TSC 4415A Precision Frequency Reference

Operations and Maintenance Manual

TIMING SOLUTIONS™

4775 Walnut Street
Suite 1B
Boulder, CO 80301
www.timing.com
Phone: (303) 939-8481

TSC 4415A Precision Frequency Reference Operations and Maintenance Manual

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1: Introduction

Note
FIRST READ THIS MANUAL THOROUGHLY.
This is especially true for the sections regarding **Safety** and **Operation.**

1.1 Symbols

These symbols (icons) appear throughout the manual as well as on the unit itself.

Symbol	Definition
Note	This symbol means the following information is a note that gives you important information that may affect how you use the 4415A.
	Caution, refer to manual. Read all instructions in this manual before using this product.
	Caution - Risk of electrical shock
	Fuse symbol.
	LAN port, network. DO NOT CONNECT TO TELECOM CONNECTIONS THAT CARRY HAZARDOUS VOLTAGES.
	Chassis ground.
CE	CE marking attesting compliance with applicable European Directives.
	Earth terminal symbol: used to indicate an earth ground connection to chassis.

1.2 About This Manual

This manual tells you how to install, set up, monitor, and troubleshoot the 4415A.

"Chapter 1, Introduction" on page 1 explains symbols that appear in the manual and on the unit as well as documentation conventions. The chapter also briefly describes the 4415A.

"Chapter 2, Installing and Setting Up the 4415A" on page 5 contains important safety information and describes how to install the 4415A, and assigning a fixed IP address.

"Chapter 3, Monitoring the 4415A" on page 9 describes how to check status and monitor alarms.

"Chapter 4, Troubleshooting the 4415A" on page 13 describes how to troubleshoot the unit, replace power supplies, and replace fuses.

"Chapter 5, Maintaining the 4415A" on page 15 describes how to maintain the unit.

"Chapter 6, Warranty and Shipping Information" on page 19 explains how to contact Timing Solutions Corporation for warranty service and provides shipping guidelines.

"Appendix A, Specifications" on page 21 contains the detailed specifications for the 4415A.

1.2.1 Conventions

This manual uses several typographical conventions to help explain how to use the 4415A.

Convention	Definition
Bold	Words in **bold** show: ■ Buttons and icons to click ■ Menu options to select ■ Commands to type ■ Non-variable information displayed in response to commands
Italics	Words in *italics* show: ■ Names of windows and dialog boxes ■ Variable information displayed in response to commands

1.3 4415A Overview

The TSC 4415A 10 MHz Low Noise Reference is a 1U (1.75") high, 19-inch, rack-mount source that produces three square wave and six sine wave outputs. The unit can be configured with redundant hot swappable 4501A-15 power supplies.

The front panel provides green/red LED status for output signals, power supplies and oscillator status.

An Ethernet port on the rear panel provides the capability to remotely monitor the status of the power supplies, input, and all output signals. Any failure in the unit will immediately provide an alarm to this port.

Figure 1 shows the 4415A's front panel, and Figure 2 shows the 4415A's rear panel.

