

WM02C/E/V Compact, WiFi 6 Companion Modules

Ver 0.93, July 2023

WM02C Series module is a powerful, highly flexible, ultra low power WiFi 6 module using Nordic nRF7002 SoC. With an integrated PCB trace antenna, a chip antenna, an u.FL, or pads for an external antenna, it allows faster time to market with reduced development cost.

A series of nRF5340 or nRF52840 modules can manage WiFi 6 modules through SPI interface. Some are certified or being certified for both BLE and Thread. The ideal modules for Matter applications.



Specifications:

- Nordic nRF7002 SoC.
- Low-power and secure Wi-Fi for the IoT
- Ideal coexistence with Bluetooth LE
- Supports IEEE 802.11 a/b/g/n/ac/ax
- Supports Target Wake Time (TWT), Orthogonal Frequency Division Multiple Access (OFDMA, Downlink and Uplink), BSS coloring
- WiFi CERTIFIED 6™, WiFi CERTIFIED™ a/b/g/n/ac, WiFi Enhanced Open™.
- Supports WPA3™, WPA2™, WPA™ - Personal and Enterprise, Protected Management Frames.
- Supports WMM®, WMM-Power Save, WiFi Agile Multiband™, WiFi Direct®.
- 2.4 GHz and 5 GHz dual-band or 2.4 GHz only
- Adjustable TX power from +5 to +19 dBm.
- Power consumption:
 - 165 mA @+15 dBm TX, 2.4 GHz, MCS7, Vbat=3.6V; 56 mA RX.
 - 244 mA @+15 dBm, 5 GHz, MCS7, Vbat=3.6V; 58 mA RX.
- SPI / QSPI
- Wi-Fi 6 Station (STA)
- 1 Spatial Stream (SS)

- 20 MHz channel bandwidth
- 64 QAM (MCS7), 86 Mbps PHY throughput
- Co-existence interfaces
- 16 castellated pins.
- Integrated shield to resist EMI
- 40 MHz main crystal on board.
- Operation voltage: 2.9V to 4.5V
- Operation temperature: -40°C to +85°C
- FCC ID:
- ISED ID:
- CE:
- Japan:
- Australia RCM:

Bluetooth Host Modules

Matter applications, Certified or being certified for BLE and Thread.

- nRF5340: BT40/BT40E/BT40F; BT40N/BT40NE(with nRF21540 PA).
- nRF52840: BT840/BT840E/BT840F; BT840N/BT840NE (with nRF21540 PA).

Certified for BLE only

- nRF5340: BC40P/BC40C/BC40M.
- nRF52840: BC840/BC840M/BC840E; BM840/BM840P; BT840X/BT840XE (with SKY66112 PA)

Model Summaries

module	WM02C	WM02V	WM02E	WM02P	WM02F
SoC	nRF7002	nRF7002	nRF7002	nRF7002	nRF7002
WiFi 6 frequencies	2.4GHz + 5GHz	2.4GHz+5GHz	2.4GHz+5GHz	2.4GHz+5GHz	2.4GHz+5GHz
Size, mm	12x20	12x25.2	12x16.2	12x12.4	12 (15.1) x23.8
BT Antenna	Chip	Chip	u.FL	Pads	High performance PCB
2.4GHz range, iPhone 14	217 meters	234 meters	200 meters		234 meters
5GHz range, iPhone 14	383 meters	403 meters	400 meters		337 meters
Availability	Sample	Sample	Sample	Sample	Sample

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1. Introduction

WM02C, WM02E, WM02P, and WM02V companion module uses a Nordic nRF7002 SoC. It supports 802.11 a/b/g/n/ac/ax in the 2.4 GHz and 5 GHz bands. All companion modules are referred as WM02C in this product specifications.

Nordic application examples use an nRF52840 or an nRF5340 SoC to manage nRF7002. Fanstel offers many nRF52840 and nRF5340 modules.

For matter application, the following modules are certified or will be certified for both BLE and Thread.

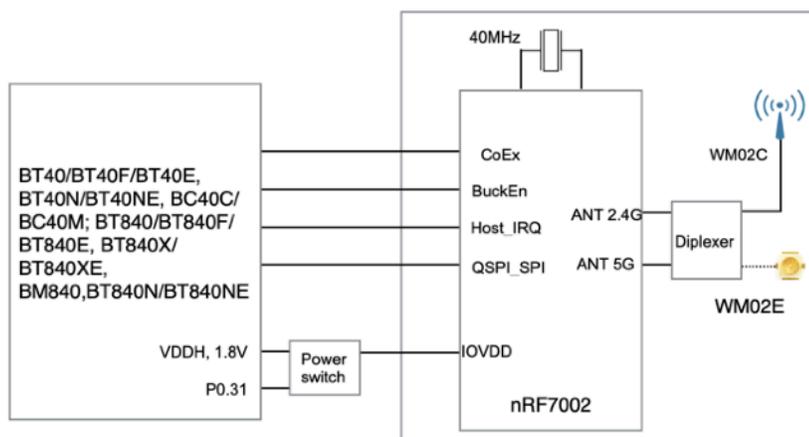
- BT840, BT840E, BT840F, nRF52840 modules certified for BLE and Thread.
- BT40, BT40E, BT40F, nRF5340 modules certified for BLE, Thread certification pending in Q1 2023.
- BT840N, BT840NE, nRF52840+nRF21540 modules. BLE and Thread certifications pending in Q1, 2023.
- BT40N, BT40NE, nRF5340+nRF21540 modules. BLE and Thread certifications pending in Q1, 2023.

The following modules can manage WM02C in WiFi 6 applications. They are certified for BLE. Fanstel has no plan for Thread certification.

- BC40C, BC40M, BC40P, compact nRF5340 modules.
- BC840, BC840M, BC804E, compact nRF52840 modules.
- BM840, BM840P, the lowest cost nRF52840 modules.
- BT840X, BT840XE, nRF51840 + SKY66112 PA modules.

