

## Doodle Labs Smart Radio – RM-915

### Small, Long-Distance COFDM/MIMO Broadband Radio

#### Smart Radio Overview

The Smart Radio is a tiny, full-featured 2x2 MIMO radio/mesh router. It has Ethernet and UART interfaces to allow easy integration into any system architecture. Smart Radios can stream 4K video from over 10 km away.



Smart Radios include Doodle Labs' proprietary BII<sup>®</sup> technology to create an advanced solution for a variety of industrial applications. For example, to allow streaming command & control and sensor data on the same link, Smart Radios feature an Ultra Reliable Low Latency Channel (URLLC) and an optimized video streaming channel.

Smart Radios are available in many frequency bands between 100 MHz and 4 GHz, allowing customers to switch the operating bands by simply swapping the radio module.

#### Key Features of the Smart Radio Platform

##### PERFORMANCE RF

- Long range and high throughput
- Available in 100 MHz – 4 GHz frequency range in form factor compatible models
- Interference resistant COFDM/MIMO for improved link quality in difficult RF environments; Multipath for LOS obstructions
- Adaptive radio modulations from BPSK up to 64QAM, with continuous per packet optimization to maximize link performance in dynamic environments
- Software defined channel size for efficient re-use of spectrum
- Software defined operating frequency for global applications
- Convolutional coding, Forward Error Correction (FEC), ACK-retransmits, Maximal Ratio Combining, Spatial Multiplexing, Beam forming and Space Time Block Coding for robust data transmission over noisy spectrum and dynamic directional orientation due to roll and pitch of mobile vehicles
- Time Division Duplexing (TDD) for bi-directional traffic

## Datasheet

### PERFORMANCE NETWORKING

- Ultra-Reliable Low Latency Channel (URLLC) for Command and Control as well as optimized video streaming channel on the same radio link
- End-to-end IP architecture for Unicast and Multicast traffic
- 256-bit AES encryption for over the air data

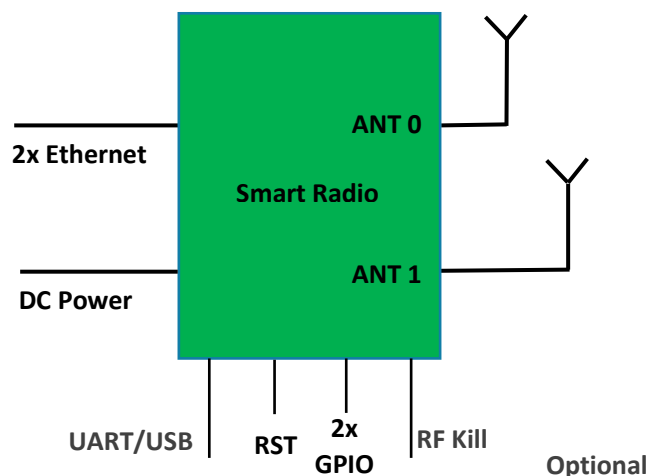
### ADDITIONAL FEATURES

- Very small size, weight, and power (SWaP) for mobile applications
- Ethernet and UART interfaces to allow easy integration into different system architectures
- Rugged, vibration resistant construction, Industrial temperature range (-40C to +85C)
- COTS – Commercial off the Shelf
- Extended lifespan and availability

