

LM-010

Radiation-Tolerant, Low Earth Orbit Disciplined Oscillator Module



Summary

The LM-010 standard platform module provides 1 PPS TTL and 10 MHz sinewave outputs that are disciplined to an external reference input. A Microchip digitally corrected OCXO or a low-power SA45S Chip Scale Atomic Clock (CSAC) is integrated into the module. This solution is designed for Low Earth Orbit (LEO) applications that demand radiation tolerance and the stability and holdover capabilities that our disciplined modules offer.

Features

- 1 PPS to 75 MHz reference frequency input
- 1 PPS TTL output signal
- 10 MHz sine wave output
- Other RF output frequencies available (OCXO version only)
- Adaptive aging correction during holdover
- Serial communications interface
- Evaluation kit with software
- Radiation tolerant

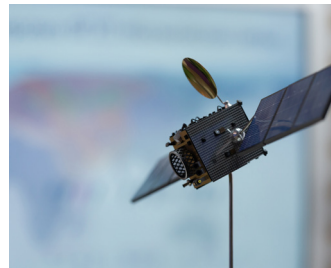
Applications



Exo-Atmosphere Missions



Low Earth Orbit Satellites

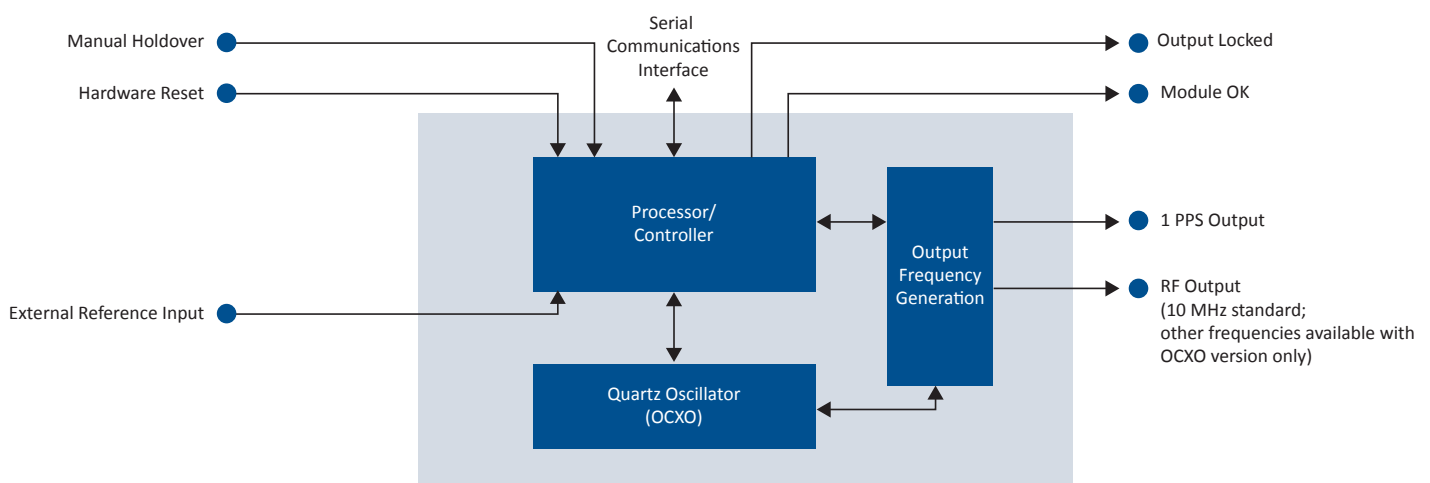


Small Satellites



Launch Vehicles

Functional Block Diagram



Comparative Performance of Standard Modules

Model	Embedded Oscillator	Typical Uses
LM-010	Digitally assisted OCXO Chip Scale Atomic Clock (CSAC)	Applications requiring 1 hour hold over as low as 3 μ s Applications requiring 1 hour hold over as low as 0.3 μ s

Holdover Performance¹

Holdover Time:	10 Minutes	1 Hour	1 Hour	24 Hours
Holdover Temperature Change:	$\Delta T = 2^{\circ}\text{C}$	$\Delta T = 2^{\circ}\text{C}$	$\Delta T = 10^{\circ}\text{C}$	$\Delta T = 2^{\circ}\text{C}$
Model	Maximum Accumulated Holdover (μ s)			
LM-010 with OCXO LM-010 with CSAC	0.2 0.01	3 0.1	11 0.3	60 2.0

