Thread Node / 2.4GHz IEEE 802.15.4 Wireless Module

Network Features

- Complete radio transceiver, embedded processor and networking software for forming a self-healing and self-configuring Thread mesh network.
- Thread Networks incorporate:
  - Device-to-device communication model and simple bridging to other IP networks.
  - No single point of failure, robust security, smooth commissioning and support for battery powered devices.
- Thread Networks deliver:
  - Mesh topology and extended range.
  - IP-based nodes with direct addressability and end-to-end security.
  - Flexibility. Not tied to specific device types neither number of nodes. Low power operation and agnostic interface for application layer.
- Compliant to 6LoWPAN, IPv6 and IEEE 802.15.4 standards.

Module Features

- Module integrates a single chip which combines an ARM® Cortex®-M0+ based 32-bit microcontroller and IEEE 802.15.4 compliant best-in-class 2.4GHz RF transceiver, designed for industrial and consumer wireless applications.
- RF modular certification include USA, Canada and EU.
- PCB assembly with chip antenna (KTWM102-11) or with W.FL (equivalent of IPEX MHF3) antenna connector (KTWM102-21).
- KiNOS (Real Time Network Operating System) inside.

Product Description

Thread Networks are self-managing, low power Internet Protocol (IPv6) networks built from wireless nodes called motes. The KTWM102 belongs to the family of Kirale's wireless module solutions, featuring a highly-integrated, low-power radio and ARM® Cortex®-M0+ 32-bit microcontroller running Kirale's embedded KiNOS networking software. Both the KTWM102-11 (with chip antenna) and the KTWM102-21 (with W.FL connector), at 16.6mm × 11.4mm, are designed for surface mount assembly.

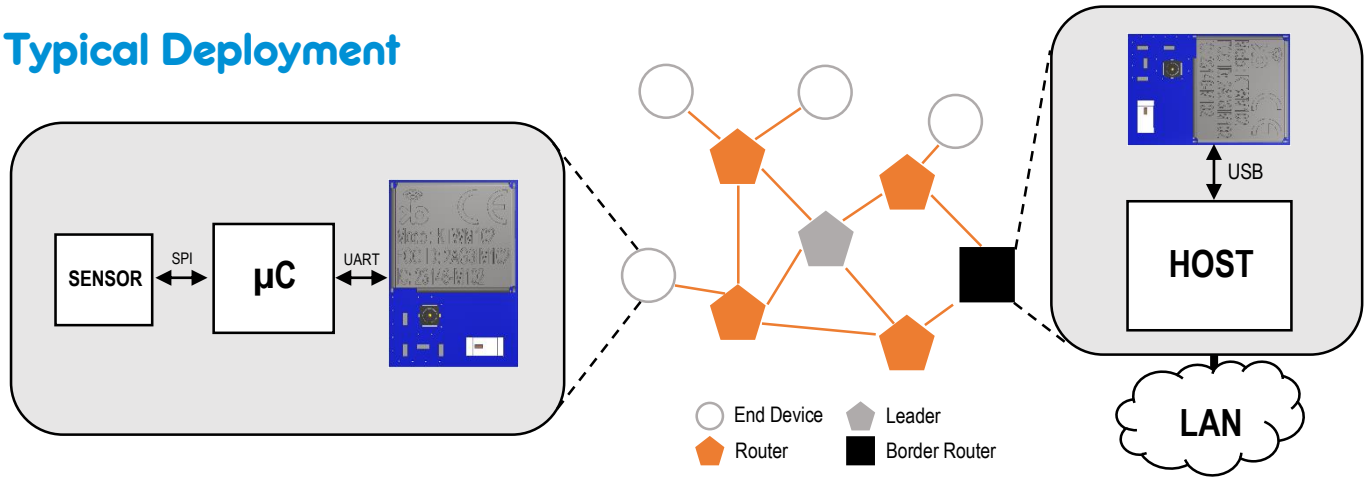
The KiNOS software provided with the KTWM102 module is fully tested and validated, allows you to update the firmware version and is readily configured via the Kirale Binary Interface (KBI through UART port) or the Command-Line Shell (KSH through USB Virtual Serial port).

Kirale's modules deliver a highly flexible network with proven reliability and low power performance in an easy-to-integrate platform.

