

Helping Customers Innovate, Improve & Grow



MD-015

The MD-015 is a Microchip GNSS disciplined atomic clock module. 1 PPS TTL, 10MHz sine wave, and 10 MHz square wave outputs are generated from an on-board low-power SA.65s Chip Scale Atomic Clock, a high-stability SA53, or a high-stability SA55 Miniature Atomic Clock which is disciplined to an embedded 72 channel multi-constellation GNSS receiver or an external reference input supporting input frequencies from 1Hz (1PPS) to 120 MHz.

## Features

- Embedded GNSS Receiver - GPS, GLONASS, Galileo
- 1pps TTL output signal
- TTL (5.0V) Standard, LVTTTL (3.3V) available
- 10MHz sinewave and square wave output
- Other RF output frequencies available
- Adaptive aging correction during holdover
- Barometric pressure correction
- Evaluation kit with software
- Serial Communications Interface

## Applications

- Basestation Communication
- Digital Video Broadcast
- E911 Location Systems
- General Timing and Synchronization
- Military Radio
- Radar Systems

## Block Diagram

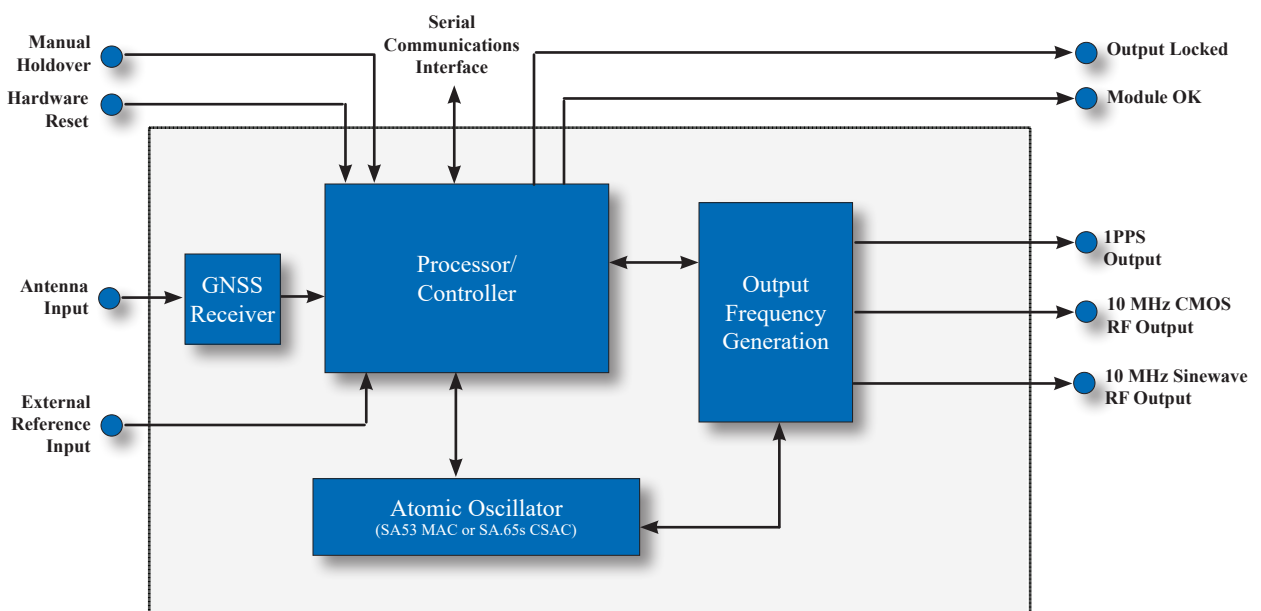


Figure 1. Functional Block Diagram

## Summary Specifications

Comparative Performance of Standard Modules						
Model	Embedded Oscillator	Typical Uses				
MD-015-0001	SA.65s CSAC	Applications requiring fast startup, low power, and 1.5uS holdover for up to 24 hours				
MD-015-0002	SA53 MAC	Applications requiring high stability and sub-microsecond holdover for up to 48 hours				
MD-015-0003	SA55 MAC	Applications requiring high stability and sub-microsecond holdover for up to 48 hours				
Hold Over Performance <sup>1</sup>						
Model	$\Delta$ Temp	Maximum Accumulated Time Error for Given Holdover Time*				
		1 hour	4 hours	8 hours	24 hours	48 hours
MD-015-0001	2°C	75 ns	300 ns	700 ns	3.5 $\mu$ s	12 $\mu$ s
MD-015-0001	10°C	250 ns	1.2 $\mu$ s	2.5 $\mu$ s	8 $\mu$ s	20 $\mu$ s
MD-015-0002	2°C	15 ns	40 ns	80 ns	310 ns	900 ns
MD-015-0002	10°C	40 ns	140 ns	280 ns	950 ns	1.2 $\mu$ s
MD-015-0003	2°C	15 ns	40 ns	80 ns	310 ns	900 ns
MD-015-0003	10°C	40 ns	140 ns	280 ns	950 ns	1.2 $\mu$ s
