

- c. **CESIUM BEAM TUBE.** Passive atomic resonator using the hyperfine resonance of Cesium 133.
- d. **"C" FIELD.** Magnetic field within the cesium beam tube for fine frequency adjustments.
- e. **ZEEMAN TRANSITIONS.** Transitions excited by application of the Zeeman frequency. These additional energy levels in the hyperfine structure are caused by applying the "C" field (Zeeman splitting). They are used to accurately measure the magnetic field inside the beam tube.
- f. **LOW FREQUENCY TRANSITIONS.** These frequencies appear in the spectrum and are dependent upon the "C" field value. They can be excited independent of the microwave power source.
- g. **MASS SPECTROMETER.** Directs cesium ions to the electron multiplier and prevents impurity ions from reaching the electron multiplier.
- h. **HOT WIRE IONIZER.** Heated tantalum ribbon ionizes cesium atoms which strike it.
- i. **ELECTRON MULTIPLIER.** Amplifies the electron current initiated by a cesium ion striking the first dynode.
- j. **BEAM CURRENT.** Current resulting from the action of the hot wire ionizer and electron multiplier.

- k. **ION PUMP.** Maintains a vacuum in the cesium beam tube by continuously pumping when the HP 5061B is on.

1-10. SPECIFICATIONS

1-11. *Table 1-1* lists the technical specifications for the HP 5061B. Specifications describe the instrument's warranted performance. Supplemental characteristics are intended to provide information useful in applying the instrument by giving TYPICAL or NOMINAL, but nonwarranted performance parameters.

1-12. INSTRUMENT IDENTIFICATION

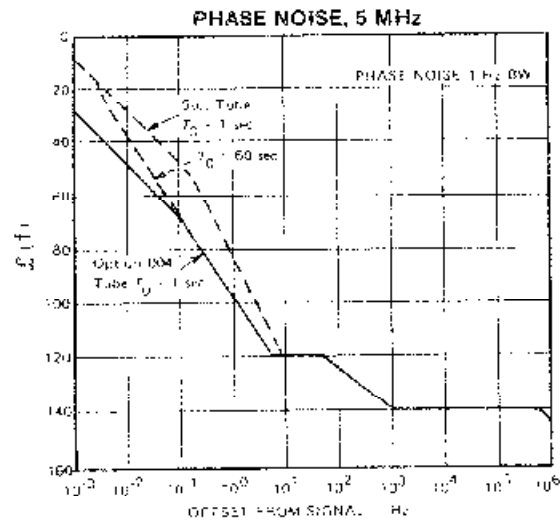
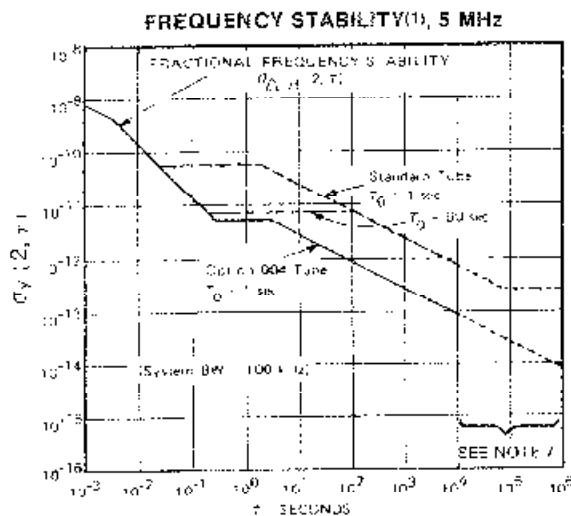
1-13. Hewlett-Packard instruments have a 10-character serial number (0000A00000). The four-digit serial prefix identifies instrument changes. The five-digit number is the serial number of each instrument. If the serial prefix does not appear on the title page of the manual, there are differences between your instrument and the manual. A manual supplement included with the manual describes the differences. If the supplement is missing, contact the nearest Hewlett-Packard Sales and Service office listed on the inside rear cover of this manual.

1-14. SAFETY CONSIDERATIONS

1-15. The Model 5061B is a Safety Class I instrument provided with a protective earth terminal. The instrument is designed and tested to international standards. Safety information pertinent to the operation and servicing of this instrument is included in appropriate sections of this manual.

