

# **CPU Embedded Wireless LAN Module IEEE802.11b/g/n**

## **WKM320AA1**

### Data Sheet

By purchase of any of products described in this document, the customer is deemed to understand and accept contents of this document.

***ATTENTION: Software related to this module may be under Japan export control. Depending on the customer's country and application (e.g. weapons), KAGA FEI may not be able to provide the software to all customers. Please contact your local KAGA FEI sales office for additional information.***

***To contact your local sales office and for additional product information, please visit  
[www.kagafei.com/jp/eng/](http://www.kagafei.com/jp/eng/)***

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## 1.Document constituent list

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General Items	KM-AG-A223019	<a href="#">1/7 - 7/7</a>
Absolute maximum ratings	KM-AM-A223019	<a href="#">1/1</a>
Electrical characteristics	KM-AE-A223019	<a href="#">1/10 – 10/10</a>
Circuit schematic	KM-MC-A223019	<a href="#">1/2 – 2/2</a>
Outline / Appearance	KM-AD-A223019	<a href="#">1/5 - 5/5</a>
Pin Layout	KM-BA-A223019	<a href="#">1/4 - 4/4</a>
Handling Precaution	MQ-H-001	<a href="#">1/2 - 2/2</a>
Packaging Specification	KM-BB-A223019	<a href="#">1/3 - 3/3</a>
Antenna Application Note	-	<a href="#">1/3 - 3/3</a>
Precautions	MQ-P-001	<a href="#">1/1</a>

Rev. record

17-Aug. 2023> Rev.1.0 Release

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## 2. General Items

### 2.1. Scope

This specification ("Specification") applies to the hybrid IC "WKM320AA1", Wireless LAN module ("Product") manufactured by KAGA FEI Co., Ltd. ("KAGA FEI").

### 2.2. Description

- ① User Code : WKM320AA1  
Model : WKM320

Note: Please let us know the Part number (WKM320AA1) to order this product.

- ② Chip : NXP 88MW320
- ③ Function : CPU embedded Radio frequency transceiver Module.  
( IEEE 802.11 b/g/n conformity)
- ④ Application : IoT devices
- ⑤ Structure : Hybrid IC loaded with silicon monolithic semiconductor.

Regarding the containment of hazardous substance in this Product, it conforms to RoHS Directive.

Ability of lead free mounting at customer's assembly  
(Heat resistance of this Product) : Yes

- ⑥ Outline : 44-pin Land Grid Array
- ⑦ Marking : Part number, Lot Number, Japan ID, FCC ID, ISED ID and manufacturer on Shielding Case
- ⑧ Country of origin : Japan or Thailand
- ⑨ Packaging : Packaging method : Tray  
Packaging unit : 840pcs  
Standard order quantity : 840pcs multiples

- ⑩ Notes :

a. Limitation of Warranty

- i) KAGA FEI provide warranties only if the product is operated under the condition set forth in this specification. Please note that KAGA FEI shall not be liable for any defect and/or malfunction arising from use of the product under the terms and conditions other than the operating conditions hereof. In addition when this product is used under environmental conditions such as over voltage which is not guaranteed, it may be destroyed in short mode. To ensure the security of customer's product, please add an extra fuse or/and a protection circuit for over voltage.

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ii) In some cases, KAGA FEI may use replacements as component parts of products. Such replacement shall apply only to component part of products, which KAGA FEI deems it possible to replace or substitute according to (i) scope of warranty provided in this specification (e.g. electric characteristics, outline, dimension, conditions of use, reliability tests, official standard (type approvals etc.)) and (ii) quality of products. KAGA FEI also ensures traceability of such replacement on production lot basis.

**b. Instruction for Use (CAUTION)**

i) This Product is not designed to be radiation-resistant. Please do not expose Product to radiation.

ii) Communication between this product and other might not be established nor maintained depending upon radio environment or operating condition of this product and other products with wireless technology.

iii) This product operates in the unlicensed ISM band at 2.4GHz. In case this product is used around the other wireless devices which operate in same frequency band of this product, there is a possibility that interference occurs between this product and such other devices. If such interference occurs, please stop the operation of other devices or relocate this product before using this product or do not use this product around the other wireless devices.

**c. Term of Support**

i) In the case that customer requests KAGA FEI to customize the hardware of this Product in order to meet such customer's specific needs, KAGA FEI will make commercially reasonable effort to modify such hardware or software at customer's expense; provide however, the customer is kindly requested to agree it doesn't mean that KAGA FEI has obligations to do so even in the case it is technically difficult for KAGA FEI.

ii) Any failure arising out of this Product will be examined by KAGA FEI regardless of before or after mass production. Customer agrees that once such failure is turned out not to be responsible for KAGA FEI after aforesaid examination, some of the technical support shall be conducted by KAGA FEI at customer's expense; provided however, exact cost of this technical support can be agreed through the negotiation by the parties.

iii) Do not alter hardware and/or software of this Product. Please note that KAGA FEI shall not be liable for any problem if it is caused by customer's alteration of Hardware without KAGA FEI prior approvals.

iv) KAGA FEI does not guarantee functions and performances which depend on the customer's firmware. KAGA FEI does not assume liabilities for defects and failures (i) in functions, performances and quality of the Customer's product incorporating the Products and (ii) which may occur as the Product is incorporated in the Customer's product.

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d. Term of Warranty

KAGA FEI warrants only that this Product is in conformity with this Specification for one year after purchase and shall in no event give any other warranty.

e. Items of the Specification

Any question arising from the Specification shall be solved in good faith through mutual discussion by the parties hereof.

f. Caution for Export Control

This Product may be subject to governmental approvals, consents, licenses, authorizations, declarations, filings, and registrations for export or re-export as required by Japanese Foreign Exchange and Foreign Trade Law (including related laws and regulations) and/or any other country's applicable laws or regulations related to export control.

If this Product will be exported or re-exported, it is strongly recommended that customers check and confirm the necessary procedures to export or re-export this Product as required by applicable laws and regulations, and if necessary, customers must obtain the necessary and appropriate approvals or licenses from governmental authority at their own risk and expense.

⑪ Japan Regulatory Information

This module is approved with the specific antenna on this module. Please ensure that your product can also bear a label with the following information. If the product is so small that it is not practicable to place the label, you can also place it in the instruction manual and package. The mark diameter shall be easily legible without using a device such as light microscopes.



® 001-A19658

It is recommended to include the following sentence in the user manual of your product:

This product installs a radio system which has been approved as a radio station in a low power data communication system based on the Radio Law.

WKM320 : 001-A19658

Region is set to US as default and 12ch(2467MHz) and 13ch(2472MHz) are disabled. Please change the region setting to Japan, if it is needed to use these channels on the final product.

⑫ Canada Regulatory Information

a) This device contains license-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's license-exempt RSS(s). Operation is subject to the following two conditions:

(1) This device may not cause interference.

(2) This device must accept any interference, including interference that may cause undesired operation of the device.

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Le présent appareil est conforme aux CNR Innovation, Sciences et Développement économique Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes:

- 1) l'appareil ne doit pas produire de brouillage;
- 2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

b) This equipment complies with ISED radiation exposure limits set forth for an uncontrolled environment and meets RSS-102 of the ISED radio frequency (RF) Exposure rules. This equipment should be installed and operated keeping the radiator at least 20cm or more away from person's body.

Cet équipement est conforme aux limites d'exposition aux rayonnements énoncées pour un environnement non contrôlé et respecte les règles d'exposition aux fréquences radioélectriques (RF) CNR-102 de l'ISED. Cet équipement doit être installé et utilisé en gardant une distance de 20 cm ou plus entre le radiateur et le corps humain.

c) Please notify certified ID by either one of the following method on your product.

Spécifiez ID certifiée dans votre produit par une de méthode suivante.

- Contains Transmitter module IC : 28568-WKM320
- Contains IC : 28568-WKM320

d) Please indicate your product name at any location on the exterior of the host product or product packaging or product literature, which shall be available with the host product or online.

e) This product is certified under the conditions of using channels 1(2412MHz) to 11(2462MHz). Please set the region as CANADA or other which uses channels from 1 to 11. If channels 12(2467MHz) or 13(2472MHz) are used, it may violate the radio regulations.

Ce produit est certifié pour une utilisation sur les canaux 1 (2412MHz) à 11 (2462MHz). Veuillez choisir la région CANADA ou toute autre région utilisant uniquement ces canaux. L'utilisation sur les canaux 12 (2467MHz) ou 13 (2472MHz) peut constituer une violation des règlements sur les radiocommunications.

f) Please include the following statements in rectangle on the user manual of the host device of this module;

This equipment complies with ISED radiation exposure limits set forth for an uncontrolled environment and meets RSS-102 of the IC radio frequency (RF) Exposure rules. This equipment should be installed and operated keeping the radiator at least 20cm or more away from person's body.

Cet équipement est conforme aux limites d'exposition aux rayonnements énoncées pour un environnement non contrôlé et respecte les règles d'exposition aux fréquences radioélectriques (RF) CNR-102 de l'ISED. Cet équipement doit être installé et utilisé en gardant une distance de 20 cm ou plus entre le dispositif rayonnant et le corps humain.

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⑬ FCC Regulatory Information

- a) 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.
- b) Please notify certified ID by either one of the following method.
- Contains Transmitter Module FCC ID: 2A6NFWKM320
  - Contains FCC ID: 2A6NFWKM320
- c) CAUTION: changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.
- d) This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment and meets the FCC radio frequency (RF) Exposure Guidelines. This equipment should be installed and operated keeping the radiator at least 20cm or more away from person's body.
- e) The antenna used for this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.
- f) This module can change the output power depending on the circumstances by the application software which is developed by module installer. Any end user cannot change the output power.
- g) This product is certified under the condition of using 1(2412MHz) to 11(2462MHz) channels. Region is set to US as default and 1 to 11 channels are used. Please set the region as default (US) and do not change. If 12(2467MHz) or 13(2472MHz) channels are used, it may violate the radio regulations.
- h) Wireless LAN of this module complies with the following standards:
- FCC part 15 Subpart C (2.4GHz band)
- i) This product is FCC approved only as a module. Manufacturers of final devices has a responsibility for the conditions which are not approved as a module. Please carry out the tests of FCC Part 15 Subpart B in case your final device installs this module.
- j) Co-location of this module with other transmitters that operate simultaneously are required to be evaluated using the FCC multi transmitter procedures. When installing this module to your final devices, please make sure to carry out all the necessary evaluations according to the applicable guidelines like follows:
- for RF exposure: KDB 447498, KDB 996369 and any other relevant guidelines
  - for EMC: KDB 996369 D04 and any other relevant guidelines
- k) When you install this module to your final devices, please ensure that your final composite product complies with the applicable FCC rules in reference to a guidance in KDB 996369.

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l) When you install this module to your final devices, please ensure to perform all the required equipment authorization and testing for the technical parameters which are not covered by the module grant (e.g., unintentional radiator Part 15 Subpart B requirements, or transmitters used in the host which are not previously approved as modules).

m) Antenna List

This module is approved along with the following antennas.

You cannot use any antennas other than the listed ones because it deviates from the accredited conditions.

Manufacturer	KAGA FEI
Part No.	N / A (Printed on PCB)
Antenna Type	Monopole
Maximum Antenna Gain	-2.9dBi

n) Please include the following statements in rectangle on the user manual of the host device of this module;

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.

FCC CAUTION: Any changes or modifications not expressly approved by the party responsible for compliance could void the use's authority to operate the equipment.

The antenna used for this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment and meets the FCC radio frequency (RF) Exposure Guidelines. This equipment should be installed and operated keeping the radiator at least 20cm or more away from person's body.

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#### ⑭ CE Regulatory Information

a) When your end product installs this module, it is required to proceed additional certification processes before placing on the market in EU member states to make your products fully comply with relative EU standards. Additionally, if your end product is subject to the restrictions of RE Directive, Article 10.10, it is required to display the required information in addition to the certification processes.

