Model GPS-1
Synchronizer Module Users Manual

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FCC COMPLIANCE

This AM transmitter complies with Part 90 of the FCC rules.

FCC ID: O2Q-DRTXM3
Formal Model Number: DRTXM3
Frequency Range: 0.530 – 1.700 MHz
Emission Designator: A3E (6K00A3E)
Power: 10 Watts

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1. Quick Start Guide

1.1. Assemble Components

With the power to the BlackMax rack turned off, assemble the components:

(1) Install the DRTXM3 Transmitter in the rack
(2) Install the GPS-1 Synchronizer in the rack
(3) Connect the circular cable from the rear of the DRTXM3 to the "Output to Transmitter" connector on the GPS-1
(4) Place the antenna outdoors with clear access to the sky
(5) Connect the antenna cable to the "GPS Antenna" input
(6) Connect the computer's serial COM port to the RS-232C connector on the GPS-1

ALWAYS SWITCH THE POWER TO THE GPS-1 OFF BEFORE CONNECTING OR DISCONNECTING THE ANTENNA. THIS IS NECESSARY BECAUSE THE ANTENNA CONTAINS ACTIVE ELECTRONIC CIRCUITRY POWERED FROM THE GPS TIMING RECEIVER. CONNECTING OR DISCONNECTING THE ANTENNA OR ANTENNA CABLE WHEN THE UNIT IS POWERED CAN RESULT IN FAILURE OF THE ANTENNA MODULE.

1.2. DC Power Connection

For some special applications such as testing, DC power can be fed to the back plane of the BlackMax rack through a jumper cable using a RED (+) and BLACK (-) pigtail jumper. Voltages are as follows:

- Nominal: 12 Volts DC
- Normal Range: 10.4 to 13.6 Volts DC.
- Maximum Range: 10 to 14 Volts DC.
- Current is typically less than 2.5 Amps DC.

1.3. Power Up

(1) With the DRTXM3 and the GPS-1 switched off, turn on the power to the BlackMax rack
(2) Turn on the power to the GPS-1. The GPS-1 front-panel indicators should be as follows:
    - GPS-1 "Power" ON
    - GPS-1 "GPS 10 MHz" ON
    - GPS-1 "GPS 1 PPS" ON
    - GPS-1 "Transmitter Lock" OFF
(3) Turn on the power to the DRTXM3. The front panel indicators should be as follows:
    - DRTXM3 "Power" ON
    - DRTXM3 "Transmit" ON
    - GPS-1 "Transmitter Lock" ON

The system is now in operating mode.

1.4. GPS Monitor Program

To check the status of the GPS synchronization, perform the following steps:

(1) Turn on the computer.
(2) Run the monitor program by clicking "Start," "Programs," "Trimble Thunderbolt," "Monitor."
(3) At the prompt select either COM1 or COM2 depending on which port the serial cable was connected to.
(4) At system power up the key indicators are:
    - COM2: 9600, 8-N-1
    - "Tx" and "Rx" are both flashing GREEN
    - All Critical Alarms are GREEN
    - All Minor Alarms are GREEN except the following five: "Satellite Tracking," "Oscillator Disciplining," "Self-Survey Activity, "Stored Position," and "Almanac" are YELLOW
(5) After about 10 minutes the key indicators are:
    - "Time" is "Not Set" which is nominal current time, but not GPS time
    - "Date" is current date
    - All Minor Alarms are GREEN except the following four: "Oscillator Disciplining," "Self-Survey Activity," "Stored Position," and "Almanac" are YELLOW
    - "GPS Status" is 1 or more satellites being tracked
    - "Signal Levels, "SV", and "AMU" indicate a few satellites as GREEN with 5.0 to 20 AMU.
(6) After about 60 minutes the key indicators are:
    - "Latitude" and "Longitude" are current values
    - "Self Survey Progress" is 100%
    - "Timing Outputs PPS" is less than 50.00 ns
    - "Timing Outputs 10 MHz" is less that 1.00 ppb
    - "Rcvr Mode" is Overdet Clock
    - "GPS Status" is Doing Fixes
    - All Minor Alarms are GREEN except the following one: "Stored Position" is YELLOW
    - "Signal Levels, "SV", and "AMU" indicate several satellites as GREEN with 5.0 to 20 AMU.

Note that the above sequence is typical and that there may be some variations based on such variables as the number of satellites visible and their relative signal strengths.

2. GPS-1 Synchronizer Module Overview

2.1. Description

The GPS-1 is the newest member of the BlackMax™ series of modular electronics. Employing GPS (Global Positioning System) satellite technology, the GPS-1 utilizes highly-accurate GPS signals to provide a very precise transmitter frequency. This allows multiple highway advisory radio (HAR) stations, with overlapping signals, to synchronously broadcast the same audio message with superior sound quality. The combined coverage area is limited only by the number of HAR's in the network, and listeners moving through the network will hear the same message as if it were being generated from a single transmitter.

A synchronous broadcast from multiple HAR's requires two key ingredients: (1) transmitters that operate at precisely the same operating frequency, and (2) a single audio source.

(1) The GPS-1 module provides the ability to precisely tune the operating frequency of the transmitter. The radio frequency (RF) signals are synchronized by phase locking them to the precise timing signals derived from GPS satellites.

(2) The single audio source is typically accomplished by establishing one HAR as the master and the remaining HAR's in the network as slaves. This is commonly done by using Radio Transmission (RT) circuits (special telephone lines provided by the local telephone service provider).