Summary Performance Characteristics

Model	Warmup Time (Min.)	Aging (ppb) ¹	Temperature Stability (ppb) ¹	Accuracy to UTC (+/- 1 σ) (ns) ²	Frequency Accuracy (+/-) ³	Warmup Power @ 25°C (W)	Steady State Power @ 25°C (W)	Voltage (V)
LM-010 with OCXO	7	30/mo.	20	20	< 1E-12	7.5	2.0	12
LM-010 with CSAC	7	0.9/mo.	0.5	20	< 1E-12	7.5	2.0	12

Phase Noise					
Model	-10 Hz	-100 Hz	-1 kHz	-10 kHz	-100 kHz
LM-010 with OCXO LM-010 with CSAC	-110 dBc/Hz -70 dBc/Hz	-125 dBc/Hz -113 dBc/Hz	-135 dBc/Hz -128 dBc/Hz	-140 dBc/Hz -135 dBc/Hz	-145 dBc/Hz -140 dBc/Hz

Allan Deviation (ADEV)				
Model	t = 1s	t = 10s	t = 100s	Condition
LM-010 with OCXO	2.5E-11	5E-11	4E-11	Still air, no temperature change
LM-010 with CSAC	3E-10	1E-10	3E-11	

RF Output Waveform Characteristics (via SMA)					
Parameter	Min.	Typical	Max.	Units	Condition
Waveform	Sine wave				
Output Power	+3.0	+9.0	+11.0	dBm	50 Ω
Harmonics			-30	dBc	50 Ω
Spurious			-65	dBc	50 Ω

1 PPS Output Characteristics (via SMA)					
Parameter	Min.	Typical	Max.	Units	
Waveform	TTL				
High-Level Output Voltage (VOH)	1.5		4.0	VDC	50Ω
Low-Level Output Voltage (VOL)		0.0	0.4	VDC	50Ω
Pulse Width	9.9	10	10.1	μs	Default setting, user programmable

External 1 PPS Reference Input (via SMA)					
Parameter	Min.	Typical	Max.	Units	Condition
Waveform	TTL				
High-Level Output Voltage (VOH)	2.0		5.0	VDC	50Ω input impedance
Low-Level Output Voltage (VOL)		0.0	0.4	VDC	50Ω input impedance
Pulse Width	10 μs to 750 ms				
Reference Frequency	1 Hz to 75 MHz				
	User configurable				

Lock Status Indicator (Pin 9)4					
Parameter	Min.	Typical	Max.	Units	Condition
Module Locked	2.8	3.3	3.8	VDC	< 5 mA load
Module Not Locked	0		0.5	VDC	< 5 mA load

Module Hardware OK Indicator (Pin 10)5					
Parameter	Min.	Typical	Max.	Units	Condition
Module Hardware OK	2.8	3.3	3.8	VDC	< 5 mA load

Module Hardware Reset (Pin 12)					
Parameter	Min.	Typical	Max.	Units	Condition
Reset Module	0		0.5	VDC	10 kΩ internal pullup

Module Holdover Reset (Pin 11)					
Parameter	Min.	Typical	Max.	Units	Condition
Enter Manual Holdover	0		0.5	VDC	5.6 kΩ internal pullup

Serial Communications Interface6,7					
Parameter	Min.	Typical	Max.	Units	Condition
Rx High-Level Input Voltage (VIH)	2.8	3.3	3.8	VDC	
Rx Low-Level Input Voltage (VIL)	0		0.5	VDC	
Tx High-Level Output Voltage (VOH)	2.8	3.3	3.8	VDC	
Tx Low-Level Output Voltage (VOL)	0		0.5	VDC	
Update Rate	1		255	Sec	User configurable
Communications Protocol	VSIP2.1				See VSIP2.1 for full details

Supply Voltage (Pin 1, 2, 15, 16)					
Parameter	Min.	Typical	Max.	Units	Condition
Supply Voltage	+11.4 +4.75	+12 +5.0	+12.6 +5.25	VDC VDC	Via pin 1,2 Via pin 15,16

Power Consumption					
Parameter	Min.	Typical	Max.	Units	Condition
Warm-up Power			7.5	W	@ 25°C
Steady-State Power with OCXO			2.0	W	12V supply @ 25°C
			1.6	W	5V supply @ 25°C
Steady-State Power with CSAC			2.0	W	12V supply @ 25°C
			1.6	W	5V supply @ 25°C