## System Integration

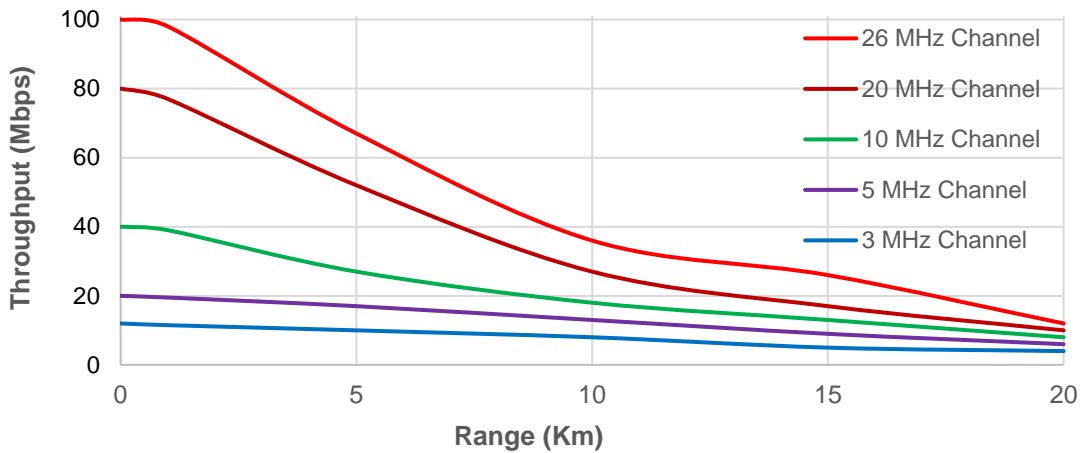
The Smart Radio is an embedded module. It has been designed to be nearly plug and play. Only Ethernet, power supply (5.5~42V), and antenna connections are required for integration.

Doodle Labs provides following documents upon request: integration guide, 3D CAD model, mechanical drawing, cable drawing, and thermal map.



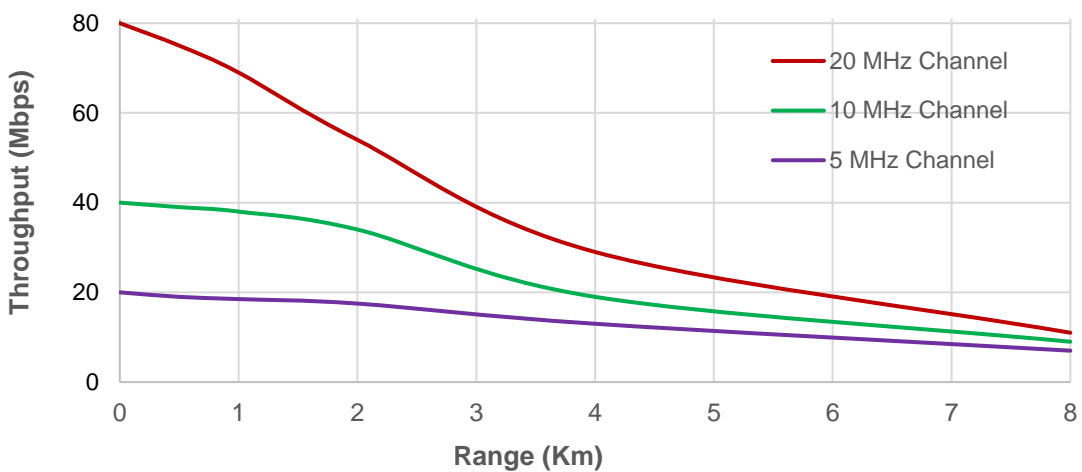
**Data Sheet**

**Xtreme Link Performance (Indicative)**



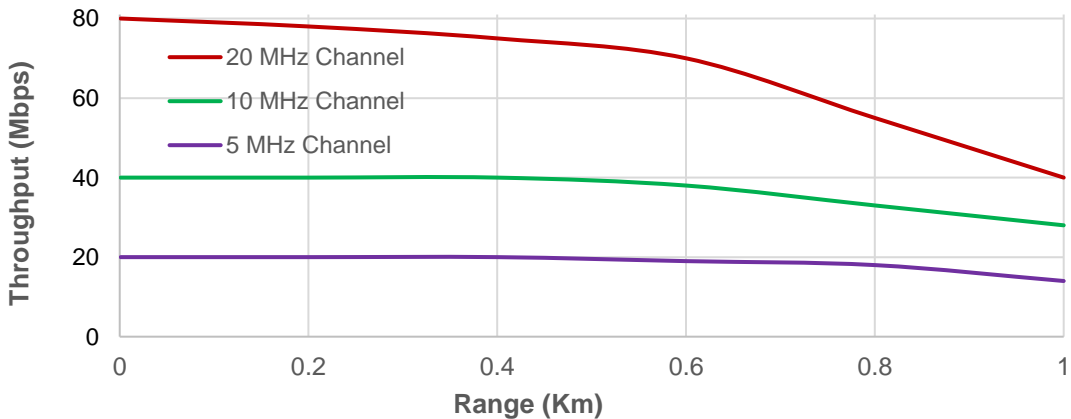
**Link Configuration:**  
9 dBi antennas on both ends of the link, Cross-polarized H and V antennas for maximum diversity.  
> 15 dBm fade margin to account for changing RF conditions.

