Linx
TECHNOLOGIES

LR Series
Receiver Module
Data Guide

Wireless made simple®

⚠ **Warning:** Linx radio frequency ("RF") products may be used 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. No Linx Technologies product is intended for use in any application without redundancies where the safety of life or property is at risk.

The customers and users of devices and machinery controlled with RF products must understand and must use all appropriate safety procedures in connection with the devices, including without limitation, using appropriate safety procedures to prevent inadvertent triggering by the user of the device and using appropriate security codes to prevent triggering of the remote controlled machine or device by users of other remote controllers.

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. This module does not have data validation built in.

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 not have frequency agility built in, but the developer can implement frequency agility with a microcontroller and the example code in Linx Reference Guide RG-00101.

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.

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Description

The LR Receiver is ideal for the wireless transfer of serial data, control, or command information in the favorable 260–470MHz band. The receiver's advanced synthesized architecture achieves an outstanding typical sensitivity of –112dBm, which provides a 5 to 10 times improvement in range over previous solutions. When paired with a compatible Linx t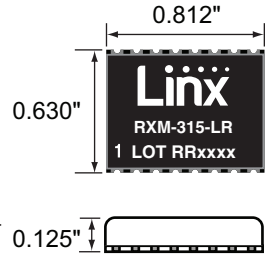ransmitter, a reliable wireless link is formed capable of transferring serial data at rates of up to 10,000bps at distances of up to 3,000 feet. Applications operating over shorter distances or at lower data rates will also benefit from increased link reliability and superior noise immunity. Housed in a tiny reflow-compatible SMD package, the LR Receiver module is footprint-compatible with the popular LC-S Receiver, allowing existing users an instant path to improved range and lower cost. No external RF components are required (except an antenna), allowing for easy integration, even for engineers without previous RF experience.

Figure 1: Package Dimensions

Features

- Long range
- Low cost
- PLL-synthesized architecture
- Direct serial interface
- Data rates up to 10,000bps
- No external RF components required
- Low power consumption
- Low supply voltage (2.1 to 3.6VDC)
- Compact surface-mount package
- Wide temperature range
- RSSI and Power-down function
- No production tuning

Applications

- Remote control
- Keyless entry
- Garage/gate openers
- Lighting control
- Medical monitoring/call systems
- Remote industrial monitoring
- Periodic data transfer
- Home/industrial automation
- Fire/security alarms
- Remote status/position sensing
- Long-range RFID
- Wire elimination

Revised 11/05/12

Ordering Information

Ordering Information	
Part Number	**Description**
TXM-315-LR	315MHz Transmitter
TXM-418-LR	418MHz Transmitter
TXM-433-LR	433MHz Transmitter
RXM-315-LR	315MHz Receiver
RXM-418-LR	418MHz Receiver
RXM-433-LR	433MHz Receiver
EVAL-***-LR	Basic Evaluation Kit

*** = Frequency
Receivers are supplied in tubes of 18 pcs.

Figure 2: Ordering Information

Absolute Maximum Ratings

Absolute Maximum Ratings				
Supply Voltage V_{CC}	−0.3	to	+3.6	VDC
Supply Voltage V_{CC}, Using Resistor	−0.3	to	+5.2	VDC
Any Input or Output Pin	−0.3	to	+3.6	VDC
RF Input		0		dBm
Operating Temperature	−40	to	+70	ºC
Storage Temperature	−45	to	+85	ºC
Soldering Temperature	+225ºC for 10 seconds			

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

Electrical Specifications

LR Series Transceiver Specifications						
Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Power Supply						
Operating Voltage	V_{CC}	2.7	3.0	3.6	VDC	
With Dropping Resistor		4.3	5.0	5.2	VDC	1,5
Supply Current	I_{CC}	4.0	5.2	7.0	mA	
Power Down Current	I_{PDN}	20.0	28.0	35.0	µA	5
Receiver Section						
Receive Frequency Range	F_C					
RXM-315-LR			315		MHz	
RXM-418-LR			418		MHz	
RXM-433-LR			433.92		MHz	
Center Frequency Accuracy		−50		+50	kHz	
LO Feedthrough			−80		dBm	2,5
IF Frequency	F_{IF}		10.7		MHz	5
Noise Bandwidth	N_{3DB}		280		kHz	
Data Rate		100		10,000	bps	
Data Output:						
Logic Low	V_{OL}		0.0		VDC	3
Logic High	V_{OH}		3.0		VDC	3
Power Down Input:						
Logic Low	V_{IL}			0.4	VDC	
Logic High	V_{IH}	V_{CC}−0.4			VDC	
Receiver Sensitivity		−106	−112	−118	dBm	4
RSSI / Analog						
Dynamic Range			80		dB	5
Analog Bandwidth		50		5,000	Hz	5
Gain			16		mv / dB	5
Voltage with No Carrier			1.5		V	5
Antenna Port						
RF Input Impedance	R_{IN}		50		Ω	5
Timing						
Receiver Turn-On Time						
Via V_{CC}		3.0	7.0	10.0	ms	5,6
Via PDN		0.04	0.25	0.50	nS	5,6

LR Series Receiver Specifications Continued						
Parameter	Symbol	Min.	Typ.	Max.	Units	Notes
Max. Time Between Transitions			10.0		ms	5
Environmental						
Operating Temperature Range		–40		+70	°C	5

1. The LR can utilize a 4.3 to 5.2VDC supply provided a 330Ω resistor is placed in series with V_{CC}.
2. Into a 50Ω load.
3. When operating from a 5V source, it is important to consider that the output will swing to well less than 5 volts as a result of the required dropping resistor. Please verify that the minimum voltage will meet the high threshold requirement of the device to which data is being sent.
4. For BER of 10^{-5} at 1,200bps.
5. Characterized, but not tested.
6. Time to valid data output.

