8130 Militarized Rubidium Frequency Standard

Symmetricom®

OPERATING MANUAL

8130A MILITARIZED RUBIDIUM FREQUENCY STANDARD

#14830-201, Rev C

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Chapter One

INTRODUCTION/PRODUCT OVERVIEW

This Operating Manual contains procedures and descriptive information for proper installation and operation of the Symmetricom 8130A Militarized Rubidium Frequency Standard.

OPERATING MANUAL SUMMARY

This Operating Manual is divided into the following chapters:

A. CHAPTER ONE – INTRODUCTION/PRODUCT OVERVIEW

This chapter includes a general description of the Symmetricom 8130A and provides some basic product information.

B. CHAPTER TWO – INSTALLATION AND OPERATION

Describes initial inspection; installation and operation of the Symmetricom 8130A.

C. CHAPTER THREE – FREQUENCY ADJUSTMENTS

Describes the procedures for the three means of frequency adjustment.

C. CHAPTER FOUR – USE OF RS-232 TERMINAL/EMULATOR

Describes command structure and rules for using the serial RS-232 port.

D. CHAPTER FIVE – SPECIFICATIONS

Describes the detailed specifications for the 8130A

PURPOSE OF EQUIPMENT

The Symmetricom 8130A Militarized Rubidium Frequency Standard is an enhanced version of the popular M-100 Rubidium Oscillator. This modern off-the-shelf militarized rubidium frequency standard is ideal for use in tactical applications where shock, vibration, humidity and other environmental factors are a challenge. The circuit boards are conformally coated for moisture resistance, and special precautions are taken for improved shock and vibration hardening. Use of a filtered power/monitor connector minimizes EMI emissions and susceptibility. Designed for ease of integration into frequency and time systems, the Symmetricom Model 8130A offers a smaller size militarized rubidium clock with a heritage of over 25 years of proven experience in the design, qualification and production of atomic frequency references.

FEATURES

Some of the important features of the Symmetricom 8130A are as follows:

- Modern Militarized Design
- COTS/SMD/PEM Devices for Lower Cost, Enhanced Features and Improved Performance
- RS-232 Digital Control and Monitoring
- Ruggedized High-Performance Rb Physics Package
- Dual 5 or 10 MHz Sine or Square Wave Outputs
- Separate Heater and Electronic Power Lines
- +15 or +22 to 32 Vdc Power Options
- Low Phase Noise Option
- Internal Temperature Compensation Option

OPTIONS

The Symmetricom 8130A is available with several options, including operation from +15 Vdc conditioned power, 5 or 10 MHz sine or square wave outputs, low phase noise, and internal temperature compensation. Unless stated otherwise, this Operating Manual assumes the standard Symmetricom 8130A configuration that operates from +22 to +32 Vdc, has 5 and 10MHz sine wave outputs with normal phase noise, and no internal temperature compensation. All currently-available Symmetricom 8130A configurations have a 15-pin male subminiature "D" power/monitor connector with the pin assignments shown in Table 2-2 in Chapter Two.

PREPARATION FOR SHIPMENT

To turn off the Symmetricom 8130A prior to shipment, remove all connections from the front panel. Package the instrument in its original packing if possible. If the original packing materials are not available, pack in a reinforced cardboard carton using foam to take up any space inside the carton. Do not use foam popcorn or crushed paper for packing, and follow normal ESD preacuations.

If the instrument is being returned to Symmetricom, contact the Service Department at (800) 938-9888 to advise of the product return.

TYPOGRAPHICAL AND OTHER CONVENTIONS

This Operating Manual uses the following conventions:

Acronyms and Abbreviations – Terms are spelled out the first time they appear in this Operating Manual. Thereafter, only the acronym or abbreviation is used. In addition, the glossary defines the acronyms and abbreviations.

Table 1-1 describes the typographical conventions that this Operating Manual uses to distinguish between the different types of information according to how they are used.

TABLE 1-1. TYPOGRAPHICAL CONVENTIONS

WHEN TEXT APPEARS THIS WAY ...	IT MEANS ...
Symmetricom 8130A Operating Manual	The title of a document or the name of a product
CRITICAL PORT-1 J1	An operating mode, alarm state, status, or chassis label.
Press the **Enter** key. Press the **Print Scrn** key.	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.
A *re-timing* application ...	A term or a word being emphasized.
Symmetricom **does not** recommend...	A word or term given special emphasis so that you do not miss the idea being presented.

WARNINGS, CAUTIONS, RECOMMENDATIONS, AND NOTES

Warnings, Cautions, Recommendations, and Notes attract attention to essential or critical information in this Operating Manual. The types of information included in each are explained as follows:

WARNING …

All warnings have this symbol. Do not disregard warnings. They are installation, operation, or maintenance procedures, practices, or statements that if not strictly observed, may result in personal injury or loss of life.

ELECTRICAL SHOCK HAZARD …

All electrical shock hazard warnings have this symbol. To avoid serious personal injury or death, do not disregard electrical shock hazard warnings. They are installation, operation, or maintenance procedures, practices, or statements that if not strictly observed, may result in personal injury or loss of life.

CAUTION …

All cautions have this symbol. Do not disregard cautions. They are installation, operation, or maintenance procedures, practices, conditions, or statements that if not strictly observed, may result in damage to or destruction of equipment or may cause a long-term health hazard.

CAUTION …

All Electrostatic Discharge (ESD) cautions have this symbol. They are installation, operation, or maintenance procedures, practices, conditions, or statements that if not strictly observed, may result in electrostatic discharge damage to, or destruction of, static sensitive components of the equipment.

RECOMMENDATION …

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

NOTE …

All notes have 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.

WHERE TO FIND ANSWERS TO PRODUCT AND DOCUMENT QUESTIONS

If you believe that this product is not performing as expected, or if you have comments about this Operating Manual, please contact your Symmetricom representative or sales office

We appreciate your suggestions on ways to improve this Operating Manual. Please mark or write your suggestions on a copy of the page and mail or fax it to …

Symmetricom – Timing, Test & Measurement
3750 Westwind Boulevard
Santa Rosa, CA 95403
US Toll Free: 1-888-367-7966
Phone: +1-707-528-1230
Fax: +1-707-527-6640
E-mail: ttmsales@symmetricom.com

Thank you for providing the information.

NOTE …

Symmetricom offers a number of applicable training courses designed to enhance product usability. Contact your Symmetricom representative or sales office for a complete list of courses and outlines.

