brandywine communications

GPS4 Satellite Synchronized Time & Frequency Standard

User Installation and Operation Manual

PRELIMINARY

Version 2.1

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1. Introduction

The GPS4 disciplined time and frequency standard is a “state of the art” device that offers many desirable features in a very compact form factor. Utilizing signals from the Navstar Global Positioning System, this unit provides highly accurate time, synchronization, and frequency functions. The unit may be operated in either GPS or UTC time modes. Local time offsets may be programmed into the unit in resolutions of minutes. A brief outline of features include:

PPS output: This 1PPS output provides a TTL output level into 50 ohms. This output is available on the front panel mounted BNC connector labeled “PPS”.

10MHz output: This 1Vrms sinusoidal output is available on the front panel mounted BNC connector labeled “10MHz”.

Synthesizer output: This is a frequency output option that is configurable at the factory to produce one of three different frequencies (19.6608 MHz, 1.544 MHz, 2.048 MHz). This output is available on the front panel mounted BNC connector labeled “SYNTH”. Other frequencies may also be synthesized – please contact the factory for more information on any particular frequency desired.

IRIG B time code output. This is a time code output used to distribute time of day information to other devices. This output is available by internal link selection as either a DC level shift code output, or a modulated time code output. It is available on the front panel BNC connector labeled “CODE”. Other time code formats are possible – please contact the factory.

Serial I/O: The GPS4 features one bi-directional control port, and one dedicated output port to provide time of day (TOD) information. The TOD output is an ASCII data string that is output one each second shortly after the 1PPS. These serial ports may be factory configured for either RS-232 (bi-polar) or RS-422 (differential) signal levels.

2. Product Specifications

2.1. Power Requirements:

Connector:	MR series locking type AMP 1-640508-0
Pin definitions	
Pin 1	Positive
Pin 2	Chassis ground
Pin 3	Negative

2.1.1. Standard

Input voltage / current:	15 VDC @ 1.4 A max, .5 A steady state
Isolation:	None

2.1.2. Power Option1

Input voltage / current	18 to 36 VDC @ 1 A to .5 A max, .5 A to .3 A steady state
Isolation:	500VDC

2.1.3. Power Option 2

Input voltage / current	36-60 VDC 1A to .34max, .5 to .2 A steady state
Isolation:	Isolated, 500 VDC

2.2. Outputs:

2.2.1. PPS

Rate:	1 pulse per second
Drive output:	TTL into 50Ω load
Reference:	Rising edge referenced to UTC (USNO) *
Width:	1ms
Connector:	Front panel BNC female.
Accuracy:	±150 ns to UTC* after stabilization period of 24 hours – static, time lock.
	Std deviation 34ns
Holdover:	less than 8 uS/8hr after learning period.

* Can be influenced by antenna delay compensation

2.2.2. 10MHz

Frequency	10 MHz
Period	100 ns

Waveform	Sinusoid (standard) or square (link selectable)	
Drive level:	1Vrms (Minimum) into a 50Ω load	
Harmonics:	<30dB	
Phase noise:	100 Hz	-140 dBc/Hz
	1000 Hz	-150 dBc/Hz
	10 kHz	-155 dBc/Hz
Stability:		
	Short term	
	1s	1×10^{-11}
	10s	1×10^{-11}
	100s	8×10^{-12}
	1000s	1×10^{-11}

Accuracy:

Long term	5×10^{-12} while locked over 24 hours
Holdover	1×10^{-10} average during 24 hour

2.2.3. SYNTHESIZER

Synthesized Output frequency per the following options
Common to all SYNTH options:

Connector:	BNC
Drive Level:	Single ended, HCMOS
Duty cycle:	50/50 ± 10%
Accuracy:	Same as 10 MHz

Synth Option 1

Frequency: 19.6608 MHz

Synth Option 2

Frequency: 2.048 MHz

Synth Option 3

Frequency: 1.544 MHz

2.2.4. Status Indicators

Type:	LED
Quantity:	Four
Indicators:	
Power Good	PWR GD: Green - Indicates system power available
Time Lock	LOCKED: Green - Indicates system time lock status
Holdover	HLDOVR: Yellow - Indicates system holdover operation

Alarm	ALARM: Red - Indicates system fault

2.3. Inputs:

2.3.1. System Reset

Function	Resets system microprocessor
Level	+5V, Active high (pin 4)
Pulse width	2 ms min
Sink Current	30mA max

2.3.2. Antenna

Connector:	BNC female
Impedance:	50 ohms
Bias voltage:	5 VDC
Bias Current:	80 mA Max

2.4. Environmental:

Operating:	-10°C to +60°C
Max rate of change:	15° C per hour

2.5. GPS Receiver:

Number of channels:	8 parallel
Band:	L1 (1575.42 MHz)

2.6. Serial Control:

Connector:	DE-9 female (socket)

2.6.1. Control port:

Baud rate:	75 – 19,200 baud, selectable by DIP switch. 4800, N,8,1 is factory setting

2.6.2. TOD port:

Protocol:	Time of day, ASCII
Baud rate:	19.2k

2.6.3. Serial option 1:

I/O levels:	RS-232

2.6.4. Serial option 2:

I/O levels:	RS-422

2.7. Hardware status:

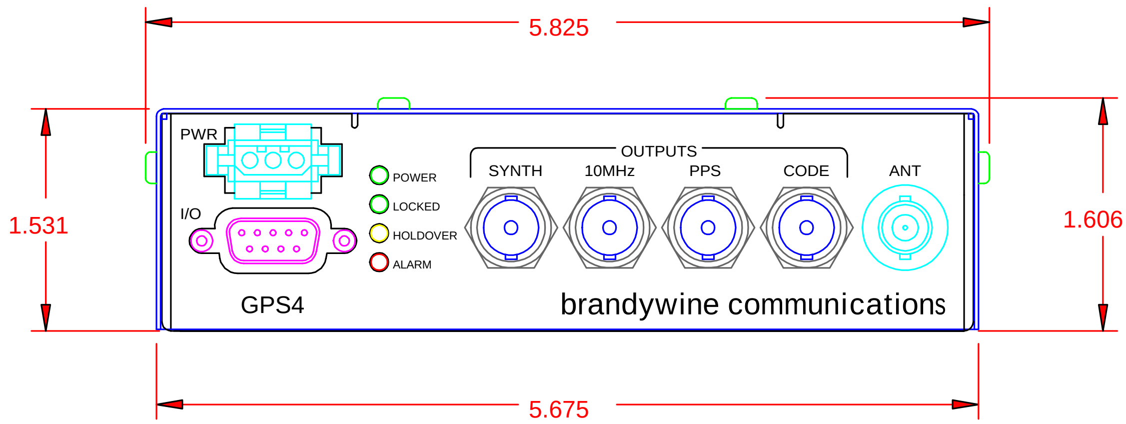
Connector:	DB-9
Levels:	Open collector – Pulled to ground through 100 ohm resistor
Max pull-up voltage	5 VDC
Max Current	30 mA
Status:	/Time lock (pin 8)
Status:	/Fault (pin 9)

2.8. Physical:

Depth	5.5 inches (139.7mm)
Width	5.8 inches (147.32mm)
Height	1.5 inches (38.1 mm)
Weight	3 lbs (1.4 kg)

Note: Specifications subject to change without notice.

2.9. Description of connectors and indicators



The GP4 provides access to all of the I/O, power, and signal connectors at the front of the chassis. A description of the various connectors and indicators follows:

Label	Function	Details		
PWR	Power input connector	Pins are numbered from left to right Pin1 = +VDC, Pin2 = Chassis, Pin3 = Ground		
I/O	Connector provides I/O for serial communications and hardware status indicators. Hardware status are open collector transistors that pull low when described status is true.	Pin	RS-232 (Standard)	RS-422 (Optional)
		1	No Connection	Control-TX-Y
		2	Control TX	Control TX-Z
		3	Control RX	Control RX-A
		4	Hardware Reset	Control RX-B
		5	Ground	Ground
		6	TOD TX	TOD-TX-Y
		7	No Connection	TOD-TX-Z
		8	/Time locked	/Time locked
		9	Fault	Fault

Label	Function	Detail
PWR GD	Power Good indicator LED	Green led indicates that +5 v power is present.
LOCKED	Time Locked indicator LED	Green led indicates time and position data synchronized since power up. Turned off after 8 hours of no satellite reception
HLDOVR	Hold-over indicator LED	Amber ledWhen illuminated indicates that the unit is in a hold-over condition.
ALARM	Alarm indicator LED	Red led indicates :- Phase lock loop control voltage within 10% of its limit. Synthesizer Lost Lock Processor malfunction 8 hours of no satellite reception
PPS	1PPS output, BNC female	Output of 1PPS at TTL levels into a 50 Ω load. 1 ms wide, rising edge on time.
10MHz	10MHz sine wave output, BNC female	Output of 10MHz at 1V rms (2.8 volts peak to peak) minimum into a 50Ω load.
SYNTH	Synthesizer output, BNC	Output of synthesizer frequency, HCMOS levels

	female	Frequency is programmed at the factory
CODE	Time code output, BNC female	IRIG B /AFNOR time code Modulated 3 V p-p, modulation ratio 3;1 nominal (Link 1 pos 2-3) IRIG B DC Level shift TTL level into 50 ohm load (Link 1 pos 1-2)
ANT	GPS antenna input, BNC female	This input connects to a L1 band (1575.42 MHz) GPS antenna. This "input" provides a +5 VDC bias voltage to the GPS antenna at up to 80 mA of current to operate a low noise amplifier or line amplifier.

3. Installation

In order to maximize the performance of the GPS4, please consider the following guide lines.

3.1. Thermal considerations

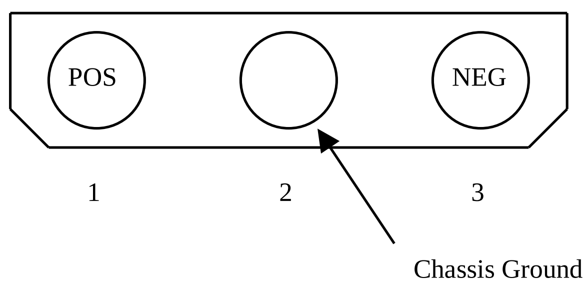
While this unit is designed to operate over a temperature range of –10 to +60 °C, optimum performance will be achieved if the unit is allowed to operate at a relatively constant temperature. The internal temperature rise is about 15 °C above the ambient temperature. For operation in environments above 50 °C forced air cooling should be provided across the unit.

Power consumption will also vary as a result of temperature. Since this unit utilizes an Ovenized Quartz Crystal Oscillator (OCXO) a significant percentage of the overall power is used by the OCXO to maintain the thermal stability of the quartz crystal oscillator. OCXO devices achieve their frequency stability over temperature by housing the quartz crystal and other thermally sensitive components in a "oven". The temperature of this oven is regulated and maintained at a relatively high temperature – usually in the 80 to 90 °C range to a very close tolerance of better than .1 °C. This elevated temperature allows the oscillator to maintain good stability while the ambient temperature that it is exposed to changes. At low ambient temperatures the oven must generate and thus consume more power to maintain the oven temperature. Higher ambient temperatures reduce the amount of power necessary to maintain the oven temperature.

3.2. Power supply connections

The GPS4 is available with different power supply options. Regardless of which power supply option is installed, the power input to the unit is D.C. only, and is supplied to the unit through a three pin power connector. This connector is labeled "PWR" and is located in the upper left portion of the front panel.

The pin assignments for the power connector are shown below. Note that the power connector pin assignments are the same for all of the different power options. Pin 1 is always the most positive supply voltage, pin 2 is always tied to the unit's chassis ground, and pin 3 is always the most negative supply voltage, also known as the power return.



In all cases the maximum power required by the GPS4 is 20 watts. Maximum power consumption will be experienced when power is first applied to the unit, and or when the unit is operating at low temperatures (0 to –10°C). The start up power will reduce to approximately 6 to 8 watts at room temperature (25 °C) after approximately 10 minutes of continuous operation.

Noise and ripple present on the DC supply should be minimized. Certain power supply options provide better noise and ripple rejection.

