

POSITIONING · FUSION · CONTROL

Autonomous Navigation & Machine Control

Frequency-control and RF-filtering guidance for autonomous systems that combine GNSS, RTK, IMU and sensor fusion to deliver position, heading, velocity and time.

Multi-Band GNSS + Time-Aligned Sensors + Deterministic Compute + Rugged Machine Control

UAVs

Mobile Robots

Autonomous Vehicles

Agricultural Machinery

Construction Equipment

Mining Equipment

Engineering Focus

Begin with the functional node: GNSS RF front end, RTK receiver, IMU and control MCU, autonomous compute, Ethernet / SerDes network, correction radio or always-on time domain.

Architecture Consideration

Position and heading continuity are system-level outcomes. Clock stability, jitter and RF selectivity should be allocated together with sensor latency, calibration, vibration, correction availability, network timing and actuator response.

26 MHz

Common published GNSS reference class.

1 PPS

Epoch alignment signal, not an oscillator.

125 MHz

High-speed Ethernet / compute reference class.

1176-1606 MHz

Multi-band GNSS RF region.

Application Scope & System Architecture

Autonomous Navigation & Machine Control covers UAVs, robots, automated road vehicles and heavy mobile equipment that fuse GNSS / RTK, inertial and environmental sensors to estimate motion and command steering, propulsion or hydraulic actuators.

Representative Equipment

Air & Mobile Robotics

- UAV flight-control platforms
- UGVs and autonomous robots
- Warehouse and inspection vehicles
- Mission computers and payloads

Road & Agricultural Vehicles

- Autonomous driving computers
- GNSS / INS localization units
- Auto-steering and implement control
- Telematics and correction gateways

Construction & Mining

- Dozer and grader control
- Excavator guidance and automatics
- Haulage and mine-site vehicles
- Rugged displays and hydraulic control

Representative Autonomous Navigation & Control Chain

Position & Perception

Multi-band GNSS / RTK · IMU
· camera · radar · LiDAR



Time Alignment

Local references ·
timestamping · PPS /
Timepulse · PTP



Fusion & Planning

State estimation · trajectory
· safety supervision



Machine Control

CAN / Ethernet / PWM ·
steering · propulsion ·
hydraulics

GNSS RF Integrity

Protect low-level multi-band signals and preserve the receiver measurement path in a dense RF environment.

Sensor Coherence

Control clock drift, timestamp offset and interface latency across GNSS, IMU and perception sensors.

Compute & Networking

Support MCU, Ethernet and high-speed SerDes references with the required waveform and jitter class.

Harsh Environment

Maintain start-up and frequency performance through vibration, shock, thermal cycling and power transients.

FCom Solution Scope

FCom supports multi-band GNSS SAW filtering, compact and high-stability TCXO references, automotive and wide-temperature crystals / CMOS oscillators, low-jitter differential oscillators, 32.768 kHz timekeeping devices and application-specific UHF correction-radio filters.

System-Level Performance

FCom components support the RF and clock functions within the design. Navigation accuracy, functional safety, steering performance and machine-control integrity are achieved through complete-system architecture, calibration and validation.

02

Select by System Node First

A frequency that is suitable for a GNSS receiver may be irrelevant to the IMU, compute network or correction modem. Define the node and electrical interface before selecting a device family.

NODE 1 · GNSS / RTK MEASUREMENT PATH

RF Filtering & Receiver Reference

Function: acquire multi-band GNSS signals and maintain a stable measurement-engine reference for code and carrier tracking.

Define: constellation bands, passband / rejection mask, exact reference frequency, waveform, supply, phase noise, temperature and vibration.

Selection direction: evaluate the receiver-defined TCXO class with frequency-specific SAW filtering; do not derive the oscillator frequency from the RF carrier.

NODE 2 · IMU, CONTROL MCU & SAFETY DOMAIN

Local Clock Roots & Always-On Time

Function: clock the inertial sensor interface, flight or machine controller, watchdog and event-log / wake domain.

Common families: 24 / 25 / 32 / 40 / 48 MHz platform clocks and 32.768 kHz RTC, subject to the selected IC.