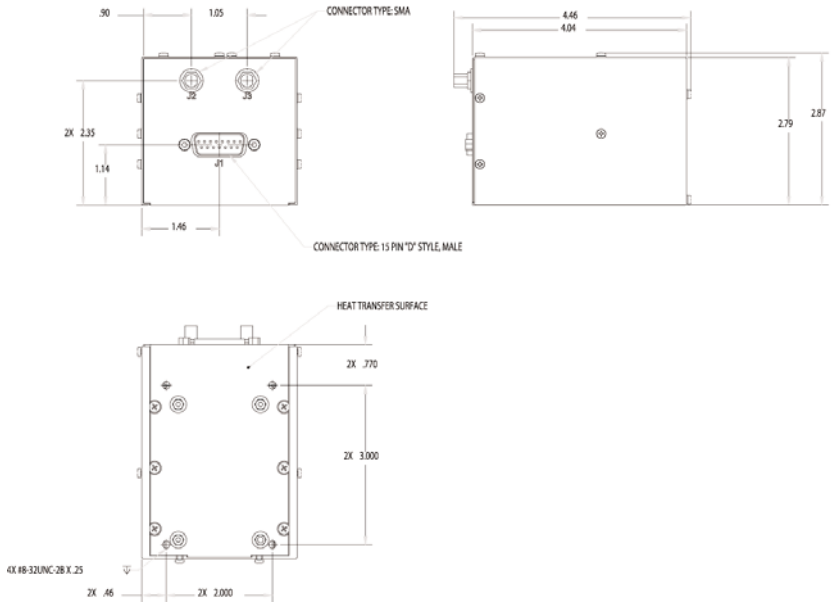
Chapter Two

INSTALLATION AND OPERATION

MOUNTING

The 8130A is designed to be mounted on its bottom plate, using 4 tapped #8 holes, as shown in Figure 2-1. This mounting surface also serves as a means of heat transfer. The unit is specified for operation to +68ºC baseplate temperature, and the corresponding upper ambient temperature limit will depend on the thermal properties of the 8130A mounting arrangement. The use of a thermal pad between the bottom of the 8130A and its heat sink is recommended. Access to the front of the unit is required for power and RF connections.

FIGURE 2-1. MODEL 8130A OUTLINE DRAWING



BASIC OPERATION

8130A operation requires only the application of DC power. After a short warm-up time, high stability 5 or 10 MHz standard frequency outputs are available. The power supply for the unit must be capable of supplying +22 to +32 Vdc (+28 Vdc nominal) at 1.5 A.

INSTALLATION

Installation of the 8130A requires that the unit be mounted as described above, and connected to the host system as described below.

CONNECTIONS

The 8130A has three connectors, a 15-pin male subminiature "D" power/monitor connector (J1) and two SMA receptacle RF output connectors (J2 and J3), as shown in Figure 2-2. Detailed information about these connectors is shown in Tables 2-1 and 2-2.

FIGURE 2-2. SYMMETRICOM 8130A CONNECTIONS

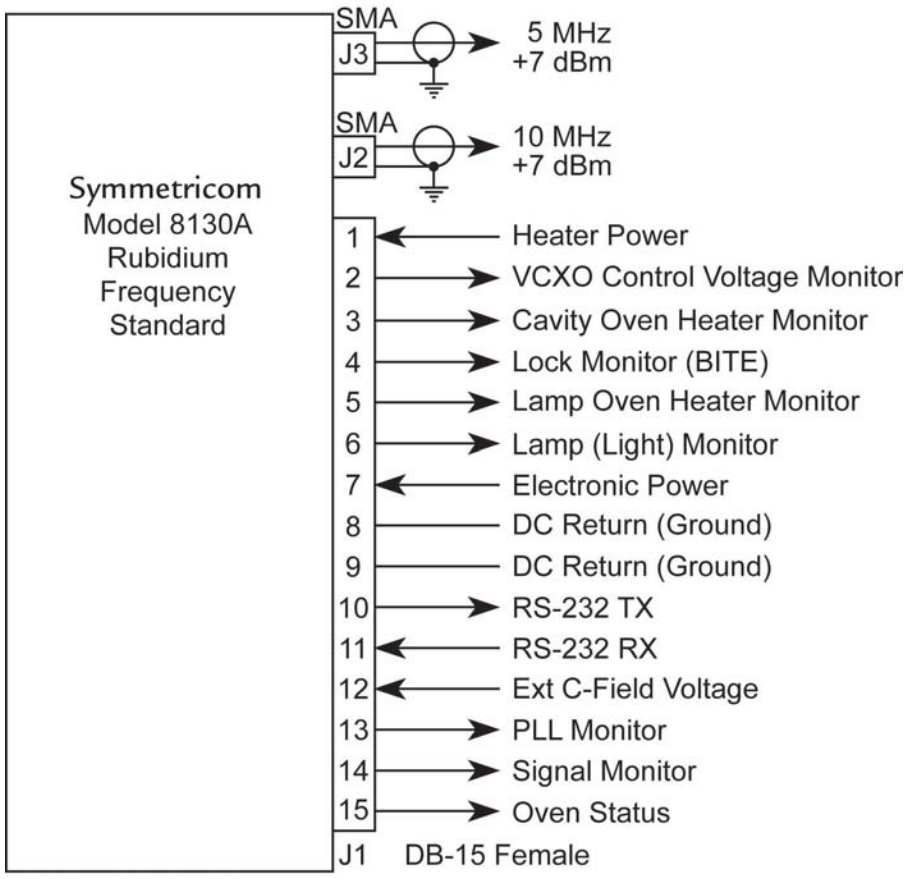


TABLE 2-1. SYMMETRICOM 8130A CONNECTOR TYPES

Connector	Function	Symmetricom 8130A	Mate
J1	Power Monitor Control	15-Pin Subminiature "D" Male Cannon No. DE-15P Amphenol No. 17DE-15P	15-Pin Subminiature "D" Female Cannon No. DE-15S Amphenol No. 17DE-15S
J2 & J3	RF Output	SMA Receptacle MIL 39012/61-3001 Solitron No. 2970-6002	SMA Jack: MIL 39012/15-3006 Solitron No. 2903-6001

TABLE 2-2. SYMMETRICOM 8130A CONNECTOR PINOUTS

Pin #	Pin Function	Notes
1	Heater Power	1, 2
2	VCXO Control Voltage Monitor	
3	Cavity Oven Heater Monitor	3
4	Lock (BITE) Monitor	9
5	Lamp Oven Heater Monitor	3
6	Lamp (Light) Monitor	
7	Electronic Power	1, 2
8	DC Return (Ground)	5
9	DC Return (Ground)	5
10	RS-232 TX	6
11	RS-232 RX	6
12	C-Field Voltage	4
13	PLL Monitor	7
14	Rubidium Signal Monitor	8
15	Oven Status Monitor	8

NOTES …

[1] The electronic and heater power leads are not common.
[2] The electronic and heater voltage is normally +22 to +32 Vdc, (+28 Vdc nominal), but may be +15 ±0.5 Vdc as an option.
[3] The heater monitors are voltages proportional to the heater currents.
[4] This pin may be used instead for the optional external C-field voltage.
[5] The DC returns are common, apply to all signals, and are connected to the chassis ground.The heater and electronic returns may be separated as an option.
[6] The TX and RX designations are from the perspective of the Symmetricom 8130A. Standard bipolar RS-232 levels are used.
[7] The PLL monitor applies to the low noise OCVCXO option.
[8] These pins may be used for other options.
[9] Lock = 0V, unlock = +5V, open collector and reverse logic optional.

