INSTRUCTION MANUAL

TYPES 1161, 1162 and 1163

COHERENT DECADE FREQUENCY SYNTHESIZERS

GENERAL RADIO COMPANY

West Concord, Massachusetts

OPERATING INSTRUCTIONS

COHERENT DECADE FREQUENCY SYNTHESIZERS

Type 1161 Type 1162 Type 1163

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Form No. 1160-0100-D February 1969

GENERAL RADIO COMPANY

West Concord, Massachusetts

specifications

Type	1161	1162	1163
Output Frequency:	0 to 100 kHz	0 to 1 MHz	30 Hz to 12 MHz
Digital Frequency Selection (per step):	0.01 Hz to 10 kHz	0.1 Hz to 100 kHz	1 Hz to 1 MHz
Smallest Directly Indicated Frequency Increments on CAD* Dial:	0.0001 Hz	0.001 Hz	0.01 Hz
Incremental Frequency Range of CAD: (manually tuned)	−10 to +100 kHz down to −0.001 to +0.011 Hz	−0.1 to +1.1 MHz down to −0.01 to +0.11 Hz	−0.1 to +1.1 MHz down to −0.1 to +1.1 Hz
RMS Phase-Noise Modulation re 1 Radian:**	−70 dB	−52 dB	−52 dB
RMS Amplitude-Noise Modulation re 100% Carrier:**	−70 dB	−70 dB	−60 dB

Reference-Frequency Source: Internal, room-temperature, quartz-crystal oscillator with temperature coefficient typically $<2 \times 10^{-7}/°C$ from 20 to 50°C. Frequency control on front panel provides adjustment range of ±7 to ±10 ppm. For better accuracy and stability the internal oscillator can be phase-locked to an external standard-frequency source supplying 0.25 to 5 V rms (into 1 kΩ at lowest levels, dropping to 50 Ω at high) at 5 MHz or any submultiple down to 100 kHz.

RMS Fractional Frequency Deviation:†

Output Frequency	Averaging Time		Averaging Time		Averaging Time	
	1 s	10 ms	1 s	10 ms	1 s	10 ms
10 MHz					3×10^{-11}	3×10^{-9}
5 MHz					6×10^{-11}	6×10^{-9}
1 MHz			3×10^{-10}	3×10^{-8}	3×10^{-10}	3×10^{-8}
0.1 MHz	3×10^{-10}	3×10^{-8}	3×10^{-9}	3×10^{-7}	3×10^{-9}	3×10^{-7}

	1161	1162	1163
Spurious Signals (discrete nonharmonic):	<−80 dB	<−60 dB	<−60 dB
Harmonic Signals (at max output):	<−40 dB	<−40 dB	<−30 dB

Output Voltage:

Monitoring Accuracy: ±0.2 V

Coupling Switch at ac: 0 to 2 V rms, metered at output connector. 50-Ω load or higher flat to within ±1 dB above 50 Hz.

Coupling Switch at dc: 0 to 0.8 rms, not metered, into high impedance (>100 kΩ) flat to within ±0.2 dB from 0 to 10 kHz.

Output Impedance Switch at 50 Ω: 0 to 2 V rms, metered behind 50 Ω ±10%.

Output Impedance Switch at 0: 0 to 2 V rms, metered at output connector. Flat to within ±1.5 dB above 50 Hz, 50-Ω load.

Operating Temperature Range:		0 to 50°C, ambient temperature
Power Required:		100 to 125 or 200 to 250 V, 50 to 400 Hz; or 20 to 28 V dc, 1.8 A approx
		55 watts
Dimensions (width x height x depth):	Bench	19 x 5½ x 15½ in. (485 x 145 x 395 mm)
	Rack	19 x 5¼ x 13 in. (485 x 135 x 330 mm)
Weight:	Net	38 lb (17.5 kg)
	Shipping	45 lb (20.5 kg)

* The CAD (Continuously Adjustable Digit) provides a frequency indication on its dial accurate to two significant figures in the internal locked mode. In the external control mode ±1½ V, approx, into 6 kΩ from an external source provides frequency control over at least ±5 major divisions centered on any manual digit setting (except that in highest rank position of CAD, sweep should not exceed limits of manual tuning). Approx −0.3 V produces a + frequency change equal to one step of digit unit at pushbutton selected position of the CAD. An internal calibrating mixer produces a beat frequency proportional to the frequency difference between the CAD and the digit units it replaces (10 kHz per Δf = digit step of selected position). This beat frequency covers 0 to 110 kHz, and a level of at least 0.5 V behind 3 kΩ is provided at the BEAT terminals. The panel meter can be switched to monitor the beat frequency, providing a self-contained calibration system that can be used to set the CAD frequency to at least four significant figures.

** Phase- and amplitude-modulation noise measured in a 0.5-Hz to 15-kHz band, after the detector, without predetection filtering. These measurements are commonly expressed by signal-to-noise ratios in a 30-kHz band centered on the signal, excluding a 1-Hz band in the center. The absolute values of the figures given are identical to these ratios (in dB).

† Period measurements on low beat frequencies between the synthesizer and a low-noise standard-freqency oscillator. Beat frequency filtered by 15-kHz low-pass filter ahead of counter. Synthesizer locked to external GR 1115 Standard-Frequency Oscillator. Signal from unlocked synthesizer may be poorer for 1-s averaging time unless in a perfectly stabilized ambient temperature, but figures given for 10 ms apply.

U.S. Patent Nos. 2,548,457; 3,300,731.

General Radio Experimenter references: 38, 9, September 1964; 39, 5, May 1965; 39, 11 & 12, November-December 1965; 41, 1, January 1967.

TABLE 1-1
EQUIPMENT CONFIGURATIONS

TYPE 1163 COHERENT DECADE FREQUENCY SYNTHESIZER 30 c/s to 12 Mc/s

Type	Catalog Number	Units Included	Calibrated Digits: Decades Only	Calibrated Digits: Decades + CAD*	Smallest Step (Digits Only)
1163-AR7C	1163-9527	7 DI Units + CAD	7	9	1 c/s
1163-AR6C	1163-9526	6 DI Units + CAD	6	8	10 c/s
1163-AR5C	1163-9525	5 DI Units + CAD	5	7	100 c/s
1163-AR4C	1163-9524	4 DI Units + CAD	4	6	1 kc/s
1163-AR3C	1163-9523	3 DI Units + CAD	3	5	10 kc/s
1163-AR7	1163-9507	7 DI Units	7		1 c/s
1163-AR6	1163-9506	6 DI Units	6		10 c/s
1163-AR5	1163-9505	5 DI Units	5		100 c/s
1163-AR4	1163-9504	4 DI Units	4		1 kc/s
1163-AR3	1163-9503	3 DI Units	3		10 kc/s

TYPE 1162 COHERENT DECADE FREQUENCY SYNTHESIZER 0 to 1 Mc/s

Type	Catalog Number	Units Included	Calibrated Digits: Decades Only	Calibrated Digits: Decades + CAD*	Smallest Step (Digits Only)
1162-AR7C	1162-9527	7 DI Units + CAD	7	9	0.1 c/s
1162-AR6C	1162-9526	6 DI Units + CAD	6	8	1 c/s
1162-AR5C	1162-9525	5 DI Units + CAD	5	7	10 c/s
1162-AR4C	1162-9524	4 DI Units + CAD	4	6	100 c/s
1162-AR3C	1162-9523	3 DI Units + CAD	3	5	1 kc/s
1162-AR7	1162-9507	7 DI Units	7		0.1 c/s
1162-AR6	1162-9506	6 DI Units	6		1 c/s
1162-AR5	1162-9505	5 DI Units	5		10 c/s
1162-AR4	1162-9504	4 DI Units	4		100 c/s
1162-AR3	1162-9503	3 DI Units	3		1 kc/s

TYPE 1161 COHERENT DECADE FREQUENCY SYNTHESIZER 0 to 100 kc/s

Type	Catalog Number	Units Included	Calibrated Digits: Decades Only	Calibrated Digits: Decades + CAD*	Smallest Step (Digits Only)
1161-AR7C	1161-9527	7 DI Units + CAD	7	9	0.01 c/s
1161-AR6C	1161-9526	6 DI Units + CAD	6	8	0.1 c/s
1161-AR5C	1161-9525	5 DI Units + CAD	5	7	1.0 c/s
1161-AR4C	1161-9524	4 DI Units + CAD	4	6	10 c/s
1161-AR3C	1161-9523	3 DI Units + CAD	3	5	100 c/s
1161-AR7	1161-9507	7 DI Units	7		0.01 c/s
1161-AR6	1161-9506	6 DI Units	6		0.1 c/s
1161-AR5	1161-9505	5 DI Units	5		1.0 c/s
1161-AR4	1161-9504	4 DI Units	4		10 c/s
1161-AR3	1161-9503	3 DI Units	3		100 c/s

*Direct reading (without calibration of CAD). If CAD is calibrated in terms the step decades, at least one more significant figure can be added.

SECTION **1**

INTRODUCTION

1.1 PURPOSE.

The Types 1161-A, 1162-A, and 1163-ACoherent Decade Frequency Synthesizers are highly accurate oscillator systems with a direct decimal-digit readout. Each permits frequency selection precise in up to nine significant figures.

The frequency of the output signal is synthesized by proper combinations of a number of frequencies, each of which is derived from a single internal master frequency. Since each of the frequencies used for the synthesizer is derived (on a proportional basis) from this crystal-oscillator source, the output is always coherent in frequency with that of the source and has the same percentage accuracy as the source.

Frequencies are selected by means of a series of from three to seven stepped-digit units plus a continuously adjustable decade (an optional module in any version of any system). Figures 1-1 and 1-2 are indicative of the system variations possible. Remote programming capability is standard.

The synthesizers are essential in applications requiring stable, sine-wave signal sources capable of ultraprecise frequency adjustment through wide frequency regions. They are also convenient for less demanding uses.

The output frequency is readily applied to automatic recording of the frequency response of networks and the frequency drift of oscillators. Frequency markers can be formed with the aid of built-in calibration circuitry of enhance these functions.

1.2 DESCRIPTION.

1.2.1 PERFORMANCE CHARACTERISTICS.

Any member of the Type 1161-A Coherent Decade Frequency Synthesizer group supplies frequencies from 0 to 100 kc/s in step increments. A fully equipped instrument has digit steps as small as 0.01 c/s and also includes a continuously adjustable decade that can be switched in beyond the smallest discrete step, or at any point in the digit series.

The Type 1162-A group is nearly identical, except that the maximum frequency is 1 Mc/s and the smallest discrete step is 0.1 c/s. Types 1161-A and 1162-A use a common chassis, thus one type can be transformed to the other by module changes.

The Type 1163-A group generates frequencies up to 12 Mc/s, with digit steps as small as 1 c/s. The Main Frame for the Type 1163-A, although possessed of the same dimensions and form factor as the Types 1161/1162 Main Frame, differs in some details and is not interchangeable.

The heart of each of the synthesizers is a set of up to seven locally controlled, plug-in modules called DI (for Digit-Insertion) units.

All frequencies are derived from a single, built-in, 5-Mc, room temperature, crystal oscillator. For maximum accuracy, this oscillator can be phase locked to an external frequency standard operating at 5 Mc/s, or any submultiple thereof, such as the General Radio Type 1115 Standard-Frequency Oscillator. Refer to paragraph 1.6.1.

The continuously adjustable decade (CAD) develops a frequency, adjustable smoothly through a digit decade, that can be standardized by comparison with the output of the DI units.

Operation of the synthesizers is simple and straightforward. The rotary switches are set so that the desired frequency is indicated by rear-lit, in-line numerals. Fixed comma and decimal-point indicators are included in the readout.

Used to supplement the frequency determined by the digital setting, the CAD can, theoretically, be

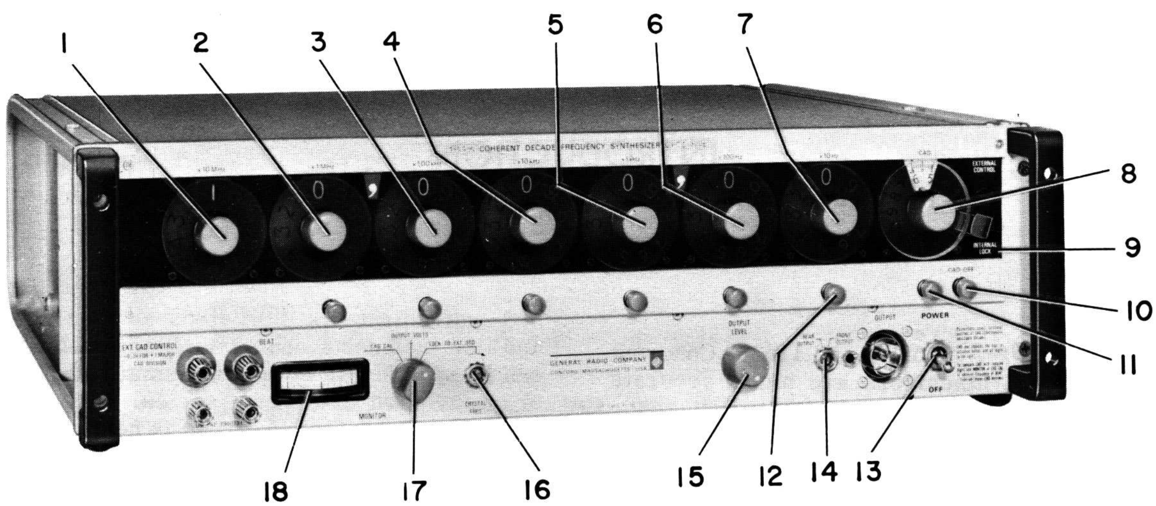


Figure 1-1. A typical Coherent Decade Frequency Synthesizer with all modules in in place. Refer to Table 1-2 for callout identification.

Note: Only the basic type-number designation appears on any instrument. Model variations must be determined by reference to Table 1-1.

TABLE 1-2
CONTROLS AND INDICATORS - ALL SYSTEMS (See Figure 1-1)

REF Fig 1-1	*Name*	*Type*	*Function*	*Related Indicator*	*Remarks*
1 through 7	Digit-Insertion Dial — Stations I-VII	Rotary switch, 11-position (13-position in first station of Type 1163)	Select digits of readout	Numeral at dial top center (illuminated)	Remotely Programmable position marked "R".
8	CAD (Continuously Adjustable Decade)	Capacitor, rotary adjustment	Supplement to step digits or substitute for a group of Digit-Insertion units	Continuously calibrated dial; also MONITOR meter with switch in CAD CAL position, or signal at BEAT for any monitor-switch position.	Used only in systems with C suffixes, e.g., -AR6C.
9	CAD Mode Control — EXTERNAL CONTROL and INTERNAL LOCK	Coaxial lever switch, 2-position	Permits electronic control of CAD frequency when in EXTERNAL CONTROL position	Illuminated sector on CAD dial (dimmed in EXTERNAL CONTROL position)	
10	CAD OFF	Latching, 2-position push-button; combined rf and lamp-control switch	Places CAD on standby when actuated	Dial sector not illuminated with CAD OFF button actuated	CAD, while not contributing to output, is still warmed up and on standby.
11	CAD enable control	Latching, 2-position push-button; combined rf and lamp-control switch	Connects CAD at end of train of installed DI units	Dial sector illuminated when CAD is in use	Dial also illuminated when any of buttons (12) actuated.
12	Digit Disable Controls — Stations I-VII (II-VII in Type 1163-A)	Latching, 2-position push-buttons; combined rf and lamp-control switches	Disable Digit-Insertion units above and to the right when latched in depressed position	Digit illumination extinguished at disabled DI units.	On CAD-equipped systems, CAD substitutes for disabled units. All disabled digits are replaced by 0's, if the CAD is not installed.
13	POWER	Toggle switch, 2-position	Main ac power-input control	Dial of active DI units illuminated when power is on	
14	OUTPUT COUPLING (AC or DC coupling for Types 1161/1162) OUTPUT IMPEDANCE (0 or 50 ohms for Type 1163)	Screwdriver-actuated, 2-position switch	Change output coupling network	MONITOR meter with switch in OUTPUT VOLTS position-scale reads 0 — 2 volts, rms	No meter indication with DC coupling. Output falls off below 30 c/s in AC position.
15	OUTPUT LEVEL	Rotary potentiometer	Control level of output signal	MONITOR meter (set to OUTPUT VOLTS)	
16	CRYSTAL FREQ	Rotary potentiometer	Fine control of free-running frequency of master crystal oscillator	MONITOR meter, in LOCK TO EXT STD position, if external standard is connected	External standard (5 Mc/s or submultiple) applied to rear-apron connector (J107). Meter shows locking voltage developed in phase detector, which locks internal crystal to external standard.
17	MONITOR control	Rotary switch, 3-position	Selects function to be monitored	MONITOR meter	
18	MONITOR	Edgewise-type meter	Calibrated 0 to 2 for OUTPUT VOLTS. Also used around center scale, for CAD CAL and LOCK TO EXT STD functions.	None	In CAD CAL position, pointer homes at center scale as frequency equality is approached, then beats at low difference frequency. In LOCK TO EXT STD position, shows amplitude and sense of locking voltage.