Referenced regulations:

- Directive 2014/53/EU
- COMMISSION IMPLEMENTING REGULATION (EU) 2017/1354 of 20 July 2017 specifying how to present the information provided for in Article 10(10) of Directive 2014/53/EU of the European Parliament and of the Council

Above regulations are referenced as of the issue date of this document. Since the aforementioned regulations have possibilities to be modified and added in the future, please make sure that you should always confirm the latest regulations.

b) KAGA FEI can provide you the test reports of conducted measurement portion for the radio module. You can utilize the test reports for the certification processes of your end product as it requires radio testing.

#### ⑮ France Regulatory Information

This radio module complies with European radiation exposure limits set forth for an uncontrolled environment and meets the European radio frequency exposure regulations. This radio module should be installed and operated keeping the radiator at least 20cm or more away from human body. When using this radio module within 20cm from human body, it can be required to proceed additional testing or evaluation for Specific Absorption Rate (SAR). When performing the additional SAR test or evaluation, please indicate the SAR value on your user instructions in a legible, intelligible and visible manner if your final device is being put into service and intended to be used in France.

Referenced regulations (France)

- Order of amending the Order of 8 October 2003 on consumer information regarding radio terminal equipment issued pursuant to Article R20-10 of the Postal and Telecommunications Code, the Order of 8 October 2003 setting out the technical specifications applicable to radio terminal equipment and the Order of 12 October 2010 on displaying the specific absorption rate of radio terminal equipment
- Order of 8 October 2003 on consumer information regarding radio terminal equipment issued pursuant to Article R20-10 of the Postal and Telecommunications Code
- Order of 8 October 2003 setting out the technical specifications applicable to radio terminal equipment
- Order of 12 October 2010 on displaying the specific absorption rate of radio terminal equipment

Above regulations are referenced as of the issue date of this document. Since the aforementioned regulations have possibilities to be modified and added in the future, please make sure that you should always confirm the latest regulations.

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### 3. Absolute maximum ratings

#### 3.1. Absolute maximum ratings

Item	Symbol	Rating				Remark
		Min.	Typ.	Max.	Unit	
Supply voltage 1	VIO	-		3.63	V	
Supply voltage 2	VIOH	-		3.63	V	
Supply voltage 3	VIOF	-		3.63	V	
Supply voltage 4	V33	-		3.63	V	
Storage temperature range	Tstg	-40		85	Degrees C	
Operation temperature range	Topr	-30	25	85	Degrees C	

#### 3.2. Recommendation operating range

Item	Symbol	Rating				Remark
		Min.	Typ.	Max.	Unit	
Supply voltage 1	VIO	3.0	3.3	3.6	V	
Supply voltage 2	VIOH	3.0	3.3	3.6	V	
Supply voltage 3	VIOF	3.0	3.3	3.6	V	
Supply voltage 4	V33	3.0	3.3	3.6	V	

#### 3.3. Built in flash memory characteristics

Item	Rating				Remark
	Min.	Typ.	Max.	Unit	
Write/Erase Cycle	10,000	-	-	Times	

## 4. Electrical characteristics

### 4.1. DIGITAL IO FEATURES

#### 4.1.1. Inter-Integrated Circuit (I2C)

The I2C bus interface complies with the common I2C protocol and can operate in standard mode (with data rates up to 100kbps), fast mode (with data rate up to 400kbps) and high-speed mode (with data rate up to 2Mbps). Additionally, high-speed mode devices and fast mode devices are downward compatible. The I2C bus interface unit has the following features:

- I2C serial interfaces consisting of a serial data line (SDL) and serial clock (SCL)
- Three speeds:
  - Standard mode (up to 100kbps)
  - Fast mode (up to 400kbps)
  - High-speed mode (2Mbps)
- Master or Slave I2C operation
- 7 or 10 bits addressing
- 16 \* 32 bits deep transmit and receive buffers, respectively
- Interrupt operation
- DMA function

#### 4.1.2. Synchronous Serial Protocol (SSP)

An SSP port is a synchronous serial controller that can be connected to a variety of external Analog-to-Digital converters (ADC), audio and telecommunication codecs, and many other devices that use serial protocols for data transfer.

The SSP ports are configurable to operate in Master mode (the attached peripheral function as a slave) or Slave mode (the attached peripheral functions as a master).

The SSP ports support serial bit rates from 1Mbps (minimum recommended speed) up to 25 Mbps. A FIFO is provided for Transmit data and a second independent FIFO is provided for Receive data. The two FIFOs are both 16 x 32 bits wide or both are 32 x 16 bits wide. The FIFOs can be loaded or emptied by the Cortex-M4F Processor or by DMA burst transfers.

The SSP port features are as follows:

- Supports Motorola Serial Peripheral Interface (SPI)
- Supports DMA transfer

#### 4.1.3. Universal Asynchronous Receiver Transmitter (UART)

- Separate 64x8 transmit and 64x11 receive FIFO memory buffers to reduce CPU interrupts
- Programmable baud rate generator
- Ability to add or delete standard asynchronous communication bits (start, stop, and parity) in the serial data
- Flow control
  - RTS(output) controlled by the UART Receive FIFO
  - CTS(input) from modem control UART transmitter
- Separate DMA requests for Transmit and Receive data services

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#### 4.1.4. Analog Digital Converter (ADC)

WKM320AA1 has ADCs with up to 16-bit resolution. ADCs has individually configurable channels, and reference voltage.

- Selectable resolution (12 to 16 bits)
- Single-ended and differential conversions
- ADC gain setting: 0.5x, 1x, 2x
- Selectable reference voltage (Vref)
  - Internal reference 1.2V
  - Internal reference 1.8V
  - External reference (Do not exceed 1.8V)

#### 4.1.5. Digital Analog Converter (DAC)

WKM320AA1 has DAC with 10-bit resolution. It includes 2 channels. Each channel can output a single-ended signal or combine both channels to output a differential signal.

- 10-bit resolution
- Flexible waveform generator (sinusoidal, triangle, etc.) at various frequency range
- Selectable output mode: single-ended or differential
- Internal or external reference voltage
- Three selectable output ranges
- Supports event trigger from GPIO

#### 4.1.6. Analog Comparator (ACOMP)

WKM320AA1 has analog comparators which operate over the full range of power supply VIO. ACOMP can select many positive inputs and negative inputs.

- 7 selectable external positive inputs
- 7 selectable external negative inputs
- 2 selectable internal positive inputs
  - DACA output
  - DACB output
- 5 selectable internal negative inputs
  - DACA output
  - DACB output
  - VIO, VIO\*0.75, VIO\*0.5, VIO\*0.25
  - Internal reference 1.2V (Vref\_12)
  - GND
- Selectable positive and negative hysteresis between 0 and 70mV with 10mV step
- Comparator output on GPIOs through alternate functionality, output inversion available

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#### 4.1.7.General Purpose Input Output (GPIO)

WKM320AA1 provides GPIO pins.

- General purpose IO – Configurable IO state as Input high / low or Output high/low.
- Be able to accept external signals as interrupt source.  
The type of interrupt is programmable with either a rising edge or falling edge.

#### 4.1.8.General Purpose Timers (GPT)

- 4 independent channels with multiple modes.
- Edge-aligned and Center-aligned Pulse Width Modulation (PWM) with frequency range from 1kHz to 25MHz.
- 1-shot mode to trigger a 1-time output change.

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## 4.2.DC Specifications

### 4.2.1.Peak Current / Power consumption

The Specification applies for Topr.= 25 degrees C, Supply voltage=Typical voltage

No.	Parameter	Condition	Symbol	Min.	Typ.	Max.	Unit	Remark
1	Peak Current	V33I	Ip1	-	-	400	mA	
2	Power consumption3	Burst Tx (72.2Mbps)	Pc3	-	267	-	mW	Duty 4.2%
3	Power consumption4	Continuous Rx (72.2Mbps)	Pc4	-	271	-	mW	
4	Power consumption5	Burst Tx (54Mbps)	Pc5	-	347	-	mW	Duty 25.4%
5	Power consumption6	Continuous Rx (54Mbps)	Pc6	-	267	-	mW	
6	Power consumption7	Burst Tx (11Mbps)	Pc7	-	545	-	mW	Duty 46.8%
7	Power consumption8	Continuous Rx (11Mbps)	Pc8	-	267	-	mW	
8	Power consumption9	Sleep (MPU: Stand By (Low Power Mode in PM2) WLAN: Deep sleep)	Pc9	-	2	-	mW	

### 4.2.2.Digital Pad Ratings

No.	Parameter	Condition	Symbol	Min.	Typ.	Max.	Unit	Remark
1	Input high voltage		VIH	0.7*VIO	-	VIO+0.4	V	Note1
				0.7*VIOH	-	VIOH+0.4	V	Note2
2	Input low voltage		VIL	-0.4	-	0.3*VIO	V	Note1
				-0.4	-	0.3*VIOH	V	Note2
3	Output high voltage	IOH=3mA	VOH	VIO-0.5V	-	-	V	Note1
				VIOH-0.5V	-	-	V	Note2
4	Output low voltage	IOL=4mA	VOL	-	-	0.4	V	

Note1: Apply to IO pads which IO domain is VIO.

Note2: Apply to IO pads which IO domain is VIOH.

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### 4.3.ADC Electrical Characteristics

The Specification applies for Topr.= 25 degrees C, Supply voltage=Typical voltage

No.	Parameter	Condition	Min.	Typ.	Max.	Unit	Remark
Reference Voltage							
1	Internal Reference Voltage		1.20	1.22	1.23	V	
2	External Reference Voltage		0.6	-	1.8	V	
Analog Inputs							
3	Absolute Input Voltage		0	-	VIO	V	Note1
4	Input Voltage Range	Single-ended with input buffer gain=0.5x	0	-	2*Vref	V	
5		Single-ended with input buffer gain=1x	0	-	Vref		
6		Single-ended with input buffer gain=2x	0	-	0.5*Vref		
7		Differential with input buffer gain=0.5x	-2*Vref	-	2*Vref		Note2
8		Differential with input buffer gain=1x	-Vref	-	Vref		Note2
9		Differential with input buffer gain=2x	-0.5*Vref	-	0.5*Vref		Note2
DC Accuracy							
10	Resolution	Single-ended	-	-	15	bits	
11		Differential	-	-	16		

Notes:

1. The input voltage for each channel must be positive and cannot exceed the VIO voltage level.
2. Differential value: (Positive channel input voltage) – (Negative channel input voltage)

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#### 4.4.DAC Electrical Characteristics

The Specification applies for Topr.= 25 degrees C, Supply voltage=Typical voltage

No.	Parameter	Condition	Min.	Typ.	Max.	Unit	Remark
Conversion Range.							
1	Voltage Conversion Range	x_RANGE[1:0] <sup>*1</sup> : 00 REF_SEL <sup>*2</sup> : 0		0.16+(0.64 * input data/1023)		V	
2		x_RANGE[1:0] : 01/10 REF_SEL : 0		0.19+(1.01 * input data/1023)		V	
3		x_RANGE[1:0] : 11 REF_SEL : 0		0.18+(1.42 * input data/1023)		V	
4		x_RANGE[1:0] : 00 REF_SEL : 1		0.08*Vref_ext+(0.32* Vref_ext*input data /1023)		V	
5		x_RANGE[1:0] : 01/10 REF_SEL : 1		0.095*Vref_ext+(0.505* Vref_ext*input data /1023)		V	
6		x_RANGE[1:0] : 11 REF_SEL : 1		0.09*Vref_ext+(0.71* Vref_ext*input data /1023)		V	
DC Accuracy							
7	Resolution				10	bits	

<sup>1</sup>Register for output voltage range control

<sup>2</sup> Register for reference selector (0x0:internal reference, 0x1:external reference(Vref\_ext))

#### 4.5.ACOMP Electrical Characteristics

The Specification applies for Topr.= 25 degrees C, Supply voltage=Typical voltage

No.	Parameter	Condition	Min.	Typ.	Max.	Unit	Remark
<b>Analog Input</b>							
1	Analog Input Voltage		0	-	VIO	V	
<b>Reference Voltage</b>							
2	Internal Reference Voltage		1.20	1.22	1.23	V	
<b>Hysteresis</b>							
3	Hysteresis	Programming in 7 steps and 0	-	0	-	mV	
			-	10	-		
			-	20	-		
			-	30	-		
			-	40	-		
			-	50	-		
			-	60	-		
			-	70	-		

Control No. KM-AE-A223019	(7/10)	Control name Electrical characteristics
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## 4.6.AC Specifications

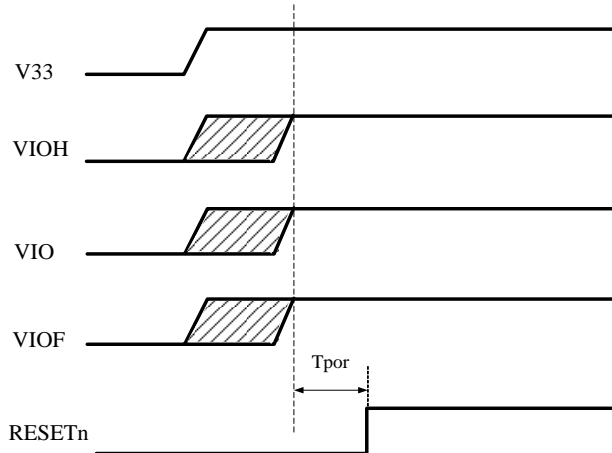
### 4.6.1.Power on sequence

No.	Parameter	Condition	Symbol	Min.	Typ.	Max.	Unit	Remark
1	Valid Power to RESETn de-asserted		Tpor	300	-	-	ms	

V33 should be powered up with or before VIOH or VIO or VIOF.

