Number: UG079
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Version: 2023.05

M20 High-Precision Navigation Module

USER MANUAL

DATASHEET

Brief Introduction

Based on Alice, the brand new automotive-grade 22nm-process GNSS SoC with high performance, M20 modules have the built-in high-precision measurement engine, navigation engine, inertial navigation unit and functional safety engine, which meet ASIL B functional safety level supporting high-performance NRTK/PPP/RTK-PPP solution, anti-interference and L-Band/CLAS SBAS signal reception, so the modules can effectively cope with harsh environments such as satellite signal interference and loss, and provide continuous, real-time and trusted high-precision position and attitude information. It can be applied to fields such as autonomous driving, advanced driving assistance, lane-level navigation, drones and intelligent robots.

Revision History

Edition	Develop/Revise Content	Release Date
V0.0	Initial	2022-04-26
V0.01	Complements the hardware architecture Update the interface signal definition	2022-10-15
V0.02	Update the interface signal definition	2022-10-29
V0.03	Supplement the requirements of welding assembly	2023-03-18
V0.04	Supplemental application notes Update mechanical properties Supplemental packaging information	2023-03-20

Contents

1 Feature Description

1.1 Brief Introduction

High-precision, full-frequency and anti-interference GNSS measurement and positioning engine

Bynav REAL (Ransac Enhanced Advanced Location) GNSS positioning engine with integrity monitoring and partial ambiguity solution algorithm is adopted, to improve the fault tolerance and fixed solution rate under multipath and interference conditions in urban environment, generating more robust positioning results. According to the requirements of safety of the intended functionality and network security, signal preprocessing and adaptive interference suppression with high quantization bits are carried out for common interference signals such as vehicle-mounted anti-tracking devices and radar/airport signal towers, which greatly improves the usability and integrity of high-precision positioning in vehicle scenarios.

L-Band, NRTK, PPP and PPP-RTK

With L-Band signals and PPP positioning, M20 can provide high-precision positioning in environments that are not covered by conventional differential services or mobile communication services. M20 supports Beidou-3 B2b PPP solution, QZSS CLAS PPP-RTK solution

and prevailing PPP-RTK differential services. It also optimizes the four bands of Beidou and Galileo to greatly improve the PPP convergence speed and the availability of high-precision positioning.

ASIL B functional safety level

M20 is designed on the basis of ISO26262 ASIL B functional safety, integrating the functional safety MCU, interface, the GNSS chip Alice with new architecture design based on functional safety requirements. It can provide high-precision navigation with system-level functional safety for smart cars and autonomous driving.

It features the following technical advantages:

- 22nm process GNSS SoC Alice
- Full constellation full-frequency GNSS (1507 channels)
- L-Band/CLAS
- NRTK/PPP/PPP-RTK
- Anti-interference and anti-deception
- AEC-Q104
- ISO 26262 ASIL B

1.2 Performance

Table 1- 1 Performance Indicators

Indicator	Index
Signal①	BDS B1I/B2I/B3I/B1C*/B2a/B2b* (PPP) GPS L1CA/L1C*/L2/L5 GLONASS L1/L2 Galielo E1/E5a/E5b/E6* QZSS L1/L2/L5/L6 (CLAS*) NAVIC L5 SBAS* L1CA L-Band
Number of Channels①	1507
Sensitivity	Acquisition -144 dBm
	Tracking -154 dBm
Re-acquisition Time	≤1s
Dynamic Limitation	Speed ≤ 550m/s Acceleration ≤4g
Measurement Accuracy	Carrier phase: ≤1mm (RMS) Pseudorange: ≤ 0.1m (RMS)
Output Rate of Observation	50Hz
Output Rate of RTK Result	10Hz (20Hz is supported in special firmware)
Single Point Positioning Accuracy	Horizontal: 1.5m (RMS) Vertical: 2.5m (RMS)
RTK Accuracy	Horizontal: 1.0cm+1ppm (RMS) Vertical: 1.5cm+1ppm (RMS)
Timing Accuracy	≤20ns (RMS)
Speed Measurement Accuracy	0.03m/s (RMS)
Initialization Time	Cold start: ≤30s Hot start: ≤5s
RTK Initialization Time	≤5s
INS Solution Delay	≤5ms
RTK Solution Delay	≤50ms

Anti-interference①	65dBc (Interference to signal ratio) Multitone interference with 6 or more pulses; Narrowband interference whose bandwidth is not less than 10% of the signal bandwidth; Fast sweep interference.
L-Band①	-133dBm (Sensitivity) 10^{-5} (Bit error rate)
Power Consumption②	500mW Standby power consumption: 0.5mW
Size	17mmx22mmx2.75mm (Typical)
Temperature	Environment ③: -40℃ ~ +105℃ Junction -40℃ ~ +125℃
	Storage ④: -55℃ ~ +150℃

* Supported in special firmware

Note① Optional.

Note② Typical value at 25℃.

Note③ There are optional temperature range of -40℃ ~ +85℃ and -20℃ ~ +65℃ depending on different module.

Note④ There are optional temperature range of -40℃ ~ +105℃ and -40℃ ~ +65 depending on different module.

1.3 Supported Protocols

Table 1- 2 Supported Protocols

Protocol	I/O	Format
RTCM 3.3	Input	Binary
NMEA 4.11/4.10/4.0/2.3/2.1	Input/Output	ASCII
BYNAY①	Input/Output	ASCII, Binary

Note①: See *UG017_ Interface Protocol* for details

2 System Architecture

The architecture diagram of the M20 high-precision navigation module is shown in Figure 2- 1.

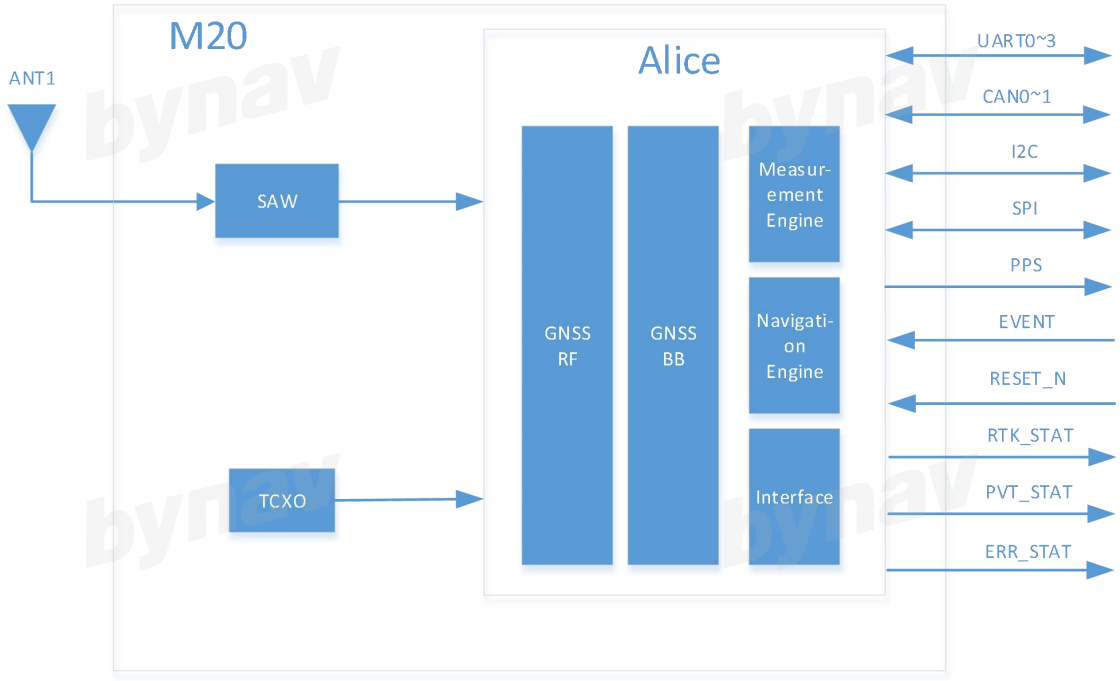
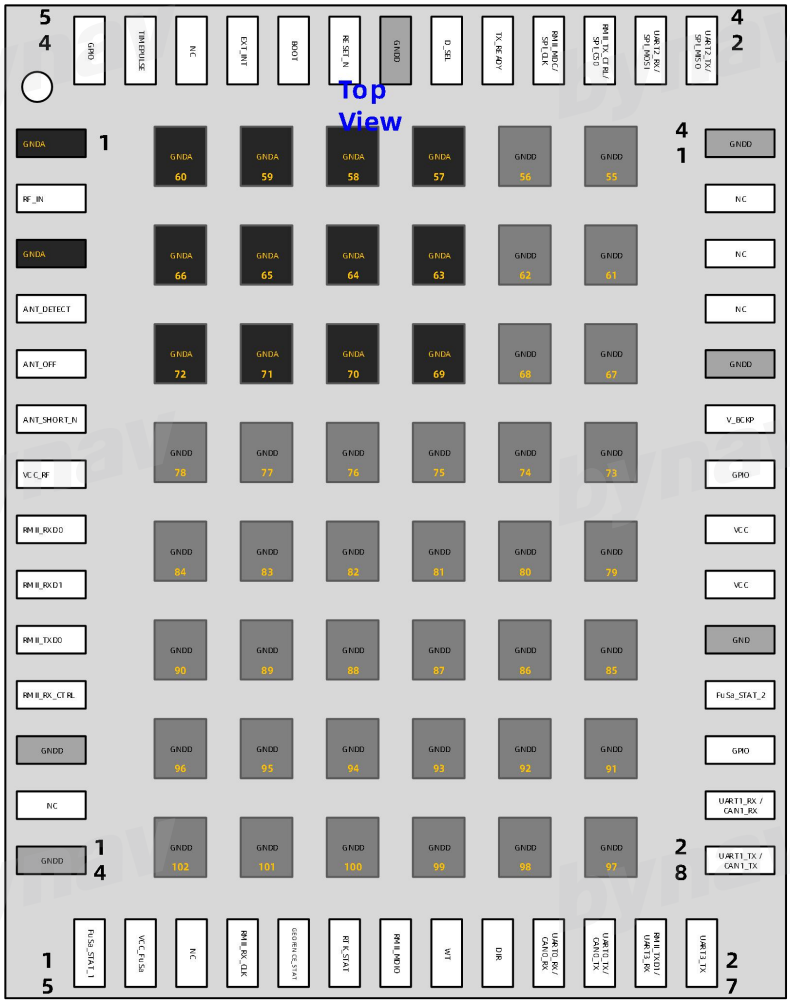


Figure 2- 1 Block Diagram

3 Pin Definition

3.1 Pin Distribution

The pin distribution of the M20 high-precision navigation module is shown in the figure below.



