

aging rate better than  $5 \times 10^{-10}$ /day

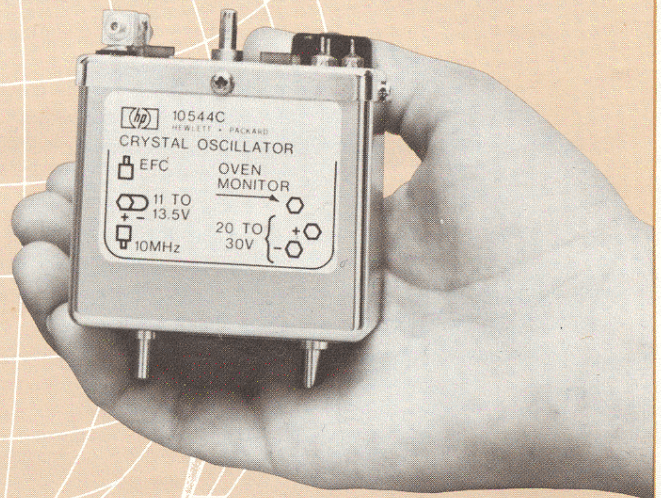
excellent phase noise

specifications for magnetic and gravitational field

provisions for shock mounting (10544C)

dc oven controller

fast warm-up



The HP Model 10544B/C Quartz Crystal Oscillators are extremely stable, compact, low-power sources 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 10544B/C make it an ideal oscillator for use in systems where the crystal output is multiplied to a higher frequency.

The unique design features, plus production efficiencies enable HP to offer, inexpensively in the 10544B/C, the better than  $5 \times 10^{-10}$ /day aging formerly available only in expensive laboratory-type oscillators. With this low aging rate of less than  $1 \times 10^{-7}$ /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 10544B/C are 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.

The HP Model 10544B/C Quartz Crystal Oscillators are modifications of the successful 10544A Oscillator. The key characteristics of low aging rate and fast warm-up are the same. The main differences between the 10544B/C and the 10544A are:

- DC oven controller vs. switching regulator
- Improved short term stability and phase noise
- 50 ohm load vs. 1000 ohm load
- Specifications for magnetic and gravitational field
- Provisions for shock mounting (10544C)

The dc oven controller reduces spurious phase modulation (non-harmonic components) to greater than 100 dB below the output signal level. This is 20 dB better than the 10544A and is of special significance where the 10 MHz output is multiplied up to higher frequencies.



## CONNECTIONS:

Power and signal connections to the 10544B 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. The 10544C uses filter feed-thru terminals for power and oven monitor, and SMB subminiature r.f. snap-on connectors for 10 MHz and EFC.

## VOLTAGE SOURCES:

The oscillator amplifier operates from a +11 to 13.5 Vdc source. The oven voltage of +20 to 30 Vdc may be obtained from a single source or a combination of sources. A single source of +20 to 30 Vdc with 10% regulation may be used to power both the oven and oscillator amplifier circuits if a simple IC regulator is used. 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.

## OVEN MONITOR:

The oscillator oven temperature is maintained by varying the oven input current through the oven control transistor. This current may be monitored by observing the voltage on the oven monitor terminal as shown in Figure 2. The voltage level will be high at turn on and low at oven cutback. The amplitude of the signal after equilibrium has been reached will depend on the ambient temperature.

## OPERATION:

After making proper connections to the oscillator, 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 10544B/C oscillator has the typical quartz crystal characteristic of aging (changing resonant frequency) slowly when the unit is off as well as when it is

