Symmetricom

5401 Airborne Disciplined Rubidium Oscillator
5402 Disciplined Rubidium Oscillator

Operating Manual

Preliminary Rev. A, May 2005

PN 8500-0150

Symmetricom, Inc.
2300 Orchard Parkway
San Jose, CA 95131-1017
U.S.A.

http://www.symmetricom.com

Copyright © 1999–2005 Symmetricom, Inc.
All rights reserved. Printed in U.S.A.
This manual is provided to assist the user in the operation and maintenance of the supplied equipment or software. It is recognized that multiple copies may be required to support even a single unit, and for this reason, permission is hereby granted to reproduce the supplied manual for the purpose stated above, provided that this notice is included as part of the copy. Additional copies are also available from Symmetricom for a nominal fee.
In no case, however, does the supply of this manual or the granting of rights to reproduce the manual, grant any rights to use information contained within to reproduce the supplied equipment or software, either in whole or in part.
The equipment or software described in this manual have been developed solely at the expense of Symmetricom and are proprietary. No unlimited rights in technical data are granted. Limited rights as per DFARS 252.227-7013 shall be effective for 10 years from the copyright date.

All product names, service marks, trademarks, and registered trademarks used in this document are the property of their respective owners.

Preface

Limited Warranty

Each new product manufactured by Symmetricom is warranted for defects in material or workmanship for a period of one year from date of shipment (“Limited Warranty”). Defects in material or workmanship found within that period will be replaced or repaired, at Symmetricom’s option, without charge for material or labor, provided the customer returns the equipment, freight prepaid, to the Symmetricom factory under this limited warranty. Symmetricom will return the repaired equipment, freight prepaid, to the customer’s facility. This one year Limited Warranty does not apply to any software or to any product not manufactured by Symmetricom.

If on-site warranty repair or replacement is required, the customer will be charged the then current field service rate for portal-to-portal travel time plus actual portal-to-portal travel charges. There is no charge for on-site warranty repair labor.

Products not manufactured by Symmetricom, but included as integral part of a system (e.g., peripherals, options), are warranted for 90 days, or longer as provided by the original equipment manufacturer, from date of shipment.

Aside from the Limited Warranty set forth above, Symmetricom makes no other warranties, express or implied, of merchantability, fitness for purpose or of any other kind or description whatsoever.

By purchasing any product manufactured by Symmetricom, the buyer consents to and agrees with Symmetricom that as a result of the exclusion of all warranties, expressed or implied, of merchantability, fitness for purpose, or otherwise, except for the limited one-year warranty for defects in material and workmanship for products manufactured by Symmetricom, that the Buyer has the sole responsibility to assess and bear all losses relating to (1) the ability of the product or products purchased to pass without objection under the contract description among merchants and buyers in the trade; (2) the conformity of the product or products to fair average quality within its contract description; (3) the fitness of the product for the ordinary purposes for which such product is used; (4) the consistency of quality and quantity within each unit of product or products and among all units involved; (5) the adequacy of containers, packaging and labeling of the product or products; (6) the conformity of the product, promises or affirmations of fact (if any) made on its label or container; and (7) the conformity of the product to standards of quality observed by other merchants in the trade with respect to products of similar description.

Limitation of Liability

By purchasing any product from Symmetricom, the Buyer consents to and agrees that the Buyer's sole and exclusive remedy for any damages or losses incurred by the Buyer as a result of Symmetricom's breach of its one-year Limited Warranty for defects in materials and workmanship or otherwise in connection with any claim respecting the product shall be limited to the repair or replacement of the product or a refund of the sales price of the product. In no event shall the Buyer be entitled to recover consequential damages or any other damages of any kind or description whatsoever.

Proprietary Notice

This document, whether patentable or non-patentable subject matter, embodies proprietary and confidential information and is the exclusive property of Symmetricom, Inc. It may not be reproduced, used or disclosed to others for any purpose except that for which it is purchased or loaned.

Where to Find Answers to Product and Document Questions

For additional information about the products described in this guide, please contact your Symmetricom representative or your local sales office. You can also contact us on the web at www.symmetricom.com.

Warnings, Cautions, Recommendations, and Notes

Warnings, Cautions, Recommendations, and Notes attract attention to essential or critical information in this guide. The types of information included in each are explained in the following examples.

Warning: To avoid serious personal injury or death, *do not* disregard warnings. All warnings use this symbol. Warnings are installation, operation, or maintenance procedures, practices, or statements, that if not strictly observed, may result in serious personal injury or even death.

Caution: To avoid personal injury, *do not* disregard cautions. All cautions use this symbol. Cautions are installation, operation, or maintenance procedures, practices, conditions, or statements, that if not strictly observed, may result in damage to, or destruction of, the equipment. Cautions are also used to indicate a long-term health hazard.

ESD Caution: To avoid personal injury and electrostatic discharge (ESD) damage to equipment, *do not* disregard ESD cautions. All ESD cautions use this symbol. ESD cautions are installation, operation, or maintenance procedures, practices, conditions, or statements that if not strictly observed, may result in possible personal injury, electrostatic discharge damage to, or destruction of, static-sensitive components of the equipment.

Electrical Shock Caution: To avoid electrical shock and possible personal injury, do not disregard electrical shock cautions. All electrical shock cautions use this symbol. Electrical shock cautions are practices, procedures, or statements, that if not strictly observed, may result in possible personal injury, electrical shock damage to, or destruction of components of the equipment.

Recommendation: All recommendations use this symbol. Recommendations indicate manufacturer-tested methods or known functionality. Recommendations contain installation, operation, or maintenance procedures, practices, conditions, or statements, that provide important information for optimum performance results.

Note: All notes use this symbol. Notes contain installation, operation, or maintenance procedures, practices, conditions, or statements, that alert you to important information, which may make your task easier or increase your understanding.

Conventions Used in This Guide

This guide uses the following conventions:

- **Acronyms and Abbreviations** – Terms are spelled out the first time they appear in text. Thereafter, only the acronym or abbreviation is used.
- **Revision Control** – The title page lists the printing date and versions of the product this guide describes.

Table 1 **Typographical Conventions** – This guide uses the typographical conventions described in Table 2.

Table 2 Typographical Conventions

When text appears this way...	... it means:
SSU-2000 User's Guide	The title of a document.
SSU CRITICAL IOC1	An operating mode, alarm state, status, or chassis label.
Select **File**, **Open**...	Click the Open option on the File menu.
Press **Enter** Press **;**	A named keyboard key. The key name is shown as it appears on the keyboard. An explanation of the key's acronym or function immediately follows the first reference to the key, if required.
SSU `Username:`	Text in a source file or a system prompt or other text that appears on a screen.
`PING` `STATUS`	A command you enter at a system prompt or text you enter in response to a program prompt. You must enter commands for case-sensitive operating systems exactly as shown.
A *re-timing* application	A word or term being emphasized.
Symmetricom ***does not*** recommend...	A word or term given special emphasis.