2.2. Features

- BlackMax™ modular design for easy installation and maintenance
- Four front-panel status LEDs indicating
  - Power
  - GPS 10 MHz
  - GPS 1 PPS (Pulse per Second)
  - HAR Transmitter Lock
- Front-panel adjustment for fine tuning the RF phase angle in degrees
- Compatible with DR2000 Central Control HAR Software (sold separately)

Figure 2-1 GPS-1 Synchronizer Module

Figure 2-2 BlackMax Rack with GPS-1 and DRTXM3 Transmitter Installed

3. GPS Transmitter System Functional Description

3.1. GPS Transmitter System Block Diagram

A block diagram of the GPS synchronized transmitter system is shown in Figure 3-1 below. A functional description of the various subsystems is given in the following subsections.

3.2. GPS Timing Receiver and Antenna Subsystem

At the upper left of the block diagram is the GPS timing receiver and antenna subsystem. These units differ from the usual hand-held GPS receiver used for position location in that they have a precision ovenized oscillator that is phase locked to GPS standard time.

3.2.1. GPS Antenna

The GPS timing receiver picks up the transmissions from the GPS satellites using the GPS antenna connected to the receiver through a 75 Ω coaxial cable. For convenience in connecting the system, a front-panel connector is provided

3.2.2. GPS Timing Receiver

The GPS timing receiver is mounted inside the GPS-1 Synchronizer module and it draws its power from the BlackMax Rack.

The outputs from the GPS timing receiver are a 10 MHz sine wave and a 1 PPS (pulse per second) digital pulse both locked to GPS standard time within 50 nano seconds (0.000 000 050 seconds) or less. The green front-panel LED indicators for "GPS 10 MHz" and "GPS 1 PPS" indicate the presence of these signals.

Note, however, that these signals will be produced whenever the GPS timing receiver is operating, whether or not it is locked to absolute GPS time. Thus, the presence of these signals as indicated by the front-panel LEDs does not assure that the system is locked to GPS time. This can only be determined by monitoring the serial output of the GPS timing receiver, as described below in Section 3.2.3.

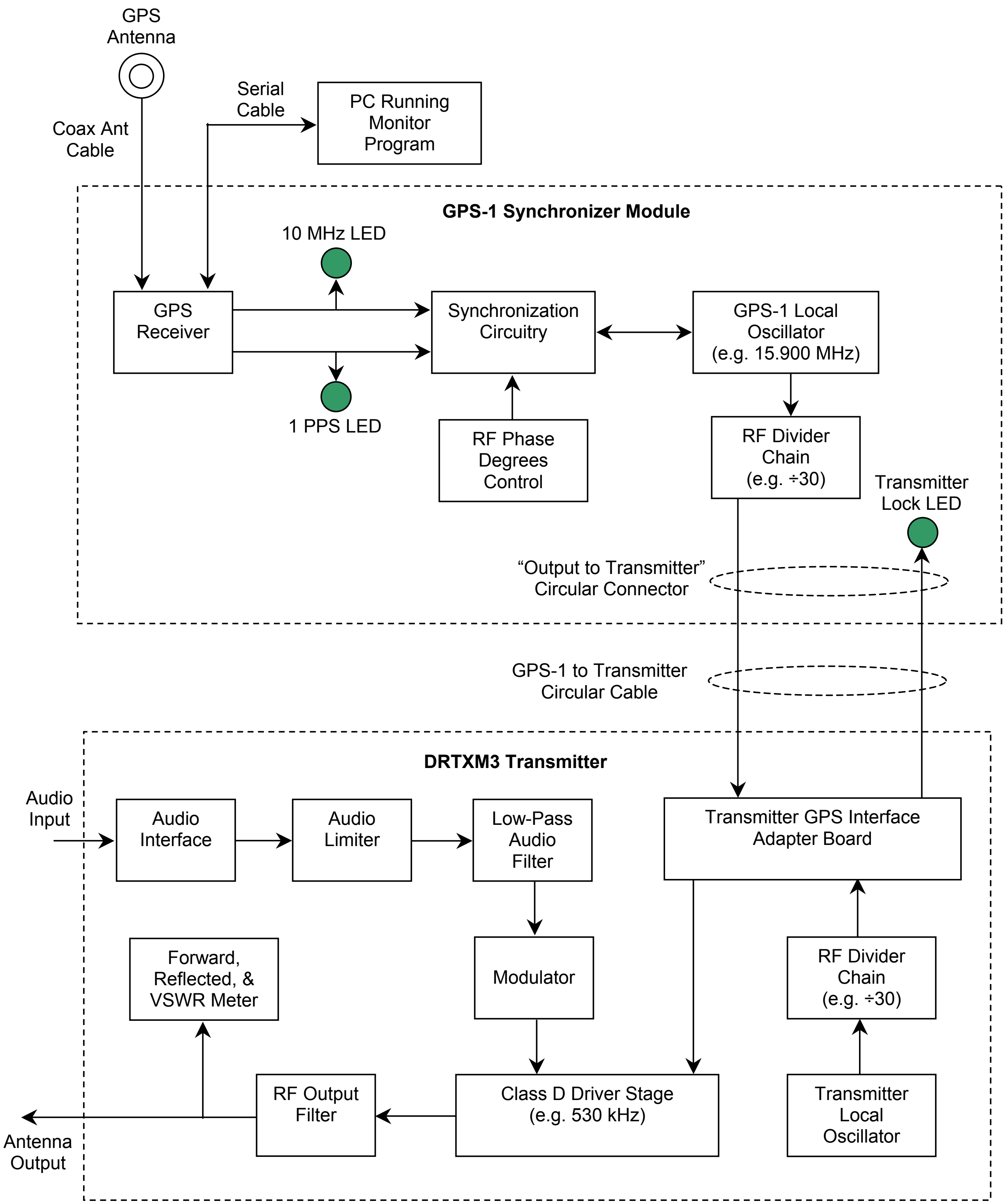

Figure 3-1 Block Diagram of GPS Synchronizer System

3.2.3. GPS Receiver Monitor Program Running on a PC

In the lower left of the block diagram is a desktop or laptop personal computer (PC) running a program that monitors and reports the status of the GPS timing receiver inside the GPS-1 Synchronizer module. As shown in the figure, the computer is connected via COM1 or COM2 through a standard DB9 serial cable to the front panel connector on the GPS-1 labeled "RS-232C."

