LX2400S Transceiver
PRELIMINARY
Specifications Subject to Change

Hardware and Software
Interface Specification
Version 3.3

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AGENCY APPROVAL OVERVIEW

	US/FCC	CAN/IC	EUR/EN**	Portable	Mobile	Fixed
LX2400-3	X	X	X	X	X	X
LX2400-10	X	X	X	X	X	X
LX2400-150	X	X			X-30cm	X-30cm

** Does not include France and Spain
Note: The product approvals above are with antennas specified below.

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 "Contains Transmitter Module FCC ID: KQL-LX2400", as well as the FCC Notice above.

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

Manufacturer	Part Number	Type	Gain	Application*	LX2400-3	LX2400-10	LX2400-150
Centurion	WCP-2400-MMCX	¼ Wave Dipole	2dBi	P/M/F		X	X
Maxrad	Z986	Patch	2.5dBi	F			X
AeroComm	NZH2400-MMCX (External)	Microstrip	1dBi	P		X	X
AeroComm	NZH2400-I (Integrated)	Microstrip	1dBi	P	X		
Nearson	S131CL-5-RMM-2450S	¼ Wave Dipole	2dBi	P/M/F		X	X
Nearson	S181FL-5-RMM-2450S	¼ Wave Dipole	2dBi	P/M/F		X	X
Nearson	S191FL-5-RMM-2450S	¾ Wave Dipole	3dBi	M/F		X	X

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

RF EXPOSURE LX2400-3 AND LX2400-10

WARNING: The LX2400-3 and LX2400-10 have been tested to ensure compliance with FCC SAR exposure limits. Any alterations to the product including use of antennas other than those specified in the table above will require the Original Equipment Manufacturer (OEM) to ensure that this product, when integrated, meets FCC SAR exposure limits.

RF EXPOSURE LX2400-150

WARNING: The LX2400-150 is approved only for mobile and base station applications. To satisfy FCC RF exposure requirements for mobile and base station transmitting devices, a separation distance of 30cm 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 OVERVIEW

Antenna Manufacturer	Part Number	Type	Gain	Application*	SAR Specifications with Body Tissue (W/Kg)		MinimumRF Exposure Distance (cm)
					LX2400-3	LX2400-10	LX2400-150
Centurion	WCP-2400-MMCX	¼ Wave Dipole	2dBi	P/M/F	N/A	0.400	30
Maxrad	MC2400	Patch	2.5dBi	F	N/A	N/A	30
AeroComm	NZH2400-MMCX (External)	Microstrip	1dBi	P	N/A	0.308	30
AeroComm	NZH2400-I (Integrated)	Microstrip	1dBi	P	0.057	N/A	N/A
Nearson	S131CL-5-RMM-2450S	¼ Wave Dipole	2dBi	P/M/F	N/A	0.265	30
Nearson	S181FL-5-RMM-2450S	¼ Wave Dipole	2dBi	P/M/F	N/A	0.189	30
Nearson	S191FL-5-RMM-2450S	¾ Wave Dipole	3dBi	M/F	N/A	0.118	30

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

Revisions	***Description***
Version 1.0	Initial Release Version - 01/20/2000
Version 2.0	Not Released
Version 3.0	Release Version - 2/15/2000 Full Document Update – major changes: 1. The Transmit Sync byte has been changed 2. The previous version called out RTS rather than TE for the Transmit Enable pin. This has been corrected
Version 3.1	Release Version - 5/23/2000 1. Corrected Serial Interface data rate to 57,600bps maximum 2. Add specifications on LX2400S-10 and LX2400S-10A 3. Add ordering information
Version 3.2	Release Version - 8/1/2000 1. Corrected RF data rate to 144,000bps maximum 2. Corrected Frequency band to 2.402GHz – 2.478GHz 3. Added new column to Table 2. Now shows 3mW & 10mW defaults 4. Corrected hop time from 120ms to 100ms 5. Added current consumptions specifications for LX2400S-10(A) 6. Changed Input Voltage tolerance from 5% to 2% 7. Updated Table 2 with new Control Bit definitions 8. Updated Section 3.2.6.1.5 to include Control Bit definitions 9. Updated FCC section.
Version 3.3	Release Version - 9/14/2000 1. Update approved antenna table and Agency Requirements 2. Correct product and developer kit part numbers

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LX2400S FEATURES

- Simple 5V TTL level serial interface for fast integration
- Integrated Antenna saves space and reduces cost
- 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

1. Overview

The LX2400S 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 LX2400S 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 LX2400S. An on-board antenna is integrated into the transceiver in the LX2400S-3. This antenna has coverage and gain similar to a dipole antenna.

LX2400S operate in a Point-to-Point or Point-to-Multipoint, Client/Server architecture. One transceiver is configured as a Server; there can be one or many Clients. To establish synchronization between radios, the Server emits a beacon, upon detecting the beacon, the Client transceiver informs the Client Host and an RF link is established.

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

- Serial Interface Data Rate – The LX2400S, when interfaced to an AeroComm RS232 interface board in the SDK (or one provided by the OEM) can be configured at popular PC serial port baud rates up to 19,200bps on the LX2400S-3 and 57,600bps on the LX2400S-10 and 115,200bps ont the LX2400S-150.
- RF Data Rate – The LX2400S transmits data over the air at a gross rate of 144,000bps.
- Effective Data Transmission Rate – The LX2400S is a highly efficient, low-latency transceiver. See Section 3.2.7 for more information.

