HIGH-PERFORMANCE

ES SERIES

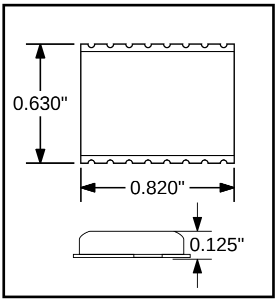
RF RECEIVER

WIRELESS MADE SIMPLE

ES RECEIVER MODULE DESIGN GUIDE

DESCRIPTION:

Housed in a tiny SMD package, the ES Series offers an impressive combination of features, performance and cost-effectiveness. The ES utilizes an advanced FM/FSK-based synthesized architecture to provide superior performance and noise immunity when compared to AM/OOK solutions. An outstanding 56Kbps maximum data rate and wide-range analog capability make the ES Series equally at home with digital data or analog sources such as audio. A host of useful features including RSSI, PDN, and an audio reference are provided. ES-Series components will be available in a wide range of frequencies to take full advantage of worldwide applications. The first model operates at 916.48MHz, which in North America allows an unlimited variety of applications including data links, audio links, process and status control, home and industrial automation, security, remote control/command, and monitoring. Like all Linx modules, the ES Series requires no tuning or external RF components (except an antenna).



PHYSICAL DIMENSIONS

FEATURES

- Ultra-compact SMD package
- FM/FSK modulation for outstanding performance/noise immunity
- Precision-frequency synthesized architecture
- Excellent sensitivity for outstanding range performance
- SAW front-end filter for superior out-of-band rejection
- Very low current for long life in battery-powered applications
- Direct interface to analog and digital sources
- High data rate - 56,000 bps max.
- Wide-range analog capability including audio 20Hz-28KHz
- No tuning or external RF components required (except antenna)
- User powerdown input
- RSSI signal strength output
- Outstanding cost-to-performance ratio

APPLICATIONS

- Wireless Data Transfer
- Wireless Analog/Audio
- Home/Industrial Automation
- Keyless Entry
- Remote Control
- Fire/Security Alarms
- Wireless Networks
- Remote Status Sensing
- Telemetry
- Long-Range RFID
- RS-232/485 Data Links
- MIDI Links
- Voice/Music Links/Intercoms

ORDERING INFORMATION

PART #	DESCRIPTION
TXM-***-ES	ES-Series Transmitter
RXM-***-ES	ES-Series Receiver
EVAL-***-ES	ES Basic Evaluation System
MDEV-***-ES	ES Master Development System
***= 916.48 (Additional Frequencies TBA)	

Revised 2/7/02

PERFORMANCE DATA RXM-xxx-ES

***ABOUT THESE MEASUREMENTS**

The performance parameters listed below are based on module operation at 25°C from a 5VDC supply unless otherwise noted.

Parameter	Designation	Min	Typ	Max	Units	Notes
POWER SUPPLY						
Operating Voltage	VCC (pin 10)	4.5	5	5.5	VDC	
Current Consumption	Icc	5.5	6	6.5	mA	
Sleep Mode			50		uA	4
ENVIRONMENTAL						
Operational Temp.		0		70	°C	4
RECEIVE SECTION						
LO Frequency	Flo	SEE TABLE 1			MHz	
Flo Tolerance		-50		+50	KHz	
Local Oscillator Feedthru			-75	-50	dBm	1,4
Spurious Emissions		compatible with FCC part 15				
Receive Sensitivity		-92	-97	-102	dBm	2
Data Rate		200		56,000	Bps	4
Required Transition Interval				5	ms	4,7
Audio Bandwidth		.02		28	KHz	3,4
Audio Level			360		mVp-p	4,5
RSSI DC Output Range			1.1 to 2.9		V	4
RSSI Gain	Grssi		30		mV/dB	4
RSSI Dynamic Range			60		dB	4
ANTENNA PORT						
Designed for Match			50		ohms	4
TIMING						
Power-on to Valid Receive		3.8	4.7	5.4	ms	4,6

NOTES:
1) Into a 50-ohm load.
2) For 10^{-5} BER at 9,600 baud.
3) The audio bandwidth is wide to accommodate the needs of the data slicer. In audio applications, audio quality may be improved by using a low-pass filter rolling off at the maximum frequency of interest.
4) These parameters are only characterized and not tested.
5) Input frequency deviation-dependent.
6) Time to receiver-readiness from the application of power to VIN or PDN going high.
7) Maximum time without a data transition.

MODEL	Center Frequency TX	Center Frequency RX LO	UNITS
RXM-433-ES	Not Released		MHz
RXM-868-ES	Not Released		MHz
RXM-903-ES	Not Released		MHz
RXM-916-ES	916.48	905.78	MHz
RXM-921-ES	Not Released		MHz

Table 1

CAUTION

This product incorporates 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.

