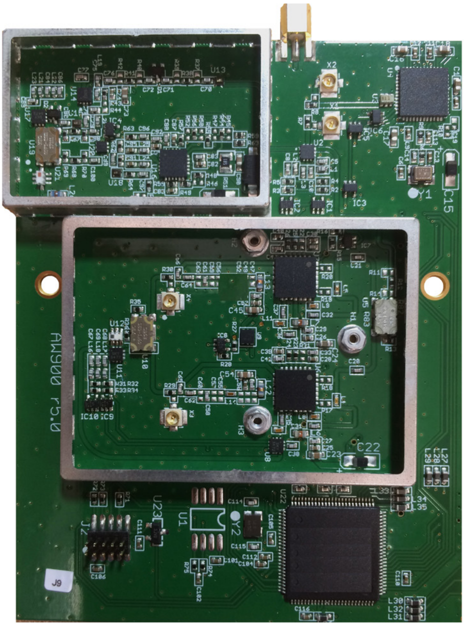

MOD090-HP

USER'S MANUAL

900 MHz High Power Module

Industrial-grade, long-range wireless Ethernet systems

AvaLAN WIRELESS

Thank you for your purchase of the MOD090-HP 900 MHz Radio Module.

Firmware and software described in this manual may be downloaded from **www.avalanwireless.com/downloads.htm**. (You can also find a pdf of the latest version of this manual.)

If you have any questions when configuring your AvaLAN system, the best place to get answers is to visit www.avalanwireless.com. If more assistance is needed, send email to support@avalanwireless.com. To speak to a live technician, please call technical support at the number below during normal business hours.

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Technical Summary

The MOD090 module allows you to build your own extreme-range, non-line-of-sight, point-to-multipoint wireless solution. The module uses the new technology in our 900Mhz and is fully FCC/IC certified for quick integration with no RF retesting required.

The MOD090 solution offers the ideal combination of the maximum allowed transmit power and unbeatable interference immunity in conjunction with high throughput and validated encryption.

The host microcontroller is responsible for configuring the keys that the MOD090-HP uses for RF communication/encryption, as well as transferring data to and from the MOD090-HP. The MOD090-HP features an 8kB transmit FIFO and a 5kB receive FIFO. The RF communication topology that the modules use is a point to multipoint star topology. There is one RF master Access Point (AP) and up to 63 RF slave Subscriber Units (SU).

Data from the AP can be sent to one specific SU or broadcast to all SUs. Broadcast data has no retransmissions and is not guaranteed to reach all SUs. Data from an SU is always sent to the AP with retransmissions.

Data is divided up into blocks for RF transmission. This division of the data allows for better interference immunity and re-transmission performance.

The digital interface to the MOD090-HP may be SPI or UART, depending upon which firmware is running in the MOD090-HP.

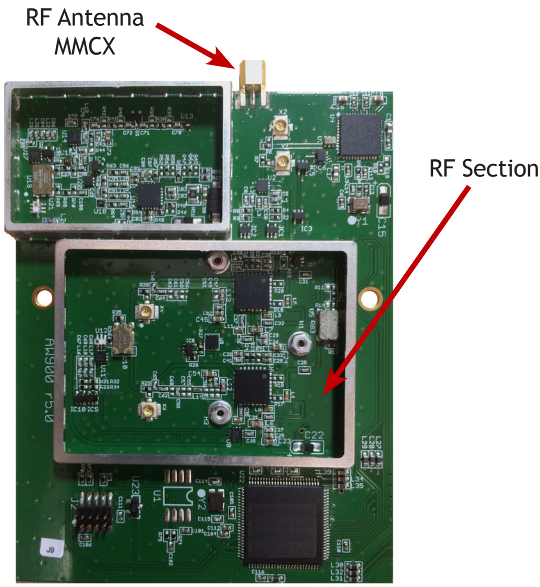
Serial Peripheral Interface (SPI) is a full duplex synchronous serial interface. SPI is a master-slave interface, with the master providing the synchronous clock.

Universal Asynchronous Receiver/Transmitter (UART) is an asynchronous serial interface that allows data to be transmitted without a clock signal, but the sender and receiver of the data must agree in advance on the timing parameters and special bits are added to each data byte to synchronize the sending and receiving units.

Selecting SPI or UART:

The choice of interface is up to the user and governed by the user's application and the nature of the host microcontroller. UART is more common, being closely related to RS-232. It is also places fewer demands on the host microcontroller. The UART interface is limited to 115,200 bits per second, while SPI may be run as high as 12 megabits per second. Whether the MOD090-HP uses SPI or UART is a choice that is controlled at boot up. By connecting a 10K resistor from Pin 8 (Error Flag) to Vcc (pull up), the MOD090-HP will boot up in UART mode. If the resistor is connected instead to ground (pull down), it will boot up in SPI mode.

Module Physical Interface



Module SPI Interfaces

Serial Peripheral Interface (SPI) is a full duplex synchronus serial interface that allows data to be shifted in and out of the AvaLAN Baseband Processor (MOD090-HP) 8 bits at a time, most significant bit first.

Each SPI requires 4 pins to be physically connected:

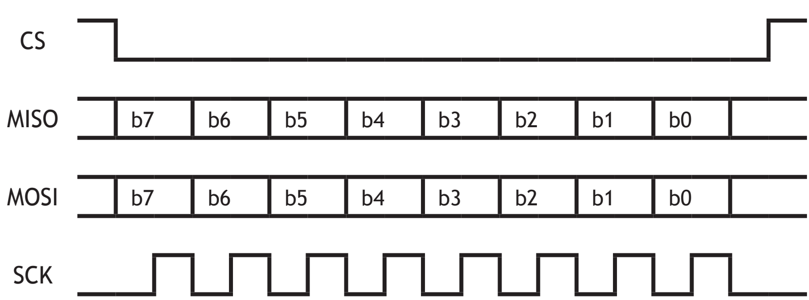
- SCK – Serial bit shift clock (provided by master SPI)
- MISO – Master In Slave Out
- MOSI – Master Out Slave In
- CS – Active low Chip Select

There are two SPI interfaces on the MOD090-HP. The first is a master SPI (SPI0), operating LEDs and DIP switches. SPI0’s connections are pins 3-6. The second is a slave SPI (SPI1) for management of the radio link, statistics, firmware upgrading, and data transfers. SPI1’s connections are on pins 12-15.

