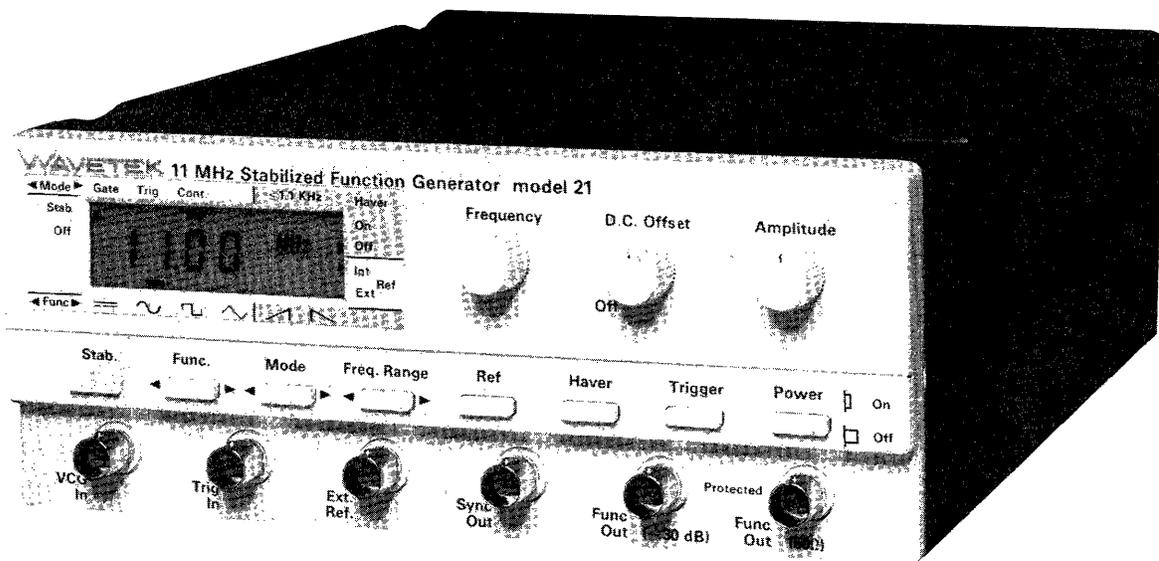


# WAVETEK

## Model 21

### 11 MHz Stabilized Function Generator



**Simplified Operator's Manual**

**SIMPLIFIED  
OPERATOR'S MANUAL  
MODEL 21  
11 MHz STABILIZED  
FUNCTION GENERATOR**

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## WARRANTY

Wavetek warrants that all products of its own manufacture conform to Wavetek specifications and are free from defects in material and workmanship when used under normal operating conditions and within the service conditions for which they were furnished.

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## SAFETY

This instrument is wired for earth grounding via the facility power wiring. Do not bypass earth grounding with two wire extension cords, plug adapters, etc.

BEFORE PLUGGING IN the instrument, comply with installation instructions.

MAINTENANCE may require power on with the instrument covers removed. This should be done only by qualified personnel aware of the electrical hazards.

The instrument power receptacle is connected to the instrument safety earth terminal with a green/yellow wire. Do not alter this connection. (Reference:  or  stamped inside the rear panel near the safety earth terminal.)

WARNING notes call attention to possible injury or death hazards in subsequent operations.

CAUTION notes call attention to possible equipment damage in subsequent operations.

SECTION  
GENERAL DESCRIPTION**1.1 MODEL 21**

Model 21 is a closed loop frequency stabilized function generator. Both short term and long term frequency accuracies are 0.09% over Model 21's 100 $\mu$  Hz to 11 MHz frequency range.

Modes are continuous, triggered and gated and output levels are to 20V peak-to-peak (10 Vp-p into 50 $\Omega$ ).

Waveforms are sine, triangle and square, ramp up, ramp down, haversine, havertriangle and dc. Above 1.1 kHz waveforms are analog generated, below, waveforms are digitally synthesized. Synthesized waveforms can be held at any point and continued from that point.

Synthesized output signal frequency is 1/1000 a reference clock frequency, which can be internal or external. By use of an external reference clock, the output range can be extended to ultra-low frequencies.

An LCD display shows frequency (3½ digits plus unit of measure) and annunciators that point to selected operating modes, etc. Output is reverse power protected.

**1.2 SPECIFICATIONS****1.2.1 Versatility****Waveforms**

Bidirectional switch selects sine  $\sim$ , triangle  $\nabla$ , square  $\square$  and dc. For frequencies below 1100Hz ramp up  $\nearrow$  and ramp down  $\searrow$  and, on Model 21, haverwaves  $\wedge$   $\wedge$  are also available.

**Operational Modes**

**Continuous:** Generator runs continuously at selected frequency.

**Triggered:** Generator is quiescent until triggered by external signal or manual trigger, then generates one complete waveform cycle at selected frequency.

**Gated:** As triggered mode, except output continues for duration of gate signal. Last waveform started is completed.

**Frequency Range**

100 $\mu$  Hz to 11 MHz in 9 overlapping decade ranges. Range switching with bidirectional switch with frequency digits; decimal and units displayed on LCD display. Each decade range capable of 1100:1 frequency change. Ranges are as follows:

Specified *Range	Lowest Obtainable Frequency
11.00 MHz to 1.00 MHz	10 kHz
1100 kHz to 100 kHz	1 kHz
110.0 kHz to 10.0 kHz	100 Hz
11.00 kHz to 1.00 kHz	10 Hz
1100 Hz to 100 Hz	1 Hz
110.0 Hz to 10.0 Hz	100 mHz
11.00 Hz to 1.00 Hz	10 mHz
1100 mHz to 100 mHz	1 mHz
110.0 mHz to 10.0 mHz	100 $\mu$ Hz

\*Waveform specifications are applicable.

**Function Output**

Waveform amplitude variable over a 20 dB range up to 20 Vp-p (10 Vp-p into 50 $\Omega$ ) at Function Out. Waveform also present at Function Out (-20 dB) with a fixed 20 dB attenuation relative to the Function Out for a full 40 dB of amplitude range. Peak output current is 100 mA maximum at Function Out. Source impedance of both outputs is 50 $\Omega$ .

**DC Offset and DC Output**

Waveform offset and dc output variable with DC Offset control with off position for calibrated zero offset. Function Out is  $\pm 10V$  maximum ( $\pm 5V$  into 50 $\Omega$ ) as offset or Vdc output. Signal peak plus offset limited to  $\pm 10V$  ( $\pm 5V$  into 50 $\Omega$ ). DC offset plus waveform attenuated proportionately at Function Out (-20 dB).

**Sync Output**

TTL pulse (50% duty cycle) at generator frequency. Will drive 10 LS TTL loads.

## VCG — Voltage Controlled Generator

Up to 1100:1 frequency change with external 0 to  $\pm 5V$  signal applied to VCG In connector. Upper and lower frequencies limited to maximum and minimum of selected range. Input impedance is  $5k\Omega$  and maximum slew rate is  $0.1V/1\mu s$ . VCG In is disconnected when the Stabilizer is engaged.

## Trigger and Gate

External TTL compatible signal at Trig In BNC triggers or gates generator output when generator is in trigger or gate mode. Generator triggers on positive edge of input or gates on for duration of high level input. External signal pulse width is 50 ns minimum with a maximum repetition rate of 5 MHz.

