LT4424-200

2.4 GHz OEM TRANSCEIVERS

Specifications Subject to Change

User's Manual
Version 1.0.0

11160 THOMPSON AVENUE
LENEXA, KS 66219
(800) 492-2320
www.lairdtech.com
wireless@lairdtech.com

Copyright Information

This material is preliminary

Information furnished by Laird Technologies in this specification is believed to be accurate. Devices sold by Laird Technologies are covered by the warranty and patent indemnification provisions appearing in its Terms of Sale only. Laird Technologies makes no warranty, express, statutory, and implied or by description, regarding the information set forth herein. Laird Technologies reserves the right to change specifications at any time and without notice.

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

Limited Warranty, Disclaimer, Limitation of Liability

For a period of one (1) year from the date of purchase by the OEM customer, Laird Technologies warrants the OEM transceiver against defects in materials and workmanship. Laird Technologies will not honor this warranty (and this warranty will be automatically void) if there has been any (1) tampering, signs of tampering; 2) repair or attempt to repair by anyone other than an Laird Technologies authorized technician.

This warranty does not cover and Laird Technologies will not be liable for, any damage or failure caused by misuse, abuse, acts of God, accidents, electrical irregularity, or other causes beyond Laird Technologies's control, or claim by other than the original purchaser.

In no event shall Laird Technologies be responsible or liable for any damages arising: From the use of product; From the loss of use, revenue or profit of the product; or As a result of any event, circumstance, action, or abuse beyond the control of Laird Technologies, whether such damages be direct, indirect, consequential, special or otherwise and whether such damages are incurred by the person to whom this warranty extends or third party.

If, after inspection, Laird Technologies determines that there is a defect, Laird Technologies will repair or replace the OEM transceiver at their discretion. If the product is replaced, it may be a new or refurbished product.

DOCUMENT INFORMATION

Revision	Description
Version 1.0.0	5/5/2009 – Initial Release Version

TABLE OF CONTENTS

Figures

Tables

LT4424 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 LT4424 is a member of Laird Technologies'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 LT4424 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 LT4424 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.

LT4424 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 288000 bps.
- Effective Data Transmission Rate – The LT4424 is a highly efficient, low-latency transceiver. The RF baud rate of the LT4424 is fixed at 576 kbps and is independent of the serial interface data rate.

This document contains information about the hardware and software interface between a Laird Technologies LT4424 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. LT4424 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
	LT4424-200:	115 mA	235 mA	385 mA	85 mA	15 mA
Channels (used to create independent networks)	US/Canada: (200 mW) 16 Channels					
Security	One byte System ID					
Interface Buffer Size	Input/Output: 256 bytes each					
RADIO						
Frequency Band	US/Canada (200mW): 2.402 – 2.478 GHz					
Radio Type	Frequency-Hopping Spread Spectrum					
Output Power (conducted, no antenna)	LT4424-200: 400mW typical					
Effective Isotropic Radiated Power (EIRP with 5dBi gain antenna)	LT4424-200: 1000mW typical					
Voltage	5V nominal ±2%, ±50mV ripple					
Sensitivity	-90dBm typical					
Range (based on dBi gain antenna)	LT4424-200: Indoors to 500 ft., Outdoors to 15000 ft.					
ENVIRONMENTAL						
Temperature (Operating) Industrial:	-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	LT4424-200: MMCX Jack					
Weight	Less than 0.7 ounce					

3. Specifications

3.1 INTERFACE SIGNAL DEFINITIONS

The LT4424 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. ***Note:** 9600_BAUD should only be used to recover the radio from an unknown baud rate and should not be used during normal operation. 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 Indicator - 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 LT4424 for power-on reset if left unconnected. After a Stable power-on (250ms) a 50us logic High pulse will reset the LT4424. 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

