OPERATING INFORMATION

SWEEP OSCILLATOR
8690B

DUPLICATE OF SECTIONS 1 THRU 3
OF YOUR OPERATING AND SERVICE MANUAL

KEEP WITH INSTRUMENT

HEWLETT hp PACKARD

HP 8690B

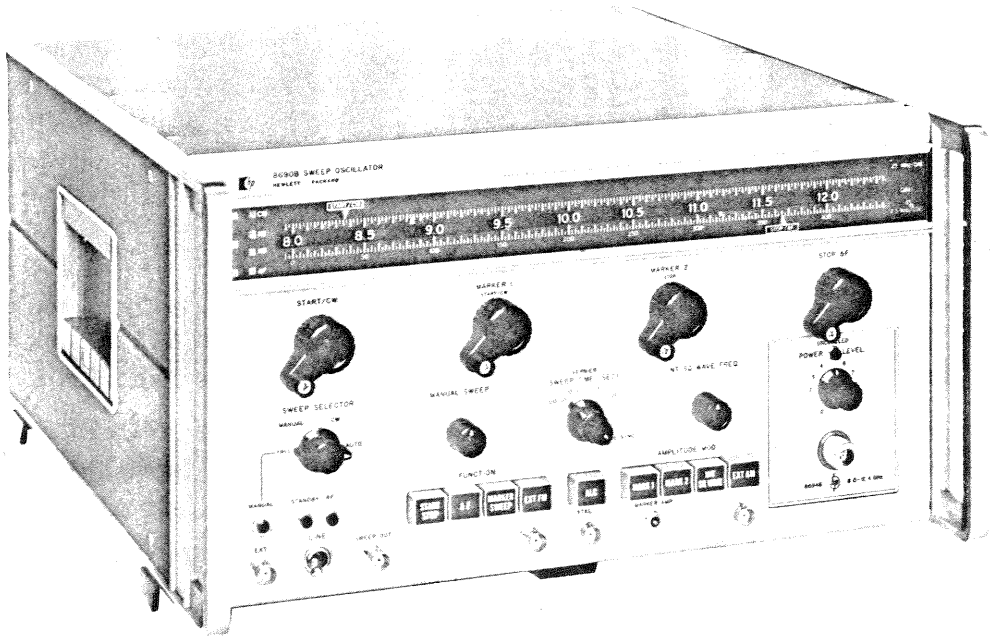


Figure 1-1. Model 8690B with RF Unit Installed

SECTION I
GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The HP 8690B Sweep Oscillator, when used with one of the 8690-series RF Units, comprises an electronically tuned signal source. The RF Units used with the 8690B Sweep Oscillator are of the following basic types:

LOW FREQUENCY
1) Solid-state with leveled and calibrated output. Model 8698A/B, 8699B.

MICROWAVE
1) PIN modulated with coaxial output. Models 8691-4B.
2) Grid modulated with coaxial output. Models 8691-4A.
3) Grid modulated with waveguide output. Models 8695-7A.

1-3. A summary of specifications covering the Sweep Oscillator/RF Unit combinations is given in Table 1-1. Detailed specifications of 8690B with 8691-7A/B RF Units are given in Table 1-2.

1-4. The Sweep Oscillator provides three linear automatic sweeps: two broadband, and one narrowband. The broadband sweeps each have independent, calibrated start and stop frequencies which are continuously adjustable over the entire frequency range of the Oscillator-RF Unit to permit sweeping up or down in frequency. The narrowband sweep varies the RF output upward through a 0 to 10% segment of the frequency range, the segment being centered anywhere in the Oscillator-RF Unit range.

1-5. One of the broadband sweeps has two internally-generated, calibrated frequency markers. The markers, individually activated and separately tuned, occur as triangular notches in the RF output. The markers may also be used with the narrowband sweep and with external frequency modulation.

1-6. Modulation capability includes internal square wave, external amplitude and external frequency modulation. Square-wave frequency is continuously variable between 950 and 1050 Hz.

1-7. RF output power level is manually adjustable and there is provision for automatic output leveling. As an indication of leveling preformance, a panel light lights automatically if any segment of the sweep is unleveled.

1-8. Internal leveling may be ordered as an option on microwave RF Units. A microwave RF Unit with internal leveling is designated by Option 001, and is available on RF Unit Model 8691-4A and 8693-4B. Internal leveling allows the Sweep Oscillator to automatically hold amplitude constant as output frequency changes.

1-9. Provision for oscilloscope and graphic recorder display of swept-frequency measurements includes RF shut-off (blanking) and penlift between sweeps, manual sweep control, a linear sawtooth voltage output concurrent with the sweep (to provide frequency reference for the display), and visual indication of sweep duration.

1-10. The microwave RF Unit signal source is a backward-wave oscillator tube (BWO), a self-contained, voltage-tunable oscillator. Fail-safe, over-load, and time delay circuits protect the BWO from power supply malfunctions and turn-on transients.

1-11. The 8690B Sweep Oscillator and 8690-series RF Units combine to permit rapid, broadband evaluation of low frequency and microwave device performance, serving as the swept-frequency source for measuring such transmission properties as reflection coefficient, attenuation, gain, directivity, and other network transfer characteristics.

1-12. INSTRUMENTS COVERED BY MANUAL

1-13. This instrument has a two-part serial number. The first four digits and the letter comprise the serial number prefix. The last five digits form the sequential suffix that is unique to each instrument. The contents of this manual apply directly to instruments having the same serial number prefix (es) as listed under SERIAL NUMBERS on the title page.

1-14. An instrument manufactured after the printing of this manual may have a serial prefix that is not listed on the title page. This unlisted serial prefix indicates that the instrument is different from those documented in this manual. The manual for this instrument is supplied with a yellow Manual Changes supplement that contains "change information" that documents the differences.

1-15. In addition to change information, the supplement may contain information for correcting errors in the manual. To keep this manual as current and accurate as possible, Hewlett-Packard recommends that you periodically request the latest Manual Changes supplement. The supplement for this manual is keyed to this manual's print date and part number, both of which appear on the title page. Complimentary copies of the supplement are available from Hewlett-Packard.

1-16. For information concerning a serial number prefix not listed on the title page or in the Manual Changes supplement, contact your nearest Hewlett-Packard office.

Table 1-1. Summary of Specifications

Sweep Oscillator/RF Unit	Frequency Range	Max. Leveled Power Output	Frequency Accuracy
8690B	--	--	--
8691A	1 - 2 GHz	≥ 100 mW	±1%
8691A Option 200	1.4 - 2.5 GHz	≥ 100 mW	±1%
8691B	1 - 2 GHz	≥ 70 mW	±10 MHz
8692A	2 - 4 GHz	≥ 70 mW	±1%
8692B	2 - 4 GHz	≥ 40 mW	±20 MHz
8692B Option 100	1.7 - 4.2 GHz	≥ 15 mW	±25 MHz
8693A	4 - 8 GHz	≥ 30 mW	±1%
8693A Option 200	3.5 - 6.75 GHz	≥ 40 mW	±1%
8693B	4 - 8 GHz	≥ 15 mW	±40 MHz
8693B Option 100	3.7 - 8.3 GHz	≥ 5 mW	±45 MHz
8694A	8 - 12.4 GHz	≥ 50 mW	±1%
8694A Option 100	7 - 12.4 GHz	≥ 25 mW	±1%
8694A Option 200	7 - 11 GHz	≥ 25 mW	±1%
8694B	8 - 12.4 GHz	≥ 30 mW	±40 MHz
8694B Option 100	7 - 12.4 GHz	≥ 15 mW	±50 MHz
8694B Option 200	7 - 11 GHz	≥ 15 mW	±40 MHz
8695A	12.4 - 18 GHz	≥ 40 mW	±1%
8695B	12.4 - 18 GHz	≥ 15 mW	±1%
8696A	18 - 26.5 GHz	≥ 10 mW	±1%
8697A	26.5 - 40 GHz	≥ 5 mW	±1%
8698A	0.1 - 110 MHz	100 mW	±1% of F.S.
8698B	0.4 - 110 MHz	20 mW	±1%
8699B	0.1 - 2.0 GHz	20 mW	±1%
	2.0 - 4.0 GHz	≥ 6.5 mW	

Table 1-2. Specifications of 8690B Sweep Oscillator with RF Unit Installed

SWEEP FUNCTIONS

Start-Stop Sweep: Sweeps from "start" to "stop" frequency setting.

Range: Both settings continuously and independently adjustable over the entire frequency range; can be set to sweep either up or down in frequency.

End-point Accuracy: Same as RF Unit frequency accuracy.

Marker Sweep: Sweeps from "Marker 1" to "Marker 2" frequency setting.

Range: Both settings continuously and independently adjustable over the entire frequency range; can be set to sweep either up or down in frequency.

End-point Accuracy: Same as RF Unit frequency accuracy.

ΔF Sweep: Sweeps upward in frequency, centered on CW setting.

Width: Continuously adjustable from zero to 10% of the frequency band; calibrated directly in MHz.

Width Accuracy: ±10% of ΔF being swept ±1% of maximum ΔF (±20% ±2% respectively with 8691A/B RF Units).

Center-frequency Accuracy: Same as RF Unit frequency accuracy.

FREQUENCY MARKERS

Two frequency markers, independently adjustable over the entire frequency range, amplitude modulate the RF output. Amplitude is adjustable from the front panel. The markers are also available for external use.

Accuracy: 1% of full scale for all RF Units.

Resolution: Better than 0.05% of RF Unit bandwidth.

Marker Output: Triangular pulse, typically -5 V peak into 1000-ohm load.

CW OPERATION

Single-frequency RF output selected by START/CW or MARKER 1 control, depending upon sweep function selected.

Accuracy: Same as RF Unit frequency accuracy.

Preset Frequencies: Start-stop sweep end points and marker frequencies can be used as four preset CW frequencies.

SWEEP MODE

Auto: Sweep recurs automatically.

Manual: Front-panel control provides continuous manual adjustment of frequency between end frequencies set in any of the above sweep functions.

Triggered: Sweep is actuated by front-panel push button or by externally applied signal between -7.5V and -25V, > 1 μsec pulse width, and > 0.1 V/μsec rise.

SWEEP CHARACTERISTICS

Sweep Time: Continuously adjustable in four decade ranges, 0.01 to 100 seconds. Can be synchronized with the power line frequency.

Sweep Indicator: Front-panel indicator lights during the sweep to provide indication of sweep duration on slower sweep times.

Sweep Output: Direct-coupled sawtooth, zero to approx. +15 V, concurrent with swept RF output. Zero at start of sweep, approximately +15 V at end of sweep regardless of sweep width or direction. Source impedance, 10,000 ohms.

Frequency Linearity: (Correlation between frequency and both the sweep and reference output.) Same as RF Unit frequency accuracy.

Blanking: RF automatically turned off during retrace, turned on after completion of retrace. On automatic sweeps, RF is on long enough before sweep starts to stabilize external circuits and equipment whose response is compatible with the selected sweep rate. Blanking disable switch provided.

Blanking Output: Direct-coupled rectangular pulse approximately -4 V coincident with RF blanking. Source impedance approximately 3000 ohms.

Penlift: For use with X-Y graphic recorders. Penlift terminals shorted during sweep, open during retrace (100-10 and 10-1 sec ranges only).

POWER LEVELING AMPLIFIER

Internal dc-coupled leveling amplifier provided.

Crystal Input: Approximately -20 to -350 mV for specified leveling at rated output; for use with negative-polarity detectors such as 780 series Directional Detectors, 423 and 424 series Crystal Detectors.

MODULATION

Internal AM: Square wave modulation continuously adjustable from 950 to 1050 Hz on all sweep times. On/off ratio greater than 20 dB at rated output.

Table 1-2. Specifications of 8690B Sweep Oscillator with RF Unit Installed (Cont'd)

External AM

Frequency Response: dc to 350 kHz unleveled, dc to 50 kHz leveled.

Sensitivity: -10 V reduces RF output level at least 30 dB below rated CW output ("A" Model RF Units, 20 dB for "B" Models).

Input Impedance: Approximately 1000 ohms.

External FM

Frequency Response: dc to 3 kHz.

Sensitivity: Deviation from CW setting approximately 6% of the frequency band per volt.

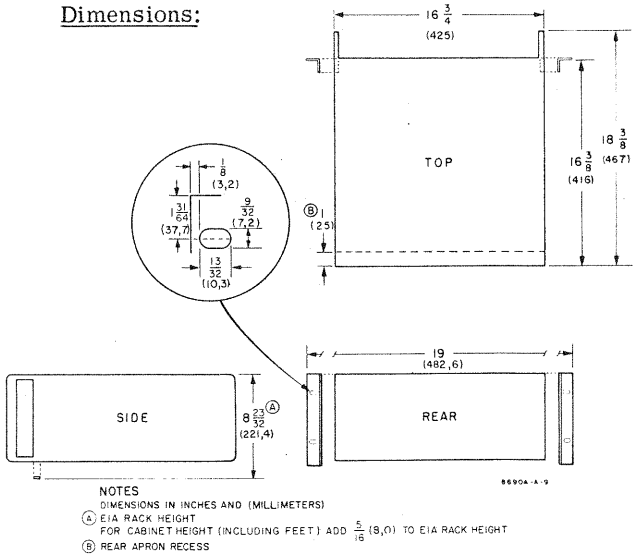
Maximum Range: Full band for modulation frequencies up to 150 Hz (approximately 17 V pp input), decreases to about 20% of the band for 3 kHz modulation.