RESETn must remain asserted for minimum of Tpor after V33 and VIOH, VIO, VIOF are stable.

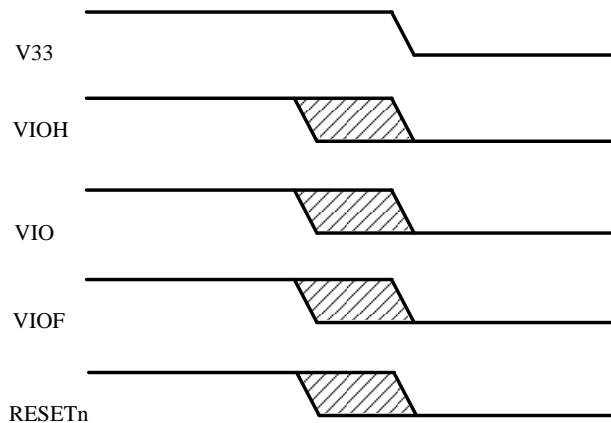
V33, VIOH, VIO and VIOF should start up from less than 0.15V.



### 4.6.2.Power off sequence

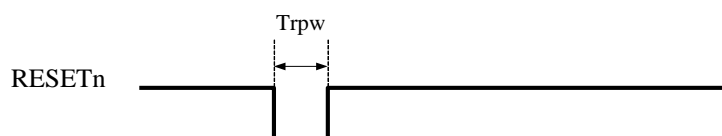
V33 should be powered off with or after VIOH or VIO or VIOF.

RESETn should not exceed VIO+0.4V.



### 4.6.3.RESETn Pulse Width

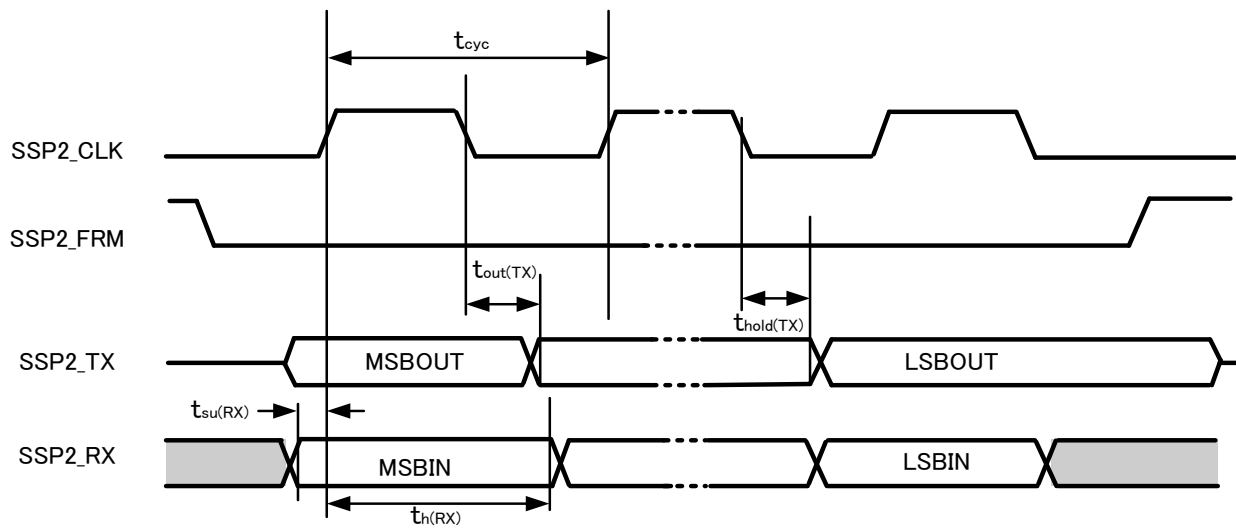
No.	Parameter	Condition	Symbol	Min.	Typ.	Max.	Unit
1	Minimum reset pulse width on RESETn pin	-	Trpw	300			ms



Control No. KM-AE-A223019	(8/10)	Control name Electrical characteristics
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#### 4.6.4.SSP timing specification

No.	Parameter	Symbol	Condition	Min.	Typ.	Max.	Unit	Remark
1	TX delay time	$t_{out(TX)}$	Master	-	-	3	ns	
			Slave	-	-	15		
2	TX hold time	$t_{hold(TX)}$	Master	-2	-	-	ns	
			Slave	0	-	-		
3	RX set up time	$t_{su(RX)}$	Master	12	-	-	ns	
			Slave	4	-	-		
4	RX hold time	$t_h(RX)$	Master	2	-	-	ns	
			Slave					
5	Serial Bit Clock cycle time	$T_{cyc}$	Master	40	-	1000	ns	
			Slave					



Control No. KM-AE-A223019	(9/10)	Control name Electrical characteristics
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#### 4.7.RF Specifications

##### 4.7.1.RF Specification s (WLAN 11n/72.2Mbps, OFDM)

The Specification applies for Ta=25 degrees C, Supply voltage =Typical voltage.

No.	Parameter	Condition	Symbol	Min.	Typ.	Max.	Unit	Remark
1	RF frequency range		FREQ	2412		2462	MHz	
2	TX Power		Po	7	9	11	dBm	Note1
3	Spectrum Mask	1 <sup>st</sup> Side Lobe	M1	-		-20	dBc	
		2 <sup>nd</sup> Side Lobe	M2	-		-28	dBc	
		3 <sup>rd</sup> Side Lobe	M3	-		-45	dBc	
4	Symbol clock tolerance		Ft	-25		25	ppm	
5	Frequency tolerance		Ft	-25		25	ppm	
6	EVM	RMS	EVM	-		-27	dB	
7	TX Out of band spurious1	30MHz to 1GHz	TOS1	-		-36	dBm	
8	TX Out of band spurious2	1GHz to 12.75GHz	TOS2	-		-30	dBm	
9	TX Out of band spurious3	1.8GHz to 1.9GHz 5.15GHz to 5.3GHz	TOS3			-47	dBm	
10	Rx sensitivity	PER<10%	SEN	-	-68	-64	dBm	
11	Maximum Input Level	PER<10%	MIL	-20		-	dBm	
12	RX Out of band spurious1	30MHz to 1GHz	ROS1	-		-57	dBm	
13	RX Out of band spurious2	1GHz to 12.75GHz	ROS2	-		-47	dBm	

Note1:Tx power should be set as typical value. If not, it may violate radio regulations of each country.

##### 4.7.2. RF Specifications (WLAN 11g/54Mbps, OFDM)

The Specification applies for Ta=25 degrees C, Supply voltage =Typical voltage

No.	Parameter	Condition	Symbol	Min.	Typ.	Max.	Unit	Remark
1	RF frequency range		FREQ	2412		2462	MHz	
2	TX Power		Po	7	9	11	dBm	Note2
3	Spectrum Mask	1 <sup>st</sup> Side Lobe	M1	-		-20	dBc	
		2 <sup>nd</sup> Side Lobe	M2	-		-28	dBc	
		3 <sup>rd</sup> Side Lobe	M3	-		-40	dBc	
4	Symbol clock tolerance		Ft	-25		25	ppm	
5	Frequency tolerance		Ft	-25		25	ppm	
6	EVM	RMS	EVM	-		-25	dB	
7	TX Out of band spurious1	30MHz to 1GHz	TOS1	-		-36	dBm	
8	TX Out of band spurious2	1GHz to 12.75GHz	TOS2	-		-30	dBm	
9	TX Out of band spurious3	1.8GHz to 1.9GHz 5.15GHz to 5.3GHz	TOS3			-47	dBm	
10	Rx sensitivity	PER<10%	SEN	-	-71	-65	dBm	
11	Maximum Input Level	PER<10%	MIL	-20		-	dBm	
12	RX Out of band spurious1	30MHz to 1GHz	ROS1	-		-57	dBm	
13	RX Out of band spurious2	1GHz to 12.75GHz	ROS2	-		-47	dBm	

Note2: Tx power should be set as typical value. If not, it may violate radio regulations of each country.

Control No. KM-AE-A223019	(10/10)	Control name Electrical characteristics
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#### 4.7.3.RF Specifications (WLAN 11b/11Mbps, CCK)

The Specification applies for Ta=25 degrees C, Supply voltage=Typical voltage

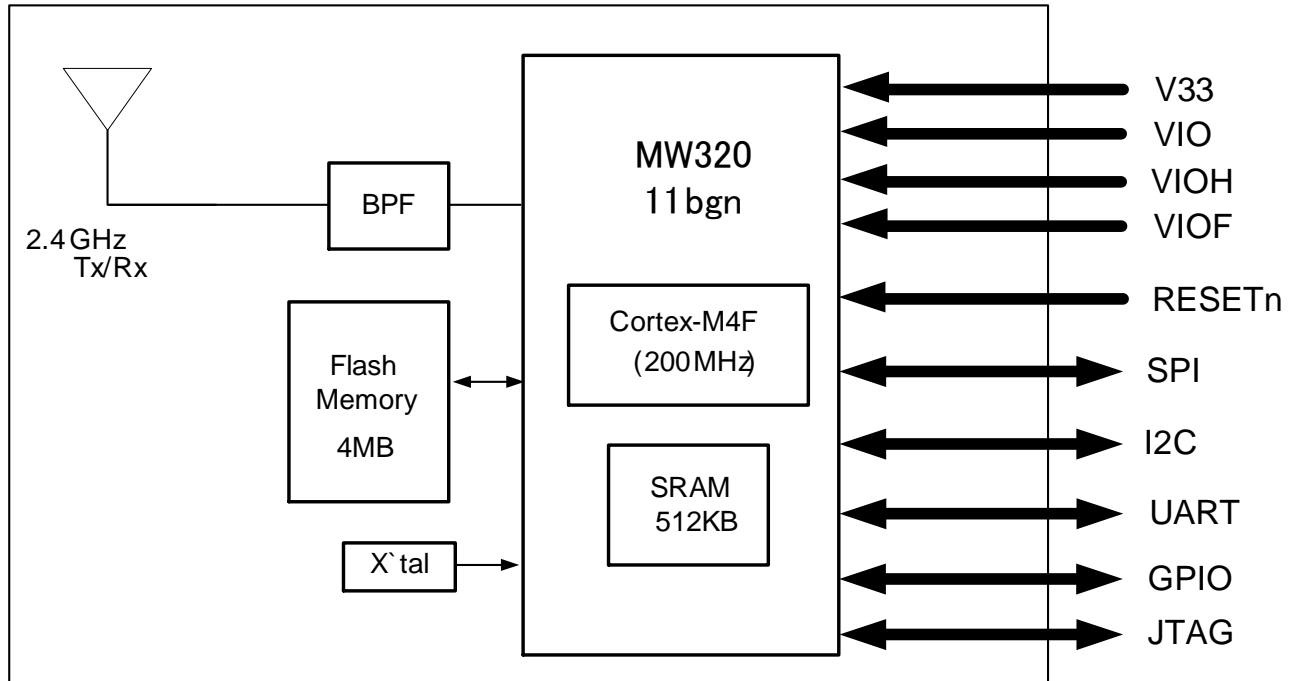
No.	Parameter	Condition	Symbol	Min.	Typ.	Max.	Unit	Remark
1	RF frequency range		FREQ	2412		2462	MHz	
2	TX Power		Po	13	15	17	dBm	Note1
3	Spectrum Mask	1 <sup>st</sup> Side Lobe	M1	-		-30	dBc	
		2 <sup>nd</sup> Side Lobe	M2	-		-50	dBc	
4	Power up-down rump	Power up	TU	-		2	us	
		Power down	TD	-		2	us	
5	Frequency tolerance		Ft	-25		25	ppm	
6	EVM	Peak	EVM	-		35	%	
7	TX Out of band spurious1	30MHz to 1GHz	TOS1	-		-36	dBm	
8	TX Out of band spurious2	1GHz to 12.75GHz	TOS2	-		-30	dBm	
9	TX Out of band spurious3	1.8GHz to 1.9GHz 5.15GHz to 5.3GHz	TOS3			-47	dBm	
10	Rx sensitivity	PER<8%	SEN		-86	-76	dBm	
11	Maximum Input Level	PER<8%	MIL	-10			dBm	
12	RX Out of band spurious1	30MHz to 1GHz	ROS1	-		-57	dBm	
13	RX Out of band spurious2	1GHz to 12.75GHz	ROS2	-		-47	dBm	

Note1: Tx power should be set as typical value. If not, it may violate radio regulations of each country.

