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A1101R08x User's Manual

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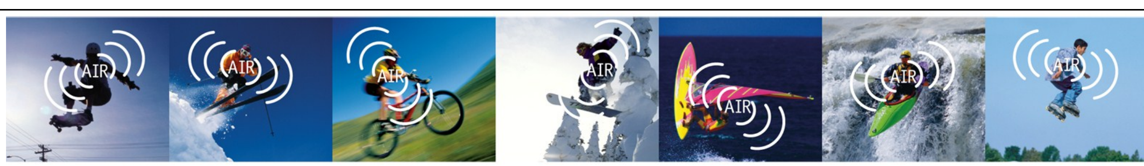

Anaren Integrated Radio

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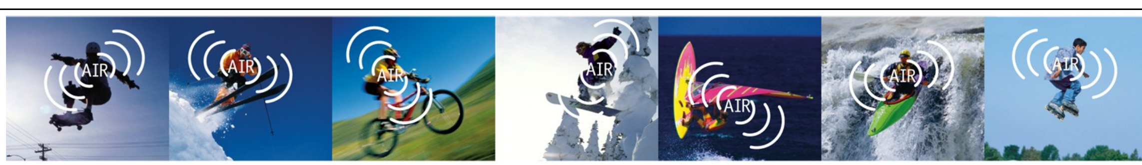
USER'S MANUAL

Models A1101R08A and A1101R08C

Contents



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1. Overview

The A1101R08A and A1101R08C are surface mount modules – each with an integrated crystal, internal voltage regulator, matching circuitry and filtering. The A1101R08A has an integral antenna, whereas the A1101R08C utilizes an external antenna through a U.FL connector (see Table 1). The modules operate in the European 868 – 870MHz ISM band, are ideal for achieving low power wireless connectivity without having to deal with extensive RF, antenna design and regulatory compliance, and provide quick time to market. The modules are 100% tested to provide consistent performance.

The A1101R08A and A1101R08C have received regulatory approvals for modular devices in Europe. The modular approval allows the OEM or end user to place either an A1101R08A or an A1101R08C with an approved antenna inside a finished product without having to perform costly regulatory testing for an intentional radiator. Section 2.3 has information on the requirements the end user/integrator must fulfill to use the modules without intentional radiator regulatory testing. The receiver section of the modules has been evaluated and approved as Category II receiver.

The A1101R08A and A1101R08C 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 2.3 for the recommended register settings to achieve optimal performance and regulatory compliance.

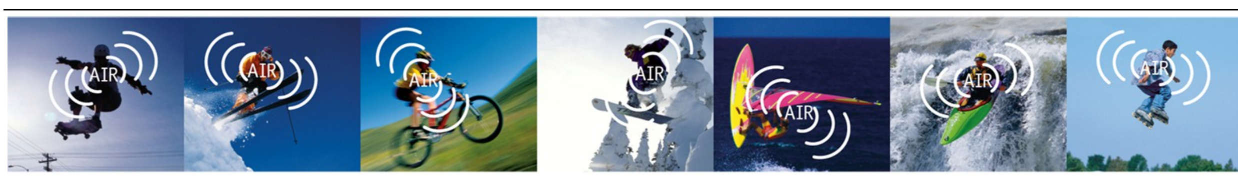
The A1101R08A measure 9x16x2.5mm and A1101R08C measures 9x12x2.5mm. The modules are footprint compatible with each other.

1.1. A1101R08A

The A1101R08A 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. A1101R08C

The A1101R08C 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 7 – Figure 8 for more information on antenna location and enclosure considerations.



1.3. Features

Features:

- Frequency range: 868-870 MHz
- Ultra small package size
  - A1101R08C : 9mm x 12mm x 2.5mm
  - A1101R08A : 9mm x 16mm x 2.5mm
- Impedance controlled multi-layer PCB
- 27 MHz Crystal Frequency
- Shielded Package
- 1.8 to 3.6 V operation
- SPI Interface
- ROHS Compliant
- LGA Footprint
- Low Power Consumption
- Regulatory compliance for ETSI
- Digital RSSI output
- Programmable channel filter bandwidth
- Programmable output power up to +12 dBm
- High sensitivity (–112 dBm at 1.2 kBaud, 1% packet error rate)
- Low current consumption (14.7 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
- Data Rate: 0.6 – 600 Kbit/Sec
- 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 ETSI EN 300 220.
- No regulatory "Intentional radiator" testing is required to integrate the module into end product. Simple certification labeling replaces testing.

1.4. Theory of Operation

The A1101R08A and A1101R08C are for low power wireless applications in the European 868 – 870MHz 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 A1101R08A and A1101R08C 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 is required, the device can enter either an Idle mode, from which it can quickly re-enter a 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 A1101R08A and A1101R08C 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 every 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 A1101R08A module has an integral antenna that is near omni-directional, whereas the A1101R08C has approved antenna options ranging from near omni-directional to shaped front/back patterns (useful for inline, professional installations). Note that the end radiation pattern depends not only on the antenna, but also on the ground plane, enclosure and installation environment.
- Filtering
  - Filtering removes spurious signals to comply with regulatory intentional radiator requirements.
- 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).

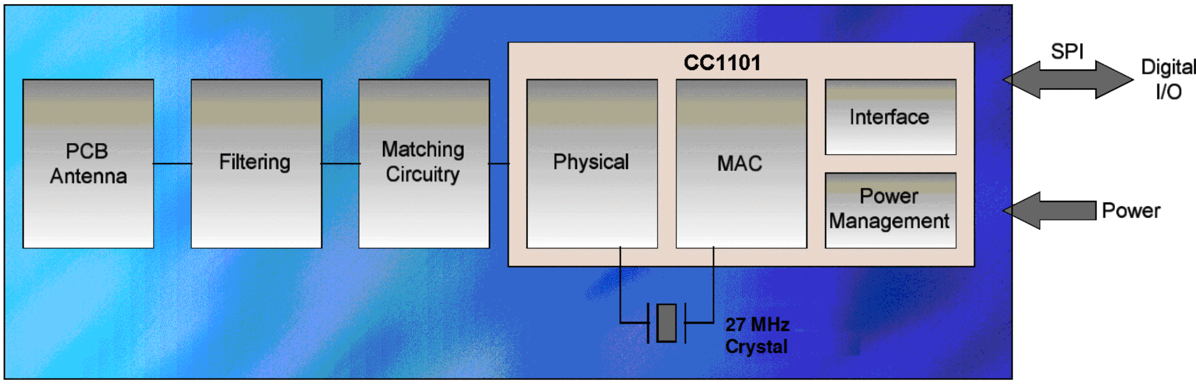


Figure 1 The functionality of the A1101R08A, using an integral antenna

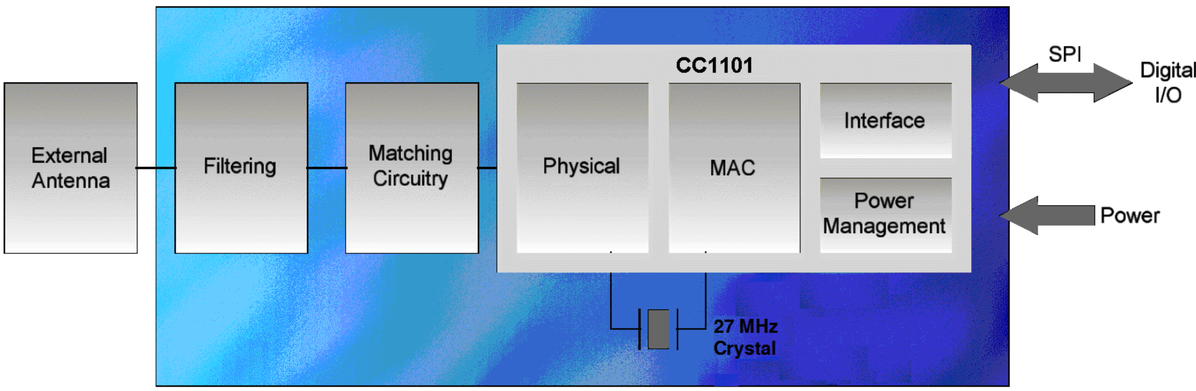


Figure 2 The functionality of the A1101R08C, using an external antenna.

