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bc635/637PCI/CPCI/PMC TIME & FREQUENCY PROCESSOR

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User's Guide

Rev. H

(March, 2000)

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Declaration of Conformity

Application of Council Directive(s) 89/339/EEC, 93/68/EEC

Standard(s) to which Conformity is Declared EN 50081-1, EN 50082-1

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Importer's Name

Importer's Address

Type of Equipment I.T.E.

Model No. bc635PCI

Serial No. Year of Manufacture 1998

I, the undersigned, hereby declare that the equipment specified above conforms to the Directive(s) and Standard(s).

Place Datum, Inc.

(Signature)

Date August 6, 1998

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bc635PCI
TIME AND FREQUENCY PROCESSOR

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CHAPTER ONE
INTRODUCTION

1.0 GENERAL

This bc635PCI/CPCI/PMC Time and Frequency Processor (TFP) User's Guide provides the following information:

- Chapter One provides a list of key features, definition of terms, and a list of performance specifications for the TFP.

- Chapter Two provides installation instructions.

- Chapter Three provides a description of the software configuration, demonstration and time utility programs supplied with the TFP.

- Chapter Four provides a functional description of all the TFP timing functions. Everyone should read this chapter.

- Chapter Five provides a description of the TFP device registers.

- Chapter Six provides a description of the dual-port RAM interface.

- Chapter Seven describes the input and output connectors located on the TFP back plate.

- Chapter Eight provides a schematic and assembly drawing for the TFP.

This manual is applicable to the following products: bc635PCI (12043 version), bc635CPCI, bc635PMC, bc635PCI (12083 version) and the bc637 (GPS) models of these boards. All sections of this manual are applicable to all boards except where noted.

1.1 KEY FEATURES

The TFP 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 binary format (UNIX seconds through 100 nanoseconds).

- 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.

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- An internal 10MHz VCXO (Voltage Controlled Crystal Oscillator) is disciplined to the reference source. The VCXO output drives all timing functions on the card. The VCXO output and a 1pps signal are provided as outputs. The TFP is also capable of disciplining an external voltage controlled oscillator. As an option, the TFP board can be ordered with an OCXO (Oven Controlled Crystal Oscillator) installed.

- All modes of operation are supplemented by flywheel operation. If the synchronization source is lost the TFP 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
0	Time Code - IRIG B, IRIG A, IEEE 1344 & NASA36
1	Free Running - 10 MHz Selected Reference (Internal or External)
2	1 PPS - External One Pulse Per Second Input
3	RTC-Uses battery backed on-board real time clock I.C. (12083 boards)
4-5	Reserved
6	GPS (bc637) - GPS Antenna/Receiver

- Generates IRIG B or IEEE 1344 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 and can be synchronized to the TFP 1pps signal.

- A Time Coincidence Strobe output is provided. It is programmable from hours through microseconds. This strobe also has an each second mode (referred to in this manual as Minor Time Mode) programmable to microseconds.

- Five maskable interrupt sources are supported. PCIbus 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.

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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 that is obtained by dividing the TFP 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. Essentially, the strobe functions 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 bc637PCI uses data packets to communicate with the optional GPS receiver.

1.3 PERFORMANCE SPECIFICATIONS

Time Code Reader

Formats	IRIGB, IRIG A, IEEE 1344 and NASA36
Carrier Range	+/- 50 PPM
Flywheel Accuracy	Drift < 2 Millisecond Per Hour (Applies To All Operational Modes)
Modulation Ratio	3:1 to 6:1
Input Amplitude	0.5 To 5 Volts Peak-To-Peak
Input Impedance	10 k , AC Coupled

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Time Code Generator

Format	IRIG B and IEEE 1344
Modulation Ratio	3:1
Output Amplitude	3 Volts Peak-To-Peak (Nominal)
DC Level Shift	TTL / CMOS Compatible

PCI Bus Characteristics

Specifications	Designed Per PCI Specification 2.2
Size	Single-Width 6.875" x 4.200"
Interrupts	Auto Configurable IntReq Level 2 – 15
Power	+5V @ 375 mA +12V @ 500 mA -12V @ 100 mA Maximum

Digital Inputs

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

Digital Outputs

1pps	TTL Rising Edge On Time 63µS Positive pulse
Periodic	TTL Rising Edge On Time, variable frequency and pulse width
Strobe	TTL 1µS Positive pulse variable delay
1, 5, 10 MHz clock	TTL (see Section 4.7 for signal characteristics)

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

Temperature	***Operating*** ***Non-Operating***	0 C to +70 C -30C to +85C
Relative Humidity	***Operating/Non-Operating***	85% @ +85C, 1000 Hrs

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CHAPTER TWO
INSTALLATION

2.0 GENERAL

Installation of PCI 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 Configuration Registers.

The only thing the user has to do is pick a vacant PCI slot and plug the Datum bc635PCI Time and Frequency Processor (TFP) into it and install the device driver. Be sure to consult the user documentation that came with your particular workstation for any specific PCI card installation instructions.

2.1 CONFIGURATION

The TFP is available with a variety of software suitable for use with either Microsoft Windows 95™ or Windows NT™. The kit includes drivers for low-level access as well as software programs for configuring and accessing the card.

2.2 INSTALLATION UNDER MICROSOFT WINDOWS 95™

1) Pick a vacant PCI slot and insert the Datum bc635PCI Time and Frequency Processor (TFP).

2) The Plug & Play architecture supported by Microsoft Windows 95 will allow your system to automatically recognize and configure the bc635/637PCI. When the Plug & Play BIOS detects the presence of a new device, it will prompt the user for a driver if one does not already exist. When prompted, insert the CD labeled "Bus Level Products" into your CD-ROM drive and select the device you wish to load. The driver can support up to 4 bc635/637PCI devices per system.

Note: If you are only installing a single card, simply select the First Device (Device 0). Windows will Prompt you to restart your computer. Click "No" and proceed to the next step.

3) Once the OS is up, open and close the CD-ROM drive to start Auto-Run. Follow the installation procedure to install the driver.

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2.3 INSTALLATION UNDER MICROSOFT WINDOWS NT™

1) Pick a vacant PCI slot and insert the Datum bc635PCI Time and Frequency Processor (TFP).
2) Insert the CD labeled "Bus Level Products" into your CD-ROM drive and follow the installation procedure.

2.4 INSTALLATION UNDER MS-DOS™

Usage of the bc635/637PCI device under the MS-DOS operating system is problematic. As the device is mapped into high memory, the card is not available to standard 16 bit DOS programs. If this combination of device and operating system is required, the customer must develop a program to enable and configure the device. While the interface to the device is well defined in this manual, the instructions for enabling and accessing the device are beyond the scope of this manual. Refer to your DOS extender documentation for further details.

2.5 INSTALLATION UNDER OTHER OPERATING SYSTEMS

Usage of the bc635/637PCI device under other operating systems will require the customer to develop a PCI driver for the device. With the wide variety of machines and operating systems that support the PCI bus, it is not possible for Datum to develop drivers for use in all of these environments. Datum will support other operating systems as the product evolves. Please check with the Datum sales personnel for the status of other drivers. While the interface to the device is well defined in this manual, the instructions for enabling and accessing the device are beyond the scope of this manual. Refer to your system documentation for further details.

NOTE: Contact factory for instructions when installing bc635/637PCI in a DEC Alpha machine.

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CHAPTER THREE
SOFTWARE PROGRAMS

3.0 GENERAL

A Configuration and Demo Program (BC635CPP.EXE), and a System Clock Utility (TRAY TIMECPP.EXE) are included with the bc635/637PCI module.

The System Clock Utility (described in section 3.7) is a system tray utility that will query the bc635PCI and set the PCI bus computer's system clock on a periodic basis, user selectable.

The BC635CPP.EXE program allows the user to access the bc635/637PCI card. This program is designed to operate under either Microsoft Windows 95™ or Windows NT™. This utility can be used to query current settings, modify settings and retrieve or monitor data generated by the card. This program requires the runtime driver to be available in order to operate. The background window of the program provides current UTC time as well as information regarding the status and interrupt bits. A full menu system (described in the following paragraphs) has been designed to provide access to the card. Each associated pull-down menu provides a logical grouping of commands. Most of the pull-down menus also include a Summary button that provides a review of the current settings associated with the logical group.

3.1 FILE MENU

This group provides a few common functions associated with Windows™ applications. However, the commands have been redefined to operate on the bc635/637PCI instead of files.

3.1.1 OPEN

This command allows the user to select a different bc635/637PCI device. By default, the program opens and operates using the first device in the system (Device 0). If this command is detected, the program will close the currently selected device before opening the newly requested device. This command will also clear the interrupt mask.

3.1.2 CLOSE

This command allows the user to close the currently selected device. This command may be used before choosing to open another device. However, its use is not mandatory. This command will clear the interrupt mask before closing the device.

3.1.3 INT START

This command allows the user to start the interrupt service routine to support the selected hardware interrupts used by the bc635/637PCI module. After starting the interrupt service routine, the user can select any interrupt source located under "Signals|Interrupts".

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3.1.4 EXIT

This command allows the user to close the device and exit the program. This command will clear the interrupt mask.

3.2 TIME MENU

This group provides access to functions that control how the bc635/637PCI card maintains time data. These functions allow the user to select where to obtain time data, whether or not to manipulate the time data and how to present the time data to the user.

3.2.1 SET MODE

This is a popup menu that allows the user to select the operating mode of the bc635/637PCI device. This menu sends the Set Mode (0x10) packet to the device. Highlighting a different mode and clicking with the mouse will change the mode. Available modes are Time Code Decoding, Freerunning, External 1PPS, RTC (available on 12083 boards only) & GPS.

3.2.2 GET BINARY TIME

This command exercises the time capture and time registers of the device. It will make 20 time requests and retrieve the 20 consecutive timestamps and display them in a box inside the program. This function is designed to display binary data. As the background window is constantly displaying time, this command is not typically used during normal operations. Currently the device only provides binary time format. The time format may be programmable in the future.

3.2.3 GET EVENT TIME

This function exercises the event capture and event registers of the device. It will make 20 event requests and retrieve the 20 consecutive timestamps from the event registers and display them in a box inside the program. This function is designed to display binary data. The bc635/637PCI device should be set to use the binary time format when executing this function. If the device is in decimal mode, the major time (in front of the decimal point) will be garbled but the minor time will still display correctly. The Demo program only supports the Event Time function in binary format.

3.2.4 SET TIME

This function allows the user to set the time on the bc635/637PCI device. A box is displayed on the screen that contains the current time from years through seconds in a decimal format. The user may change any or all of these values and select the OK button. This command will load the time properly regardless of the currently selected time format. This function is typically used when operating in either the Freerunning or External 1PPS modes. While the function may be used when operating in Time code or GPS modes, subsequent time data received from the selected reference source will overwrite the loaded time.

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3.2.5 SET YEAR

This function allows the user to set the year data. The year data may also be set with the Set Time command. Typically, this command is used when the board is operating in time code decoding mode. Many time code formats (including standard IRIG B) do not include year information in the data. Using this function will allow the bc635/637PCI device to extract the time of year data from the time code source while using year information provided by the user. The supported range is 1990 – 2037 (as shown in the demonstration program dialog box)

3.2.6 SET LOCAL OFFSET

This function allows the user to program a local offset into the bc635/637PCI device. If the local offset value is nonzero, the device will adjust any reference timing information in order to maintain a local time in bc635/637PCI clock. Use of this function only affects the time data in the TIME registers described in paragraph 5.2.9. Allowed values are –16 through +16, and can include half hour offsets.

3.2.7 SET PROPAGATION DELAY

This function allows the user to command the bc635/637PCI device to compensate for propagation delays introduced by the currently selected reference source. For example, when the unit is operating in Time code decoding mode, a long cable run could result in the input time code having a propagation delay. The delay value is programmable in units of 100ns and has an allowed range from –9999999 through +9999999.

3.2.8 SET LEAP EVENT

Operating in standard binary format, the major time register will contain a 32 bit binary value corresponding to the number of seconds elapsed since 0 hour Jan 1, 1970 UTC.

3.2.9 TIME SETTINGS

This function allows the user to modify other timing operations. The UTC Corrections may be enabled or disabled. Enabling UTC Corrections commands the device to include any leap second corrections provided by the reference source and act on any leap event data that is present. The default operation is to use UTC corrections. This function is also used to enable or disable the following options: IEEE Daylight Savings, Local Time Offset and Year Auto Increment. The board time format (Binary or Decimal) is also selected using this function.

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3.2.10 TIME CURRENT SETTINGS

This function provides a summary of all the time data. In addition to the programmable values, the values of some of the device timing data are also presented as information points. Currently, these values include leap second count, leap second event data and leap second event time and are accessed via the "UTC Data" button.

3.3 TIME CODE MENU

This function group provides access to functions controlling bc635/637PCI card operation while decoding time code. These functions allow the user to control both the time code decoding and time code generating circuits of the device.

3.3.1 DECODE

This function allows the user to select the format and modulation types associated with an input timing signal. These values control how the device attempts to decode the input time code. These values may be set regardless of the mode but will only be used in time code decoding mode. The format defines the type of the time code data. The modulation defines the envelope for the signal and which input pin the signal will be extracted from. The default format is IRIG B and the default modulation envelope is AM (amplitude modulated). The boards also support IRIG A, IEEE 1344 and NASA36.

3.3.2 GENERATOR

This function allows the user to select the format of the time code that will be generated by the bc635/637PCI device. The time code generator supports IRIG B and IEEE 1344.

3.3.3 GENERATOR OFFSET

The function allows the user to add an offset to the time code signal being produced by the bc635/637PCI device, and only affects the unit time code generation. This functionality is useful for driving time code display units so local time appears on them. Allowed values are –16 through +16, and can include half hour offsets.

3.3.4 TIME CODE CURRENT SETTINGS

This function provides a summary of all the time code data. In addition to the programmable values, other values may be presented as information points.

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3.4 SIGNALS MENU

This group provides access to functions that control various hardware timing signals either decoded or generated by the bc635/637PCI card.

3.4.1 HEARTBEAT

This function allows the user to command the bc635/637PCI to produce a clock signal at a specified frequency. The heartbeat signal, also referred to as a periodic, can be either synchronous or asynchronous to the internal 1PPS epoch in the bc635/637PCI device. This functionality is implemented in hardware on the bc635/637PCI device by emulating an Intel 82C54 counter timer chip. The heartbeat circuit has two 16 bit divisors which are clocked by the internal counter of the bc635/637PCI. As the output of the first divisor provides the clock for the second divisor, manipulating the divisor values results in various duty cycles. The output of this circuitry is capable of creating a PCI bus interrupt. See Section 4.4 for a description of how to program the heartbeat output.

3.4.2 STROBE

This function allows the user to command the bc635/637PCI to produce a hardware signal at a particular time, or at a particular point during a 1 second interval. When major/minor mode is selected, a hardware signal will be produced when the internal time of the bc635/637PCI device matches the values entered for the major and minor strobe registers. Up to 22 bits of binary major time may be supplied in addition to the microseconds loaded in the minor strobe register. This allows strobe signals to be programmed up to 48 days in advance. This function is designed to operate with the timing format in binary mode. When minor mode is selected, a strobe signal is produced every second when the internal microsecond count in the bc635/637PCI device matches the value entered in the minor strobe register.The input of the strobe register values may be done in either Binary of Decimal Time format. The output of this circuitry is capable of creating a PCI bus interrupt.

3.4.3 EVENTS

This function allows the user to command the bc635/637PCI device to monitor a hardware timing signal. The source for the signal can be either the External Event input on the device or the output of the Heartbeat (Periodic) mentioned earlier in this chapter. The External Event signal capture may be set to occur on either the rising or falling edge. The Heartbeat signal capture is always on the rising edge. When a signal occurs in the selected format, the time at which the signal occurred is loaded into the event time registers. The capture lockout checkbox can be used to control whether or not subsequent signals will overwrite the data in the event time registers. The output of this circuitry is capable of creating a PCI bus interrupt.

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3.4.4 FREQUENCY

This function allows the user to control the frequency signal output by the bc635/637PCI device. The available frequencies are 1, 5 and 10 MHz. The default state of this output is 10MHz.

3.4.5 INTERRUPTS

This function allows the user to control the generation of PCI bus interrupts by the bc635/637PCI device. This program is capable of capturing PCI bus interrupts generated by the device. The detection of an interrupt will be displayed in the background of the main window. Five "LEDs" are displayed in the upper right corner of the window background. When an interrupt occurs, the program queries the interrupt source and the associated LED is displayed in red. In order to display consecutive interrupts, the LEDs are changed back to green once per second. This may result in LEDs only remaining red for a short period of time. If the latch event time box is checked, the program will latch the time in the event time registers when an interrupt is detected. The user may query the event time registers to see when a particular event occurred.

Note: The latch event time box should not be checked when external events are selected as these already latch the time in the event registers.

3.4.6 SIGNAL CURRENT SETTINGS

This function provides a summary of all the signal data. In addition to the programmable values, other values may be presented as information points.