* Estimated performance in a static environment (except noted temperature change) after being locked for 30 days at 25°C prior to holdover entry with zero initial phase/frequency error. Detailed testing and analysis of the specific installation and usage scenario is necessary to determine more accurate holdover performance for a specific application.						

## Summary Specifications

Phase Noise					
Model	Min	Typ	Max	Unit	Condition
MD-015-0001			-50	dBc/Hz	1 Hz offset
			-70	dBc/Hz	10 Hz offset
			-113	dBc/Hz	100 Hz offset
			-128	dBc/Hz	1 kHz offset
			-135	dBc/Hz	10 kHz offset
			-140	dBc/Hz	100 kHz offset
MD-015-0002			-65	dBc/Hz	1 Hz offset
			-85	dBc/Hz	10 Hz offset
			-112	dBc/Hz	100 Hz offset
			-130	dBc/Hz	1 kHz offset
			-140	dBc/Hz	10 kHz offset
MD-015-0003			-70	dBc/Hz	1 Hz offset
			-87	dBc/Hz	10 Hz offset
			-114	dBc/Hz	100 Hz offset
			-130	dBc/Hz	1 kHz offset
			-140	dBc/Hz	10 kHz offset
ADEV					
Model	Min	Typ	Max	Condition	
MD-015-0001			3.0 E-10	1 sec tau	
			1.0 E-10	10 sec tau	
			3.0 E-11	100 sec tau	
			1.5 E-11	1000 sec tau	
			2.0 E-12	10000 sec tau	
			2.0 E-13	100000 sec tau	
MD-015-0002			5.0 E-11	1 sec tau	
			2.0 E-11	10 sec tau	
			5.0 E-12	100 sec tau	
			3.0 E-12	1000 sec tau	
			8.0 E-13	10000 sec tau	
			5.0 E-13	100000 sec tau	
MD-015-0003			3.0 E-11	1 sec tau	
			1.0 E-11	10 sec tau	
			3.0 E-12	100 sec tau	
			2.0 E-12	1000 sec tau	
			5.0 E-13	10000 sec tau	
			2.0 E-13	100000 sec tau	

Internal Receiver Characteristics		
Parameter		Condition
Type	Timing w/ Self-Survey	
Number of channels	72	
Frequency bands	GPS L1C/A	
	GLONASS L1OF	
	Galileo E1B/C	
	QZSS L1C/A	
	SBAS L1C/A	Disabled by default
Tracking capability	36 SVs	
Sensitivity	-167 dBm	Tracking (GPS & GLONASS)
	-148 dBm	Cold Acquisition (GPS & GLONASS)
	-160 dBm	Reacquisition (GPS & GLONASS)
Position Accuracy	2.5 meters CEP	GPS & GLONASS, static, -130 dBm, > 6 SVs
TTFF	25 seconds	Cold Start (GPS & GLONASS)
Maximum Navigation Update Rate (User Configurable)	10 Hz	Single-GNSS
	4 Hz	Multi-GNSS

