MN54LM Bluetooth® Low Energy Module

操作手冊

BLE Solution: Nordic NRF54LM20A

RF IC	Crystal	Chip antenna
Nordic NRF54LM20A/V1	32MHz/20ppm Embedded	Embedded

Overview and Benefits

Overview(概述)

The MN54LM from Aradconn is a highly flexible, ultra-low power, Bluetooth Low Energy module based on the nRF54LM20A SoC from Nordic Semiconductor. With an Arm® Cortex®-M33 with FPU 32-bit processor, embedded 2.4GHz transceiver, and integrated chip antenna. Providing full use of the nRF54LM20A's capabilities and peripherals, which include I2C, SPI, UART, I2S, ADC, GPIO, PWM interfaces.

愛瑞德 MN54LM-C 產品為基於 Nordic Semiconductor 的 nRF54LMA20 SoC 晶片所開發高適用性且低能耗的藍芽模組。 FPU 32 位元處理器、嵌入式 2.4GHz 收發器和整合式晶片天線的 Arm® Cortex®-M33。充分利用 nRF54LM20A 的功能和周邊，包括 I2C、SPI、UART、I2S、ADC、GPIO、PWM 介面。

Benefits(優點)

- **Bluetooth qualification and Regulatory certification reduce the burden to enter the market.**
  具備藍牙資格和監管認證減輕了進入市場的負擔。

- **Complete RF solution with no additional RF design, allowing faster time to launch a new product, and providing long working distance.**
  具備完整的無線射頻解決方案，無需額外的射頻設計，可以更快地推出新產品，並提供遠距離工作範圍。

  MN54LM: up to 500 meters in open space. @1 Mbps
  於開放場域 1Mbps 具 500 公尺的傳輸距離。

- **Compact size: (L) 13 x (W) 7.5 x (H) 2.0mm.**
  產品尺寸**(L) 13 x (W) 7.5 x (H) 2.0mm**。

- **Provides flexibility in the OEM's application development choice with full support for using Nordic SDK and firmware tools.**
  針對 OEM 開發應用提供完整的 Nordic SDK 及韌體工具支援。

1. Features (功能)

- **2.4 GHz transceiver**
  - -95.5 dBm sensitivity in 1Mbps Bluetooth® low energy mode
  - -103 dBm sensitivity in 125kbps Bluetooth® low energy mode(long range)
  - -10 to +8dBm TX power, configurable in 1 dB steps
  - Supported data rates:
    - Bluetooth® LE –LE 2 M, LE 1 Mbps, LE Coded
  - 10.9 mA/ @3V DC/DC peak current in TX (8 dBm)
  - 3.3 mA/@3V DC/DC peak current in RX
  - RSSI (1 dB resolution)

- **Arm® Cortex®-M33 32-bit processor with TrustZone® technology, 128 MHz**
  - 503 CoreMark®,3.93 CoreMark/MHz EEMBC CoreMark executing from non-volatile memory
  - Single-precision floating-point unit (FPU)
  - Memory protection unit (MPU)
  - Digital signal processing (DSP) instructions
  - Serial wire debug (SWD)

- **Memory**
  - 2.036MB NVM/512 kB RAM

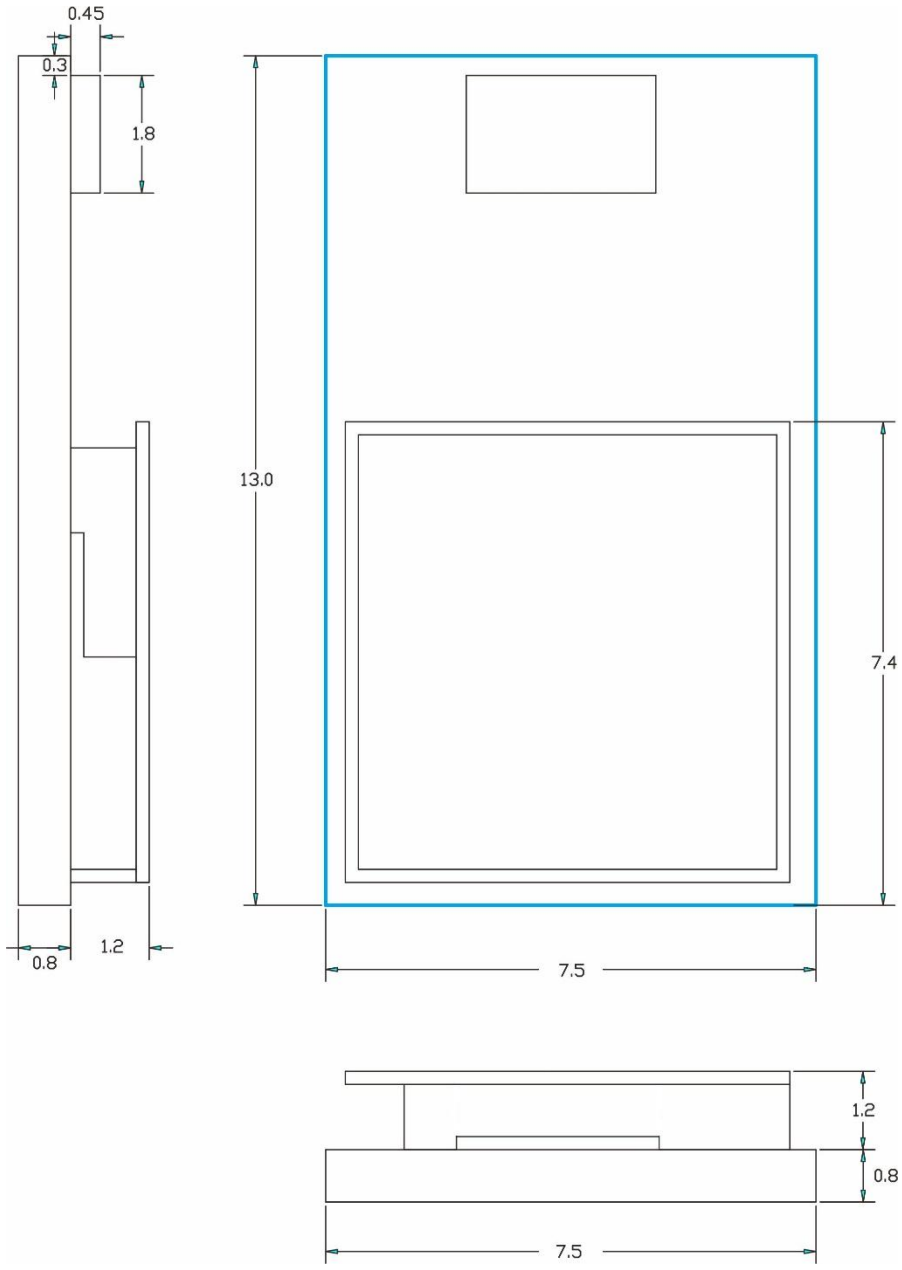
- **Coprocessor**
  - RISC-V 128MHZ Coprocessor

