

Precision Timing in VTOL and Commercial UAVs

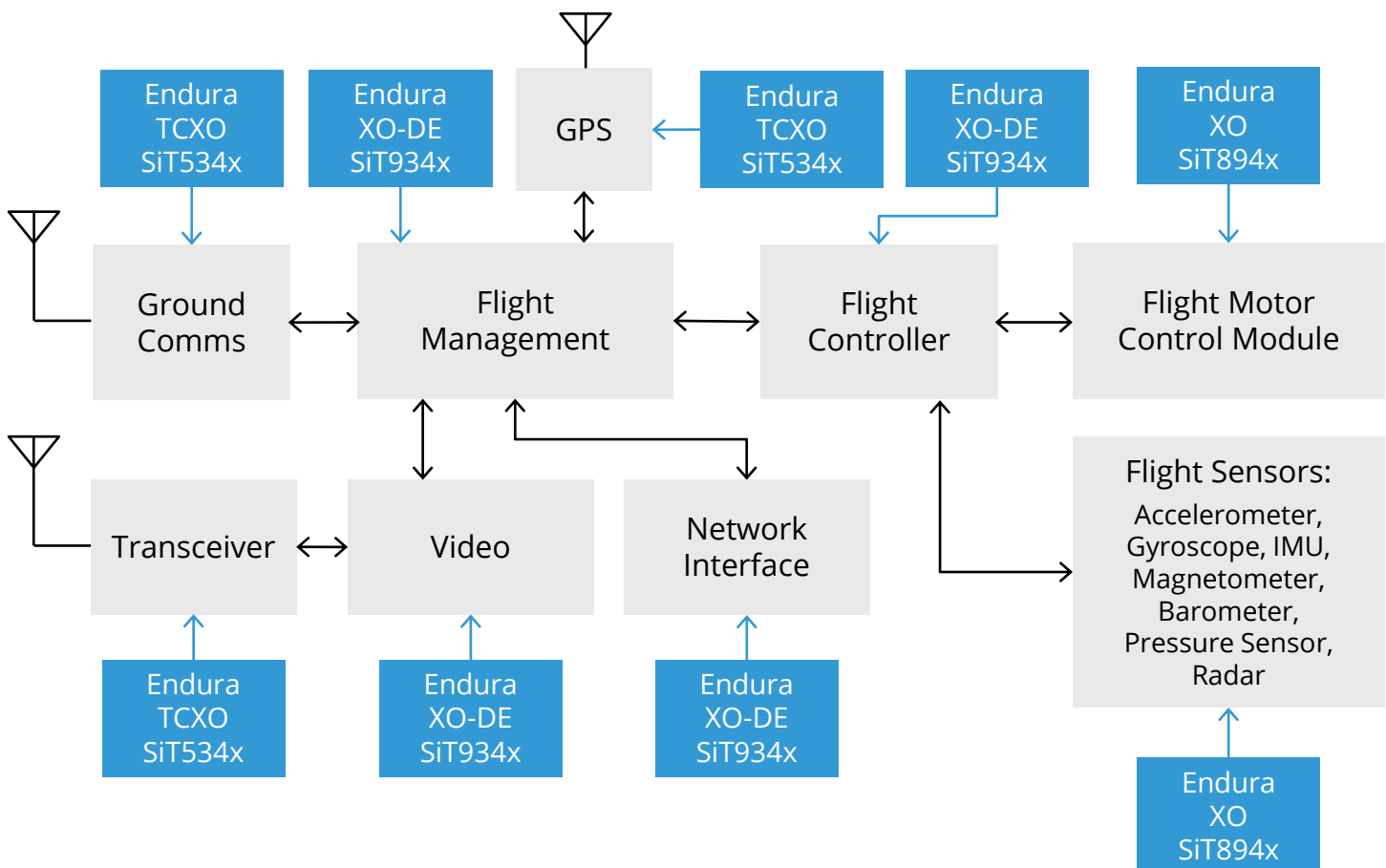
Uncrewed aerial vehicles (UAV) / drone technology has been used by the military for some time. Advancements and miniaturization in the electronics, batteries, motors and sensors of UAVs have extended the benefits of the technology to many commercial applications such as agriculture, surveying, aerial photography, remote inspection, search and rescue, and air taxis. Timing solutions that operate reliably in the dynamic environments of UAVs are no longer elusive.

Key Considerations

- Dynamic stability
- Robustness and reliability
- Ease of design

UAVs must operate, navigate and communicate through take off, cruise, and landing, even in air turbulence and adverse conditions. They use novel and complex technologies such as electrical vertical take-off and landing (VTOL). Many functionalities, previously delivered in separate subsystems, are now integrated and are packed into a small space to make UAVs agile.

Delivering stable operation, precise navigation and deterministic communication, while managing power supply noise and board layout, presents a challenge in designing the timing solution. SiTime Endura™ commercial off-the-shelf (COTS) ruggedized MEMS oscillators meet these challenges. Ruggedized Endura timing solutions are extremely reliable and remain stable and with low jitter over a wide temperature range and under severe vibrations.



