Linx TECHNOLOGIES

LT Series Transceiver Module

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 not have a frequency hopping protocol built in.

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**
TRM-315-LT	315MHz Transceiver
TRM-418-LT	418MHz Transceiver
TRM-433-LT	433MHz Transceiver
EVAL-***-LT	Basic Evaluation Kit

*** = 315, 418 (Standard), 433MHz
Transceivers are supplied in tubes of 18 pcs.

Figure 2: Ordering Information

Absolute Maximum Ratings

Absolute Maximum Ratings				
Supply Voltage V_{cc}	–0.3	to	+4.0	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	–65	to	+150	ºC
Soldering Temperature	+260ºC 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

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.

LT Series Transceiver Specifications Continued						
Parameter	**Symbol**	**Min.**	**Typ.**	**Max.**	**Units**	**Notes**
Transmitter Section						
Output Power	P_O		+9.2	+11	dBm	1,6
With a 750Ω resistor on LADJ	P_O	–4	0.0	4	dBm	2,6
Output Power Control Range		–30		MAX	dB	9
Harmonic Emissions	P_H			–36	dBc	6
Antenna Port						
RF Input Impedance	R_{IN}		50		Ω	9
Timing						
Receiver Turn-On Time						
Via V_{CC}			2.2		ms	8,9
Via PDN			0.25		ms	8,9
Max. Time Between Transitions			15.0		ms	9
Transmtiter Turn-On Time						
Via V_{CC}			2.0		ms	9
Via PDN				500	µs	9
Modulation Delay				30.0	ns	9
Transmit to Receive Switch Time			180	400	µs	9
Receive to Transmit Switch Time			490	1000	µs	9
Dwell Time		290			µs	9,11
Environmental						
Operating Temperature Range		–40		+85	ºC	9

1. With a 0Ω resistor on LADJ
2. With a 750Ω resistor on LADJ
3. I_{SINK} = 500µA
4. I_{SOURCE} = 500µA
5. I_{SINK} = 20µA
6. Into a 50Ω load
7. With a 50% square wave at 1,000bps
8. Time to valid data output
9. Characterized, but not tested
10. Receive Mode on power down (see Using the PDN Line section)
11. Minimum time before mode change

