

RADIONOVA[®] RF Antenna Module

Part No. M10478-A3

Product Specification

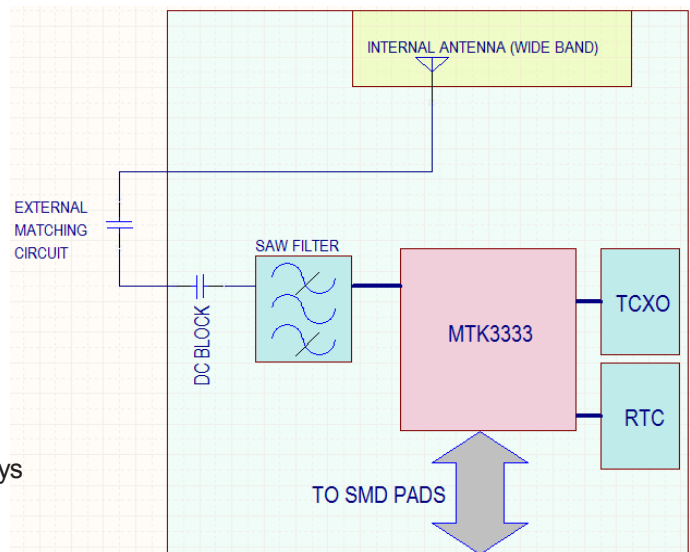
Applications

- Personal Navigation Devices (PNDs)
- Portable Media Players (PMPs)
- Personal Digital Assistants (PDAs)
- Medical / eHealth
- Smart Watches
- Asset Tracking / Personal Safety

Features

- All in one solution with wide band antenna for A full multi GNSS solution.
- Mediatek MT3333 chip
- GPS/GLONASS/GALILEO/BEIDOU (After ICD Released) Incl. QZSS, SBAS ranging.
- Max fixed update rate up to 10Hz
- Novel external matching ensure easy tuning for each platform
- AIC, Active Interference Cancellation.
- EPO (Extended Prediction Orbit), up to 30day orbit prediction, Warm TTF = <5sec
- EASY self-generated orbit prediction up to 3days

Functional Block Diagram



Description

Antenova M2M's RADIONOVA[®] M10478-A3 antenna module is an ultra compact single package solution that combines full GPS receiver and antenna on the same module. The M10478-A3 is a highly integrated multi GNSS RF antenna module. The device is based on the Mediatek MT3333 architecture combined with Antenova's antenna technology. Using patented external matching means this module is suitable from small watch applications to large tracker devices.

All front-end and receiver components are contained in a single package laminate base module, providing a complete GNSS receiver for optimum performance. The M10478-A3 operates on a versatile 2.8V-4.2V supply with low power consumption and several Low power modes for further power savings. An accurate 0.5ppm TXCO ensures short TTFF. Indoor and outdoor multi-path detection and compensation. Support multi-GNSS GPS/GLONASS /GALILEO/BEIDOU Incl. QZSS, SBAS ranging.

Providing a true drop in solution with the antenna and RF in a single SMT package, GPS RADIONOVA[®] M10478-A3 offers ease of integration and shorter design cycles for faster time to market.

Package Style

SMD Castellated pads enable SMT placement and re flow as well as hand soldering.

13.8 x 9.5 x 1.8mm RF Antenna Module

Top View



Bottom View



Antennas for Wireless M2M Applications

| Symbol | Parameter | Min | Max | Unit |
|------------|-------------------------|------|-----|------|
| V_{CC} | Main Supply Voltage | -0.3 | 4.3 | V |
| V_{IO} | Supply voltage I/O ring | -0.3 | 3.6 | V |
| V_{BATT} | VBCKP Supply | -0.3 | 4.3 | V |
| RF_{IN} | Maximum RF Input Power | N/A | +10 | dBm |
| T_{STG} | Storage Temperature | -40 | +85 | °C |
| T_A | Operating Temperature | -40 | +85 | °C |

* Exposure to absolute ratings may adversely affect reliability and may cause permanent damage.

Recommended Operating Conditions

| Symbol | Parameter | Min | Typ | Max | Unit |
|------------|-----------------------|-----|-----|-----|------|
| V_{CC} | Main Supply Voltage | 2.8 | 3.3 | 4.3 | V |
| V_{BATT} | VBCKP Supply | 2.8 | 3.3 | 4.3 | V |
| T_{OP} | Operating Temperature | -40 | - | +85 | °C |

DC Electrical Characteristics

Conditions: $V_{CC} = 3.3V$, $T_{OP} = 25\text{ °C}$

| Symbol | Parameter | Typ | Unit |
|-----------------|-----------------------------------|------|------|
| $I_{CC(PK)}$ | Peak Acquisition Current | 38 | mA |
| $I_{CC(AVG)}$ | Average Tracking Supply Current | 28 | mA |
| $I_{CC(STBY)}$ | Standby (Sleep) Power Supply Mode | <350 | μA |
| $I_{CC(BCKUP)}$ | Backup Mode | <15 | μA |

RF Specifications

Conditions: $V_{CC} = 3.3V$, $T_{OP} = 25\text{ °C}$, GPS+GLONASS

| Symbol | Parameter | Typ | Unit |
|-------------------|--|------|------|
| NF_{LNA} | LNA Noise Figure | 2.2 | dB |
| ANT_{RL} | Antenna Return Loss | -15 | dB |
| ANT_{BW} | Antenna Bandwidth at -10dB return loss | 45 | MHz |
| ANT_{EFF} | Antenna Total Efficiency | >40% | % |
| ANT_{EFF_RHCP} | Antenna RHCP Efficiency | >30% | % |

| Frequency | Standard | Typ* | Unit |
|-----------|--------------------|------|------|
| 698-798 | LTE700 | 53 | dB |
| 824-849 | Cellular CDMA | 53 | dB |
| 869-894 | GSM850 | 55 | dB |
| 880-915 | GSM900 | 55 | dB |
| 1710-1785 | GSM1800/DCS | 45 | dB |
| 1850-1910 | GSM1900/PCS | 45 | dB |
| 1920-1980 | WCDMA | 45 | dB |
| 2400-2492 | WLAN, BT and WiMAX | 42 | dB |
| 2500-2690 | LTE2600 | 42 | dB |

*Does not include antenna rejection.

Mechanical Specifications

| Parameter | Typ | Unit |
|--|---|------|
| Module exterior dimensions (L x W x H) | 13.8 (+0.1/-0.1) x 9.5 (+0.1 / -0.1) x 1.8 (+0.2 / - 0.0) | mm |
| Module support and connection | Surface mounted (SMD) | - |
| Module mass | <1 | g |

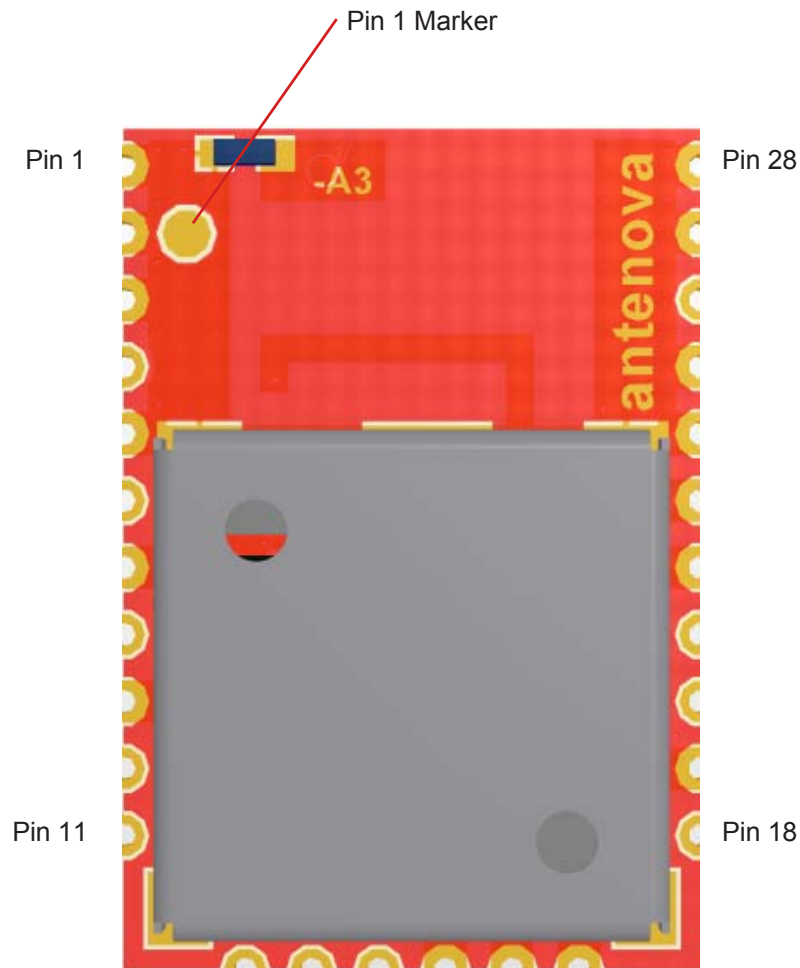
| Communication | Specification |
|--------------------------------|--|
| Data Output Protocol | NMEA 0183 V4.1 and backward compliance |
| Host Interfaces | UART |
| Default data rate on UART | 9600 default rate, changeable by input commands |
| GPS Engine | |
| Chip | MTK MT3333 Chip |
| Channels | 66 Acquisition Channels |
| TCXO | 0.5ppm |
| Accuracy | |
| Horizontal Position Accuracy | <2.5m CEP |
| Maximum Position Update Rate | 10 Hz |
| Sensitivity | |
| Acquisition (Cold) | -148dBm |
| Acquisition (Hot) | -163dBm |
| Tracking | -165dBm |
| TTFF | |
| Hot Start | <1s |
| Warm Start | <25s (typical) |
| Cold Start | <35s (typical) |
| General | |
| Maximum Altitude | <18.000 km |
| Maximum Speed | <514 m/s |
| Active Interference Cancellers | 12 multi tone active cancellers ISSCC2011 award |
| Additional Features | SBAS, WAAS, EGNOS, QRZZ, GAGAN Support |
| EPO | AGPS Orbit prediction (Network connection) |
| EASY | Orbit prediction (Module generated) |