MD-015-0001 Performance Characteristics				
Parameter	Min	Typ	Max	Condition
Supply Voltage	7.0	12.0	24.0	VDC
Warmup Time			6.0	Minutes
Locking Time	0.5	1.0	10.0	Minutes, assuming warmup complete and stable reference
Monthly Aging <sup>1</sup>			9E-10	Hz/Hz
Temp Stability			5E-10	Hz/Hz -40° to 80°
Time Accuracy <sup>2</sup>			5.0	±1σ nS
Frequency Accuracy			5E-13	Hz/Hz (adev at τ=86,000s)
PPS Jitter			120	pS
Warmup Power*			2.0	Watts
Steady State Power*			2.0	Watts
Operating Temperature	-40		80	°C
Storage Temperature	-55		90	°C
Humidity	0		95	% RH MIL-STD-810 Method 507.4
Vibe			7.7	grms, MIL-STD-810G, Operational, Figure 514.7E-1. Category 24: No loss of lock
Weight			75	grams

\* Warmup and Steady State Power does not include power required by a GNSS antenna or any input/output current sinks.

MD-015-0001 Absolute Maximum Ratings				
Parameter	Min	Typ	Max	Condition
Supply Voltage			32	VDC
Dc voltage on any I/O pin			5.5	V
Output load			10	Ohms
AC ripple			50	mVpk-pk
Storage Temperature	-55		90	°C
Shock			1000	g, MIL-STD-202-213A, Condition E
Vibe			7.7	grms, MIL-STD-810G, Operational, Figure 514.7E-1. Category 24
Weight			75	grams

**MD-015-0002 Operating / Performance Characteristics**

<b>Parameter</b>	<b>Min</b>	<b>Typ</b>	<b>Max</b>	<b>Condition</b>
Supply Voltage	7.0	12.0	24.0	VDC
Warmup Time*		8.0	12.0	Minutes
Locking Time	0.5	1.0	10.0	Minutes, assuming warmup complete and stable reference
Monthly Aging <sup>1</sup>		5E-11		Hz/Hz
Temp Stability			5E-10	Hz/Hz -40° to 75°
Temp Stability			1E-10	Hz/Hz -10° to 75°
Time Accuracy <sup>2</sup>			5.0	±1σ nS
Frequency Accuracy			5E-13	Hz/Hz (adev at τ=86,000s)
PPS Jitter			350	pS
Warmup Power**			15.25	Watts
Steady State Power**		5.25	7.0	Watts @ 65°C
Steady State Power**		7.25	9.0	Watts @ 25°C
Steady State Power**		9.25	12	Watts @ -10°C
Steady State Power**		11	15.5	Watts @ -40°C
Magnetic Sensitivity			2	Gauss (±7E-11 Hz/Hz/Gauss)
Voltage Sensitivity	-1		1	VDC (<1E-11 Hz/Hz)
Operating Temperature	-40		75	°C
Humidity				GR-63-CORE, issue 4, April 2012, section 4.1.2
Shock			30	g, 11 msec half-sine pulse per MIL-STD-202, Method 213, Test Condition J, 18 shocks (3+ & 3- per axis): no loss of lock, ≤ 4x10-8 Hz/Hz frequency perturbation momentary
Vibe			7.7	grms @ 1 hr/axis per MIL-STD-810, Fig 514.7E-1, Category 24 (General Minimum Integrity Exposure): no loss of lock.
Altitude	-1,200		50,000	Feet AMSL
Weight			150	grams

\* Increased warmup time will be observed at temperatures less than -10°C

\*\* Warmup and Steady State Power does not include power required by a GNSS antenna or any input/output current sinks.

