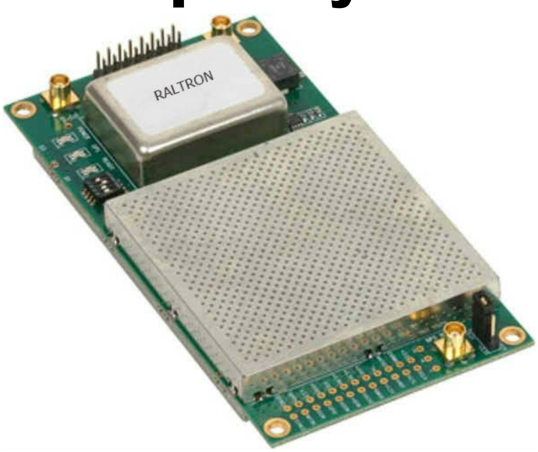
10400 N.W. 33rd Street
Miami, Florida 33172 U.S.A
Phone +1-305-593-6033 Fax +1-305-594-3973
www.raltron.com

SY-GSC10S

GPS Time and Frequency Reference Module



USER MANUAL

December 2015

WARNINGS AND NOTICES

NAVIGATING WITH THE PRODUCT

This Module is intended to be used primarily as a precise time and frequency instrument, even though it is capable of position location and navigation using the GPS system. Users are strongly advised to use good judgment if using this instrument for navigation. The user should never rely solely on any one source of information for navigation and should be aware that the position accuracy obtained from any GPS receiver can be affected by numerous sources of error such as satellite geometry, selective availability, satellite health, and electromagnetic interference. Published accuracy specifications are to be used only as a guide and are not guaranteed.

FCC NOTIFICATION

This module has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the Federal Communications Commission Rules & Regulations. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with this user manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area may cause harmful interference, in which case correction of the interference will be required at the User’s expense.

DC POWER CONNECTION

Exercise caution when connecting a power source to this Module. Make sure to observe the correct polarity, voltage and pin connection. Applying power to the unit with incorrect polarity or voltage or to the incorrect pin will damage the unit, and it will then require factory repair. Damage due to incorrect powering of the unit is not covered by any warranty.

TABLE OF CONTENTS

SECTION 1 "INTRODUCTION"

This module is a high performance GPS time and frequency reference that is designed to be incorporated into larger integrated systems. Highlights include:

- High spectral-purity 10 MHz sine wave output.
- Standard one pulse-per-second (1 PPS) timing pulse output.
- Industry standard NMEA0183 serial output message format.
- MTIE Stratum-1 compliance with frequency accuracy of $1x10^{-12}$ (long-term).
- Sawtooth-corrected timing pulse accuracy.
- GPS-disciplined ovenized oscillator with very low phase noise.
- Unit-to-Unit Phase Coherency optimization.
- State-of-the-art 16-channel high-sensitivity GPS receiver, with automatic WAAS differential corrections.
- Time, Date, Position, Altitude, Heading, Velocity Information.
- Fast Time-To-First-Fix offers high accuracy within just minutes of start-up.
- Intelligent compensation algorithm provides exceptional stability during GPS Holdover/Coast.

The commercial high-sensitivity, sixteen-channel GPS timing receiver simultaneously tracks all available satellites. The microprocessor-controlled timing and interface logic derives precise timing information from these satellites and provides additional features, including the standard 1 PPS output and associated informational messages. The timing and interface logic also controls an internal primary reference oscillator (OCXO) and additional clock features.

A low-noise active GPS antenna is required for operation of the module, which is capable of providing either 5 or 3.3 VDC to power the antenna. External gain (antenna gain less cable and connector loss) requirements are +15 to +26 dB. Built-in terrestrial interference filtering is recommended.

This document provides the information necessary to monitor and control the module from a host computer. Note that messages appear on only one port, and that the protocol is LVTTL (3.3-Volt Logic Levels). [The module does not have RS232, but the polarity of the message stream can be changed with a DIP switch to provide compatibility with most PC computers.] A Breakout Board is available from the factory for evaluation and testing that includes an LVTTL to RS232 conversion feature to make RS232 communication possible (please call for information).

The Module is capable of autonomous operation without connection to a host computer. Once power is applied, the unit requires no intervention to acquire satellites and provides the basic time and frequency functions based on factory default settings.

A GPS-disciplined ovenized crystal oscillator (OCXO) is incorporated to provide a very precise and stable frequency reference. After a few hours of tracking GPS signals, the accuracy of this source approaches that of the Cesium clocks on the GPS satellites. The output frequency is 10 MHz and is presented both as a sine wave and as a TTL square wave. The PPS timing pulse is generated by the GPS receiver when tracking sufficient satellites for a time/position determination, and is generated by the internal reference oscillator (OCXO) when in Holdover. The switch-over between tracking and Holdover is seamless to the output signal.

ANTENNA LOCATION

Before attempting to install an antenna, give careful consideration to its location and placement, as this can affect the overall performance. The primary goal is to locate the antenna in a place where it has a clear view of the sky. A secondary goal is to locate the antenna away from radio transmitters or other sources of noise that could possibly interfere with reception of the satellite signals. If several suitable locations are available, select the one with the best view of the sky.

Antennas should only be connected when the unit is not powered. Do not connect or disconnect the antenna when the unit is running as the GPS receiver calibrates the noise floor on power-up. Connecting the antenna after power-up can result in prolonged acquisition time and decreased sensitivity.

The use of an active antenna is always advisable if the RF-cable length between the unit and the antenna exceeds approximately 10 cm. Care should be taken that the gain of the LNA inside the antenna does not lead to an overload condition at the receiver. An antenna LNA gain of 15 dB is usually sufficient, even for cable lengths up to 5 m. There is no need for the antenna LNA gain to exceed 26 dB. With shorter cables and a gain above 25 dB, an overload condition might occur.

INSTALLATION

There are no special requirements for the location of the unit itself.

Avoid electromagnetic interference (EMI); keep the unit and its cabling away from sources of strong radio frequency (RF) energy such as radio transmitter cables and antennas. Also, keep the unit away from sources of heat. Normally, no special cooling provisions are required as long as adequate clearance is provided around the unit so that internally generated heat can dissipate by natural air convection.

