MODEL 650 VARIABLE PHASE SYNTHESIZER

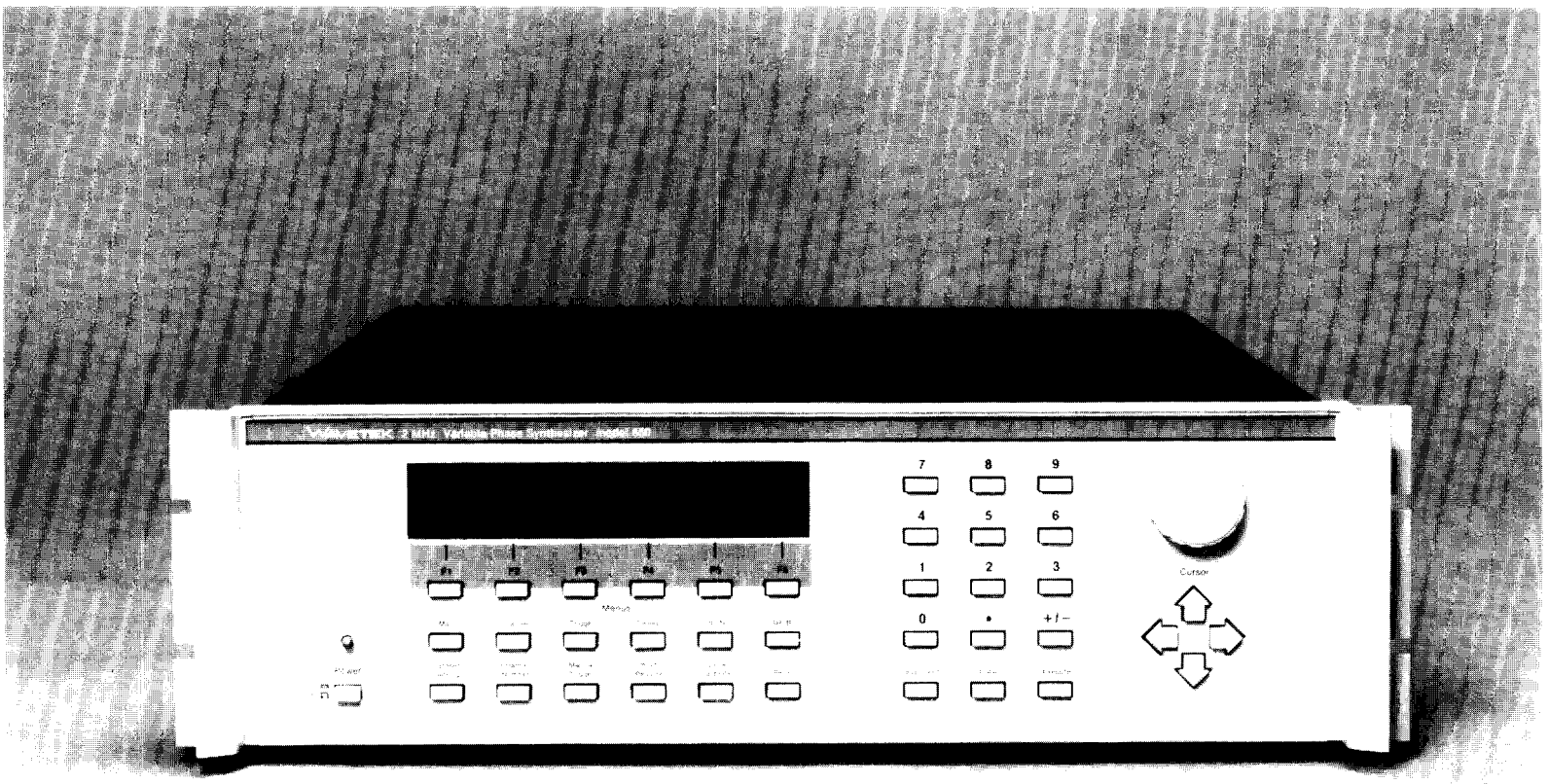
Precision 2 MHz Variable Phase Synthesizer

