

User Guide ProTime Sync

October 24, 2017

Version 1.00

*Monaghan Engineering
862 Las Colinas Drive
Dripping Springs, TX 78620 USA*

Telephone: 1-512-858-4271

Facsimile: 1-512-858-1355

<http://www.monaghan-engineering.com>

Email: techsupport@monaghan-engineering.co

Document Revisions

Date	Version Number	Document Changes
10/24/2017	1.00	Preliminary Draft

All trademarks and registered trademarks are the property of their respective owners.

Subject to change without notice.

© Monaghan Engineering, Inc. 2017 All Rights Reserved

Table of Contents

1	Introduction	5
2	Operation & Indication	6
2.1	LED Indicators.....	6
2.1.1	Module Status	6
2.1.2	Network Status	6
2.1.3	Time Sync.....	6
2.2	5 Volt Time Code Outputs	7
2.3	Ethernet.....	7
2.4	USB.....	7
2.5	Mode Switch.....	7
2.6	24 Volt Time Code Output.....	8
2.7	Power Connection	8
3	Hardware Installation	9
3.1	Power.....	9
3.2	5 VDC Time Code Outputs	9
3.3	24 VDC.....	9
4	Web Browser Interface	11
4.1	Monitor	11
4.2	Statistics.....	12
4.3	Clock.....	13
4.4	Outputs.....	13
4.5	Module.....	14
5	Firmware Update	16
5.1	Boot Loader.....	16
5.1.1	Network.....	16
5.1.2	Flash	16
5.1.3	Password.....	17
6	Appendices	19
6.1	Specifications.....	19
6.2	Modbus Register Assignments.....	19

- 6.3 Precision Time Protocol..... 23
 - 6.3.1 IEEE 1588 Technology Overview..... 23
 - 6.3.2 Typical Performance 24
- 6.4 IRIG-B Time Code..... 24
 - 6.4.1 Time Codes 24
- 6.5 DCF-77 Time Code..... 26
 - 6.5.1 Bit Definition..... 27
 - 6.5.2 Time Code Interpretation..... 27

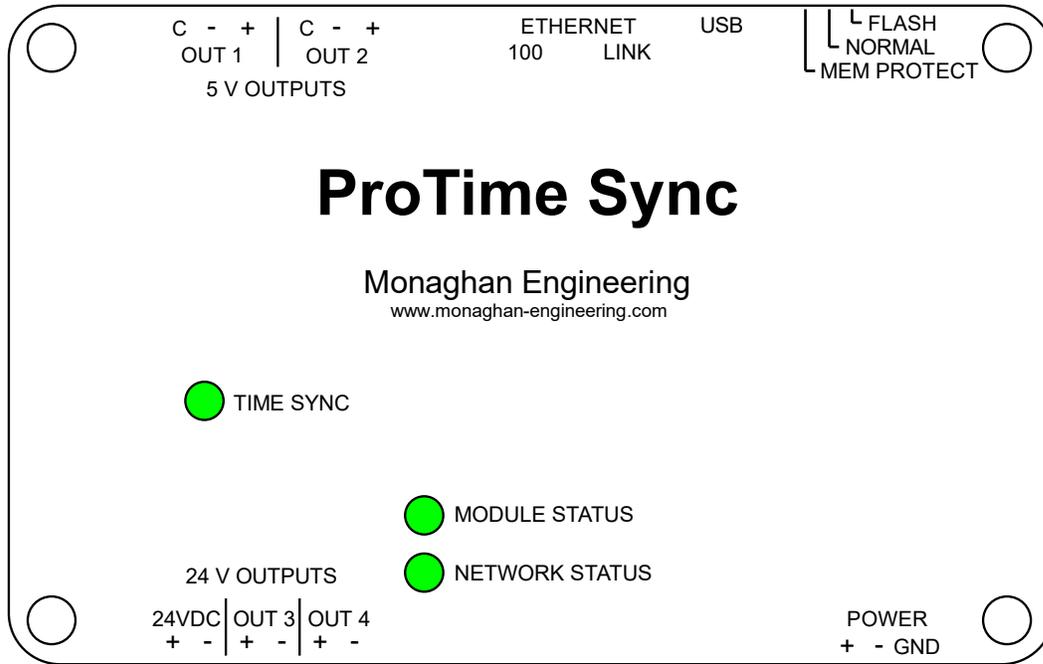
1 Introduction

The ProTime Sync is a precision time code generator. It is a network connected device that receives its time from a Network Time Server using Precision Time Protocol (PTP). The ProTime Sync has two 5 VDC and two 24 VDC time code outputs. Each output is individually programmable for 5 different time codes.

When connected to the network, the ProTime Sync will search for available network time servers. If multiple PTP time servers are available, it will track up to 5 servers and select the one with the most accurate clock. The typical accuracy of each time code output is an error of less than 1 microsecond.

2 Operation & Indication

The front panel of the ProTime Sync is labeled to show the connections, configuration switch and indicator LEDs for proper operation of the module.



2.1 LED Indicators

The LED indicators show the current operational status of the module.

2.1.1 Module Status

The Module Status LED shows the overall status of the module.

Steady Green	No errors detected.
1 Flash Red	ROM checksum error.
2 Flashes Red	RAM memory test error.
3 Flashes Red	Non-volatile memory battery low voltage.

