PKM8720DF-C13-F10 Module

DATASHEET

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TRADEMARKS

USING THIS DOCUMENT

This document is intended for the software engineer's reference and provides detailed programming information.

Though every effort has been made to ensure that this document is current and accurate, more information may have become available subsequent to the production of this guide.

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- **Technical support:** iot_support@realsil.com.cn
- **SDK website:** https://github.com/Ameba-AIoT/ameba-rtos

Contents

1 Module Overview

1.1 General Description

The PKM8720DF-C13-F10 is a multi-radio MCU module. With the open CPU architecture, customers can develop advanced applications running on the dual-core 32-bit MCU. The radio provides support for Wi-Fi 802.11 a/b/g/n in the 2.4GHz/5GHz band and BLE 5.0 communications. The rich set of peripherals and high performance make it an ideal choice for smart homes, industrial automation, consumer electronics, etc.

1.2 Features

Chipset and Memory:

- RTL8720DF-VT1-CG (named RTL8720DF thereafter) chipset embedded, dual-core processor: KM4 up to 200MHz, KM0 up to 20MHz
- KM4 on-chip memory: up to 512KB SRAM
- KM0 on-chip memory: up to 64KB SRAM
- 4MB Flash

Wi-Fi:

- 802.11 a/b/g/n 1x1, 2.4GHz & 5GHz
- Center frequency range of operating channel: 2412MHz ~ 2484MHz, 5180MHz ~ 5825MHz
- Support 20MHz/40MHz bandwidth, up to the data rate of MCS7
- Wi-Fi WEP, WPA, WPA2, WPA3, WPS; open, shared key, and pair-wise key authentication services
- Support low power Tx/Rx for short-range application
- Frame aggregation for increased MAC efficiency (A-MSDU, A-MPDU)

Bluetooth Low Energy:

- Bluetooth LE: Bluetooth 5.0
- Speed: 125Kbps, 500Kbps, 1Mbps, and 2Mbps
- Support LE secure connections
- Support LE scatternet
- Support 3 Master links/1 Slave link
- Co-existence RF design between Wi-Fi and Bluetooth

Peripherals:

- 4x UART interface, baud rate up to 6MHz
- 2 x I2C, two speed modes: standard up to 10Kbps, fast up to 400Kbps
- 2 x SDIO Host/SDIO 2.0 Device, clock up to 50MHz
- 3 x SPI Master/Slave, baud rate up to 50MHz
- 1 x USB 2.0 HS/FS/LS mode
- 11 x PWM with configurable duration and duty cycle from 0 ~ 100%
- 19 x programmable GPIOs
- KM4 and KM0 both have a GDMA controller, each with 6 channels

Antenna Option:

- On-board PCB antenna

Operating Conditions:

- Operating input voltage: (3.3 ± 10%)V
- Operating ambient temperature: -40°C to 105°C

2 Module Block Diagram

This module includes the chipset, crystal component, R/L/C components for RF matching, decoupling and RF radio antenna.

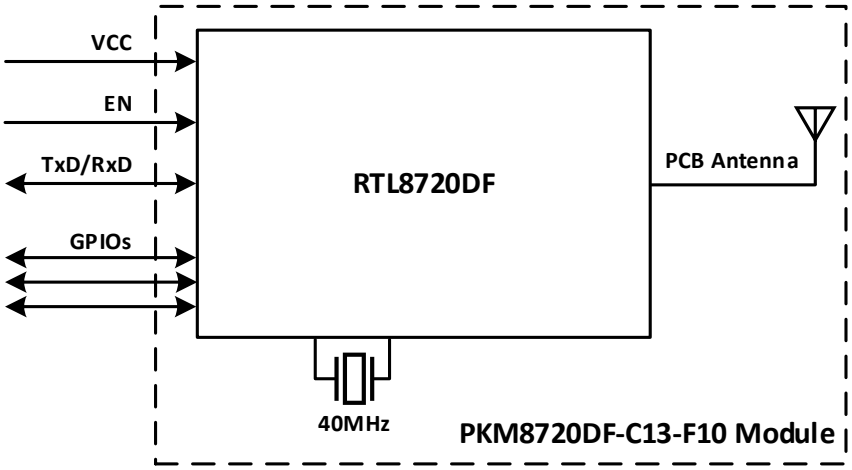


Figure 1. Block Diagram

3 Module Pin Definition

3.1 Module Pin Layout

This module has 22 pins.