WM02C Block Diagram

The block diagram of WM02C and WM02E is below.



WM02C WiFi 6 Module

- Uses an nRF7002.
- Supports 802.11 a/b/g/n/ac/ax.
- Both 2.4 GHz and 5GHz bands.
- 16 castellated pins
- Integrated horizontal chip antenna
- Size: 12x20x1.9mm.



WM02V WiFi 6 Module

- Uses an nRF7002.
- Supports 802.11 a/b/g/n/ac/ax.
- Both 2.4 GHz and 5GHz bands.
- 16 castellated pins
- Integrated vertical chip antenna
- Size: 12x25.2x1.9mm.



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WM02E WiFi 6 Module

- Uses an nRF7002.
- Supports 802.11 a/b/g/n/ac/ax.
- Both 2.4GHz and 5GHz bands.
- 16 castellated pins
- An u.FL connector for external antenna.
- Size: 12x16.2x1.9mm



WM02F WiFi 6 Module

- Uses an nRF7002.
- Supports 802.11 a/b/g/n/ac/ax.
- Both 2.4GHz and 5GHz bands.
- 16 castellated pins
- A high performance PCB antenna
- Size: 12 (15.1 in antenna area) x23.8x1.9mm



WM02P WiFi 6 Module

- Uses an nRF7002.
- Supports 802.11 a/b/g/n/ac/ax.
- Both 2.4GHz and 5GHz bands.
- 16 castellated pins
- Pads for antenna connection on the host board.
- Size: 12x12.4x1.9mm



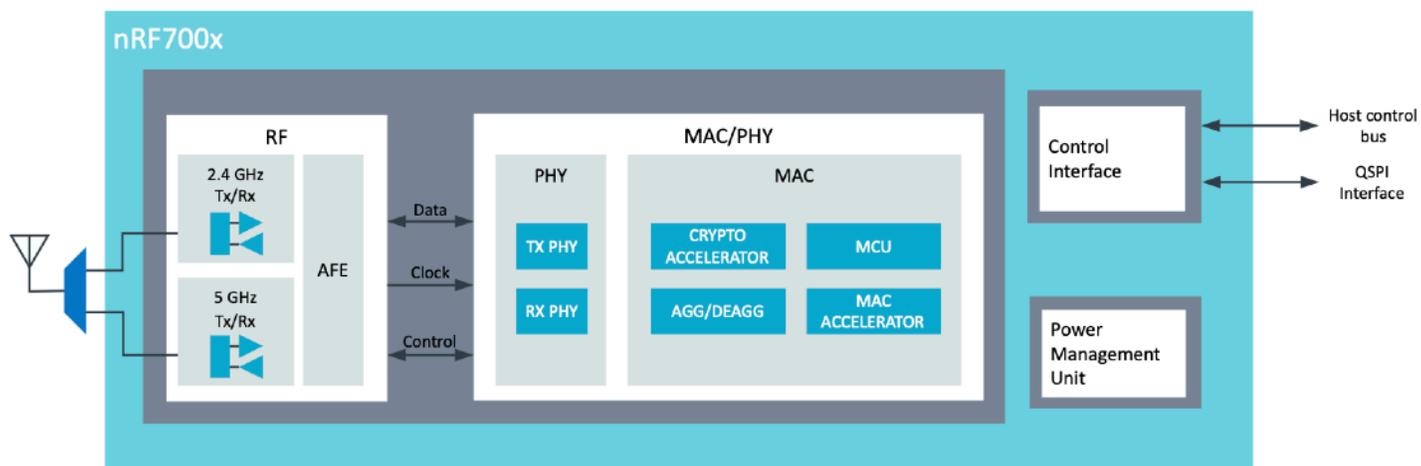
2. Product Descriptions

Brief description of nRF7002 SoC is provided. For full description of the SoC, please download from Nordic Semiconductor website.

<https://www.nordicsemi.com/Products/nRF7002>

Block Diagram of nRF7002

The following is a block diagram of Nordic nRF7002 WiFi 6 SoC.



Low-power, advanced security, seamless coexistence

The nRF7002 is a companion IC, providing seamless [Wi-Fi](#) connectivity and [Wi-Fi-based locationing](#) (SSID sniffing of local Wi-Fi hubs). It is designed to be used alongside Nordic's existing nRF52® and nRF53® Series Bluetooth Systems-on-Chip (SoCs), and nRF91® Series cellular IoT Systems-in-Package (SiPs). The nRF7002 can also be used in conjunction with non-Nordic host devices.

The nRF7002 is the first device in our portfolio of unique Wi-Fi products that will combine seamlessly with Nordic's existing ultra-low power technologies. Nordic brings their decades of ultra-low-power wireless IoT and silicon design expertise to Wi-Fi. With Wi-Fi 6 we bring added benefits to IoT applications including further efficiency gains that support long-life, battery-powered Wi-Fi operation.

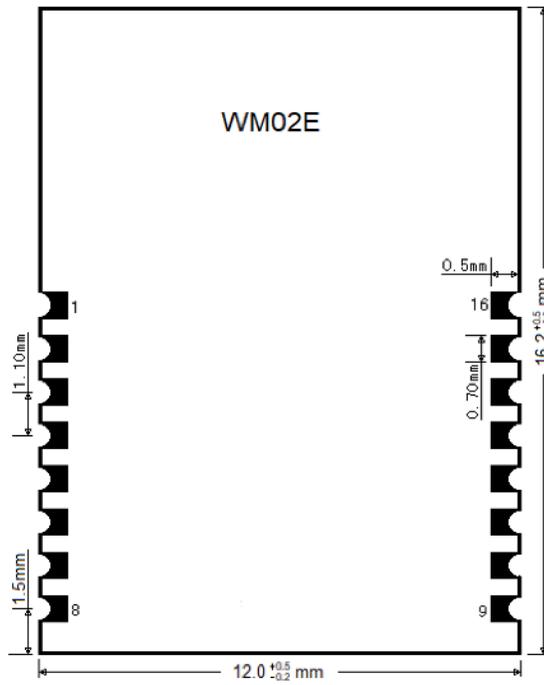
With Wi-Fi 6 we will support all wireless protocols used in [Matter](#), [Bluetooth LE](#) for commissioning, [Thread](#) for low power mesh, and Wi-Fi for high-throughput. Matter is a protocol championed by Apple, Amazon, Google, Nordic Semiconductor, Samsung, and hundreds of other companies in consumer IoT.