Figure 4: Electrical Specifications

Performance Data

These performance parameters are based on module operation at 25°C from a 3.0VDC supply unless otherwise noted. Figure 2 illustrates the connections necessary for testing and operation. It is recommended all ground pins be connected to the ground plane. The pins marked NC have no electrical connection.
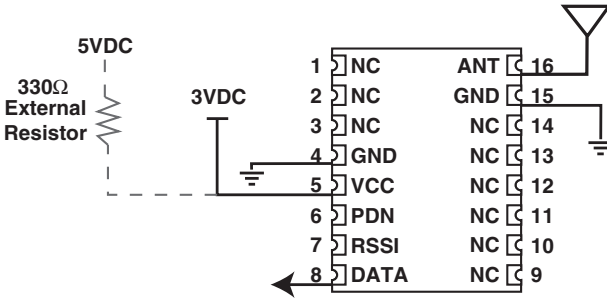

Figure 5: Test / Basic Application Circuit
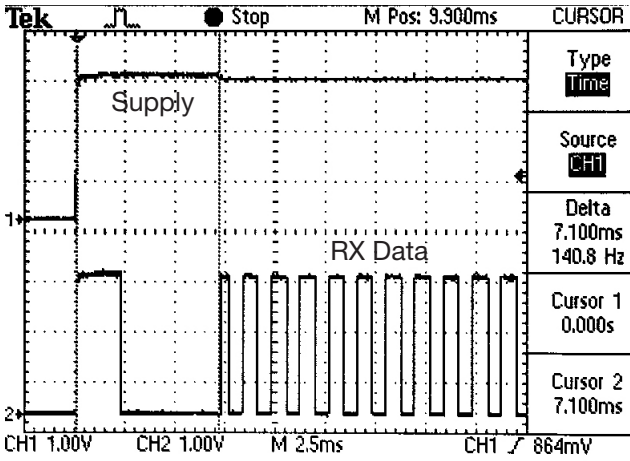
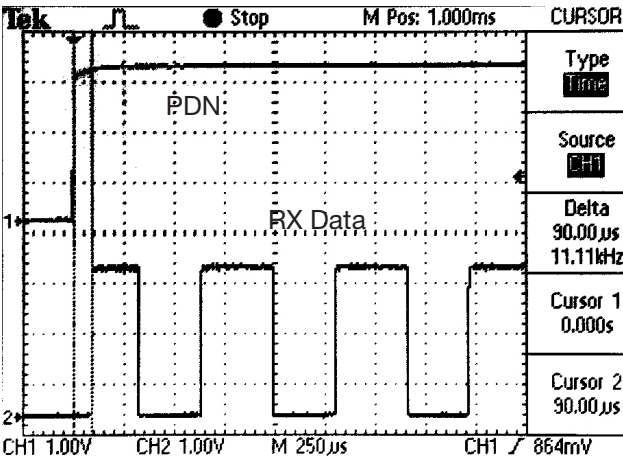## Typical Performance Graphs

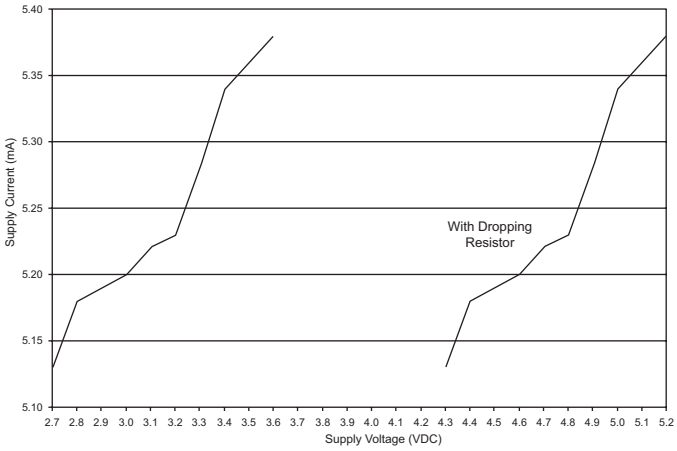Figure 6: Turn-On Time from V_{CC}

Figure 7: Turn-On Time from PDN

Figure 8: Consumption vs. Supply
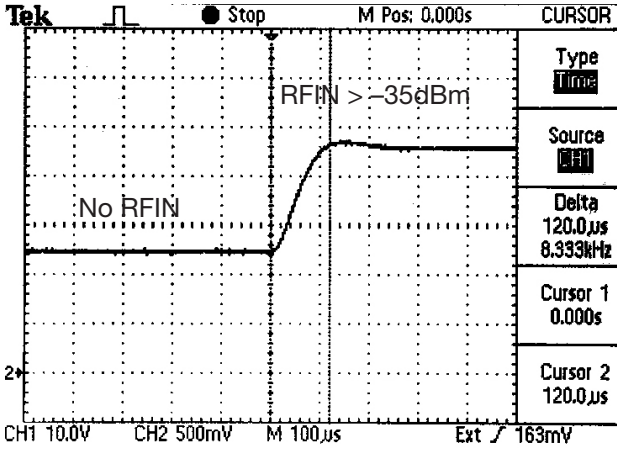
Figure 9: RSSI Response Time

Pin Assignments

1	NC	ANT 16
2	NC	GND 15
3	NC	NC 14
4	GND	NC 13
5	VCC	NC 12
6	PDN	NC 11
7	RSSI	NC 10
8	DATA	NC 9

Figure 10: LR Series Receiver Pinout (Top View)

Pin Descriptions

Pin Descriptions		
Pin Number	Name	Description
1	NC	No Connection
2	NC	No Connection
3	NC	No Connection
4	GND	Analog Ground
5	V_{CC}	Supply Voltage
6	PDN	Power Down. Pulling this line low will place the receiver into a low-current state. The module will not be able to receive a signal in this state.
7	RSSI	Received Signal Strength Indicator. This line will supply an analog voltage that is proportional to the strength of the received signal.
8	DATA	Digital Data Output. This line will output the demodulated digital data.
9	NC	No Connection
10	NC	No Connection
11	NC	No Connection
12	NC	No Connection
13	NC	No Connection
14	NC	No Connection
15	GND	Analog Ground
16	RF IN	50Ω RF Input

