

## SECTION 1. GENERAL INFORMATION

### 1.1 INTRODUCTION

The FTS 4060 Cesium Beam Frequency and Time Standard (see Figure 1-1) is an accurate and stable frequency and time reference with microprocessor control. This manual contains detailed performance and installation specifications (Section 1), operating procedures (Section 2), and theory of operation (Section 3). A companion manual SERVICE MANUAL, FTS 4060 contains service procedures, parts lists and assembly/schematic diagrams.

### 1.2 SUMMARY DESCRIPTION

The FTS 4060 Cesium Time and Frequency Standard is a primary frequency and time reference with microprocessor control. The major function of the FTS 4060 is to produce accurate, stable, and spectrally pure sinusoidal signals, and precise 1 pulse-per-second (1 PPS) timing signals. To accomplish this, a cesium beam tube resonator is used to stabilize the output of a quartz crystal oscillator. The oscillator drives output signals at both 10 and 5 MHz, and optionally at 1 MHz and 100 kHz. The 10 MHz signal is digitally divided to produce the 1 pps signal which can be advanced or delayed in 100 nanosecond steps. The FTS 4060 features both 5 MHz and 10 MHz outputs; however, the instrument is optimized at either 10 MHz or 5 MHz. The FTS 4060/201 is optimized at 10 MHz with a low phase noise floor and also includes fast warm-up. The FTS 4060/101 is optimized at 5 MHz with excellent close-in phase noise and short term stability.

A microprocessor is used to perform the following tasks:

- Digital demodulation and integration of the servo loop signals
- Monitoring of system parameters
- Control of adaptive servos including control of the loop time constant during the instrument warm-up
- Diagnostic functions to aid in troubleshooting

When turned on or at user request, an autolock routine assures lock to the correct cesium resonance by checking and correcting:

- Oscillator control voltage
- Oscillator drift rate
- Operation of modulation circuits
- Cesium beam current level

## 1.2 SUMMARY DESCRIPTION (cont'd)

Operating controls on the front panel include:

- Switches for manual adjustment of the cesium control loop (modulation and feed-back loop)
- Automatic alignment pushbutton switch; assures lock to the correct cesium resonance and calibrates beam current level if necessary.
- Switches for scanning of either the frequency control voltage or the loop gain
- Fine frequency C-field adjustment
- Control switches for synchronizing and advancing or delaying the 1 pps signal
- Switches for setting the Time-of-Day display

LED indicators on the monitor panel are provided for frequency lock/alarm, monitor alarm, ac power/alarm, and battery charge conditions. Monitor functions available on the front panel monitor meter are:

- Oscillator oven power
- Cesium oven temperature
- Cesium beam current
- Oscillator control voltage
- Supply voltage
- Battery charge current

A 25 pin type "D" connector on the rear panel provides analog outputs for the monitors listed above, as well as the ion pump current monitor. Deguassing inputs are also provided on this connector.

For module maintainability, the FTS 4060 has designed-in servicability:

- Monitoring diagnostics and automatic or manual adjustments described above
- Functional isolation at the board level
- Slide out assemblies and quick connect cables

## 1.2 SUMMARY DESCRIPTION (cont'd)

The FTS 4060 operates from 115/230 V ac or 22 to 30 V dc optional internal battery/charger provides for a nominal 1 h standby protection from power failure.

A complete list of performance characteristics is provided in Table 1-1. Figures 1-2 and 1-3 are characteristic curves of the rf output signals in the frequency and time domains. Table 1-2 lists recommended test equipment for operating and performance checks, troubleshooting, and alignment.

## 1.3 INSTRUMENT IDENTIFICATION

A slash (/) and a three-digit number, following the four-digit model number (4060) specifies an option that is supplied within the instrument. See Table 1-1 for a list of available options.