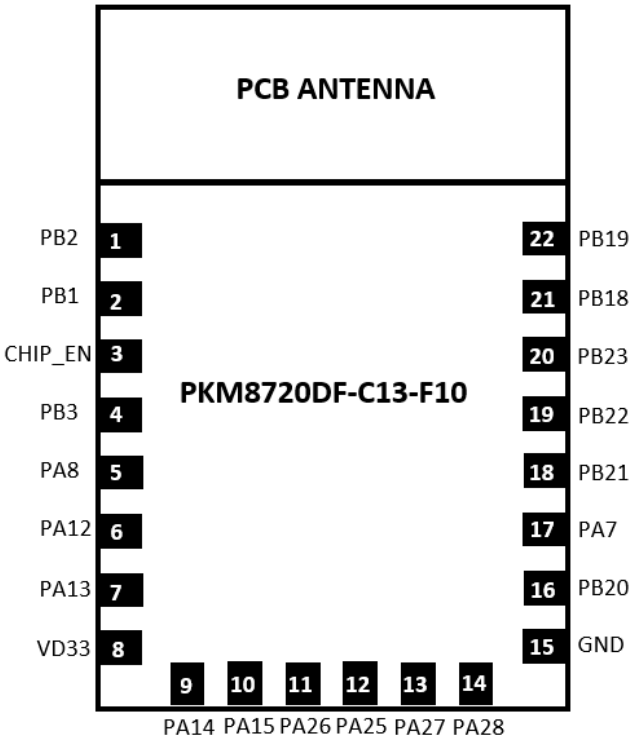


Figure 2. Module Pin Layout (Top View)

3.2 Module Pin Description

3.2.1 Pin Description

Table 1. Pin Description

Pin Name	Pin No.	Type	Description
PB2	1	I/O	GPIOB_2/UART_RXD
PB1	2	I/O	GPIOB_1/UART_TXD
CHIP_EN	3	I	● High: Enable the chip. ● Low: Module power off.
PB3	4	I/O	GPIOB_3/SWD_CLK
PA8	5	I/O	GPIOA_8/UART_LOG_RXD
PA12	6	I/O	GPIOA_12/SPI_MOSI
PA13	7	I/O	GPIOA_13/SPI_MISO
VD33	8	P	Power Supply
PA14	9	I/O	GPIOA_14/SPI_CLK/UART_RTS
PA15	10	I/O	GPIOA_15/SPI_CS/UART_CTS
PA26	11	I/O	GPIOA_26/HSDP
PA25	12	I/O	GPIOA_25/HSDM
PA27	13	I/O	GPIOA_27/SWD_DAT
PA28	14	I/O	GPIOA_28/RREF
GND	15	P	Ground
PB20	16	I/O	GPIOB_20/SDIO_CMD

PA7	17	I/O	GPIOA_7/UART_LOG_TXD
PB21	18	I/O	GPIOB_21/SDIO_CLK
PB22	19	I/O	GPIOB_22/SDIO_D0
PB23	20	I/O	GPIOB_23/SDIO_D1
PB18	21	I/O	GPIOB_18/SDIO_D2/UART RX (Default)
PB19	22	I/O	GPIOB_19/SDIO_D3/UART TX (Default)

NOTE

- ***P**: power supply*
- ***I**: input*
- ***O**: output*

3.2.2 Strapping Pins

This module has 2 strapping pins.

