MHM-2020 Active Hydrogen Maser

Summary

Expanding upon the heritage of the world's most widely installed active Hydrogen Maser, the Microchip MHM-2020 has enhanced the unique Auto-Tune design of the MHM-2010 by re-engineering the electronics and software to attain even better stability.

Capable of achieving $<3 \times 10^{-16}$ daily drift rates along with improved environmental stability, the MHM-2020 has been designed for applications requiring extreme frequency stability and low phase noise.

Designed, manufactured and tested in the USA with an eye toward long service deployments, 95% of Masers built at Microchip's dedicated Maser facility since 1999 are still in operation. Each MHM-2020 is manufactured to meet stringent quality standards and undergoes extensive performance verification testing, prior to deployment.

Features

- Telemetry monitoring via touch screen and secure Ethernet
- Dedicated keypad or USB/serial port (secure) allow flexibility in instrument control
- Drift compensation mode enabling drift as low as $<3 \times 10^{-16}$/day (typical, after 3 months)
- Low hydrogen usage for extended maintenance-free operation and demonstrated lifetime of >20 years
- Internal time-of-day clock for internal data time stamping
- 1PPS synchronization option for precise calibration to GNSS
- Multiple 1PPS and RF output options (5, 10 or 100 MHz)
- Low phase noise option
- Battery backup
- CE compliant

Applications

- Scientific frequency reference source
- National timekeeping service
- Radio astronomy: Very Long Baseline Interferometry, Arrays (VLBI, VLBA)
- Deep space tracking and navigation
- GNSS/GPS satellite monitoring

User-Friendly Interface

Telemetry monitoring via the intuitive touch-panel display, secure Ethernet or serial interface presents a variety of secure options to you.

Auto Tune With Drift Compensation

The MHM-2020 incorporates an automatic frequency control system to maintain the resonant cavity at a constant frequency relative to the hydrogen emission line. This technique enables the Maser to deliver long-term stability that is only attributed to the most stable cesium atomic standards.

Now, by pairing this technology with the new integrated Drift Compensation software, daily aging rates of $<3 \times 10^{-16}$ can be consistently achieved with the MHM-2020.

Improved Environmental Stability

The Maser is designed to withstand variable voltage, temperature and magnetic field environments. By carefully selecting electronics and controlling the manufacturing process, each MHM-2020 is designed to achieve a Temperature and Magnetic Field sensitivity of $<8 \times 10^{-15}$/ºC and $<2 \times 10^{-14}$/Gauss, respectively.

Low Phase Noise Option

The MHM-2020 can be factory configured with low phase noise outputs that enable higher resolution measurements in VLBI applications and deep space communication and observations. You no longer have to face a tradeoff between long-term and short-term stability.

Low Maintenance and Cost of Ownership

Lifetime cost of ownership for active masers is a critical consideration. The MHM-2020 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-2020 is designed for on-site module replacement. We have ensured that the current industry leading MHM-2010 Maser deployed in the field can be upgraded to the new MHM-2020 depending on the age of the unit.

Redundant Power Supply and Backup

The Maser has a quadruple-redundant power system that charges an internal backup battery. The battery will maintain full operational Maser performance for up to 8 hours continuously in a normal laboratory environment. The system also has two independent AC mains supplies. Either of these supplies alone can power the Maser should one fail or lose mains power. Each input is capable of automatic operation from either 110 VAC or 220 VAC, 50 or 60 Hz. Additionally, a 24 VDC power system can be connected as a backup to the AC supplies. In the case that all power is lost, the Maser will revert to batteries until they are depleted.

About the MHM-2020

Hydrogen Masers operate on the principle that hydrogen atoms, in the proper environment, emit microwaves at a precise frequency (1420405751 Hz). This is the well-known atomic hydrogen wavelength of 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 hydrogen masers are up to 4 times more stable than passive hydrogen masers and up to 100 times more stable than a high performance cesium standard, at measuring times up to 7 days. 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.

Key features enabling high performance and long life of the MHM-2020 hydrogen maser are the patented magnetic quadrapole technology allowing superior atomic beam focusing, cavity auto-tuning and proprietary drift compensation software algorithms.

The long maintenance-free operation, as demonstrated by the large deployment base, is enabled by using relatively low amounts of Hydrogen to minimize ion pump loading, by employing a proprietary Teflon™ coating technique on critical components, and by using a dedicated Maser facility to control the manufacturing and test-verification pedigree of each Maser.

