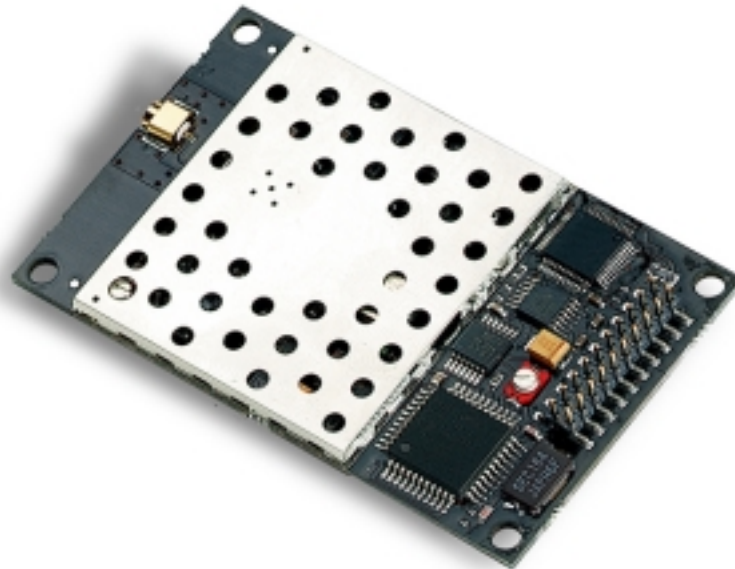# AEROCOMM

AC4424

2.4 GHz OEM TRANSCEIVERS

Specifications Subject to Change

User's Manual
Version 1.5

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DOCUMENT INFORMATION

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<u>Revision</u>   <u>Description</u>

Version 1.0   11/7/2001 – Initial Release Version

Version 1.1   10/14/2002 – Not Released

Version 1.2   10/18/2002 – Full release of AC4424 specification

Version 1.3   11/19/2002 – Made Full-Duplex incompatible with Stream Mode

Version 1.4   12/09/2002 – Changed Sub Hop Adjust setting recommendations

Version 1.5   1/30/2003 – Removed all references to Commercial and Industrial temperature. All products are now Industrial temperature. Changed Section **4.2.1 EEPROM Byte Read** to allow multiple byte reads.

Agency Approval Overview

Part Number	US/FCC	CAN/IC	EUR/EN	Portable	Mobile	Fixed
AC4424-10	X	X	X	X	X	X
AC4424-100	X	X	X		X-32cm*	X-32cm*
AC4424-200	X	X			X-32cm*	X-32cm*

* See RF Exposure warning on next page
Note: The product approvals above are with antennas specified below.

Agency Identification Numbers

Part Number	US/FCC	CAN/IC	EUR/EN
AC4424-10	KQL-PKLR2400	CAN2268391158A	X
AC4424-100	X	X	X
AC4424-200	KQL-PKLR2400-200	CAN2268391180A	

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

Item	Part Number	Mfg.	Type	Gain (dBi)	AC4424X-10	AC4424X-100	AC4424X-200
1	WCP-2400-MMCX	Centurion	1/4 Wave Dipole	2	PMF	MF	MF
2	WCR-2400-SMRP	Centurion	1/4 Wave Dipole	2	PMF		
3	MFB24008RPN	Maxrad	Omni	8	MF		
4	BMMG24000MSMARP12′	Maxrad	Omni-Mobile	1	MF		
5	BMMG24005MSMARP12′	Maxrad	Omni-Mobile	5	MF		
6	MP24013TMSMARP12	Maxrad	Panel	13	MF		
7	MUF24005M174MSMARP12	Maxrad	Omni-Mobile	5	MF		
8	MC2400	Maxrad	Patch	2.5		MF	MF
9	NZH2400-MMCX (External)	AeroComm	Microstrip	1	PMF	MF	MF
10	NZH2400-I (Integral)	AeroComm	Microstrip	1	PMF	MF	MF
11	S131CL-5-RMM-2450S	Nearson	1/4 Wave Dipole	2		MF	MF
12	S181FL-5-RMM-2450S	Nearson	1/4 Wave Dipole	2	PMF	MF	MF
13	S191FL-5-RMM-2450S	Nearson	5/8 Wave Dipole	3	PMF	MF	MF
14	S151FL-5-RMM-2450S	Nearson	Omni	5	MF	MF	MF
15	MLPV1700	Maxrad	Omni-Mobile	4	MF	MF	MF

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

RF Exposure AC4424-10

⚠️ **WARNING:** To comply with FCC RF Exposure requirements, the Original Equipment Manufacturer (OEM) must ensure that Antennas 3, 4, 5, 6 and 7 in the previous table must be installed and/or configured to operate with a separation distance of 20cm 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 Antennas 3, 4, 5, 6 and 7 in the previous table to alert users on FCC RF Exposure compliance.

