

SMART WEARABLES & HEALTH DEVICES

Smart Wearables & Health Devices

This guide supports selection of external timing and RF components for always-on timekeeping, low-power processing, wireless connectivity, health sensing and GNSS functions in compact battery-powered platforms.

Ultra-Low-Power RTC + MCU Main Clock + BLE / Wireless Reference + GNSS Reference + Compact Timing

Smartwatch & Fitness Band

Smart Ring

Health Patch

PPG / ECG Monitor

Sports & Safety Tracker

Connected Medical Accessory

Application Scope

Body-worn consumer devices, fitness and wellness monitors, compact health-sensing platforms, remote-care accessories and wearable positioning products combining RTC, sensing, processing, wireless and GNSS functions.

Selection Philosophy

Selection begins with the physical timing interface. RTC, MCU, radio and GNSS references remain separate domains even when they coexist within one wearable or are integrated inside a wireless module.

RTC & Standby

Always-on timebase, wake scheduling and retained time.

MCU & Wireless

Main clock, BLE radio and Wi-Fi + BLE reference.

Health Sensing

Sensor hub, PPG / ECG AFE and synchronized acquisition.

GNSS & RF

Positioning reference and conditional external RF filtering.

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Application Scope & Engineering Domains

Wearable platforms combine always-on timekeeping, sensing, processing and radio functions under tight power, area and startup constraints.

One wearable, multiple timing domains. A low-frequency RTC source may remain active during standby while the MCU, BLE / Wi-Fi radio, health sensor hub and GNSS receiver use separate high-frequency references only when required.

Typical Equipment

Body-Worn Consumer

Smartwatch
Fitness Band
Smart Ring
Hearable / Earbud
AR / VR Accessory

Health Monitoring

PPG / ECG Monitor
Pulse Oximeter
Skin-Temperature Monitor
Health Patch
Remote-Care Accessory

Positioning & Safety

Sports Watch
Elder-Care Device
Worker-Safety Wearable
Personal Tracker
Outdoor Navigation Device

Six Engineering Domains

RTC & Always-On

32.768 kHz sleep, wake and retained-time reference.

MCU & Sensor Hub

Application processor, algorithm hub and peripheral reference.

BLE / Wi-Fi

Radio reference for low-power connectivity and data transfer.

Biosensing AFE

PPG, ECG, temperature and motion-acquisition timing.

GNSS Positioning

High-stability receiver reference and backup timebase.

RF Front End

Conditional BLE-band or GNSS-band filtering outside integrated modules.

Physical Interface

XTAL pins · CMOS CLKIN · clipped-sine input · module-internal clock.

Power & Startup

Standby current · wake latency · oscillator startup · duty cycle.

Accuracy & Stability

Radio ppm budget · RTC drift · GNSS reference stability · temperature.

Size & Placement

1210 / 1612 / 2016 timing packages and compact CSP RF filters.

Clock-definition note: CPU operating frequency, PPG / ECG sample rate, Bluetooth 2.4 GHz carrier and GNSS L1 carrier are not external crystal frequencies. The timing component is selected from the receiving IC clock specification.

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Select by System Node First

Begin with the receiving clock pins and module boundary, then determine frequency, device class, power and package.

System Node	Clock Role	Representative External Reference	Typical Device	Selection Focus
RTC / Wake Timer	Always-on timebase	32.768 kHz	Tuning-fork crystal / low-current XO	XTAL vs CLKIN · CL · ESR · current · drift
Application MCU / Sensor Hub	Main processor / PLL reference	24-48 MHz class device-specific	Crystal / CMOS XO	frequency · CL / ESR or VDD / logic · startup
BLE / Low-Power Wireless SoC	Radio and system reference	32 / 38.4 / 48 MHz	MHz crystal / driven clock	radio ppm · startup · negative resistance · package
Wi-Fi + BLE SoC	Main crystal / RF reference	40 MHz common	MHz crystal	device-documented topology · accuracy · drive level
Health AFE / Algorithm Hub	RTC, hub or synchronized acquisition	32.768 kHz / 32 MHz only when documented	Crystal / external clock	do not infer from sample rate · noise coupling · sharing
Bare GNSS Receiver	Synthesizer / navigation reference	26 MHz class	TCXO / specified reference	active-input waveform · stability · startup · power
Wireless / GNSS Module	Module-internal reference	Usually integrated	Internal crystal / TCXO	confirm whether a host REFCLK is documented
External RF Filter Node	BLE-band / GNSS-band selectivity	2.4 GHz / 1575.42 MHz	SAW filter	RF insertion point · impedance · loss · attenuation mask