50% CEP, Open-Sky, 24hr Static, -130dBm, good view of the sky

Pin out Description

Table shows the designation and function of each pin on the M10478-A3 module. Please note that several pins have multiple functions.

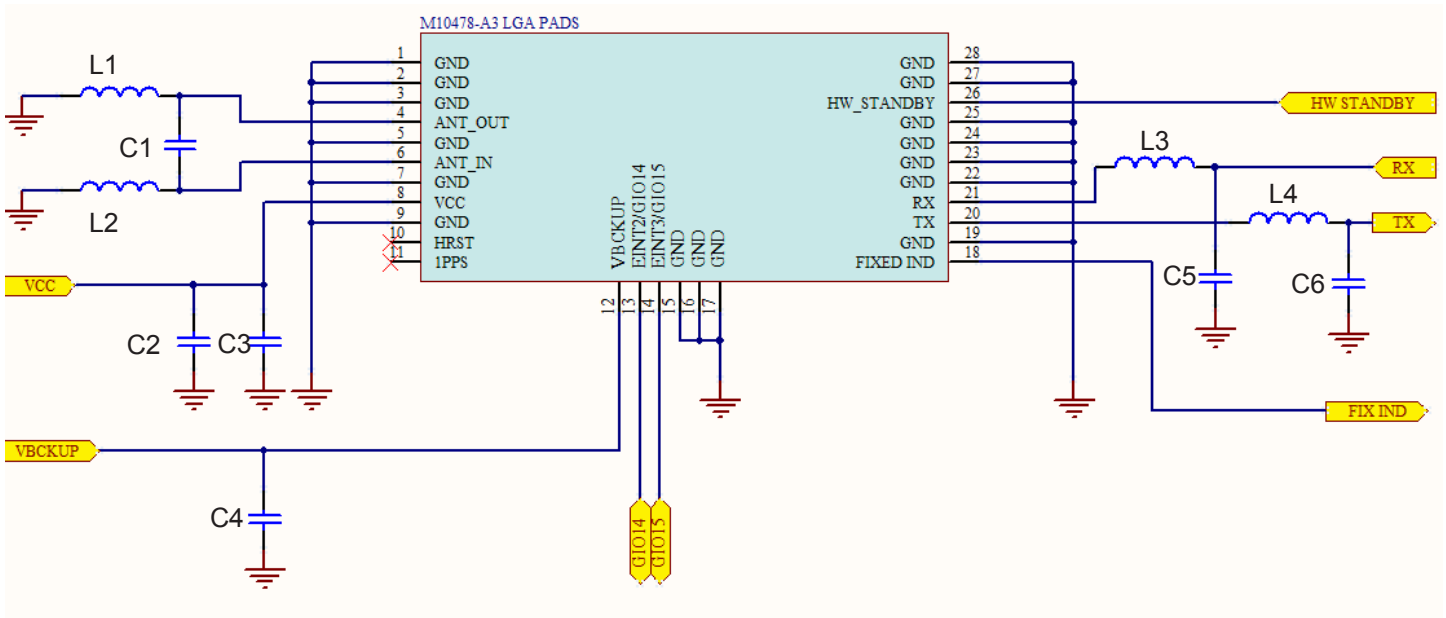
| Pin | Designator | Description |
|-----|-----------------|--|
| 1 | GND | Ground connection |
| 2 | GND | Ground connection |
| 3 | GND | Ground connection |
| 4 | ANT_OUT | RF from internal antenna to external matching circuit |
| 5 | GND | Ground connection |
| 6 | ANT_IN | RF from external matching circuit back into module |
| 7 | GND | Ground connection |
| 8 | VCC | Main DC supply, +2.8 to +4.2V |
| 9 | GND | Ground connection |
| 10 | HRST | System reset, active low |
| | TM | 1PPS Tim Mark Out |
| 12 | VBCKUP | Backup supply +2.0V to 4.2V |
| 13 | EINT2/GIO14 | TBD |
| 14 | EINT3/GIO15 | TBD |
| 15 | GND | Ground connection |
| 16 | GND | Ground connection |
| 17 | GND | Ground connection |
| 18 | FIXED INDICATOR | Indicates once a GPS fix has been obtained. |
| 19 | GND | Ground connection |
| 20 | TX | UART Transmit data line |
| 21 | RX | UART Receive data line |
| 22 | GND | Ground connection |
| 23 | GND | Ground connection |
| 24 | GND | Ground connection |
| 25 | GND | Ground connection |
| 26 | HW_STANDBY | Used to enable standby mode. If not used leave floating. |
| 27 | GND | Ground connection |
| 28 | GND | Ground connection |



Application Schematic Example for M10478-A3:

The circuit below shows a basic design for use with the UART interface.

Baud Rate = 9600



Bill of Material

| Designator | Value | Description/Comments | Quantity |
|----------------|-----------------|---|----------|
| C1, L1, L2 | TBD | Depending on device antenna matching circuit | TBD |
| C3, C4, C5, C6 | 22pF capacitor | Decoupling capacitor. Place close to corresponding pin | 4 |
| C2 | 2.2uF capacitor | Decoupling capacitor. Place close to corresponding pin | 1 |
| L3, L4 | 47nH Inductor | Filter component to suppress any potential host PCB noise | 2 |

Host Baud Rate/Protocol Selection

The baud rate and output protocol can be changed dynamically after start up using the relevant commands. Please contact Antenova for more information about protocol messages.

Host Interface Overview

UART Interface

The UART converts bytes of data to and from asynchronous start-stop bit streams as binary electrical impulses. The port contains a 16-byte FIFO, and 256 bytes of URAM. The bit rates are selectable from 4800, 9600, 38400 and 115200 bps.

The IO level from the UART port are CMOS compatible, however for RS232 compatibility the use of external level shifters will be required. The hardware configuration of the port baud can be changed dynamically by the use of commands. These will be active and saved as long as the VBACKP supply is applied.

Power Supply

The M10478-A3 uses two DC supply inputs. VBACKUP to power the RAM and RTC sections of the receiver, and VCC to power the digital and processing sections. VBACKUP is to be applied all the time to keep these sections alive. VCC can be removed to initiate a backup power save mode (See page 9). VBACKUP can be removed if a battery is also used at VBACKUP to maintain this supply. The supply is internally regulated for 2.8V meaning the external supply is versatile for a range of voltage levels.

TM (1PPS)

TM is a one pulse per second output from the receiver providing uses for timing purposes.

HRST (Hardware Reset Pin)

The External reset pin is default high by an internal 75Kohm and should be left floating if not used. To initiate a reset The pin needs to be pulled low. The module also initiates a reset if the VCC drops below the minimum 2.8V supply.

Power Management

The M10478-A3 has three power saving modes.

- Standby mode
- Back up mode
- Periodic mode

Standby Mode

Standby mode is a power saving mode that shuts down the RF section of the module and puts the processor into a standby mode. The RTC is kept alive and the RAM power is maintained to keep the module configuration. The standby state can be initiated either with a hardware signal to Pin26 or by using a command.

Hardware controlled Standby:

Enable standby mode by a low state to pin 26 (HW_STANDBY). To wake the module back to full power a high state Needs to be applied to pin 26. If Pin 26 is not to be used then it must be kept floating (not connected).