## Stabilizer

When selected, the generator frequency is stabilized at the displayed frequency to a crystal-controlled reference. The Stabilizer improves long term frequency stability for all durations to be equal to the 10 min. short term value.

When the stabilizer is on, the generator frequency is corrected to the displayed frequency  $\pm 0.09\%$  of range over the entire operating temperature range of 0 to  $+50^\circ C$ . The stabilizer is automatically turned off when the mode is taken out of continuous or Ext Ref. is enabled.

## Display

1100 count LCD frequency display with frequency ranging units (mHz, Hz, kHz, and MHz) and decimal point. Annunciators indicate selection of waveform, stabilizer and external reference status, haverwave selection and generator mode.

## External Reference

External Reference switch provides selection of internal or external control of waveform output frequency and also provides a means of holding or releasing the waveform manually, electrically or through external contact closure. External Reference connector accepts either a TTL compatible signal (1.1 MHz maximum repetition rate, 200 ns minimum pulse width) or contact closure. External reference provides four modes of operation as follows:

1. **Int Ref** Normal waveform function generator operation when in internal reference and the Ext Ref BNC is either left unconnected or connected to  $+5 Vdc$  or a TTL high.

2. **Ext Ref** External Reference operation by applying frequency to the Ref In BNC with external reference selected. Frequency input controls frequency of the selected waveform at the output. The output frequency will be 1/1000 the reference frequency. Maximum output frequency is 1100 Hz. When external reference is selected, the display is disabled and blanked.
3. **Manual Hold** at any point on the output waveform by use of the Ref button. Reference mode must be "Int Ref" as above. When Ref button is pressed, the output is stopped. When pressed again, the waveform will start again exactly where it stopped.
4. **Electrical Hold** at any point on the output waveform:
  - a. When in "Int Ref" operation and 1.1 kHz or below, hold the waveform by applying 0 Vdc or a TTL low to the Ext Ref BNC or through remote contact closure shorting out the BNC.
  - b. When in "Ext Ref" operation, hold the waveform by removing the external signals at Ext Ref BNC or bringing it to 0 Vdc.

## 1.2.2 Frequency Precision

### Frequency Display Accuracy

$\pm 1$  count of 1100 counts, which is 0.09% of range. Stabilizer maintains same reading indefinitely.

### Time Symmetry

Square waveform variation from 1100 to 100 counts on display less than:

- $\pm 0.1\%$  to 1100.00 Hz (across bottom five specified ranges),
- $\pm 1\%$  to 110.00 kHz,
- $\pm 5\%$  to 11.00 MHz.

## 1.2.3 Amplitude Precision

### Sine Variation with Frequency

Less than:

- $\pm 0.2$  dB on all ranges up through the 10.0 to 110.0 kHz range,
- $\pm 1.5$  dB to 11.00 MHz.

Referenced to 1 kHz.

## 1.2.4 Waveform Characteristics

### Sine Distortion

Less than 0.5% THD up through the 1.00 kHz to 11.00 kHz range and less than 1% THD up through the 10.0 kHz to 110.0 kHz range. All harmonics at least 40 dB

down from the fundamental across the 100 kHz to 1100 kHz range and 28 dB across the 1.00 MHz to 11.00 MHz range.

#### **Triangle Linearity**

Greater than 99% to 110 kHz.

#### **Square Wave Rise and Fall Times**

Less than 22 ns at Function Out with 10 V<sub>p-p</sub> output into 50Ω.

#### **Square Wave Total Aberrations**

Each peak less than 5% of p-p amplitude.

### **1.2.5 General**

#### **Output Protection**

Function outputs are protected against a short circuit to any voltage between  $\pm 10\text{V}$  dc and also have internal fused protection (both output and common conductors) against accidental application of up to 250 Vac or 350V dc.

#### **Stability**

**Amplitude, Frequency (Non-Stabilized) and DC Offset:**

After 30 minute warm-up:

$\pm 0.10\%$  of range for 10 minutes,

$\pm 0.50\%$  of range for 24 hours.

#### **Frequency (Stabilized):**

$\pm 0.10\%$  of range for  $\geq 10$  minutes, 0 to 50°C.

#### **Environmental**

**Temperature Range:** 25°C  $\pm$  10°C for spec operation, operates 0°C to 50°C, -20°C to +75°C for storage.

**Warm-up Time:** 20 minutes for specified operation.

**Altitude:** Sea level to 10,000 ft for operation. Sea level to 40,000 ft for storage.

**Relative Humidity:** 95% at 25°C and at sea level (non-condensing).

**Dimensions** — 211 mm (8.3 in.) wide, 86 mm (3.4 in.) high, 305 mm (12 in.) deep.

**Weight** — 3.4 kg (7 1/2 lb) net, 4.5 kg (10 lb) shipping.

**Power** — 90 to 128, 180 to 256V, 48 to 66 Hz, less than 35 VA.

#### *NOTE*

*All specifications apply for display between 1100 and 100 frequency counts; amplitude at 10 V<sub>p-p</sub> into 50Ω.*

# SECTION 2

## INITIAL PREPARATION

### 2.1 UNPACKING INSPECTION

After carefully unpacking the instrument, visually inspect all external parts for possible damage to knobs, switches, dials, indicator, connectors, surface area, etc. If damage is discovered, file a claim with the carrier who transported the instrument. The shipping container and packing material should be saved in case reshipment is required.

### 2.2 ELECTRICAL INSTALLATION

#### 2.2.1 Power Connection

##### NOTE

*Unless otherwise specified at the time of purchase, this instrument was shipped from the factory with the power transformer connected for operation on a 115 Vac line supply and with a 3/8 amp fuse.*

