

Operation of the Courtyard CY490 SPG While Connected to the GPS Receiver

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Introduction

One of the best sources of reference for both frequency and time, is the Global Positioning System.

The GPS system only transmits a complete UTC-GPS time message once every 12.5 minutes. So when powering up the GPS receiver it might be best to wait 12.5 minutes before relying on the GPS time.

The CY490 SPG uses a 12 channel GPS receiver. As the SPG is powered the GPS receiver begins searching for satellites from which it can get time, frequency and phase information.

In a good reception area as many as 12 satellites may be visible. The SPG only requires 3 satellites to be located and fully decoded before it can start using the GPS data. The search for the first 3 satellites can take up to 3 minutes, but is often accomplished in 2. If less than 3 satellites are available, the SPG will not lock to GPS.

The number of satellites can be monitored on the first menu and on the remote control program CY490MiniMessage.

The CY490MiniMessage gives a graphic view of satellites and provides much information for the user.

GPS and television

From a GPS receiver, the Master Clock can derive UTC and also add the appropriate time offset and provide corrected local time. Table 1 contains a list of the various corrections which need to be made by the SPG.

Table 1. Required Time Corrections

1	Earth Speed Drift in one day	1ms	Leap second corrections are made approximately every 18 months as determined by International Earth Rotation Service (IERS) based in Paris, France. http://hpiers.obspm.fr/eop-pc/
2	NTSC Drift in one day	75ms	Usually adjusted daily
3	Local Time	User defined	The user usually defines the offset from UTC at time of installation
4	Daylight Saving	1 hour	Twice per year

The first three above corrections are made to the time code outputs, without disturbing any of the video signals. This correction is called a jam-sync. NTSC has a 4 field color sequence and PAL* has an 8 field color sequence, so to avoid disturbing the video, there will be a discrepancy between UTC and the time code output, after a color correction of the time code numbers occurs. The maximum discrepancies for NTSC drop frame time code will be 2 fields (33ms) after a daily jam-sync and for PAL (EBU time code) it will be 2 fields (40ms), after a leap second insertion. In NTSC countries, if you jam-sync daily, drop frame time code may also be used to drive slave clocks. The maximum time drift will be 75ms. 60Hz time code is not related to video and is not affected by jam-sync operations.

The CY490 may be programmed in advance, to make time and time code number changes automatically without disturbing the video.

The CY490 does not automatically adjust for daylight saving.

The CY490 does not automatically adjust for leap seconds.

* The PAL 8 field television system runs at 50 fields per second, so one field has a duration of 20ms and one PAL cycle is completed in 160ms. At this rate there are 6.25 PAL cycles per second. When a leap second is added, the extra 0.25 cycles (2 fields or 40ms) cannot be accommodated.

1. GPS reception monitoring and system status.



The GPS receiver is continually updating the SPG via RS232 messages. The SPG relays some of this information to the remote control protocol engine. A PC connected to the remote control port and running the Courtyard (Windows) application can monitor the state of the GPS receiver and the parameters being used by the system to achieve lock.

2. Time locking.

Time lock is achieved by reading the GPS time from the receiver and calculating an appropriate timecode. There are a few problems :

NTSC frame slip. Over 24 hours the NTSC frame count slips relative to real time by a few milliseconds. A timecode reset should be implemented once every 24 hours.

The timecode needs to be checked and updated each time the GPS receiver is detected. However in marginal reception the timecode update should be suppressed until it has been valid for a number of seconds. Once the timecode has been set by the GPS receiver the SPG should not need to recheck the GPS time unless a crash lock has been forced by the phase locking arrangement.

The GPS system only transmits a complete UTC-GPS time message once every 12.5 minutes.

3. Frequency and Phase locking.

a. Frequency locking:

Frequency lock can be established in a few seconds as the oven free running frequency is within a few ppm of the GPS frequency at all times. The first time the SPG is powered with a GPS receiver the SPG waits for 3 or more satellites to be "fixed", then the SPG acquires frequency lock. This first time may take up to 5 minutes from when the GPS lock was acquired.

b. Phase locking:

The CY490 does not automatically phase to the GPS time.

The (Global Positioning System) GPS is a space based radio navigation system comprising of three main components.

