SECTION 4
CIRCUIT DESCRIPTION

4.1 BASIC WAVEFORM DEVELOPMENT

The heart of the generator (the bold path in figure 4-1) is a triangle and square wave generator. The triangle waves are developed by capacitor charging ramps that are alternately reversed in polarity. The polarity reversal is caused by a flip-flop circuit, or hysteresis switch, that in turn produces the square waves. The flip-flop changes states upon detecting amplitude limits of the charging ramps through the triangle amplifier.

As shown in figure 4-1, the VCG dial buffer sums the currents from the frequency dial, frequency vernier and VCG in connector. The VCG dial buffer is an inverting amplifier whose output voltage is used to control a positive current source and a negative current source. For symmetrical output waveforms, the currents from the two current sources are equal and directly proportional to the voltage of the VCG dial buffer output. The diode gate, which is controlled by the hysteresis switch, is used to switch the positive or the negative current to the integrating capacitor selected by the frequency multiplier. If the positive current is switched into the integrating capacitor, the voltage across the capacitor will rise linearly to generate the triangle rise transition. If the current is negative, the voltage across the integrating capacitor will fall linearly to produce the fall transition.

The triangle amplifier is a unity gain amplifier whose output is fed to the hysteresis switch. The hysteresis switch has two voltage limit points (+1.25 and −1.25V) at its input.

During the time the output voltage of the triangle amplifier is rising, the output voltage of the hysteresis switch is positive, but when the output voltage of the triangle reaches +1.25V, it triggers the hysteresis switch causing the output to switch negative. Once the control voltage into the diode gate becomes negative, it will switch the positive current out and switch the negative current in to the integrating capacitor, so that the voltage across the capacitor will reverse, starting a linear decrease of the waveform. When the decreasing voltage reaches −1.25V, the output of the hysteresis switch will switch back to positive, reversing the process. This action generates the triangle waveform as shown in figure 4-2. Since the output of the hysteresis switch is a square wave, the result is simultaneous generation of a square wave and a triangle wave at the same frequency.

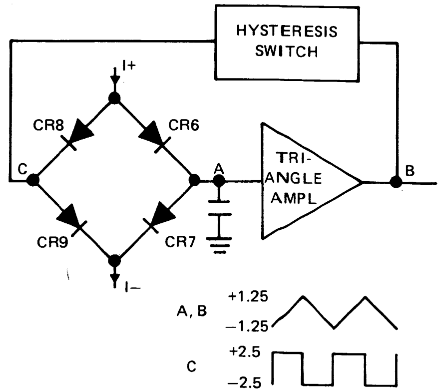


Figure 4-2. Basic Generator and Timing Diagram

The output frequency is determined by the magnitude of the capacitor selected by the frequency multiplier and the magnitude of the positive and negative current sources. Since the current sources are linearly proportional to the control voltage of the VCG circuit, the output frequency will also be linearly proportional to the control voltage.

The output of the hysteresis switch is fed to the sync amplifier and also the square wave shaper. The square wave shaper consists of a shaping circuit which limits the square wave output swing to ±1.25V. For positive pulse outputs, it limits the output voltage swing from −1.25 to 0V; and for negative pulse outputs, it limits the output swing from 0 to +1.25V. The PULSE or $\overline{\text{PULSE}}$ from the auxiliary board are bipolar and processed as the square wave.

The triangle wave from the triangle amplifier is coupled through a buffer amplifier and made available to the function selector switch. The buffer amplifier provides a low impedance to drive the sine converter circuit. The sine converter, using the nonlinear characteristics of its diodes, converts the triangle wave into a sine wave.

The square wave from the sync amplifier, processed through a one-shot and the sync out buffer, is externally available at the sync out connector. The sync pulse, then, is a TTL level pulse output of the generator frequency.

waveform with the front panel function switch. This output, a normal pulse or a complemented pulse, is routed to the square wave shaper and output, if selected, through the output amplifier as a variable amplitude pulse. The pulse modes of normal, delayed and double are shown as timing diagrams in figures 4-4, 4-5 and 4-6.

