Product Databook

Airborne 802.11b/g Value Radio
WLRG-RA-DP101

Revision 1.0

December 2007

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Contents

Figures

Tables

1.0 Overview

Airborne™ is a line of highly integrated 802.11 radios and modules. Airborne™ Radio Modules deliver a high performance, integrated solution for consumer and industrial wireless applications using the latest IEEE 802.11b/g platforms. They deliver both cost and space efficient solutions using a small profile design and a direct down SMT high density header connection to the system board.

The WLRG-RA-DP101 product family is a complete high-speed wireless solution that uses a proven 802.11b/g chipset (8385/8015) from Marvell. It provides backward compatibility with the 802.11b DSSS standard and adds the 802.11g OFDM (Orthogonal Frequency Division Multiplexing) standard support. This chip set includes integrated antenna connectors that provide a direct connection from the radio to the antenna. This bypasses the system board, which simplifies the integrator's board design. The radio is a true upgrade option because no soldered connections are required. It can be upgraded in the field or added to a managed product configuration.

The latest addition to the Airborne Value family provides a Compact Flash+ (PC16) host interface and is directly, plug-in compatible with the Airborne WLRB-RA-DP101 802.11b product.

Designed specifically with power, performance and flexibility in mind, the Airborne value radio family provides the ability to match hardware configuration with device performance, in a cost efficient solution.

Quatech supplies the highest performance M2M WiFi radio products available, these are backed with industry leading support and product warranties. Please contact Quatech for further details and connect with reliability and performance.

2.0 Conventions

The following section outlines the conventions used within the document, where convention is deviated from the deviation takes precedence and should be followed. If you have any question related to the conventions used or clarification of indicated deviation please contact Quatech Sales or Wireless Support.

2.1 Terminology

Airborne Performance Radio is used in the opening section to describe the devices detailed in this document, after this section the term radio will be used to describe the device.

2.2 Notes

A note contains information that requires special attention. The following convention will be used. The area next to the indicator will identify the specific information and make any references necessary.

The area next to the indicator will identify the specific information and make any references necessary.

2.3 Caution

A caution contains information that, if not followed, may cause damage to the product or injury to the user. The shaded area next to the indicator will identify the specific information and make any references necessary.

The area next to the indicator will identify the specific information and make any references necessary.

2.4 File Format

These documents are provided as Portable Document Format (PDF) files. To read them, you need Adobe Acrobat Reader 4.0.5 or higher. For your convenience, Adobe Acrobat Reader is provided on the Radio Evaluation Kit CD. Should you not have the CD, for the latest version of Adobe Acrobat Reader, go to the Adobe Web site (www.adobe.com).

3.0 Product Description

The product is a high performance 802.11b/g radio based upon the Marvell Libertas chipset, designed by Quatech to be a high performance, embeddable, rugged WiFi (802.11) radio solution.

3.1 General Features

- Highly integrated IEEE 802.11a/b/g wireless radio with baseband processor/MAC and RF Transceiver (Marvell 8385/8015).
- Infrastructure and AdHoc
- PC16 (Compact Flash+) Host Interface
- High Density SMT Connector
  - 50 pin Hirose digital interface (HRS DF12-50DS-0.5V) – PC16 (CF)
- Two (2) Hirose U.FL RF connectors
- Quatech standard PC16 (CF) radio form factor.
  - Dimensions: 38mm x 27mm x 5.7mm
- Industrial temp (-40°C to 85°C)
- Storage temp (-50°C to 125°C)
- Four (4) mounting holes
- FCC and Industry of Canada modular approval

3.2 Radio Features

- IEEE 802.11b/g 54 Mbps/2.4 GHz optimized for consumer and industrial applications
- Marvell chipset designed for increased battery life
- Performance optimized for web pads, mobile MP3, and other Internet appliances
- On-chip A/D and D/A converters for I/Q data, AGC, and adaptive power control
- Purely digital interface (High speed serial interface or HSSI) between the Radio Chip and the MAC/PHY chip
- Designed to meet FCC Part 15 regulatory requirements for operation in 2.4GHz ISM band
- Support for 802.11b mode 11, 5.5, 2 and 1 Megabit Per Second (Mbps) Data Rates as well as 802.11g mode 54Mbps, 48Mbps, 36Mbps, 24Mbps, 18Mbps, 12Mbps, 9Mbps, and 6Mbps Data Rates
- Supports the lEEE 802.11b Direct Sequence Specification as well as 802.11g OFDM Specification
- Supports Antenna Diversity through radio firmware control (RX only)
- Intelligent Power Control, Including Low Power Standby Mode

- Auto Transmitter power control

3.3 Medium Access Controller and Baseband Processor Features

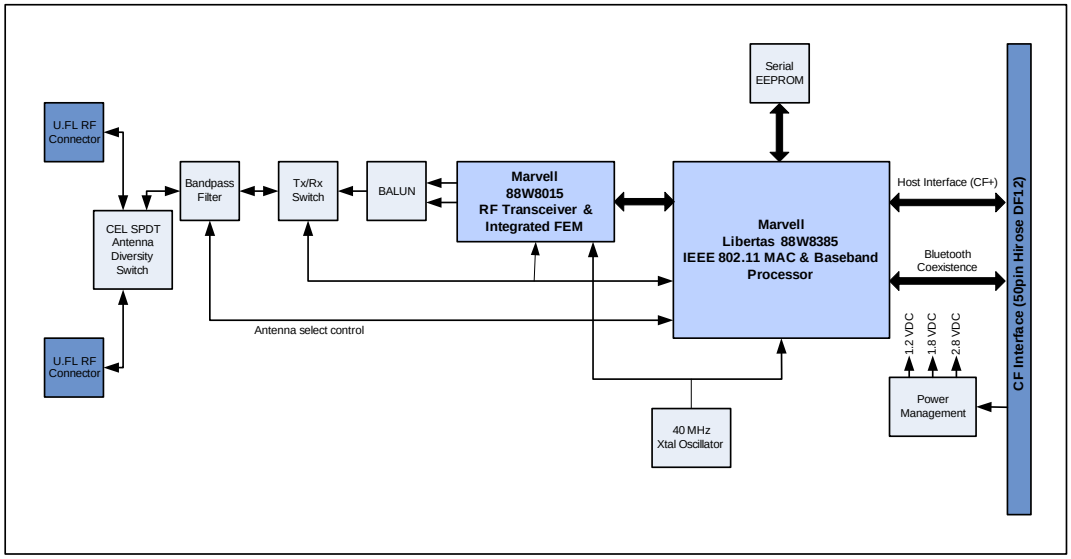
- Complete DSSS baseband processor for B-Mode and OFDM baseband processor for G-Mode
- Processing gain is FCC compliant (B-Mode)
- Targeted for OFDM multi-path Delay Spread of up to 680ns for 11Mbps, and 150ns for 54Mbps
- Programmable data rates 1, 2, 5.5, and 11Mbps for B-Mode and 6Mbps, 9Mbps, 12Mbps, 18Mbps, 24Mbps, 36Mbps, 48Mbps, and 54Mbps for G-Mode
- Supports auto-fallback of supported link rates.
- Modulation methods: DBPSK, DQPSK, and CCK for B-Mode and BPSK, QPSK, 16-QAM, and 64-QAM for A/G-Mode
- WiFi Protected Access™ (WPA) and WiFi Protected Access 2™ (WPA2) support
- Enhanced performance WEP engine
- AES Hardware acceleration (AES-CCMP) as part of 802.11i
- Seamless roaming within IEEE 802.11b/g WLAN infrastructure.
- Supports half duplex operation
- Supports short preamble (B-Mode) and antenna diversity (Rx only)
- Supports 802.11e (QoS)
- Supports 802.11h (DFS and TPC)
- Supports 802.11j channels (Japan)
- Supports radio hosted firmware host downloaded radio firmware (WLRG-RA-DP101)