3.5 HARDWARE MENU

When the Advanced menu is selected (see paragraph 3.6.4), this group provides additional access to functions that control the oscillator and its associated disciplining circuits. These functions modify the actual oscillator control function used to slave the internal oscillator to the selected reference signal. This function is not modified during standard operation.

3.5.1 SET OSC PARAMETERS

This group allows the user to select an external oscillator or the on board oscillator, in addition to enabling/disabling disciplining and jamsyncing.

3.5.2 SYNC RTC TIME TO EXT TIME

This menu item allows the user to force the RTC time on the 12083 boards to the board time.

3.5.3 HARDWARE CURRENT SETTINGS

This function provides a summary of all the oscillator data. In addition to the programmable values, other values may be presented as information points.

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3.6 SPECIAL MENU

This group provides access to those functions which do not fit in any particular category. Most of these functions are not used during normal operation.

3.6.1 BOARD RESET

This function allows the user to reset the bc635/637PCI device. This command is useful when starting a test or in the case that unexpected behavior is observed from the card. This function is not used during normal operation.

3.6.2 REGISTERS

This function allows the user to perform direct reads and writes to the bc635/637PCI device registers. While most of the functionality available through the registers can be controlled via other aspects of the demo/config program, this function may be useful for debugging purposes.

3.6.3 AUTOTIME

This functions allows the user to control the data display in the background of the main program window. If this function is turned off, the display will stop.

3.6.4 MENU

This command allows the user to switch to an advanced version of the menu. If the advanced menu is selected, more options appear in and on the menu bar at the top of the program. Note that the advanced menu contains operations which may disable the function of the bc635/637PCI device and should only be used by customers familiar and comfortable with controlling the device at this level. It may also be used in response to requests during technical support sessions. This function is not necessary for normal operations.

3.6.5 SPECIAL CURRENT SETTINGS

This function provides information related to the PCI interface to the board. This command is useful for determining whether or not the driver has obtained access to the device. It may also be used to review the PCI mapping of the device onto the bus. The interrupt level selected during PCI configuration may also be reviewed.

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3.7 SYSTEM CLOCK UTILITY (TRAY TIMECPP.EXE)

This utility is designed to operate under Win95™ and Win NT™ v4.0. This is a system tray utility that will query the bc635PCI and set the system clock on a periodic basis.

1) Double click on the **"Tray TimeCPP.exe"** to install.

2) A small world icon will show up on the lower right portion of the desktop (where the clock appears), click on that icon and it will display a window (Datum Tray Time).

3) Click setup

4) Click on Hardware if it is not already has been selected as the source for time.

5) Check the Status: -

If status is: *"Waiting for the board to acquire time"* then the time on the host computer is not synchronized to the bc635PCI time yet

If status is: *"Set Clock OK"* then the synchronizing process is taking effect.

6) Drag the program into your startup group to have it run automatically at boot.

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CHAPTER FOUR
FUNCTIONAL DESCRIPTION

4.0 GENERAL

This chapter provides a description of the bc635PCI Time and Frequency Processor (TFP) timing functions. This chapter should be read by anyone using the TFP. Several terms used in this chapter are defined in Chapter One.

4.1 TIMING MODES

The primary function of the TFP is to provide precise time to the user across the PCI bus. The TFP can derive time from any one of the sources listed in Table 4-1. In all but the Free Running mode of operation, the TFP synchronizes its on board 10 MHz oscillator to the timing source. The TFP achieves synchronization by extracting a 1pps (One Pulse Per Second) signal from the timing source and using this 1pps signal to discipline the oscillator such that the locally generated 1pps signal is matched in phase and frequency to the reference 1pps. Once synchronization is achieved, the TFP 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 TFP must also obtain major time (days, hours, minutes, seconds) from the timing source if it's available. In the Time Code Mode and the 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 4-1
TFP Timing Modes

Mode	Source of Time
0	Time Code (IRIG A, IRIG B, IEEE 1344 and NASA36)
1	Free running - on board oscillator used as reference.
2	External 1 pps - accepts input one pulse per second.
3	RTC – Uses battery backed on-board real time clock I.C. (12083 boards)
4-5	Reserved
6	GPS - uses Global Positioning System (GPS) antenna/receiver

4.1.1 MODE 0 (Time Code Mode)

In the Time Code Mode, the TFP derives time currently from the selected input time code. The TFP will accept time code in either a modulated or DCLS (DC Level Shift) form. Modulated time code is a sinusoidal analog signal that is amplitude modulated with the time. DCLS is simply the envelope of the modulated time code and is a digital signal.

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4.1.2 MODE 1 (Free Running Mode)

In the Free Running Mode, no external timing source is used. The TFP oscillator 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.

4.1.3 MODE 2 (External 1pps Mode)

In the External 1pps Mode, the TFP synchronizes its oscillator to a user supplied 1pps signal. The user must set major time manually.

4.1.4 MODE 3 (RTC)

In the real time clock mode, the TFP synchronizes its oscillator to the 1 PPS signal from the on board real time clock circuit that is present on the 12083 boards.

4.1.5 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.

4.2 TIME CAPTURE

The TFP supports two independent sets of time capture registers. Each set consists of two 32-bit wide registers that hold both the major and minor time. One register, labeled TIME0, supports time on demand across the PCI bus. 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. Chapter Five describes the available time formats used on the TFP.

The second set of time capture registers, labeled EVENT0 & EVENT1, 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 set up to capture time in response to either the Event Input (see below) or the Programmable Periodic Output (see next section).

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4.3 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 that EVENTREQ register accesses will continue to capture time even if event time capture is enabled.

4.4 PROGRAMMABLE PERIODIC OUTPUT

An often-useful TFP feature is the Programmable Periodic Output signal. The Periodic Output can optionally be synchronized to the TFP 1pps signal. 1pps synchronization works when the Periodic Output frequency is an integer value, otherwise, the 1pps signal will cut short one of the Periodic Output cycles. Setting the periodic output to a frequency less than 1Hz while in the synchronization mode will cause the periodic output to be held at a logic high level.

Terms:
n1 : Counter divider number 1
n2 : Counter divider number 2
Duty Cycle: Percentage of High Pulse width to signal period

This signal is generated by dividing down a 1 MHz clock. The 1 MHz clock is derived directly from the 10 MHz oscillator, thus the Periodic Output is synchronous with the timing source. The periodic output frequency can range from 250 kHz ($n_1 = n_2 = 2$) to less than 1Hz, and is determined by the relationship:

Frequency = 1,000,000 / (n1 * n2) Hz *Where 2 £ n1, n2 £ 65535*
Duty Cycle = (1 - (1 / n2)) * 100%

***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.

4.5 TIME COINCIDENCE STROBE OUTPUT

The TFP 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 microsecond. The rising edge of the Strobe occurs one microsecond after 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 that produces an output pulse once each second.

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4.6 PCI INTERRUPTS

The TFP supports the five sources of interrupts listed in Table 4-2. 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 TFP generates interrupts at an auto configured PCI IntReq level (LEVEL register.) When servicing a TFP interrupt, the user must read the INTSTAT register in order to determine the interrupt source(s) requesting service.

Table 4-2
TFP Interrupt Sources

Int	Source of Interrupt
0	Event input has occurred
1	Periodic output has occurred
2	Time Coincident Strobe has occurred
3	One second epoch (1 pps output) has occurred
4	GPS data packet is available (bc637PCI)

4.7 TIMING OUTPUTS

In addition to the Programmable Periodic Output and Time Coincidence Strobe, the TFP provides other useful timing outputs that are synchronized to the timing source. The 1pps output is an approximately 60-65 µsec wide pulse with the rising edge occurring at each 1 second epoch. An IRIG B or IEEE 1344 time code output signal is available in both modulated and DCLS (DC Level Shift) forms. An output frequency of 1MHz, 5MHz, or 10 MHz TTL signal (optional sinusoid available with oven oscillator option) is provided. The 10 MHz frequency comes straight from the oscillator clock. The 1MHz and 5 MHz signals are derived by dividing the oscillator clock by 10 or two, respectively.

4.8 LOGIC LEVEL MONITOR

The logic level of the External Event Input, the DCLS Time Code Input and the External 1PPS Input can be monitored by reading the INTSTAT register on the 12083 boards.

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CHAPTER FIVE
DEVICE REGISTERS

5.0 GENERAL

The bc635PCI Time & Frequency Processor (TFP) is controlled with a combination of hardware device registers and a dual-port RAM interface. This chapter describes the TFP device registers, and Chapter Six describes the dual-port RAM interface.

5.1 PCI REGISTER FIELDS

The TFP is divided into three register fields: the Boot PROM field, the dual-port RAM field, and 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 5-1 lists the card's physical memory map for those users that don't have access to the Boot PROM information.

***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 TFP micro-controller. Be sure to access the dual-port RAM as described in Chapter Six. Do not access other areas within the dual-port RAM address space.

Table 5-1
TFP Physical Memory Map

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

5.2 DEVICE REGISTER DESCRIPTION

The TFP device registers are 32-bits wide (PCI 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 5-2 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 BAR0.

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Table 5-2
TFP Device Register Summary

Offset	Type	Reset	Label	Description
0x00	A	See Note	TIMEREQ	Time Request (TIME0-1)
0x04	A	See Note	EVENTREQ	Event Request (EVENT0-1)
0x08	A	See Note	UNLOCK	Release Capture Lockout
0x0C	Reserved			
0x10	R/W	0	CONTROL	Control Register
0x14	R/W	See Note	ACK	Acknowledge Register
0x18	R/W	0	MASK	Interrupt Mask
0x1C	R/W	0	INTSTAT	Interrupt Status
0x20	W	See Note	MINSTRB	Minor Strobe Time
0x24	W	See Note	MAJSTRB	Major Strobe Time
0x28	Reserved			
0x2C	Reserved			
0x30	R	See Note	TIME0	Minor Time Holding Register
0x34	R	See Note	TIME1	Major Time Holding Register
0x38	R	See Note	EVENT0	Minor Event Holding Register
0x3C	R	See Note	EVENT1	Major Event Holding Register

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

5.2.1 TIMEREQ

Accessing this register (with a read or write operation) latches the current time and timing status in the TIME0 – TIME1 registers. The data value transferred is meaningless.

5.2.2 EVENTREQ

Accessing this register (with a read or write operation) latches the current time and timing status in the EVENT0 – EVENT1 registers. The data value transferred is meaningless.

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5.2.3 UNLOCK

Accessing this register (with a read or write operation) releases the EVENTx time capture lockout function if it has been enabled, allowing the Event Input or Periodic Output to capture a new time.

5.2.4 CONTROL

This register controls a variety of TFP hardware functions. Table 5-3 lists the function of each bit in this register.

Table 5-3
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 = Falling Edge Active (rising on 12083 boards) 1 = Rising Edge Active (falling on 12083 boards)
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	FREQSEL0	Output Frequency Select 00 = 10MHz 01 = 5MHz 1X = 1MHz
7	FREQSEL1	Output Frequency Select 00 = 10MHz 01 = 5MHz 1X = 1MHz
8 - 32	Reserved	

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5.2.5 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. See Chapter Six for more information on the format and use of this register.

5.2.6 MASK

Bits 0-4 in the MASK register correspond to interrupt sources zero through four listed in Table 5-4. An interrupt source is enabled (to generate an PCI interrupt) by writing a one to the corresponding MASK bit. Writing a zero to the interrupt MASK bit disables that interrupt.

5.2.7 INTSTAT

The INTSTAT register has the same structure as the MASK register listed in Table 5-4. 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 zero, write 0x01 to the INTSTAT register, to clear all INTSTAT bits simultaneously, write 0x1F to the INTSTAT register. A PCI interrupt is generated anytime one or more INTSTAT bits are set *and* the corresponding bit(s) are set in the MASK register. The logic level of the EVENT_IN, DCLS_IN and EXT1PPS_IN signals can be monitored by reading bits 8-10 of the INTSTAT register on the 12083 boards.

Table 5-4
INTSTAT Register

Bit	Function
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 (bc637PCI)
5	Reserved
6	Reserved
7	Reserved
8	EVENT_IN Logic Level (12083 boards)
9	DCLS_IN Logic Level (12083 boards)
10	EXT1PPS_IN Logic Level (12083 boards)
11-31	Reserved

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5.2.8 MINSTRB - MAJSTRB

These registers hold the programmed Time Coincidence Strobe time. The contents of these registers depend on the time format selected. 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 48 days beyond the current time.

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

5.2.9 TIME0 – TIME1

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

5.2.10 EVENT0 – EVENT1

These registers hold time captured by an access of the EVENTREQ register, an Event Input (if enabled) or the Programmable Periodic (if enabled). The contents of these registers depend on the time format selected.

5.2.11 TIME FORMAT

The TFP major time registers (TIME0, EVENT0, MAJSTRB) support binary time (Table 5-5 and decimal time (Table 5-6) formats. The subsecond time in decimal time format is represented in binary. The 32-bit binary format represents time as the number of seconds since midnight, January 1, 1970 UTC (Universal Time Coordinated, a.k.a. GMT), this is the standard time format found on most UNIX systems. Note that the year field is stored in the dual-port RAM. The decimal time format is derived from the “struct-tm” format used on UNIX systems. The bottom numbers in each cell in tables 5-5 and 5-6 define the bit positions for each data field. All undefined bit positions in table 5-6 are N/A.

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Table 5-5
TFP Binary Time Format

Register	Data Bits					
	31 - 28	**27 - 24**	**23 - 20**	**19 - 16**	**15 - 8**	**7 - 0**
TIME1 EVENT1	Major Time UNIX Seconds 31 - 0					
TIME0 EVENT0	N/A 31-28	Status 27 - 24	100ns 23 - 20	Binary µsecs 19 - 0		
MAJSTRB	N/A 31-22		Major Time UNIX Sec lower 22 bits 21 – 0			
MINSTRB	N/A 31-28	Status 27 - 24	N/A 23 - 20	Binary µsecs 19 - 0		

Table 5-6
TFP Decimal Time Format

Register	Data Bits					
	31 - 28	**27 - 24**	**23 - 20**	**19 - 16**	**15 - 8**	**7 - 0**
TIME1 EVENT1	Days (0–366) Bits 7-0 31-24		Hours (0 – 23) 20 - 16		Min(0–59) 12-8	Sec(0–59) 5-0
TIME0 EVENT0	Days Bit 8 28	Status 27 – 24	100ns 23 - 20	Binary µsecs 19 – 0		
MAJSTRB	N/A 31-24		Hours (0 – 23) 20-16		Min(0–59) 12-8	Sec(0–59) 5-0
MINSTRB	N/A 31-28	Status 27 - 24	N/A 23 - 20	Binary µsecs 19 - 0		

The format of the minor time registers (TIME0, EVENT0, MINSTRB) is always binary. 20 bits of binary microseconds (0 - 999,999) in the lower part of the registers with an additional four bit field of hundreds of nsecs (0 - 9) located in bits 20 - 23. Most UNIX time functions use microseconds, but the TFP maintains time to hundreds of nsecs.

5.2.12 STATUS BITS

The TFP Status bits found in the TIME0 and EVENT0 time registers are summarized in Table 5-7 and are described below. Bits 24, 25 and 26, in the PCI Windows demonstration program, are represented as LEDs labeled ‘T’, ‘P’ and ‘F’, respectively.

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Table 5-7
TIME0, EVENT0 Status Bits Summary

Bit	Description
24	Flywheeling 0: Locked To Selected Reference 1: Flywheeling (Not Locked)
25	Time Offset 0: <X Microseconds 1: >X Microseconds X = 5 (Mode 0) X = 2 (All Other Modes)
26	Frequency Offset 0: $<5 \times 10^{-8}$ 1:$>5 X 10^{-8}$
27	Reserved

5.2.13 STATUS: Flywheeling (Bit 24)

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

5.2.14 STATUS: Time Offset (Bit 25)

This bit indicates the synchronization accuracy of the TFP relative to the timing source. This bit is updated approximately once per second. When the TFP's oscillator is synchronized to less than 5 microseconds in time code mode and 2 microseconds in other modes, this bit is cleared.

5.2.15 STATUS: Frequency Offset (Bit 26)

This bit is an indication of the TFP on-board oscillator frequency offset relative to the timing source. This bit is updated approximately once per second and reflects the short-term stability of the TFP's oscillator.

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CHAPTER SIX
DUAL-PORT RAM INTERFACE

6.0 GENERAL

The byte-wide dual-port RAM (DPRAM) interface provides a communications pathway between the user and the bc635PCI Time & Frequency Processor (TFP) micro-controller (MPU). The current size RAM is 2Kx8. See Section 5-1 for the TFP physical memory map. 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 TFP for setting the timing Mode, time code format, etc. This area is also used to send data packets to the optional bc637PCI GPS receiver.

Output Area
This area holds data that the user requests from the TFP.

GPS Packet Area
This area holds packets of data from the optional bc637PCI's GPS receiver such as position, velocity, GPS status, etc.

Year Area
This area holds the year number derived from the timing source (if available). The year value algorithm retains the current year throughout a power cycle.

***Note*:** The DPRAM also holds the Boot PROM data and provides local RAM for the TFP 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 TFP firmware is updated. Each offset is a two 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)

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

ACK BIT 2
Set by the TFP 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 two set, but cannot set this bit. The transition of this bit from zero to one activates interrupt source four.