This document contains information about the hardware and software interface between an AeroComm LX2400S transceiver and an OEM Host. Information includes the theory of operation, specifications, interface definition, and mechanical drawing.

The OEM must provide the Host hardware and software to control the radio. Certain timing considerations must be followed. The OEM is responsible for ensuring the final product meets all FCC and/or appropriate regulatory agency requirements before selling any product.

2. LX2400S Specifications

GENERAL	
Interface	20 pin mini-connector, See mechanical drawing.
Serial Interface Data Rate (See 3.2.6.1.3 & 3.2.6.1.4)	LX2400S-3A, PC Baud rates up to 19,200bps LX2400S-10, PC Baud rates up to 57,600bps LX2400S-150, PC Baud rates up to 115,200bps
Power Consumption Transmit/Receive	LX2400S-3A, 100mA/80mA typical LX2400S-10, 115mA/115mA typical LX2400S-150, 400mA/115mA typical
Channels (used to create independent networks)	10
Security	Host Defined
RADIO	
Frequency Band	2.402 – 2.478 GHz
Radio Type	Spread Spectrum Frequency Hopping
Output Power (Conducted, no antenna)	LX2400S-3A, 2.5mW typical LX2400S-10, 11.0mW typical LX2400S-150, 147.9mW typical
Effective Radiated Isotropic Power (EIRP with Highest Gain Antenna)	LX2400S-3A, 3.1mW typical LX2400S-10, 25.1mW typical LX2400S-150, 288.4mW typical
Voltage	5V nominal $\pm$2%, $\pm$ 50mV ripple
Sensitivity	-90dBm typical
RF Data Rate	144Kbps
Range	LX2400S-3A, Indoors to 100 ft., Outdoors to 500 ft. LX2400S-10, Indoors to 300 ft., Outdoors to 3000 ft. LX2400S-150, Indoors to 500 ft., Outdoors to 5000 ft.
PLL Lock Time	500 us typical
ENVIRONMENTAL	
Temperature (Operating)	0 °C to +70 °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	LX2400S-3A, Integrated dipole LX2400S-10, MMCX Jack LX2400S-150, MMCX Jack
Weight	Less than 0.5 ounce

3. Theory of Operation

3.1 Interface Signal Definition

The LX2400S has a simple interface that allows OEM Host communications with the transceiver. Table 1 shows the connector pin numbers and associated functions. The I/O direction is also shown. The direction is with regard to the transceiver. All I/O is 5Vdc TTL level signals except for RSSI. All outputs are weakly pulled high (20k – 50k ohms) when left unconnected and are driven high at reset.

Table 1 – Connector J1 Pin Definitions

Pin	TYPE	Signal Name	Function
1	O	DCD	Not Implemented
2	O	TXD	Transmitted data out of the transceiver
3	I	RXD	Data input to the transceiver
4	I	DTR	Not Implemented
5	GND	GND	Signal Ground
6	O	DSR	HOP FRAME/Data Set Ready – 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. This is in response to a valid TE signal. A Client will not respond with CTS if it is not in range of a Server.
8	I	RTS	Not Implemented
9	O	RI	Not Implemented
10	PWR	VCC	5V $\pm$ 2%
11	PWR	VCC	5V $\pm$ 2%
12	I	TST_MODE	Test Mode 1. When pulled low before applying power the transceiver's serial interface is forced to a 9600,8,N, 1 rate. 2. When pulled low and the CONFIGURATION START BYTE command (See 3.2.6.2.1) is sent to the transceiver, Configuration Mode is entered to read and write parameters in EEPROM
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 low it allows the Host to write the on-board EEPROM.
15	I	UP_RESET	RESET – Controlled by the LX2400S for power-on reset if left unconnected. After a Stable power-on (4ms) A 10us high pulse will reset the LX2400S.
16	GND	GND	Signal Ground
17	I	TE	Transmit Enable – When pulled low, the transceiver switches to transmit mode and will respond with CTS when data can be transmitted by the Host.
18	I	RE	Radio Enable – When the RADIO_ENABLE_ENABLED control bit is set in EEPROM the transceiver will only allow Host communications/control when this line is pulled low. If the RADIO_ENABLE_ENABLED control bit is cleared, the transceiver ignores this input.
19	O	PLL_LOCK	Factory Use Only – NC
20	O	IN_RANGE	In Range – Active Low when a Client radio is in range of a Server on the same channel.

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

3.2 Host Software/Hardware Interface Definition

3.2.1 Host Transmit Frame Format

The LX2400S requires the following format in order to transmit a Host's data packet over the RF link. The frame consists of 3 bytes of preamble, 1 sync byte, a 16-bit length, and user data.

Byte 0 – 055H – preamble
Byte 1 – 055H – preamble
Byte 2 – 055H – preamble
Byte 3 – 03AH – sync
Byte 4 – Length High (bits 15-8)
Byte 5 – Length Low (bits 7-0)
Byte 6 – First byte Host Data
Byte n – Last byte Host Data

Length High/Length Low is a 16-bit length value that represents the length of bytes 6 through n inclusive. Both byte and packet gap times must be followed as specified in Table 4. The maximum transmit time is 20ms. The maximum length depends on the Host's Byte and Byte-Gap timing.

3.2.2 Host Receive Frame Format

The LX2400S transmits received RF data, beginning with the Length Bytes, to the Host following the reception of a valid preamble. The preamble and the sync bytes are not transmitted to the Host.