Figure 1- WLRG Radio

4.0 Block Diagrams

The following outlines the block diagram of the radio:

Figure 2 - Block Diagram for WLRG-RA-DP101



5.0 Model Numbers

The following table identifies the available model numbers for the radio family. Please contact Quatech sales for details, quotes and availability.

Table 1 - Model Numbers

Model Number	Description	WiFi	Interface	Security		RoHS
		11b/g	PC16	WEP/WPA	WPA2	
WLRG-RA-DP101	PC16 (CF+)	●	●	●	●	●
WLEG-RA-DP101	WLRG-RA-DP101 Evaluation Kit *WLRG-RA-DP1011 radio* *PCMCIA Adapter Card* *Tools/Documentation CD* *Drivers (WinCE/WinXP/Linux)*					●

6.0 Pin out and Connectors

There are a total of three connectors to the radio:

J1: Digital Compact Flash interface to radio Baseband processor.
HRS DF12-50DS-0.5V (50pin Hirose)

J2, J3: RF connectors for antenna.
Hirose U.FL.

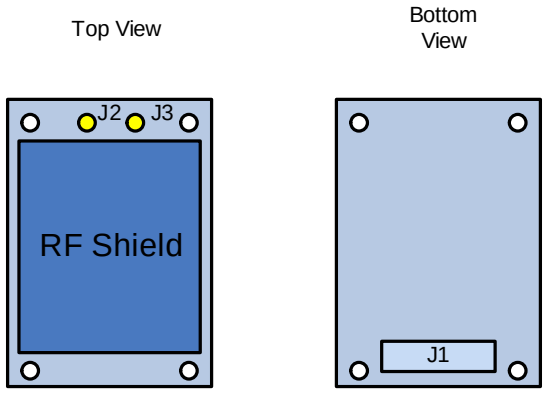


Figure 3 – J1 - 50 pin Connector Layout (WLRG-RA-DP101) – Viewed from Bottom

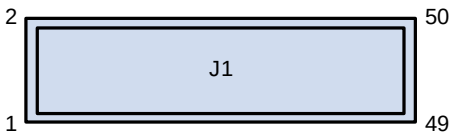


Table 2 – WLRG-RA-DP101 (PC16) Pin Definition

Pin	Signal	Pin I/O Type	Description
1	RF_VCC	Power, 0.35A	DC Power Supply 3.3V ±5%
2	RF_VCC	Power, 0.35A	DC Power Supply 3.3V ±5%
3	RF_VCC	Power, 0.35A	DC Power Supply 3.3V ±5%
4	RF_VCC	Power, 0.35A	DC Power Supply 3.3V ±5%
5	A00	5V tol, BiDir, 2mA, 50K Pull Down	Host Address Input, Bits 0
6	D00	5V tol, BiDir, 2mA, 50K Pull Down	Host Data Bus, Bits 0
7	A01	5V tol, BiDir, 2mA, 50K Pull Down	Host Address Input, Bits 1
8	D01	5V tol, BiDir, 2mA, 50K Pull Down	Host Data Bus, Bits 1
9	A02	5V tol, BiDir, 2mA, 50K Pull Down	Host Address Input, Bits 2
10	D02	5V tol, BiDir, 2mA, 50K Pull Down	Host Data Bus, Bits 2
11	A03	5V tol, BiDir, 2mA, 50K Pull Down	Host Address Input, Bits 3
12	D03	5V tol, BiDir, 2mA, 50K Pull Down	Host Data Bus, Bits 3
13	A04	5V tol, BiDir, 2mA, 50K Pull Down	Host Address Input, Bits 4
14	D04	5V tol, BiDir, 2mA, 50K Pull Down	Host Data Bus, Bits 4
15	A05	5V tol, BiDir, 2mA, 50K Pull Down	Host Address Input, Bits 5
16	D05	5V tol, BiDir, 2mA, 50K Pull Down	Host Data Bus, Bits 5
17	A06	5V tol, BiDir, 2mA, 50K Pull Down	Host Address Input, Bits 6
18	D06	5V tol, BiDir, 2mA, 50K Pull Down	Host Data Bus, Bits 6
19	A07	5V tol, BiDir, 2mA, 50K Pull Down	Host Address Input, Bits 7
20	D07	5V tol, BiDir, 2mA, 50K Pull Down	Host Data Bus, Bits 7
21	A08	5V tol, BiDir, 2mA, 50K Pull Down	Host Address Input, Bits 8
22	GND	Ground	Digital Ground
23	A09	5V tol, BiDir, 2mA, 50K Pull Down	Host Address Input, Bits 9
24	D08	5V tol, BiDir, 2mA, 50K Pull Down	Host Data Bus, Bits 8
25	GND	Ground	Digital Ground
26	D09	5V tol, BiDir, 2mA, 50K Pull Down	Host Data Bus, Bits 9
27	OE#	5V tol, BiDir, 2mA, 50K Pull Up	Host Memory Attribute Space Output Enable