Applications

- Smart Energy
- Low-Power Sensor Networks
- Safety, Security and Access Control
- Medical (MBAN) Networks and Home Health Care
- Home/Office/Hotel Automation
- Home Appliances
- HVAC Control
- Lighting Control
- Asset Tracking

Typical Deployment



Revision History

Date	Revision	Changes
11/2017	1	Draft

Contents

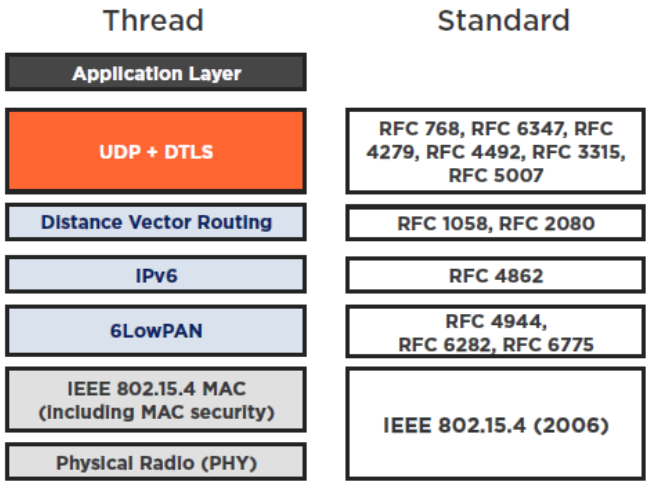
Thread Network Overview

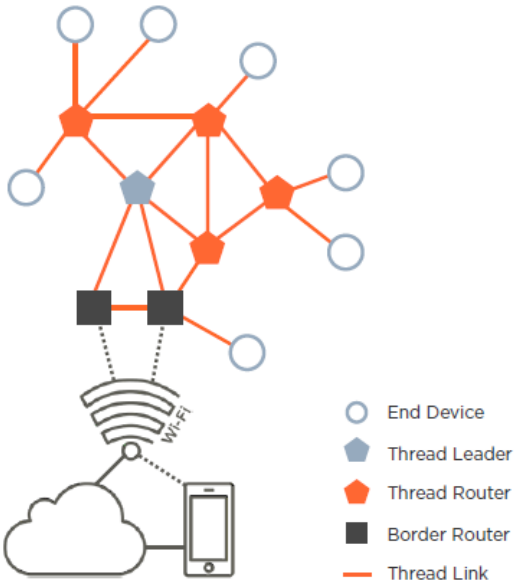
The Thread stack is an open standard for reliable, cost-effective, low-power, wireless D2D (device-to-device) communication. It is designed specifically for environments where IP-based networking is desired and a variety of application layers can be used on the stack.

These are the general characteristics of the Thread stack and network:

- **Simple network installation, start up and operation**. The smooth protocols for forming, joining, and maintaining Thread Networks allow systems to self-configure and fix routing problems as they occur.
- **Secure**. Devices do not join the Thread Network unless authorized and all communications are encrypted and secure.
- **Small and large networks**. Networks vary from several devices to hundreds of devices communicating seamlessly. The network layer is designed to optimize the network operation based on the expected use.
- **Range**. Typical devices in conjunction with mesh networking provide sufficient range to cover a normal home. Spread spectrum technology is used at the physical layer to provide good immunity to interference.
- **No single point of failure**. The stack is designed to provide secure and reliable operations even with the failure or loss of individual devices.
- **Low power**. Host devices can typically operate for several years on AA type batteries using suitable duty cycles.

The 802.15.4 MAC layer is used for basic message handling and congestion control. This MAC layer includes a CSMA (Carrier Sense Multiple Access) mechanism for devices to listen for a clear channel, as well as a link layer to handle retries and acknowledgement of messages for reliable communications between adjacent devices. MAC layer encryption and integrity protection is used on message based on keys established and configured by the higher layers of the software stack. The network layer builds on these underlying mechanisms to provide reliable end-to-end communications in the network.