Standby mode command:

Software on the host needs to send the "PMTK161 command through the UART interface.

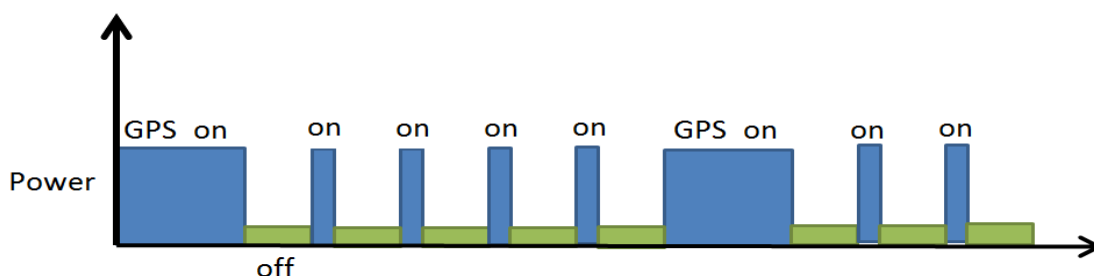
| Command | M10478-A3 standby then wakeup | Current consumption (Typ) |
|----------------|--------------------------------------|---------------------------|
| \$PMTK161,0*28 | M10478-A3 enters standby mode | <200uA |
| Any byte | M10478-A3 wakes up from standby mode | |

Back up mode

To enter backup mode the VCC simply needs to be removed. Once initiated the RTC and all configuration is saved along with any ephemeris data to allow quick TTFF once the VCC is re-applied. VBACKUP needs to be applied at all times for backup mode to run correctly.

Periodic mode

Periodic mode is a module controlled mode that reduces current consumption by only waking the module for short periods to maintain fix data. The periodic state is user configured. Contact Antenova for more information and a user command manual.



| PMTK225 setting | M10478-A3 time off/awake | Current usage (Typ) |
|--------------------------------|---|---------------------|
| PMTK225, 2,3000,18000,72000 | Module sleeps for 12secs, then wakes for 3secs periodically. 72000 is for a cold boot condition . | <200uA |

EPO (Extended Prediction Orbit) data service

The EPO allows the use of up to a 30-day orbit predictions that can be used to aid the module for an instant fix solution

- A proxy server on the customers side to update EPO files from the MTK server daily.
- Application software to access the proxy server through the internet (optional if host device can access internet)
- Software on host device to send EPO data to M10478-A3 module to allow instant fix by using EE data.

Please contact Antenova for more information. Requires permission from MTK to use service.

AIC (Active Interference Cancellation)

The AIC feature provides effective narrow-band interference and jamming elimination. The GPS signal can be recovered from the jammed signal and allows users to obtain better navigation quality. This can be beneficial since Many of today's devices have more and more functionality with regards to transmitters with many on-board antenna's.

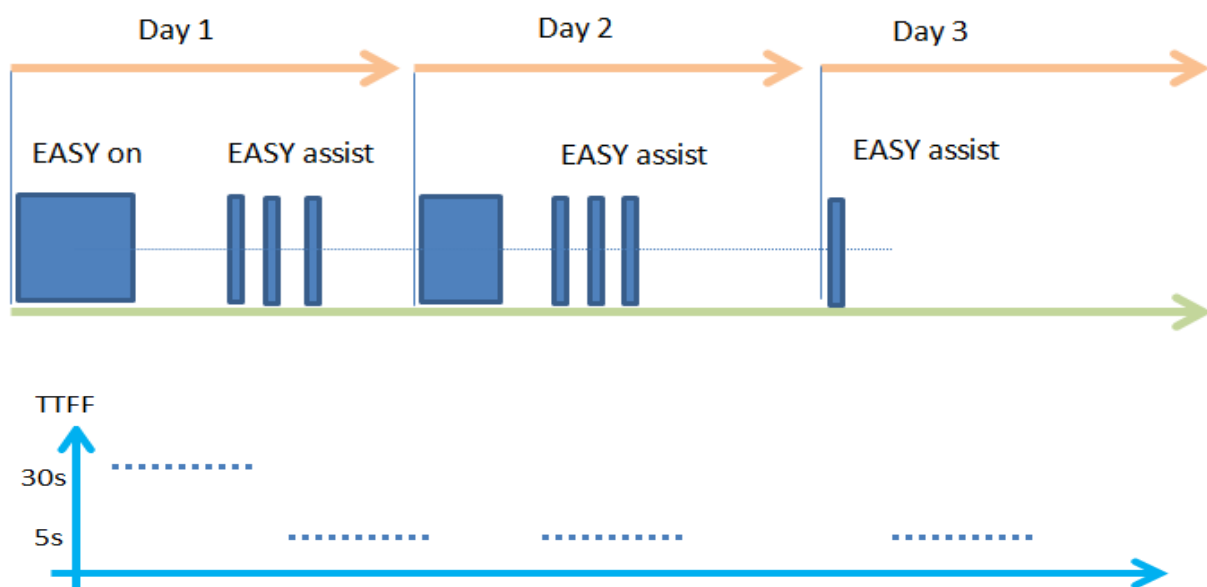
The AIC is default off and can be enabled by a PMTK command. Contact Antenova for PMTK document.

EASY (Embedded Software Assist System)

EASY works as embedded software which accelerates TTFF by predicting satellite navigation messages from received ephemeris. EASY is a fully automated receiver task that is efficiently scheduled and computed in free time of every second after a GNSS navigation solution.

EASY function is conceptually designed to automatically engage for predicting after first receiving the broadcast ephemeris. After a while (generally 10 seconds), 3 day extensions will be completely generated then all EASY functions will be maintained at a standby condition. EASY assistance is going to be engaged when the receiver requests in new TTFF condition or re-generates again with another new received ephemeris. TTFF will benefited By the EASY assistance.

EASY is default off and can be enabled by a PMTK command.



External Matching

The M10478-A3 module uses a matching circuit on the host PCB in order to fine-tune the on-board antenna to each specific application. This “external matching” allows compensating for the detuning of the antenna caused by various different components that can be close to the M10478-A3 module in the actual application (plastic case, battery, speakers etc).

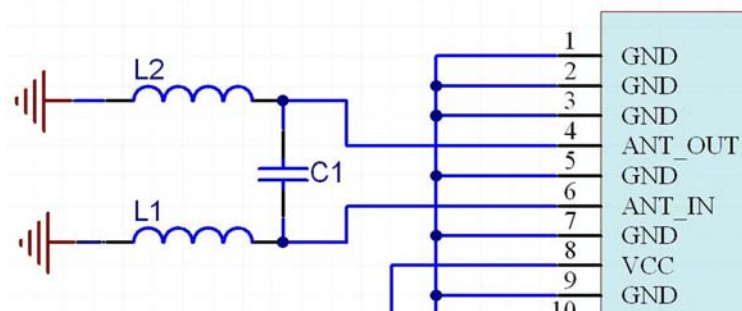
The external matching must be placed on the host PCB between ANT_OUT (PIN3) and ANT_IN (PIN1). Although 2 components are typically more than enough to match the antenna to the 50Ω impedance required, a Π -network topology with 3 components is recommended for safe proving.

Schematic

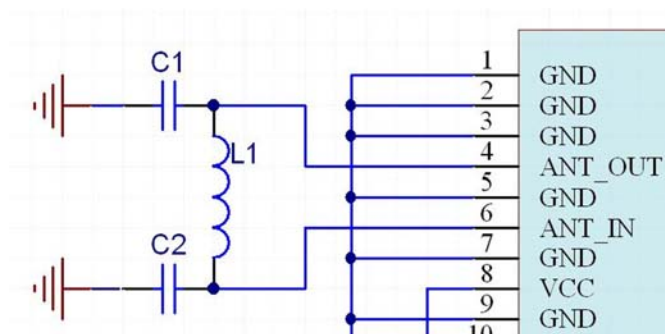
Both low-pass and hi-pass topologies for the matching network can be used with similar results. As the same footprint can be used for both topologies, the exact type and value of the components used can be determined during the optimization phase.