Preface

1 — Introduction

2 —Installation

3 —Operation

4 —Specifications

1 — Introduction

Product Overview

The purpose of the Symmetricom 5401 Airborne Disciplined Rubidium and 5402 Disciplined Rubidium Oscillator (DRO) is to provide a precise time and frequency reference for other equipment. The DRO will base this reference on a precise 1 PPS input, typically from a GPS Receiver. At the 1 PPS time signal input rollover, the DRO will measure the time difference between it and the internal Rubidium oscillator. It will continuously correct the oscillator error, smooth the GPS Receiver noise due to ephemeris and time switching errors, and provide smoothed, coherent 1 PPS time reference and a 10 MHz frequency reference signal outputs.

The DRO contains a Low Profile Rubidium Oscillator (LPRO) that is controlled by a High Resolution Disciplining assembly along with the necessary Power Supply, Buffers and Distribution Amplifiers.

The High Resolution Disciplining assembly contains the logic to discipline the Rubidium oscillator to an external 1 PPS input. This assembly also contains a 10 MHz oven oscillator that is phase locked to the Rubidium. This provides a source for low noise 10 MHz sine wave outputs.

Two 3 Channel Distribution Amplifiers are provided to output six (6) 10 MHz sine wave outputs. A 1 PPS Buffer generates six (6) 1 PPS outputs.

The DRO also has an RS232 I/O port that is used for setup, control, and to output the unit's status.

Except for the power supplies, the 5401 and 5402 are electrically identical. The power and serial RS-232 connectors are different as are the signal input and output connectors. Refer to Figure 1 and Figure 2 for illustrations of the two configurations of the DRO. Details are given in Chapter 4.

In this Operating Manual, the term "DRO" is used when the information applies equally to both the Symmetricom 5401 and the Symmetricom 5402.

Symmetricom 5401 Airborne Disciplined Rubidium Oscillator

The Symmetricom 5401 is built in an airborne package that is powered by standard aircraft power (+28 VDC) and is installed by mounting the chassis on a flat base plate. Refer to Chapter 4 for complete specifications.

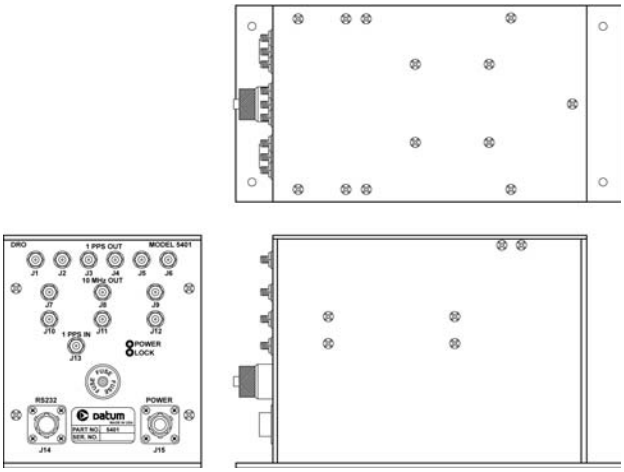


Figure 1 Symmetricom 5401 3-View

Symmetricom 5402 Disciplined Rubidium Oscillator

The Symmetricom 5402 is built in a standard rack mount configuration that is powered by commercial power anywhere in the world (85 to 264 VAC). The unit is designed to be installed in a standard 19-inch RETMA electronic enclosure. Chassis slides are recommended for support.

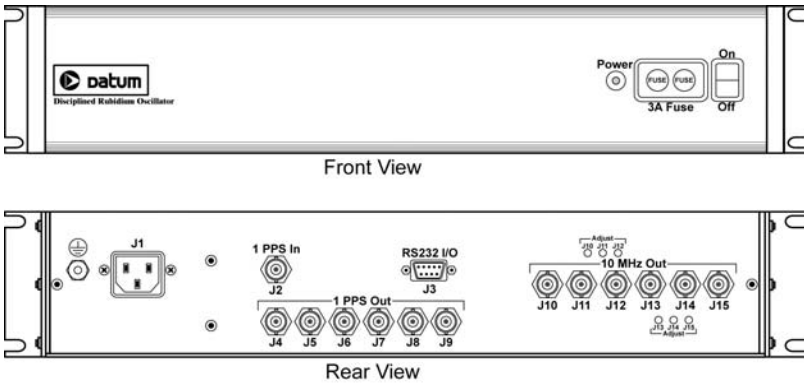


Figure 2 Symmetricom 5402 2-View

2 — Installation

Installation

This section describes the unpacking, inspection, installation, and operation of the Symmetricom 5401 and 5402 Disciplined Rubidium Oscillators.

Unpacking and Inspection

The DRO is packaged in one shipping container. Inspect the unit for visible damage (scratches, dents, etc.). If the instrument is damaged, immediately notify both Symmetricom and the responsible carrier. Keep the shipping container and packing material for the carrier's inspection.

Note: When communicating with either Symmetricom or the responsible carrier regarding shipping damage, refer to the serial number. This number is located on the front panel of the 5401 and the rear panel of the 5402.

Symmetricom 5401 Installation Procedure

1. Install the unit in the desired location and connect the unit to its power source. Refer to Chapter 4 for specifications and connector pin assignments.

2. Connect the 1 PPS input to its 1 PPS source and connect the 1 PPS and 10 MHz outputs to their desired destinations.

Connection to the RS-232 I/O is not necessary for operation, but it is desirable in order to monitor status or enter new control parameters.

Symmetricom 5401 Initial Operation

Upon completion of the installation:

1. Apply power to the unit and observe that the green POWER LED indicator illuminates. Note that this unit does NOT contain a power switch.

2. After approximately five minutes, the yellow LOCK LED indicator will illuminate indicating that the internal Rubidium oscillator has attained lock (resonance). The 10 MHz outputs are now stable for use. Disciplining of the Rubidium oscillator will begin once a 1 PPS input is present.

The 5401 is now operational and will begin to discipline the Rubidium using the control parameters that were previously stored in battery-backed RAM when the unit was last powered-down.

Symmetricom 5401 Adjustments

The amplitude of each of the 10 MHz outputs can be individually adjusted with potentiometers located on the 3-Channel Distribution Amplifier (Assembly 35039).

In order to gain access to these adjustments, do the following: (The 5401 is viewed from the rear.)

1. Remove the screws that secure the left side panel to the unit. Remove the side panel.

2. Remove the screws that secure the back panel to the unit, including the capacitor bracket.

The two Distribution Amplifiers (Assembly 35039) are located one on top of the other, as shown in Figure 3 below.

- On the top amplifier, R1 adjusts the output on front panel SMA J7.
- On the top amplifier, R18 adjusts the output on front panel SMA J8.
- On the top amplifier, R22 adjusts the output on front panel SMA J9.
- On the bottom amplifier, R1 adjusts the output on front panel SMA J10.
- On the bottom amplifier, R18 adjusts the output on front panel SMA J11.
- On the bottom amplifier, R22 adjusts the output on front panel SMA J12.