Table 1 Approved Antennae

Item	Part Number	Manufacturer	Type	Gain (dBi)
1	Integral part of A1101R08A	Anaren	Integral Antenna	2
2	66089-0806	Anaren	Monopole whip, 86mm lead	3

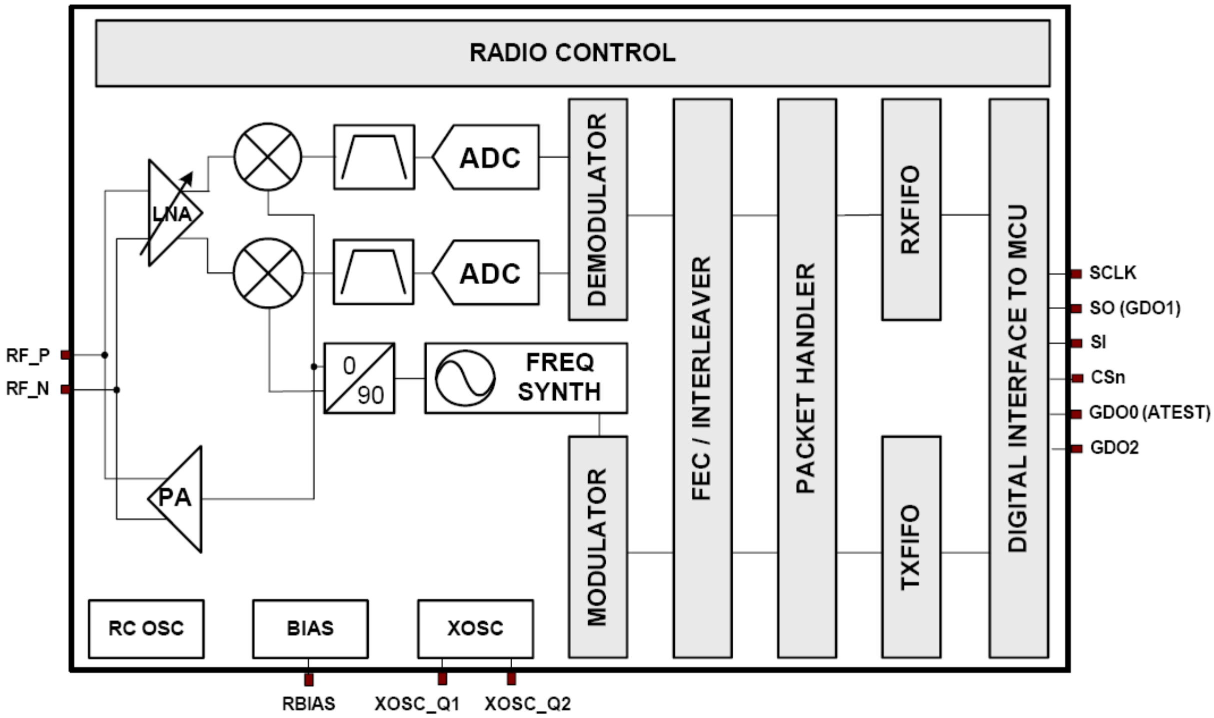


Figure 3 Transceiver IC block diagram

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 awaken 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. Configuration

Table 2 lists the radio module configuration parameters, and the level of configurability by the user.

Legend:

Certification is valid for any value choosen
Use the provided certified settings as other may degrade performance
Any modification of this value is a violation of the certification and the customer is responsible for optaining their own certification
Unused/undocumented function. The provided default value must be written. No assumption should be made on the value read from this field
Read only register (burst mode read only, command strobes otherwise).

Table 2 Configuration Parameters

Register Name	Register Address (Hex)	Retained during sleep	Bit Fields Within Register: 7	6	5	4	3	2	1	0
IOCFG2	00	1	0	GDO2_INV	GDO2_CFG					
IOCFG1	01	1	GDO_DS	GDO1_INV	GDO1_CFG					
IOCFG0	02	1	GDO0_TEMP_SENSOR_ENABLE	GDO0_INV	GDO0_CFG					
FIFOTHR	03	1	Reserved	ADC_RETENTION	CLOSE_IN_RX		FIFO_THR			
SYNC1	04	1	SYNC_MSB							
SYNC0	05	1	SYNC_LSB							
PKTLEN	06	1	PACKET_LENGTH							
PKTCTRL1	07	1	PQT			0	CRC_AUTOFLUSH	APPEND_STATUS	ADR_CHK	
PKTCTRL0	08	1	0	WHITE_DATA	PKT_FORMAT		0	CRC_EN	LENGTH_CONFIG	
ADDR	09	1	DEVICE_ADDR							
CHANNR	0A	1	CHAN							
FSCTRL1	0B	1	0		0	FREQ_IF				
FSCTRL0	0C	1	FREQOFF							
FREQ2	0D	1	FREQ[23:22]=0		FREQ[21:16]					
FREQ1	0E	1	FREQ[15:8]							
FREQ0	0F	1	FREQ[7:0]							
MDMCFG4	10	1	CHANBW_E		CHANBW_M		DRATE_E			
MDMCFG3	11	1	DRATE_M							
MDMCFG2	12	1	DEM_DCFILT_OFF	MOD_FORMAT			MANCHESTER_EN	SYNC_MODE		
MDMCFG1	13	1	FEC_EN	NUM_PREAMBLE			0		CHANSPC_E	
MDMCFG0	14	1	CHANSPC_M							
DEVIATN	15	1	0	DEVIATION_E			0	DEVIATION_M		
MCSM2	16	1	0			RX_TIME_RSSI	RX_TIME_QUAL	RX_TIME		
MCSM1	17	1	0		CCA_MODE		RXOFF_MODE		TXOFF_MODE	
MCSM0	18	1	0		FS_AUTOCAL		PO_TIMEOUT		PIN_CTRL_EN	XOSC_FORCE_ON
FOCCFG	19	1	0		FOC_BS_CS_GATE	FOC_PRE_K		FOC_POST_K	FOC_LIMIT	
BSCFG	1A	1	BS_PRE_K		BS_PRE_KP		BS_POST_K	BS_POST_KP	BS_LIMIT	
AGCCTRL2	1B	1	MAX_DVGA_GAIN		MAX_LNA_GAIN			MAGN_TARGET		
AGCCTRL1	1C	1	0	AGC_LNA_PRIORITY	CARRIER_SENSE_REL_THR		CARRIER_SENSE_ABS_THR			
AGCCTRL0	1D	1	HYST_LEVEL		WAIT_TIME		AGC_FREEZE		FILTER_LENGTH	
WOREVT1	1E	1	EVENT0[15:8]							
WOREVT0	1F	1	EVENT0[7:0]							
WORCTRL	20	1	RC_PD	EVENT1			RC_CAL	0	WOR_RES	
FREND1	21	1	LNA_CURRENT		LNA2MIX_CURRENT		LODIV_BUF_CURRENT		MIX_CURRENT	
FREND0	22	1	0		LODIV_BUF_CURRENT_TX		0	PA_POWER		
FSCAL3	23	1	FSCAL3[7:6]		CHP_CURR_CAL_EN		FSCAL3[3:0]			
FSCAL2	24	1	0		VCO_CORE_H_EN	FSCAL2				
FSCAL1	25	1	0		FSCAL1					
FSCAL0	26	1	0	FSCAL0						
RCCTRL1	27	1	0	RCCTRL1						
RCCTRL0	28	1	0	RCCTRL0						
FSTEST	29	0	FSTEST							
PTEST	2A	0	PTEST							
AGCTEST	2B	0	AGCTEST							
TEST2	2C	0	TEST2							
TEST1	2D	0	TEST1							
TEST0	2E	0	TEST0[7:2]						VCO_SEL_CAL_EN	TEST0[0]
	2F									
PARTNUM	30	1	PARTNUM							
VERSION	31	1	VERSION							
FREQOFF_EST	32	0	FREQOFF_EST							
LQI	33	0	CRC_OK	LQI_EST						
RSSI	34	0	RSSI							
MARC_STATE	35	0				MARC_STATE				
WORTIME1	36	0	TIME[15:8]							
WORTIME0	37	0	TIME[7:0]							
PKTSTATUS	38	0	CRC_OK	CS	PQT_REACHED	CCA	SFD	GDO2		GDO0
VCO_VC_DAC	39	0	VCO_VC_DAC							
TXBYTES	3A	0	TXFIFO_UNDERFLOW	NUM_TXBYTES						
RXBYTES	3B	0	RXFIFO_OVERFLOW	NUM_RXBYTES						
RCCTRL1_STATUS	3C	0		RCCTRL1_STATUS						
RCCTRL0_STATUS	3D	0		RCCTRL0_STATUS						
PATABLE	3E	1	PATABLE							
FIFO	3F	0	TXFIFO/RXFIFO							