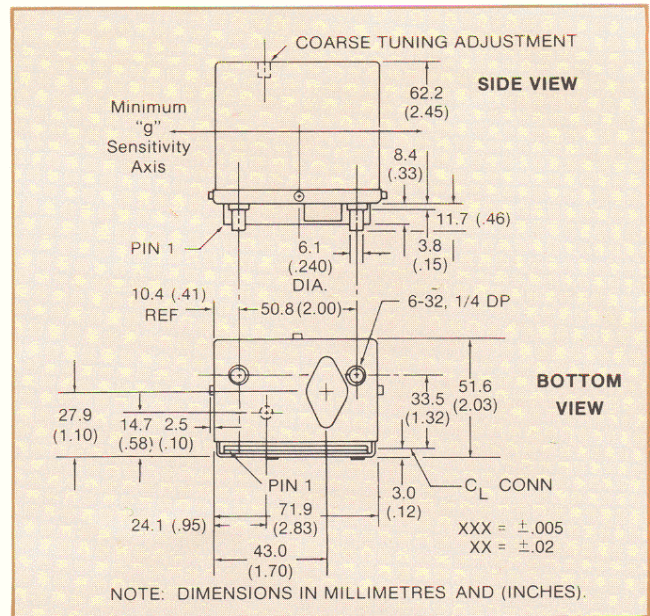


FIGURE 1  
Outline Drawing, 10544B

operating. The 10544B/C 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  $5 \times 10^{-10}$ /day. This rate can be expected to gradually decrease and typically will reach  $1 \times 10^{-10}$  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 over a range of  $2 \times 10^{-6}$  (20 Hz) by using the 18 turn screwdriver control located on top of the oscillator case. Resolution as close as  $1 \times 10^{-9}$  (.01 Hz) may be obtained. Fine frequency adjustments over a

