

# nRF93M1

## Preliminary Datasheet

v0.5

# nRF93M1 Feature overview

## Features

### Cellular

- Transceiver and baseband
- 3GPP LTE Release 14 Cat 1 bis compliant
  - Up to 5 Mbit/s uplink and 10 Mbit/s downlink
- RF transceiver for regional and global coverage
  - Power class 3, up to 23 dBm output power
  - Single 50 Ω antenna interface
- LTE band support in hardware
  - FDD: B1, B2, B3, B4, B5, B7, B8, B12, B13, B18, B19, B20, B25, B26, B28, B66, B71
  - TDD: B38, B40, B41
- Power saving features – DRX, eDRX, PSM
- IP v4/v6 stack
- Secure socket (TLS/DTLS) API
- SMS
- SIM, eSIM and softSIM support
  - 2x ETSI TS 102 221 compatible UICC interfaces
  - SGP.02 M2M, SGP.22 Consumer and SGP.32 IoT

### Wi-Fi beacon receiver for positioning

- IEEE 802.11b supported at 2.4 GHz band

### Cellular location

- Cell-ID based location reporting

### nRF Cloud Services

- Pre-provisioned for nRF Cloud services
  - Location observability and modem firmware update
- Seamless opt-in option for full range of host MCU services
  - Device management, firmware update, observability, and more

### Peripherals

- Three UARTs
  - UART2 reserved as auxiliary channel
  - UART1, primary AT port
  - UART0, dedicated to modem trace
  - Autobauding and CTS/RTS hardware flow control
- USB 2.0 device interface
  - CDC-ACM, RNDIS, and CDC-ECM functions
  - Used for AT control, network data, and diagnostic trace
- Four GPIO pins (P0.0\_AO–P0.3\_AO)
- One always on pin used as a wake-up source from System OFF
- Three pins for RF tuner control
- Two pins for coexistence interface (COEX0-1)
- Module status (STATUS) and network status (NETWORK) indicators

### Integrated power management unit

- DC/DC regulators and low drop-out regulator (LDO) for internal power rails
- Power supply output for external components
- Voltage detectors for start-up, brown-out, and battery monitoring

### Operating values

- –40 °C to +85 °C extended operating temperature
- –35 °C to +75 °C 3GPP-compliant operating temperature
- 3.3 V to 4.5 V supply voltage range, 3.8 V typical

### Package

- 17.7×15.8 mm LGA (variable ball pitch), height 2.4 mm
- 109 pads, MSL 3

## Applications

- Asset Tracking
- Fleet Management
- Security and Surveillance
- E-bikes and shared transport
- Gateway and Data Concentrators
- Telematics
- Point of Sales terminals
- Healthcare and remote patient monitoring

# 1 Revision history

Date	Version	Description
June 2026	0.5	Preliminary release

# 2 About this document

This document describes the nRF93M1 LTE Cat 1 bis cellular module: its features, electrical and mechanical characteristics, host integration interfaces, and operating conditions.

nRF93M1 ships pre-programmed with signed Nordic firmware that implements the LTE protocol stack, IP and upper-layer protocols, location features, and other functions. The host MCU controls the module through a documented AT command interface and standardized network interfaces; it does not execute customer code on the module itself. Firmware is updated in the field through Firmware Over-The-Air (FOTA) using HTTP/S, the nRF Cloud service, or Memfault.

The chapters in this document are organized by function, features and peripherals. Each chapter describes the feature, some relevant AT commands or signal interfaces, electrical characteristics where applicable, and any integration details or other relevant information.

## 2.1 Document status

The document status reflects the level of maturity of the document.

Document name	Description
Preliminary Datasheet	Applies to document versions up to 1.0. This document contains target specifications for product development.
Datasheet	Applies to document versions 1.0 and higher. This document contains final product specifications. Nordic Semiconductor ASA reserves the right to make changes at any time without notice in order to improve design and supply the best possible product.

*Table 1: Defined document names*

# 3 Product overview

nRF93M1 is an easy-to-use, compact, pre-certified LTE Cat1 bis module delivering global connectivity for more data-intensive cellular IoT. It supports up to 10 Mbps downlink/5 Mbps uplink at low power in an optimized single antenna design. nRF93M1 ships preprogrammed with signed Nordic firmware that implements the LTE protocol stack, IP and upper-layer protocols, and other functions.

The integrated 2.4GHz Wi-Fi beacon receiver and cellular location enable indoor and outdoor positioning that are fully integrated with nRF Cloud location services. This provides an easy and power-efficient way for any device to obtain location information, while allowing the flexibility to add external GNSS depending on use case and performance requirements.

The standard, flexible peripherals focus on interfaces for secure, robust and optimized designs. These include both a 2-pin LTE coexistence interface and a dedicated 3-pin RF control interface allowing band-specific match settings — recovering radiated efficiency across the full 700–2700 MHz band range for better link budget and lower power in compact, global, single-antenna designs.

Security is an integral part of nRF93M1 and nRF93M1 provides hardware-anchored device security, authenticated and encrypted firmware, and standards-based transport security (TLS 1.2, TLS 1.3, DTLS 1.2). nRF93M1 is designed to support regulatory security certification such as the CE RED radio equipment directive and the EU Cyber Resilience Act (CRA) cybersecurity regulation.

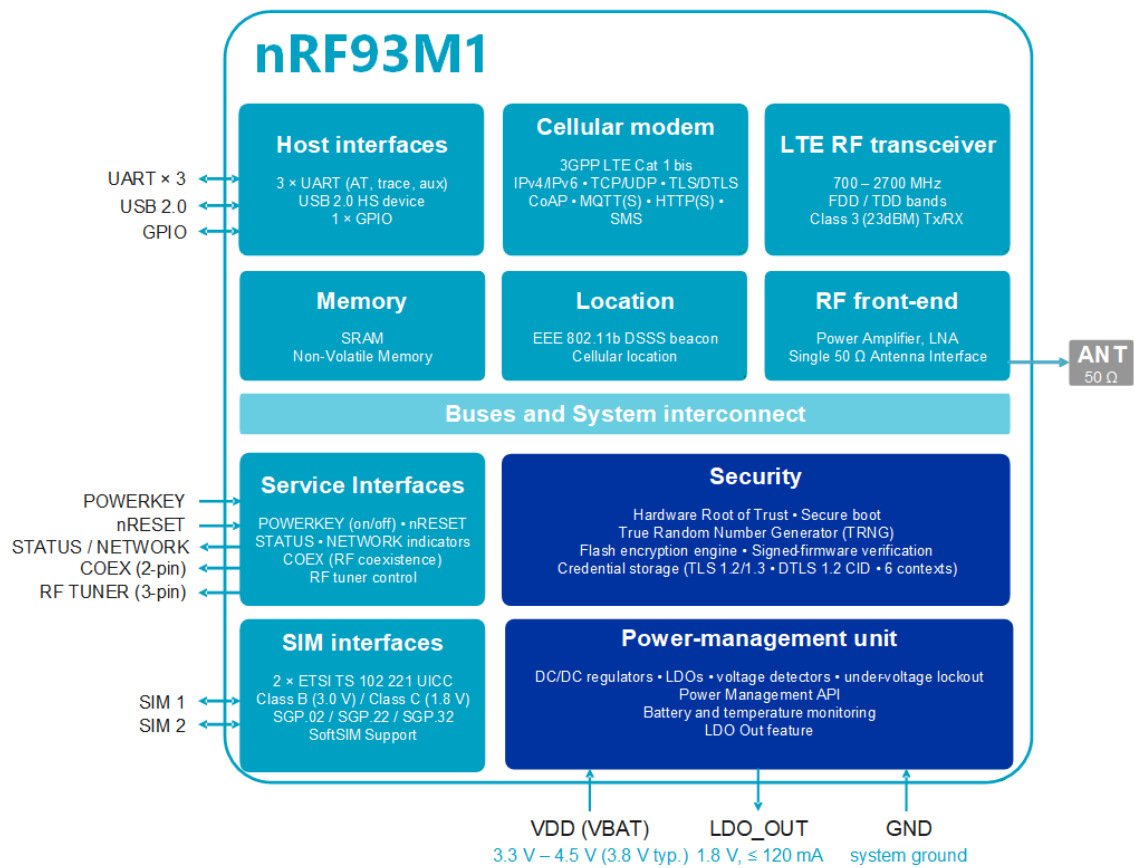
nRF93M1 comes with complete design and life cycle support also through Nordic's nRF54L host application support, which include complete application software and hardware reference designs. nRF93M1 also supports any other embedded or rich-OS host designs.

Nordic's AI-assisted development flow delivers concrete benefits when building wireless IoT solutions, including faster prototyping from idea to proof of concept on nRF93M1 Development Kit. Once your fleet of cellular IoT devices are deployed in the field, AI-assisted root-cause analysis and device debugging are enabled within the same development work flow.

nRF93M1 comes out of the box with nRF Cloud location, observability and modem-firmware-update services. It is further prepared to enable easy opt-in for a more complete set of life cycle services.

