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Anaren Integrated Radio

A1101L09x User's Manual

Release Date 11/01/11

Anaren Integrated Radio

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USERS MANUAL

Models A1101L09A and A1101L09C

Contents

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1. Overview

The A1101L09A and A1101L09C are surface mount modules – each with an integrated crystal, internal voltage regulator, Low Noise Amplifier, matching circuitry and filtering. The A1101L09A has an integral antenna, whereas the A1101L09C utilizes an external antenna through a U.FL connector (see Table1.). The modules operate in the US 902 – 928MHz ISM band and are ideal for achieving low power wireless connectivity without having to deal with extensive RF, antenna design and regulatory compliance, allowing quick time to market. The modules are 100% tested to provide consistent performance.

The A1101L09A and A1101L09C have received regulatory approvals for modular devices in the United States (FCC) and Canada under Industry Canada (IC) Radio Standards Specification (RSS) RSS-210 and RSS-Gen. The modular approval allows the OEM or end user to place either an A1101L09A or an A1101L09C with an approved antenna inside a finished product without having to perform costly regulatory testing for an intentional radiator. Section 2 has information on the requirements for the end user/integrator must fulfill to use the modules without intentional radiator regulatory testing.

The A1101L09A and A1101L09C are based on the CC1101 transceiver IC from Texas Instruments. All control lines for the transceiver are provided at module level for full control of its operation. Please see the CC1101 data sheet (www.ti.com) for how to control the modules. Please see section 8 for the recommended register settings to achieve optimal performance and regulatory compliance.

The A1101L09A measure 11x19x2.5mm and A1101L09C measures 11x14x2.5mm.

1.1. A1101L09A

The A1101L09A has an integral antenna, providing high efficiency and near omni-directional radiation pattern. This approach offers the lowest system cost when the application allows collocation of radio and antenna.

1.2. A1101L09C

The A1101L09C has a compact antenna connector that allows for locating the antenna away from the module due to form/function or in order to exit a metal enclosure, see figure 6 and figure 7 for more information on antenna location and enclosure considerations.

1.3. Features

Features:

- Frequency range: 902-928 MHz
- Ultra small package size
  - A1101L09C : 11mm x 14mm x 2.5mm
  - A1101L09A : 11mm x 19mm x 2.5mm
- Impedance controlled multi-layer PCB
- Shielded Package
- 1.8 to 3.6 V operation
- SPI Interface
- ROHS Compliant
- LGA Footprint
- Low Power Consumption
- Regulatory approvals for FCC
- Digital RSSI output
- Programmable channel filter bandwidth
- Programmable output power up to +11 dBm
- High sensitivity (–115 dBm at 1.2 kBaud, 2.2% packet error rate)
- Low current consumption (25.2 mA in RX, 1.2kBaud, input well above sensitivity limit)
- Fast startup time: 240µs from SLEEP to Rx or Tx mode
- Separate 64 byte Rx and Tx FIFOs
- Programmable data rate from 1.2 to 500 kBaud
- Sleep state: 0.4µA
- Idle State: 1.7mA

Benefits Summary:

- Operating temperature -40 to +85C
- 100% RF Tested in production
- Common footprint for all family members
- No RF engineering experience necessary
- Only requires a 2 layer PCB implementation
- Excellent receiver selectivity and blocking Performance
- Suited for systems compliant with FCC CFR47 Part 15.247 (US) and Canada under Industry Canada (IC) Radio Standards Specification (RSS) RSS-210 and RSS-Gen.
- No regulatory “Intentional radiator” testing required for integrating modules into end product. Simple certification labeling replaces testing.

1.4. Theory of Operation

The A1101L09A and A1101L09C are for low power wireless applications in the US 902 – 928MHz ISM band. The devices can be used to implement a variety of networks, including; point to point, point to multipoint, peer to peer and mesh networks.

The A1101L09A and A1101L09C both interface to an application microcontroller via an SPI bus. Physical and MAC layer functionality are accessed via the SPI bus through addressable registers as well as execution commands. Data received or to be transmitted are also accessed through the SPI bus and are implemented as a FIFO register (64 bytes each for Tx and Rx).

To transmit, a frame of data is placed in the FIFO; this may include a destination address. A transmit command is given, which will transmit the data according to the initial setup of the registers. To receive data, a receive command is given, which enables the unit to “listen” for a transmission; when such a transmission occurs, it places the received frame in the FIFO. When neither transmit nor receive are required, the device can enter either an Idle mode, from which it can quickly re-enter receive, transmit mode, or a low power sleep mode from which a crystal startup is required prior to transmit or receive operation.

Below is a block diagram for each of the A1101L09A and A1101L09C modules.

- Antenna
  - The antenna couples energy between the air and the AIR module. For applications where installations are done by an end user (non-professional), an omni-directional antenna pattern is desired; such that the application will work equally well in any direction. Similarly for peer to peer or point to multipoint applications an omni-directional pattern is desired such that all nodes have a fair chance of communicating. The A1101L09A module has an integral antenna that is near omni-directional, whereas the A1101L09C has approved antenna options ranging from near omni-directional to shaped front/back patterns (useful for inline, professional installations). Note that the end radiation patern depends not only on the antenna, but also on the ground plane, enclosure and installation environment.
    If the OEM or end user uses an antenna other than specified in Table 1, then the certification becomes void and it’s the OEM/end user responsibility to re-certify the complete product.
- Filtering
  - Filtering removes spurious signals to comply with regulatory intentional radiator requirements.
- Switch
  - Switches between transmit and receive mode which helps in reducing some loss while in transmit mode.
- LNA
  - Amplifies the receive signal intended to reduce the noise by the gain of the amplifier and to achieve the best sensitivity. The noise of the amplifier is injected directly into the received signal.
- SAW Filter
  - Surface Acoustic Wave (SAW) filters has been used for sharp cut off of the unwanted spurs which helps in maintaining good quality in the receive signal within the band of interest.
- Matching
  - Matching provides the correct loading of the transmit amplifier to achieve the highest output power, as well as the correct loading for the receive LNA to achieve the best sensitivity.
- Physical
  - The physical layer provides conversions between data, symbol and RF signal.
- MAC
  - The MAC layer is part of the Logical Link Layer and provides frame handling, addressing and medium access services.

- Microcontroller Interface
  - The microcontroller interface exposes registers and commands for the physical and MAC layers to a microcontroller.
- Power Management
  - Power management ensures a stable supply for the internal functions, as well as providing means for a low power sleep mode (in which case, most of the transceiver is power off).

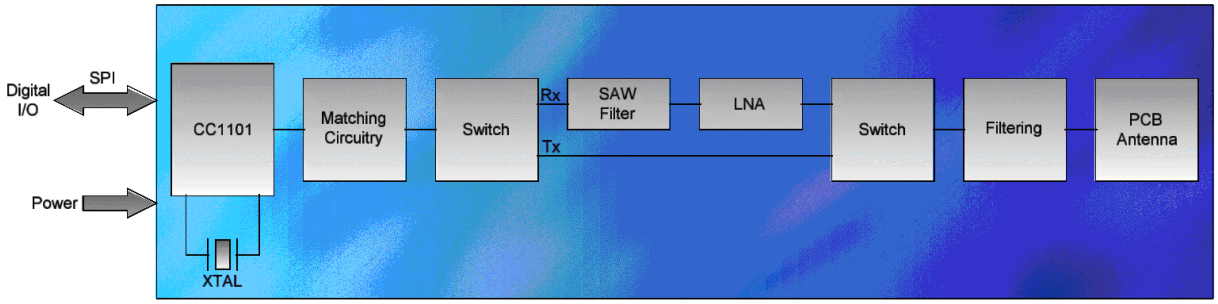


Figure 1 The functionality of the A1101L09A, using an integral antenna

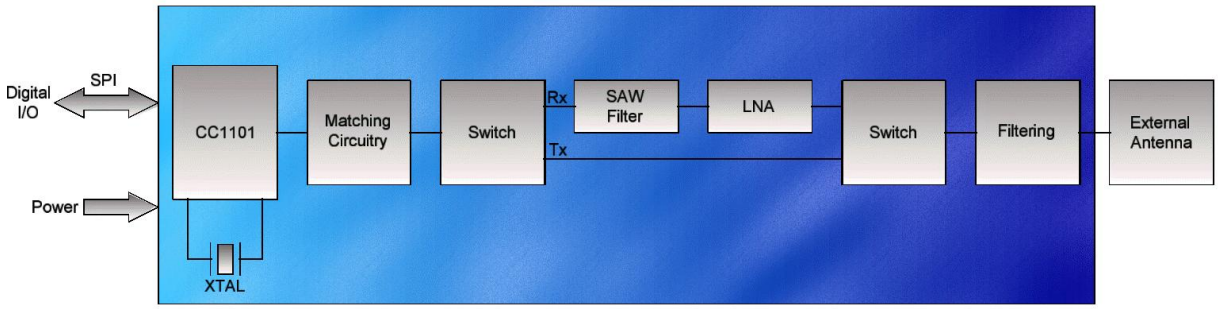


Figure 2 The functionality of the A1101L09C, using an external antenna.

