TECHNICAL MANUAL
TM 5680-0211

RUBIDIUM FREQUENCY STANDARD
MODEL FE-5680A SERIES

OPERATION AND MAINTENANCE INSTRUCTIONS

FREQUENCY ELECTRONICS, INC.

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EQUIPMENT DESCRIPTION 1-1

General 1-1.1

The **Rubidium Frequency Standard (RFS) FE-5680A Series** consists of self-contained, solid-state, modular, atomic frequency standards available in various options, depending on the output frequency, package, and supply voltage requirements. The entire series may be grouped into several versions according to the output interface, which can be adapted to different requirements.

Different options may be combined to form customized configurations based on output frequency, packaging and supply voltage requirements.

Packaging/Connectors 1-1.2

The standard **RFS** package is illustrated in Figure 1, and measures .97 x 3.47 x 4.92 inches.

Input power is supplied through a 9-pin D-subminiature connector. The RF output is supplied on an SMA coax connector.

Input/Output functions for the **RFS** are defined in Table 1.

Reference Data 1-1.3

Reference data applicable to the **RFS** are listed in Table 2. The data include output signal characteristics, environmental requirements and input requirements.

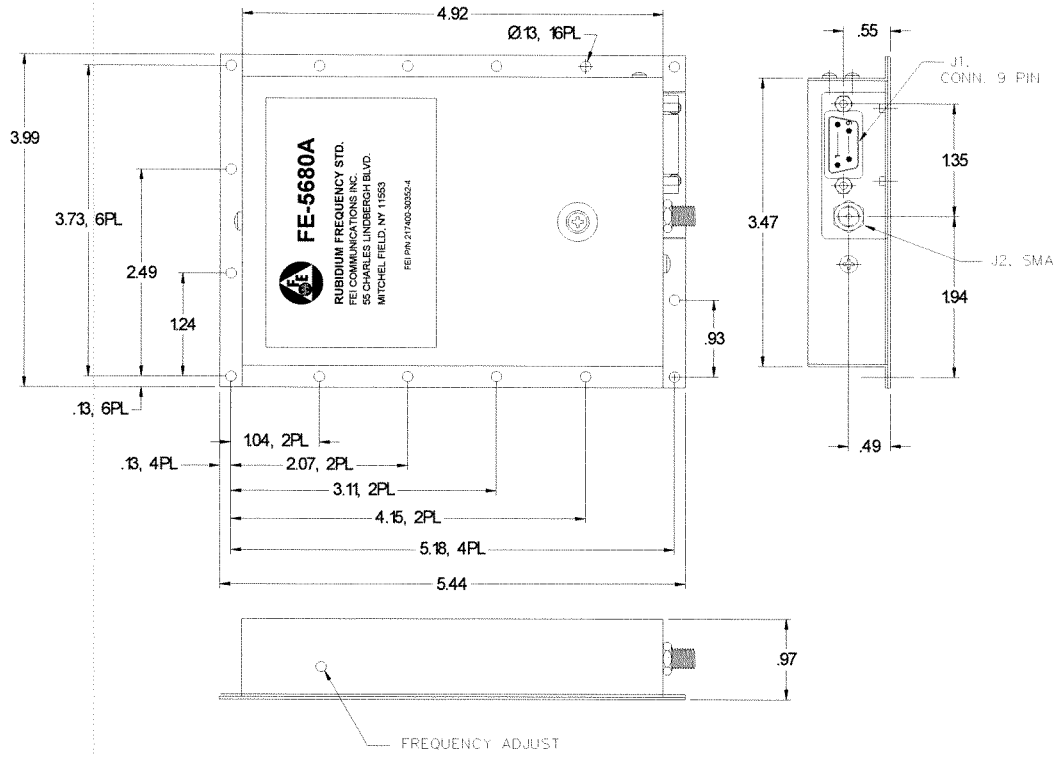

FIGURE 1. RUBIDIUM STANDARD OUTLINE MODEL FE-5680A

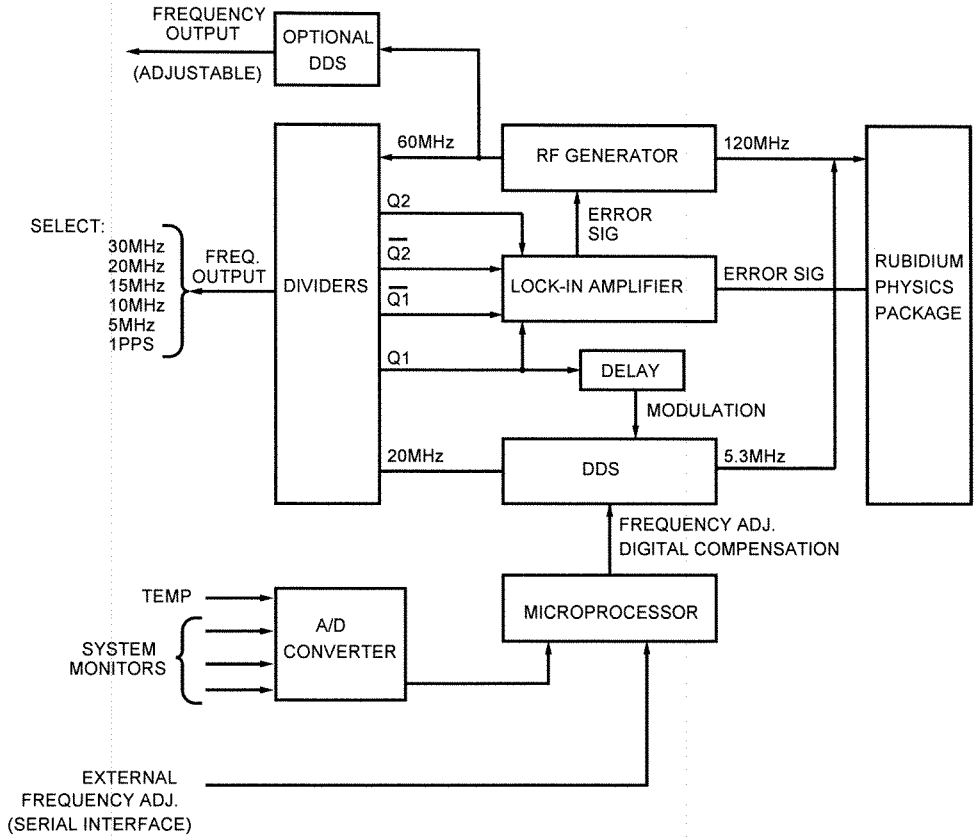

FIGURE 2. RUBIDIUM FREQUENCY STANDARD BLOCK DIAGRAM MODEL FE-5680A

TABLE 1A. CONNECTOR FUNCTIONS (EXCEPT OPTIONS 25)

PIN	FUNCTION	NOTES
J1-1	+15V	DC power input
J1-2	+15V Return	Provides DC return
J1-3	Loop Lock Indicator	Indicates whether or not the output frequency is stabilized to the Rb atomic reference