## 3.1 Block diagram

The following figure illustrates the overall system.



## 3.2 Feature matrix

Summary of the major features exposed on nRF93M1.

## Cellular

Feature	Description
3GPP release	Release 14
LTE category	Cat 1 bis (FDD + TDD)
Power class	LTE Power Class 3 (23 dBm)
Supported LTE bands LABA	FDD – B1, B3, B5, B7, B8, B20, B28 TDD – B38, B40, B41
Supported LTE bands LACA	FDD – B1, B2, B3, B4, B5, B7, B8, B12, B13, B18, B19, B20, B25, B26, B28, B66, B71 TDD – B38, B40, B41
Peak data rate (DL / UL)	10 / 5 Mbit/s
Channel bandwidths	1.4, 3, 5, 10, 15, 20 MHz
Power saving	PSM (+CPSMS), eDRX (+CEDRXS), %PTWEDRXS
NAS protocols	IPv4, IPv6, IPv4v6, Non-IP
Simultaneous PDP contexts	4 (out of CID range 1–15)
SMS	PDU mode, 3GPP TS 27.005

## Location

Feature	Description
Cellular-positioning data	Cell-info and neighbour-cell data via %NRF_CLOUD_LOCATION
Wi-Fi scan for location	2.4 GHz scan via %WIFI_SCAN; results consumed by nRF Cloud location service

## Host interfaces

Feature	Description
UART1 (primary AT port)	Up to 3 Mbps, autobaud, CTS/RTS
UART0 (trace)	UNILog binary trace, 921 600–6 000 000 bps
UART2 (auxiliary)	Up to 3 Mbps
USB device	CDC-ACM, RNDIS, CDC-ECM composite
GPIO	Always ON standard GPIO pins
SIM	Single and dual SIM slot options, hot-swap detection, SoftSIM
Powerkey	Pin for graceful powering nRF93M1 up and down into System Disabled sleep mode

Feature	Description
STATUS	Pin output for module status LED indicator
NETWORK	Pin output for network status LED indicator
Coexistence interface	Coexistence interface pins
Antenna tuner	RF control tuner

Table 2: Other interfaces and features

## nRF Cloud integration

Feature	Description
Transport	CoAP with DTLS 1.2 support
Device identity	%DEVICEUUID, %CLOUDACCESSKEY (P-256 ECC)
Authentication	JWT (%REGJWT, %JWT)
Services	Location, Messaging, Shadow, FOTA
Observability	Memfault coredump + metrics (%MEMFAULT)
FOTA transports	HTTP/S, nRF Cloud, Memfault CDN

## Security

Feature	Description
Secure boot	Signed firmware verified against hardware root of trust
Transport security	TLS 1.2, TLS 1.3, DTLS 1.2 (Connection-ID)
Concurrent security contexts	6
Credential storage	File system: %FOPEN, %FWRITE, %FDELETE; referenced via %SSLCFG

# 4 Power and Clock management

nRF93M1 integrates an optimized power management that handles the supply rails, system power-state, network-driven power-saving features, and reset behavior.

The chapter is organized as follows:

- Power supply system – VDD input, internal LDO outputs available to the host (LDO\_OUT, SIM\_VOUT), I/O power supply.
- Power supply monitoring – battery-voltage monitoring, configurable low-VBAT and high-temperature alarms, and under-voltage lockout (UVLO).
- Power management – the System ON / System OFF / System Disabled modes and the wake-up sources for each.
- Power saving features – 3GPP-defined Power Saving Mode (PSM) and extended DRX (eDRX), connected-DRX behaviour, and the AT-level CFUN functionality levels.
- Reset – the POWERKEY and nRESET pins, plus AT-level reset commands.
- Current consumption – typical current draw by operating mode (module-level characterization).

## 4.1 Power supply system

The nRF93M1 is powered from a single external VBAT supply. Internally, an integrated power-management unit (PMU) generates all the rails required by internal domains, SIM interface, and I/O.

The host PCB provides a single power rail to the two VDD (VBAT) pins and ties all GND pins to the system ground. Recommended decoupling and PCB layout are described in the Hardware design guidelines.

Pin	Direction	Purpose
VDD	Input	Module supply (VBAT). 3.3 V to 4.5 V, 3.8 V typical. See Recommended Operating Conditions for more information.
LDO_OUT	Output	Internal LDO output available to the host, nominal 1.8 V, up to 120 mA. Also supplies the module's digital I/O pins internally.
SIM1_VOUT, SIM2_VOUT	Output	SIM-card supply, switched 1.8 V or 3.0 V depending on the inserted UICC class.

Table 3: Module-level supply pins

After VDD is applied, the module remains in System Disabled mode until the POWERKEY pin is asserted. The POWERKEY pin is used to turn the modem on into the System ON state, and back into the System Disabled state.

### 4.1.1 Power On and Off

The nRF93M1 must be powered on and off through the POWERKEY pin or through AT commands.

#### POWERKEY pin

The POWERKEY pin has an always-on internal pull-up resistor that keeps it high by default.

- In System Disabled mode, pull POWERKEY low for at least 750 ms to enter System ON.
- In System ON or System OFF mode, pull POWERKEY low for at least 2 000 ms to enter System Disabled.

## AT-command level power and reset control

The host can also control the module power state through the AT command interface:

Command	Effect
AT%POWD	Power down the module to System Disabled. After this, the POWERKEY pin must be used to wake the module again.
AT%RST	Software reset; the module restarts and re-enters System ON automatically.
AT%FACTORYRESET	Reset all user-configurable settings to defaults, then restart.
AT+CFUN=1, 1	Standard 3GPP TS 27.007 reset; restarts the modem and module.

### 4.1.2 I/O Power Supply

The digital I/O pins of the nRF93M1 are driven from the module's internal LDO, fixed at 1.8 V. No external I/O supply is required from the host.

All standard digital pins (UART, USB control signals, GPIO, status indicators, coexistence interface) are referenced to the module's internal 1.8 V LDO output. The host PCB must use 1.8 V logic levels on these pins. The I/O voltage tolerance is given in the Recommended Operating Conditions chapter.

The SIM-interface pins (SIM\_CLK, SIM\_RST, SIM\_IO) follow the SIM\_VOUT rail rather than the internal 1.8 V LDO, so that the device supports both 1.8 V (Class C) and 3.0 V (Class B) UICC cards transparently. SIM\_VOUT is auto-selected by the modem firmware based on the inserted UICC class.

### 4.1.3 LDO output

nRF93M1 generates regulated rails for external use as shown in the following table.

#### Output rails

Rail	Voltage	Drives
SIM card supply	1.8 V or 3.0 V (auto-selected per UICC class)	External SIM card on the SIM_VOUT pin
LDO_OUT	1.8 V (nominal)	Low-current rail available on the LDO_OUT pin (max 120 mA)

**Note:** Internal rails inside the module package are not user-accessible and are not listed here.

## 4.2 Power supply monitoring

The nRF93M1 continuously monitors battery voltage and internal temperature, and reports threshold events to the host over the AT command interface.

### Battery voltage monitor

Battery voltage (VBAT) and temperature are exposed to the host through the %ADC AT command:

- AT%ADC="vbat" returns the current battery voltage in mV.
- AT%ADC="temp" returns the current internal temperature in °C.
- AT%ADC="all" returns both values.

## Power alarms

Power and temperature alarms can be subscribed to for the following:

- Low battery voltage, configurable thresholds (mV): 3031, 3112, 3193, 3274, 3355, 3436.
- High internal temperature, configurable thresholds: 70 °C, 80 °C, 90 °C.
- Temperature hysteresis, configurable: 10, 20, 30, 40 °C.

Each configured alarm is reported as an unsolicited result code to the host.

## Under-voltage lockout

If VBAT falls below the minimum operating voltage, the module transitions to a safe state and restarts when VBAT is restored. See the Recommended Operating Conditions chapter for supply voltage limits.

## 4.3 Power management

The power management system ensures maximum power efficiency by automatically transitioning between defined operating modes based on configuration, host interaction, and the LTE modem state.

The nRF93M1 has three system-wide power modes:

- System ON — full operation. The LTE radio, functional blocks, and peripherals are enabled and run in either RUN state or sleep to save power in IDLE state under PMU control.
- System OFF — deep low-power state. Most blocks are powered down, ongoing tasks are terminated, and SRAM is not retained. The module wakes from a configured set of sources (see System OFF).
- System Disabled — lowest functional state. Only the always-on domain remains powered; the POWERKEY pin is the only wakeup source.

Connected-DRX behavior during an active LTE connection is controlled by the host through `%MODULECFG="pmuInCdrx"`. PSM and eDRX are negotiated with the network through standard 3GPP commands; see the Power saving features sub-chapter.

### 4.3.1 System disabled

After VDD power is applied the module enters System Disabled mode. This is the lowest functional power state, in which only the always-on domain is powered.

In System Disabled:

- The cellular modem and all peripherals are powered off.
- SRAM is not retained.
- The POWERKEY pin is the only wake source. Pull it low for at least 750 ms to enter System ON.

