LINX TECHNOLOGIES

HumRC™ Series Remote Control and Sensor Transceiver

Data Guide

Wireless made simple®

Warning: Some customers may want Linx radio frequency (“RF”) products to control machinery or devices remotely, including machinery or devices that can cause death, bodily injuries, and/or property damage if improperly or inadvertently triggered, particularly in industrial settings or other applications implicating life-safety concerns (“Life and Property Safety Situations”).

NO OEM LINX REMOTE CONTROL OR FUNCTION MODULE SHOULD EVER BE USED IN LIFE AND PROPERTY SAFETY SITUATIONS. No OEM Linx Remote Control or Function Module should be modified for Life and Property Safety Situations. Such modification cannot provide sufficient safety and will void the product’s regulatory certification and warranty.

Customers may use our (non-Function) Modules, Antenna and Connectors as part of other systems in Life Safety Situations, but only with necessary and industry appropriate redundancies and in compliance with applicable safety standards, including without limitation, ANSI and NFPA standards. It is solely the responsibility of any Linx customer who uses one or more of these products to incorporate appropriate redundancies and safety standards for the Life and Property Safety Situation application.

Do not use this or any Linx product to trigger an action directly from the data line or RSSI lines without a protocol or encoder/decoder to validate the data. Without validation, any signal from another unrelated transmitter in the environment received by the module could inadvertently trigger the action.

All RF products are susceptible to RF interference that can prevent communication. RF products without frequency agility or hopping implemented are more subject to interference. This module does have a frequency hopping protocol built in, but the developer should still be aware of the risk of interference.

Do not use any Linx product over the limits in this data guide. Excessive voltage or extended operation at the maximum voltage could cause product failure. Exceeding the reflow temperature profile could cause product failure which is not immediately evident.

Do not make any physical or electrical modifications to any Linx product. This will void the warranty and regulatory and UL certifications and may cause product failure which is not immediately evident.

Ordering Information

Ordering Information	
Part Number	**Description**
HUM-***-RC	HumRC™ Series Remote Control Transceiver
HUM-900-RC-UFL	HumRC™ Series Remote Control Transceiver, Certified, UFL Connector
HUM-900-RC-CAS	HumRC™ Series Remote Control Transceiver, Certified, Castellation Connection
EVM-***-RC	HumRC™ Series Carrier Board
EVM-900-RC-UFL	HumRC™ Series Carrier Board with Certified module, UFL Connector
EVM-900-RC-CAS	HumRC™ Series Carrier Board with Certified module, Castellation Connection
MDEV-***-RC	HumRC™ Series Master Development System
EVAL-***-RC	HumRC™ Series Basic Evaluation Kit

*** = Frequency; 900MHz, 2.4GHz

Figure 2: Ordering Information

Absolute Maximum Ratings

Absolute Maximum Ratings				
Supply Voltage V_{cc}	–0.3	to	+3.9	VDC
Any Input or Output Pin	–0.3	to	V_{CC} + 0.3	VDC
RF Input		0		dBm
Operating Temperature	–40	to	+85	ºC
Storage Temperature	–40	to	+85	ºC

Exceeding any of the limits of this section may lead to permanent damage to the device. Furthermore, extended operation at these maximum ratings may reduce the life of this device.

Figure 3: Absolute Maximum Ratings

Warning: This product incorporates numerous static-sensitive components. Always wear an ESD wrist strap and observe proper ESD handling procedures when working with this device. Failure to observe this precaution may result in module damage or failure.

HumRC™ Series Transceiver Specifications						
Parameter	**Symbol**	**Min.**	**Typ.**	**Max.**	**Units**	**Notes**
Output Power Control Range						
HUM-2.4-RC			56		dB	6
HUM-900-RC-ttt			40		dB	6
Antenna Port						
RF Impedance	R_{IN}		50		Ω	4
Environmental						
Operating Temp. Range		–40		+85	ºC	4
Timing						
Module Turn-On Time						
Via V_{CC}				108	ms	4
Via $\overline{\text{POWER\_DOWN}}$				57	ms	4
Via Standby				57	ms	4
Serial Command Response						
Status, Volatile R/W			1	10	ms	8
Analog Input Reading			6	16	ms	8
NV Update, Factory Reset			80	110	ms	8
IU to RU Status High				50	ms	7
Channel Dwell Time				13.33	ms	
Interface Section						
Input						
Logic Low	V_{IL}			$0.3*V_{CC}$	VDC	
Logic High	V_{IH}	$0.7*V_{CC}$			VDC	
Output						
Logic Low, MODE_IND, CONFIRM	V_{OLM}			$0.3*V_{CC}$	VDC	1,9
Logic High, MODE_IND, CONFIRM	V_{OHM}	$0.7*V_{CC}$			VDC	1,9
Logic Low	V_{OL}			$0.3*V_{CC}$		1,10
Logic High	V_{OH}	$0.7*V_{CC}$				1,10

1. Measured at 3.3V V_{CC}
2. Measured at 25ºC
3. Input power < –60dBm
4. Characterized but not tested
5. PER = 5%
6. Into a 50-ohm load
7. No RF interference
8. From end of command to start of response
9. 60mA source/sink
10. 6mA source/sink

Figure 4: Electrical Specifications

Typical Performance Graphs

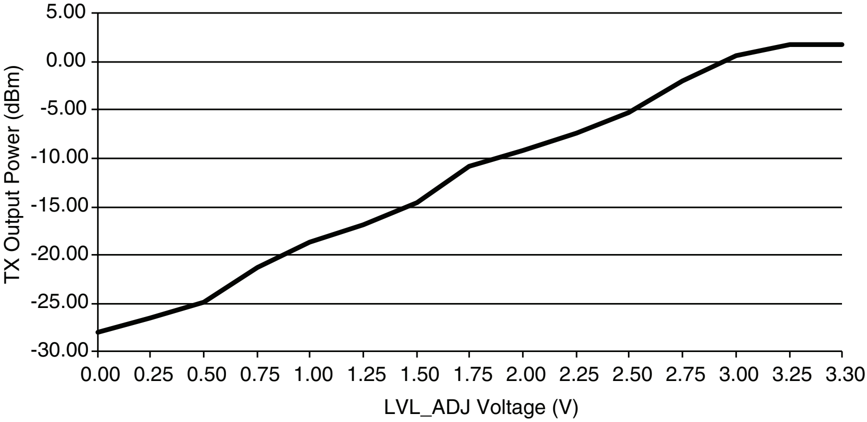


Figure 6: HumRC™ Series Transceiver Output Power vs. LVL_ADJ Resistance - HUM-2.4-RC

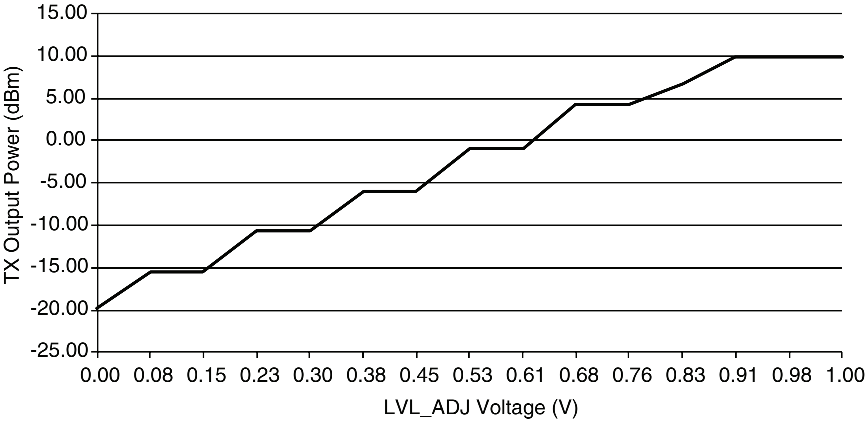


Figure 7: HumRC™ Series Transceiver Output Power vs. LVL_ADJ Resistance - HUM-900-RC

