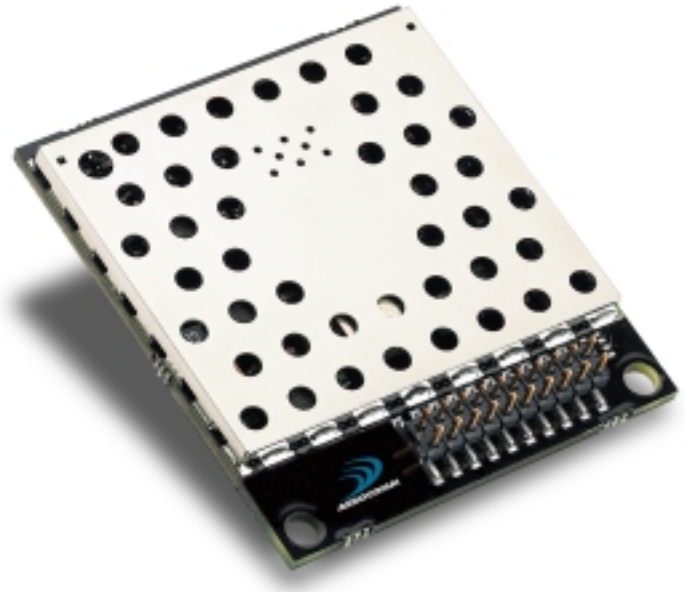
AC4490

900 MHz OEM TRANSCEIVERS

Specifications Subject to Change

User's Manual
Version 1.5



10981 EICHER DRIVE
LENEXA, KS 66219
(800) 492-2320
www.aerocomm.com
wireless@aerocomm.com

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This material is preliminary

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AEROCOMM's products are intended for use in normal commercial and industrial applications. Applications requiring unusual environmental requirements such as military, medical life-support or life-sustaining equipment are specifically not recommended without additional testing for such application.

Important Document Information

The AC4490 transceiver products are available in both commercial and industrial temperature, noted by the character 'C' or 'I' appended to the end of the family part number. For example, the part number for the commercial temperature version is AC4490C and the part number for the industrial temperature version is AC4490I. The family part number will be used throughout this document, except where specific information for the commercial or industrial temperature versions is noted.

DOCUMENT INFORMATION

Revision	Description
Version 1.0	3/15/2002 – Initial Release Version
Version 1.1	12/18/2002 – Preliminary Release
Version 1.2	12/20/2002 – Preliminary Release. Changed location of new interface pins for higher compatibility with AC4424 product family.
Version 1.3	1/29/2003 – Updated interface baud rate formula/table. Updated current consumption table. Corrected RSSI plot. Updated Interface Timeout information. Renamed product family to AC4490. Multiple byte EEPROM read/write now allowed.
Version 1.4	2/18/2003 – Added Max Power byte. Removed Write Enable references. Fixed Power Down/Up command response. Removed Peer-to-Peer bit. Added Auto Destination. Added Unicast Only bit. Added 500mW product. Revised part numbers. Updated Channel Number settings.

Agency Approval Overview

Part Number	US/FCC	CAN/IC	EUR/EN	Portable	Mobile	Fixed
AC4490-100	X	X		See Note 1	X-2.5cm*	X-2.5cm*

* See RF Exposure warning on next page

Note 1: Specific Absorption Rating (SAR) testing required for portable applications.

Agency Identification Numbers

Part Number	US/FCC	CAN/IC	EUR/EN
AC4490-100	X	X	

FCC Notice

WARNING: 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.

Labeling Requirements

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 OEM enclosure specifying the appropriate AeroComm FCC identifier for this product as well as the FCC Notice above. The FCC identifiers are listed above in the Agency Identifier Numbers section.

Antenna Warning

WARNING: This device has been tested with an MMCX connector with the antennas listed below. When integrated in the OEMs product, these fixed antennas require installation preventing end-users from replacing them with non-approved antennas. Any antenna not in the following table must be tested to comply with FCC Section 15.203 for unique antenna connectors and Section 15.247 for emissions.

Approved Antenna List

Note: We are still qualifying antennas and will add to this list as that process is completed.

Item	Part Number	Mfg.	Frequency Band	Type	Gain (dBi)	AC4490X-100
1	S467FL-6-RMM-915S	Nearson	902 – 928MHz	½ Wave Dipole	2	PMF
2	S161AH-915R	Nearson	902 – 928MHz	½ Wave Dipole	2.5	PMF
3	S331AH-915	Nearson	902 – 928MHz	¼ Wave Dipole	1	PMF
4	1020B5812-04 (Flavus 915)	gigaAnt	902 – 928MHz	¼ Wave Snap-In	-0.5	PMF

P=Portable, M=Mobile, F=Fixed/Basestation

Note: Specific Absorption Rating (SAR) testing required for portable applications.

RF Exposure AC4490-100

WARNING: To comply with FCC RF Exposure requirements, the Original Equipment Manufacturer (OEM) must ensure that the approved antenna in the previous table must be installed and/or configured to operate with a separation distance of 2.5cm or more from all persons to satisfy RF Exposure compliance.

The preceding statement must be included as a CAUTION statement in manuals for products operating with the approved antennas in the previous table to alert users on FCC RF Exposure compliance.

Figures

Tables

AC4490 Features

- ✓ Available in either 3.3V or 5V TTL level serial interface for fast integration
- ✓ Drop-in replacement for AC4424 2.4GHz product family[1]
- ✓ Two generic input and output digital lines and integrated DAC/ADC functions
- ✓ Frequency Hopping Spread Spectrum for security and interference rejection
- ✓ Cost Efficient for high volume applications
- ✓ Very low power consumption for battery powered implementations
- ✓ Small size for portable and enclosed applications
- ✓ Very Low latency and high throughput
- ✓ Industrial temperature version available (-40°C to 80°C)

1. Overview

The AC4490 is a member of AeroComm's ConnexRF OEM transceiver family. It is designed for integration into OEM systems operating under FCC part 15.247 regulations for the 900 MHz ISM band.

The AC4490 is a cost-effective, high performance, 900 MHz frequency hopping spread spectrum transceiver. It provides an asynchronous TTL level serial interface for OEM Host communications. Communications include both system and configuration data. The Host supplies system data for transmission to other Host(s). Configuration data is stored in an on-board EEPROM. All frequency hopping, synchronization, and RF system data transmission/reception is performed by the transceiver.

The AC4490 transceivers can be used as a direct serial cable replacement – requiring no special Host software for operation. They also feature a number of On-the-Fly Control Commands providing the OEM Host with a very versatile interface for any situation.

