



AG1 Cardinal Module Design Guide

Part Number: 03-100171-001

Revision: B



****Notice**** Do not attach energized power connectors to Cardinal module. De-energize all power sources before connecting to Cardinal module to prevent damage to electronics. After connections are made, then apply power.

Introduction

The Cardinal Module is a powerful, lightweight module specifically tailored to the needs of the warehouse automation market and Industry 4.0. Designed with automation robots in mind, including collaborative robots, automated storage/retrieval systems, autonomous mobile robots (AMRs), unmanned guided vehicles (UGVs), and more, the Cardinal can enhance your on-the-move connectivity in the most challenging environments. The Cardinal extends the range of traditional Wi-Fi past the limitations of fixed infrastructure using two transceivers having a combined PHY data rate of 1.73 Gbps.

- 2x2 MIMO 802.11 AC Wave2 radios:
 - (1) Dual-band 2.4/5 GHz, 2x2 MIMO transceiver, and (1) 5 GHz 2x2 MIMO transceiver.
- Up to 8 programmable independent ESSID's for client service
- (1) Ethernet 10/100/1000, auto MDI/MDIX, RJ45, 24-48V Passive POE
- (1) USB 2.0 (used for firmware update, zeroize, GPS, Modbus, SCADA, etc)
- (1) 3-pin DC power input jack, 10-53VDC
- (1) 4-pin DC Fan power and control, +5VDC
- (1) Status LED and (1) Zeroize button
- Power consumption - 4.2W (average, idle); 14.4 W (maximum, peak) @ 24V.
- Max RF TX Power: 25 dBm combined 2.4GHz / 23dBm combined 5GHz
- Wi-Fi Access Point mode for compatibility with millions of commercial off-the-shelf Wi-Fi clients and IoT devices such as laptops, tablets, smartphones, IP cameras, sensors, and other IP devices.
- Cyber Secure: Configurable per-hop, per-packet authentication between Modules; multiple cryptographic options; 256-bit AES encryption; and optional MAC address encryption.
- Form Factor: 17.8 x 98.0 x 60.68 mm (0.70" x 3.86" x 2.39") and 90 g ± 3 g (3.2 oz ± 0.1)
- Temperature: Included metal heatsink and RF shield feature allows operation at higher ambient temperature and avoids receiver desensitization due to external RF interference. Ambient/surrounding (operating) -40°C to 60°C (-40°F to 140°F) Ambient/surrounding storage (non-operating) -40°C to 85°C (-40°F to 185°F) Fan recommended for max temp operation in static environments or areas of restricted airflow.

Notice, Cautions and Warnings

****Notice**** The Cardinal module is not a sealed “stand alone” BreadCrumb® and is not meant to be installed in any way exposed to the outside elements. The Cardinal module requires installation inside a protected enclosure, drone, UGV, robot, or cabinet as the module is not sealed from ingress of dust, dirt, or water.

****Caution**** When considering a wearable deployment, care should be taken that Cardinal is not in direct contact with the body, as it can become warm to the touch during increased operation.

****Notice**** The Cardinal module should be installed in an enclosure with sufficient heat dissipation or airflow, as the device will generate heat during times of high-level data processing. The module should be installed in an enclosure with sufficient metal contact with a thermal conductive path to dissipate the heat of the device in operation. A fan is recommended if the ambient air around the module is at or near the limits of the device during operation.

****Notice**** All cables should be secured properly along with the Cardinal module to provide adequate strain relief to protect the sensitive connectors and pins.

****Notice**** Be sure to terminate any unused or disabled RF Ports using a 50 Ohm load to prevent damage to transceivers

****Notice**** Cardinal should not be mounted in close proximity to other RF-generating devices. If other RF-generating devices are adjacent, care should be taken to isolate to a minimum of 10 times the wavelength of the transmitted frequencies to reduce interference potentials.

****Notice**** As per FCC Part 15 178919 D01 Permissive Change Policy v06 “Equivalent antennas must be of the same type (e.g., yagi, dish, etc.), must be of equal or less gain than an antenna previously authorized under the same grant of certification (FCC ID), and must have similar in-band and out-of-band characteristics (consult specification sheet for cutoff frequencies). Any new antenna type, or higher gain antenna, approved under Part 15 requires a Class II permissive change, and the requirements of § 15.203 must be met”.

****Caution**** Do not connect the AG1 Cardinal module to a live power supply

****Notice**** Do not attach energized power connectors to Cardinal module. De-energize all power sources before connecting to Cardinal module to prevent damage to electronics. After connections are made, then apply power.