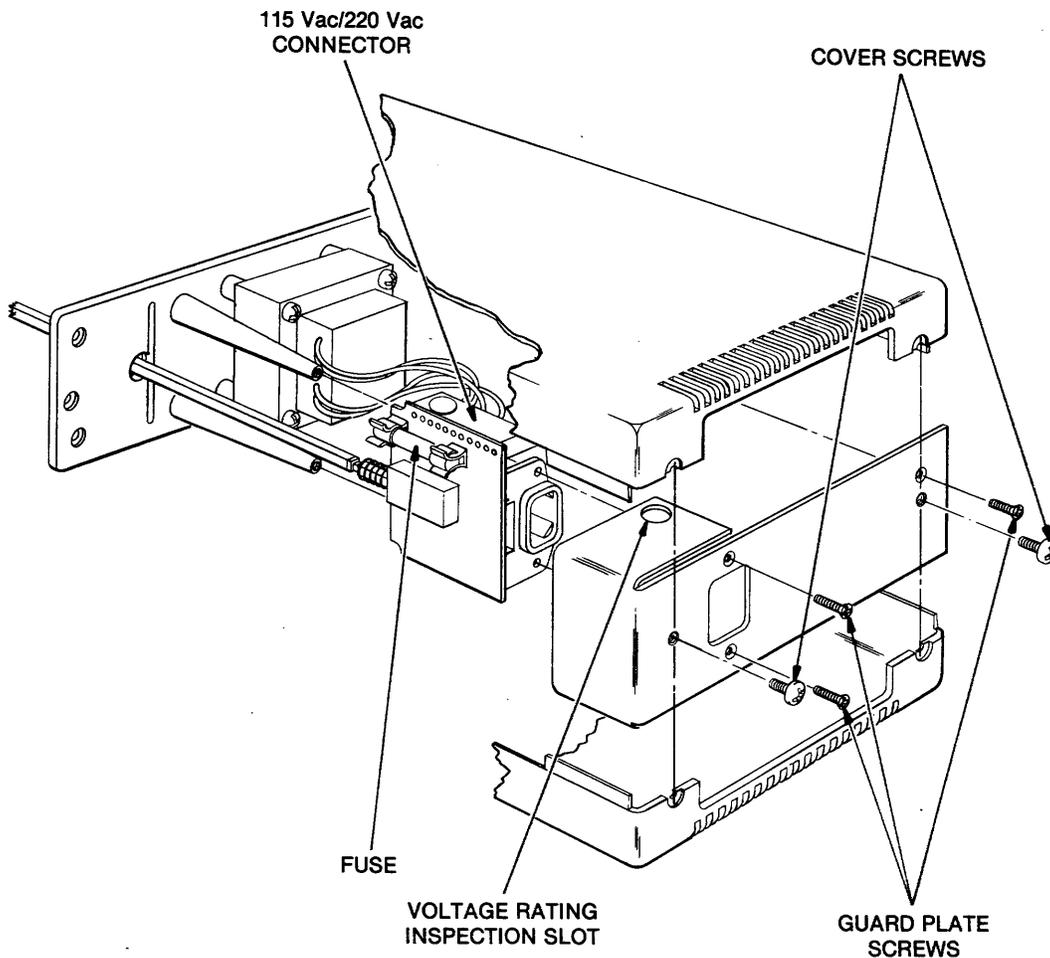


Figure 2-1. Fuse and Connector Access

An inspection slot is provided on the top of the guard plate located under the top cover. Remove the top cover by removing the two screws (figure 2-1) securing the wrap-around cover to the guard plate. Look through the inspection slot and check the voltage stamped on the connector. If 115V is visible, the power transformer is connected for operation on a 90 to 128 Vac line supply. If 220V is visible, the power transformer is connected for operation on a 180 to 265 Vac line supply. Make certain the voltage stamped on the connector matches the voltage line supply that is to be used.

If the voltage stamped on the connector does not match the input voltage to be used it will require the rotation of the connector and changing of the fuse according to the following procedure:

1. Remove the three screws attaching the guard plate.
2. Remove the guard plate.
3. Remove the connector from the circuit board, turn it over and reconnect it to the circuit board.

#### NOTE

*The connector is stamped with 115V on one side and 220V on the other side. If operating on 90 to 128 Vac line supply the 115V stamped on the connector must be visible. If operating on 180 to 265 Vac line supply the 220V stamped on the connector must be visible.*

4. Remove the fuse and replace with proper fuse.

#### NOTE

*When operating on 90 to 128 Vac line supply a 3/8 amp fuse is required. When operating on 180 to 265 Vac line supply a 3/16 amp fuse is required.*

5. Replace all items using the reverse procedure of removal.

Connect the ac line cord to the mating connector at the rear of the unit and the power source.

### 2.2.2 Signal Connections

#### NOTE

*Use RG58U 50Ω or equivalent 50Ω coaxial cables equipped with BNC connectors to distribute signals.*

Instrument BNC connectors are:

VCG IN — 0 to  $\pm 5V$ ; 5kΩ impedance; 0.1V/μs maximum slew rate.

TRIG IN — External TTL compatible signal; 50 ns minimum signal pulse width with a maximum repetition rate of 5 MHz.

EXT REF — External TTL compatible signal; 1.1 MHz maximum repetition rate, 200 ns minimum pulse width. Will also accept contact closure.

SYNC OUT — TTL compatible symmetrical square wave at generator frequency.

FUNC OUT (-20 dB) — Up to 1.00Vp-p into 50Ω impedance; up to 2.00Vp-p into an open circuit.

FUNC OUT (50Ω) — Up to 10 Vp-p into 50Ω impedance; up to 20 Vp-p into an open circuit.

#### NOTE

*Signal ground may be floated up to  $\pm 42V$  with respect to chassis ground. Be aware that all signal grounds are common and must all be floated together.*

### 2.2.3 Initial Checkout

The initial checkout procedure in table 2-2 can be used as a receiving inspection and as a post-repair checkout. This procedure verifies that the instrument is functionally operating correctly (but does not verify correct instrument calibration).

Required tools and test equipment are given in table 2-1.

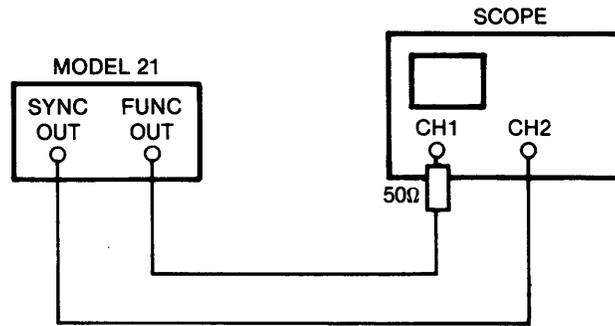
**Table 2-1. Tools and Test Equipment**

Oscilloscope, dual channel, 100 MHz bandwidth
BNC coax cable, RG58U, 3 ft length (3 each)
Voltage source, 5 Vdc
TTL generator, 200 Hz to 1.1 MHz, 5 ms pulses
50Ω feedthrough, $\pm 0.1\%$ accuracy, 2W
BNC tee, 1 male, 2 female connectors

Preset the generator front panel controls as follows:

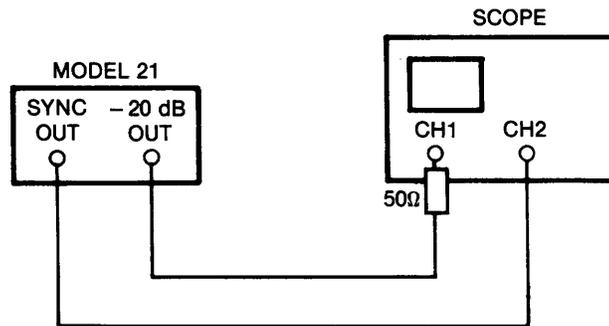
Control	Position
Frequency knob	cw
D.C. Offset knob	Off
Amplitude knob	cw

Connect as in figure 2-2.