Here are the Signal definitions for the AW900SPI in SPI mode:

Pin Number	Name	Description
1	Vcc	3.3 vdc for MOD090-HP
2	/CS_LED	Chip select for LEDs and DIP switches (active low)
3	/CS_PD	Chip select for external programming device
4	SCK0	Serial clock for LEDs and DIP switches
5	MISO0	Data in for LEDs and DIP switches
6	MOSI0	Data out for LEDs and DIP switches
7	GND	MOD090-HP Ground
8	Error Flag	1=last command not understood. Clear with /CS_BB
9	Data Ready	1=data packet available, 0=no data
10	FIFO Full Flag	1=FIFO full, don't send any more data, 0=FIFO is empty
11	Connected Flag	1=RF connection present, 0=RF searching/standby
12	/CS_BB	Chip select for MOD090-HP
13	SCK1	Serial clock for MOD090-HP
14	MOSI1	Data out for MOD090-HP
15	MISO1	Data in for MOD090-HP
16	RFVcc	3.3 vdc for RF section
17	RFGND	RF section ground

SPI0 uses mode (0,0) for clock phase and polarity. This means that the SCK0 line idles low and data is setup on the falling edge of the clock and latched on the rising edge. SPI1 uses mode (1,1), meaning that SCK1, MISO1 and MOSI1 are all idle high. Data is still set up on the falling edge and latched on the rising edge of the clock.

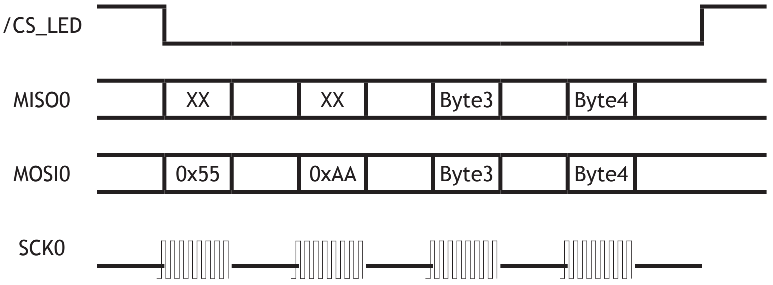


SPI0 - LEDs and DIP Switches

SPI0 is a master mode SPI that sends out 4 bytes per transaction. The first two bytes are alignment bytes and the last two contain the LED data on MOSI0, and the DIP switch data on MISO0.

The first alignment byte is 0x55, and the second is 0xAA. These two bytes are used to determine the start of the transaction (0x55) and the start of the data (0xAA).

LEDs:



A bit that is set in either of these bytes indicates that the corresponding LED should be on.

Byte3	b7	b6	b5	b4	b3	b2	b1	b0
	PWR	RX_ ACT	LCH5	LCH4	LCH3	LCH2	LCH1	LCH0

PWR: Turns on when the firmware is running. In troubleshoot mode PWR changes states on the AP every time a search for more SUs takes place. On a SU PWR changes state every time the SU responds to a search for more SUs.

RX_ACT: Indicates when data traffic has been received by the RF. RX_ACT will be set for 32ms when data has been successfully received.

LCH5..0: Indicates what RF channel is currently in use. In troubleshoot mode these bits indicate what the unit's device ID is.

Byte4	b7	b6	b5	b4	b3	b2	b1	b0
	TX_ ACT	-	RFQ5	RFQ4	RFQ3	RFQ2	RFQ1	RFQ0

TX_ACT: Indicates when data traffic is queued up for transmission across the RF. TX_ACT will be set for 32ms when data is queued up for transmission.

RFQ5..0: Indicates the quality of the RF link. The lowest quality is only b0 set, the highest quality is reached when b5 is set.

DIPs:

A bit that is set in this byte indicates that the corresponding DIP switch is on.

Byte3	b7	b6	b5	b4	b3	b2	b1	b0
	DCH5	DCH4	DCH3	DCH2	DCH1	DCH0	MODE	-

DCH5..0: Used to set the radio into manual channel mode and use the channel indicated. If DCH5..0 are all clear then the radio will be in automatic mode.

MODE: When set the unit is in troubleshooting mode, when clear the unit is in normal operation.

SPI1 - Command Interface

SPI1 is a slave mode SPI, meaning SCK is supplied by an external source. This SPI is used to configure the module, read status information, issue firmware upgrades and transfer data.

The first byte on the MOSI line after the /CS_BB line goes low is the Command Byte. This byte tells the MOD090-HP what command is to be executed.

Command Byte:

b7	b6	b5	b4	b3	b2	b1	b0
get/set	-	-	-	CMD3	CMD2	CMD1	CMD0

get/set: When set this bit indicates that information will be sent to the MOD090-HP on MOSI1 and MISO1 will be high impedance. When clear a get transaction will take place and information will be sent from the MOD090-HP on MISO1.

After the command byte is issued the master microcontroller must delay for at least 4 µs to allow the MOD090-HP enough time to prepare for the transaction.

When a transaction is complete and the /CS_BB line is high, the master microcontroller must delay for at least 6 µs to allow the MOD090-HP to finish processing the transaction.

CMD3..1: These bits are used to tell the MOD090-HP what command is to be executed.

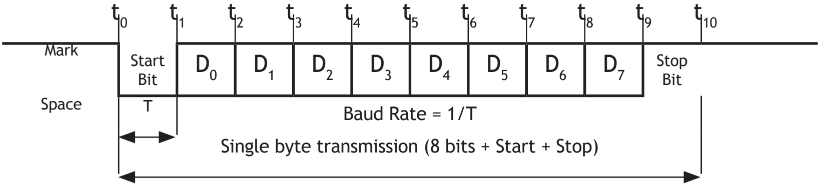
Module UART Interface

Here are the Signal definitions for the AW900SPI in UART mode:

Pin Number	Name	Description
1	Vcc	3.3 vdc for MOD090-HP
2	/CS_LED	Chip select for external programming device
3	/CS_PD	Chip select for LEDs and DIP switches (active low)Chip s
4	SCK0	Serial clock for LEDs and DIP switches
5	MISO0	Data in for LEDs and DIP switches
6	MOSI0	Data out for LEDs and DIP switches
7	GND	MOD090-HP Ground
8	NC	Not Used
9	NC	Not Used
10	NC	Not Used
11	NC	Not Used
12	NC	Not Used
13	NC	Not Used
14	MOSI1	UART TX
15	MISO1	UART RX
16	RFVcc	3.3 vdc for RF section
17	RFGND	RF section ground

In UART mode, the MOD090-HP's command interface is moved to SPI0. The LEDs and DIP switches may still be employed, but the primary purpose of this SPI port has shifted. SPI1 now becomes an asynchronous UART with TX on pin 14 and RX on pin 15 and is used for data that is transmitted and received via the RF.

At the risk of belaboring what is obvious and familiar to most engineers because of the long history of RS-232, the UART signals consist of a set of bits sent with a pre-defined clock rate. The sender must agree on what the rate is, and because the sender’s clock and receiver’s clock may not exactly agree, synchronization information is sent with each byte of data:



The Stop Bit can actually be any duration and provides the variable delay that allows synchronization between sender and receiver. Sometimes, the Stop Bit is specified to be at least two intervals. Also, sometimes a Parity Bit is sent between

D_7 and the Stop Bit, but this is rarely done anymore.

