# LC SERIES RECEIVER MODULE DATA GUIDE

## DESCRIPTION:

The LC Series is ideally suited for volume use in OEM applications such as remote control, security, identification, and periodic data transfer. Packaged in a compact SMD package, the LC receiver utilizes a highly optimized SAW architecture to achieve an unmatched blend of performance, size, efficiency and cost. When paired with a matching LC series transmitter, a highly reliable wireless link is formed, capable of transferring serial data at distances in excess of 300 Feet. No external RF components, except an antenna, are required, making design integration straightforward, even for engineers lacking previous RF experience.

**LINX RF MODULE RXM***LC**

.270 in.
6.9 mm

.580 in.
14.9 mm

.830 in.
21.2 mm
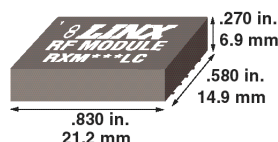
**PHYSICAL DIMENSIONS**

| | | |
|---|---|---|
| Vcc 2.7-4.2* 10 | | 1 RFIN (ANT.) |
| NC 9 | | 2 NC |
| GND 8 | | 3 GND |
| PDN/NC 7 | | 4 NC |
| Vcc 4.0-5.2* 6 | | 5 DATA OUT |

**PINOUTS (BOTTOM VIEW)**

## FEATURES:

- Low Cost
- No External RF Components Required
- Low Power Consumption
- Compact Surface-mount Package
- Stable SAW-based Architecture
- Outstanding Sensitivity

- Supports Data Rates to 5,000 bps
- Wide Supply Range (2.7-5.2 VDC)
- Qualified Data Output
- Direct Serial Interface
- No Production Tuning

## APPLICATIONS INCLUDE:

- 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

## ORDERING INFORMATION

| PART # | DESCRIPTION |
|---|---|
| EVAL-***-LC | Basic Evaluation Kit |
| MDEV-***-LC | Master Development Kit |
| TXM-315-LC | Transmitter 315 MHZ |
| TXM-418-LC | Transmitter 418 MHZ |
| TXM-433-LC | Transmitter 433 MHZ |
| RXM-315-LC | Receiver 315 MHZ |
| RXM-418-LC | Receiver 418 MHZ |
| RXM-433-LC | Receiver 433 MHZ |

*NOTE*: For reflow compatible versions, add **-R** to the end of the part number.

*** Insert Frequency

LC Receivers are supplied in tube packaging - 40 pcs. per tube.

# PERFORMANCE DATA–RXM-***-LC

### ABOUT THESE MEASUREMENTS

The performance parameters listed below are based on module operation at 25°C from a 3.3VDC supply unless otherwise noted. Figure 1 at the right illustrates the connections necessary for testing and operation.It is recommended all ground pins be connected to the groundplane. The pins marked NC have no physical connection and are designed only to add support.
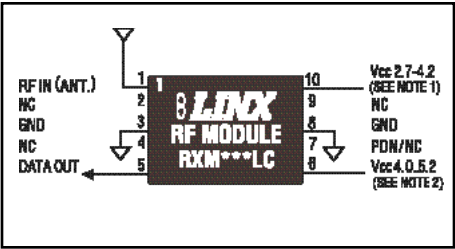


figure 1: Test/Basic application circuit

## ABSOLUTE MAXIMUM RATINGS …

| | | | | |
|---|---|---|---|---|
| Supply voltage $V_{CC}$, using pin 10 | -0.3 | to | +4.2 | VDC |
| Supply voltage $V_{CC}$, using pin 6 | -0.3 | to | +5.5 | VDC |
| Operating temperature | -30°C | to | +70°C | |
| Storage temperature | -45°C | to | +85°C | |
| Soldering temperature | +225°C for 10 sec. | | | |
| RF input, pin 1 | 0 dBm | | | |
| Any input or output pin | -0.3 | to | Vcc | |

