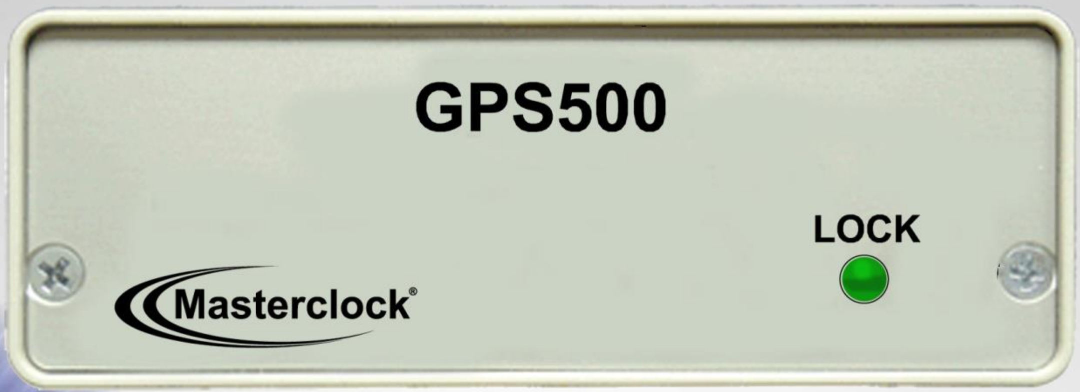

GPS 500

"Master Clock GPS Reference Device"

User Manual

DISCLAIMER

Information contained in this document is subject to change without notice. Masterclock, Inc. (hereinafter MC) makes no warranty of any kind with regard to this material, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose. MC shall not be liable for errors contained herein or for incidental or consequential damages in connection with the furnishing, performance, or use of this material. MC is not responsible for legislative changes to the Daylight Saving Time (DST) rules, nor to the systems relying on accurate time, which may be affected by such changes. Issues related to legislative changes to the DST rules are not covered under the Masterclock, Inc. limited warranty. See important *limited warranty* information on page 7.

ADVISORY NOTICE CONCERNING THE GPS SATELLITE SYSTEM AND THE GPS 500 GPS REFERENCE DEVICE

Depending on many factors beyond the control of MC, the signals that are received from the GPS satellites are subject to interference, fading, satellite failure and other influences *that could cause* the GPS 500 to generate erroneous time and/or date information and, under some conditions, *could prevent* it from generating a Time Code signal and/or cause it to generate an erroneous Time Code signal. It is the responsibility of the user to determine the adequacy and suitability of this device for the intended use.

To ensure a successful installation to your local grounding and electrical specifications, your **GPS 500** was thoroughly tested with its antenna prior to shipment.

TABLE OF CONTENTS

GPS 500 FEATURES

- Generates SMPTE / EBU or IRIG-B Time Codes
- Synchronized to atomic clock in GPS satellites
- -11.5 to +12 hour time zone offsets in 30-minute increments
- Automatic daylight saving (US & Canada time standard)
- Multiple outputs
- NMEA/Kinemetrics / Truetime serial protocol output
- Wide power supply input range: 12 to 48 VDC
- Switch compatible time zone, DST
- Switch compatible interval blanking in the Schneider Ion Meter®
- Switch compatible format and baud rate

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Installation

Time Reference

- When synchronized a GPS500's accuracy is as accurate as a GPS satellite atomic clock
- After initial synchronization, should the GPS500 lose GPS signal it will revert to an internal calibrated oscillator
- Accuracy when not synchronized: internal TCXO ± one minute per year

Outputs

- SMPTE Time Code
  - SMPTE, EBU, 24, 25 or 30 FPS
- IRIG-B Time Code
  - IRIG-B - 1 kHz modulated, level - 5 Vpp
  - IRIG-B – unmodulated, single ended 5 V
- PPS (Pulse Per second)
  - 5 V-TTL, Accuracy ± 1 µs (when synchronized)
- Serial Output
  - NMEA
  - Time code information via RS-232/485
  - Kinemetrics/Truetime protocol
- Date
  - Date encoded references (IRIG 1344 and SMPTE 309M)

Connectors

- Output : 9-pin terminal block
- Power plug: 3-pin terminal block
- Antenna: SMA female