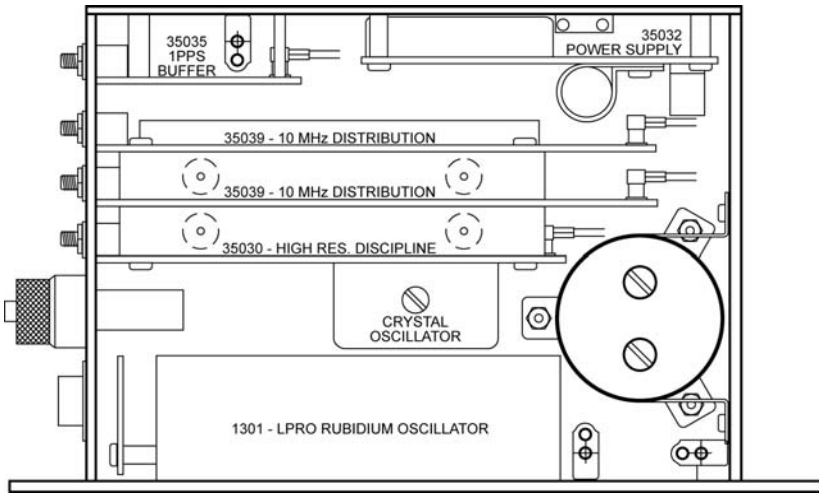


Figure 3 5401 Adjustment Locations

Symmetricom 5402 Rack Mounting Procedure

The 5402 is designed for standard nineteen-inch rack mounting.

Optional chassis slides are recommended if the unit is to be installed in an equipment rack. If slides are not used, a supporting bar or tray should be provided for the rear of the instrument. The chassis slides attach to the sides of the 5402. To mount the slides, use six # 8/32 screws, 1/2 inch long (three on each side).

Caution: If the 5402 is mounted in a rack by merely attaching the front panel to the RETMA rails, with no rear chassis support, the front panel will warp and eventually break. General Cautions/Hazards to be considered when installing the 5402 Timing Unit into an equipment rack include:

TMRA - The maximum recommended ambient temperature (TMRA) that this equipment is specified to operate in is 50ºC.

Elevated Operating Ambient Temperature - If installed in a closed or multi-unit rack assembly, the operating ambient temperature of the rack environment may be greater than room ambient. Therefore, consideration should be given to installing the equipment in an environment compatible with the maximum rated ambient temperature (TMRA).

Reduced Air Flow - The equipment has no cooling fans and depends on convection for cooling. Installation in a rack may cause an excessive heat rise if sufficient air flow is not available. Installation should be such that the amount of air flow required for safe operation of the equipment is not compromised.

Mechanical Loading - Mounting of the equipment in the rack should be such that a hazardous condition is not achieved due to uneven mechanical loading.

Circuit Overloading - Consideration should be given to the connection of the equipment to the supply circuit and the effect that overloading of circuits might have on over current protection and supply wiring. Appropriate consideration of equipment nameplate ratings should be used when addressing this concern.

Reliable Earthing - Reliable earthing of rack-mounted equipment should be maintained. Particular attention should be given to supply connections other than direct connections to the branch circuit (e.g., use power strips).

Symmetricom 5402 Installation Procedure

1. Install the unit in the desired location and connect the unit to an AC power source. Refer to Chapter 4 for specifications and connector designations and locations.

2. Connect the 1 PPS input to its 1 PPS source and connect the 1 PPS and 10 MHz outputs to their desired destinations.

Connection to the RS232 I/O is not necessary for operation, but it is desirable in order to monitor status or enter new control parameters.

Symmetricom 5402 Initial Operation

Upon completion of the installation:

1. Apply power to the unit by turning on the front panel ON/OFF power switch. Observe that the green POWER LED indicator illuminates.

2. After approximately five minutes, the internal Rubidium oscillator will have attained lock (resonance). The 10 MHz outputs are now stable for use. Disciplining of the Rubidium oscillator will begin once 1 PPS input is present.

The 5402 is now operational and will begin to discipline the Rubidium using the control parameters that were previously stored in battery-backed RAM when the unit was last powered-down.

Symmetricom 5402 Adjustments

The amplitude of each of the 10 MHz outputs can be individually adjusted with potentiometers located on the 3 Channel Distribution Amplifier (Assembly 35039). Access to these potentiometers is through holes in the rear panel. Each hole (and its associated potentiometer) is clearly labeled as to which output it adjusts. See Figure 4 for the location of the adjustments.

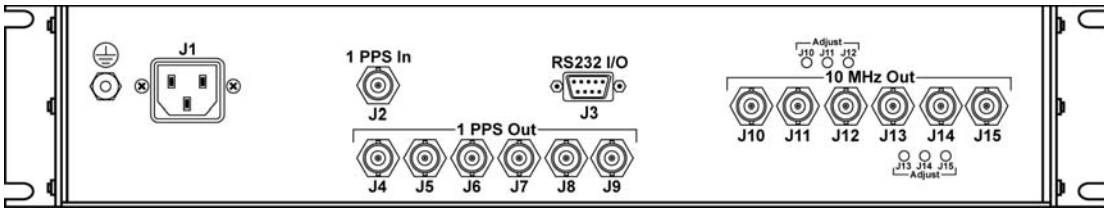


Figure 4 Symmetricom 5402 Rear Panel

3 — Operation

Neither the 5401 nor the 5402 have any external manual controls. Signal output amplitude is controlled by internal potentiometers, which are located as described in Chapter 2. All operational control of the DRO is accomplished by means of an RS-232 input/output port.

RS-232 Input/Output

The DRO has been equipped with an RS-232 interface using a 13-pin MS type connector designated as J14 RS232 on the 5401, and using a DB15 connector designated as J3 on the 5402. This serial port can be used to communicate with the DRO from a computer or a 'smart terminal.' All communication is in the ASCII format. The standard character protocol is 9600 BAUD, one start bit, eight data bits, none for parity, and one stop bit.

The connector pin assignments and designations for both connectors are given in Chapter 4.

All communication to the DRO comprises two or three categories of characters. The first category is a single character which is always an ASCII $ (Hex 24). This is the attention/log-on character. The second category is an ID ASCII character which is a command to the unit. The third category (which may or may not be applicable) is a series of ASCII data bits to input data into the DRO. Leading zeros must be used where necessary. For example, if the number to be input is fifty-two, and if the data field is a four digit number, then it must be entered as 0052.

If a mistake is made while inputting new characters (prior to the last character), issuing the "$" character will cause a reset, and the new (correct) characters can be input.

All command message inputs and response outputs end with Carriage Return (CR), Line Feed (LF).

When burst status is on, the unit will not send a response. However, configuration parameters can still be changed.

Table 1 on page 8 shows the functions available. The ASCII character is shown followed by its HEX equivalent. Comments pertaining to that specific function are also included for clarity.