J1-4	NOT USED	
J1-5	GROUND	Provides DC return, RS-232 return
J1-6	NOT USED	
J1-7	NOT USED	
J1-8	Data In	Data sent into the Rubidium
J1-9	Data Out	Data received from the Rubidium
J2	Frequency Output	

TABLE 1B. CONNECTOR FUNCTIONS: OPTION 25

PIN	FUNCTION	NOTES
J1-1	+22 TO 32 Vdc	DC power input
J1-2	+22 TO 32V Return	Provides DC return
J1-3	Loop Lock Indicator	Indicates whether or not the output frequency is stabilized to the Rb atomic reference
J1-4	NOT USED	
J1-5	GROUND	Provides DC return, RS-232 return
J1-6	NOT USED	
J1-7	NOT USED	
J1-8	Data In	Data sent into the Rubidium
J1-9	Data Out	Data received out of the Rubidium
J2	Frequency Output	

TABLE 2. REFERENCE DATA for RUBIDIUM FREQUENCY STANDARD FE-5680A

PARAMETER	SPECIFICATION
Frequency	10 MHz
Type	Sinusoidal
Amplitude (minimum)	0.5 Vrms into 50Ω (+7dBm)
Adjustment Resolution	$<1 \times 10^{-12}$ over range of +/- 5×10^{-8}
Drift	2×10^{-9} /year 2×10^{-11} /day
Short Term Stability: 1 sec ≤ 100 sec	$1.4 \times 10^{-11} / \sqrt{\tau}$
Retrace	5×10^{-11}
Phase Noise (fo = 10 MHz)	@ 10 Hz: -100 dBc @ 100 Hz: -125 dBc @ 1000 Hz: -145 dBc
Input Voltage Sensitivity	2×10^{-11} / (15V to 16V)
Frequency vs. Temperature (-5°C to +50°C)	$\pm 3 \times 10^{-10}$
Spurious Outputs	-60 dBc
Harmonics	-30 dBc
Loop Lock Indication	> 3Vdc = Unlocked < 1Vdc = Locked
Input Power (@ 25°C)	12 watts steady state, 30 watts peak
DC Input Voltage/Current	15V to 18V @ 2A peak and 0.8A steady-state except Opt 25: +22V to +32V @ 1.4 peak, 0.55A s-state
Ripple	+15V: <0.1 Vrms
Warm-up Time	< 5 minutes to lock @ 25°C
Size	25 x 88 x 125 mm .98 x 3.47 x 4.92 inches
Weight	460 grams 16 0z.