UART Mode LEDs and DIPs:

With the UART firmware running, the LED definitions are the same as for SPI mode and provide diagnostic information if desired.

The DIP switch definitions are slightly different:

	b7	b6	b5	b4	b3	b2	b1	b0
Byte3			DCH3	DCH2	DCH1	DCH0	MODE	-
Byte4						TEST		

MODE: 1 = Access Point, 0 = Subscriber Unit

DCH3 to DCH0: 4-bit binary code for the RF channel selected. (All zeros means use automatic channel switching.)

TEST: 1 = Continuous traffic for site survey testing, 0 = normal operation.

Module Command Set

The Command Sets for SPI and UART modes are somewhat different:

SPI Command Set	
Command Byte - HEX	Command
0x01	getStatus
0x02	getNetworkKey
0x03	getPrivateKey
0x04	getDeviceID
0x05	getStats
0x06	getVersion
0x07	not valid
0x08	getNumberofConnectedSUs
0x09	getRSSIreadings
0x0A	getDATAPacket
0x81	setStatus
0x82	setPublicKey
0x83	setPrivateKey
0x84	setDeviceID
0x85	setReset
0x86	not valid
0x87	not valid
0x88	not valid
0x89	not valid
0x8A	setDATAPacket
0x8B	setFirmwareStart
0x8C	setFirmwareEnd

UART Command Set	
Command Byte - HEX	Command
0x00	getStatus
0x01	getNetworkKey
0x02	getPrivateKey
0x03	getDeviceID
0x04	getStats
0x05	getVersion
0x06	getConfig
0x07	getNumberofConnectedSUs
0x08	getRSSIreadings
0x09	not valid
0x80	setStatus
0x81	setPublicKey
0x82	setPrivateKey
0x83	setDeviceID
0x84	setReset
0x85	not valid
0x86	not valid
0x87	not valid
0x89	not valid
0x8B	setDATAPacket

In the Command Descriptions that follow, the command codes for each mode are shown in the byte tables.

Status Command

The **getStatus** command is used to find out the current status of the module.

getStatus		**SPI Mode:** 0x01			**UART Mode:** 0x00			
Byte 1	b7	b6	b5	b4	b3	b2	b1	b0
	RFState	Radio	-	-	CH3	CH2	CH1	CH0

RFState: When set this bit indicates that the RF is currently connected.

Radio: Indicates what mode the radio is in, when set it is in active mode. When clear the RF is in standby mode.

CH3..0: Indicates what channel the RF is currently using.

The **setStatus** command is used to place the module in standby mode/normal operation and to set the RF into manual channel mode by assigning a specific channel.

setStatus		**SPI Mode:** 0x81			**UART Mode:** 0x80			
Byte 1	b7	b6	b5	b4	b3	b2	b1	b0
	-	Radio	-	-	CH3	CH2	CH1	CH0

Radio: Setting this bit places the radio in active mode, clearing it places it in standby mode.

CH3..0: When these bits are cleared the radio is in automatic channel mode. When any of these bits are set the radio will be in manual channel mode and use the channel indicated by these bits if it is valid.

Channel	Frequency - MHz
1	904.4
2	905.6
3	906.8
4	908.0
5	909.2
6	910.4
7	911.6
8	912.8
9	914.0
10	915.2
11	916.4
12	917.6
13	918.8
14	920.0
15	921.2
16	922.4
17	923.6
18	924.8
19	926.0

Network Key Command

The Network Key is A 32-bit number used for Network Identification. AvaLAN m-series devices with different Network Keys will not be able to communicate with each other. The Network Key can be changed without resetting the device.

The **getNetworkKey** command will read back the last 32-bit key issued to the device.

The **setNetworkKey** command stores a new 32-bit key to be used for RF communications.

getNetworkKey		**SPI Mode:** 0x02				**UART Mode:** 0x01		
setNetworkKey		**SPI Mode:** 0x82				**UART Mode:** 0x81		
	b7	b6	b5	b4	b3	b2	b1	b0
Byte 1	PK7	PK6	PK5	PK4	PK3	PK2	PK1	PK0
Byte 2	PK15	PK14	PK13	PK12	PK11	PK10	PK9	PK8
Byte 3	PK23	PK22	PK21	PK20	PK19	PK18	PK17	PK16
Byte 4	PK31	PK30	PK29	PK28	PK27	PK26	PK25	PK24

Private Key Command

The Private Key is the 128-bit key used in the AES encryption of data transmitted over the RF. This key must be set once at start up and cannot be changed without resetting the device. If two or more radios have the same Public Key but different Private Keys, they will connect with each other. However, the received data will be completely scrambled.

The **getPrivateKey** command reads back the private key issued at startup.

The **setPrivateKey** command stores the private key to be used for the AES encryption. This command should be issued only once at start up. If issued again with a different key, data corruption will occur.

getPrivateKey		**SPI Mode:** 0x03				**UART Mode:** 0x02		
setPrivateKey		**SPI Mode:** 0x83				**UART Mode:** 0x82		
	b7	b6	b5	b4	b3	b2	b1	b0
Byte 1	SK7	SK6	SK5	SK4	SK3	SK2	SK1	SK0
Byte 2	SK15	SK14	SK13	SK12	SK11	SK10	SK9	SK8

Byte 3	SK23	SK22	SK21	SK20	SK19	SK18	SK17	SK16
Byte 4	SK31	SK30	SK29	SK28	SK27	SK26	SK25	SK24
Byte 5	SK39	SK38	SK37	SK36	SK35	SK34	SK33	SK32
Byte 6	SK47	SK46	SK45	SK44	SK43	SK42	SK41	SK40
Byte 7	SK55	SK54	SK53	SK52	SK51	SK50	SK49	SK48
Byte 8	SK63	SK62	SK61	SK60	SK59	SK58	SK57	SK56
Byte 9	SK71	SK70	SK69	SK68	SK67	SK66	SK65	SK64
Byte 10	SK79	SK78	SK77	SK76	SK75	SK74	SK73	SK72
Byte 11	SK87	SK86	SK85	SK84	SK83	SK82	SK81	SK80
Byte 12	SK95	SK94	SK93	SK92	SK91	SK90	SK89	SK88
Byte 13	SK103	SK102	SK101	SK100	SK99	SK98	SK97	SK96
Byte 14	SK111	SK110	SK109	SK108	SK107	SK106	SK105	SK104
Byte 15	SK119	SK118	SK117	SK116	SK115	SK114	SK113	SK112
Byte 16	SK127	SK126	SK125	SK124	SK123	SK122	SK121	SK120

Device ID Command

The Device ID command has two uses depending on whether the device is configured as an access point (AP) or subscriber unit (SU.) In either case, the Device ID is a 6-bit number, allowing a maximum ID of 63. The Device ID must be issued at start up and must not be changed without resetting the device.