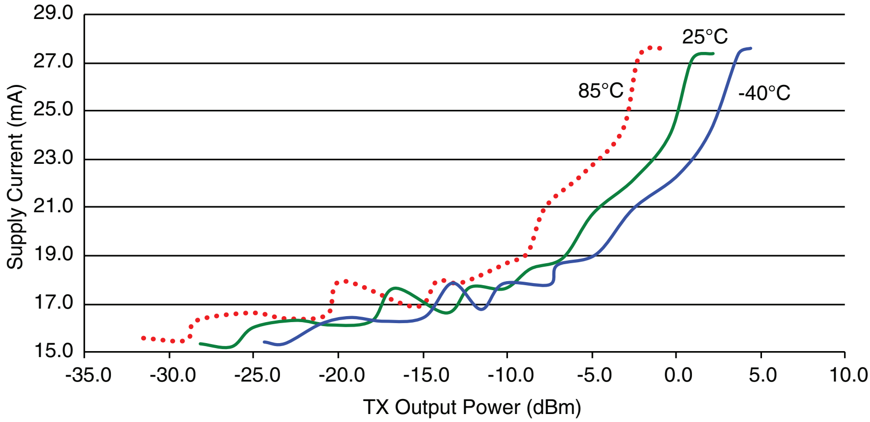


Figure 10: HumRC™ Series Transceiver Average Current vs. Transmitter Output Power at 2.5V - HUM-2.4-RC

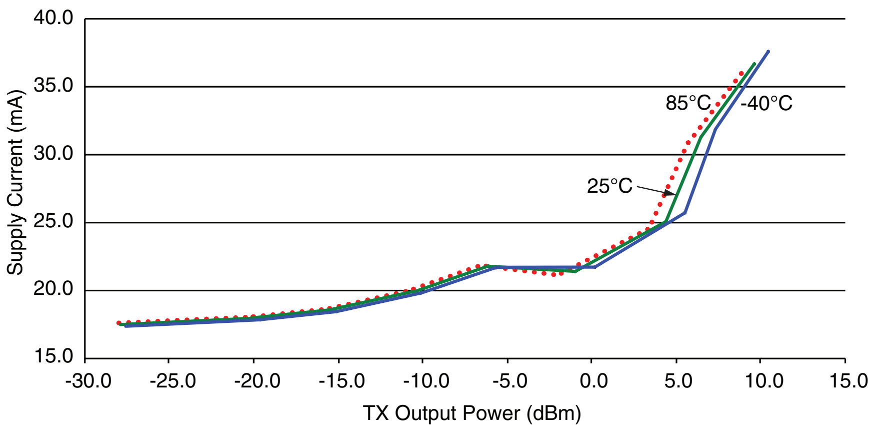


Figure 11: HumRC™ Series Transceiver Average Current vs. Transmitter Output Power at 2.5V - HUM-900-RC

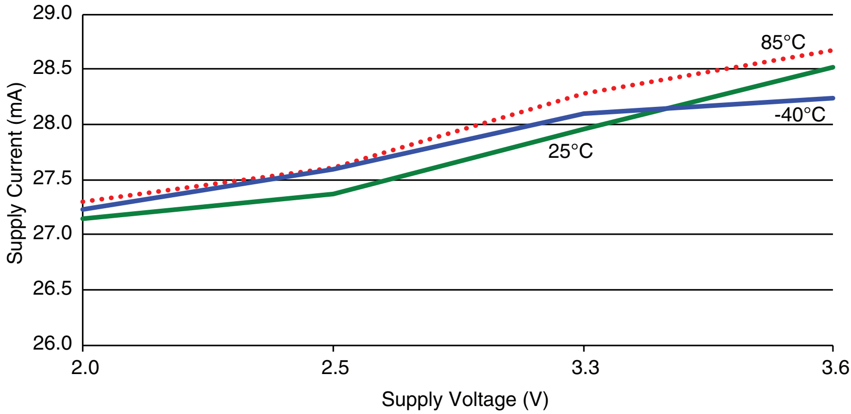


Figure 14: HumRC™ Series Transceiver TX Current vs. Supply Voltage at Max Power - HUM-2.4-RC

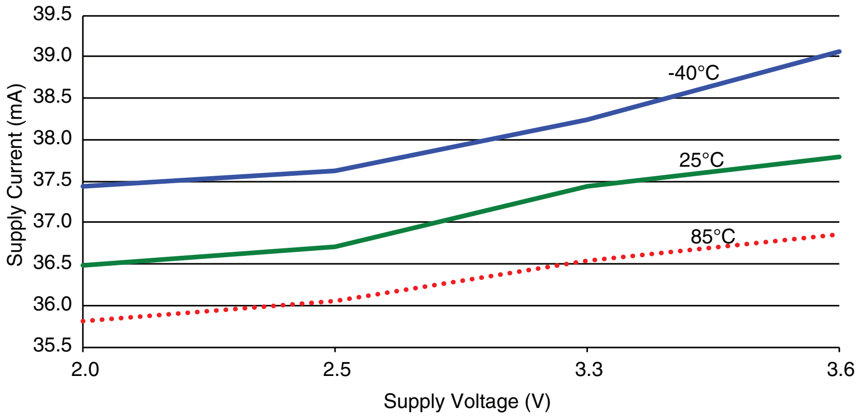


Figure 15: HumRC™ Series Transceiver TX Current vs. Supply Voltage at Max Power - HUM-900-RC

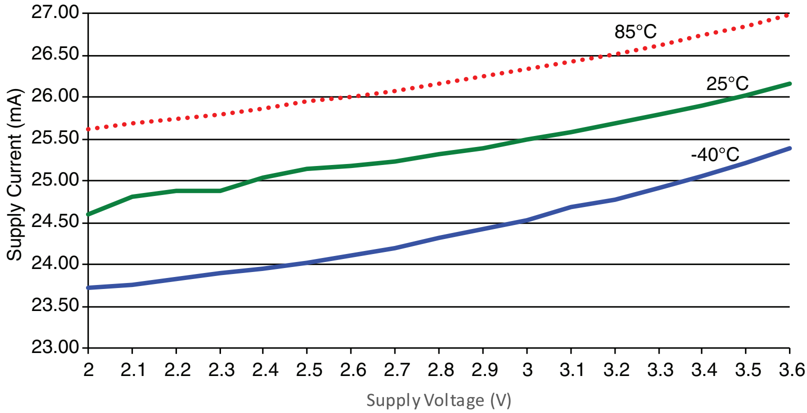


Figure 18: HumRC™ Series Transceiver RX Current Consumption vs. Supply Voltage - HUM-2.4-RC

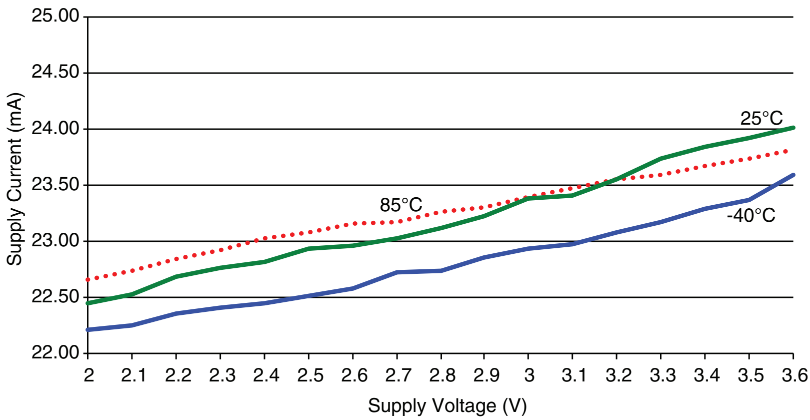


Figure 19: HumRC™ Series Transceiver RX Current Consumption vs. Supply Voltage - HUM-900-RC