Pin	Signal	Pin I/O Type	Description
28	D10	5V tol, BiDir, 2mA, 50K Pull Down	Host Data Bus, Bits 10
29	WE#	5V tol, CMOS, Input, 50K Pull Up	Host Memory Attribute Space Write Enable
30	D11	5V tol, BiDir, 2mA, 50K Pull Down	Host Data Bus, Bits 11
31	IORD#	5V tol, BiDir, 2mA, 50K Pull Up	Host I/O Space Read Strobe
32	D12	5V tol, BiDir, 2mA, 50K Pull Down	Host Data Bus, Bits 12
33	IOWR#	5V tol, BiDir, 2mA, 50K Pull Up Host	Space I/O Write Strobe
34	D13	5V tol, BiDir, 2mA, 50K Pull Down	Host Data Bus, Bits 13
35	CE1#	5V tol, BiDir, 2mA, 50K Pull Up Host	Select, Low Byte
36	D14	5V tol, BiDir, 2mA, 50K Pull Down	Host Data Bus, Bits 14
37	CE2#	5V tol, BiDir, 2mA, 50K Pull Up Host	Select, High Byte
38	D15	5V tol, BiDir, 2mA, 50K Pull Down	Host Data Bus, Bits 15
39	GND	Ground	Digital Ground
40	GND	Ground	Digital Ground
41	RESET	5V tol, CMOS, ST (Schmitt Trigger) Input, 50K Pull Up	Hardware Reset
42	IREQ#	5V tol, BiDir, 2mA, 50K Pull Up	Host interrupt Request (I/O Mode), also used as the Module's Ready (Memory Mode) output which is asserted to indicate Module initialization is complete
43	REG#	5V tol, BiDir, 2mA, 50K Pull Up	Host Attribute Space Select Memory mode: H for common memory, L for attribute memory. The signal must be low during I/O cycles when the I/O address is on the bus.
44	WAIT#	CMOS Output, 4mA, 10K Pull Up	Host device must provide a 10K Pull Up
45	RF_LED#	Input, 9mA	LED cathode
46	IOIS16#	Pull Low, Output	8 Bits or 16 Bits I/O Card selected L: 16 bit or odd byte only operation
47	STSCHG#	CMOS Output, 4mA 50K Pull Up	Host Status Change Shows the BVD1 (Battery Voltage Detect), BVD2, WP (Write Protect), or Ready status changed.
48	CD1#	Pull Low, Output	Card Detect
49	GND	Ground	Digital Ground
50	INPACK#	CMOS BiDir, 2mA, 50K Pull Up	Host I/O Decode Confirmation. Asserted by the Module when selected and responding to an I/O read cycle. Used to control the HBA (Host Bus Adaptor) tri-state buffer on/off).

7.0 Electrical & RF Specification

Table 3- Absolute Maximum Values[1]

Parameter	Min	Max	Unit
Supply Voltage Range	3.0	3.6	VDC
Supply Voltage	-0.3	4.0	VDC
Operating Temperature Range	-40	85	°C
Storage Temperature	-55	125	°C

	These are absolute ratings; exceeding these values may cause permanent damage to the device.
	All temperatures refer to ambient conditions.

Table 4 – Operating Conditions & DC Specification

Symbol	Parameter	Test Conditions	Min	Typ	Max	Units
V_{BUS}	Supply Voltage		3.135	3.3	3.465	V
I_{CCTXG}	Constant transmit current (802.11g)	*Transmitting @ 54Mb/s*		475	485	mA
I_{CCRXG}	Constant receive current (802.11g)	*Receiving valid packets @ 54MB/s*		275	325	mA
I_{CCTXB}	Constant transmit current (802.11b)	*Transmitting @ 11Mb/s*		450	500	mA
I_{CCRXB}	Constant receive current (802.11b)	*Receiving valid packets @ 11MB/s*		275	325	mA
I_{SBIEEE}	IEEE Power Save Mode	*Associated, Idle, Beacon Interval = 100ms (DTIM=10)*		8	20	mA
T_{DELAY}	Targeted Multipath Delay Spread using IEEE 802.11 Naftali	11Mbps, 8% PER		680		ns
		54Mbps, 10% PER		150		
R_{X_MAX}	IEEE Maximum Receive Level	PER < 8% (11b mode)		-10		dBm
		PER < 10% (11g mode)		-20		
IIP3	3rd Order Intercept Point (Input)	-90dBm Input		-14		dBm
		-30dBm Input		4		
	IEEE 802.11g Carrier Leakage	Per IEEE 802.11g			2	dB
T_{X_SUP}	IEEE 802.11b Carrier Suppression	Per IEEE 802.11b		15		dB
ACR	802.11b/g Adjacent Channel Rejection	PER < 8% (11b mode)[1]	36			dB
		PER < 10% (11g mode @ 54Mbps)	-1			
		PER < 10% (11g mode @ 6Mbps)	16			

1. Adjacent channel measurement is carried out on two channels separated by 25MHz (5 channels) for B/G-modes.

2. Test Conditions: Supply Voltage (V_{CC}) = 3.3VDC, Ambient Temperature 258C, unless otherwise stated.

Table 5 - PC16 (Compact Flash) Interface Specification

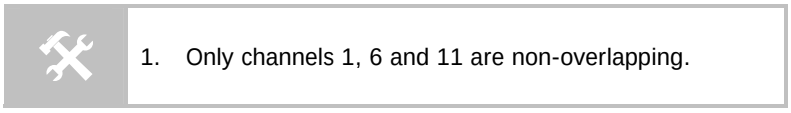
Symbol	Parameter		Min	Typ	Max	Units
V_{IHPC16}	Input HIGH Voltage	V_{BUS}=MAX, MIN	0.7 V_{BUS}			V
V_{ILPC16}	Input LOW voltage	V_{BUS}=MIN, MAX			0.3 V_{BUS}	V
V_{OHPC16}	Output HIGH Voltage	I_{OL} = 2mA, V_{BUS}=MIN		2.6		V
V_{OLPC16}	Output LOW voltage	I_{OL} = 2mA, V_{BUS}=MIN		0.05		V
I_{LPC16}	Input Leakage Current	V_{BUS}=MAX, Input = 0V or V_{CC}	-1	0.1	1	µA
C_{INPC16}	Input Capacitance			5	10	pF
$C_{OUTPC16}$	Output Capacitance			5	10	pF

Table 6 - Supported Data Rates by Band

Band	Supported Data Rates (Mbps)
802.11b	11, 5.5, 2, 1
802.11g	54, 48, 36, 24, 18, 12, 9, 6

Table 7 - Operating Channels

Band	Region	Freq Range (GHz)	No. of Channels	Channels
802.11b	US/Canada	2.401 - 2.473	11	1 - 11
	Europe	2.401 - 2.483	13	1 - 13
	France	2.401 - 2.483	4	10 - 13
	Japan	2.401 - 2.495	14	1 - 14
802.11g	US/Canada	2.401 - 2.473	11	1 - 11
	Europe	2.401 - 2.483	13	1 - 13
	France	2.446 - 2.483	4	10 - 13
	Japan	2.401 - 2.483	13	1 - 13



