

**bc637S**  
**SBus GPS Satellite Receiver System**  
**8500-0022**

**User's Guide**  
*Rev. B*  
**December, 1997**

# CHAPTER ONE

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## INTRODUCTION

### 1.0 GENERAL

This bc637S SBus Time and Frequency Processor (STFP) User's Guide provides the following information:

- Provides a list of key features, definition of terms, and a list of performance specifications for the STFP.
- Provides installation instructions and a description of the back plate assembly.
- Provides a functional description of all the STFP timing functions.
- Provides a description of the STFP device registers.
- Provides a description of the dual-port RAM interface.
- Describes the input and output connectors located on the STFP back plate.
- Provides a schematic and assembly drawing for the STFP.
- Describes the installation and use of the device driver supplied with the STFP. The device driver itself is a good programming example for anyone who wants to interface to the STFP at a low level or write their own device driver.

**1.1 KEY FEATURES**

The STFP has been designed with the following key features:

- Two independent sets of time capture registers. These registers latch and hold the current time on request. Time is provided in either a decimal format (days -  $\mu$ secs) or binary format (UNIX seconds and  $\mu$ secs.) Both time formats also provide 100 nsec time.
- One set of time capture registers can also be used for event time capture. Time is captured on the rising or falling edge (user programmable) of the event input signal or on the rising edge of the programmable periodic output signal.
- An internal 10Mhz VCXO (Voltage Controlled Crystal Oscillator) is disciplined to the reference source. The VCXO output provides all timing functions on the card. The VCXO output and a 1pps signal are provided as outputs. The STFP is capable of disciplining an external voltage-controlled oscillator
- All modes of operation are supplemented by flywheel operation. If the synchronization source is lost the STFP will continue to function at the last known reference rate.

The following operational modes are supported. Modes are distinguished by the reference source.

Mode	Source of Synchronization
<b>0</b>	Time Code - IRIG A, IRIG B, XR3, 2137, NASA 36
<b>1</b>	Free Running - On Board VCXO Used As Reference
<b>2</b>	External 1 pps - Accepts Input One Pulse Per Second
<b>3-5</b>	Reserved
<b>6</b>	GPS (Optional) - Uses GPS Receiver/Antenna (Receiver In Antenna)

- Generates IRIG B time code synchronized to the reference source. Modulated and DC level shift formats are produced simultaneously.
- A programmable periodic output is provided. The output frequency is programmable from 250kHz to less than 1Hz and can be synchronized to the STFP 1pps signal.
- A time coincidence strobe output is provided. It is programmable from hours through microseconds. This strobe also has an each second mode programmable to microseconds.
- Five maskable interrupt sources are supported. SBus IntReq levels one through seven are supported. All interrupt sources can be polled.

## 1.2 DEFINITION OF TERMS

A glossary of key terms commonly used in the discussion of timing operations is provided below.

### **Epoch**

A reference time or event. Epoch often refers to a one pulse per second event.

### **Flywheel**

To maintain time or frequency accuracy as well as local resources when a time or frequency reference has been lost or removed.

### **Event**

An event is defined here as a (rising or falling) transition of a digital signal which can be used to cause the current reference time to be captured and held thus providing an accurate time stamp of the event.

### **Periodic**

A programmable frequency which is obtained by dividing the STFP reference frequency. Periodics are sometimes referred to as “heartbeats.” Periodics may optionally be synchronous with the 1pps epoch.

### **Strobe**

A programmable time coincidence strobe output is obtained by comparing the reference time with a user programmed time to produce an output signal that transitions from low to high at the programmed time. The duration of the strobe output is usually equal to the resolution of the strobe comparators. You could refer to the strobe as an “alarm.”

### **Major Time**

Units of time larger than or equal to seconds.

### **Minor Time**

Subsecond time to whatever resolution is supported.

### **Packet**

A group of bytes conforming to a defined structure. Packets are usually used in bit serial or byte serial data transmissions to allow framing of the transmitted data. The bc637S uses data packets to communicate with the optional GPS receiver.

## 1.3 PERFORMANCE SPECIFICATIONS

**Time Code Reader**

<b>Formats</b>	IRIGA, IRIGB, XR3, 2137, NASA36
<b>Carrier Range</b>	+/- 50 PPM
<b>Flywheel Accuracy</b>	Drift < 2 Millisecond Per Hour (Applies To All Operational Modes)
<b>Modulation Ratio</b>	3:1 to 6:1
<b>Input Amplitude</b>	0.5 To 5 Volts Peak-To-Peak
<b>Input Impedance</b>	10 k , AC Coupled

**Time Code Generator**

<b>Format</b>	IRIG B
<b>Modulation Ratio</b>	3:1
<b>Output Amplitude</b>	4 Volts Peak-To-Peak (Nominal)
<b>DC Level Shift</b>	TTL/CMOS Compatible

**SBus Characteristics**

<b>Specifications</b>	Designed Per SBus Specification B.0
<b>Size</b>	Single-Width
<b>Interrupts</b>	User Programmable IntReq Level 1 - 7
<b>Power</b>	+5V @ 350 mA    +12V @ 10 mA    -12V @ 10 mA

**Digital Inputs**

<b>Event Capture</b>	TTL/CMOS Rising Or Falling Edge Triggered 20 Nanoseconds Min. Width 250 Nanoseconds Min. Period
<b>External 1pps</b>	TTL/CMOS Positive Edge On Time 20 nanoseconds minimum width

**Digital Outputs**

<b>1pps</b>	TTL Positive Edge On Time
<b>Periodic</b>	TTL Positive Edge On Time
<b>Strobe</b>	TTL Positive Edge On Time
<b>1, 5, 10 MHz clock</b>	TTL Positive Edge On Time

**External 10Mhz Input**

Digital Input (or)	TTL/CMOS 40% to 60% Duty Cycle.
Sine wave Input	2 to 4 Volts Peak-to-Peak.

**Environmental Specifications**

<b>Temperature</b>	<i>Operating</i>	0° C to +70° C
	<i>Non-Operating</i>	-50° C to +125° C
<b>Relative Humidity</b>	<i>Operating</i>	5% to 95% Non-Condensing
<b>Altitude</b>	<i>Operating</i>	-400 to 18,000 Meters MSL

## **CHAPTER TWO**

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### **INSTALLATION**

#### **2.0 INSTALLATION**

Installation of SBus boards is quite a bit simpler than in most bus architectures due to two factors:

- Geographical addressing, which eliminates the need for DIP switches and jumpers normally required to select a “base address” or interrupt level for plug-in modules.
- Auto configuration, which allows the host computer to read the device ID and other configuration information directly from the open boot PROM located on the SBus card itself so that the host can select the appropriate device driver automatically.

The only thing the user has to do is pick a vacant SBus slot and plug the bc637S into it and install the device driver. Consult the user documentation that came with your particular workstation for any specific SBus card installation instructions.

#### **2.1 BACKPLATE ASSEMBLY**

The bc637S back plate assembly is designed in two pieces:

- The back plate
- The back plate adapter.

Normally, the back plate assembly is left intact for workstation installations, but the back plate adapter can be removed for installation into systems that use the SBus as a mezzanine bus as is done with some VMEbus boards. To detach the back plate adapter, remove the two screws that hold the back plate adapter to the back plate.

## CHAPTER THREE

### FUNCTIONAL DESCRIPTION

#### 3.0 GENERAL

This chapter provides a description of all the bc637S SBus Time and Frequency Processor (STFP) timing functions. This chapter should be read by everyone using the STFP.

#### 3.1 TIMING MODES

The primary function of the bc637S (STFP) is to provide precise time to the user across the SBus. The bc637S can derive time from any one of the sources listed in Table 3-1. In all but the free running mode of operation, the bc637S synchronizes its on board 10MHz VCXO (Voltage Controlled Crystal Oscillator) to the timing source. The STFP achieves synchronization by extracting a 1pps (pulse per second) signal from the timing source and using this 1pps signal to discipline the VCXO such that the locally generated 1pps signal is matched in phase and frequency to the reference 1pps. Once synchronization is achieved, the STFP is able to maintain time even if the timing source is lost (though some timing drift will occur), this is referred to as *flywheeling*. The STFP must also obtain major time (days, hours, minutes, seconds) from the timing source if it's available. In the time code mode and the (optional) GPS mode this major time is readily available, but in the free running and external 1pps modes, major time is not available and must be set manually by the user.

**Table 3-1**  
**STFP Timing Modes**

<b>Mode</b>	<b>Source of Time</b>
<b>0</b>	Time Code - IRIG A, IRIG B, XR3, 2137, NASA 36.
<b>1</b>	Free running - on board VCXO used as reference.
<b>2</b>	External 1 pps - accepts input one pulse per second.
<b>3-5</b>	Reserved
<b>6</b>	GPS (optional) - uses GPS receiver/antenna (receiver in antenna).

#### **MODE 0 (Time Code Mode)**

In the time code mode, the STFP derives time from one of several time code formats. The STFP will accept time code in either a modulated or DCLS (DC Level Shift) form. Modulated time code is an analog signal, typically a 1kHz or 10kHz sinusoid that is amplitude modulated with the time. DCLS is simply the envelope of the modulated time code and is a digital signal.



### **MODE 1 (Free Running Mode)**

In the free running mode, no external timing source is used. The STFP VCXO is allowed to free-run. The user must set major time manually. This mode allows the user to perform timing tests when an external timing source is unavailable.

### **MODE 2 (External 1pps Mode)**

In the external 1pps mode, the STFP synchronizes its VCXO to a user supplied 1pps signal. The user must set major time manually.

### **MODE 6 (GPS [Optional])**

In the GPS mode, like the time code mode, both major and minor time are derived from the timing source. In addition to time, other information is available from the GPS system such as accurate position and velocity. This mode requires the use of a GPS sensor mounted such that the sensor has an unobstructed view to the sky. An unobstructed view to the sky is important because the GPS sensor must initially track four satellites to obtain accurate time. Thinking about the GPS system algebraically, the GPS sensor needs to find four unknown variables: X, Y, Z (position) and time, which requires four equations to solve, hence the need for four satellites. If, however, the user's position is accurately known, the GPS sensor can derive precise time from just one satellite.

## **3.2 TIME CAPTURE**

The STFP supports two independent sets of time capture registers. Each set consists of five 16 bit wide registers that hold both the major and minor time. One set, labeled TIME0 - TIME4, supports time on demand across the SBus. Time is captured in these registers whenever the user accesses a special time request register (TIMEREQ). The captured time is held until a subsequent access of the TIMEREQ register. Valid time can be read from the TIMEx registers immediately following the access of the TIMEREQ register.

The second set of time capture registers, labeled EVENT0 - EVENT4, are identical in format to the TIMEx registers. Time is captured in these registers whenever the user accesses the special time request register labeled EVENTREQ. Additionally, the EVENTx registers can be setup to capture time in response to either the event input (see below) or the programmable periodic output (see next section).

### 3.3 EVENT TIME CAPTURE

The EVENTx registers can be configured to support event time capture. An externally applied digital signal (event input) can cause time to be captured in the same way as an access of the EVENTREQ register. The user can configure the time capture to occur on a rising or falling edge of the event input signal. EVENTx time capture can also be configured to occur on the rising edge of the programmable periodic output.

**Note:** EVENTREQ register accesses will continue to capture time even if event time capture is enabled.

### 3.4 PROGRAMMABLE PERIODIC OUTPUT

An often useful STFP feature is the programmable periodic output signal. This signal is generated by dividing down a 1MHz clock. The 1MHz clock is derived by dividing the 10MHz VCXO clock by 10, thus the periodic output is synchronous with the timing source. The periodic output frequency can range from 250kHz ( $n_1 = n_2 = 2$ ) to be less than 1Hz and is determined by the relationship:

$$F_{\text{periodic}} = \frac{1}{n_1 \cdot n_2} \text{ MHz} \quad \text{where } 2 \leq n_1, n_2 \leq 65535$$

The periodic output can optionally be synchronized to the STFP 1pps signal. 1pps synchronization works best when the periodic output frequency is an integer value, otherwise, the 1pps signal will cut short one of the periodic output cycles.

**Note:** If  $n_1$  or  $n_2$  is set to 2, 1pps synchronization will not work correctly, though the periodic output frequency will be correct.

### 3.5 TIME COINCIDENCE STROBE OUTPUT

The STFP provides one time coincidence strobe output signal. The strobe output is like an alarm that is activated at some preprogrammed time. The programmed strobe time is held in the STROBE1 - STROBE4 registers. The strobe resolution is from hours through microseconds. The duration of the strobe pulse is one  $\mu\text{sec}$ . The rising edge of the strobe occurs at the programmed time. Two modes of operation are supported. In one mode, both the major and minor time are used to generate the strobe. In the other mode, only the minor time is used to generate the strobe output which produces an output pulse once each second.

### 3.6 SBus INTERRUPTS

The STFP supports the five sources of interrupts listed in Table 3-2. Each interrupt source can be individually masked off. Use the MASK register to mask on or off each interrupt source. Each interrupt source sets a bit in the INTSTAT register when it occurs. The STFP generates interrupts at a user programmable SBus IntReq level (LEVEL register.) When servicing an STFP interrupt, the user must read the INTSTAT register to determine which interrupt source(s) are requesting service.

**Table 3-2**  
**STFP Interrupt Sources**

<b>Int</b>	<b>Source of Interrupt</b>
<b>0</b>	Event input has occurred.
<b>1</b>	A Periodic output has occurred.
<b>2</b>	The Time Coincidence Strobe has occurred.
<b>3</b>	A one second epoch (1 pps output) has occurred.
<b>4</b>	A GPS data packet is available.

### 3.7 TIMING OUTPUTS

In addition to the programmable periodic output and time coincidence strobe, the STFP provides other useful timing outputs which are synchronized to the timing source. The 1pps output is a one  $\mu$ sec wide pulse whose rising edge occurs at each one second epoch. An IRIG B time code output signal is available in both modulated and DCLS (DC Level Shift) forms. An output frequency of 1MHz, 5MHz, or 10MHz (TTL levels, sinusoid not available) is provided. The 10MHz frequency comes straight from the VCXO clock. The 1MHz and 5MHz signals are derived by dividing the VCXO clock by ten or two, respectively.

## CHAPTER FOUR

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### DEVICE REGISTERS

#### 4.0 GENERAL

The bc637S STFP is controlled with a combination of hardware device registers and a dual-port RAM interface. This chapter describes the STFP device registers.

#### 4.1 SBus REGISTER FIELDS

The bc637S is divided into three register fields:

- the Boot PROM field.
- the dual-port RAM field.
- the device register field.

The boot PROM begins at address zero within the card's physical address space. The starting address and length of the two remaining spaces *should* be obtained from the "reg" attribute in the boot PROM since these attributes could conceivably change, though this is unlikely. The dual-port RAM field is listed first in the boot PROM "reg" attribute followed by the device register field. Table 4-1 lists the card's physical memory map for those users that don't have access to the boot PROM information. It may be useful to know that the boot PROM "name" attribute is "DATM,stfp" and the "model" attribute is "DATM,bc637S."

**Note:** The dual-port RAM is mapped in such a way that it contains the Boot PROM information and is also used for local RAM for the STFP micro-controller. Be sure to access the dual-port RAM. Do not access other areas within the dual-port RAM address space.

**Table 4-1**  
**STFO Physical Memory Map**

Start	Type	Size	Register Field
0x0000	Read Only	Varies	Boot PROM
0x4000	R/W	0x1000	Dual-Port RAM
0x8000	R/W	0x40	Device Registers

### 4.2 DEVICE REGISTER DESCRIPTION

The STFP device registers are 16 bits wide (SBus half-word size) but in many of the registers only a few of the bits have any significance and the rest of the bits are ignored during writes and are meaningless during reads. Registers may be read only (R), write only (W), read/write (R/W), or access (A). Access type registers perform a function simply by being read or written without regard to the data contents. It's best to use a write operation with the access type registers because most optimizing compilers will remove statements that read a register but do nothing with the data returned. In some cases a read/write register is structured to support dissimilar data in the read and write directions. Table 4-2 summarizes the type of register located at each offset and provides a brief description of the register function. The offset of each register is relative to the start of the device register field starting address found in the boot PROM.

**Table 4-2**  
**STFP Device Register Summary**

Offset	Type	Reset	Label	Description
0x00	A	See Note	TIMEREQ	Time Request (TIME0-4)
0x02	R	See Note	TIME0	Time Holding Register 0
0x04	R	See Note	TIME1	Time Holding Register 1
0x06	R	See Note	TIME2	Time Holding Register 2
0x08	R	See Note	TIME3	Time Holding Register 3
0x0A	R	See Note	TIME4	Time Holding Register 4
0x0C	Reserved			
0x0E	Reserved			
0x10	A	See Note	EVENTREQ	Time Request (EVENT0-4)
0x12	R	See Note	EVENT0	Time Holding Register 0
0x14	R	See Note	EVENT1	Time Holding Register 1
0x16	R	See Note	EVENT2	Time Holding Register 2
0x18	R	See Note	EVENT3	Time Holding Register 3
0x1A	R	See Note	EVENT4	Time Holding Register 4
0x14	W	See Note	STROBE1	Strobe Time 1
0x16	W	See Note	STROBE2	Strobe Time 2
0x18	W	See Note	STROBE3	Strobe Time 3
0x1A	W	See Note	STROBE4	Strobe Time 4
0x1C	A	See Note	UNLOCK	Release Capture Lockout
0x1E	Reserved			
0x20	R/W	0	CONTROL	Control Register
0x22	R/W	See Note	ACK	Acknowledge Register
0x24	R/W	0	MASK	Interrupt Mask
0x26	R/W	0	INSTAT	Interrupt Status
0x28	R/W	0	LEVEL	Sbus IntReq Level
0x2A	R/W	0	FCON	Feature Connector Control
0x2C0-0x3C	Reserved			

**Note:** Register contents are undefined at reset.

## CHAPTER FOUR

### 4.2.1 TIMEREQ

Accessing this register (with a read or write operation) latches the current time and timing status in the TIME0 - TIME4 registers. The data value transferred is meaningless.

### 4.2.2 TIME0 - TIME4

These registers hold time captured by an access of the TIMEREQ register. The contents of these registers depends on the time format selected.

### 4.2.3 EVENTREQ

Accessing this register (with a read or write operation) latches the current time and timing status in the EVENT0 - EVENT4 registers. The data value transferred is meaningless.

### 4.2.4 EVENT0 - EVENT4

These registers hold time captured by an access of the EVENTREQ register, an event input (if enabled) or the programmable periodic (if enabled).

*Note:* The EVENTx registers occupy the same addresses as the STROBEx registers but are read only. The contents of these registers depends on the time format selected.

### 4.2.5 STROBE1 - STROBE4

These registers hold the programmed time coincidence strobe time. The contents of these registers depends on the time format selected.

*Note:* The STROBEx registers occupy the same addresses as the EVENTx registers but are write only.

The strobe time is programmable from hours through microseconds in the decimal time format. When the time format is set to binary, only the 22 least significant bits of the major time are used (in addition to microseconds), this allows the user to program the strobe to become activated as far as forty-eight days beyond the current time.

*Note:* While programming the strobe time, disable the strobe output (see CONTROL register) to prevent spurious strobe output pulses.

**4.2.6 TIME FORMATS**

The STFP major time registers (TIME0-2, EVENT0-2, STROBE1-2) support two time formats. One format is binary; the other, decimal. The 32 bit binary format represents time as the number of seconds since midnight, January 1, 1970 UTC (Universal Time Coordinated, aka GMT), this is the standard time format found on most UNIX systems. The decimal time format is derived from the “struct tm” format also common on UNIX systems. Table 4-6 illustrates the differences between the standard “struct tm” fields and the STFP implementation.

*Note:* The year field is stored in the dual-port RAM.

*Note:* The binary time format is not supported in the time code decoder timing mode (Mode 0) primarily due to the lack of year information in standard time code formats.