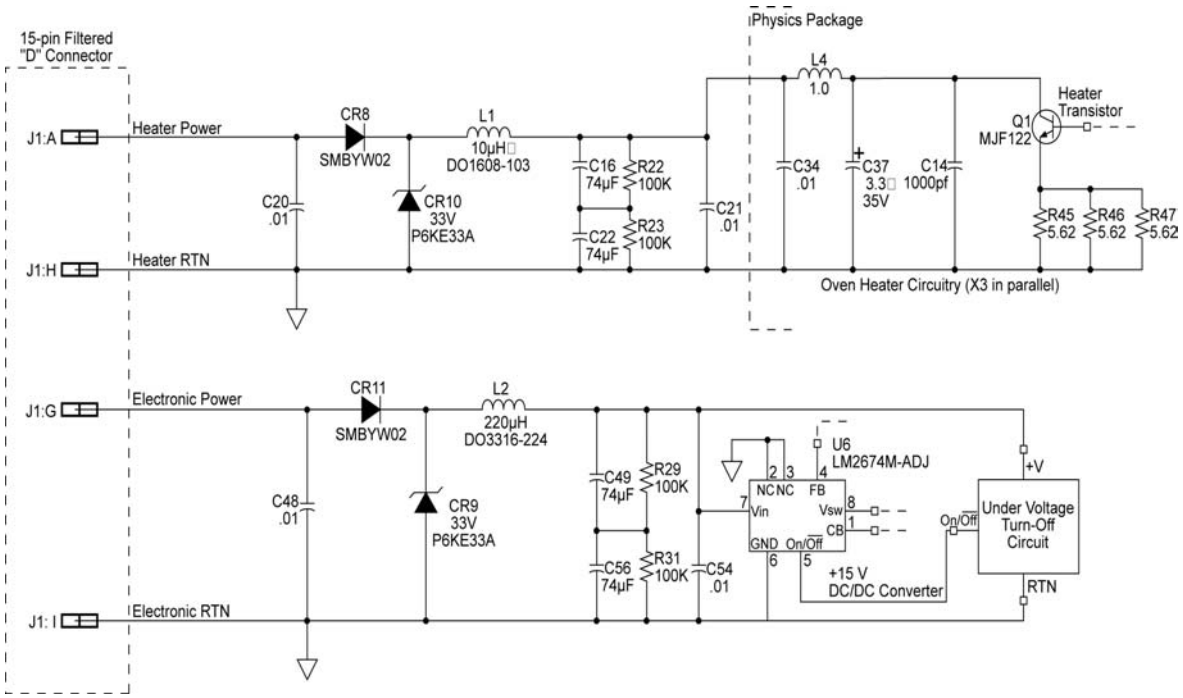
J1 POWER, MONITOR AND CONTROL CONNECTIONS

The 8130A J1 power/monitor/control connections are shown in Table 2-2. The only J1 connections necessary for operation are those to the external DC power supply (pins 1, 7, 8 and 9). The other connections are for optional monitoring and control purposes.

POWER INPUT

The 8130A requires a power supply voltage between +22 and +32 Vdc. Pins 1 and 7 (the heater and electronic power connections respectively) are normally connected together externally, and should be connected to the positive lead of a 28 V nominal DC power supply. Pins 8 and 9 (the DC return and case ground) are connected together internally, and either or (preferable) both should be connected to the negative lead of the power supply. No internal ground (case) isolation is provided, although this could be accomplished externally by mounting the unit on an electrical insulator (with consideration given to the thermal resistance added thereby). Reverse polarity protection is provided by a series diode, and transient over-voltage protection is provided by a 33-47 V zener diode. The power source should by current-limited or fused. The maximum supply current is 1.3 A at +32 Vdc during warm-up. Under steady-state conditions (after the physics package ovens are in control), the power consumption will depend inversely on the baseplate temperature. At constant baseplate temperature, because the oven power is constant, and an internal DC/DC converter conditions the electronic power, the total power is essentially independent of supply voltage. A skeleton schematic of the DC input circuit is shown in Figure 2-3.

FIGURE 2-3. POWER INTERFACE



ANALOG MONITORS

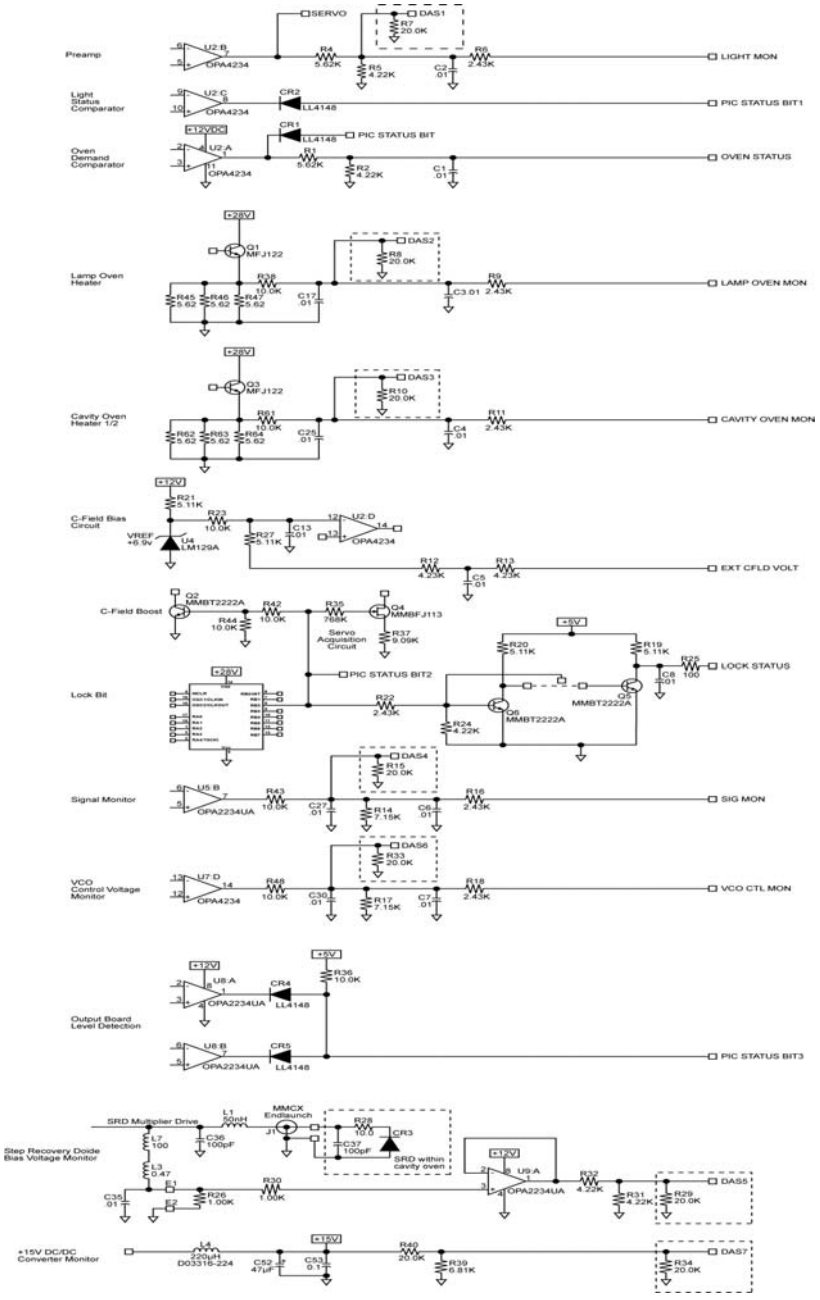
The 8130A has eight analog monitors that may be used to determine its status. These monitors are described in Table 2-3.

