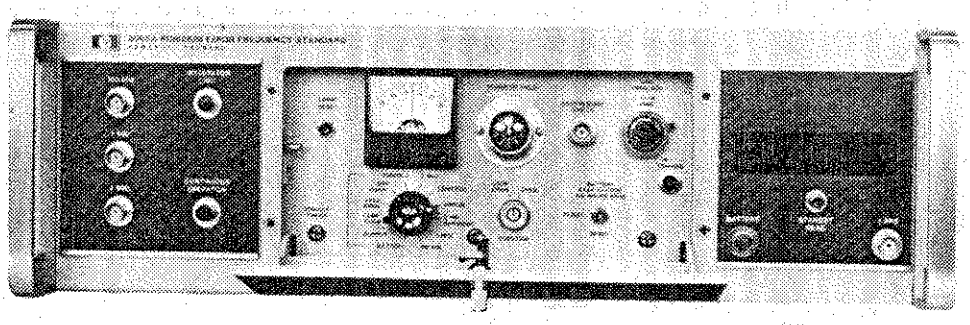
OPERATING AND SERVICE MANUAL

5065A
RUBIDIUM VAPOR FREQUENCY STANDARD



HEWLETT PACKARD

SAFETY

This product has been designed and tested according to International Safety Requirements. To ensure safe operation and to keep the product safe, the information, cautions, and warnings in this manual must be heeded. Refer to Section I for general safety considerations applicable to this product.

CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Hewlett-Packard product is warranted against defects in material and workmanship for a period of one year from date of shipment, except that in the case of certain components listed inTable 1-3 of this manual, the warranty shall be for the specified period. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by HP. However, warranty service for products installed by HP and certain other products designated by HP will be performed at Buyer's facility at no charge within the HP service travel area. Outside HP service travel areas, warranty service will be performed at Buyer's facility only upon HP's prior agreement and Buyer shall pay HP's round trip travel expenses.

For products returned to HP for warranty service, Buyer shall prepay shipping charges to HP and HP shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to HP from another country.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HP SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

THE REMEDIES PROVIDED HEREIN ARE BUYER'S SOLE AND EXCLUSIVE REMEDIES. HP SHALL NOT BE LIABLE FOR ANY DIRECT, INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER BASED ON CONTRACT, TORT, OR ANY OTHER LEGAL THEORY.

ASSISTANCE

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

RUBIDIUM VAPOR FREQUENCY STANDARD

5065A

SERIAL PREFIX: 1908A

This manual applies directly to HP Model 5065A Rubidium Vapor Frequency Standards having serial prefix 1908A.

OLDER INSTRUMENTS

Changes required to backdate this manual for older instruments are in Section VII.

OPTIONS

For instruments having Options 001, 002, or 003, refer to Sections III through VII.

5301 STEVENS CREEK BLVD., SANTA CLARA, CALIF. 95050

Manual Part No. 05065-9041
Microfiche Part No. 05065-9042

Printed: NOV 1979

HEWLETT PACKARD

MANUAL CONTENTS

This manual is supplied to help you make best use of your instrument. The manual covers eight sections of information as follows:

Section I is an introduction to the Instrument. Electrical specifications and accessories information is given.

Section II covers inspections, power, mounting, packing, shipping, and connection.

Section III outlines operating procedures.

Section IV discusses technical operations.

Section V contrains disassembly and repair procedures and an in-cabinet performance check.

Section VI lists replaceable parts.

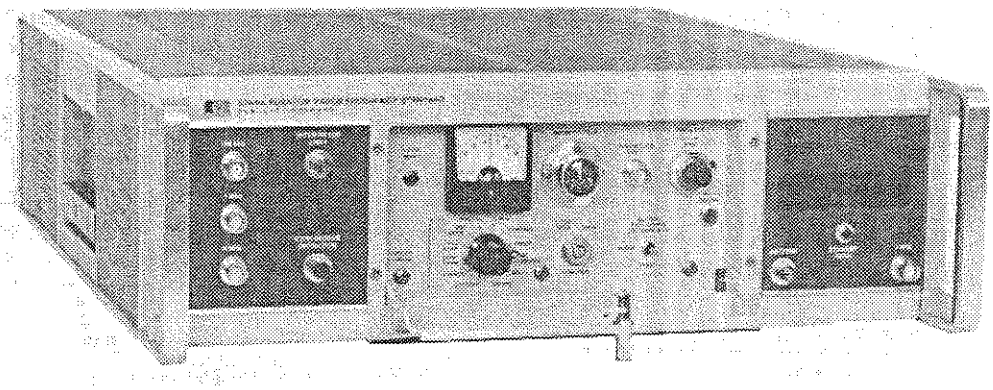
Section VII gives options and manual changes information.

Section VIII contains circuit diagrams, component locators and waveforms. Included are adjustment procedures and troubleshooting information.

HOW TO ORDER

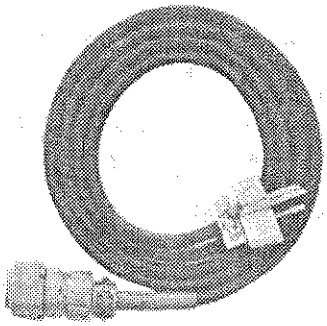
To order an operating and service manual, contact the nearest Hewlett-Packard Sales and Service Office. Give complete model, name, and nine-digit serial number. The serial number plate is on the rear panel. Comments on this manual are welcome at any Sales and Service Office.

Figure 1-1. Model 5065A and Accessories

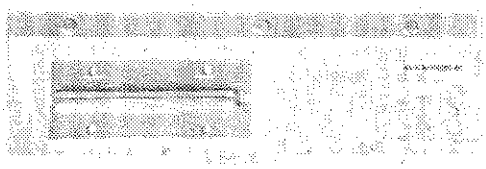


Shown with Option 003 (001 + 002 = 003)

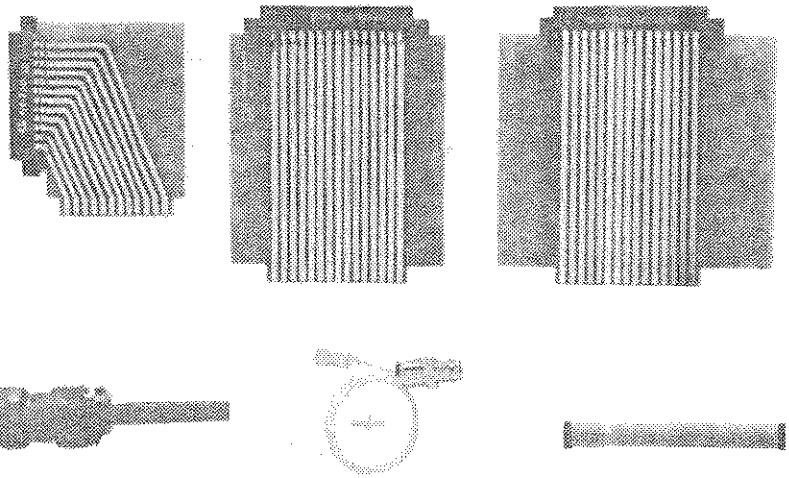
AC POWER CORD



RACK MOUNT KIT



ACCESSORY KIT



SECTION I

GENERAL INFORMATION

1-1. INTRODUCTION

1-2. Description

1-3. The Hewlett-Packard Model 5065A Rubidium Vapor Frequency Standard is a compact, self-contained secondary frequency standard which uses an optically-pumped Rubidium vapor cell as the reference element. A 5 MHz oscillator is stabilized against a natural atomic resonance, the hyperfine transition of Rubidium 87. This technique produces a long-term stability of better than 1×10^{-11} per month with excellent short-term stability which is conservatively rated at less than 5×10^{-12} rms averaged over a one-second period. Output frequencies are 5 MHz, 1 MHz, and 100 kHz.

1-4. Frequency setting for any offset of the UTC time reference is accomplished by changing the microwave excitation frequency and the magnetic field applied to an Rb^{87} vapor cell. Thumbwheel switch control (of a digital frequency synthesizer) provides approximate step adjustment of the microwave excitation frequency with a range of 1000 parts in 10^{10}. In addition, the front-panel MAGNETIC FIELD control provides for exact adjustment of the Rb^{87} hyperfine transition with a resolution of 2 parts in 10^{12}.

1-5. Options

a. A digital clock, Option 001, provides a clock display and a one pulse per second (1 PPS) electrical output. The clock pulse may be retarded up to 1-second in increments as small as 1-microsecond and as large as 0.1-second. In addition, a separate control provides continuous adjustment of clock-pulse delay from 0- to 1-microsecond.

b. Standby battery, Option 002, provides a 10-minute minimum power source (at 25°C) in the event of external ac power failure. A front-panel lamp flashes when ac power is interrupted and lights continuously during fast charge. Charge rate is controlled by a 3-position front-panel switch; FAST, CHARGE-FLOAT, RESET.

1-6. Circuit Checks and Outputs

1-7. The CIRCUIT CHECK switch and meter provide continuous monitoring of outputs and other signals. The CONTINUOUS OPERATION lamp gives an indication of correct operation. The 5 MHz, 1 MHz, and 100 kHz output levels are at least 1 volt rms when properly terminated with 50 ohms.

1-8. TERMINOLOGY

1-9. The definitions of the following terms apply to these terms as used throughout this manual.

a. ATOMIC TIME. Time scale based on the hyperfine resonance of Cesium 133.

b. UNIVERSAL TIME (UT2). Time scale based on the earth's rotation about its axis with correction for angular position and seasonal variations; proceeds at a rate slightly slower than Atomic time.

c. UNIVERSAL TIME (COORDINATED) (UTC). A piecewise uniform scale which approximates UT2 to 0.1-second by step adjustments in phase as announced by the Bureau International de l'Heure in Paris.

d. HYPERFINE RESONANCE OF Rb^{87}. Hyperfine resonant frequency arising from the difference in energy between the upper and lower ground states of Rb^{87}.

e. RVFR (Rubidium Vapor Frequency Reference). The assembly which houses the Rb^{87} lamp, filter cell, the Rb^{87} absorption cell, and the harmonic generator/mixer diode.

1-10. SPECIFICATIONS

1-11. Table 1-3 lists the technical specifications for the Model 5065A.

1-12. Table 1-1 lists equipment supplied and Table 1-2 lists accessories available for the Model 5065A.

1-13. INSTRUMENT IDENTIFICATION

1-14. Hewlett-Packard uses a two-section nine-digit serial number (0000A00000) mounted on the rear-panel to identify this instrument. The first four digits are the serial prefix and the last five digits refer to the specific instrument. If the serial prefix on your instrument differs from that listed on the title page of this manual, differences exist between the manual and your instrument. Lower serial prefixes are documented in Section VII and higher serial prefixes are covered by a manual change sheet included with the manual. If this sheet is missing contact the nearest Hewlett-Packard Sales and Service office (lists are provided at the rear of this manual).

Table 1-1. Equipment Supplied

Equipment	Description	HP Part No.
AC Power Cable	3-Conductor with ground pin	05061-6091
Accessory Kit includes:		05065-6066
Adapter	Micon, male-to-male	1250-0813
Connector	Plug, female	1251-0126
Screwdriver	Ceramic	8710-0033
Cable Assembly Test	Micon to BNC	05060-6116
Board Extender	15 pin	05065-6064
Board Extender	15 pin, extra wide	05065-6065
Board Extender	12 pin	05061-6073

Table 1-2. Accessories Available

Accessory	Description	HP Part No.
Standby Power Supply	24 Vdc, 2-ampere supply with 18 ampere-hours standby batteries	Model 5085A
Cable	Connects 5065A to 5085A dc output	103A-16A
Extension Slides and Rack	Permits sliding instrument out and tilting from rack-mounted position	1490-0718 1490-0721
Standby Power Supply	24 Vdc, 2-ampere supply with 12 ampere-hours sealed standby batteries for flying clock experiments. Operates on 6, 12, and 24 Vdc, 115 Vac/230 Vac, ±10%, 48 to 440 Hz.	K02-5060A
Rack Mount Kit	Provides conversion from bench to rack model	5060-8740

Table 1-3. Specifications

5065A

Frequency Stability:

Long term: $\pm 1 \times 10^{-11}$ per month (maximum limit of drift rate).

