# TCG 01-E


## TIME CODE GENERATOR

## User Manual

### 1st Edition


When you need to be certain.

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**1st Edition**

**May 2010**

# TABLE OF CONTENTS

# 1 INTRODUCTION

The TCG 01-E Time Code Generator produces precision time code signals, serial strings and pulses for use in synchronizing industrial control and SCADA equipment. The clock is ideally suited to providing time synchronization simultaneously to many different devices, such as Phasor Measurement Units (PMUs), Protection Relays, Remote Telemetry Units (RTUs) and other Intelligent Electronic Devices (IEDs) used in electrical sub-stations and industrial control installations.

The TCG 01-E features one amplitude modulated IRIG-B output, three user-programmable outputs and a serial port. The serial port is user-configurable to output serial strings and report event data for units fitted with event recording capability. Factory options include a choice of physical connectors: BNC, 2-pin plug, or ST Fiber. Non-fiber outputs can be ordered as TTL, RS422/485, or high voltage switching.

All TCG 01-E units feature a front panel display (Figure 1) giving visual feedback about the time data being generated on the outputs. LED indicators provide “at a glance” status information.


**Figure 1 – TCG 01-E chassis and front panel**

The optimized receiver/antenna system used by TCG 01-E obtains time with near-atomic clock precision from the GPS satellite constellation. The result is output timing accuracy similar to that normally seen only in laboratory instruments.

However, unlike laboratory instruments, TCG 01-E is suited for hostile electromagnetic environments such as sub-stations and electrical switchyards. Each output of the TCG 01-E is isolated from every other output, so that attached wiring can feed out to operating areas in different earth potential zones without compromising the overall site earthing security. Further isolation protects the internal electronics, and transient suppression devices protect I/O from both longitudinal and transverse high voltage events.

The TCG 01-E features a 100Mb Ethernet port that through which all of the units operating options are configured. Firmware license options include a stratum 1 NTP server and IEEE1588 V2 functionality. When the IEEE1588 (PTP V2) option is enabled, the unit can operate as a PTP Grand Master, an ordinary PTP clock, or a Slave-Only Clock.

The TCG 01E has “automatic IRIG-B slave” functionality and the standard clock can accept two DCLS IRIG-B signals for syncing purposes. Sync source selection is entirely automatic.

TCG 01-E occupies less than half the width of a 1U rack space. It is supplied complete with all hardware and software required for installation, including rack-mount kit, connectors, network cables, antenna cable, and antenna.

# 2 FRONT PANEL


**Figure 2 – TCG 01-E front panel**

TCG 01-E features two LED indicators on the front panel (Figure 2), together with a 2-line by 16-character FSTN backlit LCD display.

**LCD DISPLAY:** The display unit updates every second, and by default displays local time and date, together with the offset of the local time from UTC. It also provides more information on the GPS receiver operation. A recessed push-button located on the front panel between the two indicator LEDs is used to switch between display pages.

**GPS LED:** This LED shows the status of an incoming GPS signal. Refer to Section 2.2 for further details.

**IRG LED:** This LED shows the status of an incoming IRIG-B time code signal. Refer to Section 2.2 for further details.

## 2.1 LCD Display

On initial power-up, the FSTN backlit LCD display shows a copyright message, along with the serial number and revision level of the unit (Figure 3[a]). Approximately 10 seconds after power-up, the display changes automatically to indicate that it is waiting for satellites (Figure 3[b]). Once one or more satellites have been discovered, it transitions to the operating default display, (Figure 3[c]). Figure 3[d] and [e] show alternative time displays that the user can access by pushing the recessed button on the front panel between the LED indicators. Successive button-pushes can be used to cycle through all the display screens in turn. The screen display examples below all show the same instant in time.

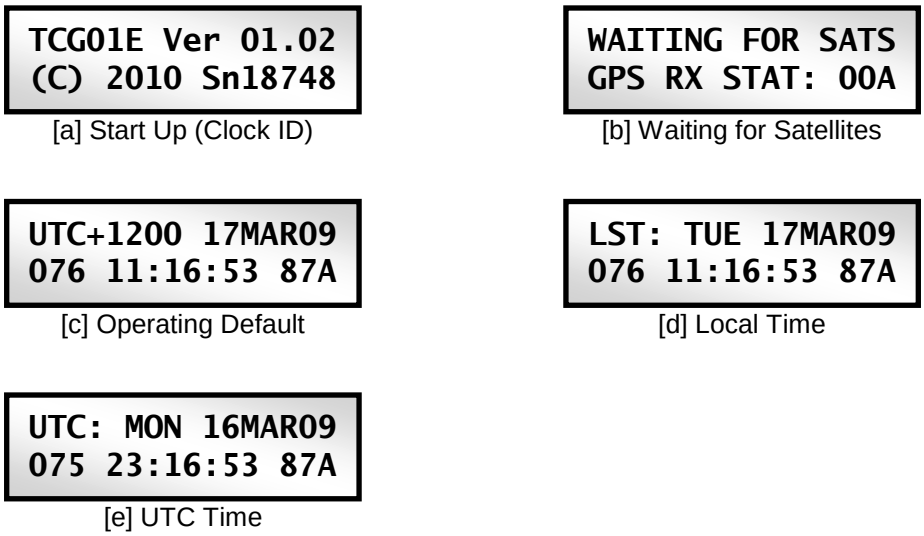



**Figure 3 – LCD display screens**

"UTC" denotes Universal Time Coordinated (approximately equivalent to GMT). The top line of screen [c] shows the clock's current local time offset from UTC (hours & minutes), together with local date. The local time day-of-year and time-of-day are on the bottom line.

Screen [c] shows that the clock is operating with a local time offset of 12 hours ahead of UTC. The local date is 1st March 2010, and the local time is 11:16:53 in the morning.

Screen [d] shows the same time and date, but also indicates that the time displayed is Local Standard Time, and that the day is Monday. “LST” denotes Local Standard Time. If daylight savings time is active, the “LST” in screen [d] changes to “LDT”, denoting Local Daylight Time.

Screen [e] shows the UTC time and date which is 11:16:53 on the evening of Sunday 28th February 2010.

The display screens in Figure 3[b], [c], [d] and [e] each show a three-character status field at the bottom right-hand side of the display (Figure 4). This three-character field provides feedback on the parameters that affect the operation of the GPS receiver.

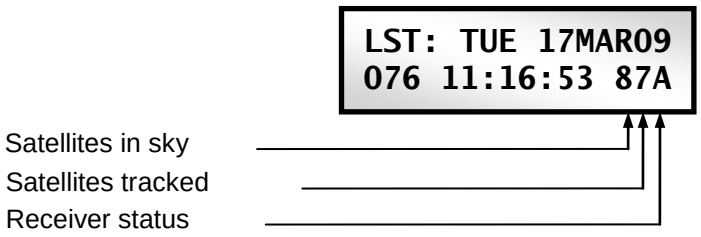



**Figure 4 – Satellite tracking status**

| **Character** | **Values** | **Description** |
|---|---|---|
| Satellites in the sky | “0”=0<br>:<br>“9”=9<br>“A”=10<br>“B”=11<br>“C”=12 | Represents the total number of satellites currently present in the sky according to the GPS almanac. “0” in this position means that TCG 01-E has lost its knowledge of the GPS satellites’ orbit geometries. This occurs if the unit has been in storage for an extended period, or if the GPS receiver has been reset. It may take up to two hours for the TCG 01-E to operate normally again. |
| Satellites tracked | “0”=0<br>:<br>“9”=9<br>“A”=10<br>“B”=11<br>“C”=12 | This digit represents the number of satellites currently being used to compute the time solution. A “0” value means that no updated time solution is available, (“out of lock” condition). If this condition persists for the “Sync Hold” time (See Section 5.7 for details) the clock will indicate the “out of sync” condition described under Section 2.2 below. |
| Receiver status | “A” | TCG 01-E in Acquisition mode **-** attempting to get satellite fixes. |
| | “G” | “Poor satellite geometry”: Satellites are positioned in almost a straight line so best accuracy cannot be obtained, but the unit will still sync to UTC. |
| | “2” | A 2D position is in use (no height). This may occur before Position Hold mode has been reached if only 3 satellites are tracked. Synchronisation is not compromised. |
| | “3” | A 3D position is in use, which includes height. A site survey begins next, so this mode is rarely seen. |
| | “S” | Site Survey in progress. TCG 01-E is calculating an accurate position; once complete the mode will change to Position hold. |
| | “P” | “Position hold”: Position is known accurately, and the GPS is providing its most accurate time, typically better than 40 ns to UTC. |

## 2.2 LED Indicators

The **GPS** LED shows the status of the GPS receiver, while the **IRG** LED shows the status of the time synchronization to UTC reference time derived from the IRIG-B time signal. Each of the two LED Indicators has five different operating modes representing five possible states of the incoming signal. These states are defined as follows:

| | |
|---|---|
| No Monitor: | The clock is not actively monitoring this input. |
| No Signal: | The clock cannot detect any input signal from this source. The most common cause is that the input cabling is faulty (e.g. disconnected or shorted in the case of the GPS antenna, or cross-wired in the case of the IRIG-B signal). |
| Seeking Lock: | A signal is present, and the clock is still gathering data from it. |
| Locked In: | The incoming signal has been fully decoded and is immediately ready to act as the source of UTC time to sync the clock if needed. |
| Signal In Use: | The incoming signal is actively being used as the source of time to maintain the clock in sync with UTC. |

The states are shown on the LED indicators by varying the flashing cadence as follows:

| **Signal State** | **Second (n)** | **Second (n+1)** | **Signal Description** |
|---|---|---|---|
| No Monitor | | | LED off always |
| No Signal | — — — — — | — — — — — | Continuous fast flash (5 flashes per sec) |
| Seeking Lock | —— —— | —— —— | Two flashes, repeating (2 flashes per sec) |
| Locked In | ———— | ———— | Single long flash, repeating (1 flash per sec) |
| Signal In Use | ———— | | LED on always |

# 3 BACK PANEL

An example TCG 01-E back panel is shown in Figure 5. Its appearance may vary, as different connector types can be fitted at the factory to suit your requirements.


**Figure 5 – Rear panel of TCG 01-E, with 2-pin connectors (P2 and P3)**

## 3.1 P1: Power Input (2 pin Connector [5.08mm])

Power is applied to the unit via this plug. Maximum steady state power consumption is 6 W, and surge protection is provided. Despite the markings on P1, the polarity of the power connection is *not* important and the unit is fully isolated internally from the power source. A mating connector is supplied that is suitable for wiring up to 1.5 $mm^2$.

The casing is isolated from the power supply inputs so that either (or neither) power supply polarity can be earthed to station earth.

The input voltage range is marked on the option label that is attached to the underside of TCG 01-E. Refer to section 6.1 for a list of orderable ranges.

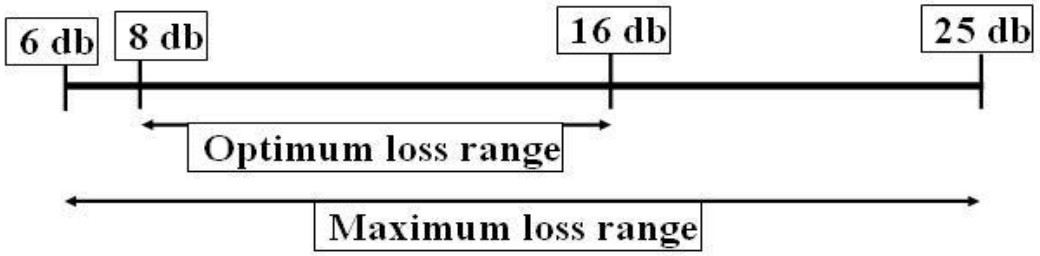
☛ **Check the label on the unit base for power supply voltage ratings!**

## 3.2 Ant: Antenna Connector (SMA Connector)

The “ant” antenna input provides an interface for an external active antenna via low-loss coaxial cable, 50 Ω impedance. 5 V DC @ 50 mA max is supplied to power an active antenna. The total combined gain of the antenna system (antenna plus cable and connectors) should fall in the range of 10 to 35 dB, the optimum being 22 dB.

TCG 01-E is normally supplied complete with a timing-optimized narrow-band antenna and 30 m of lead-in cable, this combination provides an overall gain near the optimum of 22 dB. For lead-in lengths longer than 60 m, amplification and/or larger diameter, lower loss cable can be supplied to order.

### 3.2.1 Antenna Cable Considerations:



**LMR-400** – 5.4 dB/100 ft. Plus 1 dB/connector

Optimum Length Range: 110 to 260 feet

Maximum Length Range: 74 to 425 feet

**LMR-240** – 10 dB/100 ft. Plus 1 dB/connector

Optimum Length Range: 60 to 140 feet

Maximum Length Range: 40 to 230 feet

☞ **Care should be taken to ensure that the connector is not cross-threaded when attaching the antenna lead-in cable. The connector should be tightened firmly by hand only. Do NOT over-tighten!**

A lightning protection device may be inserted into the antenna lead. A suitable device complete with additional cable connectors, a connector crimping tool and mounting hardware is available as an option (see Section 5.6 on page 32). Introduction of the lightning protector does not degrade the performance of the antenna system.

## 3.3 P2, P3: Programmable Outputs (2 pin [3.81mm] / BNC or ST Fiber)

### 3.3.1 Electrical and Physical Configuration

Each output port may be fitted at the factory according to the following:

| Electrical | Electrical Specification | Physical |
|---|---|---|
| TTL | CMOS/TTL (5 V) logic level driver output ports, 150 mA sink and source. The port is fully floating and has independent electrical isolation to 2.5 kV. | 2-pin or BNC |
| RS422 | High Speed RS422/485 (+/- 6 V) output ports. The port is Fully floating and has independent electrical isolation to 2.5 kV. | 2-pin or BNC |
| HV MOSFET | Power MOSFET Switch, allowing switching of 300 VA, 1 A max. The port is fully floating and had independent electrical isolation to 2.5 kV. Refer to Section 6.2 for suggested wiring configurations for use with Power MOSFET switching. | 2-pin |
| Fiber | ST fiber transmitters, compatible with ST-terminated 62.5 µm fiber diameter, 125 µm jacket diameter multi-mode fiber optic cabling. The maximum length of fiber recommended is 750 m. | ST Fiber |

Examples of the three connector types are given in Figures 6 – 8.


**Figure 6 – 2-pin connector**


**Figure 7 – BNC connector**


**Figure 8 – Fiber connector**

### 3.3.2 P2, P3 Programmable Output Options

The user may configure P2 and P3 to output in either inverted or non-inverted polarity:

- A use- configurable number of pulses per second, minute, hour, day with adjustable pulse-width and offset.
- IRIG-B and DCF-77 time codes.

## 3.4 P4: RS232 - Serial Port and Programmable Output (DB9 Connector)


An RS232 port (+/-9 V signal levels) is implemented via 9-way "D" male connector with signal lines: **pin 2** (serial data OUT from TCG 01-E), **pin 3** (serial data IN to TCG 01-E) and **pin 5** (signal ground) together with a programmable signal output on **pin 1**. The programmable output shares **pin 5** (signal ground).

**☛ Do NOT over-tighten the securing screws of the connector!**

TCG 01-E is normally shipped as a DCE configuration, so that a "straight-wired" Socket-to-Socket 9-way data cable can be used to connect directly to a standard PC serial port. (A suitable 2 m cable is included with each TCG 01-E.) The CTS and DSR lines are permanently asserted. As the serial outputs are usually precisely timed messages, there is no provision for either hardware or software flow control.

The RS232 signal lines are not HV-isolated from each other, but the port as a whole is isolated to a level of 2.5 kV from all other ports.

### 3.4.1 P4 Serial Strings

The serial port can be configured to output any one of a number of different serial time messages on a broadcast basis. The serial port runs at a fixed baud-rate of 9600 bps. Message formats typically operate at 8-bit no parity, no flow control and 1 stop bit. Most are transmitted once per second.