Input Impedance: Approximately 100,000 ohms.

GENERAL

Power: 115 or 230 Vac ±10%, 48 to 66 Hz. Approximately 350 watts with one RF Unit; if RF Unit holder HP 8707A is used add approximately 30 watts for each RF Unit.

Dimensions:



Weight (not including RF Unit): Net, 53 lbs. (23,9 kg). Shipping, 71 lbs. (32 kg).

Furnished: 7-1/2 ft (2290 mm) power cable with NEMA plug; rack mounting kit.

Available:

Directional Couplers	776/777	Coaxial Dual coupler, 1 to 4 GHz, 20 dB coupling, high directivity
	790 series	Ultra-flat coaxial coupler, 1 to 8.3 GHz, high directivity
	752 series	Waveguide coupler, 2.6 to 40 GHz, 40 dB directivity
Directional Detectors	781-789 series	Ultra-flat coupler with built-in detector, 1-12.4 GHz
Detectors	423	Coaxial crystal detector, 0.01 to 12.4 GHz, flat response
	424 series	Waveguide crystal detector, 2.6 to 18 GHz, flat response
	422	Waveguide crystal detector, 18 to 40 GHz, ±2 dB response
	478	Coaxial thermistor mount for 432, 0.01 to 10 GHz
	486 series	Waveguide thermistor mounts for 431, 2.6 to 40 GHz
Power Meter	432	10 μW to 10 mW full scale.
Adapter	281 series	Coax to waveguide adapter, 2.6 to 12.4 GHz
Loads, Shorts	906	Coaxial sliding load, 1 to 12.4 GHz, low load SWR
	11511/11512	Coaxial fixed short, 11511 female, 11512 male
	910 series	Waveguide termination, 2.6 to 18 GHz, low SWR
	914 series	Waveguide moving load, 2.6 to 40 GHz, 1.01 load SWR
	X923/920 series	Waveguide adjustable short 2.6 to 40 GHz
Refl. Coeff. Bridge	X8440	Reflection coefficient measurements in coax, 8.2 to 12.4 GHz
Oscilloscopes, X-Y Recorders	140/1416	Oscilloscope, calibration in dB/cm, high sensitivity
	130	Oscilloscope, calibration in V/cm, high sensitivity
	7035, Opt 01	X-Y recorder with AUTOGRIP hold down, high sensitivity
Filters	360	Low pass filters; cut off at 2.2 and 4.1 GHz
	8430 series	Bandpass filters, octave and semi-octave, 1-12.4 GHz

SECTION II
INSTALLATION

2-1. INCOMING INSPECTION.

2-2. The Sweep Oscillator was carefully inspected, both mechanically and electrically, prior to shipment. Inspect it for mechanical damage received in transit, check for supplied accessories, and test electrical performance using the performance tests in Section V. If there is any damage or deficiency, or if electrical performance is not within specifications, see the warranty inside the front cover of this manual.

2-3. PREPARATION FOR USE.

2-4. POWER REQUIREMENTS.

2-5. The Sweep Oscillator requires a power source of 115 or 230 volts ±10%, 50 to 60 Hz, single phase, which can supply approximately 350 watts.

2-6. 115/230 VOLT OPERATION.

2-7. A two-position slide switch, on the rear panel under the power line fuseholder, permits operation from either a 115- or 230-volt power source. The number visible on the switch slider indicates the line voltage for which the instrument is connected. Adjacent to the switch is the correct fuse rating for each line voltage.

2-8. To prepare the Sweep Oscillator for operation, position the 115-230 volt switch so that the number visible on the slider corresponds to the available line voltage, and install a fuse of correct rating.

CAUTION

To avoid damage to the Sweep Oscillator, set the 115-230 volt switch for the line voltage to be used BEFORE connecting the power cable.

Note

Fuse ratings when using 8690B with 8706A and 8707A:

No. of RF Units	Acceptable Range of Fuse Rating	
	115V	230V
1	4 - 6 amps	2 - 3 amps
2	4 - 6.5 amps	2 - 3.5 amps
3	4.5 - 7.5 amps	2.25 - 4 amps
4	5 - 8.5 amps	2.5 - 4.5 amps
5	5.5 - 9 amps	2.75 - 5 amps
6	6 - 10 amps	3 - 5.5 amps
7	6.5 - 10.5 amps	3.25 - 6 amps
8	7 - 12 amps	3.5 - 7 amps
9	7 - 12 amps	3.5 - 7 amps

2-9. POWER CABLE.

2-10. To protect operating personnel, the National Electrical Manufacturers' Association (NEMA) recommends that the Sweep Oscillator panel and cabinet be grounded. Accordingly, the Sweep Oscillator is equipped with a three-conductor power cable which, when plugged into an appropriate receptacle, grounds the panel and cabinet. The offset pin of the three-prong connector is the ground pin.

2-11. To preserve the protection feature when operating the Oscillator from a two-contact outlet, use a three-prong to two-prong adapter (HP Stock No. 1251-0048) and connect the green pigtail on the adapter to ground.

2-12. COOLING.

2-13. Forced air cooling is used to maintain safe operating temperatures within the Sweep Oscillator and RF Unit. The air intake and exhaust ports, cooling fan, and air filter are located at the rear of the instrument. To ensure adequate ventilation, maintain about three inches of clearance behind the cabinet.

CAUTION

Do not operate the Sweep Oscillator if the fan is not operating.

2-14. RF UNIT AIR FILTER.

2-15. The air filter, as received with a new instrument, has a coating of dust-catching substance which improves air cleaning action. To maintain adequate ventilation, clean and recoat the air filter at regular intervals. See Section V for cleaning instructions.

2-16. MAGNETIC INTERFERENCE.

2-17. When using Model 8691A/B RF Units, do not locate the Sweep Oscillator in the vicinity of a strong magnetic field; magnetic interference can be detrimental to performance.

2-18. BENCH USE.

2-19. The Sweep Oscillator cabinet has plastic feet and a foldaway tilt stand for convenience in bench operation. The tilt stand permits inclining the instrument for more convenient viewing of the control panel, and the plastic feet are shaped to make full width modular instruments self-aligning when stacked.

2-20. For portability and protection in transit, accessory Control Panel Covers are available for the Sweep Oscillator. These are metal covers which fit between the handles at the front of the instrument. Each cover has a carrying handle and is readily fastened in place by two pushbutton latches. To obtain a Control Panel Cover for the Model 8690B, order HP Stock No. 5060-0829.

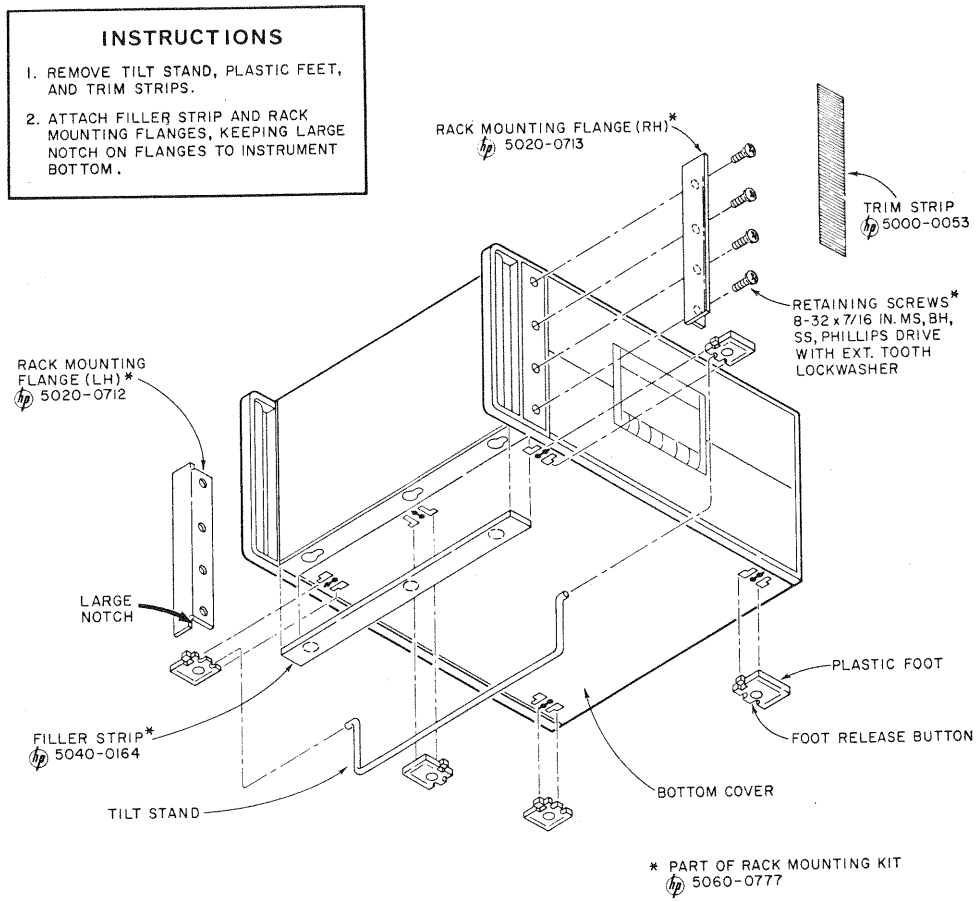


Figure 2-1. Preparation for Rack Mounting

2-21. RACK MOUNTING.

2-22. Preparation for rack mounting is illustrated in Figure 2-1. All necessary hardware is contained in the rack mounting kit supplied with the Sweep Oscillator.

Note

If the rack-mounted instrument will be subjected to shock or vibration, provide additional bracing at the rear of the cabinet.

2-23. REPACKAGING FOR SHIPMENT.

2-24. If the Sweep Oscillator is to be packaged for shipment use the original shipping container and packing materials. If these have been discarded or are not in condition for reuse, contact your local Hewlett-Packard sales and service office (see rear of this manual for locations), or follow these general instructions.

a. Wrap the Sweep Oscillator in heavy paper or plastic. (If the instrument is being shipped to a Hewlett-Packard service facility, attach a tag indicating type of servicing required, return address, model number, and full serial number.)

b. Use a strong shipping container. A carton made of 600 pound test material will usually provide adequate protection.

c. Use enough shock-absorbing material (3 to 4 inch layer) around all sides of the instrument to provide firm cushion and prevent movement inside the container. Protect the control panel with cardboard. With Hewlett-Packard "floater pack" packaging, the foam blocks provide sufficient shock protection, and additional material is unnecessary.

d. Seal the shipping container securely.

e. Mark the shipping container "FRAGILE" to assure careful handling.

Note

Because of the permanent magnetic field of Model 8691A/B RF Unit BWO, the Sweep Oscillator should not be shipped by air unless packaged to conform with air shipment regulations.

2-25. In any correspondence refer to the Sweep Oscillator by model number and full serial number.

SECTION III
OPERATION

3-1. INTRODUCTION.

3-2. The 8690B Sweep Oscillator, when used with one of the 8690-series RF Units comprises an electronically tuned microwave signal source. Each Oscillator is capable of four types of sweep: start-stop, marker, ΔF, and external FM. The first three sweeps are internally generated, while external FM permits remote tuning. The internally-generated sweeps have adjustable, calibrated end points and sweep times as well as a choice of sweep modes. The FM sweep has an adjustable CW frequency.

3-3. For start-stop sweeping independent controls determine the start and stop frequencies. Each frequency can be set anywhere within the RF Unit frequency range allowing output frequency to increase or decrease with time.

3-4. Marker sweep is the same as start-stop sweep except for a separate set of tuning controls and frequency registers.

3-5. ΔF sweep is a narrowband, variable-width sweep centered on a CW frequency. The CW frequency can be set anywhere within the range of the RF Unit, and sweep width is variable from 0 to 10 percent of the RF Unit frequency range.

3-6. For external FM sweep operation, any frequency within the RF Unit frequency range can be selected as the CW frequency with RF sweep width, rate and symmetry controlled by the externally-generated FM signal.

3-7. For start-stop sweeping, two internal RF frequency markers can be individually positioned anywhere within the selected sweep range. Each marker is produced by amplitude modulation of the RF output at the frequency selected. Since each marker is pushbutton-selected, one or both markers can be used. The triangular marker pulses are available at a rear-panel output and there is amplitude control for the RF-modulating pulses.