1.6. Applications

Ultra low-power wireless applications, operating in the 868-870 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. Approvals and Usage

The A1101R08A and A1101R08C 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. Product Approvals

2.1.1. Europe (Conformité Européenne, CE)

The A1101R08A and A1101R08C modules have been certified for use in European countries. The following testing has been completed:

Test standard ETSI EN 300 220-2 V2.3.1 (2010-02)

- Frequency Error (Normal and Extreme Conditions)
- Conducted Average Power (Normal and Extreme Conditions)
- Effective Radiated Power
- Spread Spectrum Spectral Power Density
- Transient Power
- Modulation Bandwidth
- TX/RX Spurious Emissions
- Receiver Sensitivity
- Receiver LBT Threshold
- Receiver Blocking

Test standards ETSI EN 301 489-3 V1.4.1 (2002-08), ETSI EN 62311:2008 and ETSI EN 60950-1:2006

- Radiated Emissions
- Electro-Static Discharge
- Radiated RF Susceptibility

A helpful document that can be used as a starting point in understanding the use of short range devices (SRD) in Europe is the European Radio Communications Committee (ERC) Recommendation 70-03 E, downloadable from the European Radio Communications Office (ERO) http://www.ero.dk.
The end user is responsible for ensuring compliance with harmonized frequencies and labeling requirements for each country the end device is marketed and sold.
For more information see:

- Radio And Telecommunications Terminal Equipment (R&TTE) http://ec.europa.eu/enterprise/rtte/index_en.htm
- European Conference of Postal and Telecommunications Administrations (CEPT) http://www.cept.org/
- European Telecommunications Standards Institute (ETSI) http://www.etsi.org/
- European Radio Communications Office (ERO) http://www.ero.dk/

2.2. Potential Interference Sources

- Alarm systems
  - These typically use low duty cycles and are therefore easy to avoid using acknowledge/retransmit methods
- Sensor/Control networks
  - Any network having high duty cycles must employ Listen Before Talk (LBT) in the European 868-870 MHz band, thus interference with these again can be circumvented using retransmits, or if needed due to duty cycle, implementing LBT.

2.2.1. 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.

2.3. 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.

2.3.1. Europe

Table 3 shows the approved configurations for use in Europe. All configurations are optimized for the best sensitivity. In order to meet different customer needs, a variety of datarates from 600 Baud to 600 kBaud has been provided.

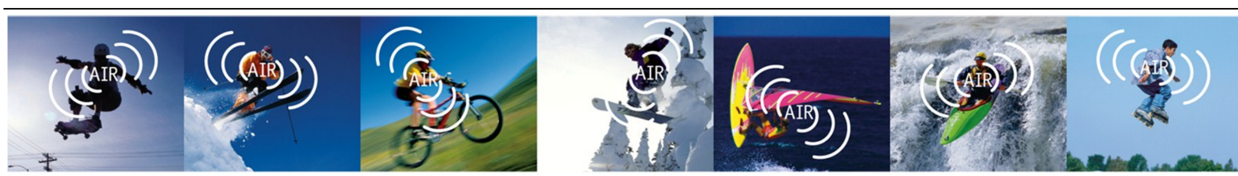


Table 3 Approved configurations

Code	Modulation Type	Datarate(kbps)	Dev / Ph. Tran.	Channel Spacing(kHz)	RX BW (kHz)
M1	MSK	500	5/8 Tb	100	844
M2	MSK	100	5/8 Tb	100	140
M3	MSK	38	5/8 Tb	50	60
M4	2-FSK	1.2	26.4 kHz	50	84
M5	2-FSK	10	36 kHz	50	121
M6	GFSK	10	13 kHz	50	60
M7	GFSK	38	18 kHz	50	70
M8	GFSK	100	46 kHz	50	211
M9	4-FSK	250	105 kHz	100	337
M10	4-FSK	500	211 kHz	100	675
M11	2-FSK	0.6	16.5 kHz	50	60
M12	GFSK	4.8	13.2 kHz	50	60
M13	GFSK	19.2	13 kHz	50	60
M14	4-FSK	600	237/263 kHz(Tx/Rx)	100	844
M15	MSK	600	5/8 Tb	100	844

Within the European 868-870 MHz ISM band, there are several sub-bands with different requirements. A summary of these bands is given in Table 6. Considering the modulation bandwidth of each modulation type, frequency drift of the module in the extreme working conditions, and the channel spacing for each configuration, usable channels for each modulation is obtained for the sub-bands. Table 7 lists the approved configurations and applicable channels for each sub-band.

Using a 27 MHz crystal inside, base frequencies and channel spacing values that are mentioned in *Table 7* has been obtained through following register settings:

Table 4 Base frequencies and corresponding CC1101 register settings

Frequency (MHz)	FREQ2 (Hex)	FREQ1 (Hex)	FREQ0 (Hex)
868.000	0x20	0x25	0xED
869.525	0x20	0x34	0x62

Table 5 Channel spacings and corresponding CC1101 register settings

Channel Spacing (kHz)	MDMCFG1.CHANSPC_E	MDMCFG0.CHANSPC_M
868.000	0x01	0xE5
869.525	0x00	0xE5

Table 6 ETSI 868-878 MHz sub-bands

Band #	Frequencies (MHz)	Apps	Max Allowed Power	Modulation Bandwidth	Channel Spacing	Modulation Types & Datarates (See below)	Restrictions	Notes
1	868 - 870	Non-specific use	25 mW	Up to 300 kHz. Analogue and/or digital voice limited to 26 kHz only	<= 100 kHz	M3, M4, M5, M6, M7, M8, M11, M12, M13	0.1% Duty cycle or LBT+AFA. When duty cycle or LBT implemented, it shall not be user dependent/adjustable. It has to be guaranteed by appropriate technical means	M1, M2, M9 and M10 should not be used for Audio and Video apps
2	868 - 870	DSSS and other wideband modulation other than FHSS	25 mW	No limit for data. 300 kHz for audio and video apps using Digital modulation, 25 kHz analogue and/or digital voice apps.	No requirement	M1, M2, M9 and M10, M14, M15	0.1% Duty cycle or LBT+AFA	Audio and Video apps are not supported. Analogue and/or digital voice apps are not supported
3	868 - 870	FHSS modulation	25 mW	300 kHz max if using Digital modulation, otherwise 25 kHz	<= 100 kHz		0.1% Duty cycle or LBT	Not supported by Anaren's A08X modules
4	868.0 - 868.6	Non-specific use	25 mW	Audio and video apps shall use digital mod with a max bandwidth of 300 kHz	No requirement but preferred channel spacing is 100 kHz	M3, M4, M5, M6, M7, M8, M11, M12, M13	1% Duty cycle or LBT+AFA. When duty cycle or LBT implemented, it shall not be user dependent/adjustable. It has to be guaranteed by appropriate technical means	
5	868.6 - 868.7	Alarms	10 mW		25 kHz, however, the whole band (100 kHz) can be used as one wideband channel for high speed data transmission	M4, M6, M7, M11, M12, M13	1% Duty cycle	Will be used as a single wideband channel
6	868.7 - 869.2	Non-specific use	25 mW	Audio and video apps shall use digital mod with a max bandwidth of 300 kHz	No requirement but preferred channel spacing is 100 kHz	M3, M4, M5, M6, M7, M8, M11, M12, M13	0.1% Duty cycle or LBT+AFA. When duty cycle or LBT implemented, it shall not be user dependent/adjustable. It has to be guaranteed by appropriate technical means	
7	869.2 - 869.25	Social Alarms	10 mW		25 kHz		0.1% Duty cycle	Not supported by Anaren's A08X modules
8	869.25 - 869.3	Alarms	10 mW		25 kHz		0.1% Duty cycle	Not supported by Anaren's A08X modules
9	869.3 - 869.4	Alarms	10 mW		25 kHz		1% Duty cycle	Not supported by Anaren's A08X modules
10	869.4 - 869.65	Non-specific use	500 mW		<=25 kHz, however, the whole band (250 kHz) can be used as one wideband channel for high speed data transmission	M3, M4, M5, M6, M7, M8, M11, M12, M13	10% Duty cycle or LBT+AFA. When duty cycle or LBT implemented, it shall not be user dependent/adjustable. It has to be guaranteed by appropriate technical means	Will be used as a single wideband channel
11	869.65 - 869.7	Alarms	25 mW		25kHz		10% Duty cycle	Not supported by Anaren's A08X modules
12	869.7 - 870	Non-specific use	25 mW	25kHz max for voice apps	No requirement	M3, M4, M5, M6, M7, M8, M11, M12, M13	1% Duty cycle or LBT+AFA. When duty cycle or LBT implemented, it shall not be user dependent/adjustable. It has to be guaranteed by appropriate technical means. For voice apps, LBT has to be implemented and the transmitter shall include a power output sensor controlling the output to a max transmit time of 1 minute for each transmission	Not supported for voice, audio or video apps
13	869.7 - 870	Non-specific use	5 mW	25kHz max for voice apps	No requirement	M3, M4, M5, M6, M7, M8, M11, M12, M13	For voice apps, LBT has to be implemented and the transmitter shall include a power output sensor controlling the output to a max transmit time of 1 minute for each transmission	Not supported for voice, audio or video apps