Physical

	5.5 x 4.13 x 1.5 in		17.3 oz
Size:	14 x 10.48 x 3.81 cm	*Weight:*	490.5 g

Case

- Cover - off-white aluminum
- Front/rear panel - clear anodized aluminum

Compliance

- CE marked – Available for sale in EU
- FCC, Part 15, Class B, emissions

Power Supply

- 12 VDC external wall mount supplied, UL & CE listed
- 115/220, 50/60 Hz
- Supplied with US, Euro-plug, British or AUS/NZ - others optionally available

Antenna Options

- **Basic** antenna package includes magnetic GPS antenna and 15' (*5m*) of cable
- **Standard** antenna package includes marine GPS antenna, mounting kit, and 50' (*15m*) of cable.

Operating Parameters

- Temperature: 0 to +70°C
- Humidity: Up to 90% (non-condensing at +25°C)

PLEASE FOLLOW THESE 4 STEPS TO INSTALL YOUR NEW GPS 500

STEP 1: CONFIGURE THE GROUND JUMPER [J5] AND SWITCHES

Prior to plugging in your clock, unscrew the two screws at the back of the GPS 500 and gently pull it out to expose the circuit board.

Set the four banks of eight DIP switches and other items using the chart (next page) as your guide.

By default the **J5 ground jumper** is off. In this state the GPS-ION's system ground is floating or a virtual ground. Connecting the J5 ground jumper connects the system ground to the Earth ground (**J4**).

STEP 2.

SECURE THE BOARD

Replace the circuit board within the case, and replace the two screws to secure the back.

STEP 3. CONNECT THE SMA ANTENNA CABLE AND 9-PIN OUTPUT CONNECTOR

Connect the GPS pre-amplified antenna to the GPS-500's SMA input with a coaxial cable.

Load the 9-pin terminal block (J2) according to your application's specifications and the inputs/outputs and switches diagram (p. 6).

STEP 4. CONNECT THE POWER CORD

Important: First ensure that the J5 ground jumper is configured to your specifications before connecting power. Connect power to the 3-pin terminal block according to the inputs/outputs and switches diagram (p. 6).

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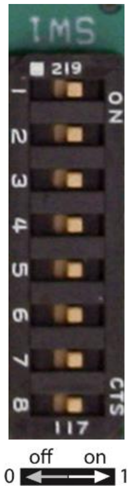
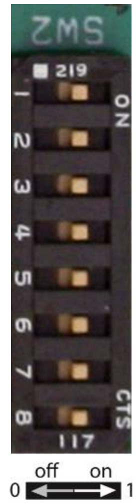


SW1 controls
Truetime and NMEA, mostly.
----

1 Truetime Lock Indicator enable
2 Truetime Interval Blanking enable
3 Disable output if GPS is not locked*
*applies to Truetime and NMEA only
4 Truetime enable
5 NMEA enable

Select the NMEA output messages

678
000 = ZDA
001 = ZDA_GGA_GSA_RMC
010 = ZDA_GGA_VTG_GLL_GSA_RMC
011 = reserved
100 = ZDA_GGA_VTG
101 = reserved
110 = ZDA_GGA_VTG_GSV
111 = reserved

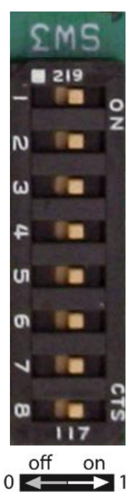


SW2 controls
Daylight Savings and Time Zone.
----
select the DST standard:
12
00 = no offset
01 = US/Canada Standard
10 = European Standard
11 = reserved

Makes the time zone offset negative
3

Adds 1/2 hour to the time zone offset
4

Set the time zone offset in hours:
5678
0000 = no offset
1000 = 1 + hours
0100 = 2 + hours
1100 = 3 + hours
0010 = 4 + hours
0101 = 5 + hours
0110 = 6 + hours
0111 = 7 + hours
0001 = 8 + hours
1001 = 9 + hours
0101 = 10 + hours
1101 = 11 + hours
0011 = 12 + hours



SW3 controls
Type of Time Code generated
Baud of debugging output

Select the type of time code to generate

1 = reserved
2 = reserved
3 = reserved
4 = reserved
5 = reserved

Set the baud rate for debugging output
678
000 = 9600
001 = 19200
010 = 38400
011 = 57600
100 = 4800
101 = reserved
110 = reserved
111 = reserved