2.1.2 Network Status

The Network Status LED shows the connection status of the module. The LED will be ON when a network connection has been established and it will be OFF when no connection is established.

2.1.3 Time Sync

The Time Sync LED shows the progress of the module as it synchronizes with a time server.

Off	No time server detected.
On Red	Synchronizing with time server.
1 Flash Green	Clock error > 50 mS.
2 Flashes Green	Clock error > 100 uS and < 50 mS.
On Green	Clock error < 100 uS.

2.2 5 Volt Time Code Outputs

Two 5-volt time code outputs are provided using the plug-in terminal block. See section 3.2 for more details.

2.3 Ethernet

An RJ-45 connector is provided for the Ethernet connection. The Green LED on the connector labeled 100 will be ON for a 100 Mb connection and OFF for a 10 Mb connection. The Yellow LED labeled Link will flash with link activity.

2.4 USB

The USB connection is not enabled with the current version of firmware.

2.5 Mode Switch

The mode switch controls the operation of the ProTime Sync module.

- Flash – When the switch is in the Flash position the module will switch to the Boot Loader mode. This mode has three purposes.
 - If the IP address of the module is not known, switching to this mode will allow access to the module. After switching to Boot Loader mode, the three LED's will start flashing three time. The module will try to request an IP address from the DHCP server.

If it is successful in receiving an IP address, the LED's will start flashing two time and the module can be accessed using a web browser using the url: ProTime_Sync/.

If the module is not able to receive an IP address the LED's will start flashing one time and the IP address will be 192.168.16.250.

A web browser can now be used to configure the network address.

- A web browser can be used to upload new firmware to the module.
- A web browser can be used set the password for any password protected web pages.

- Normal – When the switch is in Normal position the module is operating normally and can be configured using a web browser or the configuration registers can be set through Modbus commands.
- Mem Protect – When the switch is in Mem Protect position the module is operating normally but all configuration settings are locked and cannot be changed by a web browser or by Modbus commands.

2.6 24 Volt Time Code Output

Two 24-volt time code outputs are provided using the plug-in terminal block. See section 3.3 for more details.

2.7 Power Connection

The power for the module is provided using the plug-in terminal block. See section 3.1 for more details.

3 Hardware Installation

The ProTime Sync module is designed for DIN rail mounting. Wiring is connected to the module through plug-in terminal blocks. To install the module:

- Hold the module at an angle and hook the top of each mounting rail clip over the top of the mounting rail.
- Swing the module down so that the bottom hooks on the mounting clip engage the mounting rail.

To remove the module:

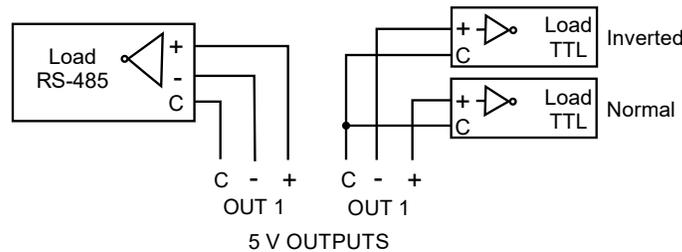
- Use a flat blade screw driver to gently pry the bottom hook of each mounting clip off the mounting rail.
- Swing the module up to remove it from the rail.

3.1 Power

The power connector is located at the lower right-hand side of the module. The correct input power voltage can be found on a label on the edge of the module closest to the power connector.

3.2 5 VDC Time Code Outputs

The two 5-volt outputs are RS-485 signals. Differential operation can be configured by using the + and - output pins. Positive unipolar operation can be configured by using the Common and + output pins. Inverted unipolar operation can be configured by using the Common and - output pins.



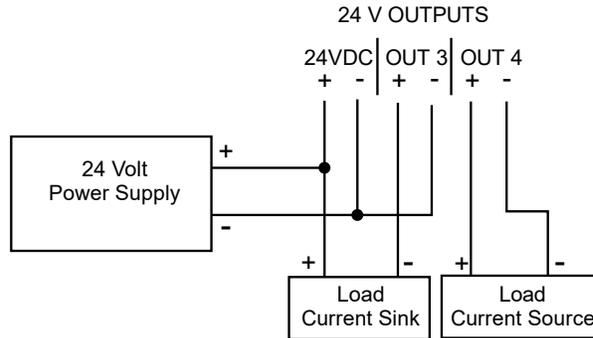
The output time code is selectable. The options are:

- IRIG-B
- DCF-77
- SER – Time code for synchronizing ProTime 100 SER modules.
- 1 PPS – Adjustable duty cycle from 10% to 90%.
- 1 KHz – Adjustable duty cycle from 10% to 90%.

3.3 24 VDC

The two 24-volt outputs are positive unipolar outputs. The 24-volt outputs can either source or sink current. For current sinking, the load is connected between the 24-volt

supply and the + output. For current sourcing, the load is connected between the + output and the - output.



The time code is selectable. The options are:

- IRIG-B
- DCF-77
- SER – Time code for synchronizing ProTime 100 SER modules.
- 1 PPS – Adjustable duty cycle from 10% to 90%.
- 1 KHz – Adjustable duty cycle from 10% to 90%.