TYPICAL PERFORMANCE GRAPHS

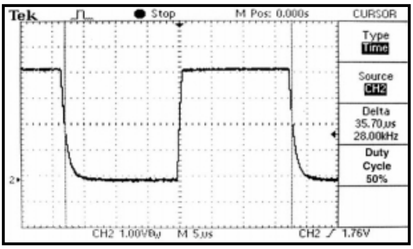


Figure 1: Receive-Bit Symmetry @ 56Kbps

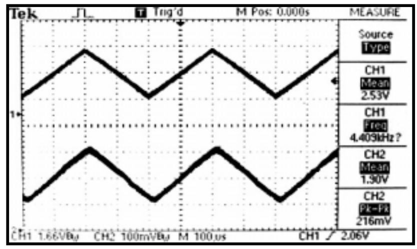


Figure 2: Triangle-Wave Modulation Linearity

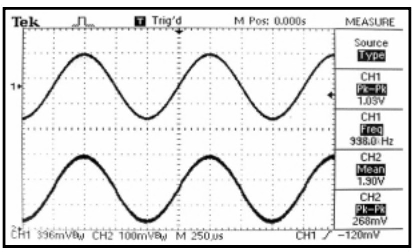


Figure 3: Sine-Wave Modulation Linearity

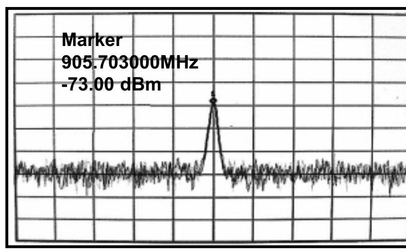


Figure 4: LO Feedthrough into 50Ω

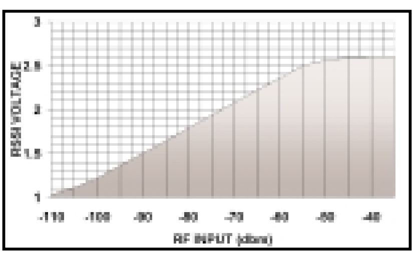


Figure 5: RSSI Characteristics Chart

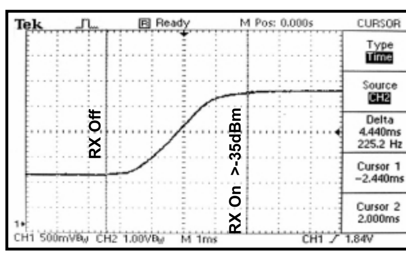


Figure 6: Worst Case RSSI Response Time

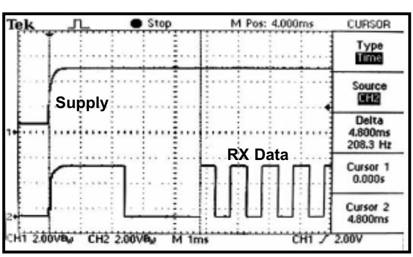


Figure 7: RX Vcc to Valid Data

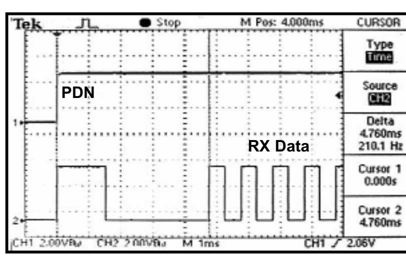


Figure 8: RX Enabled to Valid Data

PIN DESCRIPTION

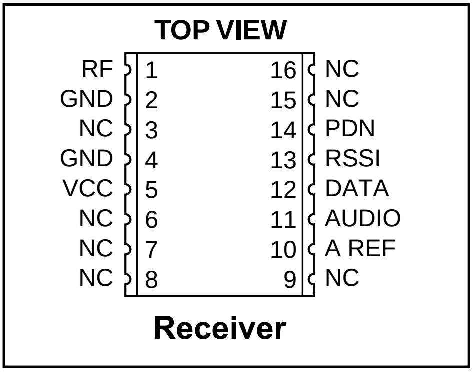


Figure 9: ES Series RX Pinouts
(viewed looking down on top cover)

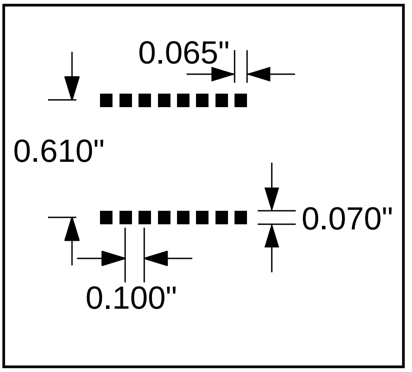


Figure 10: Recommended RX Pad Layout

PIN#	Pin Title	Description
1	RF/ANT	50Ω Antenna Port
2, 4	GND	Module Grounds Tie to Common Groundplane
3, 6, 7, 8 9, 15, 16	N/C	Not Implemented Do Not Connect Solder to Open PCB Pad Only
5	VCC	4.5-5.5VDC Supply
10	A REF	Audio RMS (Average) Voltage Reference
11	AUDIO	Recovered Analog Output
12	RXDATA	Recovered Data Output
13	RSSI	Received Signal Strength Indicator
14	PDN	Logic Low Powers Down the Receiver Logic High or Floating Powers Up

