Application Note

Doodle Labs Smart Radios for Unmanned Vehicles

State-of-the-art wireless to address challenges in unpredictable RF environments

Wireless Digital Link – The Lifeline of Unmanned Vehicles

Today a high capacity broadband wireless digital communication link is a lifeline to carry Command, Control and Communication (C3) between the UV and Control Station. Historically, because of technology constraints, unmanned systems used to have multiple wireless links. In a typical setup, narrowband datalink was used for command and control and a separate analog downlink was used to transmit images.

As the functionality of the UV's is rapidly expanding, it is necessary to have highly reliable, low latency, high capacity datalinks for command, control and streaming 4K video. Because of its importance, a lot of research work is being done in the industry to leverage the benefits of MIMO to address the RF challenges and develop new IP based networking architectures like Mobile Adhoc Networks for extending the range and support Beyond Line of Sight (BLOS) operations.

Smart Radios for Unmanned Vehicles

Doodle Labs is proud to introduce the state-of-the-art Smart Radios to the unmanned systems market. Smart Radios are built upon the foundation of best COFDM technology, native IP architecture, data security and advanced Mesh capabilities to provide wireless C3 links in the harshest of RF and physical environments. Smart Radios are developed with carefully selected features based upon many years of experience supplying the radios for the DoD.

The Smart Radios are tiny, full-featured MIMO radio and a mesh router. They have an Ethernet interface to allow easy integration into any system. With up to 1W of RF power, 2x2 MIMO technology and high Rx sensitivity, the Smart Radio can transmit large amounts of data from over 20 km away. The Smart Radio's interchangeable flexible frequency architecture can satisfy customers' requirements in any market or country. The Smart Radios are available in many frequency bands up to 4 GHz, allowing customers to switch the operating bands by simply swapping the radio.

Enabling Industrial Internet Revolution

Key Features

PERFORMANCE RF

- Interference resistant COFDM for improved link quality in congested RF environments
- Adaptive radio modulations from DSSS up to 64QAM and continuous per packet optimization to maximize link performance in dynamic environments
- Software defined channel size of 5~40 MHz for efficient re-use of spectrum
- Software defined operating frequency band for global applications
- Exceptional Multipath and NLOS performance
- Convolutional Coding, Forward error correction (FEC), Ack-retransmits for robust data transmission over noisy spectrum
- Maximal Ratio Combining and Beam forming for diversity antenna gain
- Spatial Multiplexing for enhanced throughput
- Space Time Block Coding for increased robustness in the dynamic directional orientation due to roll and pitch of the mobile vehicles.
- Time Division Duplexing (TDD) for bi-directional traffic
- Distributed control with CSMA/CA to auto balance the network for asymmetric up/down traffic and throughput requirements of each node
- Long range (up to 20 km) with adjustable RF power to reduce interference
- Fast handoff for mobile applications

PERFORMANCE NETWORKING

- End-to-end IP architecture for distributing unicast and multicast traffic
- High data throughput up to 100 Mbps
- Advanced QOS and multimedia traffic prioritizations for low latency Command and Control as well as 4K video streaming on the same link
- Multiple network access and authentication methods
- AES256, 128-bit WPA2-PSK encryption for over the air data
- Firewall - MAC/IP/protocol/port filtering for restricted access control
- Embedded network management GUI and UCI interfaces with detailed diagnostics information
- Supported Protocols - DNS, HTTP, HTTPS, IP, ICMP, NTP, TCP, UDP, RADIUS, DHCP, VLAN, STP/RSTP, VPN, IPSec, L2TP, GRE

- Support for all topologies, including infrastructure, adhoc, PtP, PtmP, and Repeater modes

ADDITIONAL FEATURES

- Very small size, weight, and power (SWaP) for mobile applications
- Choice of Ethernet or miniPCIe interfaces to allow easy integration into various applications
- Available in 100 MHz – 6 GHz frequency range in form factor compatible models
- Rugged construction, Industrial temperature range (-40C to +85C)
- Regulatory compliance for unwanted spurious emissions
- Field proven and deployed in critical applications where failure is not an option
- COTS – Commercial off the Shelf, Extended lifespan with long planned availability

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C3 for Unmanned Aerial Vehicles

The wireless link between the controller and the flyer is of upmost importance to drone manufacturers. A detailed look at the drone's operating environment shows that there are numerous factors affecting the radio performance. The effects of rapidly varying orientation (antenna shadowing, tilt and roll), can drastically change the multi-path reflections, received signal strength and link quality between the flyer and the control station. A COFDM based 2x2 MIMO radio with a mix of H and V polarity antennas can provide diversity and withstand these challenges.

