OPERATING MANUAL

MODEL 4065C
CESIUM TIME AND FREQUENCY STANDARD

Option 013, Rack Slides (FTS 6013)
Option 063, DS1 Frequency Synthesizer (see Section 4)
Option 064, CEPT Frequency Synthesizer (see Section 4)

FTS Part Number: 11846-001
Revision: J

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OPERATING MANUAL ADDENDUM

Applicable to the following:

MODEL	*MANUAL*	*PART NUMBERS*
PRS50	N/A	11271
DCD	N/A	08949
DCD	N/A	08950
3310	N/A	11227
5045A	N/A	08499
4065A	08518	08490
4040A/RS	11846	08832

Rev. -
June 23, 1999

The serial number label applied at the factory to the units above contains more information that is necessary for the electronic identification of the unit.

The unit identification (electronically stored within the unit) will be the last five digits of the serial number, which is physically marked on the unit's label.

The serial number label is a 10 digit, unique number

YYWWXXXXXX

Where:

Y = Year
W = Week of Year
X = Sequential numbers

Example:

9923000105

Serial number was assigned on the 23'rd week of 1999 (AKA Lot Date Code, LDC) and have a sequential number of 000105.

When communicating with the unit the serial number in the example above is 00105.

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SECTION 1
GENERAL INFORMATION

SECTION 1. GENERAL INFORMATION

1.1 INTRODUCTION

The FTS 4065C 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).

1.2 SUMMARY DESCRIPTION

The FTS 4065C Cesium Time and Frequency Standard is a primary frequency and time reference with microprocessor control. The major function of the FTS 4065C 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 10, 5, and 1 MHz . The 10 MHz signal is digitally divided to produce the 1 pps signal which can be advanced or delayed in 100 nanosecond steps.
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
- Diagnostic functions to aid in troubleshooting

A keyboard and a display are provided on the front panel, allowing the operator to control and monitor the 4065C. Parameters which can be controlled are:

- frequency control loop time constant and loop order
- frequency offset
- time of day
- phase adjustment

LED indicators on the monitor panel are provided to indicate the following status of the 4065C:

- lock (normal operation)
- minor alarm
- major alarm

1.2 SUMMARY DESCRIPTION (cont'd)

The FTS 4065C operates from 115/230 V ac or 38 to 71 Vdc. An 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 (4065C) specifies an option that is supplied within the instrument. See Table 1-1 for a list of available options.

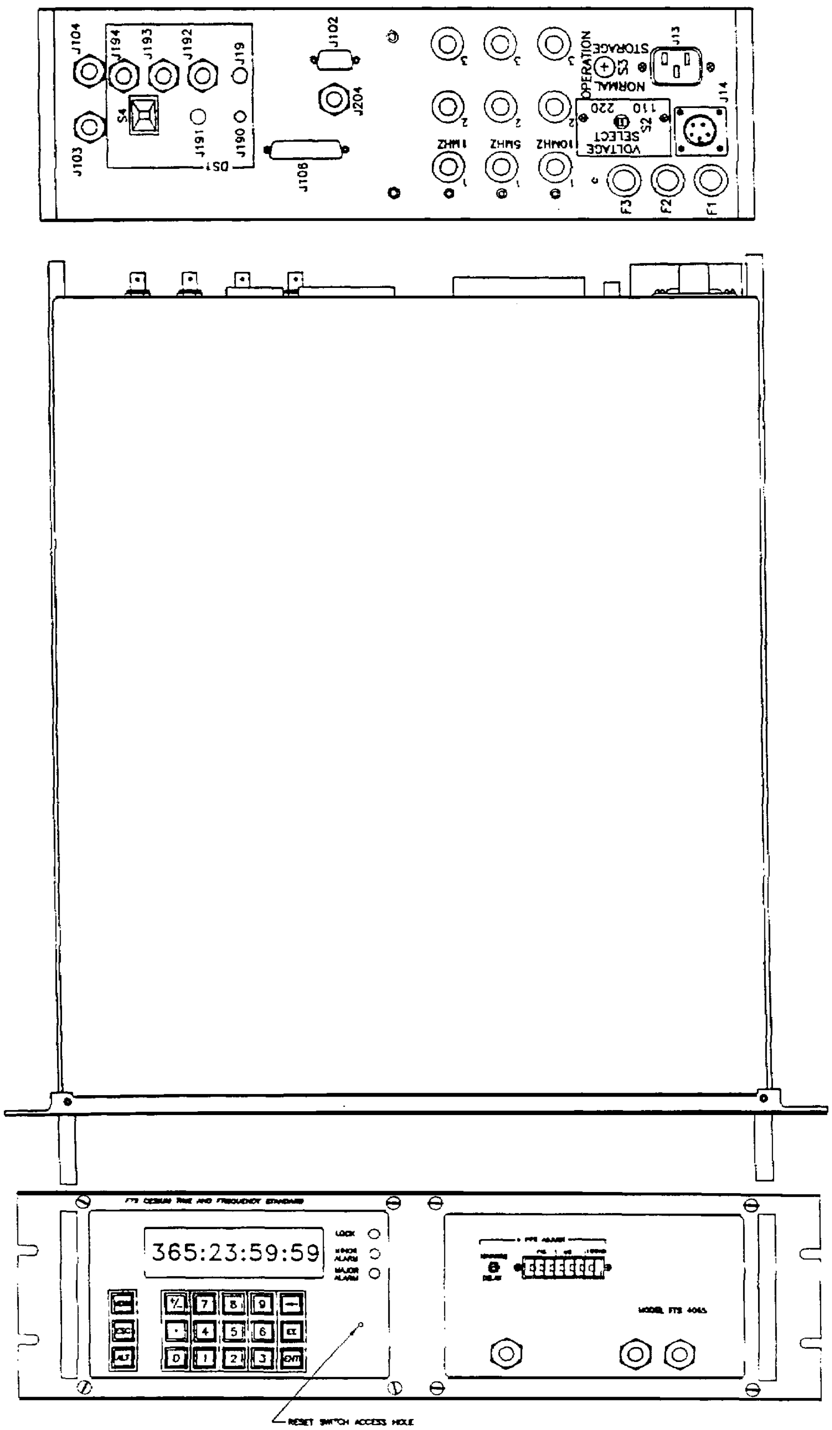


FIGURE 1-1 FTS 4065B

TABLE 1-1 SPECIFICATIONS, FTS 4065C (at 25°C unless otherwise specified)

PERFORMANCE PARAMETERS	VERSION 01 LIFETIME TUBE	VERSION 02 HIGH PERFORMANCE TUBE
ACCURACY Note 1	±1 x 10^{-12}	±5 x 10^{-13}
WARM-UP TIME (typical) Note 2	30 min.	30 min.
REPRODUCIBILITY	<1.2 x 10^{-12}	<5.0 x 10^{-13}
STABILITY		
Averaging Time (s)	Allan Deviation	Allan Deviation
10^0	1.2 x 10^{-11}	5.0 x 10^{-12}
10^1	8.5 x 10^{-12}	3.5 x 10^{-12}
Note 3 10^2	2.7 x 10^{-12}	8.5 x 10^{-13}
*10^3	8.5 x 10^{-13}	2.7 x 10^{-13}
*10^4	2.7 x 10^{-13}	8.5 x 10^{-14}
*10^5	8.5 x 10^{-14}	2.7 x 10^{-14}
*floor	5.0 x 10^{-14}	2.0 x 10^{-14}
* excluding environmental effects		
SSB PHASE NOISE	5 MHz (dBc)	
Offset (Hz)		
10^0	-106	
10^1	-135	
Note 3 10^2	-145	
10^3	-155	
10^4	-157	
10^5	-157	
SETTABILITY (Frequency)		
Range	"1 x 10^{-9}	
Resolution	1 x 10^{-15}	
Control	menu or remote	
SPECTRAL PURITY	@ 10 MHz	@ 5 MHz
Harmonics	<-40 dBc	<-40 dBc
Spurious Signals	<-80 dBc	<-80 dBc

Note 1: 100% calibrated and verified against in-house standard.
Note 2: If the FTS 4065C has been in storage for an extended period, the warm-up time may be greater than specified.
Note 3: 5 s loop time constant.

OUTPUTS

SINUSOIDAL OUTPUTS	
Rear Panel (standard 3 ea)	10 MHz, 5 MHz, 1 MHz
Amplitude	0.9 - 1.5 V rms into 50Ω load
SQUARE WAVE OUTPUT	
Selectable by keyboard or remote	0.1, 1, 5, 10 MHz
Amplitude	2 - 2.5 Vpp into 50Ω load
PULSE OUTPUTS	
Front Panel	1 pps advance/delay 0 to 999,999.9 µs
Rear Panel	1 pps advance/delay in 0.1 µs increments 1 pps master
Amplitude	>2.4 V peak into 50Ω load (TTL compatible)
Width	20 µs "5%
Rise Time	<5 ns
Jitter	<1 ns rms

CONTROLS

LOCAL (KEYBOARD) & REMOTE (RS232)	
Loop Time Constant	0.5 to 100 s
Square Wave Output	0.1, 1, 5, 10 MHz
Phase/Time Adjustment	"1 to 10,000 x 10^{-9} s
Frequency Adjustment	"1 x 10^{-15} to 10^{-9}
MONITORS	
Local - Vacuum Florescence Display	See Table 1
Remote - RS232 Bus	

GENERAL

POWER REQUIREMENTS	AC	DC
Operating Voltage	90 to 132 V 180 to 265 V	"38 to 71 V
Frequency Range	47 to 63 Hz 400 Hz	N/A
Power (operating) (warm-up and fast charge)	130 VA/90 W 175 VA/120 W	80 W 110 W
INTERNAL BATTERY Capacity Charge Time Charge Source	 1 hour at 25°C from full charge 16 hours maximum from fully discharged state AC or external DC power	
DIMENSIONS (EIA-310C) Height Width (front panel) (instrument) Depth Shipping Dimensions	 5.25" (133 mm) 19.0" (483 mm) 17.3" (440 mm) 21.0" (533 mm) 25” x 31” x 11”	
WEIGHT	70 lbs (31.7 kg)	
Additional shipping weight for re-useable HAZMAT container	34 lbs (15.4 kg) for plywood container 12 lbs (5.5 kg) for cardboard container (25” x 31” x 11”)	
NOTE: Shipping specifications may change without notice or change to this manual.		

TABLE 1-1 SPECIFICATIONS, FTS 4065C (cont'd)

ENVIRONMENT

TEMPERATURE, OPERATING	0 to 50°C
TEMPERATURE, NON-OPERATING	
Storage	-30 to +70°C
Short-term	-40 to +75°C
HUMIDITY, OPERATING	95% up to 50°C
MAGNETIC FIELD	0 to 2 gauss
SHOCK	30 g/11 ms, 3 axes
VIBRATION	MIL-STD-167-1
ALTITUDE	0 to 50,000 ft.

OPTIONS

013	Rack Slides (FTS 6013)
063	DS1 Frequency Synthesizer (covered by Addendum)
064	CEPT Frequency Synthesizer (covered by Addendum)

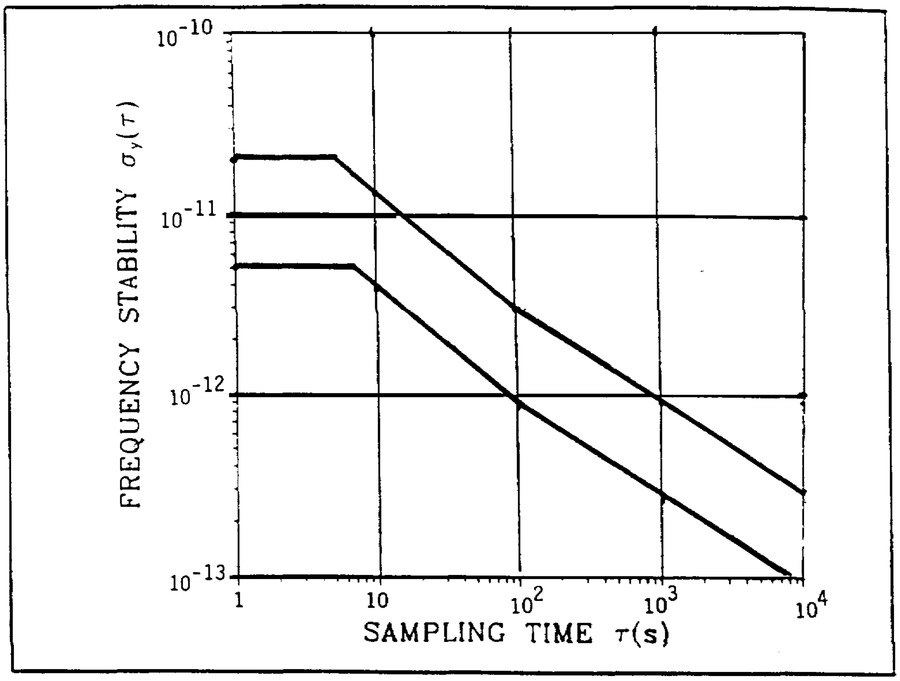


FIGURE 1-2 FREQUENCY STABILITY (1 second time constant, 2nd order loop)

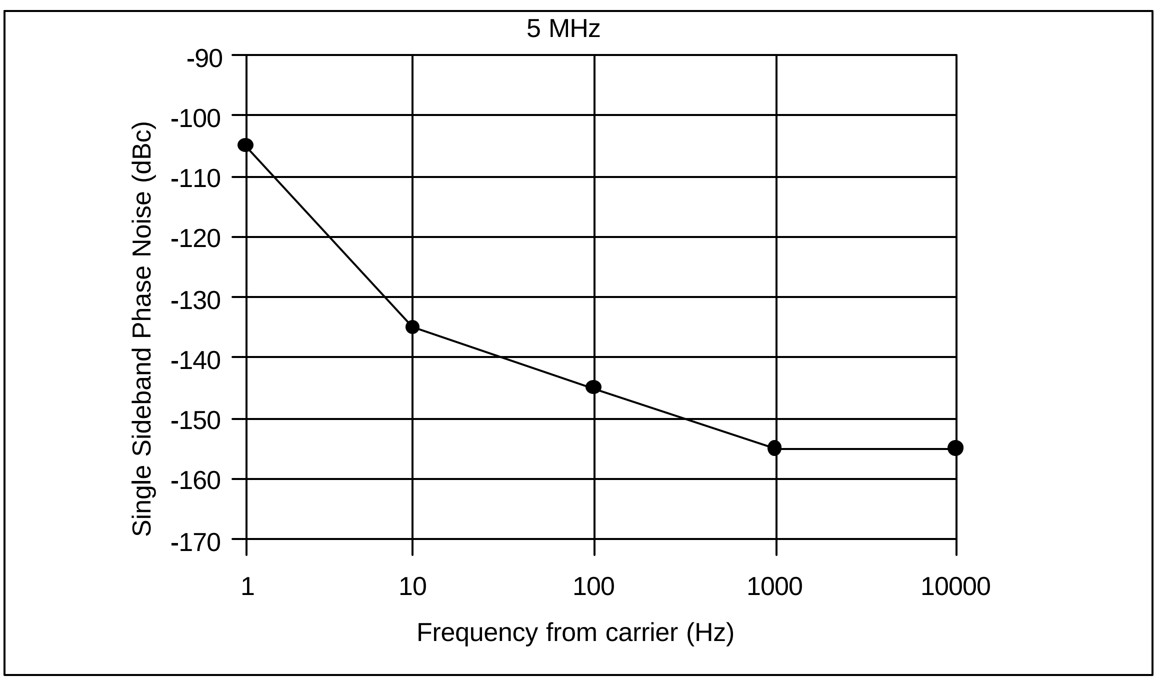


FIGURE 1-3 SINGLE SIDE-BAND PHASE NOISE SPECTRAL DENSITY (1 second time constant, 2nd order loop)

TABLE 1-2 RECOMMENDED TEST EQUIPMENT

ITEM NO. AND DESCRIPTION	REQUIRED CHARACTERISTICS	PURPOSE/USE	EXAMPLES OF APPROPRIATE EQUIPMENT
1. Primary Frequency Standard	Accuracy, stability and phase noise commensurate with FTS 4065C	Performance Check	FTS 4060, 4040., 4160, 5030
2. Spectrum Analyzer	Freq. Range: 100 kHz to 10 MHz	Performance Check Input Level: 13 dBm/50 Ω	HP8858B
3. Oscilloscope	Frequency Response: 60 MHz Sensitivity: 10 mV/div. Calibrated Sweeps: 2 s to 0.1 µs/div.	Performance Check Input Level: 13 dBm/50Ω	TEK 2213
4. Digital Multimeter	4 **2** Digit Display	Troubleshooting Adjustments	Data Precision 2480R
5. Signal Generator	Frequency: 5 Hz to 5MHz Output: up to 13 dBm/50Ω	Performance Check	HP3301A
6. Phase Comparator	Frequency: 10 MHz Linear Output: 0 - 1 V	Performance Check	FTS 6101
7. Strip Chart	Speed: 3 cm/h	Performance Check	SOLTEC S4201
8. Power Supply	Power Range: 0 to 40 V 0 to 3 A	Troubleshooting	LAMBDA LA-532
9. Termination Feedthrough	BNC, Male to Female, 50 Ω	Performance Check	TEK 011-0049-01
10. Frequency and Time-Interval Counter	Frequency: 0 to 10 MHz Sensitivity: 100 mV Accuracy: 10 ns, 10 digit display	Performance Check Troubleshooting	HP53132A

NOTE: If desired, additional test equipment, equipment combinations, and test procedures for frequency-time performance analysis may be obtained in Characterization of Clocks and Oscillators, NIST (formerly NBS) Technical Note 1337, U.S. Government Printing Office, March 1990.

1.4 STORAGE/SHELF LIFE, FTS 4065C

During storage of the FTS 4065C, there are three factors to consider; battery shelf life, cesium beam tube vacuum and shelf life.

1.4.1 Battery Storage

Prior to placing the unit in 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 (48 hours maximum for discharged batteries). After removing ac power, be sure to turn off the FTS 4065C by removing the BATTERY FUSE on the rear panel.

At storage temperatures of 35°C and above, the battery should be recharged periodically on a schedule determined by the storage temperature (see Table 1-3). To insure the most efficient recharge cycle, recharge the instrument in an ambient temperature of 25 "10°C.

Table 1-3 BATTERY RECHARGE INTERVALS

	Recharge Interval (mo)	
Temperature $^{\circ}$C	Battery Disconnected	Battery Connected
<35	24	12
45	12	6
55	6	3
65	3	1.5

Alternatively, the battery may be removed during extended high temperature storage and stored in a cooler location to preclude this maintenance procedure.

1.4.2 Cesium Beam Tube Vacuum and Standby Operation

If extended periods of storage is anticipated, the ion pump in the Cesium Beam Tube must be operated to maintain tube vacuum.

The storage mode of operation is highly recommended in these situations. Connect the 4065C to a power source (AC or DC) and place the power switch in the storage position. In this mode only the ion pump circuitry is functional.

If the unit can't be stored with a permanent source of external power, then periodic storage mode operation cycles must be performed. The minimum period of operation is 30 minutes for every six months of storage time. Refer to Section 2 for the turn-on procedure.

1.4.3 Cesium Beam Tube Shelf Life

The operating lifetime of the cesium beam tube is governed by the consumption of cesium as the cesium beam is formed in the beam tube oven.

Extended high temperature storage reduces the expected operating life of the cesium beam tube. The reduction in tube life expectancy for each year at a given temperature may be approximated by Table 1-5.

Table 1-5 CESIUM BEAM TUBE SHELF LIFE

Storage Reduced Life Temperature (°C)	Reduction in Life Expectancy per Year at Storage Temperature
40	20 d
50	1 mo
60	2 mo
70	4 mo

1.5 PREPARATION FOR SHIPMENT

CAUTION
After ac power is removed, the BATTERY FUSE must be removed; if not, the battery will continue to operate the instrument until the battery is discharged.

To turn off FTS 4065C prior to shipment, remove ac and ext dc power. Remove the battery fuse for a period of 10 seconds then reinstall.

1.5.1 Hazardous Material (HAZMAT) Shipping Considerations

FTS Cesium standards contain a small amount of cesium metal. The cesium isotope used (cesium 133) is non-radioactive. However, because of its reactive chemical properties, cesium is technically classified as a hazardous material by the U.S. Department of Transportation (USDOT) and the International Air Transport Association (IATA). During normal handling the FTS 4065C presents no danger since the cesium is encased within a vacuum sealed metal enclosure. However, hazardous materials, depending upon their specific nature, are subject to certain shipping regulations of the USDOT and the IATA. These regulations govern the shipping case as well as its labeling.

The initial shipment of every FTS cesium standard complies with HAZMAT regulations: the shipping case used has been tested and certified.

FTS has designed this case to meet current hazardous shipping regulations. The case design has been engineered to prevent damage to the unit during shipment.

In order to facilitate customer shipment of its cesium products, Frequency and Time Systems (FTS) provides certified shipping cases which comply with USDOT and IATA regulations. This case provides the necessary physical protection for the instrument during shipping. Contact FTS Technical Service for information about this service.

The cesium standard shipping case is FTS Part Number 08748-701 (vinyl covered plywood with aluminum-reinforced edges/corners) or part number 4040 (cardboard box).

1.5.2 Packing Materials

The Packing Materials are composed of:

a) an IATA case with protective anti-static foam,

b) labels to identify the shipping case:

Labels: FRAGILE LABEL
UN LABEL
DANGEROUS WHEN WET
DANGER NO PASSENGER AIRCRAFT
CESIUM UN1407I

1.5.3 Shipping Procedure

The shipper is responsible for the overall condition of the container; i.e. no visible damage to case and to properly place all labels on the case, etc. See Figure 1-4 for an illustration of the shipping container.

1.5.4 Placement Of Labels On Shipping Container

See Figure 1-5 for proper placement of labels.

Make sure an address label, proper HAZMAT labels, and packing slip (if necessary) are affixed to the shipping case and are clearly visible.

1.5.5 Shipment

Several United States and international shipping companies can accommodate properly packaged hazardous materials. United Parcel Service and Federal Express are examples for the United States. Intercontinental (617-569-4400) provides international shipping services.

Contact one of these shipping companies for assistance. If you need additional help, call FTS Shipping Department.

The following information is typically requested:

Proper Shipping Name:	Caesium (Cesium) Dangerous When Wet
Class Or Division:	4.3
UN or ID No.:	UN1407I
Quantity & Type Of Packing:	One Fiberboard Box X 5 Grams or One Plywood Box X 5 Grams * Carton(s)
Packing Inst.	412

* Insert number of cartons covered by the shipping paperwork.

FIGURE 1-4

ILLUSTRATION OF CESIUM SHIPPING CASE, FTS P/N 08748-701 OR P/N 4040

For cardboard container, place labels in similar orientation

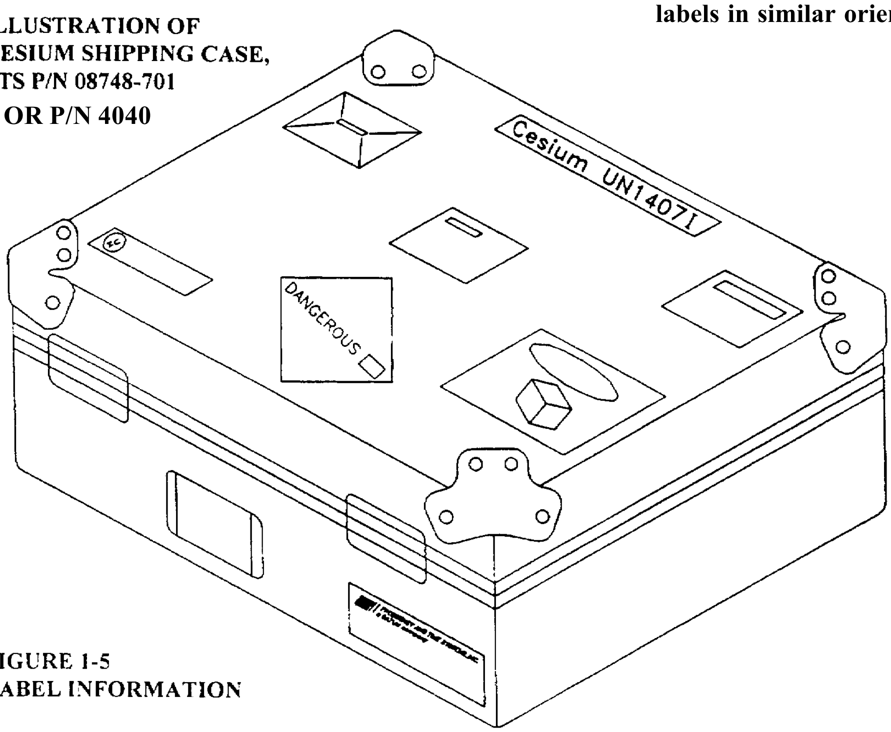
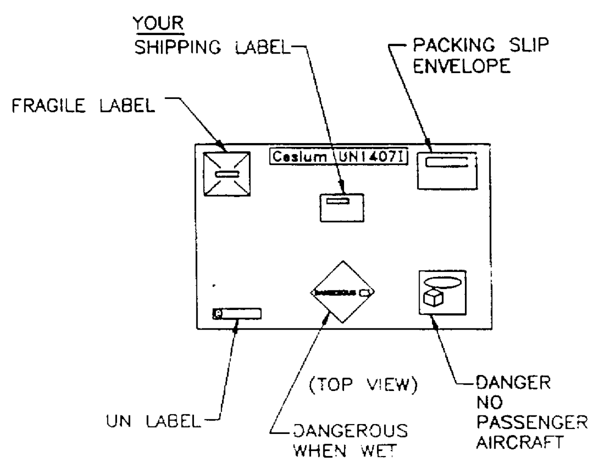


FIGURE 1-5
LABEL INFORMATION



T:\MISC_SHIPBOX

1.6 INSTALLATION

1.6.1 Environment

When installing the instrument, consideration should be given to standard environmental factors (temperature, humidity, vibration, etc.) and to the presence of magnetic fields that might affect the accuracy of the 4065C reference. Avoid installing or using the instrument near large motors, generators, transformers, or other equipment which radiate strong fields of 2 gauss or more. Also avoid placing the instrument near a strong permanent magnetic field.