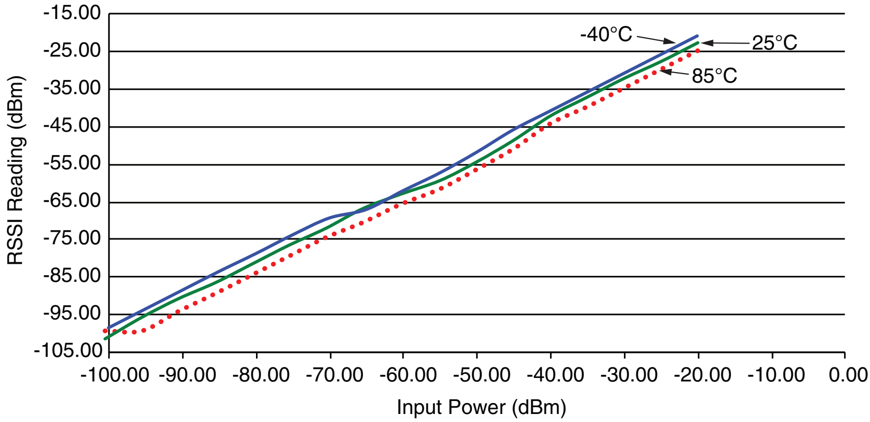


Figure 22: HumRC™ Series Transceiver RSSI Voltage vs. Input Power - HUM-2.4-RC

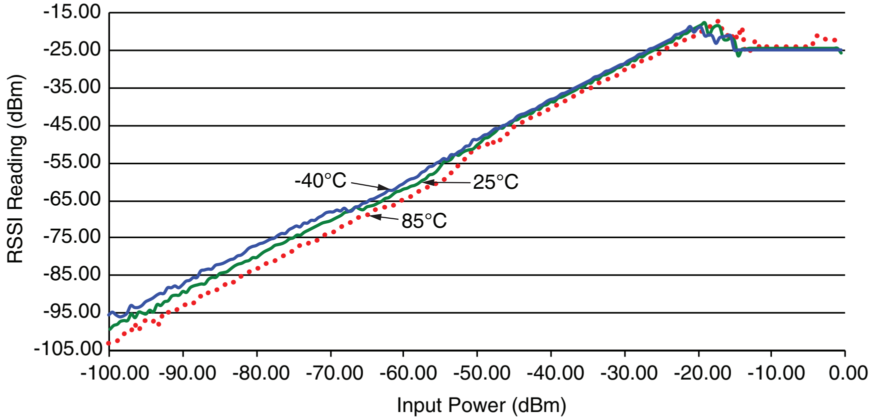


Figure 23: HumRC™ Series Transceiver RSSI Voltage vs. Input Power - HUM-900-RC

Pin Assignments

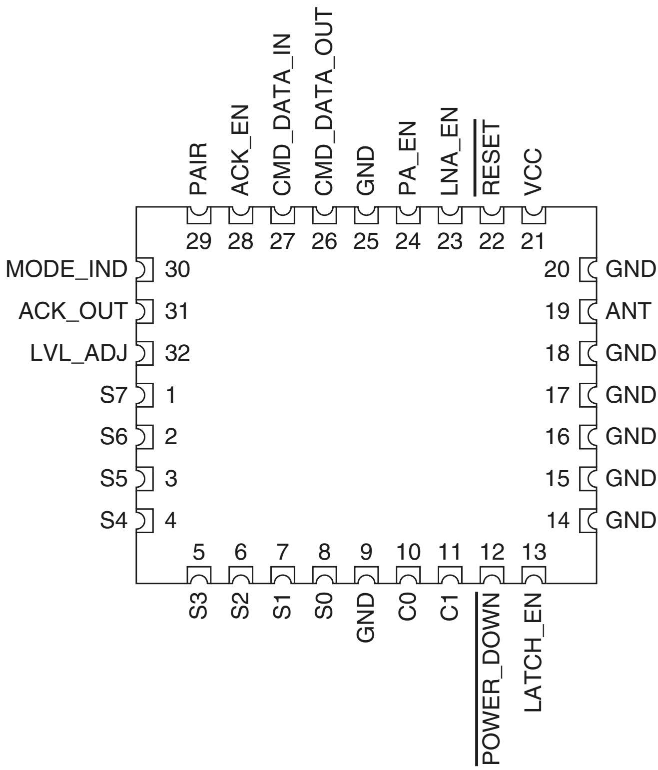


Figure 26: HumRC™ Series Transceiver Pin Assignments (Top View)

Pin Descriptions

Pin Descriptions			
Pin Number	**Name**	**I/O**	**Description**
1, 2, 3, 4, 5, 6, 7, 8	S0–S7[1]	I/O	Status Lines. Each line can be configured as either an input to register button or contact closures or as an output to control application circuitry.
9, 14, 15, 16, 17, 18, 20, 25	GND	—	Ground
10	C0	I	This line sets the input/output direction for status lines S0-S3. When low, the lines are outputs; when high they are inputs.
11	C1	I	This line sets the input/output direction for status lines S4-S7. When low, the lines are outputs; when high they are inputs.

Pre-Certified Module Pin Assignments

The pre-certified version of the module has mostly the same pin assignments as the standard version. The antenna connection is routed to either a castellation (-CAS) or a u.FL connector (-UFL), depending on the part number ordered.

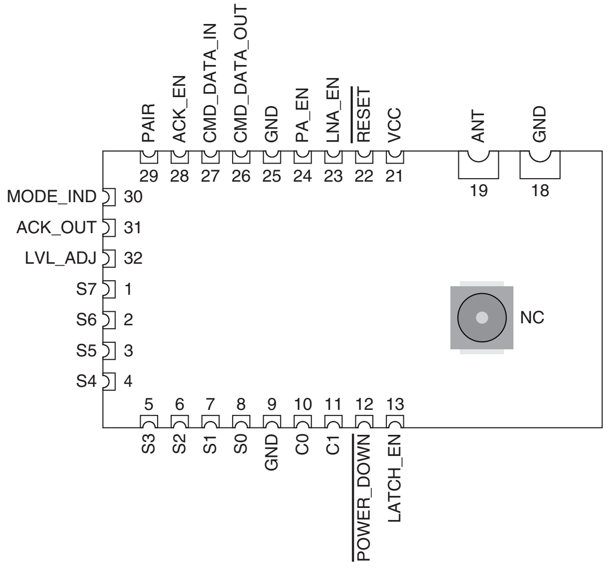


Figure 28: HumRC™ Series Transceiver Pre-certified Version Pin Assignments - Castellation Connection (Top View)

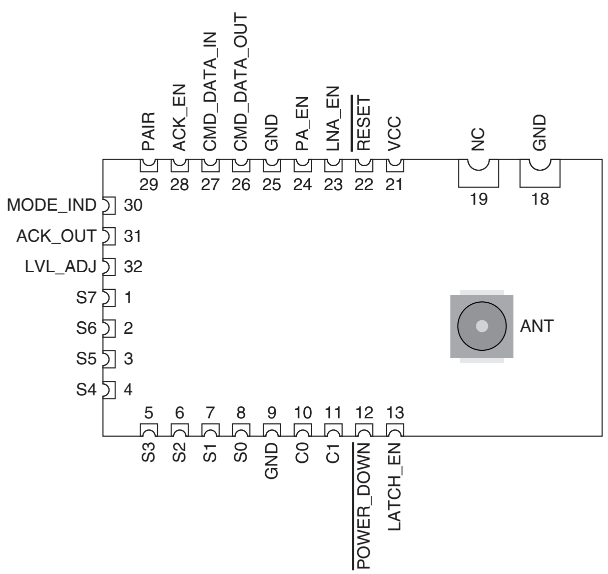


Figure 29: HumRC™ Series Transceiver Pre-certified Version Pin Assignments - UFL Connection (Top View)

Theory of Operation

The HumRC™ Series transceiver is a low-cost, high-performance synthesized FSK transceiver. Figure 32 shows the module's block diagram.