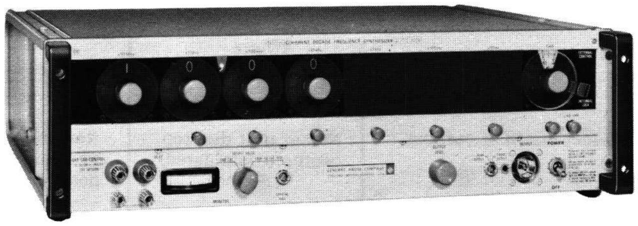


Figure 1-2. Typical -9524 synthesizer. Note the three missing Digit-Insertion units at the right and the three blank dress panels.

set to a resolution of better than 0.0001 c/s in the Type 1163-A, 0.00001 c/s in the Type 1162-A, and 0.000001 c/s in the Type 1161-A. The usable resolution is determined by oscillator stability and the time interval of interest (refer to paragraph 3.3.4).

Front-panel selection of ac or dc output coupling is provided in the Types 1161-A and 1162-A. When ac coupling is used, output voltage is indicated by the front-panel meter and is adjustable up to 2 volts into 50 ohms. Lower-level dc-coupled output, without meter indication, can be selected, when operation below 30-cycle output signal is necessary.

In the Type 1163-A dc-coupled output is not available. In units of this group, the panel meter reads output voltage either behind a 50-ohm resistor or directly at the output connector, as determined by the setting of a screwdriver-operated panel switch.

In all three types, the meter is also used:

1. to calibrate the CAD against any selected series of frequency digits set on the step-digit dials;
2. to confirm phase lock to an external standard, when such standard is connected.

The frequency of the CAD can be varied manually or by a dc-coupled external voltage for:

1. swept-frequency output;
2. narrow-band frequency modulation;
3. phase lock of the synthesizer output to external signals.

A magnified indication of the variation in synthesizer output frequency resulting from such intentional CAD variations is available at front-panel terminals, and also at the rear connector (refer to paragraphs 1.6.3 and 3.3.3).

1.2.2 MODULAR PACKAGING.

Each synthesizer, a completely self-contained frequency-generation system of modular construction, is supplied in several different configurations, as listed in Table 1-1. The variations permit the user to preselect the frequency range and the number of significant figures required in the readout for his particular application. At any time, a less-than-complete system can be expanded by the addition of plug-in modules available from General Radio.

A minimal system consists of a standard relay-rack-width chassis, known as the Main Frame, to which are attached a Power Supply unit, an Ancillary Frequency Source, an Output Mixer, and three Digit-Insertion units. All units plug in and the Digit Insertion units are interchangeable. Refer to paragraph 5.4 for mechanical details. Chassis 1160-4060 serves as the Main Frame for Types 1161-A and 1162-A; Chassis 1163-4060 is used in the Type 1163-A.

Optional extra modules include additional Digit-Insertion units and the Continuously Adjustable Decade unit (CAD). When the CAD is installed, a Calibrating Mixer unit (supplied with the CAD) is also plugged in.

Either of the Main Frames has all switching, connector, and other capabilities built in, so that no rewiring or panel drilling is necessary to change digit capacity by the addition of modules. Also, Types 1161-A and 1162-A can be changed from one to the other by the change of one plug-in module.

The specific hardware difference between these systems consists in the plug-in output mixer modules and corresponding front-panel frequency-step identification strips. The Type 1161-A Output Mixer operates at 5 Mc/s, whereas in the Type 1162-A, a 50-Mc Output Multiplier-Mixer unit is used. Both modules use the same interconnections and occupy the same space at the rear of the chassis.

The Output Multiplier-Mixer of the Type 1163-A mixes a 50/51-Mc continuously adjustable input and an input selectable in 1-Mc steps, by the left-hand frequency dial, from 50 Mc/s to 39 Mc/s.

Solid-state circuits are used exclusively for compactness and performance stability.

Front-panel controls and indicators permit rapid system self-check without recourse to internal test points or adjustments (refer to paragraph 5.3).

As normally supplied, the systems are fitted out for bench-top use but can be quickly converted for rack installation with a screwdriver. Refer to paragraph 2.1 for details.

1.3 CONTROLS AND INDICATORS.

Front-panel controls and indicators common to the three synthesizer groups are listed and described in Table 1-2. See also Figure 1-1.

1.4 CONNECTORS.

Commonly used connectors for attachment of the synthesizer to other equipments are listed and described in Table 1-3. These connectors are GR874® quick-connect, hermaphroditic, coaxial types. In each instance, locking versions of the connector are installed. These will accept either locking or nonlocking cable connectors.

In addition, certain synthesizer frequencies, which will be useful in connection with future ancillary equipment, are available at subminiature coaxial connectors at the rear of the Main Frame deck. They are listed in Table 1-4 (see Figures 1-1 and 2-2). The main output connector and the CAD control input and monitor are paralleled by BNC connectors at the rear.

TABLE 1-3
PRIMARY CONNECTORS

Name	*Ref Desig*	*Type*	*Function*	*Location*	*Remarks*
OUTPUT*	J405	GR874 coaxial	Low-loss, quick-connect terminal for output signal.	Front panel	Adaptable; refer to paragraph 1.6.7.
	J405A	BNC	Same.	Rear Bracket	
BEAT	J403	Type 938 binding posts	Terminal for external observation of CAD calibration (magnified measure of CAD frequency departure from replaced digit dials).	Front panel	Type 274-NL Patch Cord recommended accessory.
	J403A	BNC	Same.	Rear Bracket	
EXTERNAL CAD CONTROL	J401	Type 938 binding posts	Terminals for injection of external voltage to vary CAD frequency.	Front panel	0.3 Vdc equivalent to 1 major CAD dial division.
	J401A	BNC	Same.	Rear Bracket	
LOCK SIG IN	J107	GR874 coaxial, locking	Terminal for injection of 5-Mc signal (or submultiple) from external frequency standard or from another synthesizer.	Rear apron (part of AFS unit)	Type 874-R22LA Patch Cord recommended accessory.
5 MC OUT	J108	GR874 coaxial, locking	Terminal for auxiliary 5-Mc signal output.	Rear apron (part of AFS unit)	Type 874-R22LA Patch Cord recommended accessory.
100 KC OUT	J206	BNC	Terminal for auxiliary 100-kc signal output.	Rear apron (part of AFS unit)	Type 874-R22LA Patch Cord recommended accessory.

*CAUTION- Do not connect dc potential to OUTPUT without appropriate external blocking devices.

TABLE 1-4
AUXILIARY CONNECTORS

Name	*Ref Desig*	*Function*	*Remarks*
5/5.1	J150	Signal output to ancillary equipment; test point. Frequency in Mc/s.	Subminiature coaxial connectors at rear edge of Main Frame deck. Mate with Amphenol 'Subminiax' #27-7 or Type 5116-037475 connectors. J154 and J156 present but not energized in Type 1161 synthesizers.
5.0	J151		
1.0	J152		
42	J155		
50/51	J154		
50 *	J156		
5/5.1 REF	J157		
1.0	J208		
+18 V	J153	+18 V dc test point.	

*In Type 1163, J156 furnishes 50 to 39 Mc/s in 1-Mc steps.

1.5. ACCESSORIES SUPPLIED (Refer to Table 1-5).

TABLE 1-5
ACCESSORIES SUPPLIED

Item	*Type*	*Quantity*	*Function*	*Part Number*
Fuse	3AG/Slo-Blo (0.8A)	2	Spare for 115-V	5330-1200
Fuse	3AG/Slo-Blo (0.4A)	2	Spare for 215/230-V	5330-0900
Lamp	No. 327 (28V at 0.04A)	8	Spare for front-panel readout stations.	5600-1060
Bridging Unit	Plug-in	1	Spare. Completes circuits in Digit-Insertion station when active module is removed.	1160-4070
Cover Panel	Blank	1	Spare. Covers hole in front panel that results if a frequency-control module is removed.	1160-8015
Relay-rack mounting kit	Steel	1	Furnishes shelf support and necessary hardware to mount instrument in standard 19-inch relay rack.	7863-9632
Power cord	Rubber-molded, 3-wire, 7 feet long	1	Connect instrument to ac power. Rated 7A at 230 V.	4200-9622
Patch cord	Type 874-R22LA, coaxial, 3 feet	1	Connect LOCK SIG IN connector to Type 1115 frequency standard, or use at OUTPUT connector.	0874-9683

1.6 ACCESSORIES AVAILABLE.

1.6.1 EXTERNAL STANDARD-FREQUENCY OSCILLATOR — TYPE 1115

This standard meets all the requirements for a stable laboratory standard of frequency for the calibration or phase-locking control of the synthesizer output.

Its oscillator uses a 5th-overtone, 5-Mc crystal in a single-stage, proportional-control oven which maintains the crystal temperature within a few millidegrees centigrade.

A front-panel control, calibrated directly in parts in 10^{10}, allows fine control of the oscillator frequency.

The sine-wave output at 5 Mc/s, available at the rear apron, can deliver a suitable locking signal to J107 (LOCK SIG IN) at the rear of the synthesizer. A Type 874-R22LA Patch Cord is recommended for this connection. Any load from open circuit to short circuit can be connected to the output with minimal effect on the oscillator frequency.

The standard normally operates from an ac supply or, in the event of power failure or disconnection of power for up to 35 hours, from an internal, pressure-relief-type, nickel-cadmium battery supply.

1.6.2 FREQUENCY METER AND DISCRIMINATOR — TYPE 1142-A.

This analog-type frequency meter measures frequencies from 3 c/s to 1.5 Mc/s with an over-all accuracy of ±0.2%, and can be used with a recorder to produce time records of frequency change or drift.

The Type 1142-A frequency meter input connects to the front-panel binding posts marked BEAT on the synthesizer, via a Type 274-NL Patch Cord. It presents a highly magnified indication of the departure of the synthesizer output frequency from that displayed on the digit dials as the CAD frequency, when substituted for the step digits, is adjusted either manually or electrically. Refer to paragraph 3.3.3.

The precision six-inch meter is accurate to 1% of indication down to 10% of full scale. A calibrated

TABLE 1-6
TYPE 874 LOCKING COAXIAL ADAPTORS TO OTHER SERIES

Adapts to Type	*Type*	*Contains GR874 and ...*	*Connects GR874 to ...*	*Part Number*
BNC	874-QBJL	BNC Jack	BNC Plug	0874-9701
C	874-QCJL	C Jack	C Plug	0874-9703
Microdot	874-QMDJL	Microdot Jack	Microdot Plug	0874-9721
N	874-QNJL	N Jack	N Plug	0874-9711
SMA	874-QMMJL	Jack	Plug	0874-9723
SC	874-QSCJL	SC Jack	SC Plug (Sandia)	0874-9713
TNC	874-QTNJL	TNC Jack	TNC Plug	0874-9717
UHF	874-QUJL	UHF Jack	UHF Plug	0874-9719
274	874-Q2	Binding Posts	Type 274 Plug	0874-9870
APC-7	874-QAP7L	7-mm Connector	Amphenol APC-7	0874-9791

interpolation technique effectively expands the meter scale by a factor of 10, providing a readout accuracy of 0.1%.

1.6.3 SYNTHESIZER CONVERSION KITS.

Two kits are available to permit direct and rapid conversion of a Type 1161 synthesizer into a Type 1162, and vice versa. The conversion is a plug-in process that requires no rewiring or other permanent alteration. Thus, a converted synthesizer can be easily changed back to its original form. The converted instrument is complete and finished looking and indistinguishable in panel marking and every other respect from an unconverted synthesizer. Conversion in this manner from Types 1161 and 1162 to Type 1163 is not possible, however.

The kits are:

Type 1160-3040 Conversion Kit – Consists of an OMM-1 Output Multiplier-Mixer module and front-panel dial identification strip and is used to convert Type 1161 into Type 1162.

Type 1160-3030 Conversion Kit – Consists of an OM-1 Output Mixer module and front-panel dial identification strip and is used to convert Type 1162 into Type 1161.

Installation details are given in Section 5.

1.6.4 COAXIAL ADAPTORS.

As with similar General Radio equipment, the synthesizers use the quick-connect GR874 coaxial connector. However, for the user wishing to mate the instruments with components fitted with coaxial connectors of some other series, it is a simple matter to adapt to that series.

GR874 adaptors to leading commercial and military coaxial series (or to binding posts) are available to convert to the desired type. These adaptors are listed in Table 1-6.

Because the OUTPUT connector is recessed in the front panels an adaptor will protrude less than one inch beyond the panel. Over-all VSWR of the converted GR874 connector is typically no greater than that of the other-series connector by itself, and leakage at the GR874 junction is typically >120 dB down.

1.6.5 PRESET-FREQUENCY PROGRAM UNIT - 1160-P1.

The 1160-P1 Preset-Frequency Programming Unit (Figure 1-3) permits repetitive programming of seven-digit frequencies via a switch matrix. Up to 20 or 40 such channels can be selected, depending on model variations.

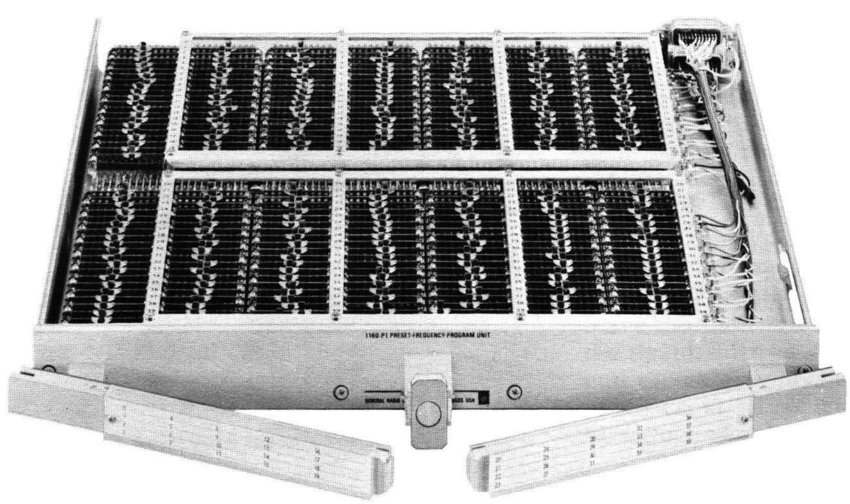


Figure 1-3. 1160-P1 Preset Frequency Programming Unit.