**\*NOTE\* 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.**

| Parameters LCRX 315MHz | Designation | Min. | Typical | Max. | Units | Notes |
|---|---|---|---|---|---|---|
| Operating Voltage Pin 10 | $V_{CC}$ | 2.7 | – | 4.2 | VDC | – |
| Operating Voltage Pin 6 | $V_{CC}$ | 4.0 | – | 5.2 | VDC | – |
| Current Continuous | $I_{CC}$ ($V_{CC}$=3V) | 4.0 | 6.0 | 7.0 | mA | 1 |
| | $I_{CC}$ ($V_{CC}$=5V) | 6.0 | 7.0 | 8.0 | mA | 2 |
| Current in Sleep | $I_{SLP}$ ($V_{CC}$=3V) | – | – | 300 | µA | 1 |
| | $I_{SLP}$ ($V_{CC}$=5V) | – | – | 370 | µA | 2 |
| Data Out Voltage Logic Low | $V_{OL}$ | 0 | – | .2 | VDC | – |
| Data Out Voltage Logic High | $V_{OH}$ | $V_{CC}$-0.3 | – | $V_{CC}$ | VDC | – |
| Receive Frequency | $F_c$ | 314.83 | 315.0 | 315.07 | MHz | – |
| Noise BW | | – | 280 | – | KHz | – |
| Sensitivity @10$^{-5}$ BER | | -92 | -95 | -100 | dBm | 3 |
| Baud Rate | | 300 | – | 4,800 | bps | _ |
| Settling Time | | 5 | 7 | 10 | mSec | 4 |

| Parameters LCRX 418MHz | Designation | Min. | Typical | Max. | Units | Notes |
|---|---|---|---|---|---|---|
| Operating Voltage Pin 10 | $V_{CC}$ | 2.7 | – | 4.2 | VDC | – |
| Operating Voltage Pin 6 | $V_{CC}$ | 4.0 | – | 5.2 | VDC | – |
| Current Continuous | $I_{CC}$ ($V_{CC}$=3V) | 4.0 | 6.0 | 7.0 | mA | 1 |
|  | $I_{CC}$ ($V_{CC}$=5V) | 6.0 | 7.0 | 8.0 | mA | 2 |
| Current in Sleep | $I_{SLP}$ ($V_{CC}$=3V) | – | – | 300 | µA | 1 |
|  | $I_{SLP}$ ($V_{CC}$=5V) | – | – | 370 | µA | 2 |
| Data Out Voltage Logic Low | $V_{OL}$ | 0 | – | .2 | VDC | – |
| Data Out Voltage Logic High | $V_{OH}$ | $V_{CC}$-0.3 | – | $V_{CC}$ | VDC | – |
| Receive Frequency | $F_C$ | 417.96 | 418.02 | 418.08 | MHz | – |
| Noise BW |  | – | 280 | – | KHz | – |
| Sensitivity @$10^{-5}$ BER |  | -92 | -95 | -100 | dBm | 3 |
| Baud Rate |  | 300 | – | 4,800 | bps | _ |
| Settling Time |  | 5 | 7 | 10 | mSec | 4 |

| Parameters LCRX 433MHz | Designation | Min. | Typical | Max. | Units | Notes |
|---|---|---|---|---|---|---|
| Operating Voltage Pin 10 | $V_{CC}$ | 2.7 | – | 4.2 | VDC | – |
| Operating Voltage Pin 6 | $V_{CC}$ | 4.0 | – | 5.2 | VDC | – |
| Current Continuous | $I_{CC}$ ($V_{CC}$=3V) | 4.0 | 6.0 | 7.0 | mA | 1 |
|  | $I_{CC}$ ($V_{CC}$=5V) | 6.0 | 7.0 | 8.0 | mA | 2 |
| Current in Sleep | $I_{SLP}$ ($V_{CC}$=3V) | – | – | 300 | µA | 1 |
|  | $I_{SLP}$ ($V_{CC}$=5V) | – | – | 370 | µA | 2 |
| Data Out Voltage Logic Low | $V_{OL}$ | 0 | – | .2 | VDC | – |
| Data Out Voltage Logic High | $V_{OH}$ | $V_{CC}$-0.3 | – | $V_{CC}$ | VDC | – |
| Receive Frequency | $F_C$ | 433.86 | 433.92 | 433.97 | MHz | – |
| Noise BW |  | – | 280 | – | KHz | – |
| Sensitivity @$10^{-5}$ BER |  | -92 | -95 | -100 | dBm | 3 |
| Baud Rate |  | 300 | – | 4,800 | bps | – |
| Settling Time |  | 5 | 7 | 10 | mSec | 4 |

## Notes:

1. $V_{CC}$ applied to pin 10.Pin 10 is connected to $V_{CC}$ for $V_{CC}$=2.7 - 4.2V. Pin 6 is not connected.
2. $V_{CC}$ applied to pin 6.Pin 6 is connected to $V_{CC}$ for $V_{CC}$=4 - 5.2V. Pin 10 is not connected.
3. For BER of $10^{-5}$ @ 4800 baud.Sensitivity is affected by antenna SWR.See figure 3.
4. Time to valid data output.