**Table 4-3  
STFP Binary Time Format**

Binary Time Format				
Data Bits				
Register	15 - 12	11 - 8	7 - 4	3 - 0
TIME0 EVENT0	Undefined	Undefined	Status Bits (See Table 4-5)	Undefined
TIME1 EVENT1 STROBE1	Binary Seconds Bits 31 - 16 (STROBE1: Binary Seconds Bits 21 - 16)			
TIME2 EVENT2 STROBE2	Binary Seconds Bits 15 - 0			
TIME3 EVENT3 STROBE3	Undefined	Undefined		
TIME4 EVENT4 STROBE4	Binary $\mu$ secs Bits 15 - 0			



**Table 4-4**  
**STFP Decimal Time Format**

Binary Time Format				
Data Bits				
Register	15 - 12	11 - 8	7 - 4	3 - 0
<b>TIME0</b> <b>EVENT0</b>	Undefined	Undefined	Status Bits (See Table 4-5)	Day Bits 11 - 8
<b>TIME1</b> <b>EVENT1</b> <b>STROBE1</b>	Days Bits 7 - 0 (STROBE1: unused)		Hours Bits 7 - 0	
<b>TIME2</b> <b>EVENT2</b> <b>STROBE2</b>	Minutes Bits 7 - 0		Hours Bits 7 - 0	
<b>TIME3</b> <b>EVENT3</b> <b>STROBE3</b>	Undefined	Undefined	100 nsecs (STROBE3: unused)	Binary $\mu$ secs Bits 19 - 16
<b>TIME4</b> <b>EVENT4</b> <b>STROBE4</b>	Binary $\mu$ secs Bits 15 - 0			

The format of the minor time registers (TIME3-4, EVENT3-4, STROBE3-4) is always the same: 20 bits of binary microseconds (0 - 999,999) with an additional 4 bit field of hundreds of nsecs (0 - 9). Most UNIX time functions use microseconds, but the STFP maintains time to hundreds of nsecs.

**4.2.7 STATUS BITS**

The STFP status bits found in the TIME0 and EVENT0 time registers are summarized in Table 4-5 and are described below.

**Table 4-5  
TIME0, EVENT0 Status Bits Summary**

<b>Bit</b>	<b>Description</b>
<b>4</b>	Flywheeling 0: Locked To Selected Reference 1: Flywheeling (Not Locked)
<b>5</b>	Time Offset 0: <X Microseconds 1: >X Microseconds X = 5 (Mode 0)    X = 2 (All Other Modes)
<b>6</b>	Frequency Offset 0: <5 x 10 <sup>-8</sup> 1: >5 X 10 <sup>-8</sup>
<b>7</b>	Reserved

**4.2.7.1 STATUS: Flywheeling (Bit 4)**

When set, this bit indicates that the STFP is not locked to the reference time source, usually because the time source has been lost or has become unusable. While flywheeling, the STFP keeps time at the last known rate. When a timing mode change occurs this bit is set until the STFP locks to the new timing source.

**4.2.7.2 STATUS: Time Offset (Bit 5)**

This bit indicates the synchronization accuracy of the STFP relative to the timing source. This bit is updated approximately once per second.

**4.2.7.3 STATUS: Frequency Offset (Bit 6)**

This bit is an indication of the STFP on-board oscillator frequency offset relative to the timing source. This bit is updated approximately once per second.

**Table 4-6**  
**struct tm Field Comparison**

<b>struct tm Field</b>	<b>UNIX</b>	<b>STFP</b>
tm_sec	Seconds (0 - 59)	Same
tm_min	Minutes (0 - 59)	Same
tm_hour	Hours (0 - 23)	Same
tm_mday	Days of Month (1 - 31)	Not Implemented
tm_mon	Month (0 - 11)	Not Implemented
tm_year	Year - 1900	Dual-Port RAM (e.g. 1994)
tm_wday	Day of Week (Sunday = 0)	Not Implemented
tm_yday	Day of Year (0 - 365)	
tm_isdst	1 if DST in Effect	Not Implemented
Others	Time Zone Name, GMT Offset, Etc.	Not Implemented

#### 4.2.8 UNLOCK

Accessing this register releases the EVENTx time capture lockout function if it has been enabled, allowing the event input or periodic output to capture a new time.

#### 4.2.9 ACK

This register is used to prevent dual-port RAM data contention problems that occur when the same address on both sides of a dual-port RAM are accessed simultaneously.

#### 4.2.10 CONTROL

This register controls a variety of STFP hardware functions. Table 4-7 lists the function of each bit in this register.

**Table 4-7  
CONTROL Register**

Bit	Name	Function
0	LOCKEN	EVENTx Capture Lockout Enable 0 = Disable Lockout 1 = Enable Lockout
1	EVSOURCE	EVENTx Time Capture Source Select 0 = Event Input (Select Active Edge With EVSENSE) 1 = Programmable Periodic (Rising Edge Active Only)
2	EVSENSE	Event Input Edge Select 0 = Rising Edge Active 1 = Falling Edge Active
3	EVENTEN	Event Capture Enable 0 = Disable 1 = Enable (Use EVSOURCE to Select Event Source)
4	STREN	Time Coincidence Strobe Output Enable 0 = Disable (Strobe Output is Held Low) 1 = Enable
5	STRMODE	Time Coincidence Strobe Mode 0 = Use Major and Minor Time for Strobe Function 1 = Use Minor Time Only for Strobe Function IN STRMODE (1) an Output Strobe is Produced Each Second
6	FREQSELO	Output Frequency Select 00 = 10MHz 01 = 5MHz 1X = 1MHz
7	FREQSEL1	Output Frequency Select 00 = 10MHz 01 = 5MHz 1X = 1MHz
8 - 15	Reserved	

**4.2.11 MASK**

Bits 0-4 in the MASK register correspond to interrupt sources zero through four listed in Table 4-8. An interrupt source is enabled (to generate an SBus interrupt) by writing a one to the corresponding MASK bit. Writing a zero to the interrupt MASK bit disables that interrupt.

4.2.12 INTSTAT

The INTSTAT register has the same structure as the MASK register. Each interrupt source sets its corresponding bit in this register when activated. The INTSTAT register bits get set regardless of the state of the MASK bits allowing the user to poll for the occurrence of the interrupt source(s). INTSTAT bits are cleared by the user by writing to the INTSTAT register with the corresponding bit(s) set. For example, to clear INTSTAT bit 0, write 0x01 to the INTSTAT register, to clear all INTSTAT bits simultaneously, write 0x1F to the INTSTAT register. An SBus interrupt is generated anytime one or more INTSTAT bits are set *and* the corresponding bit(s) are set in the MASK register.

**Table 4-8**  
**STFP Interrupt Sources**

INT	Source of Interrupt
0	Event Input Has Occurred
1	A Periodic Output Has Occurred
2	The Time Coincidence Strobe Has Occurred
3	A One Second Epoch (1 pps Output) Has Occurred
4	A GPS Data Packet is Available

4.2.13 LEVEL

The LEVEL register selects the level at which an SBus interrupt will be generated. Only bits 0 through 2 are used. The bits are encoded as follows:

Level Bit			Sbus IntReq Level
2	1	0	
0	0	0	None
0	0	1	IntReq(1)*
0	1	0	IntReq(2)*
0	1	1	IntReq(3)*
1	0	0	IntReq(4)*
1	0	1	IntReq(5)*
1	1	0	IntReq(6)*
1	1	1	IntReq(7)*

**4.2.14 FCON**

The FCON register selects the function of the bc637S feature connector according to the following table.

<b>Value</b>	<b>Function</b>
0x00	Event Input
0x01	1pps Input
0x02	DC Level Shift Time Code Input
0x03	Diagnostic: Routes Strobe Output to Event Input
0x08	1pps Output
0x09	1, 5, 10 MHz Frequency Output
0x0A	Programmable Periodic Output
0x0B	Time Coincidence Strobe Output
0x0C	DC Level Shift Time Code Output

## CHAPTER FIVE

### DUAL-PORT RAM INTERFACE

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#### 5.0 GENERAL

The byte-wide dual-port RAM (DPRAM) interface provides a communications pathway between the user and the STFP micro-controller (MPU). The ACK register is used in conjunction with the DPRAM to avoid data contention problems that can occur when a memory location is accessed simultaneously from both sides of the DPRAM. Four areas within the DPRAM are available to the user:

##### **Input Area**

This area is used for sending commands from the user to the STFP for setting the timing mode, time code format, etc. This area is also used to send data packets to the optional GPS receiver.

##### **Output Area**

This area holds data that the user requests from the STFP.

##### **GPS Packet Area**

This area holds packets of data from the optional GPS receiver such as position, velocity, GPS status, etc.

##### **Year Area**

This area holds the year number derived from the timing source (if available).

*Note:* The DPRAM also holds the boot PROM data and provides local RAM for the STFP MPU. Keep DPRAM accesses confined to the areas defined above, even reading other areas can cause DPRAM data contention problems.

The offset of each DPRAM area (relative to the DPRAM starting address) is stored at the top of the DPRAM as shown below, where “TOP” refers to the last DPRAM address. The offset values are subject to change as the STFP firmware is updated. Each offset is a 2 byte unsigned integer value.

DPRAM Address	Contents
Top	Input Area Offset (LSB)
Top-1	Input Area Offset (MSB)
Top-2	Output Area Offset (LSB)
Top-3	Output Area Offset (MSB)
Top-4	GPS Packet Area Offset (LSB)
Top-5	GPS Packet Area Offset (MSB)
Top-6	Year Area Offset (LSB)
Top-7	Year Area Offset (MSB)

## 5.1 ACK REGISTER

This register is used to prevent dual-port RAM data contention problems that occur when the same address on both sides of a dual-port RAM is accessed simultaneously. Only 3 bits in this register are used, and each bit operates independently. The function of each bit in this register is described below.

### ***ACK BIT 0***

Set by the STFP to acknowledge the receipt of a user command from the DPRAM Input Area. The user can clear this by writing to the ACK register with bit 0 set, but cannot set this bit.

### ***ACK BIT 2***

Set by the STFP to indicate that a GPS packet is available in the DPRAM GPS packet Area. The user can clear this bit by writing to the ACK register with bit 2 set, but cannot set this bit. The transition of this bit from 0 to 1 activates interrupt source four.

### ***ACK BIT 7***

The user writes to the ACK register with bit 7 set to cause the STFP to read a command from the DPRAM Input Area. This bit has no meaning when read.

## 5.2 STFP DPRAM COMMANDS

This section describes the STFP commands available through the DPRAM Interface. Commands consist of a command ID byte followed by 0 or more data bytes. The command ID byte is written to the first location in the DPRAM Input Area, followed by the command data byte(s). The following command data types are used. Command data is loaded into the DPRAM in the *big-endian* fashion; most significant byte first. Table 5-1 summarizes the DPRAM commands.

UINT8	Unsigned 8 Bit Integer (1 Byte)
INT8	Signed 8 Bit Integer (1 Byte)
UINT16	Unsigned 16 Bit Integer (2 Bytes)
INT16	Signed 16 Bit Integer (2 Bytes)
UINT32	Unsigned 32 Bit Integer (4 Bytes)
INT32	Signed 32 Bit Integer (4 Bytes)
FLOAT	ANSI / IEEE Std 754 Standard Floating-Point Format (4 Bytes)
DOUBLE	ANSI / IEEE Std 754 Standard Floating-Point Format (8 Bytes)



The following steps should be followed when sending commands to the STFP.

- Write the command ID and data bytes to the DPRAM starting at the first location in the Input Area.
- Clear bit 0 of the *ACK* register by writing 0x01 to the *ACK* register.
- Inform the STFP that a command is waiting by writing 0x80 to the *ACK* register.
- Wait for the STFP to set bit 0 of the *ACK* register. Do not begin writing another command to the Input Area until this bit becomes set.

**Table 5-1**  
**DPRAM Command Summary**

<b>ID</b>	<b>Reset</b>	<b>Command</b>
0x10	Note 1	Select STFP Timing Mode
0x11	0	Select Time Format
0x12	N/A	Set Major Time
0x13	0	Set Year
0x14	N/A	Set Periodic Output
0x15	“B”	Select Time Code Format
0x16	“M”	Select Time Code Modulation Type
0x17	0	Set Timing Offset
0x19	N/A	Request Data From STFP
0x1A	N/A	Software Reset
0x20	“T”	Select Clock Source
0x21	1	Control Jam-Sync
0x22	N/A	Force Jam-Sync
0x23	1	Control Clock Disciplining
0x24	N/A	Load D/A Converter
0x25	N/A	Set Disciplining Gain
0x30	N/A	Send Packet to GPS Receiver
0x31	N/A	Request Packet from GPS Receiver
0x32	N/A	Manual Request Packet from GPS Receiver
0x33	0	Select GPS Time Format

**Note One:** bc635S resets to Mode 0 (Time Code)  
bc637S resets to Mode 6 (GPS)

**COMMAND 0x12: BINARY TIME FORMAT**

<b>BYTE</b>	<b>TYPE</b>	<b>ITEM</b>	<b>VALUE OR RANGE</b>
0	UINT8 ID		0x12
1-4	UINT32	Binary Time	0 to $2^{32} - 1$

The time loaded by this command will not be readable until the one second epoch following the load, but by then the STFP will have incremented the time. To prevent ambiguities in the time, the user must issue this command in advance of the 800 millisecond point within the one second epoch, and should reference the current epoch.

**COMMAND 0x13 - SET YEAR**

This command allows the user to set the year.

<b>BYTE</b>	<b>TYPE</b>	<b>ITEM</b>	<b>VALUE OR RANGE</b>
0	UINT8 ID		0x13
1	UINT16	Year	1970 - 2050

**COMMAND 0x14 - SET PERIODIC OUTPUT**

This command establishes the frequency of the STFP Programmable Periodic Output.

<b>BYTE</b>	<b>TYPE</b>	<b>ITEM</b>	<b>VALUE OR RANGE</b>
0	UINT8 ID		0x14
1	UINT8	Sync Flag	0 = Don't Sync To 1pps 1 = Sync To 1pps
2-3	UINT16	Divider $n_1$	2 - 65535
4-5	UINT16	Divider $n_2$	2 - 65535

**COMMAND 0x15 - SELECT TIME CODE FORMAT**

This command selects the time code format. Use Command 0x16 to set the modulation type.

<b>BYTE</b>	<b>TYPE</b>	<b>ITEM</b>	<b>VALUE OR RANGE</b>
0	UINT8 ID		0x15
1	UINT8 format		See Below

**Format Choices**

- “A” IRIG A
- “B” IRIG B
- “C” 2137
- “N” NASA 36
- “X” XR3

**COMMAND 0x16 - SELECT TIME CODE MODULATION TYPE**

This command selects the time code modulation type. Use Command 0x15 to select the time code format.

<b>BYTE</b>	<b>TYPE</b>	<b>ITEM</b>	<b>VALUE OR RANGE</b>
0	UINT8 ID		0x16
1	UINT8 modulation		See Below

**Modulation Choices**

- “M” amplitude modulated sinewave
- “D” pulse code modulation (DC level shift)

*Note:* DC level shift not is supported for 2137 and XR3 codes.

**COMMAND 0x17 - SET TIMING OFFSET**

It is sometimes desired to program an offset into the basic STFP timekeeping functions relative to the reference input. For example, if the reference input is an IRIG B time code, there may be significant cable delay between the IRIG B generator and the STFP location. This command allows this time difference to be removed by inserting the known amount of offset between the IRIG B reference and STFP location, in this scenario, a positive offset would be used. The offset is programmable in units of one-hundred nanoseconds, and may be positive or negative.

*Note:* If offsets larger than +/- 990 microseconds are used, then the STFP jam-sync feature must be turned off using command 0x21. The reason for this requirement is that under normal operation a difference between the reference time and the STFP time greater than ±1 millisecond causes the STFP to perform a jam-sync.

<u>BYTE</u>	<u>TYPE</u>	<u>ITEM</u>	<u>VALUE OR RANGE</u>
0	UINT8 ID		0x17
1-4	INT32	offset	-9,999,999 to +9,999,999

**COMMAND 0x19 - REQUEST DATA FROM STFP**

This command requests data from the STFP which is not available via the device registers. The STFP transfers the requested data to the DPRAM Output Area. The data is available to the user as soon as the STFP sets ACK bit 0. Currently three different data packets may be requested using this command.

<b>BYTE</b>	<b>TYPE</b>	<b>ITEM</b>	<b>VALUE OR RANGE</b>
0	UINT8 ID		0x19
1	UINT8 req data type		See Below

**Requested Data Type Choices**

0	D/A Value
1	Leap Seconds (GPS Only)
2	STFP Firmware Version

The format of the response to this command for each requested data type is listed below. Responses are written to the DPRAM Output Area by the STFP.

<b>BYTE</b>	<b>TYPE</b>	<b>ITEM</b>	<b>VALUE OR RANGE</b>
0	UINT8 response type	0	
1-2	UINT16	D/A Value	0x0000 - 0xFFFF

<b>BYTE</b>	<b>TYPE</b>	<b>ITEM</b>	<b>VALUE OR RANGE</b>
0	UINT8 response type	1	
1	INT8	Leap Seconds	-128 to +127

<b>BYTE</b>	<b>TYPE</b>	<b>ITEM</b>	<b>VALUE OR RANGE</b>
0	UINT8 response type	2	
1	UINT8 major version		0 - 255
2	UINT8 minor version		0 - 255
3	UINT8 month		1 - 12
4	UINT8 day		1 - 31
5	UINT16	year	1970 - 2050

**COMMAND 0x1A - SOFTWARE RESET**

This command vectors the STFP MPU to its power-on reset point and contains no data.

**Note:** The device registers are unaffected.

**COMMAND 0x20 - SELECT CLOCK SOURCE**

This command selects the clock source for the STFP. The STFP uses a time base frequency of 10MHz. The 10MHz may be derived from the on-board VCXO or it may be supplied from an external oscillator via the J4 connector.

<b>BYTE</b>	<b>TYPE</b>	<b>ITEM</b>	<b>VALUE OR RANGE</b>
0	UINT8 ID	0x20	
1	UINT8 clock source	see below	

**Clock Source Choices**

- “T” Internal 10 MHz VCXO
- “E” External 10 MHz Clock

**COMMAND 0x21- CONTROL JAM-SYNC**

This command can be used to disable STFP jam-syncs which normally occur automatically.

<b>BYTE</b>	<b>TYPE</b>	<b>ITEM</b>	<b>VALUE OR RANGE</b>
0	UINT8 ID	0x21	
1	UINT8 jam-sync ctrl	0 = jam-syncs disabled 1 = jam-syncs enabled	

**COMMAND 0x22 - FORCE JAM-SYNC**

This command forces the STFP to perform a single jam-sync operation and contains no data. The jam-sync will occur even if jam-syncs are disabled.

**COMMAND 0x23 - CONTROL CLOCK DISCIPLINING**

This command can be used to disable disciplining of the STFP clock source which normally occurs.

<b>BYTE</b>	<b>TYPE</b>	<b>ITEM</b>	<b>VALUE OR RANGE</b>
0	UINT8 ID	0x23	
1	UINT8 discipline ctrl	0 = disciplining disabled 1 = disciplining enabled	

**COMMAND 0x24 - LOAD D/A CONVERTER**

The STFP on-board crystal oscillator frequency is voltage controlled using the output of a 16 bit D/A converter as the controlling voltage. This command allows the user to directly load a 16 bit value to the D/A converter. This feature would allow a user to fine tune the STFP time base in the free running mode. Since this voltage is routed out of the STFP via the J4 connector to allow external oscillators to be disciplined, it would provide a means to devise a frequency control algorithm independent of the STFP. The D/A output voltage ranges from 0.5 V (value = 0x0000) to 4.5 V (value = 0xFFFF.)

<b>BYTE</b>	<b>TYPE</b>	<b>ITEM</b>	<b>VALUE OR RANGE</b>
0	UINT8 ID	0x24	
1-2	UINT16	D/A value	0x0000 - 0xFFFF

**COMMAND 0x25 - SET DISCIPLINING GAIN**

This commands allows the gain and sense of the disciplining process to be set by the user. A positive gain indicates that the voltage controlled clock source frequency increases with increasing control voltage. This feature is indispensable to anyone attempting to discipline an external oscillator using the STFP.

<b>BYTE</b>	<b>TYPE</b>	<b>ITEM</b>	<b>VALUE OR RANGE</b>
0	UINT8 ID	0x25	
1-2	INT16	gain	-32768 to +32767

**COMMAND 0x30 - SEND PACKET TO GPS RECEIVER**

This command allows the user to send a GPS data packet to the GPS receiver.

**COMMAND 0x31 - REQUEST PACKET FROM GPS RECEIVER**

This command allows the user to request a GPS packet (i.e. position, velocity, status, etc.) from the GPS receiver.

**COMMAND 0x32 - MANUALLY REQUEST PACKET FROM GPS RECEIVER**

This command is similar in function to command 0x31.

