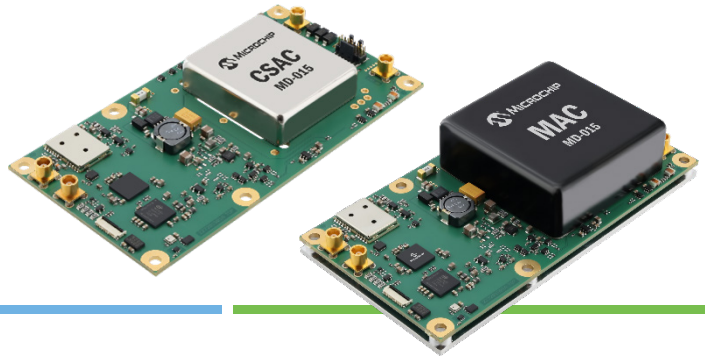
MD-015

Disciplined GNSS Atomic Oscillator Module



Summary

The MD-015 is our GNSS disciplined atomic clock module. This module can generate 1 PPS TTL, 10 MHz sine wave and 10 MHz square wave outputs from an on-board low-power SA65 Chip Scale Atomic Clock (CSAC), a high-stability SA53 Miniature Atomic Clock (MAC) or a high-stability SA55 MAC. The atomic clock onboard the module is disciplined to an embedded 72-channel multi-constellation Single-Band GNSS receiver with the option to upgrade to a configurable L1/L2 or L1/L5 Dual-Band, multi-GNSS receiver that supports GPS, Galileo, BeiDou, and NavIC or an external reference input supporting input frequencies from 1 Hz/1 PPS to 120 MHz.

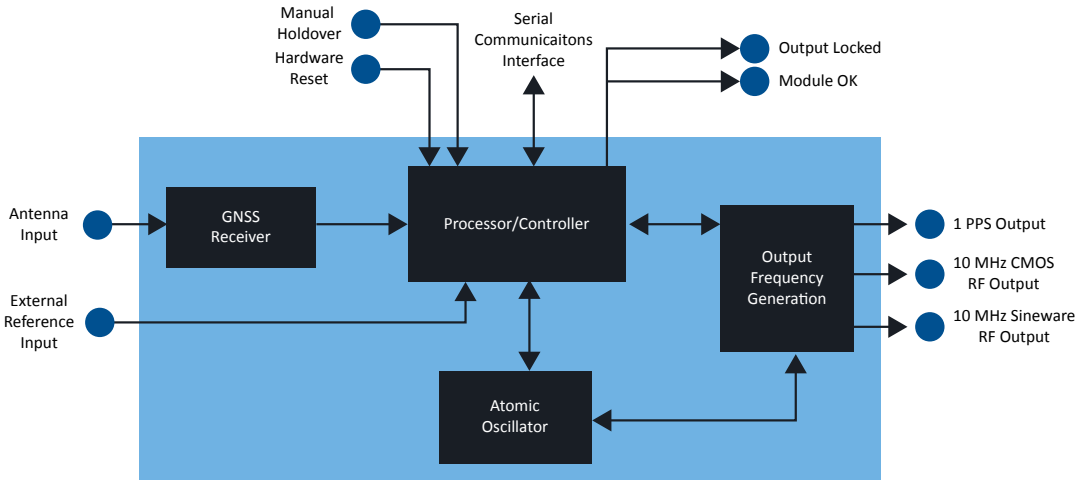
Features

- Embedded GNSS receiver—GPS, Galileo, BeiDou, and NavIC
- Single-Band and Dual-Band receiver options available
- 1 PPS TTL output signal
- 5.0V TTL standard and 3.3V LVTTL
- 10 MHz sine wave and square wave outputs
- Adaptive aging correction during holdover
- Barometric pressure correction
- Serial communication interface
- NMEA 0183 V4.1
- Evaluation kit with software

Applications

- Airborne
- Vehicle Platforms
- Radar Systems
- LTE and LTE Advanced (LTE-A)
- Laboratory Testing
- Base Stations
- MILSATCOM
- Navigation and Position Systems
- Radio Communications
- UAV/UAS
- Manufacturing Testing
- Time Syncronization

Functional Block Diagram



Specifications

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

Comparative Performance of Standard Modules

Model	Embedded Oscillator	Typical Uses
MD-015-0001-L1*	SA65 CSAC	Applications requiring fast startup, low power and 1.5 microsecond holdover for up to 24 hours
MD-015-0002-L1*	SA53 MAC	Applications requiring high stability and 800 nanosecond holdover for up to 48 hours
MD-015-0003-L1*	SA55 MAC	Applications requiring high stability and 500 nanosecond holdover for up to 48 hours