1 · Identify the Receiver

Record the MCU, radio, sensor hub, AFE, GNSS receiver or module and the exact clock / RF pins used by the design.

2 · Establish the Boundary

Determine whether the timing component is customer-selectable on the PCB, already populated on a development board or integrated inside a module.

3 · Apply Electrical Constraints

Define CL / ESR for crystals, VDD / waveform for driven clocks, or bandwidth / loss / attenuation for RF filters.

Recommended sequence: System node → physical interface → frequency → device class → accuracy / stability → power / startup → temperature → package → FCom application review.

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Frequency & Component Placement Matrix

The same wearable can contain low-frequency timing, RF / MCU references and RF-filter center frequencies; these are different component functions.

Frequency	Representative System Position	Applicability	Selection Interpretation
32.768 kHz	RTC, sleep timer, wake scheduler, retained time	Core Always-On Reference	Passive tuning-fork crystal for XTAL pins or low-current CMOS oscillator for a documented external CLKIN.
26 MHz	Bare GNSS receiver / selected wireless architecture	Receiver-Dependent	Often a high-stability active reference in GNSS; integrated GNSS modules may contain the TCXO internally.
32 MHz	BLE SoC, wearable MCU, health algorithm hub	Common Wireless Reference	External crystal at the documented HFXO pins; higher processor clocks are synthesized internally.
38.4 MHz	BLE / connected-health wireless SoC	Wireless Platform Reference	Selectable on a bare-SoC PCB but integrated inside selected wireless modules.
40 MHz	Wi-Fi + Bluetooth LE SoC	Wi-Fi / BLE Reference	External crystal requirement on selected SoCs; module variants normally integrate the crystal.
48 MHz	Selected low-power wireless MCU / radio	Platform-Dependent	External radio crystal on selected wireless MCUs; the 32.768 kHz low-frequency source is a separate domain.
1575.42 MHz	External GPS / Galileo L1 RF filtering	RF Filter — Not a Clock	Applicable only when the receiver architecture exposes an external RF filter position and its impedance / mask are defined.
2442 MHz class	External 2.4 GHz BLE / Wi-Fi band filtering	RF Filter — Not a Clock	Bandpass center and bandwidth are RF parameters; filter use is conditional on the radio front end and matching network.

32.768 kHz
RTC, wake scheduling and long-standby timebase.

26 MHz
Conditional bare-GNSS active reference.

32-48 MHz
MCU, BLE and Wi-Fi reference family.

1.575 / 2.4 GHz
Conditional RF filter positions, not oscillator frequencies.

Reference-clock interpretation: 64 / 76.8 / 96 / 192 MHz processor clocks, biosensor sampling rates, 2.4 GHz radio carriers and GNSS L1 are not automatically external timing-device frequencies. Confirm the receiving clock or RF interface before selecting a component.

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Representative Platform & Architecture Matrix

Four public platforms illustrate customer-selectable SoC clocks, populated reference boards and module-internal timing boundaries.

NORDIC SEMICONDUCTOR

Thingy:53 / nRF5340 · Multi-Sensor BLE Edge Node 1

Architecture: environmental, color / light, motion and audio sensors feed a dual-core nRF5340 for local processing and Bluetooth LE communication.

Timing evidence: an nRF53 custom PCB requires a 32 MHz external crystal; 32.768 kHz is optional for the low-frequency domain.

Sensors → nRF5340 → BLE / Mobile

Engineering interpretation: the assembled Thingy:53 already implements its clocking. Crystal selection becomes relevant when the architecture is transferred to a custom nRF5340 PCB.

