Technical Documentation

0532-DOC-M2M-ASTRO

Astronode S

Datasheet

For feedback or questions: *support@astrocast.com*

Document history

Issue/rev.	Date	Modifications
1/0	26.01.2022	First Release
0/1	01.06.2021	Initial preliminary version

Reference documents

Document name	Document number
Astronode Patch Antenna Datasheet & Integration guide	0534
REACH and RoHS Declaration	0627
APN GNSS Antenna sharing	0558
APN Astronode S low energy guidelines	0559
WP Data handling and security	0619
WP Product homologation with embedded Astronode S	0628
Astronode S MTTF/FIT Prediction Report	0676
RED Declaration of conformity	0646

In this document

This is an information

This is a warning

1 Astronode S overview

1.1 Key features

- Worldwide data communication over satellite:
  - Encrypted data communication
  - 2-level 256-bit AES with unique device key.
  - L-band frequency.
- Built-in RTC
- Low power communication:
  - TX: 76mA.
  - RX: 48 mA.
- Low power mode:
  - Sleep mode: 3.9 uA.
  - Deep sleep mode: 320 nA.
- Power supply: 3.3 V.
- User UART interface.
- Output RF impedance: 50 Ohm.
- Small form factor module:
  - Size: 31 x 35 mm +/- 0.15.
  - Weight: 5.7 gr +/- 0.2.
- Operating temperature: -20°C to 70°C.

1.2 Certifications and approvals

- CE, FCC ID 2A26901001
- RoHS, REACH

1.3 Typical use cases

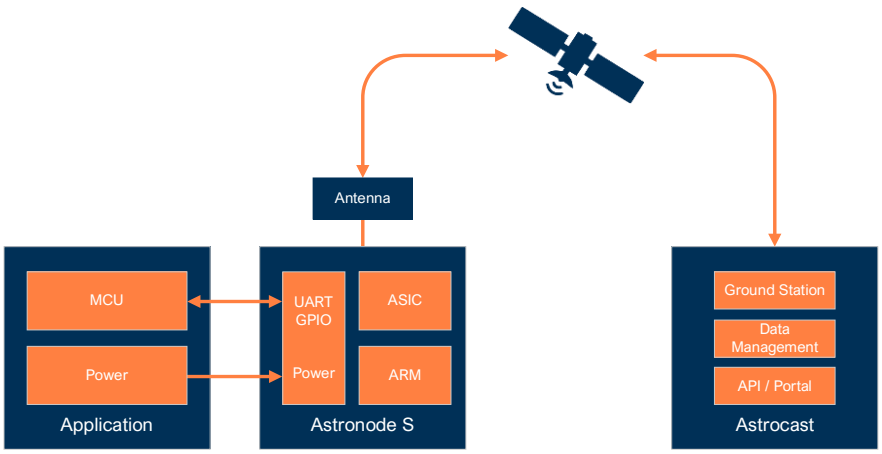
- Maritime
  - Container tracking
  - Fishing buoys
- Agriculture
  - Fuel management
  - Precision farming
- Environment
  - Weather data
  - Flow monitoring

1.4 Description

The Astronode S is a low power satellite communication module designed to connect devices to the Astrocast Satellite IoT network. Based on an ARM Cortex M33 and a proprietary ASIC for the radio part, the module handles bi-directional communication on L-band with the Astrocast satellite constellation.

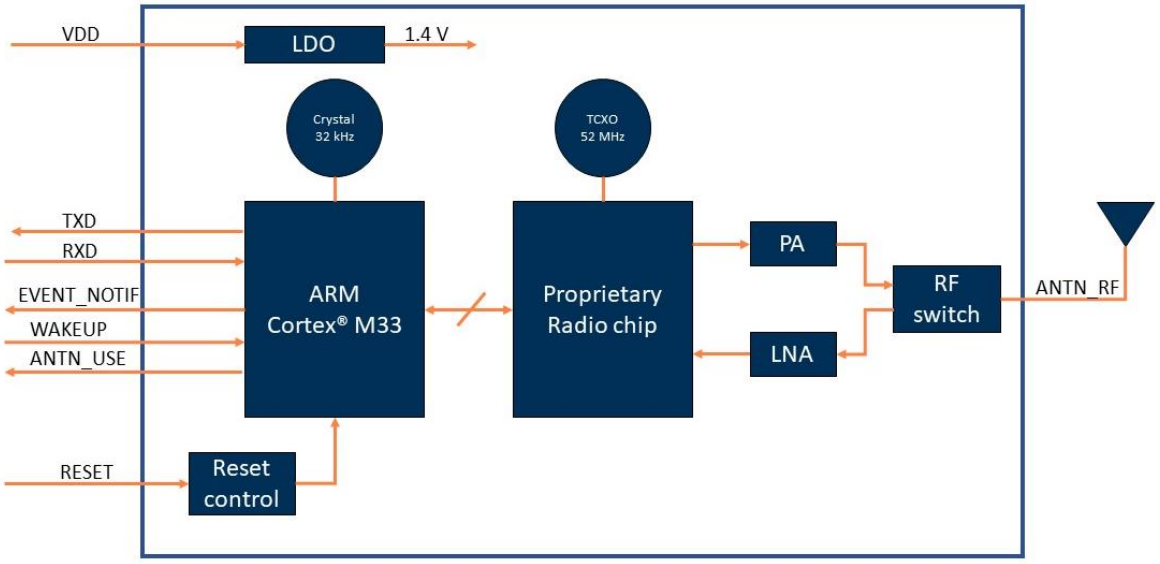
The module's interface consists of a low power UART as well as digital IO lines which enable ultra-low power mode for maximum battery lifetime.

Data can be stored at any time in the Astrocast S' message buffer with up to 8 messages and will be sent automatically on the next satellite pass. Each message features 1 to 160 bytes of payload and will be sent to the Astrocast data management with end-to-end encryption.



