HEWLETT hp PACKARD

10 MHz CRYSTAL OSCILLATOR

10544A

TECHNICAL DATA JUL 76

aging rate less than 5 x 10^{-10}/day

excellent phase noise

fast warm-up

The HP Model 10544A Quartz Crystal Oscillator is an extremely stable, compact, low-power source of 10 MHz. Fast warm-up and a low aging-rate are important for both instrument and systems applications. This is achieved using a new crystal design ruggedly mounted in a cold-welded enclosure. The crystal, along with the oscillator, buffer amplifier, and oven control circuits are all mounted inside a thermally insulated oven.

A significant improvement in signal-to-single-sideband phase-noise ratio has been accomplished by oscillator circuit modifications. This performance along with the excellent short-term stability of the 10544A make it an ideal oscillator for use in systems where the crystal output is multiplied to a higher frequency.

Model 10544A is designed to mate with standard 15-pin printed circuit board connectors which permit direct connections and eliminates the need for separate sockets and interwiring. The unit is designed to operate into a 1000 ohm load. This satisfies most solid-state input requirements.

Its unique design features, plus production efficiencies enable HP to offer, inexpensively in the 10544A, the better than 5 x 10^{-10}/day aging formerly available only in expensive laboratory-type oscillators. With this low aging rate of less than 1 x 10^{-7}/year the manufacturer of communication and test equipment can offer his customers a real cost saving by reducing the frequency of calibration necessary to stay within FCC accuracy requirements.

The 10544A is ideally suited for use in communication and navigation systems, synthesizers, time-code generators, counters, and spectrum analyzers. The 10 MHz output frequency is a convenient starting point since it is easily divided or multiplied.

A screwdriver adjustment through the top of the oven permits frequency adjustment over a range of more than 2×10^{-6} (20 Hz), yet the control is sensitive enough to allow adjustment to better than 1×10^{-9} (0.01 Hz). Frequency can also be controlled electronically over a 1 Hz range with an externally applied voltage.

To maximize oven-efficiency in the 10544A, the heater current is controlled by a switching regulator circuit. This produces switching transients at about 4 kHz on the input line and a low level spurious signal on the output. A version of the oscillator with a dc oven controller is available. It should be used when adequate input filtering is difficult or better than –80 dB nonharmonic components on the output are required.

To permit optimum performance and use of available voltages, the power inputs for the oscillator/amplifier, oven controller and oven circuits are available separately. However, with a simple external IC regulator, a single voltage regulated to 10 percent may be used. (See Figure 3.)

CONNECTIONS:

Power and signal connections are made through a 15-pin printed-circuit connector, such as CINCH 250-15-30-210 (HP Part No. 1251-0160). Connections are shown in Figure 2.

VOLTAGE SOURCES:

The Oscillator Amplifier and Oven Controller should both operate from a +11 to 13.5 Vdc source. If connected to the same source, an LC circuit, marked B in Figure 3 is then required to isolate controller switching transients from the oscillator. The oven voltage may be obtained from a single source of +20 to 30 Vdc or from a combination of negative and positive sources which combined supply 20 to 30 Vdc. If this is done, the positive oven voltage must be equal to or greater than the oven controller voltage. There must be a current path between the oven controller voltage source and the oven voltage source to return the base drive current for the oven control transistor. This may be accomplished by tying either pins 8 & 14 or 9 & 15 together.