* The L1 suffix refers to the module's standard embedded GNSS receiver. Options include **L1**: Single band or **DB**: Dual-band L1/L2 and L1/L5 configurable (see pg.3 and 4 for specifications on each)

** 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 with zero initial phase/frequency error

Holdover Performance[1]

Model	Δ Temp	Maximum Accumulated Time Error for Given Holdover Time**				
		1 Hour	4 Hours	8 Hours	24 Hours	48 Hours
MD-015-0001-L1	2°C	75 ns	300 ns	600 ns	1.5 µs	3.0 µs
MD-015-0001-L1	10°C	200 ns	600 ns	1.5 µs	4.0 µs	8.0 µs
MD-015-0002-L1	2°C	15 ns	40 ns	80 ns	310 ns	800 ns
MD-015-0002-L1	10°C	40 ns	150 ns	280 ns	950 ns	1.8 µs
MD-015-0003-L1	2°C	10 ns	30 ns	50 ns	200 ns	500 ns
MD-015-0003-L1	10°C	30 ns	100 ns	220 ns	600 ns	1.0 µs

Phase Noise					
Model	Min	Typical	Max	Unit	Condition
MD-015-0001-L1			−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-L1			−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-L1			−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**	**Typical**	**Max**	**Unit**
MD-015-0001-L1			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-L1			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-L1			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

L1 Single-Band Option		
Parameter	**Value**	**Condition**
Type	Timing with self-survey	
Number of Channels	72	
Frequency Bands	GPS L1C/A	
	GLONASS L1OF	
	Galileo E1B/C	
	QZSS L1C/A	g
	SBAS L1C/A	WAAS, EGNOS, MSAS, GAGAN (Disabled by default)
Tracking Capability	36 SVs	
Sensitivity	−167 dBm	Tracking (GPS and GLONASS)
	−148 dBm	Cold acquisition (GPS and GLONASS)
	−160 dBm	Reacquisition (GPS and GLONASS)
Position Accuracy	2.5m CEP	GPS and GLONASS, static, −130 dBm, > 6 SVs
TTFF	25s	Cold start (GPS and GLONASS)
Maximum Navigation Update Rate (User Configurable)	10 Hz	Single-GNSS
	4 Hz	Multi-GNSS
Maximum Velocity	500 m/s	
Maximum Altitude	50,000m	
Maximum Dynamic Acceleration	4g	
Timing Accuracy[2]	20 ns	1-sigma, fixed position mode, ideal conditions

L1/L2 and L1/L5 Dual-Band Option		
Parameter	**Value**	**Condition**
Type	Dual-Band Timing	L1/L2 or L1/L5 Configurable
Frequency Bands	GPS L1C/A, L2C, L5	
	Galileo E1-B/C, E5b, E5a	
	BeiDou B1I, B1C, B2I, B2a	
	NavIC SPS-L5	
	QZSS L1C/A, L2C, L5	Available when GPS is used
	SBAS L1C/A	WAAS, EGNOS, MSAS, GAGAN - disabled by default
Sensitivity	−167 dBm	Tracking (GPS + GAL + BDS)
	−148 dBm	Cold Acquisition (GPS + GAL + BDS)
	−160 dBm	Reacquisition (GPS + GAL + BDS)
Position Accuracy	2.5m CEP	GPS Only, static, -130 dBm, > 6 SVs
TTFF	29 seconds	Cold Start, GPS Only
	2 seconds	Hot Start
Maximum Navigation Update Rate (User Configurable)	20 Hz	Single-GNSS
	10 Hz	Multi-GNSS
Maximum Velocity	500 m/s	
Maximum Altitude	80,000m	
Maximum Dynamic Acceleration	4g	
Timing Accuracy[2]	5 ns	1-sigma, fixed position mode, cable delay compensated, ideal conditions

Operating Characteristics

MD-015-0001-L1 Absolute Maximum Ratings				
Parameter	**Min**	**Typical**	**Max**	**Condition**
Supply Voltage			16	VDC
DC Voltage on Any I/O Pin	−0.5		5.5	V
Output Load			10	Ohms
AC Ripple			50	mVpk-pk
Storage Temperature	−55		90	°C
Shock			1,000	g, MIL-STD-202-213A, Condition E
Vibe			7.7	grams, MIL-STD-810G, operational, Figure 514.7E-1. Category 24
Weight			75	grams

MD-015-0001-L1 Operating Performance Characteristics				
Parameter	**Min**	**Typical**	**Max**	**Condition**
Supply Voltage	7.0	12.0	14.0	VDC
Warmup Time			6.0	Minutes
Locking Time	0.5	1.0	10.0	Minutes, assuming warmup complete and stable reference
Monthly Aging[1]			9 E−10	Hz/Hz
Temperature Stability			5 E−10	Hz/Hz −40° to 80°
Frequency Accuracy			5 E−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	grams, MIL-STD-810G, operational, Figure 514.7E-1. Category 24: No loss of lock
Weight			75	grams

* Warmup and steady state power do not include power required by a GNSS antenna or any input/output current sinks.