1. Only channels 1, 6 and 11 are non-overlapping.

Table 8 - RF Characteristics – 802.11b/g

Symbol	Parameter	Rate (Mbps)	Min dBm	Average dBm / mW		Peak dBm / mW		Units
P_{OUTB}	Transmit Power Output 802.11b	11, 5.5, 2, 1	13	15	31.6	19.3	85.1	dBm/mW
P_{OUTG}	Transmit Power Output 802.11g	6, 9,12,18, 24, 36, 48, 54	10	12	15.9	21.5	141.3	dBm/mW
P_{RSENB}	Receive Sensitivity 802.11b	11		-84				dBm
		5.5		-85				
		2		-86				
		1		-86				
P_{RSENG}	Receive Sensitivity 802.11g	54		-69				dBm
		48		-70				
		36		-74				
		24		-78				
		18		-81				
		12		-83				
		9		-85				
		6		-86				
$F_{RANGEBG}$	Frequency Range		2412			2484		MHz

7.1 AC Electrical Characteristics – Transmitter

Transmit power is automatically managed by the device for minimum power consumption. The MAXIMUM transmit power at the RF connector is typically +15dBm ± 2 dB for B-Mode (all rates) and +12dBm+/-2dB for G-Mode (all rates).

7.2 Performance/Range

The following table illustrates the typical data rates, performance and range the device is capable of providing using an omni directional antenna.

Table 9 - Radio Typical Performance Range

Data Rate	**Typical Outdoor Distance** (Unity gain antenna)	**Typical Outdoor Distance** (2dBi antenna gain on each end for B/G mode)
1.0 Mb/s	240m	380m
11.0 Mb/s	135m	215m
6Mb/s 802.11g	135m	215m
6Mb/s 802.11a	49m	155m
54Mb/s 802.11g	12m	19m
54Mb/s 802.11a	4.5m	14m

Ranges are based on receiver sensitivity, Transmitter power, free-space path loss estimates, antenna gain factors, and link margin estimates. Actual range will vary from those stated. Non-line-of-site applications will result in typical values less than shown above.

The Data Rate is the supported connection rate for the wireless link, the actual data throughput for the link will be less than the stated data rates.

8.0 Antenna

The unit supports antenna connection to two Hirose U.FL connectors, located on the top surface of the radio next to the RF shielding. The radio supports Rx diversity.

Any antenna used with the system must be designed for operation within the 2.4GHz ISM band and specifically must support the 2.412GHz to 2.482GHz for 802.11b/g operation. They are required to have a VSWR of 2:1 maximum referenced to a 50ς system impedance.

8.1 Antenna Selection

The Airborne radio supports a number of antenna options, all of which require connection to the U.FL connectors on the radio. Ultimately the antenna option selected will be determined by a number of factors, these include consideration of the application, mechanical construction and desired performance. Since the number of possible combinations is endless we will review some of the more common solutions in this section. If your application is not covered during this discussion please contact Technical Support for more specific answers.

The available antenna connections include:

- Host board mounted antenna
- Host Chassis mounted antenna
- Embedded antenna

In addition to the above options, location and performance need to be considered, the following sections discuss these items.

8.2 Host Board Mounted Antenna

Host board mounted requires that an antenna connection is physically mounted to the host system board. It also requires that the host board include a U.FL connector (two (2) if diversity is being used) to allow a U.FL to U.FL coaxial lead to connect from the radio to the host board. It will then require 50ς matched PCB traces to be routed from the U.FL connector to the antenna mount.

There are several sources for the U.FL to U.FL coaxial cable these include Hirose, Sunridge and IPEX. Please contact Quatech for further part numbers and supply assistance.

This approach can simplify assembly but does require that the host system configuration can accommodate an antenna location that is determined by the host PCB. There are also limitations on the ability to seal the enclosure when using this approach.

This approach also restricts the selection of available antenna. When using this approach antennas that screw or press fit to the PCB mount connector must be used. There are many options for the antenna connector type, however if you wish to utilize the FCC/IOC modular approval the connector choice must comply with FCC regulations, these state a non-standard connector is required e.g.

TNC/SMA are not allowed (there are more that are not), RP-TNC/RP-SMA are allowed.

8.3 Host Chassis Mounted Antenna

Host Chassis mounted antennas require no work on the host PCB. They utilize an antenna type called ‘flying lead’. There are two types of flying leads; one which provides a bulkhead mounted antenna connector and one which provides a bulk head mounted antenna. The type you choose will be determined by the application.

A flying lead system connects a U.FL coaxial lead to the radio’s U.FL connector, the other end of the coax is attached to either a bulkhead mounted antenna connector or directly to an antenna that has an integrated bulkhead mount.

In either of the two cases, the use of this approach significantly reduces the antenna system development effort and provides for greater flexibility in the available antenna types and placement in the host system chassis.

When using the flying lead antenna (integrated bulk head mounting), there are no connector choice restrictions for use with the FCC/IOC modular certification. However if the flying lead connector is used, the same restrictions as identified for the Host Mounted Antenna apply.

There are many suppliers of flying lead antenna and connectors; Quatech’s Airborne Antenna product line offers a range of antenna solutions.

8.4 Embedded Antenna

Use of Embedded antenna can be the most interesting approach for M2M, industrial and medical applications. Their small form factor and absence of any external mounting provides a very compelling argument for their use. There is a downside to this antenna type and it comes with performance. Antenna performance for all of the embedded options will, in most cases, be less that that achievable with external antenna. This does not make them unusable; it will impact choice of antenna type and requires more focus on placement.

The three main embedded antenna types are PCB embedded, chip (PCB mounted) and flying lead; each has its advantages and disadvantages (See Table 10).

Table 10 - Embedded Antenna Options

Antenna Type	Features			
	Cost	Size	Availability	Performance
PCB Embedded	Lowest	Largest	Custom	Poor
Chip	Low	Small	Standard	Poor
Flying Lead	Low	Small	Standard	Fair

PCB Embedded – This approach embeds an antenna design into the host PCB. This approach is very common with add-in WiFi card (CF, PCMCIA, SDIO, etc.) as it requires no external connections and is the cheapest production approach. The lower production cost requires significant development cost and lack of performance and flexibility.

Chip – The integration of a chip antenna is simple and requires a relatively small footprint on the host system, however, it does suffer from the same limitations of flexibility and performance seen with the PCB embedded approach. There are relatively large numbers of suppliers of this type of antenna; there is also a range of configuration and performance options.