3.3. GPS-1 Local Oscillator and Divider Chain

3.3.1. GPS-1 Local Oscillator

At the upper right of the block diagram is the GPS-1 local oscillator. This oscillator is a voltage-controlled crystal oscillator (VCXO), whose frequency and phase can be fine tuned by the application of a control voltage.

3.3.2. GPS-1 Local Oscillator Operating Modes

In normal operation, the synchronization circuitry (to be described below) keeps the GPS-1 local oscillator precisely phase locked with the 10 MHz and 1 PPS signals from the GPS timing receiver. If the GPS 10 MHz signal is not present, the synchronization circuit automatically switches the GPS-1 oscillator over to GPS-1 manual control mode. In GPS-1 manual control mode the oscillator no longer has the precision of a GPS oscillator, but rather, has the precision typical of a standard HAR transmitter. Note that the various frequency control modes mentioned throughout this chapter are summarized at the end of the chapter.

3.3.3. RF Divider Chain

The RF divider chain shown below the GPS-1 local oscillator divides the oscillator frequency down to the RF frequency of the transmitter. This signal is fed to the transmitter via the front-panel circular connector labeled "Output to Transmitter" and then travels through the circular cable through the rear of the transmitter cabinet to the Transmitter GPS interface adapter board inside the transmitter.

3.4. GPS to Local Oscillator Synchronization Circuitry

3.4.1. Synchronization Circuitry

The synchronization circuitry block shown near the top center of the diagram synchronizes the GPS-1 local oscillator to the GPS timing signals. This is accomplished by dividing both the 10 MHz GPS timing signal and the GPS-1 local oscillator signal down to the greatest common divisor, namely 10 kHz (10,000 Hz). The synchronization circuitry then uses a phase-locked-loop circuit to precisely control the phase and frequency of the local oscillator so that it is always precisely synchronized with the GPS timing signals.

3.4.2. RF Phase Degrees Control

The front-panel "RF Phase Degrees Control" connects to the synchronization circuitry and precisely changes the phase of the local oscillator relative to the GPS timing signals so that the phase of the RF output from the transmitter can be adjusted through the full 360 degrees. In fact, the range of the adjustment is 000 to 999 degrees, but use of values greater than 360 is both unnecessary and not recommended.

3.5. Transmitter GPS Interface

3.5.1. Transmitter GPS Interface Adapter Board

Shown in the lower right of the block diagram is a dotted line corresponding to the DRTXM3 Transmitter. Located in the transmitter is the Transmitter GPS Interface Adapter Board which processes the frequency control signals from the GPS-1 Synchronizer module to make them suitable for controlling the transmitter RF.

3.5.2. Transmitter Local Oscillator Switching Function

The transmitter GPS interface adapter board incorporates a switching function such that if the frequency control signals from the GPS-1 are present, the transmitter will be under GPS control, but if these signals are not present, the transmitter will automatically switch over to operate from its own local oscillator.

3.5.3. Transmitter Lock LED

The transmitter GPS interface adapter board also generates the "Transmitter Lock" signal which is fed to the front panel LED on the GPS-1 Synchronizer. When this LED is lit it indicates that the transmitter is operating properly from the signal being provided from the GPS-1 synchronizer. Note that it does not necessarily indicate that the system is locked to the GPS time signal, which can only be determined using the GPS receiver monitor program running on a PC.

3.6. Summary of Frequency Control Operating Modes

The GPS synchronization system has several frequency control modes to ensure continuous operation of the system even when the mode of being fully locked to GPS time is not available. The following subsections describe these modes starting with the system operating in the fully-locked mode and continuing sequentially to the transmitter operating in stand-alone mode.

3.6.1. Fully-Locked Mode

In the fully-locked mode, the precision oscillator in the GPS receiver is phase locked to timing signals coming from the GPS satellites. Both the GPS 10 MHz and GPS 1 PPS signals from the internal oscillator are processed by the synchronizer circuit so that the GPS local oscillator is phase locked to GPS time. The RF timing signals derived from the local oscillator are fed to the transmitter and control the RF driver so that the RF power output is phase locked to the GPS time, as desired.

3.6.2. Operating Mode Without Satellite Reception

If there is no satellite reception, the system will continue to operate with the frequency and phase controlled by the ovenized oscillator in the GPS receiver. Operation in this mode can be detected by running the Trimble monitor program through the front panel RS-232C port. The frequency error in this mode will be on the order of 10^{-8} or less. Depending on the frequency error, the phase of the system will drift slightly so that, for example, two transmitters might be in phase one minute and out of phase a few minutes later. This change will mean that the exact geographical locations of the nodes in the overlap region between two transmitters will move slowly, or alternatively, with an AM receiver fixed in place, the signal will drift slowing in and out of phase. In general, this will produce little audible difference except for the short period of time when the signals are exactly out of phase, at which point there may be some slight fuzziness to the audio signal.

3.6.3. Operating Mode Without 1 PPS Timing Signal

If the 1 PPS timing signals is not present, the system continues to operate at a *frequency* that is exactly locked to GPS time, but it may not be operating at a *phase* exactly locked to GPS time. Operation in this mode is indicated by the front-panel "GPS 1 PPS" LED being off. Operating in this mode will produce only a slight change in overall system operation. This change will be that the exact geographical locations of the nodes in the overlap region between two transmitters will be different from the positions when the phase is exactly locked. In general the positions of these nodes will remain fixed until the power to the GPS-1 is turned off and then back on again.