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Mechanical Drawings

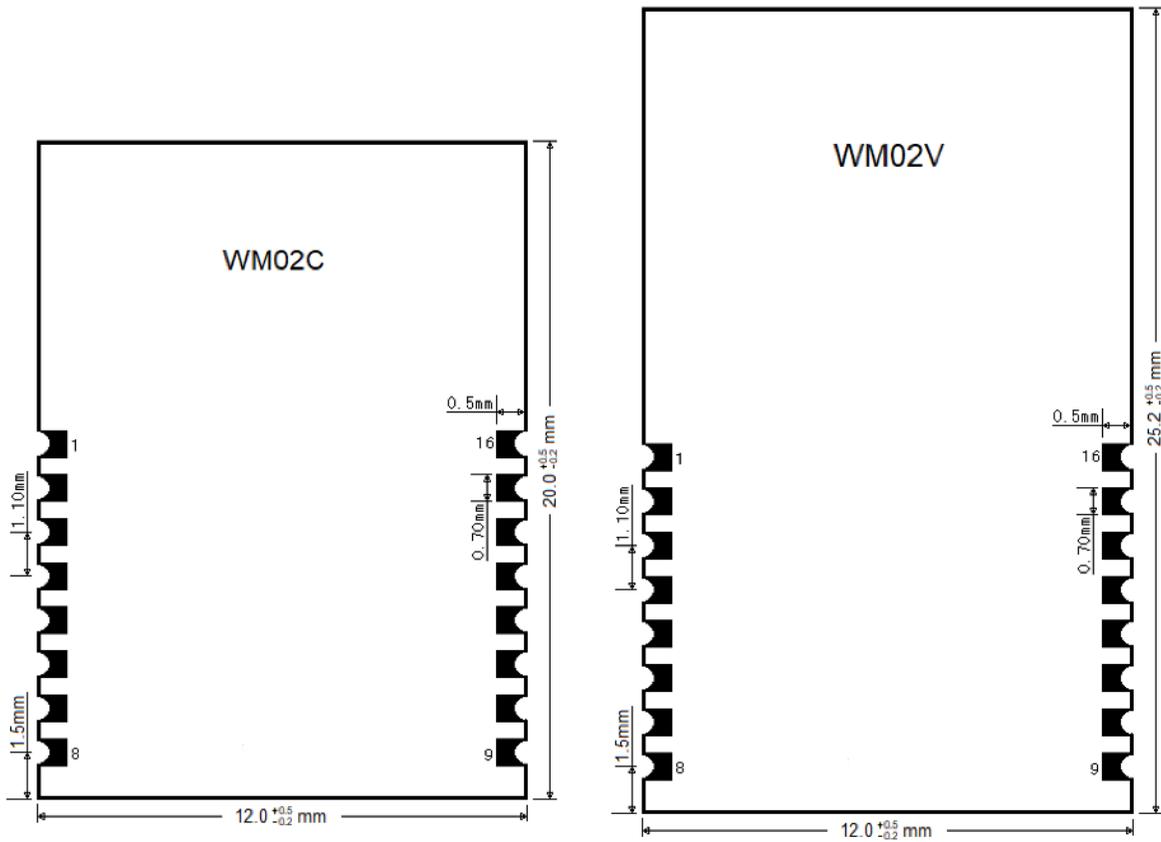
The followings are mechanical drawings of WM02E. Size is 12x16.2mm. It has 16 castellated pins. Top view of module is below.



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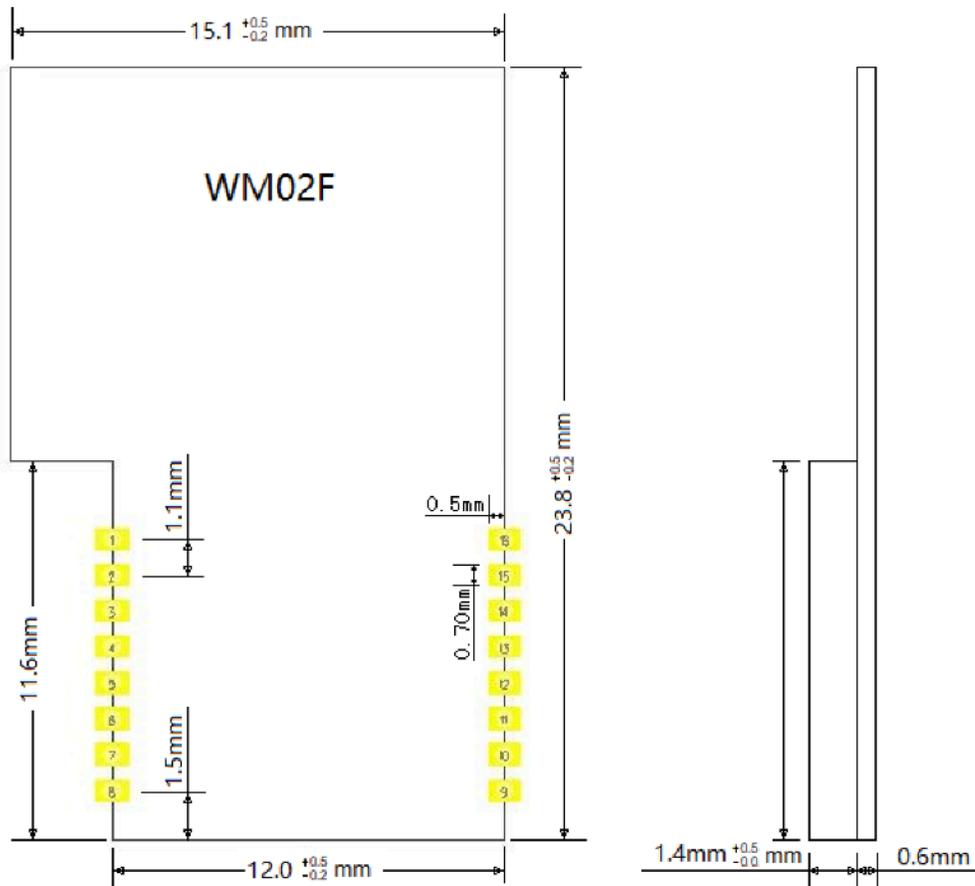
Mechanical drawings of WM02C and WM02V, top view, are below.