Flying Lead – This approach is similar to the flying lead solution for external antennas, the difference is that the form factors are smaller and provide a range of chassis and board mounting options, all for internal use. This approach suffers less from the performance and flexibility limitations of the other approaches, since the location of the antenna it not determined by the host PCB design. The assembly of a system using this approach maybe slightly more complex since the antenna is not necessarily mounted on the host PCBA.

8.5 Antenna Location

The importance of this design choice cannot be over stressed; it can in fact be the determining factor between success and failure of the WiFi implementation.

There are several factors that need to be considered when determining location:

- Distance of Antenna from radio
- Location of host system
  - Proximity to RF blocking or absorbing materials
  - Proximity to potential noise or interference
  - Position relative to infrastructure (Access Points or Laptops)
- Orientation of host system relative to infrastructure
  - Is it known
  - Is it static

To minimize the impact of the factors above the following things need to be considered during the development process:

- Minimize the distance between the radio and the location of the antenna. The coaxial cable between the two impacts the Transmit Power and Receive Sensitivity negatively. Quatech recommends using 1.32-1.37mm outer diameter U.FL coaxial cables.
- Minimize the locations where metal surfaces come into contact or are close to the location of the antenna.
- Avoid locations where RF noise, close to or over lapping the ISM bands, may occur. This would include microwave ovens and wireless telephone systems in the 2.4GHz and 5.0GHz frequency range.
- Try and mount the antenna as high on the equipment as possible.

- Try to locate the antenna where there is a minimum of obstruction between the antenna and the location of the Access Points. Typically Access Points are located in the ceiling or high on walls.
- Keep the main antenna's polarization vertical, or in-line with the antenna of the Access Points. 802.11 systems utilize vertical polarization and aligning both transmit and receive antenna maximizes the link quality.
- Utilize diversity where possible.
- Utilize both spatial and polarization diversity where possible.
  - Spatial diversity for the 2.4GHz band requires the antenna to be a minimum 5" apart.
  - Polarization diversity requires the antenna are not aligned, the angle of separation should be determined by the possible range of orientation of the host system.

Even addressing all of the above factors, does not guarantee a perfect connection, however with experimentation an understanding of the best combination will allow a preferred combination to be identified.

8.6 Performance

Performance is difficult to define as the appropriate metric changes with each application or may indeed be a combination of parameters and application requirements. The underlying characteristic that, in most cases, needs to be observed is the link quality. This can be defined as the bandwidth available over which communication, between the two devices, can be performed, the lower the link quality the less likely the devices can communicate.

Measurement of link quality can be made in several ways; Bit Error rate (BER), Signal to Noise (SNR) ratio, Signal Strength and may also include the addition of distortion. The link quality is used by the radio to determine the link rate, generally as the link quality for a given link rate drops below a predefined limit, the radio will drop to the next lowest link rate and try to communicate using it.

The reciprocal is also true, if the radio observes good link quality at one rate it will try to move up to the next rate to see if communication can be sustained using it. It is important to note that for a given position the link quality improves as the link rate is reduced. This is because as the link rate drops the radios Transmit power and Receive sensitivity improve.

From this is can be seen the looking at the link rate is an indirect way of assessing the quality of the link between the device and an Access Point. You should strive to make the communication quality as good as possible in order to support the best link rate. However be careful not to *over specify* the link rate. Consider your applications bandwidth requirements and tailor your link rate to optimize the link quality e.g. the link quality for a location at 6Mb/s is better than it would be for 54Mb/s, if the application only needs 2Mb/s of data throughput, the 6Mb/s rate would provide a better link quality.

Aside from the radio performance, there are a number of other things that contribute to the link quality; these include the items discussed earlier and choices made when looking at the overall antenna gain. The antenna gain

contributes to the Equivalent Isotropically Radiated Power (EIRP) of the system. This is part of an overall measurement of the link quality called link margin.

Link Margin provides a measure of all the parts of the RF path that impact the ability of two systems to communicate. The basic equation looks like this:

EIRP (dB) = TxP + TxA – TxC

Link Margin (dB) = EIRP – FPL + (RxS + RxA – RxC)

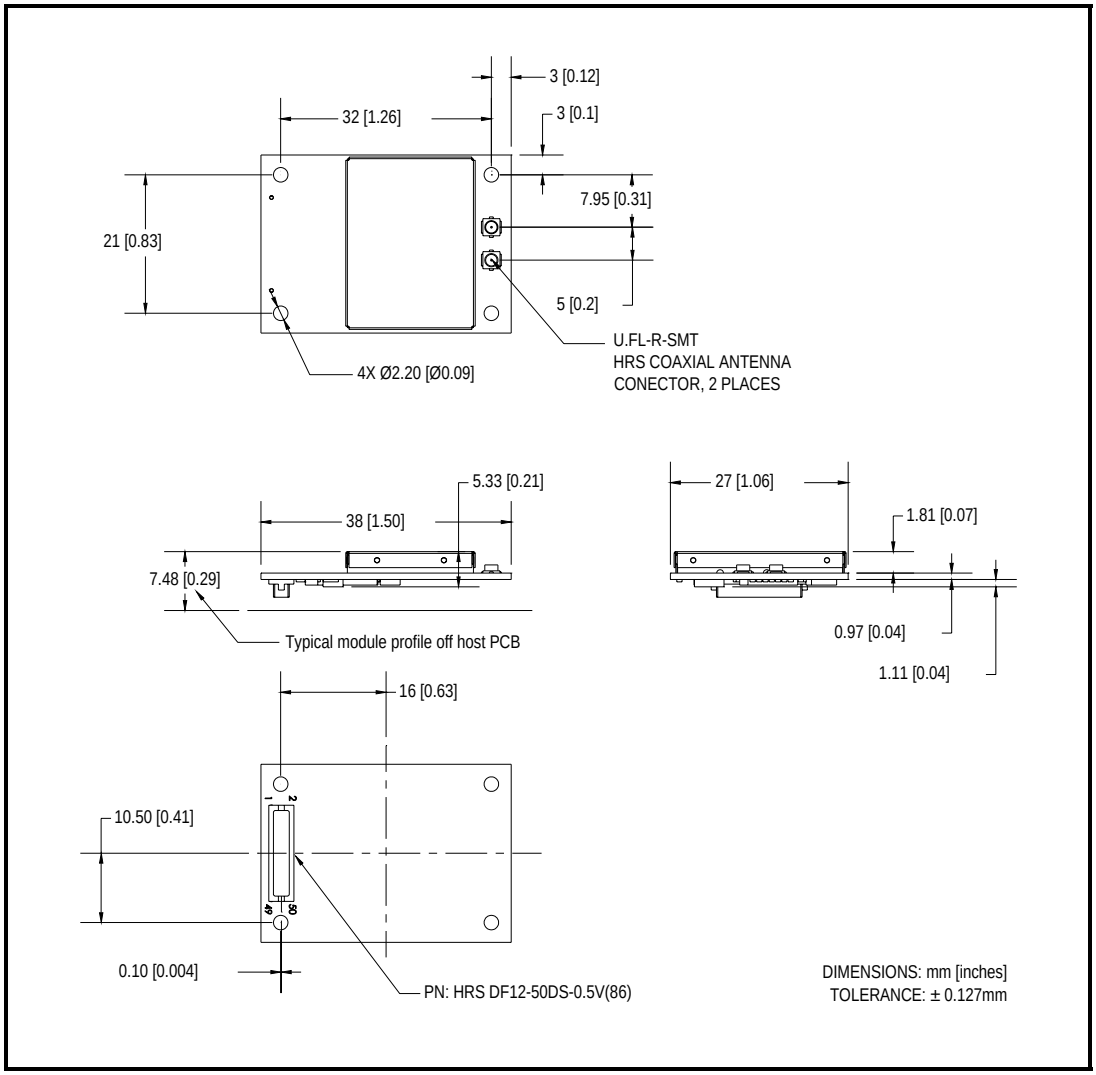
Where:
TxP = Transmitter output power (dBm)
TxA = Transmitter antenna gain (dBi)
TxC = Transmitter to Antenna coax cable loss (dB)
FPL = Free Path Loss (dB)
RxS = Receiver receive sensitivity (dBm)
RxA = Receiver antenna gain (dBi)
RxC = Receiver to Antenna coax cable loss (dB)