# PHYSICAL PACKAGING

The receiver is packaged as a hybrid SMD module with nine pins spaced 0.100" on center. The leaded SMD package allows for easy prototyping or hand assembly while "R" versions maintain full compatibility with automated pick-and-place equipment.  Modules are supplied in tube packaging.
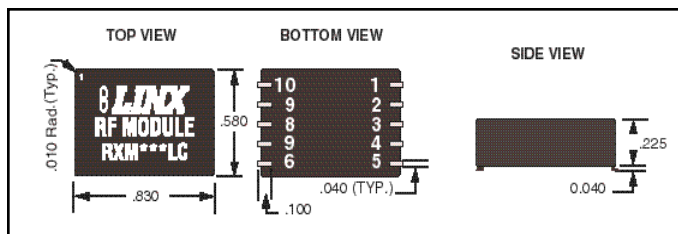


*figure 2: LC Series Receiver Package Dimensions*

# PIN DESCRIPTIONS:

### Pin 1    RF IN

The receiver antenna connects to this input. It has nominal RF impedance of 50Ω and is capacitively isolated from the internal circuitry.

### Pin 2    NO CONNECTION

Attach to an isolated pad to provide support for the module. Do not connect to power or ground.

### Pin 3    GROUND

Connect to quiet ground or groundplane. It is internally connected to pin 8.

### Pin 4    NO CONNECTION

Attach to an isolated pad to provide support for the module. Do not connect to power or ground.

### Pin 5    DATA OUT

Open collector data output w/internal pullup to $V_{cc}$. Recovered data is output on this pin. Output voltage during a high bit will average $V_{cc}$- 0.3V.

### Pin 6    POSITIVE SUPPLY (Vcc 4.0-5.2 VDC)

Use this pin for supply voltages of 4.0 VDC or greater. The supply must be clean (<20 mV pp), stable and free of high-frequency noise. A supply filter is recommended unless the module is driven from its own regulated supply or battery.

### Pin 7    POWER DOWN

Pull this line low to put the receiver in sleep mode (370 μA). Leave floating or pull high to enable the receiver.

### Pin 8    GROUND

Connect to quiet ground or groundplane. It is internally connected to pin 3.

### Pin 9    NO CONNECTION

Attach to an isolated pad to provide support for the module. Do not connect to power or ground.

### Pin 10    POSITIVE SUPPLY ($V_{cc}$ 2.7-4.2 VDC)

Use this pin in place of Pin 6 if the supply voltage is less than 4.0 volts. The supply must be clean (<20 mV pp), stable and free of high-frequency noise. A supply filter is recommended unless the module is operated from its own regulated supply or battery.
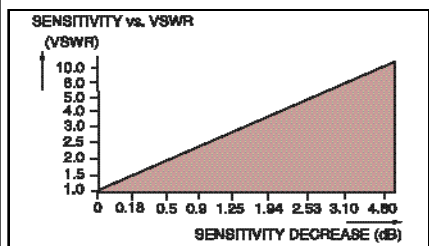
# TYPICAL PERFORMANCE GRAPHS
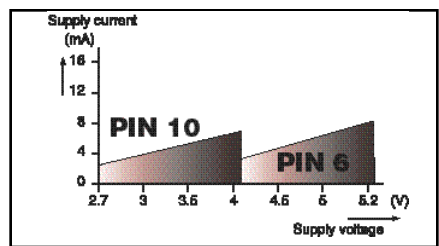


*figure 3: Sensitivity vs. VSWR*



*figure 4: 418/433MHz*
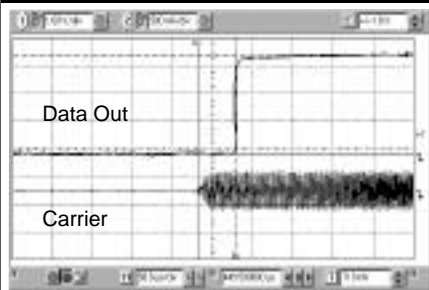*Consumption vs. Supply Voltage*



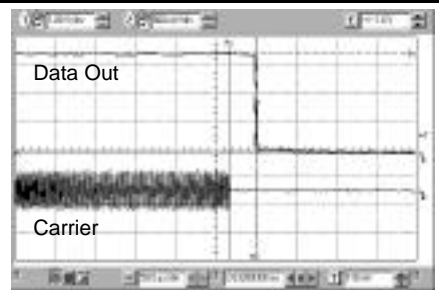*figure 5: RF in vs. Receiver response time*



*figure 6: Typical Receiver Turn-Off Time*



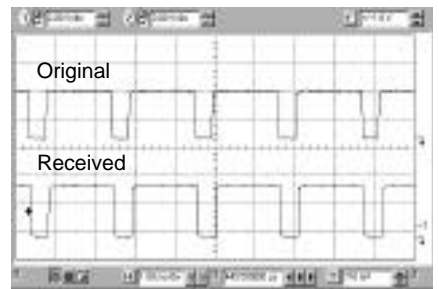*figure 7: Original vs. Received Data*
*4,800 BPS 20% Duty Cycle*