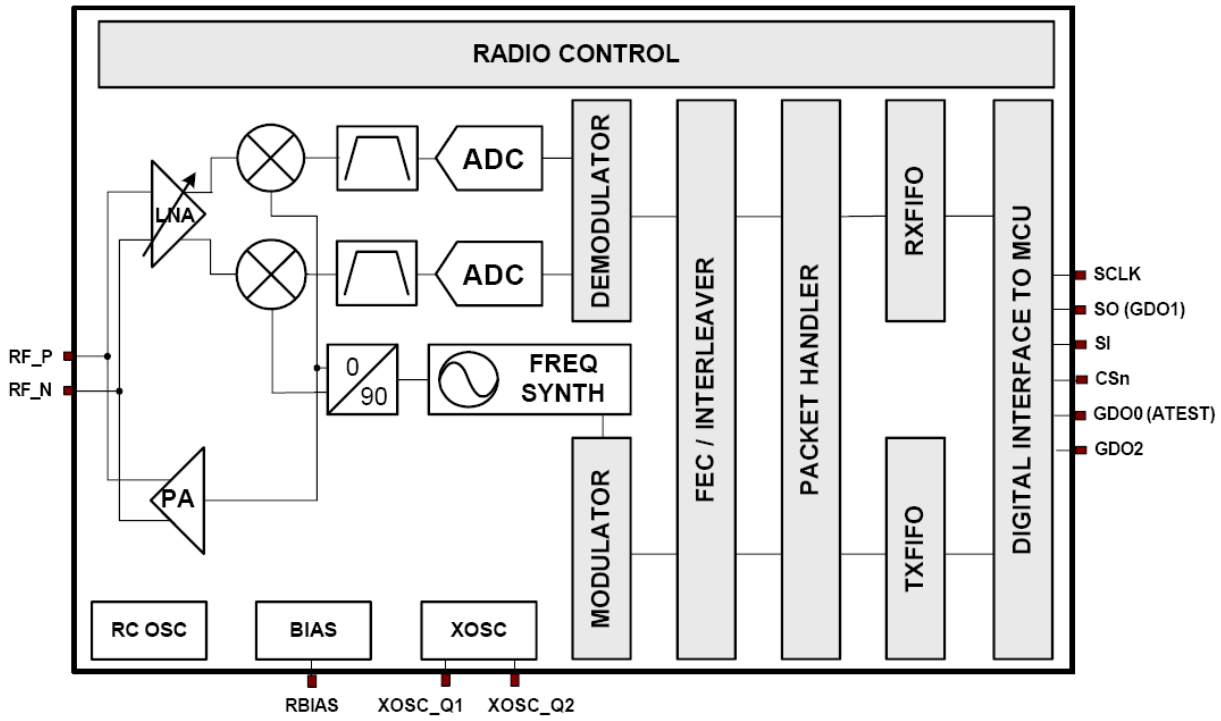


Figure 3 Transceiver IC block diagram.

1.4.1. Typical Flow

After initial setup of registers for desired behavior, the normal operation flow diagram is shown in Figure 4. In applications of infrequent data transmissions, the transceiver would be in “sleep” mode to save power (400nA). From there it would wake up and then enter “idle” mode. As part of the wake up process the crystal oscillator is started (~240µs) and the digital microcontroller interface is powered up. Before transmit or receive, the frequency synthesizer needs to be started (“FS_Wakeup”) and, having been powered off (or idle for a while), the control loop of the VCO/PLL needs to be calibrated (“calibrate”).

A data frame is loaded into the transmit FIFO and the “TX” mode is entered. The transceiver will transmit the data and enter “idle” mode after completion. When transmit is complete “RX” mode is entered to wait for the acknowledge frame. Once a frame is received, the transceiver will again enter “idle” mode. If no acknowledge frame is received within a given timeout, the data frame would be re-transmitted. If the acknowledge frame indicates that the data was received, the next data frame will be transmitted. After the last data frame has been transmitted successfully, the transceiver will again be put in “sleep” mode.

Medium access

Figure 4 Transceiver state diagram

1.5. Applications

Ultra low-power wireless applications, operating in the 902-928 MHz ISM band.

- Wireless alarm and security systems
- Industrial monitoring and control
- Wireless sensor networks
- AMR – Automatic Meter Reading
- Home and building automation
- Existing applications where simple upgrade to wireless is desired

2. Product Approvals

The A1101L09A and A1101L09C have been designed to meet most national regulations for worldwide ISM-band use. In particular, the radio modules have been certified to the following standards.

2.1. USA (Federal Communications Commission, FCC)

The A1101L09A, with integrated antenna, as well as the A1101L09C, used with the antenna listed in
Table 1 below; have been tested to comply with FCC Part 15 – 15.247 “Intentional Radiators.” The devices meet the requirements for modular transmitter approval as detailed in FCC public notice DA 00-1407 Released: June 26, 2000. The A1101L09A and A1101L09C module can be integrated into a finished product without obtaining subsequent FCC approvals.

(15.19a3) The modules comply 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.

Item	Part Number	Manufacturer	Type	Gain
1	Integral part of A1101L09A	Anaren	Integral Antenna	2 dBi
2	66089-0906	Anaren	Monopole whip, 6mm lead	3 dBi

Table 1 Approved Antenna

2.1.1. FCC Labeling Requirements

The A1101L09A and A1101L09C modules have been labeled with their own FCC ID number and if the FCC ID is not visible when the module is installed inside another device, then the outside of the finished product into which the module is installed must also display a label referring to the enclosed module. This exterior label can use wording such as the following:

Contains Transmitter Module FCC ID: X7J-A10091602

-or-

Contains FCC ID: X7J-A10091602

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.

2.1.2. End User Manual

The end user manual should include the following 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 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.

2.1.3. RF Exposure

All transmitters regulated by the FCC must comply with RF exposure requirements. OET Bulletin 65 “Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields” provides assistance in determining whether proposed or existing transmitting facilities, operations or devices comply with limits for human exposure to Radio Frequency (RF) fields adopted by the Federal Communications Commission (FCC). The bulletin offers guidelines and suggestions for evaluating compliance.

If appropriate, compliance with exposure guidelines for mobile and unlicensed devices can be accomplished by the use of warning labels and by providing end users with information concerning minimum separation distances from transmitting structures and proper installation of antennas.

The following statement must be included as a CAUTION statement in manuals and OEM products to alert end users of FCC RF Exposure compliance:

To satisfy FCC RF Exposure requirements for mobile and base station transmission devices, a separation distance of 20 cm or more should be maintained between the antenna of this device and persons during operation. To ensure compliance, operation at closer than this distance is not recommended. The antenna(s) used for this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

If the A1101L09A and A1101L09C module is used in a portable application (i.e., antenna is less than 20 cm from persons during operation), the end user is responsible for performing Specific Absorption Rate (SAR) testing in accordance with FCC rules 2.1091.

2.2. Canada (Industry Canada, IC)

The A1101L09A and A1101L09C modules have been certified for use in Canada under Industry Canada (IC) Radio Standards Specification (RSS) RSS-210 and RSS-Gen.

From section 3.2, RSS-Gen, Issue 3, December 2010, Modular Approval for category I Equipment or Category II Equipment:

"Modular approval permits the installation of the same module in a host device or multiple host devices without the need to recertify the device. Equipment certification for a modular device may be sought for either Category I equipment or Category II equipment.

Transmitters designed as modules for the installation in a host device may obtain equipment certification as a modular device provided that the applicable RSS is met and the following conditions in this section are met."

In section 7.1.2 Transmitter Antenna, it has been mentioned that the user manuals for transmitters shall display the following notice in a conspicuous location:

Notice: Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. 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 necessary for successful communication.

Avis: Sous la réglementation d'Industrie Canada, ce transmetteur radio ne peut fonctionner qu'en utilisant seulement une antenne d'un type et d'un maximum (ou moins) de gain approuvé pour l'émetteur par Industrie Canada. Pour réduire des potentielles interférences radio pour les autres utilisateurs, le type d'antenne et son gain doivent être choisis de sorte que la puissance isotrope rayonnée équivalente (PIRE) ne dépasse pas ce qui est nécessaire pour une communication réussie.

In section 7.1.2 Transmitter Antenna, it has been mentioned that the user manuals for transmitters equipped with detachable antennas shall also contain the following notice in a conspicuous location:

Notice: This radio transmitter (IC: 8975A-A10091602) has been approved by Industry Canada to operate with the antenna types listed below with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Avis: Cet émetteur radio (IC: 8975A-A10091602) a été approuvé par Industrie Canada pour fonctionner avec les types d'antennes énumérés ci-dessous avec le gain maximal admissible et l'impédance d'antenne requise pour chaque type d'antenne indiqué. Les types d'antennes ne figurant pas dans cette liste, ayant un gain supérieur au gain maximal indiqué pour ce type, sont strictement interdits pour l'utilisation avec cet appareil.

2.2.1. IC Labeling Requirements

From Section 3.2.1, RSS-Gen, Issue 3, December 2010, Labeling Requirements for the Host device:

"The host device shall be properly labeled to identify the modules within the host device.

The Industry Canada certification label of a module shall be clearly visible at all times when installed in the host device, otherwise the host device must be labeled to display the Industry Canada certification number of the module, preceded by the words "Contains transmitter module", or the word "Contains", or similar wording expressing the same meaning, as follows:

Contains transmitter module IC: XXXXXX-YYYYYYYYYYY
where XXXXXX-YYYYYYYYYYY is the module's certification number.

The applicant for equipment certification of the module shall provide with each unit of the module either a label such as described above, or an explanation and instruction to the user as to the host device labeling requirements".

Label:

Contains/Contient IC: 8975A-A10091602

Notice: This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Avis: Cet appareil est conforme avec Industrie Canada RSS standard exempts de licence (s). Son fonctionnement est soumis aux deux conditions suivantes: (1) cet appareil ne peut pas provoquer d'interférences et (2) cet appareil doit accepter toute interférence, y compris les interférences qui peuvent causer un mauvais fonctionnement du dispositif.

From section 7.1.4, RSS-Gen, Issue 3, December 2010, Radio Apparatus Containing Digital Circuits (ICES-003):

“Radio apparatus containing digital circuitry which can function separately from the operation of a transmitter or an associated transmitter, shall comply with ICES-003. In such cases, the labeling requirements of the applicable RSS apply, rather than the labelling requirements in ICES-003.”

For more information see: Industry Canada http://www.ic.gc.ca/

2.2.2. RF Exposure

All transmitters regulated by IC must comply with RF exposure limits as set forth in RSS-102, Issue 4, section 4, “Exposure Limits”. Furthermore RSS-102, Issue 4, Section 2 “Certification Requirements”, provides assistance in determining the specific requirements for compliance. If appropriate, compliance with exposure guidelines for mobile and unlicensed devices can be accomplished by the use of warning labels and by providing users with information concerning minimum separation distances from transmitting structures and proper installation of antennas.

The following statement must be included as a CAUTION statement in manuals and OEM products to alert users of IC RF Exposure compliance:

Notice: To satisfy IC RF Exposure requirements for mobile and base station transmission devices, a separation distance of 20 cm or more should be maintained between the antenna of this device and persons during operation. To ensure compliance, operation at closer than this distance is not recommended. The antenna(s) used for this transmitter must not be co-located or operating in conjunction with any other antenna or transmitter.