Table 1 DRO Commands Via RS-232

Function	Char	Hex	Comments
Status Request	$K	4B	Rb lock, Disc On/Off, 1PPS present, 1 PPS valid, TI, Running Time, DAC, Temp, Dynagain.
Discipline Off	$t	74	Turn discipline on.
Discipline On	$s	73	Turn discipline off.
Dynamic Gain Control	$J	4A	Enter floor, ceiling for Dynagain.
Enter Km	$L	4C	Base number for Km.
Enter Ko1, Ko2	$M	4D	Base number for Ko.
Enter Disgain	$A	41	Base number for Disgain.
Enter Resync Threshold	$B	42	A resync will occur if this number is exceeded.
Enter Resync Delay	$C	43	Number of consecutive seconds that delta-TI <= thres for discipline and resync to occur.
Enter Rate Threshold	$U	55	If the offset rate exceeds, then do not change discipline.
Burst Status On	$D	44	Burst every 1PPS Ext. or at .2 seconds past. Status request.
Burst Status Off	$E	45	Turn burst off.
Request TI	$u	75	Time, TI.
Enter DAC Value	$~	7E	Enter new DAC value.
Request Firmware	$`	60	Request firmware version and revision.
Enter Start-up Parameters	$F	46	During start-up dynamic gain is not automatic. Enter six dynagain values and times.
Request Start-up parameters	$G	47	Request one entry from the start-up table.
Cal Unit	$H	48	Disc off. Switch to the 2.5 volt input threshold, calibrate unit by setting fudge factor to measured TI, switch back to the original input threshold.
Set Defaults	$X	58	Defaults to all operational and start-up parameters.
Enter 1PPS Offset*	$I	49	Extra amount to be added to the Cal Value. And resync side load.
Request Setup	$N	4E	Km, Ko1, Ko2, disgain, Floor, Ceiling, rate thres, offset thres, resync threshold, resync delay, Input thres, Programmagle delay, Osc Range.
Input Threshold High/Low	$P	50	High 5 volt thres, Low 2.5 volt thres.
Enter Programmable Delay Value	$Q	51	Factory default set @ 136. Adjusts the 1PPS to be in phase with the 10MHz.
Enter Osc Control Range*	$R	52	Frequency control range from 0 to 65,535 DAC counts.
Design Verify On/Off	$S	53	Adds Filtered Rate and Filtered Offset to Status Request command.
Cal Status	$T	54	Reports if calibration is active or inactive.
Estimated Filter Time Constant	$V	56	Set time constant for Filtered Rate and Filtered Offset
Enter Dynamic Gain Factors	$Y	59	Dynagain rate factor and offset factor.

Status Request

Command Format:

S	K	C	L
		R	F

Description:

Rx - Rubidium lock; x=0 not Locked, x=1 Locked

Dx - Discipline On/Off; x=0 discipline off, x=1 discipline on

Px - 1 PPS input present; x=0 not present, x=1 present

Vx - Valid 1 PPs; x=0 unstable, x=1 stable. Time change in the 1 PPS is less than the rate threshold.

Tttttt.ttt - Time Interval; ttttt.ttt is the time interval (0 to 999999.999 microseconds) of the last 1 PPS event.

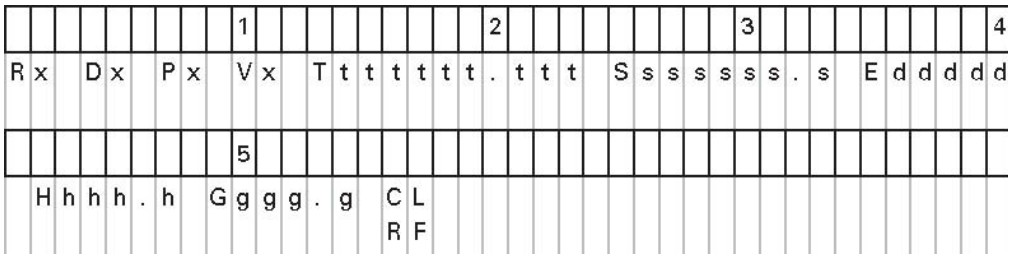
Sssssss.s - Seconds Counter; ssssss.s is the second count (0 to 999999.9 seconds) since the unit has been turned on. The count will roll over to zero when maximum is reached.

Eddddd - DAC value; ddddd is the DAC value (0 to 65535), and is proportional to the voltage applied to the oscillator.

Hhhh.h - Temperature count; hhh.h is the dithered temperature sensor value.

Ggg.g - Dynamic Gain; gg.g is the current value being used in the disciplining algorithm for dynamic gain.

Response Format:



Discipline Off

Command Format:

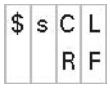
Description:

The oscillator discipline is turned off. The Rubidium control voltage (DAC value) will remain constant.

Response Format:

Discipline On

Command Format:



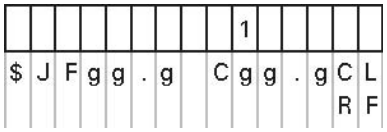
Description:

The oscillator discipline is turned on. When the conditions are favorable, the discipline algorithm will control the oscillator.

Response Format:

Dynamic Gain Control

Command Format:



Description:

The dynamic gain value determines the response time of the control loop. This command sets the upper and lower limit.

Fgg.g - Dynamic Gain Floor; the lowest value allowed for dynamic gain.

Cgg.g - Dynamic Gain Ceiling; the highest value allowed for dynamic gain.

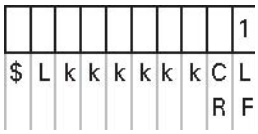
With the default values for Km, Ko1, Ko2, and Disgain, the dynamic gain will produce the following approximate time constants in the discipline control loop:

Dynamic Gain	Time Constant
4	90 minutes
5	70 minutes
8	45 minutes
10	35 minutes
20	17 minutes
30	11 minutes

Response Format:

Enter KM

Command Format:



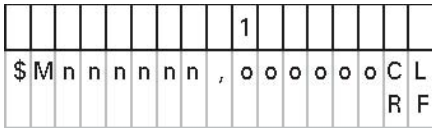
Description:

kkkkkk - Base number for Km; kkkkkk (000000 to 999999) represents a number from 0 to 0.999999. Km controls the mix ratio of offset error and frequency error compensation in the discipline algorithm.

Response Format:

Enter KO1, KO2

Command Format:



Description:

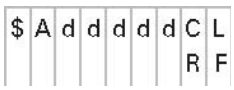
nnnnnn - Base number for Ko1; nnnnnn (000000 to 999999) represents a number from 0 to 0.999999. Ko1 controls the cut off frequency of the offset error noise filter.

oooooo - Base number for Ko2; oooooo (000000 to 999999) represents a number from 0 to 0.999999. Ko2 controls the cut off frequency of the frequency error noise filter.

Response Format:

Enter Disgain

Command Format:



Description:

ddddd - Base number for Disgain; ddddd (00000 to 99999) controls gain common to both the offset error and the frequency error paths of the discipline loop.