1.6.2 Mounting

The FTS 4065C is designed to be mounted in a standard 19-inch equipment rack. Figure 1-6 INTERFACE CONTROL DRAWING shows all applicable dimensions and mounting details. The front panel occupies a height of 5.2 inches. The FTS 4065C is 21 inches deep with a few additional inches required for attaching cables to the rear panel connectors. The FTS 4065C side plates are drilled and tapped to accept chassis rack slides. The use of chassis rack slide or other means of support is necessary because of the weight and weight distribution of the instrument.

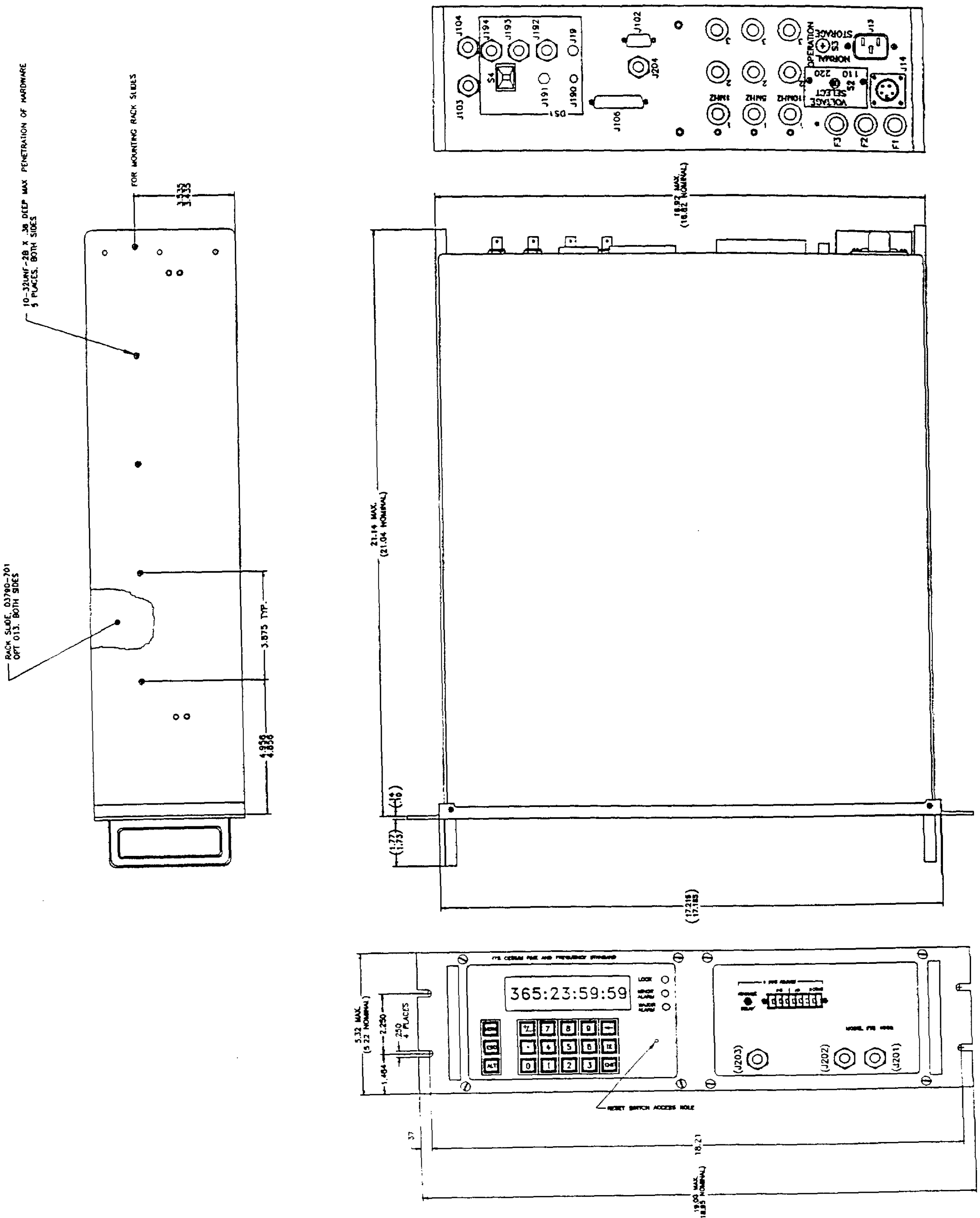


FIGURE 1-6 INTERFACE CONTROL DRAWING

FRONT PANEL		
CONN/DESCRP.	PIN OUT/PART NO./VENDOR/DESCRP.	FUNCTION
J201 BNC	819-B3800B-75 (AUTOMATIC) OR EQUIV.	10/5/1/.1 MHz
J202 BNC	819-B3800B-75 (AUTOMATIC) OR EQUIV.	1PPS
J203 BNC	819-B3800B-75 (AUTOMATIC) OR EQUIV.	1PPS SYNC

REAR PANEL			
CONN/DESCRP.	PIN OUT/PART NO./VENDOR/DESCRP.		FUNCTION
10MHz #1	KN-79-93 (KINGS) "N" CONN.		10MHz
10MHz #2	KN-79-93 (KINGS) "N" CONN.		10MHz
10MHz #3	KN-79-93 (KINGS) "N" CONN.		10MHz
5MHz #1	KN-79-93 (KINGS) "N" CONN.		5MHz
5MHz #2	KN-79-93 (KINGS) "N" CONN.		5MHz
5MHz #3	KN-79-93 (KINGS) "N" CONN.		5MHz
1MHz #1	KN-79-93 (KINGS) "N" CONN.		1MHz
1MHz #2	KN-79-93 (KINGS) "N" CONN.		1MHz
1MHz #3	KN-79-93 (KINGS) "N" CONN.		1MHz
J100 (AC INPUT)	PIN 1	3EP7 (CORCOM)	AC POWER
	PIN 2		NEUTRAL
	PIN 3		SAFETY GND
J101 (DC INPUT) 5 PIN CIRCULAR PLUG	PIN A	MS3102E14S-5P	48V SEE NOTE A
	PIN B		CHASSIS GROUND
	PIN C		DC RETURN
	PIN D		N/C
	PIN E		N/C
J102 (ALARM) 9 PIN "D" RECEPTACLE	PIN 1	DEU-9S-F0 (CANNON)	MINOR ALARM N.O
	PIN 2		MINOR ALARM COMMON
	PIN 3		MINOR ALARM N.C
	PIN 4		MAJOR ALARM N.O
	PIN 5		MAJOR ALARM COMMON
	PIN 6		MAJOR ALARM N.C
J106 25 PIN "D" RECEPTACLE	8325-6000 (3M) OR EQUIV.		RS232
J103 BNC	819-B3800B-75 (AUTOMATIC) OR EQUIV.		1PPS MASTER
J104 BNC	819-B3800B-75 (AUTOMATIC) OR EQUIV.		1PPS
J204 BNC	819-B3800B-75 (AUTOMATIC) OR EQUIV.		STATUS
F1 (3AG)	FUSE, 312006 (LITTELFUSE)		DC IN FUSE 6 AMP
F2 (3AG)	FUSE, 312006 (LITTELFUSE)		BATTERY FUSE 6 AMP
F3 (3AG)	FUSE, 313001 OR 002 (LITTELFUSE)		AC FUSE 1 AMP SB FOR UNIT WITH 230 VDC AC FUSE 2 AMP SB FOR UNIT WITH 115 VDC
J19	31-223 (OPT 063)		DS1 OUTPUT
J190	MI-332B (OPT 063)		DS1 OUTPUT
J191	TI-32BDC (OPT 063)		DS1 OUTPUT
J192	819-B3800B-75 (AUTOMATIC) OR EQUIV.		DS1 CLOCK OUTPUT
J193	819-B3800B-75 (AUTOMATIC) OR EQUIV.		DS1 8KHz OUTPUT
J194	819-B3800B-75 (AUTOMATIC) OR EQUIV.		DS1 SYNC INPUT

NOTE A: External DC input is specified at 38 to 71 Vdc. However, the unit will operate at plus six percent above the specified high limit and minus six percent below the specified lower limit of the input range.

CAUTION: Under no circumstances should the input voltage exceed 76 V. Exceeding the upper voltage limit will cause permanent damage to the unit.

Note 1.: Factory set to Low = MAJOR ALARM; High = NO ALARM; TTL Compatible (1 kilohm).

FIGURE 1-6 INTERFACE CONTROL DRAWING (cont'd)

1.6.3 Electrical Connections

The FTS 4065C may be powered from an external ac source, 115 or 230 V ac without pre-setting any switches. **HOWEVER, BE SURE TO INSTALL THE CORRECT FUSE F3 (1 A OR 2 A) ON THE REAR PANEL BEFORE APPLYING POWER.** The instrument may also be powered by an external dc source (38 to 71 V). The correct fuses are:

AC Power:	2 A SB at 115 V ac
	1 A SB at 230 V ac
Ext DC:	6 A
Battery:	6 A

Refer to Figure 1-6 for the location and contact designation for both external ac and dc power connectors.

NOTE A: External DC input is specified at 38 to 71 Vdc. However, the unit will operate at plus six percent above the specified high limit and minus six percent below the specified lower limit of the input range. **CAUTION: Under no circumstances should the input voltage exceed 76 V. Exceeding the upper voltage limit will cause permanent damage to the unit.**

1.6.4 Chassis Rack Slides (Option 013)

An FTS 6013 Rack Slide Accessory kit is recommended for mounting the FTS 4065C to a 19 inch rack assembly.

Included in the FTS 6013 are:

Rack Slides;	part number 03790-701
Connecting Hardware;	part of 03790-701

1.6.4.1 Mounting Procedure

1) Separate the inner chassis sections from each rack slide assembly.

2) Attach connecting hardware to chassis sections. See Figure 1-7 Rack Slide Assembly Diagram for placement of hardware.

3) Place five machine screws (#10-32x3/8) in the first five holes of both inner chassis sections.

4) Attach the inner chassis sections to the sides of the FTS 4065C.

5) Attach the outer and middle chassis sections to the rack and adjust the connecting hardware so that the outer and middle chassis sections will align to the FTS 4065C.

6) Slide the FTS 4065C onto the tracks of the mounted rack sections. When the slides lock, depress the stop tabs and push the FTS 4065C the rest of the way into the rack.

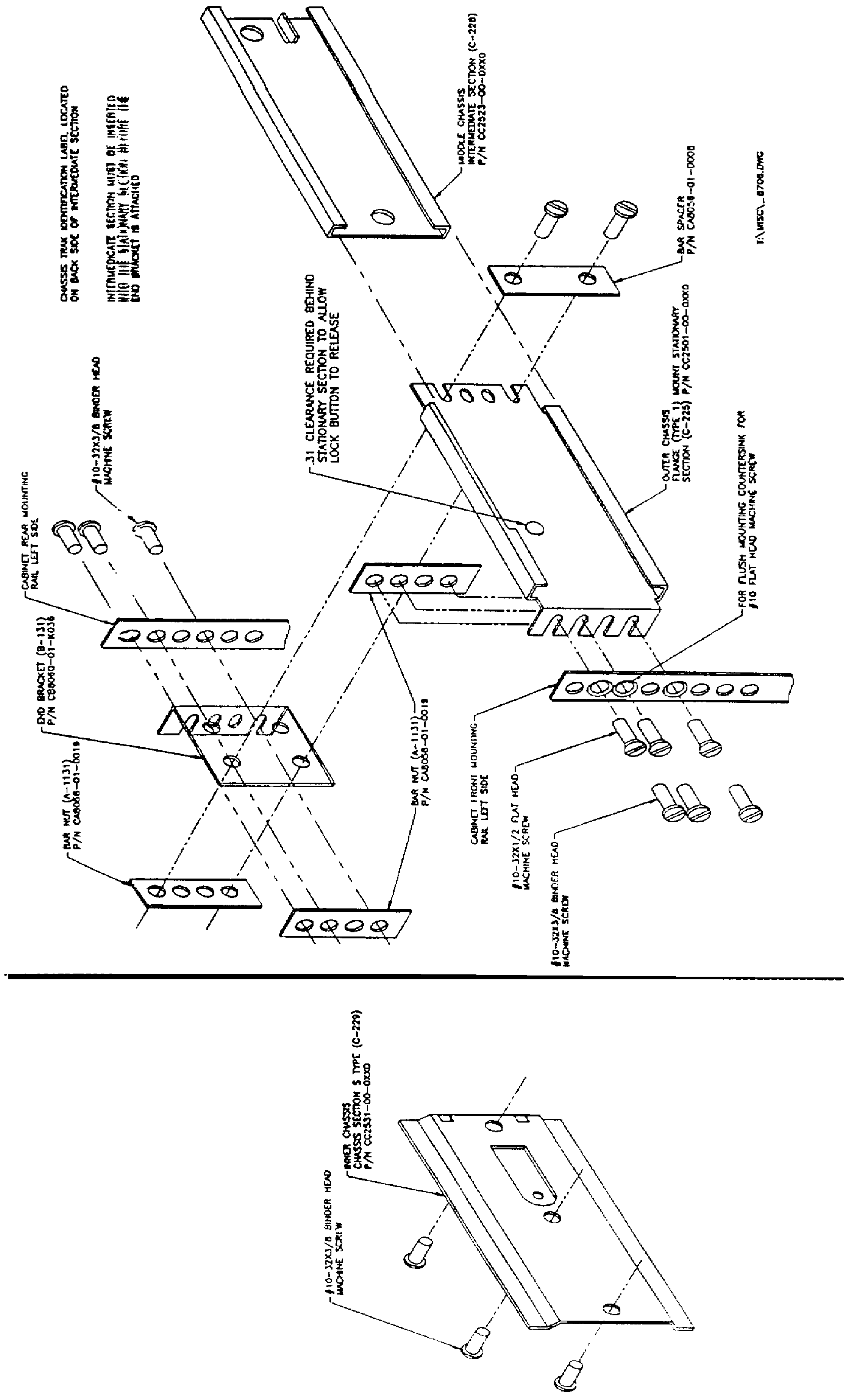


FIGURE 1-7 RACK SLIDE ASSEMBLY DIAGRAM

SECTION 2
OPERATION

SECTION 2. OPERATION

2.1 INTRODUCTION

This section describes procedures for turn-on, monitoring and for controlling pulse synchronization, alignment and other adjustments of the FTS 4065C Cesium Frequency and Time Standard.

2.2 TURN-ON PROCEDURE

Except for the application of ac power, no specific user actions are required to turn-on the FTS 4065C and obtain the specified rf output signals. However, monitor and control functions are provided and are described below. Read the entire procedure and tables below before executing the turn-on steps. Refer to Figure 1-4 for an illustration of the front and rear panels of the FTS 4065C.

1) Apply ac power to the instrument.
2) Allow the FTS 4065C to warm-up for the specified warm-up time (refer to Table 1-1).

After turn-on , the temperature of the cesium and quartz crystal ovens must be raised to their operating points. The cesium oven reaches its operating point (90 °C) in about 10 minutes. The quartz crystal oven reaches its operating point at 80 °C in about 20 minutes.

When the system monitors are within preset limits and as the oscillator approaches its nominal operating frequency, the autolock routine begins looking for the cesium resonance.

3) Frequency lock is indicated on the first line of status menu #1-operational mode. From the TOP MENU access the STATUS MENU #1 as described in the next section. The OPERATION indicator turns on and the MAJOR ALARM indicator may be reset.
4) From the TOP MENU, access ALARM MENU #1 and press two keys “ALT” and “1”, at the same time, to reset the MAJOR ALARM.

2.3 KEYBOARD DESCRIPTION

All monitor/control functions of the 4065C are accomplished by use of the control panel keypad and display. The control panel has two major modes of operation.

1) Time of Day (TOD) Display
2) 8 line x 32 character alphanumeric display for monitor and control of major functions of the instrument.

Accessing either of these two modes is made by pressing the MENU key. If the display is in the TOD mode, then pressing the MENU key will access the alphanumeric mode and vice versa.

Once the control panel has been placed in the alphanumeric mode, then all the monitor/control functions of the 4065C can be accessed by a series of menus.

The MENU structure is simple and consists of:

a) title line
b) up to four lines of either data or a command to be selected.
c) a help line providing instructions as to the possible alternatives from the present menu.

The following examples will illustrate the use of the control panel.

Example 1: Accessing a Status menu

Perform the following sequence of key strokes.

a) If the display is in the TOD mode, press the MENU key to access the alphanumeric mode.

b) Press ESC twice. This should bring the system to the TOP menu and the display should show:

Serial Number XXXXX	Title LINE
1 Status Menus 2 Alarm Menus 3 Operation Menus 4 Constant Menus	Data/Function Lines
TYPE the number of the menu	HELP Line

c) Press 1 to select the status menu.   The display should read:

STATUS 1

Operational Mode	LOCKED
Power Source	AC
Ramsey Beam	xxxx
Signal Variance	+xxx
Osc Control Voltage	-xxxx

1-6 for other STATUS menus

d) Notice that the HELP line instruction allows the selection of any of the six status menus by pressing one of the keys 1-6.

e) Press ESC to return to the Top Menu.

Example 2: Entering data to change the system operation.

The previous example demonstrated the use of the keyboard to access monitor data (STATUS MENUS). This example will demonstrate the use of the keyboard to change the operation of the 4065C. The example chosen is the setting of the Time-of-Day.

Perform the following operations:

a) Press ESC (up to 2 times if required by previous states) to access the TOP menu.

b) Press 3 to access the Operation 1 Menu.

c) Notice that the HELP line has two possible modes for this menu.

1) by pressing the keys 1-4, then OPERATION menus 1 through 4 may be accessed.

2) by simultaneous pressing ALT and keys 1-4 then one of four possible commands of OPERATION menu 1 may be accessed.

To complete the function selection at this point, press ALT 1. The updating of the TOD has thus been selected.

The HELP line should now show:

Enter Time: MM:DD:YY - HH:MM:SS

d) Enter the TOD from left to right by entering the number corresponding to:

MM - 2 digit month
DD - 2 digit day of month
YY - 2 digit year
HH - hours (24 hour format)
MM - minutes
SS - seconds

e) If a mistake is made during the entry of any of the above, the use of the <-- key will erase the entry and the correct data can be entered.

f) Press ENTER to execute the command.

g) Press ESC twice to return to TOP MENU.

h) Press MENU to change the display mode to TOD.

I) Notice that the TOD data just entered is now being displayed and updated.

2.4 OPERATIONAL CHECK

After the FTS 4065C has been operating for its specified warm-up time, check the following parameters to verify proper operation:

1) CONTROL VOLTAGE - check the control voltage by accessing status menu 1 and verify that it is within limits specified in Table 2-1.

2) BEAM CURRENT - check the beam current by accessing status menu 1 (Ramsey Beam) and status menu 4 (numerical gain and offset adjust) and verify that these parameters are within limits specified in Table 2-1.

3) Check all other monitors as listed in Table 2-1.

4) If another reference standard of known accuracy is available, a measurement of the FTS 4065C frequency offset can be made. Use the FTS 6101/001 and a chart recorder to obtain an 8 hour phase record between the reference standard and the device under test. The frequency difference may be calculated by dividing the phase change (in seconds) by the elapsed time (8 hours = 28800 seconds). For example, an offset of 5×10^{-12} produces a phase change of 144 ns in 8 hours.

2.5 TURNING OFF

To turn off the FTS 4065C, follow the steps below:

1) Remove the battery fuse (this action disconnects the internal battery if supplied).

2) Remove AC and EXT DC power.

3) Put power switch in standby position.

4) The battery fuse may be re-installed after 10 seconds of power off.

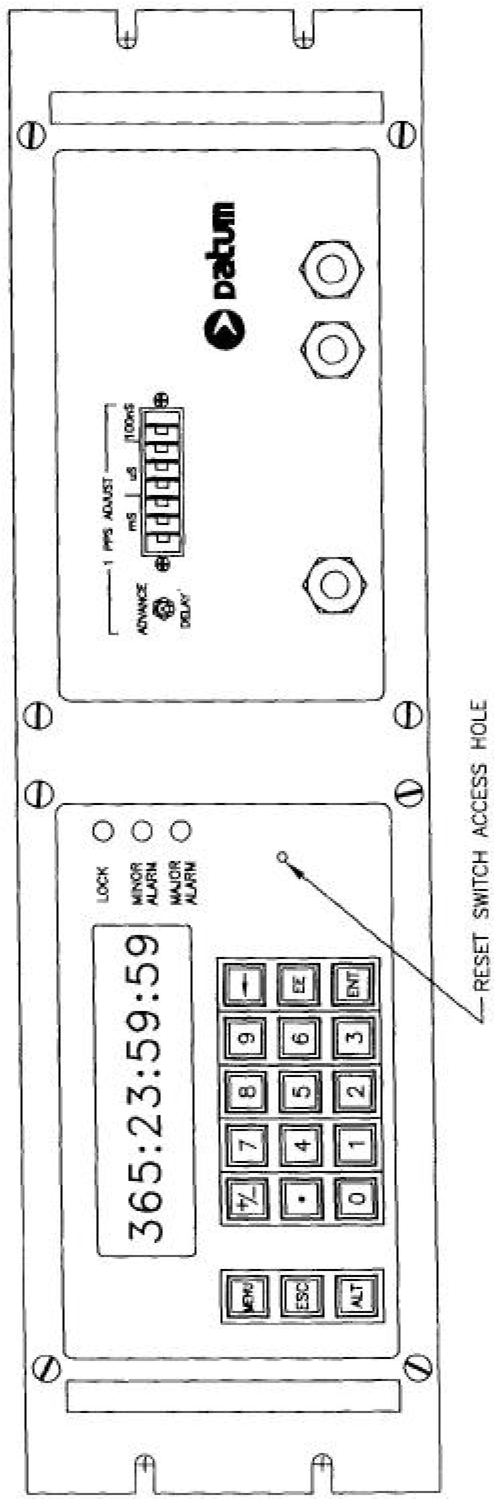


FIGURE 2-1 FTS 4065B FRONT PANEL

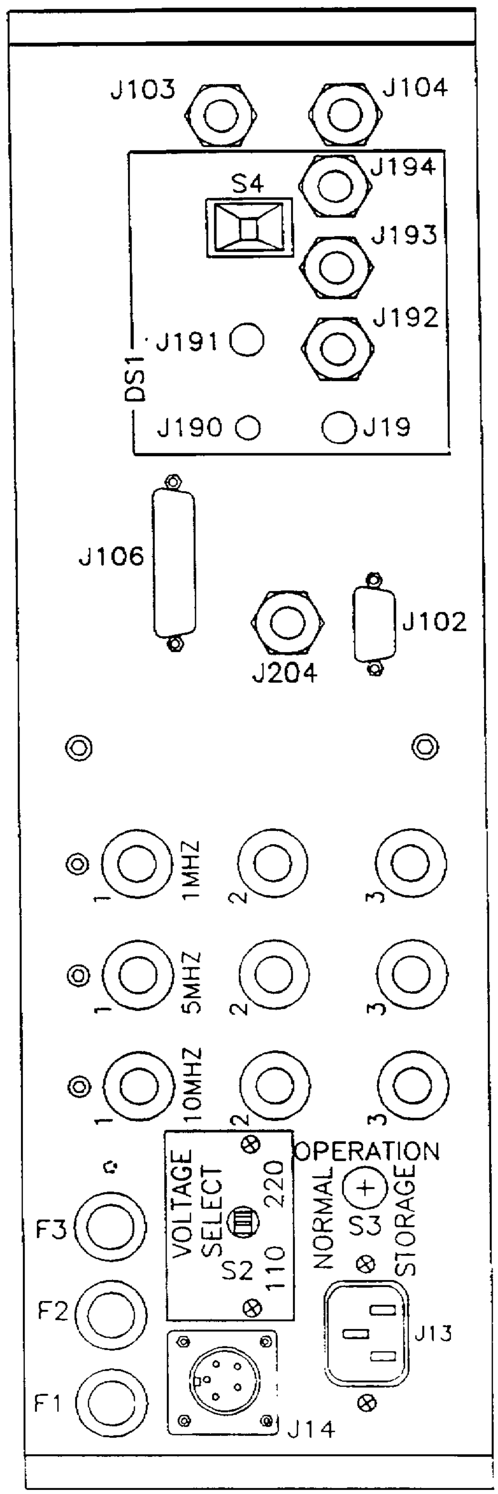


FIGURE 2-2 FTS 4065B REAR PANEL

TABLE 2-1 MONITORS

STATUS		SPECIFICATION
STATUS 1		
Operational Mode		Major/Minor/Locked
Power Source		AC/DC/BAT
Ramsey Beam		2500 " 500
Signal Variance	(075)	#225
	(076)	#62
Osc. Control Voltage		#"4500
STATUS 2		
+5 V PS Voltage		5.12 "0.40
+15 V PS Voltage		15.5 "1.5
-15 V PS Voltage		-15.5 "1.5
Ionizer V (x.xx) *		(X.XX) "0.16 V
+24 V PS Voltage		25 "2
System Voltage		33 "1
STATUS 3 *		
Spectrometer V (xx.x) *		(XX.X) "10%
C-Field Current		>17; <20
EM Voltage		>7; <11
Ion Pump Current		<240
STATUS 4		
Offset Adjust		#2500
9 GHz Adjust		0 to -4500
C-Field Adjust		#0050
Numerical Gain		1 to 5
Zeeman Beam		2000 "600
STATUS 5		
Ramsey Error		<"160 mV
Rabi Ramsey Error		<"40
Zeeman Error		<"160 mV
Rabi Zeeman Error		<"160 mV
Ramsey Confidence		<"160 mV
STATUS 6		
Cs Module Temp		Ambient +20EC
Oscillator State		Cold/Warm
Cs Oven Voltage		#7.5
DC Voltage Available		00.0

* x x x is given in CONSTANTS menu and is the nominal constant value of the parameter.

2.6 PULSE SYNCHRONIZATION AND TIME SETTING

2.6.1 1 PPS Synchronization

The steps required to synchronize the 1 pps output to a reference standard are outlined below:

1) Connect the 1 pps output of the reference standard to the SYNC connector of the FTS 4065C.

2) Perform the 1 pps sync function by the following set of keystrokes:

   a) press ESC twice or press MENU to get to the TOP MENU

   b) press 3 to get to OPERATION 1 MENU

   c) press ALT 4 to access the 1 pps sync function

   d) press ENTER to execute the 1 pps sync function

   e) press ESC twice to get to the TOP MENU

   The 1 pps output of the FTS 4065C is now synchronized to within "150 ns of the reference standard.

2.6.1.1 Left blank intentionally

2.6.1.2 Time Setting Procedure

The TOD Display provides hours, minutes and seconds in a 24-hour format. The units of seconds are synchronous with the 1 pps master output.