Avis: Pour répondre à la IC d'exposition pour les besoins de base et mobiles dispositifs de transmission de la station, sur une distance de séparation de 20 cm ou plus doit être maintenue entre l'antenne de cet appareil et les personnes en cours de fonctionnement. Pour assurer le respect, l'exploitation de plus près à cette distance n'est pas recommandée. L'antenne (s) utilisé pour cet émetteur ne doit pas être co-localisés ou fonctionner conjointement avec une autre antenne ou transmetteur.

If the A1101L09A or A1101L09C module is used in a portable application (antenna is less than 20cm from persons during operation), the integrator/OEM is responsible for performing Specific Absorption Rate (SAR) testing in accordance with IC rules and methods of RSS-102

2.3. Potential Interference Sources

- Alarm systems
  - These typically use low duty cycles and are therefore easy to avoid using acknowledge/retransmit methods
- Car alarms (internal motion sensors)
- Video surveillance
  - These are typically operated on a fixed channel determined at installation time and can be avoided by using clear channel assessment. It may be useful to change the channel used by the video surveillance equipment also, if possible.

2.3.1. Time critical data

If the user requires specific time critical data throughput that cannot tolerate the delays of potentially many re-transmissions, the user is encouraged to implement an environment-aware algorithm that periodically monitors/scans the frequency band and maintain a list of “best available” channels.

2.4. Approved Usage

These radio modules can be used in a variety of physical layer configurations; the following restricts the use to maintain compliance with the above referenced certification bodies.

The user is encouraged to use minimum power required to establish a link, thus minimizing interference.

Changes or modifications to the module and/or operation outside the limits set forth below are prohibited and could void the user’s authority to operate the modules.

Uses of these radio modules are limited to the following frequency ranges and modulation settings. Using the radio modules outside of these limitations are prohibited and could void the user’s authority to operate the modules. The user should use one of the register configurations listed below.

Anaren provides register setting files for optimal performance and compliance for each of the data rates given in the following at www.anaren.com.

2.4.1. USA & Canada

Within the USA and Canada, the modules have been approved for use as digitally modulated transmitters. In the US, the occupied bandwidth (6dB) should be greater than 500 kHz whereas in Canada, the maximum BW (99%) should be 0.5% of the center frequency. In addition, the spectral density may not exceed 8dBm/3kHz and the total output power including antenna gain may not exceed 1W. The following table shows configurations that are compliant with this use and the expected performance.

2-FSK Modulation:

Requirement					Suggested	
Data Rate	Deviation	Fomin	FoMax	Max power	Channel	Rx Filter
kb/s	KHz	MHz	MHz	dBm	KHz	KHz
1.2	228.515625	902.699799	927.293793	7	99.975586	650
38.4	228.515625	902.699799	927.293793	7	99.975586	650
100	228.515625	902.699799	927.293793	11	99.975586	650
250	228.515625	902.699799	927.293793	11	99.975586	812

MSK Modulation:

Requirement					Suggested	
Data Rate	Phase	Fomin	FoMax	Max power	Channel	Rx Filter
kb/s	deg	MHz	MHz	dBm	KHz	KHz
500	0	902.799774	927.193817	11	99.975586	650

Table 2: FCC approved configurations

It is encouraged to use a medium access technique which should include addressing of individual transceiver nodes; and should include a combination of a clear channel assessment, transmit and detect, or a frequency hopping method. This ensures that the un-licensed band can be shared with other systems/applications.

Due to FCC power spectral density requirements, the output power must be limited by the given value for each modulation types. The given Max power in Table 2 represents the PA table setting for the module to ensure the correct maximum output power. Table 3 gives a list of available output powers that the module has along with the corresponding PA table register values.

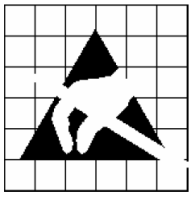
Power (dBm)	PA_Table(Hex)
11	0xC0
8.9	0xC6
7	0xCC
5	0x84
0	0x8E
-6	0x38
-10	0x27
-15	0x1E
-20	0x0E
-30	0x03

Table 3: Output Power Vs. PA Table Value

3. Electrical Characteristics

3.1. Absolute Maximum Ratings

Under no circumstances must the absolute maximum ratings given in Table 4 be violated. Stress exceeding one or more of the limiting values may cause permanent damage to the device.



Caution!
ESD sensitive device. Precaution should be used when handling the device in order to prevent permanent damage.

MSL 3

Caution!
This assembly contains moisture sensitive devices and requires proper handling per IPC/JEDEC J-STD-033

Parameter	Min	Max	Units	Condition
Supply voltage	–0.3	3.9	V	All supply pins must have the same voltage
Voltage on any digital pin	–0.3	VDD + 0.3 max 3.9	V	
Voltage on the pins RF_P, RF_N, and DCOUPL	–0.3	2.0	V	
Voltage ramp-up rate		120	kV/µs	
Input RF level		+10	dBm	
Storage temperature range	–50	150	°C	
Solder reflow temperature		260	°C	According to IPC/JEDEC J-STD-020C
ESD		750	V	According to JEDEC STD 22, method A114, Human Body Model (HBM)
ESD		400	V	According to JEDEC STD 22, C101C, Charged Device Model (CDM)

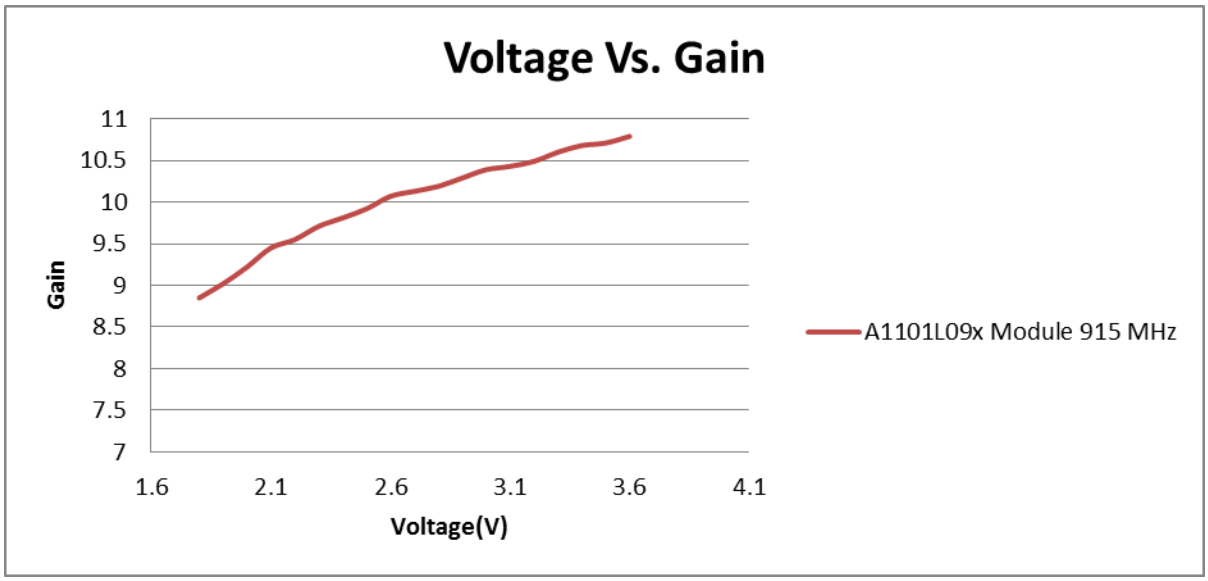
Table 4 Absolute Maximum Ratings

3.2. Operating Conditions

Parameter	Min	Max	Unit	Condition
Operating temperature	-40	85	°C	
Operating supply voltage	1.8	3.6	V	All supply pins must have the same voltage

Table 5 Operating Conditions

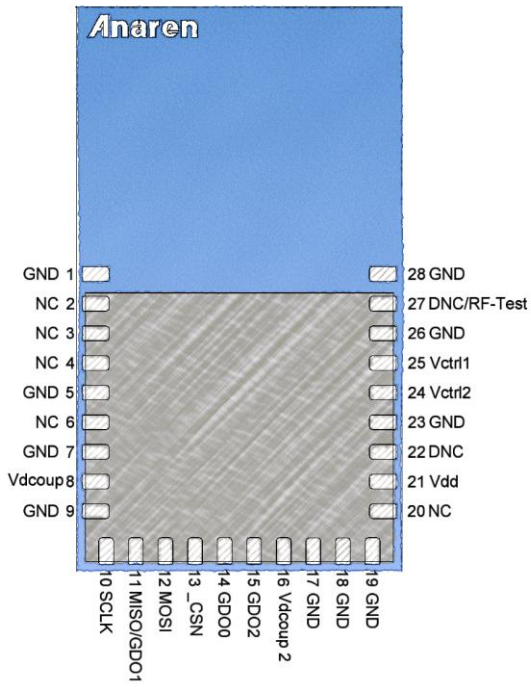
Note: As the voltage increases in pin 24 (Vctrl2) the Gain of the Module increases.



It's been recommended that in order to maintain a constant Gain a supply voltage from 2.9 to 3.1V to pin 24 (Vctrl2).

3.3. Pin Out

The A1101L09A and A1101L09C radio modules share a common pin-out.



NC = NO Connection. Pin is NOT connected internally.

DNC = Do Not Connect. Internal connection used during assembly, do not connect.

