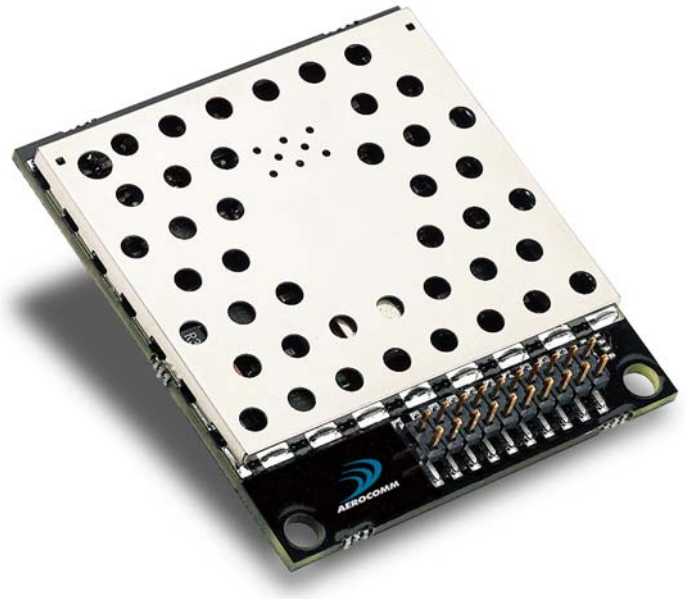
AC4790

900 MHz OEM TRANSCEIVERS

Specifications Subject to Change

User's Manual
Version 1.3



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DOCUMENT INFORMATION

Revision	Description
Version 1.0	2/21/2005 – Initial Release Version
Version 1.1	3/4/2005 – Updated Session Count Truth Table in Section 4.
Version 1.2	4/26/2005 – Updated Transmit Mode Section.
Version 1.3	3/27/2006 – Corrected API Send Data Complete. Added Australian Channels. Added 1x1 documentation. Added Original Max Power byte (0x8E) and Full Product ID (0x90). Changed Sense Adjust default to varies. Added Appendix 1 – Power Supply Application Note.

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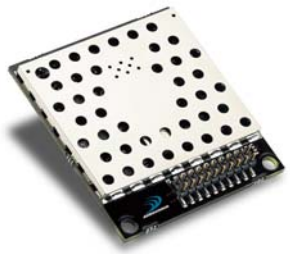
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AC4790 Transceiver Module



The compact AC4790 900MHz transceiver can replace miles of cable in harsh industrial environments. Using field-proven FHSS technology which needs no additional FCC licensing in the Americas, OEMs can easily make existing systems wireless with little or no RF expertise.

AC4790 Features

Networking and Security

- Masterless: True peer-to-peer, point-to-multipoint, point-to-point
- Retries and Acknowledgements
- API Commands to control packet routing and acknowledgement on a packet-by-packet basis
- Frequency Hopping Spread Spectrum for security and interference rejection
- Customizable RF Channel number and system ID
- Dynamic link analysis, remote radio discovery
- Software controlled sensitivity
- Hardware Protocol Status monitoring
- Two generic input and output digital lines and integrated ADC functions

Easy to Use

- Continuous 76.8 kbps RF data stream
- Software selectable interface baud rates from 1200 bps to 115.2 kbps
- Low cost, low power and small size ideal for high volume, portable and battery powered applications
- All modules are qualified for Industrial temperatures (-40°C to 80°C)
- Advanced configuration available using AT commands

OVERVIEW

The AC4790 is a member of AeroComm's ConnexRF OEM transceiver family. The AC4790 is a cost effective, high performance, frequency hopping spread spectrum transceiver; designed for integration into OEM systems operating under FCC part 15.247 regulations for the 900 MHz ISM band.

AC4790 transceivers operate in a Masterless architecture. The unique feature of this architecture is its dynamic Session extension and Collision Avoidance mechanism, which uses a proprietary scoring system to promote contention free communication and ensure that each node has fair access to the network. This instinctive dynamic peer-to-peer networking architecture enables several transceiver pairs to carry on simultaneous conversations on the same network.

To boost data integrity and security, the AC4790 uses AeroComm's field-proven FHSS technology featuring optional Data-Encryption Standards (DES). Fully transparent, these transceivers operate seamlessly in serial cable replacement applications. Communications include both system and configuration data via an asynchronous TTL or optional RS-485 serial interface for OEM Host communications. Configuration data is stored in an on-board EEPROM and most parameters can be changed on the fly. All frequency hopping, synchronization, and RF system data transmission/reception is performed by the transceiver.

This document contains information about the hardware and software interface between an AeroComm AC4790 transceiver and an OEM Host. Information includes the theory of operation, specifications, interface definition, configuration information and mechanical drawings. The OEM is responsible for ensuring the final product meets all appropriate regulatory agency requirements listed herein before selling any product.

Note: Unless mentioned specifically by name, the AC4790 modules will be referred to as the "radio" or "transceiver". Individual naming is used to differentiate product specific features. The host (PC/Microcontroller/Any device to which the AC4790 module is connected) will be referred to as "OEM Host".

Specifications

GENERAL		
20 Pin Interface Connector	Molex 87759-0030, mates with Samtec SMM-110-02-S-D	
RF Connector	Johnson Components 135-3711-822	
Antenna	AC4790-1x1: Customer must provide AC4790-200: MMCX Connector or integral antenna AC4790-1000: MMCX Connector	
Serial Interface Data Rate	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 AC4790-1x1: 33mA 54mA 80mA 28mA AC4790-200: 38mA 68mA 106mA 30mA AC4790-1000: 130mA 650mA 1300mA 30mA	
Channels	3 Channel Sets comprising 56 total channels	
Security	One byte System ID. 56-bit DES encryption key.	
Interface Buffer Size	Input/Output: 256 bytes each	
TRANSCEIVER		
Frequency Band	902 – 928 MHz	
RF Data Rate	76.8 kbps fixed	
RF Technology	Frequency Hopping Spread Spectrum	
Output Power	Conducted (no antenna) / EIRP (3dBi gain antenna) AC4790-1x1: 10mW typical / 20mW typical AC4790-200: 100mW typical / 200mW typical AC4790-1000: 743mW typical / 1486mW typical	
Supply Voltage	AC4790-1x1: 3.3V, ±50mV ripple AC4790-200: 3.3 – 5.5V, ±50mV ripple AC4790-1000*: Pin 10: 3.3 – 5.5V ±50mV ripple Pin 11: 3.3 ±3%, ±100mV ripple * Pins 10 and 11 may be tied together, provided the supply voltage never falls below 3.3 V and is capable of supplying 1.5 A of current.	
Sensitivity	-100dBm typical @ 76.8kbps RF Data Rate	
Initial Transceiver Sync time/Hop period	25ms / 50 ms	
Range, Line of Site (based on 3dBi gain antenna)	AC4790-1x1: 1 mile AC4790-200: 4 miles AC4790-1000: 20 miles	
EEPROM write cycles	20000	
ENVIRONMENTAL		
Temperature (Operating)	-40°C to 80°C	
Temperature (Storage)	-50°C to +85°C	
Humidity (non-condensing)	10% to 90%	
PHYSICAL		
Dimensions	Transceiver with MMCX Connector: 1.65" x 1.9" x 0.20" Transceiver with Integral Antenna: 1.65" x 2.65" x 0.20" AC4790-1x1: 1.00" x 1.00" x 0.162"	
Weight	Less than 0.75 ounce	
CERTIFICATIONS		
	AC4790-200	**AC4790-1000**
FCC Part 15.247	KQLAC4490-100	KQLAC4490
Industry Canada (IC)	2268C-AC4490	2268C-AC44901000

PIN DEFINITIONS

The AC4790 has a simple interface that allows OEM Host communications with the transceiver. The table below 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 AC4790-1x1 and AC4790-1000 transceivers which have 3.3V inputs). All inputs are weakly pulled High and may be left floating during normal operation (with the exceptions listed for the AC4790-1x1).

Table 1 - Pin Definitions

Module Pin	1x1 Pin	Type	Signal Name	Function
1	4	O	GO0	Session status if Protocol Status is enabled. Otherwise, generic output.
2	6	O	TXD	Transmitted data out of the transceiver
		I/O	RS485 A (True)[1]	Non-inverted RS-485 representation of serial data
3	7	I	RXD	Data input to the transceiver
		I/O	RS485 B (Invert) [1]	Mirror image of RS-485 A
4	5[2]		GI0	Generic Input pin
5	3	GND	GND	Signal Ground
6		O	Do Not Connect	Has internal connection, for **AeroComm use only.**
7	9	O	$\overline{\text{CTS}}$	Clear to Send – Active Low when the transceiver is ready to accept data for transmission.
8	10[2]	I	$\overline{\text{RTS}}$	Request to Send – When enabled in EEPROM, the OEM Host can take this High when it is not ready to accept data from the transceiver. NOTE: Keeping RTS High for too long can cause data loss.
9	19	O	GO1	Received Acknowledge status pin if Protocol Status is enabled. Otherwise, generic output.
10	2	PWR	VCC1	AC4790-1x1: 3.3V, ±50mV ripple AC4790-200: 3.3 – 5.5V, ±50mV ripple (**Pin 10 is internally connected to Pin 11)** AC4790-1000: 3.3 – 5.5V, ±50mV ripple
11	11	PWR	VCC2	AC4790-1x1: 3.3V, ±50mV ripple AC4790-200: 3.3 – 5.5V, ±50mV ripple (**Pin 11 is internally connected to Pin 10)** AC4790-1000: 3.3V ±3%, ±100mV ripple
12	23	I	$\overline{\text{Test}}$	Test Mode – When pulled logic Low and then applying power or resetting, the transceiver's serial interface is forced to a 9600, 8-N-1 rate. To exit, the transceiver must be reset or power-cycled with Test Mode logic High.
13	12	O	RSSI	Received Signal Strength - An analog output giving an instantaneous indication of received signal strength. Only valid while in Receive Mode.
14	21[2]	I	GI1	Generic Input pin
15	16	I	UP_RESET	RESET – Controlled by the AC4790 for power-on reset if left unconnected. After a stable power-on reset, a logic High pulse will reset the transceiver.
16	13	GND	GND	Signal Ground
17	17	I	$\overline{\text{Command/Data}}$	When logic Low, the transceiver interprets OEM Host data as command data. When logic High, the transceiver interprets OEM Host data as transmit data.
18	15[3]	I	AD In	10 bit Analog Data Input
19	1,8,20, 24-28	N/C	Do Not Connect	Has internal connection, for **AeroComm use only.**
20	18	O	$\overline{\text{Session Status}}$	When logic Low, the transceiver is in Session
N/A	14	RF	RF Port	RF Interface
N/A	22	I	Reset	Active Low version of UP_RESET. If RESET is used, UP_RESET should be left floating and if UP_RESET is used, RESET should be left floating.

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

[1] When ordered with a RS-485 interface (not available on the AC4790-1x1).
[2] Must be tied to VCC or GND if not used. Should never be permitted to float.
[3] If used, requires a shunt 0.1µF capacitor at pin 15 followed by a series 1kΩ resistor.

ELECTRICAL SPECIFICATIONS

Table 2 - Input Voltage Characteristics (AC4790-1000 & AC4790-1x1)

Signal Name	AC47901x1 / AC4790-1000M				AC4790-200X				Unit
	High Min.	High Max.	Low Min.	Low Max.	High Min.	High Max.	Low Min.	Low Max.	
RS485A/B	N/A	12	-7	N/A	N/A	12	-7	N/A	V
RXD	2.31	3.3	0	0.99	2	5.5	0	0.8	V
GI0	2.31	3.3	0	0.99	2	5.5	0	0.8	V
$\overline{\text{RTS}}$	2.31	3.3	0	0.99	2	5.5	0	0.8	V
$\overline{\text{Test}}$	2.31	3.3	0	0.99	2	5.5	0	0.8	V
GI1	2.31	3.3	0	0.99	2	5.5	0	0.8	V
UP_RESET	0.8	3.3	0	0.6	0.8	5	0	0.6	V
$\overline{\text{Command/Data}}$	2.31	3.3	0	0.99	2	5.5	0	0.8	V
AD In	N/A	3.3	0	N/A	N/A	3.3	0	N/A	V

Table 3 - Output Voltage Characteristics (All)

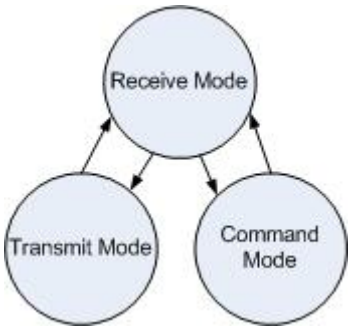
Signal Name	Module Pin	1x1 Pin	Type	High Min.	Low Max.	Unit
GO0	1	19	O	2.5 @ 8mA	0.4 @ 8mA	V
TXD	2	6	O	2.5 @ 2mA	0.4 @ 2mA	V
RS485A/B	2,3	N/A	I/O	3.3 @ 1/8 Unit Load	N/A	V
$\overline{\text{CTS}}$	7	9	O	2.5 @ 2mA	0.4 @ 2mA	V
GO1	9	19	O	2.5 @ 2mA	0.4 @ 2mA	V
RSSI	13	12	O	See Figure 1	See Figure 1	V
$\overline{\text{Session Status}}$	20	18	O	2.5 @ 2mA	0.4 @ 2mA	V

Theory of Operation

MASTERLESS ARCHITECTURE

The Masterless architecture is a true peer-to-peer architecture, where any module that has data to transmit will initiate a communication Session with a transceiver(s) within its range, transmit data and exit the Session. This architecture eliminates the need for a master which dictates data flow control, hence reducing additional system overhead and greatly improving efficiency.

Modes of Operation



The AC4790 has three different operating modes: Transmit Mode, Receive Mode and Command mode. When not in Transmit or Command Mode the radio will be in Receive Mode ready to receive data and awaiting a sync pulse from another transceiver. A transceiver will enter either Transmit or Command Mode when its OEM Host sends data over the serial interface. The state of the Command/Data pin (Pin 17) or the data contents determine which of the two modes will be entered.

Figure 1 - Modes of Operation

Transmit Mode

Any radio with data to transmit initiates a Session with other radios by transmitting a 25ms Sync Pulse. Once a Session is established the radio enters Transmit Mode and transmits the data during the remaining 25 ms of the current hop; remaining in Transmit Mode its' Session Count expires. When transmitting an Addressed packet the Session Count is defined by Session Count Refresh (EEPROM address 0xC4) + number of Transmit Retries (EEPROM address 0x4C). When transmitting a Broadcast packet Session Count is defined by Session Count Refresh (EEPROM address 0xC4) + Broadcast Attempts (EEPROM address 0x4D). Once the radio exits the Session it returns to Receive Mode.

Addressed Packets: The RF packet is sent out to the receiver designated by the **Destination Address**. **Transmit Retries** are 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 return an RF Acknowledge. 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.

Broadcast Packets: The RF packet is broadcast out to all eligible receivers on the network. **Broadcast Attempts** are 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. If API or hardware acknowledgement is enabled, a broadcast packet will always report success.

Receive Mode

If the transceiver detects a sync pulse while in Receive Mode, it will join the Session and start receiving data. While in Receive Mode, subsequent data/RF Acknowledge of up to 128 bytes can be received every hop.

When a transceiver is in Session, its' Session Count is decremented by one every hop. When the Session Count reaches zero, the transceiver exits the Session. In order to continue receiving data, the transceivers update their Session Count every time data/RF Acknowledge is received. The SLock0 and SLock1 EEPROM parameter settings control Session Count as shown in the Session Count Truth Table below.