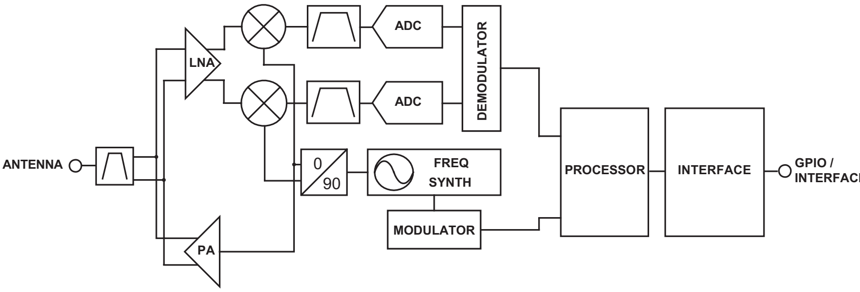


Figure 32: HumRC™ Series Transceiver RF Section Block Diagram

The HumRC™ Series transceiver operates in the 2400 to 2483MHz and 902 to 928MHz frequency bands. The transmitter output power is programmable. The range varies depending on the module's frequency band, antenna implementation and the local RF environment.

The RF carrier is generated directly by a frequency synthesizer that includes an on-chip VCO. The received RF signal is amplified by a low noise amplifier (LNA) and down-converted to I/Q quadrature signals. The I/Q signals are digitized by ADCs.

A low-power onboard communications processor performs the radio control and management functions including Automatic Gain Control (AGC), filtering, demodulation and packet synchronization. A control processor performs the higher level functions and controls the serial and hardware interfaces.

A crystal oscillator generates the reference frequency for the synthesizer and clocks for the ADCs and the processor.

Transceiver Operation

The transceiver has two modes of operation: Initiating Unit (IU) that transmits control messages and Responding Unit (RU) that receives control messages. If all of the status lines are set as inputs, then the module is set as an IU only. The module stays in a low power sleep mode until a status line goes high, starting the Transmit Operation.

If all of the status lines are set as outputs, then the module is set as an RU only. It stays in Receive Operation looking for a valid transmission from a paired IU.

A module with both input and output status lines can operate as an IU and an RU. The module idles in Receive Operation until either a valid transmission is received or a status line input goes high, initiating the Transmit operation.

When an input goes high, the transceiver captures the logic state of each of the status lines. The line states are placed into a packet along with the local 32-bit address. The IU transmits the control packets as it hops among 25 RF channels.

An RU receives the packet and checks its Paired Module List to see if the IU has been paired with the module and is authorized to control it. If the IU's address is not in the table, then the RU ignores the transmission. If the address is in the table, then the RU calculates the channel hopping pattern from the IU's address and sets its status line outputs according to the received packet. It then hops along with the IU and updates the states of its outputs with every packet. Its outputs can be connected to external circuitry that activates when the lines go high.

The RU can also send an acknowledgement back to the IU. Using the serial interface the RU can include up to two bytes of custom data with the acknowledgement, such as sensor data or battery voltage levels. Using the hardware control, if ACK_EN is high when a valid control packet is received, the RU sends back a simple acknowledgement (ACK). It can send an Acknowledge with Data (AWD) response when custom data is programmed into the module using a serial command.

Receive Operation

During Receive Operation, the module waits for a valid control message from an authorized (paired) transceiver. When a valid message is received, it locks onto the hopping pattern of the transmitter and asserts the MODE_IND line. It compares the received status line states to the Permission Mask for the IU to see if the IU is authorized to activate the lines. The module sets all authorized outputs to match the received states. Only status line outputs are affected by received commands.

The RU then checks the state of the ACK_EN line and transmits an acknowledgement packet if it is high. It looks for the next valid packet while maintaining the frequency hopping timing. As long as an RU is receiving valid commands from a paired IU, it will not respond to any other unit.

Once eight consecutive packets are missed, the RU is logically disconnected from the IU and waits for the next valid packet from any IU.

Acknowledgement

A responding module is able to send an acknowledgement to the transmitting module. This allows the initiating module to know that the responding side received the command.

When the Responding Unit (RU) receives a valid Control Packet, it checks the state of the ACK_EN line. If it is high the module sends an Acknowledgement Packet.

If the Initiating Unit (IU) receives an Acknowledgement Packet that has the same Address and Status Byte as in the Control Packet it originally sent, then it pulls the ACK_OUT line high. A continuous stream of Control Packets that triggers a continuous stream of Acknowledgement Packets keeps the ACK_OUT line high.

Connecting the ACK_EN line to V_{CC} causes the RU to transmit Acknowledgement Packets as soon as it receives a valid Control Packet. Alternately this line can be controlled by an external circuit that raises the line when a specific action has taken place. This confirms to the IU that the action took place rather than just acknowledging receipt of the signal.

The module can also be configured to transmit an acknowledgement with two bytes of preset data. This feature is enabled using the Control Source parameter through the Command Data Interface (CDI). The IU outputs the

The Pair Process

The Pair process enables two transceivers to communicate with each other. Each transceiver has a local 32-bit address that is transmitted with every packet. If the address in the received packet is not in the RU's Paired Module List, then the transceiver does not respond. Adding devices to the authorized list is accomplished through the Pair process or by a serial command. Each module can be paired with up to 40 other modules.

The Pair process is initiated by taking the PAIR line high or by sending the Pair Control serial command on both units to be associated. Activation on the PAIR line can either be a momentary pulse (less than two seconds) or a sustained high input, which can be used to extend the search and successful pairing display. With a momentary activation, the search is terminated after 30 seconds. If Pairing is initiated with a sustained high input, the search continues as long as the PAIR input is high.

When Pair is activated, the module displays the Pair Search sequence on the MODE_IND line (Figure 34) and goes into a search mode where it looks for another module that is also in search mode. It alternates between transmit and receive, enabling one unit to find the other and respond.

Once bidirectional communication is established, the two units store each other's addresses in their Paired Module List with full Permissions Mask and display the Pair Found sequence on their MODE_IND lines. The Pair Found sequence is displayed for at least 3 seconds. If PAIR is held high, the Pair Found display is shown for as long as PAIR is high. If a paired unit is already in the Paired Module List, then no additional entry is added though the existing entry's Permissions Mask may be modified.

When Pairing is initiated, the module pairs with the first unit it finds that is also in Pair Search. If multiple systems are being Paired in the same area, such as in a production environment, then steps should be taken to ensure that the correct units are paired with each other.

The Pair process can be cancelled by taking PAIR high a second time or by issuing the Pair Control command with Cancel Pairing option.