Pin #	Pin Name	Pin Type	Description
1	GND	Ground	One of ten primary ground pins
2	NC	NC	Pin is not connected internally, but is reserved for future expansion. It is recommended not to connect this pin to anything.
3	NC	NC	Pin is not connected internally, but is reserved for future expansion. It is recommended not to connect this pin to anything.
4	NC	NC	Pin is not connected internally, but is reserved for future expansion. It is recommended not to connect this pin to anything.
5	GND	Ground	One of ten primary ground pins
6	NC	NC	Pin is not connected internally, but is reserved for future expansion. It is recommended not to connect this pin to anything.
7	GND	Ground	One of ten primary ground pins
8	Vdcoup1	Analog	Optional decoupling of the modules internal Vdd supply. It is recommended to not connect anything to this pin. In particular noisy environment this pin can be used to further reduce the noise on the modules internal Vdd, please see section 3.5 for further information.
9	GND	Ground	One of ten primary ground pins
10	SCLK	Digital	SPI bus clock signal

		Input	
11	MISO/GDO1	Digital Output	SPI bus data out from radio when CSN is low, and general purpose I/O pin when CSN is high
12	MOSI	Digital Input	SPI bus data into radio
13	_CSN	Digital Input	SPI bus select (active low)
14	GDO0	Digital I/O (Analog output)	General purpose port
15	GDO2	Digital I/O	General purpose port
16	Vdcoup2	Analog	Optional decoupling of the modules internal Vdd supply. It is recommended to not connect anything to this pin. In particular noisy environment this pin can be used to further reduce the noise on the modules internal Vdd, please see section 3.5 for further information.
17	GND	Ground	One of ten primary ground pins
18	GND	Ground	One of ten primary ground pins
19	GND	Ground	One of ten primary ground pins
20	NC	NC	Pin is not connected internally, but is reserved for future expansion. It is recommended not to connect this pin to anything.
21	Vdd	Power Supply	Power supply pin
22	DNC	NC	Internal GND connection used during testing, not recommended to connect to main GND.
23	GND	Ground	One of ten primary ground pins
24	Vctrl2	Power Supply	Power Supply pin for the receive Mode.
25	Vctrl1	Power Supply	Power Supply pin for the transmit Mode.
26	GND	Ground	One of ten primary ground pins
27	DNC	NC	Internal RF output connection used during test. Connecting this pin to anything will require recertification for intentional radiators.
28	GND	Ground	One of ten primary ground pins

Table 6 Pin Descriptions

3.4. Recommended Layout

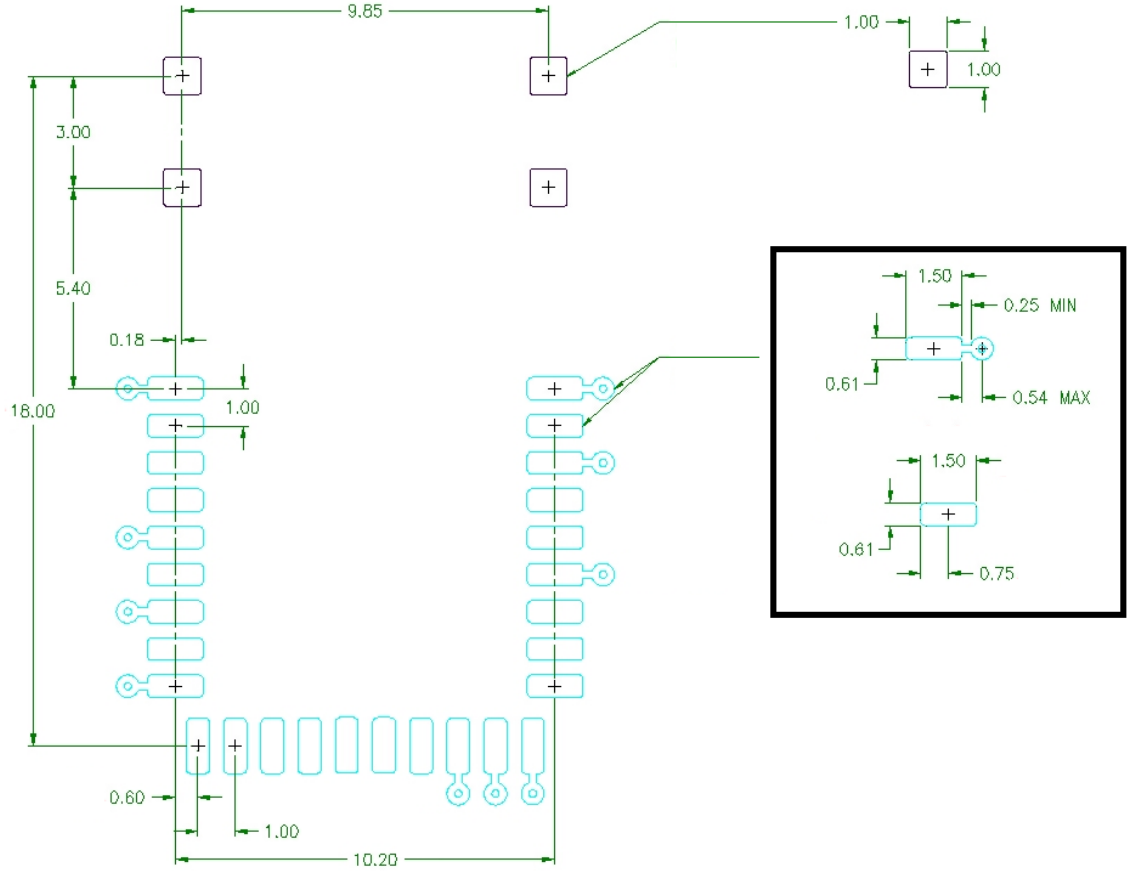


Figure 5a. Recommended PCB Layout for A1101L09A

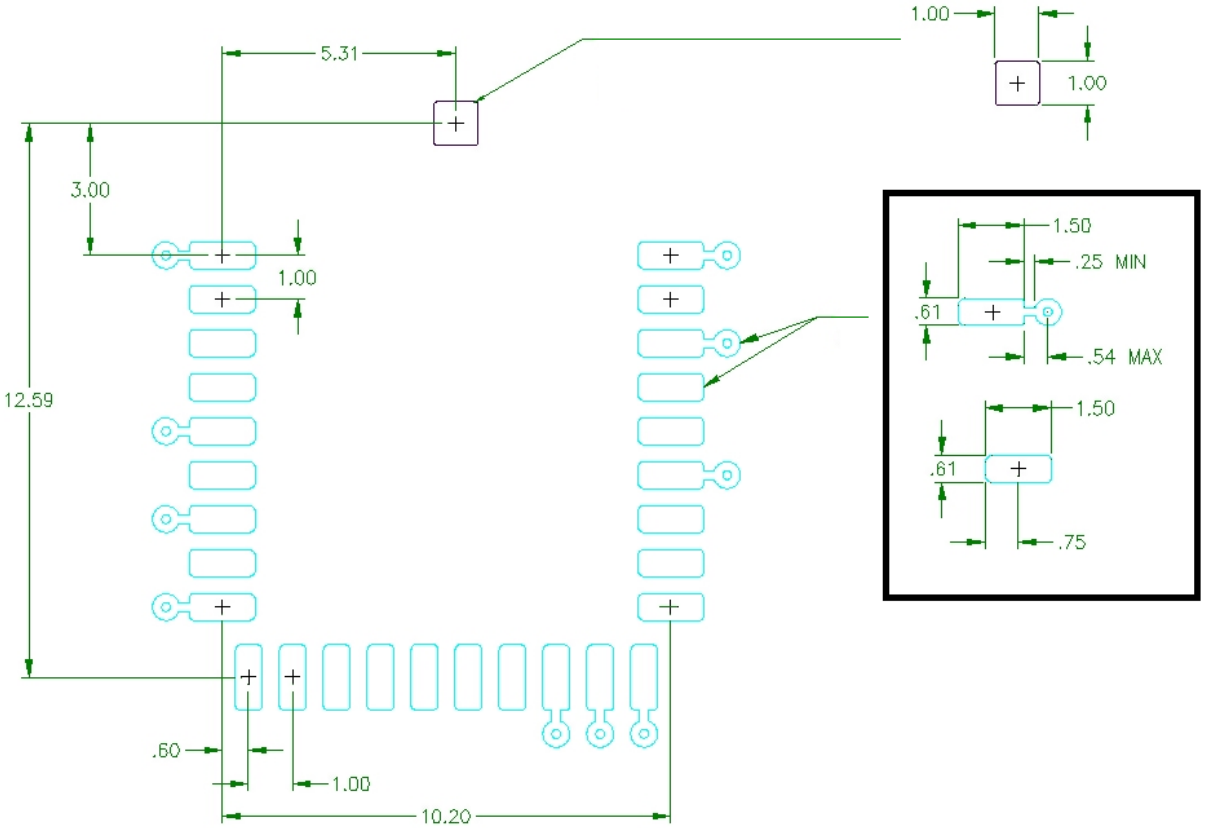


Figure 5b. Recommended PCB layout for A1101L09C

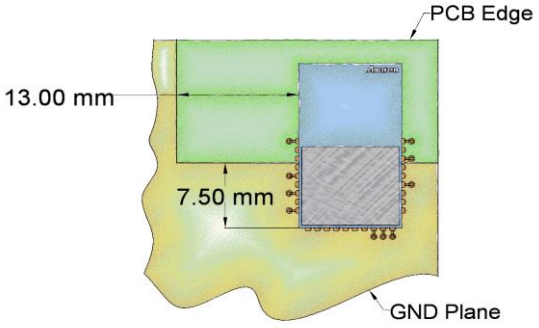


Figure 6 Mounting the A1101L09A module in a corner

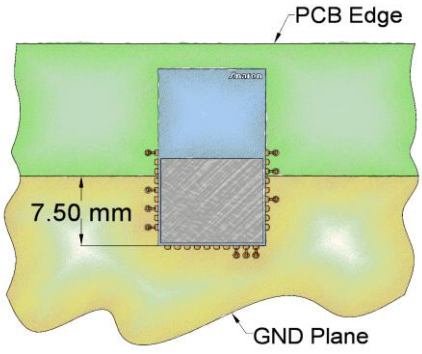


Figure 7 Mounting the A1101L09A module along an edge

3.5. Power Supply Considerations

Noise on the power supply line reduces the sensitivity of a receiver and modulates onto a transmitter's signal, both of which causes a degradation of link quality and hence a reduction in range.

The A1101L09A and A1101L09C radio modules each have an integral ferrite bead in the supply line from pin 21 (Vdd) and decoupling capacitance to reduce any noise on the incoming power supply line. Similarly pin 24 (Vctrl2) and pin 25 (Vctrl1) have decoupling capacitance to reduce the noise through the incoming power supply. This arrangement will eliminate most supply voltage noise. In particularly noisy environments (switching regulators, motor controls, etc.), it may be necessary to add additional noise reduction means.

Pin 8 (Vdcoup1) is connected to the modules internal supply line after the decoupling capacitors and can be used to probe the noise at module level. The noise level measured on pin 8 should not exceed 120mVpp when in transmit or receive mode; it may however exceed this value when setting up or accessing data to/from the FIFOs, while not actively transmitting or receiving.