To set the time-of-day, perform the following steps.

1) After the FTS 4065C is warmed up, synchronize the 1 pps output to a reference pulse, (refer to paragraph 2.6.1).

   a) Press ESC (up to 2 times if required by previous states) to access the TOP menu.
   b) Press 3 to access the Operations 1 Menu.
   c) Press ALT 1 to select the updating of the TOD.

   The HELP line should now show:

   Enter Time: MM:DD:YY - HH:MM:SS

   d) Enter the TOD from left to right by entering the number of corresponding to:

      MM- 2 digit month
      DD- 2 digit day of month
      YY- 2 digit year
      HH- hours (24 hour format)
      MM - minutes
      SS- seconds

2.6.1.2 Time Setting Procedure (cont'd)

e) If a mistake is made during the entry of any of the above, the use of the 7 key will erase the entry and the correct data can be entered.

f) Press ENTER to execute the command.

g) Press ESC twice to return to TOP MENU.

h) Press MENU to change the display mode to TOD.

I) Notice that the TOD data just entered is now being displayed and updated (notice the format of the TOD display is Day of Year, Time of Day).

2.6.1.3 1 Second Advance/Delay

The seconds count of the Time of Day can be advanced or delayed by 1 second increments through the use of the 1 second advance or the 1 second delay functions. To implement this function, perform the following keyboard commands:

a) Press ESC (up to 2 times if required by previous states) to access the TOP menu.

b) Press 3 to access the Operation 1 Menu.

c) Press ALT 2 to select the 1 second advance function.

d) Press ENTER to execute the command.

e) If the 1 second delay function was required, choose ALT 3 in Step c instead of ALT 2.

f) Press ESC twice to return to TOP MENU.

g) Press MENU to change the display mode to TOD.

2.6.1.4 1 PPM Reset

The TOD may be reset by the 1 PPM RESET function. The minutes are advanced by one count and the seconds are set to zero. To implement this function, perform the following keyboard commands:

a) Press ESC (up to 2 times if required by previous states) to access the TOP menu.

b) Press 3 to access the Operation Menu.

c) Press 2 to get to OPERATION 2 MENU.

d) Press ALT 1 to select the 1 PPM RESET function.

e) Press ENTER to execute the command.

f) Press ESC twice to return to TOP MENU.

g) Press MENU to change the display mode to TOD.

2.6.2 1 PPS Advance/Delay

The 1 pps moveable outputs may be advanced or delayed by setting the toggle switch on the front panel. The "up" position is for advancing the pulse and the "down" position is for delaying the pulse. The amount of advance or delay can be selected by entering the desired interval on the front panel thumbwheel switches. See Figure 2-3 1 PPS ADVANCE/DELAY for an illustration of the ADVANCE and DELAY features.

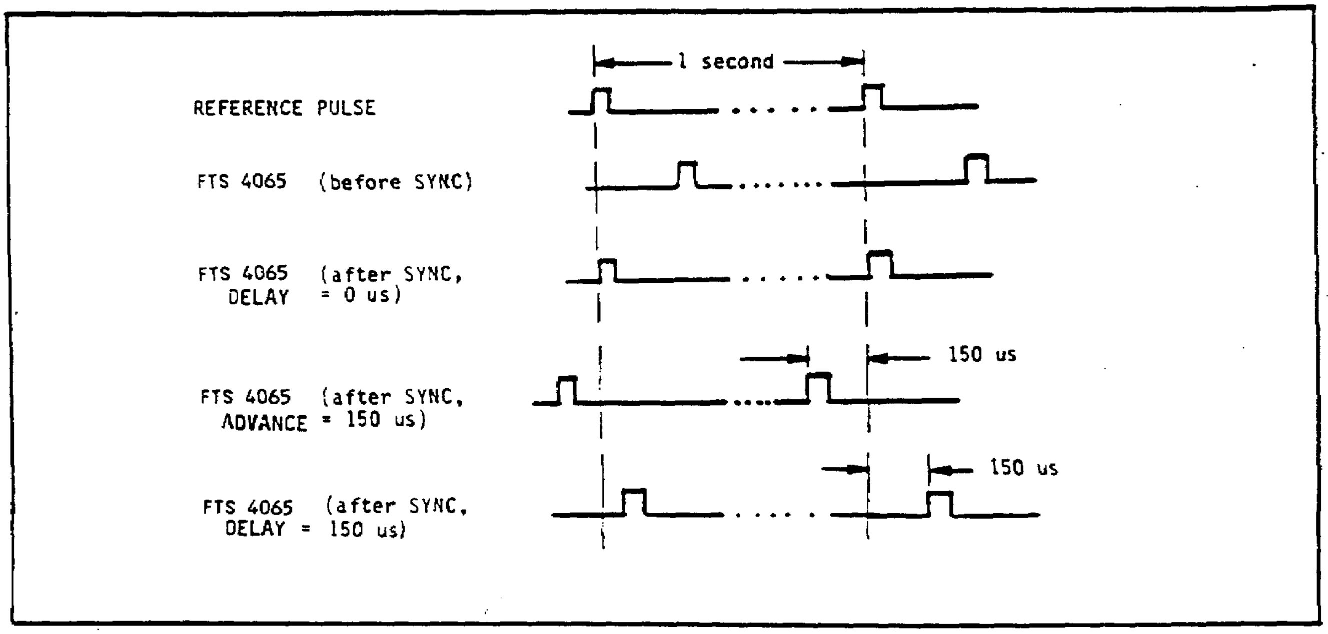


FIGURE 2-3 1 PPS ADVANCE/DELAY

2.6.2.1 1 PPS Advance/Delay Setting Procedure

1) Set advance/delay toggle switch to desired position. Set switch in "up" position labeled ADVANCE to advance the pulse or in "down" position labeled DELAY to delay the pulse.

2) Enter the amount of advance or delay by setting the seven thumbwheel switches, on the front panel, to the interval required. Resolution is in increments of 0.1 microsecond steps. The advance or delay interval is immediately executed as the thumbwheel switches are adjusted.

2.6.2.2 1 PPS Advance/Delay Verification

The 1 PPS advance or delay can be verified by the use of a time interval counter. The master 1 PPS signal is attached to channel "A" of the counter and the movable 1 PPS signal is attached to channel "B" (refer to Figure 2-4 1 PPS Advance/Delay Test Set-up). Trigger the counter on channel "A". The measurement should read within 0.1 microsecond of the setting selected. Remember that when the pulse is advanced, the counter reading is 1 second minus the switch setting. Use the 5 MHZ output (or 10 MHZ, whichever is required by the counter) from the FTS 4065C for the frequency reference to the time interval counter.

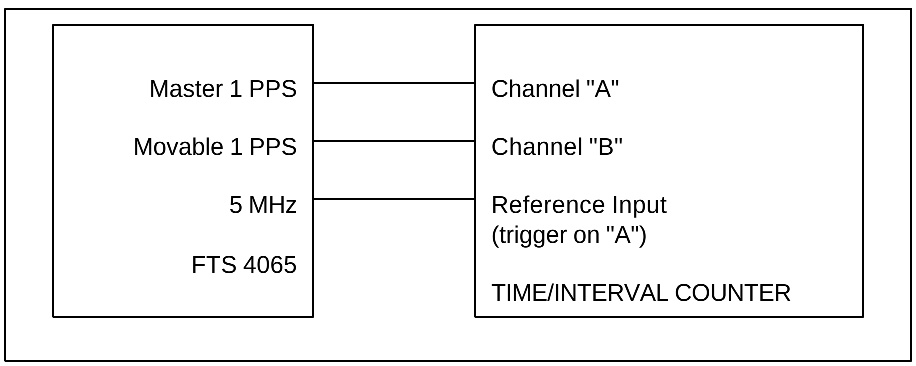


FIGURE 2-4 1 PPS ADVANCE/DELAY TEST SET-UP

2.7 OPERATIONAL COMMANDS

The commands and operational controls described in this paragraph are provided for convenience, and are not required to achieve the specified performance characteristics of the FTS 4065C.

2.7.1 Fine Frequency Adjustment

The frequency of the FTS 4065C can be made to match the frequency of another standard by adjusting the internal synthesizer.

To change the frequency perform the following operations by use of the keyboard and display

a) press ESC twice or MENU to get to the TOP menu
b) press 3 to select the OPERATION menus
c) press 2 to select OPERATION 2 menu

d) press ALT 2 to select the change function. Note that the HELP line now shows
Enter Freq Offset +XXXXXX
e) enter the frequency change in units of 1e-15
f) press ENTER to complete the frequency change command
g) press ESC twice to return to TOP menu and MENU to return to the TOD display if required.

2.7.2 Fine Phase Adjustment

The phase of the FTS 4065C can be made to match the frequency of another standard by adjusting the internal synthesizer.

The rate of phase change is 0.1 ns/s.

To change the phase perform the following operations by use of the keyboard and display

a) press ESC twice or MENU to get to the TOP menu

b) press 3 to select the OPERATION menus

c) press 2 to select OPERATION 2 menu

d) press ALT 3 to select the phase change function. Note that the HELP line now shows Enter Phase Offset +XXXX"

e) enter the phase change in units of ns

f) press ENTER to complete the phase change command

g) press ESC twice to return to TOP menu and MENU to return to the TOD display if required.

2.7.3 Fine Phase Adjustment STOP

During the execution of the phase adjustment as described in 2.7.2, the phase change can be terminated by use of the STOP PHASE OFFSET command.

To stop the phase change, perform the following operations by use of the keyboard and display.

a) press ESC twice or MENU to get to the TOP menu

b) press 3 to select the OPERATION menus

c) press 2 to select OPERATION 2 menu

d) press ALT 4 to select the phase stop change function.

e) press ESC twice to return to TOP menu and MENU to return to the TOD display if required.

2.7.4 C-Field Servo On/Off

The C-FIELD SERVO function may be enabled or disabled by use of the C-FIELD SERVO ON/OFF command. The technical details of the C-FIELD servo function from the point-of-view of the overall Cesium Module are described in Section 3.7.5. To enable/disable this function, perform the following set of keyboard commands. This function is typically enabled.

a) press ESC twice or MENU to get to the TOP menu

b) press 3 to select the OPERATION menus

c) press 3 to select OPERATION 3 menu

d) press ALT 1 to select the C-Field Servo ON/OFF function.

e) press ESC to change the state of the C-Field Servo or press nothing if the state is correct as required.

f) press ESC twice to return to TOP menu and MENU to return to the TOD display if required.

2.7.5 Time Constant

The Time Constant of the frequency control loop can be adjusted by use of the TIME CONSTANT function. The factory setting is 5s. To change the time constant, perform the following set of keyboard commands:

a) press ESC twice or MENU to get to the TOP menu

b) press 3 to select the OPERATION menus

c) press 4 to select OPERATION 4 menu

d) press ALT 1 to select the time constant function.

e) enter the time constant in units of 0.1 seconds.

f) press ENTER to complete the command.

g) press ESC twice to return to TOP menu and MENU to return to the TOD display if required.

2.7.6 Servo Order

The "filter order" of the frequency control loop can be adjusted by use of the SERVO ORDER function. The factory setting is 2. To change the order, perform the following set of keyboard commands.

a) press ESC twice or MENU to get to the TOP menu

b) press 3 to select the OPERATION menus

c) press 4 to select OPERATION 4 menu

d) press ALT 2 to select the servo order function.

e) enter the servo order (1 or 2)

f) press ENTER to complete the command

g) press ESC twice to return to TOP menu and MENU to return to the TOD display if required.

2.7.7 Selectable Frequency Out

The frequency of the TTL output on the rear panel may be selected to be 0.1, 1, 5 10 MHZ. To select the frequency, perform the following commands:

a) press ESC twice or MENU to get to the TOP menu

b) press 3 to select the OPERATION menus

c) press 3 to select OPERATION 3 menu

d) press ALT 3 to select the frequency out function.

e) enter the frequency required.

f) press ENTER to complete the frequency out command.

g) press ESC twice to return to TOP menu and MENU to return to the TOD display if required.

2.7.8 Baud Rate

The Baud Rate of the RS232 port on the rear panel of the 4065C may be changed by use of the BAUD RATE command. To change the baud rate, perform the following set of keyboard commands:

a) press ESC twice or MENU to get to the TOP menu

b) press 3 to select the OPERATION menus

c) press 3 to select OPERATION 3 menu

d) press ALT 4 to select the baud rate function.

e) enter the required baud rate.

f) press ENTER to complete the baud rate command.

g) press ESC twice to return to TOP menu and MENU to return to the TOD display if required.

2.7.9 C-Field Offset

This function is reserved for factory use only.

2.7.10 Unit Serial Number

The serial number of the unit has been programmed at the factory to correspond to the serial number assigned to the unit during manufacture. If the need arises to change this number or if the memory of the unit becomes corrupted, then the serial number may be re-entered by the following procedure.

Press MENU. Press ESC.

Press ALT 4, ALT 2, ALT 5.

Press ALT 2 and enter Serial number of the unit (see rear plate).

Be sure to enter 5 digits (e.g. S/N 1005 = 0 1 0 0 5)

2.7.11 Front Panel Reset Switch

A small hole in the front panel, located on the Front Control Panel (left), see Figure 2-1, is used to access a recessed switch, which, if depressed will cause the front panel microprocessor to reset. The Cesium beam tube module, and thus the 1 PPS and RF outputs, are not affected by this reset, however, the front panel and serial communication (via the rear panel) will be affected, including the TOD clock.

2.8 THIS SECTION LEFT BLANK INTENTIONALLY

2.9 OPERATION ON EXT DC OR INTERNAL BATTERY

When ac power is interrupted, the FTS 4065C may operate on either EXTERNAL DC or INTERNAL BATTERY. The selection of power source is made automatically by the 4065C. The hierarchy of power sources is:

1) A.C

2) EXT D.C.

3) INTERNAL BATTERY

2.9.1 Battery Replacement

When the batteries need to be replaced, refer to the following procedure and Figure 2-5:

1) Remove the top cover.

WARNING
LETHAL VOLTAGES ARE PRESENT UNDER THE TOP COVER. TAKE SPECIAL PRECAUTIONS NOT TO CONTACT THE LINE VOLTAGE AT THE REAR PANEL OR THE POWER SUPPLIES.

WARNING
THE BATTERIES ARE CAPABLE OF DELIVERING SHORT CIRCUIT CURRENTS IN EXCESS OF 200 AMPERES. SHORT CIRCUITING A BATTERY WILL PRODUCE SPARKS AND CAUSE THE BATTERY WIRING TO OVERHEAT RESULTING IN PERSONAL INJURY. DO NOT SHORT CIRCUIT THE BATTERIES.

2) Disconnect the spade clips (6) at the battery terminals.

3) Unscrew the captive fastener on the battery bracket.

4) Slide the battery bracket upwards. Remove the battery bracket.

5) Remove the three battery packs.

6) Install three new battery packs.

7) Reconnect the battery spade clips, giving special attention to the correct polarity. Refer to Figure 2-5. Install battery bracket.

CAUTION

MAKING CONNECTIONS WITH THE WRONG POLARITY OR SHORTING TERMINALS OR SPADE CLIPS TO THE CHASSIS MAY DAMAGE THE INSTRUMENT.

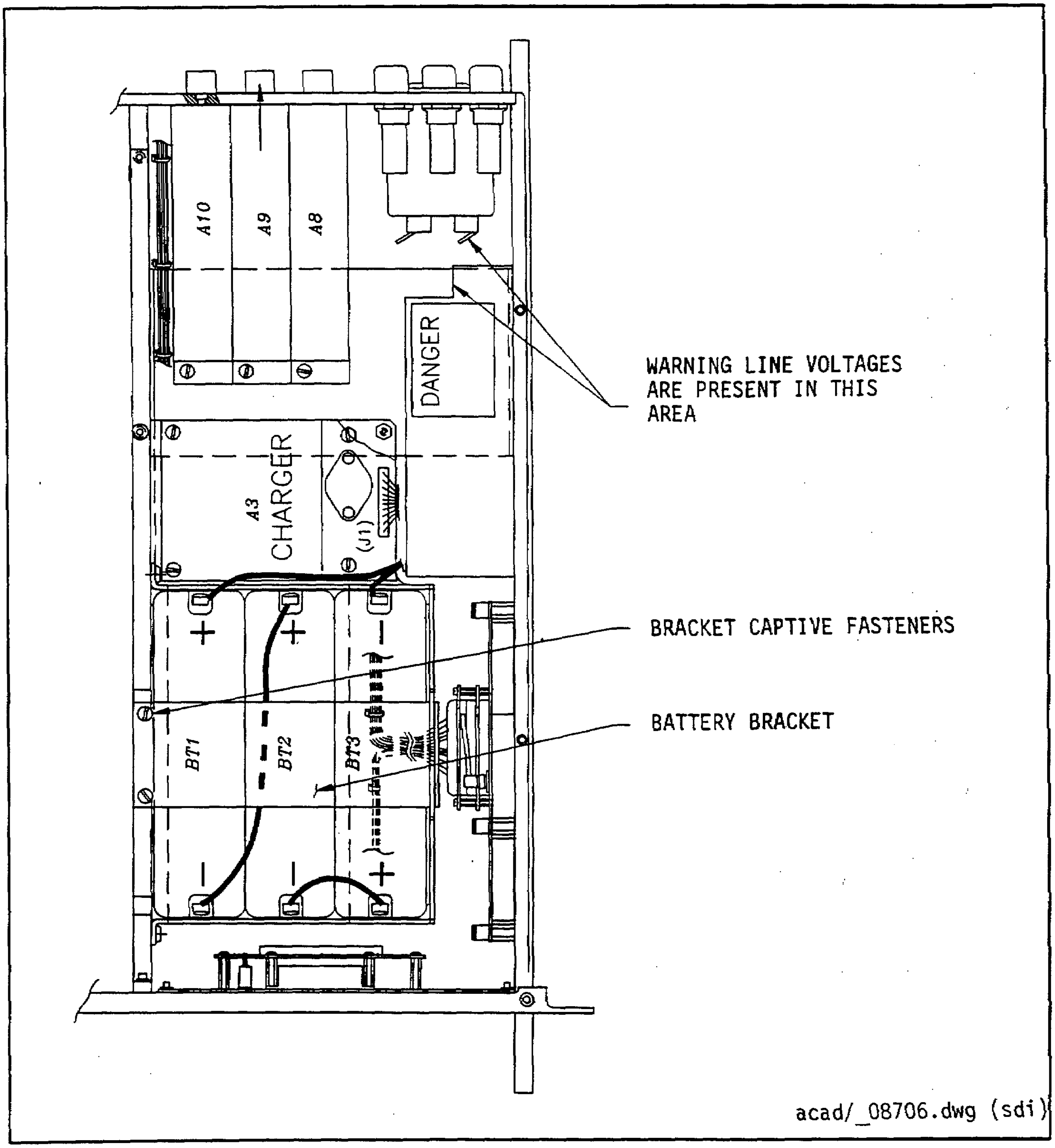


FIGURE 2-5 BATTERY REPLACEMENT

2.10 ALARMS

Normal operation of the 4065C is indicated on the front panel by the illumination of the LOCK LED. The MAJOR or MINOR ALARM LEDs would normally be OFF.
Normal operation is also represented by the state of the MINOR and MAJOR ALARM RELAY contacts available on J20 and as listed in Figure 1-6. Under normal operation, the contact listed as N.O. will be open and the contacted listed N.C. will be closed. Any failure will flip the state of the relay if the failure is defined as MAJOR or MINOR. This section will describe the parameters which are monitored in the 4065C and the ALARMS that are generated.

To reset the alarms, press ALT and 1 simultaneously then ENT from the ALARM 1 menu. All faults and alarms are latched; this allows the operator to know what fault occurred. The Alarm LED's have three attributes:

ON: indicates a fault presently exists

OFF: indicates no faults exist

FLASHING: indicates that a fault occurred at some point in time and that the instrument has since recovered.

2.10.1 ALARM 1 Menu

The alarm status (or normal operation) of the 4065C is also indicated on the ALARM menus of the front panel display. To access the alarm menus, perform the following operations on the keyboard.

a) press ESC twice or MENU once to get to the TOP MENU.
b) press 2 to get to the ALARM 1 menu. The display should now show the following:

```
                    ALARM 1

Alarms                        NONE
Cs Fault Codes      00,00,00,00,00
Lost Lock                       NO
Sys Flts

ALT 1 to reset alarms
1-3 for other ALARM menus
```

The prompt line has the option at this point to allow the user to reset the alarms (indicators and relays) by pressing ALT and 1 simultaneously. Selection of the other alarm menus is performed by pressing 2 or 3.

The main function of the ALARM 1 menu is to summarize the alarm status of the instrument. Line 1 of this menu is the top level summary of the instrument status. The possible states are:

1) NONE (normal operation)
2) MINOR (no cesium module faults; instrument level faults as defined in ALARM 3 menu)
3) MAJOR (Cesium Module) faults as defined in Line 2 of ALARM 1 and/or system level faults as defined in ALARM 3 menu).

2.10.1 ALARM 1 Menu (cont'd)

Line 3 of this menu is a summary of the last five faults as detected in the Cesium Module. These faults are as follows:

Major Faults

01: Central peak to background level >3 V or <2 V
02: Voltage difference (symmetry check of clock transition) > 40 mV
or
Voltage difference (clock pedestal) >40 mV
03: Voltage difference (Zeeman pedestal) >160 mV
04: Error on mass spectrometer voltage > 10%
05: C-field current <17 mA or >20 mA
06: Electron multiplier voltage <7 V or >11 V
07: DAC voltage < 5% or > 95% of input range
08: Oscillator control voltage $95% of range
09: Internal temperature > 80°C
11: 12.6 MHZ level out of range (3 "1.5 V)
12: +5.12 V " 0.40 V
13: +15.5 V "1.5 V
14: -15.5 V "1.5 V
15: Faulty writing in EEPROM
16: Unit restart
17: Module Configuration Lost
18: Beam Gain DAC Near Limit
Major Faults Causing Module Power Shutdown
F1: Oven heater voltage > 10 V
F2: Cold oscillator
F3: Ionizer voltage error > "0.16 V
F4: Ion Pump current > 240 µA
F5: Internal 24 V < 20 V or > 30 V

Line 3 of ALARM 1 menu indicates if the Cesium Module has lost lock since the last time, that the alarms had been reset. The possible states for this report are YES or NO.

Line 4 of the ALARM 1 menu indicates the status of the other system subassemblies (not Cesium Module). If no fault is detected, this line is blank. If a fault is detected, the fault is reported by one or more of the following acronyms:

1) PPS (one PPS subassembly)
2) CHG (battery charger)
3) DS1 (Digital Signaling 1 Synthesizer
4) RFV (RF Power Supply Voltage, +24 V from A5 Low Voltage Power Supply Assembly)
5) TOD (Time Of Day has been compromised)
6) BAT (system running on battery and exceeding duration limit specified in ALARM 2 menu
7) XDC (system running on DC and exceeding limit specified in ALARM 2 menu)
8) PWR (main system supply voltage is less than 22 volts)
9) BTV (battery voltage fail) **C feature not implemented; for future development**
10) EXT (used only in special options)
11) RF (rf output level too low)

2.10.2 ALARM 2 Menu

From the ALARM 1 menu, one can select the ALARM 2 menu by pressing 2. The ALARM 2 menu format is as follows:

```
                    ALARM 2
Time on DC                          00:00:00
Time on BAT                         1:02:13
1 DC Delay to Major                 00:00:00
2 BAT Delay to Major                00:00:00

  ALT  1-2 for one of the above
       1-3 for other ALARM menus
```

Lines 1 and 2 of this menu show the elapsed time that the instrument has operated on either of the secondary power sources, DC or battery.

Line 3 and 4 indicate the elapsed time of operation on DC or batteries before an alarm would be triggered if an alarm mode had been selected in ALARM menu 3 (see section 2.10.3). By selecting ALT 1, or ALT 2, the duration (delay) to the initiation of the alarm can be programmed.

Factory default settings are 00:00:00.

A typical setting for "2 BAT Delay to Major" is 00:30:00, since the battery capacity specification is 1 hour. In order to function, number 3 of Alarm Menu 3 must be set to MINOR (refer to paragraph 2.10.3)

The setting for "1 DC Delay to Major" must be determined by the user after determining the capacity of the external DC battery. In order to function, number 4 of the Alarm Menu 3 must be set to MINOR (refer to paragraph 2.10.3).

2.10.3 ALARM 3 Menu

From either the ALARM 1 or ALARM 2 menus, by pressing 3, one can select the ALARM 3 menu. The format of the menu is:

ALARM 3

1	Time of Day Fault (TOD)	OFF
2	Battery Charger Fault (CHG)	MAJOR
3	Battery Operation (BAT)	OFF
4	DC Operation (DC)	MINOR

ALT 1-4 for one of the above
1-3 for other ALARM menus

The ALARM 3 menu allows the user to program the system subassembly fault reporting to one of three states:

- OFF
- MINOR ALARM
- MAJOR ALARM

The system subassembly faults that can be programmed are:

- TOD Time of Day
- Battery Charger Fault
- Battery Operation
- DC Operation

Selection of ALT 1, or ALT 2, or ALT 3 or ALT 4 from the ALARM 3 menu allows the programming of each of the subassembly functions. Once one of these functions has been selected, then the mode is changed by pressing one of the following:

0 for OFF
1 for MAJOR
2 for MINOR

THE FOUR SYSTEM SUBASSEMBLY FAULTS ARE SET TO OFF AT THE FACTORY.

2.10.4 ALARM 4 Menu

From any other alarm menu, ALARM 4 can be selected by pressing 4. The format of the menu is:

1	BATTERY FAULT (BTV) **-- feature not implemented; for future development**	OFF/MAJOR/MINOR
2	DC Unavailable (DCU)	OFF/MAJOR/MINOR
3	DCU Delay to MAJOR	00:00:00
Time DC Unavailable		00:00:00

ALT 1-3 for one of the above
1-4 for other ALARM menus

SECTION 3
THEORY OF OPERATION

SECTION 3. THEORY OF OPERATION

3.1 INTRODUCTION

The various components of the FTS 4065C are illustrated in Figure 3.1. Table 1 is a list of all the major subassemblies with their reference designators and parts numbers.