1.5 Product Image

1.6 Block diagram



2 Table of content

3 Pinout table

3.1 Pin definition

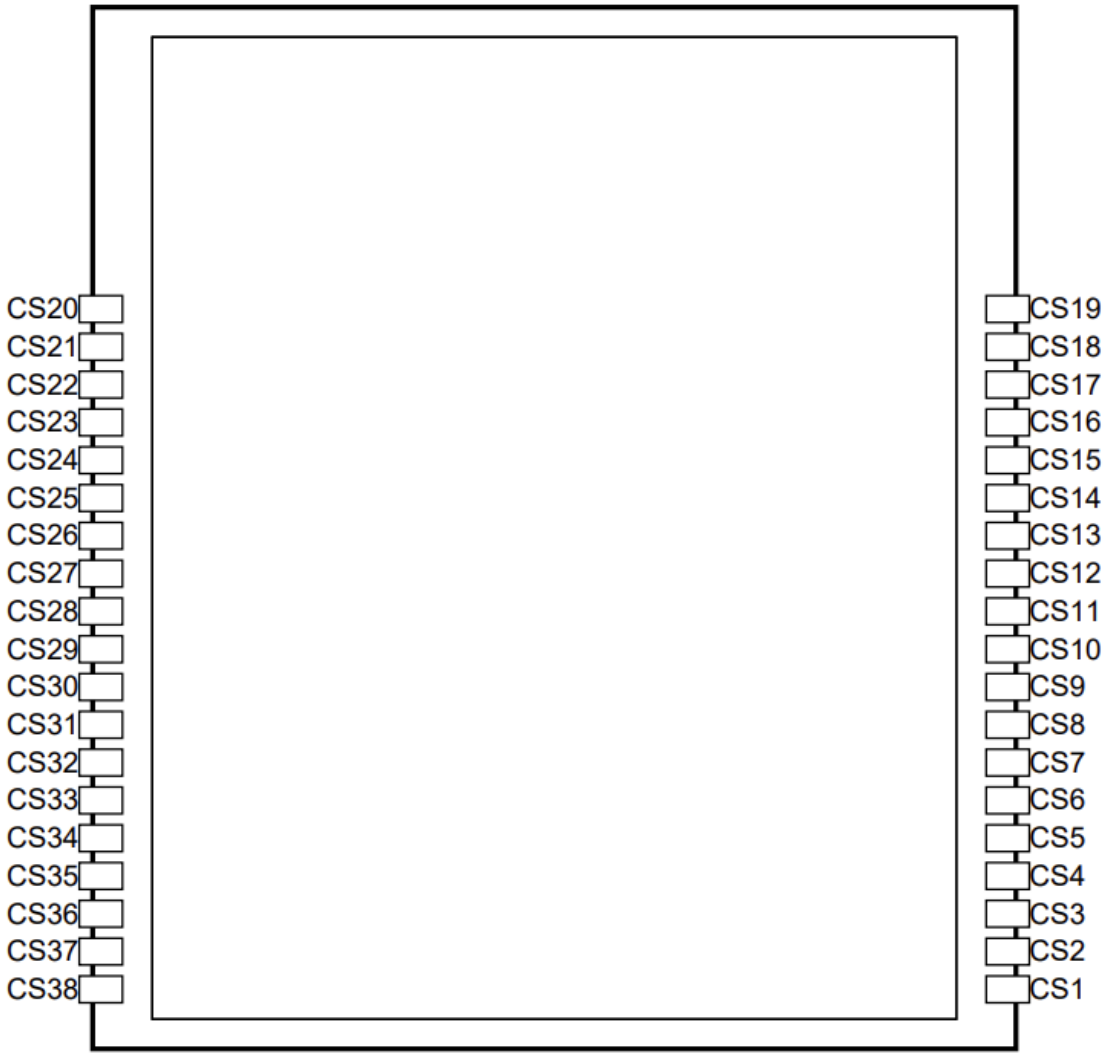


Figure 1- Pin definition – Top view

Pin name	Pin number	I/O type	Description
VDD	CS1	Power	Module power supply
VDD	CS2	Power	Module power supply
TXD	CS10	Output	TX UART of the Astronode S
RXD	CS12	Input	RX UART of the Astronode S
EVENT_NOTIF	CS4	Output	Indicates an event. Internal pull-down of 1Mohm

Pin name	Pin number	I/O type	Description
ANTN_USE	CS6	Output	Indicates when the Astronode S uses the radio. Leave unconnected if unused.
WAKEUP	CS8	Input	Wakeups the Astronode S from low power mode. Internal pull-down of 1Mohm. Leave unconnected if unused.
RESET	CS14	Input	Reset of the Astronode S. Active on rising edge. Leave unconnected if unused.
ANTN_RF	CS17	Output	RF signal 50 Ohm impedance
GND_RF	CS15	Power	RF ground (Internally connected to GND)
GND_RF	CS16	Power	RF ground (Internally connected to GND)
GND_RF	CS18	Power	RF ground (Internally connected to GND)
GND_RF	CS19	Power	RF ground (Internally connected to GND)
GND	CS3	Power	Ground
GND	CS5	Power	Ground
GND	CS7	Power	Ground
GND	CS9	Power	Ground
GND	CS11	Power	Ground
GND	CS13	Power	Ground
GND	CS23	Power	Ground
GND	CS25	Power	Ground

Pin name	Pin number	I/O type	Description
GND	CS27	Power	Ground
GND	CS29	Power	Ground
GND	CS31	Power	Ground
GND	CS33	Power	Ground
GND	CS36	Power	Ground
N.C.	CS24	-	Leave unconnected
N.C.	CS26	-	Leave unconnected
N.C.	CS28	-	Leave unconnected
N.C.	CS30	-	Leave unconnected
N.C.	CS32	-	Leave unconnected
N.C.	CS34	-	Leave unconnected
N.C.	CS35	-	Leave unconnected
RSVD	CS20	-	Reserved
RSVD	CS21	-	Reserved
RSVD	CS22	-	Reserved
RSVD	CS37	-	Reserved
RSVD	CS38	-	Reserved

Table 1 - Pin table

4 Electrical characteristics

4.1 Absolute maximum rating

At GND = 0V and all voltages are referred to the ground (unless otherwise noted)

Symbol	Ratings	Min	Max	Unit
VDD	Main supply voltage.	-0.3	4.0	V
I_{dd}	Main supply current	-	100	mA
Vi	Input voltage at input pins except RST pin.	-0.3	4.0	V
Vi_{rst}	Input voltage at RST pin.	-6.3	6.3	V
$I_{i/o}$	Output current from output pins.	-25	40	mA
Tstg	Storage temperature.	-40	85	°C

Table 2 - Absolute maximum rating

Stresses beyond those listed under Absolute Maximum ratings may cause permanent damage to the device

These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under operating conditions. Exposure to absolute maximum related conditions for extended periods may affect device reliability.

4.2 Operating conditions

At GND = 0V and all voltages are referred to ground (unless otherwise noted).

Unless otherwise specified, typical data is based on
Ta = 25°C, VDD = 3.3V

Unless otherwise specified, the minimum and maximum values are guaranteed in the worst conditions of ambient temperature and supply voltage.

4.2.1 General operating conditions

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
VDD(1)	Main supply voltage	-	3.14	3.3	3.47	V
Vi	Input voltage at input pins except RST pin	-	-0.3	-	VDD+0.3	V

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
Vi_{rst}	Input voltage at RST pin	-	-0.5	-	5.5	V
T_{opr}(2)	Operating temperature	-	-20	-	70	°C

Table 3 - General operating conditions

(1) performance under evaluation, use typical values.

(2) Performances under extreme conditions are under evaluation.

4.2.2 I/O characteristics

Characteristics for I/Os' module except for the RESET pin:

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{il}	I/O input low level voltage.	-	-	-	0.3xVDD	V
V_{ih}	I/O input high level voltage.	-	0.7x VDD	-	-	V
V_{hys}	Input hysteresis.	-	-	200	-	mV
I_{lkg}	Input leakage current.	-	-	-	+/- 100	nA
V_{ol}	Output low level voltage.	$\|I_{i/o}\|$ = 8 mA	-	-	0.4	V
V_{oh}	Output high level voltage.	$\|I_{i/o}\|$ = 8 mA	VDD-0.4	-	-	V

Table 4 - I/O characteristics

4.2.3 Reset pin

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{il}(1)	Reset input low level voltage.	-	-	-	0.6	V
V_{ih}(1)	Reset input high level voltage.	-	0.6	-	1.5	V

Table 5 - RESET pin

(1) Not measured, to be evaluated.

4.2.4 RF characteristics

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
F_{rx}	Rx frequency range.	-	1525	-	1559	MHz
F_{tx}	TX frequency range.	-	1626.5	-	1660.5	MHz
$Pout_{rf}$	RF output power.	-	14	15	16	dBm
Z_{rf}	Output RF impedance.	-	-	50	-	Ohm

Table 6 - RF characteristics

(1) Power range to be defined. The Astronode S modules are currently using $Pout_{rf}$ maximum value.

4.2.5 Power up/down

Symbol	Parameter	Conditions	Min	Max	Unit
t_{vdd}	VDD rise time rate.	-	0	100'000	us/V
	VDD fall time rate.	-	10	100'000	us/V

Table 7 - Power up/down

Do not apply any voltage on I/Os before the VDD.