Figure 11: Pin Descriptions

Module Description

The LR receiver is a low-cost, high-performance synthesized AM / OOK receiver, capable of receiving serial data at up to 10,000bps. Its exceptional sensitivity results in outstanding range performance. The LR's compact surface-mount package is friendly to automated or hand production. LR Series modules are capable of meeting the regulatory requirements of many domestic and international applications.
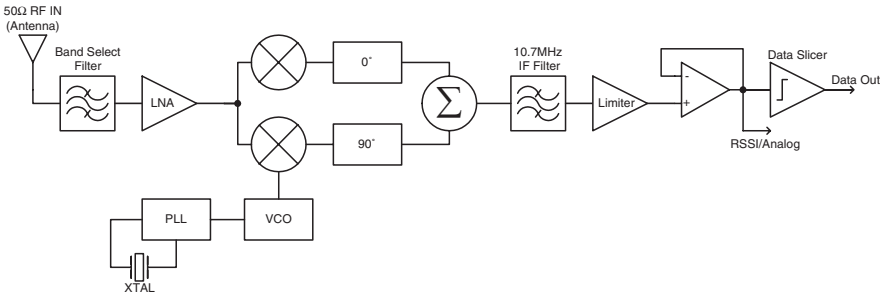

Figure 12: LR Series Receiver Block Diagram

Theory of Operation

The LR receiver is designed to recover data sent by an AM or Carrier-Present Carrier-Absent (CPCA) transmitter, also referred to as CW or On-Off Keying (OOK). This type of modulation represents a logic low '0' by the absence of a carrier and a logic high '1' by the presence

Data

Carrier

Figure 13: CPCA (AM) Modulation

of a carrier. This modulation method affords numerous benefits. The two most important are: 1) cost-effectiveness due to design simplicity and 2) higher allowable output power and thus greater range in countries (such as the U.S.) that average output power measurements over time. Please refer to Linx Application Note AN-00130 for a further discussion of modulation techniques.

The LR receiver utilizes an advanced single-conversion superheterodyne architecture. Transmitted signals enter the module through a 50Ω RF port intended for single-ended connection to an external antenna. RF signals entering the antenna are filtered and then amplified by an NMOS cascode Low Noise Amplifier (LNA). The filtered, amplified signal is then down-converted to a 10.7MHz Intermediate Frequency (IF) by mixing it with a low-side Local Oscillator (LO). The LO frequency is generated by a Voltage Controlled Oscillator (VCO) locked by a Phase-Locked Loop (PLL) frequency synthesizer that utilizes a precision crystal reference. The mixer stage incorporates a pair of double-balanced mixers and a unique image rejection circuit. This circuit, along with the high IF frequency and ceramic IF filters, reduces susceptibility to interference. The IF frequency is further amplified, filtered, and demodulated to recover the baseband signal originally transmitted. The baseband signal is squared by a data slicer and output to the DATA pin. The architecture and quality of the components utilized in the LR module enable it to outperform many far more expensive receiver products.

Power Supply Requirements

The module does not have an internal voltage regulator, therefore it requires a clean, well-regulated power source. While it is preferable to power the unit from a battery, it can also be operated from a power supply as long as noise is less than 20mV. Power supply noise can significantly affect the receiver sensitivity, therefore; providing clean power to the module should be a high priority during design.
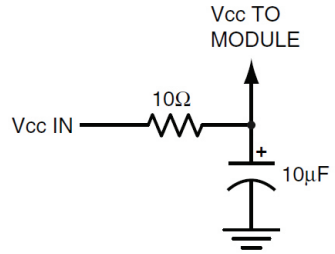

Figure 14: Supply Filter

A 10Ω resistor in series with the supply followed by a 10μF tantalum capacitor from VCC to ground will help in cases where the quality of the supply power is poor. Operation from 4.3V to 5.2V requires an external 330-ohm series resistor to prevent VCC from exceeding 3.6V. These values may need to be adjusted depending on the noise present on the supply line.

Using the PDN Pin

The Power Down (PDN) line can be used to power down the receiver without the need for an external switch. This line has an internal pull-up, so when it is held high or simply left floating, the module will be active.

When the PDN line is pulled to ground, the receiver will enter into a low-current (<40μA) power-down mode. During this time the receiver is off and cannot perform any function. It may be useful to note that the startup time coming out of power-down will be slightly less than when applying V_{CC}.

The PDN line allows easy control of the receiver state from external components, like a microcontroller. By periodically activating the receiver, checking for data, then powering down, the receiver's average current consumption can be greatly reduced, saving power in battery-operated applications.

Note: The voltage on the PDN line should not exceed V_{CC}. When used with a higher voltage source, such as a 5V microcontroller, an open collector line should be used or a diode placed in series with the control line (anode toward the module). Either method avoids damage to the module by preventing 5V from being placed on the PDN line while allowing the line to be pulled low.

Using the RSSI Pin

The receiver's Received Signal Strength Indicator (RSSI) line serves a variety of functions. This line has a dynamic range of 80dB (typical) and outputs a voltage proportional to the incoming signal strength. It should be noted that the RSSI levels and dynamic range will vary slightly from part to part. It is also important to remember that RSSI output indicates the strength of any in-band RF energy and not necessarily just that from the intended transmitter; therefore, it should be used only to qualify the level and presence of a signal.

The RSSI output can be utilized during testing or even as a product feature to assess interference and channel quality by looking at the RSSI level with all intended transmitters shut off. The RSSI output can also be used in direction-finding applications, although there are many potential perils to consider in such systems. Finally, it can be used to save system power by "waking up" external circuitry when a transmission is received or crosses a certain threshold. The RSSI output feature adds tremendous versatility for the creative designer.

The Data Output

The CMOS-compatible data output is normally used to drive a digital decoder IC or a microprocessor that is performing the data decoding. In addition, the module can be connected to an RS-232 level converter chip, like the MAX232, to a Linx USB module for interfacing to a PC, or to a standard UART. Since a UART uses high marking to indicate the absence of data, a designer using a UART may wish to insert a logic inverter between the data output of the receiver and the UART.