- The initial values can be simply chosen as the null-circuit (no impedance matching):

- Hi-pass:
 - C1 = 18pF
 - L1, L2 = Not Fitted



- Low-pass:
 - L1 = Jumper (0Ω resistor)
 - C1, C2 = Not Fitted



Type of Matching Components

- Capacitors:
 - Use 0402, COG components
- Inductors:
 - High-Q, wire wound inductors in 0402 size are recommended for maximum performance, e.g. Murata LQW15 series
 - Good quality multi-layer type inductors (e.g. Murata LQG15 series) can also be used as a lower cost alternative

Matching Procedure

The types and values of the matching components must be chosen so that the impedance seen by port ANT_IN (PIN4) is as close as possible as 50Ω. Although it is a relatively simple operation, it requires some RF skills and a VNA (Vector Network Analyzer). **Please contact an Antenova M2M FAE to get support on defining the optimal matching for your specific device.**

External Antenna Support

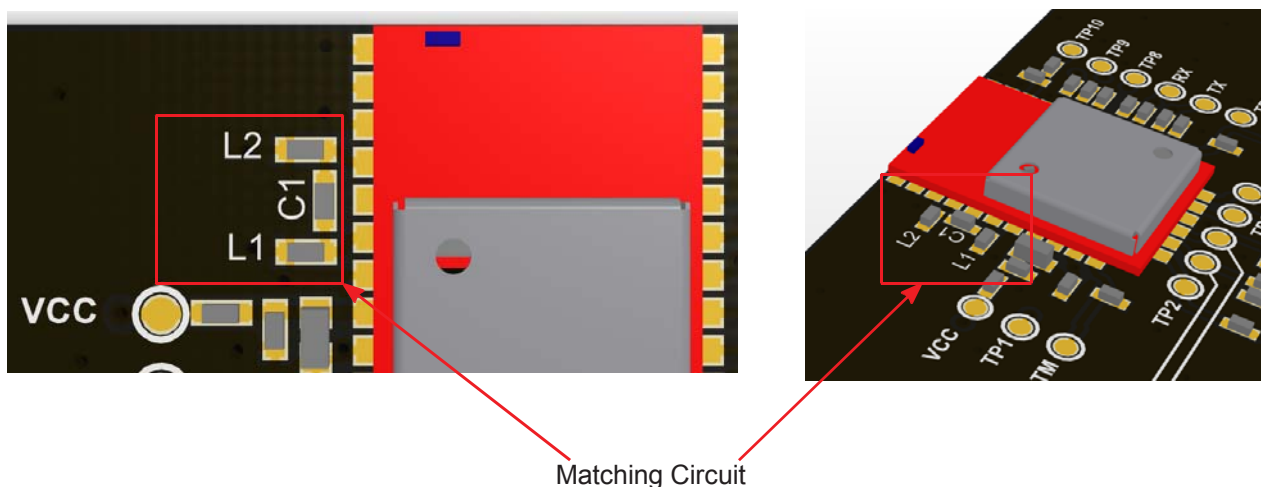
A low cost external circuit can be used to provide external antenna support. Please contact Antenova for more information, and example circuit.

PCB Matching Circuit Layout

The layout of the external matching circuit should be done using the following guidelines:

- Minimize the length of the tracks connecting the ANT_OUT and ANT_IN pads to the matching
- Minimize the length of the tracks between the components
- Use a solid groundplane under the matching circuit area
- Absolutely avoid routing any track under the matching circuit area
- Connect the top ground layer with the ground layer underneath using several vias

Layout drawings (Gerber or other format) are available from Antenova. Please contact your local FAE.

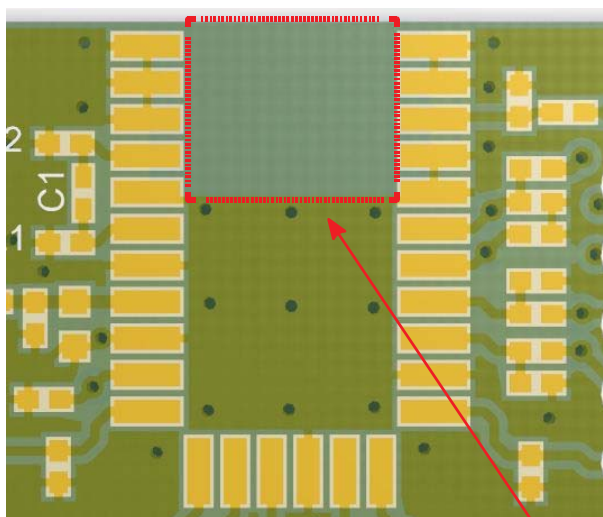


Example of external matching circuit layout

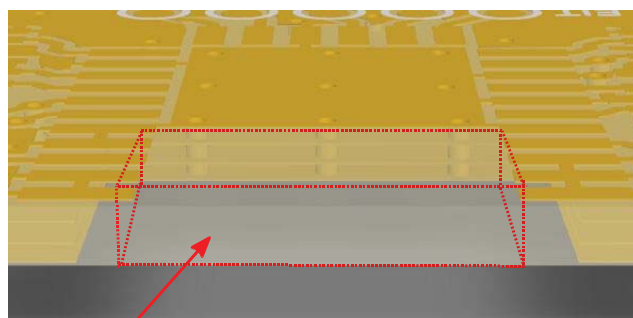
Internal Antenna Clearance

The M10478-A3 module internal antenna requires a small clearance on the host PCB to operate. The clearance means that no Ground or tracks of any kind are allowed to be within this area. This must also be clear through the entire PCB stack up. The minimum area needed clear is 6mm X 4.87mm.

Top view of M10478-A3 Footprint



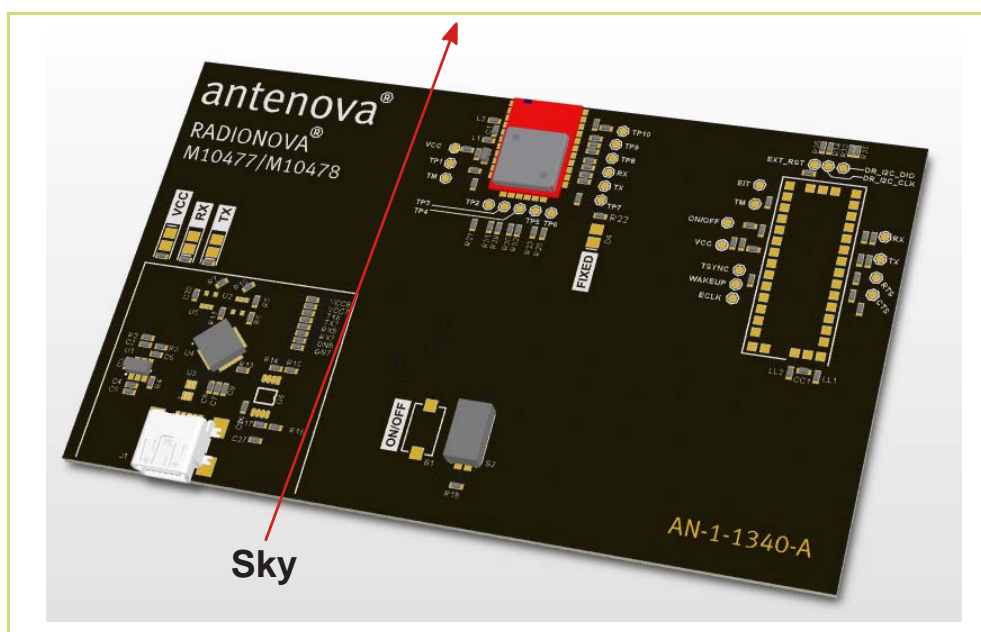
End view - 4 layer PCB stack-up



Keep out area

Typical RF Antenna Module Placement

Note: Module placement locations and orientations are critical for achieving optimal system performance. It is strongly recommended to contact Antenova M2M for design recommendations. Below is the placement shown on the Antenova evaluation PCB.