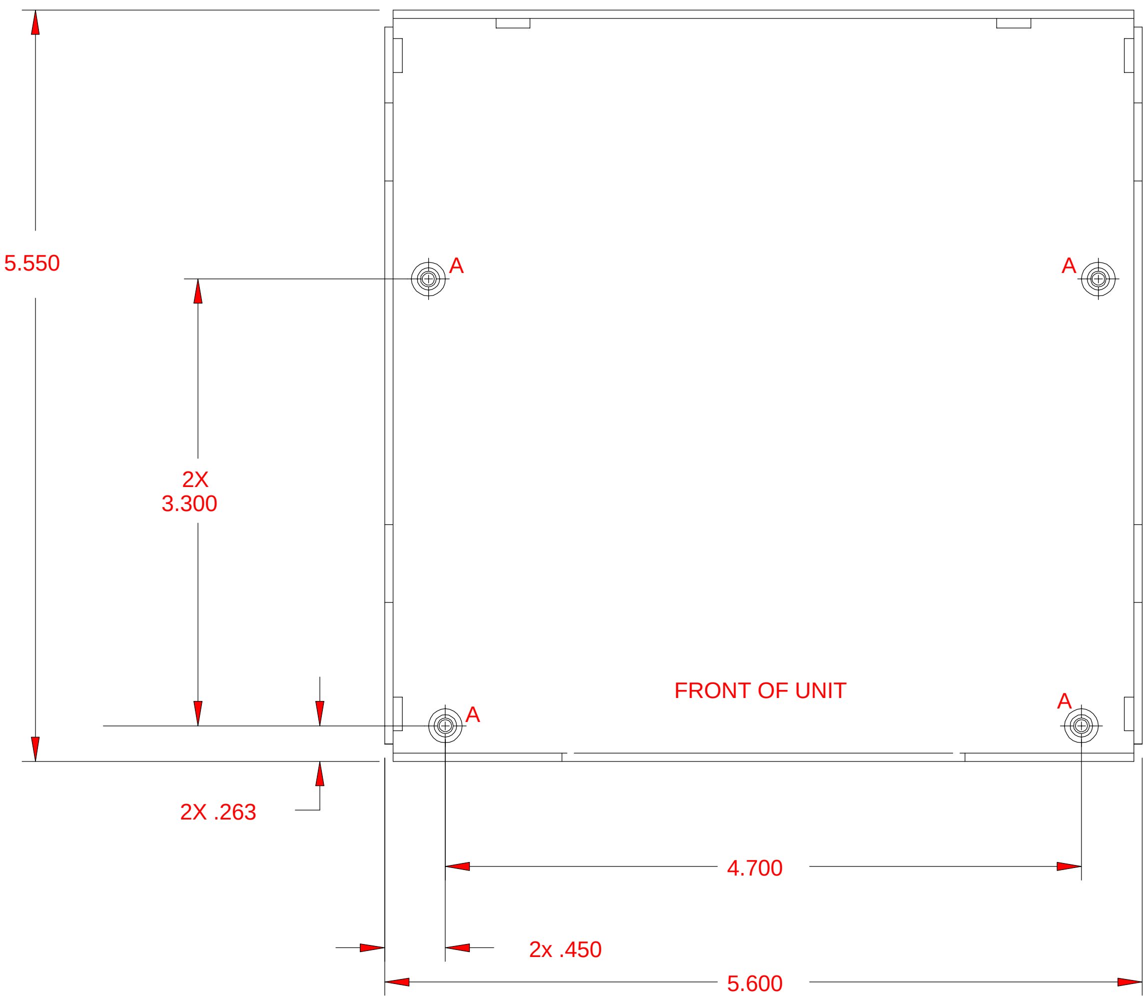
3.3. Unit mounting

Four 4-40 threaded inserts are provided in the bottom of the unit to facilitate mounting. When mounting the unit to the interior of a cabinet or other chassis, some consideration must be given to location from the standpoint of cooling, vibration, and electromagnetic interaction. One source of electromagnetic interaction can be traced to the transformers used in power supplies. Power supplies that utilize toroidal wound transformers generally provide better magnetic flux containment that the bobbin or laminated core type. In general, it is best to keep the GPS4 some distance away from the system power supply, particularly if it is an AC-DC linear or switching type supply.

In most cases the GPS4 will be used in stationary installations where vibration due to dynamic movement will not be of concern. However, the GPS4 utilizes a precision quartz oscillator, and a mechanical shock or vibration imparted to the quartz crystal can generate unwanted electrical output in the form of phase / frequency noise perturbations. In general the GPS4 should be kept away from sources of moderate or high vibration. In most cases, exposure to vibration will not be a major concern and the degradation – if any – will not be noticeable.

The orientation of the unit should be such that normal convection cooling will be allowed to function. This means that a airspace must be available around the perimeter where the air slots are located so that natural airflow will be allowed. The unit should not be mounted upside down as this will disrupt the convection air-flow cooling unless some form of forced air cooling is provided. For operation in ambient temperatures at or above 50 °C forced air cooling should be provided. See the above section titled *Thermal considerations*.

The recommended mounting hole pattern and necessary perimeter clearances are shown below. CAUTION, the mounting screw length must not exceed .25 inches as measured from the bottom surface of the unit.


5.550
A
A
2X
3.300
FRONT OF UNIT
A
A
2X .263
4.700
2x .450
5.600

3.4. Serial Interface connections

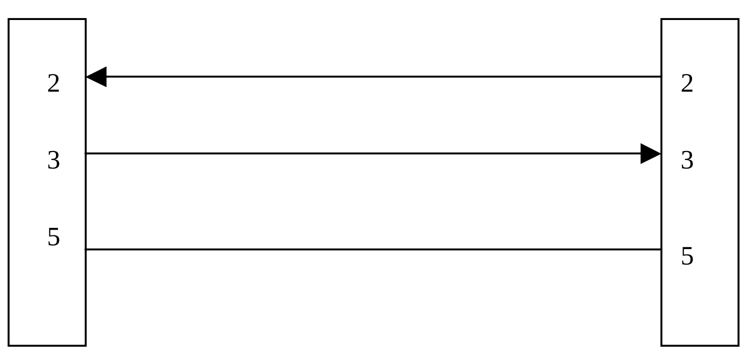
The GPS4 is shipped from the factory with either a RS-232C or RS-422 serial interface (determined by the option ordered). A bi-directional interface known as the "TxD1 / RxD1 " port and a uni-directional serial output known as the "TxD2/RxD2", which is used to output Time Of Day (TOD) are present at the D-sub 9 pin connector labeled "I/O". Both are simple interfaces that do not require or supply any hand-shake signals. Other signals present on the 9 pin D-sub connector are the */Time locked* , */Fault* , and *HWRESET* signals. These three signals provide open collector outputs that may be used as a hardware status indicator reporting the basic usability of the GPS4, as well a means of forcing a reset to the system. It is not necessary to use these signals and they may be left disconnected. The table below displays the pin assignments for both the power (PWR), and I/O connector.

Label	Function	Details		
PWR	Power input connector	Pins are numbered from left to right Pin1 = +VDC, Pin2 = Chassis, Pin3 = Ground See product label to determine unit supply voltage		
I/O	Connector provides I/O for serial communications and hardware status indicators. Hardware status (pins 8 & 9) are open collector transistors that pull low when described status is true.	Pin	RS-232 (Standard)	RS-422 (Optional)
		1	No Connection	TxD1-Y
		2	TxD1	TxD1-Z
		3	RxD1	RxD1-A
		4	Hardware Reset	RxD1-B
		5	Ground	Ground
		6	TxD2	TxD2-Y
		7	No Connection	TxD2-Z
		8	/Time locked	/Time locked
		9	Fault	Fault

3.5. **Interfacing to the serial port**

3.5.1.RS-232

The connections necessary to interface the GPS4 Control port to a standard PC serial port are shown below.



PC Serial port GPS4 Control Port

3.5.2.TxD2 ASCII Time of day output

The time of day (TOD) output is available on pin 6. This is a ASCII message that is output every second and indicates the time of the last 1PPS output. Three possiblke formats are available for this message.

3.5.3.RS-422

The GPS4 is also available with RS-422 I/O levels. The RS-422 interface uses balanced (differential) wire pairs as a means of transmitting and receiving data, thus four wires plus a common ground are required for this type of bi-directional interface. Two wires and a common ground are required for a uni-directional interface such as the TOD output. Since RS-422 is more varied in connector types and interfaces no specific connections are shown for this interface. Please refer to the pin connections and signals listed in the table above.

3.6. Antenna Installation

3.6.1.Location

Several factors need to be considered when installing the GPS antenna. In most cases the antenna is mounted externally (out doors) and is exposed to the elements. A good quality coaxial cable of 50 ohm impedance is required to connect the GPS antenna to the GPS4. The cable provides two functions; (1) to conduct the GPS RF signals (1575.42 MHz) that are received from the GPS antenna to the GPS4, and (2) to conduct the DC bias voltage (5 VDC) provided by the GPS4 to the LNA (low noise amplifier) contained inside of the GPS antenna. The antenna should be mounted securely with a clear view of the sky and with the top of the antenna pointing upward. In some installations it may not be possible to mount the antenna such that it has a clear 360 degree view of the sky – in such cases pick the location that affords the best view of the sky.

3.6.2.Exposure to high RF fields

Some installations may occur in places where a variety of high power transmitters and antennas are present. The GPS antenna should not be directly exposed or bombarded with high level RF energy. In such cases it is best to locate the antenna either above, below, or off to the side of such high power RF transmission antennas.

3.6.3.Lightning protection

The GPS4 does not provide any inherent protection against lightning strikes. In general, lightning protection (when desired or needed) is provided by an externally mounted protection device that is designed to shunt the high voltage transient to a well established earth ground. Lightning arresting devices designed for use in GPS antenna systems are available from Brandywine Communications (Part Number 001000914)

3.6.4.Antenna cable factors

Other factors affecting antenna mounting location deal with the length of cable required to provide the connection between the antenna and GPS4.

3.6.5.RF loss

The first and generally most important is the RF signal attenuation experienced in the cable. The amount of attenuation is related to the type (quality) of coaxial cable and the length of the cable. The antenna provides about 30 dB of gain to the received GPS signal. The purpose of this gain is to offset the loss that is experienced in the cable between the GPS antenna and the GPS4. It is recommended that the overall antenna system gain (antenna gain – cable loss) be between 10 and 33 dB. Thus using an antenna with 30 dB of gain, allows for about 20 dB of cable loss.
The GPS4 is shipped with 100' of antenna cable.
Additional cable configurations are possible. For distances beyond 330', an in-line amplifier is required.

Part Number	Cable length	Cable Type
002-0037	100ft	RG58 (standard)
002-0039	330 ft	RG8
002-0040	150ft	RG8
05100001	In-line Amplifier 20db	TNC/TNC connectors

4. OPERATING INSTRUCTIONS

4.1. SCOPE OF SECTION

Section 3 covers operation, initialisation and configuration of the GPS4. It is assumed that the unit has been installed in accordance with section 2 and that power has been applied.

4.2. OPERATION

During normal operation the GPS4 automatically receives, analyses and processes data from up to eight GPS satellites simultaneously. This data is used to provide time, frequency and position information which is available to the user on via a range of output interfaces.

In applications where the instrument is to be used for general test and measurement purposes it can be switched on and off as necessary. However, if the unit is to be used as a time and/or frequency standard it should be run continuously to allow long term software processing to take place which is essential if the instrument is to achieve its optimum performance. This process takes a minimum of 24 hours. The instrument carries out automatic position averaging and then transitions automatically into this 'known position' to obtain the highest possible time and frequency precision. The position averaging process also takes place during the first 24 hours after switch on.

Whenever the GPS4 is powered on it carries out a self-test routine before entering the operational program which sets the correct initial conditions for the receiver system. Satellite tracking is automatic and, provided at least one is visible, and the GPS4 already has a valid position in its battery backed receiver, time and frequency control can start within approximately 1 minute. If three or more satellites are visible three dimensional positional information will also be processed. The GPS4 internal frequency standard will warm up in 5 minutes . At the end of the warm up period the frequency controller is re-initialized.

Reception of at least one satellite is confirmed by the green Satellite Tracking indicator being turned on, and subsequent synchronization of the Time to UTC (up to 8 minutes from satellite reception) is confirmed by the Data Valid indicator being illuminated. The voltage control of the internal oscillator maintains synchronism of all outputs with GPS. If the control voltage of the internal oscillator is within 10% of end-of-range the red Alarm indicator on the instrument front panel is turned ON.

The final phase and frequency locking process may take several hours depending on the oscillator type fitted and satellite reception. Because the GPS4 uses a patented "Intelligent Phase Locked Loop" system incorporating a specially developed dynamic time constant, the control parameters are continuously modified to achieve lock in the shortest possible time and thereafter optimize performance for best time and frequency accuracy.