Table 1-1. Specifications

	Standard Beam Tube	Option 004 High Performance Beam Tube
Accuracy ⁽¹⁾ : Maintained over a temperature range of 0 to 50°C and magnetic fields up to 0.2 millitesla (2 gauss) or any combination thereof	$\pm 1 \times 10^{-11}$	$\pm 7 \times 10^{-12}$
Accuracy -- Limited Temp. Range ⁽⁵⁾	$\pm 6 \times 10^{-12}$	$\pm 4 \times 10^{-12}$
Reproducibility ⁽²⁾ (2)	$\pm 5 \times 10^{-12}$	$\pm 3 \times 10^{-12}$ (5)
Retrace ⁽³⁾	$\pm 6 \times 10^{-12}$	$\pm 1 \times 10^{-12}$ (6)
Settability (Frequency) ⁽⁷⁾	$\pm 7 \times 10^{-13}$	$\pm 1 \times 10^{-13}$ (3)
Long-term stability (for life of cesium beam tube)	$\pm 3 \times 10^{-12}$	$\pm 2 \times 10^{-12}$
DC Magnetic Field Stability, frequency change, any orientation in a 2 gauss field.	$\pm 2 \times 10^{-12}$	$\pm 2 \times 10^{-13}$
Time Constant, quartz oscillator control loop (τ_0)	1 and 60 s ⁽⁴⁾	1 s
Warm-up time at 25°C	45 min.	30 min.
Beam Tube Warranty	3 years	1 year



Notes:

- (1) See definitions, page 1-5
- (2) See Figure 1-2
- (3) With 10638A Degausser
- (4) Use 60 second time constant for increased short-term stability in controlled environments.
- (5) Over any 2.5°C Range at any temperature between 15 and 35°C

- (6) With degaussing -- Retrace is less than $\pm 2 \times 10^{-12}$ without degaussing
- (7) For values of $\tau(s) > 10^4$ seconds, instruments are not subjected to frequency stability testing on a regular basis. This portion of the curve (i.e., $\tau(s) > 10^4$ seconds) provides information useful in formulating applications for the HP 5061B.

τ (s)	FREQUENCY STABILITY*	
	Standard Tube	Option 004 Tube
10 ⁻³	8.2×10^{-10}	8.2×10^{-10}
10 ⁻²	1.5×10^{-10}	1.5×10^{-10}
10 ⁻¹	5.6×10^{-11}	1.5×10^{-11}
10 ⁰	5.6×10^{-11}	5×10^{-12}
10 ¹	2.5×10^{-11}	2.7×10^{-12}
10 ²	8×10^{-12}	8.5×10^{-13}
10 ³	2.5×10^{-12}	2.7×10^{-13}
10 ⁴	8×10^{-13}	8.5×10^{-14}

*These measurements are made with a servo loop time constant of 1 sec. ($\tau_0 = 1$ second)

Δf	PHASE NOISE,* (dB Below the Carrier)	
	Standard Tube	Option 004 Tube
10 ⁻³	-8	-28
10 ⁻²	-28	-48
10 ⁻¹	-48	-58
10 ⁰	-82	-96
10 ¹	-120	-120
10 ²	-125	-125
10 ³	140	-140
10 ⁶	-146	-146

*These measurements are made with a servo loop time constant of 1 sec. ($\tau_0 = 1$ second)

Table 1-1. Specifications (Continued)

SINUSOIDAL OUTPUTS

10 MHz, 5 MHz, 1 MHz, and 100 kHz, front and rear panel BNC.

Output Voltage: >1 Vrms into 50 ohms.

Harmonic Distortion: Down more than 40 dB from rated output.

Non-Harmonically Related Output: Down more than 80 dB from rated output.

QUARTZ OSCILLATOR

The high quality internal oscillator may be used without turning on the cesium beam tube.

Aging Rate: $<5 \times 10^{-10}$ per 24 hours.

Frequency Adjustments:

Fine: 5×10^{-8} range, with dial reading parts in 10^{-10} (nominal).

Coarse: 1×10^{-6} range, screwdriver adjustment at front panel.

ENVIRONMENTAL:

Temperature: Operating, 0 to 50°C. Stability for high performance (Option 004) beam tubes, $<\pm 5 \times 10^{-12}$ change over 0 to 20°C range. For the standard tube, $<\pm 5 \times 10^{-12}$ change from 25°C reference. Non-operating, <-40 to 75°C.

Supplemental Characteristics (Typical):

Production units have passed type testing as follows:

Humidity: Operating, to 95% at 40°C.

Altitude: $<2 \times 10^{-12}$ change up to 12.2 km (40,000 ft.) operating.

AC Magnetic Field: Less than 2×10^{-12} for 0.2 millitesla (2 gauss) peak for 50, 60 or 400 Hz fields.