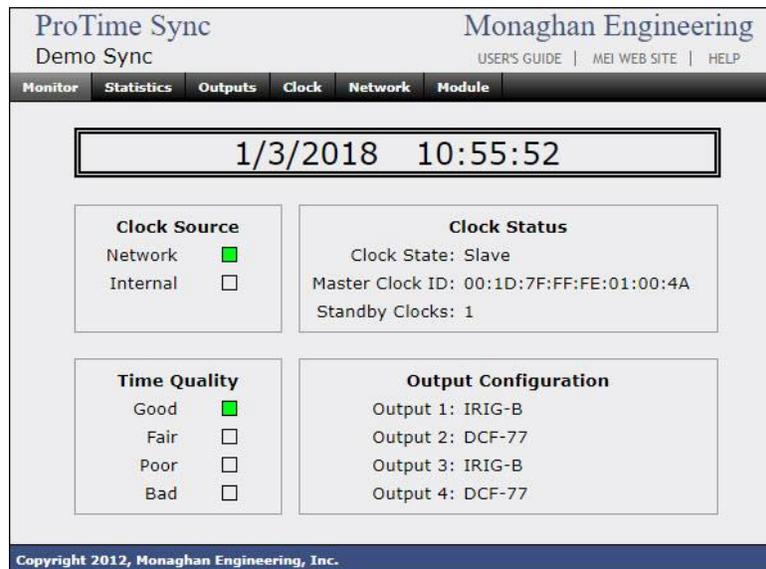
The 24-volt outputs can be configured as inverted outputs for applications that require an inverted unipolar output.

4 Web Browser Interface

The ProTime Sync contains an embedded web server. This allows the user to display data and configure the module.

4.1 Monitor

The Monitor page is an overview of the operation of the ProTime Sync.



- The Time display shows the current local date and time. The date and time will be followed by DST if daylight saving time is enabled and daylight-saving time is in effect.
- The Clock Source display shows which time source is being used by the clock for synchronization.
- The Time Quality display indicates the quality of the time signal generated by the clock. The clock continuously measures the error between its internal clock and the external time reference. The calculated error of the clock is displayed using the following values.
 - **Good** - The clock has a measured error of less than 100 μ S.
 - **Fair** - The clock has a measured or calculated error of greater than 100 μ S but less than 50 mS.
 - **Poor** - The clock has a measured or calculated error of greater than 50 mS.
 - **Bad** - The time is based on the internal battery backed-up clock. The clock has not synchronized with an external time reference since it was turned on.
- The Output Configuration display shows the time code selected for each output.
- The Clock Status display shows the status of the PTP clock.
 - Clock State - The current mode in which the clock is operating.
 - Master** : The clock is operating as a PTP master clock.
 - Slave** : The clock is synchronized to a master clock.

Sync 2 : The clock is in the final stage of synchronizing with a PTP master clock.

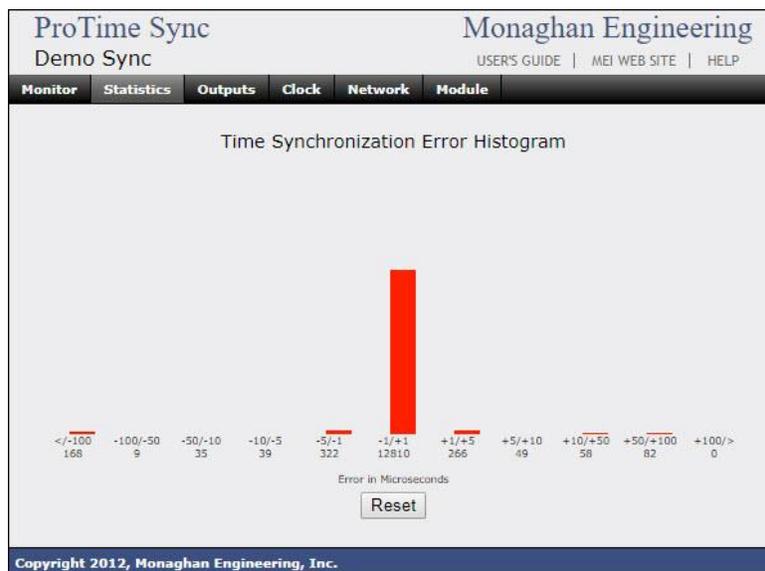
Sync 1 : The clock is in the initial stage of synchronizing with a PTP master clock.

Listening : The clock is listening for a PTP master clock.

- Master Clock ID
- Standby Clocks – The number of additional PTP master clocks on the network.

4.2 Statistics

When connected to a time source the ProTime Sync synchronizes its clock every second. During the synchronization process the module measures the current clock error and stores this information in a database. The data is then displayed as a histogram with each bar showing the relative number of samples that fell within each group and the numbers under the bars showing the actual number of samples. The display is updated every five seconds. Clicking on the Reset button will reset all the counts.



The Statistics display above shows the ProTime Sync synchronizing with a GPS receiver. The display was cleared before connecting the GPS receiver. For the first 168 seconds the error was greater than -100 uS. As the clock was being synchronized it had an error of -50 uS to -100 uS for 9 seconds, -10 uS to -50 uS for 35 seconds, and -5 uS to -10 uS for 39 seconds. It then overshot its target and had an error or +50 to +1—uS for 82 seconds, +10 to +50 uS for 58 uS and +5 to +10 uS for 49 seconds. It then oscilated between - 10 uS and +10 uS for 598 uS finally achieving an accuracy of better than 1 uS accuracy which it has held for the last 12,810 seconds.