3-8. Common to all three internal sweeps are the sweep modes, the sweep time selector, and modulation capabilities. Each sweep may be automatically recurrent, manual, or triggered. Automatically recurrent sweeping can be synchronized with the power line frequency by rotating the vernier of the sweep time selector to a detent position. In the manual sweep mode output frequency variation is operator-controlled. In the trigger mode sweeping is initiated either by a front-panel pushbutton or by external negative signals.

3-9. For CW operation, either of two controls can be used to set the output frequency: the start control of the start-stop sweep or the start control of the marker sweep. Each control is calibrated and has the full frequency range of the RF Unit.

3-10. The Sweep Oscillator-RF Unit combination has provision for automatic leveling of output power. Normally, however, output power is unleveled and has the power-frequency characteristic of the RF oscillator. For both leveled and unleveled operation, the POWER LEVEL control on the RF Unit is an uncalibrated output attenuator.

3-11. Automatic leveling maintains output power constant as frequency changes and is achieved by a closed loop feedback system. A typical leveling system consists of a directional coupler for obtaining an RF sample of known proportion, a crystal detector to sense the RF level variations, and an amplifier to furnish a signal of appropriate polarity and magnitude to control the RF source and maintain RF output constant. In practice, power is not held absolutely constant, but variations can be confined within narrow limits.

3-12. Option 001 RF Units have a complete internal leveling system activated by a front panel pushbutton. Standard Sweep Oscillator-RF Unit combinations contain only the loop amplifier mentioned above.

3-13. Provisions for oscilloscope or graphic recorder display of swept-frequency measurements include a sawtooth voltage output of constant amplitude which can be used as a time base or frequency axis, pen lift on the two slowest sweeps to raise X-Y recorder pens beween sweeps, RF shut-off (blanking) between sweeps, manual trigger and manual sweep for display calibration, and visual indication of sweep duration for positive determination of sweep start and stop.

3-14. GENERAL OPERATING INFORMATION.

3-15. RF OUTPUT CONNECTOR.

3-16. 8691-4A/B, 8699B RF Units, except Option 001 Models, have standard 50-ohm type N coaxial output connectors. The Option 001 Models have HP precision 50-ohm type N coaxial connectors which are intended for coupling to standard type N connectors (e.g., UG-21D/U) only. CAUTION: Do not couple two HP precision connectors. Dimensions of the precision connector mating parts are such that coupling two precision connectors can result in connector damage and/or damage to devices having plated type (strip) transmission lines fastened directly to the precision connector. Since the Option 001 Models utilize the precision output connector of an HP strip line directional detector as the RF output connector, other HP devices having HP precision connectors must not be coupled directly to the RF Unit.

3-17. OUTPUT POWER RANGE.

3-18. Refer to Table 1-1 for RF power output specifications.

3-19. RF INPUT LIMITATION.

3-20. Excessive reverse RF power applied to the RF output connector can damage the solid state attenuator-modulator in the B Model RF Units, or the backward-wave oscillator tube in A Model RF Units.

CAUTION

Never apply more than 1 watt RF (CW or peak pulse) from an external source to the RF Unit power output connector.

3-21. BWO LIFE.

3-23. Since operating practices affect useful tube life,

a. always provide adequate ventilation for the interior of the Oscillator by maintaining at least three inches of clearance at the rear of the cabinet;

b. ensure that the air filter is clean; and

c. avoid prolonged operation of the Sweep Oscillator with the LINE switch at STANDBY. Although there is no RF output in this state, the BWO heater is energized.

3-24. MAGNETIC INTERFERENCE.

3-25. Sweep Oscillator performance can be adversely affected by strong external magnetic fields such as those produced by magnetrons and large transformers.

3-26. CONTROLS, CONNECTORS & INDICATORS.

3-27. Front- and rear-panel controls, connectors, and indicators are shown and described in Figures 3-1 and 3-2. Locations and descriptions apply to all 8690B Sweep Oscillator-8690 series RF Unit combinations.

3-28. BASIC OPERATING PROCEDURES.

3-29. TURN-ON.

a. Set rear-panel 115-230 switch to match line voltage before connecting the power cord to the service outlet. Check that the line fuse has correct rating. (Correct fuse rating is directly above the visible number on the switch slider.)

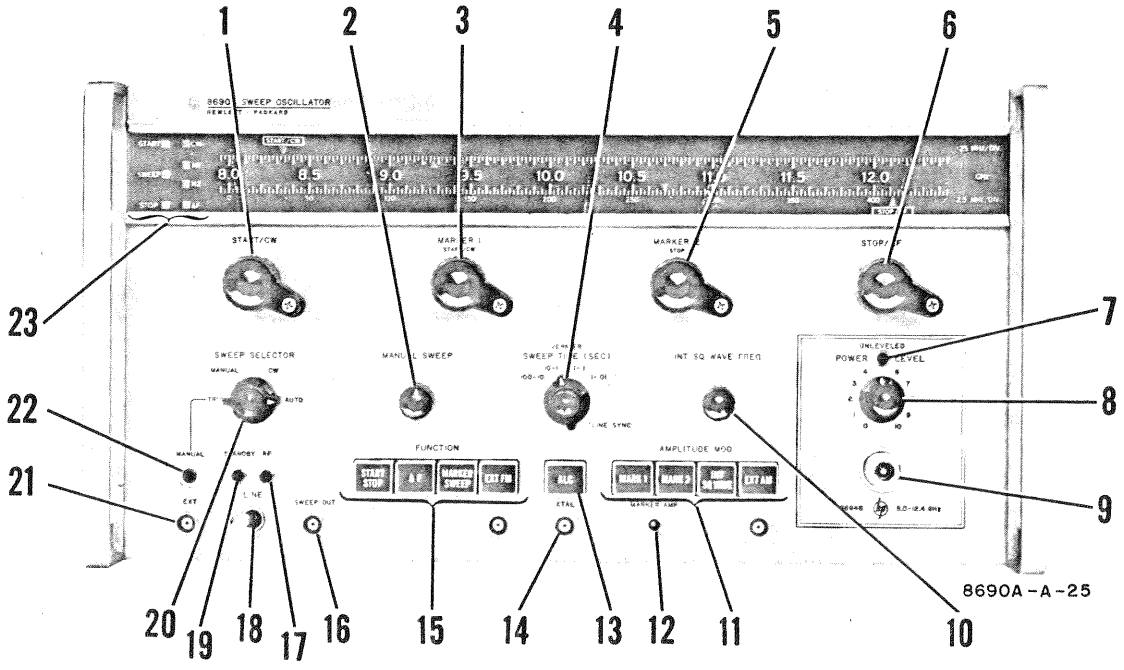


Figure 3-1. Front Panel Controls, Connectors, and Indicators

1. START/CW. Selects start frequency for start-stop sweep, CW frequency for CW operation, mid-frequency for ΔF sweep on slide-rule GHz scale.

2. MANUAL SWEEP. Manually varies frequency between end points of start-stop, ΔF, or marker sweep (counterclockwise extreme gives start frequency).

3. MARKER 1. Selects marker 1 frequency or marker sweep start frequency.

4. SWEEP TIME (SEC). Selects range of sweep time. VERNIER varies sweep time within selected range (sweep time decreases with clockwise rotation). Detent position at clockwise extreme synchronizes sweep with power line frequency.

5. MARKER 2. Selects marker 2 frequency or marker sweep stop frequency.

6. STOP/ΔF. Selects stop frequency for start-stop sweep on slide-rule GHz scale, frequency range for ΔF sweep on MHz scale.

7. UNLEVELED. Lights if POWER LEVEL set too high for leveling across selected frequency range.

8. POWER LEVEL. Adjusts RF amplitude.

9. RF Output Connector. Standard 50-ohm type N connector except on Option 01 Models which have hp precision 50-ohm type N connectors. See text.

10. INT SQ WAVE FREQ. Adjusts frequency of internal square wave modulation.

11. AMPLITUDE MOD. Select any combination of amplitude modulation: external amplitude modulation (apply signal to connector), markers, and internal square wave.

12. MARKER AMP. Adjusts amplitude of RF-modulating frequency markers, but does not affect rear-panel MARKER output.

13. ALC. Selects automatic RF leveling.

14. XTAL. Accepts leveling signal from crystal detector.

15. FUNCTION. Selects an internal sweep or external FM (SWEEP SELECTOR must be set to CW for external FM; apply FM signal to connector).

16. SWEEP OUT. Sweep voltage output (0 to +15V regardless of RF sweep width or direction).

17. RF. Indicator on when instrument is on and not in standby mode.

18. LINE. Controls line power to instrument; RF off in STANDBY; 1-min delay between OFF and RF.

19. STANDBY. Indicator on when instrument is on.

20. SWEEP SELECTOR. Selects mode of operation: CW, automatic sweep (free running or line synced), manual sweep, or triggered sweep.

21. EXT. Accepts external triggering signal when SWEEP SELECTOR is set to TRIG.

22. MANUAL. Pushbutton to start triggered sweep when SWEEP SELECTOR is set to TRIG.

23. START. Lights when START-STOP function mode is selected during automatic sweep.

    SWEEP. Lights during sweep.

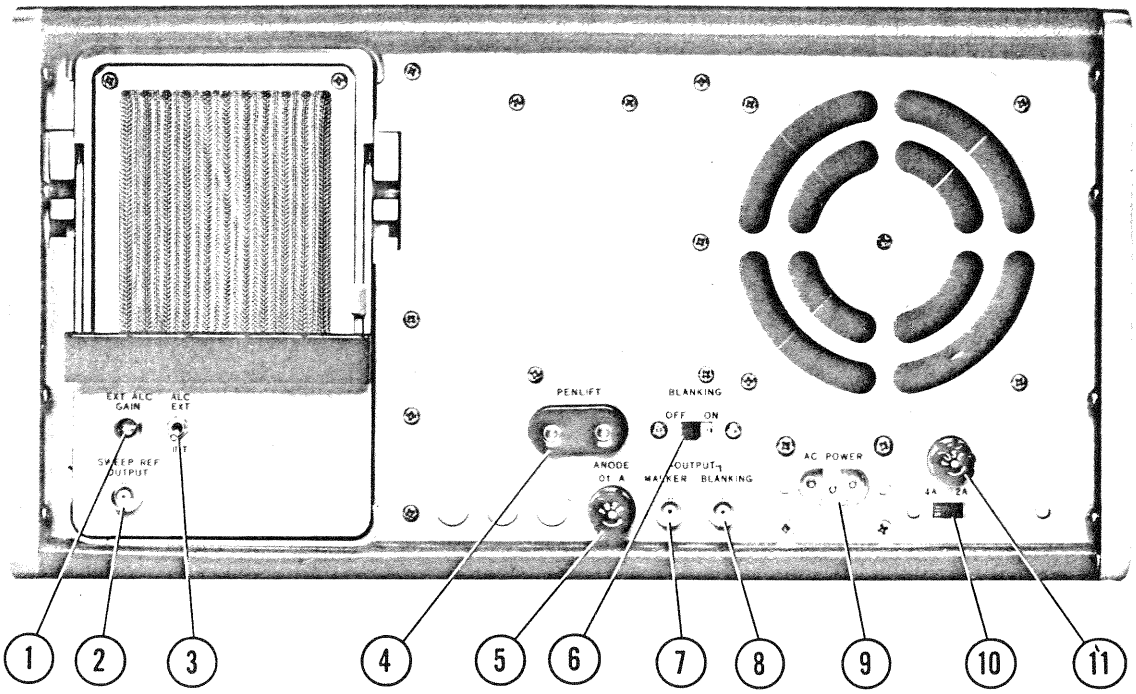
    STOP. Lights when START-STOP function mode is selected during automatic sweep.

    CW. Lights during CW operation or when ΔF function mode is selected.

    M1, M2. Lights when MARKER SWEEP function mode is selected. M1 only lights when MARKER SWEEP function mode is selected during CW operation.

    ΔF. Lights when ΔF function mode is selected during AUTO MANUAL OR TRIG operation. Does not light during CW operation.

Figure 3-1. Front Panel Controls, Connectors, and Indicators (Continued)



1. EXT ALC GAIN. (RF Unit.) Adjusts gain of ALC circuit to control flatness of leveling.

2. SWEEP REF OUTPUT. (RF Unit.) Output voltage proportional to RF frequency: 40 volts per octave. CAUTION: Application of voltage greater than ±15 volts may damage A1Q1 in RF Unit.

3. ALC. (RF Unit.) On Option 01 RF Units, this switch selects or disables an internal leveling loop.

4. PENLIFT. Terminals shorted during sweep (AUTO or TRIG sweep, two slowest sweep time ranges only).

5. ANODE. Overload prevention fuse for backward wave oscillator tube.

6. BLANKING. Allows RF to remain on during sweep recovery (OFF position). CAUTION: Application of voltage greater than ±15 volts may damage A10Q3, A10Q4.

7. MARKER OUTPUT. Frequency markers output. Pulses are triangular, typically -5 volts amplitude. Pulse amplitude is not affected by front panel MARKER AMP control. CAUTION: Application of voltage greater than ±15 volts may damage A11Q4, A11Q8.