Response Format:

Enter Resync Threshold

Command format:

Description:

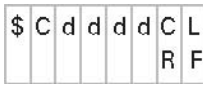
rrrrrr.rrr - Resync Threshold; rrrrrr.rrr (microseconds) is the limit value that determines if a resync will occur when disciplining restarts. A resync will always be occur after power up.

Response Format:

Enter Resync Delay

When the 1 PPS In is lost or becomes invalid (rate threshold is exceeded), the unit is placed into a holdover mode. It remains in this mode until the 1 PPS In is valid for a time period (in seconds) determined by "Resync Delay". At five seconds before discipline restarts, a determination is made as to whether the 1 PPS Out will be resynchronized (jammed). This is based on the "Resync Delay". Refer to the Discipline Sequence flowchart in Figure 5.

Command Format:



Description:

dddd - Resync Delay; dddd (5 to 9999 seconds) is the number that determines how long the 1 PPS needs to be valid before disciplining starts.

Response Format:

Enter Rate Threshold

Command Format:

Description:

rrrrrr.rrr - Rate Threshold; rrrrrr.rrr (0 to 999999.999 microseconds) is the limit value that determines if the 1 PPS input is valid. When the 1 PPS is invalid, the DAC value will not change. The unit enters holdover. Holdover is exited when the "Resync Delay" requirements have been met.

Response Format:

O	K	C	L
		R	F

Burst Status On

Command Format:

$	D	C	L
		R	F

Description:

Status will be output every second.

Response Format:

O	K	C	L
		R	F

Burst Status Off

Command Format:

$	E	C	L
		R	F

Description:

Turns burst status off.

Response Format:

No Response. When burst is on.

When burst is off:

O	K	C	L
		R	F

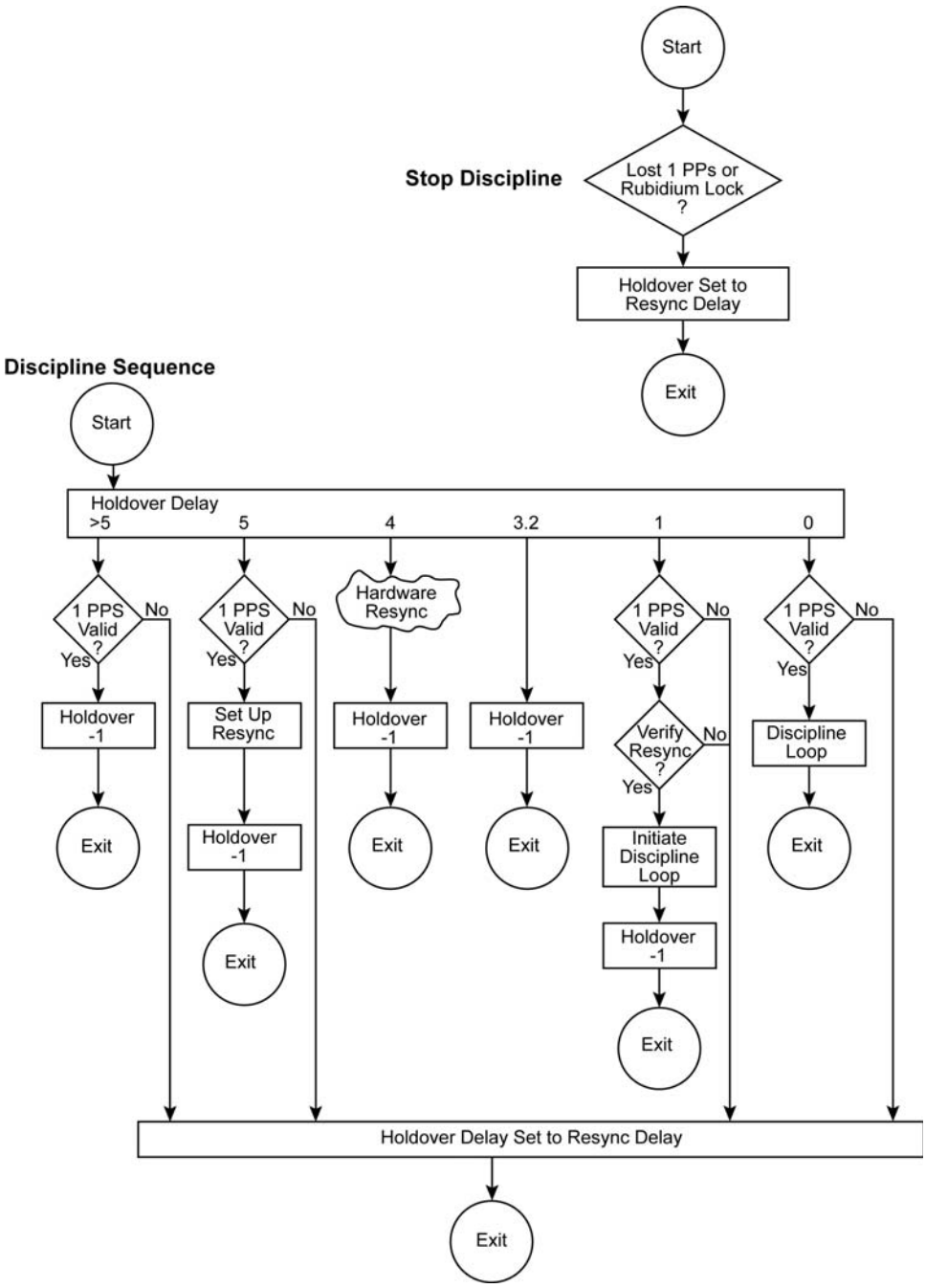
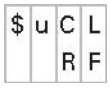


Figure 5 DRO Discipline Sequence Flowchart

Request TI

Command Format:

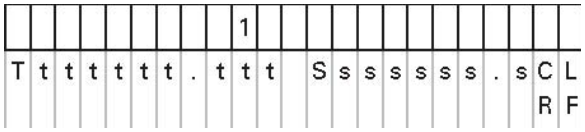


Description:

Ttttttt.ttt - Time Interval; ttttt.ttt is the time interval (0 to 999999.999 microseconds) of the last 1 PPS event.

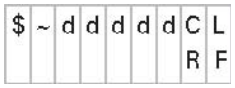
Sssssss.s - Seconds Counter; ssssss.s is the second count (0 to 999999.9 seconds) since the unit has been turned on. The count will roll over to zero when maximum is reached.

Response Format:



Enter DAC Value

Command Format:



Description:

ddddd - DAC Value; ddddd (0 to 65535 counts) controls the frequency of the oscillator.

Response Format:

Request Firmware Version

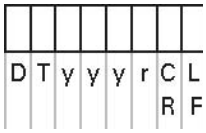
Command Format:

Description:

DTyyy - Firmware Number.

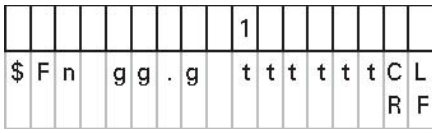
r - Revision Letter of Firmware.