**MD-015-0002 Absolute Maximum Ratings**

<b>Parameter</b>	<b>Min</b>	<b>Typ</b>	<b>Max</b>	<b>Condition</b>
Supply Voltage			32	VDC
Dc voltage on any I/O pin			5.5	V
Output load			10	Ohms
AC ripple			50	mVpk-pk
Storage Temperature	-55		100	°C
Shock (Storage / Transport)			50	g, 11 msec half-sine pulse per MIL-STD-202, Method 213, Test Condition A, 18 shocks (3+ & 3- per axis)
Vibe (Storage / Transport)			10.9	grms @ 1 hr/axis per MIL-STD-810, Fig 514.7E-1, Category 24 (General Minimum Integrity Exposure)
Altitude (Storage / Transport)	-1,200		70,000	Feet AMSL

**MD-015-0003 Operating / Performance Characteristics**

<b>Parameter</b>	<b>Min</b>	<b>Typ</b>	<b>Max</b>	<b>Condition</b>
Supply Voltage	7.0	12.0	24.0	VDC
Warmup Time*		8.0	12.0	Minutes
Locking Time	0.5	1.0	10.0	Minutes, assuming warmup complete and stable reference
Monthly Aging <sup>1</sup>		5E-11		Hz/Hz
Temp Stability			5E-10	Hz/Hz -40° to 75°
Temp Stability			1E-10	Hz/Hz -10° to 75°
Time Accuracy <sup>2</sup>			5.0	±1σ nS
Frequency Accuracy			5E-13	Hz/Hz (adev at τ=86,000s)
PPS Jitter			350	pS
Warmup Power**			15.25	Watts
Steady State Power**		5.25	7.0	Watts @ 65°C
Steady State Power**		7.25	9.0	Watts @ 25°C
Steady State Power**		9.25	12	Watts @ -10°C
Steady State Power**		11	15.5	Watts @ -40°C
Magnetic Sensitivity			2	Gauss (±7E-11 Hz/Hz/Gauss)
Voltage Sensitivity	-1		1	VDC (<1E-11 Hz/Hz)
Operating Temperature	-40		75	°C
Humidity				GR-63-CORE, issue 4, April 2012, section 4.1.2
Shock			30	g, 11 msec half-sine pulse per MIL-STD-202, Method 213, Test Condition J, 18 shocks (3+ & 3- per axis): no loss of lock, ≤ 4x10-8 Hz/Hz frequency perturbation momentary
Vibe			7.7	grms @ 1 hr/axis per MIL-STD-810, Fig 514.7E-1, Category 24 (General Minimum Integrity Exposure): no loss of lock.
Altitude	-1,200		50,000	Feet AMSL
Weight			150	grams

\* Increased warmup time will be observed at temperatures less than -10°C

\*\* Warmup and Steady State Power does not include power required by a GNSS antenna or any input/output current sinks.

**MD-015-0003 Absolute Maximum Ratings**

<b>Parameter</b>	<b>Min</b>	<b>Typ</b>	<b>Max</b>	<b>Condition</b>
Supply Voltage			32	VDC
Dc voltage on any I/O pin			5.5	V
Output load			10	Ohms
AC ripple			50	mVpk-pk
Storage Temperature	-55		100	°C
Shock (Storage / Transport)			50	g, 11 msec half-sine pulse per MIL-STD-202, Method 213, Test Condition A, 18 shocks (3+ & 3- per axis)
Vibe (Storage / Transport)			10.9	grms @ 1 hr/axis per MIL-STD-810, Fig 514.7E-1, Category 24 (General Minimum Integrity Exposure)
Altitude (Storage / Transport)	-1,200		70,000	Feet AMSL

