

Doodle Labs Smart Radio – RM-3625 (CBRS)

Advanced MIMO Mesh Router in a tiny Form Factor

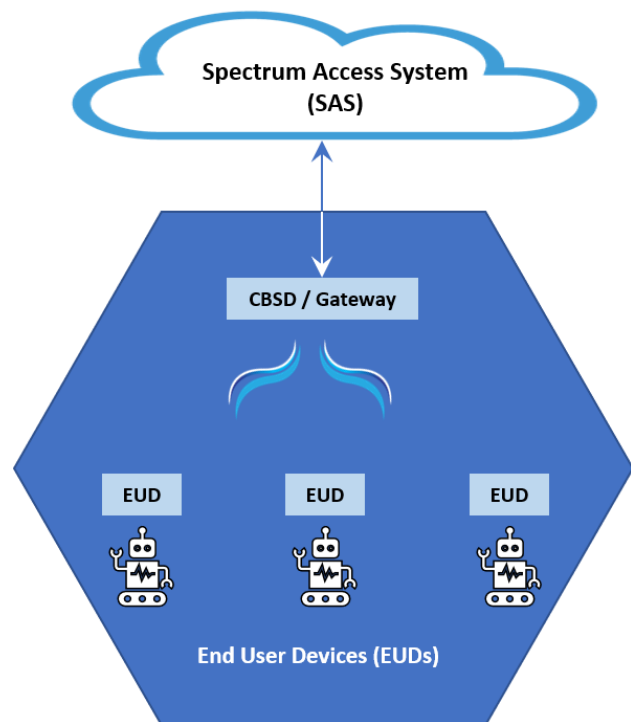
Overview

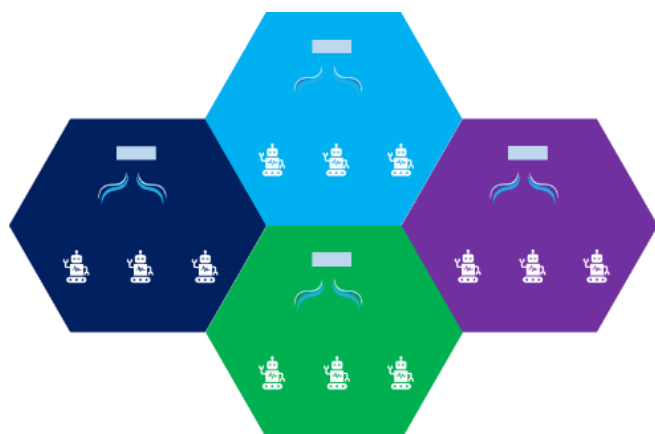
CBRS (Citizen's Broadband Radio Service) is a very large swath of license free 3.5 GHz spectrum newly released by FCC to promote the development of new applications. The FCC calls it an "Innovation band" with the intention that it will ignite the development of new use cases, like what WiFi did over 20 years ago. Because CBRS band's shared access is managed, it provides **interference protection**.

CBRS Anatomy

The figure shows the Point to Multi-Point Network architecture for the license free CBRS band. At power up, every CBSD (Citizens Broadband Radio Service Device) is required to contact the shared Spectrum Access System (SAS) over the Internet and receive operating parameters like the channel and the RF power limit. The SAS provides this authorization in accordance with other CBSDs operating in the area. The device category CBSD-A is defined for urban use cases and the high powered CBSD-B for rural-outdoor settings will be introduced in the future.

The FCC has authorized over 10 companies to operate the SAS. Doodle Labs has worked closely with [Federated Wireless](#) to ensure the interoperability of its CBSD-A and pre-configure it to make this a turn-key operation. Once the CBSD receives authorization from the SAS, it can then instruct the downstream EUD (End User Device) to begin operation.





The CBRS topology is modeled after the cellular architecture. The SAS assigns non-overlapping/non-interfering channels to the adjacent cells. This greatly increases the ability to deploy large private networks without the worry of interference.

Smart Radios for CBRS

The Smart Radios for the 3.5 GHz CBRS band are advanced 2x2 MIMO mesh routers. The RM-3625 models are fully compliant to FCC Part 96 regulatory requirements. They provide all the building blocks to deploy license free, high performance and interference free private broadband networks. The CBRS Smart Radios are available as CBSD/Gateway (Short Range CBSD-A and Rural CBSD-B), and EUD-A and EUD-B functions. The Gateways and EUDs are available in Embedded, External and Pocketable form factors to meet application specific requirements.