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

6.2 TFP DPRAM COMMANDS

This section describes the TFP commands available through the DPRAM Interface. Commands consist of a command ID byte followed by zero 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 6-2 summarizes the DPRAM commands.

TABLE 6-1

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

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

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

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Table 6-2
DPRAM Command Summary

ID	Reset	Command
0x10	Note 1	Set TFP Timing Mode
0x11	0	Set Time Register Format
0x12	N/A	Set Major Time
0x13	0	Set Year
0x14	N/A	Set Periodic Output
0x15	0x42	Set Input Time Code Format (default: 'B')
0x16	0x4D	Set Input Time Code Modulation (default: 'M')
0x17	0	Set Propagation Delay Compensation
0x18	N/A	Request UTC Time Data (bc637 only)
0x19	N/A	Request TFP Data
0x1A	N/A	Software Reset
0x1B	0x42	Set Time Code Output Format (default: 'B')
0x1C	0	Set Generator Time Offset
0x1D	0	Set Local Time Offset
0x1E	0	Set Leap Second Event
0x20	0x49	Set Clock Source (default: 'I')
0x21	1	Control Jam-Sync
0x22	N/A	Force Jam-Sync
0x24	N/A	Load D/A Converter
0x25	N/A	Set Disciplining Gain
0x26	N/A	Request Battery Status (12083 board only)
0x27	N/A	Sync External Time Data to RTC (12083 board only)
0x28	N/A	Disconnect Battery to RTC Chip (12083 board only)
0x29	N/A	Set/Request Advance/Retard Clock Value (12083 board only)
0x30	N/A	Send Packet to GPS Receiver (bc637 only)
0x31	N/A	Request Packet from GPS Receiver (bc637 only)
0x32	N/A	Manual Request Packet from GPS Receiver (bc637 only)
0x33	0	Select GPS Time Format (bc637 only)
0x34	1	Set GPS Mode Flag (bc637 only)
0x40	1	Observe IEEE 1344 Local Time Flag
0x41	N/A	Request IEEE 1344 Daylight Saving and Local Time Flags
0x42	1	Year Auto Increment Flag
0x4F	N/A	Request PCI Firmware Part Number
0xF4	N/A	Request Assembly Part Number
0xF5	N/A	Request Hardware Fab Part Number
0xF6	N/A	Request TFP Model Identification
0xFE	N/A	Request TFP Serial Number (Request only)

***Note One*:** bc635PCI resets to Mode 0 (Time Code)
bc637PCI resets to Mode 6 (GPS)

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COMMAND 0x10: SET TFP TIMING MODE

This command selects the timing mode of the TFP. The default Timing Mode for the bc635PCI is Time code Decoding Mode, for the bc637PCI is GPS Mode.

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	ID	0x10
1	UINT8	Timing Mode	See Below

TFP Timing Mode

0x00 Time Code Mode - IRIG A, IRIG B, IEEE 1344, NASA36 (bc635PCI default)
0x01 Free Running Mode - 10 MHz Selected Reference (Internal or External)
0x02 1PPS Mode - External One Pulse Per Second
0x03 Real Time Clock Mode* - Battery backed on-board real time clock IC
0x06 GPS Mode (bc637PCI) - GPS Antenna/Receiver (bc637PCI default)

***NOTE**: Supported by Hardware Version bc635/637-12083 only

COMMAND 0x11: SET TIME REGISTER FORMAT

This command allows the user to select the major time format. Available formats are Binary Coded Decimal (BCD) time format or UNIX time format. The time format affects the TIMEx, and EVENTx registers and command 0x12. The default time format is UNIX binary time format. See Tables 5-5 and 5-6 for the UNIX and BCD time register definitions, respectively.

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	ID	0x11
1	UINT8	Data Format	See Below

Time Data Format:

0x00 BCD TIME FORMAT
0x01 UNIX TIME FORMAT*

*default time data format

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COMMAND 0x12: SET MAJOR TIME

This command allows the user to load the major time to the TFP Major Time Registers in binary (UNIX) or BCD format. The format is determined by command 0x11 as referenced above. The default major time format is UNIX binary time. This command normally applies to the TFP while in modes 1 or 2. The TFP derives its major time from the selected external timing reference signal in modes 0 and 6, and from the RTC in mode 3. The time written by this command, if used in modes 0, 3or 6, will be overwritten when the selected source is providing a valid time to the TFP.

NOTE: *This command is supported in firmware revisions DT6000D and above. Boards containing firmware revisions DT6000A through DT6000C, or firmware revisions 98xxxxx, require a FW update in order to support this command.*

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	ID	0x12

Case 1: UNIX Time Data Format = 0x01 (Command 0x11, format 0x01)*

BYTE	TYPE	ITEM	VALUE OR RANGE
1-4	UINT32	UNIX Time	0 to 0xffffffff

Case2 1: BCD Time Data Format = 0x00 (Command 0x11, format 0x00)

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	ID	0x12
1-2	UINT16	Year	1970 - 2050
3-4	UINT16	Days	0 to 0x16e (0 to 366)
5	UINT8	Hours	0 to 0x17 (0 to 23)
6	UINT8	Minutes	0 to 0x3b (0 to 59)
7	UINT8	Seconds	0 to 0x3b (0 to 59)

***default time data format**

The time loaded by this command will not be readable until the one second epoch following the load. There is a possibility the TFP will have incremented the time during the load. To prevent ambiguities in the time, the user must issue this command in advance of the 800 millisecond point within the one second epoch, referencing the current epoch.

This command normally applies to the TFP modes 1 and 2. The TFP derives its major time from the timing reference signal in other modes. The format data of this command depends on the command 0x11 time format selection.

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COMMAND 0x13: SET YEAR

This command allows the user to set the year.

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

COMMAND 0x14: SET PERIODIC OUTPUT

This command establishes the frequency of the TFP Programmable Periodic Output. Chapter Three describes the relationship between the dividers n_1, n_2 and the Periodic Output frequency.

BYTE	TYPE	ITEM	VALUE OR RANGE
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: SET INPUT TIME CODE FORMAT

This command selects the time code format for TFP Timing Mode "0" time code input. (See Command 0x10.) Use Command 0x16 to set the modulation type.

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	ID	0x15
1	UINT8 format		See Below

Format Choices

0x41 IRIG A
0x42 IRIG B*
0x49 IEEE 1344 (1 kHz)
0x4E NASA36

***default time code input**

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COMMAND 0x16: SET INPUT TIME CODE MODULATION TYPE

This command selects the time code modulation type format for TFP Timing Mode "0" time code input. (See Command 0x10.). Use Command 0x15 to select the time code format.

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	ID	0x16
1	UINT8	modulation	See Below

Modulation Choices

'M' (0x4D) amplitude modulated sine wave
'D' (0x44) pulse code modulation (DC level shift)

COMMAND 0x17: SET PROPOGATION DELAY COMPENSATION

It is sometimes desired to program an offset into the basic TFP time keeping 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 TFP location. This command allows this time difference to be removed by inserting the known amount of offset between the IRIG B reference and TFP location, in this scenario, a positive offset would be used. The offset is programmable in units of 100 nanoseconds, and may be positive or negative.

***Note*:** If offsets larger than +/- 990 microseconds are used, then the TFP 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 TFP time greater than ±1 millisecond causes the TFP to perform a jam-sync.

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

COMMAND 0x18: REQUEST UTC TIME DATA (bc637 only)

This command queries current GPS to UTC time information. UTC Time Data is acquired from the GPS receiver. This command must be used in conjunction with COMMAND 0x19.

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	ID	0x18
1	UINT8	GPS Time Format	See below
2	UINT8	Leap Second	0 to 0xff
3	INT8	Leap Second Flag	See below
4-7	UINT32	Leap Event UNIX Time	0 to 0xffffffff

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GPS Time Format:

0x00	UTC Time
0x01	GPS Time

Leap Second Flag:

0xff	Deletion Event
0x00	No Event
0x01	Addition Event

COMMAND 0x19: REQUEST TFP DATA

This command requests data from the TFP that is not available via the device registers. The TFP transfers the requested data to the DPRAM Output Area. The data is available to the user as soon as the TFP sets ACK bit 0.

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

Requested Data Type Choices

0x10	Timing Mode
0x11	Timing Format
0x13	Current Year
0x14	Periodic Output
0x15	Time Code Format
0x16	Time Code Modulation
0x17	Timing Offset
0x18	UTC Info Control
0x1B	Time Code Output Format
0x1C	Generator Time Offset
0x1D	Local Time Offset
0x1E	Leap Second Setting
0x1F	TFP Firmware Version
0x20	Clock Source
0x21	Jam Synch Control
0x23	Oscillator Disciplining Control
0x24	D/A Value
0x26	Battery Status
0x29	Clock Value Offset
0x4F	FW Revision
0xF4	Assembly Number
0xF5	Hardware Revision
0xF6	TFP Model
0xFE	Serial Number

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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 TFP.

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	response type	0x10
1	UINT8	Timing Mode	0 – 3, 6

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	response type	0x11
1	UINT8	Timing Format	0 – 1

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	response type	0x12
1-4	UINT32	Binary Time	0 to 2^{32}-1

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	response type	0x13
1-2	UINT16	Year	1970 - 2050

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	response type	0x14
1	UINT8	Synch	0 - 1
2-3	UINT16	Divider n1	0x0002 - 0xFFFF
4-5	UINT16	Divider n2	0x0002 – 0xFFFF

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	response type	0x15
1	UINT8	Time Code Format	‘A’, ‘B’, ‘I’ or ‘N’

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	response type	0x16
1	UINT8	TC Modulation	‘D’,’M’

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	response type	0x17
1-4	INT32	Timing Offset	-9,999,999 to 9,999,999

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	response type	0x18
1	UINT8	Enable UTC	0 – 1
2	INT8	Leap Second Cnt	-127 to 127
3	INT8	Leap Event	-1 to 1
4 – 7	UINT32	Leap Event Time	0 – 0xFFFFFFFF

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BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8 ID	response type	0x1B
1	INT16	Time Code Output	‘B’ or ‘I’

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8 ID	response type	0x1C
1-2	INT16	Generator Offset	-16 to +16
3	UINT8	Half Hour	0 or 1

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	response type	0x1D
1-2	INT16	Local Offset	-16 to +16
3	UINT8	Half Hour	0 or 1

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	response type	0x1E
1	INT8	LS_Flag	-1 to +1
2-5	UINT32	Leap Time	0 to 0xfffffffe 1

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	response type	0x1F
1	UINT8	Major Version	0 – 255
2	UINT8	Minor Version	0 – 255
3	UINT8	month	1 – 12
4	UINT8	day	1 – 31
6-6	UINT16	year	1970 - 2050

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	response type	0x20
1	INT8	Clock Source	0 - 1

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	response type	0x21
1	INT8	Jam Synch Control	0 – 1

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BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	response type	0x23
1	INT8	Disciplining Control	0 – 1
2	INT8	Phase Control	0 – 1
3	UINT16	Phase Step	0 – 0xFFFF
4-5	INT16	Disciplining Gain	-32,768 to 32,768
6-9	SINGLE	Filter Constant	0.000001 - .999999

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	response type	0x24
1-2	UINT16	D/A value	0x0000 – 0xFFFF

COMMAND 0x1A: SOFTWARE RESET

This command vectors the TFP MPU to its power-on reset point and contains no data. Note that the device registers are unaffected.

COMMAND 0x1B: SET TIME CODE OUTPUT FORMAT

This command allows the user to select the time code format generated by the TFP on J1, pin set the IRIG AM and DCLS generation codes format

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	ID	0x1B
1	UINT8	Code Format	See below

Time Code Output Format:

0x42	IRIG B
0x49	IEEE 1344

COMMAND 0x1C: SET GENERATOR TIME OFFSET

This command is used to add/subtract an offset to the time code generator output. This command affects the generator output only.

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	ID	0x1C
1 - 2	UINT16	Local Offset	0xfff0 to 0x0010 (-16 to +16)
3	UINT8	Half Hour	0 or 1

HALF_HOUR:
0 = half hour not present (30 min)
1 = half hour present (30 min)

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COMMAND 0x1D: SET LOCAL TIME OFFSET

This command adds/subtracts local time offset to the TFP time. This command is typically used when the selected timing input is GPS (Command 0x10, Mode 6). This command affects the TFP time only. This offset does not affect the time code output. (See command 0x1C.)

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	ID	0x1D
1 - 2	UINT16	Local Offset	0xfff0 to 0x0010 (-16 to +16)
3	UINT8	Half Hour	0 or 1

HALF_HOUR:
0 = half hour not present (30 min)
1 = half hour present (30 min)

COMMAND 0x1E: PROGRAM LEAP SECOND EVENT

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	ID	0x1E
1	INT8	LS_Flag	-1 to +1
2-5	UINT32	Leap Time	0 to 0xfffffffe

Leap Second Flag: LS_Flag
1 = Insertion
-1 = Deletion (0xff)
0 = Disable

Note: Leap insertion/deletion time is represented as UNIX time (seconds since 1970)

COMMAND 0x20: SELECT CLOCK SOURCE

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

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	ID	0x20
1	UINT8	clock source	see below

Clock Source Choices

'I' (0x49) Internal 10 MHz Oscillator **default setting*
'E' (0x45) External 10 MHz Clock

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COMMAND 0x21: CONTROL JAM-SYNC

This command can be used to disable TFP jam-syncs that normally occur automatically. The default is jam-synch enabled.

It is sometimes desired to program an offset into the basic TFP time keeping 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 TFP location. Command 0x17 allows this time difference to be removed by inserting the known amount of offset between the IRIG B reference and TFP .

***Note*:** If offsets larger than +/- 990 microseconds are used, then the TFP 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 TFP time greater than ±1 millisecond causes the TFP to perform a jam-sync.

BYTE	TYPE	ITEM	VALUE OR RANGE
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 TFP to perform a single jam-sync operation and contains no data. The jam-sync will occur even if jam-syncs are disabled. (See command 0x21.)

COMMAND 0x24: LOAD D/A CONVERTER

The TFP 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 allows the user to fine tune the TFP time base in the Free Running Mode. Since this voltage is routed out of the TFP via the J4 connector to allow external oscillators to be disciplined, it provides a means to devise a frequency control algorithm independent of the TFP. The D/A output voltage ranges from 0.5 V (value = 0x0000) to 4.5 V (value = 0xFFFF.) This value is oscillator dependent. The D/A value is defined at the factory based on the on-board oscillator and stored in the EEPROM. Use COMMAND 0x19 to query the factory value.

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

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COMMAND 0x25: SET DISCIPLINING GAIN

This command 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 valuable to anyone attempting to discipline an external oscillator using the TFP.

NOTE: Use this command with caution, as it will affect the TFP disciplining routine.

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

Gain Defaults:
0x02 = Crystek 600730-30 10.0 MHz
0x14 = MTI 210-xxxx 10.0 MHz

COMMAND 0x26: REQUEST BATTERY STATUS (12083 board only)

This command queries the state of the battery. **Use this command in conjunction with COMMAND 0x19.**

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	ID	0x26
1	UINT8	Status	See below

Battery Status:

0x00	Battery Failed
0x10	Battery OK

COMMAND 0x27 – SYNCHRONIZE RTC TO EXTERNAL TIME DATA (12083 board only)

This command forces a one time synchronization of the RTC clock circuit to the current TFP time. The command is only valid for modes 1, 2, or 6. TFP cannot be in RTC mode (mode 3).

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	ID	0x27

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COMMAND 0x28: DISCONNECT BATTERY TO RTC CHIP (12083 board only)

This command causes the battery manager to not supply battery power to the RTC during the next time that board power is removed. This is used to keep the battery from being discharged while in storage. The next time the board is powered up, the battery manager will automatically resume the function of providing battery power to the RTC when the board power is removed.

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	ID	0x28

COMMAND 0x29: SET/REQUEST ADVANCE/RETARD CLOCK VALUE

This command sets/requests the value of the advance/retard clock that is used to slew the timing of the 1PPS epoch. This command will allow the user to speed up, or slow down, the on-board oscillator while the TFP is in a flywheel state or Freewheel Mode. The TFP adjusts up to 100 msec per second. Each count is 10 µsec. Use this command in conjunction with COMMAND 0x19 to request the clock offset.

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT9	ID	0x29
1-5	INT32	Adjust Value	0x80000000 to 0x7fffffff

COMMAND 0x30: SEND PACKET TO GPS RECEIVER (bc637 only)

This command allows the user to send a GPS data packet to the GPS receiver. The format and use of this command are discussed in the GPS Appendix included in this User's Guide if you have the GPS option.

COMMAND 0x31: REQUEST PACKET FROM GPS RECEIVER (bc637 only)

This command allows the user to request a GPS packet (i.e. position, velocity, status, etc.) from the GPS receiver. The format and use of this command is described in the GPS Appendix included in this manual only if you have the GPS option.

COMMAND 0x32: MANUALLY REQUEST PACKET FROM GPS RECEIVER (bc637 only)

This command is similar in function to command 0x31. Refer to the GPS Appendix for details.