RF Exposure AC4424-100

⚠️ **WARNING:** To satisfy FCC RF exposure requirements for mobile and base station transmitting devices, a separation distance of 32cm or more should be maintained between the antenna of this device and persons during operation. To ensure compliance, operations at closer than this distance is not recommended.

The preceding statement must be included as a CAUTION statement in manuals for OEM products to alert users on FCC RF Exposure compliance.

RF Exposure AC4424-200

⚠️ **WARNING:** To satisfy FCC RF exposure requirements for mobile and base station transmitting devices, a separation distance of 32cm or more should be maintained between the antenna of this device and persons during operation. To ensure compliance, operations at closer than this distance is not recommended.

The preceding statement must be included as a CAUTION statement in manuals for OEM products to alert users on FCC RF Exposure compliance.

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AC4424 Features

- ✓ Simple 5V TTL level serial interface for fast integration
- ✓ Frequency Hopping Spread Spectrum for security and interference rejection
- ✓ Cost Efficient for high volume applications
- ✓ Low power consumption for battery powered implementations
- ✓ Small size for portable and enclosed applications
- ✓ Very Low latency and high throughput
- ✓ Industrial temperature (-40°C to 80°C)

1. Overview

The AC4424 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 2.4 GHz ISM band.

The AC4424 is a cost-effective, High performance, 2.4 GHz 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 AC4424 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.

AC4424 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.

There are two data rates the OEM should be aware of:

- Serial Interface Data Rate – All transceivers can be configured to common PC serial port baud rates from 110 bps to 288,000 bps.

- Effective Data Transmission Rate – The AC4424 is a highly efficient, low-latency transceiver.

This document contains information about the hardware and software interface between an AeroComm AC4424 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.

2. AC4424 Specifications

GENERAL	
Interface	20 pin mini-connector
Serial Interface Data Rate	PC baud rates from 110 bps to 288,000 bps
Power Consumption (typical)	**Duty Cycle (TX=Transmit; RX=Receive)** 　　　　　　**10%TX　50%TX　100%TX　100%RX　Pwr-Down** AC4424-10:　90mA　　115mA　　140mA　　85mA　　15mA AC4424-100: 100mA　160mA　　235mA　　85mA　　15mA AC4424-200: 115mA　235mA　　385mA　　85mA　　15mA
Channels (used to create independent networks)	4 channel sets consisting of 16 channels each
Security	One byte System ID
RADIO	
Frequency Band	US/Canada:　　　2.402 – 2.478 GHz France:　　　　2.448 – 2.457 GHz
Radio Type	Frequency Hopping Spread Spectrum
Output Power (conducted, no antenna)	AC4424-10, 10mW typical AC4424-100, 50mW typical AC4424-200, 200mW typical
Effective Isotropic Radiated Power (EIRP with 3dBi gain antenna)	AC4424-10, 20mW typical AC4424-100, 100mW typical AC4424-200, 400mW typical
Voltage	5V nominal ±2%, ±50mV ripple
Sensitivity	-90dBm typical
Range (based on 3dBi gain antenna)	AC4424-10, Indoors to 300 ft., Outdoors to 3000 ft. AC4424-100, Indoors to 400 ft., Outdoors to 6000 ft. AC4424-200, Indoors to 500 ft., Outdoors to 10000 ft.
ENVIRONMENTAL	
Temperature (Operating) Industrial:	AC4424: -40°C to 80°C
Temperature (Storage)	-50°C to +85°C
Humidity (non-condensing)	10% to 90%
PHYSICAL	
Dimensions	1.65″ x 2.65″ x 0.20″
Antenna	AC4424-10, MMCX Jack AC4424-100, MMCX Jack AC4424-200, MMCX Jack
Weight	Less than 0.75 ounce

3. Specifications

3.1 INTERFACE SIGNAL DEFINITIONS

The AC4424 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 regard to the transceiver. All I/O is 5VDC TTL level signals except for RSSI. All inputs are weakly pulled High and may be left floating during normal operation.

