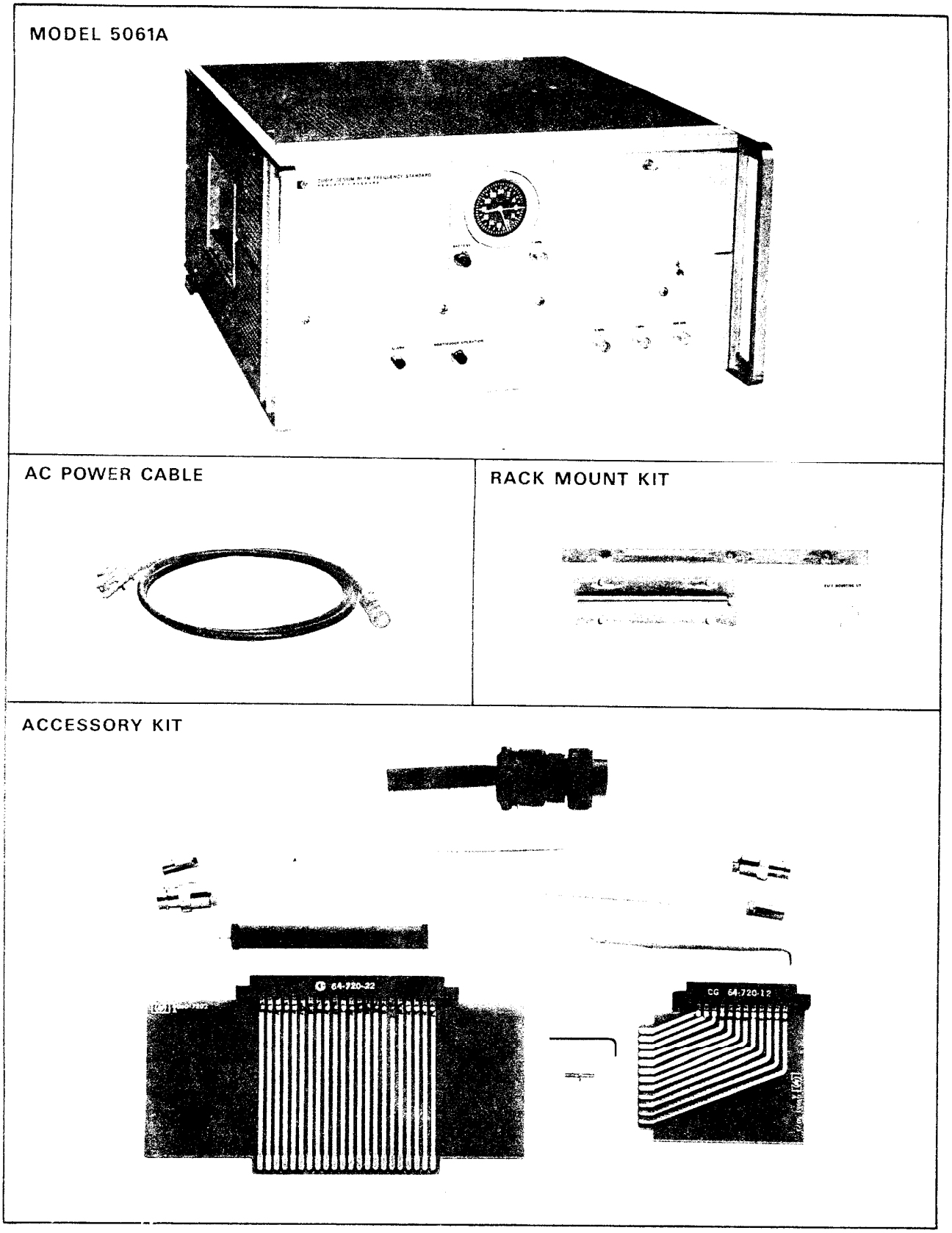
Figure 1-1. Model 5061A and Accessories



SECTION I

GENERAL INFORMATION

1-1. INTRODUCTION

1-2. Description

1-3. The Hewlett-Packard Model 5061A Cesium Beam Frequency Standard is a compact, self-contained frequency standard which uses a cesium beam tube resonator to stabilize the output frequency of a quartz crystal oscillator. Solid-state components and the closed-loop, self-checking control circuit provide an accuracy of ± 1 part in 10^{11}. Output frequencies are 5 MHz, 1 MHz, 100 kHz, and 100 kHz signal for applications such as use with a HP Model 115BR/CR Frequency Divider and Digital Clock. Atomic or UT2 (UTC) time reference is available with the 5061A. The time scale is easily changed by setting a four thumbwheel switch and a slide switch.