If the level measured is exceeding the above limit, steps should be taken to ensure maximum range, including:

- Adding decoupling capacitance to pin 8 (Vdcoup1).
- Adding additional filtering in the supply line.
- Adding an LDO in the supply line (the TPS731xx low Dropout Regulator from TI is recommended).

3.6. LNA Stability Time

The A1101L09A and A1101L09C radio modules are equipped with LNA which takes time to stabilize itself from the time it has been triggered to turn ON and also it takes time to turn OFF.

The LNA used in A1101L09A and A1101L09C radio modules takes approximately 21 µs to stabilize before it starts receiving signals and amplifying it. And similarly it takes approximately 3.5 µs to turn off completely when there is no power supply to the LNA before the radio module turns to Sleep or transmit mode.

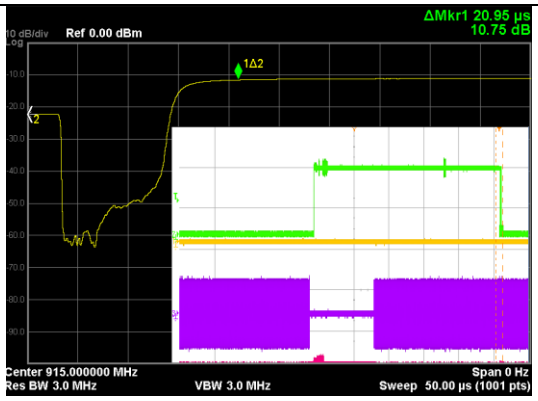


Figure 8 LNA delay to stabilize itself from the time it has been triggered ON.

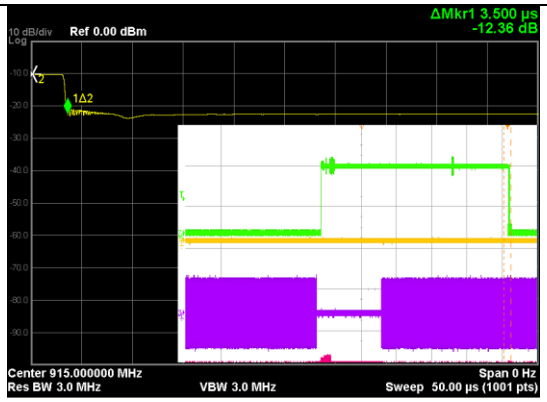


Figure 9 Delay caused by LNA to turn off

3.7. LNA Operation

The A1101L09A and A1101L09C radio modules are equipped with LNA which needs a control mechanism to both power the LNA and the receive side of the Tx/Rx switch (V+). It also requires an inverted voltage to control the Radio module actively in receive mode. The required states are specified below:

Radio Mode	V+	V-	Notes
Sleep	0V or Z	0V or Z	Tristate is potentially the better option as there is no potential residual voltage
Rx	1.8V to 3.6V	0V	
Tx	0V	1.8V to 3.6V	
Any Other State	0V or Z	Any	The current draw on V- is very minimal and thus it is not very critical in non-sleep radio modes

Table 7: LNA Operation

There are different potential methods of operation and they have been listed below.

3.7.1. Microcontroller, Two Pins

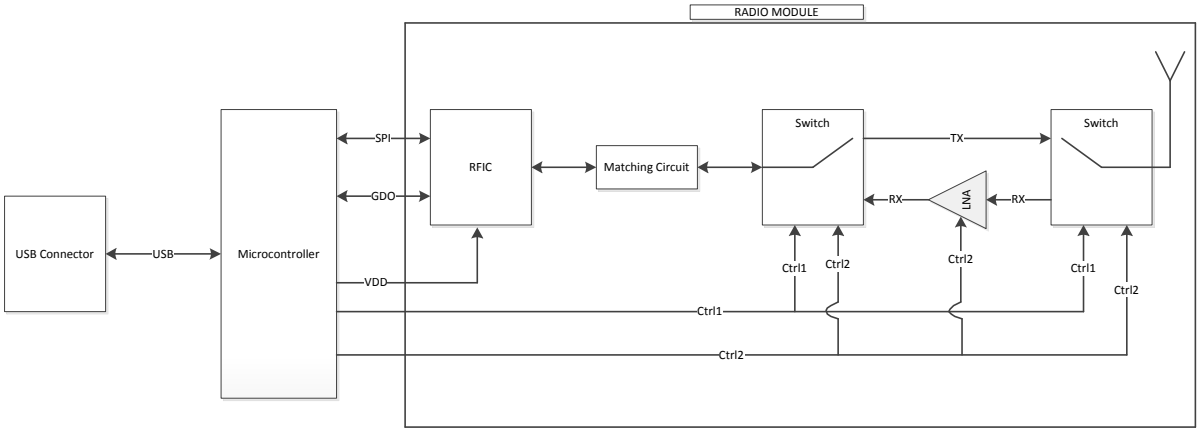


Figure 10

Ctrl1	Ctrl2	Mode
High	Low	Transmit Mode
Low	High	Receive Mode
Low	Low	Sleep Mode
High	High	Invalid State

Table 8: Microcontroller, Two pins

The V+ and V- signals are controlled directly by the microcontroller which also controls the chip in the Radio Module. When the chip of the Radio Module is in Sleep Mode, both the V+ and V- signals should be either tri-stated or made low, so there is a minimum current consumption by the module during the sleep mode. This is a low cost implementation, provided that the microprocessor has spare pins that can be assigned separately to this. This solution requires more complex coding.

3.7.2. Microcontroller, One Pin

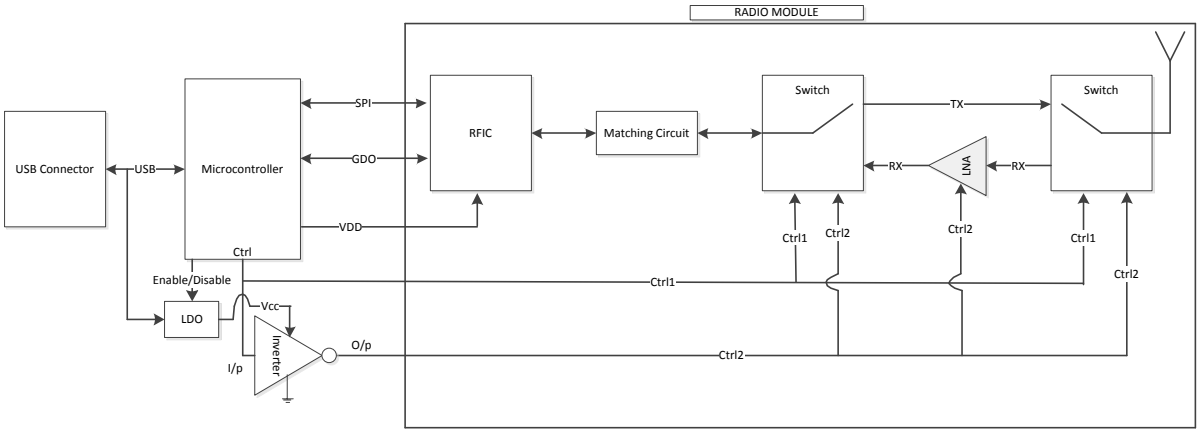


Figure 11

LDO	Ctrl	Mode
Enable	High	Transmit Mode
Enable	Low	Receive Mode
Disable	Low	Sleep Mode

Table 9: Microcontroller, One pin

The V+ and V- are controlled through one signal from the microcontroller and an inverter to control the other. This set up works well with the Rx and Tx mode, but in the Sleep Mode both V+ and V- control lines has to be low and hence the inverter is controlled by a Low-dropout regulator (LDO), which indeed has to be controller through a microcontroller. Alternatively the inverter could be tri-stated, but it would still draw current although it is not very much. Additionally a weak pull-down resistor would also be required on the input to the inverter in case the input was floated during sleep mode, to avoid oscillation.

3.7.3. Two GDO pins

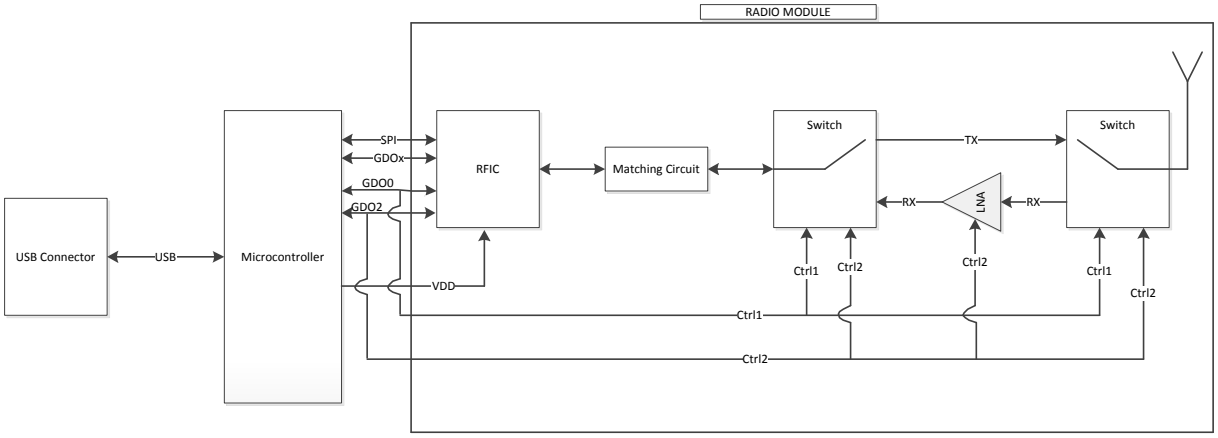


Figure 12

Ctrl1	Ctrl2	Mode
High	Low	Transmit Mode
Low	High	Receive Mode
Low	Low	Sleep Mode
High	High	Invalid State

Table 10: Two GDO pins

The V+ and V- signals are controlled directly by the Radio Module GDO pins 0 and 2. However one of these pins should be typically used to generate interrupts to the microcontroller. The pin assignments of GDO pins are:

GDO	Description
27 (0x1B)	PA_PD. Note: PA_PD wil have the same signal level in SLEEP and TX states. To control an external PA or RX/TX switch in applications where the SLEEP state is used it is recommended to use GDOx CFGx=0x2F instead.
28 (0x1C)	LNA_PD. Note: LNA_PD will have the same signal level in SLEEP and RX states. To control an external LNA or RX/TX switch in applications where the SLEEP state is used it is recommended to use GDOx CFGx=0x2F instead.