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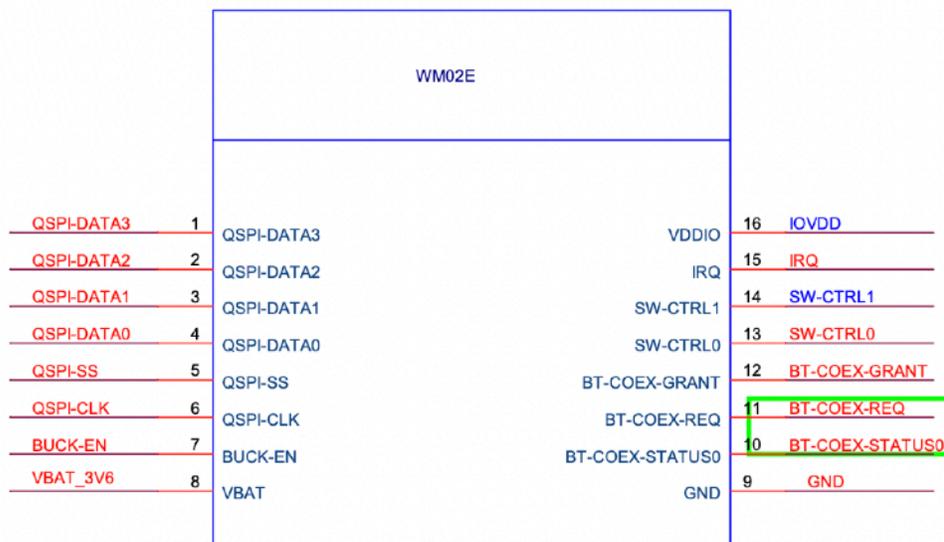
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Mechanical drawings of WM02F, top view.



Pin Assignments of WM02C

The followings are WM02C pin assignment. Pin functions are in a table in next section. Please refer to Nordic nRF7002 Product Specifications for detailed descriptions and features supported.



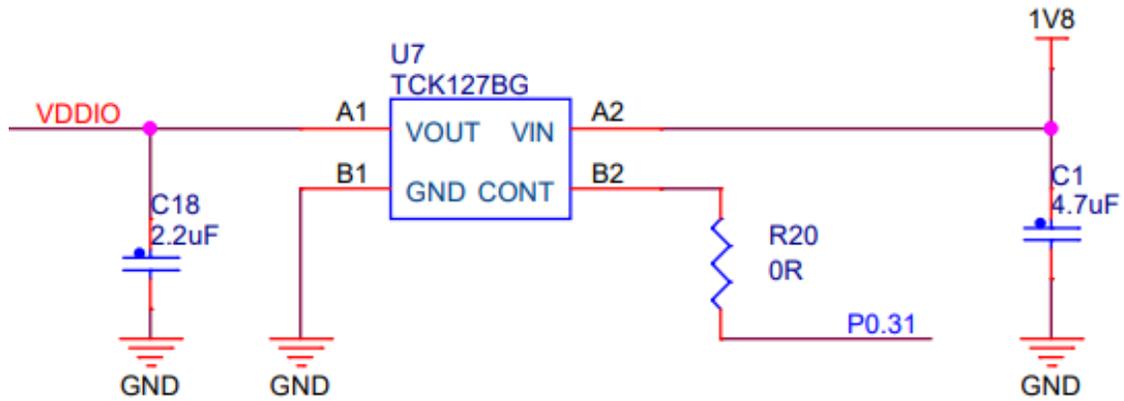
Short Range (SR) device in the following table is a Bluetooth/Thread (BT) device or an nR5340/nRF52840 module in the Fanstel applications.

Pin Function

WM02C	nRF7002	WM02C	Descriptions
pin#	pin#	pin name	Descriptions
1	40	QSPI-Data3	QSPI Data 3
2	39	QSPI-Data2	QSPI Data 2
3	38	DSPI-Data1	QSPI Data 1
4	37	QSPI-Data0	QSPI Data 0
5	36	QSPI-SS	GPIO, digital
6	35	QSPI-CLK	GPIO, digital
7	30	BuckEn	GPIO, digital
8	13	Vbat	VDD power supply voltage, 2.9 to 4.5V, typically 3.6V.
9	47	GND	Ground
10	41	BT-CoEx-Status0	Indicates if the SR transaction is TX or RX.
11	42	BT-CoEx-REQ	SR device requesting a TX/RX transaction
12	43	BT-CoEx-Grant	Indicates that the SR device is granted access for this transaction.
13	44	SW-CTRL0	Used for antenna switch control in shared antenna mode.
14	45	SW-CTRL1	In 4-wire mode, this carries the SR 1 bit priority signal. In 3-wire shared antenna mode, this can be optionally used as antenna switch control.
15	46	IRQ	Host processor interrupt request.
16	48	IOVDD	IO VDD power supply

Powering Up Sequence

Fanstel combo modules and evaluation boards use a Toshiba power switch in the following circuitry to control powering up sequence.