Note: GNDA and GNDD are all grounded pads and GNDD are GND for digital part, GNDA are GND for analog part

Figure 3- 1 Pin Distribution

3.2 Pin Signal Definition

The pins of the M20 high-precision navigation modules are defined in

the following table.

Table 3- 1 Pin Definition

No.	Name	I/O	Description
1	GND	-	Ground
2	RF_IN	I	RF signal input
3	GND	-	Ground
4	ANT_DETECT	I	Active antenna detection
5	ANT_OFF	O	The external LNA is off
6	ANT_SHORT_N	I	External active antenna short-circuit detection
7	VCC_RF	O	Power supply for the external antenna
8	RMII_RXD0	I	RMII data input 0
9	RMII_RXD1	I	RMII data input 1
10	RMII_TXD0	O	RMII data output 0
11	RMII_RX_CTRL	I	Network data input control
12	GND	-	Ground
13	NC	-	Leave unconnected if not used
14	GND	-	Ground
15	FuSa_STAT_1	O	Functional safety status indication①
16	VCC_FuSa	I	Functionally safe power supplies①
17	NC	I	Leave unconnected if not used
18	RMII_RX_CLK	I	Reference clock provided by PHY to MII
19	GEOFENCE_STAT	O	GEOFENCE status output
20	RTK_STAT	O	RTK status indication
21	RMII_MDIO	I/O	Input and output of data management
22	WT	I	Wheel speed signal input ②
23	DIR	I	Input signal
24	UART0_RX/CAN0_RX	I	UART0 input by default, supporting function configuration
25	UART0_TX/CAN0_TX	O	UART0 output by default, supporting function configuration
26	RMII_TXD1/UART3_RX	I	RMII Data Sending 1 by default, supporting function configuration
27	UART3_TX	O	UART3 output
28	UART1_TX /CAN1_TX	I	UART1 output by default, supporting

			function configuration
29	UART1_RX /CAN1_RX	O	UART1 input by default, supporting function configuration
30	GPIO	I/O	Universal input-output interface
31	FuSa_STAT_2	O	Functional safety status indication①
32	GND	-	Ground
33	VCC	I	Main power input
34	VCC	I	Main power input
35	GPIO	I/O	Universal input-output interface
36	NC	-	Leave unconnected if not used
37	GND	-	Ground
38	NC	-	Leave unconnected if not used
39	NC	-	Leave unconnected if not used
40	NC	-	Leave unconnected if not used
41	GND	-	Ground
42	UART2_TX/SPI_MISO*	O	UART2 output by default, supporting function configuration
43	UART2_RX/SPI_MOSI*	I	UART2 input by default, supporting function configuration
44	RMII_TX_CTRL/SPI_CS0*	I/O	RMII data output control by default, supporting function configuration
45	RMII_MDC/SPI_CLK*	I/O	RMII data management clock by default, supporting function configuration
46	TX_READY	O	TX status indication ③
47	D_SEL	I	Interface selection (UART and network are selected by default, switching is not supported yet)
48	GND	-	Ground
49	RESET_N	I	Reset, active low
50	BOOT	I	Enable internal program update ④
51	EXT_INT	I	External interrupt ⑤
52	NC	I	Leave unconnected if not used
53	TIMEPULSE	O	Pulse output
54	GPIO	I/O	General GPIO

* SPI is supported in special firmware.

Note ①: Functional safety is supported in automotive-grade version. Leave

unconnected if you don’t have need for functional safety, otherwise, please contact us for functional safety manual.

Note ②: The pulse width of the WT signal should be greater than 500ns.

Note ③: TX_READY outputs nothing by default, which can be defined according to user’s need.

Note ④: The level of BOOT has been fixed inside the module, no pull-up or pull-down needs to be done.

Note ⑤: EXT_INT is not supported without customized firmware.

4 Electrical Specification

4.1 Absolute Maximum Ratings

Table 4- 1 Absolute Maximum Ratings

Parameter	Name	Condition	Min.	Max.	Unit
Power Supply VCC Ramp Voltage	VCC		-0.5 20	3.6 8000	V μs/V
Input Pin Voltage	V_{in}	VCC≤3.1V VCC > 3.1 V	-0.5 -0.5	VCC + 0.5 3.6	V V
VCC_RF Output Current	ICC_RF			100	mA
RF_IN Input Power	P_{RFIN}	50Ω Impedance		10	dBm
Storage Temperature	T_{stg}		-55	150	℃

4.2 Operating Conditions

Table 4- 2 Recommended Operating Conditions

Parameter	Name	Condition	Min.	Typical	Max.	Unit
Main Power Supply	VCC_3V3	The actual values should be within maximum and minimum voltage ranges	3.0	3.3	3.6	V
Peak Current Input	I_{Peak}	VCC = 3.3 V			300	mA
Functional Safety Power Supply	VCC_FuSa		3.0	3.3	3.6	V
External RF Gain	G_{RFIN}		17	30	50	dB
RF Noise Factor	NF		2	3	4	dB
Junction Temperature	T_j		-40		125	℃
Operating temperature	$T_{operation}$		-40	25	105	℃

5 Communication Interface

5.1 UART

The baud of UART interface can be changed, but not the hardware flow control. UART0 is multiplexed with CAN0, and the default configuration is UART0; UART1 is multiplexed with CAN1, and the default configuration is UART1; UART2 is multiplexed with SPI, and the default configuration is UART2; UART3 is multiplexed with RMII and RMII is enabled by default. The above configurations are controlled by configuration files in software.

Table 5- 1 UART Parameters

Name	Parameter	Min.	Max.	Unit
Ru	Baud rate	9600	921600	bit/s
△Tx	Tx baud rate accuracy	-1%	+1%	-
△Rx	Rx baud rate tolerance	-2.5%	+2.5%	-

5.2 SPI

M20 module has an SPI slave interface multiplexed with UART2 and RMII. It is not enabled by default, which can be changed through software configuration according to users' need. The SPI can communicate with an external host, with the M20 module being a slave. The maximum transfer rate of SPI is 125kB/s and the maximum clock frequency of SPI is 5.5MHz.

5.3 CAN

The M20 module has 2 CANFD interfaces, CAN0 and UART0 multiplex, CAN1 and UART1 multiplex. The UART is enabled by default, but the CAN interface can be enabled through software to meet users' need.

The transfer rate of CANFD is in the range of 500K~2Mbps.

5.4 RMII

The M20 module has one RMII network interface which is multiplexed with SPI interface, default configuration is RMII network interface.

5.5 Default Interface Settings

The external communication interface settings are described as follows:

Table 5- 2 Default Interface Settings

Interface	Setting
UART0 Output	Up to 921600 baud, 8 bits, no parity bit, 1 stop bit. NMEA messages, BYNAV commands, RTCM protocol supported.
UART0 Input	Up to 921600 baud, 8 bits, no parity bit, 1 stop bit. BYNAV commands supported.
UART1 Output	Up to 921600 baud, 8 bits, no parity bit, 1 stop bit. NMEA messages, BYNAV commands, RTCM protocol supported.
UART1 Input	Up to 921600 baud, 8 bits, no parity bit, 1 stop bit. BYNAV commands, RTCM protocol supported.
UART2 Output	Up to 921600 baud, 8 bits, no parity bit, 1 stop bit. NMEA messages, BYNAV commands, RTCM protocol supported.
UART2 Input	Up to 921600 baud, 8 bits, no parity bit, 1 stop bit. BYNAV commands, RTCM protocol supported.
UART3 Output	Up to 921600 baud, 8 bits, no parity bit, 1 stop bit. NMEA messages, BYNAV commands, RTCM protocol supported.
RMII Output	The maximum rate is 100 Mbps. NMEA messages, BYNAV commands, RTCM protocol supported.

RMII Input	The maximum rate is 100Mbps. BYNAV commands, RTCM protocol supported.

6 Application Guide

6.1 Antenna Input

The M20 module has a set of antenna interfaces to receive GNSS satellite signals, so it can provide satellite timing and positioning. Currently only active antennas are supported.

The input of the RF signal has to meet the requirement of impedance of 50 ohm on the PCB trace and Coplanar waveguide planar transmission line structure as shown below. In order to ensure coherence with ground, it is recommended to lay vias every few millimiters.

