MAC-SA5X

Miniature Atomic Clock

Summary

For applications requiring atomic clock stability performance that are unable to accommodate the size and power requirements of rack-mount equipment, the Miniaturized Rb Atomic Clock (MAC-SA5X) is a low-profile, PCB-mountable oscillator. It provides designers with a source of reliable and stable frequency within minutes of power-on.

By leveraging Coherent Population Trapping (CPT) technology used in the Chip Scale Atomic Clock (CSAC) and the previous generation "MAC - SA.3Xm", the new MAC – SA5X family of clocks is the latest advancement in small atomic oscillators. CPT based oscillators feature a laser to interrogate the Rb atoms and achieve atomic resonance. This allows a reduction in size and power compared to traditional lamp-based clocks, without compromising the performance one would expect from an atomic clock: fast retrace, resistance to static g-forces, resistance to temperature changes and low frequency drift rates.

MAC-SA5X shares the same footprint with the legacy SA.3Xm and many traditional OCXOs, but its performance versus size is unparalleled. It's hardware and software have been completely redesigned to add new features such as 1PPS synchronization, improve stability and operate over a wide range of thermal environments. This combination of features along with the ability to quickly provide an atomic frequency reference, is particularly powerful for mobile applications where every minute and every Watt counts.

SA5X Family

Two performance levels are offered to meet a variety of performance and budgetary requirements: SA53 and SA55. The base-performance SA53 is targeted for applications that require an economical solution for frequency stability, such as portable test equipment. The high-performance SA55 has superior aging, TempCo, stability and phase noise compared to the SA53. It may be deployed in existing rubidium applications such as base stations and other applications that require precision frequency and long hold-over.

Applications

- Stand-alone (free-run) stable frequency source for audio equipment, LTE base stations, smart grid and enterprise network infrastructure
- Extended holdover for base stations
- Portable test equipment
- Autonomous sensor networks

Features

- Sub-microsecond holdover for 48 hour missions*
- Drift rate $<5x10^{-11}$Hz/Hz /mo (SA55)
- Operating Temperature –40°C to +75°C
- Temperature-induced frequency errors $<5x10^{-11}$ Hz/Hz from –10°C to +75°C
- Backwards compatible pin-out/footprint of legacy MAC-SA.3Xm oscillator
- Rapid, reliable warm-up time <8 minutes
- 1PPS output and input for easy calibration/synchronization
- New software allows greater control and health monitoring
- Lead free: RoHS compliant
- Small size: 2 × 2 × 0.7 inches

*Predicted assuming zero initial phase/frequency offset, static environment, 25°C, on for 30 days prior to holdover.

Specifications @ 5V & 25°C (ambient), unless noted otherwise

Electrical

RF Output (Pin 3)			
Frequency		10 MHz	
Format		CMOS (0 to 3.3V)	
Load Impedance		1 MΩ	
Rise/Fall time		< 4 nS	
Duty Cycle		50% ±10%	
Quantity		1	
1PPS Output (Pins J1-17, 19)			
Format		LVDS Square Wave	
Level		EIA/TIA-644 compliant	
Rise/Fall time		< 4 nS	
Pulse Width (Programmable)		20 µS (100 nS – 100 mS, 10 nS step)	
Quantity		1	
1PPS Input (Pins J1-5,7 or J1-1,3)			
Format		LVDS Rising Edge	
Level		EIA/TIA-644 compliant	
Quantity		2	
Minimum PW		100 nS	
Serial Communication (Pins 7,8)			
Protocol		RS232 UART	
Format		CMOS (0 to 3.3V)	
Tx/Rx Impedance		1 MΩ	
BAUD rate		57600	
High Speed Communication (Pins J1-2,4,6)			
Protocol		USB compatible	
Built In Test Equipment (BITE) Output (Pin 6)			
Format		CMOS (0 to 3.3V)	
Load Impedance		1 MΩ	
Logic		0 = Normal Operation 1 = No Physics Lock	
Alarm Output (J1-20)			
Format		CMOS (0 to 3.3V)	
Load Impedance		1 MΩ	
Logic		0 = Normal Operation, 1 = Alarm	
Power Input (Pin 5)			
Voltage Range		4.5 to 32 VDC	
Power Consumption		**Typical (W)	Max (W)
Operating	@ 65°C: @ 25°C: @ –10°C: @ –40°C:	4.0 6.3 8.3 10.0	6 8 11 14
Warmup	@All Temps:		14

**Ambient temperature. Each thermal environment will affect exact power consumption/TempCo. Contact factory for details. DO NOT EXCEED 75°C MEASURED AT BASEPLATE.