If the address table is full when the PAIR line is raised, the Pair Table Full sequence is displayed on the MODE_IND line for 10 seconds and neither of the Pairing units stores an address. In this case, the module should either be reset to clear the address table or the serial interface can be used to remove addresses.

Mode Indicator

The Mode Indicator line (MODE_IND) provides feedback about the current state of the module. This line switches at different rates depending on the module's current operation. When an LED is connected to this line it blinks, providing a visual indication to the user. Figure 34 gives the definitions of the MODE_IND timings.

MODE_IND Timing	
Module Status	**Display**
Transmit Mode	Solid ON when transmitting packets.
Receive Mode	Solid ON when receiving packets.
Pair Search	ON for 100ms, OFF for 900ms while searching for another unit during the Pair process
Pair Found	ON for 400ms, OFF for 100ms when the transceiver has been Paired with another transceiver. This is displayed for at least 3 seconds.
Pair Error	ON for 100ms, OFF for 100ms when the address table is full and another unit cannot be added.
Remote Pair Error	ON for 100ms, OFF for 100ms, ON for 100ms OFF for 300ms when the remote unit's address table is full and a Pair cannot be completed.
Pair Cancelled	ON for 100ms, OFF for 200ms, ON for 100ms when the Pair process is cancelled.
Reset Acknowledgement	ON for 600ms, OFF for 100ms, ON for 200ms, OFF for 100ms, ON for 200ms and OFF for 100ms when the reset sequence is recognized.
Extended Pair Cancelled	Solid ON when the pairing operation is cancelled and waiting for the PAIR line to go low.

Figure 34: MODE_IND Timing

Reset to Factory Default

The transceiver is reset to factory default by taking the Pair line high briefly 4 times, then taking and holding Pair high for more than 3 seconds. Each brief interval must be high 0.1 to 2 seconds and low 0.1 to 2 seconds (1 second nominal high / low cycle). The sequence helps prevent accidental resets. Once the sequence is recognized the MODE_IND line blinks the Reset Acknowledgement defined in Figure 34 until the PAIR line goes low. After the Reset Acknowledgement is shown and PAIR goes low, the configuration is initialized. Factory reset also clears the Paired Module table but does not change the local address. If the PAIR input timing doesn't match the reset sequence timing an Extended Pair Cancel sequence is shown when PAIR goes low. The module reverts to normal operation without a reset or pairing.

Receiver Duty Cycle

The module can be configured to automatically power on and off while in receive mode. Instead of being powered on all the time looking for transmissions from an IU, the receiver can wake up, look for data and go back to sleep for a configurable amount of time. If it wakes up and receives valid data, then it stays on and goes back to sleep when the data stops. This significantly reduces the amount of current consumed by the receiver. It also increases the time from activating the IU to getting a response from the RU.

The duty cycle is controlled by the Duty Cycle serial command through the CDI. DCycle sets the number of seconds between receiver turn-on points as shown in Figure 36.

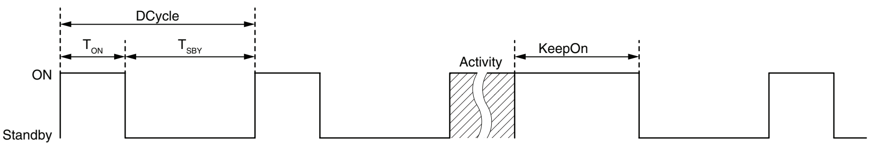


Figure 36: Receiver Duty Cycle

The module's average current consumption can be calculated with the following equation.

$$I_{AVG} = \frac{(T_{ON} \times I_{RX}) + (T_{SBY} \times I_{SBY})}{DCycle}$$

Figure 37: Receiver Duty Cycle Average Current Consumption Equation

T_{ON} is fixed at about 0.326 seconds and T_{SBY} = DCycle - T_{ON}. The receiver current (I_{RX}) and standby current (I_{SBY}) vary with supply voltage, but some typical values are in Figure 38.

HumRC™ Series Typical Current Consumption				
	V_{CC} (VDC)	2.5	3.3	3.6
HUM-2.4-RC	I_{RX} (mA)	21.45	21.82	22.03
	I_{SBY} (mA)	0.00040	0.00058	0.00063
HUM-900-RC	I_{RX} (mA)	22.94	23.73	24.02
	I_{SBY} (mA)	0.00040	0.00058	0.00063

Figure 38: HumRC™ Series Transceiver Typical Current Consumption

Using the LATCH_EN Line

The LATCH_EN line sets the outputs to either momentary operation or latched operation. During momentary operation the outputs go high for as long as control messages are received instructing the module to take the lines high. As soon as the control messages stop, the outputs go low.

During latched operation, when a signal is received to make a particular status line high, it remains high until a separate activation is received to make it go low. The transmission must stop and the module must time out before it will register a second transmission and toggle the outputs.

When the LATCH_EN line is high, all of the outputs are latched. A serial command is available to configure latching of individual lines.

Using the Low Power Features

The Power Down ($\overline{\text{POWER\_DOWN}}$) line can be used to completely power down the transceiver module without the need for an external switch. This line allows easy control of the transceiver power state from external components, such as a microcontroller. The module is not functional while in power down mode.

If all of the status lines are configured as inputs, then the module operates as an IU only. It automatically goes into a low power state waiting for one of the inputs to be asserted. This conserves battery power until a transmission is required.

Frequency Hopping

The module incorporates a Frequency Hopping Spread Spectrum (FHSS) algorithm. This provides immunity from narrow-band interference and complies with FCC and IC guidelines.

The module uses 25 RF channels as shown in Figure 39. Each channel has a time slot of 13.33ms before the module hops to the next channel. This equal spacing allows a receiver to hop to the next channel at the correct time even if a packet is missed. Up to seven consecutive packets can be missed without losing synchronization.

The hopping pattern (sequence of transmit channels) is determined from the transmitter's address. Each sequence uses all 25 channels, but in different orders. Once a transmission starts, the module continues through a complete cycle. If the input line is taken low in the middle of a cycle, the module continues transmitting through the end of the cycle to ensure balanced use of all channels.

Frequency hopping has several advantages over single channel operation. Hopping systems are allowed a higher transmitter output power, which results in longer range and better performance within that range. Since the transmission is moving among multiple channels, interference on one channel causes loss on that channel but does not corrupt the entire link. This improves the reliability of the system.

The Command Data Interface

The HumRC™ Series transceiver has a serial Command Data Interface (CDI) that offers the option to configure and control the transceiver through software instead of through hardware. This interface consists of a standard UART with a serial command set. This allows for fewer connections in applications controlled by a microcontroller as well as for more control and advanced features than can be offered through hardware pins alone.

The CMD_DATA_IN and CMD_DATA_OUT connect to the module's UART. An automatic baud rate detection system allows the interface to run at a variable data rate from 9.0kbps to 60.0kbps, covering standard rates from 9.6 to 57.6kbps.

The Command Data Interface has two sets of operators. One is a set of commands that performs specific tasks and the other is a set of parameters that are for module configuration and status reporting.

The HumRC™ Series Transceiver Command Data Interface Reference Guide has full details on each command. Some key features available with the serial interface are:

- Configure the module through software instead of setting the hardware lines.
- Change the output power, providing the ability to lower power consumption when signal levels are good and extend battery life.
- Individually set which status lines are inputs and outputs.
- Individually set status line outputs to operate as momentary or latched.
- Add or remove specific paired devices.
- Individually set Permission Masks that prevent certain paired devices from activating certain status line outputs.
- Change the module's local address for production or tracking purposes or to replace a lost or broken product.
- Put the module into a low power state to conserve battery power.

