# gENERAL DESCRIPTION 

## SCOPE OF MANUAL

This manual provides instructions for operating, testing, and maintaining the Wavetek Programmable Waveform Synthesizer. Sections 1 through 5 include the necessary information for the basic Model 157. Section 6 consists of Difference Data that describe specific differences, if any, from the basic model.

## SCOPE OF EQUIPMENT

The Model 157 is a precision source of selectable sine, square, or triangle waveforms that are generated from 100 $\mu \mathrm{Hz}$ ( $23 / 4$ hours per cycle) to 1 MHz in 10 ranges. Output amplitudes are selectable from 1 millivolt to 10 volts, peak-to-peak, into a 50 -ohm load. This instrument incorporates a voltage-controlled generator that may be swept over a 1000:1 frequency ratio with a 0 -volt to 5 -volt analog input for frequency modulation of the selected output frequency.

Four modes of operation can be programmed with the front-panel controls. Three modes of operation are programmable from a remote source by static logic levels or contact closures. Frequency, amplitude, and function also are programmable from either the front-panel controls or a remote source.

The instrument is packaged for mounting in a standard 19 -inch rack or for operating on a test bench.

## MODES OF OPERATION

Front-panel pushbutton operation provides the following operational modes:

1. VCG with manual calibration.
2. Automatic calibration.
3. Trigger.
4. Search.

Remote logic-level or contact-closure programming provides the following operational modes:

1. Automatic calibration.
2. Trigger.
3. VCG without manual calibration.

## VCG With Manual Calibration Mode

This mode is selected at the front panel for accurately calibrating the output frequency. After calibration, the Model 157 may be swept about the calibrated center frequency with a VCG input.

## Automatic Calibration Mode

This mode is selected at the front panel or programmed from the remote source to provide an accurate fixedfrequency output by closed-loop operation.

## Trigger Mode

This mode is selected at the front panel or programmed from the remote source to place the Model 157 in a standby state until a positive pulse is applied through a connector on the rear panel. The standby state for the sine and triangle waveforms is 0 -volts dc . For the square wave, the standby state is the positive peak value of the programmed amplitude. A tone-burst output starts at the positive-going edge of the input pulse and continues, at the programmed frequency, for the duration of the pulse plus the time required for the generator to complete the last cycle. Another front-panel pushbuttom permits a single cycle of the programmed frequency to be generated without an external pulse input. The same function can be accomplished remotely by injecting an input pulse having less duration than a single cycle of the programmed frequency.

## Search Mode

This mode is selected at the front panel for sweeping the entire selected frequency range to find a specific frequency. In this mode, digital programming of frequency is disabled and the generator functions in open-loop operation.

## VCG Without Manual Calibration Mode

This mode is obtained in remote-control operation when none of the preceding functions are programmed. In this
mode, the generator is in the open-loop operation and the output frequency is determined by the digitallyprogrammed frequency and a VCG input signal. If the input signal is dc, the generator output frequency will be the digitally-programmed frequency proportionally modified by the level of the input signal. A positive input level increases the generator output frequency, and a negative level decreases the output frequency. If the input signal is ac, the output frequency will be frequency modulated over a band that is proportional to the signal amplitude at a rate that is equal to the signal frequency.

## REMOTE CONTROL OPERATIONS

Transfer of control to a remote source is accomplished by depressing the REMOTE pushbuttons and turning the rotary switches to their R positions. Control of generator mode, function, and each rotary switch may be transferred to the REMOTE connector collectively or independently. (Refer to Operations section.) Any or all of these controls may then be programmed in BCD/binary format at the 50 -pin REMOTE connector on the rear panel. Synchronizing, trigger, and VCG input signals are connected to the Model 157 through separate BNC connectors on the rear panel for either local or remote-program applications. Programming an automatic calibration command simultaneously with a synchronizing, trigger, or VCG input signal is a not-allowed operation.

## FUNCTIONAL DESCRIPTIONS

## Programming

Operation by contact closure (local/remote) or by automatic data processing (ADP) is controlled by binary states. The coding format is modified BCD, BCD, or binary. The coded program controls numerical frequency, frequency range, numerical amplitude, amplitude range, function selection, and generator mode selection. Circuit functions are implemented by reed-relay contact closures and digital-to-analog converters (DAC).

In the simplified block diagram of Figure 1-1, all switch symbols represent a switching function that can be commanded either remotely or locally. The binary code is converted by the frequency DAC into an analog voltage which is applied to an inverter and error-sensing circuit. The outputs of these circuits establish the operating state for the voltage-controlled generator (VCG).