Control No. KM-MC-A223019	(1/2)	Control name Circuit Schematic
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## 5.Circuit Schematic

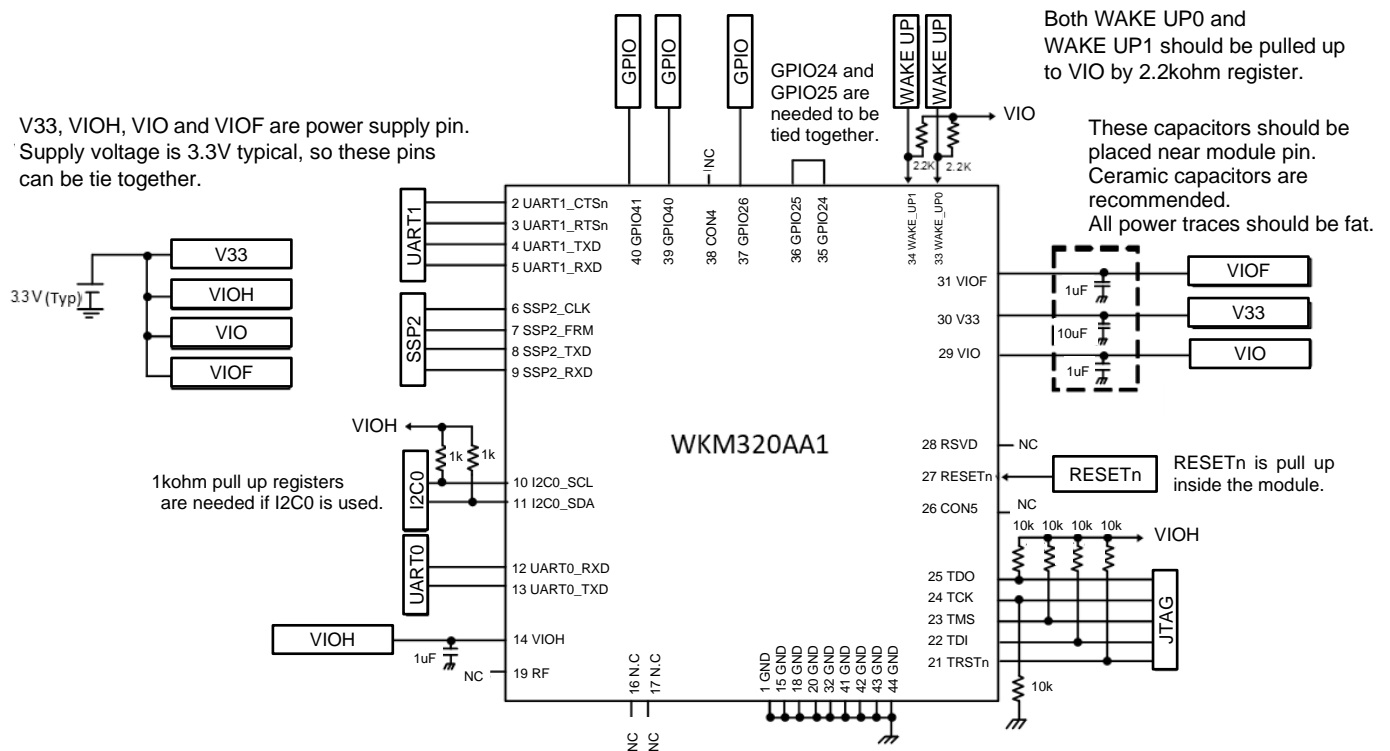
### 5.1.Block Diagram



Control No. KM-MC-A223019	(2/2)	Control name Circuit Schematic
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## 5.2.Example of peripheral circuit schematics

WAKE UP signal is used to wake up from PM mode (low power mode). When the signal is Hi level, it can enter PM mode. During PM mode, When the signal goes to Lo level, it exits PM mode. WAKE UP0 and WAKE UP1 stay Lo level when these signals are not connected to anywhere(opened). Usually, these signals need 2.2kohm pull-up resistor to VIO. When it enters PM mode without pull-up resistor, it will exit PM mode immediately.



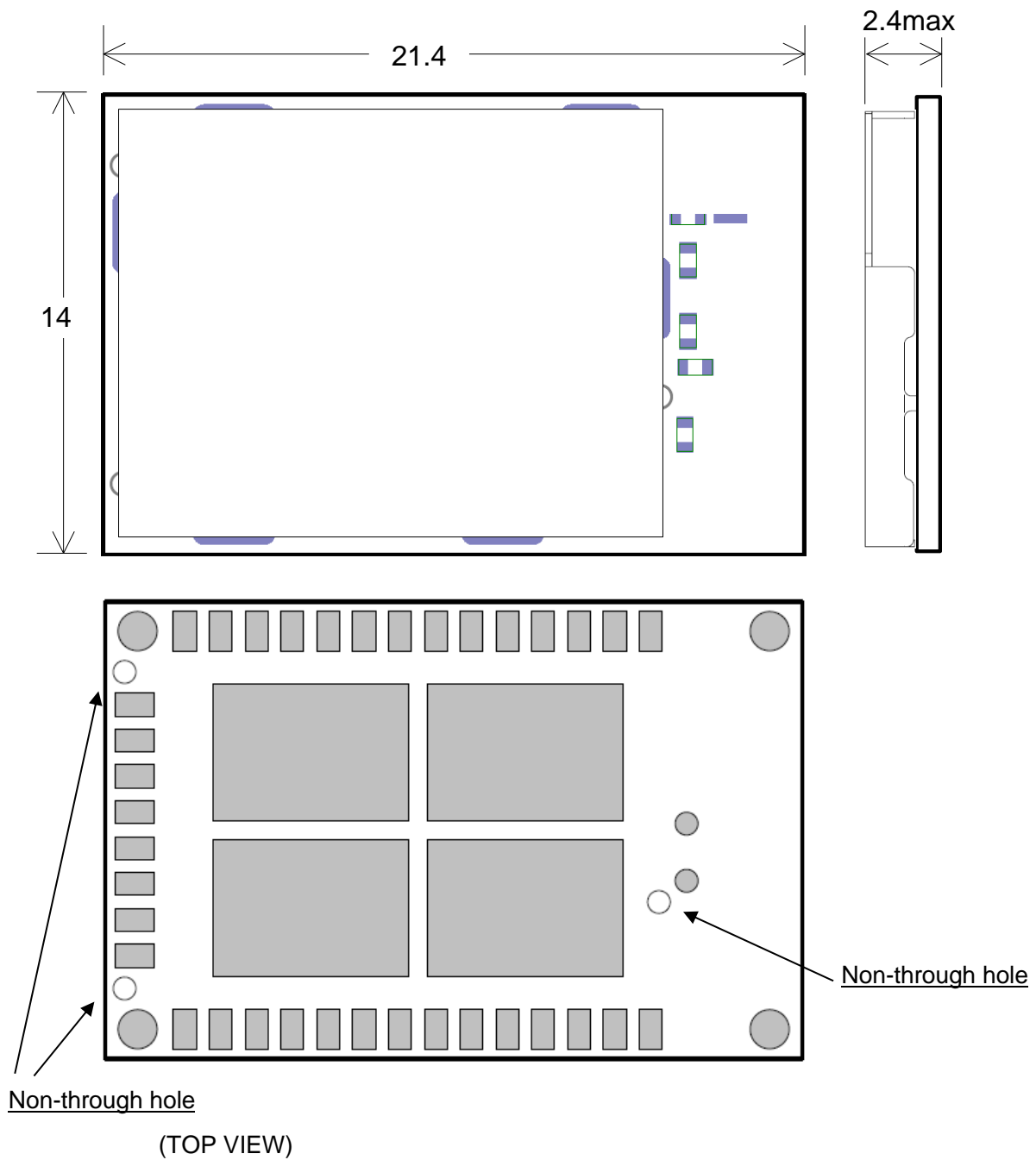
Note1: All IO pins should be left open (no need to pull up or pull down) if not used.

Control No. KM-AD-A223019	(1/5)	Control name Outline/Appearance
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## 6.Outline/Appearance

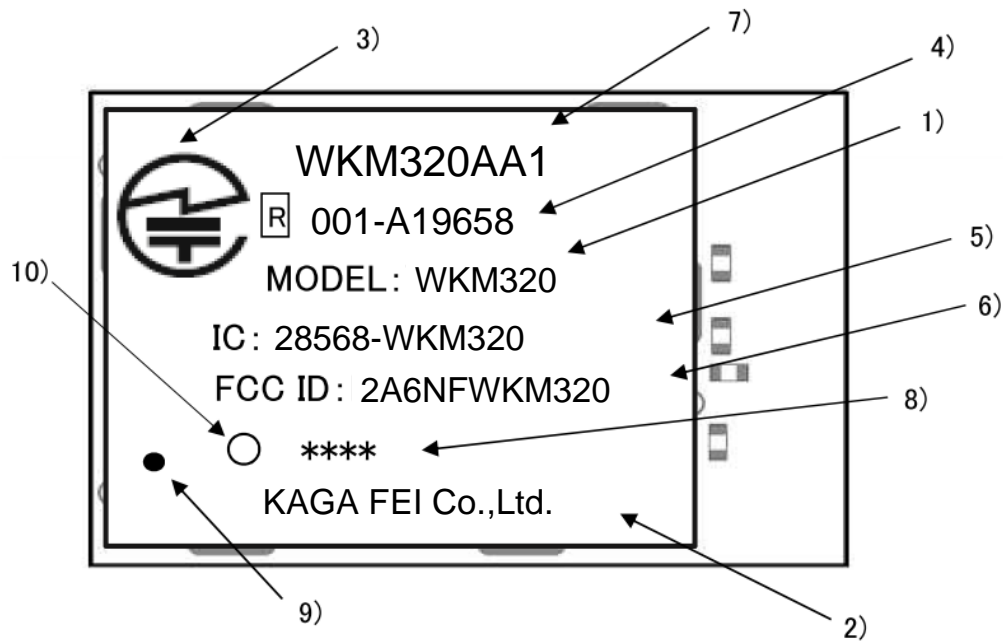
### 6.1.OUTLINE

Unit: mm, Tolerances unless otherwise specified: +/- 0.2mm



Control No. KM-AD-A223019	(2/5)	Control name Outline/Appearance
------------------------------	-------	------------------------------------