Figure 1-4. 1160-P2 Sweep and Marker Generator.

A programmed frequency is selected by the closure of a single contact to ground. Programmed frequencies can be stored indefinitely or can be easily reset to a new frequency, since the settings of rows of miniature switches are used to select the frequency.

1.6.6 SWEEP AND MARKET GENERATOR - 1160-P2.

The 1160-P2 Sweep and Marker Generator (Figure 1-4) takes advantage of the sweep capability of any synthesizer containing a CAD unit. The 1160-P2 sweeps the CAD frequency over a width adjustable from ±1 to ±5 CAD divisions (up to ±10 divisions with CAD at center of dial). The actual sweep width can range from 1.2Mc/s to ±1/10 the frequency interval-per-step of the least significant decade, and, except for widest sweeps, can be centered on any frequency in the synthesizer's normal operating range. The oscilloscope-horizontal sweep voltage provided is independent of the frequency sweep width selected. Slow automatic and manual sweep speeds, very narrow sweep widths, and stable center frequency and markers make the 1160-P2 particularly useful for testing high-Q devices.

The 1160-P2 generates a synthesized marker that occurs at the frequency to which the DI units are set. Side markers can be located symmetrically 1.0 to 5.9 CAD divisions from the center marker. Actual frequency spacing of these markers depends upon the functional position of the CAD unit.

1.6.7 STANDARD-FREQUENCY OSCILLATOR - 1160-P3.

The 1160-P3 Standard-Frequency Oscillator (Figure 1-5) is a stable 5-Mc/s source to which a synthesizer's internal oscillator can be locked for improved long-term stability and reduced temperature dependence. The 1160-P3 contains a temperature controlled crystal oven, buffer amplifier, and power supply and operates directly from the ac line independent of the synthesizer power switch. It mounts directly on the rear of any synthesizer model, adding only a few inches to its depth.

Figure 1-5. 1160-P3 Standard-Frequency Oscillator mounted on a typical synthesizer.

SECTION **2**

INSTALLATION

2.1 MOUNTING.

The synthesizer is fitted with rubber-footed aluminum end frames for bench use. Each end frame is attached to the instrument with two panel screws and four 10-32 Phillips-head screws with notched washers.

For a rack-mounting option, special brackets and hardware are furnished to attach the instrument and its cabinet to a standard 19-inch relay rack (see Figure 2-1). These brackets permit either cabinet or instrument to be withdrawn independently.

To install the instrument in a relay rack:

a. Remove the synthesizer from its cabinet; first, remove the four knurled front-panel screws, accessible through the clearance holes in the handles, and release the cabinet clamps at the rear.

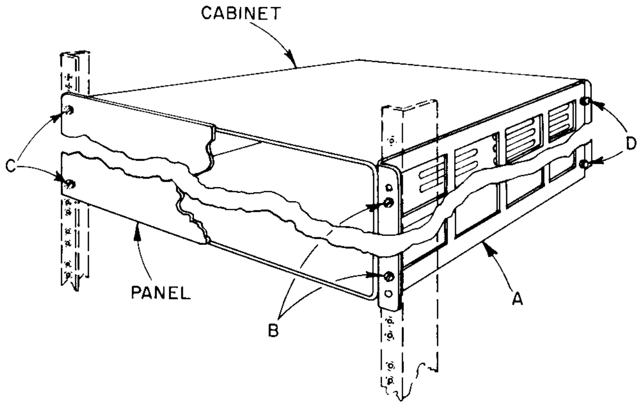


Figure 2-1. Relay-rack installation.

b. Remove the end frames from the cabinet with a Phillips-head screwdriver.

c. Attach each mounting bracket (A) to the rack with two 12-24 round-head screws (B). Use the inside holes on the bracket flange; the flange must be in front of the rack rail. The shelf lip must face in.

d. Slide the empty cabinet into the brackets until the edge of the front opening is flush with the rack rail.

e. Install the knurled screws (D), supplied with the brackets, in each side of the cabinet, through the slots in the rear of the bracket.

f. Slide the instrument into the cabinet, and tighten the rear clamps, if desired.

g. Insert the four knurled screws with attached washers (C) through the panel and the bracket and thread them into the rack. The washers are provided to protect the face of the instrument.

To remove the instrument from the rack, remove only the four panel screws (C) and slide the instrument forward out of the rack. To remove the cabinet and leave the instrument mounted in the rack, loosen only the thumb screws (D) at the rear of the brackets and pull the cabinet back off the instrument from the rear of the rack. Rear clamps, if used, must be released or tightened appropriately.

2.2 POWER CONNECTION

2.2.1 AC POWER.

Use the power cord provided to connect the synthesizer to a source of power, as indicated on the plate near the input socket at the rear of the instrument. The long cylindrical pin (ground) makes direct contact to the metal frame of the instrument.

Selection of the correct line-voltage range is made via the slide switch on the Power Supply by moving the switch until the correct range is visible. The line frequency of ac inputs should not exceed the range 50 to 400 c/s.

2.2.2 DC POWER.

The instrument can be operated from a battery supply of 20 to 28 volts, at 1.8 amperes. To so operate, remove the normal ac input-power cord and connect the positive side of the battery to a plug, part no. 4270-0900, or a metal pin 0.050 inch in diameter for insertion in J551 in the rear panel of the Power Supply module. The negative side of the battery must be connected directly to the instrument frame. If a power ON-OFF switch is desired, it must be inserted in the external wiring – the panel switch is not in circuit.

NOTE

The external dc supply should be of low impedance, such as is provided by a battery; otherwise, the internal regulator circuits may not start. If a poorly regulated dc supply must be used, the regulator can usually be started by momentary connection of J552 to the positive side of the supply, after it has come up to rated voltage.

2.3 ENVIRONMENTAL CONSIDERATIONS.

2.3.1 TEMPERATURE.

The synthesizer will operate within specifications in ambient temperatures ranging from 0 to 50°C.

2.3.2 MAGNETIC FIELDS.

Care has been taken to minimize effects of internal power-line-frequency magnetic fields on the quality of the output signal. There are, however, many ferrite-tuned and ferrite-shielded tuned circuits in the instrument, and magnetic fields from other equipments mounted nearby can, if strong enough, produce phase-modulation effects which will degrade the output signal. If power-line sidebands must be minimized, care must be taken to keep equipments that generate large external fields well separated from the instruments, or suitable additional magnetic shielding must be interposed.

2.4 DISTRIBUTION OF AUXILIARY FREQUENCIES.

GR874 coaxial terminals mounted on the rear apron of the instrument permit two fixed-frequency signals of 5 Mc/s and 100 kc/s to be taken from the synthesizer. Both are frequency coherent with the output signal and are well isolated to prevent unwanted loading effects.

One application of these terminals is to use the 5-Mc signal of one synthesizer to phase-lock the internal crystal oscillator of a second synthesizer. This can be accomplished by interconnection of the 5-MC terminal of the first instrument with the LOCK SIG IN terminal of the second. A Type 874-R22LA Patch Cord is recommended for the interconnection. Refer to paragraph 3.5 for the phase-lock procedures.

2.5 SYSTEM ALTERATION.

If your synthesizer was originally purchased as a partially complete system, the missing modules for the Digit-Insertion and/or CAD stations can be added, one at a time or as a group. No special tools are required and the change can be accomplished in minutes, with no need for rewiring or metal cutting. Retain as maintenance spares the blank panel cover and the DI Bridging Unit removed from activated stations. Refer to paragraph 5.4 for mechanical details.

SECTION **3**

OPERATING PROCEDURE

CAUTION

Do not apply dc potential to the OUTPUT without appropriate blocking devices. This precaution will avoid damage to the output amplifier circuitry.

3.1 EQUIPMENT TURN-ON.

Operation of the Coherent Decade Frequency Synthesizer to generate precision-frequency sine waves is quite straightforward. All that is necessary is to apply power, set the frequency dials to the desired frequency, and adjust the signal at the OUTPUT connector with the OUTPUT LEVEL control. The output voltage is measured by the MONITOR meter when the MONITOR switch is set at OUTPUT VOLTS. The output frequency is displayed by the dials.

NOTE

The Digit Insertion Unit dials have the ten digit positions 0 to 9 plus an eleventh position marked "R". When the dial is placed in the R position at any digit location, control of that digit is transferred to switching or other circuits that may be plugged into the connector at the rear of the digit unit. Refer to the separate section of this book on the DI unit for details. At any of the numbered dial positions, however, control remains with the local dial.

3.2 EQUIPMENT WARM-UP.

Since the equipment is all solid-state except for the dial lamps, no warm-up time is required to generate output. However, in applications where the synthesizer is phase-locked to an already operating external standard, such as the 1160-P3 Standard-Frequency Oscillator, it is necessary to allow complete equipment warm-up to a steady-state condition, if the ultimate in stability is required. Very small frequency errors due to phase drifts of tuned circuits in the synthesizer can be important in some demanding applications.

For extremely precise work, a warm-up period of two hours or more is recommended. In fact, round-the-clock operation is desirable when feasible, if high precision is apt to be required on short notice. To conserve the dial light bulbs during standby periods, depress the left-most disable button and set the CAD mode switch to EXTERNAL CONTROL.

3.3 CONTINUOUSLY ADJUSTABLE DECADE CONTROL.

3.3.1 GENERAL.

To make use of the Continuously Adjustable Decade (CAD) to control the output frequency, and to maintain a continuous or intermittent monitor of the CAD, observe the operating instructions permanently displayed on a front-panel instruction plate, which are as follows:

> Pushbuttons select functional position of CAD (continuously adjustable decade).
> CAD dial replaces the digit at actuated button and all digits to the right.
> To compare CAD with replaced digits use MONITOR at CAD CAL or observe frequency at BEAT (10 kc/s per major CAD division).

This condensed instruction reminds the user of the following points:

1. If any of the gray pushbuttons is depressed (and thereby automatically latched), the digit displayed on the dial directly above the actuated button and all the digits to the right are disabled, with regard to their effects on the output frequency, and replaced by the CAD unit. If the CAD OFF button is depressed, the CAD is removed from circuit but is still operative and will not be subject to warm-up drift when later reconnected.

2. The replaced digits (which are no longer illuminated by the dial lamps but are still legible) may be used as a reference for adjustment of the CAD. There are two methods of comparison between the CAD and the darkened digits, as described in paragraphs immediately following. Refer also to paragraphs 4.4 through 4.6 for a more detailed discussion of the principles involved.

The output frequency of the "replaced" group of DI units, between 5 and 5.1 Mc/s, is also available at the subminiature coaxial connector marked 5/5.1 REFERENCE on the rear edge of the chassis deck.*

3.3.2 INTERNAL CAD MONITOR.

With the MONITOR switch in the CAD CAL position, the MONITOR meter will read upscale (right from center), if the CAD is far removed in frequency from the replaced digits. As the CAD is tuned either manually or electrically (refer to paragraph 3.3.5) to approach equality with the replaced digits, the pointer will move toward center scale and, as equality is nearly achieved, the pointer will follow the beat frequency between the CAD signal and the signal from the replaced digit-unit group. If the beat frequency is low enough to be visible as a fluttering of the pointer, the CAD has been set accurately enough to replace at least three of the darkened digit dials correctly.

3.3.3 EXTERNAL CAD MONITOR.

Regardless of the position of the MONITOR switch, a signal appears at the BEAT binding posts which is directly proportional in frequency to the difference between the CAD output and that of the digit group which it has replaced. The Type 1142-A Frequency Meter is recommended for observation of signals present at these terminals when a deliberate offset is desired between the CAD and the replaced digits. As shown on the front-panel instruction plate, this frequency difference appears at the rate of 10 kc/s per major (numbered) CAD division. This means that if the CAD has been set to replace the digits displayed on the darkened dials exactly, the signal at the BEAT terminals is at zero frequency. If the CAD is changed in tuning by an amount corresponding to one major division on its dial, <u>or</u> if the dial directly above the actuated button is changed by one number (from 4 to 3 or from 4 to 5, for example), the signal at the BEAT terminals will change by 10 kc/s. Smaller or larger tuning changes produce correspondingly smaller or larger proportional changes in the frequency at BEAT. Similarly, a change of one number of the digit dials immediately to the right of the actuated button, or a change of one minor division of the CAD dial, will result in a 1-kc signal change at the BEAT terminals, etc. Whenever the CAD is being used with either manual or electrical control for frequency sweep or search, this signal at the BEAT terminals may be used as a magnified measure of the departure of the output frequency from that displayed on the whole series of frequency dials.†

3.3.4 ADDITIONAL PRECISION DIGITS FROM CAD.

Paragraphs 3.3.1 through 3.3.3 show how the CAD can easily be set to precise equality with up to 4 digit dials. This feature makes it possible to generate a frequency known to several more significant figures than would be possible using only the stepped digit dials and the CAD dial markings. This capability is of most use in a stripped-down instrument, such as a Type 1162-AR4C although complete instruments sometimes can usefully employ this technique.

> EXAMPLE: To set an output frequency of 953,241.72 c/s from a Type 1162-AR4C Synthesizer (which has only four digit dials), proceed as follows:
>
> a. Set the four digit dials to 4172.
>
> b. Push the button under the first (left-most) digit unit and, with the MONITOR switch in the CAD CAL position, adjust the CAD dial in the neighborhood of 4.172 until visible low-frequency beats occur on the MONITOR meter. (If these beats are slower than 5 c/s, the setting is good to the full four figures.)
>
> c. Now push the button under the CAD unit itself and reset the four digit dials to 9532. The output frequency from the synthesizer is now 953,241.72 c/s, the first four digits being defined by the step dials and the last four by the CAD.

Frequencies set up in this way can usually be relied on through the final figure over a period of sev-

*Not installed in some early production models.

† "Coherent Decade Frequency Synthesizers," *General Radio Experimenter*, Vol 38 No 9, September 1964, pp 11 and 13.

eral minutes, provided the CAD mode switch is in the INTERNAL LOCK position, where random drifts of the CAD are minimized. The CAD stability can be estimated, in any given situation, by observation of changes in the beat note on the MONITOR meter while controls are set for comparison with the digits as in step b above. If this beat is observed to remain below 10 c/s over a period of time, the uncertainty in the fourth figure of the CAD contribution during this period is no greater than one unit (uncertainty of 0.01 c/s in the numerical example above).

3.3.5 CAD MODE SELECTION.

The CAD can operate in either of two modes, as selected by the lever switch coaxial with its dial. In the INTERNAL LOCK position of this switch, the CAD is in a highly stable configuration; in this mode its frequency can be changed only by manual control of its knob. In the EXTERNAL CONTROL switch position, the CAD is somewhat less stable with regard to ambient-temperature effects upon it, but it can now be tuned electrically by a signal impressed on the EXTERNAL CAD CONTROL binding posts, as well as by the knob. The dial lighting of the CAD is dimmed in the EXTERNAL CONTROL position of the switch.

When the CAD is switched for external control, a signal of 0.3 Vdc applied to the EXTERNAL CAD CONTROL binding posts will change the CAD frequency by an amount approximately equal to one major division of its dial, from a starting point as indicated by its dial setting. Positive control voltage decreases the CAD frequency, and vice versa. This relationship is recorded on the panel, adjacent to the EXTERNAL CAD CONTROL binding posts, for easy reference. The CAD can be controlled electrically up to ±5 divisions (or more) about any center frequency at which its dial is set.

