# TECHNICAL MANUAL
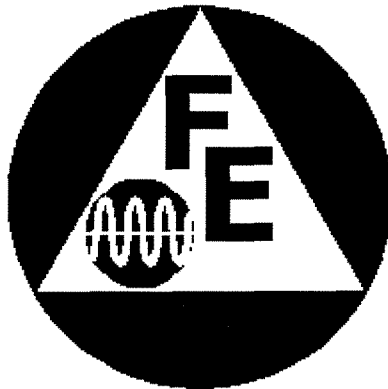# TM 5680-0211



## *RUBIDIUM FREQUENCY STANDARD*
## *MODEL FE-5680A SERIES*

# OPERATION AND MAINTENANCE INSTRUCTIONS

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## Section 1. TECHNICAL DESCRIPTION

### 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.
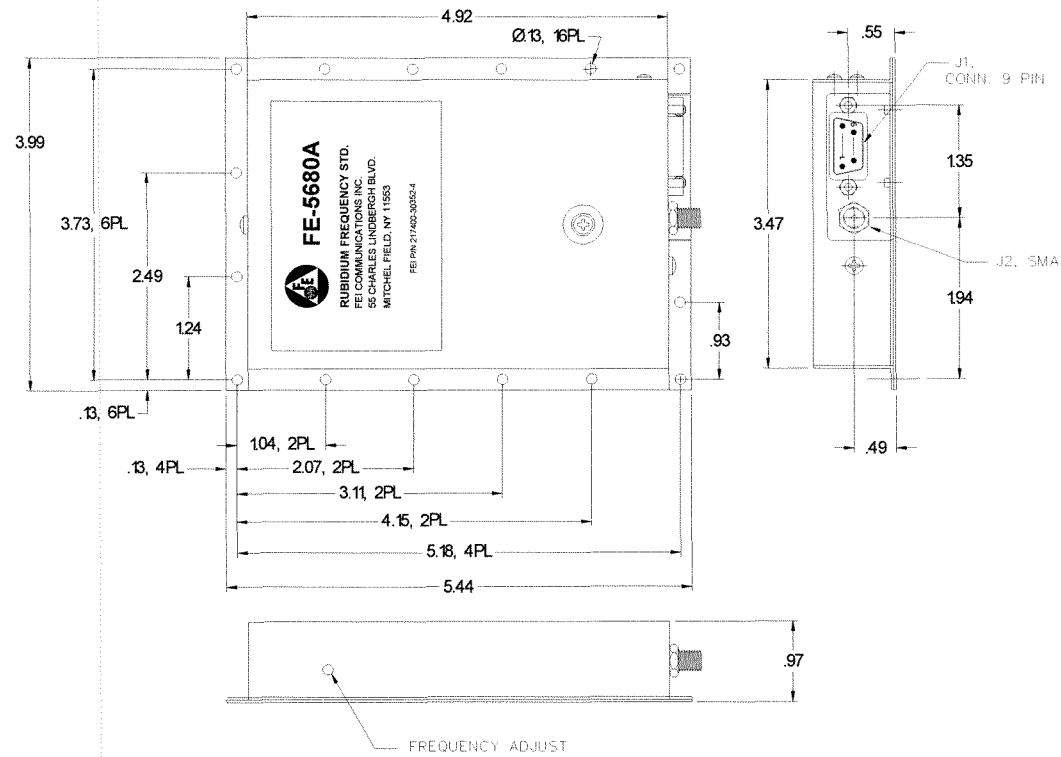
FIGURE 1.  RUBIDIUM STANDARD OUTLINE MODEL FE-5680A
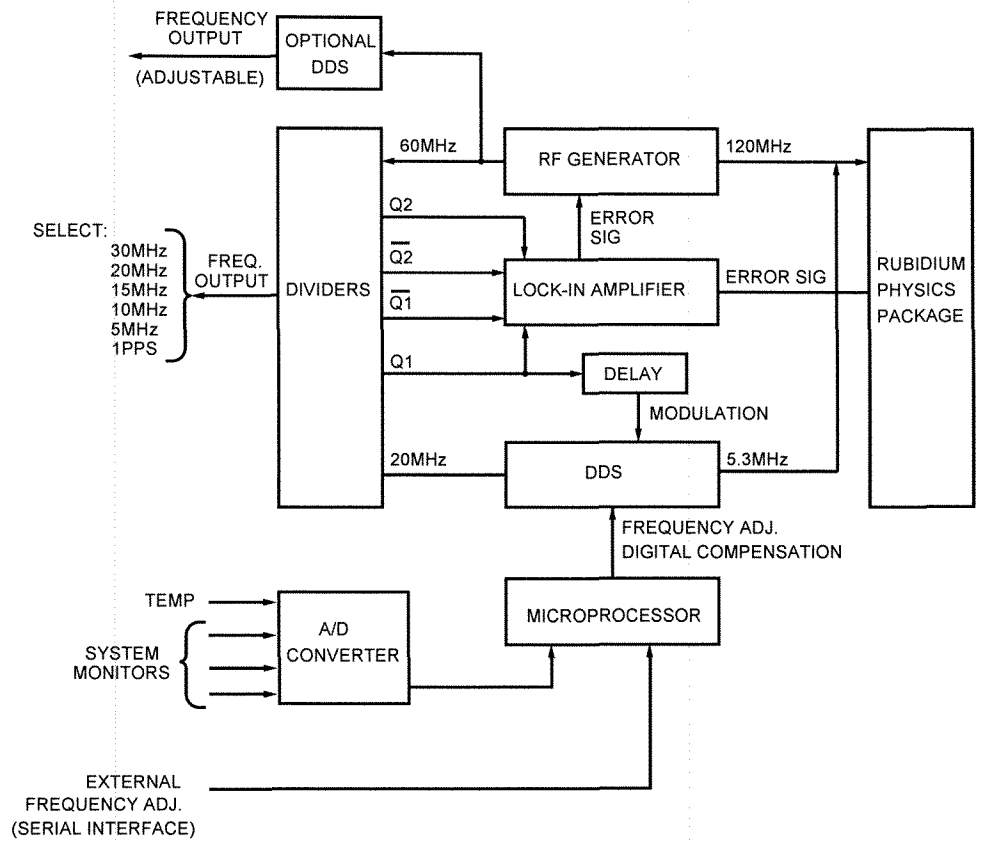
FIGURE 2. RUBIDIUM FREQUENCY STANDARD BLOCK DIAGRAM MODEL FE-5680A

## 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 50$\Omega$ (+7dBm) |
| Adjustment Resolution | $<1 \times 10^{-12}$ over range of +/- $5 \times 10^{-8}$ |
| Drift | $2 \times 10^{-9}$ /year<br>$2 \times 10^{-11}$ /day |
| Short Term Stability: 1 sec $\leq$ 100 sec | $1.4 \times 10^{-11}$ / $\sqrt{\tau}$ |
| Retrace | $5 \times 10^{-11}$ |
| Phase Noise (fo = 10 MHz) | @ 10 Hz: -100 dBc<br>@ 100 Hz: -125 dBc<br>@ 1000 Hz: -145 dBc |
| Input Voltage Sensitivity | $2 \times 10^{-11}$ / (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<br>< 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<br>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<br>.98 x 3.47 x 4.92 inches |
| Weight | 460 grams<br>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).

## 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 $6.8126 \times 10^{-6}$ Hz. For an FE-5680A device with an output frequency of 10 MHz, this corresponds to a relative frequency setting resolution of $6.8126 \times 10^{-13}$.

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.

**Frequency Electronics, Inc.**
**55 Charles Lindbergh Blvd.**
**Mitchel Field, NY 11553**
**Tel (516) 794-4500**
**Fax (516) 794-4340**