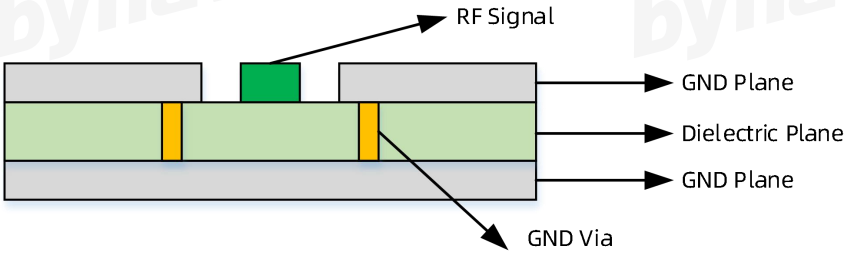


Figure 6- 1 Schematic Structure of Coplanar Waveguide Planar Transmission Line

6.1.1 RF Circuit Design

The impedance characteristics of the radio frequency (RFIN) interface of the M20 module are required to be 50Ω and the internal structure of GNSS RF in the module is shown in the figure below.

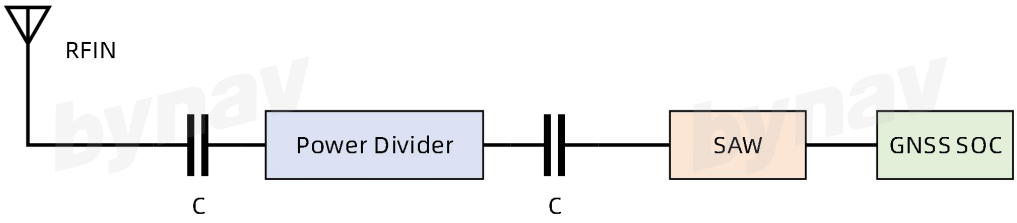


Figure 6- 2 Internal RF Front-end Structure1

The trace between the input interface of the M20 module RF and the RF coaxial connector also needs to be controlled in the impedance range, in order to ensure RF performance, the more conservative design is to add a matching network in the RF link and the matching network is generally divided into L-type, T-type and π-type which is recommended.

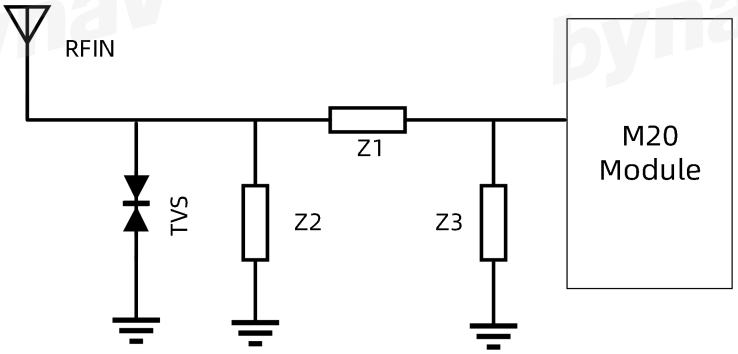


Figure 6- 3 Schematic Diagram of π-type Matching Network

Specification for schematic:

- The components in the above RF matching circuit are capacitors and inductors and the LC components are as close as possible to the antenna port; by default, Z1 is 0R resistors and no components are mounted on Z2 and Z3;
- If static electricity is introduced into the antenna, it is recommended to increase the electrostatic protection using TVS with ultra-low junction capacitance (C_j) which is recommended to be less than 0.5 pF and ensure that the reverse breakdown voltage of the TVS is more than 10 V, it is recommended to be 15 V or larger;

- There is an external output feed power supply inside the module, if an external feed is used, it needs to be connected to the RF trace through 27~100 nF of capacitance.

Specification for PCB Design:

- The RF line should be surrounded by grounding copper which should have as many GND vias as possible to ensure that the grounding impedance is as small as possible. Otherwise, the entire loop area of the RF signal reference ground will increase;
- The PCB trace between the M20 module and the RF line needs to be within 50Ω impedance and its length should be as short as possible;
- The reserved π-type matching circuit should be close to the RF input in PCB layout to facilitate debugging;
- There can't be right angles in RF trace, which will lead to discontinuity of impedance and reflect of the signal, so the receiving efficiency of the antenna will reduce. The arc line can be adopted as shown below when you need to turn a corner.

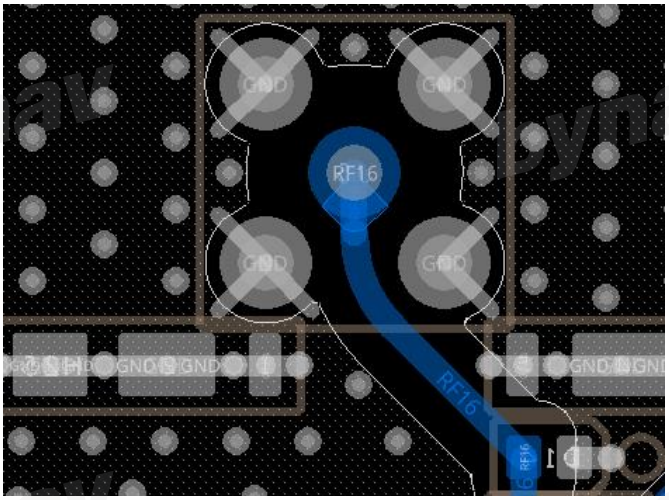


Figure 6- 4 RF Signal Arc Trace

- The RF trace cannot be forked. If the position of the matching circuit reserved on the RF trace is improper, the fork of the RF trace may occur and lead to impedance discontinuity;
- Do not take other signal lines in the projection area on the back of the RF trace and make sure you lay a complete GND as a reference layer for the RF trace; The RF back trace will split the reference layer, resulting in impedance discontinuity and signal reflection will also occur, if the back trace is a high-speed digital signal line, the noise of the digital signal will be coupled to the RF signal;
- The relevant parameters of RF trace impedance are PCB dielectric constant, PCB thickness, RF trace width, the width of RF trace to the same layer GND and the stacked structure of PCB;
- To reduce the possibility of antenna performance degrading due to larger RF pads if a SMA connector is used, both the first and second layers under the module RF pad are recommended to be hollowed

out as shown in the figure below.

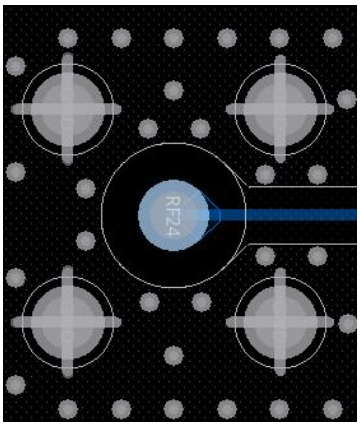


Figure 6- 5 PCB Design Reference for RF

- The layout of module RF signals and RF-related components should be kept away from strong interference sources such as digital circuits, switching power supplies, power transformers, power inductors or clocks.

6.1.2 RF Power Supply

The M20 module provides VCC_RF for external active antenna feeding, supporting up to 3.3V@100mA.

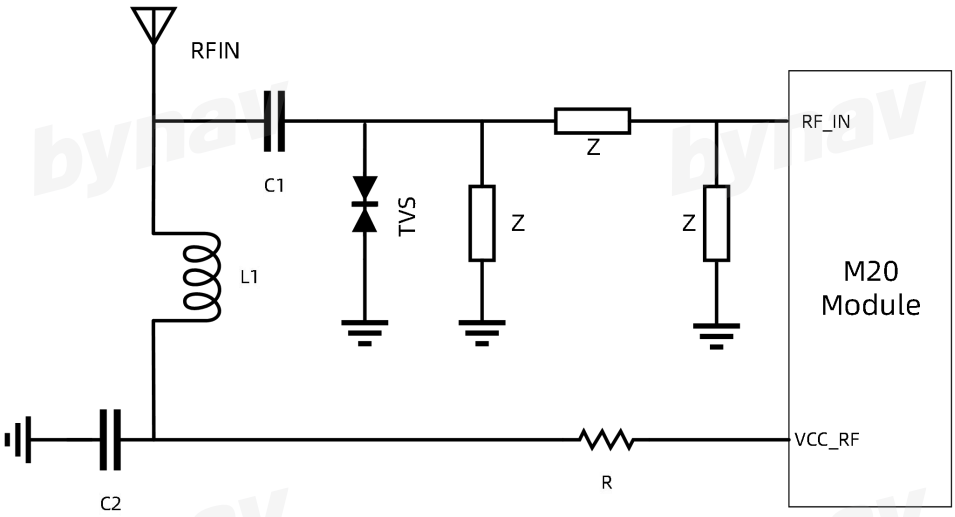


Figure 6- 6 Reference Design for Active Antenna

The C1 capacitor is used to block the DC signal of the feed; The L1 inductor is used to eliminate the risk of the RF signal leaking into the VCC_RF; When the active antenna is shorted to GND, R is used to protect the module.

6.1.3 Recommended Active Antenna Specifications

The recommended antenna specifications for the M 2 module are shown in the table.

Table 6- 1 Recommended Active Antenna Specification

Frequency Range①	1164~1249MHz & 1559~1609 MHz
Bandwidth	>5 MHz
Polarization	Right-handed circular polarization (RHCP)
Standing-wave Ratio	< 1.5
Gain	28~40dB
Noise Factor	<1.5 dB
Shaft Ratio	≤2dB
Phase Center Bias	<2 mm

Note ①: If L-Band is needed, the antenna should also support 1525MHz~1559MHz.

6.2 Power Supply Design

The design and layout of the power circuit is a very important part in the entire product design and the rationality of the power supply design affects the performance of the entire product.

The M20 module mainly has two power inputs: main power supply V CC_3V3 and VCC_FuSa.