4.2.6 Current consumption

Those measurements were done on the devkit @ Ta = 25, VDD = 3.3V.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
I_{tx} (1)	TX current.	-	-	76	-	mA
I_{rx} (1)	RX current.	-	-	48	-	mA
I_{active} (1)	Active state current	-	-	7.6	-	mA
I_{idle} (1)	Idle state current	-	-	3.7	-	mA
I_{s} (1)	Sleep mode current.	-	-	3.9	-	uA
I_{ds} (1)	Deep sleep mode current.	-	-	320	-	nA

Table 8 - Current consumption

(1) Disparity under evaluation.

4.3 Timing requirements

4.3.1 Wakeup timings

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
t_{wus}	Wakeup time from sleep mode.	-	-	-	8.5	us
t_{wuds}	Wakeup time from deep sleep mode.	-	-	-	100	ms
t_{wurst}	Wakeup time from a reset.	-	-	-	400	ms

Table 9 - wakeup timings

4.3.2 Reset timings

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
t_{r_hhm}	Minimum high hold time RESET pin.	-	1	-	-	ms
t_{r_lhm}	Minimum low hold time RESET pin.	-	1	-	-	ms

Table 10 - Reset timings

5 Detailed description

5.1 UART protocol

User UART interface configuration:

Parameter	Value
Baud rate	9600 bps
Data bits	8 bits
Stop bits	1 bit
Parity	None
Hardware flow control	None

Table 11 - UART protocol

The RXD pin should never be floating. It must be connected to a device or tied to the ground with a pull-down

If RXD gets some glitches, some dummy read commands can be sent or a reset of the device can be performed with the RESET pin.

5.2 Sleep modes

The Astronode S has two sleep modes, which can be configured with the "Deep Sleep Mode" bit in the configuration register.

Mode	“Deep Sleep Mode” configuration bit
Sleep	0
Deep sleep	1

Table 12 - Sleep modes

Sleep mode is used in the default configuration. The module will automatically enter sleep when it is idle. The wakeup pin is not required in this mode as it will automatically wake up and receive characters on the asset interface UART.

Deep sleep mode can be enabled in the configuration register. In this mode, the module is in a very low power state. To wake up from this mode, the WAKEUP pin must be asserted high, and it takes t_{wuds} (Table 9) before having the UART communication available.

The application note *APN 0559 Astronode S low energy applications* explains which mode to use for the best power savings according to the application

5.3 Event interrupt

The EVENT_NOTIF pin is asserted high by the Astronode S when an event occurs. The pin comes back to low when all events were cleared or unmasked. In the Table 13, there is the lists of events and the way how to clear or unmask them.

Event	Clearing	Unmasking
Message acknowledgement	Cmd: SAK_RR followed by SAK_CR	Cmd: CFG_WR Field: Message Ack Event Pin Mask
Astronode S has reset	Cmd: RES_CR	Cmd: CFG_WR Field: Reset Notification Event Pin Mask

Table 13 - Events

5.4 ANTN_USE pin

The pin ANTN_USE goes high when the Astronode S module is using the antenna. It allows the sharing of the L-band antenna with other application such as GNSS.

The ANTN_USE is asserted during those events:

- During the satellite search phases.
- During the satellite contact phase.

The application note *APN 0558 GNSS Antenna sharing* explains in detail how to organize the shared access to the antenna and the activities of the satellite search and contact phases

5.5 Reset function

The reset is asserted with a rising edge on the RESET pin. The schematic of the system is in Figure 2.

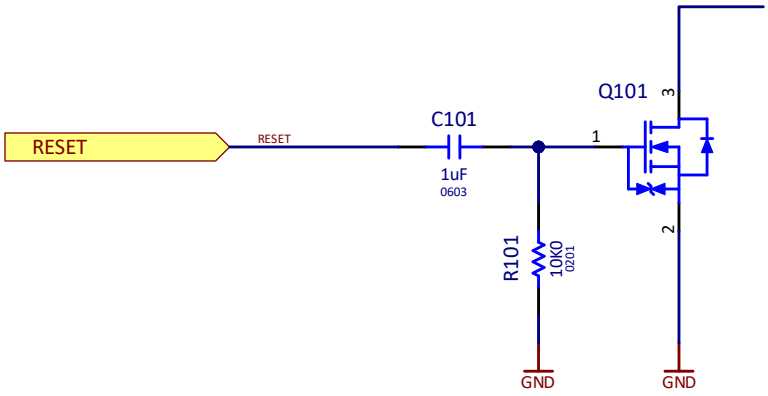


Figure 2 - RESET schematics.

5.6 Power up/down sequence

Power up sequence:

- The power rail VDD must be supplied first before applying any voltage on I/Os of the module. The rise time is limited by t_{vdd} (Table 7).

Power down sequence:

- Before turning down the power rail VDD, all I/Os should not have any voltage applied. The failing time is limited by t_{vdd} (Table 7).

The diagram of the power up/down sequence is shown in the Figure 3.

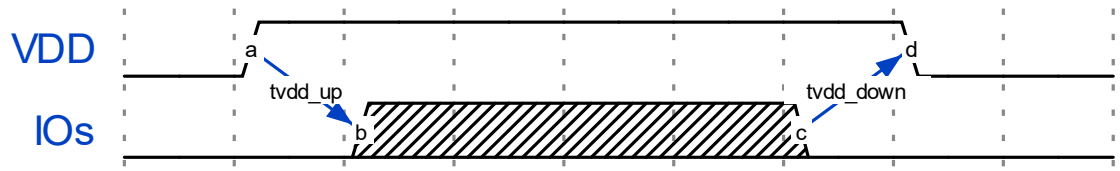


Figure 3 - Power up/down diagram

5.7 Schematics example

Figure 4 shows a schematic example using the Astronode S. It only needs bulk capacitors for VDD. Their values depend on the system design. Two capacitors of 10uF X7R are used on the devkit.

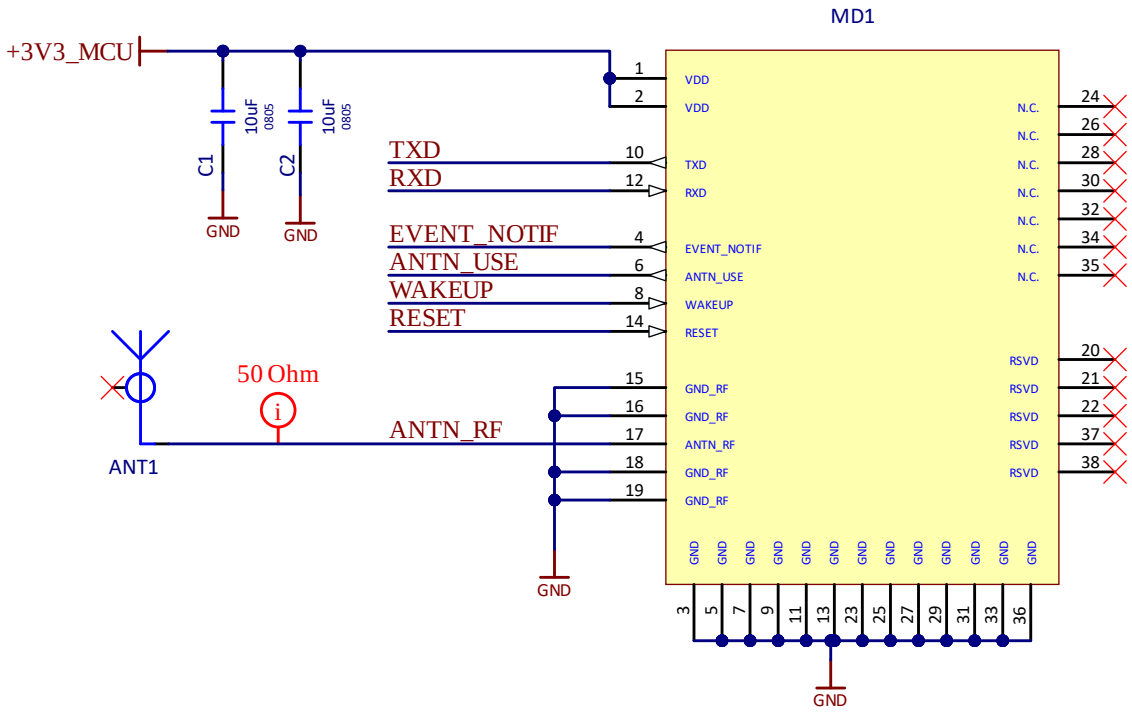


Figure 4 - Astronode S schematic example

5.8 Layout guideline

The layout of the carrier board is important to get the best performance from the Astronode S module. This section assumes that the reader has some knowledge about RF and transmission line design.