*figure 8: Original vs. Received Data*
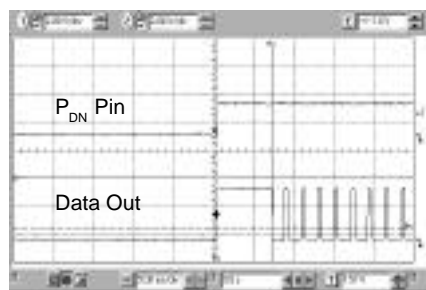*4,800 BPS 80% Duty Cycle*



*figure 9: Power-On Settling Time*
*(Time to Valid Data)*

# PRODUCTION GUIDELINES

The LC modules are packaged in a hybrid SMD package. Versions are available to support hand- or automated-assembly techniques. Since LC devices contain discrete components internally, the assembly procedures are critical to insuring the reliable function of the LC product. The following procedures should be reviewed with and practiced by all assembly personnel.

# PAD LAYOUT

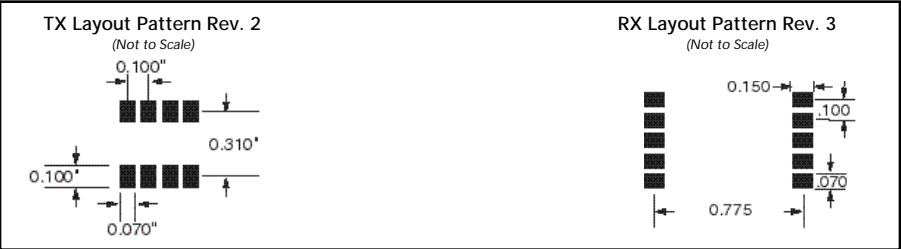The following pad layout diagrams are designed to facilitate both hand and automated assembly.



*figure 10: Recommended Pad Layout*

# RECEIVER HAND ASSEMBLY

If the recommended pad guidelines (Rev. 3) have been followed, the modules, pins and pads will protrude slightly past the module edges. Use a fine soldering tip to heat the board pad, then introduce solder to the pad at the module's edge. The solder will wick underneath the module providing reliable attachment. As with the transmitter it is usually best to secure a corner and then work around the device.
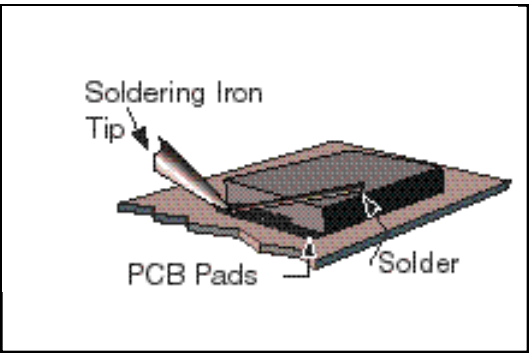


*figure 11:LC-RX Soldering Technique*

## Absolute Maximum Solder Times
Hand-Solder Temp. TX +225°C for 10 Sec.
Hand-Solder Temp. RX +225°C for 10 Sec.
Recommended Solder Melting Point +180°C
Reflow Oven: +220° Max. (See adjoining diagram)

# AUTOMATED ASSEMBLY

For high-volume assembly most users will want to auto-place the modules. Receivers bearing an "R" designation have been designed to maintain compatibility with reflow processing techniques; however, due to the module's 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 process. The reflow profile below should be closely followed 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 insure that it meets the requirements necessary to successfully reflow all components while still meeting the limits mandated by the modules themselves.
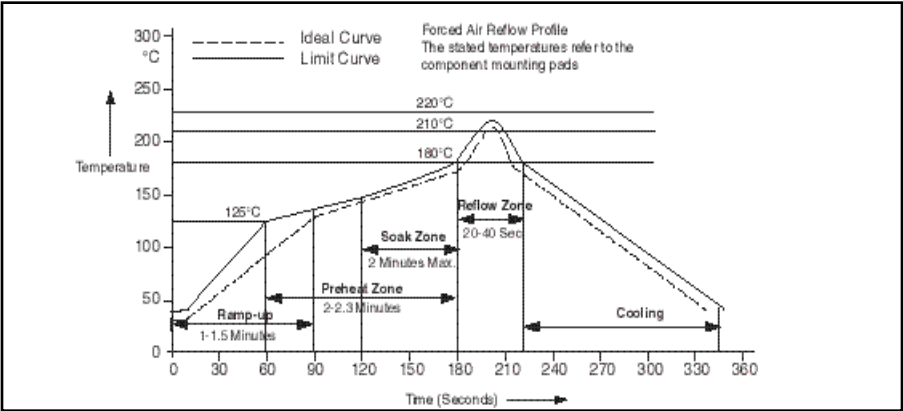


*figure 12: Required reflow profile*                    *Revision 2 - 11/98*

### 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 module not be subjected to shock or vibration during the time solder is liquidus.