4.5 WIDTH AND DELAY ONE-SHOTS

The pulse width and delay one-shots feature front panel adjustable current sources to regulate the capacitor charge time and as a result, the one-shot pulse width. The steady state condition of the one-shot circuit is as shown in figure 4-7: Upon triggering, $\overline{Q}$ goes low, the switch transistor switches off and the capacitor begins to charge. When the voltage across the capacitor is sufficient, the level detector senses the set level, the flip-flop is cleared and the circuit reverts to its steady state condition. The duty cycle of the one-shots is limited by the capacitor discharge time when returning to steady state conditions.

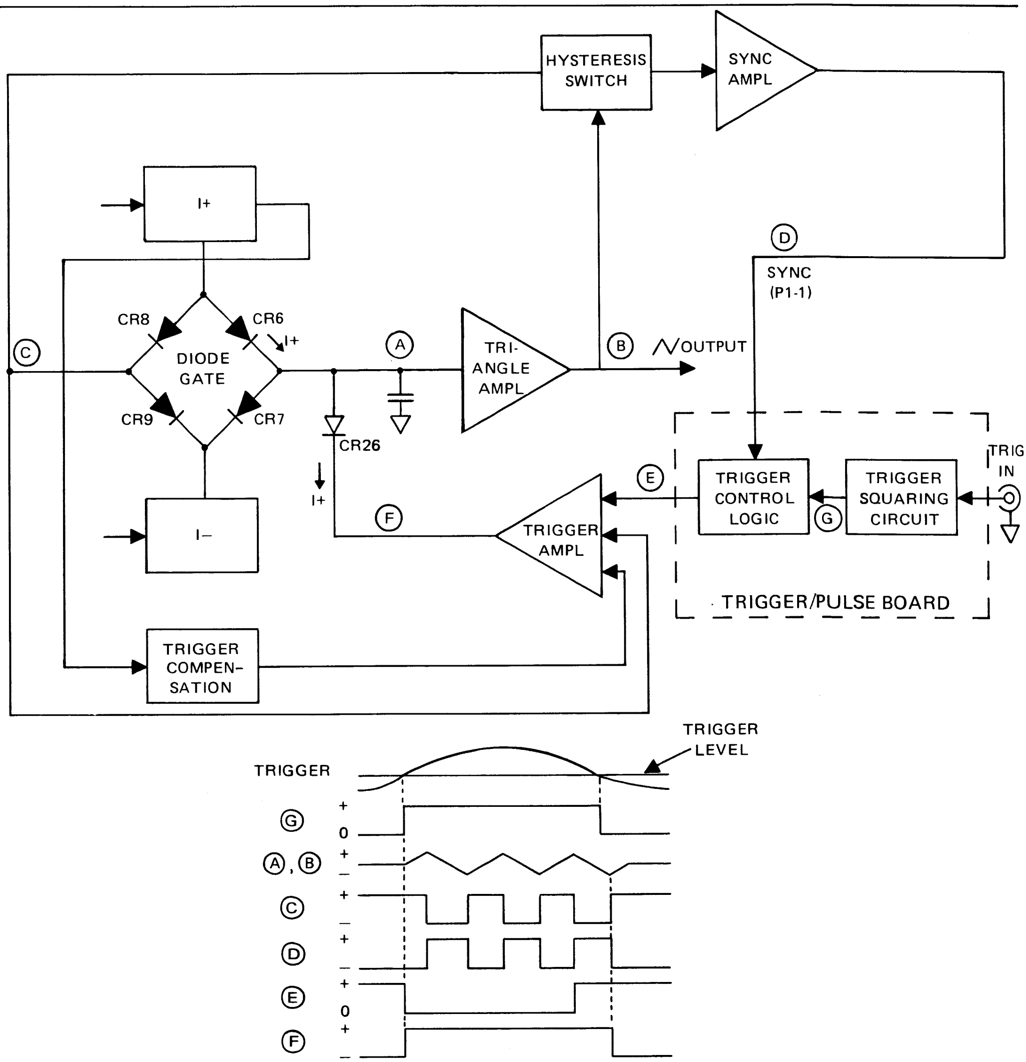


Figure 4-3. Trigger Circuit and Timing

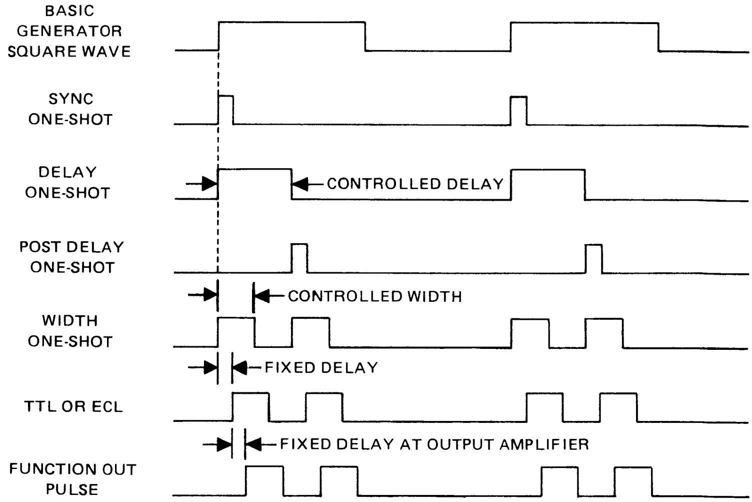


Figure 4-6. Double Mode Timing

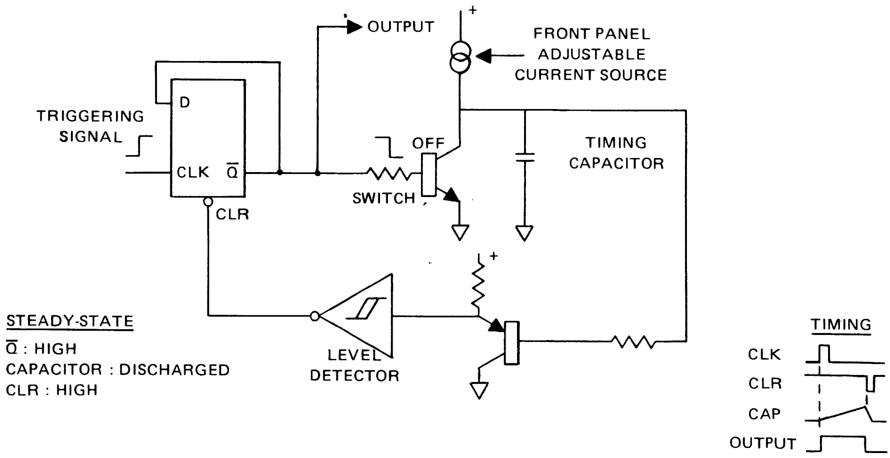
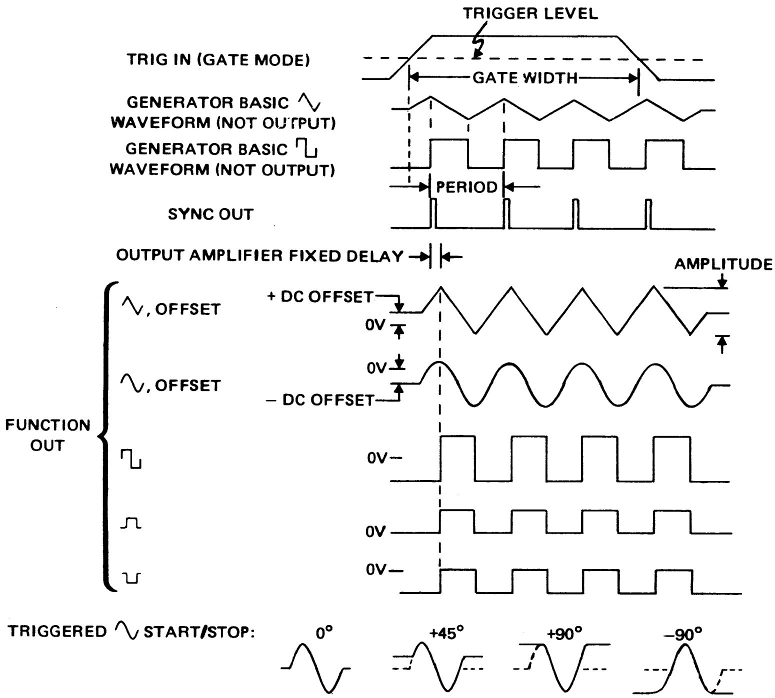