The receiver's output may appear to switch randomly in the absence of a transmitter. This is a result of the receiver sensitivity being below the noise floor of the board. This noise can be handled in software by implementing a noise-tolerant protocol as described in Application Note AN-00160. If a software solution is not appropriate, the squelch circuit in the figure below can be used and the designer can make a compromise between noise level and range.
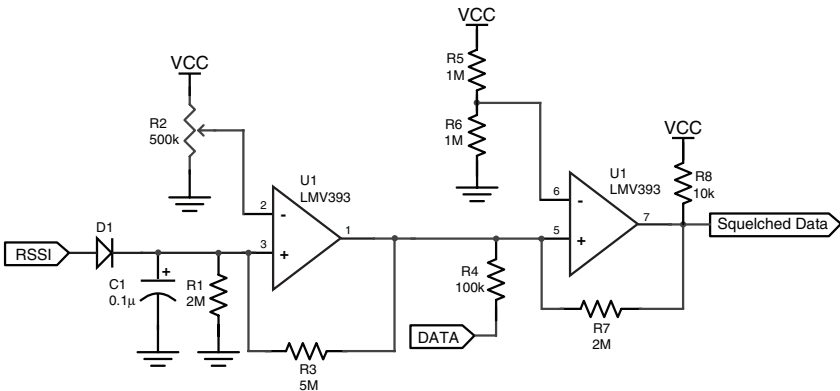

Figure 15: LR Receiver and LS Decoder

Receiving Data

Once an RF link has been established, the challenge becomes how to effectively transfer data across it. While a properly designed RF link provides reliable data transfer under most conditions, there are still distinct differences from a wired link that must be addressed. Since the LR modules do not incorporate internal encoding / decoding, the user has tremendous flexibility in how data is handled.

It is always important to separate what types of transmissions are technically possible from those that are legally allowable in the country of intended operation. Application Notes AN-00125 and AN-00140 should be reviewed along with Part 15, Section 231 for further details on acceptable transmission content.

If you want to transfer simple control or status signals, such as button presses or switch closures, and your product does not have a microprocessor on board or you wish to avoid protocol development, consider using an encoder and decoder IC set. These chips are available from a wide range of manufacturers including Linx, Microchip, and Holtek. These chips take care of all encoding and decoding functions and generally provide a number of data pins to which switches can be directly connected. In addition, address bits are usually provided for security and to allow the addressing of multiple receivers independently. These ICs are an excellent way to bring basic remote control / status products quickly and inexpensively to market. Additionally, it is a simple task to interface with inexpensive microprocessors such as the Microchip PIC or one of many IR, remote control, DTMF, and modem ICs.

Protocol Guidelines

While many RF solutions impose data formatting and balancing require-
ments, Linx RF modules do not encode or packetize the signal content in
any manner. The received signal will be affected by such factors as noise,
edge jitter, and interference, but it is not purposefully manipulated or altered
by the modules. This gives the designer tremendous flexibility for protocol
design and interface.

Despite this transparency and ease of use, it must be recognized that there
are distinct differences between a wired and a wireless environment. Issues
such as interference and contention must be understood and allowed for in
the design process. To learn more about protocol considerations, we
suggest you read Linx Application Note AN-00160.

Errors from interference or changing signal conditions can cause corruption
of the data packet, so it is generally wise to structure the data being sent
into small packets. This allows errors to be managed without affecting large
amounts of data. A simple checksum or CRC could be used for basic error
detection. Once an error is detected, the protocol designer may wish to
simply discard the corrupt data or implement a more sophisticated scheme
to correct it.

Interference Considerations

The RF spectrum is crowded and the potential for conflict with other
unwanted sources of RF is very real. While all RF products are at risk from
interference, its effects can be minimized by better understanding its
characteristics.

Interference may come from internal or external sources. The first step is to
eliminate interference from noise sources on the board. This means paying
careful attention to layout, grounding, filtering, and bypassing in order to
eliminate all radiated and conducted interference paths. For many prod-
ucts, this is straightforward; however, products containing components
such as switching power supplies, motors, crystals, and other potential
sources of noise must be approached with care. Comparing your own
design with a Linx evaluation board can help to determine if and at what
level design-specific interference is present.

External interference can manifest itself in a variety of ways. Low-level
interference will produce noise and hashing on the output and reduce the
link's overall range.

High-level interference is caused by nearby products sharing the same frequency or from near-band high-power devices. It can even come from your own products if more than one transmitter is active in the same area. It is important to remember that only one transmitter at a time can occupy a frequency, regardless of the coding of the transmitted signal. This type of interference is less common than those mentioned previously, but in severe cases it can prevent all useful function of the affected device.

Although technically it is not interference, multipath is also a factor to be understood. Multipath is a term used to refer to the signal cancellation effects that occur when RF waves arrive at the receiver in different phase relationships. This effect is a particularly significant factor in interior environments where objects provide many different signal reflection paths. Multipath cancellation results in lowered signal levels at the receiver and, thus, shorter useful distances for the link.

Typical Applications

Figure 16 shows a circuit using the Linx LICAL-DEC-MS001 decoder. This chip works with the LICAL-ENC-MS001 encoder to provide simple remote control capabilities. The decoder will detect the transmission from the encoder, check for errors, and if everything is correct, the encoder's inputs will be replicated on the decoder's outputs. This makes sending key presses very easy.
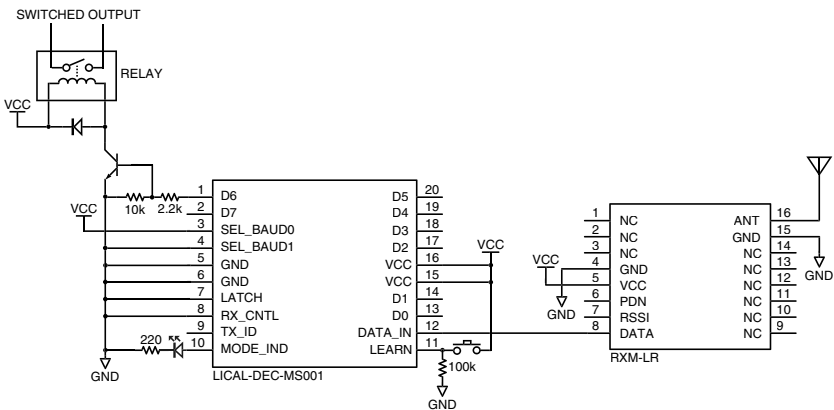