8. BLANKING OUTPUT. Direct-coupled rectangular pulse of about -4V amplitude coincident with RF blanking. Pulse is present during automatic and triggered sweeping whether or not BLANKING is set to ON.

9. AC POWER. Power cable receptacle (offset pin connected to Sweep Oscillator chassis).

10. 115/230. Permits operation from 115 or 230 volts.

11. FUSE. Select rating to match line voltage (correct rating above number visible on 115/230 switch slider).

Figure 3-2. Rear Panel Controls and Connectors

b. Ensure the RF Unit is firmly seated into position and the locking handle is secured before applying power.

c. Connect Sweep Oscillator to power source.

d. Set front-panel LINE switch to RF. After about one to two minutes delay the RF indicator should glow. Failure of the indicator to glow is an indication of malfunction.

CAUTION

Do not use the Sweep Oscillator if the cooling fan does not operate when power is turned on.

3-30. STANDBY OPERATION.

3-31. When the LINE switch is set to STANDBY there is no RF output, but heaters of all electron tubes are energized and operating potentials are supplied to all circuits except the RF oscillator. This condition permits nearly immediate RF output when the LINE switch is set to RF, provided at least one minute has elapsed between OFF and STANDBY.

3-32. With no FUNCTION selectors depressed, the CW dial lamp will glow regardless of the settings of other controls.

3-33. SWEEP FUNCTIONS.

3-34. The Sweep Oscillators have four sweep functions which are designated Start-Stop, ΔF, Marker, and External FM. Four separate pushbuttons, each labeled for the function it selects, determine the type of swept-frequency operation.

3-35. START-STOP SWEEP.

3-36. For the start-stop sweep function, the sweep start and stop frequencies are separately adjustable to any frequency within the range of the RF Unit. Since the output frequency varies from the start frequency to the stop frequency, sweeping can be either up or down with time. In addition, sweeping can be automatically recurrent, triggered or manual, with variable sweep time for recurrent and triggered sweeping. All amplitude modulation capabilities can be used with the start-stop sweep and output power may be leveled or unleveled. Instructions for obtaining start-stop sweep are given in Figure 3-3.

3-37. ΔF SWEEP.

3-38. With ΔF sweep, output frequency varies upward through a segment of the RF Unit frequency range which is adjustable in width from zero to 10% of full range and centered on any frequency within the RF Unit range. All trigger and amplitude modulation capabilities may be used and sweep time, in the automatic and triggered modes, can be varied from 10 milliseconds to 100 seconds. RF output power may be leveled or unleveled. Figure 3-4 gives instructions for obtaining ΔF sweep.

3-39. MARKER SWEEP.

3-40. Marker sweep is similar to start-stop sweep with individual start and stop frequency controls and frequency registers which are separate from those of the start-stop sweep. The only functional difference between start-stop and marker sweep is that the RF frequency markers cannot be used with the marker sweep. Figure 3-5 gives instructions for obtaining marker sweep.

3-41. EXT FM.

3-42. The External FM function provides a means of obtaining output frequency which varies under the control of an externally-produced signal. Output frequency variation that is linear with time results from application of a voltage variation which is also linear with time. Positive-going voltage causes output frequency to increase while negative-going voltage causes output frequency to decrease. Maximum upward deviation is the full frequency range of the RF Unit, but downward deviation is restricted to approximately one-half the frequency range. The CW frequency of the FM sweep is calibrated and manually adjustable over the full frequency range. When the CW frequency is set below mid-range, total deviation can be the full frequency range. The external FM input is direct-coupled to permit remote frequency programming.

3-43. During external FM operation both the SWEEP SELECTOR and SWEEP TIME switch are inoperative, but there is full amplitude modulation capability and RF output power may be leveled or unleveled. Instructions for external FM operation are given in Figure 3-6.

3-44. FM LIMITATIONS.

CAUTION

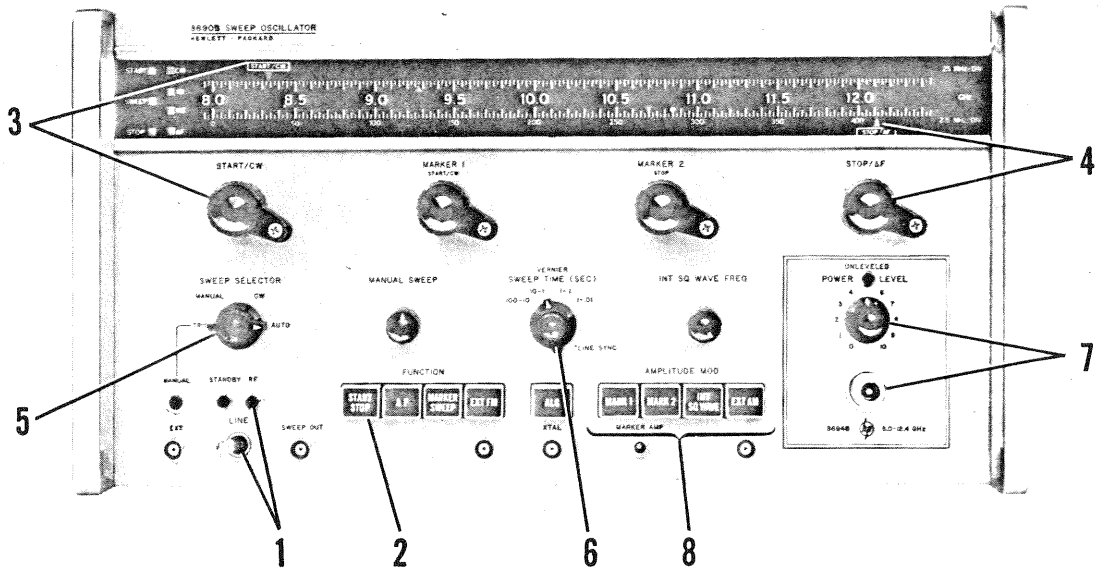
The Sweep Oscillator can be damaged by application of FM signals which exceed the safe operating limits given in the charts of Figure 3-7.

Chart A gives the percent of frequency range swept for each CW setting and FM input voltage (external FM signal frequencies less than 150 Hz). Chart B gives voltage limits for external FM signal frequencies above 150 Hz.

3-45. NEVER EXCEED THE FM VOLTAGE LIMITS GIVEN IN CHARTS A AND B OF FIGURE 3-7. Where there is a difference between limits indicated by charts A and B always use the smaller amplitude.

3-46. SWEEP MODES.

3-47. The sweep modes are designated TRIG, MANUAL, CW, and AUTO, the mode in use being determined by the setting of the SWEEP SELECTOR.



1. Set LINE to RF; RF indicator lights.

2. Press START-STOP; on dial START and STOP light. Check that all other pushbuttons are released.

3. Select sweep start frequency with START/CW.

4. Select sweep stop frequency with STOP/Δ F.

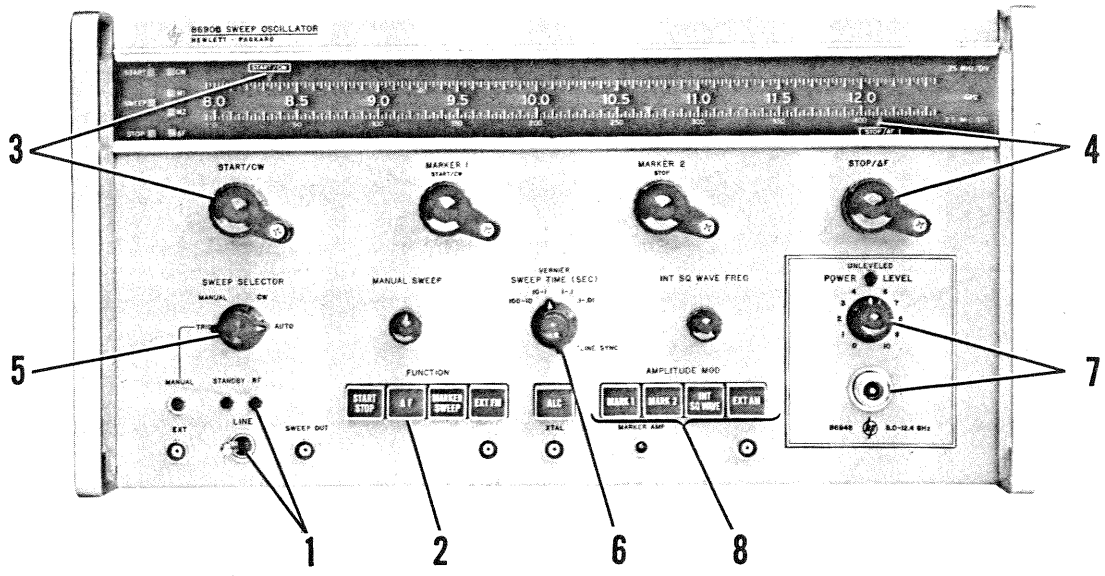
5. Choose AUTO, MANUAL or TRIGgered sweep mode with SWEEP SELECTOR. See Sweep Modes for mode characteristics.

6. With AUTO or TRIG mode set SWEEP TIME to desired range. Vary time within selected range with red VERNIER: clockwise rotation decreases time. To synchronize AUTO sweep with power-line frequency, switch VERNIER into LINE SYNC position. (LINE SYNC gives shortest sweep time of the range selected.)

7. Use POWER LEVEL as an uncalibrated output attenuator. For standard and Option 01 RF Units RF output is maximum at 10, minimum at 0. Attenuation range depends on whether RF is leveled or unleveled. With unleveled operation range is 30 dB minimum. See RF Power Leveling for leveled operation characteristics.

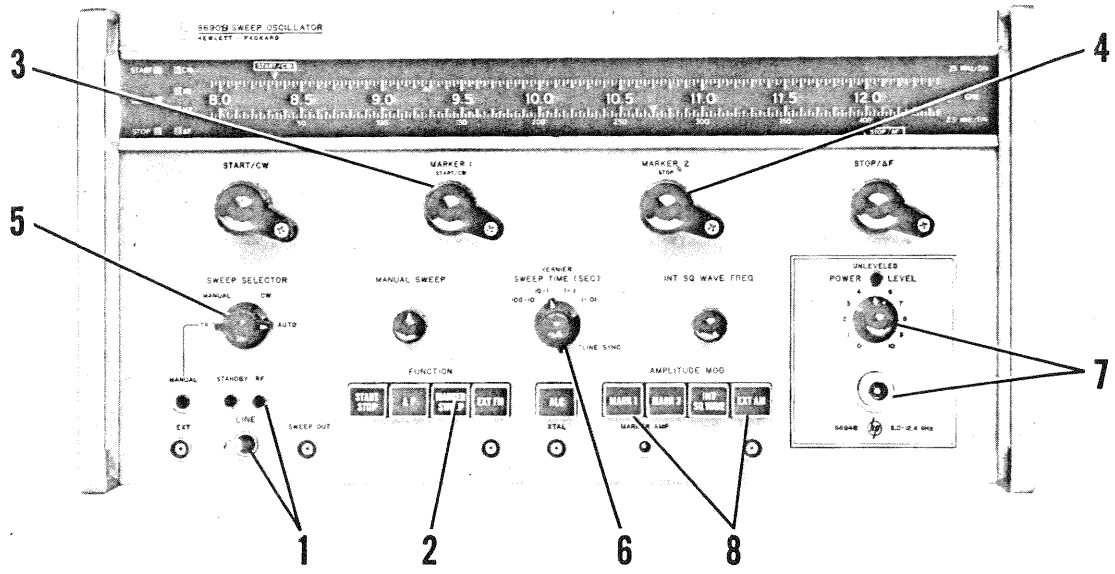
8. Start-stop sweep has full amplitude modulation capability. See Amplitude Modulation.