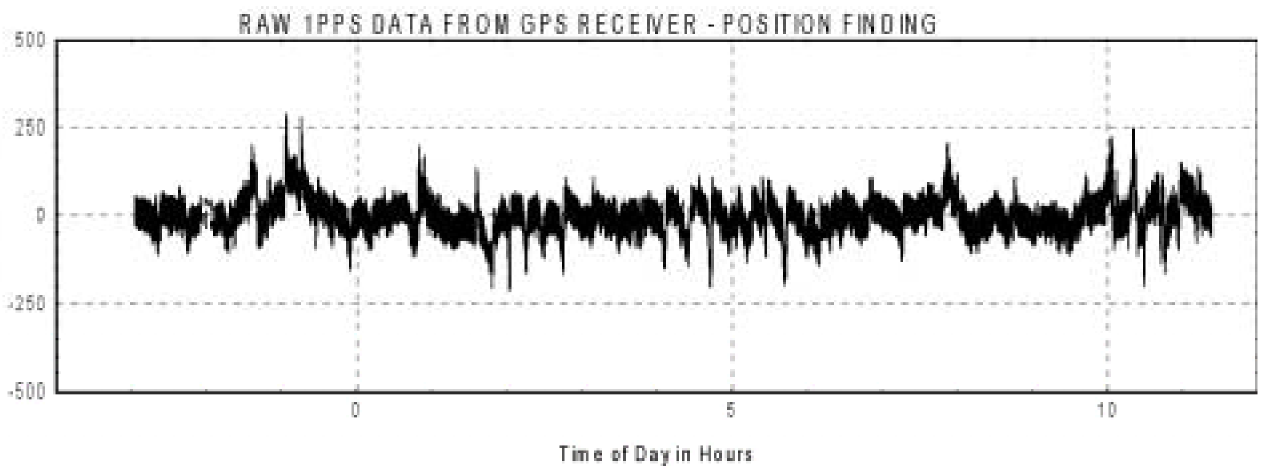
Note that if after a position has been successfully navigated the number of satellites tracked drops to 4 or less satellites the satellite receiver automatically selects 2D positioning mode and continues to recover time. If it then drops to 3, 2 or 1 satellites positioning is suspended but time is recovered. The satellite receiver 1pps is disabled if no satellites are tracked and the GPS4 runs in 'holdover' continuing to maintain all outputs. After 8 hours of lost reception the red Alarm indicator is turned ON.

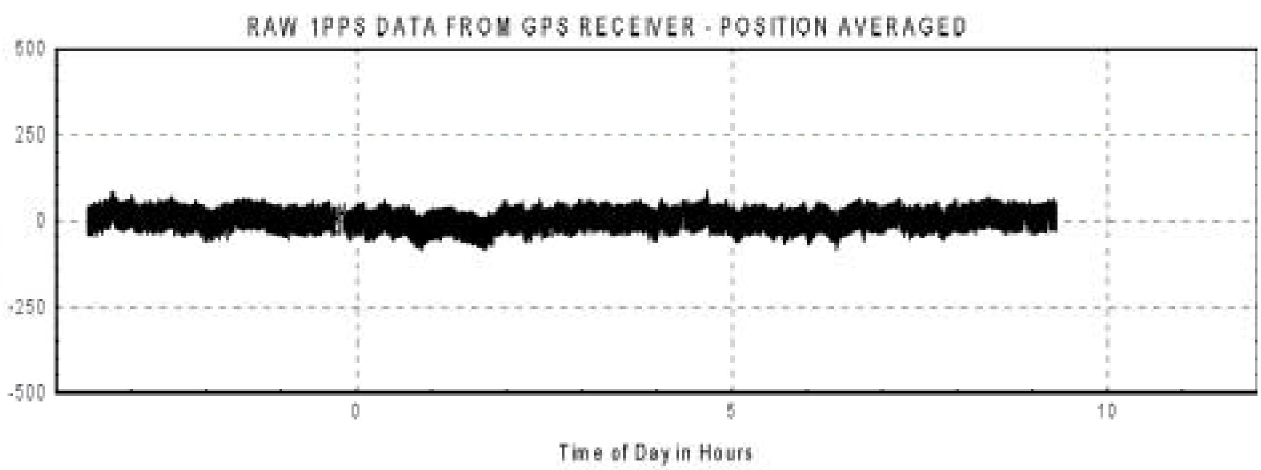
If the instrument has a recent almanac on switch-on the start up time (after system initialization has been completed) is approximately:-

Initial Acquisition	1-15 sec.
Satellite re-acquisition	25 sec
Tracking	20 sec
Navigating	1 min from start-up
Position Averaging complete	24hours from start-up

Synchronization of receiver timing will normally be completed within 1½ minutes of switch-on. If the receiver does not have an almanac already backed up in memory then, after switch on, it will take typically 8 or 9 minutes to acquire the necessary parameters to enable precise time acquisition, as indicated by illumination of the Valid Time indicator on the GPS4 front panel or by assertion of the Valid Time status bit in the time message.

For fixed position operation precise averaging of position is carried out by the GPS4 over 24 hours. The reason for averaging is illustrated below, showing that the raw time data, before processing is carried out by the GPS4, is improved by a factor of 3 when the GPS4 has averaged its position. The vertical scale on the graphs is 1pps deviation in nanoseconds. These results were obtained with SA OFF.





4.3. SERIAL DATA COMMUNICATIONS

The GPS4 has two asynchronous serial ports which communicate with the user. They are suitable for connection to other equipment such as printers, computers and terminals. They can be factory configured as RS232 or RS422. This section describes the options in more detail.

4.4. Controi TxD1/RxD1

TxD1 is designed for communication with the user, giving access to instrument status and GPS reception information. RxD1 receives commands and data requests from the user.

SW1 Controls TxD1/RxD1 Baud Rate and character format. Prior to alteration of the switch, disconnect the power connection to the GPS4 and observe all normal safety precautions when opening the instrument to access 8 way DIL switch SW1

Table 3a TxD1/RxD1 Character Format

Switch	1	2	3	4	5	6	7	8
ON	- Baud Rate Selection - See Table Below				Parity	Odd Parity	8 Data bits	2 Stop bits
OFF					No Parity	Even Parity	7 Data bits	1 Stop bit

Table 3b TxD1/RxD1 Baud Rate

SW1-1	SW1-2	SW1-3	SW1-4	Baud
OFF	OFF	OFF	OFF	75
ON	OFF	OFF	OFF	110
OF	ON	OFF	OFF	134.5
ON	ON	OFF	OFF	150
OFF	OFF	ON	OFF	300
ON	OFF	ON	OFF	600
OFF	ON	ON	OFF	1200
ON	ON	ON	OFF	1800
OFF	OFF	OFF	ON	2400
ON	OFF	OFF	ON	4800
OFF	ON	OFF	ON	4800
ON	ON	OFF	ON	9600
OFF	OFF	ON	ON	9600
ON	OFF	ON	ON	19200
OFF	ON	ON	ON	19200
ON	ON	ON	ON	19200

Factory default SW1 setting is 4800 baud, 8 data, No parity, 1 stop:-

SW1

OFF	-		-		-	-		-
ON		-		-			-	
	1	2	3	4	5	6	7	8

4.4.1.TxD1 / RxD1 User Commands and GPS4 Responses

GPS4 Asynchronous Serial Port RxD1/TxD1 provides Time, Position and Status data on request from the user; furthermore it can accept user commands for example to set output time to UTC or Local, set the Local Time offset from UTC

The user can obtain information from the GPS4 by sending single ASCII character requests terminated by <CR><LF>. The GPS4 response message structure is based on the NMEA-0183 Standard for interfacing Marine Electronics Navigation Devices; the same structure is used for commands from the user that set GPS4 operating parameters. User characters are sampled at 1ms intervals and will be missed if more than 1 character is received per millisecond. **If there is no time delay between characters sent to the GPS4 then the maximum baud rate for user commands is 4800.**

The requested record will be directed to the GPS4 serial port TxD1 output. All characters transmitted by the GPS4 are consistent with ASCII character or control codes. When hexadecimal numbers are transmitted, to communicate status bit values for example, they are transmitted as ASCII characters 0 through 9 and A through F (A through F always being in upper case).

Reserved characters are used to indicate the beginning and end of records in the data stream, and to delimit data fields within a record. As an exception the time request may be a single character, optionally without termination, to minimize the overhead of obtaining a time stamp response from the GPS4.

```
Record Start Character
|Special ID (P=Proprietary)
| |   Originator ID (RCC=Radio code Clocks)
| |   |    Interface ID (G=GPS)
| |   |    |          Data
| |   |    |           |                        Checksum Field Delimiter
| |   |    |           |                        |Checksum
| |   |    |           |                        | |
$PRCCG..................................*CK<CR><LF>
    |
    |____________Block Label
```

The reserved characters are:

Table 4

Character	Hex Value	Usage
$	24	Start of Record Identifier
<CR><LF>	0D 0A	End of Recode Identifier
,	2C	Record field Delimiter
*	2A	Checksum field Delimiter

The notation CK indicates the optional checksum value of the message, computed by exclusive-ORing all the bytes between the $ and the * characters. The $, * and checksum are not included in the checksum computation. For commands sent to the GPS4 the checksum may be omitted, in which case the associated '*' must be omitted. The GPS4 will recognise the <CR> as the end of message and will not attempt to verify the missing checksum. If the checksum is attached by the user it will be checked by the GPS4 and the message will be rejected if an error is detected. Errors in the format of the message will also cause its rejection.

The list of the available single character requests is as follows:-

Table 5

Request	Response
a<CR><LF>	Version Number, Time, Position Averager and Output Status information.
c<CR><LF>	Pulse output (local/utc) time or Pulse Period, Polarity, Pulse Length
e<CR><LF>	Modulated Timecode, Pulsed Output, TxD1 Format, TxD2 Format
f<CR><LF>	Frequency and Phase Controller data
h<CR><LF>	Health Status of Satellites
j<CR><LF>	Leap second Date and UTC-GPS seconds offset value
l<CR><LF>	Location and Signal Strength of Satellites (up to three records)
n<CR><LF>	Version Number of Firmware and GPS Engine
o<CR><LF>	Run UTC/Local Time, Local Time hours offset
p<CR><LF>	Position of GPS Receiver Antenna.
s<CR><LF>	Additional Information (Including Magnetic Deviation)
t	Precision Time request*

*The Precision Time request is handled as a priority. The 't' request need not be followed by <CR><LF> (but if <CR><LF> is appended it will be ignored)

The GPS4 continually polls the GPS receiver for satellite status and associated information. If the user request requires information from the GPS engine, the GPS4 immediately forwards the information it has already acquired in its internal buffer. The associated response is returned immediately. If several requests have been sent prior to completion of the responses then the order of the responses may be different from the order of the requests.

The Precision Time request is given priority. The time at which the request character was received is logged at the next whole millisecond and the GPS4 transmits as soon as the serial port is free. This special message is not in the NMEA format but in the industry standard Type 2 Serial Data Format of Time and Frequency Solutions Ltd. (described below).

4.5. Message Formats

4.5.1.a Time and Date with Status, Position Averager Status and Output Status

Requested by a<CR><LF>

```
Field  1 2   3        4        5 6 7      8
$PRCCG,A,007,19:53:19,07/06/00,9,3,1,0000,00*09
```

Field	Contents of Field
1	Fixed Text "A"
2	Version number of GPS4 firmware 000 to 999
3	Hours Minutes Seconds
3	Day of Month, Month and Year
4	Status is the ASCII representation of a hexadecimal character between 0 and F. Each bit of the hexadecimal character represents the following status condition when set to 1 (or the opposite at 0):-

Bit 3 (MSB)	Bit 2	Bit 1	Bit 0 (LSB)
Valid Time	Not GPS Locked	Local Time	Leap Year

5 Number of position average samples accumulated (target is 100)

6 Position Average Mode:
"0"= Not Averaging
"1"= Averaging
"2"= Known Averaged Position In Use

7 Output status (16 bits in 4 digits) as detected by output detectors. Each hexadecimal character represents 4 bits and each bit set to '1' corresponds to the status described in the following table being true. When no failures are detected four '0's are transmitted.

BIT 15	BIT 14	BIT 13	BIT 12	BIT 11	BIT 10	BIT 9	BIT 8
Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved
					Always 1	Always 1	Always 1

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0 (LSB)
Synthesizer PLL Unlocked	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved	Reserved
	Always 1	Always 1	Always 1	Always 1	Always 1	Always 1	Always 1

8 Control Status (8 bits in 2 digits) as reported by the frequency controller. Each bit set to '1' corresponds to the status described in the following table being true

BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1	BIT 0 (LSB)
One or more OP Failures detected	No satellites for 8 hours	Reserved	Oscillator Frequency control near its limit	Frequency Error Oscillator cannot be controlled	Reserved	(Rubidium Oscillator Status shows Rubidium Cold)	Reserved

Example of Output

```
$PRCCG,A,007,13:56:48,09/06/00,9,100,2,0000,00*0B
```

Software version 007, requested at 13 hours 20 minutes and 15 seconds on 9th June 2000 with time status showing Valid Time, Synchronized, UTC in leap year. 100 position samples have been accumulated so position averaging is completed and the GPS receiver is reporting that it is in Known Position, there are no output or control failures.