CONNECTION TO A PERSONAL COMPUTER

The Module can be connected to a personal computer by means of the available Breakout Board that converts the LVTTL to RS-232 for serial communications. However, most personal computers will accept the logic levels of the Module directly, as long as the polarity is correct. There is a set of four DIP switches on the top of the Module and DIP switch #1 changes the polarity of the serial message output. If the Module is connected to a Breakout Board or other RS-232 converter, the DIP switch should be in the “OFF” (down) position. If the Module is to be connected directly to a personal computer, the polarity will need to be reversed and placing DIP switch #1 in the “ON” (up) position will accomplish this.

POWER INPUT

Power is supplied to the Module via the 16-pin header connector. See the pinout table on the page 16 for the input pin connection. You may supply power from any source that can supply a reasonably clean DC voltage in the range of 12 to 26 VDC at the required current for the supply voltage. The Module does have its own power conditioning.

SECTION 2 “COMMUNICATION”

Communication is through an asynchronous TTL- or LVTTL-compatible serial interface using message formats (ASCII) derived from the National Marine Electronics Association industry standard (NMEA 0183 version 2.3 pronounced “knee-ma”). The module does NOT follow all of the NMEA 0183 electrical interface recommendations, but the message protocol follows NMEA 0183 guidelines. A Breakout Board Evaluation Kit is available from the factory to facilitate evaluation and system development. Several third-party software utilities are available as freeware that will read and display the NMEA 0183-compatible information messages for monitoring the operations of the Module.

Messages from the Module to the host computer appear on pin 6 of the 16-pin header connector (Tx). Messages to the Module from the host computer must be applied to pin 5 of the 16-pin header connector (Rx).

The communication parameters are:

Baud rate	9600 bps default
Data bits	8
Stop bit	1
Parity	None
Handshake	None

Messages from the Module to the host computer appear on pin 6 of the 16-pin header connector (Tx)
Messages to the Module from the host computer must be applied to pin 5 of the 16-pin header connector (Rx)

NMEA 0183 PROTOCOL

The NMEA 0183 Standard specifies a data protocol for communications between *talking* instruments and *listening* instruments. This module is a *talking* instrument. The Module baud rate is set to the default rate of 9600 bps. The baud rate can be set to higher baud rates using message $PTFR010 (see below).

The NMEA 0183 data protocol uses simple ASCII characters in an asynchronous serial communications mode. NMEA 0183 refers to commands and messages as "sentences". Each sentence begins with a dollar sign '$' (hex 0x24) and ends with a carriage return and line feed <CR><LF> (<0x0D><0x0A>). Data is comma delimited. Between the last data character and the <CR><LF> is an asterisk '*' (0x2A) and a checksum. The checksum is the Exclusive-Or (XOR) of all characters between the dollar sign '$' and the asterisk '*'. For some sentences the checksum is optional. If there is no checksum, then there is no asterisk '*'. There is no comma before the asterisk.

There are three types of sentences: 1) a *Talker* sentence, 2) a *Proprietary* sentence, and 3) a *Query* sentence.

Talker sentences are essentially output messages and NMEA 0183 defines the format of standard messages. After the '$' there is a 5-character message identifier. The first two characters of the identifier are always 'GP', signifying that it is a GPS-based instrument. The next three characters identify which message it is of the standard NMEA 0183 messages. Examples of each message are shown below in Section 2. The messages available for output in this protocol are:

GPGGA	GPS Fix Data
$GPGSV	Satellites in View Data
$GPRMC	Recommended Minimum Navigation Data
$GPZDA	Time and Date

Proprietary sentences are allowed by NMEA 0183 and are unique to each manufacturer. They are used for information that is not defined in any of the standard messages, that is more useful in a different format than any of the standard messages, or that is for input of information (commands). Each Proprietary sentence begins with a '$P', followed by a three-character manufacturer identification ('TFR' for *Time and Frequency Reference*), then whatever identifier and data that the manufacturer defines as long as it follows the *general* format of NMEA 0183 sentences.

Some *Proprietary* sentences are used for factory default settings that can be changed by the User. The command to change the setting is also the message to report the setting. Other *Proprietary* sentences are only for reporting of specific items of information that cannot be changed by the User. We sometimes refer to *Proprietary* Input Sentence as a 'command' and a *Proprietary* Output Sentence as a 'message'. A *Proprietary* input command is automatically followed by the corresponding output message, confirming the information that was input. Examples of each command/message are shown in Section 3. Our Proprietary sentences are:

Identifier	Description	Type
$PTFR006	User Time Bias	Input/Output
$PTFR007	Timing Mode	Input/Output
$PTFR009	Multiplexer1 Output	Input/Output
$PTFR014	Multiplexer2 Output	Input/Output
$PTFR010	Baud Rate	Input/Output
$PTFR017	Query Mode	Input/Output
$PTFR023	Miscellaneous	Input/Output
$PTFR061	Time Valid Reporting	Output Only
$PTFR065	Alarm Status Reporting	Output Only
$PTFR079	Coast Timer Reporting	Output Only
$PTFR080	Phase Lock Status Reporting	Output Only

Query sentences are the means for a "*listening*" device to request the output of an individual *Talker* or *Proprietary* sentence. They are discussed below under **COMMUNICATION MODES**.

COMMUNICATION MODES

The Module normally broadcasts the entire set of standard NMEA 0183 messages (*Talker* sentences) on a repeating basis each second without any requests from the host computer, and the *Proprietary* sentences only when requested by a specific *Query* command. This is the default mode of operation and is referred to as ***Broadcast Mode***. With the streaming *Talker* sentences, all of the most relevant information is available once per second on a continual basis. The information in the *Proprietary* sentences is generally fixed (until changed) and so is only output in response to a request. If it is desired to have a *Proprietary* sentence included in the stream of messages broadcast each second, a *Query* command request for it will need to be sent once each second.

The other communication mode is called ***Query Mode***, in which no sentences are broadcast unless requested and all desired messages must be requested individually with a *Query* command by the host computer. ***Query Mode*** allows the host computer to receive only the message that it wants, when it wants it, rather than have to continually read all of the streaming message identifiers until it finds the message that it is looking for.

The User must set and unset the ***Query Mode*** using proprietary command $PTRF017. either with a serial communications program or via his own application. See Section 3 – "Proprietary Sentences".