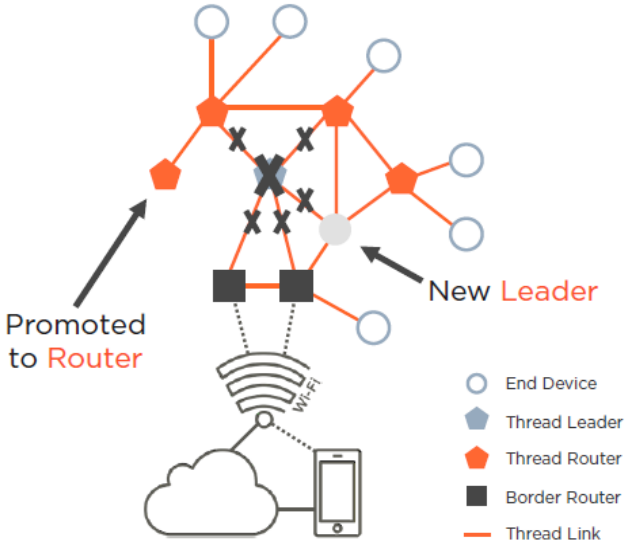




There are four device types:

- **Border Routers**. It is a specific type of Router that provides connectivity from the 802.15.4 network to adjacent networks on other physical layers (for example, Wi-Fi and Ethernet). Border Routers provide services for devices within the 802.15.4 network, including routing services for off-network operations. There may be one or more Border Routers in a Thread Network.
- **Routers**. They provide routing services to network devices. Routers also provide joining and security services for devices trying to join the network. Routers are not designed to sleep. Routers can downgrade their functionality and become REEDs (Router-eligible End Devices).
- **Router-eligible End Devices**. REEDs have the capability to become Routers but due to the network topology or conditions these devices are not acting as Routers. These devices do not generally forward messages or provide joining or security services for other devices in the Thread Network. The Thread Network manages REEDs becoming Routers if necessary without user interaction.
- **Sleepy End devices**. They are host devices. They communicate only through their Parent Router and cannot forward messages for other devices.

In a system comprised of devices running the Thread stack, none of these devices represents a single point of failure. While there are a number of devices in the system that perform special functions, the design of the Thread stack is such that they can be replaced without impacting the ongoing communication within the Thread Network. For example, a sleepy Child requires a Parent for communications so this Parent represents a single point of failure for its communications. However, the sleepy device can and will select another Parent if its Parent is unavailable so this transition should not be visible to the user.



A Router or Border Router can assume a Leader role for certain functions in the Thread Network. This Leader is required to make decisions within the network. For example, the Leader assigns Router addresses and allows new Router requests. The Leader role is elected and if the Leader fails, another Router or Border Router assumes the Leader role. It is this autonomous operation that ensures there is no single point of failure.

The Thread stack supports full mesh connectivity between all Routers in the Thread Network. The actual topology is based on the number of Routers in the Thread Network. If there is only one Router or Border Router, then a basic star topology with a single Router is formed. If there is more than one Router then a mesh topology is automatically formed.

Mesh networks make radio systems more reliable by allowing radios to forward messages for other radios. For example, if a node cannot send a message directly to another node, the mesh network forwards the message through one or more intermediary nodes. The nature of the Thread Network is that all Router nodes maintain routes and connectivity with each other so the mesh is constantly maintained and connected.

In a mesh network, the sleepy end devices or REEDs do not route for other devices. These devices send messages to a Parent that is a Router. This Parent Router handles the routing operations for its Child devices.

Thread provides two commissioning methods:

- Configuring commissioning information directly onto a device using an out-of-band method. The commissioning information allows the joining device to attach to the proper Thread Network as soon as it is introduced to the network.
- Establishing a commissioning session between a joining device and a commissioning application on a smartphone, tablet, or the web. The commissioning session securely delivers commissioning information to the joining device, allowing it to attach to the proper Thread Network.

On-demand route discovery is commonly used in low-power 802.15.4 networks. However, on-demand route discovery is costly in terms of network overhead and bandwidth due to route discovery requests flooding the network.

In a Thread Network, all Routers periodically exchange single-hop MLE advertisement packets containing link cost information to all neighbor Routers, and path costs to all other Routers in the Thread Network. Through these periodic, local updates, all Routers have up-to-date path cost information to any other Router in the Thread Network, so on-demand route discovery is not required. If a route is no longer usable, Routers can make a selection on the next most suitable route to the destination. This self-healing routing mechanism allows Routers to quickly detect when other Routers have dropped off the Thread Network, and calculate the best path to maintain connectivity to all other devices in the Thread Network.

