

LOW-POWER SENSING & DISTRIBUTED MONITORING

Sensors, Energy & Remote Monitoring

Balance low power, sampling accuracy, wireless stability and long-duration timekeeping across sensing, data-acquisition and remote-monitoring platforms.

Low Power + Sampling Accuracy + Wireless Stability + Long-Duration Timekeeping

Wireless Sensors

Condition Monitoring

Energy Metering

Data Loggers

Remote Gateways

LPWAN / GNSS

Application Scope

Battery-powered sensor nodes, precision data acquisition, energy and utility metering, condition monitoring, LPWAN / wireless telemetry and wired remote gateways.

Selection Philosophy

Select by timing domain first. RTC, metrology, ADC MCLK, wireless RF reference and gateway clocks can have very different power, accuracy, startup and environmental requirements.

Timekeeping

RTC, wake scheduling, timestamping and long-duration logging.

Sampling

ADC / AFE master clocking, acquisition timing and digital filtering.

Wireless

BLE, Sub-GHz, LoRa, cellular and GNSS frequency references.

Communication

MCU, Ethernet PHY, RMII and remote-gateway timing.

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Application Scope & Engineering Domains

Treat timekeeping, measurement, wireless and gateway timing as separate design domains before assigning an external crystal or oscillator.

Sensors, Energy & Remote Monitoring systems frequently spend long periods in standby, wake for measurement, process sensor data and transmit intermittently. The best timing solution therefore depends on both frequency accuracy and the power / startup behavior of the clock source.

Typical Equipment

Sensing & DAQ

Industrial Sensors
Condition Monitoring
Vibration / Pressure / Temperature
Acquisition
Remote I/O & Data Loggers

Energy & Metering

Smart Electricity Meters
Energy / Power Monitoring
Solar & ESS Monitoring
Utility / Submetering Nodes

Remote Monitoring

BLE / Wi-Fi Sensor Nodes
LoRa / Sub-GHz Telemetry
Cellular / GNSS Monitoring
Industrial Remote Gateways

Four Engineering Domains

Low-Power Timekeeping

32.768 kHz RTC / wake / timestamp domain; focus on ESR, CL, current and long-duration stability.

Sampling & DAQ

ADC / AFE MCLK, digital filtering and acquisition control; output data rate is normally derived from the master clock.

Wireless / RF

High-frequency crystal or TCXO for RF PLL / system reference; accuracy requirements vary by radio architecture.

System & Gateway

MCU, Ethernet PHY, RMII and supervisory timing for local or remote connectivity.

Main Technical Requirements

Power Budget

Standby current · wake interval · oscillator startup · active duty cycle.

Measurement Integrity

MCLK accuracy · sampling architecture · jitter where required · long-term drift.

RF Stability

Frequency error · thermal drift · crystal vs TCXO · RF-front-end selectivity.

Environment

Local PCB temperature · qualification · outdoor exposure · supply-voltage range.

Frequency boundary: ADC sample rate, sensor polling interval, SPI / I²C rate, CPU frequency and wireless bit rate are typically derived timing parameters. External timing-device selection should begin with the XTAL / CLKIN / MCLK / REFCLK node documented for the target device.

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Select by System Node First

Identify the external timing node before choosing frequency, clock topology, power class and accuracy level.

System Node	Typical Function	Representative Reference	Typical Device	Selection Focus
RTC / Wake / Logger	Long-duration timekeeping	32.768 kHz	Tuning-fork crystal / low-current XO	CL · ESR · startup · standby current · ppm budget
Energy Metering IC	Metrology reference	12.288 MHz	MHz crystal / driven clock	Oscillator circuit · drive level · frequency accuracy
Precision ADC / DAQ	ADC master-clock input	Architecture dependent 16.384 MHz public example	Crystal / CMOS MCLK	ADC MCLK mode · divider · filter / ODR relationship
Wireless MCU / Radio	RF / system reference	24 / 26 / 32 / 38.4 / 48 MHz	Crystal / TCXO	Radio P/N · CL · ppm · temperature · startup
Ethernet PHY	Remote gateway	25 MHz	Crystal / XO	PHY oscillator mode and total ppm budget
RMII	Externally driven MAC-PHY reference	50 MHz	CMOS XO	REF_CLK direction · logic level · duty cycle
Sub-GHz RF Front End	Out-of-band rejection / selectivity	433 / 868 / 915 MHz class	SAW filter where required	Band · bandwidth · insertion loss · attenuation
GNSS RF Front End	L1 filtering / interference control	1575.42 MHz	SAW filter where required	Center frequency · passband · loss · stopband
Sample / Poll / Bit Rate	Derived timing	Application dependent	Controller / ADC / radio generated	Select the upstream external reference separately

Low-Power Timing

Selection begins by confirming whether the RTC / MCU uses a passive 32.768 kHz crystal or a driven low-frequency clock. Current consumption and startup behavior can be key design considerations.

