5071B

Primary Frequency Standard

Summary

The 5071B primary frequency standard is the successor to the 5071A. The unit has been designed as a complete form, fit and function replacement of the 5071A. All connections and commands remain unchanged. The internal electronics of the 5071B were updated with modern circuitry, including Microchip microprocessors (MPUs), to ensure continuity of supply for all components into the next decade and RoHS compliance. The 5071B has undergone over 18 months of long-term stability testing and extensive qualifications to ensure the 5071B meets or exceeds all performance specifications.

Features

- Easy to use with automatic startup and intuitive menu structure
- Fast warm up ±5.0 x 10^{-13} accuracy in 30 minutes or less for high-performance tube
- Integrated clock and message displays
- Multiple timing and frequency inputs and outputs with easy access at front and rear
- Automatic synchronization of 1PPS signal
- Remote interface and control including alarm output
- Meets requirements in the new ITU-T G.811.1 ePRC standard

Benefits

- Maintains exceptional accuracy and stability even in unstable environments—unsurpassed stability in the lab or field
- Accuracy ±5.0 × 10^{-13} for high performance
- Stability ≤5.0 × 10^{-12} for high performance (for 1 second averaging time)
- Environmental stability ±8.0 × 10^{-14} for high performance (frequency change for any combination of environmental conditions)
- Long-term stability ≤1.0 × 10^{-14} for high performance (for 5-day averaging time)
- Proven reliability with an average mean time between failures (MTBF) of greater than 160,000 hours
- Full traceability to NIST
- AC and DC input and internal battery back-up

The 5071B primary frequency standard has the accuracy and stability you need for both laboratory and field applications. A stability specification for 30-day averaging time means the 5071B will keep extremely predictable time and phase for long periods. Further, the 5071B can be used for long-term averaging of noisy signals such as GPS.

The 5071B is easy to use. No more manual start-up steps or complicated adjustments—everything is automatic. A logical menu structure simplifies front panel operations, selections, and status reporting. Remote control features tailor the 5071B for complete operation and manageability in virtually any location.

Meeting the Needs of Leading- Edge Metrology and Calibration Labs

Timekeeping and National Standards Laboratories verify the stability and accuracy of their in-house cesium standards to Coordinated Universal Time (UTC), provided by the Bureau International des Poids et Mesures (BIPM) in Paris. A standard's accuracy and reliability determine the quality of service these timekeeping labs provide. Of even greater concern is the stability of a standard. Stability directly affects a laboratory's ability to deliver timekeeping and calibration services to its clients.

The 5071B offers exceptional stability and is the first cesium standard to specify its stability for averaging times longer than one day. The instrument takes into account environmental conditions that can heavily influence a cesium standard's long-term stability. Digital electronics continuously monitor and optimize the instrument's operating parameters.

Thus, the 5071B's response to environmental conditions such as temperature and humidity are virtually eliminated. The 5071B primary frequency standard maintains its accuracy and stability, even in unstable environments.

Satellite Communications

Stable frequency generation is required to transmit and receive signals properly between ground terminals and communication satellites. Frequency flexibility is also needed to adjust for satellite-to-satellite carrier-frequency differences. The 5071B's state-of-the-art technology produces offset and primary frequencies with the same guaranteed stability.

For secure communications, precise timing synchronization ensures that encrypted data can be recovered quickly. Frequency-agile signals also require exact synchronization between transmitter and receiver during channel hops.

The 5071B automates the synchronization to any external 1PPS signal, greatly simplifying this aspect of satellite communications.

The 5071B and GPS

The 5071B primary frequency standard can work very well with a GPS timing receiver to produce and maintain highly accurate time and frequency.

The GPS system provides accurate time, frequency, and location information worldwide by means of microwave radio broadcasts from a system of satellites. Timing accuracy for the GPS system is based, in large part, on the accuracy and stability of a number of 5071B primary frequency standards. These standards are maintained by the GPS system, the US Naval Observatory, and various timing laboratories around the world that contribute to UTC, the world time scale.

Because of their accurate time reference, GPS signals processed by a good GPS timing receiver can provide highly accurate time and frequency outputs. However, since GPS receivers rely on very low level microwave signals from the satellites, they sometimes lose accuracy because of interfering signals, local antenna problems, or bad satellite data.