4.3 Clock

The Clock page shows the configuration values for the clock. The ProTime Sync internal clock is always set to UTC. This display provides the conversion factors necessary to maintain the correct time.

- **Time Zone** - The time zone control allows the configuration of the offset from local time to UTC.
- **Daylight Saving Time Enable** - When this box is checked the PME GPS 0100 will indicate that the time is daylight saving time when it is in effect.
- **Daylight Saving Start and Stop** – The times at which Daylight-Saving Time starts and stops.

4.4 Outputs

The Outputs page shows the configuration values for the time code outputs. When the configuration values are provided by Unity, the “Submit” and “Reset” buttons will be disabled.



The time code outputs are individually programmable. The options are:

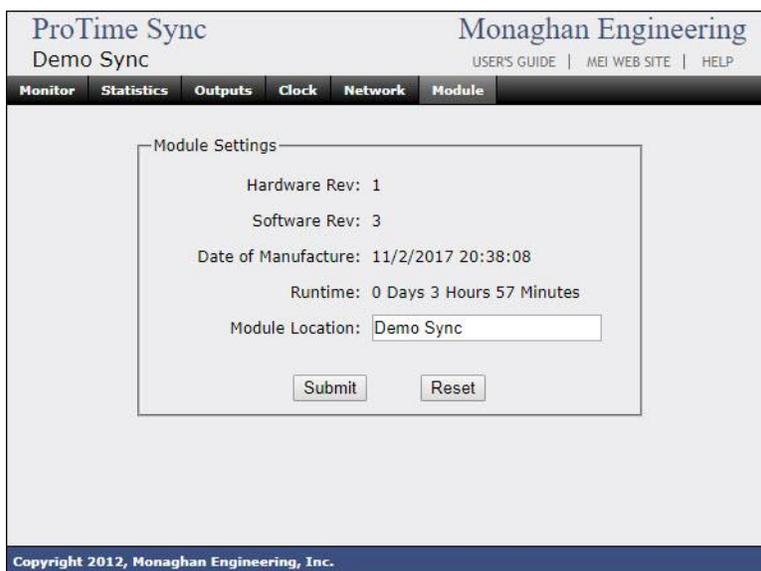
- IRIG-B
- DCF-77
- SER Serial
- 1 KHz
- 1 PPS

The 24-volt output can be inverted by checking the “Invert” box.

The duty cycle of the 1 PPS and 1 KHz may be adjusted from 10% to 90%.

4.5 Module

The Module page shows information about the module.



- **Hardware Rev** – The hardware revision of the module.
- **Software Rev** – The software revision of the module.
- **MAC Address** – The MAC address of the module.
- **Date of Manufacture** – The date the module was manufactured.
- **Runtime** – The elapsed time since the module was last reset.
- **Module Location** - This is a fifteen-character string that is displayed in the upper left-hand side of each web page.

5 Firmware Update

The ProTime Sync firmware can be updated by the user.

5.1 Boot Loader

The ProTime Sync supports web based firmware updates while in Boot Loader mode. To enter the boot loader, move the switch on the top of the module to the FLASH position. In approximately 5 seconds the module will re-boot and all the front panel LEDs will begin to flash.

- **3 Flashes** – The module is requesting an IP address from the DHCP server.
- **2 Flashes** – The module has received an IP address from the DHCP server. The module can be accessed by entering “ProTime_Sync/” in the address field of your browser.
- **1 Flash** – The module was not able to obtain an IP address from the DHCP server. It was assigned a default address of **192.168.16.250**.

The ProTime Sync can be returned to operating mode by moving the switch on the top of the module to the Normal or Mem Protect position.

5.1.1 Network

The Network page is used to configure the network setting for the module. If the network address of the module is not known, it can be started in Boot Mode and then configured using this page.

ProTime Sync - Flash Mode Monaghan Engineering
Demo Sync Revision 4 | HELP

Network Flash Password

IP Settings

MAC Address: 00:50:C2:51:5C:49

Module Name:

Media Type: 10/100BaseTx Auto ▼

Address Type: Static ▼

IP Address: 192.168.16.148

Subnet Mask: 255.255.255.0

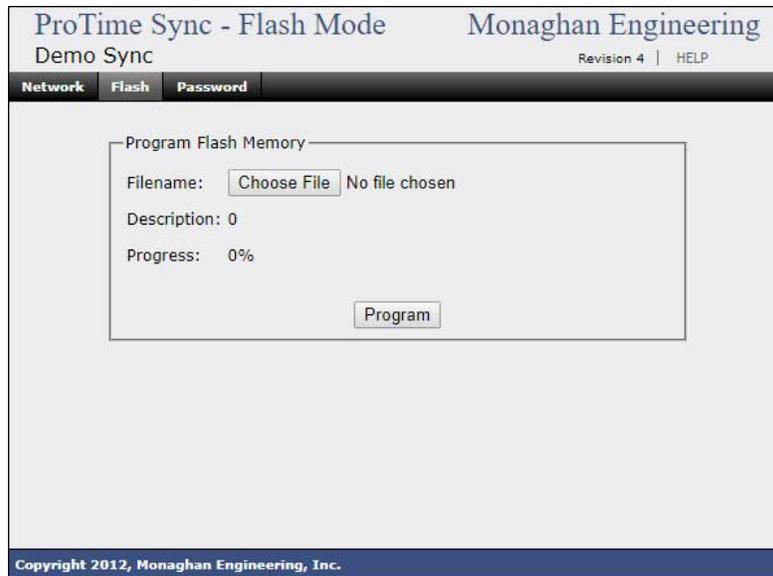
Gateway: 192.168.16.1

Submit Reset

Copyright 2012, Monaghan Engineering, Inc.