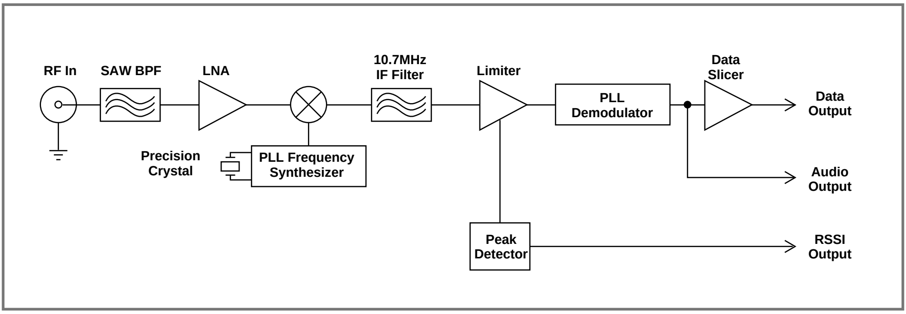


Figure 11: ES-Series Block Diagram

INTRODUCTION

The RXM-xxx-ES module is a single-channel receiver designed for the wireless reception of digital or analog information over distances of <1000 feet outside and <500 feet inside. The RXM-xxx-ES is based on high-performance synthesized single conversion superhet architecture. FM/FSK modulation and SAW filtering are utilized to provide superior performance and noise immunity over AM-based solutions. The ES series is incredibly compact and cost-effective when compared with other FM/FSK devices. Best of all, it is packed with many useful features and capabilities which offer maximum application flexibility to the designer. Some of these features which will be discussed in depth in this design guide are:

AUDIO	(buffering, filtering, and relationships between Audio and Data)
AUDIO REF.	(use in data slicing circuits)
DATA	(slicing, protocol, add-on circuits and timing)
RSSI	(interference detection, and using RSSI to validate data)

THEORY OF OPERATION

The receiver operates in a single conversion superhet configuration, with an IF of 10.7 MHz and a baseband analog bandwidth of 28kHz. It is capable of receiving a signal as low as -97dBm (typical). Out-of-band interferers such as cell phones are filtered at the front end by a SAW band-pass filter. The filtered signal is then amplified and down-converted to the 10.7 MHz IF by mixing it with a LO frequency generated by a PLL locked VCO. The 10.7 MHz IF is amplified, filtered, and finally a PLL demodulator is used to recover the baseband analog signal from the carrier. This analog signal is low-pass filtered and then made externally available to the user via the audio pin.

The analog output can be individual frequencies or complex waveforms such as voice or music. It is also passed to the data slicer for squaring of digital content. The audio pin can also be used to recover unsquared data in instances where a designer wishes to use an external data slicer.

The ES receiver also features a high-performance on-board data slicer for recovery of data transmission. Its output is internally derived from the filtered analog baseband which is squared and made externally available at the RX DATA pin. The data slicer is capable of recreating squared waveforms in the .1 to 28kHz band, giving a data-rate bandwidth of 200bps to 56Kbps.

THEORY OF OPERATION (CONT.)

It is important to note that this receiver does not provide hysteresis or squelching of the DATA output. This means that in the absence of a valid transmission or transitional data, the DATA output will slice randomly. The effects of this noise or "hash" must be considered relative to the application and will be discussed in further detail later in this guide.

The receiver features a RSSI output (Received Signal Strength Indicator). The RSSI pin gives a linear voltage output corresponding to incoming signal level. The RSSI output has many valuable uses including interference assessment, signal strength indication, external data squelching and qualification, and transmitter presence indication. Since RSSI values vary from part to part and correspond to signal strength and not necessarily distance, the pin is not recommended for range-finding applications.

No external RF components (excluding an antenna) are required. Linx offers a wide selection of antennas designed for use with the receiver module.

DESIGN CONSIDERATIONS

Like all Linx modules, the ES-Series is designed for ease of application even by inexperienced users. It must be recognized, however, that all wireless links differ from hardwired applications in several key ways. The most obvious are perhaps timing and interference, but there are other critical areas which are important to consider as well. These include:

Transparency • Timing • Interference

Board Layout • Antenna Selection • Legal Compliancy

MODULE TRANSPARENCY

ES-Series components do not encode or packetize the signal content in any manner. Naturally 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 ES modules. This transparency eliminates the issues of variable latency common to traditional radio modems and gives the designer tremendous flexibility in the structure of signals or protocol. A drawback to this approach is that the performance and reliability of the link are in part determined by external factors such as the quality of software and hardware.

TIMING CONSIDERATIONS

There are two general areas of timing that are important to consider when designing with the receiver: the actual time value for each is listed under the “Performance Specifications” section of this document.