For the AP the Device ID is the maximum SU ID that is allowed to connect to the RF network.

For the SU the Device ID is the individual ID number assigned to the device. This ID number is used as an address during data transfers.

The **getDeviceID** command reads back the configured ID.

The **setDeviceID** command configures the device to be either an AP or an SU and what ID to use.

getDeviceID		**SPI Mode:** 0x04			**UART Mode:** 0x03			
setDeviceID		**SPI Mode:** 0x84			**UART Mode:** 0x83			
	b7	b6	b5	b4	b3	b2	b1	b0
Byte 1	D1	D0	MID5	MID4	MID3	MID2	MID1	MID0

D1, D0: These bits report or configure whether the device is an AP or an SU:

D1	D0	Mode
0	0	Not Configured
0	1	AP
1	0	AP
1	1	SU

MID5..0: These bits read back or set the configured ID. For an AP this is the maximum ID number that is allowed to join the RF network. For an SU it is the number to use to join the RF network.

Stats Command

The **getStats** command is used to gather all the statistics that the MOD090-HP is collecting about the RF link. The statistics are, total number of packets transferred, total number of packets that failed to make it across the RF, total number of packets that successfully made it across the RF, total number of broadcast packets, total number of unicast packets, average transmitted packet size in the last 32 packets, average received packet size in the last 32 packets, and percentage block error rate.

The statistics can be read from the MOD090-HP at any time during normal operation.

getStats		**SPI Mode:** 0x05			**UART Mode:** 0x04			
	b7	b6	b5	b4	b3	b2	b1	b0
Byte 1	TP23	TP22	TP21	TP20	TP19	TP18	TP17	TP16
Byte 2	TP31	TP30	TP29	TP28	TP27	TP26	TP25	TP24
Byte 3	TP7	TP6	TP5	TP4	TP3	TP2	TP1	TP0
Byte 4	TP15	TP14	TP13	TP12	TP11	TP10	TP9	TP8
Byte 5	FP23	FP22	FP21	FP20	FP19	FP18	FP17	FP16
Byte 6	FP31	FP30	FP29	FP28	FP27	FP26	FP25	FP24
Byte 7	FP7	FP6	FP5	FP4	FP3	FP2	FP1	FP0
Byte 8	FP15	FP14	FP13	FP12	FP11	FP10	FP9	FP8
Byte 9	PP23	PP22	PP21	PP20	PP19	PP18	PP17	PP16
Byte 10	PP31	PP30	PP29	PP28	PP27	PP26	PP25	PP24

Byte 11	PP7	PP6	PP5	PP4	PP3	PP2	PP1	PP0
Byte 12	PP15	PP14	PP13	PP12	PP11	PP10	PP9	PP8
Byte 13	BC23	BC22	BC21	BC20	BC19	BC18	BC17	BC16
Byte 14	BC31	BC30	BC29	BC28	BC27	BC26	BC25	BC24
Byte 15	BC7	BC6	BC5	BC4	BC3	BC2	BC1	BC0
Byte 16	BC15	BC14	BC13	BC12	BC11	BC10	BC9	BC8
Byte 17	UC23	UC22	UC21	UC20	UC19	UC18	UC17	UC16
Byte 18	UC31	UC30	UC29	UC28	UC27	UC26	UC25	UC24
Byte 19	UC7	UC6	UC5	UC4	UC3	UC2	UC1	UC0
Byte 20	UC15	UC14	UC13	UC12	UC11	UC10	UC9	UC8
Byte 21	ATX7	ATX6	ATX5	ATX4	ATX3	ATX2	ATX1	ATX0
Byte 22	ATX15	ATX14	ATX13	ATX12	ATX11	ATX10	ATX9	ATX8
Byte 23	ARX7	ARX6	ARX5	ARX4	ARX3	ARX2	ARX1	ARX0
Byte 24	ARX15	ARX14	ARX13	ARX12	ARX11	ARX10	ARX9	ARX8
Byte 25	BER7	BER6	BER5	BER4	BER3	BER2	BER1	BER0
Byte 26	BER15	BER14	BER13	BER12	BER11	BER10	BER9	BER8

Bytes 1 to 4 are the 32-bit total number of packets sent and received (TP0 to TP31).

Bytes 5 to 8 are the 32-bit total number of failed packets sent and received (FP0 to FP31).

Bytes 9 to 12 are the 32-bit total number of passed packets sent and received (PP0 to PP31).

Bytes 13 to 16 are the 32-bit total number of broadcast packets sent and received (BC0 to BC31).

Bytes 17 to 20 are the 32-bit total number of unicast packets sent and received (UC0 to UC31).

Bytes 21 and 22 are the 16-bit average transmitted packet size over the last 32 packets (ATX0 to ATX15).

Bytes 23 and 24 are the 16-bit average received packet size over the last 32 packets (ARX0 to ARX15).

Bytes 25 and 26 are the 16-bit percentage block error rate. BER15..8 is the integer part and ranges from 0 to 100. BER7..0 is the 2-digit fractional part and ranges from 0 to 99. The block error rate is calculated over the last 1000 data blocks.

Version Command

The **getVersion** command is used to determine the firmware version running in the MOD090-HP.

getVersion		SPI Mode: 0x06			UART Mode: 0x05			
	b7	b6	b5	b4	b3	b2	b1	b0
Byte 1	RFV3	RFV2	RFV1	RFV0	PV3	PV2	PV1	PV0
Byte 2	RV7	RV6	RV5	RV4	RV3	RV2	RV1	RV0
Byte 3	RV15	RV14	RV13	RV12	RV11	RV10	RV9	RV8

PV0 to PV3 is the 4-bit product version number.

RFV0 to RFV3 is the 4-bit radio version number.

RV0 to RV15 is the 16-bit firmware release version number.

Connected SUs Command

The **getNumberofConnectedSUs** command is used on the AP only, if issued on the SU it will return all zeros. It returns the current number of SUs that are connected to the RF network (5-bit number, CC0 to CC4).

getNumberofConnectedSUs			SPI Mode: 0x08		UART Mode: 0x07			
	b7	b6	b5	b4	b3	b2	b1	b0
Byte 1	x	x	x	CC4	CC3	CC2	CC1	CC0

RSSI Command

The **getRSSIReadings** command is used to determine if possible interference exists in the RF environment. The MOD090-HP can perform a spectrum analysis scan, stepping through the frequency band and measuring the peak and average power received at each frequency. Note: When two or more radios are actively linked, the AP will tell the SUs to cease transmitting when it goes into spectrum scan mode. However, when an SU scans, it will likely see a peak transmission from another radio.