Measurement Timing

For energy metrology and precision ADCs, the dedicated CLKIN / MCLK requirement should be verified independently from the sample rate or host MCU operating frequency.

Wireless Timing

The same RF reference frequency may be implemented with either a crystal or TCXO, depending on the radio architecture, temperature range and required frequency accuracy.

Recommended selection sequence: System node → external vs derived → crystal vs driven clock → frequency → power / startup → temperature / accuracy → RF or measurement constraints → representative FCom series.

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Frequency & Component Placement Matrix

Organize external references by timing function; keep derived sampling, processor and protocol rates in a separate layer.

Reference	System Position	Typical Role	Clock / RF Device	Engineering Focus
32.768 kHz	RTC / wake / timestamp	Long-duration low-power timing	Crystal or low-current XO	CL / ESR, startup, current, temperature, timekeeping error
12.288 MHz	Energy metering IC	Dedicated metrology reference	MHz crystal / external clock	Oscillator circuit, drive level, ppm and temperature
16.384 MHz	Precision DAQ example	ADC MCLK feeding divider / digital filter	Crystal / CMOS clock	MCLK architecture; ODR and bandwidth are derived
24 / 26 / 32 / 38.4 / 48 MHz	Wireless MCU / radio	RF PLL / system reference	MHz crystal / TCXO	Radio-specific CL, accuracy, startup and thermal drift
25 MHz	Ethernet PHY	Wired remote-gateway reference	Crystal / XO	PHY clock topology and total frequency budget
50 MHz	RMII	Driven REF_CLK	CMOS XO	Source direction, logic voltage, duty cycle and routing
433 / 868 / 915 MHz	Sub-GHz RF front end	Optional RF selectivity / rejection	SAW filter	Region, passband, insertion loss and stopband attenuation
1575.42 MHz	GNSS-assisted monitoring	Optional L1 RF filtering	SAW filter	Passband width, loss, interference environment
Derived	ADC sample / MCU CPU / radio data	Internal timing	Derived from the upstream reference	Verify the upstream MCLK / XTAL / REFCLK source

Timekeeping

For 32.768 kHz timekeeping, μ A-level current, ESR / CL compatibility and reliable wake scheduling may be more important than the tighter ppm performance required in some RF domains.

Measurement

12.288 MHz metrology and ADC MCLK nodes should be validated against the target oscillator circuit and drive / logic requirements.

Wireless / RF

Crystal, TCXO and optional SAW filtering address different problems: frequency generation, temperature accuracy and RF selectivity.

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Representative Platform & Architecture Examples

Public platforms illustrate real timekeeping, sampling, metrology and RF-reference architectures. FCom device selection remains independent and should be verified against the final system design.

NORDIC SEMICONDUCTOR

nRF52840 Reference Circuitry · Wireless Sensor Node 1

Architecture: multiprotocol wireless SoC with separate high-frequency RF/system and low-frequency sleep/timekeeping references.

Clock evidence: official reference circuitry specifies a 32 MHz crystal with CL = 8 pF and a 32.768 kHz crystal with CL = 9 pF.

32.768 kHz → Sleep / RTC + 32 MHz RF / System

Selection insight: RF stability and long-duration low-power timing should be optimized as separate clock domains.

ANALOG DEVICES

CN0540 · Precision Condition-Monitoring DAQ 2

Architecture: IEPE sensor / analog front end → AD7768-1 precision 24-bit ADC → digital processing / FPGA.

Clock evidence: the public reference design uses a 16.384 MHz MCLK; output data rate and measurement bandwidth are derived through MCLK division and digital-filter decimation.

16.384 MHz MCLK → ADC → Filter / ODR

Selection insight: ADC sample rate and measurement bandwidth are derived from the ADC clock architecture and should be evaluated separately from the external reference frequency.

ANALOG DEVICES

ADE9153A · Energy Metering Architecture 3

Architecture: voltage / current sensing → dedicated metrology IC → energy / power-quality processing → host communication.