Figure 3-3. Start-Stop Sweep Operation



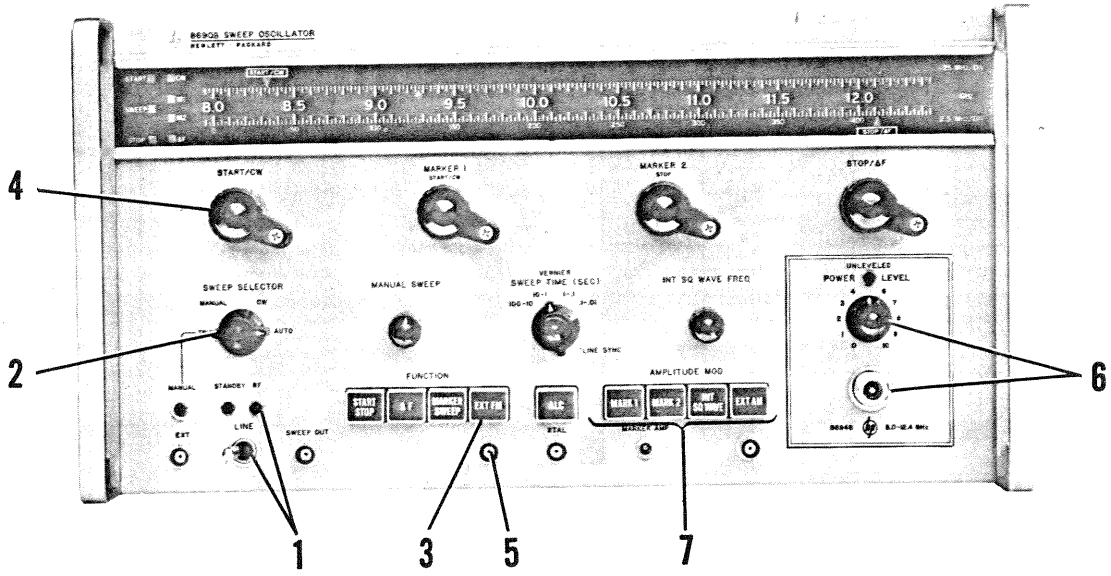
1. Set LINE to RF; RF indicator lights.
2. Press ΔF; on dial, CW and ΔF light. Check that all other pushbuttons are released.
3. Select sweep center frequency with START/CW.
4. Select sweep width on MHz scale with STOP/ΔF.
5. Choose AUTO, MANUAL, or TRIGgered sweep mode with SWEEP SELECTOR. See Sweep Modes for mode characteristics.
6. With AUTO or TRIG mode set SWEEP TIME to desired range. Vary time within selected range with red VERNIER: clockwise rotation decreases time. To synchronize AUTO sweep with power-line frequency, switch VERNIER into LINE SYNC position. (LINE SYNC gives shortest sweep time of the range selected.)
7. Use POWER LEVEL as an uncalibrated output attenuator. For standard and Option 01 RF Units RF output is maximum at 10, minimum at 0. Attenuation range depends on whether RF is leveled or unleveled. With unleveled operation range is 30 dB minimum. See RF Power Leveling for leveled operation characteristics.
8. ΔF sweep has full amplitude modulation capability. See Amplitude Modulation.

Figure 3-4. ΔF Sweep Operation



1. Set LINE to RF; RF indicator lights.
2. Press MARKER SWEEP; M1 and M2 light. Check that all other pushbuttons are released.
3. Set start frequency with MARKER 1 START/CW.
4. Set stop frequency with MARKER 2 STOP.
5. Choose AUTO, MANUAL, or TRIGgered sweep mode with SWEEP SELECTOR. See Sweep Modes for mode characteristics.
6. With AUTO or TRIG mode set SWEEP TIME to desired range. Vary time within selected range with red VERNIER: clockwise rotation decreases time. To synchronize AUTO sweep with power-line frequency, switch VERNIER into LINE SYNC position. (LINE SYNC gives shortest sweep time of the range selected.)
7. Use POWER LEVEL as an uncalibrated output attenuator. For standard and Option 01 RF Units RF output is maximum at 10, minimum at 0. Attenuation range depends on whether RF is leveled or unleveled. With unleveled operation range is 30 dB minimum. See RF Power Leveling for leveled operation characteristics.
8. Marker sweep has external amplitude and internal square wave modulation capability. See Amplitude Modulation.

Figure 3-5. Marker Sweep Operation



1. Set LINE to RF; RF indicator lights.

2. Set SWEEP SELECTOR to CW.

3. Press EXT FM; on dial, CW lights. Check that all other pushbuttons are released. Specified calibration accuracy requires additional 3 minute stabilization time.

4. Select the desired CW frequency with START/CW.

5. Connect frequency-modulating voltage to external FM input.

CAUTION

Observe voltage and frequency limits given in Figure 3-7.

6. Use POWER LEVEL as an uncalibrated output attentuator. For standard and Option 001 RF Units RF output is maximum at 10, minimum at 0. Attenuation range depends on whether RF is leveled or unleveled. With leveled operation range is 30 dB minimum. See RF Power Leveling for leveled operation characteristics.

7. External FM operation has full amplitude modulation capability. See Amplitude Modulation.

Figure 3-6. External FM Operation

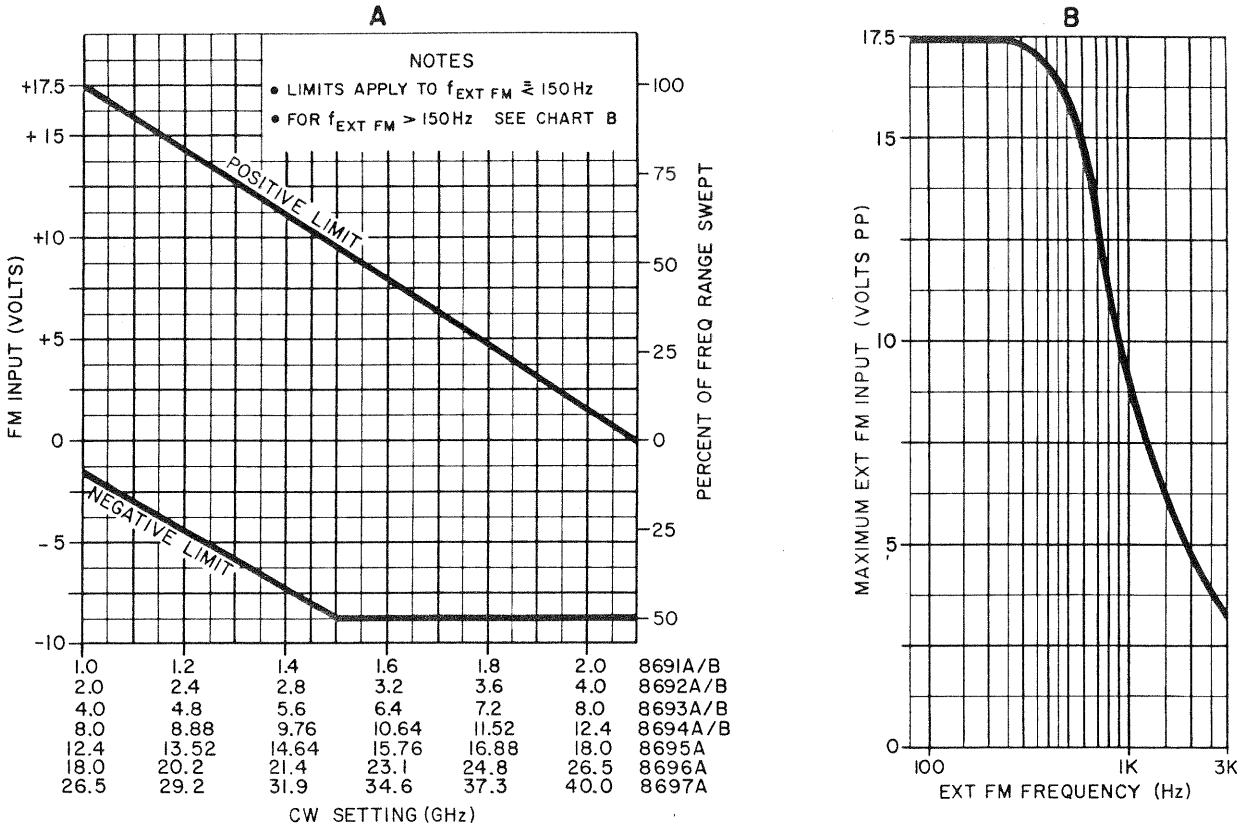


Figure 3-7. External FM Limitations

3-48. AUTO.

3-49. The AUTO sweep mode provides automatically recurrent sweeping for any sweep time selected by the SWEEP TIME controls and may be used with any sweep function except external FM. When the red SWEEP TIME vernier is in the detent LINE SYNC position, automatic sweeping is synchronized with the power-line frequency.

3-50. During AUTO sweeping the output frequency changes linearly with time and SWEEP light is on during each sweep.

3-51. Four sweep-synchronized outputs are activated during AUTO operation: SWEEP, SWEEP REF, BLANKING and PENLIFT. In addition, the RF output is automatically turned off, or blanked, between sweeps if the rear-panel BLANKING switch is ON.

3-52. TRIGGERED.

3-53. The triggered sweep mode permits manual one-shot sweeping and recurrent sweeping synchronized with an externally-produced signal, and may be used with any sweep function except external FM. A single sweep starts each time the front-panel MANUAL pushbutton is pressed and/or each time a suitable negative pulse is applied to the EXT input. Sweeping time is determined by the SWEEP TIME (SEC) controls but LINE SYNC is inoperative during triggered sweeping.

3-54. During a triggered sweep the output frequency changes linearly with time, and the SWEEP light is on.

3-55. Externally-produced trigger signals must have negative polarity, width greater than 1 μsec and rise time of at least 0.1 volt/μsec. Less than 25 volts amplitude will trigger a sweep. During slow sweeps a sweep can be interrupted and reset by pressing the MANUAL pushbutton.

3-56. Four sweep-synchronized outputs are activated during TRIG operation: SWEEP, SWEEP REF, BLANKING and PENLIFT. In addition, the RF output is automatically turned off, or blanked, between sweeps if the rear-panel BLANKING switch is ON.

3-57. CW.

3-58. The CW mode gives single-frequency operation and may be used with either the start-stop or marker sweep functions. Output frequency can be set anywhere in the RF Unit frequency range. Obtain CW output as follows:

a. Set LINE to RF.

b. Set SWEEP SELECTOR to CW; on dial, CW lights.

c. Press START-STOP or MARKER SWEEP.

d. Tune to desired frequency using START/CW or MARKER 1 as indicated by the sweep function selected.

e. Control output power with POWER LEVEL. For standard and Option 01 RF Units output power is maximum at 10, minimum at 0. POWER LEVEL is uncalibrated but has an attenuation range of at least 30 dB with unleveled output, 10 dB with leveled output.

f. Internally square wave or externally amplitude modulate the RF output. See Amplitude Modulation.

g. Use automatic RF power leveling to stabilize output level and improve source match. See RF Power Leveling.

3-59. During CW operation RF blanking, PENLIFT, SWEEP, and SWEEP outputs are not operational. However, a voltage proportional to output frequency is available at the RF Unit rear-panel SWEEP REF OUTPUT.

3-60. MANUAL.

3-61. The manual sweep mode permits manual tuning between the end frequencies of the start-stop, marker, or ΔF sweep. Any of the amplitude modulation functions may be used with manual sweep, and RF output can be leveled or unleveled. Both the SWEEP and SWEEP REF outputs are operational during manual sweeping, but RF blanking, PENLIFT and the SWEEP light do not function.

3-62. To sweep a frequency range manually, set controls for the desired sweep function using the appropriate instructions from Figures 3-3, 3-4, or 3-5 but set SWEEP SELECTOR to MANUAL and use MANUAL SWEEP to vary output frequency. Clockwise rotation varies output frequency toward the stop frequency of the selected sweep. Counterclockwise rotation varies output frequency toward the sweep start frequency. The SWEEP light does not function with manual sweeping.

3-63. Manual sweep is particularly useful for calibration of a display device such as an oscilloscope or graphic recorder prior to automatic swept-frequency measurements. Its use in this application is described in more detail under Displaying Swept-Frequency Measurements.

3-64. SWEEP TIME CONTROL.

3-65. The sweep time control consists of a four-position range selector and a vernier for continuous adjustment of sweeping time within the limits of each time range. Clockwise rotation of the vernier decreases sweeping time, the clockwise rotation limit giving the minimum time, and the counterclockwise limit giving the maximum time of the range selected. The detent LINE SYNC position of the vernier synchronizes sweeping with the power line frequency, but restricts sweeping time to the minimum of the range selected.

3-66. The sweep time controls are operational with start-stop, ΔF, and marker sweeps in the AUTO and TRIG modes. However, LINE SYNC does not function with triggered sweeps.

3-67. SWEEP OUTPUT.

3-68. SWEEP OUTput is an output frequency related positive voltage to provide a time or frequency axis for displaying swept frequency measurements. This positive voltage has fixed range, typically 0 to 15 volts, irrespective of sweep width. Zero is always coincident with the sweep start frequency and +15 volts is always coincident with the sweep stop frequency. With automatic and triggered sweeps, SWEEP OUT is a linear ramp synchronized with the RF sweep. During manual sweeps, SWEEP OUT voltage change is concurrent with output frequency change. SWEEP OUT functions with start-stop, marker, and ΔF sweeps in the AUTO, MANUAL and TRIG modes.

3-69. SWEEP REFERENCE OUTPUT.

3-70. The RF Unit rear-panel SWEEP REF OUTPUT is a direct-coupled positive voltage proportional to output frequency. SWEEP REF is 40 volts per octave and is determined by RF Unit A1R36 and A1R37 for the particular frequency range of the RF Unit used. Voltage change is concurrent with output frequency change, the actual range and dc limits being determined by the RF sweep width and its location in the frequency range. SWEEP REF OUTPUT is provided with all sweep functions and modes.

3-71. PENLIFT.

3-72. The rear-panel PENLIFT terminals furnish a sweep-synchronized writing control for graphic recorders equipped to write in response to a remote short circuit. The PENLIFT terminals are shorted during the RF sweep, open between sweeps. The PENLIFT circuit operates during AUTO and TRIG sweeps in the two slowest sweep time ranges only.