AC4490 transceivers operate in a Point-to-Point or Point-to-Multipoint, Client-Server or Peer-to-Peer architecture. One transceiver is configured as a Server and there can be one or many Clients. To establish synchronization between transceivers, the Server emits a beacon. Upon detecting a beacon, a Client transceiver informs its Host and a RF link is established.

This document contains information about the hardware and software interface between an AeroComm AC4490 transceiver and an OEM Host. Information includes the theory of operation, specifications, interface definition, configuration information and mechanical drawing.

The OEM is responsible for ensuring the final product meets all FCC and/or appropriate regulatory agency requirements listed herein before selling any product.

[1] See AC4424/AC4490 Integration Guide for details

2. AC4490 Specifications

GENERAL						
Interface	20 pin mini-connector					
Serial Interface Data Rate	PC baud rates from 1200 bps to 115,200 bps					
Power Consumption (typical)	**Duty Cycle (TX = Transmit; RX = Receive)**					
		10%TX	**50%TX**	**100%TX**	**100%RX**	**Pwr-Down**
	AC4490-100:	43mA	95mA	160mA	30mA	TBD
Channels (used to create independent networks)	5 Channel Sets comprising 58 total channels					
Security	One byte System ID					
RADIO						
Frequency Band	US/Canada: 902 – 928 MHz Australia: 915 – 928 MHz					
Radio Type	Frequency Hopping Spread Spectrum					
Output Power (conducted, no antenna)	AC4490-100: 50mW typical					
Effective Isotropic Radiated Power (EIRP with 3dBi gain antenna)	AC4490-100: 100mW typical					
Voltage	3.3 or 3.3 - 6V ±2%, ±50mV ripple					
Sensitivity	-100dBm typical					
Range (based on 3dBi gain antenna)	AC4490-100: 10,000 ft.					
ENVIRONMENTAL						
Temperature (Operating) Commercial:	AC4490C: 0°C to 60°C					
Industrial:	AC4490I: -40°C to 80°C					
Temperature (Storage)	-50°C to +85°C					
Humidity (non-condensing)	10% to 90%					
PHYSICAL						
Dimensions	1.65” x 1.9” x 0.20”					
Antenna	AC4490-100: MMCX Jack or Integral Antenna					
Weight	Less than 0.75 ounce					

3. Specifications

3.1 INTERFACE SIGNAL DEFINITIONS

The AC4490 has a simple interface that allows OEM Host communications with the transceiver. **Table 1 – Pin Definitions**, shows the connector pin numbers and associated functions. The I/O direction is with respect to the transceiver. All outputs are 3.3VDC levels and inputs are 5VDC TTL with the exception of RSSI, AD In and AD Out, which are all analog. All inputs are weakly pulled High and may be left floating during normal operation.

Table 1 – Pin Definitions

Pin	Type	Signal Name	Function
1	O	GO0	Interruptible Generic Output pin
2	O	TXD	Transmitted data out of the transceiver
3	I	RXD	Data input to the transceiver
4	I	GI0	Interruptible Generic Input pin
5	GND	GND	Signal Ground
6	O	Hop Frame	Active Low when the transceiver is hopping.
7	O	CTS	Clear to Send – Active Low when the transceiver is ready to accept data for transmission.
8	I	RTS	Request to Send – When enabled in EEPROM, active Low when the OEM Host is ready to accept data from the transceiver. NOTE: Keeping RTS High for too long can cause data loss.
9	O	GO1	Generic Output pin
10	PWR	VCC	3.3 or 3.3 – 6V ± 2%, ± 50mV ripple
11	PWR	VCC	3.3 or 3.3 – 6V ± 2%, ±50 mV ripple
12	I	9600_BAUD	9600_BAUD – When pulled logic Low before applying power or resetting the transceiver's serial interface is forced to a 9600, 8, N, 1 rate. To exit, transceiver must be reset or power-cycled with 9600_Baud logic High.
13	O	RSSI	Received Signal Strength - An analog output giving a relative indication of received signal strength while in Receive Mode
14	I	GI1	Generic Input pin
15	I	UP_RESET	RESET – Controlled by the AC4490 for power-on reset if left unconnected. After a Stable power-on, a logic High pulse will reset the AC4490. Do not power-up the transceiver with this pin tied Low.
16	GND	GND	Signal Ground
17	I	Command/Data	When logic Low, transceiver interprets Host data as command data. When logic High, transceiver interprets Host data as transmit data.
18	I	AD In	Analog Data Input
19	O	AD Out	Analog Data Output
20	O	IN_RANGE	In Range – Active Low when a Client radio is in range of a Server on same Channel with the same System ID.

I = Input to the transceiver O = Output from the transceiver

3.2 ELECTRICAL SPECIFICATIONS

Table 2 – Input Voltage Characteristics

Pin	Type	Name	High Min.	High Max.	Low Min.	Low Max.	Unit
3	I	RXD	2	5.5	0	0.8	V @ 5µA
4	I	GI0	2	5.5	0	0.8	V @ 5µA
8	I	RTS	2	5.5	0	0.8	V @ 5µA
12	I	9600_Baud	2	5.5	0	0.8	V @ 5µA
14	I	GI1	2	5.5	0	0.8	V @ 5µA
15	I	UP_RESET	0.8	5.5	0	0.6	V @ 5µA
17	I	Command/Data	2	5.5	0	0.8	V @ 5µA
18	I	AD In	N/A	3.3	0	N/A	V @ 1µA

Table 3 – Output Voltage Characteristics

Pin	Type	Name	High Min.	Low Max.	Unit
1	O	GO0	2.5 @ 8mA	0.4 @ 8mA	V
2	O	TXD	2.5 @ 2mA	0.4 @ 2mA	V
6	O	Hop Frame	2.5 @ 2mA	0.4 @ 2mA	V
7	O	CTS	2.5 @ 2mA	0.4 @ 2mA	V
9	O	GO1	2.5 @ 2mA	0.4 @ 2mA	V
12	O	Packet Frame	2.5 @ 2mA	0.4 @ 2mA	V
13	O	RSSI	See Figure 1	See Figure 1	V
19	O	AD Out	N/A	N/A	V[2]
20	O	IN_RANGE	2.5 @ 2mA	0.4 @ 2mA	V

3.3 SYSTEM TIMING

Care should be taken when selecting transceiver architecture as it can have serious effects on data rates, latency timings, and overall system throughput. The importance of these three characteristics will vary from system to system and should be a strong consideration when designing the system.

3.3.1 Serial Interface Data Rate

The Serial Interface Data Rate is programmable by the Host. This is the rate the Host and transceiver communicate over the serial bus. Possible values range from 1200 bps to 115,200 bps. The only supported mode is asynchronous – 8-bit, No Parity, 1 Start Bit, and 1 Stop Bit**.**

[2] AD Out is an unbuffered, high impedance output and **must be buffered** by the OEM Host when used.