This is a complex subject and requires more information that is presented here, Quatech does recommend at least looking at the subject and evaluating any system at a basic level.

It is then possible, with a combination of the above items and an understanding of the application demands, to achieve a link quality optimized for the application and host design. It is important to note that this is established with a combination of hardware selection, design choices and configuration of the radio.

9.0 Mechanical Outline

Figure 4 - WLRG-RA-DP101 Family Mechanical Outline



10.0 Drivers and Software

Quatech supports its radios with a collection of drivers and tools. Driver supports OS's which include WinXP, WinCE and Linux 2.6. These drivers are supplied with the radio in the development kit or can be obtained directly from Quatech Technical Support.

A range of engineering tools are also available to assist in the integration of the radio into a system, evaluation of the radio for application suitability and regulatory testing. Please contact Quatech Sales or Technical Support for more information and availability of these tools.

11.0 Integration Guidelines

The Airborne Performance Radio is designed for integration in to a wide range of advanced electronic systems and diverse applications, the success of the integration and final performance of the integrated system depends upon the integration process and hardware design, the following section provides a set of guidelines to optimize the integration of the radio.

The following guidelines address hardware design requirements for the integration of the radio under normal conditions, should your application not be able to support the listed guidelines please contact Quatech.

11.1 General Requirements

- 3.3VDC6 5% on all V_{DD} pins
- Digital Ground on all V_{SS} pins
- Mechanical mounting method other than J1

11.2 Power Supply Guidelines

- 3.3VDC6 5%
- 500mA constant current
- 3000mA start-up current for 35ms
- 150mV ripple voltage (f<50Hz) at constant receive current

11.3 EMI/EMF Guidelines

To minimize electromagnetic interference (EMI) and radio frequency interference (RFI), pay strict attention to power and signal routing near the Radio. As much as possible, the keep-clear area below the Radio should be a solid copper ground plane. It is anticipated that the Radio will be mounted on a board with a committed ground plane. Ensure the PCB interconnect has a designed impedance of 50-75 Ohms.

To keep signal impedance as low as possible, connect the ground plane to internal ground planes by several vias. Ground signals to the Radio connector should connect directly to the ground plane below the Radio. Individual ground connections to the Radio should have a solid ground connection, preferably directly to the ground plane on the same surface side where the Radio resides. Do not connect ground pins directly to an inside layer ground plane using vias only.

Keep interconnects from the Radio connector as short as possible on the mounting layer. All inboard signals–including pin numbers–must immediately transition to a different routing layer using a via as close to the connector as possible. Outboard signals (odd pin numbers) should also be kept to a minimum length.

11.4 Circuit Board Layout Guidelines

When considering capacitance, calculations must consider all device loads and capacitances due to printed circuit board traces. Capacitance due to the traces depend on a number of factors, including the trace width, dielectric material from which the circuit board is made, and proximity to ground and power planes.

The mating connector required on the host board is a DF12(4.0)-50DP-0.5, the manufacturer is Hirose.

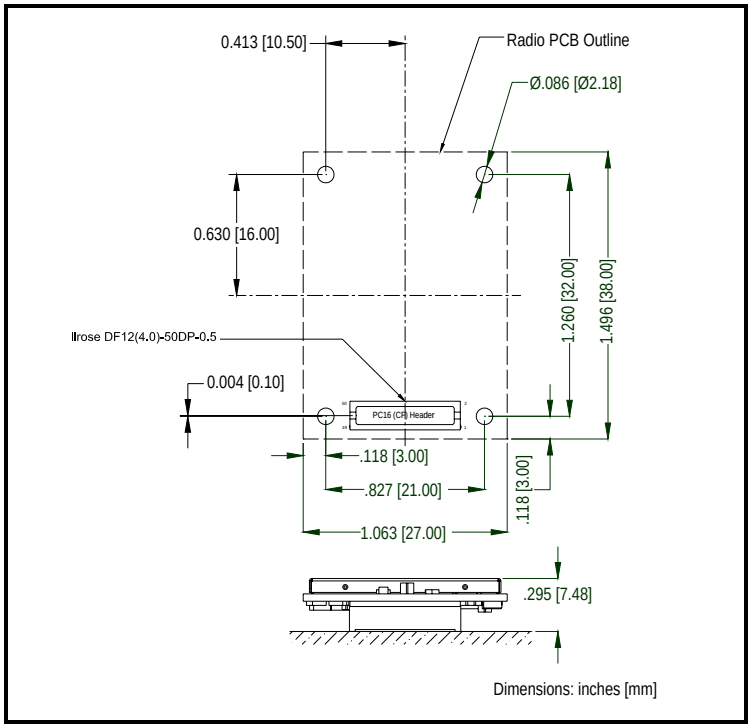
11.5 Mounting Guidelines

Special care must be observed when placing the Module. In particular:

- The antenna must not be mounted beneath any other printed circuit boards, components, or metallic housing.
- The proximity of the antenna to large metallic objects can affect the range and performance of the Module.
- Packaging and enclosure designers must carefully review the placement of the Module in the enclosure to minimize interference or blocking sources.