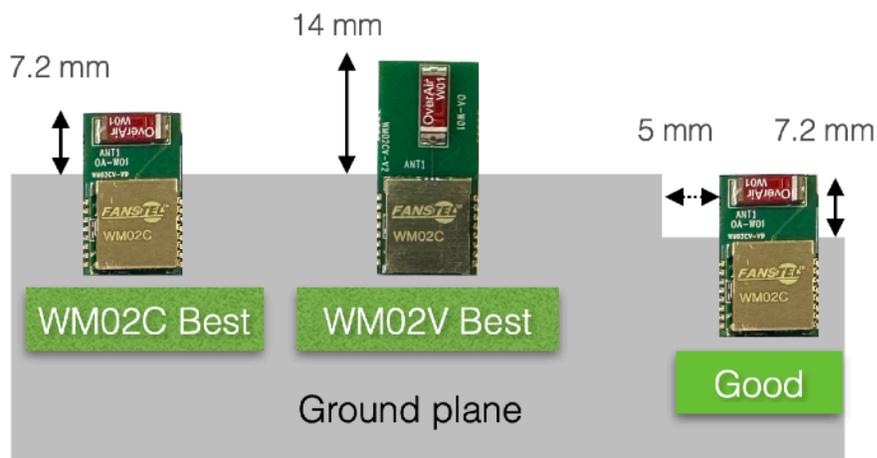
Please refer to the EV board schematics for connection to WM02C and its host BT40.

Mounting WM02C/V on the Host PCB

Suggestions for prototyping during module development in early 2023:

- The physical size of module with an u.FL or PCB antenna is likely to stay as specified.
- The antenna area of modules with a chip antenna can change as we are developing multiple versions with chip antennas from multiple suppliers. The modules with the best RF performance will be certified and in production. The module soldering pads are the same. The antenna area can be different. Please have clearance on your host board for expanded antenna area. Or, the entire antenna area of module be outside of the host board.

The following figure shows recommended mounting of WM02C and WM02V modules on the host PCB. There is no mounting restriction for WM02E with an u.FL connector.



- For the best WiFi range performance, the antenna area of WM02C module shall extend 7.2 mm outside the edge of host PCB board, or 7.2 mm outside the edge of a ground plane.
- For the best WiFi range performance, the antenna area of WM02C module shall extend 14 mm outside the edge of host PCB board, or 14 mm outside the edge of a ground plane.
- The next choice is to place WM02C on a corner of host PCB, the antenna area shall extend 7.2 mm from the edge of ground plane. Ground plane shall be at least 5 mm from the edge of the antenna area of module.
- We don't recommend mounting WM02C/V module in the middle of a host PCB.

For the best WiFi range performance, keep all external metal at least 30mm from the antenna area.

Host Board Layout

Library components for some PCB layout software are available. Or, it can be extracted from EV-WM02C evaluation board Gerber files. Gerber files can be downloaded from:

<http://www.fanstel.com/download-document/>.

3. WiFi Range Measurements

Description of measurement site, measurement methods, and range raw data between an iPhone 14 and a WiFi 6 module are available at:

<https://www.fanstel.com/wifirange>

Preliminary Measurement Results

- A WiFi module engineering sample is used to measure range with an iPhone 14.
- The WiFi module antenna is 2 meters above ground, pointing to the sky.
- A tester holds the iPhone 14, about 1.5 meters above ground.
- 12 measurements for each frequency band: Antenna facing iPhone for the first measurement, antenna rotates clockwise by 30 degrees after each measurement.
- Nordic SDK 2.3.0 is used in these measurement.
- We will re-measure WiFi ranges with SDK 2.5.0 when available.

Module	Freq.	WiFi ranges with an iPhone 14, rotate clockwise by 30 degrees after each measurement.												
		0	30	60	90	120	150	180	210	240	270	300	330	Average
WM02C	2.437G	230	235	225	220	215	215	210	210	210	210	210	215	217
WM02C	5.745G	380	385	385	386	390	382	382	380	385	382	382	375	383
WM02V	2.437G	230	240	260	250	250	240	234	215	220	215	220	230	234
WM02V	5.745G	400	405	405	406	406	400	400	403	400	405	408	402	403
WM02F	2.437G	280	270	260	260	200	210	220	220	220	220	220	230	234
WM02F	5.745G	385	390	350	380	375	370	370	350	350	270	240	210	337
WM02E	2.437G	200												200
WM02E	5.745G	400												400

Deployment Recommendations

- To have the best WiFi data reception, direct line of sight between 2 devices should be away from ground or wall.
- If one device must be installed closer to ground or a wall, install other devices far away from a wall or ground.
- Indoor condition is different for different building. We suggest testing WiFi data reception in the building with the worst case condition.

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4. WM02C Evaluation Board

An evaluation board consists of the followings:

- Mini USB cable
- Evaluation board with a BT40F module as the host MCU.
- 10-conductor cable for connection to Nordic nRF5340 DK(DK is not included)



Nordic Development Tools

A Nordic nRF5340-DK is recommended for programming this evaluation board. Nordic development tools can be downloaded from Nordic website.