Byte 0 – Length High
Byte 1 – Length Low
Byte 2 - First byte Host Data
Byte n – Last byte of Host Data

3.2.3 Hopping Status

If the SW_HOP_FRAME_ENABLE bit is set in EEPROM, The LX2400S sends an XOFF character to the Host when it is ready to hop. Following the completion of the hop, the LX2400S sends an XON character to inform the Host that the hop is completed. The Host must parse these bytes and assume if transmitting a packet, the data did not reach the destination(s) and re-transmit the packet.

XOFF = 0E2H	Transmitted at the start of a frequency hop.
XON = 0ACH	Transmitted at the completion of a frequency hop.

The Host can also detect hopping status by monitoring the DSR pin on the connector. The DSR pin is always enabled.

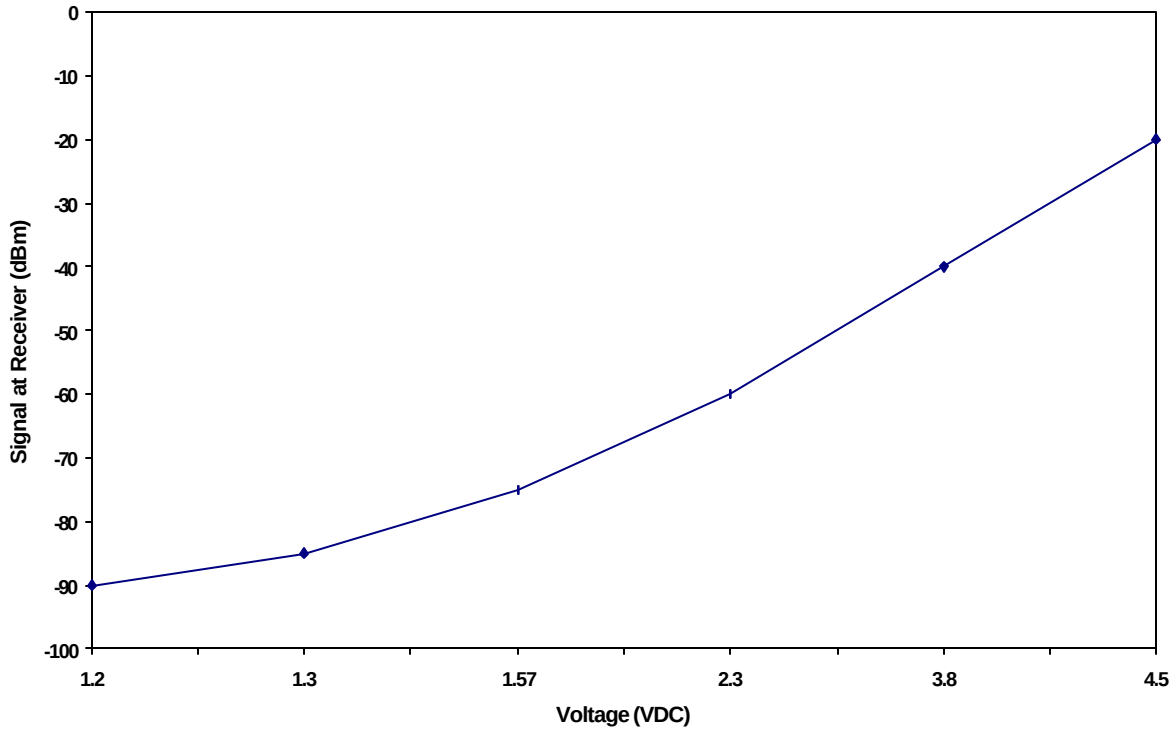
3.2.4 In Range

The IN_RANGE pin at the connector will be driven low when a Client radio is in range of a Server on the same channel. If the Client cannot hear a LX2400S Server for 10 S, the LX2400S Client drives the IN_RANGE pin high and enters a search mode looking for a LX2400S Server. As soon as it detects a Server, the IN_RANGE pin will be driven low. The LX2400 Server can determine what Clients are in range by the Server's Host software polling the LX2400S Client's Host.

3.2.5 RSSI

Received Signal Strength Indicator is used by the Host as an indication of instantaneous signal strength at the receiver. The Host must calibrate RSSI without a signal being presented to the receiver. Figure 1 shows approximate RSSI performance. The RSSI pin requires the Host to provide a 27kΩ pull-down to ground. Output is 1.20V to 4.50V.

Figure 1 - RSSI Voltage vs. Received Signal Strength



3.2.6

3.2.6 LX2400S Configuration Parameters and Commands

3.2.6.1 Configuration Parameters

The Host can program various parameters. The data is stored in EEPROM and becomes active on the next power on reset of the LX2400S. Table 2 gives the locations and functions of the parameters that can be read or written by the Host. Factory default values are also shown.

Note: Non-Host parameters are used in the EEPROM. The Host must only write to the locations in Table 2. Any other location may cause the radio to malfunction.