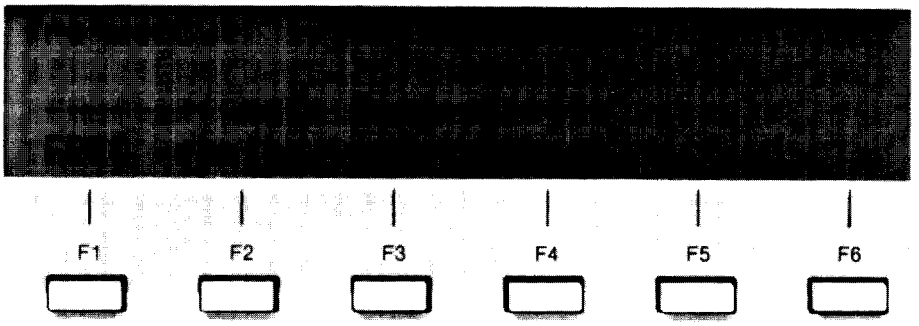
- **0.005 Phase Accuracy at Low Frequencies**
- **2 or 4 Channels in a 5¼ in. High, 19 in. Unit**
- **Up to 40 Channels Cascadeable**
- **Flexible Phase and Frequency Sweep Modes**
- **High Accuracy Output up to 50 Vp-p**

Capabilities
Model 650 represents the ultimate in variable phase generator design. The instrument combines superb phase accuracy, synthesizer frequency accuracy, high output amplitude capability and excellent stability. The standard model has two channels which can be expanded to four. As many as ten Model 650's can be cascaded to obtain 40 channels of phase controlled signals. In addition to sine waves, each output can be independently programmed to square, triangle and variable duty-cycle square and ramp waveforms.

Accuracies
Amplitude accuracy is ±0.5% below 100 kHz and frequency accuracy is 5 ppm. Frequency resolution is an incredible 10 digits or 100 μHz, and even at 50 Vp-p the output voltage resolution is 1 mV.

The unit is fully programmable via GPIB (IEEE-488). Many operating and sweep modes make it suitable for a multitude of applications related to analog and digital design work, phase meter calibration, phased arrays, avionics, industrial robotics and communications.





Menu Driven Display in Plain English Makes the 650 Easy to Use

Specifications

WAVEFORMS (FUNCTIONS)

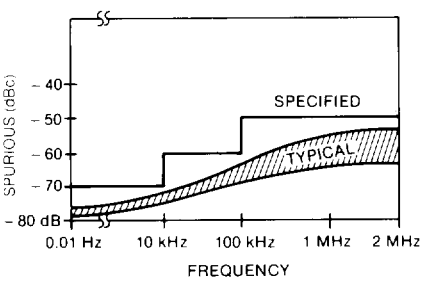
Programmable sine, square, triangle, ramp, dc and variable-duty-cycle-square and ramp.

Range

Sine, Square: 0.1 mHz to 2 MHz.
Ramp, Triangle: 0.1 mHz to 200 kHz.
Resolution: 10 digits or 0.1 mHz.
Accuracy: ± 5 ppm.
Stability: ± 3 ppm.

Waveform Quality

Sine Wave:



Spurious Nose vs. Frequency

Frequency	Spurious	Harmonics
⩽10kHz	⩽ – 70dBc	⩽ – 60dBc
⩽100kHz	⩽ – 60dBc	⩽ – 50dBc
⩽2MHz	⩽ – 50dBc	⩽ – 40dBc

Square Wave:
Rise/Fall Time: ⩽75ns.
Aberrations: ⩽5% Vp-p.
Duty Cycle: 20 to 80% ± 1%.

Triangle/Ramp:
Linearity: ⩾99% ⩽10kHz; ⩾90% <200kHz.
Duty Cycle: 0 to 100% ± 1%.

PRIMARY MODES

Continuous
All channels run continuously.

Triggered
All channels are quiescent until triggered by an external, internal, GPIB or front panel trigger upon which one signal cycle is output.

Gated
As triggered mode except output signals will be present as long as the gate signal is present.

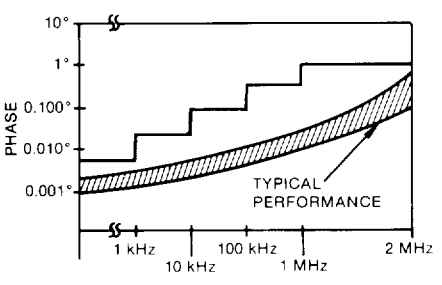
Burst
All channels are quiescent until triggered, upon which a pre-programmed number of signal cycles (burst count) is output.
Burst Count: 1 to 65535.

SECONDARY MODES

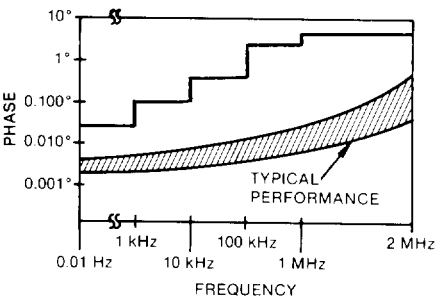
Phase Shift
Phase of each channel can be programmed with respect to the main generator. Channel No. 1 usually serves as a reference channel with the other channels having variable phase. Phase shift applies to all waveforms programmed for the particular channel.
Phase Resolution: 10 millidegrees.
Phase Accuracy: For compared channels of equal amplitude and compared channels of unequal amplitude with amplitude ratios up to 10.