**COMMAND 0x33 - SELECT GPS TIME FORMAT**

This command allows the user to select between GPS time and UTC when using timing mode 6 (GPS). The relationship between UTC and GPS time is shown below.

$$\text{UTC} = \text{GPS Time} - \text{Leap Seconds}$$

<b>BYTE</b>	<b>TYPE</b>	<b>ITEM</b>	<b>VALUE OR RANGE</b>
1	UINT8 ID		0x33
2	UINT8 GPS time format		0 = UTC 1 = GPS Time



## CHAPTER SIX

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### INPUTS AND OUTPUTS

#### 6.0 GENERAL

All input and output connectors are located on the back plate assembly. Figure 6-1 shows the bc637S back plate with all the connectors. Connectors J1, J2, and J3 are SMB type connectors. You can connect directly to J1-J3 with mating SMB type connectors, or you can use the SMB-to-BNC adapter cables provided with the bc637S to connect BNC cables to these connectors. Connector J4 is a 15 position high-density (HD) female D-subminiature type connector. This connector carries all of the input/output signals available on the bc637S except for the modulated time code input and output signals. Connector J5 is an eight position mini-DIN connector used for the optional GPS receiver/antenna.

#### 6.1 J1 - TIME CODE INPUT

The J1 connector is used for the time code input signal. This connector accepts the modulated time code input only. Use either the J3 Feature Connector or the J4 HD connector for DCLS time code.

#### 6.2 J2 - TIME CODE OUTPUT

The J2 connector is used for the IRIG B time code output signal. This connector provides the modulated time code output only. Use either the J3 Feature Connector or the J4 HD connector for the DCLS time code output.

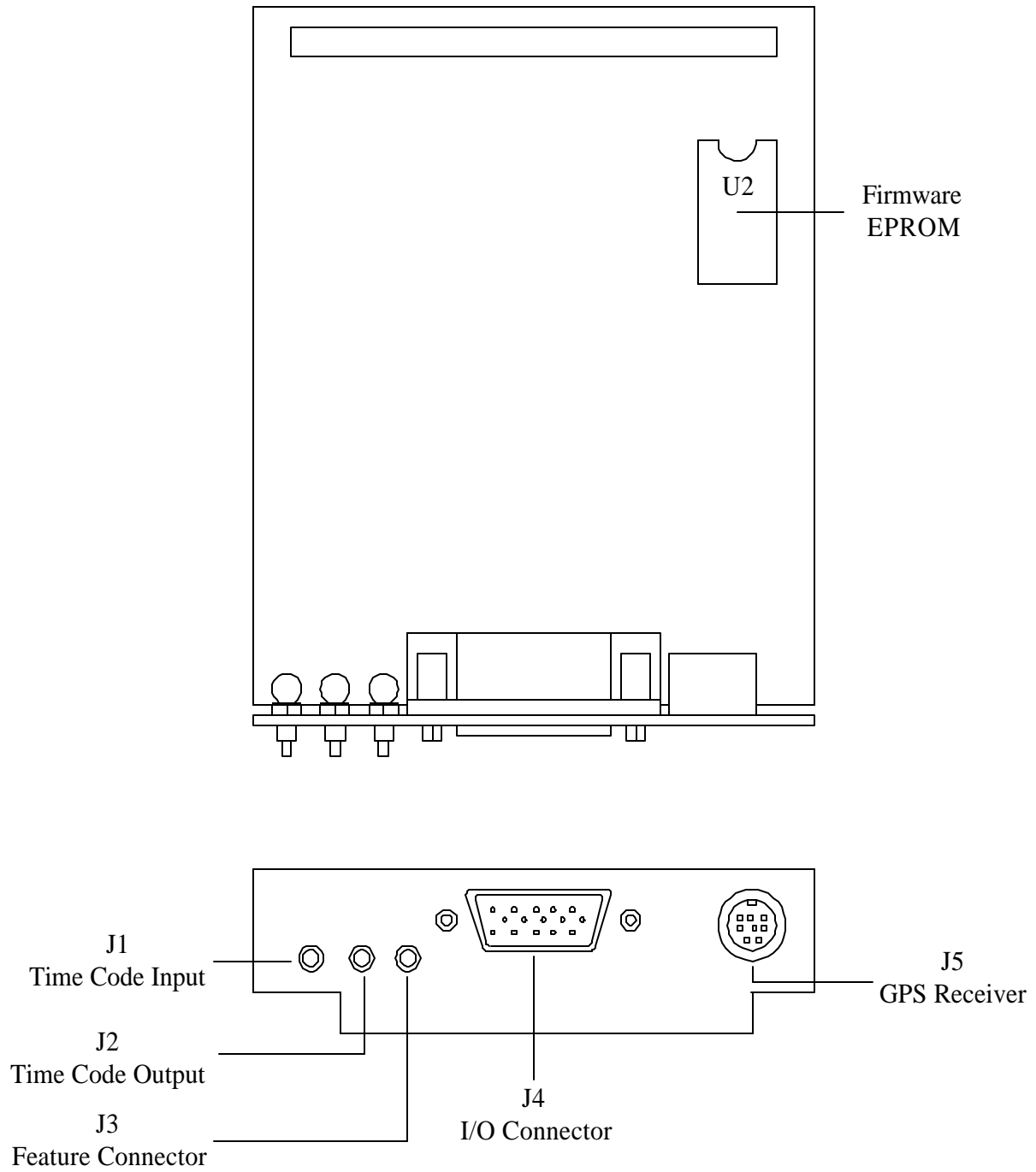
#### 6.3 J3 - FEATURE CONNECTOR

The J3 connector can be configured to carry any one of the I/O signals listed in Table 6-1. The FCON register value selects the signal carried by J3. When J3 is configured as an input, the corresponding input on the J4 connector is deactivated, but when J3 is configured as an output the output signal is active on both J3 and J4. At reset J3 is configured as the Event Input. When FCON is set to the Diagnostic setting (0x03), both the Event Input and the Strobe Output are deactivated, and J3 is configured as an input, though the input signal is ignored.

#### 6.4 J4 - INPUT/OUTPUT CONNECTOR

The J4 connector carries all the available bc637S input and output signals except for the modulated time code input and output signals found on J1 and J2. Table 6-2 lists the pin assignments for this connector.

**Figure 6-1**  
**bc637S Back Plate and Connectors**



**Table 6-1**  
**J3 Feature Connector Signal Options**

<b>FCON Value</b>	<b>Signal</b>
0x00	Event Input
0x01	1pps Input
0x02	DC Level Shift Time Code Input
0x03	Diagnostic: Routes Strobe Output to Event Input
0x08	1pps Output
0x09	1, 5, 10 MHz Frequency Output
0x0A	Programmable Periodic Output
0x0B	Time Coincidence Strobe Output
0x0C	DC Level Shift Time Code Output

**6.5 GPS RECEIVER/ANTENNA**

The J5 connector carries the signals required to interface the bc637S to the optional GPS receiver/antenna. Table 6-3 lists the pin assignments for this connector. Data communications between the bc637S and the GPS receiver is via RS-422 signals. Additionally, the GPS receiver provides a 1pps signal to the bc637S. When the bc637S is connected directly to the GPS receiver, the 1pps is an open collector type signal (pin 8), but when the optional cable extender box is used, the 1pps signal is transmitted via RS-422 (pins 5 and 8). The +12V output is fused through a “PolySwitch” type device which will shut off the +12V output in the event that excess current is drawn and will automatically reset itself once the excess current drain is removed. The +12V output is not normally used to provide power to the GPS antenna because the antenna draws about 200mA of current which far exceeds the SBus specification of 30mA per slot. The GPS antenna is therefore powered with an external wall mount power supply provided with the GPS option.

**Table 6-2**  
**J4 Pin Assignments**

<b>Pin</b>	<b>Signal</b>
1	10 MHz Input
2	DCLS Time Code Input
3	Programmable Periodic Output
4	Time Coincidence Strobe Output
5	1, 5, 10 MHz Output
6-10	Ground
11	DCLS Time Code Output
12	1pps Input
13	Event Input
14	1pps Output
15	Frequency Control Output

**Table 6-3**  
**J5 Pin Assignments**

<b>Pin</b>	<b>Signal</b>
1	GPS Rx Data(+) From GPS
2	GPS Rx Data(-) From GPS
4	GPS Tx Data(+) To GPS
7	GPS Tx Data(-) To GPS
8	GPS 1pps (+) From GPS <i>or</i> GPS 1pps Open Oscillator From GPS
5	GPS 1pps (-) From GPS
6	+12V Output To GPS (Not Normally Used)
3	Ground

## CHAPTER SEVEN

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### DEVICE DRIVER

#### 7.0 GENERAL

The loadable device driver provides a simple interface to the bc635S SBus Time and Frequency Processor (STFP) module. The driver description is provided in a typical UNIX manual page format. Two versions of the driver are available: compatible with the SunOS 4.1.x operating system and compatible with Solaris 2.x (SunOS 5.x) operating system.

#### 7.1 INSTALLATION

Loadable device drivers are simple to install because they can be added to a running system without the need to reconfigure the kernel, though the driver can also be configured into the kernel if desired. Refer to your system administration documentation for instructions on configuring device drivers into the kernel. The steps required to install the loadable driver are list below.

##### 7.1.1 INSTALLATION UNDER SunOS 4.1X

The STFP module can generate interrupts, though they must be enabled by the user with an `ioctl(2)` request. To maintain flexibility, the STFP hardware allows the user to select the SBus IntReq level (IntReq(1)\* - IntReq(7)\*) used by the STFP. This flexibility, however, creates a minor problem; the driver must know the relationship between the SBus IntReq level and the SPARC processor's *ipl* (Interrupt Priority Level). Since there is no way for the driver to determine this relationship, the user must tell the driver what it is by modifying the `STFP_IPL` and `STFP_INTREQ_LEVEL` defined constants in the `stfp.c` driver source code. If this information is not correct, and the STFP generates an interrupt then your system will surely crash! The relationship between the SBus IntReq level and the *ipl* for a SPARCstation 1 is shown below.

**Note:** This relationship is probably different for different workstation models.

SBus IntReq Level	SPARCstation 1 ipl
7	9
6	8
5	7
4	5
3	3
2	2
1	1

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The following command line will compile the stfp.c source code into an object file. You may need to specify a different kernel architecture for the -D option.

```
venus# cc -c -O2 -Dsun4c stfp.c
```

Following compilation, the driver is ready to be loaded using the following modload(8) function.

```
venus# modload stfp.o -entry _stfp_vdcmnd
```

Create one or more character device files in the /dev directory with the mknod(8) function. The major device number can be found with modstat(8). In the following example, the minor device number is zero.

```
venus# mknod /dev/stfp0 c major minor
```

Use modunload(8) to unload the driver from the system. Use modstat(8) to determine the module-id.

```
venus# modunload -id module-id
```

### 7.1.2 INSTALLATION UNDER SOLARIS 2.X (SunOS 5.X)

The STFP module can generate interrupts, though they must be enabled by the user with an ioctl(2) request. To maintain flexibility, the STFP hardware allows the user to select the SBus IntReq level (IntReq(1)\* - IntReq(7)\*) used by the STFP. In order to select desired IntReq level edit the stfp.conf file changing the “interrupts” property value

The following command lines will compile the stfp.c source code.

```
venus# cc -D_KERNEL -c stfp.c  
venus# ld -r -o stfp stfp.o
```

Copy stfp and stfp.conf files into the /usr/kernel/drv directory (note that the stfp.conf file is necessary only if you want to use interrupt level different from the default). The driver is ready to be installed using following add\_drv(1M) function.

```
venus# add_drv -m ‘* 0666 root sys’ stfp
```

Use modunload(1M) to unload the driver from the system. Use modstat(1M) to determine the module-id.

```
venus# modunload -i module-id
```

**Name**

stfp - bc635S SBus Time and Frequency Processor device driver.

**SYNOPSIS**

```
#include "stfpio.h"
```

**DESCRIPTION**

The "stfp" device driver supports the Datum Inc, Bancomm-Timing Division bc635S SBus Time and Frequency Processor (STFP) module, as well as the GPS version, the bc635S. The STFP supports time code decoding, synchronization to an external 1pps (pulse per second) signal, a free running mode, and the GPS satellite system. Several timing outputs, all synchronous with the timing source, are provided, including an IRIG B time code signal, a 1pps, programmable periodic, a time coincidence strobe, and a 1, 5, or 10MHz clock.

The driver supports up to three STFP modules. The open(2), close(2), read(2), write(2), and ioctl(2) system calls are supported. Most STFP functions, including the reading of the time, are accesses through the ioctl(2) call.

**Read/Write Calls**

The only purpose for the read(2) call is to read a GPS data packet that was previously requested with an ioctl(2) or write(2) call. These packets contain position, velocity, GPS system status, and other GPS information. One GPS packet is read for each read(2) call. The maximum GPS packet size is defined by STFP\_MAX\_READ found in "stfpio.h." Refer to the GPS documentation for GPS packet details.

The packet data contains floating-point types as well as various integer types, but these elements cannot be directly accessed when read into a char buffer because they are not properly aligned in memory. To obtain access to the various types of GPS data elements, union structures are generally used. For example, to extract a 4 byte float from the packet data, use the union shown below. Copy four consecutive bytes of packet data into the fconv.uc[] array, starting with fconv.uc[0] (since Sun workstations are big-endian machines,) then access the float data as fconv.f.

```
union {
    float    f;
    u_char  uc[4];
} fconv;
```

Following a successful read(2) call, the read buffer will contain the packet length, ID, and data bytes of the requested GPS data packet as described in the GPS documentation section *Communicating with the GPS Receiver*.

**Note:** A successful `read(2)` call will return the number of bytes read which will equal the packet length plus 1 (one for the packet length byte itself.)

The `write(2)` call allows the user to send commands to the STFP. The STFP commands are used to set the timing mode, time code format, and other STFP functions. The write buffer must contain the STFP command ID and zero or more command data bytes. As with GPS packets, command data consists of various data types that must be converted to a char array for the `write(2)` call. The maximum number of bytes used for a command is defined by `STFP_MAX_WRITE` found in “`stfpio.h`.” Most commands are implemented with `ioctl(2)` calls which are much simpler to use since they provide the conversion of data to an array of chars as required.

Since most STFP commands can be executed with `ioctl(2)` calls, the only really useful function for the `write(2)` call is to execute the STFP commands that write data packets to the GPS receiver. In fact, the `write(2)` call is the only way to send GPS data packets to the GPS receiver. When `write(2)` is used to execute the “Manually Request Packet from GPS Receiver” command (command 0x32 described in the GPS documentation) and a response is expected (non-zero response packet ID), the `write(2)` call puts the calling process to sleep until the response arrives. The driver will not call `sleep()` if the user has directed the driver to send a signal on the occurrence of the `INT_PACKET` (GPS packet available) interrupt. The response packet can take 10’s or 100’s of milliseconds to arrive. The `read(2)` call can then be used to read the response packet.

### **Ioctl Calls** `ioctl (fd, request[, arg])`

The `ioctl(2)` *request* codes, as well as all the other defined constants listed below, are contained in “`stfpio.h`.” For most `ioctl()` functions, *arg* is a pointer to data either used by or returned by the function. Other functions either ignore *arg* or use it directly as an **int** value. In many functions, most of which have *request* labels of the form `SELXXX` or `CONTROLXXX`, the **int** value selects some option from a list of options defined in “`stfpio.h`.”

Following each *request* code below is the *arg* type expected by the driver.

`SELTIMINGMODE`, int

Selects the STFP timing mode specified in the **int** *arg*.

`SELTIMEFORMAT`, int

Selects between the decimal and binary time formats. The decimal time format is characterized by the `stfp_time` structure. The binary time format is characterized by the `stfp_timeval` structure. These structures are declared in “`stfpio.h`.”



TIMEREQUEST, int

EVENTREQUEST, int

The driver writes to the TIMEREQ or EVENTREQ register (the **int** value is ignored) which causes time to be captured and held in the TIME<sub>x</sub> or EVENT<sub>x</sub> registers. No time data is transferred.

RDTIME, \*struct stfp\_time

RDEVENT, \*struct stfp\_time

Reads time from the STFP TIME<sub>x</sub> or EVENT<sub>x</sub> registers assuming the time format is decimal. Time is *not* captured with these requests.

RDTIMETV, \*struct stfp\_timeval

RDEVENTTV, \*struct stfp\_timeval

Reads time from the STFP TIME<sub>x</sub> or EVENT<sub>x</sub> registers assuming the time format is binary. Time is *not* captured with these requests.

RDTIMEREQ, \*struct stfp\_time

RDEVENTREQ, \*struct stfp\_time

These requests capture and read time from the STFP TIME<sub>x</sub> or EVENT<sub>x</sub> registers assuming the time format is decimal.

RDTIMETVREQ, \*struct stfp\_timeval

RDEVENTTVREQ, \*struct stfp\_timeval

These requests capture and read time from the STFP TIME<sub>x</sub> or EVENT<sub>x</sub> registers assuming the time format is binary.

WRSTROBE, \*struct stfp\_time

Writes time to the STROBE<sub>x</sub> registers assuming the time format is decimal. This request disables the Strobe output while the STROBE<sub>x</sub> registers are written.

WRSTROBETV, \*struct stfp\_timeval

Writes time to the STROBE<sub>x</sub> registers assuming the time format is binary. This request disables the Strobe output while the STROBE<sub>x</sub> registers are written.

CONTROLSTROBE, int

This request performs a variety of functions relevant to the Time Coincidence Strobe feature.

SELTCFORMAT, int

Selects the time code format.

SELTCMOD, int

Selects the time code modulation type.

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SETTIME, \*struct stfp\_time

Manually sets the STFP major time assuming the time format is decimal. The minor time is not affected.

SETTIMETV, \*struct stfp\_timeval

Manually sets the STFP major time assuming the time format is binary. The minor time is not affected.

SETPERIODIC, \*struct periodic

This request sets the Programmable Periodic output frequency and enables the 1pps synchronous mode.

SETTIMINGOFFSET, int

Sets the STFP timing offset with the **int** *arg* value.

SELFREQUENCYOUT, int

Selects output frequency (1, 5, or 10MHz).

SELFCONN, int

Selects the function of the J3 Feature Connector.

CONTROLEVENT, int

This request performs a variety of functions relevant to the Event Time Capture feature.

CAPUNLOCK, int

This request writes to the STFP UNLOCK register to release the Event Capture Lockout feature (if enabled via CONTROLEVENT).

RDFIRMVERSION, \*struct stfp\_version

This request reads the STFP micro controller firmware version. The version structure contains major and minor version numbers and the version release date.

SETINTSIGNAL, int

Setup one or more interrupt sources to generate a signal (SIGUSR1) to the process making this ioctl(2) call. The **int** *arg* is comprised of one or more interrupt source bits (defined in “stfpio.h”) OR’ed together. The following ioctl(2) call would cause the driver to send a signal on the occurrence of the Event Input and/or Strobe Output interrupt. The signal handler can use the RDINTSIGNAL request to find out which interrupt source(s) caused the signal. An *arg* value of 0 will disable signals.

ioctl (fd, SETINTSIGNAL, INT\_EVENT | INT\_STROBE);

RDINTSIGNAL, \*int

Use this request to find out which interrupt source(s) generated the last signal. Use the SETINTSIGNAL request to enable signals. The driver automatically clears the INTSTAT bits during its interrupt service routine.

RDINTSTAT, \*int

CLRINTSTAT, int

These requests allow the user to read and clear bits in the STFP INTSTAT register. All INTSTAT bits can be read, but only those bits that are not setup to generate a signal can be cleared. Use these requests to poll for the occurrence of one or more interrupt source(s) instead of using signals.

CONTROLTIMEBASE, int

This request performs a variety of timebase control functions, such as oscillator disciplining and jam-sync control, clock selection, etc.

SETDAC, int

Loads the STFP D/A Converter with the **int arg** value.

RDDAC, \*int

Reads the STFP D/A converter value.

REQGPSPACKET, int

This request is for users of the bc635S, the GPS version of the bc635S. The **int arg** contains one of the GPS packet ID's supported with the *Retrieve Packet from GPS Receiver* command (command 0x31). The STFP monitors and stores several commonly requested packets that the GPS receiver broadcasts periodically to the STFP. These packets are available to be read immediately. GPS packets that are not monitored by the STFP are requested from the GPS receiver by the STFP. Since this task can take 10's or 100's of milliseconds, the driver puts the calling process to sleep until the GPS packet becomes available. The driver will not call sleep() if the user has directed the driver to send a signal on the occurrence of the INT\_PACKET (GPS packet available) interrupt. The requested packet is read using the read(2) call.