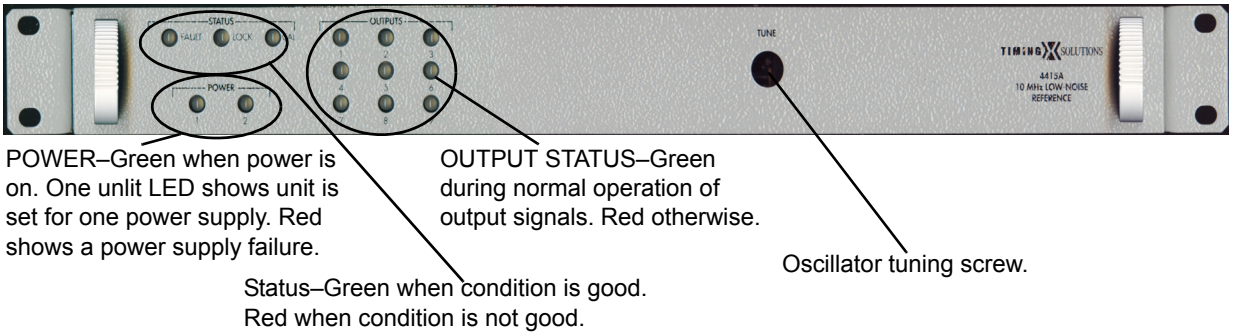

Figure 1: Front panel

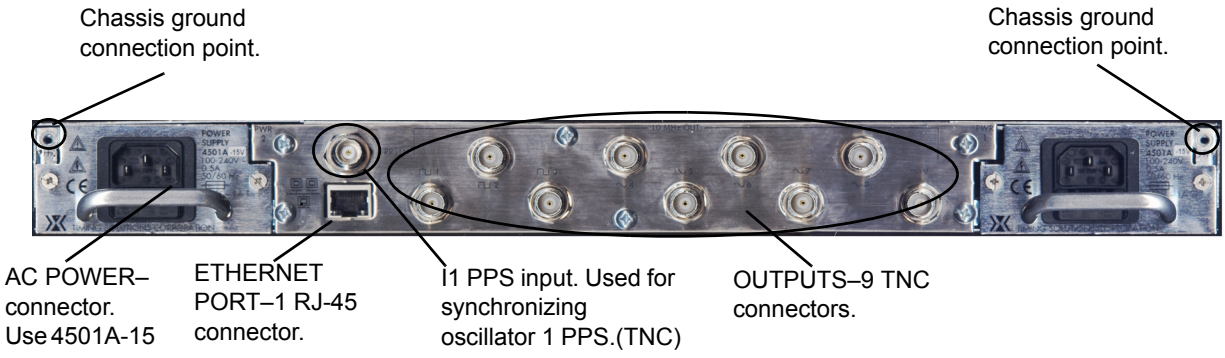

Figure 2: Rear panel

2: Installing and Setting Up the 4415A

2.1 Safety First!

Warning

Do not attempt to install or operate this equipment if you have not first acquired proper training.

Ensure that all cables are properly connected. The power cord must be easy to remove from the back.

Verify that input line voltage and current capacity are within specifications before turning on the unit.

Disconnect all sources of input power before removing the top cover of this unit.

Operating and maintenance personnel must receive proper training before installing or maintaining electrical equipment.

2.2 Unpacking

To unpack the TSC 4415A unit:

1. Unpack and carefully inspect the unit.
2. Check for physical damage.
3. If no physical damage is apparent, then proceed with making appropriate connections.
   - If physical damage is observed, then immediately contact Timing Solutions and the carrier.
4. Save the shipping container for submitting any necessary claims to the carrier.

Warning

INSTALL IN A PROTECTED ENVIRONMENT; NOT SUITABLE FOR OUTDOOR USE!

2.3 Cleaning

- Clean the main chassis with a soft cloth dampened with a mild soap and water solution.

Warning

Do not spray or use too much liquid when cleaning the unit. Liquid can enter the unit and damage sensitive electronic components.

2.4 Installing the 4415A

The 4415A ships ready for installation into a standard 19" (48.3 cm) rack. It can be mounted from the front or rear of the chassis using rack mount ears supplied with the unit.

2.4.1 Materials Required for Installation

- North American or European IEC power cord. One or the other will be supplied with the unit.
- Customer-supplied double-shielded RG223 cables with TNC connectors from source for the number of devices you plan to connect to the 4415A.
- Customer-supplied shielded CAT 5 LAN cable for network connection (RJ-45).
- Rack-mount slide kit from General Devices, C-300-S-126, -128 or -130 (Optional).
- Rack mounting screws if mounting in a rack.
- Screwdriver for the rack mount screws and slide as needed.

2.4.2 Making Connections

2.4.2.1 Input Power

The input power to the unit is supplied through a 3-prong power cable.

To connect the power cable:

1. Plug the female end of the cable into the AC power input on the rear of the unit.
2. Plug the male end of the cable into a 90V~ to 240V~, 50/60 Hz power source.

2.4.2.2 Output Signals

- Connect up to nine cables to the output TNC connectors on the rear panel of the unit.

2.4.2.3 LAN - Ethernet Network Port (Optional)

- Connect a network LAN cable (not supplied with the unit) to the LAN port on the back of the unit.