Figure 16: LR Receiver and MS Decoder

Figure 17 shows a typical RS-232 circuit using the LR receiver and a Maxim MAX232 chip. The LR will output a serial data stream and the MAX232 will convert that to RS-232 compliant signals.
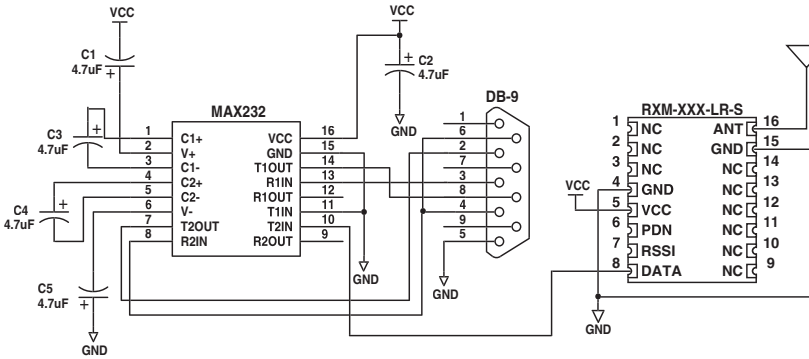

Figure 17: LR Receiver and MAX232 IC

Figure 18 shows an example of combining the LR Series receiver with a Linx SDM-USB-QS-S USB module. The LR will output a serial data stream and the USB module will convert that to low-speed USB compliant signals.
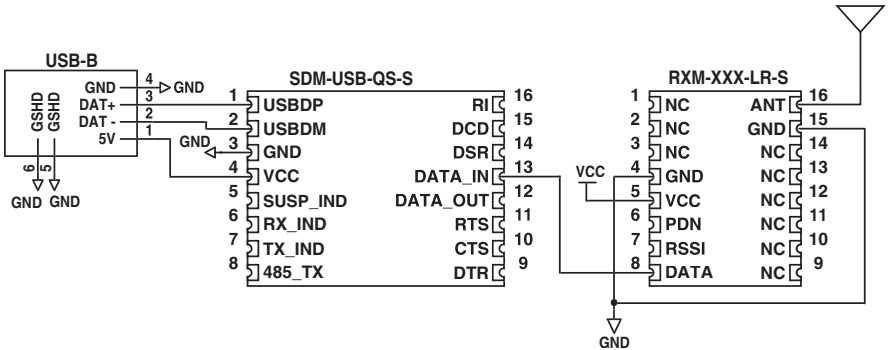

Figure 18: LR Receiver and Linx USB Module

Board Layout Guidelines

If you are at all familiar with RF devices, you may be concerned about specialized board layout requirements. Fortunately, because of the care taken by Linx in designing the modules, integrating them is very straight-forward. Despite this ease of application, it is still necessary to maintain respect for the RF stage and exercise appropriate care in layout and appli-cation in order to maximize performance and ensure reliable operation. The antenna can also be influenced by layout choices. Please review this data guide in its entirety prior to beginning your design. By adhering to good layout principles and observing some basic design rules, you will be on the path to RF success.

Figure 19 shows the suggested PCB footprint for the module. The actual pad dimensions are shown in the Pad Layout section of this manual. A ground plane (as large as possible) should be placed on a low-er layer of your PC board opposite the module. This ground plane can also be critical to the performance of your antenna, which will be discussed later. There should not be any ground or traces under the module on the same layer as the module, just bare PCB.
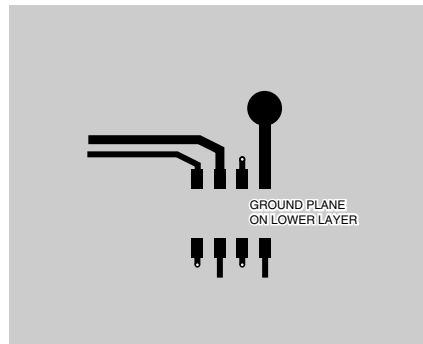
Figure 19: Suggested PCB Layout

During prototyping, the module should be soldered to a properly laid-out circuit board. The use of prototyping or "perf" boards will result in horrible performance and is strongly discouraged.

No conductive items should be placed within 0.15" of the module's top or sides.

Do not route PCB traces directly under the module. The underside of the module has numerous signal-bearing traces and vias that could short or couple to traces on the product's circuit board.

The module's ground lines should each have their own via to the ground plane and be as short as possible.

AM / OOK receivers are particularly subject to noise. 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. Make sure internal wiring is routed away from the module and antenna, and is secured to prevent displacement.

The power supply filter should be placed close to the module's V_{CC} line.

In some instances, a designer may wish to encapsulate or "pot" the product. Many Linx customers have done this successfully; however, there are a wide variety of potting compounds with varying dielectric properties. Since such compounds can considerably impact RF performance, it is the responsibility of the designer to carefully evaluate and qualify the impact and suitability of such materials.

The trace from the module to the antenna should be kept as short as possible. A simple trace is suitable for runs up to ⅛-inch for antennas with wide bandwidth characteristics. For longer runs or to avoid detuning narrow bandwidth antennas, such as a helical, use a 50-ohm coax or 50-ohm microstrip transmission line as described in the following section.