1. Start-up time

Start-up time is the time to receiver readiness from the application of power to the VIN pin or the PDN pin going high.

Receiver readiness is determined by valid data at the DATA pin. (This assumes a valid incoming data stream.)

TIMING CONSIDERATIONS (CONT.)

2. Required transition interval.

This is the maximum amount of time that can elapse without a transition on the TX or RX data pin.

For digital content, this specification defines the minimum frequency that can be reliably conveyed across the link. This specification is important since the designer must always think of data in both the analog and the digital domain. Because the data stream is asynchronous and no particular format is imposed, it is possible for the data to meet the baud-rate requirements of the module and yet violate the analog frequency parameters. For example, if a 255 (0FF hex) is being sent continuously, the receiver would view the data as a DC level. The receiver would hold that level until a transition was required to meet the minimum frequency requirement. If no transition occurred, data integrity could not be guaranteed. Thus, while no particular signal structure or code-balancing requirement is imposed, the designer must insure that both analog and digital signals have transitions suitable to meet the transition-interval specification.

INTERFERENCE CONSIDERATIONS

It must be recognized that many bands are widely used, and the potential for conflict with other unwanted sources of RF is very real. Despite careful design, all RF products are at risk from interference.

Interference may come from internal or external sources. The designers' first responsibility is to make sure that nothing under their control is an interference source. This means careful attention to layout, grounding, filtering and bypassing in order to eliminate all radiated and conducted interference paths. For many products this is a very straightforward task; however, products incorporating 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. Thanks to the capture properties of an FM system, the receiver will still function when an intended signal is present at a useable level above the interference.

Another type of interference can be caused by higher-powered devices such as hopping spread-spectrum devices. Since these devices move rapidly from frequency to frequency they will usually cause short, intense losses of information. Bursting errors of this type are generally dealt with in protocol.

High-level interference is caused by products sharing the same frequency in proximity or from near-band high-power devices. Fortunately, 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.

A spectrum analyzer is the primary tool of the RF engineer for assessing interference sources and levels, but is often not available due to its cost. Fortunately, the RSSI voltage output can also be used as a diagnostic tool to determine the presence and strength of interference during the development process. Use of the RSSI pin is described elsewhere in this guide.

INTERFERENCE CONSIDERATIONS (CONT.)

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. Multipath effects are a particularly significant factor in interior environments where objects provide many varied signal-reflection paths. Multipath cancellation results in lowered signal levels at the receiver and thus shorter useful distances for the link.

USING THE RXM-xxx-ES FOR ANALOG APPLICATIONS

The ES series is an excellent choice for sending a wide range of analog information, including audio. The ability of the ES to receive combinations of analog and digital signals also opens new areas of opportunity for creative product design.

The AUDIO output of the receiver may contain simple or complex analog signals within the specified audio bandwidth. Signal sources ranging from a single frequency to complex content such as audio are handled with ease .

The AUDIO output of the receiver should be buffered and filtered to obtain maximum signal quality. This is particularly important because the audio output is AC-coupled, which means any DC loading will cause errors in the data slicer since data is derived from the audio voltage. For voice, a 3-4KHz low-pass filter is often employed. For broader-range sources such as music, a 12-20KHz cutoff may be more appropriate.

The signal-to-noise ratio (SNR) of the audio will depend on the bandwidth you select. The higher the SNR, the less “hiss” you will hear in the background. For the best SNR, choose the lowest filter cutoff appropriate for the intended signal. For applications which require truly high fidelity, audio RF links designed expressly for this purpose may prove to be a more appropriate solution; however, a compandor may also be used with the ES-series transmitter to provide further SNR improvements.

To avoid audible white noise or hiss when no transmission is present the designer may wish to implement a squelch circuit to provide muting. This is easily accomplished with a simple circuit such as that shown below.

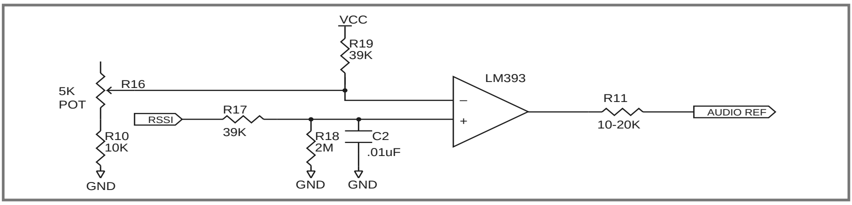


Figure 12: Squelch Circuit

Analog squelching is implemented by comparing RSSI to a voltage reference (typically a voltage divider) with an open collector-style comparator. When the voltage from RSSI becomes lower than the voltage reference, the comparator output is pulled to GND. This is useful because this output can be used to disable the Analog Amplifier circuit either when the receiver is out of range or the transmitter is turned off. Of course it is the designer's responsibility to choose a squelch topology that best fits the specific needs of their product.