The host can place an active module into System Disabled from the AT command interface using `AT %POWD`; after that command, only POWERKEY can wake the module again.

### 4.3.2 System OFF

In System OFF, all core system functionality is powered down, ongoing tasks are terminated, and SRAM is not retained. The module wakes from a defined set of sources.

Wake-up sources from System OFF:

- Always-on GPIO pins (P0.0\_AO and P0.1\_AO) — host-driven wake on programmable edge.
- UART1 DTR pin — host-driven wake when the UART has been put into low-power mode.
- UART1 Incoming data—if configured to 9600 baud or lower prior to entering sleep.
- USB VBUS detect — wake when USB power is presented.
- POWERKEY — manual wake.

- Internal paging timer — modem-internal wake on the next configured PSM or eDRX paging occasion.
- SIM hot-swap detect — wake when SIM presence transitions on a slot configured for detection.

### 4.3.3 System ON

In System ON, the LTE radio and all functional blocks are operational and managed by the modem firmware.

Within System ON, the modem firmware automatically transitions between ACTIVE and IDLE sleep to minimize current consumption while meeting LTE service requirements. The host application can influence this behavior through:

- AT+CFUN — set radio activity (0 minimum functionality, 1 full functionality, 4 airplane mode).
- AT+CPSMS — request 3GPP Power Saving Mode (PSM) parameters (T3324, T3412-ext).
- AT+CEDRXS and AT%PTWEDRXS — request extended DRX cycle and Paging Time Window.
- AT%MODULECFG="pmuInCdrx" — allow or inhibit sleep during connected DRX.
- AT%PMUCFG — change the internal sleep-level configuration.

Modem-internal sleep transitions are reported to the host through the %SLEEPMODE URC.

**Note:** Module and sleep level API and configuration details is expected to change for the final, commercial release of the modem firmware due to upcoming power management optimizations and improvements. No functional change is expected.

## 4.4 Power-saving features

The nRF93M1 supports the 3GPP power-saving mechanisms Power Saving Mode (PSM), extended Discontinuous Reception (eDRX), and connected/idle DRX, complemented by host-controllable modem functionality levels and a multi-level sleep functionality levels.

Power saving is largely transparent to the host: once configured, the modem firmware manages state transitions automatically, and the module enters the deepest power state compatible with the current connection and the traffic pattern. Host-side AT commands provide the configuration hooks.

The sub-topics describe each mechanism in detail:

- Power Saving Mode (PSM) — long timers for deep sleep between activity bursts.
- Extended Discontinuous Reception (eDRX) — extended paging cycle for periodic wake-up.
- Discontinuous Reception (DRX and connected-DRX) — short paging cycles in idle and connected states.
- Modem functionality levels (+CFUN) — coarse-grained control of radio and LTE stack.

### 4.4.1 Power Saving Mode (PSM)

PSM is a 3GPP-defined low-power state in which the UE remains registered to the network but stops monitoring the paging channel, allowing long battery-saving sleep periods between user-initiated activity bursts.

PSM is requested through the AT+CPSMS AT command.

The <mode> parameter controls whether PSM is enabled (1), disabled (0), or disabled with a parameter reset (2).

### Network constraints

The network sets the granted timer values, other time value, and may reject PSM entirely. Operator-specific minimum may also apply, such as a minimum T3412 of 190 min.

## References

See 3GPP TS 23.682 for the PSM feature definition and 3GPP TS 24.008 for the timer encoding. The nRF93M1 AT Command Manual documents the full +CPSMS syntax.

### 4.4.2 Extended DRX (eDRX)

eDRX extends the paging cycle in the idle RRC state, trading response latency for lower average current on an otherwise idle cellular link.

## Configuration

eDRX is requested through AT+CEDRXS.

The currently negotiated eDRX parameters are read back with AT+CEDRXRDP.

## Paging Time Window

The proprietary %PTWEDRXS AT command configures the Paging Time Window (PTW) jointly with the requested eDRX parameters. PTW can be requested in the range 1.28 s to 20.48 s. The PTW determines how long the UE monitors for paging within each eDRX cycle.

## Relationship to PSM

eDRX and PSM are complementary and the two mechanisms can be enabled simultaneously; the network and the application together decide the balance.

### 4.4.3 DRX and connected DRX

Discontinuous Reception (DRX) reduces receiver activity in the RRC Idle state; connected DRX (cDRX) applies the same principle during an active RRC connection and is managed transparently by the modem.

## Idle-mode DRX

In RRC Idle, the modem wakes periodically at the shorter of the USIM-configured or the network-configured DRX cycle to monitor the paging channel. Idle-mode DRX parameters are set by the network; no host AT command changes this. Using eDRX extends the paging cycle beyond the short DRX cycles.

## Connected DRX

Connected DRX is negotiated between the device and the network per the active RRC configuration and is handled by the modem. The modem firmware controls how ON IDLE is used between the cDRX on duration windows to save power.

The host can influence this decision through the proprietary module configuration

```
%MODULECFG="pmuInCdrx":
```

- 0 — do not enter deep sleep during connected DRX.
- 1 — allow deep sleep during connected DRX (default).

### 4.4.4 Modem functionality levels

The AT+CFUN command provides coarse-grained host control of the modem, allowing the LTE radio and stack to be deactivated without fully powering down the module.

## Supported functionality levels

<fun>	Behavior
0	Minimum functionality. RF TX off, LTE stack deactivated. The AT command interface and all non-radio functionality remain available.
1	Full functionality. RF on, LTE stack active (default after registration).
4	Flight mode. RF off; all non-radio functionality remains available.

The <rst> parameter controls whether the command triggers a reset: 0 no reset (default), 1 reset and restart with normal-mode +CFUN=1.

### Initial state at power-on

The +CFUN state adopted at power-on is configurable through

%MODEMCFG="CfunInit",<fun>,<max\_delay>:

- <fun> = 0, 1 or 4 — initial functionality level.
- <max\_delay> = 0–65 535 s — delay between modem boot and protocol stack power-on.

By default the device uses minimum functionality (<fun>=0) with a <max\_delay> of 0 s.

## 4.5 Reset

The nRF93M1 can be reset through the dedicated nRESET pin or through AT commands.

### nRESET pin

The nRESET pin is active-low. It has an internal 120 kΩ pull-up so that it remains high if left floating; the host PCB does not need an external pull-up resistor.

- Pulling nRESET low for at least **300 ms** and then releasing it triggers a full module reset.
- nRESET is only intended for emergency or production-line reset; in normal operation, prefer the AT-level reset commands.
- The pin may be left floating in production designs that do not use it.

### POWERKEY pin

The POWERKEY pin is the host-driven on/off switch and has an always-on internal pull-up:

- From *System Disabled*: pull POWERKEY low  $\geq 750$  ms to start the module and enter *System ON*.
- From *System ON* or *System OFF*: pull POWERKEY low  $\geq 2\,000$  ms to power down to *System Disabled*.

### AT reset commands

Command	Effect
AT%RST	Software reset; the module restarts and re-enters <i>System ON</i> .
AT+CFUN=1, 1	3GPP TS 27.007 reset; restarts the modem.
AT%FACTORYRESET	Reset all user-configurable settings to factory defaults, then restart.
AT%POWD	Enter <i>System Disabled</i> ; only POWERKEY can wake the module afterwards.

## 4.6 Current consumption

Typical current consumption figures for the nRF93M1 under a range of operating conditions.

### Consumption by operating mode

TBD — pending module-level measurement.

Mode	Typ	Max	Unit
System Disabled	TBD	TBD	μA
System OFF	TBD	TBD	μA
PSM	TBD	TBD	μA
eDRX (short cycle)	TBD	TBD	μA
eDRX (long cycle)	TBD	TBD	μA
Idle DRX	TBD	TBD	mA
Connected DRX	TBD	TBD	mA
RX continuous	TBD	TBD	mA
TX at 23 dBm (Power Class 3)	TBD	TBD	mA
Wi-Fi scan	TBD	TBD	mA
Flight mode	TBD	TBD	mA

Measurement conditions: VBAT = 3.8 V, ambient T<sub>A</sub> = 25 °C, 50 Ω unless otherwise stated.

# 5 LTE Modem and connectivity stack

The LTE Cat 1 bis modem is 3GPP release 14 compliant and supports Class 3, up to 23dBm output over a single 50  $\Omega$  antenna pin on FDD and TDD bands. It is field upgradable through differential firmware updates over serial and cellular interfaces.

It is optimized for low power operation and hence also supports LTE power saving mechanisms such as power saving mode (PSM) and extended discontinuous reception (eDRX).

In addition to the standardized LTE L1-L3 stacks the modem also included IP and the most used higher layer connectivity stack and security layers.

- IPv4 and IPv6
- TCP and UDP
- TLS and DTLS
- CoAP
- MQTT
- HTTP(S)

Additional stack options can be supported in the future as part of the firmware update releases.

## 5.1 Supported bands and frequencies

nRF93M1 supports the LTE bands listed in the following table. Individual bands may be enabled or disabled at runtime via the `AT%BAND` command.