SW4 controls
Type, format and "Coded Expressions" of time code

1
0 = SMPTE
1 = IRIG

2,3 when SMPTE
00 = SMPTE 30 frames per second
01 = SMPTE 25 frames per second
10 = SMPTE 24 frames per second
11 = Time Code output disabled

2,3 when IRIG
00 = IRIG B0 DCLS (PWM)
01 = IRIG B1 AM
10 = reserved
11 = Time Code output disabled

4,5 when SMPTE
00 = SMPTE - Leitch date encoding
01 = SMPTE - 309M Date Encoding MM/DD/YY, Time Zone included
10 = SMPTE - 309M Date Encoding Modified Julian Date (MJD), Time Zone included
11 = reserved

4,5 when IRIG
00 = BCDtoy
01 = BCDtoy, SBS
10 = BCDtoy, BCDyear, SBS
11 = reserved

Note: there are 7 expressions output by a TCG module but the GPS500 will output only the 3 at left.

toy = time of year
BCD = Binary Coded Decimal
SBS = Straight Binary Seconds

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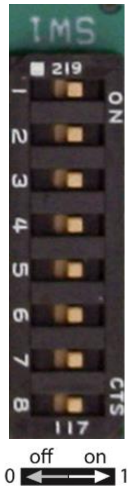


SW1 controls
Truetime and NMEA.
----

1 Truetime Lock Indicator enable.

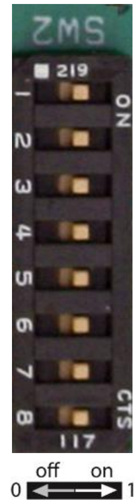
2 Truetime Interval Blanking enable.

3 Disable output if GPS is not locked. Applies to Truetime and NMEA only.

4 Truetime enable.

5 NMEA enable.

Select NMEA output messages:
678
000 = ZDA
001 = ZDA_GGA_GSA_RMC
010 = ZDA_GGA_VTG_GLL_GSA_RMC
011 = reserved
100 = ZDA_GGA_VTG
101 = reserved
110 = ZDA_GGA_VTG_GSV
111 = reserved



SW2 controls
Daylight Savings and Time Zone.

Select the DST standard:
12
00 = no offset
01 = US/Canada Standard
10 = European Standard
11 = reserved

3 Makes the time zone offset negative

4 Adds 1/2 hour to the time zone offset

Set the time zone offset in hours:
5678
0000 = no offset
1000 = 1 + hours
0100 = 2 + hours
1100 = 3 + hours
0010 = 4 + hours
0101 = 5 + hours
0110 = 6 + hours
0111 = 7 + hours
0001 = 8 + hours
1001 = 9 + hours
0101 = 10 + hours
1101 = 11 + hours
0011 = 12 + hours

SW3 controls
Time Code and PPS control,
Time Quality control,
Baud of Truetime/NMEA output.

1
0 = Output time code whether GPS is locked or unlocked.
1 = Do not output time code when GPS is unlocked.

2 Time Quality of IRIG-B 1344.
0 = Do not indicate Time Quality.
1 = Indicate Time Quality.

3, 4 = unused

5 PPS Output-see also SW4-6,7,8
0 = No PPS output if GPS unlocked
1 = PPS output will be from processor if GPS unlocked.

Baud of Truetime/NMEA output:
678
000 = 9600
001 = 19200
010 = 38400
011 = 57600
100 = 4800
101 = reserved
110 = reserved
111 = reserved

SW4 controls
Type, format and "Coded Expressions" of time code.