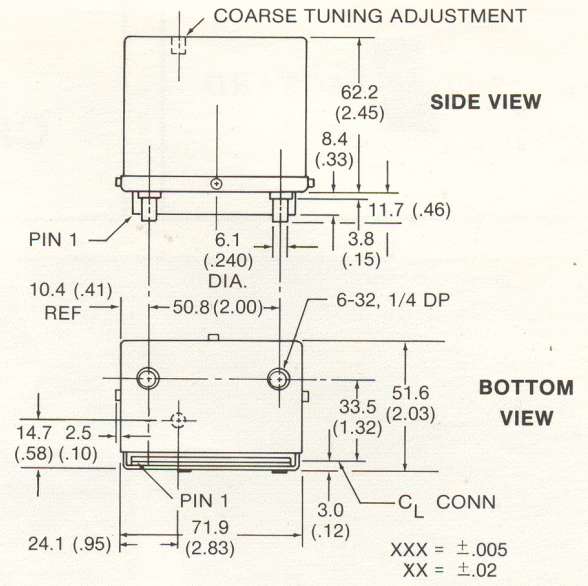
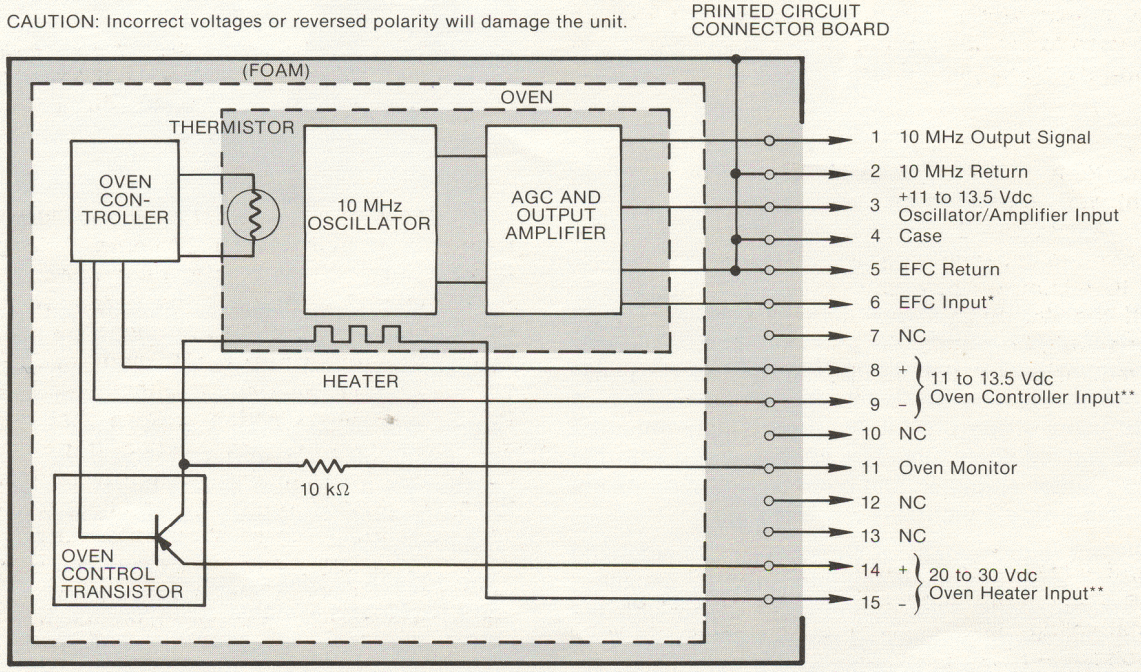


FIGURE 1
Outline Drawing



*Connect Pin 5 to Pin 6 if external EFC (Electronic Frequency Control) is not used.
**A return path must be provided between the oven controller and heater supplies to return the base drive current from the oven control transistor. This may be accomplished by tying either Pins 8 & 14, or Pins 9 & 15 together.

FIGURE 2
Block Diagram

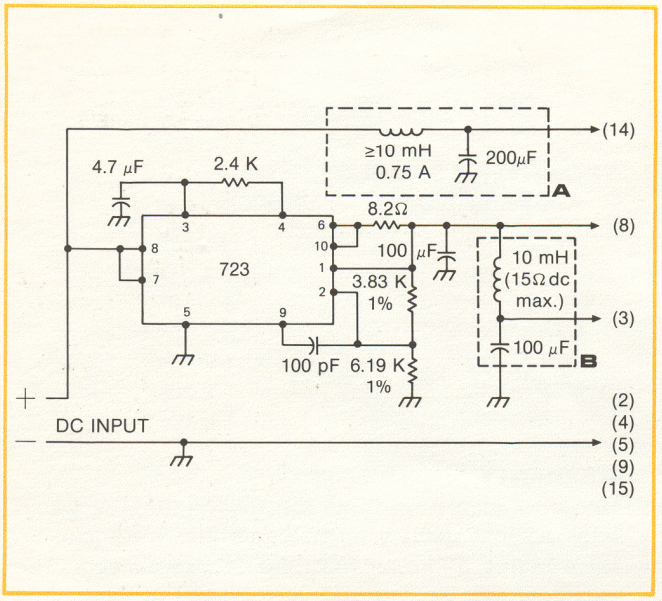


FIGURE 3

I.C. Voltage Regulator 723, (HP Part No. 1826-0010) TO5 configuration to supply 11½V to oscillator/amplifier and oven controller. Circuits A and B are decoupling filters.