In spite of these problems, a GPS timing receiver can be an excellent backup and reference to a local 5071B primary frequency standard. The GPS receiver provides an independent reference that can be used to verify the accuracy of a caesium standard, or it can be used as a temporary backup should the cesium standard need repair. The local 5071B standard has better stability, better output signal quality, and is not perturbed by interfering signals, intermittent signal loss, or bad satellite data.

With these characteristics, the synergy created by combining a good quality GPS timing receiver and a 5071B primary frequency standard can produce a highly robust, inexpensive, and redundant frequency and time system.

Exceptional Accuracy

The intrinsic accuracy of the improved cesium beam tube (CBT) assures that any high performance 5071B will power up to within ±5.0 x 10^{-13} of the accepted standard for frequency. This is achieved under full environmental conditions in 30 minutes or less, and without the need for any adjustments or alignments.

Unsurpassed Stability

The 5071B high-performance cesium beam tube guarantees stability to be better than 1.0 x 10^{-14} for averaging times of five days or greater. The 5071B is the first cesium standard to specify stability for averaging times longer than 1.0 x 10^{5} seconds (approximately one day).

The 5071B is also the first cesium standard to specify and guarantee a flicker floor. Flicker floor is the point at which the standard's stability ($\sigma_y(2, \tau)$) does not change with longer averaging. The high performance 5071B flicker floor is guaranteed to be 1.0 x 10^{-14} or better. Long-term measurements at the National Institute of Standards and Technology (NIST) show that the flicker floor is typically better than 5.0 x 10^{-15}.

Unstable environments are normal for many cesium standard applications. The 5071B features a number of microprocessor controlled servo loops which allow it to virtually ignore changes in temperature, humidity, and magnetic fields.

The 5071B delivers exceptional performance over very long periods of time, greatly increasing the availability of critical time and frequency services. Actual measurements made at NIST have demonstrated that a 5071B with the high-performance CBT will drift no more than 5.0 x 10^{-14} over the entire life of the CBT.

Traditional Reliability

The 5071B design is based off its predecessor, the 5071A, which has demonstrated an average mean time between failures (MTBF) of greater than 160,000 hours since its introduction in 1992. This data is based on actual field repair data. Backing up this reliability is a 10-year warranty on the standard long-life cesium beam tube and a 5-year warranty for the high performance tube.

Complete repair and maintenance services are available at our repair center in Beverly, Massachusetts.

Full Traceability to NIST

Microchip provides NIST traceability to the accuracy measurements made on every 5071B. Traceability to NIST is maintained through the NIST-supplied Time Measurement and Analysis System (TMAS). This service exceeds the requirements of MIL-STD-45662A and can be a valuable tool in demonstrating traceability to your customers.

High-Performance Cesium Beam Tube

The 5071A high performance cesium beam tube is optimal for the most demanding operations. The high-performance tube offers a full-environment accuracy specification of $\pm 5.0 \times 10^{-13}$ —two times better than the specification for the standard tube. Stability is also significantly improved. The high-performance tube reaches a flicker floor of 1.0×10^{-14} or better, and long-term measurements at NIST show that the flicker floor is typically better than 5.0×10^{-15}.

Integrated Systems and Remote Operation

Today, cesium standards are often integrated into telecommunication, satellite communication, or navigation systems as master clocks. To accommodate these environments, the 5071A provides complete remote control and monitoring capabilities. Instrument functions and parameters can be interrogated programmatically.

Communication is accomplished using the standard commands for programmable instruments (SCPI) language and a dedicated RS-232C port. Also, a rear panel logic output can be programmed to signal when user-defined abnormal conditions exist.

For uninterruptible system service, an internal battery provides 45 minutes of backup in case of AC power failure. Thus, the 5071A can be managed easily even in the most remote locations.

Straightforward Operation

Internal microprocessor control makes start-up and operation of the 5071A extremely simple. Once connected to an AC or DC power source, the 5071A automatically powers up to its full accuracy specifications. No adjustments or alignments are necessary during power-up or operation for the life of the cesium tube.

