



Model FTS-1050A/015

Disciplined Quartz Frequency Standard

Serial Number _____
October 14, 1999
Revision G

OPERATING MANUAL
MODEL FTS 1050A/015
DISCIPLINED QUARTZ FREQUENCY
STANDARD

Option Coverage: 001 100 kHz Output
002 Internal Standby Battery and Automatic Charger
003 1 PPS Output

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CHAPTER 1 GENERAL INFORMATION

1.1 INTRODUCTION

1.1.1 Scope of Manual

This manual (FTS Part Number 06686-001-00000) provides detailed instructions for installing and operating the FTS 1050A/015 Quartz Frequency Standard.

The manual is configured as follows:

Chapter 1 General Information

A general description of the instrument, technical specifications, theory of operation.

Chapter 2 Installation

Instructions for inspecting, unpacking, and making external connections.

Chapter 3 Operation

Turn-on and turn-off instructions, descriptions for all indicators, monitors, and controls.

Chapter 4 Maintenance

Reshipping information, troubleshooting guidelines, and routine maintenance.

Chapter 5 Options

Information for standard FTS 1050A/015 options.

1.1.2 Configurations Covered

Chapters 1 through 4 apply to the base configuration of the instrument. Information pertaining to options, is supplied in Chapter 5. When information in the main manual and Chapter 5 differ, Chapter 5 shall govern.

1.1.3 Warranty Information

Frequency and Time Systems, Inc. warrants that this product is free from defects in material and workmanship for a period of one year from the original date of delivery. Warranty service will be performed on the unit at the FTS factory (unless the return of only a subassembly is authorized by FTS), or, at FTS' discretion, in the field. Upon return to the factory, FTS will, at no further expense to the customer, repair or replace (at FTS' option) the unit or subassembly provided that the unit or subassembly has not been improperly installed, maintained, interfaced, or operated outside of its environmental specifications or otherwise misused and has not been repaired or modified without authorization by FTS.

The customer shall prepay shipping charges for units returned to FTS, and FTS shall pay for the return of the repaired or replaced unit to the customer.

1.2 INSTRUMENT IDENTIFICATION

The instrument is designated with a four or five digit model number (1050A). A slash (/) and a three digit number following the model number, specifies an option that is supplied within the instrument. The instrument model number and serial number appear on an adhesive label that is located on the instrument rear panel.

1.3 INSTRUMENT DESCRIPTION

The FTS 1050A/015 is a Disciplined Quartz Frequency Standard (DFS) that phase-locks a precision quartz crystal oscillator to an external 5 MHz reference signal. Sinusoidal outputs at frequencies of 1 MHz, 5 MHz, and 10 MHz (1 each, independently buffered), are available at the instrument's rear panel. Refer to Table 1-1 for instrument specifications.

A front panel switch provides selection of a 1 or 100 second loop time constant (LTC). This allows the user to optimize the overall performance of the phase lock loop with respect to reference signal noise.

The FTS 1050A/015 retains the current reference signal value within digital memory, providing a frequency memory resolution of $\pm 2.5 \times 10^{-12}$. Upon removal of the external reference, the oscillator control voltage for the last locked frequency, is maintained and the instrument operates with the internal oscillator in an open-loop mode. In this mode, the oscillator frequency can be adjusted over a range of 4×10^{-7} , using front panel controls. The minimum adjustment is 4×10^{-12} . The oscillator is automatically relocked to the reference when it is reapplied.

The FTS 1050A/015 is rack-mountable and measures $\approx 19" \times 3.5" \times 16.8"$. The front panel contains:

- Instrument status indicators
- Monitors
- A Loop Time Constant selection control
- Frequency controls
- Alarm reset switches

The rear panel contains:

- Signal output connectors
- A remote monitor connector
- Power connectors
- Fuses

TTL-compatible (open collector) logic signals are provided at a rear-panel connector for remote monitoring of the instrument.

The FTS 1050A/015 is normally operated from a 115 or 230 V ac, 47 to 400 Hz source. The instrument can also be powered with a DC input from 26 to 30 V.

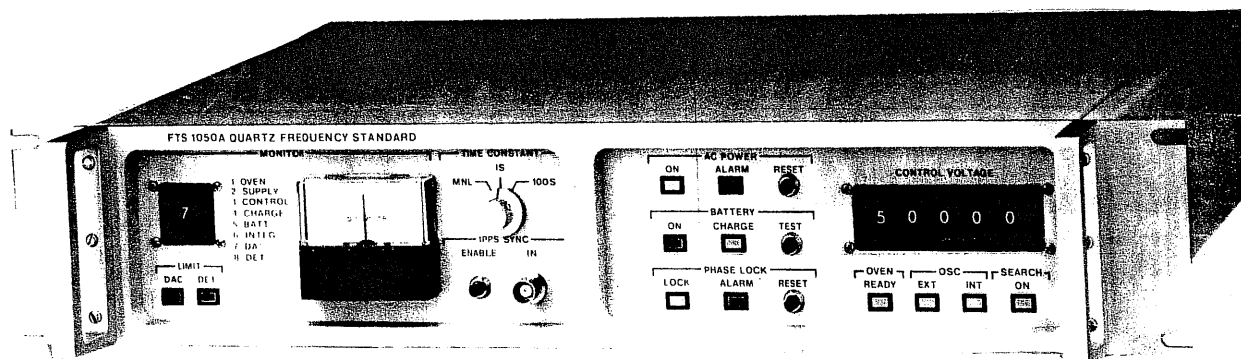


Figure 1-1 FTS 1050A/015 Disciplined Quartz Frequency Standard (Shown with Options 002 and 003)

1.4 SPECIFICATIONS

Table 1-1 Specifications FTS 1050A/015 Quartz Frequency Standard

Parameter	Specification
Outputs Output Amplitude/50 Ω Harmonic Distortion Spurious Signals: 5 MHz 1 MHz, 10 MHz	1 MHz, 5 MHz, and 10 MHz 1 V rms -40 dB -80 dB -70 dB
Aging Per Day (Note 1) Short Term Stability For averaging time of: 1 s 10 s 100 s	1×10^{-10} 1×10^{-12} 1×10^{-12} 1×10^{-12}
SSB Phase Noise (5 MHz output; BW=1 Hz) For offset from signal of:	1 Hz -116 dBc 10 Hz -140 dBc 100 Hz -150 dBc 1 kHz -157 dBc 10 kHz -160 dBc
Warm-Up Time to Lock	30 minutes
Frequency Adjustment Range Front of Panel (5 digit)	4×10^{-7}
Maximum Frequency Change as a Function of: Operating Temperature Load Change (50 $\Omega \pm 10\%$)	1×10^{-9} 5×10^{-11}
Operating Temperature Range	0 to 50 $^{\circ}\text{C}$
Non-Operating Temperature Range	-60 to 80 $^{\circ}\text{C}$
External Phase Lock External Reference Freq External Ref. Amplitude Resolution Loop Time Constant Digital Tuning Range Automatic Acquisition Range	5 MHz 1 V rms 2×10^{-12} 1 s or 100 s; switch selectable 2×10^{-8} 2×10^{-8}
Power Requirements AC Input DC Input	115 or 230 V $\pm 10\%$; 47 to 400 Hz 30 W (typ.) at 25 $^{\circ}\text{C}$ 26 to 30 V dc; 13 W (typ.) at 25 $^{\circ}\text{C}$
Dimensions Height Width Depth	3.5" (89 mm) 19" (483 mm) 18" (457 mm)
Weight	21 lb (9.5 kg)

Note 1: Aging typically improves to a level of parts in 10^{11} per day. Aging rates as low as 1×10^{-12} have been observed after years of unperturbed operation.

1.5 FUNCTIONAL DESCRIPTION

Figure 1-2 is a block diagram of the FTS 1050A/015 Quartz Frequency Standard.

The FTS 1050A/015 consists of the following functional blocks:

- Signal Distribution
- Phase-locked Loop
- Monitoring and Control Circuitry
- Power Distribution

1.5.1 Signal Distribution

The main assemblies for generating user output signals are the Oscillator and the RF Assemblies.

The oscillator contains an SC-cut crystal and an integral controller oven. This provides frequency stability by controlling the internal temperature over a wide range of ambient temperatures. The oscillator provides two independently buffered 5 MHz sinusoidal signals. One signal is directly available to the user via the rear panel; the other provides a reference input to the RF Assembly.