Selection direction: choose crystal or CMOS oscillator by the IC clock-input topology; confirm CL / ESR for crystals and input level / load for oscillators.

NODE 3 · AUTONOMOUS COMPUTE & SENSOR NETWORK

Ethernet, GMSL, PCIe & SerDes References

Function: support high-bandwidth camera, radar, LiDAR, switch and compute links while preserving the allocated link-jitter budget.

Common families: 25, 100, 125 and 156.25 MHz; output may be CMOS, LVDS, LVPECL or HCSL.

Selection direction: specify output standard, termination, RMS jitter integration band, supply and temperature before assigning a differential oscillator.

NODE 4 · RTK CORRECTION & CONNECTIVITY

UHF Radio, Cellular, Wi-Fi & Ethernet

Function: receive RTCM or proprietary corrections and exchange mission, map or fleet data without coupling RF noise into the GNSS chain.

Common families: 26 / 32 / 38.4 / 40 / 48 / 50 / 52 MHz references; 410-475 or 902-928 MHz UHF channels.

Selection direction: treat the correction-radio clock and RF filter as a separate domain; channel plan, occupied bandwidth and region are mandatory.

PPS / Timepulse / PTP

These mechanisms align time domains and sensor timestamps. They do not replace the local oscillators used between timing events, and their latency or cable delay must be included in the synchronization budget.

Actuation & Environment

Motor, steering and hydraulic control nodes prioritize deterministic response, start-up margin, wide-temperature operation and resistance to vibration or supply disturbance. Qualification class alone does not replace system validation.

03

Frequency & Component Placement Matrix

The frequencies below represent recurring values found in publicly documented platforms. Final selection is matched to the exact GNSS, sensor, controller, modem, PHY or SerDes device used in the customer design.

Frequency / Signal	Common Placement	Engineering Meaning	FCom Selection Direction	Qualification Note
32.768 kHz	RTC, wake and event-log domain	Low-power timekeeping during sleep or controlled shutdown	Tuning-fork crystal or ultra-low-current 32 kHz XO class	Match CL, ESR, drive level, start-up and backup supply
24 / 25 MHz	MCU, sensor control, Ethernet / 100BASE-T1 PHY	Local clock or PHY reference; 24 MHz bus speed is not automatically an XO requirement	Automotive crystal or wide-temperature CMOS XO class	Follow the selected IC clock-input and load specification
26 MHz	GNSS / RTK receiver and selected wireless platforms	Common published local-reference value; the exact frequency remains chipset-specific	Compact clipped-sine TCXO class	Match amplitude, load, phase noise, supply and vibration sensitivity
32 MHz	RTK radio, Wi-Fi / Bluetooth or control platform	Radio / connectivity reference independent of the GNSS measurement clock	Crystal, TCXO or CMOS XO according to the transceiver input	Match the regional radio architecture and reference tolerance
38.4 / 40 / 48 / 50 / 52 MHz	GNSS, cellular, wireless, PMIC or controller platform	Chipset-driven family with strong waveform and voltage dependence	TCXO, crystal or CMOS XO selected by the actual IC	Specify the exact value required by the selected chipset
100 / 125 / 156.25 MHz	Domain compute, Ethernet switch, PCIe / SerDes	High-speed reference where output standard and jitter dominate	Low-jitter differential XO where LVDS / LVPECL / HCSL is required	Match termination and RMS jitter integration bandwidth
1176.45 / 1207.14 MHz	L5 / E5a / B2a and E5b / B2 GNSS RF paths	Lower multi-band measurement channels for RTK and robust positioning	Signal-specific or combined lower-band SAW selection	Validate bandwidth, group delay and adjacent-service rejection
1227.60 / 1268.52 MHz	GPS / QZSS L2 and BeiDou B3 RF paths	Additional carrier-phase measurement channels	Dedicated L2 or B3 SAW selection when enabled by the receiver	Match the signal set and discrete-versus-wideband topology
1561.098 / 1575.42 MHz	BeiDou B1I and GPS L1 / Galileo E1 / BeiDou B1C RF paths	Primary upper GNSS acquisition and tracking region	Wide upper-band or separate B1I / L1-family SAW path	GLONASS-inclusive designs require separately verified coverage
1 PPS / Timepulse	GNSS-to-compute or sensor synchronization	Epoch marker used with timestamp and local-clock domains	Interface and timebase integration, not an oscillator product	Validate pulse level, latency, propagation delay and loss behavior

RF Carrier vs Clock

1176-1606 MHz values define GNSS RF-filter placement. The TCXO or crystal frequency inside the receiver is defined separately by the chipset.