Microstrip Details

A transmission line is a medium whereby RF energy is transferred from one place to another with minimal loss. This is a critical factor, especially in high-frequency products like Linx RF modules, because the trace leading to the module's antenna can effectively contribute to the length of the antenna, changing its resonant bandwidth. In order to minimize loss and detuning, some form of transmission line between the antenna and the module should be used, unless the antenna can be placed very close (<⅛-in.) to the module. One common form of transmission line is a coax cable, another is the microstrip. This term refers to a PCB trace running over a ground plane that is designed to serve as a transmission line between the module and the antenna. The width is based on the desired characteristic impedance of the line, the thickness of the PCB, and the dielectric constant of the board material. For standard 0.062" thick FR- 4 board material, the trace width would be 111 mils. The correct trace width can be calculated for other widths and materials using the information below. Handy software for calculating microstrip lines is also available on the Linx website, www.linxtechnologies.com.
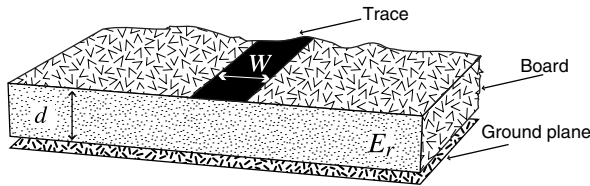
$$E_e = \frac{E_r+1}{2} + \frac{E_r-1}{2} \cdot \frac{1}{\sqrt{1+12d/W}}$$

$$Z_0 = \begin{cases} \dfrac{60}{\sqrt{E_e}} \cdot ln\left(\dfrac{8d}{W} + \dfrac{W}{4d}\right) & \text{For } \dfrac{W}{d} \le 1 \\[4ex] \dfrac{120\pi}{\sqrt{E_e} \cdot \left(\left(\dfrac{W}{d} + 1.393 + 0.667 \cdot 1n\left(\dfrac{W}{d} +1.444\right)\right)\right)} & \text{For } \dfrac{W}{d} \ge 1 \end{cases}$$

E_r = Dielectric constant of PCB material

Figure 20: Microstrip Formulas

Example Microstrip Calculations			
Dielectric Constant	Width/Height Ratio (W/d)	Effective Dielectric Constant	Characteristic Impedance (Ω)
4.80	1.8	3.59	50.0
4.00	2.0	3.07	51.0
2.55	3.0	2.12	48.0

Figure 21: Example Microstrip Calculations

Pad Layout

The following pad layout diagram is designed to facilitate both hand and automated assembly.

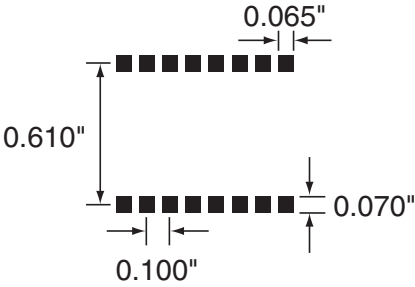

Figure 22: Recommended PCB Layout

Production Guidelines

The modules are housed in a hybrid SMD package that supports hand or 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. 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.
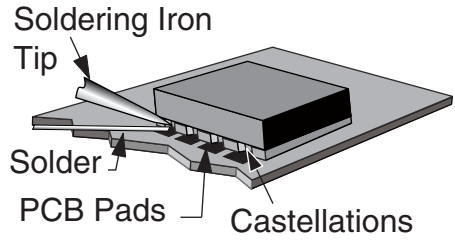

Figure 23: Soldering Technique

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 listed below.

> ⚠ **Warning:** Pay attention to the absolute maximum solder times.
>
> | Absolute Maximum Solder Times |
> | --- |
> | Hand Solder Temperature TX: +225ºC for 10 seconds |
> | Hand Solder Temperature RX: +225ºC for 10 seconds |
> | Recommended Solder Melting Point: +180ºC |
> | Reflow Oven: +255°C Max. (See Figure 25) |

Figure 24: Absolute Maximum Solder Times

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Automated Assembly

For high-volume assembly, most users will want to auto-place the modules. The modules have been designed to maintain compatibility with reflow processing techniques; however, due to the 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.

Reflow Temperature Profile

The single most critical stage in the automated assembly process is the reflow stage. The reflow profile below should not be exceeded, since excessive temperatures or transport times during reflow will irreparably damage the modules. Assembly personnel will need to pay careful attention to the oven's profile to ensure that it meets the requirements necessary to successfully reflow all components while still remaining within the limits mandated by the modules. The figure below shows the recommended reflow oven profile for the modules.
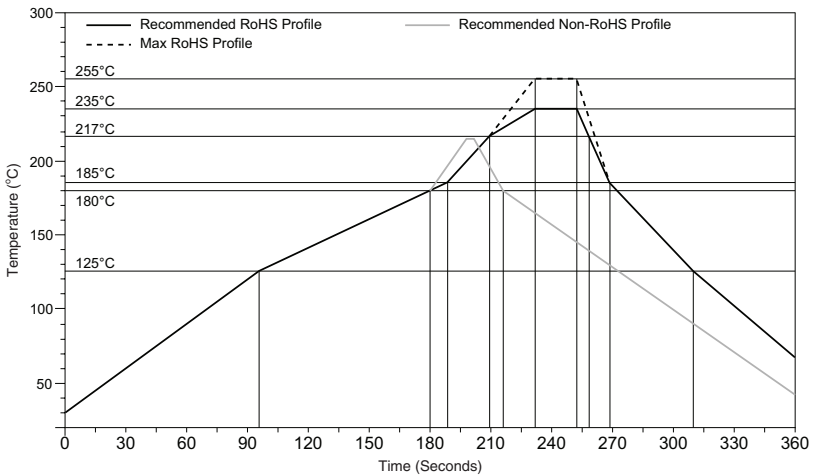

Figure 25: Maximum Reflow Profile

Shock During Reflow Transport

Since some internal module components may reflow along with the components placed on the board being assembled, it is imperative that the modules not be subjected to shock or vibration during the time solder is liquid. Should a shock be applied, some internal components could be lifted from their pads, causing the module to not function properly.