6.2.1 VCC_3V3

VCC is the main power input of the module, the power input range is 3.0 V~3.6V, and the recommended value is 3.3 V, which is used to supply the baseband and RF devices inside the module. The performance of the power supply, such as load capacity, ripple, noise, power supply rejection ratio, will directly affect the performance and stability of the module, as shown in the figure below for the recommended power supply design.

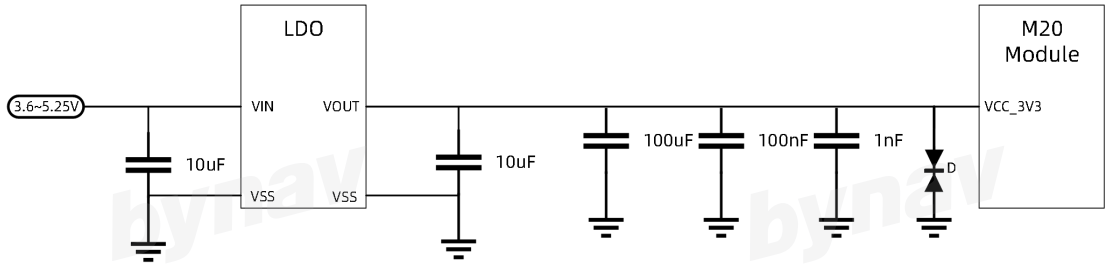


Figure 6- 7 Recommended Design for Power Supply

To ensure optimal module performance, a low-noise 3.3V LDO for RF is used for power supply. A low-noise linear regulator with an output noise voltage ≤30 μV_{RMS}, a power supply rejection ratio of ≥-70dB, and an output current ≥ 600mA is recommended.

- ✧ It is recommended to use a chip multilayer ceramic capacitor with low ESR, and the withstand voltage value should be greater than 1.5 times the main supply voltage;
- ✧ D is an ESD protection device, if ESD protection is required, the position of D needs to be as close as possible to the position of

the module power interface;

- ✧ Place magnetic beads and bypass capacitors close to the module to filter out high-frequency interference in the power supply;
- ✧ Recommended LDOs are NCV8705/TPS7A8101/MIC29302.

6.2.2 VCC_FuSa

The VCC_FuSa is the power input of the functional safety module inside the module, the power input range is 3.0 V~3.4V, and 3.3 V@20mA (Max) is recommended. (If not used, it can be merged with VCC_3V3 or floated).

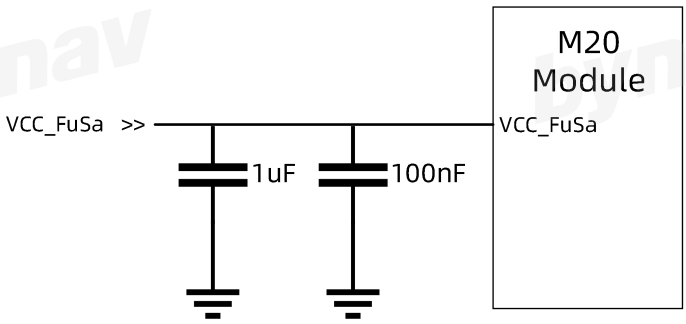


Figure 6- 8 Recommended Design for FuSa Power Supply

6.3 Minimal Design

The diagram of minimal design is shown below, UART2 is used to connect to a host device, UART3 is optional and can be used to receive RTCM data.

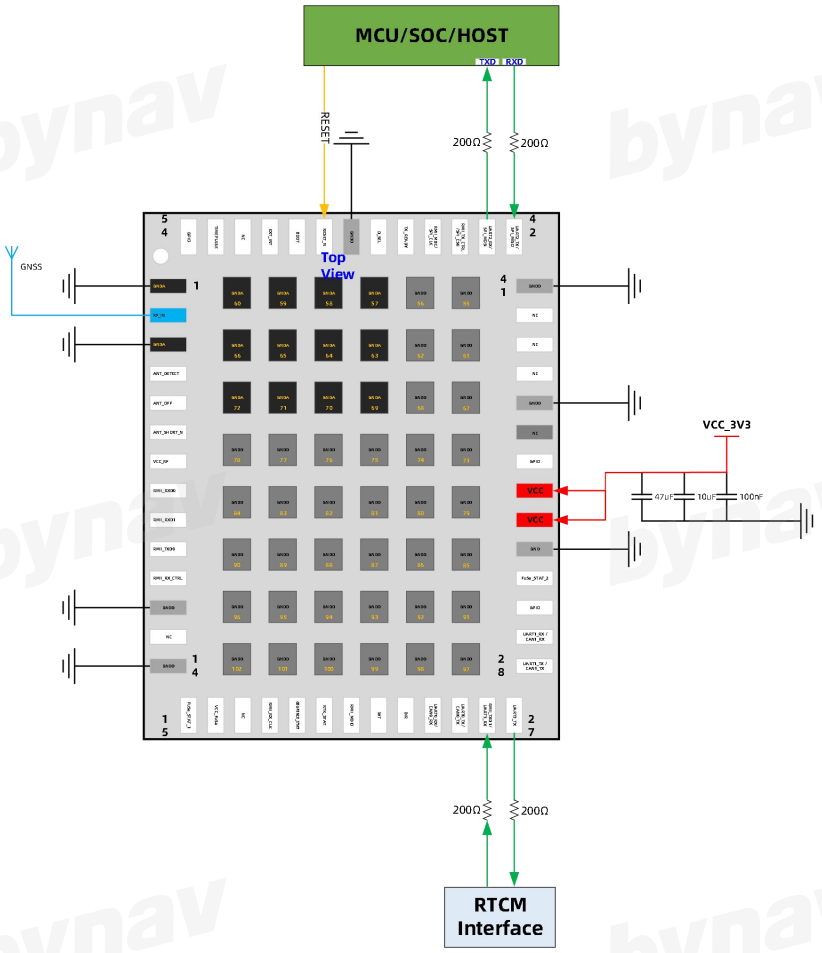


Figure 6- 9 Minimal Design

Please follow the tips below in design:

1. **VCC** needs power supply of 3.3V;
2. Please ensure reliable connection between GND pins (GNDA and GNDD) and the ground。

6.4 UART Interface

M20 modules provide 4 UARTs, for detailed configuration parameters, please refer to 5.1.

Table 6- 2 UART Pin

Name	I/O	Level
UART0_RX/CAN0_RX	I	3V3_LVTTL

UART0_TX/CAN0_TX	O	3V3_LVTTL
RMII_TXD1/UART3_RX	I	3V3_LVTTL
UART3_TX	O	3V3_LVTTL
UART1_TX /CAN1_TX	O	3V3_LVTTL
UART1_RX /CAN1_RX	I	3V3_LVTTL
UART2_TX/SPI_MISO	O	3V3_LVTTL
UART2_RX/SPI_MOSI	I	3V3_LVTTL

The application information for the UART interface section is as follows:

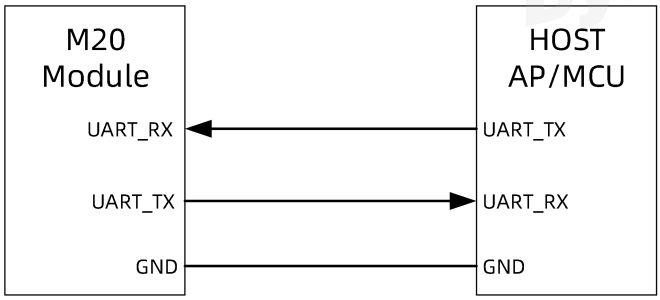


Figure 6- 10 Recommended Design for UART

Pay attention to the following When it comes to the schematic:

- Mind the correspondence between signal connections;
- If the level of the HOST device is inconsistent with the level of the M20 module, level shifting design is required;
- The RX or TX naming of the M20 module and the HOST device in the figure is based on the device itself.

Pay attention to the following when it comes to layout design:

- Less signal lines' crossover with other traces and if it cannot be avoided, cross them perpendicularly to reduce coupling;
- Avoid areas where static electricity may be introduced;
- It is recommended to surround the trace with ground planes if

there is enough space.

6.5 SPI Interface

M20 modules can provide one set of SPI interfaces and refer to Section 5.2 for detailed configuration parameters.

Table 6- 3 SPI Pin

Name	I/O	Level
UART2_TX/SPI_MISO	O	3V3_LVTTL
UART2_RX/SPI_MOSI	I	3V3_LVTTL
RMII_TX_CTRL/SPI_CS0	I/O	3V3_LVTTL
RMII_MDC/SPI_CLK	I/O	3V3_LVTTL

The application information for the SPI interface section is as follows:

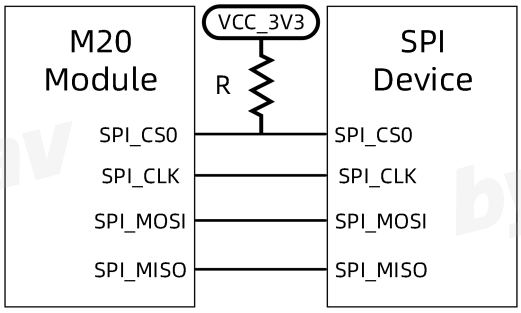


Figure 6- 11 Recommended Design for SPI Interface

6.6 CAN Interface

M20 modules can provide 2 sets of CAN interfaces, detailed configuration parameters refer to 5.3.