1
0 = SMPTE
1 = IRIG

2,3 when SMPTE
00 = SMPTE 30 frames per second
01 = SMPTE 25 frames per second
10 = SMPTE 24 frames per second
11 = Time Code output disabled

2,3 when IRIG
00 = IRIG B0 DCLS (PWM)
01 = IRIG B1 AM
10 = reserved
11 = Time Code output disabled

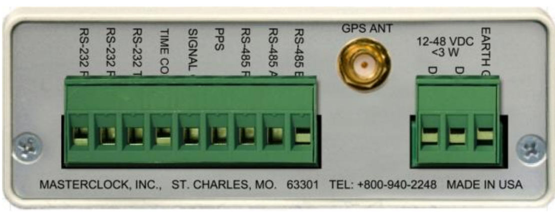
4,5 when SMPTE
00 = SMPTE - Leitch date encoding
01 = SMPTE - 309M Date Encoding MM/DD/YY, Time Zone included
10 = SMPTE - 309M Date Encoding Modified Julian Date (MJD), Time Zone included
11 = reserved

4,5 when IRIG
00 = BCDtoy (IRIG Bx00)
01 = BCDtoy, SBS (IRIG Bx01)
10 = BCDtoy, BCDyear, SBS (IRIG Bx02)*
11 = reserved
*Only time quality bits 20-23 set.
See SW3-switch 2.

Note: 7 expressions can be output by other Masterclock generators, but GPS500 will output only these 3.

toy = time of year.
BCD = Binary Coded Decimal.
SBS = Straight Binary Seconds.

Operation



OPERATING THE GPS500 FOR THE FIRST TIME

When the GPS500 is initially powered up (after having been shipped to a new location) **the time to first fix** (time to acquire satellites and reference GPS time) **could be up to 25 minutes**. However, the typical wait time is **2 to 5 minutes**. A variety of factors, including atmospheric conditions, type of antenna, antenna location and antenna cable length, may affect the time to first fix.

Set the **DIP switches** to your desired settings

Upon powering up the device and acquiring a GPS lock, the GPS 500 will output GPS time. After a few minutes the device will receive the leap second information (automatic) and self-adjust to output UTC time.

When the GPS 500 unit is powered down, the GPS navigation module within it maintains startup data with an internal backup battery. The unit will restart much faster if the location, time and number of overhead satellites has not changed since the last power down.

LED POWER INDICATOR AND GPS LOCK STATUS

The small green light on the faceplate of the GPS 500 is your LED power indicator. After applying power the following indications will be visible.

INDICATION: One blink per second
GPS is locked. Power is on.

INDICATION: Two blinks per second
GPS is not locked (it is freewheeling). Power is on.
The time reference is the internal clock.

INDICATION: Off No blinking
No power.

Antenna Location

Above: The basic antenna that comes with your GPS 500 package.

Below: The standard antenna may be purchased separately.
It mounts on a PVC pipe, typically outdoors.

INDOOR CAN BE A PROBLEM

Obstructions may block signal reception if your GPS 500 antenna is not properly located. Try to find an unobstructed view of the sky. In some cases this can be accomplished by placing the included **basic antenna** adjacent to a window. However, in most cases good reception will require mounting a **standard antenna** outside of the building, perhaps on a roof. It is possible that the system will operate indoors and under certain obstructions, but this can only be determined by trial and error, ultimately leading to a successful installation.

BASIC ANTENNA INCLUDED

Your GPS 500 package comes complete with a basic antenna. If a cable extension is required, lengths up to 500 feet with pre-amplified antennas are available from Masterclock.

STANDARD ANTENNA OPTION

A more weather resistant antenna is available. It is the **Standard Antenna** and it has the following specs:

Gain: 32dB pre-amplified

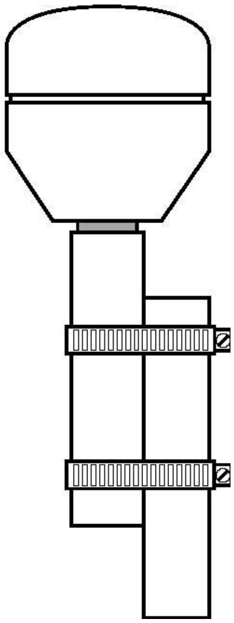
Voltage: 3.5-5 VDC - 27 mA(max)

Connector: SMA Female

Dimensions: 3.7dia x 5.5h in [9.3dia x 14h cm]

Weight: 6.7 oz (190 g)
Environment: -40° to +85°C with high humidity

GLOBAL POSITIONING SYSTEM AND PRECISE TIME AND FREQUENCY


Typical roof antenna mounting

The Global Positioning System (GPS) is a worldwide radio-navigation system formed from a constellation of 24 satellites that continuously orbit the earth. Each GPS satellite has on board several atomic clocks that are precisely synchronized to Universal Time Coordinated (UTC) provided by the U.S. Naval Observatory (USNO). Coded signals are broadcast by each of the satellites with the exact time and position of the satellite. All GPS receivers use an antenna to receive these signals. By using a GPS receiver optimized for time and not position it is possible to get extremely precise time synchronization with the satellite's atomic clocks.