ANALOG DEVICES

MAXREFDES104# · Multi-Parameter Health Sensor Platform 2

Architecture: PPG + ECG AFE, temperature and motion sensing connect through the MAX32674 algorithm hub and MAX32666 Bluetooth host MCU.

Timing evidence: MAX32666 documents a 32 MHz crystal for Bluetooth and a 32.768 kHz crystal / clock for the RTC domain.

PPG / ECG / Temp. → Hub + MCU → Bluetooth GUI

Engineering interpretation: radio, RTC and low-noise biosignal acquisition coexist, but sensor sample rates do not define the external crystal.

SILICON LABS

xG27-DK2602A / EFR32BG27 · Coin-Cell Connected Health 3

Architecture: environmental, motion, light, Hall and audio sensors connect to an EFR32BG27 MCU / 2.4 GHz radio with CR2032 support.

Timing evidence: the BRD2602A schematic identifies X1 = 38.4 MHz at HFXTAL_I / HFXTAL_O; BGM270S integrates this crystal inside the module.

Sensor Domains → EFR32BG27 → 2.4 GHz Radio

Engineering interpretation: 38.4 MHz is a PCB selection point for the bare SoC, but not for the module; 76.8 MHz is internally derived.

QUECTEL

LG77L(C) + EVB · Low-Power Wearable GNSS 4

Architecture: GNSS antenna and SAW / LNA front end feed the synthesizer, navigation engine, processor and RTC, with UART / I²C / 1PPS to the host.

Timing evidence: the public block diagram shows an internal 26 MHz TCXO and internal 32.768 kHz crystal.

GNSS Antenna → LG77L Module → Wearable Host

Engineering interpretation: both references are module-internal. 1PPS and GNSS carrier frequencies are not substitutes for the internal 26 MHz reference.

Platform-use boundary: references to third-party platforms are provided solely to illustrate clock and RF insertion points. They do not imply that FCom products are used, approved, qualified, endorsed or pin-compatible with the cited platforms.

05 Always-On Sensing + BLE Timing Architecture

Representative external timing from the standby domain into health sensing, local processing and wireless communication.



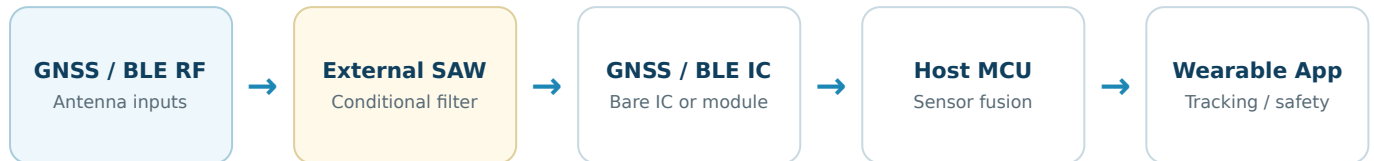
NODE 1 Passive RTC Crystal	32.768 kHz XTAL pins Used where the MCU / RTC contains the oscillator loop and requires an external tuning-fork resonator.	Selection checks CL · ESR · tolerance · drive level · startup · backup-power behavior.	Representative FCom option FCT-1S — 1210 2-SMD; 32.768 kHz; initial-frequency-tolerance options down to ±5 ppm; -40 to +125°C; CL 6-12.5 pF; ESR 70-90 kΩ.
NODE 2 MCU / BLE Crystal	32 / 38.4 / 40 / 48 MHz External resonator path for selected BLE, Wi-Fi + BLE and wearable MCU oscillator loops.	Selection checks Exact frequency · CL · ESR · negative resistance · drive · startup · ppm.	Representative FCom option FCX-1M — 1612 4-SMD; 24-60 MHz; initial-frequency-tolerance options down to ±5 ppm; frequency-stability options down to ±10 ppm; -40 to +125°C; CL 18 pF or project-specified; ESR 30-60 Ω. FCX-1S may be evaluated when a 1210 footprint is essential, subject to startup and ESR validation.
NODE 3 Driven RTC CLKIN	Low-current clock input Applicable only when the receiver accepts a driven CMOS 32.768 kHz source rather than a passive crystal.	Selection checks 1.5 / 1.8 V input compatibility · current budget · output load · enable behavior.	Representative FCom option FCO-6K-UC — 2016 4-SMD; 32.768 kHz CMOS; 1.5 / 1.8 V; frequency-stability option of ±20 ppm; -40 to +105°C; 1.4-1.8 μA.