For mechanical clearance, performance, and emissions reasons, there should be no components placed on the main printed circuit board facing the Module. This area should be clear of any components. The recommended mounting footprint for the radios can be seen in Figure 5.

Figure 5 - WLRG-RA-DP101 Mounting Footprint



11.6 RESET Timer Guidelines

Figure 6 - RESET Pulse Timing

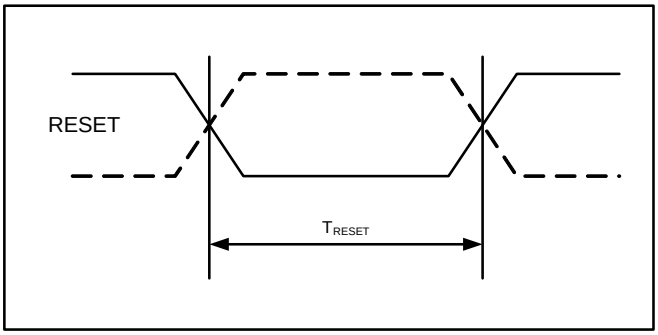


Table 11 - RESET Timing

Symbol	Parameter		Min	Typ	Max	Units
T_{RESET}	RESET minimum pulse width	V_{CC}=MAX, MIN	10[1]	100		ns

1. This is the minimum value guaranteed for a valid RESET. Smaller values may trigger the reset circuit.

12.0 Certification & Regulatory Approvals

The unit complies with the following agency approvals:

Table 12 - Regulatory Approvals

Country	Standard	Status
North America (US & Canada)	FCC Part 15 Sec. 15.107, 15.109, 15.207, 15.209, 15.247 Modular Approval	Granted
Europe	CISPR 16-1 :1993 ETSI EN 300 328 Part 1 V1.2.2 (2000-07) ETSI EN 300 328 Part 2 V1.1.1 (2000-07)	Completed
Japan	ARIB STD-T71 v1.0, 14 (Dec 2000) ARIB RCR STD-T33 (June 19, 1997) ARIB STD-T66 v2.0 (March 28, 2002)	Pending

12.1 FCC Statement

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 to an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for assistance.

Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

12.2 FCC RF Exposure Statement

To satisfy RF exposure requirements, this device and its antenna must operate with a separation distance of a least 20 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

12.3 Information for Canadian Users (IC Notice)

This device has been designed to operate with an antenna having a maximum gain of 5dBi for 802.11b/g band. An antenna having a higher gain is strictly prohibited per regulations of Industry Canada. The required antenna impedance is 50 ohms.

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

Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

12.4 FCC/IOC Modular Approval

This document describes the Airborne WLN FCC modular approval and the guidelines for use as outlined in FCC Public Notice (DA-00-1407A1).

The WLRG-RA-DP101 is covered by the following modular grants:

Country	Standard	Grant
North America (US)	FCC Part 15 Sec. 15.107, 15.109, 15.207, 15.209, 15.247 Modular Approval	F4AWLNG1
Canada	RSS 210 Modular Approval	39139A-WLNG1

By providing FCC modular approval on the Airborne WLN modules, the customers are relieved of any need to perform FCC part15 subpart C Intentional Radiator testing and certification, except where they wish to use an antenna that is not already certified.

Quatech supports a group of pre-approved antenna; use of one of these antennas eliminates the need to do any further subpart C testing or certification. If an antenna is not on the list, it is a simple process to add it to the pre-approved list without having to complete a full set of emissions testing. Please contact Quatech Technical support for details of our qualification processes.

Please note that as part of the FCC requirements for the use of the modular approval, the installation of any antenna must require a professional installer. This is to prevent any non-authorized antenna being used with the radio. There are ways to support this requirement but the most popular is to utilize a non-standard antenna connector, this designation includes the reverse polarity versions of the most popular RF antenna types (SMA, TNC, etc.). For more details please contact Quatech.

The user is advised that changes or modifications not expressly approved by the party responsible for FCC compliance could void the user's authority to operate the equipment.

Antennas approved for use with this grant are:

Nearson	S141AH-2450S
WiMo	17010.1
Nearson	S151M2-L-2450S
Nearson	S181TR-2450S
Nearson	S151M2-L-2450S
Antenex	TRA24003P
Laird	MAF 94045

The following documents are associated with this applications note:

- FCC Part 15 – Radio Frequency Devices
- FCC Public Notice – DA-00-1407A1 (June 26th, 2000)

Quatech recommends that during the integration of the radio, into the customers system, that the referenced design guidelines, outlined in section 11.0 of this manual, be followed. Please contact Quatech Technical Support if you have any concerns regarding the hardware integration.

Contact Quatech Technical support for a copy of the FCC and IOC grant certificates, the test reports and updated approved antenna list.

13.0 Physical & Environmental Approvals (Preliminary)

The device has passed the following primary physical and environmental tests. The test methods referenced are defined in SAE J1455 Aug1994.

Table 13 - Mechanical Approvals

Test	Reference	Conditions
Temperature Range (Operational)		-40°C to +85°C
Temperature Range (Non-Operational)		-50°C to +125°C
Humidity	Sect 4.2	0-95%RH @ 38°C condensing
Salt Spray	Sect 4.3	5%NaCl @ 35°C, 1000hrs
Altitude	Sect 4.8	Operational: 0-15,000ft (+6.4 PSIA Internal Non-operational: 0-40,000ft (+12 PSIA Internal)
Vibration	Sect 4.9	Operational: 2.4 Grms, 10-1K Hz, 1hr per axis Non-operational: 5.2 Grms, 10-1K Hz, 1hr per axis
Shock	Sect 4.10	Operational: 20Gs MAX, 11ms half-sine pulse
Product Drop	Sect 4.10.3.1	1m onto concrete, any face or corner, 1 drop
Packaging Drop	Sect 4.10.2.1	32 inches onto concrete on each face and corner. Packaged in ‘for transit’ configuration.