Table 2. Strapping Pin

Pin Name	Pin No.	Default State	Description
PA7	17	Pull up	1: Normal mode (default) 0: Flash download mode
PA27	13	Pull up	1: Normal mode (default) 0: Test mode

4 RF Characteristic

4.1 Wi-Fi Radio Standard

Table 3. Wi-Fi Radio Standard

Wi-Fi Wireless Standard	Description
Wi-Fi frequency range	● 2412MHz ~ 2484MHz (2.4GHz ISM Band) ● 5180MHz ~ 5825MHz (5GHz)
Wi-Fi wireless standard	IEEE 802.11 a/b/g/n
Wi-Fi wireless standard Modulation	DSSS, DBPSK, DQPSK, CCK and OFDM (BPSK/QPSK/16-QAM/64-QAM)
Wi-Fi wireless data rate	● 802.11a: 6/9/12/18/24/36/48/54 Mbps ● 802.11b: 1/2/5.5/11 Mbps ● 802.11g: 6/9/12/18/24/36/48/54 Mbps ● 802.11n: HT20 MCS0-7, HT40 MCS0-7

4.1.1 Wi-Fi 2.4GHz Band RF Transmitter Specification

Table 4. Wi-Fi 2.4GHz Transmitter Performance Specification

Parameter	Condition	Min.	Typ.	Max.	Unit
Frequency Range	Center channel frequency	2412		2484	MHz
Output power with spectral mask and EVM compliance[1]	1Mbps CCK		20		dBm
	11Mbps CCK		18		dBm
	BPSK rate 1/2, 6Mbps OFDM		20		dBm
	64QAM rate 3/4, 54Mbps OFDM		17		dBm
	HT20-MCS 0, BPSK rate 1/2		19		dBm
	HT20-MCS 7, 64QAM rate 5/6		16		dBm
	HT40-MCS 0, BPSK rate 1/2		19		dBm
	HT40-MCS 7, 64QAM rate 5/6		16		dBm
Tx EVM Output power variation Carrier suppression	BPSK rate 1/2, 6Mbps OFDM		-25	-5	dB
	64QAM rate 3/4, 54Mbps OFDM		-34	-25	dB
	HT20-MCS 0, BPSK rate 1/2		-29	-5	dB
	HT20-MCS 7, 64QAM rate 5/6		-34	-28	dB
	HT40-MCS 0, BPSK rate 1/2		-25	-5	dB
	HT40-MCS 7, 64QAM rate 5/6		-35	-28	dB
	After do power trim at FT	-1.5		1.5	dBm
				-30	dBm
Harmonic output power (IC port)	2nd harmonic		-23	-21.9	dBm
	3rd harmonic		-15	-14	dBm

NOTE

[1] The power level is tested after Digital Pre-Distortion (DPD) enable.

4.1.2 Wi-Fi 2.4GHz Band RF Receiver Specification

Table 5. Wi-Fi 2.4GHz Receiver Performance Specification

Parameter	Condition	Min.	Typ.	Max.	Unit
Frequency Range	Center channel frequency	2412		2484	MHz
802.11b Rx Sensitivity	1Mbps CCK		-98		dBm
	2Mbps CCK		-96		dBm
	5.5Mbps CCK		-94		dBm
	11Mbps CCK		-91		dBm
802.11g Rx Sensitivity	BPSK rate 1/2, 6Mbps OFDM		-95		dBm
	BPSK rate 3/4, 9Mbps OFDM		-94		dBm