Serial Setup Configuration for Stand-alone Operation

The serial interface offers access to a number of advanced features that cannot be controlled through hardware configuration alone. However, not all products need or use a microcontroller or processor, but would benefit from some of the advanced features.

Many of the configuration settings can be written once and then used by the module thereafter. This allows the modules to be configured through a temporary serial connection and then operate in a stand-alone fashion without a permanent serial connection.

For example, a product can have a small header or connector so that the serial lines can be connected to a PC in production test. The PC writes the configurations required by the application to the module and is then disconnected. The module uses these configurations in its normal operation.

Command Data Interface Commands	
Command	**Description**
Read	Read the current value in volatile memory. If there is no volatile value, then the non-volatile value is returned.
Write	Write a new value to volatile memory.
Read NV	Read the value in non-volatile memory.
Program	Program a new value to non-volatile memory.
Set Default Configuration	Set all configuration items to their factory default values.
Erase All Addresses	Erase all paired addresses from memory.
Transmit Control Data	Transmit a control message.
Transmit ACK	Transmit an acknowledgement for received data.
Transmit AWD	Transmit an Acknowledge With Data (AWD) response with two bytes of custom data.
Transmit IU Packet	Transmit a general IU packet.
NV Update	Write all NV changes to NV memory
Pair Control	Initiate / Cancel RF Pairing with another module

Figure 40: HumRC™ Series Transceiver Command Data Interface Commands

Basic Hardware Operation

The following steps describe how to use the HumRC™ Series module with hardware only. Basic application circuits that correspond to these steps are shown in Figure 42.

1. Set the C0 and C1 lines opposite on both sides.

2. Press the PAIR button on both sides. The MODE_IND LED begins flashing slowly to indicate that the module is searching for another module.

3. Once the pairing is complete, the MODE_IND LED flashes quickly to indicate that the pairing was successful.

4. The modules are now paired and ready for normal use.

5. Pressing a status line button on one module (the IU) activates the corresponding status line output on the second module (the RU).

6. Taking the ACK_EN line high on the RU causes the module to send an acknowledgement to the IU. The ACK_OUT line on the IU goes high to indicate that the acknowledgement has been received. Tying the line to V_{cc} causes the module to send an acknowledgement as soon as a command message is received.

This is suitable for basic remote control or command systems. No programming is necessary for basic hardware operation. The Typical Applications section shows additional example schematics for using the modules.

The Command Data Interface section describes the more advanced features that are available with the serial interface.

Typical Applications

Figure 43 and Figure 44 show circuits using the HumRC™ Series transceiver.

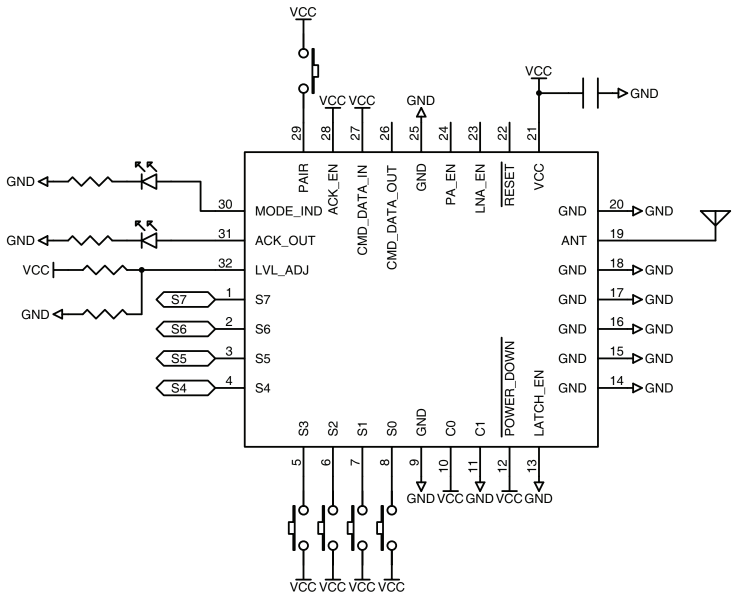


Figure 43: HumRC™ Series Transceiver Basic Application Circuit

In this example, C0 is high and C1 is low, so S0–S3 are inputs and S4–S7 are outputs. The inputs are connected to buttons that pull the lines high and weak pull-down resistors to keep the lines from floating when the buttons are not pressed. The outputs would be connected to external application circuitry.

LATCH_EN is low, so the outputs are momentary.

The Command Data Interface is not used in this design, so CMD_DATA_IN is tied high and CMD_DATA_OUT is not connected.

ACK_OUT and MODE_IND are connected to LEDs to provide visual indication to the user.

PAIR is connected to a button and pull-down resistor to initiate the Pair Process when the button is pressed.

ACK_EN is tied high so the module sends acknowledgements as soon as it receives a control message.

Usage Guidelines for FCC and IC Compliance

The pre-certified versions of the HumRC™ Series module (HUM-900-RC-UFL and HUM-900-RC-CAS) are provided with an FCC and Industry Canada Modular Certification. This certification shows that the module meets the requirements of FCC Part 15 and Industry Canada license-exempt RSS standards for an intentional radiator. The integrator does not need to conduct any further intentional radiator testing under these rules provided that the following guidelines are met:

- An approved antenna must be directly coupled to the module's U.FL connector through an approved coaxial extension cable or to the module's castellation pad using an approved reference design and PCB layer stack.
- Alternate antennas can be used, but may require the integrator to perform certification testing.
- The module must not be modified in any way. Coupling of external circuitry must not bypass the provided connectors.
- End product must be externally labeled with "Contains FCC ID: OJM900MCA / IC: 5840A-900MCA".
- The end product's user's manual must contain an FCC statement equivalent to that listed on page page 45 of this data guide.
- The antenna used for this transceiver must not be co-located or operating in conjunction with any other antenna or transmitter.
- The integrator must not provide any information to the end-user on how to install or remove the module from the end-product.

Any changes or modifications not expressly approved by Linx Technologies could void the user's authority to operate the equipment.

Additional Testing Requirements

The HUM-900-RC-UFL and HUM-900-RC-CAS modules have been tested for compliance as an intentional radiator, but the integrator is required to perform unintentional radiator testing on the final product per FCC sections 15.107 and 15.109 and Industry Canada license-exempt RSS standards. Additional product-specific testing might be required. Please contact the FCC or Industry Canada regarding regulatory requirements for the application. Ultimately is it the integrator's responsibility to show that their product complies with the regulations applicable to their product. **Versions other than the -UFL and -CAS have not been tested and require full compliance testing in the end product as it will go to market.**

Product Labeling

The end product containing the HUM-900-RC-UFL or HUM-900-RC-CAS must be labeled to meet the FCC and IC product label requirements. It must have the below or similar text:

Contains FCC ID: OJM900MCA / IC: 5840A-900MCA

The label must be permanently affixed to the product and readily visible to the user. “Permanently affixed” means that the label is etched, engraved, stamped, silkscreened, indelibly printed, or otherwise permanently marked on a permanently attached part of the equipment or on a nameplate of metal, plastic, or other material fastened to the equipment by welding, riveting, or a permanent adhesive. The label must be designed to last the expected lifetime of the equipment in the environment in which the equipment may be operated and must not be readily detachable.

FCC RF Exposure Statement

To satisfy RF exposure requirements, this device and its antenna must operate with a separation distance of at least 20cm from all persons and must not be co-located or operating in conjunction with any other antenna or transmitter.