Temperature of the oscillator oven is maintained by varying the duty-cycle of the oven input current through a control transistor. A non-inductive voltage source is required to prevent excessive voltage transients that could damage the control transistor. In addition, it may be desirable to provide decoupling between the oven switching transients and other circuits operating from the same power source. The filter marked A in Figure 3 can be used to provide both the non-inductive voltage source and the decoupling filter.

Power for the 10544A may be obtained from a single source of +20 to +30 Vdc (15 to 30 Vdc for 10° to 71°C operation) with 10 percent regulation using a simple IC regulator. A suggested circuit is shown in Figure 3. The resistor and capacitor connected to terminals 3 and 4 of the IC minimize ripple and noise in the regulated output. If the decoupling filter marked A is used, the capacitor should be placed close to the pin 14 connection to minimize radiation of the switching transient noise.

OVEN MONITOR:

The output signal at pin 11 (with respect to pin 15) indicates the temperature condition of the oscillator oven. The signal voltage level depends on the value of oven supply voltage at pins 14 and 15.

Duty-cycle of the signal at pin 11 depends on the oven temperature; long duty-cycle at turn-on and short duty-cycle at operating temperature. The corresponding dc voltage monitored with a high-impedance voltmeter is maximum when the oven is cold (at turn-on) and minimum when the oven is at operating temperature.

OPERATION:

Connect the oscillator through a 15-pin printed-circuit connector. Allow a 24-hour warm-up time for stabilization before adjusting frequency. At initial turn-on, the oscillator may require several days to achieve its specified aging rate.

FREQUENCY ADJUSTMENT:

The crystal in the 10544A oscillator has the typical quartz crystal characteristic of aging (changing resonant frequency) slowly when the unit is off as well as when it is operating. The 10544A crystal is made from high quality natural quartz and extreme care is exercised to eliminate contamination in the crystal enclosure to minimize aging. Each oscillator is aged at the factory to insure that its aging rate is better than 5×10^{-10}/day. This rate can be expected to gradually decrease and typically will reach 1.0×10^{-10} within one year. The coarse tuning adjustment permits periodic change back to exactly 10 MHz. The adjustment range is adequate to cover in excess of 10 years at the typical aging rate.

Oscillator frequency may be adjusted by using the 18-turn screwdriver adjustment located on the top of the oscillator case. Fine frequency adjustments may be made with a range of $\geq 1 \times 10^{-7}$ using -5 to +5 volts dc applied to the electronic frequency control input, pin 6.

A simple method of frequency adjustment is the "oscilloscope drift" method. The oscillator frequency may be adjusted against a reference or "house" standard and drift can be monitored.

Methods for measuring frequency are described in HP Application Note 52-2. For minimum distortion the oscillator output must be terminated with a 1000-ohm load.

OPERATIONAL TESTS:

Apply the proper input voltages and allow the output frequency to stabilize for 24-hours. Adjust the output frequency to 10 MHz as described under FREQUENCY ADJUSTMENT and check the output voltage with an RF Voltmeter or calibrated oscilloscope. Be sure to terminate the output with a 1000-ohm load. If the output voltage or frequency is not within specification, check the input voltages and determine that the regulation and noise are within specification. If the input power or current are substantially different from those shown in the specifications, return the oscillator to HP for repair. The oven input power should decrease within a few minutes after turn-on as the oven temperature stabilizes. Continued full input power indicates a malfunction of the oven controller and will damage the oscillator by overheating.

SERVICE:

The 10544A is designed for factory repair only. Field repair should not be attempted. Repairs are handled promptly on an exchange basis through the nearest HP Sales and Service Office. Order HP Part No. 10544-60511 for exchange oscillator.

SPECIFICATIONS

FREQUENCY: 10 MHz. See note (1).

▶ **AGING RATE:** $<5 \times 10^{-10}$/day after 24-hour warmup. See note (2). $<1 \times 10^{-7}$ per year for continuous operation.

TEMPERATURE COEFFICIENT:
$<1.5 \times 10^{-8}$ frequency change over a −55°C to 71°C temperature range. $<7 \times 10^{-9}$ over 0 to 71°C range.

LOAD:
$<5 \times 10^{-10}$ frequency change for ±25 percent change in 1000 ohm load.