Short term*: for 5 MHz output.

Fractional Frequency Fluctuations	Avg. Time (τ)
$< 7.5 \times 10^{-10}$	1 ms
$< 1.5 \times 10^{-10}$	10 ms
$< 1.5 \times 10^{-11}$	0.1 s
$< 5 \times 10^{-12}$	1 s
$< 1.6 \times 10^{-12}$	10 s
$< 5 \times 10^{-13}$	100 s
$< 5 \times 10^{-13}$	1000 s

Calibration Accuracy: Set at factory to $\pm 1 \times 10^{-11}$ of specified time scale.

Settability: $\pm 2 \times 10^{-12}$.

Time Scale: Set at factory to UTC unless specified differently.

Tunability: Coarse Frequency Synthesizer Adjustment: Range: 1000×10^{-10}
Resolution: $< 2 \times 10^{-9}$, thumbwheel adjust.
Fine Frequency Magnetic Field Adjustment:
Range: 2×10^{-9} Resolution: 2×10^{-12}

Warm-up: Within 1×10^{-10} in 1 hour and 5×10^{-11} in 4 hours of final frequency after 24 hours "off" time at 25° C. Units typically warm-up to better than ±2 parts in 10^{11} of factory calibrated frequency.

***DEFINITION OF TERMS**

Short-Term Stability:

See Statistics of Atomic Frequency Standards by David W. Allen, Proceedings of IEEE, Feb. 1966, p. 221, and HP Application Note 116 for measurement details.

Settability:

The degree to which an oscillator may be adjusted to correspond with a reference. This is also termed calibration.

OUTPUTS:

Frequencies: 5 MHz, 1 MHz, 100 kHz.
Voltages Levels: >1 V rms into 50 ohms at 5 MHz, 1 MHz, 100 kHz.
Connectors: BNC Front and Rear for 5 MHz, 1 MHz, 100 kHz.
Harmonic Distortion: (5 MHz, 1 MHz, 100 kHz) Down more than 40 dB from rated output.
Nonharmonically Related Output: (5 MHz, 1 MHz, 100 kHz) Down more than 80 dB from rated output.
Signal-to-Noise Ratio: For 1 and 5 MHz, >87 dB at rated output (in a 30 kHz noise bw).

ENVIRONMENTAL:

Temperature, Operating: 0° to 50° C. Frequency change is $< \pm 4 \times 10^{-11}$ from frequency reference at at 25° C.
Temperature, Nonoperating: -40° to +75° C. (With Options to 50° C.)
Production Units Have Passed Type Test as Follows:
HUMIDITY: 0 to 95% relative humidity.
VIBRATION: MIL-STD-167 and MIL-E-5400, CURVE I, with isolators.
SHOCK: MIL-T-21200, and MIL-E-5400 (30 G's).
ELECTROMAGNETIC COMPATIBILITY (EMC): MIL-I-6181D and MIL-STD-461, Class A.
ALTITUDE: Frequency change is $> 5 \times 10^{-11}$ from 0 to 40,000 ft.
FREQUENCY STABILITY DUE TO:
Magnetic Fields: $< 5 \times 10^{-12}$ for 1 gauss dc change or 1 gauss peak ac, 60 ±10% Hz and 400 ±10% Hz.
Line Voltage: $< 4 \times 10^{-12}$ over specified input range.

MATING CONNECTORS:

EXT DC input: HP 1251-0126 (5-contact), Cannon MS 3106E-14S-5S (Series ME) furnished.

POWER: 115 or 230 Vac ±10%, 50 to 400 Hz, or 23 to 30 Vdc.
Approx. power required:

	24 Vdc	115 Vac
Without Options	35 W	49 W
Option 001 (Add)	7.5 W	10 W
Option 002 (Add)	0 W	6 W
Option 003 (Add)	7.5 W	16 W

WEIGHT: Net, 34 lb (15,4 kg). Shipping, 51 lb (23,5 kg). Option 001, add 2 lb (0,9 kg). Option 002, add 3.5 lb (1,6 kg).

WARRANTY: 1 year, except 3 years for RVFR.

Table 1-3. Specifications (Continued)

OPTION 001 TIME STANDARD

CLOCK PULSE:
Rate: 1 pulse per second. **Rise Time:** <50 ns.
Fall Time: <1 μs. **Amplitude:** +10V peak ±10%
Jitter: 5 ns rms are with 50Ω load. **Width:** 20 μs min. All specs **Output:** Front-panel BNC.

SYNCHRONIZATION: Automatic to 10 ±1 μs, delayed from reference input pulse (rear BNC). Manual adj. to ±50 ns. Reference pulse must be >+5 v with a rise time <50 ns and width >0.5 μs.

CLOCK MOVEMENT: 24-hour LED Digital Clock.

OPTION 002 STANDBY POWER SUPPLY

CAPACITY: 10-minute minimum at 25° C after full charge (incl. Option 001).

CHARGE CONTROL: Front panel, Fast Charge-Float-Reset switch.

INDICATOR: A front-panel light flashes when ac power is interrupted and battery is being used. A continuous light indicates a fast charge condition.

OPTION 003

Combines Options 001 and 002

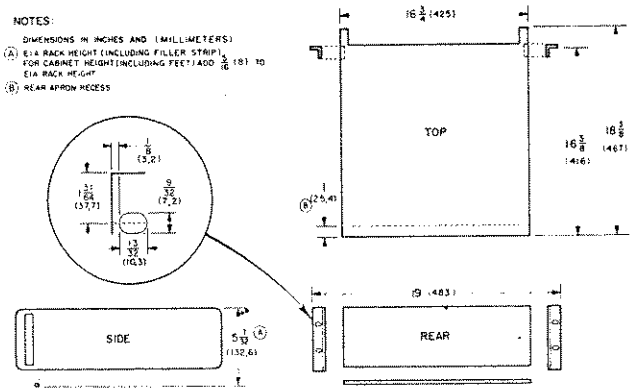
PERFORMANCE OF QUARTZ OSCILLATOR ONLY
(Rubidium Control Loop Open)

AGING RATE: $< \pm 5 \times 10^{-10}$ per 24 hours.

FREQUENCY ADJUSTMENTS:
Fine Adjustment: 5×10^{-8} range, with dial readings of parts in 10^{10}.
Coarse Adjustment: 1 part in 10^6, screwdriver adjustment at front panel.

STABILITY:
As a Function of Ambient Temperature: Frequency change is less thatn 2.5×10^{-9} total from 0° to +50° C.
As a Function of Load: $\pm 2 \times 10^{-11}$ from open circuit to short, 50ΩR, L, or C load change.
As a Function of Supply Voltage: $\pm 5 \times 10^{-11}$ for 23 to 30 Vdc from 26 Vdc reference, or for 115/230 Vac ±10%.

DIMENSIONS:



SECTION II

INSTALLATION

2-1. UNPACKING AND INSPECTION

2-2. If the shipping carton is damaged, ask that the carrier's agent be present when the instrument is unpacked. Inspect instrument for damage (scratches, dents, broken knobs, etc.). If instrument is damaged or fails Performance Check, notify the carrier and the nearest Hewlett-Packard Sales and Service office immediately (Sales and Service Offices listed inside back cover). Retain the shipping carton and the padding material for the carrier's inspection. The office will arrange for repair or replacement without waiting for the claim against the carrier to be settled.

2-3. STORAGE AND SHIPMENT

2-4. Environment

2-5. Temperatures during storage and shipment should be limited as follows:

a. Maximum temperature: +75° C (165° F), +50° C (122° F) with Options 001, 002, or 003. Longterm storage +35° C (95° F).

b. Minimum temperature: -40° C (-40° F).

NOTE (Option 002 Only)

When placing the 5065A in storage, remove the top cover and momentarily remove fuse F4 located directly over the battery. Replace the fuse. When ac power is reapplied, the battery will be automatically switched into the circuit.

2-6. Extended Storage

2-7. If the Model 5065A is to be stored for an extended period (longer than 2 months) or if immediate operation is required after storage, then RVFR tube should have power applied to it for the duration of the storage as described in the following procedure.

2-8. RVFR Storage Procedure

a. Remove all power from 5065A and remove bottom cover.

b. Disconnect the red and black twisted pair of wires from XA4(1) and XA8(1) respectively.

c. Obtain a current-limiting power supply capable of producing 100 milliamps (power supply voltage is not important).

d. Before turning on power supply, place a short across its output terminals.

e. Connect the power supply as shown in Figure 2-1. The short should remain in place on the power supply output.

f. Set power supply voltage and current controls to minimum position. The precautions of steps d, e, and f are to prevent the filter capacitor on the power supply output from discharging into the RVFR.

g. Turn on Power Supply and adjust voltage high enough so output current can be set with current-limit control. Read current on power supply meter.

h. Set current-limit control so supply output current is 100 mA.

i. Reduce voltage control setting so that it is just above the point where further reduction would reduce the power supply output current.

j. Recheck polarity of power supply connection to red and black wires. This must be properly connected.

k. Remove short from power supply output to allow current to flow into the RVFR. Adjust power supply voltage and/or current limit to bring current to 100 mA.

l. The power supply should remain connected for the duration of storage.

2-9. When the 5065A is to be operated again:

1. Disconnect the power supply and reconnect RVFR red wire to XA4(1) and the black wire to XA8(1). Check POLARITY.

2. Apply power to the 5065A. Follow turn-on procedure in Section III.

2-10. Packaging

2-11. To protect valuable electronic equipment during storage or shipment always use the best packaging methods available. Your Hewlett-Packard Sales and Service office can provide packing material such as that used for original factory packaging. Contract packaging companies in many cities can provide dependable custom packaging on short notice. Here is a recommended method:

2-12. The original packaging procedure is to:

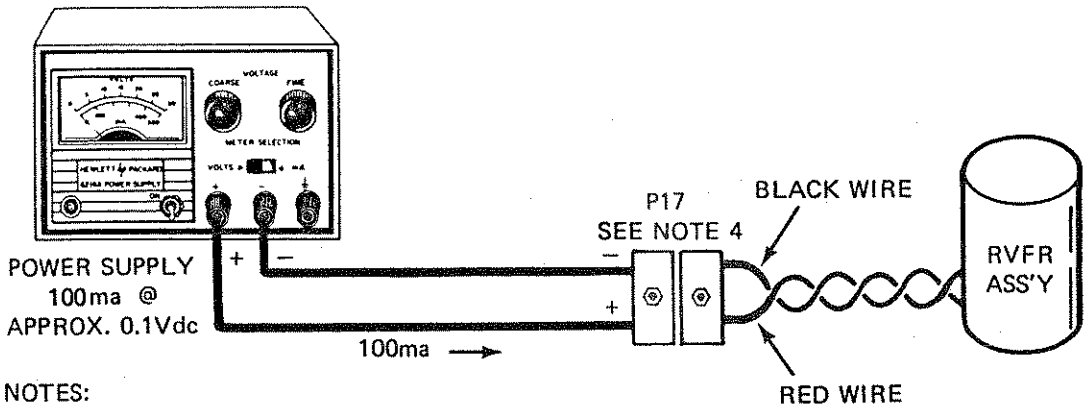
a. Wrap the instrument in large plastic sheet or bag.

b. Place the wrapped instrument into a "same-size" carton (HP Part No. 9211-1102).

c. When the carton is sealed, install 4 polyurethane foam, post-packs (HP Part No. 9220-1316) on each corner of the carton.

d. Install boxed instrument into the final cardboard outer carton (HP Part No. 9211-1101) seal effectively and label properly.

Figure 2-1. Electrical Hookup for RVFR Storage



NOTES:

1. Only red and black wires need be connected to power.
2. Be sure polarity is correct: RVFR "red.. wire is positive (+), and "black" is negative.
3. Nominal voltage at red and black wires will be approximately 0.1 VDC.
4. See Note on Figure 3-1.

2-13. Alternate methods which provide effective protection for the instrument can also be used, however, the previously described method is considered the better one.

2-14. ELECTRICAL CONNECTIONS

2-15. Power Connection

CAUTION

The Model 5065A has the negative side of its power supply grounded. When operating with auxiliary equipment such as an external battery or clock, check to ensure that the equipment can be connected together.