Table 4 - Session Count Truth Table

Case	SLock0	SLock1	Transceiver receiving an addressed packet	Transceiver receiving a broadcast packet
1	0	0	Radio loads its Current Session Count with its Session Count Refresh.	Radio loads its Current Session Count with its Session Count Refresh
2	0	1	Radio loads its Current Session Count with (its Transmit Retries + its Session Count Refresh)	Radio loads its Current Session Count with (its Broadcast attempts + its Session Count Refresh)
3*	1	0	Radio loads its Current Session Count with the remote radio's Session Count	Radio loads its Current Session Count with the remote radio's Session Count
4	1	1	Radio loads its Current Session Count with the remote radio's Current Session Count	Radio loads its Current Session Count with the remote radio's Current Session Count

*** EEPROM Default**

Note 1: For both Broadcast/Addressed packets, the Session Count for Full Duplex is 2x the value of Session Count in Half Duplex.

Note 2: It is best to have all the transceivers with the same Session Count Refresh (EEPROM address C4h) value. Session Count Refresh must not be set to 0h.

Help Me Decide:

Case 1: In this case, a radio loads its Session Count with its Session Count Refresh. This is suitable for Half Duplex communication where immediate response is not received from the remote radio.

Case 2: In this case, a radio loads its Session Count with (its Session Count Refresh + its Transmit Retries). This case is suitable for applications where there are high levels of interference and it is likely that transmit retries will be necessary to maintain reliable communications.

When an addressed packet or a response to a broadcast packet is sent, the sending radio will listen for a successful acknowledgement. If an acknowledgement is not sent, the radio will resend the packet until either an acknowledgement is received or it has exhausted all available transmit retries. If two radios are on the last hop of the current session and a retry is required, it is possible that once the current session has ended the receiving radio could go into session with a different radio and miss the final packet of the previous session. Adding the radios Transmit retries to its Current Session Count will ensure that the radio does not exit the session when the remote radio is using a Transmit Retry.

Case 3: In this case a radio loads its Session Count with the remote radio's Session Count. This is suitable for full duplex applications as the Session is extended as long as there is communication.

Note: This is the default case with which the radio ships and works well for almost all applications.

Case 4: In this case, a radio loads its Session Count with the remote radio's current Session Count. This is suitable for daisy chain applications and large networks in which radios cannot stay in session longer than needed.

Command Mode

A radio will enter Command Mode when data is received over the serial interface from the OEM Host and either the Command/Data pin (pin 17) is logic Low or the received data contains the "AT+++" (Enter AT Command Mode) command. Once in Command Mode, all data received by the radio is interpreted as command data. Command Data can be either EEPROM Configuration or On-The-Fly commands.

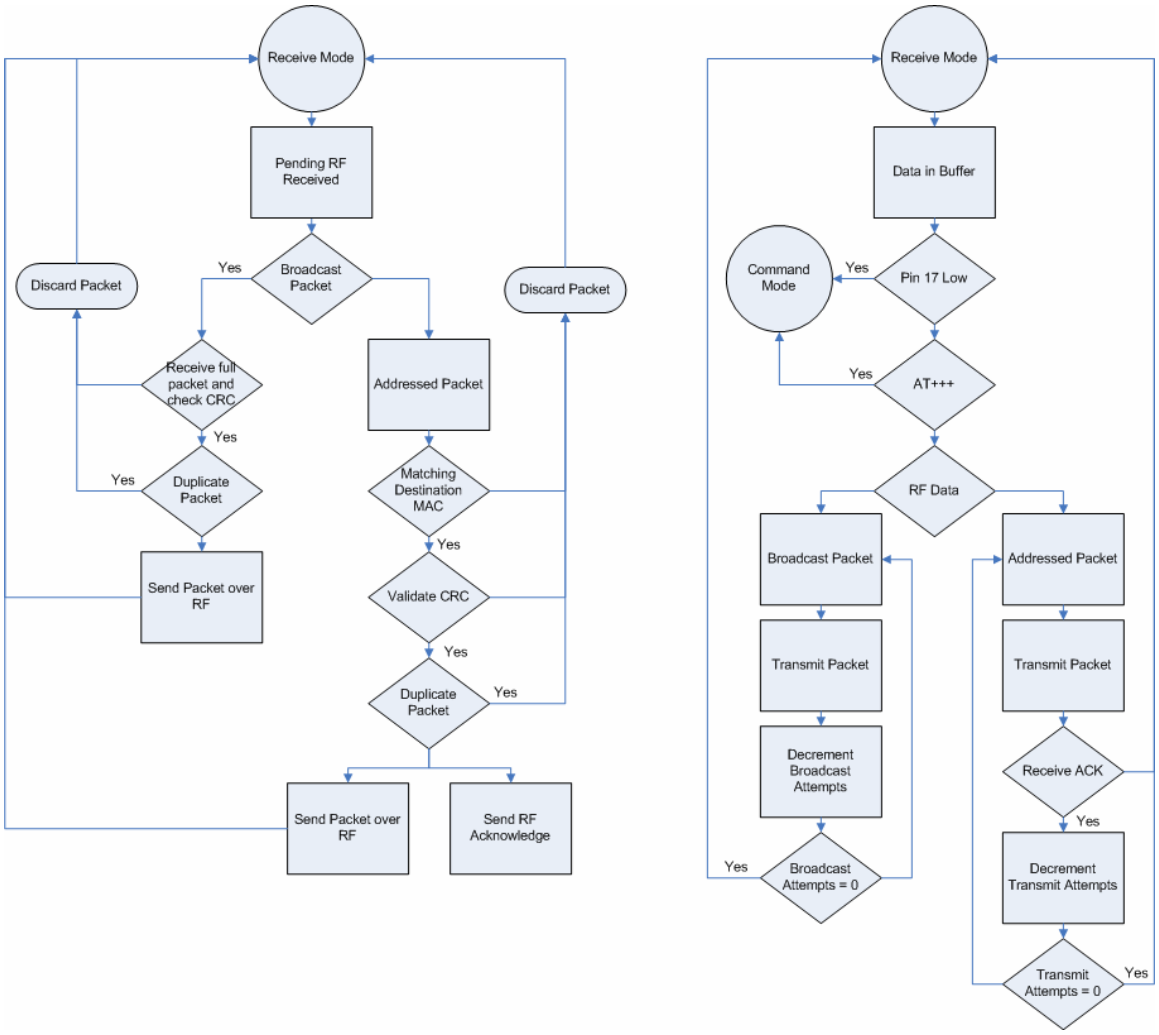


Figure 2 - Pending RF & Data in Buffer Flow

API Control

API Control is a powerful feature that the Masterless Protocol offers. When enabled, the API Transmit Packet, API Send Data Complete and API Receive Packet features provide dynamic packet routing and packet accounting ability to the OEM Host,

thereby eliminating the need for extensive programming on the OEM Host side. This ability of the protocol makes it ideal for any legacy system.

API Transmit Packet

API Transmit Packet is enabled when bit-1 of the **API Control** byte is enabled. The OEM Host should use the following format to transmit a packet over the RF.

0x81	Payload Data Length (0x01- 0x80)	Session Count Refresh	Transmit Retries/Broadcast Attempts	Destination MAC (2,1,0)	Payload Data

1) If the OEM Host does not encode the header correctly, the transceiver will send the entire string (up to 0x80 bytes) and will look for the header in the next data.
2) Although the 7 bytes of overhead are not sent over the RF, they are kept in the buffer until the packet is sent. Keep this in mind so as to not overrun the 256-byte buffer.
3) Setting MAC to FFh FFh FFh will broadcast the packets to all available transceivers.

API Send Data Complete

API Send Data Complete is enabled when bit-2 of the **API Control** byte is enabled. The transceiver sends the OEM Host the following data upon receiving an RF Acknowledge from the remote transceiver or exhausting all attempts.

0x82	RSSI	RSSI *	0x00: Failure 0x01: Success

1) The RSSI is how strong the remote transceiver heard the local transceiver, RSSI* is how strong the local transceiver heard the remote transceiver.
2) Successful RF Acknowledge updates the Success/Failure bit.
3) When the transceiver is transmitting Broadcast Packets it will always return success after exhausting all Broadcast Attempts.
4) API Send Data Complete can be used as a software send data complete indicator
5) The transceiver could receive a failure even though the packet was received as it could have missed the RF Acknowledge from the remote transceiver.

API Receive Packet

API Receive Packet is enabled when bit-0 of the **API Control** byte is enabled. Upon receiving a packet the radio sends its OEM Host the packet in the following format.

0x81	Payload Data Length	RSSI	RSSI*	Source MAC (2,1,0)	Payload Data

The RSSI is how strong the remote transceiver heard the local transceiver, RSSI* is how strong the local transceiver heard the remote transceiver.



Quick Tip:

Note: When both API Send Data Complete and API Receive Packet on the API Control are enabled, Send Data Complete will be received before the transceiver gets an API Receive Packet. This order may get reversed when the API Send Data Complete is missed and is being resent after the API Receive Packet is received.

Serial Interface

In order for an OEM Host and a transceiver to communicate over the serial interface they need to have the same serial data rate. Refer to the following sections to ensure OEM Host Data Rate matches the Serial Interface Baud Rate.

OEM Host Data Rate

The OEM Host Data Rate is the rate with which the OEM Host and transceiver communicate over the serial interface. This rate is independent of the RF baud rate, which is fixed at 76.8 kbps. Possible values range from 1200 bps to 115,200 bps. **Note: Enabling Parity cuts throughput in half and the Interface Buffer size in half.** The following asynchronous serial data formats are supported:

Data bits	Parity	Stop bits	Transceiver Programming Requirements
8	N	1	Parity disabled
7	N	2	Parity disabled
7	E, O, M, S	1	Parity disabled
9	N	1	Parity enabled
8	N	2	Parity enabled
8	E, O, M, S	1	Parity enabled
7	E, O, M, S	2	Parity enabled
Mark (M) corresponds to 1 and Space (S) corresponds to 0			

Table 5 - Supported Serial Formats

Serial Interface Baud Rate

This two-byte value determines the baud rate used for communicating over the serial interface to a transceiver. **Table 6 - Baud Rate/Interface 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 Test pin (Pin 12) is pulled logic Low at reset, the baud rate will be forced to 9,600.** The RF baud rate is fixed at 76.8 Kbps and is independent of the interface baud rate. For Baud Rate values other than those shown in **Table 6** the following equation can be used:

$$\text{Baud} = 0x100 - \frac{14.7456E^6}{64 \times \text{Desired baud}} \qquad (1)$$

Baud H = Always 0

Baud L = Low 8 Bits of BAUD (base 16)

Table 6 - Baud Rate/Interface Timeout

Baud Rate	BaudL (0x42)	BaudH (0x43)	Minimum Interface Timeout (0x58)	Stop bit Delay (0x3F)
115,200	0xFE	0x00	0x02	0xFF
57,600[1]	0xFC	0x00	0x02	0x03
38,400	0xFA	0x00	0x02	0x08
28,800	0xF8	0x00	0x02	0x0E
19,200	0xF4	0x00	0x03	0x19
14,400	0xF0	0x00	0x04	0x23
9,600	0xE8	0x00	0x05	0x39
4800	0xD0	0x00	0x09	0x7A
2400	0xA0	0x00	0x11	0x FC
1200	0x40	0x00	0x21	0x00[2]

[1] 57,600 is the default baud rate.

[2] 0x00 will yield a stop bit of 421uS. The stop bit at 1200 baud should be actually 833us.

Flow Control

Flow control refers to the control of data flow between transceivers. It is the method used to handle data in the transmit/receive buffer and determines how data flow between the transceivers is started and stopped. Often, one transceiver is capable of sending data much faster than the other can receive and Flow control allows the slower device to tell the faster device when to pause and resume data transmission.

When a transceiver has data to send, it sends a **R**eady **T**o **S**end signal and waits for a **C**lear **T**o **S**end response from the receiving unit. If the receiving radio is ready to accept data it will assert its CTS low. These signals are sent apart from the data itself on separate wires.

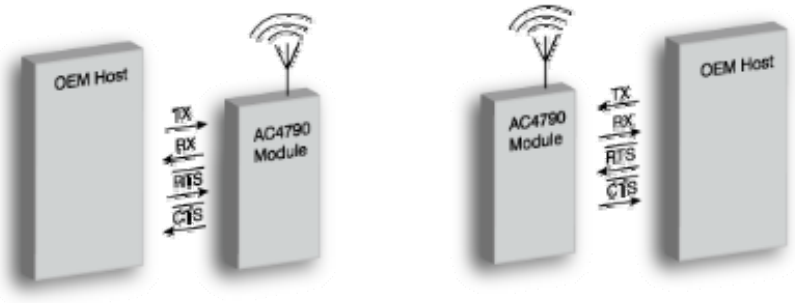


Figure 3 - Hardware Flow Control

Quick Tip:

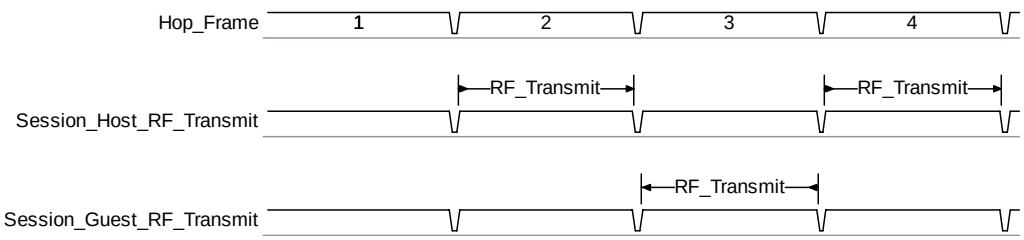
CAN I IMPLEMENT A DESIGN USING JUST TXD, RXD AND GND (THREE-WIRE INTERFACE)?

Yes. However, it is strongly recommended that your hardware monitor the CTS pin of the radio. CTS is taken High by the radio when its interface buffer is getting full. Your hardware should stop sending at this point to avoid a buffer overrun (and subsequent loss of data).

You can perform a successful design without monitoring CTS. However, you need to take into account the amount of latency the radio adds to the system, any additional latency caused by Transmit Retries or Broadcast Attempts, how often you send data, non-delivery network timeouts and interface data rate. Polled type networks, where the Server host requests data from the Client host and the Client host responds, are good candidates for avoiding the use of CTS. This is because no one transceiver can monopolize the RF link. Asynchronous type networks, where any radio can send to another radio at any point in time, are much more difficult to implement without the use of CTS.

HALF DUPLEX / FULL DUPLEX

When Half Duplex communication is chosen, the AC4790 will send a packet out over the RF whenever it can. This can cause packets sent by multiple transceivers at the same time to collide with each other over the RF. To prevent this, Full Duplex communication can be chosen. Full Duplex shares the bandwidth intelligently to enable two-way collision-free communication by calculating the amount of time until the next hop to ensure that it has time to send the packet. If there is enough time, it will send the packet: if not, it will wait until its next appropriate hop. The radio which initiates the session transmits during the even hops while the remaining radio(s) will transmit during the odd hops. Although the RF hardware is still technically half duplex, the bandwidth sharing makes the transceiver seem full duplex. Enabling Full Duplex can cause overall throughputs to be cut in half.



Note: All transceivers on the same network must have the same setting for Full Duplex.