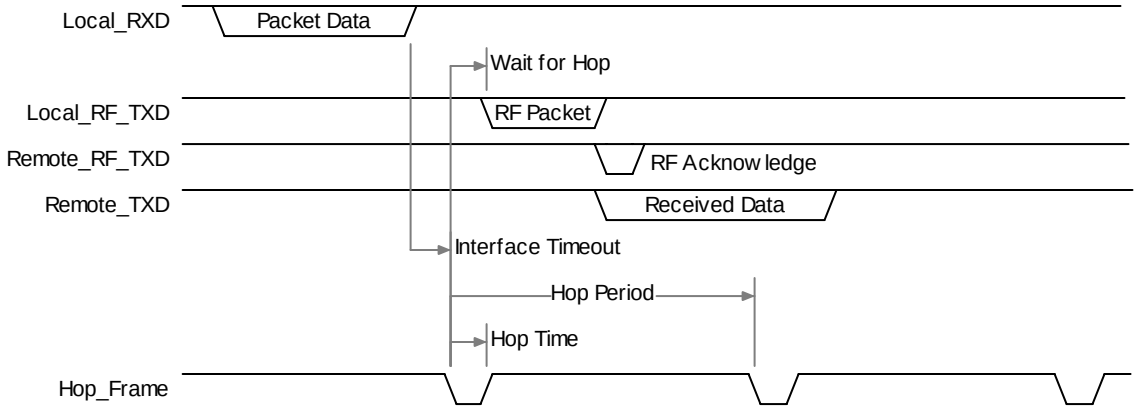
Care should be taken when selecting transceiver architecture as it can have serious effects on data rates, latency timings, and Overall System Throughput. The importance of these three characteristics will vary from system to system and should be a strong consideration when designing the system.

3.3.1 Serial Interface Data Rate

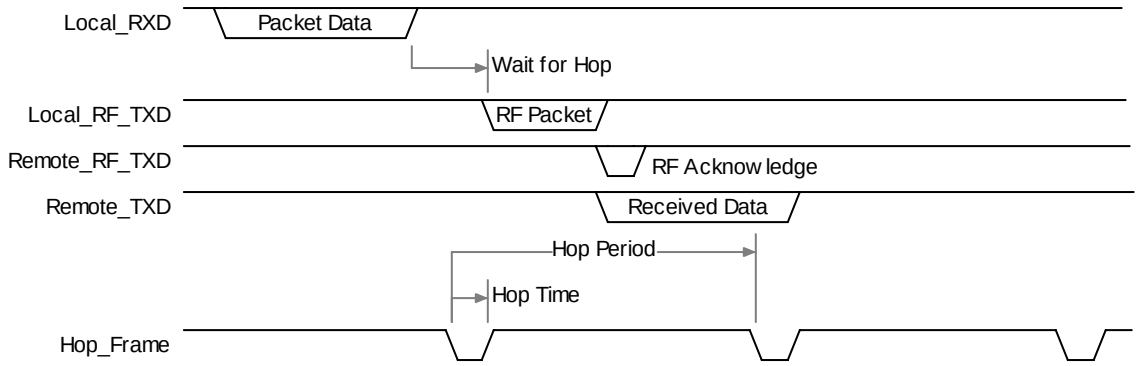
The Serial Interface Data Rate is programmable by the Host. This is the rate the Host and transceiver communicate over the serial bus. Possible values range from 110 bps to 288,000 bps. **The only supported mode is asynchronous – 8-bit, No Parity, 1 Start Bit, and 1 Stop Bit.**

3.3.2 Timing Diagrams

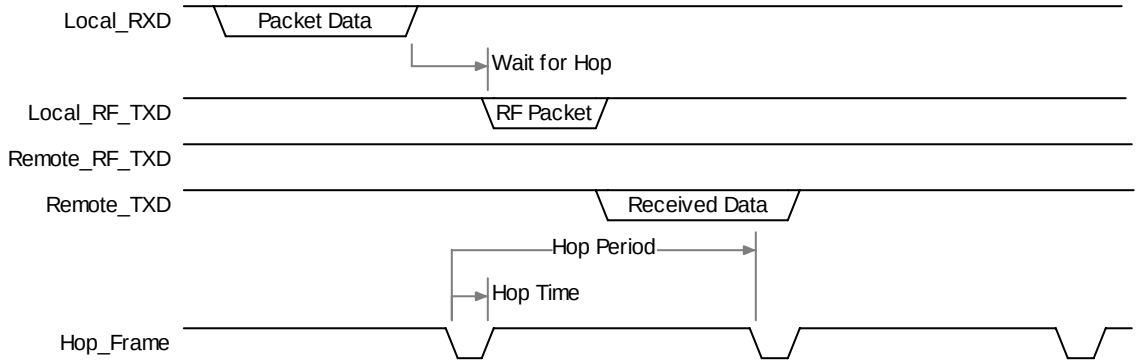
Addressed Acknowledge Mode with Interface Timeout:



Addressed Acknowledge Mode with No Interface Timeout:



Broadcast Acknowledge Mode with No Interface Timeout:



Broadcast Acknowledge Mode with Interface Timeout:

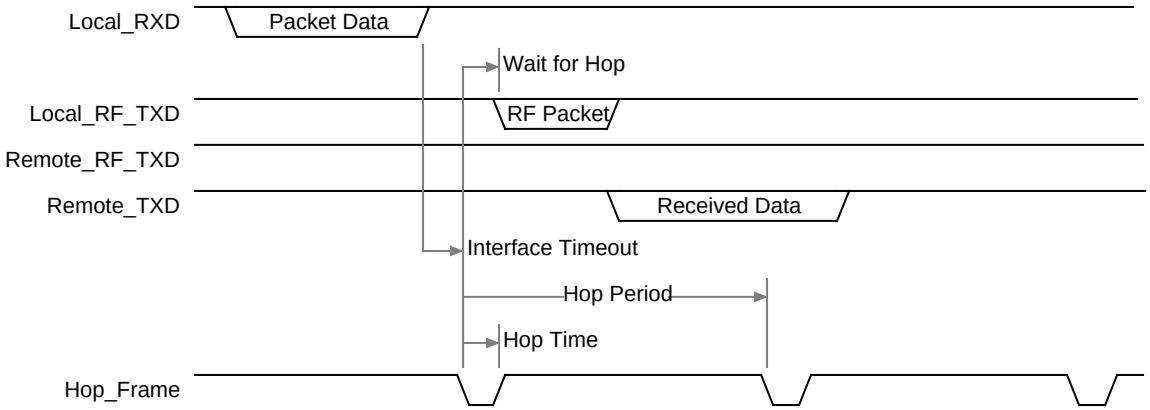


Table 4 – Timing Parameters

Parameter	Typical Time (ms)
Hop Time	1
Hop Period	8

3.3.3 Maximum Overall System Throughput

When configured as shown in the table below, an LT4424 transceiver is **capable** of achieving the listed throughput. However, in the presence of interference or at longer ranges, the transceiver may not be able to meet these specified throughputs.

Table 5 – Maximum Overall System Throughputs

RF Mode	Interface Baud Rate	Duplex	Direction	Throughput (bps)
Acknowledge	115200	Half	One way	80k
Acknowledge	115200	Full	Both ways	40k

4. Configuring the LT4424

4.1 EEPROM PARAMETERS

A Host can program various parameters that are stored in EEPROM and become active after a power-on reset. **Table 6 – EEPROM Parameters**, gives the locations and descriptions of the parameters that can be read or written by a Host. Factory default values are also shown. **Do not write to any EEPROM addresses other than those listed below. Do not copy a transceiver's EEPROM data to another transceiver. Doing so may cause the transceiver to malfunction.**