TABLE 2-3. ANALOG MONITORS

J2 Pin #	Name	Description	Formula	Remarks
2	VXCO Control Voltage	Voltage of frequency lock loop.	V_{VCXO}= V MON	Sweeps during lock acquisition.
3	Cavity Oven Heater	Voltage proportional to cavity oven heater current.	$I_{CO\ HTR}$= 1068 mA/V MON	1.87Ω current sampling R for 1 of 2 heaters.
4	Lock (BITE)	Logic level indicating that the Rb FLL is locked. Locked=OVDC	H=Lock	Overall BIT/BITE indicator. (0 to +5VDC)
5	Lamp Oven Heater	Voltage proportional to lamp oven heater current.	$I_{LO\ HTR}$= 534 mA/V MON	1.87Ω current sampling resistor.
6	Lamp (Light)	Voltage at preamp output proportional to dc photodetector current.	I_{LIGHT} = 10 µA/V MON	AC component shows recovered Rb signal waveform.
13	PLL	Voltage of OCVCXO phase lock loop.	V_{PLL}= V MON	Applies to low phase noise option only.
14	Rb Signal	Voltage proportional to rms value of 2nd harmonic Rb signal.	V SIG= V MON-5	2nd harmonic signal present only when unit is locked.
15	Oven Status	Logic level indicating that the physics package ovens are in control.	H=Both ovens in control	Indicates that warm up is done.

While it is not necessary to do anything with these monitors, it is recommended that, at a minimum, the Lock (BITE) signal be used to indicate that the unit is functioning properly. A skeleton schematic of the analog and status monitors is shown in Figure 2-4a.

FIGURE 2-4A. ANALOG AND STATUS MONITORS



DIGITAL MONITORS

The digital monitors provide a 2-byte (4 hex character) number with a 0 to 4095 count range that corresponds to a value of 0 to 2.048 volts. This value can be scaled as shown in the table below to provide the actual monitor reading These monitors are produced by a 12-bit analog-to-digital converter data acquisition system and are described in Table 2-4.

TABLE 2-4. DIGITAL MONITORS

Chan #	Name	Description	Formula	Remarks
0	Lamp (Light)	Voltage at preamp output proportional to DC photodetector current.	I_{LIGHT} = 10 µA/v	Voltage gradually rises during warm-up.
1	VCXO Control Voltage	Voltage of Rb frequency lock loop.	VVCXO= 6VMON	Sweeps during lock acquisition.
2	Lamp Oven Heater	Voltage proportional to lamp oven heater current.	ILO HTR= 534 MA/V MON	1.87Ω current sampling resistor.
3	Cavity Oven Heater	Voltage proportional to cavity oven heater current.	ICO HTR= 1068 MA/V MON	1.87Ω current sampling R for 1 of 2 heaters.
4	Rb Signal	Voltage proportional to rms value of 2nd harmonic Rb signal.	VSIG= 6VMON-5	2nd harmonic signal present only when unit is locked.
5	+15 V	+15 Vdc output from internal DC/DC converter.	V15= 10VMON	No DC/DC converter for +15 Vdc option.
6	PLL	Voltage of OCVCXO phase lock loop.	VPLL= 6VMON	Applies to low phase noise option only.
7	SRD Bias	DC bias voltage of step recovery diode microwave multiplier.	VSRD= 6VMON	

In addition, the unit has a temperature monitor that indicates the temperature on the motherboard. It is representative of the internal ambient temperature and is used as the basis for the internal temperature compensation.

It is not necessary to do anything with these monitors.

STATUS MONITORS

The 8130A has five digital status monitors that may be used to determine its status, as described in Table 2-5.

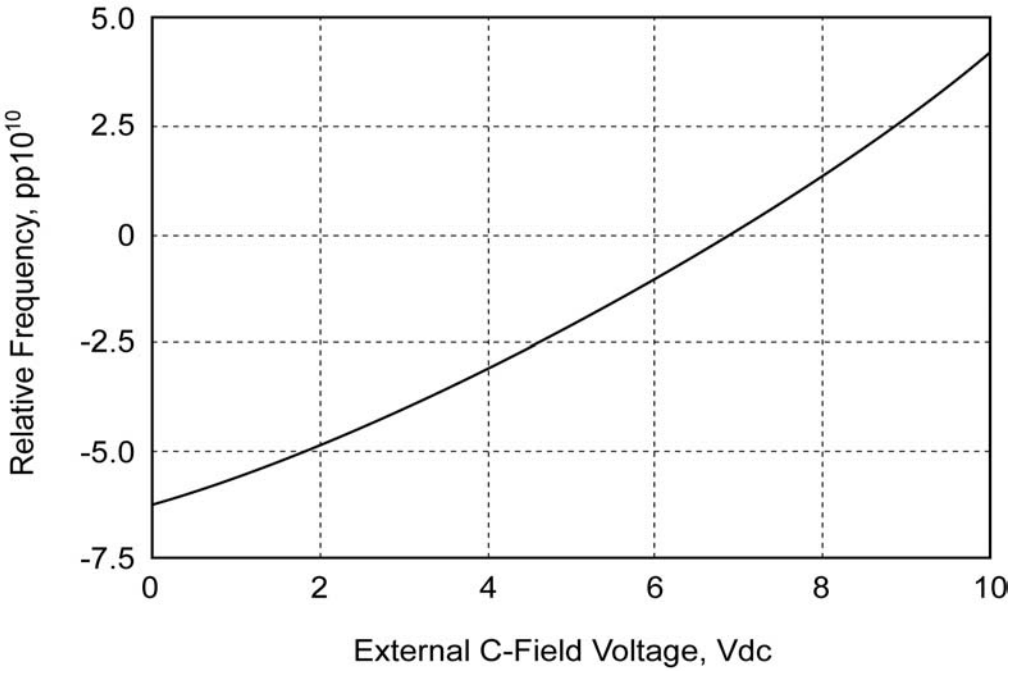
TABLE 2-5. STATUS MONITORS

Bit #	Name	Description	Sense	Remarks
1	Lock	Status of Rb frequency lock loop	H=Unlock	Same as analog Lock (BITE)
2	Ovens	Status of physics package ovens	H=At Temp	Indicates warm-up done
3	Light	Status of Rb lamp	H=No Light	Indicates lamp lit
4	PLL	Status of OCVCXO PLL	H=Unlock	Low noise option
5	O/P	Status of RF outputs	H=No Fault	Both outputs sensed

C-FIELD VOLTAGE

The external C-field voltage input can be used to make analog frequency adjustments (such as locking the Symmetricom 8130A to a GPS time and frequency reference). This control characteristic is shown in Figure 2-5.