Figure 4: Electrical Specifications

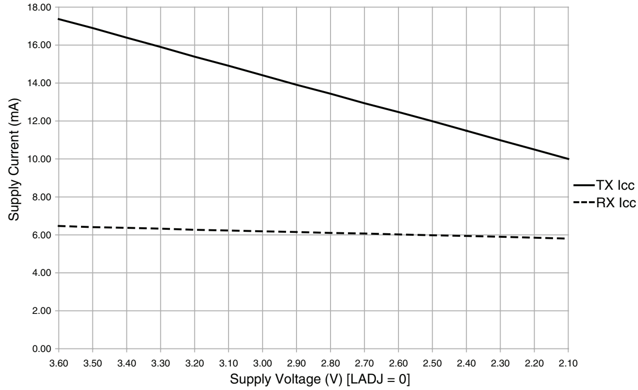

Figure 8: Current Consumption vs. Supply

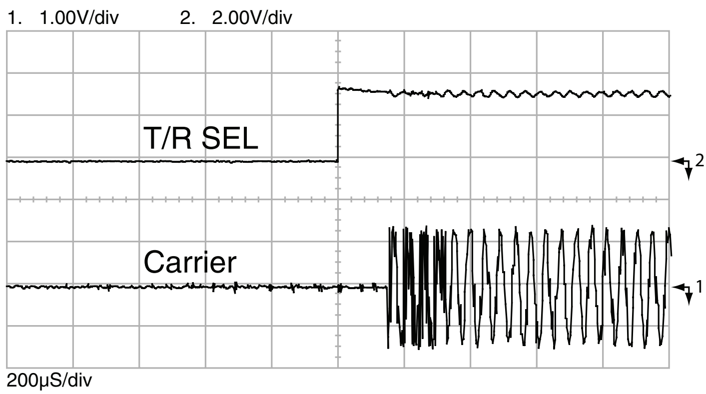

Figure 9: RX to TX Change Time

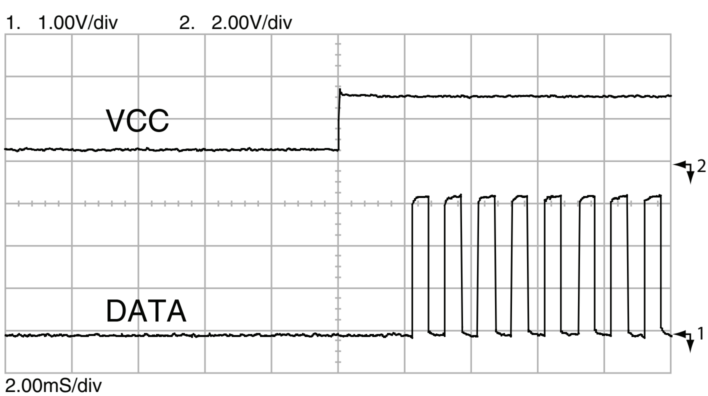

Figure 10: TX to RX Change Time

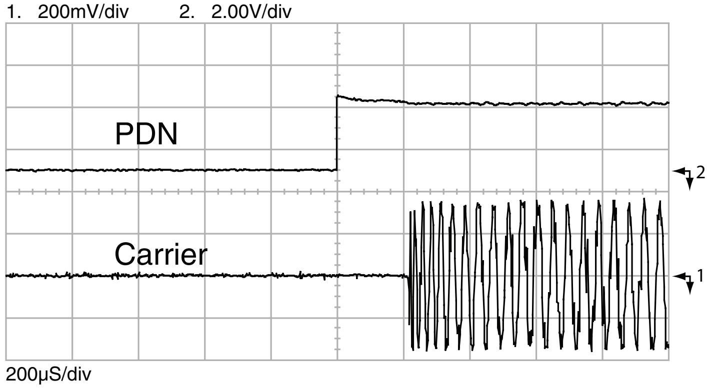

Figure 14: TX Turn-On Time from PDN

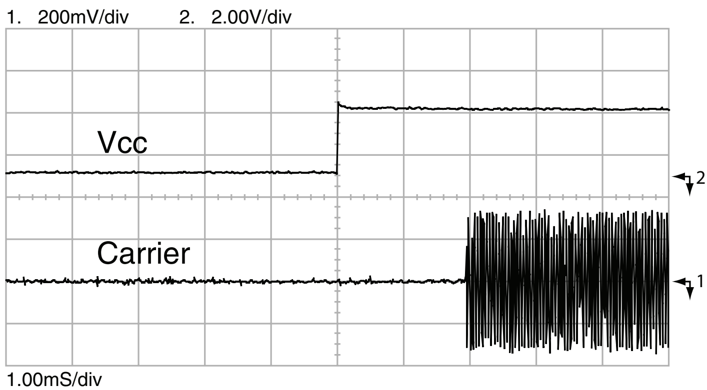

Figure 15: TX Turn-On Time from V_{CC}

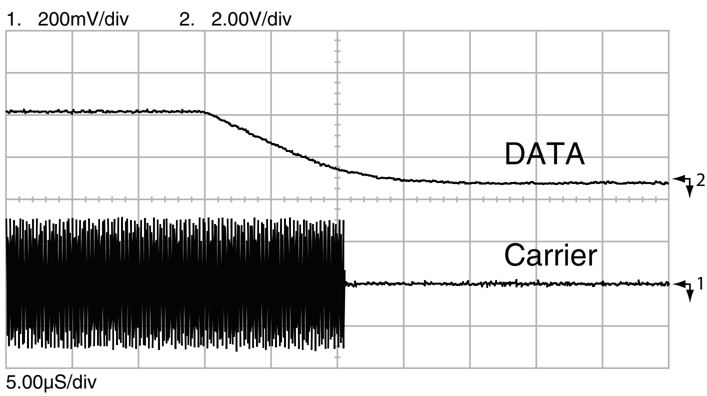

Figure 16: TX Turn-Off Time

Module Description

The LT Series transceiver is a low-cost, high-performance synthesized AM OOK transceiver capable of transmitting and receiving serial data at up to 10,000bps over line-of-site distances of up to 3,000 feet (1000m). Its exceptional receiver sensitivity and highly stable transmitter output result in outstanding range performance. The transceiver is completely self-contained and does not require any additional RF components except an antenna. This greatly simplifies the design process, reduces time to market, and reduces production assembly and testing costs. The LT is housed in a compact surface-mount package that integrates easily into existing designs and is equally friendly to prototyping and volume production. The module's low power consumption makes it ideal for battery-powered products.

