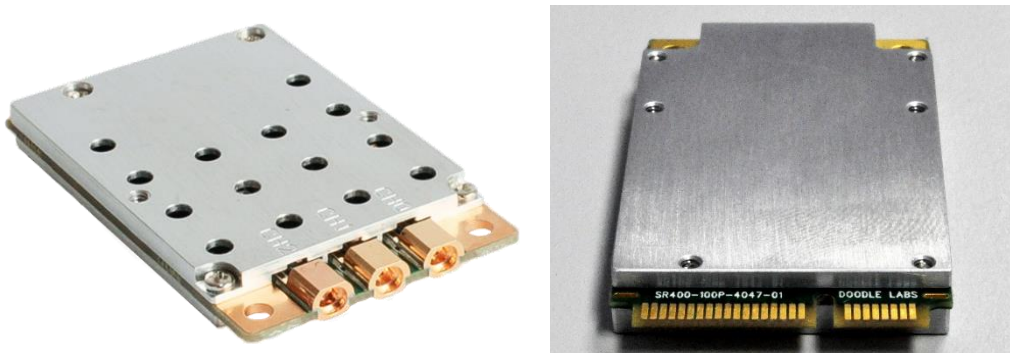


Doodle Labs ACM-DB-3-R2 Industrial Wi-Fi Transceiver

Product Family Overview

Doodle Labs' portfolio of Industrial Wi-Fi transceivers offer the industry's best-in-class performance. These transceivers have high transmit power for long-range communication and has been designed to withstand operation in extremely challenging environments. In addition, these transceivers feature high interference immunity that allows successful operation in today's congested Wi-Fi environments. The transceivers are FCC, CE, and IC certified and have been deployed in numerous demanding applications.

Figure 1. Top and bottom views of the ACM-DB-3-R2 transceiver with MMCX connectors.



Target Applications

The Doodle Labs Industrial Wi-Fi transceivers meet the demanding needs of customers across a broad range of industries. Examples include:

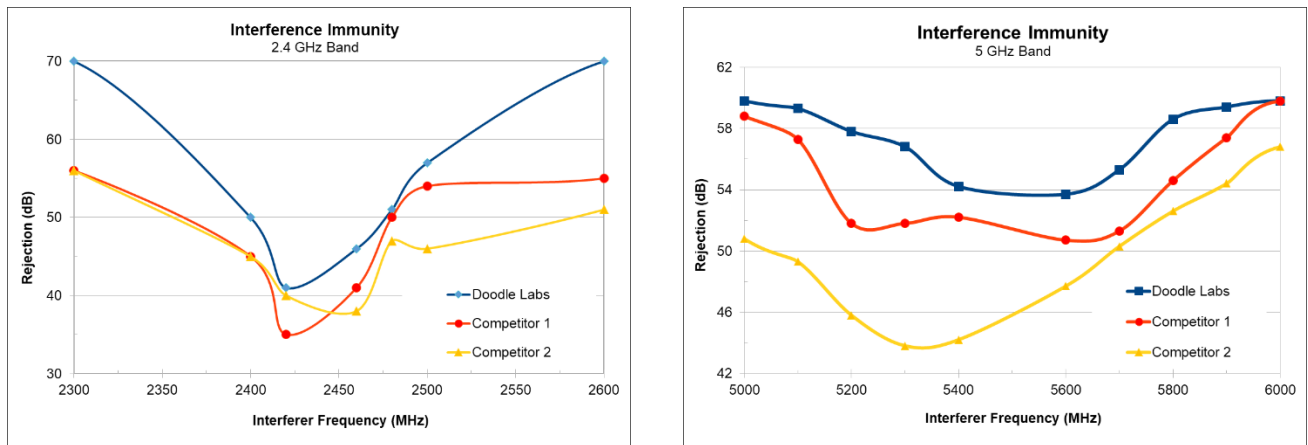
- Unmanned Vehicles – Drones
- Unmanned Robots
- Industrial IoT applications
- Rugged/Military requirements with extended temperature and vibration resiliency
- Mesh Networking deployments
- Passenger Wi-Fi access aboard airplanes and trains
- Streaming HD Video Surveillance Cameras
- Wireless Infrastructure in harsh operating conditions of the Oil/Gas fields and Mines