## Files

/dev/stfp*n* - STFP character device file(s) installed with mknod(8).

stfp.c - STFP device driver source code

stfpio.h - STFP header file for user programs.

**See Also**

The rest of the bc635S User's Guide.

**open(2), close(2), read(2), write(2), ioctl(2), signal(2)**

**Examples**

There are several example programs included with the driver distribution.

**Diagnostics**

Diagnostic and tracking messages can be turned on by defining the STFP\_DEBUG constant when the driver is compiled.

**Bugs**

Under SunOS 4.1.x the driver has no way to determine the relationship between the SBus IntReq\* level and the *ipl* (interrupt priority level) which the driver needs to know to setup interrupts properly. The user must therefore provide this information to the driver by modifying the STFP\_IPL and STFP\_INTREQ\_LEVEL constants in the stfp.c driver source.

## CHAPTER EIGHT

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### GPS RECEIVER INTERFACE

#### 8.0 GENERAL

The bc637S GPS System consists of a bc637S SBus Time and Frequency Module (STFP) equipped with special firmware, an Acutime GPS receiver/antenna module manufactured by Trimble Navigation Ltd., and an interconnecting cable. The bc637S module communicates with the Acutime via RS-422 serial (9600 bps) lines. The Acutime also provides a 1pps signal to the bc637S.

*Note:* The most common difficulty encountered using GPS equipment is antenna position. The GPS antenna must be located in an area which has a clear view of the sky. The GPS signals cannot penetrate foliage or structures. A good antenna position will provide optimal timing performance.

#### 8.1 GPS TIMING MODE (MODE 6) CHARACTERISTICS

In order to function with the Acutime GPS Receiver the bc637S module must operate in timing mode 6 (GPS timing mode). This is the default timing mode for the bc637S when equipped with the special GPS firmware which is a standard part of the bc637S GPS system. The GPS timing mode is characterized by the following:

- The 1pps signal generated by the Acutime GPS receiver provides the timing reference for all timing functions.
- The on-board 10MHz VCXO is disciplined to the GPS 1pps signal whenever the Acutime is tracking a sufficient number of satellites. If too few satellites are tracked then the bc637S will flywheel.
- The bc637S extracts major time and satellite tracking status information from data packets sent from the Acutime. By default, the bc637S provides UTC time to the user. The user can select GPS time instead by issuing the DPRAM command 0x33 (select GPS time format).
- The bc637S provides a communications pathway between the user and the Acutime GPS receiver. This pathway is most often used to receive GPS data packets for position, velocity, and GPS system status.
- The bc637S ignores all other timing sources (i.e. the time code input and external 1pps input signals.)

## 8.2 COMMUNICATING WITH THE GPS RECEIVER

The dual-port RAM (DPRAM) interface provides the communications pathway between the user and the Acutime GPS Receiver. Using DPRAM commands and the DPRAM GPS Packet Area, the user can send and receive GPS data packets. A GPS data packet consists of a packet length byte, a packet ID byte, and 0 or more data bytes. A packet length of 0 indicates that no valid packet ID and data bytes are present. The GPS data packet structure is summarized below:

<u>BYTE</u>	<u>ITEM</u>
0	packet length = N = number of packet data bytes + 1 (for the packet ID byte)
1	packet ID
2 - N	packet data bytes

The GPS packet IDs and packet data formats are described later in this appendix and are taken from Trimble Navigation’s Acutime manuals. The user can determine the packet length from the Acutime documentation. The Acutime documentation describes a packet structure that includes, in addition to the packet ID and packet data bytes, header and trailer bytes and byte-stuffing/unstuffing. The bc637S automatically adds (when sending packets) and removes (when receiving packets) the header and trailer bytes and handles all byte-stuffing/unstuffing operations. The bc637S user should be concerned with the packet length, packet ID, and packet data bytes only.

### 8.2.1 SENDING GPS DATA PACKETS TO THE GPS RECEIVER

To send a GPS data packet to the Acutime use the DPRAM command “Send Packet to GPS Receiver” (command ID 0x30.) The format of this command is shown below:

<u>BYTE</u>	<u>TYPE</u>	<u>ITEM</u>	<u>VALUE OR RANGE</u>
0	UINT8	command ID	0x30
1	UINT8	packet length	1 - 255
2	UINT8	packet ID	0x00 - 0xFF
3 - N	UINT8	packet data bytes	0 - 255

GPS packet data consists of various integer and floating-point data types. The user must convert these data types to an array of bytes.

## 8.2.2 RECEIVING GPS DATA PACKETS FROM THE GPS RECEIVER

The DPRAM GPS packet area holds packets received from the Acutime. The bc637S writes GPS packets to this area upon user request. The format of the packets in the GPS packet area is shown below:

<u>BYTE</u>	<u>TYPE</u>	<u>ITEM</u>	<u>VALUE OR RANGE</u>
0	UINT8	packet length	1 - 255, 0 = no valid packet
1	UINT8	packet ID	0x00 - 0xFF
2 - N	UINT8	packet data bytes	0 - 255

There are two DPRAM commands that retrieve GPS Packets. These commands are described below. The bc637S sets ACK register bit 2 whenever it writes a GPS packet to the GPS packet area. The transition of ACK register bit 2 from 0 to 1 is interrupt source 4 (GPS packet available.) The user must clear ACK register bit 2.

### 8.2.2.1 RETRIEVE PACKET FROM GPS RECEIVER (COMMAND 0X31)

This command allows the user to retrieve a GPS packet (i.e. position, velocity, status, etc) from the GPS receiver by specifying the packet ID of the GPS packet of interest. Packets that can be retrieved with this command are listed below. Packets not found on this list must be retrieved with Command 0x32. The format of command 0x31 is shown below:

<u>BYTE</u>	<u>TYPE</u>	<u>ITEM</u>	<u>VALUE OR RANGE</u>
0	UINT8	command ID	0x31
1	UINT8	packet ID	0x00 - 0xFF

Some of the more commonly requested GPS packets are sent from the Acutime to the bc637S either periodically (e.g. position fix) or whenever they change (e.g. satellite selection.) The bc637S monitors these packets and stores them in on-board RAM so that they can be transferred to the user immediately upon request. The rest of the GPS packets must be retrieved from the Acutime by the bc637S whenever the user requests them.

**Note:** It can take 10's or 100's of milliseconds for the bc637S to retrieve a packet from the Acutime. GPS packets that are monitored by the bc637S are identified below.

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<u>Packet ID</u>	<u>Monitored</u>	<u>Packet Description</u>
0x41	No	GPS Time
0x42	Yes	Single-Precision Position Fix, XYZ ECEF
0x43	Yes	Velocity Fix, XYZ ECEF
0x44	Yes	Satellite Selection
0x45	No	Acutime Firmware Version
0x46	Yes	Health of Acutime
0x47	No	Signal Level For All Satellites ( <i>Note:</i> The first byte returned will be the length of the packet)
0x48	No	GPS System Message
0x49	No	Almanac Health Page For All Satellites
0x4A	Yes	Single-Precision Position Fix, Lat/Long/Alt
0x4B	Yes	Machine/Code ID And Additional Status
0x4D	No	Oscillator Offset
0x4F	No	UTC Parameters
0x55	No	I/O Options
0x56	Yes	Velocity fix, East-North-Up (ENU)
0x57	No	Information About Last Computed Fix
0x5E	No	Additional Fix Status
0x83	No	Double-Precision Position Fix, XYZ ECEF
0x84	No	Double-Precision Position Fix, Lat/Long/Alt

The retrieve packet command works as follows:

- If the requested packet is being monitored and a local copy exists, then the bc637S transfers its local copy of the packet to the DPRAM GPS packet area, sets ACK bit 2, then sets ACK bit 0 to acknowledge the retrieve packet command.
- If the requested packet is not being monitored or if the bc637S has not yet received a monitored packet, then the bc637S must request the packet from the Acutime by sending the appropriate request packet to the Acutime. Once the request has been sent to the Acutime the bc637S sets ACK bit 0 to acknowledge the retrieve packet command. Later, when the Acutime responds with the retrieved packet, the bc637S transfers the packet to the DPRAM GPS Packet Area and sets ACK bit 2. If the Acutime does not respond to the request within a timeout period (typically three seconds), then the bc637S sets the packet length byte in the DPRAM GPS packet area to 0 and sets ACK bit 2.
- If the retrieved packet ID is not on the list above, the bc637S sets the packet length byte in the DPRAM GPS packet area to 0, sets ACK bit 2, then sets ACK bit 0.



**8.2.2.2 MANUALLY REQUEST PACKET FROM GPS RECEIVER (COMMAND 0X32)**

This command is a hybrid of commands 0x30 and 0x31. With this command the user specifies the packet length and ID of a packet sent by the Acutime (response packet) and specifies the packet length, ID, and data for the packet to be sent to the Acutime (request packet.) The bc637S sends the request packet to the Acutime and transfers the response packet to the DPRAM GPS packet area when it arrives. If the response packet ID is 0x00 then the bc637S will ignore the response, in which case, this command would be functionally identical to command 0x30. The bc637S sets ACK bit 0 once the request packet is sent to the Acutime. Later, when the response packet has been transferred to the DPRAM GPS packet area, the bc637S sets ACK bit 2. As with command 0x31, if the Acutime fails to respond within a timeout period, the bc637S sets the packet length in the DPRAM GPS packet area to zero and then sets ACK bit 2.

*Note:* A response packet length of 0 (ZERO) (Byte 1) will return any packet with the corresponding response packet ID (Byte 2). This is use full for packets like 0x47 that return variable length responses.

<u>BYTE</u>	<u>TYPE</u>	<u>ITEM</u>	<u>VALUE OR RANGE</u>
0	UINT8	command ID	0x32
1	UINT8	response packet length	1 - 255
2	UINT8	response packet ID	0x00 - 0xFF
3	UINT8	request packet length	1 - 255
4	UINT8	request packet ID	0x00 - 0xFF
5 - N	UINT8	request packet data bytes	0 - 255

As an example of this command, let's suppose the user wants to retrieve packet 0x5B (satellite ephemeris status) for satellite number six. The Acutime sends packet 0x5B in response to packet 0x3B (request satellite ephemeris status.) Packet 0x3B specifies the PRN number for the satellite of interest, in this case, satellite number six. The appropriate command structure for this example is shown below.

<u>BYTE</u>	<u>ITEM</u>	<u>VALUE</u>
0	command ID	0x32
1	response packet length	17
2	response packet ID	0x5B
3	request packet length	2
4	request packet ID	0x3B
5	satellite PRN number	6

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Another example would be returning the SNR of the currently tracking satellites:

<u>BYTE</u>	<u>ITEM</u>	<u>VALUE</u>
0	command ID	0x32
1	response packet length	0
2	response packet ID	0x47
3	request packet length	1
4	request packet ID	0x27

### 8.3 ACUTIME GPS RECEIVER

The Acutime GPS receiver module is manufactured by Trimble Navigation Ltd. in Sunnyvale, Ca. The current generation of the Acutime is a six channel C/A code receiver and antenna integrated in a compact weatherproof housing which mounts like an antenna. Table 8-1 lists the Acutime performance specifications.

**Table 8-1**  
**Acutime Performance Summary**

<b>Item</b>	<b>Description</b>
Number of channels	6
Receiver Frequency	1.575 GHz C/A Code
Time to First Fix	
1> Brief power off	1.5 Minutes
2> Needs ephemeris	3.5 Minutes
3> Needs Almanac	5 to 15 Minutes
Dynamics	
1> Velocity	300 Meters/Sec (600 Knots)
2> Acceleration	19.5 m/s/s (2 g's)
3> Jerk	20 m/s/s/s
Position Accuracy	25 Meters CEP (PDOP < 6)
Velocity Accuracy	0.2 Meters/sec (PDOP < 6)
1pps Accuracy	- 2 Microseconds
Solution Modes	
4 Satellite	3-D Position, Velocity, And Time
3 Satellite	Same As Above (Altitude Hold)
1 Satellite	Static Position Time Only
Auto	1,3,4 Sat. Auto Transitions
Power	+12VDC @ 0.2 Amp

## 8.4 POSITION FIX MODES

One of the most confusing aspects of GPS operation is the selection of the position fix mode (GPS packet 0x22.) The Acutime supports the following four GPS position fix modes.

### **Position Fix Mode 0**

This mode uses as many satellites as are available to perform both position fixes and timing functions. Confusion arises because this mode selection interacts with the dynamics code selection (GPS packet 0x2C.) If a non-static dynamics code is selected then only three or four satellites will be used because the GPS sensor assumes that it is moving. If only three satellites are usable then altitude will be held constant. If a static dynamics code is entered then mode zero will use three or four satellites for a navigation solution as previously, however, if only one or two satellites are available the sensor will use the satellite with highest elevation to continue calculating bias and bias rate (the timing functions will continue unimpaired). It is very advantageous, therefore, to enter a static dynamics code if the sensor is static.

### **Position Fix Mode 1**

In this mode, a user specified satellite is used for timing functions. If mode 1 is selected, only a single satellite will be used for timing, and the current position will be assumed accurate and static.

GPS packet 0x34 allows the satellite associated with mode one to be selected. This packet has one data byte which specifies the PRN of the desired satellite. If a data byte value of 0 is entered, then the sensor will always track the single satellite which has the highest elevation within the constellation in view.

It is very advantageous to operate in a single satellite highest elevation mode for timing applications. The greatest contribution to timing error is the electron content variation in the path between the satellite and the receiver. This variation is minimized by selecting the highest elevation satellite.

### **Position Fix Mode 3 and 4**

These modes are rarely used for timing applications unless the user operational platform is dynamic. Mode three is particularly useful in a marine environment where the sensor altitude is relatively constant.

## 8.5 bc637S GPS DEFAULT PARAMETERS

The bc637S sends the following GPS packets to the Acutime on reset or whenever the timing mode is changed to GPS timing mode 6.

### *Set Operating Parameters (GPS packet 0x2C)*

<u>PACKET DATA ITEM</u>	<u>VALUE</u>
Packet ID	0x2c
Dynamics Code	4 (Static)
Elevation Angle Mask	0.1745 Radians (10 Degrees)
Signal Level Mask	6.0
PDOP Mask	12.0
PDOP Switch	8.0

### *Set High-8 / High-6 Mode (GPS packet 0x75)*

<u>PACKET DATA ITEM</u>	<u>VALUE</u>
packet ID	0x75
mode	0 (high-8)

### *Set I/O Options (GPS packet 0x35)*

<u>PACKET DATA ITEM</u>	<u>VALUE</u>
Packet ID	0x35
Position	0x03
Velocity	0x03
Timing	0x00
Auxiliary	0x00

To change any of the packet 0x35 options, keep the following information in mind:

- The bc637S monitors position and velocity packets so the “position” and “velocity” options should be sent with bits 0 and 1 set; the bc637S extracts major time from time packets broadcast by the Acutime so the “timing” option should be sent with bits 0, 1, and 2 cleared.

## 8.6 GPS SYSTEM OVERVIEW

The GPS system consists of three parts called segments:

- The space segment consists of eighteen satellites and three spares broadcasting the radio navigation signals.
- The control segment tracks the satellites and uploads orbital information (ephemerides) and clock corrections. There are five monitor stations, three up-link stations, and one master control station.
- The user segment tracks and receives the radio navigation signals and computes user position and time.

The signals transmitted from the satellites consist of two modulated carriers: L1 at 1.575 GHz and L2 at 1.227 GHz. The L1 signal is modulated with both a C/A code and a P code. The L2 signal is modulated with a P code only. Civilian access to the system is provided through the C/A code. The P code is intended for authorized military users only. The Acutime operates on the C/A code.

The Acutime determines time and position by measuring the time of arrival of the satellite signals. If the user has no knowledge of either time or position, then four satellites are required to determine a solution for the four unknown quantities X,Y,Z and time. If position is known and static, then time can be determined by measuring the time of arrival of a single satellite signal. Each satellite broadcasts information which allows the user to calculate the position of the satellite. Knowledge of this position, the user position, and a model of the transmission path characteristics allows accurate time determination.

The structure and content of the satellite signals and the decoding and solution determination algorithms are beyond the scope of this User's Guide. Further information may be obtained from the paperback overview Guide to GPS Positioning, by David Wells, published by Canadian GPS Associates.

## CHAPTER NINE

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### TRIMBLE STANDARD INTERFACE PROTOCOL (TSIP)

#### 9.0 INTRODUCTION

Depending how the system designer uses Trimble Standard Interface Protocol (TSIP) to configure the GPS receiver, final system performance can be optimized for any number of applications. For example, an aircraft or vessel operating with an unobstructed view of the sky, will most likely have different GPS operating requirements than vehicle operations in a downtown “urban canyon” environment, where frequent satellite blockages are the rule rather than the exception.

TSIP gives the system designer an unprecedented degree of freedom in choosing settings most appropriate to the task at hand; however, along with this flexibility, comes the responsibility of making intelligent selections which are consistent with each other and the overall system objective.

The GPS receiver is provided with certain factory default settings, which will suffice for a great number of applications. For those requiring customization, application hints are provided for each packet, in the sections that follow. The key operative is to make judicious use of the powerful features TSIP has to offer the system designer. The system designer will greatly enhance overall system performance while reducing development time.

#### 9.1 INTERFACE SCOPE

The Trimble Standard Interface Protocol is used in a large number of Trimble three and six channel board and navigation sensor designs. The protocol was originally defined for the Trimble Advanced Navigation Sensor (TANS) and is colloquially known as the TANS protocol even though applying to many other devices. References in this document to the TANS protocol should not be taken to apply to the TANS unit only, but to the whole range of Acutime sensors with the exception of those devices operating with an ASCII interface only. One important difference is that the RS-422 version has one bi-directional port only.

For the RS-232 Acutime range of sensors there are some particular considerations for the setup of Serial Channel A and Channel B (or Channels 1 and 2). Channel 1 operates in the same way as for all other Trimble two, three and six satellite channel sensors (for example, there is a series of automatic outputs - described in the attached table). Do not confuse the number of satellite channels with the number of serial channels (or ports). There is no relationship between the two. Reference is often made to serial channel or port interchangeably.

The second serial channel is a receive only, i.e. it is intended normally for receipt of RTCM corrections. The default setting on start-up is 9600 baud, 8 bit, odd parity, and 1 stop bit.

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This document describes in detail the format of the transmitted data, the packet identification codes, and all available information over the output channel to allow the user to choose the data required for his particular application. The Acutime transmits some of the information (position and velocity solutions, etc.) automatically when it is available, while other information is transmitted only on request. Additional packets may be defined for particular products and these will be covered in the specifications for those products as necessary.

The bi-directional channel is the interface for command, control, and data output, for integration with control systems, vehicle tracking and management systems, navigation processors, displays, and other user equipment. The channel protocol is based on the transmission of packets of information between the user equipment and the unit. Each packet includes an identification code (1 byte, representing 2 hexadecimal digits) that identifies the meaning and format of the data that follows. Each packet begins and ends with ASCII control characters.

The TSIPPC utility, part of the GPS Software Toolkit, is designed to exercise many of the TSIP packets. The system integrator can use the utility to test the reaction of the sensor to these commands.

### 9.2 KEY ACUTIME SETUP PARAMETERS

Correct selection of the right operating parameters is a major factor in getting the best performance from the sensor. Packets 22 (set fix mode), 2C (set operating parameters), 35 (set I/O options), and packet 62 (set DGPS mode) are provided to change the receiver setup to the specific conditions of a particular user. The default values for the parameters in these packets are chosen to allow the receiver to operate well under the most varied and demanding conditions. A user may choose to change the default parameters if the receiver is only required to perform in a specific or limited environment. The user should be warned that when the receiver is exposed to operating conditions which are different from the conditions described by the user setup, then the performance may be degraded. A brief description of the main parameters in these packets is given below so that a designer may understand the trade-off involved with a particular setup.

Initially the system designer needs to consider carefully the environment in which the receiver is expected to operate. There is a trade-off between how frequently a position fix is output versus the absolute accuracy of the fix. The system designer needs to decide which takes priority and then make the appropriate selections. This becomes increasingly important when frequent satellite blockages are expected, as in downtown “urban canyon” environments and heavily foliated areas.