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COMMAND 0x33: SET GPS TIME FORMAT (bc637 only)

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. The default setting is UTC.

UTC = GPS Time - Leap Seconds

BYTE	TYPE	ITEM	VALUE OR RANGE
1	UINT8	ID	0x33
2	UINT8	GPS time format	0 = UTC (default) 1 = GPS Time

COMMAND 0x34: SET GPS MODE FLAG (bc637 only)

By default, the TFP directs the GPS receiver to static operational mode or station mode after the tracking bit resets to zero (0). This command allows the user to disable this feature. See GPS manual for packet 0x2c for details.

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	ID	0x34
1	UINT8	Flag	0 or 1

GPS Mode Flag:

0 = disable
1 = enable (default)

COMMAND 0x40: OBSERVE LOCAL TIME FLAG

This command programs the local time observed flag. If the local time flag is enabled, the TFP adjusts its time data with this flag. See **Command 0x1d** for programming local time offset.

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	ID	0x40
1	UINT8	Flag	0 or 1

Local Time Observe Flag:

0 = disable
1 = enable (default)

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COMMAND 0x41: REQUEST LOCAL TIME OBSERVE FLAG

This command queries the daylight savings and local time observed flag. Use this command in conjunction with COMMAND 0x19.

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	ID	0x41
1	UINT8	flag	0x- 0xff

Flag:

bit0 = reserve
bit1 = reserve
bit2 = reserve
bit3 = local time observe flag
bit4 – bit7 = don't care

COMMAND 0x42: YEAR AUTO INCREMENT FLAG

This command turns on the year auto increment flag. The year variable is stored into the EEPROM at the beginning of each year if the flag is enabled (default).

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	ID	0x42
1	UINT8	Flag	0 or 1

Year Auto Increment Flag:

0 = disable
1 = enable (default)

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COMMAND 0x4F: PCI FIRMWARE PART NUMBER (request only)

This command allows the user to request the TFP firmware revision number.

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	ID	0x4f
1	UINT8		'D'
2	UINT8		'T'
3	UINT8		'6'
4	UINT8		'0'
5	UINT8		'0'
6	UINT8		'0'
7	UINT8		Rev
8	UINT8		Rev
9	UINT8		Rev
10	UINT8		Rev
11	UINT8		Rev

Rev = Revision of the Firmware Part Number

COMMAND 0xF4: ASSEMBLY PART NUMBER (request only)

This command queries the assembly part number of the TFP. The assembly number is an identification of the revision hardware. **Use this command in conjunction with COMMAND 0x19.**

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	ID	0xf4
1-2	UINT16	ASSEMBLY	12043 or 12083

Assembly:

12043 = old hardware
12083 = new hardware

The assembly number is located on the left-hand side of the component side of the PCB.

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COMMAND 0XF5: HARDWARE FAB PART NUMBER (request only)

This command queries the hardware fab part number of the TFP. The number is an identification of the fab being used for this hardware. Use this command in conjunction with COMMAND 0x19.

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	ID	0xf5
1-2	UINT16	ASSEMBLY	12042 or 12082

Assembly:

12042 = old hardware
12082 = new hardware

The assembly number is located on the backside of the PCB.

COMMAND 0xF6: TFP MODEL IDENTIFICATION (request only)

This command queries the PCI family TFP part number. **Use this command in conjunction with COMMAND 0x19.**

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	ID	0xf6
1	UINT8	Model	‘B’
2	UINT8	Model	‘C’
3	UINT8	Model	‘6’
4	UINT8	Model	‘3’
5	UINT8	Model	‘5’ or ‘7’
6	UINT8	Model	‘P’
7	UINT8	Model	‘C’
8	UINT8	Model	‘I’

Model:

“BC635PCI” = IRIG model only
“BC637PCI” = GPS model

COMMAND 0xFE: TFP SERIAL NUMBER (request only)

This command queries the TFP part number. **Use this command in conjunction with COMMAND 0x19.**

BYTE	TYPE	ITEM	VALUE OR RANGE
0	UINT8	ID	0xf7
1-4	UINT32	SN	0x00 – 0xffffff

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CHAPTER SEVEN
INPUTS AND OUTPUTS

7.0 GENERAL

Three different configurations are possible. Table 7-1 shows the connector types provided with each board configuration.

TABLE 7-1

Board Type	Assembly Number	J1	J2	J3	GPS Ant	J4
bc635/637PCI	12043	'DS'	'DP'			
bc635/637PCI	12083	'DS'			SMB (1)	SMB (2)
bc635/637PMC	12073	Micro 'D'	SMB	SMB		Micro 'D'
bc635/637CPCI	12063	'DS'	'DP'			

Notes: 1. Provided with GPS Option
2. Provided with Bias-T Option

7.1 SIGNAL I/O CONNECTOR

This connector is used for most of the I/O signals as defined in table 7-2. This connector is J1 'DS' type for all boards except the bc635/637PMC, where it is J4 'DP' type.

TABLE 7-2

J1 15 PIN 'DS' or PMC J4 15-PIN MICRO 'DP'		
Pin	**Direction**	**SIGNAL**
1	input	External 10MHz input
2	n/a	Ground
3	output	Strobe output
4	output	1PPS output
5	output	Time Code output (AM)
6	input	External Event input
7	input	Time Code input (AM)
8	n/a	Ground (Recommended Time Code return)
9	output	Oscillator Control Voltage output
10	input	Time Code input (DCLS)
11	output	Time Code output (DCLS)
12	n/a	Ground
13	output	1,5,10 MHz output
14	input	External 1PPS input
15	output	Periodic Pulse output

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7.2 ACCUTIME GPS CONNECTOR

This connector is used primarily for connecting the Acutime GPS. It is a high density 15-pin DP type connector J2 on the bc637PCI 12043 and bc637CPCI boards (see table 7-3), or a 9-pin micro DP type connector J1 on the bc637PMC (see table 7-4). This connector is not provided on the bc637PCI 12083 board. Data communications between the board and the GPS receiver are via RS-422 signals. Additionally, the GPS receiver provides a 1pps signal to the board. When the board is connected directly to the GPS receiver, the 1pps is an open collector type signal, but when the optional cable extender box is used, the 1pps signal is transmitted via RS-422. 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 (>300 milliamps) and will automatically reset itself once the excess current drain is removed.

TABLE 7-3

PCI 12043 and CPCI J2 15-PIN 'DP'		
J2	Direction	SIGNAL
1	input	RS-422 Rx (+)
2	input	RS-422 Rx (-)
3	n/a	No Connect
4	n/a	No Connect
5	n/a	Ground
6	input	Bootstrap Load Enable
7	input	GPS 1PPS
8	input	GPS 1PPS RS-422 Rx (+)
9	input	GPS 1PPS RS-422 Rx (-)
10	n/a	Ground
11	output	RS-422 GPS Tx (+)
12	output	RS-422 GPS Tx (-)
13	output	GPS +12VDC
14	n/a	Ground
15	output	GPS +12VDC

TABLE 7-4

PMC J1 9-PIN 'Micro DP'		
J1	Direction	SIGNAL
1	input	RS-422 Rx (+)
2	input	RS-422 Rx (-)
3	n/a	Ground
4	output	RS-422 GPS Tx (+)
5	output	RS-422 GPS Tx (-)
6	input	GPS 1PPS
7	input	GPS 1PPS RS-422 Rx (-)
8	input	GPS 1PPS RS-422 Rx (+)
9	output	GPS +12VDC

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7.3 Ace Module GPS ANTENNA

When an optional GPS module is installed on the bc637PCI, assembly 12083, this connector provides the antenna interface to an external antenna.

7.4 BIAS-T

When an optional bias-t is provided for use with an on-board GPS module for the bc637PCI assembly 12083, this J4 connector provides +5VDC to the Bias-T module. The +5VDC output is fused through a “polyswitch” type device that will shut off the +5VDC output in the event that excess current is drawn (>300 mA) and will automatically reset itself when the excess current drain is removed.

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CHAPTER EIGHT
DRAWING SET

8.0 GENERAL

This chapter contains the schematic diagram, assembly drawing, and parts list for the following assemblies:

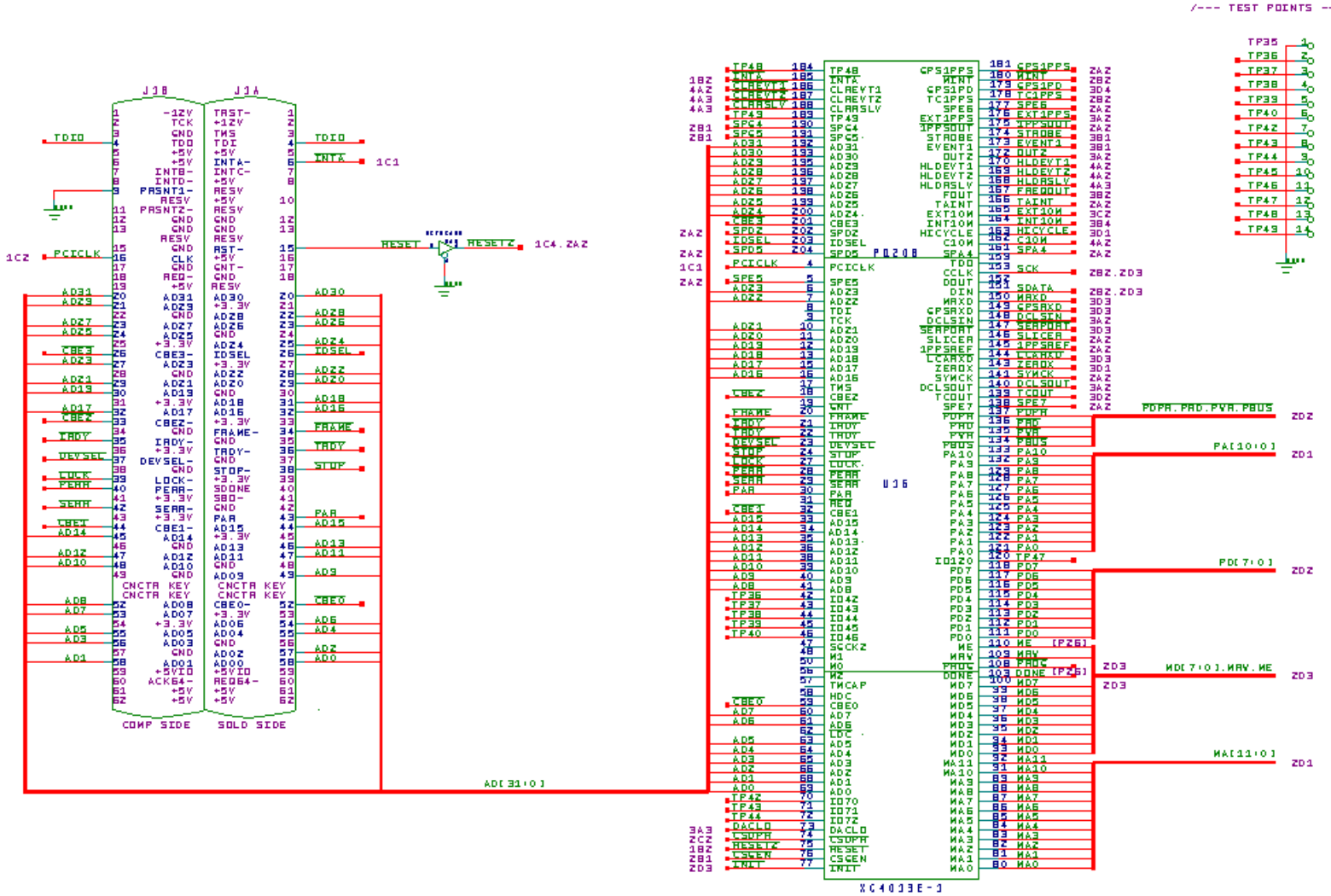
Board	Assembly	Rev
bc635/637PCI	12043	E
bc635/637PCI	12083	N/C
bc635/637PMC	12073	E
bc635/637CPCI	12063	E

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REV	DESCRIPTION	DATE	APPV
-	NEXT ASSY: 12043	11-29-97	HM
A		12-08-97	HM
B	ECO T7800	7-29-98	DL
C	ECO T7804	7-31-98	DL

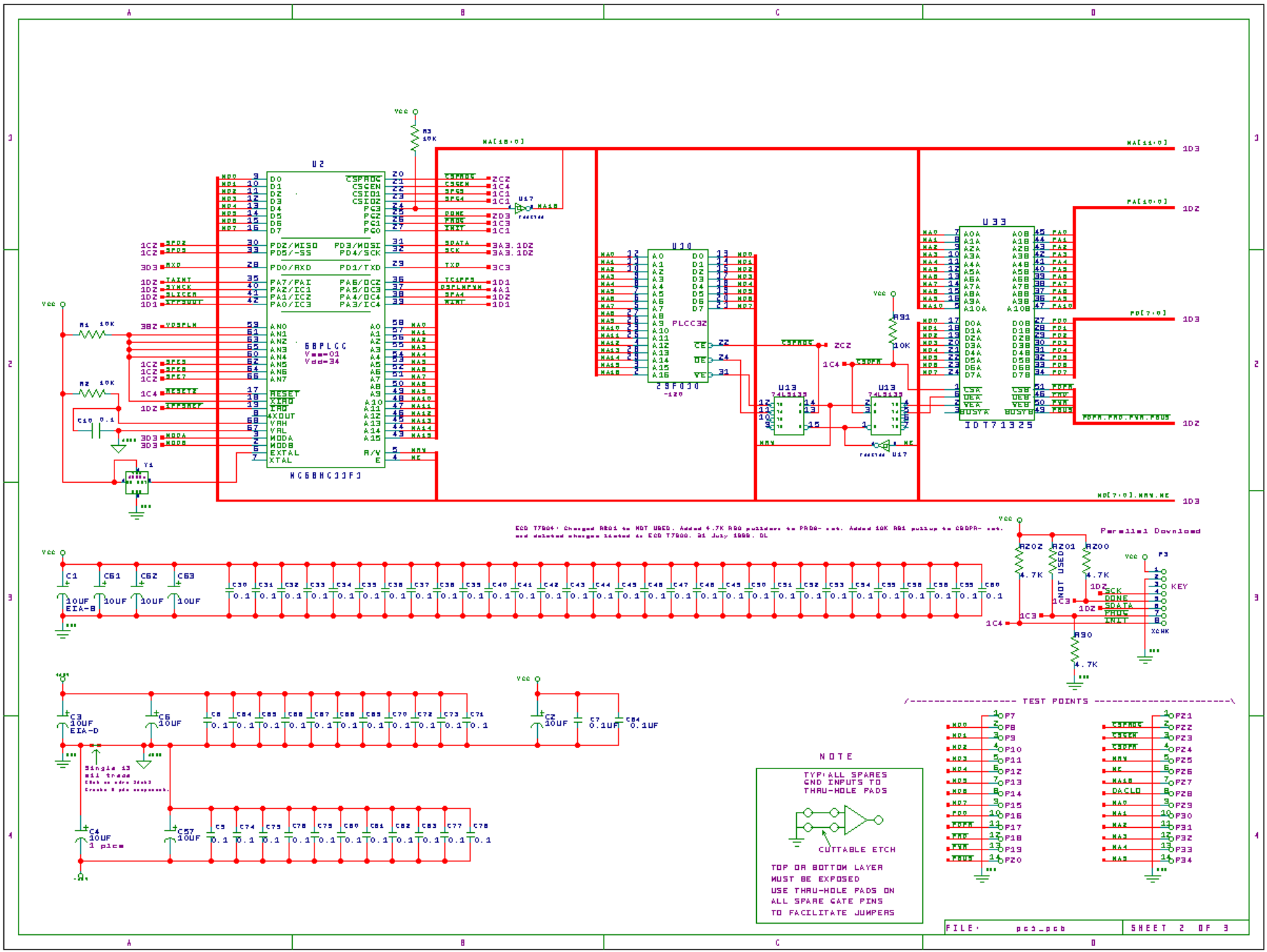


PROJECT: bc635pci	DATUM INC BANCOMM DIVISION		
FILE: pci_pcb			
DRAWN BY: H. Haller	bc635pci PCB SCHEMATIC		
DATE: 7-31-98	PN: 12040	REV: C	SHEET 1 OF 3