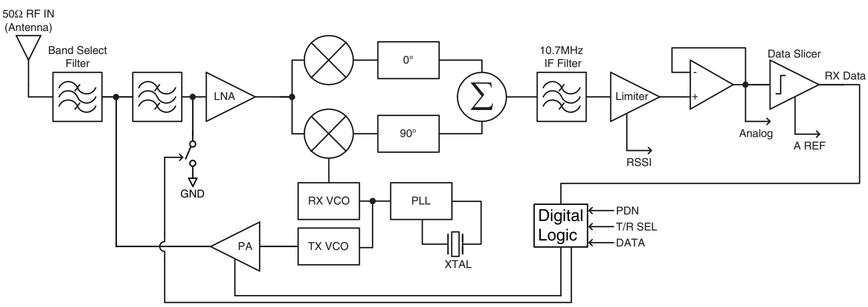

Figure 19: LT Series Transceiver Block Diagram

Theory of Operation

The LT Series transceiver sends and recovers data by AM or Carrier-Present Carrier-Absent (CPCA) modulation, also referred to as 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 of a carrier (Figure 20). This method affords numerous benefits. The two most important are: 1) cost-effectiveness due to design simplicity and 2) higher legally-allowable output power and thus greater range in countries (such as the US) that average output power measurements over time.

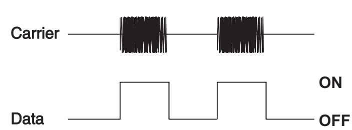

Figure 20: CPCA (AM) Modulation

The LT's receiver chain utilizes an advanced synthesized superheterodyne architecture and achieves exceptional sensitivity. Transmitted signals enter the module through a 50-ohm RF port intended for single-ended connection to an external antenna. RF signals entering the antenna are

Using LADJ

The Level Adjust (LADJ) line allows the transceiver's output power to be easily adjusted for range control, lower power consumption, or to meet legal requirements. This is done by placing a resistor between V_{CC} and LADJ. The value of the resistor determines the output power level. When LADJ is connected to V_{CC}, the output power and current consumption are the highest. Figure 5 shows a graph of the output power vs. LADJ resistance.

This line is very useful during FCC testing to compensate for antenna gain or other product-specific issues that may cause the output power to exceed legal limits. A variable resistor can be temporarily used so that the test lab can precisely adjust the output power to the maximum level allowed by law. The variable resistor's value can be noted and a fixed resistor substituted for final testing. Even in designs where attenuation is not anticipated, it is a good idea to place a resistor pad connected to LADJ and V_{CC} so that it can be used if needed. For more sophisticated designs, LADJ can also be controlled by a digital potentiometer to allow precise and digitally-variable output power control.

Using the RSSI Line

The transceiver'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. The RSSI levels and dynamic range vary slightly from part to part. It is important to remember that the 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. Using RSSI to determine distance or data validity is not recommended.

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. RSSI 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.

Using the Data Line

The CMOS-compatible DATA line is used for both the transmitter data and the recovered receiver data. Its function is controlled by the state of the T/$\overline{R}$_ SEL line, so it is an input when in transmit mode and an output when in receive mode. The output is normally connected to a transcoder IC or a microprocessor for data encoding and decoding.

It is important to note that the transceiver does not provide hysteresis or squelching of the DATA line when in receive mode. This means that, in the absence of a valid transmission or transitional data, the DATA line switches randomly. This noise can be handled in software by implementing a noise-tolerant protocol as described in Linx Application Note AN-00160. If a software solution is not appropriate, then the transceiver can be squelched.

Squelching disables the DATA output when the RSSI voltage falls below a reference level. This prevents low amplitude noise from causing the DATA line to switch, reducing hash during times that the transmitter is off or during transmitter steady-state times which exceed 15ms.

The voltage on the A REF line is the analog reference voltage that is used by the transceiver's data circuit. The received signal must be higher than this voltage for the DATA line to activate and must then fall lower than this output for the DATA line to deactivate. This voltage dynamically follows the midpoint of the received signal's voltage. There is always about 30mVp-p noise riding on the signal's voltage. During times with no carrier or during transmitter steady-state times exceeding 15mS, the reference voltage reaches a point where the noise causes the output to switch randomly.

To squelch the DATA line, an offset can be added to the A REF line by connecting a resistor to V_{CC}. This offset keeps the reference voltage above the noise, and quiets the DATA line. Typical resistor values are between 1M-ohm and 10M-ohm.