Shock: MIL-T-28800C, Class 3 (30 g's, 11 ms)

Vibration: Meets the provisions of MIL-T-28800C (survival only) and MIL-STD-167-1.

EMI: MIL-STD-461B, Part 7, Class B (CE03 broadband requires relaxation of 20 dB below 40 kHz).

POWER: 115V $\pm 10\%$, 48 to 440 Hz, 230V $\pm 10\%$, 48 to 66 Hz, or 22 to 30 Vdc.

Approximate power required.

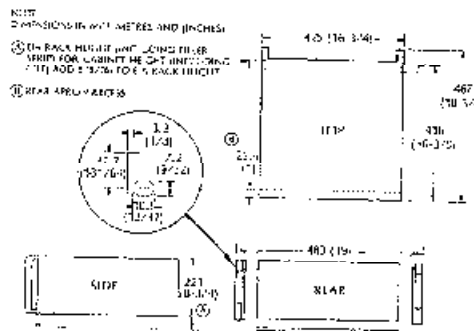
	DC	AC
5061B and 5061R with Option 004	30W	44W
Option 003	Add 5W	Add 16W
Note: The above figures do not apply during instrument warmup.		

NET WEIGHT: 29.1 kg (64 lbs.); Option 003, add 2.7 kg (6 lbs.); Option 004, add 1.8 kg (4 lbs.); Options 003 & 004, add 4.5 kg (10 lbs.). Add 9.1 kg (20 lbs.) for standard instrument's and 25 kg (55 lbs.) for Option 004 instrument's shipping weight.

ACCESSORIES FURNISHED: Power Cord, 1.80 cm (6 ft.), detachable. Accessory Kit, HP 05061-6070, includes two extender boards, test cables, maintenance tools, and a mating connector 1251-0126 for EXT DC input.

ACCESSORIES AVAILABLE: EXT DC cable connects 5061B to 5089A Standby Supply, 05089-60101. 10638A Degausser for use with Option 004 High Performance Tube. See page 1-6 for details. Rack Mounting Kit, Option 908.

DIMENSIONS:



MATING CONNECTORS:

EXT DC Input: 1251-0126 (5-contact), Cannon MS 3106E-14S-3S (Series ME) furnished.

AC Line: 1251-2457, Cannon MS3106A 18-228W.

Degausser: 1251-2797, Bendix PT06A-14-18P1005.

WARRANTY: Instrument, 1 year; optional battery, 1 year (see page 1-3 for beam tube warranty).

OPTION 003

TIME STANDARD AND STANDBY POWER SUPPLY

TIME STANDARD

CLOCK DISPLAY: 24 hour LCD readout in hours, minutes, and seconds driven by Clock Pulse.

Rate: 1 pulse-per-second.

Amplitude: +10V $\pm 10\%$ peak.

Width: 20 μ sec minimum.

Rise Time: <50 ns.

Fall Time: <50 ns.

Jitter: <1 ns rms pulse-to-pulse and pulse-to-5 MHz.

Output: Buffered front and rear BNC connectors. All specs are with 50 Ω load.

SYNCHRONIZATION (REAR BNC): Automatic, 100 ns (± 100 ns) delayed from the reference input pulse. Manual adjustable to ± 50 ns. Reference pulse must be $>+5$ V, with a rise time of <50 ns.

STANDBY POWER SUPPLY

CAPACITY: 45 minutes minimum at 25°C at full charge from sealed nickel-cadmium batteries.

CHARGE CONTROL: Automatic when ac power is connected.

INDICATOR: A front panel light flashes when ac power is interrupted and battery is being used.

OPTION 004

HIGH PERFORMANCE CESIUM BEAM TUBE

Replaces standard beam tube and may be installed with any of the above options. See page 1-3 for specifications and warranty. For optimum performance, the 10638A Degausser should be ordered.

Table 1-1. Specifications (Continued)