A 1 and 10 MHz PCB Assembly is contained within the RF Assembly. This assembly accepts a 5 MHz input signal from the oscillator and doubles it to 10 MHz and divides it to 1 MHz, producing buffered user outputs.

1.5.2 Phase-Locked Loop

The 1050A/015 automatically senses the presence of an external 5 MHz frequency reference and phase-locks the internal oscillator to that reference. The principal subassemblies involved are:

- the Oscillator
- the Phase Detector PCB (part of the RF Assembly), and
- the Digital to Analog Converter (DAC) PCB

The Phase Detector Assembly uses phase detector and integrator circuitry to create an integrated error voltage proportional to the phase difference between the external reference and the internal oscillator 5 MHz signals. The integrator automatically retains the last value of oscillator control voltage upon loss or removal of the reference signal.

The error signal is applied to the DAC PCB Assembly which contains circuitry to provide a frequency control voltage to the oscillator. The control voltage is a combination of:

- The integrator output (attenuated),
- A counter containing a digital word whose contents change whenever the error voltage exceeds a preset limit, and
- An input from the front panel CONTROL VOLTAGE switch assembly.

If the external reference signal is removed, the integrator and counter maintain their present levels and the CONTROL VOLTAGE switch assembly provides the only control of the oscillator output frequency.

1.5.3 Monitor and Control Circuitry

The Monitor and Control circuitry is contained within several assemblies. The assemblies and their monitor and control functions are listed below.

The Monitor PCB Assembly:

- Accepts external DC and AC power inputs and automatically switches between them (priority is AC).
- Provides monitoring circuitry and activates the front panel status indicators for AC power and the oscillator oven.
- Contains circuitry to reset the AC ALARM LED indicator.

The Acquire PCB Assembly:

- Activates front panel status indicators for the external and internal 5 MHz levels and phase lock loop status (LOCK, ALARM, DET).
- Interfaces with the front panel TIME CONSTANT selection switch when used in the 1 s or 100 s positions.
- Provides monitor outputs to the rear panel REMOTE MONITOR connector.
- Contains circuitry to reset the PHASELOCK ALARM indicator.

The Phase Detector PCB Assembly:

- Contains level detector circuits to determine the presence of the external reference and internal oscillator 5 MHz signals.
- Monitors the status of the phase-locked loop.
- Monitors the phase detector and integrator

The DAC:

- Monitors the contents of the DAC counter and activates the DAC LIMIT LED indicator if preset limits are exceeded.
- Interfaces with the front panel TIME CONSTANT selection switch when used in the MNL position.
- Interfaces with the front panel MONITOR meter and switch and for DET, INTEG, and DAC monitors.

1.5.4 Power Distribution

AC input power is converted to an unregulated DC voltage (+22 to +30 V) at the input. This voltage and external DC power (if applied), are applied to the Monitor PCB Assembly where power source selection is performed. The instrument normally operates from AC power. If AC power is interrupted, DC power is used (if available) until AC is restored.

A power regulator supplies the oscillator with +22 V and is controlled by the Monitor PCB Assembly during crystal oven warm-up. A power supply assembly accepts +22 V dc and supplies +22, +5, +15, and -15 V dc to the other assemblies.

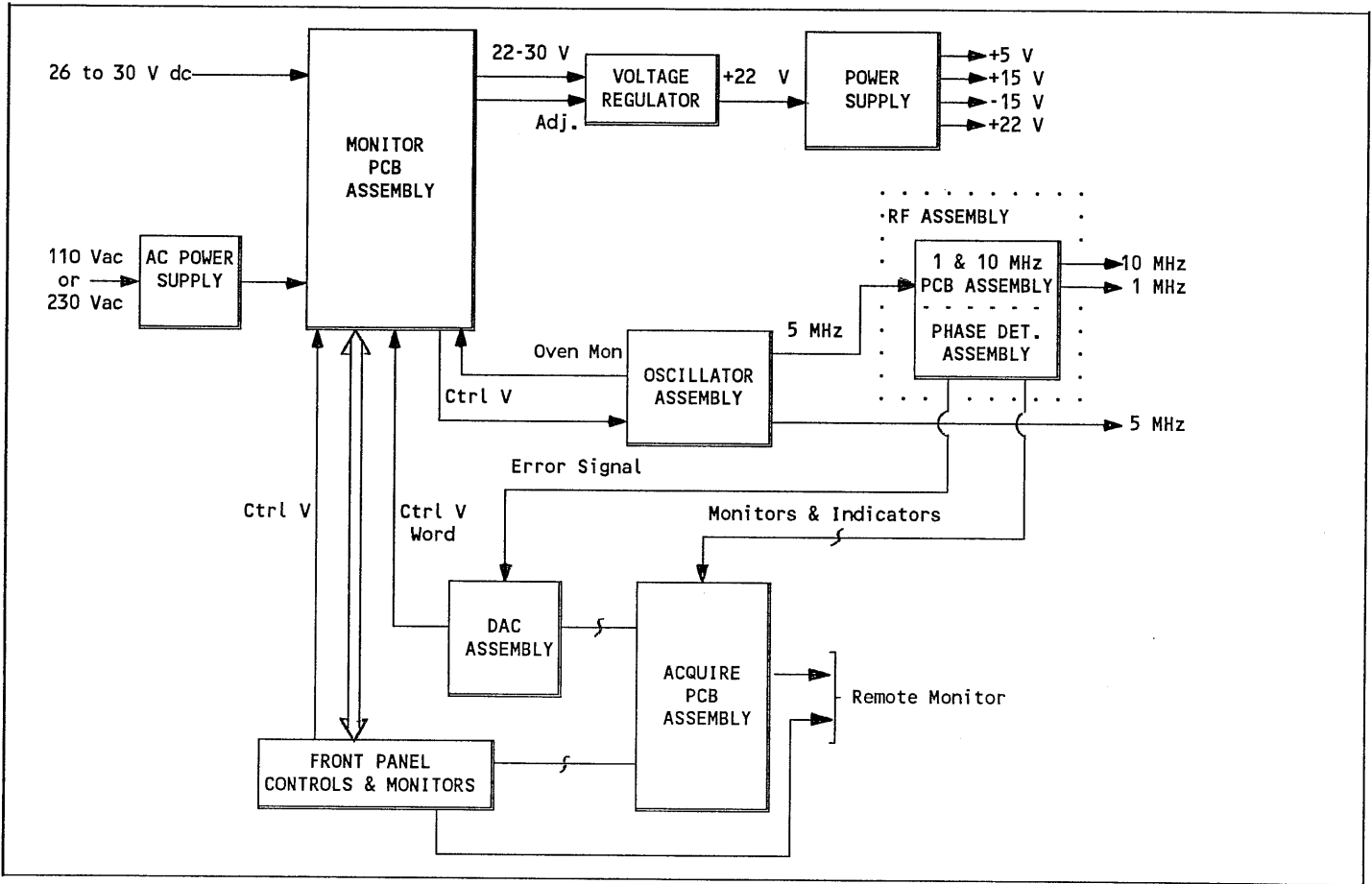


Figure 1-2 FTS 1050A/015 Disciplined Quartz Frequency Standard Block Diagram

Chapter 2 INSTALLATION

2.1 INTRODUCTION

This chapter provides information for inspecting, installing, and making connections to the FTS 1050A/015.

The FTS 1050A/015 requires no special equipment for installation and handling. Figure 2-1 shows the outline dimensions of the instrument. Three additional inches are required at the rear panel to attach power and signal cables.

2.2 UNPACKING/INSPECTION

CAUTION!

**Static electricity can damage electronic circuitry!
Use proper static precautions when handling the instrument.**

Unpack all equipment carefully and check it against the purchase order for completeness.

If the shipping carton is damaged, inspect the equipment for damage. If you suspect that it was damaged in transit, notify Frequency and Time Systems and the carrier who delivered the equipment. Retain the shipping carton and packing material for the carrier's inspection.

2.3 SUPPLIED EQUIPMENT

The following items are supplied with the FTS 1050A/015:

<u>Item</u>	<u>Qty</u>	<u>Part Number</u>
AC power cord	1	17250 (Belden)
DC power input mating connector	1	MS3106A-14S-2S (Cannon)
DC power output mating connector	1	MS3106A-14S-2P (Cannon)

2.4 RACK MOUNTING

The FTS 1050A/015 front panel contains mounting ears for attaching to a standard 19" instrument or relay rack. Each ear has two slotted openings that accept #10 screws.