## Band list

Band	Uplink (MHz)	Downlink (MHz)	Duplex
B1	1920–1980	2110–2170	FDD
B2	1850-1910	1930-1990	FDD
B3	1710–1785	1805–1880	FDD
B4	1710–1755	2110-2155	FDD
B5	824–849	869–894	FDD
B7	2500–2570	2620–2690	FDD
B8	880–915	925–960	FDD
B12	699-716	729–746	FDD
B13	777-787	746–756	FDD
B18	815-830	860–875	FDD
B19	830-845	875–890	FDD
B20	832–862	791–821	FDD
B25	1850-1915	1930–1995	FDD
B26	814-849	859–894	FDD
B28	703–748	758–803	FDD
B66	1710-1780	2110–2200	FDD
B71	663-698	617-652	FDD
B38	2570–2620	2570–2620	TDD
B40	2300–2400	2300–2400	TDD
B41	2496–2690	2496–2690	TDD

## Runtime band selection

The set of enabled bands can be locked or restricted with `AT%BAND`. The command accepts a bitmap of bands to enable; `AT%BAND=?` returns the full supported-band list. See the AT Command Manual for the exact syntax.

## Peak data rates

Direction	Peak rate
Downlink	Up to 10 Mbit/s in a 20 MHz channel (Category 1 bis limit)
Uplink	Up to 5 Mbit/s in a 20 MHz channel (Category 1 bis limit)

Achievable rates depend on channel conditions, the serving cell's configuration, and the application-layer protocol overhead.

## 5.2 Connectivity stacks

nRF93M1 provides a full IPv4/IPv6 data-plane with integrated TCP, UDP, TLS, DTLS, HTTP, HTTPS, MQTT, CoAP, and sockets, exposed to the host through AT commands and a USB network interface.

### Transport and application protocols

Feature	Details
IP versions	IPv4, IPv6, IPv4v6 (dual-stack), Non-IP. PDP type configured via +CGDCONT.
Sockets	Up to 12 concurrent TCP/UDP sockets (%SKTCREATE... family). Per-send payload up to 1400 bytes. Bind, listen (backlog 1–4), accept, and Release Assistance Indication (RAI) on send.
DNS	%DNS=<url> resolves a domain name to an IP address.
ICMP ping	%PING — count 1–255 or continuous, payload 1–1500 B, per-request timeout 1 000–600 000 ms.
ICMP echo reply	Gated by %MODULECFG="icmpEchoReply" (0 disabled default, 1 enabled v4+v6, 2 IPv4 only, 3 IPv6 only).
HTTP / HTTPS client	GET, range-GET, POST, POST from file, READ, READ to file. URL up to 2 048 bytes; file body up to available file-system space. Content-type and SSL context per %HTTPCFG.
CoAP	Used by the nRF Cloud services over DTLS 1.2 (libcoap).
TLS / DTLS	Mbed TLS 3.6.5; TLS 1.2, TLS 1.3, DTLS 1.2; DTLS Connection-ID (RFC 9146); 6 concurrent contexts. See the Security chapter for cipher suites.

## 5.3 SMS

The nRF93M1 supports SMS in PDU mode for mobile-originated and mobile-terminated short messages, with support for delivery-status reporting.

### Operational mode

The public AT command set exposes **PDU mode only**. Encoding follows 3GPP TS 23.040 and TS 23.041.

## SMS AT commands

Command	Purpose
+CMGS	Send an SMS (mobile-originated).
+CMT	Unsolicited result code for an incoming SMS delivered directly to the TE.
+CNMA	New-message acknowledgement to the network.
+CDS / +CDSI	Delivery-status URC: direct (+CDS) or stored-in-ME (+CDSI).
+CMTI	Unsolicited result code for an SMS stored in the module.
+CNMI	Subscribe to SMS URCs and select delivery routing.
+CSCA	Configure the SMS service-centre address.

## Constraints

- Only one AT client at a time may be registered as the SMS client. Any new SMS registration requires the previous registration to be released.
- Cell broadcast (+CSCB) is **not supported**.

## 5.4 Firmware update

nRF93M1 supports two over-the-air firmware-update transports and UART or USB based production-line flashing path. Each over-the-air path delivers cryptographically signed images that are verified against the hardware root-of-trust before activation.

### Over-the-air firmware update

Path	Description
HTTP(S) FOTA	AT%HTTPFOTADL downloads an image directly from a host-supplied URL. TLS security context, content-type, and transport parameters are set through %HTTPCFG.
nRF Cloud FOTA	AT%NRFCLOUDFOTA with operations: 0 check host-application OTA, 1 download host-application chunk, 2 check modem firmware, 3 check and apply modem firmware, 4 clear cached URL. Chunks are Base64-encoded with CRC-16/CCITT-FALSE framing.

### Production-line firmware updates

For production-line and bring-up, the module accepts firmware over UART using the Nordic download tool. The download agent boots at 115 200 bps and can be set to 3 Mbps for faster transfer.

### Security guarantees

All firmware images are cryptographically signed. The signature is verified during the boot stage against the hardware root-of-trust. Images that fail verification are rejected and the module rolls back to the previously known-good image. See the Security chapter for details.

## 5.5 AT command interface

nRF93M1 is controlled by the host through a standards-aligned AT command set, exposed on the primary UART and on a USB CDC-ACM interface.

### Standards base

- ITU-T V.250 — generic AT command syntax, serial-line behaviour, baud, flow control.
- 3GPP TS 27.007 — general, network, and mobile-termination commands.
- 3GPP TS 27.005 — SMS AT commands (PDU mode).
- Nordic-specific extensions — prefixed with % (for example %MODULECFG, %NRF\_CLOUD\*).

### Result codes

Final result codes emitted by the module are OK, ERROR, +CME ERROR: <err>, and +CMS ERROR: <err>.

Verbosity is selected by +CMEE: 0 disabled (generic ERROR), 1 numeric, 2 verbose. Vendor-specific +CME ERROR values start at 512.

### Runtime command discovery

The list of AT commands available at runtime can be retrieved with AT+CLAC.

### Multiplexing

The module supports 3GPP TS 27.010 multiplexing (CMUX) via AT+CMUX, in both basic (transparency 0) and advanced (transparency 1) variants. Port speeds 600 bps to 3 Mbps are supported. A typical invocation AT+CMUX=0 starts basic CMUX.

## 5.6 SIM Interfaces

Two external SIMs and software SIMs are supported with commands/API to support selection between the SIMs. SIM cards with ISO/IEC 7816-3 specified interfaces are supported and the supported UICC/eUICC interface is compliant with the following

- ETSI TS 102 221 – Smart Cards, UICC-Terminal interface, Physical and logical characteristics
- ETSI TS 103 383 – Smart Cards, Embedded UICC, Requirements Specification

The physical interface for the eUICC is the same as the removable UICC. Both class B (supply voltage 3.0 V) and class C (supply voltage 1.8 V) operation is supported. If two external SIMs are used, both must use the same class/voltage.

For eUICC, M2M SGP.02, Consumer SGP.22, and IoT SGP.32 SIM provisioning is supported.

SoftSIM is supported through a standard SIM API, available upon request.

## 5.7 RF control external interface

The nRF93M1 provides a dedicated 3-pin interface for controlling external RF applications, such as antenna tuner devices.

## 5.8 LTE coexistence interface

The nRF93M1 provides a dedicated two-pin COAX interface for RF control and RF interference avoidance towards a companion radio device such as an external positioning device or Bluetooth® Low Energy device.

## 5.9 RF front-end interface

The device has a single-ended (SE) 50 Ω antenna interface where an antenna is connected.

## 5.10 RF electrical specification

TX power, RX sensitivity, and maximum input power at the nRF93M1 antenna port.

### TX power

nRF93M1 operates at LTE Power Class 3 up to 23 dBm output power (nominal 23 dBm conducted).

### RX sensitivity

Band	Channel BW	Sensitivity (dBm)
B1	10 MHz	TBD
B3	10 MHz	TBD
B5	10 MHz	TBD
B7	10 MHz	TBD
B8	10 MHz	TBD
B20	10 MHz	TBD
B28	10 MHz	TBD
B38	10 MHz	TBD
B40	10 MHz	TBD
B41	10 MHz	TBD

### Maximum RF input power

TBD — module-level qualification required.

### Production RF test support

For production-line RF characterization the nRF93M1 supports a non-signalling RF test mode via `AT%RFTEST`. The command supports single-tone transmit at 0–23 dBm and RSSI-based receive characterization across the supported bandwidth set (1.4, 3, 5, 10, 15, 20 MHz). The `AT%PRODDONE` command latches the production-complete flag after the test sequence.

# 6 Wi-Fi Location

nRF93M1 can operate as a Wi-Fi beacon receiver supporting IEEE 802.11b DSSS reception in the 2.4 GHz band for access point (AP) based positioning. It performs signal reception and passive detection and decoding of beacon frames. Operations can be time-multiplexed with cellular functionality.

Scanning occurs when LTE is in RRC Idle mode (DRX/eDRX), PSM, or when cellular functionality is fully deactivated and can be configured and started through AT Commands. Positioning is determined by a location service such as Nordic nRF Cloud using the reported beacon data.