An intuitive menu structure is accessible using the front panel LCD display and keypad. These menus—Instrument State, Clock Control, Instrument Configuration, Event Log, Frequency Offset and Utilities—logically report status and facilitate control of the instrument. These functions are described as follows.

Instrument State

Overall status is displayed, including any warnings in effect. Key instrument parameters such as C-field current, electron multiplier voltage, ion pump current, and cesium beam tube oven voltage are available. You can initiate a hard copy report of this data on your printer with the push of a button.

Clock Control

Set the time and date, schedule leapseconds, adjust the epoch time (in 50 ns steps), and automatically synchronize the 1PPS signal to within 50 ns of an external pulse using this menu.

Instrument Configuration

Set the instrument mode (normal or standby) and assign frequencies (5 MHz or 10 MHz) to the two independently programmable output ports; configure the RS-232C data port.

Event Log

Significant internal events (power source changes, hardware failures, warning conditions) are automatically recorded with the time and date of their occurrence. A single keystroke produces a hard copy on your printer for your records.

Frequency Offset (Settability)

Output frequencies may be offset by as much as 1.0×10^{-9} in steps of approximately 6.3×10^{-15}. All product stability and output specifications apply to the offset frequency.

Utilities

The firmware revision level and cesium beam tube identification information can be displayed.

Accuracy and Long-term Stability[1]

Specification	
Conditions (any combination of)	
Temperature	0 °C–50 °C
Humidity	0 to 85% (40 °C max)
Magnetic Field	DC, 55, 60 Hz, 2G peak any orientation
Shock and vibration	100-mm drop
Accuracy	
Standard performance	$\pm 1.0 \times 10^{-12}$
High performance	$\pm 5.0 \times 10^{-13}$
Frequency Change vs. Environment	
Standard performance	$\pm 1.0 \times 10^{-13}$
High performance	$\pm 8.0 \times 10^{-14}$
Warm-up time (typical)	30 minutes
Reproducibility	$\pm 1.0 \times 10^{-13}$
Settability	
Range	$\pm 1.0 \times 10^{-9}$
Resolution	6.3×10^{-15}
Control	Through RS-232 port

[1]Lifetime accuracy (high performance CBT only) after a minimum two-month warm-up. Change no more than 5.0×10^{-14} for the life of the CBT.

Stability (Allan Deviation)

Average Time (s)	Standard Performance	High Performance
0.01	$\le 7.5 \times 10^{-11}$	$\le 7.5 \times 10^{-11}$
0.1	$\le 1.2 \times 10^{-11}$	$\le 1.2 \times 10^{-11}$
1	$\le 1.2 \times 10^{-11}$	$\le 5.0 \times 10^{-12}$
10	$\le 8.5 \times 10^{-12}$	$\le 3.5 \times 10^{-12}$
100	$\le 2.7 \times 10^{-12}$	$\le 8.5 \times 10^{-13}$
1,000	$\le 8.5 \times 10^{-13}$	$\le 2.7 \times 10^{-13}$
10,000	$\le 2.7 \times 10^{-13}$	$\le 8.5 \times 10^{-14}$
100,000	$\le 8.5 \times 10^{-14}$	$\le 2.7 \times 10^{-14}$
10 days	$\le 5.0 \times 10^{-14}$	$\le 1.0 \times 10^{-14}$
30 days	$\le 5.0 \times 10^{-14}$	$\le 1.0 \times 10^{-14}$
Flicker floor: Guaranteed	$\le 5.0 \times 10^{-14}$	$\le 1.0 \times 10^{-14}$
Typical	$\le 1.5 \times 10^{-14}$	$\le 5.0 \times 10^{-15}$

SSB Phase Noise

Offset (Hz)	10 MHz Output	5 MHz Output
1	≤–100 dBc/Hz	≤–106 dBc/Hz
10	≤–130 dBc/Hz	≤–136 dBc/Hz
100	≤–145 dBc/Hz	≤–145 dBc/Hz
1,000	≤–150 dBc/Hz	≤–150 dBc/Hz
10,000	≤–154 dBc/Hz	≤–154 dBc/Hz
100,000	≤–154 dBc/Hz	≤–154 dBc/Hz