3.6.4. Operating Mode Without 10 MHz Timing Signal

If the 10 MHz timing signal from the GPS timing receiver is not present, the system automatically switches over to the local oscillator in the GPS-1 Synchronizer. Operation in this mode is indicated by the front-panel "GPS 10 MHz" LED being off. The frequency error in this mode will be on the order of 10^{-6} or less. In this mode the phase of the system will drift so that there may be a waffling sound depending on the frequency error of the GPS-1 local oscillator,

3.6.5. Operating Mode Without GPS-1 Synchronizer Signal to Transmitter

If the frequency control signals from the GPS-1 synchronizer are not present at the transmitter, the GPS interface adapter board automatically switches over to the transmitter's local oscillator. Operation in this mode is indicated by the front-panel "Transmitter Lock" LED being off. In this mode the phase of the system will drift so that there may be a waffling sound depending on the frequency error of the DRTXM3 local oscillator,

4. GPS Synchronized HAR System Setup

4.1. Overview

This section gives a step-by-step procedure for setting up the equipment in a synchronized HAR system.

Under normal conditions, when the transmitter system is mounted in the Black Max rack unit, power is fed to it through the back plane from the DRPSM1 AC power supply or from the solar DC system and no external power connection is needed.

For some special applications such as testing , power can be fed to the back plane of the BlackMax rack through a jumper cable using a RED (+) and BLACK (-) pigtail jumper. Voltages are as follows:

- Nominal: 12 Volts DC
- Normal Range: 10.4 to 13.6 Volts DC.
- Maximum Range: 10 to 14 Volts DC.
- Current is typically less than 2 Amps DC.

4.2. DRTXM3 Transmitter Setup and Checkout in Stand-Alone Mode

4.2.1. Set Transmitter Internal controls

Some of the internal controls can be accessed through the holes in the rear panel. Access to others requires removal of the side panel by removing the 8 Phillips head screws holding it in place.

(1) SLIDE SWITCH S3 FOR LIMITER IN / OUT: The limiter switch is typically IN during normal operation. The limiter may be switched OUT under special conditions such as when testing.

(2) SLIDE SWITCH S4 FOR LOW-PASS FILTER IN / OUT: The low pass filter (LPF) switch is typically IN for normal operation. The low pass filter may be switched OUT under special conditions such as when testing or when operating with an external filter.

(3) DIP SWITCH S1 FOR INPUT SELECT: Under normal conditions, when the transmitter is mounted in the Black Max rack unit, the audio signal from the digital recorder player is fed to the transmitter through the backplane and switch S1 segment 2 should be ON and all others should be OFF. Under standalone operation, when a test signal is being fed through the rear-panel RCA input jack J1, switch S1 segment 1 should be ON and all others should be OFF.

(4) DIP SWITCH SEGMENT S2-E FOR TRANSMITTER ENABLE: Under normal operation, the transmitter enable signal is fed to the unit from the back plane. When operating under standalone conditions DIP switch S2 segment E, which is the fifth segment from the top, should be ON (right) to enable the transmitter RF output.

(5) DIP SWITCH SEGMENTS S2 A, B, C, D FOR FREQUENCY SELECT: The four upper segments of dip switch S2 select the frequency divider and

must remain unchanged from the positions set when the transmitter was manufactured to prevent damage to the output transistors.

4.2.2. Install Transmitter Module in the Black Max Rack

With the power to the BlackMax rack turned off, install the DRTXM3 transmitter module in the rack. Route the cable with the circular connector from the back of the transmitter under the BlackMax rack, but leave it unconnected.

4.2.3. Connect Audio Input Cable to Transmitter Module

For bench testing, the audio input to the transmitter is provided via the rear-panel RCA connector J1. Nominal level is 0.775 Vrms for 100% Modulation.

4.2.4. Connect Audio Input and RF Output Cables to Transmitter Module

Connect a coaxial cable from the RF output of the transmitter either to the antenna or to whatever antenna matching or surge suppression device is being used between the transmitter and the antenna. The nominal output impedance is 50 Ohms and the nominal power level is 10 Watts. Audio input is into rear-panel RCA connector J1. Nominal level is 0.775 Vrms for 100% Modulation.

4.2.5. Power the Transmitter Module

Turn the front-panel power switch on the DRTXM3 transmitter module to the off position. Turn on the power to the BlackMax rack and confirm that the other modules, if any, have powered up correctly. Using the front-panel power switch on the transmitter, turn on the power. If there are any unusual noises or other indications of transmitter problems, turn the transmitter off immediately.

4.2.6. Checkout Transmitter Module in Stand-Alone Mode

If no problems are detected when the transmitter power is applied, check out the operation of the transmitter using the standard procedures for non-synchronized transmitters, to make sure it is operating correctly in the stand alone mode. The front-panel controls and indicators are described in the following two sub-sections. (See the BlackMax Operations Manual for more details.)

4.2.7. Front-Panel Controls

The DRTXM3 Transmitter front-panel controls are as follows:

- POWER Switch turns transmitter on.
- POWER LED indicates power on.
- MEASURE switch selects function of 20 LED bar-graph display as VSWR, FORWARD power, or REFLECTED power.
- TRANSMIT LED indicates transmitter is in transmit mode.
- LIMIT LED indicates limiter is enabled and is actively limiting modulation.
- MODULATION LEDs indicate percent modulation.

- POWER Switch is located at the bottom of the front panel of the transmitter. Switch it on to turn on the transmitter power. The POWER LED will illuminate.