2.5 Assigning a Fixed IP Address

The 4415A contains a Lantronix® Xport™ Ethernet to RS-232 converter, which provides the 4415A's Ethernet connection.

The 4415A ships from the factory with a default IP address of 0.0.0.0, which enables DHCP. If the network has a DHCP server, it will assign each unit an IP address, gateway address, and subnet mask when the unit starts up.

To monitor multiple 4415As remotely through their Ethernet connections, each unit must have a unique fixed IP address. You identify which unit is the source of an alarm by its IP address. Follow the instructions in this section to assign a unit's IP address.

Note

For more detailed information, see the *Xport™ User Manual.* You can download the *Xport™ User Manual* from the Lantronix® Web site as an Adobe® Acrobat® PDF file. Go to: http://www.lantronix.com

If you want to permanently configure the IP address, you must install the Lantronix® DeviceInstaller software. This software is available only by downloading from the Lantronix® Web site. Go to: http://www.lantronix.com

To permanently assign the ID address:

1. Obtain the following network information from your system administrator for each 4415A you want to install:

   IP Address: _____ _____ _____ _____

   Subnet Mask: _____ _____ _____ _____

   Gateway: _____ _____ _____ _____

2. Connect a Windows® PC to the same local subnet as the 4415A.
3. Install and start the Lantronix® DeviceInstaller software.
4. Click the **IP** icon or select **Assign IP Address** on the **Tools** menu.
   - The hardware device number and IP address appear in the *Assign IP Address* dialog box.
5. Type the new IP address and click **OK.**
   - The new IP address appears in the Lantronix® DeviceInstaller window.
6. Test the IP address by pinging the 4415A's Xport™ on the Lantronix Xport Installer window. Click the **Ping** icon or select **Ping Device** on the **Tools** menu.
   - The *Ping Device* window should show the IP address of the 4415A's Xport™ device, and it should show successful replies if the IP address has been configured correctly.
7. Exit the browser.

3: Monitoring the 4415A

3.1 Accessing the System

There are two different ways to communicate with the unit. One way is to access the 4415A system remotely by connecting to its Command-And-Response (CNR) Port through the Ethernet connection. The CNR port (Port 10001), which uses TCP/IP, lets users input commands, displays results of the commands, and publishes alarms as they occur.

When users telnet to the CNR port, the system displays a flashing underscore prompt. This prompt shows that the system is ready to accept a command or provide alarms.

An IVI compliant driver is also available from Timing Solutions.

3.2 Checking System Status

3.2.1 Checking Alarms and Input Frequency

If you have software that is monitoring the 4415A's alarms, you will see alarms in the following format:

ALARM*cccccc*\r\n where

The cccccc represents hexadecimal numbers, with each bit position representing one output. Least significant bit (LSB) is farthest right. The most significant bit (MSB) is farthest left.

cccccc is the current alarm where 0 = no alarm condition and 1 = alarm condition.

Example: *ALARM000008\r\n* indicates the Sine 4 output has a level fault.

Table 6 describes each alarm bit.

The system can report current alarms, latched alarms, and the frequency of the input signal.

To check system status:

- Type: **S**

  You do not need to type a carriage return or line feed.

The system returns ***S****nnnnnn,bbbbbb*\r\n

where:

nnnnnn = 6 characters comprising 24 bits

bbbbbb = 6 characters comprising 24 bits, latched status since the last S command

Sending an additional **S** command will clear a latched status if the fault is cleared.

Table 6: Alarm bit descriptions

bit position	Description	Status
23	FLL lock	0=no fault 1=fault, >.04Hz
22 (for future use)		
21 (for future use)		
20	rubidium fault status	0=no fault 1=fault
19 (for future use)		
18 (for future use)		
17 (for future use)		
16 (for future use)		
15 (for future use)		
14 (for future use)		
13 (for future use)		
12	Power Supply 2	0=no fault 1=fault
11	Power supply 1	0=no fault 1=fault
10 (for future use)		
9 (for future use)		
8	Sine 9 level	0=no fault 1=fault
7	Sine 8 level	0=no fault 1=fault

bit position	Description	Status
6	Sine 7 level	0=no fault 1=fault
5	Sine 6 level	0=no fault 1=fault
4	Sine 5 level	0=no fault 1=fault
3	Sine 4 level	0=no fault 1=fault
2	Sq 3 level	0=no fault 1=fault
1	Sq 2 level	0=no fault 1=fault
0	Sq 1 level	0=no fault 1=fault