TABLE 1-1 SPECIFICATIONS, FTS 4060  
(at 25 °C unless otherwise specified)

PERFORMANCE

ACCURACY	$\pm 7 \times 10^{-12}$	
RETRACE (Reproducibility)	$\pm 3 \times 10^{-12}$	
SETTABILITY (Frequency)	$\pm 2 \times 10^{-13}$	
FREQUENCY CHANGE Over operating temperature Under dc magnetic field (2 gauss)	$< 5 \times 10^{-12}$ $< 2 \times 10^{-12}$	
OPERATING TEMPERATURE RANGE	0 to 50 °C	
STABILITY $\sigma_f(\tau)$  <u>Averaging Time (<math>\tau</math>)</u>  1 s 10 s 100 s 1,000 s 10,000 s	<u>FTS 4060/201</u>  1x10 <sup>-11</sup> 1x10 <sup>-11</sup> 5x10 <sup>-12</sup> 2x10 <sup>-12</sup> 5x10 <sup>-13</sup>	<u>FTS 4060/101</u>  7x10 <sup>-12</sup> 7x10 <sup>-12</sup> 5x10 <sup>-12</sup> 2x10 <sup>-12</sup> 5x10 <sup>-13</sup>
SSB PHASE NOISE $L(f)$ of 5 MHz Output (1 Hz Bandwidth)  <u>Offset from Carrier (f)</u>  1 Hz 10 Hz 100 Hz 1000 Hz	<u>@ 10 MHz</u>  -90 dBc -120 dBc -140 dBc -150 dBc	<u>@ 5 MHz</u>  -100 dBc -130 dBc -140 dBc -140 dBc

TABLE 1-1 SPECIFICATIONS, FTS 4060 (cont'd)

PERFORMANCE (cont'd)

SPECTRAL PURITY  Harmonics Spurious Signals Signal-to-phase noise ratio in 30 kHz noise BW	<u>@ 10 Mhz</u>	<u>@ 5 MHz</u>
	<-30 dBc <-80 dBc > 81 dB	<-40 dBc <-80 dBc > 87 dB
WARM-UP TIME *	<u>FTS 4060/201</u> 20 min	<u>FTS 4060/101</u> 45 min

\*Note: If the FTS 4060 has been in storage for an extended period, the warm-up time may be greater than speceified

OUTPUTS

SINUSOIDAL OUTPUTS Rear Panel (standard 1 ea) (w/Option 061) Front Panel (w/Option 061)  Amplitude	10 MHz, 5 MHz Add 1 MHz, 100 kHz Add 5 MHz, 1 MHz, 100 kHz  1.0 V rms into 50 ohm load
PULSE OUTPUTS (w/Opt 116 or 117)  Front Panel Rear Panel  Amplitude Width Rise Time Fall Time	1 pps advance/delay 1 pps advance/delay 1 pps master 10 V + 1 V peak into 50 ohm load 20 us +10% <50 ns <2 us
MONITOR OUTPUTS  -beam current -oscillator oven power -oscillator control voltage -cesium oven temperature -supply voltage -charge current	(25 contact "D" connector on rear panel; also on front panel meter) 0 to 5 V

TABLE 1-1 SPECIFICATIONS, FTS 4060 (cont'd)  
(at 25 °C unless otherwise specified)

INPUTS

<p>PULSE SYNCHRONIZATION INPUT (front panel)(w/Opt 116 or 117)</p> <p>Amplitude Width Rise Time Synchronization Accuracy</p>	<p>4 to 10 V peak into 50 ohm load &gt; 500 ns &lt; 50 ns &lt; +150 ns</p>
<p>C-FIELD DEGAUSS</p>	<p>2 contacts on rear panel "D" connector</p>
<p>ZEEMAN INPUT</p>	<p>Front panel BNC connector 42.82 kHz @ 1 V rms</p>
<p>CONTROLS</p> <p>Lock Alarm Indicator Reset AC Power Alarm Reset Modulation On/Off Loop Open/Close Loop Gain Adjustment Loop Time Constant Select Oscillator Control Voltage Adjust Alignment Control C-field Adjust Sync Enable TOD Display: Set, Fast, Slow, Start</p>	