## 6.2.Indication of Shield Case



- 1) Model : WKM320
- 2) Manufacturer : KAGA FEI Co.,Ltd.
- 3) Japan technical conformity mark
- 4) Japan ID : 001-A19658
- 5) ISED ID : 28568-WKM320
- 6) FCC ID : 2A6NFWKM320
- 7) Part number : WKM320AA1
- 8) Lot number : Four digits
- 9) 1pin mark :  $\phi 0.6\text{mm}$  hole on the shield case
- 10) Identifying mark

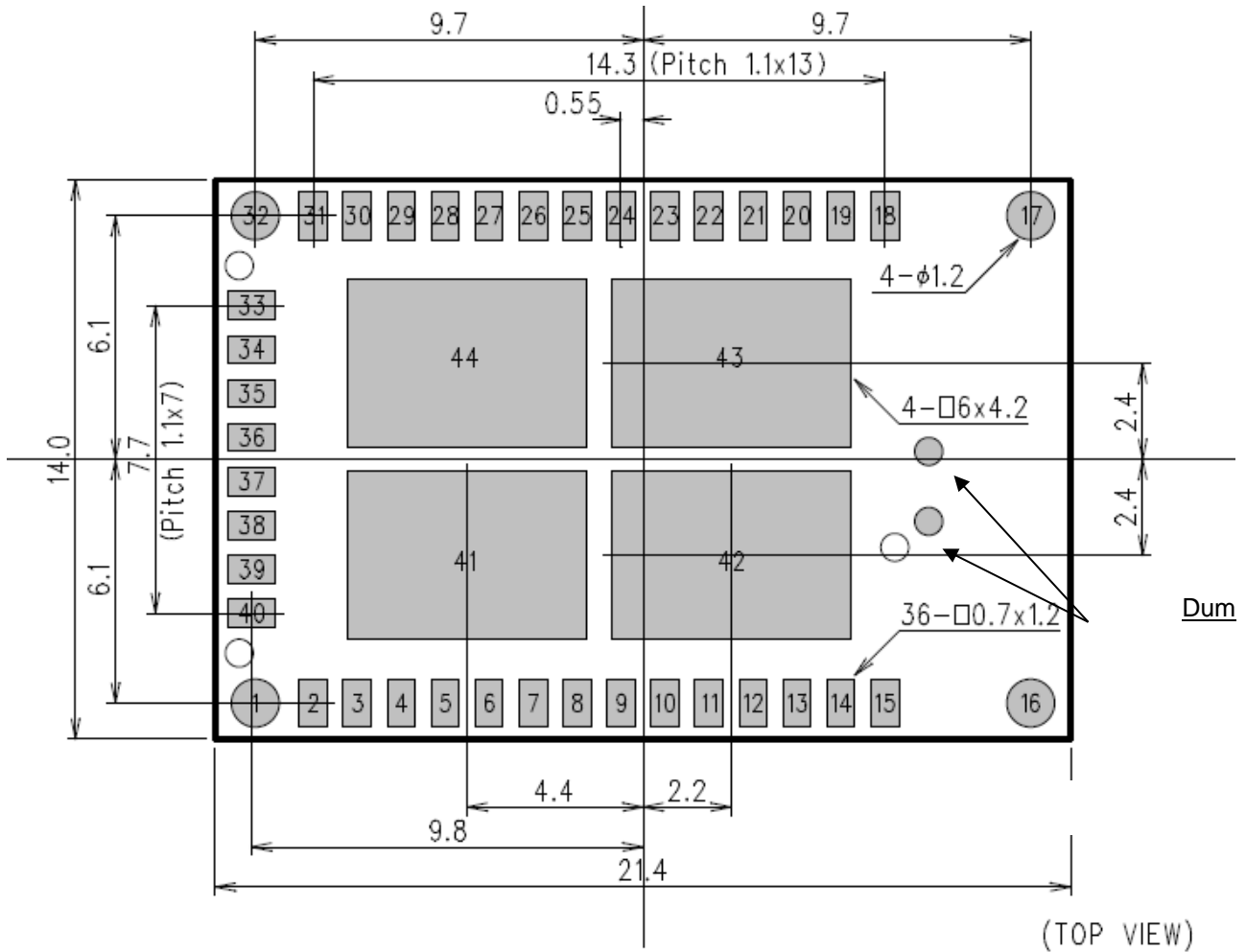
Control No.  
KM-AD-A223019

(3/5)

Control name  
Outline/Appearance

### 6.3.Module Pad Dimension

Unit: mm, Tolerances unless otherwise specified: +/- 0.2mm



Control No.  
KM-AD-A223019

(4/5)

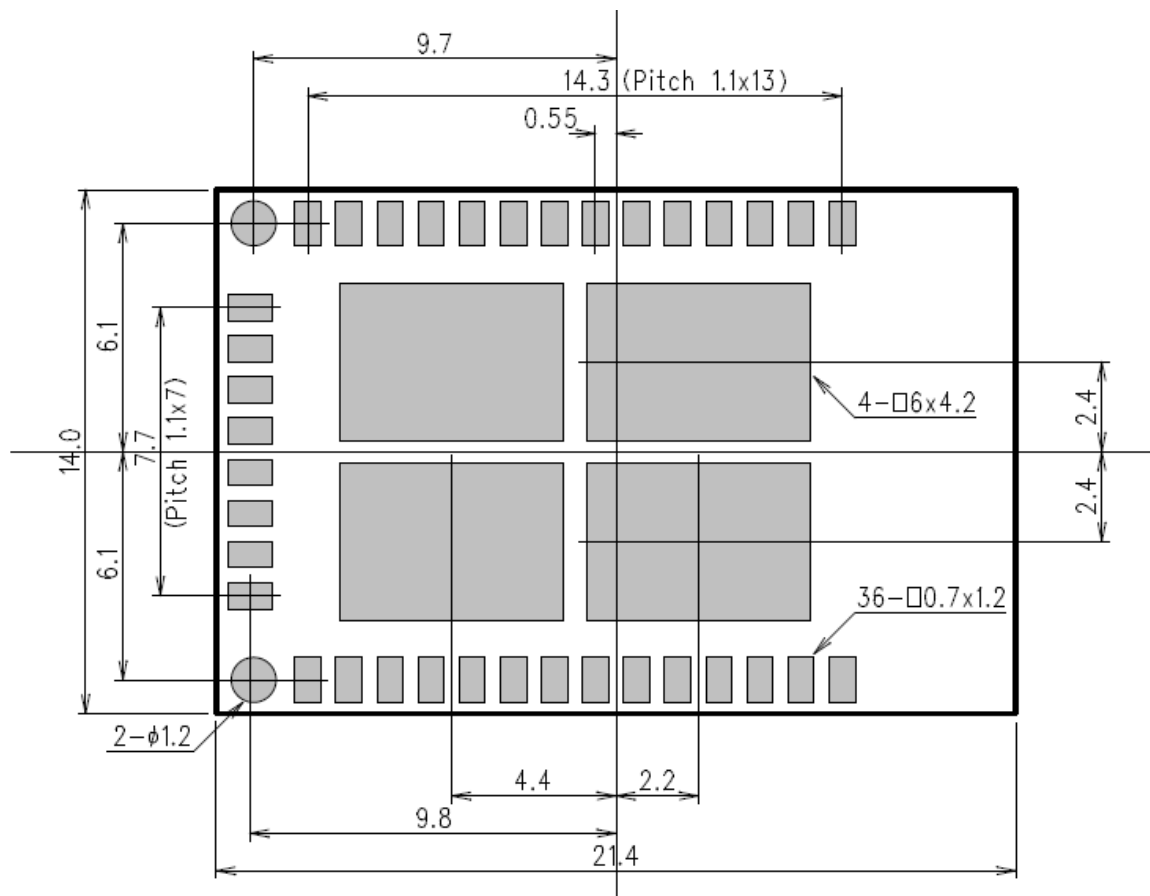
Control name  
Outline/Appearance

#### 6.4.Recommended Land Pattern Dimension

We recommend that pad sizes on mother board and pad sizes on module should be the same except for Pad-16 and Pad-17. Pad-16 and Pad-17 are not needed to solder on mother board and Land patterns for these pads are not needed.

Unit: mm

(Top View)



Control No.  
KM-AD-A223019

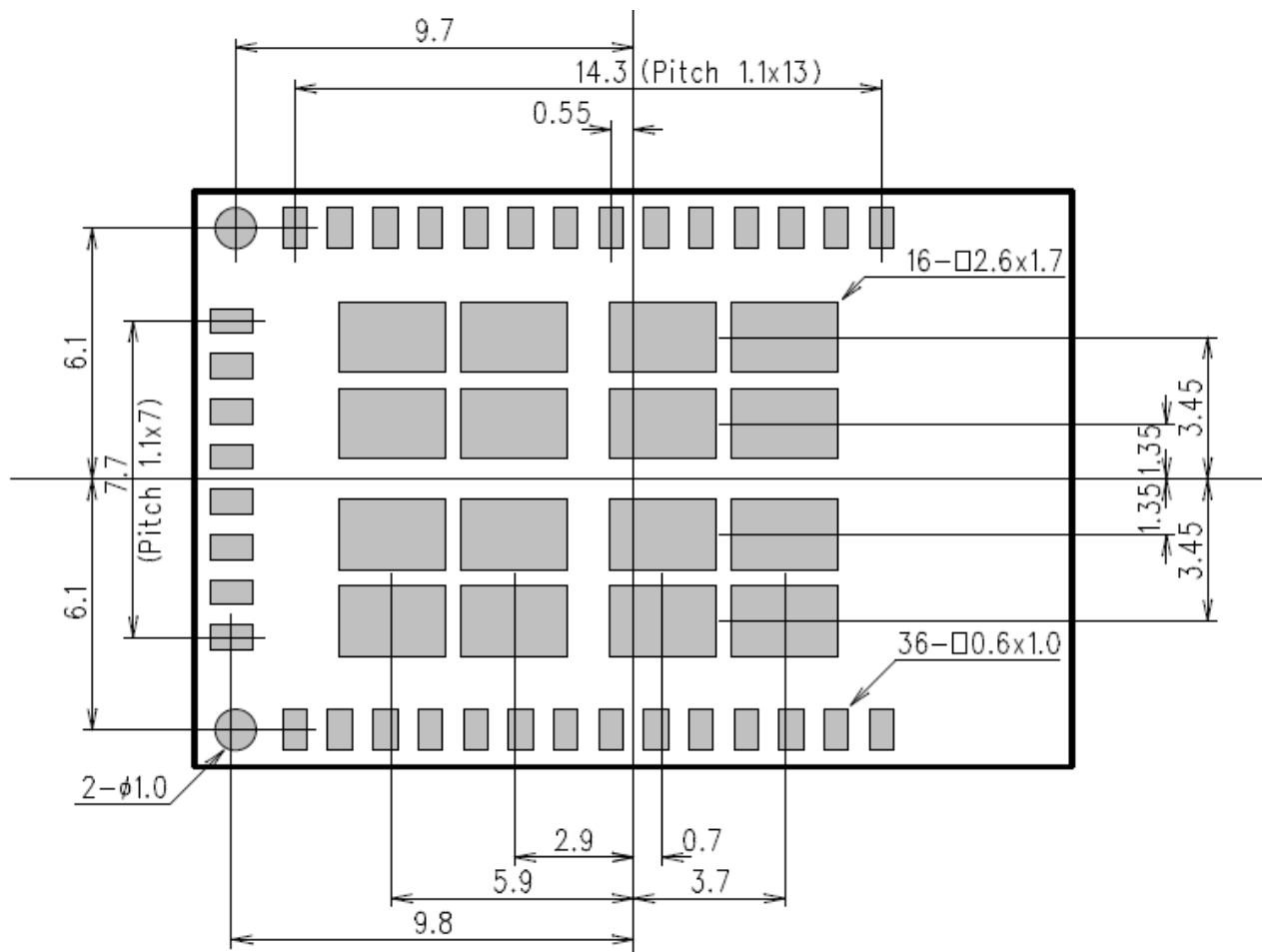
(5/5)

Control name  
Outline/Appearance

### 6.5.Recommended Metal Mask (Solder Mask) Conditions

Mask size see bellow. Thickness of the Metal Mask should be in the range 0.1 mm

Unit: mm



Control No. KM-BA-A223019	(1/4)	Control name Pin Layout
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## 7.Pin Layout