If one contrasts the sensor performance required for an aircraft, flying level, or a marine vessel, in a calm sea, with that of a truck or bus being driven in an area of partial or complete blockage due to buildings and trees, then it is clear that different demands are being made on the sensor. Accuracy of the position fix is optimized when the “Synchronized Measurements” (Packet 35) option is ON. By doing so, the GPS will only output a position fix when it has continuous lock on three or more satellites simultaneously.

In a downtown urban canyon, it is difficult to maintain continuous lock on a given satellite constellation for any length of time. The sensor may find it almost impossible to pick up signals simultaneously from three or four satellites and will also be subject to continuous constellation shifts, since the satellites are frequently blocked from view by tall buildings. Other limitations are also set by the masks for PDOP, elevation and signal strength (SNR). Therefore, the system designer would be satisfied with a lower accuracy provided that fix density (or frequency) is at an acceptable level. Switching the “Synchronized Measurements” option to OFF gives the receiver more latitude in selecting and propagating old measurements to yield a position fix, with less accuracy than one which maintained continuous lock.

The user can check for this condition occurring by setting the Additional Fix Status ON. Packet 5E will identify the number of old measurements being used. Such data is most useful where the sensor is being used as part of a DR system; checking the independence of measurements can be used as a weighting parameter in computing the overall solution from the combined sensor suite.

*Note:* Minimize Projection is set ON by default; in this case where obscuration occurs, new positions will be computed for three to four seconds using the last velocity vector before obscuration occurred. This may not be desirable in combined sensor systems and should therefore be set OFF.

One should also resist the temptation to set the elevation and SNR masks too low. The satellite geometry is sometimes improved considerably by selecting low elevation satellites. They are subject to significant signal degradation by the greater ionospheric and tropospheric attenuation that occurs. They are also subject to more obscuration by the passing scenery when the sensor is in a moving vehicle. The code phase data from those satellites is therefore more difficult to decode and therefore has more noise. If possible the elevation mask should set between 5° and 10° minimum.

The vehicle dynamics should also be correctly set so that the search algorithm for satellites operates in optimum fashion if there has been a complete loss of lock with the satellites due to short periods of obscuration. A more detailed discussion of the effects of the various parameters is set out below.



### **Fix Mode**

The preferable fix mode is 3-D, where altitude is calculated along with the latitude, longitude, and time. However, this requires four satellites with a PDOP below the PDOP mask set in packet 2C in order to obtain a position. Normally, this will provide the most accurate solution. Thus, if only 3-D solutions are desired, then the user should request 3-D manual mode. Depending on how the PDOP mask is set, this may be restrictive when the receiver is subjected to frequent obscuration, or when the geometry is poor due to an incomplete constellation.

Alternatively, if the user only wants a 2-D solution, then 2-D manual should be requested. In this case, the sensor uses either the last altitude obtained in a 3-D fix, or the altitude supplied by the user. However, any error in the assumed altitude will effect the accuracy of the latitude and longitude solution. High accuracy users should avoid this mode and should expect fixes with accuracy's which are at best as accurate as the supplied altitude. If a marine user enters sea-level as the altitude, then small errors in the horizontal solution will occur when the sea state is rough or there are high tidal variations. However, these errors may be smaller than the altitude errors induces by SA, so 2-D may be preferable for a marine user who does not want to observe "unusual" altitudes.

The default mode is AUTO 2-D/3-D, where the receiver first attempts to obtain a 3-D solution with a PDOP below both the PDOP mask and PDOP switch. If this is not possible, then the receiver attempts to obtain a 2-D solution with a PDOP less than the PDOP mask. This mode supplies fairly continuous position fixes even when there is frequent obscuration. This mode is preferable for most land or air applications, where altitude changes are occurring and there is occasional obscuration.

### **Operating Parameters**

These parameters are used to define the maximum dynamics the user expects to experience, and also to define the set of satellites which are usable based on the satellite geometry at the user's position.

### **Dynamics Code**

The default is AIR mode, where the receiver assumes a high dynamic environment. In this case, the satellite search and reacquisition routines are optimized to tolerate high accelerations. A user which is subject to only benign accelerations (less than 1g) may benefit by selection of LAND or SEA mode where the search and reacquisition routines assume a low acceleration environment. In this case, satellite loss-of-lock is due more often to obscuration rather than extreme dynamics.

**Elevation Mask**

This is the minimum elevation angle for satellites to be used in a solution output by the receiver. Satellites which are near the horizon are typically more difficult to track due to signal attenuation and are also generally less accurate due to higher variability in the ionospheric and tropospheric corruption of the signal. When there are no obstructions, the receiver can generally track a satellite down to near the horizon. However, when this mask is set to low, the receiver may experience frequent constellation switching due to low elevation satellites being obscured. Frequent constellation switching is undesirable because small position jumps may be experienced when SA is present and DGPS is not available to remove these effects. The benefit of a low elevation mask is that more satellites are available for use in a solution and a better PDOP may be yielded. The current mask is set to five degrees and provides a reasonable tradeoff of the benefits and drawbacks. High accuracy users may prefer a mask angle around ten degrees, where the ionosphere and troposphere begin to be more predictable.

**Signal Level Mask**

This mask defines the minimum signal strength for a satellite to be used in a solution. There is some internal hysteresis on this threshold which allows brief excursions below the threshold if lock is maintained and the signal was previously above the mask. The mask has been set to 4.0 in V1.14 and higher versions due to increased tracking capability now included. The mask should only be lowered cautiously since this mask is also used to minimize the effects of jammers on the receiver. High accuracy users may use a slightly higher mask of 5.0-6.0 since weaker measurements may be slightly noisier. However, good performance is available with the default setting.

**PDOP Mask and Switch**

The PDOP mask is the maximum PDOP for which any 2-D or 3-D solution will be made. The switch is the level at which the receiver stops attempting a 3-D solution, and tries for a 2-D solution when in automatic 2-D, 3-D mode. The switch level has no affect on either manual mode. Raising the PDOP mask will generally increase the fix density during obscuration, but the fixes with the higher PDOP will be less accurate (especially with SA present). Lowering the mask will improve the average accuracy at the risk of lowering the fix density.

**Time of Fix Parameters**

There are basically three options available for specifying the time of the GPS solution. When a satellite is in a normal continuous tracking mode, the time-of-applicability of the measurements is at 0.25 seconds and 0.75 seconds within each GPS second.

**Default Mode**

In the default mode, the time of solution is the time at which the GPS solution is computed. Thus, all measurements are projected by an interval which is roughly the amount of time it takes to compute the solution. The benefit of this approach is that the receiver provides a solution which is applicable as close to the time of transmission as possible, which minimizes the burden on the user's computer. The drawback is that the measurement projection (which is exactly the same as dead-reckoning with velocity) may induce some error during high accelerations.

### **Integer Second**

In the integer second mode, the most recent measurements are projected to next integer second, and the solution is then valid at this time. The benefit of this mode is obviously the standard fix time. The drawbacks are that some measurement projection is performed and that the fix may be slightly older than with the default option.

### **Minimized Projection**

In this mode, the time of solution is the time of the most recent measurements. If all measurements are taken at exactly the same time, then there is no measurement projection. If a selected satellite's measurement time is lagging the most recent measurement, then it is projected to this time. The only penalty is that the fix will be older than a fix provided with the above timing options. This is the best choice for users performing non real-time error analysis, or non real-time DGPS solution-space corrections. This is also the preferable mode for users integrating GPS with other sensors, where communication lags are the dominant latencies, and thus the time lag between the applicability and availability of the fix is small. This option is only available in version 1.14 and higher.

### **Synchronized Measurements**

In this mode, all measurements are required to have the same time tag. This only applies to a six channel receiver, where selected satellites are tracked continuously on their own channel. If a satellite is lost which is in the selected set for the solution, then no fix will be made until a new selection is made. In the usual case (when the synchronized measurement is off), slightly older measurements are tolerated (on the order of three to five seconds) in order to provide solutions when obscurations make it impossible to obtain exactly concurrent measurements from each satellite. The synchronized measurement mode combined with the minimized projection timing mode allows absolutely no measurement projection. This mode is ideal for vehicles which experience high accelerations and want the highest accuracy. However, obscurations may reduce the fix density when there are limited satellites, so this mode should be used cautiously.

### **Additional Fix Status**

Setting bit 3 of the auxiliary byte in packet 35 will cause packet 5E to be output with each fix. Packet 5E has been added to give additional information about the fix concerning measurement latency. Packet 3E can be used to request packet 5E. These packets are in versions 1.14 and higher.

The least significant 3 bits of byte 1 of this packet contain the number of measurements used in the fix which were considered old. (Use of an old measurement will immediately cause a new satellite selection.) It turns out that some latency is desirable to “self-aid” the receiver, since a solution which has some projection error is probably good enough to help re-acquisition of lost satellites, and is probably better than no fix at all. These fixes are now flagged as containing old measurements with this packet.

The least significant three bits (Bits 0-2) of byte 0 of packet 5E contain the number of measurements used in the current solution that were also used in a previous solution. This gives an indication of how much independent information is contained in each fix. (NB for a three channel sequencing receiver, the channel allocation and fix rate may make it impossible for a new measurement to be taken from each satellite between fixes which are less than a second apart. Thus, it is possible to re-use a measurement in consecutive fixes even though the measurement is not considered old based on the current satellite distribution on sequencing channels). This information is useful when integrating the receiver with additional sensors. The fourth bit (Bit 3) of this byte flags fixes whether differential Doppler velocity was available.

The fifth bit (Bit 4) of byte 0 is used to flag fixes which are computed but are not output since the receiver is converging after being in an approximate position mode. In this case, the receiver says that it is doing fixes but no positions are being output. This condition is now flagged with this bit.

### **DGPS Mode**

In manual DGPS mode, the receiver only computes solutions if corrections are available for the satellites which are selected. This is the most accurate mode, but it is also the most selective, since the fix density is dependent on the availability of corrections. The auto mode avoids the fix density problem but opens the door to the possibility of going in and out of DGPS mode, which will cause position and velocity jumps. If accuracy is critical, one should stick with manual mode. On the other hand, if fix density is critical, auto DGPS is probably safer.

In summary, the default parameters chosen allow the receiver to perform well in almost any environment. The user can optimize the receiver to a particular application if the vehicle dynamics and expected level of obscuration are understood. If the receiver is then taken out of this environment, then a specifically tuned receiver may not operate as well a receiver with the default options. Table One shows some possible parameter selections as a function of the dynamics, obscuration, and whether accuracy or fix density is important. (NA: not applicable, DC: don't care, i.e., could be set either way.)

**Table One**  
**Suggested Parameter Settings**

Parameter	High Obscuration		Low Obscuration	
	Accuracy	Fixes	Accuracy	Fixes
<b>Fix Mode</b>	man 3D	Auto	man 3D	Auto
<b>Elevation Mask</b>	10	5	10	5
<b>Signal Mask</b>	6.0	4.0	6.0	4.0
<b>PDOP Mask</b>	6.0	12.0	6.0	12.0
<b>PDOP Switch</b>	NA	8.0	NA	8.0
<b>Timing Mode</b>	min proj	DC	min proj	DC
<b>Sync Meas.</b>	OFF	OFF	ON	ON
<b>Min. Projection</b>	ON	DC	ON	DC
<b>DGPS Mode</b>	man ON	DC	man ON	DC

### 9.3 APPLICABLE DOCUMENTS

Unless otherwise indicated, the issue of each document which was in effect on 1 May 1987, is the issue to be used.

#### SS-GPS-300B

System Specification for the NAVSTAR Global Positioning System.

#### ICD-GPS-200

NAVSTAR GPS Space Segment/Navigation User Interfaces.

#### 17035

Trimble Advanced Navigation Sensor, Specification and User's Manual, Rev. A, October 1990.

#### RTCM (SC-104)

RTCM Recommended Standards For Differential NAVSTAR GPS Service, Version 2.0.  
RTCM Special Committee No. 104. Published by the Radio Technical Commission For Maritime Services, Washington, D.C. January 1, 1990.

GPS - A Guide to the Next Utility - Trimble 1990 An introduction in non-mathematical terms to the GPS system.

Proceedings - Institute of Navigation Washington DC A series of three abstracts published between 1980 and 1986, of papers from the Journal of the Institute of Navigation. Essential source material for any system designer.

## CHAPTER TEN

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### SIGNAL CHARACTERISTICS

#### 10.0 SIGNAL CHARACTERISTICS

##### 10.1 GENERAL

The user interface signals are EIA RS-422 balanced conductor pairs. For the short line lengths anticipated, the user's receive-end need not be terminated. The format is standard serial, sent least significant bit first, at 9,600 baud, with 8 data bits, odd parity, and 1 stop bit. "Clear to send" flow control signals are included in the design and should be used to eliminate the possibility of over-run.

TSIP will also operate with RS-232 configurations.

**Note:** Several packets have significant effects on the operation of the Acutime sensor where an external battery back-up is used for the internal memory. These are noted in the text and the system designer should be aware of these effects in the structure of the software.

##### 10.2 PACKET DATA FORMAT

Each packet type is described below. Where necessary, specific data formats are given.

The *integer* data type is a 16 bit signed number sent in 2s-complement format, most significant byte first.

A floating point number, sometimes called "scientific notation" (for decimal numbers), or a *real* number, consists of a signed mantissa and a signed exponent. The precision is determined by the number of digits in the mantissa, and the range of expressible values is determined by the number of digits in the exponent. In a *non-zero binary* floating-point number, the mantissa consists of a "1," followed by the binary point, followed by the fractional part of the mantissa. Note that the leading binary "1" is redundant.

For floating-point numbers, the Acutime uses the ANSI/IEEE Std 754 IEEE standard for binary floating-point arithmetic, in which the formatted exponent is biased to avoid the use of an exponent sign, the mantissa's redundant leading "1" is omitted, and various special cases are specified. The IEEE 754 standard specifies two degrees of precision, "SINGLE" and "DOUBLE," both of which are used in the Acutime; the *double* precision format uses more bits both in the mantissa (for greater precision) and in the exponent (for greater range). The IEEE 754 format is described briefly below.

The sign bit is "1" for a negative number and is "0" for a positive number.

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To ensure that the formatted exponent is non-negative, and thus to avoid the use of an exponent sign, the formatted exponent (the biased exponent) is the sum of the actual (signed, unbiased) exponent plus a constant (the bias).

The redundant leading “1” is not included; only the fractional part of the mantissa is included and is called the “fraction.”

The value zero is formatted by setting both the biased exponent and the fraction to zero. Note that this special case must be recognized as zero and not interpreted as described above for a non-zero number.

The IEEE 754 standard specifies various other special cases. For programming and for detailed data analysis, the user should consult the IEEE standard.

The Acutime “SINGLE” data type is a 32 bit (4 byte) single-precision floating-point number in the ANSI/IEEE Std 754 SINGLE (short) format. The first byte sent contains the sign bit of the mantissa and the 7 most significant bits of the biased exponent. The second byte contains the least significant bit of the biased exponent, followed by the 7 most significant bits of the fraction (the part of the mantissa to the right of the binary point). The remaining 2 bytes complete the fraction. The exponent bias is +127; i.e., the biased exponent is the actual exponent +127. With the implied (not formatted) leading “1,” the single-precision mantissa contains 24 significant bits.

The Acutime “DOUBLE” data type is a 64 bit (8 byte) double-precision floating-point number in the ANSI/IEEE Std 754 DOUBLE (long) format. The first byte sent contains the sign bit of the mantissa and the 7 most significant bits of the biased exponent. The second byte contains the 4 least significant bits of the biased exponent, followed by the 4 most significant bits of the fraction. The remaining 6 bytes complete the fraction. The exponent bias is +1,023. With the implied (not formatted) leading “1,” the double-precision mantissa contains 52 significant bits.

### 10.3 PACKET STRUCTURE

In both directions of information transmission, the data format conforms to a packet structure as follows. Each packet starts with the two-character sequence.

<DLE>      The ASCII “data link escape” character, 1 byte, value 10 hex.

<id>        The packet type identification number, 1 byte, expressed as two hexadecimal digits. This byte can have any value other than 10 hex (ASCII <DLE>) or 3 hex (ASCII <ETX>). The values and their meanings are given in the remainder of this chapter.

Each packet ends with the two-character sequence.

<DLE>        The ASCII “data link escape” character, 1 byte, value 10 hex.

<ETX>        The ASCII “end-of-text” character, 1 byte, value 03 hex.

The packet format is shown below:

<DLE> <id> ... data bytes ... <DLE> <ETX>

Each packet data byte can have any 8 bit value, with the one requirement that any data byte of value 10 hex (<DLE>) must be sent twice. The receiving devices (in both the Acutime and the user’s data terminal) must compress all occurrences of two <DLE> characters into one <DLE> data byte. The data portion of the packet may be from 0 to 255 bytes long, not counting <DLE> stuffing.

### 10.3.1 PACKETS SENT BY THE USER TO ACUTIME

The table below provides the packet ID numbers sent by the user to Acutime, a short description of each packet, and the identities of the packets which Acutime sends in response. In some cases, the response packets depend on user-selected options. These selections are covered in the packet descriptions below. Details are provided for each packet type in the following sections. Descriptions of some packets assume availability of battery-backed memory. The battery has to be provided externally through Pin 5 if required.



Table One

<id> (hex)	Description	Response Packet Sent By Acutime
1D	Clear Oscillator Offset	--
1E	Clear Battery Back-Up then Reset	--
1F	Request Software Versions	45
20	Request Almanac	40
21	Request Current Time	41
22	Mode Select (2-D, 3-D, Auto)	--
23	Initial Position (XYZ ECEF)	--
24	Request Acutime Position Fix Mode	44 or 6D
25	Initiate Soft Reset and Self Test (Equivalent to Cycling Power)	45, 46, 4B, 42 or 83, 4A or 84
26	Request Health	46, 4B
27	Request Signal Levels	47
28	Request GPS System Message	48
29	Request Almanac Health Page	49
2A	Altitude for 2-D Mode	--
2B	Initial Position (Latitude, Longitude, Altitude)	--
2C	Set/Request Operating Parameters	4C
2D	Request Oscillator Offset	4D
2E	Set GPS Time	4E
31	Accurate Initial Position (XYZ Cartesian ECEF)	--
32	Accurate Initial Position (Latitude, Longitude, Altitude)	
34	Satellite Number for Single Satellite Mode	--
35	Set/Request I/O Options	55
36	Velocity Aiding of Acquisition	--
37	Request Status and Values of Last Possible and Velocity	57; 42 or 83 or 4A or 84; 43 or 56
38	Request/Load Satellite System Data	58
39	Set/Request Satellite Disable or Ignore Health	59
3A	Request Last Raw Measurement	5A
3B	Request Satellite Ephemeris Status	5B
3C	Request Tracking Status	5C
3D	Configure Channel A for RTCM (SC-104) Differential GPS	3D
3E	Request Additional Fix Parameters	5D
62	Set/Request Differential GPS Position Fix Mode	82
65	Request Differential Correction Status	85
75	Set/Request Best 4/High 6/Smart-8 Mode	76

### 10.3.1.1 1D CLEAR OSCILLATOR OFFSET

This packet commands the Acutime to clear the oscillator offset stored in battery-backed memory. This packet contains one data byte equal to the ASCII letter “C,” 43 hex. Packet 2D hex can be used to request the current value of the offset. This information is used mainly for service. In normal use, there is no need to send this packet.

### 10.3.1.2 1E CLEAR BATTERY BACK-UP, THEN RESET

This packet commands the Acutime to clear all battery back-up data and to perform a software reset. This packet contains one data byte equal to the ASCII letter “K,” 4B hex.

**\* \* \* CAUTION \* \* \***

All almanac, ephemeris, current position, mode, and calibration information is lost by the execution of this command. In normal use, this packet should not be sent.

### 10.3.1.3 1F REQUEST SOFTWARE VERSIONS

This packet requests information about the version of software running in the Navigation and Signal Processors. This packet contains no data bytes. The Acutime returns packet 45 hex.

### 10.3.1.4 20 REQUEST ALMANAC

This packet requests almanac data for one satellite from the Acutime. This packet contains 1 data byte specifying the satellite PRN number. The Acutime returns packet 40 hex.

### 10.3.1.5 21 REQUEST CURRENT TIME

This packet requests current GPS time. This packet contains no data. The Acutime returns packet 41 hex.