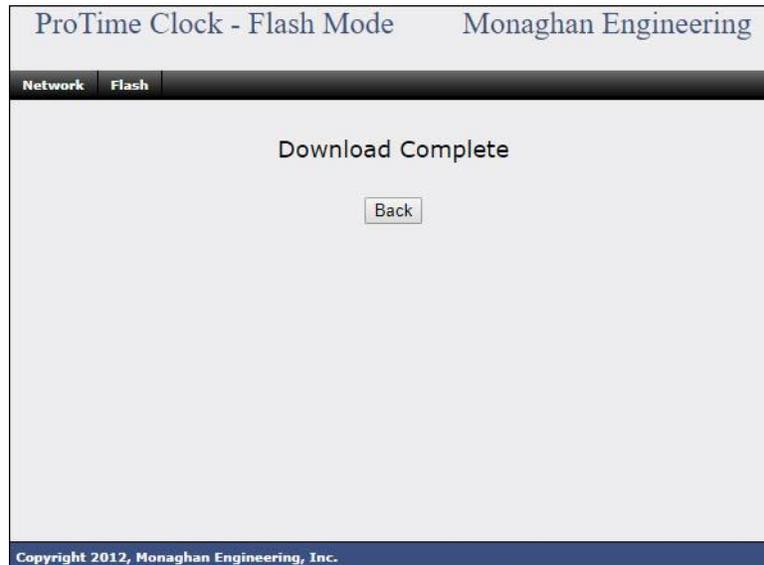
5.1.2 Flash

The Flash page is used to download the new firmware to the ProTime Sync module.



Click the “Choose File” button to select the firmware image to load. Click “Program” to start the programming process. The front panel LED’s will stop flashing for approximately 5 seconds while the Flash memory is erased. The program description will then be displayed and the Progress indicator will show the percentage complete.

After the firmware has been updated the “Download Complete” screen will appear.



5.1.3 Password

The Password page is used to program a system password for password protected pages. There are currently no password protected pages used.

ProTime Sync - Flash Mode
Demo Sync

Monaghan Engineering
Revision 4 | HELP

Network Flash Password

Module Password

Password:

Submit

Copyright 2012, Monaghan Engineering, Inc.

Enter up to a 15-character password and click on “Submit”.

6 Appendices

6.1 Specifications

- Input Power
 - 24 VDC Option – 18 VDC to 32 VDC
 - 48 VDC Option – 36 VDC to 64 VDC
 - 125 VDC Option – 90 VDC to 160 VDC
 - 120 VAC Option – 90 VAC to 250 VAC
- 5 Volt Output – 60 mA : 32 Standard RS-485 Loads
- 24 Volt Output - +/- 100mA
- 24 Volt Output Supply Voltage – 18 VDC to 32 VDC

6.2 Modbus Register Assignments

Register	Data Type	Description
		CONFIGURATION DATA
400003	Integer	IRIG-B Offset – Time offset from UCT (+/- 12 Hours)
400006	Integer	Daylight Saving Time Select 0 = Standard Time 1 = Enable Daylight Saving Time Calculation
400007	Integer	Daylight Saving Time Start Month (1 – 12)
400008	Integer	Daylight Saving Time Start Day (1 – 31)
400009	Integer	Daylight Saving Time Start Hour (0 – 23)
400010	Integer	Daylight Saving Time Stop Month (1 – 12)
400011	Integer	Daylight Saving Time Stop Day (1 – 31)
400012	Integer	Daylight Saving Time Stop Hour (0 – 23)
400020	Byte	MAC Address MSB (Read Only)
400021	Byte	MAC Address (Read Only)
400022	Byte	MAC Address (Read Only)
400023	Byte	MAC Address (Read Only)

400024	Byte	MAC Address (Read Only)
400025	Byte	MAC Address LSB (Read Only)
400026	Byte	IP Address MSB (0 - 255)
400027	Byte	IP Address (0 - 255)
400028	Byte	IP Address (0 - 255)
400029	Byte	IP Address LSB (0 - 255)
400030	Byte	Subnet Mask MSB (0 - 255)
400031	Byte	Subnet Mask (0 - 255)
400032	Byte	Subnet Mask (0 - 255)
400033	Byte	Subnet Mask LSB (0 - 255)
400034	Byte	Gateway Address MSB (0 - 255)
400035	Byte	Gateway Address (0 - 255)
400036	Byte	Gateway Address (0 - 255)
400037	Byte	Gateway Address LSB (0 - 255)
400038 - 400045	Char Array	Module Name (15 Characters - 8 Registers)
400046	Integer	IP Speed 0 = Auto Negotiate 1 = 10 Mbps 2 = 100 Mbps
400048	Integer	Firmware version (Read Only)
400051	Integer	IP Duplex 0 = Full Duplex 1 = Half Duplex
400058	Integer	Output 1 0 = IRIG-B 1 = DCF-77 2 = SER Serial Time Code 3 = 1 Pulse Per Second 4 = 1 KHz