3.4 OUTPUT ADJUSTMENTS.

The remaining panel controls for routine operation consist of the OUTPUT LEVEL control and the OUTPUT COUPLING* screwdriver-operated switch, which changes the normal ac-coupled output-amplifier circuits to direct coupling. Dc coupling is used only when very low output frequencies are required. In the AC position of the OUTPUT COUPLING switch, the MONITOR switch in its OUTPUT VOLTS position connects the meter to read from 0 to 2 V rms at the output connector. In the DC position the monitor meter is no longer connected, but 0.8 volt rms is available at the OUTPUT connector at frequencies as low as desired, down to dc. The OUTPUT LEVEL control still functions, but the source impedance is generally high and is variable with setting, up to about 4 kilohms.

3.5 OPERATION WITH EXTERNAL STANDARD.

The fully clockwise position of the MONITOR switch, marked LOCK TO EXT STD, is of use only in applications where the stability of the internal crystal standard is not adequate and a signal from a more stable standard, such as the General Radio Type 1160-P3 Standard-Frequency Oscillator, has been connected to the LOCK SIG IN connector at the rear of the instrument. If such a signal (0.2 V rms or more, at 5 Mc/s or at a submultiple of 5 Mc/s down to 100 kc/s) has been supplied, and if the MONITOR switch is in the LOCK TO EXT STD position, the meter indicates the error voltage generated in a phase detector which disciplines the internal crystal oscillator to conform in frequency with the external standard. To check for proper operation of this phase lock, rotate the screw-driver control marked CRYSTAL FREQ and confirm that the meter follows this control smoothly from one side of center, through center, and over to the other side. The CRYSTAL FREQ control should be left so that the meter is centered, although phase lock will still obtain at any other meter indication that is still under control of the screw-driver adjustment.

*In the Type 1163 this control is marked OUTPUT IMPEDANCE, and determines whether a 50-ohm resistor is or is not connected in series with the output. The meter reads voltage delivered from a 5-ohm (approximate) source impedance at the input side of this 50-ohm resistor. In the ZERO position of the control the meter is directly across the output.

3.6 CRYSTAL-OSCILLATOR ADJUSTMENT.

The CRYSTAL FREQ control can also be used as a vernier control on the frequency of the internal master oscillator, if an external locking signal is not connected. In such a case, some reference (such as a counter or other frequency meter, or a Lissajous pattern obtained with a known stable frequency on an oscilloscope) may be used. A signal sample can be taken from either of the two GR874 connectors at the rear of the instrument, on the AFS unit, marked 100 KC OUT or 5 MC OUT, or from the main output receptacle on the front panel, at whatever frequency has been dialed.

3.7 CAD DIAL INTERPRETATION.

The CAD dial displays its setting in a fashion designed to eliminate any chance for misreading. Like all the other frequency controls, the CAD knob increases output frequency with clockwise rotation. The dial carries a series of numbered fiducial lines, each of which is read against the fixed, fine-scale, illuminated sector. Figure 3-1 illustrates the principle.

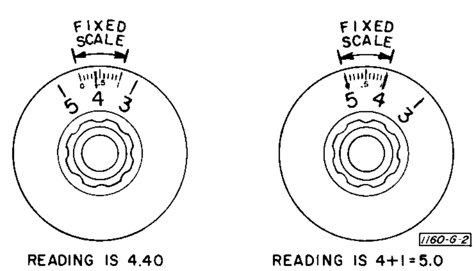


Figure 3-1. Representative readings of Continuously Adjustable Decade (CAD) dial.

3.8 SYSTEM SELF-CHECK.

Warning circuitry extinguishes the dial lamp of a malfunctioning Digit Insertion unit. In addition, the design provides for a very easy routine check for proper frequency generation. Details are covered in paragraph 5.3.

3.9 OPERATION OF SYSTEMS NOT FULLY EQUIPPED.

The design of the synthesizers permits operation with less than the full complement of digit units. The CAD can also be omitted for some applications. However, inclusion of the CAD is recommended in any but the most specialized systems. It provides very useful general-purpose features.

All the operational features discussed above (refer to paragraphs 3.1 to 3.8) apply to any of the partially equipped units, if one remembers that:

1. The CAD dial reading follows directly the last installed digit dial (when the CAD is in circuit as a result of pushing B_8, Figure 5-1).

2. All buttons under stations where digit units have not been installed act just the same as B_8—if any of them is depressed, the CAD is contributing to the output frequency and its dial reading follows immediately after the last installed dial.

3. It important that a DI Bridging Unit (part number 1160-4070) be installed in each Digit Insertion unit station not otherwise filled. (These are installed at the factory as components of partially equipped models).

NOTE

DI Bridging Unit is supplied with each synthesizer. If for any reason one of the originally installed digit units must be removed, its place should be filled by a digit unit taken from the right-hand end of the group of installed units and the bridging unit should be used to fill the resulting gap. (A bridging unit may be installed at any DI station except the X1MC decade of the 1163. But, unless the installed digit units are continuous, starting at the left-hand end of the chassis, the dial strip will not indicate frequency step size correctly.)

4. If the CAD unit is omitted, a CAD Bridging Unit (part number 1160-4080) should take its place. If this is done, all pushbuttons to the right of the one under the last installed digit unit are ineffective and may be depressed with no penalty.

NOTE

If the CAD Bridging Unit is not installed, it is necessary to see to it that the CAD OFF button is always depressed, otherwise the instrument will not generate proper frequencies.

5. If the CAD is omitted, none of the self-checks (paragraph 3.8) can be performed, although a partial check can still be made, without additional equipment, by setup of a 1- or 2-cycle output frequency, as noted in paragraph 5.6.5.

SECTION **4**

PRINCIPLES OF OPERATION

4.1 GENERAL.

The Types 1161-A, 1162-A, and 1163-A Coherent Decade Frequency Synthesizers are so nearly identical that, except as noted, the principles of operation are the same for each. Treatment here is restricted to the system level.

4.2 DIFFERENCES BETWEEN SYSTEMS.

All three equipments are fundamentally beat-frequency oscillators. In each, a fixed frequency is subtracted (in an output mixer) from an adjustable frequency, and the resulting difference-frequency signal, suitably amplified, is the final output. (In the

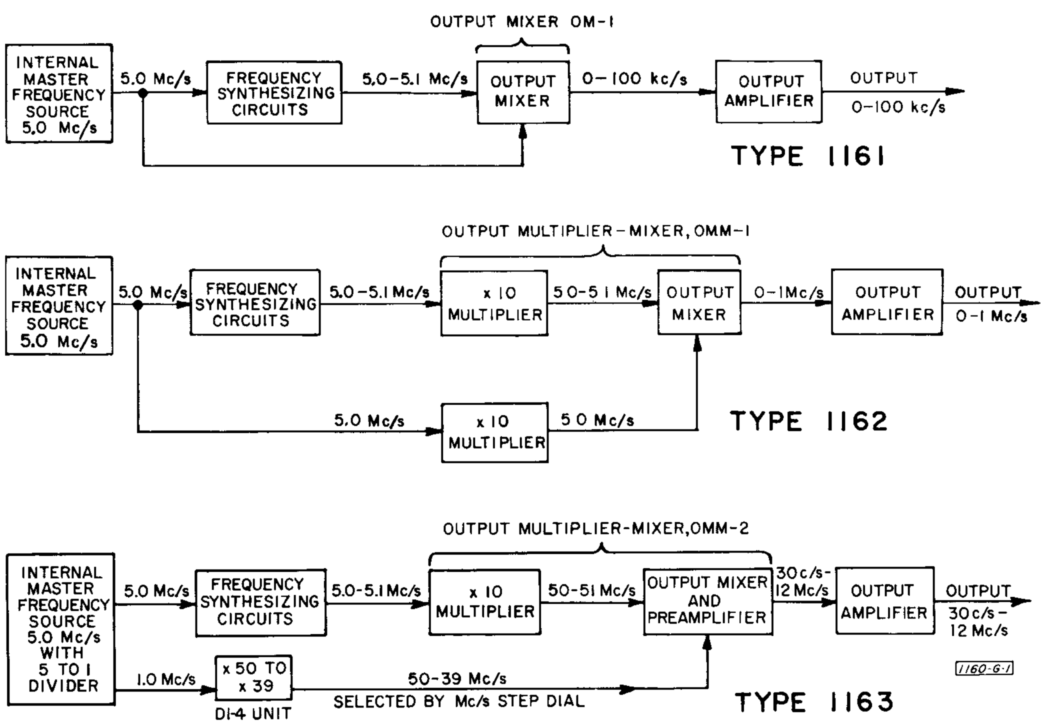


Figure 4-1. Elementary functional diagram of synthesizer circuitry.

Type 1163-A, the "fixed" frequency is itself adjustable, in 1-Mc steps, by the left-hand frequency dial).

In the Type 1161-A synthesizer, 5.0 Mc/s is subtracted from a dial-selected frequency ranging from 5.0 to 5.1 Mc/s. In the Type 1162-A synthesizer, 50.0 Mc/s is subtracted from a frequency lying between 50 and 51 Mc/s to produce the output. In the Type 1163-A, a 1-Mc signal between 50 and 39 Mc/s is subtracted from the synthesized frequency lying between 50 and 51 Mc/s. These relationships are shown in the basic block diagrams of Figure 4-1. As can be seen, the major differences between systems is in the use of the Output Mixer module, OM-1, in the Type 1161-A, use of the Output Multiplier-Mixer, OMM-1 in the Type 1162-A, and in Type 1163-A the use of a slightly different Main Frame chassis, with the megacycle-selector unit, RDI-4, and the OMM-2 Output Multiplier-Mixer installed. In the Types 1161-A and 1162-A, the Output Mixer modules are of identical physical size and can be plugged into the (1160-4060) Main Frame, thus transforming one type of instrument into the other. (A corresponding dial-strip change is also necessary.) As noted, the Type 1163-A uses a different Main Frame (1163-4060).

The remaining modules of either the Type 1161-A or 1162-A are as follows:

- Ancillary Frequency Source
- Frequency synthesizing circuits, comprising:
  - Digit-Insertion units (3 to 7 may be installed)
  - Continuously Adjustable Decade
- Calibrating Mixer
- Power Supply

In the Type 1163-A the Main Frame is slightly different, and a special module – the RDI-4 – occupies the left-hand digit position.

These modules will be briefly described before the general synthesizing principle is discussed. The modules appear in Figure 4-2 and a top view of the Main Frame is shown in Figure 4-3.

NOTE

Detailed descriptions of each of the plug-in modules, and of each of the Main Frames, are contained in separate sections included in this book under headings appropriate to the unit in question.

4.3 MODULAR COMPONENTS.

4.3.1 GENERAL.

The DI, CAD, AFS, CM-1, and PS-3 are used in all three synthesizers and will be described first. The Output Mixer OM-1 is unique to the Type 1161-A and is replaced, in the Type 1162-A, by the OMM-1. The RDI-4 and the OMM-2 are used only in the Type 1163-A, which, as noted above, also has a slightly different chassis.

4.3.2 DIGIT-INSERTION UNIT – TYPE 1160-RDI-1B.

This module, basic to all the frequency-synthesizer assemblies in this series, is used repetitively to provide selection of each available digit. A DI unit is plugged in behind each of the digit dials.

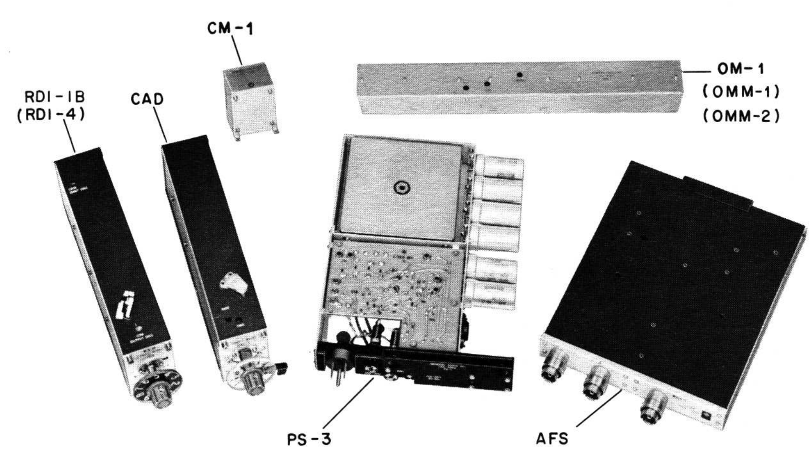
The RDI-1B provides ten local-control digit-selection positions on its dial, plus an "R" position which transfers control to a connector at the rear of the RDI-1B unit itself.

4.3.3 CONTINUOUSLY ADJUSTABLE DECADE – TYPE 1160-CAD.

This unit provides continuous frequency coverage on a single dial over wide or narrow frequency regions as selected by pushbuttons. It may be omitted if continuous coverage is not required, although it is valuable for system self-checks (refer to paragraph 3.8). It is used in all synthesizers.

4.3.4 ANCILLARY FREQUENCY SOURCE – AFS

In this module is the 5-Mc/s master crystal oscillator from which all frequencies used in the synthesis are derived. It furnishes an output at 42 Mc/s, which is fed to all the DI units and to the CAD. It also generates a "picket fence" of frequencies spaced



LEGEND

RDI-1B	Digit-Insertion Unit
RDI-4	Digit-Insertion Unit (Type 1163 only)
CAD	Continuously Adjustable Decade
CM-1	Calibrating Mixer
PS-3	Power Supply
OM-1	Output Mixer (Type 1161)
OMM-1	Output Multiplier-Mixer (Type 1162)
OMM-2	Output Multiplier-Mixer (Type 1163)
AFS	Ancillary Frequency Source

Figure 4-2. Typical synthesizer modules. Dial-light panels for a Digit unit and the CAD are shown on top of their respective modules.

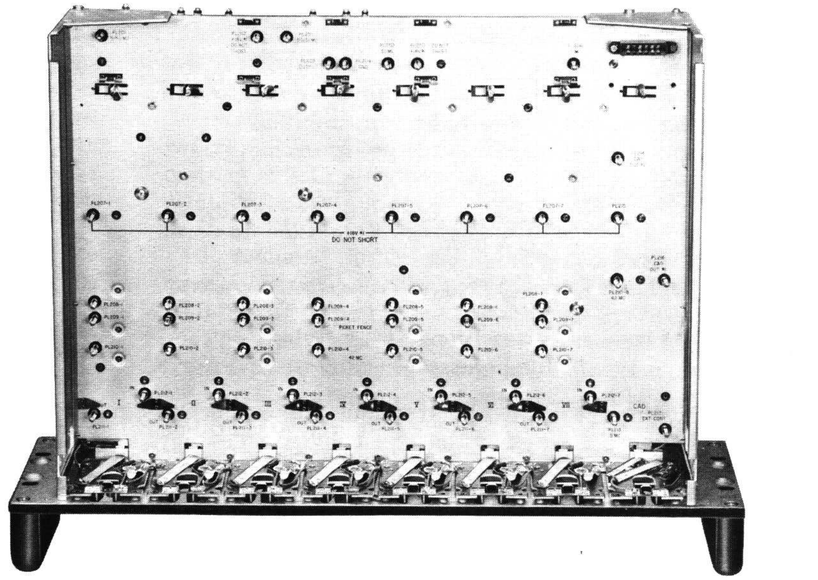


Figure 4-3. Top view of synthesizer Main Frame chassis used for Type 1161-A and 1162-A (refer to Section BA). The Main Frame for the Type 1163-A is nearly the same (refer to Section BB).

100 kc/s apart between 3 and 3.9 Mc/s. This picket fence is used in each DI unit for digit-selection purposes. It also supplies 1.0 Mc/s to RDI-4 unit in the Type 1163-A.