WARMUP:
Within 5×10^{-9} of final value 20 minutes after turn-on, at 25°C and 20 Vdc. See note (3).

ADJUSTMENT:

Coarse Frequency Range:
$>2 \times 10^{-6}$ (20 Hz) centered on 10 MHz with 18 turn control.

Electronic Frequency Control (EFC):
$\geq 1 \times 10^{-7}$, control range −5 Vdc to +5 Vdc.

OUTPUT 10 MHz:

Voltage:
1 Vrms ±20% into 1000 ohms from oscillator's ac coupled (.01 μF) emitter-follower.
(output must be terminated with 1000 ohms)

Harmonic Distortion:
Down more than 25 dB from rated output.

Spurious Phase Modulation, Discrete Sidebands, 10 Hz to 50 kHz:
Down more than 80 dB from rated output.

Signal-to-Single-Sideband Phase-Noise Ratio:
(1 Hz Measurement Bandwidth):

Offset from 10 MHz (Hz)	Ratio (dB)
1	83
10	120
100	140
1,000	145
10,000	145

ENVIRONMENTAL:
Temperature, operating −55°C to +71°C.
Temperature, storage −55°C to +75°C.
Altitude: 15.2 km (50,000 feet)
Humidity: 95% RH at 40°C.
No permanent degradation from the following:
Vibration: 0.01" peak-to-peak, 10 to 55 Hz.
Shock: 30 G, 11 ms, 1/2 sinewave.

SHORT-TERM STABILITY:

Averaging Time (s)	Stability $\left[\sigma_{\Delta f/f}(2,\tau)\right]$
10^{-4}	5×10^{-8}
10^{-3}	5×10^{-9}
10^{-2}	5×10^{-10}
10^{-1}	5×10^{-11}
10^{0}	1×10^{-11}
10^{1}	1×10^{-11}
10^{2}	2×10^{-11}

WARRANTY:
Hewlett-Packard warrants the 10544A 10 MHz Oscillator against defects in materials and workmanship for a period of 1 year from the date of delivery. The oscillator will be repaired or replaced at no charge during the warranty period.

CONNECTORS:
Printed circuit—mates with CINCH 250-15-30-210 (HP 1251-0160) or equivalent (see Figure 2).

SIZE:
72 mm x 52 mm x 62 mm, (see Figure 1).
(2-13/16" x 2-1/32" x 2-7/16",~14 cu. in.)

WEIGHT:
0.31 kg (11 oz).

NOTES:
(1) Frequencies from 4.5 to 12 MHz available on special order.
(2) For oscillator off-time less than 24 hours.
(3) Final value is defined as frequency 24 hours after turn-on. With 15 Vdc oven input, warm-up time is 60 minutes.
(4) A 10% voltage change will cause a frequency change of $<1 \times 10^{-8}$ for <2 min.
▶ (5) 15 Vdc, 10° to 71°C operating temperature, still air.
16 Vdc, 0° to 71°C operating temperature, still air.
(6) Steady state oven power decreases approximately linearly from 6W at −55°C to 0.5 W at +71°C.

▶ **INPUT VOLTAGES/VOLTAGE COEFFICIENTS:**

Input Circuit	Required Voltage	Required Current/Power	Voltage Coefficients	
			Voltage Change	Frequency Change
Oscillator/Amplifier	11.0–13.5 Vdc Noise<100 μV	18 mA typ., 25 mA max.	1%	$<5 \times 10^{-10}$
Oven Controller	11.0–13.5 Vdc	10 mA typ., 15 mA max.		
Oven	20–30 Vdc See note (5).	Turn on load is 43 ohms, minimum. Power drops to steady state value (3W) after 15 min. at 25°C with 20 Vdc applied. See note (6).	10%	$<1 \times 10^{-10}$ See note (4).

NOTE: See Input Voltages section for details concerning use of common power supplies.

▶ INDICATES CHANGES FROM PRIOR SPECIFICATIONS

For more information, call your local HP Sales Office or East (301) 948-6370 • Midwest (312) 677-0400 • South (404) 434-4000 • West (213) 877-1282. Or, write: Hewlett-Packard, 1501 Page Mill Road, Palo Alto, California 94304. In Europe, Post Office Box 349, CH-1217 Meyrin 1, Geneva, Switzerland. In Japan, Yokogawa-Hewlett-Packard, 1-59-1, Yoyogi, Shibuya-Ku, Tokyo, 151.

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