3-73. RF BLANKING.

3-74. The RF blanking automatically attenuates the power output at least 30 dB ("A" Model RF Units, 20 dB for "B" Models) between sweeps giving a no-output reference trace on an oscilloscope display of swept-frequency measurement. Blanking can be used with start-stop, marker, and ΔF sweeps in the AUTO and TRIG modes. With AUTO sweeps the blanking interval ends slightly in advance of RF sweep start to allow external circuits and equipment to stabilize. The RF blanking can be disabled with the rear-panel BLANKING On-Off switch.

3-75. During automatic and triggered sweeping a rectangular negative pulse coincident with the RF blanking is present at the rear-panel BLANKING OUTPUT. The pulse has 3.5 to 4 volts amplitude and is independent of the BLANKING ON-OFF switch setting.

3-76. EXPANDED SWEEP OPERATION.

3-77. Certain swept-frequency measurements, such as bandpass filter evaluation, require rapid examination of more than one frequency band (e.g., filter overall response characteristic, pass and stop bands).

3-78. Because the start-stop and marker sweeps are independent they can be used in combination with the internal frequency markers to obtain expanded sweep presentation. For instance, start-stop sweep can be used to cover a broad frequency range such as the overall response characteristic of the filter mentioned above. If a segment of this range (the stop band, for example) merits detailed examination, the internal frequency markers can be activated and tuned to bracket the important segment. Then, pressing MARKER SWEEP expands the bracketed segment to occupy the full presentation and full sweep time. Without further adjustment, the original sweep may be restored by pressing START-STOP.

3-79. The foregoing example of expanded sweep operation assumes one sweep range within another. However, the two sweep ranges need not be one within the other or even overlap; they may each cover separate, remote segments of the RF Unit frequency range.

3-80. FOUR PRESET CW FREQUENCIES.

3-81. The manual sweep control, in conjunction with the CW mode and the start-stop and marker sweep functions, can be used to obtain four preset CW frequencies as follows:

a. Select four different frequencies using START/CW, STOP/ΔF, MARKER 1, and MARKER 2 controls.

b. Rotate MANUAL SWEEP fully clockwise.

c. Set SWEEP SELECTOR to CW.

d. Press START-STOP to obtain CW output at frequency indicated by START/CW dial pointer.

e. Press MARKER SWEEP to obtain CW output at frequency indicated by MARKER 1 setting.

f. Set SWEEP SELECTOR to MANUAL to obtain CW output at frequency indicated by MARKER 2 setting.

g. Press START-STOP to obtain CW output at frequency indicated by STOP/ΔF dial pointer.

3-82. AMPLITUDE MODULATION.

3-83. EXTERNAL AM.

3-84. The Sweep Oscillator RF output may be amplitude modulated by signals applied to the front-panel connector under the EXT AM pushbutton. External amplitude modulation is possible with any sweep mode or function. Frequency response is dc to 350 kHz for unleveled RF output and dc to 50 kHz for leveled output. Negative 10 volts reduces RF output at least 30 dB below rated CW output ("A" Model RF Units, 20 dB for "B" Models).

3-85. INTERNAL FREQUENCY MARKERS.

3-86. Two calibrated frequency markers can be independently adjusted over the full frequency range of the RF Unit. One is tuned by the MARKER 1 control and the other by the MARKER 2 control. Each marker amplitude-modulates the RF output with a wedge-shaped notch at the frequency indicated by the appropriate marker dial pointer. The front-panel MARKER AMP control permits amplitude adjustment of the amplitude-modulating marker but does not affect the amplitude of the pulses at the rear-panel MARKER OUTPUT. The amplitude of these pulses is typically -5 volts peak into a 1000-ohm load.

3-87. Activated separately by the MARK 1 and MARK 2 pushbuttons, the markers can be used individually or simultaneously during start-stop, ΔF, or external FM operation with the auto, manual, or triggered mode. In addition, markers may be used in combination with external amplitude or internal square-wave modulation.

3-88. INTERNAL SQUARE WAVE.

3-89. Internally-generated square-wave modulation can be used with any sweep function or sweep mode and with marker or external amplitude modulation. At rated RF output the square wave on-off ratio exceeds 20 dB. The INT SQ WAVE pushbutton selects square wave modulation, and INT SQ WAVE FREQ permits continuous adjustment of frequency from 950 to 1050 Hz.

3-90. RF POWER LEVELING.

3-91. A requirement for rapid, broadband evaluation of microwave devices is constant RF power in the frequency range of interest. The backward-wave oscillator (BWO) used as the microwave source in the RF Unit does not generate constant RF power throughout the operating frequency range. The RF power output of a BWO usually consists of minor, narrowband variations superimposed on a gross variation, as illustrated in Figure 3-8. Minor variations are typically less than 3 dB while the gross variation may be as great as 10 dB. By deriving a signal which is the inverse of this power characteristic and applying it as amplitude control, the RF power output can be maintained essentially constant with changing frequency. This control of output power is called leveling.

3-92. The leveling system in the 8690B Sweep Oscillator-8690 series RF Units is a negative feedback closed loop. The system senses RF power variations and automatically produced amplitude-control signals which reduce power variations.

3-93. A typical negative feedback closed leveling loop (Figure 3-9) consists of a directional coupler to sample RF output, a crystal detector to convert instantaneous RF power variations in the sample to proportional dc, and a differential amplifier to compare the dc against a reference and furnish an amplified difference signal. This difference signal, applied as RF amplitude control, determines magnitude of leveled power and reduces power variations.

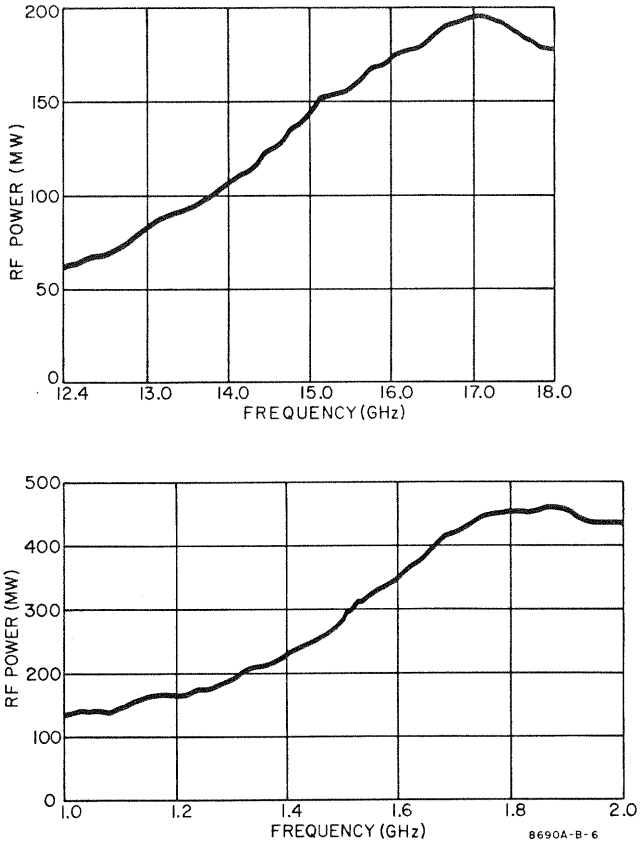


Figure 3-8. Typical RF Power Output Characteristics of 1-2 GHz and 12.4-18GHz BWO Tubes

3-94. In the leveling loop the differential amplifier acts to keep the input from the crystal detector equal to the dc reference and, by feedback action, causes the leveling loop to maintain crystal detector output constant. The same feedback action would also maintain RF power in the coupler main line constant, but between the detector output and the coupler main line are several frequency-dependent variables which prevent main line power from being absolutely constant. Such factors as detector frequency response, coupling variation with frequency, coupler-to-detector match, and coupler directivity each affect the flatness of RF power in the coupler main line. Nevertheless, the leveling loop can reduce power variations from a deviation as great as 10 dB to less than 1 dB over the RF Unit tuning range.

3-95. In addition to holding RF power constant with changing frequency, the leveling loop also improves source match. The amount of improvement is determined by the directivity and main-line SWR of the RF-sampling directional coupler: the greater the directivity and the smaller the main-line SWR, the greater the source match improvement. The practical limit to the effect of directivity, however, is usually the coupler main-line SWR. For coaxial couplers having main-line SWR of 1.2:1, for instance, directivity exceeding 26 to 30 dB produces no significant source match improvement. Similarly, for a waveguide coupler having main-line SWR of 1.05:1 the practical directivity limit is about 40 dB.

3-96. LEVELING POINT CONSIDERATIONS.

3-97. The closed leveling loop holds RF power constant at the point of RF sampling. Thus, if sampling is done at the RF Unit power output connector, discontinuities in the transmission system between the connector and load cause uncontrollable power variations at the load. However, if the sampling point is located as near the load as possible, transmission system discontinuities are contained within the leveling loop and their effects are automatically compensated.

3-98. The effect of leveling point location on power variations at the load is shown in Figure 3-10. Although X-Y recorder plot A was obtained with the coupler-detector external to the Sweep Oscillator, the plot is also valid for Option 01 RF Units which have an internal directional detector. Although the plots were made using a 1-2 GHz BWO, this comparison is typical for all RF Unit frequency ranges.

3-99. Recorder plot A was made with a HP 360 Low-Pass Filter (arrow, Figure 3-10) connected between the sampling coupler and load to simulate transmission irregularity between leveling loop and load. The filter has maximum SWR of 1.4:1 and the load, consisting of a 50-ohm termination and HP 478 Thermistor Mount, has an SWR of about 2:1. The resultant power variation in the frequency range swept is approximately 1 dB. In contrast, recorder plot B shows power variation at the load reduced to 0.25 dB with the leveling point at the load.

3-100. Remote-point leveling is accomplished using the same systems and procedures as those given in succeeding paragraphs for leveling at the RF output, the only difference being that the RF-sampling directional detector or directional coupler and RF detector are located at the system point where leveled RF power is required, not at the RF Unit power output connector.

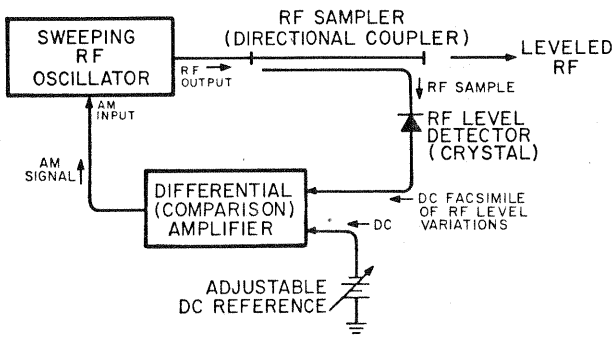


Figure 3-9. Typical Leveling Loop

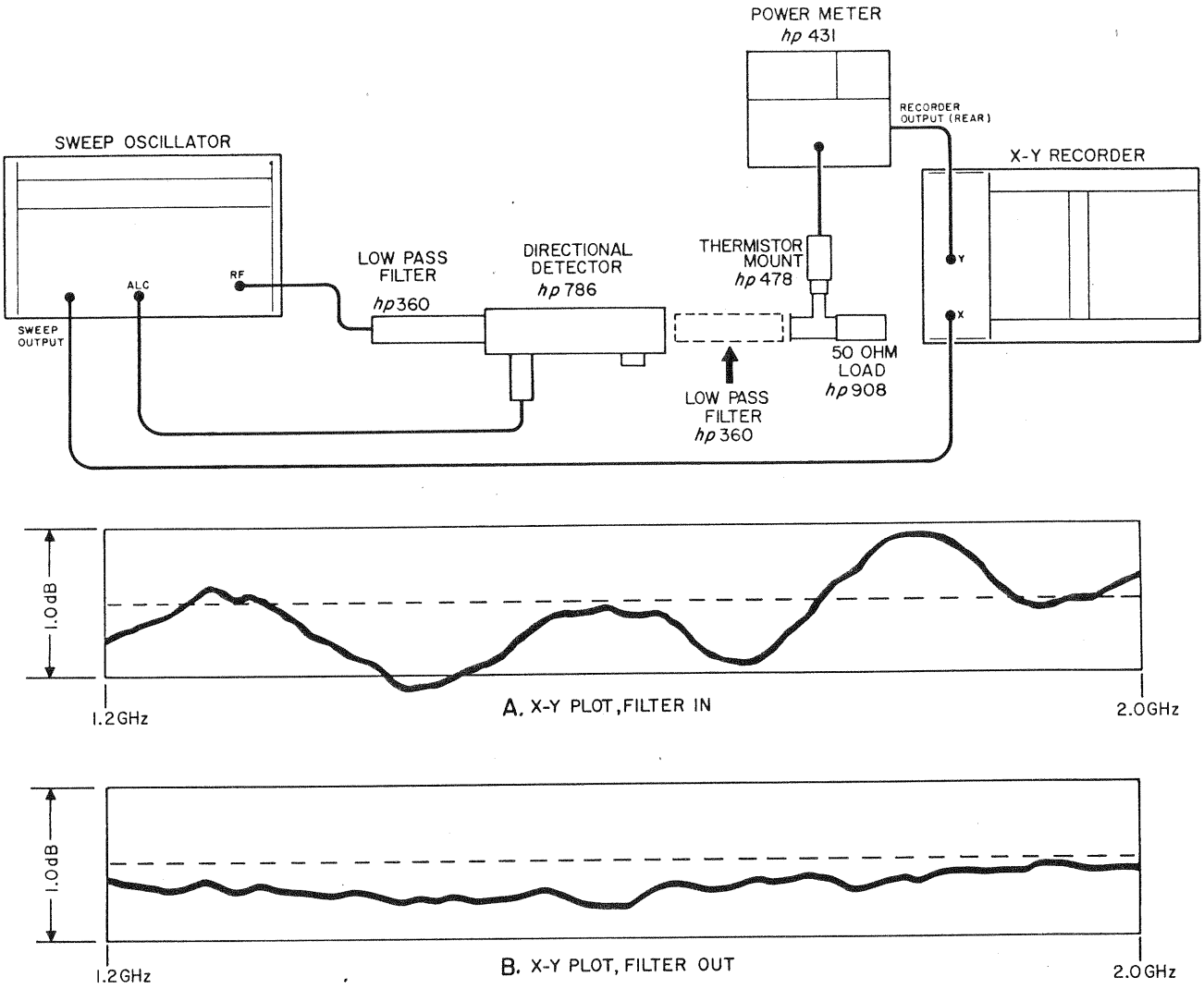


Figure 3-10. Effect of Leveling Point on Power Variation

3-101. DEPENDENCY OF MAXIMUM LEVELED POWER ON FREQUENCY.