4.3.5 CALIBRATING MIXER — CM-1.

This simple module compares the output frequency of the CAD unit with the dialed output frequency of any chosen group of DI units for self-calibration or marker generation. If the CAD unit is not installed in a system, this mixer is omitted also.

4.3.6 OUTPUT MIXER, OM-1, AND OUTPUT MULTIPLIER-MIXER, OMM-1.

These modules, mechanically interchangeable, provide frequency translation between the synthesizing modules and the output circuits of the Types 1161-A and 1162-A synthesizers, respectively. Replacement of one by the other in the (1160-4060) Main Frame changes the instrument from a Type 1161-A to a Type 1162-A, or vice versa.

4.3.7 POWER SUPPLY — PS-3.

This unit accepts ac power from the line or dc from a 20- to 28-V battery and supplies 18 V, regulated, to operate the synthesizer.

4.3.8 DIGIT-INSERTION UNIT — TYPE 1163-RDI-4.

The RDI-4 unit, which supplies digit steps of 1 Mc/s, is mounted on the 1163-4060 chassis in the left-hand digit station. Its only signal input is one of 1.0 Mc/s, taken from the AFS unit. Its output is one of 12 frequencies (from 50 to 39 Mc/s) that are beat with a signal (between 50 and 51 Mc/s) synthesized by the DI units. The RDI-4 unit has the same form factor as the DI and bears a dial marked from 0 to 11 that reads 1-Mc steps in the final output frequency plus the 'R' position that transfers control to a connector at the rear of the module.

4.3.9 OUTPUT MULTIPLIER-MIXER 1163-OMM-2.

This module, which is of the same size and shape as the OM-1 and OMM-1 of the Type 1161/1162 synthesizers, plugs into the top rear of the chassis of the Type 1163-A. It combines the output frequency of the train of DI units to produce the final output frequency of the synthesizer. It also includes a preamplifier for the output-frequency signal generated in the low-level mixer of this unit.

4.3.10 MAIN FRAME.

Figure 4-3 shows the Main Frame into which the above listed modules are plugged to make up either a Type 1161-A or a Type 1162-A synthesizer. Its deck is of "sandwich" construction, with banana plugs protruding downward to engage the power supply and the AFS, and upward to connect with all other modules. It contains the pushbutton switches that control the functional position of the CAD, the monitoring circuits, and the final-output amplifier. The Main Frame for the Type 1163-A is nearly identical.

4.4 THE SYNTHESIZING PRINCIPLE.

The discussion which follows is based on the Types 1161-A and 1162-A. The Type 1163-A utilizes all the principles described here, with some additions which are covered separately in paragraph 4.7.

The blocks in Figure 4-1 labeled "Frequency Synthesizing Circuits" comprise, in a complete instrument, a train of eight units of the same outside dimensions (seven DI units and a CAD). In the synthesizing process, the signal starts at the right-hand end of the train (at the CAD unit) and proceeds toward the left through seven* identical Digit Insertion units in sequence, being slightly modified in accordance with the dialed digit information as it passes through each unit. The frequency level, through this whole section, is always between 5.0 and 5.1 Mc/s.

Each DI module in the synthesizer receives an input signal at about 5 Mc/s, modifies the frequency of this signal very slightly in two steps, and delivers the modified frequency (again near 5 Mc/s) as an input to the next DI unit in the train. Figure 4-4 is an elementary diagram showing the essential processes performed in a DI unit.

*Six, in the Type 1163

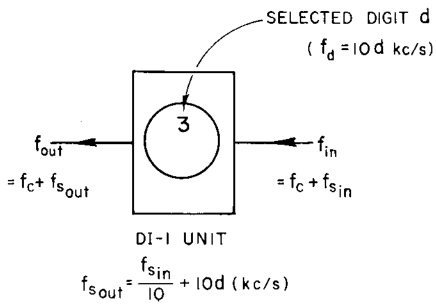


Figure 4-4. Signal traversing a typical DI Digit-Insertion unit.

In Figure 4-4 each signal (input and output) is shown as having a frequency that, for convenience, may be regarded as the sum of two components. The first component is a "carrier" frequency, which remains unchanged through all the DI units at 5000 kc/s.

The second component is the "signal" component. The signal component always lies between 0 and 100 kc/s.

The signal component is modified by passage through each Digit-Insertion unit in the following very simple ways, as indicated in the figure. If we denote the total input frequency by

$$f_{in} = f_c + f_{s_{in}} \quad \text{kc/s} \qquad (4\text{-}1)$$

and the output frequency by

$$f_{out} = f_c + f_{s_{out}} \quad \text{kc/s} \qquad (4\text{-}2)$$

then the DI unit performs operations so that:

$$f_{out} = f_c + \frac{f_{s_{in}}}{10} + 10\,d \text{ kc/s} \qquad (4\text{-}3)$$

or

$$f_{s_{out}} = \frac{f_{s_{in}}}{10} + 10\,d \quad \text{kc/s} \qquad (4\text{-}4)$$

where

f_{in}, f_{out} = total input and output frequencies

f_c = carrier component, invariant

$f_{s_{in}}$ = signal component of input

$f_{s_{out}}$ = signal component of output

d = selected digit, from 0 to 9 in integral steps.

For convenience in following frequency changes through the train of digit units, we can disregard the carrier component, since this passes through unchanged, and concentrate on only the signal component, as in Equation (4-4).

Figure 4-5 shows four DI units (A, B, C, D), each with digits selected as indicated, and the signal-component flow through the train, from right to left. Observe the correspondence between the signal component of output frequency from unit A (24.39 kc/s) and the digit dial settings (2439). The output frequency from <u>any</u> unit in such a train of digit units will have a signal component that is, in kilocycles per second:

$$f_s = 10d_1 + d_2 + 0.1\,d_3 + 0.01\,d_4 + \ldots \qquad (4\text{-}5)$$

where d_1 represents the dialed digit on the unit at which the output frequency is measured, and d_2 through d_n represent digits dialed on successive units to the right.

Equation (4-4) defines the two fundamental operations performed on the signal component by each digit unit, which permit frequency synthesis in steps as small as may be desired. These operations are:

1. Divide the input signal component by 10.
2. Add to this a digit component that is 10 times the dialed digit (in kc/s), and pass the result on to the input of the next DI unit in the train.

4.5 CAD SWITCHING AND SELF CALIBRATION.

Behind each pushbutton on the panel is an rf switch which controls the functional position of the CAD and also arranges for the self-calibration feature. The simplified block diagrams of Figure 4-6 and 4-7 illustrate the principle; for more detailed information, see the separate sections on the Main Frames. The actual switching is a little more complex than shown in Figures 4-6 and 4-7, due to the necessity for shielding, but the signal paths are the same.

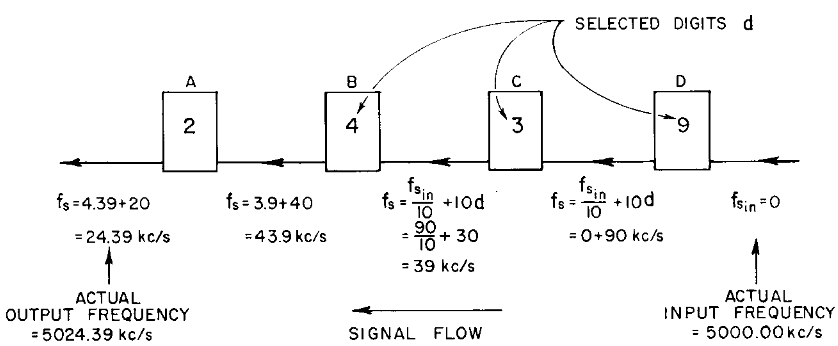


Figure 4-5. Signal flow through four Digit-Insertion units shown to illustrate synthesis of desired signal component.

Figure 4-6 shows seven DI units with dials set as indicated by the numbers in the boxes at the top. The resulting "signal components" (refer to Equation 4-4) of frequency passing between them appear below the boxes. The CAD unit, although present, is disconnected from the train because the CAD OFF button unlatches all other buttons, so that the switches are positioned as shown in Figure 4-6.

Figure 4-7 is the same except that B_5 has now been depressed, so that the CAD is operative and its output becomes the input to digit unit number 4.

With reference to Figures 4-6 and 4-7, observe that:

1. The output frequency is the same in each, though in Figure 4-6 seven digit units are working and the CAD is idle, while in Figure 4-7 four digit units and the CAD cooperate to produce the output frequency.

2. The beat-frequency output from the Calibrating Mixer is 0 in Figure 4-7, indicating that the CAD has correctly replaced digit units numbers 5, 6, and 7.

Consider now what would have been the result in Figure 4-7 if the CAD dial had been set to 6.13 instead of 5.13 as shown. First, the signal components would have been modified as indicated in the first five lines of Table 4-1.

Second, the synthesizer output frequency would have been increased by 1.00 c/s (if Type 1161-A), or by 10.0 c/s (if Type 1162-A), and third, the beat frequency available at the BEAT binding posts would have changed from 0 to 10 kc/s, as shown at the bottom of the table.

If button B_6 is pushed instead of B_5, a change of one major division of the CAD will still produce a 10-kc/s change at BEAT, but the effect on the output frequency in the Type 1161-A is only 0.1 c/s.

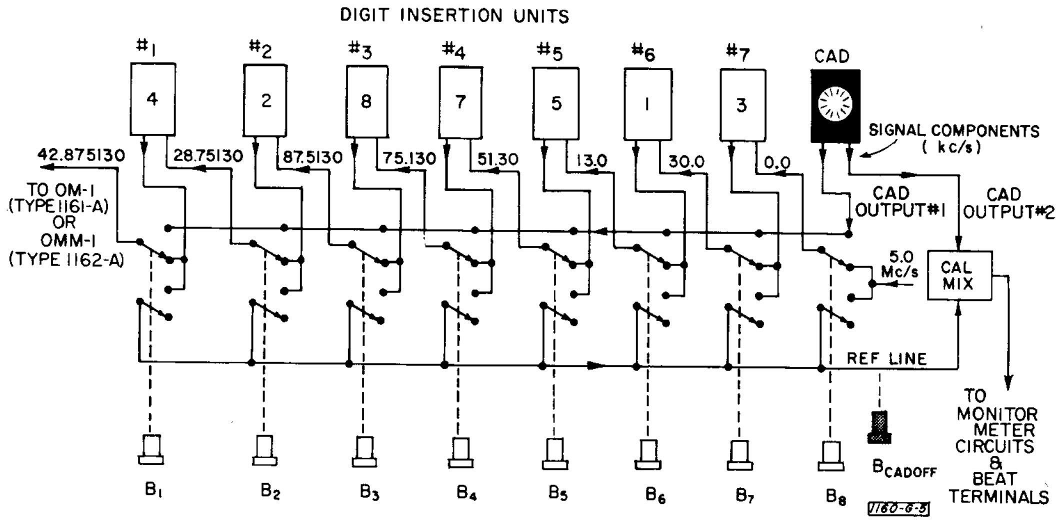


Figure 4-6. Example of synthesis achieved by seven Digit-Insertion units. Pushbutton $B_{CAD\ OFF}$ has been actuated so that CAD is not contributing to the output.

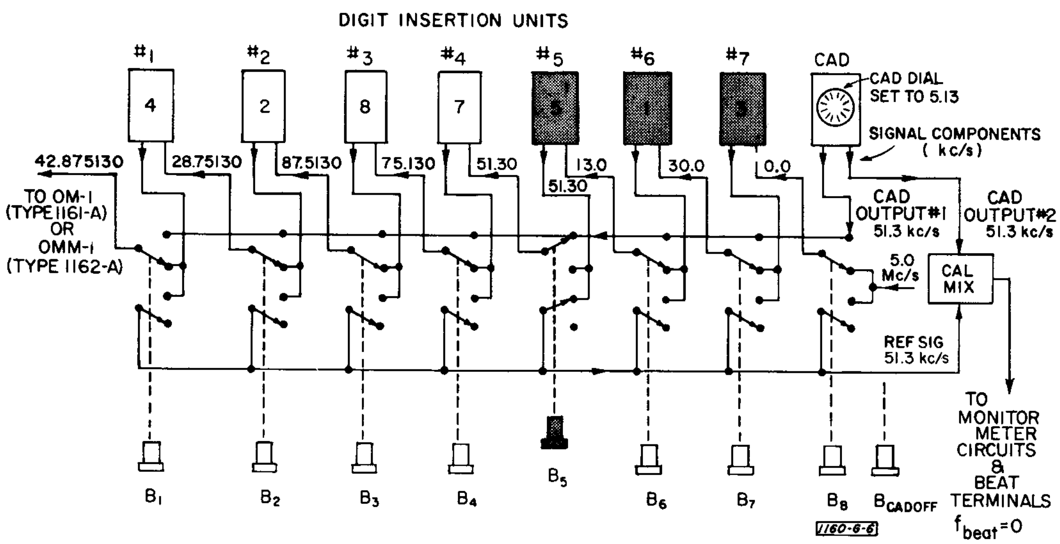


Figure 4-7. Example of synthesis by four Digit-Insertion units and the CAD. Pushbutton B_5 has been actuated so that the input to digit unit 4 comes from CAD. The output of the digit unit 5 is compared with the CAD output in the Calibrating Mixer. As shown, zero beat is achieved.

TABLE 4-1
EFFECT OF CAD ON SYNTHESIZER READOUT

Signal Components	*CAD at 5.13 as in Figure 4-7*	*CAD at 6.13*
Input to digit unit 4	51.3 kc/s	61.3 kc/s
Input to digit unit 3	75.13 kc/s	76.13 kc/s
Input to digit unit 2	87.513 kc/s	87.613 kc/s
Input to digit unit 1	28.7513 kc/s	28.7613 kc/s
Output of digit unit 1	42.87513 kc/s	42.87613 kc/s
Synthesizer Output (if Type 1161)	42,875.13 c/s	42,876.13 c/s (change = 1.0 c/s)
Synthesizer Output (if Type 1162)	428, 751.3 c/s	428,761.3 c/s (change = 10.0 c/s)
Output at BEAT terminals	0	10 kc/s

Or, if button B_3 is depressed, one major division change of the CAD will change the output frequency by 100 c/s in the Type 1161-A or by 1 kc/s in the Type 1162-A. In either event, the change at BEAT is still 10 kc/s.

4.6 DIAL LIGHTING.

Behind each dial is a white plastic plug-in assembly which contains a lamp bulb. In normal operation, each of these lamps is turned on whenever the corresponding digit unit (or CAD) is contributing to the output frequency.

A second set of switches, operated by the pushbuttons (but not shown in Figures 4-6 and 4-7), serves to turn off all digit-dial lights above and to the right of any actuated button, and to turn on the CAD dial lamp. Figure 4-8 shows the wiring of these switches, and also the set of transistors, mounted on the lamp-switching cards behind the front panel, which sense malfunction of phase lock in a digit unit and extinguish the corresponding dial light to give warning.

Pushbuttons B_1 through B_7 operate the lamp switches of Figure 4-8 and also the rf switches of Figures 4-6 and 4-7. B_8 operates only an rf switch, and $B_{CAD\ OFF}$ controls only a lamp switch, as shown. When $B_{CAD\ OFF}$ is actuated, the CAD lamp is off and all other lamps are on; whenever any other button is depressed, the CAD dial is illuminated.

NOTE

Each button, when actuated, latches in the depressed position and at the same time releases all other buttons to normal position.