****Notice**** To avoid possible damage to the Cardinal radio(s), always turn off power to the module before connecting or disconnecting external antennas.

****Notice**** Antennas should not be directly mounted.

****Notice**** While the Cardinal module is not tested for high shock or vibration, care should be taken when mounting the module, its enclosure, and accessories to protect them from unintended high forces.

Notice, Cautions and Warnings (Cont.)

Antennas

Professional Installation Is Required

Professional installation is required for this device and will be performed only by someone knowledgeable of its use. Rajant Corporation will ensure that the device is only marketed and sold to professionals. The device is not sold to the general public and is sold only for industrial or commercial use by professional installers.

****Notice**** Antenna Installation

The installer should configure the conducted output power level according to country regulations and the applicable EIRP limit. Professional installation of equipment is required to ensure compliance with health and safety issues.

****Caution**** Exposure to Radio Frequency Radiation

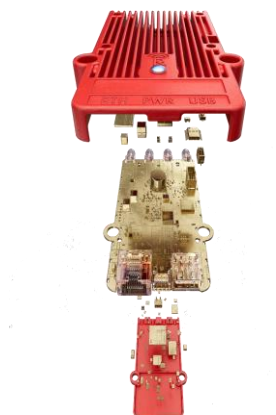
To satisfy RF exposure requirements a minimum safe distance must be maintained between this device's antennas and all persons while the device is operating. The minimum distance for this model is stated in the FCC chapter of this guide.

Required Antenna Separation

AG1 antennas may not be co-located. To satisfy this requirement, each antenna must be installed with a minimum separation distance of 20 cm from the antenna of any other radio frequency transmitter. For installations that will experience vibration or shock, all antennas should be externally mounted and attached using cables. Low loss RF cable is recommended for cable attached antennas. If a radio port is not required for a given application, the port should be disabled in software using BC|Commander, and a 50 Ohm terminator should be installed.

****Notice**** Interference

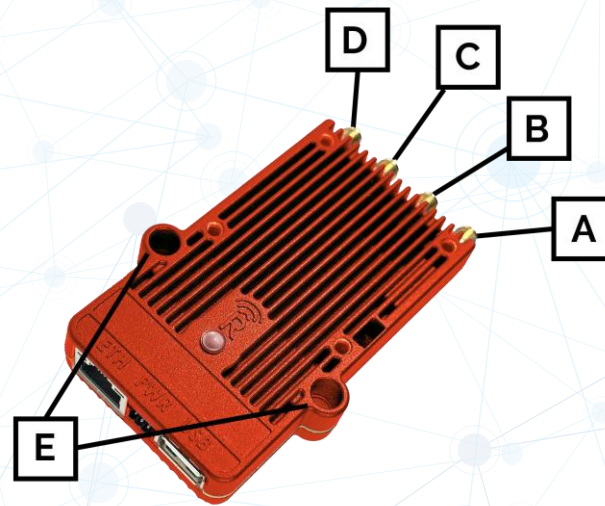
To reduce potential radio interference to other users, the antenna type and its gain should be chosen so that the equivalent isotopically radiated power (EIRP) is not more than that permitted for successful communication.



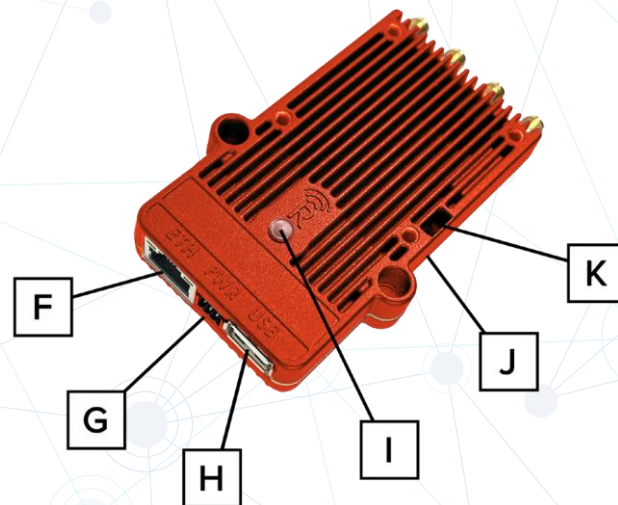
Enclosure Features

The external features of the AG1 Cardinal module enclosure are shown in the following images.