Antenna Selection

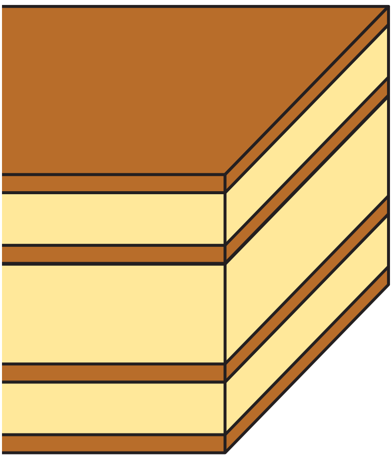
Under FCC and Industry Canada regulations, the HUM-900-RC-UFL and HUM-900-RC-CAS radio transmitters may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by the FCC and Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

The HUM-900-RC-UFL and HUM-900-RC-CAS radio transmitters have been approved by the FCC and Industry Canada to operate with the antenna types listed in Figure 45 with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Conformément à la réglementation d’Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d’un type et d’un gain maximal (ou inférieur) approuvé pour l’émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l’intention des autres

Castellation Version Reference Design

The castellation connection for the antenna on the pre-certified version allows the use of embedded antennas as well as removes the cost of a cable assembly for the u.FL connector. However, **the PCB design and layer stack must follow one of the reference designs for the certification on the HUM-900-RC-CAS to be valid.** Figure 46 shows the PCB layer stack that should be used. Figure 47 shows the layout and routing designs for the different antenna options. Please see the antenna data sheets for specific ground plane counterpoise requirements.



Layer Name	Thickness	Material
Top Layer	1.4mil	Copper
Dielectric 1	14.00mil	FR-4 (Er = 4.6)
Mid-Layer 1	1.4mil	Copper
Dielectric 2	28.00mil	FR-4 (Er = 4.6)
Mid-Layer 2	1.4mil	Copper
Dielectric 3	14.00mil	FR-4 (Er = 4.6)
Bottom Layer	1.4mil	Copper

Figure 46: HumRC™ Series Transceiver Castellation Version Reference Design PCB Stack

Note: The PCB design and layer stack for the HUM-900-RC-CAS must follow these reference designs for the pre-certification to be valid.

The HUM-900-RC-UFL and the HUM-900-RC-CAS must use one of the antennas in Figure 45 in order for the certification to be valid.

The HUM-900-RC and HUM-2.4-RC have not been tested and require full compliance testing in the end product as it will go to market.

All modules require unintentional radiator compliance testing in the end product as it will go to market.

Power Supply Requirements

The module does not have an internal voltage regulator, therefore it requires a clean, well-regulated power source. The power supply noise should be less than 20mV. Power supply noise can significantly affect the module's performance, so providing a clean power supply for the module should be a high priority during design.

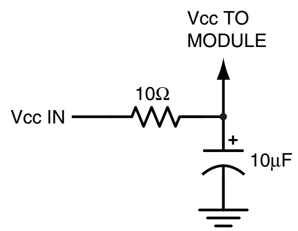


Figure 48: Supply Filter

A 10Ω resistor in series with the supply followed by a 10µF tantalum capacitor from V_{cc} to ground helps in cases where the quality of supply power is poor (Figure 48). This filter should be placed close to the module's supply lines. These values may need to be adjusted depending on the noise present on the supply line.

Antenna Considerations

The choice of antennas is a critical and often overlooked design consideration. The range, performance and legality of an RF link are critically dependent upon the antenna. While adequate antenna performance can often be obtained by trial and error methods, antenna design and matching is a complex task. Professionally designed antennas such as those from Linx (Figure 49) help ensure maximum performance and FCC and other regulatory compliance. Please see "General Antenna Rules" for more information.

Figure 49: Linx Antennas

It is usually best to utilize a basic quarter-wave whip until your prototype product is operating satisfactorily. Other antennas can then be evaluated based on the cost, size and cosmetic requirements of the product. Additional details are in Application Note AN-00500.

Pad Layout

The pad layout diagrams below are designed to facilitate both hand and automated assembly. Figure 50 shows the footprint for the smaller version and Figure 51 shows the footprint for the pre-certified version.

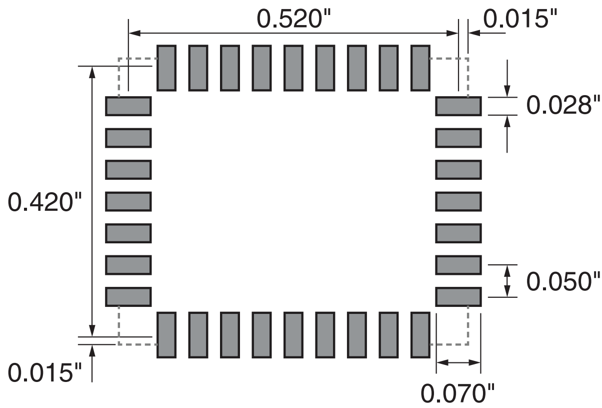


Figure 50: HUM-***-RC Recommended PCB Layout

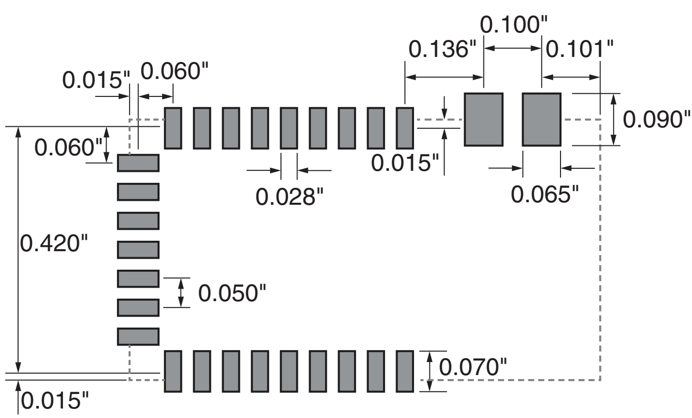


Figure 51: HUM-***-RC-UFL/CAS Recommended PCB Layout

Board Layout Guidelines

The module's design makes integration straightforward; however, it is still critical to exercise care in PCB layout. Failure to observe good layout techniques can result in a significant degradation of the module's performance. A primary layout goal is to maintain a characteristic 50-ohm impedance throughout the path from the antenna to the module. Grounding, filtering, decoupling, routing and PCB stack-up are also important considerations for any RF design. The following section provides some basic design guidelines.

During prototyping, the module should be soldered to a properly laid-out circuit board. The use of prototyping or "perf" boards results in poor performance and is strongly discouraged. Likewise, the use of sockets can have a negative impact on the performance of the module and is discouraged.

The module should, as much as reasonably possible, be isolated from other components on your PCB, especially high-frequency circuitry such as crystal oscillators, switching power supplies, and high-speed bus lines.

When possible, separate RF and digital circuits into different PCB regions.

Make sure internal wiring is routed away from the module and antenna and is secured to prevent displacement.

Do not route PCB traces directly under the module. There should not be any copper or traces under the module on the same layer as the module, just bare PCB. The underside of the module has traces and vias that could short or couple to traces on the product's circuit board.

The Pad Layout section shows a typical PCB footprint for the module. A ground plane (as large and uninterrupted as possible) should be placed on a lower layer of your PC board opposite the module. This plane is essential for creating a low impedance return for ground and consistent stripline performance.

Use care in routing the RF trace between the module and the antenna or connector. Keep the trace as short as possible. Do not pass it under the module or any other component. Do not route the antenna trace on multiple PCB layers as vias add inductance. Vias are acceptable for tying together ground layers and component grounds and should be used in multiples. The -CAS version must follow the layout in Figure 47.