Washability

The modules are wash resistant, but are not hermetically sealed. Linx recommends wash-free manufacturing; however, the modules can be subjected to a wash cycle provided that a drying time is allowed prior to applying electrical power to the modules. The drying time should be sufficient to allow any moisture that may have migrated into the module to evaporate, thus eliminating the potential for shorting damage during power-up or testing. If the wash contains contaminants, the performance may be adversely affected, even after drying.

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. A professionally designed antenna, such as those from Linx, will help ensure maximum performance and FCC compliance.

Figure 26: Linx Antennas

Linx transmitter modules typically have an output power that is slightly higher than the legal limits. This allows the designer to use an inefficient antenna, such as a loop trace or helical, to meet size, cost, or cosmetic requirements and still achieve full legal output power for maximum range. If an efficient antenna is used, then some attenuation of the output power will likely be needed. This can easily be accomplished by using the LADJ line or a T-pad attenuator. For more details on T-pad attenuator design, please see Application Note AN-00150.

A receiver antenna should be optimized for the frequency or band in which the receiver operates and to minimize the reception of off-frequency signals. The efficiency of the receiver's antenna is critical to maximizing range performance. Unlike the transmitter antenna, where legal operation may mandate attenuation or a reduction in antenna efficiency, the receiver's antenna should be optimized as much as is practical.

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. You may wish to review Application Note AN-00500 "Antennas: Design, Application, Performance" and Application Note AN-00501 "Understanding Antenna Specifications and Operation."

Antenna Sharing

In cases where a transmitter and receiver module are combined to form a transceiver, it is often advantageous to share a single antenna. To accomplish this, an antenna switch must be used to provide isolation between the modules so that the full transmitter output power is not put on the sensitive front end of the receiver. There are a wide variety of antenna switches that are cost-effective and easy to use. Among the most popular are switches from Macom and NEC. Look for an antenna switch that has high isolation and low loss at the desired frequency of operation. Generally, the Tx or Rx status of a switch will be controlled by a product's microprocessor, but the user may also make the selection manually. In some cases, where the characteristics of the Tx and Rx antennas need to be different or antenna switch losses are unacceptable, it may be more appropriate to utilize two discrete antennas.
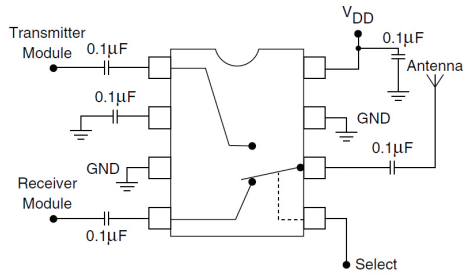

Figure 27: Linx Antennas

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 will be obtained from a quarter or half-wave straight whip mounted at a right angle to the ground plane. 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.
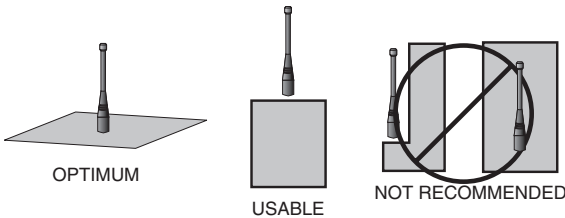

OPTIMUM

USABLE

NOT RECOMMENDED

Figure 28: 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 half-wave dipole. 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 > the overall length of the half-wave radiating element. This is often not practical due to size and configu-ration constraints. In these instances, a designer must make the best use of the

VERTICAL λ/4 GROUNDED ANTENNA (MARCONI)

DIPOLE ELEMENT

λ/4

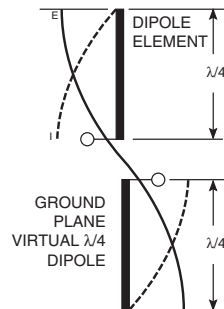GROUND PLANE VIRTUAL λ/4 DIPOLE

λ/4

Figure 29: Dipole Antenna

area available to create as much ground plane as possible in proximity to the base of the antenna. In cases where the antenna is remotely located or the antenna is not in close proximity to a circuit board, ground plane, or grounded metal case, a metal plate may be used to maximize the antenna's performance.

5. Remove the antenna as far as possible from potential interference sources. Any frequency of sufficient amplitude to enter the receiver's front end will reduce system range and can even prevent reception entirely. Switching power supplies, oscillators, or even relays can also be significant sources of potential interference. The single best weapon against such problems is attention to placement and layout. Filter the module's power supply with a high-frequency bypass capacitor. Place adequate ground plane under potential sources of noise to shunt noise to ground and prevent it from coupling to the RF stage. Shield noisy board areas whenever practical.

6. In some applications, it is advantageous to place the module and antenna away from the main equipment. This can avoid interference problems and allows the antenna to be oriented for optimum performance. Always use 50-ohm coax, like RG-174, for the remote feed.
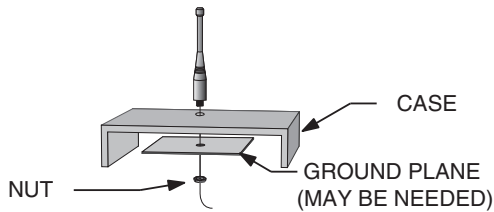

CASE

GROUND PLANE
(MAY BE NEEDED)

NUT

Figure 30: Remote Ground Plane

Common Antenna Styles

There are literally 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 provides outstanding overall performance and stability. A low-cost whip is can be easily fabricated from a wire or rod, but most design-ers 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 31: 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 half or quarter-wave antenna is normally employed. Its size and natural radiation resistance make it well matched to Linx modules. The proper length for a straight quarter-wave can be easily determined using the adjacent formula. It is also

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

Figure 32:
L = length in feet of quarter-wave length
F = operating frequency in megahertz

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.