Figure: AG1 Cardinal Module Enclosure Features



- (A) SMA Antenna Port "A" Dual-band 2.4/5 GHz, 2x2 MIMO transceiver wlan0
- (B) SMA Antenna Port "B" Dual-band 2.4/5 GHz, 2x2 MIMO transceiver wlan0
- (C) SMA Antenna Port "C" 5 GHz 2x2 MIMO transceiver wlan1
- (D) SMA Antenna Port "D" 5 GHz 2x2 MIMO transceiver wlan1
- (E) Bolt/Screw Mounting Holes - M6 or 0.25in x 16mm long hole



- (F) RJ45 female connector for Ethernet and PoE (Power over Ethernet)
- (G) 3 Pin Direct DC power connector. Hirose part DF3A-3P-2DS
*Mating connector, Hirose part DF3-3S-2C with crimp pins DF3-2428SC
- (H) USB Type-A female
- (I) Status LED (RGB) - status, warning, error codes, and link state *Refer to User Guide
- (J) Zeroize - Pinhole metal cutout for inset pushbutton switch, on bottom side
- (K) Fan connector - 4-pin connector for Fan power and control (optional)

Mounting Guidelines

****Notice**** The Cardinal module is not a sealed “stand-alone” BreadCrumb and is not meant to be installed in any way exposed to the outside elements. The Cardinal module requires installation inside a protected enclosure, drone, UGV, robot, or cabinet as the module is not sealed from ingress of dust, dirt, or water.

- The Cardinal module should be mounted securely in an enclosure with sufficient metal contact with a thermal conductive path for heat dissipation and/or provide ample airflow as the device will generate heat during times of high-level data processing. A fan is recommended if the ambient air around the module is at or near the limits of the device during operation. All cables (RF and Power) should be secured with strain relief.
- Cardinal should not be mounted in close proximity to other RF-generating devices. If other RF-generating devices are adjacent, care should be taken to isolate to a minimum of 10 times the wavelength of the transmitted frequencies to reduce interference potentials.
- Cardinal may be used indoors in open air with as much surface exposed as possible to maximize airflow.

Power Guidelines

The Cardinal module utilizes two possible power sources. Either by Passive PoE or direct DC Power. The Direct DC Power connector is field installable.

****Caution**** Do not connect the AG1 Cardinal module to a live power supply

Input Voltage Eth Port: 24v – 48v Passive PoE

It is important to note that Cardinal Module needs a Clean DC power source. Voltage spikes will damage the module. The use of a power conditioner will be needed to protect the module.

When connecting to a DC power source a 3-amp inline fuse should be installed near the power source.

Clean Direct DC Input Voltage Requirements:

- 10 to 53v VDC Absolute, 12/24/48 VDC Nominal
- Input Load Regulation < 5% (of nominal supply)
- Input Ripple and Noise < 1% (of nominal supply)
- Startup Delay based on minimal input voltage threshold of 10VDC
- Minimum Startup Load of 4W
- Input Isolation of 1500VDC typical
- DC Power Input is reverse bias protected but not reverse operational

Both Ethernet and DC power cables should be secured with strain relief near the Cardinal module to prevent damage from vibration or other movement.

Below are instructions for installing the 3-pin direct DC connector. The instructions below show how to setup a quick direct DC power using an AC/DC transformer. However, the instructions apply to other Direct DC connections.

DC Power Connector Assembly Instructions:

- Note the location of the Positive wire – The one with white-dashed line
- Add DF3-crimp pin to the Pos and Neg wires, using an appropriate crimp-tool (DF3-TA2428HC or equivalent)
 - If crimp tool is not available soldering on the pins and manually crimping them is acceptable
- Slide a 1-inch piece of 3/32 inch heat-shrink-tubing onto the power wire
- Insert the appropriate crimped wires into the DF2-3S-2C connector, noting where Pin-1 is (notch)
- See chart below (1-Pos, 2-NC, 3-Neg) (Connect the crimped-wire with white-dashed line to Pin-1 Pos)
- Slide heat-shrink tubing into place and apply appropriate heat to shrink it down



AC Adaptor BOM: 22-100042-001

QTY	Rajant PN	Name	MFG	MFG PN
1	87-100026-001	AC Adapter, 24.0DCV, 1000mA	Triad Magnetics	WSU240-1000-R
1	71-100126-001	Conn, 2MM Receptacle Housing, 3 POS Crimp	Hirose	DF3-3S-2C
1	73-100108-001	Pin, Crimp-Tin, 24 - 28 AWG DF3	Hirose	DF3-2428SC
2	89-100085-002	Heat-Shrink-Tubing - 1/16 Inch Dia. 1/4 Inch	Quaktek	Q2-Z- RK1-1/16-01-6IN-36 (or Equiv)
1	89-100085-005	Heat-Shrink-Tubing - 3/16 Inch Dia. 1 Inch	Quaktek	Q2-Z-RK1-3/16-01-6IN-24 (or Equiv)