Additionally, in a typical UAV application, physical constraints also play a significant role. A small SWaP (Space, Weight and Power) are the most demanding requirements for on-boarding the radio equipment on the flyer.

Most commercial drones currently available on the market can go at a maximum speed of approximately 50 mph, and need maximum range of about one mile, though that is changing rapidly with higher capability drones. The uplink connection from ground controller to the UAV requires low latency throughput of about 0.5 Mbps/sec to send command and control information. The downlink from the drone to the controller requires about 5-10 Mbits/sec of low jitter throughput for streaming real-time 4k video data.

Doodle Labs offers a wide variety of radios and transceivers with best-in-class performance that can fit into different UAV system architectures. Many commercial drone manufacturers use Doodle Labs long range Industrial Wi-Fi transceivers (2.4 and 5 GHz) with MIMO to establish spatial diversity link to mitigate the effects of challenging radio conditions, and to improve the robustness of the connection. The most common configuration uses two antennas at both ends.

For special defense and public safety related applications requiring even longer range, Doodle Labs offers Smart Radio and Prism-WiFi transceivers. These models are available in many different frequencies. Choice of operating frequency plays an important role to balance the range, power consumption and the antenna weight. At lower frequencies, the signal propagation is longer, power consumption is lower while antenna size/weight are larger. So even though it may seem counterintuitive, use of higher frequency with higher gain antennas may provide longer range.

C3 for Unmanned Ground Vehicles

The Unmanned Ground Vehicles (UGV) are used to replace humans in hazardous situations. Like the UAV, these robotics missions require wireless links that are dependable, low latency for Command and Control and high capacity, low jitter for streaming 4K video.

However, there are some important differences. For UGVs, relatively short links that can penetrate deep and handle multipath reflections inside the buildings is the most important criteria. Again, the MIMO technology provides a good solution for handling these harsh RF environments.

Because of the low height of the robots and the controllers, signal loss due to the Fresnel zone obstruction plays a significant role. This requires a careful choice of operating frequency to achieve the desired range and penetration. At lower frequencies, the RF signals travel longer distance and signal penetration is deeper. However, larger Fresnel zone obstruction is detrimental. It is recommended to use antennas with up-tilted radiation pattern to guide the signals away from ground.

In most cases, a low SWaP (Space, Weight and Power) is not a very important criteria (except in case of some very small robots it can be critical). On the other hand, a small SWaP can be an important requirement for handheld controller units.

Doodle Labs' large product portfolio allows the robot manufacturers to make these various tradeoffs and select the best matching radios with best performance. Many UGV manufactures use Doodle Labs MIMO radio modules and have achieved non-line-of-sight (NLOS) range of up to 300 meters and be able to stream 4K surveillance video.

C3 for Unmanned Surface Vehicles

Unmanned surface vehicles (USV) or Autonomous Surface Vehicles (ASV) are remote controlled vehicles that operate on the surface of the water. USVs are valuable in oceanography applications as they are more capable and cheaper to operate.

Ability to operate wirelessly over water is a critical requirement. The MIMO radios can harness the multipath signals reflected from the water surface to increase the reliability and robustness of communication. What was previously a cause for interference is now an asset.

Doodle Labs Products for Unmanned Systems

With a focus on mobile applications, Doodle Labs offers a comprehensive line of wireless products for Unmanned Vehicles market. The product portfolio includes radio modules for many different frequencies and with different interfaces to easily integrate with any system architecture.

Description	Model No.
Industrial Wi-Fi transceivers, long range with low SWaP	11ac and 11n Series
Smart Radio platform with Ethernet interface	RM Series
Prism-WiFi Transceivers with miniPCIe interface	NM Series
Frequency shifters for CPU boards with embedded WiFi	HM Series