3-102. Maximum leveled RF power cannot exceed the minimum available from the BWO in the frequency range being swept. Also, the maximum leveled RF power available from a particular Sweep Oscillator depends upon the frequency range being swept and the output power characteristic of the microwave oscillator (BWO) in the RF Unit used. Figure 3-11 shows the output power characteristics of a typical 1 to 2 GHz and 12.4 to 18 GHz oscillators. The Figure indicates the maximum leveled RF power available for three sweep ranges within each frequency range. Dot shading indicates maximum leveled power available over a full frequency range; diagonal shading shows additional leveled power available in segments of the frequency range. Microwave oscillators in the frequency ranges 2 to 12.4 GHz and 18 to 40 GHz have similar output power characteristics; that is, RF output is minimum toward the lower frequency limit of the tuning range and increases with frequency to a maximum at, or near, the upper limit of the tuning range, However, actual maximum and minimum RF power available varies from frequency range to frequency range and from BWO to BWO in the same frequency range. Therefore, a microwave power meter such as the HP Model 431 with an appropriate thermistor mount is required both for determining maximum leveled RF power and for obtaining required RF power.

3-103. LEVELING EQUIPMENT.

3-104. The leveling amplifier in the Sweep Oscillator-RF Unit combination is intended for use with HP 423 and 424 Crystal Detectors, HP directional detectors, HP directional couplers. Since these components are available in both coaxial and waveguide models, RF leveling is possible in either transmission system. Components for coaxial RF leveling systems and waveguide leveling systems are listed in Table 1-2.

3-105. THE RF SAMPLER. The RF power output can be sampled either by a directional coupler or a directional detector. A directional detector is a direc-

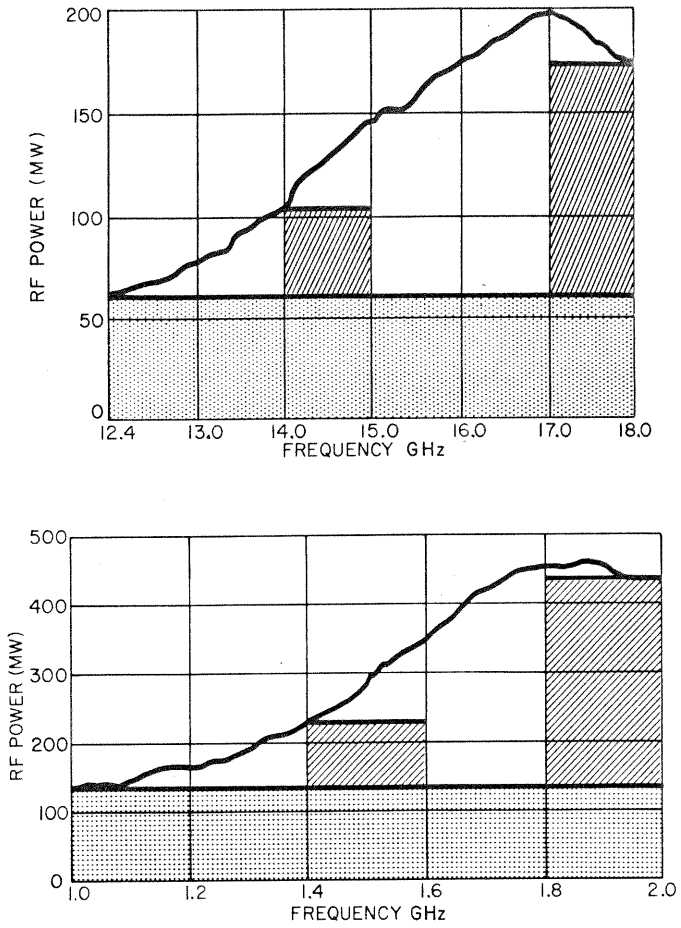


Figure 3-11. Comparison of Maximum Leveled RF Power and Frequency Range Swept

tional coupler matched to a sensitive, flat-responding crystal detector. With the directional detector, performance variables such as coupling variation with frequency, detector frequency response, and coupler-detector match are grouped and specified as frequency response.

3-106. Whether the RF sampler is a directional coupler or directional detector there is a critical coupling attenuation required to assure proper operation of the leveling loop. Coupling attenuation should be 20 to 23 dB with the Models 8691A/B, through 8694A/B, and 8695A, 10 to 13 dB with the Models 8696A and 8697A. In addition, the smaller the coupling variation with frequency and the greater the directivity, the better the leveling.

3-107. THE RF DETECTOR. A crystal detector may be used to derive the dc signal proportional to RF power variations required to operate the leveling amplifier, which must receive a negative polarity signal, is intended for use with HP 423 and 424 Crystal Detectors, and HP directional detectors.

3-108. A crystal detector permits use of the full sweep time range of the Sweep Oscillator. Thus, sweeping time can be short enough to give steady oscilloscope display of swept-frequency measurements, a capability especially useful for continuous display of the effects of tuning or adjusting a device under test.

3-110. LOW-PASS OR BANDPASS FILTER. To minimize the effects of RF harmonics, which can degrade leveling and cause measurement errors, a low-pass or bandpass filter should be inserted into the RF main line within the leveling loop. Including the filter in the leveling loop provides automatic compensation for its transmission properties.

3-111. OSCILLOSCOPE MONITOR. For RF power leveling using a crystal detector, an oscilloscope should be used to indicate when the RF Unit POWER LEVEL and EXT ALC GAIN controls are set to give optimum leveling. If an oscilloscope is used to display the results of swept-frequency measurements, it can serve to monitor leveling performance as well. If no such display is used, the monitor oscilloscope should be connected between the RF detector and the Sweep Oscillator. For standard RF Units, loop performance can be monitored by means of a type BNC tee connector at the crystal detector video output or at the Sweep Oscillator XTAL input.

3-112. LEVELING PERFORMANCE.

3-113. For proper leveling without ALC loop oscillations, the ALC voltage returned to the 8690B XTAL input must be 100 mV or less. To ensure this requirement, always maintain an open loop ALC voltage of 50 mV or less. For RF detectors such as the HP Model 423, with a square law load, this voltage will not be exceeded if the input power to the RF detector is held to 1 mW or less.

3-114. When a traveling wave tube (TWT) amplifier is used, leveling signals should be applied to the 8690B. A low pass filter should be connected to the output of the TWT and an isolator connected to the input of a directional coupler. Directional Couplers should be used to provide RF input to the RF detector, rather than to use a directional detector. The directional coupler permits insertion of additional attenuation if required to hold the power at the detector to 1 mW or less.

3-115. The RF power leveling capability of the systems illustrated in Figures 3-12 through 3-17 is determined mainly by the frequency-dependent performance variables of the RF sampler and RF detector. Coupling variation with frequency, coupler-to-detector mismatch, coupler directivity and detector frequency response all affect leveling. The level variations given in Tables 3-1 and 3-2 are those resulting from the maximum effect of the error sources present in leveling loops assembled from appropriate components

Table 3-1. Leveling Performance of Coaxial Leveling Loops

Leveling Loop	Maximum Power Variation (dB)[1]							
	Load SWR = 1				Load SWR = 1.5			
	1-2 GHz	2-4 GHz	4-8 GHz	8-12.4 GHz	1-2 GHz	2-4 GHz	4-8 GHz	8-12.4 GHz
Figure 3-12 with Coupler and Detector	±0.66	±0.68	±0.72		±0.82	±0.88	±0.92	
Figure 3-12 with Directional Detector	±0.40	±0.40	±0.40	±0.60	±0.56	±0.60	±0.60	±0.80

[1] Worst case: Errors summed arithmetically (see Paragraph 3-115).

Table 3-2. Leveling Performance of Waveguide Leveling Loops

Leveling Loop	Maximum Power Variation (dB)[1]									
	Load SWR = 1					Load SWR = 1.5				
	2.60-3.95 GHz	3.95-5.85 GHz	5.85-8.2 GHz	7.05-10.0 GHz	8.2-12.4 GHz	2.60-3.95 GHz	3.95-5.85 GHz	5.85-8.2 GHz	7.05-10.0 GHz	8.2-12.4 GHz
Fig. 3-13 with Coupler and Detector	±0.95	±0.95	±0.94	±0.94	±1.04	±0.98	±0.98	±0.98	±0.98	±1.08
Fig. 3-13 with Directional Detector					±0.60					±0.64
Fig. 3-14	±0.64	±0.64	±0.64	±0.64	±0.74	±0.68	±0.68	±0.68	±0.68	±0.78

[1] Worst case: Errors summed arithmetically (see Paragraph 3-115).

listed in Table 1-2. However, the error effects in such leveling systems are vector quantities having phase relationships which vary with frequency and do not always cause maximum error. Rather, total error is more usually the rms of the error quantities. Therefore, leveling likely will be better than indicated, but the performance figures given permit comparing the capabilities of the systems illustrated in Figures 3-12 through 3-14.

3-116. Two values of load SWR are included in the tables to indicate how the load on the leveling system influences leveling performance. This loading effect results from the imperfect directivity of the RF-sampling coupler which allows some of the power reflected from the load to reach the RF detector and cause level variations. For a given coupler, load-produced level variation is proportional to load SWR.

3-117. LEVELING CONTROLS, INDICATORS AND INPUTS.

3-118. ALC PUSHBUTTON. The ALC pushbutton activates the internal leveling amplifier.

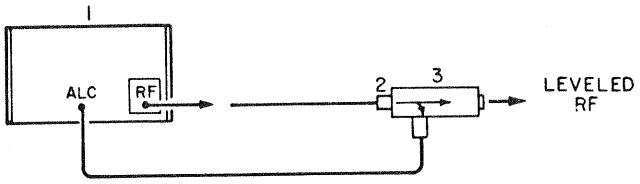
3-119. ALC SWITCH. On Option 001 RF Units only, the rear panel ALC switch activates an internal leveling system.

3-120. POWER LEVEL CONTROL. The two-section RF Unit POWER LEVEL control sets magnitude of leveled RF power.

3-121. EXT ALC GAIN CONTROL. This rear panel RF Unit control varies leveling loop sensitivity to RF level variations.

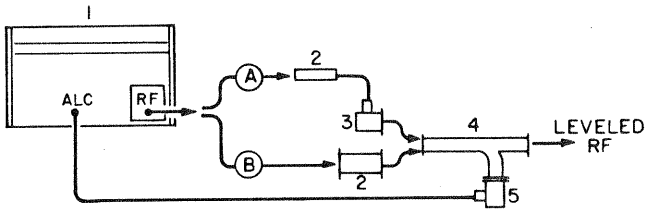
3-122. LEVELING SIGNAL INPUTS. The front-panel XTAL input accepts crystal detector-derived leveling signals.

3-123. POWER LEVEL INDICATOR. The UNLEVELED indicator functions only when the ALC pushbutton is pressed (rear panel RF Unit ALC switch is set to INT). When the UNLEVELED light is off, the entire sweep is leveled; when on, all or part of sweep is unleveled.