Absolute Maximum Ratings					
Parameter	Min.	Typical	Max.	Units	Condition
Supply Voltage			15	VDC	
DC Voltage on Any I/O Pin	-0.5		5.5	V	
Output Load	10			Ω	
AC Ripple			50	mV peak to peak	10 Hz to 1 MHz

Environmental Conditions					
Parameter	Min.	Typical	Max.	Units	Condition
Operating Temperature	-40		+85	°C	With OCXO option
Operating Temperature	-10		+70	°C	With CSAC option
Humidity at 40°C			90	%	
Storage Temperature	-55		+85	°C	

Physical Characteristics					
Parameter	Min.	Typical	Max.	Units	Condition
Weight			190	g	With OCXO option
			200	g	With CSAC option

Reliability					
Qualification includes various aging, extreme temperature, shock and vibration, temperature cycling and IR reflow simulations. The LM-010 family can meet the following qualification tests:					

Environmental Compliance	
Parameter	Conditions
Mechanical Shock (operating)	MIL-STD-202, Method 213 Condition B (75g, 6 ms)
Mechanical Shock (non-operating)	MIL-STD-202, Method 213A Condition D (500g)
Mechanical Vibration	MIL-STD-883, Method 2026 Condition I-B (7.3 Grms, 15 min)
Resistance to Solvents	MIL-STD-202, Method 215
Thermal Cycles	800 (-40 to +85°C)
MTBF	503,000 hrs, MIL-HDBK-217F (space flight, 50°C)
Radiation, Total Ionizing Dose (TID)	With OCXO: 50 krad (Si)
	With CSAC: 20 krad (Si)
Radiation (Single Event)	Fluence 4e8 protons/cm ²
Single Event Latch-up/Upset (SEL/SEU)8	Immune up to 28 MeV-cm ² /mg

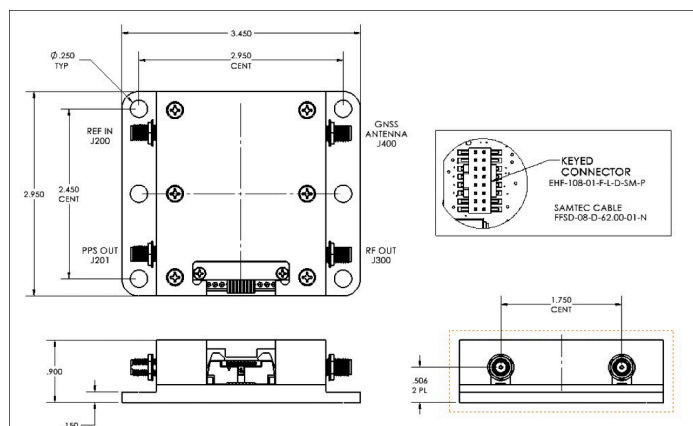
ESD Ratings	
Although ESD protection circuitry has been designed into the LM-010, proper precautions should be taken when handling and mounting. Microchip employs a Human Body Model (HBM) and a Charged-Device Model (CDM) for ESD susceptibility testing and design protection evaluation.	

Model	Minimum	Conditions
Human Body Model	1,500V	MIL-STD-883, Method 3015
Charged Device Model	1,000V	JEDEC, JESD22-C101

Accessories

Microchip Part Number	Description
LM-01X_EVAL-KIT	Evaluation kit only (module must be ordered separately)

Package Outline



16-Pin I/O Connections		
Number	Name	Description
1	+12V	Power supply
2	+12V	Power supply
3	Ground	Ground
4	Ground	Ground
5	Rx	Serial communication receive
6	Tx	Serial communication transmit
7	N/C	No connect
8	N/C	No connect
9	Locked	Logic high = Output locked to reference
10	Module OK	Logic low = Failure with module operation
11	MOD IRQ	Module IRQ
12	Reset	Hardware reset
13	Ground	Ground
14	Ground	Ground
15	+5V	Power supply
16	+5V	Power supply