Endura Timing Solutions

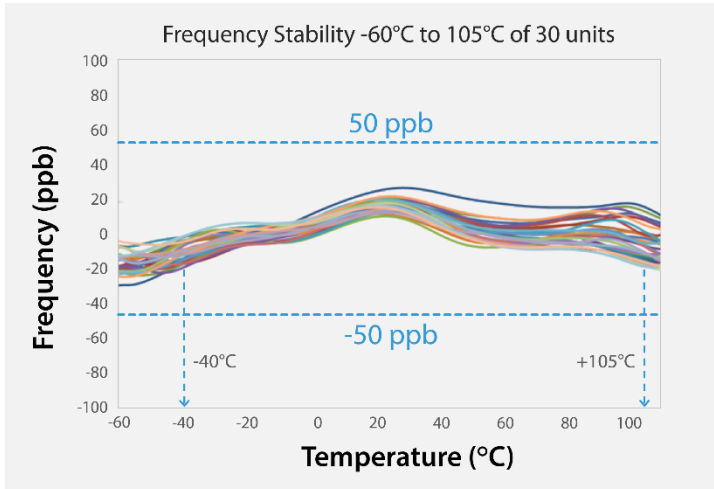
Type	Product	Frequency	Key Features	Key Values
Single ended oscillator	SiT8944	1 to 60 MHz	<ul style="list-style-type: none"> ±10 ppm to ±50 ppm frequency stability over temp range -55°C to 105°C 	<ul style="list-style-type: none"> Better frequency and jitter margin enhance system stability and robustness Easy availability of any device configuration Minimizes EMI from the oscillator
	SiT8945	60 to 220 MHz	<ul style="list-style-type: none"> 0.1 ppb/g frequency stability Low jitter < 0.5 ps RMS¹ 1.8 V, 2.5 V, 3.3 V 	
Differential oscillator	SiT9346	1 to 220 MHz	<ul style="list-style-type: none"> Low jitter 0.23 ps RMS¹ LVPECL, LVDS, HCSL 2.5 to 3.3 V 	<ul style="list-style-type: none"> Meets demanding jitter requirements Small PCB footprint, easier layout Easy design due to flexibility MEMS reliability
	SiT9347	220 MHz to 725 MHz	<ul style="list-style-type: none"> -40°C to 105°C 3.2 x 2.5 mm package 	
DCXO	SiT3541	1 to 220 MHz	<ul style="list-style-type: none"> Digital frequency control I²C/SPI ±3200 ppm pull range 5 ppt resolution 	<ul style="list-style-type: none"> Eliminates need for external DAC to control a VCXO Better accuracy, lower noise due to digital control
	SiT3542	220 MHz to 725 MHz	<ul style="list-style-type: none"> ±10 ppm to ±50 ppm frequency stability over temp range 	
Super-TCXO	SiT5146	1 to 60 MHz	<ul style="list-style-type: none"> ±0.5 to ±2.5 ppm stability ±15 ppb/°C 	<ul style="list-style-type: none"> Extremely stable under shock and vibration No change in phase noise under vibrations Minimizes link drops due to shock, vibration, or temperature change I²C/SPI digital control available to speed design
	SiT5147	1 to 60 MHz	<ul style="list-style-type: none"> 0.009 ppb/g frequency stability -55°C to 105°C 	
	SiT5346	1 to 60 MHz	<ul style="list-style-type: none"> ±0.1 to ±0.25 ppm stability ±1 ppb/°C 	
	SiT5347	60 to 220 MHz	<ul style="list-style-type: none"> 0.009 ppb/g frequency stability -40°C to 105°C 	
	SiT5348	1 to 60 MHz	<ul style="list-style-type: none"> ±50 ppb stability ±1 ppb/°C 	
	SiT5349	60 to 220 MHz	<ul style="list-style-type: none"> 0.009 ppb/g frequency stability -40°C to 105°C 	

¹ 12 kHz to 20 MHz integration range

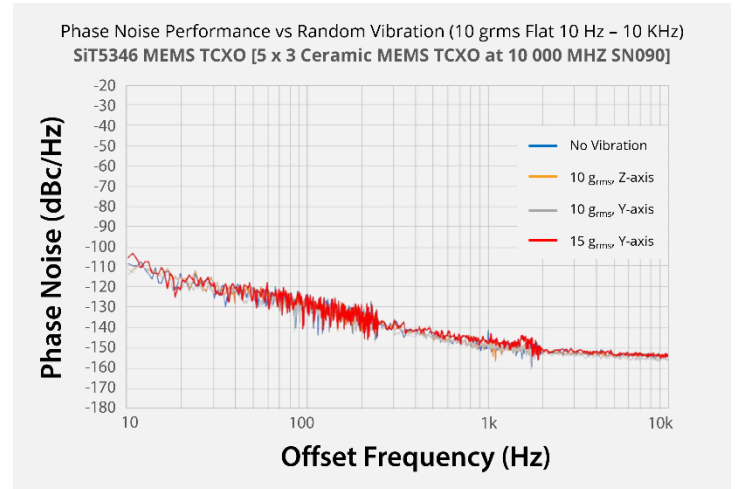
Endura COTS ruggedized oscillators are engineered for mission critical aerospace and defense applications that operate in harsh environments.