The sides of the FTS 1050A/015 are equipped with threaded holes for attaching rack slides (3, #8 holes per side). An FTS 6013 Slide Rack Accessory kit is recommended for mounting to a rack.

2.4.1 Rack-Slide Mounting Procedure

This procedure is applicable for mounting the FTS 6013 Rack Slide Kit to the FTS 1050A/015. Materials included in the kit are:

Rack Slides; (2 slides; 3 sections/slide)	part number 03790-701
Connecting Hardware	part of 03790-701

- 1) Separate the Flange Mount 2.4 sections (B) from each rack slide assembly. Refer to Figure 2-2 Rack Slide Assembly Diagram.
- 2) Attach the end brackets and bar nuts connecting hardware to the rear of the instrument rack per Figure 2-2.
- 3) Place three machine screws (#8-32 x 3/8) in the first three holes of both Inner Chassis sections (A).

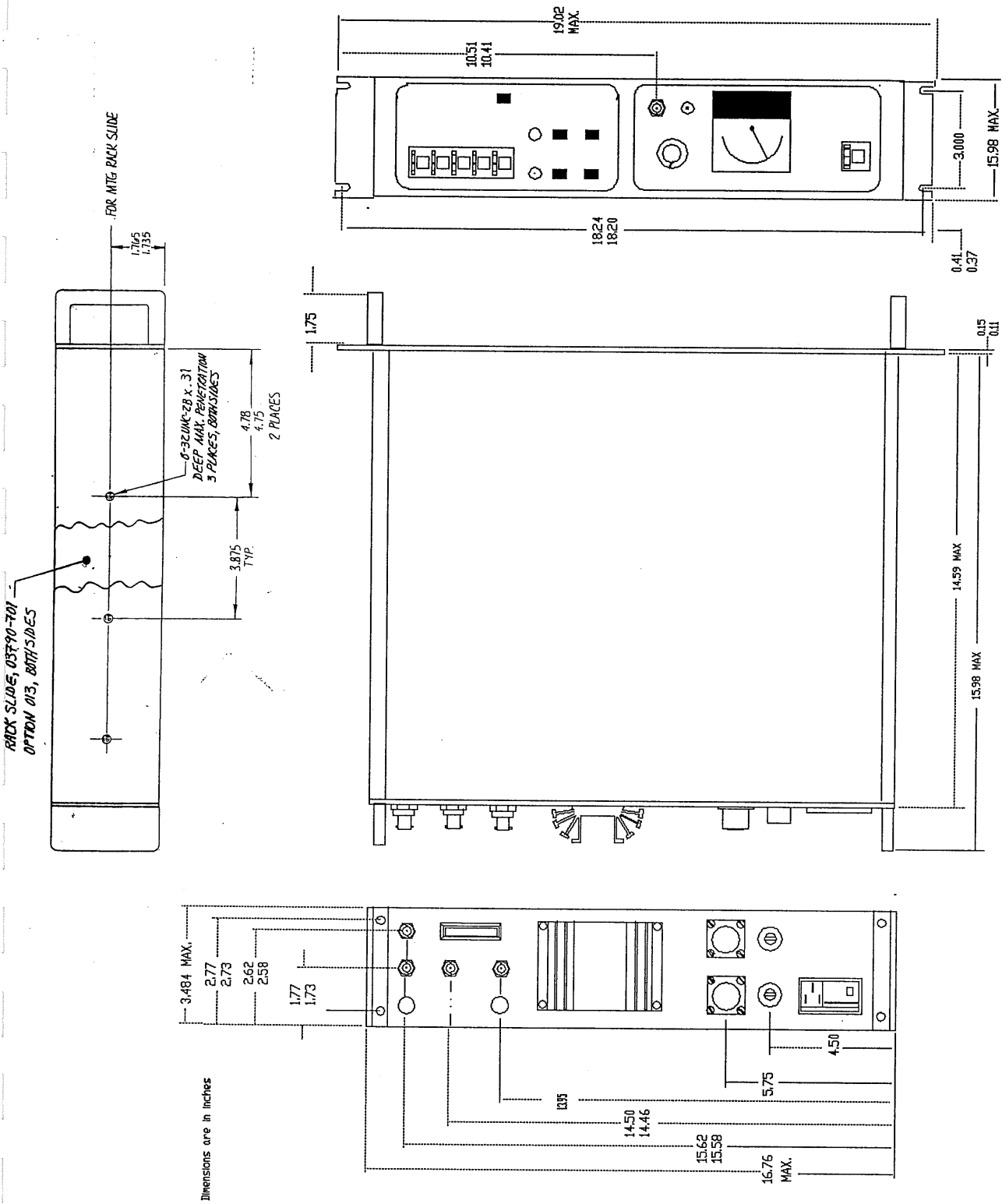


Figure 2-1 FTS 1050A Outline Diagram

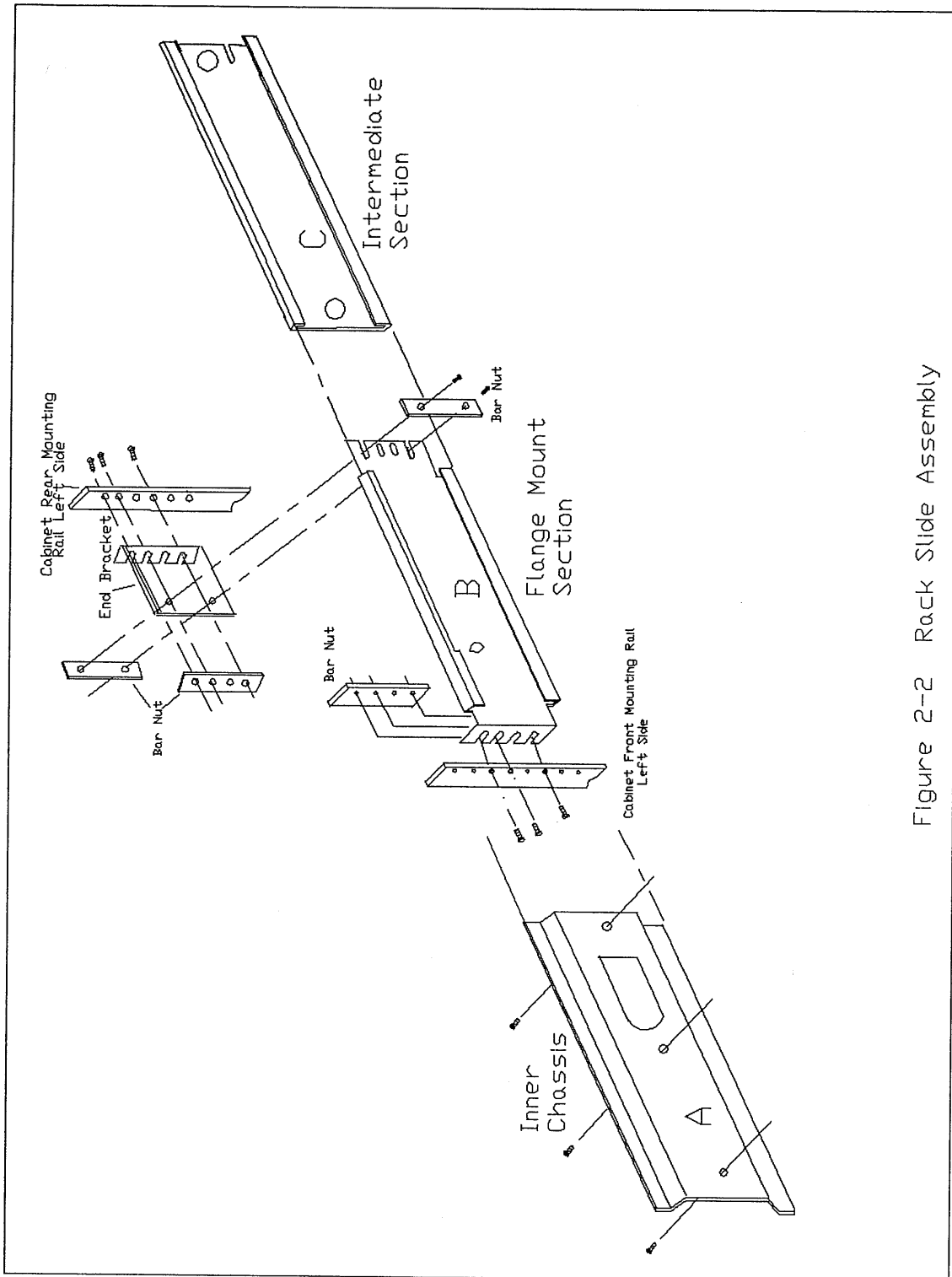


Figure 2-2 Rack Slide Assembly

2.4.1 Rack-Slide Mounting Procedure (continued)

- 3) Place machine screws (#10-32 x 3/8) in the holes of both Inner Chassis sections (A). Leave the hole behind the stop tab open on each assembly.
- 4) Place an aluminum spacer bar (D) over the exposed screws on each Inner chassis section.
- 5) Attach both Inner Chassis sections with spacer bars, to the sides of the FTS 1050A/015 by tightening the screws into the holes provided.
- 6) Insert the Intermediate slide sections (C) within the Flange Mount 2.4 sections past the stop tabs.
- 7) Secure the Flange Mount 2.4 sections to the rack.
- 8) Slide the FTS 1050A/015 into the tracks of the mounted rack sections. When the slides lock, depress the stop tabs and push the FTS 1050A/015 the rest of the way into the rack.
- 9) Secure the FTS 1050A/015 to the rack with four screws placed through the slotted openings on the instrument's front panel.

2.4.2 Demounting Procedure

- 1) Remove the four front panel screws securing the FTS 1050A/015 to the rack.
- 2) Slide the instrument outward (away from the rack) until the slide sections lock.
- 3) Press the slide rack stops to release the lock and pull the instrument outward past the stops.
- 4) Continue to pull forward until the instrument is free from the rack slides. The Inner slide sections stay attached to the sides of the FTS 1050A/015.

2.5 CONNECTIONS

Figure 2-3 is an illustration of the FTS 1050A/015 rear panel.

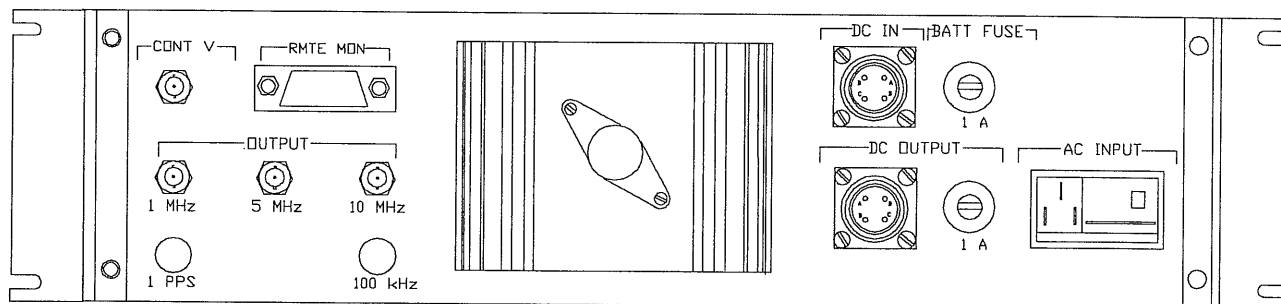


Figure 2-3 FTS 1050A/015 Rear Panel

2.5.1 AC Power

The FTS 1050A/015 operates from 120 ± 10 V ac or 230 ± 10 V ac. Line frequency can be from 47 to 440 Hz. The AC input is equipped with a line voltage selector card, a three-prong power receptacle, and a fuse holder with a fuse pull lever (refer to Figure 2-4).

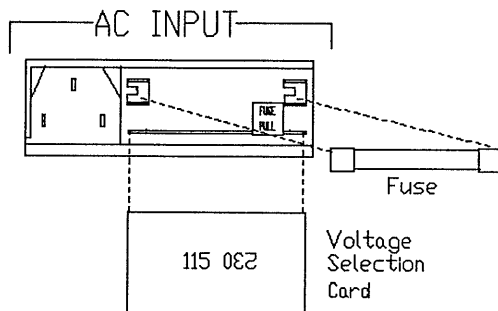


Figure 2-4 AC Power Connector

Use the following procedure for connecting AC power:

NOTE: There is no power switch for the FTS 1050A/015. The instrument is operational as soon as power is applied.

- 1) Locate the AC INPUT connector on the instrument rear panel and check that the line voltage selector PCB is in the proper position. Either 115 or 230 should be visible. The positions are as follows:

<u>V_{in}</u>	<u>Card Position</u>
110 to 130 V ac	115
220 to 240 V ac	230