**Pro Link Performance (Indicative)**



**Link Configuration:**  
6 dBi antennas on both ends of the link, Cross-polarized H and V antennas for maximum diversity.  
> 15 dBm fade margin to account for changing RF conditions.

**Standard Link Performance (Indicative)**



**Link Configuration:**  
3 dBi antennas on both ends of the link, Cross-polarized H and V antennas for maximum diversity.  
> 10 dBm fade margin to account for changing RF conditions.

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## Technical Specifications (900 MHz Band)



Model Category	Standard	Pro	Xtreme
<b>ORDERING CODES</b>			
Radio Configuration	2x2 MIMO		
With 2x Ethernet and UART interfaces	RM-915-2H-SS	RM-915-2H-PS	RM-915-2H-XS
Evaluation Kit	RM-915-2H-SS-EK	RM-915-2H-PS-EK	RM-915-2H-XS-EK
Special Configurations	<ul style="list-style-type: none"> <li>• Compact models (37x57x11 mm, 40 grams) with Single RF stream</li> <li>• USB and GPIO interfaces</li> </ul>		
<b>PERFORMANCE OVERVIEW</b>			
Max Operating Range (Indicative)	1 Km	8 Km	>20 Km
Max Data Throughput at 10-meter range (Indicative)	80 Mbps (20 MHz Channel) 40 Mbps (10 MHz Channel) 20 Mbps (5 MHz Channel)		100 Mbps (26 MHz Channel) 12 Mbps (3 MHz Channel)
Interference Immunity	Standard	SAW filters on RF and ANT ports for strong out of band noise immunity	+ Adjustable squelch for resistance against high-power jamming
Over the Air Data Encryption	128-bit AES hardware data encryption @ full rate		256-bit AES software encryption (12 Mbps max throughput)
Operating Modes	Mesh, AP, Client and Transparent Bridge		+ Gateway
Command & Control channel	Advanced QoS	Ultra-Reliable Low Latency Channel (URLLC)	
Video Channel	Advanced QoS	Optimized video streaming channel	
<b>RF SPECIFICATIONS</b>			

## Data Sheet

Model Category	Standard	Pro	Xtreme
Frequency Range	902-928 MHz Channel plans available for all countries in Americas, Australia, New Zealand, and China		
Channel Sizes (Software Selectable)	5, 10, 20 MHz		3, 5, 10, 20, 26 MHz
RF Power Output (Typ) Each radio individually calibrated	0.1W (20 dBm) @ MCS 0,8  0.1W (20 dBm) @ MCS 3,11  0.1W (20 dBm) @ MCS 5, 13  0.1 mW (20 dBm) @ MCS 7, 15	0.5W (27 dBm) @ MCS 0,8  0.5W (27 dBm) @ MCS 3,11  0.4W (26 dBm) @ MCS 5,13  250mW (24 dBm) @ MCS 7,15	1W (30 dBm) @ MCS 0,8  0.8W (29 dBm) @ MCS 3,11  0.4W (26 dBm) @ MCS 5,13  250mW (24 dBm) @ MCS 7,15
RF Power Control	In 1 dBm steps, Tolerance $\pm 1$ dBm		
Integrated Antenna Port Protection	NA	Able to withstand open port, >10 KV (contact) and >15KV (open air discharge) as per IEC-61000-4-2	
Hardware RF Kill function for Airborne applications	NA	NA	Pin 4 of AUX connector
NETWORKING SPECIFICATIONS			
Mesh Router	Self-Forming/Self-Healing, Peer to Peer		
Multicast	Standard Rate	High Rate	
Custom Software Package Manager	OPKG		
Radio Management	LuCI Web Interface, and UCI command line interface		
Access control	Password, MAC, IP, Port filtering		
Network Security	VPN, IPSec, L2TP, GRE, STP		
Supported Protocols	IPv6, QoS, DNS, HTTPS, IP, ICMP, NTP, DHCP, VLAN		
Software Upgrade	Over the air software upgrade supported		
HARDWARE SPECIFICATIONS			