**10.3.1.6 22 POSITION FIX MODE SELECT**

This packet commands the Acutime to operate in a specific position fix mode. This packet contains 1 data byte indicating the mode, as follows:

Mode	Data Byte Value	PKTNON Key Command
Automatic	0 (Default Value)	^N
One Satellite (0-D)	1	^T
Three Satellite (2-D)	3	n
Four Satellite (3-D)	4	N

This selection is held in battery-backed memory

The one satellite (0-D) mode uses a single satellite to determine receiver clock error (time) and error rate (frequency) when the position is known precisely. In this mode, the Acutime computes no positions or velocities. Instead, the Acutime sends packet 54 hex with the clock bias and bias rate. This can be used for time transfer applications and to enable the Acutime to maintain the accuracy of the one pps (Pulse Per Second) output even if a full position fix cannot be done.

**10.3.1.7 23 INITIAL POSITION (XYZ CARTESIAN ECEF)**

This packet provides the Acutime with an approximate initial position in Cartesian ECEF (Earth Centered, Earth Fixed) WGS-84 coordinates. This packet causes a world-wide search for the user's position, starting at the position entered via this packet. That takes about six to ten seconds before the Acutime can provide more fixes. This packet is useful if the user has moved more than about 1,000 miles after the previous fix. (The Acutime can initialize itself without any data from the user. This packet merely reduces the time required for initialization.) This packet does not cause a software reset.

The data format is shown below:

The X-axis points toward the intersection of the equator and the Greenwich meridian, the Y-axis points toward the intersection of the equator and the 90° meridian, and the Z-axis points toward the North Pole.

Byte #	Item	Type	Units
0-3	X	SINGLE	Meters
4-7	Y	SINGLE	Meters
8-11	Z	SINGLE	Meters

**10.3.1.8 24 REQUEST ACUTIME POSITION FIX MODE**

This packet requests current position fix mode of the Acutime. This packet contains no data. The Acutime returns packet 44 hex or 6D hex.

**10.3.1.9 25 INITIATE SOFT RESET AND SELF TEST**

This packet commands the Acutime to perform a software reset. This is equivalent to cycling the power. The Acutime performs a self-test as part of the reset operation. This packet contains no data. The Acutime returns packets 41, 45, 46, 4B, (42 and 4A) or (83 and 84), all hex. The Acutime sends packet 45 hex only on power-up and reset (or on request). Thus if packet 45 appears not to be requested, then either the Acutime power was cycled or the Acutime was reset.

**10.3.1.10 26 REQUEST HEALTH**

This packet requests health and status information from the Acutime. This packet contains no data. The Acutime returns packet 46 hex and 4B hex.

**10.3.1.11 27 REQUEST SIGNAL LEVELS**

This packet requests signal levels for all satellites currently being tracked. This packet contains no data. The Acutime returns packet 47 hex.

**10.3.1.12 28 REQUEST GPS SYSTEM MESSAGE**

This packet requests the GPS system ASCII message sent with the navigation data by each satellite. This packet contains no data. The Acutime returns packet 48 hex.

**10.3.1.13 29 REQUEST ALMANAC HEALTH PAGE**

This packet requests the Acutime to send the health page from the almanac. This packet contains no data. The Acutime returns packet 49 hex.

**10.3.1.14 2A ALTITUDE FOR 2-D MODE**

This packet provides the altitude to be used for manual two dimensional (three satellite) mode. This altitude is used for Auto 2-D mode until a 3-D fix is performed. This packet contains one SINGLE number (4 bytes) specifying the altitude in meters, using the WGS-84 model of the earth or MSL geoid altitude depending on I/O options (set by packet 35). This altitude value is held in battery-backed memory.

**10.3.1.15 2B INITIAL POSITION (LATITUDE, LONGITUDE, ALTITUDE)**

This packet provides the Acutime with an approximate initial position in latitude and longitude coordinates (WGS-84). This packet causes a world-wide search for the user's position, starting at the position entered via this packet. That takes about six to ten seconds before the Acutime can provide more fixes. This packet is useful if the user has moved more than about 1,000 miles after the previous fix. (The Acutime can initialize itself without any data from the user. It merely requires more time.) This packet does not cause a software reset.

The data format is shown below.

Byte #	Item	Type	Units
0-3	Latitude	SINGLE	Radians, North
4-7	Longitude	SINGLE	Radians, East
8-11	Altitude	SINGLE	Meters

**10.3.1.16 2C SET/REQUEST OPERATING PARAMETERS**

This packet optionally sets the operating parameters of the Acutime receiver and requests the current values after setting them. The data format is shown below. The Acutime returns packet 4C hex.

The dynamics code indicates the expected vehicle dynamics and is used to assist the initial solution.

The elevation angle mask determines the lowest angle at which the Acutime tries to track a satellite.

The signal level mask sets the required signal level for a satellite to be used for position fixes.

The PDOP mask sets the maximum PDOP with which position fixes are calculated. The PDOP switch selects the 2-D and 3-D mode. If four or more satellites are available and the resulting PDOP is not greater than the PDOP switch value, then three dimensional fixes are calculated. The PDOP switch is effective only in the automatic 2-D/3-D mode.

Byte Number	Item	Type	Units	Default Value
0	Dynamics Code	BYTE		Three (See Table)
<b>Value</b>		<b>Meaning</b>		<b>Assumed Velocity</b>
	0	Current Value is Left Unchanged		
	1	Land		< 120 Knots
	2	Sea		< 50 Knots
	3	Air (Difficult)		< 800 Knots
	4	Static		Stationary
1-4	Elevation Angle Mask	SINGLE	Radians	0.1745 (10°)
5-8	Signal Level Mask	SINGLE	- - -	Six
9-12	PDOP Mask	SINGLE	- - -	Twelve
13-16	PDOP Switch (3-D or 2-D)	SINGLE	- - -	Eight

A negative value in a SINGLE field leaves that current setting unchanged.

This information is held in memory.

Mode 4 selection informs the Acutime that it is stationary. Any position fix computed or provided via the data channels is assumed to be accurate indefinitely. When the dynamics code is set to static (byte value = 4) and the fix mode is automatic (set by packet 22 hex), then the Acutime enters automatic one satellite mode when a position fix cannot be performed but there is at least one usable satellite. In this mode, no positions or velocities are computed. Instead, the Acutime sends packet 54 hex with the clock bias and bias rate. As long as the Acutime is truly stationary, this mode can be used for time transfer applications and to enable the Acutime to maintain the accuracy of the 1pps (pulse per second) output even if a full position fix cannot be done.

#### 10.3.1.17 2D REQUEST OSCILLATOR OFFSET

This packet requests the calculated offset of the Acutime master oscillator. This packet contains no data. The Acutime returns packet 4D hex. This packet is used mainly for service. The permissible oscillator offset varies with the particular Acutime unit.

#### 10.3.1.18 2E SET GPS TIME

This packet provides the approximate GPS time of week and the week number to the Acutime. The Acutime returns packet 4E hex. The data format is shown below. The GPS week number reference is Week # 0 starting January 6, 1980. The seconds count begins at the midnight which begins each Sunday morning.

Byte Number	Item	Type	Units
0-3	GPS Time of Week	SINGLE	Seconds
4-5	GPS Week Number	INTEGER	Weeks

This packet normally is not needed as the internal battery-powered clock keeps time to sufficient accuracy for finding position rapidly.

#### **10.3.1.19 31 ACCURATE INITIAL POSITION (XYZ CARTESIAN ECEF)**

This packet is identical in content to packet 23 hex. This packet provides an initial position to the Acutime in XYZ coordinates. However, the Acutime assumes the position provided in this packet to be accurate. This packet is used for satellite acquisition aiding in systems where another source of position is available and in time transfer (one-satellite mode) applications. For acquisition aiding, the position provided by the user to the Acutime in this packet should be accurate to a few kilometers. For high-accuracy time transfer, position should be accurate to a few meters.

#### **10.3.1.20 32 ACCURATE INITIAL POSITION (LATITUDE, LONGITUDE, ALTITUDE)**

This packet is identical in content to packet 2B hex. This packet provides the Acutime with an approximate initial position in latitude, longitude, and altitude coordinates. However, the Acutime assumes the position provided in this packet to be accurate. This packet is used for satellite acquisition aiding in systems where another source of position is available and in time transfer (one-satellite mode) applications. For acquisition aiding, the position provided by the user to the Acutime in this packet should be accurate to a few kilometers. For high-accuracy time transfer, position should be accurate to a few meters.

#### **10.3.1.21 33 REQUEST A-TO-D READINGS**

Since the Acutime does not have an internal A-to-D chip, this function is not supported.

#### **10.3.1.22 34 SATELLITE NUMBER FOR ONE-SATELLITE MODE**

This packet allows the user to control the choice of the satellite to be used for the one-satellite mode. This packet contains 1 byte. If the byte value is 0, the Acutime chooses the usable satellite with the highest elevation above the horizon. This automatic selection of the highest satellite is the default action, and the Acutime does this unless it receives this packet. If the byte value is from 1 to 32, the packet specifies the PRN number of the satellite to be used. This selection is not kept in battery-backed memory.

### 10.3.1.23 35 SET/REQUEST I/O OPTIONS

This packet requests the current I/O option states and optionally allows the I/O option states to be set as desired. To request the option states without changing them, the user sends only the packet “<DLE> (35 hex) <DLE> <ETX>” with no data bytes included. To change any option states, the user includes 4 data bytes with the values indicated below in the packet. The I/O options, their default states, and the byte values for all possible states are shown below. A glossary is given at the end of the table. These option states are held in battery-backed memory. The Acutime returns packet 55 hex.

Byte Number	Parameter Name	Bit Position	Default Bit Value	Option	Associated Packet
0	Position	0 (LSB)	1	XYZ ECEF Output 0: Off 1: On	42 or 83
		1	0	LLA Output 0: Off 1: On	4A or 84
		2	0	LLA ALT Output 0: HAE WGS-84 1: MSL Geoid	4A or 84 or 8F-01 or 8F-02
		3	0	ALT Input 0: HAE WGS-84 1: MAL Geoid	2A
		4	0	Precision-of-Position Output 0: Send Single-Precision Packet 42 and/or 4A. 1: Send Double-Precision Packet 83 and/or 84.	
		5	0	Super Packet Output 0: Off 1: On	
		6	0	Super Packet Format 0: Binary 1: ASCII	
		7	0	Unused	

**Note:** If bit 5 is 0, then no super packets are output. If bit 5 and bit 6 are 1, then packet 8E-01 is output. If bit 5 is 1, and bit 6 is 0, then packet 8F-02 is. If super packet output is selected then 8F-01 or 8F-02 packets are output instead of the standard 4A or 84 packets.



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Byte Number	Parameter Name	Bit Position	Default Bit Value	Option	Associated Packet
1	Velocity	0	1	XYZ ECEF Output 0: Off 1: On	43
		1	0	ENU Output 0: Off 1: On	56
		2-7	Unused		
2	Timing	0	0	Time Type 0: GPS Time 1: UTC	
		1	0	Fix Computation Time 0: ASAP 1: Next Integer Sec	
		2	0	Output Time 0: When Computed 1: Only on Request	37
		3	0	Synchronized Measurements 0: Off 2: On	
		4	0	Minimize Projection (V1.14 Onwards)	
		5-7	Unused		
3	Auxiliary	0	0	Raw Measurements 0: Off 1: On	5A
		1	0	Doppler Smoothed Code Phase (V1.12 Onwards) 0: Off 1: On	
		2	0	Additional Fix Status (V1.14 Onwards) 0: Off 1: On	5E
		3-7	Unused		

Glossary for the table on the previous page:

**ALT**

Altitude.

**ECEF**

Earth-Centered, Earth-Fixed.

**XYZ**

Cartesian Coordinates.

**LLA**

Latitude, Longitude, Altitude.

**HAE**

Height Above Ellipsoid.

**WGS-84**

Earth Model (Ellipsoid).

**MSL Geoid**

Earth (Mean Sea Level) Mode.

**UTC**

Coordinated Universal Time.

**10.3.1.24 36 VELOCITY AIDING OF ACQUISITION**

In this packet the user provides velocity information to the Acutime from an external source to aid in satellite acquisition and reacquisition.

Byte	Item	Type	Units
0	Coordinate Select	BYTE	
<b>Byte Value</b>	<b>Meaning</b>		
0	XYZ		
1	ENU (East, North, Up)		
1	Velocity Aiding Enable Flag	BYTE	
<b>Byte Value</b>	<b>Meaning</b>		
0	Disable Velocity Aiding		
1	Enable Velocity Aiding (See Below)		
<b>Byte Value</b>	<b>Meaning</b>		
2-5	X or East Velocity	SINGLE	Meters/Second
6-9	Y or North Velocity	SINGLE	Meters/Second
10-13	X or Up Velocity	SINGLE	Meters/Second

If the velocity aiding enable flag is set to “1,” the Acutime assumes that the velocity data is accurate to twenty-five meters per second or better and that it can be used for aiding. The Acutime continues to use this data until another packet 36 hex is sent with the aiding enable flag set to “0” (to disable velocity aiding). Once aiding has begun, the Acutime must be informed (via a new packet 36) of any velocity changes greater than twenty-five meters per second until velocity aiding is disabled. Once acquisition occurs, the aiding data is ignored, but if acquisition later is lost, then the aiding data is used again.

#### 10.3.1.25 37 REQUEST STATUS AND VALUES OF LAST POSITION AND VELOCITY

This packet requests information regarding the source codes, time of last fix, and GPS week and UTC offset. The Acutime returns packet 57 and the appropriate position packet 42 or 4A, or 83 or 84, and the appropriate velocity packet 43 or 56, based on the I/O options in effect.

#### 10.3.1.26 38 REQUEST/LOAD SATELLITE SYSTEM DATA

This packet is not supported by the GPS Software Toolkit - PKTMON. This packet requests current satellite data (almanac, ephemeris, etc.) or permits loading initialization data from an external source (for example, by extracting initialization data from an operating Acutime unit via a data logger or computer and then using that data to initialize a second Acutime unit). The Acutime returns packet 58.

**Note:** The Acutime can initialize itself without any data from the user, it merely requires more time.

To request data without loading data, use only bytes 1 through 2, to load data, use all bytes. Before loading data, observe the caution notice below.

Byte Number	Item	Type	Byte Value	Meaning
0	Operation	BYTE	1	Request Data From Acutime
			2	Load Data Into Acutime
1	Type of Data	BYTE	1	Not Used
			2	Almanac
			3	Health Page, T_oa, WN_oa
			4	Ionosphere
			5	UTC
			6	Ephemeris
2	Sat PRN #	BYTE	0	Data That is Not Satellite ID Specific
			1 to 32	Satellite PRN Number
3	Length (n)		BYTE	Number of Bytes of Data to be Loaded
4 to n+3	Data		n BYTES	

**\* \* \* CAUTION \* \* \***

Proper structure of satellite data is critical to Acutime operation. Data format, content, and protocol should be obtained through consultation with Trimble Navigation before using this feature.

Improper data can cause the Acutime software to lock up immediately after turn on, so that any battery-backed memory cannot be cleared except by removing the battery backup voltage. (The Acutime is not damaged physically by improper data, but it may be unusable until it is serviced.) *Requesting* data is *not* hazardous. *Loading* data improperly *is* hazardous. Use this packet only with extreme caution.

**10.3.1.27 39 SET/REQUEST SATELLITE DISABLE OR IGNORE HEALTH**

Normally the Acutime selects satellites for use in GPS solution according to whether the candidate satellites are in good health and whether they satisfy the mask values for elevation angle, signal level, and PDOP. This packet allows the user to tell the Acutime either to disable unconditionally the selection of any particular satellite or to ignore the health of any particular satellite that otherwise is acceptable for selection. The Acutime returns packet 59.

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It should be noted that when viewing the satellite disables list, the satellites are not numbered but are in numerical order. The disabled satellites are signified by a one and enabled satellites are signified by a zero.

Byte Number	Item	Type	Byte Value	Meaning
0	Operation	BYTE	1	Enable for Selection (Default)
			2	Disable for Selection
			3	Request Enable or Disable Status of All Thirty-two Satellites.
			4	Heed Health on Satellite (Default)
			5	Ignore Health on Satellite
			6	Request Heed or Ignore Status on All Thirty-two Satellites.
1	Satellite #	BYTE	0	All Thirty-two Satellites
			1 to 32	Any One Satellite PRN Number

This information is *not* held in battery-backed memory. At power-on and after a reset the default values are set for all satellites.

**\* \* \* CAUTION \* \* \***

Ignoring health can cause the Acutime software to lock up, as an unhealthy satellite may contain defective data. Generally, such software lock-up is cleared by the Acutime user, although improper data can cause the Acutime software to lock up immediately after turn-on, so that the battery backed memory cannot be cleared except by instrument service. (The Acutime is not damaged physically by this, but it may be unusable until it is serviced.) Use extreme caution in ignoring satellite health.

### 10.3.1.28 3A REQUEST LAST RAW MEASUREMENT

This packet requests the most recent raw measurement data for one specified satellite. The Acutime returns packet 5A hex.

Byte Number	Item	Type	Byte Value	Meaning
0	Satellite #	BYTE	0	All Satellites in the Current Tracking Set
			1-32	Desired Satellite

**10.3.1.29 3B REQUEST CURRENT STATUS OF SATELLITE EPHEMERIS DATA**

This packet requests the current status of satellite ephemeris data. The Acutime returns packet 5B hex.

Byte Number	Item	Type	Byte Value	Meaning
0	Satellite #	BYTE	0	All Satellites in the Current Tracking Set
			1-32	Desired Satellite

**10.3.1.30 3C REQUEST CURRENT SATELLITE TRACKING STATUS**

This packet requests the current satellite tracking status. The Acutime returns packet 5C hex.

Byte Number	Item	Type	Byte Value	Meaning
0	Satellite #	BYTE	0	All Satellites in the Current Tracking Set
			1-32	Desired Satellite

**10.3.1.31 3D REQUEST OR SET DATA CHANNEL A CONFIGURATION FOR DIFFERENTIAL CORRECTIONS**

This packet requests, and optionally sets, the data channel A configuration for differential corrections. This configuration includes the baud rate, number of bits, parity, and number of stop bits for channel A and also the language mode. When this packet is used only to request the configuration the packet contains no data bytes. When this packet is used to set the configuration, the packet contains the data bytes shown below.

The language mode is defined as follows. For transmission, the language mode specifies whether packets are output on channel A. For reception, the language mode specifies whether packets or RTCM data are received on channel A (1).

The baud rate for the transmitter and the receiver can be set independently, but the number of bits, parity, and the stop bits are common between them. The default mode is packets for both transmission and reception at 9,600 baud with 8 data bits, odd parity, and 1 stop bit.

When the language mode for reception is set to RTCM (SC-104), raw RTCM (SC-104) data is accepted on channel A for differential GPS corrections. These corrections are used only if the GPD mode is set to manual GPD or automatic with packet 62.

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When a Acutime receives a packet 3D with no data bytes, it responds with packet 3D with current settings.

**Note:** The default of byte 5 is set to RTCM automatically on start-up, with default settings for the port at 9600, 8, 0, and 1.

Byte	Item	Type	Units
0	XMT Baud Rate Code	BYTE	0: 50      8: 2400 1: 110      9: 4800 4: 300      11: 9600 5: 600      12: 38.4K 6: 1200     28: 19.2K
1	RVC Baud Rate Code	BYTE	0: 50      8: 2400 1: 110      9: 4800 4: 300      11: 9600 5: 600      12: 38.4K 6: 1200     28: 19.2K
2	Parity and #bits/Char Code	BYTE	xxxpppbppp:      0: Even Parity 1: Odd Parity 4: No Parity bb:                    2: 7 3: 8
3	Stop Bits Code	BYTE	7: 1 Stop Bit 15: 2 Stop Bits
4	Language Mode for Transmission	BYTE	0: Packets 1: Off 5: NMEA
5	Language Mode for Reception	BYTE	0: Packets 1: RTCM (SC-104)

**Note (1):** In most RS-232 versions of the sensor, RTCM input for the second channel is the default mode at power-on to allow for direct connection to a radio modem. The default speed is 9600, eight, zero, one.

**Note (2):** If the bit is set to 5, then output is standard NMEA ASCII, GGA + VTG.

This information is held in battery backed memory. After loss of battery backed memory, the default values are set.