2-16. LINE VOLTAGE. The Model 5065A can be operated from either 115- or 230-volt (±10%) ac power lines. A slide switch on the rear panel permits quick conversion for operation from either voltage. Insert a narrow-blade screwdriver in the switch slot and set the switch to expose the correct numbers to correspond to the line voltage used (Table 2-1). The instrument is supplied with a 115-volt fuse; change this fuse for 230-volt operation (Table 2-1).

IMPORTANT

Before connecting ac power to the instrument, be certain slide switch is properly positioned for 115 or 230 volt operation.

Table 2-1. 115/230 Volt Conversion

Conversion	115 Volts	230 Volts
Slide Switch	Right	Left
AC Line Fuse	1A slo-blo	0.5 A slo-blo

2-17. POWER CABLE. The Model 5065A is equipped with a detachable three-conductor power cable. Install as follows:

a. Connect the round, three-conductor female plug to the ac line jack on the instrument rear panel.

b. Connect male plug (two-blade with round grounding pin) to three-conductor (grounded) outlet. Exposed portions of the instrument are grounded through the round pin for safety; when only two-conductor outlets are available, use connector adapter (HP Stock No. 1251-0048) and connect short wire from adapter to a suitable ground.

2-18. Mating Connectors

2-19. Table 2-2 lists the Model 5065A front and rear panel connectors and their respective mating connectors. Not all connectors listed are shipped with the instrument but are included in the table as useful information for installation.

2-20. OPERATION AS BENCH OR RACK INSTRUMENT

2-21. The Model 5065A is shipped from the factory ready for operation as a bench instrument. Parts necessary to convert the instrument for operation as a rack-mounted instrument are not supplied. When orderd separately, Rack Mounting Kit is available by ordering HP Part No. 5060-8740. To convert for rack operation, refer to Figure 2-1 and proceed as follows:

a. Remove feet (press the foot-release button, slide foot forward toward center of instrument, and lift off).

b. Remove adhesive-backed trim strips on sides, just behind front handles.

c. Attach filler strip along bottom edge of front panel.

d. Attach mounting brackets to sides (larger corner notch toward bottom of instrument, see Figure 2-2). Instrument is now ready to mount in standard 19-inch rack.

2-22. INSTALLATION LOCATION

2-23. The Rb^{87} absorption cell in the RVFR Assembly A12 is slightly sensitive to external magnetic fields. Avoid installing this instrument near large motor-generators, transformers, or other equipment which radiate strong magnetic fields of 2 Gauss or more.

Figure 2-2. Conversion for Rack Mounting

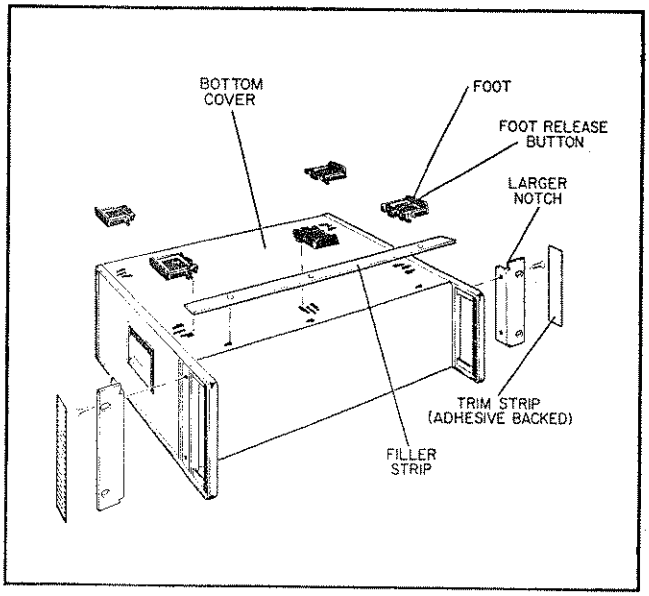


Table 2-2. Mating Connectors

Connector Description	Connector HP Part No.	Mating Connector HP Part No.	Mating Connector Description
Rear BNC Female jack (J1, 2, 3, 4, 5)	1250-0140	1250-0061*	BNC male plug, UG88/U
EXT DC, 5-pin male jack (J9)	1251-0111	1251-0126	5-pin female plug
AC LINE, 3-pin male jack (J8)	1251-1458	1251-2457	3-pin female plug
Front Panel OUTPUT Signal jacks (J10, 11, and 12)	1250-0102	1250-0061*	BNC male plug, UG88/U
1 PPS, BNC jack (J14) Option 001 only	1250-0102	1250-0061*	BNC male plug, UG88/U
*These connectors not shipped with the instrument.			

SECTION III

OPERATION

3-1. INTRODUCTION

3-2. This section provides operating procedures for the 5065A Rubidium Vapor Frequency Standard. Tables 3-1 and 3-2 gives the basic turn-on procedure. Figures 3-9, 3-10, and 3-11 explain front, top, and rear controls and connectors.

3-3. OPTIONS 001 AND 002 (Option 003 = 001 and 002)

3-4. Operating procedures for Option 001 (Time Standard) and Option 002 (Standby Power Supply) are covered in Paragraphs 3-19 through 3-31.

3-5. OPERATING PROCEDURE

3-6. General

3-7. In instruments equipped with Option 002, Standby Power Suply, remember that the internal standby battery is fully discharged when delivered and must be brought to full charge (16 hours minimum) before it can deliver rated standby power. Battery charging instructions are included in Figure 3-2, Turn-On Procedure. For more standby power, available accessories are the HP Model 5085A Standby Power Supply or HP Model K02-5060A Power Supply.

3-8. Turn-On Procedure (see Figure 3-2)

3-9. Turn-On After Long Storage

If the 5065A has been in storage for longer than 2 months, there is a possibility of cell flooding occurring in the RVFR tube. If after 1 hour of warm-up from initial turn-on no 2nd harmonic is present, then cell flooding can be suspected. The following procedure should be used to incorrect cell flooding.

a. Remove all power from 5065A and remove bottom cover.

b. Disconnect the red and black twisted pair of wires from XA4(1) and XA8(1) respectively.

c. Obtain a current-limiting power supply capable of producing 1 amp (power supply voltage is not important).

d. Before turning on power supply, place a short across its output terminals.

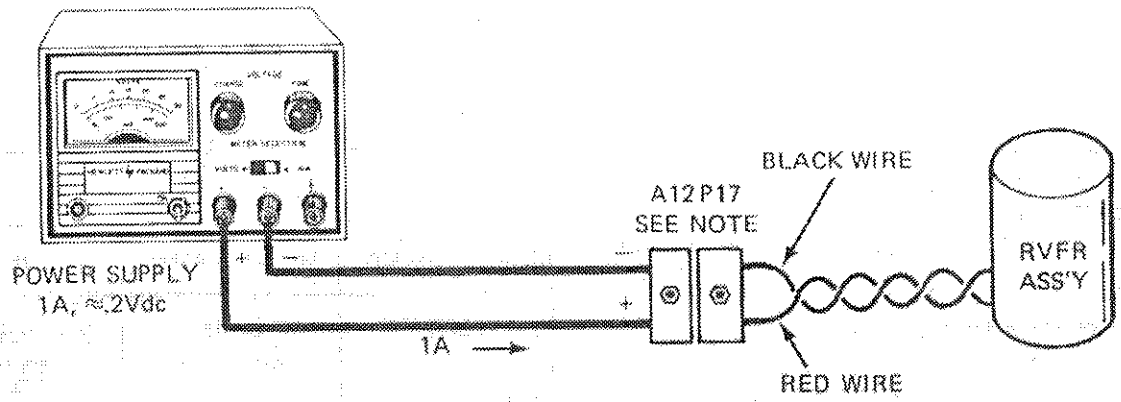
e. Connect the power supply as shown in Figure 3-1. The short should remain in place on the power supply output.

f. Set power supply voltage and current controls to minimum position. The precautions of steps d, e, and f are to prevent the filter capacitor on the power supply output from discharging into the RVFR.

Table 3-1. Operating Checks

CIRCUIT CHECKS		
Switch Position	Meter Indication	Description
BATTERY	35-45 Option 002)	Indicates battery voltage
SUPPLY	38 - 42	Indicates +20 volts regulated supply
LAMP OVEN	10 - 45	Indicates power to lamp oven in RVFR
CELL OVEN	10 - 45	Indicates power to absorption cell oven in RVFR
OSC OVEN	25 - 50	Indicates power to quartz OSC oven
PHOTO I	25 - 50	Indicates RVFR output current
5 MHz	35 - 45 (no load)	Indicates 5 MHz output level
CONTROL	-50 to +50	Indicates dc control voltage to quartz oscillator
ERROR	0	Indicates frequency difference between RVFR and microwave field as a dc voltage
2ND HARMONIC	20 - 50	Indicates 2ND HARMONIC level
1 MHz	38 - 42 (no load)	Indicates 1 MHz output level
100 kHz	38 - 42 (no load)	indicates 100 kHz output level

Figure 3-1. RVFR Pumping



NOTE: Instruments serial number 1732A00791 and above do not have the P17/J17 connector but have the cable soldered. In this case, disconnect the wires and connect directly to the power supply. Mating Connector for P17 is HP Part No. 1251-1113 (Winchester Part No. JF1P-1-SA).

g. Turn on Power Supply and adjust voltage high enough so output current can be set with current-limit control. Read current on power supply meter.

h. Set current-limit control so supply output current is 1A.

i. Reduce voltage control setting so that it is just above the point where further reduction would reduce the power supply output current.

j. Recheck polarity of power supply connection to A12P17. This must be properly connected.

k. Remove short from power supply output to allow current to flow into the RVFR. Adjust power supply voltage and/or current limit to bring current to 1A.

l. Reconnect 5065A to AC line. Set front panel MODE switch to LOOP OPEN, meter switch to 2nd HARMONIC. Allow power supply and 5065A to operate continuously.

m. Within 12 to 48 hours signal should begin to appear on 2ND HARMONIC meter. NOTE: the quartz oscillator on the 5065A must be within about 1×10^{-7} of 5 MHz for the signal to appear. If possible, set the 5065A oscillator against a reference standard before proceeding.

n. Check 2ND HARMONIC meter readings twice per day until reading is greater than 10 or reaches a maximum. If this does not occur within 15 days then cell flooding is not the problem.

o. When checking 2ND HARMONIC meter reading also record meter reading in PHOTO I position.

p. When 2ND HARMONIC reading is maximum o greater than 10, remove power from 5065A. Remove powe supply connection, and reconnect red wire to XA4(1) and the black wire to XA8(1).

q. Replace bottom cover and reconnect AC powe to 5065A. The 5065A internal circuit will now optimiz the rubidium in the RVFR. Operate the 5065A contin uously for about 1 week. The 2ND HARMONIC readin should stabilize. If the meter stabilizes at greater than 2 the instrument can be returned to service. If the readin is less than 25 perform adjustments described in para graphs 5-24 thru 5-31 in the 5065A Operating and Servic Manual.

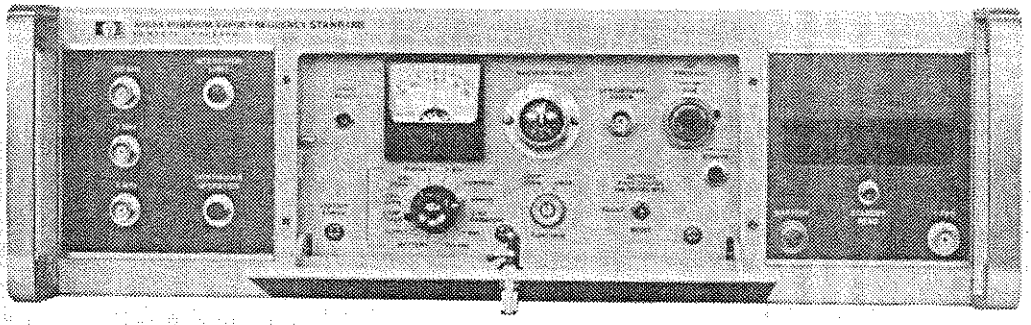
3-10. FREQUENCY OFFSET AND CALIBRATION

3-11. The Rubidium Vapor Frequency Standard is secondary frequency standard with a specified long ter stability drift less than 1 part in 10^{11} per month.

