Microsemi MHM 2010™

Active Hydrogen Maser

MHM 2010 Front Panel

MHM 2010 Back Panel

Features

- Patented magnetic quadrapole for superior atomic beam focusing
- Low hydrogen usage for extended maintenance-free operation
- Demonstrated life of over 20 years
- Unique stand-alone auto-tuning feature provides exceptional long-term stability performance
- Proprietary Teflon™ coating technique, eliminating any re-coating requirement and extending maintenance-free life
- CE-compliant
- A low phase noise option for superior short-term stability in an active hydrogen maser
- Standard two year warranty

Applications

- Scientific frequency reference source
- National timekeeping service
- Radio astronomy: VLBI, VLBA
- Deep space tracking and navigation
- GNSS/GPS satellite monitoring

The MHM 2010 is the world's most widely installed active hydrogen maser for applications that require extreme frequency stability, low phase noise, and long service life. It is the only commercially available active hydrogen maser manufactured in the USA with a stand-alone cavity switching auto-tuning technique.

Hydrogen masers operate on the principle that hydrogen atoms, in the proper environment, emit radiation of a precise frequency (1420 MHz) and spectral line width (21 cm). Phase locking this extremely small power and high-purity signal to a very high-performance quartz oscillator, provides the user with incredible long-term stability, as well as excellent phase noise.

Active masers are typically four times more stable than passive hydrogen masers and 100 times more stable than high performance cesium up to 7 days of operation. Active maser advantages in metrology include low clock noise (eliminating the necessity for reference clock noise corrections) and a 10,000 times shorter interval to reach a specified frequency stability compared to high-performance cesium.

Each MHM 2010 is manufactured to meet quality standards, and carefully checked at each stage to ensure a top-quality product. Once built, the units are subjected to extensive performance testing, verifying all aspects of operation. All maser product design, manufacturing, and testing is conducted at a Microsemi facility dedicated to these operations.

Auto-Tuning

The MHM 2010 incorporates an automatic frequency control system to maintain the cavity at a constant frequency relative to the hydrogen emission line. This technique enables the MHM 2010 to deliver long-term stability that is only attributed to the most stable cesium atomic standards.

Environmental Sensitivity

The MHM 2010 is designed for low sensitivity to temperature, magnetic field, and power supply changes.

Outputs

The MHM 2010 provides multiple 5, 10, and 100 MHz outputs and 1PPS. Multiple configurations can be ordered to optimize the varied applications.

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Low Phase Noise Output Option

The MHM 2010 can be factory configured with low phase noise outputs that enable higher resolution measurements in VLBI applications and provide improved reference signals for maser timing systems. Users no longer have to face a trade-off between long-term and short-term stability.

Low Lifetime Cost of Ownership and Maintenance-Free Operation

Lifetime cost of ownership for active masers is a critical consideration. The MHM 2010 is designed for long life and low maintenance. The hydrogen supply is adequate for over 20 years of operation. An efficient hydrogen state selector minimizes the load on the ion pumps (<0.01 mole per year), and the pumps themselves are designed for over 20 years of life at nominal hydrogen flux. The Teflon bulb coating virtually eliminates any re-coating requirement and has a demonstrated life of over 20 years. Should it be required, the MHM 2010 is designed for on-site module replacement.

Specifications

Stability

Time	Allan Deviation (Measured in 0.5 Hz Bandwidth)	
	Standard	Low Phase Noise Option
1 s	1.5×10^{-13}	8.0×10^{-14}
10 s	2.0×10^{-14}	1.5×10^{-14}
100 s	5.0×10^{-15}	4.0×10^{-15}
1,000 s	2.0×10^{-15}	2.0×10^{-15}
10,000 s	1.5×10^{-15}	1.5×10^{-15}

- Floor* — $<1.2\times10^{-15}$ typical (standard) $<1.0\times10^{-15}$ typical (low phase noise option)
- Long term** — Typical spec ranges between 2×10^{-15} per day and 2×10^{-16} per day, depending on several factors in the operating environment
- Auto-tuning — No external reference required

* Typically achieved after extended period of unperturbed, continuous operation. Temperature variation: ±0.25 °C. Relative humidity: ±10%.

** Typically achieved after extended period of unperturbed continuous operation of over 12 months. Temperature variation ± 0.25 °C. Relative humidity: ±10%.