- **Operating condition**
  - 1.7 V to 3.6 V supply and I/O voltage
  - Single 32 MHz crystal operation
  - Optional 32.768 kHz clock
  - Operating temperature from -40°C to 85°C

• Peripherals

- 30 general purpose I/O pins
- High-Speed USB interface(USBHS)
- Global RTC (GRTC) that can run in System OFF mode and implement a shared system timer
- Seven 32-bit timers with counter mode
- Two individual watchdog timers for secure and non-secure context (WDT)
- Up to seven fully featured serial interfaces with EasyDMA ,supporting I2C, SPI and UART
    - One high-speed SPIM up to 32 MHz, six up to 8 MHz
    - One high-speed UARTE up to 4 Mbps, six up to 1 Mbps
    - Six TWI up to 400 kHz and I2C compatible
- I2S two channel Inter-IC sound interface
- Pulse density modulation (PDM) interface
- Three pulse width modulation (PWM) four-channel units with autonomous waveform generator.
- SAADC with up to eight programmable gain channels.
  14-bit at 62.5ksps, 12-bit at 125 ksps, and up to 10-bit at 2 Msps.
- Two quadrature decoders (QDEC)
- Comparator and low-power comparator with wake-up from System OFF mode
- Temperature sensor

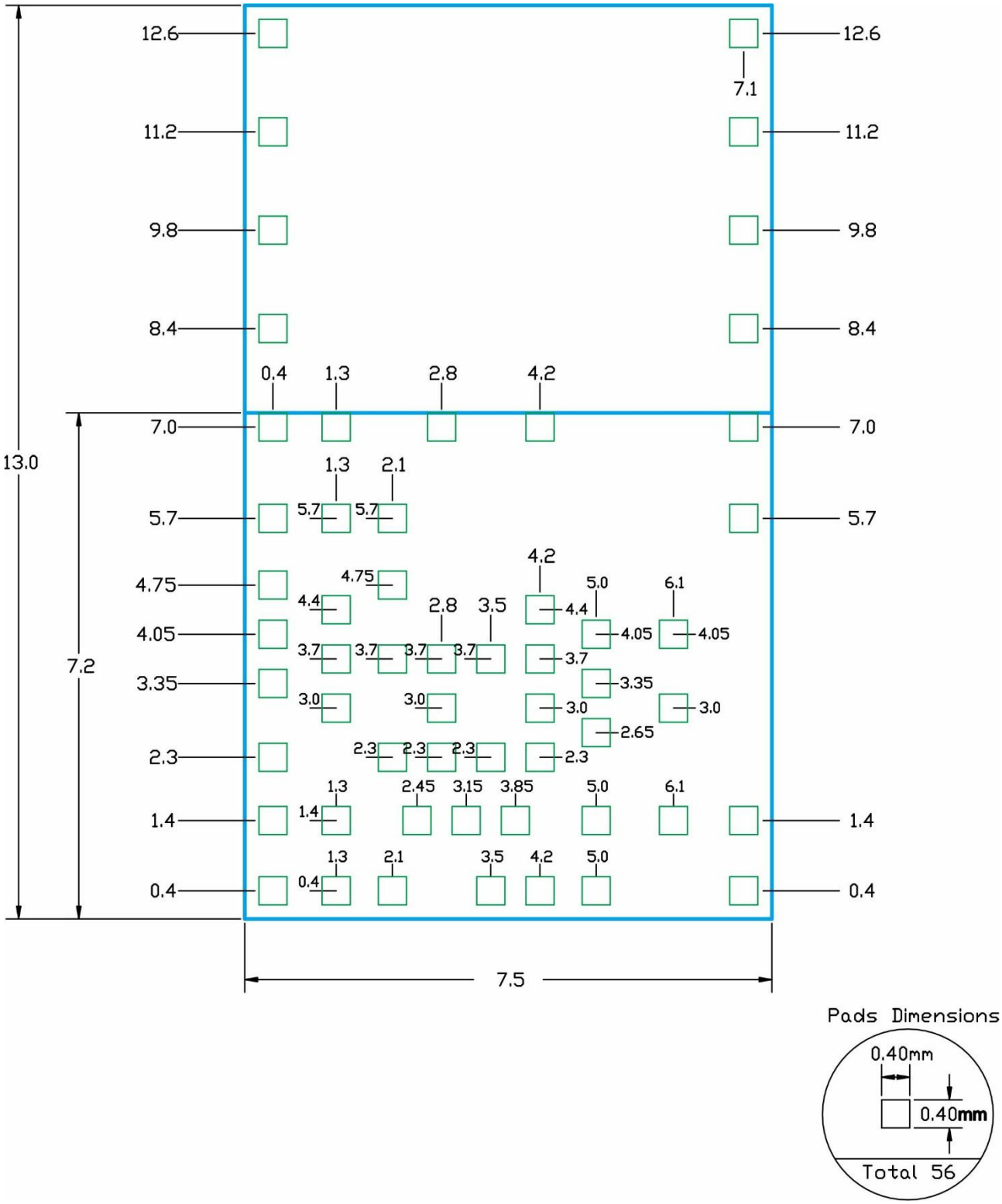
2.1 Dimensions



All dimensions are in millimeters.