Front View



Back View

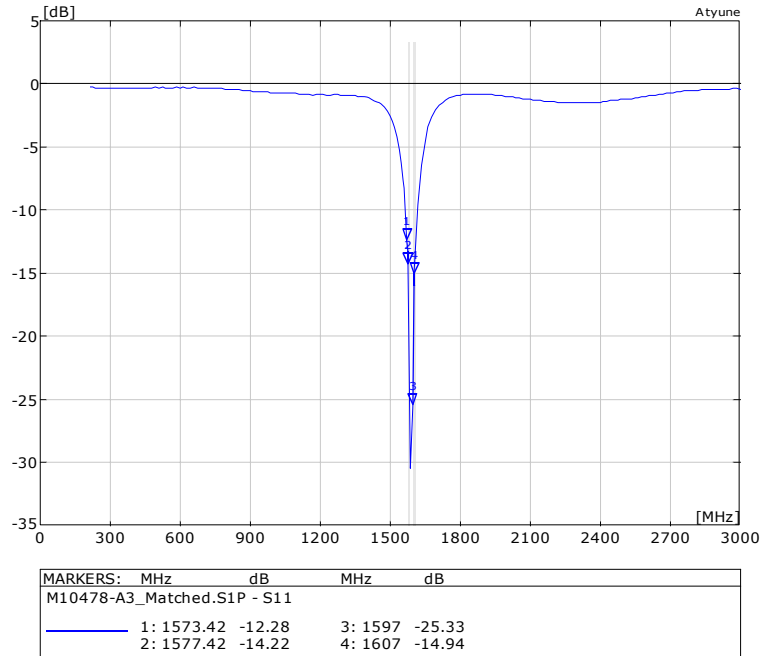


Side View

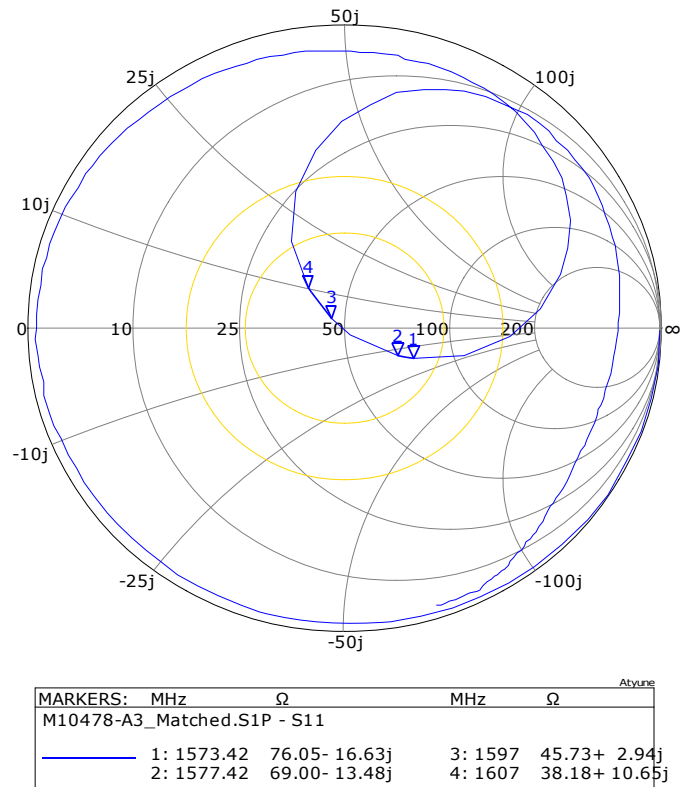


Typical Antenna Matching Results

Typical antenna matching as seen by ANT_IN (Pin 3) is shown in the following plot. The matching bandwidth at -10dB is typically 45MHz. Measured on M10478-U1 test board.

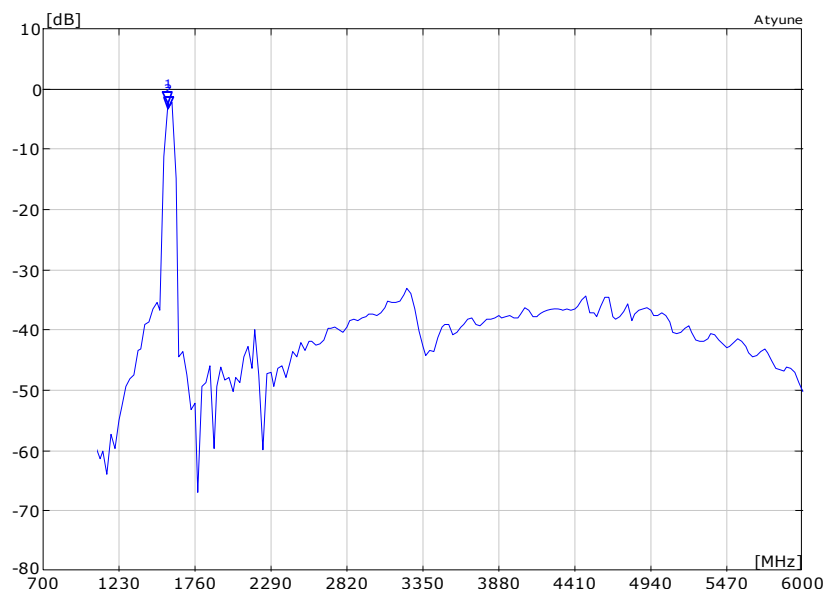


Typical antenna return loss after matching

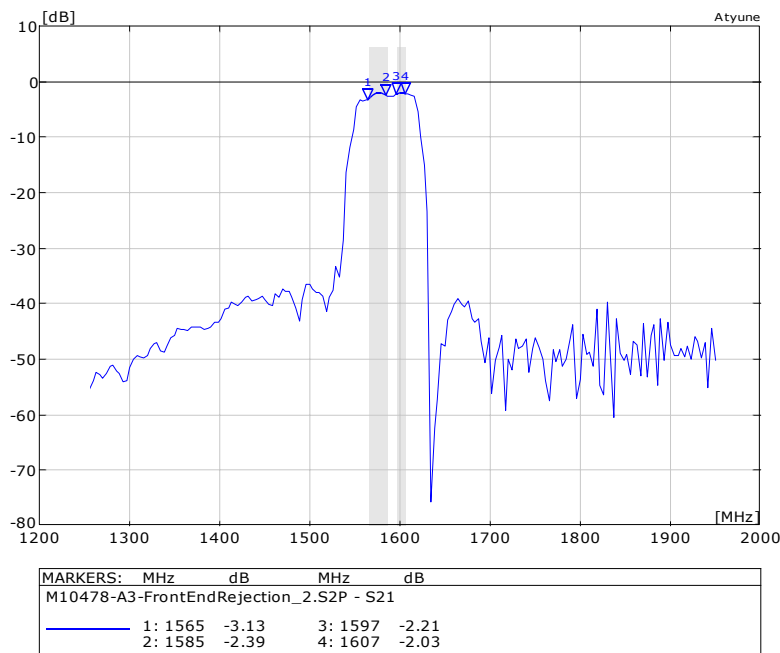


Front-end Rejection

The figure below shows the rejection for the input SAW filter before the RF input, including the effect of pads, tracks and decoupling. The plot can be useful to calculate the isolation required from adjacent transmitters in order to avoid the saturation of the LNA.



Input SAW Rejection - Wideband

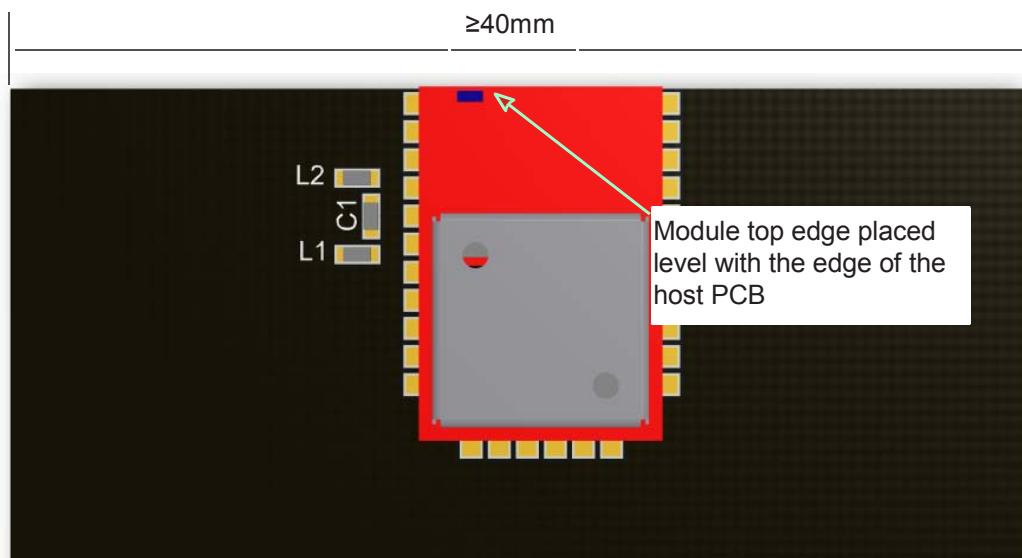


Input SAW Rejection - Narrowband

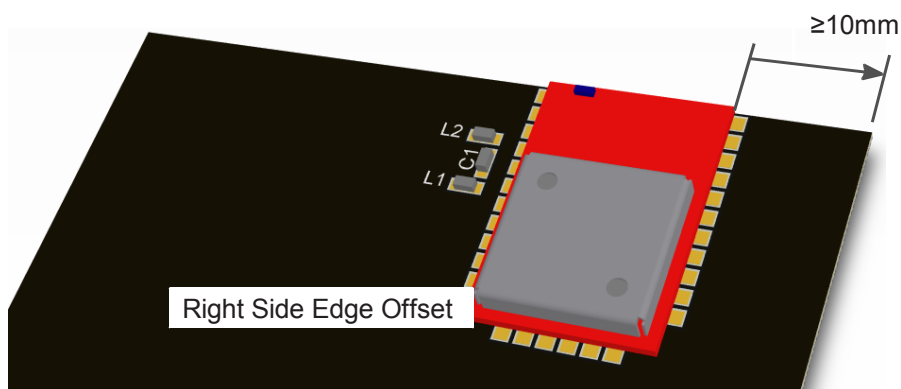
Module Placement Guidelines

Due to the internal antenna, care must be taken when defining the placement of the module on the host PCB. Here are some guidelines that should be used when deciding the position of the module.

