Using a Transmitter and Receiver to Create a Transceiver

Application Note AN-00301

Introduction

One application for Linx RF modules is to make a transceiver out of the separate transmitter and receiver modules. This allows for the bi-directional transfer of information while using low-cost and easily implemented Linx RF modules. The only additional RF component required is an antenna switch.

The Antenna Switch

An example of an antenna switch is shown in Figure 1.

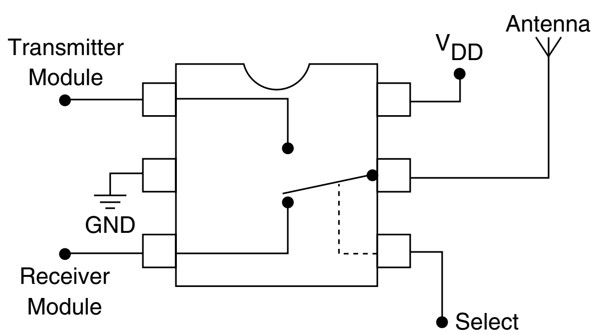

Figure 1: Typical Antenna Switch

The antenna switch is an Integrated Circuit (IC) that will connect the antenna to either the transmitter or the receiver based on the logic state of one or two control lines. The switch serves two primary purposes. First, it maintains a 50-ohm match between the antenna and the modules. If you were to connect both modules directly to the antenna, then each part would see a 25-ohm impedance. This mismatch would result in losses that would degrade the range and performance of the system.

Second, it prevents the full output power of the transmitter from being placed directly onto the sensitive front end of the receiver. While this probably would not damage the receiver, it would saturate the front end and take several tens of milliseconds for the receiver's sensitivity to return to the point where it can see a signal.

Antenna switches (also called T/R switches or RF switches) are small, inexpensive, typically six-pin ICs. They are available from several manufacturers, most notably NEC <www.cel.com>, Macom <www.macom.com>, and Peregrine Semiconductor <www.peregrine-semi.com>.

Linx does not recommend a specific part over another. Most switches are very similar in performance, and one application may benefit from one package or pinout while another application may benefit from a different package or pinout. Look for the highest isolation between the Tx and Rx ports (typically around 30dB) plus the lowest insertion loss between the Tx or Rx port and the antenna port (typically around 0.5dB) at the frequency and impedance of interest. Some switches have one control line and a V_{CC} line and others have two control lines, but all of them will have the same basic operation. It is up to the designer to select the package and manufacturer that works best for each application.

A Transceiver Using the LR Series

As with any RF design, the board layout is critical to the performance of the product. Careful attention must be paid to the routing of the traces and to the ground plane to ensure that noise is not picked up or radiated in a manner that would degrade the performance or compromise the ability of the product to get an FCC certification. The figure below shows an example layout of a transceiver using the LR Series and an antenna switch with a single control line.

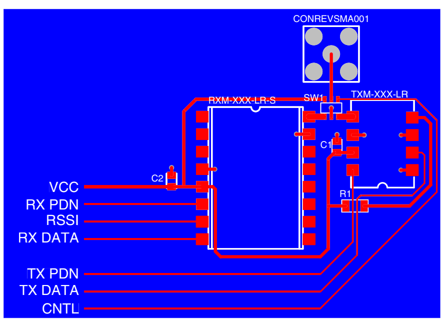

Figure 2: Example Transceiver Layout Using the LR Series

Objects on the top layer are red. Objects on the bottom layer are blue. Silkscreen and overlay are white and the holes and vias are gray. The first thing to note with this layout is the solid ground plane on the bottom layer. This is very important with RF design, as the ground plane will act as the counterpoise for the antenna (essentially the other half of the antenna when a ¼-wave monopole is used) and will keep the board quiet by preventing any noise on the board from getting coupled into the RF stage. This is one of the most important aspects of a successful RF design.

Each connection to ground, for the modules and for the other components, has its own via to the bottom layer. This is another important design element, as it prevents the formation of loops that can act as antennas, potentially causing noise and harmonic problems. A nice side effect of this is that it reduces the number of traces on the board, making the design look simpler and helping reduce crossovers on complicated boards.

The antenna switch in this example has one control line and a connection to VCC. Because of the size of the pins on the switch, a microstrip line on this standard 0.062"-thick board is not possible. Instead, the traces are the same size as the pads and the runs are short. This keeps the trace impedance down as much as possible and keep any frequency pulling to a minimum. A thinner board or multiple layers would allow these traces to be properly microstripped, but, as in this case, it is not always practical.

Many antenna switches will recommend coupling capacitors on the port lines to prevent the DC bias in the switch from getting into other stages. LR Series modules have a series capacitor as a part of their output match that can also act as coupling capacitors, so no additional components are needed on these lines.