Bus Rate vs Reference

Ethernet or sensor data rate may differ from the external reference value. The applicable PHY, serializer, sensor or controller data sheet defines the required clock.

Configuration Note

This matrix identifies the relevant product class. FCom confirms frequency-specific electrical options and final ordering codes through application review.

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Representative Platform & Architecture Matrix

Four publicly documented platforms show how the clock architecture changes from a compact RTK flight controller to an autonomous-driving computer, agricultural auto-steering system and rugged earthmoving control platform.

HOLYBRO · OPEN AUTOPILOT ECOSYSTEM

Pixhawk 6X + H-RTK ZED-F9P

01

Pixhawk 6X combines an STM32H753 FMU with three IMUs, dual GPS inputs, dual CAN and 100 Mbps Ethernet. The H-RTK ZED-F9P platform supports multi-constellation L1 / L2 reception, centimeter-class RTK, DroneCAN / UART and a configurable Timepulse output. The modular stack separates GNSS, inertial sensing, flight control and mission-computer interfaces.

GNSS / RTK + Timepulse → Triple IMU + FMU → CAN / PWM / Ethernet

Design focus: compact receiver reference, GNSS RF selectivity, controller clock and optional Ethernet PHY reference. Platform validation includes vibration behavior and sensor-time alignment.

NVIDIA

DRIVE AGX Orin / DRIVE Hyperion Architecture

02

The public DRIVE AGX Orin platform provides GMSL camera inputs, high-bandwidth Ethernet and multiple CAN interfaces for sensor fusion and vehicle control. DRIVE OS documents an external grandmaster, PTP hardware clocks, PPS-to-TSC synchronization, camera FSYNC alignment and time-aware LiDAR connectivity across multiple time domains.

GNSS / INS + Sensor Time → PTP / PHC / TSC → Fusion / Planning / CAN

Design focus: defined Ethernet, switch and SerDes reference inputs where differential output and jitter are specified. PTP / PPS distributes system time while local references maintain the individual clock domains.

JOHN DEERE

Precision Essentials + AutoTrac Universal 300

03

The published solution combines a StarFire 7500 multi-constellation receiver with SF-RTK, a G5 Plus display, JDLink modem and AutoTrac Universal 300 steering unit. Terrain compensation corrects for machine roll and pitch, while the connectivity layer transfers operations data and correction services without replacing the local steering-control loop.

GNSS + RTK Correction → Terrain Compensation → Display / Auto-Steering

Design focus: receiver reference, attitude-sensor clock, guidance controller and modem clock are treated as separate domains. Wide temperature, long operating hours and mechanical vibration are considered together with the ppm budget.

TRIMBLE

Earthworks Grade Control Platform

04

Earthworks supports machine-control configurations using dual GNSS, single GNSS, UTS or laser references with cross-slope and IMU sensing. The control computer and display convert position and machine attitude into automatic blade, boom, bucket or tiltrotator commands through the hydraulic-control interface.

GNSS / UTS + IMU → Earthworks Controller → Hydraulic Actuation

Design focus: rugged GNSS, sensor and controller references selected for shock, vibration and thermal change. Holdover oscillators are considered when the platform defines a compatible reference input and a quantified GNSS-outage requirement.

How to use these examples: the public platforms illustrate representative system architectures and potential clock locations. Component use, qualification and exact frequencies remain specific to each customer design; no third-party endorsement or existing FCom design-in is implied.

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FCom Selection Guidance by Critical Function

The four representative FCom options below illustrate component classes that directly support architecture and interface decisions. FCom confirms the frequency-specific oscillator configuration and final ordering code after reviewing the applicable electrical interface.