	QPSK rate 1/2, 12Mbps OFDM		-93		dBm
	QPSK rate 3/4, 18Mbps OFDM		-90		dBm
	16QAM rate 1/2, 24Mbps OFDM		-87		dBm
	16QAM rate 3/4, 36Mbps OFDM		-84		dBm
	64QAM rate 1/2, 48Mbps OFDM		-79		dBm
	64QAM rate 3/4, 54Mbps OFDM		-77		dBm
802.11n Rx Sensitivity BW = 20MHz Mixed Mode 800ns Guard Interval Non-STBC	MCS 0, BPSK rate 1/2		-95		dBm
	MCS 1, QPSK rate 1/2		-92		dBm
	MCS 2, QPSK rate 3/4		-89		dBm
	MCS 3, 16QAM rate 1/2		-86		dBm
	MCS 4, 16QAM rate 3/4		-83		dBm
	MCS 5, 64QAM rate 2/3		-78		dBm
	MCS 6, 64QAM rate 3/4		-77		dBm
	MCS 7, 64QAM rate 5/6		-75		dBm
802.11n Rx Sensitivity BW = 40MHz Mixed Mode 800ns Guard Interval Non-STBC	MCS 0, BPSK rate 1/2		-93		dBm
	MCS 1, QPSK rate 1/2		-89		dBm
	MCS 2, QPSK rate 3/4		-86		dBm
	MCS 3, 16QAM rate 1/2		-83		dBm
	MCS 4, 16QAM rate 3/4		-80		dBm
	MCS 5, 64QAM rate 2/3		-75		dBm
	MCS 6, 64QAM rate 3/4		-74		dBm
	MCS 7, 64QAM rate 5/6		-72		dBm
Maximum Receive Level	6Mbps OFDM		0		dBm
	54Mbps OFDM		0		dBm
	MCS 0		0		dBm
	MCS 7		0		dBm
Receive Adjacent Channel Rejection	1Mbps CCK		43		dB
	11Mbps CCK		41		dB
	BPSK rate 1/2, 6Mbps OFDM		40		dB
	64QAM rate 3/4, 54Mbps OFDM		22		dB
	HT20, MCS 0, BPSK rate 1/2		39		dB
	HT20, MCS 7, 64QAM rate 5/6		20		dB
	HT40, MCS 0, BPSK rate 1/2		29		dB
	HT40, MCS 7, 64QAM rate 5/6		10		dB

4.1.3 Wi-Fi 5GHz Band RF Transmitter Specification

Table 6. Wi-Fi 5GHz Transmitter Performance Specification

Parameter	Condition	Min.	Typ.	Max.	Unit
Frequency Range	Center channel frequency	5180		5825	MHz
Output power with spectral mask and EVM compliance[1]	BPSK rate 1/2, 6Mbps OFDM		18		dBm
	64QAM rate 3/4, 54Mbps OFDM		14		dBm
	HT20-MCS 0, BPSK rate 1/2		17		dBm
	HT20-MCS 7, 64QAM rate 5/6		13		dBm
	HT40-MCS 0, BPSK rate 1/2		17		dBm
	HT40-MCS 7, 64QAM rate 5/6		13		dBm
Tx EVM	BPSK rate 1/2, 6Mbps OFDM		-24	-5	dB
	64QAM rate 3/4, 54Mbps OFDM		-29	-25	dB
	HT20-MCS 0, BPSK rate 1/2		-26	-5	dB
	HT20-MCS 7, 64QAM rate 5/6		-31	-28	dB
	HT40-MCS 0, BPSK rate 1/2		-23	-5	dB
	HT40-MCS 7, 64QAM rate 5/6		-31	-28	dB
Output power variation	After doing power trim at FT	-1.5		1.5	dBm
Carrier suppression				-30	dBm

NOTE

[1] The power level is tested after Digital Pre-Distortion (DPD) enable.