400059	Integer	Output 2 0 = IRIG-B 1 = DCF-77 2 = SER Serial Time Code 3 = 1 Pulse Per Second 4 = 1 KHz
400060	Integer	Output 3 0 = IRIG-B 1 = DCF-77 2 = SER Serial Time Code 3 = 1 Pulse Per Second 4 = 1 KHz
400061	Integer	Output 4 0 = IRIG-B 1 = DCF-77 2 = SER Serial Time Code 3 = 1 Pulse Per Second 4 = 1 KHz
400062	Integer	Output 3 Polarity 0 = Normal 1 = Inverted
400063	Integer	Output 4 Polarity 0 = Normal 1 = Inverted
400064	Integer	1 PPS Duty Cycle (10 - 90)
400065	Integer	1 KHz Duty Cycle (10 - 90)
400067 - 400073	Char Array	Module Location
		TIME DATA
400201	Integer	Time Source 0 = Internal Oscillator 5 = Network - PTP
400203	Integer	Day of Week (1 - 7)
400204	Integer	Month (1 - 12)

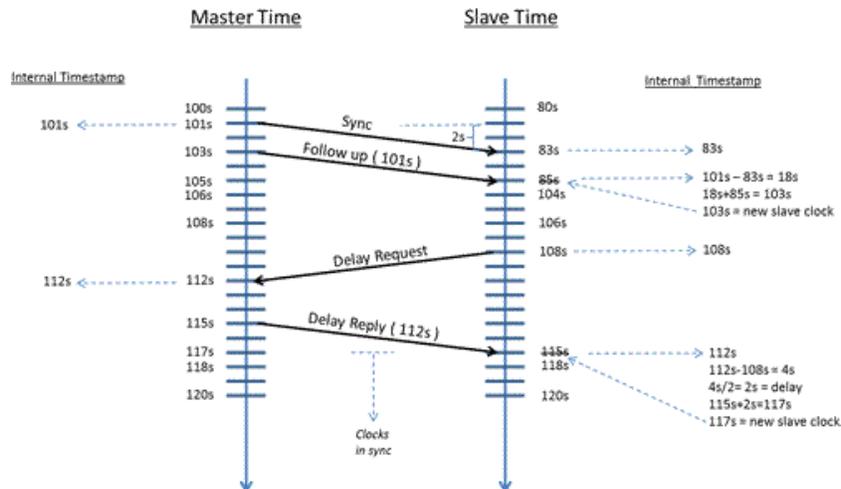
400205	Integer	Day (1 - 31)
400206	Integer	Year (1984 - 2200)
400207	Integer	Hour (0 - 23)
400208	Integer	Minute (0 - 59)
400209	Integer	Second (0 - 59)
400221	Integer	Time Quality 0 = Good (Less than 1mS error) 1 = Fair (Less than 50mS error) 2 = Poor (Greater than 50mS error) 3 = Bad (No precision time reference found)
400222	Integer	Daylight Saving Time 0 = Standard Time 1 = Daylight Saving Time

6.3 Precision Time Protocol

Measurement and automation applications often must precisely synchronize events over a widely distributed system. For example, an industrial automation system may need to synchronize distributed motion controllers, or a control system may need gather time stamped event data from multiple locations. The IEEE 1588 precision time protocol (PTP) provides a standard method to synchronize devices on a network with sub-microsecond precision. The protocol synchronizes slave clocks to a master clock ensuring that events and timestamps in all devices use the same time base.

6.3.1 IEEE 1588 Technology Overview

By synchronizing multiple clocks over networks such as Ethernet, IEEE 1588 provides sub-microsecond synchronization over long distances with standard cabling. There are two steps for synchronizing devices using IEEE 1588: (1) determine which device serves as the master clock, and (2) measure and correct time skew caused by clock offsets and network delays. When a system is initialized, the IEEE 1588 protocol uses the Best Master Clock algorithm to automatically determine which clock in the network is the most precise. It becomes the master clock. All other clocks become slaves and synchronize their clocks with the master.



Because the time difference between the master clock and slave clock is a combination of the clock offset and message transmission delay, correcting the clock skew is done in two phases -- offset correction and delay correction. The master clock initiates offset correction using "sync" and "follow-up" messages (see Figure 1). When the master sends a sync message, the slave uses its local clock to timestamp the arrival of the sync message and compares it to the actual sync transmission timestamp in the master clock's follow-up message. The difference between the two timestamps represents the offset of the slave plus the message transmission delay. The slave clock then adjusts the local clock by this difference at point A. To correct for the message transmission delay, the slave uses a second set of sync and follow-up messages with its corrected clock to calculate the master-to-slave delay at point B. The second set of messages is necessary to account for variations in network delays. The slave then timestamps the sending of a delay request message. The master clock timestamps the arrival of the delay request message. It then sends a delay response message with the delay request arrival timestamp at point C. The difference between the timestamps is the slave-to-master delay. The slave averages the two

directional delays and then adjusts the clock by the delay to synchronize the two clocks. Because the master and slave clocks drift independently, periodically repeating offset correction and delay correction keeps the clocks synchronized.

