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# Agilent 8904A

# Multifunction Synthesizer dc to 600 kHz

Technical Specifications

**Build complex waveforms from common signals**




The Agilent Technologies 8904A Multifunction Synthesizer uses VLSIC technology to create complex signals from six fundamental waveforms. The standard 8904A digitally synthesizes precise sine, square, triangle, ramp, white noise, and dc waveforms and routes these signals to a single output. Option 001 adds three more identical internal synthesizers (channels) which can either modulate the first synthesizer or be summed to the output. Frequency, amplitude, waveform, phase, and destination can be independently set for each synthesizer. Available modulation types for channel A include AM, FM, F M, DSBSC, and pulse modulation. Option 002 adds a second 50 Ω output, providing a second separate signal for two channel applications. Option 003 adds fast hop and digital modulation capability to the 8904A. Option 005 allows multiple 8904As to be phase synchronized for applications which require the use of more than one 8904A. Option 006 changes output one of the 8904A from a 50 Ω floating output to a 600 Ω, high-power balanced output. With this option, the 8904A can deliver 10 volts rms into a 600 Ω load from 30 Hz to over 100 kHz. All this unique capability makes the Agilent 8904A a powerful new tool for demanding applications like VOR, ILS, FM stereo, and communications signaling.

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# AGILENT 8904A SPECIFICATIONS

*Specifications describe the instruments' warranted performance (<50 Ω output only unless noted) for automatic operation. Mathematically derived characteristics denote parameters which can be derived from specifications and knowledge of the digital generation methods used in the 8904A. Supplemental characteristics are intended to provide information useful in applying the instrument by giving typical, but not warranted, performance parameters. These are noted as "typical," "normal," or "approximate."*

## Frequency

**Range**:
Sine wave: 0 Hz to 600 kHz
Square, triangle, ramp: 0 Hz to 50 kHz
**Resolution:** 0.1 Hz
**Accuracy:**
Internal 10 MHz timebase: ±50 ppm
External 10 MHz timebase: Same as accuracy and stability of external timebase

## AC amplitude (sinewave)

**Range**: 0 to 10 $V_{p-p}$ into a 50 Ω load
**Resolution**: 3½ digits
**Accuracy (Amplitude >40 $mV_{p-p}$ into 50 Ω):**
1%, 0.1 Hz to 100 kHz
3%, 100 kHz to 600 kHz
**Flatness (Amplitude >630 $mV_{p-p}$ into 50 Ω):**
±0.1% (±0.009 dB), 0.1 Hz to 100 kHz
±1.0% (±0.09 dB), 100 kHz to 600 kHz

## Spectral Purity (sine wave)

**THD+N (Including spurs, amplitude >50 mV rms into 50 Ω):**
–63 dBc rms (0.07%), 20 Hz to 7.5 kHz, 30 kHz BW
–63 dBc rms (0.07%), 7.5 kHz to 20 kHz, 80 kHz BW
–55 dBc rms (0.18%), 20 kHz to 100 kHz, 750 kHz BW

## Phase (sine wave)

**Range:** 0 to 359.9°
**Resolution:** 0.1° or 0.001 radians
**Increment Accuracy (Relative to 0° for a fixed frequency):**
±0.05°, 0.1 Hz to 100 kHz

## DC Amplitude

**Range:** 0 to ±10 V open circuit
**Resolution:** Three and a half digits
**Accuracy:** ±20 mV or ±2.1%, whichever is greater

## Gaussian Noise

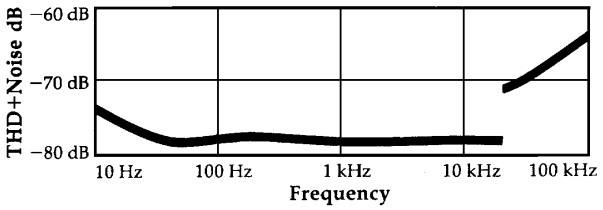
**Spectral Characteristic:** Equal energy per unit bandwidth ("white")
**Amplitude Range:** 0 to 10 $V_{p-p}$ into a 50 Ω load[1]
**Resolution:** Three and a half digits