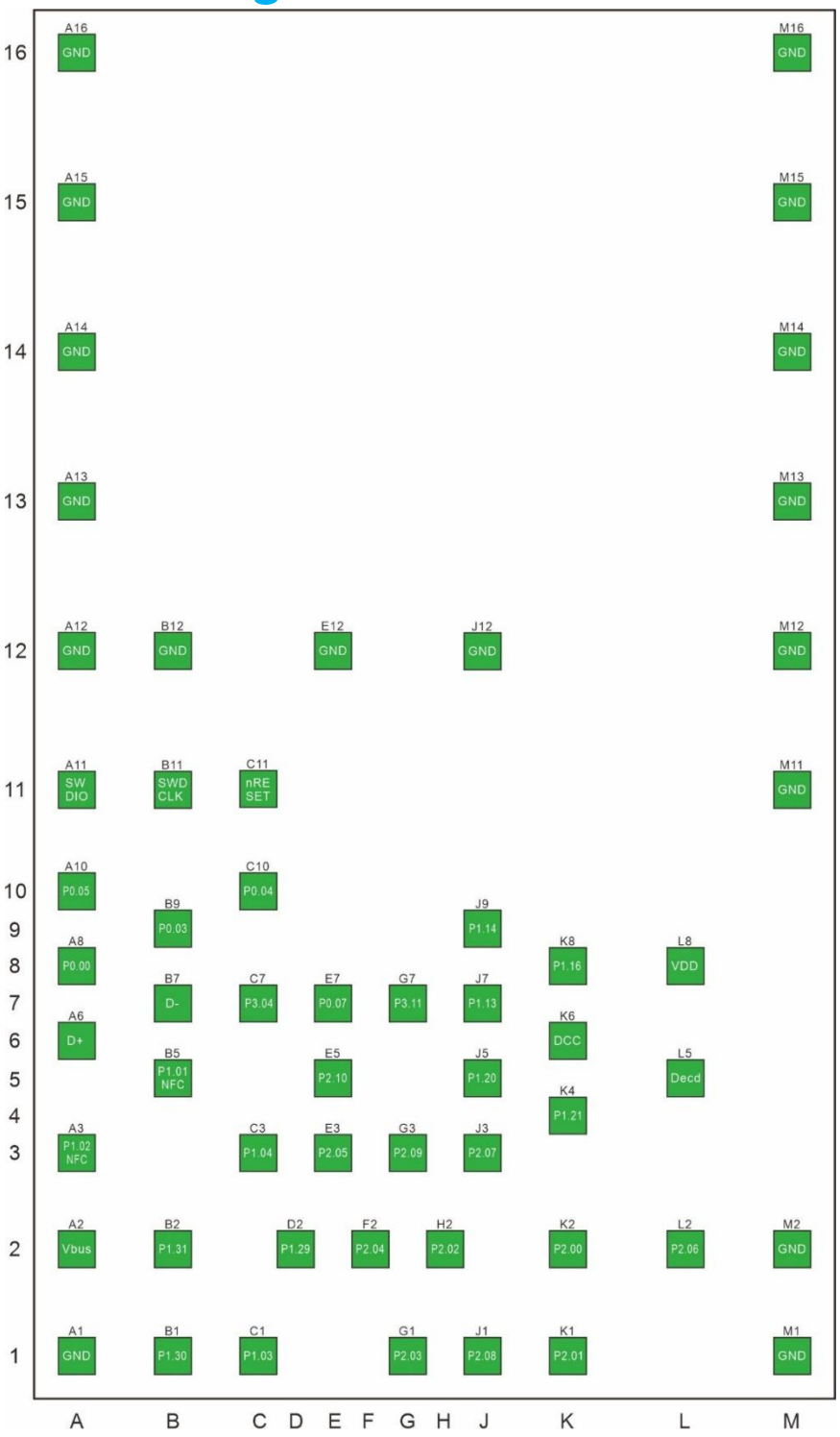
Item	Dimension	Tolerance
Length	13.0mm	±0.30 mm
Width	7.5mm	±0.30mm
Height	2.0mm	±0.30mm

2.2 Footprint



All dimensions are in millimeters.

3. Pin Assignment



Pin No.	Name	Pin function	Description
(A1)	GND	Ground	The pad must be connected to a solid ground plane
(A2)	VBUS	Power	USB 5V supply
(A3)	P1.02	Digital I/O	General-purpose I/O
	NFC2	NFC input	NFC antenna connection
(A6)	D+	Analog I/O	USB D+ line
(A8)	P0.00	Digital I/O	General-purpose I/O
(A10)	P0.05	Digital I/O	General-purpose I/O
(A11)	SWDIO	Debug	Serial wire data. Bidirectional with standard-drive and on-chip pull-up.
(A12)	GND	Ground	The pad must be connected to a solid ground plane
(A13)	GND	Ground	The pad must be connected to a solid ground plane
(A14)	GND	Ground	The pad must be connected to a solid ground plane
(A15)	GND	Ground	The pad must be connected to a solid ground plane
(A16)	GND	Ground	The pad must be connected to a solid ground plane
(B1)	P1.30	Digital I/O	General-purpose I/O
	AIN2	Analog input	Analog input
(B2)	P1.31	Digital I/O	General-purpose I/O
	AIN1	Analog input	Analog input
(B5)	P1.01	Digital I/O	General-purpose I/O
	NFC1	NFC input	NFC antenna connection
(B7)	D-	Analog I/O	USB D- line
(B9)	P0.03	Digital I/O	General-purpose I/O
	GRTC PWM	Clock PIN	GRTC PWM output
(B11)	SWDCLK	Debug	Serial wire clock. Input with on-chip pull-down.
(B12)	GND	Ground	The pad must be connected to a solid ground plane
(C1)	P1.03	Digital I/O	General-purpose I/O
	AIN7	Analog input	Analog input
		Clock pin	Can be set as TWI
(C3)	P1.04	Digital I/O	General-purpose I/O
	AIN6	Analog input	Analog input
		Clock pin	Can be set as TWI
(C7)	P3.04	Digital I/O	General-purpose I/O
		Clock pin	Can be set as TWI
(C10)	P0.04	Digital I/O	General-purpose I/O
	GRTCLFCLKOUT	Clock PIN	GRTC LF clock output
(C11)	nRESET	Reset	Pin reset with on-chip pull-up
(D2)	P1.29	Digital I/O	General-purpose I/O
	AIN3	Analog input	Analog input
(E3)	P2.05	Digital I/O	General-purpose I/O
		Digital I/O	SPIM/SPIS CSN
		Digital I/O	UARTE RTS
		Digital I/O	QSPI CSN