3.3.2 Latency Times

TBD

3.3.3 Maximum Overall System Throughput

When configured as shown in the table below, an AC4490 transceiver is **capable** of achieving the listed throughput. However, in the presence of interference or at longer ranges, the transceiver may not be able to meet these specified throughputs.

Table 4 – Maximum Overall System Throughputs

RF Mode	Interface Baud Rate	Duplex	FEC	Direction	Throughput (bps)
Stream	57.6k	Half	Disabled	One way	TBD
Stream	57.6k	Half	Enabled	One way	TBD
Acknowledge	57.6k	Half	Disabled	One way	TBD
Acknowledge	57.6k	Full	Disabled	Both ways	TBD

4. Configuring the AC4490

4.1 EEPROM PARAMETERS

A Host can program various parameters that are stored in EEPROM and become active after a power-on reset. **Table 5 - EEPROM Parameters**, gives the locations and descriptions of the parameters that can be read or written by a Host. Factory default values are also shown. **Do not write to any EEPROM addresses other than those listed below. Do not copy a transceiver's EEPROM data to another transceiver. Doing so may cause the transceiver to malfunction.**

Table 5 – EEPROM Parameters

Parameter	EEPROM Address	Length (Bytes)	Range	Default	Description
Product ID	00H	40			40 bytes - Product identifier string. Includes revision information for software and hardware.
Sub Hop Adjust	36H	1	00 – FFh	66h	This value should only be changed when recommended by Aerocomm
Channel Number	40H	1	00 – 39h	00h	Set 0 = 00 – 0Fh (US/Canada) Set 1 = 10 – 2Fh (US/Canada) Set 2 = 30 – 37h (Australia) Set 3 = 38h (France High Power) Set 4 = 39h (France Low Power)
Server/Client Mode	41H	1	01 – 02h	02h	01h = Server 02h = Client
Baud Rate Low	42H	1	00 – FFh	FCh	Low Byte of the interface baud rate.
Baud Rate High	43H	1	00h	00h	Always 00h
Control 0	45H	1		00010100b (14h)	Settings are: Bit 7 – **AeroComm Use Only** Bit 6 – **AeroComm Use Only** Bit 5 – Sync to Channel 0 = Don't Sync to Channel 1 = Sync to Channel Bit 4 – **AeroComm Use Only** Bit 3 – Packet Frame 0 = Disable Packet Frame 1 = Use pin 12 as Packet Frame Bit 2 – RF Mode 0 = RF Stream Mode 1 = RF Acknowledge Mode Bit 1 – RF Delivery 0 = Addressed 1 = Broadcast Bit 0 – FEC 0 = No Forward Error Correction 1 = Use Forward Error Correction

Parameter	EEPROM Address	Length (Bytes)	Range	Default	Description
Frequency Offset	46H	1	00 – FFh	00h	
Transmit Retries	4CH	1	01 – FFh	10h	
Broadcast Attempts	4DH	1	01 – FFh	04h	
API Control	56H	1		01000011b (43h)	Settings are: Bit 7 – **AeroComm Use Only** Bit 6 – **AeroComm Use Only** Bit 5 – Unicast Only 0 = Receive Unicast and Broadcast packets 1 = Only receive Unicast packets Bit 4 – Auto Destination 0 = Use Destination Address 1 = Set Destination to Server Bit 3 – **AeroComm Use Only** Bit 2 – RTS Enable 0 = RTS Ignored 1 = Transceiver obeys RTS Bit 1 – Duplex Mode 0 = Half Duplex 1 = Full Duplex Bit 0 – Auto Config 0 = Use EEPROM values 1 = Auto Configure Values
Interface Timeout	58H	1	02 – FFh	04h	
Sync Channel	5AH	1	00 – 3Fh	01h	
RF Packet Size	5BH	1	01 – 40h	46h	
CTS On	5CH	1	01 – FFh	D2h	
CTS On Hysteresis	5DH	1	01 – FFh	ACh	
Max Power	63H	1	00 – FFh	60h	
Destination ID	70H	6		6 Bytes	
System ID	76H	1	00 – FFh	01h	
MAC ID	80H	6		6 Bytes	Unique IEEE MAC Address

4.2 EEPROM CONFIGURATION COMMANDS

The configuration set allows the Host to modify the operation of the transceiver. If the Command/Data pin (Pin 17) is pulled logic Low, a transceiver will interpret incoming Host data as Command Data. The Host can then read and write parameters using the various configuration commands listed below. To exit Configuration Mode, the Host must perform a hardware or power-on reset or issue an Exit Command Mode command to the transceiver.

4.2.1 EEPROM Byte Read

Upon receiving this command, a transceiver will transmit the desired data from the address requested by the Host.

Host Command:
Byte 1 = C0h
Byte 2 = Address
Byte 3 = Length (01…FFh = 1…255 bytes; 00h = 256 bytes)

Transceiver Response:
Byte 1 = C0h
Byte 2 = Address
Byte 3 = Length
Byte 4…n = Data at requested address(s)

4.2.2 EEPROM Byte Write

Upon receiving this command, a transceiver will write the data byte to the address specified but will not echo it back to the Host until the EEPROM write cycle is complete. The write can take as long as 10ms to complete. Following the write cycle, a transceiver will transmit the data byte to the Host. Multiple byte EEPROM writes are allowed up to a length of 128 bytes. An EEPROM boundary exists between addresses 7Fh and 80h. No single EEPROM write command shall write to addresses on both sides of that EEPROM boundary.

Host Command:
Byte 1 = C1h
Byte 2 = Address
Byte 3 = Length (01 – 80h)
Byte 4…n = Data to store at Address

Transceiver Response:
Byte 1 = C1h
Byte 2 = Address
Byte 3 = Length (01 – 80h)
Byte 4 = Last data byte written by this command

4.2.3 EEPROM Exit Configuration Command

The OEM Host can cause the transceiver to exit command mode by issuing the Exit Configuration Command mode command to the transceiver. **However, the transceiver will not reflect any of the changes programmed into the EEPROM until the transceiver is reset.**

Host Command:
Byte 1 = 56h

Transceiver Response:
Byte 1 = 56h

4.3 ON-THE-FLY CONTROL COMMAND REFERENCE

The AC4490 transceiver contains static memory that holds many of the parameters that control the transceiver operation. Using the "CC" command set allows many of these parameters to be changed during system operation. Because the memory these commands affect is static, when the transceiver is reset, these parameters will revert back to the settings stored in the EEPROM. **Do not to modify undocumented static addresses as undesired operation may occur. All "CC" commands must be issued from the Host to the transceiver with Command/Data (Pin 17) pulled logic Low. To exit "CC" mode, simply take the Command/Data pin High.**

4.3.1 Status Request

The Host issues this command to request the status of the transceiver.

