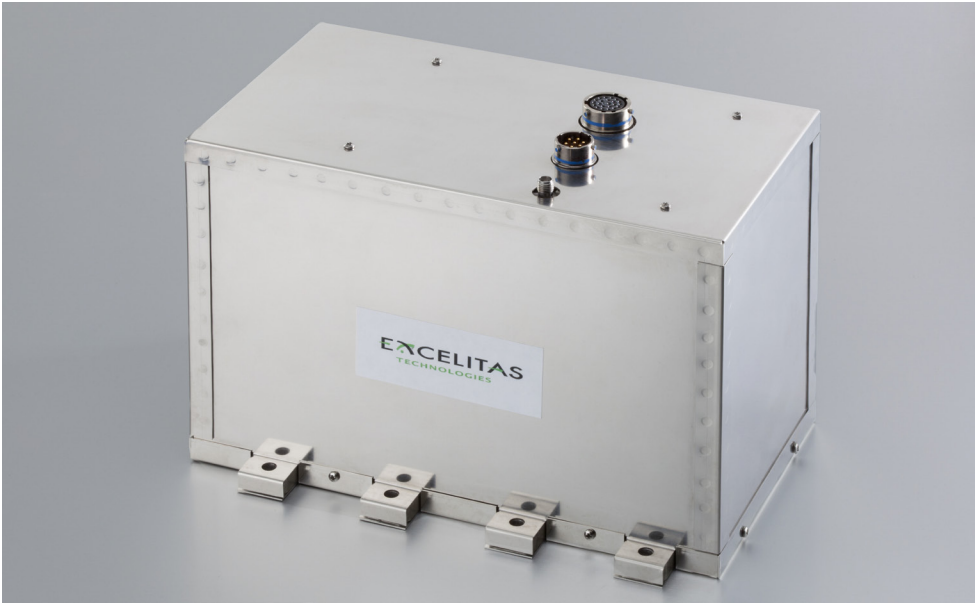


High-Performance Space-Qualified Rubidium Atomic Frequency Standard (RAFS)



Key Features

- High-Stability: 2×10^{-12} at $\tau = 1$ second
- Low Power: ≤ 14 watts
- Low Drift: $\leq 5 \times 10^{-14}$ /day
- High-Reliability: 700,000 Hr MTBF
- Fully Space-Qualified
- Radiation Hardened
- Negligible Environmental Sensitivities
- Small Size: 5.0" x 8.5" x 6.0"
- Low Weight: < 14 lbs.

Applications

- Global Navigation Satellite Systems (GNSS)

The Excelitas Rubidium Atomic Frequency Standard (RAFS) is an exceptionally High-Performance and High-Reliability Space-Qualified rubidium (Rb) clock developed for Global Navigational Satellite Systems. It is the highest performance device of this type currently available, combining exceptional stability and low drift with negligible environmental sensitivity, while offering the low size, weight and power advantages of a rubidium frequency standard. The design has been fully documented and qualified for all space requirements, including radiation. The RAFS offers exceptional performance as a precise time and frequency reference for demanding applications.

The RAFS employs classical rubidium gas cell atomic frequency standard principles. It utilizes a physics package with a discrete isotopic filter cell for best stability. The relatively large, cool absorption cell and thin film spectral filter provide exceptionally high signal-to-noise ratio and excellent short term stability. Calorimetric Rb lamp process control and screening assures long life. The "natural frequency" output of 13.4 MHz permits the use of a low complexity, single loop design for improved reliability. Operation at low fixed magnetic bias field improves stability and reduces magnetic and radiation sensitivity. An integral baseplate temperature controller greatly reduces the overall temperature sensitivity by utilizing a thermal insulator that can be tailored to meet various panel operating temperatures. While the RAFS may be operated in air, operating in a vacuum environment that eliminates barometric sensitivity, the extremely low temperature, magnetic, radiation and voltage sensitivities mean that the unit has extremely low sensitivity to all environmental effects, providing a very low flicker floor. The low aging rate of $< 5 \times 10^{-14}$ /day is exceptionally smooth and modelable using either a log or diffusion fit to the data.