If the card is in the wrong position, pull the card straight out (gently) using flat-nosed pliers, turn the card around so that the selected line voltage marking (115 or 230) is right-side-up when reading it (do not turn the card upside down), and re-insert the card into the connector.

- 2) Insert a fuse into the fuse holder after verifying that it is the proper rating. Use a 1 A fuse for 110 to 130 V ac; a 500 mA fuse for 220 to 240 V ac.
- 3) Connect the power cord (provided) to the three-prong receptacle.
- 4) Plug the power cord into a power outlet.
- 5) Verify that the AC POWER ON indicator is lit.

NOTE: The AC ALARM indicator is also lit and remains lit until manually reset.

- 6) Press the front panel AC RESET switch to turn off the AC ALARM indicator.

2.5.2 DC Power

The FTS 1050A/015 can operate from an external + 26 to + 30 V dc source capable of supplying up to 2 A. DC power is applied to a rear panel 4-pin circular (MS3102A-14P-2S) connector. A mating connector (MS3106A-14S-2S) is provided for constructing a power cable. Refer to Figure 2-5 for an illustration of this connector.

The DC IN connector pin-out is:

<u>Pin</u>	<u>Function</u>
A	+ 22 to + 30 Vdc positive
B	No Connection
C	Return
D	No Connection

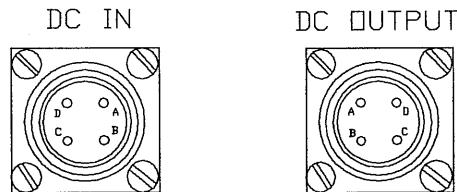


Figure 2-5 DC Power Connections

Use the following procedure for connecting DC power:

- 1) Locate the DC IN connector on the rear panel.
- 2) Attach a power cable equipped with a mating circular connector, to the DC IN connector.

NOTE: This input is protected against polarity reversal, but is not fused. It is suggested that the DC power source be current limited at 2 A.

The FTS 1050A/015 can be operated on DC power by removing the AC power input. If only DC power is used, verify that the front panel AC POWER ON indicator is off and that the AC ALARM indicator is on.

2.5.3 DC Output Power

The DC OUTPUT provides a fused +22 to +30 Vdc (at 1 A max.) output for powering accessories. The connector is a 4-pin circular connector (PN MS3102A-14S-2S). Refer to Figure 2-5 for an illustration of the connector. A mating connector (MS3106A-14S-2P) is provided for constructing a power cable.

The DC OUT connector pin-out is:

<u>Pin</u>	<u>Function</u>
A	≈+28 Vdc, unregulated (when battery powered)
B	+22 to + 30 Vdc, unregulated (when AC powered)
C	Return
D	No Connection

2.5.4 Output Signals

All output signals (1, 5, and 10 MHz) are available on rear panel BNC connectors. Each output is 1 V rms/50 Ω , independently buffered, and short-circuit protected. Terminate the outputs with 50 Ω when applying them to electronic measuring equipment.

There are two plugged holes beneath the output BNC connectors, that are reserved for the 100 kHz (Option 001) and the 1 PPS (Option 003) outputs.

2.5.5 External Reference

A 5 MHz reference signal can be applied to the rear panel BNC connector labeled EXT OSC. The external reference should be applied after the instrument has run uninterruptedly for more than 1 hr. After attaching the external signal, observe that the front panel OSC EXT indicator is off. Refer to Table 1-1 for input signal requirements.

2.5.6 Remote Monitor

The status of the front panel LOCK, LIMIT DET, LIMIT DAC, OSC EXT, and OSC INT indicators are available at a rear panel connector labeled RMTE MON. Indicator status is in the form of TTL-compatible logic signals. The signals are at a logic low when the indicator is on.