Pin No.	Name	Pin function	Description
(E5)	P2.10	Digital I/O	General-purpose I/O
		Digital I/O	SPIM/SPIS CSN
		Digital I/O	UARTE RTS
(E7)	P0.07	Digital I/O	General-purpose I/O
		Clock pin	Can be set as TWI
(E12)	GND	Ground	The pad must be connected to a solid ground plane
(F2)	P2.04	Digital I/O	General-purpose I/O
		Digital I/O	SPIM/SPIS SDI
		Digital I/O	UARTE CTS
		Digital I/O	QSPI D1
(G1)	P2.03	Digital I/O	General-purpose I/O
		Digital I/O	QSPI D2
(G3)	P2.09	Digital I/O	General-purpose I/O
		Digital I/O	SPIM/SPIS SDI
		Digital I/O	UARTE CTS
(G7)	P3.11	Digital I/O	General-purpose I/O
(H2)	P2.02	Digital I/O	General-purpose I/O
		Digital I/O	SPIM/SPIS SDO
		Digital I/O	UARTE TXD
		Digital I/O	QSPI D0
(J1)	P2.08	Digital I/O	General-purpose I/O
		Digital I/O	SPIM/SPIS SDO
		Digital I/O	UARTE TXD
(J3)	P2.07	Digital I/O	General-purpose I/O
		Digital I/O	SPIM DCX
		Digital I/O	UARTE RXD
(J5)	P1.20	Digital I/O	General-purpose I/O
	XL1	Analog input	Connection to 32.768kHz crystal (LFXO)
	Radio 5	Digital I/O	DFEGPIO : Direction Finding Antenna select GPIO
(J7)	P1.13	Digital I/O	General-purpose I/O
		Clock pin	Can be set as TWI
(J9)	P1.14	Digital I/O	General-purpose I/O
		Clock pin	Can be set as TWI
(J12)	GND	Ground	The pad must be connected to a solid ground plane
(K1)	P2.01	Digital I/O	General-purpose I/O
		Clock PIN	SPIM/SPIS SCK
		Clock PIN	QSPI SCK
(K2)	P2.00	Digital I/O	General-purpose I/O
		Digital I/O	SPIM DCX
		Digital I/O	UARTE RXD
		Digital I/O	QSPI D3
(K4)	P1.21	Digital I/O	General-purpose I/O
	XL2	Analog input	Connection to 32.768kHz crystal (LFXO)
	Radio 6	Digital I/O	DFEGPIO : Direction Finding Antenna select GPIO

Pin No.	Name	Pin function	Description
(K6)	DCC	Power	DC/DC regulator output
(K8)	P1.16	Digital I/O	General-purpose I/O
	Radio 1	Digital I/O	DFEGPIO : Direction Finding Antenna select GPIO
(L2)	P2.06	Digital I/O	General-purpose I/O
		Clock PIN	SPIM/SPIS SCK
(L5)	DECD	Power	0.9 V regulator supply decoupling
(L8)	VDD	Power	Power supply
(M1)	GND	Ground	The pad must be connected to a solid ground plane
(M2)	GND	Ground	The pad must be connected to a solid ground plane
(M11)	GND	Ground	The pad must be connected to a solid ground plane
(M12)	GND	Ground	The pad must be connected to a solid ground plane
(M13)	GND	Ground	The pad must be connected to a solid ground plane
(M14)	GND	Ground	The pad must be connected to a solid ground plane
(M15)	GND	Ground	The pad must be connected to a solid ground plane
(M16)	GND	Ground	The pad must be connected to a solid ground plane

3.1 GPIO Recommended usage

Module PIN N0.	NRF54LM20A GPIO	Recommended usage
QSPI		
K2	P2.00	QSPI D3
K1	P2.01	QSPI SCK
H2	P2.02	QSPI D0
G1	P2.03	QSPI D2
F2	P2.04	QSPI D1
E3	P2.05	QSPI CSN
TWI (Note: TWIM and TWIS must use clock pins for both SDA and SCL)		
B9	P0.03	TWI
C10	P0.04	TWI
E7	P0.07	TWI
C1	P1.03	TWI
C3	P1.04	TWI
J7	P1.13	TWI
J9	P1.14	TWI
C7	P3.04	TWI
UARTE 00		
K2	P2.00	RXD
H2	P2.02	TXD
F2	P2.04	CTS
E3	P2.05	RTS
UARTE 00		
J3	P2.07	RXD
J1	P2.08	TXD
G3	P2.09	CTS
E5	P2.10	RTS
SPI 00		
K2	P2.00	SPIM DCX
K1	P2.01	SPIM/SPIS SCK
H2	P2.02	SPIM/SPIS SDO
F2	P2.04	SPIM/SPIS SDI
E3	P2.05	SPIM CSN

SPI 00		
L2	P2.06	SPIM/SPIS SCK
J3	P2.07	SPIM DCX
J1	P2.08	SPIM/SPIS SDO
G3	P2.09	SPIM/SPIS SDI
E5	P2.10	SPIM CSN
NFC		
B5	P1.01	NFC1
A3	P1.02	NFC2
PWM		
	Port 1	PWM
	Port 3	PWM
Clock Output		
C10	P0.04	GRTC LF clock output (32.768KHZ)
Analog Input		
B2	P1.31	AIN1
B1	P1.30	AIN2
D2	P1.29	AIN3
C3	P1.06	AIN6
C1	P1.03	AIN7
Radio (Direction Finding Antenna select GPIO)		
K8	P1.16	Radio 1
J5	P1.20	Radio 5
K4	P1.21	Radio 6