Architecture note: a passive crystal and a CMOS oscillator are different electrical sources. They are not interchangeable without a documented XTAL-bypass or external-clock mode at the receiving device.

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Wearable GNSS + Wireless RF Architecture

Representative timing and conditional RF-filter positions for a wearable that combines positioning and 2.4 GHz connectivity.



26 MHz GNSS Reference

A high-stability active reference is relevant only when a bare GNSS receiver exposes a compatible reference input. A complete module may already integrate its TCXO.

Selection focus: waveform, amplitude, VDD, ppm, startup and power.

1575.42 MHz GNSS Filter

An external L1 SAW filter may be evaluated to add selectivity where the antenna / LNA / receiver design provides a documented filter insertion point.

Selection focus: bandwidth, insertion loss, impedance and attenuation mask.

2.4 GHz Wireless Filter

A compact bandpass SAW can be considered ahead of a BLE / Wi-Fi receiver when coexistence or out-of-band blocking requires external selectivity.

Selection focus: full passband, loss, matching and radio power.

GNSS REF External Active Reference

Target condition

Bare GNSS IC with a documented clipped-sine reference input in the 26 MHz class.

Published product capability

2016 package · 10–52 MHz · 1.8–3.3 V · high-stability TCXO.

Representative FCom option FVT-6S

— frequency-stability options down to ± 0.5 ppm; -40 to $+85^{\circ}\text{C}$; clipped sine; published phase-noise reference of -115 / -135 / -148 dBc/Hz at 100 Hz / 1 kHz / 10 kHz.

RF PATH Conditional SAW Filtering

Conditional GNSS L1 filter FSF1411-1575M42-2M4-1.1-40

1575.42 MHz; CSP1411; 2.4 MHz bandwidth; 1.1 dB insertion loss; 40 dB stopband attenuation.

Conditional 2.4 GHz filter FSF1109-2442M-79M-1.2-40

2442 MHz; CSP1109; 79 MHz bandwidth; 1.2 dB insertion loss; 40 dB stopband attenuation.

Application boundary

Both filters require RF-mask, impedance, power, matching and complete-system validation. They are not inferred from the carrier frequency alone.

Module boundary: Quectel LG77L and Silicon Labs BGM270S illustrate integrated timing. Their internal TCXO / crystal is not a host-PCB replacement point; any external filter must also be supported by the module reference design.

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FCom Selection Guidance by Design Condition

The options below illustrate FCom series or complete SAW part numbers with potential selection value at defined timing or RF nodes. Final suitability and exact ordering codes are confirmed after the receiving interface is reviewed.

Always-On RTC

Passive 32.768 kHz XTAL or low-current driven CLKIN.

MCU / BLE XTAL

Compact 24–60 MHz reference for documented oscillator loops.

GNSS Reference

Conditional high-stability active reference for a bare receiver.

External RF Filter

Only where antenna and receiver architecture expose the node.