4.2.8. MEASURE Switch

The DRTXM3 Transmitter front-panel MEASURE switch is located at the top of the front panel and controls the function of the 20 LED bar-graph display as follows:

- In the VSWR position it indicates the Voltage Standing Wave Ratio, which tells how well the antenna is tuned. The lower the reading (the fewer LEDs that are lit) the better the VSWR. The normal reading for the VSWR meter will be between 0 (no LEDs lit) and 1.6 (five LEDs lit).
- In the FORWARD position the LED bar-graph display indicates how much power the transmitter is producing.
- In the REVERSE position the LED bar-graph display indicates how much power is reflected by the imbalance in the antenna. A higher VSWR reading corresponds with a REVERSE power reading. The actual power that is transmitted can be determined by subtracting the REVERSE power measurement from the FORWARD power measurement.

4.3. GPS-1 Synchronizer Setup and Checkout in Stand-Alone Mode

4.3.1. Install GPS-1 Synchronizer Module in the Black Max Rack

With the rack power off, install the GPS-1 Synchronizer module in the BlackMax rack immediately to the right of the DRTXM3 transmitter. Leave the front-panel circular "Output to Transmitter" disconnected temporarily when first installing the module.

4.3.2. Power the GPS-1 Synchronizer Module

Turn the front-panel power switch on the GPS-1 Synchronizer module and the front-panel power switch on the DRTXM3 transmitter to the off position. Turn on the power to the BlackMax rack and confirm that the other modules, if any, have powered up correctly. Using the front-panel power switch on the GPS-1, turn on the power. The front-panel green "Power" LED as well as the green front-panel "GPS 10 MHz" LED should come on instantaneously. The green front-panel "GPS 1 PPS" LED should come on within a few seconds. The green front-panel "Transmitter Lock" LED should be off.

Note that the timing receiver is switched off whenever the GPS-1 Synchronizer Module is switched off and then must go through its recovery process whenever it is switched back on.

4.4. GPS-1 Synchronizer & Transmitter Setup and Checkout

4.4.1. GPS-1 to Transmitter Setup

Switch off the power to both the transmitter and the GPS-1. Connect the circular connector from the transmitter to the "Output to Transmitter" receptacle on the front panel of the GPS-1. Turn on the power to the GPS-1 and reconfirm that the top three green LED's are on and the "Transmitter Lock" LED is off.

4.4.2. GPS-1 to Transmitter Checkout

Make sure that the RF antenna cable is connected to the RF output receptacle on the DRTXM3. Using the front-panel power switch on the transmitter, turn on the power. If there are any unusual noises or other indications of transmitter problems, turn it off immediately. Otherwise, the front-panel "Transmitter Lock" LED should now be on.

4.5. GPS Timing Receiver Setup and Checkout

4.5.1. Installing ThunderBolt CD ROM Manual and Monitor Software

To install the monitor software on a PC, insert the Trimble CD ROM labeled "User Guides and Software Tools for Timing Products." Run the SETUP program and when prompted, check the option for ThunderBolt.

After setup is complete, from the windows desktop click "Start" "Programs" "Trimble Thunderbolt" to view the manual or run the monitor software program.

4.5.2. GPS Antenna Installation

To install the GPS antenna follow the instructions in the Trimble ThunderBolt manual Chapter 2 "Getting Started," Section 2.1 "ThunderBolt Setup." Note that all of the power connections are already made internally. The front-panel connector labeled "GPS Antenna" goes directly to the input of the Trimble ThunderBolt and thus should be used whenever the manual instructions refer to the connector on the ThunderBolt unit.

Although the GPS antenna may operate to some degree indoors, this mode of operation is considered marginal and is not recommended. Instead, the antenna should be mounted outdoors with a clear view of the southern sky. See the Timing Receiver Manual for additional information on mounting the antenna module. The antenna cable should be routed to the receiver using good standard practices for coaxial cable.

ALWAYS SWITCH THE POWER TO THE GPS-1 OFF BEFORE CONNECTING OR DISCONNECTING THE ANTENNA. THIS IS NECESSARY BECAUSE THE ANTENNA CONTAINS ACTIVE ELECTRONIC CIRCUITRY POWERED FROM THE GPS TIMING RECEIVER. CONNECTING OR DISCONNECTING THE ANTENNA OR ANTENNA CABLE WHEN THE UNIT IS POWERED CAN RESULT IN FAILURE OF THE ANTENNA MODULE.

4.6. GPS ThunderBolt Monitor Program Setup and Operation

4.6.1. Establish Serial Connection between ThunderBolt and Computer

Connect the serial port of the PC to the front panel DB9 connector labeled "RS-232C." Note whether the cable is connected to COM1 or COM2 since the monitor program will request this information when starting up.

4.6.2. GPS Timing Receiver Monitor Software

After the software setup from the CD ROM is completed as described in section 4.5.1, run the monitor software program from the windows desktop by clicking "Start," "Programs," and "Trimble Thunderbolt." A view of a typical window is given in Figure 4-1 below and another typical view is given in the Trimble ThunderBolt manual Chapter 2 "Getting Started," Section 2.2 "Software Interface," Sub-section 2.2.1 "ThunderBolt Monitor Program."