1. SWEEP OSCILLATOR
2. LOW PASS OR BANDPASS FILTER
3. DIRECTIONAL COUPLER AND CRYSTAL DETECTOR OR DIRECTIONAL DETECTOR

Figure 3-12. Coaxial Leveling Loop Using Crystal Detector



1. SWEEP OSCILLATOR
2. LOW PASS OR BANDPASS FILTER
3. WAVEGUIDE TO COAXIAL OUTPUT
4. DIRECTIONAL COUPLER
5. CRYSTAL DETECTOR

(A) FOR COAXIAL OUTPUT RF UNITS
(B) FOR WAVEGUIDE OUTPUT RF UNITS

Figure 3-13. Waveguide Leveling Loop Using Crystal Detector

3-124. In general, the RF Unit EXT ALC GAIN control determines the ability of the leveling system to reduce RF power variations and POWER LEVEL controls the magnitude of leveled power. Thus, EXT ALC GAIN can be considered an RF flatness control and POWER LEVEL an RF amplitude control. RF Unit Models 8691A thru 8697A have enough function overlap between EXT ALC GAIN and POWER LEVEL that the settings of both controls must be optimized during initial leveling adjustments and thereafter whenever RF amplitude is changed. Clockwise rotation of EXT ALC GAIN improves RF flatness but can cause the leveling loop to oscillate; hence, the optimum EXT ALC GAIN setting is just counterclockwise of that which causes loop oscillation.

3-125. LEVELING AT THE RF OUTPUT.

3-126. Figures 3-12 through 3-14 illustrate closed loop leveling systems for automatically leveling the RF power output. The systems of Figures 3-14 and 3-17 each use two directional couplers to minimize coupling variation with frequency. The coupling variation of one coupler compensates for the coupling variation of the other, reducing coupling inaccuracy to the difference in coupling characteristics between the couplers. This remaining factor can be effectively eliminated with couplers selected for nearly identical coupling characteristics. Such matched couplers are available from Hewlett-Packard in various combinations of coupling attenuation. For each combination, attenuation accuracy between main and secondary line output is specified and is typically ±0. 2 dB or better.

3-127. STANDARD SWEEP OSCILLATOR USING CRYSTAL DETECTOR.

3-128. LOOP ASSEMBLY.

a. Assemble the leveling loop of Figure 3-12, 3-13, or 3-14 using appropriate equipment listed in Table 1-2.

b. Connect crystal detector video output to Sweep Oscillator XTAL input.

c. Connect an oscilloscope to monitor leveling loop performance. Connect the oscilloscope vertical input (dc-coupled) to a BNC tee connector at the crystal detector video output, and connect the horizontal input (dc-coupled) to the Sweep Oscillator SWEEP OUT.

3-129. LOOP OPERATION.

a. Obtain desired mode of operation from the Sweep Oscillator.

b. Adjust EXT ALC GAIN maximum clockwise. (Rear panel, RF Unit.)

c. Press ALC.

d. Rotate POWER LEVEL knob to a convenient reference on the 0 to 10 scale. (For maximum resolution set to 10.)

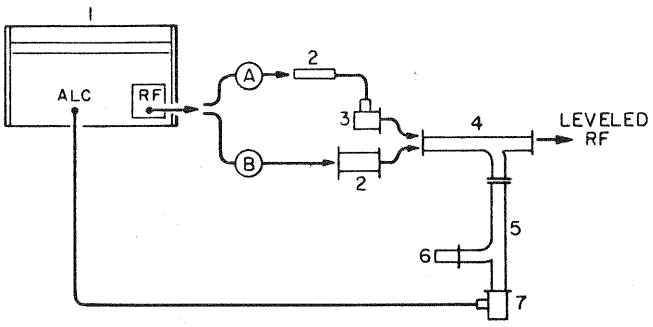
e. If POWER LEVEL is set for more RF power than the least available in the selected sweep range, the UNLEVELED light will light. To level the entire sweep, rotate POWER LEVEL until the UNLEVELED light goes out. Leveled RF power is now the maximum available in the selected frequency range.

f. If an oscilloscope monitoring ALC loop performance shows loop oscillation, adjust RF Unit rear panel EXT ALC GAIN until oscillation just ceases. Always adjust RF Unit EXT ALC GAIN and LEVEL SHUNT/POWER LEVEL controls in combination to ensure maximum leveled RF power without loop oscillation.

Note

To change power level control resolution, remove the top cover of the sweep oscillator and set screwdriver operated RF Unit A1R1 LEVEL SHUNT until the UNLEVELED light goes out.

g. To reduce leveled RF power rotate POWER LEVEL knob counterclockwise: attenuation range is 10 dB, minimum. When using RF Unit Models 8691A thru 8697A, readjust EXT ALC GAIN after each change of power level.



1. SWEEP OSCILLATOR
2. LOW PASS OR BANDPASS FILTER
3. WAVEGUIDE TO COAXIAL ADAPTER
4. & 5. MATCHED DIRECTIONAL COUPLERS
6. LOAD
7. CRYSTAL DETECTOR

(A) FOR COAXIAL OUTPUT RF UNIT
(B) FOR WAVEGUIDE OUTPUT RF UNIT

Figure 3-14. Coupler-Compensated Waveguide Leveling Loop Using Crystal Detector

3-130. OPTION 001 RF UNITS.

3-131. LOOP ASSEMBLY.

3-132. Option 001 RF Units, having internal leveling loops, require no external equipment to furnish leveled RF power. However, Option 001 RF Units do require a power meter to indicate actual leveled power, and an oscilloscope to indicate optimum leveling. Note: the rear panel ALC switch must be at INT to activate the internal leveling loop. In the EXT position, the loop is disabled.

3-133. LOOP OPERATION.

a. Set Sweep Oscillator for desired mode of operation.

b. Set ALC switch to INT.

c. If POWER LEVEL is set for more RF power than the least available in the frequency range being swept, the UNLEVELED light will light. Rotate POWER LEVEL counterclockwise until UNLEVELED light remains off during the sweep interval. Output power is now leveled at maximum possible in the selected frequency range.

3-134. EXT ALC GAIN ADJUSTMENT.

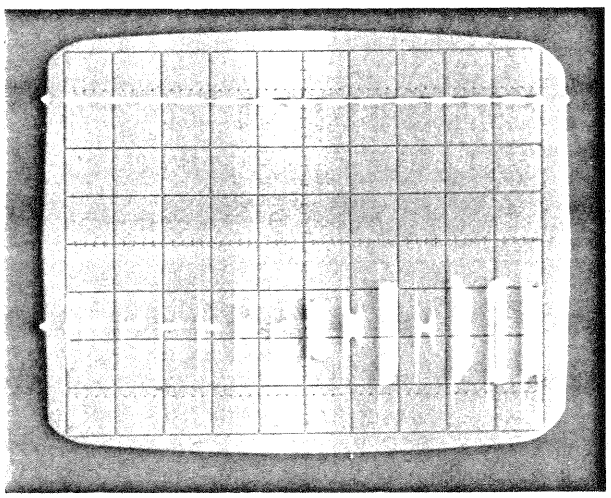
3-135. Gain of the leveling loop is affected by the directional coupler used. The EXT ALC GAIN adjustment on the RF Unit rear panel permits operator adjustment of ALC loop gain.

3-136. Proper ALC gain adjustment is obtained by observing an oscilloscope display of the leveled RF output. With 8690B square wave modulation on, adjust EXT ALC GAIN for optimum leveled display without square wave overshoot as shown in Figure 3-15.

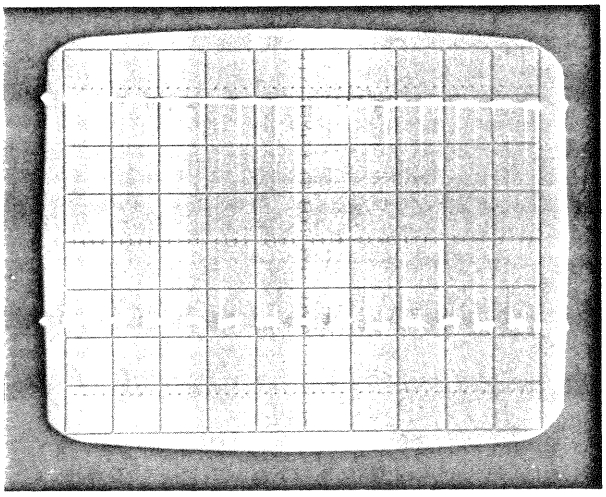
3-137. DISPLAYING SWEPT-FREQUENCY MEASUREMENTS.

3-138. OSCILLOSCOPE DISPLAY.

3-139. The use of an oscilloscope in conjunction with a sensitive, fast-responding detector such as a crystal permits continuous visual display of swept-frequency measurements, a capability which is especially useful if a device is to be adjusted while under test.



Incorrect



Correct

Figure 3-15. Example Oscilloscope Displays of Correct and Incorrect EXT ALC GAIN Adjustment

3-140. For oscilloscope display the Sweep Oscillator SWEEP OUT furnishes the horizontal deflection signal. Since SWEEP OUT is a linear sawtooth voltage synchronized with the sweep, it provides an accurate axis of frequency for the display. In addition, automatic blanking of the RF output during retrace results in a continuous zero-power reference trace for the display.

3-141. The display oscilloscope should have direct-coupled vertical and horizontal inputs and 10 kHz minimum vertical bandwidth. Reflection measurements can require vertical sensitivity of microvolts per centimeter: 50 to 100 μV/cm is usually adequate. The HP 140 Oscilloscope with 1400 and 1420 horizontal plug-ins satisfies these requirements.

3-142. Detailed information about improved measurement systems and calibration techniques for transmission studies using the Sweep Oscillator is available in HP Application Note 65, Swept-Frequency Techniques. The Note contains: procedures for assembling, calibrating, and operating systems for transmission and reflection measurements using leveled HP Sweep Oscillators; instructions for using the HP 1416 Swept Frequency Indicator oscilloscope plug-in to display measurements directly in dB; and a list of measuring equipment for the 1 to 40 GHz frequency range. The Note also contains a set of scales calibrated in reflection and transmission units which can be affixed to the graticule of a conventional oscilloscope to adapt it to swept-frequency measurements. Copies of Application Note 65 are available at no charge from your local Hewlett-Packard sales and service office.

3-143. X-Y RECORDER DISPLAY.

3-144. The X-Y graphic recorder affords a convenient means of permanently recording swept-frequency measurements, providing a plot of transmission variations with time or frequency. To facilitate X-Y recording, the Sweep Oscillator has manual sweep for recorder calibration; a linear ramp voltage output synchronized with output frequency to operate the recorder X-system; indication of sweep duration for positive determination of sweep start and stop; internally-generated, tunable frequency markers for accurate calibration of frequency range; and automatic penlift to raise the recorder pen between sweeps.

3-145. Penlift is intended for recorders equipped to raise the pen in response to an open circuit. The Sweep Oscillator rear-panel PENLIFT terminals are open-circuit in the interval between sweeps during CW and triggered sweep operation with either of the two slowest sweep time ranges.

3-146. RECORDER CALIBRATION.

3-147. Figure 3-16 shows a setup for X-Y plotting of the output power-frequency characteristic of the Sweep Oscillator. Other swept-frequency measurements for which the recorder is a popular display device include SWR, attenuation, gain, directivity, and leveling performance.

3-148. Calibrate the recorder as follows:

a. Set the Sweep Oscillator to sweep the frequency range of interest using a sweep time compatible with recorder response.

b. Set SWEEP SELECTOR to MANUAL.

c. Rotate MANUAL SWEEP maximum counterclockwise (for CW output at sweep start frequency), and adjust recorder Y-zero for convenient pen position.

d. Adjust recorder X-system to locate pen at a convenient start point.

e. Rotate MANUAL SWEEP from full counterclockwise to full clockwise (for CW output at sweep stop frequency) observing maximum vertical displacement of the pen during the sweep.

f. Set recorder X-sensitivity to terminate recorder pen traverse at a convenient location on the chart, and adjust Y-sensitivity to give required resolution.

g. If sensitivity and zero of the recorder X and Y systems are interdependent, repeat steps d through f to ensure desired chart calibration.

h. Set SWEEP SELECTOR to TRIG. For one-shot sweeps, set SWEEP SELECTOR to TRIG and press MANUAL TRIGGER to start sweep. (A sweep can be terminated and restarted by pressing MANUAL TRIGGER.) The recorder pen lifts automatically during retrace if the recorder is equipped for pen lift in response to an open circuit.

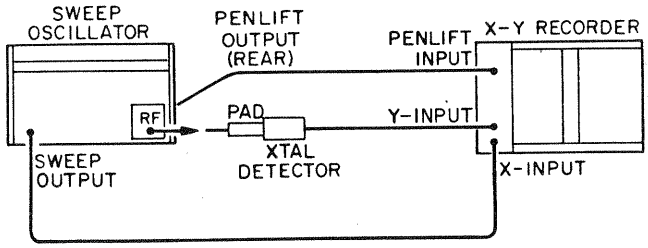


Figure 3-16. Typical X-Y Recorder Setup to Plot Sweep Oscillator Power Output Characteristic

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