- The module top edge must be placed almost level with the edge of the host PCB
- The edge of the host PCB that the module is to be placed at must be a minimum of 40mm in length.

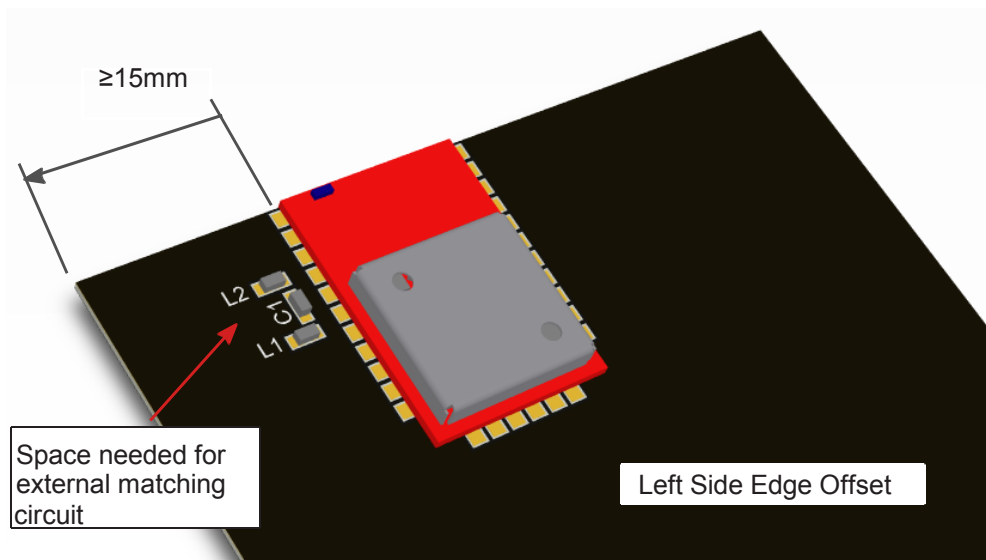


- The central placement of the module is advised. However, an offset placement is also possible.
- For an offset closer to the PCB edge to the right side of the module, a minimum of 10mm distance is required to the edge of the host PCB.

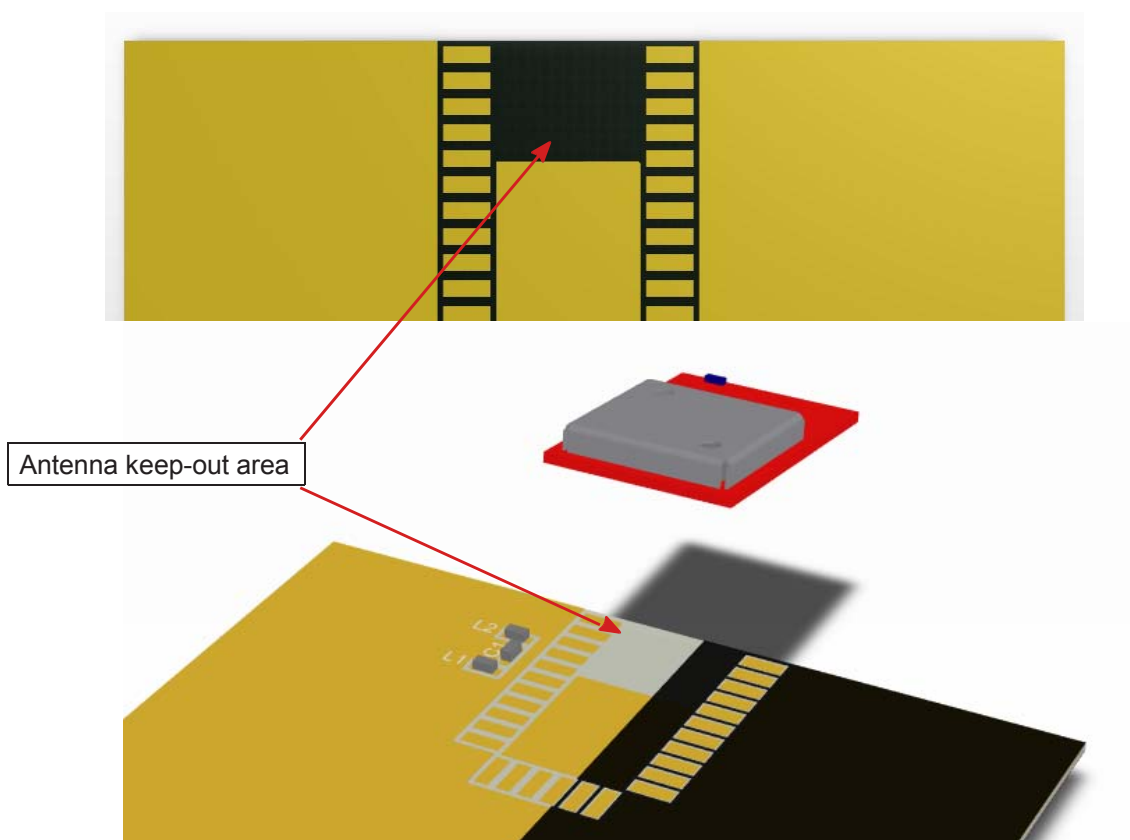


- For an offset closer to the PCB edge on the left side of the module, a minimum of 15mm distance is required to the edge of the host PCB. This additional distance is due to the matching circuit placement.

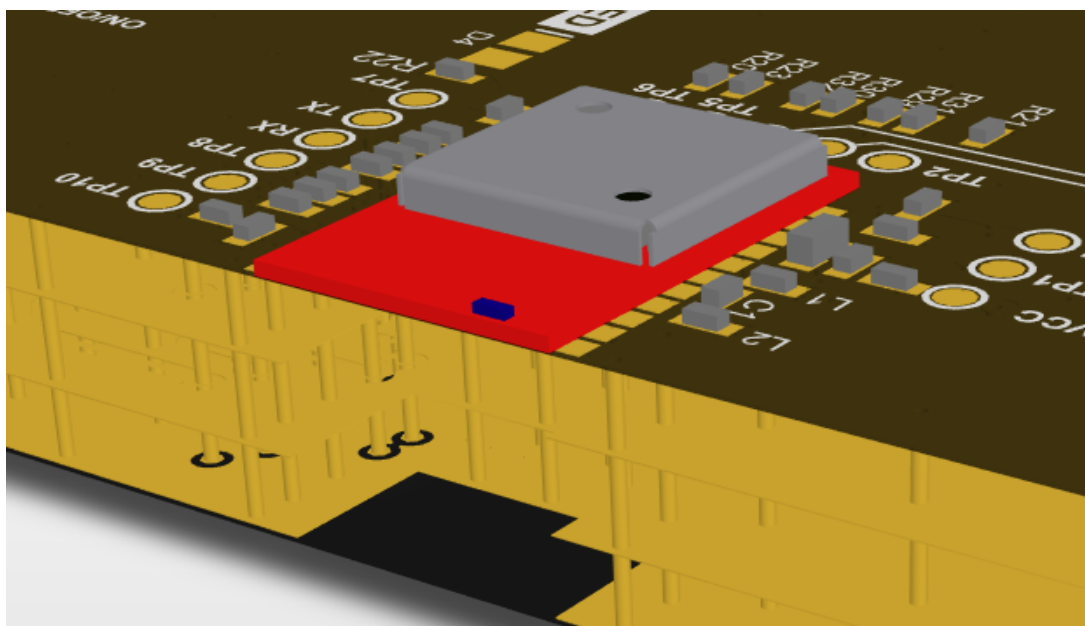
- For an offset closer to the PCB edge to the left side of the module, a minimum of 15mm distance is required to the edge of the host PCB. This additional distance is due to the matching circuit placement.



- The antenna uses the host PCB ground to effectively radiate. As such, a GND plane must be placed on the host PCB on at least one layer.
- In the example below, the only area void of GND is the antenna keep-out area.