Response Format:



Enter Start-up Parameters

Command Format:



Description:

n - Start-up Index; n (1 to 6) selects which one of 6 elements in the start-up table that will be modified.

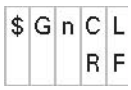
gg.g - Dynamic Gain Value; gg.g (0 to 99.9) represents the dynamic gain value that will be used during start-up for element "n".

tttttt - End Time; tttttt is the end time of element "n" (based on Rubidium lock). The next element in the start-up table will be used after this time.

Response Format:

Request Start-up Parameters

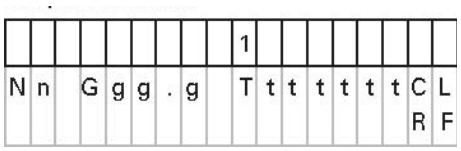
Command Format:



Description:

n - Start-up Index; n (1 to 6) selects which one of 6 elements in the start-up table that will be reported.

Response Format:



Description:

Nn - Start-up Index; n (1 to 6) identifies which one of 6 elements in the start-up table was reported.

Ggg.g - Dynamic Gain Value; gg.g (0 to 99.9) represents the dynamic gain value that will be used during start-up for element "n".

Tttttt - End Time; tttttt is the end time of element "n". The next element in the start-up table will be used after this time. The time is the number of times the discipline loop has been run. Using a time of "000000" will cause that element to be skipped.

Note: If element 1 is used (not 000000), then a 1 PPS resync will occur before element 2 starts. After all 6 elements have been completed, and before normal operation begins, the discipline filter will be reinitialized.

Calibrate Unit

Command Format:

Description:

Commands a self-calibration. Before commanding a Self-Cal, connect one of the 1 PPS outputs to the 1 PPS input using a short coax cable. The unit will be set to provide an output 1 PPS based on the electrical length of the cable used to connect the output to the input. The maximum cable delay is limited to 1 microsecond.

Note: The "Calibrate Status" command should be used to verify that the calibration has completed (takes several minutes). The programmable delay value, that controls the phase relationship of the 1 PPS to the 10 MHz, should be set prior to running "Calibrate Unit".

Response Format:

Set Defaults

Command Format:

Description:

Returns the unit to a default state.

Table 2 Default Values

Parameter	Default Value
Discipline	On
Dynamic Gain Floor	4
Dynamic Gain Ceiling	30
Dynamic Gain Rate Factor	0.0005 ns
Dynamic Gain Offset Factor	5.0 ns
Km	0.99997
Ko1	0.99984
Ko2	0.99984
Disgain	1280
Resync Threshold	1 μs
Resync Delay	60 seconds
Rate Threshold	0.04 μs
Burst	On
DAC	32767
Start-up Parameters	See Note 1: Start-up Parameters, on page 20.
Default Calibrate Unit (Cable Delay)	0
1PPS Offset	0
Input Threshold	High
Programmable Delay Value	036
Oscillator Control Range	5e-9
Design Verification	Off
Rate Error TC	0.9995
Offset Error TC	0.9995

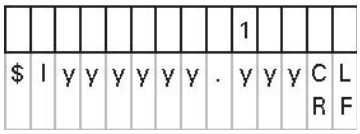
Note 1: Start-up Parameters

N	Dynamic Gain	Time
1	.1	360
2	99	1140
3	60	1740
4	30	2760
5	20	0
6	11	0

Response Format:

Enter 1 PPS Offset (not implemented)

Command Format:



Description:

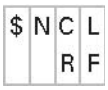
yyyyyy.yyy - 1 PPS Offset; yyyyyy.yyy (0 to 999999.999 microseconds) is amount of extra delay applied to the 1 PPS output. It is added to the unit zero point and the resync side load value.

Note: There is a hardware limitation on the resync control of approximately ±12 microseconds. Any 1 PPS offset values outside of this range will change the zero point but not the resync value.

Response Format:

Request Setup Parameters

Command Format:



Description:

In Table 3 is a list of the data found in the response. The data is in the same format as the associated "Enter" command. A space exists between each of the parameters, except where noted. The total count is 176 characters.

Table 3 Response Format

Variable	Return String	Count	First
Dynamic Gain Floor	DFgg.g	6	1
Dynamic Gain Ceiling	DCgg.g	6	8
Dynamic Gain Rate Factor	DRrr.rrrr (in nanoseconds)	9	15
Dynamic Gain Offset Factor	DOoooo (in nanoseconds)	5	25
Km	KM.kkkkkk	9	31
Ko1	KO1.nnnnnn	10	41
Ko2	KO2.oooooo	10	52
Disgain	DGdddddd	7	63
Resync Threshold	RTrrrrrr.rrr (in microseconds)	12	71
Resync Delay	RDdddd (in microseconds)	6	84
Rate Threshold	RArrrrrr.rrr (in microseconds)	12	91
Burst	BUx (x = 0 = Off, x =1 = On)	3	104
Default Calibrate Unit	CZrr.rrrr (in microseconds)	9	108
1PPS Offset	POyyyyyy.yyy (in microseconds)	12	118
Input Threshold	ITx (x = 0 = High, x = 1 = Low)	3	131
Programmable Delay Value	PDddd	5	135
Oscillator Control Range	ORsrr.rrrr (in microseconds)	10	141
Design Verification	DVx (x = 0 = Off, x = 1 = On)	3	152
Rate Error TC	RCnnnnnn	8	156
Offset Error TC	Ocoooooo (no space here)	8	165
	CR LF	2	174

Input Threshold High/Low

Command Format:

$	P	x	C R	L F

Description:

The input 1 PPS can be sliced at two deferent levels. This command selects which slicing level is used. x=0 - High 5 volt input threshold, x=1 - Low 2.5 volt input threshold.

Response Format:

O	K	C R	L F

Enter Programmable Delay Value

Command Format:

$	Q	y	y	y	C R	L F

Description:

The yyy is a number from 000 to 255. The number is the delay value sent to a programmable delay. The programmable delay moves the 1 PPS outputs and allows them to be aligned to the 10 MHz.

Response Format:

O	K	C R	L F

Enter Oscillator Control Range (not implemented)

Command Format:

										1	
$	R	s	r	r	.	r	r	r	r	C R	L F

Description:

The srr.rrrr is a number from -99.9999 to +99.9999 microseconds per second. The number is frequency change from DAC = 00000 to 65535 of the unit. This number is used in the discipline algorithm to help compensate for oscillators with different frequency

Note: It is assumed that the DAC output and oscillator control are linear. If not, then the oscillator control range should be extrapolated from a subset of the control curve that is near zero frequency error.