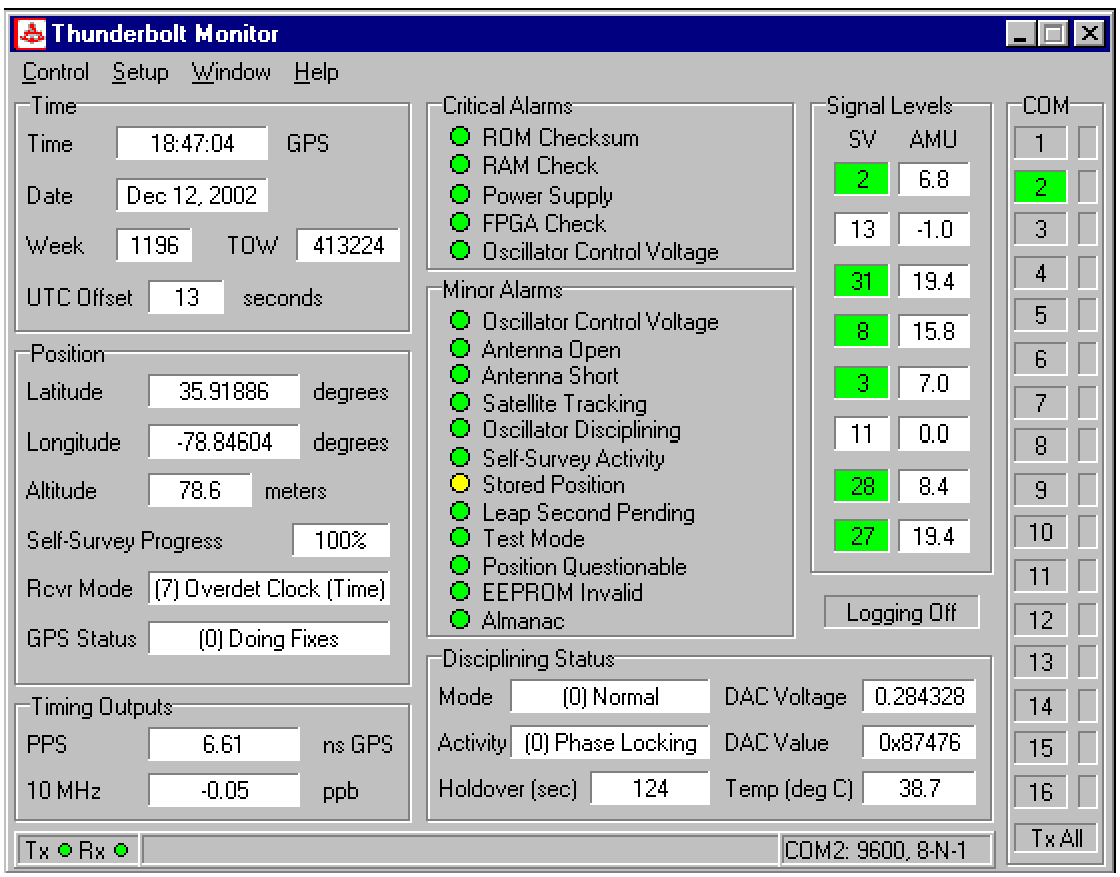

Figure 4-1 Typical Trimble ThunderBolt Monitor Program Window

4.7. GPS ThunderBolt Monitor Program Typical Conditions

The following subsections show typical conditions for the various groups of indications in the GPS ThunderBolt monitor program. A description of the functionality of each of these parameters is given in Appendix I.

4.7.1. Serial Communications

The Serial Communications functions and status under typical operating conditions are shown in the following table.

Communications Function Name	Typical Status at Power Up (~1 min)	Typical Status During Initial Survey (~10 min)	Typical Status When Fully Stabilized (~60 min)
COM channel number in right column	Box 1 or 2 Green as appropriate	Box 1 or 2 Green as appropriate	Box 1 or 2 Green as appropriate
COM ID in lower right	COM1 or COM2 as appropriate	COM1 or COM2 as appropriate	COM1 or COM2 as appropriate
Baud Rate	9600	9600	9600
Bits	8	8	8
Parity	N	N	N
Stop Bits	1	1	1
Tx	Flashing Green	Flashing Green	Flashing Green
Rx	Flashing Green	Flashing Green	Flashing Green

4.7.2. Time Functions

The Time function names and status under typical operating conditions are shown in the following table.

Time Function Name	Typical Status at Power Up (~1 min)	Typical Status During Initial Survey (~10 min)	Typical Status When Fully Stabilized (~60 min)
Time	00:00:15	18:47:04	18:47:04
Date	Aug 22, 1999	Dec 12, 2002	Dec 12, 2002
Week	1024	1196	1196
TOW	15	413224	413224
UTC Offset	0	13	13

4.7.3. Position Functions

The Position function names and status under typical operating conditions are shown in the following table.

Position Function Name	Typical Status at Power Up (~1 min)	Typical Status During Initial Survey (~10 min)	Typical Status When Fully Stabilized (~60 min)
Latitude	0	0	35.91886
Longitude	0	0	-78.84604
Altitude	0	0	78.6
Self Survey Progress	1%	10%	100%
Rcvr Mode	(4) Full Pos 3D	(4) Full Pos 3D	(7) Overdet Clock

			(Time)
GPS Status	(1) No Time	(4) Only 1 Usable SV	(0) Doing Fixes

4.7.4. Timing Outputs

The Timing Outputs and status under typical operating conditions are shown in the following table.

Timing Output **Function Name**	**Typical Status at Power Up (~1 min)**	**Typical Status During Initial Survey (~10 min)**	**Typical Status When Fully Stabilized (~60 min)**
PPS	0	0	6.61
10 MHz	0	0	-0.05

4.7.5. Critical Alarms

The critical alarm names and the alarm status under typical operating conditions are shown in the following table.

Critical Alarm **Function Name**	**Typical Status at Power Up (~1 min)**	**Typical Status During Initial Survey (~10 min)**	**Typical Status When Fully Stabilized (~60 min)**
ROM Checksum	Green	Green	Green
Ram Check	Green	Green	Green
Power Supply	Green	Green	Green
FPGA Check	Green	Green	Green
Oscillator Control Voltage	Green	Green	Green

4.7.6. Minor Alarms

The minor alarm names and the alarm status under typical operating conditions are shown in the following table.