TIMEBASE — .2ms/DIV  
 CH1 VERT — 2V/DIV  
 CH2 VERT — 2V/DIV  
 TRIGGER — CH2  
 DISPLAY — CH1

**Figure 2-2.**



TIMEBASE — .2ms/DIV  
 CH1 VERT — 50mV/DIV  
 CH2 VERT — 2V/DIV  
 TRIGGER — CH2  
 DISPLAY — CH1

**Figure 2-3.**

Table 2-2. Initial Checkout

Step	Control	Operation	Observation
1	Power button	On	CH1: 10 Vp-p sine CH2: TTL square Display: Approximately 1.1 kHz, Sine, Cont, Int. Ref., Haver Off, Stab Off.
2	Func button	Step to right	CH1: Functions match display.
3	Func button	Select DC	CH1: 0 Vdc Display: 0 kHz
4	D.C. Offset knob	cw	CH1: $\leq -5$ Vdc
5	D.C. Offset knob	ccw (not in detent); return to detent	CH1: $\geq +5$ Vdc CH1: 0 Vdc
6	Function button	Select sine	CH1: 10 Vp-p sine
7	Frequency knob	ccw; return cw	Display: 1100:1 frequency change
8	Frequency range	Step right	Display: Frequency increments by decades to 11 MHz
9	Frequency range	Step left; return to 1.1 kHz range	Display: Frequency decrements by decades to 110 mHz
10	Amplitude knob	ccw; return cw	CH1: Approximately 1.00 Vp-p sine
11		Connect scope as in figure 2-3.	CH1: Approximately 1.00 Vp-p sine
12		Connect scope as in figure 2-2.	
13	Func button	Select triangle	CH1: 10 Vp-p triangle
14	Mode button	Select Trig	CH1: 0 Vdc
15		Connect scope in figure 2-4.	CH1: Triggered triangle CH2: Trigger input Display: Trig selected, numbers blanked
16	Mode button	Select Gate	CH1: Gated triangle CH2: Trigger input Display: Gate
17	Haver button	On; reset Haver to Off	CH1: Gated Haver triangle CH2: Trigger input Display: Hav selected

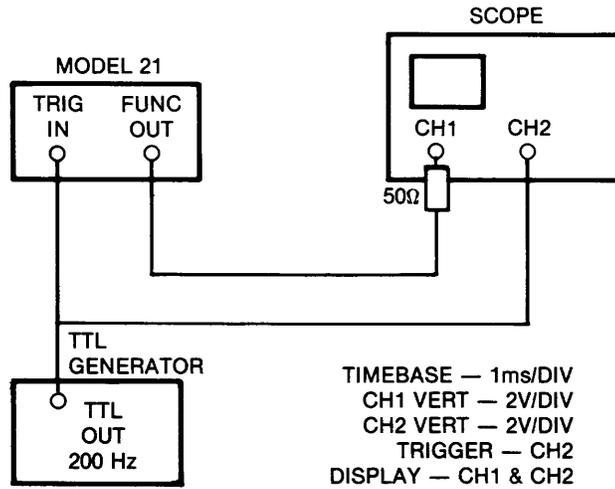


Figure 2-4.

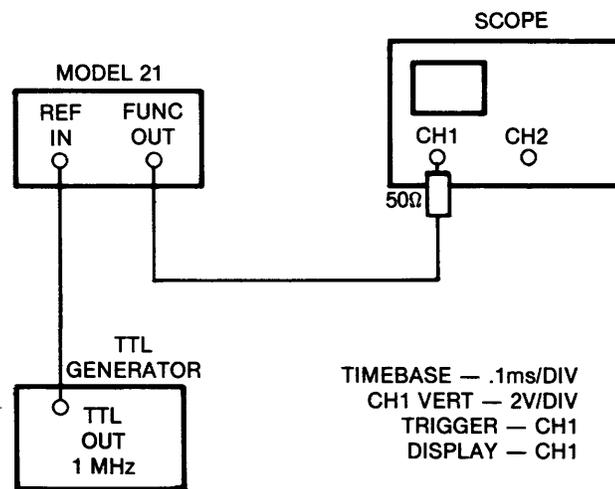


Figure 2-5.

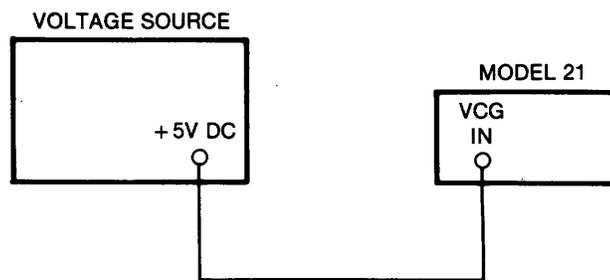


Figure 2-6.

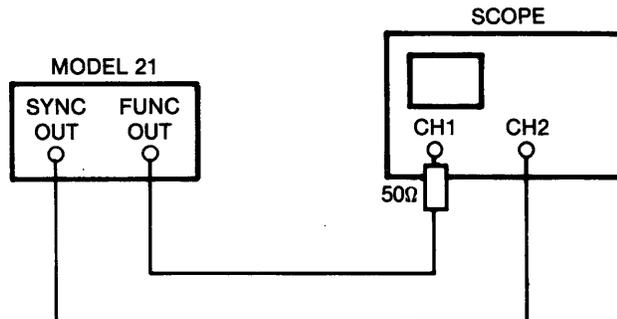
Table 2-2. Initial Checkout (Continued)

Step	Control	Operation	Observation
18		Disconnect trigger input (trigger on and display CH1 of scope)	CH1: 0 Vdc
19	Trigger button	Push	CH1: Continuous triangle as button is pushed
20	Mode button	Select continuous	—
21	Func button	Select square	—
22	Ref button	Select external	Display: Ext Ref, numbers blanked
23		Connect scope as in figure 2-5	CH1: 1 kHz square (1 cycle)
24	Ref button	Select internal	CH1: 10 Vp-p square
25		Connect scope as in figure 2-2	—
26	Frequency knob	Select 500 Hz	CH1: 500 Hz square (1 cycle)
27	Scope	X10 magnification.- Adjust position for edge of square wave at center of graticule	CH1: One edge of square
28	Stab button	Select Stab On	Display: Stab On
29	Frequency knob	Quickly turn cw until edge moves 2 divisions on scope	CH1: Edge slowly moves back to center of graticule
30	Frequency knob	Quickly turn cw until edge moves 2 divisions on scope	CH1: Edge begins to move toward center then jumps to left side of graticule. Display: Stab Off
31	Frequency knob	ccw	Display: Approximately 0.001 kHz
32		Connect scope as in figure 2-6.	Display: Approximately 1.1 kHz

### 3.1 OPERATION DEMONSTRATION

These steps display the flexibility and versatility of the Model 21 by demonstrating each front panel control. An external generator and an oscilloscope are needed to verify operation as the Model 21 capabilities are demonstrated.

#### 1. POWER-UP



TIMEBASE — .2ms/DIV  
 CH1 VERT — 2V/DIV  
 CH2 VERT — 2V/DIV  
 TRIGGER — CH2  
 DISPLAY — CH1

Setup	Observation
1. Frequency knob: cw D.C. Offset knob: Off Amplitude knob: cw Power button: On	1. CH1: 10 Vp-p sine CH2: TTL square Display: Approximately 1.1 kHz, Sine, Cont, Int Ref, Hav Off, Stab Off Cont, Int Ref, Hav Off, Stab Off

#### Comments

The Model 21 powers up in a specific mode. When ac power is applied to the instrument a sine wave will be output. The power-up frequency range is the 1100 Hz maximum.

The three front panel knobs are control potentiometers. They control frequency setting within a range, amplitude of output waveform and dc offset. There is no power-up setting of these three controls, however, all other power-up states are fixed.

Sync Out is a TTL level square wave, TTL compatible signal driven from a TTL gate. It is capable of driving 10 standard LS TTL loads, and is used for synchronizing a scope or driving TTL or CMOS logic directly. Therefore, it can be either a synchronization output or an auxiliary output.