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## Data Sheet

Model Category	Standard	Pro	Xtreme
Operating Voltage	5.5~42V DC		
Dimensions	65 x 57 x 11 mm, 60 grams		
Antenna Connection	2x MMCX-Female		
Host Interface	2x Ethernet and UART ports		
Temperature range (Operating)	-10°C to +50°C	-40°C to +70°C	-40°C to +85°C
	System's thermal design should ensure that the radio's case temperature is maintained within these specifications.		
Shock and Vibration Resistance	Standard	Compliant to MIL-STD-202G for high shock and vibration	
DC Power Consumption	<ul style="list-style-type: none"> <li>• 8W @ Max RF power in UDP data Tx mode</li> <li>• 3.4W in data Rx mode</li> <li>• 1.2W in Sleep mode</li> </ul>	<ul style="list-style-type: none"> <li>• 8.5W @ Max RF power in UDP data Tx mode</li> <li>• 3.4W in data Rx mode</li> <li>• 1.2W in Sleep mode</li> </ul>	<ul style="list-style-type: none"> <li>• 9W @ Max RF power in UDP data Tx mode</li> <li>• 3.4W in data Rx mode</li> <li>• 1.2W in Sleep mode</li> </ul>
Reliability	Standard	Extreme Reliability, IPC Class 2 standard with Class 3 options	
Integrated CPU	MIPS 24K, 540 MHz, 32MB Flash, 64MB DDR2 RAM		
MTBF	>25 years		
Humidity (Operating)	0% – 95% (Non-condensing)		
Life Cycle Planning	Standard	Extended lifespan with 3 years' guaranteed availability	Extended lifespan with 7 years' guaranteed availability
<b>REGULATORY INFORMATION</b>			
FCC ID	2AG87RM-915-2H		
Industry Canada (IC)	21411-RM9152H		
Regulatory Requirements	Designed and verified to meet various regulatory requirements. Formal testing and approval are required for the Integrator's		

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## Data Sheet

Model Category	Standard	Pro	Xtreme
	antenna type. The Integrator is responsible for obtaining all regulatory approvals in target markets for the finished product.		
RoHS/WEEE Compliance	Yes. 100% Recyclable/Biodegradable packaging		
ADDITIONAL RF SPECIFICATIONS			
Radio Data Rates (Dynamic Per Packet Link Auto Adaptation)	MCS15 = 64QAM (5/6) MCS14 = 64 QAM (3/4) MCS13 = 64 QAM (2/3) MCS12 = 16QAM (3/4) MCS11 = 16QAM (1/2) MCS10 = QPSK (3/4) MCS9 = QPSK (1/2) MCS8 = BPSK (1/2) MCS7 = 64QAM (5/6) MCS6 = 64 QAM (3/4) MCS5 = 64 QAM (2/3) MCS4 = 16QAM (3/4) MCS3 = 16QAM (1/2) MCS2 = QPSK (3/4) MCS1 = QPSK (1/2) MCS0 = BPSK (1/2)		
Wireless Protocol	TDD with Carrier Sense Multiple Access with Collision Avoidance		
Wireless Error Correction	FEC, ARQ		
Freq Accuracy	±10 ppm Max over life		
Antenna Signal Strength	-25 to -85 dBm (Recommended), Absolute Maximum=+12 dBm		
Control for External Power Amp	NA	DC biased signal over RF port	
Receiver LNA Gain	>10 dB		
Rx Sensitivity (3 MHz Channel BW)	NA		-100 dBm @ MCS 0 -97 dBm @ MCS 1 -95 dBm @ MCS 2