Minor Alarm **Function Name**	**Typical Status at Power Up (~1 min)**	**Typical Status During Initial Survey (~10 min)**	**Typical Status When Fully Stabilized (~60 min)**
Oscillator Control Voltage	Green	Green	Green
Antenna Open	Green	Green	Green
Antenna Short	Green	Green	Green
Satellite Tracking	Yellow	Yellow	Green
Oscillator Disciplining	Yellow	Yellow	Green
Self-Survey Activity	Yellow	Yellow	Green
Stored Position	Yellow	Yellow	Yellow
Leap Second Pending	Green	Green	Green
Test Mode	Green	Green	Green
Position Questionable	Yellow	Green	Green
EEPROM Invalid	Green	Green	Green
Almanac	Yellow	Green	Green

4.7.7. Disciplining Status

The Disciplining Status function names and status under typical operating conditions are shown in the following table.

Disciplining Status **Function Name**	**Typical Status at Power Up (~1 min)**	**Typical Status During Initial Survey (~10 min)**	**Typical Status When Fully Stabilized (~60 min)**
Mode	(10) Power Up	(4) Recovery	(0) Normal
Activity	(6) Inactive		(0) Phase Locking
Holdover (sec)	0	0	124
DAC Voltage	0.000000	0.000000	0.284328
DAC Value	0x80000	0x80000	0x87476
Temp (deg C)	38.7	38.7	38.7

4.7.8. Signal Levels

The Signal Levels under typical operating conditions are shown in the following table.

Signal Level **Function Name**	**Typical Status at Power Up (~1 min)**	**Typical Status During Initial Survey (~10 min)**	**Typical Status When Fully Stabilized (~60 min)**
SV	None Green	1, 2, or 3 Green	3 to 6 Green
AMU	0.0 on most or all	0.0 on most, 5.0 to 20.0 on a few	5.0 to 20.0 on several

5. Appendix I—List of Monitor Software Functions

The functions of each of the boxes in the ThunderBolt monitor program are listed below. The numerical examples below correspond to Figure 4-1 above.

5.1. Serial Communications

5.1.1. Serial Communications Properties

The serial communications properties are listed in the lower right corner of the window and show the COM port, the baud rate, the number of bits, parity, and the number of stop bits, e.g. COM2: 9600, 8-N-1.

5.1.2. Tx and Rx Indicators

The Tx and Rx indicators in the lower left corner of the window indicate when the software is transmitting serial messages to the timing receiver in the GPS-1 and when it is receiving messages back from the timing receiver. In normal operation both indicators flash green. If the software is attempting to communicate with the receiver, but is not receiving messages back from it, the Tx indicator will flash green, but the Rx indicator will not. Typical causes could be that the serial cable is not connected, that a null modem connector is required, the correct COM port is not being used, or that the GPS receiver is not powered up.

5.1.3. COM

The COM column on the right side of the window indicates which COM port is being used.

5.2. Time Functions

5.2.1. Time (GPS)

The “Time GPS” box shows the current GPS time in 24 hour format, e.g. 18:47:04. Note that this is GPS time and not UTC (Universal Time). See below for a description of the UTC offset. When first powered up, this box will show the seconds since power up, e.g. 15. As soon as the receiver locks on to one satellite, this box will show an approximately correct GPS time. When the receiver is fully locked this box will show the exact GPS time.

5.2.2. Date

The “Date” box shows the current date, e.g. Dec 12, 2002. When first powered up, this box will show the date the last firmware mod, e.g. Aug 22, 1999. As soon as the receiver locks on to one satellite, this box will show the exact date.

5.2.3. GPS Week

The “GPS Week” box shows the time in weeks since the inception of GPS, e.g. 1196. When first powered up, this box will show the week of the last firmware mod, e.g. 1024.

5.2.4. TOW (Time of Week)

The “TOW” box shows the time of week in seconds since the beginning of the GPS week, e.g. 413224. When first powered up, this box will show the time in seconds since power up, e.g. 15.

5.2.5. UTC Offset (Seconds)

The “UTC Offset” box shows the number of seconds between GPS time and UTC time. This offset is required because GPS time runs continuously, while UTC time incorporates leap seconds to maintain coordination with celestial time. GPS time is numerically larger than UTC time by the UTC offset. Therefore, to convert from GPS time to UTC time, subtract the offset. To convert from UTC time to GPS time add the offset. At the present time (December 2002) the offset is 13 seconds.

5.3. Position Functions

5.3.1. Latitude (Degrees)

The “Latitude” shows the north-south latitude in decimal degrees (not degrees, minutes, and seconds), e.g. 35.91886. The latitude can either be a stored position or it can be determined by the unit.

To convert to degrees, minutes and seconds:

(1) Use the whole part as the degrees, e.g. 35.91886 gives 35 degrees
(2) Multiply the remaining fraction by 60 and use the whole part as minutes, e.g. 0.91886 x 60 = 55.1316 gives 55 minutes.
(3) Again multiply the remaining fraction by 60 and use the result as decimal seconds e.g. 0.1316 x 60 = 7.89 seconds

5.3.2. Longitude (Degrees)

The “Longitude” shows the east-west longitude in decimal degrees (not degrees, minutes, and seconds), e.g. -78.84604. The longitude can either be a stored position or it can be determined by the unit.

5.3.3. Altitude (Meters)

The “Altitude” shows the height above sea level in meters to the nearest tenth, e.g. 78.6 meters.

5.3.4. Self-Survey Progress

The “Self-Survey Progress” box gives an approximate percent completion of the self survey.