Table 2 – Configuration Parameters

PARAMETER	EEPROM ADDRESS	DEFAULT 3mW	DEFAULT 10mW	FUNCTION
TYPE	**41H**	**02H**	**02H**	**Determines if the transceiver is acting as a Client or Server.** **01H = Server** **02H = Client**
CHANNEL	**40H**	**00H**	**00H**	**Programmed channel** **CHANNEL = 00H to 09H**
BAUDH	**43H**	**00H**	**00H**	**The High Byte of the programmed baud rate.**
BAUDL	**42H**	**1EH**	**0AH**	**The Low Byte of the programmed baud rate**
TIMEOUT	**53H**	**FEH**	**FEH**	**Serial Byte Gap Timeout Value**
CONTROL	**45H**	**10H**	**10H**	**Radio Control Byte:** **Bit 7 - Not used - RESERVED (Always 0)** **Bit 6 – BEACON_ALWAYS** **0 = Server beacons after 2.5 seconds of inactivity** **1 = Server sends beacon after every hop** **Bit 5 - Not used - RESERVED (Always 0)** **Bit 4 - Not used - RESERVED (Always 1)** **Bit 3 – DATA_FRAME** **0 = Disable packet frame** **1 = Enable packet frame** **Bit 2 - Not used - RESERVED (Always 0)** **Bit 1 – RADIO_ENABLE_ENABLED** **0 = Disable RE** **1 = Enable RE** **Bit 0 – SW_HOP_FRAME_ENABLE** **0 = Disable XON/XOFF** **1 = Enable XONXOFF**

3.2.6.1.1 TYPE parameter

The TYPE byte tells the transceiver to operate in Client or Server mode. See Section 4 for more detail on the usage of this parameter.

3.2.6.1.2 CHANNEL parameter

The LX2400S can be programmed to one of ten different channels. Client mode transceivers will receive and transmit to a Server on the same channel as programmed. Servers will receive and transmit to Clients on the same channel as programmed. CHANNEL can be programmed with a value ranging from 0 to 9.

3.2.6.1.3 BAUDRATE parameter

This two-byte value determines the baud rate used for communicating over the serial interface to the LX2400S. TABLE 3 lists values for some popular baud rates. Baud rates below 1200 are not supported. When programming a baud rate the Host must program the associated TIMEOUT value. This value is not used if the TST_MODE line on the connector is pulled low at reset. The baud rate will be forced to 9600.

For Baud Rate values other than shown in Table 3, the following equations 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)

3.2.6.1.4 TIMEOUT parameter

The TIMEOUT value is the amount of time the LX2400S will allow between bytes when receiving serial bytes from the Host and receiving bytes on the RF link. It is equal to between two and four byte times. TIMEOUT can always be less than the value specified or calculated, but, never greater.

Table 3 – Baud Rate/Timeout

BAUDRATE	BAUDH	BAUDL	TIMEOUT
57600*	00H	0AH	FDH
38400*	00H	0FH	FCH
28800*	00H	14H	FBH
19200	00H	1EH	F9H
14400	00H	28H	F7H
9600	00H	3CH	F3H
4800	00H	78H	E7H
2400	00H	F0H	CEH
1200	01H	E0H	9CH

* Not Available with LX2400S-3A

For Timeout values other than shown in Table 3, the following equations can be used:

IBT = 10/desired baud rate
TIMEOUT = (base16) High 8 bits of [2^16-(24/18.432E+06/IBT)]

3.2.6.1.5 CONTROL parameter

The individual bits in the control byte alter the operation of the LX2400S. The Bit definitions follow:

Bit 0 – Controls if the LX2400S sends XON and XOFF characters to the Host, XOFF at the start of the HOP and XON at the end of the HOP.
Bit 1 – Controls if the LX2400S uses the RE pin on the connector to enable Host communications.
Bit 2 – Reserved for future use, always cleared to 0.
Bit 3 – Pin 12 transitions low at the start of a packet and high at the completion of a packet.
Bit 4 – Reserved for future use, always set to 1.
Bit 5 – Reserved for future use, always cleared to 0.
Bit 6 – Controls when the Server sends beacons for Client synchronization. This bit is configurable to send a beacon after every HOP or after 2.5 seconds has elapsed since the Server's Host has sent data. This bit can used to substantially decrease the amount of time it takes Clients to synchronize with the Server.

3.2.6.2 Configuration Commands

The configuration commands allow the Host to read and write EEPROM transceiver configuration parameters. The LX2400S looks at the first byte of a sequence from the Host. If the first byte is the CONFIGURATION START BYTE, and the TST_MODE pin is pulled low at the connector, the LX2400S will enter Configuration Mode. The Host can then read and write parameters using the EEPROM BYTE READ and EEPROM BYTE WRITE commands. The command begins with Byte 0. All bytes are echoed back to the Host as they are received. The Host must not assert TE when using this mode. To exit Configuration Mode the Host must perform a hardware or power-on reset.

3.2.6.2.1 CONFIGURATION START BYTE command

This byte is sent once by the Host to enter Configuration Mode. After receiving this byte from the Host with the TST_MODE pin pulled low at the connector, EEPROM read and write commands can be sent to the Host. **The length byte must be set to 01H. Only single byte reads/writes are allowed**.

Byte 0 = 065H

3.2.6.2.2 EEPROM BYTE READ command

The read routine includes the read command, address, and length bytes. Upon receiving this command, the LX2400S will transmit the desired data from the address requested by the Host. **The length byte must be set to 01H. Only single byte reads are allowed.**

Byte 0 = 0C0H	Read Command
Byte 1 = 0xxH	Address (from TABLE 2)
Byte 2 = 01H	Length = 01H

3.2.6.2.3 EEPROM BYTE WRITE command

The write routine includes the write command, address, length, and data bytes. Upon receiving this command, the LX2400S 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, the LX2400S will transmit the data byte to the Host. The WR_ENA on the connector must be pulled low to enable the write prior to issuing this command or the write will not occur. **The length byte must be set to 01H. Only single byte writes are allowed.**

Byte 0 = 0C1H	WRITE Command
Byte 1 = 0xxH	Address (from TABLE 2)
Byte 2 = 01H	Length = 01H
Byte 3 = 0xxH	Data

NOTE: The WR_ENA pin on the connector should only be pulled low before sending an EEPROM BYTE WRITE command and must be held low until the data byte is echoed to the Host.