DEFINITION OF TERMS	
<p>Accuracy</p> <p>The degree to which an oscillator frequency corresponds to that of an accepted definition. The currently accepted definition is that of the 13th General Conference of Weights and Measures. In practice, this involves comparison with some generally accepted physical embodiment of this definition such as the NBS Frequency Standard. The specified accuracy of the 5061B Cesium Beam Frequency Standard is intrinsic to it and is achieved without calibration.</p>	<p>acquired by continuous phase comparison for an interval of 48 hours or more against the Hewlett-Packard House Standard. The intrinsic reproducibility of the 5061B is the same as that of the 5061A. All individual units are tested to meet this specification.</p>
<p>Reproducibility</p> <p>The degree to which an oscillator will produce the same frequency from one occasion to another after proper alignment. This does not include calibration.</p>	<p>Settability</p> <p>The degree to which the frequency of an oscillator may be adjusted to correspond with a reference. This is also termed calibration.</p>
<p>Retrace</p> <p>The degree to which a cesium standard will produce the same frequency from one occasion to another after cessation of power for periods up to one month without a re-alignment. This does not include calibration.</p>	<p>Stability</p> <p>A. Long-Term frequency is defined as the absolute value (magnitude) of the fractional frequency change with time. An observation time sufficiently long to reduce the effects of random noise to an insignificant value is implied. Frequency changes due to environmental effects must be considered separately.</p> <p>B. Short-Term stability is defined as the standard deviation of fractional frequency fluctuations due to random noise in the cesium standard. It may also be expressed as a standard deviation of phase. This specification must include the number of samples, the averaging time, the repetition time, and the system bandwidth.</p>
<p>Intrinsic Reproducibility</p> <p>The intrinsic reproducibility of the 5061B (see Figure 1-2) is the measure of the repeatability from one independently aligned unit to another. The small spread indicates that any HP 5061B with an Option 004 High Performance Tube will produce a frequency within $\pm 3 \times 10^{-12}$ without calibration. The data was</p>	<p>See "Statistics of Atomic Frequency Standards" by David W. Allan, Proceedings of IEEE, Feb 1966, P. 291, and HP Application Note 116 for measurement details.</p>

FREQUENCY COMPARISONS OF
INDEPENDENTLY ALIGNED 5061A's
(OPTION 004 HIGH PERFORMANCE TUBE)

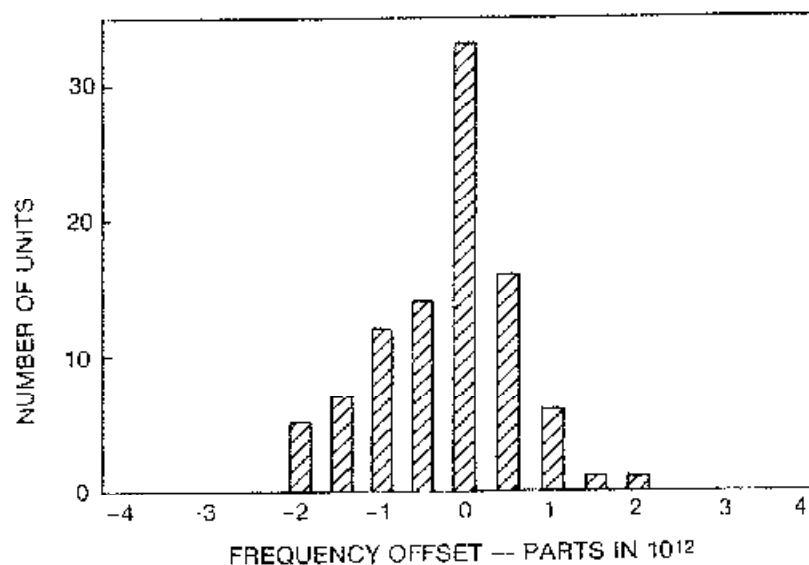


Figure 1-2. Frequency of Independently Aligned 5061A
Cesium Beam Standards with with Option 004 High Performance Tubes

1-16. ACCESSORIES

1-17. *Table 1-2* lists equipment supplied and *Table 1-3* lists accessories available for the HP Model 5061B.

Table 1-2. Equipment Supplied

Equipment	Description	HP Part No.
AC Power Cable	Three-conductor with ground pin	05061-6039 [*]
Accessory Kit:		05061-6070
1. Adapter	Micon, male to-male	1250-0813
2. Connector	Plug (female)	1251-0126
3. Screwdriver	Ceramic	8710-0033
4. Wrench	Key, 4 Spline	8710-0055
5. Screwdriver	Offset	8730-0007
6. Wrench	1/8 inch open-end	8710-1111
7. Board Extender	22 pin	5060-7202
8. Cable Assembly	Test, Micon-to-BNC (2 supplied)	05060-6116
9. Extender, 90° bend	12 pin	05061-6073

^{*}This part number will vary depending on country of destination. See *Figure 2-1* for additional power cable part numbers that are available.