#### 2. FUNCTIONS

##### Setup

1. Func button: Press on right then left

##### Observation

1. CH1: Functions match display annunciator positions.

#### Comments

Look at the bottom edge of the LCD display and check the functions. The Func button selects sine, square, triangle, ramp up, ramp down or dc by pressing either on the left or right side of the switch. The function annunciator on the display shows your selection.

The power-up frequency range is the highest frequency range that has all functions and all waveforms available. There are four higher ranges and four lower ranges (see paragraph 1.2). In the top four ranges, the Model 21 is a basic analog sine/triangle/square function generator. The ramps and haver functions are not available.

In the lower five ranges, the waveforms are no longer produced by the function generator directly. The function generator runs 1000 times the output frequency. It is a clock source to clock a digital waveform synthesizer. The waveforms are then synthesized so that instead of smooth analog waveforms, each waveform is made up of 1000 steps derived from a counter and digital to analog converter. All functions on the front panel are then available: dc, sine, triangle, square, and the two ramps. In addition, the sine and triangle may be output as haversine and havertriangle.

### 3. DC

Setup	Observation
1. Func button: DC	1. CH1: 0 Vdc Display: 0 kHz
2. D.C. Offset knob: cw	2. CH1: $\leq -5$ Vdc
3. D.C. Offset knob: ccw but not Off	3. CH1: $\geq +5$ Vdc
4. D.C. Offset knob: Off	4. CH1: 0 Vdc

#### Comments

DC voltage and dc offset of waveforms may be as great as  $\pm 5V$  maximum (into  $50\Omega$  load). The Off position ensures no offset.

### 4. FREQUENCY

Setup	Observation
1. Func button: Select sine	1. CH1: 10 Vp-p sine
2. Frequency knob: ccw	2. Display: 1 Hz
3. Frequency knob: cw	3. Display: 1100:1 frequency change, approximately 1100 Hz

#### Comments

The breadth of each individual range is 1100:1; therefore, frequency will go from 1 on the display to 1100 as the frequency knob is turned.

Setup	Observation
1. Freq Range button: Step right	1. Frequency increments by decades to 11 MHz
2. Freq Range button: Step left	2. Display: Frequency decrements by decades to 110 mHz
3. Freq Range button: Return to 1.1 kHz range	3. Display: 1100 Hz

#### Comments

This generator is capable of going up to 11 MHz, and it downranges in decades so that the top of each range is 11 MHz, then 1.1 MHz, 110 kHz, 10 kHz, 1.1 kHz, 110 Hz, 11 Hz, 1.1 Hz and 110 mHz, the latter is the top of the bottom range. Each one of these ranges has

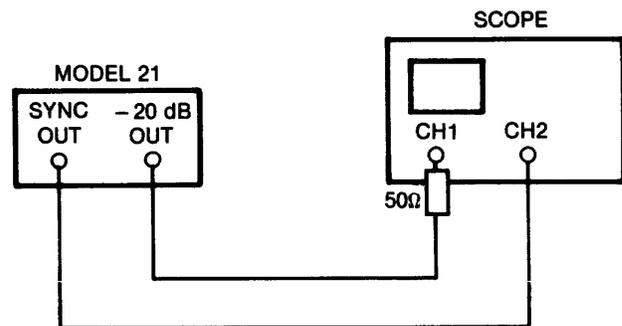
a 1100:1 span. The "in spec" portion of each range extends from 100 to 1100 counts on the display, overlapping and providing continuous "in spec" frequency from 10 mHz all the way up to 11 MHz.

### 5. AMPLITUDE

Setup	Observation
1. Amplitude knob: ccw	1. CH1: Approximately 1.00 Vp-p sine
2. Amplitude knob: Return to cw	2. CH1: Approximately 10 Vp-p sine

#### Comments

At Func Out ( $50\Omega$ ) a maximum of 10V peak-to-peak amplitude into a  $50\Omega$  load (or 20 Vp-p into open circuit) will be present.



TIMEBASE — .2ms/DIV  
 CH1 VERT — 50mV/DIV  
 CH2 VERT — 2V/DIV  
 TRIGGER — CH2  
 DISPLAY — CH1

Setup	Observation
1. Func Out (-20 dB): As in figure above	1. CH1: Approximately 1.00 Vp-p sine

#### Comments

Function out, marked Func Out ( $-20$  dB), is an attenuated version of the main output. Both of these functions have a  $50\Omega$  source impedance and their amplitudes are controlled by the Amplitude knob.

### 6. TRIGGER AND GATE

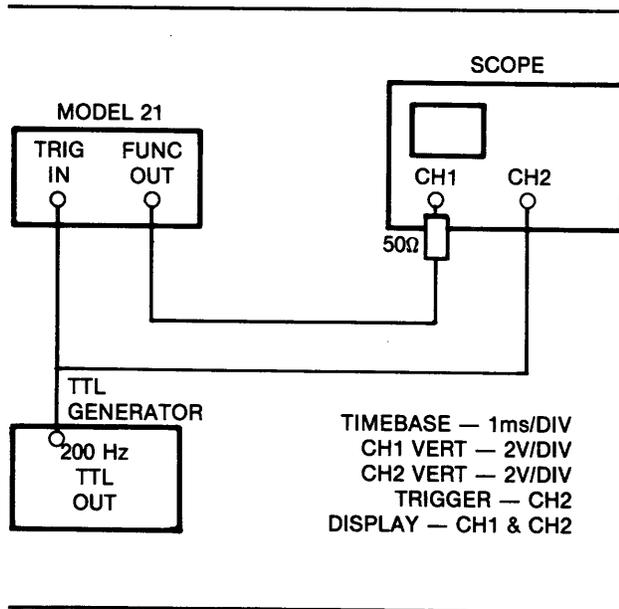
Setup	Observation
1. Func button: Select Triangle	1. CH1: 10 Vp-p triangle
2. Mode button: Select Trig	2. CH1: 0 Vdc

**Comments**

The output is in continuous mode at power-up. The modes gated, continuous, and triggered, can be selected by pressing either on the left or right side of the Mode button. In a mode other than continuous, waveforms will not be output until triggered.

The trigger baseline (Trigger or Gate mode) is at some dc level. If dc offset is zero, baseline is 0 Vdc for the sine or the triangle. For the square wave the trigger baseline is at the lower level of the square wave. For ramp up, the baseline is at the lower level of the ramp. For ramp down, the baseline is at the upper level of the ramp.

Notice the LCD frequency display is blanked when not in continuous mode.



**Setup**

1. Connect scope and TTL generator as shown above

**Observations**

1. CH1: Triggered triangle  
CH2: Triggered input  
Notice CH1/2 phase relationship  
Display: Trig selected, numbers blanked

**Comments**

The external TTL Signal is applied to the Trig In connector for external triggering and gating. Triggering occurs on a low to high transition or a rising edge.

**Setup**

1. Mode button: Select Gate

**Observation**

1. Gated triangle  
CH2: Trigger input  
Notice CH1/2 phase relationship  
Display: Gate selected, numbers blanked

**Comments**

Gating occurs starting with the rising edge of the trigger signal and has a duration the same as the width of the positive portion of that trigger waveform. Therefore, it is gated on during the time the waveform is high plus the time required to complete the final cycle.