## Mathematically Derived Characteristics

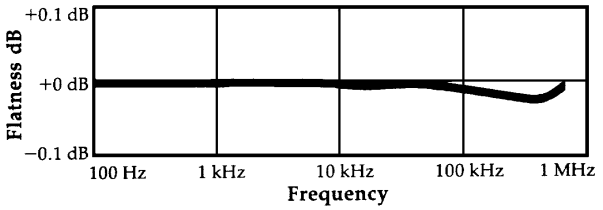
***Noise Flatness (Amplitude >100 $mV_{p-p}$ into 50 Ω):***
*±0.5 dB, 0.1 Hz to 100 kHz*
*±1.0 dB, 100 kHz to 600 kHz*

***Supplemental Characteristics***
***Number of Outputs:*** *One standard; two with Option 002*
***Number of Internal Channels:*** *One standard, two with Option 002; four with Option 001*
***Standard Waveforms:*** *Sine, square, triangle, ramp, dc, and Gaussian white noise*
***AC Amplitude Accuracy:*** *Typically:*
*Square wave: <3% at 20 kHz*
*Triangle: <4% at 20 kHz*
*Gaussian white noise: <5%*
*Ramp: <7% at 20 kHz*
***Square Wave Rise-time/Fall-time:*** *Typically <2.5 µs*
***Spurious (Typically the higher of):*** *–50 dBc or 500 $µV_{p-p}$, 100 kHz to 600 kHz, 20 MHz BW*
***Noise Crest Factor:*** *Typically >4.4*
***Switching Speed (via GPIB):*** *Typically <25 ms*

***Typical THD+Noise in 80 kHz measurement BW (above 20 kHz, in a 750 kHz measurement BW) at 5 $V_{p-p}$ into a 50 Ω load***




***Typical level flatness (1 kHz reference) at 5 $V_{p-p}$ into a 50 Ω load***

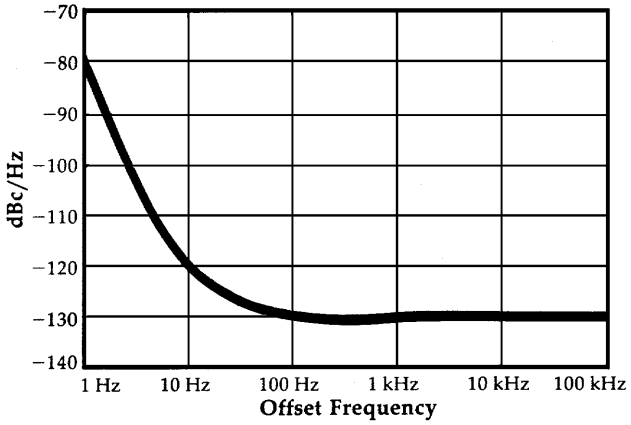



1. $\text{Noise Voltage} / \sqrt{\text{Hz}} \approx \dfrac{\text{Peak Voltage}}{(\text{Crest Factor}) \times 2 \times \sqrt{\text{Bandwidth}}} \approx \dfrac{\text{Vpk}}{(4.4) \times (2) \times \sqrt{745\ \text{kHz}}}$



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***Typical SSB phase noise at 500 kHz***




## OPTION 001 SPECIFICATIONS

**(50 Ω outputs only)**

### Modulation

Modulation for channel A ONLY, and specified for sinewave carrier and modulation. Internal channels B, C, and D can be used to either collectively modulate channel A with one modulation type, or can provide simultaneous modulation of channel A with any of the available modulation types. External modulation is NOT possible.

