SECTION 1
GENERAL DESCRIPTION

1.1 MODEL 178

The Model 178 Programmable Waveform Synthesizer is a 1 μHz to 50 MHz multifunction sweep synthesizer that can operate as a trigger, gate or burst generator at levels to 20 volts peak-to-peak. It is synthesized to 8 digits in all modes.

Its main generator, an 8 digit 50 MHz synthesizer, produces sine and square waves and, at reduced frequencies, triangles, ramps, pulses and haverwaves.

An external reference input can phase lock the synthesizer by locking the reference source. Phase locking allows the synthesizer to operate as a variphase generator with phase offset in 0.01° increments.

The output level is specified into a 50Ω load from 1 mV to 20 Vp-p with 3 digits resolution. DC offset can be programmed to vary the waveform base line ±10V. Amplitude is displayed in units of Vp-p, Vrms or dBm for any waveform.

The internal sweep generator varies the main generator frequency (linearly or logarithmically) between the start and stop frequencies. The sweep generator has its own operating modes: triggered, gated, hold at start and hold at stop. In addition, ten programmable frequency markers, available one at a time, can be used to indicate critical frequencies within the sweep. The sweep generator can internally trigger the main generator to produce pulses with a 10 μs to 10 min. repetition rate and 5 μs to 5 days pulse width.

Two external inputs may be used to phase- or amplitude-modulate the synthesizer. If the synthesizer is phase modulated, the main generator (when operating at frequencies above 500 kHz) varies up to ±360°. When amplitude modulated, the output can be modulated up to 200%.

Data entry is from the front panel or GPIB with microprocessors controlling the data. Numeric input is entered in free format: fixed, floating or exponential notation. Parameters may be entered in any order. Internally, all entries are checked for errors and interactively displayed on the front panel.

Up to 5 complete sets of programming may be stored and rapidly recalled.

1.2 OPTIONS

Option 001 allows up to 40 sets of complete front panel settings to be stored in memory. Memory is battery backed up (internally recharged) for 60 days (minimum) retention of settings. Memory is expandable to 240 settings.

Option 002 provides an additional high stability frequency reference crystal for greater accuracy. The high stability frequency has an accuracy of $\pm 5 \times 10^{-8}$ and an aging rate of 5×10^{-9}/day (average) or $<4 \times 10^{-8}$/week.

1.3 SPECIFICATIONS

1.3.1 Versatility

Waveforms

Sine ∿ , square ⊓ , triangle △ , ramps ◿, ◺, haversine ⩚, ⩛, havertriangles ⩚ , ⩛ , AM (sine) ◇◇ , and DC.

Operational Modes

NOTE

1. *All modes are synthesized.*
2. *See Frequency Range Section for frequency capability in each mode.*
3. *Trigger modes: Trigger jitter <1% of waveform period.*

Continuous: Generator runs continuously.

Triggered: Generator is quiescent until triggered by an external signal, internal sweep signal, GPIB or manual trigger, then generates one cycle at selected frequency.

Gated: As triggered mode, except generator oscillates for the duration of the gate signal plus the remainder of the waveform in progress.

Triggered Haverwave: As triggered mode, except output is a sine or triangle waveform starting at −90° (or +90°).

Gated Haverwave: As gated mode, except output is a sine or triangle waveform starting at −90° (or +90°).

Triggered Burst: As triggered mode, except the number of cycles output for each trigger input is selectable from 1 to 65,536 (2^{16}) counts.

Triggered Haverwave Burst: As triggered burst, except output is a sine or triangle waveform starting at −90° (or +90°).

Frequency Sweep: Output frequency can be swept by internal sweep generator. (See Sweep Generator).

Frequency Range
Low-end frequency for all waveforms is 1μHz.

Continuous Mode:
∿ , ⊓ , ◊◊ (AM sine) to 50 MHz.
∿ to 500 kHz.
◿, ◺ to 20 kHz.

All Triggered Gated and Burst Modes:
∿ , ⊓ , ∿ , ◊◊ (AM sine) to 200 kHz.
◿, ◺ to 20 kHz.

Main Output
All waveforms are available to 20 Vp-p maximum into 50Ω load. Combined amplitude/dc offset waveforms not to exceed ±10V peak into 50Ω. Output voltage into an open circuit is double indicated voltage when a voltage less than ±5V peak is selected. Output available from front or rear. Source impedance: 50Ω (for <10V output), hi Z (for >10V output). Output may be floated up to 42V peak.