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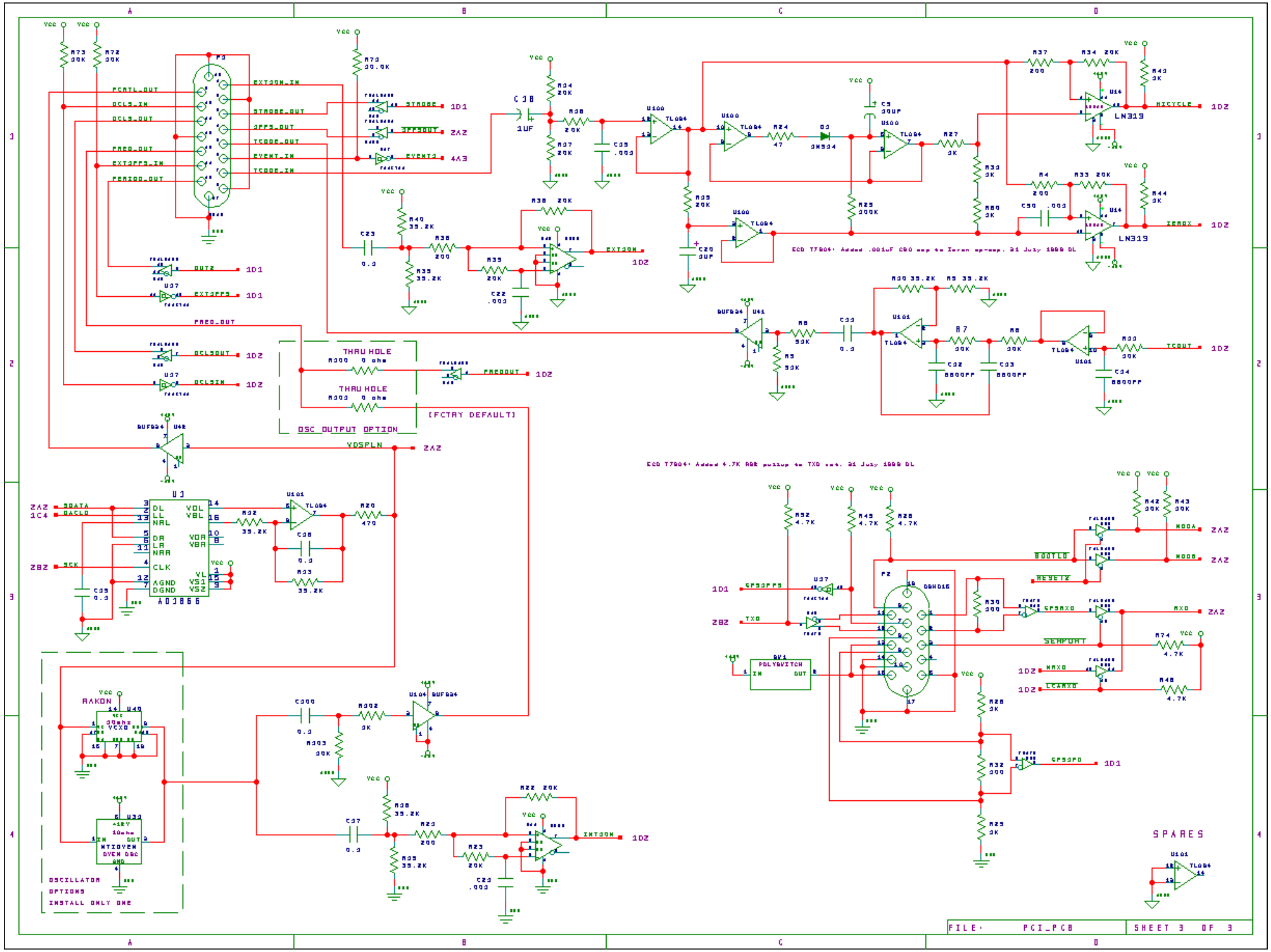
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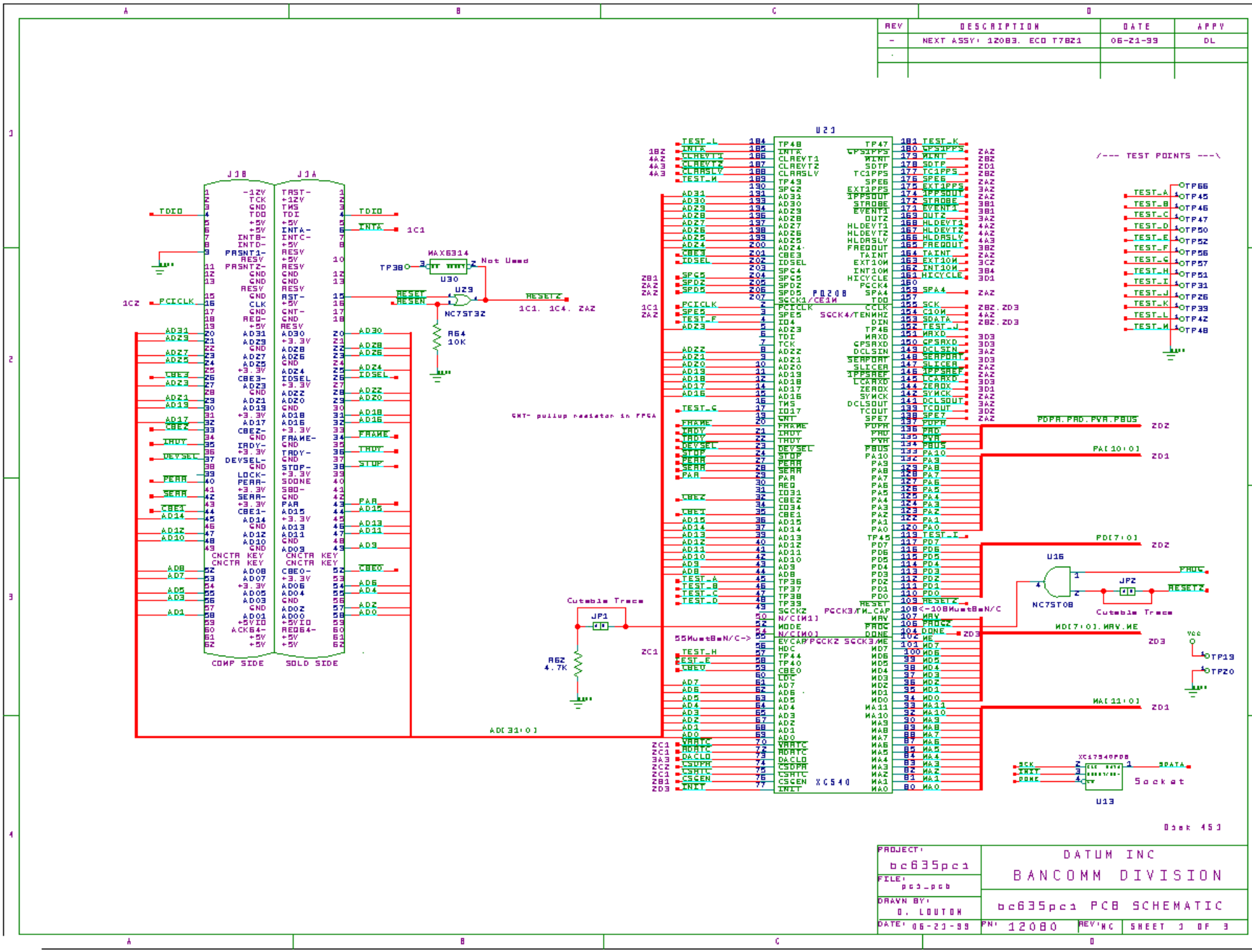
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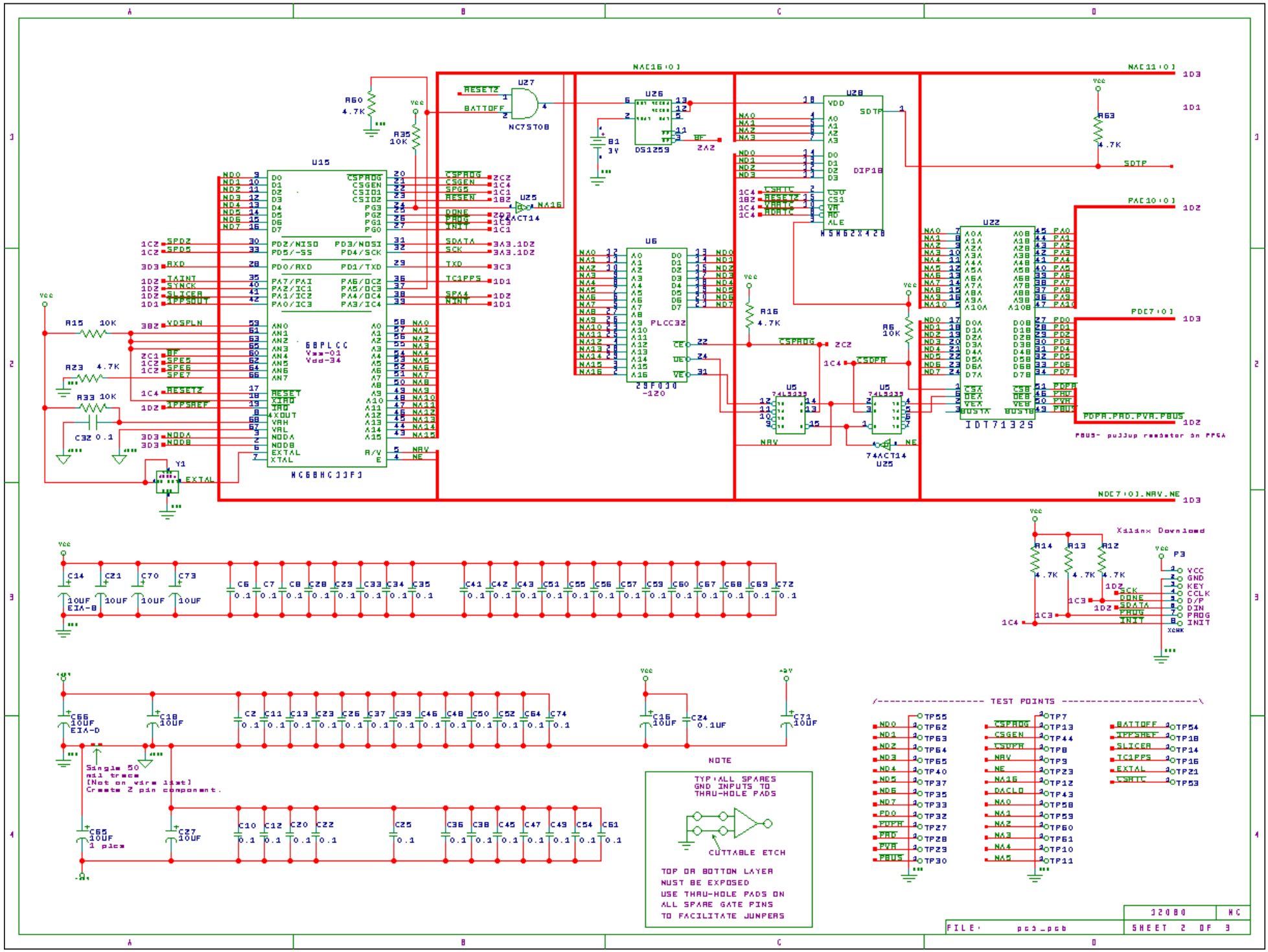
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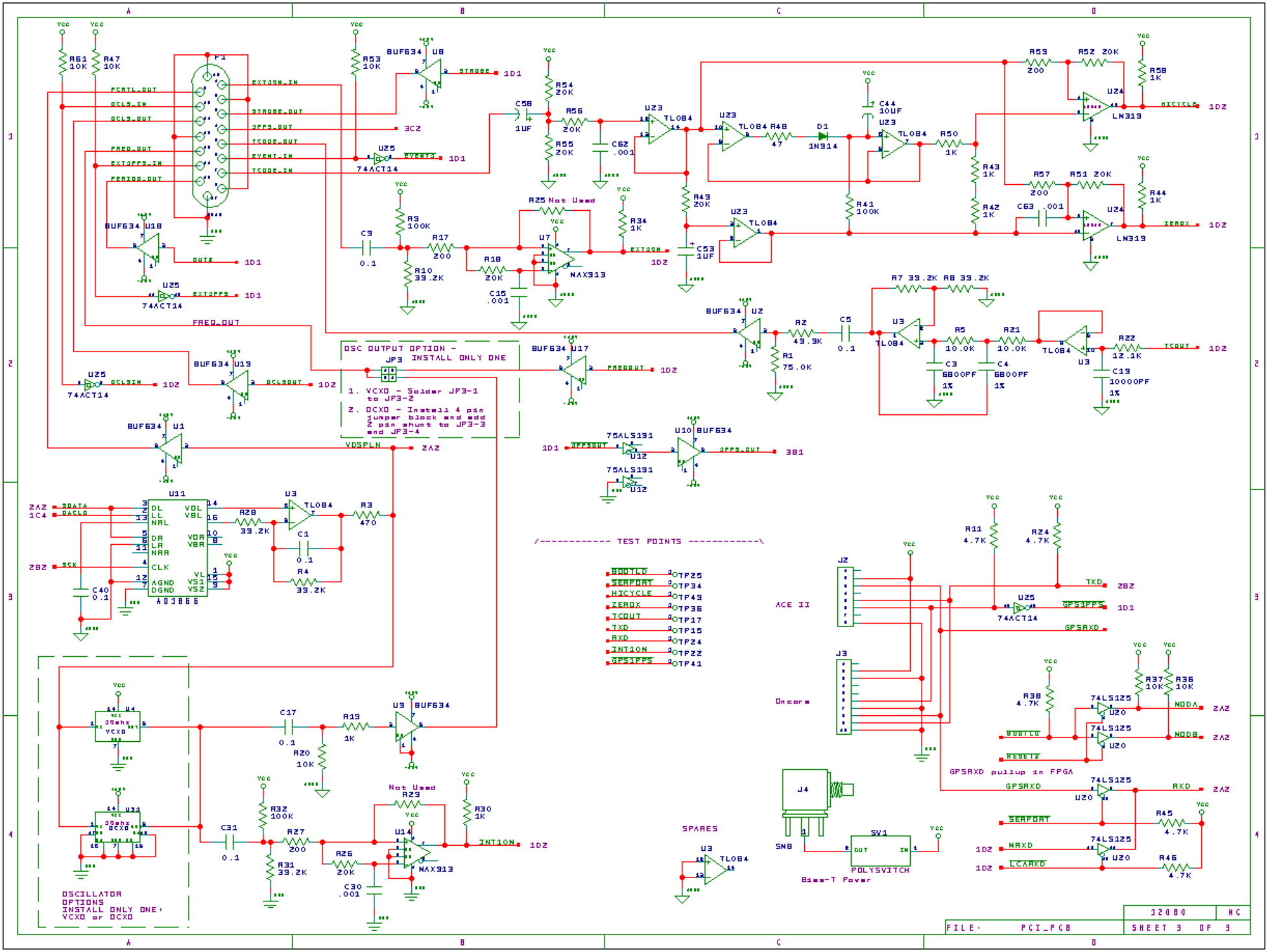
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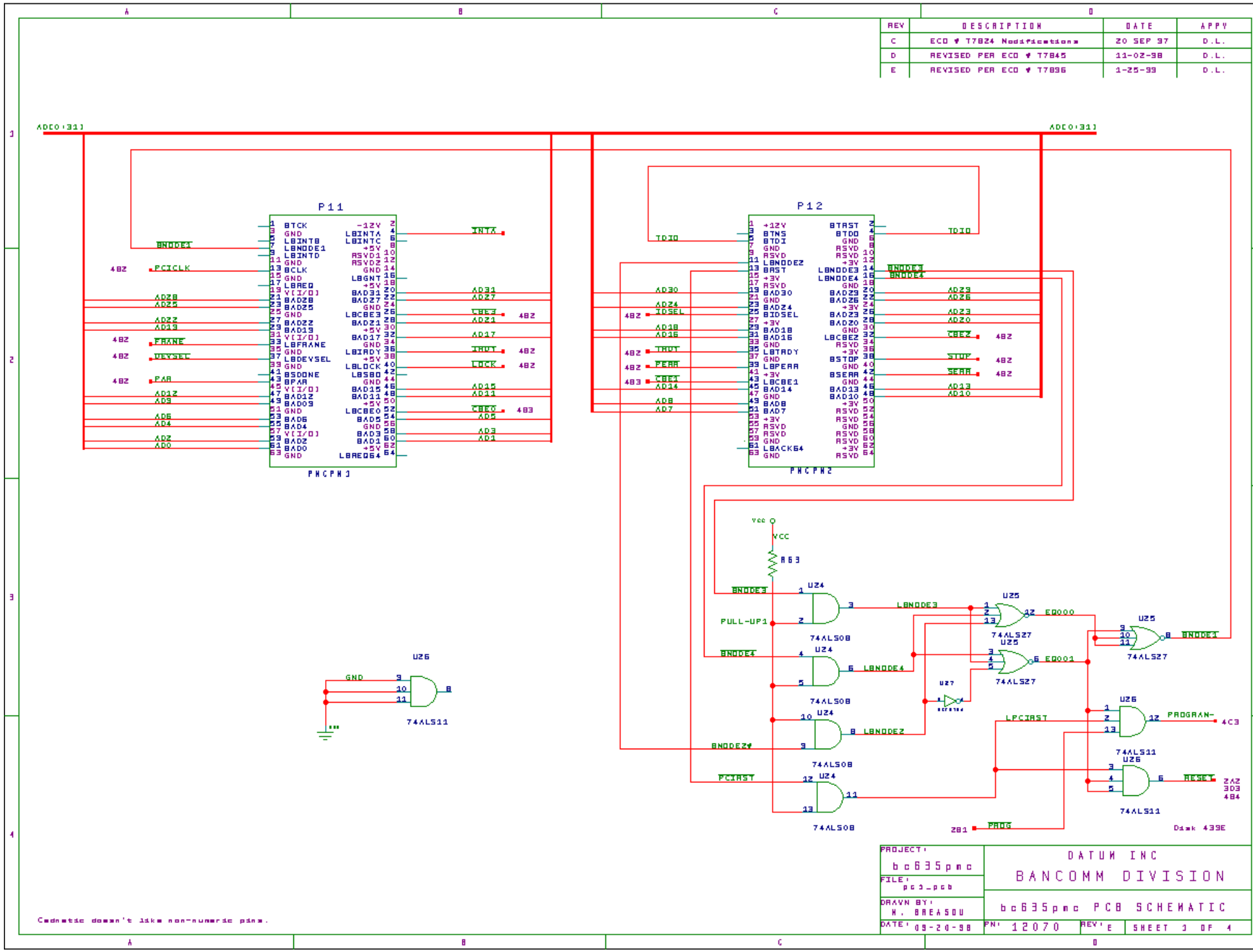
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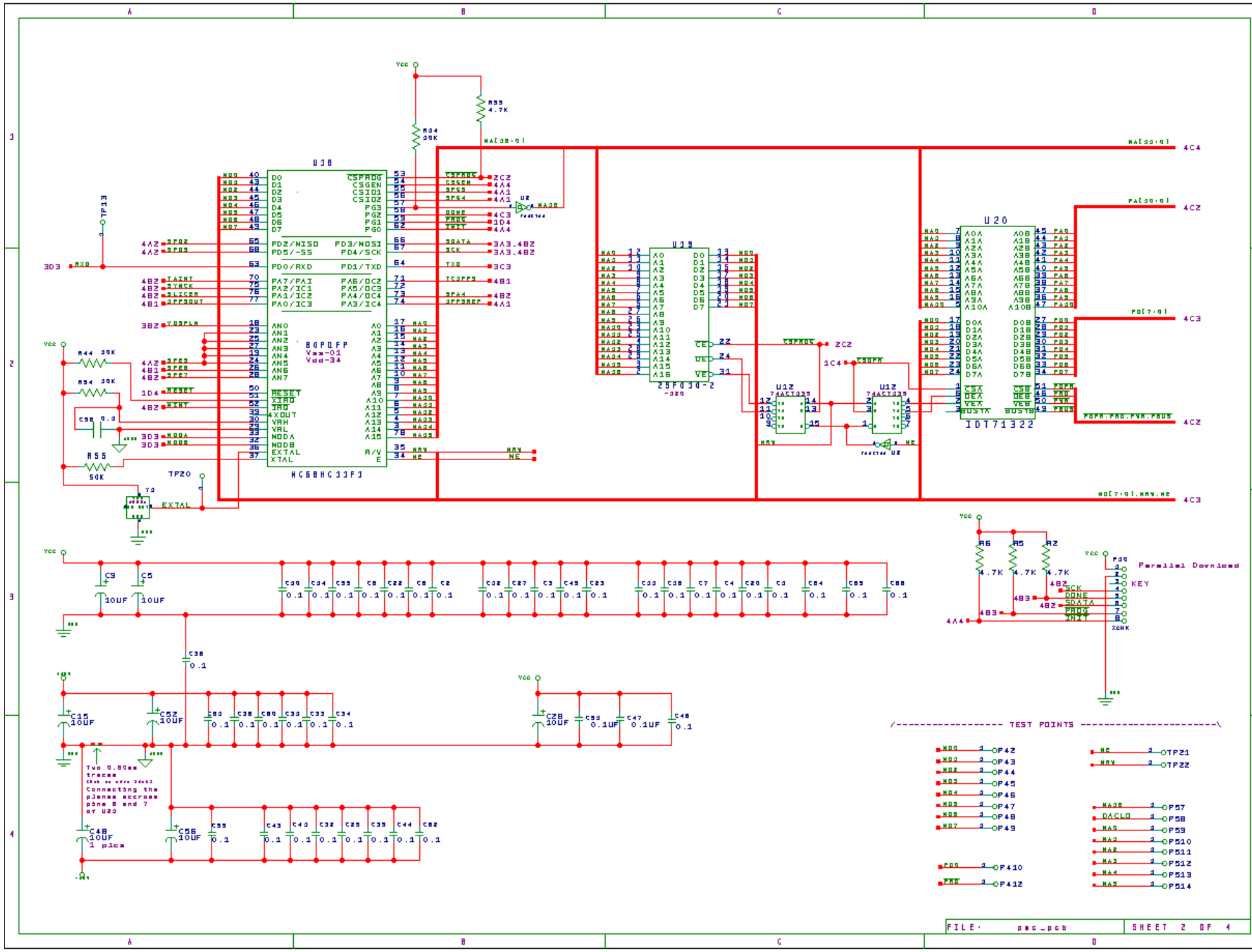