INTERFACE TIMEOUT/RF PACKET SIZE

Interface Timeout (EEPROM address 0x58), in conjunction with **RF Packet Size** (EEPROM address 0x5B), 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 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 0.5ms increments and has a tolerance of ±0.5ms. The default value for Interface Timeout is **0x04 (2ms).**

RF Packet Size – When the number of bytes in the transceiver transmit buffer equals RF Packet Size, those bytes are sent out as a complete RF packet. It is much more efficient to send a few large packets rather than many short packets as each packet sent over the RF contains extra header bytes which are not included in the RF Packet Size. RF packet size can be set to a maximum of **0x80**.

SYSTEM TIMING AND LATENCY

Care should be taken when selecting transceiver architecture, as it can have serious effects on data rates, latency, 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.

Quick Tip:

IN HIGH-DENSITY APPLICATIONS, WHAT AMOUNT OF LATENCY SHOULD BE EXPECTED?

It is not easy to predict the exact amount of latency in high-density applications. There are many variables that affect system latency. The three variables that most affect the latency are the network load, the distance between transceivers, and whether the transceivers are operating in a broadcast or addressed mode. There is no fixed answer as to how much latency will be introduced in the system when considering high-density applications. In these cases we can just offer qualitative analysis of the latency in high-density applications. As the network load increases, then the number of collisions that will occur increases. As the number of collisions increase, then the system latency increases. As the distance between the transceivers increases, so to does the system latency. Finally, when transceivers operate in addressed mode they will retry sending a packet up to the number of time specified in the transmit retry parameter specified in the EEPROM. As the number of retries increases, the system latency will increase also.

MAXIMUM OVERALL SYSTEM THROUGHPUT

When operating as shown in the Table 7, an AC4790 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 the specified throughput.

RF Status	Half Duplex Throughput (bps)	Full Duplex Throughput (bps) each way
Radio not in continuous Session	25k	12.5k
Radio continuously in Session	45k	22.5k

Table 7 - Maximum Overall System Throughput

RANDOM BACK OFF

Random Back Off – The transceivers utilize a Carrier Sense Multiple Access (CSMA) protocol with random back off and a selectable back-off seed. Therefore, in the event of a collision, the transceiver will back off and retry the packet. Specifically, when two transceivers detect a collision, each transceiver will choose a random number of packet times that it will wait before retrying the packet. This random number is selected from a pool of numbers defined by the back-off seed and consists of a number between 1 and 2, 1 and 4, 1 and 8, 1 and 16, 1 and 32, 1 and 64, 1 and 128 and 1 and 256. In a very dense network, where more than two transceivers could experience a collision, it is important to have a higher random back-off seed.

Quick Tip:

WHAT EFFECTS WILL RANDOM BACK OFF HAVE ON SYSTEM LATENCY?

As the Random Back Off value increases, the overall latency also increases.

- Worst Case Latency (Half Duplex) = 50 ms Hop * Number of Retries * Maximum Random Value
- Worst Case Latency (Full Duplex) = 100 ms Hop * Number of Retries * Maximum Random Value

SYSTEM ID/RF CHANNEL NUMBER

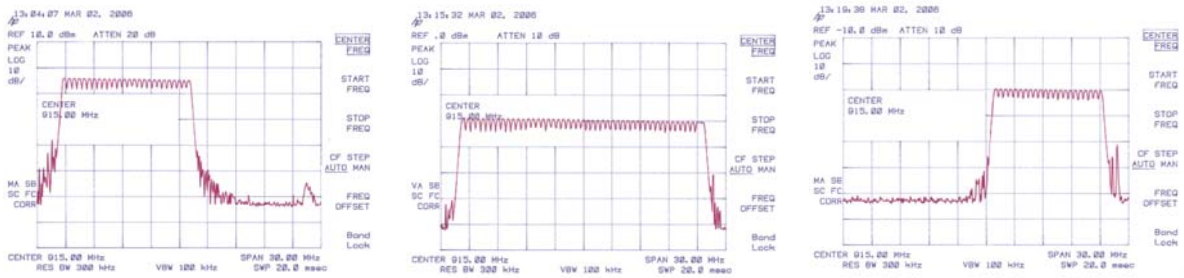
System ID – System ID (EEPROM address 0x76) is similar to a password character or network number and makes network eavesdropping more difficult. A transceiver will not establish a Session or communicate with another transceiver on a different System ID or Channel Number.

RF Channel Number – Channels 0x00-0x0F and 0x30-0x37 only use 26 hops. Channels 0x10 – 0x2F use 50 hops. Other than that Channel Number (EEPROM address 0x40) can be considered as another byte of System ID.

**All channels in a channel set hop on the same frequencies only in a different order.

Table 8 - RF Channel Number Settings

Channel Set	RF Channel Number Range (0x40)	Frequency Details and Regulatory Requirements	Countries
0 (AC4790-1x1, AC4790-200)	0x00 – 0x0F	902 – 928MHz (26 hop bins)	US/Canada
1 (AC4790-1x1, AC4790-1000)	0x10 – 0x2F	902 – 928MHz (50 hop bins)	US/Canada
2 (AC4790-1x1, AC4790-200, AC4790-1000)	0x30 – 0x37	915 – 928 MHz (22 Hop Bins)	US/Canada (-1x1/-200) Australia (-1x1/-200/-1000)



RF Channels 0x00-0x0F | RF Channels 0x10-0x2F | RF Channels 0x30-0x37

Figure 4 - RF Channel Numbers

DES (Data Encryption Standard) – Encryption is the process of encoding an information bit stream to secure the data content. The DES algorithm is a common, simple and well-established encryption routine. An encryption key of 56 bits is used to encrypt the packet. The receiver must use the exact same key to decrypt the packet; otherwise garbled data will be produced.

To enable DES, EEPROM Byte 0x45, bit 6 must be set to a value of 1. To disable DES, set bit 6 to a value of 0. The 7 byte (56 bits) Encryption/Decryption Key is located in EEPROM Bytes 0xD0 – 0xD6. **It is highly recommended that this Key be changed from the default.**

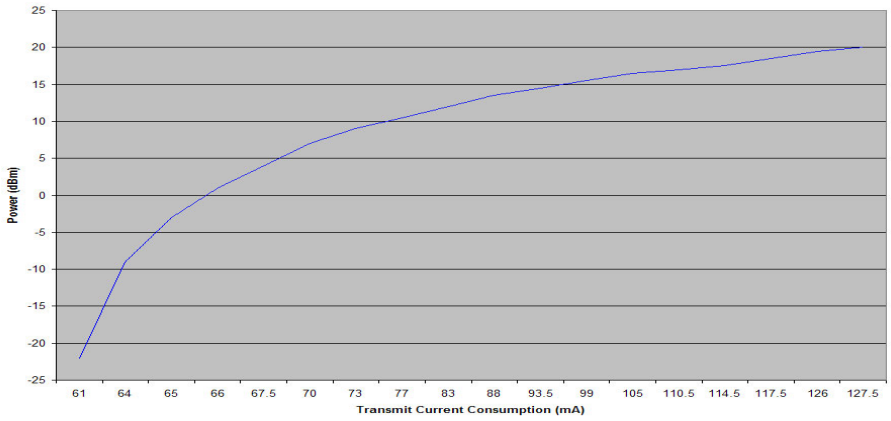
MAX POWER

Max Power provides a means for controlling the RF output power of the AC4790. Output power and current consumption can vary by as much as ±10% per transceiver for a particular Max Power setting. Contact AeroComm for assistance in adjusting Max Power. The following graphs show current consumption versus output power. Output power can be represented in dBm (decibels per meter) and mW (milliwatts). The equations for converting between the two are shown below in Equations 2 & 3:

$$\text{Power (dBm)} = 10\log_{10} \text{Power (mW)} \quad (2)$$

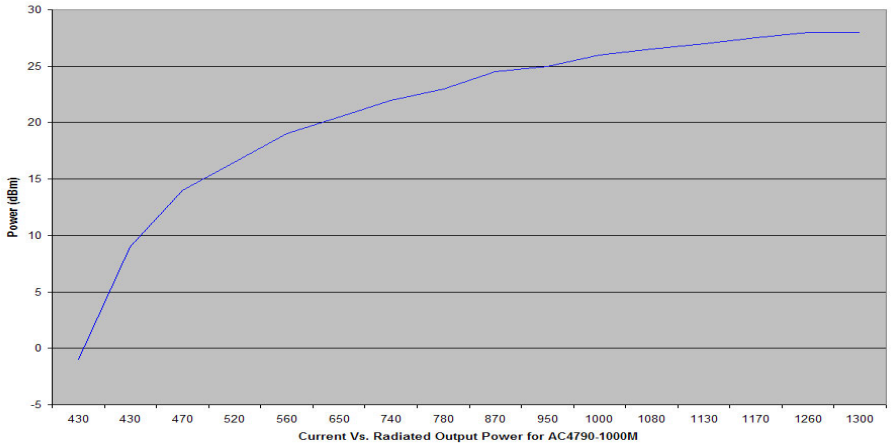
$$\text{Power (mW)} = 10^{(\text{Power(dBm)}/10)} \quad (3)$$

Figure 5 - Current vs. Output Power for AC4790-200



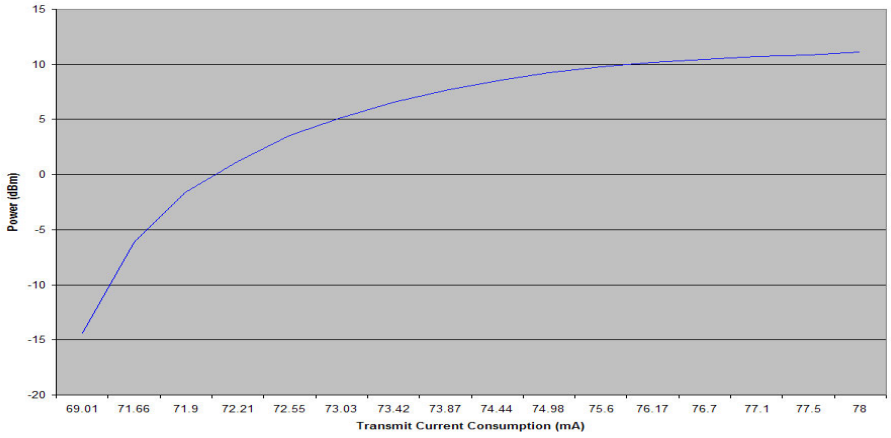
Output Power (mW)	Current (mA)	EEPROM Setting
100	127.5	0x60
90	125	0x 1E
70	117.5	0x 0F
50	110.5	0x 0D
28	93.5	0x 0A
15.75	83	0x 08
5	70	0x 05
0.5	65	0x 02

Figure 6 - Current vs. Output Power for AC4790-1000



Output Power (mW)	Current (mA)	EEPROM Setting
743	1300	0x 0F
743	1300	0x 50
562	1170	0x 0D
500	1130	0x 0C
398	1000	0x 0A
316	950	0x 09
112	650	0x 05
45	520	0x 03
7.94	430	0x 01

Figure 7 - Current vs. Output Power for AC4790-1x1



Output Power (mW)	Current (mA)	EEPROM Setting
13	79	0x 60
12.75	78	0x 50
7.15	74.5	0x 08
5.82	73.87	0x 07
4.52	73.42	0x 06
3.29	73.03	0x 05
1.33	72.2	0x 03

Quick Tip:

The max power is set during Production and may vary slightly from one transceiver to another. The output power and current draws shown above can vary by as much as ±10% from the values listed.

The max power can be set as low as needed, however it should never be set higher than the original factory default setting.

Hardware Interface

Below is a description of all hardware pins used to control the AC4790.

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 serve as generic input pins. When Protocol Status (byte C2h of EEPROM) is disabled, GO0 & GO1 serve as generic outputs. When Protocol Status is enabled, pins GO0 and GO1 serve as the Session Status and Receive Acknowledge Status pins, respectively. Reading and writing of these pins can be performed using CC Commands (details can be found in the ***On-the-Fly Control Command Reference***).

Hardware Protocol Status
When the GO0 pin is configured as the Session Status pin, GO0 is normally Low. GO0 will go High when a Session is initiated and remain High until the end of the Session. When the GO1 pin is configured as the Receive Acknowledge Status pin, GO1 is normally Low and will go High upon receiving a valid RF Acknowledgement and remain High until the end (rising edge) of the next hop.

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

Serial TTL
The AC4790-200 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, at 3.3V levels, to the OEM Host via the TXD pin. **The AC4790-1000 transceiver ONLY accepts 3.3V level signals.**

RS-485
When equipped with an onboard RS-485 interface chip, TXD and RXD become the half duplex RS-485 pins. The transceiver interface will be in Receive Mode except when it has data to send to the OEM Host. TXD is the non-inverted representation of the data (RS485A) and RXD is a mirror image of TXD (RS485B). The transceiver will still use RTS (if enabled).

$\overline{\text{CTS}}$ Handshaking (pin 7)

The AC4790 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 loss will occur. The transceiver prevents this loss by asserting CTS High as the buffer fills up and taking CTS Low as the buffer is emptied. **CTS On** and **CTS Off** control the operation of CTS. CTS On specifies the amount of bytes that must be in the buffer for CTS to be disabled (logic 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 Off.

Note: The **CTS On/Off** bytes of the EEPROM can be set to 1, in which case CTS will go high as data is sent in and low when buffer is empty.

$\overline{\text{RTS}}$ Handshaking (pin 8)

With **RTS** disabled, the transceiver will send any received data to the OEM Host as soon as it is received. However, some OEM Hosts are not able to accept data from the transceiver all of the time. With RTS enabled, the OEM Host can prevent the transceiver from sending it data 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 256 byte receive buffer fills up.

$\overline{\text{Test}}$ (pin 12)

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). To exit, the transceiver must be reset or power-cycled with Test pin logic High.

Quick Tip:

This pin is used to recover transceivers from unknown baud rates only and should not be used during normal operation. If the desired baud rate is 9600, the transceiver's Serial Interface Baud Rate should be programmed to 9600 baud.

RSSI (pin 13)

Instantaneous RSSI

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

1) Power up only one transceiver in the coverage area.

2) Measure the RSSI signal to obtain the minimum value with no other signal present.

3) Power up another transceiver and begin sending data from that transceiver to the transceiver being measured. Make sure the two transceivers are separated by approximately ten feet.

4) Measure the peak RSSI, while the transceiver is in Session, to obtain a maximum value at full signal strength.

Validated RSSI

As RSSI is only valid when the local transceiver is receiving an RF packet from a remote transceiver, instantaneous RSSI can be very tricky to use. Therefore, the transceiver stores the most recent valid RSSI value. The OEM Host issues the ***Report Last Good RSSI*** command to request that value (details can be found in the ***On-the-Fly Control Command Reference***). Additionally, validated RSSI can be obtained from Receive Packet and Send Data Complete API commands and from the Probe command. Validated RSSI is not available at the RSSI pin. The following equation approximates the RSSI curve:

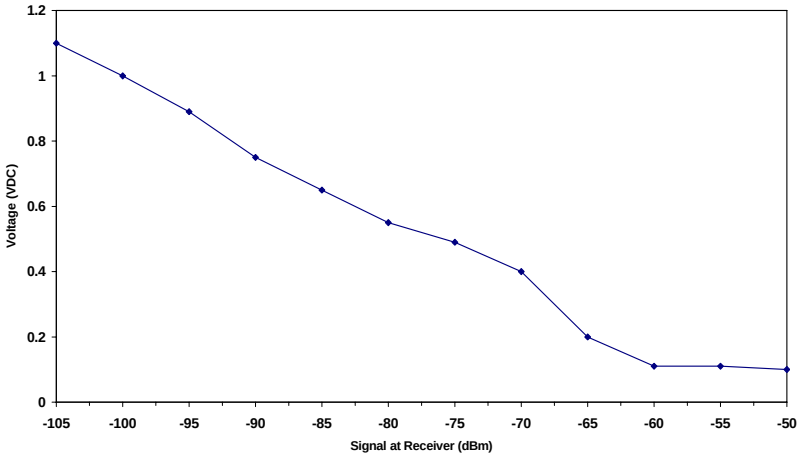


Figure 8 - RSSI Voltage vs. Received Signal Strength

$$\text{Signal Strength (dBm)} = \left(-46.9 * V_{RSSI}\right) - 53.9 \quad (4)$$

UP_Reset (pin 15)

UP_Reset provides a direct connection to the reset pin on the AC4790 microprocessor and is used to force a soft reset. For a valid reset, reset must be asserted High for a minimum of 10ms.