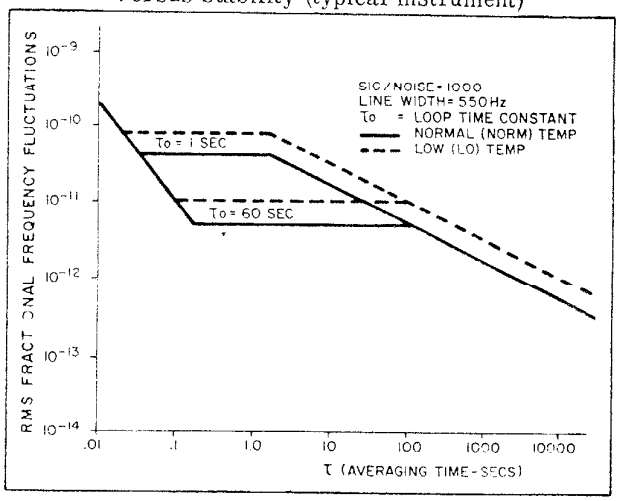
1-4. In the beam tube, a state-selected beam of Cesium 133 atoms passes through a microwave cavity. When the frequency of the applied microwave magnetic field, derived by multiplying the quartz crystal oscillator frequency, is near the hyperfine transition frequency of Cesium 133 (9,192,631,770.0 Hz), the microwave signal induces transitions from one hyperfine energy level to another. Those atoms which have undergone such a transition are detected by a hot wire ionizer and electron multiplier. The microwave field is phase-modulated at a low frequency of 137 Hz. When the microwave frequency deviates from the center of the atomic resonance, the current from the electron multiplier contains a frequency component which is the same as the modulation frequency. The magnitude of this component is proportional to the frequency deviation and the phase indicates whether the microwave signal is above or below the transition frequency. This component is filtered, amplified, and synchronously detected to provide a dc voltage proportional to the frequency deviation. The integral of this dc voltage is used to automatically correct the quartz oscillator frequency.

1-5. The cesium beam tube exhibits outstanding reliability for its guaranteed life of 10,000 hours. Cesium beam tube life may be extended by operating the cesium beam oven at a lower temperature (see Paragraph 3-10). However, the signal-to-noise ratio decreases, causing decreased short-term stability as shown in Figure 1-2.

1-6. Circuit Checks and Outputs

1-7. Check circuits provide continuous monitoring of the 5 MHz output signal. Automatic logic circuits present an indication of correct operation. The 5 MHz, 1 MHz, and 100 kHz output levels are at least 1 volt rms when terminated with 50 ohms. The output of the separate 100 kHz signal, used for external clock applications, is 0.5 volts rms (minimum) when terminated with 1000 ohms.

Figure 1-2. Cesium Oven Temperature Versus Stability (typical instrument)



1-8. TERMINOLOGY

1-9. The definitions of the following terms apply to these terms as used throughout this manual.

a. UNIVERSAL TIME (UT2). Time scale based on the earth's rotation about its axis with correction for angular position and seasonal variation.

b. UNIVERSAL TIME (COORDINATED) (UTC). A piecewise uniform scale which approximates UT2 to 0.1 second by offset adjustments and step adjustments in phase as announced by the International Time Bureau (BIH).

c. ATOMIC TIME. Time scale based on the hyperfine resonance of Cesium 133.

d. CESIUM BEAM TUBE. Passive atomic resonator using the hyperfine resonance of Cesium 133.

e. "C" FIELD. Magnetic field within the cesium beam tube for fine frequency adjustments.

f. 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.

g. 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.

h. MASS SPECTROMETER. Directs cesium ions to the electron multiplier and prevents impurity ions from reaching the electron multiplier.

Table 1-1. Specifications

5061A CESIUM BEAM STANDARDS

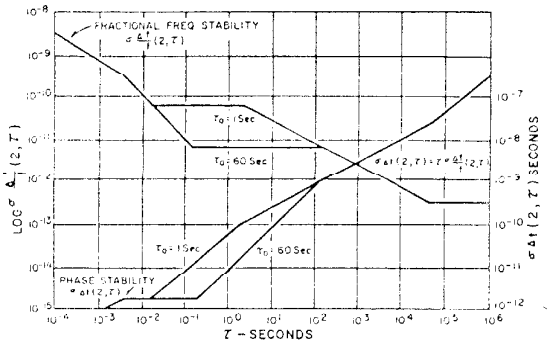
Accuracy: *$\pm 1 \times 10^{-11}$ for temperatures from 0 to 50°C. Magnetic fields up to 2 gauss or any combination thereof.

Reproducibility: *$\pm 5 \times 10^{-12}$.

Settability (Frequency): *$\pm 7 \times 10^{-13}$.

Long Term Stability: *$\pm 5 \times 10^{-12}$ for life of cesium tube.

Short Term Stability: Front panels switch (behind door) selects 1 sec or 60 sec loop time constant (see figure below).



Warm-up Time: 45 minutes to fully operational from 25°C ambient temperature.

Harmonic Distortion: (5 MHz, 1 MHz, and 100 kHz). Down more than 40 dB from rate output.

Non-Harmonically Related Output: (5 MHz, 1 MHz, and 100 kHz). Down more than 80 dB from rated output.

Output Frequencies: 5 MHz, 1 MHz, 100 kHz front and rear BNC connectors.

Output Voltages: > 1V rms into 50Ω:

Time Scale: Adjustable with 4 thumbwheel switches and a slide switch from 0 to -700×10^{-10}. 12.63 MHz test frequency available on rear panel.