Table 1 – Pin Definitions

Pin	Type	Signal Name	Function
1		NC	No Connect
2	O	TXD	Transmitted data out of the transceiver
3	I	RXD	Data input to the transceiver
4		NC	No Connect
5	GND	GND	Signal Ground
6	O	Hop Frame	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		NC	No Connect
10	PWR	VCC	5V ± 2%, ± 50mV ripple
11	PWR	VCC	5V ± 2%, ±50 mV ripple
12	I/O	9600_BAUD/ Packet Frame	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. Packet Frame – When programmed 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.
13	O	RSSI	Received Signal Strength - An analog output giving a relative indication of received signal strength while in Receive Mode
14	I	WR_ENA	EEPROM Write Enable – When pulled logic Low, it allows the Host to write the on-board EEPROM. Resetting the transceiver with this pin pulled Low may corrupt EEPROM data.
15	I	UP_RESET	RESET – Controlled by the AC4424 for power-on reset if left unconnected. After a Stable power-on (50ms) a 50us logic High pulse will reset the AC4424. 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		NC	No Connect
19		NC	No Connect
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 – DC Input Voltage Characteristics

Pin	Type	Name	High Min.	High Max.	Low Min.	Low Max.	Unit
3	I	RXD	0.2Vcc+0.9	Vcc+0.5	-0.5	0.2Vcc-0.1	V
8	I	RTS	0.2Vcc+0.9	Vcc+0.5	-0.5	0.2Vcc-0.1	V
12	I	9600_Baud	0.2Vcc+0.9	Vcc+0.5	-0.5	0.2Vcc-0.1	V
14	I	WR_ENA	0.7Vcc	Vcc+1	-0.3	0.5	V
15	I	UP_RESET	0.7Vcc	Vcc+0.5	-0.5	0.2Vcc-0.1	V
17	I	Command/Data	0.2Vcc+0.9	Vcc+0.5	-0.5	0.2Vcc-0.1	V

Table 3 – DC Output Voltage Characteristics

Pin	Type	Name	High Min.	Low Max.	Unit
2	O	TXD	Vcc-0.7 @ -30µA	0.4 @ 1.6mA	V
6	O	Hop Frame	Vcc-0.7 @ -30µA	0.4 @ 1.6mA	V
7	O	CTS	Vcc-0.7 @ -30µA	0.4 @ 1.6mA	V
12	O	Packet Frame	Vcc-0.7 @ -30µA	0.4 @ 1.6mA	V
13	O	RSSI	See Figure 1	See Figure 1	V
20	O	IN_RANGE	Vcc-0.7 @ -30µA	0.4 @ 1.6mA	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 110 bps to 288,000 bps. The only supported mode is asynchronous – 8-bit, No Parity, 1 Start Bit, and 1 Stop Bit.

3.3.2 Latency Times

TBD

3.3.3 Maximum Overall System Throughput

When configured as shown in the table below, an AC4424 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. **Note: Higher overall system throughputs are possible. Contact technical support for details.**

Table 4 – Maximum Overall System Throughputs

RF Mode	Interface Baud Rate	Duplex	FEC	Direction	Throughput (bps)
Stream	192k	Half	Disabled	One way	192k
Stream	192k	Half	Enabled	One way	64k
Acknowledge	115,200	Half	Disabled	One way	80k
Acknowledge	115,200	Full	Disabled	Both ways	40k

4. Configuring the AC4424

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. <u>**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.**</u>

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	80h, D0h	D0h	D0h = Acknowledge 80h = Stream
Channel Number	40H	1	00 – 3Fh	00h	Set 0 = 00 – 0Fh (US/Canada) Set 1 = 10 – 1Fh (US/Canada) Set 2 = 20 – 2Fh (US/Canada) Set 3 = 30 – 3Fh (France)
Server/Client Mode	41H	1	01 – 02h	02h	01h = Server 02h = Client
Baud Rate Low	42H	1	00 – FFh	05h	Low Byte of the interface baud rate.
Baud Rate High	43H	1	00 – FFh	00h	High Byte of the interface baud rate.