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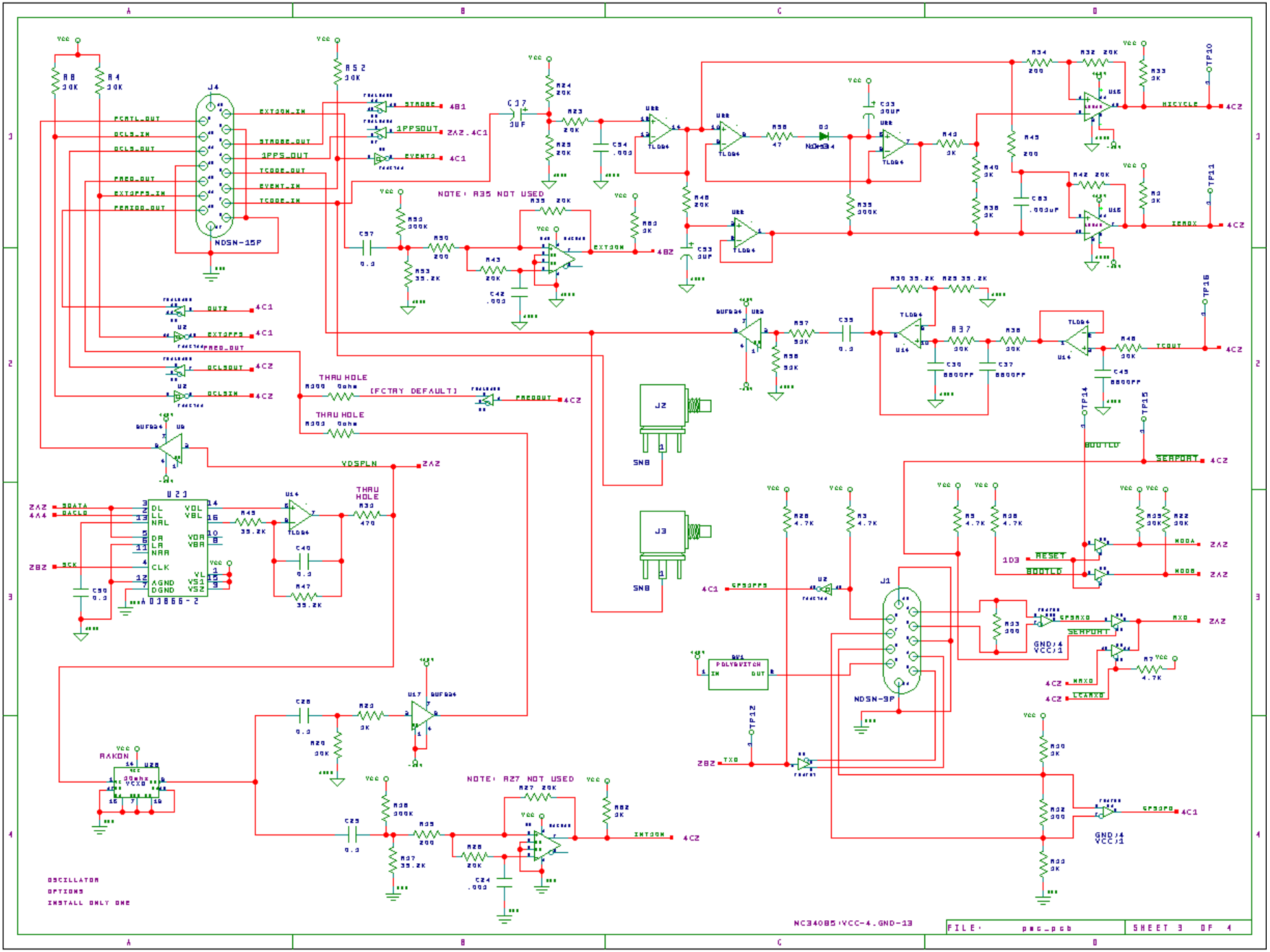
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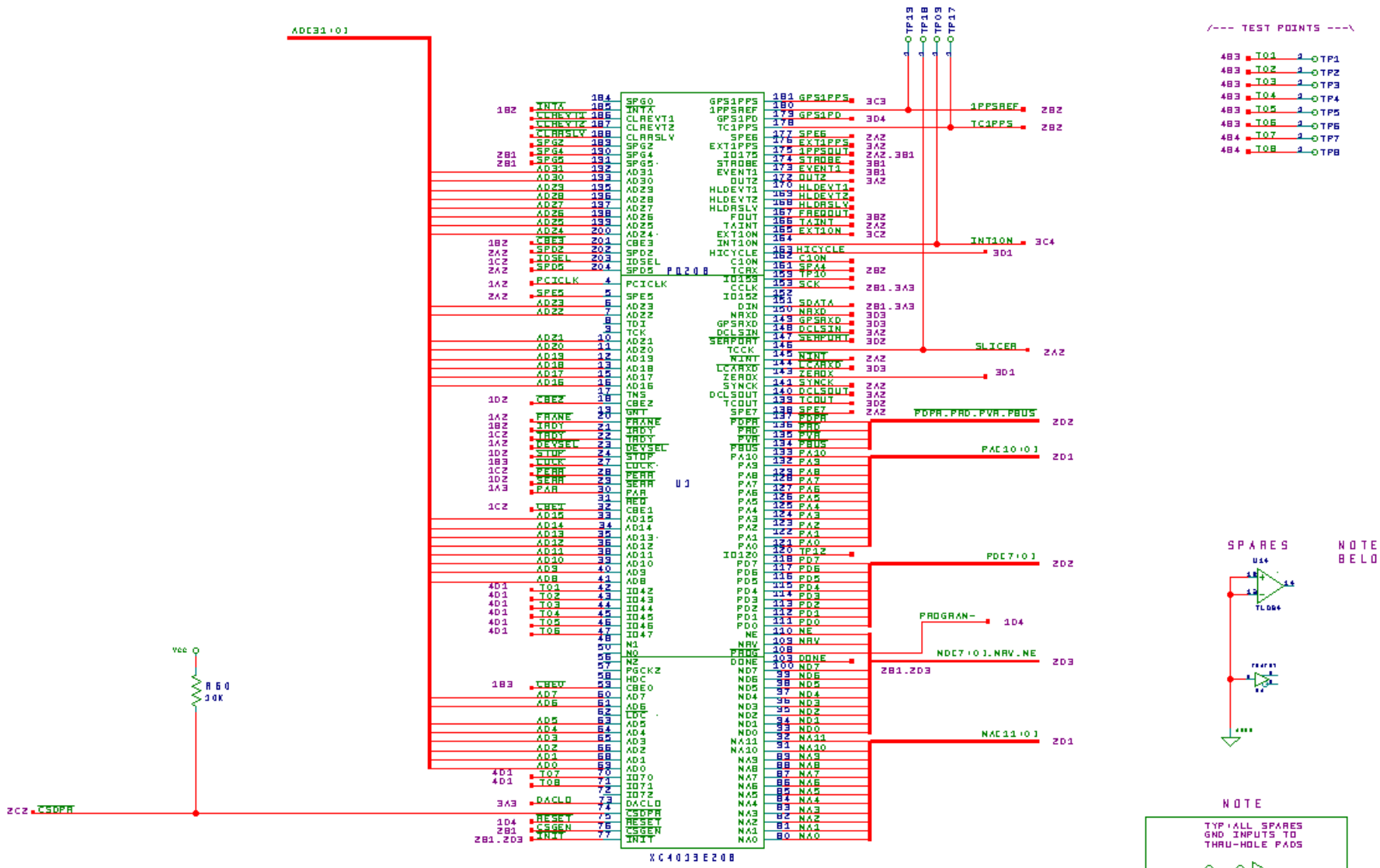
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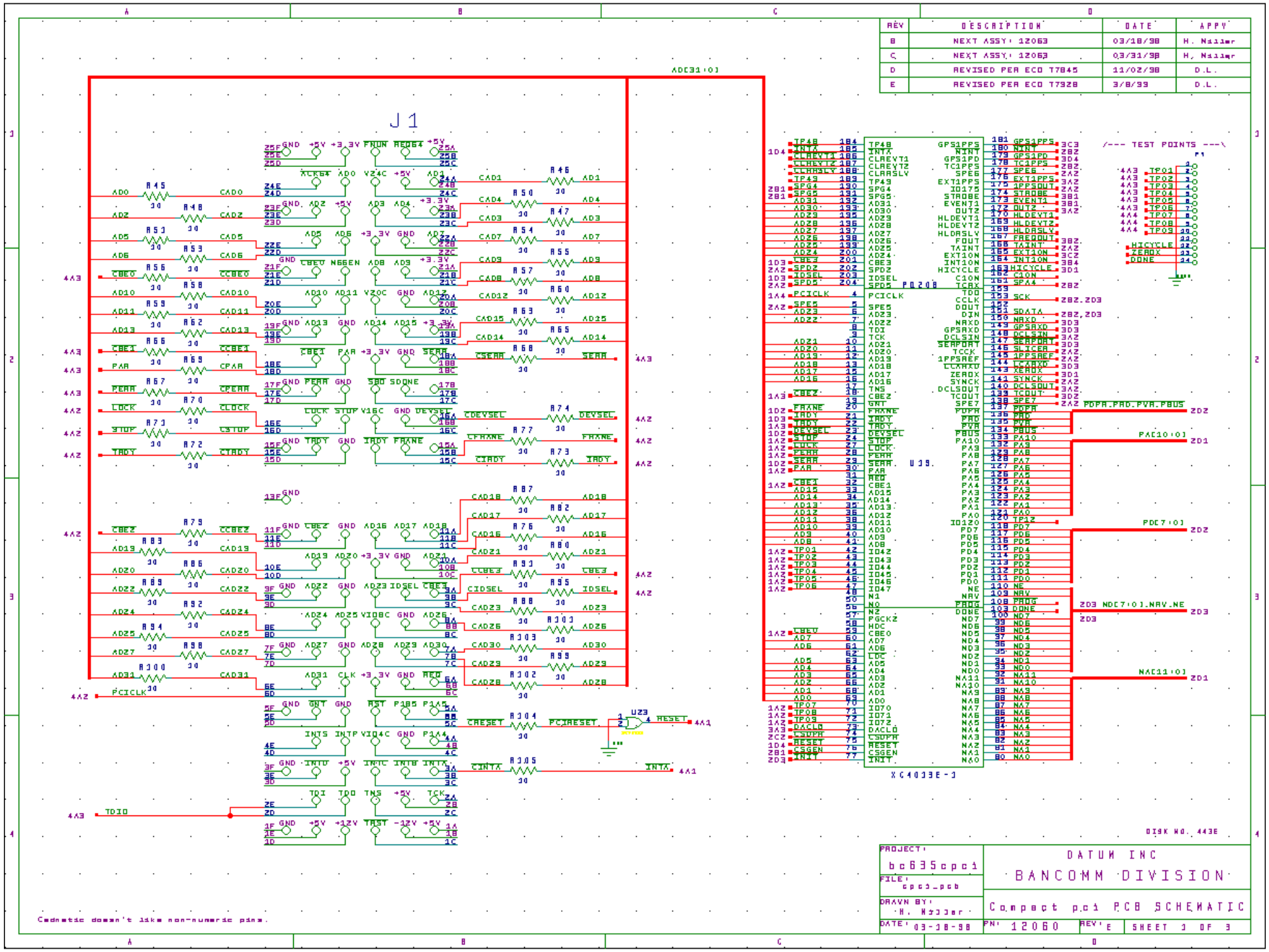
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REV	DESCRIPTION	DATE	APPV
B	NEXT ASSY: 12063	03/18/98	H. Nailer
C	NEXT ASSY: 12063	03/31/98	H. Nailer
D	REVISED PER ECO T7845	11/02/98	D.L.
E	REVISED PER ECO T7928	3/8/99	D.L.