Performance Parameters	
Time to Lock	8m (> –10°C) 12m (< –10°C)
Analog Tuning Range	$\pm 1 \times 10^{-8}$ Hz/Hz (Resolution: 1×10^{-11} Hz/Hz) (0 to 5V into 5 kΩ)
Digital Tuning Range	$\pm 1 \times 10^{-6}$ Hz/Hz (Resolution: 1×10^{-15} Hz/Hz)
Frequency Offset	$\pm 5 \times 10^{-11}$ Hz/Hz (at shipment)
Retrace	$\pm 5 \times 10^{-11}$ Hz/Hz (after 24h on, 48h off, 12h on)
1PPS output jitter	< 1 nS (100s Avg)

Stability

ADEV	SA55 (Hz/Hz)	SA53 (Hz/Hz)
τ = 1 S	$< 3 \times 10^{-11}$	$< 5 \times 10^{-11}$
τ = 10 S	$< 1 \times 10^{-11}$	$< 1.6 \times 10^{-11}$
τ = 100 S	$< 3 \times 10^{-12}$	$< 5 \times 10^{-12}$
τ = 1,000 S	$< 1 \times 10^{-12}$	
τ = 10,000 S	$< 3 \times 10^{-12}$	
Aging	**SA55 (Hz/Hz)**	**SA53 (Hz/Hz)**
Monthly***	$< 5 \times 10^{-11}$	$< 1 \times 10^{-10}$
Yearly	$< 6 \times 10^{-10}$	$< 1.5 \times 10^{-9}$
Daily***	$< 2.5 \times 10^{-11}$	$< 2.5 \times 10^{-11}$

*** After 1month and 1day of continuous operation, respectively

Phase Noise (SSB)	SA55 (dBc/Hz)	SA53 (dBc/Hz)
1 Hz	<–70	<–65
10 Hz	<–87	<–85
100 Hz	<–114	<–112
1 kHz	<–130	<–130
10 kHz	<–140	<–140
Spurious (non-harmonic)	< -85 dBc	

TempCo (Peak-to-Peak)	SA55 (Hz/Hz)	SA53 (Hz/Hz)
–10 to +75°C (baseplate)	$\leq 5 \times 10^{-11}$	$\leq 1 \times 10^{-10}$
–40 to +75°C**	$\leq 1 \times 10^{-10}$	$\leq 5 \times 10^{-10}$

Environmental

Operating	
Temperature Range	–40°C to +75°C**
Magnetic Sensitivity (frequency change)	< 2 Gauss (±7 × 10^{-11} Hz/Hz /Gauss)
Voltage Sensitivity (frequency change)	± 1VDC (<1 × 10^{-11} Hz/Hz, p-p)
Vibration	7.7 g_{rms}/axis per MIL-STD-810, Fig 514.7E-1, Category 24 (General Minimum Integrity Exposure): no loss of lock.
Shock	30g, 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
Humidity	GR-63-CORE, issue 4, April 2012, section 4.1.2
Altitude	50,000 feet

Non-Operating (Storage & Transport)	
Temperature Range	–55°C to +100°C
Vibration	10.9 Grms @ 1 hr/axis per MIL-STD-810, Fig 514.7E-1, Category 24 (General Minimum Integrity Exposure)
Shock	50g, 11 msec half-sine pulse per MIL-STD-202, Method 213, Test Condition A, 18 shocks (3+ & 3- per axis)
Altitude	70,000 feet

Name	Part Number	Description
MAC-SA55	090-44550-01	5 x 10^{-11}/mo, 5 x 10^{-11} Tempco, AT disabled
MAC-SA53	090-44530-01	1x10^{-10}/mo, 1x10^{-10} Tempco, AT disabled Note: AT = Analog Tuning
MAC-SA5X Kit	090-44500-000	Developers Kit. Does not include MAC

Mechanical

Size	2 x 2 x 0.7 in.
Weight	< 100 g (3.5 oz)
MTBF	149,743 h (Ground Benign, per MIL-HDBK-217F, 40°C baseplate)
RoHS	2011/65/EU