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	00h, 2Eh	00h	Channel Set 0 = N/A Channel Set 1 = 00h Channel Set 2 = 00h Channel Set 3 = 2Eh
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 – RF Architecture
					   0 = Server-Client
					   1 = Peer-to-Peer
					Bit 5 – **AeroComm Use Only**
					Bit 4 – **AeroComm Use Only**
					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	01 – FFh	F0h	
Sync Channel	5AH	1	00 – 3Fh	01h	
RF Packet Size	5BH	1	01 – 40h	40h	
CTS On	5CH	1	01 – FFh	C0h	
CTS On Hysteresis	5DH	1	01 – FFh	80h	
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. The WR_ENA pin (Pin 14) must be pulled logic Low to enable the write prior to issuing this command or the write will not occur, requiring the transceiver to be reset. The length byte must be set to 01h. Only single byte writes are allowed.

Host Command:
    Byte 1 = C1h
    Byte 2 = Address
    Byte 3 = 01h
    Byte 3 = Data to store at Address

Transceiver Response:
    Byte 1 = C1h
    Byte 2 = Address
    Byte 3 = 01h
    Byte 4 = Data to store at Address

Note: The WR_ENA pin on the connector should only be pulled logic Low before sending an *EEPROM Byte Write* command and must be held logic Low until the data byte is echoed to the Host.

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 AC4424 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.**

Table 6 – Static Memory Address Map

Static Bank #	Address	Description
1	67h – 69h	Lower 3 bytes of Destination Address

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 with Forced Acquisition Sync

The Host issues this command to change the channel of the transceiver and force the transceiver to actively 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)

4.3.3 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

4.3.4 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 = 00h

4.3.5 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 = 00h

4.3.6 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

4.3.7 Read Static Bank #1 Byte

The OEM Host issues this command to the transceiver to read Static Bank #1 Bytes. Static Bank #1 is a bank of memory that holds many of the parameters that control the radio. Using the Read/Write Static Bank #1 command allows these parameters to be changed dynamically. Because the memory bank is static, when the radio is reset, these parameters will revert back to the settings stored in EEPROM. Be careful not to change undocumented Static Bank addresses as undesired operation may occur.

Host Command:
>   Byte 1 = CCh
>   Byte 2 = 0Ah
>   Byte 3 = 00 – FFh corresponding to a valid Static Bank #1 address

Transceiver Response:
>   Byte 1 = CCh
>   Byte 2 = 00 – FFh corresponding to a valid Static Bank #1 address

4.3.8 Write Static Bank #1 Bytes

The Host issues this command to the transceiver to write Static Bank #1 Bytes. Static Bank #1 is a bank of memory that holds many of the parameters that control the radio. Using the Read/Write Static Bank #1 command allows these parameters to be changed dynamically. Because the memory bank is static, when the radio is reset, these parameters will revert back to the settings stored in EEPROM. Be careful not to change undocumented Static Bank addresses as undesired operation may occur.

Host Command:
> Byte 1 = CCh
> Byte 2 = 0Bh
> Byte 3 = 00 – FFh corresponding to a valid Static Bank #1 address
> Byte 4 = 00 – FFh corresponding to new value for address specified by Byte 3

Transceiver Response:
> Byte 1 = CCh
> Byte 2 = 00 – FFh corresponding to a valid Static Bank #1 address
> Byte 3 = 00 – FFh corresponding to new value for address specified by Byte 2

4.3.9 Read Static Bank #2 Bytes

The Host issues this command to the transceiver to read Static Bank #2 Bytes. Static Bank #2 is a bank of memory that holds many of the parameters that control the radio. Using the Read/Write Static Bank #2 command allows these parameters to be changed dynamically. Because the memory bank is static, when the radio is reset, these parameters will revert back to the settings stored in EEPROM. Be careful not to change undocumented Static Bank addresses as undesired operation may occur.

Host Command:
> Byte 1 = CCh
> Byte 2 = 0Ch
> Byte 3 = 00 – FFh corresponding to a valid Static Bank #2 address

Transceiver Response:
> Byte 1 = CCh
> Byte 2 = 00 – FFh corresponding to a valid Static Bank #2 address

4.3.10 Write Static Bank #2 Bytes

The Host issues this command to the transceiver to write Static Bank #2 Bytes. Static Bank #2 is a bank of memory that holds many of the parameters that control the radio. Using the Read/Write Static Bank #2 command allows these parameters to be changed dynamically. Because the memory bank is static, when the radio is reset, these parameters will revert back to the settings stored in EEPROM. Be careful not to change undocumented Static Bank addresses as undesired operation may occur.