3-12. Over a period of time, it may be necessary t check the offset that has accrued since last calibratio and recalibrate the instrument to a primary frequenc standard.

3-13. Frequency adjustment can be made after dete mining the frequency error with respect to a referenc Front panel MAGNETIC FIELD control is then adjuste tod correct any frequency offset.

Figure 3-2. Turn-On Procedure



1. Set rear 115/230 Vac switch to correspond with line voltage used.

2. Check that function switch is set at OPER and OSC FREQ FINE is set at 250. It should remain in this position during normal operation.

3. Connect ac power cord (supplied) between rear ac jack and ac line power.

4. On units equipped with Option 002, Standby Power Supply, press BATTERY switch to RESET; then switch to FAST CHARGE. Note that BATTERY lamp comes on. If ac line power fails, the BATTERY lamp will pulse.

5. Allow 1-hour warmup and then press START/AUTO to START momentarily. In units equipped with Option 001, a mechanical lock prevents placing this switch at AUTO START.

6. Press LOGIC RESET. CONTINUOUS OPERATION lamp should come on to indicate that frequency-stabilizing feedback loop is locked. If not, refer to Section V. Use 50 Ω load on outputs.

7. Rotate CIRCUIT CHECK (all positions) and check for meter readings (Table 3-1). If readings do not check out, refer to troubleshooting information in Section V. Note: After a 1-hour warmup, the 5065A is within approximately 1 part in 10^{10} of the UTC Time Scale and within approximately 5 parts in 10^{11} after 4 hours.

NOTE

If CONTINUOUS OPERATION lamp goes off after instrument has warmed up, the CIRCUIT CHECK meter switch should be set to the LAMP OVEN and CELL OVEN positions. If either meter indication is full scale, the instrument should be turned off immediately. If not the RVFR assembly could be damaged.

8. Let the 5065A battery continue to fast charge for a total of 16 hours. At the end of this time, set BATTERY switch to FLOAT for a continuous trickle charge

9. After 24 hours running time, thermal equilibrium is established and meter readings are stabilized. Rotate CIRCUIT CHECK switch through all positions and record readings on the door chart.

10. See Paragraph 5-7 for periodic adjustments.

Table 3-2. Front Panel Lamp Indications

FRONT PANEL LIGHTS		DESCRIPTION
INTEGRATOR LIMIT	CONTINUOUS OPERATION	
OFF	ON	Indicates Normal Operation
ON	ON	Indicates quartz oscillator is locked to resonant frequency of RVFR but oscillator has exceeded one-half its control range. To correct this proceed as follows: 1. Set CIRCUIT CHECK switch to CONTROL. 2. Adjust OSC FREQ ADJ COARSE control for zero on CIRCUIT CHECK meter. NOTE: this adjustment may cause CONTINUOUS OPERATION lamp to go off. If this occurs, momentarily press LOGIC RESET button. CONTINUOUS OPERATION lamp should come on and stay on.
ON	OFF	Indicates one of the following troubles: 1. Quartz oscillator control limit has been exceeded. To correct, set CIRCUIT CHECK to CONTROL, adjust OSC FREQ ADJ COARSE for zero on CIRCUIT CHECK meter, then momentarily press LOGIC RESET. 2. Synthesizer Assembly A1 failure.
OFF	OFF	Press LOGIC RESET switch. If CONTINUOUS OPERATION lamp does not come on, look for one or more of the following troubles: 1. Quartz oscillator not locked to Rubidium resonance. 2. 2nd harmonic signal too low. 3. Fundamental signal too high. 4. Cell or lamp ovens not operating normally. Check CELL OVEN and LAMP OVEN on CIRCUIT CHECK meter. If meter is maximum TURN INSTRUMENT OFF. 5. Synthesizer failure. 6. FUNCTION switch not set to OPER.

3-14. The two following calibration technique measures the changing phase relationship between the 5065A 5 MHz output and a primary frequency standardd (HP 5061A Cesium Beam Frequency Standard or equivalent) 5 MHz output over an 8-hour period. Either procedure may be used and both are equally accurate. The phase change is converted to frequency error and the necessary MAGNETIC FIELD adjustment is set in.

3-15. The procedure is divided into two parts; Table 3-9 lists recommended test instruments and equipment. However, items with equivalent specifications may be substituted.

a. Calibrating the measurement system.

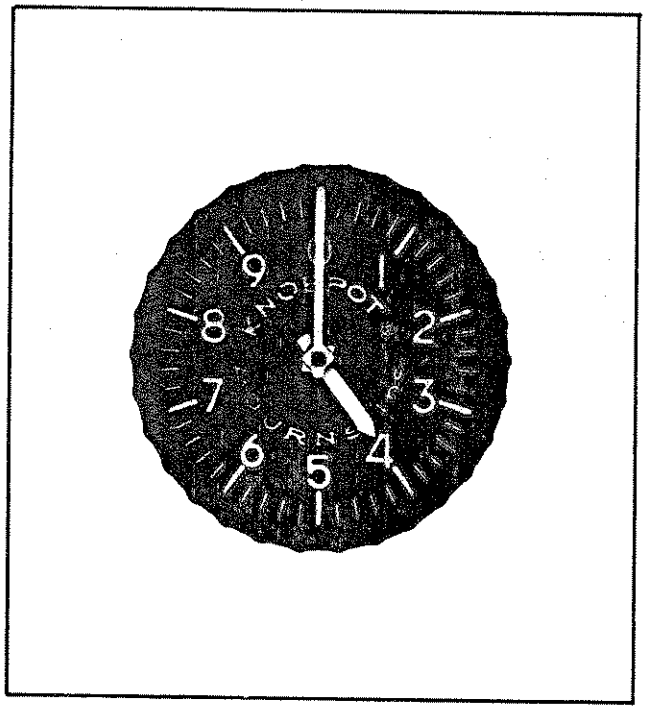
b. Performing the error measurement.

3-16. Calibrating the Measurement System: To calibrate the system for phase error measurement, proceed as follows:

a. Connect equipment as shown in Figure 3-5.

b. Set HP 8405A FREQ RANGE to agree with input frequency (5 MHz).

Figure 3-3. Magnetic Field Control



c. Zero HP 8405A PHASE meter by cranking in necessary offset with METER OFFSET control and the red ZERO knob.

d. With the meter zeroed, set the RANGE switch at +6. Recenter the PHASE meter with the red ZERO knob.

e. Set strip chart recorder range to .5 volt. Set pen to chart scale center with recorder zero control.

f. Set HP 8405A phase range to ±180 and change METER OFFSET by +180°.

g. Adjust 10k ohm pot for full scale pen deflection on recorder.

h. Change METER OFFSET polarity to (-) using the center knob of the METER OFFSET CONTROL. Pen should move to opposite chart edge. Make required fine adjustments to record zero and 10k pot for full scale chart deflection. The recorder is now calibrated for 360° or 0.2μsec full scale.

3-17. Frequency Difference Measurement: To perform the frequency difference measurement, proceed as follows:

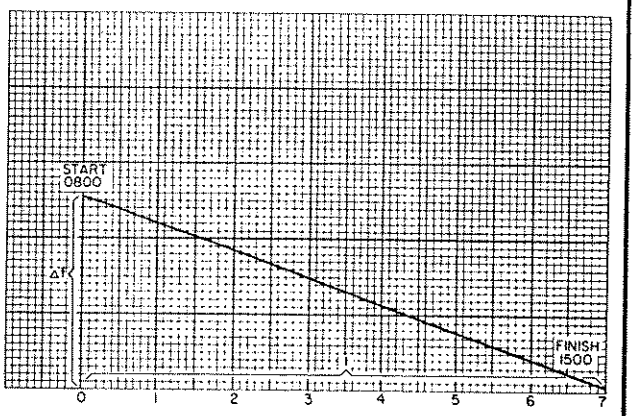
a. Connect equipment shown in Figure 3-6.

b. Set HP 8405A Vector Voltmeter PHASE RANGE to 180° and METER OFFSET switch to 0.

c. Determine frequency error Δf/f using the relationship $\frac{\Delta t}{t} = \frac{\Delta f}{f}$.

d. Since chart calibration is 0.2 μsec full range (at 5 MHz), error in proportional parts can be determined from the strip chart record as illustrated in Figure 3-4.

Figure 3-4. Error Measurement



Example: Assume instrument under test has a phase change (over a 7-hour measurement period) of 0.1μsec (recorder half scale)

$$\frac{\Delta t}{t} \quad \frac{0.1\mu s}{7\ \text{hrs.}} \quad \frac{1 \times 10^{-7}\text{s}}{2.52 \times 10^{4}\text{s}} = 3.96 \times 10^{-12}\ \text{freq. diff.}$$

e. Since one minor division of the MAGNETIC FIELD adjustment changes the 5065A frequency by 4 parts in 10^{12}, in Figure 3-4, the dial would be changed one minor division. During the phase measurement a cw movement of the HP 8405A phase meter indicates the 5065A frequency is higher than the reference standard and a ccw movement indicates the frequency is lower than the reference. If the MAGNETIC FIELD adjustment is at the end of the range:

1. Set the Magnetic Field adjustment to 5.00 and measure the frequency offset again. This is the "desired change in offset" Item 2 in Table 3-4. See Table 3-6 for an example of this calculation.

f. Increasing the MAGNETIC FIELD setting increases the 5065A frequency and decreasing this setting lowers it. Make this adjustment as required to align the 5065A with the reference standard.

g. After the MAGNETIC FIELD control has been reset, another phase comparison will show if the adjustment is correct, or if another adjustment is needed.

3-18. FREQUENCY COMPARISON USING K34-59991A LINEAR PHASE DETECTOR

a. Connect the K34-59991A OUTPUT terminals to a HP 680 Strip Chart Recorder or equivalent. Set recorder for 1V full scale and 1 in./hr. and turn on recorder.

b. Connect K34-59991A to line power and turn on the power switch.

Table 3-3. Frequency Offset Change Instructions

1. Remove instrument top cover and note setting of TIME SCALE thumbwheel and position of HI-LO switches. Record this information in Item 1.

NOTE

Be certain to include the correct algebraic sign (+ or -) with the numbers used in the following calculations.

2. Locate thumbwheel switch setting in Table 3-7 and record the corresponding Offset $\times 10^{-10}$ value in Item 1 under Offset ($\times 10^{-10}$).

3. Record the desired change in offset under Item 2 in the space provided.

4. Algebraically add the sum of Item 1 and Item 2 (Offset $\times 10^{-10}$) and record the total in Item 3.

5. Locate the nearest Offset $\times 10^{-10}$ in Table 3-7 that corresponds to the total offset recorded in Item 3. Record this offset, its corresponding TW switch setting, and HI-LO switch setting under Item 4 in the appropriate spaces provided.

6. Algebraically subtract Item 4 from Item 3 and record this remaining Frequency Offset in Item 5.

7. Divide the remainder recorded in Item 5 by 2 and record the answer in Item 6.

NOTE

The division in Step 7 is performed to convert the frequency offset to be corrected by MAGNETIC FIELD ADJUSTMENT into front panel MAGNETIC FIELD control setting.

8. Note present front panel MAGNETIC FIELD control setting and record this setting in Item 7.

9. Algebraically add the new MAGNETIC FIELD control setting from the setting recorded in Item 7. Record this total in Item 8.

NOTE

If the addition performed in Step 9 gives a negative number or a number greater than 10, the synthesizer setting selected in Item 4 must be changed. Select the adjacent offset from Table 3-7 closest to total offset recorded in Item 3, and record this new information in Item 4. Repeat Steps 5 through 9 using the new data. (See example, Table 3-4.)

10. Record Item 4 and Item 8 information in spaces provided under Item 9.

11. Set Synthesizer Assembly A1, TIME SCALE thumbwheel switch to the new setting recorded in Item 9a.

12. Set Synthesizer Assembly A1, HI-LO switch to the position recorded in Item 9b. Replace instrument top cover.

13. Adjust front panel MAGNETIC FIELD control to the setting recorded in Item 9c. Then perform Frequency Offset and Calibration (paragraph 3-10) again to align the 5065A with the reference standard.

14. Set front panel CIRCUIT CHECK switch to CONTROL and slowly adjust OSC FREQ COARSE control for CIRCUIT CHECK meter indication of "0".