### Amplitude Modulation (with Option 001)

**Rate:** 0 Hz to 600 kHz
**Depth Range:** 0% to 100% of carrier amplitude
**Resolution:** 0.1% of carrier amplitude

### Frequency Modulation (with Option 001)

**Rate:** 0 Hz to 600 kHz
**Deviation Range:** 0 Hz up to 600 kHz; however $F_{carrier} + F_{deviation} \leq 600$ kHz
**Resolution:** 0.1 Hz or 3½ digits, whichever is less

### Phase Modulation (with Option 001)

**Rate:** 0 Hz to 600 kHz
**Range:** 0° up to 179.9° per channel, however:

$$F_{carrier} + \left\{ \frac{(F_{mod} \times Dev°)}{57.3} \right\} \leq 600 \text{ kHz}$$

**Resolution:** 0.1° or 0.001 radians

### Pulse or DSBSC Modulation (with Option 001)

**Rate:** 0 Hz to 50 kHz (up 600 kHz for DSBSC)

### Summation (with Option 001)

**Two, Three, or Four Channels** may be summed into a single output. Two or three channels may be summed for modulation of channel A. All combinations of channels are acceptable, EXCEPT FOR: {A+C and B+D} or {A+D and B+C} at the same time.
**Channel-to-Channel Phase Accuracy (Equal amplitude, sinewave signals summed into one output):** +0.1 degrees or 30 ns, 0.1 Hz to 100 kHz, whichever is greater

## Mathematically Derived Characteristics

**AM Accuracy (The higher of):** ±0.024% AM or ±0.20% of setting, up to 20 kHz modulation rate and 100 kHz carrier, 1% to 99% depth
**FM Accuracy (The higher of):** ±0.1 Hz or ±0.28% of setting, up to 20 kHz modulation rate, 20 kHz deviation, and where $F_{carrier} + F_{deviation} \leq 100$ kHz
F **M Accuracy (The higher of):** ±0.1° or ±0.28% of setting, up to 20 kHz modulation rate, where:

$$\left\{ \frac{(F_{mod} \times Dev°)}{57.3} \right\} \leq 20 \text{ kHz, and}$$

$$F_{carrier} + \left\{ \frac{(F_{mod} \times Dev°)}{57.3} \right\} \leq 600 \text{ kHz}$$

**DSBSC Peak Envelope Accuracy:** Same as amplitude accuracy, up to 20 kHz modulation rate
**Phase Accuracy when One Channel is used to Modulate Channel A (sinewave):** ±0.15° or 30 ns, whichever is greater, 0.1 Hz to 100 kHz frequency

***Supplemental Characteristics***
***VOR Bearing Accuracy:*** *Typically ±0.05°*
***AM Accuracy (At a 1 kHz rate and 600 kHz carrier):*** *Typically <±0.2%*
***FM Accuracy (At a 1 kHz rate, 20 kHz deviation, and 600 kHz carrier):*** *Typically <±0.2% of setting*
***Pulse Modulation Level Accuracy:*** *Typically 5% up to 20 kHz pulse rate*
***DSBSC Carrier Suppression:*** *Typically >72 dB*
***Intermodulation (Two equal signals summed into one output):*** *Typically:*
*<–70 dBc, for frequencies up to 100 kHz*
*<–60 dBc, for frequencies 100 to 600 kHz*

*Specifications for level accuracy, modulation accuracy, and spectral purity are all referenced to the peak of the composite signal less 3 dB. When signals are summed the specification for each individual signal is degraded by its amplitude relative to the peak of the composite signal.*



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### FM Stereo Mode (with Option 001)

**Test Signal Modes:** Left = Right, Left = – Right, Left only, and Right only
**Test Tone Frequency Range:** 20 Hz to 15 kHz
**Composite Signal Level:** Up to 10 $V_{p-p}$ into 50 Ω
**Pilot Tone Level:** 0% to 100% of composite level
**Pilot Tone Level Resolution:** 0.1% of composite level
**Pilot Tone Frequency Range:** 0.1 Hz to 600 kHz (default frequency 19 kHz)
**Pilot Tone Phase Adjustment Range:** 0.0 to 359.9°
**Subcarrier Frequency Range:** 0.1 Hz to 600 kHz (default frequency 38 kHz)
**Pre-emphasis:** 25 µsec, 50 µsec, and 75 µsec