Host Command:
    Byte 1 = CCh
    Byte 2 = 0Dh
    Byte 3 = 00 – FFh corresponding to a valid Static Bank #2 address
    Byte 4 = 00 – FFh corresponding to new value for address specified by Byte 3

Transceiver Response:
    Byte 1 = CCh
    Byte 2 = 00 – FFh corresponding to a valid Static Bank #2 address
    Byte 3 = 00 – FFh corresponding to new value for address specified by Byte 2

4.3.11 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

4.3.12 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

4.3.13 Temperature Update

The Host issues this command to update the transceiver with the ambient temperature. This command is only valid on AC4424 family transceivers not already fitted with a temperature sensor.

Host Command:
    Byte 1 = CCh
    Byte 2 = A3h
    Byte 3 = D8h – 50h (corresponding to the ambient temperature in °C)

Transceiver Response:
    Byte 1 = CCh
    Byte 2 = D8h – 50h (corresponding to the ambient temperature in °C)

5. Theory of Operation

5.1 HARDWARE INTERFACE

Below is a description of all hardware pins used to control the AC4424.

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

The AC4424 accepts 5V TTL level asynchronous serial data in 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).

5.1.2 Hop Frame (pin 6)

The AC4424 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.

5.1.3 CTS Handshaking (pin 7)

The AC4424 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. The following equation should always be used for setting CTS On, CTS On Hysteresis and **RF Packet Size**:

CTS On – CTS On Hysteresis = RF Packet Size

5.1.4 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.**

5.1.5 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.

5.1.6 RSSI (pin 13)

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.

Figure 1 shows approximate RSSI performance. Output is 1.20V to 4.50V.

Figure 1 – RSSI Voltage vs. Received Signal Strength
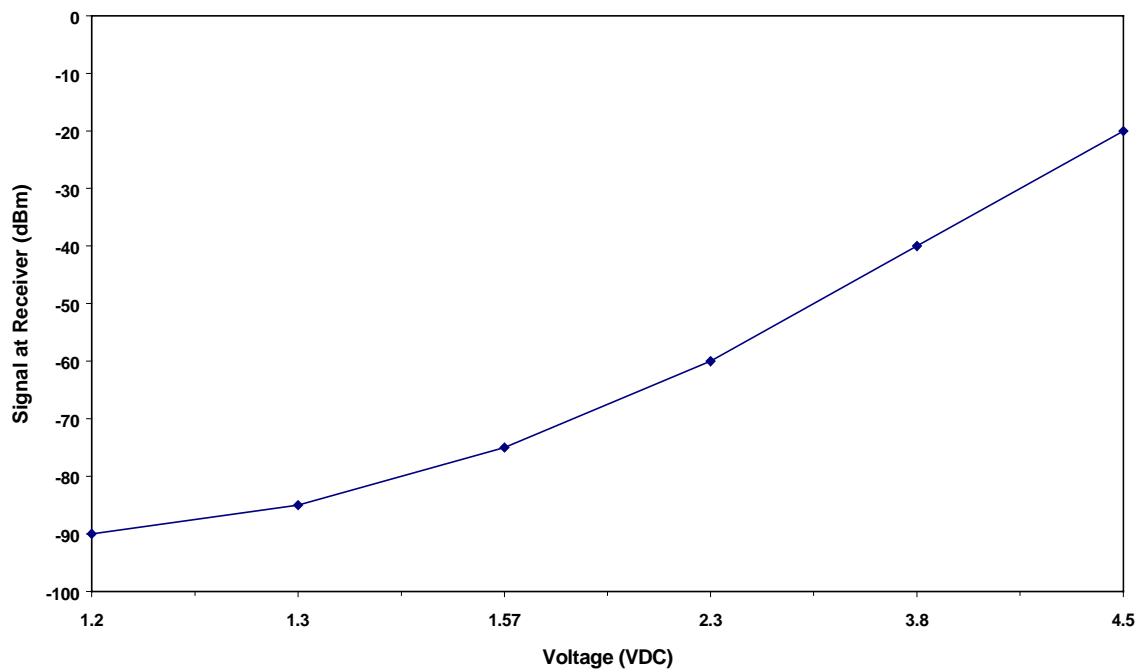
5.1.7 Wr_Ena (EEPROM Write Enable) (pin 14)

Wr_Ena is a direct connection to the Write Enable line on the EEPROM. When logic Low, the EEPROM's contents may be changed. When logic High, the EEPROM is protected from accidental and intentional modification. It is recommended that this line only be Low when an EEPROM write is desired to prevent unintentional corruption of the EEPROM.