Frequency	Sine Wave Phase Accuracy For Equal Ampl Angle	Unequal Ampl Angle
<1 kHz*	0.005°	0.020°
<10 kHz	0.030°	0.100°
<100 kHz	0.100°	0.500°
<1 MHz	0.500°	2.000°
<2 MHz	1.000°	5.000°

*At phase settings equal to 360/n where n is an integer in the range 1 – 8192.



Phase Accuracy for Amplitude Ratio 1:1



Phase Accuracy for Amplitude Ratio 1:10

Phase Delay
Phase offset of a channel may be programmed in delay time rather than in degrees. Model 650 will automatically compute phase in degrees (for any frequency) for a given delay.
Delay Resolution: 3 digits.
Delay Range: – 2 to + 2ms.

Modulation
There are six different amplitude, frequency and phase modulation modes used in combination with the primary modes. Refer to the **Modulation Modes** section for details.

Sweep
There are 29 different sweep modes covering phase sweeps, frequency sweeps and combined phase/frequency sweeps in combination with the primary modes. Details on sweep modes are given in the Sweep Generator section.

Phaselock
In phaselock mode, Model 650 will lock onto an external reference in the frequency range of 40Hz to 2 MHz. The main generator frequency will then be kept to the initial reference frequency. If the reference frequency changes in excess of ± 10%, Model 650 will reset its main generator frequency to the new frequency.
Phaselock Range: 40Hz to 2MHz.
Initial Lock Time: ⩽4 sec.
Re-lock Time: 100 periods + 100ms.

Delta Frequency
One channel at a time can run at a frequency that differs up to ± 1000 Hz from the main frequency. For example, the main generator and Ch1 can be run at a given frequency, Ch2 can run at a given frequency ratio, while Ch3 can run at yet another ratio and finally Ch4 can be operated at (N x main frequency) ± (N x delta frequency) whereas N is a ratio in the range 1 to 99 and delta frequency is a frequency in the range 0.1 mHz to 1000 Hz.
Range: – 1000 to + 1000 Hz.
Resolution: 3 digits but max 0.1 mHz.
Accuracy: 0.1%.

TRIGGERING

The 650 can be triggered via its internal trigger generator or an external trigger

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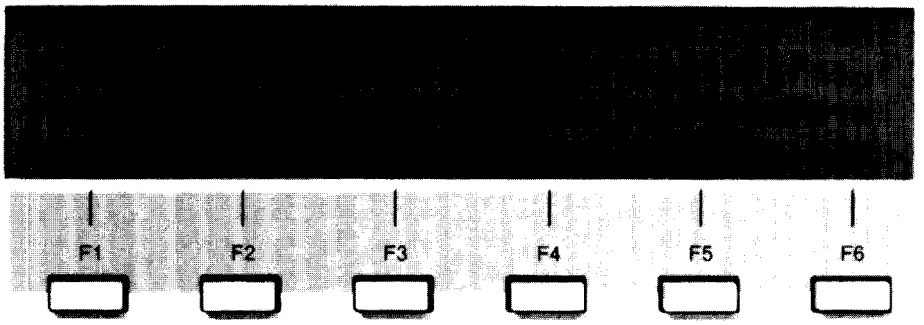


Display of Trigger Menu. Selected: External Source, Positive Slope, Trigger Level 1.4 Vdc

signal. In external trigger mode, trigger level and signal polarity are selectable.

Internal Trigger Signal

External Availability: Present at Marker Out connector in non-sweep modes.
Range: 2.5 mHz to ≥200 kHz.
Resolution: 3 digits.
Accuracy: 0.1%.

External Trigger Signal

Frequency Range: 0 to ≥200 kHz.
Amplitude Range: +10 to −10V.
Level Setting Resolution: 0.1V.
Level Accuracy: ±0.3V.

MODULATION

Amplitude Modulation

Range: 0 to 100%.
AM Bandwidth: 0 to 20 KHz.
Modulation Gain (VCG): 10.
AM Input Impedance: >10kΩ.
Protection: ± 50 Vdc (Momentary).

Phase Modulation

Range: Programmable 0 ± 1080°.
PM Bandwidth: 25 kHz.
Voltage Controlled Phase Modulation (VCPM): −1V to +1V for full modulation between programmed start and stop phase with 8 bit resolution.
PM Input Impedance: ≥1MΩ.
Protection: ±50 Vdc momentary.