USING THE ES FOR DIGITAL APPLICATIONS

As previously discussed, it is important to note that this receiver does not provide hysteresis or squelching of the DATA output. This means that in the absence of a valid transmission or transitional data the DATA output will slice randomly. In many applications this "hash" will be ignored by the decoder or system software, but, depending on your application, it may be helpful to use an external circuit to provide data squelching and hysteresis.

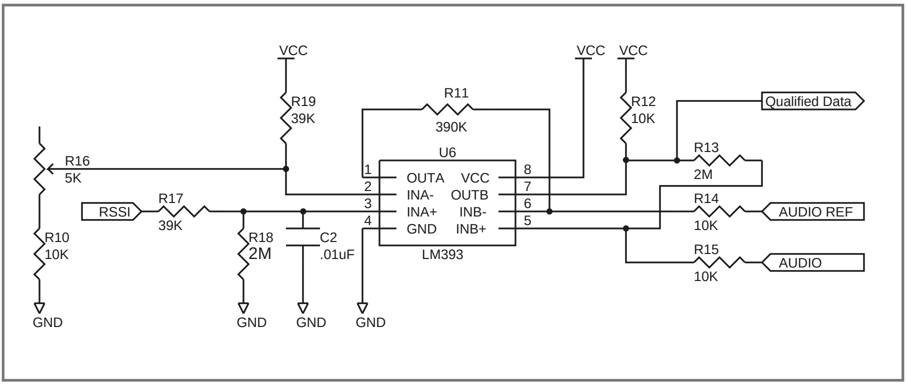


Figure 13: Squelch/Hysteresis Diagram

Creating a DATA circuit that has additional hysteresis characteristics is very basic and requires very few parts, thanks to the AUDIO REF. output of the ES. All you need is a couple of resistors to provide some isolation for the AUDIO and AUDIO REF. outputs, a high-value feedback resistor, a pull-up resistor and an open collector comparator. This circuit is useful if your application cannot handle data hashing during times that the transmitter is off or during transmitter steady-state times that exceed 5mS.

The RSSI and AUDIO REF. outputs of the ES allow a wide variety of squelch circuits to be implemented. One such possibility is the circuit above which is used by Linx on the ES Master Development kit and may be employed for audio or data squelching. It is ultimately the responsibility of the designer to determine what, if any, circuit would be most appropriate for the needs of their product.

Data squelching in the circuit above is accomplished by comparing RSSI to a voltage reference (typically a voltage divider) with an open-collector-style comparator. When the voltage from RSSI becomes lower than the voltage reference, the comparator output is pulled to GND. This is useful because this output can be used to disable the data-slicer circuit either when the receiver is out of range or the transmitter is turned off.

The squelch threshold will normally be set as low as possible to assure maximum sensitivity and range. It is important to recognize that in many actual use environments, ambient noise and interference may enter the receiver at levels well above the squelch threshold. For this reason it is always recommended that the product's protocol be structured to allow for the possibility of "hashing" even when an external squelch circuit is employed.

A TYPICAL SYSTEM EXAMPLE

1) Power up the receiver

The receiver is powered up by bringing VCC to supply voltage and allowing PDN to either float or be pulled up to supply (PDN uses an internal pull-up resistor and does not require voltage to enable the receiver). Once the receiver is enabled, the PLL will begin trying to lock.

2) Wait for receiver to stabilize

This step is necessary to allow the receiver time to stabilize. When the PLL is locked and the data slicer is stable, the receiver is ready to receive valid data. During the settling time, the receiver output may produce scraps of data; therefore, the data can only be considered reliable once the settling time has passed.

3) Receive a transmitted packet

The transmitted data should be structured into small packets. That way receive errors can be managed easily without affecting large amounts of data. Packets should be transmitted so that there is no space between bytes. For purposes of illustration, let's look at a packet format which would be typically used with a UART:

[uart sync byte] [start byte] [data packet]

The UART Sync-Byte is used to ensure that the start-bit for the start-byte will be accurately detected. It is a single byte with a value of 255 (0FF hex).

A Start-Byte often follows the Sync Byte to intelligently qualify the Data Packet which will follow. Detection of the Start Byte would be performed by the computer or microcontroller connected to the receiver.

Let’s consider the packet format outlined above being received and sent to a UART. A UART interprets the start-bit of a byte as a 1-0 transition. When the incoming data is 101010 or hash... it is hard to actually find the start-bit. This problem is solved by the UART Sync Byte. The purpose of the Sync Byte is to create a high marking period of at least a byte length so that the start-bit of the following Start Byte can be correctly recognized.

The Start Byte following the Sync Byte is used by the receiving computer or microcontroller to intelligently identify the beginning of a data packet. The Start Byte value should be chosen so that it does not appear in the data stream. Otherwise, a receiver may “wake up” in the middle of a packet and interpret data in the packet as a valid Start Byte. There are many other, more complicated ways to organize the protocol if this restriction cannot be met.