5.1.8 UP_Reset (pin 15)

UP_Reset provides a direct connection to the reset pin on the AC4424 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 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 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 AC4424.

5.2.1 RF Architecture (Server-Client/Peer-to-Peer)

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.

In Server-Client architecture, the Server communicates with the Clients and the Clients **only** communicate with the Server. Enabling **Peer-to-Peer Mode** will allow all radios on the network to communicate with each other. **Note: All transceivers on the same network must have the same setting for Peer-to-Peer and there must still be one, and only one, Server present in a Peer-to-Peer network.**

5.2.2 RF Mode

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

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 AC4424 protocol parameter and its settings are as follows:

Table 7 – Sub Hop Adjust Settings

RF Mode	Sub Hop Adjust
Acknowledge	D0h
Stream	80h

5.2.4 Duplex Mode

In Half Duplex mode, the AC4424 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 160uS decrements. The actual timeout created by Interface Timeout is equal to the 2's complement of Interface Timeout times 160uS. The default value for Interface Timeout is F0H or 2.56ms.

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 110 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. <u>If the 9600_BAUD pin (Pin 12) is pulled logic Low at reset, the baud rate will be forced to 9,600</u>. For Baud Rate values other than those shown in **Table 5 - Baud Rate**, the following equation can be used:

$$\text{BAUD} = (18.432\text{E}+06/(32*\text{desired baud rate}))$$

BaudH= High 8 bits of BAUD (base16)
BaudL = Low 8 bits of BAUD (base16)

Table 8 – Baud Rate

Baud Rate	BaudL (42h)	BaudH (43h)	Minimum Interface Timeout (58h)
288,000	02h	00h	FFh
192,000	03h	00h	FFh
115,200	05h	00h	FEh
57,600	0Ah	00h	FDh
38,400	0Fh	00h	FCh
28,800	14h	00h	FBh
19,200	1Eh	00h	F9h
14,400	28h	00h	F7h
9,600	3Ch	00h	F2h
4800	78h	00h	E5h
2400	F0h	00h	CBh
1200	E0h	01h	97h
300	80h	07h	01h
110	74h	14h	01h

5.2.7 Network Topology

RF Channel Number – RF Channel Number provides a physical separation between co-located networks. The AC4424 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 AC4424. Frequency Offset is a protocol parameter used to satisfy unique international requirements. **Co-located networks must use the same Channel Set.**

Table 9 – US and International RF Channel Number Settings

Channel Set	RF Channel Number Range (40h)	Frequency Offset (46h)	Countries
0	00h – 0Fh	N/A	US,Canada
1	10h – 1Fh	0	US,Canada
2	20h – 2Fh	0	US,Canada
3	30h – 3Fh	2Eh	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 Auto Config

The AC4424 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 192,000 baud Stream Mode, 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 10 – Auto Config Parameters

| Parameter	Auto Config Value
RF Packet Size	40h
CTS On	C0h
CTS On Hysteresis	80h