Production Guidelines

The module is housed in a hybrid SMD package that supports hand and automated assembly techniques. Since the modules contain discrete components internally, the assembly procedures are critical to ensuring the reliable function of the modules. The following procedures should be reviewed with and practiced by all assembly personnel.

Hand Assembly

Pads located on the bottom of the module are the primary mounting surface (Figure 55). Since these pads are inaccessible during mounting, castellations that run up the side of the module have been provided to facilitate solder wicking to the module's underside. This allows for very quick hand soldering for prototyping and small volume production. If the recommended pad guidelines have been followed, the pads will protrude slightly past the edge of the module. Use a fine soldering tip to heat the board pad and the castellation, then introduce solder to the pad at the module's edge. The solder will wick underneath the module, providing reliable attachment. Tack one module corner first and then work around the device, taking care not to exceed the times in Figure 56.

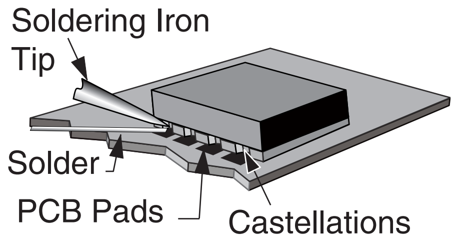


Figure 55: Soldering Technique

Warning: Pay attention to the absolute maximum solder times.

Absolute Maximum Solder Times
Hand Solder Temperature: +427ºC for 10 seconds for lead-free alloys
Reflow Oven: +255ºC max (see Figure 57)

Figure 56: Absolute Maximum Solder Times

Automated Assembly

For high-volume assembly, the modules are generally auto-placed. The modules have been designed to maintain compatibility with reflow processing techniques; however, due to their hybrid nature, certain aspects of the assembly process are far more critical than for other component types. Following are brief discussions of the three primary areas where caution must be observed.

General Antenna Rules

The following general rules should help in maximizing antenna performance.

1. Proximity to objects such as a user's hand, body or metal objects will cause an antenna to detune. For this reason, the antenna shaft and tip should be positioned as far away from such objects as possible.

2. Optimum performance is obtained from a ¼- or ½-wave straight whip mounted at a right angle to the ground plane (Figure 58). In many cases, this isn't desirable for practical or ergonomic reasons, thus, an alternative antenna style such as a helical, loop or patch may be utilized and the corresponding sacrifice in performance accepted.

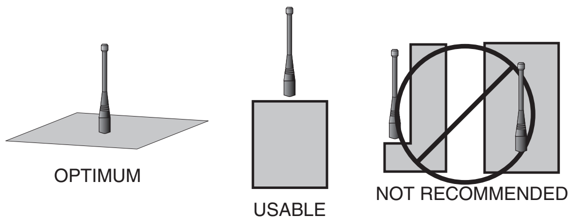


Figure 58: Ground Plane Orientation

3. If an internal antenna is to be used, keep it away from other metal components, particularly large items like transformers, batteries, PCB tracks and ground planes. In many cases, the space around the antenna is as important as the antenna itself. Objects in close proximity to the antenna can cause direct detuning, while those farther away will alter the antenna's symmetry.

4. In many antenna designs, particularly ¼-wave whips, the ground plane acts as a counterpoise, forming, in essence, a ½-wave dipole (Figure 59). For this reason, adequate ground plane area is essential. The ground plane can be a metal case or ground-fill areas on a circuit board. Ideally, it should have a surface area less than or equal to the overall length of the ¼-wave radiating element. This is often not practical due to size and configuration constraints. In these instances, a designer must make the best use of the area available to create as much ground

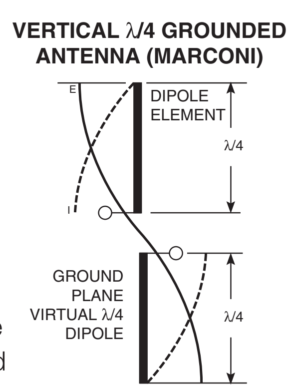


Figure 59: Dipole Antenna

Common Antenna Styles

There are hundreds of antenna styles and variations that can be employed with Linx RF modules. Following is a brief discussion of the styles most commonly utilized. Additional antenna information can be found in Linx Application Notes AN-00100, AN-00140, AN-00500 and AN-00501. Linx antennas and connectors offer outstanding performance at a low price.

Whip Style

A whip style antenna (Figure 61) provides outstanding overall performance and stability. A low-cost whip can be easily fabricated from a wire or rod, but most designers opt for the consistent performance and cosmetic appeal of a professionally-made model. To meet this need, Linx offers a wide variety of straight and reduced height whip style antennas in permanent and connectorized mounting styles.

Figure 61: Whip Style Antennas

The wavelength of the operational frequency determines an antenna's overall length. Since a full wavelength is often quite long, a partial ½- or ¼-wave antenna is normally employed. Its size and natural radiation resistance make it well matched to Linx modules. The proper length for a straight ¼-wave can be easily determined using the formula in Figure 62. It is also possible to reduce the overall height of the antenna by using a helical winding. This reduces the antenna's bandwidth but is a great way to minimize the antenna's physical size for compact applications. This also means that the physical appearance is not always an indicator of the antenna's frequency.

$$L = \frac{234}{F_{MHz}}$$

Figure 62:
L = length in feet of quarter-wave length
F = operating frequency in megahertz

Specialty Styles

Linx offers a wide variety of specialized antenna styles (Figure 63). Many of these styles utilize helical elements to reduce the overall antenna size while maintaining reasonable performance. A helical antenna's bandwidth is often quite narrow and the antenna can detune in proximity to other objects, so care must be exercised in layout and placement.

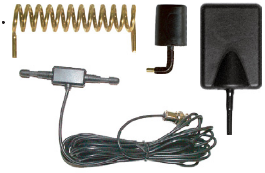


Figure 63: Specialty Style Antennas

Regulatory Considerations

Note: Linx RF modules are designed as component devices that require external components to function. The purchaser understands that additional approvals may be required prior to the sale or operation of the device, and agrees to utilize the component in keeping with all laws governing its use in the country of operation.

When working with RF, a clear distinction must be made between what is technically possible and what is legally acceptable in the country where operation is intended. Many manufacturers have avoided incorporating RF into their products as a result of uncertainty and even fear of the approval and certification process. Here at Linx, our desire is not only to expedite the design process, but also to assist you in achieving a clear idea of what is involved in obtaining the necessary approvals to legally market a completed product.

For information about regulatory approval, read AN-00142 on the Linx website or call Linx. Linx designs products with worldwide regulatory approval in mind.

In the United States, the approval process is actually quite straightforward. The regulations governing RF devices and the enforcement of them are the responsibility of the Federal Communications Commission (FCC). The regulations are contained in Title 47 of the United States Code of Federal Regulations (CFR). Title 47 is made up of numerous volumes; however, all regulations applicable to this module are contained in Volume 0-19. It is strongly recommended that a copy be obtained from the FCC's website, the Government Printing Office in Washington or from your local government bookstore. Excerpts of applicable sections are included with Linx evaluation kits or may be obtained from the Linx Technologies website, www.linxtechnologies.com. In brief, these rules require that any device that intentionally radiates RF energy be approved, that is, tested for compliance and issued a unique identification number. This is a relatively painless process. Final compliance testing is performed by one of the many independent testing laboratories across the country. Many labs can also provide other certifications that the product may require at the same time, such as UL, CLASS A / B, etc. Once the completed product has passed, an ID number is issued that is to be clearly placed on each product manufactured.

Linx Technologies
159 Ort Lane
Merlin, OR, US 97532

Phone: +1 541 471 6256
Fax: +1 541 471 6251

www.linxtechnologies.com