Phase Offset: Output phase may be changed from ±1000 revolutions (±360,000°) in 0.01° resolution steps to 500 kHz and 0.1° (or better) resolution steps above 500 kHz.

Amplitude Conversion
Permits entry and display of amplitude for all waveforms in units of Vrms, Vp-p and dBm.

DC Offset and DC Voltage Output
0 to ±10 Vdc into 50Ω. Output voltage is double into open circuit when voltage less than ±5 Vdc is selected.

Auxiliary Outputs
TTL and TTL Sync: At generator frequency, 50Ω source impedance, 50% duty cycle, <5 ns transition time.

Reference Output: 10 MHz, 1 Vp-p sine, 50Ω source impedance.

Sweep Ramp: (See Sweep Generator).

Frequency Marker: (See Sweep Generator).

Inputs
Trigger: A TTL level transition can trigger or gate both main generator and/or internal sweep generator. Triggering slope up (⨍) or down (⨍) is selectable.

Reference: An external 0.5V to 10 Vp-p sine or pulse clock of ±5 ppm or better stability and accuracy automatically locks the internal reference. External clock may be 1, 2, 3..., 9 or 10 MHz. Input impedance is 1 kΩ.

Amplitude Modulation: Modulation levels up to 20 kHz. Input impedance is 600 ohms. Amplitude reduced by approximately 50% with 0V input. 5.4 Vp-p, ±15%, ac signal (with 0V offset) provides 99% modulation. AC signal with −2.7 Vdc, ±15%, provides 200% modulation. Modulation bandwidth typically 10 MHz. Sync output unaffected by modulation.

Phase Modulation: Rates from DC to 10 kHz minimum. Input impedance is 10 kΩ. ±5V input delivers approximately ±360° shift. Output deviation is ÷100 for main output frequencies 500 kHz and below.

Data Entry
Front panel keyboard with display and GPIB programming.

1.3.2 Main Generator

1.3.2.1 Frequency Resoltion

8 digits or 1μHz.

1.3.2.2 Frequency Precision

Accuracy

Better than 0.0005% of program setting, ±0.01 μHz.

Stability
Long Term: $\pm 1 \times 10^{-6}$/mo.

Temperature: $\pm 1.2 \times 10^{-7}$/°C.

Signal to Phase-Noise
Better than −46 dB in a 30 kHz band centered on carrier but excluding a ±1 Hz band around the carrier.

Spurious
−60 dBc or 30 μV whichever is greater, 1 μHz to 500 kHz.
−48 dBc or 30 μV whichever is greater, 500 kHz to 50 MHz.

1.3.2.3 Amplitude Precision

Resolution and Accuracy

NOTE
DC offset range is 0 to ± 10 Vdc.

Amplitude Range	Accuracy (Amplitude)
10.02 to 20.00 Vp-p	±1% ±20 mV
1.01 to 10.0 Vp-p	±1% ±10 mV
0.101 to 1.00 Vp-p	±3% ±2 mV
10.1 to 100 mVp-p	±4% ±100 μV
1.00 to 10.0 mVp-p	±5% ±20 μV

NOTE
Specified for 1 kHz sine wave, or for dc output into a precision 0.1% 50Ω load.

Resolution: 3 digit ≤10.0 Vp-p, 4 digit (20 mV) >10 Vp-p.
DC Offset: ±1% of setting ±40 mV (worst case).

NOTE
Amplitude and dc offset share the output attenuator.

Frequency Response

Frequency Range	Response
1 μHz to 20 kHz	±1%
20 kHz to 500 kHz	±3%
500 kHz to 25 MHz	±7%
25 MHz to 50 MHz	±15%

Specified relative to 1 kHz sine wave, <6 Vp-p, 0V offset into 50Ω.
For ⊓ add 1% . For ∿ add 1% to 20 kHz; for greater than 20 kHz, unspecified.
For ⟋ , ⟍ add 5% to 10 kHz; add 15% to 20 kHz.

Amplitude and Offset Stability
Short Term: 0.1% ± 1 mV for 10 min.
Long Term: 0.5% ± 5 mV for 6 months.
Measured at room temperature.

1.3.2.4 Waveform Characteristics

Sine Distortion

Harmonically related signals less than:
−55 dB to 50 kHz.
−40 dB to 500 kHz.
−30 dB to 50 MHz.
Specified for 1 Vrms (2.83 Vp-p) sine wave.