### 7.1.Pin layout

Pin No.	Module pin name	Type	Power domain	Description	88MW320 GPIO No.
1	GND	-	Ground	GND	-
2	UART1_CTSn	I	VIO	UART1 CTSn (L: Clear to send, H: Not clear to send)	GPIO42
3	UART1_RTSn	O	VIO	UART1 RTSn (L: Request to send, H: Not request to send)	GPIO43
4	UART1_TXD	O	VIO	UART1 TXD	GPIO44
5	UART1_RXD	I	VIO	UART1 RXD	GPIO45
6	SSP2_CLK	I/O	VIO	Synchronous Serial Interface (SPI_CLK)	GPIO46
7	SSP2_FRM	I/O	VIO	Synchronous Serial Interface (SPI_CSN)	GPIO47
8	SSP2_TXD	O	VIO	Synchronous Serial Interface (SPI_DO)	GPIO48
9	SSP2_RXD	I	VIO	Synchronous Serial Interface (SPI_DI)	GPIO49
10	I2C0_SCL	I/O	VIOH	I2C0 SCL. Pull up to VIOH with 1kohm register if use this pin.	GPIO5
11	I2C0_SDA	I/O	VIOH	I2C0 SDA. Pull up to VIOH with 1kohm register if use this pin.	GPIO4
12	UART0_RXD	I	VIOH	UART0 RXD	GPIO3
13	UART0_TXD	O	VIOH	UART0 TXD	GPIO2
14	VIOH	I	VIOH	I/O Digital Power Supply	-
15	GND	-	Ground	GND	-
16	N.C	-	-	Dummy pad. No connect and do not solder.	-
17	N.C	-	-	Dummy pad. No connect and do not solder.	-
18	GND	-	Ground	GND	-
19	RF	I/O	-	WLAN RF Interface (2.4 GHz Transmit/Receive) Should be left open and do not trace longer than land pattern.	-
20	GND	-	Ground	GND	-
21	TRSTn	I	VIOH	JTAG-TRSTN (Active L)	GPIO10
22	TDI	I	VIOH	JTAG-TDI	GPIO9
23	TMS	I	VIOH	JTAG-TMS	GPIO8
24	TCK	I	VIOH	JTAG-TCK	GPIO7
25	TDO	O	VIOH	JTAG-TDO	GPIO6

Control No. KM-BA-A223019	(2/4)	Control name Pin Layout
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Pin No.	Module pin name	Type	Power domain	Description	88MW320 GPIO No.
26	CON5	I/O	VIO	Configuration Pin. Should be left open. (Boot from internal flash memory)	GPIO16
27	RESETn	I	VIO	RESET signal (Active low) Pulled up to VIO with 51kohm register inside the module.	-
28	RSVD	-	-	No Connect. Should be left open.	-
29	VIO	I	VIO	I/O Digital Power Supply	-
30	V33	I	V33	3.3V Power Supply	-
31	VIOF	I	VIO_F	I/O Digital Power Supply	-
32	GND	-	Ground	GND	-
33	WAKE_UP0	I	VIO	Wakeup-0 signal (Active L). Should be pulled up to VIO with 2.2kohm register outside the module.	GPIO22
34	WAKE_UP1	I	VIO	Wakeup-1 signal (Active L). Should be pulled up to VIO with 2.2kohm register outside the module.	GPIO23
35	GPIO24	I/O	VIO	GPIO24 and GPIO25 are used to calibrate RC32k inside the module. Tie GPIO24 and GPIO25 outside the module and do not tie other signal.	GPIO24
36	GPIO25	I/O	VIO	GPIO24 and GPIO25 are used to calibrate RC32k inside the module. Tie GPIO24 and GPIO25 outside the module and do not tie other signal.	GPIO25
37	GPIO26	I/O	VIO	General Purpose I/O 26	GPIO26
38	CON4	I/O	VIO	Configuration Pin. Should be left open. (Boot from internal flash memory)	GPIO27
39	GPIO40	I/O	VIO	General Purpose I/O 40.	GPIO40
40	GPIO41	I/O	VIO	General Purpose I/O 41.	GPIO41
41	GND	-	Ground	GND	-
42	GND	-	Ground	GND	-
43	GND	-	Ground	GND	-
44	GND	-	Ground	GND	-

\*Note: IO pins should be left open if not used, unless otherwise noted.

Control No. KM-BA-A223019	(3/4)	Control name Pin Layout
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## 7.2.IO Pin alternate functions

Pin No.	Function0	Function1	Function2	Function3	Function4	Note
2	GPIO_42	ADC0_Channel0/ ACOMP0_Channel0/ ACOMP1_Channel0	<b>UART1_CTSn</b>	SSP1_CLK		
3	GPIO_43	ADC0_Channel1/ ACOMP0_Channel1/ ACOMP1_Channel1 DAC_Channel_B_Output	<b>UART1_RTSn</b>	SSP1_FRM		
4	GPIO_44	ADC0_Channel2/ ACOMP0_Channel2/ ACOMP1_Channel2/ DAC_Channel_A_Output	<b>UART1_TXD</b>	SSP1_TXD		
5	GPIO_45	ADC0_Channel3/ ACOMP0_Channel3/ ACOMP1_Channel3/ EXT_VREF - ADC or DAC external voltage reference input	<b>UART1_RXD</b>	SSP1_RXD		
6	GPIO_46	ADC0_Channel 4/ ACOMP0_Channel 4/ ACOMP1_Channel 4/	UART2_CTSn	<b>SSP2_CLK</b>		
7	GPIO_47	ADC0_Channel 5/ ACOMP0_Channel 5/ ACOMP1_Channel 5/	UART2_RTSn	<b>SSP2_FRM</b>		
8	GPIO_48	ADC0_Channel 6/ ACOMP0_Channel 6/ ACOMP1_Channel 6/	UART2_TXD	<b>SSP2_TXD</b>		
9	GPIO_49	ADC0_Channel 7/ ACOMP0_Channel 7/ ACOMP1_Channel 7/	UART2_RXD	<b>SSP2_RXD</b>		
10	GPIO_5	GPT0_Channel5	<b>I2C0_SCL</b>			
11	GPIO_4	GPT0_Channel4	<b>I2C0_SDA</b>			
12	GPIO_3	GPT0_Channel3	<b>UART0_RXD</b>	SSP0_RXD		
13	GPIO_2	GPT0_Channel2	<b>UART0_TXD</b>	SSP0_TXD		
21	<b>TRSTn</b>	GPIO_10	UART2_RXD	SSP2_RXD	I2C1_SCL	
22	<b>TDI</b>	GPIO_9	UART2_TXD	SSP2_TXD	I2C1_SDA	
23	<b>TMS</b>	GPIO_8	UART2_RTSn	SSP2_FRM	I2C0_SCL	
24	<b>TCK</b>	GPIO_7	UART2_CTSn	SSP2_CLK	I2C0_SDA	
25	<b>TDO</b>	GPIO_6	I2C1_SDA			
26	<b>GPIO_16</b>	CON[5]				

Control No. KM-BA-A223019	(4/4)	Control name Pin Layout
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Pin No.	Function0	Function1	Function2	Function3	Function4	Note
33	<b>WAKE_UP0</b>	GPIO_22				
34	<b>WAKE_UP1</b>	GPIO_23				
35		<b>GPIO_24</b>				
36		<b>GPIO_25</b>				
37		<b>GPIO_26</b>				
38	<b>GPIO_27</b>	CON[4]				
39	<b>GPIO_40</b>	DAC_External_Tri gger0	ACOMP0_GPIO_ OUT	ACOMP1_GPIO_ OUT		
40	<b>GPIO_41</b>	DAC_External_Tri gger1	ACOMP0_EDGE_ PULSE	ACOMP1_EDGE_ PULSE		

Note: Please revise the board file to the following contents.

```

1.
int board_32k_osc()
{
    return false;
}

2.
int board_rc32k_calib()
{
    return true;
}

3.
void board_uart_pin_config(int id)
{
    switch (id) {
        case UART0_ID:
            GPIO_PinMuxFun(GPIO_2, GPIO2_UART0_TXD);
            GPIO_PinMuxFun(GPIO_3, GPIO3_UART0_RXD);
            break;
        case UART1_ID:
            GPIO_PinMuxFun(GPIO_42, GPIO42_UART1_CTSn); // Not required without Flow control.
            GPIO_PinMuxFun(GPIO_43, GPIO43_UART1_RTSn); // Not required without Flow control.
            GPIO_PinMuxFun(GPIO_44, GPIO44_UART1_TXD);
            GPIO_PinMuxFun(GPIO_45, GPIO45_UART1_RXD);
            break;
        case UART2_ID:
            /* Not implemented yet */
            break;
    }
}

```

Control No. MQ-H-001	(1/2)	Control name Handling Precaution
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## 8. Handling Precaution

This specification describes desire and conditions especially for mounting.

### Desire/Conditions

- (1) Environment conditions for use and storage
  1. Store the components in an environment of < **40deg-C/90%RH** if they are in a moisture barrier bag packed by KAGA FEI.
  2. Keep the factory ambient conditions at < **30deg-C/60%RH**.
  3. Store the components in an environment of < **25±5deg-C/10%RH** after the bag is opened.  
(The condition is also applied to a stay in the manufacture process).

- (2) Conditions for handling of products

Make sure all of the moisture barrier bags have no holes, cracks or damages at receiving. If an abnormality is found on the bag, its moisture level must be checked in accordance with 2 in (2).

Refer to the label on the bag.

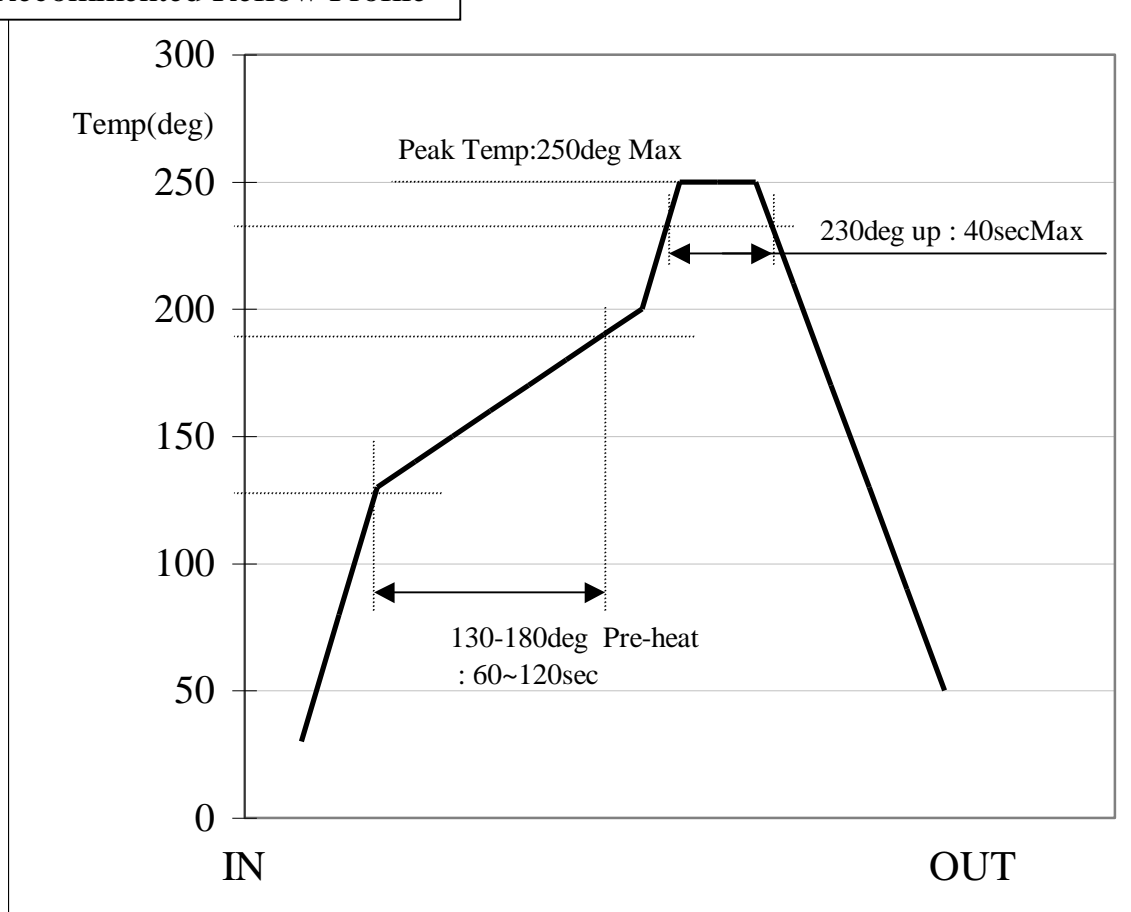
1. All of the surface mounting process (reflow process) must be completed **in 12 months** from the bag seal date.
2. Make sure humidity in the bag is less than **10%RH** immediately after open, using a humidity indicator card sealed with the components.
3. **All** of the surface mounting process (reflow process including rework process) must be completed in **168 hours** after the bag is opened (inclusive of any other processes).
4. If any conditions in (1) or condition 2 and 3 in (2) are not met, bake the components in accordance with the conditions at **125deg-C 24hours**.
5. As a rule, baking the components in accordance with conditions 4 in (2) shall be once.
6. Since semi-conductors are inside of the components, they must be free from static electricity while handled.(<100V) Use ESD protective floor mats, wrist straps, ESD protective footwear, air ionizers etc., if necessary.
7. Please make sure that there are lessen mechanical vibration and shock for this module, and do not drop it.
8. Please recognize pads of back side at surface mount.
9. Washing the module is not recommended. If washing cannot be avoided, please test module functionality and performance after thoroughly drying the module.  
We cannot be held responsible for any failure due washing the module.
10. Please perform temperature conditions of module at reflow within the limits of the next page.  
Please give the number of times of reflow as a maximum of 2 times.