Clock evidence: ADE9153A specifies 12.288 MHz nominal CLKIN and supports either its crystal oscillator interface or an externally driven clock.

12.288 MHz → Metrology Clock → Energy / PQ Engine

Selection insight: a dedicated metrology device can require its own reference independent of the host processor.

SEMTECH

SX1262 Development Platforms · LoRa Remote Monitoring 4

Architecture: remote sensor / MCU → SX1262 LoRa transceiver → Sub-GHz LPWAN link.

Clock evidence: SX1262DVK1CAS publishes a 32 MHz XTAL reference while SX1262DVK1PAS publishes a 32 MHz TCXO reference.

32 MHz XTAL OR 32 MHz TCXO → SX1262

Selection insight: frequency alone does not determine the device class; RF accuracy and operating conditions drive crystal-versus-TCXO selection.

Platform reference note: these public platforms are shown to illustrate representative timing architectures. Final frequency, device type, electrical limits, RF filtering and qualification should be verified against the selected target device, final schematic and applicable component specifications.

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Battery-Powered Wireless Sensor & Data Logger

Separate the always-on timekeeping domain from the high-frequency sensor / wireless reference so that power, accuracy and startup can be optimized independently.

Representative Architecture



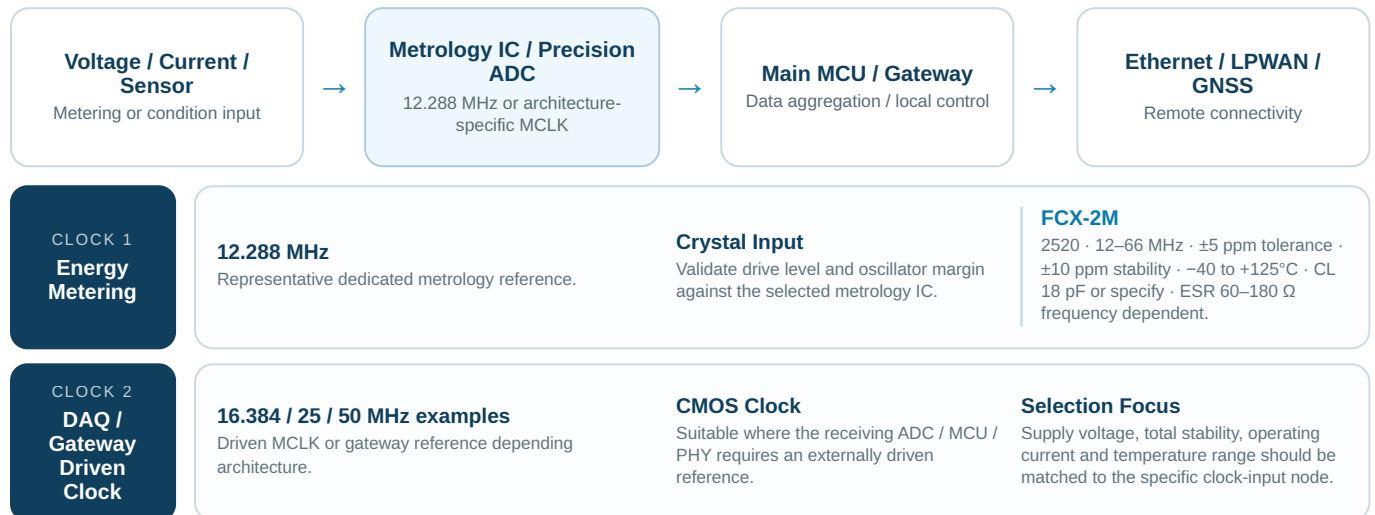
Wireless timing note: the same reference frequency may be implemented with a crystal or TCXO. The appropriate device class depends on the radio architecture, temperature range and required RF frequency accuracy.

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Energy, Precision DAQ & Remote-Gateway Architecture

Measurement timing, system communication and optional RF filtering can coexist in one platform while remaining separate selection domains.

System Architecture



Optional RF Front-End Extension

868 MHz LPWAN

A discrete SAW filter can be considered where the regional Sub-GHz RF architecture requires additional selectivity or out-of-band rejection.

Select by center frequency · bandwidth · insertion loss · stopband attenuation

915 MHz LPWAN

For 915 MHz remote-monitoring designs, center frequency, bandwidth, package and impedance should be matched to the RF path.