Specifications

Electrical

Frequency Outputs	(4)	
Frequency	[2] 5 MHz, 10 MHz[2]	[1] 100 kHz and [1] 1 MHz
Format	Sine	Sine
Amplitude	≥1 Vrms	≥1 Vrms
Harmonic	≤–40 dBc	≤–40 dBc
Non-harmonic	≤–80 dBc	
Connector	N	BNC
Load Impedance	50 Ω	50 Ω
Location	Rear panel	Rear panel
Isolation Between Ports	≥110 dB (typical)	

Timing Outputs	(3) 1PPS
Format	1PPS
Amplitude	≥2.4 V into 50 Ω (TTL compatible)
Pulse Width	20 µs
Rise Time	≤5 ns (slew rate $>10^{10}$ volt/second at 1.5 V)
Jitter	≤1 ns rms
Connector	BNC
Load Impedance	50 Ω
Location	One front panel Two rear panel timing outputs

Sync input	(2) 1PPS (Each may be independently armed)
Amplitude	2 V—10 V max
Pulse Width	100 ns min to 100 µs max
Rise time	≤50 ns
Jitter	≤1 ns rms
Connector	BNC
Load Impedance	50 Ω
Location	One front panel One rear panel
Manual Sync	
Range	+/–0.5 s
Resolution	50 ns
Auto Sync	+/–50 ns

[2]Each output can be set to either 5 MHz or 10 MHz from the front panel or by remote control.

AC Power Requirements	
Operating Voltage	100, 120 VAC ±10%, 45 Hz–440 Hz
	220, 240 VAC ±10%, 45 Hz–66 Hz
Power	
Operating	50W (Standard Performance) 58W (High Performance)
Warm-up	100W
DC Power Requirements	**22 VDC–42 VDC**
Power	
Operating	45W (Standard Performance) 50W (High Performance)
Warm-up	85W
Internal Standby Battery	
Capacity	45 minutes from full charge
Charge Time	16 hours max from fully discharged state
Charge source	AC input power supply

Remote System Interface and Control

RS-232-C (DTE configuration)

Complete remote control and interrogation of all instrument functions and parameters

Specification	
Software Command Set	Standard Commands for Programmable Instruments (SCPI), version 1990.0 adapted for RS-232C
Connector	9-pin male rectangular D subminiature type
Location	Rear panel
Alarm (TTL)	BNC
Output	TTL High, Normal TTL Low, Fault
Circuit is TTL open collector with internal pull-up resistor. Circuit can sink up to 10 mA.	

Dimensions/Weight	
Height	133.4 mm
Width	425.5 mm
Depth	523.9 mm
Weight	30 kg
MTBF	>160,000 hours

General Environment	
Temperature	
Operating	0°C to 55°C
Non-operating	–40°C to 70°C
Humidity	0 to 95% RH (45 °C max)
Magnetic Field	DC, 55, 60 Hz 2 gauss Peak–Any Orientation
Atmospheric Pressure	≤1.0 × 10^{-13} change in frequency for pressure down to 19 kPa (Equivalent to an altitude of 12.2 km)
Shock and Vibration	• Shipboard Vibration MIL-STD-167-1, Paragraph 5.1.2.4.3 • Random Vibration MIL-PRF-28800F, Paragraph 3.8.4.1 for Class 3 units (2.06 grms 5-500 Hz for 10 min/axis, 3 axes) • Hammer Blow Shock Test, MIL-S-901C, Grade A, Class 1, Type A • Seismic Testing in accordance with ASCE 7-10 Section 13.2.5. Will maintain containment of Cesium metal (CAESIUM UN1407) after testing to ICC-ES AC 156.
EMI/EMC	• FCC Part 15 Subpart B Class A • KN61000-6-3 Radiated/Conducted Emissions • EN55011 Conducted Emissions • KN/EN61000-3-2, -3 (AC) • EN61000-4-4, -5, -6, -11 • KN61000-6-1 Immunity Tests • KN61000-6-1, -3 (48VDC)
UL Safety	IEC 61010-1:2010 (Third Edition)

Ordering Information

Part Number	Description
5071B-C001	High-performance tube
5071B-C002	Standard performance tube
5071B-C007	High-performance tube with 48 VDC option
5071B-C008	Standard performance tube with 48 VDC option

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