Control No.  
MQ-H-001

(2/2)

Control name  
Handling Precaution

### Recommended Reflow Profile



Control No. KM-BB-A223019	(1/3)	Control name Packaging Specification
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## 9. Packaging Specification

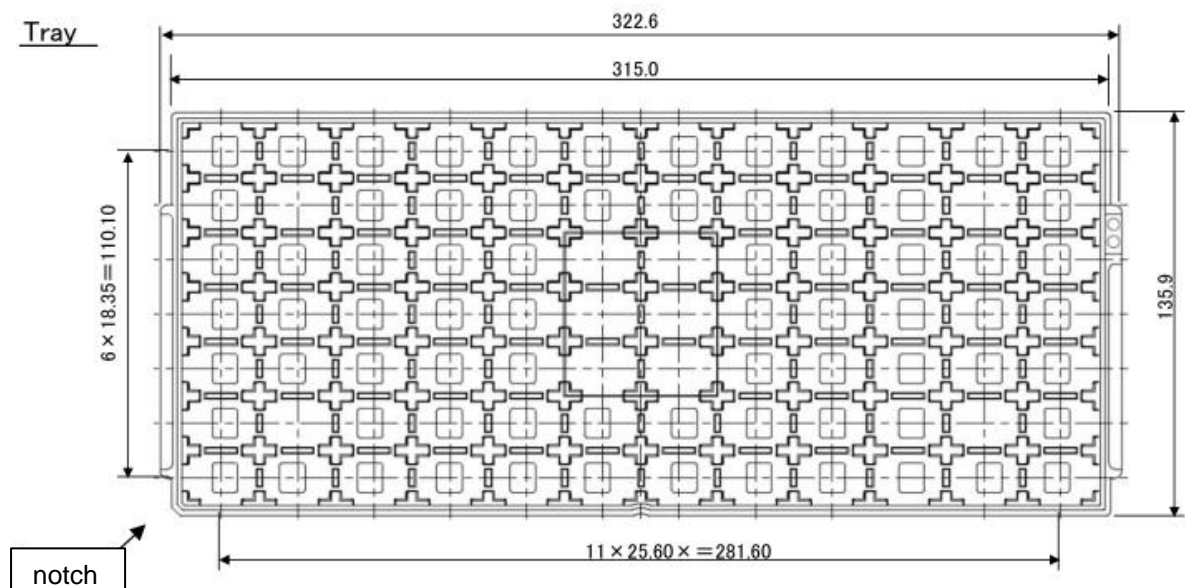
### (1) Packaging Material

Name	Outline	Materials	Note
Tray	315×135.9×7.62(mm)	Conductive PPE	84 pieces/tray
Antistatic band	8mm wide	Antistatic PP	-
Desiccant	-	Desi-Pak	-
Humidity indicator card	-	-	-
Aluminum moisture barrier bag	260×460(mm)	(AS)PET / AL/ NY / PE(AS)	-
Buffer corrugated paper	-	Corrugated fiberboard	-
Label	-	-	-
Corrugated cardboard box (Inner)	345×205×95(mm)	Corrugated fiberboard	-
Corrugated cardboard box (Outer)	436×361×220(mm)	Corrugated fiberboard	

### (2) Packaging Unit

$$84 \text{ pieces/tray} \times 10 \text{ trays} = 840 \text{ pieces}$$

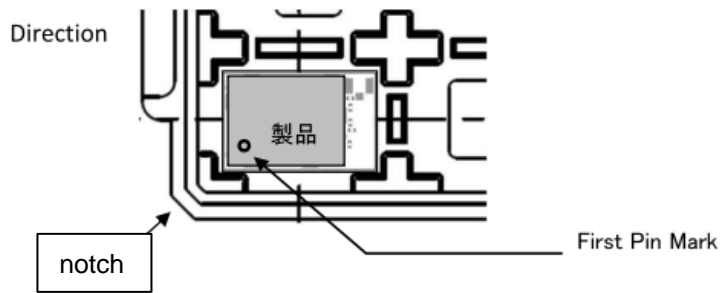
### (3) Packaging Figure



Control No.  
KM-BB-A223019

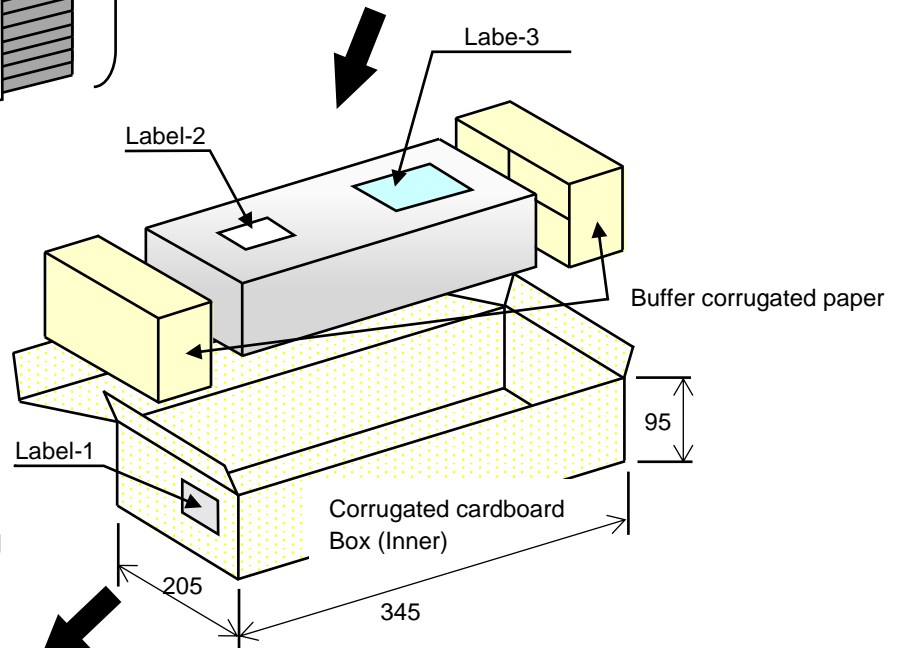
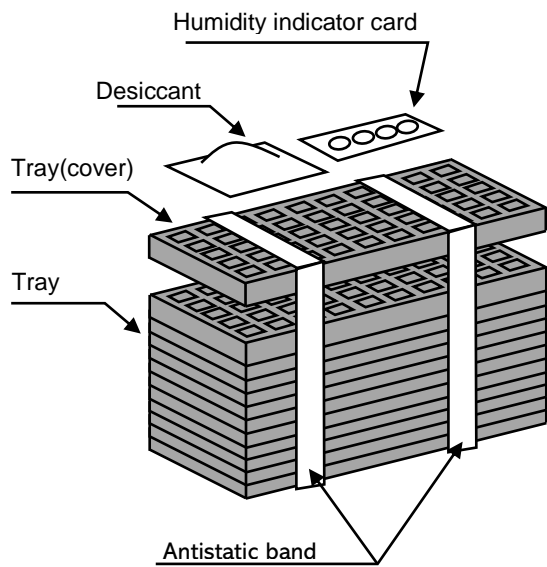
(2/3)

Control name  
Packaging Specification

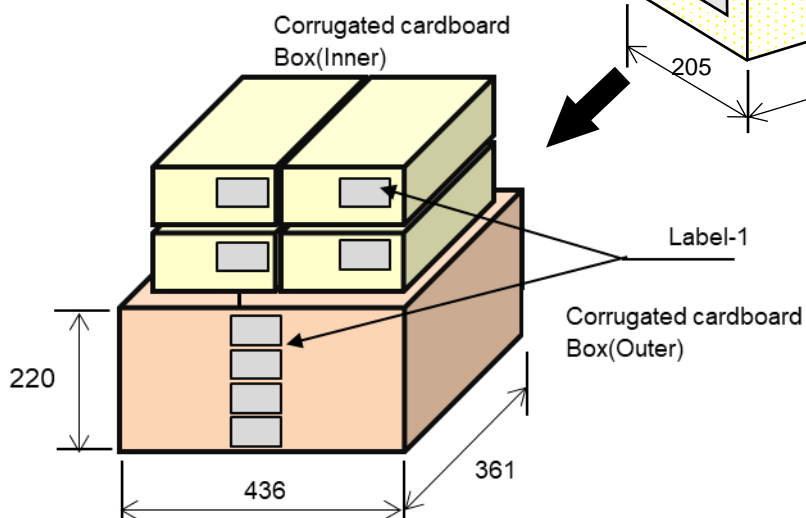


### Inner Box

Note : Stack the trays in the same direction.



### Outer Box



Control No. KM-BB-A223019	(3/3)	Control name Packaging Specification
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(4) Label

Label-1

- Purchase order
- Part No.
- Quantity
- Lot No.
- Country of origin

Label-2

- Serial No.
- Part No.
- Quantity
- Country of origin

Label-3

- Caution label
- MSL Level 3

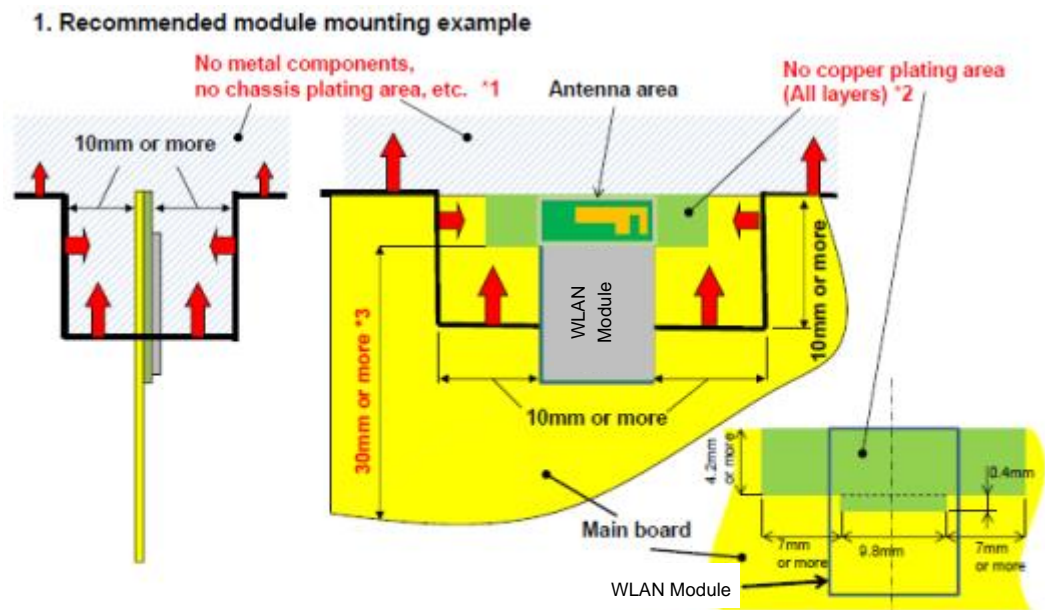
Control No.