Key Features

PERFORMANCE RF

- Long range (field tested >50km) and high throughput (up to 35 Mbps)
- Interference resistant COFDM for robust link quality in difficult RF environments
- Exceptional Multipath and NrLOS MIMO performance
- Adaptive radio modulations from BPSK up to 64QAM, with continuous optimization to maximize link performance in dynamic environments
- Software defined channel size for efficient re-use of spectrum
- Convolutional coding, Forward Error Correction (FEC), ACK-retransmits, Maximal Ratio Combining, Spatial Multiplexing, and Space Time Block Coding for robust data transmission over noisy spectrum
- Single channel, Time Division Duplexing (TDD) for bi-directional traffic
- Resistant to high-power jamming signals
- Built-in Spectrum Scanner to help mitigate interference issues

PERFORMANCE NETWORKING

- Ultra-Reliable Low Latency Channel (URLLC) for Command and Control
- Optimized video streaming channel for Unicast and Multicast transport
- AES128/256 bit encryption
- End-to-end IP architecture with Ad Hoc, WDS transparent bridge, Client, AP, and Internet Gateway operating modes
- Embedded network management APIs

ADDITIONAL FEATURES

- Very small size, weight, and power for mobile applications
- Ethernet, USB, and UART interfaces to allow easy integration into different system architectures
- Leverage the benefits of the most extensible OpenWrt ecosystem and install 3rd party IoT applications
- Rugged, vibration resistant construction (MIL-STD)
- MIL spec temp range (-40C to +85C)
- High quality, manufactured in ISO 9001 and ISO 14001 certified facilities
- Extended lifespan and availability

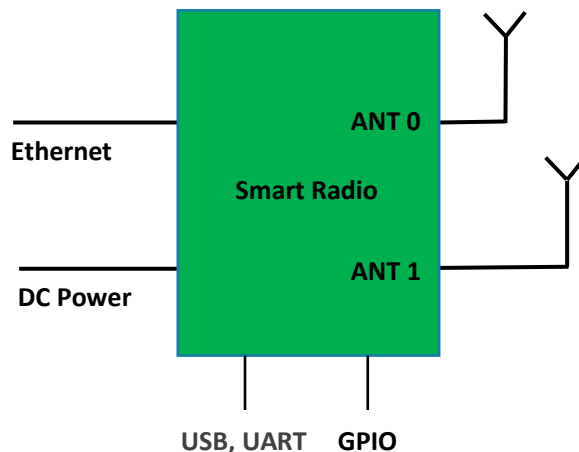
For more information, please visit - <https://doodlelabs.com/smart-radio/>

System Integration

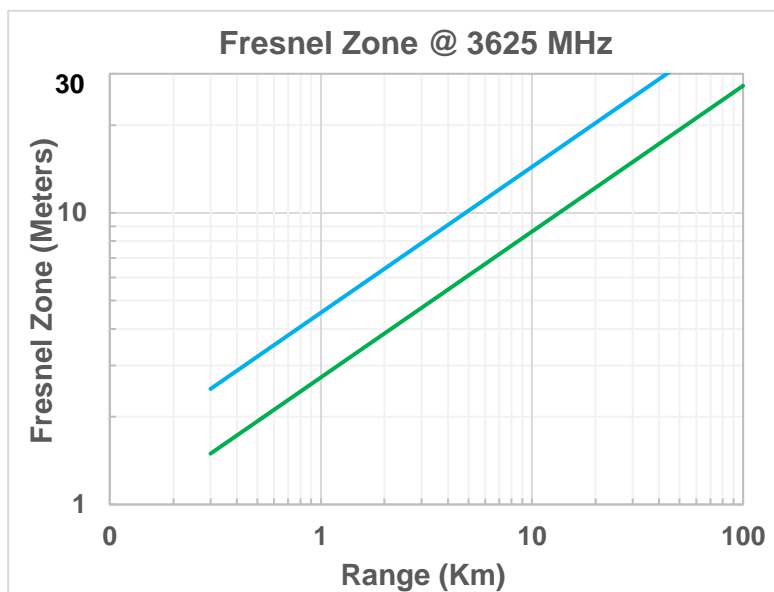
The Smart Radio has been designed to be nearly plug and play. Only Ethernet/USB, power supply, and antenna connections are required for integration.