FIGURE 2-5. SYMMETRICOM 8130A C-FIELD CHARACTERISTIC



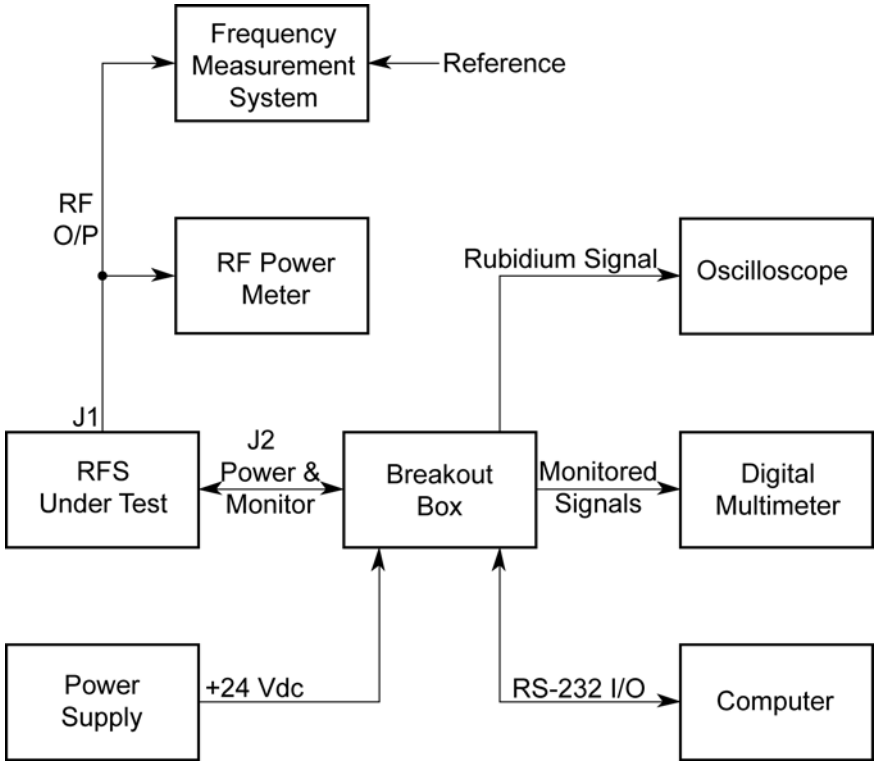
RS-232 INTERFACE

The RS-232 interface can be used be used for control and monitoring purposes. Its main function is to make frequency adjustments. See Chapter Four for detailed information about using the RS-232 user interface through the Windows Terminal Emulator.

FUNCTIONAL TEST SETUP

A typical 8130A functional test setup is shown in Figure 2-6. Connections to the 8130A power, monitor and control leads can be facilitated with a breakout box. This device connects between an 8130A under test, its power supply, a PC serial port, an oscilloscope and a digital voltmeter. The PC can use a terminal emulation or other program to communicate with the 8130A via its RS-232 interface. In addition, the oscilloscope can observe the Rb signal, and the digital voltmeter can measure the various RFS monitors, and its heater and electronic DC supply currents via the 4-terminal current sensing resistors.

FIGURE 2-6. 8130A FUNCTIONAL TEST SETUP



Chapter Three

FREQUENCY ADJUSTMENTS

The Symmetricom 8130A has three means of frequency adjustment:

1. RS-232 user interface
2. Analog C-field voltage
3. C-Field circuit resistance

The preferred frequency adjustment method is via the RS-232 user interface using a terminal emulator or other program that implements the following (upper-case ASCII) commands:

F Read frequency
I Increment frequency
D Decrement frequency
W Write frequency
X Store frequency

The F and W commands each transmit or receive 32 bits (4-bytes) of tuning data as 8 ASCII hex characters to or from the external terminal. The I and D commands make up/down tuning adjustments in steps of about 3.41×10^{-13}. The X command causes the current tuning data to be permanently stored in the EEPROM memory within the Symmetricom 8130A.

The analog C-field interface implements a traditional means of frequency adjustment whereby the value of the internal physics package DC magnetic bias field can be varied. In the Symmetricom 8130A, this adjustment is deliberately limited to a range of about $\pm 5 \times 10^{-10}$ to reduce sensitivity to external magnetic fields. Coarse frequency adjustments must be made with the self-contained digital frequency synthesizer. Fine analog adjustments are supported for applications such as locking the unit to an external reference or GPS receiver.

The Symmetricom 8130A C-field tuning characteristic is:

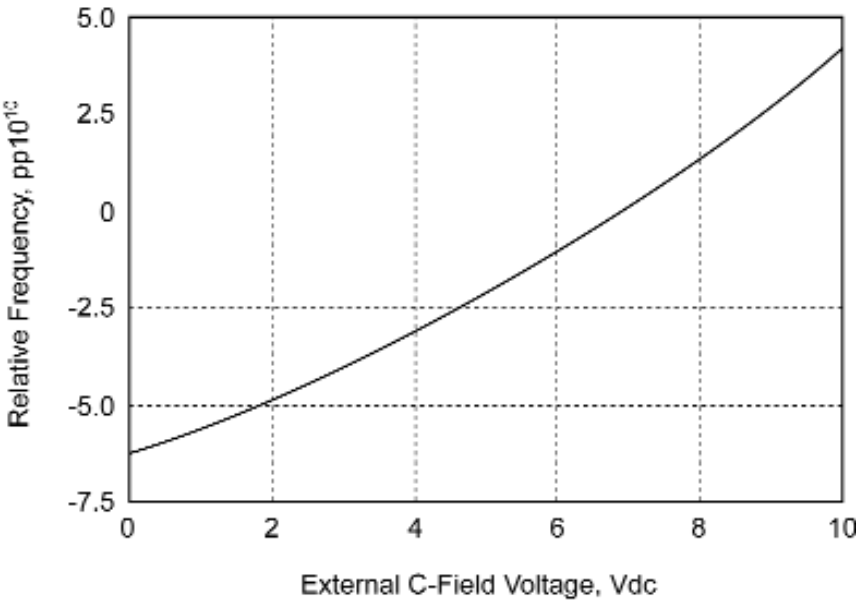
$$\text{Relative Frequency, pp}10^{10} = [(V_{ext} + 6.9)^2 \bullet 4.43 \times 10^{-2}] - 8.43$$

which is plotted in Figure 3-1 below.

The Symmetricom 8130A does not have an internal frequency adjustment potentiometer. If a means for mechanical frequency adjustment is needed, it can be implemented by connecting a variable resistance between the J1 Pin 12 C-Field connection and ground. Because of the limited adjustment range, this method of frequency adjustment is intended only to supplement, not replace, the digital interface.

If not used for voltage or resistance tuning, the C-Field pin is normally not connected. While it can be used to monitor the internal C-field reference voltage, for best stability, it should not be externally loaded.

FIGURE 3-1. C-FIELD CHARACTERISTIC



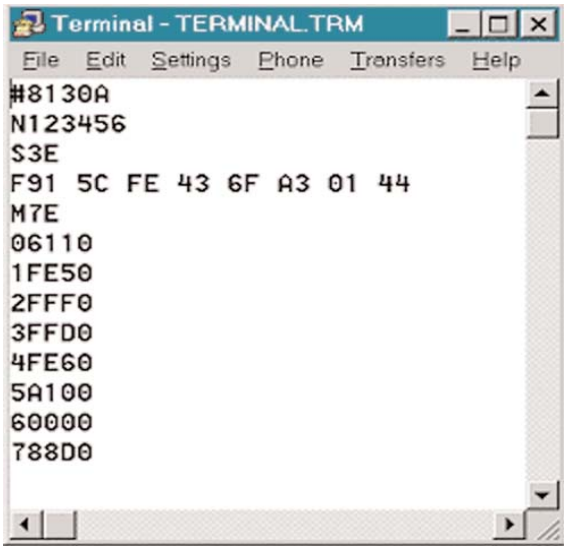
Chapter Four

USE OF RS-232 TERMINAL/EMULATOR

INTRODUCTION

The most basic way to communicate with a Symmetricom 8130A Rubidium Frequency Standard via its user interface is by means of an RS-232 terminal or terminal emulator. This can be useful to test the interface, to perform simple operations, or to control the unit automatically. For example, sending the "N" command will provide the serial number of the unit, and sending the A00 01 command will turn on the internal temperature compensation. The screen of a PC running the Microsoft Terminal program and connected to an 8130A is shown in Figure 4-1 below.