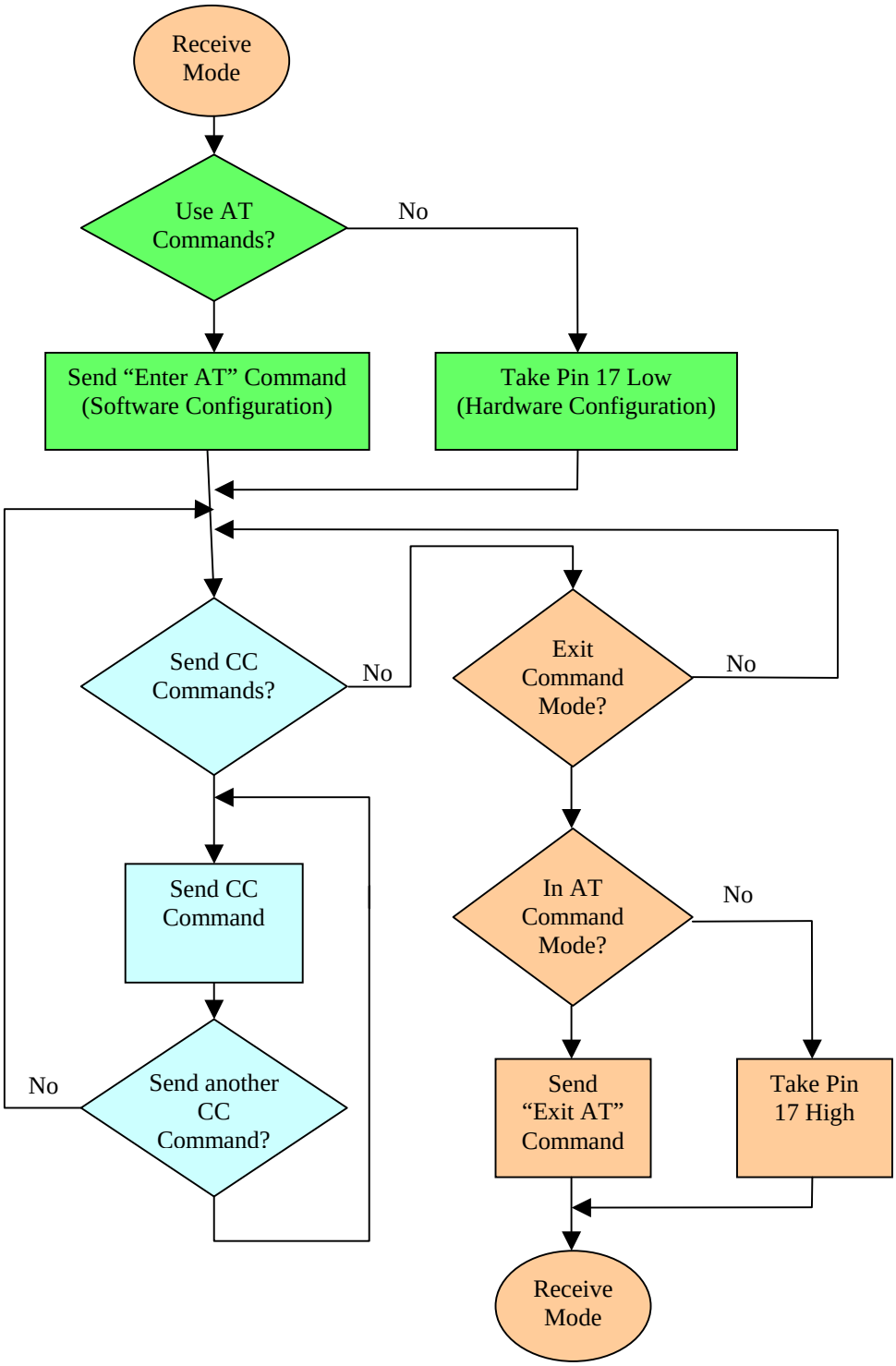
Table 6 – EEPROM Parameters

Parameter	EEPROM Address	Length (Bytes)	Range	Default	Description
Product ID	00H	40			40 bytes - Product identifier string. Includes revision information for software and hardware.
Channel Number	40H	1	00 – 0Fh	00h	Refer to Table 8
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 – **Laird Technologies Use Only** Bit 6 – **Laird Technologies Use Only** Bit 5 – Reserved (Set to Zero) Bit 4 – **Laird Technologies Use Only** Bit 3 – Packet Frame 0 = Disable Packet Frame 1 = Use pin 12 as Packet Frame Bit 2 – **Laird Technologies Use Only** Bit 1 – RF Delivery 0 = Addressed 1 = Broadcast Bit 0 – **Laird Technologies Use Only**
Transmit Retries	4CH	1	01 – FFh	10h	Maximum number of times a packet is sent out when Addressed Packets are selected.
Broadcast Attempts	4DH	1	01 – FFh	04h	Maximum number of times a packet is sent out when Broadcast Packets are selected.

