Space CSAC-SA45

Chip-Scale Atomic Clock

Features

- Power consumption <120 mW
- Less than 17 cc volume, 1.6" × 1.39" × 0.45"
- Radiation Tolerant: At least 20 kRad Cobalt Gammas
- 64 MeV proton irradiations up to 5.7 x 10^{+10} protons/cm^2 total fluence demonstrated full recoveries to all observed events
- 10 MHz CMOS-compatible output
- 1PPS output and 1PPS input for synchronization
- Comprehensive monitoring and control interface
- Short-term stability (Allan Deviation) of 3×10^{-10} at $\tau = 1$ sec
- IPC-610 Class 2

Applications

- Satellite timing and frequency control
- Satellite clock reference
- Assured Position, Navigation and Timing (PNT)
- Atomic clock accuracy
- Satellite cross-linking

The Space Chip Scale Atomic Clock (CSAC)

The space Chip Scale Atomic Clock (CSAC) is a radiation-tolerant, low power consumption device ideal for Low Earth Orbit (LEO) missions. It offers atomic accuracy and built-in 1 PPS disciplining for synchronized applications like earth observation, which require precise time-stamping. The CSAC's atomic stability allows it to operate independently of external references such as GNSS for extended periods while maintaining accuracy. Its small temperature coefficient ensures reliable performance despite significant temperature fluctuations in LEO environments.

Manufactured as a Commercial Off-the-Shelf (COTS) part to IPC-610 Class 2 standards, the space CSAC uses radiation-tolerant commercial electronic components. COTS products typically have shorter lead times and lower costs compared to traditional space-grade oscillators. A "careful COTS" approach ensures each batch undergoes rigorous radiation testing to exceed 20 krad before production, bridging the gap between pure COTS and costly full rad-hard space-grade components.

Aside from radiation tolerance, the Space CSAC is functionally equivalent to a standard CSAC-SA45. It provides 10 MHz and 1PPS outputs at standard CMOS levels, with short-term stability (Allan Deviation) of 3×10^{-10} at $\tau = 1$ sec. It accepts a 1PPS input for calibration to an external reference clock such as a GNSS derived timing signal.

CLOCKSTUDIO™

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

Specifications[1]

Electrical

RF Outputs	
Frequency	10 MHz
Format	CMOS
Amplitude	0 V to VCC
Load Impedance	1 MΩ
Quantity	1
1PPS Output	
Rise/fall Time (10%–90%) at Load Capacitance 10 pF	<10 ns
Pulse Width	100 µs
Level	0 V to VCC
Logic High (VOH) Min	2.80 V
Logic Low (VOL) Max	0.30 V
Load Impedance	1 MΩ
Quantity	1
1PPS Input	
Format	Rising edge
Low Level	<0.5 V
High Level	2.5 V to VCC
Load Impedance	1 MΩ
Quantity	1
Serial Communications	
Protocol	RS232
Format	CMOS 0 V to VCC
Tx/Rx Impedance	1 MΩ
Baud Rate	57600
Built-In Test Equipment (BITE) Output	
Format	CMOS 0 V to VCC
Load Impedance	1 MΩ
Logic	0= Normal operation 1= Alarm
Power Input	
Operating	<120 mW
Warmup	<140 mW
Input Voltage (VCC)	3.3 ± 0.1 VDC

[1]At input voltage VCC = 3.3 VDC and ambient temperature = 25 °C, unless otherwise specified.

Performance Parameters

Specification	Details
Warm-up Time	<180 s
Analog Tuning	Range: $\pm 2.2 \times 10^{-8}$ Resolution: 1×10^{-11} Input: 0 V–2.5 V into 100 kΩ
Digital Tuning	Range: $\pm 1 \times 10^{-6}$ Resolution: 1×10^{-12}
Maximum Offset at Shipment	$\pm 5 \times 10^{-11}$
Maximum Retrace (48 hrs Off)	$\pm 5 \times 10^{-10}$

Stability

Observation Time	ADEV
τ = 1 s	3×10^{-10}
τ = 10 s	1×10^{-10}
τ = 100 s	3×10^{-11}
τ = 1000 s	1×10^{-11}

Frequency Drift[2]	
Monthly	$<9 \times 10^{-10}$
Yearly	$<1 \times 10^{-8}$

[2]Typical, after 30 days of continuous operation.