A coupling capacitor may be needed on the antenna line, depending on the type of antenna. Shown in this example is a reverse polarity SMA connector for a monopole antenna, which is essentially a wire. This type of antenna is an open circuit at DC and does not require a capacitor. Some loop trace antenna designs are short circuits at DC and would require a capacitor.

C1 and C2 are filter capacitors that serve two functions. First, they prevent line noise from getting into the modules and potentially reducing the sensitivity of the receiver or causing harmonic problems with the transmitter. Second, and probably less intuitive, they prevent RF energy from the modules from traveling back down the supply line. The traces on the boards can easily act as antennas and radiate the RF energy off of the board. The danger with this is not that they might compete with the antenna on your product, but that they will efficiently radiate harmonics, which are whole number multiples of the center frequency. As the frequency gets higher, the required antenna length gets shorter, so some traces can make great antennas at higher harmonics. The FCC regulations are strict when it comes to radiating these harmonics, so filter capacitors are essential.

R1 is a level-adjust resistor for the transmitter. The value of this resistor will determine the output power of the transmitter. It is always a good idea to include this so that the FCC test lab can easily adjust the output power to the maximum level allowed by law. If there is no provision for adjustment and the output is too high, then the lab will fail the product; if it is too low, then you will be sacrificing range and performance. In this example, the resistor was selected to be a 1206 size in order to jump the Power Down line and DATA line rather than cut the ground plane with a trace. Multiple layer boards could route these two lines on an inner layer and make the resistor smaller, but the important thing is to keep the ground plane as solid as possible.

Note that the supply trace was run under the receiver, contrary to standard Linx recommendations. In general, it is best to avoid this, but if the situation demands a trace directly under the module, then there are a couple of guidelines. First, keep it to a minimum. Do not run any more traces under the module than is absolutely necessary. Keep the traces close to the digital side and away from the RF side. This will help keep RF energy from being coupled onto the traces. Adding filter capacitors to the traces will help remove any RF energy that does get onto the line. This makes the supply trace the leading candidate to get run under a module, since it should have filter capacitors anyway.

Avoid running any traces under the transmitter. The transmitter has high levels of RF energy that would cause more problems if it got coupled onto a trace. The receiver has much lower levels of RF energy and is less likely to cause problems. Again, the best way to avoid problems is to not run traces under the modules at all.

The PDN lines allow the module not in use to be powered down, saving current consumption and also preventing the modules from interfering with each other. The LR Series transmitter's oscillator will be active unless either the PDN or VCC line is low. The DATA line will activate the amplifier, so it will be on when the DATA line is high and off when the DATA line is low. When the amplifier is off, the oscillator will be on the output at around –70dBm. With around 30dB of isolation through the switch, the receiver will see a signal of about –100dBm on its input, meaning that the intended signal will have to be greater than this to be accurately received. The LR Series receiver has a typical sensitivity of –112dBm, so this will significantly reduce the range of the LR-based system. This makes it important to be able to power the transmitter down when in receive mode.

A Transceiver Using the ES Series

The figure below shows a layout with the ES Series RF module.

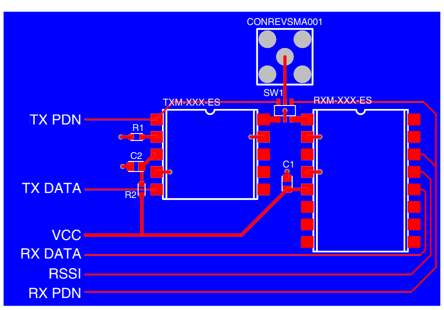

Figure 3: Example Transceiver Layout Using the ES Series

There are a couple of differences between this layout and the previous one. The biggest change is the antenna switch. This switch has two control lines instead of a control line and a supply line. The control lines for the switch have been connected to the Power Down lines for the modules so that the modules can be powered down and the switch changed at the same time.

ES Series modules also have series capacitors as part of the internal matching network, so no coupling capacitors are needed on the antenna lines.

C1, C2, and R1 all perform the same functions as in the previous example. The ES Series transmitter requires a 3V supply while the ES Series receiver requires a 5V supply. Resistor R2 is used to drop the 5V supply to 3V for the transmitter.

Sending Data with the Transceiver

Sending data with the transceiver is the same as for any other transceiver. The actual software algorithm will probably be different for each application, but the basic idea is this:

- Power on one of the modules. which one depends on which side should transmit first.
- Throw the switch to connect the active module to the antenna.
- Transfer data.
- Power down the active module.
- Power up the other module.
- Throw the switch to connect the active module to the antenna.
- Transfer data.

This algorithm can be used as the starting point for creating the software. One other thing to consider is that it is a good idea to packetize the data to protect against corruption due to interference. Application Note AN-00160 goes into detail about how to create a noise-tolerant protocol.

TE TECHNICAL SUPPORT CENTER

USA:	+1 (800) 522-6752
Canada:	+1 (905) 475-6222
Mexico:	+52 (0) 55-1106-0800
Latin/S. America:	+54 (0) 11-4733-2200
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