The host microcontroller sends the resolution settings to the MOD090-HP, then gets channel information back from the MOD090-HP. The host microcontroller must delay while the MOD090-HP completes the scan before reading any data. In SPI mode, the MOD090-HP will use the Data Ready line (pin 9) to indicate when the scan is complete and the data is available. In UART mode, the host microcontroller needs to issue the command and wait for data to be returned.

getRSSIReadings		**SPI Mode:** 0x09			**UART Mode:** 0x08			
	b7	b6	b5	b4	b3	b2	b1	b0
Byte 1	SS3	SS2	SS1	SS0	EXP3	EXP2	EXP1	EXP0

Note that this command is an exception to the general rule that "get" commands receive data and "set" commands send it. This command must be followed by sending one byte of configuration information and then reading back a variable number of data bytes.

SS0 to SS3 is the frequency step size (valid numbers are 1, 2, 4, 8).

EXP0 to EXP3 is the base-2 exponent of the number of samples to collect and average together at each frequency step.

EXP3...0	Number of Samples
0	1
1	2
2	4
3	8
4	16
5	32
6	64
7	128
8	256

The number of samples and frequency step size affects the amount of time it takes to scan the band. A step size of 1 and exponent of 8 takes approximately 2 seconds to scan the band. A step size of 8 and exponent of 32 takes approximately 300ms to scan.

Although a higher step size and lower exponent scan much faster, a complete picture of the band may not be formed. Devices that only transmit for a very short period of time may be missed with a fast scan.

	b7	b6	b5	b4	b3	b2	b1	b0
Byte 2	BASE7	BASE6	BASE5	BASE4	BASE3	BASE2	BASE1	BASE0
Byte 3	BASE15	BASE14		BASE12		BASE10	BASE9	BASE8

BASE is a 16-bit integer constant that provides the index offset for establishing the RF frequency. For the MOD090-HP, this value is 1688.

	b7	b6	b5	b4	b3	b2	b1	b0
Byte 4	NUM7	NUM6	NUM5	NUM4	NUM3	NUM2	NUM1	NUM0
Byte 5	DEN7	DEN6	DEN5	DEN4	DEN3	DEN2	DEN1	DEN0
Byte 6	MAX7	MAX6	MAX5	MAX4	MAX3	MAX2	MAX1	MAX0

MAX is an 8-bit integer constant that represents the number of RF channels that the radio uses. For the MOD090-HP, this value is 19. It is important to save this number because it tells you how many bytes of data to read next:

	b7	b6	b5	b4	b3	b2	b1	b0
Byte 7	MK7	MK6	MK5	MK4	MK3	MK2	MK1	MK0
Byte 8	MK15	MK14	MK13	MK12	MK11	MK10	MK9	MK8
...	Repeat MAX times to read all the values							

MK is a 16-bit integer that contains the Index value for each RF channel. Bytes 7 and 8 will repeat until MAX values have been read. (For the MOD090-HP, this will total 24 bytes, Byte7 through Byte30.)

	b7	b6	b5	b4	b3	b2	b1	b0
Byte 31	DP7	DP6	DP5	DP4	DP3	DP2	DP1	DP0
Byte 32	DP15	DP14	DP13	DP12	DP11	DP10	DP9	DP8

DP is the 16-bit integer number of data points in the spectrum scan. The value will depend upon the frequency step size specified in Byte1. The next 4 data bytes will be repeated DP times.

	b7	b6	b5	b4	b3	b2	b1	b0
Byte 33	OFS7	OFS6	OFS5	OFS4	OFS3	OFS2	OFS1	OFS0
Byte 34	OFS15	OFS14	OFS13	OFS12	OFS11	OFS10	OFS9	OFS8
Byte 35	PEAK7	PEAK6	PEAK5	PEAK4	PEAK3	PEAK2	PEAK1	PEAK0
Byte 36	AVG7	AVG6	AVG5	AVG4	AVG3	AVG2	AVG1	AVG0
...	Repeat DP times to read all the spectrum data							

OFS is the 16-bit integer Index value for this data point. The range of this index is 0 to (128 − Frequency Step Size). For example, with a step size of 1, the maximum value of OFS is 127, but with a step size of 8, the maximum value is 120.

PEAK is an 8-bit integer representing the peak power detected at each frequency.

AVG is an 8-bit integer representing the average power detected at each frequency.

Both the PEAK and AVG readings are a logarithmic scale, with a value of zero corresponding to -100 dBm and a value of 255 corresponding to -15 dBm:

$$\text{Power in dBm} = -\left(100 - \left((\text{Sample Value}) / 3\right)\right)$$

Please be aware that this scale is approximate. Linearity is poor above -20 dBm or below -90 dBm.

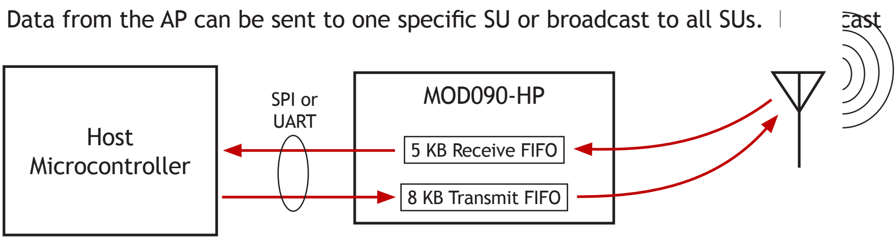
Data Commands

The data commands are used to transfer data between the MOD090-HP and the host microcontroller that is intended for RF transmission.

The MOD090-HP’s receive FIFO does not have data protection. This means that when data is received from the RF, the host microcontroller has up to 50ms to remove the data from the FIFO before data corruption occurs.

The transmit FIFO does utilize data protection. If the host microcontroller attempts to send data to the MOD090-HP while the transmit FIFO is full (indicated to the host microcontroller using the FIFO_Full line) the data will be discarded. Please note that in UART mode, there is no FIFO_Full line. Because the UART baud rate is much slower than the radio’s transmit rate, transmit overflow should not occur.

Data from the AP can be sent to one specific SU or broadcast to all SUs. cast



data has no retransmissions and is not guaranteed to reach all SUs. Data from an SU is always sent to the AP with retransmissions. Data is divided up into blocks for RF transmission. This division of the data allows for better interference immunity and re-transmission performance.

The **getPacket** command is used to read received data from the MOD090-HP. The Data Ready line (pin 9) will be asserted when data is present in the receive FIFO and will remain asserted until all data is read. Once the Data Ready line has been asserted the host microcontroller has approximately 50ms until the data becomes corrupted in a high traffic scenario. Obviously in UART mode, the host microcontroller must be ready to receive data at any time.

getPacket		**SPI Mode:** 0x0A				**UART Mode:**	N/A
	b7	b6	b5	b4	b3	b2	b1	b0
Byte 1	-	ID6	ID5	ID4	ID3	ID2	ID1	ID0
Byte 2	S7	S6	S5	S4	S3	S2	S1	S0
Byte 3	-	-	-	-	-	S10	S9	S8
Byte 4	DATA7	DATA6	DATA5	DATA4	DATA3	DATA2	DATA1	DATA0
...	Byte 4 is repeated until all the data is received							

ID0 to ID6 is the 7-bit integer Device ID of the Subscriber Unit the data was received from (Access Point only, for a Subscriber Unit the data is undefined).