Table 11: GDO pin assignment

However, it is clearly stated that this setting is not recommended during the sleep mode (CC1101 Data sheet http://www.ti.com/lit/ds/symlink/cc1101.pdf, Section 26, General Purpose/Test Output Control pins). The GDO pin has to be set to 2F (Inverse 6F) by the microcontroller. During the sleep mode the pins are set to 0 or high-z which leads to the scenario that the GDO pins cannot be used for signal interrupts. The code becomes more complex as these control pins are set through the SPI bus.

3.7.4. One GDO pin

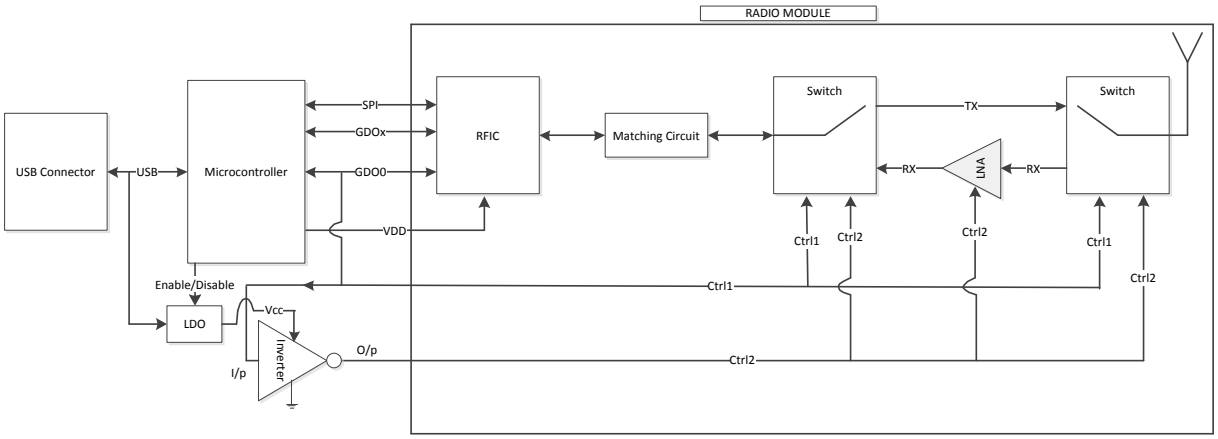


Figure 13

LDO	Ctrl	Mode
Enable	High	Transmit Mode
Enable	Low	Receive Mode
Disable	Low	Sleep Mode

Table 12: One GDO pin

The V+ and V- are controlled through one signal from the Radio Module GDO pin and an inverter to control the other. This has the advantage of separating the interrupt signal pin separately from the V+ and V- control signals, but on the other hand it requires a Low-dropout regulator (LDO) to control the inverter during the sleep mode. To avoid the LDO, the inverter

can be tri-stated which still draw current. A week pull-down resistor would be required to the input of the inverter to avoid oscillation. Either way, there is an additional component to it.

3.8. External Interference

When an external signal with higher power level is interfered with the A1101L09A or A1101L09C radio module during its operation, it shuts down completely at that particular in-band interference frequency and the sensitivity is affected in the adjacent channels.

The LNA is operated through one GDO pin method which has an inverter to control the other control line.

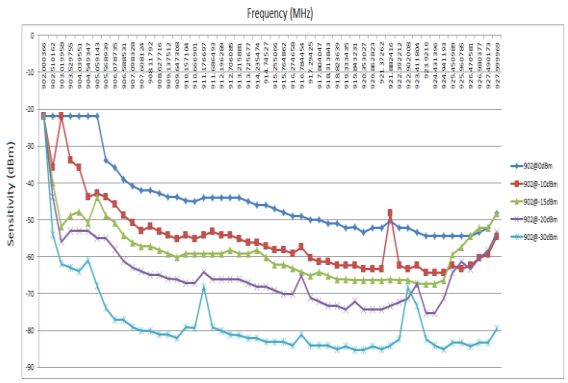


Figure 14 External interference at in-band frequency of 902 MHz

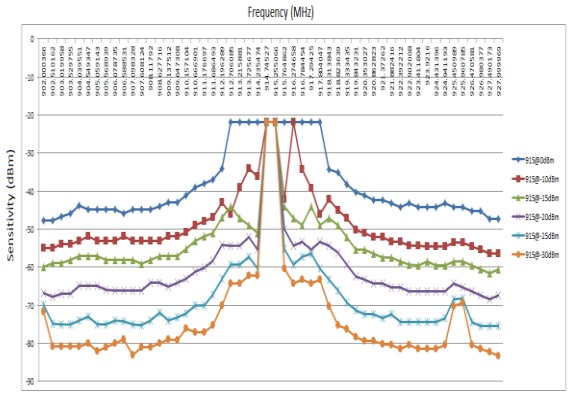


Figure 15External interference at in-band frequency of 915 MHz

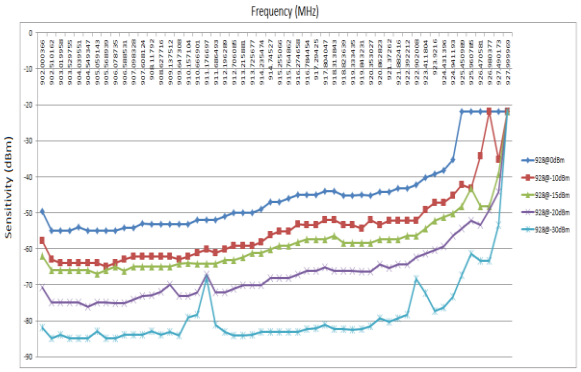


Figure 16 External interference at in-band frequency of 928 MHz

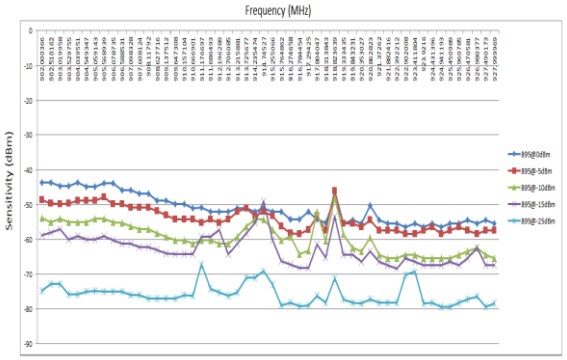


Figure 17 External interference at out-of-band frequency of 895 MHz

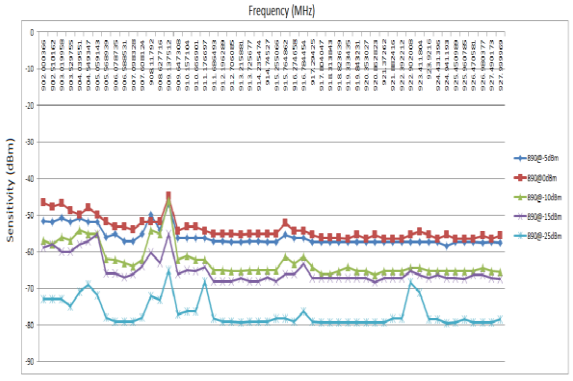


Figure 18 External interference at out-of-band frequency of 890 MHz

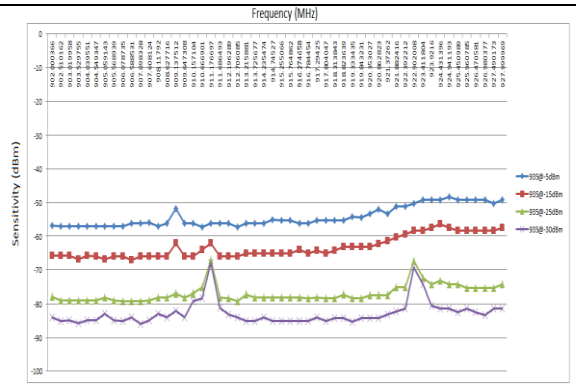


Figure 19 External interference at out-of-band frequency of 935 MHz

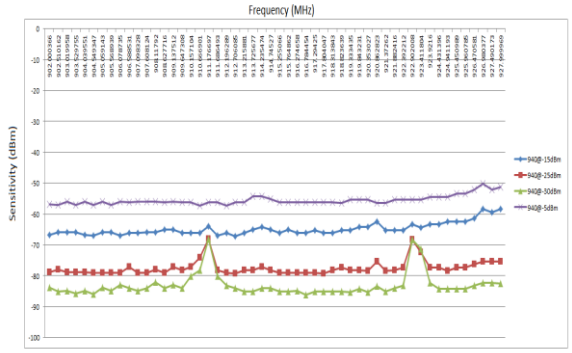


Figure 02 External interference at out-of-band frequency of 940 MHz

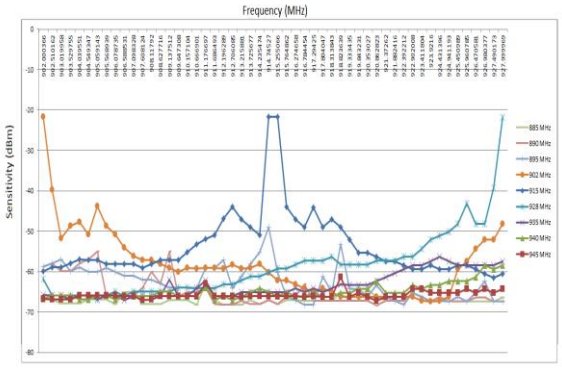


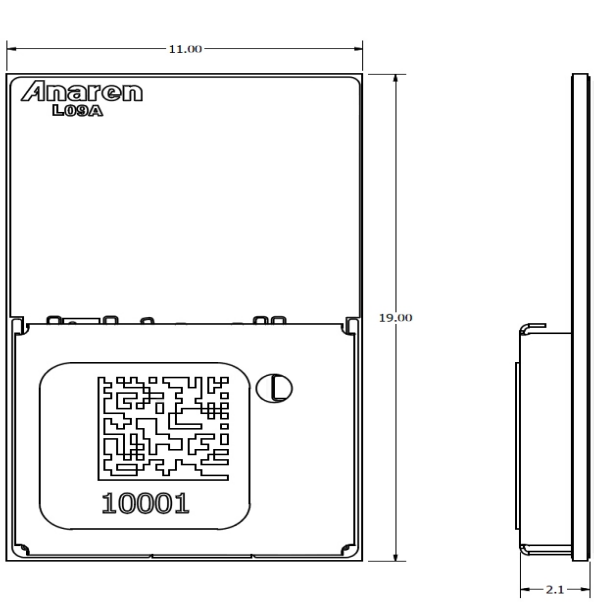
Figure 21 Comparison of different interference frequency at a power level of -15 dBm