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Model Category	Standard	Pro	Xtreme
			-92 dBm @ MCS 3 -87 dBm @ MCS 4 -85 dBm @ MCS 5 -82 dBm @ MCS 6 -79 dBm @ MCS 7  -97 dBm @ MCS 8 -83 dBm @ MCS 9 -91 dBm @ MCS 10 -88 dBm @ MCS 11 -84 dBm @ MCS 12 -80 dBm @ MCS 13 -79 dBm @ MCS 14 -78 dBm @ MCS 15
Rx Sensitivity (5 MHz Channel BW)		-98 dBm @ MCS 0 -95 dBm @ MCS 1 -93 dBm @ MCS 2 -90 dBm @ MCS 3 -85 dBm @ MCS 4 -83 dBm @ MCS 5 -80 dBm @ MCS 6 -77 dBm @ MCS 7  -95 dBm @ MCS 8 -91 dBm @ MCS 9 -89 dBm @ MCS 10 -85 dBm @ MCS 11 -82 dBm @ MCS 12 -78 dBm @ MCS 13 -77 dBm @ MCS 14 -76 dBm @ MCS 15	
Rx Sensitivity (10 MHz Channel BW)		-96 dBm @ MCS 0	

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## Data Sheet

Model Category	Standard	Pro	Xtreme
		-93 dBm @ MCS 1 -91 dBm @ MCS 2 -88 dBm @ MCS 3 -83 dBm @ MCS 4 -81 dBm @ MCS 5 -78 dBm @ MCS 6 -75 dBm @ MCS 7  -93 dBm @ MCS 8 -89 dBm @ MCS 9 -87 dBm @ MCS 10 -84 dBm @ MCS 11 -80 dBm @ MCS 12 -76 dBm @ MCS 13 -75 dBm @ MCS 14 -74 dBm @ MCS 15	
Rx Sensitivity (20 MHz Channel BW)		-93 dBm @ MCS 0 -90 dBm @ MCS 1 -88 dBm @ MCS 2 -85 dBm @ MCS 3 -80 dBm @ MCS 4 -78 dBm @ MCS 5 -75 dBm @ MCS 6 -72 dBm @ MCS 7  -90 dBm @ MCS 8 -86 dBm @ MCS 9 -84 dBm @ MCS 10 -81 dBm @ MCS 11 -77 dBm @ MCS 12 -73 dBm @ MCS 13 -72 dBm @ MCS 14 -71 dBm @ MCS 15	

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## Data Sheet

Model Category	Standard	Pro	Xtreme
Rx Sensitivity (26 MHz Channel BW)	NA		-92 dBm @ MCS 0 -89 dBm @ MCS 1 -87 dBm @ MCS 2 -84 dBm @ MCS 3 -79 dBm @ MCS 4 -77 dBm @ MCS 5 -74 dBm @ MCS 6 -71 dBm @ MCS 7 -89 dBm @ MCS 8 -85 dBm @ MCS 9 -83 dBm @ MCS 10 -80 dBm @ MCS 11 -76 dBm @ MCS 12 -72 dBm @ MCS 13 -71 dBm @ MCS 14 -70 dBm @ MCS 15
Receive Adjacent Channel Rejection (ACR)	>18 dB @ 6 Mbps (Typ)		
Receive Alternate Channel Rejection (ALCR)	>35 dB @ 6 Mbps (Typ)		
Receive Noise Figure	+4 dB		
Transmitter Adjacent Channel Leakage Ratio (ACLR)	-28 dB <sub>r</sub> (F <sub>c</sub> ± ChBW)		
Transmitter Spurious Emission Suppression	-55 dB <sub>c</sub>		

\* Specifications are subject to change without prior notice.

## Band Introduction – 900 MHz ISM Band

The 900 MHz band is also known as the 33-centimeter band and ranges from 902 to 928 MHz. RF signals at 900 MHz can penetrate through building walls, vegetation, and other obstacles. 900 MHz signals can also go around objects by refraction. Due to these transmission characteristics, broadband communication in the 900 MHz band achieves a good balance of range, penetration, and throughput.

The 900 MHz band is license-free in large parts of the world: all of ITU’s region 2 (23 countries in Americas) and some additional countries like China, Australia, New Zealand and South Korea. In the USA, like WiFi, FCC Part 15 certified radios are permitted for unlicensed operation. A private wireless broadband network implemented in a license-free band avoids the recurring monthly cost of public cellular network.

## Additional Doodle Labs Products - 900 MHz ISM Band

Description	Model No.
2x2 MIMO Broadband Transceiver with miniPCIe interface	NM-915
2x2 MIMO Smart Radio with Ethernet interface	RM-915
2x2 MIMO Band shifter for Wi-Fi to 915 MHz	FM-915