A crystal oscillator at nominal 13.4 MHz produces the output signal via an output amplifier. This RF output path is hardened against transient radiation. The 13.4 MHz crystal oscillator also excites the Rb physics package via a phase modulator and frequency multiplier chain. This produces a discriminator signal that is processed by a servo amplifier to lock the crystal oscillator to the Rb atomic resonance. Temperature controllers, a lamp exciter and a precision C-field source support the operation of the physics package, while a dc/dc converter and linear regulators provide power for the RAFS circuits. An integral controller stabilizes the RAFS baseplate temperature and several analog monitors are available to assess the operation of the unit.

High-Performance Space-Qualified Rubidium Atomic Frequency Standard

TABLE 1 Specifications

Input Power	28.0 VDC \pm 4.0 VDC
	\leq 39 W total steady-state with BTC
	\leq 14W basic clock at +45°C baseplate
	\leq 65 W during warm-up
Warm-up	\leq 1 hour to $\pm 2 \times 10^{-10}$
Monitors	0 to +5 VDC, 5k Ω source impedance

TABLE 2 Baseplate Temperature Controller (BTC)

Set-Point	+45°C \pm 1°C
Stabilization Factor	integral controller
Thermal Insulator	0.7 W/°C
Heater Demand Power	\leq 28 W

TABLE 3 Outputs

RF Output	13.40134393 MHz Sinewave
	+18 dBm \pm 1.5 dB
	All harmonics \leq 50 dBc
	All spurious \leq -85 dBc ($f_0 \leq f \leq 2f_0$)
	\leq -50 dBc ($2f_0 \leq f \leq 3f_0$)
Analog Monitors	Lock, Light, Signal, VCXO, Baseplate Temperature (2)
	Ovens (3), Power Supplies (4), ALC, C-Field, BTC