FIGURE 4-1. MICROSOFT TERMINAL PROGRAM



SETUP

Before the 8130A RS-232 interface can be used, the unit must be connected via a custom cable to the serial port of an RS-232 terminal (or a PC running a terminal emulator program). Three wires are required (in addition to those supplying power to the unit and providing other control and monitoring functions), as shown below:

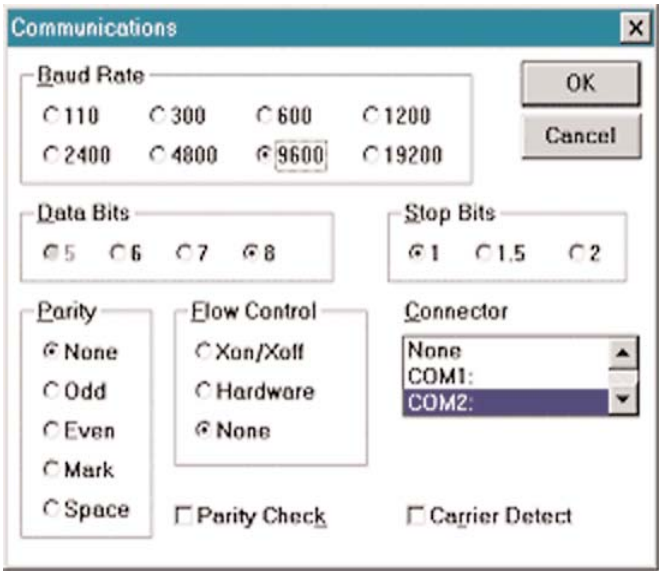
Signal Name	8130A	PC Serial Port		
& Abbreviation	J2	Pin	9-Pin	25-Pin
Transmit Data	TD	11	3	2
Receive Data	RD	10	2	3
Signal Ground	SG	8 & 9	5	7

Note that the signal names are from the perspective of the PC. The 8130A interface uses standard ±12V RS-232 signal levels and requires the following communications port settings:

Baud Rate	= 9600
# Data Bits	= 8
# Stop Bits	= 1
Parity	= None
Flow Control	= None

These parameters must be set, and the correct COM port must be selected, as shown for the Microsoft Terminal program in Figure 4-2 below. The connection may be tested by issuing a "#" command, which should elicit a response of "8130A".

FIGURE 4-2. COMMUNICATIONS SETTINGS



WARNING …

It is possible to impair or even stop the operation of a 8130A Rubidium Frequency Standard by loading incorrect parameters into it via the RS-232 user interface. It is strongly recommended that the original hex values of the frequency and modulation rate be read with the F and M commands (see Figure B.2.1), and those values recorded before making any changes. It is particularly important not to permanently store incorrect values into the 8130A EEPROM memory with the X command. If necessary, the following default values can be used to restore operation of an improperly programmed 8130A Rubidium Frequency Standard:

Parameter	Hex Value	Write Command
High Freq	44 08 E0 00	WB0E8064400E00844
Low Freq	44 06 E8 B0	
Mod Rate	7E	

It could also become necessary to restore all the temperature compensation data to its default hex value of 00.

Under no circumstances should the modulation rate be changed.

TABLE 4-1. USER INTERFACE COMMAND SYNTAX

Parameter	Total # of Chars	Format [ ] = Sent to unit h = hex character n = alphanumeric char	Oper-ation	Remarks
Frequency	25	[F]hh hh hh hh hh hh hh hh	Read	Bytes spaced
	17	[Whhhhhhhhhhhhhhhh]	Write	
	1	[X]	Store	
Modulation Rate	3	[M]hh	Read	
	3	[Rhh]	Write	
	1	[X]	Store	
Frequency Up or Down	1	[I]	Inc	
		[D]	Dec	
Status	3	[S]hh	Read	Bit field
Temperature	3	[T]hh	Read	
		[A00 01]	On	Space required
		[A00 00]	Off	
		[Chh]hh	Read	
		[Ahh hh]	Write	Space required
Monitors	5	[0]hhhh thru [7]hhhh	Read	
Model #	6	[#]8130A	Read	
S/N	7	[N]nnnnnn	Read	
		[*]nnnnnn	Write	Do not change
S/W Version	4	[V]nnn	Read	
Elapsed Time	7	[H]hhhhhh	Read	
# Turn-Ons	7	[Y]hhhhhh	Read	
Timer Interrupts	1	[<]	Disable	Bracket other commands
	1	[>]	Enable	

See notes on the following page.

NOTES …

1. The [ ] brackets indicate data sent to unit – they are not actual characters.
2. All commands must be upper case.
3. All command sequences end with LF/CR ("\n\r").
4. All invalid commands return the error code E.
5. All data bytes are formatted as pairs of hex characters.
6. Spaces in the command sequences must be observed as shown.
7. The total # of chars does not include LF/CR after command.
8. The frequency data is transmitted as low freq, high freq, LS bytes first.
9. The status bits and monitor channels are as follows:

Bit	Status	Chan	Monitor
0	N/A	0	Light
1	Lock	1	VCXO
2	Ovens	2	Lamp Oven
3	Light	3	Cavity Oven
4	PLL	4	Signal
5	O/P	5	+15V Supply
6	N/A	6	PLL
7	N/A	7	SRD Bias

10. The * command should not be used to change the S/N of a unit.

USER INTERFACE COMMANDS

The Symmetricom 8130A user interface can be activated to read status, monitor or frequency parameters by sending one of the commands listed in Table 4-2 as a single of ASCII character followed by a carriage return character. The 8130A will respond by sending 2-8 ASCII hex (0-F) characters representing the value of the requested parameter, followed by a carriage return. In all cases, the first hex character sent or received represents the most significant 4 bits of the most significant byte, and the character sequence continues in descending order toward the least significant 4 bits of the least significant byte. Some of these commands (such as loading the S/N and temperature compensation data) are reserved for factory calibration and test purposes. The user interface can also be used to write tuning data by sending the W command as a pair of ASCII characters, 8 ASCII hex characters representing the nominal frequency value, and a carriage return character. The unit will make no response, but the new frequency can be verified with the "F" command. Similarly, the optional O/P DDS can be written and read with the "P" and "O" commands. Temperature compensation data are written and read with the "T" and "A" commands respectively. These are one-byte incremental corrections that are added to the nominal four-byte DDS frequency word. With the PIC16F628 microcontroller, correction values are stored at ² 1.28ºC increments from -40ºC to +80ºC with a resolution of ² 3.41×10^{-13}.

Table 4-2 is a complete list of commands for the Symmetricom 8130A.