Frequency Modulation

Programmable start and stop frequency in range 0.1 mHz to 2 MHz.
FM Bandwidth: 20 kHz.
Voltage Controlled Frequency Modulation (VCFM): −1V to +1V for full modulation between programmed start and stop frequency values with 8 bit resolution.

Frequency Shift Keying

Asynchronous (Async FSK) and Synchronous (Sync FSK).
Max Rate of FSK: 40 kHz (25 μs per step).
Max No. of Different Frequencies in FSK Mode: 100.
Switching Time Between Frequencies: ≤500 ns.

Phase Shift Keying

Max Rate of PSK: 65 kHz.
Phase Shift Keying Capabilities: Dual Phase Shift Keying (DPSK) and Quadrature Phase Shift Keying (QPSK) through sequenced phase sweep mode.
Max No. of Different Phase Values in PSK Mode: 100.

Pulse Position Modulation

Max Rate of PPM: 65 kHz.
Max No. of Different PPM Values: 100.

CHANNEL OUTPUTS

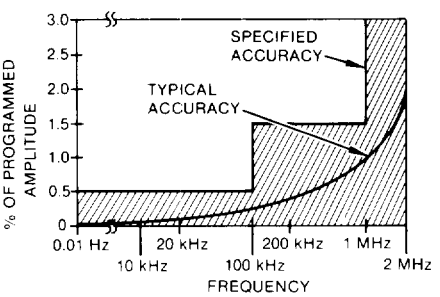
Each channel can individually be programmed for the following parameters.

Function

Sine, square, triangle, dc, ramp or programmable duty cycle square or ramp.

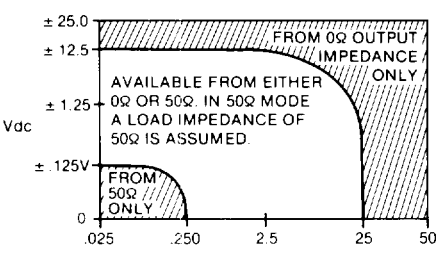
Amplitude

Range, Resolution and Accuracy: Refer to table 1. Range is restricted by dc offset as shown in the second diagram.



NOTES: 1. All accuracies ±2 mV.
2. 0Ω output impedance into high impedance load or 50Ω output impedance into 50Ω, 0.001% accurate load
3. Triangle and ramp to 200 kHz only

Amplitude Accuracy vs. Frequency



NOTES: 1. Maximum output current in 0Ω modes ±0.5A
2. Output voltage ≤250 mVp-p or ±125 mVdc are available from 50Ω impedance only.

Available and Permissible DC Offset and AC Amplitude Combinations.

Offset

Range, Resolution and Accuracy: Refer to table 2. Range is restricted by ac amplitude as shown in the diagram.

DC

Maximum Range: ±12.5mV to ±25V.
Range, Resolution and Accuracy: Refer to table 3.

Frequency Ratio

Each channel can be set at a ratio of 1 to 99 times the main frequency.

Output Impedance

Output impedance can be programmed to be either 0Ω or 50Ω or the output can be turned off (output relay open). In the 50Ω mode a 50Ω termination is assumed.

SWEEP

The 29 sweep modes allow phase sweep, frequency sweep, synchronous and asynchronous FSK modes and combinations of phase and frequency sweeps. Furthermore, phase and frequency can be swept in a linear, log, sine or random fashion. Sweep time and Start-Stop Phase/Frequency are programmable with synthesizer accuracy and resolution. Indexed phase and/or frequency sweep modes are available which allow the user to preprogram up to 100 steps of frequency and phase values. The whole or partial sequence can then be stepped through under internal sweep generator or external trigger control. In addition, sweep modes can be continuous, triggered, triggered with reset, hold and reverse, etc. Finally, a sweep can be interrupted by an external, GPIB or front panel hold command while an operator may monitor phase or frequency via the front panel display. A waveform hold allows external, GPIB, or front panel "freezing" of a waveform at its current dc voltage value. To allow very high sweep rates on the one hand while providing optimum accuracy at the other, a sweep can be compensated or uncompensated. In the compensated sweep mode, extreme amplitude flatness and very high phase accuracy are maintained by applying correction values previously stored in the Autocal (refer to **Calibration**) database. In the uncompensated mode, these correction values are ignored and in their place very high sweep rates are provided. Because of the enormous number of sweep mode, time, trigger and compensation combinations, it is not practical to specify all possibilities. The following data and illustrations allow the user to derive timing and/or resolution parameters where necessary. Detailed information is available in the applications manual or from Wavetek's Applications Engineering Department.