$\overline{\text{Command}}$/Data (pin 17)

When logic High, the transceiver interprets incoming OEM Host data as transmit data to be sent to other transceivers and their OEM Hosts. When logic Low, the transceiver interprets OEM Host data as command data.

AD In (pin 18)

AD In can be used as a cost savings to replace Analog-to-Digital converter hardware. Reading of this pin can be performed locally using the Read ADC command found in the ***On-the-Fly Control Command Reference***.

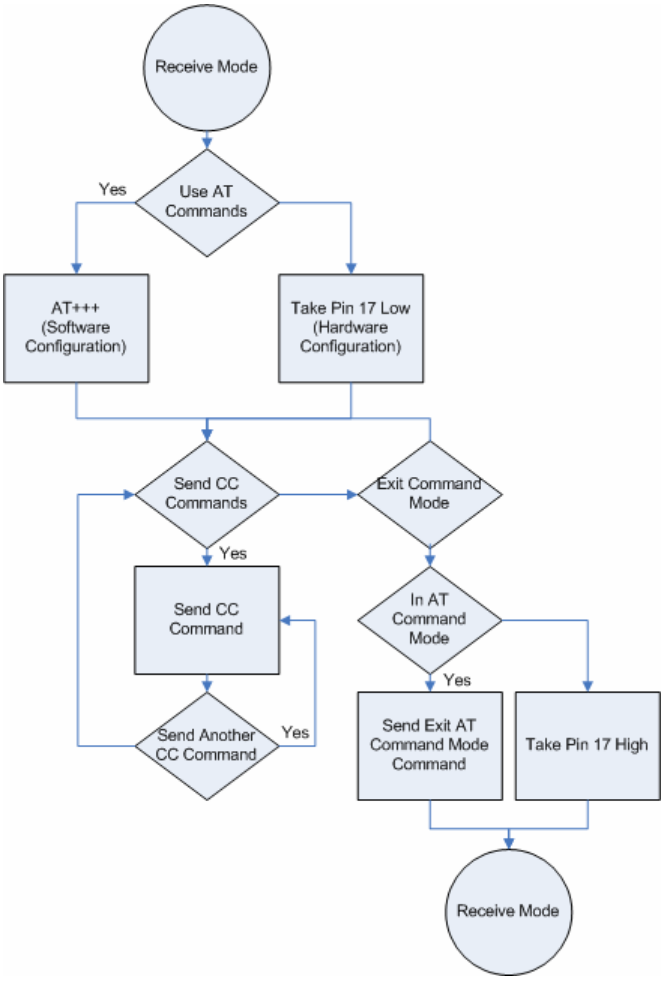
$\overline{\text{Session Status}}$ (pin 20)

Reports logic Low during a Session and logic High when not in Session. The inverse of this pin can be obtained from pin GO0 when Protocol Status is enabled.

Configuring the AC4790

The AC4790 can be configured using the CC Configuration Commands. The CC Commands can be issued using either Hardware or Software Configuration. To use Hardware Configuration, pin 17 of a transceiver must be asserted Low. Software Configuration can be used by entering AT Command Mode before issuing the CC Commands.

Figure 9 - Configuration Flow of the 4790[6]



AC4790 AT COMMANDS

The AT Command mode implemented in the AC4790 creates a virtual version of the Command/Data pin. The "Enter AT Command Mode" Command asserts this virtual pin Low (to signify Command Mode) and the "Exit AT Command Mode" Command asserts this virtual pin High (to signify Data). Once this pin has been asserted Low, all On-the-Fly CC Commands documented in the manual are supported.

When in AT Command Mode, the user cannot send or receive RF packets. However, an ambiguity of approximately 10ms exists where, if the "Enter AT Command Mode" Command has been sent to the transceiver at the same time an RF packet is being received, the RF packet could be sent to the OEM Host before the "Enter AT Command Mode" Command response is sent to the OEM Host.

Enter AT Command Mode

Prior to sending the "Enter AT Command Mode" Command to the transceiver, the OEM Host must ensure that the RF transmit buffer of the transceiver is empty (if the buffer is not empty, the "Enter AT Command Mode" Command will be interpreted as packet data and transmitted out over the RF). This can be accomplished by waiting up to one second between the last transmit packet and the AT Command. The Enter AT Command mode command is as follows:

Command: 0x41 0x54 0x2B 0x2B 0x2B 0x0D
Number of Bytes Returned: 4
Response: 0xCC 0x43 0x4F 0x4D



Quick Tip:

In order to send the Enter AT Command Mode command, the RF Packet Size must be set to a minimum of six.

Exit AT Command Mode

To exit AT Command Mode, the OEM Host should send the following command:

Command: 0xCC 0x41 0x54 0x4F 0x0D
Number of Bytes returned: 4
Response: 0xCC 0x44 0x41 0x54

ON-THE-FLY CONTROL COMMANDS (CC COMMAND MODE)

The AC4790 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. While in CC Command mode using pin 17 (Command/Data), the RF interface of the transceiver is still active. Therefore, it can receive packets from remote transceivers while in CC Command mode and forward these to the OEM Host.

While in CC Command mode using AT Commands, the RF interface of the transceiver is active, but packets sent from other transceivers will not be received. The transceiver uses Interface Timeout/RF Packet Size to determine when a CC Command is complete. Therefore, there should be no delay between each character as it is sent from the OEM Host to the transceiver or the transceiver will not recognize the command. If the OEM Host has sent a CC Command to the transceiver and an RF packet is received by the transceiver, the transceiver will send the CC Command response to the OEM Host before sending the packet. However, if an RF packet is received before the Interface Timeout expires on a CC Command, the transceiver will send the packet to the OEM Host before sending the CC Command response.

When an invalid command is sent, the radio scans the command to see if it has a valid command followed by bytes not associated with the command, in which case the radio discards the invalid bytes and accepts the command. In all other cases, the radio returns the first byte of the invalid command back to the user and discards the rest.

Command Quick Reference

Command Name	Command (All Bytes in Hex)						Return (All Bytes in Hex)					
AT Enter Command Mode	0x41	0x54	0x2B	0x2B	0x2B	0x0D	0xCC	0x43			0x4F	0x4D
Exit AT Command Mode	0xCC	0x41	0x54		0x4F	0x0D	0xCC	0x44			0x41	0x54
Firmware Version Request	0xCC	0x00	0x00		-		0xCC	Firmware Version			0x00 – 0x03 (Ignore this byte)	
Change Channel	0xCC	0x01	New Channel		-		0xCC	New Channel			-	-
Broadcast Packets	0xCC	0x08	0x00: Addressed 0x01: Broadcast		-		0xCC	0x00 or 0x01			-	-
Write Destination Address	0xCC	0x10	Byte 4 of destination's MAC		Byte 5	Byte 6	0xCC	Byte 4 of destination's MAC			Byte 5	Byte 6
Read Destination Address	0xCC	0x11	-		-		0xCC	Byte 4 of destination's MAC			Byte 5	Byte 6
Auto Destination	0xCC	0x15	bit -0: Auto Destination bit-4: Enable Auto Destination				0xCC	bit - 0: Auto Destination bits -1 – 7: 0				
Read API Control	0xCC	0x16	-				0xCC	API Control				
Write API Control	0xCC	0x17	API Control				0xCC	API Control				
Read Radio Table	0xCC	0x18	.				0xCC	# Of Transceivers in Table (max8)	Mac (2,1,0)	RSSI	RSSI*	Stale count
									Returned for all the radios in the Table			
Read Digital Inputs	0xCC	0x20	-		-		0xCC	bit - 0: GI0 bit - 1: GI1	-	-		
Read ADC	0xCC	0x21	0x01: AD In 0x02: Temp 0x03: RSSI		-		0xCC	MSB of 10 bit ADC	LSB of 10 bit ADC	-		
Write Digital Outputs	0xCC	0x23	bit - 0: GO0 bit -1: GO1		-		0xCC	bit - 0: GO0 bit - 1: GO1	-		-	
Set Max Power	0xCC	0x25	New Max Power		-		0xCC	Max Power	-		-	
Enter Probe	0xCC	0x8E	0x00: exit Probe 0x01: enter probe				0xCC	0x00: -Or- 0x01:				
Read Temperature	0xCC	0xA4	- -				0xCC	Temp (°C)	-			
EEPROM Byte Read	0xCC	0xC0	Starting Address		Length (0: 256)		0xC0	Starting Address	Length		Data at those addresses	
EEPROM Byte Write	0xCC	0xC1	Starting Address	Length (0x01 – 0x80)	Data bytes to be written		-	Starting Address	Length		Data written to last byte	
Soft Reset	0xCC	0xFF	-		-		-	-	-		-	

Firmware Revision Request

The OEM Host issues this command to request the firmware of the transceiver.

Command: 0xCC 0x00 0x00
Number of bytes returned: 3
Response: 0xCC Version XX
Parameter Range: XX = 0x00-0x03 (ignore this byte)

Change Channel

The OEM Host issues this command to change the channel of the transceiver.

Command: 0xCC 0x01 Channel
Number of bytes returned: 2
Response: 0xCC Channel

Broadcast Packets

The OEM Host issues this command to change the transceiver operation between Addressed Packets and Broadcast Packets. If Addressed Packets are selected, the transceiver will send all packets to the transceiver designated by the Destination Address programmed in the transceiver. If Broadcast Packets are selected, the transceiver will send its packets to all transceivers on that network. Setting bit-7 of API Control to 1 can also enable Broadcast Packets.

Command: 0xCC 0x08 Data1
Number of bytes returned: 2
Response: 0xCCh Data1
Parameter Range: Data1 = 00 for Addressed 01 for Broadcast



Quick Tip:

When bit-7 of the API Control is used to set the (Broadcast/Addressed) Packets of a transceiver, the radio must be reset before issuing this command. However, bit-7 can still be used to change the (Broadcast/Addressed) Packets if resetting the transceiver is not desired.

Write Destination Address

The OEM Host issues this command to the transceiver to change the Destination Address.

Note: Only the three Least Significant Bytes of the MAC Address are used for packet delivery.

Command: 0xCC 0x10 MAC3 MAC2 MAC1
Number of bytes returned: 4
Response: 0xCC MAC3 MAC2 MAC1
Parameter Range: 0x00 – 0xFF corresponding to 3 LSB's of destination MAC Address

Read Destination Address

The OEM Host issues this command to the transceiver to read the Destination Address.

Note: Only the three Least Significant Bytes of the MAC Address are used for packet delivery.

Command: 0xCC 0x11
Number of bytes returned: 4
Response: 0xCC MAC3 MAC2 MAC1
Parameter Range: 0x00 – 0xFF corresponding to 3 LSB's of destination MAC Address

Auto Destination

The Host issues this command to change the settings for Auto Destination. When issuing this command, the Auto Destination setting will only be changed if the corresponding enable bit is set (Control1 Parameter, EEPROM Address 56h, bit-4).

Command: 0xCC 0x15 Data1
Number of Bytes Returned:
Response: 0xCC Data2
Parameter Range: Data1 = Bit 0: Auto Destination Bit 4: Enable Auto Destination Modification Data2 = Bit 0: New Auto Destination Setting Bit 1: New Auto Channel Setting Bits 2 – 7: 0

Read API Control

The OEM Host issues this command to the transceiver to read the API Control byte.

Command: 0xCC 0x16
Number of bytes returned: 2
Response: 0xCC API Control

Write API Control

The OEM Host issues this command to the transceiver to write the API Control byte.

Command: 0xCC 0x17
Number of bytes returned: 2
Response: 0xCC API Control

Set Max Power

The OEM 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. The radios are shipped at maximum allowable power.

Command: 0xCC 0x25 New_Max_Power
Number of bytes returned: 2
Response: CCh New_Max_Power

Read Temperature

The OEM Host issues this command to read the onboard temperature sensor. The transceiver reports the temperature in °C where 0 – 80h corresponds to 0 – 80°C and where D8h – 0h corresponds to -40 – 0°C.

Command: 0xCC 0xA4
Number of bytes returned: 2
Response: 0xCC Temperature
Parameter Range: Temperature = 0xD8 – 0x80

Read Digital Inputs

The OEM Host issues this command to read the state of both digital input lines.

Command: 0xCC 0x20
Number of bytes returned: 2
Response: 0xCC Data1
Parameter Range: Data1 = bit-0 – GI0, bit-1– GI1, bits 2 – 7: 0

Read Radio Table

The OEM Host issues this command to read the Radio Table that resides on the transceiver. The Radio Table stores information for up to the last 8 transceivers that sent it a packet. This information is very useful for providing alternative data paths.

Command: 0xCC 0x18
Response: Byte 1 = 0xCC Byte 2 = # of transceivers in this table (0x00-0x08) Byte 3 = Mac (2,1,0) of transceiver #1 Byte 4 = RSSI Byte 5 = RSSI* Byte 6 = Stale Count of transceiver #1 Byte 7 = Mac (2,1,0) of transceiver #2 Byte 8 = RSSI Byte 9 = RSSI* Byte 9…n = Stale Count of transceiver #2…and so on.

Stale Count: The Stale Count Reload (0x4F) determines the amount of time a radio will stay active in the Radio Table. The Stale Count (min: 0x00, max: depends on the EEPROM Setting) for a radio is set to 0 when a packet is received; it then gets incremented by one every 100ms. When the Stale Count of a radio reaches the Stale Count Reload (0x4F) the radio is considered Stale. A Radio Table can hold up to a maximum of 8 radios' information; however if the Radio Table is full and 9th radio is received, the first radio that is Stale is replaced with the new radio. If none of the radios are stale, the oldest radio in the table is replaced with the new radio.

Signal Strength (dBm)	RSSI Value (hex)
4	0x0E
-2 to 1	0x0D
-12 to -6	0x0C
-36 to -22	0x0B
-42 to -39	0x0C
-46	0x0D
-49	0x0E
-52	0x11
-56	0x17
-59	0x1C
-62	0x2B
-66	0x40
-69	0x55
-72	0x62
-76	0x71
-79	0x78
-82	0x84
-86	0x9A
-89	0xAD
-92	0xBD

Quick Tip:

The RSSI is how strong the remote transceiver heard the local transceiver, RSSI* is how strong the local transceiver heard the remote transceiver. The table above can be used to convert the RSSI to the corresponding signal strength. One dBm is equal to approximately four steps.