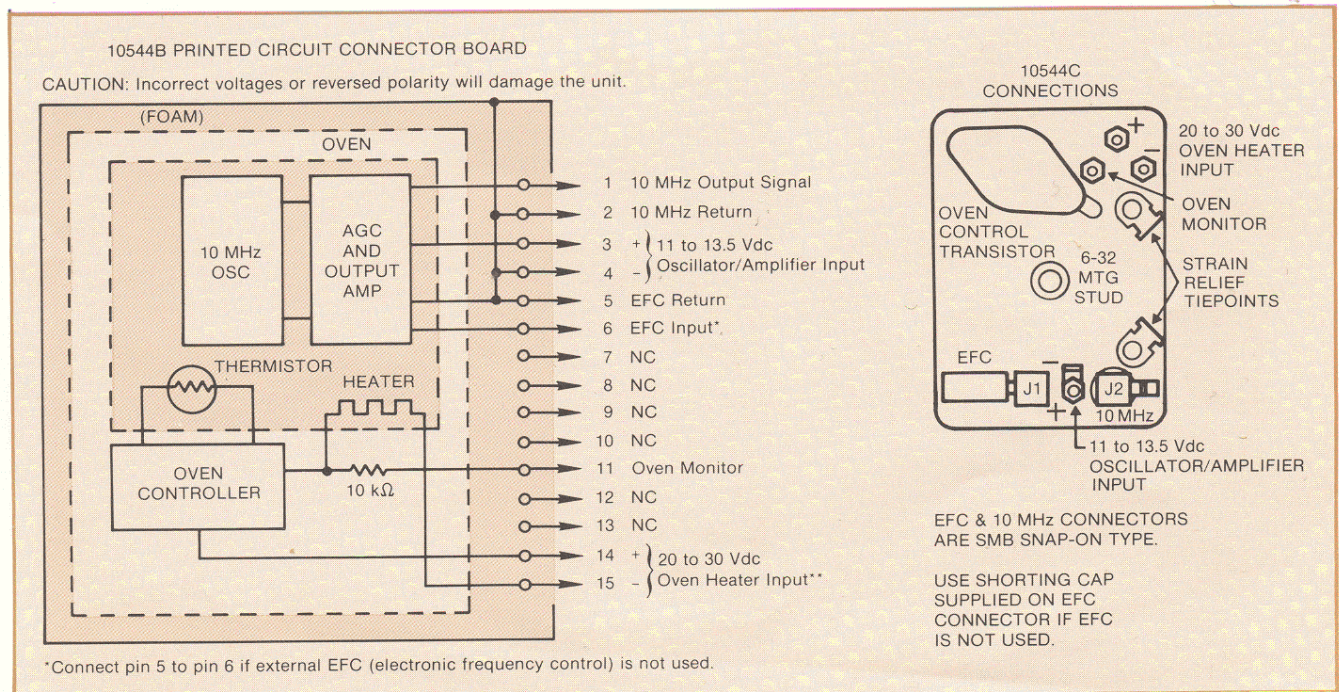


FIGURE 2  
Block Diagram



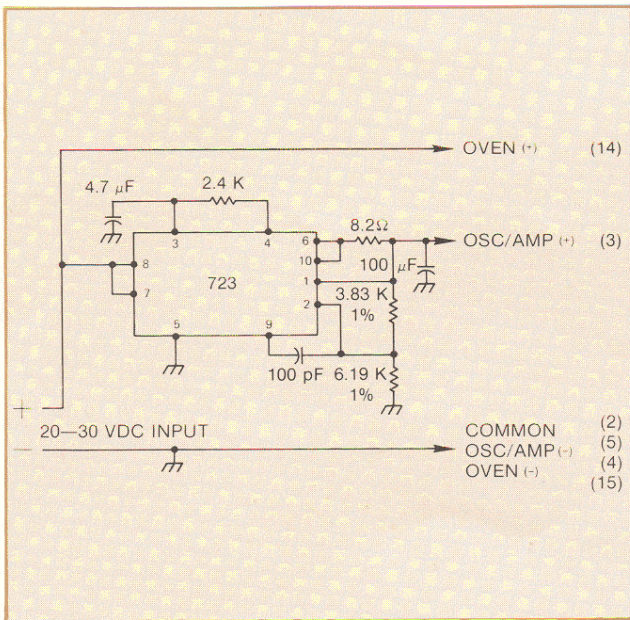


FIGURE 3

I.C. Voltage Regulator 723, (HP Part No. 1826-0010)  
TO5 Configuration to supply 11.5V to oscillator/amplifier

range of at least  $1 \times 10^{-7}$  (1 Hz) may be made by applying a  $-5$  to  $+5$  Vdc signal to the electronic frequency control input, EFC. As the EFC signal goes more positive, the oscillator frequency will go lower.

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 50-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 50-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 about 15 minutes after turn-on as the oven temperature stabilizes. Continued full input power indicates a malfunction of the oven controller.

### GRAVITATIONAL SENSITIVITY:

A frequency change due to a change in orientation of the oscillator may be observed due to the changed gravitational stress on the crystal. The maximum frequency shift will be less than  $\pm 4 \times 10^{-9}$  for any reorientation of the oscillator. Typical values for gravitational frequency shift is  $\pm 1 \times 10^{-9}$  per g. Turning the oscillator end over end, therefore, will typically result in a  $2 \times 10^{-9}$  shift, since the effective gravitational field will have changed by 2 g's.

Returning the oscillator to its original orientation will cause the frequency to return to its original value.

If the oscillator will be subjected to changing gravitational stress, or vibrational stress, it should be mounted so that the effect on frequency will be minimized. This may be accomplished by mounting the oscillator such that the gravitational or vibrational force will be along the axis shown in Figures 1 and 4.

### DIFFERENCES BETWEEN THE "B" AND "C"

The difference between the 10544B and 10544C is in the method of making electrical connections. The "B" uses a printed circuit connector board, while the "C" makes use of filter feed-thru terminals for the power connections and oven monitor and SMB snap-on type rf connectors for the 10 MHz output and EFC input.

Mechanically, the "C" has one internally threaded mounting stud on the bottom cover and two on the top, where the "B" has two studs on the bottom cover and none on the top. Since there is no printed circuit board extending through the package in the "C" the bottom cover overlaps the can on all four sides, improving the r.f. shielding.

Since the "C" has mounting studs on both the top and bottom, vibration isolators such as LORD #J2924-2-1 may be used to further isolate the 10544C from a shock or vibration environment.

### SERVICE:

The 10544B/C are 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. 10544-60512 for 10544B exchange oscillator, or 10544-60513 for 10544C exchange oscillator.