3.2.2 PPS position and Rubidium Status

To check the 1 PPS offset and Rubidium status:

- Type: **R**

The system returns Rnnnnnnnn,bbbb,rrrr,ooooooooox

Where:

nnnnnnnn = 8 hex characters representing PPS position in nanoseconds.

bbbb = GPS status (for future version)

rrrr = Rubidium status (normally should be 3 when calibrating)

x - factory use

3.2.3 Checking Model Number and Software Version

Both commands are case sensitive. You do not need to type a carriage return or line feed.

To check the TSC model number:

- Type: **I**

The system returns **I4415A-00\r\n**.

To check the software version

- Type: **V**

The system returns **V***xx***\r\n** where *xx* is the software version

4: Troubleshooting the 4415A

Perform all of the following procedures before returning the unit for service. If the unit still appears to have a problem, then call Timing Solutions Corporation and request technical support. Have the serial number of your unit ready to give to a technical representative.

4.1 Replacing Fuses

If you know that a local event caused blown fuses throughout a rack, you can replace the fuses in each 4501A-15 power supply.

Required for this procedure:

- Small flat-head screwdriver
- Replacement fuse for a standard IEC 320 power entry module with fuse (5 x 20 mm, 1-amp, 250-volt fuse)

To replace a fuse:

1. Disconnect the power cable from the back of the 4501A-15.
2. Using a small screwdriver, open the fuse cover on the back of the 4501A-15.
3. Replace the old fuses as necessary.
4. Close the fuse cover.
5. Reconnect the power cable to the back of the 4501A-15.

4.2 Solving Operational Problems

If the unit does not operate properly after you have verified that:

- the correct power is applied to the rear of the 4415A

  and

- the fuses are good,

return the unit to TSC for repair.

5: Maintaining the 4415A

The 4415A consists of a low phase noise quartz oscillator which is frequency locked to a high stability rubidium oscillator. The 4415A outputs are derived from the quartz oscillator. The rubidium oscillator's frequency can be calibrated by connection to a high accuracy PPS (pulse per second) signal and issuing a command over the Ethernet connection. The quartz frequency is controlled internally by a DC control signal, and the center of its control range is adjusted with the adjusting screw accessible from the 4415A front panel. A frequency detector and feedback loop compare the output of the quartz oscillator with the rubidium frequency and force the quartz frequency to be very close. Both of these oscillators drift over time and must be calibrated periodically. Given the aging specifications of the oscillators, it is recommended that this procedure is performed annually to ensure performance to specification.

The only periodic maintenance required is annual calibration of the internal oscillators. There are two parts of this calibration procedure. First, the **F** command is used to calibrate the rubidium oscillator to an externally supplied PPS signal. The **A** command can abort this procedure and return to the previously saved frequency. Second, the **O** command breaks the feedback loop controlling the quartz oscillator and sets the control voltage to the center of the range. This allows the adjusting screw to be used to set the center of the quartz frequency range to the rubidium frequency. Both the **O** and **F** commands will time out automatically after about eight or 40 minutes respectively, or can be ended manually by the **D** command. All of these commands are described below.

5.1 Calibrating the Rubidium Oscillator Frequency with an external PPS signal

To calibrate the rubidium oscillator frequency with an external PPS signal:

Connect a high-accuracy PPS signal to the PPS IN connector on the chassis. The level should be 0 to +3.3 or +5 Volts. The accuracy and stability of this signal will determine the final accuracy of the 4415A. Connect a frequency counter with a resolution of 1 mHz or better to a 4415A sine output connector to verify the success of this calibration procedure.

Connect to the Ethernet port through a connection such as Telnet.

Send the command **F** over the Ethernet connection. If the PPS signal is present and stable, there will be no further output on the Ethernet port until the Calibration mode times out after about 40 minutes (**!F:T** from the 4415A Ethernet port), is terminated manually (**D**, response ***D:F***) or aborted (**A**, response ***A:F***), or PPS quality deteriorates (***$F:E***). The mode should not be terminated manually before at least 20 minutes to allow time for an accurate frequency determination. Note that the **D** command saves the newly calibrated frequency while ending the mode, while the **A** command returns to the previously saved frequency setting.