Features

Best-in-class features include:

- Modular FCC, CE and IC certifications to expedite system integration
- Integrated LNA for best-in-class Rx sensitivity to pick up low energy signals from mobile phones
- Up to 30 dBm of RF power to get the largest possible area coverage
- Extended temperature range from -40C to +85C.
- Electrical Stress protection on Antenna ports for outdoor operation
- Long product life cycle to meet the needs of Industrial IoT applications
- High interference immunity for Wi-Fi congested environment
- Hardware “RF Kill” feature to meet the FAA requirement for airborne applications
- High band isolation to support concurrent dual band operation for multi-band routers

Figure 2. Interference immunity performance compared to leading competitors.



ACM-DB-3 Specifications

Table 1. Technical Specifications.

Ordering Code	ACM-DB-3-R2 with MMCX connectors ACM-DB-3-R2 with U.FL connectors
Radio Configuration	3x3 MIMO, Dual Band
Special Features	<ul style="list-style-type: none"> – Extended lifespan with planned availability for long time – Extreme Reliability, IPC Class 2 standard with Class 3 options – Compliant to MIL-STD-202G, Qualified for high shock/vibration environments
Design-In Documentation	https://www.doodlelabs.com/technologies/technical-library/
MAC Chipset	Qualcomm Atheros: QCA9890-BR4B with Extended Temperature range
Software Support	Open Source Linux Drivers ath10k for 11ac models OpenWRT (Wireless Router/Linux OS)
Center Frequency Range	5.180 GHz ~ 5.825 GHz 2.412 GHz ~ 2.484 GHz This varies by the regulatory domain
Channel Bandwidth*	20, 40 and 80 MHz channels
Radio Modulation/Data Rates (Dynamic Link Adaptation)	<u>802.11ac</u> : MCS0-9 (5.x GHz) <u>802.11a</u> : 6, 9, 12, 18, 24, 36, 48 and 54 Mbps (5.x GHz) <u>802.11n</u> : MCS0-23 (5.x and 2.4 GHz) <u>802.11b/g</u> : 1, 2, 5.5, 6, 9, 11, 12, 18, 24, 36, 48 and 54 Mbps (2.4 GHz)
802.11ac Wave 1 Capabilities	<ul style="list-style-type: none"> • 802.11 dynamic frequency selection (DFS) as an AP and Client • Packet aggregation: A-MPDU (Tx/Rx), A-MSDU (Tx/Rx), Maximal ratio combining (MRC), Cyclic shift diversity (CSD), Frame aggregation, block ACK, 802.11e compatible bursting, Spatial multiplexing, cyclic-delay diversity (CDD), low-density parity check (LDPC), Space Time Block Code (STBC) • Phy data rates up to 1.3 Gbps (80 MHz channel)

<p>802.11n version 2.0 Capabilities</p>	<ul style="list-style-type: none"> • 802.11 dynamic frequency selection (DFS) as an AP and Client • Packet aggregation: A-MPDU (Tx/Rx), A-MSDU (Tx/Rx), Maximal ratio combining (MRC), Cyclic shift diversity (CSD), Frame aggregation, block ACK, 802.11e compatible bursting, Spatial multiplexing, cyclic-delay diversity (CDD), low-density parity check (LDPC), Space Time Block Code (STBC) • Phy data rates up to 450 Mbps (40 MHz channel)
<p>Operating Modes</p>	<p>AP, Client, and Adhoc modes for Access Point, PtP, PtMP, and Mesh networks</p>
<p>MAC Protocol</p>	<p>TDD with Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA)</p>
<p>Wireless Error Correction</p>	<p>FEC, ARQ</p>
<p>Wireless Data Security</p>	<p>128 bit AES, WEP, TKIP and WAPI hardware encryption. Support for IEEE 802.11d, e, h, i, k, r, v, w and time stamp standards</p>
<p>FIPS Certification</p>	<ul style="list-style-type: none"> • Small packet size (96 bytes) in AES encryption at full packet rate. • FIPS 140-2, Level 2 (Temper Evidence Shield), Loop back mode to facilitate FIPS AES certification.