15. If CONTINUOUS OPERATION lamp is off, wait 2 minutes, then momentarily press front panel LOGIC RESET button. CONTINUOUS OPERATION lamp should come on and stay on. The 5065A offset has been changed and the instrument is operating normally.

Table 3-4. Typical Frequency Offset Change, Sample (Insufficient MAGNETIC FIELD Control)

ITEM	OFFSET ($\times 10^{-10}$)	TW SWITCH SETTING	HI-LO SWITCH
1. Present synthesizer Assy TIME SCALE settings (see Table 3-7 for corresponding frequency offset)	-163.770	8619	HI
2. Desired change in Offset	-1×10^{-9}		
3. Sum (Item 1) + (Item 2)	-173.770		
4. Nearest synthesizer setting (Table 3-8)	-172.789	8238	HI
5. Remaining offset to be adjusted by MAGNETIC FIELD control	-.98	(-173.770) - (-172.789) (Item 3) - (Item 4)	
6. Change required in MAGNETIC FIELD control setting	-.49	Item 5 / 2	.98 / 2
7. Present MAGNETIC FIELD control setting	5.00		
8. New MAGNETIC FIELD control setting	4.51	(-.49) + (5.00)	
9. New offset settings are:			
a. Synthesizer TW switch		Item 4	8238
b. Synthesizer HI-LO switch		Item 4	HI
c. MAG FIELD control		Item 8	4.51

Figure 3-5. Equipment Setup for Calibrating Phase Measurement System

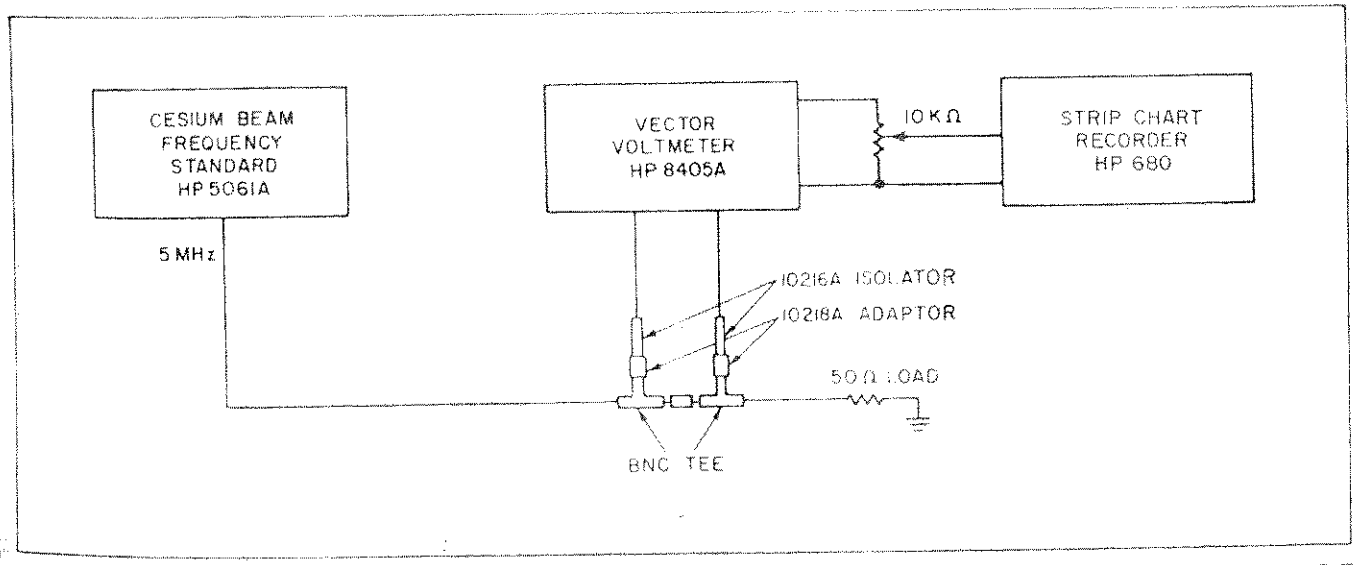
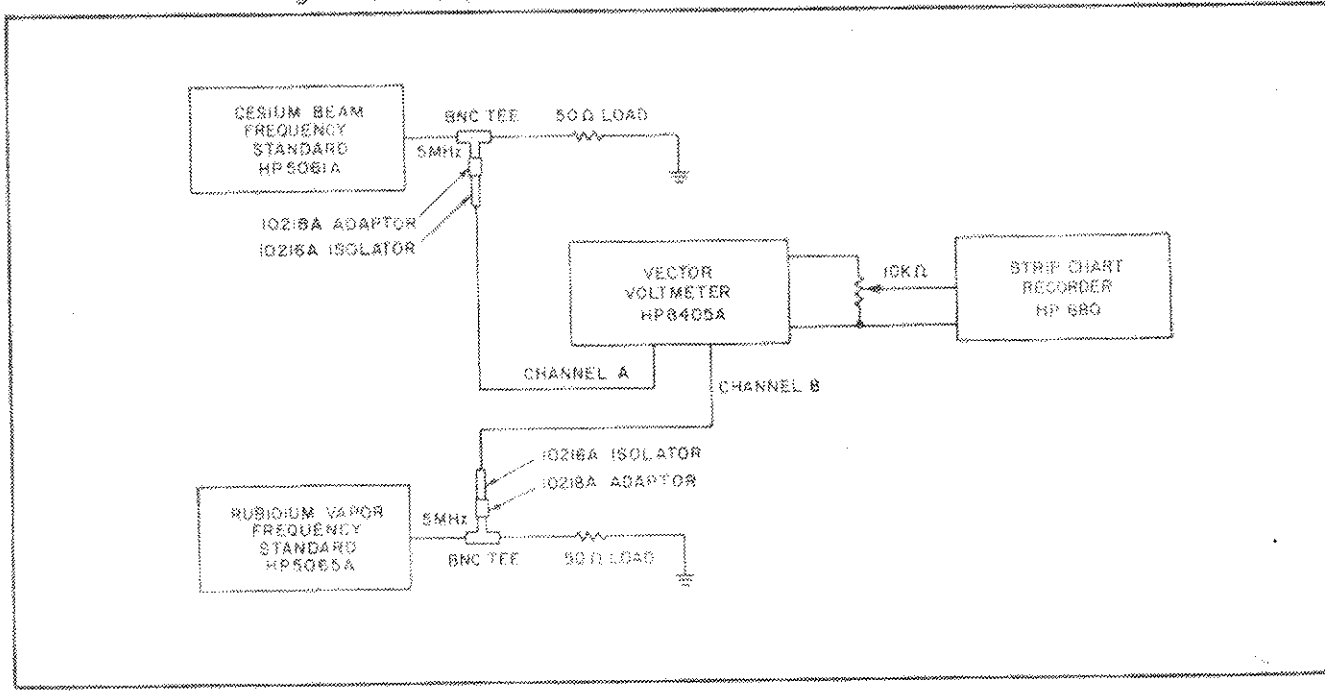


Table 3-5. Typical Frequency Offset Change, 0×10^{-10} Offset to -300×10^{-10}

ITEM	OFFSET ($\times 10^{-10}$)	TW SWITCH SETTING	HI-LO SWITCH
1. Present synthesizer Assy TIME SCALE settings (see Table 3-9 for corresponding frequency offset)	_____	_____	_____
2. Desired change in offset	_____		
3. Sum (Item 1) + (Item 2)	_____		
4. Nearest synthesizer setting (Table 3-8)	_____	_____	_____
5. Remaining offset to be adjusted by MAGNETIC FIELD control	_____	(Item 3) - (Item 4)	
6. Change required in MAGNETIC FIELD control setting	_____	$\frac{\text{Item 5}}{2}$	
7. Present MAGNETIC FIELD control setting	_____		
8. New MAGNETIC FIELD control setting	_____	Item 6) + (Item 7)	
9. New offset settings are:			
a. Synthesizer TW switch		Item 4._____	
b. Synthesizer HI-LO switch		Item 4._____	
c. MAG FIELD control		Item 8._____	

Figure 3-6. Equipment Setup for Frequency Difference Measurement



c. Connect a reference 5 MHz to INPUT A and the 5065A 5 MHz output to INPUT B.

d. Set "Zero-Oper-Full" front panel mounted toggle switch to "Zero". Adjust "Zero Scale" control for a zero scale trace on recorder.

e. Set switch to "Full" and adjust "Full Scale" control for a full scale trace on recorder.

f. Check both "Zero" and "Full Scale" outputs and readjust if necessary.

g. The recorder will now provide a continuous record of frequency comparison and will be automatically reset when the recorder pen reaches zero or full-scale position.

h. With the recorder set for 1 volt full scale and 1 in./ hr., the phase difference recorder will be 0.2 μsec full scale with 5 MHz inputs. See Figure 3-4 for an example of a frequency difference measurement under these conditions.

3-19. OPERATION WITH TIME STANDARD OPTION 001 (or 003)

3-20. Option 001 provides Model 5065A with a one pulse-per-second clock output. The divider drive is an internally connected 1 MHz signal from A6 frequency Divider Assembly. TIME DELAY controls are located on the A5 Assembly and can be seen with the top cover removed. The TIME DELAY six thumbwheel switch controls the phase of the clock-pulse output from 1 microsecond to 1 second with respect to an external reference. The 0-1 microsecond TIME DELAY screwdriver adjustment allows fine adjustment over any 1 microsecond portion of the thumbwheel settings.

3-21. The time standard option includes a 24 hour, LED digital clock assembly (A19) which indicates time in hours, minutes and seconds. The SYNC button on Divider Assembly A5 enables the instrument to synchronize to an external reference standard. The digital clock is set by pressing the SET pushbutton, SLOW/FAST switch and HOLD pushbutton (located on rear of clock).

3-22. SETTING THE CLOCK PHASE TO AN EXTERNAL CLOCK

3-23. The phase difference between the 5065A 1-PPS output and an external reference clock may be set to any desired point between coincidence and 1 second by using the following procedure. The technique used will depend on the Model 5065A application and individual user requirements.

3-24. Automatic Synchronization

3-25. To automatically synchronize the 1-PPS output pulse and the internal clock drive with an external 1-PPS reference, proceed as follows:

a. Remove the top cover for access to TIME DELAY controls.

b. Rotate the 0-1 sec TIME DELAY control maximum cw for minimum delay (do not overtighten).

c. Set the TIME DELAY thumbwheel switches for the desired time delay of the clock pulse. The thumbwheel switches read directly. However, there is a 9-11 μsec built-in delay in the digital divider circuit which should be added to the time-delay calculation.

d. Connect the reference pulse to the rear SYNC INPUT jack (must be greater than +5V with less than 50 nanoseconds rise-time and a width greater than 0.5 μsec.

e. Press SYNC pushbutton on A5 Assembly and hold down at least 1-second. The next tick of the clock output will be delayed according to the setting of the thumbwheel switches (plus the 9 to 11 μsec built-in delay). For more precise adjustment of time delay, the 0-1 μsec TIME DELAY provides continuous delay adjustment from 0-1 μsec.

f. When the clock pulse is synchronized, the digital clock will advance in synchronism with the instrument 1PPS.

g. For a delay of less than 10 μsec, the thumbwheel switches are first set at 999.999. Then the thumbwheel setting is decreased as required and final adjustment is made with the 0 to 1 μsec TIME DELAY control. Use an arrangement like that of Figure 3-8 to accurately measure time intervals between the two 1-PPS pulses. For short delay intervals, use an oscilloscope. For longer delay intervals, use the optional counter arrangement.

3-26. Manual Synchronization

3-27. If the reference pulse does not meet the requirements for sync operation (>+5V, <50 nanosecond rise time, and width >0.5 μsec), use the technique of Figure 3-8 to measure time intervals. Set time delay of the 5065A 1-PPS output as required with the TIME DELAY thumbwheel switches and 0-1 μsec control. For small delay intervals, use an oscilloscope. For larger delay intervals, use the optional counter arrangement.