Table 6- 4 CAN Pin

Name	I/O	Level
UART0_RX/CAN0_RX	O	3V3_LVTTL
UART0_TX/CAN0_TX	I	3V3_LVTTL
UART1_TX /CAN1_TX	I/O	3V3_LVTTL
UART1_RX /CAN1_RX	I/O	3V3_LVTTL

The application information for the CAN interface section is as

follows:

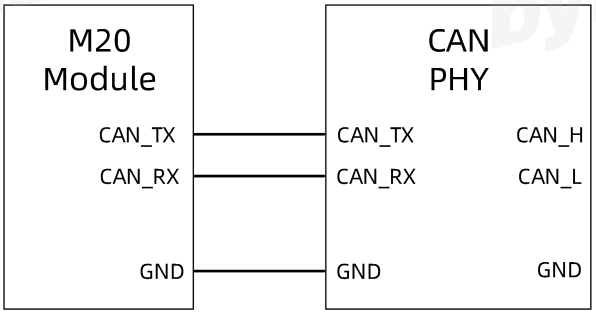


Figure 6- 12 Recommended Design for CAN Interface

6.7 RMII Interface

M20 modules can provide 1 set of RMII interfaces and refer to Section 5.4;

Table 6- 5 RMII Pin

Name	I/O	Level
RMII_RXD0	I	3V3_LVTTL
RMII_RXD1	I	3V3_LVTTL
RMII_TXD0	O	3V3_LVTTL
RMII_RX_CTRL	I	3V3_LVTTL
RMII_RX_CLK	I	3V3_LVTTL
RMII_MDIO	I/O	3V3_LVTTL
RMII_TXD1/UART3_RX	I	3V3_LVTTL
RMII_TX_CTRL/SPI_CS0	I/O	3V3_LVTTL
RMII_MDC/SPI_CLK	I/O	3V3_LVTTL

The application information of the RMII interface section is as follows:

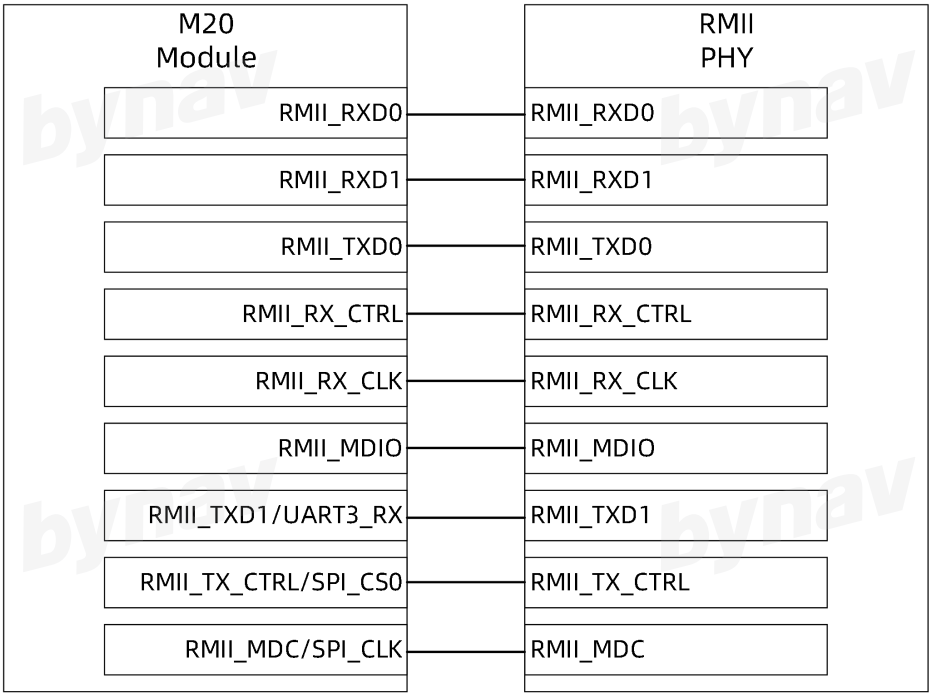


Figure 6- 13 Recommended Design for RMII Interface

6.8 Reset Interface

The module will startup when inputting high level to the RESET_N pin after 35ms of power on.The typical voltage for a high-level signal is 3.3V. If an IO control of non-3.3V level is used to reset the module, level shifting is required. The reference circuit for the reset section is as follows:

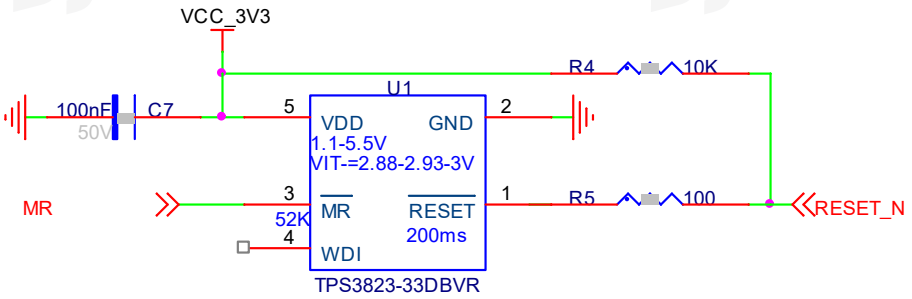


Figure 6- 14 Reference Circuit for the Reset Section

6.9 Application of Interface

The M20 module includes multiple interfaces such as UART/CAN/ RMII/SPI with data of differential, wheel speed and position, which meets the need of most users, please refer to Table 6- 6 for the combinations of intefaces.

Table 6- 6 Multiplexing of Interface

Combination	UART0	UART1	UART2	UART3	CAN0	CAN1	RMII	SPI
M2_1	ON	ON	ON	ON	OFF	OFF	OFF	OFF
M2_2	ON	OFF	ON	ON	OFF	ON	OFF	OFF
M2_C1	ON	ON	ON	ON*	OFF	OFF	ON	OFF
M2_3	ON	OFF	ON	ON*	OFF	ON	ON	OFF
M2_4	ON	OFF	OFF	ON	OFF	ON	OFF	ON
M2_X2E	OFF	OFF	ON	ON*	ON	ON	ON	OFF

*Only UART3_TX is available.

The time-sharing multiplexing will be respectively used for UART2 and SPI, UART3 and RMII, CAN0/1 and UART0/1.

6.10 PCB Layout

Here's a few key points in power supply design:

- The bypass capacitor needs to be placed close to the power supply pin of the module to filter out the high-frequency noise signal in the power supply.
- In the main power loop of the module, the PCB trace width should ensure that the current above 500 mA can be safely passed and there is no obvious loop voltage drop. The trace

width of PCB is at least 0.5mm to ensure that the ground plane of the power supply part is as complete as possible;

- GNSS RF circuits are noise-sensitive and should be kept away from devices or circuits generating noise or strong interference, such as audio circuits, RF circuits and DC-DC power supplies.

6.11 Thermal Management

M20 module has temperature-sensitive devices inside, which needs to ensure constant temperature. Therefore, the module itself should also be away from the heat-generating or low temperature area during the PCB layout. The inside TCXO is sensitive to temperature changes and if the temperature changes suddenly, it will affect the tracking of satellite signals. Therefore, the module should be at a certain distance from the heating device, cooling fan or heat dissipation hole.

6.12 Electromagnetic Interference Precautions

Any signal line longer than 3mm can act as an antenna and RF signals from surroundings are transmitted to the GNSS receiving module as noise, thus affecting GNSS positioning performance.

EMI has to be considered, the power of signals GNSS antennas receive is very low, so GNSS modules are susceptible to interference from any type of nearby RF sources. Out-of-band and in-band interferences are the main type of interference:

1. Out-of-band interference: Usually the maximum power of signals in any wireless communication system (such as LTE, GSM, WCDMA, WIFI, BT) which enters the module through the antennas or unshielded traces is much higher than the GNSS signal, affecting the GNSS positioning performance. it can be effectively improved by adding a SAW filter to the RF front end. Also, it is necessary to keep the GNSS receiving antennas and modules away from the wireless communication system with strong transmission power and its antenna.

In addition, strong interference signals may produce intermodulation signals that fall within the GNSS frequency band and have negative impact on the performance of GNSS modules.

2. In-band interference: its frequency is very close to the GNSS frequency. Such interference is usually caused by harmonics of signals from displays, buses or clocks. Ways to optimization are as follows:

- Keep the connection to GND reliable in the design;
- Shielding RF lines from signal lines;
- Optimizing layout, keeping GNSS modules and antennas away from noise sources;
- Add filters to interference sources: put low-pass filter in the digital signal output port and band-pass filter in the RF signal output port such as LTE, GSM, WCDMA, WIFI and BT.

7 Manufacturing

7.1 Assembly and Welding

M20 module is a precision device with LGA package. To ensure proper SMD soldering and avoid problems such as virtual soldering and short circuit, it is recommended to adopt reflow soldering instead of the heat gun whose temperature is too high and uneven, the module function and performance will be seriously damaged after using a heat gun to weld.

7.1.1 SMD Device Requirements

7.1.1.1 Placement Machine

- Feeder: support Tape and Tray;
- Image processing: optical alignment;
- Nozzle diameter: select according to the size of the module body (17.00 mm×22.00mm, typical value) to ensure the stability of the module mounting.

Note:

It is recommended that the diameter of the nozzle is not less than 40% of the length of the short side, for example, if the module size is 17.0mm×22.0mm, it is recommended to choose a nozzle with a diameter of more than 8mm (you can

choose a suitable one from nozzles attached to different equipment).