4.5.2.c Pulse Output Data and Command

Requested by c<CR><LF>

Sending the single letter 'c' followed by <CR><LF> requests a message from the GPS4 that describes its Pulse Output from SK4/J10. The same message format transmitted to the GPS4 sets the Pulse output parameters which are stored in non-volatile RAM. The pulse output (logic levels 0V and 5V from 50R) can be commanded to be normally low, going high for the pulse duration or normally high, going low for the pulse duration. There are two ways to specify the pulse occurrence and duration. (Note also that the logic level at SK4 can be commanded to be a timecode – see the E command)

1. Pulse output can be specified to occur at a UTC or Local Time. In this case Pulse outputs always start at the second's edge (UTC to within +/-150ns) and terminate the specified number of milliseconds later. 'Don't Care' characters in the definition of the pulse time allow hours, minutes or seconds values to be ignored. The default Pulse Output setting is UTC midnight, positive pulse 100ms long. The minimum pulse duration is 1ms and the maximum is 9999ms.

2. Alternatively, multiple pulses per second can be specified. In this case the PERIOD of the pulse stream is specified, together with the pulse active duration. The minimum Period is 2ms and the maximum period is 9999ms. Immediately after receipt of the command, the current pulse (if active) is terminated and the first new pulse commences at the start of the next second's edge. If the pulse period, specified in milliseconds, is a sub-multiple or a multiple of seconds then the pulses remain synchronised with 1pps. If the contrary is true, then the pulses may require multiple seconds before the start of a pulse coincides with 1pps; however, they are always strictly related to real-time milliseconds as long as the instrument is locked to GPS.

Remember that if the checksum is to be omitted in the user command to the GPS4 then the '***' MUST BE OMITTED** from the end of the message so that the GPS4 recognises that no checksum is available.

Form 1 of the command `(Pulse output at specified time, Local or UTC)`:-

```
Field  1 2       3
$PRCCG,C,UHHMMSS,+9999*CK<CR><LF>
```

Form 2 of the command `(Pulse output with specified period)`:-

```
Field  1 2     3
$PRCCG,C,P9999,+9998*50<CR><LF>
```

Field	Contents of Field
1	Fixed Text letter 'C'
2	**EITHER** 'U'=UTC of Pulse Output Time 'L'=Local Time of Pulse Output Time Followed by HHMMSS=Hours Minutes Seconds of Pulse Output Time Leading zeros MUST be present in the Time field – for example 5 hours is 05 If HH or MM or SS are to be ignored then XX is transmitted (where X=ascii code 58hex) **OR** 'P'=Specifies the period in ms is the following number 2 to 9999

3 '+' = Pulse output when active is +5V from 50R, when inactive is 0V from 50R

'-' = Pulse output when active is 0V from 50R, when inactive is +5V from 50R

9999 from 1 to 4 digits (leading zeros NOT required) defines pulse length in milliseconds

Note that the GPS4 responds to the pulse setting command by echoing the message as recomputed from the values originally transmitted by the user, after they have been decoded for use by the GPS4, and ALWAYS adds its own checksum to its message output. Illegal commands are ignored, except for the case where the pulse length is commanded to be greater than the pulse period, in which case it is reset to 1ms pulse length.

Examples of pulse commands and responses where UTC or Local time is specified.

(1) $PRCCG,C,L202500,+100*79<CR><LF>

Pulse output commences at 20 hours 25 minutes 00 seconds Local Time and is active at +5V for 100 milliseconds.

(2) $PRCCG,C,UXXXXXX,+1*65<CR><LF>

Pulse output commences once per second and is active at +5V for 1 millisecond.

(3) $PRCCG,C,UXXXX10,-500*66<CR><LF>

Pulse output commences once per minute at 10 seconds past the minute and is active at 0V for 500ms .

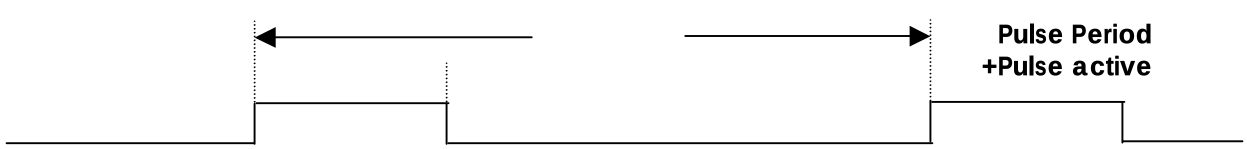
(4) $PRCCG,C,UXX0000,+500*61<CR><LF>

Pulse output commences once per hour at 00 seconds past the minute and is active at +5V for 500ms

(5) $PRCCG,C,UXX00XX,+500*61<CR><LF>

Pulse output commences once per second at 00 minutes past the hour for one minute (until minutes change to 01) and is active at +5V for 500ms

Examples where the Period of the pulse is specified instead of the UTC or Local Time.



Pulse period may be 2ms minimum to 9999ms maximum, pulse width is 1ms minimum to 9998ms maximum. If the pulse length command asks for a length greater than the period then it is automatically reset to 1ms.

(6) $PRCCG,C,P1000,+500*65<CR><LF>

Pulse output has a period of 1000ms and is active high for 500ms. This is a square wave at 1Hz, positive edge commencing at the second's edge. It will remain synchronised.

(7) `$PRCCG,C,P2,+1*52<CR><LF>`

Pulse output has a period of 2ms and is active high for 1ms. This is a square wave at 500Hz; positive edges will remain synchronised with the seconds' edges because the period 2ms is a sub-multiple of 1s.

(8) `$PRCCG,C,P2,-1*54<CR><LF>`

Pulse output has a period of 2ms and is active high for 1ms. This is a square wave at 500Hz; negative edges will remain synchronised with the seconds' edges because the period 2ms is a sub-multiple of 1s and a negative pulse is specified.

(9) `$PRCCG,C,P9999,+9998*50<CR><LF>`

Pulse period is 9999ms; pulse output is high for 9998ms. Output is high except for 1ms at the end of the pulse. The period is not a multiple of 1Hz. The output goes high for the first time at the 1Hz edge following the receipt of the command. The next pulse starts 1ms before 10s has elapsed. 9999 seconds must pass before the pulse commences again at a seconds edge.

4.5.3.d Dilution of Precision values and satellites used

Requested by d<CR><LF>

Field

```
       1 2 3  4  5  6  7  8  9  10 11...15    16    17
$GPGSA,A,1,NN,NN,NN,NN,NN,NN,NN,NN,,,,,,PP.PP,HH.HH,VV.VV*CK<CR><LF>
```

Field	Contents of Field	
1	“A” or “M”	Operationa “M”=2D only Mode “A”=2D/3D Auto-switching mode
2	“1” to “3”	Positioning status “1”=Positioning Interrupted “2”=2D positioning “3”=3D positioning
3-14	NN	Satellite numbers 01 to 32 used for positioning Note a null field is output unless a satellite is available
15	PP.PP	PDOP (combined DOP) Note “00.00” is output unless 3D positioning is performed
16	HH.HH	HDOP (horizontal DOP) Note “00.00” is output while positioning is interrupted
17	VV.VV	VDOP (vertical DOP) Note “00.00” is output unless 3D positioning is performed

Example Message

```
$GPGSA,A,3,03,15,17,19,21,22,23,27,,,,,01.96,01.05,01.66*37<CR><LF>
```

4.5.4.e Time-code and Serial Data Output Formats

Requested by e<CR><LF>

Sending the single letter 'e' followed by <CR><LF> requests a message from the GPS4 that describes its timecode outputs and serial data formats. The same message format transmitted to the GPS4 can be used to set the Timecode and Serial Data formats. **Pulsed output is reported only; use the C command to define the Pulsed Output requirement in terms of UTC/Local Time pulses or Period defined pulses, in each case with required pulse length.**

Field 4 is reserved to allow FUTURE definition of different formats from TxD1. TxD1 is fixed as a Serial Type 2 requested time message.

The E command message format is
Field

```
        1 2 3 4 5
$PRCCG,E,X,X,X,X*CK<CR><LF>
```

Field	Contents of Field	
1	E	Fixed letter E identifies the command
2	0 to 4 or X	Timecode 1 Type
	0	None – 1kHz sinewave carrier at maximum level only
	1	IRIG B – 1kHz modulated carrier
	2	XR3/2137 – 1kHz Modulated Carrier
	3	VELA – 1kHz Modulated Carrier
	4	NASA 36 – 1kHz Modulated Carrier
	X	DO NOT CHANGE CURRENT OUTPUT SELECTION
3	0 to 3 or X	Pulsed Output Type
	0	None
	1	Digital Timecode (0 to 5V from 50R) as Timecode 1 above
	2	UTC/Local Time Defined Pulse Output – **set by C Command only**
	3	Period Defined multipulse Output – **set by C command only**
	X	DO NOT CHANGE CURRENT OUTPUT SELECTION
4	1 to 3 or X	Reserved for TxD1 Serial Data Format selection (not in use)
5 Selection	1 to 3 or X	TxD2 Automatic or Requested Serial Data Output Format
	1	Type 1 Format `20:34:45 31/05/01 151 4`
	2	Type 2 Format `20:34:45.678 31/05/01 151 4`
	3	GPS4 Format `2001,151:20:34:45,3,1`
		At power on, TxD2 automatically transmits the selected time message 1/second. On receipt of a lower case 't', TxD1 outputs the time at which 't' was received, in the currently selected format above, and then becomes a request port, only transmitting the time message on receipt of 't' from the user. The user must send 'r' to switch to turn on the automatic output of a time message once per second.

Example Messages

`$PRCCG,E,1,1,1,1*2C<CR><LF>`	TC1 Modulated Timecode Output is IRIG B (1kHz carrier) TC2 Pulse Output is IRIG B (0 and 5V from 50R) TxD1 is _Type 2 serial data requested only (this output is not currently changed by the command) TxD2__ is Type 1 format data, automatically output 1 per second until 't' request, when it becomes requested only until 'r' is received. 't' and 'r' do not require <CR><LF> termination. _____
`$PRCCG,E,2,1,1,1*2F<CR><LF>`	TC1 is Modulated Timecode Output is XR3/2137 (1kHz carrier) TC2 is Pulse Output is XR3/2137 (0 and 5V from 50R) TxD1 is _Type 2 serial data requested only (this output is not currently changed by the command) TxD2 J12 is Type 1 format data, automatically output 1 per second until 't' request, when it becomes requested only until 'r' is received. 't' and 'r' do not require <CR><LF> termination.
`$PRCCG,E,3,1,1,1*2E<CR><LF>`	TC1 Modulated Timecode Output is VELA (1kHz carrier) TC2 Pulse Output is VELA (0 and 5V from 50R) TxD1 is _Type 2 serial data requested only (this output is not currently changed by the command) TxD2 is Type 1 format data, automatically output 1 per second until 't' request, when it becomes requested only until 'r' is received. 't' and 'r' do not require <CR><LF> termination.
`$PRCCG,E,4,1,1,1*29<CR><LF>`	TC1 Modulated Timecode Output is NASA36 (1kHz carrier) TC2 Pulse Output is NASA36(0 and 5V from 50R) TxD1 is _Type 2 serial data requested only (this output is not currently changed by the command) TxD2__ is Type 1 format data, automatically output 1 per second until 't' request, when it becomes requested only until 'r' is received. 't' and 'r' do not require <CR><LF> termination.
`$PRCCG,E,1,1,1,2*29<CR><LF>`	TC1 Modulated Timecode Output is IRIG B(1kHz carrier) TC2 Pulse Output is IRIG B (0 and 5V from 50R) TxD1 is _Type 2 serial data requested only (this output is not currently changed by the command) TxD2__ is Type 2 format data, automatically output 1 per second until 't' request, when it becomes requested only until 'r' is received. 't' and 'r' do not require <CR><LF> termination.

Remember, to change TC2 to a timed pulse output, the 'C' command must be used because a specification of Pulse Time or Period and Pulse Duration is required. For example, make TC2 output a 1ms positive pulse with a 2ms period (500Hz, +ve edge ‘on time’)

```
$PRCCG,C,P2,+1*52<CR><LF>
```

Send e<CR><LF> to query the output set-up:-

```
$PRCCG,E,1,3,1,2*2D
```

TC1 Modulated Timecode Output is IRIG B(1kHz carrier)
TC2 Pulse Output is a Pulse with period specification
TxD1 is _Type 2 serial data requested only (this output is not currently changed by the command)
TxD2__ is Type 2 format data, automatically output 1 per second until ‘t’ request, when it becomes requested only until ‘r’ is received. ‘t’ and ‘r’ do not require <CR><LF> termination.