Each *Talker* and *Proprietary* sentence has a related *Query* command. The response to a *Query* command is a one-time only output of the requested sentence containing the most recent information. Some *Proprietary* output messages can alternatively be queried by resending the input command. *Proprietary* input commands are acknowledged by the output of the message reflecting the information that was input. So, if it is desired to query the information in a *Proprietary* sentence, a *Query* command can be sent or the information that is expected to be in the sentence can be re-sent with an input command which will result in an output message that reports it.

The format for *Query* commands is $CCGPQ,XXX<CR><LF> where the first two characters after the '$' identify the listening device that is asking for the message ('CC' means "computer" but can be any two characters), the next two characters are 'GP' and indicate that it is our GPS-based instrument that is talking, the next character is always 'Q' and means 'Query', and XXX is the three-character identifier of the message name that is being requested. Checksums are optional and not used for *Query* Commands.

MESSAGE	QUERY COMMAND
$GPGGA	$CCGPQ,GGA<CR><LF>
$GPGSV	$CCGPQ,GSV<CR><LF>
$GPRMC	$CCGPQ,RMC<CR><LF>
$GPZDA	$CCGPQ,ZDA<CR><LF>
$PTFR006	$CCGPQ,006<CR><LF>
$PTFR007	$CCGPQ,007<CR><LF>
$PTFR009	$CCGPQ,009<CR><LF>
$PTFR014	$CCGPQ,014<CR><LF>
$PTFR010	$CCGPQ,010<CR><LF>
$PTFR017	$CCGPQ,017<CR><LF>
$PTFR023	$CCGPQ,023<CR><LF>
$PTFR061	$CCGPQ,061<CR><LF>
$PTFR065	$CCGPQ,065<CR><LF>
$PTFR079	$CCGPQ,079<CR><LF>
$PTFR080	$CCGPQ,080<CR><LF>

SECTION 3 "STANDARD NMEA 0183 SENTENCES"

The standard NMEA 0183 *Talker* sentences are of the general format:

```
$GPXXX,data1,data2,data3,data4,data5*CS<CR><LF>
```

where: $GP is always the same and identifies the *talking* device as GPS-based
XXX is the message identifier
data1, data2, data3,… designates various data fields
* indicates that a checksum follows
CS is the two character hex-format Exclusive-Or (XOR) of all characters between the '$' and the '*'
<CR><LF> is a carriage return followed by a line feed

The entire set of standard NMEA 0183 *Talker* sentences are broadcast on a repeating basis each second without any requests from the host computer. This is the default mode of operation and is referred to as ***Broadcast Mode***. If it is preferred that no sentences are broadcast unless specifically requested on a sentence-by-sentence basis, then the communication mode must be set to ***Query Mode*** using *Proprietary* command $PTRF017 described in Section 3 below.

The message formats and examples of the NMEA 0183 standard *talker* sentences are as follows:

$GPGGA – GPS Fix Data

Example:

```
$GPGGA,HHMMSS.00,DDMM.MMMM,N,DDDMM.MMMM,W,S,UU,PP.P,AAAAA.A,M,\0,\0,\0,\0*CSCRLF
```

Name	Example	Units	Description
Message ID	$GPGGA		
Time	063012.00	HHMMSS.SS	UTC Time in Hours, Minutes, Seconds
Latitude	3406.1141	DDMM.MMMM	Degrees and decimal minutes
N/S	N		North or South
Longitude	11747.8376	DDDMM.MMMM	Degrees and decimal minutes
E/W	W	East or West	
GPS Status	1	0/1	0=Not Valid, 1=Valid
Satellites Used	10	0-12	# of Satellites used in position calculation
DOP	01.2	0-99.9	Dilution of Precision
Altitude	00279.9	meters	0-18000
Units	M	Always meters	Altitude Units
Null	\0		
Null	\0		
Null	\0		
Null	\0		
Checksum	*??	XOR	
[CR][LF]	[CR][LF]	End of Message	Carriage Return / Line Feed

$GPGSV – Detail Satellite Data

Example:

```
$GPGSV,3,1,12,09,69,049,42,12,71,039,43,29,88,170,45,02,33,299,47*CSCRLF
$GPGSV,3,2,12,19,11,037,31,21,55,223,44,04,18,305,24,07,25,112,39*CSCRLF
$GPGSV,3,3,12,11,29,133,39,14,60,011,29,17,46,207,35,13,71,284,41*CSCRLF
```

Name	Example	Units	Description
Message ID	$GPGSV		
# of Messages *	3		Total number of messages in GSV group
Message # *	1		Number of this message
Sats in View	12		Total number of Satellites in View
SVID	09		Satellite Identification (PRN) – Channel 1
Elevation	69	Degrees (max 90 °)	Satellite Elevation – Channel 1
Aximuth	049	Degrees (0 – 359 °)	Satellite Azimuth – Channel 1
SNR (C/N_o)	42	dBHz	Signal Strength – Channel 1
SVID	12		Satellite Identification (PRN) – Channel 2
Elevation	71	Degrees (max 90 °)	Satellite Elevation – Channel 2
Aximuth	039	Degrees (0 – 359 °)	Satellite Azimuth – Channel 2
SNR (C/N_o)	43	dBHz	Signal Strength – Channel 2
….repeat	….repeat	….repeat	….repeat
SVID	13		Satellite Identification (PRN) – Channel 12
Elevation	71	Degrees (max 90 °)	Satellite Elevation – Channel 12
Aximuth	284	Degrees (0 – 359 °)	Satellite Azimuth – Channel 12
SNR (C/N_o)	41	dBHz	Signal Strength – Channel 12
Checksum	*??	XOR	
[CR][LF]	[CR][LF]	End of Message	Carriage Return / Line Feed

* Only 4 channels of information included in each message. Multiple GSV messages may be required, depending on the number of satellites being tracked.