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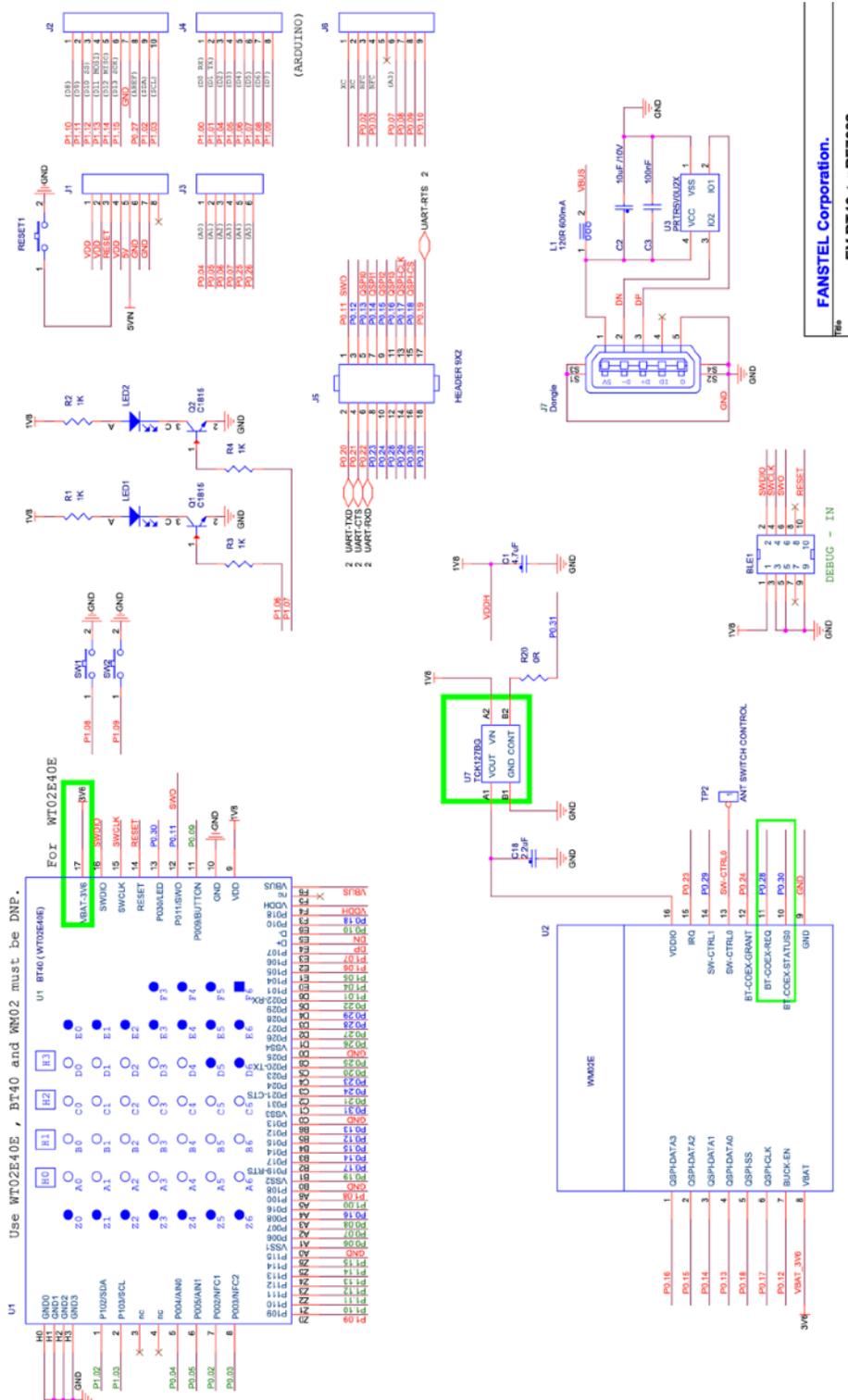
To program the BT40F module on the evaluation board:

- Download and set up on your Windows PC or MAC, nRF command line tool 10.2.1 or newer.
<https://www.nordicsemi.com/Software-and-Tools/Development-Tools/nRF-Command-Line-Tools/Download>
- Download and set up on your Windows PC or MAC, nRF Connect desktop 3.2.0 or newer.
<https://www.nordicsemi.com/Software-and-Tools/Development-Tools/nRF-Connect-for-desktop>
- Connect EV-WM02C to the **Debug out** connector of a Nordic nRF5340-DK.
- Use **nRF Connect** to program BT40F module on the EV board.

WM02C EvaluationBoard Schematics

Evaluation board can be used as a reference design for using modules. The first page of EV-WM02C schematics.