TABLE 4-2. RS-232 USER INTERFACE COMMANDS

Command	R/W	Description	Arguments	Format
Read 1-Byte Status Bits				
S	R	Bit 1: Lock Bit 2: Ovens Bit 3: Light Bit 4: PLL Bit 5: O/P	0=Lock, 1=Unlock 0=In Control, 1=Demand 0=Light, 1=No Light 0=Lock, 1=Unlock 0=No O/P, 1=O/P	1 byte/2 ASCII hex chars Status bits packed into 1 byte Bits 0 and 6-7 are not used
Read 2-Byte Monitor Values from 12-Bit A/D Converter (0000h thru 0FFFh)				
0	R	Light Monitor	Light voltage	2 bytes/4 ASCII hex chars DAS has 8 channels
1	R	VCXO Monitor	VCXO control voltage	
2	R	Lamp Oven Monitor	LO heater current	
3	R	Cavity Oven Monitor	CO heater current	
4	R	Signal Monitor	2nd harmonic signal	
5	R	+15V Monitor	DC/DC converter output	
6	R	PLL Monitor	For optional OCVCXO	
7	R	SRD Bias Monitor	SRD mult bias voltage	
Increment or Decrement Freqeuncy				
I	—	Increment Frequency	None	RFS O/P Freq + ≈ 3.41×10^{-13}
D	—	Decrement Frequency	None	RFS O/P Freq - ≈ 3.41×10^{-13}
Read 4-Byte Frequency, 1-Byte Mode Rate or 2-Byte Temperature/Frequency Compensation Data				
F	R	Frequency	Main DDS tuning word	4 bytes/8 ASCII hex chars
M	R	Mod Rate	TMR0 setting	1 byte/2 ASCII hex chars
C	R	Temp Compensation Note: The temp comp value at index 00h is a flag to turn the compensation on/off	Incremental DDS correction wrt value at +25ºC (33h). Comp data extends from index 01h = -40ºC to 6Ah = +80ºC	2 bytes/4 ASCII hex chars 1st byte represents temp index in ≈ 1.28°C increments. 2nd byte represents temp compensationvalue as signed int (00-FFh = +128 to -127)
O	R	Frequency	Optional O/P DDS	4 bytes/8 ASCII hex chars
Write 4-Byte Frequency, 1-Byte Mod Rate or 2-Byte Temperature/Frequency Compensation Data				
W	W	Frequency	Main DDS tuning word	4 bytes/8 ASCII hex chars
R	W	Mod Rate	TMR0 setting	1 bytes/2 ASCII hex chars
A	W	Temp Compensation	DDS corrections	See "C" command above
X	W	Save Freq & Rate Data in EEPROM Memory	None	Follows W and/or R command
P	W	Frequency	Optional O/P DDS	4 bytes/8 ASCII hex chars
Miscellaneous Read-Only Values				
V	R	S/W Version #	—	3 ASCII chars (e.g., 015)
#	R	Model Number	—	5 ASCII chars (e.g., 8130A)
N	R	Serial Number	S/N of unit	6 ASCII chars (e.g., 123456)
T	R	Temperature	Temp comp index	2 hex chars (00-FF)
Y	R	# On/Off Cycles	—	6 ASCII chars (e.g., 0-999999)
H	R	Elapsed Time	Total operating time, min	6 ASCII chars (≈0-32 years)
Control Commands				
*	W	Write S/N	S/N of unit	6 ASCII chars (e.g., 123456)
<	W	Disable Timer Interrupts	None - Stops elapsed time and temp comp activity	Disable timer interrupts while sending other commands
>	W	Enable Timer Interrupts		
Error Code				
E	—	Error Code	Invalid Command	
All Others	R	Reserved	—	—

NOTES …

1. By sending [W] tuning commands that increment or decrement only one of the high and low DDS words, it is possible to adjust the frequency of the 8130A in steps of about 3.41×10^{-13}. The resulting change in the modulation deviation is negligible (4 mHz).

2. The sense of the [I] and [D] commands corresponds to the RFS O/P frequency; the DDS frequency changes in the same direction. The high and low DDS hex words are incremented and decremented alternately, providing a resolution of 3.41×10^{-13}.

3. Send [<] command before any other command sequence to stop timer interrupts that can interfere with external RS-232 communications, and [>] command afterwards to re-enable elapsed time and (optional) temperature compensation. Two [<] commands, or checking for a LF/CR response, are recommended to avoid possibility of one occurring during timer isr.

SOFTWARE DESCRIPTION

The 8130A user interface responds to the ASCII character commands shown in the preceding table. Most of these commands are processed only by the processor on the motherboard, but the [I], [D], [W] and [R] commands also involve the processor on the RF board via the PBus internal communications bus. The motherboard software comprises two sections, a main loop that waits for and processes user commands, and a timer interrupt service routine that accumulates elapsed time and performs optional temperature compensation. The timer interrupts are automatically disabled while the software is processing user commands. But because it is possible for the unit to fail to respond to a user interface command while it is processing a timer interrupt, it is necessary that the timer interrupts be manually disabled at the start of a command sequence by the [<] command. Because that command itself could be missed, sending two such commands is recommended. It is also necessary that the [>] command be sent at the end of a command sequence to re-enable the timer interrupts.

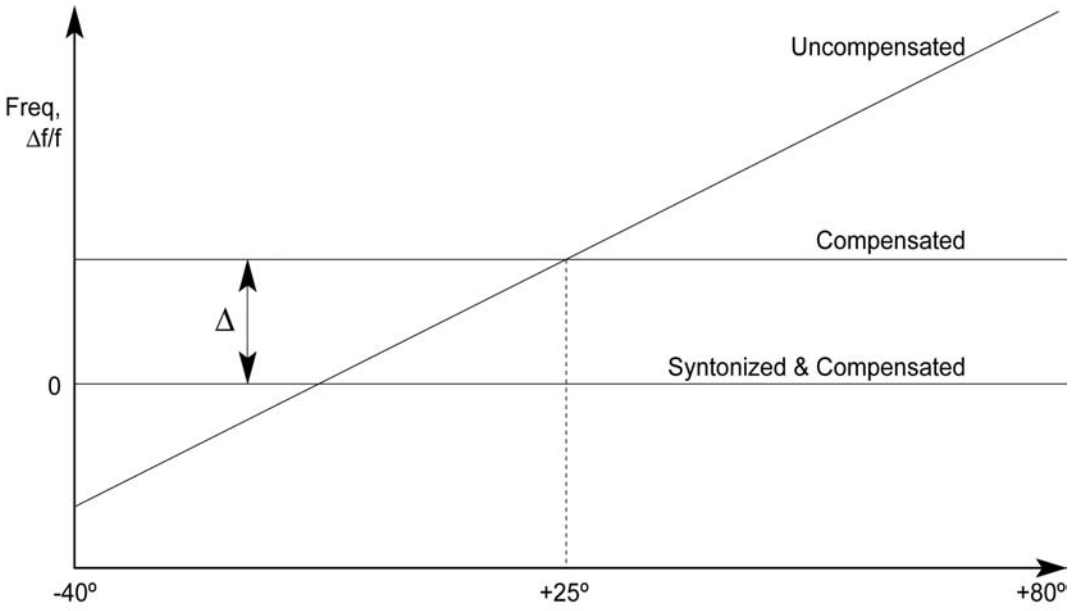
All non-volatile data is stored in the EEPROM of the motherboard processor. These data include S/N, frequency, modulation rate, # turnons, elapsed time, TC flag and TC values. The model # is hard-coded into the software. The stored frequency is the uncompensated value at +25ºC. TC values can be written into the unit using the [A] command. When activated by the [A00 01] command sequence, TC corrections are applied to the DDS frequency at 20-second intervals.