Design Condition	Representative FCom Option	Published Capability / Application Rationale	Key Check Before RFQ
32.768 kHz XTAL pins + minimum area	FCT-1S	1210 2-SMD; initial-frequency-tolerance options down to ± 5 ppm; -40 to $+125^{\circ}\text{C}$; CL 6–12.5 pF; ESR 70–90 k Ω .	RTC CL · ESR limit · drive · startup
RTC oscillator loop explicitly requires 3 pF CL	FCT-2M-LC	2012 2-SMD; 32.768 kHz; ± 20 ppm; -40 to $+125^{\circ}\text{C}$; CL 3 pF; ESR 80 k Ω .	3 pF topology · stray capacitance · ESR
Receiver accepts driven 1.5 / 1.8 V RTC CLKIN	FCO-6K-UC	2016 4-SMD; CMOS; frequency-stability option of ± 20 ppm; -40 to $+105^{\circ}\text{C}$; 1.4–1.8 μA .	CLKIN mode · VIH/VIL · load · enable
24–60 MHz MCU / BLE XTAL pins	FCX-1M	1612 4-SMD; initial-frequency-tolerance options down to ± 5 ppm; frequency-stability options down to ± 10 ppm; -40 to $+125^{\circ}\text{C}$; CL 18 pF or project-specified; ESR 30–60 Ω . FCX-1S is a conditional 1210 alternative.	Frequency · CL · ESR · negative resistance
Receiver requires local driven 3–60 MHz CMOS CLKIN	FCO-1C	1612 4-SMD; 1.8 / 2.5 / 3.3 V; frequency-stability option of ± 20 ppm; -40 to $+125^{\circ}\text{C}$; CMOS; published current value of 15 mA.	Power budget · VDD · load · OE / startup
Bare GNSS IC accepts a clipped-sine active reference	FVT-6S	2016 6-SMD; 10–52 MHz; 1.8–3.3 V; frequency-stability options down to ± 0.5 ppm; -40 to $+85^{\circ}\text{C}$; clipped sine.	26 MHz availability · amplitude · input mode · current
External GNSS L1 / 2.4 GHz RF filter position is documented	FSF1411-1575M42-2M4-1.1-40 FSF1109-2442M-79M-1.2-40	Complete FCom part numbers for compact CSP1411 GNSS L1 and CSP1109 2.4 GHz filter options. Suitability depends on the required RF mask and circuit topology.	Impedance · passband · loss · attenuation · power

Ordering information: FCT, FCX, FCO and FVT are shown at series level. FCom confirms the complete ordering code—including frequency, CL, tolerance / stability, voltage, output and option suffixes—against the applicable specification during application review and quotation. The two SAW entries are complete FCom part numbers and remain subject to RF validation.

ENGINEERING SELECTION SUPPORT

Request an FCom Wearable Timing Review

Provide the target MCU / radio / RTC / AFE / GNSS part number, clock or RF pins, frequency, CL / ESR or supply / waveform, current budget, temperature, package and project stage. FCom application engineering will use these details to evaluate suitable options.

[Start Engineering Review →](#)

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Engineering Validation & Minimum RFQ

Wearable timing is defined by the receiver interface, power states, startup behavior and module boundary in addition to frequency.

RTC / Long Standby

- Exact MCU / RTC part number
- XTAL pins or driven CLKIN
- 32.768 kHz CL / ESR or VDD / current
- Backup / sleep power state
- Required timekeeping drift

MCU / BLE / Wi-Fi

- Exact SoC part number
- 32 / 38.4 / 40 / 48 MHz clock pins
- Crystal loop or external-clock mode
- CL / ESR / negative resistance
- Radio ppm and startup limit

GNSS Reference

- Bare IC or complete module
- Reference-input frequency and waveform
- Required stability / phase noise
- Startup and operating current
- Antenna / interference environment

External RF Filtering

- Antenna / LNA / receiver topology
- Center frequency and full mask
- Bandwidth / insertion loss / attenuation
- Port impedance and matching
- Maximum RF power and temperature

Minimum RFQ Information

Information Category	What to Provide
Application / System Node	RTC, application MCU, BLE / Wi-Fi SoC, sensor hub, health AFE, GNSS receiver or external RF filter.
Target Device	Exact receiving IC or module part number and clock / RF schematic location.
Clock / RF Topology	Passive crystal loop, CMOS CLKIN, clipped-sine reference, integrated module clock or external RF-filter path.
Crystal Requirements	Frequency, package, CL, ESR, tolerance / stability, drive level, startup and operating temperature.
Oscillator / TCXO Requirements	Frequency, VDD, waveform, amplitude, stability, current, phase noise if specified, load, OE and startup.
Program Requirements	Prototype quantity, sample date, annual volume, validation plan, production location, lifecycle and compliance documentation.