GENERAL

Warranty 3 years including Cesium Beam tube. 1 year for optional battery and clock.

Environmental:

Temperature:

Operating, 0 to 50°C. Stability, over full operating temperature range, $< \pm 5 \times 10^{-12}$ change from 25°C reference. Nonoperating, -40 to +75°C.

Production units have passed type testing as follows:

Humidity: 0 to 95% operating.

Altitude: $< 2 \times 10^{-12}$ change up to 40,000 feet operating.

Magnetic: Stability in 2 gauss field, any orientation, $< \pm 2 \times 10^{-12}$ change.

Vibration: MIL-STD-167; MIL-T-21200 with isolators.

Shock: MIL-T-21200, Class 1 and MIL-E-5400 (30 G's).

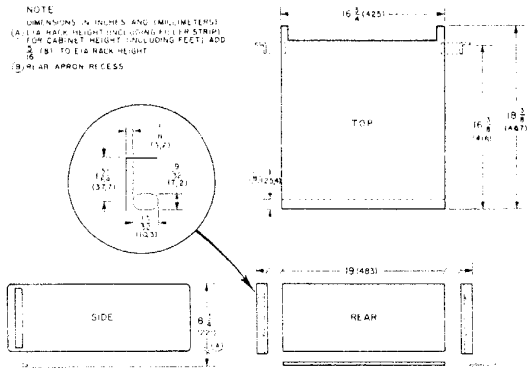
EMC: MIL-I-6181D. (Also known as RFI).

Power:

115 or 230V ac ±10%, 48 to 440 Hz, or 22 to 30V dc. Approximate power required:

Without Options	DC	AC
	27W	43W
Option 001	Add 7.5W	10W
Option 002	Add 4.5W	22W
Option 003	Add 12W	32W

Dimensions:



*DEFINITION OF TERMS

Accuracy: The degree to which oscillator frequency is the same as that of an accepted primary standard (for example, the U.S. Frequency Standard) or the degree to which oscillator frequency corresponds to the accepted definition, presently that of the 13th General Conference of Weights and Measures (see "Time Scales").

Reproducibility: The degree to which an oscillator will produce the same frequency from unit to unit and from one occasion of operation to another. Included within this definition is the degree to which the frequency of an oscillator can be set by a calibration procedure.

Intrinsic Reproducibility: The degree to which an oscillator will reproduce a given frequency without the need for calibrating adjustments either during manufacture or afterward. This quality is a characteristic of an apparatus design, not of a resonance.

Long Term Stability: Total fractional frequency drift for the life of the cesium beam tube.

Table 1-1. Specifications (cont'd)

GENERAL Cont'd.

Weight: Net 60 lbs (33, 3 kg), no options. Option 001 add 2 lbs (1, 1 kg). Option 002 add 5 lbs (2, 27 kg).

Accessories Furnished:
Power Cord, 6 ft (180 cm), detachable.
Rack Mounting Kit, HP 5060-0777.
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 5061A to 5085A standby supply, 103A-16A.

Mating Connectors:
EXT DC Input: 1251-0126 (5-contact), Cannon MS 3106E-14S-5S (Series ME) furnished.
AC Line: 1251-0038, Cannon MS 3160A-10SL-35(C).

CESIUM BEAM TUBE

Length: 16 inches.
Operating Life: 3 years guaranteed.
Shelf Life: 2 years in temperatures up to 35°C for new tube with full operating life expectance remaining, if storage is according to recommended procedures.

QUARTZ OSCILLATOR

Aging Rate: < 5 parts in 10^{10} per 24 hours.
Frequency Adjustments:
Fine Adjustment: 5 parts in 10^8 range, with dial reading parts in 10^{10}.
Coarse Adjustment: 1 part in 10^6, screwdriver adjustement at front panel.

Stability:
As a Function of Ambient Temperature:
$< 2.5 \times 10^{-9}$ total from 0° to +50°C.
As a Function of Load: $< \pm 2 \times 10^{-11}$ for open circuit to short, and 50 Ω R, L, C load change.
As a Function of Supply Voltage:
$< \pm 5 \times 10^{-11}$ for 22 to 30V dc, or for 115/230V ac, ±10%.

OPTION 001 TIME STANDARD

Clock Pulse:
Rate: 1 pulse per second.
Amplitude: +10V ±10% peak.
Width: 20 μs min.
Rise Time: < 50 ns.
Fall Time: < 1 μs.
Jitter: < 5 ns rms pulse-to-pulse.
All specs are with 50 Ω load.
Outputs: Front and Rear Isolated BNC.

Synchronization (rear BNC): Automatic, 10 μs (±1 μs) delayed from reference input pulse. Manual adj. to < ±50 ns. Reference pulse must be ≥ +5V, with a rise time of < 50 ns.

Clock Movement: 24 hours, Patek Philippe.

OPTION 002 STANDBY POWER SUPPLY

Capacity: 30 minutes minimum (1 hour typical) at 25°C at full charge. Includes Option 001.
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 003

Combines Options 001 and 002.