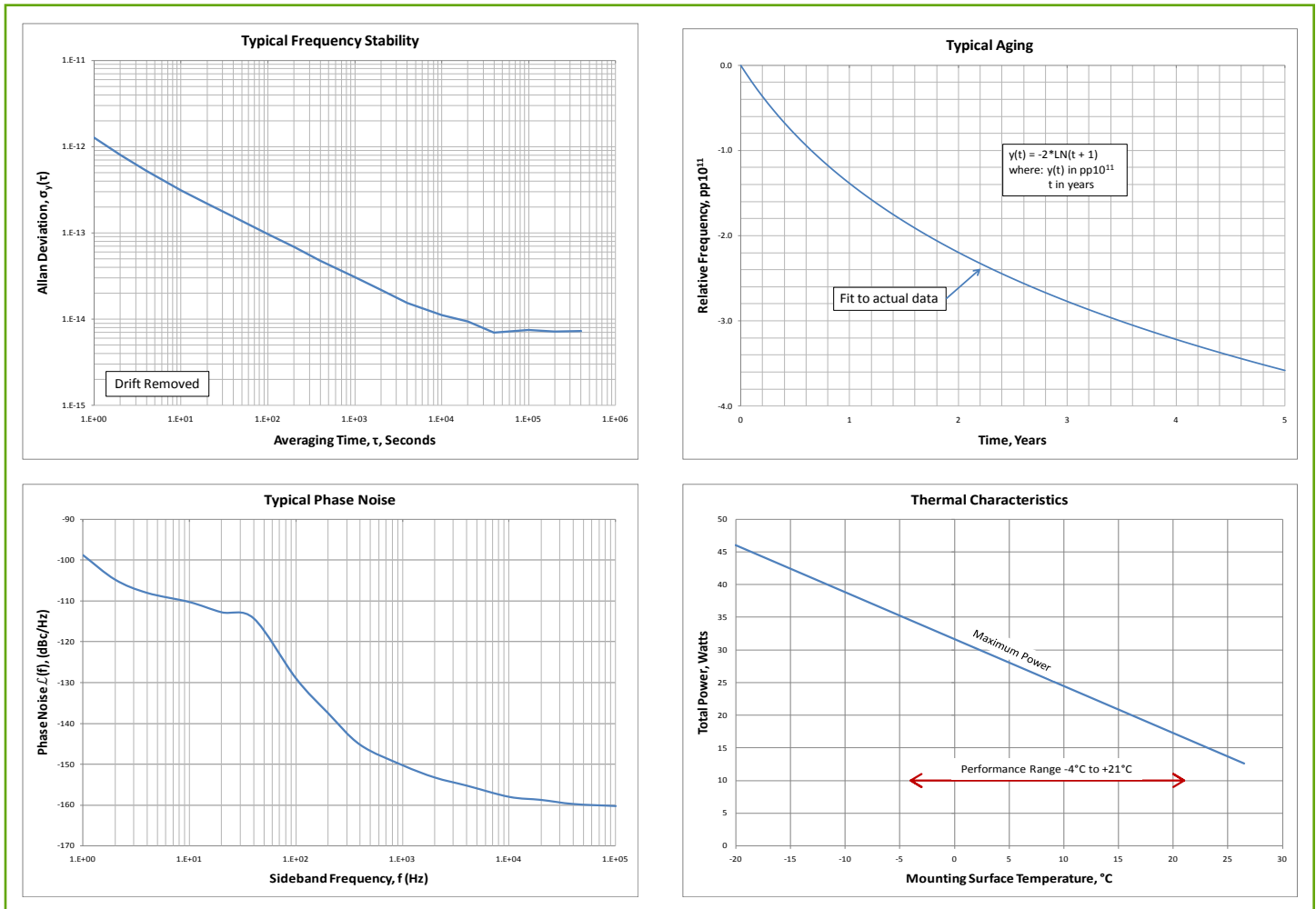
TABLE 4 Frequency

Nominal Frequency	13.40134393 MHz
Accuracy	$\pm 1 \times 10^{-9}$ at shipment
Trim Range	None (Fixed C-Field)
Stability $\sigma_y(\tau)$	$\leq 2 \times 10^{-12} \tau^{-1/2} + 2 \times 10^{-14}$ ($1 \leq \tau \leq 10^5$ seconds, drift removed)
Drift	$\leq 1 \times 10^{-13}$ /day at BOL operation
	$\leq 5 \times 10^{-14}$ /day after 1 year of continuous operation
Phase Noise, f(f)	\leq -95 dBc/Hz at $f = 1$ Hz, decreasing at -10 dB/decade to $f = 100$ kHz
Temperature Sensitivity	$\leq 2 \times 10^{-13}$ /°C typical w/o BTC, below noise level for $\pm 1.5^\circ\text{C}$ with BTC
Voltage Sensitivity	$\leq 3 \times 10^{-12}$ for 25.5 VDC to 28.0 VDC
Magnetic Sensitivity	$\leq 1 \times 10^{-12}$ /Gauss
Barometric Sensitivity	$\leq 1 \times 10^{-13}$ /mbar typical
Retrace	$\leq 5 \times 10^{-12}$ (to same environmental conditions)