Squelching the output reduces the sensitivity of the receiver and therefore the range of the system. For this reason, the squelch threshold is normally set as low as possible, but the designer can make the compromise between noise level on the DATA line and range of the system. Figure 21 shows a graph of the sensitivity vs. the squelch resistor. Note that squelching causes some bit stretching and contracting, which could affect PWM-based protocols.

Transferring 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. The LT Series is intended to be as transparent as possible and does not incorporate internal encoding or decoding, so a user has tremendous flexibility in how data is handled.

If the product transfers simple control or status signals such as button presses or switch closures and it does not have a microprocessor on board (or it is desired to avoid protocol development), consider using a remote control encoder and decoder or a transcoder IC. These chips are available from a wide range of manufacturers including Linx. They 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 units independently. These ICs are an excellent way to bring basic remote control / status products to market quickly and inexpensively. Additionally, it is a simple task to interface with inexpensive microprocessors, IR, remote control or modem ICs.

It is always important to separate the types of transmissions that are technically possible from those that are legally allowable in the country of intended operation. Linx Application Notes AN-00125, AN-00128 and AN-00140 should be reviewed, along with Part 15, Section 231 of the Code of Federal Regulations for further details regarding acceptable transmission content in the US All of these documents can be downloaded from the Linx website at www.linxtechnologies.com.

Another area of consideration is that the data structure can affect the output power level. The FCC allows output power in the 260 to 470MHz band to be averaged over a 100ms time frame. Because OOK modulation activates the carrier for a ‘1’ and deactivates the carrier for a ‘0’, a data stream that sends more ‘0’s has a lower average output power over 100ms. This allows the instantaneous output power to be increased, thus extending range.

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 24) help ensure maximum performance and FCC and other regulatory compliance.

Figure 24: Linx Antennas

Linx transmitter modules typically have an output power that is 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.

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.

Interference Considerations

The RF spectrum is crowded and the potential for conflict with 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 products, 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 produces noise and hashing on the output and reduces 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 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 shorter useful distances for the link.

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.

Each of the module's ground pins should have short traces tying immediately to the ground plane through a via.

Bypass caps should be low ESR ceramic types and located directly adjacent to the pin they are serving.

A 50-ohm coax should be used for connection to an external antenna. A 50-ohm transmission line, such as a microstrip, stripline or coplanar waveguide should be used for routing RF on the PCB. The Microstrip Details section provides additional information.

In some instances, a designer may wish to encapsulate or "pot" the product. There are a wide variety of potting compounds with varying dielectric properties. Since such compounds can considerably impact RF performance and the ability to rework or service the product, it is the responsibility of the designer to evaluate and qualify the impact and suitability of such materials.

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 29). 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 30.

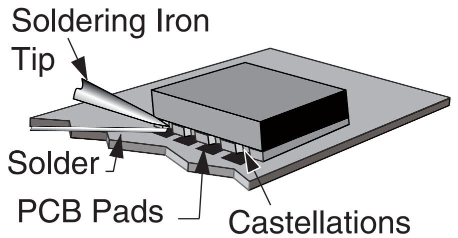

Figure 29: Soldering Technique

Warning: Pay attention to the absolute maximum solder times.

Absolute Maximum Solder Times
Hand Solder Temperature: +427°C for 10 seconds for lead-free alloys
Reflow Oven: +255°C max (see Figure 31)

Figure 30: 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 32). 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.

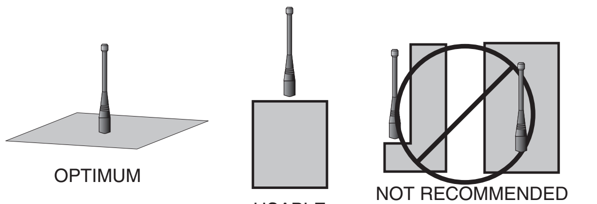

Figure 32: Ground Plane Orientation

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 33). 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

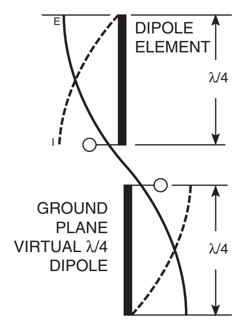

Figure 33: Dipole Antenna

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 35) 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 35: 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 36. 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 36:
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 37). 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.

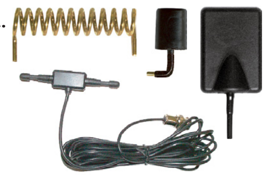

Figure 37: Specialty Style Antennas

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.

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