Square Wave Rise and Fall Time
Less than 10 ns, 1.01 to 10.00 Vp-p.
Less than 12 ns, greater than 10 Vp-p.

Square Wave Aberrations
≤5% ± 50 mV of p-p voltage.

1.3.3 Sweep Generator

Sweep generator is fully synthesized and may be used independently or for frequency sweeping and triggering the main generator. Frequency sweep may be selected linear or logarithmic, and up or down. Sweep may be triggered, interrupted with hold, and continued with resume.

1.3.3.1 Sweep Modes

Continuous Sweep: Sweep generator sawtooth runs continuously.

Triggered Sweep: Incoming trigger causes a single sweep and resets to the start frequency.

Triggered Sweep/Triggered Reset: As in triggered sweep, but sweep holds at stop frequency until subsequent trigger returns frequency to start frequency.

1.3.3.2 Sweep Characteristics

Sweep Time
0.01 to 600.00 sec, 10μs resolution.

Sweep Output
0 to approximately +5V ramp synthesized to 2000 steps per sweep. 600Ω output impedance.

Frequency Marker Output
TTL levels. One of the ten preset markers can be selected. Output is low when the main generator frequency is below marker frequency; output is high when above. Crystal clock accuracy equal to that of synthesizer.

Maximum Sweep Range
Low Band: 1 μHz to 500 kHz.
High Band: 5 kHz to 50 MHz.

Minimum Sweep Range

Linear: Any start and stop frequencies with a minimum separation of:

Low Band: 20 mHz per 1 s of sweep time.
High Band: 2 Hz per 1 s of sweep time.

Log: Any start and stop frequencies with ratio greater than 2.

Sweep Resolution
Frequency Resolution including Start, Stop, Hold, Markers: 8 digits or 1 μHz.

Sweep Frequency Update: Every 5 μs (lin and log).

Log Slope Update: Every 2 ms.

1.3.3.3 Pulses

⊓⊔ function triggered by sweep generator. Pulse parameters of period and width are controlled by sweep time and main generator frequency respectively. Pulses are generated to high synthesizer resolution and accuracy. Pulses include continuous, single, burst, gated and complement.

Period
10 μs to 600s.
4 digits or 10 μs resolution (Control: Sweep Time);
jitter <2% of pulse width.

Width
5 μs to 500,000s (>5 days);
8 digits resolution (Control: Main Frequency);
<0.05% jitter.

NOTE
Width is usable to 1 μs.

1.3.4 General

Stored Settings
Up to 5 complete instrument setups can be stored and recalled from volatile (RAM) memory. Settings may be modified or deleted.

GPIB Programming
Standard General Purpose Interface Bus (GPIB) programming per IEEE Standard 488-1978. Interface is optically isolated from signal ground. Interface includes Listener (AH1 and L4), Talker (SH1 and T6), SRQ (SR1), Local Lockout (RL1), Device Clear (DC1), Group Execute Trigger (DT1) capabilities, and open collector logic (E2).

Parameter	Time
Command Handshake	15 μs
Data Handshake	65 μs
Frequency	11 ms
Amplitude	14 ms
DC Offset	14 ms
Mode	4 ms
Function	5 ms
Output	4 ms
Stored Settings	13 ms
Execute	8 ms

NOTE
Above programming speeds are typical. Programming times vary with different controllers. Data rate follows slowest listener on bus.

Environmental
Accuracy applies for 25°C ±10°C after 30 minutes warm-up unless otherwise noted. Instrument will operate from 0°C to 50°C to 10,000 ft altitude at 90% relative humidity. Storage temperature from −25°C to +65°C.

Dimensions
44.5 cm (17.5 in.) wide; 13.3 cm (5¼ in.) high; 53.4 cm (21 in.) deep. Supplied with rack mount adapters.

Weight
13.6 kg (30 lb) net; 19.4 kg (43 lb) shipping.

Power
90 to 105V, 108 to 126V, 198 to 231V or 216 to 252V; 48 to 67 Hz; less than 180 watts.

1.3.5 Options

001 Additional Stored Settings
Provides nonvolatile memory for 240 additional stored settings. Memory is battery backed up (internally recharged) for 60 day (minimum) retention of settings.

002 High Stability Frequency Reference

An additional frequency reference crystal for greater accuracy.

Accuracy: $\pm 5 \times 10^{-8}$
Aging Rate: 5×10^{-9}/day (average) $< 4 \times 10^{-8}$/week.