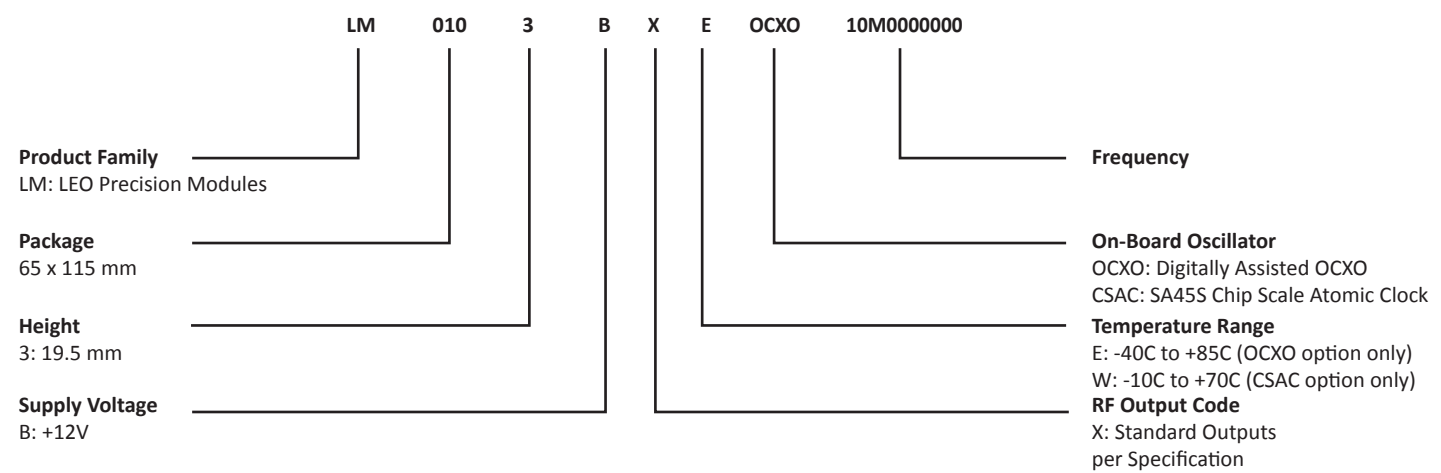
Notes:

- RF and 1 PPS input and output connectors are SMA type
- Keyed connector is Samtec EHF-108-01-F-L-D-SM-P type
- Dimensions in inches

Ordering Information

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 holdover 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.

Part Numbering Diagram



Available Models	
LM-0103-BXE-OCXO-10M0000000	LM-0103-BXW-CSAC-10M0000000

Notes

1. Aging performance is after seven days of power-on time. Temperature stability and aging rates are when device is not locked. Performance is measured in still air.
2. Assuming that the user has applied a cable delay correction and allowed the module to lock to reference for 24 hrs
3. ADEV at t = 86400s while locked after 24 hrs. of locked operation
4. The Status Locked indicates when the module is fully locked to a reference
5. The Hardware OK i indicates when the module is operating properly without any failures, including hardware, software or parameter out of range
6. The Rx pin is the serial interface input, and the Tx pin is the serial interface output
7. Serial configuration: 115,200 baud with 8 data bits, 1 stop bit, no parity, no flow control; additional baud rate options available by user configuration
8. The module is designed to tolerate transient upset events without experiencing latch-up or permanent damage. Recovery from an upset event is managed through one of the following mechanisms: automatic watchdog timer reset, external reset input or manual power cycling. When equipped with the CSAC option, recovery may occur via watchdog reset; however, in some cases, a full power cycle may be required to restore normal operation.

Technical Support

North and South America

Microchip Technology Inc.
3870 North First Street San Jose, CA 95134-1702
Toll-free in North America: 1-888-367-7966, option 3
Telephone: 408-428-7907
Email: SJO-FTD.Support@microchip.com
Web: <https://microchipsupport.force.com/s/>

Europe, Middle East, and Africa

Microchip FTS EMEA
Altlaufstrasse 42
85635 Hoehenkirchen-Siegersbrunn Germany
Telephone: +49 700 3288 6435
Email: FTD.EMESupport@microchip.com
Web: <https://microchipsupport.force.com/s/>

Asia

Microchip Technology (India) Pvt. Ltd.
Phase 1, Plot No. 149/B, Block A, EPIP,
Whitefield, Industrial Area, Bengaluru,
Karnataka 560066, India
Email: SJO-FTD.Support@microchip.com
Web: <https://microchipsupport.force.com/s/>

GNSSDO-Specific Technical Support

Timing-Modules-MHS@microchip.com