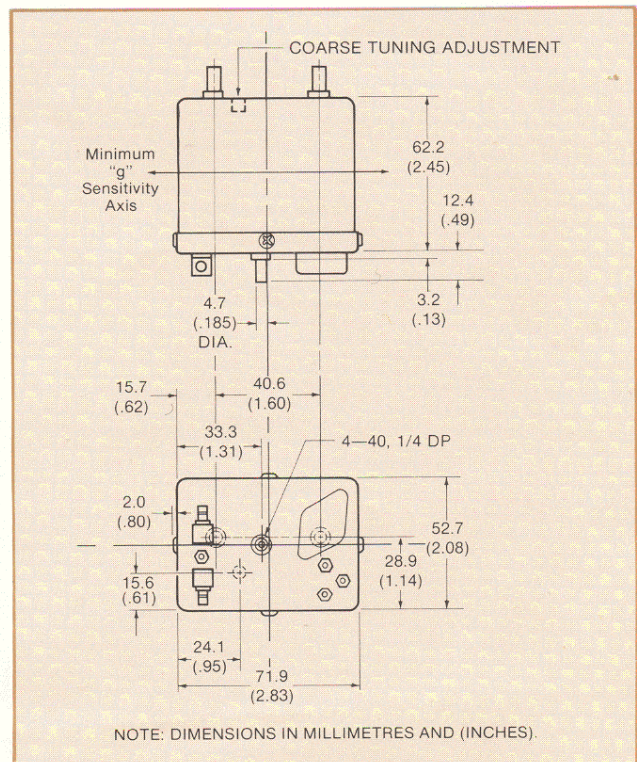


FIGURE 4  
Outline Drawing, 10544C



# SPECIFICATIONS

**FREQUENCY:** 10 MHz.

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

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

**LOAD:**  $< 5 \times 10^{-9}$  frequency change for  $\pm 10$  percent change in 50 ohm load.

**WARMUP:** Within  $5 \times 10^{-9}$  of final value 20 minutes after turn-on, at  $25^{\circ}\text{C}$  and 20 Vdc. See note (2).

**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:**  $0.6 \pm 0.1$  Vrms into 50 ohms (output must be terminated with 50 ohms).

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

**Spurious Phase Modulation, Discrete Sidebands, 10 Hz to 50 kHz:** Down more than 100 dB from rated output.

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

Offset from 10 MHz (Hz)	Ratio (dB)
1	85
10	120
100	140
1,000	150
10,000	150

**ENVIRONMENTAL:**

**Temperature:** Operating  $-55^{\circ}\text{C}$  to  $+71^{\circ}\text{C}$ .  
 Storage  $-55^{\circ}\text{C}$  to  $+75^{\circ}\text{C}$ .

**Magnetic Field:** Sidebands due to 0.1 millitesla (1 Gauss) rms at 100 Hz; down more than 90 dB from carrier.

**Gravitational Field:**  $< 4 \times 10^{-9}$  frequency change for 2 g static shift (turnover).

No permanent degradation from the following:

**Altitude:** 15.2 km (50,000 feet)

**Humidity:** 95% RH at  $40^{\circ}\text{C}$ .

**Vibration:** 0.015" peak-to-peak, 10 to 55 Hz.

**Shock:** 30 G, 11 ms, 1/2 sinewave.

**SHORT-TERM STABILITY:**

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

Measurement bandwidth: 100 kHz

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

**CONNECTORS:**

**10544B:** Mates with CINCH 250-15-30-210 (HP 1251-0160) or equivalent (not supplied).

**10544C:** Solder terminals and SMB Snap-on connectors, mates with Cablewave Systems, Inc. #700156 or equivalent (not supplied).

**SIZE:**

72 mm x 52 mm x 62 mm, (see Figures 1 and 4).  
 (2-13/16" x 2-1/32" x 2-7/16", ~ 14 cu. in.)

**WEIGHT:** 0.31 kg (11 oz).

**NOTES:**

- (1) For oscillator off-time less than 24 hours.
- (2) Final value is defined as frequency 24 hours after turn-on.
- (3) A 10% voltage change will cause a frequency change of  $< 1 \times 10^{-8}$  for  $< 2$  minutes.
- (4) Steady state oven power decreases approximately linearly from 7W at  $-55^{\circ}\text{C}$  to 1.2 W at  $+71^{\circ}\text{C}$  (typical).

**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 $< 100 \mu\text{V}$	18 mA typ., 25 mA max.	1%	$< 5 \times 10^{-10}$
Oven	20—30 Vdc	Turn on load is 43 ohms, minimum. Power drops to approximately 4.5 W after 15 minutes at $25^{\circ}\text{C}$ with 20 Vdc applied. See note (4).	10%	$< 1 \times 10^{-10}$ See note (3).

NOTE: See Voltage Sources section for details concerning use of common power supplies.

For more information, call your local HP Sales Office or East (301) 948-6370 • Midwest (312) 255-9800 • 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, CH-1217 Meyrin 2, Geneva, Switzerland. In Japan, Yokogawa-Hewlett-Packard, 1-59-1, Yoyogi, Shibuya-Ku, Tokyo, 151.