Offset	Phase Noise (SSB)
1 Hz	<–50 dBc/Hz
10 Hz	<–70 dBc/Hz
100 Hz	<–113 dBc/Hz
1 kHz	<–128 dBc/Hz
10 kHz	<–135 dBc/Hz
100 kHz	<–140 dBc/Hz

Environmental

Specification	Details
Operating Temperature	–10°C to 70°C
Temperature Sensitivity (TempCo)	$\pm 5 \times 10^{-10}$ Maximum Frequency Change over Operating Temp Range (Maximum Rate of Change 0.5°C per Minute)
Voltage Sensitivity	$\pm 4 \times 10^{-10}$ Maximum Frequency Change over allowable Voltage Range
Magnetic	$\pm 9 \times 10^{-11}$/Gauss Maximum frequency change per Gauss (≤2.0 Gauss)
Radiated Emissions	Compliant to FCC part 15, Class B, when mounted properly onto host PCB
Vibration	Maintains lock under MIL-STD-810G, Operational, 7.7 grms per Figure 514.7E-1. Category 24
Humidity	0%–95% RH per MIL-STD-810, Method 507.4
Storage and Transport (Non-operating)	
Temperature	–55 °C to 85 °C
Vibration	MIL-STD-810G, 7.7 g_{rms} per Figure 514.7E-1. Category 24
Shock	MIL-STD-202-213A, Condition E, 1000 g

Radiation Tolerance

Radiation Tolerance	
TID	>20 kRad Cobalt Gammas, $<5 \times 10^{-10}$ frequency offset change
SEL, SEU	64 MeV proton irradiations up to $5.7 \times 10^{+10}$ protons/cm^2 total fluence demonstrated full recoveries to all observed events

Physical

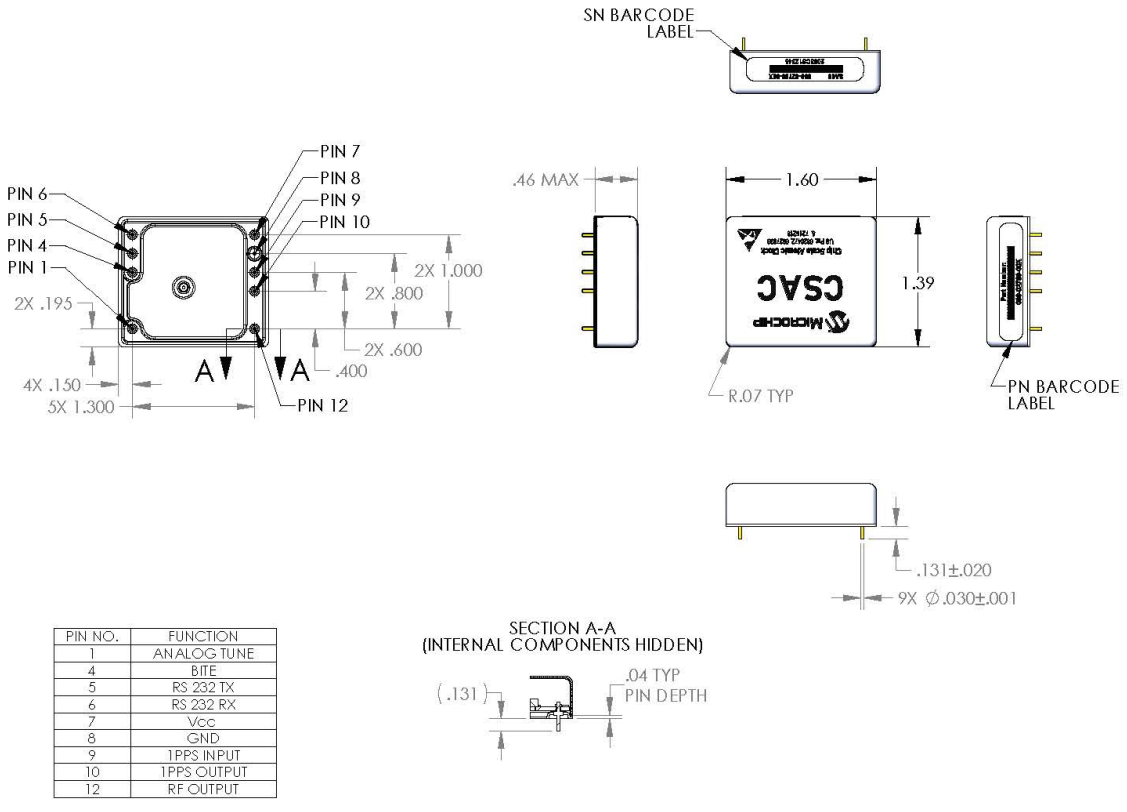
Specification	Detail
Weight	<35 g (<1.23 oz)
Size	1.6" × 1.39" × 0.45"
MTBF	>100,000 hours

Solder

Hand solder using 63/37 tin/lead solder with maximum soldering tip of 329 °C (625 °F).

Ordering Information

Part Number	Description	Output Frequency
090-02984-007	Space chip-scale atomic clock	10 MHz



PIN NO.	FUNCTION
1	ANALOG TUNE
4	BITE
5	RS 232 TX
6	RS 232 RX
7	Vcc
8	GND
9	1PPS INPUT
10	1PPS OUTPUT
12	RF OUTPUT