After termination of the Rubidium Calibration mode, measure the output frequency. Note that the output is actually the disciplined quartz oscillator frequency. Therefore, the frequency should be

measured at least 30 seconds after the end of the Rubidium Calibration mode. This allows the quartz oscillator to settle after any frequency change that might have occurred just before the end of the mode. The measured frequency should be within 1 mHz of a true 10 MHz signal. If the output frequency is not correct, this procedure should to be repeated, as the rubidium may require another attempt, or more time, to adjust its output frequency properly.

5.2 Adjusting the Quartz Oscillator Frequency

This procedure should only be done after the Rubidium Oscillator Frequency Calibration procedure has been performed.

5.2.1 To adjust the quartz oscillator frequency:

Remove the outer screw cover through the access hole in the panel. Behind it is an adjusting screw. This adjustment changes the open loop quartz oscillator frequency by about 2 Hz per turn. There is a backlash of about one eighth of a turn, and the desired final adjustment position range is a small fraction of a turn. There is also a 5-10 second time constant in the oscillator's response, so it is necessary to proceed slowly.

Connect the 4415A sine output to a frequency counter with a resolution of 0.02 Hz or less and a time constant of less than three seconds. If the rubidium oscillator has recently been calibrated from the same reference that the counter uses, then its frequency will be very close to 10 MHz. If not, its frequency must be measured separately, since the difference is to be set to near zero. (If the rubidium and quartz oscillator frequencies are close enough for the 4415A to lock, the output in normal operation is very close to the rubidium frequency. The 4415A output before the **O** command can then be used to measure the rubidium frequency. However, it cannot be used as a reference to adjust the quartz frequency, since all output frequencies change when the adjusting screw is turned.)

Connect to the Ethernet port through a connection such as Telnet.

Send the command **O** over the Ethernet connection. The unit's Ethernet port will begin pushing data consisting of lines of control loop parameters, and the front panel LED display will change to a frequency error display. If corner LEDs 1 and 9 are alternating, the frequency offset from the rubidium oscillator is greater than 1-2 Hz. If a single LED is on, its position indicates the magnitude and direction of the frequency offset. (This LED frequency indicator can be used more easily after becoming familiar with the tuning characteristics by using a frequency counter. See description below.)

Turn the adjusting screw to set the quartz oscillator to the same frequency as the rubidium oscillator. As the final point is neared, approach from one direction to avoid backlash. If you overshoot, go back at least one quarter turn and approach again from the same direction. Leaving the screwdriver in the screw slot while waiting for the last adjustment to settle makes the process easier. The final frequency difference should be less than about 100 mHz, after settling for 30 seconds after the last adjustment. This is an open loop procedure, so the frequency difference will be much smaller in normal operation. Note that after about eight minutes, the Quartz Adjust mode will time out automatically, emitting the string **!O:T** on the Ethernet port. This closes the frequency control loop, causing the frequency difference to go to zero (with a time constant of about 15 seconds) and the LED display to change. Be sure that the adjustment mode is still active when determining that the error is small enough.

After the desired frequency is reached, type **D** to end the adjustment mode. If the response is **ERROR**, the Quartz Adjust mode has timed out and is no longer active. Type **O** to restart the mode, check the frequency, and if it is still within 100 mHz, type **D**. The response will then be **D:O**, indicating manual termination. When done, replace the cover over the adjusting screw.

5.2.2 Using the LED frequency indication:

(Due to the backlash and adjustment delay, this technique is best learned while using a frequency counter.) If alternate corners are flashing, the rate directly indicates the period of the beat frequency between the quartz and rubidium oscillators, but not the direction of the offset. With large changes (about 1 turn), determine the approximate desired tuning point. If the alternation frequency increases, the center point is in the other direction. If the corner alternation stops and then restarts, the target point has been passed. The goal at this stage is to reach a point where only one of the nine numbered LEDs is on, or possibly two adjacent ones alternating. This occurs within a range of approximately one turn centered on the target point.