**Setup**

1. Disconnect trigger at Trig In
2. Trigger button: Push

**Observation**

1. CH1: 0 Vdc
2. CH1: Continuous triangle as long as button is pushed

**Comments**

The manual Trigger button produces one complete waveform cycle each time it is pressed when in trigger mode. In gate mode the waveforms are generated continuously as long as the Trigger button is held in.

**7. HAVERWAVES**

**Setup**

1. Haver button: Select On

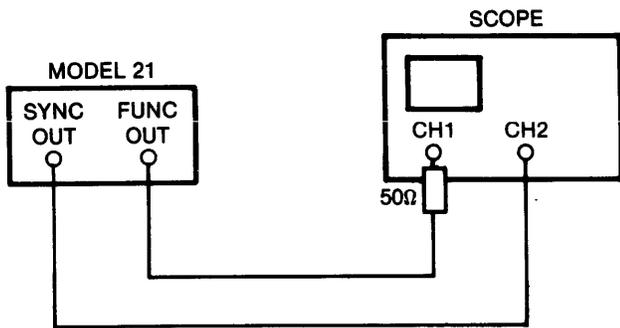
**Observation**

1. CH1: Gated havertriangle  
CH2: Trigger input  
Notice CH1/2 phase relationship  
Display: Haver selected, numbers blanked

**Comments**

Haver button operates in trigger or gated modes when the generator is in the 1100 Hz range or lower. The haver function can be a triangle or a sine with the trigger baseline down at the bottom of the waveform, - 90° phase instead of 0° phase at the center of the waveform. Ramps cannot be selected for haver operation.

8. INTERNAL/EXTERNAL REFERENCE MODES



TIMEBASE — .2ms/DIV  
 CH1 VERT — 2V/DIV  
 CH2 VERT — 2V/DIV  
 TRIGGER — CH2  
 DISPLAY — CH1

**Setup**

1. Connect scope as shown above.  
 Mode: Cont  
 Func: Sine  
 Haver: Select Off  
 Ref button: Int

**Observation**

1. 10 Vp-p sine

**Comments**

With the Ref button selected to Int and the Ext Ref connector left open or connected to +5 Vdc or a TTL high the generator is in the normal waveform generation mode with frequency determined by the frequency control and displayed on the LCD display.

**Setup**

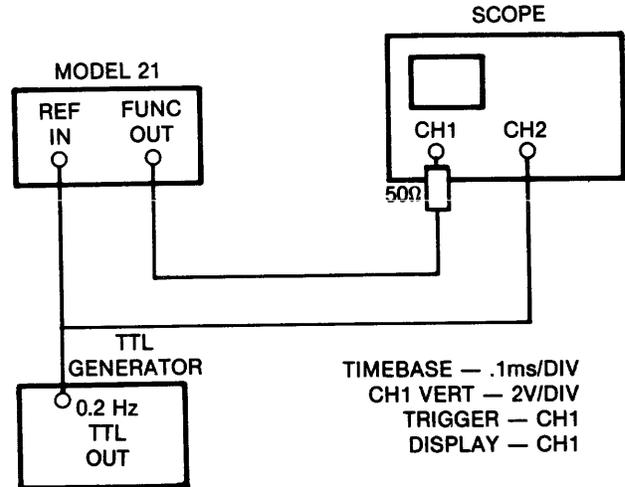
1. Ref button: Ext

**Observation**

1. Some DC level

**Comments**

With Ext Ref selected and the Ext Ref connector left open, or brought to dc, waveform generation will hold at an instantaneous point until the external frequency is reactivated. Since there is no reference signal, there is no function output. Change the Ref to Int and the output will start. Change back to Ext Ref and the output will stop. The Ref button is the manual hold switch.



TIMEBASE — .1ms/DIV  
 CH1 VERT — 2V/DIV  
 TRIGGER — CH1  
 DISPLAY — CH1

**Setup**

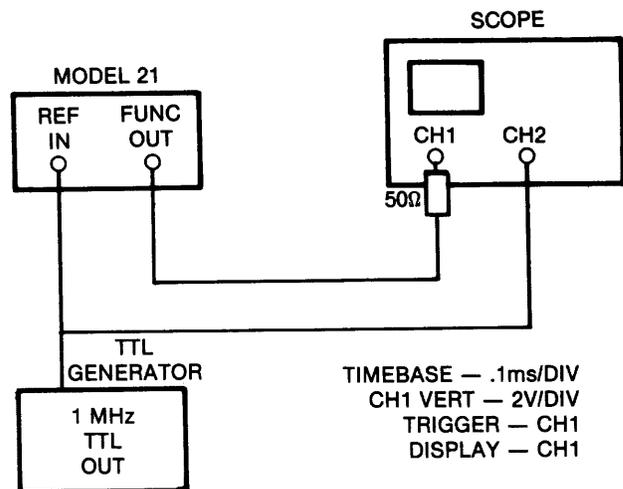
1. Connect scope and TTL generator as shown above  
 Ref button: Int

**Observation**

1. CH1: 1.1 kHz sine when TTL input is high, waveform hold when TTL input is low

**Comments**

The function generator of Model 21 is clocking the digital waveform synthesizer and the synthesized waveforms can be held at an instantaneous point by introducing a TTL low to the Ext Ref connector or through remote contact closure shorting out the BNC. When the TTL signal at the Ext Ref connector is high the generator will run, when it is low the generator will stop. When the waveform is let go it starts off from the point it stopped.



TIMEBASE — .1ms/DIV  
 CH1 VERT — 2V/DIV  
 TRIGGER — CH1  
 DISPLAY — CH1

**Setup**

1. Ref button: Ext  
Function: Square  
TTL Generator:  
1 MHz

**Observation**

1. CH1: 1 kHz square (1 cycle)

**Comments**

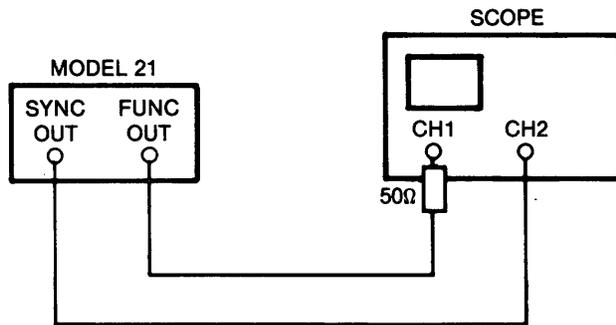
With an external frequency applied to the Ext Ref connector and with Ext Ref selected the external frequency will control the frequency of the selected waveform at the output. The external frequency at Ref In will be divided by 1000 to produce the output frequency, for a maximum output frequency of 1100 Hz. When Ext Ref is selected, the frequency display is disabled and blanked.

4. Frequency knob: Quickly turn frequency knob cw until edge moves 2 div.
4. Edge slowly moves back to center of graticule

**Comments**

When the stabilizer is turned on, the frequency locks at the display frequency reading. Stabilizer circuits maintain generator frequency at this setting over a range of several percent. Thus, both long and short term frequency stability are improved from their open-loop values to  $\pm 1$  count ( $\pm 0.09\%$ ) and over the full 0°C to +50°C operating range of the instrument.