(1/3)

Control name

Antenna Application Note

## 10. Antenna Application Note



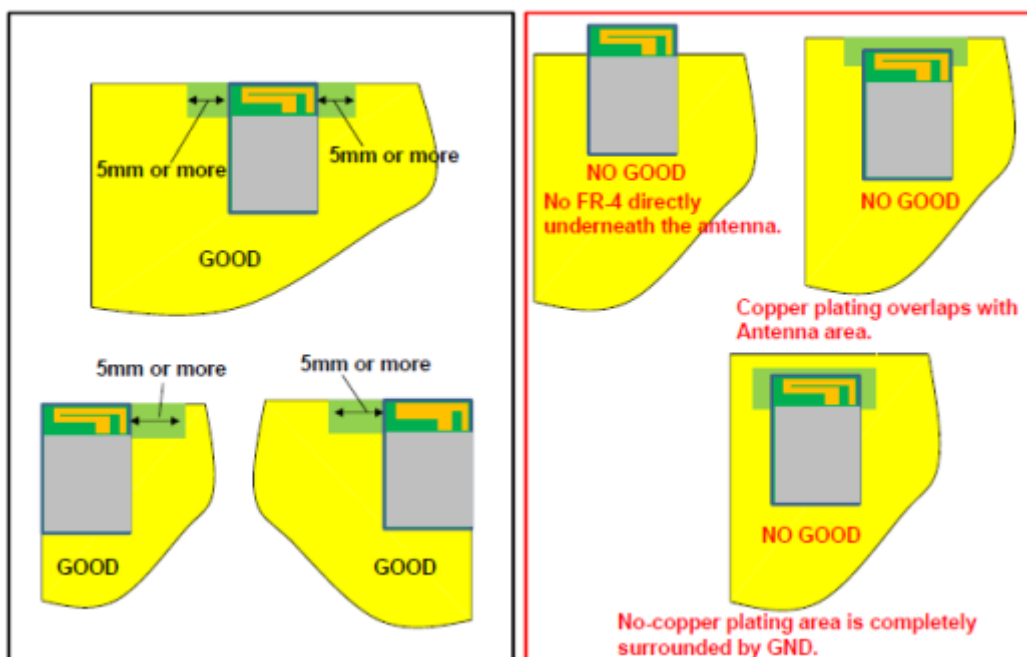
\*1 Please do not place any metal components in **blue shaded space**. \*1) We do not recommend to place any metal objects upper space of the module in the above figure. If it needs to place metal objects, please consider to keep the metal off from the antenna as far as you can. Such as signal line and metal chassis as possible except for main board while mounting the components in \*1 space on the main board is allowed except for no copper plating area. (\*2).

\*2 This area is routing prohibited area on the main board. Please do not place copper on any layer. Please remain use of FR-4 dielectric material. The antenna is tuned with the FR-4.

\*3 Characteristics may deteriorate when **GND pattern** length is less than 30mm. It should be 30 mm or more as possible.

Even when above mentioned condition is satisfied, communication performance may be significantly deteriorated depending on the structure of the product.

### 2. Other module mounting examples



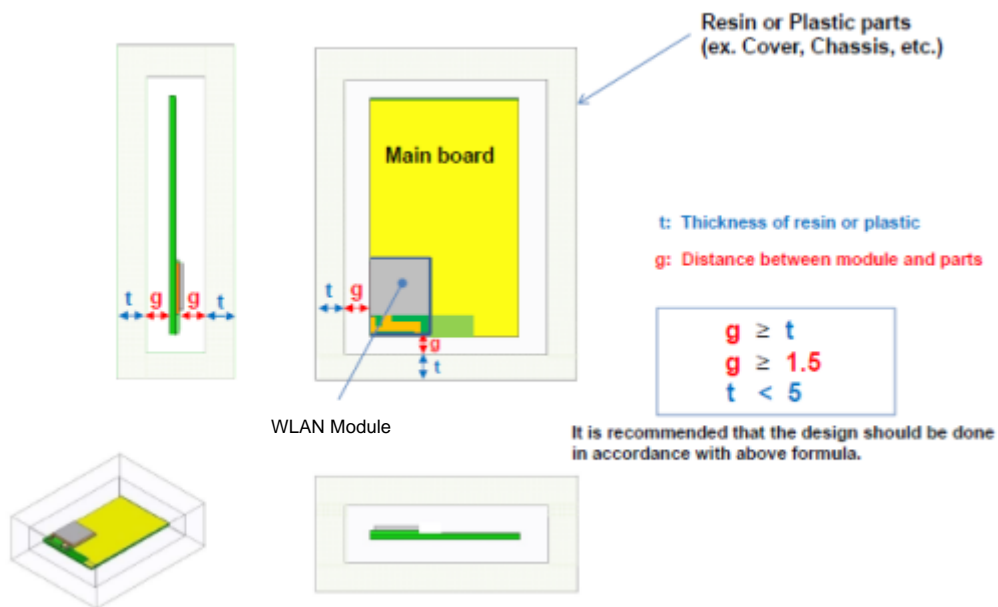
Control No.

(2/3)

Control name

Antenna Application Note

### 3. Placement of resin or plastic parts



Control No.

(3/3)

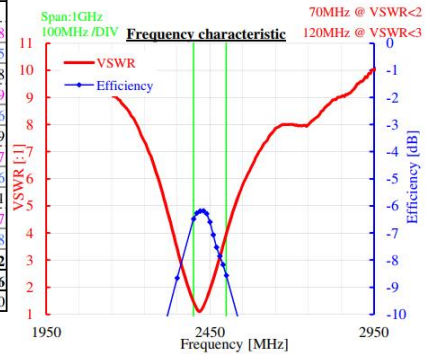
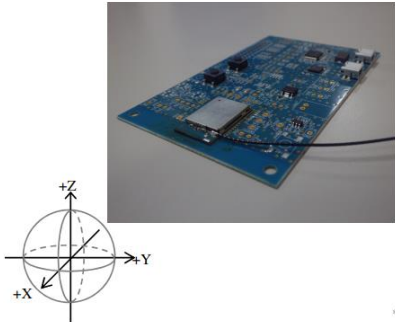
Control name

Antenna Application Note

#### 4. Directional characteristics example (when mounted on evaluation board)

**Measurement data of antenna**

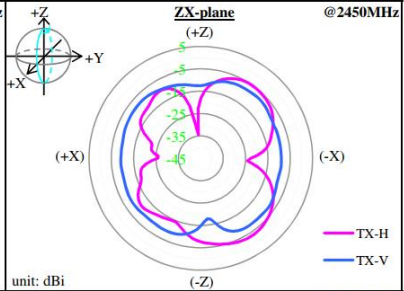
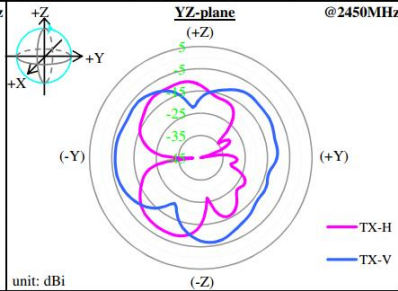
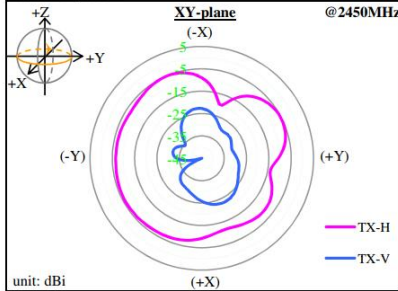
Frequency [MHz]		@2400	@2450	@2500
Peak gain		[dBi]		
3-plane	TX-H	-2.9	-3.5	-5.8
	TX-V	-6.7	-6.5	-8.5
		-2.9	-3.5	-5.8
Average gain		[dBi]		
XY-plane	TX-H	-7.7	-7.6	-9.8
	TX-V	-28.0	-27.2	-28.5
	Plus(H,V)	-7.6	-7.6	-9.8
YZ-plane	TX-H	-14.6	-14.0	-14.9
	TX-V	-10.1	-9.8	-11.6
	Plus(H,V)	-8.8	-8.4	-9.9
ZX-plane	TX-H	-8.4	-9.2	-11.7
	TX-V	-9.5	-9.2	-10.6
	Plus(H,V)	-5.9	-6.2	-8.1
3-plane	TX-H	-9.3	-9.5	-11.7
	TX-V	-11.5	-11.2	-12.8
		-7.3	-7.3	-9.2
Efficiency [dB]		-6.5	-6.6	-8.6
VSWR [∶1]		1.5	1.9	4.0

**Appearance and coordinates definition**


\*Note: Peak gain(3-plane)=Peak(XY(H),XY(V),YZ(H),YZ(V),ZX(H),ZX(V))

\*Note:The value is average value in 1 round of each inclination direction angle.

\*Note: Average gain(3-plane)=Average(XY(Plus(H,V)),YZ(Plus(H,V)),ZX(Plus(H,V)))

**Radiation pattern**


#### 5. About this Application Note

- This Application Note has been prepared as a reference material to help obtaining the antenna performance mounted on **WKM320AA1** module better while it is not guaranteed or assured to obtain better communication performance and distance.
- This product “**WKM320AA1** module” has been certified and matching circuit constant for antenna within module cannot be changed when ambient environment condition changes. The product must be re-certified when matching circuit constant is changed.

## Precautions

- Please conduct validation and verification of our products in actual condition of mounting and operating environment before using our products.
- The products listed in this Specification are intended for use in general electronic equipment (e.g., AV equipment, OA equipment, home electric appliances, office equipment, information and communication equipment including, without limitation, mobile phone, and PC). Please be sure to contact KAGA FEI for further information before using the products for any equipment which may directly cause loss of human life or bodily injury (e.g., transportation equipment including, without limitation, automotive powertrain control system, train control system, and ship control system, traffic signal equipment, disaster prevention equipment, medical equipment classified as Class I, II or III by IMDRF, highly public information network equipment including, without limitation, telephone exchange, and base station).  
Please do not incorporate our products into any equipment requiring high levels of safety and/or reliability (e.g., aerospace equipment, aviation equipment, medical equipment classified as Class IV by IMDRF, nuclear control equipment, undersea equipment, military equipment).  
When our products are used even for high safety and/or reliability-required devices or circuits of general electronic equipment, it is strongly recommended to perform a thorough safety evaluation prior to use of our products and to install a protection circuit as necessary.  
Please note that unless you obtain prior written consent of KAGA FEI, KAGA FEI shall not be in any way responsible for any damages incurred by you or third parties arising from use of the products listed in this Specification for any equipment requiring inquiry to KAGA FEI or prohibited for use by KAGA FEI as described above.
- Information contained in this Specification is intended to convey examples of typical performances and/or applications of our products and is not intended to make any warranty with respect to the intellectual property rights or any other related rights of KAGA FEI or any third parties nor grant any license under such rights.
- Please note that the scope of warranty for our products is limited to the delivered our products themselves and KAGA FEI shall not be in any way responsible for any damages resulting from a fault or defect in our products.
- The contents of this Specification are applicable to our products which are purchased from our sales offices or authorized distributors (hereinafter "KAGA FEI's official sales channel"). Please note that the contents of this specification are not applicable to our products purchased from any seller other than KAGA FEI's official sales channel.
- The contents of this Specification are applied in preference to any agreement between you and KAGA FEI or KAGA FEI's official sales channel (e.g., supply and purchase agreement, quality assurance agreement).
- You will have deemed accepted the contents of this Specification upon usage of our products.
- Caution for Export  
Some of our products listed in this specification may require specific procedures for export according to "U.S. Export Administration Regulations" and other applicable regulations.

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