GPS Antennas and Cables

The signals from the GPS satellites operate in the "semi-visible" spectrum of the L1 band (1575.42 MHz) with a minimum signal level of -162.0 dBW. With this very low signal strength the GPS antenna must be able to "see" the sky to acquire the signals. Practically speaking the antenna must have a clear view of the sky and thus be mounted on a roof, or in some cases in a window. The antennas are relatively small, coffee cup size or smaller, and are connected to the GPS receiver typically via coaxial cable.

Since the GPS signal is very weak the antenna usually amplifies the signal to drive it through the cable to the receiver. Antenna cable however offers some resistance and the GPS signal strength will attenuate as it travels down the cable. GPS receiver sensitivity is finite so if the cable length is too long the signal will be too weak for the receiver to detect it. Consequently it is very important to know the distance in advance between the antenna and the receiver so that the proper cable solution can be installed.

Antenna Types

There are two basic antenna types used with GPS timing receivers; roof mounted and window mounted. The roof mounted antenna is required for the more accurate GPS clocks since at least three satellites are required to be in view at all times to maintain timing accuracy, typically nanoseconds to UTC. The window mounted antenna is applicable for the network time servers which operate with a lesser degree of accuracy, typically microseconds or in some cases low milliseconds to UTC, and can function with as few as one intermittent satellite in view. The roof mounted antenna is always preferable since by nature of its location has the best view of the sky. A variation on the roof antenna is the GPS Down/Up converter used for very long cable runs. This is a special GPS antenna that receives the GPS signal and down

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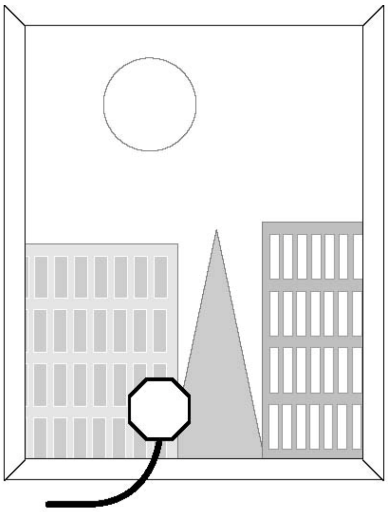
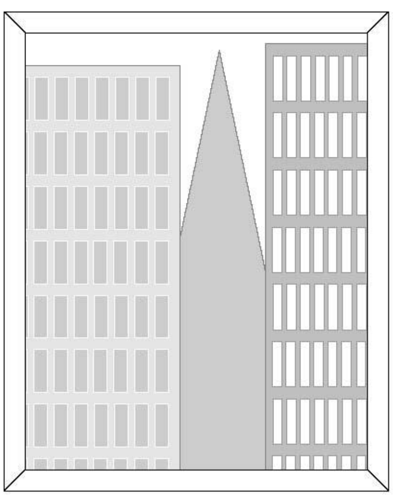
converts it to a lower frequency that is then sent down the cable. Next to the GPS receiver is an up converter that converts the signal back to the original frequency and delivers it to the GPS receiver. This process is transparent to the GPS receiver.