PROJECT:	bc635cpci
FILE:	cpci_pcb
DRAWN BY:	H. Nailer
DATE:	03-18-98

DATUM INC
BANCOMM DIVISION

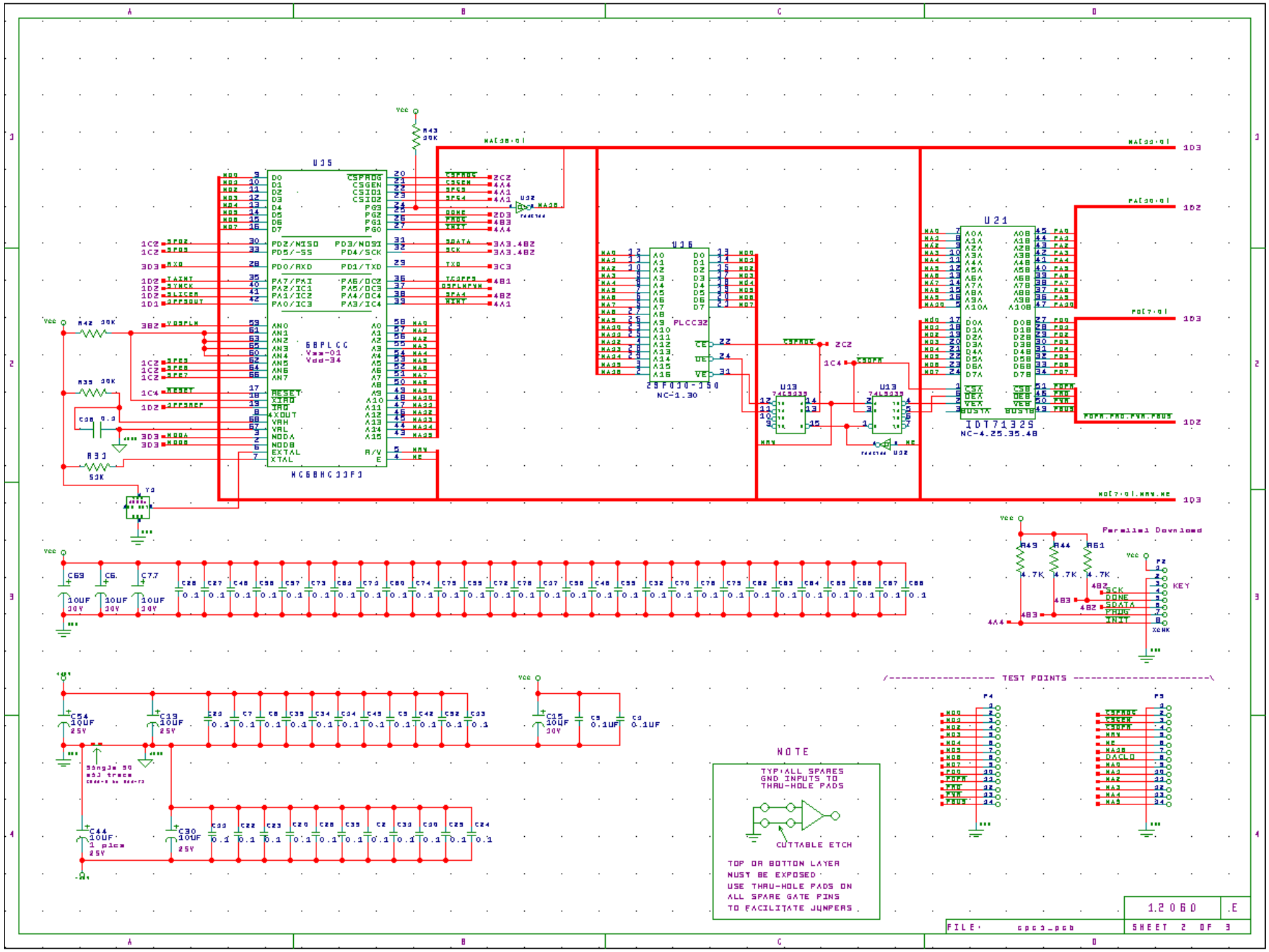
Compact pci PCB SCHEMATIC

PN: 12060 REV: E SHEET 1 OF 3

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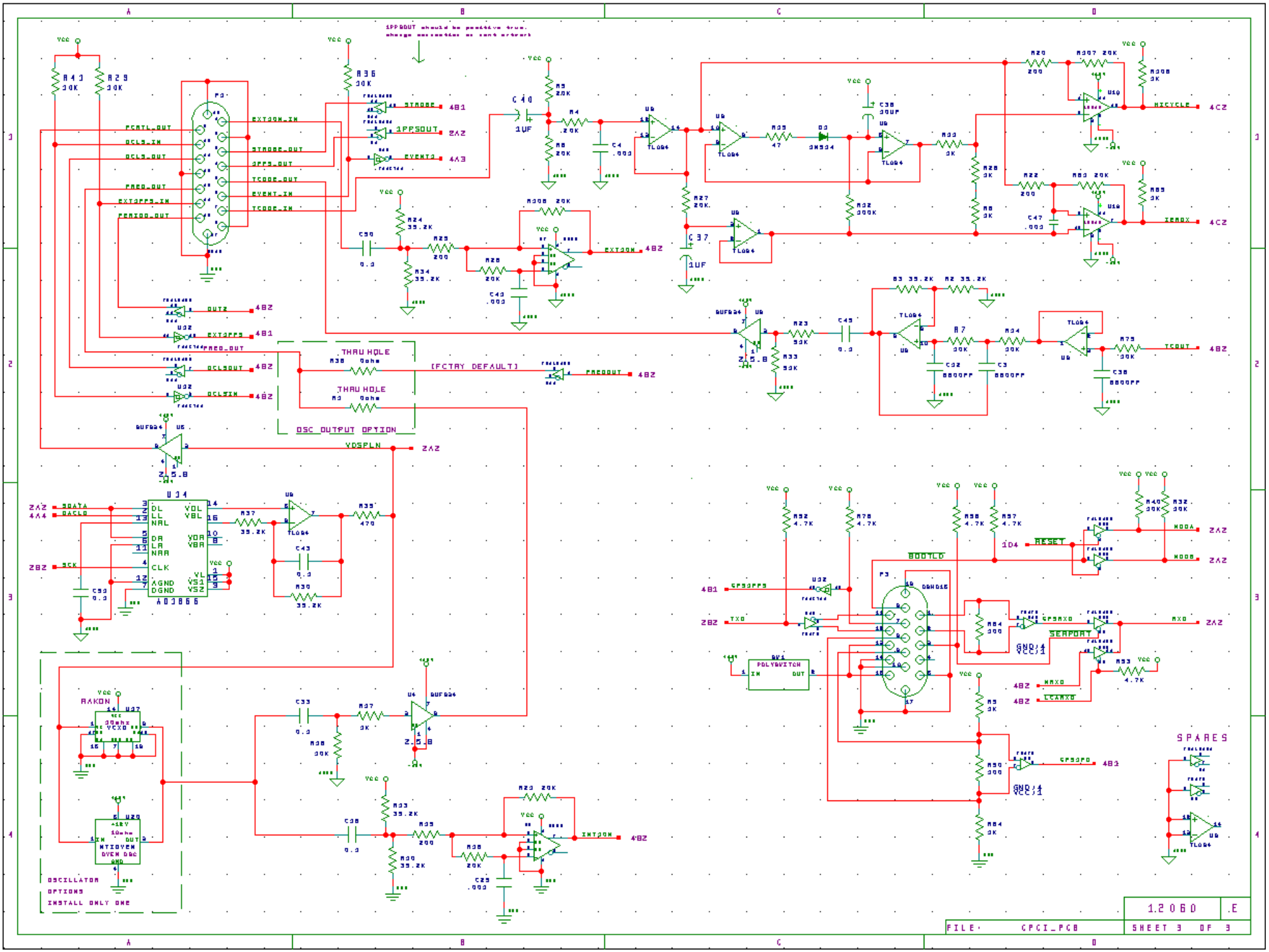
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APPENDIX A

GPS FIELD UPGRADE

A.0 HARDWARE INSTALLATION

WARNING: The BC635/BC637PCI is a static sensitive device. All modifications to this product should be in a static free workspace and performed by a qualified assembler or technician.

Parts included in GPS Field upgrade kit:

PART NUMBER	DESCRIPTION	QUANTITY
2310-4101	Standoff 4-40x5/16	4
55183	GPS Timing Module	1
91200	Antenna Kit	1
4001	4-40x3/16 Screw	8
4048	#4 Split Washer	8
8029	#10 Washer	2

Tools needed for installation:

Small Phillips screwdriver
¼ inch nut driver or open end wrench

Installation: See Figure 1 for visual aid

1. Remove hole plug from front panel location GPS ANT.
2. Install standoffs part number 2310-4101 using four 4-40x3/16 screws (Part number 4001) and four split washers (Part number 4048) to the four mounting holes on the 55183 GPS Timing Module.
3. Remove nut and washer from 55183 SMB connector.
4. Install two #10 washers (Part number 8029) on 55183 SMB connector.
5. Install 55183 on bc635PCI module. Insert the 55183 SMB connector through front panel and secure the standoffs to the bc635PCI module using four 4001 screws and four 4048 washers. Note that some of the mounting holes on the bc635PCI module are oblong for mounting different size GPS Timing Modules. The mounting holes on the GPS timing will locate the standoffs in the correct location.
6. Install washer and nut to 55183 SMB connector. WARNING: DO NOT OVER TIGHTEN. SMB CONNECTOR CAN BE DAMAGED IF TOO MUCH TORQUE IS APPLIED TO THE NUT.
7. Run cable to the roof and install antenna. Antenna needs clear view of the sky.
8. Hardware installation is complete.

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A.1 FIRMWARE FIELD UPGRADE KIT INSTRUCTIONS

If you are running Windows 95, 98, NT or 2000 Operating System(s), follow the steps below. For all other Operating Systems, contact Datum @ (800) 348-0648.

Upgrade Steps:

1- Run the bc635cpp.exe program

2- Under Help click on Hardware Version. Write the board serial number in the line below. Contact Datum Customer Service to obtain the password number for the board, and write the password number below.

Serial Number:

Password:

3- Under Special|Menu click on 'Advanced'

4- Select 'PCI' and click on 'Datum Setting', a pop-up menu will appear.

5- Two upgrade options are available: upgrade the 'Crystal' from 'Standard' to 'MTI oven', and upgrade the model from 'bc635PCI' to 'bc637PCI' GPS.

6- To upgrade the model, select the 'Model' button and click on 'bc637PCI' button. Enter the password, listed above, in the password field. Select the OK button to change the model number.

7- Note that the password will only work with the board that has the serial number listed above.

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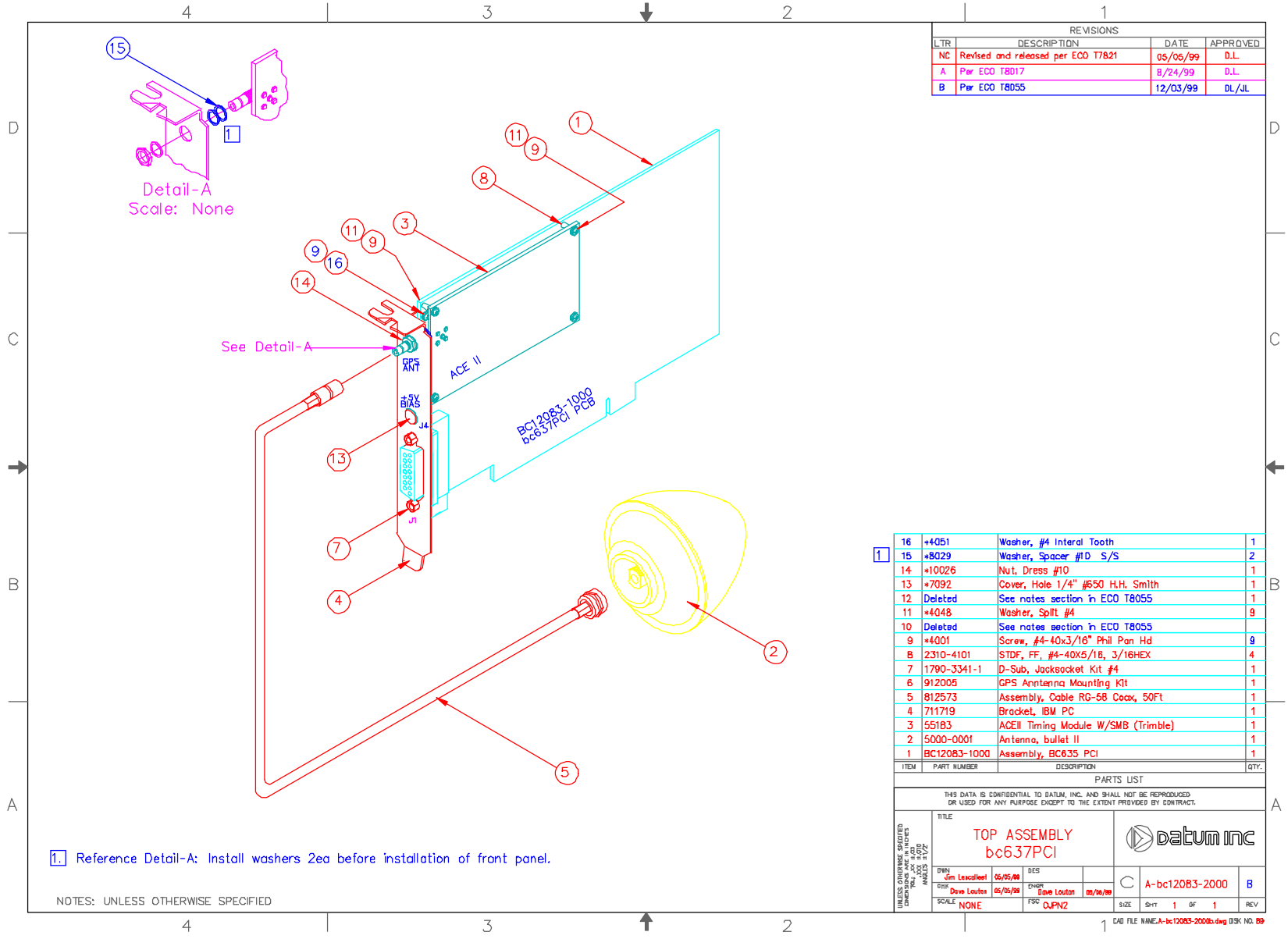


Figure 1 Top Assembly Drawing

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APPENDIX B
GPS RECEIVER INTERFACE

B.0 GENERAL

The bc637PCI GPS System consists of a bc637PCI PCI Time and Frequency Module (TFP) equipped with special firmware, an Acutime GPS receiver/antenna module manufactured by Trimble Navigation Ltd., and an interconnecting cable. The bc637PCI module communicates with the Acutime via RS-422 serial (9600 bps) lines. The Acutime also provides a 1pps signal to the bc637PCI.

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.

B.1 GPS TIMING MODE (MODE 6) CHARACTERISTICS

In order to function with the Acutime GPS Receiver the bc637PCI module must operate in Timing Mode 6 (GPS Timing Mode.) This is the default timing mode for the bc637PCI when equipped with the special GPS firmware which is a standard part of the bc637PCI 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 10 MHz 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 bc637PCI will flywheel.

- The bc637PCI extracts major time and satellite tracking status information from data packets sent from the Acutime. By default, the bc637PCI provides UTC time to the user. The user can select GPS time instead by issuing the DPRAM command 0x33 (Select GPS Time Format) described in Chapter Five.

- The bc637PCI 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 bc637PCI ignores all other timing sources (i.e. the time code input and external 1pps input signals.)

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B.2 COMMUNICATING WITH THE GPS RECEIVER

The dual-port RAM (DPRAM) interface described in Chapter Five 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 zero or more data bytes. A packet length of zero indicates that no valid packet ID and data bytes are present. The GPS data packet structure is summarized below:

BYTE	ITEM
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 bc637PCI automatically adds (when sending packets) and removes (when receiving packets) the header and trailer bytes and handles all byte-stuffing/unstuffing operations. The bc637PCI user should be concerned with the packet length, packet ID, and packet data bytes only.

B.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:

BYTE	TYPE	ITEM	VALUE OR RANGE
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.

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B.2.2 RECEIVING GPS DATA PACKETS FROM THE GPS RECEIVER

The DPRAM GPS Packet Area holds packets received from the Acutime. The bc637PCI writes GPS packets to this area upon user request. The format of the packets in the GPS Packet Area is shown below:

BYTE	TYPE	ITEM	VALUE OR RANGE
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 bc637PCI sets ACK register bit two whenever it writes a GPS packet to the GPS Packet Area. The transition of ACK register bit two from zero to one is interrupt source four (GPS Packet Available.) The user must clear ACK register bit two.

B.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:

BYTE	TYPE	ITEM	VALUE OR RANGE
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 bc637PCI either periodically (e.g. position fix) or whenever they change (e.g. satellite selection.) The bc637PCI 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 bc637PCI whenever the user requests them. Note that it can take 10's or 100's of milliseconds for the bc637PCI to retrieve a packet from the Acutime. GPS packets that are monitored by the bc637PCI are identified below.

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Packet ID	Monitored	Packet Description
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 (***Note***: 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 bc637PCI 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 bc637PCI has not yet received a monitored packet, then the bc637PCI 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 bc637PCI sets ACK bit 0 to acknowledge the retrieve packet command. Later, when the Acutime responds with the retrieved packet, the bc637PCI 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 3 seconds), then the bc637PCI sets the packet length byte in the DPRAM GPS Packet Area to zero and sets ACK bit 2.