The FTS 4065C consists of:

- Power Supply Circuit
- Time and Frequency Generating Circuitry
- Front Panel Controls and Display
- A Cesium Frequency Module (CFM)

3.2 POWER SUPPLY

The FTS 4065C is powered from one of three sources:

- 115 V ac / 230 Vac
- External ±38 to 71 Vdc
- Internal 24 V battery that provides for a minimal 1 hour standby protection.

The FTS 4065C is normally powered by an input of 115 Vac, 47 to 400 Hz. The power supply consists of:

- AC to DC Power Supply
- DC Input Power Supply
- Charger
- Battery Assembly
- Low Voltage Power Supply

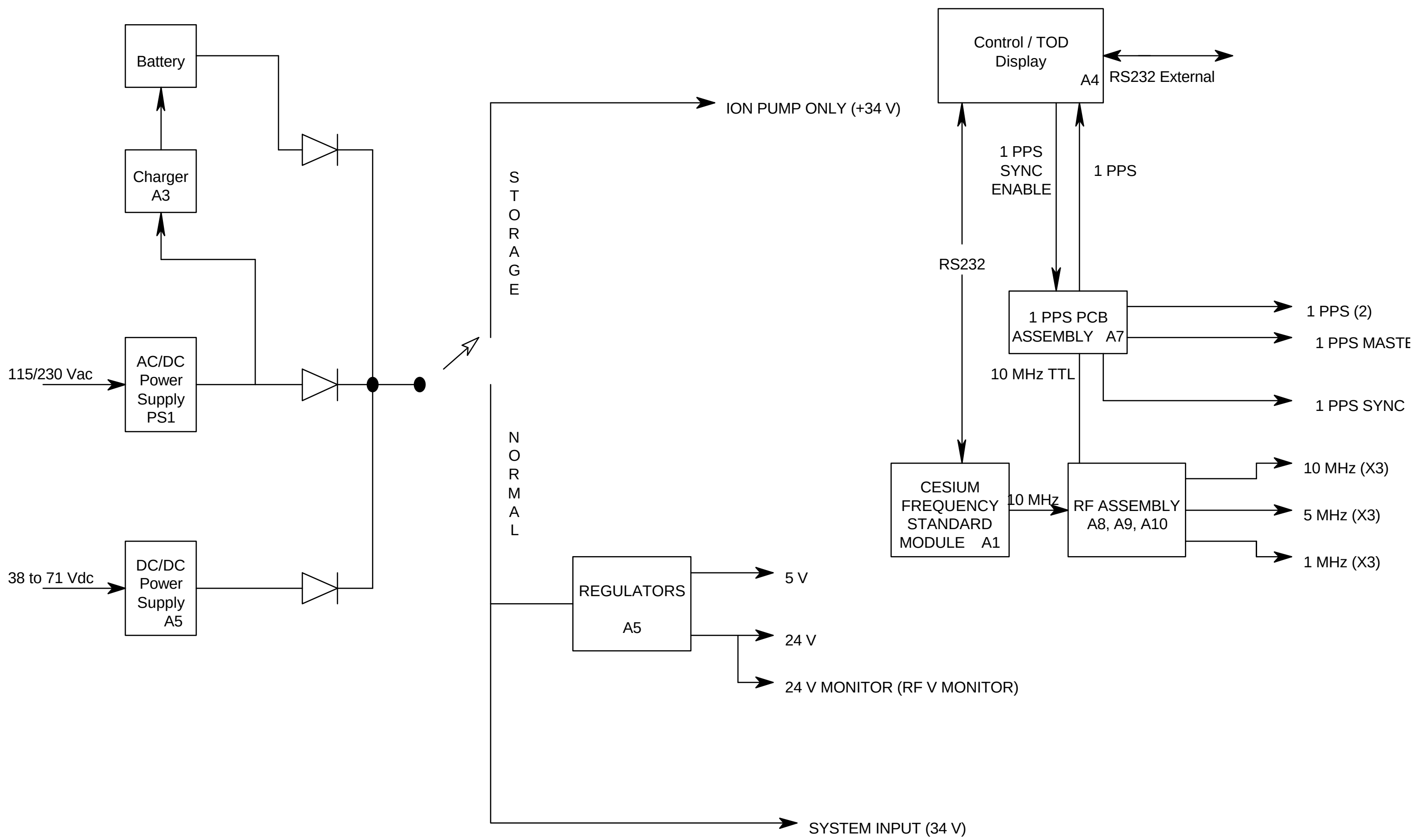


FIGURE 3.1 FTS 4065C BLOCK DIAGRAM

TABLE 1

CESIUM FREQUENCY & TIME STANDARD (4065C) ASSEMBLY BREAKDOWN

REF DESIGNATOR	ASSEMBLY NAME	FTS P/N
A1	CESIUM MODULE	08499-5XX
A3	CHARGER	08577-501
A4	CONTROL PANEL, LEFT	08527-501
A5	LOW VOLTAGE POWER SUPPLY	08476-501
A6	MONITOR PANEL, RIGHT	08529-501
A6A1	THUMBWHEEL INTERFACE	05042-502
A7	1 PPS BOARD	08451-501
A8	HIGH ISO BUFFER, (10 MHZ)	08486-501
A9	HIGH ISO BUFFER, (5 MHZ)	08486-502
A10	HIGH ISO BUFFER, (1 MHZ)	08486-503
PS1	POWER SUPPLY (ABBOTT)	Z34BX1-3

The output voltage of the AC/DC power supply is 34 V. The output voltage of the DC/DC power supply is 31 V and the normal range of the battery is 21.7 to 29.5. This set of voltages when combined through steering diodes provides a natural hierarchy for selection of power source, namely:

1) AC is the primary source
2) DC is the secondary source
3) internal battery is the last and standby source

The output of the steering diodes forms the system power source. This source is switched by a master power switch to control the two power modes of the instrument.

1) Normal operation
2) Standby operation: This is Ion Pump Only mode: where all circuits are depowered except for the ion pump of the Cesium Beam Tube.

The system voltage is regulated to produce 5 V, 24 V. These, together with the system voltage and the ion pump voltage, form the power input complement of the instrument.

The 24 V is the filtered supply to the RF buffers. This voltage is monitored by the front panel controller. If this voltage is not in the range of 22 V to 26 V, then a MAJOR ALARM is reported by the controller.

3.2.1 Battery And Automatic Charger

The Battery and Automatic Charger consists of a 24 V battery, which will provide a minimum of 1 h of instrument operation in the event of ac power loss. The option also includes battery-charging and control circuits.

The internal battery is a 12-cell, sealed, lead-acid battery with a rated capacity of 5 Ah. The battery is conservatively rated for 1 h of operation at 25 ^{o}C; the normal current drain of the FTS 4065C is approximately 2.5 A at 24 V.

The battery-charger input power is the 34 Vdc output from the AC/DC power supply.

The battery charger is comprised of a printed-circuit board and a current regulator mounted in the FTS 4065C. The charger normally supplies a trickle-charging current of about 10 mA to the battery pack. Periodically, at about 25 to 35 second intervals, the charger tests the state of the batteries by briefly increasing the charging voltage. If the battery is nearly fully charged, only a very short pulse of battery current will result and the charger level will return to trickle.

If the battery is discharged, the increase in battery voltage will cause a large increase in the charging current and the charger will lock in to the fast-charge mode. The fast-charge cycle begins a constant current charging rate of about 500 mA. After approximately 3 to 4 hours, the battery charger will switch to a constant voltage mode for an additional 5 to 7 hours and then automatically revert to a trickle charge to top off the battery. The full charge cycle is completed in 12 to 16 hours. Refer to Figure 3.2.1.

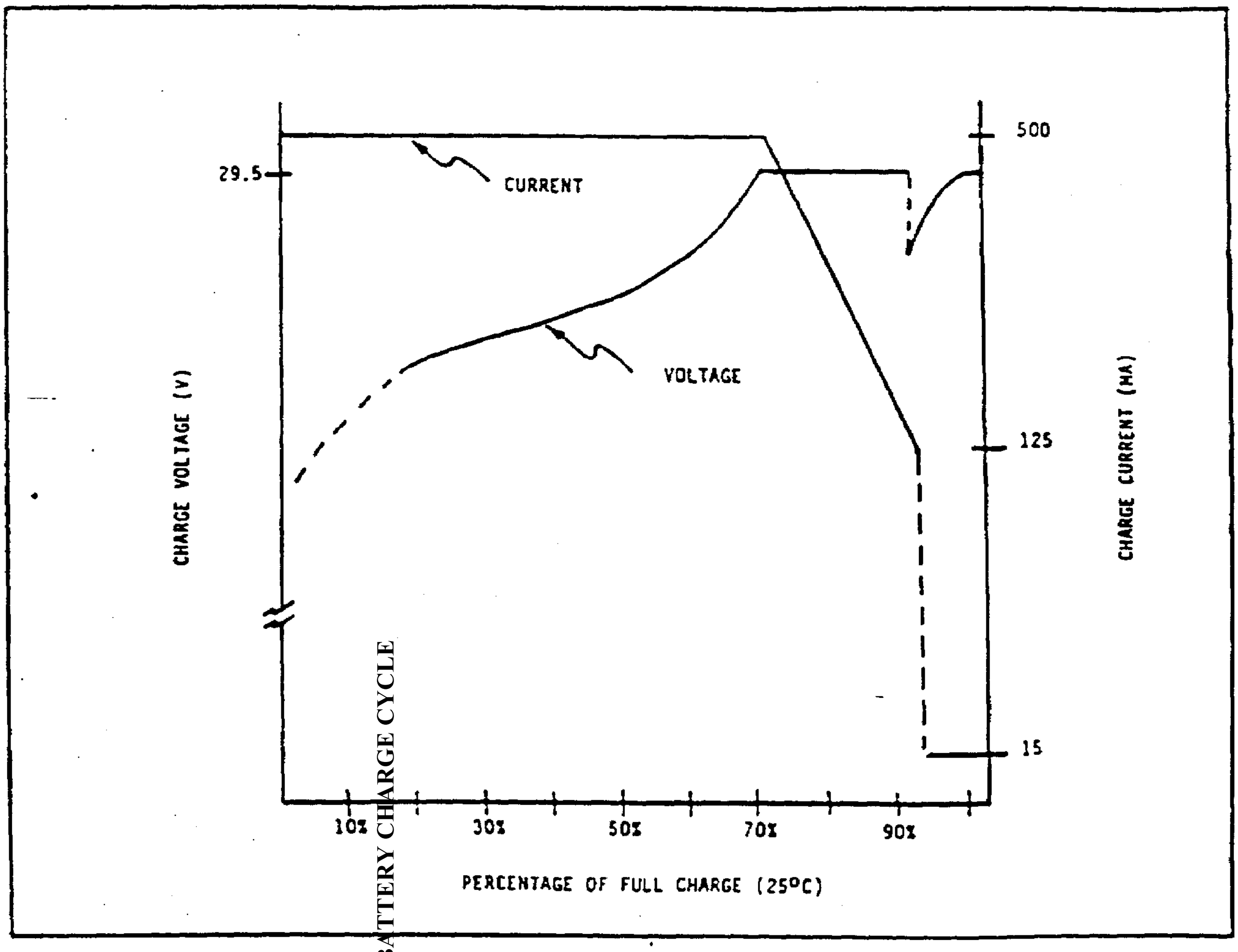


FIGURE 3.2.1 BATTERY CHARGE CYCLE

3.3 FREQUENCY DISTRIBUTION AND TIME GENERATION

3.3.1 Buffered RF Outputs

All RF user outputs are derived from the 10 MHZ output signal of the CFM. Refer to Figure 3.3.1 for an illustration of the FTS 4160 signal distribution.

The Frequency Distribution circuitry consists of:

- A 10 MHZ Analog Buffer Assembly where the 10 MHZ input signal is buffered to produce three 10 MHZ outputs and 1 TTL output.
- A 5 MHZ Analog Buffer Assembly where the 10 MHZ input signal is divided by two, filtered and split to produce three 5 MHZ outputs.
- A 1 MHZ Analog Buffer Assembly where the 10 MHZ input signal is divided by 10, filtered and split to produce three 1 MHZ outputs.
- Each of the outputs of each assembly has an amplitude detector circuit connected at the output node. If the amplitude is low, a fault signal is generated and a MAJOR FAULT will be indicated by the front panel controller.

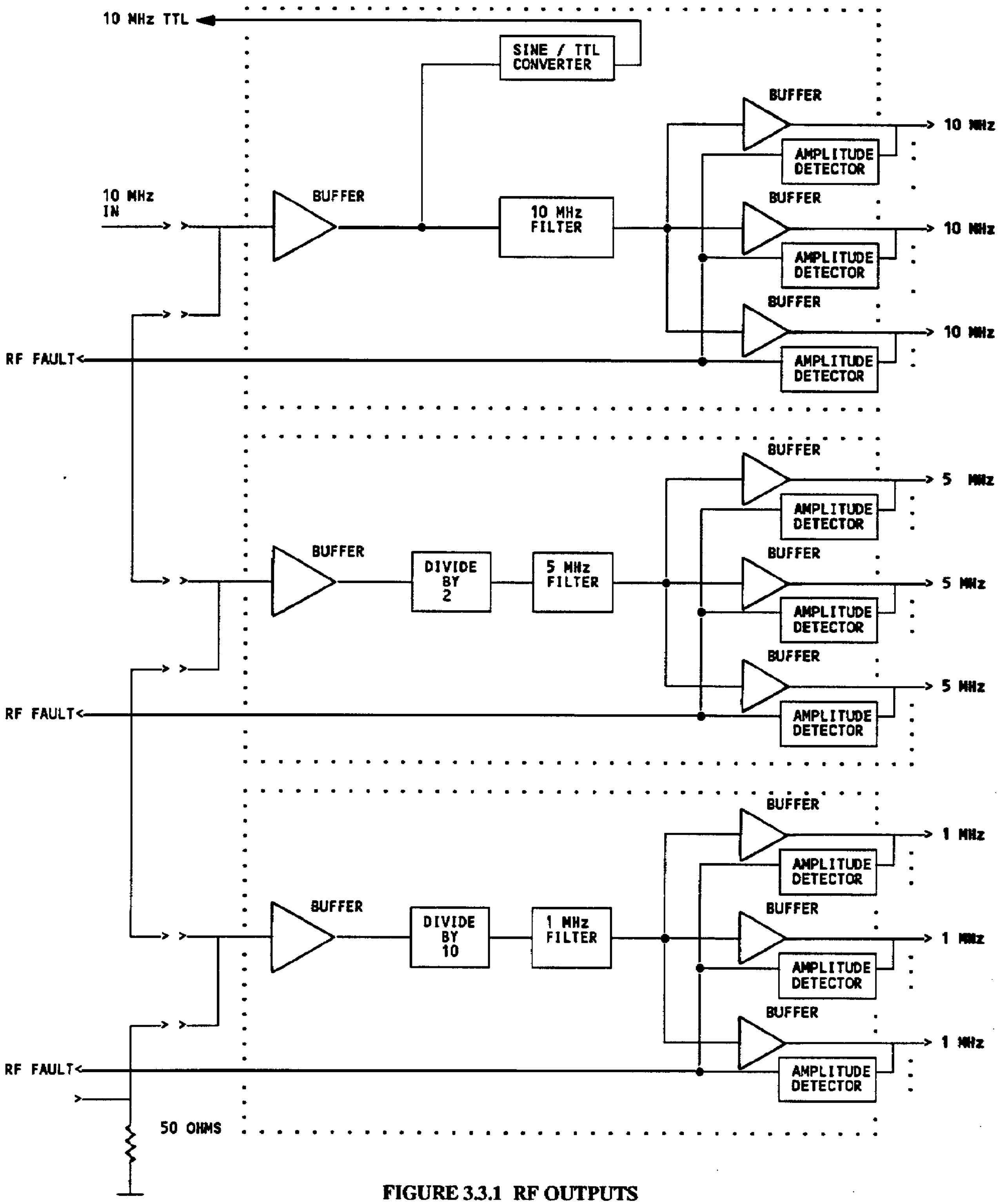


FIGURE 3.3.1 RF OUTPUTS

3.3.2 1 PPS, TOD Display and 1 PPS Advance/Delay

The 10 MHZ TTL signal from the RF Buffer also drives a divide-by-10^7 counter to produce a 1 pps, 20 us timing pulse. See Figure 3.3.2. The pulse is split and buffered to produce two TTL-level peak output signals.

An external reference pulse may be used to synchronize the 1 pps output signal to within ±150 ns of the reference pulse. The reference pulse clears the counters on the rising edge of the first reference pulse and releases the counters on the rising edge of the second reference pulse.

The master 1 pps signal drives the front panel time-of-day (TOD) display. The clock format is day of year:hours (24 hour format): minutes:seconds.

The 1 pps master signal is also fed to the advance/delay circuitry which, clocked at 10 MHZ, advances or delays (depending upon the toggle switch position) the pulse in another cascaded counter, by the number selected in the front panel thumbwheel switches. For example, if a one millisecond delay is selected, the counters finish counting the 1 s interval 1 ms later than the master 1 pps signal. If a 1 ms advance is selected, the counters finish counting the 1 s interval 1 ms before the master 1 pps signal. The advanceable/delayable 1 pps signal is buffered and routed to the front and rear panels. Each of the buffered outputs has a pulse detector circuit connected directly at the output. If the pulse is missing due to circuit failure or by a short, a fault is generated. This fault is reported by the front panel controller as a MAJOR FAULT.

The 1 pps signal also drives the front panel time-of-day (TOD) display. See Section 2, para. 2.6.1.2 for time setting information.

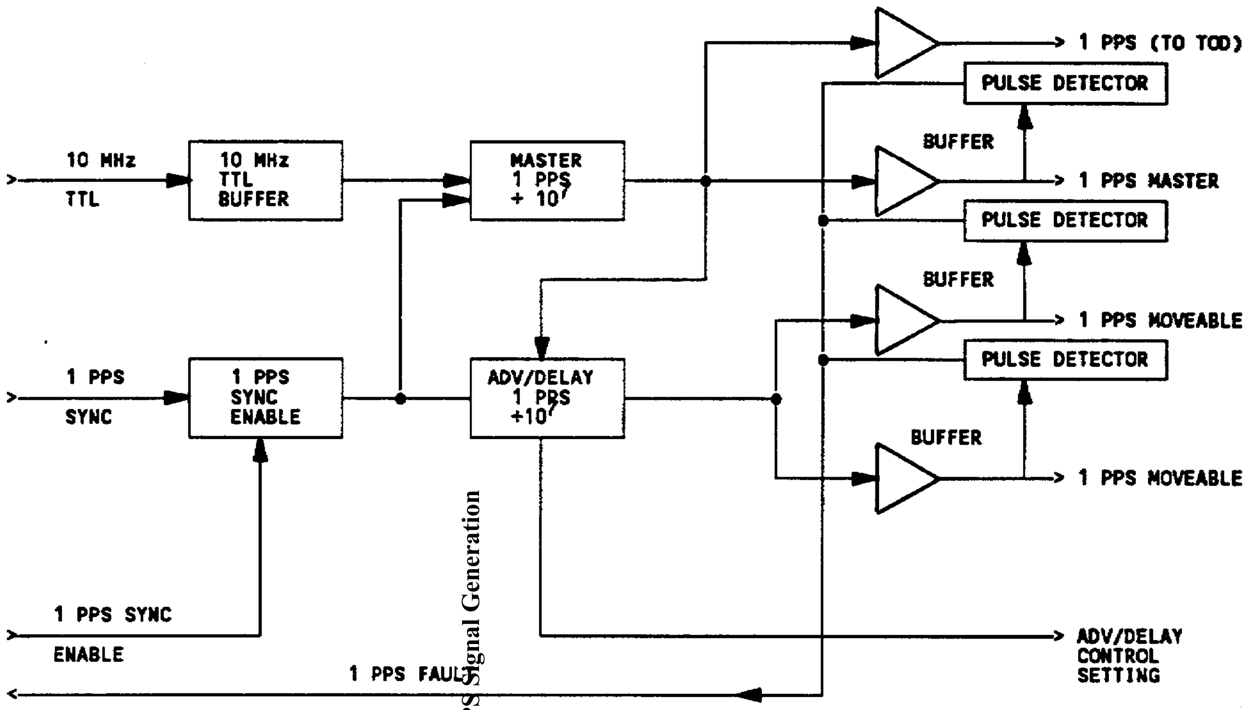


Figure 3.3.2 1 PPS Signal Generation

3.4 FRONT PANEL SIGNALS, CONTROLS AND INDICATORS

The Front Panel consists of:

- A Monitor Panel, Assembly, A7
- A Control Panel Assembly, A6

The Monitor Panel contains 3 BNC connectors; one for a movable 1 pps outputs, for a 1 pps SYNC input, and one for the programmable TTL RF output.

The Monitor Panel also contains the Advance/Delay switch and control setting for the 1 PPS circuitry.

The Control Panel Assembly consists of:

- 16 key keyboard
- alphanumeric/graphic vacuum florescent
- 3-alarm LED indicators showing:
- LOCK
- MAJOR
- MINOR

See Section 2, para. 2.3, for keyboard and display operational information.

3.5 CESIUM FREQUENCY MODULE (CFM)

3.5.1 Introduction

For years, cesium frequency sources have been constantly improved so as to satisfy the increasingly stringent specifications of time and frequency reference equipment. The availability of easy-to-operate instruments of reduced size and weight and of exceptional accuracy and stability provides the user with great flexibility in the application of cesium standards meeting the stringent requirements of navigation, communication and timing systems.

The cesium frequency module is an atomic frequency standard based on a hyperfine transition in the ground state of the cesium 133 atom. The frequency of this transition defines the international time unit : the second.

3.5.2 Principle Of Operation

The CFM consists of (Figure 3.5.1).

- A quartz oscillator whose frequency is locked to the hyperfine transition frequency (clock transition) of the cesium atom.

- A cesium atomic beam resonator (cesium tube).

- Control circuits, driven by the quartz oscillator frequency, delivering an interrogation signal. This signal is fed to the atomic resonator. The response of the resonator is a signal whose amplitude is maximum when the interrogation signal frequency is equal to the clock transition frequency.

- Servo loop circuits, fed by the tube output signal, which control the quartz oscillator frequency so that the interrogation frequency is locked to the clock transition.

- Power supplies.

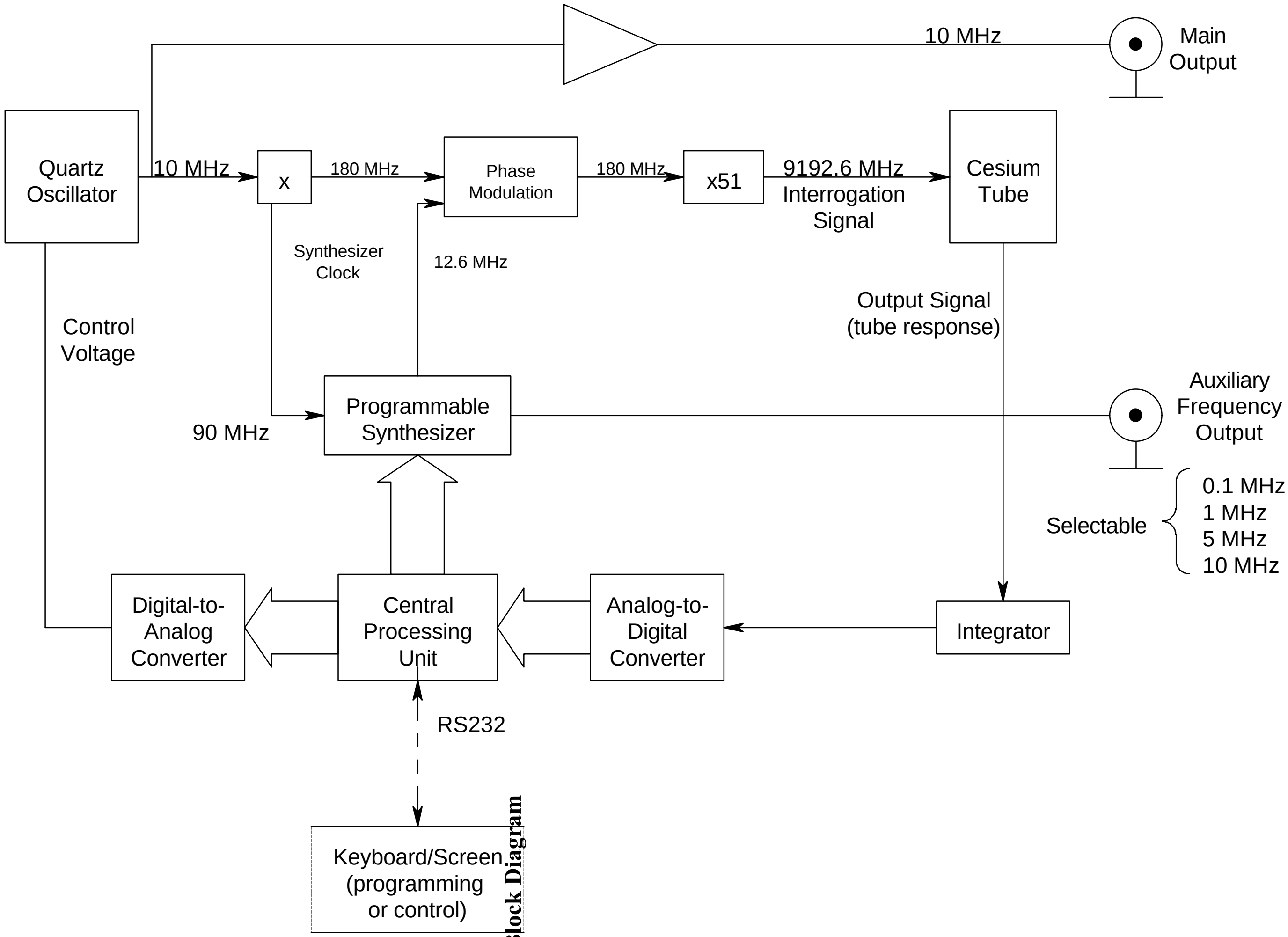


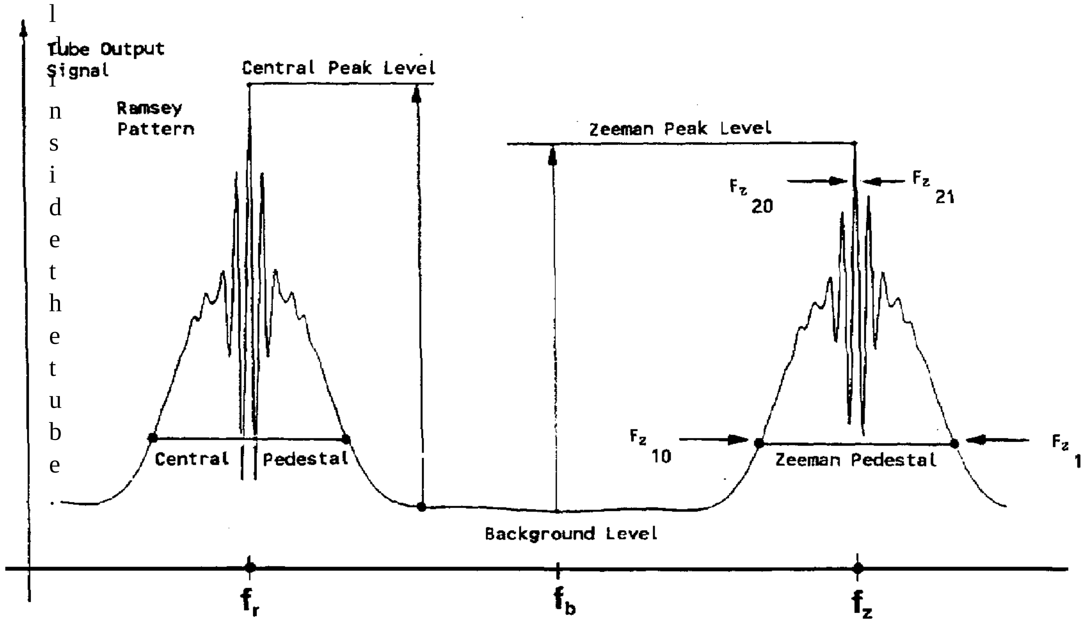
Figure 3.5.1 Block Diagram

3.5.2 Principle Of Operation (cont'd)

A cesium tube can be thought of as a quadrupole: when the frequency of the input signal scans the atomic transition, the output signal is a microcurrent of variable amplitude; the tube acts as a very narrow band-pass filter coupled to an amplitude detector.