6. Application Examples

TBD

7. Dimensions

All AC4424 products measure 1.65″W x 2.65″L. 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 – AC4424 with
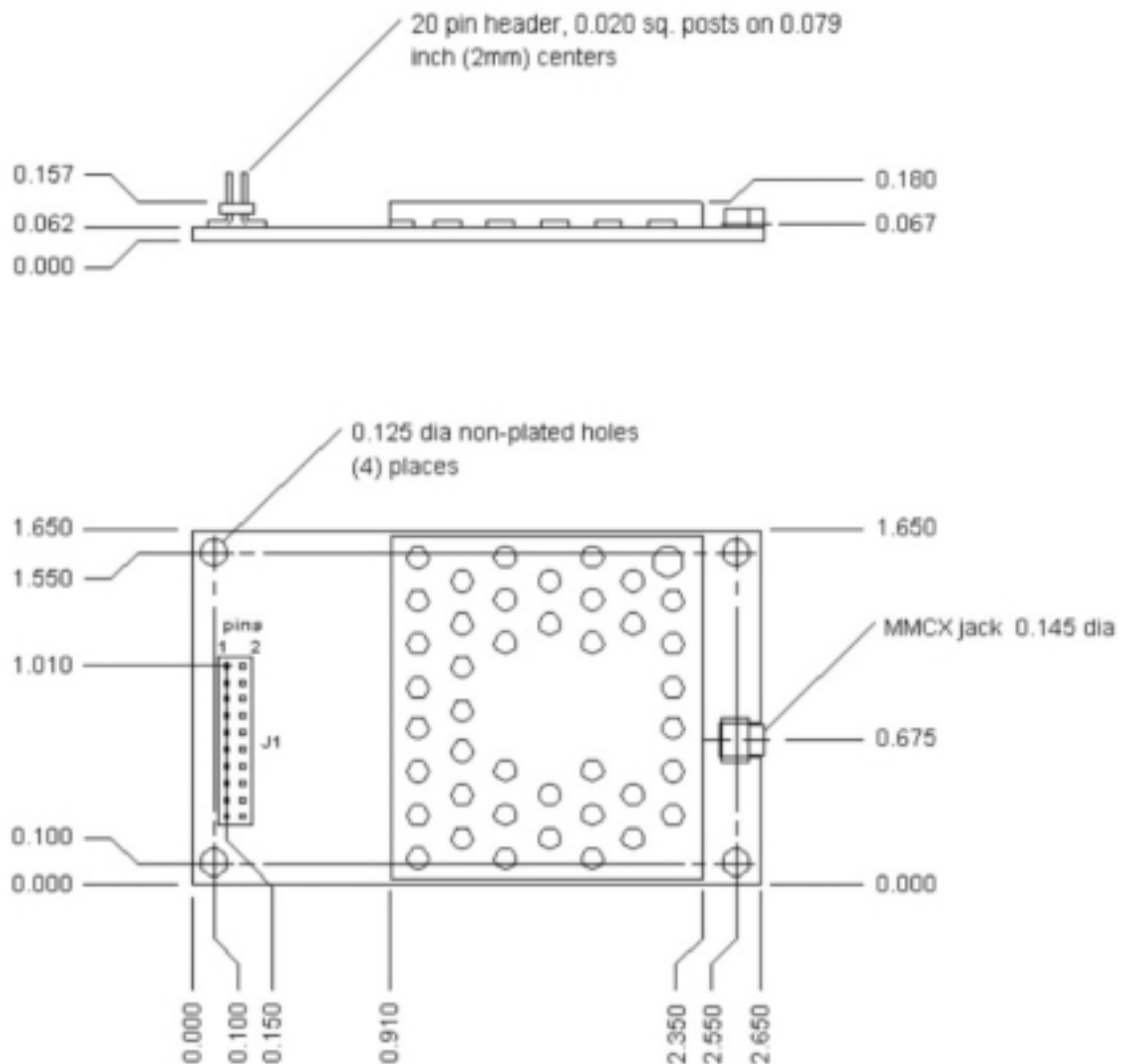
8. Ordering Information

8.1 PRODUCT PART NUMBERS

<u>**AC4424-10**</u>: AC4424 with 10mW output power, interface data rates to 288Kbps, MMCX antenna connector, -40°C to 80°C

<u>**AC4424-100**</u>: AC4424 with 50mW output power, interface data rates to 288Kbps, MMCX antenna connector, -40°C to 80°C

<u>**AC4424-200**</u>: AC4424 with 200mW output power, interface data rates to 288Kbps, MMCX antenna connector, -40°C to 80°C

8.2 DEVELOPER KIT PART NUMBERS

<u>**SDK-4424I-10**</u>: Includes (2) AC4424-10 transceivers, (2) RS232 Serial Adapter Boards, (2) 6Vdc unregulated power supplies, (2) Serial cables, (2) S151FL-5-RMM-2450S dipole antennas with 5″ pigtail and MMCX connector, configuration/testing software, Integration engineering support

<u>**SDK-4424I-100**</u>: Includes (2) AC4424-100 transceivers, (2) RS232 Serial Adapter Boards, (2) 6Vdc unregulated power supplies, (2) Serial cables, (2) S151FL-5-RMM-2450S dipole antennas with 5″ pigtail and MMCX connector, configuration/testing software, Integration engineering support

<u>**SDK-4424I-200**</u>: Includes (2) AC4424-200 transceivers, (2) RS232 Serial Adapter Boards, (2) 6Vdc unregulated power supplies, (2) Serial cables, (2) S151FL-5-RMM-2450S dipole antennas with 5″ pigtail and MMCX connector, configuration/testing software, Integration engineering support