Table 2. Tx and Rx performance at 5 GHz.

Tx/Rx Specification	Radio Modulation	Coding Rate	Tx Power ($\pm 2\text{dBm}$) ²	Rx Sensitivity (Typ)
5 GHz (20 MHz Channel) – 11ac models				
802.11a, STBC	BPSK	1/2	27	-96
802.11a	64 QAM	3/4	22	-81
802.11ac, 802.11n	BPSK	1/2	27	-96
802.11ac, 802.11n	16 QAM	3/4	25	-84
802.11ac, 802.11n	64 QAM	5/6	22	-75
802.11ac	256 QAM	3/4	20	-72
5 GHz (40 MHz Channel) – 11ac models				
802.11ac, 802.11n	BPSK	1/2	27	-93
802.11ac, 802.11n	16 QAM	3/4	25	-81
802.11ac, 802.11n	64 QAM	5/6	22	-75
802.11ac	256 QAM	5/6	20	-68
5 GHz (80 MHz Channel) – 11ac models				
802.11ac	BPSK	1/2	26	-87
802.11ac	16 QAM	3/4	24	-78
802.11ac	64 QAM	5/6	21	-72

802.11ac	256 QAM	5/6	19	-65
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Table 3. Tx and Rx performance at 2.4 GHz.

Tx/Rx Specification	Radio Modulation	Coding Rate	Tx Power ($\pm 2\text{dBm}$) ²	Rx Sensitivity (Typ)
2.4 GHz (20 MHz Channel) – 11ac models				
802.11b Single Stream, STBC	1 Mbps	CCK	29	-100
802.11g	64 QAM	3/4	24	-80
802.11n	BPSK	1/2	29	-95
802.11n	16 QAM	3/4	27	-83
802.11n	64 QAM	5/6	24	-76
2.4 GHz (40 MHz Channel) – 11ac models				
802.11n	BPSK	1/2	29	-91
802.11n	16 QAM	3/4	27	-80
802.11n	64 QAM	5/6	24	-73

Note 1: It is advantageous to use the smallest channel bandwidth that can support the throughput requirements. Smaller bandwidths provide more channels to choose and help avoid interference issues.

Note 2: Total Tx power for all streams. Max allowed Tx power depends on the regulatory domain. De-rating of -1 dBm for U.FL connector.

Table 4. Additional RF performance information.

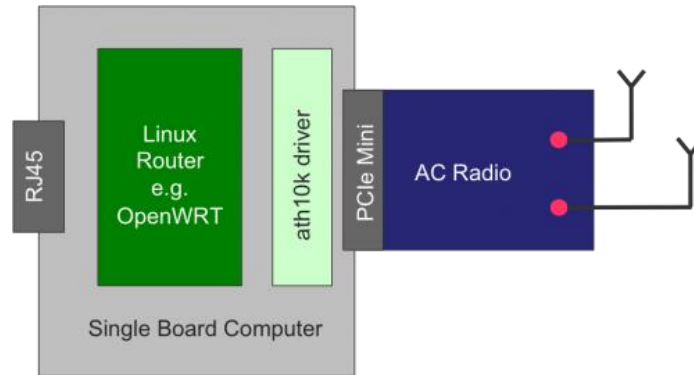
Antenna Signal Strength	-35 to -85 dBm (Recommended), Absolute Maximum=+12 dBm
Interference Immunity	SAW filters on RF ports for immunity against high power cellular transmissions in the neighboring 2.4 GHz bands.
Antenna port isolation for concurrent operation	Up to +10 dBm signal strength for 5 GHz signal without degrading 2.4 GHz operation Up to +5 dBm signal strength for 2.4 GHz signal without degrading 5.x GHz operation
Integrated Antenna Port Protection	10 kV
Receiver LNA Gain	>10 dB
Receiver Adjacent Channel Rejection (ACR)	>18 dB @ 11a, 6 Mbps (Typ)
Receiver Alternate Channel Rejection (ALCR)	>35 dB @ 11a, 6 Mbps (Typ)
Receive chain Noise Figure	+6 dB
Transmitter Adjacent Channel Leakage Power Ratio (ACLR)	45 dB ($F_c \pm ChBW$)
Transmitter Spurious Emission Suppression	-40 dBc
RF Power control	In 0.5 dBm steps. Accuracy of power calibration loop ± 2 dBm. Each transceiver individually calibrated and tested.
RF Hardware Disable (RF Kill)	Pin 20 of miniPCI-E interface. (Required for FAA compliance)