Note: Notice the trend between 4dBm and -12dBm does not follow the curve. This is because RSSI

Read ADC

The OEM Host issues this command to read any of the three onboard 10 bit A/D converters. Because the RF is still active in on-the-fly Command Mode, the transceiver will not process the command until there is no activity on the network. Therefore, the Read RSSI command is useful for detecting interfering sources but will not report the RSSI seen from a remote transceiver on the network. The equations for converting these 10 bits into analog values are as follows:

Analog Voltage = (10 bits / 0x3FF) * 3.3V

Temperature (°C) = ((Analog Voltage - 0.3) / 0.01) – 30

RSSI Value (dBm) = -105 + (0.22 * (0x3FF – 10 bits))

Command: 0xCC 0x21 Data1
Number of bytes Returned: 3
Response: 0xCC Data2 Data3
Parameter Range: Data1 = 0x00 – AD In 0 x01 – Temperature 0x02 – RSSI Data2 = MSB of requested 10 bit ADC value Data3 = LSB of requested 10 bit ADC value

Write Digital Outputs

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

Note: This command should be used only when Protocol Status (0xC2) is not set to 0xE3.

Command: 0xCC 0x23 Data1
Number of bytes returned: 2
Response: 0xCC Data1
Parameter Range: Data1 = bit 0 – GO0, bit 1 – GO1

Probe

Enabling bit-6 of API Control will enable this command. When the OEM Host issues this command, the transceiver sends out a query every 500ms. The transceivers, which receive this query, will randomly choose a query to respond to. This helps prevent multiple transceivers from trying to respond to the same Probe at the same time. After responding to a Probe, the transceivers will wait for approximately 10sec before responding to any other probe.

Note: While executing the Probe command, the transceiver can perform normal RF communications.

Command: 0xCC 0x8E Data1
Number of bytes returned: 2
Response: 0xCC Data1
Parameter Range: Data1 = 0x00 – Disable Probe 0x01 – Enable Probe

Apart from the Transceiver response for the command, there are two other responses that return vital data to the OEM Hosts. This data is very useful to monitor the network and make decisions on rerouting data packets accordingly.

Response 1: Remote Transceiver's response to its OEM Host on receiving a Probe.

This response helps a radio identify the radio that probed it. This response also returns RSSI value, which is helpful in determining the strength of the wireless link between radios.

Byte 1 = 0x86
Byte 2 = RSSI (How strong the remote transceiver heard the local transceiver)
Bytes 3 – 5 =3 bytes of MAC Address of the radio sending the Probe.

Note: This response is received only when Probe Report (0xC9) is set to 0xE3.

Response2: Transceiver's response to its OEM Host on hearing the Remote transceiver's reply (Probe Acknowledge):

This response helps a radio identify the radio that received its probe. This response also returns RSSI and RSSI* values, which can be analyzed to determine how strong the link is.

Byte 1 = 0x87
Byte 2 = RSSI (How strong the remote transceiver heard the local transceiver)
Byte 3 = RSSI* (How strong the local transceiver heard the remote transceiver)
Byte 4 - Byte 6 = 3 bytes of MAC Address of the remote transceiver

EEPROM Byte Read

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

Command: 0xCC 0xC0 Data1 Data2
Number of bytes returned: 4+
Response: 0xCC Data1 Data2 Data3
Parameter Range: Data1 = EEPROM address Data2 = Length (0x01-0x80) Data3 = Requested data

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 OEM 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 OEM 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.

Command: CCh C1h Data1 Data2 Data
Number of bytes returned: 4+
Response: CCh Data1 Data2 Data
Parameter Range: Data1 = EEPROM address Data2 = Length (1-80h) Data = Data written



Quick Tip:

The EEPROM is limited to 20,000 write cycles. In order to avoid unnecessary writes, it is recommended that you perform a read before issuing the write command to verify that the byte requires writing. It is possible while performing an EEPROM write without a stable power supply that the EEPROM can become corrupted, rendering the radio inoperable.

Reset Command

The OEM Host issues this command to perform a soft reset of the transceiver.

Any transceiver settings modified by CC Commands will be overwritten by values stored in the EEPROM.

Command: CCh FFh
Number of bytes returned: None
Response: None

EEPROM Parameters

The OEM Host can program various parameters that are stored in EEPROM which become active after a power-on reset. Table 9 - EEPROM Parameters, gives the locations and descriptions of the parameters that can be read or written by the OEM 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 9 - EEPROM Parameters

Parameter	EEPROM Address	Length (Bytes)	Range	Default	Description
Product ID	0x00	40			40 bytes - Product identifier string. Includes revision information for software and hardware.
Stop bit Delay	0x3F	1	0x00 – 0xFF	0xFF	For systems using the RS-485 interface or Parity, the serial stop bit might come too early (especially at slower interface baud rates). Stop bit Delay controls the width of the last bit before the stop bit occurs. 0xFF = Disable Stop bit Delay (12us) 0x00 = (256 * 1.6us) + 12us 1 – 0xFE = (value * 1.6us) + 12us
Channel Number	0x40	1	0x00 – 0x2F	AC4790-1x1: 0x00 AC4790-200: 0x00 AC4790-1000: 0x10	Set 0 = 0x00 – 0x0F (US/Canada): AC4790-1x1/200 Set 1 = 0x10 – 0x2F (US/Canada): AC4790-1x1/1000 Set 3 = 0x30 – 0x37 (US/Canada): AC4790-1x1-200 (Australia): AC4790-1x1/200/1000
Baud Rate Low	0x42	1	0x00 – 0xFF	0xFC	Low Byte of the interface baud rate. Default baud rate is 57,600.
Baud Rate High	0x43	1	0x00	0x00	Always 0x00
Control 0	0x45	1		0x00	Settings are: bit-7 – 0 bit-6 – DES Enable 0 = Disable Encryption 1 = Enable Data Encryption bits-5 – 0: 0
Transmit Retries	0x4C	1	0x01 – 0xFF	0x04	Maximum number of times a packet is sent out when Addressed Packets is selected.
Broadcast Attempts	0x4D	1	0x01 – 0xFF	0x04	Total number of times a packet is sent out when Broadcast Packets is selected.
Stale Count Reload	0x4F	1	0x01 – 0xFF	0x40	Determines the amount of time a transceiver will keep another transceiver (say transceiver A) active in its Radio Table. This counter is reset every time a packet is received from that transceiver (A).
Control1	0x56	1		01000011b (0x43)	Settings are: bit-7 – AeroComm Use Only bit-6 – 1 bit-5 – 0 bit-4 – Auto Destination 0 = Use Destination Address 1 = Automatically set Destination to last radio received from bit-3 – 0 bit-2 – RTS Enable 0 = RTS Ignored 1 = Transceiver obeys RTS bit-1 – Duplex 0 = Half Duplex 1 = Full Duplex bit-0 – Auto Config 0 = Use EEPROM values 1 = Auto Configure Values

Parameter	EEPROM Address	Length (Bytes)	Range	Default	Description
Interface Timeout	0x58	1	0x02 – 0xFF	0x04	Specifies a byte gap timeout, used in conjunction with RF Packet Size to determine, when a packet coming over the interface is complete (0.5ms per increment).
RF Packet Size	0x5B	1	0x01 – 0x80	0x80	Used in conjunction with Interface Timeout, specifies the maximum size of an RF packet.
CTS On	0x5C	1	0x01 – 0xFF	0xD2	CTS will be deasserted (High) when the transmit buffer contains at least this many characters.
CTS Off	0x5D	1	0x00 – 0xFE	0xAC	Once CTS has been deasserted, CTS will be reasserted (Low) when the transmit buffer contains this many or less characters.
Max Power	0x63	1	0x00 – 0x60	Set in production and can vary	Used to increase or decrease transmit power output. The transceivers are shipped at maximum allowable power.
Parity	0x6F	1	0xE3, 0xFF	0xFF	0xE3 = Enable Parity 0xFF = Disable Parity Note: Enabling Parity cuts throughput in half and the Interface Buffer size in half.
Destination ID	0x70	6		FF, FF, FF, FF, FF, 0xFF	Specifies destination for RF packets.
System ID	0x76	1	0x00 – 0xFF	0x01	Similar to a network password. Radios must have the same system ID to communicate with each other.
RS-485 DE	0x7F	1	0xE3, 0xFF	0xFF	0xE3 = GO0 is active Low DE for control of external RS-485 hardware. 0xFF = Disable RS-485 DE
MAC ID	0x80	6			Factory programmed unique IEEE MAC Address.
Original Max Power	0x8E	1	-	Set in production and can vary	Copy of original Max Power EEPROM setting. This address may be modified but should not be modified.
Product ID	0x90	15			Bytes 0x90 – 0x93: Product ID - 4490, 4486, 4868, 4790 Bytes 0x94-95: Prefix - CL, CN or AC Bytes 0x96-0x99: Power - 200M, 200A, 1000, 1x1. Note: there will be a period in front of the 1x1 to keep the field at four bytes. 0x9A – 0x9C: Interface - 232, 485, TTL. 0x9D – 0x9E: Setup script; 01 is stock 0x9F: Reserved for future use; always 0xFF
API Control	0xC1	1		00010000 (0x10)	Settings are: bit-7 – Broadcast Packets 0 = Addressed Packets 1 = Broadcast Packets bit-6 – Probe 0 = Disable Probe 1 = Enable Probe bit-5 – SLock1 0 = Disable 1 = Enable bit-4 – SLock0 0 = Disable 1 = Enable bit-3 – Unicast Packets 0 = Broadcast or Addressed Packets 1 = Addressed Packets only bit-2 – Send Data Complete Enable 0 = Disable 1 = Enable bit-1 – API Transmit Packet Enable 0 = Disable Transmit API Packet 1 = Enable Transmit API Packet bit-0 – API Receive Packet Enable 0 = Disable Receive API Packet 1 = Enable Receive API Packet
Protocol Status	0xC2	1	0x00 – 0xFF	0xE3	Determines if the GO0 and GO1 serve as generic output or serve as the protocol status.
Session Count Refresh	0xC4	1	0x00 – 0xFF	0x08	This byte specifies the number of hops a transceiver stays in Session with another transceiver

Parameter	EEPROM Address	Length (Bytes)	Range	Default	Description
Random Back-Off	0xC3	1	0x0 – 0xFF	0x00	The Random amount of time a transceiver waits when a collision occurs, before resending the packet again. 0x00 = Disable Random Backoff 0x01 = Wait 1-2 packet times, then retry 0x03 = Wait 1-4 packet times, then retry 0x07 = Wait 1-8 packet times, then retry 0x0F = Wait 1-16 packet times, then retry 0x1F = Wait 1-32 packet times, then retry 0x3F = Wait 1-64 packet times, then retry 0x7F = Wait 1-128 packet times, then retry 0xFF = Wait 1-256 packet times, then retry
Sense Adjust	0xC8	1	0x00 – 0xFF	Set in production and can vary	The minimum RSSI required by a transceiver to establish a Session Status on hearing a long beacon.
Probe Report	0xC9	1	0x00 – 0xFF	0xE3	When this byte is set to 0xE3, upon receiving a probe the transceiver sends a Probe Report to its OEM Host.
DES Key	0xD0	7	0xx0 – 0xFF	0D, 1D, 2D, 3D, 4D, 5D, 0x6D	56-bit Data Encryption key
CTS Off	0x5D	1	0x00 – 0xFE	0xAC	Once CTS has been deasserted, CTS will be reasserted (Low) when the transmit buffer contains this many or less characters.

Dimensions

Critical parameters are as follows:

Interface Connector – 20 pin OEM interface connector (Molex 87759-0030, mates with Samtec SMM-110-02-S-D)

MMCX Jack – Antenna connector (Johnson Components 135-3711-822)