The connector is a 15-pin, "D"-style connector (ITT/Cannon part number DA15P) and mates to an ITT/Cannon DB-15S. Connector contact assignments are as follows:

Contact #	Function	Contact #	Function
1	LOCK	9	---
2	LIMIT DET	10	---
3	LIMIT DAC	11	---
4	OSC EXT	12	---
5	OSC INT	13	---
6	GROUND	14	---
7	---	15	---
8	---		

Figure 2-6 Remote Monitor Connector

The LOCK, LIMIT DET, LIMIT DAC, EXT OSC, and INT OSC digital monitors are brought out to the RMTE MON connector on the rear panel. Each indicator monitor output is TTL-compatible and open collector; the output is low when the corresponding front panel lamp is lit.

Chapter 3 OPERATION

3.1 INTRODUCTION

This Chapter describes detailed procedures for turn-on, frequency tuning, operation with external DC power, and turn-off. Normal operational status is defined as operating from AC power with DC power applied as a backup, an external reference employed, and the oscillator warmed-up and phase-locked to the external reference.

3.2 TURN-ON AND WARM-UP

To turn on the instrument:

- 1) Follow the steps listed in paragraph 2.5.1 if operating from AC power.
- 2) Follow the steps listed in paragraph 2.5.2 if operating from DC power.
- 3) Follow the steps listed in paragraph 2.5.1 then paragraph 2.5.2 if operating from AC power and using DC power for backup.

The instrument takes approximately 30 minutes to reach an accuracy of $2e-8$ /day and 30 days to reach 1×10^{-10} /day (without an external reference applied). When the oscillator's crystal oven is close to its operating temperature, the OVEN READY indicator blinks. When the oven has reached equilibrium, this indicator is on steady.

3.3 INITIAL ACQUISITION OF PHASELOCK

The following procedure describes the steps for initial acquisition of phaselock. Allow at least one hour of operation after turn-on before attempting phaselock.

- 1) Set the TIME CONSTANT switch to MNL (manual).
- 2) Apply the external reference to EXT OSC. Note that the four indicators turn on: SEARCH ON, OSC EXT, LOCK, and ALARM.
- 3) Reset PHASELOCK ALARM.
- 4) Select INTEG (position 6) on the front panel rotary switch.
- 5) Adjust the CONTROL VOLTAGE thumbwheel switch assembly until the integrator voltage reads 0 V.
- 6) Turn the TIME CONSTANT switch to 1 s. The SEARCH indicator should go off, the LOCK indicator stays on.
- 7) If operation at 100 s time constant is desired, turn the TIME CONSTANT switch to 100 s. Wait until the INTEG monitor settles to a zero reading at 1 s time constant before switching to 100 s. Switching too soon causes the RF detector to drift past its limits activating the LIMIT DET indicator.

Note: Up to 24 hours of continuous operation of the oscillator may be required before the 1050A/015 will maintain lock at 100 s.

If the LIMIT DAC indicator comes on during locked operation or reacquisition, but the PHASE LOCK indicator stays on, the DAC is near the end of its tuning range. The CONTROL VOLTAGE must be readjusted as in steps (3-5) above (select TIME CONSTANT MNL). This adjustment can be made at a time that is convenient to the user because the typical oscillator aging rate (after 30 days continuous operation) allows for at least 50 days before the DAC reaches the end of its range (0 or 5 V on the 7. DAC monitor). After readjustment, wait at least five minutes after selecting 1 s before switching to 100 s.

3.4 OPERATION WITHOUT EXTERNAL REFERENCE

To operate the FTS 1050A/015 in an unlocked mode, disconnect the external reference. Observe that the PHASELOCK ALARM indicator is on and the PHASELOCK LOCK and OSC EXT indicators are off.

Ensure that the TIME CONSTANT switch is set to 1 s or 100 s. This maintains the last locked control voltage to approximately $\pm 60 \mu\text{V}$. Typically, this corresponds to parts in 10^{12} fractional frequency offset from the last lock to external reference.

Do not switch to the TIME CONSTANT switch to MNL or the DAC resets to midrange and the frequency control voltage memory is lost!

3.5 TURN-OFF AND RESTART

To turn off the FTS 1050A/015, remove AC and external DC (if applied) power from the rear panel. To restart, re-apply AC and/or DC power to the instrument.

NOTE: The AC RESET switch must be pressed to clear the AC POWER ALARM and the PHASELOCK RESET switch to clear the PHASELOCK ALARM.

NOTE: Repeated cycling of power may damage the oscillator!

The oscillator may warm-up in less than 30 minutes, as indicated by the OVEN READY LED, if power is removed for only a short amount of time.

After a deliberate or accidental interruption of phaselock, the 1050A/015 automatically phase-locks when the reference signal is restored and the frequency offset is within the capture range of the DAC (1×10^{-8}). Leave the TIME CONSTANT switch at 1 s or 100 s. If the instrument does not relock, repeat Section 3.2.

3.6 FRONT PANEL

Figure 3-1 is an illustration of the FTS 1050A/015 front panel. Items are indexed and cross-referenced in the paragraphs that follow.

Some items are listed as not applicable (N/A). They are reserved for instrument Options and are detailed in the applicable section of the Options Chapter (Chapter 5.0).

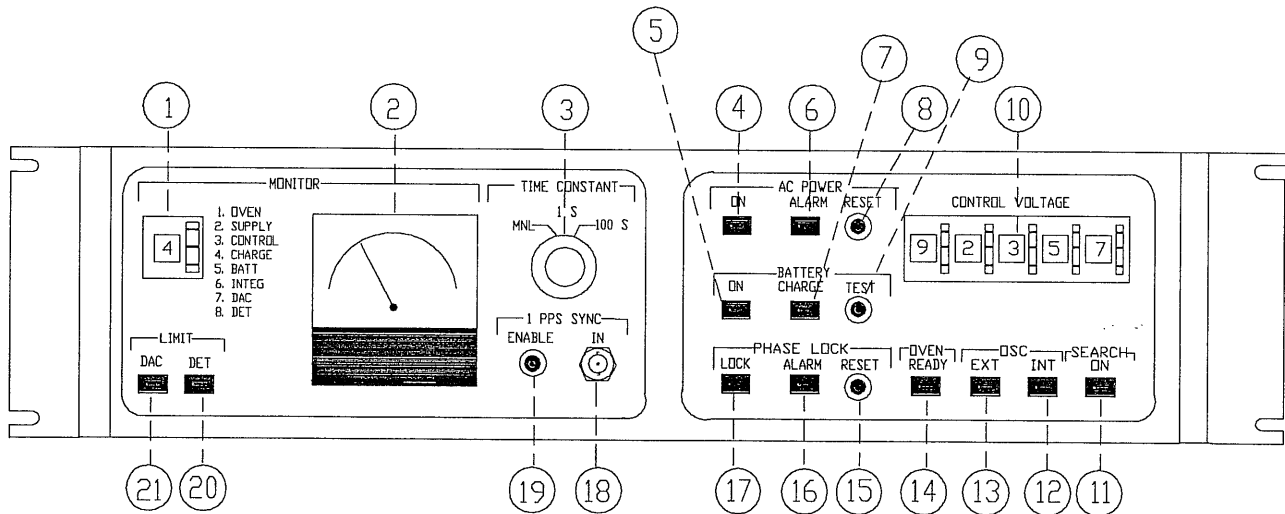


Figure 3-1 FTS 1050A/015 Front Panel

3.6.1 Indicators

Table 3-1 describes the indicators supplied on the FTS 1050A/015 front panel. An indicator not matching the condition listed under Normal Status, does not necessarily mean the instrument is malfunctioning (depending upon type of power supplied, time since warm-up, etc...). Refer to the definition of normal operating status given in paragraph 3.1.