GENERAL

POWER REQUIREMENTS	<u>AC</u>	<u>DC</u>
Operating Voltage	115/230 V ac +10%	22 to 30 V dc
Frequency Range	47 to 400 Hz	N/A
Power (operating)	68 W	28 W
(warm-up)	128 W	48 W
Option 061 Additional RF Outputs	Add 4 W	Add 4 W
Option 010 Internal Batt/Charger (Fast Charge)	Add 16 W	N/A
(Trickle Charge)	Add 2 W	N/A
Option 116 Time of Day Display	Add 12 W	Add 6 W
Option 117 TOD Display with 1 PPS Delay	Add 6 W	Add 3 W

TABLE 1-1 SPECIFICATIONS, FTS 4060 (cont'd)  
(at 25 °C unless otherwise specified)

GENERAL (cont'd)

<b>MATING CONNECTORS</b>	
Rear Panel	
AC Line Input	Belden #17250 Power Cord
External DC Input	MS3106A-14S-5S
DC Output (Accessory Power)	MS3106A-14S-2P
RF and 1 pps Outputs	BNC
Monitor Output	25 Contact, male, Cannon #DB-25P
Front panel	
1 PPS Output	BNC
RF Outputs	BNC
SYNC Input	BNC
Zeeman Input	BNC
<b>FUSES</b>	
AC Line Input @ 115 V	2 A SB, 0.25" x 1.25"
@ 230 V	1 A SB, 0.25" x 1.25"
Ext DC Input	4 A, 0.25" x 1.25"
Battery	2 A, 0.25" x 1.25"
DC Output	2 A, 0.25" x 1.25"
<b>DIMENSIONS</b>	
Height	133 mm (5.2")
Width	483 mm (19")
Depth	533 mm (21")
<b>WEIGHT</b>	
FTS 4060	27.2 kg (60 lbs)
Option 010 Internal Battery/Charger	Add 4.5 kg (10 lbs)

ENVIRONMENT

TEMPERATURE, OPERATING	0 to 50 °C
TEMPERATURE, NON-OPERATING	
Storage	-40 to +50 °C
Short-term	-40 to +75 °C
HUMIDITY, OPERATING	95% up to 50 °C
MAGNETIC FIELD	0 to 2 gauss

TABLE 1-1 SPECIFICATIONS, FTS 4060 (cont'd)  
(at 25 °C unless otherwise specified)

MODEL SELECTION

FTS 4060/201	FTS 4060/101
<p>10 MHz output signal optimized for low phase noise floor and fast warm-up. One RF output each at 10 MHz and 5 MHz located on the rear panel.</p>	<p>5 MHz output signal optimized for excellent close-in phase noise and short-term stability. One RF output each at 5 MHz and 10 MHz located on the rear panel.</p>

OPTIONS

010	Internal Battery and Automatic Charger
013	Chassis Rack Slides
014	Latching Door for Control Panel
015	10 h Standby Battery Power Supply (external)
061	Additional RF Outputs: 1 MHz, 100 kHz
116	Time of Day Display with 1 PPS Advance/Delay
117	1 PPS Advance/Delay