$GPRMC – Minimum Recommended Data

Example:

```
$GPRMC,063012.00,A,3406.1141,N,11747.8346,W,000.00,000.0,160310,\0,\0,A*CSCRLF
```

Name	Example	Units	Description
Message ID	$GPRMC		
Time	063012.00	HHMMSS.SS	UTC Time in Hours, Minutes, Seconds
Status	A	A/V	A=Valid, V=Not Valid
Latitude	3406.1141	DDMM.MMMM	Degrees and decimal minutes
N/S	N		North or South
Longitude	11747.8376	DDDMM.MMMM	Degrees and decimal minutes
E/W	W		East or West
SOG	000.00	Knots	Speed over ground
COG	000.0	Degrees	Coarse over ground
Date	160310	DDMMYY	March 16, 2010
Null	\0		
Null	\0		
Mode	A	A/D/N	A=GPS, D=DGPS, N=Not Valid
Checksum	*??	XOR	
[CR][LF]	[CR][LF]	End of Message	Carriage Return / Line Feed

$GPZDA – Date and Time

Example:

`$GPZDA,063012.00,16,03,2010,\0,\0*CSCRLF`

Name	Example	Units	Description
Message ID	$GPZDA		
Time	063012.00	HHMMSS.SS	UTC Time in Hours, Minutes, Seconds
Day	16	DD	16th
Month	03	MM	March
Year	2010	YYYY	2010
Local Hours	\0		Null
Local Minutes	\0		Null
Checksum	*??	XOR	
[CR][LF]	[CR][LF]	End of Message	Carriage Return / Line Feed

SECTION 4 "PROPRIETARY SENTENCES"

The NMEA 0183 *Proprietary* sentences are of the general format:

$PTFRXXX,data1,data2,data3,data4,data5*CS<CR><LF>

where: $PTFR is always the same and identifies the message as *Proprietary* to the Time and Frequency Reference
XXX is the message identifier
data1, data2, data3,… designates various data fields
* indicates that a checksum follows
CS is the two character hex-format Exclusive-Or (XOR) of all characters between the '$' and the '*'
<CR><LF> is a carriage return followed by a line feed

Proprietary sentences are output only when requested by a specific *Query* command. This is true in both the default ***Broadcast Mode*** of operation and the alternative ***Query Mode***. The information in the *Proprietary* sentences is generally fixed (until changed) and so is only output in response to a request. If it is desired to have a *Proprietary* sentence included in the stream of messages broadcast each second, a *Query* command request for it will need to be sent once each second.

The response to a *Query* command is a one-time only output of the requested sentence containing the most recent information. Some *Proprietary* output sentences can alternatively be queried by resending the input command. *Proprietary* input commands are acknowledged by the output of the message reflecting the information that was input. So, if it is desired to query the information in a *Proprietary* sentence, a *Query* command can be sent or the information that is expected to be in the sentence can be re-sent with an input command which will result in an output message that reports it.

When sending a *Proprietary* Input sentence, it is not necessary to include the checksum. The sentence will be accepted without it. The response output sentence will, however, include the checksum. For example, to set the Multiplexer #1 Output, the command can be given: $PTFR009,1 <CR><LF> (without the checksum). The response Output sentence will be: $PTFR009,1*34 (with the checksum).

The message formats and examples of the NMEA 0183 *Proprietary* sentences are as follows:

$PTFR006 – USER TIME BIAS

Example: $PTFR006,+,00052*3A<CR><LF> Query Command: $CCGPQ,006<CR><LF>

Name	Example	Units	Description
Message ID	$PTFR006		
Sign	+	+ or -	positive
Bias Value	00052	Nanoseconds	52 nanoseconds
Checksum	*3A	XOR	
[CR][LF]	[CR][LF]	End of Message	Carriage Return / Line Feed

User Time Bias is a parameter that allows you to introduce a user-specified bias into all timing related functions of the module. The range of bias you can enter is ±99,999 ns. Negative values cause the timing functions to occur later in absolute time while positive values cause them to occur earlier.

$PTFR007 – TIMING MODE

Example: $PTRF007,0*3B<CR><LF> Query Command: $CCGPQ,007<CR><LF>

Name	Example	Units	Description
Message ID	$PTFR007		
Timing Mode	0	0, 1, or 3	0 = Dynamic, 1 = Static, 3 = Auto Survey
Checksum	*3B	XOR	
[CR][LF]	[CR][LF]	End of Message	Carriage Return / Line Feed

Two timing modes are provided for maximum accuracy and flexibility. In the **Dynamic Timing Mode**, the reference position for the purpose of determining precise time is the current position as determined by the GPS position solution. This mode must be used 1) if current location coordinates are not yet known, or 2) if position is expected to change, such as when operating on a moving platform (i.e. location is not fixed). Dynamic Timing Mode is the factory-set default mode.

When operating in the **Static Timing Mode**, a fixed position is used as the reference for deriving time and position coordinates are no longer recalculated. In this case, the position used is that position previously derived from GPS. In Static Timing Mode, information from all satellites tracked is used for timing, and time remains valid as long as at least one satellite is tracked. Static Timing Mode is the best for timing accuracy because three out of the four variables are removed from the timing solution.

A related function is the **Auto Survey Mode**. This Mode can be used to determine the precise current location. Auto Survey takes the average of 10,000 position measurements and then automatically switches the unit to Static Timing Mode. The Auto Survey function takes about 3 hours to complete. When a system is first installed in a new, permanent location, it is best to invoke the Auto Survey Mode to establish very accurate position coordinates that are then to be used for all future timing calculations.

When the unit is commanded to change from **Dynamic Timing Mode to Static Time Mode**, a “mini”-Auto Survey is first performed to obtain a usable reference position. This can take a variable amount of time, from a few seconds to as much as one minute, for the position to be reasonably accurate for use in Static Mode. The Output response sentence will report Auto Survey Mode (‘3’) during the period that it is calculating its reference position and then will automatically switch to Static Timing Mode (‘1’).

$PTFR008 – MASTER RESET

Example: `$PTFR008,1*CS<CR><LF>` (Check Sum not required on input)

Name	Example	Units	Description
Message ID	$PTFR008		
Master Reset	1	1 only	1 = Master Reset
Checksum	*??	XOR	
[CR][LF]	[CR][LF]	End of Message	Carriage Return / Line Feed

WARNING: Clearing all GPS data from memory will require significant time before normal operations are ready to resume.