TABLE 5 Environmental Specifications

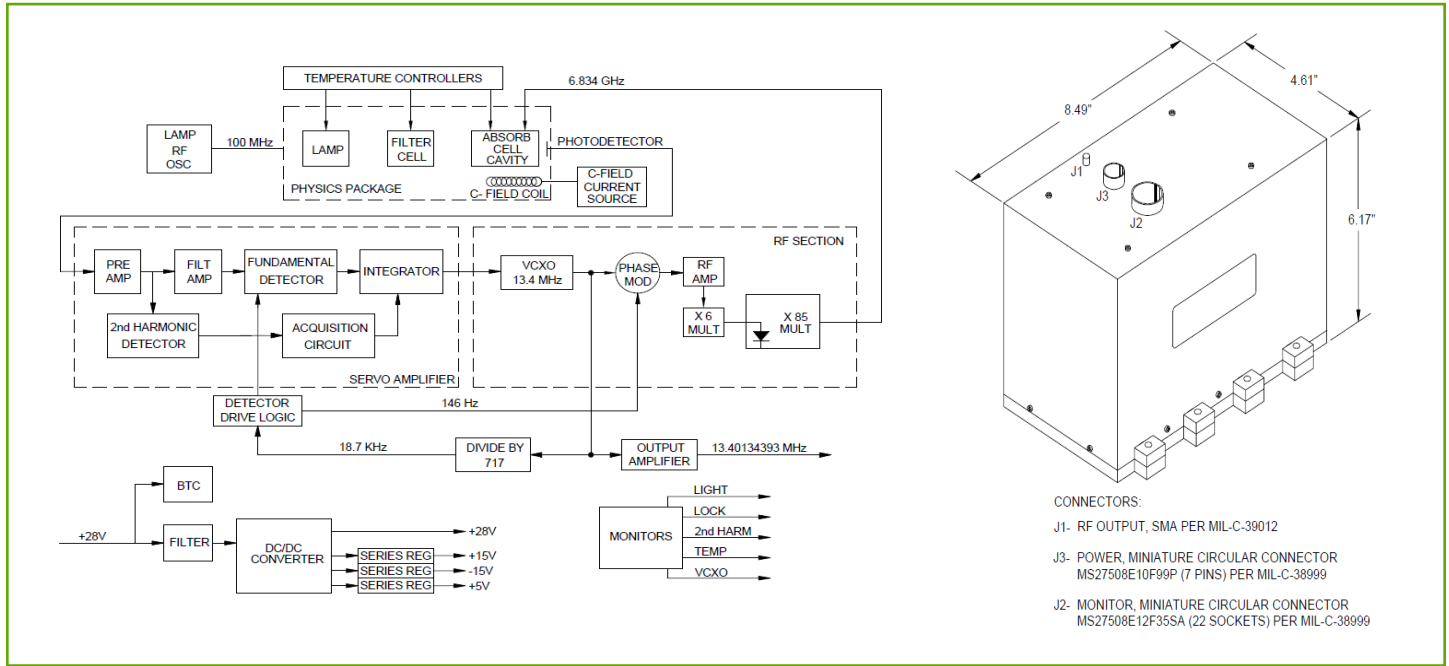
Operating Temperature	Full performance with BTC range between -4°C and +21°C panel temperature. Functional between -20°C to +45°C panel temperature.
Storage Temperature	-34°C to +71°C
Altitude	Sea level to vacuum
Vibration	12.4g rms, 20 Hz to 2 kHz
Pyroshock	1500 g max to 10 kHz
Thermal Cycling	-34°C to +71°C
Acceleration	20 g
Radiation	Hardened to withstand natural and manmade space environments, including phase-continuous operation through transient radiation
EMI	Per MIL-STD-461E
EMP / SGEMP	Hardened to withstand
On-Off cycling endurance	≥ 1000 cycles

FIGURE 1 Typical Performance



High-Performance Space-Qualified Rubidium Atomic Frequency Standard

FIGURE 2 Block Diagram/Mechanical



About Excelitas Technologies

Excelitas Technologies is a global technology leader focused on delivering innovative, customized solutions to meet the lighting, detection, energetic, frequency standards and high-reliability power needs of OEM customers.

From aerospace and defense applications to industrial, safety and security, medical lighting, analytical instrumentation, and clinical diagnostics, Excelitas Technologies is committed to enabling our customers' success in their specialty end-markets. Excelitas Technologies has approximately 3,000 employees in North America, Europe and Asia, serving customers across the world.

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