Host Command:
Byte 1 = CCh
Byte 2 = 00h
Byte 3 = 00h

Transceiver Response:
Byte 1 = CCh
Byte 2 = Firmware version number
Byte 3 = Data1

Where:
Data1 =
00 for Server in Normal Operation
01 for Client in Normal Operation
02 for Server in Acquisition Sync
03 for Client in Acquisition Sync

4.3.2 Change Channel without Forced Acquisition Sync

The Host issues this command to change the channel of the transceiver. The transceiver will not begin acquisition sync until its Range Refresh timer expires.

Host Command:
Byte 1 = CCh
Byte 2 = 01h
Byte 3 = RF Channel Number (Hexadecimal)

Transceiver Response:
Byte 1 = CCh
Byte 2 = RF Channel Number (Hexadecimal)

4.3.3 Change Channel with Forced Acquisition Sync

The Host issues this command to change the channel of the transceiver and force the transceiver to immediately begin synchronization.

Host Command:
Byte 1 = CCh
Byte 2 = 02h
Byte 3 = RF Channel Number (Hexadecimal)

Transceiver Response:
Byte 1 = CCh
Byte 2 = RF Channel Number (Hexadecimal)

4.3.4 Server/Client Command

The Host issues this command to change the mode (Server or Client) of the transceiver and can force the transceiver to actively begin synchronization.

Host Command:
Byte 1 = CCh
Byte 2 = 03h
Byte 3 = Data1

Where:
Data1 =
00 for Server in Normal Operation
01 for Client in Normal Operation
02 for Server in Acquisition Sync
03 for Client in Acquisition Sync

Transceiver Response:
Byte 1 = CCh
Byte 2 = Software Version Number
Byte 3 = Data1

Where:
Data1 = Data1 from Host Command

4.3.5 Sync to Channel Command

The Host issues this command to change the **Sync Channel** byte. This will only affect operation when **Sync to Channel** is enabled in the EEPROM

Host Command:
Byte 1 = CCh
Byte 2 = 05h
Byte 3 = Data1

Where:
Data1 = New Sync Channel

Transceiver Response:
Byte 1 = CCh
Byte 2 = 05h
Byte 3 = Data1

Where:
Data1 = Data1 from Host Command

4.3.6 Power-Down Command

After the Host issues the power-down command to the transceiver, the transceiver will de-assert the In_Range line after entering power-down. A Client transceiver in power-down will remain in sync with a Server for a minimum of 2 minutes. To maintain synchronization with the Server, this Client transceiver should re-sync to the Server at least once every 2 minutes. This re-sync is accomplished by issuing the **Power-Down Wake-Up Command** and waiting for the In Range line to go active. Once this occurs, the Client transceiver is in sync with the Server and can be put back into power-down.

Host Command:
Byte 1 = CCh
Byte 2 = 06h

Transceiver Response:
Byte 1 = CCh
Byte 2 = RF Channel Number

4.3.7 Power-Down Wake-Up Command

The Power-Down Wake-Up Command is issued by the Host to bring the transceiver out of power-down mode.

Host Command:
Byte 1 = CCh
Byte 2 = 07h

Transceiver Response:
Byte 1 = CCh
Byte 2 = RF Channel Number

4.3.8 Broadcast Mode

The Host issues this command to change the transceiver operation between **Addressed Mode** and **Broadcast Mode**. If addressed mode is selected the transceiver will send all packets to the radio designated by the **Destination Address** programmed in the transceiver.

Host Command:
Byte 1 = CCh
Byte 2 = 08h
Byte 3 = 00 for addressed mode, 01 for broadcast mode

Transceiver Response:
Byte 1 = CCh
Byte 2 = 00 for addressed mode, 01 for broadcast mode

4.3.9 Write Destination Address

The Host issues this command to the transceiver to change the Destination Address. This is a **very powerful** command that provides the OEM Host with a means for ad-hoc networking. **Only the three Least Significant Bytes of the MAC Address are used for packet delivery.**

Host Command:
Byte 1 = CCh
Byte 2 = 10h
Bytes 3 – 5 = 00 – FFh corresponding the three LSB's of the destination MAC Address

Transceiver Response:
Byte 1 = CCh
Bytes 2 – 4 = 00 – FFh corresponding the three LSB's of the destination MAC Address

4.3.10 Read Destination Address

The Host issues this command to the transceiver to read the Destination Address. This is a **very powerful** command that provides the OEM Host with a means for ad-hoc networking. **Only the three Least Significant Bytes of the MAC Address are used for packet delivery.**

Host Command:
Byte 1 = CCh
Byte 2 = 11h

Transceiver Response:
Byte 1 = CCh
Bytes 2 – 4 = 00 – FFh corresponding the three LSB's of the destination MAC Address

4.3.11 Read Digital Inputs

The Host issues this command to read both digital input lines.

Host Command:
Byte 1 = CCh
Byte 2 = 20h

Transceiver Response:
Byte 1 = CCh
Byte 2 = Data1

Where:
Data1 = bit 0 – GI0, bit 1 – GI1

4.3.12 Read ADC

The Host issues this command to read any of the three onboard A/D converters.

Host Command:
Byte 1 = CCh
Byte 2 = 21h
Byte 3 = Data1

Where:
Data1 = 00h – AD In, 01h – Temperature, 02h – RSSI

Transceiver Response:
Byte 1 = CCh
Byte 2 = Data1
Byte 3 = Data2

Where:
Data1 = MSB of requested 12 bit ADC value
Data2 = LSB of requested 12 bit ADC value

4.3.13 Report Last Valid RSSI

As RSSI values are only valid when the local radio is receiving a RF packet from a remote radio, instantaneous RSSI can be very tricky to use. Therefore, the transceiver stores the most recent valid RSSI value. The Host issues this command to request that value. Note: This value will default to FFh if no valid RSSI measurement has been made.

Host Command:
Byte 1 = CCh
Byte 2 = 22h

Transceiver Response:
Byte 1 = CCh
Byte 2 = Data1

Where:
Data1 = Most significant 8 bits of last valid RSSI reading.

4.3.14 Write Digital Outputs

The Host issues this command to write both digital output lines to particular states.