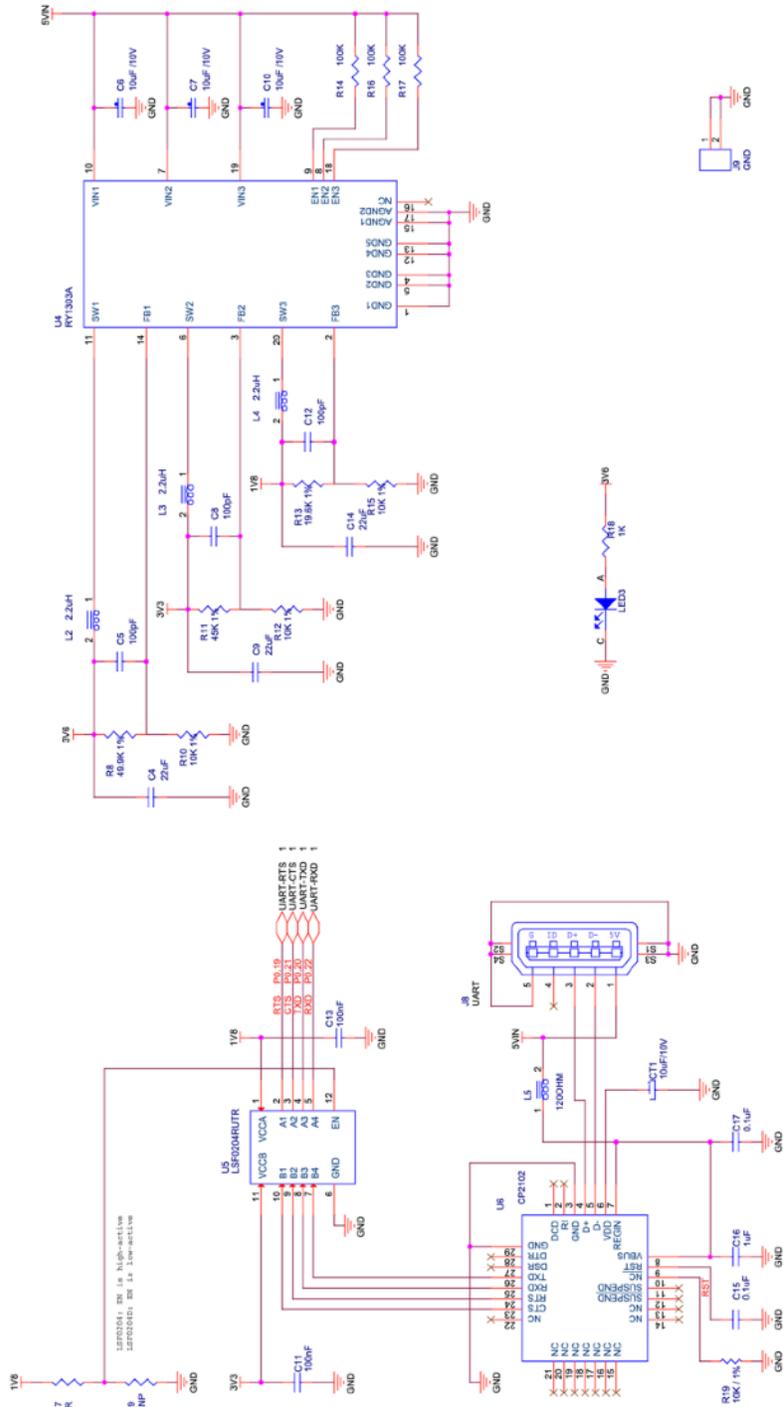
- A BT40/BT40F, nRF5340 module is mounted at the U1 location.
- The WiFi 6 module under evaluation, is mounted at the U2 location.
- A Toshiba power switch TCK127BG (U7) for power up sequencing is embedded in the WT02E40E series combo module. It is not embedded in the WM02C series companion module.



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The second page of EV-WM02C schematics.



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5. Production

Preloaded Firmware

Production testing codes are not erased before shipping from factory. To load your firmware, please erase the entire chip and re-program using instruction below.

```
//program BT840 Bootloader+Softdevice+Application hex
```

```
nrfjprog -f NRF52 --program BT840_AT_3in1PC181113.hex --chiperase --reset
```

```
//The file BT840_AT_3in1PC181113.hex = softdevice S140v6.1.1+BT840_AT_UARTwithout32K+bootloader
```

AT Command Codes

AT command codes are used for production testing. Up to date codes can be downloaded from:

<https://www.fanstel.com/download-document/>

You can erase and reprogram with your codes. Or, use AT command codes as preloaded.

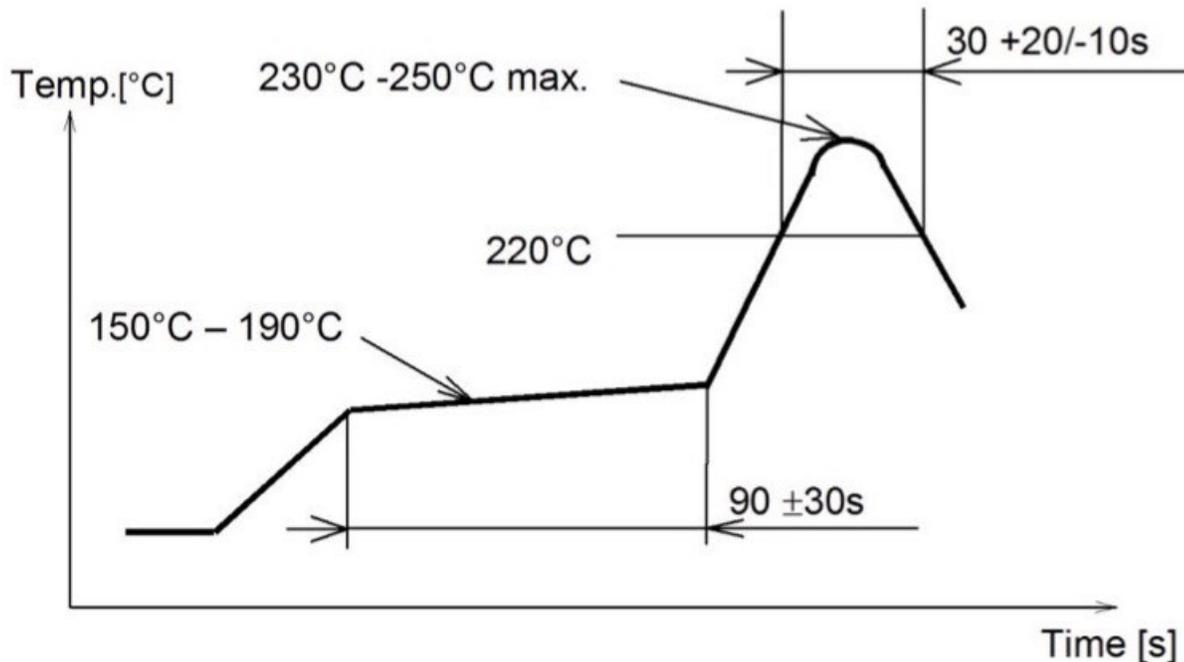
Because of the size of AT command codes, a bootloader is not included in BC805M. DFU OTA is not possible for the preloaded codes. However, it is possible to erase the preloaded codes and load your own codes with a bootloader through the SWDIO interface.

Programming services are available in factory with MOQ and programming charges.

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Soldering Temperature-Time Profile for Re-Flow Soldering

Maximum number of cycles for re-flow is 2. No opposite side re-flow is allowed due to module weight.