Figure 4-7. Width and Delay One-Shots

3.2.4 Voltage Controlled Function Generator Operation

Operation as a voltage controlled function generator (VCG) is as for a manually controlled function generator, only the frequency within particular ranges is additionally controlled with dc levels (±2V excursions) injected at the VCG IN connector. Set the frequency dial to a reference from which the frequency is to be voltage controlled.

1. For frequency control with positive dc inputs at VCG IN, set the dial for a lower frequency limit.
2. For frequency control with negative dc inputs at VCG IN, set the dial for an upper frequency limit.
3. For modulation with an ac input at VCG IN, set dial at desired center frequency. Do not exceed the maximum dial range of the selected frequency range.



NOTES

1. *Period is controlled by the generator frequency setting.*
2. *In trigger mode, just one period is generated for each trigger pulse.*
3. *DC offset plus peak waveform voltage > | 7.5V | causes waveform clipping.*

Figure 3-5. Waveform Characteristics

The upper and lower limits are defined by the maximum and minimum dial (2) settings multiplied by (17). VCG input will not drive the generator beyond the normal dial limits of a range.

(17) **FREQ/PERIOD MULT Switch**

The outer knob selects one of ten frequency/period multipliers for the dial (2) setting. Frequency, then period, are noted at each setting.

VERNIER Control

A fine adjustment of the frequency dial (2) setting.

Not Shown **EXT DC OFFSET IN Connector (Rear Panel)**

Applied voltage offsets the selected waveform linearly. Offset is 1V for each −1V applied with output connected into an open circuit. Maximum input is ±7.5V. Offset is affected by the attenuator (8)

Not Shown **GCV OUT Connector (Rear Panel)**

This connector gives a 0 to +2V signal proportional to the frequency of the generator within any given range. The signal can be used as the X drive for X-Y recorders.

3.2 OPERATION

Perform the initial checkout in Section 2 for the feel of the instrument. Any questions concerning individual controls and connectors may be answered in paragraph 3.1.

3.2.1 Signal Termination

3.2.1.1 FUNCTION OUT Signal

Proper signal termination, or loading, of the generator connectors is necessary for its specified operation. For example,

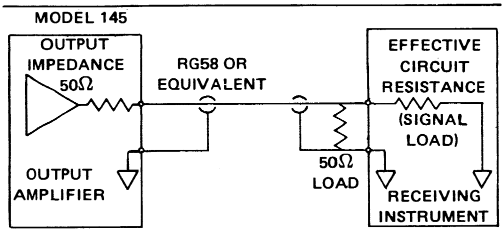


Figure 3-2. Signal Termination

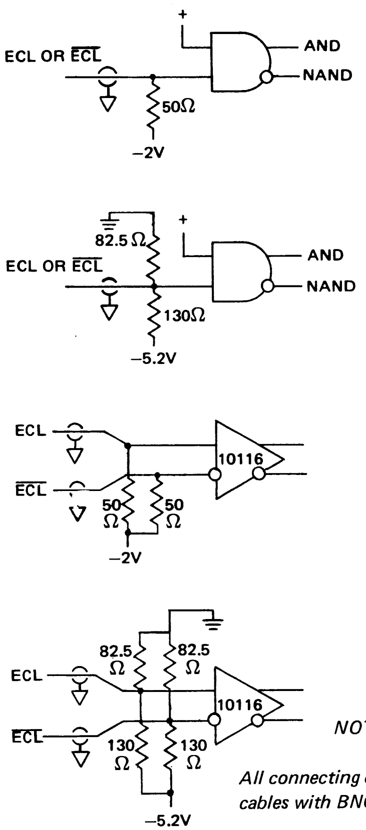
the proper termination of the main output is shown in figure 3-2. Placing the 50Ω terminator, or 50Ω resistance, in parallel with a higher impedance matches the receiving instrument input impedance to the generator output impedance, thereby minimizing signal reflection or power loss on the line due to phase angle mismatch.