A wide range of message strings and protocols can be output on this port. They include:

- NGTS protocol (transmits once per minute)
- IRIG J-17
- Seven preset messages, String/Tekron A—G for compatibility with most IED.
- NMEA ZDA and RMC messages
- GPS Binary/Messages, these are subject to change without notice.

See Appendix B for details of each of the message string formats.

A common application for the programmable output on P4-pin 1 (RS232 level) is to provide an independent drive to an RS232-Fiber converter unit for use in transporting time-code/pulse signals to a distant location. (Tekron manufactures a range of interface devices (MOFRs) that include such converters.) In such cases, **pin 1** should be "broken out" of the 9-way cable optionally used to connect to an external PC, and used in conjunction with **pin 5** (signal return).

### 3.4.2 P4-pin 1 Programmable Output

The user may configure the P4-pin 1 output to operate with inverted or non-inverted polarity, and:

- A user-configurable number of pulses per second, minute, hour, day with adjustable pulse-width and offset.
- IRIG-B and DCF-77 time codes.

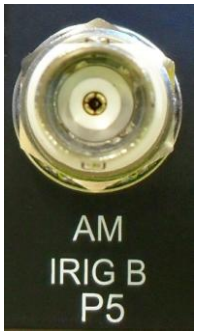
**☛ N.B: TCG 01-E's specifically ordered with the serial port in DTE configuration do NOT support the P4-pin 1 output. The default shipping configuration is DCE.**

## 3.5 Earth Stud (M4 Nut)


An M4 bolt (to chassis) is provided for earthing of cable shields. This is located under the serial port to the left of the P4 designator.

## 3.6 P5: AM IRIG-B Output (BNC Connector)

P5 provides amplitude modulated IRIG-B (B12x) over a BNC connector.



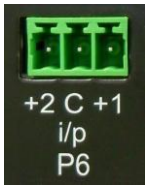

Use either coaxial cable or shielded twisted pair, to feed signal from P5 to any connected IED. When using shielded twisted pair, connect the shield to ground.

The mark/space amplitude modulation ratio is 10:3, and peak to peak output level is 9 V (max), 100 Ω impedance. The output is fully floating, and is transformer-isolated to a minimum of 2.5 kV.

This output is *not* programmable for other types of signal, and the IRIG-B code is present whenever the unit is powered. The particular IRIG-B data content is as specified by the configuration program.

☛ **Most devices with amplitude-modulated IRIG-B time sync inputs have an input impedance of between 4 kΩ and 20 kΩ, and maximum allowable peak- to-peak level of 6 V or so. The P5 output on TCG 01-E is designed to drive many of these devices all in parallel, with a terminating resistor (typically 100-180 Ω) fitted at the far end of the coax line feeding all of the attached loads. In this way P5 can drive at least 20, and typically 30 or more devices without any external amplification required. !!! The terminating resistor is essential to ensure good noise immunity and correct voltage levels!!!**

## 3.7 P6: Event Recording / Sync to IRIG-B Input (3-pin 3.81 mm Connector)




Two input channels with common return that may be driven by TTL logic levels. This port is implemented via a 2-pin plug-able connector. Wiring size is up to 1.0 $mm^2$ and the input is isolated to 2.5 kV.

"C" is the common reference (0 V), and "+2" and "+1" are TTL inputs 2 and 1 respectively. Input burden is 7 mA at 5 V.

P6 is used for either:

- Event recording on units with this option fitted. For a full description, see Appendix B
- Synchronisation of TCG 01-E to an external IRIG-B signal. See Section 5.3.4 for further information on this feature.

## 3.8 P7: Sync Relay (3-pin 3.81 mm Connector)


A set of isolated change-over relay output via 3-pin plug-able connector – capable of switching up to 2 A at 230 V AC, or 300 mA at 150 V DC. Wiring size is to 1.0 $mm^2$ using the supplied mating plug. Isolation is 2.5 kV minimum.

This relay is active ("C" and "NO" connected) whenever the TCG 01-E has established stable time sync from the GPS satellites. The active relay output indicates that all of the other output signals are operating within specification. The connector accommodates 1.0 $mm^2$ cabling.

TCG 01-E outputs maintain accuracy for a time after the loss of satellite sync, and the sync relay can be configured to remain active (indicating "in sync") for a period following the loss of satellite signals. The default period is one minute, but this can be altered up to a maximum period of 42 minutes and 30 seconds (2550 seconds).

## 3.9 P8: RCM – Remote Configuration Module (RJ45 Connector)


The remote configuration module option (RCM), features an RJ45 connector supporting a 100 Mbps Ethernet port (100baseT). A standard (i.e. non-crossover) drop lead should be used to connect the TCG 01-E to a convenient port on a local network hub or switch. If a direct connection to a PC is required, a crossover drop lead should be used.

Located adjacent to the Ethernet port are four LEDs which convey multiple statuses.

The green **lnk** LED indicator lights when a network cable (UTP drop lead) is correctly connected between the TCG01-E RJ45 port and the local network hub/switch or PC.

The **lck** indicator illuminates steadily when the TCG 01 has a validated source of UTC time and is synchronized to that source. In most cases, the source will be time from the GPS satellite constellation, but could also be time from an externally connected IRIG-B source (see ) or, if the TCG 01 unit has been optioned appropriately, (see ) time from a distant PTP master.

The two lower indicators **err** and **sec** should remain off during normal operation. These indicators may flicker for a few seconds immediately following power-on, and they can also flicker continuously when the RCM sub-system is in “Set-Up” mode. However, after the RCM has completed initialization self-checks and has a valid Ethernet network address, these indicators should turn off and stay off.

# 4 INSTALLATION

## 4.1 Identification

Each TCG 01-E unit is shipped with an identification label on the base. The label provides details of the particular options fitted to the unit, the power supply requirement, the serial number and firmware revision.

☛ **Check the identification label on the base of the unit to ensure that the correct model has been supplied before proceeding to install!**

## 4.2 Packing List

Each TCG 01-E kit is shipped with the following:

- TCG 01-E time code generator
- GPS antenna optimized for stationary applications, with mounting plinth
- Antenna lead-in cable fitted with matching connectors
- 19" rack mounting plate
- Cat-5 Ethernet cables
- Configuration software
- User manual – this document

## 4.3 GPS Antenna and Cable Installation

### GPS Antenna

The TCG 01-E unit's standard shipping configuration includes an active GPS antenna radome specifically designed for industrial/static timing environments, together with a pipe-mounting plinth. The mechanical diagram below shows the radome and pipe mounting plinth attached. Refer to Appendix A.1 for the complete antenna specifications.

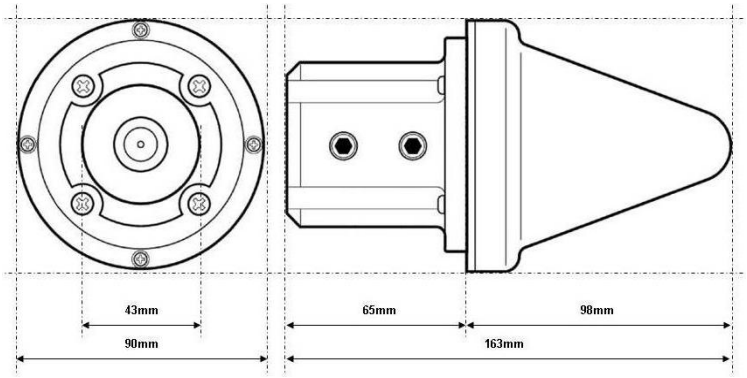



**Figure 9 – Dimensions of antenna pipe-mounting plinth**

The antenna pipe-mounting plinth (Figure 9) is designed to fit over the top of a pipe like a capping. The mount has an internal diameter of 43 mm, to fit a pipe with external diameter of between 40 and 42 mm (1¼ inch / 32 mm nominal ID galvanized pipe). The top end of the pipe should be cut flat, so that the rubber gasket inside the antenna mount sits flush against it, forming an effective weather seal. The mount is fixed to the pipe with two stainless steel M8 hexagon- socket setscrews (supplied).

## Available Accessories

Antenna cable - Refer to Appendix A.3.

Adjustable antenna mounting bracket - Refer to Appendix A.2.

Lightning protection kit - Refer to Appendix A.6.

In-line amplifier - Refer to Appendix A.5.

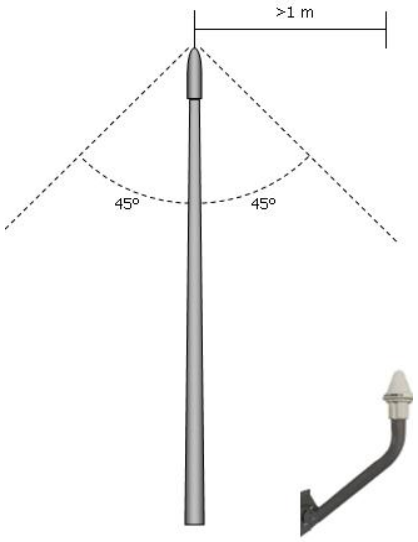
## Pre-installation

Prior to the acquisition and installation of a GPS Clock, ascertain where and how you will fix the antenna to ensure that the clock will perform nominally.

### Step 1 – GPS antenna placement

The GPS antenna should be installed in a position where it has a clear view of the satellites. When surveying a site prior to installation, consider any fixed or moving obstructions which may affect GPS reception (E.g. Terrain, Pylons, mobile obstructions…). Avoid close proximity to antennas from other services where possible. The antenna has excellent rejection characteristics to out-of-band signals, as does the GPS receiver, but high-powered RF signals in close proximity to the antenna may swamp the very low-level signals from the GPS satellites.

### Reducing the risk of lightning strike




The first line of protection against the effects of lightning-induced surge events involves positioning the antenna in a “lightning-protected zone”. In practice, this means ensuring that there is at least one other earth-bonded structure located in the same rooftop area (e.g. another antenna, or a lightning rod) that reaches significantly higher than the top of the GPS antenna. The GPS Antenna should then be mounted so that it lies within a 45-degree angle from the top of the other earth-bonded structure. The GPS antenna mount itself should also be securely bonded directly to the building protection earth – and not connected via any of the other earthed structures.

The risk of lightning strike is greatly reduced if the installation is carried out as described above. However, there is no way to completely prevent lightning strikes. In areas that are especially prone to lightning, a lightning arrestor device should also be installed to further reduce the risk of damage.

### Lightning protection

At installations where lightning frequently occurs, it is prudent to install a lightning arrestor between the antenna and clock. Tekron's antenna lightning protection kit LPK 01 provides additional protection through the use of an impulse suppressor. In the event of a lightning-derived high voltage surge, the impulse suppressor activates, short-circuiting the cable directly to earth.

### Step 2 – Antenna mounting bracket

The antenna pipe-mounting plinth is designed to fit over the top of a user-supplied pipe like a capping. The pipe should have an external diameter of between 40 and 42 mm (1¼ inch / 32 mm nominal ID galvanized pipe). The top end of the pipe should be cut flat, so that the rubber gasket inside the antenna mount sits flush against it, forming an effective weather seal.

Establish the mounting method for the pipe, such as strapping or bolting to a frame on the edge of the building, or strapping to an air conditioning exhaust or similar. The base of the pipe needs to be accessible for the cable entry, if this is not practical, then a hole or slot can be made in the side of the pipe to allow the cable to enter and be passed up to the top of the pipe.

An adjustable antenna mounting bracket can be ordered from Tekron. Refer to appendix A.2 for specifications.

**Step 3 – Antenna cable**

Calculate the cable length required between the antenna and GPS Clock, allowing 5 – 10% extra for contingencies.

Tekron GPS Clocks can be ordered with 15, 30, or 60 meters of high performance RF cable factory-fitted with a TNC-type male connector at one end, and a SMA male connector at the other. The TNC-type connector mates with the connector on the antenna and provides a robust weather-resistant connection. The smaller SMA connector mates with the connector on the GPS clock rear panel and is only fractionally larger in diameter than the cable itself; this facilitates installation in conduit and through small apertures.

Custom lengths can be ordered upon request however additional costs may be incurred.

Where antenna cable distance exceeds 60 meters, either lower loss (e.g. LMR400UF) cable can be used or an in-line amplifier can be installed. Refer to Tekron for further advice.

## Installation

**Step 4 – Antenna cable installation**

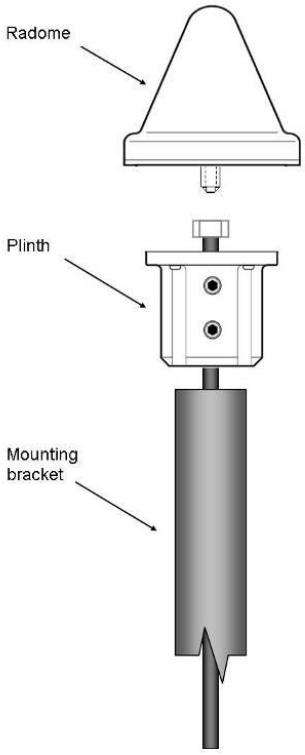
While the cable shielding is excellent, the cable should not be routed in close proximity to power cables or other RF cables carrying transmitter signals – in particular, parallel runs are to be avoided if possible. If such runs are absolutely unavoidable, a minimum separation of 300 mm may be used as a guideline.

The GPS receiver has excellent out of band rejection characteristics, as does the antenna itself. However, sound engineering practice should not rely on these factors alone to guarantee performance. Careful installation will enhance the long-term reliability and on-going stability of the Time Code Generator.

The absolute minimum bend radius for the antenna cable supplied is 40mm, but it is preferable to use a larger radius if possible. Caution should be taken at all times during the installation of the cable to avoid crushing or shorting the cable.

**Step 5 – GPS antenna installation**

Feed the antenna cable up the mounting bracket/ pipe from the bottom end, through the plinth, and connect directly to the TNC connector on the base of the antenna. It is advisable to wrap self-amalgamating tape around the connector to seal the connection and provide protection against moisture ingress.

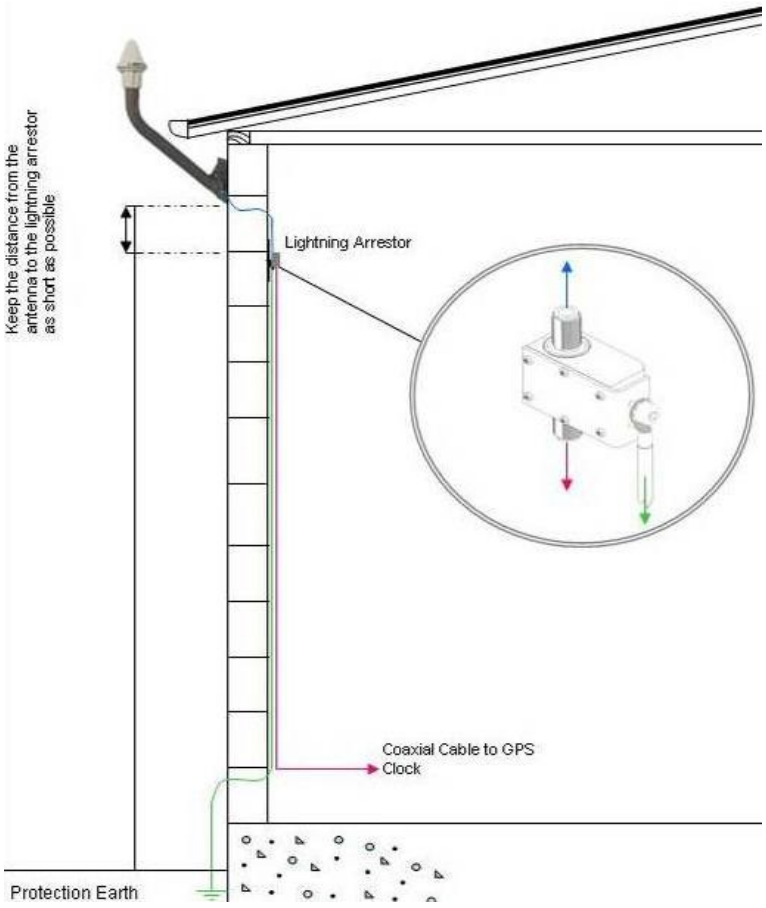



Fasten the antenna to the plinth using the four stainless screws supplied with the kit. The complete antenna assembly can then be placed on the mounting bracket/ pipe and secured by tightening the grub screws on the side of the plinth using the supplied Hex key.