$PTFR009 – MULTIPLEXER #1 OUTPUT

Example: $PTFR009,0*35<CR><LF> Query Command: $CCGPQ,009<CR><LF>

Name	Example	Units	Description
Message ID	$PTFR009		
MUX1 Output	0	0 – 8	See valid settings below
Checksum	*3	XOR	
[CR][LF]	[CR][LF]	End of Message	Carriage Return / Line Feed

where: 0 = 10 MHz TTL output (factory default)
1 = 5 MHz TTL output
2 = 1 MHz TTL output
3 = 100 kHz TTL output
4 = 10 kHz TTL output
5 = 1 kHz TTL output
6 = (reserved)
7 = PPS output
8 = OFF

$PTFR010 – BAUD RATE

Example: $PTFR010,3*3E<CR><LF> Query Command: $CCGPQ,010<CR><LF>

Name	Example	Units	Description
Message ID	$PTFR010		
Baud Rate	3	3 – 7	See valid settings below
Checksum	*3E	XOR	
[CR][LF]	[CR][LF]	End of Message	Carriage Return / Line Feed

where: 3 = 9600 baud (factory default)
4 = 19200 baud
5 = 38400 baud
6 = (reserved for 57,600 baud) Contact factory for custom version
7 = (reserved for 115,200 baud) Contact factory for custom version

$PTFR014 – MULTIPLEXER #2 OUTPUT

Example: `$PTFR014,8*31<CR><LF>` Query Command: `$CCGPQ,014<CR><LF>`

Name	Example	Units	Description
Message ID	$PTFR014		
MUX2 Output	8	0 – 8	See valid settings below
Checksum	*31	XOR	
[CR][LF]	[CR][LF]	End of Message	Carriage Return / Line Feed

where: 0 = 10 MHz TTL output
1 = (reserved for optional output)
2 = (reserved for optional output)
3 = (reserved for optional output)
4 = (reserved for optional output)
5 = (reserved for optional output)
6 = (reserved for optional output)
7 = PPS output
8 = OFF (factory default)

$PTFR017 – QUERY MODE

Example: `$PTFR017,0*3A<CR><LF>` Query Command: `$CCGPQ,017<CR><LF>`

Name	Example	Units	Description
Message ID	$PTFR017		
Communication Mode	0	0, 1	0 = ***Broadcast Mode*** (factory default) 1 = ***Query Mode***
Checksum	*3A	XOR	
[CR][LF]	[CR][LF]	End of Message	Carriage Return / Line Feed

In ***Broadcast Mode***, the entire set of standard NMEA 0183 messages (*Talker* sentences) are output on a repeating basis each second without any requests from the host computer, and the *Proprietary* sentences are output only when requested by a specific *Query* command. With the streaming *Talker* sentences, all of the most relevant information is available once per second on a continual basis. The information in the *Proprietary* sentences is generally fixed (until changed) and so is only output in response to a request. If it is desired to have a *Proprietary* sentence included in the stream of messages broadcast each second, a *Query* command request for it will need to be sent once each second.

In ***Query Mode***, no sentences are broadcast unless requested and all desired messages must be requested individually with a *Query* command by the host computer. ***Query Mode*** allows the host computer to receive only the message that it wants, when it wants it, rather than have to continually read all of the streaming message identifiers until it finds the message that it is looking for.

$PTFR023 – MISCELLANEOUS

Example: `$PTFR023,1,0,0*0D<CR><LF>` Query Command: `$CCGPQ,023<CR><LF>`

Name	Example	Units	Description
Message ID	$PTFR023		
Antenna Alarm	1	0, 1	0 = Antenna Alarm Disabled 1 = Antenna Alarm Enabled (factory default)
MUX Outputs	0	0,1	0 = MUX outputs enabled at Time Valid (default) 1 = MUX outputs enabled at power-on
External PPS Input	0	0,1	0 = External PPS Input NOT enabled (default) 1 = External PPS Input enabled
Checksum	*0D	XOR	
[CR][LF]	[CR][LF]	End of Message	Carriage Return / Line Feed

$PTFR025 – STATUS INDICATORS

Example: `$PTFR025,1,0,0,0,00013530,9<CR><LF>` Query Command:`$CCGPQ,025<CR><LF>`

Name	Example	Units	Description
Message ID	$PTFR025		
Timing Status	1	0, 1	0 = Time Not Valid, 1 = Time Valid
Coast Condition	0	0, 1	0 = No Coast Condition (not in Holdover) 1 = Coast Condition Alarm (in Holdover)
Antenna Good	0	0, 1	0 = Antenna Good 1 = Antenna Current Sense Fault Condition
10 MHz Good	0	0, 1	0 = 10 MHz Frequency Output Good 1 = 10 MHz Output Fault Condition Alarm
Coast Timer	00013530	HHHHMMSS	1 Hour, 35 Minutes, 30 Seconds
Phase Lock Status	9	0 – 9	See explanations below
[CR][LF]	[CR][LF]	End of Message	Carriage Return / Line Feed

Checksum is not used on *proprietary* messages that are status-reporting outputs only.

where:`HHHHMMSS` = Amount of time (Hours, Minutes, Seconds) that the unit has been in Coast/Holdover.

Status Value	Description	Tuning Mode	Phase Lock State
0	OCXO warm-up	1	NO
1	Coarse OCXO tuning	2	NO
2	Entered Coast condition during Mode 2 tuning	3	NO
3	Fine tuning OCXO, waiting for phase lock.	4	NO
4	Fine tuning OCXO, approaching phase lock	4	NO
5	Entered Coast condition during Mode 4 tuning	5	NO
6	External PPS Input Mode enabled	6	NO
7	External PPS Input Mode enabled	6	YES
9	Phase Lock Achieved	4	YES

For Phase Coherent Radio and Time Difference of Arrival applications, $PTFR025 should be monitored for a value of "9" for the highest accuracy and highest levels of phase coherency with 1PPS. A value of "5" is acceptable for short periods of time during temporary satellite outages. The Coast Timer in $PTFR079 reports how long the unit has been in holdover mode.

SECTION 5 "CONNECTIONS, PIN ASSIGNMENTS, INDICATORS"

CONNECTIONS

The Module has two vertical MCX jacks that are used for the primary timing and frequency reference outputs, a third vertical MCX jack that is used for the input from the GPS Antenna, and a dual-row, 16-pin (2x8) 0.100"-pitch header connector that is used for all other input/output plus power and serial communications (System Interface).

The **primary timing output** (MCX jack) is a One-Pulse-Per-Second (1PPS) that is synchronized to UTC. The positive pulse is rising edge on-time, TTL levels into 50Ω, 1ms nominal pulse-width, 10ns maximum rise-time. The time associated with the pulse is available on the serial port of the System Interface connector. An additional 1PPS output appears on Pin 2 of the System Interface connector. Both of these 1PPS signals are sawtooth-corrected in real-time and derived directly from the timing-optimized GPS receiver. A filtered 1PPS that is generated from the primary reference oscillator appears on Pin 11 of the System Interface connector and is coherent with the zero-crossing of the 10 MHz frequency reference output. The filtered 1PPS is essentially jitter-free, but its accuracy to UTC is dependent upon the reference oscillator being finely-tuned (in phase with GPS). Special care should be taken when using the filtered 1PPS in applications that anticipate possibly long periods of Coast/Holdover.