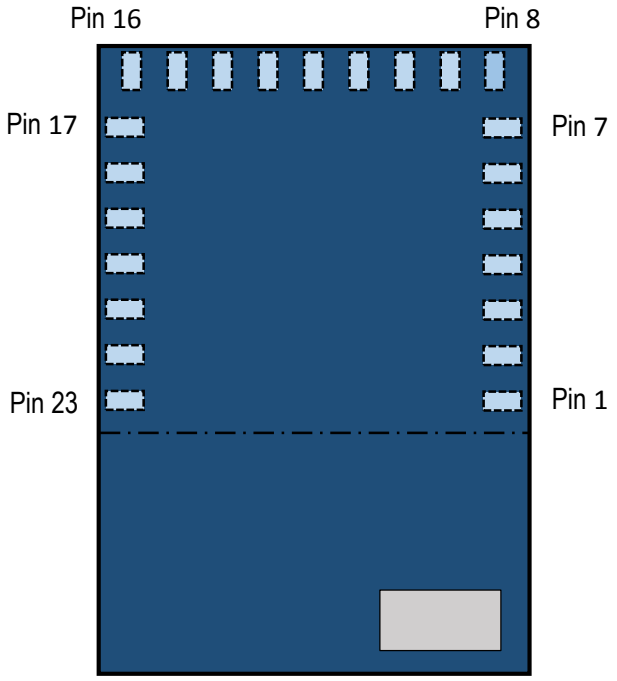
Devices operating in the field may be reset accidentally or on purpose for a variety of reasons. Devices that have been reset need to restart network operations without user intervention. For this to be done a set of information needs to be stored in non-volatile storage. This includes:

- Network information such as PAN ID.
- Security material (each key used).
- Addressing information from the network to form the devices IPv6 addresses.

Source: Thread Group

For more information about Thread Networks please visit www.threadgroup.org

Pin Configuration



Top view

Pin No.	Pin Name	Pin Type	Pin Description
1	PA27	GPIO	Unused
2	PA28	GPIO	Unused
3	RESET_n	Input	External Reset. Active low
4	GND	Ground	Ground
5	SWCLK	Input	Serial Wire Debug Interface
6	SWDIO	Input/output	Serial Wire Debug Interface
7	GND	Ground	Ground
8	VCC_3v3	Power	Input Power Supply
9	USB_D+	Input/output	Data + Port (USB 2.1 spec.)
10	USB_D-	Input/output	Data – Port (USB 2.1 spec.)
11	PA06	Input	USB Detection. Active low
12	PA07	Output	Led Control Signal. Active low
13	PA08	Output	UART Tx
14	PA09	Input	UART Rx
15	GND	Ground	Ground
16	VCC_3v3	Power	Input Power Supply
17	GND	Ground	Ground
18	PA14	GPIO	Unused
19	PA15	GPIO	Unused
20	PA16	GPIO	Unused
21	PA17	GPIO	Unused
22	PA18	GPIO	Unused
23	PA19	GPIO	Unused

Module Description

The KTWM102 is a completely self-contained 2.4GHz IEEE 802.15.4 Thread module. Based on Atmel® SMART™ SAM R21 series of low-power microcontrollers using the 32-bit ARM® Cortex®-M0+ processor and an integrated ultra-low power 2.4GHz ISM band transceiver.

It comes with Kirale's Network Operating System (KiNOS), a high optimized network stack, fully compiled yet is configurable via the Kirale Binary Interface (KBI) or the Command-Line Shell (KSH), which allows a host application to interact with the network and supports all Thread network roles, making it suitable for a wide range of applications.

KTWM102 module is implemented as 23-pin reflow solderable module in a tiny form factor (16.6mm × 11.4mm × 2.2mm) to allow size constrained applications. The KTWM102 family is certified and qualified, enabling customers to speed up time to market by greatly reducing the design and certification phases of development.