Decision 1 • GNSS / RTK Receiver Reference

FVT-6S Series

Compact TCXO reference for receivers that require a clipped-sine input. A larger-package or higher-stability class can be considered where the receiver specification and system error budget call for additional margin.

Selection window: 2016 · 10-52 MHz · clipped sine

Reference specification: ± 0.5 ppm option · -40 to +85°C

Supply: 1.8 / 2.5 / 2.8 / 3.0 / 3.3 V

Application inputs: Exact frequency · amplitude · load · phase noise · G sensitivity

Decision 2 • Rugged Controller Crystal

FCX-1S-A Series

Compact passive crystal for an MCU, PHY or controller with an integrated oscillator loop. For devices that accept an external CMOS clock, an oscillator should be evaluated against the input specification.

Selection window: 1210 · 24-76.8 MHz · AEC-Q200

Reference specification: ± 10 ppm tolerance option · ± 50 ppm stability option · -40 to +125°C

Application inputs: Frequency · CL · ESR · drive level · start-up margin

Topology note: Crystal-loop and external-CMOS inputs use different solutions

Decision 3 • High-Speed Compute / Ethernet Reference

FCO-2L-UJ Series

Low-jitter differential reference for compute, Ethernet, PCIe or SerDes devices with LVDS, LVPECL or HCSL clock inputs.

Package: 2520 · 6-SMD

Frequency: 100-220 MHz

Output / VDD: LVPECL, LVDS or HCSL · 1.8 / 2.5 / 3.3 V

Reference specification: 50 fs jitter typ. · ± 20 ppm option · -40 to +125°C

Decision 4 • Primary GNSS RF Path

FSF3030-1575M42-32M736-1.4-30

Upper-band SAW reference for the L1 / E1 / B1C path. L2, L5 / E5 and BeiDou B3 are treated as separate RF channels and matched to the receiver band plan.

Center / bandwidth: 1575.42 MHz · 32.736 MHz

Reference values: 1.4 dB insertion loss · 30 dB stopband value

Selection relevance: Directly affects supported constellations and RF coexistence

Application inputs: Full rejection mask · matching · S-parameters · B11 / GLONASS coverage

RTC / Wake Domain

A 32.768 kHz crystal supports controllers or RTCs with a dedicated oscillator loop. FCom matches the device to load capacitance, ESR, drive level, start-up margin and operating temperature.

RTK Radio Filtering

410-475 MHz and 902-928 MHz links are selected according to the regional channel plan. FCom confirms the filter after the occupied bandwidth, impedance and full rejection mask are defined.

Architecture-Dependent Options

OCXO, VCXO and crystal-filter products may be evaluated where the platform includes an external reference input, a tunable timing loop or a narrowband IF architecture with defined performance requirements.

Selection note: the four representative options above identify positions with direct architecture or interface relevance. Final oscillator ordering codes are matched to frequency, supply, waveform, stability, load / termination, temperature and packaging. SAW selection additionally includes S-parameters, matching, passband and rejection-mask validation.

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Primary Technical & Public Architecture References

Platform and frequency statements are based on official semiconductor, module and equipment-manufacturer publications. FCom product specifications reflect the current portfolio information used for this guide.

PUBLISHED GNSS CLOCK EXAMPLE

ST Teseo-LIV3R

Official module information identifies a 26 MHz TCXO and dedicated 32 kHz RTC within a compact GNSS architecture.

st.com · Teseo-LIV3R

VEHICLE ETHERNET CLOCKING

TI DP83TC812S-Q1

Official 100BASE-T1 PHY information supports the 25 MHz vehicle-network reference example and -40 to +125°C environment.

ti.com/product/DP83TC812S-Q1

UAV / ROBOT CONTROL PLATFORM

Holybro Pixhawk 6X

Official FMU, triple-IMU, dual-GPS, CAN and 100 Mbps Ethernet platform specifications.