5.8.1 RF track design

The insertion loss of the PCB track between the antenna and ANTN_RF (pin CS17) is critical in performance of Astronode S module. This track must be routed as a **50 Ohm transmission line** and must be kept as **short** as possible.

If the carrier board is implemented with FR4, transmission lines longer than 3 cm should be avoided. Rogers laminates with low dissipation factors such as RO4350B are better options for implementing longer transmission lines.

For RF signal integrity and reducing the interference with other signals in the carrier board, use a solid copper plane without any splits under the RF trace. If the carrier board includes an edge connector, route the ground planes to the edge of the PCB to cover underneath the connector.

Figure 5 shows an example of a 4 layers PCB stack up, implemented with FR4 with relative permittivity of 4.1. RF transmission line parameters are calculated using online calculators for coplanar waveguide ground (CPWG). The trace dimension should be checked with the PCB manufacturer.

For a 50 Ohm line in the proposed layer stack, the trace dimension has the following parameters according the Figure 6: S = 900 um, W = 200 um.

#	Name	Type	Thickness	Dk
	Top Solder	Solder Mask	0.01mm	3.5
1	Top Layer	Signal	0.035mm	
	Dielectric 1	Prepreg	0.374mm	4.2
2	Layer 1	Signal	0.035mm	
	Dielectric 2	Core	0.254mm	4.1
3	Layer 2	Signal	0.035mm	
	Dielectric 3	Prepreg	0.374mm	4.2
4	Bottom Layer	Signal	0.035mm	
	Bottom Solder	Solder Mask	0.01mm	3.5

Figure 5 - 4 layers stack-up example

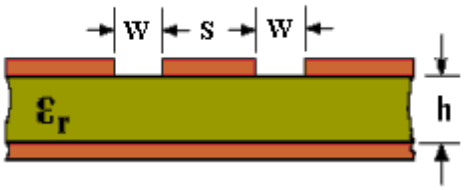


Figure 6 - CPWG

As shown in Figure 7, the top ground planes should be well connected to the ground plane under the RF line using stitching vias close to the edge of the top ground planes. The spacing used on the Astronode S+ product is 1mm. The rule of thumb for via stitching spacing is to keep the spacing shorter than 1/20th of the wavelength of the highest frequency. The signal wavelength can be computed with the following equation.

$$\lambda = \frac{300}{f \cdot \sqrt{Dk}} \ (mm)$$

λ: Wavelength of the signal (mm)

f: Highest frequency of the signal (GHz)

Dk: Dielectric constant of the PCB

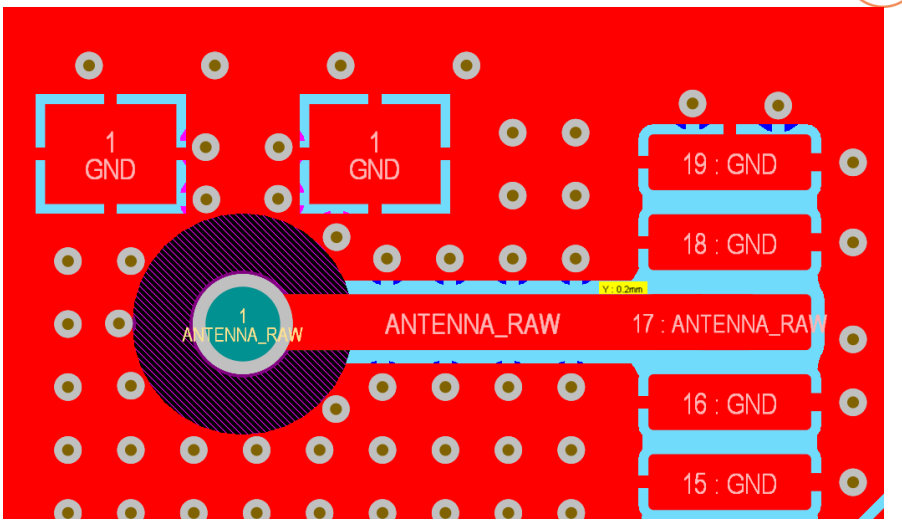


Figure 7 - stitching vias

5.8.2 Carrier board with integrated Patch antenna

A ceramic patch antenna can be mounted directly on the back of Astronode S carrier board. In this case the bottom layer of the PCB should be covered with solid ground plane without any slots or splits. Consider the antenna manufacturer recommendations for the minimum size of the required ground plane. Please refer to the *0534 Datasheet & Integration guide* for the Astronode Patch Antenna integration.

The antenna ground plane should be connected to the transmission line ground plane with multiple vias around the antenna feed connection (Figure 7). For the optimal operation, the feed via should be also designed with a characteristic impedance of 50 Ohm. This can be done by adjusting the clearance of the ground planes in all the layers of the PCB, depending on the diameter and metalized area of the via.

5.8.3 Carrier board with connector

In some applications, RF cable is used to connect the Antenna to Astronode S module. In this case, the cable length and material should be selected so the insertion loss of the cable does not exceed 0.5 dB.

For this configuration, the RF track on the carrier board is terminated with a connector. As shown in the Figure 8, the center pad of the RF connector can be larger than the width of the implemented transmission line. This will create impedance discontinuity which increases the transmission line losses as the larger pad capacitively loads the line.