When the frequency f of the microwave interrogation signal scans the clock frequency, the output signal of the cesium tube has the schematic behavior shown in Figure 3.5.2. A large resonance, called pedestal or Rabi resonance, is topped by interference fringes or Ramsey fringes (Ramsey pattern). The central fringe, or central line, provides the reference to which the interrogation signal frequency and, consequently, the quartz oscillator frequency are locked.

Moreover, the microwave spectrum displays six other resonances of similar structure, symmetrically disposed and regularly spaced about the central resonance; one of these is shown in Figure 3.5.2. The central frequency of this resonance pattern (Zeeman line) is linearly dependent on the magnetic field inside the cesium tube: by measuring this frequency it is possible to know and to stabilize the magnetic field inside the tube.



A programmable frequency synthesizer, controlled by a microprocessor and with a short response time, is used to periodically probe several characteristic points of the tube response. This probing is based on two principles:

• 1st PRINCIPLE:

When two frequencies symmetrically disposed about fr (central line) are alternately programmed, the tube output current switches between two levels; their difference is related to the offset of the quartz oscillator frequency from the resonant frequency.

Digitized, this difference is processed by the microprocessor and then fed back to the quartz oscillator.

• 2nd PRINCIPLE:

As the servo loop time constant is much longer than the measuring cycle time, it is possible to periodically "steal" one measuring cycle which is then used to program other frequencies in order to check the different useful characteristic points of the tube response.

Thus, by using this flexible frequency synthesizing technique and the many possibilities offered by a microprocessor driven system, the time frequency standard performs, permanently and in real time operation, the following functions:

- Check of the central line centering through symmetrical testing of the pedestal.
- Measurement of the central line peak value relative to background.

3.5.3 Description And Operation

3.5.3.1 Atomic Resonator

The standard cesium tube operates like a passive resonator. The resonator output signal displays very narrow resonances (Q = 2E7) when the interrogation signal microwave frequency is close to one of the transition frequencies of the cesium atom.

3.5.3.1.1 Characteristic Transitions

Fig 3.5.3.1.1a shows the 16 possible energy levels of the ground state of the cesium atom versus the magnetic field; they are specified by the quantum numbers F,m (F=3 or 4, m=-F -F+1, ..., F-1, F). A microwave magnetic field can induce atomic transitions from one state (3,m) to another (4,m') on the following conditions:

1) The microwave frequency is equal to E/h, where E = the energy difference between the two levels

   h = 6.6 E-34 Js (Planck's constant)

2) m = m' if the microwave magnetic field and the static magnetic field (called C-field) are parallel.

When the static magnetic field is weak (B <1E-5 [T]), the corresponding transition frequencies are equidistant and result in the microwave spectrum (tube response) of Figure 3.5.2.

The resonance frequency changes with the magnetic field according to the following relations:

a) if m = 0, the change is quadratic:

$f_0\ (B) = f_{00} + 427.45 \times 10^8\ B^2$ [Hz]

where f_{00} = 9,192,631,770 Hz (by definition of the SI second), and B is given in Tesla.

This (3;0 - 4;0) transition is largely insensitive to magnetic field variations and thus is used as a frequency reference in cesium standards. The (3;0-4;0) transition is the "clock transition" and the corresponding frequency is the "clock frequency".

b) if m P 0, the resonance frequency change with the magnetic field is linear:

$f_m(B) = f_{00} + m\ 7.0084 \times 10^9\ B$ [Hz]

where B is given in Tesla and m = -3; -2; -1; +1; +2; +3.

The linear variation of these 6 transition frequencies is due to the Zeeman effect.

f1, called the Zeeman frequency is especially interesting since it can be used to measure and, if necessary, to servo lock the magnetic field to a preset constant value.

In a strong magnetic field (B > 1 [T], Figure 3.5.3.1.2a) the energies of the 3;m and 4;-4) states decrease with the magnetic field B, whereas they increase for the other (4;m) states. This feature is used for state selection, or selective deviation of atoms in a strong and inhomogeneous magnetic field.

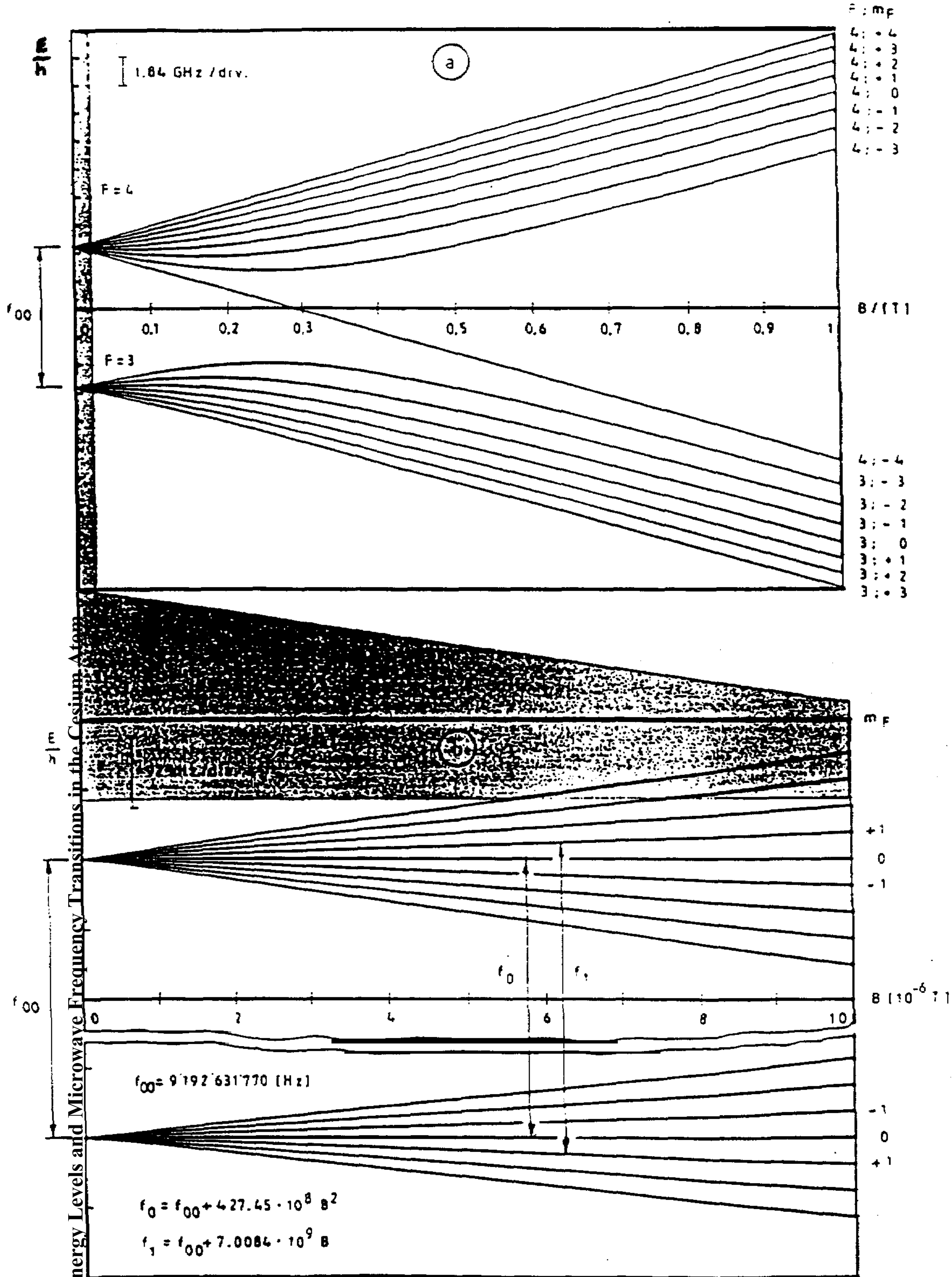


Figure 3.5.3.1.1a Energy Levels and Microwave Frequency Transitions in the Cesium Atom

3.5.3.1.2 Resonator Description and Operation

The resonator is set in a metallic vacuum vessel, thoroughly leakproof and in which a ion pump maintains a very high vacuum (Figure 3.5.3.1.1B). The cesium is placed in a small oven; the heated atoms evaporate through an opening appropriately shaped to produce an atomic beam parallel to the tube length. When they leave the oven, the atoms are equally distributed in each of the 16 energy levels; they then undergo a selective deflection by the strong inhomogeneous magnetic field inside the A magnet gap (first state selector). Atoms in the (3;m) and (4;-4) states, with lower energy in strong magnetic field, are deflected towards strong field regions whereas the other atoms move in the other direction.

The (3;m) and (4;-4) atoms selected by the A magnet enter, through two successive magnetic shields, a region of weak and very homogeneous magnetic field (C-field; B = 6 µT). The u-shaped microwave cavity (Ramsey cavity) is placed in this region in such a way as to twice intercept the atomic beam path; when the atomic beam enters the cavity, the atoms are subjected to a microwave field at frequency f_0 which induces transition from (F=3;m=0) to (4;0) state and are then deflected by the second state selector (B magnet) towards the detector.

The detector is a metal filament electrically heated at high temperature; the impinging atoms are re-emitted as ions that are then accelerated by an electric field and deflected by a mass spectrometer towards the first dynode of an electron multiplier. The electron multiplier output is a current proportional to the atomic flux on the detector; this current is the output signal of the cesium tube.

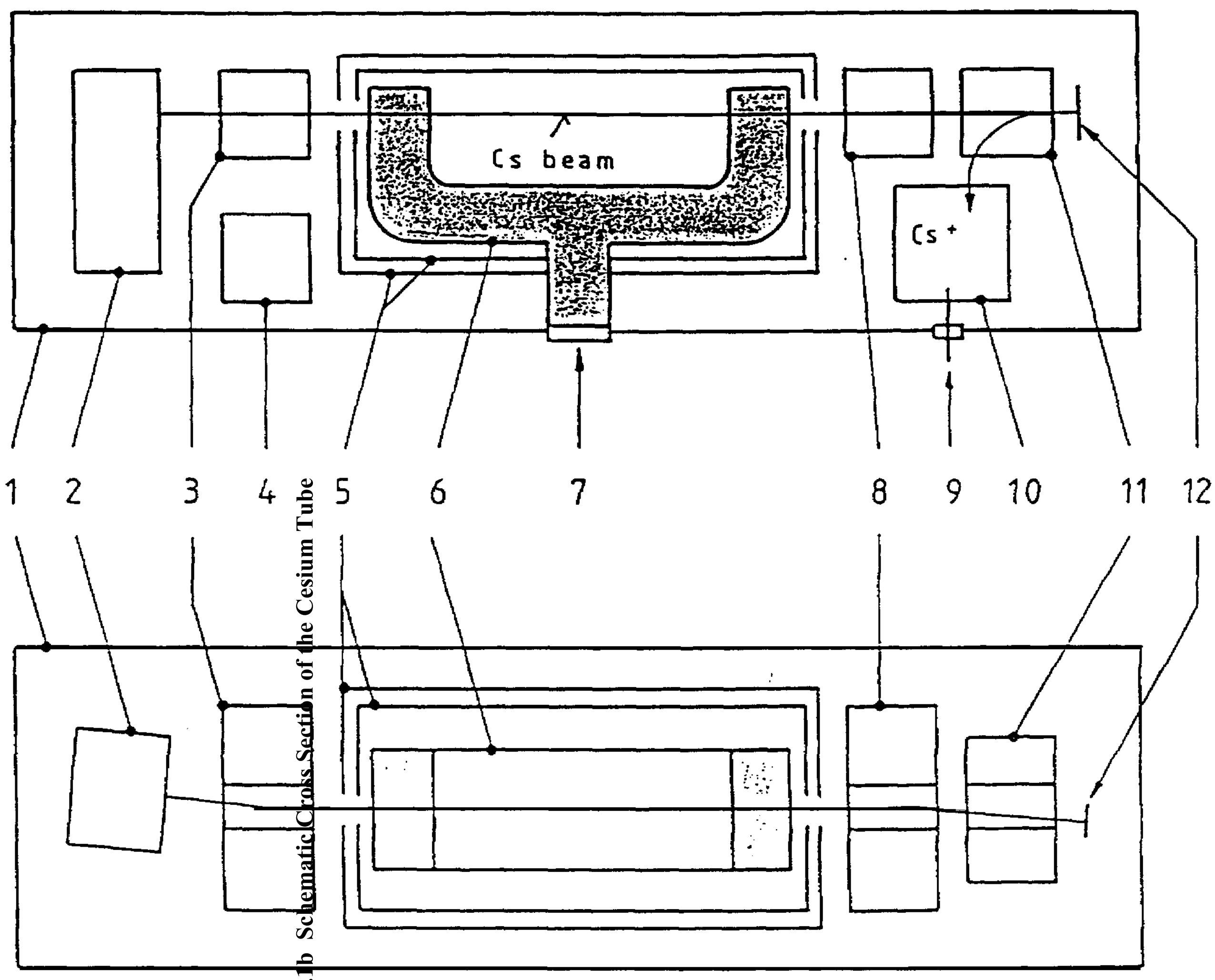


Figure 3.5.3.1.1b Schematic Cross Section of the Cesium Tube

1. Vacuum envelope
2. Cesium source
3. A magnet
4. Ion Pump
5. Magnetic shields
6. Microwave cavity (Ramsey cavity)
7. Microwave interrogation signal input
8. B magnet
9. Error signal output
10. Electron multiplier
11. Mass filter
12. Ionizer filament

3.5.4 Control Circuits Description

The control circuit's main function is to generate, starting from the quartz oscillator, an interrogation signal fr with a frequency close to the hyperfine transition frequency (f_0) of cesium.

These circuits also supply:

- Signals with fixed frequencies between 100 kHz and 10 MHZ (auxiliary output signal).
- An interrupt signal IT (of 17.92 ms period) for the microprocessor.
- 90 MHZ signal; derived by the 9 times multiplication of the oscillator frequency (10 MHZ).
- A 12.631....MHZ signal, synthesized by direct digital (sine lookup method) techniques. This signal is added to 9180 MHZ (10 MHZ multiplied by 9 and 102) to generate the interrogation signal at the hyperfine Cesium frequency of 9192.631....MHZ. The frequency of the synthesizer is controlled by the microprocessor and programmed to a set of frequencies which scan various points of the beam tube response.

3.6 SERVO LOOP DESCRIPTION (see Figure 3.6)

3.6.1 Amplifier - Integrator

The tube output signal is fed to a preamplifier and a programmable gain amplifier then to an integrator.

The integrator has a DC level compensation circuit controlled by a voltage delivered by the D/A converter.

The amplification is ten times higher during servo clock control periods than during test periods.

The integrator temporarily latches the output voltage while it is digitized before starting on the next acquisition cycle.

3.6.2 Analog-to-Digital Converter

The output voltage from the integrator is converted by the A/D Converter to a binary number which is read then processed by the microprocessor to determine the correction to be applied to the quartz oscillator.

The A/D converter also digitizes other voltages, which are delivered by the multiplexer.

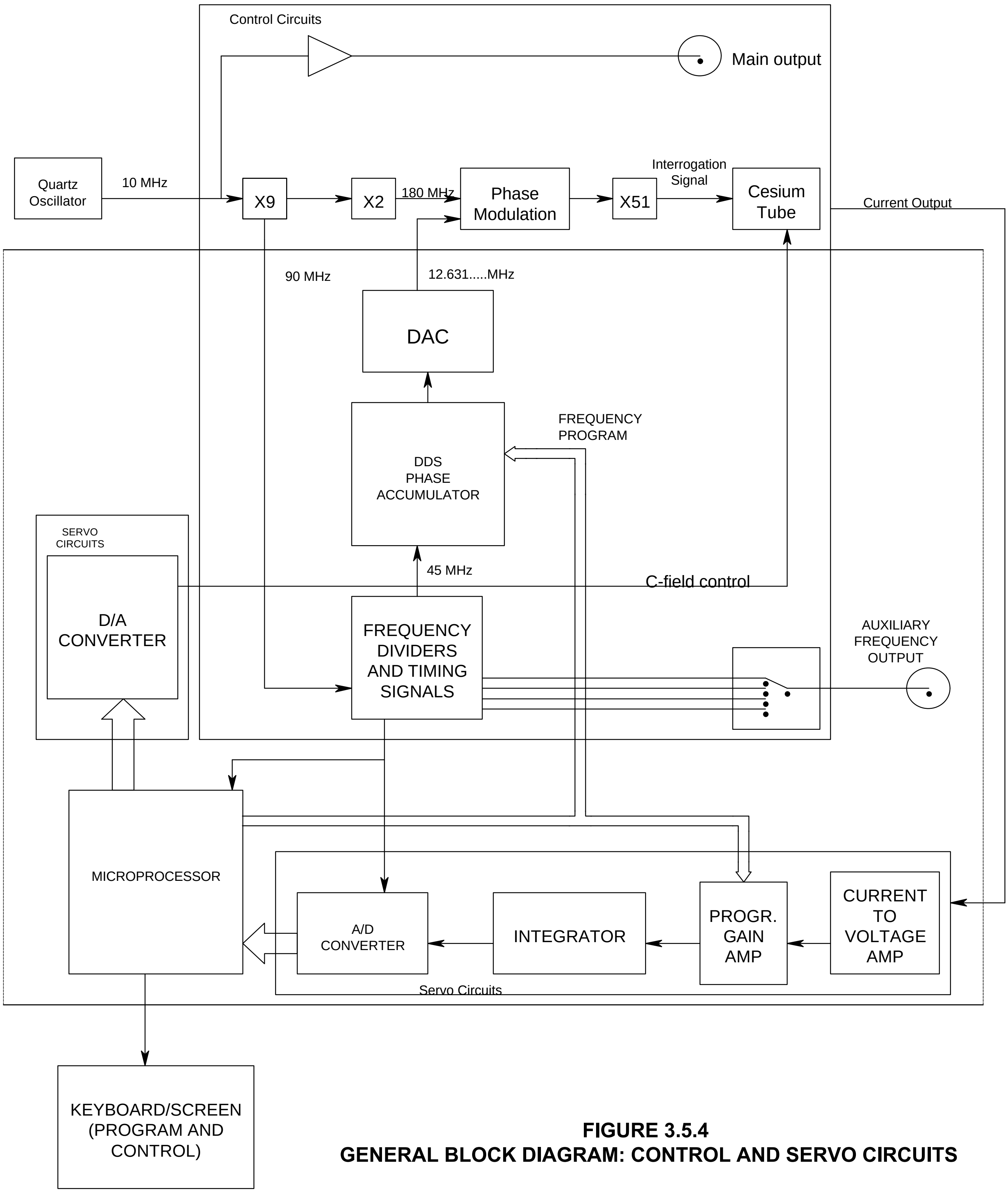


FIGURE 3.5.4
GENERAL BLOCK DIAGRAM: CONTROL AND SERVO CIRCUITS

rfflow\cont_srv.flo

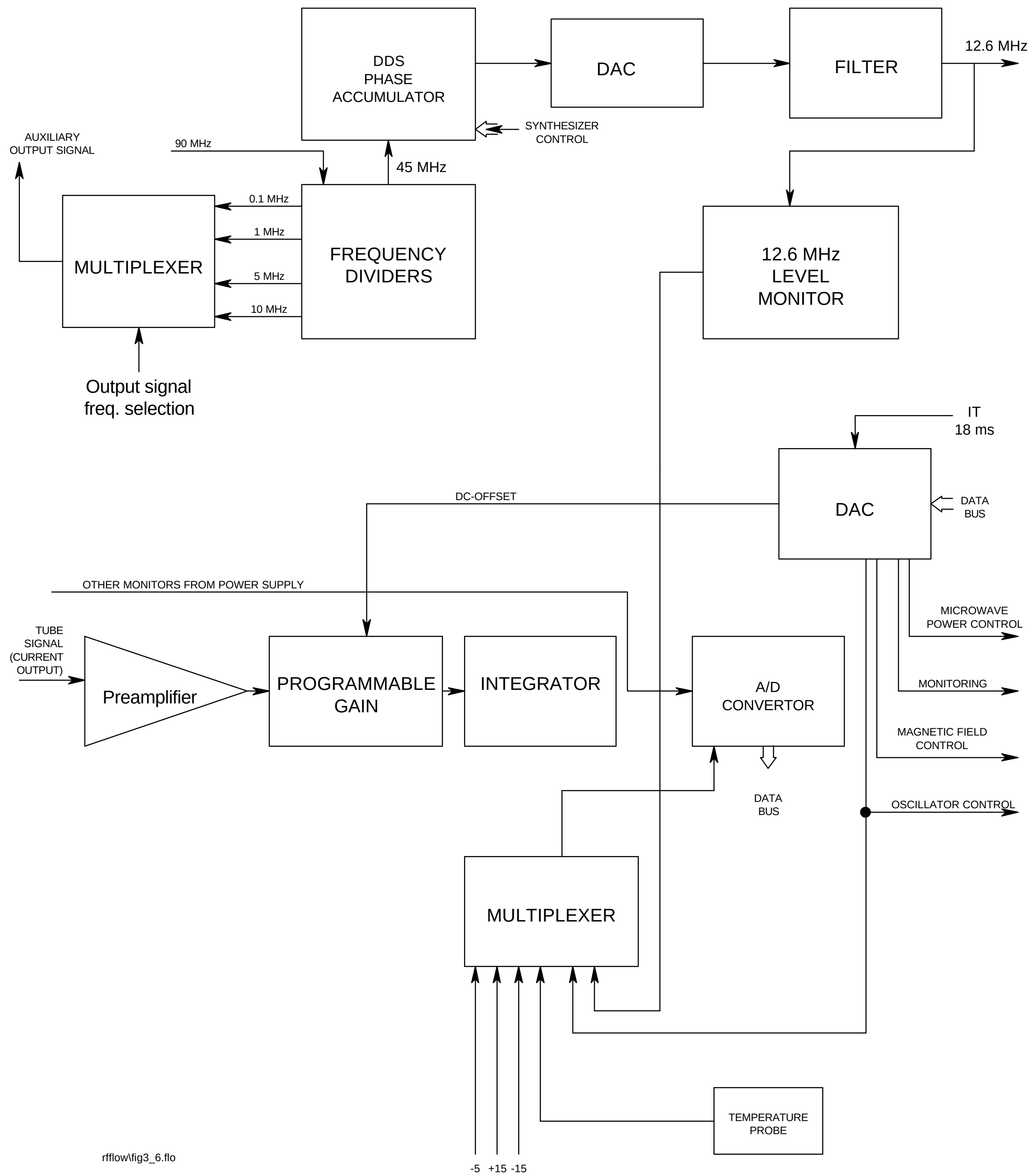


FIGURE 3.6
BLOCK DIAGRAM: SERVO AND CONTROLS (ANALOG CIRCUITS)

3.6.3 Quartz Oscillator Frequency Control

The quartz oscillator frequency is controlled by means of the output voltage from the servo loop (1st order or 2nd order loop, the latter allowing the use of large time constants without introducing phase error due to medium term instability of the oscillator).

The 16 bit value of the control voltage is supplied by the microprocessor to a high resolution D/A converter. The minimum resolution on the control voltage from this DAC circuit is 0.2 µV, which allows correction of the oscillator frequency in 3e-14 steps.

3.6.4 Microprocessor

The microprocessor uses a 68B09 microprocessor.

The interrupt signals NMI, IRQ and SWI are used. The 1.2288 MHZ microprocessor clock is driven by a 4.9152 MHZ quartz, as is also a 2.4576 MHZ clock used by the baud rate generator.

The power reset circuit supplies a 10 ms RESTART pulse at turn-on.

The memory is composed of:

- A 36 kbytes of program memory.
- A 2 kbytes of static RAM.
- A 2 kbytes of EEPROM memory. Writing in this memory is protected while in the RESTART phase and afterward by a software lock.

The memory space allocation is shown in Figure 3.6.4.

An RS232C serial link is provided.

The transmission speed can be auto-adjusted to that of the connected peripheral or temporarily fixed.

A WATCH DOG system, controls the correct program operation. The WATCH DOG circuit automatically supplies a RESTART pulse if it is not re-initialized at least every 10 seconds. In order to detect the software problems with a 100% probability, two initializing pulses are simultaneously sent to the WATCHDOG circuit; the circuit then checks that these two pulses are indeed simultaneous: in fact, the first one opens a gate allowing the validation of the second one.