***Supplemental Characteristics***
***FM Stereo Multiplex Separation:***
*L-R: Typically >65 dB, audio frequency 20 Hz to 15 kHz*
*M-S: Typically >70 dB, audio frequency 20 Hz to 15 kHz*
***Multiplex Subcarrier Suppression:*** *Typically >70 dB*

### Tone Sequence (with Option 001)

**Number of Different Frequencies:** 16 user definable tones each with an individual on time and off time
**On-time Duration:** 0 ms, 0.80 ms to 655.35 ms
**Off-time Duration:** 0 ms, 0.80 ms to 655.35 ms (zero off time *and* zero on time NOT allowed)
**Timing Resolution:** 0.01 ms (10 µs)
**Timing Accuracy:** ±0.02 ms (+20 µs)
**Sequence Length:** 750 tones, user definable from front panel or GPIB programmable

### DTMF Sequence (with Option 001)

**Number of Tone Pairs:** 16 standard DTMF tone pairs (0-9, A-D, #, *). Frequencies per Bell Technical Reference Publication 48005.
**On-time Duration:** 0 ms, 1.00 to 655.35 ms
**Off-time Duration:** 0 ms, 1.00 to 655.35 ms (zero off time *and* zero on time NOT allowed)
**Timing Resolution:** 0.01 ms (10 µs)
**Timing Accuracy:** ±1 ms
**Sequence Length:** 750 DTMF tones, user definable from front panel or GPIB programmable

### Digital Sequence (with Option 001)

**User Definable:** On level (±10 V open circuit), Off level (±10 V open circuit), and period
**Sequence Entry:** Binary, octal, or hexadecimal
**Sequence Length:** Up to 3,000 bits
**Period Duration:** 0.10 ms to 655.35 ms
**Period Resolution:** 0.01 ms (10 µs)
**Period Accuracy:** ±0.02 ms (±20 µs)
**Control Modes (Applies to tone, DTMF and digital sequence modes):** Manual sequence (allows stepping through sequence), single sequence, and continuously peat sequence. Sequence can also be triggered by exter nal TTL pulse.

### Hop Ram Sequence (with Option 001)

**Number of Different States:** 16 user definable states each with an amplitude, frequency, and phase value
**Waveforms:** Sine, square, ramp, triangle, dc, and white Gaussian noise
**Sequence Entry:** Binary, octal, or hexadecimal
**Sequence Length:** Up to 3,000 tones in binary mode (two states used), or up to 750 tones in hex mode (all 16 states used)
**Sequence Clock Frequency Range:** 0.1 Hz to 10 kHz
**Sequence Clock Frequency Resolution:** 0.1 Hz
**Sequence Burst Range:** One repetition up to 127
**Control Modes:** Manual sequence (allows stepping through sequence), burst sequence (1 to 127), and continuously repeat sequence. Sequence can be triggered by external TTL pulse.

## OPTION 002 SPECIFICATIONS

**(50 Ω outputs only)**

**Output 1 to Output 2 Phase Accuracy (Sine waves at the same frequency):** *±0.1 degrees or 30 ns, 0.1 Hz to 100 kHz, whichever is greater*

***Supplemental Characteristics***
***Output 1 to Output 2 Cross-talk (The higher of):***
*Typically:*
*–100 dB or 20 µ$V_{p-p}$, 0.1 Hz to 20 kHz*
*–95 dB or 20 µ$V_{p-p}$, 0.1 Hz to 100 kHz*
*–90 dB or 30 µ$V_{p-p}$, 0.1 Hz to 600 kHz*



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## OPTION 003 SPECIFICATIONS

**(50 Ω outputs only)**

**Direct Addressing of Channel A:** Up to 16 phase-frequency-amplitude states of channel A may be preset and directly addressed with four TTL-compatible inputs. Timing for fast hopping must be provided by an EXTERNAL source.