Table 3-1 Indicators

Item#	Designation	Color	Normal Status	Description
4	AC POWER ON	Green	ON	ON = FTS 1050A/015 is operating from AC power
6	AC POWER ALARM	Red	OFF	ON = AC power has been interrupted. This indicator stays on until reset by the operator.
14	OVEN READY	Green	ON	ON steady = Crystal oven is at operating temperature. ON blinking = Crystal oven is approaching equilibrium.
5	BATTERY ON	Green	N/A	Reserved for Battery option
7	BATTERY CHARGE	Yellow	N/A	Reserved for Battery option
17	PHASELOCK LOCK	Green	ON	ON = Internal oscillator is phase-locked to the external 5 MHz reference. Remains on until external reference is removed.
16	PHASELOCK ALARM	Red	OFF	ON = Oscillator phase-locked has been interrupted. This indicator remains latched until manually reset.
13	OSC EXT	Green	ON	ON = An external reference signal of sufficient amplitude, is applied to the EXT OSC connector.
12	OSC INT	Green	ON	ON = Internal oscillator providing an RF signal of sufficient amplitude.
11	SEARCH ON	Yellow	OFF	ON = FTS 1050A/015 is in the initial acquisition mode. This indicator is always on when the TIME CONSTANT switch is set to MNL and an external reference is applied. The indicator may light if phase lock cannot be sustained during operation with 1 or 100 s time constant.
20	LIMIT DET	Red	OFF	ON = RF phase detector has exceeded preset limits; warning of imminent loss of phase lock. This indicator is activated when monitor 8. DET is >2.9 V or <-2.9 V.
21	LIMIT DAC	Red	OFF	ON = The digital electronic tuning word has exceeded preset limits. This indicator is activated when monitor 7. DAC is <1.3 V or >3.7 V

3.6.2 Controls

Table 3-2 describes the front panel controls for the FTS 1050A/015. Controls listed as reserved are described in the appropriate section of the Options Chapter.

Table 3-2 Controls

Item#	Designation	Description
8	AC POWER RESET	Clears the AC POWER ALARM indicator if AC power is applied.
10	CONTROL VOLTAGE	5-position thumbwheel switch assembly. Used for tuning the oscillator. Maximum tuning range is 4×10^{-7} with a minimal increment of 4×10^{-12}

Table 3-2 Controls (continued)

9	BATTERY TEST	Reserved for Battery Option
19	1 PPS SYNC ENABLE	Reserved for 1 PPS Option
15	PHASELOCK RESET	Resets the PHASELOCK ALARM indicator after phaselock is reacquired.
3	TIME CONSTANT MNL TIME CONSTANT 1 s TIME CONSTANT 100 s	Used for coarse-tuning the oscillator during phaselock initialization. Selects a 1 second time constant for the phase-locked loop. Selects a 100 second time constant for the phase-locked loop.

3.6.3 Monitors

Table 3-3 describes the two front panel items used for monitoring operating parameters. Table 3-4 describes the functions for each monitor.

Table 3-3 Monitors

Item#	Designation	Description
1	MONITOR (select switch)	8-position thumbwheel switch used for selecting the parameter to be shown on the meter.
2	MONITOR (meter)	Scaled analog meter for displaying selected monitor. Scale is from -5 to +5 V.

Table 3-4 Monitor Switch Positions

Pos.#	Designation	Range	Normal	Description
1	OVEN	0 to 5 V	3.3 to 3.7 V	Represents the crystal oven temperature. Triggers OVEN READY indicator when <3.7 V. This monitor reading is initially about 5 V and falls as the oven temperature is raised.
2	SUPPLY	0 to 5 V	2.2 V	Represents the regulated supply voltage to the 1050A/015's electronics. Should be 3.1 V during warm-up. Scale factor: 1/10
3	CONTROL	0 to 5 V	1 to 4 V	Represents the control voltage applied to the oscillator. The meter reading is 1/2 of the control voltage applied to the oscillator.
4	CHARGE	N/A	N/A	Reserved for Battery Option
5	BATT	N/A	N/A	Reserved for Battery Option
6	INTEG	-5 to +5 V		Represents the integrator output voltage. The meter reading is 1/2 of the integrator output level.
7	DAC	0 to 5 V	1.3 to 3.7 V	Represents the DAC output voltage. The meter reading is 1/2 of the DAC voltage output. Triggers the LIMIT DAC indicator when <1.3 V or >3.7 V; Preset to 2.5 V when the TIME CONSTANT is set to MNL.
8	DET	-5 to 5 V	0 V	Represents the DAC output voltage. The meter reading is 1/2 of the RF Detector output level. Approximately 0 V during locked operation. Triggers the LIMIT DET indicator when >2.9 V or <-2.9 V.

3.6.4 External Connections

The BNC connector labeled 1 PPS SYNC IN (Item 18) is reserved for the 1 PPS Option.

3.7 MANUAL FREQUENCY ADJUSTMENT

This procedure is intended for oscillator adjustments when an external reference is not employed. Refer to Section 3.3 if making an adjustment with an external reference applied.

3.7.1 Control Voltage Adjustment Switch Assembly

The FTS 1050A/015 is shipped with the CONTROL VOLTAGE switches preset to center the oscillator. Note the initial setting before changing any switch position!

NOTE: Allow 24 hours after turn-on for the oscillator to settle, before making a frequency adjustment.

The output signal frequencies can be offset by a total range of $\approx 4 \times 10^{-7}$ with a minimum increment of 4×10^{-12} . All outputs are affected equally by this adjustment because they are derived from a common source (the oscillator).

Adjustment is done by changing the front panel CONTROL VOLTAGE setting. Refer to Figure 3-2 for an illustration of the switch assembly. The frequency adjustment increments are as follows:

Switch #	Increment/Step
1	4×10^{-12}
2	4×10^{-11}
3	4×10^{-10}
4	4×10^{-9}
5	4×10^{-8}

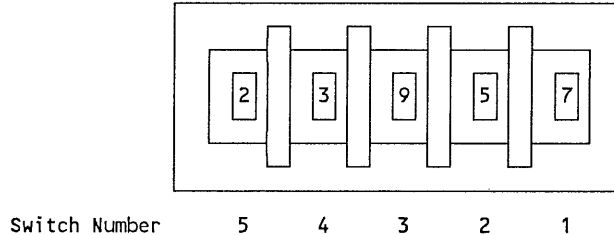


Figure 3-2 CONTROL VOLTAGE Switch Assembly

NOTE: These switches are always active.

3.7.2 Manual Frequency Adjustment Procedure.

This procedure assumes that the operator is familiar with standard methods of measuring frequency offsets of parts in 10^{12} and that no external 5 MHz reference is connected.

To adjust the output frequencies:

- 1) Measure the frequency offset.
- 2) Divide the absolute value of the offset by 4×10^{-12} (the least Increment/Step).

The result is the number of positions that the switch settings will change. See Section 3.7.1 for a cross-reference between switch number and Increment/Step.

3.7.2 Manual Frequency Adjustment Procedure (continued)

- 3) Change the affected switches by the amounts determined in Step 3, as follows:

If the internal oscillator frequency offset is positive, decrease the switch settings.

If the internal oscillator frequency offset is negative, increase the switch settings.

- 4) Repeat Steps 1 through 3 until the frequency offset is $< 4 \times 10^{-12}$.

FREQUENCY ADJUSTMENT EXAMPLE:

Frequency offset = -7.0×10^{-10}

$7.0 \times 10^{-10} \div 4 \times 10^{-12} = 175$ (result)

Switch #	5	4	3	2	1	
	5	4	2	2	3	(Initial Setting)
+	0	0	1	7	5	(*Change in Switch Settings)
	5	4	3	9	8	(New Switch Setting)

*The change is positive because the frequency offset is negative.

CHAPTER 4 MAINTENANCE

4.1 RE-ORDERING INFORMATION

To reorder any subassembly, contact the Marketing Department at Frequency and Time Systems. Supply the Assembly name and FTS Part Number for the subassembly along with the purchase order number. Table 4-1 lists the subassemblies and their FTS part numbers.

Table 4-1 List of Subassemblies

<u>Reference Designator</u>	<u>Assembly Name</u>	<u>FTS Part Number</u>
A1	Oscillator	05818-503
A2	RF Box Assembly	2481G1
A2A1	1 & 10 MHz Output PCB Assembly	02830-501
A2A3	Phase Detector PCB Assembly	02454-501
A3	Monitor PCB Assembly	06722-501
A5	Power Supply Assembly	02485G2
A5A1	Power Supply PCB Assembly	02466-501
A6	Acquire PCB Assembly	02466-501
A7	DAC PCB Assembly	02452-501

4.2 SUGGESTED TEST EQUIPMENT

Table 4-2 Suggested Test Equipment List

Test Item	Required Characteristics	Purpose/Use	Examples of Appropriate Equipment
Power Supply	Power Range: 0 to 28 V 0 to 3 A	Troubleshooting	Lambda LA-532
Multimeter	4 ½ Digit Display	Troubleshooting Adjustments	Data Precision 2480R
Oscilloscope	Freq. Response: 60 MHz Sensitivity: 10 mV/div Cal. Sweeps: 2 s to 0.1 s/div	Performance Checks Troubleshooting	TEK 2213
Frequency Reference	Accuracy, stability, and phase noise commensurate with FTS 1050A	Performance Checks	FTS 1050A/015; FTS 9500
Frequency Comparator	Frequency: 10 MHz Linear Out.: 0 to 1 V dc	Performance Checks	FTS 6102
Strip Chart Recorder	Speed: 3 cm/hr Span: 1, 10 V/fs	Performance Checks	Soltec S4201
Time Interval and Frequency Counter	Frequency: 0 to 10 MHz Sensitivity: 100 mV Accuracy: 10 ns 10 digit display	Performance Checks Troubleshooting	HP 5328A

4.3 OSCILLATOR TUNING ADJUSTMENT

As the digital electronic tuning voltage nears the limit of the DAC, the LIMIT DAC indicator turns on first, followed by the LIMIT DET, PHASELOCK ALARM, and SEARCH. The LIMIT indicators are an early warning of loss of lock. The SEARCH light indicates that the reacquisition logic has switched electronically to a search mode (short time constant) because the required frequency adjustment has gone beyond the control range of the DAC. Re-tuning the oscillator should correct for this condition.