Cautions, Design Notes, and Installation Notes

Failure to follow the guidelines set forth in this document may result in degrading of the product's functions and damage to the product.

Design Notes

- (1) Follow the conditions written in this specification, especially the control signals of this module.
- (2) The supply voltage has to be free of AC ripple voltage (for example from a battery or a low noise regulator output). For noisy supply voltages, provide a decoupling circuit (for example a ferrite in series connection and a bypass capacitor to ground of at least 47uF directly at the module).
- (3) This product should not be mechanically stressed when installed.
- (4) Keep this product away from heat. Heat is the major cause of decreasing the life of these products.
- (5) Avoid assembly and use of the target equipment in conditions where the products' temperature may exceed the maximum tolerance.
- (6) The supply voltage should not be exceedingly high or reversed. It should not carry noise and/or spikes.
- (7) this product away from other high frequency circuits.

Notes on Antenna and PCB Layout

- (1) Don't use a module with internal antenna inside a metal case.
- (2) For PCB layout:

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- Avoid running any signal line below module whenever possible,
- No ground plane below antenna,
- If possible, cut-off the portion of main board PCB below antenna.

Installation Notes

- (1) Reflow soldering is possible twice based on the time-temperature profile in this data sheets. Set up the temperature at the soldering portion of this product according to this reflow profile.
- (2) Carefully position the products so that their heat will not burn into printed circuit boards or affect the other components that are susceptible to heat.
- (3) Carefully locate these products so that their temperatures will not increase due to the effects of heat generated by neighboring components.
- (4) If a vinyl-covered wire comes into contact with the products, then the cover will melt and generate toxic gas, damaging the insulation. Never allow contact between the cover and these products to occur.
- (5) This product should not be mechanically stressed or vibrated when reflowed.
- (6) If you want to repair your board by hand soldering, please keep the conditions of this chapter.
- (7) Do not wash this product.
- (8) Refer to the recommended pattern when designing a board.
- (9) Pressing on parts of the metal cover or fastening objects to the metal will cause damage to the unit.
- (10) For more details on LGA (Land Grid Array) soldering processes refer to the application note.

Usage Condition Notes

- (1) Take measures to protect the unit against static electricity. If pulses or other transient loads (a large load applied in a short time) are applied to the products, check and evaluate their operation before assembly on the final products.
- (2) Do not use dropped products.
- (3) Do not touch, damage or soil the pins.
- (4) Follow the recommended condition ratings about the power supply applied to this product.
- (5) Electrode peeling strength: Do not add pressure of more than 4.9N when soldered on PCB
- (6) Pressing on parts of the metal cover or fastening objects to the metal cover will cause damage.
- (7) These products are intended for general purpose and standard use in general electronic equipment, such as home appliances, office equipment, information and communication equipment.

Storage Notes

- (1) The module should not be stressed mechanically during storage.

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(2) Do not store these products in the following conditions or the performance characteristics of the product, such as RF performance will be adversely affected:

- Storage in salty air or in an environment with a high concentration of corrosive gas.
- Storage in direct sunlight
- Storage in an environment where the temperature may be outside the range specified.
- Storage of the products for more than one year after the date of delivery storage period.

(3) Keep this product away from water, poisonous gas and corrosive gas.

(4) This product should not be stressed or shocked when transported.

(5) Follow the specification when stacking packed crates (max. 10).

Safety Conditions

These specifications are intended to preserve the quality assurance of products and individual components. Before use, check and evaluate the operation when mounted on your products. Abide by these specifications, without deviation when using the products. These products may short-circuit. If electrical shocks, smoke, fire, and/or accidents involving human life are anticipated when a short circuit occurs, then provide the following failsafe functions, as a minimum.

(1) Ensure the safety of the whole system by installing a protection circuit and a protection device.

(2) Ensure the safety of the whole system by installing a redundant circuit or another system to prevent a dual fault causing an unsafe status.

Other Cautions

(1) This specification sheet is copyrighted. Reproduction of this data sheet is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices.

(2) Do not use the products for other purposes than those listed.

(3) Be sure to provide an appropriate failsafe function on your product to prevent an additional damage that may be caused by the abnormal function or the failure of the product.

(4) This product has been manufactured without any ozone chemical controlled under the Montreal Protocol.

(5) These products are not intended for other uses, other than under the special conditions shown below. Before using these products under such special conditions, check their performance and reliability under the said special conditions carefully to determine whether or not they can be used in such a manner.

- In liquid, such as water, salt water, oil, alkali, or organic solvent, or in places where liquid may splash.
- In direct sunlight, outdoors, or in a dusty environment
- In an environment where condensation occurs.

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- In an environment with a high concentration of harmful gas.
- (6) If an abnormal voltage is applied due to a problem occurring in other components or circuits, replace these products with new products because they may not be able to provide normal performance even if their electronic characteristics and appearances appear satisfactory.
- (7) When you have any question or uncertainty, contact Fanstel.

Packaging

Production modules are delivered in reel, 1000 modules in each reel.

FCC LABEL

The Original Equipment Manufacturer (OEM) must ensure that the OEM modular transmitter must be labeled with its own FCC ID number. This includes a clearly visible label on the outside of the final product enclosure that displays the contents shown below. If the FCC ID is not visible when the equipment is installed inside another device, then the outside of the device into which the equipment is installed must also display a label referring to the enclosed equipment

The end product with this module may subject to perform FCC part 15 unintentional emission test requirement and be properly authorized.

This device is intended for OEM integrator only.

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Revision History

- Jan. 2023, Ver. 0.90: Initial draft release.
- Feb. 2023, Ver. 0.91: Update block diagram and EV board schematics.
- Mar. 2023, Ver. 0.92: Update module names and add preliminary WiFi range measurement results.
- July 2023, Ver. 0.93: update WiFi range measurements for new chip antenna.

WM02C/E/V Compact, WiFi 6 Companion Modules

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