7.1.1.2 Welding Requirements

1. The M20 module is automotive grade, so reflow soldering equipment with ten temperature zones and above is required;

2. The requirements for lead-free reflow soldering furnace temperature. The peak temperature of the measurement point of the bottom pad should reach 238 °C, the maximum temperature with reflow fixture is recommended between 240 °C ~ 246 °C, according to the degree of heat absorption and size of the material of the carries in furnce, the time when temperature is higher than 217 °C should be accordingly extended by 10s to prevent cold welding;

3. If the thickness of the carrier PCB for modules is less than 1.0mm, it is recommended to make a reflow loader or furnace tray to prevent the PCB from deforming at high temperature and affecting the coplanarity of welding;

4. For the surface treatment of the carrier board's pad, it is recommended to choose the same gold immersion process as it is for the module's pads, electroplating nickel/gold or electroless nickel/gold plating process; It is not recommended to use the tin spray plate surface treatment method;

5. It is recommended to use no-clean solder paste, so the module

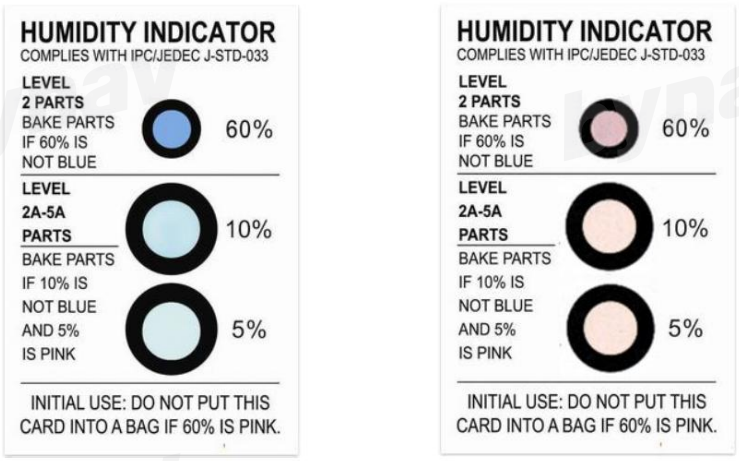
after welding does not need to be cleaned;

6. Recommendations for welding:

- Solder paste model and composition: OM338 SAC405/Nr.143714 (Cookson Electronics).
- Alloy: Sn95.5/Ag4/Cu0.5 (95.5%Tin/4%Silver/0.5%Copper)
- Solder paste melting point: 217 °c
- Stencil thickness: 0.20mm.

7.1.2 Humidity Sensitivity Level

M20 modules are moisture-sensitive, according to IPC-JEDEC, MSL (Moisture Sensitivity Level) of the M20 module is defined as 3. Before use, it is necessary to confirm whether the packaging is in good condition, after opening the package, check the status of the humidity indicator card in the vacuum bag. If 5% indicator circle is pink and 10% indicator circle is no longer blue on humidity indicator card as shown in the figure below, the modules need to be baked before use.



正常湿度卡　　变粉色

Figure 8- 1 Three-point Humidity Indicator Card

7.1.3 Baking

It is highly recommended to bake the modules before welding and the baking conditions are as follows:

- The module should be baked at 120±5 ℃ for 8~24 hours;
- The baked modules have to be welded within 12 hours, otherwise it should be re-baked, see the baking process described in IPC/JEDEC J-STD-033.

7.1.4 Preheating

During the initial heating of the modules, they will be dried, please note that the preheating stage cannot replace the baking mentioned above, the temperature requirements of the preheating stage are as follows:

- Temperature rise rate: up to 3℃/s. If the temperature rises too quickly during the preheating, excessive device drift may occur;
- Time: 60~120 seconds. If the preheating is insufficient, larger

solder balls are produced. By contrast, excessive preheating will cause more tin dross and solder balls;

- Finishing temperature: 150℃~200℃. Too low temperature will often cause the paste not to melt in areas with high heat capacity.

7.1.5 Storage

Recommended storage conditions: temperature 23℃±5℃ and relative humidity of 35%~60%.

Storage period (under sealed vacuum packaging conditions): Under recommended storage conditions, the Storage period is 12 months.

7.1.6 Workshop Life and Temperature/Humidity Control

Products with moisture sensitivity class 3 have a workshop life of 168 hours (**see note below**). In the workshop temperature of 23 ℃ ± 5 ℃ and the relative humidity of 60%, the module needs to be through reflow soldering or other high-temperature operation within 168 hours after unpacking, otherwise, the module needs to be stored in an environment with a relative humidity of less than 10% (for example, a moisture-proof cabinet) to keep the product dry.

Note:

1. Suitable only if the workshop environment with low relative humidity complies with the IPC/JEDEC J-STD-033 specification; If you are not sure whether the temperature and humidity environment of the workshop meets the conditions, or the relative humidity is greater than 60%, please complete reflow soldering within 24 hours after unpacking, please do not unpack a large amount in advance;

2. To prevent and reduce the occurrence of poor welding such as blistering and delamination caused by moisture, the strorage should be strictly under control and it is not recommended to expose it to air for a long time after unpacking the vacuum packaging;
3. If 1) the sealed vacuum packaging leaks, 2) moisture sensitive control requirements are not satisfied after packaging being opened, 3) the modules are stored in bulk or over 1 year, pre-bake treatment is required before the module is surface mounted or repaired, and it needs to be baked at a high temperature of 120 ±5℃ for 24 hours to prevent blistering, cracking and delamination after high temperature welding caused by moisture;
4. Before baking, the module needs to be taken out from the packaging and placed on the high-temperature resistant appliance (plastic tray or packaging reel is forbidden to bake directly); re-baked modules have to be welded within 12 hours after baking, otherwise they need to be stored in a drying cabinet. ESD protection should be implemented when taking out or placing the module and anti-static gloves is required;
5. After the baking is completed, when the bare module is put online, the placement machine should bring a tray, the method is as follows: Method 1: Use a special tray with matching size; Method 2: When there is no matching tray, you can cut multiple carrier tapes of the same length out of the black electrostatic carrier tape used to wrap up the modules and put them neatly on the pallet of the surface mounting machine as a simple tray.

7.1.7 Requirements for the Production of Stencils

In order to ensure sufficient solder and reliability of the M20 module in LGA package when welding, the stencil needs to be locally thickened (Step-up) at the module position and the front (printing surface) thickening method is adopted; The recommended stencil thickness in the module area is: 0.20mm. It can also be adjusted according to the measured thickness of the solder paste (≤ 0.20mm) and the actual

conditions and empirical values of the SMT factory.

7.1.8 Automatic Placement

Use a suitable nozzle and make sure that the nozzle suck at the center of gravity of the module, the placement speed is medium. The image recognition detection pass rate should be 100% to avoid unstable moving. After the module is mounted to the PCB, each pin of the module is aligned with the center of the solder paste.

7.1.9 Reflow Soldering

It is recommended to set the furnace temperature curve based on the test of real plate or furnace plate. In the test of furnace plate, the furnace temperature plate needs to be connected to the thermocouple temperature detection test point at the center pad and pin position at the bottom of the module to ensure that the module pin reaches the required soldering temperature. The recommended furnace temperature curve (lead-free SMT reflow soldering) is as follows:

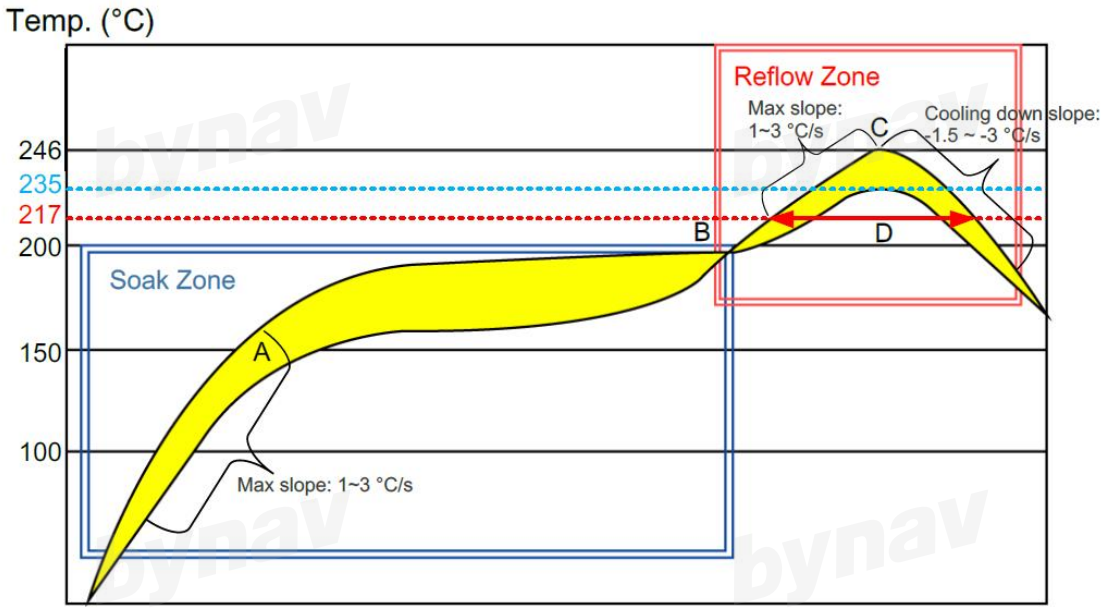


Figure 8- 2 Recommended Furnace Temperature for M20 Series Module Assembly

Table 8- 1 Temperature Requirement

Requirement	Recommended Value
Soak Zone	
Maximum temperature ramp slope	1~3℃/s
Constant temperature time (time between A and B: 150℃~200℃).	70~120s
Reflow Zone	
Maximum temperature ramp slope	1~3℃/s
Reflux time (D: period exceeding 217 ℃).	40~70s
Maximum temperature	235℃~246℃
Cooling slope	-1.5~-3℃/s
Number of reflows	
Maximum number of reflows	1