### 10.3.1.32 3E REQUEST ADDITIONAL FIX PARAMETERS

This packet is sent to request the attributes of a position fix, i.e. the number of old measurements used in the fix, whether differential Doppler velocity is available, and whether the fix has converged. The response is packet 5E. Packet 35 can be set to request packet 5E automatically.

### 10.3.1.33 62 REQUEST/SET DIFFERENTIAL POSITION FIX MODE

This packet requests and optionally sets the differential position fix mode of the Acutime. When this packet is used to request the mode the packet contains no data bytes. When this packet is used to set the mode the packet contains only 1 data byte to specify the mode. In response, the Acutime always sends packet 82 which contains the current mode.

The following modes can be set:

0	Manual GPS (Differential off) (default)
1	Manual GPD (Differential on)
2 or 3	Automatic

“Manual GPS” (mode 0) sets the Acutime to do position solutions without differential corrections, even if the differential corrections are available.

“Manual GPD” (mode 1) sets the Acutime to do position solutions only if valid differential correction data are available.

“Automatic” (data byte value = either 2 or 3), the Acutime automatically sets itself to mode 2 (differential currently off) if the Acutime is not receiving differential correction data for all satellites in a constellation which meets all other masks. It automatically sets itself to mode 3 (differential currently on) if it is receiving differential correction data for all satellites in a constellation which meets all other masks. Packet 82 which the Acutime sends in response to receiving packet 62, indicates whether the Acutime currently is in mode 2 or 3.

An attempt to set a mode outside this set results in simply requesting packet 82.

The selected mode (manual GPS, manual GPD, or automatic) is held in battery-backed memory.



### **10.3.1.34 65 REQUEST DIFFERENTIAL CORRECTION STATUS**

This packet requests the status of differential corrections for a specific satellite or for all satellites for which data is available. This packet contains only 1 byte specifying the PRN number of the desired satellite or zero to request all available. The response is a packet 85 for each satellite.

### **10.3.1.35 75 SET/REQUEST BEST 4/HIGH 6/SMART 8-MODE**

This packet sets the constellation mode of the Acutime. The Acutime returns packet 76.

In High 6 mode, the receiver will attempt to track the six highest elevation satellites as determined by the almanac, and will use up to six satellites in an over-determined solution.

In Best 4 mode, the Acutime chooses four satellites with the best geometry for a position fix and tracks the other four. In case one of the best four satellites is temporarily masked, one of the other four can be swapped in immediately to provide a position fix.

Smart 8 is a sequencing mode which tracks the highest eight satellites and uses up to eight satellites in an over-determined solution.

To simply request the mode, the packet is sent with no data bytes.

To set the mode, a single data byte is sent. The data byte can have one of the three values:

- 0 = Best 4 Mode
- 1 = High 6 (Over Determined) Mode (Default Mode for the Acutime)
- 2 = Smart 8 (Over Determined Smart Sequencing) Mode

### 10.3.2 PACKETS SENT BY ACUTIME TO THE USER

The table below provides the packet ID numbers sent by the Acutime to the user, a short description of each packet, and an indication of when the packet is sent. Details are provided for each packet type in the following sections.

Id (Hex)	Description	When Sent			Response to Packet Number
		Power Up	Automatic	If Selected	
40	Almanac Data for Specified Sat		X		20
41	GPS Time	X (1)	X (1)		21
42	Single-Precision XYZ Position	X (2)		X	25, 37
43	Velocity Fix (XYZ ECEF)			X	37
44	Satellite Selection, PDOP, Mode			X	24
45	Software Version Information	X			1F, 25
46	Health of Acutime		X	X	25, 26
47	Signal Level for all Satellites				27
48	GPS System Message				28
49	Almanac Health Page for all Sats			X	29
4A	Single-Precision LLA Position	X (2)		X	25, 37
4B	Machine Code/Status	X	X		25, 26
4C	Report Operating Parameters				2C
4D	Oscillator Offset			X	2D
4E	Response to Set GPS Time				2E
54	One Satellite Bias and Bias Rate		X		22
55	I/O Options				35
56	Velocity Fix (ENU)			X	37
57	Information About Last Computed Fix				37
58	GPS System Data/Acknowledge				38
59	Sat Enable/Disable and Health Heed				39
5A	Raw Measurement Data		X		3A
5B	Satellite Ephemeris Status		X		3B
5C	Satellite Tracking Status				3C
5E	Additional Fix Status			X	3E, 35
5F	Severe Failure Report		X		
6D	All-In-View Satellite Selection				24
76	Best 4/High 6/Smart 8 Mode				75
82	Differential Position Fix Mode				62
83	Double-Precision XYZ Position	X (2)		X	25, 37
84	Double-Precision LLA Position	X (2)		X	25, 37
85	Differential Correction Status				65

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**Note (1):** If the current GPS time is not known, this packet is not sent at power-up or automatically.

**Note (2):** At turn-on, the Acutime sends packets 42 and 4A if the I/O single-precision-of-position option is selected and sends packets 83 and 84 if the I/O double-precision-of-position option is selected. At power-up, these packets are sent with negative time-of-fix.

**Note (3):** Channel A is silent unless a request for data is received. The automatic outputs shown above apply *only* to Channel B.

### 10.3.2.1 40 ALMANAC DATA PAGE

This packet provides almanac data for a single satellite. The Acutime sends this packet on request (packet 20 hex) and when the data is received from a satellite. The data format is shown below.

Byte #	Item	Type	Units
0	satellite	BYTE	(Identification Number)
1	T_zc	SINGLE	Seconds
5	week number	INTEGER	Weeks
7	eccentricity	SINGLE	(Dimensionless)
11	T_oa	SINGLE	Seconds
15	i_o	SINGLE	Radians
19	OMEGA_dot	SINGLE	Radians/Second
23	square root A	SINGLE	(Meters) <sup>1/2</sup>
27	OMEGA o	SINGLE	Radians
31	omega	SINGLE	Radians
35	M o	SINGLE	Radians

These symbols are defined in ICD-GPS-200.

T\_zc is normally positive. If no almanac data is available for this satellite, then T\_zc is negative. T\_zc and the week number in this packet refer to the Z-count time and week number at the time the almanac was received. The remaining items are described in the ICD-GPS-200.

### 10.3.2.2 41 GPS TIME

This packet provides the current GPS time of week and the week number. The Acutime sends this packet in response to packet 21 hex and during an update cycle. Update cycles occur every fifteen seconds when not doing fixes and occur every 150 seconds when doing fixes.

The data format is shown below.

Byte #	Item	Type	Units
0-3	GPS Time Of Week	SINGLE	Seconds
4-5	GPS Week Number	INTEGER	Weeks
6-9	GPS/UTC Offset	SINGLE	Seconds

**Note:** GPS time differs from UTC by a variable integral number of seconds.  $UTC = (GPS\ time) - (GPS/UTC\ offset)$ .

The GPS week number reference is week number zero starting January 6, 1980.

The seconds count begins with zero each Sunday morning at midnight. A negative indicated time-of-week indicates that time is not yet known. In that case, the packet is sent only on request. The following table shows the relationship between the information in packet 41, and the packet 46 six status code.

Approximate Time Accuracy	Time Source	Sign (TOW)	Packet 46 Status Code
None	No Time At All	-	01 Hex
Unknown Approximate	Time From Real Time Clock or Packet 2E	+	01 Hex
20 to 50 msec + Clock Drift	Time from Satellite	+	Not 01 Hex
Full Accuracy	Time from GPS Solution	+	00 Hex

**Note:** Acutime has no real-time clock hardware. For the most accurate GPS time, before using the GPS time from packet 41, verify that the packet 46 status code is 00 hex (“doing position fixes”).

### 10.3.2.3 42 SINGLE-PRECISION POSITION FIX, XYZ ECEF

This packet provides current GPS position fix in XYZ ECEF coordinates. If the I/O “position” option is set to “XYZ ECEF” and the I/O “precision-of-position output” is set to single-precision, then the Acutime sends this packet each time a fix is computed. The data format is shown below:

Byte #	Item	Type	Units
0-3	X	SINGLE	Meters
4-7	Y	SINGLE	Meters
8-11	Z	SINGLE	Meters
12-15	Time-of-Fix	SINGLE	Seconds

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The time-of-fix is in GPS time or UTC as selected by the I/O “timing” option. At start-up, this packet or packet 83 is also sent with a negative time-of-fix to report the current known position. Packet 83 provides a double-precision version of this information.

### 10.3.2.4 43 VELOCITY FIX, XYZ ECEF

This packet provides current GPS velocity fix in XYZ ECEF coordinates. If the I/O “position” option is set to “XYZ ECEF, then the Acutime sends this packet each time a fix is computed if selected by the I/O “timing” option. The data format is shown below:

Byte #	Item	Type	Units
0-3	X Velocity	SINGLE	Meters/Second
4-7	Y Velocity	SINGLE	Meters/Second
8-11	Z Velocity	SINGLE	Meters/Second
12-15	Bias Rate	SINGLE	Meters/Second
16-19	Time-of-Fix	SINGLE	Seconds

The time-of-fix is in GPS time or UTC as selected by the I/O “timing” option.

### 10.3.2.5 44 SATELLITE SELECTION

This packet provides a list of satellites used for position fixes by the Acutime. The packet also provides the PDOP, HDOP, and VDOP of that set and provides the current mode (automatic or manual, 3-D or 2-D). The Acutime sends this packet in response to packet 24 hex and whenever a new satellite selection is attempted. The Acutime attempts a new selection every thirty seconds and whenever satellite availability and tracking status change. The data format is shown below.

Byte #	Item	Type	Value	Meaning
0	Mode	BYTE	01 Hex 03 Hex 04 Hex 11 Hex 13 Hex 14 Hex	Auto, 1-Satellite, 0-D Auto, 3-Satellite, 2-D Auto, 4-Satellite, 3-D Manual, 1-Satellite, 0-D Manual, 3-Satellite, 2-D Manual, 4-Satellite, 3-D
1-4	4 Satellite Numbers	4 BYTES		4 Satellite Numbers
5-8	PDOP	SINGLE		PDOP
9-12	HDOP	SINGLE		HDOP
13-16	VDOP	SINGLE		VDOP
17-20	TDOP	SINGLE		TDOP

PDOP value of 0 indicates that the Acutime is not doing fixes, usually because there are not enough healthy usable satellites for position fixes. In this case, the satellite number list contains up to four of the satellites which are usable. Empty satellite number bytes contain 0. Negative PDOP values indicate that the PDOP is greater than the PDOP mask value and therefore the Acutime is not performing fixes.

#### 10.3.2.6 45 SOFTWARE VERSION INFORMATION

This packet provides information about the version of software in the navigation and signal processors. The Acutime sends this packet after power-on and in response to packet 1F hex. The data format is two 5 byte sequences, each of which has the format shown below.

Byte #	Item	Type
0	Major Version Number	BYTE
1	Minor Version Number	BYTE
2	Month	BYTE
3	Day	BYTE
4	Year Number Minus 1900	BYTE

The first 5 bytes refer to the navigation processor and the second 5 bytes refer to the signal processor.

#### 10.3.2.7 46 HEALTH OF ACUTIME

This packet provides information about the satellite tracking status and the operational health of the Acutime. The Acutime sends this packet after power-on or software initiated resets, in response to packet 26 hex, during an update cycle, when a new satellite selection is attempted, and when the Acutime detects a change in its health. Packet 4B hex is always sent with this packet. The data format is given in the table on the following page.

Byte #	Item	Byte Type	Value	Meaning
0	Status Code	BYTE	00 Hex	Doing Position Fixes
			01 Hex	Don't Have GPS Time Yet
			02 Hex	Not Used
			03 Hex	PDOP is Too High
			08 Hex	No Usable Satellites
			09 Hex	Only One Usable Satellite
			0A Hex	Only 2 Usable Satellites
			0B Hex	Only 3 Usable Satellites
			0C Hex	The Chosen Satellite is Unusable (4)
1	Error Codes	BYTE		

The error codes are encoded into individual bits within the byte. The bit positions and their meanings are shown below.

Bit Position	Meaning if Bit Value = 1
0 (LSB)	Battery Back-Up Failed (1), (5)
1	Signal Processor Error (1)
2	Alignment Error, Channel or Chip 1 (1)
3	Alignment Error, Channel or Chip 2 (1)
4	Antenna Feed Line Fault (2)
5	Excessive Ref Freq. Error (3)
6	(Unused)
7 (MSB)	(Unused)

- Note (1):** After this error is detected, its bit remains set until the Acutime is reset.
- Note (2):** This bit follows the current status of the antenna feed line fault-detection circuitry. Since Acutime has an integral antenna assembly, this information is of itself of little import. It is only shown here for sake of completeness, being important for sensors with separate antennas.
- Note (3):** This bit is "1" if the last computed reference frequency error indicated that the reference oscillator is out of tolerance. (Packet 2D requests the oscillator offset and packet 4D returns the oscillator offset to the user.)
- Note (4):** This message occurs when the one-satellite mode is in effect and a specific satellite has been chosen with packet 34 hex but that satellite is unusable.
- Note (5):** This bit is always set as the Acutime receiver battery backup is not installed.

**10.3.2.8 47 SIGNAL LEVELS FOR ALL SATELLITES**

This packet provides received signal levels for all satellites currently being tracked or on which tracking is being attempted (i.e., above the elevation mask and healthy according to the almanac). The Acutime sends this packet only in response to packet 27 hex. The data format is shown below:

Byte #	Item	Type
0	Count	BYTE
1	Satellite Number One	BYTE
2- 5	Signal Level One	SINGLE
6	Satellite Number Two	BYTE
7-10	Signal Level Two	SINGLE
(Etc.)	(Etc.)	(Etc.)

Up to twelve satellite number/signal level pairs may be sent, indicated by the count field. Signal level is normally positive. If it is 0 then that satellite has not yet been acquired. If it is negative then that satellite is not currently in lock. The absolute value of signal level field is the last known signal level of that satellite.

The signal level provided in this packet is a linear measure of the signal strength after correlation or de spreading.

**10.3.2.9 48 GPS SYSTEM MESSAGE**

This packet provides the 22 byte ASCII message carried in the GPS satellite navigation message. The Acutime sends this packet in response to packet 28 hex and when this data is received from a satellite.

The message effectively is a bulletin board from the Air Force to GPS users. The format is free-form ASCII. The message may be blank.

**10.3.2.10 49 ALMANAC HEALTH PAGE**

This packet provides health information on thirty-two satellites. Packet data consists of 32 bytes each containing the 6 bit health from almanac page twenty-five. The first byte is for satellite number one, and so on. The Acutime sends this packet in response to packet 29 hex, and when this data is received from a satellite.



Byte #	Item
1	Health of Satellite Number One
2	Health of Satellite Number Two
.	.
.	.
.	.
32	Health of Satellite Number Thirty-Two

In each data byte of this packet, a value “0” indicates that the satellite is healthy. All other values indicate that the satellite is unhealthy.

**10.3.2.11 4A SINGLE-PRECISION LLA POSITION FIX**

This packet provides current GPS position fix in LLA (latitude, longitude, and altitude) coordinates. If the I/O “position” option is set to “LLA” and the I/O “precision-of-position output” is set to single-precision, then the Acutime sends this packet each time a fix is computed. The data format is shown below:

Byte #	Item	Type	Units
0-3	Latitude	SINGLE	Radians; + For North, - For South
4-7	Longitude	SINGLE	Radians; + For East, - For West
8-11	Altitude	SINGLE	Meters
12-15	Clock Bias	SINGLE	Meters
16-19	Time-of-Fix	SINGLE	Seconds

Altitude is referred to the WGS-84 ellipsoid or the MSL Geoid, depending on which I/O “LLA altitude” option is selected.

The time-of-fix is in GPS time or UTC, depending on which I/O “timing” option is selected.

This packet also is sent at start-up with a negative time-of-fix to report the current known position.

Packet 84 provides a double-precision version of this information.

**\* \* \* CAUTION \* \* \***

When converting from radians to degrees, significant and readily visible errors will be introduced by use of an insufficiently precise approximation for the constant p(PI). The value of the constant PI as specified in ICD-GPS-200 is 3.1415926535898.

**10.3.2.12 4B MACHINE/CODE ID AND ADDITIONAL STATUS**

The Acutime transmits this packet in response to packets 25 and 26 and following a change in state. In conjunction with packet 46, "health of Acutime," this packet identifies the Acutime and may present error messages. The machine ID can be used by equipment communicating with the Acutime to determine the type of Acutime to which the equipment is connected. Then the interpretation and use of packets can be adjusted accordingly.

Byte #	Item	Type	Value	Meaning
0	Machine ID	BYTE	1B	6-Channel Acutime
1	Status 1	BYTE		

The error codes are encoded into individual bits within the byte. The bit positions and their meanings are shown below:

Bit Position	Meaning if Bit Value = 1		
0 (LSB)	Synthesizer Fault		
1	Battery Powered Time Clock Fault		
2	A-to-D Converter Fault (Not Used)		
3	The almanac stored in the Acutime, is not complete and current.		
4-7	Not used		
2	Status 2	BYTE	Super Packets Supported

**10.3.2.13 4C REPORT OPERATING PARAMETERS**

This packet provides several operating parameter values of the Acutime. The Acutime sends this packet in response to packet 2C hex. The data format is shown below.

The dynamics code indicates the expected vehicle dynamics and is used to assist the initial solution.

The elevation angle mask determines the lowest angle at which the Acutime tries to track a satellite.

The signal level mask sets the required signal level for a satellite to be used for position fixes.

The PDOP mask sets the maximum PDOP with which position fixes are calculated. The PDOP switch sets the threshold for automatic 3-D/2-D mode. If four or more satellites are available and the resulting PDOP is not greater than the PDOP mask value, then three-dimensional fixes are calculated.

Byte #	Item	Type	Units	Default
0	Dynamics Code	BYTE		
Value	Meaning	Assumed Velocity		
0	Current value is left unchanged.			
1	Land	< 120 Knots		
2	Sea	< 50 Knots		
3	Air (Default)	< 800 Knots		
4	Static	Stationary		
Byte #	Item	Type	Units	Default
1-4	Elevation Angle Mask	SINGLE	Radians	0.1745 or 10°
5-8	Signal Level Mask	SINGLE	---	6
9-12	PDOP Mask	SINGLE	---	12
13-16	PDOP Switch (3-D or 2-D)	SINGLE	---	8

A negative value in a SINGLE field leaves that current setting unchanged.

This information is held in battery-backed memory.

#### 10.3.2.14 4D OSCILLATOR OFFSET

This packet provides the current value of the Acutime master oscillator offset in Hertz at carrier. This packet contains one SINGLE number. The Acutime sends this packet in response to packet 2D hex. The permissible offset varies with the Acutime unit.

#### 10.3.2.15 4E RESPONSE TO SET GPS TIME

Indicates whether the Acutime accepted the time given in a Set GPS time packet. The Acutime sends this packet in response to packet 2E hex. This packet contains 1 byte.

Value	Meaning
ASCII "Y"	The Acutime accepts the time entered via packet 2E. The Acutime has not yet received the time from a satellite.
ASCII "N"	The Acutime does not accept the time entered via packet 2E. The Acutime has received the time from a satellite and uses that time. The Acutime disregards the time in packet 2E.

**10.3.2.16 54 ONE-SATELLITE BIAS AND BIAS RATE**

The Acutime sends this packet to provide the computed clock-only solution when the Acutime is in the manual or automatic one-satellite mode.

<b>Byte</b>	<b>Item</b>	<b>Type</b>	<b>Units</b>
0-3	Bias	SINGLE	Meters
4-7	Bias Rate	SINGLE	Meters/Second
8-11	Time of Fix	SINGLE	Seconds

The bias is the offset of the Acutime internal time clock from GPS time. Bias is expressed as meters of apparent range from the satellites. It is used to correct the 1pps output. Bias rate is the frequency error of the Acutime internal oscillator. It is expressed as apparent range rate.

**\* \* \* CAUTION \* \* \***

For accurate interpretation of the propagation delay, the precise constant for the speed of light must be used. The WGS-84 value for the speed of light is 299,792,458 meters per second.

## 10.3.2.17 55 I/O OPTIONS

This packet provides current I/O options in effect in response to packet 35 request. The data format is the same as for packet 35 hex and is repeated below for convenience.