As we have learned, there is always a possibility of errors from interference or changing signal conditions causing corruption of the data packet, so some form of error checking should be employed. A simple checksum or CRC could be used. Once an error is detected, the protocol designer may wish to simply discard the corrupt data or to develop a scheme for the data packet so error correction can take place.

The preceding steps indicate the general events involved on the receiver side of a simple data link. While the designer's choice of protocol may be significantly different it must take into account the issues outlined in order to insure product reliability under field conditions.

POWER-SUPPLY CONSIDERATIONS

Unlike many Linx modules, the ES receiver does not have an on-board regulator. Therefore, the supply voltage must be carefully controlled to avoid damage to the part. The nominal operating voltage is 5V +/-10%.

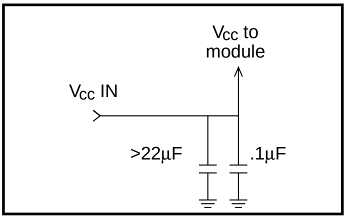


Figure 14: Suggested supply filter

The user must also insure that the supply source is clean and free of noise. Power-supply noise will manifest itself as AM and FM noise and can significantly affect receiver sensitivity. Providing a clean power supply for the module should be a high design priority.

The module’s power-supply line should have bypass capacitors placed close to the module and configured as shown in the adjoining figure. Actual capacitor values will vary depending on noise conditions and frequency.

USING THE PDN PIN

The receiver's Power Down pin (PDN) can be used to power the receiver down without the need for an external switch. When the PDN pin is held high or simply left floating the module will be active and consuming full current. The PDN pin has an internal pull-up and therefore does not require any external components to power-up the module.

It is only necessary to pull down the PDN pin if you wish to power down the module. When the PDN pin is pulled to ground the receiver will enter into a low-current (<50uA) powerdown 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 powerdown will be slightly less than when applying Vcc. This handy pin allows easy control of the receiver state directly from external components such as microcontroller or keypad.

USING THE RSSI PIN

The receiver's Received Signal Strength pin (RSSI) serves a variety of uses. The RSSI pin has a dynamic range of 60dB (Typical) and outputs a voltage proportionate to incoming signal strength. A graph of the RSSI pin's characteristics appears on page 3 of this manual. It should be realized 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 used to create external squelch circuits as described in previous sections. It 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 in such systems that must be considered. Finally, the RSSI pin can be used to save system power by "waking up" external circuitry when a transmission is received or crosses a certain threshold. As you can see the RSSI output feature adds tremendous versatility for the creative designer.

BOARD LAYOUT CONSIDERATIONS

If you are at all familiar with RF devices, you may be concerned about specialized layout requirements. Fortunately, because of the care taken by Linx in the ES-Series design, integrating the receiver into your own product is very straightforward. Despite this ease of application it is still wise to maintain respect for the RF stage and exercise appropriate care in layout and application in order to maximize performance and assure reliable operation.

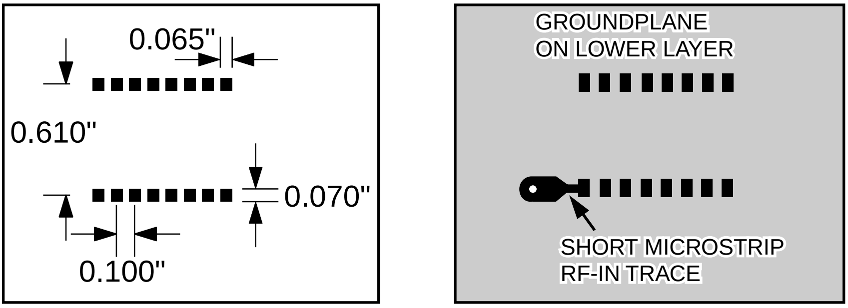


Figure 15: Recommended pad geometry and PCB layout

Here are a few basic design and layout rules, which will help you enjoy a trouble-free path to RF success.

Figure 15 shows the suggested PCB footprint for the ES-Series receiver. This footprint is suitable for hand- or reflow-assembly techniques.

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

No PCB traces or vias should be placed underneath the receiver module on the PCB layer contacting the module. A groundplane (as large as possible) should be placed on the far side of the PCB under the ES receiver. This groundplane can also be critical to the performance of your antenna. The groundplane's effect as an antenna counterpoise will be discussed in greater detail in later sections.

The ES 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.

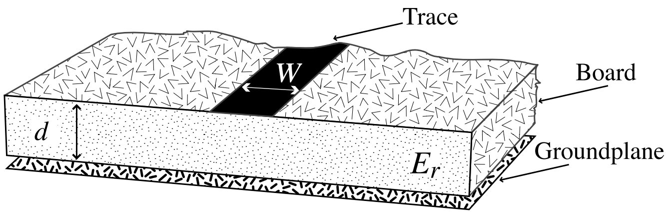
The power-supply filter components should be placed close to the module's Vcc line.

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 designer's responsibility to carefully evaluate the impact of such materials.