The [W] command enters frequency data into working memory, but does not store it in EEPROM. The new frequency will be lost if the unit is shut off, or if the TC flag is turned off. Subsequent TC corrections are applied incrementally and remain applicable after a frequency load. The uncompensated +25ºC frequency value is read from EEPROM when the TC corrections are deactivated. The [X] command stores the current frequency data in EEPROM. The unit may be syntonized by using the [W] command to zero the frequency error, followed by the [X] command to save it in EEPROM. That should be done only at +25ºC unless the TC flag is on.

TABLE 4-3. COMMAND DESCRIPTIONS

Command	Description
F	Read the current frequency that is in working memory. This value includes any TC corrections that may have been applied.
W	Write a frequency value into the working memory. If TC is on, subsequent temperature corrections will be applied incrementally.
I, D	Increment or decrement the current frequency that is in working memory.
X	Save the current working frequency in EEPROM.
A00 00	Turn off Temperature compensation. Read the frequency that is in EEPROM into working memory.
A00 01	Turn on temperature compensation. Sum the incremental temperature corrections from center (25ºC) to the current temperature and add them to the current working directory.

FIGURE 4-3. FREQUENCY SYNTONIZATION



The elapsed time indication is a 3-byte count of minutes having a range of about 32 years. The weight of one count for the three bytes is about 1 minute, 4.3 hours and 46 days. More exactly, the minute count is based on 60 1-second counts having an actual rate of 20 MHz divided by 4*256*256*76, or 1.0038677015 Hz. Thus the minute count is high by about 0.39% (334 seconds/day). That bias can be corrected by scaling the elapsed time reading. The exact LSB weight is 0.9961472 minute, and the whole elapsed time count can be converted to hours by dividing it by 60.2320621. Two other factors tend to bias the elapsed time low, truncation of the LS byte and loss of counts during user command processing. Only the two most significant bytes are stored in EEPROM, so, on average, about 128 minutes are lost when a unit is turned off. This error can be corrected for approximately by adding 2 hours for each turn-on that is recorded for the unit. The count loss due to command processing is small in any normal operating scenario.

Chapter Five

SPECIFICATIONS

NOTE …

All performance is at an ambient temperature of 25°C unless otherwise specified.

ELECTRICAL SPECIFICATIONS

Output Frequency/Waveform:	5 or 10 MHz sine or square wave			
Output Level (2 outputs):	+7.0 ±1.5 dBm (each output)			
	0.5 Vrms nominal into 50			
Output Impedance:	50 nominal at 5 or 10 MHz			
Phase Noise (SSB), £(f), dBc/Hz:	SB Freq	Standard 10 MHz	Low Noise 10 MHz	Low Noise 5 MHz
	1 Hz	-70 dBc/Hz	-85 dBc/Hz	-95 dBc/Hz
	10 Hz	-90 dBc/Hz	-115 dBc/Hz	-125 dBc/Hz
	100 Hz	-120 dBc/Hz	-140 dBc/Hz	-140 dBc/Hz
	1 kHz	-135 dBc/Hz	-150 dBc/Hz	-150 dBc/Hz
	10 kHz	-140 dBc/Hz	-150 dBc/Hz	-150 dBc/Hz
	100 kHz	-140 dBc/Hz	-150 dBc/Hz	-150 dBc/Hz
Spectral Purity:	Harmonics:		<-30 dBc	
	Non-Harmonics:		<-80 dBc	
Aging:	Monthly (after 1 month):		<3 E-11/month	
	10 Years		<1 E-9	
Frequency Accuracy at Shipment	1 E-11 (@ +25° C)			
Frequency Retrace	<5 E-11			
Short Term Stability		Standard 10 MHz	Low Noise 10 MHz	
	t = 1 sec	<1 E-11	<3E-11	
	t = 10 sec	<3 E-12	<3E-11	
	t = 100 sec	<1 E-12	<1E-12	
Frequency Control:	Analog Freq. Adj. Range		1 E-9	
	Digital Freq. Adj. Resolution		3.4 E-13	
Warm-up:	AT –40° C	At 25° C		
Time to Lock:	<14 min	<8 min		
Time to 5 E-10:	<17 min	<10 min		
Max. Input (Watts) @ 28 V	<35 Watts	<35 Watts		
Steady-State (Watts) @ 28 V	<22 Watts	<15 Watts		

Input Voltage Range: (Separate heater and electronic power lines)	+22 to 32 Vdc, protected against reverse polarity and transients (+15 ±0.5 Vdc as an option)	
Voltage Sensitivity	5.0E-12 (10% voltage change from nominal 28 Vdc)	
Input Power, Quiescent:	+28 Vdc < 12 W @ +25° C baseplate +28 Vdc < 8 W @ +68° C baseplate	
Status Indicators: (TTL Logic)	Lock (BITE) RF O/P Light	Oven Demand
Analog Monitors: (0-12 Vdc)	Light Lamp Oven Signal	Control Voltage Cavity Oven PLL (Optional)
RS-232 Control/Monitor Interface:	Provides ID, status/monitor information, and frequency/operating parameter adjustments. Protocol: 9600, 8, 1, None, No flow control	

NOTE …

Consult factory for application support, complete SCD test reports or special requirements.

ENVIRONMENTAL SPECIFICATIONS

Operating Temperature:	-40°C ambient to +68°C baseplate
Temperature Sensitivity:	<3 E-10 over operating temperature range
Storage Temperature:	-62°C to +85°C
Thermal Shock: Non-operating	MIL-STD-202, Method 107, Test Condition A, 10 cycles –40 to +68°C
Orientation Sensitivity:	<5 E-11 for any orientation
Pressure Sensitivity:	<1 E-13/mbar
Altitude:	
Operating	Sea level to 40,000 ft
Non-operating	Seal level to vacuum
Static Acceleration:	<5 E-11 for 10 g in any direction
Magnetic Field Sensitivity	<2 E-11/Gauss
Relative Humidity	
Operating	0 to 95% RH per MIL-STD-810, Method 507.1, Procedure II
Salt Fog:	MIL-STD-810, Method 509.1, Procedure 1
Vibration:	
Operating	MIL-STD-810E, Method 514.4, Category 10
Non-operating	MIL-STD-202, Method 204, Test Condition A, 0.3 in. DA (Sine) 10 g to 500 Hz
Shock:	
Non-operating	MIL-STD-202, Method 213, Test Condition J, 30 g, 11 msec, half-sine
Acoustic Noise:	MIL-STD-810, Method 512.2
EMI:	
MIL-STD-461 for Class A1 and A3 Equipment	
Emissions	CE03, CE07, RE02
Susceptibility	CS01, CS02, CS06, RS02, RS03
MTBF:	
MIL-HDBK-217F,	9,000 Hours @ +40° C baseplate
On-Off Cycling Endurance:	3,600 cycles at any temperature
Life:	20 years

PHYSICAL SPECIFICATIONS

Weight:	<2.0 lbs. maximum
Dimensions:	4.04" D x 2.92" W x 2.87" H
Warranty:	1 year