**9. STABILIZER**



TIMEBASE — .2ms/DIV  
CH1 VERT — 2V/DIV  
CH2 VERT — 2V/DIV  
TRIGGER — CH2  
DISPLAY — CH1

**Setup**

1. Frequency knob: Quickly turn cw until edge moves two divisions on scope

**Observation**

1. CH1: Edge begins to move toward center than jumps to left side of graticule  
Display: Stab Off

**Comments**

If the stabilizer lock-in range is exceeded by moving the frequency control or by subjecting the instrument to excessive environmental conditions or if generator mode is taken out of continuous or placed in external reference, the generator will automatically deselect stability. While stability is selected the VCG In connector is internally disconnected and cannot modify generator frequency.

**Setup**

1. Connect scope as above  
Mode button: Select Cont  
Frequency knob: Select 500 Hz  
Function: Square

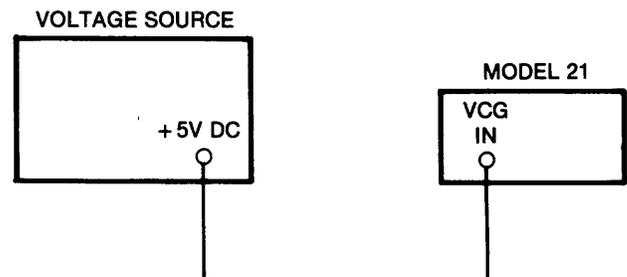
**Observation**

1. CH1: 500 Hz square (1 cycle)

2. Scope: X10 magnification. Adjust position for edge of square wave at center of graticule
3. Stab button: Select Stab

2. CH1: One edge of square
3. Display: Stab selected

**10. VCG**



**Setup**

1. Freq knob: ccw
2. Connect voltage source as shown above

**Observation**

1. Display: Approximately 0.001 kHz
2. Display: Approximately 1.1 kHz

**Comments**

The VCG (Voltage Control of Generator) is an electronic means of controlling frequency. Zero to  $\pm 5$  Vdc at VCG In (5k $\Omega$  input impedance) controls the frequency across one full range. Therefore, with the frequency control turned fully ccw for 1/1100 of full range frequency, and +5V applied to VCG In, the frequency is driven to the top of the range.

**3.2 CONTROLS AND CONNECTORS**

For quick reference, individual control and connector explanations are keyed to figure 3-1.

**1 Display**

A four digit (1100 count) LCD frequency display. Incorporates annunciators that indicate waveform selection, stabilizer on/off, haverwave on/off, mode, and internal/external reference.

**2 Frequency Control**

Frequency knob sets the frequency within one of nine ranges set by Freq. Range button. Frequency output is monitored and shown on the LCD display. Control ratio is 1100:1 in each range.

**3 D.C. Offset Control**

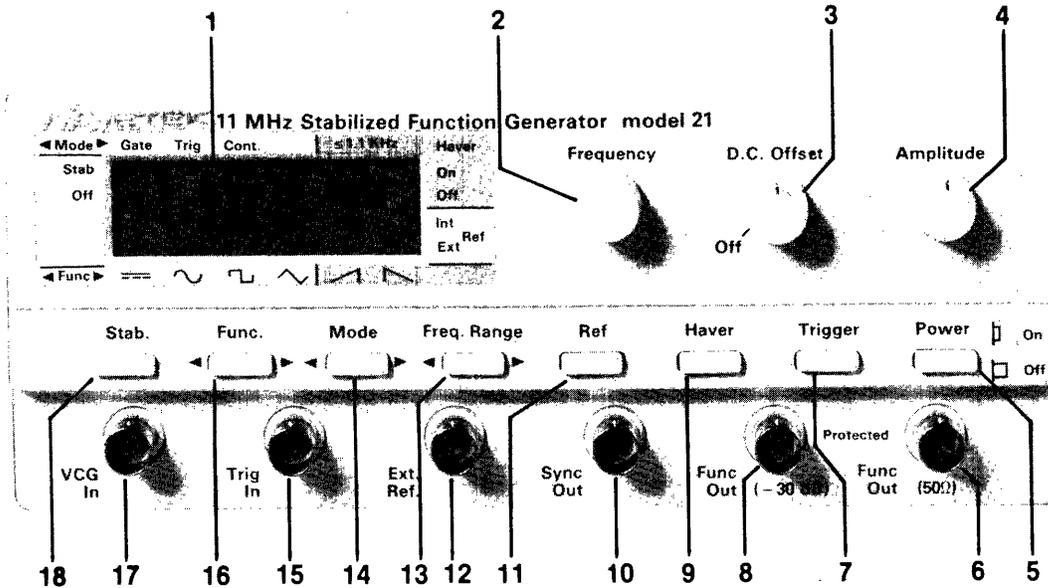
DC voltage and offset of waveforms are controlled by the D.C. Offset knob. Center of the waveform reference (figure 3-2) is skewed positive (up) with clockwise rotation, negative (down) with counterclockwise rotation. Offset and dc voltage maximums are  $\pm 5$ V (50 $\Omega$  terminated). A full counterclockwise detent position ensures zero offset.

**4 Amplitude Control**

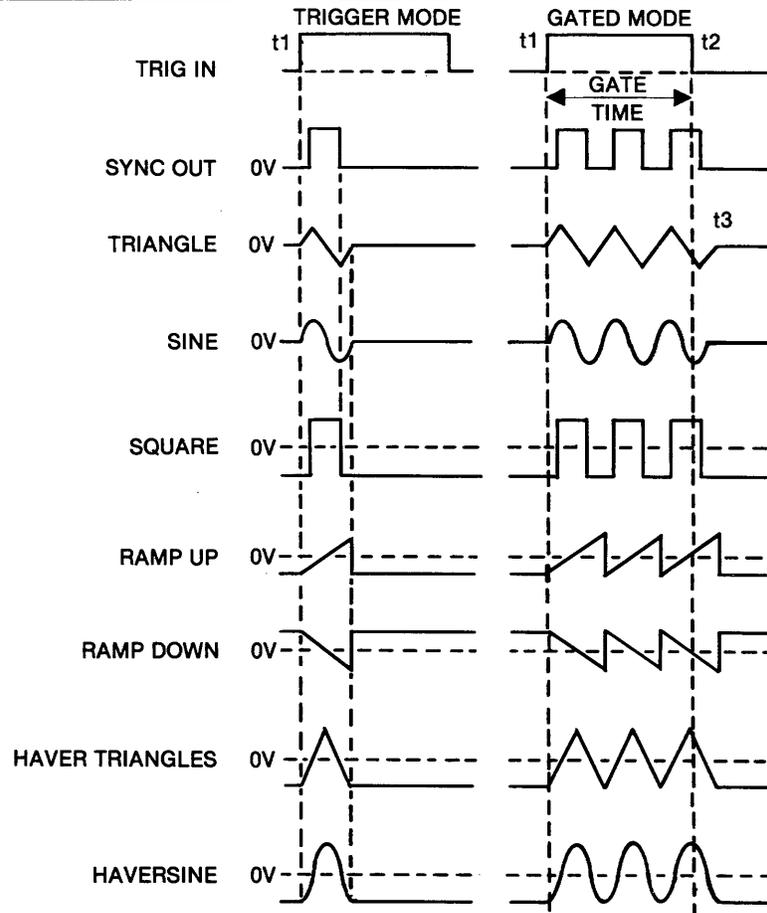
The Amplitude knob controls waveform amplitude, dc amplitude and waveform with dc offset amplitude. Maximum amplitude is with the knob fully clockwise (see table 3-1). Amplitude is decreased 20 dB with the knob fully counterclockwise.