Specifications @ 25˚C (ambient), unless noted otherwise.

Electrical

RF Output	
Frequency	5, 10 or 100 MHz
Amplitude	1 Vrms
Load Impedance	50Ω
Power	13 dBm
Quantity	Model dependent
1 PPS Output	
Format	TTL
Level	> 3V into 50Ω
Rise/Fall Time	< 3 nS
Pulse Width	20 µS
Jitter	< 10 pS rms
Synchronization	< 15 nS (to 1 PPS input)
Quantity	2 (option)
1PPS Input (Auto-Sync)	
Format	TTL
Level	> 3V into 50Ω
Rise Time	< 5 nS
Pulse Width	≥ 20 µS
Jitter	< 1 nS rms
Quantity	1 (option)

Communication and system monitoring	
Telemetry Monitoring	RS-232, USB, Touch screen and Secure Ethernet (or optional on-board SD card storage)
Instrumentation Control	RS-232, USB or keypad

Power Input	
Voltage Range	85 to 264 VAC
Frequency Range	47 to 63 Hz
Power Consumption	75W (operating) 150W (peak)
DC Iinput (optional)	22 to 28 VDC 3.1 A (typical)
Battery Backup	8 hours

Performance Parameters

Frequency Control	7×10^{-10} Hz/Hz
Frequency Resolution	7×10^{-17} Hz/Hz
Note: The synthesizer maintains continuous phase throughout frequency changes	
Temperature Sensitivity	8×10^{-15}/ºC
Magnetic Sensitivity	2×10^{-14}/Gauss
*Voltage sensitivity	$<1 \times 10^{-14}$
*Note: max frequency perturbation when switching between power supply sources	

Stability

	ADEV (Standard)	ADEV (-LPN option)
τ = 1S	1.5×10^{-13}	8×10^{-14}
τ = 10S	2×10^{-14}	1.5×10^{-14}
τ = 100S	5×10^{-15}	4×10^{-15}
τ = 1,000S	2×10^{-15}	2×10^{-15}
τ = 10,000S	1.5×10^{-15}	1.5×10^{-15}
Note: Measured in 0.5 Hz Bandwidth		
**Floor	$<1.2 \times 10^{-15}$	$<1 \times 10^{-15}$
**Note: Typically achieved after extended period of unperturbed, continuous operation. Temperature variation: ±0.25°C. Relative humidity: ±10%.		

**Daily Aging $<3 \times 10^{-16}$ (typical)

Note: Achievable after >3mo's operation while applying integrated drift compensation software

Phase Noise (SSB)

-LPN Option			
Offset	5 MHz (dBc/Hz)	10 MHz (dBc/Hz)	100 MHz (dBc/Hz)
1 Hz	<–130	<–124	<–102
10 Hz	<–150	<–138	<–117
100 Hz	<–158	<–146	<–126
1 kHz	<–160	<–150	<–133
10 kHz	<–160	<–153	<–134
100 kHz	<–160	<–153	<–134

Standard			
Offset	**5 MHz (dBc/Hz)**	**10 MHz (dBc/Hz)**	**100 MHz (dBc/Hz)**
1 Hz	<–116	<–110	<–90
10 Hz	<–135	<–129	<–109
100 Hz	<–148	<–142	<–122
1 kHz	<–155	<–149	<–129
10 kHz	<–155	<–149	<–129
100 kHz	<–155	<–149	<–129

Mechanical

- Size 107 x 46 x 76 cm
- Weight 216 kg (246 kg w/ batteries)
- Warranty 2 year

Ordering Information

Description	Model No
MHM-2020 3 -5MHz, 5 -10MHz	76001-201
MHM-2020 4 -5MHz, 4 -10MHz	76001-202
MHM-2020 3 -5MHz, 4 -10MHz, 2 -1PPS	76001-203
MHM-2020 3 -5MHz, 4 -10MHz, 2 -100MHz	76001-204
MHM-2020 3 -5MHz, 3 -10MHz, 2 -100MHz, 2 -1PPS	76001-205
Low Noise Option	76001-LPN
Replace Ethernet Telemetry monitoring with SD-card option	76001-SD
UPGRADE EXISTING MHM-2010 MASER TO MHM-2020 w/ NEW ELECTRONICS (contact factory for availability)	76001-U

For More Information

www.microsemi.com

396-76001-000 DS00003090A