Placement is preferred in Window with clear view of sky



This window is not a preferred location due to line of sight obstructions

Antenna Placement and Mounting

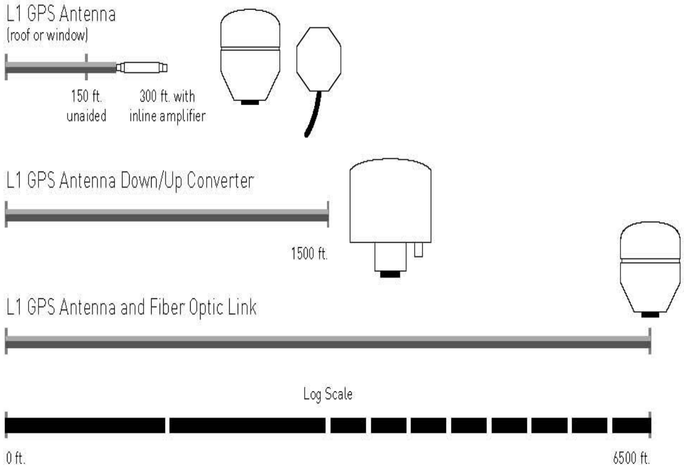
Roof Antenna Placement: When selecting a site for the roof antenna, find an outdoor location that provides full 360-degree visibility of the horizon. In most cases, this means locating the antenna as high as possible, such as on the roof. Any obstructions may degrade unit performance by blocking the satellite signals. Blocked signals can increase the time for satellite acquisition, or prevent acquisition altogether.
A short mounting mast and hose clamps are provided with the roof antenna to mount the antenna to a pole or the peak of a building. The antenna mounting mast and clamps are well suited to attach the antenna to a vent pipe or mast affixed to the roof. The pipe must be rigid and able to withstand high winds without flexing..

Typical roof antenna mounting

GPS Receivers can be susceptible to reflected GPS signals called multipath. MultiPath interference is caused by reflected signals that arrive at the antenna out of phase with the direct signal. This interference is most pronounced at low elevation angles from 10 to 20 degrees above the horizon. The height of the mast/antenna may be extended upward to prevent multipath interference. The antenna should also be at least three to six feet (1-2 m) from a reflecting surface.

Window Antenna Placement

The window mount antenna is suitable for use only with the network time server products with appropriate versions of firmware. For window mounted antenna installations it is best to use a window with the best view of the sky. For windows with equivalent views, orientations that face the equator are preferred. Generally more satellites will be in view toward the equator than away from it, east or west facing windows will also work. Polar facing windows will also work but in general are not preferred. Windows that have the best view of the sky are always preferred regardless of orientation.
Attach the antenna above the window sill versus at the top of the window. This will improve the upward visibility from the antenna to the sky. Note that some window glazing treatments may reduce or block the GPS signals, preventing the time server from acquiring the time.



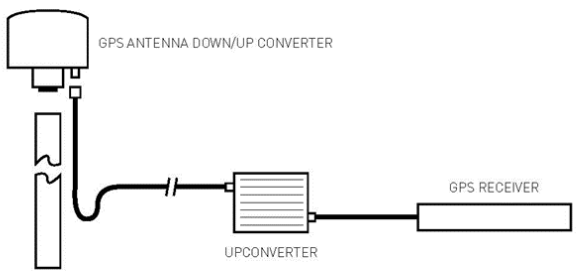
Antenna Cable Configurations/Options

Antenna cabling solutions typically vary depending on how far the antenna is installed from the GPS receiver. 150 feet (45 m) is the unaided cable length limit for many GPS timing receivers. Adding a GPS inline amplifier extends the cable length an additional 150 feet (45 m). Beyond 300 feet (90 m) alternative methods may be used. Figure 3 highlights the cable lengths and the antenna solutions that enable them.

In-line Amplifier

In-line amplifiers overcome signal attenuation in by amplifying the GPS signal, adding an additional 150 feet (45 m) in cable length. The inline amplifier attaches directly in line with the antenna cable and uses the same power as the antenna; no extra wiring is required.

GPS Down/Up converter



The GPS Down/Up converter makes cable runs of 250 to 1500 feet (75 m to 457 m) possible. GPS signal down conversion requires a special GPS antenna and corresponding signal up-converter. The antenna module converts the signal down to a lower frequency that is less susceptible to attenuation, and transmits it the length of the cable to the up-converter. The up converter restores the signal to the normal GPS signal frequency for the receiver. The down/up conversion process is transparent to the GPS receiver. As with any precision GPS timing receiver, only cable delay and down conversion delays need to be entered into the receiver. Power is supplied by the GPS receiver. In the case of Bus level GPS receivers an external power supply is used. It is important to note that the cable used in GPS down/up conversion is different than the standard cable.

Fiber Optic Links

Fiber-optic connections function as a transparent link between the antenna and GPS receiver equipment. These links eliminate the limitations of copper systems by enabling longer transmission distances while retaining the highest level of signal quality. In addition, fiber optics provide several other significant network advantages, including simplified network design, ease of installation, and immunity from EMI/RFI and lightning.