The trace from the receiver to the antenna should be kept as short as possible. A simple trace is suitable for runs up to 1/8 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, particularly in high-frequency products like the ES, 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 is needed, unless the antenna connection can be made in close proximity: <1/8 in. to the module. One common form of transmission line is coax cable, another is the *microstrip*. This term refers to a PCB trace running over a groundplane which is designed to serve as a transmission line between the module and the antenna. The width is based on the desired characteristic impedance, the thickness of the PCB, and its dielectric constant. For standard .062 thick FR-4 material, the trace width would be 111 mils. The correct trace width can be calculated for other widths and materials using the information below.



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

$$Z_0 = \begin{cases} \dfrac{60}{\sqrt{E_e}} \cdot \ln\left(\dfrac{8d}{W} + \dfrac{W}{4d}\right) & \text{For r } \dfrac{W}{d} \le 1 \\[2ex] \dfrac{120\pi}{\sqrt{E_e} \cdot \left(\dfrac{W}{d} + 1.393 + 0.667 \cdot \ln\left(\dfrac{W}{d} + 1.444\right)\right)} & \text{For } \dfrac{W}{d} \ge 1 \end{cases}$$

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

Figure 16: Microstrip formulas (Er = Dielectric constant of pc board material)

GUIDELINES FOR OPTIMUM 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 mounting position or antenna style 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. Objects in close proximity to the antenna can cause direct detuning while those farther removed will alter the antenna's pattern and symmetry.
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 on the circuit board. Ideally, the antenna would be centered on the groundplane to be used as counterpoise and its surface area would be ≥ the overall length of the 1/4-wave radiating element. This is often not practical due to size and configuration constraints. In these instances the 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 such compromises are necessary it should be recognized that the range and reliability of the link can be significantly affected.

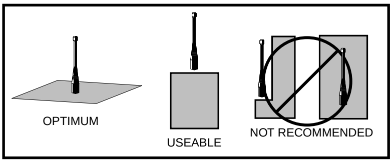


Figure 17: Groundplane Orientation

5. In some applications it is advantageous to place the RF module 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 50Ω coax such as RG-174 for the remote feed. If 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.

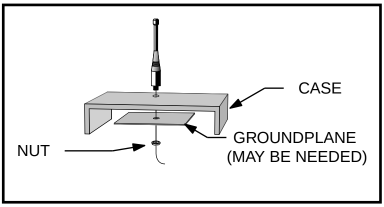


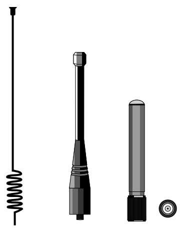
Figure 18: Remote Groundplane

6. Remove the antenna as far as possible from potential interference sources. There are many possible sources of internally generated interference. Switching power supplies, oscillators, even relays can also be significant sources of potential interference. Remember, 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 all potential sources of noise. Shield noisy board areas when practical.

COMMON ANTENNA STYLES

The antenna is a critical and often overlooked component which has a significant effect on the overall range, performance and legality of an RF link. There are hundreds of antenna styles that can be successfully employed with the ES Series. Following is a brief discussion of styles commonly utilized in compact RF designs. Additional antenna information can be found in Linx application notes #00500, #00100, #00126 and #00140.

Whip Style



A whip-style monopole antenna provides outstanding overall performance and stability. A low-cost whip can be easily fabricated from wire or rod, but most product 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.

The wavelength of the operational frequency determines an antenna's overall length. Since a full wavelength is often quite long, a partial 1/4-wave antenna is normally employed. Its size and natural radiation resistance make it well matched to Linx modules. The approximate length for a straight 1/4-wave antenna can be easily found using the formula below. It is also possible to reduce the overall height of the antenna by using a helical winding; therefore, the physical appearance is not always an indicator of the antennas frequency.

1/4-wave wire length frequencies:

433MHz = 6.5"
868MHz = 3.24"
902-928MHz = 3.06"

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

Where:
L=length in feet of quarter-wavelength
F=operating frequency in megahertz

Example:

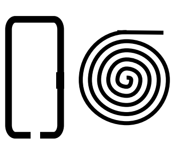
$$\frac{234}{916\text{MHz}} = .255$$

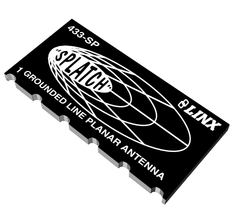
.255 x 12" = 3.06"

Specialty Styles

Linx offers a wide variety of specialized antenna styles and variations. Many of these styles utilize helical elements to reduce the overall antenna size while maintaining excellent performance characteristics. 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.

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 its cost advantages, PCB antenna styles are generally inefficient and useful only for short-range applications. Loop-style antennas are also very sensitive to changes in layout or substrate dielectric which can introduce consistency issues into the production process. In addition, printed styles initially 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 introduce instability in the RF stages.