Figure 10 - AC4790 (with MMCX connector) Mechanical

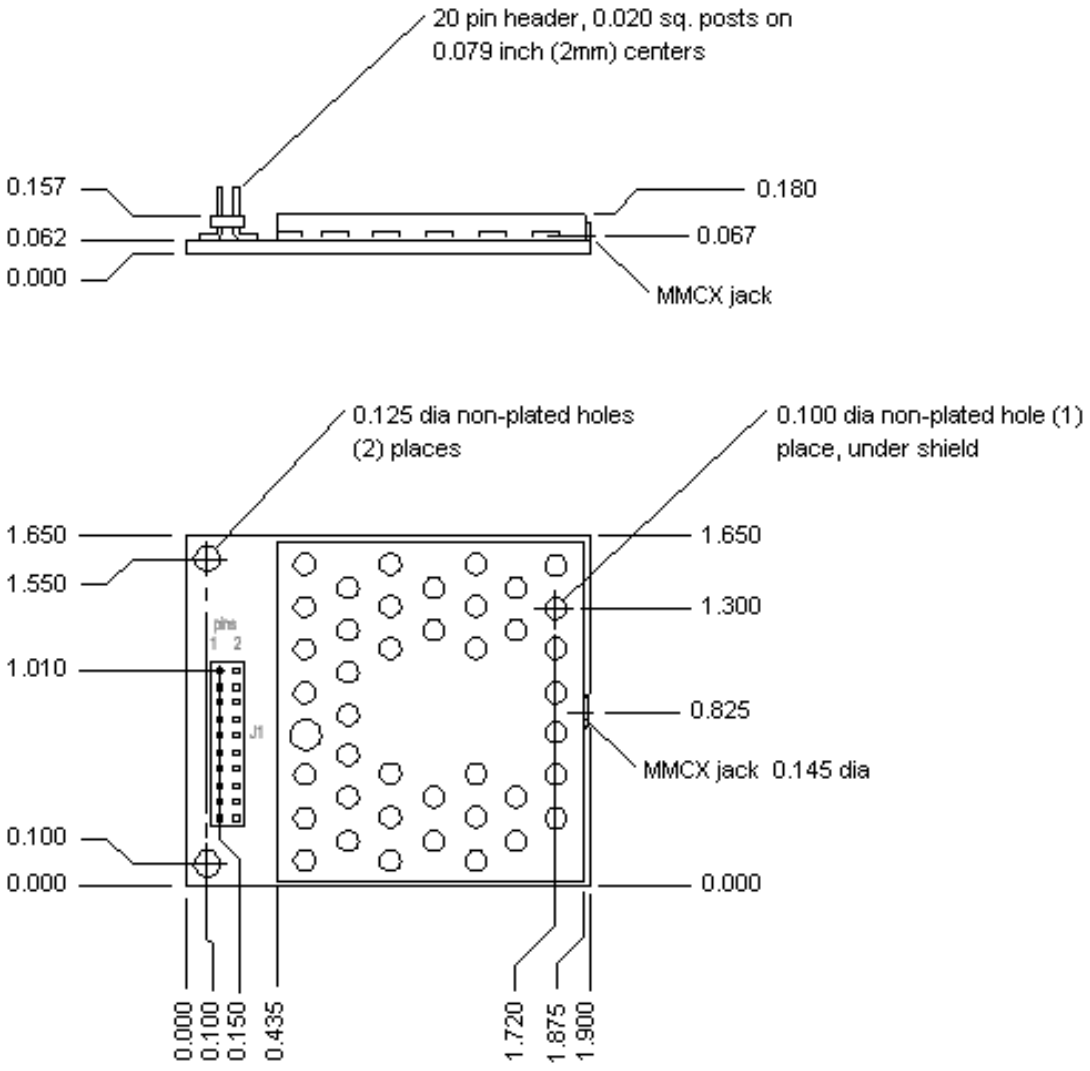


Figure 11 - AC4790 (with integral gigaAnt antenna on top) Mechanical

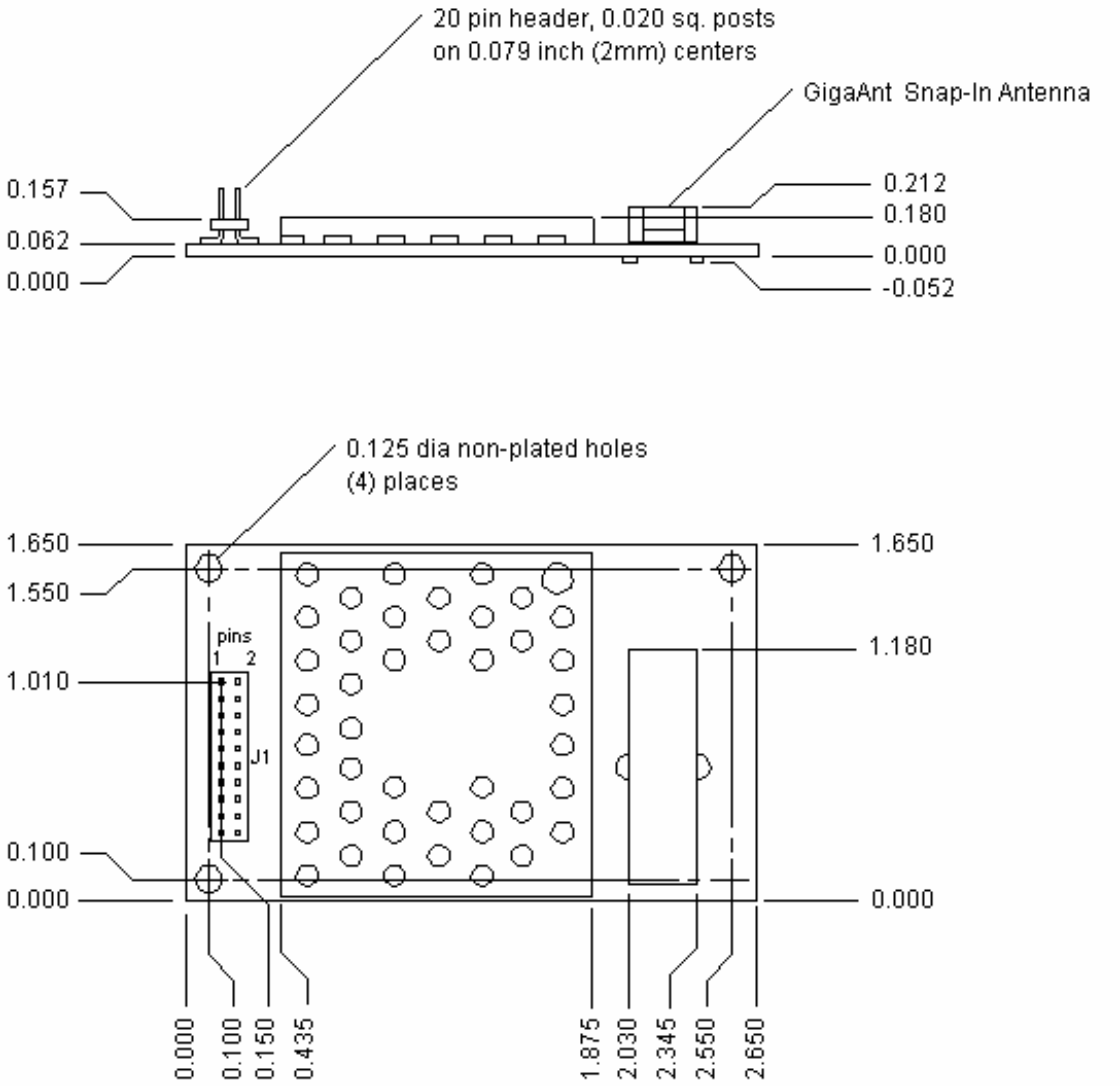


Figure 12 - AC4790 (with integral gigaAnt antenna on bottom) Mechanical

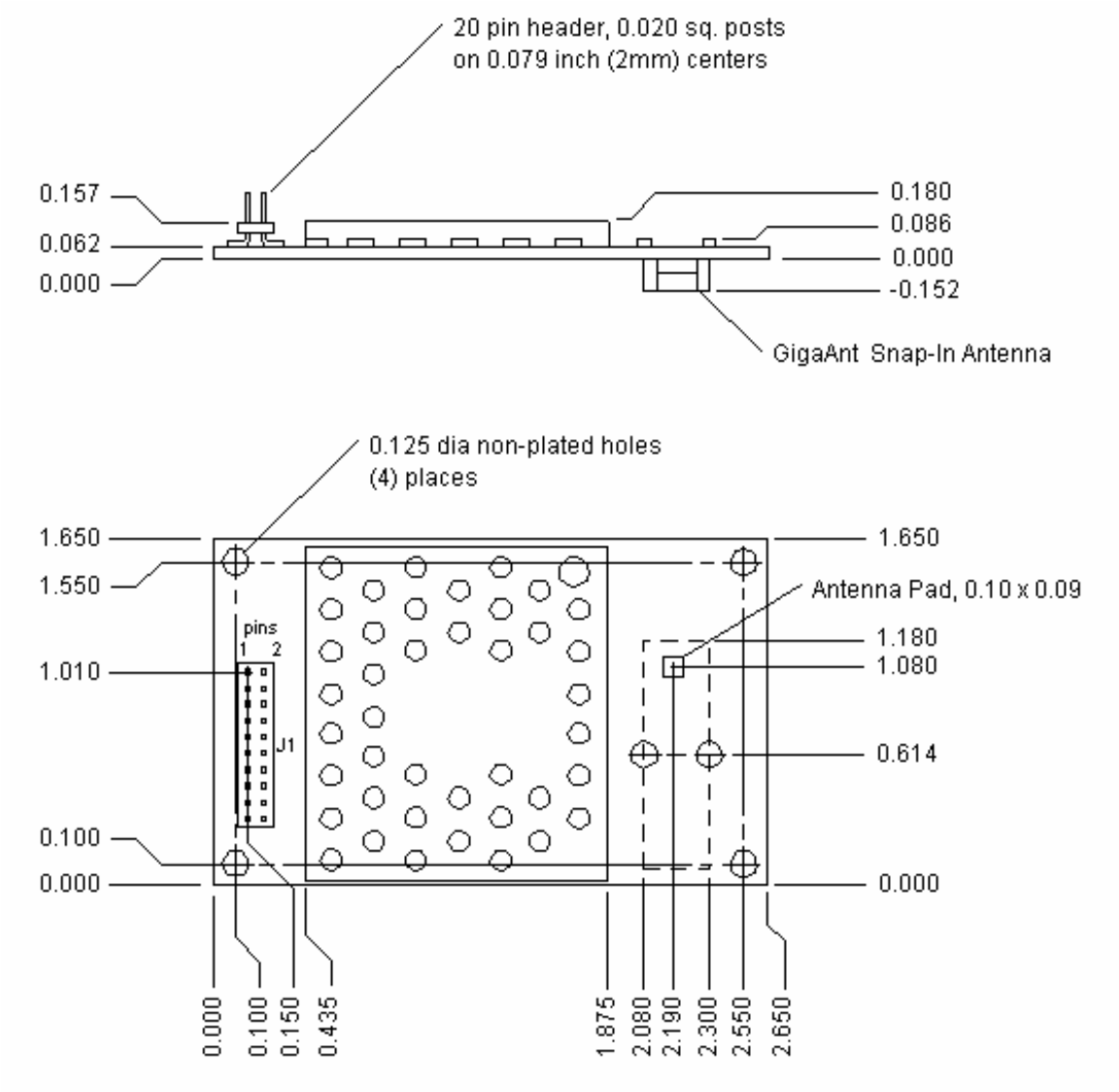


Figure 13 - AC4790-1x1 Mechanical

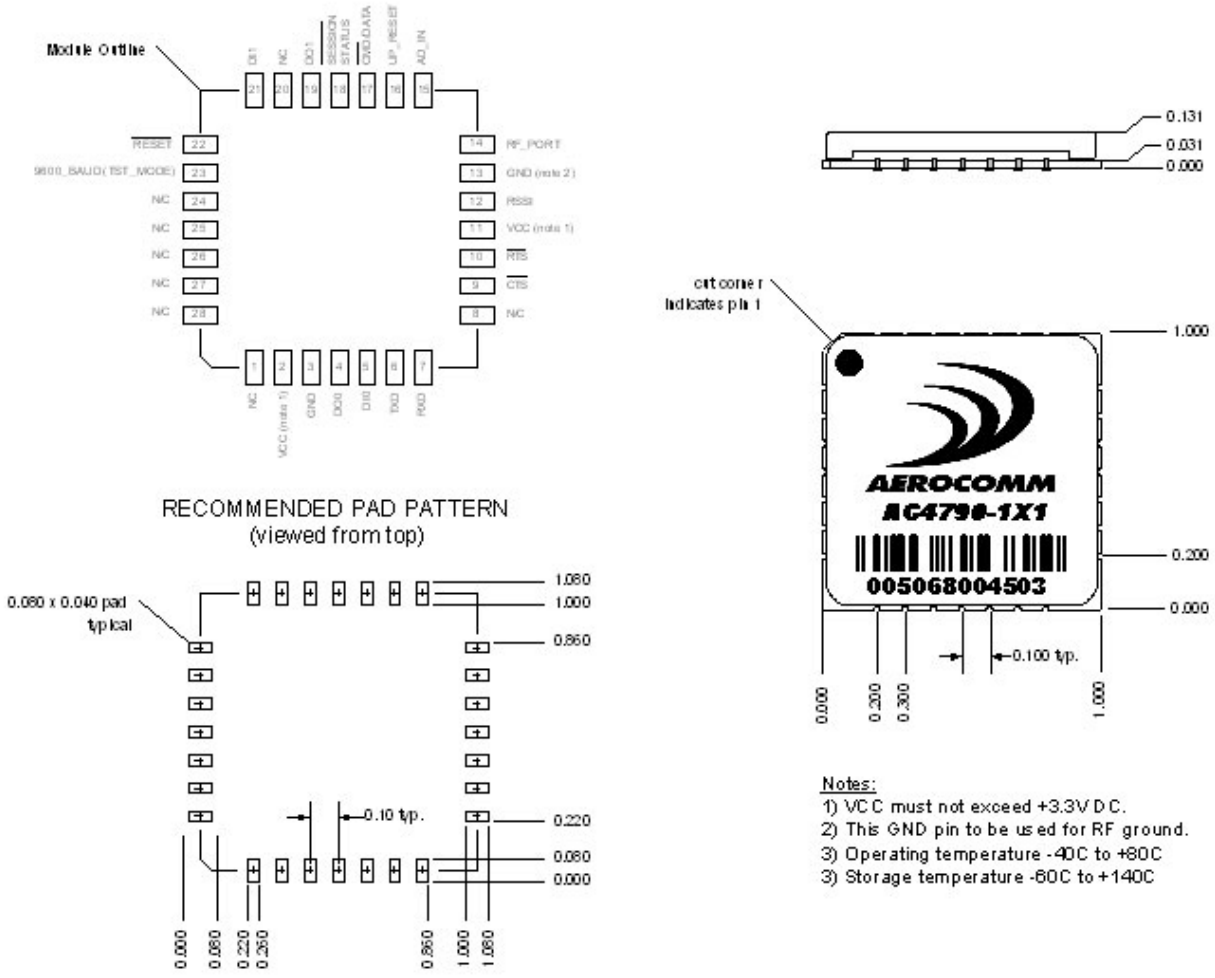
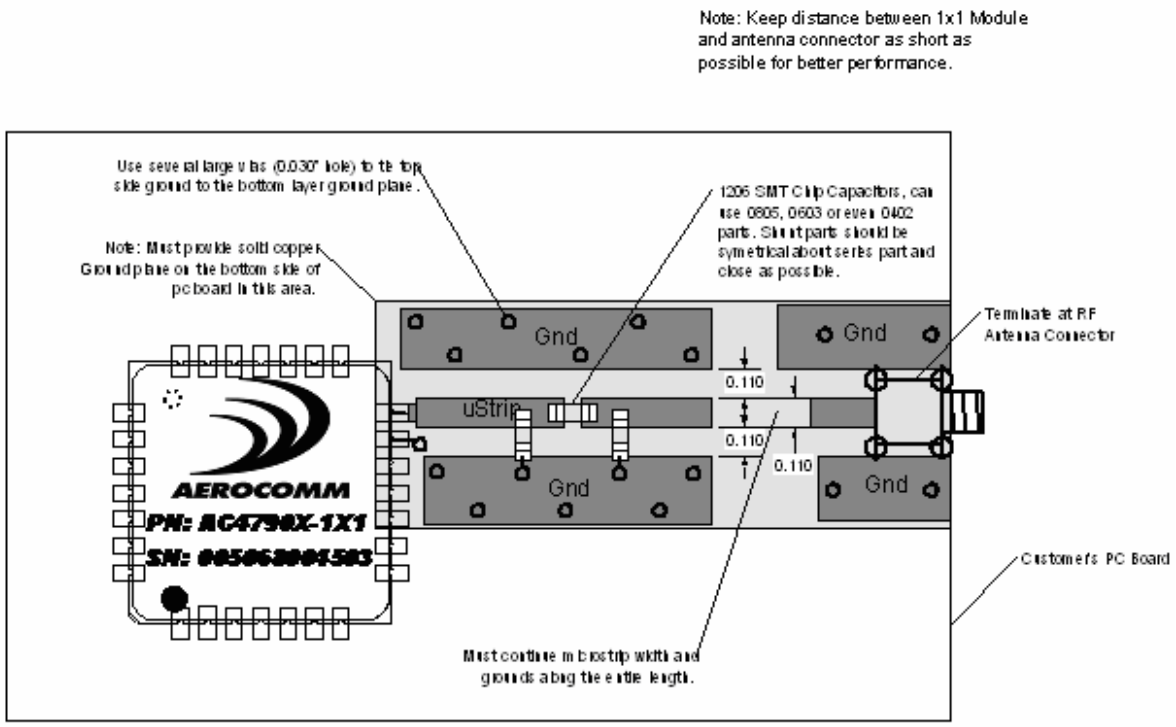


Figure 14 - AC4790 1x1 PCB Considerations

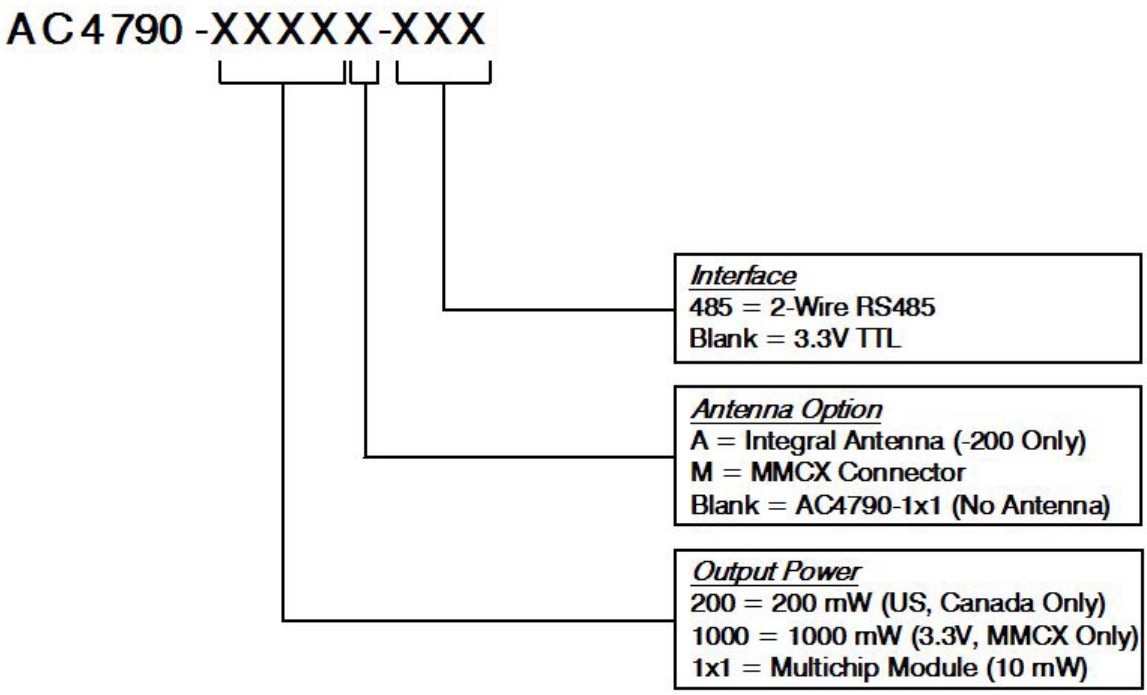


PCB THickness Notes:
For 0.062 thick PC board microstrip width and spacing is 0.110 inches.