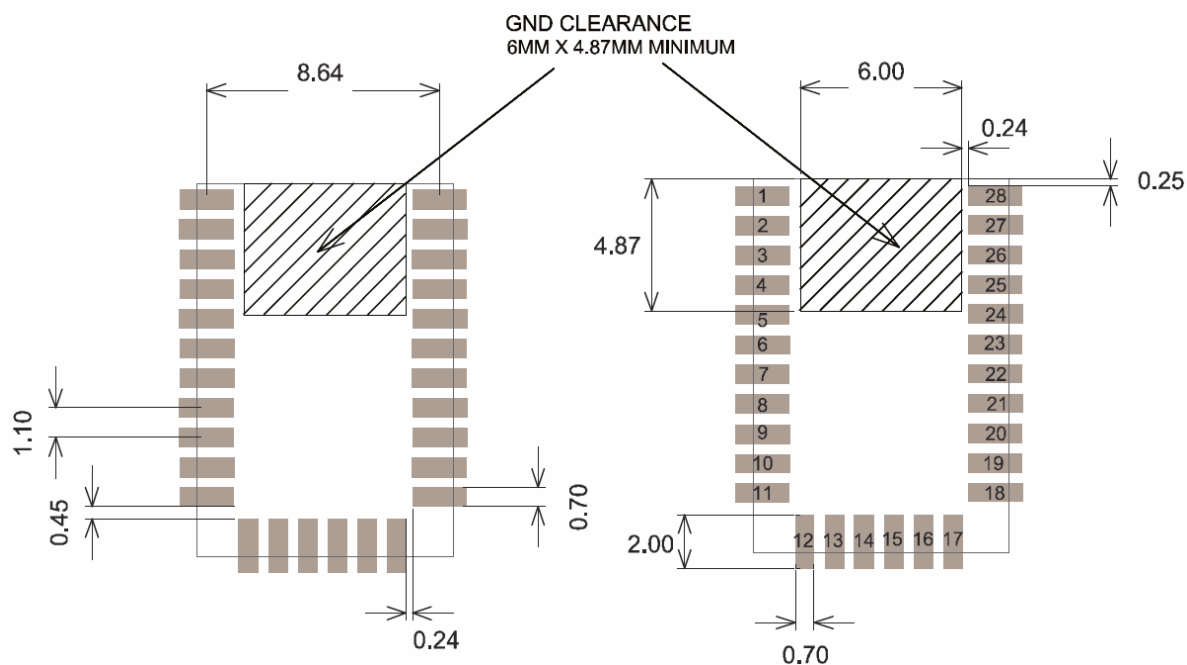
- An ideal stack-up for a host PCB would be to use the top and bottom layers as GND planes, while using the internal layers for any signal and power planes. This not only helps the GPS antenna to perform effectively, but also helps to reduce any potential noise issues that can be associated with mixed signal PCB's.
- An exaggerated example below shows a 4 layer host PCB, GND flooding all available space not used by signals or components.



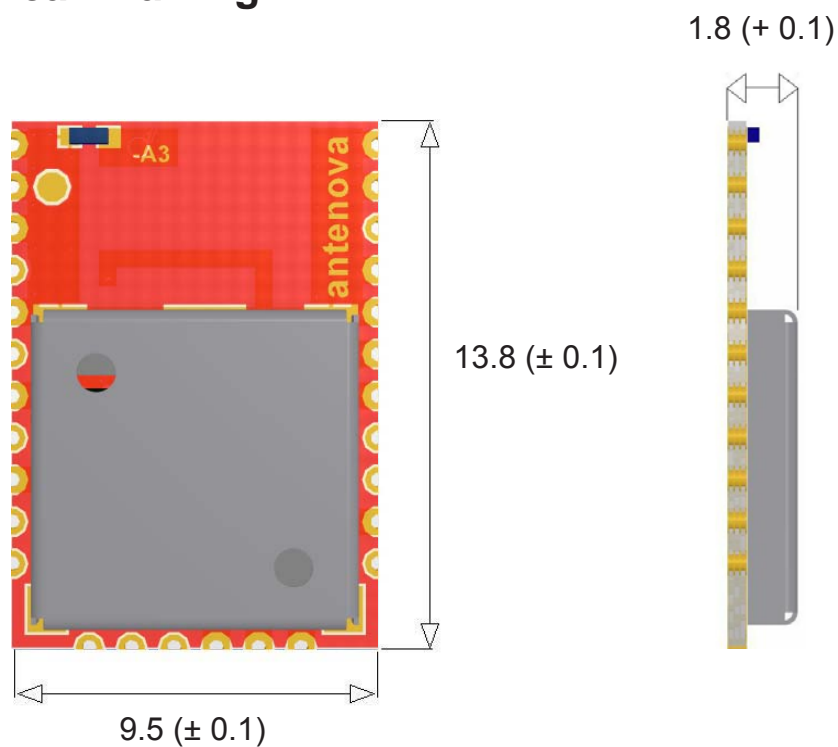
Please contact Antenna M2M for advice on placement.

Below is the recommended footprint for the module. This footprint allows hand soldering.

- All pads are 0.7mm x 2mm
- Pitch is 1.1mm



Mechanical Drawing



All dimensions in mm

Placement

Typical placement systems used for any BGA/LGA package are acceptable. Recommended nozzle diameter for placement: 5mm

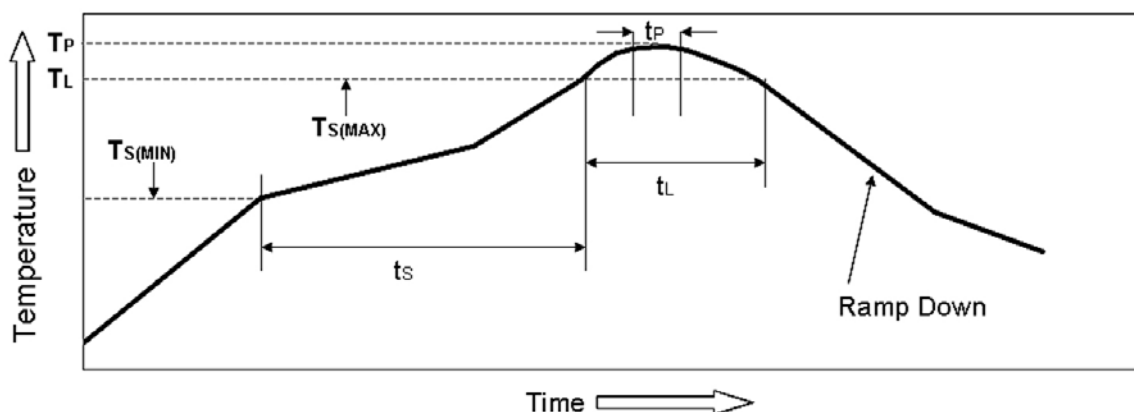
Soldering Paste

Use of “No Clean” soldering paste is strongly recommended, as it does not require cleaning after the soldering process has taken place. An example of suitable soldering paste is Alpha OM350.

Soldering

The recommended soldering profile for M10478-A3 is shown below. However, it is the responsibility of the Contract Manufacturer to determine the exact reflow profile used, taking into consideration the parameters of the host PCB, solder paste used, etc.

| Profile Feature | | Pb-Free Solder |
|---|----------------------------------|----------------|
| Pre-Heat | Temperature (T_s) Min | 130°C |
| | Temperature (T_s) Max | 220°C |
| | Time (t_s) | <150s |
| Reflow | Liquidus Temperature - (T_l) | 220°C |
| | Time (t_l) | 45-90s |
| Peak Package Body Temperature (T_p) | | 245°C |
| Time within 5°C of peak temp (t_p) | | 30s |
| Average Ramp up rate - $T_s(\text{max})$ to (T_p) | | 3°C/s |
| Ramp Down Rate | | 6°C/s max |



Example Reflow profile

The Pb Free Process-Package Peak Reflow Temperature is 260°C.

Exceeding the maximum soldering temperature could permanently damage the module.

Multiple Soldering

The M10478-A3 module can be submitted up to 2 reflow soldering processes.

Upside-down soldering is acceptable but it is recommended that the Contract Manufacturer qualify the process before mass production. The second reflow must take place within the recommended floor life limit (MSL3). Please contact Antenova for further information.

Hand Soldering

Hand-soldering and rework of the M10478-A3 module is acceptable, however care must be taken to avoid short circuits due to the small size of the module pads.