Linx offers a low-cost planar antenna called the “SPLATCH” which is an excellent alternative to the sometimes problematic PCB trace style. This tiny antenna mounts directly to a product's PCB and requires no testing or tuning. Its design is stable and it provides excellent performance in light of its compact size.

PRODUCTION GUIDELINES

The ES modules are packaged in a hybrid SMD package which has been designed to support hand- or automated-assembly techniques. Since the ES device contains discrete components internally, the assembly procedures are critical to insuring the reliable function of the ES product. The following procedures should be reviewed with and practiced by all assembly personnel.

RECEIVER HAND ASSEMBLY

The ES Receiver's primary mounting surface is 16 pads located on the bottom of the module. Since these pads are inaccessible during mounting, plated 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 and efficient hand soldering for prototyping and small volume production.

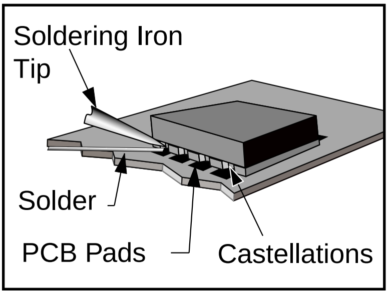


Figure 19: Soldering Technique

If the recommended pad placement has been followed, the pad on the board will extend slightly past the edge of the module. Touch both the PCB pad and the module castellation with a fine soldering tip. Tack one module corner first, then work around the remaining attachment points using care not to exceed the solder times listed below.

Note:

Care should be taken, especially when hand-soldering, not to use excessive amounts of flux as it will wick under the module and potentially cause irregularity in its function. In most cases, no-clean flux is the best choice

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)

RECEIVER AUTOMATED ASSEMBLY

For high-volume assembly, most users will want to auto-place the modules. The modules have been designed to maintain compatibility with most pick-and-place equipment; however, due to the module's hybrid nature certain aspects of the automated 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 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 insure that it meets the requirements necessary to successfully reflow all components while remaining within the limits mandated by the modules themselves.

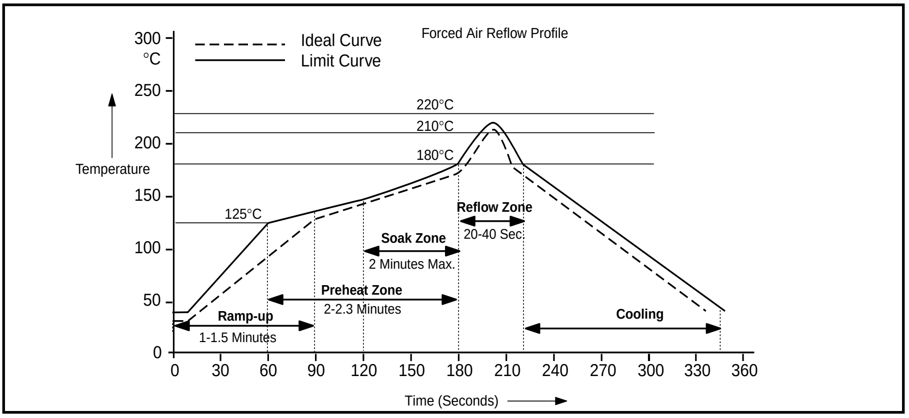


Figure 20: Maximum reflow profile

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 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. Linx recommends wash-free manufacturing techniques: however, the modules can be subject to a wash cycle provided that a drying time is allowed prior to applying electrical power to the parts. The drying time should be sufficient to allow any moisture which may have migrated into the module to evaporate, thus eliminating the potential for shorting damage during power-up or testing.

LEGAL CONSIDERATIONS

NOTE: ES 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 approvals necessary 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 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

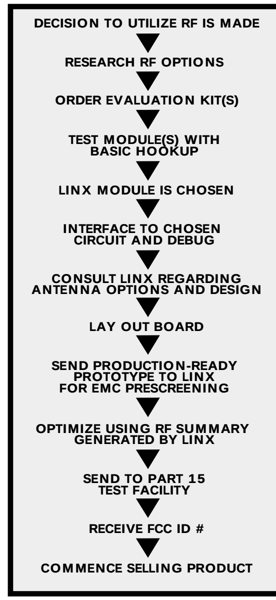
International approvals are slightly more complex, although many modules are designed to allow all international standards to be met. If you are considering the export of your product abroad, you should contact Linx Technologies to determine the specific suitability of the module to your application.

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.

ACHIEVING A SUCCESSFUL RF IMPLEMENTATION

Adding wireless capabilities 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 Linx RF modules, the design and approval process will be greatly simplified. It is 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, but you may even find the process enjoyable.



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
00100	RF 101: Information for the RF-challenged
00102	RS-232: A brief overview
00125	Considerations for operation within 260-470 band
00130	Modulation techniques for low-cost RF data links
00126	Considerations for operation in the 902 Mhz to 928 Mhz band
00140	The FCC Road: Part 15 from concept to approval
00150	Use and design of T-Attenuation Pads
00500	Antennas: Design, Application, Performance

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