MD-015-0002-L1 Operating Performance Characteristics				
Parameter	**Min**	**Typical**	**Max**	**Condition**
Supply Voltage	7.0	12.0	14.0	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[1]		5E−11		Hz/Hz
Temp Stability			5E−10	Hz/Hz −40° to 75°
Temp Stability			1E−10	Hz/Hz −10° to 75°
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+ and 3− per axis): no loss of lock, ≤ 4×10−8 Hz/Hz frequency perturbation momentary
Vibe			7.7	grams @ 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

MD-015-0002-L1 Absolute Maximum Ratings				
Parameter	**Min**	**Typical**	**Max**	**Condition**
Supply Voltage			16	VDC
DC Voltage on Any I/O Pin	−0.5		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+ and 3− per axis)
Vibe (Storage/ Transport)			10.9	grams @ 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-L1 Operating Performance Characteristics				
Parameter	**Min**	**Typical**	**Max**	**Condition**
Supply Voltage	7.0	12.0	14.0	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[1]		5 E−11		Hz/Hz
Temp Stability			5 E−10	Hz/Hz −40° to 75°
Temp Stability			1 E−10	Hz/Hz −10° to 75°
Frequency Accuracy			5 E−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+ and 3− per axis): no loss of lock, ≤ 4×10−8 Hz/Hz frequency perturbation momentary
Vibe			7.7	grams @ 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-L1 Absolute Maximum Ratings				
Parameter	**Min**	**Typical**	**Max**	**Condition**
Supply Voltage			16	VDC
DC Voltage on Any I/O Pin	−0.5		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+ and 3− per axis)
Vibe (Storage/ Transport)			10.9	grams @ 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

GPS Antenna Specifications					
Parameter	**Min**	**Type**	**Max**	**Units**	**Condition**
Antenna Bias Voltage	4.0	4.8	5.1	VDC	
Antenna Current[3]		20	100	mA	

RF Output Waveform Characteristics (via MCX)					
Parameter	**Min**	**Type**	**Max**	**Units**	**Condition**
Waveform	Sinewave				
Output Power	+3.0	+9.0	+11.0	dBm	50 Ohms
Harmonics			−30	dBc	50 Ohms
Spurious			−85	dBc	50 Ohms

RF Output Waveform Characteristics (via Pin 8)					
Parameter	**Min**	**Type**	**Max**	**Units**	**Condition**
Waveform	HCMOS				
High-Level Output Voltage (VOH)	4.0		5.0	VDC	< −0.5 mA load
Low-Level Output Voltage (VOL)		0.0	0.4	VDC	< 0.5 mA load
Rise/Fall Time		3	5	ns	15 pF
Duty Cycle	40	50	60	%	15 pF

1 PPS Output Characteristics (via MCX and Pin 2)					
Parameter	**Min**	**Type**	**Max**	**Units**	**Condition**
Waveform	TTL				
High-Level Output Voltage (VOH)	3.0		5.0	VDC	50 Ohms
Low-Level Output Voltage (VOL)		0.0	0.4	VDC	50 Ohms
Pulse Width	9.9	10	10.1	µs	Default setting, user programmable

External 1 PPS Reference Input (Pin 1)					
Parameter	**Min**	**Type**	**Max**	**Units**	**Condition**
Waveform	TTL				
High-Level Output Voltage (VOH)	2.0		5.0	VDC	50 Ohms input impedance
Low-Level Output Voltage (VOL)		0.0	0.4	VDC	
Pulse Width	1.0			µs	

Lock Status Indicator (Pin 9)[4]					
Parameter	**Min**	**Type**	**Max**	**Units**	**Condition**
Module Locked	4.5	5.0	5.5	VDC	< 5 mA load
Module Not Locked	0		0.5	VDC	< 5 mA load

Module Hardware OK Indicator (Pin 10)[5]					
Parameter	**Min**	**Type**	**Max**	**Units**	**Condition**
Module Hardware OK	4.5	5.0	5.5	VDC	< 5 mA load
Module Hardware Failure	0		0.5	VDC	< 5 mA load