**Digital Modulation:** By appropriately setting the 16 direct control registers, the Agilent 8904A may be used as a digital modulator. Examples of signals which can be generated with this technique include FSK or multilevel FM (up to 16 levels), BPSK, QPSK, and QAM.

***Supplemental Characteristics***

***Switching Speed:***

***Via Digital Port:*** *Typically <8 µs, <20 µs for full filter settling*

***Via GPIB:*** *Typically <8 ms*

***Maximum Switching Rate (via digital control port):*** *Approximately 400 kHz*

***Maximum Allowable Address Skew (via digital port):*** *25 ns for valid results*

## OPTION 005 SPECIFICATIONS

**(50 Ω outputs only)**

**Unit to Unit Phase Accuracy:** Additional 30 nsec error, 0.1 Hz to 100 kHz. (Total phase error between units is then the greater of ±0.1° or 60 nsec, 0.1 Hz to 100 kHz.)

**Maximum Number of Synchronized Units:** 8 units using low-loss power splitters (for a total of 16 phase related outputs if all units have Option 002)

**Recommended Power Splitters:**

≤4 units synchronized: Mini-circuits model ZSC-4-3 or equivalent

≤8 units synchronized: Mini-circuits model ZFSC-8-1 or equivalent

***Supplemental Characteristics***

***Unit to Unit Phase Accuracy:*** *Typically <15 nsec additional error, 0.1 Hz to 100 kHz (Total typical phase error between units is then the greater of ±0.1 degree or 30 nsec, 0.1 Hz to 100 kHz)*

## OPTION 006 SPECIFICATIONS

**(Sine wave only)**

All specifications for the standard 50 Ω 8904A are degraded by the accuracy, flatness, and distortion specifications of the Option 006, 600 Ω transformer coupled output. Because the transformer output was designed for passing sinewaves only, all specifications apply to that waveform. The Option 006 output will not pass digital sequences available with Option 001. In addition, phase accuracy is degraded and therefore not specified for Option 006.

**Output Type:** Fully floating/balanced transformer coupled output

**Usable Output Frequency Range:** 30 Hz to 200 kHz

### AC Amplitude (sine wave only)

**Range:**

Open circuit: 0 to 20 Vrms

600 Ω load: 0 to 10 Vrms

150 Ω load: 0 to 4 Vrms

50 Ω load: 0 to 1.5 Vrms

**Resolution:** $3\frac{1}{2}$ digits

**Accuracy (amplitude >40 mVrms into a balanced 600 Ω load):**

6% (0.5 dB) 30 Hz to 20 kHz

12% (1.0 dB) 30 Hz to 100 kHz

**Flatness (amplitude >40 mV rms into a balanced 600 Ω load, 1 kHz reference):**

+0.15 dB, –0.15 dB, 30 Hz to 20 kHz

+0.15 dB, –0.75 dB, 30 Hz to 100 kHz

### Spectral Purity (sine wave only)

**THD+N (including spurs, amplitude 140 mVrms to 10 Vrms into a balanced 600 Ω load):**

–46 dB (0.50%), 30 Hz to 300 Hz, 30 kHz BW, amplitude <1 $V_{rms}$ into a balanced 600 Ω load

–60 dB (0.10%), 300 Hz to 7.5 kHz, 30 kHz BW

–63 dB (0.07%), 7.5 kHz to 20 kHz, 80 kHz BW

–55 dB (0.18%), 20 kHz to 100 kHz, 750 kHz BW

***Supplemental Characteristics***

***Balance:*** *Typically >40 dB, 30 Hz to 50 kHz*

***Output Impedance:*** *Nominally 600 Ω at 1 kHz*

***Flatness (amplitude >40 mV rms into a balanced 600 Ω load, 1 kHz reference):*** *+0.15 dB, –4.0 dB, 30 Hz to 200 kHz*

***THD+N (including spurs, amplitude 140 mVrms to 1 Vrms into a balanced 600 Ω load):*** *<–50 dB (0.32%), 30 Hz to 300 Hz, 30 kHz BW*