Lightning Arrestor

In-line lightning arrestors are mounted on a low impedance ground between the antenna and the point where the cable enters the building. They require no additional power or wiring except the ground lead.

Cable Delay

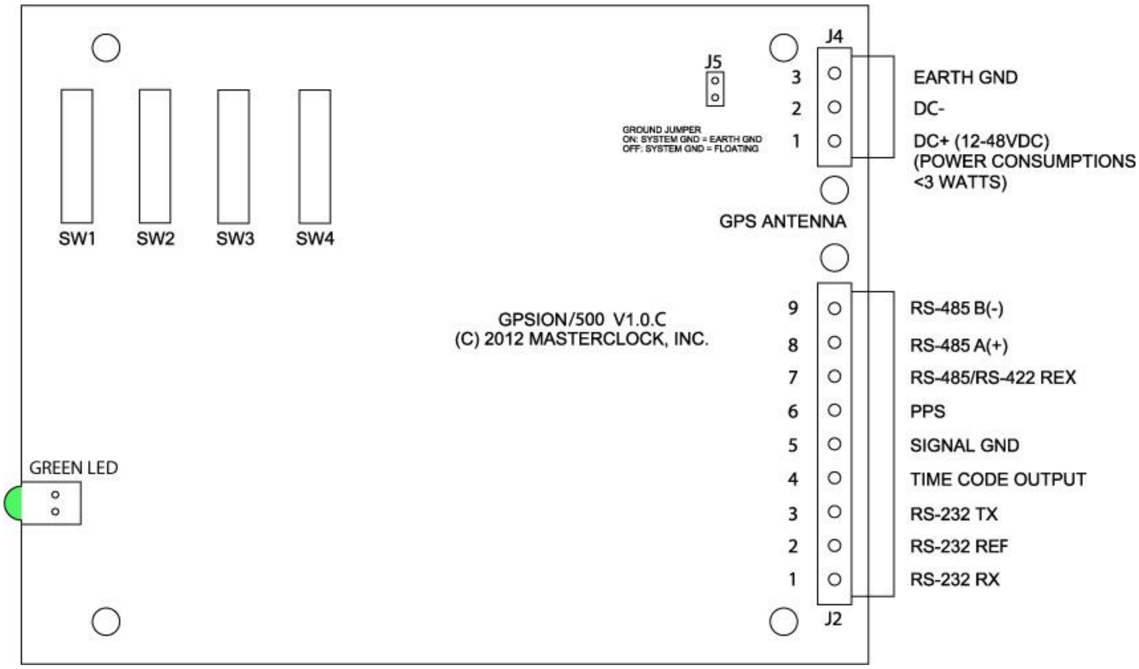
GPS position as well as precise UTC time is determined at the point the GPS signals are received at the antenna. Since the antenna is typically attached to the GPS timing receiver via a cable, signal propagation delays through the cable cause the time calculated by the receiver to be slightly behind UTC. In GPS clocks with nanosecond and microsecond accuracies this is a critical factor. In products such as network time servers cable delay is not important because time transfer over IP networks degrades the time to the millisecond level.