Doodle Labs provides extensive design-in documents at:

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



Smart Radio-CBRS Indicative Performance



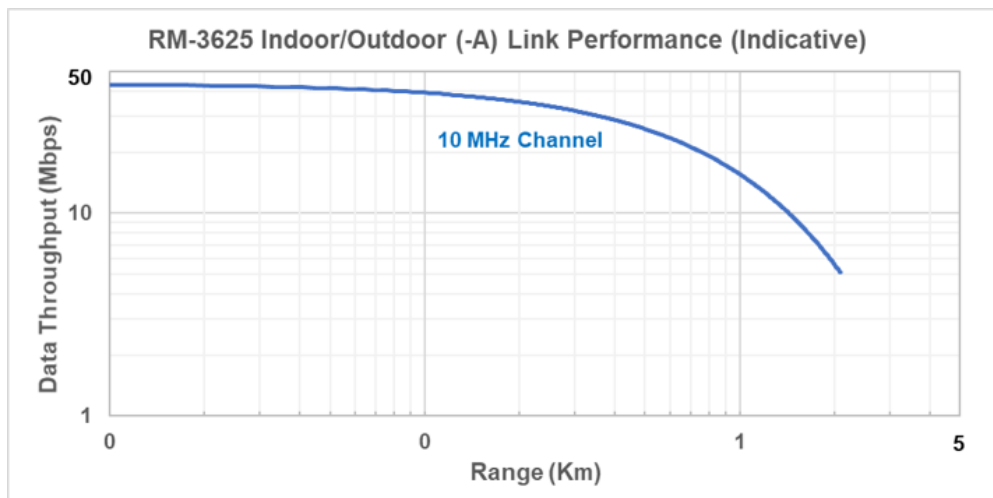
Fresnel Zone Clearance^{RF}

Line of Sight (LOS) is defined by Fresnel Zones which are ellipse shaped areas between any two radios. The radius of the *Fresnel Zone* at its widest point is shown the figure.

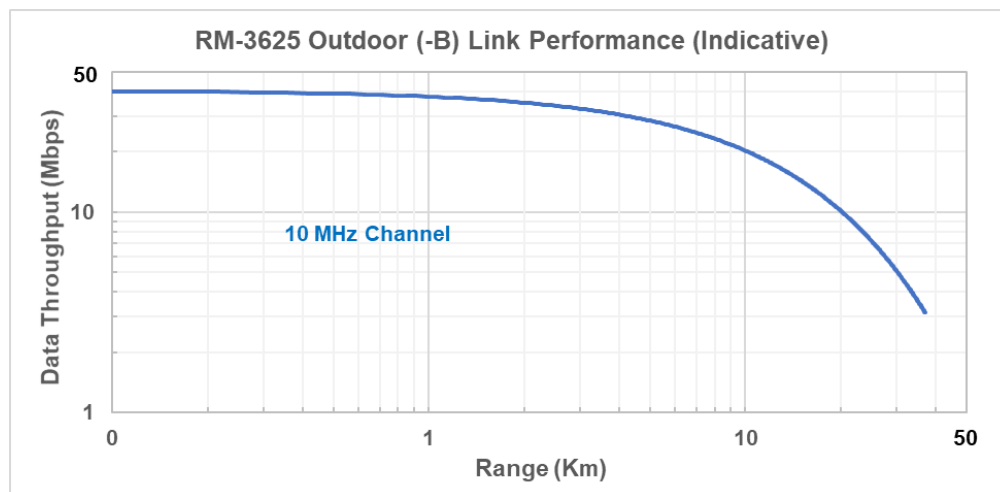
The primary Fresnel zone is required to be at least 60% clear of any obstruction to ensure the highest performance of wireless link.