Data Rates

Various data rates, timings, and system architecture need to be considered when determining Overall System Throughput in a RF data system. The Host controls the Serial Interface Data Rate. The LX2400S has a fixed RF Data Rate. The Effective Data Transmission Rate is determined from both Host and LX2400S operation.

3.2.7.1 Serial Interface Data Rate

The Serial Interface Data Rate is programmable by the Host. This is the rate the Host and the LX2400S communicate over the Serial bus. Typical values range from 1200bps to 57,600bps. The only supported mode is asynchronous – 8-bit, No Parity, 1 Start Bit, and 1 Stop Bit.

3.2.7.2 RF Data Rate

The RF Data Rate is the rate the LX2400S transmits and receives over the RF link. It is fixed at 144,000bps, 8-bit, Parity, 1 Start Bit, and 1 Stop Bit.

3.2.7.3 Effective Data Transmission Rate

The maximum Effective Data Transmission Rate (EDTR) is defined as the rate of **one-way continuous** transmission of data packets sent by a Host. It includes the transmitter turn-on and turn-off delays, HOP time, Host data byte timing and the number of bytes per packet sent by the Host. Beacon timing is not used in this calculation -- since it is only transmitted when data has not been received by the LX2400S from the Host for approximately 2.5 seconds. Data from the Host is transmitted on the RF link as it is received from the Host assuming the system is in sync and the RE pin is in the active state (if enabled). The following example illustrates the EDTR at 57,600bps assuming a 32-bit CRC is included with the Host system data bytes.

EXAMPLE:

Example data packet:
NPSL = Number of Host preamble, sync and length bytes = 6
NHSD = Number of Host system data bytes = 192
NHED = Number of Host error detection bytes = 4
TXON* = Transmitter on delay = 1ms
TXOFF* = Transmitter off delay = 1ms
HTM* = Hop overhead in a 1 second period = 8.34ms
BAUDRATE = Serial Interface Baud Rate = 57,600bps

Calculations:
IBT = Interface byte time = 10/BAUDRATE = 0.174ms
IGT = Interface Byte gap time = 0
PKT = Packet time = (NPSL + NHSD + NHED) * (IBT +IGT) = 35.07ms

EDTR = (1-HTM) * NHSD/(TXON+TXOFF+PKT) = (1-0.00834) * 192/37.07E-03 = 5136 bytes per second or 51360 bits per second.
Efficiency = (51360 /57600)*100 = 89%

*Timing is preliminary

3.2.7.4 Overall System Throughput

The maximum Overall System Throughput (OST) is related to the EDTR and the Host's system implementation. Typical systems implement an acknowledgement of received data. This can take the form of either an immediate or delayed response (a response acknowledging many packets). In a polled system, where the Server sends a packet to the Client Host and waits for data to be returned, the Server Host usually does not require separate acknowledge packets because the returned data becomes the acknowledgement. Other systems, which transmit non-critical or repeated data, may not use any form of acknowledgement.

The following examples give OST for 3 different systems and uses the values from the previous section. Other systems are possible:

1 – POSITIVE ACK SYSTEM -- An acknowledgement response packet for each packet received.

Additional example data:
NHRD = Number of Host system response bytes = 3 (e.g. command and two address bytes)

Calculations:
PKT = Packet time = (NPSL + NHSD + NHED) * (IBT + IGT) = 35.07ms
RSPT = Response time = (NPSL + NHRD + NHED) * (IBT + IGT) = 2.26ms

OST = (1-HTM) * NHSD / (TXON+ PKT + TXOFF + TXON + RSPT + TXOFF) / NHSD =
(1-0.00834) * 192/41.33E-03 = 4607 bytes per second or 46070 bits per second.
Efficiency = (46070 /57600) *100 = 80%

2 – POLLED SYSTEM -- An acknowledgement response via returned Host data.

Additional example data:
$NHSD_{Server}$ = Number of Host system data bytes = 192
$NHSD_{Client}$ = Number of Host system data bytes = 192

Calculations:
PKT = Packet time = (NPSL + NHSD + NHED) * (IBT + IGT) = 35.07ms

OST = (1-HTM) * ($NHSD_{Server}$ + $NHSD_{Client}$)/((TXON+TXOFF+PKT)*2) =
(1-0.00834) * 384/74.14E-03 = 5136 bytes per second or 51360 bits per second
Efficiency = (51360 /57600) *100 = 89%

3 – REPEATED DATA SYSTEM --No acknowledgement response.

OST = EDTR = 51360 bits per second
Efficiency = (51360 /57600)*100 = 89%

*Timing is preliminary

4. Interfacing to the LX2400S

4.1 OPERATING MODES

The LX2400S uses an 8-bit programmable asynchronous serial interface to communicate to a Host. The interface uses one start bit, eight data bits, and one stop bit. Only the interface baud rate is programmable by the Host.