4.5.5.f Frequency and Phase Controller Data

Requested by **`f<CR><LF>`**

Field

```
        1 2     3     4     5       6         7          8         9      10 11 12
$PRCCG,F,+XXX,+XXX,+XXX,+XXXXX,+X.XE-
XX,+X.XXEXX,DDDHHMMSS,+XX.X,XX,XX,XX*CK<CR><LF>
```

The field lengths shown are typical but not fixed (leading zeros or spaces are not necessarily transmitted)

Field	Contents of Field	Description	Range
1	F	Fixed text "F" identifies the message type	Ascii 'F'
2	+XXX	Instantaneous Phase (ns) (Signed Decimal integer)	–499999999 +500000000 Typical +0 2 chars to 10 chars
3	+XXX	Phase controller value (ns) (Signed Decimal integer)	Will always be '+0' in GPS4 controller output 2 chars
4	+XXX	Average Phase (ns) (Signed Decimal Integer)	-32768 to +32767 Min 2 chars Limited to 5 chars Sign replaced by '%' If out of range
5	+XXXXX	Frequency Controller value (Signed decimal integer +0 = Nominal Center)	-32768 to +32767 2 chars to 6 chars
6	+X.XE-XX	Last Frequency Controller correction (Decimal Scientific notation)	1.0E-8 to 0.00E-14 7 chars to 9 chars
7	+X.XXE-XX	Frequency Trend (Decimal Scientific notation)	±1.0E-8 to ±0.00E-14 7 chars to 9 chars
8	DDD:HH:MM:SS	UTC at Last Correction (Day of year, hours, minutes, seconds)	Fixed 12 chars
9	+XX.X	Reserved for Temperature in degrees C (not used in GPS4 controller which outputs +69.4)	+0.0 is 4 chars +69.9 is 5 chars
10	XX	Status of Phase and Frequency Controller (00 to FF)	Fixed 2 ascii hex chars
11	XX	PLL Constraint ('TCSW') and Status	Fixed 2 ascii hex chars
12	XX	Oscillator Type (00 to FF)	Fixed 2 ascii hex chars

Example Message

```
$PRCCG,F,-450,-382,+0,-2186,+3.0E-13,+1.14E-
10,144:09:54:00,+69.4,60,03,03*3B<CR><LF>
```

The items highlighted are defined as follows:-

Instantaneous Phase

The instantaneous phase measurement between 1pps recovered from the satellite receiver and a 1pps generated by the internal precision oscillator, reported in ns. The resolution of the measurement is 50ns; the maximum value is limited to 0.5s (beyond which the value is converted by calculation of [1s-Phase] and the sign is reversed). A positive sign always means that the phase of the 1pps derived from the local oscillator, and output to the user, is ahead of the satellite receiver 1pps. Similarly a negative sign means that the instrument output 1pps is behind the satellite receiver 1pps.

The instantaneous phase value is output even when the satellite receiver 1pps signal is known not to be valid, as indicated by the status.

Average Phase

The mean value of instantaneous phases readings that have been accepted. The resolution of this output is 1ns. Occasionally instantaneous phase readings can be rejected by the GPS4 (and therefore not included in the average) for several reasons, for example:-

Corrupt satellite data
Out of limit phase measurement
Excessive inaccuracy due to reintroduction of Selective Availability.

Phase Controller Value

The current value of the phase controller used to adjust the local 1pps to UTC. In the GPS4 instrument this phase control figure is always set to zero since, following initialisation, the 1pps is maintained in phase with the satellite 1pps by frequency control. If a large 1pps phase offset is detected for any reason (for example after a long period of holdover) values from 6µs to 20ms are removed by phase stepping of the output 1pps in 400ns steps. An error larger than 20ms is corrected by resynchronisation.

Frequency Controller Value

The decimal value for the 16 bit DAC used for controlling the frequency of the internal oscillator. The oscillator is initially factory calibrated with a centre control value which is stored in EEPROM; this value is transmitted to the DAC after switch-on. As the oscillator gradually ages this value increases or decreases to maintain the correct output frequency. Maximum range of the DAC is ±32767 counts where a positive increase indicates an increase in oscillator frequency.

At switch on the GPS4 frequency control system starts with a fast time constant to achieve frequency correction of the oscillator in the shortest possible time. This process causes some rapid frequency changes while the oscillator is coarsely adjusted via the DAC. When sufficient measurement and control history has been accumulated in memory and processed a medium time constant is implemented which results in smaller and less frequent correction to the local oscillator. Finally, and after more extensive measurement and control data has been stored and processed, the slow time constant is implemented which results in optimum frequency control strategy and hence accuracy of the internal oscillator.

The time taken to change from FAST to MEDIUM to SLOW depends on several parameters such as oscillator stability, satellite reception and temperature changes but typical values are ½hour to MEDIUM and 1.9 hours to SLOW for a precision crystal ovened oscillator, and 2.2hours MEDIUM 9hrs to SLOW for a standard Rubidium oscillator.

OSCILLATOR TYPE	WARM UP TIME	TIME IN FAST	TIME IN MEDIUM
XTAL_2	5min	10min	52min
XTAL_1	5min	30min	1.9hr
Rb_2	10min	2.2hr	9hr
Rb_1	10min	4.5hr	36hr

Last Frequency Controller Correction

The value of the last frequency correction applied by the 16bit DAC. When the instrument has found its average position and the oscillator has overcome the high value of aging experienced in the first few days after switch-on, this value will usually be either zero or the lowest possible frequency increment (for example 3E-13 for XTAL_1). The GPS4 controller algorithm works to keep each correction step magnitude below the short term noise level of the oscillator type fitted such that the action of correction does not degrade the short term stability of the oscillator which is better than can be recovered from GPS.

Frequency Trend

The movement in average phase over a specified measurement period. The measurement period is dependent on the oscillator option fitted and on the time elapsed since start-up. For example, for a general purpose ovened oscillator the period starts at 1sec and, after ten samples of 1 second, increases to 10 seconds and after ten samples, increases to 100 seconds at which point the measurement resolution is 1×10^{-11}. The sample intervals and measurement periods for four oscillator options are shown below.

OSC Type	Sample Interval	Measurement Period	Frequency Measurement Resolution
TCXO	1s	1s 10s 100s	1E-9 1E-10 1E-11
XTAL_2 (General Purpose)	1s	1s 10s 100s	1E-9 1E-10 1E-11
XTAL_1 (Medium Performance)	10s	10s 100s 1000s	1E-10 1E-11 1E-12
Rb_1 (High Performance)	100s	100s 1000s 10000s	1E-11 1E-12 1E-13

Phase readings are stored at every sample interval and the value transmitted is updated at this point even when the measurement period is 1000 seconds. This output gives the user a continuous and uninterrupted general indication of frequency accuracy of the internal disciplined oscillator.

UTC at Last Correction

The time at which the last frequency controller correction was applied is output in the format shown above.

Status of the Phase and Frequency Controller

Two ascii hex characters indicate the status of the controller where '1' represents the described status in the table below

msb			lsb msb				lsb
PLL Limit	Reject PLL Data	/TMV Not Time Mark Valid	Reject Phase (HW Lim)	Reject Phase (Noise)	Rb Status Cold	Medium	Slow

PLL Constraint

consists of two ascii hex characters which each represent 4 bits of status where '1' represents the described status

msb			lsb	msb			lsb
PLL Control 'TCSW' Bit 3	PLL Control 'TCSW' Bit 2	PLL Control 'TCSW' Bit 1	PLL Control 'TCSW' Bit 0	Valid Time	RJ Code	Output or Synthesis er Fault	Frequenc y Control Fault

PLL Control represents the user's test command of a constraint called 'TCSW' which has been applied to the frequency disciplining section. Values are shown in the table below.

PLL Control 'TCSW'	PLL Constraint
'0'	No constraint. Standard 3 time-constant loop is running
'1'	PLL is commanded to 'fast' only control
'2'	PLL Loop is open with the EFC set for Centre Frequency
'3'	PLL Loop is open with the EFC frozen at its last setting
'4'	PLL Loop is open with the EFC set to maximum
'5'	PLL Loop is open with the EFC set to minimum

Valid Time — is set to 1 when the GPS4 has synchronized to the satellite receiver. It is reset to 0 if 8 hours elapses without satellite reception, or after the user re-enters time from the keypad, until the GPS4has re-synchronized to GPS Time. It is reset to 0 if 15 consecutive 1pps recovered time pulses are outside the allocated phase limit. It is reset to 0 if a Frequency Error is detected.

Reject Code	is set to 1 at power-on and when satellite receiver Time Recovery data is marked Not Valid, or is late or inconsistent. During this condition the GPS4 is outputting back-up time not verified by comparison with GPS data.
Output or Synthesiser Fault	is set to1 if any of up to 10 output failures has been detected or if the E1/T1 Synthesiser is not locked. Each of the 10 outputs is monitored for amplitude and a failure results in this bit being set; the associated indicator LED for the output will be turned OFF. If the E1/T1 Synthesiser is faulty then a Red LED indicator is turned ON on the main PCB.
Frequency Control Fault	is set to 1 if the frequency controller is unable to set the oscillator frequency to track the reference frequency from the GPS receiver.

Oscillator Type consists of two ascii hex characters which each represent 4 bits of status where '1' represents the described status.

msb			lsb	msb			lsb
Reserved	Reserved	Reserved	Reserved	Osc Type Bit 3	Osc Type Bit 2	Osc Type Bit 1	Osc Type Bit 0

The oscillator type is determined a parameter stored in the EEPROM.

EEPROM CODE				
00	High Grade Rubidium/Cs	Positive	LPFRS opt A	48 hours
01 TO 07	RESERVED			
08	Standard grade plain Xtal	Positive		
09	Brandywine OCXO (SC)	Positive		9 hours

4.5.6.h Health Status of Satellites

Requested by h<CR><LF>

Format of this response is

```
Field 1      2            3
$PFEC,GPanc,YYMMDDhhmmss,XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX*CK<CR><LF>
```

Field		Contents of Field
1	GPanc	Fixed text identifier
2	YYMMDDhhmmss	Almanac Date/Time Where YY=Year, MM=Month, hh=hours,mm=mins,ss=secs
3	X	32 columns, being status of satellite PRN 1 - 32 where status is:-
	“0”	Almanac not collected yet or that satellite is not launched yet
	“1”	unhealthy (not used for positioning or timing)
	“2”	healthy (usable for positioning and timing)

Example Response

```
$PFEC,GPanc,990524095412,22222222220022222220222222202220*4D<CR><LF>
```

4.5.7.j Leap Second Information (Firmware 13+)

Requested by j <CR><LF>

Format of this response is

```
Field   1 2            3   4
$PRCCG,J,YYMMDDhhmmss,+1,dd*CK<CR><LF>
```

Field		Contents of Field
1	J	Fixed text identifier "J"
2	YYMMDDhhmmss	Leap Second Date Where YY=Year, MM=Month, hh=hours,mm=mins,ss=secs
	000000000000	Where the Leap Second Date information has not been acquired. Usually a GPS satellite announces the date, time and value for leap second adjustment repeatedly for two to six months before the adjustment is actually executed. After the adjustment has been made the announcement is continued for some period of time. In this period of post-execution announcement, if the pre-execution announcement was not received, the leap second field 3 below is filled with 00 because it is no longer available from satellites.
3	+1	Leap second to be inserted at Leap Second Date
	-1	Leap second deleted at Leap Second Date
	00	00 Leap Second Date has passed or parameter is not yet available
4	SS	GPS-UTC seconds offset
	00	Where the GPS-UTC value has not yet been acquired. This field accumulates leap seconds since the GPS system started operation on January 6th 1980. As of April 2001 this value is 13

Example Response

```
Field   1 2          3  4
$PRCCG,J,9901010000,+1,13*CK<CR><LF>
```

4.5.8.l Location and Signal-Noise ratio of Satellites

Requested by `l<CR><LF>`

The response to the l request contains a maximum of three records.