Link Distance (Indicative Performance)

Smart Radio's Mesh Rider waveform has been field tested for >100km. The link distance depends on many factors, mainly Antenna gain, Line of Sight obstructions, Fresnel Zone clearance and environmental noise conditions. The charts below give an indication of radio's performance in a typical configuration. For more details, refer to the App Note – [Optimizing the Link Distance](#)



CBSD-A Antenna = 6 dBi, EUD Antenna = 3 dBi, PtmP configuration
Fade Margin = 10 dBm, Fresnel Zone 60% Clearance



CBSD-B to CBSD-B for PtP configuration. Antenna = 17 dBi
Fade Margin = 20 dBm, Fresnel Zone 60% Clearance

Technical Specifications (CBSD/Gateway)



Model Category	Pro	Xtreme
ORDERING CODES		
Model # (Embedded)	RM-3625-2J-SDA-M	RM-3625-2J-SDB-M
Model # (Pocketable)	RM-3625-2J-SDA-P	RM-3625-2J-SDB-P
Model # (External)	RM-3625-2J-SDA-E	RM-3625-2J-SDB-E
Evaluation Kit	TBD	
Design-In Documentation	https://doodlelabs.com/technologies/technical-library/	
PERFORMANCE OVERVIEW		
Protocol Compatibility	Fully compatible with Mesh Rider Waveform	
Operating Modes	Gateway/AP (CBSD-A), Transparent Client Bridge (EUD-A)	Gateway/AP (CBSD-A), Rural Gateway/AP (CBSD-B), Transparent Client Bridge (EUD-A), Transparent Clint Bridge (EUD-B)
Max Operating Range (Indicative)	2 Km (Recommended)	40 Km (Recommended)
Max Data Throughput at 10-meter range (Indicative)	35 Mbps (10 MHz Channel)	
Over the Air Data Encryption	128-bit AES hardware data encryption @ full rate	128-bit AES hardware data encryption @ full rate, 256-bit AES software data encryption @ 12 Mbps
Command & Control Channel	Ultra-Reliable Low Latency Channel (URLLC). Latency 1.5-10 ms	
Video Channel	Optimized video streaming with Unicast and Multicast transmission	
Automatic Transmit Power Control	Intelligently adjusts the transmit output power based on signal strength. Allows the Smart Radios to be utilized in a widely dispersed and dynamic network.	
RF SPECIFICATIONS		
Radio Configuration	2x2 MIMO	

Datasheet (Preliminary)

Model Category	Pro	Xtreme
Frequency Range	3550-3700 MHz (Supports GA and PAL users)	
Channel Sizes (Software Selectable)	10 MHz	3, 5, 10 MHz
Channel Aggregation	NA	Up to 4 channels
RF Power Output (Typ) Each radio individually calibrated	300mW, 25 dBm @ MCS 0, 8 300mW, 25 dBm @ MCS 3, 11 300mW, 25 dBm @ MCS 5,13 250mW, 24 dBm @ MCS 7, 15	1W, 30 dBm @ MCS 0, 8 1W, 30 dBm @ MCS 3, 11 400mW, 26 dBm @ MCS 5,13 250mW, 24 dBm @ MCS 7, 15
Antenna Signal Strength	-25 to -85 dBm (Recommended), Absolute Maximum= +12 dBm	
Receiver LNA Gain	>20 dB	
RF Power Control	In 1 dBm steps, Tolerance ± 1 dBm	
Integrated Antenna Port Protection	Able to withstand open port, >10 KV (contact) and >15KV (open air discharge) as per IEC-61000-4-2	
Radio Data Rate (Modulation Coding Scheme – MCS)	Dynamic Link Auto Adaptation	
Wireless Error Correction	FEC, ARQ	
Frequency Accuracy	± 20 ppm max over life	± 10 ppm max over life
NETWORKING SPECIFICATIONS		
Mesh Router	Self-Forming/Self-Healing, Peer to Peer	
Video Multicast	1080p HD Video to 2 stations (Recommended)	1080p HD video to 4 stations (Recommended)
Custom Software Package Manager	OPKG	
Radio Management	APIs, SSH, LuCI Web Interface, UCI command line, and SNMP	
Access control	Password, MAC, IP, Port filtering	
Network Security	VPN, L2TP, STP	
Supported Protocols	IPv6, QoS, DNS, HTTPS, IP, ICMP, NTP, DHCP, VLAN	

Datasheet (Preliminary)