14.0 Glossary

Term	Description
802.11	Wireless standards developed by the IEEE that specify an "over-the-air" interface for wireless Local Area Networks. 802.11 is composed of several standards operating in different radio frequencies.
802.11a	802.11a is an IEEE specification for wireless networking that operates in the 5 GHz frequency range (5.150 GHz to 5.825 GHz) with a maximum 54 Mbps data transfer rate. The 5 GHz frequency band is not as crowded as the 2.4 GHz frequency, because the 802.11a specification offers more radio channels than the 802.11b/g. These additional channels can help avoid radio and microwave interference.
802.11b	802.11b is the international standard for wireless networking that operates in the 2.4 GHz frequency range (2.4 GHz to 2.4835 GHz) and provides a throughput of up to 11 Mbps.
802.11g	802.11g is similar to 802.11b, but this standard provides a throughput of up to 54 Mbps. It also operates in the 2.4 GHz frequency band but uses OFDM radio technology in order to boost overall bandwidth.
Access Point	An interface between a wireless network and a wired network Access Points can combine with a distribution system such as Ethernet to create multiple radio cells (BSSs) that enable roaming throughout a facility.
Ad-Hoc mode	A wireless network composed of only stations and no Access Point. Also referred to as “peer-to-peer” networks
Association service	An IEEE 802.11 service that an enables the mapping of a wireless station to the distribution system via an Access Point.
Asynchronous transmission	Type of synchronization where there is no defined time relationship between transmission of frames.
Authentication	The process a station uses to announce its identify to another station. IEEE 802.11 specifies two forms of authentication: open system and shared key.
Bandwidth	The amount of transmission capacity available on a network at any point in time. Available bandwidth depends on several variables such as the rate of data transmission speed between networked devices, network overhead, number of users, and the type of device used to connect PCs to a network.
Basic Service Set (BSS)	A set of 802.11-compliant stations that operate as a connected wireless network.
Bits per second (bps)	A measurement of data transmission speed over communication lines based on the number of bits that can be sent or received per second.
BSSID	Basic Service Set Identifier. A 48-bit identifier used by all stations in a BSS in frame headers. Usually MAC address.
Clear channel assessment	A function that determines the state of the wireless medium in an IEEE 802.11 network.
Client	Any computer connected to a network that requests services (files, print capability) from another member of the network.
Command Line Interface (CLI)	A method of interacting with the Airborne WLN Module by sending it typed commands.
Direct sequence spread spectrum (DSSS)	Combines a data signal at the sending station with a higher data rate bit sequence, which many refer to as a chip sequence (also known as processing gain). A high processing gain increases the signal’s resistance to interference. The minimum processing gain that the FCC allows is 10, and most products operate under 20.
Disassociation service	An IEEE 802.11 term that defines the process a station or Access Point uses to notify that it is terminating an existing association.
Distribution service	An IEEE 802.11 station uses the distribution service to send MAC frames across a distribution system.
GPIO	General Purpose Input/Output refers to the digital I/O lines.
Host application	The environment within which the Module is embedded - typically includes a processor, which forms part of an OEM’s product and application.
Hot spot	Same as an Access Point, usually found in public areas such as coffee shops and airports.
IEEE	Institute of Electrical and Electronic Engineers, an international organization that develops standards for electrical . The organization uses a series of numbers, like the Dewey Decimal system in libraries, to differentiate between the various technology families.

Term	Description
Independent Basic Service Set Network (IBSS Network)	An IEEE 802.11-based wireless network that has no backbone infrastructure and consists of at least two wireless stations. This type of network is often referred to as an Ad-Hoc network because it can be constructed quickly without too much planning.
Infrastructure mode	A client setting providing connectivity to an Access Point. As compared to Ad-Hoc mode, whereby PCs communicate directly with each other, clients set in Infrastructure mode all pass data through a central Access Point. The Access Point not only mediates wireless network traffic in the immediate neighborhood, but also provides communication with the wired network. See Ad-Hoc and AP.
LAN application	A software application that runs on a computer, which is attached to a LAN, Intranet or the Internet, and using various protocols can communicate with the Module.
Local Area Network	A system of connecting PCs and other devices within the same physical proximity for sharing resources such as Internet connections, printers, files and drives. When Wi-Fi is used to connect the devices, the system is known as a wireless LAN or WLAN.
Medium Access Control Layer	One of two sub-layers that make up the Data Link Layer of the OSI reference model. The MAC layer is responsible for moving data packets to and from one network node to another across a shared channel.
MPDU	MAC Protocol Data Unit, the unit of data exchanged between two peer MAC entities using the services of the physical layer (PHY).
MSDU	MAC Service Data Unit, information that is delivered as a unit between MAC service Access Points (SAPs).
Peer-to-peer network	A wireless or wired computer network that has no server or central hub or router. All the networked PCs are equally able to act as a network server or client, and each client computer can talk to all the other wireless computers without having to go through an Access Point or hub. However, since there is no central base station to monitor traffic or provide Internet access, the various signals can collide with each other, reducing overall performance. Also referred to as “ad-hoc” networks
RS-232	An EIA standard that specifies up to 20 Kbps, 50 foot, serial transmission between computers and peripheral devices.
RSSI	Relative Signal Strength Indicator or Receive Signal Strength Indicator, is a measure of the received signal strength against the maximum internal receive signal strength (determined during the radios test and calibration). Usually displayed as a percentage.
RTOS	An operating system implementing components and services that explicitly offer deterministic responses, and therefore allow the creation of real-time systems. An RTOS is characterized by the richness of the services it provides, the performance characteristics of those services, and the degree that those performance characteristics can be controlled by the application engineer (to satisfy the requirements of the application).
Service Set Identifier (SSID)	An identifier attached to packets sent over the wireless LAN that functions as a "name" for joining a particular radio network (BSS). All radios and Access Points within the same BSS must use the same SSID, or their packets will be ignored.
Secure Digital Input Output (SDIO)	Standards based high speed serial interface, maintained by the SD Card Association (www.sdcard.org).
Telnet	A virtual terminal protocol used in the Internet, enabling users to log into a remote host.
Transceiver	A device for transmitting and receiving packets between the computer and the medium.
Transmission Control Protocol (TCP)	A commonly used protocol for establishing and maintaining communications between applications on different computers. TCP provides full-duplex, acknowledged, and flow-controlled service to upper-layer protocols and applications.
Wide Area Network (WAN)	A communication system of connected PCs and other computing devices across a large local, regional, national or international geographic area. Also used to distinguish between phone-based data networks and Wi-Fi. Phone networks are considered WANs and Wi-Fi networks are considered wireless LANs.
Wi-Fi	Wireless-Fidelity: Wi-Fi is the common name used for 802.11 wireless network technology.
Wi-Fi Alliance	A non-profit international association formed in 1999 to certify interoperability of wireless LAN products based on IEEE 802.11 specification.
Wired Equivalent Privacy (WEP)	A security protocol for wireless LANs defined in the IEEE 802.11 standard. WEP is designed to provide the same level of security as a wired LAN.

Term	Description
WLAN	Also referred to as a wireless LAN. A type of local-area network that uses high-frequency radio waves rather than wires to communicate between nodes and provide network connectivity.

15.0 Change Log

The following table indicates all changes made to this document:

Version	Date	Section	Change Description	Author
1.0	12/1/2007	-	Preliminary Release	ACR

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