Table 1-3. Accessories Available

Accessory	Description	HP Part No.
Standby Power Supply	22 to 28 Vdc, 2-amp supply with 15 amp-hours standby capacity (at 25°C).	5089A
Cable	Connects 5061B to the 5089A dc output.	05089-60101
(a) Extension Slides, and (b) Slide Adapter	Permits sliding instrument out and tilting from rack-mounted position.	(a) 1490-0718 (b) 1490-0721
Degausser	For degaussing Option 004 High Performance Cesium Beam Tube.	10638A
Rack Mounting Kit	Provides conversion from bench to rack.	5060-8742
Distribution Amplifier	Amplifies and allows 5061B output RF signal distribution to remote locations.	5087A

1-18. RECOMMENDED TEST EQUIPMENT FOR THE HP 5061B

1-19. Recommended test equipment for performance testing is listed in *Table 1-4*. Other test instruments may be used if their specifications equal the required characteristics. The recommended measuring systems must be composed of a number of standard and special

instruments connected together. Therefore, the performance of the measurement system is being checked as well as the performance of the Cesium Beam Frequency Standard. Some measurement systems will require considerable effort to duplicate and also to verify that an out-of-specification measurement is traceable to the instrument being tested or to the test equipment.

Table 1-4. Recommended Test Equipment

Instrument	Required Characteristics	Use	Model
Primary Frequency Standard	Frequency: 5 and 1 MHz Output level: 1 Vrms @ 50Ω Accuracy: $\pm 7 \times 10^{-12}$	Performance Check	HP 5061B with Option 003 and 004
Electronic Counter	Frequency Range: 0 to 90 MHz Sensitivity: 20 mVrms EXT STD input: 5 MHz	Performance Check	HP 5345A
Electronic Counter*	Frequency: 0 to 100 MHz Pulse Width A: 5 ns to 10 ms Rise/Fall Time A: 30 ns to 10 ms Time Interval A to B: -1 ns to 10^3 sec	Adjustments Performance Check	HP 5334A
Feedthrough Termination	50Ω male and female BNC	Performance Check	No Recommendation
Spectrum Analyzer	Frequency Range: 1 kHz to 110 MHz Response: ±0.5 dB Sensitivity: -130 dBm Scan Width: 2 kHz to 100 MHz Stability: Residual FM <20 Hz peak-to-peak	Performance Check	HP 141T with HP 8552B and HP 8553B
Vector Voltmeter**	Frequency: 1 MHz to 1 GHz Voltage Range: 1.5 mV to 1 Vrms	Performance Check	HP 8405A
Phase Comparator**	Frequency Range: 100 kHz to 10 MHz Input Sensitivity: 0.1 Vrms Output: 1V into 100 kΩ for 360° phase change	Performance Check	HP K34-59991A
Strip Chart Recorder	Chart Speed: 1 in./hr. Spans: 1V Full Scale Input Resistance: 200 kΩ/Volt Accuracy: 0.2% full scale	Performance Check	No Recommendation
Audio Oscillator	Frequency Range: 5 Hz to 1.2 MHz Dial Accuracy: ±3% Output Impedance: 600Ω	Performance Check Adjustments	No Recommendation
Time Interval Counter	Resolution of >2 nsec per measurement	Performance Check	HP 5370A/B
RMS Voltmeter	Voltage Range: 1 mV to 3V full scale Frequency Range: 10 Hz to 10 MHz Accuracy: ±5% full scale	Performance Check	HP 3400A
RF Voltmeter	Voltage Range: 1 mV to 3V full scale Frequency Range: 10 kHz to 1.2 GHz	Performance Check	HP 3406A

Table 1-4. Recommended Test Equipment (Continued)

Instrument	Required Characteristics	Use	Model
Oscilloscope	Vertical Frequency Response: dc to 100 MHz Sensitivity: 0.005 V/cm Calibrated Sweeps: 1 sec to 0.05 μ sec/cm Input Coupling: 50 Ω	Performance Check	No Recommendation
Fixed Attenuator	Attenuation: 20 dB \pm 6 dB Frequency Range: dc-12.4 GHz Impedance: 50 Ω nominal Maximum Power Input: 2 Watt	Performance Check Troubleshooting	HP 8491A Option 020, 20 dB pad (2 each)
Degausser***		Performance Check	HP 10638A
<p>*The HP 5334A is recommended as an alternative approach to the 1 PPS parameter check (pulse width and rise/fall time) for the Option 003. It is also useful in the manual synchronization of the 1 PPS output (Option 003) with an external clock reference.</p> <p>**The HP 8405A or the HP K34-59991A may be used for frequency comparison measurements. It is not necessary to have both units.</p> <p>***The HP 10638A Degausser is designed for use with the Option 004 High Performance Beam Tube to achieve settability of $\pm 1 \times 10^{-13}$ and reproducibility of $\pm 3 \times 10^{-12}$.</p>			