Section 2. OPERATION AND USE

INSTALLTION 2-1

Site Selection 2-1.1

The selected installation site should be within standard ambient temperature and ranges as specified in Table 2, and should be free from strong surrounding magnetic fields.

Cabling Data 2-1.2

Use Table 3 to configure cabling for the **RFS**.

TABLE 3. CABLING DATA

DESIGNATION	UNIT CONNECTOR	MATING CONNECTOR
J1	DE9PU	DE9S
J2	SMA Female	SMA Male

TURN-ON PROCEDURE 2-2

Perform the following steps to verify the **RFS** is operating properly. If the unit does not meet all requirements refer to **REPAIR** section of this manual.

a. Connect power to the power connector (J1) of Rubidium Frequency Standard (**RFS**) under test.

b. For all options except Option 25: Connect pin 1 to a DC Power Supply capable of supplying +15 Vdc at a peak current of 2.0A.

For Option 25: Connect pin 1 to a DC Power Supply capable of supplying +22 to 32 Vdc at a peak current of 1.4A.

c. Connect pins 2 (all options) and labeled **return** to the DC Power Supply Return.

d. Turn on power and allow the **RFS** to warm up for 5 minutes.

e. Measure the **LOOP LOCKED** Indicator Voltage (pin 3) and verify it is less than 1 Vdc.

f. Measure frequency at SMA connector J2. (Note: frequency accuracy of the FE-5680A is better than most counters).

FREQUENCY ADJUSTMENT 2-3

Introduction 2-3.1

The FE-5680A output frequency can be adjusted digitally over the RS-232 interface (pins 8 and 9). This feature is available as option 2, and is not available on units purchased without this option. The frequency can be adjusted with a resolution of 6.8126×10^{-6} Hz. For an FE-5680A device with an output frequency of 10 MHz, this corresponds to a relative frequency setting resolution of 6.8126×10^{-13}.

In order to perform frequency adjustments to the FE-5680A over the serial interface, commands conforming to the protocol described in this section must be sent. The signal levels must conform to the RS-232C requirements. Commands are sent to the FE-5680A on the DATA IN line (pin 8), and responses from the FE-5680A are received on the DATA OUT line (pin 9). The DATA IN and DATA OUT signals are referenced to system ground, pin 5.

This Section describes the serial message protocol between the FE-5680A and a computer.

Protocol Format 2-3.2

Each message is comprised of a command header and optional data. The command header has a command ID, message length and command checksum. Some messages may have data as well. If data is present, data is appended after the command checksum and its length is dependent of the specific command.

Command format:

[Command ID] [Message length] [Command checksum] [Data…Data…Data…] [Data Checksum]

Where:

Command ID – 8 bit unsigned integer
Message Length – 16 bit unsigned integer
Command Checksum – 8 bit unsigned integer
Data – Variable length data
Data Checksum – 8 bit unsigned integer calculated by taking the exclusive-or of each byte

Table 4 illustrates the byte ordering of the serial message protocol. If a particular command does not have any associating data, then the message length is 4 bytes.

Table 4

Message Section	Offset	Description
Command Header	0	Command ID
	1	Low-byte of message length
	2	High byte of message length
	3	Check of byte offset 0,1, and 2
Data	4	Data Byte 0
	5	Data Byte 1
	.	
	.	
	.	
	n	Data Byte n
	n+1	Checksum of byte 4 to n

Commands 2-3.3

2-3.3.1 Set Frequency Offset, Save to EEPROM – 2Ch

This command is used to perform a frequency adjustment which will be "remembered" by the FE-5680A. If the FE-5680A is turned off after this type of frequency adjustment, it will return to the adjusted frequency setting after being powered on at a later time. Typically this command is used for infrequent frequency adjustments used to correct the FE-5680A output for frequency aging effects.

Note: If a long time elapses ,between powering down and powering on, frequency aging may result in a slightly different output frequency.