This is a location solution ideal for cost and power sensitive devices. For more information also please refer to the nRF93M1 AT Command documentation

# 7 Cellular Location

Cellular location enables the estimation of device position based on the mobile network cells visible to the specific device. The nRF93M1 reports serving-cell and neighbour-cell information through AT commands. Positioning is determined by a location service such as Nordic nRF Cloud using the reported cell data.

This is a solution ideal for cost and power sensitive devices. For more information also please refer to the nRF93M1 AT Command documentation

# 8 Device interfaces

nRF93M1 exposes host-side and other interfaces for communication, data, control, and status.

## 8.1 Status and Network indicators

The nRF93M1 includes module and network status indicator features available through the STATUS and NETWORK pins.

### 8.1.1 STATUS indicator

The STATUS pin indicates the nRF93M1 operational status during all modes including System OFF sleep, and as shown in table below.

Mode	Description
Pin is high	Module is powered, initialized and running normally
Pin is low	Module is not properly powered and/or not initialized and running normally

### 8.1.2 NETWORK indicator

The NETWORK pin indicates the nRF93M1 network status as shown in the table below and network status can easily be read and interpreted from a connected LED.

Mode	Network status	LED Indication
Pin pulses with 200ms high / 1800ms low duty cycle	Searching	Slow pulsing, low intensity
Pin pulses with 1800ms high / 200ms low duty cycle	RCC Idle	Slow pulsing, high intensity
Pin pulse with 125ms high / 125ms low cycle	RCC Connected	Fast pulsing

## 8.2 USB

The nRF93M1 has a USB 2.0 compliant slave peripheral that supports Full-Speed (12 Mbps) and High-Speed (480 Mbps) modes. This interface can be used for commands, data, and tracing.

## 8.3 UART

nRF93M1 provides three asynchronous UART peripherals, each with dedicated functionality:

- UART1 — primary AT command and data port.

- UART0 — modem trace output (UniLog binary).
- UART2 — auxiliary data channels.

The UARTs support low-power operation and can be used as nRF93M1 wake-up sources from System OFF sleep when the UART is configured to 9 600 baud or below prior to entering System OFF.

### 8.3.1 UART1 – Primary

UART1 is the primary serial interface used for AT commands, data, and firmware updates.

The default baud rate is 115 200 bit/s. The following baud rates are supported:

- 600, 1 200, 2 400, 4 800, 9 600, 19 200, 38 400, 57 600, 115 200, 230 400, 460 800, 921 600 bit/s.

Autobauding is enabled by setting `+IPR=0`. CTS/RTS hardware flow control is supported.

UART1 supports low-power operation and can be used as nRF93M1 wake-up source from System OFF sleep when the UART is configured to 9 600 baud prior to entering System OFF. The DTR pin is the wake input.

### 8.3.2 UART0 – Trace

UART0 is dedicated to modem trace output from the nRF93M1. It carries the proprietary UniLog binary log stream for use with Nordic's cellular monitor tool or for capture and supply to Nordic as part of technical support.

The default baud rate is 3 Mbit/s and the port supports up to 6 Mbit/s.

See the Modem trace topic in the Debug and trace chapter for runtime port selection and trace configuration.

### 8.3.3 UART2 – Auxiliary

UART2 is an auxiliary serial interface available for applications preferring or needing a second data/communication channel.

## 8.4 GPIO

The nRF93M1 exposes one always-on general-purpose I/O pins, P0.0\_AO. It can be used as digital input and output and remain available across System ON and System OFF power states to be used as wake-up sources to bring the module out of System OFF sleep on a host-driven edge.

# 9 Security

The nRF93M1 provides hardware-anchored device security, authenticated and encrypted firmware, and standards-based transport security (TLS 1.2, TLS 1.3, DTLS 1.2).

## Platform security

The nRF93M1 platform security is anchored in module hardware and includes the following hardware-backed mechanisms:

- Secure boot. A hardware root-of-trust verifies the authenticity and integrity of every firmware image loaded at power-on. Unsigned or tampered images are rejected.
- Flash encryption. Code and secrets stored in internal non-volatile memory are protected by on-chip flash encryption, tying the stored image to the device.
- Hardware true random number generator (TRNG). An on-chip TRNG seeds all cryptographic operations (TLS handshake ephemerals, key generation, nonces).
- Signed firmware update. Firmware updates are cryptographically verified against the root-of-trust before activation; failed verification triggers rollback to the previously known-good image. See [Firmware update](#) on page 19 for supported firmware-update transports (HTTP and nRF Cloud).

## Transport security

The nRF93M1 provides transport-layer security services built on Mbed TLS 3.6.5:

- TLS 1.2 and TLS 1.3 (RFC 5246, RFC 8446).
- DTLS 1.2 (RFC 6347), used for CoAP over UDP.
- DTLS Connection-ID per RFC 9146 for NAT resilience on power-saving cellular links.
- Up to 6 concurrent SSL/DTLS contexts, each independently configurable for protocol, cipher suite, certificates, PSK identity, SNI, and session cache.
- Three security levels (`seclvl 0` — no authentication, `seclvl 1` — server authentication, `seclvl 2` — mutual authentication).

The cipher suites exposed through the AT command interface (`%SSLCFG`) are:

Value	Suite	Notes
0xC0AD	TLS_ECDHE_ECDSA_WITH_AES_256_GCM	Preferred — ECC key exchange, smaller certs
0xC09F	TLS_DHE_RSA_WITH_AES_256_GCM	Classic RSA-based fallback

Pre-shared-key (PSK) authentication is supported when both `psk_identity` and `psk_key` are configured on the same SSL context.

## Credential storage

X.509 certificates, device private keys, and root CAs are stored as files in the module's file system. They are managed through the file system AT commands:

- `%FOPEN / %FWRITE / %FCLOSE` — write a PEM-encoded credential (CA certificate, device certificate, or private key) to a named file.
- `%FREAD` — read back a stored file.
- `%FDELETE` — delete a stored credential file.

- %FSHA256 — verify the SHA-256 hash of a stored file.

SSL/DTLS contexts reference credentials by file path using %SSLCFG (for example, "cacert", "clientcert", "clientkey"). Credentials are retained across reset and power cycles.

### **Regulatory certification**

The nRF93M1 is designed to support regulatory security certification such as the CE RED radio equipment directive.

# 10 Debug and trace

The nRF93M1 supports firmware tracing through a dedicated UART or USB modem-trace port.

The nRF93M1 produces a real-time binary modem trace in the UniLog format, which can be captured over UART or USB for post-processing with the Nordic tool-chain.

## Trace output

Trace level and output is selectable at runtime with the `%MODULECFG="logPortSel"` AT command and is produced on:

- UART0 at up to 6 Mbit/s (minimum 921 600 bit/s).
- USB diagnostic ACM port (CDC-ACM interface on the module's USB composite device).
- Either port individually, or both simultaneously.

The trace stream is live; no internal buffering or storage is required by the module itself. The host must capture the stream in real time to avoid drop.

## Coredump and metrics export

For field-deployed devices, the nRF93M1 integrates nRF Cloud firmware-observability, which stores coredumps and periodic metrics heartbeats in the secure file system and uploads them to the nRF Cloud on demand. See the nRF Cloud services chapter for more information.

# 11 nRF Cloud services

nRF93M1 integrates with nRF Cloud to provide device provisioning, data messaging, device shadow, cell- and Wi-Fi-based location, firmware update, and firmware observability.

## Overview

nRF Cloud services are exposed through a family of `%NRF_CLOUD*` AT commands. The transport is CoAP over DTLS 1.2 (libcoap and Mbed TLS), which keeps message overhead small while secure and is compatible with cellular power-saving modes. Each cloud transaction emits a `%COAP: URC` that carries the transport-layer status for that request.

## Provisioning and authentication

Each device presents two stable identities and two short-lived credentials to the cloud:

- `%DEVICEUUID` — a 36-character device UUID that is generated once and stored in non-volatile memory.
- `%CLOUDACCESSKEY` — a P-256 ECC public key in Base64-DER form. The corresponding private key is generated on-chip once and never leaves the device.
- `%REGJWT` — a signed registration JWT used during device on-boarding.
- `%JWT` — a short-lived authentication JWT (approximately 1 hour validity). The device system time must be valid for the JWT to be accepted by the cloud.

## Data services

- **Location** (`%NRF_CLOUDLOCATION`) — several location methods covering single-cell, multi-cell, Wi-Fi, and combinations. The response carries `<latitude>`, `<longitude>`, `<uncertainty_m>`, `<fulfilled_method>`. Multi-cell and Wi-Fi methods require the modem to be in RRC Idle.
- **Messaging** (`%NRF_CLOUDMESSAGE`) — publishes a JSON payload to the cloud over CoAP (for example `{"appId": "BUTTON", "data": "1"}`).
- **Shadow** (`%NRF_CLOUDSHADOW`) — reads a dotted path from the device's desired shadow and writes a dotted path into the reported shadow.
- **FOTA** (`%NRF_CLOUDFOTA`) — see the firmware-update description in the LTE Modem chapter.