## Error Loop Operation

The inverter input to the VCG is disconnected in the search
mode (represented by $S_{1}$ in Figure 1-1) so that the frequency range may be manually swept with a front-panel control. The frequency error-sensing circuit is disconnected in search, trigger, and VCG modes. In automatic calibration, this circuit operates in closed loop and corrects for frequency drift.

The error-sensing circuit operates between 100 Hz to 1 kHz . Therefore, when the programmed frequency is greater than 1 kHz , the divider circuit is automatically switched between the output of the hysteresis switch and the error-circuit input (represented by $S_{3}$ ).

The divider circuit consists of three cascaded divide-by-ten counters that are progressively engaged as the frequency is increased. With all three circuits engaged, the divider output is 0.001 of the input frequency which reduces the top frequency range of the generator to within the error-circuit band.

## High-Frequency Range

Frequences from 100 Hz to 1 MHz are produced by conventional function-generator techniques. The integrator output is a triangle wave and the hysteresis switch output is a square wave, each being interdependent with the other. The frequency program establishes the charging slope for the integrator and selects the proper integrating capacitance for the specific frequency range. In the trigger mode, a square-wave output from the hysteresis switch is coupled through $\mathrm{S}_{2}$ to enable the trigger circuit.

The triangle wave is coupled through $\mathrm{S}_{6}$ to the sine converter which transforms the input waveform into a sinusoidal wave at its output. The programmed function at $S_{7}$ (triangle, square, or sine) is then given the necessary gain by the output amplifier before being applied to the attenuation network.

The output level program then selects the required attenuation network to provide the desired output amplitude for the selected waveform over the 100 Hz to 1 MHz range.

## Low-Frequency Range

Waveforms with frequencies from 100 Hz down to $100 \mu \mathrm{~Hz}$ are synthesized from the basic generator square-wave output by the counter and waveform DAC. The counter circuit counts the input pulses to produce square waves at 0.001 of the input frequency. One output is applied through $S_{2}$ to enable the trigger circuit in the lowfrequency range when this mode is selected. Another counter output pulse is applied through $\mathrm{S}_{5}$ to the functionselection circuit $\mathrm{S}_{7}$. All pulses from the counter are coupled to the waveform DAC that transforms the binary bits into a


Figure 1-1. Simplified Block Diagram
triangle waveform at 0.001 of the generator frequency over the range of $100 \mu \mathrm{~Hz}$ to 100 Hz .

For frequencies from 100 Hz down to $100 \mu \mathrm{~Hz}$, the divider is progressively switched into the counter input through $\mathrm{S}_{4}$ as described previously for the error-sensing circuit.

Sine conversion, function selection, amplification, and output attenuation are executed in the same manner as described for the high-frequency range.

## SPECIFICATIONS

VERSATILITY

## Waveforms

Sine $\downarrow$, square $\sqcap$, and triangle $\vee$.

Dynamic Frequency
$100 \mu \mathrm{~Hz}(2.77 \mathrm{hr})$ to $1 \mathrm{MHz}(1 \mu \mathrm{sec})$ in 10 ranges.

## Outputs

$\downarrow, ~ Z, ~ \vee$ selectable and digitally variable from 0.001 to 10 V p-p into a 50 -ohm load in 4 ranges with 3-digit resolution ( 0.002 to 20 V p-p open circuit).

## NOTE

Output may be shorted without damage to instrument.

## VCG Voltage-Controlled Generator

Over 1000:1 frequency ratio with 0 -volt to 5 -volt input signal. Input impedance is $10 \mathrm{k} \Omega$.

## OPERATIONAL MODES

## Trigger Mode

Generator may be triggered to produce single cycles on command or gated to produce any discrete number of cycles by applying a + gate signal to trigger input for the length of the desired burst.
Input impedance is 10 k .
Plus gate required is +5 volts to +50 volts.

## Auto Cal Mode

Generator has an automatic control loop to maintain the ouput frequency for high accuracy and stability.

## Manual Cal Mode

Generator is manually calibrated using the control loop but is then returned to the open-loop condition when momentary switch is released so that it may be swept or triggered.

## Search Mode

Generator frequency control within the selected range is transferred from the digital controls to a single turn analog control for convenient manual sweeping of the entire range.

## Sync In

Within the upper 4 ranges, the instrument may be frequency synchronized to an external signai of approximately $1 \vee \mathrm{p}-\mathrm{p}$ that is within $1 \%$ of the free-rurining frequency. The induced sine distortion will be less than $1 \%$.