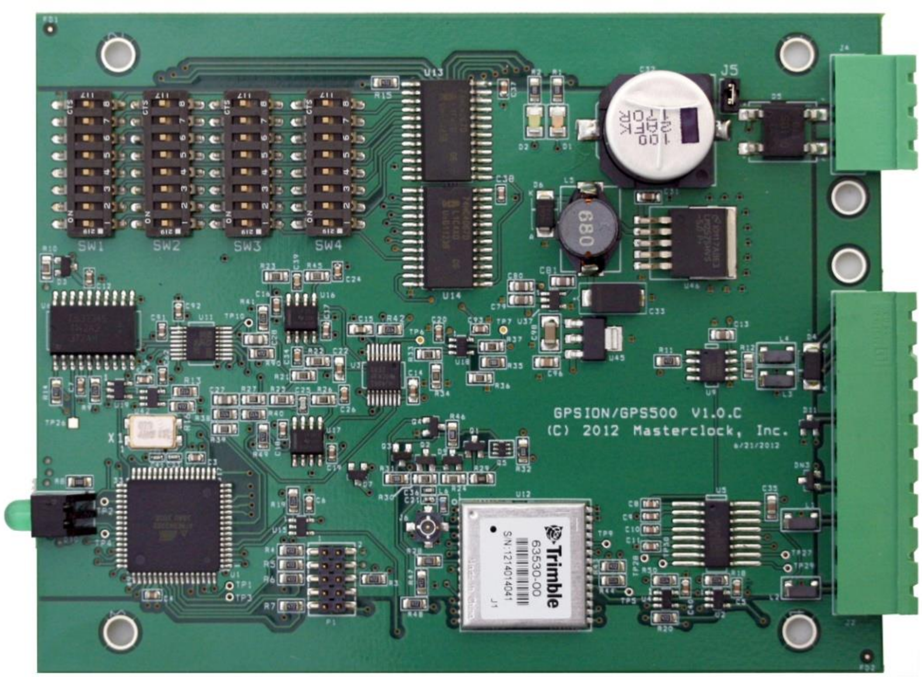
Cable delay is a function of the cable type. RG-59 cable for example typically delays the signal 1.24 ns/ft. For 50 feet of cable (15 m) the delay would be 62 nanoseconds. Cable delay is removed by advancing the antenna signal inside the GPS receiver. In this example, advancing the signal +62 nanoseconds removes all cable latency. Solutions such as the GPS Down/up converter also introduce signal latency but this latency can also be removed by adjusting the signal. All precision GPS timing receivers with nanosecond or microsecond timing accuracy have the ability to compensate for cable delay.

Advanced Planning

It is time well spent to estimate in advance the cable length from the GPS antenna to the receiver for any planned installation. Cable lengths that are too short or too long can each introduce problems. In some cases adding an inline amplifier and some extra cable may be a quick and economical solution. In other instances retrofitting for a GPS down/up converter may be necessary which will require installing a different cable type. Keep in mind that some extra cable coiled in a ceiling leftover from over estimating the cable length is not necessarily negative. Provided you know the length of the total cable, the cable delay can be accounted for and the timing accuracy maintained.

Inputs/Outputs and Switches Diagram





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INTERVAL BLANKING

During the following noted periods the GPS500 does not output a timestamp, per the request of our customers needing these quiet intervals.

MID-INTERVAL	INTERVAL
	mm:ss - mm:ss
xx: 00:00	58:45 - 01:15
xx: 05:00	03:45 - 06:15
xx: 10:00	08:45 - 11:15
xx: 15:00	13:45 - 16:15
xx: 20:00	18:45 - 21:15
xx: 25:00	23:45 - 26:15
xx: 30:00	28:45 - 31:15
xx: 35:00	33:45 - 36:15
xx: 40:00	38:45 - 41:15
xx: 45:00	43:45 - 46:15
xx: 50:00	48:45 - 51:15
xx: 55:00	53:45 - 56:15

LIMITED WARRANTY

The following **Masterclock, Inc. Product Warranty** extends only to the original purchaser.

Masterclock warrants every GPS 500 against defects in materials and workmanship for a period of five years from date of sale. If Masterclock receives notice of such defects during the warranty period, Masterclock will, at its option, either repair or replace defective products.

Should Masterclock be unable to repair or replace the product within a reasonable amount of time, an alternate remedy shall be a refund of the purchase price upon return of the product to MC. This warranty gives the customer specific legal rights. Other rights, which vary from state to state or province to province, may be available.

EXCLUSIONS

The above warranty shall not apply to defects resulting from improper or inadequate maintenance by the customer, customer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation and maintenance (if applicable).

CONTACT US

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1-636-724-3776 (fax)

International
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1-636-724-3776 (fax)

Sales
sales@masterclock.com

Technical Support
support@masterclock.com

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In any state or province which does not allow the foregoing disclaimer, any implied warranty of merchantability or fitness for a particular purpose imposed by law in those states or provinces is limited to the one-year duration of the written warranty.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE THE CUSTOMER'S SOLE AND EXCLUSIVE REMEDIES. IN NO EVENT SHALL MASTERCLOCK BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

In any state or province which does not allow the foregoing exclusion or limitation of incidental or consequential damages, the customer may have other remedies.

HARDWARE REPAIR SERVICE

You may return your GPS 500 to MC for repair service at any time. First, however, please contact the factory at **1-636-724-3666** for a return authorization.