4.1.4 Wi-Fi 5GHz Band RF Receiver Specification

Table 7. Wi-Fi 5GHz Receiver Performance Specification

Parameter	Condition	Min.	Typ.	Max.	Unit
Frequency Range	Center channel frequency	5180		5825	MHz
802.11g Rx Sensitivity	BPSK rate 1/2, 6Mbps OFDM		-93		dBm
	BPSK rate 3/4, 9Mbps OFDM		-93		dBm
	QPSK rate 1/2, 12Mbps OFDM		-92		dBm
	QPSK rate 3/4, 18Mbps OFDM		-89		dBm
	16QAM rate 1/2, 24Mbps OFDM		-86		dBm
	16QAM rate 3/4, 36Mbps OFDM		-83		dBm
	64QAM rate 1/2, 48Mbps OFDM		-78		dBm
	64QAM rate 3/4, 54Mbps OFDM		-76		dBm
802.11n Rx Sensitivity BW = 20MHz Mixed Mode 800ns Guard Interval Non-STBC	MCS 0, BPSK rate 1/2		-93		dBm
	MCS 1, QPSK rate 1/2		-91		dBm
	MCS 2, QPSK rate 3/4		-88		dBm
	MCS 3, 16QAM rate 1/2		-85		dBm
	MCS 4, 16QAM rate 3/4		-82		dBm
	MCS 5, 64QAM rate 2/3		-77		dBm
	MCS 6, 64QAM rate 3/4		-75		dBm
	MCS 7, 64QAM rate 5/6		-74		dBm
802.11n Rx Sensitivity BW = 40MHz Mixed Mode 800ns Guard Interval Non-STBC	MCS 0, BPSK rate 1/2		-91		dBm
	MCS 1, QPSK rate 1/2		-88		dBm
	MCS 2, QPSK rate 3/4		-85		dBm
	MCS 3, 16QAM rate 1/2		-82		dBm
	MCS 4, 16QAM rate 3/4		-79		dBm
	MCS 5, 64QAM rate 2/3		-74		dBm
	MCS 6, 64QAM rate 3/4		-73		dBm
	MCS 7, 64QAM rate 5/6		-71		dBm
Maximum Receive Level	6Mbps OFDM		0		dBm
	54Mbps OFDM		0		dBm
	MCS 0		0		dBm
	MCS 7		0		dBm
Receive Adjacent Channel Rejection	BPSK rate 1/2, 6Mbps OFDM		21		dB
	64QAM rate 3/4, 54Mbps OFDM		11		dB
	HT20, MCS 0, BPSK rate 1/2		19		dB
	HT20, MCS 7, 64QAM rate 5/6		7		dB
	HT40, MCS 0, BPSK rate 1/2		30		dB
	HT40, MCS 7, 64QAM rate 5/6		13		dB

4.2 Bluetooth LE Radio Standard

4.2.1 Bluetooth LE RF Transmitter Specification

Table 8. Bluetooth LE Transmitter Performance Specification

Parameter	Condition	Min.	Typ.	Max.	Unit
Frequency Range	Center channel frequency	2402		2480	MHz
Tx Output Power	LE1M	-10	4.5	10	dBm
	LE2M				
Modulation Characteristics (LE1M)	ΔF1 Avg.	225		275	kHz
	ΔF2 Max.	185			kHz
	Modulation Index (ΔF2 Avg./ΔF1 Avg.)	0.8			
Modulation Characteristics (LE2M)	ΔF1 Avg.	450		550	kHz
	ΔF2 Max.	370			kHz
	Modulation Index (ΔF2 Avg./ΔF1 Avg.)	0.8			
Modulation Characteristics	ΔF1 Avg.	247.5		252.5	kHz

Stable Modulation (LE1M)	ΔF2 Max.	185			kHz
	Modulation Index (ΔF2 Avg./ΔF1 Avg.)	0.8			
Modulation Characteristics Stable Modulation (LE2M)	ΔF1 Avg.	495		505	kHz
	ΔF2 Max.	370			kHz
	Modulation Index (ΔF2 Avg./ΔF1 Avg.)	0.8			

4.2.2 Bluetooth LE RF Receiver Specification

Table 9. Bluetooth LE Receiver Performance Specification

Parameter	**Condition**	**Min.**	**Typ.**	**Max.**	**Unit**
Frequency Range	Center channel frequency	2402		2480	MHz
Rx Sensitivity @30.8% PER	LE1M		-100.9		dBm
	LE2M	-	-95	-	

5 Module Electrical Characteristics

5.1 Module Operating Conditions

Table 10. Module Operating Conditions

Symbol	Parameter	Min.	Typ.	Max.	Units
VCC	Power supply voltage	3.0	3.3	3.6	V
T_A	Ambient operating temperature	-40		105	℃
T_S	Storage temperature range	-65		150	℃

5.2 Module DC Characteristics

Table 11. DC Characteristic (3.3V, 25°C)

Symbol	Parameter	Conditions	Min.	Typ.	Max.	Units
V_{IH}	Input-High Voltage	CMOS level	2.0			V
V_{IL}	Input-Low Voltage	CMOS level			0.8	V
V_{OH}	Output-High Voltage	CMOS level VDD=3.3V±10% IOH max.	2.4			V
V_{OL}	Output-Low Voltage	TTL level VDD=3.3V±10% IOL max.			0.4	V
V_{T+}	Schmitt-trigger High Level		1.78	1.87	1.97	V
V_{T-}	Schmitt-trigger Low Level		1.36	1.45	1.56	V
I_{IL}	Input-Leakage Current	VIN=3.3V or 0	-10	±1	10	μA