## Sync Out

A fixed amplitude square wave is brought out at 1 k impedance for syncing scopes or other equipment.

## HORIZONTAL PRECISION

## Auto Cal Mode

Frequency accuracy from programmed input or front-panel selector switches is $\pm 0.01 \%$ of programmed frequency, plus

1 digit). Closed-loop stability is within $\pm 0.005 \%$ of programmed frequency at constant temperature for a 24 -hour period.
Loop will settle to within the accuracy specified within 1 msec minimum and 3 sec maximum, depending on frequency and range.

## Manual Cal Mode

Instrument can be calibrated to an accuracy of $\pm 0.02 \%$ of programmed frequency and triggered or frequency modulated about this accurate center frequency.
Open-loop stability is within $0.05 \%$ of setting for 8 -hour period at constant temperature.

## VCG Bandwidth

1 MHz .
Slew rate $100 \%$ of range per $\mu$ sec.

## VCG Linearity

Frequency vs input voltage-best straight-line method.
$\pm 0.1 \% 100 \mu \mathrm{~Hz}-10 \mathrm{kHz}$.
$\pm 1 \% 10 \mathrm{kHz}-100 \mathrm{kHz}$.
$\pm 3 \% 100 \mathrm{kHz}-1 \mathrm{MHz}$

## VERTICAL PRECISION

Amplitude change with frequency is less than 0.1 db to 100 kHz and 0.5 db to 1 MHz .

## Peak-to-Peak Voltage Accuracy \% of Program

1 V to 10 V range $\pm(0.1 \%+5 \mathrm{mV})$.
0.1 V to 1 V range $\pm(1 \%+1 \mathrm{mV})$.

10 mV to 100 mV range $\pm(1 \%+0.1 \mathrm{mV})$.
1 mV to 10 mV range $\pm(1 \%+0.1 \mathrm{mV})$.

## Amplitude Symmetry

All waveforms are symmetrical about ground $\pm 1 \%$ of full range.
Trigger start-stop point will be $0 \vee \pm 0.5 \%$ of output amplitude program.

## PURITY

## Sine Wave Distortion

Less than:
$0.5 \% 100 \mu \mathrm{~Hz}$ to 10 kHz
$1 \% 10 \mathrm{kHz}$ to 100 kHz
$3 \% 100 \mathrm{kHz}$ to 1 MHz

## Triangle Linearity

Greater than:
$99 \% 1 \mathrm{~Hz}$ to 100 kHz
$95 \% 100 \mathrm{kHz}$ to 1 MHz

Square Wave Rise and Fall Time
Less than 100 nsec.

## ISOLATION

Output signal can be raised above ground up to 250 V . Caution must be taken as all exposed BNC connectors are at raised potential.

## ENVIRONMENTAL

## Temperature

Specifications apply at $25^{\circ} \mathrm{C} \pm 5^{\circ} \mathrm{C}$.
Operating temperature range $0^{\circ} \mathrm{C}$ to $50^{\circ} \mathrm{C}$.

## REMOTE CONTROL SPECIFICATIONS

## Configuration A (Standard)

True or Logic " 1 " $=0$ volt $\pm 1$ volt.
Note: 0 volt sinks approximately 1.5 mA .
False or Logic " 0 " = +2 volts to +10 volts.
Note: Open circuit voltage is approximately +2 volts.

## Configuration B

True or Logic " 1 " $=0$ volt $\pm 1$ volt.
Note: 0 volt sinks approximately 1.5 mA .
False or Logic " 0 " = -2 volts to -10 volts.
Note: Open circuit voltage is approximately -2 volts.

## Configuration C

True or Logic " 1 " $=-2$ volts to -10 volts.
Note: -2 volts sinks approximately 1.5 mA .
False or Logic " 0 " $=0$ volt to -1 volt.
Note: Open circuit voltage approximately +0.7 volts.

## Configuration D

True or Logic " 1 " = +2 volts to +10 volts.
Note: +2 volts sinks approximately 1.5 mA .
False or Logic ' 0 ' $=0$ volt to +1 volt.
Note: Open circuit voltage approximately -0.7 volts.

## Program Transition Time

1 msec.

## MECHANICAL

## Weight

$24 \mathrm{lb}, 34 \mathrm{lb}$ shipping.

## Power

105 Vac to 125 Vac or 210 Vac to $250 \mathrm{Vac}, 50 \mathrm{~Hz}$ to 400
Hz.
50 watts of power required.

NOTE
Precision specifications apply over $10 \%$ to $100 \%$ of selected range.