3-28. Setting the Clock

a. Remove top cover.

b. Set hours, minutes, and seconds by placing the SLOW/FAST toggle switch at FAST, and momentarily depress the SET pushbutton for rapid advance of the display. Place toggle switch to SLOW and press SET pushbutton for slow advance of the display.

c. Set seconds on the display slightly ahead of the reference clock, and then press the HOLD pushbutton. Release HOLD pushbutton when reference clock time is identical to the digital clock.

d. Replace the instrument top cover.

Table 3-6. Offset Frequency Settings

Offset ($\times 10^{-10}$)	Synthesizer Thumbwheel Setting	Synthesizer Frequency	HI-LO Switch Setting
-1000.619	9348	5314417.18	LO
-986.784	9189	5314426.63	
-977.485	9030	5314432.99	
-970.804	8871	5314437.56	
-958.700	8394	5314445.83	
-950.573	7758	5314451.38	
-940.729	5691	5314458.11	
-930.051	9841	5314465.41	
-911.851	7472	5314477.85	
-903.502	8267	5314483.55	
-893.419	8744	5314490.45	
-888.110	8903	5314494.07	
-881.000	9062	5314498.93	
-870.988	9221	5314505.78	
-855.841	9380	5314516.13	
-844.926	8919	5314523.59	
-840.537	8458	5314526.59	
-830.246	9539	5314533.62	
-817.281	8776	5314542.46	
-809.448	9237	5314547.84	
-800.445	8935	5314553.99	
-789.990	8029	5314561.14	
-777.700	9698	5314569.54	
-763.045	8347	5314579.55	
-754.607	8951	5314585.32	
-745.271	9253	5314591.70	
-737.056	8808	5314597.32	
-723.264	9555	5314606.74	
-712.141	8522	5314614.34	
-707.350	8967	5314617.62	
-695.305	9412	5314625.85	
-685.873	8681	5314632.30	
-678.286	9269	5314637.48	
-666.835	9126	5314645.31	
-658.605	8983	5314650.93	
-647.504	8697	5314658.48	
-640.497	8411	5314663.31	
-630.506	7696	5314670.14	LO
-621.028	5980	5314676.62	
-608.302	9857	5314685.31	
-591.175	7013	5314697.02	
-582.542	8014	5314702.92	
-572.122	8586	5314710.04	
-562.949	8872	5314716.31	
-556.364	9015	5314720.81	
-547.544	9158	5314726.84	
-535.114	9301	5314735.34	
-526.775	8745	5314741.04	
-516.291	9444	5314748.20	
-502.712	9031	5314757.48	
-497.249	8618	5314761.22	HI

Offset ($\times 10^{-10}$)	Synthesizer Thumbwheel Setting	Synthesizer Frequency	HI-LO Switch Setting
-484.432	9587	5314769.98	HI
-472.694	8491	5314778.00	
-468.270	8904	5314781.02	
-458.497	9317	5314787.70	
-447.258	9047	5314795.38	
-440.981	8777	5314799.67	
-430.592	7697	5314806.77	
-418.827	9730	5314814.81	
-403.318	8253	5314825.41	
-396.379	8793	5314830.16	
-389.910	9063	5314834.58	
-378.205	9333	5314842.58	
-367.897	8936	5314849.62	
-360.496	8142	5314854.68	
-350.578	9603	5314861.46	
-336.597	8682	5314871.02	
-330.570	9079	5314875.14	
-315.411	9476	5314885.50	
-303.530	8825	5314893.62	
-293.966	9349	5314900.15	
-286.102	8571	5314905.53	
-279.522	9222	5314910.03	
-269.131	9095	5314917.13	
-255.182	8841	5314926.66	
-250.274	8714	5314930.02	
-240.036	8333	5314937.01	
-230.504	7698	5314943.53	
-221.054	6301	5314949.99	
-205.481	9873	5314960.63	
-191.251	5952	5314970.36	
-181.450	7603	5314977.05	
-172.789	8238	5314982.97	
-163.770	8619	5314989.14	
-154.389	8873	5314995.56	
-147.878	9000	5315000.00	
-139.498	9127	5315005.73	
-128.265	9254	5315013.40	
-112.423	9381	5315024.23	
-101.785	8889	5315031.50	
-97.677	8397	5315034.31	
-88.401	9508	5315040.65	
-77.379	8651	5315048.18	
-71.051	9143	5315052.51	
-60.293	8413	5315059.86	
-47.664	9635	5315068.49	
-32.628	8867	5315078.77	
-26.959	9032	5315082.64	
-14.426	9397	5315091.21	
-6.024	8556	5315096.95	
0.000	9159	5315101.07	

Table 3-7. Synthesizer Setting vs. Frequency Offset
(See Table 3-6 for Thumbwheel Switch Settings)

Synthesizer Thumbwheel Setting	Offset ($\times 10^{-10}$)	Synthesizer Thumbwheel Setting	Offset ($\times 10^{-10}$)
5691	-940.729	8889	-101.785
5952	-191.251	8903	-888.110
5980	-621.028	8904	-468.270
6301	-221.054	8919	-844.926
7013	-591.175	8935	-800.445
7472	-911.851	8936	-367.897
7603	-181.450	8951	-754..607
7696	-630.506	8967	-707.350
7697	-430.592	8983	-658.605
7698	-230.504	9000	-147.878
7758	-950.573	9015	-556.364
8014	-982..542	9030	-977.485
8029	-789.990	9031	-502.712
8142	-360.496	9032	-26.959
8238	-172.789	9047	-447.258
8253	-403.318	9062	-881.000
8267	-903..502	9063	-389.910
8333	-240.036	9079	-330.570
8347	-763.045	9095	-269.131
8394	-958.700	9126	-666.835
8397	-97.677	9127	-139.498
8411	-640.497	9143	-71.051
8413	-60.293	9158	-547.544
8458	-840.537	9159	-0.000
8491	-472.694	9189	-986.784
8522	-712.141	9221	-870.988
8556	-6.024	9222	-279.522
8571	-286.102	9237	-809.448
8586	-572.122	9253	-745.271
8618	-497.249	9254	-128.265
8619	-163.770	9269	-678.286
8651	-77.379	9301	-535.144
8667	-32.628	9317	-458.497
8681	-685.873	9333	-378.205
8682	-336.597	9348	-1000.619
8697	-647.564	9349	-293.966
8714	-250..274	9380	-855.841
8744	-893.419	9381	-112.423
8745	-526.775	9412	-695.305
8776	-817.281	9444	-516.291
8777	-440.981	9476	-315.411
		9539	-830.264
8793	-396.379	9555	-723.264
8808	-737.056	9587	-484.432
8825	-303.530	9603	-350.578
8841	-255.182	9698	-777.700
8871	-970.804	9730	-418.827
8872	-562.949	9857	608.302
8873	-154.369	9873	-205.481

Table 3-8. Recommended Test Equipment

Instrument Type	Required Characteristics	Recommended Instrument
Frequency Standard	Frequency: 5 MHz Output Level: 1 V rms into 50 ohms	HP Model 5061A
Recorder	Strip Chart, 1 inch/hr.	HP Model 680
Vector Voltmeter	Frequency: 1 MHz to 1 GHz Voltage range: 1.5 mV to 1 V rms	HP Model 8405A
Terminations	Impedance: 50 ohms	HP Model 11048B

3-29. OPERATION WITH STANDBY POWER SUPPLY OPTION 002

3-30. Option 002 provides the 5065A with at least 10 minutes of standby power so that the Model 5065A can be moved; for example, from one room to another. Maximum recharge (FAST CHARGE) takes 16 to 18 hours. Necessary recharge time can be calculated on the basis of 1½ hours charge time per minute of standby operation up to a maximum of 16 to 18 hours. The front-panel BATTERY warning light indicates three battery-circuit conditions:

a. Flashes on and off when instrument is powered from internal battery supply (when disconnected from line power).

b. On when battery is being FAST CHARGED (with 5065A connected to line power).

c. Off with BATTERY switch at FLOAT (continuous trickle charge).

3-31. If the instrument must be turned off for any reason, remove ac power and then momentarily disconnect F4 (this is the fuse located over the battery). In this manner, relay A2K1 is unlatched to de-energize the circuits and prevent battery drain.