Paragraph 3.7 supplies procedures for re-tuning the oscillator. It is suggested that the oscillator be re-tuned when the CONTROL monitor is <1 V or >4 V. After readjustment, wait until the 6. INTEG monitor settles to zero after selecting 1 s before switching to 100.

Note: The ratio between frequency change and monitored control voltage is 8×10^{-8} /Volt.

4.4 TROUBLESHOOTING GUIDELINES

The FTS 1050A/015 needs little maintenance. Should a malfunction occur:

- Check the input power for proper level and connection.
- Check the fuse.
- Insure that the external reference meets specification and is connected.
- Check the output signal connections and verify that they are not loose or shorted.
- Verify that the CONTROL VOLTAGE switch assembly is at the desired setting.

4.5 RESHIPMENT

4.5.1 Repacking

No special preparation other than standard packing procedures are required to protect the instrument during shipment. Connectors should be protected with connector covers or the instrument should be wrapped in plastic before packaging. Custom foam packing material is preferred because it conforms to the shape of the instrument. Take special care to protect the front and rear panels.

4.5.2 Equipment Return Procedure

To return this unit to the factory for repair:

- 1) Obtain a return authorization from FTS prior to returning the unit for service. Call FTS Customer Service (1-508-927-8220) for a return authorization.
- 2) Provide a description of the trouble, unit model number, serial number, and warranty expiration date.
- 3) Provide return shipping information (customer contact, address, phone number, etc..).
- 4) Ship the unit to FTS, transportation prepaid and insured, with the Return Authorization Number and unit serial number clearly marked on the outside of the carton, to:

Frequency and Time Systems, Inc.
34 Tozer Road
Beverly, Massachusetts, 01915
Attn: Technical Service Department

CHAPTER 5 OPTIONS

5.0 INTRODUCTION

This chapter provides information regarding options for the FTS 1050A/015. The information is supplemental to the first four chapters and should be integrated with them. Specifications, control functions, indicators, operational procedures, etc. remain as presented in Chapters 1 through 4 unless modified within this chapter.

5.1 OPTION 001 100 kHz OUTPUT

5.1.1 OPTION DESCRIPTION

Option 001 adds a buffered 100 kHz output to the FTS 1050A/015. The output signal is sinusoidal with an amplitude of 1 V rms into 50 Ω and is available via a rear panel BNC connector (see Figure 2-3).

An additional PCB Assembly is used in the RF Assembly to produce the 100 kHz output. This output is derived from a 10 MHz input provided by the 1 & 10 MHz Assembly. Figure 5-1 is a block diagram of the RF Assembly with the 100 kHz PCB Assembly.

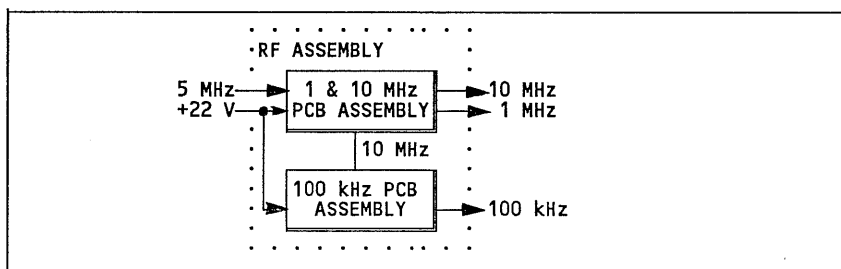


Figure 5-1 Block Diagram, RF Assembly with 100 kHz Option

5.1.2 SPECIFICATIONS

Table 5-1 Specifications Option 001, 100 kHz Output

Parameter	Specification
Output	100 kHz
Output Amplitude/50 Ω	1 V rms
Harmonic Distortion	-40 dB
Spurious Signals	-70 dB
Connector	BNC

5.1.3 INSTALLATION

No additional installation is required.

5.1.4 OPERATION

No operational controls, monitors, or indicators of the FTS 1050A/015 are affected.

5.1.5 MAINTENANCE

Except for a change in the RF Box subassembly configuration, all information presented in Chapter 4 is valid for an FTS 1050A/015 with Option 001.

5.1.5.1 Replaceable Subassemblies

Table 5-2 is a list of additional and/or replacement subassemblies included with Option 001.

Table 5-2 List of Subassemblies

Reference Designator	Assembly Name	FTS Part Number
A2	RF Box Assembly	2494G2
A2A1	100 kHz PCB Assembly	02465-501

5.2 OPTION 002 INTERNAL BATTERY AND CHARGER

5.2.1 OPTION DESCRIPTION

Option 002 adds an internal battery and battery charger to the FTS 1050A/015. The internal battery is a +28 V (nominal), 14 cell, sealed, lead acid battery pack, with a rated capacity of 5 AH. The battery furnishes up to 6 hours of continuous operation (@ 25 °C). At increased ambient temperatures, this time decreases.

In the event of an external power loss, the instrument automatically switches to operate from the internal battery. If both the external AC and DC power sources are absent, the internal battery continues to operate the instrument until it is discharged below a pre-set level. When the cut-off point is reached, the battery is switched out and the FTS 1050A/015 turns off, preventing permanent damage.

This option supplies full battery charging capabilities. The charge level of the internal battery is continuously monitored.

5.2.1.2 Functional Description

With Option 002, the Monitor PCB Assembly is replaced with a Controller PCB Assembly. The controller contains circuitry for:

- Testing the battery,
- Battery voltage and charging current monitoring,
- Charging control circuitry,
- Power source switching, and
- Performing the functions described in Section 1.5.1.

5.2.1.3 Specifications

Table 5-3 Specifications, Option 002 Internal Battery

Parameter	Specification
Voltage	28 V dc (nominal)
Number of Cells	14; 2 V/cell
Battery Capacity (@25 °C)	5 AH
Low Voltage Cut-off Level	<26 V dc
Recharge Time	16 hours maximum
Storage Temperature	0 to +60 °C
Storage Time	@ 0 °C 7,200 days (≈18 years) @ 23 °C 1,200 days (≈3 years) @ 60 °C 60 days
Weight	12 lbs (5.5 kg)

5.2.1.4 Storage Requirements

Prior to placing the instrument into storage, the internal battery should be brought to a fully charged condition by operating the instrument from AC power for a suitable length of time (16 hours maximum for discharged batteries).

Store the FTS 1050A/015/002, in an dry area with an ambient temperature between -40 to 60 °C. Ensure that the battery fuse is removed before storing the instrument.

At storage temperatures of 35 °C and above, the battery should be recharged periodically on a schedule determined by the storage temperature (see Table 5-4). To insure the most efficient recharge cycle, recharge the batteries at an ambient temperature of 25 ± 10 °C.

Table 5-4 Battery Recharge Time Table

Temperature	Time before Recharge
<35 °C	24 mo.
45 °C	12 mo.
55 °C	6 mo.
60 °C	3 mo.

5.2.3 INSTALLATION

Place a 1 A fuse in the rear panel connector labeled BATT FUSE (see Figure 2-3).

NOTE: This fuse must be removed to disconnect the batteries.

5.2.4 OPERATION

5.2.4.1 Turn-On Procedure with Option 002

The turn on procedure is the same as detailed in Section 3.2. After completing Section 3.2, install the rear panel battery fuse.