6 Module Schematics

6.1 Module Internal Schematics

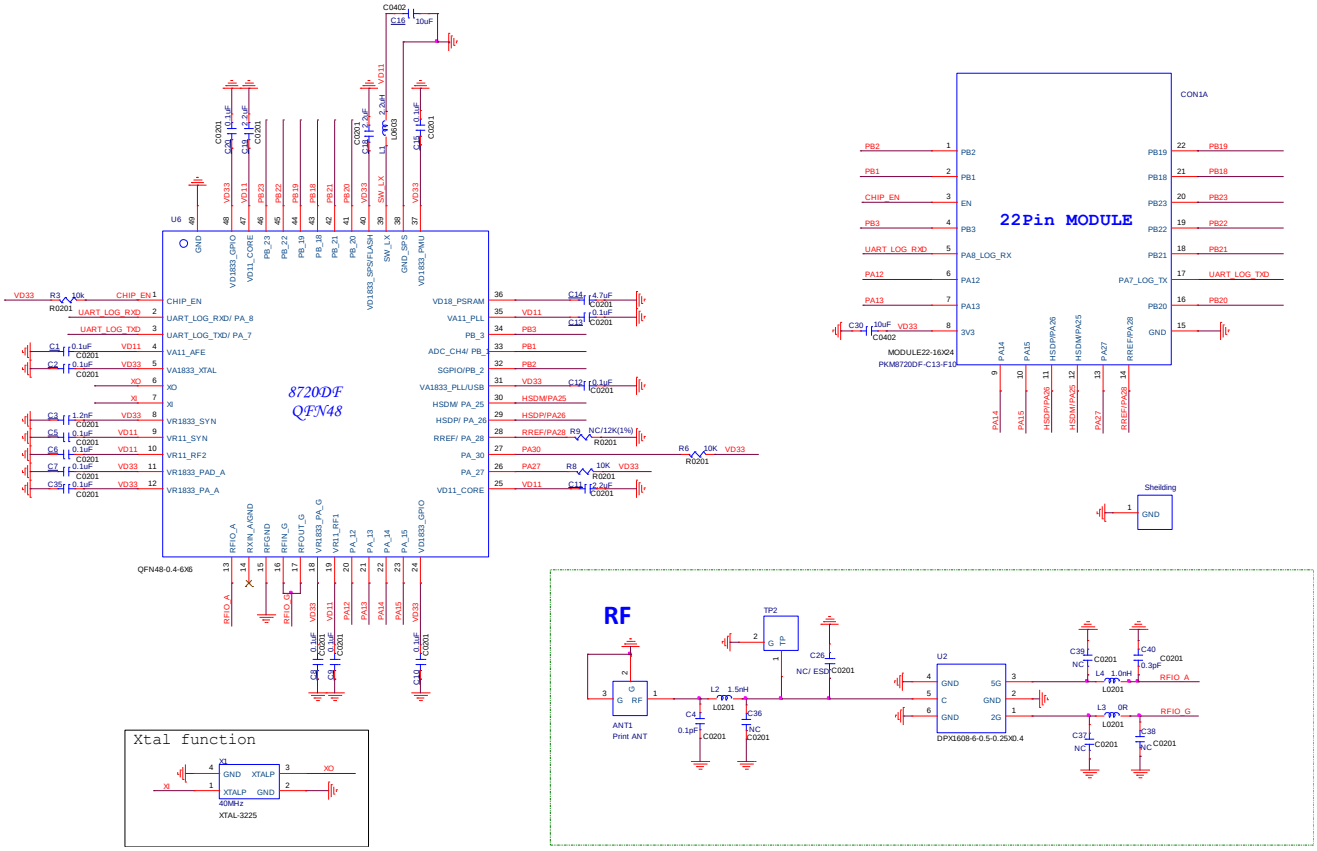


Figure 3. Module Internal Schematics

7 Physical Dimensions

Module dimension: 24 ± 0.2mm (L) x 16 ± 0.2mm (W) x 2.3 ± 0.1mm (H)

