

MAC-SA57

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 users with a reliable and stable frequency source within minutes of power-on.

By leveraging Coherent Population Trapping (CPT) technology used in the Chip Scale Atomic Clock (CSAC), the MAC-SA5X family of clocks delivers Rubidium-performance in a 2 × 2 inch package. 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, exceptional temperature stability 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. Its hardware and software have been completely redesigned to add new features such as 1PPS synchronization, improve stability, and operate over a wide temperature 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.



This product is compatible with Microchips Clockstudio™ software tool for control and analysis of atomic clocks:
microchip.com/clockstudio

SA5X Family

MAC-SA57 leverages the heritage of the SA5X family by offering the highest level of performance in the exact same package and pin-out as the SA53 and SA55. Its low frequency drift rate of $2\text{E-}11$ /mo and low temperature sensitivity ($\Delta f < 2\text{E-}11$) enable impressive holdover performance in the most demanding mission environments.

Applications

- LTE base stations
- Smart grid
- Enterprise network infrastructure
- Portable test equipment
- Autonomous sensor networks
- Data center timing card

Features

- Holdover capability: <120 ns of error for 24 hour missions¹
- Drift rate $< 2 \times 10^{-11}$ Hz/Hz /mo
- Operating temperature -40°C to $+75^\circ\text{C}$
- Maximum temperature-induced frequency errors $< 2 \times 10^{-11}$ Hz/Hz
- Rapid, reliable warm-up time <8 minutes
- 1PPS output and input for easy calibration/synchronization
- New software allows greater control and health monitoring
- Small size: 2 × 2 × 0.7 in. (51 × 51 × 18 mm)

¹ Predicted assuming zero initial phase/frequency offset, static environment, 25°C , on for 30 days prior to holdover.

Specifications @ 5V and 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	
1 PPS 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	
1 PPS Input (Pins J1-5,7 or J1-1,3)			
Format		LVDS Rising Edge	
Level		EIA/TIA-644 compliant	
Quantity		2	
Minimum Pulse Width		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 2.0 compatible	
Built In Test Equipment (BITE) Output (Pin 6)			
Format		CMOS (0 to 3.3V)	
Load Impedance		1 MΩ	
Logic		Low = Normal Operation High = No Physics Lock	
Alarm Output (Pin J1-20)			
Format		CMOS (0 to 3.3V)	
Load Impedance		1 MΩ	
Logic		Low = Normal Operation, High = Alarm	
Power Input (Pin 5)			
Voltage Range		4.5 to 32V DC	
Power Consumption		Typical (W)	Max (W)
Operating Temperature ²	65°C:	4.0	6
	25°C:	6.3	8
	-10°C:	8.3	11
	-40°C:	10.0	14
Warmup	@ All Temps:		14
² Ambient temperature. 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	> ±1 × 10 ⁻⁸ Hz/Hz (Resolution: 1 × 10 ⁻¹¹ Hz/Hz) (0 to 5V into 5 kΩ)
Digital Tuning Range	±1 × 10 ⁻⁶ Hz/Hz (Resolution: 1 × 10 ⁻¹⁵ Hz/Hz)
Frequency Offset	< ±5 × 10 ⁻¹¹ Hz/Hz (at shipment)
Retrace	< ±5 × 10 ⁻¹¹ Hz/Hz (after 24h on, 48h off, 12h on)
1PPS output jitter	< 1 ns (100s Avg)

Stability

ADEV	SA57 (Hz/Hz)
τ = 1 s	< 1.5 × 10 ⁻¹¹
τ = 10 s	< 5 × 10 ⁻¹²
τ = 100 s	< 1.5 × 10 ⁻¹²
τ = 1,000 s	< 5 × 10 ⁻¹³
τ = 10,000 s	< 1.5 × 10 ⁻¹²
Frequency Drift	SA57 (Hz/Hz)
Monthly ³	< 2 × 10 ⁻¹¹
Yearly	< 2.4 × 10 ⁻¹⁰
Daily ⁴	< 2.5 × 10 ⁻¹¹
³ After 1 month of continuous operation	
⁴ After 1 day of continuous operation	
Phase Noise (SSB)	SA57 (dBc/Hz)
1 Hz	< -70
10 Hz	< -90
100 Hz	< -114
1 kHz	< -135
10 kHz	< -140
Spurious (non-harmonic)	< -85 dBc
TempCo (Peak-to-Peak)	SA57 (Hz/Hz)
-40 to +75 °C ²	< 2 × 10 ⁻¹¹

Environmental

Operating	
Temperature Range	-40 °C to +75 °C ²
Magnetic Sensitivity (frequency change)	< 2 Gauss ($\pm 7 \times 10^{-11}$ Hz/Hz /Gauss)
Voltage Sensitivity (frequency change)	± 1 V DC ($< 1 \times 10^{-11}$ 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 ms half-sine pulse per MIL-STD-202, Method 213, Test Condition J, 18 shocks (3+ & 3- per axis): no loss of lock, $\leq 4 \times 10^{-8}$ Hz/Hz frequency perturbation momentary
Humidity	GR-63-CORE, issue 4, April 2012, section 4.1.2
Altitude	50,000 feet

²Ambient temperature. Each thermal environment will affect exact power consumption/TempCo. Contact factory for details. DO NOT EXCEED 75°C MEASURED AT BASEPLATE.

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 ms 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-SA57	*090-44570-01	2×10^{-11} /mo, 2×10^{-11} TempCo, AT disabled
MAC-SA5X Kit	090-44500-000	Developers Kit. Does not include MAC

*append "-EU" suffix to part number to order from our European Union facility

Mechanical

Size	2 × 2 × 0.7 in.
Weight	< 100 g (3.5 oz)
MTBF	149,743h (Ground Benign, per MIL-HDBK-217F, 40°C baseplate) 2,078,563h (Ground Fixed, Telcordia SR-332, 40°C baseplate)
RoHS	2011/65/EU

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