- Designed for wide temperature operation from -55°C to 125°C and high shock and vibration environments
- Specified, qualified and manufactured using 6-sigma statistical process control and deliver datasheet performance with no derating
- 100% screened with power cycle over the full temperature range to deliver low DPPM
- Customers find that Endura MEMS oscillators operate better than military and Hi-Rel oscillators at commercial price point

SiT5348 Super-TCXO Frequency Stability



SiT5348 Super-TCXO Phase Noise Under Vibration



Designed for Harsh Environments

- ✓ Up to -55°C to 125°C
- ✓ 20x better g-sensitivity^[1] (± 0.009 ppb/g)
- ✓ 50x better vibration survivability^[1] (70g)
- ✓ 20x better shock survivability^[1] (30,000g)
- ✓ No change in jitter or phase noise under vibration
- ✓ 38x better df/dT ^[1] (1 ppb/°C)
- ✓ Operates at >70,000 foot altitude

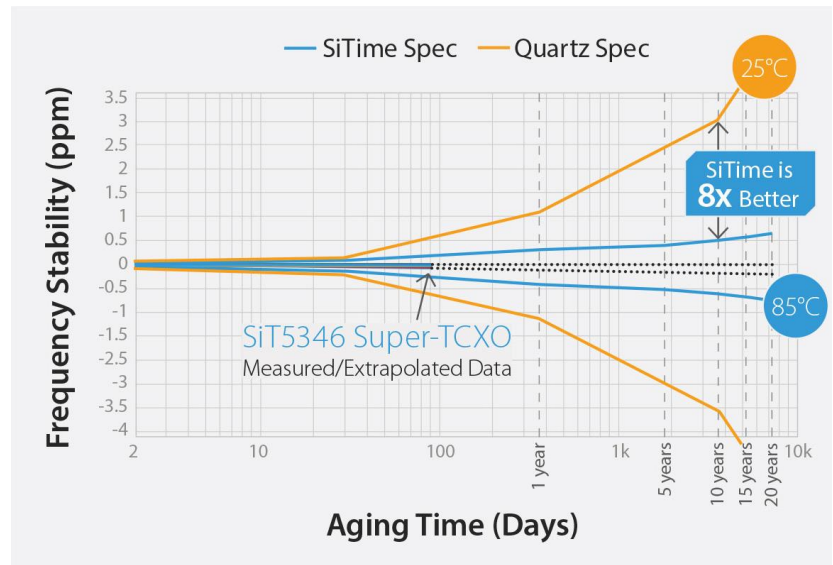
Easy to use and simplify designs

- ✓ Smaller package^[1]
- ✓ Integrated LDOs and DCXO option
- ✓ No derating necessary
- ✓ Fewer external components needed^[1]
- ✓ High power supply noise rejection (0.2 ps/mV)
- ✓ Low vibration and temperature sensitivity
- ✓ Low sensitivity to board bending
- ✓ ppb-level accuracy with TCXO; saves power vs. OCXO

[1] When compared to quartz oscillators

Failure is not An Option

- ✓ No frequency jumps
- ✓ No activity dips
- ✓ No cold start issues
- ✓ 6-sigma process control
- ✓ COTS screened over temperature with power cycling
- ✓ <0.5 DPPM
- ✓ 2 billion hours MTBF
- ✓ 20-year aging (+ 400 ppb)



- SiTime devices are typically smaller than crystal devices and are available in plastic packages. Due to the coefficient of thermal expansion (CTE) being closer to the CTE of a PCB, plastic packages improve the solder joint reliability compared to the ceramic packages required for crystal resonators and oscillators.
- SiTime differential oscillators offer state-of-the-art jitter performance.
- SiTime Endura products eliminate the headaches of quartz oscillators. They simplify design, reduce problems discovered during verification and qualification, shorten product development and time to certification, support production ramp up and continuous supply, and ease trouble shooting through the life of the product.

Applications

SiTime Endura oscillators are the timing solution of choice in a numbers of UAV subsystems

- | | |
|---|----------------------------|
| • Automated flight control | • Camera and video sensors |
| • Flight management and health monitoring | • Communication |
| • Network control | • Collision avoidance |
| • Data management | • Weather radar |
| • GNSS receiver | • Performance monitoring |
| • Flight sensors, IMU and gyroscopes | • Engine propulsion system |
| • Navigation | • Landing system control |

SiTime recommends using only Endura in aerospace and defense applications.



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