S0 to S10 is the 11-bit integer size of the Data packet in bytes (number of data bytes to read).

The **setPacket** command is used to submit data to the transmit FIFO for RF transmission. The FIFO Full line (Pin 10) will be asserted if the transmit FIFO cannot accept any more data. If the host microcontroller attempts to submit data while the FIFO Full line is asserted then the Error Flag will also become asserted and the data being submitted will not be entered into the FIFO. In UART mode, the host microcontroller is responsible for avoiding overflow.

setPacket		**SPI Mode:** 0x8A				**UART Mode:**	0x89
	b7	b6	b5	b4	b3	b2	b1	b0
Byte 1	BC	ID6	ID5	ID4	ID3	ID2	ID1	ID0
Byte 2	S7	S6	S5	S4	S3	S2	S1	S0
Byte 3	-	-	-	-	-	S10	S9	S8
Byte 4	DATA7	DATA6	DATA5	DATA4	DATA3	DATA2	DATA1	DATA0
...	Byte 4 is repeated until all the data is sent.							

BC is the Broadcast Flag. BC = 1 means send the packet to all Subscriber Units.

BC = 0 means send the packet only to the Device ID specified in the rest of Byte 1.

ID0 to ID6 is the 7-bit integer Device ID of the Subscriber Unit that is to receive the data. Note that if BC = 1 and there is a non-zero Device ID specified, then all Subscribers **but** the one specified will receive the data.

S0 to S10 is the 11-bit integer size of the Data packet in bytes (number of data bytes being sent).

Reset Command

The **setReset** command is used to reset the MOD090-HP and can be issued at any time durning normal operation. After a reset has been issued the MOD090-HP takes approximately 300 ms to restart. After restart all previously configured data (Public and Private Keys, Device ID and type) will be lost.

setReset	**SPI Mode:**	0x85		**UART Mode:**	0x84

There are no other bytes required to reset the device. The host microcontroller should simply issue the **setReset** command.

Firmware Upgrading

If an update of the MOD090-HP's firmware becomes desirable, a new firmware image will be supplied by AvaLAN. If a USB interface exists, such as that used in the EVAL board and recommended for UART applications, then the firmware upgrade will be handled by a software utility provided by us. If the MOD090-HP is used in SPI mode and you wish to build firmware update into your host microcontroller's code, here is how to do it.

The following information applies to SPI Mode only:

Once a **setFirmwareStart** (0x8B) command has been issued to the MOD090-HP, all other commands except for **setPacket** (0x8A) and **setFirmwareEnd** (0x8C) become invalid and will cause the Error Flag to assert if they are issued. The host microcontroller must deassert the /CS_BB line (pin 12) and then wait for a minimum of 5 µs and the DATA Ready line (pin 9) to be asserted before reasserting /CS_BB to send the first data block.

The firmware image is partitioned into data blocks with a payload size of 64 bytes. Each block is sent as it's own transaction and must use the **setPacket** command to be issued to the MOD090-HP. Since data can be submitted to the MOD090-HP faster than it can be stored in flash, the FIFO Full line must be carefully observed to make sure none of the blocks are lost.

If the last firmware block is not a full 64 bytes, it must be padded with zeros.

setPacket		**SPI Mode:**	0x8A					
	b7	b6	b5	b4	b3	b2	b1	b0
Byte 1	BC	ID6	ID5	ID4	ID3	ID2	ID1	ID0
Byte 2	S7	S6	S5	S4	S3	S2	S1	S0
Byte 3	-	-	-	-	-	S10	S9	S8
Byte 4	OFS7	OFS6	OFS5	OFS4	OFS3	OFS2	OFS1	OFS0
Byte 5	OFS15	OFS14	OFS13	OFS12	OFS11	OFS10	OFS9	OFS8
Byte 6	DATA7	DATA6	DATA5	DATA4	DATA3	DATA2	DATA1	DATA0
Byte 7	DATA15	DATA14				DATA10	DATA9	DATA8
...	Bytes 6 and 7 are repeated 32 times.							
Byte 70	CHK7	CHK6	CHK5	CHK4	CHK3	CHK2	CHK1	CHK0
Byte 71	CHK15	CHK14	CHK13	CHK12	CHK11	CHK10	CHK9	CHK8

BC must be set and ID0 to ID6 must be clear. (Byte 1 is 0x80.)

S0 to S10 must be set to 68. (Byte 2 is 0x44 and Byte3 is 0x00.)

OFS0 to OFS15 is the 16-bit integer firmware block number. This value will be included in the checksum calculation.

DATA0 to DATA15 is the 16-bit firmware data, 32 values per block.

CHK0 to 15 is the 16-bit integer checksum value for the block. It is calculated in the host microcontroller as follows:

1. Initialize a 16-bit register to 0x1911.
2. Add the 16-bit data value to the register beginning with the firmware block number.
3. Perform a rotate left with no carry by 5 bit positions.
4. Repeat steps 2 and 3 for all 34 words (OFS and DATA).

Once all blocks have been submitted to the MOD090-HP, then the host microcontroller must issue the **setFirmwareEnd** (0x8C) command. Once the **setFirmwareEnd** command has been issued to the MOD090-HP, the host microcontroller must wait for the programming to complete. The MOD090-HP will indicate this by deasserting the Data Ready line (pin 9). Once the Data Ready line is deasserted, programming is complete and it is safe to reset the MOD090-HP with the **setReset** command (0x85). A reset is required before the MOD090-HP will begin executing the new firmware image.

Programming Examples

Note that these examples apply to SPI mode.

Initialization Example

To initialize the MOD090-HP follow these steps:

1. At startup delay for 300 ms to allow the MOD090-HP enough time to initialize.
2. Assert /CS_BB (drive the line low) and issue **setNetworkKey** (0x82) command and delay for 4 µs.
3. Send 3 bytes with 24-bit Network Key value.
4. Deassert /CS_BB (drive the line high) and delay for 6 µs.
5. Assert /CS_BB and issue **setPrivateKey** (0x83) command and delay for 4 µs.
6. Send 16 bytes with 128-bit Private Key value.
7. Deassert /CS_BB and delay for 6 µs.
8. Assert /CS_BB and issue **setDeviceID** (0x84) command and delay for 4 µs.
9. Send one byte indicating what type of device and ID number.
10. Deassert /CS_BB and delay for 6 µs.
11. Assert /CS_BB and issue **setStatus** (0x81) command and delay for 4 µs.
12. Send one byte with bit 6 set to take radio out of standby mode.
13. Deassert /CS_BB.
14. Wait for Connected Flag to be set

The MOD090-HP is now initialized and connected, ready to send and receive data.