A typical system consists of one LX2400S operating in Server Mode (LX2400S Server) communicating with one or many LX2400S(s) operating in Client Mode (LX2400S Client). In this architecture, Clients communicate with a single Server. Clients do not communicate with other Clients. Data transmitted by a Server is received by all of the Clients that are in-range. The Server receives the data sent by the Client. All protocol functions (retries, addressing, CRCs, etc.) are performed by the Host software. All frequency hopping and synchronization is provided automatically by the LX2400S without Host intervention.

The Firmware in the LX2400S is operating in one of five modes. The Host can determine through hardware and/or software what mode the LX2400S is operating in using the DSR pin or the software XON/XOFF data.

4.1.1 RECEIVE MODE

The LX2400S is in RECEIVE MODE, by default, when it is not in any other operating mode. While in this mode, the LX2400S is looking for valid preamble and sync data bytes from a transmitter. When valid preamble and sync bytes are detected, the LX2400S will transmit data received on the RF link to the Host using the HOST RECEIVE FRAME FORMAT. **A Client LX2400S will only accept data from its Host when it is in-range of a valid LX2400S Server.**

4.1.2 TRANSMIT MODE

The Host software initiates transmission of a data packet on the RF link by lowering TE, waiting for CTS to go low, followed by sending the specified preambles bytes, sync byte, data length, and data. Both maximum data byte gaps and packet times must be adhered to. At the end of the transmission TE must return to a Logic Level High. After TE is taken high by the Host, the LX2400S will drive CTS high. This indicates the LX2400S is returning to RECEIVE MODE. The Host software must perform MAC layer functions (retries, addressing CRCs, etc.). **If the Client LX2400S is not in-range of a LX2400S Server, TRANSMIT MODE will not be entered. The Client LX2400S will not respond with CTS.**

The following sequence transmits a packet on the RF link:

1. The Host drives the TE pin low.
2. The LX2400S responds by driving CTS low.
3. The Host sends serial bytes as specified in the HOST TRANSMIT FRAME FORMAT. The LX2400S transmits the HOST TRANSMIT FRAME FORMAT on the RF link as it receives each byte from the Host.
4. The Host drives TE high after the last byte is received by the LX2400S.
5. The LX2400S responds by driving CTS high and returns to RECEIVE MODE.

4.1.3 CONFIGURATION MODE

The CONFIGURATION MODE is used to read and write the EEPROM -- allowing the Host to set channels, baud rates, etc. See TABLE 2. While in this mode the LX2400S will not receive any data over the RF link. TE and CTS are not used.

The Host enters this mode with the following sequence:

1. The Host pulls the TST_MODE pin low.
2. The Host sends the CONFIGURATION START BYTE to the LX2400S.
3. The Host pulls the WR_ENA pin low if writing.
4. The Host sends the EEPROM BYTE READ or the EEPROM BYTE WRITE command.
5. The Host Repeat Steps 3 and 4 until done.
6. The Host drives pins TST_MODE and WR_ENA high.
7. The Host resets the LX2400S.

NOTE: The WR_ENA pin should not be permanently tied low as brownout conditions can corrupt EEPROM data.

4.1.4 HOPPING MODE

The HOPPING MODE is controlled by the LX2400S. The LX2400S hops approximately every 100ms. During this time, the LX2400S is changing the frequency it will use to transmit and receive. The LX2400S informs the Host of the hop by asserting the DSR pin at the connector or by using the XON/XOFF received bytes if enabled in the EEPROM in the sequence. The DSR pin will frame the hopping procedure. **When the Host software detects the hopping mode during a transmission of a packet, it can be assumed that the packet did not reach it's destination and the Host should re-send the packet.**

4.1.5 BEACON MODE

Beacon mode applies to a LX2400S Server only. In order to synchronize the hopping of all LX2400Ss in a system, the LX2400S Server will transmit beacon data consisting of system timing information at a periodic rate. This occurs by default after transceiver reset and initialization. The beacon is transmitted once per HOP time -- immediately after a HOP occurs. Beacons are not transmitted when the LX2400S Server is transmitting data from the HOST over the RF link. If the LX2400S Server does not receive data for approximately 2.5 seconds from the Server Host, the LX2400S Server will resume transmitting Beacons. This provides continuous synchronization data for the LX2400S Clients. The beacon data is not transmitted or available to either the Client or Server Host. The beacon takes approximately 2ms to complete. The LX2400S indicates that it is executing a HOP with the DSR pin and a XON/XOFF sequence if enabled.

The Server Host can ignore the HOP if the Host software has retry capabilities or can tolerate non-delivery of data. Empirical testing shows a 3 to 5 percent loss of data when ignoring the HOP indicators. (See "LX2400S Hopping and Beacon Timing" in Section 4.5)

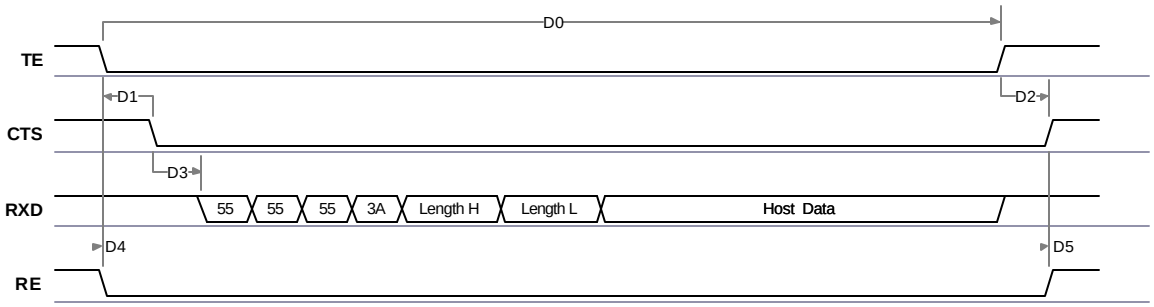
4.2 LX2400S GLOBAL Timing Parameters

Table 4 – Global Timing Parameters

Timing is preliminary and not guaranteed for production

NAME	MIN	TYP	Max	COMMENT
t_{RT}		TBD	1ms	Receive to Transmit settling time – Transmit Off
t_{TR}		TBD	1ms	Transmit to Receive settling time – Transmit Off
t_{TXMOD}			20ms	Longest amount of time to continuously send data
t_{PackG}	1ms			TX Packet Gap
t_{ByteG}			1 byte time	Maximum Byte Gap