Environmental

- Temperature sensitivity — $<1.0\times10^{-14}$/°C
- Magnetic sensitivity — $<3.0\times10^{-14}$/Gauss
- Power source sensitivity — $<1.0\times10^{-14}$

Control

- Synthesized frequency resolution — 7.0×10^{-17}
- Frequency control range — 7.0×10^{-10}

Note: The synthesizer maintains continuous phase throughout frequency changes.

Available Outputs

Frequency	Amplitude
5 MHz	13 dBm
10 MHz	13 dBm
100 MHz	13 dBm

- Load impedance — 50 Ω

Timing Output

- Format — 1 PPS (positive going pulse)
- Amplitude — >3 V into 50 Ω (TTL compatible)
- Pulsewidth — 20 µs
- Rise time — <3 ns
- Jitter — <10 ps RMS

Timing Input

- Auto-sync input — 1 PPS
- Amplitude — >3 V into 50 Ω (TTL-compatible)
- Pulsewidth — ≥20 µs
- Rise time — <5 ns
- Jitter — <1 ns RMS
- Synchronization input to output: — <15 ns

Phase Noise £(f)

Bandwidth	Outputs		
	5 MHz	10 MHz	100 MHz
1 Hz	≤–116 dBc	≤–110 dBc	≤–90 dBc
10 Hz	≤–135 dBc	≤–129 dBc	≤–109 dBc
100 Hz	≤–148 dBc	≤–142 dBc	≤–122 dBc
1 kHz	≤–155 dBc	≤–149 dBc	≤–129 dBc
10 kHz	≤–155 dBc	≤–149 dBc	≤–129 dBc
100 kHz	≤–155 dBc	≤–149 dBc	≤–129 dBc

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Low Phase Noise Option

Bandwidth	Outputs		
	5 MHz	10 MHz	100 MHz
1 Hz	≤–130 dBc	≤–124 dBc	≤–102 dBc
10 Hz	≤–150 dBc	≤–138 dBc	≤–117 dBc
100 Hz	≤–158 dBc	≤–146 dBc	≤–126 dBc
1 kHz	≤–160 dBc	≤–150 dBc	≤–133 dBc
10 kHz	≤–160 dBc	≤–153 dBc	≤–134 dBc
100 kHz	≤–160 dBc	≤–153 dBc	≤–134 dBc

Power

- Operating voltage — 85 VAC to 264 VAC
- Frequency range — 47 Hz to 63 Hz
- Peak power — 150 W
- Operating power — 75 W
- External DC input — 22 VDC to 28 VDC 3.1 A (typical)
- Standby battery pack — 8 hours of operation

Physical

- Height — 42.0" (106.68 cm)
- Width — 18.0" (45.72 cm)
- Depth — 30.0" (76.0 cm)
- Weight — 475 lbs (216 kg) (without batteries***)

*** Add 66 lbs (30 kg) for batteries.

Ordering Information

Part Number	Description
75001-101	(3) 5 MHz, (1) 10 MHz, (1) 100 MHz
75001-102	(3) 5 MHz, (1) 10 MHz, (2) 100 MHz
75001-103	(3) 5 MHz, (1) 10 MHz, 1PPS sync, 1PPS output
75001-104	(3) 10 MHz, 1PPS sync, (2) 1PPS output
75001-105	(2) 5 MHz, (1) 100 MHz, 1PPS sync, 1PPS output
75001-106	(2) 5 MHz, (2) 10 MHz, 1PPS sync, (2) 1PPS output
75001-107	(2) 5 MHz, (2) 10 MHz, (1) 100 MHz
75001-108	(2) 5 MHz, (1) 10 MHz, (1) 100 MHz, 1PPS sync, 1PPS output
75001-109	(3) 5 MHz, (2) 10 MHz, (2) 100 MHz
75001-110	(3) 5 MHz, (3) 10 MHz
75001-111	(4) 5 MHz, (2) 10 MHz
75001-112	(3) 10 MHz, (2) 100 MHz, 1PPS sync, (2) 1PPS output
75001-113	(3) 5 MHz, (1) 10 MHz, (2) 100 MHz, 1PPS sync, 1PPS output
75001-114	(3) 5 MHz, (1) 10 MHz, (1) 100 MHz, 1PPS sync, (2) 1PPS output

Note: To order the optional Low Phase Noise option of the maser add LPN to the end of the part number.
For example 75001-101 LPN.

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