**Step 6 – Installing the lightning protection kit (when applicable)**

The lightning protector must be firmly mounted to a conductive metal surface that is itself bonded to the building protective earth. Ensure that a good electrical connection is made between the surge protector and the earthing system. All earthing connections should be as short as possible, should have no sharp bends or loops.

The preferred mounting position is on the inside of the building's exterior wall, adjacent to the antenna lead entry point.




Refer to the lightning protection installation guide for connection details.

## Summary

## Pre-installation steps:

**Step 1 – GPS antenna placement**

Locate a position to mount the GPS antenna where it has a clear view of the sky, away from RF transmitters, and in a lightning protected zone.

**Step 2 – Antenna mounting bracket**

Establish a mounting method and procure a suitable mounting pipe.

**Step 3 – Antenna cable**

Calculate the cable length required between the antenna and GPS Clock, allowing 5 to 10 % extra for contingencies.

### Installation steps:

**Step 4 – Antenna cable installation**

Run the cable from the antenna to the GPS clock. Where possible, allow a separation of 300 mm between the antenna cable and other cables including power or cables carrying other RF signals. Ensure that the cable bends are greater than 40 mm in radius.

**Step 5 – GPS antenna installation**

Feed the antenna cable up the mounting bracket from the bottom end, through the plinth, and connect directly to the TNC connector on the base of the antenna. It is advisable to wrap self-amalgamating tape around the connector to seal the connection and provide protection against moisture ingress.

Fasten the antenna to the mounting plinth using the four stainless screws supplied with the kit. The complete antenna assembly can then be placed on the mounting bracket/ pipe and secured by tightening the grub screws on the side of the plinth using the supplied hex key.

Secure the completed antenna assembly and mounting bracket to the previously prepared mounting structure.

**Step 6 – Installing the lightning protection kit (when applicable)**

The lightning protector must be firmly mounted to a conductive metal surface that is itself bonded to the building protective earth. Ensure that a good electrical connection is made between the surge protector and the earthing system. All earthing connections should be as short as possible, should have no sharp bends or loops.

The preferred mounting position is on the inside of the building's exterior wall, adjacent to the antenna lead entry point.

Refer to the lightning protection installation guide for connection details.

☛ **All TCG 01-E antenna installations should follow the guidelines above.**

## 4.4 Mounting the TCG 01-E

The clock can be used on a bench or mounted in a rack. Each unit ships with a rack-mount bracket. (Figure 10).


**Figure 10 – TCG 01-E with rack-mount bracket**

## 4.5 Operation

☛ **Check the label on the base for voltage requirements before switching on!**

Connect the antenna lead and the antenna (with a good view of the sky). Then connect the power source to **P1**.

The time required that will achieve tracking and synchronization given a good view of the sky is typically within a minute. Reactivating a unit that was previously synchronized thousands of kilometers away from the present position will take longer but not more than 45 minutes.

# 5 TCG 01-E CONFIGURATION SOFTWARE

## 5.1 Introduction

Configuration software is provided on a CD with all TCG 01-E units. This software is compatible with all versions of the Windows operating system from Windows 2000 through to Windows 7. The software uses the PC's Ethernet port to communicate with the clock. Each clock ships with a straight-wired Ethernet cable (for connection to a LAN switch) and a cross-over Ethernet cable (for direct connection to a PC).

### 5.1.1 Connection via LAN

Run the supplied CD and locate the configuration software, which is in [Drive] "\TCG01E\GPSClock Config.exe". This software may be run directly from the CD or be copied to a local folder. [Drive] is typically "D:"

Apply power to TCG 01-E and connect the unit to a network switch located on the LAN using a CAT5e Straight-wired Ethernet cable (2M cable supplied with clock). Using a PC connected to the LAN, run the configuration software program "GPSClock Config.exe". The configuration software will automatically locate and identify all Tekron "E" level clocks that are connected to the LAN on the same sub-net as the PC.

☛ **Preset IP addresses are NOT required if PC and clock(s) are on the same IP sub-net.**

The window shown in Figure 11 will appear showing the clock Type and Serial Numbers of all Ethernet-configurable Tekron clocks found on the sub-net of the LAN. Select the serial no of the unit you would like to configure and click "Open".

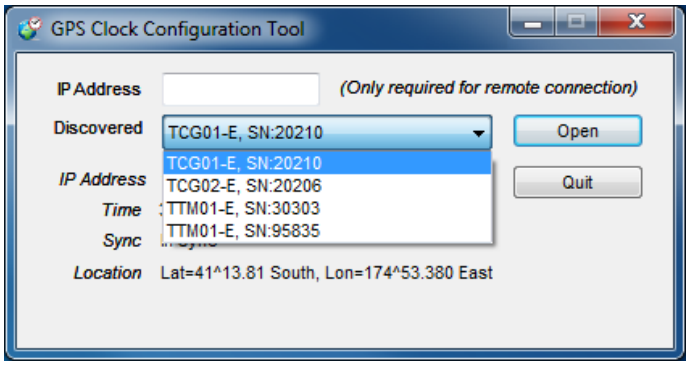



**Figure 11 – Unit selection**

☛ **If no units are found on the network and you are confident that the TCG 01-E is connected properly, check the Windows firewall settings on your PC to ensure that the program is not being blocked.**

Tekron clocks that have already been configured with an IP address also support remote configuration over one or more network routers (WAN). The user can communicate with the target clock by entering the clock's IP address in the field provided (See Figure 11 above). The availability of the remote configuration feature over a WAN is dependent on the WAN configuration. Please refer to your WAN support personnel for further information.

After successful connection, the configuration tool opens with the "Time" tab active (Figure 12).

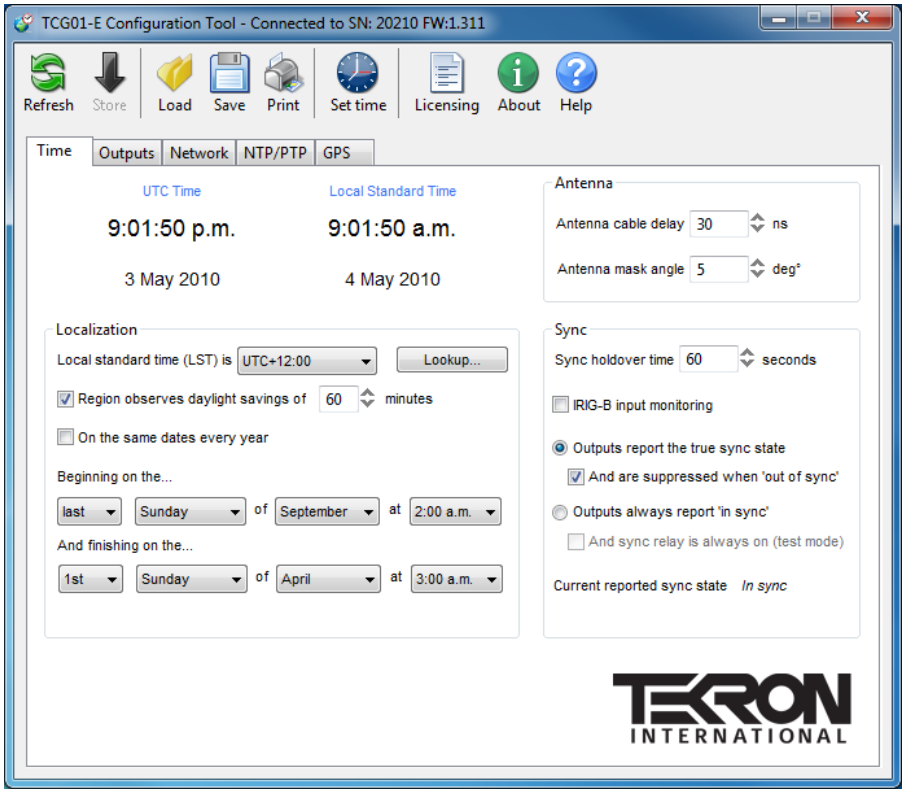



**Figure 12 – Time configuration tab**

### 5.1.2 Direct connection method

Run the supplied CD and locate the configuration software, which is in [Drive] "\TCG01E\GPSClock Config.exe". This software may be run directly from the CD or be copied to a local folder. [Drive] is typically "D:".

Apply power to TCG 01-E and connect the unit via an Ethernet crossover cable to a PC and run the configuration software program "GPSClock Config.exe". As in the case of connection via a LAN, a window will appear showing the serial number of the TCG 01-E unit connected. Select the serial no of the unit and click "open" to see the "Time" tab as per Figure 12.

☛ **If the TCG 01-E unit is not found and you are confident that the units are connected properly, check the Windows firewall settings on your PC to ensure that the program is not being blocked.**

## 5.2 Toolbar

### 5.2.1 Refresh and Store


Changes made in the configuration tool can be applied to the TCG 01-E using the "Store" button. After storing the configuration changes, The TCG 01-E will reset, so will register a loss of sync for a brief period. Note that the "Store" button can *only* be selected when the configuration displayed does not match what is actually stored in the clock.

The "Refresh" button can be used to undo any changes that have been made to the configuration options on screen that have not yet been stored using the "Store" button.

### 5.2.2 Load, Save and Print


General Clock Configuration data can be saved on your PC as a ".cfg" file using the "Save" button, and loaded using the "Load" button. Note that configuration options in the Network and NTP/PTP tabs are *not* loaded, as these are dependent upon your network architecture and are specific to individual units and/or locations. Loaded changes are not applied to the TCG 01-E until the "Store" button is pressed.

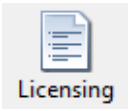
The "Print" button prints a text document listing all currently stored configuration data.

### 5.2.3 Set Time


When the true time is unknown and the antenna is disconnected, the time can be arbitrarily set using the "Set Time" button. This function allows the TCG 01-E to be used as a signal source for testing the ability of externally attached equipment to correctly process received time codes through unusual time transitions such as the 28/29 February rollover during leap years, or daylight savings transitions.

The TCG 01-E would normally be configured with **"Outputs report "in sync" always"** and ***"And sync relay is always on"*** settings activated when arbitrarily setting the time.

### 5.2.4 Licensing




The "Licensing" button opens a window in which new license keys can be entered to enable additional functionality. Currently NTP Server and/or PTP functions are controlled in this way. A license may be purchased at any time to activate these features.

### 5.2.5 About and Help


The "About" button opens a windows showing copyright information and firmware/software version numbers.

A context-sensitive help window can be opened using the "Help" button. Move the mouse cursor over the configuration option for which you require help.

## 5.3 Time Tab

The "Time" tab (Figure 12) displays the current time and contains regional, antenna and synchronization settings.

### 5.3.1 Localization

**Local Standard Time (LST)**

The time offsets define the number of hours (and, in rare cases, minutes) that the local time differs from UTC time. A positive offset means that the local time is ahead of UTC.

**Lookup…**

The "Lookup…" button provides a convenient way to automatically set time offset and daylight savings parameters simply by selecting a geographical location. Note: this information is derived from Windows™ Date and Time settings, so should be verified as correct before use.

**Region observes daylight savings**

Selecting this option allows the TCG 01-E to be configured to make daylight savings changes automatically.

Further options are then made available including:

- DST (Daylight Savings Time) offset in reference to LST (Local Standard Time).
- Fixed date or fixed rule for calculating a date method.

### 5.3.2 Antenna

**Antenna Cable Delay**

All antenna systems introduce signal delay (depending on the cable length). To optimize the precision of the output signals enter a value in this field corresponding to 4ns per meter of antenna cable. For example, if the antenna cable has a length of 30 meters, enter “120”.

**Antenna Mask Angle**

This is the elevation above the horizon below which satellites will not be used in time and position calculations. A good starting value is 5°, but this may need to be increased in areas with land based obstacles to prevent time quality loss due to multi-pathing effects. Increasing this value reduces the field of sky view so may reduce the number of satellites in view at any given time.

### 5.3.3 Synchronization

**Sync Holdover Time**

This parameter is used to control the period after loss of satellite sync that will be tolerated before TCG 01-E will show the “loss of sync” status, and release the “sync” relay. Correct installation will make the “loss of sync” event rare, although in areas with poor GPS coverage there can be occasions where satellite tracking is momentarily lost. The “sync holdover” feature is used to mask these effects.

The accuracy of all outputs when there is a complete satellite “blackout” is maintained to the sub-microsecond level over short periods (a few minutes), and to within 30 µs for up to 40 minutes. A single satellite signal sufficiently recovers accuracy to within 1 µs.

☛ **In typical SCADA operations, time syncing to within 0.5 ms is considered adequate. Setting Sync Hold to the maximum (2550 seconds) will prevent “loss of sync” alarms in the event that satellites are temporarily obstructed.**

**Outputs report the true sync state**

Under normal conditions this option should be selected. The clock reports the true state of synchronization to the connected IEDs.

***And are suppressed when “out of sync”***

This option suppresses TCG 01-E outputs when it goes out of sync. The sync relay operation is unaffected by this option and will still indicate the true sync state of TCG 01-E.

**Outputs report “in sync” always ******

The clock will output time sync signals as if it were synced to GPS, even if this is not true (e.g. there is no antenna attached). In this mode the sync indication outputs will be active at all times.

***And sync relay is always on ******

Enabling this option forces TCG 01-E to output time sync signals as if it were synced to GPS, even if this is not true (e.g. there is no antenna attached). In this mode the sync relay will be on at all times.

When the TCG 01-E is in this mode, the time can be arbitrarily set. This function allows the TCG 01-E to be used as a signal source for testing the ability of externally attached equipment to correctly process received time codes through unusual time transitions such as the 28/29 Feb rollover during leap years, or daylight savings transitions.

☛ **The latter two options (marked ****) are typically used only for testing. They should NEVER be used in applications where a true UTC time reference is required.**

### 5.3.4 IRIG-B Input Monitoring

This feature provides a means to monitor signal activity on the two input channels of **P6**. The TCG 01-E clock automatically detects an external IRIG-B signal input on either or both of the **P6** input lines (Figure 13). Normally, if no signal is present, the **IRG** LED will remain off, and will only light up if an IRIG-B signal is detected. When this option is selected, the **IRG** LED will be active at all times, flashing to show the "no signal" state if there is no IRIG-B signal detected on either input channel (see Section 2.2).

☛ **The IRIG-B input monitoring function also forces the clock to expect an IRIG-B signal on** P6**, channel 2 (terminals [+2, C]). This means that, in clocks equipped with the event recording factory option, activating the IRIG-B input monitoring function redefines the operation of** P6**, channel 2 to be an IRIG-B input instead of an event input.**

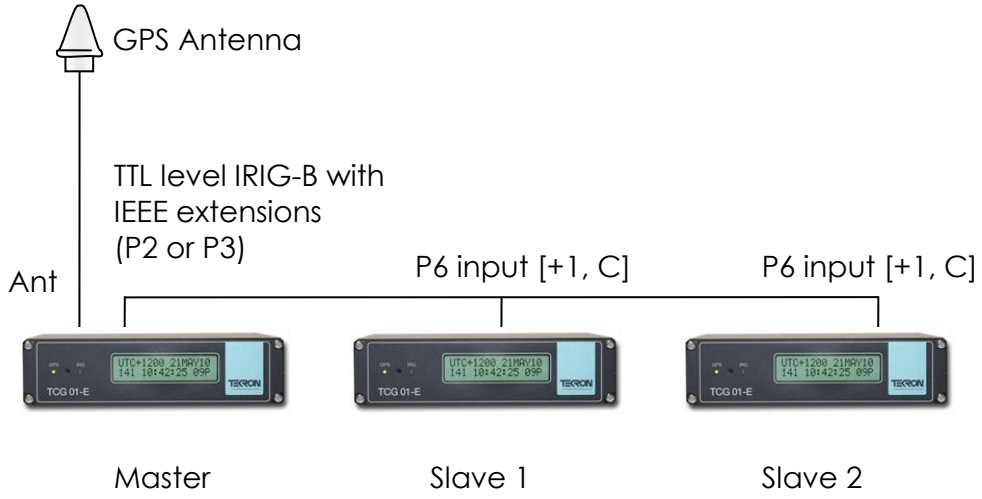



**Figure 13 – Multiple Time Code Generators with one GPS antenna**

## 5.4 Outputs Tab

The "Outputs" tab (Figure 14) enables the selection and configuration of TCG 01-E output ports.