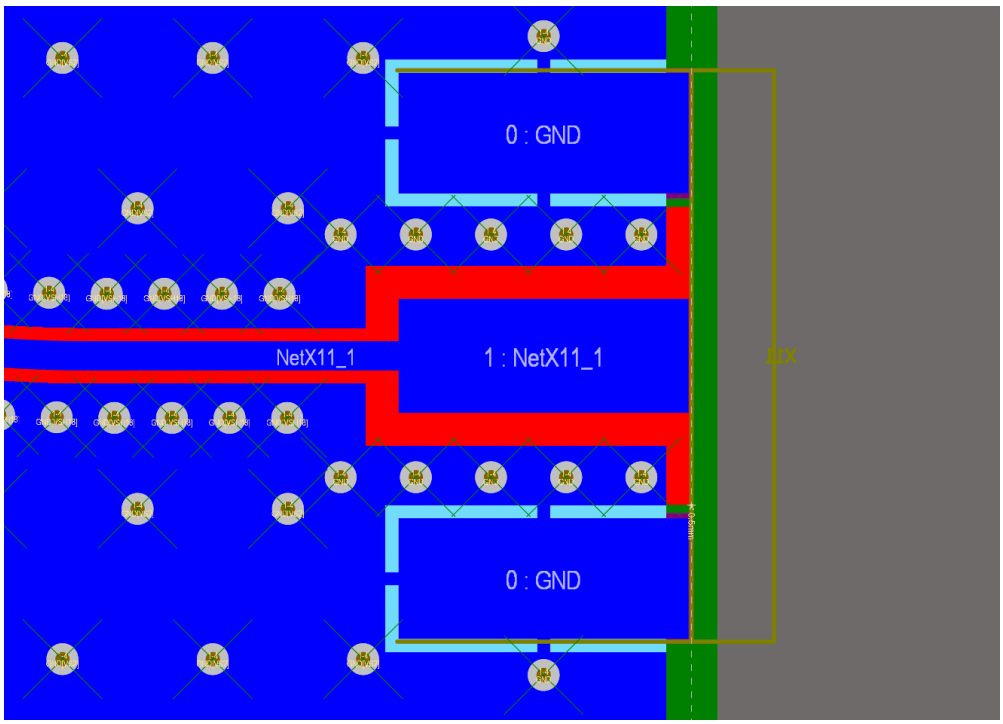


Figure 8 - Impedance discontinuity

To reduce this transition discontinuity, we can consider the RF pad as a short transmission line and try to make characteristic impedance of the pad close to 50 ohms. Depending on the PCB layer stack up, one of the following solutions can be used to reduce the effect of this discontinuity:

- Increase the width of the RF track by increasing the gap width or substrate thickness. This might create another discontinuity in transmission line connection to the Astronode's pad, but the effect of this discontinuity is less significant than connector connection.
- Increase the ground plane gaps between the RF pad of connector and ground. This will mitigate the effect to some extent but might not fully resolve it.
- Remove the ground plane under the connector RF pad and use the next layer as ground plane for RF pad impedance design. The Figure 9 shows this solution. Use multiple vias around the connector to connect the transmission line ground to the connector ground.

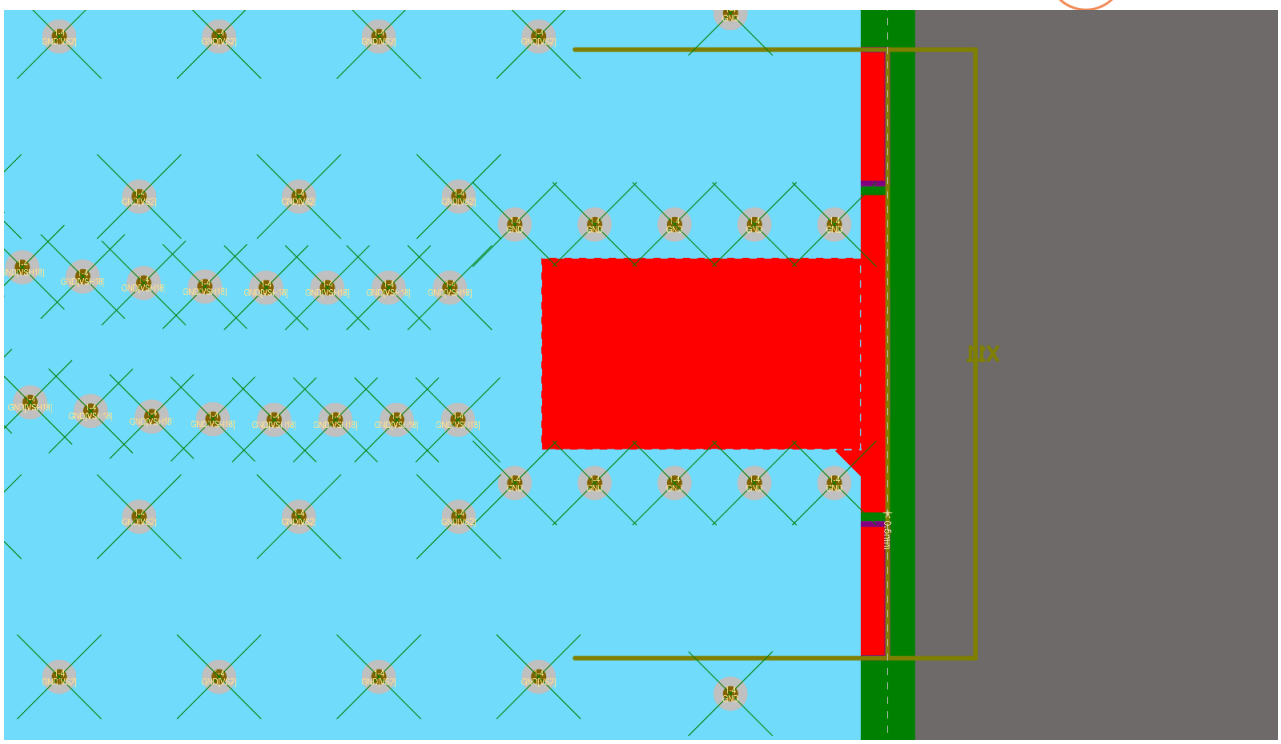


Figure 9 - Removing ground under the RF pad

5.9 Keep out area

There are exposed copper areas underneath the Astronode S. If the Astronode S is directly soldered on the PCB, keep the solder mask under the module.

We do not recommend routing any signal underneath the module to avoid any cross-talk with the signals on the bottom of the module