On power-up the 1PPS on the MCX jack appears as soon as the module self-configures, but without reference to UTC until satellite signals are acquired and proper time determined. Once the Time Valid condition has been reached, the PPS pulse will be moved to its proper place in time, resulting in a one-time aberration in the pulse interval. The 1PPS on Pin 2 of the System Interface connector does not appear (signal stays low) until Time Valid is achieved. [For Future Revision: The 1PPS on Pin 11 of the System Interface connector does not appear (signal stays low) until Phase-lock is achieved.] The delay in the appearance of signals on Pins 2, 8 and 11 until Time Valid is achieved is a Factory Default setting that can be changed with an input command ($PTFR023 – Miscellaneous) to have the signals instead appear as soon as the module self-configures.

The **primary frequency output** is a high spectral purity 10 MHz sine wave that is phase-locked to GPS. It is a +10dBm signal into 50Ω (± 2dBm). It appears immediately upon power-on. During the first approx. 3 minutes, the reference oscillator is warming up and no correction is attempted. After warm-up, the module begins to tune to reference oscillator to its designed frequency in coarse-to-fine steps, using GPS as the reference, through a series of dynamically-adjusted time constants. It then holds the oscillator on frequency (10 MHz), with adjustments for any disturbance (e.g. temperature change, Aging, movement, etc.). If the reference is ever lost due to the GPS satellite signal being temporarily interrupted by blockage or interference ("Coast/Holdover"), the control algorithms will work to maintain the stability of the frequency output as much as possible. When GPS signal is reacquired, tuning resumes seamlessly to recover from any accumulated frequency drift.

A 10 MHz TTL version (square wave) of the primary frequency output is available on the Multiplexer outputs (Pin 8 by default). This signal is derived from the same source. Only the waveform is different.

An **External PPS Input** can be supplied to Pin 1 of the System Interface connector as an alternative source for tuning and synchronization. The pulse should swing between 0 Volts to 2 Volts minimum, 5 Volts maximum. The External PPS Input feature must be enabled with an input command ($PTFR023 – Miscellaneous). When enabled, the module will ignore the PPS received from the GPS receiver and will look instead to Pin 1 for an input pulse. If a PPS pulse is present, the module will use it. If a pulse is not present, the module will go into Holdover/Coast until a pulse appears. The module will continue to function just as it would if it were using GPS for its timing reference, only substituting the input from Pin 1, and will continue to do so until the External PPS Input feature is again disabled by input command. While the External PPS Input is enabled, the module will increment its internal time base using the external PPS pulse and will ignore time information from the GPS receiver. While the External PPS Input is disabled, any external signal on Pin 1 will be ignored. (Signal should not exceed 5 VDC to avoid any damage to input driver). When the module is operating with External PPS Input enabled, message $PTFR025 – Status Indicators will report a status value of 6 or 7 (depending on phase-lock condition), and the LED indicators will operate as normal except that they will flash on and off every half-second.

CONNECTIONS (cont'd)

The **GPS Antenna** must be an active antenna with a noise figure of < 3 and gain of at least 15 dB at the input connector. The GPS Antenna should be connected to the input connector prior to applying power to the module so that the GPS receiver can calibrate its noise floor for maximum sensitivity. The Module has a current-sensing circuit to monitor whether the Antenna is drawing normal operating current (___ to ___A). If the Antenna current is outside the normal range, an Antenna Alarm is reported in an output message ($PTFR025 – Status Indicators), the "FAULT" logic indicator on Pin10 of the System Interface connector will go high, and the Power LED Indicator will show Yellow, all indicating a hardware fault. The Antenna current-sensing circuit can be disabled for low-power or shared antenna installations with an input command ($PTFR023 – Miscellaneous).

The GPS Antenna can be either 5-Volt or 3.3-Volt. Power is supplied depending on the placement of the **Antenna Power Jumper** on the topside of the Module. The jumper is marked and should be properly placed for the power required by the antenna. Damage to the antenna can occur if the jumper is placed incorrectly. If the jumper is left off, no power will be supplied to the antenna. This may be desired if the antenna is being shared with another instrument that supplies the power. The Module will still function with the antenna being powered by another instrument, but the current-sensing circuit will indicate a FAULT as mentioned above. This is a situation where disabling the antenna alarm with message $PTFR023 would be advised.

PIN ASSIGNMENTS

The Pin Assignments of the **System Interface** connector are

1 - External PPS Input (when enabled by command) or reserved for Custom I/O
2 - 1PPS Out (TTL into 50Ω)
3- GND
4- GND
5- Rx – Serial interface Receive (see NMEA 0183 Protocol)
6- Tx – Serial interface Transmit (see NMEA 0183 Protocol)
7- FLASH Programming Boot Loader (for uploading new firmware into Flash memory)
8- MUX1 Output [Selected with $PTFR009 command] (10 MHz TTL into 50Ω)
9- "LOCKED" Hardware Logic Indicator for Locked to GPS (see explanation below)
10- "FAULT" Hardware Logic Indicator for Hardware Malfunction (see explanation below)
11- MUX2 Output [Selected with $PTFR014 command] (reserved for 1PP2S on even seconds)
12- "RESET" Hardware Reset
13- GND
14- GND
15- Vcc (12 to 26 VDC)
16- Vcc (12 to 26 VDC)

Pin Assignment Descriptions

Pin 1 can be used to input an external PPS source for tuning and synchronization. The External PPS Input function must be enabled by User Command input ($PTFR023). The Factory Default is for the External PPS Input function to not be enabled.

The signals that appear on Pin 8 and Pin 11 can be changed by User command input ($PTFR009 and $PTFR014). The Factory Defaults are for Pin 8 to be 10 MHz TTL and Pin 11 to be "off".

The FLASH pin (7) is the Boot Loader activation for uploading new firmware into Flash memory of the Atmel AT89C51RE2 microcontroller. The Atmel Flash Utility ("FLIP") must be used for uploading new files. Grounding this pin causes the microcontroller to enter Boot Loader mode. If this pin is grounded inadvertently, the Module will not function and will appear to be dead.