### 5.4.1 Programmable Outputs

**P2 / P3 / P4-pin 1**

Each of the three outputs (**P2**, **P3** and **P4**-pin 1) can be programmed to give one of four different output waveforms. Selection between the four options is achieved via a drop-down menu (Figure 14). The options available **independently** for each output are:

1 DCF-77 Output Pulse Simulation
2 IRIG-B DCLS (B000/B001 or B002/B003)
3 IRIG-B Modified Manchester Encoded (B220/B223 or B221/B222)
4 User Defined Pulse Sequence (separate definition stored for each output)

Each of the three programmable outputs can also be inverted in its operation.

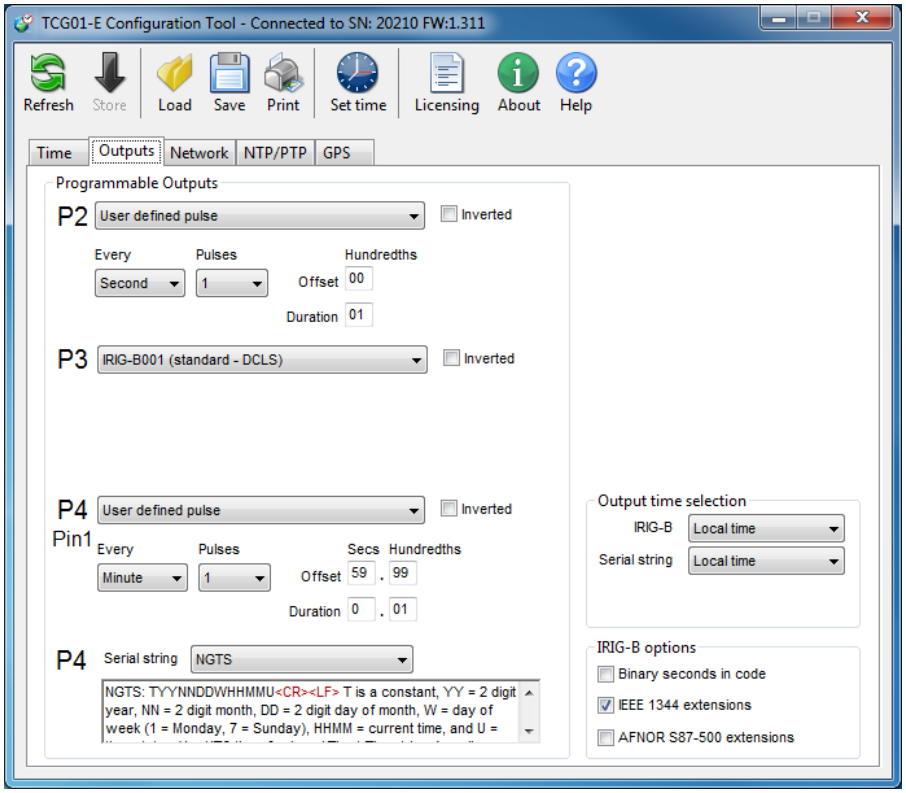



**Figure 14 – Outputs configuration tab**

☛ **Figure 14 shows the settings for a user-defined pulse on the P4-pin 1 output. The values shown will result in a single pulse per minute. The pulse will begin 59.99 seconds after the start of the minute, and will last for 1/100th of a second (10 ms). These settings of the pulse output on P4-pin 1 are normally used in conjunction with the "NGTS" string on P4 to give an NGTS synchronisation protocol.**

In the case of the User-Defined Pulse option being selected for any outputs, further parameters are entered to define the pulse sequence. The parameters are as follows:

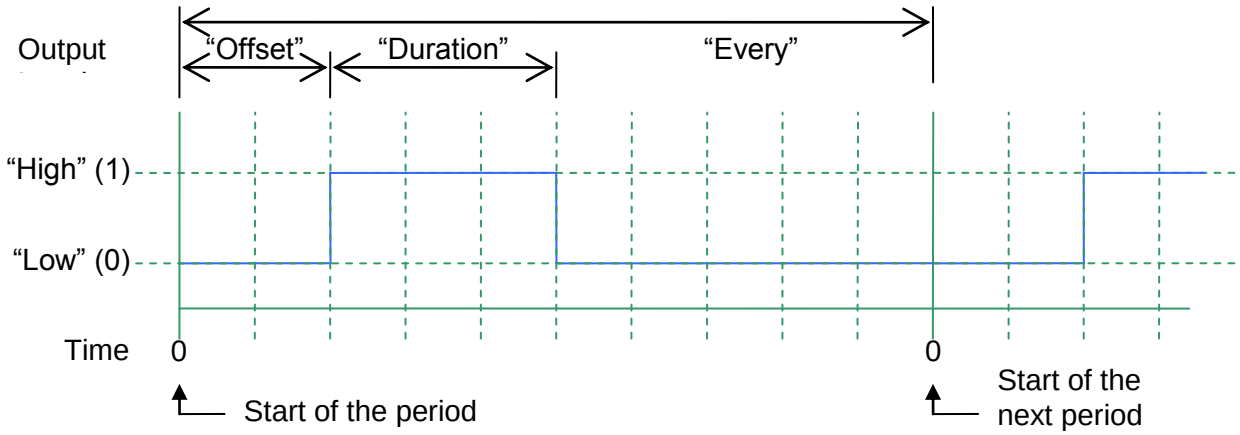
(1) A drop-down menu allows the user to choose to have pulses output every "second", "minute", "hour", or "day". Specify the frequency of pulses under the "Every" and "Pulses" fields: The table below shows what number of pulses per second are valid:

| Period "Every" | Number of "Pulses" |
|---|---|
| Second | 1, 2, 3, 4, 10, 20, 50, 1000 |
| Minute | 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30 |
| Hour | 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30 |
| Day | 1, 2, 3, 4, 6, 8, 12 |

(2) Specify the "Offset" this is the interval from the start of the day, hour, minute, or second to the start of the pulse.

(3) Specify the "Duration"; this is the time the pulse stays asserted.

(4) Check "inverted" to swap the polarity of the pulse – that is "High" and "Low" levels are swapped.




**Serial string**

The serial port output P4 operates at a fixed data rate of 9600 bps with no flow control and 8-bit, no parity format unless otherwise specified. The standard TCG 01-E outputs are broadcast messages sent at regular intervals. The broadcast repetition rates, timings, and message content are all described in the Serial Output Strings B. Descriptions of each string are also displayed below the dropdown selection box in the configuration tool.

## 5.4.2 IRIG-B Options

The IRIG-B time code includes Local (or UTC) Time -see Section 5.4.3 in the form of Seconds, Minutes and Hours fields, together with Day_of_Year and a two-digit Year fields. Additional data can be selected for transmission in all of the outputs that are programmed for IRIG-B.

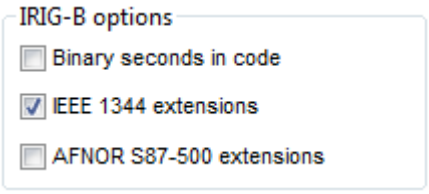



**Figure 15 – IRIG-B output options**

**Binary seconds in code**

The "Binary seconds in code" field (Figure 15) is an option specified by IRIG standard 200-04. If this option is selected, all of the outputs programmed for IRIG-B code – including the amplitude-modulated output - will include the "Binary Seconds of Day" data.

**IEEE 1344 extensions**

Outputs programmed for IRIG-B code will additionally output: impending leap second information, local time offset, impending daylight savings change, and time-quality information all in accordance with IEEE1344 specification. Synchro-phasor Standard C37.118 specifies that these extensions be present when syncing Synchrophasor equipment.

**AFNOR S87-500 extensions**

If this option is selected, all of the outputs programmed for IRIG-B code will also output: day of week, month, and day of month in accordance with the European AFNOR S87-500 specification.

### 5.4.3 Output Time Selection

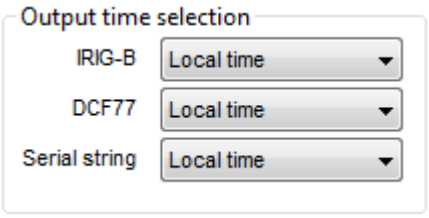



**Figure 16 – Output time selection**

**IRIG-B**

When selected from the menu shown in Figure 16, UTC time will be output in IRIG-B time code signals. Otherwise, local time using the current localization settings will be output.

**DCF77**

When selected, UTC time will be output in DCF77 time code signals. Otherwise, local time using the current localization settings will be output.

**Serial string**

When selected, UTC time will be output in serial strings. Otherwise, local time using the current localization settings will be output.

## 5.5 Network Tab

This tab contains network addresses and options such as SNMP and Syslog (Figure 17).

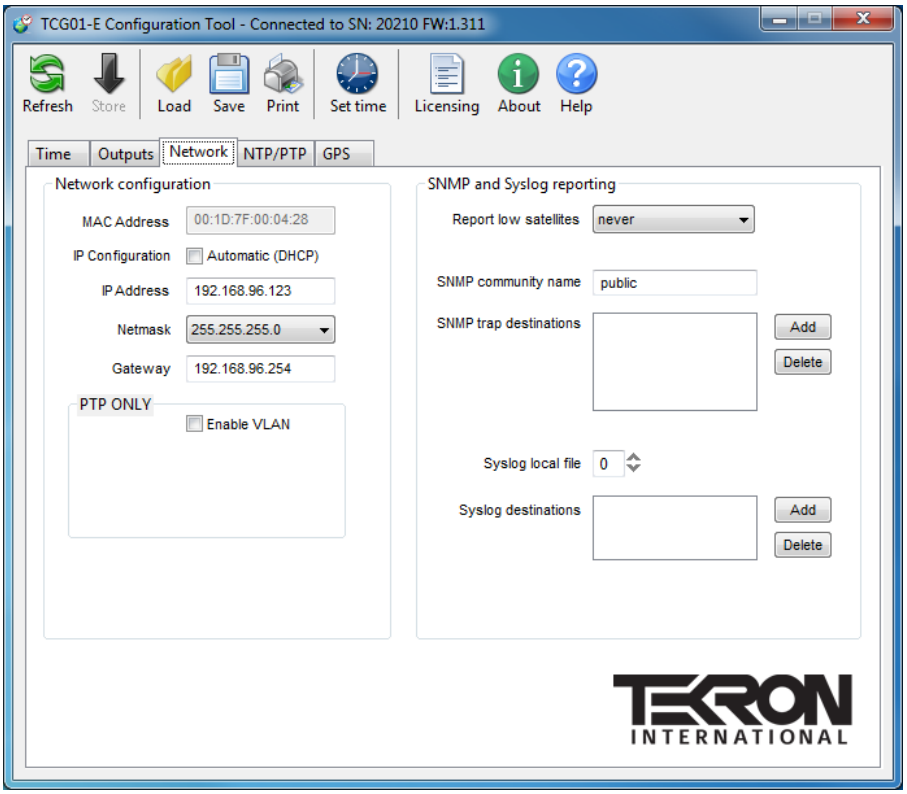



**Figure 17 – Network configuration tab**

### 5.5.1 Network Configuration

***Mac Address***

Shows the MAC address assigned to the unit. This field cannot be modified.

***IP Configuration***

Selecting “Automatic” will invoke DHCP operation. Networks that include a DHCP server offer automatic address allocation via **D**ynamic **H**ost **C**onfiguration **P**rotocol (DHCP). In such a network, the unit will automatically use DHCP to fetch a dynamic address if it does not already have a fixed address configured.

***Host IP Address***

If a DHCP server is unavailable, or if fixed addressing is preferred, an IP address can be entered manually

***Netmask***

Set to 255.255.255.0 for a standard class C network.

***Gateway***

Please refer to your network administrator for the correct setting in this field.

### 5.5.2 VLAN (PTP ONLY)

***VLAN ID***

This parameter sets the ID inside the VLAN tag used by PTP packets. If the ID is not known, a value of 0 is set by default. Otherwise, the input range is 0 to 4094.

***VLAN Priority***

This parameter sets the priority inside the VLAN tag. If the priority is not known a value of 0 is set by default. Otherwise the input range is 0 to 7.

### 5.5.3 Simple Network Management Protocol (SNMP) and Syslog Reporting

***Report low satellites***

If the number of GPS Satellites drops below this threshold, an SNMP message “low satellites” is generated. After the unit has been operating with four satellites or more, the clock is tuned such that it can maintain full specified accuracy even if satellite visibility drops to just one satellite. For this reason, the default value for this parameter is “1”. This prevents the transmission of numerous unnecessary “low satellites” messages.

***SNMP community name***

The default value is “public”. This may be changed to suit the specific SNMP architecture on the network if required. If SNMP is not implemented for other purposes on the network, then the “public” setting allows the use of a simple SNMP trap display utility running on a remote monitoring PC to display the status messages sent from the unit.

***SNMP trap destination***

This parameter allows for up to five destination IP addresses to be entered. Machines on any or all of these IP addresses can then receive the status messages from the unit. Even if there is no formal SNMP system running on the network, the messages can be received and displayed on the destination machines running “Windows NT” or higher using the freeware utility “SNMPTRAP.EXE”, which is on the CD supplied with the TCG 01-E kit.

***Syslog local file***

Normally you would set to zero unless further categorizations of the syslog messages are required.

***Syslog destination***

One or two IP addresses may be entered to define destination machines running system logs.

## 5.6 NTP/PTP Tab

A TCG 01-E unit licensed for NTP operation provides a complete Stratum-1 time-server function while still retaining all other output services. Specific time-sync client protocols supported are NTP and SNTP. A further license operation enables support for PTP (V2) also.

This tab (Figure 18) is inactive and appears grayed out unless the NTP/SNTP or NTP/SNTP and PTP options are ordered (refer to Section 5.2.4 for instructions on enabling an NTP or PTP license).

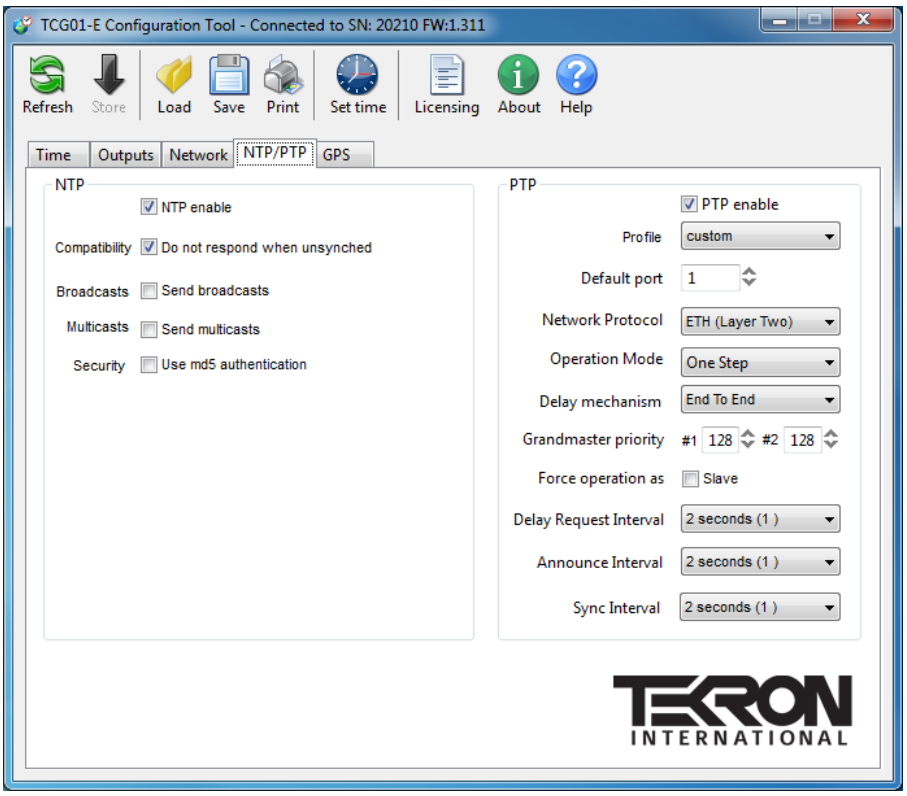



**Figure 18 – NTP/PTP configuration tab**

### 5.6.1 NTP

***NTP Enable***

Select this box to activate NTP/SNTP.