## Specifications

GPS Antenna					
Parameter	Min	Typical	Max	Units	Condition
Antenna Bias Voltage	4.0	4.8	5.1	V <sub>DC</sub>	
Antenna Current <sup>4</sup>		20	100	mA	
RF Output Waveform Characteristics (via MCX)					
Parameter	Min	Typical	Max	Units	Condition
Waveform	Sinewave				
Output Power	+3.0	+9.0	+11.0	dBm	50 Ohm
Harmonics			-30	dBc	50 Ohm
Spurious			-85	dBc	50 Ohm
RF Output Waveform Characteristics (via pin 8)					
Waveform	HCMOS				
High Level Output Voltage (V <sub>OH</sub> )	4.0		5.0	V <sub>DC</sub>	<-0.5mA Load
Low Level Output Voltage (V <sub>OL</sub> )		0.0	0.4	V <sub>DC</sub>	<0.5mA Load
Rise/Fall Time		3	5	nSec	15 pF
Duty Cycle	40	50	60	%	15 pF
1pps Output Characteristics (via MCX and pin 2)					
Parameter	Min	Typical	Max	Units	Condition
Waveform	TTL				
High-level output voltage (V <sub>OH</sub> )	3.0		5.0	V <sub>DC</sub>	50 Ohms
Low-level output voltage (V <sub>OL</sub> )		0.0	0.4	V <sub>DC</sub>	50 Ohms
Pulse Width	9.9	10	10.1	uSec	default setting, user programmable
External 1PPS Reference Input (Pin 1)					
Waveform	TTL				
High-Level Output Voltage (V <sub>OH</sub> )	2.0		5.0	V <sub>DC</sub>	50 Ohms input impedance
Low-Level Output Voltage (V <sub>OL</sub> )		0.0	0.4	V <sub>DC</sub>	
Pulse width	1.0			uSec	
Lock Status Indicator (Pin 9) <sup>3</sup>					
Parameter	Min	Typical	Max	Units	Condition
Module Locked	4.5	5.0	5.5	V <sub>DC</sub>	<5mA Load
Module Not Locked	0		0.5	V <sub>DC</sub>	<5mA Load
Module Hardware OK Indicator (Pin 10) <sup>4</sup>					
Module Hardware OK	4.5	5.0	5.5	V <sub>DC</sub>	<5mA Load
Module Hardware Failure	0		0.5	V <sub>DC</sub>	<5mA Load
Module Hardware Reset (Pin 12)					
Reset Module	0		0.5	V <sub>DC</sub>	10 kOhm internal pullup
Manual Holdover Set (Pin 11)					
Enter Manual Holdover	0		0.5	V <sub>DC</sub>	5.6 kOhm internal pullup
Serial Communications Interface <sup>6,7</sup>					
Rx high-level input voltage (V <sub>IH</sub> )	4.5	5.0	5.5	V <sub>DC</sub>	100 kOhm internal pullup
Rx low-level input voltage (V <sub>IL</sub> )	-0.5		0.5	V <sub>DC</sub>	
Tx high-level output voltage (V <sub>OH</sub> )	4.5	5.0	5.5	V <sub>DC</sub>	
Tx low-level output voltage (V <sub>OL</sub> )	-0.5		0.5	V <sub>DC</sub>	
Status Reporting Interval	1		255	s	User configurable
Communications Protocol	VSIP2.1/NMEA 0183 V4.1				See VSIP2.1 for Full Details
Baud Rate	9,600	115,200	460,800	baud	User configurable

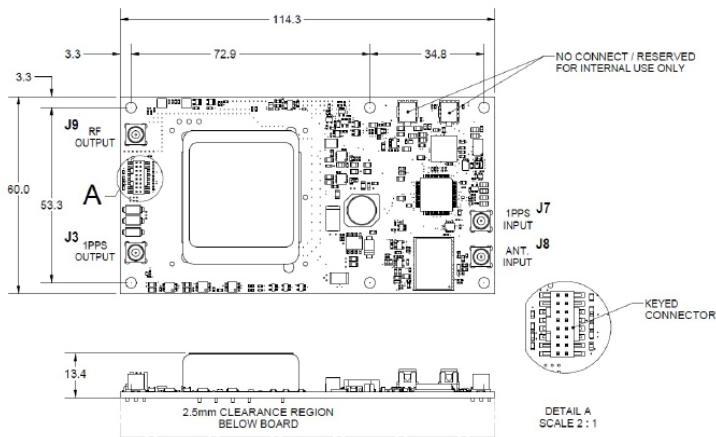
# Reliability

Although ESD protection circuitry has been designed into the MD-015, proper precautions should be taken when handling and mounting. Microchip employs a human body model (HBM) and a charged-device model (CDM) for ESD susceptibility testing and design protection