Figure 4-8 shows seven error-sensing probes, each of which makes contact to a pin protruding through the front panel of the Digit Insertion unit installed behind the corresponding dial lamp. Each of these pins is normally at a positive potential with respect to ground. Hence, the transistors shown in Figure 4-8 are all turned on, and each lamp circuit to ground is complete. Lamps corresponding to button B_5 (which is depressed) and to B_6 and B_7 are extinguished by the opening of the switch at B_5, which disconnects the voltage source from these lamps.

In the event of a phase-lock malfunction in a DI unit, however, the probe in the digit unit at fault will be at ground potential. The corresponding transistor is turned off and the lamp extinguished. (For details of the error-sensing circuits, see the separate sections of this book on the Digit-Insertion units.)

An additional switch, ganged with the EXT CONTROL-INTERNAL LOCK switch, is shown at the right of Figure 4-8. As indicated, this inserts a resistor in series with the CAD dial lamp, when the CAD mode switch is in the EXTERNAL CONTROL position, to dim the lamp.

4.7 TYPE 1163-IDENTITIES AND DIFFERENCES.

The only important difference between the Type 1163-A and its two lower-frequency counterparts is in the signals fed to its output mixer, to generate the final output-frequency band. In what follows, familiarity with the material of paragraphs 4.1-4.6 is assumed.

In the Type 1163-A, the output mixer is fed, on one side, by a synthesized frequency between 50 and 51 Mc/s, produced exactly as in the Type 1162-A, by multiplication by ten of the output frequency of a train of DI units (see Figure 4-1).

The other side of the output mixer is supplied by one of twelve frequencies, selected by the dial of the RDI-4 unit, which lie between 50 and 39 Mc/s at 1-Mc intervals. The RDI-4 unit occupies the left-hand digit-unit station on the Main Frame, in a location corresponding to the highest-rank digit unit in the Type 1161 or 1162. Since the input and output signals of the RDI-4 are different from those of a DI, the chassis wiring of the Type 1163-A is different in this region.

The RDI-4 unit takes 1.0 Mc/s as its only signal input, and, by sampling-phase-detector and locked-oscillator techniques, develops an output at 50 Mc/s when its dial is set at 0, 49 Mc/s at a dial setting of 1, and so on, to an output of 39 Mc/s at 11 on its dial.

This output signal is fed by wiring in the sandwich deck to the output mixer in the Output Multiplier-Mixer Unit, OMM-2.

Since the CAD can never functionally replace the RDI-4, the pushbutton under this unit is not installed in the 1163-4060 chassis.

Otherwise, the operation of the pushbuttons and of the CAD is exactly as in the Types 1161-A and 1162-A, described in detail earlier. Figures 4-6, 4-7, and 4-8 are adequate for an understanding of the principles involved, if one bears in mind that the #1 digit-unit station is occupied by an RDI-4 Unit, which supplies 1-Mc spaced frequencies to the OMM-2. Pushbutton B_1 and its associated switching are omitted, and the output to the other side of the OMM-2 is taken, via the switch associated with button B_2, from the last (sixth) DI Unit, in station #2.

The Output Multiplier-Mixer OMM-2 has the same dimensions as the OM-1 or the OMM-1 and occupies a corresponding position on the chassis. About half is occupied by circuits identical with those in the OMM-1 for multiplication of 5/5.1 to 50/51 Mc/s. The other half contains the mixer and a preamplifier that raises the output of this low-level mixer to a level suitable for input to the Output Amplifier, mounted behind the bottom of the front panel.

The Output Amplifier is very similar to that used in the 1160-4060 chassis but has greater bandwidth, on account of the 12-Mc top frequency.

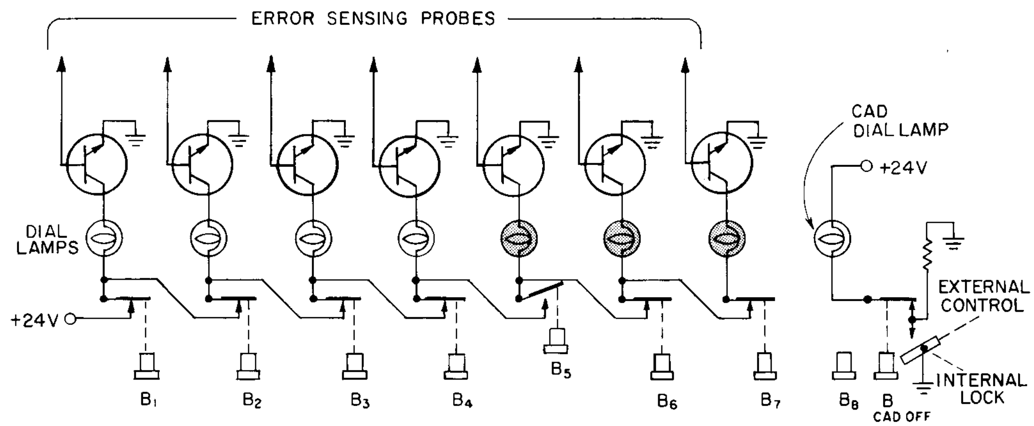


Figure 4-8. Dial-lamp switching circuits with B_5 actuated; lamps 5, 6 and 7 are off, CAD lamp is on. See also Figures 4-6 and 4-7 for rf switching, also controlled by pushbuttons B_1 through B_8. This figure (plus Figures 4-6 and 4-7) is illustrative of either a Type 1161-A or Type 1162-A synthesizer. In a Type 1163-A, pushbutton B_1 and its associated switching are omitted, and station #1 is occupied by an RDI-4 Unit. Refer to sub-sections BA and BB on the Main Frame.

SECTION **5**

SERVICE AND MAINTENANCE

5.1 WARRANTY.

We warrant that each new instrument sold direct is free from defects in material and workmanship and that, properly used, it will perform in full accordance with applicable specifications for a period of two years after original shipment. Any instrument or component that is found within the two-year period not to meet these standards after examination by our factory, District Office, or authorized repair agency personnel will be repaired or, at our option, replaced without charge, except for tubes or batteries that have given normal service.

The two-year warranty stated above attests the quality of materials and workmanship in our products. When difficulties do occur, our service engineers will assist in any way possible. If the difficulty cannot be eliminated by use of the following service instructions, please write or phone our Service Department, giving full information of the trouble and of steps taken to remedy it. Be sure to mention the serial and type numbers of the instrument.

NOTE

Each interchangeable plug-in module carries its own individual serial number, and the serial number on the front panel of the synthesizer applies only to the Main Frame.

Before returning an instrument to General Radio for service, please write to the Service Department or nearest District Office, requesting a "Returned Material Tag." Use of this tag will ensure proper handling and identification. For instruments not covered by the warranty, a purchase order should be forwarded to avoid unnecessary delay.

5.2 SERVICE INSTRUCTIONS.

This section is devoted to a description of the mounting arrangements for the various plug-in modules and to suggestions for methods of localizing trouble to a particular module, if any system malfunction is discovered. Refer to paragraph 5.3 for system self-check procedures. Most of the following is written in terms of the Types 1161-A/1162-A synthesizers. Applications to the Type 1163-A should be obvious, since all units are so nearly identical. For more details on the differences, refer also to Sections BA and BB, on the Main Frames, and the sections on the modules.

If improper frequency generation in a Type 1163-A is suspected, refer also to Section DC.

5.3 SYSTEM SELF-CHECK.

5.3.1 GENERAL.

The calibration circuitry permits a very easy check of each digit unit, by the methods discussed below. Refer to the digit dials by number, from D_1 to D_7, and to the pushbuttons by number, from B_1 to B_8 plus $B_{CAD\ OFF}$, as indicated in Figure 5-1.

NOTE

Set the MONITOR switch at CAD CAL, as indicated, and the CAD mode switch in the INTERNAL LOCK position.

5.3.2 LOW-END CHECK (ZEROS).

To check the low-end ("0" digit) frequency of all installed DI Digit-Insertion units, proceed as follows:

a. Set all digit dials to zero, and actuate B_8, under the CAD unit.

b. Adjust the CAD dial to (or close to) 0.000 to achieve a visible low-frequency oscillation of the needle of the MONITOR meter.

NOTE

By this process, the actual output frequency of the CAD has been set to 5.0 Mc/s, exactly corresponding to digit "0". (The error, at 5 Mc/s, is only the visible beat frequency, which is completely negligible in its effect on the synthesizer output frequency.)

c. Now actuate B_7. (If the instrument is a stripped-down version, with fewer than 7 DI units, actuate the button under the last installed unit.) In a complete instrument the digit dial reading is now $000000\underline{0}$, (the underline under the last digit indicates that the button under this digit has been depressed). If digit-unit 7 is behaving properly in its "0" position, the beat on the MONITOR meter will be unchanged from that set-up under step a. If the beat disappears, digit-unit 7 is not operating properly and should be serviced. (See detailed section of this book on the DI unit.)

d. Actuate B_6. (Digit dial reading is $00000\underline{0}0$, with actuated button indicated by underline, as before.) Beat on MONITOR should be unchanged. If it disappears, digit-unit 6 needs service.

e. Continue to actuate buttons progressively toward the left, from reading $0000\underline{0}00$ through $000\underline{0}000$ and so on to $\underline{0}000000$, with B_1 actuated.* If all digit units are generating "0's" properly, the beat on the MONITOR meter will be unchanged through this whole sequence. If the low-frequency beat disappears when any button is depressed, the digit unit at that station needs attention. (It may easily be removed for repair, the only penalty being the temporary loss of one digit of resolution. Refer to paragraph 5.5.1 for procedural details.)

5.3.3 HIGH-END CHECK (NINES).

To check the high end ("9" digit) proceed as follows:

a. Set D_1 to 9 (so that the reading is $\underline{9}000000$, with all other digit dials still at 0 and B_1 actuated).†

b. Then, adjust the CAD to (or close to) 9.000 to achieve a low-frequency beat on the MONITOR meter.

c. Depress button B_2 and set D_2 to 9 (reading is now $9\underline{9}00000$). If both the digit units at D_1 and D_2 are behaving normally, the beat will be unchanged. (If it is not, refer to paragraph 5.3.5.)

d. Continue, in sequence, to set dials to 9 and to depress buttons, from reading $99\underline{9}0000$ through $999\underline{9}000$ to $999999\underline{9}$. If all digit units are normal, the beat on the MONITOR meter will be unchanged through this sequence. If the visible beat disappears at any step, the digit unit at that station probably needs servicing. (Refer to the section of this book on the DI unit.)

5.3.4 SEQUENTIAL CHECK OF OTHER DIGITS.

In general, a check of the end points, at 0 and 9, will give reasonable assurance that the intermediate digits are also functioning properly, but in case of doubt any digit can be confirmed. For instance, set D_1 to 4, depress button B_1, and set the CAD for a visible beat. Then, set D_2 to 4 and depress B_2, for a reading of $4\underline{4}00000$, and continue (as in paragraphs 5.3.2 and 5.3.3) through readings of $44\underline{4}0000$ to $444444\underline{4}$. (Digits 4 and 5, as well as 0 and 9, are logical candidates for this sort of check, since the internal-selection scheme in the DI requires a tracking adjustment between the lower and upper halves of the decade.)

5.3.5 RESOLUTION OF AMBIGUITY.

If step c of paragraph 5.3.3 fails to check, it is possible that the unit at D_1 may itself be in error in the "9" position. In this case the CAD, having been set erroneously to agree with D_1 (which is here assumed to be wrong) will not give a proper check against a correct D_2. On the other hand, D_1 may be right and D_2 wrong. To resolve this ambiguity, compare D_2 with D_3 (reading $9\underline{9}00000$ compared with $99\underline{9}0000$) or any other adjacent pair of digit units, to make sure that the CAD has been set to a true reading of 9.000. Once this has been done, the now-verified correct setting of the CAD can be used to discover an error in the unit at D_2 (reading $9\underline{9}00000$ fails to produce a visible beat). If D_2 is found to be correct and D_1 fails, then the unit at D_1 is in need of service.

5.3.6 CHECK BY DIAL-LIGHT FAILURE.

The procedures of paragraphs 5.3.2 and 5.3.3 will always spot a malfunction at the frequency endpoints of any digit unit, and these checks are quite easy to perform. However, built-in warning circuitry will usually provide a direct and immediate indication

*In the Type 1163-A, the maximum number of DI units that can be installed is 6 and button B_1 is omitted. To check the operation of the RDI-4 unit, installed in the last station, consult Section DD.

†In the Type 1163-A, D_1 is on the RDI-4 unit, so the starting point of this series of checks is at D_2, with a dial reading of $X\underline{9}00000$. The RDI-4 setting, indicated by X, is immaterial.

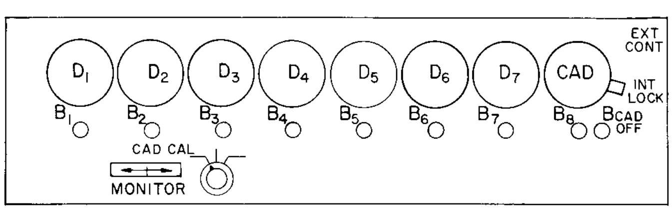


Figure 5-1.
Dial and pushbutton designators for system self-check procedures.

of such trouble, should it occur. These circuits automatically extinguish the dial lighting for a digit unit in which failure has developed. Refer to paragraph 4.6 and the detailed section of this book on the DI unit. See also the section on the RDI-4 unit used in the Type 1163-A, which has a similar provision for warning by dial light.

NOTE

This dial-light failure might, however, be caused by burn-out of the lamp itself, or by a fault in the wiring or switching in the lamp circuit. The procedures of paragraphs 5.3.2 to 5.3.5 may be followed whenever any doubt exists as to the exact cause.

5.3.7 NONSEQUENTIAL DIGIT CHECK.

It is possible to check any dial digit by comparison, through the CAD, with the corresponding digit on another Digit Insertion unit. For example, if unit 7 is known to be good and there is some doubt about unit 6, compare all digits in unit 6 with those in unit 7 as follows:

a. Set both dials to 0, depress B_7, and adjust the CAD for a visible beat on the monitor meter.

b. Depress B_6; the beat should be unchanged.

c. Set both dials to 1, press B_7, and adjust the CAD for a visible beat.

d. Return D_7 to 0 and depress B_6; beat should be unchanged.

e. Continue through the remaining digits, remembering that each time before B_6 is depressed the reading of D_7 must be returned to 0.

By an analogous process, any digit unit can be checked against any other to its right, provided that it is known that all digit units to the right of the suspected unit are performing properly.

5.3.8 FREQUENCY CHECK NOT REQUIRING CAD

Another type of frequency check is possible, using the 5/5.1-Mc and the 5/5.1-Mc REFERENCE signal at J150 is the output of the group of DI units and J157, at the rear of the chassis deck.

When a panel pushbutton is actuated, the 5/5.1-Mc signal at J150 is the output of the group of DI units to the left of the actuated button (and the CAD if present). The 5/5.1-Mc REFERENCE signal (J157) is the output of the DI group above, and to the right of the actuated button.

Therefore, it is possible to form a 1:1 Lissajous pattern between these two signals, if the dials of the two groups of DI-1 units are set to equality. (The CAD, if installed, will terminate the left-hand group and should be set at 0 or the pattern will drift). In this way, any series of dial settings of one group of DI units can be compared with the same settings on the other group.

Signals from these connectors can, of course, be compared or measured individually in any other convenient way (frequency-counter measurements, or audio-beat comparison, for instance).

5.4 REMOVAL OF MODULES FROM THE CHASSIS.

5.4.1 GENERAL.

Remove the four knurled screws on the front panel (accessible through the handles), release the cabinet clamps at the rear (if in use), and withdraw the instrument from its cabinet. (See Figure 5-2).

CAUTION

The power switch must first be OFF, or preferably, the power cord should be disconnected.