When only one LED is on, its position indicates the distance and direction to zero frequency difference. If LED 5 is on, the error is less than about 40 mHz. It is very difficult to reach this. LED 4 means the error is less than about 80 mHz, and a very small clockwise adjustment will reduce the error. LED 3 means <~200 mHz, turn clockwise; LED 2 <~400 mHz, and LED 1 <~800 mHz. LEDs 6-9 have the same scales and indicate counterclockwise adjustment is needed.

The final adjustment should leave LED 4, 5, or 6 on after settling for at least 30 seconds, indicating an error of less than ~80 mHz. LED 3 or 7 (error less than ~200 mHz) may be acceptable, especially after the unit has operated for a year of more.

5.2.3 Aborting the Rubidium Calibration Operation

If it is desired to abort the rubidium frequency calibration and return it to the same frequency setting as before the **F** command was given, type **A**. The Ethernet port will respond **A:F**. The rubidium oscillator will immediately return to its previous setting, and the quartz oscillator will follow it with a time constant of about 15 seconds. (This command does not apply to quartz oscillator adjustment. Turning the quartz adjusting screw cannot be undone except by turning it back.)

5.3 Manually Terminating Rubidium Calibration and Quartz Adjust Commands

Both the Rubidium Calibration and Quartz Adjust commands will time out automatically. However, either can be manually terminated by typing **D**. The response will be **D:F** or **D:O**. depending on which command was active. In both cases, the state of the adjustment at the time of the **D** command will be saved.

6: Warranty and Shipping Information

This chapter provides information on how to contact Timing Solutions Corporation for warranty service, as well as shipping guidelines for the 4415A.

6.1 Warranty Information

The 4415A carries a warranty from Timing Solutions Corporation for a period of 1 year from date of shipment.

For repairs, contact Timing Solutions Corporation:

- Phone (303) 939-8481
- Fax (303) 443-5152

Address written correspondence to:

Timing Solutions Corporation
4775 Walnut Street, Suite 1B
Boulder, CO 80301
USA

6.2 Shipping Information

If you need to ship this system for any reason, including returning equipment to Timing Solutions for warranty service, follow these shipping instructions. Failure to follow these instructions may damage your system.

6.2.1 Packing Instructions

- Always ship the 4415A appropriately packaged to protect it from damage.
- No cables or connectors may be attached to the rear of the chassis.
- Wrap the chassis in plastic to protect against moisture.

Appendix A: Specifications

A.1 EC Declaration of Conformity

In accordance with EN 45014:1998

We Timing Solutions Corporation

Of 4775 Walnut Drive Suite 1B
Boulder, CO 80301
USA

declare that:

Equipment	Phase Noise Test Set
Model Number	**TSC 4415A**
Product Options	None

in accordance with the following Directives:

73/23/EEC	The Low Voltage Directive and its amending directives
89/336/EEC	The Electromagnetic Compatibility Directive and its amending directives

has been designed and manufactured to the following specifications:

Safety: EN61010-1: 2001
Safety Requirements for Electrical Equipment for Measurement, Control and Laboratory Use - Part 1: General Requirements

EMC EN61326-1: 2001
Electrical Requirements for Electrical Equipment for Measurement, Control and Laboratory Use - Part 1: General Requirements
EN 55011 Class A
Radiated Emissions

I hereby declare that the equipment named above has been designed to comply with the relevant sections of the above referenced specifications. The unit complies with all essential requirements of the Directives.

Signed by:

Name: S.R. Stein
Position: President

Done at Boulder, Colorado U.S.A on 4 May 2006

A.2 EMC and EMI compliance

The TSC 4415A meets the following requirements:

Electromagnetic Compatibility, MIL-PRF_28800F, Sect. 3.9
Conducted Emissions, power leads
CISPR 11, Class A, 150 KHz to 30 MHz
Conducted Immunity, power leads
IEC 61000-4-6, 3 V AC-RMS, 150 kHz to 80 MHz, 80%
Amplitude Modulation with 1KHz sine wave
Conducted Immunity, power leads, spikes
IEC 61000-4-4, 1KV Peak for AC Lines, 0.5 KV Peak for Signal, Control, and DC Lines, 5nS Tr and 50 nS Th The, 5 kHz repetition frequency
Radiated Emissions, electric field
CISPR 11, Class A, 30 MHz to 1000MHz
Radiated Immunity, electric field
IEC 61000-4-3, 3 V/m, 80 MHz to 1000 MHz, 80% Amplitude Modulation with 1 KHz sine wave
Electrostatic Discharge Immunity
IEC 61000-4-2, 4 KV Contact Discharge, 8 KV air Discharge

A.3 Electrical Specifications

Table 3 lists the electrical specifications for the 4415A.