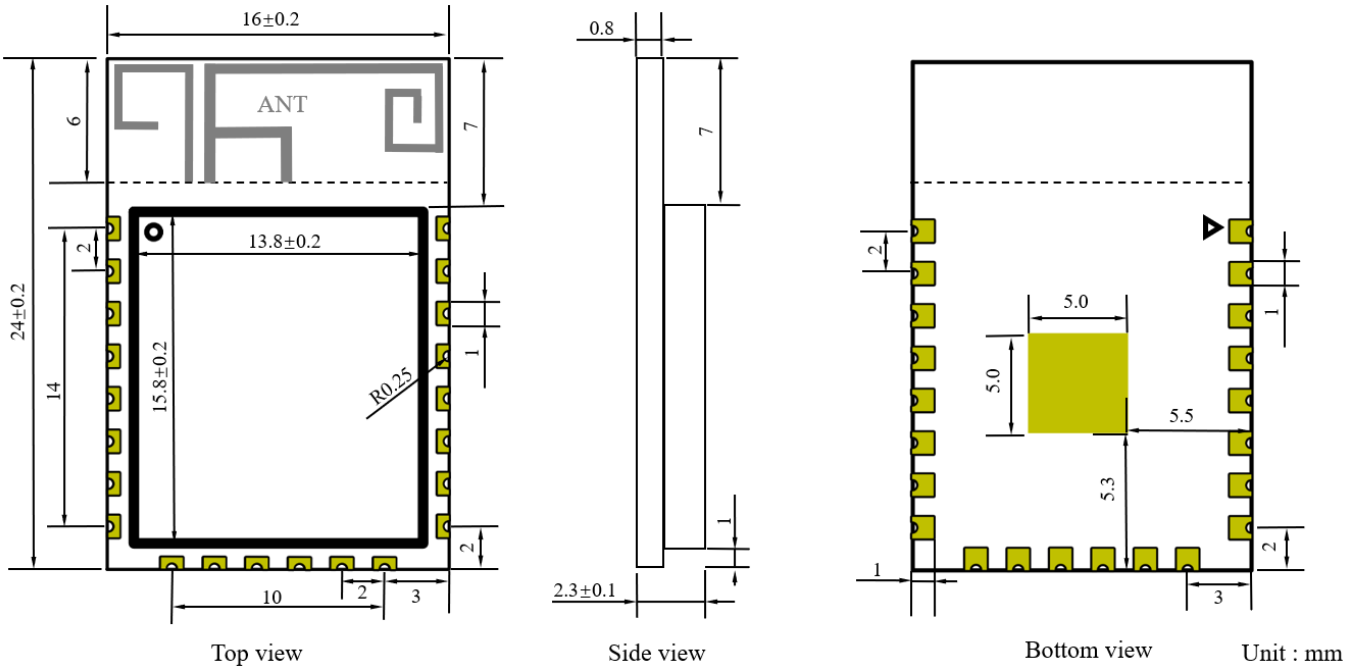


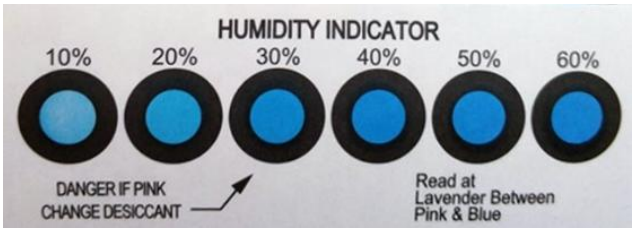
Figure 4. Module Physical Dimensions

8 Product Handling

8.1 Storage Conditions

The storage conditions for a delivered module:

- Moisture sensitive level (MSL): 3
- Calculated shelf life in sealed bag: 12 months at <40°C and <90% relative humidity (RH)
- Peak package body temperature: 260°C
- A humidity indicator card (HIC) in the packaging bag.



- After bag is opened, the module that will be subjected to reflow solder or other high temperature process must be
  - Mounted within: 168 hours of factory conditions ≤30°C/60% RH, or
  - Stored per J-STD-033
- The module needs to be baked in the following cases:
  - The packaging bag is damaged before unpacking.
  - There is no humidity indicator card (HIC) in the packaging bag.
  - After unpacking, circles of 10% and above on the HIC become pink.
  - The total exposure time has lasted for over 168 hours since unpacking.
  - More than 12 months have passed since the sealing of the bag.
- If baking is required, refer to IPC/JEDEC J-STD-033 for bake procedure.