Parameter	EEPROM Address	Length (Bytes)	Range	Default	Description
API Control	56H	1		01000011b = 43h	*Settings are:* Bit 7 – **Laird Technologies Use Only** Bit 6 – RF Architecture 0 = Server-Client 1 = Peer-to-Peer Bit 5 – **Laird Technologies Use Only** Bit 4 – Auto Destination 0 = Use Destination Address 1 = Automatically set Destination to Server Bit 3 – **Laird Technologies 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	Specifies a byte gap timeout, used in conjunction with RF Packet Size to determine when a packet coming over the interface is complete (160 μs per increment).
RF Packet Size	5BH	1	01 – 40h	40h	Used in conjunction with Interface Timeout; specifies the maximum size of an RF packet.
CTS On	5CH	1	01 – FFh	C0h	CTS will be deasserted (High) when the transmit buffer contains at least this many characters
CTS On Hysteresis	5DH	1	01 – FFh	80h	Once CTS has been deasserted, CTS will be reasserted (Low) when the transmit buffer contains this many or less characters.
Destination ID	70H	6		6 Bytes	Specifies destination for RF packets.
System ID	76H	1	00 – FFh	01h	Similar to network password. Radios must have the same System ID to communicate with each other.
MAC ID	80H	6		6 Bytes	Unique IEEE MAC Address
Random Backoff	C3h	1	00 - FFh	00h	00h = Disable Random Backoff 01h = Wait 1-2 packet times, then retry 03h = Wait 1-4 packet times, then retry 07h = Wait 1-8 packet times, then retry 0Fh = Wait 1-16 packet times, then retry 1Fh = Wait 1-32 packet times, then retry 3Fh = Wait 1-64 packet times, then retry 7Fh = Wait 1-128 packet times, then retry FFh = Wait 1-256 packet times, then retry

4.2 CONFIGURING THE LT4424 [1]

4.3



[1] Resetting the LT4424 at any time will exit Configuration or CC Command mode.

COMMAND REFERENCE

Command Name	Command (All Bytes in Hex)						Return (All Bytes in Hex)				
AT Enter Command Mode	41h	54h	2Bh	2Bh	2Bh	0Dh	CCh	43h	4Fh	4Dh	
Exit AT Command Mode	CCh	41h	54h		4Fh	0Dh	CCh	44h	41h	54h	
Status Request	CCh	00h	00h		—		CCh	Firmware Version	00h: Server In Range 01h: Client In Range 02h: Server Out of Range 03h: Client Out of Range		
Change Channel with Forced Acquisition	CCh No	02h	New Channel		—		CCh	New Channel	—	—	
Server/Client	CCh	03h	00h – Server in Normal Operation 01h – Client in Normal Operation 02h – Server in Acquisition Sync 03h – Client in Acquisition Sync				CCh	Firmware Version	00h – Server in Normal Operation 01h – Client in Normal Operation 02h – Server in Acquisition Sync 03h – Client in Acquisition Sync		
Power-Down	CCh	06h	—		—		CCh	Channel	—	—	
Power-Down Wake-Up	CCh	07h	—		—		CCh	Channel	—	—	
Broadcast Mode	CCh	08h	00h: Addressed 01h: Broadcast -		CCh		00h or 01h	—	—		
Write Destination Address	CCh	10h	Byte 4 of destination's MAC				Byte 5 of destination's MAC	Byte 6 of destination's MAC	CCh	Byte 4 of destination's MAC	Byte 5 of destination's MAC
Read Destination Address	CCh	11h	—		—	CCh	Byte 4 of destination's MAC	Byte 5 of destination's MAC	Byte 6 of destination's MAC	Byte 6 of destination's MAC	
EEPROM Byte Read	CCh	C0h	Start Address		Length (01h – 80h)		CCh	Start Address	Length	Data at Addresses	
EEPROM Byte Write	CCh	C1h	Address		Length (01h)		Data to be Written	Address	Length (01h)	Data Written	
Soft Reset	CCh	FFh				CCh	FFh				

4.4 LT4424 AT COMMANDS

The AT Command mode implemented in the LT4424 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 10 ms 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.

NOTE: The RF packet size must be set to a minimum of 6 bytes in order to enter Command mode using the Enter AT Command mode command.

4.4.1 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 will be 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 OEM Host must also ensure that the RF Packet Size for the transceiver is set to a minimum of six.** The Enter AT Command mode command is as follows:

OEM Host Command:

41h	54h	2Bh	2Bh	2Bh	0Dh

Transceiver Response:

CCh	43h	4Fh	4Dh

4.4.2 Exit AT Command Mode

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

OEM Host Command:

CCh	41h	54h	4Fh	0Dh

Transceiver Response:

CCh	44h	41h	54h

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

The LT4424 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.