Specifications

Thread Device Capabilities Supported	
Device types	All types (Border Router included)
No. of Children	64
EUI-64/EUI-48	Factory-assigned
System-On-Chip	
Manufacturer	Microchip (Atmel)
Model	ATSAMR21E19A
Processor	32-bit ARM® Cortex®-M0+
Flash	768KB (256KB + 512KB)
SRAM	32KB
Radio	
Frequency range	2.405GHz to 2.480GHz
Transmit power	5dBm
Receiver sensitivity	-104dBm
Antenna	Onboard chip or external through W.FL connector @ 50 ohms
Host Interfaces	
USB	Native USB 2.1 supporting ACM (Serial), ECM (Ethernet) and DFU (Firmware Upgrade) specifications
UART	2-pin configuration @ 115.2K bauds
Embedded Firmware	
KiNOS	Kirale's Network Operating System (upgradeable through any supported Host interfaces)
Module Current Consumption (V_{CC} = 3.3V, T_A = 25 ºC, P_{TX} = 0dBm, UART Host interface enabled)	
Idle Mode	TBD
Transmit Mode	TBD
Receive Mode	TBD
Sleep Mode	TBD
Certifications	
FCC	FCC part 15 modular certification ID: 2AG3IM102

Antenna Options

KTWM102 module supports two antenna options, a 2.4GHz chip antenna and external antenna connection through W.FL connector (see Ordering Information section). The regulatory certification for external antenna has been completed with the following configuration:

- Omnidirectional antenna with 2.15dBi gain and a RP-SMA female connector and W.FL to RP-SMA male cable (95mm in length).

An adequate ground plane is necessary to provide good efficiency. The ground plane of the host board on which the module is mounted increases the effective antenna ground plane size and improves the antenna performance.

The position of the module on the host board and overall design of the product enclosure contribute to antenna performance. Poor design affects radiation patterns and can result in reflection, diffraction and/or scattering of the transmitted signal. For optimum antenna performance, the KTWM102-1x module should be mounted at the PCB end/corner with the antenna edge facing out. For best performance, module should be placed with chip antenna area overhanging the edge of the host board. If this is not possible in a design, module should have a PCB board area below chip antenna with no copper or any other metal present.

It is also best to keep some clearance between the antenna and nearby objects. This includes how the module is mounted in the product enclosure.

Evaluation Dongle

Kirale has developed a full featured Evaluation Dongle that provides all you need to evaluate Thread Mesh Networks. Based on KTWM102-11 module, allows for easy use of all Thread and Host configurations. You can order directly at www.kirale.com

Part Number	Description
KTDG102	Evaluation Dongle with USB and UART interface based on KTWM102-11 module with chip antenna.

Module Operation

The KTWM102 module family has been conceived to be used as a Network Co-Processor (NCP). RF Module can be controlled over the UART and/or USB interfaces as a peripheral to an external host processor and it requires only four pins to be connected in case of simplest configuration.

Power Supply

Two pins are provided for VCC and three pins for GND in the edge connector of the module. Recommended supply voltage is 3.3 V_{dc}. No additional external components are mandatory for the supply pins.

The RESET_n pin usage is optional (the functionality is also available by software) and no external components are required since RC filter is included in the module.

All not used pins must be left unconnected.

USB interface

When the module is to be operated by the host via its USB interface the additional required pins are USB_D+ and USB_D- for USB data. The USB interface enables the Command-Line Shell (KSH) via Virtual Serial Port, which is enabled by default and the Border Router mode via Ethernet emulation (CDC ECM), which comes disabled.

The PA06 pin enables or disables the module's USB peripheral, reducing power consumption (useful for battery powered detachable devices).

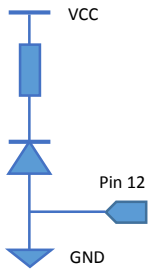
UART interface

When the module is to be operated by the host via its UART interface the additional required pins are PA08 (module's serial Tx) and PA09 (module's serial Rx). The UART interface enables the Kirale Binary-Interface (KBI). UART mode is enabled by default.

Led signaling

The PA07 pin is used to signal different statuses of the module. Blinking modes are detailed in the specific interface manual. Led mode is enabled by default.

Typical LED connection



SWD interface

The Serial Wire Debug Interface of the module's SoC is exposed to the edge connector on pins SWDCLK and SWDIO, enabling flash programming and debugging of third party firmwares. Please refer to the "Atmel SAM R21E Datasheet" for more information.

WARNING: Kirale declines all responsibility derived from the use of non-official firmware releases on its modules.