5.4.2 REMOVAL OF A DIGIT INSERTION UNIT.

Each digit unit is held in place by two front-panel screws (concealed under the dial strip at the top of the panel) and by a hold-down clamp in the deck at the rear of the unit. To remove a digit unit, proceed as follows:

a. Remove the dial strip, which is held in place by the two Phillips-head screws at its ends.

b. Loosen the two Allen-head setscrews in the knob, by use of a 3/32-inch hex wrench, and remove the dial. Then pull the dial lamp-holder forward out of the panel. (There is a threaded insert in the top center of the lamp-holder into which a 4-40 screw can be inserted to serve as a handle).

NOTE-DIAL INDEXING

The shaft of each digit unit has the numeral "5" stamped on it, visible when the dial is removed. When the shaft is turned so that this numeral is up, the unit is in the "5" digit position. Prior to dial remount, make sure the dial number 5 is positioned to correspond to this marking.

c. Release the rear clamp, using a straight-bladed screwdriver in the slot of the clamp screw. Turn counterclockwise until the clamping bar swings out of the recess in the rear of the digit unit. (To reinstall the unit, it may be necessary to take an additional turn or two counterclockwise, in order to raise the clamping bar high enough to swing freely into the recess, when the clamp screw is tightened clockwise.)

d. Grasp the unit by its shaft, and at the rear, and lift vertically for about 5/8 inch until the banana plugs are disengaged. Then continue to raise the rear and angle the unit out.

5.4.3 REMOVAL OF THE CONTINUOUSLY ADJUSTABLE DECADE, CAD.

Procedures are the same as for the removal of a digit unit, described in paragraph 5.4.2, except that the EXTERNAL CONTROL/INTERNAL LOCK switch crank must be pulled off the shaft, after the dial is removed.

CAUTION

Position this switch at EXTERNAL CONTROL before removal or remount; otherwise, the leaf-spring contact which controls lamp dimming may be damaged.

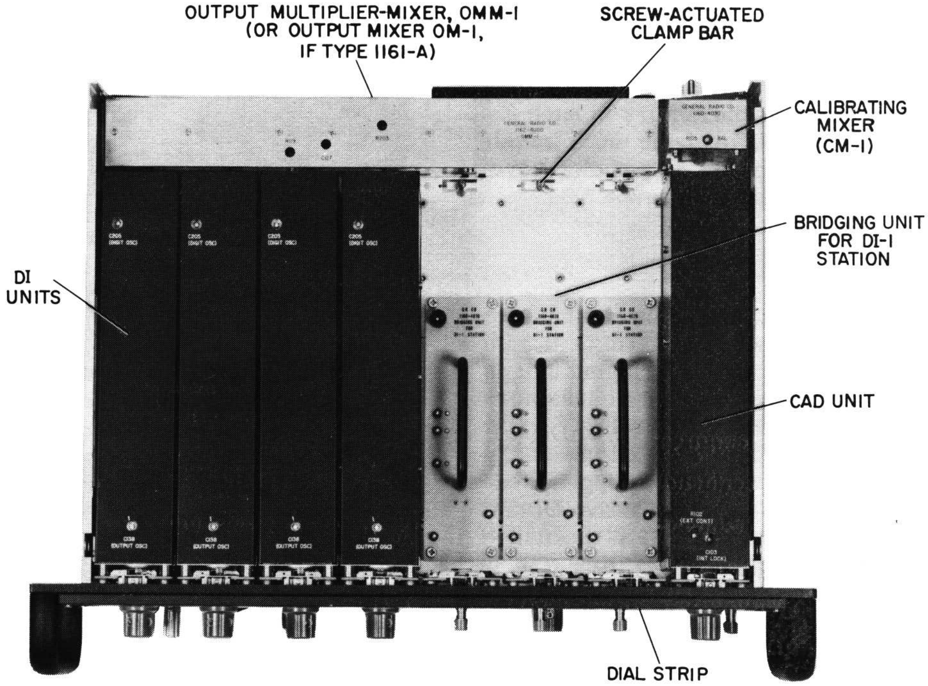


Figure 5-2. Type 1162-9524 Synthesizer top view, cabinet removed. (DI units shown less filter plugs.)

NOTE-DIAL INDEXING

To reinstall the CAD dial, turn the shaft clockwise to the stop. Then install the dial to read "11" (i.e., set the dial line marked "10" at the lampholder dial line marked "1", for proper dial registration).

5.4.4 REMOVAL OF THE CALIBRATING MIXER, CM-1.

Remove the three 4-40 screws from the ears at the base of the cover of the unit and lift vertically.

5.4.5 REMOVAL OF OUTPUT (MULTIPLIER) MIXER.

The Output Mixer, OM-1, (Type 1161-A, the Output Multiplier-Mixer, OMM-1 (Type 1162-A), or the Output Multiplier-Mixer, OMM-2 (Type 1163-A) is held in place by two 4-40 screws passing through the gussets on the end pans of the chassis into threaded inserts near the ends of the unit. Remove these screws, and lift the unit vertically until the banana plugs are disengaged. Small, circular posts mounted in the end plates of the unit may be used as pry-points for a screwdriver, to lift the unit clear of the banana plugs.

5.4.6 REMOVAL OF THE ANCILLARY FREQUENCY SOURCE, AFS (Figure 5-3).

This unit is held in place by two 1 1/2-inch, 10-32 screws which pass vertically through the unit into threaded inserts in the deck of the chassis. With the instrument upside down, take out these screws and lift the unit vertically until the banana plugs are disengaged.

CAUTION

Do not lift at an angle (e.g., by means of the GR874 connectors at rear only). This may damage the banana plugs. Similar precautions should be observed in removal of other modules.

5.4.7 REMOVAL OF THE POWER SUPPLY, PS-3.

This unit is secured by one 1 1/2-inch, 10-32 screw, which passes through the unit into the deck of the chassis, and by two more 10-32 screws (with special heads), which thread into the back edge of the sandwich deck. Remove these screws and lift the unit vertically until the banana plugs are disengaged.

5.5 USE OF BRIDGING UNITS.

5.5.1 DIGIT-INSERTION BRIDGING UNIT.

Each synthesizer, as delivered, is provided with a spare DI bridging unit (part number 1160-4070) and an accompanying dial-slot cover plate (part number 1160-8015) as separate accessories. If a DI unit (other than RDI-4) must be removed (for service or for any other reason), its place can be taken by the bridging unit and the synthesizer will continue to be operative, although with one less available digit.

NOTE

The 1163 synthesizer cannot operate without a properly functioning RDI-4 module.

For trouble-analysis purposes, the bridging unit may be plugged in directly in place of any removal DI unit. If it is intended to keep the bridging unit installed for some time, however, it is desirable to fill the gap resulting from removal of a DI unit. Transfer the last DI unit to the right into the vacated position and plug in the bridging unit to the right of the resulting continuous group of DI units. This will maintain proper correspondence between the digit steps engraved on the dial strip and the actual digit steps.

Synthesizers purchased only partially equipped have bridging units installed at the factory in each unfilled station. Figure 5-2 shows bridging units installed in such a synthesizer. Figure 1-2 shows cover plates installed to complete panel dress.

5.5.2 CAD BRIDGING UNIT.

When the CAD is omitted or removed, it is desirable (but not absolutely essential) to replace it with CAD Bridging Unit, 1160-4080. If this bridging unit is installed, the pushbuttons behave in more or less normal fashion. That is, when button B_8 or $B_{CAD\ OFF}$ (see Figures 4-6 through 4-8), or the button under any unoccupied DI station in the partially equipped models, is operated, the input to the first active DI unit will be 5 Mc/s (signal component 0 kc/s). If the bridging unit is not installed and the CAD OFF button is actuated, this 5-Mc input will still be applied correctly to the first active DI unit.

NOTE

If any other button is inadvertently depressed, this proper input will not be supplied, if the CAD Bridging Unit is missing.

5.5.3 OPERATION WITHOUT BRIDGING UNITS.

The primary function of the DI bridging unit is to connect together the input and output banana plugs at the vacated position. These are the two plugs nearest the front of the deck, PL211-X and PL212-X (X is the digit station number I through VII). The bridging unit also supplies proper loading on the picket-fence line (PL208-X and PL209-X) and on the 42-Mc line (PL210-X), but this loading is not essential, particularly if only one or two DI units are missing. So, in an emergency, PL211-X and PL212-X can be connected together with a clip lead, if a bridging unit is not available, and normal operation will be achieved.

Correspondingly, signal paths can be completed to simulate the CAD bridging unit by connection of PL213 to PL216, but it is probably easier just to depress the CAD OFF button when the CAD is removed.

CAUTION

The bridging units are designed to protect the +18V banana plug (PL207-X) from accidental grounding. If a unit is removed and replaced by a clip lead instead of a bridging unit, be careful not to ground this plug.

5.5.4 COVER PLATE 1160-8015.

This cover plate, which hides the keyhole cutout in the panel when a DI or CAD unit is missing, is held in place by one screw only, in its lower right hand corner. The left-hand-corner screwhead passes through a clearance hole in the plate.

NOTE

For removal or installation, do not remove both screws or the lamp-switching panel, which is also held by these screws, may become dislocated.

5.6 SYSTEM TROUBLE ANALYSIS.

5.6.1 GENERAL.

The modular construction used for all three synthesizers makes it relatively easy to diagnose system trouble, particularly if spare modules of the various kinds are at hand. Suggestions for determination of the module responsible for system failure follow.

5.6.2 SINGLE DIAL-LAMP FAILURE.

If one dial lamp fails at all positions of its dial and the others behave normally, the bulb is probably burned out. Remove the lamp and inspect it. If the lamp is not defective, the associated module should be checked. DI units can be compared with the CAD as described in paragraph 5.3. In the Type 1163 synthesizer, the CAD check cannot be made on the RDI-4 units. A frequency measurement at the output connector can be made to check operation of the RDI-4. If the RDI-4 lamp is out, and the frequency measurement at the output jack is normal, check the output jack with an oscilloscope for frequency jitter, indicating instability in the RDI-4 phase-lock loop (see Section DD).

Remove any defective DI unit and replace it with another, a bridging unit, or even a clip lead (refer to paragraph 5.5.3). A defective RDI-4, however, can be replaced only by another RDI-4 unit.

5.6.3 TOTAL DIAL-LAMP FAILURE.

If all dial lamps fail simultaneously, the trouble is probably in the power supply. If the synthesizer is otherwise behaving properly, a wiring fault in the chassis-lamp circuits should be suspected. Also a defective AFS unit can sometimes cause all lamps to go out because of improper frequencies on the picket-fence or 42-Mc lines (refer to paragraph 5.6.4).

In the Type 1163, if all DI lamps go out, but the RDI-4 lamp does not, the 42-Mc and picket-fence section of the AFS unit can still by faulty. Failure in the 1-Mc section of the AFS can also cause total lamp failure, or an apparent RDI-4 failure (in the Type 1163).

5.6.4 IMPROPER FREQUENCY GENERATION.

If lamp behavior is normal, but the self-check (refer to paragraph 5.3) or other test indicates improper frequency generation, the trouble is probably in the AFS unit, but might be in some DI unit.

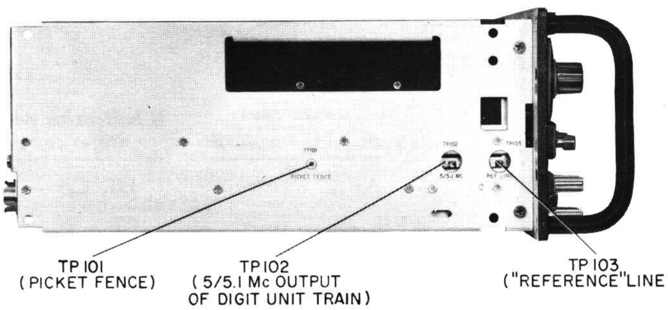


Figure 5-3. Synthesizer left-hand side view, cabinet removed (Types 1161 or 1162).

NOTE

A dial may have been installed with improper registration (refer to paragraph 5.4.2).

If the first DI (number 7 in a complete unit) seems to agree properly with the CAD dial under self-check procedures of each of its digits, proceed through the DI train from right to left, checking each unit in turn, until the defective one is found. If this procedure fails to locate the trouble (and particularly if the number 7 DI doesn't check closely with the CAD), then test the AFS (or replace it if a spare is available).

5.6.5 FREQUENCY 10X OR 0.1X (TYPE 1161 or 1162).

If the output frequency is ten times (or one-tenth) the dial indication, the wrong dial strip has been installed in reassembly. A check that the dial strip corresponds with the installed OM-1 or OMM-1 (Type 1161-A or Type 1162-A, respectively) can be done entirely from the front of the instrument. Set up 2 c/s on the dials, throw the MONITOR switch to OUTPUT VOLTS, with AC OUTPUT COUPLING selected, and OUTPUT LEVEL at maximum. If all is proper, the MONITOR meter will follow the 2-cycle output frequency. The indication will be near the zero end of the scale, because the cutoff for ac coupling is at 30 c/s. (Incidentally, this test also checks the 0's of all the DI units to the left of the 1-cycle-per-step position.)

5.6.6 INADEQUATE "CRYSTAL FREQ" RANGE.

The CRYSTAL FREQ control on the front panel permits relatively fine control of the free-running frequency of the internal master crystal oscillator. There is also a coarse control, which can be adjusted slightly, if for any reason the range of the panel control proves inadequate. The coarse control is C128, accessible through the bottom of the AFS unit, without removal of the unit from the chassis. To readjust this control, first set the fine control approximately at center. Then, measure the (free-running) output at the rear-apron connectors, 5 MC OUT (J108) or 100 KC OUT (J206), while making the adjustment.

NOTE

Use a nonmetallic screwdriver.

5.6.7 OUTPUT MISSING OR ABNORMALLY LOW.

First confirm that the OUTPUT COUPLING switch is in the AC position, if the MONITOR meter is being used for output-voltage indication. If trouble persists with this control properly set, the fault may be in the final DI unit, in the chassis wiring (including the push-button switches), in the output-mixer module that is installed, or in the output amplifier. If the final DI is at fault, the self-check (refer to paragraph 5.3) will probably fail at button B_1.

Look for +18±0.2 Vdc at J153 (rear apron) to ascertain that B+ is available from the power-supply module. If the reading is abnormal, refer to Sections BA or BB plus GC.

If B+ is present, look for the indications called for in Table 5-1 at externally available test points. With three exceptions, these trouble-analysis observations can be made at rear-apron test points and will not require instrument disassembly. However, for access to TP101, TP102 and AT201, the synthesizer must be removed from its case. These observations will help to isolate malfunction to the module level. Detailed module service instructions are given in the referenced, tabbed sections that follow.

For the observations called for in Table 5-1 the synthesizer should be synchronized with the 100-kc time base of the counter, which should be connected to LOCK SIG IN (J107 on the rear apron). Alternative trouble analysis techniques are presented in Table 5-2.

5.7 SERVICE AT THE MODULE LEVEL.

A thorough knowledge of the principles of operation, and of all the circuit arrangements by which the desired operation is achieved, is required for detailed trouble-shooting in this equipment. In separate sections of this book will be found additional descriptive matter on the principles of operation of the Main Frames and of each of the module types used in the synthesizers, together with photographs, circuit diagrams, and parts lists. Instrument servicing is relatively easy, since suspected modules can so readily be replaced by known good ones or, in the case of the DI or the CAD, jumpered out. Repair service on modules can be obtained at the factory or, in most instances, at the nearest General Radio District Office (see rear of manual).