Pin Assignment Descriptions (cont'd)

The LOCKED pin (9) is a hardware version of the GPS LED described below. When the GPS receiver is locked on satellites and calculating position/time normally, the pin is low. When the GPS receiver loses contact with the satellites and goes into Holdover/Coast, the pin goes high.

The FAULT pin (10) is a hardware indicator of fault conditions. In its normal state, the pin is low. If the antenna current-sensing circuit indicates a fault condition, the pin goes high. If the 10 MHz monitoring circuit indicates a fault condition, the pin goes high.

The RESET pin is for a hardware version of Master Reset and accomplishes the same result as message $PTFR008 above. Under normal conditions this pin is high. Grounding this pin clears memory and causes a restart of the microcontroller, a restart of the GPS receiver, and all options to be reset to factory defaults.

WARNING:
Performing the Master Reset operation clears all GPS data, including position, time and date, and Almanac. This feature should seldom (if ever) be required. It is provided as a means of recovering in the event that a transient error has caused the unit to operate improperly. Clearing all GPS data from memory will cause the GPS receiver to have to collect all new data. Significant time will be required before normal operations are ready to resume.

See below for a description of the meaning of the three LED indicators

INDICATORS

The best way to monitor the status of the GPS receiver and progress in tuning the oscillator is to observe the status messages that are output from the serial communications port. However, there are three LED indicators that can provide insight into the information without reading the messages. The meaning of the three LED indicators is as follows:

POWER	GPS	READY	DESCRIPTION
rapid flash	rapid flash	rapid flash	Start-up: The unit is completing initialization tasks (10 flashes).
green	red	red	Warm-up: POWER: Normal. GPS: Not yet supplying valid time information. READY: Still in Warm-up
green	green	yellow	Warm-up: POWER: Normal. GPS: Time Valid. Tracking satellites normally. READY: Coarse Tuning. Not yet phase-locked.
green	green	green	Normal: POWER: Normal. GPS: Time Valid. Tracking satellites normally. READY: Phase-locked. Ready for precision timing.
green	yellow	yellow	Holdover: POWER: Normal. GPS: No longer tracking satellites normally. READY: Unit is no longer fine-tuning due to lack of input from GPS, but is in holdover mode to maintain oscillator accuracy. In holdover mode for less than 3 hours.
green	yellow	red	Holdover: POWER: Normal. GPS: No longer tracking satellites normally. READY: Coasting for more than 3 hours.
yellow	green	green	POWER: Antenna Alarm. No power taken by antenna. Antenna apparently functioning, so may be DC-blocked for antenna-splitting, may be below low-power threshold, or may be a functioning passively. Alarm: GPS: Time Valid. Tracking satellites normally. READY: Phase-locked. Ready for precision timing.
yellow	red	red	POWER: Antenna Alarm. No power taken by antenna. Alarm: GPS: Not yet supplying valid time information. READY: Not yet phase-locked.
red	red	red	Abnormal: POWER: 10 MHz Alarm Condition. No signal. GPS: Not tracking satellites. Never achieved Time Valid. READY: Not phase-locked.
yellow flash	yellow flash	green flash	<u>External PPS Input Mode</u> POWER: Antenna Alarm. No power taken by antenna. GPS: No longer tracking satellites normally. READY: Phase-locked.

The detail descriptions of the LED indicators are as follows:

POWER LED

After the rapid flashing (10 times) during Start-up, the Power LED should remain green whenever there is power. If it is not green, there could be a potential problem. If the Power LED is yellow, this indicates an Antenna Alarm condition caused by the GPS antenna not drawing power above the current-sensing circuit threshold. It is most frequently due to the antenna not being connected, but could be due to a very low-power antenna (not a problem) or due to the antenna-voltage jumper not being installed. If the Module is sharing an antenna with another instrument that is providing the antenna with its power, then removing the antenna-voltage jumper will avoid over-powering the antenna. The Antenna Alarm is an advisory indicator only and can be disabled with Message $PTFR023. The Module will operate normally as long as it is receiving GPS signals. If the Antenna Alarm is unexpected, first check to make sure all connections from the Module to the antenna are secure and that the cable has continuity end-to-end before concluding that the antenna is malfunctioning (very rare). If the Power LED is red, this indicates a 10 MHz Hardware Alarm caused by the 10 MHz signal either not being present or being below the signal strength specification threshold. This is also extremely rare and would likely indicate either an excessive load on the 10 MHz signal or a malfunction requiring repair. In summary:

POWER LED **GREEN**: Power on. Normal
POWER LED **YELLOW**: Antenna Alarm. Little or no current is being drawn by the antenna.
POWER LED **RED**: 10 MHz Alarm. 10 MHz signal is nonexistent or below the signal strength threshold.

GPS LED

After initialization, the GPS receiver will search for satellites based on its last known position, its real-time clock, and Almanac information in its memory. If it is missing any of this information or does not find satellite signals where expected, it will proceed according to a search algorithm. During this time the GPS LED will be red. When satellites have been acquired, a time/position solution has been determined, and the UTC time-offset variable has been obtained from the Almanac, the module declares “Time Valid” and the GPS LED will be green. If satellite signal is subsequently lost, due to blockage or interference, the GPS LED will go to yellow indicating that it is in holdover. When satellite signal is reacquired and Time Valid reestablished, the GPS LED will go back to green. If the GPS LED is ever red, this means that the GPS receiver has never achieved Time Valid since power-up; otherwise the GPS LED will only toggle between green and yellow. If the GPS LED is ever red after at least once being green, you can assume that power had been lost at some point and the unit is cycling again through its normal sequence. In summary:

GPS LED **GREEN**: Time Valid. GPS receiver is tracking satellites normally.
GPS LED **YELLOW**: Holdover/Coast. GPS receiver is not tracking sufficient satellites for normal operation. Time was once valid, but now satellite signals either blocked or interfered, or antenna disconnected.
GPS LED **RED**: Time Never Valid. Time Valid has never been achieved during the current power cycle.