6.3.2 Typical Performance

Most IEEE 1588 implementations will have sub-microsecond skew, but actual performance is highly application-specific. For example, the IEEE 1588 protocol does not specify the clock frequency in the master and slaves; thus, lower-frequency clocks have poorer time resolution resulting in less-accurate timestamps in the PTP synchronization messages. Clock stability is another implementation dependency. Clocks based on temperature-controlled crystal oscillators (TCXOs) and oven-controlled crystal oscillators (OCXOs) have higher stability, usually in the parts per billion, compared with clocks using uncontrolled crystal oscillators, with stability in the parts per million. Clocks with lower stabilities will drift apart faster, resulting in more frequent frequency and phase corrections or resulting in larger skews. Another factor is network topology. The simplest network topology -- two devices on a single cable -- provides less network jitter than many devices linked using routers and switches. If more than one subnet is required to increase distance or number of devices, then a network switch with an accurate IEEE 1588 clock, called a boundary clock, becomes the master clock and synchronizes the devices on the subnets. Also, wide variations in network traffic may negatively impact clock skew as the delay correction lags current traffic conditions. Because many factors can degrade skew performance, benchmarking and monitoring actual skew performance over time is recommended.

6.4 IRIG-B Time Code

Inter-range instrumentation group time codes, commonly known as IRIG time codes, are standard formats for transferring timing information. The standards were created by the Telecommunications Working Group of the U.S. military's Inter-Range Instrumentation Group (IRIG), the standards body of the Range Commanders Council. Work on these standards started in October 1956, and the original standards were accepted in 1960.

The original formats were described in IRIG Document 104-60, later revised and reissued in August 1970 as IRIG Document 104-70, upgraded later that year as the IRIG Document to the status of a Standard, IRIG Standard 200-70. The latest version of the Standard is IRIG Standard 200-16 from August 2016.

6.4.1 Time Codes

The different timecodes defined in the Standard have alphabetic designations. A, B, D, E, G, and H are the standards currently defined by IRIG Standard 200-04.

The main difference between codes is their rate, which varies between one pulse per minute and 10,000 pulses per second.

IRIG time code					
Code	Bit rate	Bit time	Bits per frame	Frame time	Frame rate
A	1000 Hz	1 ms	100	100 ms	10 Hz
B	100 Hz	10 ms	100	1000 ms	1 Hz
D	$\frac{1}{60}$ Hz	1 minute	60	1 hour	$\frac{1}{3600}$ Hz
E	10 Hz	100 ms	100	10 s	0.1 Hz
G	10 kHz	0.1 ms	100	10 ms	100 Hz
H	1 Hz	1 s	60	1 minute	$\frac{1}{60}$ Hz

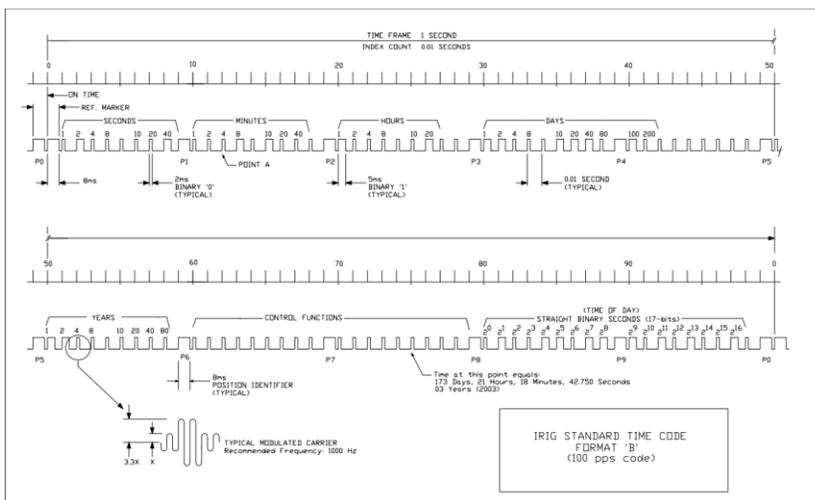
The bits are modulated on a carrier. A three-digit suffix specifies the type and frequency of the carrier, and which optional information is included:

- **Modulation type**
 - 0 - (DCLS) Direct Current Level Shift (width coded)
 - 1 - Sine wave carrier (amplitude modulated)
 - 2 - Manchester modulated
- **Carrier frequency**
 - 0 - No carrier (DCLS)
 - 1 - 100 Hz (10 ms resolution)
 - 2 - 1 kHz (1 ms resolution)
 - 3 - 10 kHz (100 μ s resolution)
 - 4 - 100 kHz (10 μ s resolution)
 - 5 - 1 MHz (1 μ s resolution)
- **Coded expressions** - Binary-coded decimal day of year, hours, minutes, and (for some formats) seconds and fractions are always included. Optional components are:
 - **Year number** (00–99; century is not coded)
 - **User Defined** - control functions occupying bits not defined by IRIG
 - **Straight Binary Seconds** - 17-bit binary counter that counts from 0 to 86399.
 - 0 - BCD, CF, SBS
 - 1 - BCD, CF
 - 2 - BCD
 - 3 - BCD, SBS
 - 4 - BCD, BCD_Year, CF, SBS
 - 5 - BCD, BCD_Year, CF
 - 6 - BCD, BCD_Year
 - 7 - BCD, BCD_Year, SBS