Note:

1. Furnace temperature: the actual soldering temperature is affected by other external factors, such as the presence of a furnace carrier, solder paste, the size and thickness of the substrate, the heat resistance requirements of the components and the board design. Please confirm with our engineers in time if the recommended parameters cannot be reached, otherwise the module may be damaged due to this reason;
2. Furnace carrier: for motherboards with thickness of less than 1.0mm, it is recommended to use furnace carrier or plates with high Tg to prevent PCB deformation caused by warpage when heated, thereby affecting module welding;
3. Cooling: The controlled cooling slope prevents negative welding effects (the solder joint becomes more brittle) and mechanical stress inside the product. Controlled cooling can help achieve a bright welding surface, fine crystalline particles and low contact angle, avoiding warpage of the shield caused by rapid cooling;
4. Visual inspection: after welding, use X-ray and optical magnifying glass to check the welding quality, please refer to related standards in IPC-A-610F for details. Customers can choose the corresponding welding grade from 3 classes according to the application environments and scenarios of the

product, it is recommended to use the 3rd level standards for automotive application;

5. It is not recommended to use leaded solder paste which is different from our module process for the following reasons: compared to lead-free paste, the melting point of leaded solder paste is 34 ℃ lower. In addition, due to the lower temperature in the reflow process parameters, the time is correspondingly less, which is easy to make BGA in the module half-molten in the secondary reflow soldering and lead to incomplete soldering. If leaded paste has to be used, please make sure that the reflow temperature exceeds 220℃ for more than 45s and the peak temperature reaches 240℃.

7.1.10 SMT Furnace Recommendation

Because the module contains BGA chips, SMD resistor, SMD capacitor and other SMD componets and is also connected to PCB with solder which also melts at high temperature. If the furnace temperature is too high, the solder inside the module will also completely melt, at this time, if the module encounters large vibration, such as excessive vibration of the conveyor belt in the reflow furnace or the bumper, the BGA components and other devices inside the module are easy to shift or fake soldering. Therefore，please pay attention to:

- Please adopt active solder paste from brands such as Alpha.
- **The module must be mounted using SMT machine**, it is not recommended to place it by hand or weld it by hand;
- It is recommended to perform reflow soldering only once, which can improve the yield of the product;
- **Please strictly control the pressure and speed in surface mounting**;

- It is necessary to use a reflow furnace with more than 8 temperature zones and strictly control the furnace temperature curve;
- Keep the module still in the furnace. To ensure smooth furnace passing, the furnace with tracks (chains) should be used if it is possible and don't use the barbed wire in furnace passing;
- When the furnace temperature curve is not suitable, for example, the furnace temperature is too high, and solder of carrier board melt well, but the module defect rate is high due to componets drifts and short circuit after BGA melting again. Later on, the furnace temperature curve is adjusted, so both the welding quality of the carrier board and the board-level reliability of the module were improved.

7.2 ESD Protection

M20 modules are electrostatic sensitive (ESD), and ESD protection should be implemented when packaging, handling or assembling modules.

8 Mechanical Specification

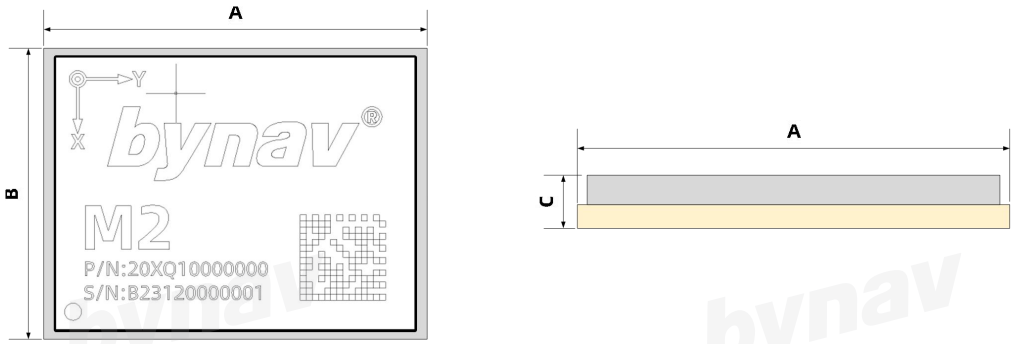
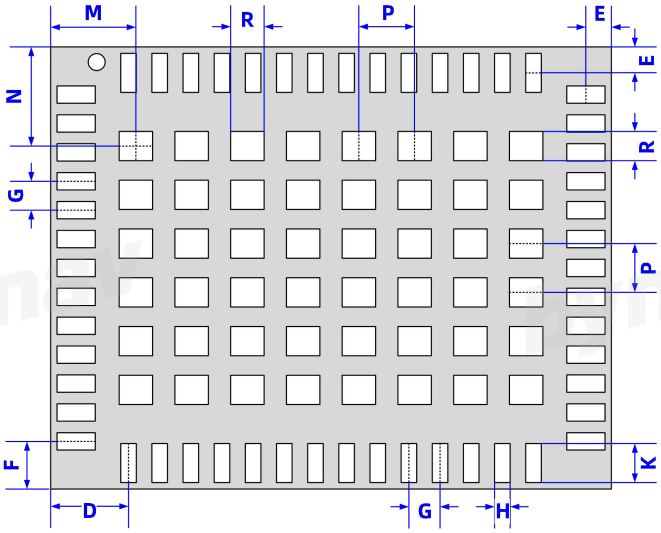


Figure 9- 1 Appearance



Symbol	Min.(mm)	Typ.(mm)	Max.(mm)
A	21.8	22.00	22.35
B	16.80	17.00	17.20
C	2.55	2.75	2.95
D	3.65	3.85	4.05
E	0.85	1.05	1.25
F	1.7	1.90	2.10
G	1.05	1.10	1.15
H	0.70	0.80	0.96
K	1.20	1.50	1.80
M	3.45	3.65	3.85
N	3.05	3.25	3.45
P	2.05	2.10	2.15
R	0.88	1.10	1.32
Weight	TBD		

Figure 9- 2 Size of Bottom Pad

9 Labeling And Ordering Information

9.1 Product Labels

The current product labels of the M20 modules are as follows:

Figure 10- 1 Module Label

9.1.1 Product Number

The product number is shown in the figure below, which mainly contains information such as product ID, firmware type and internal product features.

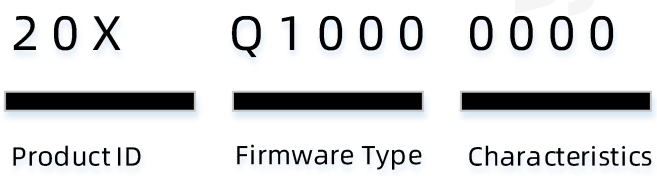


Figure 10- 2 PN Label

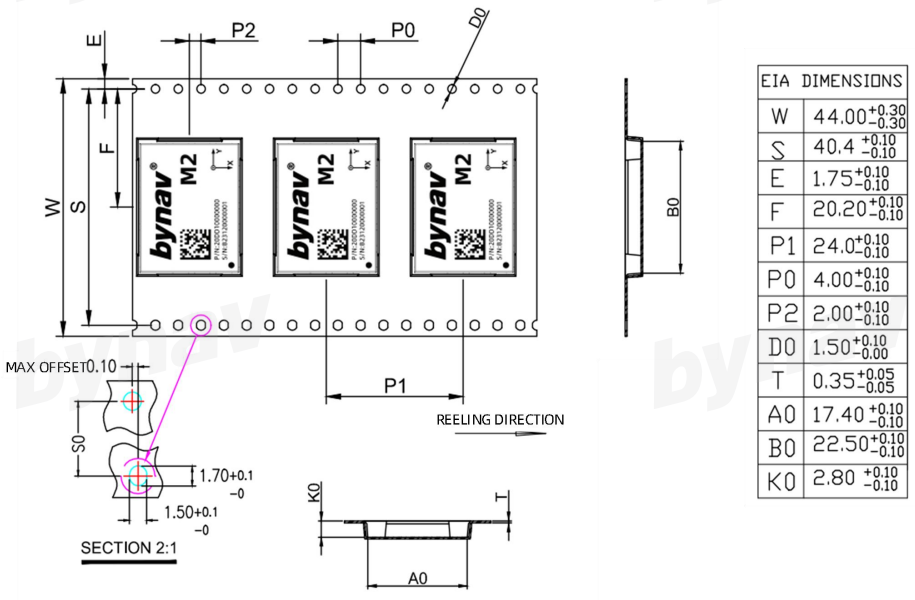
9.1.2 Serial Number

The serial number is shown in the figure below, which mainly contains information such as firmware version, module launch year and week, and internal number.