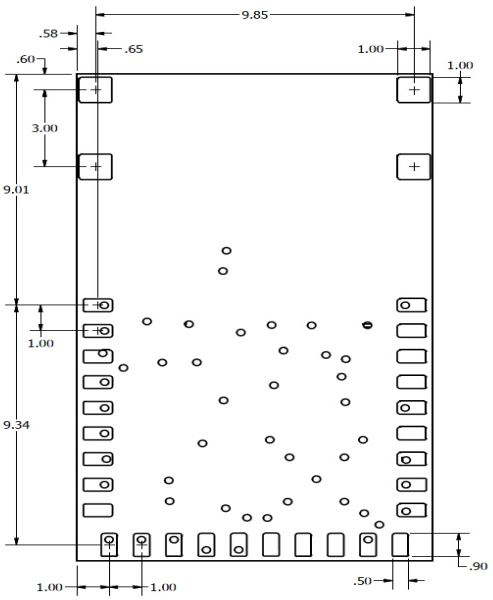
Note: The sensitivity reading doesn't correspond to the right sensitivity reading as the interference signals are connected externally with the A1101L09x radio modules.

4. Mechanical and Process

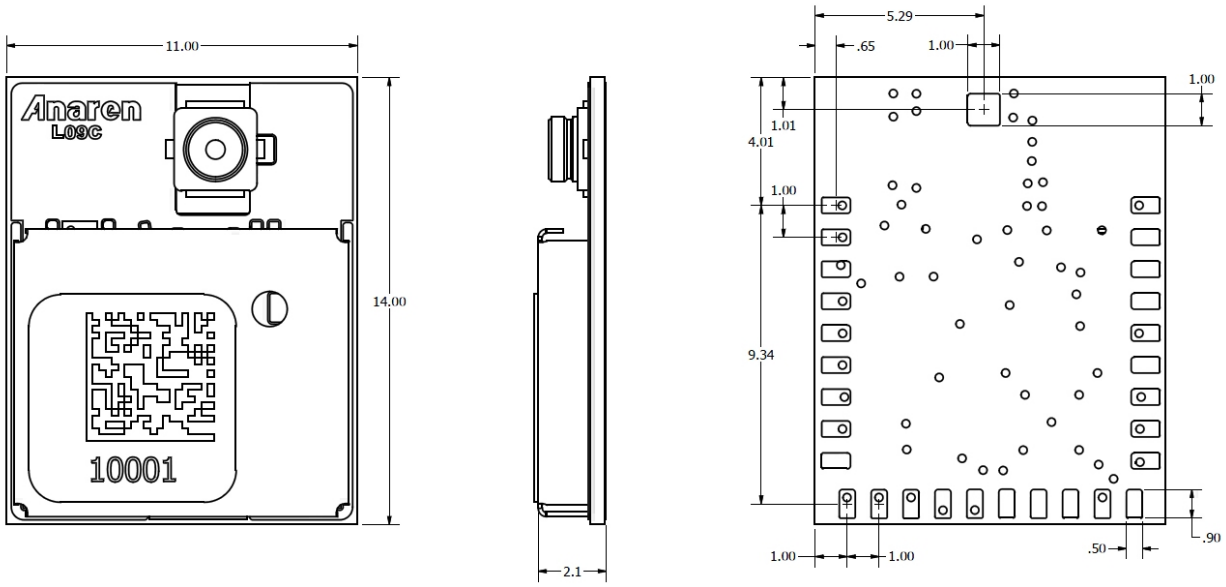
4.1. Dimensions

4.1.1. A1101L09A





4.1.2. A1101L09C

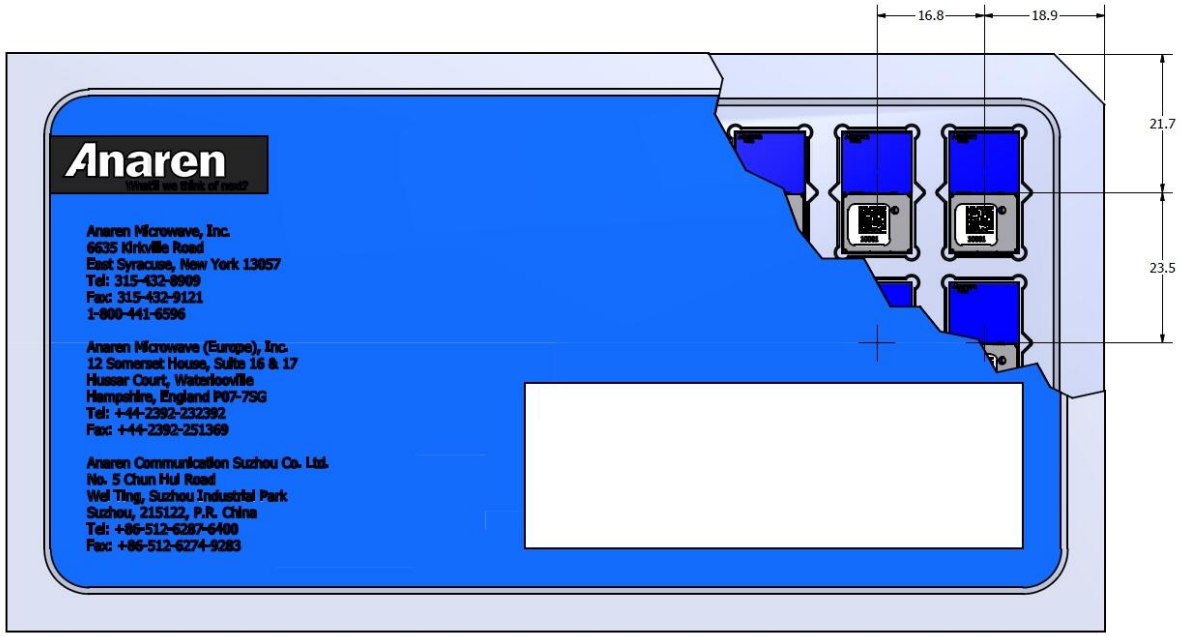


4.2. Packaging

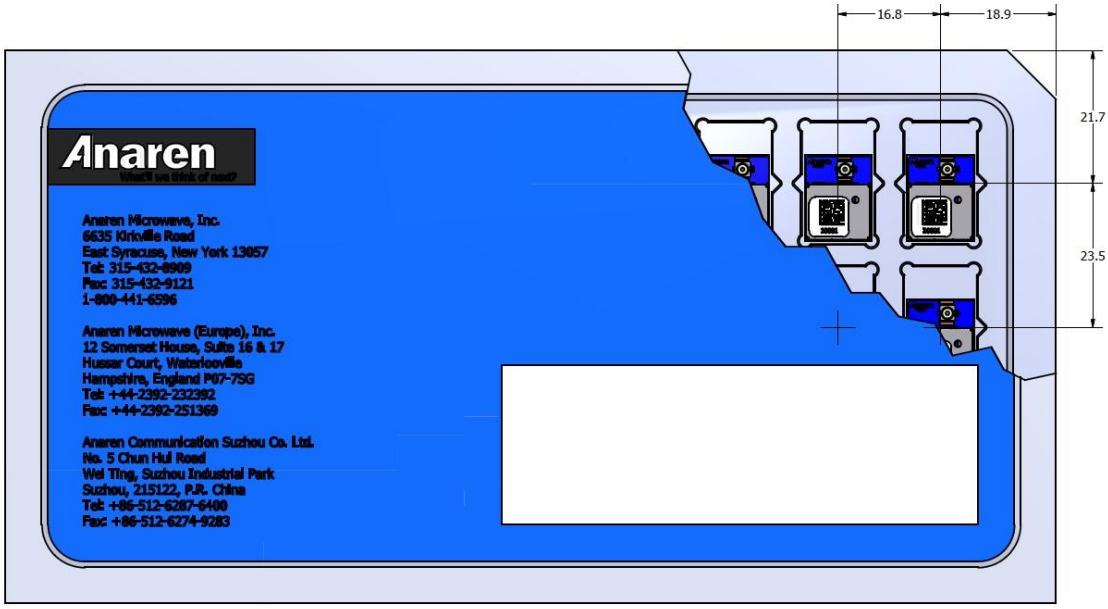
AIR modules are available in Matrix Tray and Tape & Reel packaging for high-volume assembly. Details of packaging provided below:

4.2.1. Matrix Tray Packaging

A1101L09A00GM Matrix Tray Packaging Detail (27/Tray)

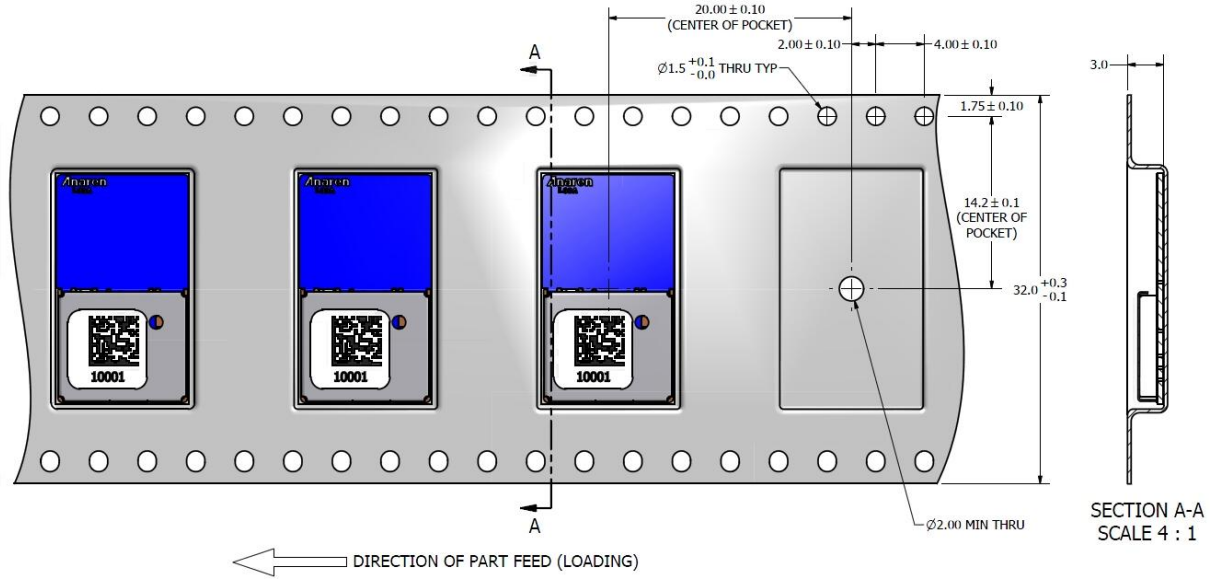


A1101L09C00GM Matrix Tray Packaging Detail (27/Tray)