The Format of each response is

```
Field  1 2 3  4  5  6   7  8  9  10  11 12 13 14  15 16 17  18 19
$GPGSV,N,n,NN,SS,XX,XXX,XX,SS,XX,XXX,XX,SS,XX,XXX,XX,SS,XX,XXX,XX*CK<CR
><LF>
```

Field	Contents of Field	
1	N	Total Number of messages (1 to 3)
2	n	Number of this message
3	NN	Number of satellites in line-of-site (with elevation > 5 deg only) (00 to 12)
4	SS	1st Satellite PRN
5	XX	1st Satellite elevation (degrees 05 to 90)
6	XXX	1st Satellite azimuth (degrees 000 to 359)
7	XX	1st Satellite signal-noise-ratio (dBHz 00 to 99)
8-11		2nd Satellite details
12-15		3rd Satellite details
16-19		4th Satellite details

Example messages

```
$GPGSV,2,1,07,03,41,270,51,06,18,083,33,17,64,083,49,19,09,329,45*74
$GPGSV,2,2,07,22,74,208,48,23,21,126,45,25,06,195,39*4B
```

PRN	Shows the unique identification number of the satellite from 1 to 32.
Elv	Shows the elevation of each satellite in degrees.
Az	Shows the azimuth of each satellite in degrees.
S/N	Shows the signal to noise ratio of each satellite in dB where below 40 is poor, 40-46 is average and above 46 is good. The signal to noise ratio is a relative value for a single receiver and may not be the same for two receivers operating in identical conditions.

4.5.9.n Firmware Version Number

Requested by n<CR><LF>

Software version number only is output in the following format:

```
Field       1  2     3               4
$PRCCG,N,nnn,ppppppp-vvv,t*CK<CR><LF>
```

Field	Contents of Field
1	Fixed Text letter "N"
2	3 digit decimal firmware serial number with leading zeros included.
3	7 digit Engine program and 3 digit version number
4	Test result

For example if the firmware version is EGPS13 and Engine is 4850102 version 009

```
$PRCCG,N,013,4850102-009,1*CK<CR><LF>
```

The firmware resides in both flash memory and EPROM. If the flash memory has been reprogrammed then the current version may be a higher number than is quoted by the label on the EPROM. It is possible to revert to the EPROM firmware by fitting the jumper at LK1. If reprogramming of the flash memory is to be undertaken then LK1 **must** be open.

4.5.10. o Offset of Local Time Data and Command

Requested by o<CR><LF>

Local time parameters as listed below are reported by the GPS4 in response to the single character o<CR>LF> request. The same format is used in a user command transmitted to the GPS4 to set the Local Time parameters which are stored in non-volatile RAM. The message format must be exactly as shown including the colon and dummy data for the minutes offset (which is not used). Remember that if the checksum is to be omitted the **'*' MUST BE OMITTED** from the end of the message so that the GPS4 recognizes that no checksum is available.

Note that the Pulse output time (see 'c' response and associated command) has its own Local Time/UTC switch which is independent of the 'o' command Local Time/UTC switch for time and timecode outputs. However the sign and number of hours offset of Local Time is programmed by the 'o' command alone. The user can set GPS4 timecode output to UTC but generate pulse outputs which follow Local Time.

```
Field  1 2 3
$PRCCG,O,U,+HH:00*CK<CR><LF>
```

Field	Contents of Field
1	Fixed Text letter "O"
2	'U'=Time and Timecode outputs are UTC 'L'=Time and Timecode outputs are Local Time
3	'+' Add the following hours offset to UTC to obtain Local Time '-' Subtract the following hours offset from UTC to obtain Local Time HH=Number of Hours offset (MUST have a leading zero if < 10 hours, or two zeros if the value is zero). The maximum offset is + or – 23 hours :00=hours and minutes separator and data reserved for minutes offset

Example commands

```
$PRCCG,O,L,+01:00*7A<CR><LF>
```

The timecode output and the time returned in response to the 't' time request is Local Time. Local Time is UTC with one hour added. The count of offset time rolls over through days to years if required.

```
$PRCCG,O,L,-23:00*7C<CR><LF>
```

The timecode output and the time returned in response to the 't' time request is Local Time. Local Time is UTC with 23 hours subtracted. The count of offset time borrows from days through to years if required.

When a command has been accepted by the GPS4 the message is echoed but the contents of the response are recalculated from the data used by the GPS4 to implement the user request. A checksum is always returned.

4.5.11. p Position of GPS Antenna

Requested by p<CR><LF>

Format of this response is

```
Field  1      2          3 4          5 6 7  8     9       10 11    121314
$GPGGA,hhmmss,DDMM.MMMM,N,DDDMM.DDDD,E,s,NN,00.00,AAAAAA.A,M,GGGG.G,M,,*CK<
CR><LF>
```

Field	Contents of Field	
1	hhmmss	Time (UTC) of position update
2	DDMM.MMMM	Latitude (Degrees,minutes,decimal fraction of minutes)
3	N	"N"=North "S" = South
4	DDDMM.MMMM	Longitude
5	W	"W"=West "E" = East
6	Status	"0" Positioning not operational (or KNOWN position) "1" Positioning operational "2" Differential positioning
7	NN	Number of satellites used for positioning
8	DOP	DOP (2D: HDOP, 3D: PDOP)
9	Altitude	AAAAAA.A (-00999.9 to 017999.9)
10	M	Unit for Altitude (M=Metres)
11	GGGG.G	Geoid Altitude (-999.9 to 9999.9)
12	M	Unit for Geoid Altitude (M=Metres)
13	Null field	Reserved for DGPS Data (Time elapsed since last RTCM-SC104 data updating)
14	Null field	Reserved for DGPS Station ID

Example Response

```
$GPGGA,095427,5147.1358,N,00049.8371,E,1,06,01.71,000026.0,M,0046.3,M,,
*73
```

4.5.12. Software Reset Command

The instrument can be reset by an NMEA style command

```
$PRCCG,Z,0*2F<CR><LF>
```

As with other NMEA style commands to the GPS4, it is not necessary but it is recommended that the checksum be included at the end of this message; the value is always '2F' since the content of the command is fixed. The message must contain the correct header, the right number of characters, the Z and the 0 and the correct checksum. The '0' in the field after the 'Z' is the number zero (ascii code 30 hex) and describes the type of reset. If the message corresponds correctly to the reset command and the checksum is valid, the GPS4 returns the message as acknowledgment and waits 160ms, then re-starts the initialisation as though the instrument had just been switched on. The initialisation messages are output as each stage is completed. Note that there is a pause of about 5 seconds after the reset (a decimal point is output as each second passes) in which the download of new firmware to the GPS4 flash memory could be initiated. A typical output is:-

```
L=load ESC=RUN.....
Initialise - Clear RAM
Initialise DUART
TFS Ltd. C Mon Jun  4 2001 16:49
Testing IC27 RAM......IC27 RAM PASSED
Test IC27 NV_RAM Contents.IC27 PASSED - Using RAM based Parameters
Testing IC28 ROM......IC28 ROM PASSED  Cksum = F9D3
Test Alarm ON then OFF
Testing Indicators.......
Osc is XTAL4 OSA 8410 TCXO...Calibration Found
Initialise PLL...PLL Initialised Slope Positive
TC1=IRIG   TC2=Pulses
Pulse msg : $PRCCG,C,P2,+1*52
TimCod msg: $PRCCG,E,1,3,1,3*2C
Offset msg: $PRCCG,O,L,+01:00*7A
Alarm Masks
 1234 5678  1234 5678
 1111 1111  1111 1111
Set Timers
Run GPS4 EGPS17
```

4.5.13. s Additional information (Including Magnetic Declination)

Requested by s<CR><LF>

Format of this response is

```
Field  1      2 3         4 5          6 7    8     9      10   11
$GPRMC,hhmmss,A,DDMM.MMMM,N,DDDMM.DDDD,E,000.0,000.0,DDMMYY,MMM.M,W*CK<
CR><LF>
```

Field	Contents of Field	
1	hhmmss	Time (UTC) of position update
2	A or V	A=Positioning V=Positioning interrupted or KNOWN position
3	DDMM.MMMM	Latitude (Degrees,minutes,decimal fraction of minutes)
4	N	"N"=North "S" = South
5	DDDMM.MMMM	Longitude (Degrees,minutes,decimal fraction of minutes)
6	W	"W"=West "E" = East
7	Speed	Speed in Knots (000.0 to 999.9)
8	True Course	True Course in degrees (000.0 to 359.9)
9	DDMMYY	UTC Date as day, month, year (1994 to 2040)
10	MMM.M	Magnetic Deviation in degrees (000.0 to 180.0)
11	W	"W" (MAG=TRUE-DEV) or "E" (MAG=TRUE+DEV)

Example Response

```
$GPRMC,095431,A,5147.1362,N,00049.8371,E,000.3,005.7,240599,003.1,W*6F
```

4.5.14. t Request Precision Time

Requested by t

The purpose of this request is to capture time for data logging, time tagging etc. This message takes priority over other messages which will be inhibited while "t" is active. Therefore, if a message is already being transmitted, use of the "t" request may cause a disjointed message when the high priority output is immediately transmitted. The time in the message reflects the instant the stop bit of "t" was received, advanced by 1ms to compensate for typical character delay. If the serial port is busy when a request is received it will be ignored. Maximum request rate will depend on Baud rate, for example, at 4800 baud the serial port can transmit about ten messages per second. The format of the message is "Type 2"

Type 2 Format

```
Field      1            2         3   4 5
           HH:MM:SS.SSS DD/MN/YY NNN W S<CR><LF>
```

Field	Contents of Field
1	Hours, Minutes, Seconds, Milliseconds (UTC)
2	Day of Month, Month, Year.
3	Day of Year (Jan1 = 001).
4	Day of Week (Mon=1 Sun=7).
5	Status.

The status character is an ASCII representation of a hexadecimal figure from 0 to F (see section 3.3) where the bits are allocated as follows

Bit 3 (MSB)	Bit 2	Bit 1	Bit 0 (LSB)
Valid Time	Reject Code	Local Time	Leap Year

Valid Time is set to 1 when the GPS4 has synchronised to the satellite receiver. It is reset to 0 if 8 hours elapses without satellite reception, or after the user re-enters time from the keypad, until the GPS 8000 has re-synchronised to GPS Time. It is reset to 0 if 15 consecutive 1pps recovered time pulses are outside the allocated phase limit. It is reset to 0 if a Frequency Error is detected.

Reject Code is set to 1 at power-on and when satellite receiver Time Recovery data is marked Not Valid, or is late or inconsistent. During this condition the GPS4 is outputting back-up time not verified by comparison with GPS data. It is quite normal for occasional 'Reject Code' indications to be seen.

Local Time is set to 1 for Local Time. It is reset to 0 for UTC.

Leap Year is a year divisible by 4, including the century if also divisible by 4 (as is 2000 but not 2100).

Example message (fixed format 31 characters including spaces):

For a request made at thirty four minutes, three seconds and 123 milliseconds past eight in the evening on Tuesday the 15th. March 1988 with the GPS Synchronised Master Clock reporting Valid Time, GPS Locked, UTC in a Leap Year:-

```
20:34:03.123 17/03/88 077 2 9<CR><LF>
```

The status character '9' is indicating:-

Bit 3 (MSB)	Bit 2	Bit 1	Bit 0 (LSB)
1	0	0	1
Valid Time	Synchronised last second (no reject code)	UTC	Year is a Leap Year.

4.6. TxD2/RxD2 Messages

The GPS4 second serial output is configured to output serial data in the user's chosen format automatically after initialization. The format selection can be changed by entering a simple command into the TxD1/RxD1 command port. Three formats are shown below. Other customer specific outputs and protocols are available. The baud rate and character format are fixed as described above (19200,8,N,1).

To request data from the port the user sends the character 't' to request time. The port sends the message, reporting the time at which 't' was received, and the automatic 1/s output stops. No further output is transmitted until a further request 't' is received. To restore the automatic 1/s output the user must send 'r' to the port.

Type 1 Format

```
Field       1        2        3    4
            HH:MM:SS DD/MN/YY NNN  W<CR><LF>
```

Field	Contents of Field
1	Hours, Minutes, Seconds (UTC)
2	Day of Month, Month, Year.
3	Day of Year (Jan1 = 001).
4	Day of Week (Mon = 1 Sun = 7).

Example message (fixed format 25 characters including spaces and termination).

```
20:34:03 08/11/91 312 5<CR><LF>
```

Type 2 Format – See section 3.6 above

The second port responds in an identical format to that described for TxD1/RxD1. Both ports can be polled rapidly and asynchronously to report the time to independent users.