**Table 3-1. Maximum Voltage at 0 dB**

Function	Open Circuit	50 Termination
	20 Vp-p	10 Vp-p
DC	$\pm 10$ V	$\pm 5$ V



**Figure 3-1. Controls and Connectors**



**Figure 3-2. Waveform Phase Relationships**

#### 5 Power Switch

Power is turned on and off with the Power button. The frequency display becomes active when power is turned on. Power-up conditions are:

Stab: Off	VCG In: (N.A.)
Func: Sine	TRIG In: (N.A.)
Mode: Cont	Ext Ref: (N.A.)
Freq Range: 1100 Hz	Sync Out: TTL square
Ref: Int	Func Out (-30 dB): 1 kHz sine
Haver: Off	Func Out (50Ω): 1 kHz sine
Trigger: (N.A.)	
Power: On	

#### 6 Function Output Connector (50Ω)

The selected function signals **16** are output at the Func Out (50 Ω) connector. Amplitude is controlled by the Amplitude knob. Maximum output is 10 V<sub>p-p</sub> into a 50Ω load (20 V<sub>p-p</sub> into open circuit). Source impedance is 50Ω.

#### 7 Trigger Switch

In triggered and gated modes **14**, the Trigger button triggers a single cycle of waveform output and, in gated mode, gates the output until released. The quiescent output depends on the waveform selection and dc offset (see figure 3-2). A gated cycle started prior to button release is completed.

#### 8 Function Output Connector (-20 dB)

The selected function signals are output at the Func Out (-20 dB) connector. Amplitude is controlled by the Amplitude knob and has a fixed 20 dB attenuation relative to Func Out (50Ω). Source impedance is 50Ω.

#### 9 Haver Switch

The Haver button selects normal 0° (Haver Off) or -90° (Haver On) start/stop phase of triggered sine and triangle (a haverwave; figure 3-2). When the button is pressed the annunciator arrow on the display indicates Haver On or Off. Haver On can be selected only in the trigger or gated modes **14**, in the 1100 Hz or lower frequency ranges **13** and with sine and triangle function **16** only.

## 10 Sync Output Connector

Output is fixed amplitude (0 to about 5V) TTL pulse at generator frequency. This output can be used as a synchronizing reference for the Function Outputs. Phase of the waveforms relative to the sync output is shown in figure 3-2.

## 11 Reference Switch

The button provides the selection of internal or external reference of waveform output frequency and a means of holding or releasing the waveform manually. When this switch is pressed an annunciator arrow on the display indicates Int or Ext Ref operation. When operation in the 1100 Hz or lower range with no input to Ref In connector, this button acts as an instantaneous hold; press again to start the waveform at the same point that it was held. Also see **12**.

## 12 External Reference Connector

The Ext Ref connector accepts either a TTL compatible signal (1.1 MHz maximum repetition rate, 200 ns minimum pulse width) or contact closure. External reference allows four modes of operation; two modes require a signal or switch closure at Ext Ref connector. The modes are:

**Normal** waveform function generator operation when in internal reference **11** and the Ext Ref BNC is either left unconnected or connected to +5 Vdc or a TTL high.

**External Reference** operation by applying frequency to the Ref In BNC with external reference selected **11**. Frequency input controls frequency of the selected waveform at the output. The output frequency will be 1/1000 the reference frequency. Maximum output frequency is 1100 Hz. When external reference is selected, the display is disabled and blanked.

**Manual Hold** at any point on the output waveform by use of the Ref button. Reference mode must be "Normal" as above. When Ref button is pressed, the output is stopped. When pressed again, the waveform will start again exactly where it stopped.

**Electrical Hold** at any point on the output waveform:

1. When in "Normal" operation and 1.1 kHz or below, hold by applying 0 Vdc or a TTL low to the Ext Ref BNC or through remote contact closure shorting out the BNC.

2. When in "External Reference" operation, hold by removing or bringing input to 0 Vdc.

## 13 Frequency Range Switch

Freq Range stepping switch, when pushed on the left or right, steps through the sine ranges. The Frequency knob selects the frequency within a range. Frequency output is monitored by the LCD display. Each range has an 1100:1 breadth. Refer to paragraph 1.2 for range specifications. The "in spec" portion of each range extends from 100 through 1100 counts on the display. "In spec" operation extends from 100 Hz through 11 MHz. Power-up state is the 1100 Hz range.

## 14 Mode Switch

The Mode stepping switch, when pushed on the left or right, steps through the three modes of operation. The mode selected on the display is indicated by an annunciator. The modes are:

Continuous — Waveform or dc output is present unless a hold **11** is applied

Triggered — Output is at 0 Vdc (for square wave, untriggered output is at lower level of the square) until triggered **7**, **15**, at which time one cycle of waveform is output.

Gated — As for triggered except output continuous for the duration of the trigger (gate) signal. When the signal stops, the last waveform cycle started is completed.

## 15 Trigger In Connector

The Trig In connector accepts TTL level inputs that trigger and gate the generator in trigger and gated modes **14**, respectively. A positive-going excursion triggers or gates the generator operation. A negative-going excursion ends gated operation. Figure 3-2 shows triggering and gating of the generator waveforms at time t1. When triggered, a full cycle of the selected waveform is output to its completion. When gated, and gating is removed (time t2) the last cycle started is completed (time t3).

## 16 Function Switch

The Func stepping button, when pushed on the left or right, steps through sine  $\sim$ , triangle  $\wedge$ , square  $\square$ , ramp up  $\nearrow$ , ramp down  $\searrow$ , and dc. Waveform output is indicated by an annunciator arrow on the display. The ramps are not available in the top four frequency ranges. In these ranges, the Model 21 is a conventional analog generator. When in the lower five ranges, the waveforms are no longer produced by the function generator directly. The function generator runs 1000 times the apparent output frequency and becomes a clock source to clock a digital

waveform synthesizer. The waveforms are then synthesized so that instead of continuous waveforms, each waveform is made up of 1000 steps from a counter. All functions on the front panel are then available — dc, sine, triangle, square, and the two ramps. If haver is selected **9** only sine and triangle functions may be selected. The power-up function is sine.

#### **17 VCG In Connector**

DC voltage excursions of up to 0 to  $\pm 5$  volts at the VCG In connector summed with the Frequency knob control frequency within the selected range. Positive inputs increase and negative inputs decrease frequency. Frequency excursions of 1100:1 are possible when the Frequency knob is either fully clockwise or

counterclockwise. VCG allows external sweeping by applying a ramp or external modulating by an alternating signal such as a sine wave. Input impedance is  $5k\Omega$ . If frequency stabilization is selected, the VCG In connector is internally disconnected. The generator frequency can follow changes in VCG In voltage with slew rates up to 0.1 volts per  $\mu s$ . This corresponds to maintaining full deviation in frequency for a 1 Vp-p square wave at VCG In with frequencies up to 50 kHz.

#### **18 Stabilizer Switch**

The Stab button maintains the generator frequency within  $\pm 1$  LSD. An annunciator arrow on the display indicates Stab or Off. The stabilizer is automatically deselected whenever the generator mode is taken out of continuous or the external reference is On.

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