## 11.1 Observability

nRF93M1 integrates observability for periodic metrics heartbeats and upload of diagnostic data to the Memfault Cloud.

# 12 Hardware and layout

## 12.1 Pin assignments

The following sections describe the nRF93M1 hardware and layout specifications.

### 12.1.1 Module pin assignments

The pin assignment table and figure describe the assignments for this variant of the chip.

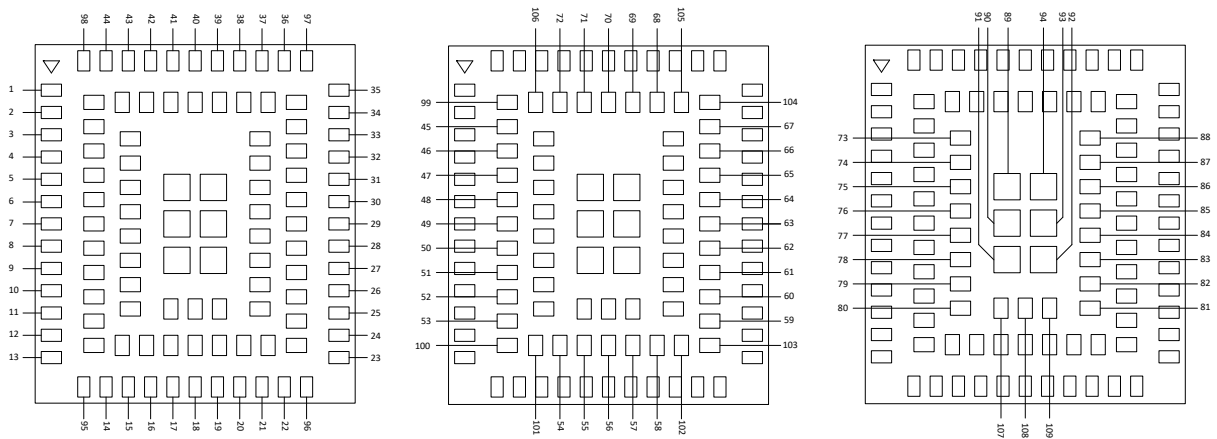


Figure 1: Module pin assignments, top view

Pin	Name	Function	Description
1	<b>GND</b>	Power	Ground
2	<b>GND</b>	Power	Ground
3	<b>GND</b>	Power	Ground
4	<b>GND</b>	Power	Ground
5	<b>P0.0_AO</b>	Digital I/O	Always on general purpose I/O
6	<b>P0.1_AO</b>	Digital I/O	RF tuner control
7	<b>POWERKEY</b>	Module Power on/off	Power the module on or off
8	<b>GND</b>	Power	Ground
9	<b>GND</b>	Power	Ground
10	<b>GND</b>	Power	Ground
11	<b>SIM1_IO</b>	Digital I/O	SIM1 data
12	<b>SIM1_RST</b>	Digital I/O	SIM1 reset
13	<b>SIM1_CLK</b>	Digital I/O	SIM1 clock
14	<b>SIM1_VOUT</b>	Power	SIM power supply
15	<b>nRESET</b>	Digital I/O	Module reset pin

Pin	Name	Function	Description
16	<b>NETWORK</b>	Digital I/O	Network status indicator
17	<b>UART1_RXD</b>	Digital I/O	UART1 Receive
18	<b>UART1_TXD</b>	Digital I/O	UART1 Transmit
19	<b>UART1_DTR</b>	Digital I/O	UART1 Data Terminal Ready
20	<b>UART1_RI</b>	Digital I/O	UART1 Ring Indicator
21	RESERVED		Connect thermally and mechanically to the application board but leave electrically unconnected.
22	<b>UART1_RTS</b>	Digital I/O	UART1 Request To Send
23	<b>UART1_CTS</b>	Digital I/O	UART1 Clear To Send
24	<b>LDO_OUT</b>	Power	LDO power out. nominal 1.8V, max 120mA
25	<b>STATUS</b>	Digital I/O	Module operating status
26	<b>GND</b>	Power	Ground
27	<b>GND</b>	Power	Ground
28	<b>UART2_RXD</b>	Digital I/O	UART2 Receive
29	<b>UART2_TXD</b>	Digital I/O	UART2 Transmit
30	<b>GND</b>	Power	Ground
31	<b>GND</b>	Power	Ground
32	<b>GND</b>	Power	Ground
33	<b>GND</b>	Power	Ground
34	<b>GND</b>	Power	Ground
35	<b>ANT</b>	RF	Single-ended 50 $\Omega$ LTE antenna pin
36	<b>GND</b>	Power	Ground
37	<b>GND</b>	Power	Ground
38	<b>UART0_RXD</b>	Digital I/O	UART0 Receive (modem trace)
39	<b>UART0_TXD</b>	Digital I/O	UART0 Transmit (modem trace)
40	<b>GND</b>	Power	Ground
41	<b>GND</b>	Power	Ground
42	<b>VDD</b>	Power	Power Supply
43	<b>VDD</b>	Power	Power Supply
44	<b>GND</b>	Power	Ground
45	<b>GND</b>	Power	Ground
46	<b>GND</b>	Power	Ground
47	<b>GND</b>	Power	Ground
48	<b>GND</b>	Power	Ground

Pin	Name	Function	Description
49	<b>GND</b>	Power	Ground
50	<b>GND</b>	Power	Ground
51	<b>GND</b>	Power	Ground
52	<b>GND</b>	Power	Ground
53	<b>GND</b>	Power	Ground
54	<b>GND</b>	Power	Ground
55	<b>GND</b>	Power	Ground
56	<b>GND</b>	Power	Ground
57	RESERVED		Connect thermally and mechanically to the application board but leave electrically unconnected.
58	RESERVED		Connect thermally and mechanically to the application board but leave electrically unconnected.
59	<b>USB_DP</b>	Digital I/O	USB differential data +
60	<b>USB_DN</b>	Digital I/O	USB differential data -
61	<b>USB_VBUS</b>	Digital I/O	USB VBUS input and System OFF wake-up
62	<b>SIM2_CLK</b>	Digital I/O	SIM2 clock
63	<b>SIM2_RST</b>	Digital I/O	SIM2 reset
64	<b>SIM2_IO</b>	Digital I/O	SIM2 data
65	<b>SIM2_VOUT</b>	Power	SIM power supply
66	<b>UART2_RTS</b>	Digital I/O	UART2 Request To Send
67	<b>UART2_CTS</b>	Digital I/O	UART2 Clear To Send
68	<b>GND</b>	Power	Ground
69	<b>GND</b>	Power	Ground
70	<b>GND</b>	Power	Ground
71	<b>GND</b>	Power	Ground
72	<b>GND</b>	Power	Ground
73	<b>GND</b>	Power	Ground
74	<b>GND</b>	Power	Ground
75	<b>GND</b>	Power	Ground
76	<b>GND</b>	Power	Ground
77	<b>GND</b>	Power	Ground
78	<b>GND</b>	Power	Ground
79	<b>SIM1_DET</b>	Digital I/O	SIM1 detect. If not used it must be left floating.

Pin	Name	Function	Description
80	GND	Power	Ground
81	GND	Power	Ground
82	RESERVED		Connect thermally and mechanically to the application board but leave electrically unconnected.
83	GND	Power	Ground
84	GND	Power	Ground
85	GND	Power	Ground
86	GND	Power	Ground
87	GND	Power	Ground
88	GND	Power	Ground
89	GND	Power	Ground
90	GND	Power	Ground
91	GND	Power	Ground
92	GND	Power	Ground
93	GND	Power	Ground
94	GND	Power	Ground
95	GND	Power	Ground
96	GND	Power	Ground
97	GND	Power	Ground
98	GND	Power	Ground
99	GND	Power	Ground
100	P0.2_AO	Digital I/O	RF tuner control
101	P0.3_AO	Digital I/O	RF tuner control
102	GND	Power	Ground
103	RESERVED		Connect thermally and mechanically to the application board but leave electrically unconnected.
104	COEX0	Digital I/O	Coexistence and RF Control interface
105	COEX1	Digital I/O	Coexistence and RF Control interface
106	GND	Power	Ground
107	GND	Power	Ground
108	GND	Power	Ground
109	GND	Power	Ground

Table 4: LGA pin assignments

## 12.2 Mechanical specifications

Dimensions in millimeters for the nRF93M1 LGA 15.8 x 17.7 x 2.4 mm package

### 12.2.1 Module package

The nRF93M1 uses a 17.7×15.8×2.4 mm LGA package with variable ball pitch. All dimensions are in millimetres and follow JEDEC tolerance conventions unless otherwise stated.