Model Category	Pro	Xtreme
Software Upgrade	Over the air software upgrade supported	
HARDWARE SPECIFICATIONS		
Operating Voltage	Embedded: 5.5~42V DC External: 5.5V~42V DC, Passive PoE Pocketable: 6V~22V (Compliant to USB-PD standard)	
Dimensions	Embedded: 65 x 57 x 12 mm, 70 grams External: 148 x 137 x 58 mm, 540 grams Pocketable: 70 x 95 x 15 mm, 150 grams	
Antenna Connections	Embedded: 2x MMCX External: 2x RP-SMA Pocketable: 2x RP-SMA and integrated antennas for 3.5 GHz, 2.4 GHz WiFi and GPS	
Host Interface	Embedded: 2x Ethernet, 2x USB (Host), UART, 2x GPIO, GPS External: 2x Ethernet, 2x USB (Host), UART, 2x GPIO, GPS Pocketable: WiFi, USB (Host), USB (Device), Ethernet, UART, GPIO	
Integrated GPS	Simultaneous multiple constellations (GPS/Galileo/Glonass/BeiDou/QZSS), 1.5 meter CEP position accuracy, -163 dBm tracking sensitivity	
Temperature range (Operating)	-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.	
Ingress Protection	Embedded: IP50 (dust protected, no liquids) External: IP67 (immersion under water) Pocketable: IP63 (Spray falling up to 60° from vertical)	
Shock and Vibration Resistance	Standard	Compliant to MIL-STD-810H for high shock and vibration
DC Power Consumption	<ul style="list-style-type: none">• 8W @ Max RF power in UDP data Tx mode• 5.6W in data Rx mode• 1.8W in Sleep mode	<ul style="list-style-type: none">• 14W @ Max RF power in UDP data Tx mode• 5.6W in data Rx mode• 1.8W in Sleep mode
Reliability	Standard	Extreme Reliability, IPC Class 2 standard with Class 3 options
Integrated CPU	MIPS24Kc, 650 MHz, 32MB Flash, 64MB DDR2 RAM	

Datasheet (Preliminary)

Model Category	Pro	Xtreme
MTBF	>235k hours (25 years)	
Humidity (Operating)	0% – 95% (Non-condensing)	
Life Cycle Planning	Extended lifespan with 3 years guaranteed availability	Extended lifespan with 7 years guaranteed availability
REGULATORY INFORMATION		
FCC ID	2AG87RM-3625 (In Progress)	
Flammability Rating	UL94 V-0 compliant	
Regulatory Requirements	Designed and verified to meet various regulatory requirements. Formal testing and approval are required for the Integrator's 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	

* Specifications are subject to change without prior notice.

Technical Specifications (End User Device, EUD)



The Smart Radios are available as lower cost End User Devices (EUD) to work with the CBSD/Gateway devices. The EUDs can interoperate with all CBSD options available. The table below shows only the specifications that are different than the CBSD specifications.

Model Category	Pro	Xtreme
ORDERING CODES		
Model # (Embedded)	RM-3625-2J-UDA-M	RM-3625-2J-UDB-M
Model # (Pocketable)	RM-3625-2J-UDA-P	RM-3625-2J-UDB-P
Model # (External)	RM-3625-2J-UDA-E	RM-3625-2J-UDB-E
Integrated GPS	NA	Yes
EUD SPECIFICATIONS		
Operating Modes	Transparent Client Bridge	
RF Power Output (Typ)	23 dBm	
DC Power Consumption	8.2 W @ 23 dBm 5.6 W @ RX 1.8 W @ standby	
REGULATORY INFORMATION		
FCC ID	2AG87RM-3625 (In Progress)	

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Additional RF Specifications (Applies to all CBSD and EUD models)

Model Category	Pro	Xtreme
ADDITIONAL RF SPECIFICATIONS		
Receive Adjacent Channel Rejection (ACR)	>34 dB @ 6 Mbps (Typ)	
Receive Noise Figure	+4 dB	
Transmitter Adjacent Channel Leakage Ratio (ACLR)	-28 dBr ($F_c \pm \text{ChBW}$)	
Transmitter Spurious Emission Suppression	-55 dBc	
Radio Data Rates (Dynamic 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)	
Rx Sensitivity (10 MHz Channel BW)	-96 dBm @ MCS 0 -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	

Datasheet (Preliminary)

Model Category	Pro	Xtreme
	-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 (5 MHz Channel BW)	NA	-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 (3 MHz Channel BW)	NA	-100 dBm @ MCS 0 -97 dBm @ MCS 1 -95 dBm @ MCS 2 -92 dBm @ MCS 3 -87 dBm @ MCS 4 -85 dBm @ MCS 5 -82 dBm @ MCS 6 -79 dBm @ MCS 7

Datasheet (Preliminary)

Model Category	Pro	Xtreme
		-97 dBm @ MCS 8 -93 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

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