***Compatibility***

***Do not respond when unsynched***

Selecting this option causes the time server not to respond to NTP time synch requests unless it is itself synced to UTC time.

***Broadcasts***

***Send Broadcasts***

If this option is selected, the unit prompts for a poll interval. The unit will then broadcast time packets at the interval specified.

***Send Multicasts***

If this option is selected, the unit prompts for a poll interval and Multicast Group IP. The unit will then broadcast time packets at the interval specified to the multicast group specified.

***Security***

***Use MD5 authentication***

The TCG 01-E supports fully encrypted requests. If this option is selected, the unit then prompts for five ASCII or Hex keys. PTP

**PTP Enable**

Select this box to activate PTP.

**Profile**

This drop down list allows a quick method of programming the TCG 01-E to output PTP based on industry recognized profiles. The custom setting allows you to set your own PTP network and operational parameters.

- Default
- Communications
- Telecom
- Power
- Custom

**Default Port**

Select the PTP default port

**Network Protocol**

The network protocol must be consistent across the entire sub net. Most common in use is UDP.

- UDP
- Ethernet Layer 2

**Operation Mode**

Operation mode is a network wide parameter. In any given network, only one mode of operation will be present.

- One Step
- Two Step

**☛ Select two step operation if the mode is unknown.**

**Delay Mechanism**

Delay mechanism is a network wide parameter. The delay selected must be consistent across the network.

- End-to-End
- Peer-to-Peer

**☛ Use Peer-to-Peer in an IEEE1588 network containing transparent switches. Use End-to-End if standard switches are used in the network.**

**Grandmaster Priority**

This feature should only be used in a test environment. It enables the unit's BMC (Best Master Clock Algorithm) to be over ridden, and an alternate priority defined by the user can be allocated to the unit.

The input range is 1 to 255, where 1 is the highest priority. The default setting is 128.

**Force Operation as Slave**

Check this box to force the unit to act as a slave unit only. In this mode, the unit will never allow itself to become a master clock even in the presence of a GPS signal.

**Delay Request Interval**

Delay request interval specifies the minimum permitted mean time interval between successive Delay Request messages.

**Announce Interval**

Announce interval specifies the mean time interval between successive Announce messages.

**Sync Interval**

The sync interval specifies the mean time interval between successive Sync messages.

## 5.7 GPS Tab

The information in the "GPS" tab helps with troubleshooting and optimizing an antenna installation.

### 5.7.1 Satellite Visibility

Visible satellites are shown on a polar-display. The rings mark the 'elevation' and the sectors mark 'azimuth'. The center of the display represents directly overhead and the elevation is 90° at this point. The edge of the display, elevation = 0°, represents the horizon. The 'azimuth' is a compass direction where 0° represents true north, 90° is east and 180° is south. Satellites being used are marked by a colored cross on the display, and a blue bar on the Satellite Signal Strength Indicator, otherwise it is gray on both.

Satellite trails and a minimum elevation plot (the blue area) are also shown in the polar display. Over time this minimum elevation plot will show the viewable horizon. An example of a minimum elevation plot obtained from Wellington, New Zealand is shown in Figure 19. This example shows that there is poor satellite coverage in southern latitudes.

**To ensure reliable performance, when operating TCG 01-E at extreme southern latitudes, position the antenna with a clear view of the northern sky. Similarly, when operating in extreme northern latitudes, the antenna must be able to "see" the southern sky.**

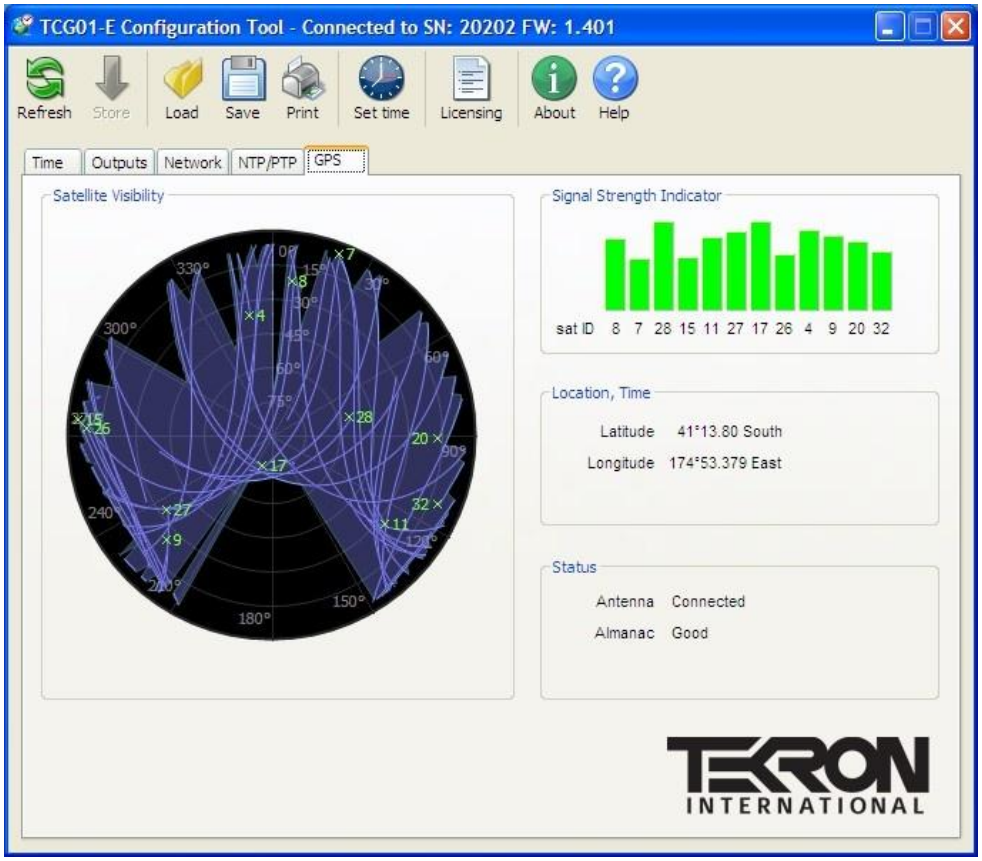



**Figure 19 – GPS configuration tab showing trails and minimum elevations**

### 5.7.2 Signal Strength Indicator

The signal strength indicator gives real-time information regarding the signal reception from GPS satellites.

- Green bars indicate good satellite reception.
- Orange bars indicate poor reception.

### 5.7.3 Location

This shows the latitude and longitude of the installation.

### 5.7.4 Status

This shows the Antenna and Almanac status.

# 6 FACTORY HARDWARE OPTIONS

## 6.1 Power Supply Options

This table shows the three different power supply configurations that may be ordered with TCG 01-E.

| Designator | DC Input Range |
|---|---|
| L (Low) | 12-36 V DC |
| M (Medium) | 20-72 V DC |
| H (High) | 90-300 V DC |

## 6.2 High Voltage (MOSFET) Output Option

TCG 01-E may be ordered with either or both of the **P2** and **P3** outputs configured with a high voltage FET switching transistor instead of the standard 5 V logic output. When fitted in this manner, each output can switch an external load of up to 300 VA, with a maximum "on" current rating of 1 A, and a maximum rated Voltage of 300 V DC.

External wiring should be arranged so that the external high voltage supply line (up to 300 V DC max) is connected, via a fuse, to the load (Figure 20). The return connection from the load is then wired to one terminal of the **P2 (P3)** output, and the other terminal of the **P2 (P3)** output is then wired to complete the circuit back to the other side of the power supply. Do not connect the high voltage supply to P2 or P3 unless the high voltage option is fitted – check the label on the base of the TCG 01-E unit.

☛ **IMPORTANT! It is the user's responsibility to provide adequate protection in the form of an external fuse to protect the external power supply, the TCG 01-E output switch and the load. Note: At all times, the polarity of the P2 (P3) connections should be such that conventional current flow is into the "+" terminal and out of the "0" terminal – i.e. "+" is at higher positive potential than "0".**

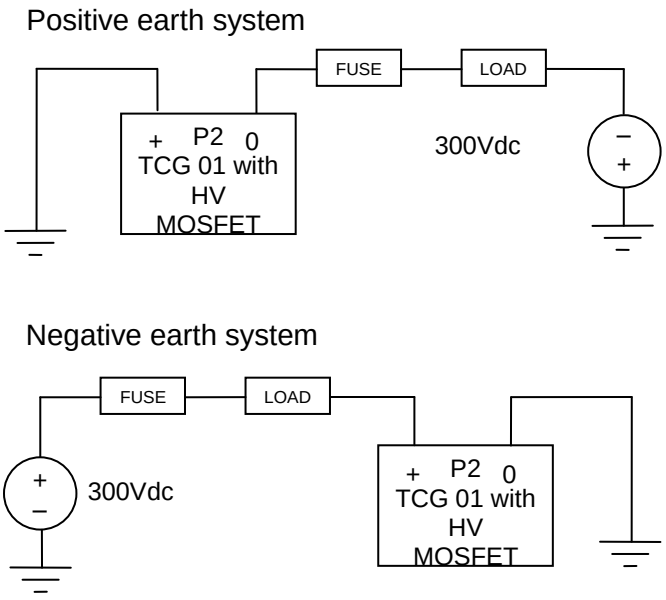



**Figure 20 – High voltage MOSFET output switch option: Suggested wiring arrangements**

Output isolation (from chassis and other I/O) is still maintained when the HV option is fitted. This simplifies the external load/supply arrangements, particularly when operating with positive-earth systems – as in many utility facilities.

## 6.3 Event Recording Option

### 6.3.1 Introduction

### General Description & Specification

TCG 01-E clocks ordered with the event recording (time-tagging) option provide event recording channels on each channel of **P6**. This is a TTL level input with an input burden of 7 mA.

Recorded time tags contain timestamps corresponding to the rising edge of a pulse. The minimum pulse duration is 1 µs, and the maximum rate of time tag recording is 100 tags per second (aggregated over both inputs). In the event of pulses occurring simultaneously on both inputs, both events are captured and recorded independently with the same time data.

N.B. The event recording option makes use of the same input connectors as the automatic slave (IRIG-B input) function described in Section 5.3.4. In clocks fitted with event recording, the external IRIG-B input function can still be accessed by selecting the "IRIG-B input monitoring" feature (see Section 5.3.4). In this case, only one of the two event recording channels is accessible (**P6**, channel 1) and an IRIG-B signal will be expected on **P6**, channel 2.

### Tag Data

Time tags use UTC time, and each tag includes the year, day of year, hour, minute and second, as well as fraction of second to a resolution and accuracy of 100 ns. TCG 01-E measures time internally in 40 ns intervals, rounding to the nearest 100 ns for time tag storage purposes, thus allowing accuracy to equate to resolution. Each tag record includes the input channel number, as well as the clock sync status as at the tag time.

### Tag Storage

TCG 01-E stores time tags in a data queue designed as a circular buffer. The maximum number of time tags that may be stored is 512. If further events occur when the buffer is full, TCG 01-E sets an overflow status and continues storing tags, overwriting the oldest data first.

### Tag Retrieval

The user can retrieve time tags from the buffer using a request/response protocol operating over TCG 01-E's serial port interface. Tags are retrieved from the buffer - oldest data first.

TCG 01-E can be configured to broadcast either status or serial time strings over the serial port. Most users of the time tag option will want to suppress all broadcast outputs to simplify the task of time tag data collection. However, if output strings *are* programmed, then TCG 01-E will still output time tag information when requested, timing the responses to avoid interference with the other traffic on the port.

### 6.3.2 TCG 01-E Command / Response Message structure

Units equipped with the event recording option provide four command/response message pairs that specifically support time tag management and retrieval.

All command and response messages used by TCG 01-E have the same structure:-

Prefix: 2 bytes (ASCII "@" characters)
Type: 2 bytes (ASCII alphabetic characters - case matters!)
Data: n* bytes (May be ASCII or binary data)

* The length of the "Data" field is determined by "Type". Command and Response commands, while sharing the same "Type" field, have different data content and length.

Checksum: 1 byte, binary XOR over all bytes in the "Type" and "Data" fields
Suffix: 2 bytes (ASCII <CR><LF>)

### 6.3.3 TCG 01-E Commands related to Event Time Tagging

These commands and their responses contain ASCII characters only. A general serial communications program can be used to explore the event recording command/retrieval functions manually. Note that the TCG 01-E native serial protocol does *not* include station addressing. In a network-connected system, the address of the Serial to Ethernet interface device can serve as the station address. Tekron International can supply such devices if required.

## Ps command: Get Status

The Ps command invokes a **Ps** response that contains the clock status – which includes the number of tags currently in the time-tag event buffer.

Command (7 bytes [0-6]): Transmitted format: @@**Ps#**<**CR**><**LF**>
Response: (33 bytes [0-32]): Received format: @@**Ps**{26 data bytes}{cs}<**CR**><**LF>**

| Byte # | Description (Data bytes only, bytes 4-29 in received message) |
|---|---|
| 4 | Antenna feed fault –[A] only if antenna line is short or open circuit * |
| 5 | No GPS Solutions – [T] only if no satellites are available for time calculations * |
| 6 | S/N level low – [S] only if S/N level is abnormally low for more than an hour * |
| 7 | Oscillator Error High – [X] only if Oscillator Control value is extreme * |
| 8 | Oscillator DAC out of range – [H] or [L] only if Oscillator Control tending towards extreme * |
| 9 | GPS Fail – [B] only if internal GPS receiver sub-system not operating properly * |
| 10 | Not implemented – ASCII [space] always |
| 11 | Tracking Satellites – [0-9] = # of satellites in time solution (see note 1 below) |
| 12 | Receiver Operating Mode – [0-5] see note 2 below |
| 13 – 15 | Time Tag Queue Indicator – [000-512, 999] # of tags in queue (999=overflow) |
| 16 – 18 | Outage Indicator – [000-999] Hours since receiver was last locked to GPS signals. Becomes non-zero one hour after loss of lock. Resets to zero when lock is re-acquired |
| 19 – 20 | Outage Indicator – [00-59] Minutes since receiver was last locked to GPS signals. Becomes non-zero one minute after loss of lock. Resets to zero when lock is re-acquired. |
| 21 | Oscillator Correction. Most significant 4 bits of 16-bit D/A converter used for oscillator control. Range is ASCII [@] to [O] (hex 40 to hex 4F) |
| 22 | Oscillator Correction. More significant 6 bits of 16-bit D/A converter used for oscillator control. Range is ASCII [@] to [del] (hex 40 to hex 7F) |
| 23 | Oscillator Correction. Least significant 6 bits of 16-bit D/A converter used for oscillator control. Range is ASCII [@] to [del] (hex 40 to hex 7F) |
| 23 | Frequency Error. Local Oscillator frequency offset as compared with GPS received signal. In ASCII, ±00000-99999 referenced to 1E-12 |

## Notes concerning the Ps command:

* An ASCII [space] is transmitted if there is no alarm condition present

1. TCG 01-E can track up to 12 satellites simultaneously. The message limitation of 9 is to retain compatibility with older equipment using this message format.