READY LED

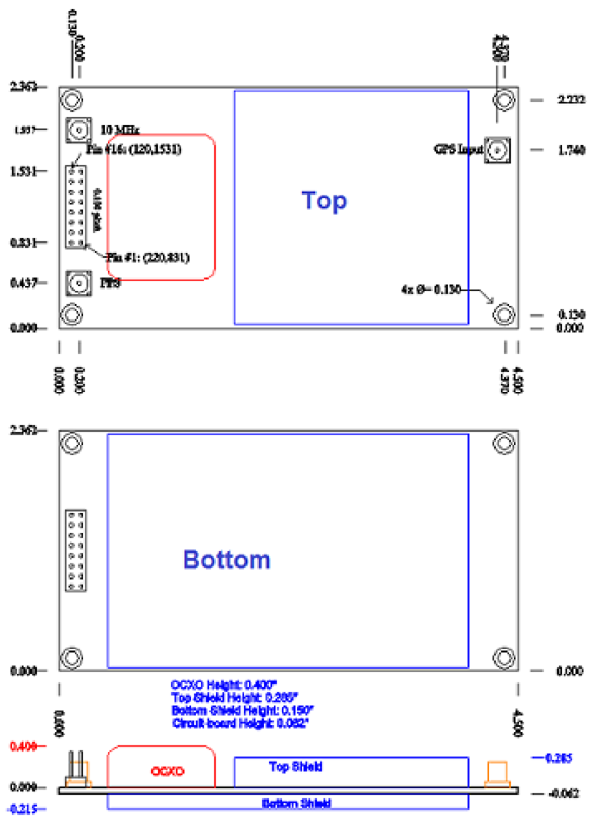
The Ready LED indicates the state of the phase-lock detection and oscillator tuning. During start-up and warm-up, the Ready LED will be red. When warm-up is complete and Time Valid is achieved, the tuning algorithm will begin to coarse-tune and the Ready LED will turn to yellow. When the dynamic time-constant tuning algorithm has achieved a sufficient state of fine-tuning, the Ready LED will change to green – indicating phase-lock [$PTFR080 Phase-Lock Status = 9]. If the GPS receiver goes into holdover, the Ready LED will change back to yellow as a warning that the oscillator is not being tuned with GPS, but can likely still be usable for most applications as proprietary holdover mode technology minimizes drift. After 3 hours of holdover the Ready LED will change from yellow to red. This Coast Alarm condition is simply a warning that the module has been coasting without GPS as a reference for over 3 hours and so may not be usable, depending on the tolerance of the application. In summary:

READY LED **GREEN**: Ready. Phase-locked. Oscillator in fine-tuning and sufficiently ready to enter Holdover/Coast if necessary.
READY LED **YELLOW**: Not quite Ready. Initial coarse-tuning. After Ready, oscillator no longer being tuned to GPS, but signals likely still usable. Coasting less than 3 hours.
READY LED **RED:** Not Ready. Either phase-lock never achieved, or Coasting for more than 3 hours. Timing and frequency references may no longer be within specification due to drift.

SECTION 6 – "SPECIFICATION"

DIMENSIONS

The dimensions of the module are 2.362" x 4.500". The circuit-board is 0.062". The bottom shield height is 0.150". The top shield height is 0.285". The tallest component on the top is the OCXO. It is available in different height options. The minimum height for the OCXO is 0.400". This results in an overall bottom-to-top height of 0.620". The mounting holes are 0.130" in diameter and are centered 0.130" in from the edges on each corner. The mounting holes are plated and grounded.



- **PINS USED**

The SY-GSC10S has two RF connectors type MCX[1] used for 10MHz and 1PPS mounted on the top. The module uses a dual row 16 pin (2x8) 0.100" header as I/O connector[2] for status, control and communication interface mounted on the bottom. Reference User Manual for pin assignments.

Note 1: The suggested manufacturer is RADIALL part number R113 426 000W.
Note 2: The suggested manufacturer is AMP part number 104351-8.

- **SPECIFICATIONS**

General Specifications	Mechanical	4.50"x 2.36" x 1.06" (114.3 x 60 x 27 mm)	
	Time Reference	GPS (Timing optimized)	
	Frequency Reference	OCXO standard (Phase locked to GPS)	Alternate OCXO, DOCXO, or TCXO options available consult Raltron
	Operating Temperature	-20°C to +70°C	
	Storage Temperature	-40°C to +85°C	
	Humidity	Up to 95% non-condensing	
Frequency Outputs	Output Signal	10 MHz Sine Wave	
	Output Level	+10 dBm nominal into 50 ohms	
	Phase Noise	1Hz < -90 dBc/Hz	
		10Hz < -124 dBc/Hz	
		100Hz < -140 dBc/Hz	
		1KHz < -150 dBc/Hz	
		10KHz < -152 dBc/Hz	
		100KHz < -155 dBc/Hz	
	Output Signal – 2	10 MHz Square Wave (TTL Level into 50 ohms)	
	Long-term Stability (while tracking	$1x10^{-12}$ after 24 hours of tracking	
	Short-term Stability	$1x10^{-11}$ (Δt = 1 sec)	
Timing Outputs	1PPS	Level: TTL into 50 ohms	
	1PPS2S on even seconds	Level: TTL into 50 ohms	
	Accuracy	<±25 nsec to UTC while tracking	
	Jitter	<3 nsec typical	
	Holdover Stability	≤1 µs over 4 hours (Static Temperature and Position)	
Data Output	RS-232 Serial Port, selectable baud	NMEA 0183 format: $GPGGA, $GPGSV, $GPRMC, $GPZDA. Date, Time, Position, Velocity, Bearing, Status, GPS Monitoring	
	Logic transition indicators	Locked to GPS and Hardware Status	
Data Input	RS-232 Serial Ports, 9600 baud	NMEA 0183 format for input of Default overrides	
GPS Performance	Receiver Architecture	12 parallel channels, Timing Optimized GPS Receiver C/A code, L1 Carrier (1575.42 MHz), 5-Volt Active Antenna Code plus Carrier Tracking, Update rate: Once per second. Maximum Altitude: 18000m; Maximum Velocity: 515 m/sec	
	Time to First Fix	< 5 seconds typical (hot), <40 seconds typical (cold)	
Power	Input Supply Voltage	12 to 26 VDC	Special order: 5 VDC conditioned
	Warm-up Current (<3 min)	540 mA @ 12 VDC typical (6.5 Watt)	
	Steady State Operating Current	270 mA @ 12 VDC typical (3.2 Watt)	
Connectors	10 MHz	MCX	
	1 PPS	MCX	
	GPS Input	MCX	
	Power, Data, Auxiliary Outputs	16 pin Header, 0.1" pitch	