6 Mechanical

6.1 Mechanical drawing

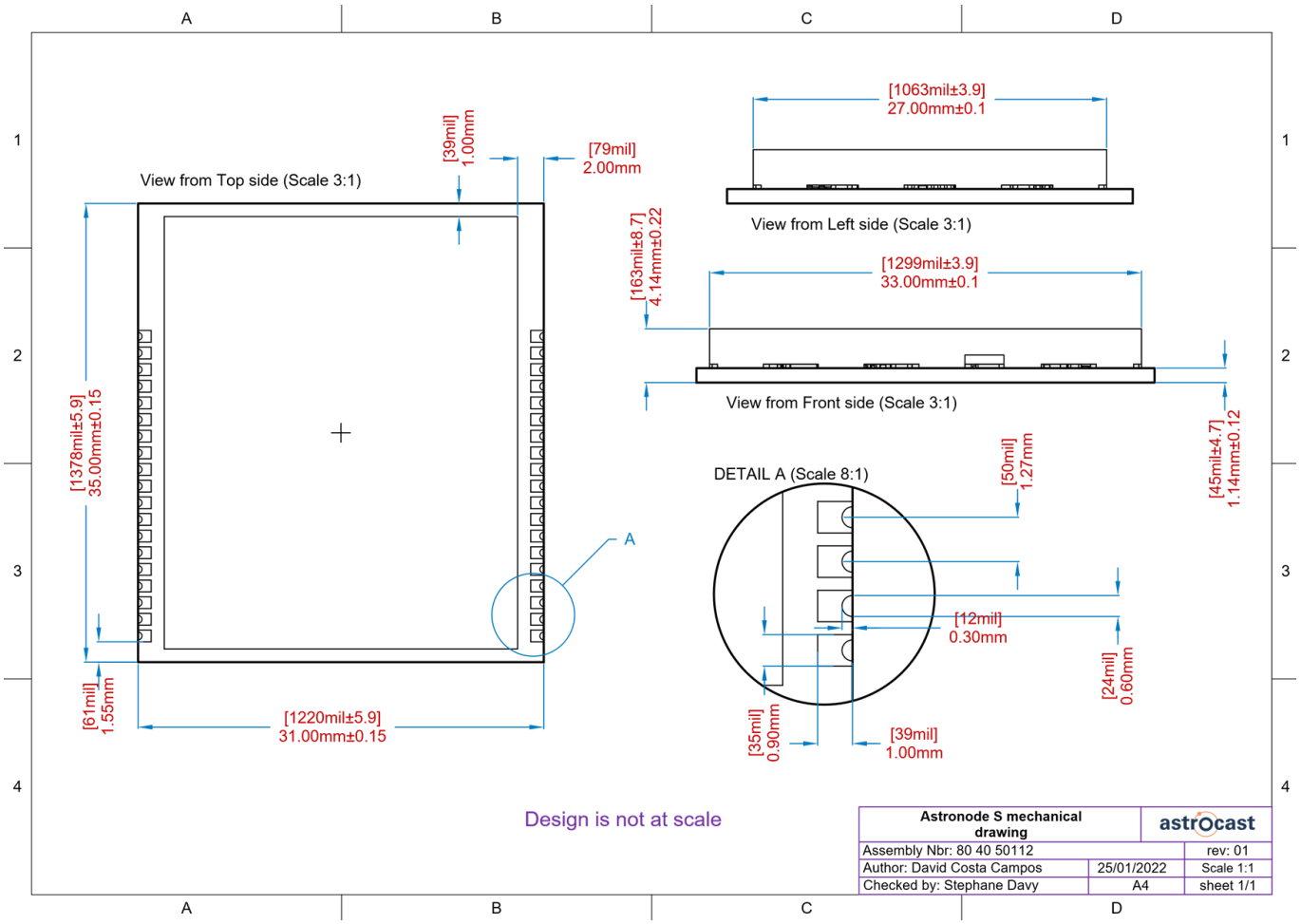


Figure 10 - Astronode S mechanical drawing

6.2 Recommended land pattern

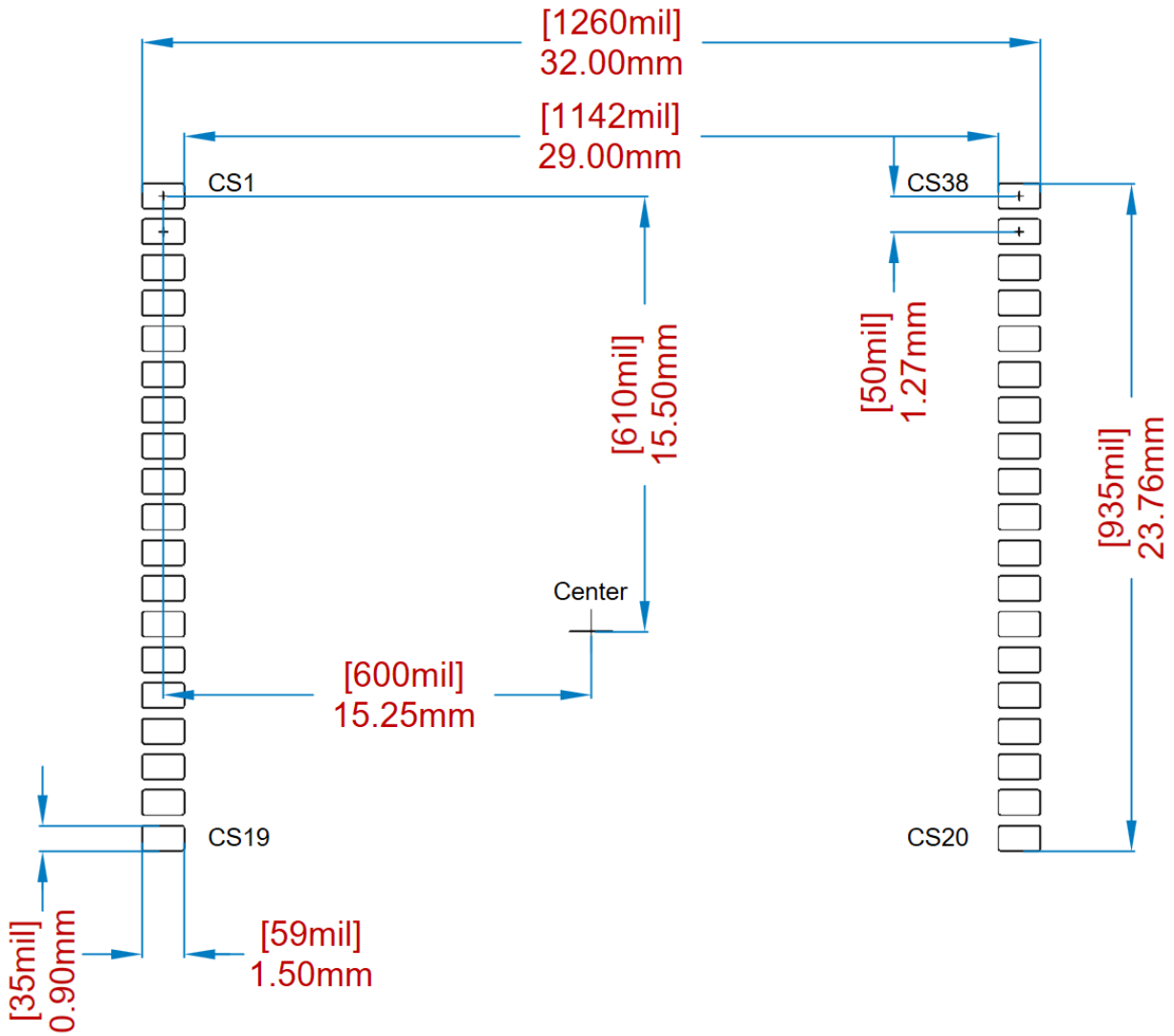


Figure 11 - Recommended land pattern

7 Product handling and soldering

7.1 Soldering Profile

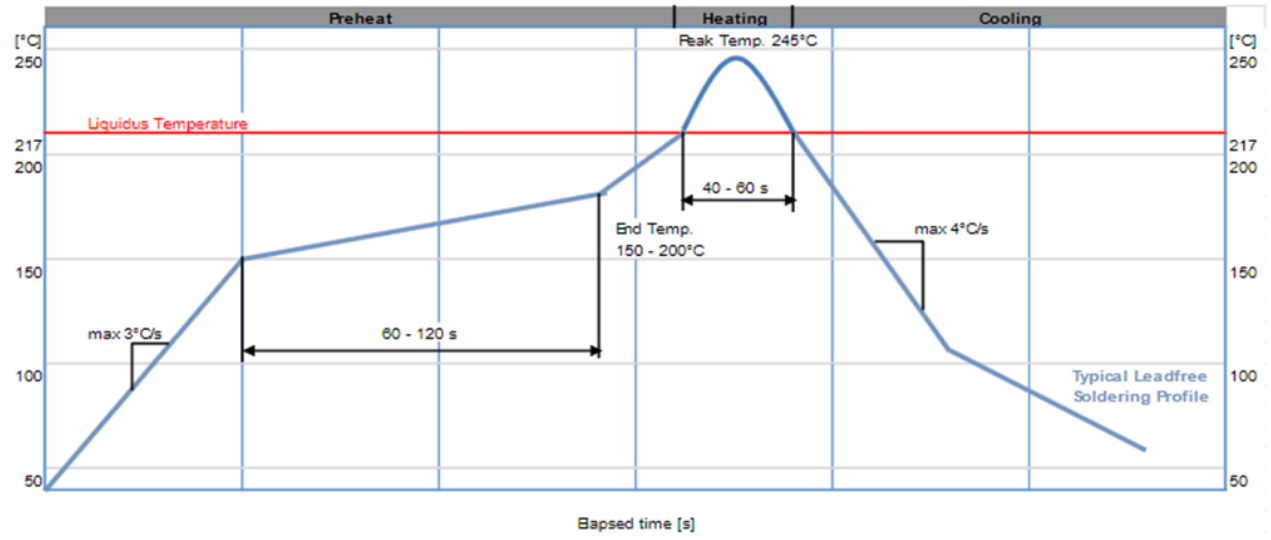


Figure 12 - Soldering profile

Repeated reflow soldering processes and soldering the Astronode S upside-down are not recommended. Boards with components on both sides may require two reflow cycles. In this case, the Astronode S should always be placed on the side of the board that is submitted into the last reflow cycle. The reason for this is the risk of the Astronode S falling off due to the significantly higher weight in relation to other components. For best results, use a "no clean" soldering paste and eliminate the cleaning step after the soldering.