NOTE

Level and body temperature are defined by IPC/JEDECJ-STD-020.

8.2 Production Instructions

- The PKM8720DF-C13-F10 module can be packaged with the SMT process according to the customer's PCB designed to be SMT-packaged. After being unpacked, the module must be soldered within 24 hours. Otherwise, it needs to be put into the drying cupboard where the relative humidity is not greater than 10%; or it needs to be packaged again under vacuum and the exposure time needs to be recorded (the total exposure time cannot exceed 168 hours).
  - SMT devices needed:
    - Mounter
    - SPI
    - Reflow soldering machine
    - Thermal profiler
    - Automated optical inspection (AOI) equipment
  - Baking devices needed:
    - Cabinet oven
    - Anti-electrostatic and heat-resistant trays
    - Anti-electrostatic and heat-resistant gloves
- Baking settings:
  - Temperature: 40°C and ≤ 5% RH for reel package and 125°C and ≤5% RH for tray package (use the heat-resistant tray rather than a plastic container)
  - Time: 168 hours for reel package and 12 hours for tray package
  - Alarm temperature: 50°C for reel package and 135°C for tray package
  - Production-ready temperature after natural cooling: < 36°C
  - Re-baking situation: If a module remains unused for over 168 hours after being baked, it needs to be baked again.
  - If a batch of modules is not baked within 168 hours, do not use the wave soldering to solder them. Because these modules are Level-3 moisture-sensitive devices, they are very likely to get damp when exposed beyond the allowable time. In this case, if they are soldered at high temperatures, it may result in device failure or poor soldering.
- In the whole production process, take electrostatic discharge (ESD) protective measures.

- To guarantee the passing rate, it is recommended to use the SPI and AOI to monitor the quality of solder paste printing and mounting.

8.3 Recommended Oven Temperature Curve

There are some differences between the set temperatures and the actual temperatures. All the temperatures listed in this datasheet are obtained through actual measurements.

For the SMT process, set oven temperatures according to Figure 5.

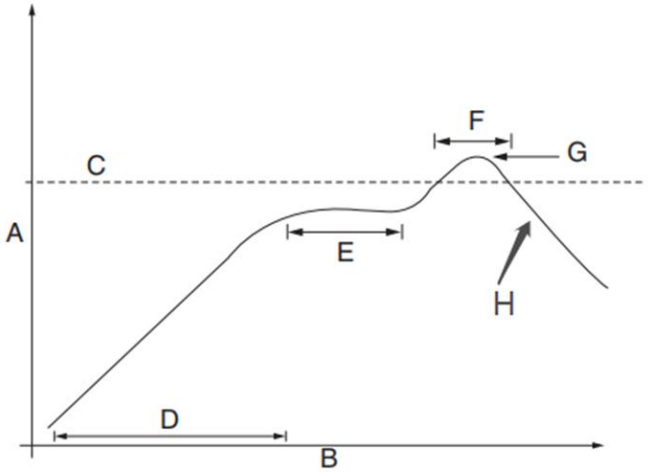


Figure 5. Reflow Soldering Curve Diagram

- D: Rising speed = (1 ~ 3)°C/s, 20°C ~ 150°C, 60s ~ 90s
- E: Average preheating temperature = 150°C ~ 200°C, 60s ~ 120s
- F: Temperature fluctuation > 217°C, 50s to 70s; peak temperature = 235°C ~ 245°C
- H: Drop speed = (1 ~ 4)°C/s

NOTE

Adjust the balance time to ensure the rationalization treatment of gas when tin paste solves. If there are too much gaps on the PCB board, increase the balance time. Considering that the product is long placed in the welding area, to prevent components and bottom plate from damage.

9 Revision History

Data	Revision	Change Note
2023-03-30	1.0	Initial release
2024-08-27	1.1	Change contact email
2025-09-25	1.2	Correct some formats