Quality and Environmental Specifications

| Test | Standard | Parameters |
|-----------------------------|--|---|
| PCB Inspection | IPC-6012B, Class 2. Qualification and Performance Specification for Rigid Printed Boards - Jan 2007 | |
| Assembly Inspection | IPC-A-610-D, Class 2 "Acceptability of electronic assemblies" | |
| Temperature Range | ETSI EN 300 019-2-7 specification T 7.3 | -30 °C, +25 °C, +85 °C, operating |
| Damp Heat | ETSI EN 300 019-2-7 specification T 7.3 | +70 °C, 80% RH, 96 hrs, non-operating |
| Thermal Shock | ETSI EN 300 019-2-7 specification T 7.3 E | -40 °C ... +85 °C, 200 cycles |
| Vibration | ISO16750-3 | Random vibration, 10~1000Hz, 27.8m/s ² , 8hrs/axis, X, Y, Z 8hrs for each 3 axis non-operating |
| Shock | ISO16750-3 | Half-sinusoidal 50g, 6ms, 10time/face, ±X, ±Y and ±Z non-operating |
| Free Fall | ISO16750-3 | 1m height, 2 drops on opposite side |
| ESD Sensitivity | JEDEC, JESD22-A114 ESD Sensitivity Testing Human Body Model (HBM), Class 2 JEDEC, JESD22-A115 ESD Sensitivity Testing Machine Model (MM), Class B | +2000V - Human hand assembly +200V - Machine automatic final assembly |
| Shear | IEC 60068-2-21, Test Ue3: Shear | Force of 5N applied to the side of the PCB |
| Moisture/Reflow Sensitivity | IPC/JEDEC J-STD-020D.1 | MSL3 |
| Storage (Dry Pack) | IPC/JEDEC J-STD-033C | MSL3 |
| Solderability | EN/IEC 60068-2-58 Test Td | More than 90% of the electrode should be covered by solder. Solder temperature 245 °C ± 5 °C |

Moisture Sensitivity

Antenova ships all devices dry packed in tape on reel with desiccant and moisture level indicator sealed in an airtight package. If on receiving the goods the moisture indicator is pink in color or a puncture of the airtight seal packaging is observed, then follow J-STD-033 "Handling and Use of Moisture/Reflow Sensitive Surface Mount Devices".

Storage (Out of Bag)

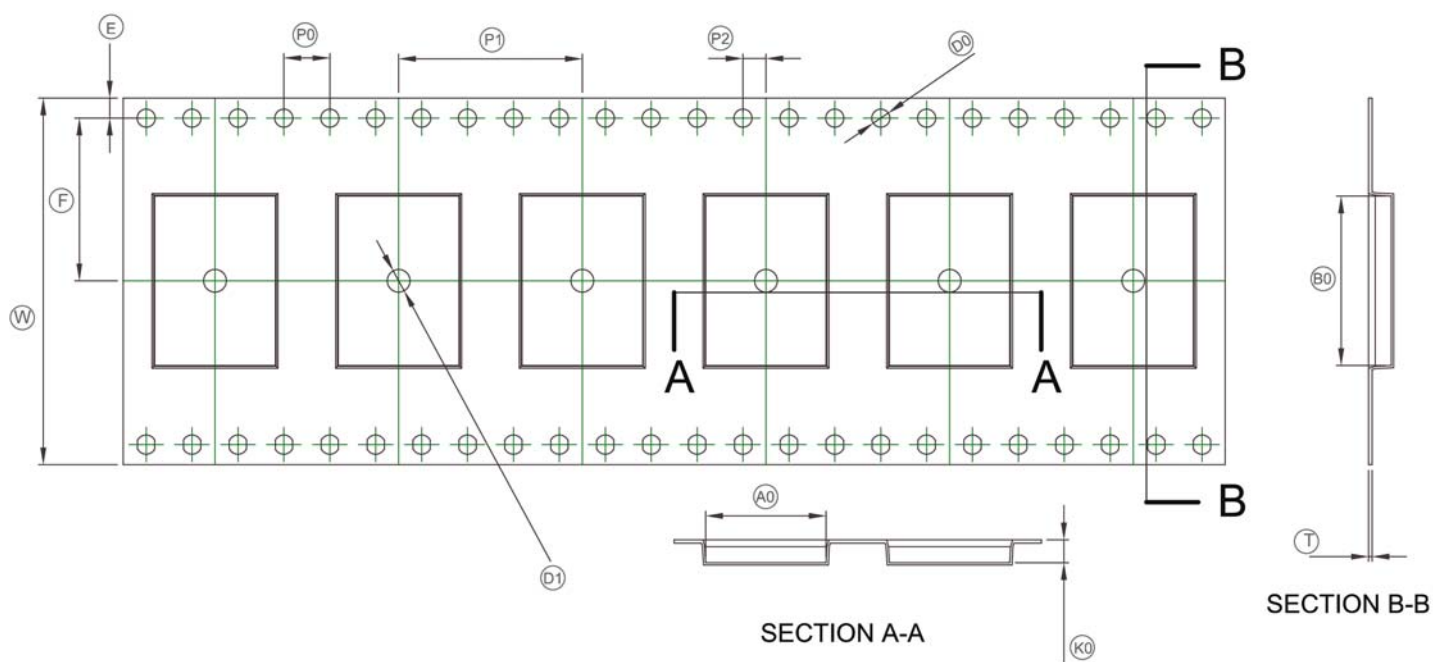
The M10478-A3 modules meet MSL Level 3 of the JEDEC specification J-STD-020D - 168 hours Floor Life (out of bag) ≤30 °C/60% RH. If the stated floor life expires prior to reflow process then follow J-STD-033 "Handling and Use of Moisture/Reflow Sensitive Surface Mount Devices".

Hazardous material regulation conformance

The RF antenna module meets RoHS requirements.

Packaging

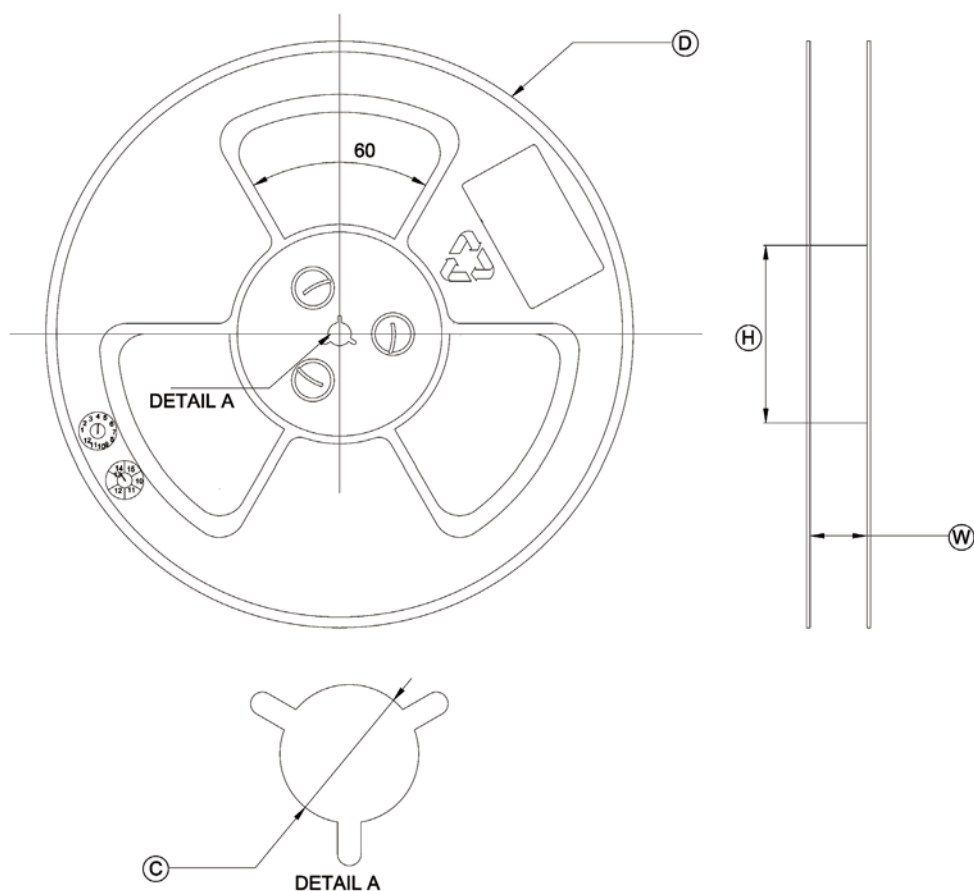
Tape Characteristics



| W | F | E | P0 | P1 | P2 |
|-----------|-----------|----------|----------|------------|----------|
| 32.00±0.3 | 14.20±0.1 | 1.75±0.2 | 4.00±0.1 | 16±0.1 | 2.00±0.1 |
| D0 | B0 | T | K0 | A0 | D1 |
| 1.55±0.1 | 14.80±0.1 | 0.30±0.1 | 2.00±0.1 | 10.50±0.05 | 0.85±0.1 |

Dimensions in mm

| Quantity | Leading Space | Trailing Space |
|-----------------|-------------------------|-------------------------|
| 1000 pcs / reel | 50 blank module holders | 50 blank module holders |



| Width (W) | Reel Diameter (D) | Hub Diameter (H) | Shaft Diameter (C) |
|--------------|----------------------|---------------------|-----------------------|
| 32.0mm | 330.0±2mm | 100.0mm | 13.0+0.2/-0.0mm |



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Certificate No: 4598

Antennas for Wireless M2M Applications