Cleaning the Astronode S is not recommended. Residues underneath the Astronode S cannot be easily removed with a washing process. Cleaning with alcohol or other organic solvents can result in soldering flux residues flooding into areas that are not accessible for post-wash inspections.

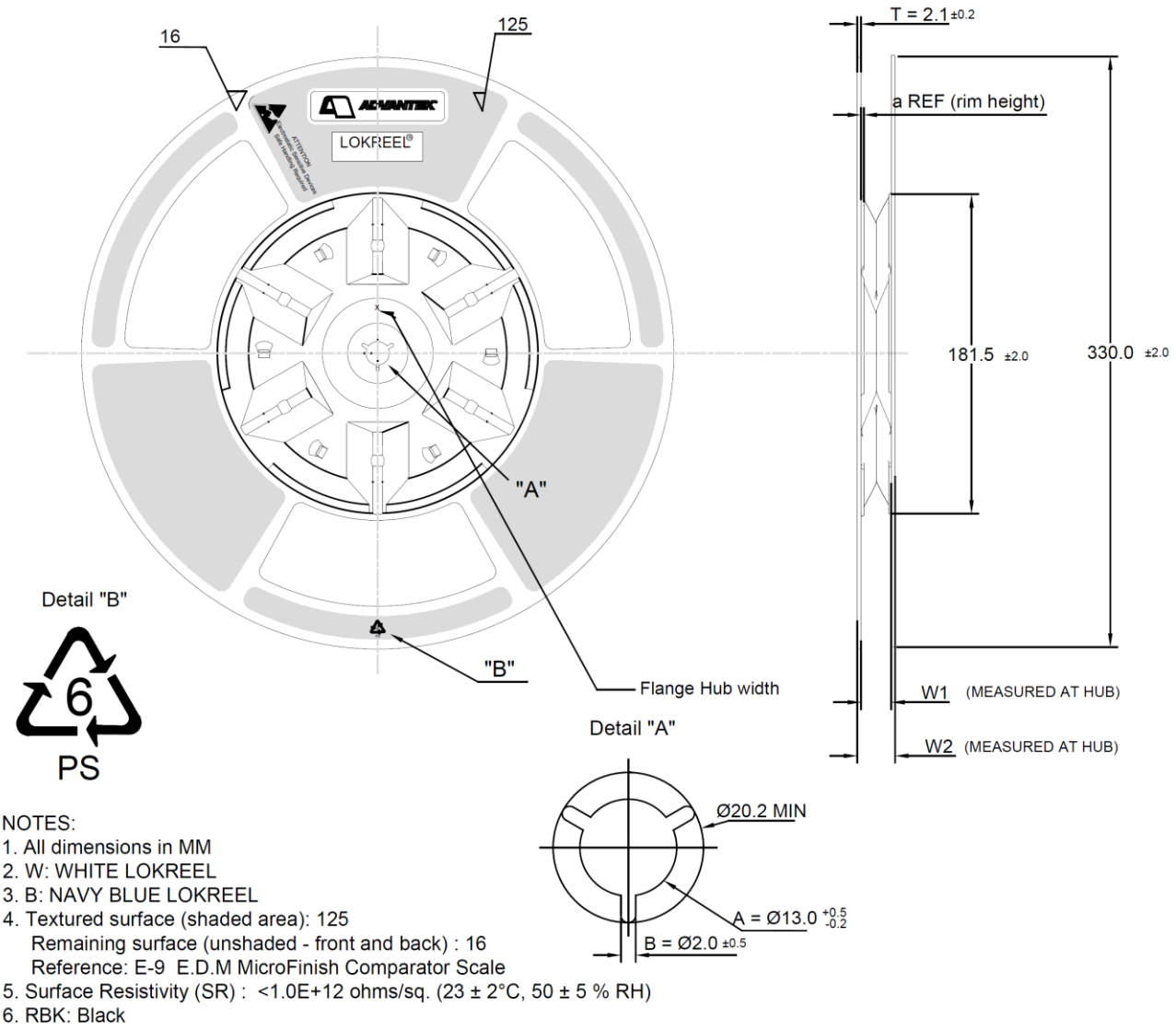
7.2 ESD precautions

Astrocast recommends the product to be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

The Astronode S contains exposed GPIOs which are electrostatic sensitive. Handling the Astronode S without proper ESD protection may destroy or damage it permanently

8 Packaging

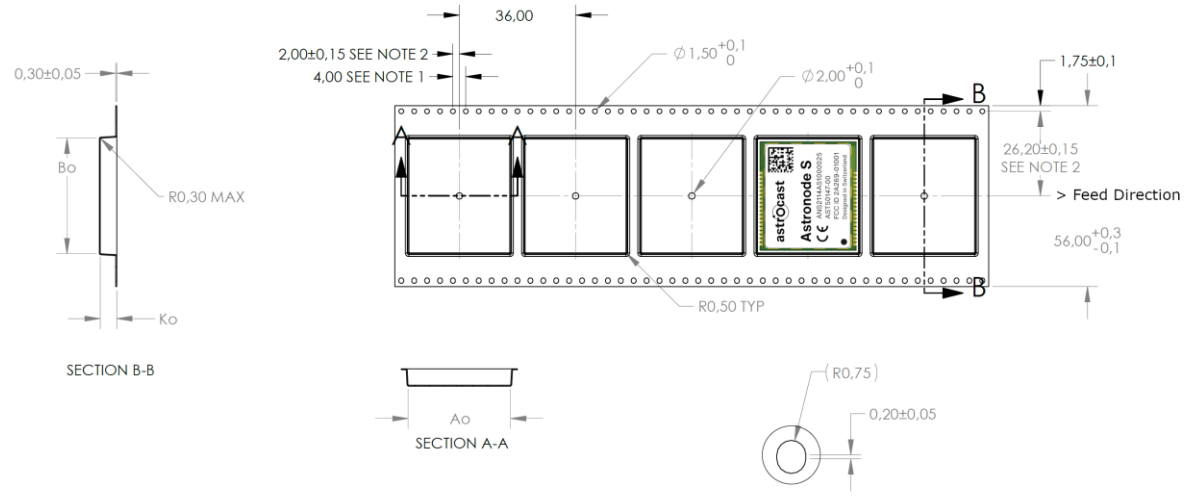
8.1 Reel RL33728RBK



NOTES:
1. All dimensions in MM
2. W: WHITE LOKREEL
3. B: NAVY BLUE LOKREEL
4. Textured surface (shaded area): 125
   Remaining surface (unshaded - front and back) : 16
   Reference: E-9 E.D.M MicroFinish Comparator Scale
5. Surface Resistivity (SR) : <1.0E+12 ohms/sq. (23 ± 2°C, 50 ± 5 % RH)
6. RBK: Black

Parameter	Value	Tolerance / Test Method
Assembled hub width	56mm	-
W1	56.8mm	+0.6mm / -0.4mm
W2 Max	62.2mm	-
Tensile strength	3500PSI	ASTM D 638
Elongation	20%	ASTM D 638
Izod impact strength	11.7KJ/m^2	ASTM D 256
Flexural modulus	280000PSI	ASTM D 790

Parameter	Value	Tolerance / Test Method
Heat distortion temperature	70.6°C	ASTM D 648
Specific gravity	1.06	ASTM D 792
Surface resistivity	≥1.0E5, <1.0E12 Ohms/square	ASTM D 257
Color	Black	-



	DIM	±
Ao	31,80	0.1
Bo	35,80	0.1
Ko	5,10	0.1

NOTES:
1. 10 SPROCKET HOLE PITCH CUMULATIVE TOLERANCE ±0.2
2. POCKET POSITION RELATIVE TO SPROCKET HOLE MEASURED AS TRUE POSITION OF POCKET, NOT POCKET HOLE.
3. Ao AND Bo ARE MEASURED ON A PLANE AT A DISTANCE "R" ABOVE THE BOTTOM OF THE POCKET.