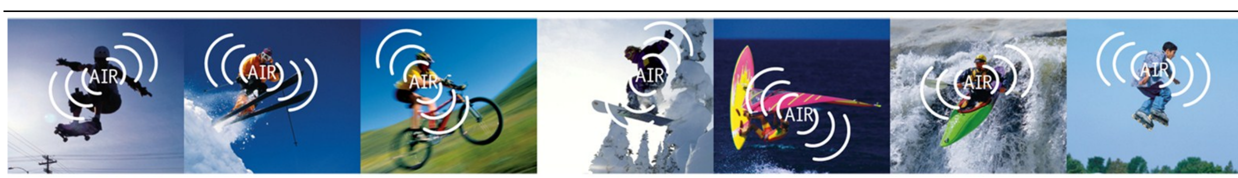
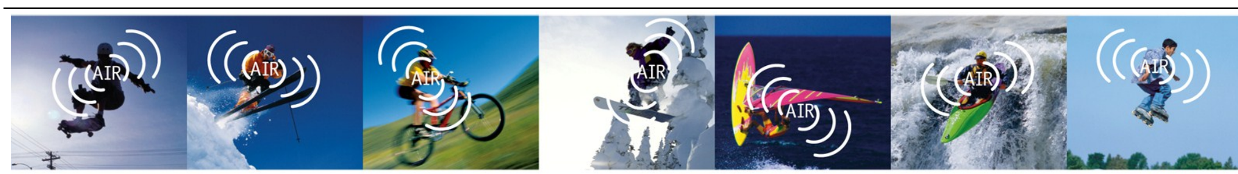


Table 7 Applicable Channels for Sub-Bands

Modulation Code	Sub-Band	Base Frequency (MHz)	Channel Spacing (kHz)	First Applicable Channel Number	Last Applicable Channel Number
M1	2	868.000	100	6	14
M2	2	868.000	100	2	18
M3	1	868.000	50	4	37
M3	4	868.000	50	4	9
M3	6	868.000	50	18	21
M4	1	868.000	50	2	38
M4	4	868.000	50	2	10
M4	6	868.000	50	16	22
M4	12	868.000	50	36	38
M4	13	868.000	50	36	38
M4	10	869.525	50	0	0
M5	1	868.000	50	4	37
M5	4	868.000	50	4	9
M5	6	868.000	50	18	21
M6	1	868.000	50	2	39
M6	4	868.000	50	2	11
M6	6	868.000	50	16	23
M6	12	868.000	50	36	39
M6	13	868.000	50	36	39
M6	10	869.525	50	0	0
M7	1	868.000	50	2	38
M7	4	868.000	50	2	10
M7	6	868.000	50	16	22
M7	12	868.000	50	36	38
M7	13	868.000	50	36	38
M7	10	869.525	50	0	0
M8	1	868.000	50	4	37
M8	4	868.000	50	4	9
M8	6	868.000	50	18	21
M9	2	868.000	100	3	17
M10	2	868.000	100	0	10
M11	1	868.000	50	2	39
M11	4	868.000	50	2	11
M11	6	868.000	50	16	23
M11	12	868.000	50	36	39
M11	13	868.000	50	36	39
M11	10	869.525	50	0	0
M12	1	868.000	50	2	38
M12	4	868.000	50	2	10
M12	6	868.000	50	16	22
M12	12	868.000	50	36	38
M12	13	868.000	50	36	38
M12	10	869.525	50	0	0
M13	1	868.000	50	2	39
M13	4	868.000	50	2	11
M13	6	868.000	50	16	23
M13	12	868.000	50	36	39
M13	13	868.000	50	36	39
M13	10	869.525	50	0	0
M14	2	868.000	100	6	14
M15	2	868.000	100	7	14



In order to comply with the output power limitations in Europe, the maximum values given in Table 8 below should be observed. Modulations M1, M2, M9, M10, M14 and M15 are considered to be wideband modulations and therefore subject to the spectral density requirements. Lower power levels for these configurations ensure compliance to the specifications.
Table 9 gives available output powers along with the corresponding PA Table register values in hexadecimal format.

Table 8 CW Output Powers

	Sub-Bands 1, 2, 4, 6 ,10, 12	Sub-Band 13
Modulation Code	OutputPower (dBm/Hex)	OutputPower (dBm/Hex)
M1	4.4 (0x83)	N/A
M2	-2.3 (0x62)	N/A
M9	2.2 (0x8A)	N/A
M10	4.6 (0x82)	N/A
M14	4.8 (0x80)	N/A
M15	4.8 (0x80)	N/A
All other types	12 (0xC0)	6.5 (0xCE)

Table 9 Output Power vs. PA Table Value

Power (dBm)	PA_Table(Hex)	Power (dBm)	PA_Table(Hex)
12	0xC0	4.2	0x84
11.6	0xC1	4	0x85
11.3	0xC2	3.7	0x86
10.9	0xC3	3.4	0x87
10.5	0xC4	3	0x88
10.2	0xC5	2.6	0x89
9.7	0xC6	2.5	0xCF
9.4	0xC7	2.2	0x8A
9	0xC8	1.7	0x8B
8.6	0xC9	1.1	0x8C
8.3	0xCA	0.5	0x8D
8	0xCB	-0.9	0x60
7.5	0xCC	-2.3	0x62
7	0xCD	-5	0x66
6.5	0xCE	-7	0x69
4.8	0x80	-10	0x28
4.7	0x81	-15	0x24
4.6	0x82	-20	0x18
4.4	0x83	-30	0x04

2.3.1.1. Spectrum Access and Mitigation Requirements

As part of the requirements for compliance, the applications must observe the restrictions that are listed in Table 6.Specifically, the spectrum access and mitigation requirements (e.g. Duty Cycle or LBT+AFA) have to be met. Some sub-bands (see Table 6) allow limited Duty cycling while some others let the user choose between limited Duty cycling and LBT+AFA implementation. In case of LBT+AFA, AFA (Adaptive Frequency Agility) has to be implemented in the customer's SW stack since there is no specific hardware support for this functionality.

2.3.1.1.1. Duty Cycling

Table 6 lists all sub-bands together with the usage requirements. In this table, Duty Cycling requirements are listed under "**Restrictions**" column. It applies to all transmitters excluding those with a LBT facility with AFA (explained in the next sub-section). The Duty Cycle is defined as the ratio, expressed as a percentage, of the maximum transmitter "ON" time monitored over one hour, relative to a one hour period. The device may be triggered either automatically or manually. And, depending on how the device is triggered, the duty cycle is either fixed or random.