FCom FSF SAW Filter family · configuration selected from the RF requirement

1575.42 MHz GNSS L1

GNSS-assisted monitoring may use a discrete L1 filter where the receiver front end requires additional interference rejection.

Select from the FCom FSF family by passband and rejection requirement

RF-filter note: SAW filtering is an RF-front-end option for applications requiring additional selectivity or interference rejection. Final selection should follow the complete radio, antenna and regional band plan.

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FCom Selection Guidance by Design Condition

Representative series are shown only where power, topology, frequency accuracy, temperature or RF selectivity creates a meaningful selection decision.

Long-Duration Timing

Passive or driven 32.768 kHz selection based on RTC topology and standby current.

Measurement Clocking

Dedicated metrology and ADC MCLK references validated against the receiving oscillator circuit.

Wireless Stability

Crystal vs TCXO based on radio frequency accuracy, temperature and startup requirements.

RF Front End

Optional SAW filtering for Sub-GHz / GNSS where discrete selectivity is required.

Design Condition	Representative FCom Series	Key Matrix Specifications	Selection Relevance
Passive 32.768 kHz RTC / wake clock	FCT-2M	2012 · 32.768 kHz · ±5 ppm · -40...+125°C · CL 6–12.5 pF · ESR 70–90 kΩ.	Suitable for compact long-duration timekeeping where the RTC / MCU provides a compatible passive 32 kHz oscillator circuit.
Driven 32.768 kHz with µA-level current priority	FCO-6K-UC	2016 · 1.5 / 1.8 V · CMOS · ±20 ppm · -40...+105°C · 1.4–1.8 µA.	Designed for battery-powered nodes requiring an active low-frequency reference with µA-level current.
12.288 MHz energy-metrology crystal input	FCX-2M	2520 · 12–66 MHz · ±5 ppm tolerance · ±10 ppm stability · -40...+125°C · configurable CL.	Representative low-MHz crystal family for metrology ICs that provide a compatible crystal oscillator input.
24–48 MHz wireless / sensor crystal input	FCX-2S	2016 · 16–96 MHz · ±5 ppm tolerance · ±10 ppm stability · -40...+125°C · configurable CL.	Compact passive reference for platform-specific 24 / 26 / 32 / 38.4 / 48 MHz wireless and sensing nodes.
Driven MHz clock: prioritize power or temperature	FCO-2C-UP / FCO-6C	FCO-2C-UP: 1–50 MHz · 0.9 / 1.2 / 1.5 V · 0.9–3 mA · -40...+85°C. FCO-6C: 1.5–50 MHz · 1.8 / 2.5 / 3.3 V · ±20 ppm · -40...+125°C.	Selection depends on whether the design prioritizes lower-voltage / lower-current operation or a wider operating-temperature range.
Wireless / GNSS accuracy beyond standard crystal / XO	FVT-6S	2016 · 10–52 MHz · clipped sine · ±0.5 ppm · -40...+85°C · 1.8 / 2.5 / 2.8 / 3.0 / 3.3 V.	Appropriate where the target RF device requires and supports tighter TCXO-class frequency stability.

Architecture-specific extensions: FCom SAW Filters can be considered where a Sub-GHz or GNSS front end requires discrete RF selectivity. VCXO, OCXO, Crystal Filter and SAW Resonator solutions are available for architectures with corresponding pullability, oven-controlled stability, narrowband IF filtering or resonator requirements.

ENGINEERING SELECTION SUPPORT

Request an FCom Sensing & Remote-Monitoring Timing Recommendation

Send the target MCU / ADC / metrology IC / radio / PHY together with the exact clock pin, frequency, CL / ESR or supply / output, temperature, current budget and RF requirements.

[Start Engineering Review →](#)

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Engineering Validation & Selection Checklist

Confirm low-power behavior, oscillator compatibility, measurement-clock requirements and RF architecture before final component selection.