Parameter	Value	Tolerance / Test Method
Overhang Start	400mm	Minimum
Overhang End	160mm	Minimum

8.2 MSL levels

The astronode S module is a moisture sensitive device rated at Moisture Sensitive level 3 (MSL 3) per IPC/JEDEC J-STD-20.

After opening the moisture sealed storage bag, modules that will be subjected to reflow solder or other high temperature processes must be:

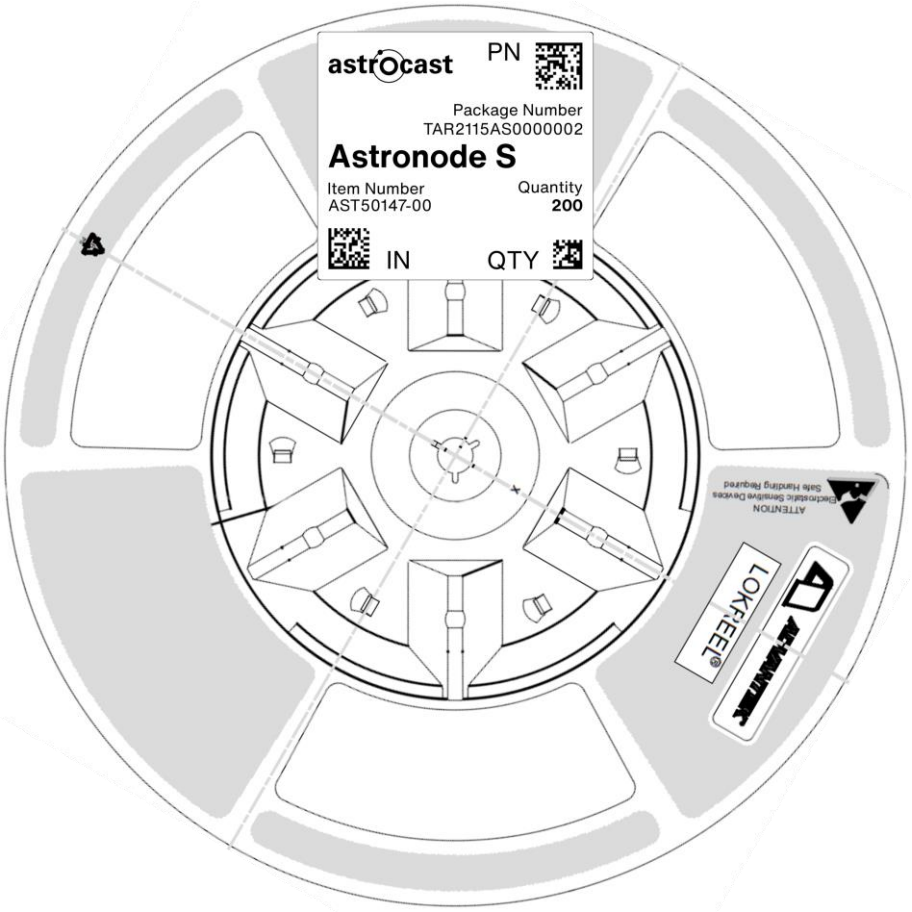
- Mounted to a circuit board within 168 hours at factory conditions (≤30°C and <60% RH)
- Or continuously stored per IPC/JEDEC J-STD-033

Modules that have been exposed to moisture and environmental conditions exceeding packaging and storage conditions must be baked before mounting according to IPC/JEDEC-J-STD-033.

Failure to meet packaging and storage conditions will result in irreparable damage to modules during solder reflow

9 Labelling and ordering information

9.1 Package labelling



1	Package Number in text and Data Matrix format
2	Item Number in text and Data Matrix format
3	Quantity in text and Data Matrix format

9.1.1 Package Number format

T	A	R	Y	Y	W	W	D	D	X	X	X	X	X	X	X
			1		2		3					4			

1	Package date: last two digits of the year
2	Package date: week number of the year
3	Production site
4	Unique identifier

9.2 Product labelling

Figure 13 - Product label

1	Serial Number in Data matrix format
2	Serial Number
3	Item Number
4	FCC ID
5	Pin-1 Marker

9.2.1 Serial Number format

A	N	S	Y	Y	W	W	D	D	X	X	X	X	X	X	X
			1		2		3					4			

1	Production date: last two digits of the year
2	Production date: week number of the year
3	Production site
4	Unique identifier

9.3 Ordering codes

ITEM NUMBER	STATE	DESCRIPTION
AST50147-00	ACTIVE	Astronode S
AST50120-00	EOL	Astronode S preliminary production 2021

10 Certifications

10.1 Qualified antenna

The Astronode S has been qualified with Astronode Patch Antenna from Astrocast (item number: AST50127-00). The required antenna impedance is 50 Ω.

Antenna type	Maximum gain
RHCP patch antenna mounted on PCB	3 dBi

Any antenna of the same general type and of equal or less directional gain as listed in the above table can be used in the regulatory areas that have a full modular radio approval if testing is performed to verify that no performance changes compromising compliance have been introduced. In countries applying the ETSI standards, the radiated emissions are always tested with the end-product and the antenna type is not critical, but antennas with higher gain may violate some of the regulatory limits. Antenna types with more gain than 3 dBi may require a fully new certification. Please consult your test house or notified body.

Astrocast imposes an E.I.R.P of maximum 20 dBm for any product integrating the Astronode S

10.2 CE

The Astronode S is in conformity with essential requirements of the radio Equipment Directive (RED) (2014/53/EU). Please note that the Astronode S is not an end-product. It is on the responsibility of the manufacturer to ensure the compliance.

10.3 FCC

The FCC ID of the Astronode S is 2A269-01001

This device complies with Part 15 of the FCC Rules. Operating it is subject to the following conditions:

1. The device may not cause harmful interference, and
2. The device must accept any interference received, including interference that may cause undesirable operation.

Any changes or modifications not expressly approved by Astrocast could void the user's authority to operate the equipment

10.3.1 Class B device note

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

10.3.2 End product labelling

If the FCC ID of the Astronode S is not visible when it is integrated in another device, the manufacturer must label the following statement in a visible area or with e-label:

"Contains FCC ID 2A269-01001"

10.4 Distance to human body

The minimum distance from the Astronode S+ must be above 20cm.

10.5 Applicable standards

In the Table 14, the list of applicable standards is shown.

	CE	FCC
EMC	EN 301 489-1 v2.2.3:2019-11 EN 301 489-20 v2.1.1:2019-04	Part 15 B
Radio	EN 301 426 v2.1.2:2016-11	Part 25
Safety	EN 62368-1:2014	-
Health	EN 62311:2008	Part 2.1091

Table 14 - Standards list