Bare SoC vs Module

A bare SoC may expose crystal pins while its module version integrates the same reference internally.

Passive vs Driven Clock

XTAL pins and CLKIN pins require different source types, voltage assumptions and startup validation.

Reference vs RF Filter

26 MHz may be a GNSS reference; 1575.42 MHz is an RF carrier / filter frequency. They are not interchangeable roles.

Frequency alone does not define the final part: the receiving device, interface mode, power architecture, module boundary and RF topology determine which FCom series and configuration should be evaluated.

09

Engineering FAQ & Application Review

Common wearable timing questions, representative public references and the information required for FCom engineering review.

Is the MCU operating frequency the external crystal frequency?

No. A 32 / 38.4 / 40 / 48 MHz crystal can feed an oscillator / PLL domain while higher processor clocks are generated internally.

Does Bluetooth at 2.4 GHz require a 2.4 GHz oscillator?

No. The 2.4 GHz carrier is synthesized from a lower-frequency reference. A 2.4 GHz SAW, when present, is an RF filter.

Is GNSS L1 at 1575.42 MHz the GNSS reference clock?

No. 1575.42 MHz is an RF carrier / filter frequency. A receiver can use a separate reference such as 26 MHz.

Can a module-internal crystal be replaced on the host PCB?

Normally no. An external timing opportunity exists only if the module exposes a documented reference input.

Can one 32.768 kHz crystal serve every RTC domain?

Only when the device documentation defines a valid clock-output and sharing scheme. Separate MCU, hub and GNSS RTC domains must not be assumed to share.

Can a CMOS oscillator replace a passive crystal?

Only when the receiving device provides a supported bypass / external-clock mode with compatible voltage and waveform limits.

When is a TCXO appropriate?

When a bare GNSS or precision wireless receiver specifies an active high-stability reference. A complete module may already contain the TCXO.

When should an external SAW filter be considered?

Only when the RF chain exposes a filter location and the required passband, impedance, loss, attenuation and power are defined.

Representative Public Technical References

1. **Nordic Semiconductor:** Thingy:53 — nRF5340 multi-sensor Bluetooth LE prototyping platform.
2. **Nordic Semiconductor:** nRF53 PCB guidelines — mandatory 32 MHz and optional 32.768 kHz crystal guidance.
3. **Analog Devices:** MAXREFDES104# Health Sensor Platform 3.0 — PPG, ECG, temperature, motion and Bluetooth architecture.
4. **Analog Devices:** MAX32665 / MAX32666 — 32 MHz Bluetooth and 32.768 kHz RTC clock interfaces.
5. **Silicon Labs:** xG27-DK2602A — compact EFR32BG27 sensor and coin-cell development platform.
6. **Silicon Labs:** BRD2602A user guide — X1 38.4 MHz HFXTAL implementation.
7. **Quectel:** LG77L series — low-power wearable GNSS module and EVB resources.
8. **Quectel:** LG77L(C) hardware design — internal 26 MHz TCXO, 32.768 kHz XTAL and RF architecture.
9. **Texas Instruments:** CC2642R-Q1 — external 48 MHz crystal and selectable 32.768 kHz low-frequency source.
10. **Espressif Systems:** ESP32-S3 hardware guidelines — compulsory 40 MHz external crystal on bare-SoC designs.

FCom product specification note: product information in this guide is presented at series or representative-configuration level unless a complete SAW part number is shown. Exact ordering codes, guaranteed limits and availability are confirmed against the applicable FCom specification and quotation.

ENGINEERING REVIEW

Smart Wearables & Health Devices Review

Provide the target MCU / radio / RTC / AFE / GNSS part number, timing or RF interface, frequency, CL / ESR or supply / waveform, current budget, temperature, package and project stage. FCom application engineering can evaluate suitable series and configuration options for board-level validation.

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

This guide provides representative application and product-selection guidance. Final component selection is confirmed against the latest target-device documentation and the applicable FCom product specification, followed by validation on the complete board and system. For regulated healthcare or medical equipment, timing-component selection does not replace the equipment manufacturer's system safety, performance, EMC or regulatory validation.