### Washability

The modules are wash resistant, but are not hermetically sealed. They may be subject to a standard wash cycle; however, a twenty-four-hour drying time should be allowed before applying electrical power to the modules. This will allow any moisture that has migrated into the module to evaporate, thus eliminating the potential for shorting during power-up or testing.

## MODULE DESCRIPTION

The LC-RXM is a low-cost, high-performance SAW-(Surface Acoustic Wave) based CPCA (Carrier-Present Carrier-Absent) receiver, capable of receiving serial data at up to 5,000 bits/second. Its exceptional sensitivity provides outstanding range at the maximum data rate. While oriented toward high-volume automated production, the LC's compact surface-mount package is also friendly to prototype and hand production. When combined with a Linx LC series transmitter a highly reliable RF link capable of transferring digital data over line-of-sight distances in excess of 300 feet (90M) is formed.
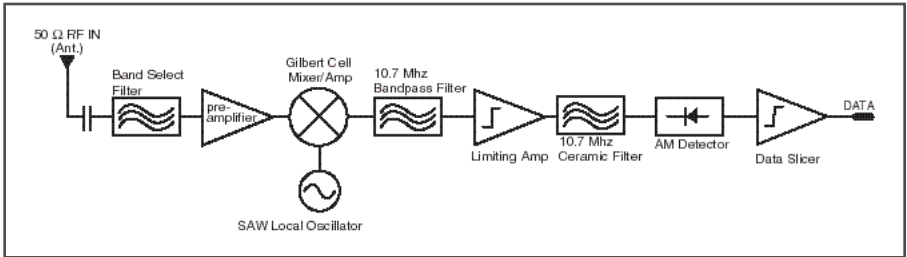


*figure 13: LC Series Receiver Block Diagram*

## THEORY OF OPERATION

The LC-RXM is designed to recover data sent by a CPCA (Carrier-Present Carrier-Absent) transmitter. This type of AM modulation is often referred to by other designations including CW and OOK. As the CPCA designation suggests, this type of modulation represents a logic low '0' by the absence of a carrier and a logic high '1' by the presence of a carrier. This
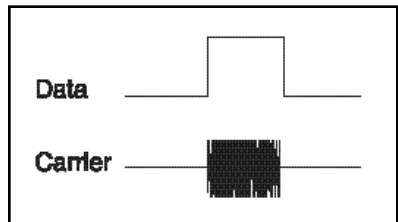


*figure 14: CPCA (AM) Modulation*

modulation method affords numerous benefits. Two most important are:1) Cost-effectiveness due to design simplicity and 2) Higher output power and thus greater range in countries (such as the US) which average output power measurements over time. Please refer to Linx application note #00130 for a further discussion of modulation techniques including CPCA.

The LC series utilizes an advanced single-conversion superhet design which incorporates a SAW device, high IF frequency and multi-layer ceramic filters. The SAW (Surface Acoustic Wave) device has been in use for more than a decade but has only recently begun to receive the widespread acclaim its outstanding capabilities deserve. A SAW device provides a highly accurate frequency source with excellent immunity to frequency shift due to age or temperature. The use of SAW devices in both the LC transmitter and receiver modules allows the receiver's pass opening to be quite narrow, thus increasing sensitivity and reducing susceptibility to near-band interference. The quality of components and overall architecture utilized in the LC series is unusual in a low-cost product and is one of the primary reasons the LC receiver is able to outperform even far more expensive products.

# POWER SUPPLY REQUIREMENTS

The receiver module requires a clean, well-regulated power source. While it is preferable to power the unit from a battery, the unit can also be operated from a power supply as long as noise and 'hash' is less than 20 mV. A 10Ω resistor in series with the supply followed by a 10μF tantalum capacitor from $V_{cc}$ to ground will help in cases where the quality of supply power is poor.
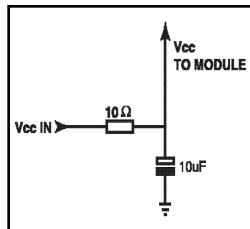


*figure 15: Supply Filter*

# THE DATA OUTPUT

A CMOS-compatible data output is available on pin 5. This output is normally used to drive directly a digital decoder IC or a microprocessor which is performing the data decoding. The receiver's output is internally qualified, meaning that it will only transition when valid data is present. In instances where no carrier is present the output will remain low. Since a UART utilizes 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 LC-RXM and the UART.