For automatic operated devices, either software controlled or pre-programmed devices, the OEM integrator or end product developer shall declare the duty cycle class or classes in the end-product user manual or user guide. For manual operated or event-dependent devices, with or without software controlled functions, the integrator shall declare whether the device once triggered, follows a pre-programmed cycle, or whether the transmitter remains on until the trigger is released or the device is manually reset. The integrator shall also give a description of the application for the device and include a typical usage pattern. The typical usage pattern as declared by the integrator shall be used to determine the duty cycle and hence the duty class.

Where an acknowledgement is required, the additional transmitter on-time shall be included and declared by the integrator.

In a period of 1 hour, the duty cycle shall not exceed the spectrum access and mitigation requirement values as given in Table 6. For frequency agile devices without LBT, the duty cycle shall apply to the total transmission time as given in Table 6, or shall not exceed 0.1 % per channel in a period of 1 hour.

2.3.1.1.2. LBT & AFA

Listen Before Talk (LBT) is used to share spectrum between SRD transceiver equipment with similar power and bandwidth. In order to make maximum use of the available channels, intelligent or polite equipment may use a Listen Before Talk (LBT) protocol with a preferred option of Adaptive Frequency Agility (AFA). AFA is defined as the capability of the equipment to dynamically change channel within its available frequencies for proper operation.

LBT (Listen Before Talk) functionality is built in the A110LR09X modules, and the approved configurations are made to meet the LBT Threshold limits. However**, LBT timing parameters, specific to the end product, have to be established through controlling software and declared by the OEM integrator or end-product developer in the product user manual or user guide.** A brief description and limits of these parameters are given as follows:

- ***Minimum Transmitter off-time*** is the period where a specific transmitter shall remain off after a transmission or a communication dialogue between units or a polling sequence of other units on the same frequency. The minimum TX off-time has to be ***greater than 100 ms***.

- ***LBT minimum listening time*** is the minimum time that the equipment listens for a received signal at or above the LBT threshold level immediately prior to transmission to determine whether the intended channel is available for use.

  LBT minimum listening time, t_L, has two parts: the fixed part, t_F, and the pseudo random part, t_{PS}. $t_L = t_F + t_{PS}$. The fixed part of the minimum listening time is 5 ms. The pseudo random part has to be randomly varied between 0 ms and 5 ms or more in equal steps of 0.5 ms as the following:

  - If the channel is free from traffic at the beginning of the listen time, and remains free throughout the fixed part of the listen time, then t_{PS} is automatically set to zero by the equipment itself
  - If the channel is occupied by traffic when the equipment either starts to listen or during the listen period, then the listen time commences from the instant that the intended channel is free. In this situation the total listen time t_L shall comprise t_F and the pseudo random part, t_{PS}.

  Algorithmic details and values have to be declared by the provider of the equipment.

- ***Maximum dead time*** is the period between the end of the listening time and the start of the transmission. The maximum dead time cannot exceed **5 ms**.

- ***Maximum transmitter on-time*** is the maximum time the transmitter can be on during:

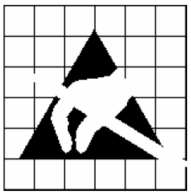
  - A single transmission. The limit is **1 s**, and the actual value has to be declared.
  - Multiple transmissions and acknowledgements for a communication dialogue or polling sequence of other units under the condition that the channel is free. The limit is **4 s**, and the actual value has to be declared.
  - Within 1 hour for any 200 kHz of spectrum. The limit is **100 s**.

NOTE: Longer accumulated transmission time is possible by implementing more AFA channels.

3. Electrical Characteristics

3.1. Absolute Maximum Ratings

Under no circumstances must the absolute maximum ratings given in
Table 10 be violated. Stress exceeding one or more of the limiting values may cause permanent damage to the device.

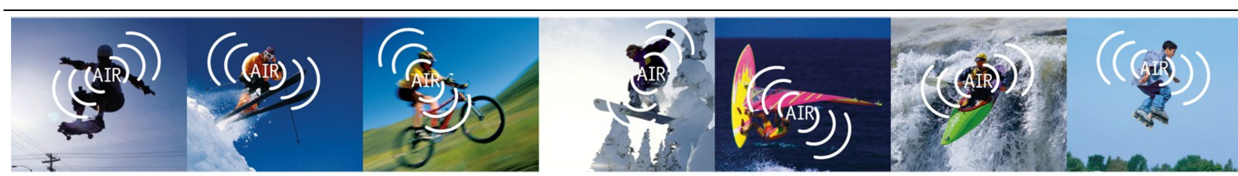


Caution!
ESD sensitive device. Precaution should be used when handling the device in order to prevent permanent damage.

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

Table 10 Absolute Maximum Ratings

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 STD22, method A114, Human Body Model (HBM)
ESD		400	V	According to JEDEC STD22, C101C, Charged Device Model (HBM)



3.2. Operating Conditions

Table 11 Operating Conditions

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

3.3. Pin Out

The A1101R08A and A1101R08C radio modules share a common pin-out and foot print, that is also shared by Anaren modules using other frequencies -- thus enabling easy changeover from one to another, e.g. if changing the frequency, antenna scheme, or adaptive antenna tuning is desired. Below the common footprint are shown.

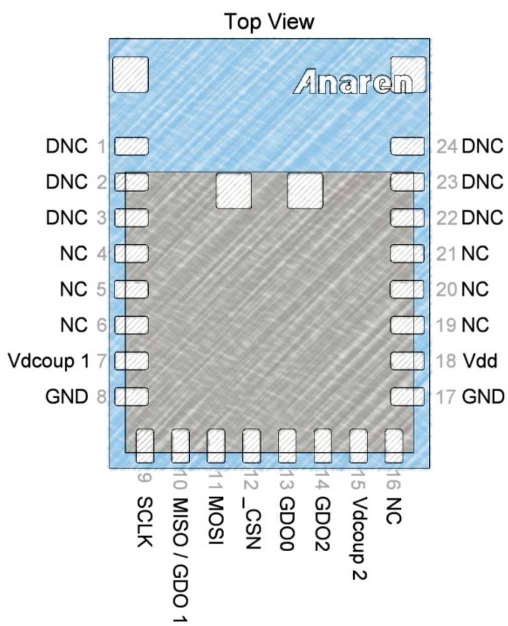


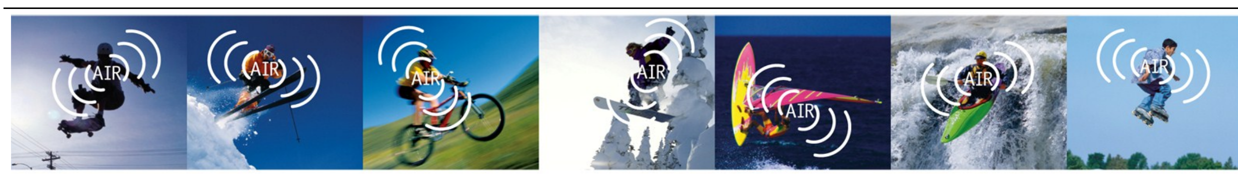
Figure 5 Pin Out

NC = NO Connection. Pin is NOT connected internally.

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

Table 12 Pin Descriptions

Pin #	Pin Name	Pin Type	Description
1	DNC	NC	Internal GND connection used during testing, not recommended to connect to main GND.
2	DNC	NC	Internal RF output connection used during test. Connecting this pin to anything will require recertification for intentional radiators.
3	DNC	NC	Internal GND connection used during testing, not recommended to connect to main GND.
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	NC	NC	Pin is not connected internally, but is reserved for future expansion. It is recommended not to connect this pin to anything.
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	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.
8	GND	Ground	One of two primary ground pins
9	SCLK	Digital Input	SPI bus clock signal
10	MISO/GDO1	Digital Output	SPI bus data out from radio when CSN is low, and general purpose I/O pin when CSN is high
11	MOSI	Digital Input	SPI bus data into radio
12	_CSN	Digital Input	SPI bus select (active low)
13	GDO0	Digital I/O (Analog output)	General purpose port
14	GDO2	Digital I/O	General purpose port
15	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.
16	NC	NC	No Connect, the pin is not connected internally, but is reserved for future expansion. It is recommended not to connect this pin to anything.
17	GND	Ground	One of two primary ground pins
18	Vdd	Power Supply	Power supply pin
19	NC	NC	Pin is not connected internally, but is reserved for future expansion. It is recommended not to connect this pin to anything.
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	NC	NC	Pin is not connected internally, but is reserved for future expansion. It is recommended not to connect this pin to anything.
22	DNC	NC	Internal GND connection used during testing, not recommended to connect to main GND.
23	DNC	NC	Pin is not connected internally, but is reserved for future expansion. It is recommended not to connect this pin to anything.
24	DNC	NC	Internal GND connection used during testing, not recommended to connect to main GND.