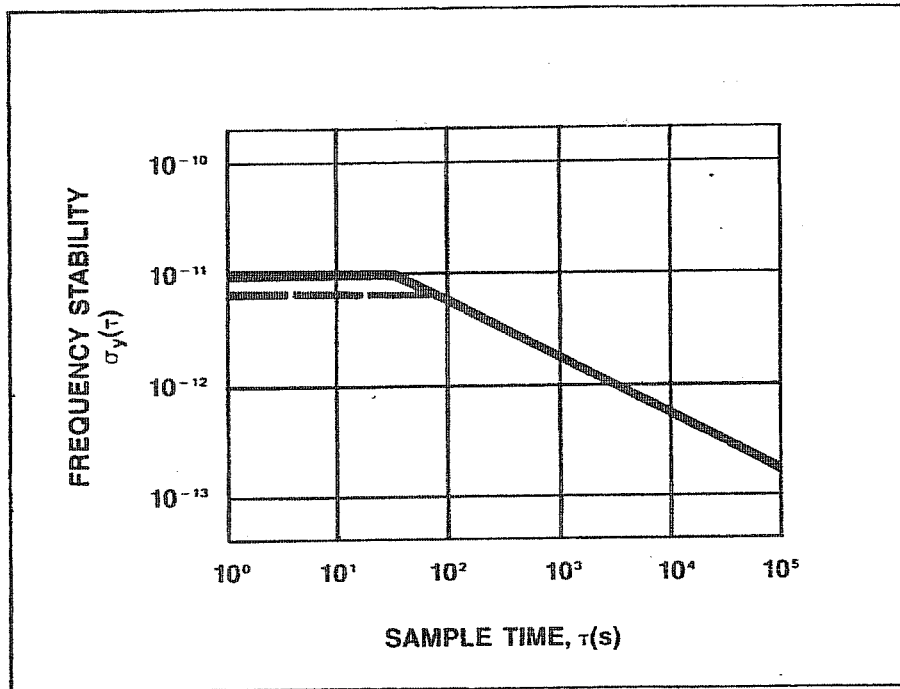


FIGURE 1-2 FREQUENCY STABILITY

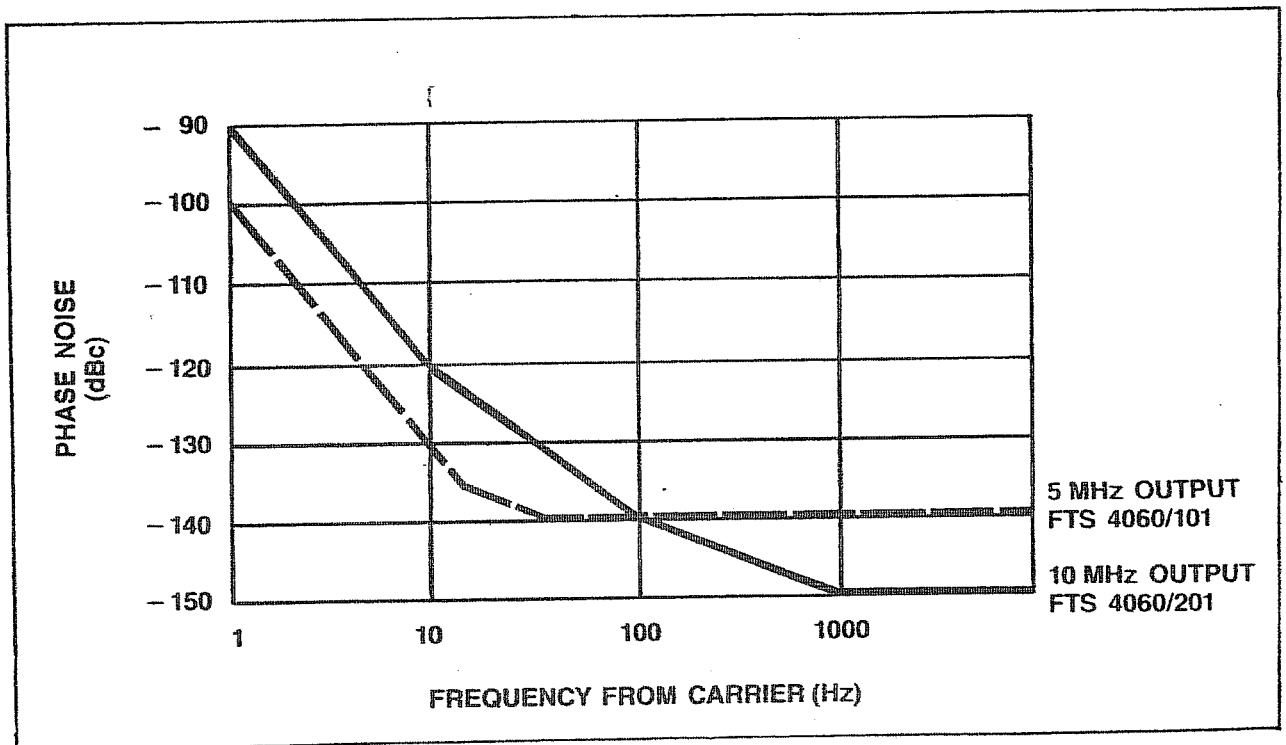


FIGURE 1-3 SINGLE SIDE-BAND PHASE NOISE SPECTRAL DENSITY