- If the retrieved packet ID is not on the list above, the bc637PCI sets the packet length byte in the DPRAM GPS Packet Area to zero, sets ACK bit 2, then sets ACK bit 0.

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B.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 bc637PCI 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 bc637PCI will ignore the response, in which case, this command would be functionally identical to command 0x30. The bc637PCI 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 bc637PCI sets ACK bit 2. As with command 0x31, if the Acutime fails to respond within a timeout period, the bc637PCI 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.

BYTE	TYPE	ITEM	VALUE OR RANGE
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.

BYTE	ITEM	VALUE
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:

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

B.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 B-1 lists the Acutime performance specifications.

Table B-1
Acutime Performance Summary

Item	Description
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

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B.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.

B.5 bc637PCI GPS DEFAULT PARAMETERS

The bc637PCI sends the following GPS packets to the Acutime on reset or whenever the Timing Mode is changed to GPS Timing Mode 6.

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Set Operating Parameters (GPS packet 0x2C)

PACKET DATA ITEM	VALUE
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)

PACKET DATA ITEM	VALUE
packet ID	0x75
mode	0 (high-8)

Set I/O Options (GPS packet 0x35)

PACKET DATA ITEM	VALUE
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 bc637PCI monitors position and velocity packets so the “position” and “velocity” options should be sent with bits 0 and 1 set; the bc637PCI extracts major time from time packets broadcast by the Acutime so the “timing” option should be sent with bits zero, one, and two cleared.

B.6 GPS SYSTEM OVERVIEW

The GPS system consists of three parts called segments:

- The space segment consists of 18 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 uplink stations, and one master control station.

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- 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. T he 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 manual. Further information may be obtained from the paperback overview Guide to GPS Positioning, prepared by David Wells and published by the Canadian GPS Associates.

B.7 GPS PACKET DEFINITIONS

The following pages describe the GPS packets available with the Acutime GPS Receiver. These pages were taken directly from Trimble Navigation's Acutime Manual (Rev A, 1992). Datum Inc does not take responsibility for the form or content of the folowing pages. Additionally, the section numbers do not follow the same order as this appendix. **Trimble Standard Interface Protocol (TSIP)**

Version 1.15

1.0 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 and 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.

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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.

1.1 INTERFACE SCOPE

The Trimble Standard Interface Protocol is used in a large number of Trimble 3 and 6 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 thus 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 RS422 version has one bi-directional port only.

For the RS232 Acutime range of sensors there are some particular considerations for the setup of Serial Channel A and Channel B (or Channels 1 & 2).Channel 1 operates in the same way as for all other Trimble 2, 3 and 6 satellite channel sensors, i.e. 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.

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. As will be discussed, 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. Some knowledge of the theory of the GPS system is assumed; those readers wishing to refresh their knowledge of the theory are directed to Section 2 of this document for references. 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 PKTMON 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.

1.2 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

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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 so doing, the GPS will only output a position fix when it has continuous lock on three or more satellites simultaneously.

In a downtown urban canyon, however, 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 3 or 4 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' options to OFF, gives the receiver more latitude in selecting and propagating old measurements to yield a position fix, albeit 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 also that Minimize Projection is set ON by default; in this case where obscuration occurs, new positions will be computed for 3-4 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, however, 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 degrees 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.

1. **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.

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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.

2. **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.

   (a) **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.

   (b) **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.

   (c) **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.

   (d) **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

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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.

3. **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.

   (a) **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.

   (b) **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.

   (c) **Minimized Projection** In this mode, the time of solution is the time of the most recent measurements. Thus, 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.

4. **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 if off), slightly older measurements are tolerated (on the order of 3-5 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.

5. **Additional Fix Status** Setting bit three 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 three bits of byte one 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.

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The least significant three bits (Bits 0-2) of byte zero 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 zero 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.

6. **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 1 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 1: Suggested Parameter Settings

	High Obscuration		Low Obscuration	
Parameter	Accuracy	Fixes	Accuracy	Fixes
Fix mode	man 3D	Auto	man 3D	Auto
Elevation mask	10	5	10	5
Signal mask	6.0	4.0	6.0	4.0
PDOP mask	6.0	12.0	6.0	12.0
PDOP switch	NA	8.0	NA	8.0
Timing mode	min proj	DC	min proj	DC
Sync meas.	OFF	OFF	ON	ON
Min. projection	ON	DC	ON	DC
DGPS mode	man ON	DC	man ON	DC

2.0 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

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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 3 abstracts published between 1980 & 1986 of papers from the Journal of the Institute of Navigation. Essential source material for any system designer.

3.0 SIGNAL CHARACTERISTICS

3.1 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 one stop-bit. "Clear to send" flow control signals are included in the design and should be used to eliminate the possibility of over-run. For details, see Section 3.7 of the manual, *Digital Communication Interface*.

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.

3.2 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.

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."

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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 (unformatted) 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 (unformatted) leading "1," the double-precision mantissa contains 52 significant bits.

3.3 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 2 hexadecimal digits. This byte can have any value other than 10 hex (ASCII <DLE>) or 03 hex (ASCII <ETX>). The values and their meanings are given in the remainder of this appendix.

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

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3.3.1 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.

<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
25	initiate soft reset & self-test (equivalent to cycling power)	45,46, 4B, 42 or 83 4A or 84
26	request health	46, 4B
27	request signal level	47
28	request GPS system message	48
29	request almanac health page	49
2A	altitude for 2-D mode	--
2B	initial position (Lat, Lon, Alt)	--
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 (lat, lon, alt)	
34	satellite number for 1-sat mode	--
35	set/request I/O options	55
36	velocity aiding of acquisition	--
37	request status and values of last pos & vel	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

3.3.1.1 **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. Note that 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.

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3.3.1.2 **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.

3.3.1.3 **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.

3.3.1.4 **20** Request Almanac

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

3.3.1.5 **21** Request Current Time

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

3.3.1.6 **22** Position Fix Mode Select

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

Mode	Data byte value	PKTMON key command
Automatic	0 (default value)	^N
1-satellite (0-D)	1	^T
3-satellite (2-D)	3	n
4-satellite (3-D)	4	N

This selection is held in battery-backed memory

The 1-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.

3.3.1.7 **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.

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This packet causes a world-wide search for the user's position, starting at the position entered via this packet. That takes about 6 to 10 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. (Note that 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 degree 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

3.3.1.8 **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.

3.3.1.9 **25** Initiate Soft Reset & 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 unrequested, then either the Acutime power was cycled or the Acutime was reset.

3.3.1.10 **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.

3.3.1.11 **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.

3.3.1.12 **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.

3.3.1.13 **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.

3.3.1.14 **2A** Altitude for 2-D Mode

This packet provides the altitude to be used for Manual 2-dimensional (3 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-

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backed memory.

3.3.1.15 **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 6 to 10 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. (Note that 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

3.3.1.16 **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 4 or more satellites are available and the resulting PDOP is not greater than the PDOP switch value, then 3-dimensional fixes are calculated. The PDOP switch is effective only in the automatic 2-D/3-D mode.

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Byte #	Item	Type	Units	Default value
0	Dynamics code	BYTE	3 (see table)	

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

1-4	Elevation angle mask	SINGLE	radians	0.1745 (10 degrees)
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 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 1-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 one pps (Pulse Per Second) output even if a full position fix cannot be done.

3.3.1.17 **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.

3.3.1.18 **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 #	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.

3.3.1.19 **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

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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.

3.3.1.20 **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.

3.3.1.21 **33** Request A-to-D Readings

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

3.3.1.22 **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 one 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.

3.3.1.23 **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. Please review the discussion in Section 1.2 to help in selection of the right settings. 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.

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Byte #	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: 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	Superpacket output 0: off 1: on	
		6	0	Superpacket format 0: binary 1: ASCII	
		7	0	unused	

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

1	velocity	0	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 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 codephase (V1.12 onwards) 0: raw 1: smoothed	
	2	0		Additional Fix Status(V1.14 onwards) 0: off 1: on	5E
	3 - 7	unused			

Glossary for the table above:

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

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3.3.1.24 **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	
Byte Value	**Meaning**		
0	XYZ		
1	ENU (East, North, Up)		
1	Velocity aiding enable flag	BYTE	
Byte Value	**Meaning**		
0	disable velocity aiding		
1	enable velocity aiding (See note below.)		
Byte Value	**Meaning**		
2-5	X or East velocity	SINGLE	meters/second
6-9	Y or North velocity	SINGLE	meters/second
10-13	Z 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 25 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 25 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.

3.3.1.25 **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.

3.3.1.26 **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 that 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 0 through 2; to load data, use all bytes. Before loading data, observe the caution notice below.

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Byte #	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. Dataformat, content, and protocol should be obtained through consultation with Trimble Navigation before use of 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.

3.3.1.27 **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.

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 "1" and enabled satellites are signified by a "0".

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Byte #	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 32 satellites
			4	Heed health on satellite (default)
			5	Ignore health on satellite
			6	Request heed-or-ignore status on all 32 satellites
1	Satellite #	BYTE	0	all 32 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

Improperly 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.

3.3.1.28 **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 #	Item	Type	Byte value	Meaning
0	Satellite #	BYTE	0	All satellites in the current tracking set
			1-32	Desired satellite

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3.3.1.29 **3B** Request Current Status Of Satellite Ephemeris Data

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

Byte #	Item	Type	Byte value	Meaning
0	Satellite #	BYTE	0	All satellites in the current tracking set
			1-32	Desired satellite

3.3.1.30 **3C** Request Current Satellite Tracking Status

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

Byte #	Item	Type	Byte value	Meaning
0	Satellite #	BYTE	0	All satellites in the current tracking set
			1-32	Desired satellite

3.3.1.31 **3D** Request or Set Data Channel A Configuration for Differential Corrections

This packet is not supported by the GPS Software Toolkit - PKTMON. 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 one 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.

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

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(1) Note: The default of byte 5 is set to RTCM automatically on start-up, with default settings for the port at; 9600, 8, o, 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	RCV 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		

Byte	Item	Type	Units		
2	Parity and # bits/char code	BYTE	xxxpppbb		
			ppp:		
				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)	

Notes: 1) In most RS232 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. Note that the default speed is 9600,8,o,1.

2) If the bit is set to 5, then output is standard NMEA ASCII, GGA + VTG. See Appendix 3 for syntax.

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

3.3.1.32 **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. Note also that Packet 35 can be set to request Packet 5E automatically.

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3.3.1.33 **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 one 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; and the Acutime automatically sets itself to mode 3 (differential currently on) if the Acutime 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.

3.3.1.34 **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 one byte specifying the PRN number of the desired satellite or zero to request all available. The response is a packet 85 for each satellite.

3.3.2 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.

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Id (hex)	Description	When Sent			
		Power-up	Auto-matic	If selected	Response to Packet Number
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 & 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 & 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		
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

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

(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.

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

3.3.2.1 **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.

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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	$(meters)^{1/2}$
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.

3.3.2.2 **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 15 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 that 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 # 0 starting January 6, 1980.

The seconds count begins with "0" 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 status code.

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approx. 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

Application 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").

3.3.2.3 **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

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.

3.3.2.4 **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.

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3.3.2.5 **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 30 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	Auto, 1-satellite, 0-D
			03 hex	Auto, 3-satellite, 2-D
			04 hex	Auto, 4-satellite, 3-D
			11 hex	Manual, 1-satellite, 0-D
			13 hex	Manual, 3-satellite, 2-D
			14 hex	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 zero 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 zero. Negative PDOP values indicate that the PDOP is greater than the PDOP mask value and therefore the Acutime is not performing fixes.

3.3.2.6 **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.

3.3.2.7 **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 following table.

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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 1 usable satellite
			0A hex	Only 2 usable satellites0B hex Only3 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)

Notes: **(1)** After this error is detected, its bit remains set until the Acutime is reset.

(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.

(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.)

(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.

(5) **This bit is always set as the Accutime receiver battery backup is not installed.**

3.3.2.8 **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

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Byte #	Item	Type
0	Count	BYTE
1	Satellite number 1	BYTE
2- 5	Signal level 1	SINGLE
6	Satellite number 2	BYTE
7-10	Signal level 2	SINGLE
(etc.)	(etc.)	(etc.)

Up to 12 satellite number/signal level pairs may be sent, indicated by the count field. Signal level is normally positive. If it is zero 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.

3.3.2.9 **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.

3.3.2.10 **49** Almanac Health Page

This packet provides health information on 32 satellites. Packet data consists of 32 bytes each containing the 6-bit health from almanac page 25. First byte is for satellite #1, 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 # 1
2	health of satellite # 2
.	.
.	.
.	.
32	health of satellite # 32

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.

3.3.2.11 **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

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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.

3.3.2.12 **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	20	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.

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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	Superpackets supported

3.3.2.13 **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 4 or more satellites are available and the resulting PDOP is not greater than the PDOP mask value, then 3-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^{o}
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.

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3.3.2.14 **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.

3.3.2.15 **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 one 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.

3.3.2.17 **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.

Byte	Item	Type	Units
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 one pps 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.

3.3.2.18 **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.

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Byte #	Parameter Name	Bit Position	Default Bit Value	Associated Option	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	4A or 84
		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	Superpacket output 0: off 1: on	
		6	0	Superpacket format 0: binary 1: ASCII	
		7	0	unused	

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

Byte #	Parameter Name	Bit Position	Default Bit Value	Associated Option	Packet
1	velocity	0	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 0: on 1: off	(V1.14 onwards)
		5-7	0	unused	
3	Auxiliary	0	0	raw measurements 0: off 1: on	5A
		1	0	Doppler smoothed codephase (V1.14 onwards) 0: raw 1: smoothed	
		2	0	Additional Fix Status 0: off 1: on	(V1.12 onwards)
		3 - 7	unused		

Glossary for the table above:(from 3.3.2.18)

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:	coordinated universal time

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3.3.2.19 **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.

3.3.2.20 **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	---

Value	Meaning
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

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3.3.2.21 **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 to 32	satellite PRN number
3	length *(n)*	BYTE		number of bytes of data to be loaded
4 to n+3	dat	*n* BYTES		

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3.3.2.22 **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 below.

Byte #	Item	Type	Byte Value	Meaning
0	Operation	BYTE		
			3	The remaining bytes tell whether Acutime is allowed to select each satellite.
			6	The remaining bytes tell whether Acutime heeds or ignores each satellite's health as a criterion for selection.
1 to 32	Satellite # (1 byte per satellite)	32 BYTES	(Depends on byte 0 value.)	
			0	Enable satellite selection or heed satellite's health. Default value.
			1	Disable satellite selection or ignore satellite's health.

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

3.3.2.23 **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 32 GPS satellites.

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The sample length (Byte 1) is the number of milliseconds over which the measurement was averaged. Thus 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, and 5) accumulator sample rate and statistics. The approximation is very accurate from 0 to 25 AMU's.

The codephase (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. Thus, 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 1575.42 MHz, referenced to the receiver's internal oscillator (TCXO). Thus, 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 codephase (modulo mS) to a user determined integer number of mS between user and satellite.

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

1/16 * C/A code chip	977.517ns/16	61.0948 ns
		61.0948* speed of light, m/s
		18.3158 meter

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:

C/A code epoch * speed of light	=	1 ms* speed of light, m/s
		300km (approx.)
		299.792458 km (precise)

3.3.2.24 **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.

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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.

3.3.2.25 **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)	210	
	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	6-channel Acutime only
00010	3	6-channel Acutime only
00011	4	6-channel Acutime only
00100	5	6-channel Acutime only
00101	6	6-channel Acutime only
76543		

Byte #	Item	Type	Units
2	acquisition flag	BYTE	

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Byte Value	Meaning
0	never acquired
1	acquired
2	re-opened search

3	ephemeris flag	BYTE	

Byte Value	Meaning
0	flag not set
=0	good ephemeris for this satellite (< 4 hours old, good health)

4-7	signal level	SINGLE	same as in packet 46 hex
8-11	GPS time of last msmt	SINGLE	seconds

Byte Value	Meaning
<0	no measurements have been taken
≥0	center of the last measurement taken from this satellite

12-15	elevation	SINGLE	radians

Approximate elevation of this satellite above the horizon. Updated about every 15 seconds. Used for searching and computing measurement correction factors.

16-19	azimuth	SINGLE	radians

Approximate azimuth from true north to this satellite. Updated typically about every 3 to 5 minutes. Used for computing measurement correction factors.

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.

21	integer msec flag	BYTE

Byte Value	Meaning
0	don't have good knowledge of 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

22	bad data flag	BYTE

Byte Value	Meaning
0	flag not set
1	bad parity
2	bad ephemeris health

23	data collect flag	BYTE

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Byte Value	Meaning
0	flag not set
>0	The Acutime currently is trying to collect data from this satellite.

3.3.2.25.5 **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	# 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
	5-7	Unused
1	0-2	# of measurements in current fix that are old (3-5 s)
	3-7	Unused

3.3.2.26 **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.

3.3.2.27 **82** Differential Position Fix Mode

This packet provides the differential position fix mode of the Acutime. This packet contains only one 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.

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"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.

3.3.2.28 **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.

3.3.2.29 **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 3.1415926535898.

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3.3.2.30 **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

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