Type 3 Format – GPS4 Format

```
Field       1    2            3 4
            YYYY,DDD:HH:MM:SS,T,S<CR><LF>
```

Field	Contents of Field
1	Year (UTC)
2	Day of Year (Jan1 = 001), Hours, Minutes, Seconds
3	TFOM
4	Status of Time

Example message (fixed format 23 characters including commas and termination).

```
2001,156:15:17:43,3,1<CR><LF>
```

TFOM is Time Figure of Merit

TFOM	
9	10ms <PPS
8	1ms < PPS ≤10ms

S is S

Status S	
0	Coasting
1	Time Locked

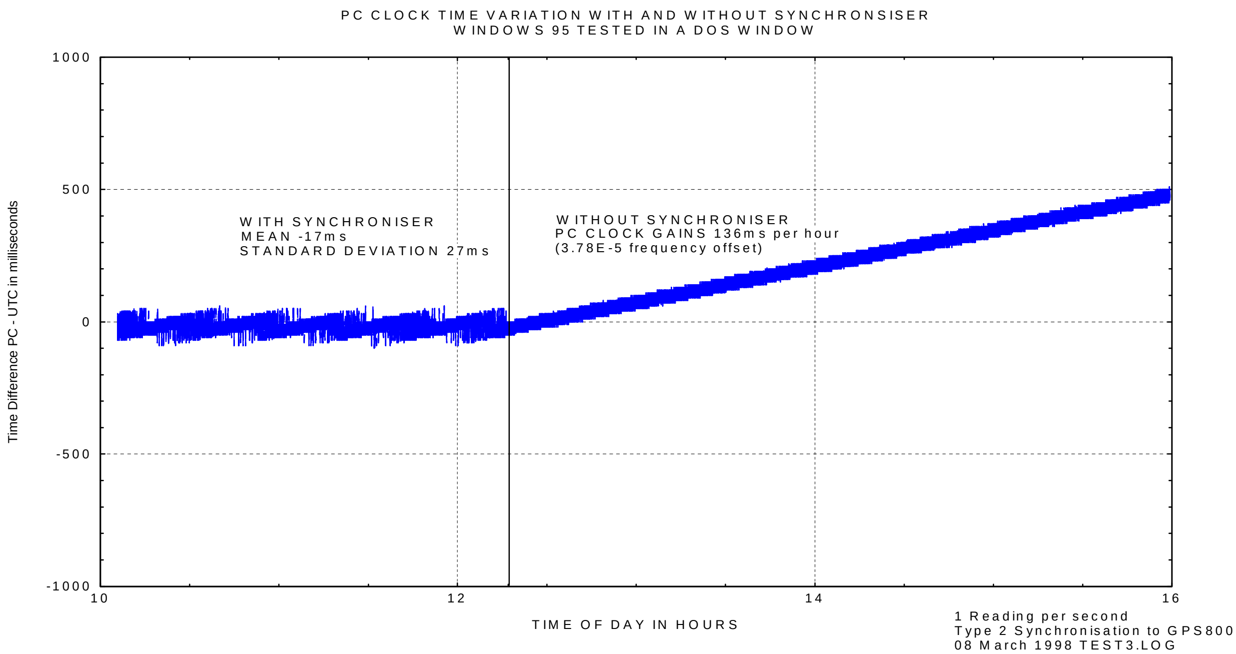
7	100µs < PPS ≤ 1ms
6	10µs < PPS ≤ 100µs
5	1µs < PPS ≤100ns
4	100ns < PPS ≤ 1µs
3	PPS ≤ 100ns

2	Holdover
3	Recovery
4	Power-up

4.7. Synchronising Computer Equipment to the GPS4.

Brandywine Communications offer SYNCHRONISER ©, a specially designed application for systems running Windows 95, 98 or NT. Synchroniser is designed to synchronise PC's and work stations precisely to the GPS4 serial data output on Type 2 time request protocol or by means of one of the regular serial data message formats.

The graph below shows the performance of a 200MHz Pentium II PC Running Windows 95, polling an external GPS4 clock Type 2 Serial output through a serial port. At about 12:30 the Synchronising source was removed to show comparison with the PC's own clock performance.



4.8. IRIG B and AFNOR NF 2 87-500 Timecode output

IRIGB/AFNOR NF 2 87-500 timecode is generated as standard by the GPS4. This timecode consists of a 1kHz carrier which is modulated in the pattern described below. The carrier and the timecode is synchronised precisely to GPS time by the GPS4

IRIG format B specification

Time: Universal Time (UTC)

Time frame: 1.0 second.

Code Digit Weighting: BCD and SB as follows:

a Binary Coded Decimal time-of-year Code Word : 30 binary digits.

(1) Seconds, minutes, hours and days.
(2) Recycles yearly.

b Straight Binary time-of-day Code Word : 17 binary digits.
(1) Seconds only.
(2) Recycles each 24 hours.

a BCD: Word begins at Index Count 1. Binary coded elements occur between Position Identifier Elements (7 for seconds; 7 for minutes; 6 for hours; 8 and 2 for days) until the Code Word is complete. An Index Marker occurs between decimal digits in each group to provide separation for visual resolution.

b SB: Word begins at Index Count 80. Five decimal digits (17 binary coded elements) occur with a Position Identifier between the 9th and 10th binary coded elements.

Bit order: Least significant digit occurs first.

Element rate: 100 per second.

Element identification:

a "On time" reference point for all elements is the leading edge.
b Index marker 2ms.
(Binary zero or uncoded element).
c Code digit 5ms.
(Binary one).
d Position Identifier-10 per second 8ms.
(Refers to the leading edge of the succeeding element).
e Reference Marker-1 per second Two consecutive Position Identifiers.

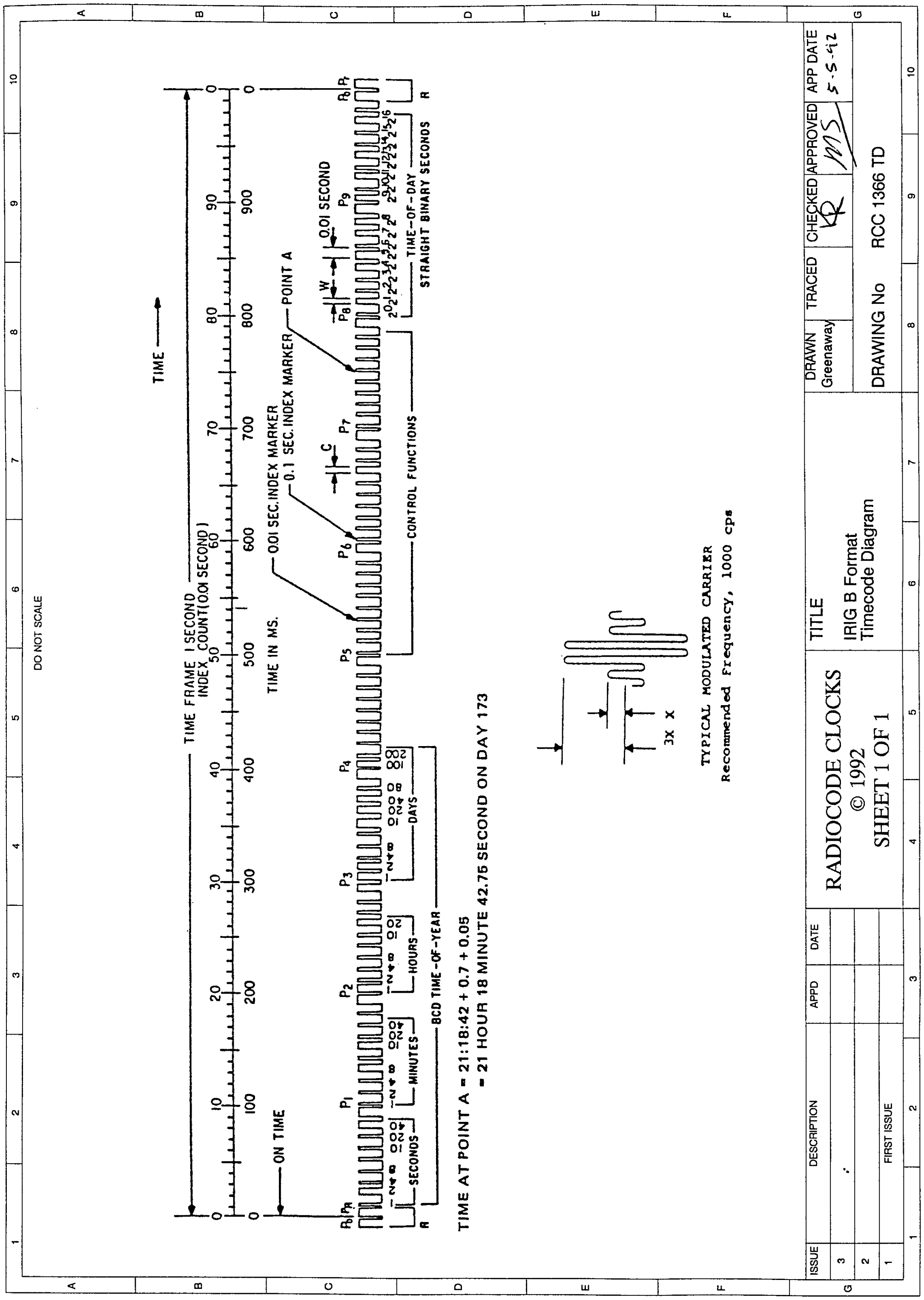
The "on time" point to which the Code Word refers is the leading edge of the second Position Identifier.

Resolution:	10 ms (unmodulated).
	1ms (modulated).
Carrier frequency:	1kHz when modulated.

IRIG B and AFNOR AFNOR NF 2 87-500 Timecode Bit Allocation

Each time-code bit is 10ms duration and therefore contains 10cycles of the 1kHz carrier. In table below '0' is 2ms higher level carrier duration ,'1' is 5ms higher level duration, 'Marker' is 8ms higher level duration. The standard output level for the higher level carrier (AFNOR specification) is 0dB into 600R (2.17V p-p ±10%). The lower level is 1/3 of the higher level, or the higher level -10dB. There are 100 bits total in one second with bit 0 (an 8ms marker) starting at the second's edge. The GPS4 is normally configured to send the full AFNOR specification time-code contents when IRIG B is selected.

Bit	Weight	CODE		Bit	Weight	CODE
00	Marker Pr	IRIG B		50	Year 1	AFNOR
01	Seconds 1	IRIG B		51	Year 2	AFNOR
02	Seconds 2	IRIG B		52	Year 3	AFNOR
03	Seconds 4	IRIG B		53	Year 4	AFNOR
04	Seconds 8	IRIG B		54	Always 0	IRIG B
05	Always 0	IRIG B		55	Year 10	AFNOR
06	Seconds 10	IRIG B		56	Year 20	AFNOR
07	Seconds 20	IRIG B		57	Year 40	AFNOR
08	Seconds 40	IRIG B		58	Year 80	AFNOR
09	Marker P1	IRIG B		59	Marker P6	IRIG B
10	Minutes 1	IRIG B		60	Month 1	AFNOR
11	Minutes 2	IRIG B		61	Month 2	AFNOR
12	Minutes 4	IRIG B		62	Month 4	AFNOR
13	Minutes 8	IRIG B		63	Month 8	AFNOR
14	Always 0	IRIG B		64	Always 0	IRIG B
15	Minutes 10	IRIG B		65	Month 10	AFNOR
16	Minutes 20	IRIG B		66	Always 0	AFNOR
17	Minutes 40	IRIG B		67	Always 0	AFNOR
18	Always 0	IRIG B		68	Always 0	IRIG B
19	Marker P2	IRIG B		69	Marker P7	IRIG B
20	Hours 1	IRIG B		70	Day of Month 1	AFNOR
21	Hours 2	IRIG B		71	Day of Month 2	AFNOR
22	Hours 4	IRIG B		72	Day of Month 4	AFNOR
23	Hours 8	IRIG B		73	Day of Month 8	AFNOR
24	Always 0	IRIG B		74	Always 0	AFNOR
25	Hours 10	IRIG B		75	Day of Month 10	AFNOR
26	Hours 20	IRIG B		76	Day of Month 20	AFNOR
27	Always 0	IRIG B		77	Always 0	IRIG B
28	Always 0	IRIG B		78	Always 0	IRIG B
29	Marker P3	IRIG B		79	Marker P8	IRIG B
30	Day of Year 1	IRIG B		80	Counter Clock 2^0	IRIG B
31	Day of Year 2	IRIG B		81	Counter Clock 2^1	IRIG B
32	Day of Year 4	IRIG B		82	Counter Clock 2^2	IRIG B
33	Day of Year 8	IRIG B		83	Counter Clock 2^3	IRIG B
34	Always 0	IRIG B		84	Counter Clock 2^4	IRIG B
35	Day of Year 10	IRIG B		85	Counter Clock 2^5	IRIG B
36	Day of Year 20	IRIG B		86	Counter Clock 2^6	IRIG B
37	Day of Year 40	IRIG B		87	Counter Clock 2^7	IRIG B
38	Day of Year 80	IRIG B		88	Counter Clock 2^8	IRIG B
39	Reference P4	IRIG B		89	Marker P9	IRIG B
40	Day of Year 100	IRIG B		90	Counter Clock 2^9	IRIG B
41	Day of Year 200	IRIG B		91	Counter Clock 2^10	IRIG B
42	Always 0	IRIG B		92	Counter Clock 2^11	IRIG B
43	Always 0	IRIG B		93	Counter Clock 2^12	IRIG B
44	Day of Week 2	AFNOR		94	Counter Clock 2^13	IRIG B
45	Day of Week 4	AFNOR		95	Counter Clock 2^14	IRIG B
46	Day of Week 4	AFNOR		96	Counter Clock 2^15	IRIG B
47	Always 0	IRIG B		97	Counter Clock 2^16	IRIG B
48	Always 0	IRIG B		98	Counter Clock 2^17	IRIG B
49	Marker P5	IRIG B		99	Marker P0	IRIG B