Send Data Example (AP Side)

1. If Connected Flag is clear or FIFO Full Flag is set then end.
2. Else assert /CS_BB (drive line low) and issue **setPacket** (0x8A) command and delay for 4 µs.
3. Send first byte indicating if a broadcast packet or a unicast packet.
4. Send two bytes indicating data size in bytes.
5. Send all data bytes
6. Deassert /CS_BB (drive line high) and delay for 6 µs.

Get Data Example (AP Side)

1. If Data Ready Flag is set assert /CS_BB (drive line low) and issue **getPacket** (0x0A) command and delay for 4 µs.
2. Gets first byte to determine what SU sent the packet.
3. Get next two bytes to determine the packet size in bytes.
4. Get all data bytes
5. Deassert /CS_BB (drive line high) and delay for 6 µs.
6. If Data Ready is still set then repeat all steps.

RSSI Example

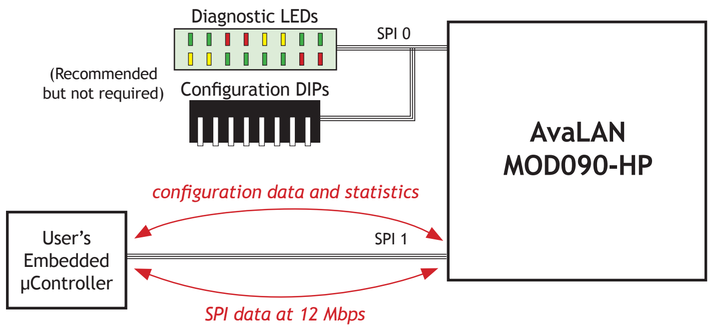
1. Assert /CS_BB (drive line low) and issue **getRSSIreadings** (0x09) command and delay for 4 µs.
2. Send first byte to tell MOD090-HP what step size and number of samples to use.
3. Get two bytes to determine the Base Frequency multiplier.
4. Get two bytes to determine the Numerator and Denominator for frequency calculations.
5. Get one byte to determine how many channel markers there are.
6. Get all channel markers.
7. Wait for Data Ready to be set.
8. Get two bytes to determine the number of data points to be read.
9. Get four bytes for Step Number, Peak Power, and Average Power.
10. Repeat step 9 for all data points.
11. Deassert /CS_BB (drive line high) and delay for 6 µs.

Firmware Update Example

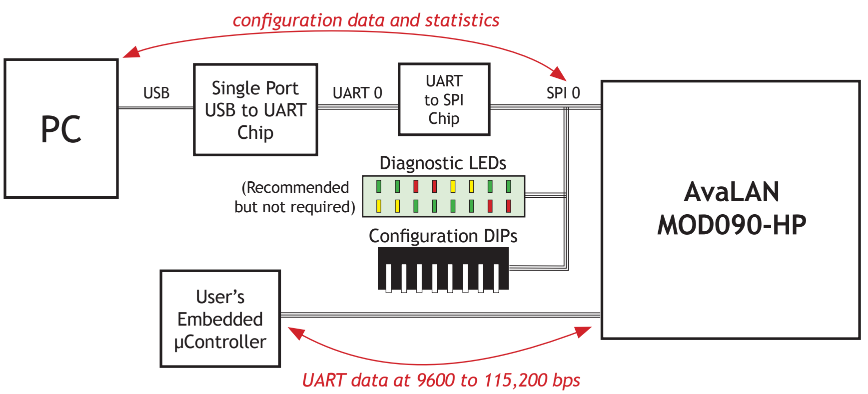
1. Assert /CS_BB (drive line low) and issue **setFirmwareStart** (0x8B) command and deassert /CS_BB (drive line high).
2. Delay for 5 µs.
3. Wait for Data Ready to be asserted.
4. While FIFO Full is set wait.
5. Assert /CS_BB and issue **setPacket** (0x8A) command and delay for 4 µs.
6. Send first byte as 0x80
7. Send next two bytes as 0x44 and 0x00 respectively, for packet size of 68.
8. Send two bytes to indicate Firmware block offset of following payload.
9. Send 64 payload bytes.
10. Send two bytes for checksum.
11. Delay 4 µs then check Error Flag.
12. If Error Flag is clear then deassert /CS_BB and delay for 4 µs. Prepare next Firmware block and loop to Step 4.
13. Else if Error Flag is set then deassert /CS_BB and delay for 4 µs. Loop to Step 4.
14. Repeat steps 4 to 13 until all firmware blocks have been sent.
15. Once all blocks have been sent assert /CS_BB and issue **setFirmwareEnd** (0x8C) command and deassert /CS_BB.
16. While Data Ready flag is set wait.
17. Assert /CS_BB and issue **setReset** (0x85) command and deassert /CS_BB.

Implementation Block Diagrams

Suggested SPI User Implementation:



Suggested UART User Implementation:



Note that if you are using the MOD090-HP in UART mode, you may wish to include a USB interface to SPI0 similar to that implemented in the Evaluation Board. This would allow you to modify the configuration, to read back operating statistics and to perform spectrum analysis. If those capabilities are not needed, then the cost and space can be avoided.

Technical specifications

CHARACTERISTIC	MOD090-HPMMCX
RF transmission rate	200 Kbps to 2.38 Mbps
Data Throughput	1.63 Mbps
Maximum Output power	+30 dBm at 2.38 Mbps +30 dBm at 200 Kbps
Minimum Output power	+10 dBm at 2.38 Mbps +10 dBm at 200 Kbps
Output Power Increment	+1 dBm
Radio Modes	OFDM, OQPSK, using proprietary TDMA Support for IEEE 802.15.4g modes
Receiver Sensitivity	-94 dBm at 2.38 Mbps -107 dBm at 200 Kbps
Range	60 miles at 2.38 Mbps 100 miles at 200 Kbps
RF channels/bandwidth	19 non-overlapping OFDM channels at 1.2 MHz
Frequency selection	Automatic or manually selectable
RF Interfaces	MMCX
Data Encryption	128Bit AES CBC, OFB, CFB, CTR, ECB modes
Antenna Detection	Reflected power detector (VSWR) can analyze antenna and RF cable problems
Error correction technique	Forward error correction and retransmission
Adjacent band rejection	SAW receiver filter attenuates cellular and pager interference
Power consumption	Transmit: 12 Watts Receive: 0.8 Watts
Voltage	6 VDC
Temperature range	-40° C to +85° C
Size	68 x 88 x 7 mm not including connectors

FCC Certification

The MOD090-HP RF module complies with Part 15 of the FCC rules and regulations. Compliance with the labeling requirements, FCC notices, and antenna usage guidelines is required. To operate under AvaLAN Wireless FCC Certification, RF modules/integrators must comply with the following regulations:

1. The system integrator must ensure that the text provided with this device (see FCCRequired Label Text on page 11) is placed on the outside of the final product and within the final product operation manual.
2. The AW900G2HP RF module may be used only with antennas that have been tested and approved for use with this module refer to AW900G2HP Approved Antennas on page 31.