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## GENERAL

**Store Recall:** 35 nonvolatile
**Output Type:** Floating or grounded, GPIB programmable. Maximum float voltage (signal + float): 10 V peak maximum from high or low side to chassis ground.
**Zero-crossing Outputs (Available in channel configuration mode only)**: For each channel, a TTL-compatible zero-crossing output and polarity output are provided. The zero-crossing output pulses high for approximately 600 ns each time the channel phase goes through 0 or 180°. The polarity output is high for phases of 0 to 180°s, low for 180 to 360°. These outputs do not reflect any user-specified phase offsets.
**External Timebase Input:** 10 MHz accepted at a nominal level of 0.1 to 5 V peak, automatic switching.
**Timebase Output:** Output level >0 dBm (0.3 V peak) into a 50 Ω load. Output signal will be the internal timebase unless an external timebase is connected to the external timebase input. When an external timebase is connected, it will be routed to the timebase output connector.
**Temperature:**
Operating: 0° C to 50° C
Storage: –20° C to 70° C
**Humidity Range:** 95% RH, 0° C to 40° C
**Remote Operation:** GPIB. A11 functions except the line switch are remotely controllable
**GPIB Compatibility:** SH1, AH1, T6, TEO, L4, LEO, SR1, RL1, PP1, DC1, DTO, CO
**Power:** 100/120 V (±10%); 48 to 440 Hz
220/240 V (±10%); 48 to 66 Hz. 80 VA maximum
**Weight:** Net 5.9 kg (12.8 lb.); Shipping 13 kg ( 28.6 lb.)
**Dimensions:** 133 mm H x 213 mm W x 513 mm D
(5.25 x 8.36 x 20.2 inches)
**System II Size:** 5¼ H x 5½ W x 20 D
**EMI:** Meets conducted and radiated interference of VDE 0871/6.78 class B (radiated at 10 meters). Meets MIL 461B conducted (CE03) and radiated (RE02) interference.

***Supplemental Characteristics***
***Output Impedance:*** *Typically 50 Ω ±3%, 0.1 Hz to 600 kHz*

## AGILENT 8904A ORDERING INFORMATION

### 8904A Multifunction Synthesizer (One 50 Ω output standard)

**Option 001:** Add three internal channels, channel A modulation, channel summation, and channel A sequence capability.
**Option 002:** Add second internal synthesizer and 50 Ω output
**Option 003:** Add fast hop and digital modulation capability
**Option 004:** Move outputs to rear panel (Not available with either Option 005 or 006)
**Option 005:** Add unit to unit phase synchronization capability
**Option 006:** Changes output 1 from a 50 Ω output to a transformer coupled, 600 Ω balanced output
**Option 910:** Provides a total of two sets of operation and calibration manuals (08904-90007) and service manuals (08904-90008)
**Option 915:** Add service manual (Does not come standard, part number 08904-90008)
**Option W30:** Extended repair service
**08904-61024:** Rack mount kit for a single 8904A (includes are required parts and hardware)
**08904-61025:** Rack mount kit for mounting two 8904As side by side (includes all required parts and hardware)
**9211-2682:** Ruggedized transit case for one 8904A

### Retrofit Kit Ordering Information

### 8904A Retrofit kits (all are customer retrofittable)

**11816A:** Retrofit kit for Option 001
**11817A:** Retrofit kit for Option 002
**11818A:** Retrofit kit for Option 003
**11827A:** Retrofit kit for Option 005 (not available for units with serial numbers less than 2948AXXXXX)
**11837A:** Retrofit kit for Option 006 (not available for units with serial numbers prior to 2948AXXXXX)



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Asia Pacific:
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(fax) (852) 2506 9284

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Printed in U.S.A. 9/00
5965-9456E

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