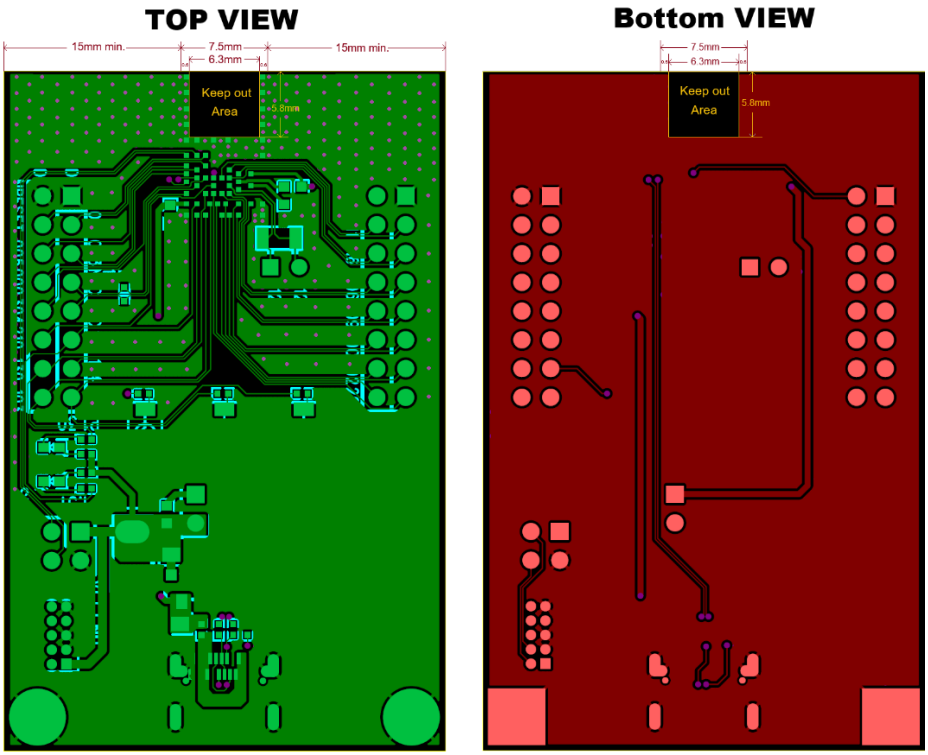
Port Special function and characteristics					
Port	Wakeup source	Extra high drive	Pin sense /detect	GPIOTE	Maximum speed(MHz)
P0	Yes	No	Yes	Yes	8
P1	Yes	No	Yes	Yes	8
P2	No	Yes	No	No	64
P3	Yes	No	Yes	Yes	8

4 Layout design notes

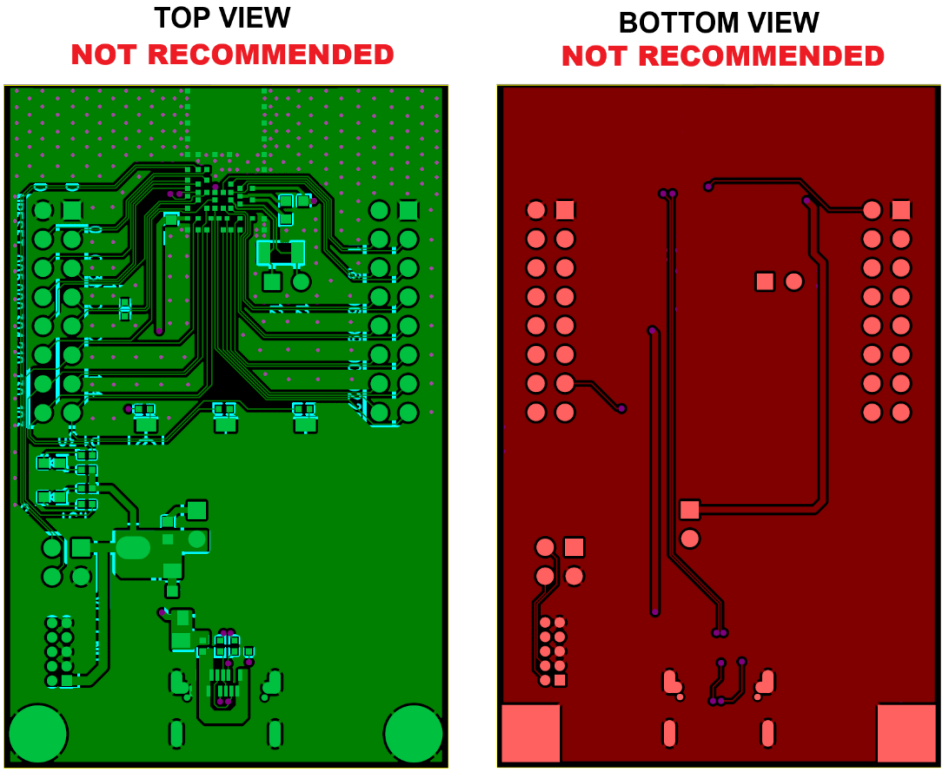
4.1 Recommended RF layout and ground plane

It is recommended to place the module:

- In the center (horizontal) of any mother PCB edge, with GND planes to the left and right
- Keep out Area should be included in the corresponding position of the antenna in each layer.
- Add via hole around GND pads on the mother PCB as many as you can, especially on the four corners and antenna area.



4.2 Not Recommended RF layout and ground plane



4.3 Antenna keep out when proximity to Metal

• The minimum safe distance for metals without seriously compromising the antenna tuning is 4cm (bottom, top, left, right).
• Metal close to the antenna (bottom, top, left, right) will degrade RF performance. Any metal closer than 2 cm will significantly degrade RF performance.

5.1 Operation Conditions

Parameter	Min.	Max.	Unit
Supply voltage			
VDD	-0.3	+3.9	V
VSS		0	V
VBUS	-0.3	+6.0	V
I/O pin voltage			
$V_{I/O}$, VDD ≤3.6 V	-0.3	VDD+0.3	V
$V_{I/O}$, VDD >3.6 V		3.9	V
Environmental			
Storage temperature	-40	+125	°C
	Recommended storage temperature<40°C		
	Recommended storage relative humidity <70%		
MSL (moisture sensitivity level)		3	
ESD HBM (human body model)		2	KV
ESD CDM (charged device model)		250	V
Flash memory			
Endurance		10,000	Write/erase cycles
Retention		10 years at 85°C	

5.2 System Clock

The MN54LMrequires two clocks, a high frequency clock and a low frequency clock.
MN54LM

- The high frequency clock (HFCLK)

HFCLK is provided on-module by a high-accuracy 32 MHz/±20 ppm crystal for radio and CPU operation.

- The low frequency clock (LFCLK)

LFCLK can be provided internally by an RC oscillator (±250 ppm) with calibration, or externally by a 32.768 kHz crystal.