Table 1. Amplitude Range, Resolution and Accuracy

Output Impedance	Range (Vp-p)	Resolution	Accuracy ≤100 kHz	Accuracy ≤1 MHz	Accuracy ≤2MHz
0Ω	2.5 – 50	1 mV	± 0.5% ± 2 mV (typ: ± 0.2% ± 1 mV)	± 1.5% ± 2 mV (typ: ± 0.3% ± 1 mV)	± 3% ± 2mV (typ: ± 1.5% ± 1 mV)
50Ω	0.025 – 0.25	10μV			
	0.25 – 2.5	100μV			
	2.5 – 25	1 mV			

Table 2. Offset Range, Resolution and Accuracy

Output Impedance	Range (Vp-p)	Resolution	Accuracy
0Ω	± 25	1 mV	0.5% ± 30mV
50Ω	± 12.5	1 mV	0.5% ± 20mV
	± 1.25	0.1 mV	0.5% ± 10mV
	± 0.125	10μV	0.5% ± 5mV (typ: 0.1% ± 3mV)

Table 3. DC Range, Resolution and Accuracy

Output Impedance	Range (Vp-p)	Resolution	Accuracy
0Ω	± 25V	1 mV	0.3% ± 10mV
50Ω	± 12.5V	1 mV	0.3% ± 5mV
	± 1.25V	0.1 mV	0.3% ± 2mV
	± 0.125V	10μV	0.3% ± 1mV

Frequency Sweep

Modes:

1:Continuous with Reset.
2:Continuous with Reverse.
3:Triggered with Reset.
4:Triggered with Reverse.
5:Triggered with Hold and Reset.
6:Triggered with Hold and Reverse.
7:Synchronous FSK.
8:Asynchronous FSK.
9:Externally Triggered Sequence.
10:Continuous (Looping) Sequence.
11:Stepped Sequence on Trigger.
12:External FM.

Range: 0.1 mHz to 2 MHz.
Resolution: 10 digits but max 0.1 mHz.
Accuracy: 5ppm ± 10 μHz.
Sequenced Sweeps (Modes 9, 10, 11): No. of Programmable Steps (Index): 1 to 100.
Frequency Switching Time: ≤500 ns.
Throughput: Refer to table 4.

Phase Sweep

Modes:

13:Continuous with Reset.
14:Continuous with Reverse.
15:Triggered with Reset.
16:Triggered with Reverse.
17:Triggered with Hold and Reset.
18:Triggered with Hold and Reverse.
19:Externally Triggered Sequence.
20:Continuous (Looping) Sequence.
21:Stepped Sequence on Trigger.
22:Delta Frequency Sweep.
23:External PM (Phase Modulation).

Range: -10^6 to $+10^6$ degrees continuous.
Resolution: 10 millidegrees.
Accuracy: Refer to table.
Sequenced Sweeps (Modes 19, 20, 21): No. of Programmable Steps (Index): 1 to 100.
Phase Switching Time: ≤500 ns.
Throughput: Refer to table 4.

Combined Frequency and Phase Sweep

Modes:

24:Combined Simultaneous. Frequency/Phase Sweep (with identical start/stop frequency for all channels, except for ratio <>1, but individually programmed start and stop phase for each channel).
25:Triggered Combined Sweeps with Hold and Reset.
26:Externally Triggered Frequency/Phase Sequence.
27:Continuous (Looping) Frequency/Phase Sequence.
28:Stepped Frequency/Phase Sequence on Trigger.
29:External Combined FM/PM.

Range, Resolution and Accuracy: Same as for Frequency Sweep and Phase Sweep.

Sequenced Sweeps (Modes 26, 27, 28): No. of Programmable Steps (Index): 1 to 100.
Switching Time: ≤500 ns.
Throughput: Refer to table 4.

Sweep Functions

Linear: Sweep progresses linearly from programmed start to stop value.
Log: Sweep progresses in a logarithmic fashion from start to stop value.
Random: Swept parameter changes in a random pattern uniformly distributed between start and stop value.
Sine: Swept parameter (frequency, phase or both) changes in a sinusoidal pattern from start to stop value.

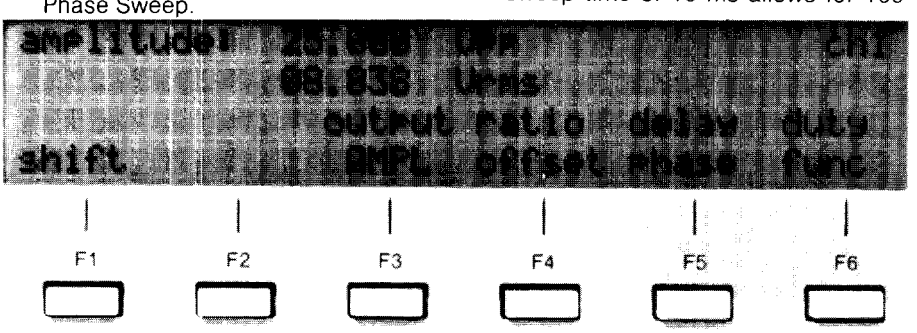
NOTE: In combined sweep modes 24 and 25, only the linear sweep function is allowed.