docs.holybro.com · Pixhawk 6X

MULTI-BAND RTK PLATFORM

Holybro H-RTK ZED-F9P

Official multi-constellation bands, RTK precision, update rates, interfaces and configurable Timepulse specifications.

docs.holybro.com · H-RTK F9P

AUTONOMOUS COMPUTE PLATFORM

NVIDIA DRIVE AGX

Official compute, GMSL camera, Ethernet and CAN interface specifications for DRIVE AGX Orin.

developer.nvidia.com/drive/agx

MULTI-DOMAIN TIME SYNCHRONIZATION

NVIDIA DRIVE OS Time Sync

Official PTP / PHC, PPS-to-TSC, camera FSYNC and time-aware sensor-network synchronization topology.

developer.nvidia.com · Time Synchronization

PRECISION AGRICULTURE PLATFORM

John Deere Precision Essentials

Official StarFire 7500, G5 Plus, JDLink and AutoTrac Universal 300 system combination; receiver pages describe RTK accuracy options.

deere.com · Precision Essentials

CONSTRUCTION MACHINE CONTROL

Trimble Earthworks

Official dual / single GNSS, UTS / laser and sensor configurations for automatic machine grade control.

trimble.com · Earthworks

Reference note: public sources establish representative architectures, interfaces and signal families. Processor speed, network bit rate and Timepulse values are interpreted separately from external oscillator requirements. Third-party names are included for technical reference and do not imply endorsement, qualification or commercial affiliation.

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Minimum Information for an Engineering RFQ

For an accurate recommendation, please provide one requirement set for each GNSS, controller, network, radio or RTC function rather than only a general application description.

1 • Platform & Functional Node

- UAV, robot, road vehicle, agricultural or heavy-equipment platform
- GNSS receiver, IMU, controller, compute, network, radio or RTC node
- Prototype / production architecture and replaceable component position
- Normal, correction-loss, GNSS-degraded and recovery operating modes

2 • GNSS / RTK & RF Plan

- Required constellations and exact GNSS signal families
- RTK correction source, transport and regional UHF channel plan
- Discrete-band or combined GNSS RF-front-end topology
- Antenna, LNA, cable, matching and coexistence environment

3 • Clock Electrical Interface

- Exact frequency and crystal / XO / TCXO function
- Clipped sine, CMOS, LVDS, LVPECL or HCSL output
- Supply, load / termination, amplitude and enable behavior
- For a crystal: CL, ESR, C0, drive level and negative resistance

4 • Stability, Noise & Synchronization

- Initial tolerance, temperature stability and aging
- Phase-noise mask or RMS jitter integration band
- PPS / Timepulse / PTP relationship to the local reference
- Maximum timestamp offset, drift and reference-loss interval

5 • Mechanical & Environmental Profile

- Operating / storage temperature and thermal-gradient profile
- Vibration spectrum, shock, mounting orientation and board resonance
- Package, height, footprint and keep-out constraints
- Power interruption, brownout and controlled-shutdown behavior

6 • Qualification & Program Data

- AEC / industrial qualification and PPAP expectations
- Prototype quantity, validation stage and required sample date
- Annual volume, lifetime and change-control requirements
- Required compliance, reliability and traceability documentation

GNSS / Fusion Validation

Measure acquisition, carrier continuity, heading, drift and re-convergence with representative antenna, dynamics, temperature and correction outages.

Network Validation

Verify link start-up, timestamp alignment, eye / jitter margin, EMC coupling and behavior during switch, cable or reference disturbances.

Machine Validation

Test steering, motor or hydraulic response through vibration, thermal cycling, supply transients and GNSS-degraded operating modes.

Send one RFQ line per clock or RF-filter function. FCom Engineering will identify the most relevant product series and an efficient validation path. **Technical Review →**

08

Autonomous Navigation & Machine Control FAQ

Does a tighter TCXO directly guarantee better navigation accuracy?

No. Accuracy is determined by the antenna and RF path, GNSS geometry, correction quality, inertial-sensor errors, calibration, time alignment and fusion algorithm. The TCXO must satisfy the receiver and system error budget.

Is 1575.42 MHz the GNSS receiver oscillator frequency?