The EEPROM parameters and a Command Reference are available in **Section 4, Configuring the LT4424**, of this manual.

4.5.1 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

4.5.2 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)

4.5.3 Server/Client

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 = Firmware Version Number
Byte 3 = Data1

Where:
Data1 = Data1 from Host Command

4.6 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

4.7 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 to the three LSB's of the destination MAC Address

Transceiver Response:

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

4.8 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 to the three LSB's of the destination MAC Address

4.9 EEPROM BYTE READ

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

OEM Host Command:

Byte 1 = CCh
Byte 2 = C0h
Byte 3 = Start Address
Byte 4 = Length (01 - 80h)

Transceiver Response:

Byte 1 = CCh
Byte 2 = Start Address
Byte 3 = Length
Byte 4…n = Data at requested addresses

4.10 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 not allowed. **Caution: The maximum number of write cycles that can be performed is 100,000.**

OEM Host Command:

Byte 1 = CCh
Byte 2 = C1h
Byte 3 = Address
Byte 4 = Length (01h)
Byte 5…n = Data to store at Address

Transceiver Response:

Byte 1 = Address
Byte 2 = Length (01h)
Byte 3 = Data byte written by this command

4.11 RESET

The OEM Host issues this command to perform a soft reset of the transceiver (same effect as using the Reset pin). Any transceiver settings modified by CC Commands (excluding EEPROM writes) will be overwritten by values stored in the EEPROM.

OEM Host Command:

Byte 1 = CCh
Byte 2 = FFh

Transceiver Response:

Byte 1 = CCh
Byte 2 = FFh

5. Theory of Operation

5.1 HARDWARE INTERFACE

Below is a description of all hardware pins used to control the LT4424.

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

The LT4424 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 LT4424 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 LT4424 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.

9600_BAUD should only be used to recover the radio from an unknown baud rate and should not be used during normal operation. When 9600_BAUD is pulled logic Low, Broadcast Mode is disabled.

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.

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 LT4424 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 50 μs.

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, Configuring the LT4424)**.

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 5 seconds, 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 LT4424.

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

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** 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.

5.2.3 Random Back Off

Random Back Off – If multiple LT4424 transceivers try to send packets out over the RF at the exact same time, the packets will collide and will not be received by the intended receiver. In fact, if after a collision occurs, both transceivers retry at the same time, the retry will also fail. To avoid further collisions, a transceiver can be programmed to wait a random number of packet times (hops) before resending its data. The amount of randomness is controlled by this parameter. Keep in mind that selecting a larger value for Random Back Off will increase the overall latency of the LT4424. The latency calculation becomes:

Worst Case Latency = 8 ms Hop * # of retries * Maximum Random Value

[multiply by 16 ms if using Full Duplex mode]

Latency is a very important consideration when using a wireless device. The LT4424 has a 256 byte interface buffer. If, due to latency, the radio cannot send the data out over the RF as fast as data is coming into the radio over the serial interface, the buffer will eventually fill up. If data continues coming into the radio once the buffer is full, the buffer will overflow and the new incoming data will be lost. It is strongly recommended that the radio host monitor the CTS pin to avoid this situation. The transceiver asserts this pin high as the buffer is filling to signal the OEM Host to stop sending data. The transceiver will take CTS Low once the buffer becomes less full.

Random Backoff Settings:

- 00h – Wait 1 packet time, then retry (Random Back Off is disabled)
- 01h – Wait 1 – 2 packet times, then retry
- 03h – Wait 1 – 4 packet times, then retry
- 07h – Wait 1 – 8 packet times, then retry
- 0Fh – Wait 1 – 16 packet times, then retry
- 1Fh – Wait 1 – 32 packet times, then retry
- 3Fh – Wait 1 – 64 packet times, then retry
- 7Fh – Wait 1 – 128 packet times, then retry
- FFh – Wait 1 – 256 packet times, then retry
-

5.3 DUPLEX MODE

In Half Duplex mode, the LT4424 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. 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.

5.4 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.