Host Command:
Byte 1 = CCh
Byte 2 = 23h

Transceiver Response:
Byte 1 = CCh
Byte 2 = Data1

Where:
Data1 = bit 0 – GO0, bit 1 – GO1

4.3.15 Write DAC

The Host issues this command to write AD Out to a particular voltage. NOTE: AD Out is an unbuffered, high impedance output and **must be buffered** by the OEM Host when used.

Host Command:
Byte 1 = CCh
Byte 2 = 24h
Byte 3 = Data1
Byte 4 = Data2

Where:
Data1 = Update Period where: T_{Update} = (255 * (Data1 + 1)) / 14.7256^{+06}
Data2 = Duty Cycle where: Vout = (Data2 / 100h) * Vcc

Transceiver Response:
Byte 1 = CCh
Byte 2 = Data1
Byte 3 = Data2

Where:
Data1 = Data1 from Host Command
Data2 = Data2 from Host Command

4.3.16 Set Max Power

The Host Issues this command to limit the maximum transmit power emitted by the transceiver. This can be useful to minimize current consumption and satisfy certain regulatory requirements.

Host Command:
Byte 1 = CCh
Byte 2 = 25h
Byte 3 = Data1

Where:
Data1 = New **Max Power**

Transceiver Response:
Byte 1 = CCh
Byte 2 = Data1

Where:
Data1 = Data1 from Host Command

4.3.17 Transmit Buffer Empty

The Host issues this command to determine when the RF Transmit buffer is empty. The Host will not receive the transceiver response until that time.

Host Command:

Byte 1 = CCh
Byte 2 = 30h

Transceiver Response:

Byte 1 = CCh
Byte 2 = 00h

5. Theory of Operation

5.1 HARDWARE INTERFACE

Below is a description of all hardware pins used to control the AC4490.

5.1.1 GIn (Generic Inputs 0 and 1) (pins 4 and 14 respectively) and GOn (Generic Outputs 0 and 1) (pins 1 and 9 respectively)

Both GIn pins, when enabled in EEPROM, serve as negative-going edge triggered generic input pins. Both GOn pins, when enabled in EEPROM, serve as generic output pins. The following functions can be accomplished with these pins.

GIn/GOn Options:

1) A negative-going edge is detected on either GIn pin. The state of both pins is transmitted over the RF (as configured by **RF Mode**) and will be presented to corresponding GOn pins on the remote radio(s).

2) A "CC" command is issued to force an update on remote radio's GOn pins. The state of both local GIn lines is transmitted over the RF (as configured by **RF Mode**) and will be presented to corresponding Gon pins on the remote radio(s).

3) The ***Read Digital Inputs*** "CC" command is issued to read the state of both GIn pins locally (details can be found in the ***On-the-Fly Control Command Reference***).

4) The ***Write Digital Outputs*** "CC" command is issued to write all GOn pins locally to particular states (details can be found in the ***On-the-Fly Control Command Reference***).

5) A "CC" command is issued to write the GOn pins on a remote radio to particular states. Those states are transmitted over the RF (as configured by **RF Mode**) and will be presented to the corresponding pins on the remote radio(s).

5.1.2 TXD (Transmit Data) and RXD (Receive Data) (pins 2 and 3 respectively)

The AC4490 accepts 3.3 or 5VDC TTL level asynchronous serial data on the RXD pin and interprets that data as either Command Data or Transmit Data. Data is sent from the transceiver to the OEM Host via the TXD pin. The data must be of the format 8-N-1 (8 data bits, No Parity bits, One stop bit).

5.1.3 Hop Frame (pin 6)

The AC4490 is a frequency hopping spread spectrum radio. Frequency hopping allows the system to hop around interference in order to provide a better wireless link. Hop Frame transitions logic Low at the start of a hop and transitions logic High at the completion of a hop. The OEM Host is not required to monitor Hop Frame.

5.1.4 CTS Handshaking (pin 7)

The AC4490 has an interface buffer size of 256 bytes. If the buffer fills up and more bytes are sent to the transceiver before the buffer can be emptied, data corruption will occur. The transceiver prevents this corruption by asserting CTS High as the buffer fills up and taking CTS Low as the buffer is emptied. **CTS On** in conjunction with **CTS On Hysteresis** control the operation of CTS. CTS On specifies the amount of bytes that must be in the buffer for CTS to be disabled (High). Even while CTS is disabled, the OEM Host can still send data to the transceiver, but it should do so carefully. Once CTS is disabled, it will remain disabled until the buffer is reduced to the size specified by CTS On Hysteresis.

5.1.5 RTS Handshaking (pin 8)

With **RTS Mode** disabled, the transceiver will send any received packet to the OEM Host as soon as the packet is received. However, some OEM Hosts are not able to accept data from the transceiver all of the time. With RTS Mode Enabled, the OEM Host can keep the transceiver from sending it a packet by disabling RTS (logic High). Once RTS is enabled (logic Low), the transceiver can send packets to the OEM Host as they are received. **Note: Leaving RTS disabled for too long can cause data loss once the transceiver's receive buffer fills up.**

5.1.6 9600 Baud/Packet Frame (pin 12)

9600_BAUD – When pulled logic Low before applying power or resetting, the transceiver's serial interface is forced to a 9600, 8-N-1 (8 data bits, No parity, 1 stop bit) rate. To exit, transceiver must be reset or power-cycled with 9600_Baud logic High.

Packet Frame – When enabled in EEPROM, Packet Frame will transition logic Low at the start of a received RF packet and transition logic High at the completion of the packet.