2. mode=1: satellite search, 2D/3D fix,
mode=2: GPS Automatic site survey,
mode=3: GPS position hold (most accurate time)

## Pc command: Clear Time-Tag Buffer

The Pc command invokes a **Pc** response that returns the number of time-tags that were in TCG 01-E's event buffer when the **Pc** command was received. The event buffer is then cleared.

Command (7 bytes [0-6]): Transmitted format: @@**Pc3**<**CR**><**LF**>
Response (10 bytes[0-9]): Received format: @@**Pc**{3 data bytes}{cs}<**CR**><**LF**>

| Byte # | Description (Data bytes only, bytes 4-6 in received message) |
|---|---|
| 4 – 6 | ASCII [000-512, 999] Number of time-tag entries in TCG 01-E queue before reset. |

## Pt command: Get next Time-Tag

The Pt command invokes a **Pt** response that contains a single time-tag record – the oldest one in the data queue. Successive "Pt" commands will result in successive time tag data being retrieved. If the queue is empty, the **Pt** response is a null time tag. (ASCII [0] characters in all fields except delimiters).

Command (7 bytes [0-6]): Transmitted format: @@**Pt$**<**CR**><**LF**>
Response (33 bytes [0-32]): Received format: @@**Pt**{26 data bytes}{cs}<**CR**><**LF**>

| **Byte #** | **Description (Data bytes only, bytes 4-29 in received message)** |
|---|---|
| 4 | Day of Year in ASCII, 001 to 366 |
| 7 | Delimiter, ASCII [:] (hex 3A) |
| 8 – 9 | Hour of Day in ASCII, 00-23 |
| 10 | Delimiter, ASCII [:] (hex 3A) |
| 11 –12 | Minute of Hour in ASCII, 00-59 |
| 13 | Delimiter, ASCII [:] (hex 3A) |
| 14 – 15 | Second of Minute in ASCII, 00-60 |
| 16 | Delimiter, ASCII [.] (hex 2E) |
| 17 – 23 | Fraction of Second in ASCII (100's of nanoseconds), 0000000-9999999 |
| 24 | Quality Indicator. Codes are:<br>ASCII [space] (hex 20) if receiver locked, sub-100 ns Output accuracy<br>ASCII [?] (hex 3F) if receiver unlocked for more than 1 minute<br>ASCII [*] (hex 2A) if receiver in alarm mode – antenna fail |
| 25– 27 | Outage Indicator – [000-999] Hours since receiver was last locked to GPS signals. Becomes non-zero one hour after loss of lock. Resets to zero when lock is re-acquired. |
| 28 | Delimiter, ASCII [#] (hex 23) |
| 29 | Number of Time-Tag Channel in ASCII, 1-2 |

## Pr command: Repeat last Tag Sent

The Pr command invokes a Pr response that contains a single time-tag record – the same data that was sent in response to the last Pt command.

Command (7 bytes [0-6]): Transmitted format: **@@Pr"**<**CR**><**LF**>
Response (33 bytes [0-32]): Received format: @@**Pr**{26 data bytes}{cs}<**CR**><**LF**>

Data format is identical to **Pt** data format above

## 6.4 Lightning Protection Option

A lightning Protection kit may be fitted into the antenna lead-in cable. The kit contains a protection device, two coaxial cable connectors, a connector crimp tool, and mounting hardware. Refer to A.6 on page 42 for specifications and installation information.

### 6.4.1 General

The first line of protection against the effects of lightning-induced surge events involves positioning the antenna in a "lightning-protected zone" as far as is possible. In practice, this means ensuring that there is at least one other earth-bonded structure located in the same rooftop area (e.g. another antenna, or a lightning rod) that reaches significantly higher than the top of the GPS antenna. The GPS Antenna should then be mounted so that it lies within a 45-degree angle from the top of the other earth-bonded structure. The GPS antenna mount itself should also be securely bonded directly to the building protection earth – and *not* connected via any of the other earthed structures.

However, this will *not* provide immunity from damage caused by a direct lightning strike, or voltages induced in the antenna lead-in cable due to side flashes or induction.

☛ **All Tekron antenna installations should follow the guidelines above – regardless of whether a separate lightning protection device is to be fitted to the antenna lead-in cable.**

In areas with a low incidence of electrical storms, careful attention to antenna positioning and earth connections may be all the protection deemed necessary. The antenna lightning protection kit LPK01 affords additional security through the use of an impulse suppressor installed in the antenna lead-in coax cable. In the event of a lightning-derived high voltage surge occurring on the coaxial cable, the impulse suppressor activates, short-circuiting the cable directly to the protection ground.

☛ **While the LP kit provides a high degree of protection, there is no guarantee of protection against ALL surge related events, including a direct lightning strike to the antenna. Careful antenna positioning is strongly advised!**

The performance of the antenna system under normal (non-surge) conditions is unaffected by the introduction of a correctly installed EMP Protector.

### 6.4.2 LPK01 Kit Contents

| Quantity | Description |
|---|---|
| 1 | Polyphasor DGXZ+06NFNF-A Impulse Suppressor |
| 2 | N-type Male Crimp Style Coaxial cable connector set to match antenna cable |
| 1 | Crimp Tool to match the above connectors (RG59) |
| 1 | Roll Self-amalgamating Insulation tape |

### 6.4.3 Installation

The impulse suppressor should be installed as per the instructions provided with the impulse suppressor.

For the lightning protector to be effective, it must be firmly mounted to a conductive metal surface that is itself bonded to the building protective earth. **Please ensure that a good electrical connection is made between the surge protector and the earthing system.**

All earthing connections should be as short as possible, should have no sharp bends or loops and should not be coiled to take up extra cable.

The preferred mounting position is on the inside of the building's exterior wall, adjacent to the antenna lead entry point.

☛ **The absolute minimum bend radius for the antenna cable supplied is 40 mm, but it is preferable to use a larger bending radius if possible. One way of achieving this is by positioning the protector so that the incoming antenna cable comes through the wall about 150 mm away from the protector's connector. This provides some space to ease the incoming cable into a gentle arc back on to the connector.**

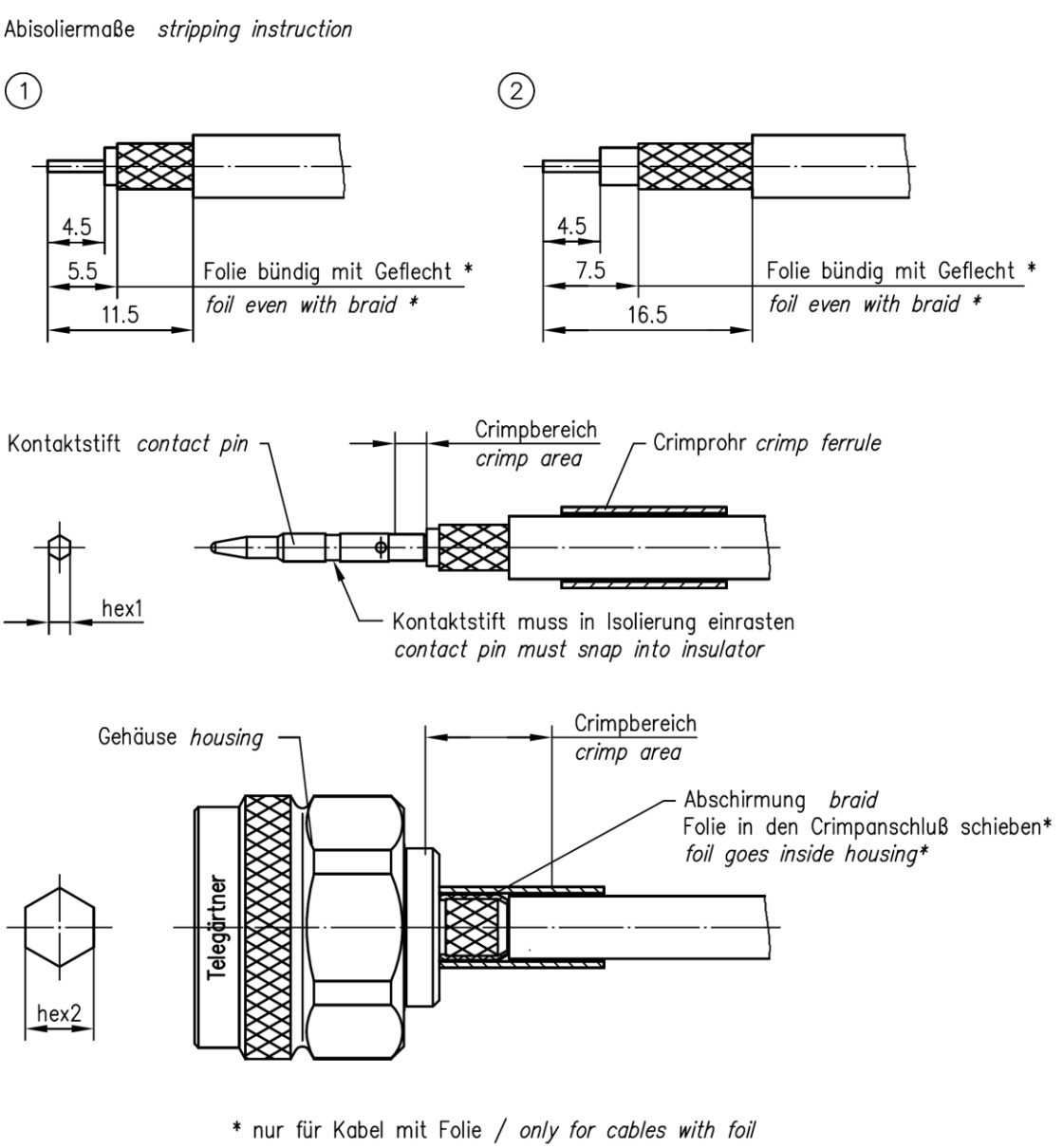
The antenna cable must be cleanly cut at the appropriate point and the resulting two ends terminated with the N-type connectors provided. The connectors are then attached to the protector assembly and tightened firmly by hand. Seal each of the connections by stretch-wrapping them with the self-amalgamating tape supplied in the kit. The seal provides protection against moisture ingress, and prevents the connections from loosening over time.

Care must be taken to mount the N-type connectors to the coax cable correctly according to Figure 21 (T00100B3300). As the GPS antenna operates at a frequency in excess of 1.5 GHz, it is ***essential*** that the cable be prepared ***exactly*** as per the drawing (**Use Option 2 measurements shown** – all measurements in millimeters). A crimp tool is included in the kit – use the 0.68" die for the centre pin and the 0.256" die for the external hex housing.

Montagecode B33XX assembly code

# Montageanweisung
# *Assembly Instruction*

Montagecode B33XX assembly code




| XX | Crimpeinsatz *crimp insert* | 6kt.1 x Länge *hex1 x length* | 6kt.2 x Länge *hex2 x length* | Abisoliermaße *stripping instruction* | |
|---|---|---|---|---|---|
| 05 | N01001A0005 | 1.69x2.5 | 5.41x8 | ① | |
| 06 | N01001A0007 | 1.69x2.5 | 6.48x8 | ② | |

| Index *index* | Änderung *modification* | Datum *date* | Name *name* |
|---|---|---|---|
| | | | |

| | Datum *date* | Name *name* |
|---|---|---|
| Gez. *drawn* | 29.09.00 | HM |
| Gepr., *app'd* | 11.10.00 | GJ |

**Serie N crimp**
***Series N crimp***

| Unterl.–Art | TG–Nr. |
|---|---|
| R | T00100B3300 |

Original *original* A4 | Blatt *sheet* 1/1

Maßstab *scale* 2:1

Ersatz für/*replacement for*

Telegärtner



**Figure 21 – N-type connector cable preparation and termination**

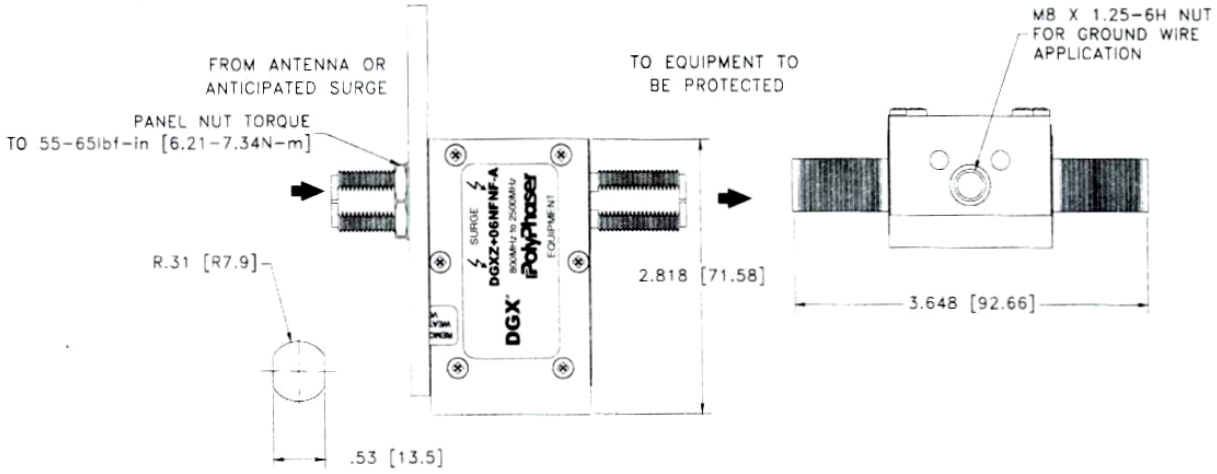
8100-1870
Rev. G
11/20/03

# IMPULSE SUPPRESSOR INSTALLATION

PLEASE READ **DANGER** SHEET BEFORE INSTALLING

## DGXZ+06NFNF-A

The DGXZ+06NFNF-A is used as a transmit and/or receive unit with dc voltage up to 6Vdc to power up a receive only Preamp generally located near the top of the tower at the antenna. Maximum average RF power use is 0.25 watts. Connect this unit in the direction it is labeled. The dc circuit has spike protection to suppress spikes over +6.5V to the dc Power Supply. This DGXZ+06NFNF-A is capable of 20,000 Amp maximum surges and has a frequency range of 800MHz to 2.5GHz.




**IT IS VERY IMPORTANT THIS UNIT BE GROUNDED TO A LOW IMPEDANCE (LOW R AND LOW L) GROUND SYSTEM IN ORDER TO WORK PROPERLY.** When attaching grounding stud (M8), use maximum of 88.5 lbf-in. [10 N-m] of torque. "N" mating connector torque is 15-20 lbf-in. [1.70-2.26 N-m]. We strongly recommend this ground be interconnected to the tower ground and power ground to form one system. To minimize the "in-air" interconnect inductance to the ground system since skin effect is present, use as straight and as large a surface area strap as possible. Keep bends to 8.0" [203.2mm] radius or larger.

The transmission line is only one means of having damaging impulse energy enter your equipment. We strongly recommend power line and telephone line protectors be used on the equipment.

**LIMITED TEN YEAR WARRANTY**

ENG-F-016 Rev. E 05/03

PolyPhaser Corporation warrants this product to meet or exceed the published specifications of the time of manufacturing and to be free of manufacturing defects for a ten year period after proven date of purchase. PolyPhaser Corporation makes no claims, nor extends any warranty to include an "IMPLIED WARRANTY OF MERCHANTABILITY OR IMPLIED WARRANTY OF FITNESS FOR ANY PARTICULAR PURPOSE". PolyPhaser Corporation assumes no responsibility for personal injury, property damage, and any other losses. This warranty is limited to the repair, replacement or refund of purchased price of this product only and it will be PolyPhaser Corporation's decision as to whether this unit is defective and as to which of the above mentioned actions will be taken. PolyPhaser Corporation extends no obligation to update or modify any of its existing products as newly developed products are marketed.