Low-Power Timekeeping

- 32.768 kHz crystal or driven XO?
- CL / ESR and oscillator margin
- Backup / standby supply voltage
- Active current and sleep duty cycle
- Wake interval / timestamp accuracy
- Local temperature range

Sensor / DAQ / Metering

- Exact ADC / AFE / metrology P/N
- CLKIN / MCLK frequency and mode
- Crystal drive level or CMOS input limits
- MCLK divider / digital-filter architecture
- Accuracy / jitter requirement
- Sample rate evaluated as derived timing

Wireless / RF

- BLE / Sub-GHz / LoRa / cellular / GNSS
- Exact radio / modem P/N
- Crystal vs TCXO support
- Reference ppm over temperature
- Startup / wake behavior
- SAW passband / insertion / attenuation where used

Remote Gateway

- MCU / PHY / network processor P/N
- 25 MHz crystal vs 50 MHz RMII REF_CLK
- Supply / logic level and duty cycle
- Outdoor / industrial temperature
- Ethernet / RS-485 / CAN architecture
- Clock routing / EMI environment

Minimum RFQ Information

Information Category	What to Provide
Application	Sensor / logger / energy meter / condition monitor / wireless endpoint / remote gateway and deployment environment.
Target IC / Clock Node	Exact MCU / ADC / metrology IC / radio / PHY and XTAL / CLKIN / MCLK / REFCLK / RTC pin or schematic section.
Crystal Requirement	Frequency, package, CL, ESR, tolerance, stability, operating temperature and drive-level / startup constraints.
XO / TCXO Requirement	Frequency, VDD, output type, total stability, current limit, startup, temperature and RF accuracy requirement.
RF Filter Requirement	Center frequency, passband / bandwidth, insertion loss, stopband attenuation, impedance and package.
Power Profile	Battery / mains power, target battery life, sleep current, measurement interval, wake duration and transmit interval.
Program	Prototype quantity, sample date, EAU, production location, qualification and lifecycle expectations.

Ordering-code note: the FCom product matrix provides series-level parameter ranges for crystals, XOs and TCXOs, while SAW Filter configurations are frequency-specific. Final ordering codes should be confirmed after the electrical and application requirements are defined.

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Engineering FAQ & Application Review

Common interpretation questions, platform references and the information required for a focused FCom selection review.

Does ADC sample rate determine the crystal frequency?

No. ADC output data rate and bandwidth are commonly derived from MCLK, dividers and digital-filter settings. The external timing device should be selected from the documented MCLK / CLKIN requirement.

Does every sensor require its own crystal?

No. Many sensors use clocks generated by the host MCU or an integrated oscillator. An external crystal is required only when the target device provides and specifies an external timing node.

When should a 32.768 kHz XO be considered instead of a crystal?

Where the receiving device expects a driven clock or the system benefits from a defined active source. Current, supply voltage and accuracy should be reviewed against the battery budget.

When is a TCXO appropriate?

When the radio / GNSS / cellular architecture has a documented frequency-accuracy requirement over temperature beyond the standard crystal / XO path and supports the selected TCXO output.

Is 50 MHz a universal Ethernet crystal frequency?

No. 50 MHz is commonly associated with selected RMI driven-clock modes. The PHY should be checked for 25 MHz crystal / clock versus 50 MHz REF_CLK requirements.

When is a SAW filter useful?

Where the RF front end requires discrete band selectivity or interference rejection. Center frequency, bandwidth, insertion loss and stopband attenuation must be chosen from the complete RF design.

Representative Public Technical References

1. **Nordic Semiconductor:** nRF52840 reference circuitry — 32 MHz and 32.768 kHz external crystal domains.
2. **Analog Devices:** CN0540 precision condition-monitoring reference design — 16.384 MHz MCLK example and derived ODR / bandwidth.
3. **Analog Devices:** ADE9153A energy metering IC.
4. **Analog Devices:** ADE9153A data sheet — 12.288 MHz CLKIN crystal / external-clock specification.
5. **Semtech:** SX1262DVK1CAS — 32 MHz XTAL reference platform.
6. **Semtech:** SX1262DVK1PAS — 32 MHz TCXO reference platform.

FCom specification basis: the current FCom product matrix was reviewed across Quartz Crystal Resonators, Tuning Fork Crystals, Crystal Oscillators, VCXO, TCXO, OCXO, Crystal Filters, SAW Resonators and SAW Filters. The guide highlights only the product families relevant to the timing and RF-selection decisions described in this application.

ENGINEERING REVIEW

Sensors, Energy & Remote-Monitoring Timing Review

Share the target clock node, frequency, CL / ESR or VDD / output, temperature, current budget, measurement architecture and RF requirements. FCom can review the system timing domains and recommend an appropriate series and configuration.

[Request Engineering Review →](#)
[FCom Solutions](#)

Public third-party platforms are shown for architecture reference only. FCom component selection should be verified against the latest target-device documentation, the applicable FCom datasheet and complete system-level validation.