For 0.031 thick PC board microstrip width and spacing is 0.055 inches.

Ordering Information

PRODUCT PART NUMBER TREE



DEVELOPER KIT PART NUMBERS

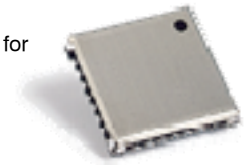
All the above part numbers can be ordered as a development kit by prefacing the part number with "SDK-". As an example, part number AC4790-200A can be ordered as a development kit using the following part number: SDK-AC4790-200A.

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

Agency Compliancy Information

AC4790-1x1

Due to the RF antenna trace residing on the OEM Host PCB, the FCC will not grant modular approval for the AC4490-1x1 and requires the OEM to submit their completed design for approval. Contact AeroComm for the approval procedure.



AGENCY IDENTIFICATION NUMBERS

Agency compliancy is a very important requirement for any product deployment. AeroComm has obtained modular approval for its products so the OEM only has to meet a few requirements to be eligible to use that approval. The corresponding agency identification numbers and approved antennas are listed in the table below.

Table 10 - Agency Identification Numbers

Part Number	US/FCC	CAN/IC
AC4790-200	KQLAC4490-100	2268C-AC4490
AC4790-1000	KQL-AC4490	2268C-44901000

APPROVED ANTENNA LIST

The following antennas are approved for operation with the AC4790 as identified. **The OEM is free to choose another vendor's antenna of equal or lesser gain and similar type as an antenna appearing in the table and still maintain compliance.**

Table 11 - AC4790 Approved Antenna List

AeroComm Part Number	Manufacturer Part Number	Manufacturer	Type	Gain (dBi)	AC4790-200A	AC4790-200M	AC4790-1000M
0600-00019	S467FL-5-RMM-915S	Nearson	½ Wave Dipole	2		X	X
0600-00025	S467FL-5-RMM-915	Nearson	½ Wave Dipole	2		X	X
0600-00024	S467AH-915S	Nearson	½ Wave Dipole	2		X	X
0600-00027	S467AH-915	Nearson	½ Wave Dipole	2		X	X
0600-00028	S161AH-915R	Nearson	½ Wave Dipole	2.5		X	X
0600-00029	S161AH-915	Nearson	½ Wave Dipole	2.5		X	X
0600-00030	S331AH-915	Nearson	¼ Wave Dipole	1		X	X
	1020B5812-04 Flavus	gigaAnt	Microstrip	-0.5	X		

FCC / INDUSTRY CANADA (IC) REQUIREMENTS FOR MODULAR APPROVAL

In general, there are two agency classifications of wireless applications; portable and mobile.

Portable – Portable is a classification of equipment where the user, in general, will be within 20cm of the transmitting antenna. Portable equipment is further broken into two classes; within 2.5cm of human contact and beyond 2.5cm (NOTE: Ankles, feet, wrists and hands are permitted to be within 2.5cm of the antenna even if the equipment is designated as being greater than 2.5cm). The AC4790 is not agency approved for portable applications. The OEM is required to have additional testing performed to receive this classification. Contact Aerocomm for details.

Mobile – Mobile defines equipment where the user will be 20cm or greater from the transmitting antenna. The antenna must be mounted in such a way that it cannot be moved closer to the user with respect to the equipment, although the equipment may be moved. NOTE: Ankles, feet, wrists and hands are permitted to be within 20cm of mobile equipment.

OEM Equipment 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 below. The FCC identifiers are listed above in the Agency Identification Numbers chart.

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.

Antenna Requirements

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

Caution: Any change or modification not expressly approved by AeroComm could void the user's authority to operate the equipment.

Agency Compliancy Information

Warnings Required in OEM Manuals

RF Exposure for Warning for Mobile Equipment

WARNING: This equipment has been approved for mobile applications where the equipment should be used at distances greater than 20cm from the human body (with the exception of hands, wrists, feet and ankles). Operation at distances less than 20cm is strictly prohibited.

Channel Warning

The OEM must prevent the end user from selecting a Channel not approved for use by the FCC/IC.

Appendix I - Power Supply Application Note

Here is a simple switching power supply that provides enough current to easily power any Aerocomm OEM module. It utilizes low cost, off the shelf components that fit into a small area. This supply has an input voltage range of +6 volts to +18 volts and will output +3.4 volts at 1.5 amps.

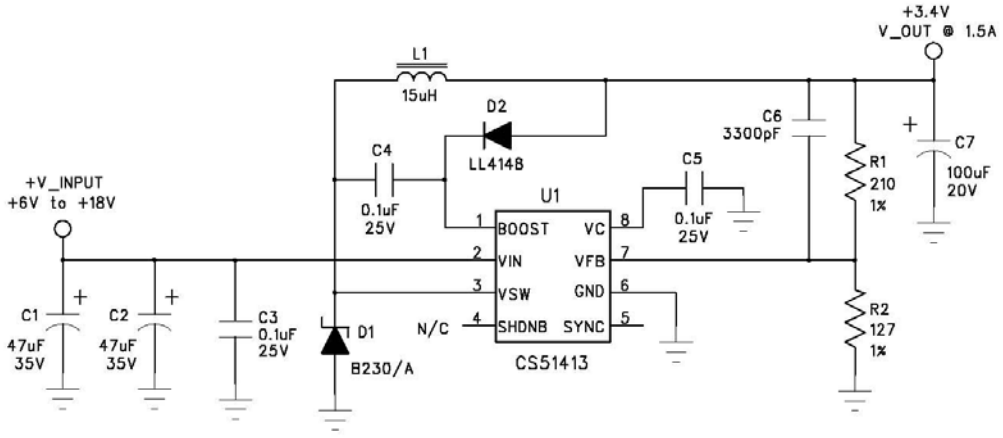
Included is a schematic, bill of material with manufacture's name and part numbers and a sample PC board layout. It is important to follow the layout suggestions and use large areas of copper to connect the devices as shown in the layout. It is also important to hook up the ground traces as shown and use multiple vias to connect input and output capacitors to the bottom side ground plane.

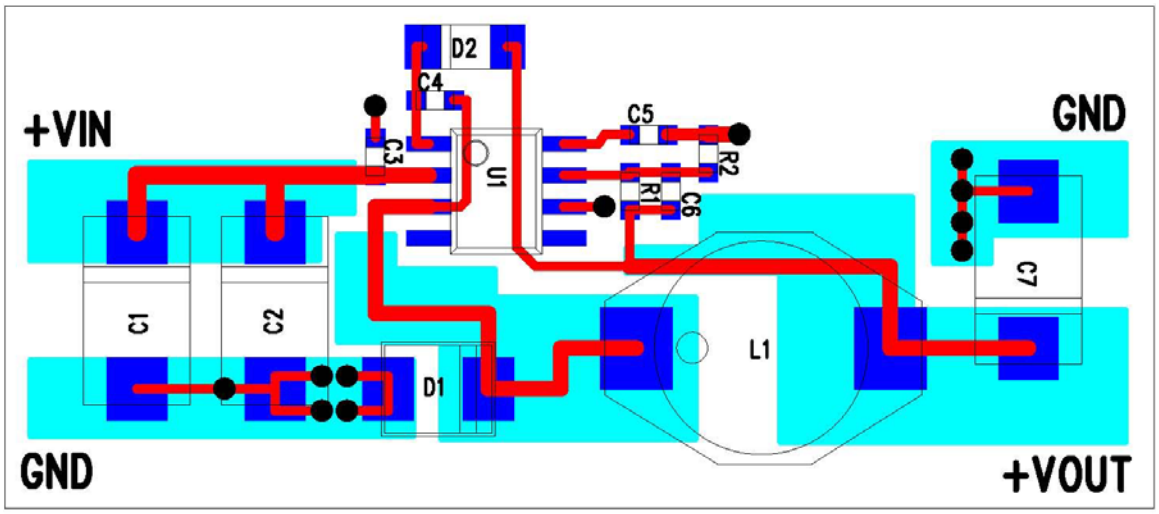
If the input voltage will be less than 12 volts then C1 and C2 can be replaced with a single 100uF 20 volt capacitor (same part number as C7). This will reduce board space and lower costs further. If you are powering an AC5124 module, R1 can be changed to a 373 ohm 1% resistor. This will change the output to +5 volts at 1.0 amps.

Bill of Materials

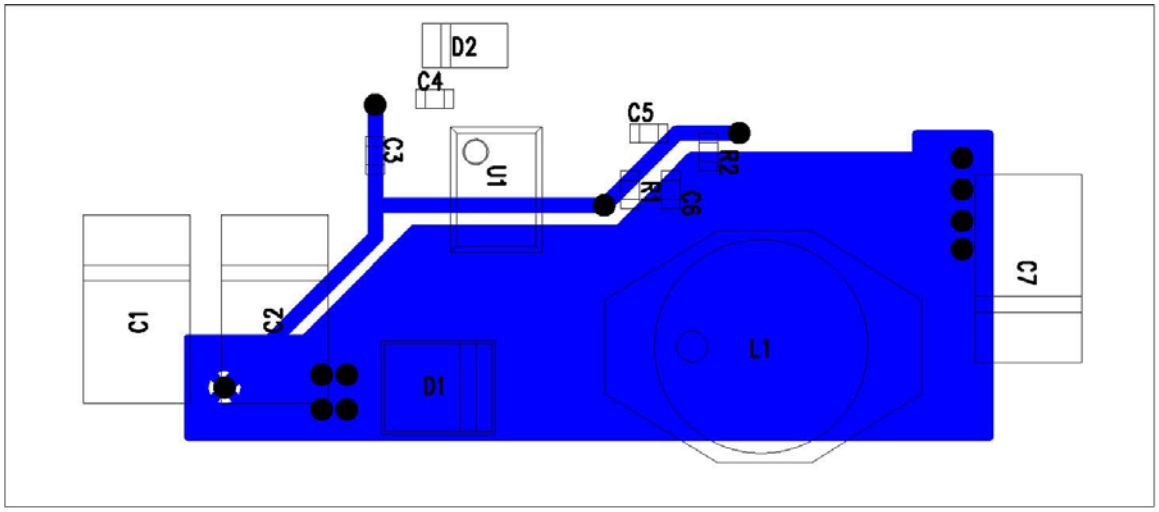
Qty	Reference	Value	Description	Mfg.	Mfg. part number
1	R1	210	Res, 0603, 210, 1/16W, 1%	KOA	RK73H1JT2100F
1	R2	127	Res, 0603, 127, 1/16W, 1%	KOA	RK73H1JT1270F
2	C1 C2	47uF	Cap, Tant, 7343, 47uF, 35V	AVX	TPSE476M035R0200
3	C3 C4 C5	0.1uF	Cap, Cer, 0603, 0.1uF, Y5V, 25V	Murata	GRM39Y5V104Z025AD
1	C6	3300pF	Cap, Cer, 0603, 3300pF, X7R, 50V	Murata	GRM39X7R332K050AD
1	C7	100uF	Cap, Tant, 7343, 100uF, 20V	Kemet	T491X107K020A5
1	D1	B230/A	Diode, SMB, B230/A, 2A, Schottkey	Diodes, Inc.	B230/A
1	D2	LL4148	Diode, MELF, LL4148, Switch Diode	Diodes, Inc.	LL4148
1	L1	15uH	Xfmr, 2P, SMT, 15uH, 2A	Coiltronics	UP2.8B150
1	U1	CS51413	IC, CS51413, 8P, SO, Switch Reg Ctrl.	On-Semicond.	CS51413

Switching Power Supply





Top Side Artwork



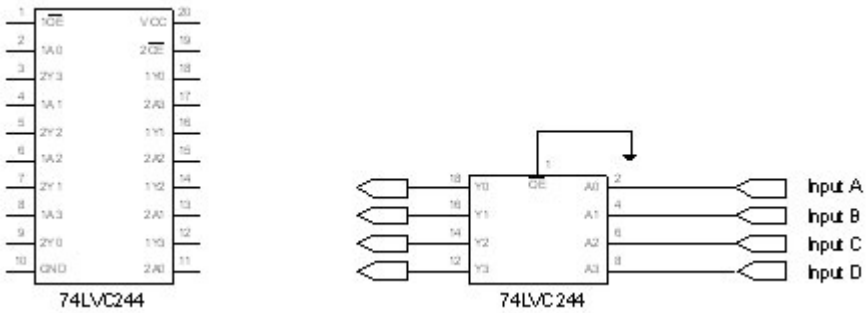
Bottom Side Artwork
(Viewed from the Top)

Appendix II – Converting from 5V levels to 3.3V levels

Converting from 5V to 3.3V

The AC4790-1000M and the AC4790-1x1 have 3.3 V input levels. However, this can cause problems if a designer wants to use an older 5V circuit in the same design. Some of the most common voltage conversion methods are described below.

1. Voltage Level Conversion IC's
This is the easiest and most efficient method. Aerocomm recommends the TI SN74LVC244A Octal Buffer/Driver. Inputs can be driven from either 3.3 or 5V systems, allowing the device to be used in a mixed 3.3/5V system.



The datasheet for the SN74LVC244A can be downloaded from TI's website,

http://focus.ti.com/docs/prod/folders/print/sn74lvc244a.html

All inputs are weakly pulled high and are equipped with a 10 kΩ pullup resistor. Aerocomm recommends that all unused inputs be pulled high.

2. Passive Voltage Divider
While a resistor voltage divider can successfully drop the 5V to the required 3.3V, it will draw static current all of the time. Typically this method is only suitable for one-way 5V to 3.3V conversion. When choosing the resistor values, one should remember to include the radio's internal 10 kΩ resistor on the input signals.

Appendix III - API

I. Daisy Chain / Repeater

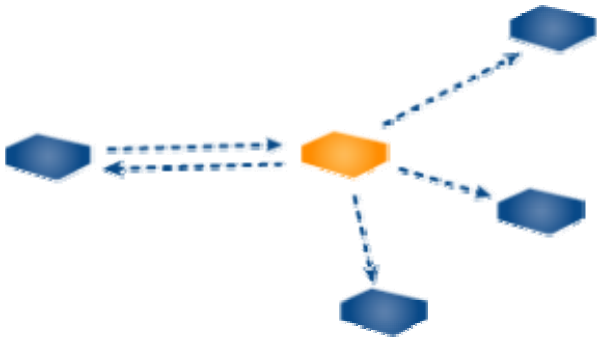
With the use of API commands a daisy chain or repeater can be implemented easily with the AC4790. Radio A would send a packet to radio B which would store the data in its buffer. When the session between A & B has ended, radio B initiates a session with radio C which in turn stores the data until the current session has ended. Radio C will then initiate a session with radio D and so on. Radio D can either send data back down the line to radio A, forward it to another radio or end the chain.