It is important to realize that the data output of the receiver may be subject to some pulse stretching or shortening. This is caused by a combination of oscillator start-up time on the transmitter and ring-down time in the receiver's ceramic filter. It is important to consider this effect when planning protocol. To learn more about protocol considerations for the LC series we suggest you read Linx applications note #00232.

# RECEIVING DATA

Once a reliable 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 LC modules do not incorporate internal coding/decoding, a user has tremendous flexibility in how data is handled.

It is always important to separate what type of transmissions are technically possible from those that are legally allowable in the country of intended operation. You may wish to review application notes #00125 and #00140 along with Part 15 Sec. 231 for further details on acceptable transmission content.

Another area of consideration is that of data structure or protocol. If you are not familiar with the considerations for sending serial data in a wireless environment you will want to review Linx application note #00232 (Considerations for sending data with the LC series). These issues should be clearly understood prior to commencing a significant design effort.

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 your product 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: Microchip (Keeloq), Holtek, and Motorola. These chips take care of all encoding, error checking, 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 IC's 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 IC's.
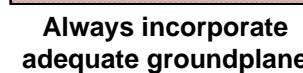
### Basic Remote Control Receiver Circuit

Figure 16 shows an example of a basic remote control receiver utilizing a decoder chip from Holtek. When a key is pressed at the transmitter, a corresponding pin at the receiver goes high. A schematic for the transmitter/encoder circuit may be found in the LC transmitter guide. These circuits can be easily modified and clearly demonstrate the ease of using the Linx LC modules for remote control applications.



*figure 16: Basic Remote Control Receiver*

# BOARD LAYOUT CONSIDERATIONS

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 LC series, integrating an LC receiver is very straightforward. This ease of application is a result of the advanced multi-layer isolated construction of the module. Internally all high-frequency components occupy an upper board level while baseband components are isolated on the lower board level. By adhering to good layout principles and observing a few basic design rules you can enjoy a straightforward path to RF success.



**Always incorporate adequate groundplane**

1. No conductive items should be placed within .25 in. of the module's top or sides.

2. A groundplane should be placed under the module as shown. In most cases, it will be placed on the bottom layer. The amount of overall plane area is also critical for the correct function of many antenna styles and is covered in the next section.

3. Keep receiver module away from interference sources. Any frequency of sufficient amplitude to enter the receiver's front end will reduce system range, cause bit errors, and may even prevent reception entirely. There are many possible sources of internally generated interference. High speed logic is one of the worst in this respect, as fast logic edges have harmonics which extend into the UHF band and the PCB tracks radiate these harmonics most efficiently. Microprocessors with external busses are generally incompatible with sensitive radio receivers. Single-chip microprocessors do not generally pose a problem. Switching power supplies, oscillators, even relays can also be significant sources of potential interference. Here again, the single best weapon against such problems is attention to placement and layout. Filter the supply with a high-frequency bypass capacitor as described above. Place adequate groundplane under all potential sources of noise.

4. Observe appropriate layout practice between the module and its antenna. A simple trace may suffice for runs of less than .25" but longer distances should be covered using 50Ω coax or a 50Ω microstrip transmission line. This is because the trace leading to the module can effectively contribute to the length of the antenna thus lowering its resonant bandwidth. In order to minimize loss and detuning, a microstrip transmission line is commonly utilized.The term microstrip refers to a PCB trace running over a ground-plane, the width of which has been calculated to serve as a 50Ω transmission line between the module and antenna. This effectively removes the trace as a source of detuning.The correct trace width can be easily calculated using the information below.
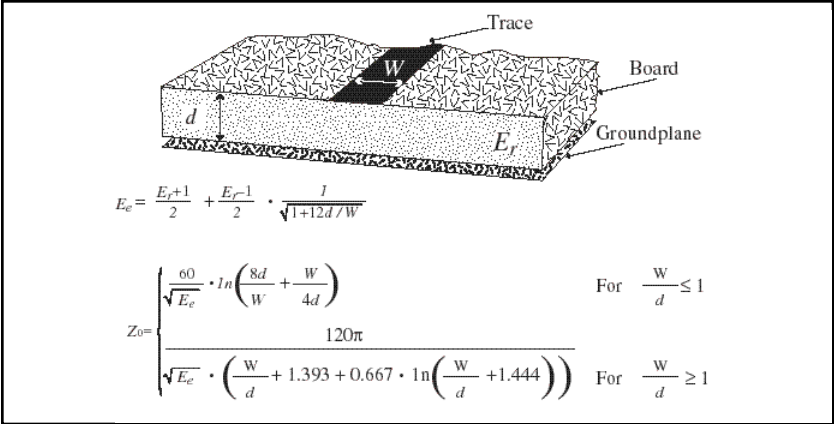