5.1.7 RSSI (pin 13)

Instantaneous RSSI

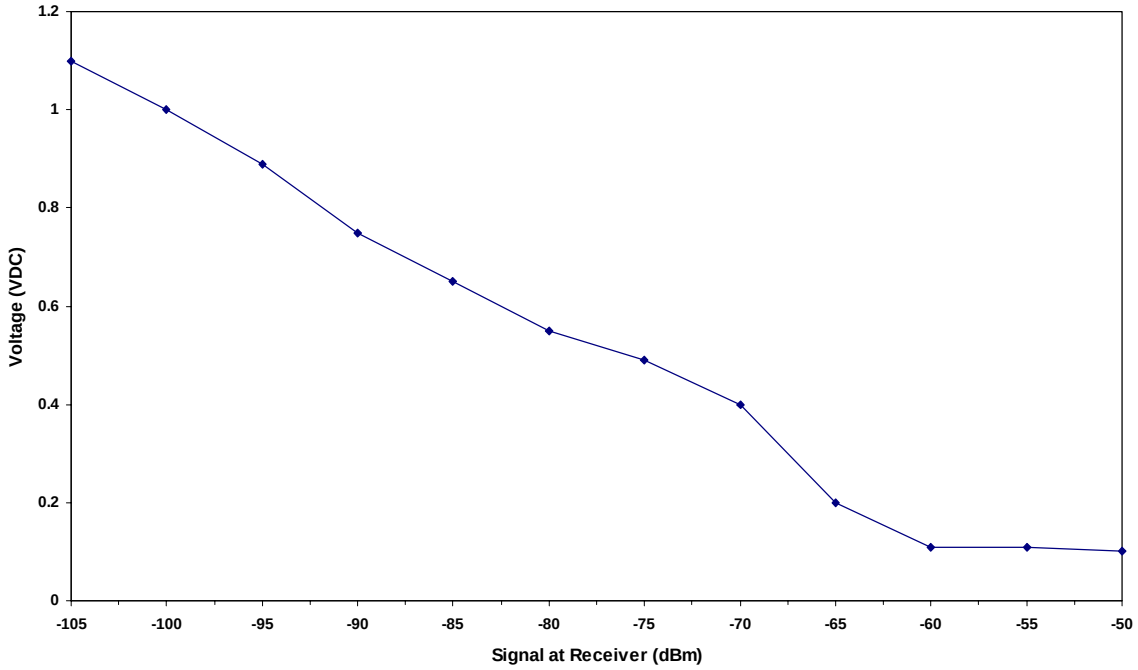
Received Signal Strength Indicator is used by the Host as an indication of instantaneous signal strength at the receiver. The Host must calibrate RSSI without a RF signal being presented to the receiver. Calibration is accomplished by following the steps listed below to find a minimum and maximum voltage value.

1) Power up only one Client (no Server) transceiver in the coverage area.
2) Measure the RSSI signal to obtain the minimum value with no other signal present.
3) Power up a Server. Make sure the two transceivers are in close proximity and measure the Client's peak RSSI once the Client reports In Range to obtain a maximum value at full signal strength.

Validated RSSI

As RSSI values are only valid when the local radio is receiving a RF packet from a remote radio, instantaneous RSSI can be very tricky to use. Therefore, the transceiver stores the most recent valid RSSI value. The Host issues the ***Report Last Good RSSI*** command to request that value (details can be found in the ***On-the-Fly Control Command Reference***). Validated RSSI is not available at the RSSI pin.

Figure 1 – RSSI Voltage vs. Received Signal Strength



5.1.8 UP_Reset (pin 15)

UP_Reset provides a direct connection to the reset pin on the AC4490 microprocessor. To guarantee a valid power-up reset, this pin should never be tied Low on power-up. For a valid power-on reset, reset must be High for a minimum of 50us.

5.1.9 Command/Data (pin 17)

When logic High, transceiver interprets Host data as transmit data to be sent to other transceivers and their Hosts. When logic Low, transceiver interprets Host data as command data **(see section 4)**.

5.1.10 AD In and AD Out (pins 18 and 19 respectively)

When enabled in EEPROM, AD In and AD Out can be used as a cost savings to replace Analog-to-Digital and Digital-to-Analog converter hardware. The following conditions are all possible when enabled in EEPROM. Note: AD Out is an unbuffered, high impedance output and **must be buffered** by the OEM Host when used.

1) A refresh rate can be programmed in EEPROM to cause a transceiver to read the AD In port and send the state of that port over the RF (as configured by **RF Mode**) and will be presented to the AD Out pin on the remote radio(s).

2) A "CC" command is issued to cause a transceiver to read the AD In port locally and send the state of that port over the RF (as configured by **RF Mode**) and will be presented to the AD Out pin on the remote radio(s).

3) The ***Read ADC*** command is issued to read the state of AD In locally (details can be found in the ***On-the-Fly Control Command Reference***).

4) The ***Write ADC*** command is issued to write the AD Out pin to a particular state locally (details can be found in the ***On-the-Fly Control Command Reference***).

6) A "CC" command is issued to write the AD Out pin on a remote radio(s) to a particular state. This state is transmitted over the RF (as configured by **RF Mode**) and will be presented to the AD Out pin on the remote radio(s).

5.1.11 In Range (pin 20)

The IN_RANGE pin at the connector will be driven logic Low when a Client is in range of a Server on the same **RF Channel** and **System ID**. If a Client cannot hear a Server for 7.5s, it will drive the IN_RANGE pin logic High and enter a search mode looking for a Server. As soon as it detects a Server, the IN_RANGE pin will be driven logic Low. A Server Host can determine which Clients are in range by the Server's Host software polling a Client's Host.

5.2 SOFTWARE PARAMETERS

Below is a description of all software parameters used to control the AC4490.

5.2.1 RF Architecture (Unicast/Broadcast)

The Server controls the system timing by sending out regular beacons (transparent to the transceiver Host) which contain system timing information. This timing information synchronizes the Client radios to the Server.

Each network should consist of only one Server. There should never be two Servers on the same **RF Channel Number** in the same coverage area, as the interference between the two Servers will severely hinder RF communications.

The AC4490 runs a Peer-to-Peer type architecture where all transceivers, whether Servers or Clients, can communicate with all other transceivers. To prohibit transceivers from receiving broadcast packets, **Unicast Only** can be enabled.

5.2.2 RF Mode

All radios located on the same network must use the same RF Mode.

RF Delivery Overview

All packets are sent out over the RF as either addressed or broadcast packets. Addressed packets are only received by the radio specified by **Destination Address**. If addressed packets are desired, the Destination Address should be programmed with the **MAC ID** of the destination radio. To simplify EEPROM programming, **Auto Destination** can be enabled in Clients which allows the Client to automatically set its Destination Address to the address of the Server. Broadcast packets are sent out to every eligible transceiver on the network. If broadcast packets are desired, **RF Delivery** should be set to Broadcast.

Acknowledge Mode

In Addressed Acknowledge Mode, the RF packet is sent out to the receiver designated by the **Destination Address**. **Transmit Retries** is used to increase the odds of successful delivery to the intended receiver. Transparent to the OEM Host, the sending transceiver will send the RF packet to the intended receiver. If the receiver receives the packet free of errors, it will tell the sender. If the sender does not receive this acknowledge, it will assume the packet was never received and retry the packet. This will go on until the packet is successfully received or the transmitter exhausts all of its retries. The received packet will only be sent to the OEM Host if and when it is received free of errors.

In Broadcast Acknowledge Mode, the RF packet is broadcast out to all eligible receivers on the network. In order to increase the odds of successful delivery, **Broadcast Attempts** is used to increase the odds of successful delivery to the intended receiver(s). Transparent to the OEM Host, the sending transceiver will send the RF packet to the intended receiver. If the receiver detects a packet error, it will throw out the packet. This will go on until the packet is successfully received or the transmitter exhausts all of its attempts. Once the receiver successfully receives the packet it will send the packet to the OEM Host. It will throw out any duplicates caused by further Broadcast Attempts. The received packet will only be sent to the OEM Host if it is received free of errors.