3.2.1.2 TTL PULSE OUT Signals

The TTL and $\overline{\text{TTL}}$ PULSE OUT outputs can drive 50Ω and higher impedance terminations.

3.2.1.3 ECL PULSE OUT Signals

The ECL and $\overline{\text{ECL}}$ PULSE OUT outputs are driven by MC10124's. The signals must be properly terminated at the point that they enter an external ECL circuit. Several connection possibilities are shown in figure 3-3.



NOTE

All connecting cables are RG58 cables with BNC connectors.

Figure 3-3. ECL Terminations

Table 3-1. Period to Frequency Conversion

Converted Frequency Dial Values
(Based on f = 1/T where ⌐L⌐)
|←T→|

Time	Freq	Time	Freq	Time	Freq
.5	2	2.3	.44	4.1	.24
.6	1.67	2.4	.42	4.2	.24
.7	1.43	2.5	.4	4.3	.23
.8	1.25	2.6	.39	4.4	.23
.9	1.11	2.7	.37	4.5	.22
1	1	2.8	.36	4.6	.22
1.1	.91	2.9	.35	4.7	.21
1.2	.83	3	.33	4.8	.21
1.3	.77	3.1	.32	4.9	.2
1.4	.71	3.2	.31	5	.2
1.5	.67	3.3	.3		
1.6	.63	3.4	.29		
1.7	.59	3.5	.29		
1.8	.56	3.6	.28		
1.9	.53	3.7	.27		
2	.5	3.8	.26		
2.1	.48	3.9	.26		
2.2	.46	4	.25		

Symbols

M = 10^6
k = 10^3
m = 10^{-3}
μ = 10^{-6}
n = 10^{-9}

To use the dial calibration marks when setting period time, the period must be converted to frequency.

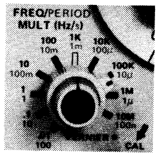
Example: Set generator for a 23 μs pulse period.

1. Find the number 23 (or .23, 2.3, etc.) in the Time column. Note its form and Freq equivalent.

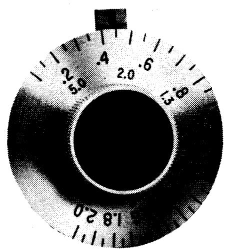
Time	Freq
2.3	.44

2. Express 23 μs using the 2.3 form: 2.3 X 10^{-5}.

3. Set FREQ/PERIOD MULT switch to the equivalent of 10^{-5}: 10μ.



4. Set the dial to the frequency equivalent of 2.3: .44.



NOTE: Refer to paragraph 1.2 for dial accuracy.

TRIGGER LEVEL Control

Determines the level at which the input trigger signal at the TRIG IN connector (15) is accepted as a trigger or gate in the trigger and gate modes. The trigger level can be varied from fully cw, where a positive-going excursion thru approximately −10V is a trigger, to fully ccw, where a positive-going excursion thru approximately +10V level is a trigger.

(4) **MANUAL TRIGGER Switch**

Triggers or gates the output signal when GENERATOR MODE switch (3) is at TRIG or GATE. In trigger mode, one cycle is output when the switch is pressed. In gate mode, cycles are continuously output as long as the switch is held down.

NOTE
Set TRIGGER LEVEL (3) fully ccw.

(5) **PULSE DELAY Control**

When NORMAL/DOUBLE/DELAYED switch (6) is at DELAYED, PULSE DELAY selects one of six time ranges for delay of pulse with respect to the undelayed signal leading edge. When (6) is at DOUBLE, PULSE DELAY selects the time between double pulse leading edges.