Module Hardware Reset (Pin 12)					
Parameter	**Min**	**Type**	**Max**	**Units**	**Condition**
Reset Module	0		0.5	VDC	10 kOhm internal pullup

Module Holdover Reset (Pin 11)					
Parameter	**Min**	**Type**	**Max**	**Units**	**Condition**
Enter Manual Holdover	0		0.5	VDC	5.6 kOhm internal pullup

Serial Communications Interface[6,7]					
Parameter	**Min**	**Type**	**Max**	**Units**	**Condition**
Rx High-Level Output Voltage (VIH)	4.4	5.0	5.5	VDC	100 kOhm internal pullup
Rx Low-Level Output Voltage (VIL)	0		0.5	VDC	< 0.5 mA load
Tx High-Level Output Voltage (VOH)	4.5	5.0	5.5	VDC	15 pF
Tx Low-Level Output Voltage (VOL)	0		0.5	VDC	15 pF
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

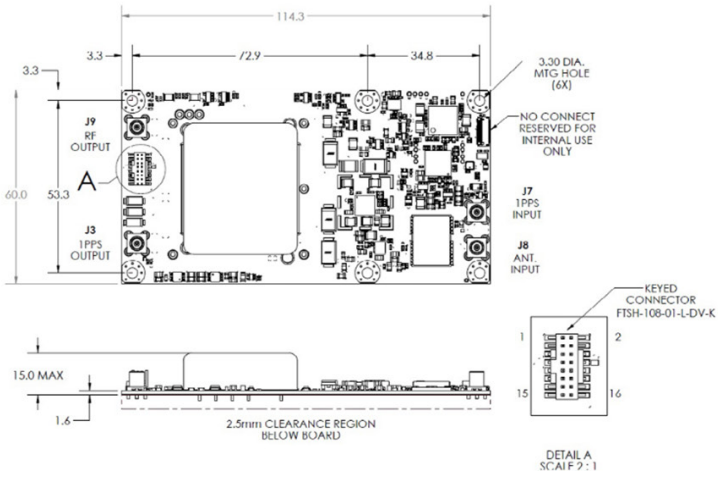
Although ESD protection circuitry has been designed into the MD-015, proper precautions should be taken when handling and mounting.

Microchip employs a Human Body Model (HBM) and a Charged-Device Model (CDM) for ESD susceptibility testing and design protection evaluation.

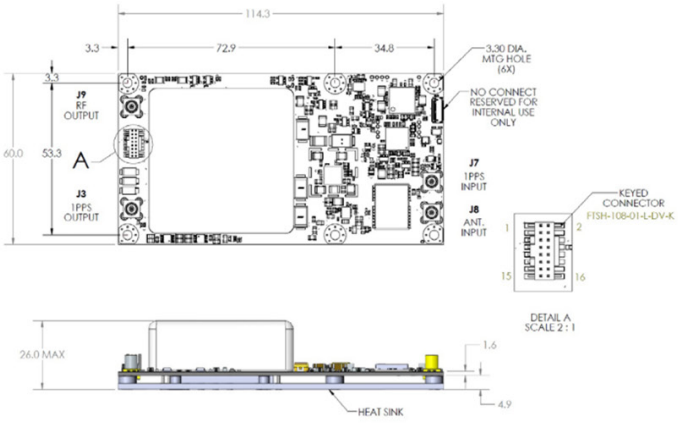
Model	Minimum	Conditions
Human Body Model	1,500V	MIL-STD-883, Method 3015
Charged Device Model	1,000V	JEDEC, JESD22-C101

Package Outline

MD-015-0001-L1



MD-015-0002-L1 & MD-015-0003-L1



Notes:

- RF and 1 PPS input and output connectors are MCX type (SMA, SMB, MMCX connectors require additional part numbers).
- Keyed connector is Samtec FTSH-108-01-L-DV-K type
- Dimensions in millimeters
- 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 communication receive
6	Tx	Serial communication 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 Part Number	Description
MD-01X_EVAL-KIT	Evaluation kit only (module must be ordered separately)

Ordering Information Instructions

Customization to customer requirements is available and is common for this level of integration. Common customizations include alternate 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.

	Available Models	
MD-015-0001-L1	MD-015-0002-L1	MD-015-0003-L1
MD-015-0001-DB	MD-015-0002-DB	MD-015-0003-DB

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. Antenna over current flag will be set if maximum current is exceeded as circuit has overcurrent protection
4. The status locked indicator is intended to indicate when the module is fully locked to a reference
5. 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
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

Technical Support

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GNSSDO Specific Technical Support

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