Response Format:

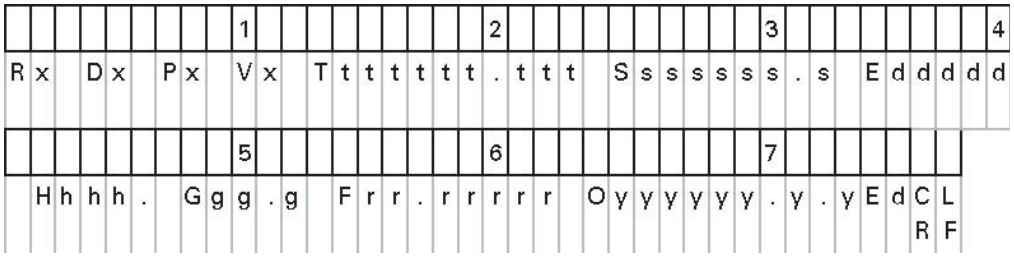
Design Verify On/Off

Command Format:

Description:

Determines whether filtered rate or filter offset is returned in a status request. When x = 0, the extra data is not included. When x = 1, the extra data is included.

The response to the status command is changed to the following:



Frr.rrrrrr - Filtered rate in microseconds; rr.rrrrrr is the an average frequency rate error calculated internally by the unit. This is one of the values used by the program to determine the dynamic gain.

Oyyyyyy.yyy - Filtered offset in microseconds; yyyyyy.yyy is the an average time error calculated internally by the unit. This is one of the values used by the program to determine the dynamic gain.

Response Format:

Cal Status

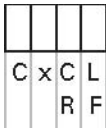
Command Format:

Description:

Cx - Calibration status:

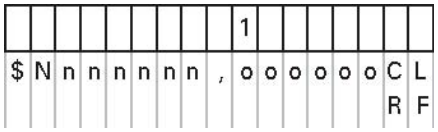
x = 0	not doing a calibration.
x = 1	calibration in progress.
x = ?	last calibration failed (no 1 PPS, cable missing, noisy 1 PPS, or wrong 1 PPS).

Response Format:



Enter Estimation Filter Time Constant

Command Format:



Description:

nnnnnn - Base number for the filtered rate exponential integrator; nnnnnn (000000 to 999999) represents a number from 0 to 0.999999.

oooooo - Base number for the filtered offset exponential integrator; oooooo (000000 to 999999) represents a number from 0 to 0.999999.

Response Format:

O	K	C R	L F

Enter Dynamic Gain Factors

Command Format:

								1						
$	Y	Y	r	r	.	r	r	r	r	O	o	o	o	C R	L F

Description:

Rrr.rrrr - Rate Factor; the normalizing value (in nanoseconds) for rate when calculating the next dynamic gain.

Oooo - Offset Factor; the normalizing value (in nanoseconds) for offset (TI) when calculating the next dynamic gain.

Response Format:

O	K	C R	L F

4 — Specifications

This section contains the electrical, physical, and environmental specifications for the 5401 and 5402 Disciplined Rubidium Oscillator.

Input Specifications and Characteristics

Table 4 Input Specifications and Characteristics

5401 DC Power Input (J15) Type	MS27499E10B5P
Connector Pin Assignments:	
Pin	**Function**
A	Rubidium Lock Status
B	Chassis Ground
C	Not Used
D	+28 VDC (+18 to +36 VDC) (Approximately 2.5 amps at initial turn-on and 1.4 amps after stabilization.)
E	Power Return
5401 Fuse	10 amp fast blow, 3 AG
5402 AC Power Input (J1) Type	IEC connector
Using the standard power supply:	
Input Voltage	5401: DC = +18 V to 36 VDC, MIL-STD-704 < 80 W (warmup) < 40 W (steady-state)
	5402: AC = 90 to 240 VAC (47-440 Hz) < 80 W (warmup) < 40 W (steady-state)
5402 Fuse	3 amp fast blow, Microfuse
DRO 1 PPS Input Type	5401: Isolated SMA (J13)
	5402: Isolated BNC (J2)
The 1 PPS input accepts a signal with the following characteristics:	
Level	TTL or +10 VDC ±1 VDC, selectable via RS-232
Rise Time	< 20 nanoseconds (10% to 90%)
Fall Time	< 1 microsecond (90% to 10%)
Pulse Width	20 nanoseconds to 100 microseconds
Input Impedance	50

Table 4 Input Specifications and Characteristics (Continued)

5401 RS-232 Input/Output Type	MS27499E10B35S
5401 Connector Pin Assignments:	
Pin	**Function**
1	Chassis Ground
2	Transmitted Data
3	Received Data
4	Signal Ground
5-13	Not Used
5402 RS232 Input/Output Type	DB9
5402 Connector Pin Assignments:	
Pin	**Function**
2	Transmitted Data
3	Received Data
5	Signal Ground
DRO RS-232 Parameters:	
Baud	9600
Parity	None
Word Length	8 Bits
Stop Bits	1

Output Specifications and Characteristics

Table 5 Output Specifications and Characteristics

DRO 1 PPS Output Type	5401: Isolated SMA (J1-J6)
	5402: Isolated BNC (J4-J9)
The DRO outputs 1 PPS signals with the following characteristics:	
Level	> 3 V peak into 50Ω (TTL-compatible)
Rise Time	5 nanoseconds (20% to 80%)
Fall Time	1 microsecond (90% to 10%)
Pulse Width	20 microseconds ±0.1 microseconds
Output Impedance	50Ω

Table 5 Output Specifications and Characteristics (Continued)

Coherence[a]	The 1 PPS OUT time delay is < 10 nanoseconds from the mean of the 1 PPS Input	
Port to Port Isolation	90 dB	
Isolation (with respect to 1 PPS input)	90 dB	
DRO 10 MHz Output Type	5401: Isolated SMA (J7-J12)	
	5402: Isolated SMA (J10-J15)	
The DRO outputs 10 MHz signals with the following characteristics (After a 30 minute warm-up at an ambient temperature of 25ºC):		
Level	1.6 to 3.0 volts peak-to-peak (adjustable)	
Output Impedance	50Ω	
Short Term Accuracy	3.0 x 10-11 RMS @ 1 second	
Long Term Accuracy	5 x 10-12 RMS @ 1000 seconds (while disciplining)	
Stability	2.5 x 10-12 Alan Deviation @ 100 seconds	
Quiescent Phase Noise	**Symmetricom 5401**	**Symmetricom 5402**
1 Hz	< –94 dBc/Hz	< –85 dBc/Hz
10 Hz	< –110 dBc/Hz	< –100 dBc/Hz
100 Hz	< –140 dBc/Hz	< –130 dBc/Hz
1000 Hz	< –147 dBc/Hz	< –140 dBc/Hz
10 kHz	< –152 dBc/Hz	< –145 dBc/Hz
Spurs	**Symmetricom 5401**	**Symmetricom 5402**
Harmonic	40 dBc	40 dBc
Non-Harmonic	50 dBc	50 dBc
Port to Port Isolation	> 99 dB	> 99 dB
Coherence	2 nanoseconds (zero crossing of the 10 MHz sine wave with respect to the rising edge of the 1 PPS output.)	