5.3.5. Receiver Mode

The "Receiver Mode" box gives the status of the receiver. The possible conditions are:

(1) Automatic
(2) Single Satellite
(3) Horizontals
(4) Full Position (Normal condition at power-up)
(5) DGPR Reference
(6) Clock Hold
(7) Over-determined Clock (Normal condition when fully stabilized)

5.3.6. GPS Status

The "GPS Status" box gives the status of GPS system. The possible conditions are:

(0) Doing Fixes
(1) Don't Have GPS Time
(2) PDOP Is Too High
(3) No Usable Sats
(4) Only 1 Usable Sat (Typical mode as satellites are acquired)
(5) Only 2 Usable Sats (" " " " " ")
(6) Only 3 Usable Sats (" " " " " ")
(7) The Chosen Sat Is Unusable
(8) TRAIM Rejected The Fix

5.4. Timing Outputs

5.4.1. PPS___ns GPS

The "PPS___ns GPS" shows the estimated error between the 1 pulse per second output and the true GPS time, e.g. 6.61 nano seconds. Typical values are less than 50 nano seconds.

5.4.2. 10 MHz___ppb

The "10 MHz___ppb" shows the estimated frequency error of the 10 MHz output in parts per billion to the nearest hundredth, e.g. -0.05 ppb. Typical values are on the order of one part per billion or less.

5.5. Critical Alarms

The five critical alarms indicate failures in the GPS timing receiver are:

5.5.1. ROM Checksum

When red, a firmware ROM checksum error was detected at reset.

5.5.2. RAM Check

When red, a RAM failure was detected at reset.

5.5.3. Power Supply

When red, one or more power supply voltages have failed.

5.5.4. FPGA Check

When red, an FPGA failure was detected at reset.

5.5.5. Oscillator Control Voltage

When red, the oscillator control voltage is at the power supply rail, meaning that the control voltage has no more range.

None of these failures are field repairable. If one of them occurs, try power cycling the unit to see if it the error is recoverable. Otherwise the unit will need to be repaired.

5.6. Minor Alarms

There are 12 minor alarms that indicate the functioning of the GPS receiver. These alarms are:

5.6.1. Oscillator Control Voltage

When yellow, the oscillator control voltage is near a rail. To correct, either give the system time to recover (¼ to 1 hour) or cycle power to put the system in reset and then give the system time to stabilize.

5.6.2. Antenna Open

When yellow, the antenna input is open, i.e. the antenna is not connected. To correct, connect the antenna, repair the antenna cable, or replace a possibly faulty antenna unit.

5.6.3. Antenna Short

When yellow, the antenna input is shorted. To correct, repair the antenna cable or replace a possibly faulty antenna unit.

5.6.4. Satellite Tracking

When yellow, no satellites are usable. This is a normal stage in the locking process. If this condition persists for more than 1 hour, cycle power to put the system in reset and then give the system time to stabilize.

5.6.5. Oscillator Disciplining

When yellow, the oscillator is not being disciplined. This is a normal stage in the locking process. If this condition persists for more than 1 hour, cycle power to put the system in reset and then give the system time to stabilize.

5.6.6. Self-Survey Activity

When yellow, a self survey is in progress. This is a normal part of the locking procedure. If this condition persists for more than 1 hour, cycle power to put the system in reset and then give the system time to stabilize.

5.6.7. Stored Position

When yellow, no stored position exists. This is a normal operating mode unless a position has been manually entered for some reason.

5.6.8. Leap Second Pending

When yellow, a leap second event is pending. This is a normal (although rare) operating condition and does not affect the operation of the GPS transmitter system.

5.6.9. Test Mode

When yellow, the unit is in a test mode.

5.6.10. Position Questionable

When yellow, the position accuracy is questionable.

5.6.11. EEPROM Invalid

When yellow, invalid EEPROM segments were detected at reset.

5.6.12. Almanac

When yellow, the almanac is not complete or current.

5.7. Disciplining Status

5.7.1. Disciplining Mode

The “Mode” box gives the disciplining mode. The possible modes are:

(0) Normal (Normal condition when fully stabilized)
(1) Power-Up (Normal condition at power up)
(2) Auto Holdover
(3) Manual Holdover
(4) Recovery (Normal condition after satellites have been lost)
(5) Not Used
(6) Disciplining Disabled

5.7.2. Disciplining Activity

The “Activity” box gives the disciplining activity. The possible activities are:

(0) Phase Locking (Normal condition when fully stabilized)
(1) Oscillator Warming Up

(2) Frequency Locking
(3) Placing PS
(4) Initializing Loop Filter
(5) Compensating OCXO
(6) Inactive (Normal condition at power up)

5.7.3. Holdover (sec)

The "Holdover" is the time in seconds that the local GPS oscillator has been controlling the frequency. Very large values suggest that the system has lost contact with the GPS satellites.

5.7.4. DAC Voltage

The "DAC Voltage" is the value of the correction voltage being applied by the Digital to Analog Converter to the GPS oscillator to phase lock it with the GPS time. Typical values are a few volts or less, e.g. 0.284328. Excessive values will trigger the Oscillator control Voltage Minor or Critical Alarm.

5.7.5. DAC Value

The "DAC Value" is the digital value of the correction being applied by the Digital to Analog Converter to the GPS oscillator to phase lock it with the GPS time. Typical values are 5 Hexadecimal digits, e.g. 0x87476. The value 0x80000 corresponds to no applied voltage.

5.7.6. Temp (deg C)

The "Temp (deg C)" is the temperature inside the GPS receiver cabinet. Typical values are 10 to 20 degrees C above ambient.

5.8. Signal Levels

5.8.1. SV

The "SV" box gives the satellite number. Green color indicates that the satellite is being used.

5.8.2. AMU

The "AMU" box gives the satellite signal strength. Typical values are 0 to 20.