$$E_e = \frac{E_r+1}{2} + \frac{E_r-1}{2} \cdot \frac{1}{\sqrt{1+12d/W}}$$

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

*figure 17: Microstrip formulas (Er = Dielectric constant of pc board material)*

| Dielectric Constant | Width/Height (W/d) | Effective Dielectric Constant | Characteristic Impedance |
|---|---|---|---|
| 4.8 | 1.8 | 3.59 | 50.0 |
| 4 | 2 | 3.07 | 51.0 |
| 2.55 | 3 | 2.12 | 48.0 |

5. In some applications, it is advantageous to place receiver and its antenna away from the main equipment.This avoids any interference problems and allows flexible orientation of the receiver antenna to achieve optimum RF performance.

## RECEIVER ANTENNA CONSIDERATIONS

The choice of antennas is one of the most critical and often overlooked design considerations. The range, performance, and legality of an RF link is critically dependent upon the type of antenna employed.Proper design and matching of an antenna is a complex task requiring sophisticated test equipment and a strong background in principles of RF propagation. While adequate antenna performance can often be obtained by trial and error methods, you may also want to consider utilizing a professionally designed antenna such as those offered by Linx. Our low-cost antenna line is designed to ensure maximum performance and compliance with Part 15 attachment requirements.

# ANTENNA CONSIDERATIONS (CONT.)

A receiver antenna should give its optimum performance at the frequency or in the band for which the receiver was designed, and capture as little as possible of other 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 a reduction in antenna efficiency or attenuation, the receiver's antenna should be optimized as much as is practical.

It is usually best to utilize a basic quarter-wave whip for your initial concept evaluation. Once the prototype product is operating satisfactorily, a production antenna should be selected to meet the cost, size and cosmetic requirements of the product. To gain a better understanding of the considerations involved in the design and selection of antennas please review application note #00500 "Antennas: Design, Application, Performance".

**The following notes should help in optimizing antenna performance:**

1. Proximity to objects such as a user's hand or 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 1/4- or 1/2-wave straight whip mounted at a right angle to the groundplane. In many cases this isn't desirable for practical or ergonomic reasons;thus, an alternative antenna style such as a helical, loop, patch, or base-loaded whip may be utilized.

3. If an internal antenna is to be used, keep it away from other metal components, particularly large items like transformers, batteries, and PCB tracks and groundplanes. In many cases, the space around the antenna is as important as the antenna itself.

4. In many antenna designs, particularly 1/4-wave whips, the groundplane acts as a counterpoise, forming, in essence, a 1/2-wave dipole. For this reason adequate groundplane area is essential. The groundplane can be a metal case or ground-fill areas on a circuit board. Ideally, it should have a surface area $\geq$ the overall length of the 1/4-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 groundplane in proximity to the base of the antenna as possible. When the antenna is remotely located or the antenna is not in close proximity to a circuit board plane or grounded metal case, a small metal plate may be fabricated to maximize antenna 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, 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 groundplane under potential sources of noise. Shield noisy board areas whenever practical.

6. In some applications it is advantageous to place the receiver and its antenna away from the main equipment.This avoids interference problems and allows the antenna to be oriented for optimum RF performance. Always use 50$\Omega$ coax, such as RG-174, for the remote feed.

# COMMON ANTENNA STYLES

From a coat hanger to a tuned Yagi, there are literally hundreds of antenna styles and variations that can be employed. Following is a brief discussion of the three styles most commonly utilized in compact RF designs. The selection chart broadly categorizes key areas of antenna performance. In reviewing this section it is important to recognize that each antenna style will produce widely varying results based on the specific design execution and optimization. Additional antenna information can be found in Linx application notes #00500, #00100, #00125 and #00140. Linx also offers a broad line of antennas and connectors which offer outstanding performance and cost-effectiveness.