Electrical Characteristics

Symbol	Parameter	Condition	Min.	Typ.	Max.	Unit
V_{CC}	Power Supply Voltage		2.7	3.3	3.6	V
V_{PIN}	Pin Voltage		GND-0.3	–	V_{CC}+0.3	V
P_{RF}	RF Level		–	4	5	dBm
T_S	Storage Temperature		-40	–	125	ºC
T_A	Temperature Range		-40	25	85	ºC
V_{ESD}	ESD robustness	Human Body Model (HBM)	4			KV
		Charged Device Model (CDM)	550			V

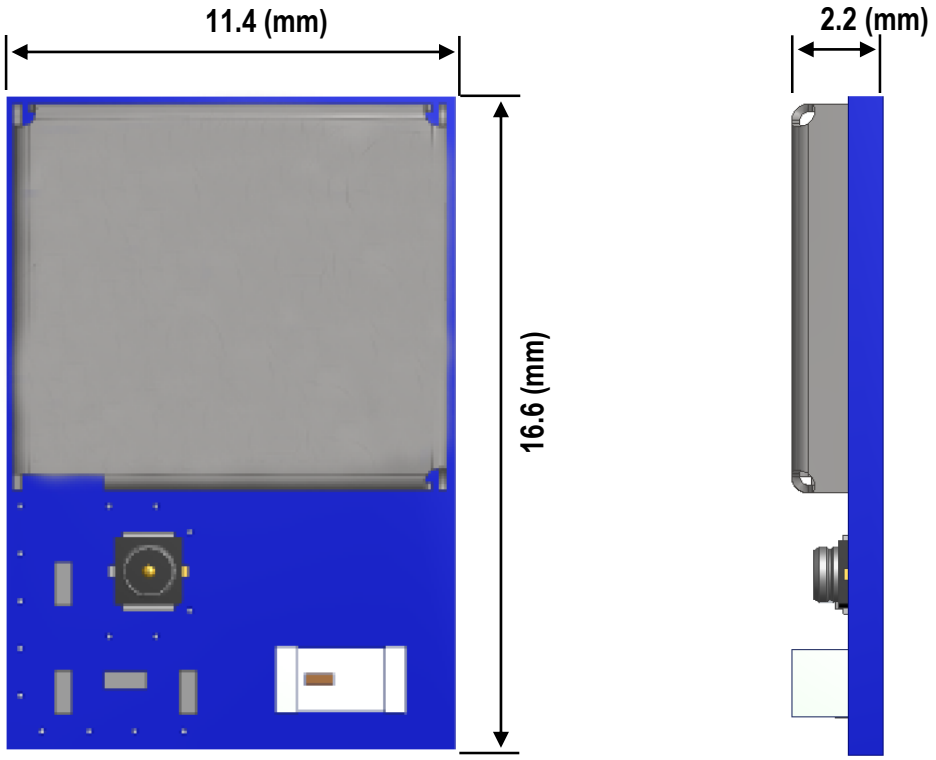
Ordering Information

Email sales@kirale.com for quotes and ordering, or visit our website at www.kirale.com

Part Number	Description
KTWM102-11	Rev 1, 23-Lead (16.6mm x 11.4mm x 2.2mm) PCB with Chip Antenna. Tape&Reel Package.
KTWM102-21	Rev 1, 23-Lead (16.6mm x 11.4mm x 2.2mm) PCB with W.FL (IPEX MHF3) Connector. Tape&Reel Package.

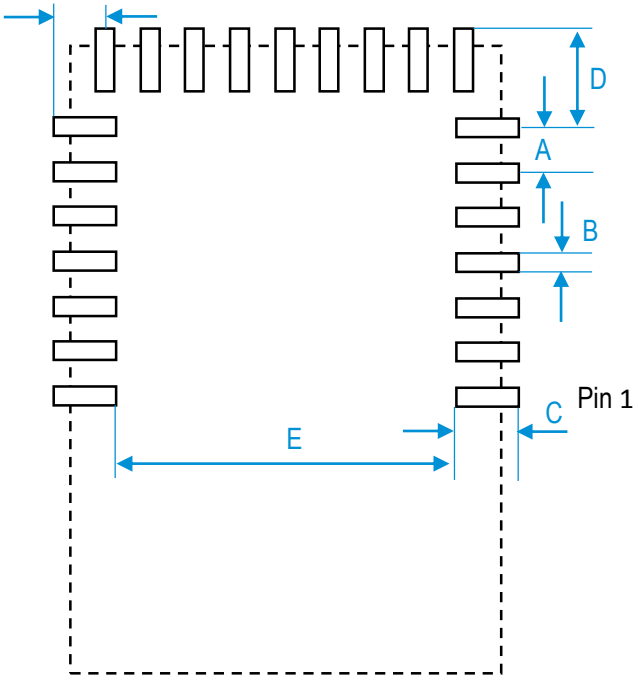
Package Description

Dimensions and Marking



Recommended PCB Footprint

Symbol	Description	Distance
A	Pitch	1.20 mm
B	Pad dimension	0.50 mm
C	Pad dimension	1.65 mm
D	Pad edge to pad center	2.60 mm
E	Pad edge to pad edge	8.90 mm
F	Pad edge to pad center	1.30 mm