Figure 3-7. Internal Measurement with Automatic Synchronization

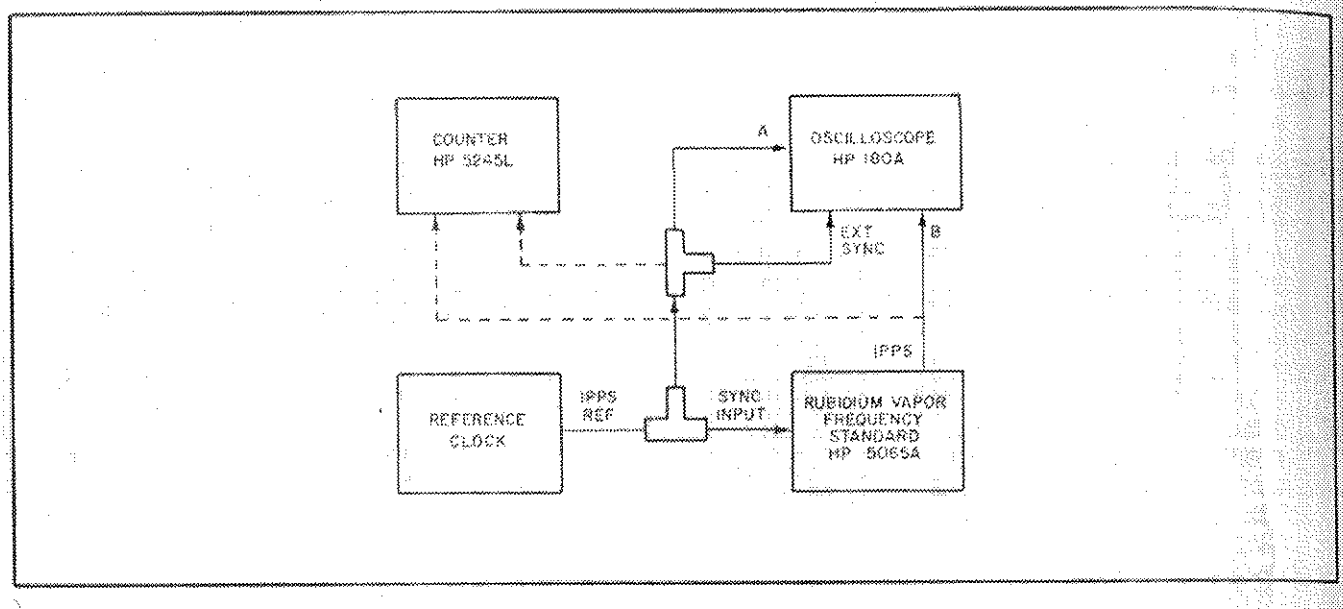


Figure 3-8. Internal Measurement with Manual Synchronization

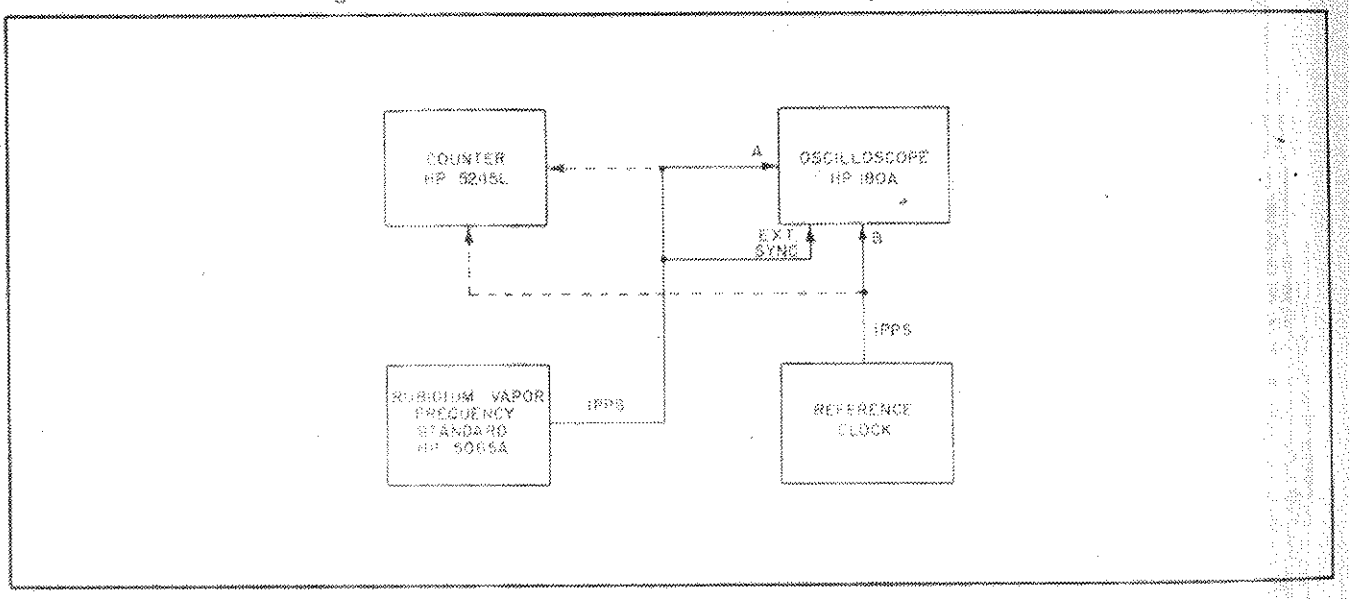
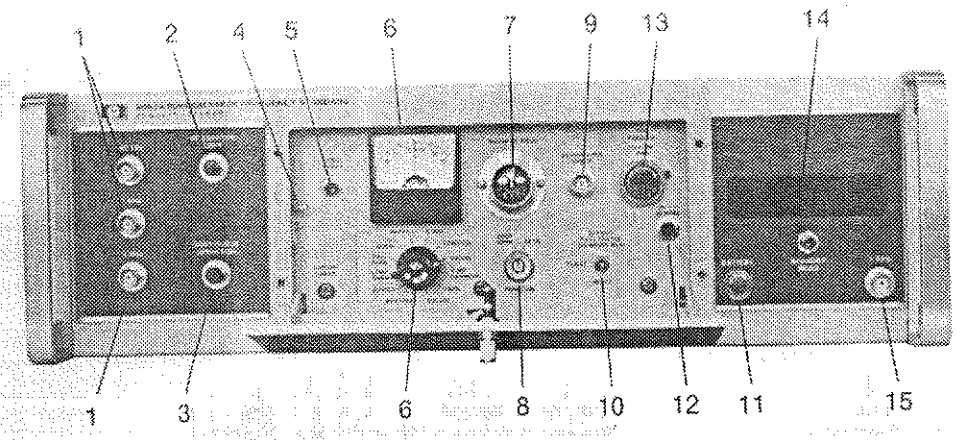


Figure 3-9. Front Panel Controls



1. OUTPUTS: 5 MHz, 1 MHz, 100 kHz: BNC jacks paralleled with rear-panel outputs. Output level is 1 volt rms (minimum) into 50 ohm load.

2. INTEGRATOR LIMIT lamp: Normally off indicating that quartz oscillator dc correction voltage is less than the dynamic limit of ±5 Vdc. When ON, indicates that quartz oscillator dc correction voltage is approaching the dynamic limit of ±5 Vdc.

3. CONTINUOUS OPERATION lamp: Normally on, indicates circuits are functioning properly.

4. START-AUTO/START divider mode switch: Allows regenerative dividers to be operated in one of two modes: to manually start dividers, momentarily press to START, then release; for automatic start, set to AUTO START.

5. LOGIC RESET switch: Push to reset logic circuit and enable CONTINUOUS OPERATION lamp when operation is resumed after power interruption, repair, or adjustment.

6. CIRCUIT CHECK meter and switch: Provides monitoring of various circuits for operation checks and trouble indication, as specified in Table 5-3.

7. MAGNETIC FIELD adjustment: A high-resolution, 10-turn potentiometer with clock dial, controls the magnetic field within the RVFR Assy. Used as a fine control to set the 5065A to a specific frequency. A change of one minor division will change the frequency by 4 parts in 10^{14}. Total adjustment is 2 parts in 10^9.

8. FUNCTION switch: Controls the instrument mode of operation. OPERATE: Instrument operating with quartz oscillator locked to the RVFR resonant frequency. LOOP OPEN: All circuits operating with loop open.

9. SYNTHESIZER CHECK jack: Synthesizer Assembly A1 output frequency is available at this BNC jack to check Synthesizer operation as outlined in TIME SCALE CHECK of Table 5-2.

10. BATTERY switch (Option 002 and 003 only): Controls BATTERY lamp and internal standby battery charging rate. Three position switch has three functions:
    a. FAST CHARGE: Charges battery at rapid rate with 16 hours maximum charging time.
    b. FLOAT: Standby battery receives trickle charge (normal position).
    c. RESET: Resets BATTERY lamp circuits after ac line power failure.

11. BATTERY lamp (Option 002 and 003 only): Operates with front panel BATTERY switch. Flashes on and off when ac power fails. When BATTERY switch is set to FAST CHARGE (16 HOURS MAX) lamp is on. Set BATTERY switch to RESET to turn lamp off.

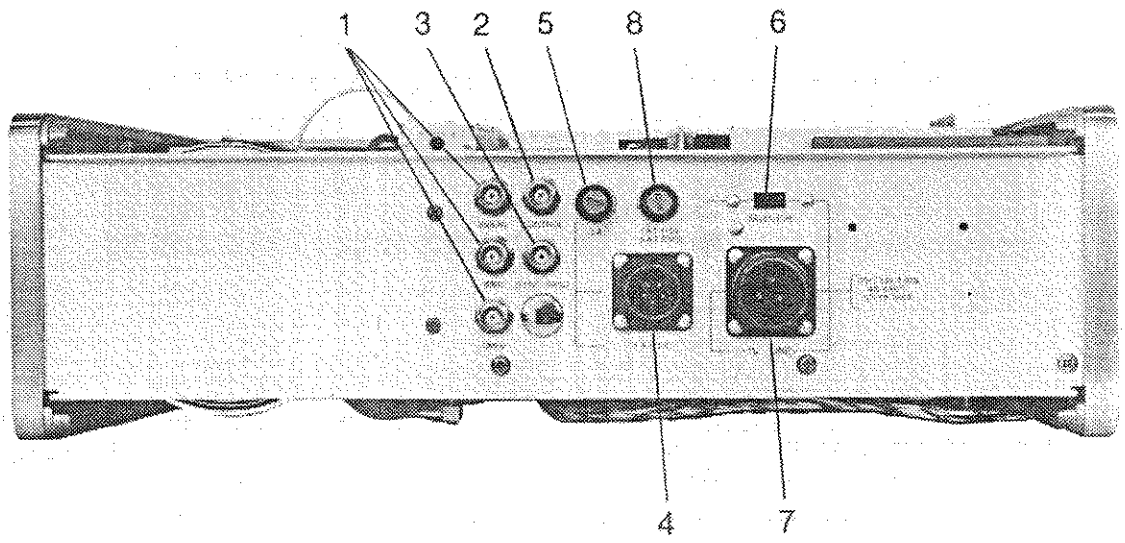
12. OSC FREQ ADJ COARSE: Provides quartz oscillator frequency adjustment of 1 part in 10^6. Use only COARSE control to correct oscillator frequency with frequency-locked operation.

13. OSC FREQ ADJ FINE: Control used for testing only. Normally set to 250.

14. 24-Hour Digital Clock (Option 001 and 003 only): See Paragraph 3-29.

15. 1 PPS (Option 001 and 003 only): +10V peak, 20 μsec pulse at 1 pulse-per-second rate

Figure 3-10. Rear Panel Operating Controls



1. OUTPUTS - 5 MHz, 1 MHz, 100 kHz: BNC jacks paralleled with front panel outputs.

2. CONTROL jack: Normally not used. Connected to voltage control point between integrator and quartz oscillator.

3. SYNC INPUT jack (Option 001 only): Input to digital divider circuits for external synchronizing pulse. External synchronizing pulse must be +5 V or more with rise-time of less than 50 nsec, and width >0.5 μsec.

4. EXT DC connector: Five-pin male connector. Connects 5065A to external 24-volt dc supply.

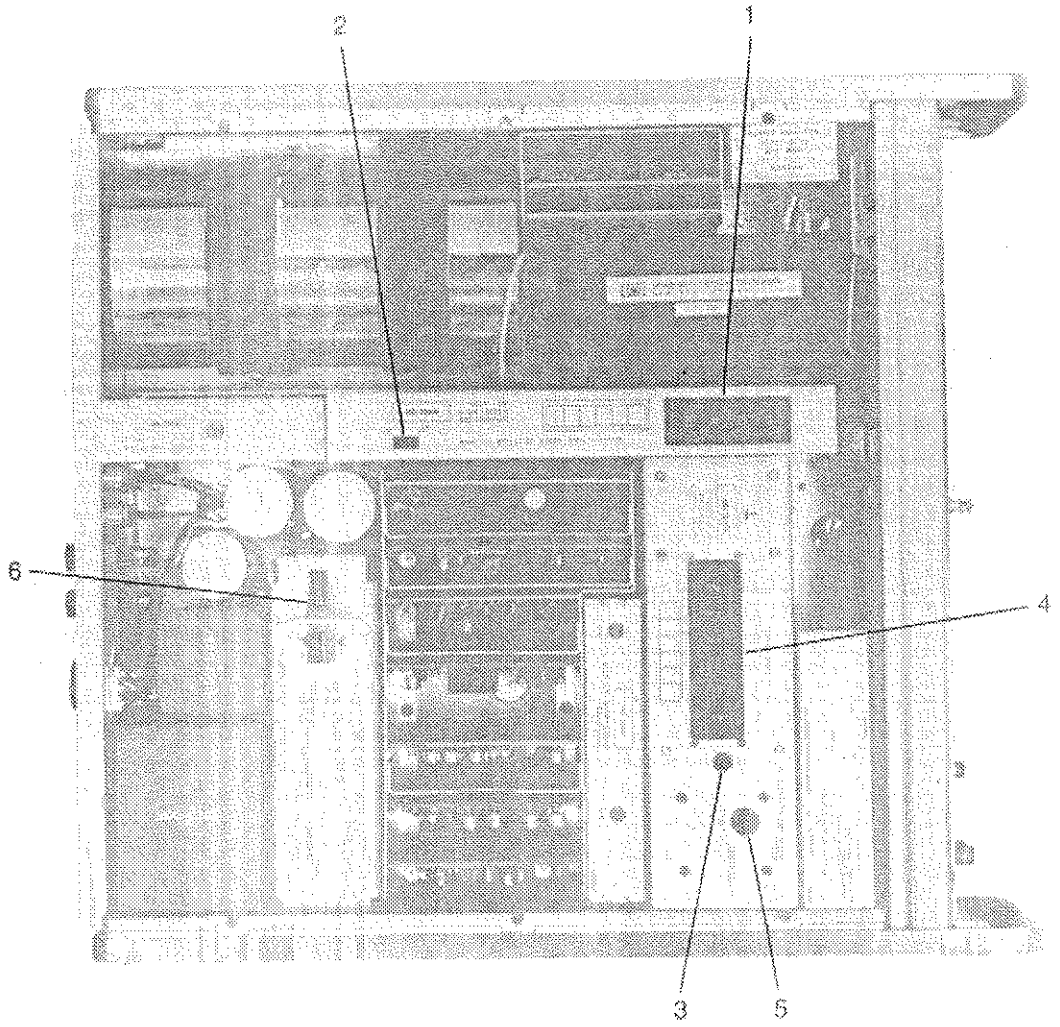
5. EXT DC fuse (F2): 3-ampere fuse (HP Part No. 2110-0003) for external 24-volt dc power.

6. 115V/230V AC LINE switch: Set to expose correct ("115" or "230") for the ac line voltage used.

7. AC LINE jack: Accepts round female connector on power cable supplied.

8. AC LINE fuse: 1-ampere Slo-Blo fuse (HP Part No. 2110-0007) for 115 Vac operation or 0.5 ampere Slo-Blo (HP Part No. 2110-0008) for 230 Vac operation.

Figure 3-11. Top Operating Controls



1. Synthesizer TIME CLOCK SELECTOR thumbwheel switch: selects synthesized frequency.

2. Synthesizer TIME SCALE SELECTOR HI-LO switch: used with thumbwheel switch to select synthesized frequency.

3. Clock SYNC switch (Option 001 and 003 only): Synchronizes digital clock with an external clock when depressed; clock remains synchronized when released.