Stream Mode

In Broadcast Stream mode, the RF packet is broadcast out to all eligible receivers on the network. In Addressed Stream Mode, the RF packet is sent out to the receiver designated by the **Destination Address**. The sending transceiver will send each RF packet out once. There are no retries on the packet. Whether or not the packet contains errors, the receiver(s) will send the packet to the OEM Host. However, if receiver is not able to receive the packet in its entirety (there are bytes missing), it will not send the packet to the OEM Host. In order to increase the odds of successful delivery, **Forward Error Correction (FEC)** may be used. FEC is used (transparent to the OEM Host) to increase the odds of correctly receiving a packet sent over the RF. When enabled, the transceiver will send every byte over the RF 3 times and then perform a best-of-three bit-wise decision on the received bytes. Enabling FEC can cut overall throughput by 1/3. **Note: All transceivers on the same network must have the same setting for FEC. Stream Mode is incompatible with Full Duplex Mode.**

5.2.3 Sub Hop Adjust

Sub Hop Adjust is an AC4490 protocol parameter and should only be modified at the recommendation of Aerocomm.

5.2.4 Duplex Mode

In Half Duplex mode, the AC4490 will send a packet out over the RF when it can. This can cause packets sent at the same time by a Server and a Client to collide with each other over the RF. To prevent this, Full Duplex Mode can be enabled. This mode restricts Clients to transmitting on odd numbered frequency "bins" and the Server to transmitting on even frequency bins. Though the RF hardware is still technically half duplex, it makes the radio seem full duplex. This can cause overall throughputs to be cut in half. **Note: All transceivers on the same network must have the same setting for Full Duplex. Full Duplex mode is incompatible with Stream RF mode.**

5.2.5 Interface Timeout/RF Packet Size

Interface timeout, in conjunction with **RF Packet Size**, determines when a buffer of data will be sent out over the RF as a complete RF packet based on whichever condition occurs first.

Interface Timeout – Interface Timeout specifies a maximum byte gap in between consecutive bytes. When that byte gap is exceeded, the bytes in the transmit buffer are sent out over the RF as a complete packet. Interface timeout is adjustable in 1ms increments and has a tolerance of ±1ms. Therefore, the Interface Timeout should be set to a minimum of 2. The default value for Interface Timeout is 4 or 4ms.

RF Packet Size – When the amount of bytes in the transceiver transmit buffer equals RF Packet Size, those bytes are sent out as a complete RF packet.

5.2.6 Serial Interface Baud Rate

This two-byte value determines the baud rate used for communicating over the serial interface to a transceiver. **Table 5 - Baud Rate/Timeout** lists values for some common baud rates. Baud rates below 1200 baud are not supported. For a baud rate to be valid, the calculated baud rate must be within ±3% of the OEM Host baud rate. **If the 9600_BAUD pin (Pin 12) is pulled logic Low at reset, the baud rate will be forced to 9,600.** For Baud Rate values other than those shown in **Table 5 - Baud Rate**, the following equation can be used:

$$BAUD = 100h - (14.7456E^{+06} / (64 * \text{desired baud rate}))$$

BaudH = Always 0
BaudL = Low 8 bits of BAUD (base16)

Table 6 – Baud Rate

Baud Rate	BaudL (42h)	BaudH (43h)	Minimum Interface Timeout (58h)
115,200	FEh	00h	02h
57,600	FCh	00h	02h
38,400	FAh	00h	02h
28,800	F8h	00h	02h
19,200	F4h	00h	02h
14,400	F0h	00h	03h
9,600	E8h	00h	03h
4800	D0h	00h	05h
2400	A0h	00h	09h
1200	40h	00h	11h

5.2.7 Network Topology

RF Channel Number – RF Channel Number provides a physical separation between co-located networks. The AC4490 is a spread spectrum frequency hopping radio with a fixed hopping sequence. Without synchronizing the different networks to each other, different channel numbers could possibly interfere with each other and create "cross-talk." To avoid cross-talk interference, co-located networks should use **Sync-to-Channel**. A Server radio with Sync-to-Channel enabled will synchronize its frequency hop timing to a system located on the RF Channel specified by **Sync Channel**. The only requirement is that Sync Channel be numerically less than RF Channel. Therefore, every co-located network will be synchronizing to the network with the lowest RF Channel. Four Channel sets are provided for the AC4490. **Co-located networks must use the same Channel Set.**

Table 7 – US and International RF Channel Number Settings

Channel Set	RF Channel Number Range (40h)	Frequency Details and Regulatory Requirements	Countries
0	0 – 0Fh	902 – 928MHz (26 hop bins)	US/Canada
1	10 – 2Fh	902 – 928MHz (50 hop bins)	US/Canada
2	30 – 37h	915 – 928MHz	Australia
3	38h	869.4 – 869.5MHz (Up to 500mW at 10% maximum transmit vs. receive duty cycle)	France
4	39h	869.7 – 870MHz (Up to 5mW with no duty cycle requirement)	France

System ID – System ID is similar to a password character or network number and makes network eavesdropping more difficult. A receiving radio will not go in range of or communicate with another radio on a different System ID.

5.2.8 Frequency Offset

Frequency Offset is an AC4490 protocol parameter and should only be modified at the recommendation of Aerocomm.

5.2.9 Auto Config

The AC4490 has several variables that control its RF performance and vary by **RF Mode** and **RF Architecture**. Enabling Auto Config will bypass the value for these variables stored in EEPROM and use predetermined values for the given Interface Baud Rate. **Auto Config has been optimized for 115,200 baud Acknowledge Mode and all lower baud rates. It should only be disabled with recommendation from AeroComm.** Below is a list containing some of the variables affected by Auto Config and their respective values:

Table 8 – Auto Config Parameters

Parameter	Auto Config Value
RF Packet Size	46h
CTS On	D2h
CTS On Hysteresis	ACh

5.2.10 Max Power

Max Power provides a means for controlling the RF transmit output power of the AC4490. The following table lists some common values for Max Power and their current consumption. Output power and current consumption can vary by as much as ±10% per radio.