A repeater can be implemented in the same manner as the Daisy Chain.

II. Loopback repeater

The simplest repeater to implement is the loopback repeater. A loopback repeater can be created by connecting the radio's TX and RX lines together. When the radio receives data it will retransmit the data to all available radios in range. The repeater will forward the data to all available radios as well as back to the radio which sent the data to the repeater. It is important to ensure that two such repeaters are never in range of each other as they will continuously transmit data back and forth to each other.

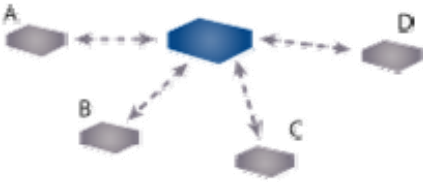


Quick Tip:

When using a loopback repeater the radio which sent the data to the repeater will receive the data up to the repeater's number of broadcast attempts (i.e. 4 broadcast attempts = 4 received packets.)

III. Broadcast API Packet

This configuration has several variations and is ideal for applications in which one radio sends a string of data to several radios where no response is required. The broadcast API packet can also be used in applications where one radio sends a string of data and in turn receives a response from one or more of the receiving radios. In the simplest network, Random Back Off could be used to ensure that the responses do not collide. If two or more packets collide, the radios will back off and retry the transmission in a random number of hops within the random



seed range.

81h 01h 08h 04h FFh FFh FFh AAh

Radios A, B, C, & D receive the packet and send it to the OEM Host in the following format:
81h 01h XXh XX*h 01h 23h 45h AAh

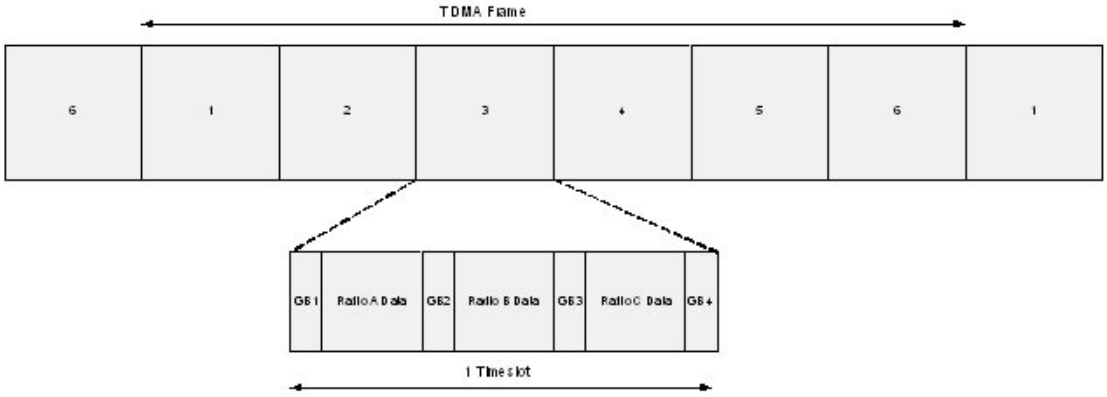
Advanced

For a more intelligent network, a Time Division Multiple Access (TDMA) system could be implemented. In this system various radios transmit data to a shared radio during an assigned time interval. The system is synchronous so when a radio is transmitting it is the only one and has full access to the shared radio's bandwidth. To utilize a TDMA system a radio must store its data for the period of time between its transmissions or bursts. A typical format for data passing through a shared radio is shown below. A frame consists of arriving bursts from remote radios being served. Each frame is then divided into multiple time slots. The bursts do not have to have the same durations and can be longer for heavy-traffic stations. To prevent overlaps, guard intervals can be inserted to absorb small timing errors in burst arrivals.

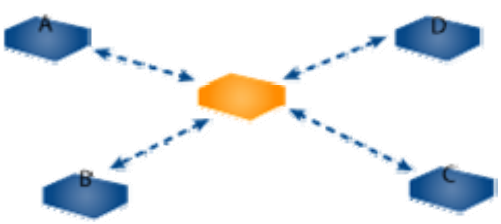
Implementation:

1. Server sends broadcast packet which includes sync pulse.
2. Remote radios hear the sync pulse and join the session
3. Radio A transmits data during time interval t = 1
4. Radio B transmits data during time interval t = 2……..
5. Radio N transmits data during time interval t = N -1

This type of implementation requires careful planning and should allow enough time for each radio to retry if necessary. If Full Duplex is enabled, the radio which initiates the session will transmit during the even numbered hops while the remote radios will transmit during the odd numbered hops.



IV. Polling Network



The Transmit and Receive API commands can be used for applications where it is necessary for one unit to poll several others for data. The radio requesting the poll can use the Transmit API command to dynamically switch from one radio to another. The remote radio will receive the poll request and transmit the appropriate response to the polling radio. If the Receive API feature is enabled, the polling unit will send the remote response to the OEM host which can then determine the MAC address of the sending radio and relay the information as needed. Once the polling radio is finished communicating with the remote radio, the Transmit API command can once again be used to change the destination address. This process continues until all radios have been successfully polled.

1. Master to radio A using TX API:
   81h 01h 08h 04h 12h 34h 56h AAh

2. Radio A receives the packet which tells it to begin transmitting its' information. Radio A sends the information back to the master unit and the session expires after 8 hops.

3. Master switches to radio B using TX API:
   81h 01h 08h 04h 12h 34h ABh AAh

4. Radio B receives the packet which tells it to begin transmitting its' information. Radio B sends the information back to the master unit and the session expires after 8 hops.

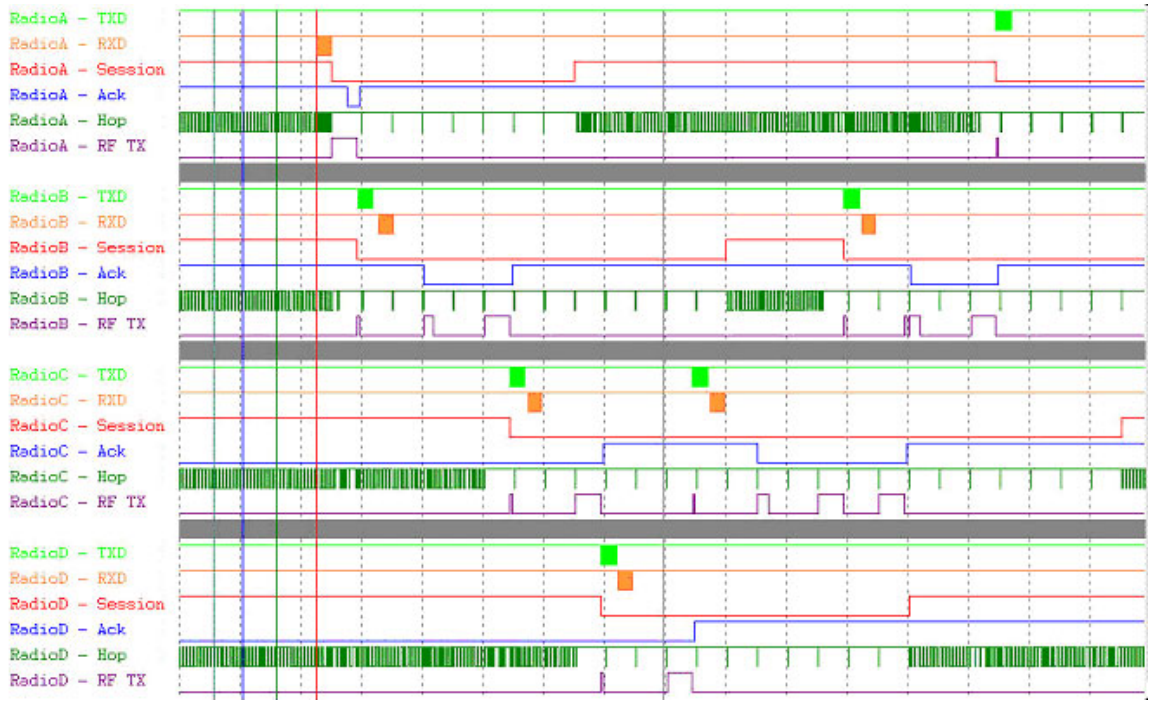
5. Master switches to radio C using TX API:
   81h 01h 08h 04h 12h 34h CDh AAh

6. Radio C receives the packet which tells it to begin transmitting its' information. Radio C sends the information back to the master unit and the session expires after 8 hops.

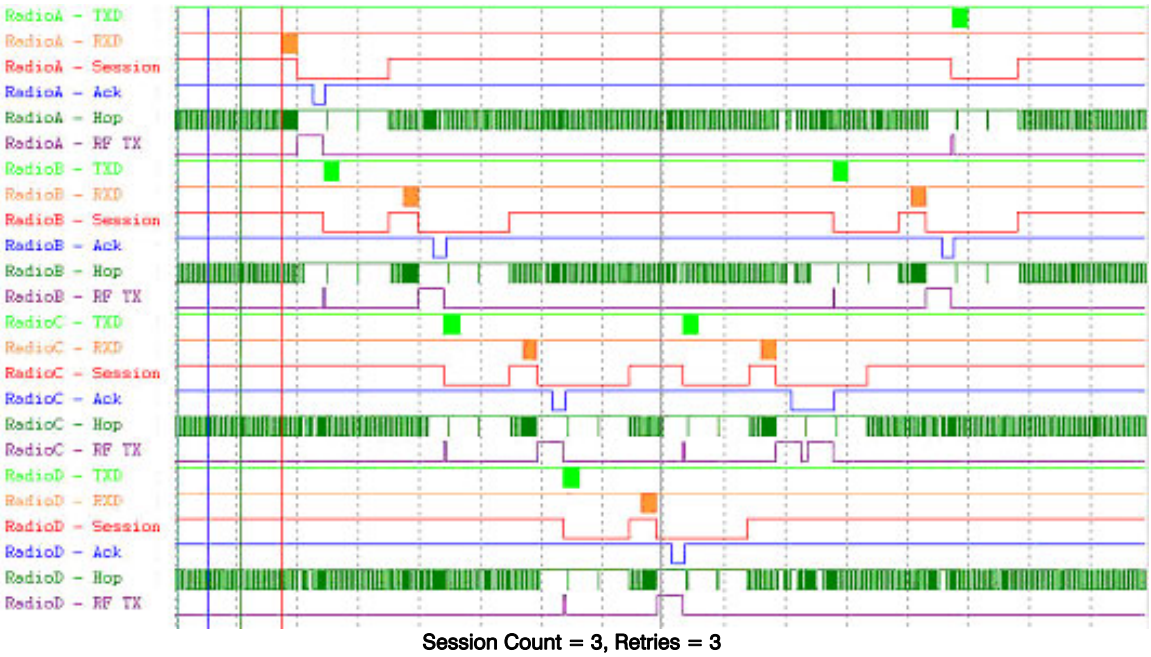
7. Master switches to radio D using TX API:
   81h 01h 08h 04h 12h 34h EFh AAh

8. Radio D receives the packet which tells it to begin transmitting its' information. Radio D sends the information back to the master unit and the session expires after 8 hops.

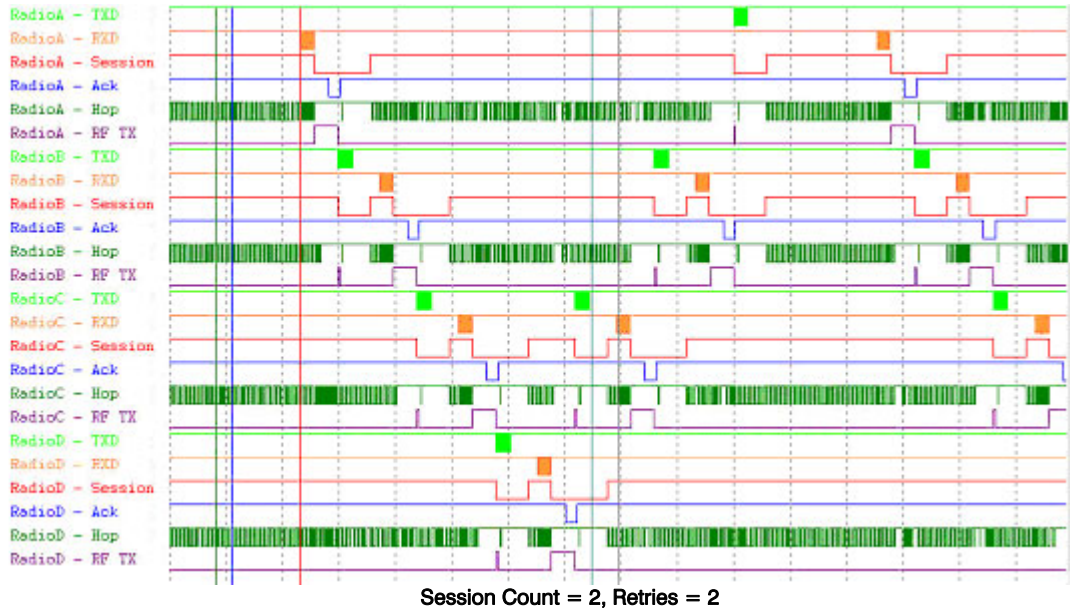
Appendix IV – API Timing Diagrams



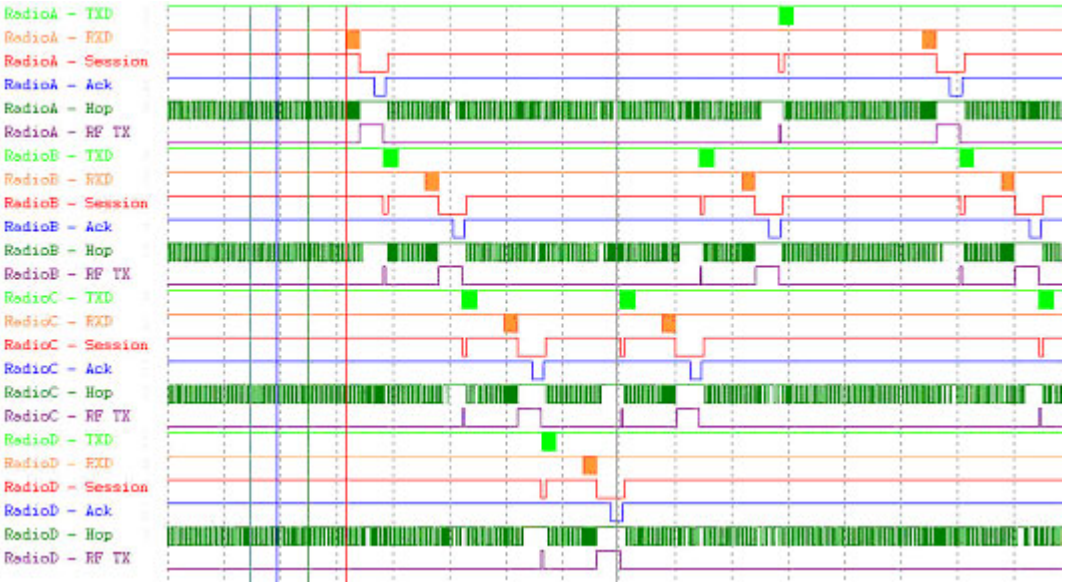
Session Count = 8, Retries = 3



Session Count = 3, Retries = 3



Session Count = 2, Retries = 2



Session Count = 1, Retries = 1

The timing diagrams above show the radios performance with varying Session Count and Retry values. Data was sent from Radio A – B – C – D and then from D – C – B – A.

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