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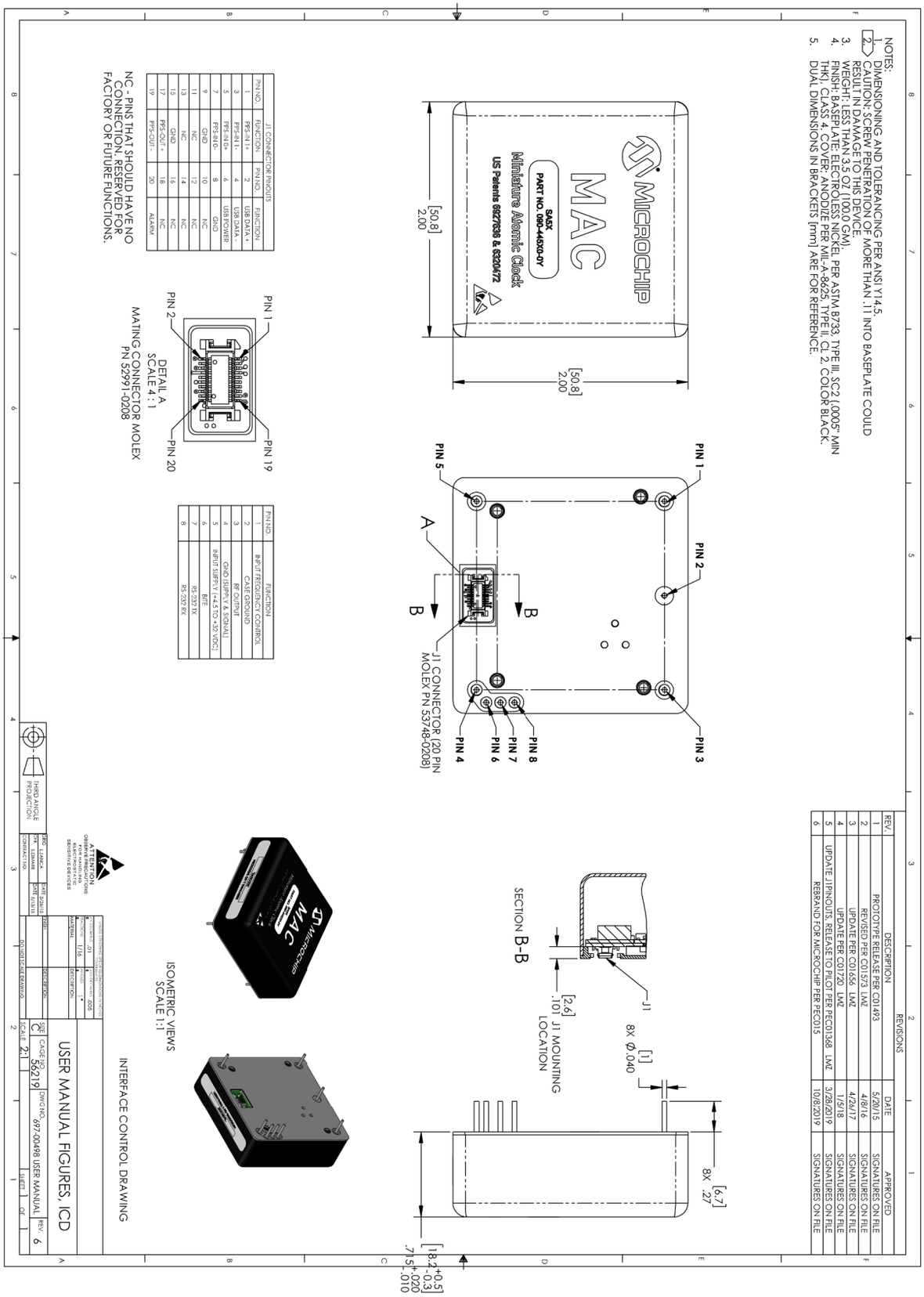
Baseplate Connector	
Pin	Function
1	Analog Tuning
2	Case Ground
3	RF Output
4	GND (Signal & Supply)
5	Input Supply (4.5 to 32V)
6	BITE
7	RS-232 Tx
8	RS-232 Rx

J1 Connector	
Pin	Function
1	PPS-in 1+
3	PPS-in 1-
5	PPS-in 0+
7	PPS-in 0-
9	GND
11	NC
13	NC
15	GND
17	PPS-out +
19	PPS-out -
2	USB data +
4	USB data -
6	USB Power
8	GND
10	NC
12	NC
14	NC
16	NC
18	NC
20	ALARM



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