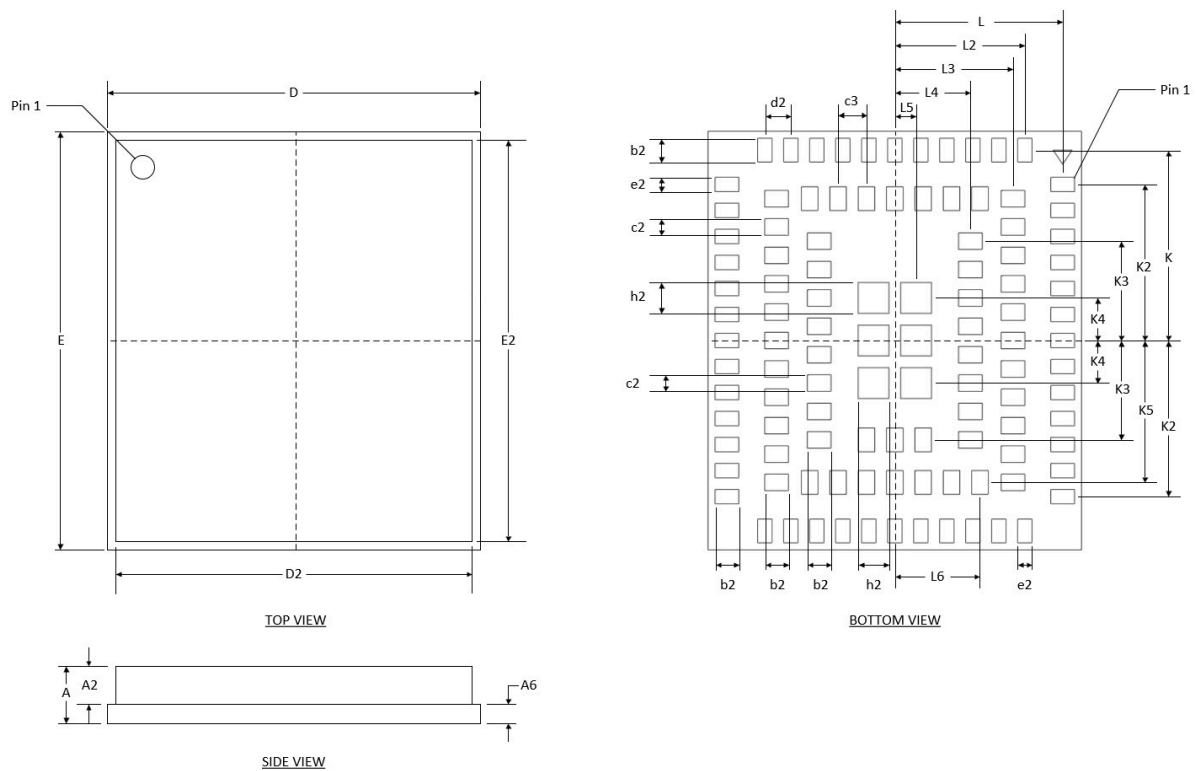


Figure 2: Package dimensions in millimeters

	Min.	Nom.	Max.
A	2.2	2.4	2.6
A2		1.6	
A6		0.8	
b2		1	
c2		0.7	
c3		1.2	
D	15.65	15.8	15.95
D2		15.1	
d2		1.1	
E	17.55	17.7	17.85
E2		17	
e2		0.6	
h2		1.3	
K		8.05	
K2		6.6	
K3		4.2	
K4		1.8	
K5		6	
L		7.1	
L2		5.5	
L3		5	
L4		3.2	
L5		0.9	
L6		3.6	

Table 5: Package dimensions in millimeters

Attribute	Value
Package type	LGA, variable ball pitch
Body size (D × E × A)	17.7 × 15.8 × 2.4 mm (nominal)
Pin count	109
Weight	1.5 g
RoHS / REACH	Compliant

Table 6: Package attributes

## 12.3 Reference circuitry

To ensure good RF performance when designing PCBs, using the PCB layouts and component values provided by Nordic Semiconductor is highly recommended.

Documentation for the different package reference circuits, including Altium Designer files, PCB layout files, and PCB production files can be downloaded from the product page at [www.nordicsemi.com](http://www.nordicsemi.com)

This section contains reference circuitry showing the components to support the design of on-chip features.

**Note:** This is not a complete list of configurations, but all required circuitry is shown for further configurations.

### 12.3.1 nRF93M1 reference design

For Bill of Materials (BOM), PCB layout and thermal design, see the nRF93M1 Hardware Design Guidelines.

## 12.4 Thermal characteristics

Thermal data for the nRF93M1 module, including ambient operating range, junction-to-ambient resistance, and guidance for host-PCB thermal design.

The following topic provides thermal parameters for module-level PCB design and thermal analysis.

### 12.4.1 Thermal characterization

Module-level thermal-resistance and temperature-monitoring data.

#### Operating temperature range

nRF93M1 operates over an ambient temperature range of  $-35\text{ }^{\circ}\text{C}$  to  $+75\text{ }^{\circ}\text{C}$ . Module-level derating (if any) is given in the Recommended Operating Conditions chapter.

#### Thermal resistance

Parameter	Value	Unit
Junction-to-ambient thermal resistance, $\theta_{JA}$	TBD	$^{\circ}\text{C}/\text{W}$
Junction-to-case thermal resistance, $\theta_{JC}$	TBD	$^{\circ}\text{C}/\text{W}$
Junction-to-top characterization parameter, $\psi_{JT}$	TBD	$^{\circ}\text{C}/\text{W}$
Junction-to-board characterization parameter, $\psi_{JB}$	TBD	$^{\circ}\text{C}/\text{W}$

Measurements follow JEDEC standards JESD51-2 ( $\theta_{JA}$ ,  $\psi_{JT}$ ) and JESD51-8 ( $\theta_{JC}$ ) on a 2s2p test board.

#### On-chip temperature monitor

The host application can read the on-chip temperature through the proprietary `AT%ADC` command. A temperature-threshold alarm can be configured through `AT%PALARM`, which raises a URC when the die temperature exceeds a configurable high-temperature limit.

## Host PCB guidance

For reliable operation at elevated ambient temperature:

- Use a thermal-relief-free copper pour under the module footprint on the host PCB to improve heat spreading.
- Add thermal vias beneath the module when the host PCB uses inner ground planes.
- Avoid placing heat-generating components (high-current regulators, RF power amplifiers, or CPU) directly adjacent to the nRF93M1.

## 12.5 Assembly-related instructions

nRF93M1 is delivered in a sealed dry pack and follows standard JEDEC handling guidelines for surface-mount LGA modules.

Follow these guidelines when integrating the nRF93M1 on the host PCB:

- Storage – keep modules in the sealed dry pack at  $\leq 30$  °C/60% RH until ready for assembly.
- Floor life – once the dry pack is opened, complete reflow within 168 hours at  $\leq 30$ °C/60% RH (MSL 3).
- Baking – if floor life or storage conditions are exceeded, bake per JEDEC J-STD-033 before reflow.
- Reflow profile – use a profile compatible with IPC-7530, peak 240°C  $\pm$ 5 °C, max 3 reflow cycles.
- RESERVED pins – connect thermally and mechanically to the host PCB but leave electrically unconnected.
- Antenna routing – route the ANT pin with a controlled-impedance 50  $\Omega$  transmission line; keep the line short and clear of digital aggressors.
- VBAT decoupling – place bulk + high-frequency decoupling capacitors close to the VDD pins per the Hardware Design Guidelines.
- ESD handling – observe ESD-protected handling per JESD625 (Class 1C HBM, Class C1 CDM).

For more detailed instructions related to assembly, see nRF93M1 Hardware Design Guidelines.

# 13 Recommended operating conditions

The operating conditions are the physical parameters that the chip can operate within.

Symbol	Parameter	Notes	Min.	Nom.	Max.	Units
VDD	Battery input voltage	Including voltage drop, ripple and spikes.	3.3	3.8	4.5	V
LDO_OUT	LDO output voltage	Internal LDO output; supplies GPIO pads and is available to the host. 1.8 V only on the nRF93M1.	1.71	1.80	1.89	V
V <sub>OH</sub>	GPIO output high level voltage	Tracks LDO_OUT (1.8 V).	TBD	TBD	TBD	V
V <sub>SIM,1.8</sub>	SIM card supply voltage (1.8 V mode)	Auto-selected from UICC class. Supplied by internal LDOSIM.	1.71	1.80	1.89	V
V <sub>SIM,3.0</sub>	SIM card supply voltage (3 V mode)	Auto-selected from UICC class. Supplied by internal LDOSIM.	2.85	3.00	3.15	V
T <sub>A</sub>	Operating ambient temperature		-30	25	+75	°C

Table 7: Recommended operating conditions

**Note:** There can be excessive leakage at VDD and/or LDO\_OUT if any of these supply voltages is outside its range given in the table above.

**Note:** It is not recommended to use high voltage, high drive GPIO outputs (VOH,HDH and VOH,HDL) with high frequency, high capacitance loads unless needed, as this may increase noise level and affect radio receiver performance. High drive/high load should especially be avoided on GPIO pins close to the radio front end.

## 13.1 LDO\_OUT Considerations

LDO\_OUT is the internal LDO output that supplies the GPIO pads and is available to the host as an auxiliary low-current rail.