VARIABLE Control

Inner knob selects delay time within the range selected by the outer knob.

(6) **NORMAL/DOUBLE/DELAYED Switch**

Selects the pulse parameters as follows:

NORMAL – Pulse of width and frequency set by front panel switches appears at TTL, $\overline{TTL}$, ECL,

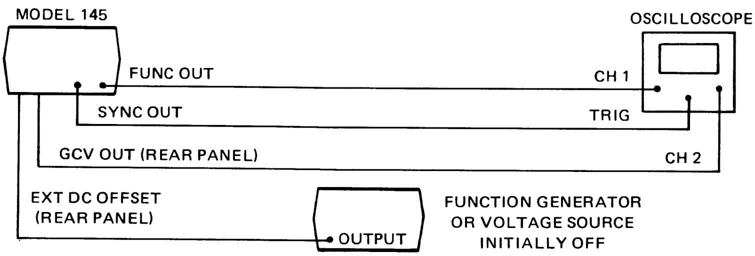


Figure 2-1. Initial Setup

Table 2-1. Acceptance Procedure

Step	Control	Position/Operation	Observe
1	POWER	ON	1 kHz square wave.
2	Dial	Rotate dial. Return to 1.0.	Rotation ccw increases frequency of square on one channel and dc level on other channel; cw decreases frequency and dc level.
3	FREQ/PERIOD MULT	Rotate switch. Return to 1K.	Rotation cw increases frequency; ccw decreases frequency (dc level not affected).
4	VERNIER	Rotate ccw. Return to CAL.	Rotation ccw gives a small decrease in frequency.
5	ATTENUATION	Rotate ccw. Return to 0.	Rotation ccw reduces square wave amplitude.
6	ATTENUATION VERNIER	Rotate ccw.	Square wave amplitude decreases.
7	DC OFFSET	Rotate cw. Return to OFF.	Square wave is immediately offset below previous level; then waveform moves up to a positive level. OFF returns waveform to original position. (Clipping occurs at ±15V.)
8	Function Generator or Voltage Source	Vary input voltage.	Waveform dc level varies.

Remove EXT DC OFFSET IN cable and connect to VCG IN connector. Remove GCV OUT cable.

Step	Control	Position/Operation	Observe
9	Function Generator or Voltage Source	Vary input voltage; then disconnect input.	Frequency increases with increased voltage, decreases with decreased voltage.
10	ATTENUATION VERNIER	Rotate cw.	– – –
11	FUNCTION	Rotate to DC, ∿, ⋀⋁, ⊓⊔, ⎍, ⊔⊓, then ∿.	Note dc level on scope. ∿, ⋀⋁ and ⊓⊔ should be centered on dc level. ⎍ should rest on dc level, ⊔⊓ should rise to dc level.
12	GENERATOR MODE	GATE	A dc level.
13	MANUAL TRIG	Press down.	A series of sine waves.

Impedance: 10 kΩ, 33 pF.
Pulse Width: 25 ns minimum.
Repetition Rate: 10 MHz maximum.
Adjustable Triggered Signal Start/Stop Point (sine and triangle only): Approximately –90° to +90° to 2 MHz.

1.2.3 Frequency Precision

Dial Accuracy
±3% of full range from X .01 Hz to X 1 MHz.
±5% of full range on X 10 MHz.

Time Symmetry
Square wave variation less than:
±1% from 0.001 Hz to 200 kHz
±0.5% from 20 Hz to 20 kHz

1.2.4 Amplitude Precision

Amplitude Change With Frequency
Sine variation less than:
±0.1 dB for 0.001 Hz to 200 kHz
±0.5 dB for 200 kHz to 2 MHz
±3.0 dB for 2 to 20 MHz

Step Attenuator Accuracy
0.3 dB per 20 dB step at 2 kHz.