Table 4. Sequenced Sweeps Throughput

Sequence Mode	Compensation On	Compensation Off
9:Triggered Frequency	1.24 kHz	42 kHz
10:Continuous Frequency	1.24 kHz	38 kHz
11:Stepped Frequency	1.24 kHz	37 kHz
19:Triggered Phase	1.26 kHz	70 kHz
20:Continuous Phase	1.26 kHz	61 kHz
21:Stepped Phase	1.25 kHz	58 kHz
26:Triggered Combined	1.22 kHz	24 kHz
27:Continuous Combined	1.21 kHz	23 kHz
28:Stepped Combined	1.21 kHz	22 kHz

Sweep Times and Resolution

Sweep times and resolution greatly depend on the chosen sweep function (linear, log, sine or random), the swept parameter (frequency, phase or both) and whether or not compensation of parameters is required. The fastest sweep time of 10 ms allows for 100



Display of Channel 1's Parameter Menu. Selected: Amplitude, 25.000 Vp-p (8.838 Vrms).

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sweeps per second. In compensated mode, the fastest sweep time of 200 ms allows for 5 sweeps per second. The longest sweep time is 10^7 seconds or approximately 116 days. Compensation is generally only necessary if sweeping in frequency ranges over 100 kHz.

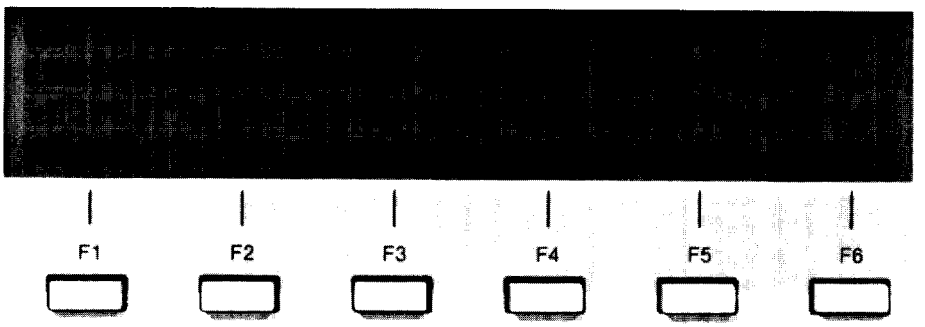
Sweep Time:

Range: 10 ms to 10^7 sec.
Resolution: 3 digits but max 1 ms.
Accuracy: 0.1%.
Sweep Resolution: Phase and frequency sweep resolution can be derived using the following fixed step rate table.
Fixed Step Rates: (For combinations of sweep function, swept parameter and compensation.) Refer to the following table.

Fixed Step Rates

Sweep Function	Compensation On (Steps/sec)	Compensation Off (Steps/sec)
Frequency Sweep		
Linear	1443	13,333
Log	962	4,167
Sine	1053	6,667
Random	1156	15,400
Phase Sweep		
Linear	1176	20,000
Log	1010	5,263
Sine	1064	7,143
Random	1183	22,200
Combined Frequency and Phase Sweep		
Linear	1053	6,667

Example: Assume a linear frequency sweep with a start frequency of 20 kHz, a stop frequency of 40 kHz and a sweep time of 2 seconds. In the lower frequency ranges, the compensation is not necessary therefore the uncompensated sweep is chosen, hence, a resolution of 13333 steps per second applies (Frequency Sweep, Linear Function, Compensation Off). This results in a total of 26666 steps in 2 seconds, thus a step size of (40 kHz − 20 kHz)/26666 or 0.75 Hz. Similarly, a linear phase sweep from 0° to 90° in a time of 1 second would result in phase increments of 76.5 millidegrees (rounded to 75 millidegrees) in compensated and 4.5 millidegrees (rounded to 5) in uncompensated mode. To arrive at these numbers simply divide the sweep range (90°) by the number of steps per second.



Display of Calibration Menu. Selected: Manual Calibration. Display: Step 2.