Products may be covered under the following U.S. Patents: 5,986,869 6,061,223 6,115,227 6,236,551 6,243,247 other U.S. and Foreign Patents Pending

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### 6.4.4 Disclaimer

TEKRON INTERNATIONAL disclaims any liability or responsibility for the results of improper or unsafe installation practice including, but not limited to, any excessive performance degradation of the antenna system resulting from incorrect field installation of coaxial cable connectors.

# 7 FIRMWARE UPGRADE INSTRUCTIONS

## 7.1 General

TCG E series clocks can be upgraded in the field. The latest firmware is available to be downloaded from the customer resources section on the Tekron International website: www.tekroninternational.com.

The TCG E series of clocks operate with two firmware sub-systems. TCG E Series clocks running Clock firmware 1.xx require a dual upgrade method. The main clock must be upgraded via the serial port, while the Ethernet sub-system (known as the RCM – Remote Communications Module) is updated over Ethernet. The dual upgrade method applies to *all* TCG 01-E units currently running V1.xx firmware.

The V1.xx up-date process requires a PC running Windows NT or later, equipped with both a serial port and Ethernet communications. For best reliability, a “true” serial port should be used as USB serial ports can suffer from compatibility problems. In addition to the straight-through wired Ethernet cable supplied with each clock, a serial cable wired straight through (a minimum of pins 2, 3 and 5 for 9-pin PC serial port) is also required.

TCG E series clocks running V2.xx will operate with a single Ethernet procedure which will upgrade both of the internal modules seamlessly.

The latest instructions on upgrade procedure are included with the upgrade firmware on our web-site. Be sure to check the latest instructions prior to attempting field update.

# Appendix

## A SPECIFICATIONS

### A.1 GPS Antenna

#### Physical Specifications

| Property | | Metric |
|---|---|---|
| Dimensions | Diameter | 90 mm |
| | Height | 98 mm (without connector or plinth) |
| Weight | | 200 g |

#### Environmental Specifications

| Performance Property | ° C |
|---|---|
| Operating Temperature Range | -40~+85 |

#### Electrical Specifications

| Performance Property | Metric |
|---|---|
| Polarisation | Right hand circular polarisation |
| Bandwidth | 1575.42 MHz ± 1.023 MHz |
| Power Supply | 5 V DC ± 0.5 V |
| Current Drain | 20 mA Typical |
| | 27 mA Maximum |
| Total Gain | 38 dBi Typical |
| | 30 dBi At 90º elevation |
| Attenuation | 60 dB at 1525 MHz, 1625 MHz (± 50 MHz on centre frequency) |
| Output VWSR | 1.5 Typical |
| Output VWSR | 2.5 Maximum |
| Lightning Protection | 80 V for IEC1000-4-5 standard |

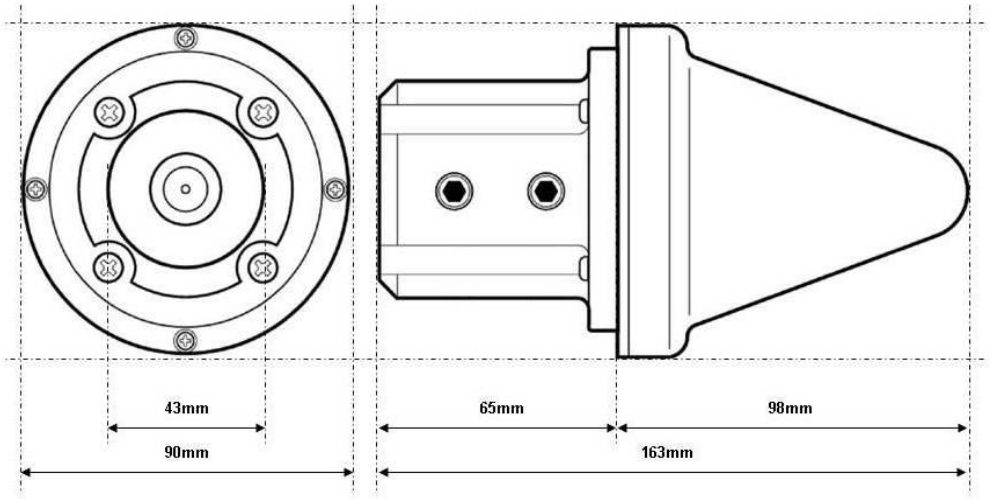


**Figure 22 – Antenna pipe-mounting plinth**

## A.2 Adjustable Antenna Mounting Bracket

The steel adjustable antenna mounting bracket (Figure 23) will assist in the dissipation of energy should the antenna be struck by lightning. The mounting bracket should be securely bonded directly to the building protection earth – and not connected via any of the other earthed structures.

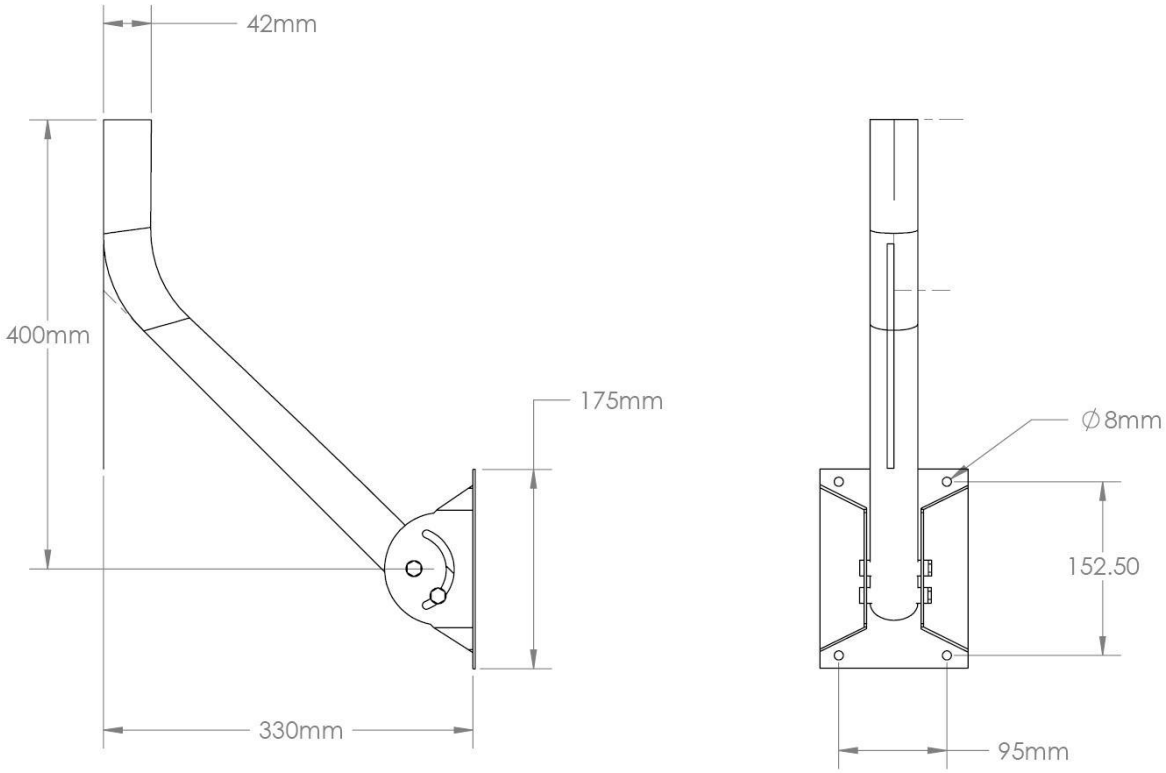


**Figure 23 – Antenna mounting bracket**

## A.3 Antenna Cable

The TCG 01-E can be ordered with 15, 30, or 60 meters of high performance LMR240 cable factory-fitted with a TNC-type male connector at one end, and a SMA male connector at the other. The TNC-type connector mates with the connector on the antenna and provides a robust and weather-resistant connection. The smaller SMA connector mates with the connector on the TCG 01-E and is only fractionally larger in diameter than the cable itself; this facilitates installation in conduit and through small apertures.

Custom lengths can be ordered upon request (additional charges may occur).

Where antenna cable distances exceed 60 meters, LMR400 can be used, or an in-line amplifier can be installed. Refer to Tekron for further advice.

### Environmental Specifications

| **Performance Property** | **° C** |
|---|---|
| Operating Temperature Range | -40~+85 |

### Electrical Specifications

| **Performance Property** | **Metric** |
|---|---|
| Attenuation (1575.42MHz) | 38.9 dB/100m |
| Velocity of Propagation | 84 % |
| Dielectric Constant | 1.42 NA |
| Time Delay | 3.97 ns/m |
| Impedance | 50 Ω |
| Capacitance | 79.4 pF/m |
| Inductance | 0.20 µH/m |
| Shielding Effectiveness | >90 dB |
| DC Resistance Inner Conductor | 14.1 Ω/km |
| DC Resistance Outer Conductor | 12.8 Ω/km |
| Voltage Withstand | 1500 V DC |
| Jacket Spark | 5000 V RMS |
| Peak Power | 5.6 kW |

## A.4 TCG 01-E Unit

### Physical Specifications

| Property | | Metric |
|---|---|---|
| Dimensions | Width | 160 mm |
| | Depth | 155 mm |
| | Height | 40 mm |
| Weight | | 800 g |

### GPS Receiver

L1 (1575.42 MHz) Frequency, C/A Code, 12-Channel, parallel-tracking receiver.

| Performance Property | | Metric |
|---|---|---|
| Position Accuracy | Horizontal | <9 m (90%) |
| | Altitude | <18 m (90%) |
| Timing Accuracy | | <15 ns to UTC |
| Acquisition | Reacquisition | <2 s (90%) |
| | Hot Start | <18 s (90%) |
| | Warm Start | <45 s (90%) |
| | Cold Start | <50 s (90%) |
| Sensitivity | Acquisition | -136 dBm |
| | Tracking | -140 dBm |
| Voltage | | 3.0~5.5 V DC |

### Oscillator Specifications

| Oscillator Type | | Stability |
|---|---|---|
| Conventional Oscillator | XO | 5 parts in $10^8$ |

(Stability: Freewheeling stability, following tuning by 4 or more GPS satellites for at least 30 minutes.)

### Input and Output Specifications

| Type | Electrical | Physical | Accuracy at the port |
|---|---|---|---|
| AM IRIG-B (modulated) | 9 V | BNC | ≤1 µs of UTC |
| TTL | 5 V | 2 pin Phoenix or BNC | ≤100 ns of UTC |
| RS422/485 | | 2 pin Phoenix or BNC | ≤100 ns of UTC |
| RS232 | | DB9 | ≤1.5 µs of UTC |
| HV Switching (MOSFET) | | 2 pin Phoenix | ≤100 ns of UTC |
| Fiber | N/A | ST | ≤100 ns of UTC |
| NTP/ SNTP | | RJ45 | ≤200 ns of UTC |

### Environmental Specifications

| Performance Property | ° C |
|---|---|
| Operating Temperature Range | -10~+65 |

### Electrical Specifications

| Performance Property | | Metric |
|---|---|---|
| Power Supply | Low Voltage | 12-36 V DC |
| | Medium Voltage | 20-72 V DC |
| | High Voltage | 90-300 V DC |
| Power drain | | 6 W max |

## Isolation & Protection

All inputs and outputs feature 2.5 kV isolation from each other. In addition, the logic level outputs (**P2** and **P3**) are each protected against damage from transverse voltage events via a three-stage network of varistor, auto-resetting fuse, and transient suppressor diode.

☛ **Fuse and varistor protection is removed when the switching MOSFET factory option is fitted. The user must provide an external power supply and suitable fusing to use the MOSFET output option (see Section 6.2 on page 28 for further information).**

Varistor protection and current limiting (nominally 5 mA) are employed for protection on the general-purpose input.

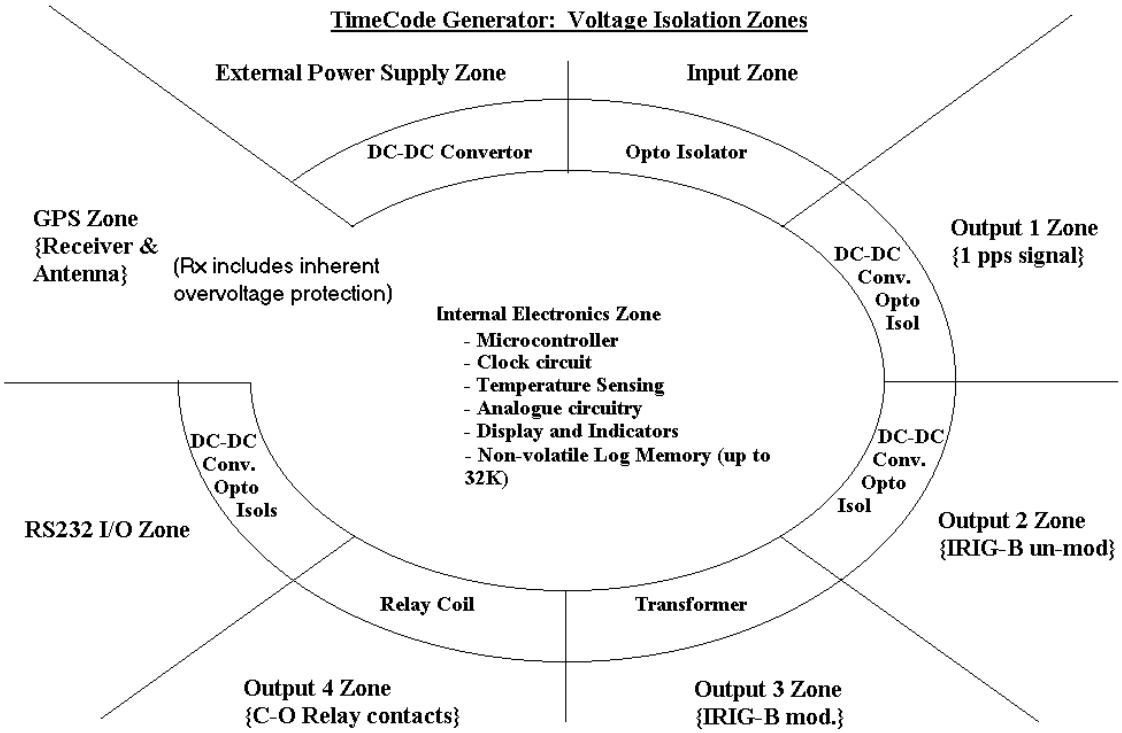


**Figure 24 – TCG 01-E isolation zones**

Transformer isolation via DC-DC converter is used for the main power supply and for power to each of the logic output-drive circuits. The serial communications interface is also separately powered via isolating DC-DC converter. High-speed, fixed delay opto-isolators are used in each of the time-sensitive signaling paths. The isolation does not degrade the time accuracy of the output signals, as the fixed delays of the isolating components (together with the delay associated with the antenna lead-in) are all internally compensated.

## A.5 In-line Amplifier

The Raven LA Series inline amplifier, filters and amplifies GPS signals to extend cable runs hundreds of feet.

### Physical:

| | |
|---|---|
| Length | 95 mm (approximately) |
| Diameter | 163 mm |
| Weight | 420 g |
| Connector type | N-Type Female (Both ends) |

### Electrical Specifications

| | |
|---|---|
| Power Consumption | 8 mA |
| Input Voltage | 3 – 8 V DC |
| Operating Current | < 10 mA typical |
| Noise Figure | < 4 dB typical |

### Environmental:

| | |
|---|---|
| Operating Temperature | -55 ~ 45°C |

## A.6 Lightning Protection Kit

The Polyphaser GX™ Series is like no other DC-passing protector. It has separate circuits for RF-path protection and DC pass protection. This “extra” - filtering allows us to provide the lowest let through voltage in the industry. The GX™ Series is the protector to which all others are compared, and is the standard protector for GPS and tower mounted equipment.