4.3 LX2400S Transmit Mode Timing

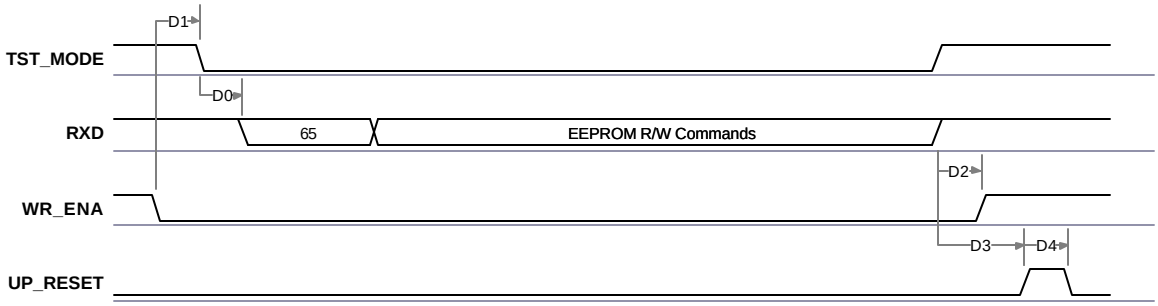


*RE can be ignored if not enabled.

Table 5 – Transmit Mode Timing

NAME	MIN	TYP	MAX	COMMENT
D0			20ms	Timing is preliminary and not guaranteed for production
D1			1ms	Timing is preliminary and not guaranteed for production
D2		10us		Timing is preliminary and not guaranteed for production
D3	0			Timing is preliminary and not guaranteed for production
D4	0			Timing is preliminary and not guaranteed for production
D5			0	Timing is preliminary and not guaranteed for production

4.4 LX2400S Configuation Mode Timing

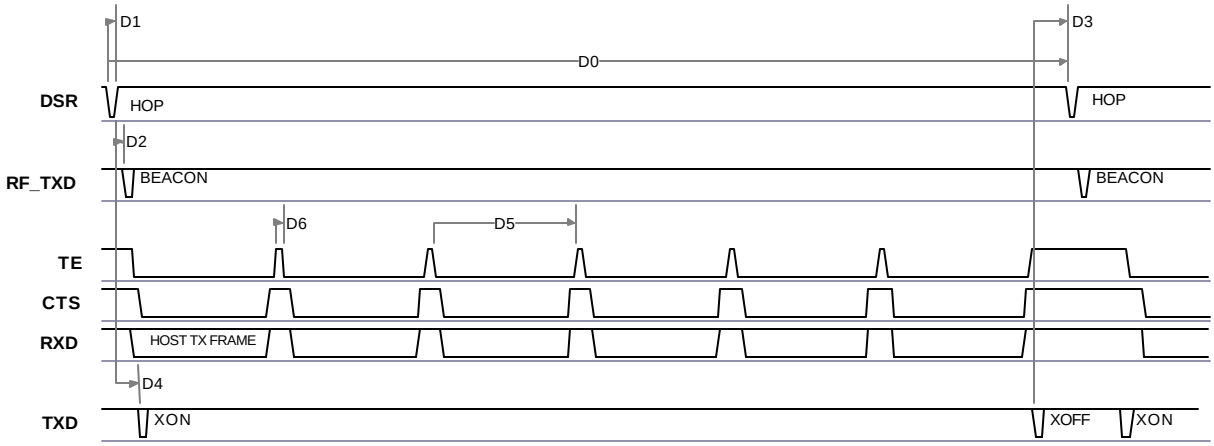


* WR_ENA is used only when writing to EEPROM

Table 6 – Configuration Mode Timing

NAME	MIN	TYP	MAX	COMMENT
D0			0	Timing is preliminary and not guaranteed for production
D1	1ms			Timing is preliminary and not guaranteed for production
D2	10ms			When executing an EEPROM WRITE
D3	1ms			Timing is preliminary and not guaranteed for production
D4	4ms			Timing is preliminary and not guaranteed for production

4.5 LX2400S Hopping and Beacon Timing



* Beacons are only transmitted if RXD has been idle for approximately 2.5 seconds.
* Diagram shows Host synchronous with the HOP.