Modulation Sampling Speed

Module Mode	Compensation On	Compensation Off
12: Ext FM	1.21 kHz	20.8 kHz
23: Ext PM	1.22 kHz	25.0 kHz
29: Comb FM + PM	1.03 kHz	5.1 kHz

MASTER/SLAVE CAPABILITIES

Up to 10 Model 650's, each with up to 4 channels can be cascaded for a total of 40 phase-coherent, phase-controlled signals. Model 650 can be programmed to be either the master unit or a slave unit. Units are interconnected by three BNC cables for synchronization. Phase accuracy of slave units is equal to 2x the tolerance levels specified under Phase Accuracy.

CALIBRATION

Model 650 has internal calibration facilities that render classical calibration procedures obsolete. There are only two basic adjustments for the main generator and reference/calibration circuits, namely, the frequency of the internal 10 MHz clock and the reference voltage for the Ref/Cal circuits. Each output channel also has five adjustments. Three of the adjustments, filter flatness and two amplitude adjustments, are factory set and are not expected to undergo changes. The other two adjustments concern waveform quality and digital-to-analog conversion. With the exception of waveform quality (an adjustment that typically is required only once) the other calibration steps require no more than a high accuracy counter and DVM. The calibration procedure is stepped through via a "plain English" menu built into Model 650. Complete calibration of a four channel Model 650 can be accomplished in a matter of minutes without the need for a manual or lengthly procedure.

Once the calibration is completed, an autocal procedure is initiated which performs a self-characterization of analog circuitry within 1 minute for a two channel unit (2 minutes for a 4 channel unit). The autocal procedure requires no external measurements or additional instruments. The results of the self-characterization are stored in battery protected memory. Thus all non-linearities and differential delays of analog circuits are measured, and correction values are then computed and stored in the autocal database. These correction values are then used to obtain optimum amplitude and phase accuracy at any given frequency. Furthermore, a quick-cal feature is available. Since the autocal procedure stores its correction parameters under given ambient conditions, the data may not give optimum results if ambient temperatures change significantly. Quick-cal initiates a calibration procedure that provides optimum accuracy for the particular instrument setup; i.e., amplitude/offset/phase at a specific frequency for the prevailing ambient conditions. Within seconds, this results in optimum instrument accuracy which therefore provides consistent performance under varying conditions. The autocal correction parameters can be disabled and enabled under menu/front panel control to allow basic verification of analog circuits. If Model 650 cannot obtain the specified accuracies in either autocal or quick-cal, it will generate an error message which directs the operator to the appropriate circuits. Because autocal requires very little time (one minute for a 2 channel unit) it provides an excellent way of fast performance verification giving the operator (or the ATE system) maximum operational confidence. Because of these easy to use and fast automated calibration steps, periodic maintenance/calibration can be minimized and replaced by an "as needed" policy.

STORED SETTINGS

In addition to the stored sequence values for frequency and phase, Model 650 can store up to 25 complete instrument setups including every parameter for every channel you have seleced. Moreover the 650 also stores the current setup automatically so you may turn the unit off and return the next day, week or month and with 4 keystrokes restore any of 25 setups exactly the way you stored them.

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GPIB INTERFACE

Model 650 has a built-in alphabetical syntax list allowing you to start programming within minutes after unpacking the unit. The built-in "HELP" file can be printed out via a computer to give you your own syntax list. The 650 is extremely flexible in accepting GPIB commands.

For example you may program frequency by sending the "strings" shown below and the 650 will accept each of them!

Output @701:"FR 1000 EX"
Output @701:"Freq 1000 Execute"
Output @701:Frqncy 1E3 Exct"
Output @701:Frequency 1000 Execute"

Moreover, the 650 will detect programming errors. Syntax errors and parameter errors are detected, identified and categorized by the 650. The Input and SRQ buffers, each 256 characters long, can be displayed via the front panel or read by a computer. So all programing problems can be displayed, allowing easy program debugging. SRQ masks can be defined and, for example, even low battery voltage (for memory protection) will generate a service request. In short, the 650 reflects Wavetek's experience in providing easy to use, yet sophisticated programmable products.

Address Range
0 to 30 switch selectable. If enabled via rear panel switch, address can also be changed from front panel.

Subsets
SH1, AH1, TE0, L4, RL1, PP0, DC1, C0, E2.

I/O CONNECTIONS

Reference Out
Impedance: 50Ω source.
Level: TTL, <0.4V, >2.4V into 50Ω.
Fanout: 10 reference inputs.
Frequency: 10 MHz, ±5 ppm.
Protection: ±5 Vdc momentary.

Reference In
Impedance: >1kΩ ac coupled.
Level: >500 mVp-p, <50 Vdc.
Frequency: 10 MHz ± 1%.
Protection: ±50 Vdc momentary.