### Physical Specifications

| **Property** | | **Metric** |
|---|---|---|
| Dimensions | Width | 93 mm |
| | Depth | 72 mm |
| | Height | 36 mm |
| Weight | | 200 g |
| Connector type | | N-Type Female (Both ends) |

### Electrical Specifications

| | |
|---|---|
| Operating Voltage | 6.5 V DC |
| Maximum RF Power (@20°C) | 300 W |
| Frequency | 800- 2500 MHz |
| Insertion Loss | <0.1 dB (Typical) |
| Return Loss | >26 dB |
| Surge (Max) Multi strike | 20 kA @ 8x20 µs (IEC 61000-4-5) |
| Surge Throughput Energy: | <15 µJ @ 6 V DC to 610 µJ @ 60 V DC (4 kV/2 kA 8x20 µs waveform) |
| User current | ≤4 A |

### Environmental:

| | |
|---|---|
| Relative Humidity | 0 to 95% |
| Vibration | 1G @ 5 Hz to 500 Hz |
| DC Resistance | <0.1 Ω Typical |
| Temperature | -50°C to +85°C |

Fully weatherized housing meets IEC 60529 IP67
Meets Bellcore #TA-NWT-00487 (Procedure 4.11) wind driven 120 MPH rain intrusion

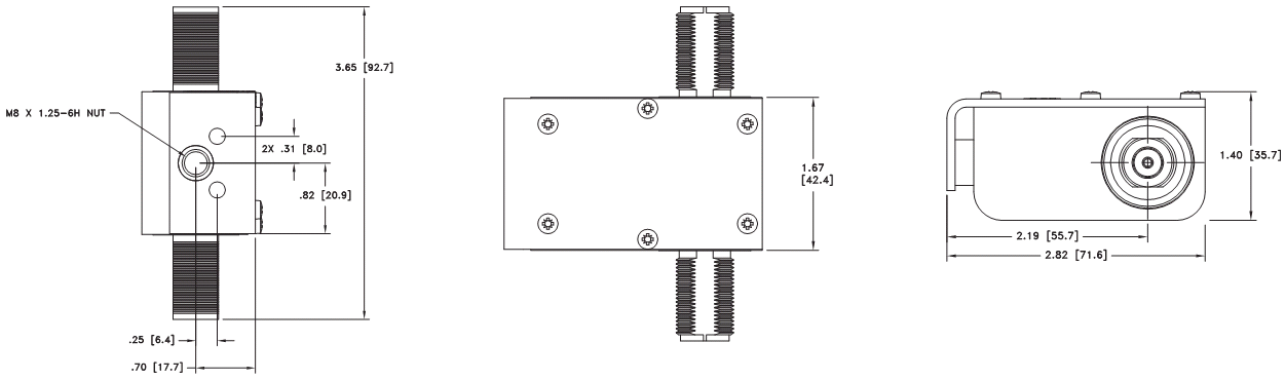


**Figure 25 – Lightning arrester**

# B SERIAL OUTPUT STRINGS

## B.1 NGTS Time Code O/P on P4

| | |
|---|---|
| About | Normally used in conjunction with 10 ms pulse on P4 pin 1 that finishes precisely on the minute. See the hint in Section 6.4.1. |
| Timing | Transmitted once per minute. Sent during the last second before the minute rollover to which the data in the string refers. |
| Comms | 9600bd, 8-bit ASCII, no parity |
| Definition | TYYMMWhhmmx<CR><LF> |

| Placeholder | Content |
|---|---|
| T | "T" |
| yy | Last two digits of the year: e.g. “12” = the year 2012 |
| mm | Month: “00” = January … “12” = December |
| w | Day of week: “01”=Monday … “07”=Sunday |
| hh | Two digit hour |
| mm | Two digit minute |
| x | Time mode: ”0” = Local time, “1” = UTC time |
| <CR> | Carriage Return: HEX 0D |
| <LF> | Line Feed: HEX 0A |

| Example | Interpretation |
|---|---|
| T020422112340<CR><LF> | Monday 22 April 2002 – 12:34 local time |

## B.2 IRIG J-17 Time Code O/P on P4

| | |
|---|---|
| About | This code is compatible with IRIG Standard 212-00. |
| Timing | Transmitted once every second. The leading edge of the “start” bit of the first character <SOH> is exactly on the second that the message describes. |
| Comms | 9600bd, 7-bit ASCII, odd parity |
| Definition | <SOH>ddd:hh:mm:ss<CR><LF> |

| Placeholder | Content |
|---|---|
| <SOH> | HEX 01 |
| ddd | Day of year: range “001”—“366” |
| : | HEX 3A |
| hh | hour: “00”—”23” |
| mm | minute: “00”—“2 |
| ss | Seconds: “00”—“59” |
| <CR> | HEX 0D |
| <LF> | HEX 0A |

| Example | Interpretation |
|---|---|
| <SOH>112:12:34:36<CR><LF> | day 112, time 12:34:36 |

## B.3 String-A Time Code O/P on P4

About — This code is very similar in data content to the IRIG J-17 code, but adds a two-character field containing the year, and uses 8-bit ASCII, no parity data format.

Timing — Transmitted once every second. The leading edge of the “start” bit of the first character <SOH> is exactly on the second that the message describes.

Comms — 9600bd, 8-bit ASCII, no parity

Definition — <SOH>ddd:hh:mm:ss:yy<CR><LF>

| Placeholder | Content |
|---|---|
| <SOH> | HEX 01 |
| ddd | Day of Year: range “001”—“366” |
| : | HEX 3A |
| hh | hour: “00”—”23” |
| mm | minute: “00”—“59” |
| ss | seconds: “00”—“59” |
| yy | year: “00”—“99” representing the last two digits of the year |
| <CR> | HEX 0D |
| <LF> | HEX 0A |

| **Example** | **Interpretation** |
|---|---|
| <SOH>112:12:34:36<CR><LF> | day 112, time 12:34:36 |

## B.4 String-B Time Code O/P on P4

About — This code substitutes a “Quality” indicator byte for the year field, but otherwise is identical in form, function and timing to String-A.

Timing — Transmitted once every second. The leading edge of the “start” bit of the first character <SOH> is exactly on the second that the message describes.

Comms — 9600bd, 8-bit ASCII, no parity

Definition — <SOH>DDD:hh:mm:ssQ<CR><LF>

Refer to String-A table (above) for the definitions of the common digits:

| “Quality” Character (Q) | | Meaning |
|---|---|---|
| HEX | ASCII | |
| 20 | <Space> | Clock in sync, timing accuracy is better than 60 ns |
| 2E | . (full stop) | Clock is accurate to 1 µs |
| 2A | * | Clock is accurate to 10 µs |
| 23 | # | Clock is accurate to 100 µs |
| 3F | ? | Clock accuracy may be worse than 100 µs |

| **Example** | **Interpretation** |
|---|---|
| <SOH>112:12:34:36?<CR><LF> | day 112, time: 12:34:36, >100 µs sync error |

## B.5 String-C Time Code O/P on P4

| | |
|---|---|
| About | This code is effectively a combination of String-A and String B. It provides both year information and a sync indicator field. |
| Timing | Transmitted once every second. The leading edge of the “start” bit of the first character, <CR>, is exactly on the second to which the message data refers. |
| Comms | 9600bd, 8-bit ASCII, no parity |
| Definition | <CR><LF>Q★yy★ddd★hh★mm★ss.000★★★ |

| Placeholder | Content |
|---|---|
| <CR><LF> | HEX 0D,0A |
| Q | Quality indicator: “ “ = in-sync, “?” = out-of-sync |
| ★ | HEX 20 (space) |
| yy | Year: “00”—“99” representing the last two digits of the year |
| ★ | HEX 20 (space) |
| ddd | Day of year: range “001”—“366” |
| ★ | HEX 20 (space) |
| hh | hour: “00”—”23” |
| mm | minute: “00”—“59” |
| ss | seconds: “00”—“59” |
| .000 | ASCII “.000” |
| ★ | HEX 20 (space) |
| ★ | HEX 20 (space) |
| ★ | HEX 20 (space) |

| Example | Interpretation |
|---|---|
| <CR><LF>? 02 112 12:34:36.000 | day 112 of year (20)02, time: 12:34:36, out-of-sync |

## B.6 String-D Time Code O/P on P4

String-D is IDENTICAL in content to String-B, but the second mark is at the leading edge of the start-bit of the (<CR>).

| Example | Interpretation |
|---|---|
| <SOH>112:12:34:36?<CR><LF> | day 112, time: 12:34:36, >100 µs sync error |

## B.7 String-E Time Code O/P on P4

| | |
|---|---|
| About | This provides time, year information, and a sync indicator field. |
| Timing | The string is transmitted once every second, with the leading edge of the "start" bit of the <CR> exactly on the second. |
| Comms | 9600bd, 8-bit ASCII, no parity |
| Definition | <SOH>yyyy:ddd:hh:mm:ssQ<CR><LF> |

| Placeholder | Content |
|---|---|
| <SOH> | HEX 01 |
| yyyy | 4-digit year |
| : | HEX 3A |
| ddd | Day of year: range "001"—"365" |
| hh | hour: "00"—"23" |
| mm | minute: "00"—"59" |
| ss | seconds: "00"—"59" |
| Q | Quality character, as defined in String-B (above) |

| Example | Interpretation |
|---|---|
| <SOH>2004:112:12:34:36?<CR><LF> | 2004, day 112, 12:34:36pm, >100us sync error |

## B.8 String-F Time Code O/P on P4

| | |
|---|---|
| About | This string complies with the protocol required to drive Vorne type Time Displays |
| Timing | The string is transmitted once every second, with the leading edge of the "start" bit of the last <BEL> exactly on the second. |
| Comms | 9600bd, 8-bit ASCII, no parity |
| Definition | <CR><LF>1100<CR><LF>44hhmmss<CR><LF>54ddd<CR><LF><br><CR><LF>45HHMMss<CR><LF>55DDD<CR><LF><BEL> |

| Placeholder | Content |
|---|---|
| <CR><LF> | HEX 0D, 0A |
| 1100 | ASCII "1100" |
| 44 | ASCII "44" (means local time follows) |
| 54 | ASCII "54" (means local day of year follows) |
| 45 | ASCII "45" (means UTC time follows) |
| 55 | ASCII "55" (means UTC day of year follows) |
| ddd | Local day of year: "001"—"365" |
| hh | Local hour of day: "00"—"23" |
| mm | Local minute of day: "00"—"60" |
| ss | seconds: "00"—"59" |
| DDD | UTC Day of year: "001"—"365" |
| HH | UTC hour: "00"—"23" |
| MM | UTC minute: "00"—"59" |
| <BEL> | HEX 07 |

## B.9 String-G Time Code O/P on P4

| | |
|---|---|
| About | This general time string is used predominantly in Europe |
| Timing | The string is transmitted once every second, with the leading edge of the “start” bit of the last <ETX> exactly on the second. |
| Comms | 9600bd, 8-bit ASCII, no parity |
| Definition | <STX>Swhhmmssddmmyy<LF><CR> <ETX> |

| Placeholder | Content |
|---|---|
| <STX> | HEX 02 |
| s | Clock Status (see below) |
| w | Day of Week (see below) |
| hh | hour of day: “00”—”23” |
| mm | minute of day: “00”—“60” |
| ss | seconds: “00”—“59” |
| dd | day of month: “01”—“31” |
| mm | month of year: “01”—”12” |
| yy | year: “10”—“99” |
| <LF> | HEX 0A |
| <CR> | HEX 0D |
| <ETX> | HEX 03 |

The s “Clock Status” is an ASCII character in the range 0-9, A-F representing a single hex digit (nibl)

| bits 3 2 1 0 | |
|---|---|
| x x x 0 | No announcement for time change |
| x x x 1 | Announcement for time change (DST-LST-DST) – active for an hour before |
| x x 0 x | Local Standard Time (LST) |
| x x 1 x | Daylight Saving Time (DST) |
| 0 0 x x | Time/date invalid – clock is out of sync |
| 0 1 x x | Hold-over mode – running on local Oscillator |
| 1 0 x x | GPS / IRIGB controlled mode |
| 1 1 x x | GPS / IRIGB controlled mode (high accuracy) |

The w “Day of Week” is an ASCII character in the range 1-7, 9, A-F representing a single hex digit (nibl)

| bits 3 2 1 0 | |
|---|---|
| 1 x x x | UTC time |
| x 0 0 1 | Monday |
| x 0 1 0 | Tuesday |
| x 0 1 1 | Wednesday |
| x 1 0 0 | Thursday |
| x 1 0 1 | Friday |
| x 1 1 0 | Saturday |
| x 1 1 1 | Sunday |

| **Example** | **Interpretation** |
|---|---|
| <STX>E3123456170410<LF><CR><ETX> | High Accuracy Mode, DST, Wednesday, 12:34:56, 17 April 2010 |

## B.10 NMEA ZDA Time Code O/P on P4

| | |
|---|---|
| About | This string is in accordance with the NMEA-0183 standard in content, but is transmitted at 9600bd.. |
| Timing | Transmission is once every second. The leading edge of the “start” bit of the “$” is exactly on the second. |
| Comms | 9600bd, 8-bit ASCII, no parity |
| Definition | $GPZDA,hhmmss.00,dd,mm,yyyy,s,xx,yy*CC<CR><LF> |

| Placeholder | Content |
|---|---|
| $GPZDA | ASCII “$GPZDA” |
| , | ASCII “,” (comma) |
| hh | UTC hour of day: “00”—”23” |
| mm | UTC minute of day: “00”—“60” |
| ss | UTC Seconds: “00”—“59” |
| .00 | ASCII ”.00” |
| dd | UTC day of month: “01”—“31” depending on which month |
| mm | UTC month: “01”—“12”, “01” = January |
| yyyy | UTC year, 4 digit. |
| s | Local time zone offset sign (+ve means local time leads UTC) |
| xx | Local time zone offset from UTC in hours |
| yy | Local time zone offset from UTC in minutes |
| * | ASCII “*” |
| CC | 2-digit hex representation of the result of XORing the 8 data bits of each character between, but not including the "$" and "*". (00-FF) |
| <CR><LF> | HEX 0D, 0A |

| **Example** | **Interpretation** |
|---|---|
| $GPZDA,123456.0023042010+1200* | UTC time is 12:34:56, 23 April 2010, the local time offset is +12:00 |

## B.11 NMEA RMC Time Code O/P on P4

| | |
|---|---|
| About | This string is compatible with and defined by the NMEA-0183 standard. |
| Timing | Transmission is once every second. The leading edge of the “start” bit of the “$” is exactly on the second. |
| Comms | 9600bd, 8-bit ASCII, no parity |
| Definition | $GPRMC,hhmmss.00,a,tt,tt.tttt,n,ggg,gg.gggg,w,0.0,0.0,DDMMYY,0.0,E*CC<CR><LF> |

| Placeholder | Content |
|---|---|
| $GPZDA | ASCII “$GPRMC” |
| , | ASCII “,” (comma) |
| hhmmss | UTC hour of day, minute of day, seconds |
| . | ASCII “.” (full stop) |
| 0 | ASCII “0” |
| a | Status: “A” = valid, “V” = invalid |
| tt,tt.tttt | Latitude (degrees, minutes): “00,00.0000”—“89,59.9999” |
| N | Latitude (north/south): “N” = north, “S” = south |
| ggg,gg,gggg | Longitude (degrees, minutes): “000,00.0000”—“359,59.9999” |
| W | Longitude (east/west): “E” = east, “W” = west |
| Ddmmyy | UTC day of month, month, 2-digit year: |
| E* | ASCII “E*” |
| CC | 2-digit hex representation of the result of XORing the 8 data bits of each character between, but not including the "$" and "*". |
| <CR><LF> | HEX 0D, 0A |

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