No. It is an RF carrier frequency for the L1 / E1 / B1C family. The receiver local reference is a much lower chipset-specific frequency, commonly within the tens-of-megahertz range.

Does every autonomous platform use a 26 MHz GNSS reference?

No. 26 MHz is common in published GNSS designs, but the exact frequency, waveform, supply and load are defined by the selected receiver, RF IC or module.

When is a low-jitter differential oscillator justified?

It is relevant when the compute, Ethernet, PCIe or SerDes device requires LVDS, LVPECL or HCSL and the link jitter budget supports an external oscillator. It is not a default requirement for every controller.

Can PPS or PTP replace the local oscillator?

No. PPS and PTP align time domains. Sensors, processors and interfaces still require continuous local clocks between synchronization events, and the oscillator affects short-term interpolation and holdover behavior.

Should an OCXO be added for operation during GNSS loss?

Not automatically. Mobile autonomy normally bridges outages with IMU, odometry, map and perception fusion. An OCXO is considered only when a compatible reference input and a quantified holdover requirement justify its size, power and warm-up.

Can a 915 MHz SAW be used for every RTK correction radio?

No. The radio region, center frequency, channel bandwidth, duplexing, power, rejection mask and impedance must match. 410-475 MHz and 902-928 MHz systems require different filters and regulatory review.

Does an automotive-qualified component make the system automotive-qualified?

No. Component qualification supports the design, but system qualification also requires schematic, PCB, thermal, EMC, safety, manufacturing and vehicle-level validation.

Selection principle: define the node, interface and error budget first; then select frequency, waveform, RF bandwidth, stability, jitter, temperature, package and qualification. Public platform names illustrate architecture and do not constitute cross-reference or replacement approval.

09

Convert the Architecture into a Qualified Selection

FCom Engineering reviews the clock or RF-filter function in the context of the complete navigation, compute and machine-control architecture before confirming a frequency-specific configuration.

01 · Define the Node

Identify the GNSS, IMU, controller, autonomous compute, network, correction-radio or RTC function.

02 · Define the Interface

Provide the exact frequency, signal family, waveform, supply, load / termination and component location.

03 · Apply the Budget

Allocate stability, phase noise / jitter, RF loss and rejection, time offset, temperature, aging and vibration.

04 · Validate the Platform

Confirm operation in the completed RF path, clock tree, synchronization topology and machine-control loop.

What to Send

- System block diagram or relevant schematic section
- Selected receiver, sensor, controller, PHY or compute device
- GNSS bands and RF passband / rejection requirements
- Clock frequency, waveform, load, stability and noise budget
- Environment, qualification, samples, schedule and annual volume

What FCom Provides

- Representative product series or SAW ordering-code recommendation
- Matched electrical, RF and environmental configuration
- Loading, matching, termination and layout considerations
- Recommended validation checkpoints and documentation scope
- Sample / production feasibility and delivery discussion

Typical Review Outcomes

Defined Function	Recommended Product Class	Information Required for Final Selection
Compact GNSS / RTK measurement reference	Clipped-sine TCXO	Exact frequency, supply, amplitude / load, phase noise, temperature and dynamics
Vehicle MCU / PHY or rugged controller root	AEC crystal or wide-temperature CMOS XO	Clock topology, CL / ESR or input load, total ppm budget, start-up and qualification
High-speed compute / Ethernet / SerDes	Low-jitter differential XO	LVDS / LVPECL / HCSL, termination, integrated jitter band, supply and temperature
Multi-band GNSS or RTK-radio RF path	Frequency-specific SAW filter	Passband, insertion loss, group delay, rejection zones, impedance and RF environment

Discuss Your Autonomous Navigation Architecture

Send the platform node, selected chipset, GNSS bands, correction method, exact clock or RF-filter requirement, temperature, vibration, package and qualification needs. FCom will recommend the most relevant product and validation path.

[General Inquiry](#)
[Technical Support](#)

Product-data note: the specifications shown in this guide reflect the current FCom portfolio information. Frequency availability, final guaranteed limits and complete ordering codes are confirmed through application review and the applicable product documentation.