Table 7 – Hopping and Beacon Timing

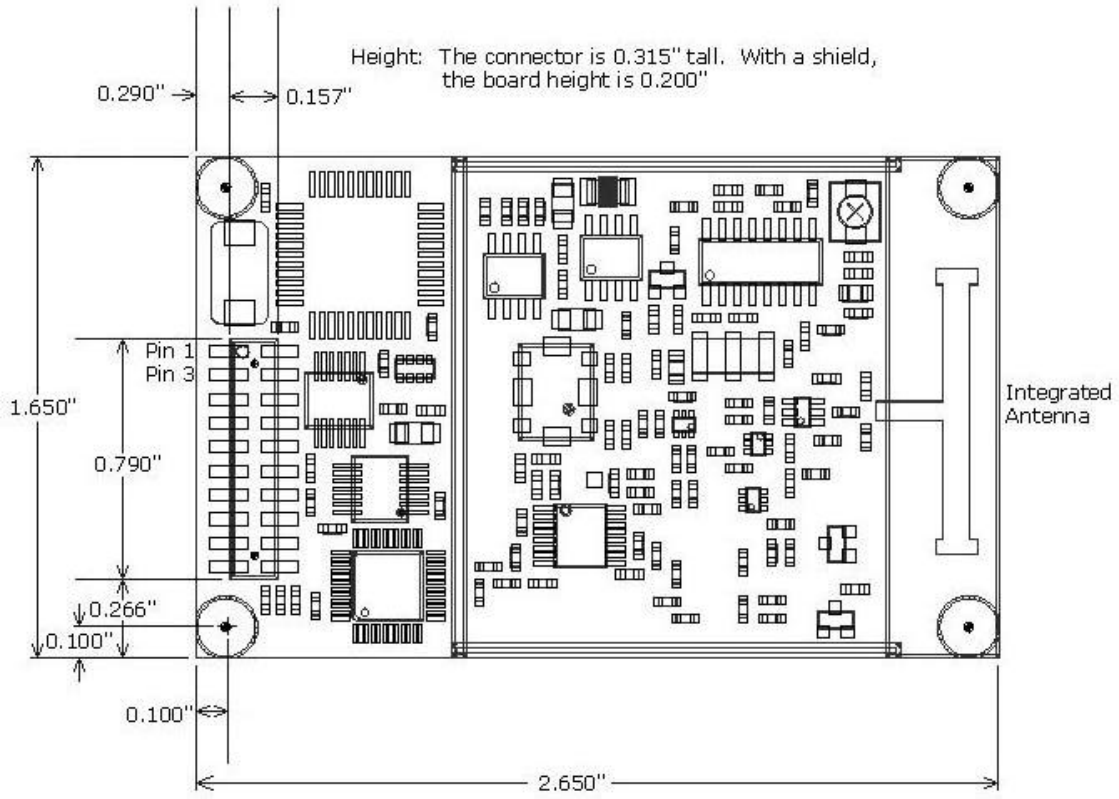
NAME	MIN	TYP	MAX	COMMENT
D0		100ms		Timing is preliminary and not guaranteed for production
D1		1ms		Timing is preliminary and not guaranteed for production
D2		1ms		Timing is preliminary and not guaranteed for production
D3		1ms		Timing is preliminary and not guaranteed for production
D4	1ms			Timing is preliminary and not guaranteed for production
D5			20ms	Timing is preliminary and not guaranteed for production
D6	1ms			Timing is preliminary and not guaranteed for production

5. Mechanical Overview

5.1 Transceiver

The LX2400S measures 1.65” x 2.65”. Critical parameters are as follows:
J1 – 20 pin connector (lower left edge) SAMTEC TMM-110-01-L-D-SM
(4) Mounting holes are 0.100” diameter.

Figure 1. Mechanical Overview of LX2400S



5.2 Antenna

The LX2400S-3A and the LX2400S-10A incorporate an Aerocomm NZH antenna on the transceiver board. The NZH is a highly efficient, microstrip, center-fed dipole design with a broad pattern. The NZH is matched to the RF circuits yielding superior performance. This is important when using low-power RF transceivers because a poor or marginally matched antenna will drastically reduce the operating distance between transceivers. Special consideration must be given to the antenna placement in the OEM’s design. Materials in close proximity (up to 4 inches) can affect antenna performance. Aerocomm can assist the OEM with fine-tuning the antenna and/or enclosure that will incorporate the transceiver. Contact your AeroComm OEM salesman or OEM customer support for assistance. The LX2400S-10 and LX2400-150 incorporate an MMCX jack (Telegartner P/N J0134A0081) allowing the OEM to select antennas with specific characteristics.

6. Ordering Information

6.1 Product Part Numbers

LX2400S-3, LX2400S with 3mW output power, interface data rates to 19,200bps, integrated antenna
LX2400S-10, LX2400S with 10mW output power, interface data rates to 57,600bps, MMCX ant connector
LX2400S-150, LX2400S with 150mW output power, interface data rates to 115,200bps,

6.2 Developer Kit Part Numbers

SDK-LX2400S-3, Includes (2) LX2400S-3A transceivers, (2) RS232 Serial Adapter Boards, (2) 6Vdc unregulated power supplies, (2) Serial cables, configuration/testing software, Integration engineering support

SDK-LX2400S-10, Includes (2) LX2400S-10 transceivers, (2) RS232 Serial Adapter Boards, (2) 6Vdc unregulated power supplies, (2) Serial cables, (2) S191FL-5-RMM-2450S dipole antennas with 5" pigtail and MMCX connector, configuration/testing software, Integration engineering support

SDK-LX2400S-150, Includes (2) LX2400S-150 transceivers, (2) RS232 Serial Adapter Boards, (2) 6Vdc unregulated power supplies, (2) Serial cables, (2) S191FL-5-RMM-2450S dipole antennas with 5" pigtail and MMCX connector, configuration/testing software, Integration engineering support