3.4. Recommended Layout (dimensions in mm)

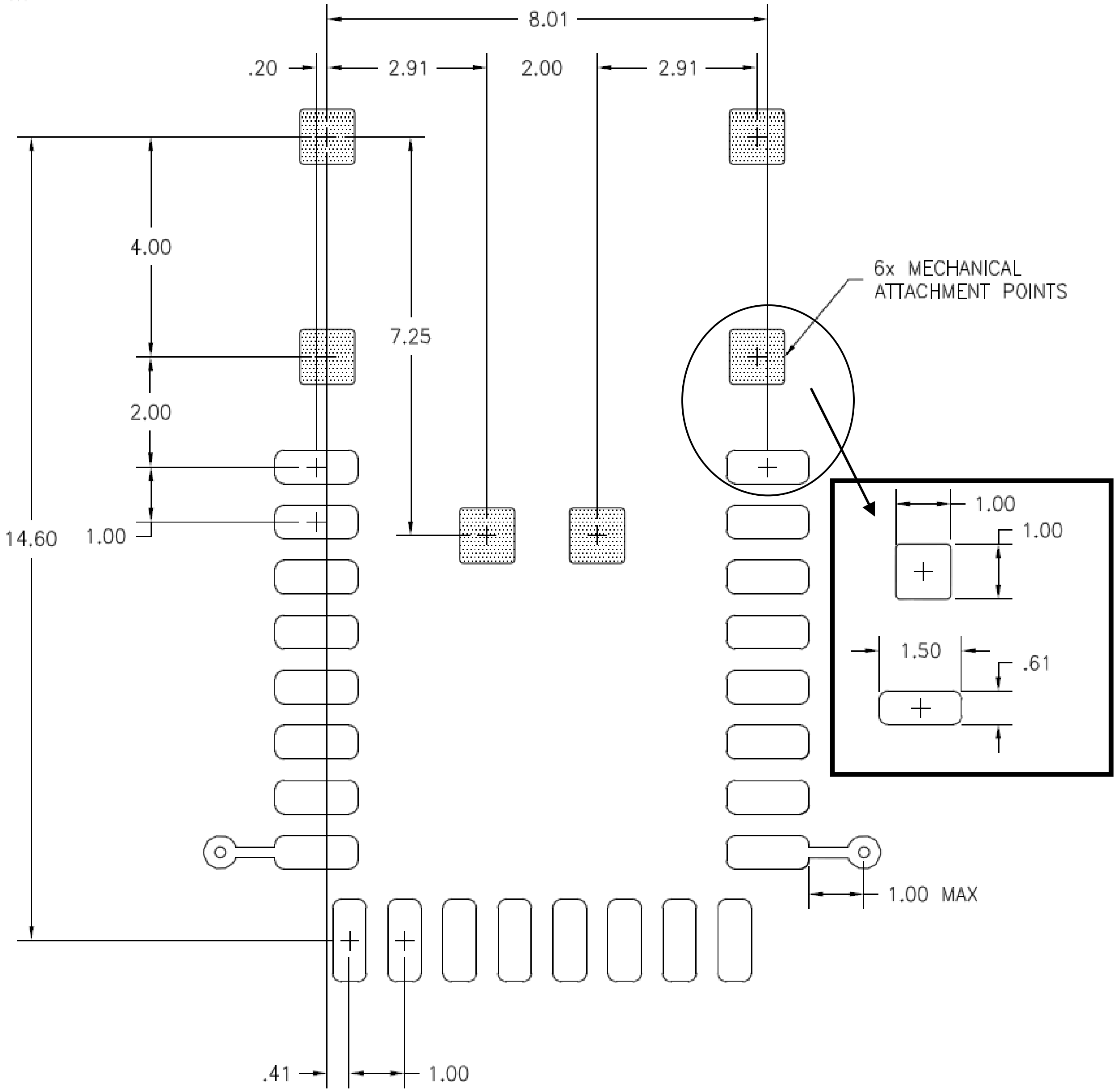
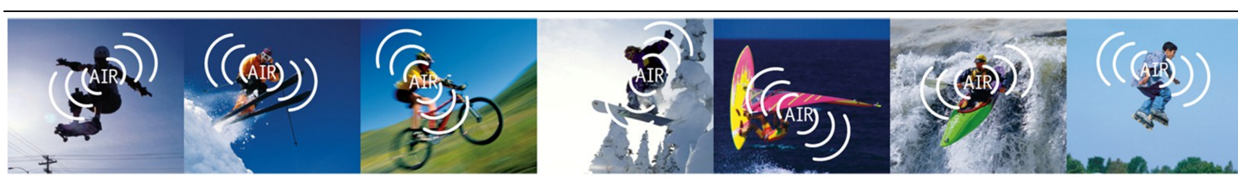


Figure 6 Recommended PCB layout



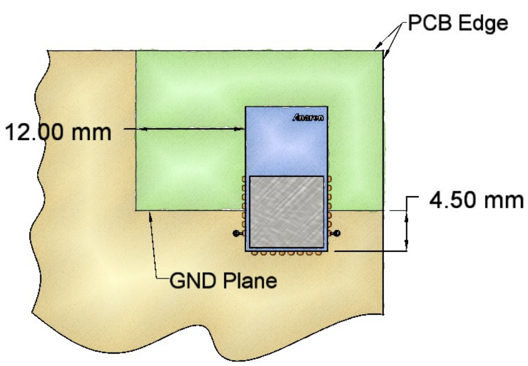


Figure 7 Mounting the module in a corner

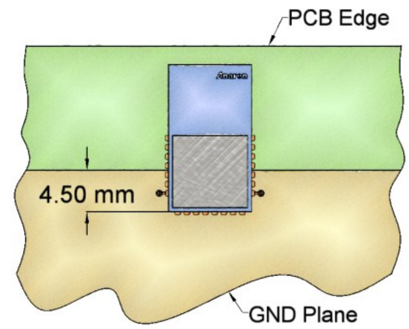


Figure 8 Mounting the module along an edge

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 A1101R08A and A1101R08C radio modules each have an integral ferrite bead in the supply line from pin 18 (Vdd) and decoupling capacitance to reduce any noise on the incoming power supply line. 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 7 (Vdcoup1) is connected to the modules internal supply line after the ferrite bead and decoupling capacitors and can be used to probe the noise at module level. The noise level measured on pin 7 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 7 (Vdcoup1).
- Adding additional filtering in the supply line.
- Adding an LDO in the supply line (the TPS734xxx low Dropout Regulator from TI is recommended).