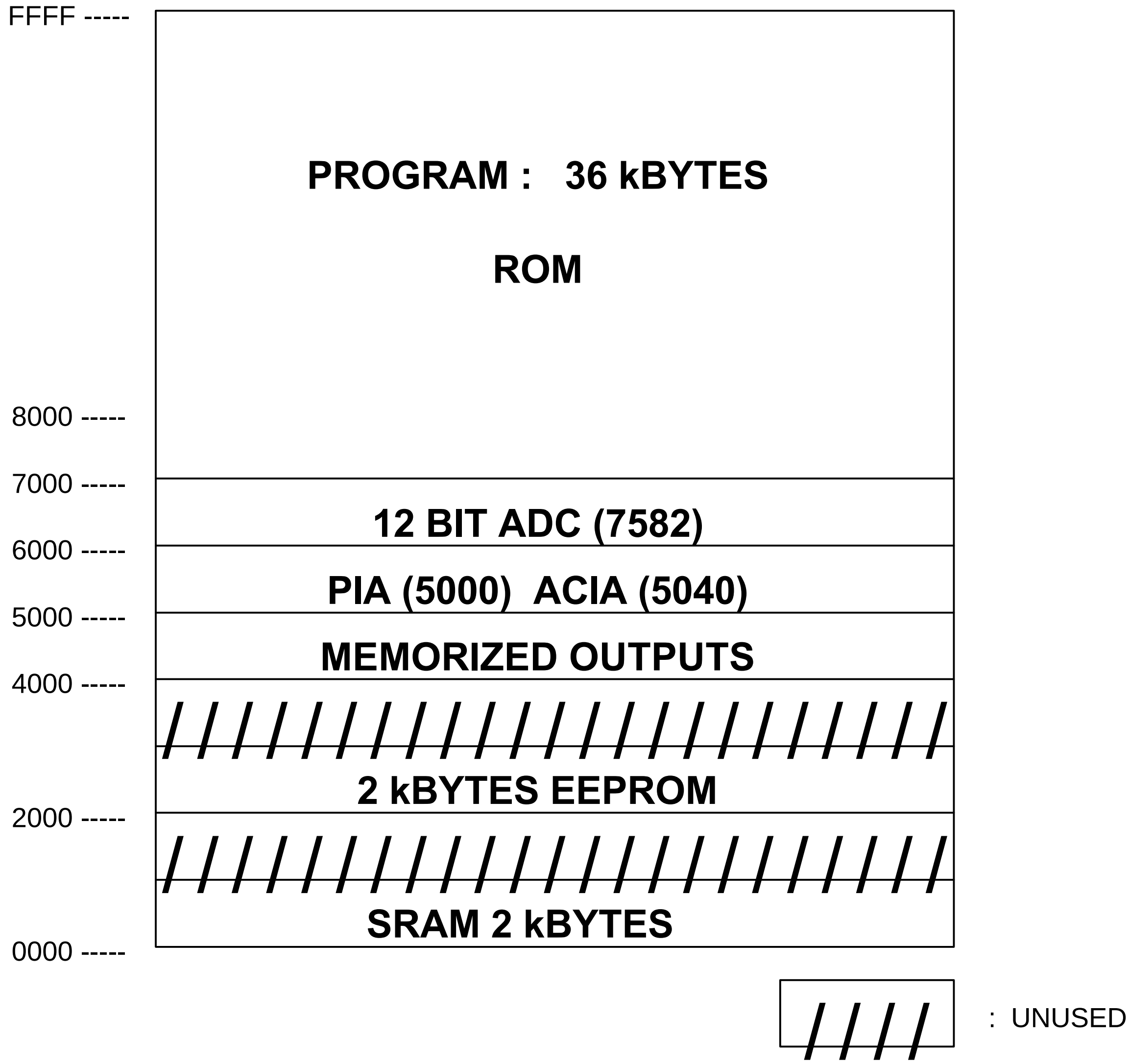


FIGURE 3.6.4
MEMORY SPACE ALLOCATION

3.7 CONTROL AND SERVO CIRCUITS OPERATION

3.7.1 Measurement Sequences

The clock operation (Figures 3.7.1a and 3.7.1b) is divided into elementary periods of 17.92 ms by the IT interrupt signal coming from the frequency synthesizer.

At the beginning of each elementary period, the interrogation frequency changes and so does the tube output signal. After a 2 ms dead time (to eliminate transients), the signal is averaged over 16 ms by analog integration; it is then latched and processed by the microprocessor depending on the interrogation frequency (servo loop, test, etc).

The clock operation is composed of a start-up phase (para. 3.7.2) followed by the normal operation phase (para. 3.7.3). During the normal operation phase, the clock frequency servo is periodically interrupted for elementary periods of testing described later (para. 3.7.4).

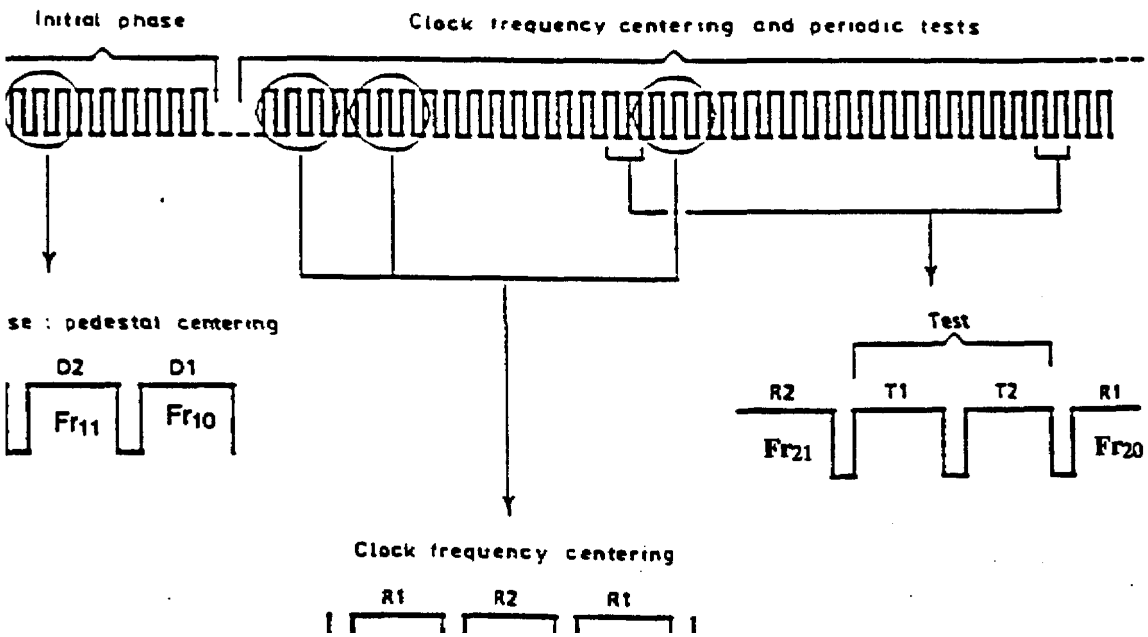


FIGURE 3.7.1A RESONATOR INTERROGATION SEQUENCES

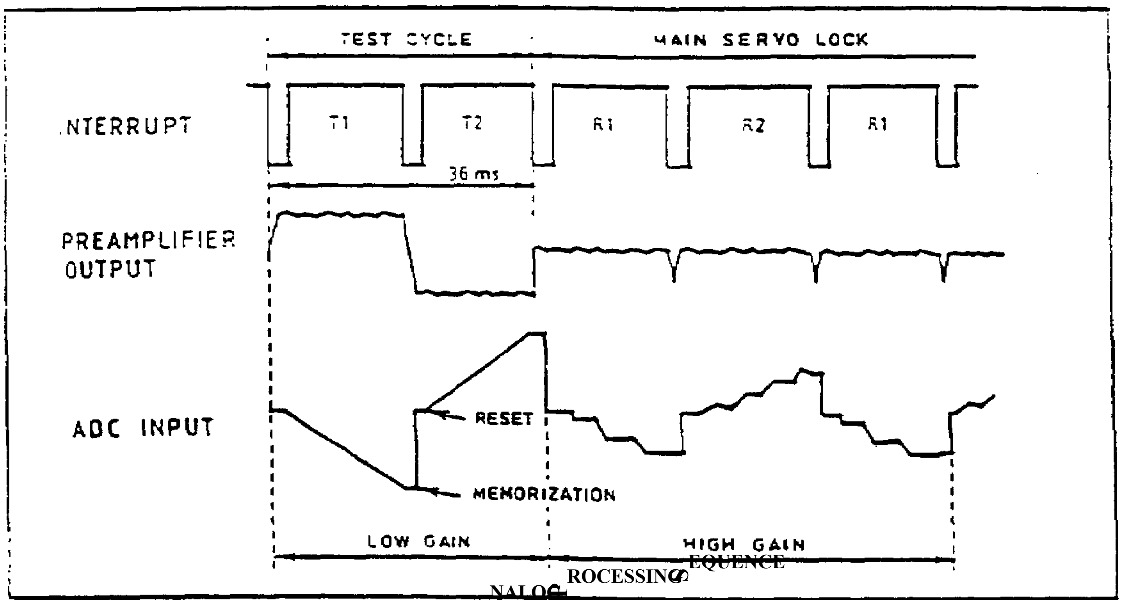


Figure 3.7.1b Analog Processing Sequence

3.7.2 Start-Up Phase (see Figure 3.7.2)

While in the start-up phase, the servo loop control centers the quartz oscillator frequency on the clock resonance pedestal.

To that end, the control circuits apply to the tube input, periodically, for successive periods of 17.92 ms (D1 and D2 in Figure 3.7.1a), two signals of frequencies fr_{10} and fr_{11} equal to fr ± 5 kHz. These frequencies fr_{10} and fr_{11} are symmetrical about fr, the clock central peak frequency.

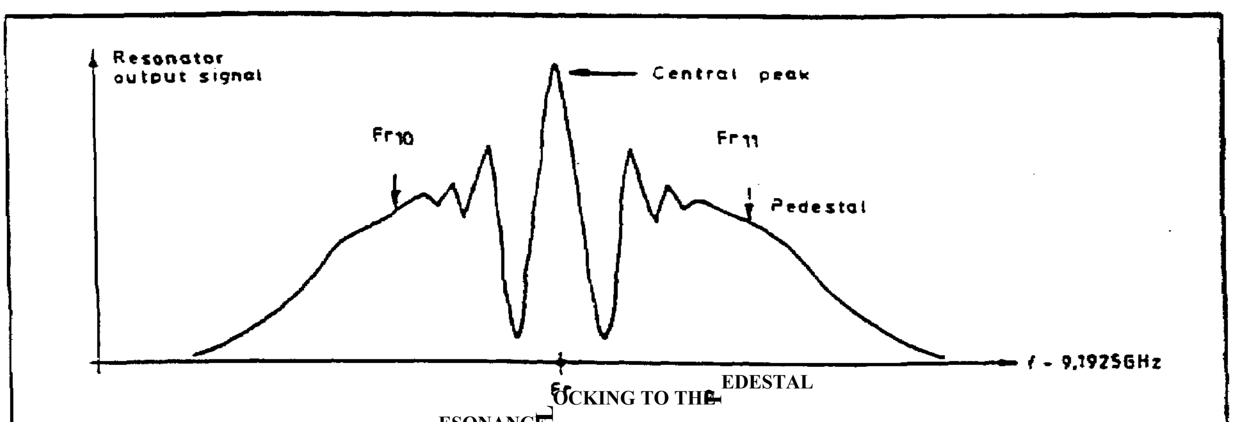


Figure 3.7.2 Clock Resonance Locking to the Pedestal

The control circuits supply fr_{10} and fr_{11} by alternately programming, the frequency synthesizer output. As the pedestal wings are symmetrical about the central line, the signal levels associated with fr_{10} and fr_{11} are equal when their mean frequency is centered on the pedestal. Any difference between these levels induces a correction of the oscillator frequency. The start-up phase, resulting in the centering of fr_{10} and fr_{11} on the pedestal, goes on until the centering error is smaller than approximately 500 Hz.

3.7.3 Central Peak Frequency Lock (Figures 3.7.3a & 3.7.3b)

The quartz oscillator frequency is locked to the clock resonance central peak frequency in the following way: the control circuits apply to the tube input two signals fr_{20} and fr_{21}, alternately and for successive periods of 17.92 ms (R1 and R2 in Figure 3.7.1b). The frequencies fr_{20} and fr_{21} are supplied by the control circuits by programming, the frequency synthesizer output. These frequencies are centered on the Ramsey central peak fo.

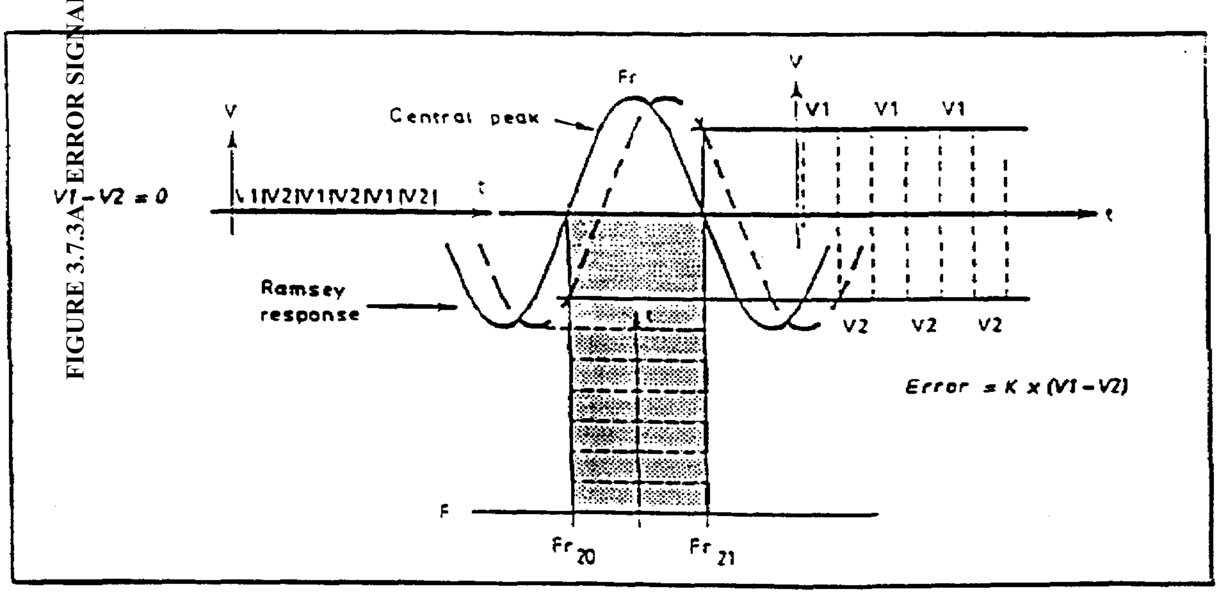


FIGURE 3.7.3A ERROR SIGNAL GENERATION

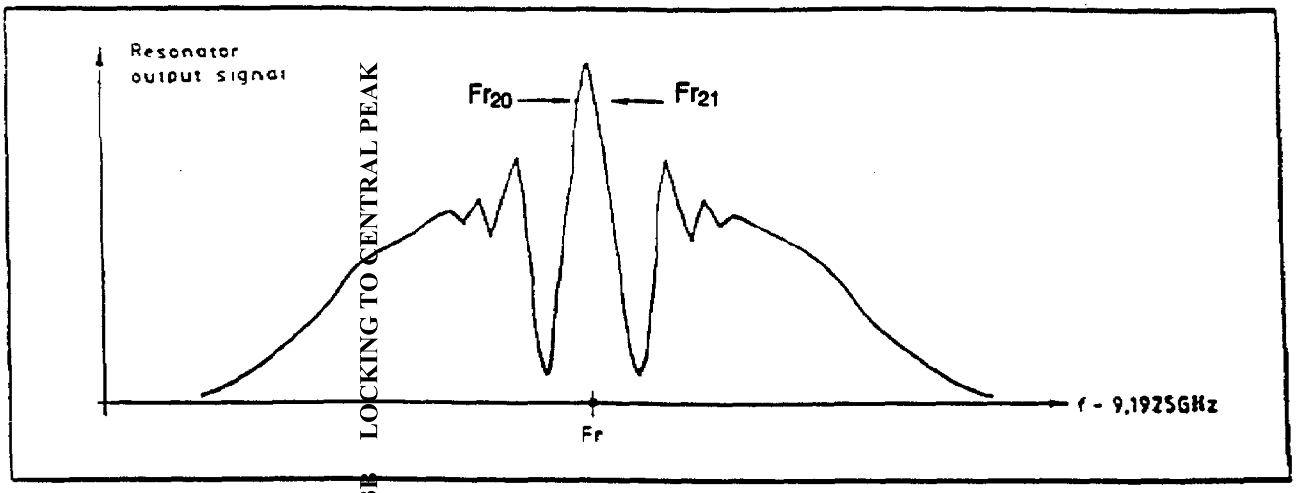


FIGURE 3.7.3B LOCKING TO CENTRAL PEAK

The central peak wings are symmetrical about the clock central peak fo, so if the frequencies fr_{20} and fr_{21} are not exactly symmetrical about fo, the tube output signal levels V1 and V2 (Figure 3.7.3a) differ by an amount V, proportional to the centering error:

f = ½(fr_{20} + fr_{21})-fo. This difference is then used to lock the oscillator so that f = 0.

The oscillator servo loop operates either as a first order loop with a time constant adjustable from 0.1 to 10 seconds or as a second order loop with a time constant from 0.5 to 100 seconds. This second order loop cancels the phase error due to a thermal or mechanical shock or to a gravity change, especially when long time constants are used.

3.7.4 Test Cycle

As previously mentioned, two successive 17.92 ms periods (T1, T2 in Figure 3.7.1b) are periodically "stolen" from the normal servo operation for testing purposes.

This test sequence occurs once in 36 periods, i.e. in 645.12 ms, and lasts two 17.92 ms periods (T1 and T2). The introduction of this test sequence is made possible by the large value of the oscillator loop time constant with respect to the length of two successive measuring cycles.

During these periods T1, T2, the microprocessor can alternately program 11 distinct frequencies in order to:

a) Servo control the difference between Zeeman and clock frequency (Zeeman frequency lock=C-field servo).

b) Monitor central peak-to-background value.

c) Monitor the Zeeman peak-to-background value.

d) Check the central peak symmetry.

e) Check the clock resonance pedestal symmetry.

f) Servo control the microwave power.

3.7.5 Zeeman Frequency Lock

Zeeman frequency lock is used to maintain the C-field value constant by regulating the current in the C-field coil so that the Zeeman-to-clock frequency difference is equal to a set value. It is thus possible to reduce the influence on the frequency of magnetic perturbation (variations in the shield magnetization due, for instance, to the ambient magnetic field or to temperature changes). This servo lock can be turned off at the user's will.

This Zeeman frequency lock is performed in a manner similar to the central peak lock, with a pedestal centering start-up phase followed by a Zeeman peak lock.

In the start-up phase resulting in pedestal centering (Figure 3.5.2) two test frequencies fz_{10} and fz_{11} equal to fz ± 7 kHz are applied to the tube input, alternately and for two successive periods T1 and T2. These frequencies fz_{10} and fz_{11} are delivered by the control circuits by programming the frequency synthesizer.

In the Zeeman peak frequency lock, two other frequencies, fz_{20} and fz_{21}, are applied to the tube input for two other successive periods T1 and T2. These frequencies are nearly centered on the Zeeman frequency fz and are approximately equal to fz ± 350 Hz. They are delivered by the control circuit by programming the synthesizer.

The associated output signals are processed as in para. 3.7.3; the feedback signal is used to adjust the C-field current.

3.7.6 Signal-to-Background Monitoring (Central Peak)

This monitoring (see Figure 3.5.2) is done during T1, T2 test periods, for instance every 6450 ms, by alternately applying to the tube input first a signal with frequency fr, centered on Ramsey central peak, then a signal with frequency fb, (background signal) centered halfway between the clock and the Zeeman resonance. These frequencies are delivered by the control circuits by alternately programming the frequency synthesizer.

The difference between the associated tube output signals directly measures the central peak-to-background level. This level is then regulated by correcting the input gain of the feedback loop. Thus, in spite of tube aging, loop gains and alarm levels can be kept constant.

3.7.7 Signal-to-Background Monitoring (Zeeman peak)

This monitoring (see Figure 3.5.2) is done during T1 and T2 test periods by applying, to the tube input, signals with frequency fz (centered on Zeeman central peak) and with frequency fb (background signal). Frequencies fz and fb are supplied by the control circuit by programming the synthesizer.

3.7.8 Central Peak Symmetry Check

In order not to accidentally center the quartz oscillator on a side resonance (Figure 3.7.8), the control circuits apply to the tube input, during successive test periods T1 and T2, signals with frequencies fr_{30} and fr_{31}, equal to fr ±386 Hz, symmetrical about the central peak and near the first valleys. These frequencies are supplied by the control circuits, by programming the synthesizer.

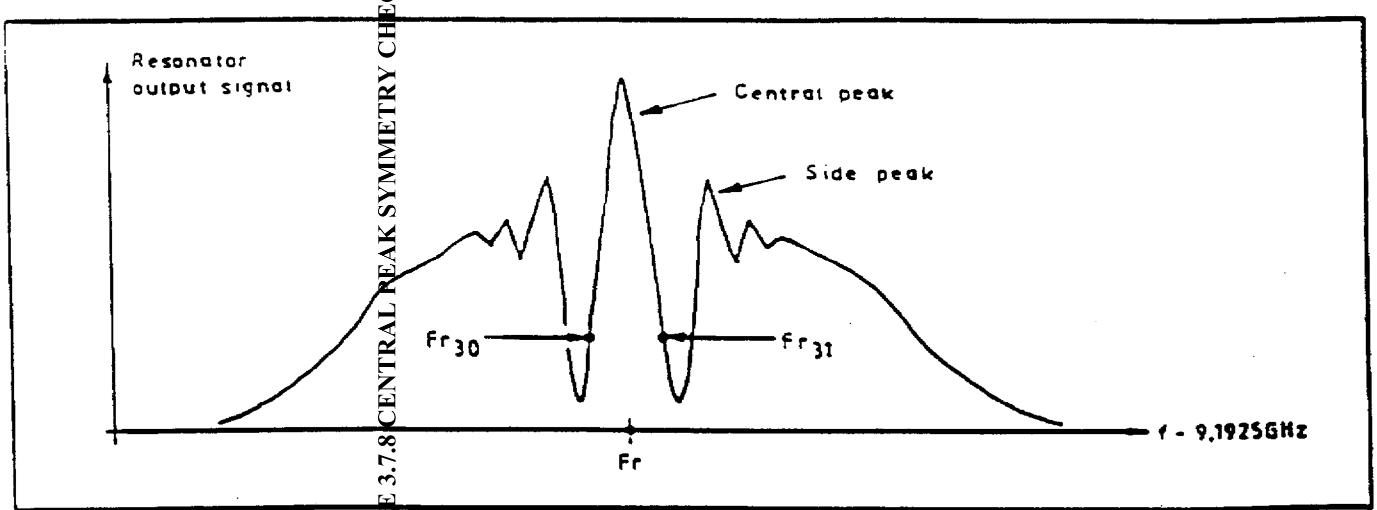


FIGURE 3.7.8 CENTRAL PEAK SYMMETRY CHECK

3.7.9 Central Pedestal Symmetry Check

In a similar way, a check of the quartz oscillator overall centering on the pedestal is done by applying to the tube, during successive test periods T1 and T2, signals with the same frequencies fr_{10} and fr_{11} that are used in the initial phase operation (see para. 3.7.2).

3.7.10 Microwave Power Servo

The microwave power servo lock is done by applying to the tube input, during successive test periods T1 and T2, signals with frequency fr at various power levels controlled by the output stage of 90 MHZ to 9.2 GHz multiplier. The associated output levels are used to set the microwave power level so as to maximize the tube output level at the central peak resonance (fr). This servo loop reduces the microwave power variations due to ambient temperature changes.

3.7.11 Other Functions

The microprocessor also controls the D.C. level at the preamplifier input.

The correction voltage, measured at the D/A converter output is defined as the mean value of the integrator output signals in two successive control periods R1 and R2.

Moreover, the microprocessor can monitor various operating voltages and temperatures, generate alarm levels and cut off the tube power supply in case of major failure.

SECTION 4
OPTION 063, DS1 FREQUENCY SYNTHESIZER
OPTION 064, CEPT FREQUENCY SYNTHESIZER

Addendum for the FTS 4065C
Cesium Time and Frequency Standard
Operating Manual P/N 11846-001

Applicability: Option 063, DS1 Frequency Synthesizer

1.0 GENERAL INFORMATION

This addendum provides supplemental information to the FTS 4065C Operating Manual when Option 063 is included. Information presented in the manual is applicable to the Model FTS 4065C/063 with the following exceptions:

- Ignore all references to a 1 pps outputs
- Ignore all references to the Time-of-Day clock display and controls
- Ignore all references to the Advance and Delay feature

Option 063 is not available with the 1 PPS outputs.

1.1 General Description

Option 063 adds a DS1 Telecommunications Synthesizer PCB Assembly, A7, to the FTS 4065C. With Option 063, the FTS 4065C can serve as a stand alone Stratum 1 Master Clock or as a component of a master clock system.

The Telecommunications Synthesizer Assembly, A7, replaces the 1 PPS Advance/Delay PCB, A7.

Option 063 adds the following outputs to the rear panel of the instrument:

- A balanced 1.544 MHZ, framed all ones, DS1 signal.
- An 8 kHz, TTL signal synchronous with the DS1 Frame Markers.
- A 1.544 MHZ TTL clock.

All three outputs are phase-locked to a 10 MHZ reference input provided by the Cesium Frequency Module, A1.

The DS1 output is switch selectable (via jumper switches on the PCB) to provide either a D4 or Extended Superframe (ESF) format. Figure A1 provides an illustration of the D4 and ESF formats. The DS1 output is adjustable for matching cable length to the DSX1 cross connect template at the end of the cable.