[a]The setup parameters have an effect on the coherence. Refer to the RS232 I/O description in Chapter 3. Port to Port Isolation 90 dB Isolation (with respect to 1 PPS input) 90 dB.

5401 Indicators (Front Panel)

Table 6 5401 Indicators (Front Panel)

Power (LED)	Indicates power applied to the unit (see Figure 6).
Lock (LED)	Indicates Rubidium Locked status (see Figure 6).

5402 Indicators (Front Panel)

Table 7 5402 Indicators (Front Panel)

Power (LED)	Indicates power applied to the unit (see Figure 7).

DRO Internal Time Bases

Table 8 DRO Internal Time Bases

LPRO (Low Profile Rubidium Oscillator)	
Output Waveform	10 MHz sine wave
Output Level	0.55 VRMS into 50
Output Impedance	50
Short Term Stability:	
t=1 second	2.5×10^{-11}
t=10 seconds	0.8×10^{-11}
t=100 seconds	0.25×10^{-11}
Aging	5×10^{-11}/month
Phase Noise:	
1 Hz	75 dBc/Hz
10 Hz	89 dBc/Hz
100 Hz	128 dBc/Hz
1000 Hz	140 dBc/Hz
10 kHz	147 dBc/Hz

Table 8 DRO Internal Time Bases (Continued)

Spurs:	
Harmonic	50 dBc
Non-Harmonic	90 dBc
Input Voltage Range	+19 to +32 VDC
Input Power (Quiescent)	13 watts @ 25ºC (+24 VDC)

10 MHz Oven Oscillator

Table 9 10 MHz Oven Oscillator

Output Waveform	10 MHz sine wave
Output Level	0.5 VRMS into 50
Output Impedance	50
Temperature Stability	±3 x 10-8 over a temperature range of –20ºC to +70ºC
Short Term Stability	
t=1 second	5×10^{-11}
Aging	5×10^{-10}/day, 1.5×10^{-7}/year
Phase Noise	
10 Hz	120 dBc/Hz
100 Hz	145 dBc/Hz
1000 Hz	160 dBc/Hz
10 kHz	165 dBc/Hz
50 kHz	168 dBc/Hz
Spurs	
Harmonic	20 dBc
Non-Harmonic	20 dBc
Input Voltage Range	+12 VDC
Input Power (Quiescent)	1.5 watts @ 25ºC

5401 Dimensions

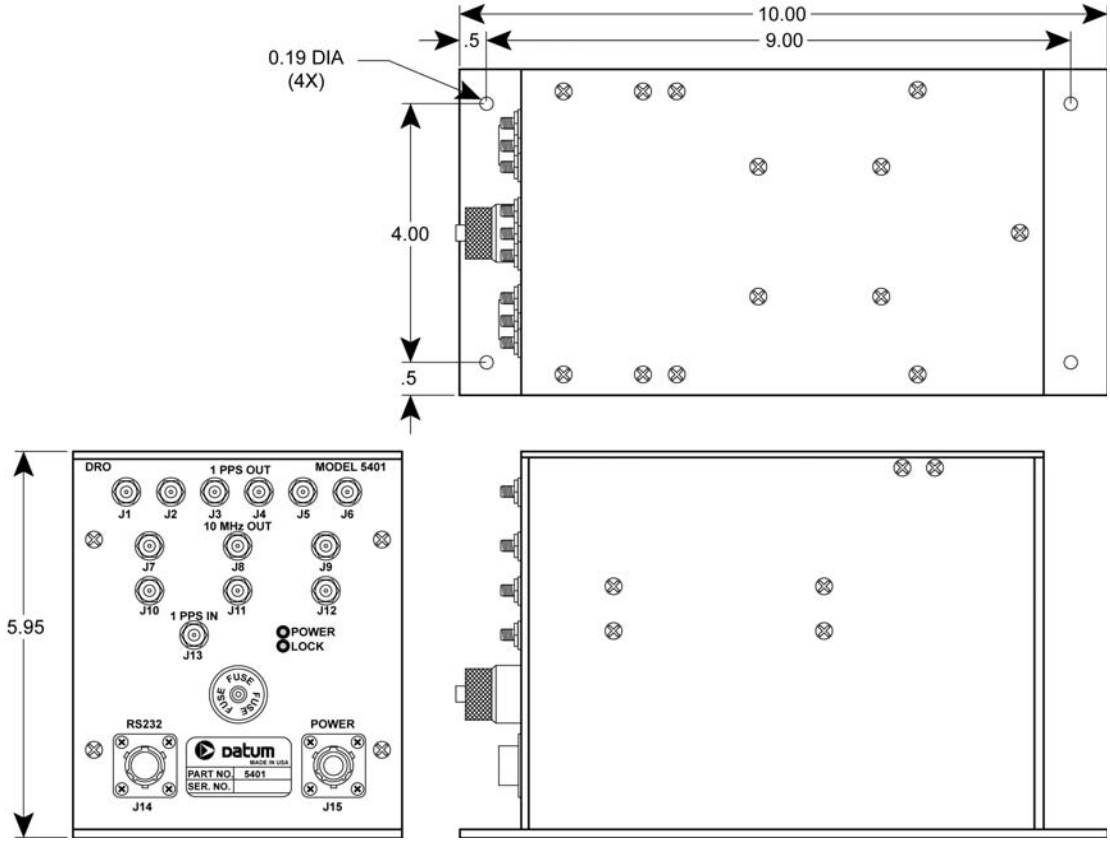


Figure 6 5401 Mounting Dimensions

5401 Weight

Approximately 8 pounds.

5402 Weight

Approximately 10 pounds.

5402 Dimensions

Height	1.75 inches
Width	17 inches (19 inches with mounting ears)
Depth	12 inches

Figure 7 5402 Front Panel

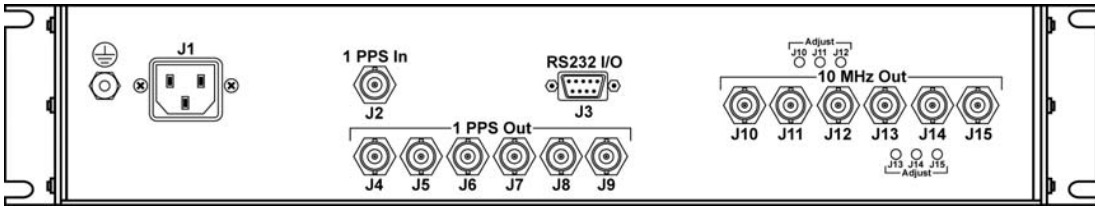


Figure 8 5402 Rear Panel

Environment

DRO Operating Temperature	–20ºC to +50ºC
DRO Operating Humidity	95% (non-condensing) up to 50ºC
EMI	FCC and CE (EN55022) Class B for Conducted and Radiated Emissions
Vibration (5401 only)	Operating: MIL-E-5400, per Curve IIA and IIIB (remains locked to 5G)
Crash Safety Shock (5401 only)	30 g's for 11 ms
MTBF:	100,000 hours