## LC Antenna Selection Chart

| PARAMETER | LOOP | HELICAL | WHIP |
|---|---|---|---|
| Ultimate performance | ● | ●● | ●●● |
| Ease of design setup | ● | ●● | ●●● |
| Size | ●● | ●●● | ● |
| Immunity to proximity effects | ●●● | ●● | ● |
| Range (open ground to similar antenna) | 100 ft. | 200 ft. | 300+ ft. |

●=FAIR        ●●=GOOD        ●●●=EXCELLENT

## Whip Style
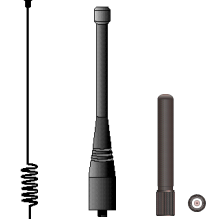
1/4-wave wire lengths for LCfrequencies:
**315Mhz=8.9"**
**418Mhz=6.7"**
**433Mhz=6.5"**

A whip-style antenna provides exceptional performance and is easy to integrate. A low-cost whip is generally made of a wire or rod while more expensive whip designs are encapsulated in rubber or plastic to improve appearance and minimize the potential for damage to the antenna element. A whip is often combined with a helical winding to reduce the overall length. This technique is commonly referred to as "base loading". The wavelength of the frequency to be received or transmitted determines an antenna's length.Since a full-wave antenna is quite long, a partial wavelength antenna such as a 1/2- or 1/4-wave is generally used. For testing, or even production, a whip can be easily made from a piece of solid conductor wire cut to the appropriate length.Length for a half-wave is easily determined using the following formula.The resultant length may be divided in half for a quarter-wave.

$$L = \frac{468}{F_{MHz}}$$

Where:
*L=length in feet of half-wave length*
*F=operating frequency in megahertz*

## Helical Style

A helical is a wire coil usually wound from steel, copper or brass. This antenna is very efficient given its small size. The helical is an excellent choice for products requiring good range performance and a concealed internal antenna element. Care must be exercised in placement, however, as a helical detunes badly when located in proximity with other conductive objects. Because a helical has a high Q factor its bandwidth is very narrow and inter-coil spacing has a pronounced effect on antenna performance. For this reason is it usually best to utilize a pre-made helical which has been professionally optimized to achieve maximum performance.

## Loop Style

A loop or track-style antenna is usually printed directly on the PCB making it the most cost-effective of antenna styles. There are many different styles and shapes of loops which can be utilized, including spirals and rectangles. A loop has excellent immunity to proximity detuning (e.g., a user's body) and is easily concealed inside products which have a plastic case. Despite these advantages a loop is difficult to match and tune without expensive RF test equipment.An improperly designed loop will have a very high SWR and may induce harmonics. For this reason a helical or whip style is usually a better choice for applications requiring maximum range performance.

# LEGAL CONSIDERATIONS

*NOTE: LC Series Modules are designed as component devices which 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 operation 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.

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. The regulations are contained in the Code of Federal Regulations (CFR), Title 47. 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 book store. Excerpts of applicable sections are included with Linx evaluation kits or may be obtained from the Linx Technologies web site (www.linxtechnologies.com). In brief, these rules require that any device which 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 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 which is then 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 the LC modules, for compliance with the Part 15 technical standards, should be addressed to:

Federal Communications Commission
Equipment Authorization Division
Customer Service Branch, MS 1300F2
7435 Oakland Mills Road
Columbia, MD 21046
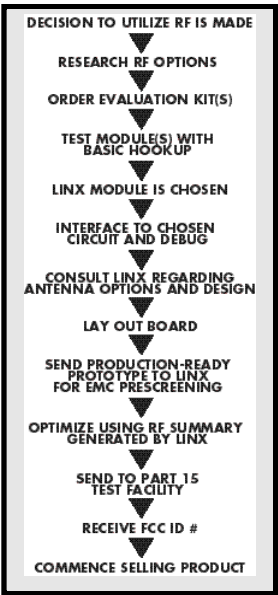Tel:(301) 725-1585 / Fax:(301) 344-2050    E-Mail:labinfo@fcc.gov

International approvals are slightly more complex, although many 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.

# SURVIVING AN 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 premade RF modules, such as the LC series, the design and approval process will be greatly simplified. It is still important, however, to have an objective view of the steps necessary to insure 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 at the right.

In reviewing this sample design path you may notice that Linx offers a variety of services, such as antenna design, and FCC prequalification, 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.

DECISION TO UTILIZE RF IS MADE
↓
RESEARCH RF OPTIONS
↓
ORDER EVALUATION KIT(S)
↓
TEST MODULE(S) WITH BASIC HOOKUP
↓
LINX MODULE IS CHOSEN
↓
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

**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.

| NOTE # | LINX APPLICATION NOTE TITLE |
|--------|------------------------------|
| 00232 | General considerations for sending data with the LC Series |
| 00500 | Antennas: Design, Application, Performance |
| 00130 | Modulation techniques for low-cost RF data links |
| 00125 | Considerations for operation in the 260 Mhz to 470 Mhz band |
| 00100 | RF 101: Information for the RF challenged |
| 00110 | Understanding the performance specifications of receivers |
| 00140 | The FCC Road: Part 15 from concept to approval |
| 00150 | Use and design of T-Attenuation Pads |

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## Disclaimer

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