Internal 32.768 kHz RC oscillator (LFRC)

Description	Min.	Typ.	Max.	Unit
Nominal frequency		32.768		kHz
Frequency tolerance for LFRC after calibration (calibration performed at least every 8 seconds)			±500	ppm
Run current for 32.768 kHz RC oscillator		0.7		uA
Startup time for 32.768 kHz RC oscillator		1000		us

External 32.768 kHz crystal oscillator (LFXO)

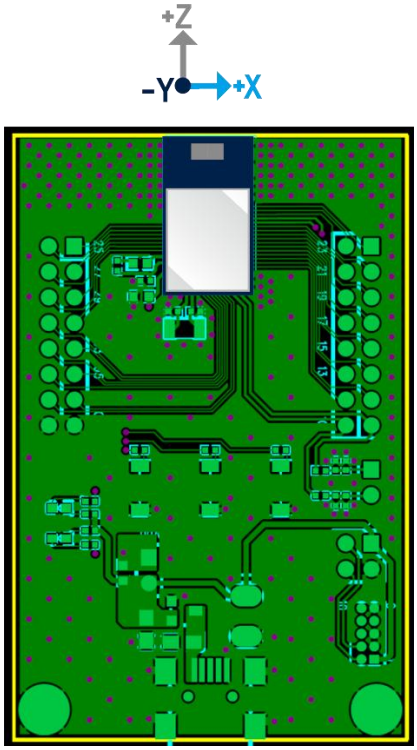
Parameter	Description	Min.	Typ.	Max.	Unit
	Crystal frequency		32.768		kHz
	Frequency tolerance requirement for BLE stack			±500	ppm
	Frequency tolerance requirement for ANT stack			±50	ppm
	Run current for 32.768 kHz crystal oscillator		0.23		uA
CL	Load capacitance	6		9	pF

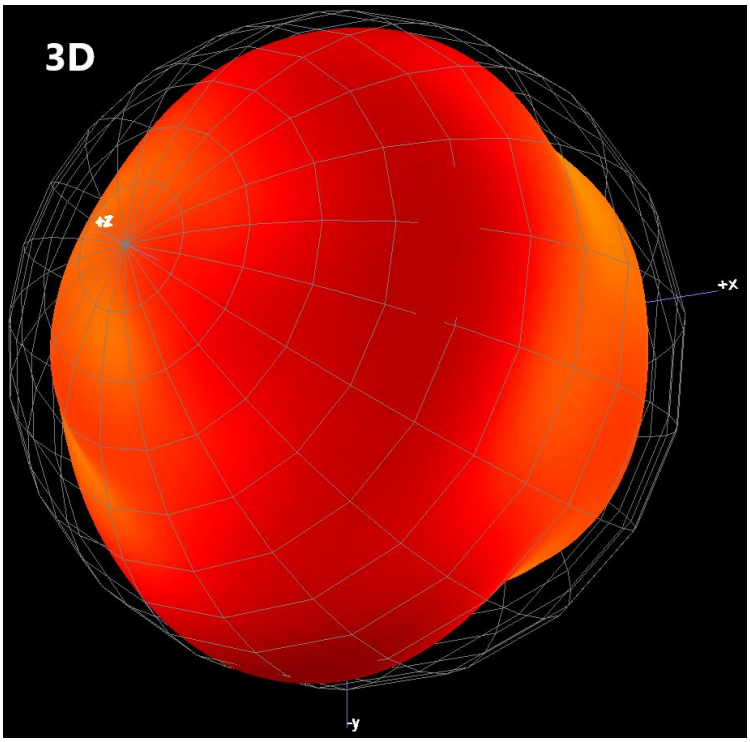
An external crystal provides the lowest power consumption and greatest accuracy.

Using the internal RC oscillator with calibration provides acceptable performance for BLE stack at a reduced cost and slight increase in power consumption.