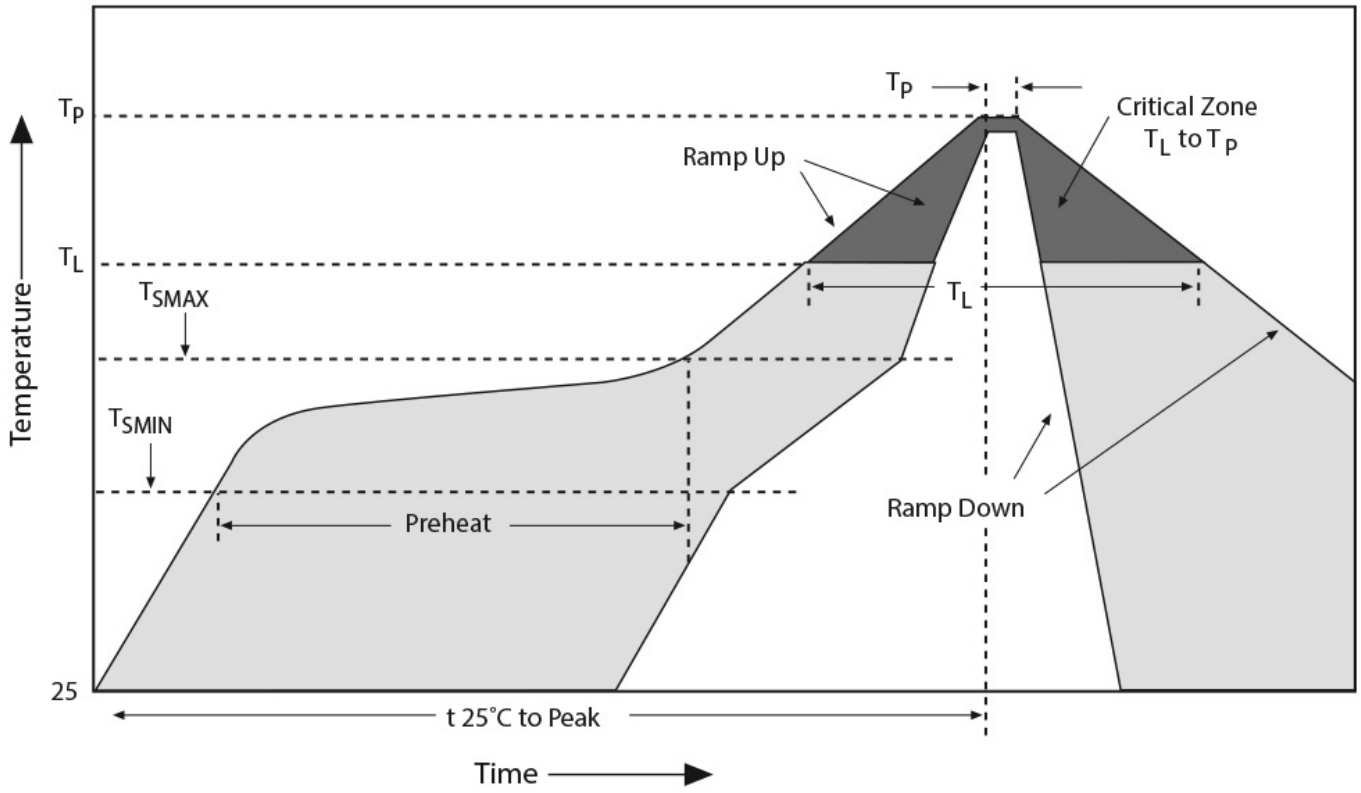


Soldering Information

Use of "No-Clean" solder paste is recommended to avoid the requirement for a cleaning process. Cleaning the module is strongly discouraged because it will be difficult to ensure no cleaning agent and other residuals are remaining underneath the shielding can as well as in the gap between the module and the host board.