Specialty Styles

Linx offers a wide variety of specialized antenna styles. Many of these styles utilize helical elements to reduce the overall antenna size while maintain-ing 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 33: Specialty Style Antennas

Loop Style

A loop- or trace-style antenna is normally printed directly on a product's PCB. This makes it the most cost-effective of antenna styles. The element can be made self-resonant or externally resonated with discrete components, but its actual layout is usually product specific. Despite the cost advantages, loop-style antennas are generally inefficient and useful only for short-range applications. They are also very sensitive to changes in layout and PCB dielectric, which can cause consistency issues during production. In addition, printed styles are difficult to engineer, requiring the use of expensive equipment, including a network analyzer. An improperly designed loop will have a high SWR at the desired frequency, which can cause instability in the RF stage.
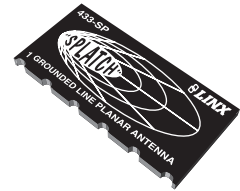

Figure 34: Loop or Trace Antenna

Figure 35: SP Series "Splatch" Antenna

Linx offers low-cost planar and chip antennas that mount directly to a product's PCB. These tiny antennas do not require testing and provide excellent performance in light of their small size. They offer a preferable alternative to the often-problematic "printed" antenna.

Regulatory Considerations

> Note: Linx RF modules are designed as component devices that require external components to function. The modules are intended to allow for full Part 15 compliance; however, they are not approved by the FCC or any other agency worldwide. The purchaser understands that 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 your 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 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. Linx offers full EMC pre-compliance testing in our HP/Emco-equipped test center. Final compliance testing is then 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 your completed product has passed, you will be issued an ID number that is to be clearly placed on each product manufactured.

Questions regarding interpretations of the Part 2 and Part 15 rules or measurement procedures used to test intentional radiators such as Linx RF modules for compliance with the technical standards of Part 15 should be addressed to:

Federal Communications Commission
Equipment Authorization Division
Customer Service Branch, MS 1300F2
7435 Oakland Mills Road
Columbia, MD, US 21046
Phone: +1 301 725 585 | Fax: +1 301 344 2050
Email: labinfo@fcc.gov

ETSI Secretaria
650, Route des Lucioles
06921 Sophia-Antipolis Cedex
FRANCE
Phone: +33 (0)4 92 94 42 00
Fax: +33 (0)4 93 65 47 16

International approvals are slightly more complex, although Linx modules are designed to allow all international standards to be met. If you are considering the export of your product abroad, you should contact Linx Technologies to determine the specific suitability of the module to your application.

All Linx modules are designed with the approval process in mind and thus much of the frustration that is typically experienced with a discrete design is eliminated. Approval is still dependent on many factors, such as the choice of antennas, correct use of the frequency selected and physical packaging. While some extra cost and design effort are required to address these issues, the additional usefulness and profitability added to a product by RF makes the effort more than worthwhile.

Achieving a Successful RF Implementation

Adding an RF stage brings an exciting new dimension to any product. It also means that additional effort and commitment will be needed to bring the product successfully to market. By utilizing pre-made RF modules the design and approval process is greatly simplified. It is still important, however, to have an objective view of the steps necessary to ensure a successful RF integration. Since the capabilities of each customer vary widely, it is difficult to recommend one particular design path, but most projects follow steps similar to those shown in Figure 36.

In reviewing this sample design path, you may notice that Linx offers a variety of services (such as antenna design and FCC pre-qualification) that are unusual for a high-volume component manufacturer. These services, along with an exceptional level of technical support, are offered because we recognize that RF is a complex science requiring the highest caliber of products and support. "Wireless Made Simple" is more than just a motto: it's our commitment. By choosing Linx as your RF partner and taking advantage of the resources we offer, you will not only survive implementing RF, you may even find the process enjoyable.

DECIDE TO UTILIZE RF
▼
RESEARCH RF OPTIONS
▼
ORDER EVALUATION KIT(S)
▼
TEST MODULE(S) WITH BASIC HOOKUP
▼
CHOOSE LINX MODULE
▼
INTERFACE TO CHOSEN CIRCUIT AND DEBUG
▼
CONSULT LINX REGARDING ANTENNA OPTIONS AND DESIGN
▼
LAY OUT BOARD
▼
SEND PRODUCTION-READY PROTOTYPE TO LINX FOR EMC PRESCREENING
▼
OPTIMIZE USING RF SUMMARY GENERATED BY LINX
▼
SEND TO PART 15 TEST FACILITY
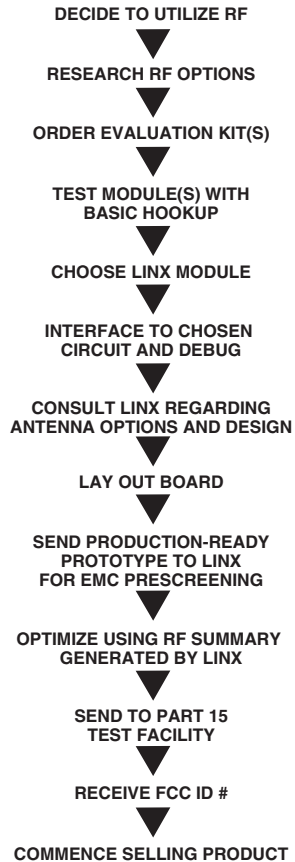▼
RECEIVE FCC ID #
▼
COMMENCE SELLING PRODUCT

Figure 36: Typical Steps for Implementing RF

Helpful Application Notes From Linx

It is not the intention of this manual to address in depth many of the issues that should be considered to ensure that the modules function correctly and deliver the maximum possible performance. As you proceed with your design, you may wish to obtain one or more of the following application notes which address in depth key areas of RF design and application of Linx products. These applications notes are available online at www.linxtechnologies.com or by contacting the Linx literature department.

Helpful Application Note Titles	
Note Number	**Note Title**
AN-00100	RF 101: Information for the RF Challenged
AN-00125	Considerations for Operation Within the 260–470MHz Band
AN-00130	Modulation Techniques for Low-Cost RF Data Links
AN-00140	The FCC Road: Part 15 from Concept to Approval
AN-00150	Use and Design of T-Attenuation Pads
AN-00160	Considerations for Sending Data over a Wireless Link
AN-00232	General Considerations for Sending Data with the LC Series
AN-00500	Antennas: Design, Application and Performance

Figure 37: Helpful Application Note Titles

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