5.5 SERIAL INTERFACE BAUD RATE

This two-byte value determines the baud rate used for communicating over the serial interface to a transceiver. **Table 7 - Baud Rate** 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. **If the 9600_BAUD pin (Pin 12) is pulled logic Low at reset, the baud rate will be forced to 9,600.** For Baud Rate values other than those shown in **Table 7 - Baud Rate**, the following equation can be used:

BAUD = (18.432E+06/(32*desired baud rate))

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

Table 7 – Baud Rate

Baud Rate	BaudL (42h)	BaudH (43h)	Minimum Interface Timeout (58h)
288000	02h	00h	FFh
192000	03h	00h	FFh
115200	05h	00h	FEh
57600	0Ah	00h	FDh
38400	0Fh	00h	FCh
28800	14h	00h	FBh
19200	1Eh	00h	F9h
14400	28h	00h	F7h
9600	3Ch	00h	F2h
4800	78h	00h	E5h
2400	F0h	00h	CBh
1200	E0h	01h	97h
300	80h	07h	01h
110	74h	14h	01h

~~5.2.9~~*Auto Config*

The LT4424 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 115200 baud Acknowledge Mode and all lower baud rates. It should only be disabled with recommendation from Laird Technologies.** Below is a list containing some of the variables affected by Auto Config and their respective values:

Table 8 – Auto Config Parameters

Description[2]	EEPROM Address	Default	Acknowledge Mode
	47	5	5
	48	60	60
	4E	8	9
	50	FD	FD
	51	2	2
	52	0	0
	53	E4	E4
	54	5	5
	55	50	50
	57	7	7
	59	4	4
RF Packet Size	5B	40	40
CTS On	5C	C0	C0
CTS Hysteresis	5D	80	80
	5E	0E	0E
	5F	3	3

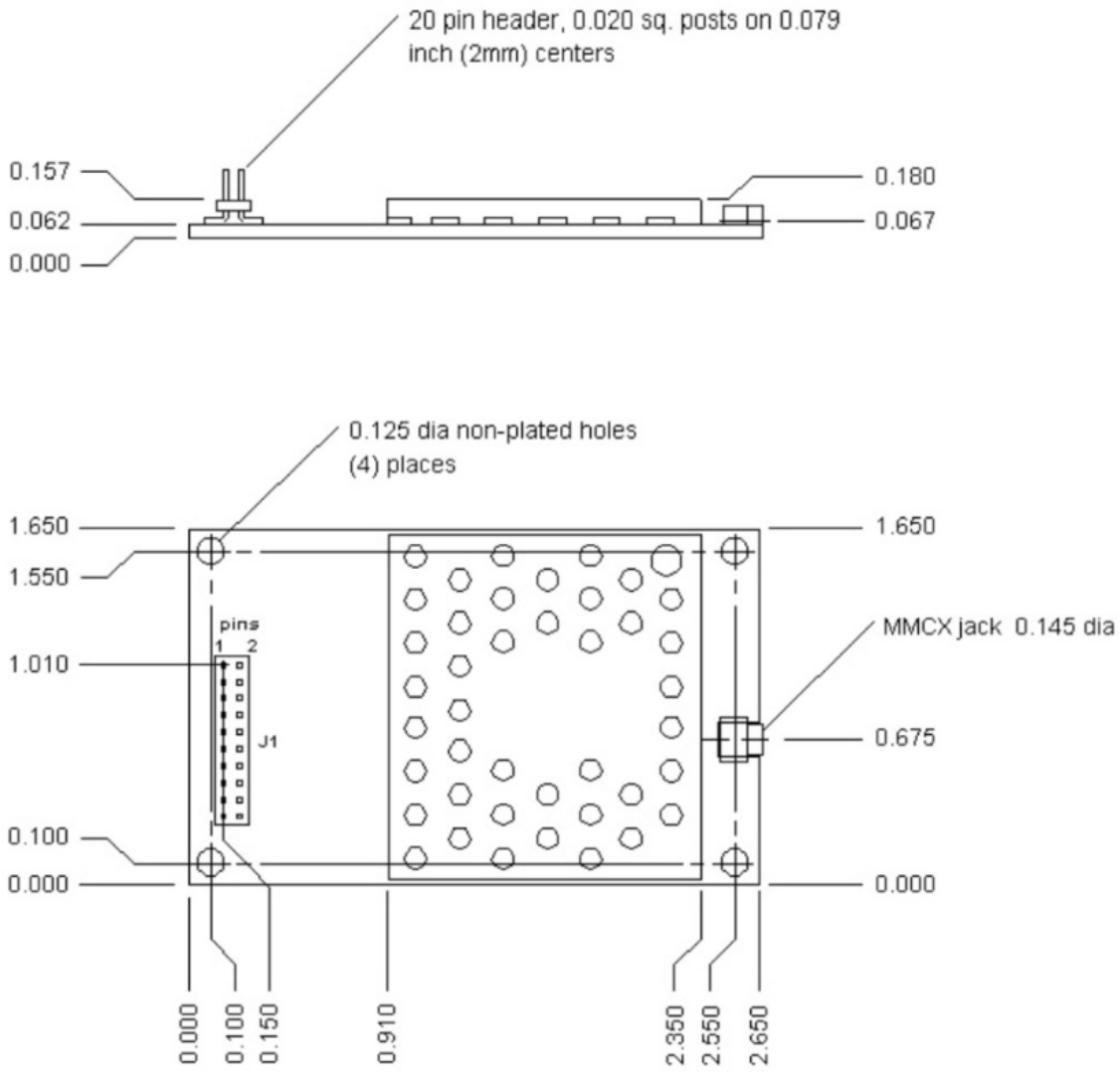
[2] Parameters without a Description are undocumented protocol parameters and should only be modified to a value other than shown in this table when recommended by Laird Technologies.