The first is known as the space segment which consists of a constellation of 24 operational satellites. Each satellite generates a navigation message based on data periodically uploaded from the Control Segment and adds the message to a 1.023MHz Pseudo Random Noise Coarse/Acquisition (C/A)

code sequence. The satellite modulates the resulting signal on to a 1575.42 MHz L-band carrier to create a spread spectrum ranging signal which it then transmits to the user community. Each C/A code is unique which allows each satellite to be identified.

The second, the Control Segment, consists of a Master Control Station (MCS), ground antennas and monitor stations. The MCS is located at Falcon Air Force Base, Colorado and is the central control node for the GPS satellite constellation. It is responsible for all aspects of command and control such as:

- Routine satellite bus and payload status monitoring
- Satellite maintenance and anomaly resolution
- Monitoring and management of position service performance
- Navigation data upload operations
- Prompt detection and response to service failures.

The third segment is the receivers which can be used to determine their position and the current time. These are what is in your CY490 SPG.

Each satellite provides data required to support the position determination process. The data includes information required to determine:

- satellite time of transmission
- satellite position
- satellite health
- satellite clock correction
- propagation delay effects
- time transfer to UTC
- constellation status

It does this using five sub-frames of information :

- Sub-frame 1 contains GPS week number, satellite accuracy and health, and satellite clock correction terms.
- Sub-frame 2 contains ephemeris parameters.
- Sub-frame 3 contains ephemeris parameters.



- Sub-frame 4 contains almanac and health data for satellites 25-32, special messages, satellite configuration flags and ionospheric and UTC data.
- Sub-frame 5 contains almanac and health data for satellites 1-24, almanac reference time and week number.

GPS time is established by the Control Segment and is referenced to a UTC (as maintained by the U.S. Naval Observatory) zero time point defined as midnight on the night of January 5, 1980. It is maintained to be within one microsecond of UTC (modulo one second). The largest unit used in stating GPS time is one week.

Why you have to wait so long for the UTC offset?

The time used by the GPS system does not include leap seconds. This means that every eighteen months or so, its "time" changes by one second with respect to UTC which does include leap seconds. The difference between GPS time and UTC is 13 seconds in early 1999 and is referred to as the UTC offset. This value is obtained by the GPS receiver from the satellites in a "navigation message".

The navigation message is transmitted by the satellite on the L1 data link at a rate of 50 bits per second. The message structure uses a basic format of a 1500 bit long frame (30 seconds) made up of five sub-frames with each sub-frame being 30 bits long. Sub-frames 4 and 5 are repeated 25 times each, so that a complete message will require the transmission of 25 full frames (12 1/2 minutes).

The UTC offset is only transmitted once per frame, so it is only transmitted once every 12 1/2 minutes. Depending where you were in the cycle when the GPS receiver is first switched on, it can thus be up to 12 1/2 minutes until the UTC offset value is transmitted from a satellite.

Further reading

More information can be found at <http://www.navcen.uscg.gov/gps/geninfo/>

The most recent Leap Second events.

After the leap second insertion at Midnight time on 31 December 2005 :

GPS-UTC = +14s (GPS will be ahead by fourteen seconds).

After the leap second insertion at Midnight time on 31 December 2008 :

GPS-UTC = +15s (GPS will be ahead by fifteen seconds).

Glossary

Almanac. A set of parameters included in the GPS satellite navigation message that a receiver uses to predict the approximate location of a satellite. The almanac contains information about all of the satellites in the constellation.

Ephemeris. A description of the path of a celestial body indexed by time (from the Latin word, ephemeris, meaning diary). The navigation message from each GPS satellite includes a predicted ephemeris for the orbit of that satellite valid for the current hour. The ephemeris is repeated every 30 seconds and is in the form of a set of 16 Keplerian-like parameters with corrections that account for the perturbations to the orbit caused by the earth's gravitational field and other forces.

Epoch. A particular instant of time or a date for which values of data are given, or a given period of time during which a series of events take place.

UTC (Coordinated Universal Time). The time scale based on the atomic second but occasionally corrected, by the insertion of leap seconds, to keep it approximately synchronized with Earth's rotation. The leap second adjustments keep UTC within 0.9 seconds of UT1.