The offset sent to the FE-5680A with this command is saved in EEPROM memory. The EEPROM can be written to at least 100,000 times with no loss of information, however, if too many writes are performed (more than 100,000) the validity of the stored values could become questionable. It is recommended that this command be used no more than once per hour. This insures a life of >10 years for the EEPROM memory.

Input Command: 2C 09 00 25 aa bb cc dd <cs>
Data:

aa bb cc dd	32 bit signed integer where aa is the most significant byte and dd is the least significant byte of the 32 bit signed integer.
Data Length:	4 bytes
Command Length:	9 bytes
Remarks:	This command sets the frequency offset. Value represents a 32 bit signed integer.
Range:	00 01 1E B1 = 73,393 = +0.5 Hz
	FF FF E1 4F = -73,393 = -0.5 Hz

2-3.3.2 Set Frequency Offset, Don't Save to EEPROM – 2Eh

This command is used to perform a frequency adjustment which will ***not*** be "remembered" by the FE-5680A. If the FE-5680A is turned off after this type of frequency adjustment, it will return to the pre-adjusted frequency setting after being powered on at a later time. Typically this command is used for locking the FE-5680A to a more stable reference. There is no limit on how often this command can be sent to the FE-5680A.

Input Command: 2E 09 00 27 aa bb cc dd <cs>
Data:

aa bb cc dd — 32 bit signed integer where aa is the most significant byte and dd is the least significant byte of the 32 bit signed integer.

Data Length: 4 bytes

Command Length: 9 bytes

Remarks: This command sets the frequency offset. Value represents a 32bit signed integer.

Range: 00 01 1E B1 = 73,393 = +0.5 Hz
FF FF E1 4F = -73,393 = -0.5 Hz

2-3.3.3 Request Frequency Offset – 2Dh

Input Command: 2D 04 00 29

Command Length: 4 bytes

Response: 2D 09 00 24 aa bb cc dd <cs>

Data:

aa bb cc dd — 32 bit signed integer where aa is the most significant byte and dd is the least significant byte of the 32 bit signed integer.

Data Length: 4 bytes

Response Length: 9 bytes

Remarks: This command reads the Frequency Offset value. Value represents a 32 bit signed integer.

SAMPLE OFFSET COMMANDS

USING THE DON'T SAVE COMMAND FOR DIGITAL TUNING IN A CONTROL LOOP

ASSUMING A POSITIVE 5E-08 OFFSET IS REQUIRED, THE NUMBER OF BITS REQUIRED FOR THIS OFFSET WOULD BE

5E-08 / RESOLUTION = 5E-08 / 6.8126E-13 = 73,393 (BASE 10)

IN ORDER TO PROGRAM THE OFFSET YOU WOULD NEED TO CONVERT THIS NUMBER TO HEXADECIMAL.

73,393 (BASE 10) CONVERTS TO 00011EB1 (HEX).

THE FOLLOWING BYTES WOULD BE SENT TO PROGRAM THE OFFSET:

2E 09 00 27 00 01 1E B1 AE

WHERE AE IS THE EXCLUSIVE-OR CHECKSUM OF THE OFFSET BYTES 01,01,1E, AND B1

USING THE SAVE COMMAND FOR FREQUENCY ADJUSTMENT DUE TO AGING

ASSUMING A NEGATIVE 5E-08 OFFSET IS REQUIRED, THE NUMBER OF BITS REQUIRED FOR THIS OFFSET WOULD BE

5E-08 / RESOLUTION = 5E-08 / 6.8126E-13 = -73,393 (BASE 10)

IN ORDER TO PROGRAM THE OFFSET YOU WOULD NEED TO CONVERT THIS NUMBER TO HEXADECIMAL.

-73,393 (BASE 10) CONVERTS TO FFFEE14F (HEX). FOR NEGATIVE OFFSETS YOU NEED TO TAKE THE 2'S COMPLEMENT OF THE POSITIVE OFFSET.

THE FOLLOWING BYTES WOULD BE SENT TO PROGRAM THE OFFSET:

2C 09 00 25 FF FE E1 4F AF

WHERE AF IS THE EXCLUSIVE-OR CHECKSUM OF THE OFFSET BYTES FF,FE,E1, AND 4F

THE LAST EXAMPLE WILL ALSO STORE THE OFFSET VALUE TO NON-VOLATILE EEPROM MEMORY

Section 3. REPAIRS

GENERAL 3-1

The Rubidium Frequency Standard (RFS) is not field repairable. All units that need repair should be shipped to the address given below. Prior to returning any units, contact the Marketing Department at extension 5030 to obtain an RMA number.

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