6. Dimensions

The LT4424 measures 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 (Johnson Components P/N 135-3711-822) mates with any manufacturer's MMCX plug

Figure 1 – LT4424 with MMCX



7. Ordering Information

7.1 Product Part Numbers

LT4424-200: LT4424 with 400 mW output power, interface data rates to 288 Kbps, MMCX antenna connector, -40°C to 80°C

7.2 Developer Kit Part Numbers

SDK-4424-200: Includes (2) LT4424-200 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

8. Regulatory Information

8.1 AGENCY IDENTIFICATION NUMBERS

Part Number	US/FCC	CANADA/IC
LT4424-200	KQL-4424200	2268C-4424200

~~8.3~~APPROVED ANTENNA LIST

Item	Part Number	Mfg.	Type	Gain (dBi)
1	MFB24008	Maxrad	Omni	8
2	NZH2400-MMCX	Laird Technologies	Microstrip	1
3	ID2450-RS36[2]	Laird Technologies	Panel	9
4	S151FC-L-(132)PX-2450S	Nearson	Dipole	5

1. The OEM is free to choose another vendor's antenna of like type and equal or lesser gain as an antenna appearing in the table and still maintain compliance.

~~8.3~~8.2 FCC/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 20 cm of the transmitting antenna. Portable equipment is further broken down into two classes; within 2.5 cm of human contact and beyond 2.5 cm. The LT4424 not agency approved for portable applications. The OEM is required to have additional testing performed to receive this classification. Contact Laird Technology for more details.

Mobile – Mobile defines equipment where the user will be 20 cm or greater from the transmitting equipment. 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.

This equipment has been approved for mobile applications where the equipment should be used at distances greater than 20 cm from the human body. Operation at distances of less than 20 cm would require additional RF exposure evaluation, including SAR requirement according to FCC RF Exposure guideline.

NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does not cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user in encouraged to try to correct the interference by one or more of the following measures:

- Re-orient or relocate the receiving antenna
- Increase the separation between the equipment and the receiver
- Connect the equipment to an outlet on a circuit that is different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

8.3 OEM EQUIPMENT LABELING REQUIREMENTS

WARNING: The 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 Laird Technology FCC identifier for this product as well as the FCC notice below. The FCC identifiers are listed above.

Contains FCC ID:KQL-4424200 This enclosed device complies with Part 15 of the FCC Rules, Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) This device must accept any interference received, including interference that may cause undesired operation

Label and text information should be in a size of type large enough to be readily legible, consistent with the dimensions of the equipment and the label. However, the type size for the text is not required to be larger than eight point.

8.4 ANTENNA REQUIREMENTS

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

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

Caution: Any changes or modifications not expressly approved by Laird Technology could void the user's authority to operate the equipment.

8.5 WARNINGS REQUIRED IN OEM MANUALS

WARNING: This equipment has been approved for mobile applications where the equipment should be used at distances greater than 20cm from the human body. Operation at distances of less than 20cm is strictly prohibited and requires additional SAR testing.