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Precision Timing in Drone Systems

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Drone technology is rapidly evolving. The global drone industry is at a pivotal point, with technological advancements and regulatory frameworks shaping its future. Today's drone applications have expanded beyond aerial photography and recreational use into areas such as agriculture, logistics, surveying, public safety, disaster response, and industrial inspection. Drones have rapidly become indispensable in industries that require efficiency, precision and innovation to take them to new heights.

As drone systems become more sophisticated, electronic systems require highly accurate timing and stable frequency control to ensure reliable operation. Crystals and oscillators serve as the fundamental timing and frequency reference components in drone electronics. Their frequency stability, temperature performance, and noise characteristics directly affect flight control accuracy, navigation precision, communication reliability, and sensor synchronization.

Requirements in Drone Systems

A drone is a UAV (Unmanned Aerial Vehicle), a pilotless aircraft operated remotely or via autonomous programming. However, not all UAVs are drones in the strict sense, that they can be highly complex and highly sensitive pieces of equipment used by the military in strategic deployment. Drones have become increasingly prevalent across various industries due to their versatility and ability to perform tasks that might be challenging, dangerous, or inefficient for manned aircraft. The development and integration of UAV technology continue to advance, driven by innovations in materials, battery life, sensor capabilities, and artificial intelligence.

These complex aircrafts are controlled remotely through radio communication or autonomously through high-performance programmed flight systems. A typical drone electronic architecture includes several key modules:

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- **Flight Control System:** the software that runs on the flight controller hardware to interpret sensor data, executing flight algorithms, and controlling the drone's movements.
- **GNSS Navigation System:** provides positioning data that allows drones to move through the sky confidently and independently. Drones need continuous updates about their location to execute flight paths. GNSS supplies this information, enabling drones to follow waypoints programmed in advance.

- **RF Communication System:** the backbone of the communication system that enables drones to receive commands from the ground control station and transmit data, such as video footage, telemetry, and sensor readings.
- **Propulsion System:** At the core of drone propulsion systems are the motors and propellers. These components work in tandem to generate lift and thrust, enabling the drone to ascend, descend, and travel in various directions. Drones with conventional engines are either too expensive, heavy, or both, making battery-powered devices the norm.
- **Imaging and Sensor Systems:** deliver high-resolution images and integrate thermal sensors making them indispensable for a wide range of applications. These systems serve as vital tools for real-time data collection, enhanced situational awareness and improved decision-making.
- **AI and Data Processing Platforms:** systems combine CPUs, GPUs, and dedicated neural processing units into tightly integrated modules optimized for inference at the edge. These modules support real-time computer vision, sensor fusion, and advanced analytics while operating within strict power and weight constraints.

All of these modules rely on stable clock signals for data processing and system synchronization. Crystals and oscillators provide the timing reference and frequency reference required for coordinated operation.

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How Crystals and Oscillators are Used in Drones

Flight Control System. Crystals or oscillators provide the system clock for the flight controller processor or MCU, ensuring precise control loop execution and stable flight operation. In modern drone operations, maintaining stable and accurate flight is essential it enables drone position holding that allows drones to maintain a fixed distance from an object under inspection. This feature is crucial for drones performing tasks that require hovering, such as aerial photography, surveying, and inspection.

Navigation and Positioning (GNSS). Oscillators with high frequency stability improve positioning accuracy, particularly in high-precision applications such as RTK. TCXOs provide a highly stable frequency output that remains consistent, even with temperature fluctuations, ensuring that the drone accurately locks onto and tracks satellite signals.

Communication Systems. Wireless communication modules require precise frequency references to maintain carrier stability. Frequency drift may lead to reduced signal quality, shorter communication range, or communication link failure. Stable crystal oscillators and TCXOs ensure carrier frequency accuracy, lowers bit error rates (BER), and prevents signal dropouts. Crystal oscillators are responsible for a drone's wireless communications, micro-processing on both ends, Bluetooth and/or Wi-Fi, timing capture, cameras, sensors, and navigation.

Imaging and Sensor Systems. Advanced imaging and sensor systems in drones are rapidly evolving, integrating technologies like CMOS sensors, LiDAR, thermal imaging (LWIR/MWIR), and hyperspectral sensors for enhanced navigation, mapping, and surveillance. These systems, often using high-precision crystal oscillators (TCXOs) for timing synchronization, enable advanced capabilities such as obstacle avoidance, autonomous flight, and real-time 3D scanning. Stable clock signals ensure accurate data acquisition and synchronization across multiple sensors.

Low Power Requirements. Power efficiency has emerged as a critical factor for drones. For small drone platforms, low-power oscillators and low-voltage designs help reduce overall power consumption and extend flight endurance. A more energy-efficient drone can stay airborne longer, enabling it to cover larger areas, complete more complex tasks, and reduce the need for frequent landings and battery changes.

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Key Timing Requirements for Drone Applications

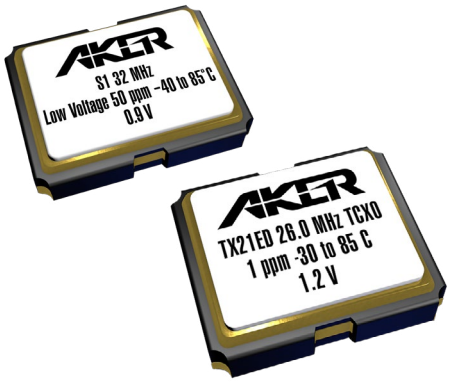
Drone systems typically require frequency components with:

- High frequency stability
- Low power consumption
- Low phase noise
- Compact package size
- High reliability and vibration resistance

AKER Drone Timing Solutions

As a professional crystal and oscillator manufacturer and frequency solutions provider, Aker Technology delivers timing components specifically tailored for UAV systems including::

- Quartz Crystals
- CMOS Oscillators
- Differential Oscillators
- TCXO
- High reliability and vibration resistance



These solutions ensure precise timing for reliable flight data synchronization, low phase noise for stable communication, high-stability for environmental resilience, and a diverse product portfolio that supports flight control, GNSS, communication, and mission-critical modules.

AKER solutions help customers build high-performance and reliable UAV systems.

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Learn More About AKER Timing Solutions

Model	Frequency (MHz)
C3E	12 M,16 M, 24 M, 25 M, 26 M, 27 M,40 M,48 M,54 M
C2E	
C1E	
S3	0.032768 M, 12 M, 16 M, 24 M, 25 M, 26 M, 27 M, 40 M, 48 M,54 M
S2	
S1	
TX32	10 M, 16.368 M, 19.2 M, 20 M, 26 M, 38.4 M
TX22	
TX21	

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