TABLE 5-1

SYSTEM TROUBLE ANALYSIS

Test Points	*Synthesizer Type*	*Normal Indications**	*Modules Involved*	*If Indication Abnormal,† Refer to Section*
J150	1161/2/3	5.0 Mc/s plus 10 kc/s x DI-1 dial readings	DI, AFS	DI, CB
J151	1161/2/3	5.0 Mc/s	AFS	CB
J152	1161/2/3	1.0 Mc/s	AFS	CB
J154	1162/3	50/51 Mc/s (10X J150)	OMM-1, OMM-2, DI, AFS	FB, FC DI, CB
J155	1161/2/3	42 Mc/s	AFS	CB
J156	1162	50 Mc/s	OMM-1, AFS	FB, CB
J156	1163	50 Mc/s minus 1 Mc/s x RDI-4 dial reading	RDI-4, AFS	DC, CB
J157	1161/2/3	5.0 Mc/s +10 kc/s x "replaced" DI dial readings	DI, AFS	DI, CB
AT201	1161	Synthesizer output frequency	OM-1, OMM-1, OMM-2	FA, FB, FC
TP102	1161/2/3	5.0 Mc/s +10 kc/s x CAD major division‡	CAD	EA
J403A	1161/2/3	CAD output frequency minus "replaced" DI output frequency	CM-1	EA
TP101	1161/2/3	Picket Fence waveform (Figure 5-4)	AFS	CB

NOTES:
*Frequencies above can be measured with a sensitive (0.1 V) 50-Mc counter or counter/scaler combination such as a GR Type 1191-Z (100). Use an oscilloscope (such as Tektronix 543 with C/A plug-in) for the waveform at TP101.
†If signals are absent completely, chassis shorts or opens may be causing difficulty; see Sections BA or BB.
‡With B1 depressed; (B2 in Type 1163).

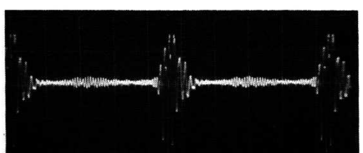

2.0 V/cm   2.0 μs/cm

Figure 5-4.
Picket-Fence waveform at TP101.

TABLE 5-2

SYSTEM TROUBLE ANALYSIS – ALTERNATIVE OSCILLOSCOPE LISSAJOUS PATTERN TECHNIQUES

Rear Apron Test Points	*Synthesizer Type*	*Normal Indication Frequencies – Mc/s* V	H	*Modules Involved*	*If Indication Abnormal, Refer to Section*
J108, J152	1161/2/3	5	1	AFS	CB
J155, J152	1161/2/3	42	1	AFS	CB
J156, J152	1163	39/50	1	RDI-4	DD
J108, J156	1162	50	5	OMM-1	FB
J108, J206	1161/2/3	5	0.1	AFS	CB

NOTES: Patterns should be stationary and jitter free.
Use an oscilloscope (such as Tektronix 543, with C/A plug-in).

TABLE 5-3

TEST EQUIPMENT

Instrument	*Recommended Type**
Fixed Attenuator, 20 dB	GR 874-G20L
Tee, coaxial	GR 874-TL
Termination, 50-Ω, coaxial	GR 874-W50BL
Digital Frequency Meter	GR 1191
Distortion and Noise Meter	GR 1932
Metered Variac® Autotransformer	GR W5MT3AW
Coaxial Patch Cord	GR 874-R22LA
Coaxial Adaptor, GR874-to-BNC Jack	GR 874-QBPA (3 required)
RF Voltmeter	GR 1820 with 1820-P2 plug-in
RF Distortion Meter	Boonton, 85C
Wave Analyzer	Hewlett-Packard 310
Oscilloscope	Textronix 547 with 1A1 Vertical Plug-in and P6008 10X probe.
Volt-Ohmmeter	Simpson 260
Patch Cord	GR 776-B

*or equivalent

5.8 MINIMUM PERFORMANCE STANDARDS.

5.8.1 GENERAL.

The following tests are provided to demonstrate synthesizer compliance with the published specifications at incoming inspection or following repair or calibration. The specific model described in these tests is the 1162-9527 synthesizer, which includes seven DI units and the CAD. These tests can be interpreted for other models and their variations by extracting the basic method and modifying it for the synthesizer at hand.

5.8.2 TEST EQUIPMENT.

The items listed in the Table 5-3 are recommended for performance of the ensuing tests.

5.8.3 OUTPUT FREQUENCY RANGE.

The System Self-Check of paragraph 5.3 offers convenient procedures to verify generation of proper frequencies. Connect equipment as shown in Figure 5-5 and make additional checks as follows:

Connect the output of the synthesizer to the counter. Use the GR 874-QBPA Adaptor to attach the

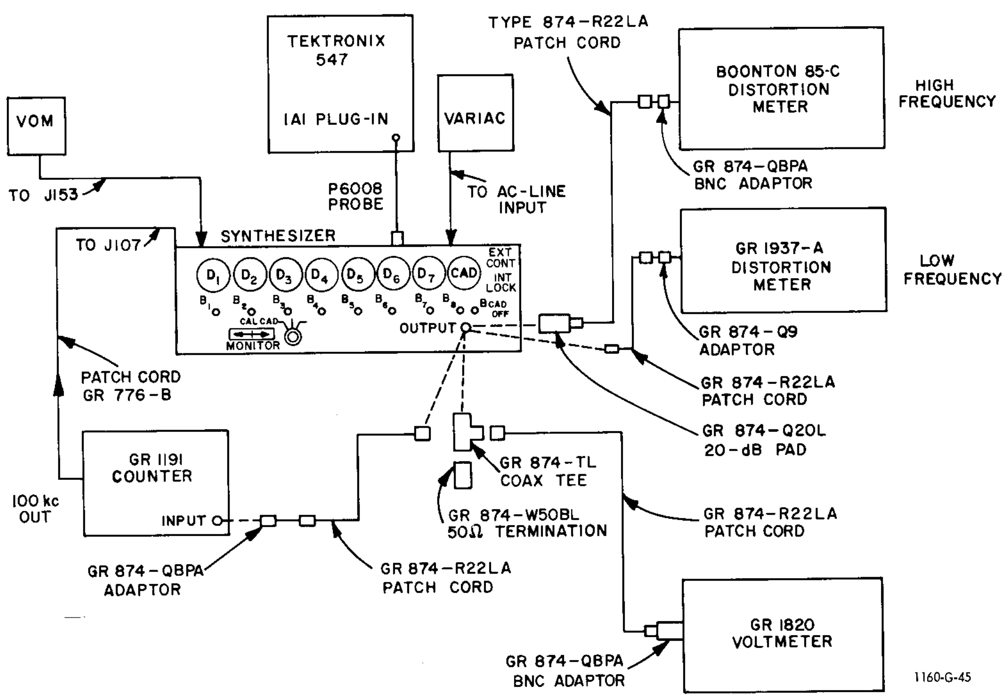


Figure 5-5. Test setup.

TABLE 5-4

CAD CHECK
(All DI dials set to "9")

Cad Position	*Cad Setting*	*Counting Time (Seconds)*	*Reading Digits*
1	5.0	.01	0.5000 MHz
2	5.0	.01	0.9500 MHz
3	5.0	.01	0.9950 MHz
4	5.0	.1	999.50 kHz
5	5.0	1	999.950 kHz
6	5.0	10	999995.0 Hz
7	5.0	10	999999.5 Hz
8	0.0	10	999999.9 Hz
8	10	10	1000000.0 Hz

GR874 patch cord to the counter. Connect the 100-kHz OUTPUT of the counter time base to the LOCK SIG IN (J107) of the AFS. (For counter-type frequency measurements, the time-base for counter and synthesizer must be locked together, if the results are to be meaningful at extreme resolution).

a. Set the meter function switch to LOCK TO EXT STD.

b. Adjust the synthesizer CRYSTAL FREQ control (front panel) for a locked condition (center reading on the MONITOR meter with deflection adjustable smoothly around center by means of the CRYSTAL FREQ control).

c. Set all the DI dials to "9".

d. Push in the CAD OFF button.

e. Set the counter to measure frequency with the appropriate counting times. The counter should indicate 999,999.5 kHz ±1 count. (A 10-second counting time will be required to display the X0.1-Hz digits; 0.01 second will be needed to see the X100 kHz digits.)

f. Repeat these observations at step digit settings for 500.0000-kHz and 50 Hz. At the 50-Hz setting, vary the position of the rightmost step digit and observe the variation in the counter indication to the same tolerance.

To check the CAD pushbutton switches (main signal path), reset the step-digit dials to all 9's. With the CAD mode switch set to INT LOCK, set the CAD dial to "5.00", push in the button under DI #7 (rightmost DI). Measure the frequency as above to be 999,999.5 Hz (10-second counting time). Repeat for remaining pushbuttons. For any or all of these settings ascertain that the digit supplied by the CAD ("5" in the examples) corresponds to the CAD dial setting, by changing the CAD tuning and verifying that the counter follows the variations. The counter digits "50" in Table 5-4 may read anywhere within the range from 49 to 51 (when the CAD is set exactly at 5.0), without exceeding CAD calibration tolerance. Variations of ±1 in the final digit may also be noted, caused by the ±1 count uncertainty characteristic of counters.

The above series of checks serve the primary function of assuring that the signal paths through the CAD pushbutton switches are functioning properly. To confirm that the "CAD CAL" frequency-reference circuits of these switches are also correct, use the procedures of paragraph 5.3.

5.8.4 OUTPUT AMPLITUDE.

a. Set the frequency of the synthesizer to 500.0000 kHz; CAD OFF, OUTPUT COUPLING at AC.

b. Connect the GR874-TL and GR874-W50BL to the OUTPUT connector of the synthesizer.

c. Connect the 1820 Voltmeter to the GR874-TL.

d. Adjust the synthesizer OUTPUT LEVEL control for an indication of 2.0 V on the 1820 Voltmeter.

e. Set the dials to 999,999.9, then set them to read 50 Hz.

The response variation as indicated by the 1820 Voltmeter, from the lowest indication to the highest, must be less than 2 dB.

f. Reset the frequency of the synthesizer to 500.0000 kHz.

g. Set the OUTPUT LEVEL control fully counterclockwise with the MONITOR-meter switch at OUTPUT VOLTS.

h. The panel meter must indicate zero (±1 linewidth on the meter scale).

i. Adjust the OUTPUT LEVEL control for an indication of 2.0 volts on the 1820 Voltmeter. The MONITOR meter should read 2.0 volts within the width of a scale marking.

5.8.5 SPURIOUS FREQUENCY OUTPUTS.

Harmonic Distortion.

a. Connect the Distortion Meter to the GR874-TL.

b. Set the frequency of the synthesizer to 15.0000 kHz.

c. Adjust the OUTPUT LEVEL control for a panel-meter indication of 2.0 volts.

d. Calibrate the Distortion Meter and measure the distortion.

e. The distortion must be at least 40 dB below signal. (30 dB for 1163)

f. Remove the Distortion Meter, Type 874-TL and Type 874-W50BL from the output connector.

g. Connect a Type 874-R22LA to the OUTPUT connector and connect the distortion meter to the Type 874-R22LA, via the Type 874-G20L Pad and the Type 874-QBPA Adaptor.

h. Set the frequency of the synthesizer to 999.9999 kHz.

i. Measure the distortion at 2.0 volts output to be down at least 40 dB below signal. (30 dB for 1163)

j. Remove the distortion meter and the Type 874-R22LA from the synthesizer.

Nonharmonic Distortion.

a. Connect the HP Model 310 Wave Analyzer to the OUTPUT connector of the synthesizer.

TABLE 5-5

TYPE 1162 SYNTHESIZER REPRESENTATIVE SPURIOUS OUTPUTS

Test	*Synthesizer Dial Freq (kHz)*	*Analyzer Tuning (kHz)*
1	8	5.6
2	60	6
3	60	40
4	60	160
5	260	160
6	260	226
7	460	352
8	460	446
9	660	654

b. Set the controls as follows:

ABSOLUTE-RELATIVE switch	- RELATIVE
MAX INPUT VOLTAGE switch	- 1
BANDWIDTH switch	- 200
RANGE (DB) switch	- 0
MODE switch	- NORMAL

TABLE 5-6

SPURIOUS ANALYSIS BY TEST NUMBER – TYPE 1162

Test	*Spurious* Class*	Signals (kHz) F_o	F_s	Δf_s	$(f_o)_1$	$(f_d)_1$	$(f_o)_2$	*Mechanism*
1	3/5	8	5.6	2.4	5000.8	3000	—	3 x 5000.8 = 15002.4 5 x 3000 = 15000.0 Δf_s = 2.4
2	F. T.	60	6	54	5006	—	5060	5060-5006 = 54
3	100 kHz	60	40	100	—	—	—	$F_s = \pm(F_o \pm \Delta f_s)$ = -(60 - 100) = 40
4	100 kHz	60	160	100	—	—	—	$F_s = \pm(F_o \pm \Delta f_s)$ = +(60 +100) = 160
5	100 kHz	260	160	100	—	—	—	F_s = +(260-100) = 160
6	F. T.	260	226	34	5026	—	5060	5060-5026 = 34
7	2/3	460	352	108	5046	3400	—	2 x 5046 = 10092 3 x 3400 = 10200 108
8	F. T.	460	446	14	5046	—	5060	5060-5046 = 14
9	F. T.	660	654	6	5066	—	5060	5066-5060 = 6

*See Table 5-7

c. Set the synthesizer dial to 008,000.0 kHz.

d. Push in the CAD OFF button.

e. Tune the FREQUENCY controls of the wave analyzer around 8 kHz for peak indication of the analyzer meter.

f. Adjust the OUTPUT LEVEL control of the synthesizer to make this peak indicate 0 dB on the analyzer meter.

g. Retune analyzer to 5.6 kHz and measure the spurious level at this frequency.

h. In similar fashion set the dials according to the Table 5-5 and measure spurious-frequency amplitudes at the indicated frequencies.

i. The spurious output levels as indicated by the analyzer meter must be at least -60 dB relative to signal.

5.8.6 MISCELLANEOUS MEASUREMENTS.

a. Connect the synthesizer to the Wattmeter-Variac, set to 117 V ac. Turn on all the dial lights by pushing in the pushbutton under the CAD. The input power as indicated by the wattmeter must not exceed 55 W.

b. Use the oscilloscope to check that there is an rf output of at least 0.1 V across 1kΩ at all appropriate jacks on the rear apron, at frequencies as specified at the jacks.

c. Observe +18 ±0.2 Vdc at J153 on the rear apron with the volt-ohmmeter.

5.8.7 PROGRAMMABLE OPERATION TEST.

Prepare the synthesizer for programmable operation as called for in the DI instructions and perform frequency checks at will.

TABLE 5-7

SPURIOUS FREQUENCY CLASSES

Class	Δf_s *(kHz)*	*Remarks*
100 kHz	$\pm(F_o \pm 100)$	"Picket-fence" spacing is 100 kHz
2/3	$\pm(2f_o - 3f_d)_1$	Internal in #1 DI
3/5	$\pm(3f_o - 5f_d)_1$	Internal in #1 DI
F. T.	$\pm (f_o)_1 - (F_o)_2$	Output-input frequencies of #1 DI

Δf_s = Spacing between desired signal and spurious sideband $= \pm(F_o \pm F_s)$

F_o = Synthesizer output signal frequency $= 10(f_o)_1 - 50$ MHz

F_s = Synthesizer output spurious frequency $= \pm(F_o \pm \Delta f_s)$

$(f_o)_1$ = Frequency of output oscillator of DI unit in first station

$(f_d)_1$ = Frequency of digit oscillator of DI unit in first station

$(f_o)_2$ = Frequency of output oscillator of DI unit in second station

F. T. = Feedthrough