4. Mechanical and Process

4.1. Radio Module Details (dimensions in mm)

4.1.1. A1101R08A

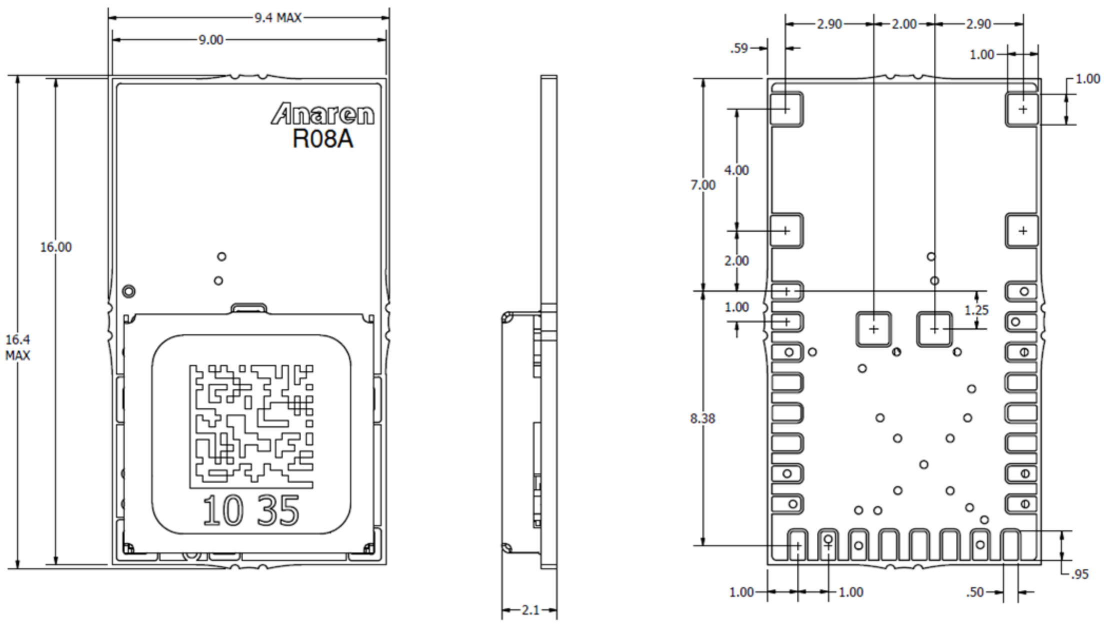


Figure 9 A1101R08A dimensions

4.1.2. A1101R08C

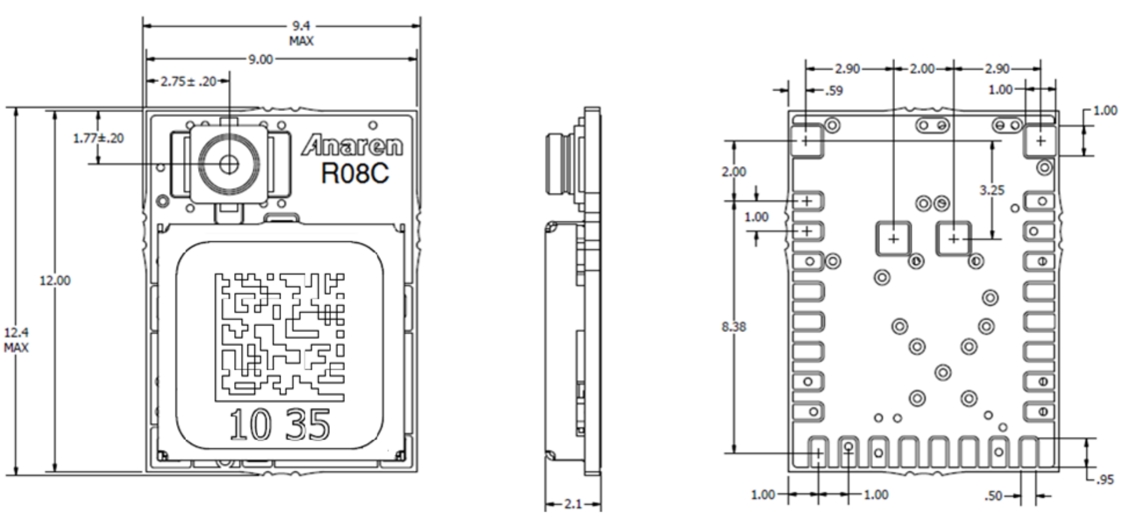


Figure 10 A1101R08C dimensions

4.2. Packaging Details (dimensions in mm)

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

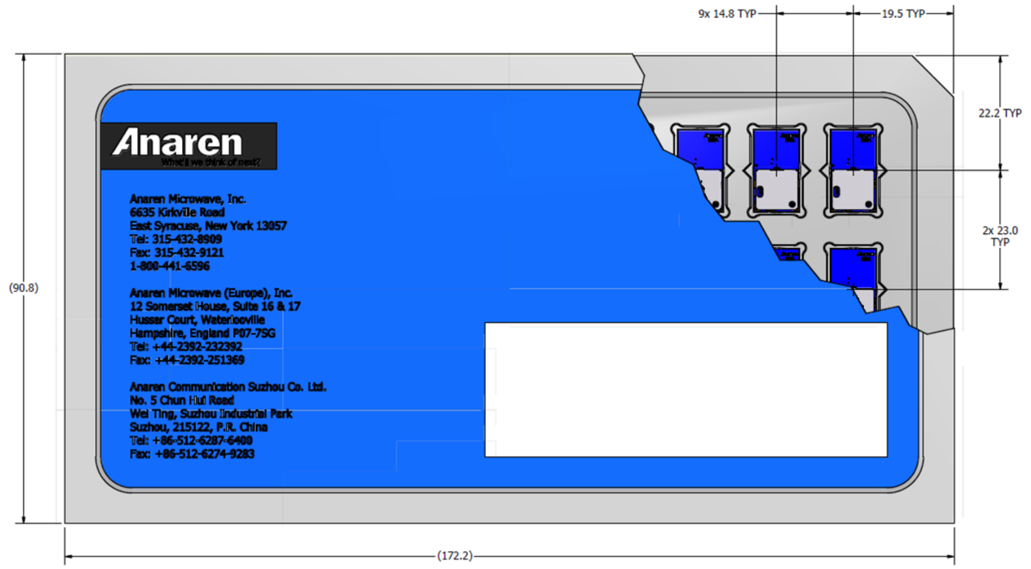


Figure 11 A1101R08A00GM Matrix Tray Packaging Detail (30/Tray)

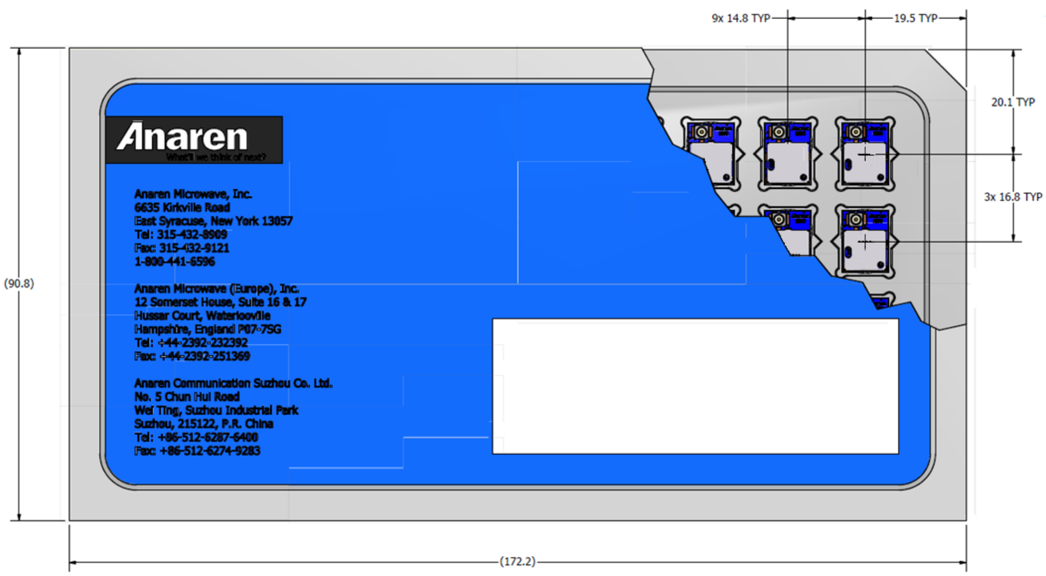


Figure 12 A1101R08C00GM Matrix Tray Packaging Detail (40/Tray)