Table 5. Physical, Environment, and Other Specifications.

Host Interface	miniPCI-Express 1.2 Standard
Host CPU Board	Any CPU board with miniPCle interface
Operating Voltage	3.3 Volts from miniPCI-Express connector
Power Consumption	5.3W @ Max power, in continuous data transfer mode on all chains 2.5W @ 20 dBm power (ETSI max), in continuous data transfer mode on all chains 0.9W in continuous data receive mode 250 mW in Sleep mode
Temperature range	-40°C to +85°C (shield case)
Humidity (Operating)	0% – 95% (Non-condensing)
Dimensions	30 x 50 x 4.75 mm, 12 grams. High Res Photos – Mechanical drawings and 3D-CAD files available upon request
MTBF	27 years
Regulatory Requirements	Designed and Verified to meet various regulatory requirements. Formal testing and approval is required based on the Integrator’s particular host platform and antenna type. The Integrator is also responsible for obtaining all required regulatory approvals in target markets for the finished product.
FCC ID	2AG87ACM-DB-3-R2
CE/ETSI	Conforms with all the requirements of the European Directive 1999/5/EC – EN 301 893 V1.8.1, EN 300 328 V.1.8.1, EN 301 489-1 V1.9.2, EN 301 489-17 V2.2.1, EN 60950-1:2006 + A11:2009 + A1:2010 + A12:2011+ A2:2013
Industry Canada (IC)	21411-ACMDB3R2
RoHS/WEEE Compliance	Yes. 100% Recyclable/Biodegradable packaging

System Integration

Figure 3. System Integration Block Diagram.



As shown in the block diagram, the modular nature of the MIMO radio transceivers allow for accelerated development of the wireless modem. Any embedded Single Board Computer with standard miniPCI-Express interface is required. The Linux distribution OpenWRT has evolved over time and provides advanced features in a wireless router. It is a stable distribution and many OEMs are using OpenWRT as a starting point and customize further for their application. The distribution includes the ath10k driver to interface with the MIMO transceivers. Both OpenWRT and open source drivers (ath9k and ath10k) have extensive online documentation available. User group forums also provide responsive technical support.

Portfolio Index

Doodle Labs' Industrial Wi-Fi transceiver portfolio provides configurations optimized for a vast variety of project needs. All models are form-factor compatible. For information on other models, please visit - <http://www.doodlelabs.com/products/wi-fi-band-radio-transceivers/>

Doodle Labs provides extensive design-in documents at:

<https://www.doodlelabs.com/technologies/technical-library/>

FCC Statement

FCC standards: FCC CFR Title 47 Part 15 Subpart C Section 15.247 and FCC CFR Title 47 Part 15 Subpart E Section 15.407: 2016

External Antenna with gain ANT0: 3dBi, ANT1: 3dBi, ANT2: 3dBi

FCC Regulatory Compliance:

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.

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.

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

If power exceeds the limit and the distance(Over 20cm distance in actual use between the device and user) is compliance with the requirement

RF Exposure Compliance:

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment should be installed and operated with a minimum distance of 20cm between the radiator and any part of your body.