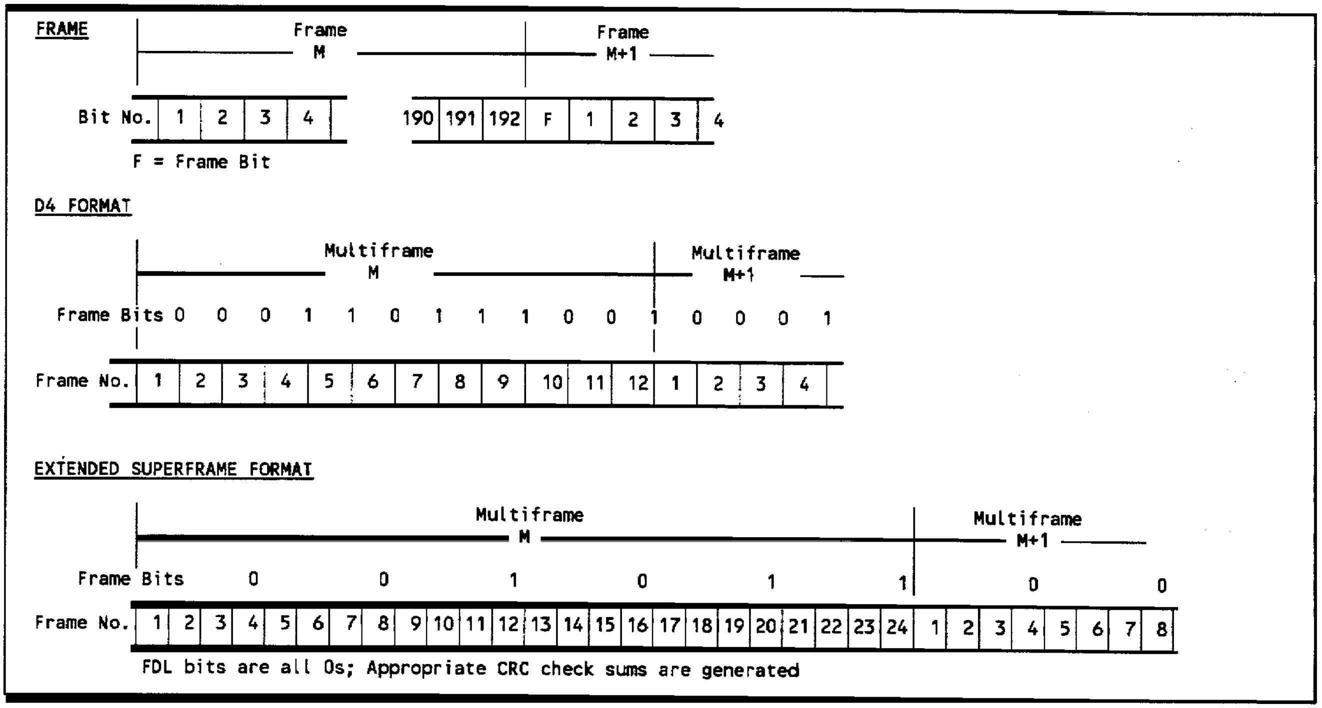


Figure 1 Frame, D4 and Extended Superframe Formats

The following input is added to the rear panel:

Frame Synchronization

This input allows the DS1 and Frame Alignment output signals to be synchronized to an external reference.

The following control is added to the rear panel of the FTS 4065C:

- A Line Length Adjust switch for adjusting the DS1 output signal shape and amplitude.

Table 1 is a list of specifications applicable to Option 063 and supplements Table 1-1 in the manual.

Table 1 Specifications, DS1 Synthesizer

OUTPUTS	
DS1	
Signal Type	DS1, balanced
Frequency	1.544 MHZ
Format	Framed all 1's (D4 or ESF)
Jitter	<0.05 U.I.
Connector	WECO 310 Plug
Maximum Cable Length	655 feet
Frame Marker	
Signal Type	TTL
Frequency	8 kHz
Connector	BNC
TTL clock	
Signal Type	TTL
Frequency	1.544 MHZ
Connector	BNC
INPUTS	
Frame Synchronization	
Signal Type	TTL compatible, active low
Frequency	8 kHz or submultiple of 8 kHz
Connector	BNC
CONTROLS	
Cable Select	8-Position Thumbwheel Switch, rear panel
D4/ESF	2-Position jumper switches, on PCB

2.0 OPERATION

2.1 Connections

All Option 063 external connections are made at the FTS 4065C rear panel. The FRAME SYNC input, FRAME MARKER output, and TTL CLOCK output use BNC connectors. The DS1 output uses a WECO-310-compatable jack.

The unit's 10 MHZ output is also routed to the DS1 Synthesizer Assembly. Loss of the 10 MHZ removes the frequency reference to the DS1 Synthesizer, causing an Alarm.

2.2 Operating Instructions

2.2.1 Cable Selection

After cable connections are made, set the rear panel CABLE SELECT switch to the nominal position for cable length used (maximum length is 655 feet). Refer to Table 2 or to the rear panel for a chart relating nominal switch position to cable type/length.

Table 2 Cable Select

Switch Setting	Line Length Selected (feet)	Cable Type
4	0 - 150	ABAM, PIC & PULP
3	150 - 275	
2	275 - 550	
1	550 - 655	

Switch positions 0 and 5-8 are not used.

2.2.2 Synchronizing

The frame alignment of the DS1 output can be synchronized to an external reference. It is suggested that a TTL pulse with a repetition rate of 8 kHz (or a submultiple of 8 kHz) signal be used for synchronization because the frames repeat at an 8 kHz rate.

To synchronize, briefly apply the reference signal to the rear panel BNC connector labeled FR SYNC IN.

Another FTS 4065C may be used as a reference by connecting its FR MKR output to the FR SYNC input to the unit being synchronized.

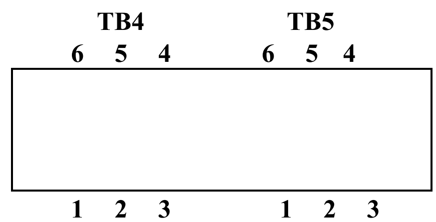
2.2.3 D4/Extended Superframe Selection

The DS1 format may be switched to D4 or ESF by setting the switch assembly (located on the Synthesizer Assembly) as shown in Table 3.

WARNING: Remove power to the FTS 4065C before opening the cover.

CAUTION: The FTS 4065C contains components that are static sensitive. Use proper static precautions when touching any internal parts. To access the Synthesizer Assembly, remove the bottom cover to the FTS 4065C.

Table 3 DS1 Format Jumper Positions



D4:	TB4	2-5 shorted
	TB5	2-5 shorted
ESF:	TB4 all removed	
	TB5 all removed	

2.3 Monitoring

System operating status is monitored in the same manner as described in the manual with the following changes:

- An alarm originating from the DS1 Synthesizer Assembly activates the front panel "DS1" indicator and will cause a Major alarm.
- A MAJOR alarm originating from the Cesium Standard will disable the DS1 output.

2.3.1 DS1 Alarm

A DS1 alarm can be caused by:

- Loss of internal 10 MHZ reference input signal to the assembly,
- Loss of DS1 Synthesizer phase-lock, or
- Loss of the DS1 output signal.

3.0 THEORY OF OPERATION

3.1 Functional Description

The DS1 Synthesizer consists of:

- A Digital Phase-locked Synthesizer
- DS1 Format Generator and Synchronization Circuit
- Frame Detector Circuit
- Alarm Circuitry
- Power Converter

Refer to Figure 3 for a block diagram of the DS1 Synthesizer Assembly.

3.1.1 Digital Synthesizer

The digital synthesizer section phase-locks a 6.176 MHZ VCXO to a 10 MHZ reference signal that is supplied by the Cesium Frequency Module, A1. Both the 6.176 MHZ and the 10 MHZ signals are digitally divided, phase compared, and integrated to provide a control voltage to the VCXO.

The first divide-by-four stage yields a 1.544 MHZ signal. This signal is distributed to:

- The DS1 Format Generating Circuitry to provide the T1 clock
- The rear panel as a buffered 1.544 MHZ TTL output.

3.1.2 DS1 Format Generator and Synchronization Circuit

3.1.2.1 DS1 Formatting

The required DS1 formatted TTL output is provided by a Serial Receiver/Transmitter driven by the 1.544 MHZ clock signal. The formatted data is applied to a T1 Line Interface device.

The Line Interface device transforms the TTL signal (from the serial transmitter) into the appropriately shaped Alternating Mark Inverted (AMI) pulse. The line length select switch provides a BCD input for the pulse shape selected.

3.1.2.2 DS1 synchronization

The Receiver/Transmitter accepts an external SYNC signal (see Table 1 for specifications) and synchronizes the start of the frame to the sync reference. Synchronization occurs on the next clock pulse after the SYNC input has returned to a logic "1".

3.1.3 Frame Detector

The Frame Detector accepts a five-bit BCD word from the Receiver/Transmitter that is the binary value of the channel being transmitted. At the start of the next frame, logic circuitry detects a binary "00000" and provides a Frame Marker output pulse.

3.1.4 Power Converter

The DS1 Synthesizer Assembly accepts +5 V dc from the FTS 4065C's 5 V regulator (VR1) and converts it to "12 V dc. A DC to DC IC regulator is used.

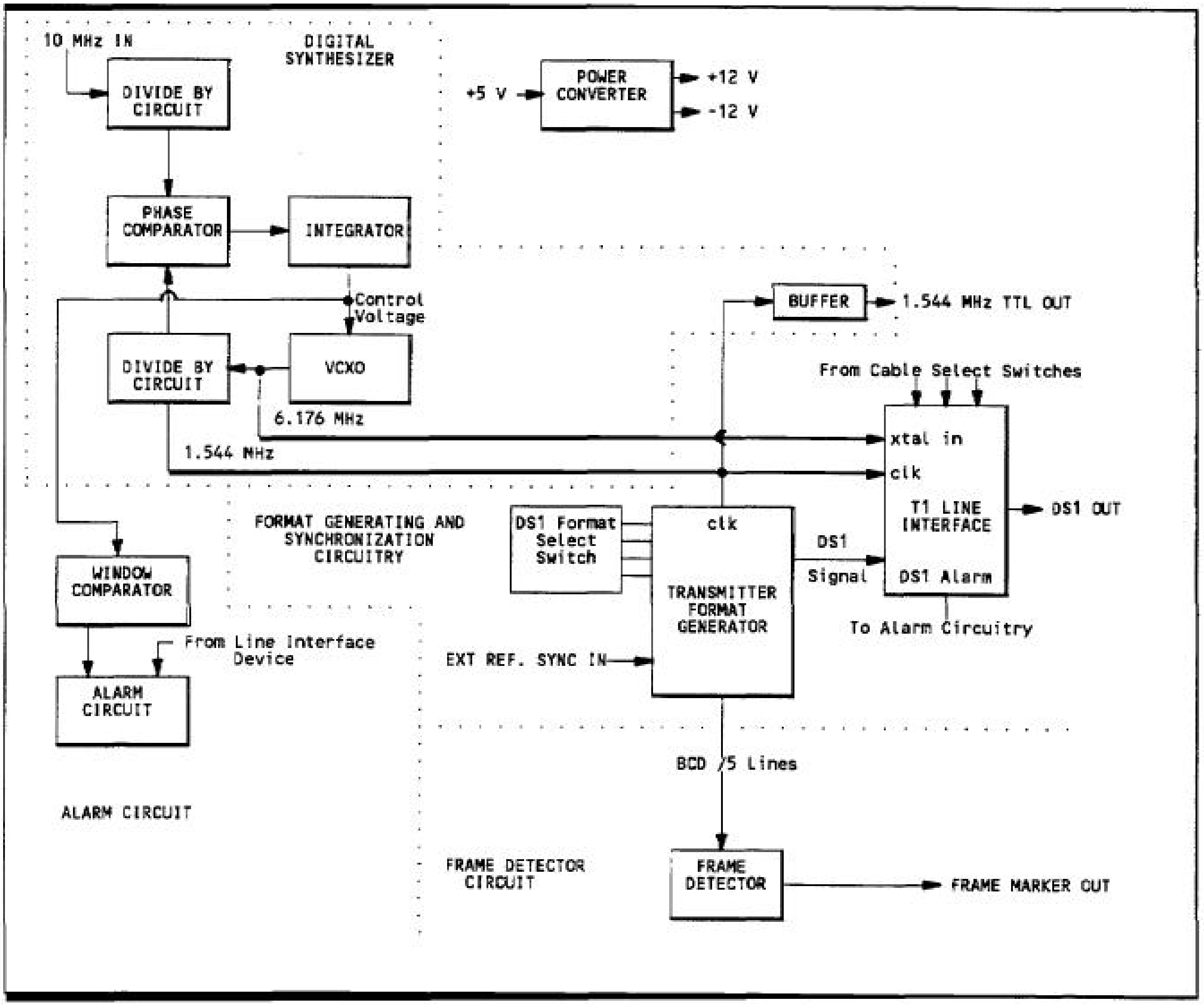


Figure 3 DS1 Synthesizer Assembly Block Diagram

Addendum for the FTS 4065C
Cesium Time and Frequency Standard
Operating Manual P/N 11846-001
Applicability: Option 064, CEPT Frequency Synthesizer

1.0 SCOPE

This addendum provides supplemental information to the FTS 4065C Operating Manual when Option 064 is included. Information presented in the manual is applicable to the Model FTS 4065C/064 except that the following features are not available:

- The 1 PPS
- The Time-of-Day clock display and controls
- The Advance and Delay

2.0 OPTION DESCRIPTION

Option 064 adds a CEPT Telecommunications Synthesizer PCB Assembly to the FTS 4065C. With Option 064, the FTS 4065C can serve as a Stratum 1 Master Clock or as a component of a master clock system.

The Telecommunications Synthesizer Assembly, A7, replaces the 1 PPS Advance/Delay PCB, A7.

Option 064 adds the following outputs to the rear panel of the instrument:

- A balanced or unbalanced 2.048 MHZ CEPT signal.
- An 8 kHz, TTL signal synchronous with the CEPT Frame Markers.
- A 2.048 MHZ TTL clock.

All three outputs are phase-locked to a 10 MHZ reference input provided by the Cesium Frequency Module, A1.

Figure 1 provides an illustration of CEPT format.

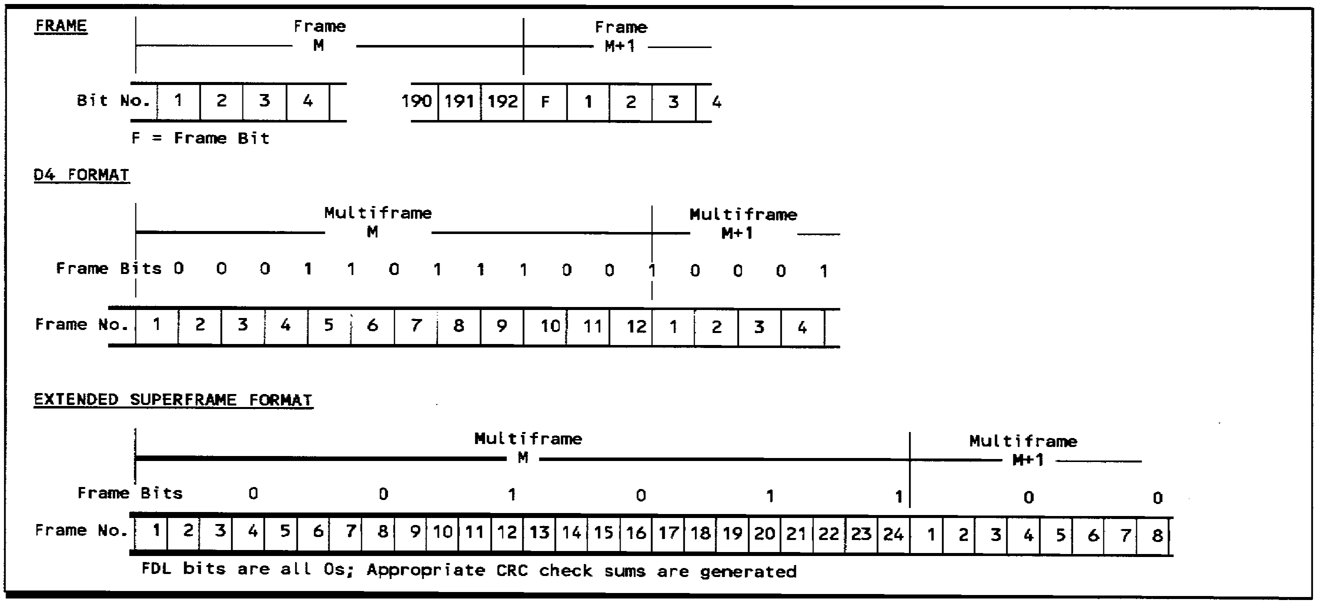


Figure 1 Time Slot, Frame, and CEPT Formats

The following are added to the rear panel:

- FRAME SYNCHRONIZATION input for synchronizing the CEPT and FRAME ALIGNMENT outputs to an external reference.
- A contact closure summary alarm.
- A Line Length Adjust switch for adjusting the CEPT output signal shape and amplitude.

Table 1 is a list of specifications applicable to Option 064 and supplements Table 1-1 in the manual.

2.1 Functional Description

Refer to Figure 3 for a block diagram of the CEPT Synthesizer Assembly.

The synthesizer phase-locks a VCXO to a 10 MHZ reference signal supplied by the Cesium Frequency Module, A1. Both the VCXO and the 10 MHZ signals are digitally divided, phase compared, and integrated to provide a control voltage to the VCXO.

The output of the VCXO is digitally divided to produce a 2.048 MHZ signal. This signal is:

- Supplied to the rear panel as a buffered TTL output
- Formatted and output as either a balanced or unbalanced CEPT signal.

A Frame Detector circuit determines the start of each frame and provides a Frame Marker output pulse with each occurrence.

The CEPT Synthesizer Assembly accepts +5 V dc from the FTS 4065C's and converts it to "12 V dc. A DC/DC IC regulator is used.

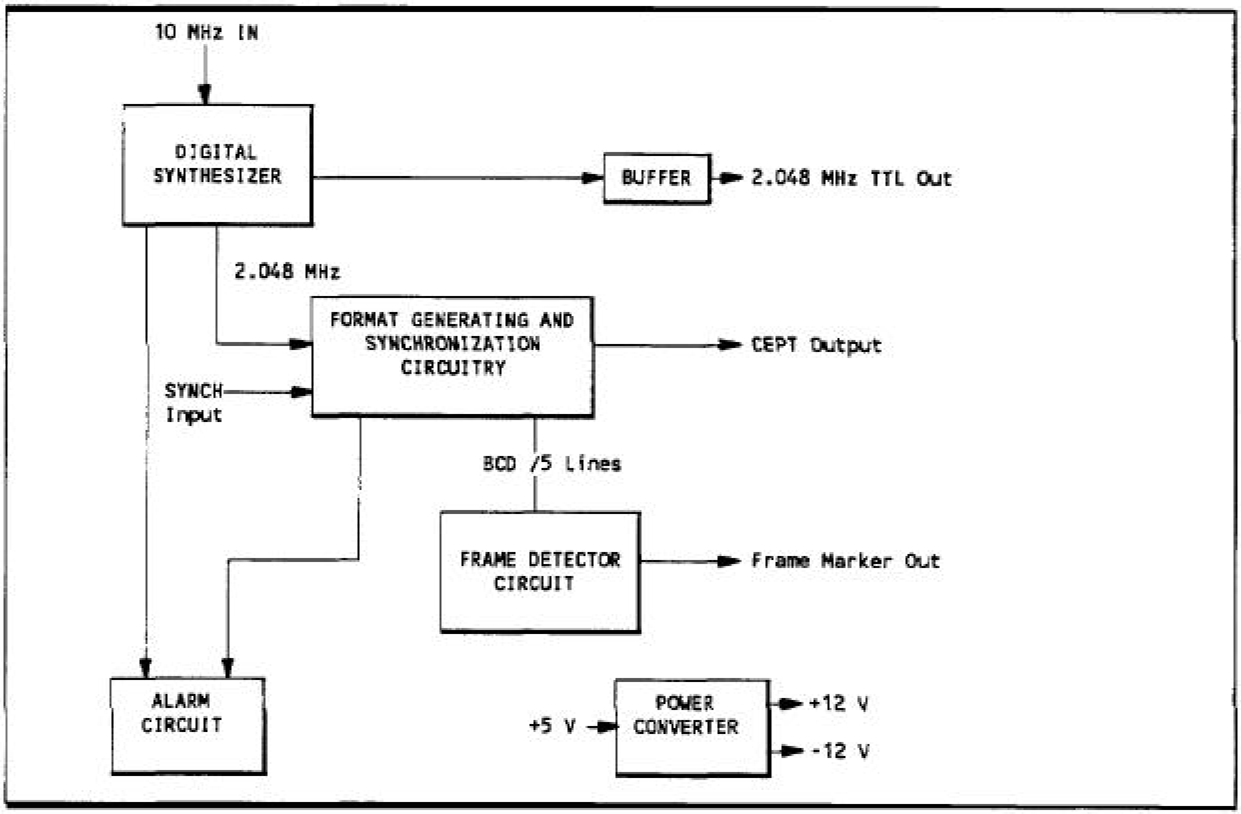


Figure 3 CEPT Synthesizer Assembly Block Diagram

2.2 Specifications

Table 1 Specifications, CEPT Synthesizer

<u>OUTPUTS</u> CEPT Signal Type Frequency Format Jitter Connector Balanced Unbalanced Maximum Cable Length	 CEPT, balanced or unbalanced 2.048 MHZ Framed all 1's <0.05 U.I. 120 Ù, WECO 310 Jack 75 Ù, BNC 655 feet
Frame Marker Signal Type Frequency Connector	 TTL 8 kHz BNC
TTL Clock Signal Type Frequency Connector	 TTL 2.048 MHZ BNC
<u>INPUTS</u> Frame Synchronization Signal Type Frequency Connector	 TTL, compatible, active low 8 kHz or submultiple of 8 kHz BNC
<u>CONTROLS</u> Cable Select	 8-position thumbwheel switch, rear panel

3.0 INSTALLATION

3.1 Connections

All Option 064 external connections are made at the FTS 4065C rear panel. The FRAME SYNC input, UNBALANCED CEPT output, FRAME MARKER output, and TTL CLOCK output use BNC connectors. The balanced CEPT output uses a WECO-310-compatable jack.

The unit's output is also routed to the CEPT Synthesizer Assembly. Loss of the 10 MHZ removes the frequency reference to the CEPT Synthesizer, causing an Alarm.

3.2 Cable Selection

After cable connections are made, ensure that the rear panel CABLE SELECT switch is set to position 7. Positions 0-6 and 8 are reserved for other options and may affect the quality of the CEPT signal if selected.

4.0 OPERATING INSTRUCTIONS

4.1 Synchronizing

The frame alignment of the CEPT output can be synchronized to an external reference. See Table 1 for input signal requirements.

To synchronize, briefly apply the reference signal to the rear panel BNC connector labeled FR SYNC IN. Another FTS 4065C/064 may be used as a reference by connecting its FR MKR output to the FR SYNC input to the unit being synchronized. Synchronization occurs on the next clock pulse after the SYNC input has returned to a logic "1".

4.2 Monitoring

Instrument status is monitored as described in the manual with the following changes:

- A MAJOR alarm originating from the Cesium standard will disable the CEPT output.
- An alarm originating from the CEPT Synthesizer Assembly activates the front panel "DS1" indicator (See Section 2.3.1 for causes of this alarm).

4.3 CEPT Alarm

A CEPT alarm can be caused by:

- Loss of internal 10 MHZ reference input signal to the assembly,
- Loss of CEPT Synthesizer phase-lock, or
- Loss of the CEPT output signal.

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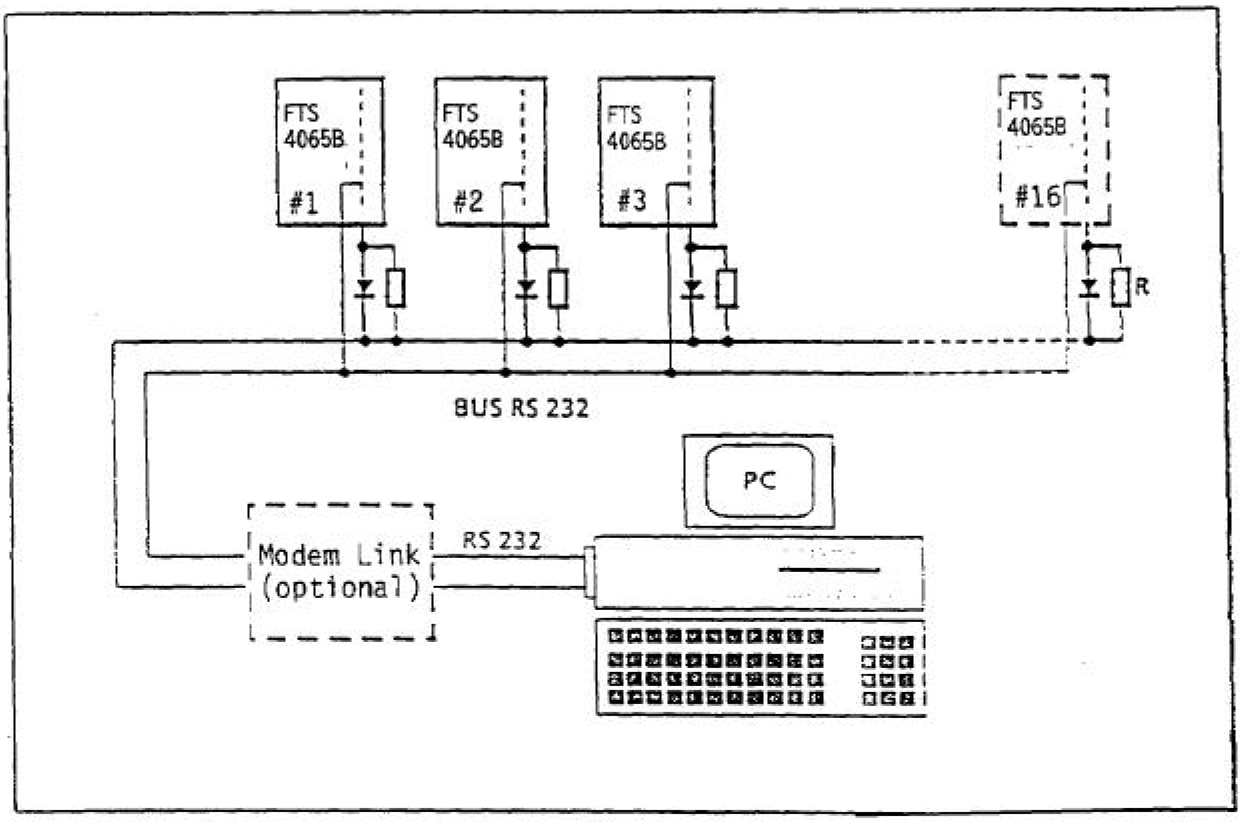
LIST OF FIGURES

A.1 OBJECT OF THE MONITOR.EXE SOFTWARE

Software is provided with the FTS 4065C to allow remote control and comprehensive performance monitoring of the instrument.