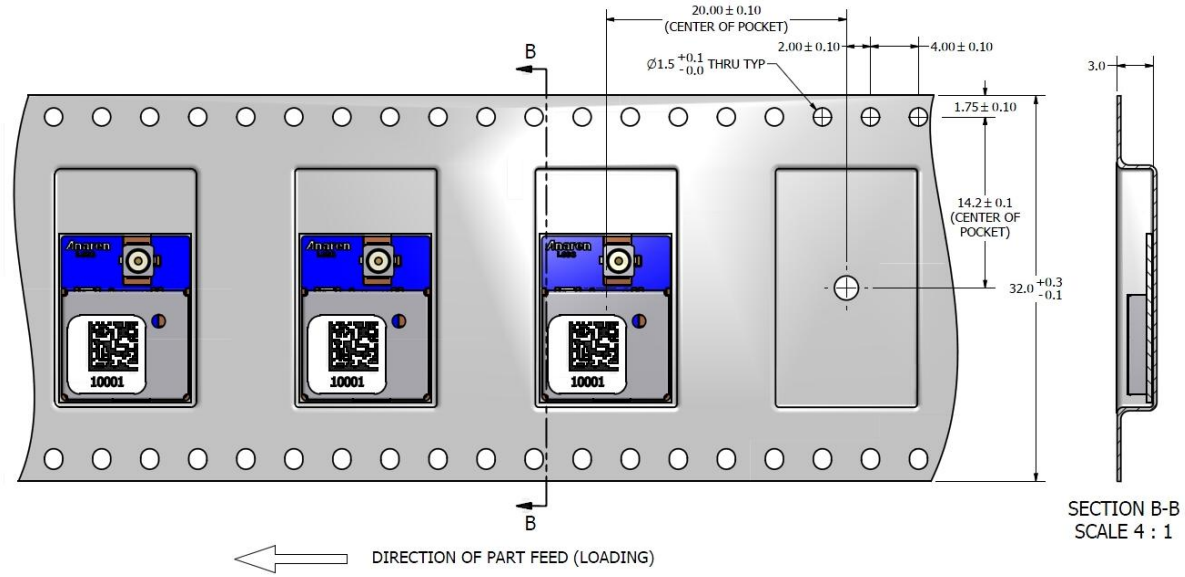


4.2.2. Tape-Reel Packaging

A1101L09A00GR Tape-Reel Packaging Detail (500/Reel)



A1101L09C00GR Tape-Reel Packaging Detail (500/Reel)



4.3. Soldering

AIR Modules may be mounted either manually (for prototyping or low volume production), or automatically for high-volume production.

A no-clean tin/silver/copper (SAC) solder is recommended, however lead based no-clean pastes may also be used.

> **CAUTION:** AIR Modules are designed for no-clean fluxes only. DO NOT use water-based fluxes that require aqueous cleaning after solder. Spot cleaning with a flux remover and toothbrush may be performed with care.

4.3.1. Manual Mounting Procedure

The recommended soldering method is reflow of a paste solder on a hot plate. This method works provided the bottom of the board where the AIR module is to be mounted is accessible, and there are no bottom-side components in the way.

An aluminum or copper block may be placed on the hot plate surface to transfer heat to a localized area on the board where the AIR module is mounted

- Set the hot plate to the reflow temperature solder manufacturer's recommended
- Apply solder paste to the pads on the board receiving the AIR module
- Place the AIR module carefully onto the dispensed solder
- Using tweezers or another holding device, carefully place board with AIR module onto the hot plate surface (or metal block)
- Apply heat until reflow occurs, per solder paste manufacturer's recommendations
- Carefully remove the board and place on a heat-resistant surface to cool
- Check assembly electrically to confirm there are no opens or shorts

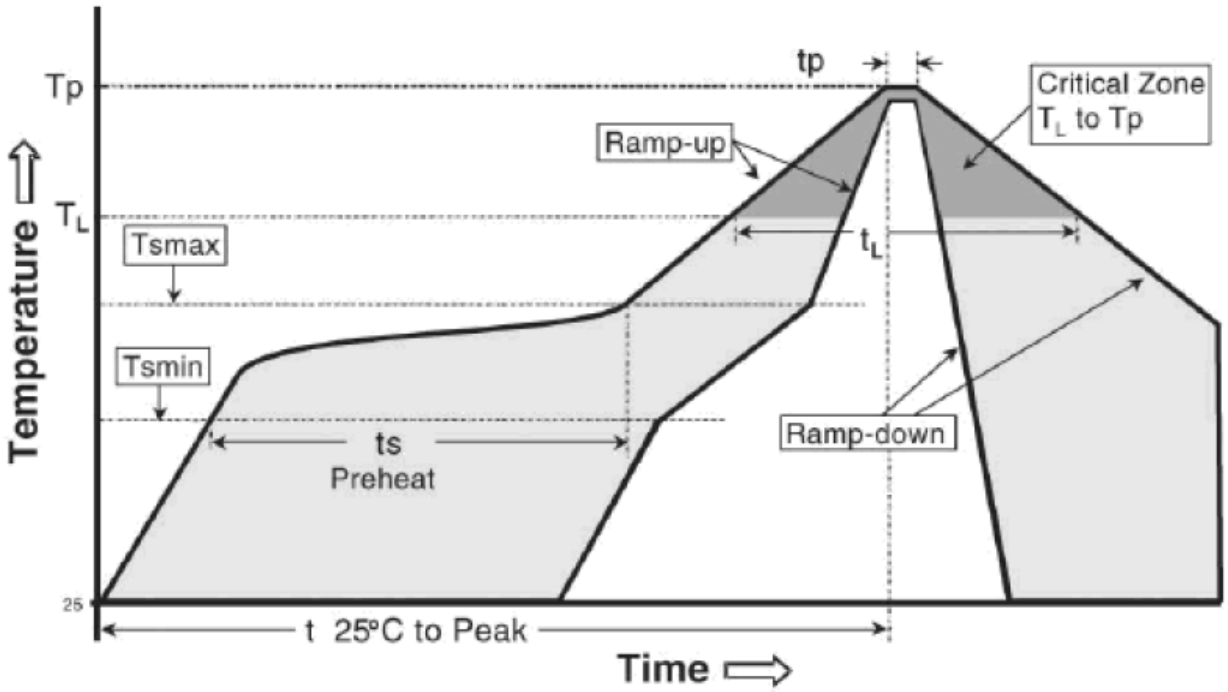
4.3.2. Automated Mounting Procedure

The AIR Radio Module recommended solder reflow profile is based on IPC/JEDEC J-STD-020.

Table 5-2 Classification Reflow Profiles

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Average ramp-up rate (Tsmax to Tp)	3° C/second max.	3° C/second max.
Preheat - Temperature Min (Ts_{min}) - Temperature Max (Ts_{max}) - Time (Ts_{min} to Ts_{max}) (ts)	 100 °C 150 °C 60-120 seconds	 150 °C 200 °C 60-180 seconds
Time maintained above: - Temperature (T_L) - Time (t_L)	 183 °C 60-150 seconds	 217 °C 60-150 seconds
Peak Temperature (Tp)	See Table 4.1	See Table 4.2
Time within 5°C of actual Peak Temperature (tp)[2]	10-30 seconds	20-40 seconds
Ramp-down Rate	6 °C/second max.	6 °C/second max.
Time 25°C to Peak Temperature	6 minutes max.	8 minutes max.

Note 1: All temperatures refer to topside of the package, measured on the package body surface.
Note 2: Time within 5 °C of actual peak temperature (tp) specified for the reflow profiles is a "supplier" minimum and "user" maximum.



Classification Reflow Profile

SnPb Eutectic Process - Package Peak Reflow Temperatures

Package Thickness	Volume mm^3 <350	Volume mm^3 ≥ 350
<2.5 mm	240 +0/-5 °C	225 +0/-5°C
≥ 2.5 mm	225 +0/-5°C	225 +0/-5°C

Pb-free Process - Package Peak Reflow Temperatures

Package Thickness	Volume mm^3 < 350	Volume mm^3 350 - 2000	Volume mm^3 > 2000
< 1.6 mm	260 °C *	260 °C *	260 °C *
1.6 mm - 2.5 mm	260 °C *	250 °C *	245 °C *
> 2.5 mm	250 °C *	245 °C *	245 °C *
* Tolerance: The device manufacturer/supplier shall assure process compatibility up to and including the stated classification temperature at the rated MSL level			

HISTORY

Date	Author	Change Note No./Notes
10/12/2011	Vivekanandh Elangovan	Initial Draft for Rev 3 Module
10/17/2011	Vivekanandh Elangovan	Recommended PCB Layout has been changed
10/20/2011	Vivekanandh Elangovan	Recommended Ground pattern has been updated
10/21/2011	Vivekanandh Elangovan	RF Exposure for IC has been updated
11/01/2011	Richardson	Removed FCC logo

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Thank you for learning more about the
Anaren Integrated Radio (AIR) module line.
If you have additional questions,
need samples, or would like a quote –
please do not hesitate to email the AIR team
at AIR@anaren.com or contact any of these
authorized distributors of the AIR product line.

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