Notice to OEM integrator

If the FCC ID is not visible when the module is installed inside another device, then the outside of the device into which the module is installed must also display a label referring to the enclosed module. The end product shall have the words "Contains Transmitter Module FCC ID: 2AG87ACM-DB-3-R2".

The device must be professionally installed.

The intended use is generally not for the general public. It is generally for industry/commercial use.

The connector is within the transmitter enclosure and can only be accessed by disassembly of the transmitter that is not normally required. The user has no access to the connector.

Installation must be controlled. Installation requires special training.

Any company of the host device which installs this modular with unlimited modular approval should perform the test of radiated & conducted emission and spurious emission, etc. according to FCC part 15C: 15.247 and 15.207, 15B Class B and Part 15 Subpart E Section 15.407 requirement, only if the tests result comply with FCC part 15C: 15.247 and 15.207, 15B Class B and Part 15 Subpart E Section 15.407 requirement, then the host can be sole legally.

When the module is installed inside another device, the user manual of the host contain below

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

IC statement

RSS-Gen Issue 5, RSS-247 Issue 2

This device contains licence-exempt transmitter(s)/receiver(s) that comply with Innovation, Science and Economic Development Canada's licence-exempt

RSS(s). Operation is subject to the following two conditions:

(1) This device may not cause interference.

(2) This device must accept any interference, including interference that may cause undesired operation of the device.

The term "IC: " before the certification/registration number only signifies that the Industry Canada technical specifications were met.

This product meets the applicable Industry Canada technical specifications.

Cet appareil contient des émetteurs / récepteurs exemptés de licence conformes aux RSS (RSS) d'Innovation, Sciences et Développement économique

Canada. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit

accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

L'émetteur/récepteur exempt de licence contenu dans le présent appareil est conforme aux CNR d'Innovation, Sciences et Développement économique

Canada applicables aux appareils radio exempts de licence.

L'exploitation est autorisée aux deux conditions suivantes :

1) L'appareil ne doit pas produire de brouillage;

2) L'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Please notice that if the ISED certification number is not visible when the module is installed inside another device, then the outside of the device into which

the module is installed or display a label referring to the enclosed module. This exterior label can use wording such as the following: "Contains IC: 21411-ACMDB3R2" any similar wording that expresses the same meaning may be used.

l'appareil hôte doit porter une étiquette donnant le numéro de certification du module d'Industrie Canada, précédé des mots « Contient un module

d'émission », du mot « IC: 21411-ACMDB3R2 » ou d'une formulation similaire exprimant le même sens, comme suit

The device meets the exemption from the routine evaluation limits in section 2.5 of RSS 102 and compliance with RSS-102 RF exposure, users can obtain

Canadian information on RF exposure and compliance.

Le dispositif rencontre l'exemption des limites courantes d'évaluation dans la section 2.5 de RSS 102 et la conformité

à l'exposition de RSS-102 rf, utilisateurs peut obtenir l'information canadienne sur l'exposition et la conformité de rf.

This transmitter must not be co-located or operating in conjunction with any other antenna or transmitter. This equipment should be installed and operated

with a minimum distance of 20 centimeters between the radiator and your body.

Cet émetteur ne doit pas être Co-placé ou ne fonctionnant en même temps qu'aucune autre antenne ou émetteur.

Cet équipement devrait être installé et

actionné avec une distance minimum de 20 centimètres entre le radiateur et votre corps.

B1 for indoor use only

B1 pour usage intérieur uniquement

This radio transmitter IC: 21411-ACMDB3R2 has been approved by Innovation, Science and Economic Development Canada to operate with the antenna types listed below, with the maximum permissible gain indicated. Antenna types not included in this list that have a gain greater than the maximum gain indicated for any

type listed are strictly prohibited for use with this device.

3) The host device will use antennas: External Antenna with gain ANT0: 3dBi, ANT1: 3dBi, ANT2: 3dB