This software processes the data and parameters transmitted by the RS-232 serial link between one or several 4065C units (16 max.) and a PC (IBM-PC or compatible), as illustrated in Figure A.1.

It allows data file creation and real time or off-line graphic display of all the data.

Figure A.1

Remote Control of One or Several Standards Using a Microcomputer

APPENDIX A
REMOTE CONTROL SOFTWARE

A.2 SETTING-UP THE SERIAL LINK

Verify by using the main menu that the S/N of the unit corresponds to the number affixed to the rear panel nomenclature plate. If there is a discrepancy or the display reads X X X X X, follow the instructions in Section 2.7.10 to re-enter the S/N.

Connect the FTS 4065C to the PC using Figure A.2. Select the Baud Rate and activate the RTS/CTS handshake by:

a) press ESC twice or MENU to get to the TOP menu.

b) press 3 to select the OPERATION menus.

c) press 3 to select OPERATION 3 menu.

d) press ALT 4 to select the baud rate function.

e) enter the required baud rate.

f) press ENTER to complete the baud rate command.

g) press 4 to select OPERATION 4 menu.

h) press ALT 4 to select RTS/CTS Handshake function.

i) press 1 to activate the RTS/CTS Handshake function.

j) press ENTER to complete the Handshake function.

k) press ESC twice to return to the top menu.

Below is a brief explanation of how to use the MONITOR.EXE program included with the instrument.

Three command line parameters must be provided to the MONITOR.EXE program at launch:

1) Serial Port Number
2) Baud Rate
3) PC Speed Index

Example:

```
2   >  PC serial port number (1 or 2)

       (2 ---> port N  2) 3 or 4 not valid


4   >  Baud rate

                1 : 300

                2 : 600

                3 : 1200

                4 : 2400

                5 : 4800

                6 : 9600

       (4 ---> 2400 Bauds)


6   >  PC speed index

        0 (slow PC) to 9 (fast PC)

        (6 ---> medium speed)
```

The recommended values are equal to 146.

Example:

"C:\>MONITOR 146" means:	PC serial port number	: 1
Baud rate		: 4 ! 2400 bauds
Speed index		: 6 ! medium speed

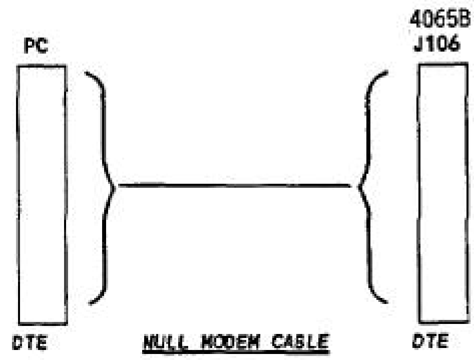


Figure A.2

Serial Link between FTS 4065C and PC

A.3 OPERATING INSTRUCTIONS

After turn-on, the screen displays 2 windows with the following parameters and alarms:

F1-Prmt:F2-Grph:F3-GrSel:F4-GrScl:F5-Inp:F6-Save:F7-Rate:F8--Unit:F9-Nml:F10-Help

- FTS 4065C/5045A/4040A/RS Control Monitor -

```
  Parameters

Rate:  4  0          Unit:00030          Day:032 Time:00h22mn24s

 Ramsey error.: +0000  Offset ctrl. : +0962   +24 V Supply : 24.99

 RabRam error.: +0000  LoopGain fct.:  2.32   Oven voltage : 04.1

 Zeeman error.: -0014  Ramsey C.test: +0000   Spectro.volt.: 15.5

 RabZee error.: +0006  9 GHz Pw ctrl: -2714   HotWire volt.: 0.68

 O.C.X.O cmd. : -0649  +05 V Supply : +5.17   C-Field curr.: 17.9

 Ramsey level :  2502  Temperature  : +42.2   HTEM supply  : 09.3

 C-Field ctrl.: -0077  +15 V Supply : +15.4   Pump current : 000

 Zeeman level :  1707  -15 V Supply : -16.0   ShrtTerm StDv: +193

  Alarms

                          LOCKED
```

The upper line displays a reminder of the commands triggered by the function keys <F1> to <F10>.

A.3.1 Parameters

Rate: Shows sampling rate and countdown time to next acquisition. This parameter can be modified using <F7> (serial input rate).

(The sampling rate must be compatible with the PC speed and the number of connected units when data is saved on the disk). Sampling rates which are too short will not allow sufficient time for data acquisition and disk storage.

```
Input rate

Type time rate : 4 sec
```

Unit: Displays the number of the unit under control. This parameter can be modified using <F8>.

Day and Time: Day and Time of measurements. Starts at turn-on and can be modified using <F1>.

<F10> (Help Menu) displays a window with the explicit functions of the keys.

```
        Help menu
Q         : Quit Program to D.O.S
R         : Reset graphic spooler
S         : Restore graphic spooler
V         : Program Version and serial input mode
F1        : Display or change FTS Cesium Module
ALT F1    : Display FTS 4065C parameters
CTRL F1   : Change FTS 4065C parameters
F2        : Graphic display on
ALT F2    : Color graphic display on (EGA or VGA required)
F3        : Graphic data selection
F4        : Graphic scales setting
F5        : Input mode (recorded file selection or serial input)
F6        : Output file selection
F7        : Serial input rate in seconds
F8        : Connected units number and unit plot choice
```

```
F9        : Display "FTS Cesium Module" constants

Space     : Repeat data acquisition or file reading

Esc       : Exit from graphic display
```

- <F8> (Unit selection) opens a window which lists the connected units. Allows modification of this list and selection of the unit under control.

  CAUTION: ONLY the connected units may be included in this list.

Thus the serial number of disconnected units must be set equal to zero.

To select the unit under control, position the pointer opposite the chosen unit serial number by means of the <UP> or <DOWN> keys, then press <ENTER>. The new configuration is then stored in an IDENT.DAT file.

By pressing the <ESC> key, the normal procedure is resumed without modification or storage in the IDENT.DAT. file.

```
          Unit selection

      V.arrows +Ret. to select

            Unit 00003

            Unit 00002

            Unit 00000

            Unit 00000

            Unit 00000

            Unit 00000
```

- <F5> (Input mode). This function allows off-line reading of a data file. It stops the current data saving that will have to be restarted using <F6>. Enter the file number chosen among the existing .CFM files.

```
              Input mode


      Unit file     U_____ .CFM


        or serial input (ENTER)


    .CFM files list on disk

 U00245.CFM    U00246.CFM     U00247.CFM

 U00002.CFM

 12728320 Bytes free
```

next window offers selection of the reading mode for the data file.

Read one line of 1: reads each line of the data file
Read one line of N: read every on Nth line which changes the graphic display scale (for instance, read one line of 4 to enlarge the time span of the scale displayed by 4-fold.)

```
          Input mode

File reading mode :


Read one line of  __
```

In the "read" mode, keying:

- **<ENTER>** starts the file reading
- **<ESC>** stops the reading
- **<SPACE>** restarts the file reading from the beginning.

@ <F6> (Data saving). Keying <Y> opens or reopens N files assigned to the N selected units.

```
          Output file

  Save data in output file Uxxxxx.CFM

            (  Y / N )


   .CFM files list on disk

U00245.CFM    U00246.CFM    U00247.CFM

U00002.CFM

12728320 Bytes free
```

- <F1> (Remote control) opens a window which gives access to the following parameters of the selected 5045A or 4040A/RS, thereby allowing their modification.

```
    Remote control

  Adj. frequency (10-15)   : +000000

  Manual C.field (10-13)   : +000

  Time updating (ns)       : +0000

  Reset time updating      :

  Order and Time Constant  : 2 03.1 sec

  Time/Date (Module Only)  : 473 18h05mn51s

  Sqr.out(0.1-1-5-10MHz)   : 05.0 MHz

  General alarm reset      :   ALM:00 (00,00,00,00,00)

  C. field auto-control    : ON

  Cursor Movement          :     Backspace
             Exit          : Press ESC
```

The new values are transmitted by <ENTER>.

The sign appears when the reset is performed with the <ENTER> key.

- CTRL <F1> Opens a window which gives access to the following FTS 4065C system parameters of the selected unit, thereby allowing their modification.

```
    FTS 4065 Control

  DC Delay to MAJOR        : 00:00:00 (HH:MM:SS)

  Battery Delay to MAJOR   : 00:00:00

  Time of Day Fault (TOD)  : Major (MAJor/MINor/OFF)

  Charger Fault (CHG)      : Minor

  Battery Operation (BAT)  : Minor

  DC Operation (DC)        : Off

  Battery Fault (BTV)      : Off

  PPS Sync Enable          :       (ENTER)

  PPS Advance (1 second)   :

  PPS Delay (1 second)     :
```

- ALT <F1> Opens a window which displays FTS 4065C system monitor parameters of the unit under control.

```
   FTS 4065C System Parameters

Power Source            : AC

System Voltage          : 30.2

Time on DC              : 00:00:00

Time on Batteries       : 00:00:00

Lost Lock               : No

Press ESC to Exit
```

- <F9> Nominals) opens a window which displays nominals and constants of the unit under control.

```
  Nominals

Hot-wire voltage nominal     : 0.79V

Spectrometer voltage nominal : 16.1V

Beam Signal DAC Gain Value   : 002

dF(dt ) model (t C - F10-13) : -15:+00 +15:+00 +45:+00 +75:+00

12.6 MHz level nominal       : +0150 mV

Rabi-Zeeman offset (mV)      : -0030 mV

Console language             : English

Unit comments                : 10/88

5045A software version       : ver m.n
```

A.3.2 Alarms

```
Alarms

            LOCKED
```

The message in the window center provides information about the state of the unit.

- INITIALIZATION : Start-up phase, shorter than 45 min. No error detection during start-up.
- LOCKED : No fault.
- MINOR ALARM : Small error with no danger to the unit.
- MAJOR ALARM : Major Fault: Unit is not operating properly.

Messages are classified in two groups: Major and Minor faults.

Major Fault messages:

Ramsey-backgrnd >3V or <2V
Rabi-Ramsey error >40 mV
Rabi-Zeeman error >160 mV
Spectrometer voltage drift
C-Field current <17 or >20 mA
EM supply <7V >11V
DAC input error out 5 to 95%
Oscillator cmd. >90%; >95%
Internal temperature >80^{o}C
12.6 MHz Power out of range
+5.1V Supply voltage > "0.40 V
+15 V Supply voltage > "1.5 V
-15 V Supply voltage > "1.5 V
EEPROM Write Error
Unit Restart
Module Configuration Lost

Minor Fault messages:

Oscillator Cmd >90%; 95%
Beam Gain DAC Near Limit

Major Faults causing module power supply shutdown:

Excess oven heating > 10V/45 min
Excess O.C.X.O heating
Hot-Wire volt error > "0.16V
Ion-Pump current > 240 ì A
24V Supply voltage <20V >30V
Reset the alarms <F1> after correcting the error.

A.3.3 Graphic Display

<F3> (Graphic data selection) opens a window displaying the parameters. Selection ismade with the <UP> and <DOWN> or with the field first character keys, then bypressing <SPACE>.

The selection consists of 1 to 6 parameters maximum. The display format will automatically adapt to the number of chosen parameters.

Normal operation is resumed by pressing <ENTER>.

Selection is not modified by entering the window and exiting by means of <ESC>.

```
Graph parameters
   Moving     : Vert. or hor. arrows or 1st char.

   Selection  : Space

   Out        : Return

   Select 6 parameters max.


Ramsey error.:    Offset ctrl. :    +24 V Supply :

RabRam error.:    LoopGain fct.:1   Oven voltage :

Zeeman error.:    Ramsey C.test:2   Spectro.volt.:

RabZee error.:    9 GHz Pw ctrl:    HotWire volt.:

O.C.X.O cmd. :    +05 V Supply :    C-Field curr.:

Ramsey level :    Temperature  :3   HTEM supply  :

C-Field ctrl.:    +15 V Supply :    Pump current : <--

Zeeman level :    +15 V Supply :    ShrtTerm StDv:
```

<F2> (Graphic display). The parameters chosen above are graphically displayed. The horizontal scale is given in the last line. An example is shown in Figure A.3.3.

S = X total scale

C = X center offset

These scales can be modified using <F4>. The Y time scale is given in min/div. and depends on the sampling rate at the time of filing (see F5). The total scale has 12 divisions.

To move out of the graphic mode back to the read mode press <ESC>. Once in the read mode;

- <F2> displays the last graph.

- <R> restarts the graphic display.

- <S> restores the graphic display erased by <R>.

In real-time display (serial port), the data display does not stop when it reaches the end of the time scale but starts at the top again and overprints the first traces.

In off-line display , the file reading stops at the end of the time-scale, awaiting a "print display" order by means of the <SPACE> or <SHIFT-PrtSc> keys.

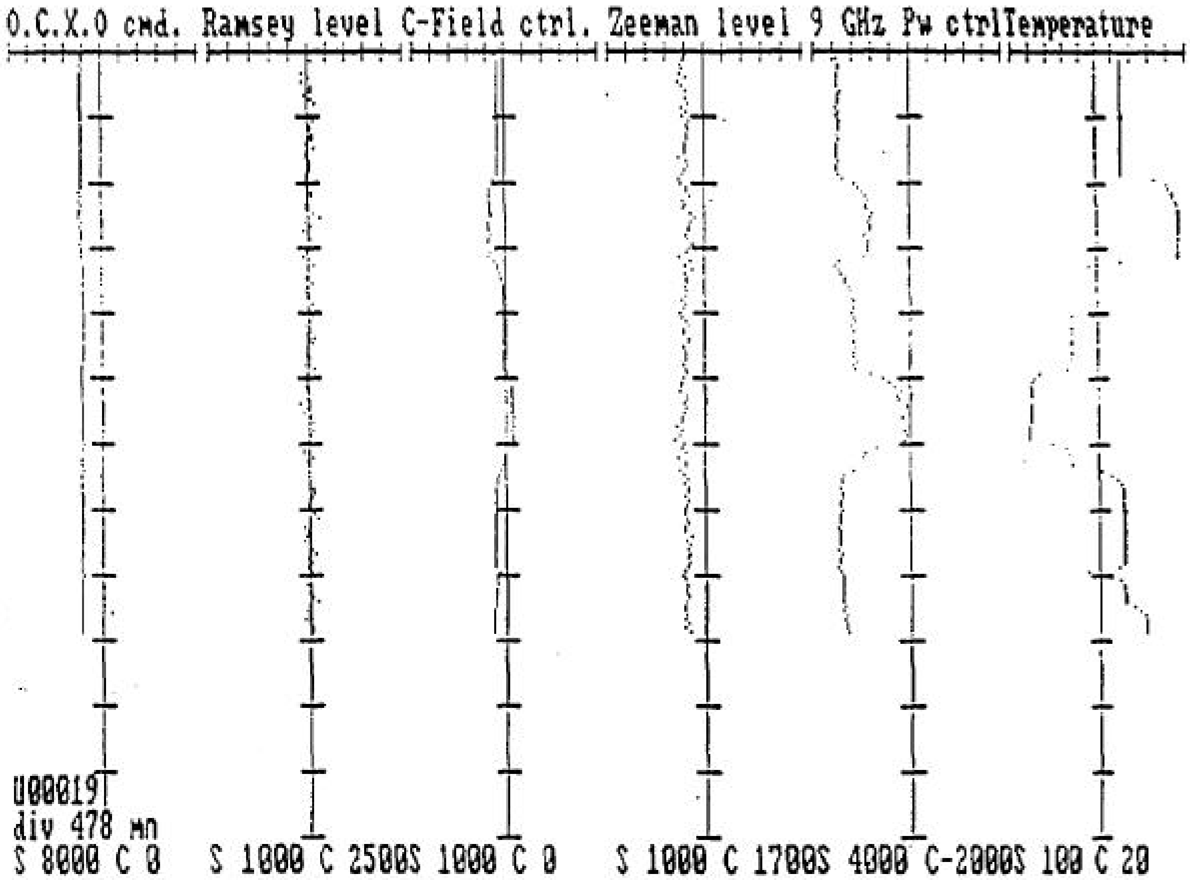


Figure A.3.3
Graphic Display Example (response to a temperature step)

<F4> (Graphic scales) displays the scales in use. The method is the same as for the other window: to change a value, first select the field, press <ENTER>, enter the new alue and press <ENTER> again.

To move out of the window key <ENTER>. These keys store the scales in a SCALE.DAT file.

If no files exist at the start of the program, default values are used.

Default values are shown below.

```
Graph scale

   Moving      : Vert. or hor. arrows or 1st char.

   Modify      : SPACE  --> new value --> ENTER

   Out         : Type Space or ENTER.

          Scale  -  Axis           Scale  -  Axis


Ramsey error.: 400     0     +05 V Supply : 1     5

RabRam error.: 200     0     Temperature  : 100   30

Zeeman error.: 400     0     +15 V Supply : 10    15

RabZee error.: 200     0     -15 V Supply : 10   -15

O.C.X.O cmd. : 8000    0     +24 V Supply : 10    24

Ramsey level : 1000    2500  Oven voltage : 10     5

C-Field ctrl.: 8000    0     Spectro.volt.: 20    10

Zeeman level : 1000    1700  HotWire volt.: .5    .75

Offset ctrl. : 8000    0     C-Field curr.: 20    10

LoopGain fct.: 5       2.5   EM supply    : 5     10

Ramsey C.test: 200     0     Pump current : 200   100

9 GHz Pw ctrl: 4000   -2000  ShrtTerm StDv: 1000  500
```

A.3.4 Miscellaneous functions

<Q> key : Quits program to D.O.S.

<R> key : Resets graphic spooler. (The spooler is a section of memory which stores one screenful of selected graphical data. Re-setting the spooler permits the overwriting of this section of memory with incoming real time data).

<S> key : Restores graphic spooler. (Restoring the spooler permits the viewing of graphical data that has been previously stored in this section of memory).

<V> key : Program version and serial input mode.

A.4 Format of ASCII Strings Transmitted & Received at the PC

When not using the FTS Model 4065C monitoring software, it is possible to directly send and receive information from the instrument.

Communicating with the 4065C directly through a computer's serial port is accomplished using a variety of ASCII character sequences. The formats of these sequences are described below.

Unless otherwise noted:

a) Square brackets indicate control characters as follows:

Notation	ASCII code (decimal)
[STX]	02
[ETX]	03
[CR]	10
[LF]	13

b) n indicates a digit from 0 to 9.

c) _ (underscore) indicates a space (ASCII code 32)

3. REQUEST VARIABLES DATA MESSAGE

Format: [STX]D*1 nnnnn [ETX]

NOTE: nnnnn represents the 5-digit serial number of the 4065C. In response to this ommand the 4065C will return a string of 338 characters (including control characters). Each variable is positioned in the string according to the following table:

Position in string	Contents	Example
1-3	Control characters	[STX][CR][LF]
4-11	ID number plus space	ID00001_
12-15	Day of year plus space *	234_
16-26	Time plus space *	23h59mn59s_
27-28	Servo order plus space	2_
29-32	Operating mode plus space	R+Z_
33-54	Alarms state plus space	ALM:00(00,00,00,00,00)
55-60	C-field adjustment plus space	C+015_
61-69	Frequency fine tuning plus space	F-000000_
70-77	+24 volt power supply plus space	+25.23_V
78-83	Filtering time constant	Ct10.1
84-85	Control characters	[CR][LF]
86-90	Clock servo voltage diff. (input)	R+013
91-98	Clock pedestal servo voltage diff. (input)	RR_+0012
99-103	Zeeman servo voltage diff. (input)	Z+008
104-111	Zeeman pedestal servo voltage diff. (input)	RZ +0036
112-118	Oscillator servo output voltage	AR-1318
119-124	Clock peak to background level diff.	PR2495
125-131	Zeeman servo output voltage	AZ+0080
132-137	Zeeman peak to background level diff.	PZ1677
138-144	Preamplifier DC level servo output voltage	AO+0822
145-151	Numerical gain	GN*3.28
152-158	Clock(Ramsey) peak symmetry check	LA+0001
159-165	Microwave power servo control voltage Pu-0408	
166-167	Control characters	[CR][LF]
168-174	+5 volt supply plus space	+5.17V_
175-181	Internal case temperature plus space	T+35.5_
182-188	+15.5 volt supply plus space	+15.4V_
189-195	-15.5 volt supply plus space	-16.0V_
196-199	Quartz oscillator cold (warm) plus space OLc_	
200-206	Cesium oven supply voltage plus space	FO04.5_
207-213	Mass spectrometer voltage plus space	VS15.5_
214-220	Cesium tube ionizer voltage plus space	VF1.66_
221-227	C-field coil current plus space	IC17.9_
228-234	HTEM control voltage plus space	HT10.6_
235-240	Ion pump current plus space	IP025_
241-247	Standard Deviation of clock servo voltage difference over 30s	+137 mV
248-249	Control characters	[CR][LF]
250-258	Time on DC before major alarm (hr,min,sec) plus space	01:30:15_
259-267	Time on batteries before major alarm (hr,min,sec) plus space	00:30:00_
268-269	TOD fault indicator (M, m or O) plus 1 space Key: M=Major, m=Minor, O=OFF	M_
270-271	Battery charger fault indicator (M, m or O) plus 1 space	m_

* The date-time stamp in the remote data message is derived from the FTS 4065 TOD clock. If it is not set, it is filled with X's.

Position in string	Contents	Example
272-273	Battery Operation fault indicator (M, m or O) plus 1 space	O_
274-275	DC fault indicator (M, m or O) plus 1 space	M_
276-277	Battery Fault (BTV) (M, m or O) plus 1 space	O_
278-281	Power source (BAT plus 1 space, AC or DC plus 2 spaces)	AC_ _
282-286	System voltage plus 1 space	33.1 _
287-295	Time on DC (hours,minutes,seconds) plus 1 space	01:15:00_
296-304	Time on batteries (hours,minutes,seconds)	00:10:00
305-309	Alarm Status: M0m0 M0m0_	

where M = MAJOR Attribute
m = MINOR Attribute
0 = No Alarms
1 = Alarm with Recovered Fault
2 = Alarm without Recovered Fault

Example:"M2m1_" indicates that a MAJOR fault exists presently and a MINOR fault has occurred but instrument has recovered.

Position in string	Contents	Example
310-311	Lock Lost Indicator Y or N plus space	N_
312-319	4065 System Fault Summary Provides a summary of all faults present in 4065 system:	SYS:1024

NO FAULTS =	0
TOD	= 1
CHG	= 2
PWR	= 4
XDC	= 8
BAT	= 16
BTV	= 32
RFV	= 64
DS1	= 128
EXT	= 256
PPS	= 512
RF	= 1024

For example, if the faults TOD, PPS and BAT were logged by the system, the message would appear as such: SYS:0529 = 512 + 16 +1

320-322 Control characters + ETX [CR][LF][ETX]

4. REQUEST CONSTANTS DATA MESSAGE

Format: [STX]D*2 nnnnn [ETX]

Note: nnnnn represents the 5-digit serial number of the 4065C.

In response to this command the 4065C will return a string of 145 characters (including control characters). Each variable is positioned in the string according to the following table:

Position in string	Contents	Example
1-3	Control characters	[STX][CR][LF]
4-11	ID number plus space	ID00001_
12-15	Day of year plus space	234
16-25	Time plus space	23h59mn59_
26-34	Nominal spectrometer voltage plus space	Vs_14.0V_
35-43	Nominal tube ionizer voltage plus space	Vf_1.07V_
44-52	Beam Signal DAC Gain Value	GDAC_002_
53-60	F(t^o) correction model at -15^{o}C plus space	-15:+10_
61-68	F(t^o) correction model at +15^{o}C plus space	+15:+00_
69-76	F(t^o) correction model at +45^{o}C plus space	+45:-03_
77-83	F(t^o) correction model at +75^{o}C plus space	+75:+04_
84-85	Control characters	[CR][LF]
86-93	Nominal 12.6MHz level plus space	Pi+0345_
94-101	Zeeman offset (asymmetry compensation) plus space	Oz-0045_
102-113	Auxiliary output signal frequency plus 2 spaces	Fo:05.0MHz__
114-120	Console mode language plus space	CDU:GB_
121-135	Comments (TXT: plus 10 characters plus space)	TXT:2/25/91____
136-142	Program version	ver 1.1
143-145	Control characters	[CR][LF][ETX]

A.4 Format of ASCII strings transmitted & received at the PC (cont'd)

5. REMOTE CONTROL COMMANDS

General Format: [STX]Wdd nnnnn ccccccccc[ETX]

Notes: nnnnn represents the 5-digit serial number of the 4065C.

ccccccccc represents the 9-character data field. Unless otherwise noted c designates a don't care value.

dd represents the 2-digit function code for the commands specified in the following table:

Function Code	Command	Data field format
00	Reset Cesium module alarms	ccccccccc
01	Frequency Adjust	+nnncccccc or -nnncccccc
02	C-Field Adjust	+nnnncccc or -nnnncccc
03	Phase Offset	+nnnncccc or -nnnncccc
04	Stop phase offset	ccccccccc
05	Zeeman servo off	ccccccccc
06	Zeeman servo on	ccccccccc
07	Set auxiliary output signal	
	(0.1 MHz)	1cccccccc
	(1 MHz)	2cccccccc
	(5 MHz)	3cccccccc
	(10 MHz)	4cccccccc
08	Set elapsed days and time (4040A/RS ONLY) (where hh represents a 2-digit hour count, mm represents a 2-digit minute count, and ss represents a 2-digit second count)	nnnnhhmmss
	Set Date and Time (4065C)	mm/dd/yy-hh:mm:ss
10	Set filter order and time constant (where o represents the digit 0, 1 or 2)	o_nn.nccc
20	Set time on DC or battery before allowing a major alarm (DC)	hh:mm:ss1
	Battery (where hh represents a 2-digit hour count, mm represents a 2-digit minute count and ss represents a 2-difit second count	hh:mm:ss2
21	Set fault mode	
	(PPS)	m2ccccccc
	(Battery Charger)	m3ccccccc
	(Battery)	m4ccccccc
	(DC)	m5ccccccc
22	1 PPS Synch	ccccccccc
23	1 PPS Delay	ccccccccc
24	On Time TOD Message	ccccccccc
25	1 PPS Advance	ccccccccc

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