Figure 10- 3 SN Tag

10 Tape and Reel

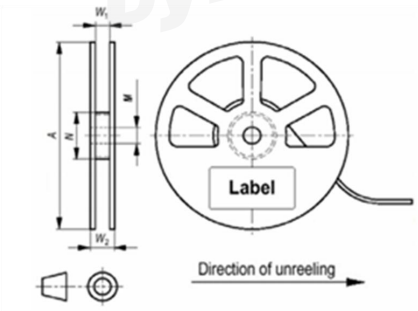
The M20 module is packaged in a vacuum-sealed aluminum foil anti-static bag using carrier tape and reel, which is equipped with desiccant and moisture sensitive grade card. When using the reflow soldering process to weld the module, please strictly abide by the IPC-7350 standard. The M20 module carrier tapes are as follows:



EIA DIMENSIONS	
W	44.00 +0.30 −0.30
S	40.4 +0.10 −0.10
E	1.75 +0.10 −0.10
F	20.20 +0.10 −0.10
P1	24.0 +0.10 −0.10
P0	4.00 +0.10 −0.10
P2	2.00 +0.10 −0.10
D0	1.50 +0.10 −0.00
T	0.35 +0.05 −0.05
A0	17.40 +0.10 −0.10
B0	22.50 +0.10 −0.10
K0	2.80 +0.10 −0.10

Figure 11- 1 Carrier Tape Information

The M20 modules use the standard Type C Reel as follows:



A	N	W1	W2	M
330	100 +/-1	44.3(-0/+0.3)	44.9+/- 0.3	#13 (-0.2/+0.5)

Unit: mm
Qty per roll: 250 pcs
Length: 12.48 m

Figure 11- 2 Reel Information

11 Appendix：Reference Design

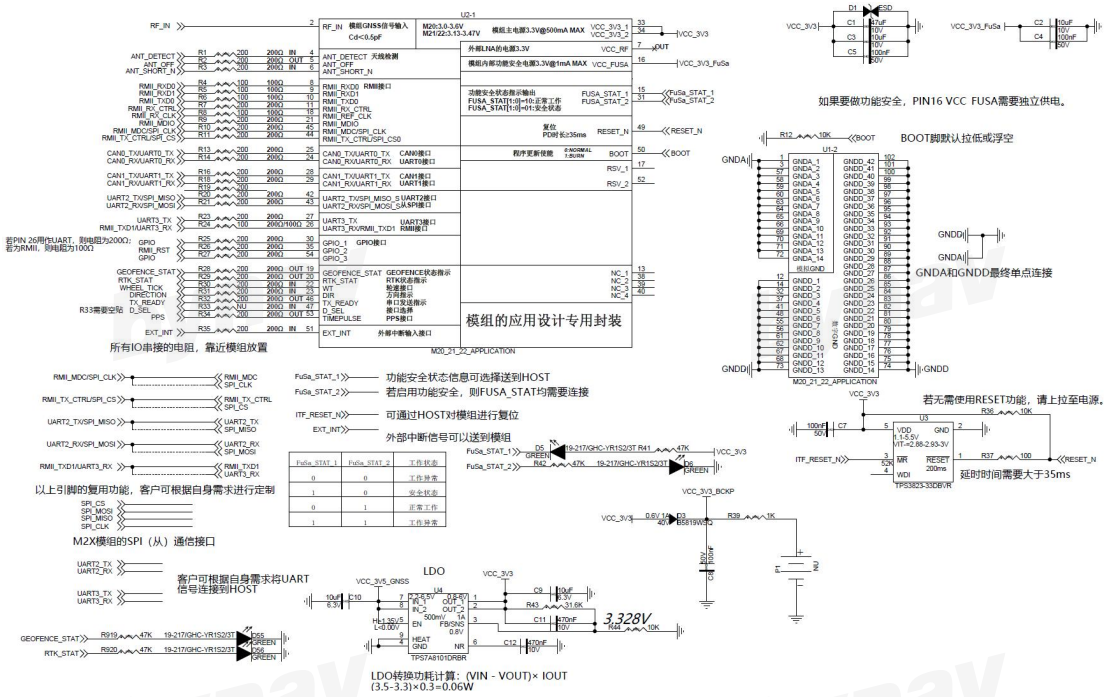


Figure 13- 1 M20 Partial Reference Design

参考设计中的VCC_5V用途有3个：
一是用于外部有源天线的馈电电源（主要面对应用场合是外部有源天线为5V的环境）；
二是用于参考设计中CAN的PHY的电源；
三是用于参考设计中Level shifter的电源。
若实际使用外部有源天线需要采用3.3V电源馈电，则可以和模组的VCC_3V3连接；若外部有源天线需要采用5V电源馈电，需要客户根据自己的整板电源方案给出一路5V电源（关于VCC_5V的来源，官方设计中并未给出）；

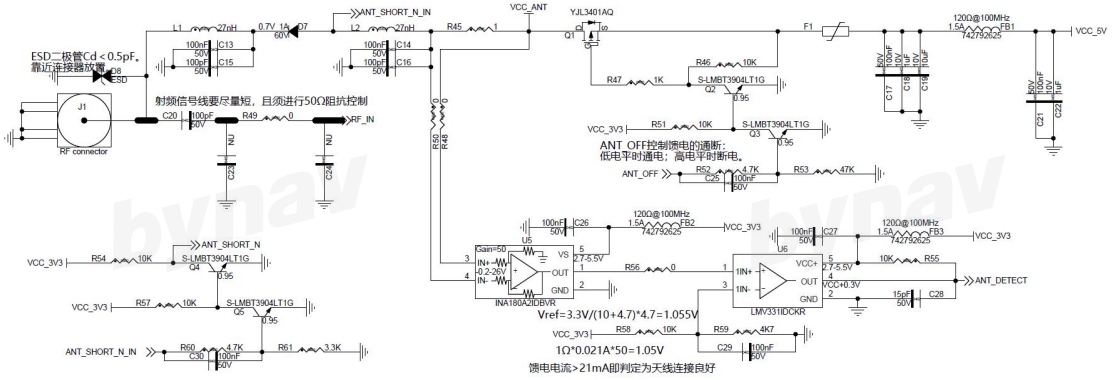


Figure 13- 2 Partial Reference Design for RF

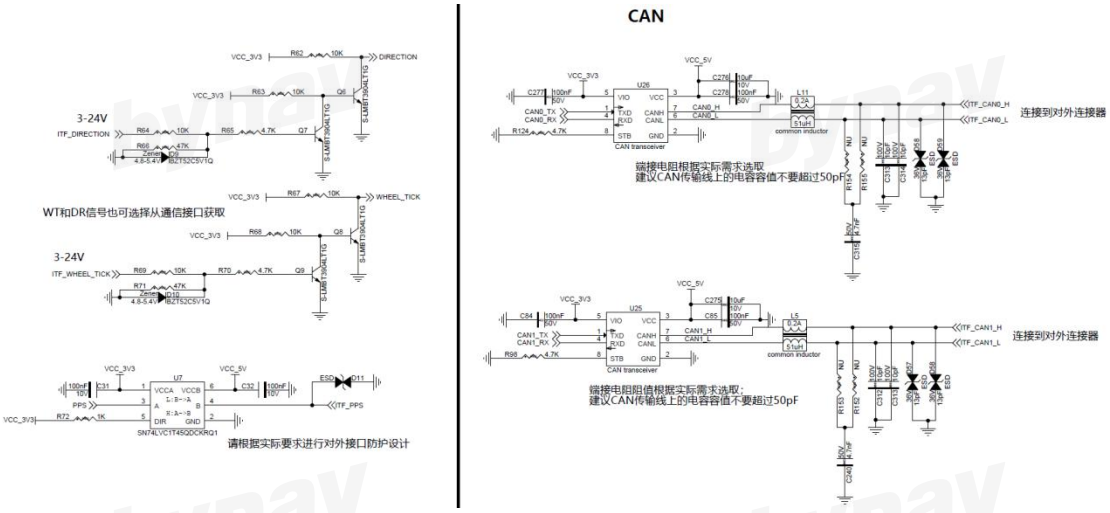


Figure 13- 3 Partial Reference Design for WT&DIR&PPS&CAN

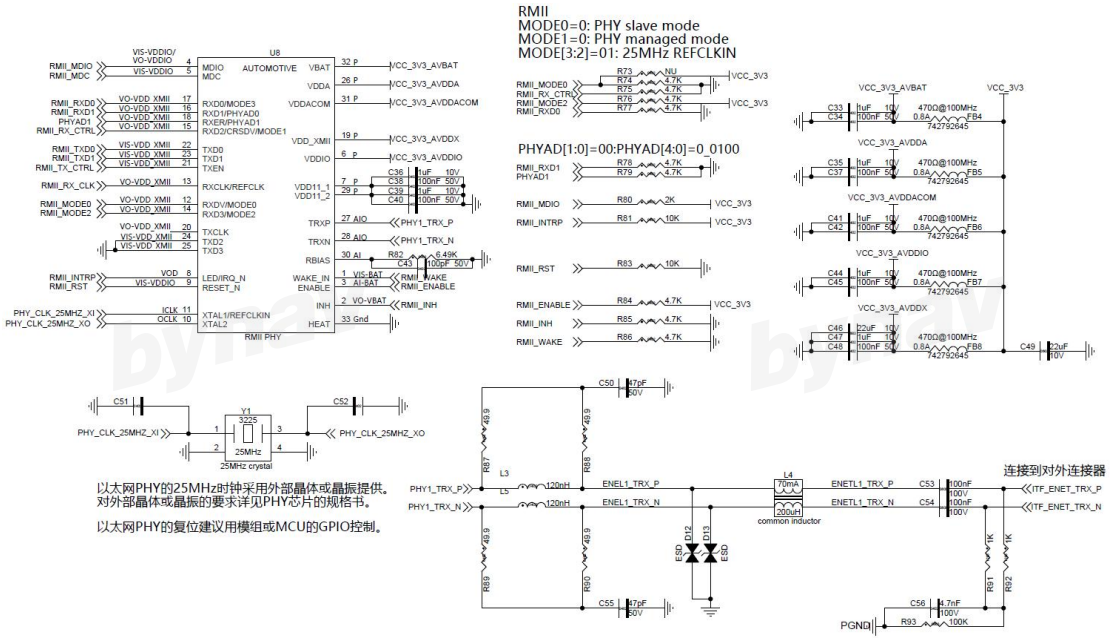


Figure 13- 4 Partial Reference Design for ETHERNET