 TRIM-CAB-D-D-100 (TSAT-cPCI Only)

This cable acts as an extension cord for a board that is using the Trimble GPS Receiver. It consists of a 100' cable with DB-15 connectors (one male, one female) on the ends. It connects to a board on one end, and to the standard TRIM-CAB-STD cable on the other end. It does not connect directly to the Trimble GPS Receiver.

6.1.2 GPS Optic Isolator (TSAT-cPCI Only)

The GPS Optic Isolator system combines a GPS receiver/antenna, a fibre optic transmitter, a fibre optic receiver, and a standard KSI GPS timing board. The satellite information that is received via the GPS antenna is passed to a fibre optic transmitter via an extension cable. The fibre optic transmitter converts the signal and feeds it to a fibre optic receiver, which then converts the data back and sends it to a standard GPS timing board that can be controlled via a graphical user interface on standard PC. All of this is possible while the GPS Receiver and the actual timing board are up to 500 meters away.

7 Driver Support

Please contact your sales representative for information about Spectracom's bus-level timing board driver support for Windows, Linux, VxWorks, and a variety of other platforms. You may also visit our website at www.spectracomcorp.com to download datasheets and manuals.

REVISION HISTORY

Revision Level	*ECN Number*	*Description*
A	**—**	First conversion of legacy KSI documentation to Spectracom documentation.
B	**2022**	Corrected errors in Phase Noise values. Removed reference to Option 05. Made minor style and format changes.
C	**2218**	Changed lower limit of IRIG-B input voltage range to 3.6V.
D	**2295**	Corrections to various IRIG-A and IRIG-B specifications.

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