Opposite-side reflow is prohibited due to the module weight. You must not place the module on the bottom of your PCB and reflow.

Parameter	Value
Temperature min (T_{SMIN})	150 °C
Temperature max (T_{SMAX})	200 °C
Time from T_{SMIN} to T_{SMAX}	60-120 seconds
Ramp-up rate (T_L to T_P)	3 °C/second max.
Liquidous temperature (T_L)	217 °C
Time maintained above T_L	60-150 seconds
Peak package body temperature (T_P)	250 °C
Time within 5 °C of T_P	20-30 seconds
Time from 25 °C to T_P	20-30 seconds
Ramp-down rate (T_P to T_L)	6 °C/second max.
Maximum number of reflow cycles	2



Regulatory Statements

Federal Communications Commission (FCC)

Compliance Statement

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.

Radiation Exposure Statement

This equipment complies with FCC RF radiation exposure limits set forth for an uncontrolled environment. This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter. This equipment should be installed and operated with minimum distance 20cm between the radiator& your body.

The devices must be installed and used in strict accordance with the manufacturer's instructions as described in this document.

WARNING: Changes or modifications not expressed approved by the part responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement

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

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

To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that permitted for successful communication.

This device has been designed to operate with the antenna listed below, and having a maximum gain of 2.15dB. Antennas not included in this list or having a gain greater than 2.15dB are strictly prohibited for use with this device. The required antenna impedance is 50 ohms.

- Omnidirectional antenna with 2.15dBi gain and a RP-SMA female connector and W.FL to RP-SMA male cable (95mm in length).

OEM Responsibilities to comply with FCC Regulations

The KTWM102 Module has been certified for integration into products only by OEM integrators under the following conditions:

1. The antenna and transmitter must not be co-located with any other transmitter or antenna.
2. The module shall be only used with the antennas that has been originally tested and certified with this module.

As long as the two conditions above are met, further transmitter testing will not be required. However, the OEM integrator is still responsible for testing their end-product for any additional compliance requirements required with this module installed (for example, digital device emissions, PC peripheral requirements, etc.).

IMPORTANT NOTE: In the event that these conditions cannot be met (for certain configurations or co-location with another transmitter), then the FCC authorizations are no longer considered valid and the FCC ID Certification Number cannot be used on the final product. In these circumstances, the OEM integrator will be responsible for re-evaluating the end product (including the transmitter) and obtaining a separate FCC authorization.

WARNING: The OEM is still responsible for verifying end product compliance with FCC Part 15, subpart B limits for unintentional radiators through an accredited test facility.

End Product Labelling

The KTWM102 Module is labeled with its own FCC ID ertification Number. If the FCC ID Certification Number are not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. In that case, the final end product must be labeled in a visible area with the following:

"Contains Transmitter Module FCC ID: 2AG3IM102"

Or *"Contains FCC ID: 2AG3IM102"*

The OEM of the KTWM102 Module must only use the approved antenna listed above, which have been certified with this module. The OEM integrator has to be aware not to provide information to the end user regarding how to install or remove this RF module in the user manual of the end product which integrates this module. The end user manual shall include all required regulatory information/warning as show in this manual.

Conformité Européenne (CE)

The KTWM102 family is conform to the provisions of the directives:

- 2014/53/EU Radio Equipment Directive (RED). The following requirements have been applied:

Directive reference	Standard - Detail	Version	Release Date	Description of Standard
2014/53/EU RED Part 3.1a	EN 60950 – 1		2006	Safety of Information Technology Equipment
2014/53/EU RED Part 3.1b	EN 301 489 – 1	2.2.0	03/2017	Common Technical Requirements
	EN 301 489 – 17	3.2.0	03/2017	Wideband Transmission (2.4GHz)
2014/53/EU RED Part 3.2	EN 300 328	2.1.1	11/2016	Electromagnetic compatibility and Radio Spectrum Matters (ERM)

- 2011/65/EU Restriction of the Use of certain Hazardous Substances in Electrical and Electronic Equipment (RoHS 2).
- 2012/19/EU Waste of Electrical and Electronic Equipment (WEEE).

OEM integrators should consult with qualified test house to verify all regulatory requirements have been met for their complete device.

Declaration of Conformity and supporting test reports are available at www.kirale.com.