1.2.5 Waveform Characteristics

Sine Distortion
< 0.5% on X 100 Hz to X 10 kHz.
< 1.0% on X .01 to X 10 Hz and X 100 kHz.
All harmonics 34 dB below fundamental on X 1 MHz.
All harmonics 26 dB below fundamental on X 10 MHz.

Square Wave Rise/Fall Times
At FUNCTION OUT < 20 ns for 15V p-p output into 50Ω load.

1.2.6 Pulse Generator

Pulse Outputs
Variable amplitude pulse, and simultaneous fixed ECL, $\overline{\text{ECL}}$, TTL and $\overline{\text{TTL}}$ pulses and TTL sync pulse. All outputs can drive 50Ω terminations.

Operational Modes
Continuous, triggered and gated plus the following.
Normal Pulse: Adjustable width pulse in phase with sync signal.
Delayed Pulse: Pulse delayed with respect to normal pulse. Pulse delay and pulse width adjustable.
Double Pulse: Two pulses for every period. Time between pulses and pulse width adjustable. Minimum period 100 ns.

Pulse Period Range
50 ns to 10,000s in 10 overlapping ranges with approximately 1% vernier control.

Pulse Width
25 ns to 1 ms in 5 overlapping ranges with vernier control. Includes OFF and square wave.

Pulse Delay
50 ns to 10 ms in 6 overlapping ranges with vernier control.

Duty Cycle
Duty cycles to 70% for periods > 100 ns (< 10 MHz); for periods < 100 ns (> 10 MHz) duty cycles are approximately 50%.

Function Output
Variable to 30V p-p (15V p-p into 50Ω). DC offset and attenuation are same as for function generator.

Pulse Rise/Fall Times
At FUNCTION OUT, < 20 ns for 15V p-p output into 50Ω load.

1.2.7 General

Stability
Short Term: ±0.05% for 10 minutes.
Long Term: ±0.25% for 24 hours.
Percentages apply to amplitude, frequency and dc offset.

Environmental
Specifications apply at 25°C ±5°C. Instrument will operate from 0°C to 50°C ambient temperatures.

Dimensions
28.6 cm (11¼ in.) wide; 14.5 cm (5¾ in.) high; 27.3 cm (10¾ in.) deep.

Weight
5 kg (11 lb) net; 6.6 kg (14½ lb) shipping.

Power
90 to 105V, 108 to 126V, 198 to 231V and 216 to 252V selectable; 48 to 400 Hz; less than 30 watts.

NOTE

All specifications apply from 0.1 to 2.0 on frequency dial when FUNCTION OUT output is at maximum and 50Ω terminated. Function generator specifications apply when PULSE WIDTH control is OFF.

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.

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

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

WARRANTY

All Wavetek instruments are warranteed against defects in material and workmanship for a period of one year after date of manufacture. Wavetek agrees to repair or replace any assembly or component (except batteries) found to be defective, under normal use, during this period. Wavetek's obligation under this warranty is limited solely to repairing any such instrument which in Wavetek's sole opinion proves to be defective within the scope of the warranty when returned to the factory or to an authorized service center. Transportation to the factory or service center is to be prepaid by purchaser. Shipment should not be made without prior authorization by Wavetek.

This warranty does not apply to any products repaired or altered by persons not authorized by Wavetek, or not in accordance with instructions furnished by Wavetek. If the instrument is defective as a result of misuse, improper repair, or abnormal conditions or operations, repairs will be billed at cost.

Wavetek assumes no responsibility for its product being used in a hazardous or dangerous manner either alone or in conjunction with other equipment. High voltage used in some instruments may be dangerous if misused. Special disclaimers apply to these instruments. Wavetek assumes no liability for secondary charges or consequential damages and, in any event, Wavetek's liability for breach of warranty under any contract or otherwise, shall not exceed the purchase price of the specific instrument shipped and against which a claim is made.

Any recommendations made by Wavetek for use of its products are based upon tests believed to be reliable, but Wavetek makes no warranty of the results to be obtained. This warranty is in lieu of all other warranties, expressed or implied, and no representative or person is authorized to represent or assume for Wavetek any liability in connection with the sale of our products other than set forth herein.