Antenna Guidelines

****Notice**** As per FCC Part 15 178919 D01 Permissive Change Policy v06 “Equivalent antennas must be of the same type (e.g., yagi, dish, etc.), must be of equal or less gain than an antenna previously authorized under the same grant of certification (FCC ID), and must have similar in-band and out-of-band characteristics (consult specification sheet for cutoff frequencies). Any new antenna type, or higher gain antenna, approved under Part 15 requires a Class II permissive change, and the requirements of § 15.203 must be met”.

Rajant has certified Cardinal under FCC part 15 with the following Rajant antennas, to permit maximum power high performance use, and minimal footprint dual-band dual-port MIMO use:

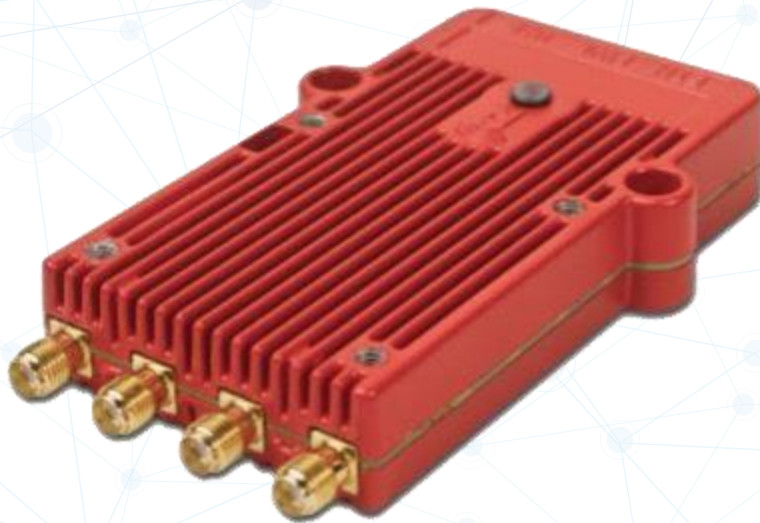
KMA-2400-5-NM -- Vertically Polarized Dipole, Omni-Directional, 2.4-2.5GHz, 5dBi
 KMA-5800-6-NM -- Vertically Polarized Dipole, Omni-Directional, 5.7-5.9GHz, 6dBi
 KMA-5250-7-NM -- Vertically Polarized Dipole, Omni-Directional, 5.15-5.35GHz, 7dBi
 RLP-2450-5-4-SM (PUCK-12) -- Vertically Polarized, Omni-Directional, 2.4-2.5/5.0-7.2GHz, 5dBi
 The maximum gain certified is 7db

If Cardinal is deployed with one of the antennas certified by Rajant or with an alternate Rajant approved antenna which is of the same type and equal or lesser gain, Rajant’s modular certification may be leveraged. With this approach, the final product should only require FCC Digital emissions testing: Part 15B. Otherwise, you will have to complete radio certifications for every country you deploy Cardinal in.

Unlike most Rajant BreadCrumb products, the Cardinal module utilizes standard SMA female type antenna connectors rather than N type connectors. The Cardinal module does not use RP-SMA type connectors.

This needs to be taken into consideration during the installation of coax as these connectors are more susceptible to damage. Coax should be secured with strain relief near the Cardinal module to prevent damage from vibration or other movement.

****Notice**** Be sure to terminate any unused or disabled RF Ports using a 50 Ohm load. See link below.



<https://www.amazon.com/Coaxial-Terminators-Connector-Terminator-Termination/dp/B07G2PBZBL>

FCC Compliance Statement

FCC:

FCC ID: VJA-AG15250M

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions:

- (1) This device may not cause harmful interference, and
- (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

NOTE:

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the device is operated in a commercial environment. This device generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with this instruction manual, may cause harmful interference to radio communications. Operation of this device in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at their own expense.

This device must be installed and operated with a minimum distance of 20 cm between the radiator and user body.

Industry Canada (IC):

This Class A digital apparatus complies with Canadian ICES-003 and RSS-210 rules.
Cet appareil numérique de la classe A est conforme à la norme NMB-003 et CNR-210 du Canada.