Table 9 – Max Power Settings

Max Power (Address 63h)	100% Transmit Current (mA)	Transmit Power Output(dBm)
00h	47	-20
01h	50	-10
02h	50.5	-3
03h	52	1
04h	55	4
05h	58.5	7
06h	63.5	9
07h	69	10.5
08h	76	12
09h	83	13.5
0Ah	90.5	14.5
0Bh	97.5	15.5
0Ch	105	16.5
0Dh	111.5	17

6. Application Examples

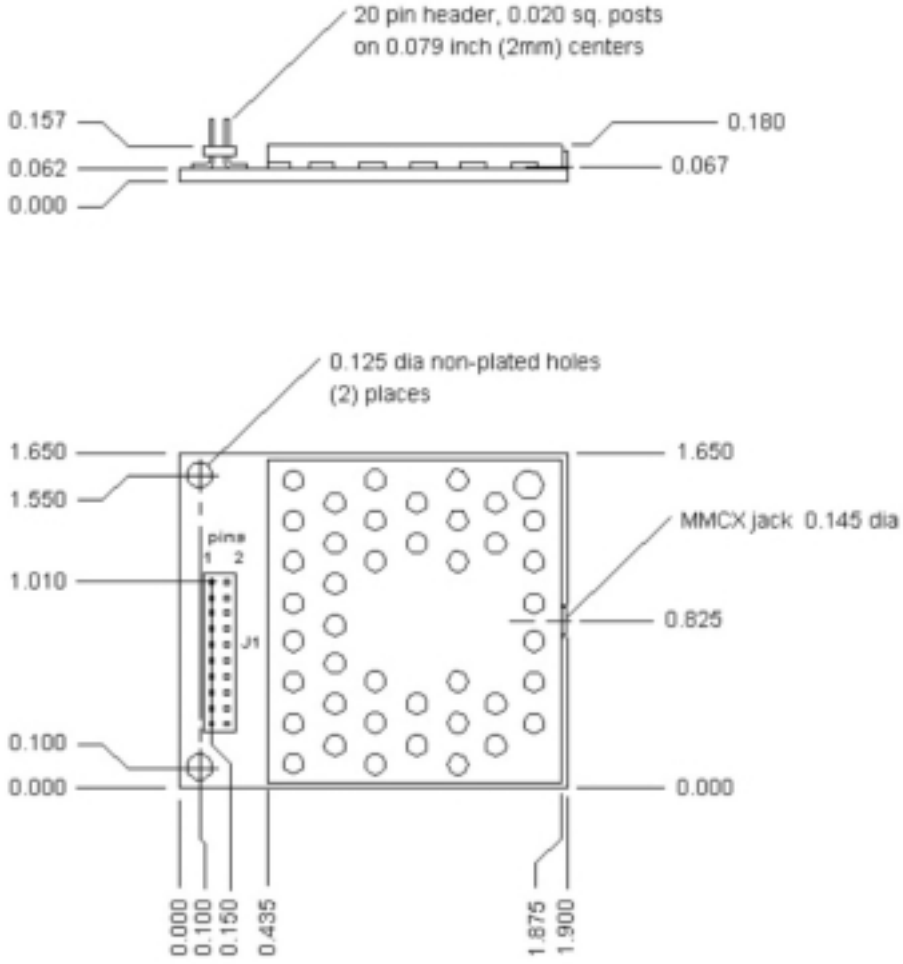
TBD

7. Dimensions

All AC4490 products measure 1.9"L x 1.65"W. Critical parameters are as follows:

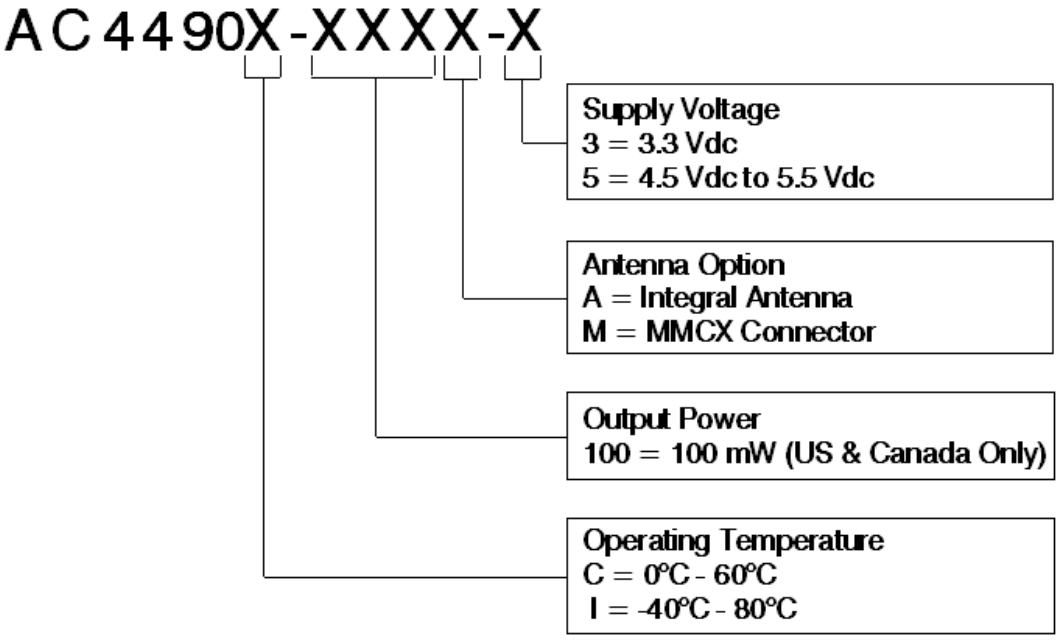
- **J1** – 20 pin OEM interface connector (Samtec TMM-110-01-L-D-SM, mates with Samtec SMM-110-02-S-D)
- **MMCX Jack** – Antenna connector (Telegartner P/N J01341C0081) mates with any manufacturer's MMCX plug

Figure 2 - AC4490 Top & Side View



8. Ordering Information

8.1 PRODUCT PART NUMBER TREE



8.2 PRODUCT PART NUMBERS

Order transceivers using the following part number tables:

3.3V, 100 mW Part Numbers	
AC4490C-100A-3	AC4490I-100A-3
AC4490C-100M-3	AC4490I-100M-3

4.5 – 5.5V, 100 mW Part Numbers	
AC4490C-100A-5	AC4490I-100A-5
AC4490C-100M-5	AC4490I-100M-5

8.3 DEVELOPER KIT PART NUMBERS

Order Developer Kits using the following part number tables:

4.5 – 5.5V, 200 mW Developer Kit Part Numbers
SDK-AC4490I-100A-5
SDK-AC4490I-100M-5

All Developer Kits include (2) transceivers, (2) RS232 Serial Adapter Boards, (2) 6Vdc unregulated power supplies, (2) Serial cables, (2) S467FL-6-RMM-915S dipole antennas with 6" pigtail and MMCX connector, configuration/testing software, and integration engineering support.