4. Clock TIME DELAY thumbwheel switch (Option 001 and 003 only): selects time delay between an external reference pulse and the internal 1 pulse-per-second clock pulse. Adjustable in decade steps from 1 μs to 1 sec.

5. 0-1 μSEC TIME DELAY control (Options 001 and 003 only): allows continuous adjustment of clock pulse delay over any 1 μsec range.

6. Battery fuse (F4): removed momentarily to disconnect optional standby battery from circuit for storage or shipment. Battery will remain disconnected after fuse is replaced.

SECTION IV

THEORY OF OPERATION

4-1. THEORY

4-2. General

4-3. For circuit theory on individual assemblies, refer to the schematic fold-out pages at the rear of this manual.

4-4. The simplified block diagram of Figure 5-6 shows the frequency-stabilizing feedback loop. The 5 MHz quartz oscillator output is stabilized, first by comparing the 5 MHz output in a frequency-synthesizing and multiplying process with the resonant frequency of Rb^{87} and then translating the difference frequency into a control voltage which corrects the quartz oscillator frequency.

4-5. Oscillator Assembly A10 generates the 5 MHz for A3 Multiplier where 5 MHz is: (1) phase modulated at 137 Hz, (2) multiplied to 60 MHz and, (3) combined with the synthesized 5.315. . . MHz after multiplication to 60 MHz. The 5.315. . . MHz is derived from 5 MHz in a frequency-synthesizing process. The combined 60 MHz and 5.315. . . MHz signal goes from A3 Multiplier to the harmonic generator step-recovery diode in A12 RVFR (Rubidium Vapor Frequency Reference) Assy. The harmonic generator/step-recovery diode couples to the Rb^{87} absorption cell which is housed in a microwave cavity tuned to 6.834685 GHz, the Rb^{87} resonant frequency. In the harmonic generator/step-recovery diode, 5.315. . . MHz phase-modulates the 114th harmonic of 60 MHz to produce the 6.834685. . . GHz lower sideband which matches the microwave cavity resonance and causes energy level transitions in the Rb^{87} gas.

4-6. Figure 4-3 shows the Rb^{87} absorption cell which contains the Rb^{87} gas. A 100-MHz oscillator in A12 RVFR Assy drives the lamp filled with Rb^{87} gas. The resulting light output passes through the Rb^{85} filter cell and the Rb^{87} absorption cell. The light output of the Rb^{87} absorption cell is monitored by a photodiode. Rb^{85} photo excitation is removed in the Rb^{85} filter cell to remove undesired transitions. When the Rb^{87} gas is excited by the 6.834685. . . GHz microwave field at its resonant frequency, it increases in opacity to reduce light transmission about ½% as illustrated in Figure 4-1. This phenomenon permits using Rb^{87} gas as a frequency reference. Phase modulation at 137 Hz (in A3 Multiplier) produces a sinusoidal scan of the excitation frequency. As a result, 2nd harmonic 274 Hz appears in the photodiode output when "on" frequency and fundamental 137 Hz appears when "off" frequency, as shown in Figure 4-2. For example, as the 6.834685 . . . GHz excitation is steered towards the Rb^{87} natural resonance by the feedback action of the frequency-control system, second harmonic appears in the photodiode output is mostly 2nd harmonic 274 Hz with a small amount of 137 Hz.

4-7. Temperature control of the Rb^{87} lamp and absorption cell in the A12 RVFR Assy is accomplished by temperature control circuits in the A11 Temperature Control Assy working with temperature sensors and heating elements in A12 cell and lamp ovens. Operating current for these ovens is monitored in the CELL OVEN and LAMP OVEN positions of the CIRCUIT CHECK switch. The A10 Oscillator Assy has its own temperature-control circuit for the 5 MHz quartz oscillator. Operating current for the oscillator oven is monitored in the OSC OVEN position of the CIRCUIT CHECK switch.

Figure 4-1. Rubidium Absorption Plot

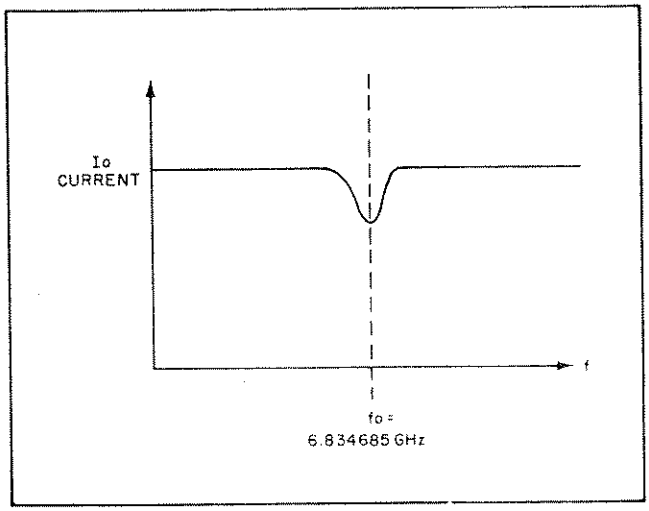
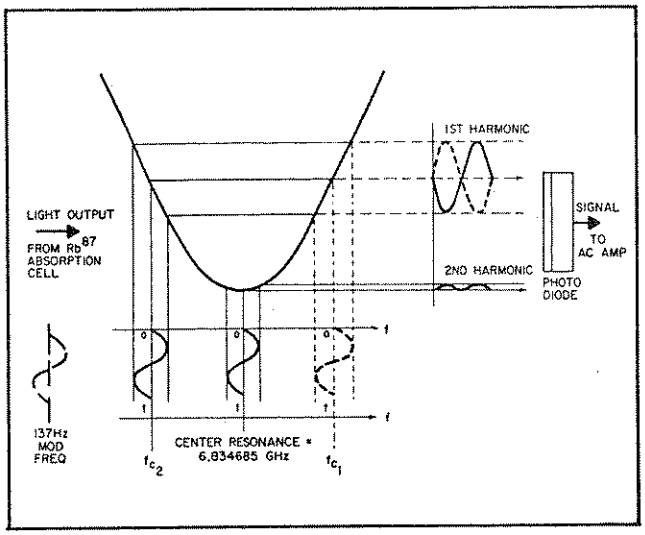


Figure 4-2. Rb^{87} Absorption Cell Output



4-8. The A12 RVFR photodiode output is applied to A7J1. This signal contains a fundamental frequency of 137 Hz, a second harmonic of 274 Hz and is proportional to the frequency error. The composite input signal is amplified and then the 137 Hz and 274 Hz signals are separated, filtered and amplified. The 137 Hz output at A7("Y") is connected A8(18) and the 274 Hz output at A7("WBO") is connected to the 2ND HARMONIC position of MI via A17(13).

4-9. In A8 Phase Detector, a reference 137 Hz signal is compared in phase with the 137 Hz input signal. The resulting dc output is either positive or negative depending on the phase of the 137 Hz input. Also, the dc output amplitude is proportional to the 137 Hz input amplitude. This dc output goes to the ERROR position of the CIRCUIT CHECK meter and to A9 Integrator Assembly.

4-10. In A9 Integrator Assembly, the dc error signal is amplified and integrated to slow feedback loop response. Connecting to this assembly is the FUNCTION switch which opens the control loop so that the A10 Oscillator can operate independently. In this LOOP OPEN position, A9 output is shorted to the input and the error signal is not amplified. With the FUNCTION switch at OPERate, the amplified and integrated dc control voltage connects to a varactor diode in A10 quartz oscillator circuit to correct the 5 MHz output frequency.

4-11. One 5 MHz output from A10 Oscillator is routed through a power amplifier in A3 Multiplier Assembly to A13 Buffer Amplifier. In A13 module, power amplifiers feed A1 Synthesizer and the front and rear 5 MHz output jacks. The second 5 MHz output from A10 Oscillator supplies A6 1 MHz Frequency Divider.

4-12. The A6 1 MHz Frequency Divider processes 5 MHz in a regenerative frequency divider to produce 1 MHz. One MHz outputs go to the front and rear 1 MHz output jacks and also to A4, 100 kHz Frequency Divider. A start circuit, which includes the START-AUTO-START switch, provides for manual or automatic starting of the regenerative divider circuit. Another A6 output is 1 MHz from a buffer amplifier which feeds the A5 Digital Divider Assembly.

4-13. The front panel START-AUTO-START switch permits manual starting so that frequency-divider circuits will not restart automatically. In the AUTO-START position, this switch provides for automatic restarting of divider circuits so the 5065A instrument can serve as a frequency source. When the Option 001 Time Standard is installed, a mechanical lock prevents using the AUTO-START position.

4-14. The A4 Frequency Divider processes the A6 1 MHz output through a decade divider to produce 100 kHz at front and rear 100 kHz output jacks

4-15. OPTION 001, TIME STANDARD

4-16. Time Standard Option 001 consists of A5 Digital Divider, A16 Digital Divider Power Supply, and the front panel mechanical clock. The A5 module processes 1 MHz to produce digitally delayed 1 PPS output pulses. A SYNC INPUT jack at the rear enables the user to synchronize with an extternal reference. Incremental delay of the 1 PPS output is set by the TIME DELAY thumbwheel switches. Continuously-variable delay of the 1 PPS output, that is processed by the A16 module for a "tick" pulse output at the front-panel 1 PPS jack, is set by the 0-1μsec TIME DELAY adjustment.

4-17. An additional A5 control is the SYNC switch. To synchronize the 1 PPS output with a reference pulse, the SYNC pushbutton is depressed for at least 1-second and then released. If a sync pulse is connected to the rear SYNC INPUT jack, one reference pulse will enter the synchronizing circuits during the 1-second interval. This pulse will reset the digital divider. The output 1 PPS "tick" pulse from the 1 PPS front panel jack will then be in sync with the reference pulse.

4-18. Two 1 PPS inputs connect to the A16 Digital Divider Power Supply from the A5 module. One input pulse is shaped in a blocking oscillator and then amplified to provide the front panel 1 PPS "tick" output. The other 1 PPS input triggers a flip-flop stage which provides clock-driving pulses. The flip-flop output drives push-pull amplifiers to pulse the front-panel clock at a 1 PPS (or 10 PPS) rate.

4-19. The A14 Logic Assembly monitors several key points in the 5065A circuits and turns off the CONTINUOUS OPERATION lamp to indicate an operational discontinuity when one or more of the logic inputs indicate a "non-operating" condition. These logic inputs are shown in Table 4-1. In addition to the CONTINUOUS OPERATION lamp output, the Logic Assembly delivers an INTEGRATOR LIMIT lamp output when the A9 integrator output exceeds 50% of maximum. After an operational discontinuity, the LOGIC RESET switch resets the CONTINUOUS OPERATION lamp when all logic inputs are "operational."

Table 4-1. Logic Signals

Signal	Non-Operational Condition
a. Synthesizer Lock Signal	When present
b. AC Amplifier 2nd Harmonic Signal	When absent
c. Phase Detector Fundametal Error Signal	When too much signal
d. Cell Temperature Signal	When cell oven is full on or turned off
e. Lamp Temperature Signal	When lamp oven is full on or turned off
f. Function Switch Signal	When present with Function switch at LOOP OPEN

4-20. OPTION 002, STANDBY POWER SUPPLY

4-21. Standby Power Supply Option 002 automatically cuts in battery power if there is an ac (or dc) line interruption; for example when the unit is moved. This is accomplished by floating the battery across the power supply so that the battery takes over should ac (or dc) line power fail. This option consists of A2 Battery Charger Assembly, the nickel-cadium battery, and the BATTERY switch and lamp. The nickel-cadium standby battery is charged as desired in either FAST CHARGE mode or a FLOAT (trickle charge) mode by a constant current charging circuit. The front panel BATTERY lamp pulses on and off to indicate a line-power discontinuity. With the BATTERY switch at FAST CHARGE, the BATTERY lamp glows steadily.

4-22. The FAST CHARGE position of the BATTERY switch is used to recharge the battery after discharge. After charging in the FAST CHARGE position, the BATTERY switch is set to FLOAT, for a trickle charge to maintain battery charge.

Figure 4-3. RVFR Assembly Block Diagram