Trigger Input
Impedance: >5 kΩ.
Level: >500 mVp-p, <±10 Vdc.
Input: 0 to >200 kHz, 20 ns min.
Protection: ±50 Vdc momentary.

Hold Input
Impedance: <1 kΩ.
Level: TTL, active low.
Protection: ±20 Vdc momentary.
Function: selectable sweep or waveform hold.

FM/PM Input
Impedance: >1 MΩ.
Level: −1 to +1V (for full range).
Protection: ±50 Vdc.

Sampling Speed

Mode	Comp Off	Comp On
Ext FM	20 kHz	1kHz
Ext PM	25 kHz	1kHz
Ext FM/PM	5 kHz	1kHz
Resolution	8 mV	
Accuracy	± 5%	

Marker Out
Impedance: 50Ω source.
Level: TTL, <0.4V, >2.4V into 50Ω.
Output: Low when freq/phase < marker.
Protection: ±20 Vdc momentary.

2.048 V Out
Impedance: 1 kΩ.
Level: 2.048V ± 5 mV.
Output: Internal V ref cal test point.
Protection: ±50 Vdc momentary.

Phase Cal Input
The Phase Cal input is intended to externally calibrate a master/slave pair or group, or to measure phase shift through external circuits. When these measurements are not being made a relay disconnects the BNC from internal circuits.
Impedance: >300Ω.
Level: 40 Vp-p max.
Input: Slave channel for multi-unit cal.
Protection: Unprotected when calibrating, protected to ±100 Vdc otherwise.

Horiz Out
Impedance: 1 kΩ.
Level: 0 to + 10 Vdc.
Output: % of sweep.
Accuracy: ±2%.
Resolution: 40 mV.
Protection: ±50 Vdc momentary.

Phase Out*
Impedance: <50Ω.
Level: TTL.
Output: Sync pulse for master/slave configuration.
Protection: None.

Phase Clear*
Impedance: <50 ohm.
Level: TTL.
Output: Clear pulse for master/slave configuration.
Protection: None.

*Phase Out and Phase Clear are only used to lock units together in a master/slave pair or group.

Channel Func Out
Impedance: 50Ω, 0Ω selectable.
Level: −25 V to +25 V.
Output: Main function output.
Protection: Current limit at 500 mA. Withstands ±60 Vdc indefinitely.

Sync Out
Impedance: 50Ω source.
Level: TTL, <0.4, >2.4 V into 50Ω.
Output: Sync in phase with sine wave. Phase accuracy not specified.
Protection: ±20 Vdc momentary.

AM Input
Impedance: >10 kΩ.
Level: 0 to +5 V.
Input: Modulation signal up to 20 kHz BW.
Protection: ±50 Vdc momentary.

GENERAL

Environmental
Temperature Range: 0° to 50°C. 25° ± 10°C for specified performance.
Warm-up Time: 20 minutes for specified performance.
Relative Humidity: 95% at 25°C and sea level (non-condensing).
Altitude: Sea level to 10,000 ft for operation. Sea level to 40,000 ft for storage.
Dimensions: 44.5 cm (17.5 in.) wide; 13.3 cm (5.3 in.) high; 53.3 cm (21 in.) deep.
Weight: 16.3 kg (36 lb).
Power: 90 to 126, 190 to 252 Vac, 48 to 66 Hz, ≤250 watts.

OPTIONS

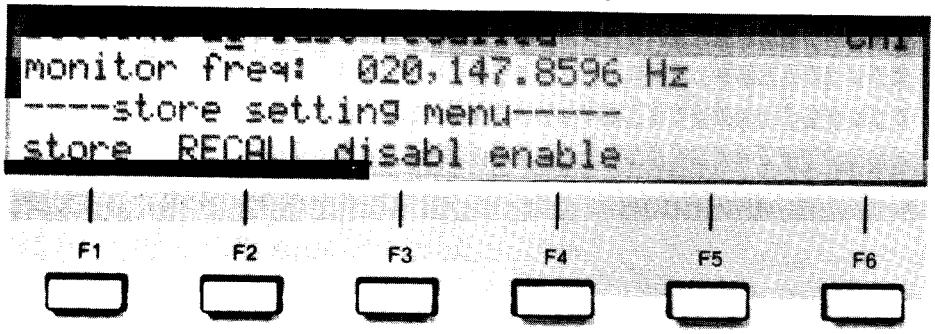
001: Two Additional Channels
Two additional channels and the associated RAM board mount in the chassis for a total of four channels.
010: MATE Interface

FACTORY/FOB

San Diego, CA

PRICE

Model 650	**$8500**
Option 001	**$3500**
Option 010	**$2400**



Display of the Stored Setting Menu. Selected: Recall Setting 25.