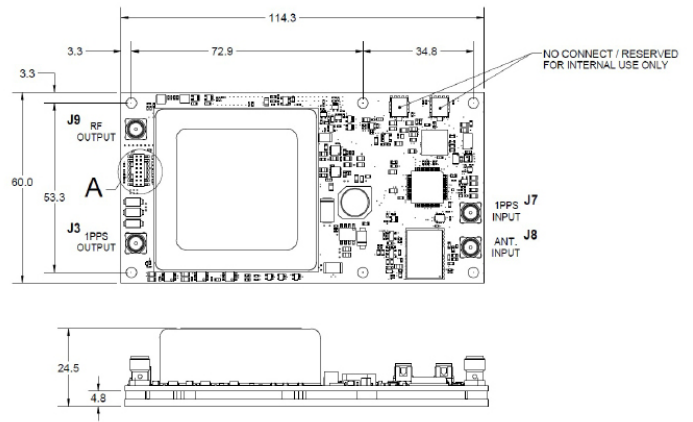
ESD Ratings		
Model	Minimum	Conditions
Human body model	1500 V	MIL-STD-883C, Method 3015
Charged device model	1000 V	JEDEC, JESD22-C101

# Package Outline

**MD-015-0001**



**MD-015-0002 & MD-015-0003**



**Notes:**

- RF and 1pps input and output connectors are MCX type (SMA, SMB, MMCX connectors require additional part numbers).
- Keyed connector is Samtec FTSH-108-01LDVK type.
- Dimensions: mm
- Module height in part number is the sum of oscillator height, board, and clearance

**16 Pin I/O Connections**

Number	Name	Description
1	Ref In	External Reference Input
2	PPS Out	1 PPS Output
3	Ground	Ground
4	Ground	Ground
5	Rx	Serial Communications Receive
6	Tx	Serial Communications Transmit
7	Vcc	Power Supply
8	RF Out	RF HCMOS Output
9	Locked	Logic-high = Output locked to GPS
10	Module OK	Logic low = Failure with module operation
11	ManHold	Manual Holdover Input
12	Reset	Hardware reset
13	Ground	Ground
14	Ground	Ground
15	Vcc	Power Supply
16	Vcc	Power Supply



## Accessories

Microchip Partnumber	Description
MD-015-EK	Evaluation Kit only
MD-015-0001-EK	MD-015-0001 Module with Evaluation Kit
MD-015-0002-EK	MD-015-0002 Module with Evaluation Kit
MD-015-0003-EK	MD-015-0003 Module with Evaluation Kit

## Ordering Information Instructions

Customization to unique customer requirements is available and is common for this level of integration. Common customizations include alternate output frequencies, temperature ranges, differing values and methods of hold over specification, and holdover optimization in the frequency domain. The table below lists existing combinations available as of the date of publication of this data sheet. Please contact the factory for additional options.

Available Models		
<b>MD-015-0001</b>	<b>MD-015-0002</b>	<b>MD-015-0003</b>

## Notes

- 1) Aging performance is after 1 month of power-on time. Temperature and aging rates are when device is not locked. Performance measured in still air.
- 2) After customer applies correct offset using cable delay command while locked, after 24 hours of locked operation
- 3) The status locked indicator is intended to indicate when the module is fully locked to a reference.
- 4) The Hardware OK indicator is intended to indicate when the module is operating properly without any failures, including hardware, software or parameter out of range.
- 5) Antenna over current flag will be set if maximum current is exceeded. Circuit has overcurrent protection.
- 6) The Rx pin is the serial interface input and the Tx pin is the serial interface output.
- 7) Serial configuration: 8 data bits, 1 stop bit, no parity, no flow control

## Contact Information

### USA:

100 Watts Street  
Mt Holly Springs, PA 17065  
Tel: 1.717.486.3411  
Fax: 1.717.486.5920

### Europe:

Landstrasse  
74924 Neckarbischofsheim  
Germany  
Tel: +49 (0) 7268.801.0  
Fax: +49 (0) 7268.801.281



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