Labeling Requirements

In order to inherit AvaLAN's FCC Certification, compliance requires the following be stated on the device and within its operation manual:

FCC ID: R4N-AW900G2HP 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.

Label Warning WARNING The Original Equipment Manufacturer (OEM) must ensure that FCC labeling requirements are met. This includes a clearly visible label on the outside of the final product enclosure that displays the contents shown in the figure below.

Figure A.1. Required FCC Label for OEM products containing the AvaLAN MOD090-HP OEM RF Module

Contains FCC ID: R4N-AW900G2HP
The enclosed device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (i.) this device may not cause harmful interference and (ii.) this device must accept any interference received, including interference that may cause undesired operation.

FCC Notices

Adherence to the following is required:

IMPORTANT: The AW900G2HP OEM RF Modules has been certified by the FCC for use with other products without any further certification (as per FCC section 2.1091). Changes or modifications not expressly approved by AvaLAN could void the user's authority to operate the equipment.

IMPORTANT: The RF module has been certified for remote and base radio applications. If the module will be used for portable applications, the device must undergo SAR testing.

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: Re-orient or relocate the receiving antenna, Increase the separation between the equipment and receiver, Connect equipment and receiver to outlets on different circuits, or Consult the dealer or an experienced radio/TV technician for help.

FCC Limited Modular Approval

This is an RF module approved for Limited Modular use operating as a mobile transmitting device with respect to section 2.1091 and is limited to OEM installation for Mobile and Fixed applications only. During final installation, end-users are prohibited from access to any programming parameters. Professional installation adjustment is required for setting module power and antenna gain to meet EIRP compliance for high gain antenna(s).

Final antenna installation and operating configurations of this transmitter including antenna gain and cable loss must not exceed the EIRP of the configuration used for calculating MPE. Grantee (AvaLAN) must coordinate with OEM integrators to ensure the end-users and installers of products operating with the module are provided with operating instructions to satisfy RF exposure requirements.

The FCC grant is valid only when the device is sold to OEM integrators. Integrators are instructed to ensure the end-user has no manual instructions to remove, adjust or install the device.

Module and Host Product Labelling Requirements

Any product for which Modular Approval (MA) or Limited Modular Approval (LMA) is being sought shall meet the above labelling requirements.

The Host Marketing Name (HMN) must be displayed (according to e-labelling requirements) or indicated at any location on the exterior of the host product or product packaging or product literature, which shall be available with the host product or online.

The host product shall be properly labelled to identify the modules within the host product.

The Innovation, Science and Economic Development Canada certification label of a module shall be clearly visible at all times when installed in the host product; otherwise, the host product must be labelled to display the Innovation, Science and Economic Development Canada certification number for the module, preceded by the word "Contains" or similar wording expressing the same meaning, as follows:

Contains IC: 5303A-AW900G2HP where: 5303A-AW900G2HP is the module's certification number.

The applicant for a certified module shall provide with each certified module to the user, either a host label, such as described above, or an explanation and instructions to the user as to the host product labelling requirements.

Antenna Warning

WARNING: This device has been tested with MMCX connectors with the antennas listed in AW900G2HP Approved Antennas on page 31. When integrated into OEM products, fixed antennas require installation preventing end-users from replacing them with non-approved antennas. Antennas not listed in the AW900G2HP Approved Antennas on page 31 must be tested to comply with FCC Section 15.203 (unique antenna connectors) and Section 15.247 (emissions).

WARNING: WARNING: The FCC requires that all spread spectrum devices operating within the Unlicensed radio frequency bands must limit themselves to a maximum radiated power of 4 Watts EIRP. Failure to observe this limit is a violation of our warranty terms, and shall void the user’s authority to operate the equipment. This can be stated as follows:

RF power - cable loss + antenna gain <= 36 dBm EIRP

Fixed Base Station and Mobile Applications

AvaLAN Modules are pre-FCC approved for use in fixed base station and mobile applications. When the antenna is mounted at least 20 cm (8”) from nearby persons, the application is considered a mobile application.

Portable Applications and SAR Testing

When the module will be used closer than 20 cm to nearby persons, then the application is considered “portable” and requires an additional test be performed on the final product. This test is called the Specific Absorption Rate (SAR) testing and measures the emissions from the module and how they affect the person.

RF Exposure

(This statement must be included as a CAUTION statement in OEM product manuals.)

WARNING: This equipment is approved only for mobile and base station transmitting devices. Antenna(s) used for this transmitter must be installed to provide a separation distance of at least 22.72 cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

To fulfill FCC Certification requirements:

1. Integrator must ensure required text [Figure 1] is clearly placed on the outside of the final product.
2. AW900G2HP Module may be used only with Approved Antennas that have been tested with this module.

IC RSS-102 RF Exposure statement:

This system has been evaluated for RF Exposure per RSS-102 and is in compliance with the limits specified by Health Canada Safety Code 6. The system must be installed at a minimum separation distance from the antenna to a general bystander of 33.76 cm to maintain compliance with the General Population limits.

L’exposition aux radiofréquences de ce système a été évaluée selon la norme RSS-102 et est jugée conforme aux limites établies par le Code de sécurité 6 de Santé Canada. Le système doit être installé à une distance minimale de 33.76 cm séparant l’antenne d’une personne présente en conformité avec les limites permises d’exposition du grand public.

Antenna Pattern	Type	Gain
Omni directional	Monopole	≤ 6dBi
Directional	Yagi	≤ 15dBi
Directional	Panel	≤ 10dBi

Type certified Antennas

IC (Industry Canada) Certification

This device complies with Industry Canada licence-exempt RSS standard(s). 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.

Le présent appareil est conforme aux CNR d'Industrie 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, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Contains Model AW900G2HP Radio, IC: 5303A-AW900G2HP

Integrator is responsible for its product to comply with IC ICES-003 & FCC Part 15, Sub. B - Unintentional Radiators. ICES-003 is the same as FCC Part 15 Sub. B and Industry Canada accepts FCC test report or CISPR 22 test report for compliance with ICES-003.

Transmitters with Detachable Antennas

This radio transmitter (IC: 1846A-XLRP) has been approved by Industry Canada to operate with the antenna types listed in AW900G2HP Approved Antennas abov with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Le présent émetteur radio (IC: 1846A-XLRP) a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés ci?dessous et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

Detachable Antenna

Under Industry Canada regulations, this radio transmitter may operate using only an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peutfonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvépour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillageradioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne etson gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépassepas l'intensité nécessaire àl'établissement d'une communication satisfaisante.