The following restrictions should be taken into consideration:

- LDO\_OUT is derived from VDD; ensure VDD is applied before using LDO\_OUT.
- LDO\_OUT should be considered de-energised before removing VDD.
- If VDD is supplied and LDO\_OUT is grounded externally, extra current consumption can be generated on VDD.
- If ENABLE is low, do not drive LDO\_OUT high from an external source.

# 14 Absolute maximum ratings

Maximum ratings are the extreme limits to which the chip can be exposed for a limited amount of time without permanently damaging it. Exposure to absolute maximum ratings for prolonged periods of time may affect the reliability of the device.

Note	Min.	Max.	Unit
VDD	-0.3	5.5	V
LDO_OUT	-0.3	3.9	V
SIM_1V8	1.65	1.95	V
GND		0	V

Table 8: Supply voltage

Note	Min.	Max.	Unit
$V_{I/O}, LDO\_OUT \leq 3.6\text{ V}$	-0.3	$LDO\_OUT + 0.3$	V

Table 9: I/O pin voltage

Note	Min.	Max.	Unit
ANT antenna input level		10	dBm
RF port ruggedness	Maximum deviation from 50 $\Omega$ without damaging the module	10:1	VSWR

Table 10: Radio

Note	Min.	Max.	Unit
Storage temperature	-40	95	°C
Reflow conditions	For reflow profiling guidelines, see Guidelines for Temperature Profiling for Mass Soldering Processes (Reflow and Wave), Figure 3-1 Thermal Profile Schematic		
MSL	Moisture Sensitivity Level	3	
ESD HBM	Human Body Model	TBD	kV
ESD HBM Class	Human Body Model Class	TBD	
ESD CDM	Charged Device Model	TBD	V
ESD CDM Class	Charged Device Model Class	TBD	

Table 11: Environmental (LGA package)

Note	Min.	Max.	Unit
Endurance	100,000		Write/erase cycles
Retention	10 years at 75°C		y
No internal voltage boost converters			

Table 12: Flash memory

# 15 Ordering information

This chapter contains information on IC marking, ordering codes, and container sizes.

## 15.1 LGA marking

The nRF93M1 package is laser-marked on the top side with vendor identification, product name, build code, and traceability information.

The nRF93M1 package is marked as shown below.

- Row 1 – Nordic Semiconductor.
- Row 2 – Product name and build code (see [Order code](#) on page 41).
- Row 3 – Serial number (year code, week code, lot code).
- Row 4 – IMEI.

The detailed mapping between marking fields and the order code grammar is given in [Code ranges and values](#) on page 42.

## 15.2 Box labels

The nRF93M1 shipping containers carry an outer box label that includes the order code, lot code, quantity, and traceability information.

The outer box label artwork is to be defined.

## 15.3 Order code

The nRF93M1 order code identifies the product family, package, function variant, build code, and shipping container.

The order code has the following structure:

nRF93M1-LA<xA>-<CC>

Each field of the order code is defined in the table below. The associated build-code and serial-number fields, used in package marking and shipping-container labels, are defined in [Code ranges and values](#) on page 42.

Abbreviation	Definition and implemented codes
nRF93	nRF93 Series product
M1	Module variant
LA	Package variant code (LGA)
<xA>	Function variant code (band/region option — see <a href="#">Ordering options</a> on page 43)
<H><P><F>	Build code: H hardware version, P production configuration, F firmware version (only visible on shipping container label)
<YY><WW><LL>	Serial number: year, assembly week, lot code
<VC><XXXXX><ZZ>	Vendor code, alphanumeric serial number, checksum
<CC>	Container code (reel size — see <a href="#">Code ranges and values</a> on page 42)

Table 13: Order code abbreviations

## 15.4 Code ranges and values

This topic defines the value ranges used in the nRF93M1 order code, build code, and serial number.

<H>	Description
[A . . Z]	Hardware version/revision identifier (incremental)

Table 14: Hardware version codes

<P>	Description
[0 . . 9]	Production device identifier (incremental)
[A . . Z]	Engineering device identifier (incremental)

Table 15: Production configuration codes

<F>	Description
[A . . N, P . . Z]	Version of preprogrammed firmware
[0]	Delivered without preprogrammed firmware

Table 16: Firmware version codes

<YY>	Description
[23 . . 99]	Production year: 2023 to 2099

Table 17: Year codes

<WW>	Description
[01 . . 53]	Week of production

Table 18: Week codes

<LL>	Description
[AA . . ZZ]	Wafer production lot identifier

Table 19: Lot codes

<VC>	Description
[LQ]	Module manufacturer

Table 20: Vendor code

<XXXXX>	Description
[00000 . . ZZZZZ]	Alphanumeric serial number

Table 21: Serial number

<ZZ>	Description
[00 . . ZZ]	Alphanumeric serial-number checksum

Table 22: Serial number checksum

<CC>	Description
R7	7" reel
R	13" reel

Table 23: Container codes

## 15.5 Ordering options

nRF93M1 is offered in multi-regional and global LTE-band variants on 7" and 13" reels.

The available nRF93M1 order codes and the corresponding minimum ordering quantities are listed in the following table.

Order code	Minimum ordering quantity (MOQ)	Comment
nRF93M1-LABA-R	1 000	Multi-regional band option, 13" reel
nRF93M1-LABA-R7	100	Multi-regional band option, 7" reel
nRF93M1-LACA-R	1 000	Global band option, 13" reel
nRF93M1-LACA-R7	100	Global band option, 7" reel

Table 24: nRF93M1 order codes

# 16 Regulatory information

The nRF93M1 undergoes regulatory certifications, ensuring both regional compliances and compatibility with the LTE 3GPP specification.

Information about certified bands and status for ongoing certifications will be added in a future version of this document.

# 17 Legal notices

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# Contents

nRF93M1 Feature overview	ii
<b>1 Revision history</b>	<b>3</b>
<b>2 About this document</b>	<b>4</b>
2.1 Document status	4
<b>3 Product overview</b>	<b>5</b>
3.1 Block diagram	5
3.2 Feature matrix	6
<b>4 Power and Clock management</b>	<b>9</b>
4.1 Power supply system	9
4.1.1 Power On and Off	9
4.1.2 I/O Power Supply	10
4.1.3 LDO output	10
4.2 Power supply monitoring	10
4.3 Power management	11
4.3.1 System disabled	11
4.3.2 System OFF	11
4.3.3 System ON	12
4.4 Power-saving features	12
4.4.1 Power Saving Mode (PSM)	12
4.4.2 Extended DRX (eDRX)	13
4.4.3 DRX and connected DRX	13
4.4.4 Modem functionality levels	13
4.5 Reset	14
4.6 Current consumption	15
<b>5 LTE Modem and connectivity stack</b>	<b>16</b>
5.1 Supported bands and frequencies	16
5.2 Connectivity stacks	18
5.3 SMS	18
5.4 Firmware update	19
5.5 AT command interface	20
5.6 SIM Interfaces	20
5.7 RF control external interface	20
5.8 LTE coexistence interface	21
5.9 RF front-end interface	21
5.10 RF electrical specification	21
<b>6 Wi-Fi Location</b>	<b>22</b>
<b>7 Cellular Location</b>	<b>23</b>
<b>8 Device interfaces</b>	<b>24</b>
8.1 Status and Network indicators	24
8.1.1 STATUS indicator	24

8.1.2 NETWORK indicator. . . . .	24
8.2 USB. . . . .	24
8.3 UART. . . . .	24
8.3.1 UART1 – Primary. . . . .	25
8.3.2 UART0 – Trace. . . . .	25
8.3.3 UART2 – Auxiliary. . . . .	25
8.4 GPIO. . . . .	25
<b>9 Security. . . . .</b>	<b>26</b>
<b>10 Debug and trace. . . . .</b>	<b>28</b>
<b>11 nRF Cloud services. . . . .</b>	<b>29</b>
11.1 Observability. . . . .	29
<b>12 Hardware and layout. . . . .</b>	<b>30</b>
12.1 Pin assignments. . . . .	30
12.1.1 Module pin assignments. . . . .	30
12.2 Mechanical specifications. . . . .	34
12.2.1 Module package. . . . .	34
12.3 Reference circuitry. . . . .	36
12.3.1 nRF93M1 reference design. . . . .	36
12.4 Thermal characteristics. . . . .	36
12.4.1 Thermal characterization. . . . .	36
12.5 Assembly-related instructions. . . . .	37
<b>13 Recommended operating conditions. . . . .</b>	<b>38</b>
13.1 LDO_OUT Considerations. . . . .	38
<b>14 Absolute maximum ratings. . . . .</b>	<b>39</b>
<b>15 Ordering information. . . . .</b>	<b>41</b>
15.1 LGA marking. . . . .	41
15.2 Box labels. . . . .	41
15.3 Order code. . . . .	41
15.4 Code ranges and values. . . . .	42
15.5 Ordering options. . . . .	43
<b>16 Regulatory information. . . . .</b>	<b>45</b>
<b>17 Legal notices. . . . .</b>	<b>46</b>