4.2.2. Tape-Reel

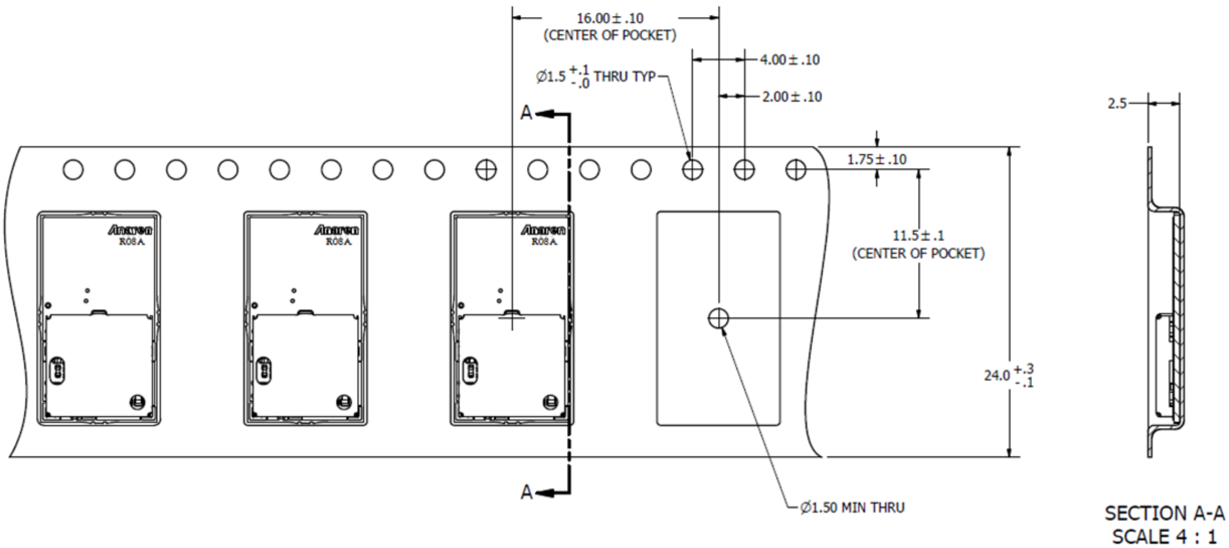


Figure 13 A1101R08A00GR Tape-Reel Packaging Detail (500/Reel)

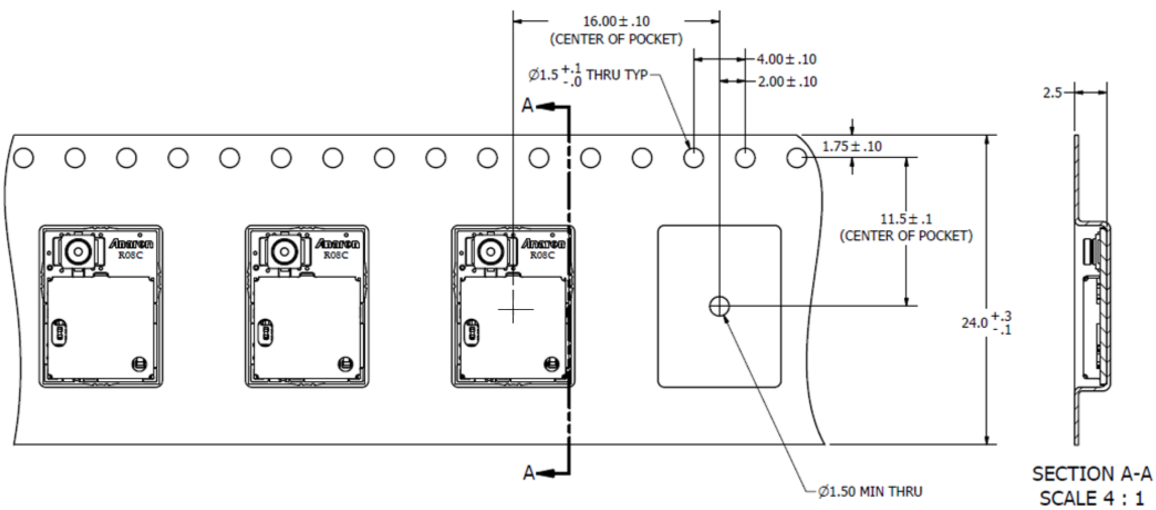


Figure 14 A1101R08C00GR Tape-Reel Packaging Detail (500/Reel)

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

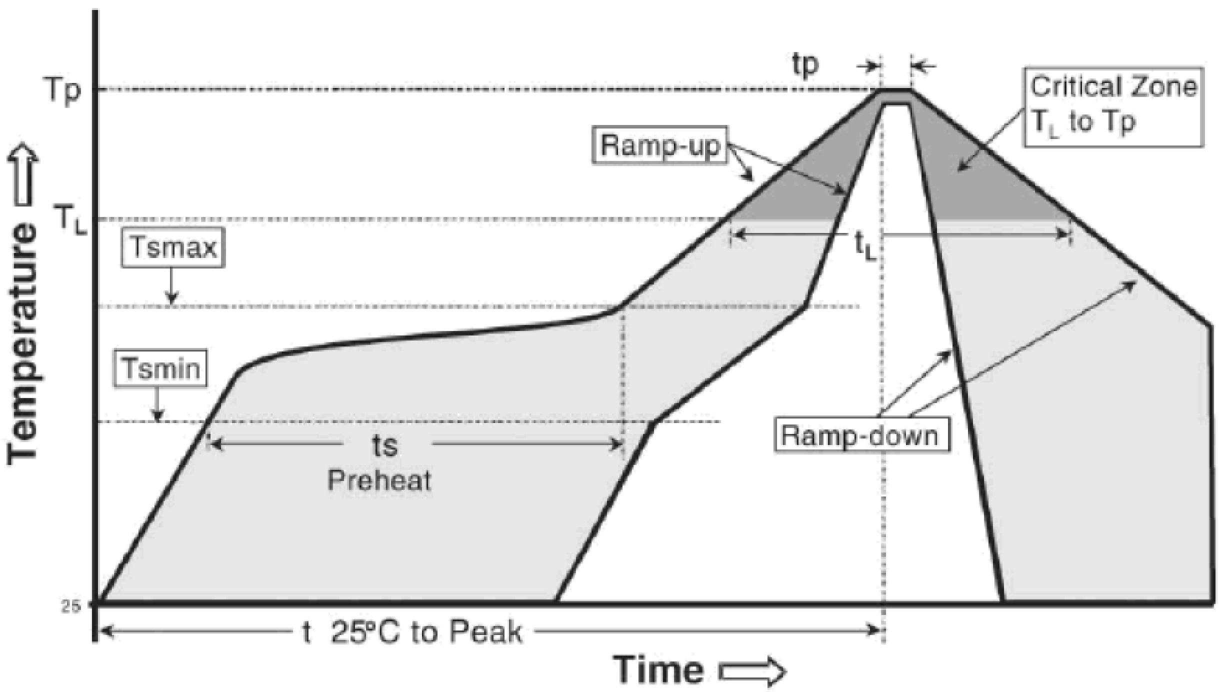
4.3.2. Automated Mounting Procedure

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

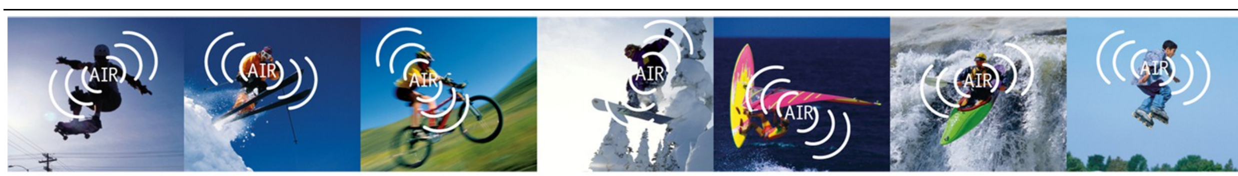
Package Thickness	Volume mm^3 <350	Volume mm^3 ≥ 350
<2.5 mm	240 +0/-5 °C	225 +0/-5°C
≥ 2.5 mm	225 +0/-5°C	225 +0/-5°C

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			

DOCUMENT HISTORY

Date	Author	Change Note No./Notes
07/28/11	Sula	Initial Draft
01/26/12	Richardson	Initial Release
02/01/12	Sula	- Section 1.3. - Freq. Range is corrected - Section 2.2 – modified with Sensor/control networks - Section 2.3.1.1 - Spectrum Access and Mitigation Requirements has been re-formatted and made a new section Section 3.4. - Fig 9 and Fig 10, both were removed
02/24/12	Sula	Some formatting applied in figures, no textual change



Attach distributor contact information here

If you have additional questions, need samples, or would like a quote – please email the AIR team at AIR@anaren.com .

For a full list of our franchised distributors, please visit our website: http://www.anaren.com/air/

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East Syracuse, NY 13057	Hussar Court, Waterlooville	Wei Ting, Suzhou Industrial Park
Tel: +1 315 432 8909	Hampshire, England P07-7SG	Suzhou 215122, PR China
+1 800 411 6596	Tel: +44 2392 232392	Tel: +86 512 6287 6400
Fax: +1 315 432 8970	Fax: +44 2392 251369	Fax: +86 512 6274 9283