DO NOT SCALE
TIME
TIME FRAME 1 SECOND
INDEX COUNT (0.01 SECOND)
TIME IN MS.
ON TIME
0.01 SEC. INDEX MARKER
0.1 SEC. INDEX MARKER
POINT A
0.01 SECOND
CONTROL FUNCTIONS
TIME-OF-DAY
STRAIGHT BINARY SECONDS
SECONDS
MINUTES
HOURS
DAYS
BCD TIME-OF-YEAR
TIME AT POINT A = 21:18:42 + 0.7 + 0.05
= 21 HOUR 18 MINUTE 42.75 SECOND ON DAY 173
3X X
TYPICAL MODULATED CARRIER
Recommended Frequency, 1000 cps
RADIOCODE CLOCKS
© 1992
SHEET 1 OF 1
TITLE
IRIG B Format
Timecode Diagram
DRAWN
Greenaway
TRACED
CHECKED
APPROVED
APP DATE
DRAWING No
RCC 1366 TD
ISSUE
DESCRIPTION
APPD
DATE
FIRST ISSUE

4.9. NASA36 Timecode output option

NASA 36 Timecode must be specified at time of ordering. NASA36 Timecode operates in a similar manner to IRIG B, with the bit allocations described below. 1kHz is the standard carrier for NASA36 Timecode.

NASA36 format specification

Time:	Universal Time (UTC) or Local Time
Time frame:	1.0 second.
Code Digit Weighting:	BCD as follows:
a	Binary Coded Decimal time-of-year Code Word : 30 binary digits. (1) Seconds, minutes, hours and days. (2) Recycles yearly.
	Word begins at Index Count 1. Binary coded elements occur between Position Identifier Elements 600ms duration every 100ms from 100ms to 900ms inclusive.
Bit order:	Least significant digit occurs first.
Element rate:	100 per second.
Element identification:	
a	"On time" reference point for all elements is the leading edge.
b	Index marker 2ms. (Binary zero or uncoded element).
c	Code digit 6ms. (Binary one).
d	Position Identifier-9 per second 6ms. (Refers to the leading edge of the succeeding element).
e	Reference Marker -1 per second Five consecutive Position Identifiers. Followed by a zero
Resolution:	10 ms (unmodulated). 1ms (modulated).
Carrier frequency:	1kHz when modulated.

NASA36 Bit Allocation

Bit	Weight		Bit	Weight
00	Reference Always 0		50	Position Identifier
01	Seconds 1		51	Hours 10
02	Seconds 2		52	Hours 20
03	Seconds 4		53	Always 0
04	Seconds 8		54	Always 0
05	Always 0		55	Always 0
06	Always 0		56	Always 0
07	Always 0		57	Always 0
08	Always 0		58	Always 0
09	Always 0		59	Always 0
10	Marker		60	Position Identifier
11	Seconds 10		61	Day of Year 1
12	Seconds 20		62	Day of Year 2
13	Seconds 40		63	Day of Year 4
14	Always 0		64	Day of Year 8
15	Always 0		65	Always 0
16	Always 0		66	Always 0
17	Always 0		67	Always 0
18	Always 0		68	Always 0
19	Always 0		69	Always 0
20	Position Identifier		70	Position Identifier
21	Minutes 1		71	Day of Year 10
22	Minutes 2		72	Day of Year 20
23	Minutes 4		73	Day of Year 40
24	Minutes 8		74	Day of Year 80
25	Always 0		75	Always 0
26	Always 0		76	Always 0
27	Always 0		77	Always 0
28	Always 0		78	Always 0
29	Always 0		79	Always 0
30	Position Identifier		80	Position Identifier
31	Minutes 10		81	Day of Year 100
32	Minutes 20		82	Day of Year 200
33	Minutes 40		83	Day of Year 400
34	Always 0		84	Day of Year 800
35	Always 0		85	Always 0
36	Always 0		86	Always 0
37	Always 0		87	Always 0
38	Always 0		88	Always 0
39	Always 0		89	Always 0
40	Position Identifier		90	Position Identifier
41	Hours 1		91	Control Functions
42	Hours 2		92	Control Functions
43	Hours 4		93	Control Functions
44	Hours 8		94	Control Functions
45	Always 0		95	Position Identifier
46	Always 0		96	Position Identifier
47	Always 0		97	Position Identifier
48	Always 0		98	Position Identifier
49	Always 0		99	Position Identifier

4.10. 2137 Timecode output option

2137 timecode must be specified at time of ordering. 1kHz is the standard carrier frequency for 2137.

2137 format specification

Time:	Universal Time (UTC)
Time frame:	1.0 second.
Code Digit Weighting:	BCD Binary Coded Decimal time-of-day Code Word : 20 binary digits. Hours, minutes, seconds. Recycles each 24 hours.
Code Word Structure	Word begins during the first 40ms Index Count of the current time frame. Binary coded elements occur every 40ms during the current time frame (6 for hours; 7 for minutes; 7 for seconds) until the Code Word is complete. A Reference Marker occurs during the last 40ms index count of the current time frame.
Bit Order	Most significant digit occurs first.
Element rate:	25 per second.
Element identification:	a "On time" reference point for all elements is the leading edge. b Index Marker 12ms. (Binary zero). c Code digit 24ms. (Binary one).
d	Reference marker : 1 per second 36ms. The "on time" point to which the code word refers is the trailing edge of the Reference Marker.
Resolution:	1ms (1kHz modulated). 4ms (250Hz modulated). 200ms (unmodulated).
Carrier frequency:	1kHz or 250Hz when modulated.

4.11. VELA Timecode Output Option.

VELA timecode must be specified at time of ordering

The VELA logic level time-code output is a positive pulse commencing at the second's edge with a duration of 200, 500 or 800ms according to the details below.

SECOND	FUNCTION	DURATION	SECOND	FUNCTION	DURATION
0	P0	800ms	30	P3	800ms
1	Year 8		31		200ms
2	Year 4		32	Mins 40	
3	Year 2		33	Mins 20	
4	Year 1		34	Mins 10	
5		200ms	35	Mins 8	
6		200ms	36	Mins 4	
7	DOY 200		37	Mins 2	
8	DOY 100		38	Mins 1	
9		200ms	39		200ms
10	P1	800ms	40	P4	800ms
11	DOY 80		41	MSS 8000	
12	DOY 40		42	MSS 4000	
13	DOY 20		43	MSS 2000	
14	DOY 10		44	MSS 1000	
15	DOY 8		45	MSS 800	
16	DOY 4		46	MSS 400	
17	DOY 2		47	MSS 200	
18	DOY 1		48	MSS 100	
19		200ms	49		200ms
20	P2	800ms	50	P5	800ms
21		200ms	51	MSS 80	
22		200ms	52	MSS 40	
23	Hours 20		53	MSS 20	
24	Hours 10		54	MSS 10	
25	Hours 8		55	MSS 8	
26	Hours 4		56	MSS 4	
27	Hours 2		57	MSS 2	
28	Hours 1		58	MSS 1	
29		200ms	59	R	800ms

P0 to P5 and R are 800ms markers. Durations not shown are 200ms for a zero weighting or 500ms for the weight shown. The count MSS is the count of minutes elapsed since the clock has been synchronised. It is set to 9999 at switch-on, reset at synchronisation and incremented once per minute if the clock is not synchronised. If the counter reaches maximum it ceases to count any further; the maximum count of 9999 minutes represents 6.9 days.

5. Maintenance and Calibration

5.1. Scope of Section

Section five describes the recommended maintenance checks for the GPS4 and outlines a general approach to fault finding and repair.

5.2. Routine Maintenance

During normal operation the GPS4 functions automatically and does not require continuous manual intervention. Preventative maintenance can therefore be restricted to a regular inspection of status indicators .

5.3. Fault Finding

CAUTION

In the case of equipment malfunction or failure, Brandywine Communications strongly recommends that the GPS4 is returned to the factory for repair. If this is not practical, fault finding and repair must only be undertaken by a qualified test engineer. Brandywine Communications will not accept any liability for injury or damage caused during fault finding and repair by the user.

Internal fault finding and repair of the GPS4 requires specialized knowledge and non standard test equipment developed by Time & Frequency Solutions Ltd. Identification of a malfunction to module level is straightforward using the self test routines and status indicators. The following table identifies the most likely module responsible for a fault condition.

Built in test	Suspect module
ANT FLT	ANTENNA/RECEIVER
INIT FAIL	MICROCOMPUTER
RCVR FLT	RECEIVER
OSC I/P FLT	INTERNAL OSCILLATOR
FRQ ERR FLT	INTERNAL OSCILLATOR (may require adjustment)
RAM FAIL	MICROCOMPUTER
EFC LIM FLT	INTERNAL OSCILLATOR (may require adjustment).
ROM FAIL	MICROCOMPUTER

A malfunction of the output interfaces will be immediately apparent to the user. A major failure of the power supply will cause a complete loss of functionality. .

It should be noted that the instrument contains static sensitive devices. .

The precision oscillator installed in the GPS4 may be one of several different types. The oscillator is factory installed and does not require further adjustment. The type of oscillator fitted is detected automatically and is described in the power-on message; the type is specified by an entry in EEPROM memory.

6. DIAGRAMS

FIGURE 7. Table of Link Settings

LINK	STANDARD BUILD	CONSEQUENCE
PL1	NO FIT	Emulator Port
R90	NO FIT	TXD2- (TOD) RS422 CONNECTION OPEN
R91	NO FIT	TXD2+ (TOD) RS422 CONNECTION OPEN
R92	FIT	TXD2 (TOD) RS232 OUTPUT CONNECTED
R93	NO FIT	RXD1 RS422 INPUT BUFFER OUTPUT CONNECTION OPEN
R94	NO FIT	RXD1+ RS422 CONNECTION OPEN
R95	NO FIT	TXD1- RS422 CONNECTION OPEN
R96	NO FIT	TXD1+ RS422 CONNECTION OPEN
R97	NO FIT	RXD1- RS422 CONNECTION OPEN
R98	FIT	HARDWARE RESET FROM PIN 4 OF SK1 (9 WAY DTYPE)->RESET
R99	FIT	RXD1 RS232 INPUT FROM PIN 3 SK1->RS232 RECEIVER
R100	FIT	TXD1 RS232 OUTPUT FROM PIN 2 SK1
R101	FIT	RXD1 RS232 INPUT BUFFER OUTPUT->UART
LK1	2-3 FIT	Output 1kHz modulated carrier Timecode TC1 (IRIG B)
LK1	1-2	Output DC level shift time code TC2
LK3	OPEN	NO RS422 TERMINATION
LK5	OPEN	NO SiRF ENGINE PROGRAMMING
LK6	2-3 FIT	10MHz SINEWAVE OUTPUT
LK6	1-2	10MHz TTL OUTPUT
LK7	OPEN	TEST LINK INTO CPLD / OR TEST SIGNALS FROM CPLD
LK8	OPEN	SCREWDRIVER RESET CONTACTS
LK9	1-2	/CS6 STROBES WATCHDOG
LK10	OPEN	RUNS FROM FLASH MEMORY (JUMPER FOR EPROM ONLY)
SK1	FIT	9 WAY D TYPE SOCKET FOR COMMUNICATIONS
SK2	NO FIT	MOTOROLA ENGINE CONNECTOR
J1	BNC	IRIG B OUTPUT
J2	BNC	1PPS OUTPUT
CON3	NO FIT	SiRF ENGINE CONNECTOR
CON4	->Engine	FURUNO GT77 ENGINE CONNECTOR
CON5	Not used	OPTIONAL Rb CONNECTOR
CON6	Not used	OPTIONAL Rb 10MHz
J7	BNC	10MHz OUTPUT
CON 8	10 WAY HEADER	PROGRAMS F3GPSNT1
CON9		POWER INPUT
CON10	10 WAY HEADER	PROGRAMS F3SYN1
J11	BNC	19.6608MHz OUTPUT