Byte Number	Parameter Name	Bit Position	Bit Value	Default Option	Associated Packet
0	Position	0 (LSB)	1	XYZ ECEF Output 0: Off 1: On	42 or 83
		1	0	LLA Output 0: Off 1: On	4A or 84 or 8F-01 or 8F-02
		2	0	LLA ALT Output 0: HAE WGS-84 1: MSL Geoid	
		3	0	ALT Input 0: HAE WGS-84 1: MSL Geoid	2A
		4	0	Precision-of-Position Output 0: Send single-precision packet 42 and/or 4A. 1: Send double-precision packet 83 and/or 84.	
		5	0	Super Packet Output 0: Off 1: On	
		6	0	Super Packet Format 0: Binary 1: ASCII	
		7	0	Unused	

**Note:** If bit 5 is 0 then no super packets are output. If bit 5 and bit 6 are 1 then packet 8E-01 is output. If bit 5 is 1, and bit 6 is 0 then packet 8F-02 is. If super packet output is selected then 8F-01 or 8F-02 packets are output instead of the standard 4A or 84 packets.

SIGNAL CHARACTERISTICS

Byte Number	Parameter Name	Bit Position	Bit Value	Default Option	Associated Packet
1	Velocity	1		XYZ ECEF Output 0: Off 1: On	43
		1	0	ENU Output 0: Off 1: On	56
		2-7	0	Unused	
2	Timing	0	0	Time Type 0: GPS Time 1: UTC	
		1	0	Fix Computation Time 0: ASAP 1: Next Integer Sec	
		2	0	Output Time 0: When Computed 1: Only on Request	37
		3	0	Synchronized Measurements (V1.14 Onwards) 0: Off 1: On	
		4	0	Minimize Projection (V1.14 Onwards) 0: On 1: Off	
		5-7	0	Unused	
3	Auxiliary	0	0	Raw Measurements 0: Off 1: On	5A
		1	0	Doppler Smoothed Code Phase (V1.14 Onwards) 0: Raw 1: Smoothed	
		2	0	Additional Fix Status (V1.12 Onwards) 0: Off 1: On	
		3-7		Unused	

## CHAPTER TEN

Glossary for the table on the previous page:

### **ALT**

Altitude.

### **ECEF**

Earth-Centered, Earth-Fixed.

### **XYZ**

Cartesian Coordinates.

### **LLA**

Latitude, Longitude, Altitude.

### **HAE**

Height Above Ellipsoid.

### **WGS-84**

Earth Model (Ellipsoid).

### **MSL geoid**

Earth (Mean Sea Level) Model.

### **ENU**

East-North-Up (Same as LLA).

### **UTC**

Universal Coordinated Time.

**10.3.2.18 56 VELOCITY FIX, EAST-NORTH-UP (ENU)**

If East-North-Up (ENU) coordinates have been selected for the I/O “position” option, the Acutime sends this packet under the following conditions:

- (1) each time that a fix is computed.
- (2) in response to packet 37 hex (last known fix). The data format is shown below.

Byte #	Item	Type	Units
0-3	East Velocity	SINGLE	m/s; + for East, - for West
4-7	North Velocity	SINGLE	m/s; + for North, - for South
8-11	Up Velocity	SINGLE	m/s; + for up, - for down
12-15	Clock Bias Rate	SINGLE	m/s
16-19	Time-of-Fix	SINGLE	Seconds

The time-of-fix is in GPS or UTC time as selected by the I/O “timing” option.

**10.3.2.19 57 INFORMATION ABOUT LAST COMPUTED FIX**

This packet provides information concerning the time and origin of the previous position fix. The Acutime sends this packet, among others, in response to packet 37 hex. The data format is shown below.

Byte #	Item	Type	Units
0	Source of Information	BYTE	---
<b>Value</b>		<b>Meaning</b>	
	00 Hex	None	
	01 Hex	Regular Fix	
	02 Hex	Initialization Diagnostic	
	04 Hex	Initialization Diagnostic	
	05 Hex	Entered by Packet 23 Or 2b	
	06 Hex	Entered by Packet 31 Or 32	
	08 Hex	Default Position After Ram Battery Fail	
Byte #	Item	Type	Units
1	Manuf. Diagnostic	BYTE	---
2-5	Time of Last Fix	SINGLE	Seconds, GPS Time
6-7	Week of Last Fix	INTEGER	Weeks, GPS Time



**10.3.2.20 58 SATELLITE SYSTEM DATA/ACKNOWLEDGE FROM ACUTIME**

This packet provides GPS data (almanac, ephemeris, etc.). The Acutime sends this packet under the following conditions:

- (1) on request.
- (2) in response to packet 38 hex (acknowledges the loading of data). The data format is shown below.

Byte #	Item	Type	Byte Value	Meaning
0	Operation	BYTE	0	Acknowledge, Can't Use
			1	Acknowledge
			2	Data Out
			3	No Data on SV
1	Type of Data	BYTE	1	Not Used
			2	Almanac
			3	Health page, T_oa, WN_oa
			4	Ionosphere
			5	UTC
			6	Ephemeris
2	Sat PRN #	BYTE	0	Data that is not Satellite-ID-Specific
			1-32	Satellite PRN Number
3	length ( <i>n</i> )	BYTE		Number of Bytes of Data to be Loaded
4 to n+3	dat	<i>n</i> BYTES		

**10.3.2.21 59 STATUS OF SATELLITE DISABLE OR IGNORE HEALTH**

Normally the Acutime selects satellites for use in GPS solution according to whether the candidate satellites are in good health and whether they satisfy the mask values for elevation angle, signal level, and PDOP. This packet reads back whether the user has told the Acutime to disable unconditionally the selection of any particular satellite and whether the user has told the Acutime to ignore the health of any particular satellite that otherwise is acceptable for selection. The Acutime sends this packet in response to packet 39 hex. The data format is shown on the following page.

Byte #	Item	Type	Byte Value	Meaning
0	Operation	BYTE	3	The remaining byte tells whether or not the Acutime is allowed to select each satellite.
			6	The remaining bytes tell whether or not the Acutime heeds or ignores each satellite's health as a criterion for selection.
1 to 32	Satellite #	*32 BYTES	0	Enable satellite selection or heed satellite's health. Default value.
			1	Disable satellite selection or ignore satellite's health.

\* 1 byte per satellite.

This information is *not* held in battery-backed memory. At power-on and after a reset, the default values are set for all satellites.

### 10.3.2.22 5A RAW MEASUREMENT DATA

This packet provides raw GPS measurement data. If the I/O “auxiliary” option has been selected, the Acutime sends this data automatically as measurements are taken. The Acutime also sends this packet in response to packet 3A hex. The data format is shown below.

Byte #	Item	Type	Units
0	Satellite PRN Number	BYTE	-----
1	Sample Length	SINGLE	msec
5	Signal Level	SINGLE	
9	Code Phase	SINGLE	1/16th chip
13	Doppler	SINGLE	Hertz
17	Time of Measurement	DOUBLE	sec

#### Application Note

Packet 5A provides the raw satellite signal measurement information used in computing a fix.

The *satellite PRN* (Byte 0) number is a unique identification for each of the thirty-two GPS satellites.

## CHAPTER TEN

The *sample length* (Byte 1) is the number of milliseconds over which the measurement was averaged. If the sample length is 428, then the receiver tracked the satellite and collected the measurement over a 428 millisecond period. Acutime uses a 500 millisecond dwell time per satellite, however, if the channel is sequencing on several satellites, the sample length will be closer to 400 milliseconds due to reacquisition and loop setting times.

The *signal level* (Byte 5) is a linear approximation of C/N0 which is stated in antenna amplitude measurement units (AMU's), a Trimble devised unit. An approximate correlation of AMU levels to C/N0 follows:

5 AMU's	-20 dB SNR
16 AMU's	-10 dB SNR or AMU's 51 *
26 AMU's	-5 dB SNR

The C/N0 is affected by five basic parameters:

- 1) signal strength from the GPS satellite.
- 2) receiver/antenna gain.
- 3) pre-amplifier noise figure.
- 4) receiver noise bandwidth.
- 5) accumulator sample rate and statistics.

The approximation is very accurate from 0 to 25 AMU's.

The *code phase* (Byte 9) value is the average delay over the sample interval of the received C/A code and is measured with respect to the receiver's millisecond timing reference. It includes all receiver, satellite, and propagation biases and errors. It is expressed in 1/16th of a C/A code chip.

The *Doppler* (Byte 13) value is apparent carrier frequency offset averaged over the sample interval. It is measured with respect to the nominal GPS L1 frequency of 1575.42MHz, referenced to the receiver's internal oscillator (TCXO). It includes all receiver and satellite clock frequency errors. It is expressed in Hertz at the L1 carrier.

The *time-of-measurement* (Byte 17) is the center of the sample interval and measured by adding the Acutime supplied code phase (module mS) to a user determined integer number of mS between user and satellite.

Since the Acutime code phase resolution is 1/16th of a C/A code chip, this corresponds to:

$$\begin{array}{lcl}
 1/16 * \text{C/A code chip} & 977.517\text{ns}/16 & 61.0948 \text{ ns} \\
 & & 61.0948 * \text{speed of light, m/s} \\
 & & 110.3158 \text{ meter}
 \end{array}$$

The integer millisecond portion of the pseudo-range must then be derived by utilizing the approximate user and satellite positions. Rough user position (within a few hundred kilometers) must be known; the satellite position can be found in its almanac/ephemeris data.

Each mS integer corresponds to:

$$\begin{array}{lcl}
 \text{C/A code epoch} * \text{speed of light} & = & 1 \text{ ms} * \text{speed of light, m/s} \\
 & & 300\text{km (approx.)} \\
 & & 299.792458 \text{ km (precise)}
 \end{array}$$

**10.3.2.23 5B SATELLITE EPHEMERIS STATUS**

This packet is sent in response to packet 3B and when a new ephemeris (based on IODE) is received. It contains information on the status of the ephemeris in the receiver for a given satellite. The structure of packet 5B is as follows.

Byte #	Item	Type	Meaning or Units
0	SV PRN Number	BYTE	
1-4	Time of Collection	REAL	Seconds
5	Health	BYTE	
6	IODE	BYTE	
7	toe	REAL	Seconds
11	Fit Interval Flag	BYTE	
12-15	SV Accuracy (URA)	REAL	Meters

SV PRN number is from 1 to 32 representing the satellite PRN number. Time of collection is the GPS time when this ephemeris data was collected from the satellite. Health is the 6 bit ephemeris health. IODE, toe, and fit interval flag are as described in ICD-GPS-200. SV Accuracy (URA) is converted to meters from the 4 bit code as described in ICD-GPS-200.

## 10.3.2.24 5C SATELLITE TRACKING STATUS

This packet provides tracking status data for a specified satellite. Some of the information is very implementation-dependent and is provided mainly for diagnostic purposes. The Acutime sends this packet in response to packet 3C hex. The data format is shown below.

Byte #	Item	Type	Units
0	Satellite PRN Number	BYTE	Number, 1 to 32
1	Channel and Slot Code	BYTE	

This is an internal coding of the hardware tracking channel and of the slot within the channel to which the specified satellite currently is assigned.

Bit Position	Value	Meaning
2 to 0 (LSB)	<u>210</u>	
	000 (LSB)	Slot 1
	001	Slot 2
	010	Slot 3
	011	Slot 4
	100	Slot 5
	101	Slot 6

7(MSB) to 3: channel number, starting with zero.

Bits 7-3	Channel	Used by
00000	1	All Acutime
00001	2	Six Channel Acutime Only
00010	3	Six Channel Acutime Only
00011	4	Six Channel Acutime Only
00100	5	Six Channel Acutime Only
00101	6	Six Channel Acutime Only

SIGNAL CHARACTERISTICS

Byte #	Item	Type	Units
2	Acquisition Flag	BYTE	
<b>Byte Value</b>		<b>Meaning</b>	
0		Never Acquired	
1		Acquired	
2		Re-opened Search	
Byte #	Item	Type	Units
2	Ephemeris Flag	BYTE	
<b>Byte Value</b>		<b>Meaning</b>	
0		Flag Not Set	
0		Good Ephemeris for this Satellite (<4 Hours Old, Good Health)	
Byte #	Item	Type	Units
4-7	Signal Level	SINGLE	Same As In Packet 46 Hex
8-11	GPS Time Of Last Msmt	SINGLE	Seconds
<b>Byte Value</b>		<b>Meaning</b>	
<0		No Measurements Have Been Taken	
≥0		Center of the last measurement was taken from this satellite.	
Byte #	Item	Type	Units
12-15	Elevation	SINGLE	Radians

Approximate elevation of this satellite above the horizon. Updated about every fifteen seconds. Used for searching and computing measurement correction factors.

Byte #	Item	Type	Units
16-19	Azimuth	SINGLE	Radians

Approximate azimuth from true north to this satellite. Updated typically about every three to five minutes. Used for computing measurement correction factors.

Byte #	Item	Type	Units
20	Old Measurement Flag	BYTE	

Byte Value		Meaning	
0		Flag Not Set	
>0		The last measurement is too old to use for a fix computation.	
Byte #	Item	Type	Units
21	Integer msec Flag	BYTE	
Byte Value		Meaning	
0		Don't have good knowledge of this integer millisecond range to this satellite.	
1		Msec from sub-frame data collection.	
2		Verified by a bit crossing time.	
3		Verified by a successful position fix.	
4		Suspected msec error.	
Byte #	Item	Type	Units
22	Bad Data Flag	BYTE	
Byte Value		Meaning	
0		Flag Not Set	
1		Bad Parity	
2		Bad Ephemeris Health	
Byte #	Item	Type	Units
23	Data Collect Flag	BYTE	
Byte Value		Meaning	
0		Flag Not Set	
>0		The Acutime is currently trying to collect data from this satellite.	

**10.3.2.25 5E ADDITIONAL FIX STATUS**

This packet describes attributes of a position fix. The information is requested by packet 3E or sent after each fix if bit 2 of AUX BYTE in packet 35 is set.

Byte	Bit	Meaning
0	0-2	Number of measurements in current fix that were used in a previous fix.
	3	1: No differential Doppler velocity available.
		0: Differential Doppler velocity available.
	4	1: Fix still converging (when status code = , i.e. doing fixes).
0: Fix converged.		
1	5-7	Unused
	0-2	Number of measurements in current fix that are old (3-5 s).
	3-7	Unused

**10.3.2.26 5F FAILURE REPORT**

If a severe failure prevents the Acutime from operating, the Acutime sends this packet at turn-on if the failure does not preclude doing so. Generally, the Acutime sends nothing following this packet. The packet data bytes consist of “02” followed by an ASCII text message which describes the failure.

**10.3.2.27 6D ALL-IN-VIEW SATELLITE SELECTION**

This packet provides a list of satellites used for position fixes by the Acutime. The packet also provides the PDOP, HDOP, and VDOP of that set and provides the current mode (automatic or manual, 3-D or 2-D). The Acutime sends this packet in response to packet 24 hex and whenever a new satellite selection is attempted. The Acutime attempts a new selection every thirty seconds and whenever satellite availability and tracking status change. If four satellites are being used to generate a 3D position or three satellites for a 2D position, packet 44 is sent instead of 6D, however; if more than four satellites are being used to generate the position, packet 6D is sent instead of packet 44, so it is recommended that the user listen for both packets.

This packet has variable length equal to 16+nsvs (minimum four), where “nsvs” is the number of satellites used in the solution. The data format is shown on the following page.

*Note:* Supported only in TSIP core code version 1.16 and later.



Byte #	Item	Type	Bit	Value	Meaning
0	Mode	BYTE	0-2	3	2D
				4	3D
			3	0	Auto
				1	Manual
			4-7	--	nsys
1-4	PDOP	SINGLE			PDOP
5-8	HDOP	SINGLE			HDOP
9-12	VDOP	SINGLE			VDOP
13-16	TDOP	SINGLE			TDOP
(16+NSVS)	SV PRN	BYTE			

**10.3.2.28 76 BEST 4/HIGH 6/SMART 8 - MODE**

This packet shows whether the Acutime is in High-6 or High-8 mode. It returns one byte:

This packet is sent in response to packet 75 hex.

- 0 = Best 4 Mode
- 1 = High 6 (Over Determined) Mode (Default Mode for the Acutime)
- 2 = Smart 8 (Over Determined Smart Sequencing) Mode

### 10.3.2.29 82 DIFFERENTIAL POSITION FIX MODE

This packet provides the differential position fix mode of the Acutime. This packet contains only 1 data byte to specify the mode.

This packet is sent in response to packet 62 and whenever a satellite selection is made and the mode is Auto GPS/GPD (modes 2 and 3).

The Acutime switches automatically between modes 2 and 3 based on the availability of differential corrections for a constellation which meets all other masks. If such a constellation is not available, then the Acutime stays in its current automatic mode (2 or 3), and does not do position solutions.

Valid modes are:

- 0 Manual GPS (Differential Off)
- 1 Manual GPD (Differential On)
- 2 Auto GPS (Differential Currently Off)
- 3 Auto GPD (Differential Currently On)

“Manual GPS” (mode 0) means that the Acutime does position solutions without differential corrections, even if the differential corrections are available.

“Manual GPD” (mode 1) means that the Acutime only does position solutions if valid differential correction data are available.

“Automatic GPS” (mode 2) means that the Acutime is not receiving differential correction data for all satellites in constellation which meets all other masks, and is doing non-differential position solutions.

“Automatic GPD” (mode 3) means that the Acutime is receiving differential correction data for all satellites in a constellation which meets all other masks, and is doing differential position solutions.

**10.3.2.30 83 DOUBLE-PRECISION XYZ POSITION FIX AND BIAS INFORMATION**

This packet provides current GPS position fix in XYZ ECEF coordinates. If the I/O “position” option is set to “XYZ ECEF” and the I/O double-precision-of-position option is selected, the Acutime sends this packet each time a fix is computed. The data format is shown below.

Byte #	Item	Type	Units
0-7	X	DOUBLE	Meters
8-15	Y	DOUBLE	Meters
16-23	Z	DOUBLE	Meters
24-31	Clock Bias	DOUBLE	Meters
32-35	Time-of-Fix	SINGLE	Seconds

The time-of-fix is in GPS time or UTC, as selected by the I/O “timing” option. At start-up, if the I/O double-precision-of-position option is selected, this packet is also sent with a negative time-of-fix to report the current known position.

Packet 42 provides a single-precision version of this information.

**10.3.2.31 84 DOUBLE-PRECISION LLA POSITION FIX AND BIAS INFORMATION**

This packet provides current GPS position fix in LLA coordinates. If the I/O “position” option is set to “LLA” and the double-precision-of-position option is selected, the Acutime sends this packet each time a fix is computed. The data format is shown below.

Byte #	Item	Type	Units
0-7	Latitude	DOUBLE	Radians; + for North, - for South
8-15	Longitude	DOUBLE	Radians; + for East, - for West
16-23	Altitude	DOUBLE	Meters
24-31	Clock Bias	DOUBLE	Meters
32-35	Time-of-Fix	SINGLE	Seconds

The time-of-fix is in GPS time or UTC, as selected by the I/O “timing” option. At start-up, this packet is also sent with a negative time-of-fix to report the current known position.

Packet 4A provides a single-precision version of this information.

## \* \* \* CAUTION \* \* \*

When converting from radians to degrees, significant and readily visible errors will be introduced by use of an insufficiently precise approximation for the constant  $p(\pi)$ . The value of the constant  $\pi$  as specified in ICD-GPS-200 is 3.145926535898.

**10.3.2.32 85 DIFFERENTIAL CORRECTIONS STATUS**

This packet provides the status of differential corrections for a specific satellite. It is sent in response to packet 65. The format of this packet is as follows:

Byte	Item	Type	Units
0	Satellite PRN Number	BYTE	
1	Summary Status Code	BYTE	
2	Station Health	BYTE	
3	Satellite Health (UDRE)	BYTE	
4	IODE 1	BYTE	
5	IODE 2	BYTE	
6	Z-count as Time-of-Week	SINGLE	Seconds
10	Range Correction	SINGLE	Meters
14	Range-Rate Correction	SINGLE	m/sec
18	Delta Range Correction	SINGLE	Meters

The summary status code is encoded as follows:

- 0 Good Correction Data
- 1 Good Delta Correction Data
- 2 Station Health Bad (5 or 7)
- 3 Data Too Old (60 Seconds)
- 4 UDRE too High (>4)
- 5 IODE Mismatch with Ephemeris

## **CHAPTER ELEVEN**

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### **DRAWING SET**

#### **11.0 GENERAL**

This chapter contains the schematic diagram, assembly drawing, and parts list for the bc637S SBus Time and Frequency Processor.