5.2.4.2 Turn-off Procedure with Option 002

NOTE: The battery fuse must be removed when the unit is turned off or the battery continues to operate the FTS 1050A/015 until it is discharged to <26 V.

- 1) Remove the 1 A fuse from the BATT FUSE receptacle located on the rear panel of the instrument.
- 2) Remove external power (AC and DC).

5.2.4.3 Indicators, Controls, and Monitors

Tables 5-5, -6 and -7 list the indicators, controls, and monitors that are activated with Option 002. These items are accessible at the front panel of the FTS 1050A/015. Refer to Figure 3-1 for their locations.

Table 5-5 Option 002 Indicators

Item#	Designation	Color	Description
5	BATTERY ON	Green	On = FTS 1050A/015 is operating from the internal battery.
7	BATTERY CHARGE	Yellow	On = Battery is being charged. Indicator blinks when the battery is near full capacity.

Table 5-6 Option 002 Controls

Item#	Designation	Description
9	BATTERY TEST	Disconnects external power to test the internal battery. If the battery is faulty, AC power is reconnected without affecting instrument performance. Battery level can be read on the front panel meter.

Table 5-7 Option 002 Monitors

Pos.#	Designation	Range	Normal	Description
4	CHARGE	0 to 5 V	1 to 2 V	Represents the charge current to the battery. 1.5 V during trickle charge. 4.5 V during fast charge. BATTERY CHARGE indicator is on.
5	BATT	2.6 to 3.0 V	2.5 to 3.5 V	Represents the battery voltage (scale = 1/10). This monitor is active only when operating on internal battery or when the BATTERY TEST switch is depressed.

5.2.4.4 Operation on External Power with Option 002

All operational controls, indicators and monitors operate as described in Section 3 when Option 002 is included. The main difference is that switch-over to battery, low voltage cut-out, and battery charging functions have been added. These functions are described in the following sections.

The hierarchy of power sources is:

- 1) AC
- 2) External DC
- 3) Battery.

5.2.4.4.1 AC power

When operating on AC power, the battery charge is maintained, the BATTERY indicators (ON and CHARGE) and monitors (BATT and CHARGE) are enabled.

5.2.4.4 Operation on Internal Battery

When the FTS 1050A/015 is operating from the internal battery, the BATTERY ON and AC ALARM indicators are lit. Operation from battery power can be manually selected by inserting a 1 A battery fuse and removing all external power (AC and DC).

When the battery voltage drops below 26 V dc, it is disconnected and the instrument turns off. The battery low-voltage cut-off relay is automatically reset upon restoration of AC power. For maximum cycle life, always recharge the internal battery by applying AC power, as soon as possible after discharge. To turn the battery off before the cut-off point, the battery fuse must be removed.

5.2.4.5 Battery Monitoring

5.2.4.5.1 Battery voltage

When operating under battery power, the battery voltage level can be read on the MONITOR meter by selecting MONITOR switch position 5. BATT.

To monitor the battery level while operating on external AC or DC power:

- 1) Set the MONITOR switch to position 5. BATT.
- 2) Push and hold the BATTERY TEST button. Observe that the BATTERY ON indicator lights.
- 3) Read the MONITOR meter and verify that the battery voltage reads between 2.6 and 3.1 V (26 to 31 V dc).

If the battery voltage is above 26 V and stays above 26 V under load, the FTS 1050A/015 continues to operate on the battery as long as the test button is depressed. If the battery voltage drops below 26 V, the controller automatically switches back to the external power source without interruption of normal operation.

5.2.4.5.2 Battery charging current

The internal battery is normally in a trickle charge condition whenever AC power is applied and the battery fuse is installed, to maintain the battery at maximum capacity. After the battery has been discharged and AC power is restored, the charger automatically recharges the battery; first at a fast charge rate (CHARGE indicator on), then tapering to a slower rate (CHARGE indicator blinking at 30 s intervals) and finally to a trickle rate (CHARGE indicator may not blink at all). The full charge cycle is completed in 12 to 16 hours.

The charge current can be monitored by selecting position 4. CHARGE on the MONITOR meter. The meter range is ± 50 mA full scale when the charge indicator is off and ± 500 mA when the indicator is on.

NOTE: The fast charge rate is inhibited during oscillator oven warm-up; the battery charger remains in the trickle mode, regardless of the state of the battery, until the OVEN READY indicator lights.

5.2.5 MAINTENANCE

5.2.5.1 Replaceable Subassemblies

Table 5-8 is a list of additional and/or replacement subassemblies included with Option 002.

Table 5-8 List of Subassemblies

Reference Designator	Assembly Name	Part Number
A3	Controller PCB Assembly	02496-501 (FTS)
*BT1	Battery, 12 V	0800-0016 (Gates)
*BT2	Battery, 8 V	0800-0027 (Gates)
*BT3	Battery, 8 V	0800-0027 (Gates)
F2	Fuse, 1 A	318001 (Littlefuse)

*BT1, 2 and 3 wired in series comprise the Battery Assembly.

5.2.5.1 Battery Replacement Procedure

- 1) Remove external power to the FTS 1050A/015.
- 2) Remove the rear panel BATT fuse.
- 3) Remove the top cover
- 4) Unscrew the battery bracket thumbscrew and remove the bracket.
- 5) Remove the clip-on battery leads.
- 6) Remove the Battery Assembly.
- 7) Repeat Steps 1 to 6 in reverse order to replace the Battery Assembly.

5.3 OPTION 003 1 PPS OUTPUT

5.3.1 OPTION DESCRIPTION

Option 003 adds a 1 PPS output to the FTS 1050A/015. The 1 PPS output is a TTL compatible squarewave and can be synchronized to an external reference. The 1 PPS output signal is accessible at a rear panel BNC connector.

An additional PCB Assembly is included to generate the 1 PPS signal. The signal is derived from a 10 MHz input from the RF Assembly (refer to Figure 5-2) by digital division. The 1 PPS PCB Assembly also contains circuitry for synchronizing the 1 PPS output signal to an external reference. Figure 5-2 is a block diagram of the RF Assembly with the 100 kHz PCB Assembly.

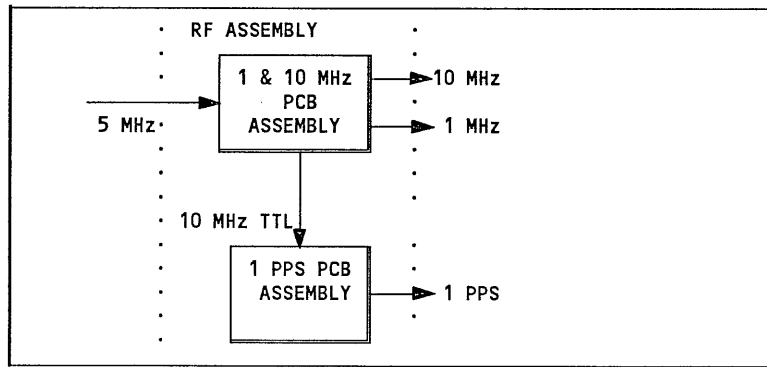


Figure 5-2 Block Diagram, RF Assembly with 100 kHz Option

5.3.2 SPECIFICATIONS

Table 5-9 Specifications, Option 003 1 PPS Output

Parameter	Specification
1 PPS Output Signal Amplitude	TTL Compatible
Synchronization Input Amplitude Frequency Rise Time	3 to 10 V into 50 Ω 1 Hz <30 ns

5.3.3 INSTALLATION

No additional installation is required.

5.3.4 OPERATION

5.3.4.1 1 PPS Synchronization

The 1 PPS output signal can be synchronized to within ± 400 ns of the positive going edge of an external reference pulse. To synchronize:

- 1) Connect the reference pulse to the front panel BNC connector labeled 1 PPS SYNC IN. Ensure that this signal meets the requirements listed in Table 5-9.
- 2) Depress the front panel pushbutton labeled ENABLE for at least 1 second.
- 3) Remove the synchronization input.

5.3.5 MAINTENANCE

Except for the addition of the 1 PPS PCB Assembly, all information presented in Chapter 4 is valid for an FTS 1050A/015/003.

5.3.5.1 Replaceable Subassemblies

Table 5-10 is a list of additional and/or replacement subassemblies included with Option 003.

Table 5-10 List of Subassemblies

Reference Designator	Assembly Name	FTS Part Number
A4	1 PPS PCB Assembly	02456-501