5.3 Antenna information

5.3.1 The orientation of Antenna

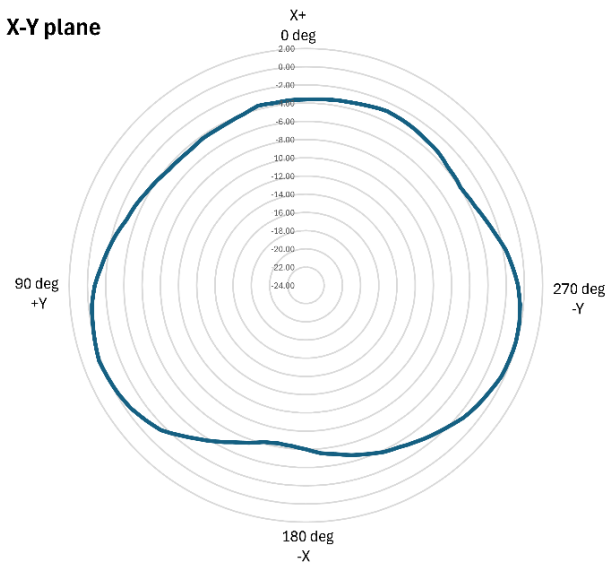


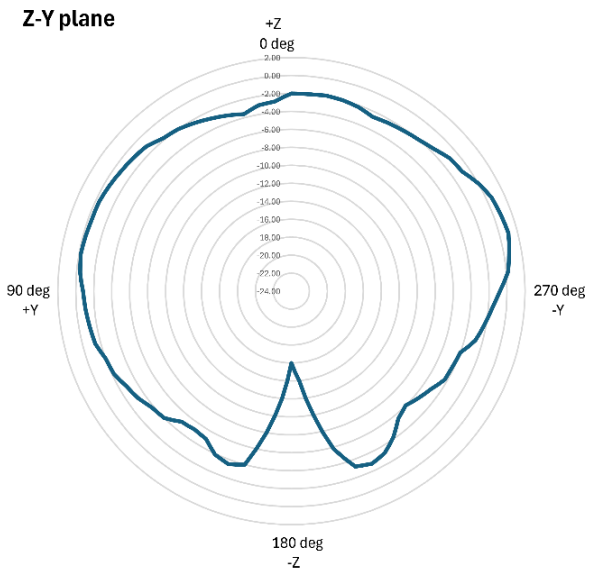


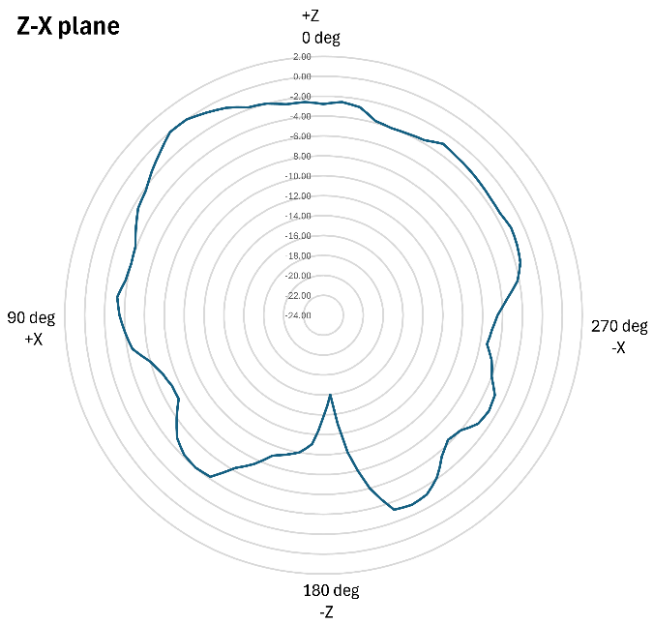
5.3.2 Antenna Gain and Efficiency

Frequency	Gain(dBi)	Efficiency
2400MHZ	-0.21	42
2410MHZ	0.22	45
2420MHZ	0.52	47
2430MHZ	0.92	50
2440MHZ	1.05	51
2450MHZ	0.87	50
2460MHZ	0.62	48
2470MHZ	0.43	44
2480MHZ	0.19	40
2490MHZ	-0.27	35

5.3.3 Antenna Pattern 2D







6. BN54LM-C20 evaluation board

BN54LM-C20 is a full-featured evaluation board for MN54LM-C20 that supports:

M1:MN54LM-C20 module

J6: USB Type C

J3/J4: Complete I/O pinout to headers

J1/J2: On-board programming and debugging interface

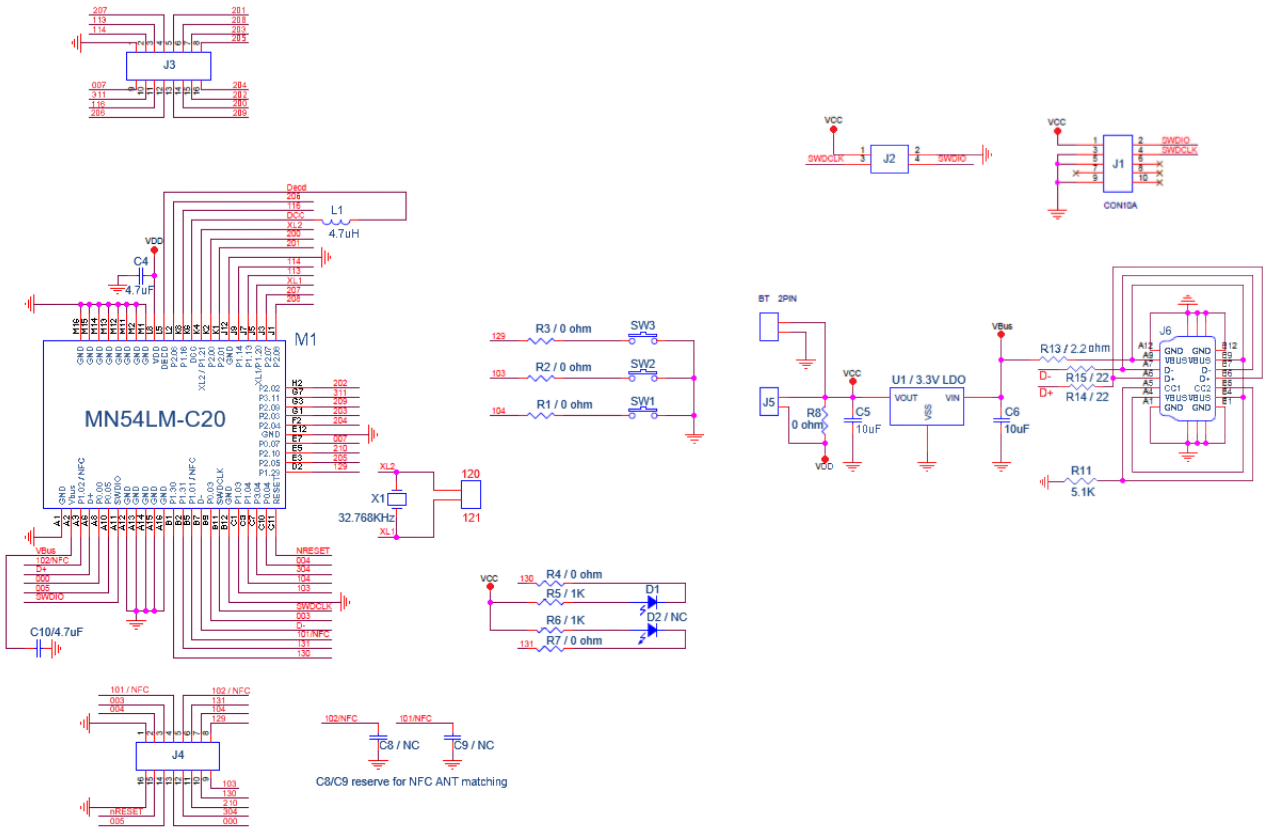
X1:32.768 kHz crystal

D1: One user LED

SW1/SW2/SW3: Three user buttons

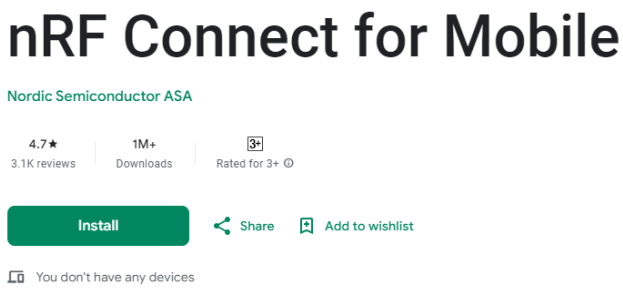
C8/C9: NFC ANT matching

L1: DC-TO-DC power inductor

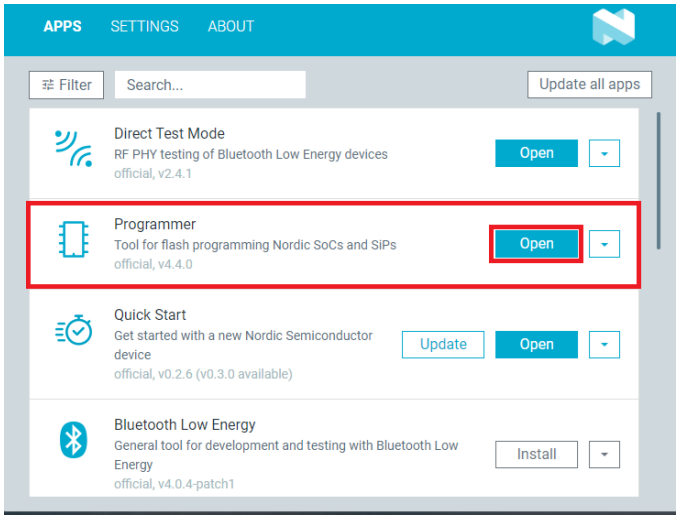


7. How to programming your code

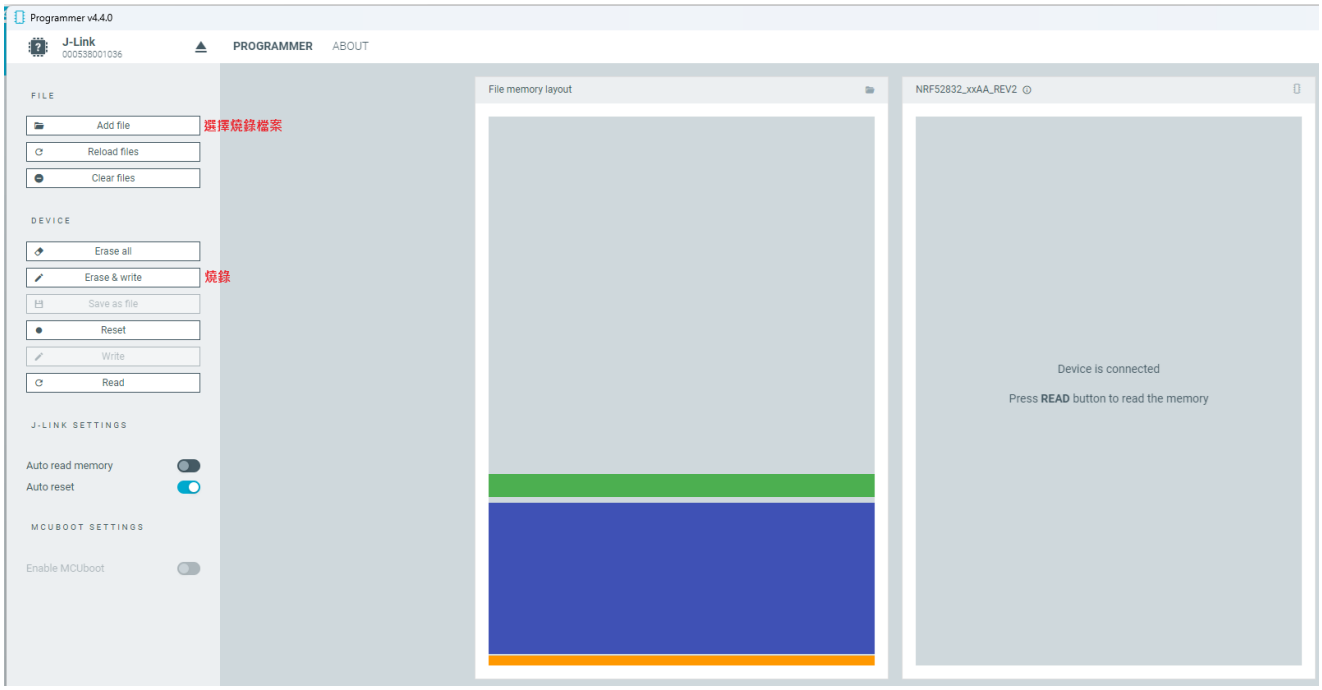
7.1 Download NRFConnect for Desktop



7.2 Open programmer



7.3 chose your hex file



8.1 USA (FCC Certificate)

8.1.1 FCC ID and Labeling requirements

The MN54LM series hold full modular certification, are assigned the

FCC ID number: 2BLIDMN54LM

If the FCC ID is not visible when the module is installed inside OEM device, then the outside of the finished product must also display a label referring to the enclosed module. The end product must in any case be labelled on the exterior with:

Contains FCC ID: 2BLIDMN54LM

8.1.2 Federal Communication Commission Interference Statement:

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation.
This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one of the following measures:

- **Reorient or relocate the receiving antenna.**
- **Increase the separation between the equipment and receiver.**
- **Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.**
- **Consult the dealer or an experienced radio/TV technician for help.**

***FCC Caution*: To assure continued compliance, any changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate this equipment. (Example - use only shielded interface cables when connecting to computer or peripheral devices).**

FCC Radiation Exposure Statement

This equipment complies with FCC RF radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance of 20 centimeters between the radiator and your body.

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

The antennas used for this transmitter must be installed to provide a separation distance of at least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

8.1.3 FCC Notice:

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions:
(1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

8.1.4 RF Exposure Statement:

This module is approved for installation into mobile and/or portable host platforms.

This device is intended only for OEM integrators under the following conditions:
(1) The transmitter module may not be co-located with any other transmitter or antenna.
(If the condition above is met, further transmitter test will not be required.)

(2) The OEM integrator is still responsible for testing their end-product for any additional compliance requirements required for satisfying RF Exposure compliance when this module installed.

8.2 NCC Certificate (Taiwan)

8.2.1 NCC ID and Labeling requirements
MN54LM 系列依天線不同,可分為 **4** 種型式 **,** 認證為 **4** 個不同的 **NCC ID**

NCC logo and NCC ID

MN54LM-C : **CCAH**

MN54LM-P : **CCAH**

MN54LM-S : **CCAH**

MN54LM-U: **CCAH**

NCC 警語:

「取得審驗證明之低功率射頻器材，非經核准，公司、商號或使用者均不得擅自變更頻率、加大功率或變更原設計之特性及功能。低功率射頻器材之使用不得影響飛航安全及干擾合法通信；經發現有干擾現象時，應立即停用，並改善至無干擾時方得繼續使用。前述合法通信，指依電信管理法規定作業之無線電通信。低功率射頻器材須忍受合法通信或工業、科學及醫療用電波輻射性電機設備之干擾。」