The recognized signal identification numbers for each format according to the standard 200-04 consist of:

Permissible Code Formats			
Format	Modulation Type	Carrier Frequency	Coded Expressions
A	0,1,2	0,3,4,5	0,1,2,3,4,5,6,7
B	0,1,2	0,2,3,4,5	0,1,2,3,4,5,6,7
D	0,1	0,1,2	1,2
E	0,1	0,1,2	1,2,5,6
G	0,1,2	0,4,5	1,2,5,6
H	0,1	0,1,2	1,2

Thus, the complete signal identification number consists of one letter and three digits. For example, the signal designated as B122 is deciphered as follows: Format B, Sine wave (amplitude modulated), 1 kHz carrier, and Coded expressions BCDTOY.



6.5 DCF-77 Time Code

DCF77 is a German longwave time code signal and standard-frequency radio station. The time code broadcast by the station is referred to as the DCF-77 Time Code.

6.5.1 Bit Definition

DCF-77 uses pulse width modulation to encode the data bits. A binary 0 is encoded as a 0.1 second positive pulse starting at the beginning of the second. A binary 1 is encoded as a 0.2 second positive pulse starting at the beginning of the second. As a special case, the last second of each minute is marked by no pulse being generated.

6.5.2 Time Code Interpretation

The time is represented in binary-coded decimal. It represents civil time, including summer time adjustments. The time transmitted is the time of the *following* minute; e.g. during December 31 23:59, the transmitted time encodes January 1 00:00.

The first 20 seconds are special flags. The minutes are encoded in seconds 21–28, hours during seconds 29–34, and the date during seconds 36–58.

Two flags warn of changes to occur at the end of the current hour: a change of time zones, and a leap second insertion. These flags are set during the hour up to the event. This includes the last minute before the event, during which the other time code bits (including the time zone indicator bits) encode the time of the first minute after the event.

Bit	ID	Description
:00		Start of Minute. Always 1.
:01		Civil warning bit.
:02		Civil warning bit.
:03		Civil warning bit.
:04		Civil warning bit.
:05		Civil warning bit.
:06		Civil warning bit.
:07		Civil warning bit.
:08		Civil warning bit.
:09		Civil warning bit.
:10		Civil warning bit.

:11		Civil warning bit.
:12		Civil warning bit.
:13		Civil warning bit.
:14		Civil warning bit.
:15	R	Abnormal operation
:16	A1	Summer time announcement. Set during hour before change.
:17	Z1	Set to 1 when CEST is in effect.
:18	Z2	Set to 1 when CST is in effect.
:19	A2	Leap second announcement. Set during hour before leap second.
:20	S	Start of encoded time. Always 1.
:21	1	Minutes (0-59)
:22	2	Minutes (0-59)
:23	4	Minutes (0-59)
:24	8	Minutes (0-59)
:25	10	Minutes (0-59)
:26	20	Minutes (0-59)
:27	40	Minutes (0-59)
:28	P1	Even parity over minutes, bits 21 – 28.
:29	1	Hours (0-23)
:30	2	Hours (0-23)

:31	4	Hours (0-23)
:32	8	Hours (0-23)
:33	10	Hours (0-23)
:34	20	Hours (0-23)
:35	P2	Even parity over hours, bits 29 – 35.
:36	1	Day of Month (1 – 31)
:37	2	Day of Month (1 – 31)
:38	4	Day of Month (1 – 31)
:39	8	Day of Month (1 – 31)
:40	10	Day of Month (1 – 31)
:41	20	Day of Month (1 – 31)
:42	1	Day of Week (Monday = 1, Sunday = 7)
:43	2	Day of Week (Monday = 1, Sunday = 7)
:44	4	Day of Week (Monday = 1, Sunday = 7)
:45	1	Month (1 – 12)
:46	2	Month (1 – 12)
:47	4	Month (1 – 12)
:48	8	Month (1 – 12)
:49	10	Month (1 – 12)
:50	1	Year (0 – 99)

:51	2	Year (0 – 99)
:52	4	Year (0 – 99)
:53	8	Year (0 – 99)
:54	10	Year (0 – 99)
:55	20	Year (0 – 99)
:56	40	Year (0 – 99)
:57	80	Year (0 – 99)
:58	P3	Even parity over date, bits 36 – 58.
:59		No pulse sent.

In the event of an added leap second, a 0-bit is inserted during second 59, and the special missing bit is transmitted during the leap second itself, second 60.

Although the time code only includes two digits of year, it is possible to deduce two bits of century using the day of week. There is still a 400-year ambiguity, as the Gregorian calendar repeats weeks every 400 years, but this is sufficient to determine which years ending in 00 are leap years.

The time zone bits can be considered a binary-coded representation of the UTC offset. Z1 set indicates UTC+2, while Z2 indicates UTC+1.