Table 3:

Item	Specification
Protection Class	Class I (Grounded Type)
AC Power Input Voltage	90 – 240 V~
AC Power Input Frequency	50 - 60 Hz
Power Consumption	15 W maximum
AC Power Inlet Type	Note: Use only 4501A-15 power supplies in the 4415A IEC 60320 sheet C14 DC input power supply
AC Power Supply Cord Set	18 AWG (0.75 mm^2 minimum)
AC Power Mains Fuse	2 - 250V~1A slo blo 5x20 mm.
1 PPS Signal Input	■ Impedance: 50 Ω ■ CMOS 0-3.3 V or 0-5V
Connectors	■ Output: 9 TNC, six sinewave, three TTL ■ Network: RJ-45 ■ 1 PPS Input: TNC
Output Voltage	■ 3 dBm +/- 0.5 dBm into 50 ohms (Sinewave Outputs) ■ TTL compatible into 50 ohms (Square Wave Outputs)

Table 3:

Item	Specification
Frequency Accuracy (after 24 hours)	■ +/-(1 x 10E-9) per year
Manual Trim Range	■ +/-(1 x 10E-9) minimum
10 MHz output stability	■ Short Term (100 seconds): 1 x 10^{-12} to 3 x 10^{-12} ■ Long Term (1 month): 1 x 10^{-11} Typical ■ 10% VAC change: 1 x 10^{-11} ■ Temperature (-10º to +55º C): 1 x 10^{-10}
SSB Phase Noise (Measured)	■ 1 Hz Offset <= -115 dBc/Hz ■ 10 Hz Offset <= -140 dBc/Hz ■ 100 Hz Offset <= -160 dBc/Hz ■ 1 kHz Offset <= -168 dBc/Hz ■ 10 kHz Offset <= -170 dBc/Hz ■ 100 kHz Offset <= -170 dBc/Hz ■ 1 MHz Offset <= -170 dBc/Hz
Spurious (Non-power line related)	■ <-137 dBc at offsets =+/-300 Hz, except <-134 at 20 Hz and <-130 at 60 Hz
Harmonic Distortion	■ <-40 dBc
Warm-Up Time to Lock (max. time required for frequency to lock to the atomic resonance frequency)	■ <= 5 minutes at 25º C
MTBF	■ 114,687 Hours Calculation Model: MIL-HDBK-217 FN2 Calculation Method: Method I Case 3 using MIL-HDBK-217 FN2, Method I Case 3, at 30C operating temperature

A.4 Environment Specifications

Warning

This unit is for **INDOOR USE ONLY.** It is not protected against a harmful ingress of moisture.

- Pollution Degree II per EN61010-1
- Installation (Over-Voltage) Category II for transient over-voltages per EN 61010-1
- Equipment suitable for continuous operation

Table 4 lists the environmental specifications for the 4415A.

Table 4: Environment specifications

Item	Temperature	Relative Humidity	Altitude
In Use	-10°C to +55°C	5% to 95% (non-condensing)	3,000 meters (9,843 feet)
Storage	-40°C to 71°C	5% to 95%	
Transportation	-40°C to 71°C	95%	

A.5 Physical Specifications

Table 5 lists the physical specifications for the 4415A.

Table 5: Physical specifications

Item	Specification
Width	Standard 19-inch rack mount
Height	Standard 1U
Depth	13.4 inches
Weight	15 pounds

Glossary

\n	Line feed
\r	Carriage return
CNR	Command and Response
DHCP	Dynamic Host Configuration Protocol
ESD	electrostatic discharge
LED	light-emitting diode
LSB	least significant bit
MSB	most significant bit
PDF	portable document format
PWA	printed wiring assembly
RF	radio frequency
TSC	Timing Solutions Corporation

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