Application Note

Receivers MLX71120/21
With Balanced Loop Antenna

Scope

This application note describes the use of the MLX71120 and MLX71121 RF receivers in a balanced loop antenna configuration.

The application note provides a detailed application schematic with the complete component list as well as some measurement results such as sensitivity and spurious response rejection. All circuit schematics are based on the MLX71121 receiver with integrated IF filter. The same loop antenna configuration applies to the MLX71120 that requires an external IF filter.

Applications

- ❒ Very small RF receivers with no external antenna
- ❒ Good selectivity receivers without using a SAW filter

Related Melexis Products

MLX71120 and MLX71121 multi-band RF receivers, please refer to the latest data sheets under

http://www.melexis.com/Assets/MLX71120_DataSheet_5231.aspx
http://www.melexis.com/Assets/MLX71121_DataSheet_5154.aspx

Theory of operation

Since the MLX71120/21 receivers have two identical LNAs and a differential mixer input, they can be used with a balanced loop antenna using a simple capacitive matching arrangement. The LNAs can have a common output tuning circuit, and each LNA can drive one of the balanced mixer inputs.

Application Circuit

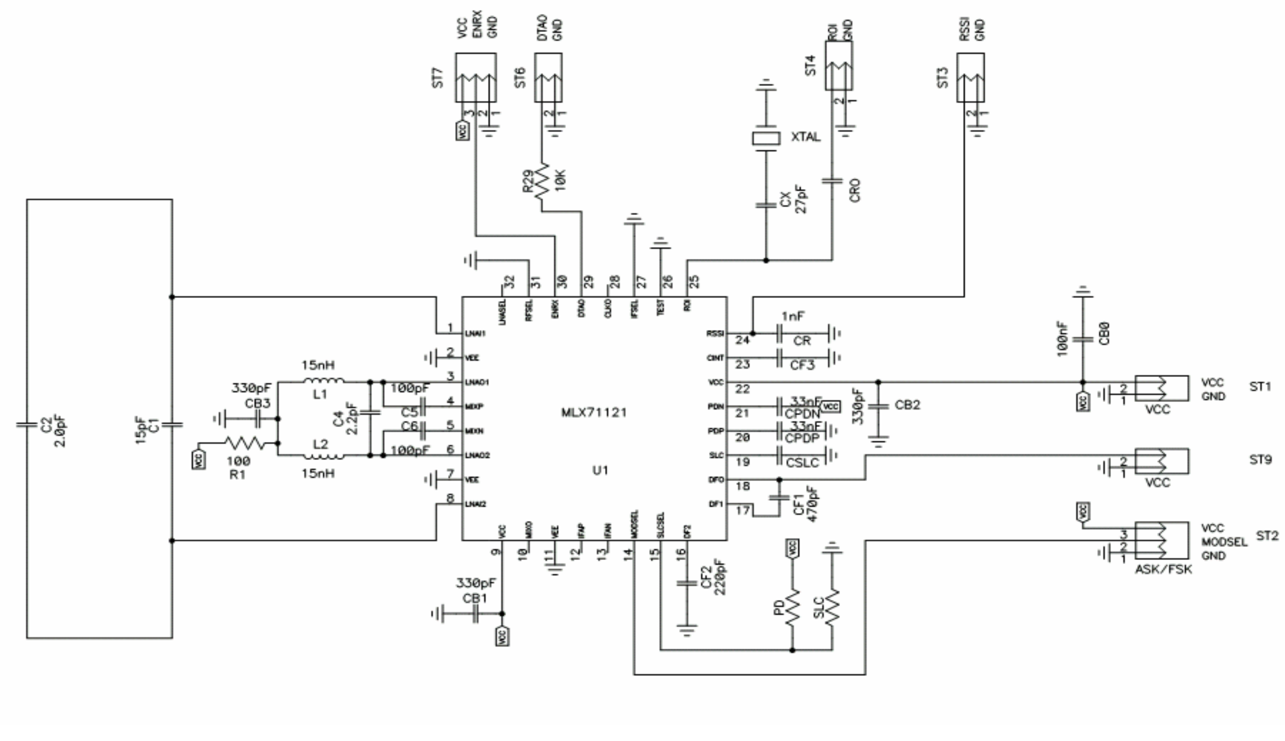

Figure 1: 433.92MHz Loop Antenna Receiver

The two LNA inputs LNA1 (pin 1) and LNA2 (pin 8) are connected to the loop antenna. C1 and C2 tune the loop antenna and the ratio of C2 to C1 match the loop to the LNA inputs. At 433MHz, each LNA has an input resistance of about 300 Ohms in parallel with about 3pF. Therefore, it presents a load of about 600 Ohms across C1.

The loop used on the receiver PC board has an inductance of 66.76nH and tunes with 2.02pF at 433.92MHz. The series combination of C1 and C2 tunes the loop.

The unloaded quality factor of the loop Q_0 is about 380 and its reactance is 182 Ohms, so the unloaded impedance is

$$380 \times 182\Omega = 69k\Omega$$

The receiver input loads the loop so the Q_L must be less than 380.
Where Q_0 is the unloaded Q and Q_L is the loaded Q of the loop.

The insertion loss of a tuned circuit is given by the equation:

$$\frac{Q_0}{Q_0 - Q_L}$$

Therefore, it is necessary to make a compromise is between the receiver sensitivity and the desired selectivity because more selectivity requires a higher loaded Q, and this results in more insertion loss.

In this case, a loaded Q of 120 has been selected, and this results in a loop impedance of

$$120 \times 182\Omega = 21.8k\Omega$$

This is the parallel combination of the unloaded loop impedance and the transformed receiver input resistance, so the receiver must load the loop with 31.8kΩ.

This gives an impedance ratio from the receiver input of $\frac{31.8k\Omega}{600\Omega} = 53$

Therefore, $C_2 = \sqrt{53} \times 2.02pF = 14.71pF$ and $C_1 = 2.34pF$

In the final circuit, C2 = 15pF and C1 = 2pF gave the maximum receiver output measured at the RSSI output on pin 24.

The LNA pins LNAO1 and LNAO2 are open collector outputs, so each output must be supplied with DC through an inductor. It would be possible to tune each inductor with a parallel capacitor, but it is also possible to use one capacitor across both inductors. In this case it is C4 and it is ½ the value of the capacitance normally required to tune each inductor.

The rest of the receiver is the same as for the standard MLX71120 or MLX71121 evaluation boards.

The receiver sensitivity using the loop antenna can be calculated.

$$P_R = \frac{\lambda^2}{4\pi} G_R \frac{E^2}{377}$$

Where : P_R = received power

G_R = receiving antenna gain. In this case, $G_R \approx$ 1.5 x radiation efficiency

E = electric field strength at the antenna

Some of the received signal is dissipated in the antenna and some goes to the receiver input.

$$P_{RCV} = P_R \frac{Q_0 - Q_L}{Q_0}$$

P_{RCV} = power delivered to the receiver input.

If P_{RCV} is known from receiver measurements, then E in $\mu V/m$ can be calculated.
This is left as an exercise for the reader. The calculations have been entered in a spreadsheet which is available at Melexis applications support.

Below is an application circuit for 315MHz using the same loop as for 433.92MHz.

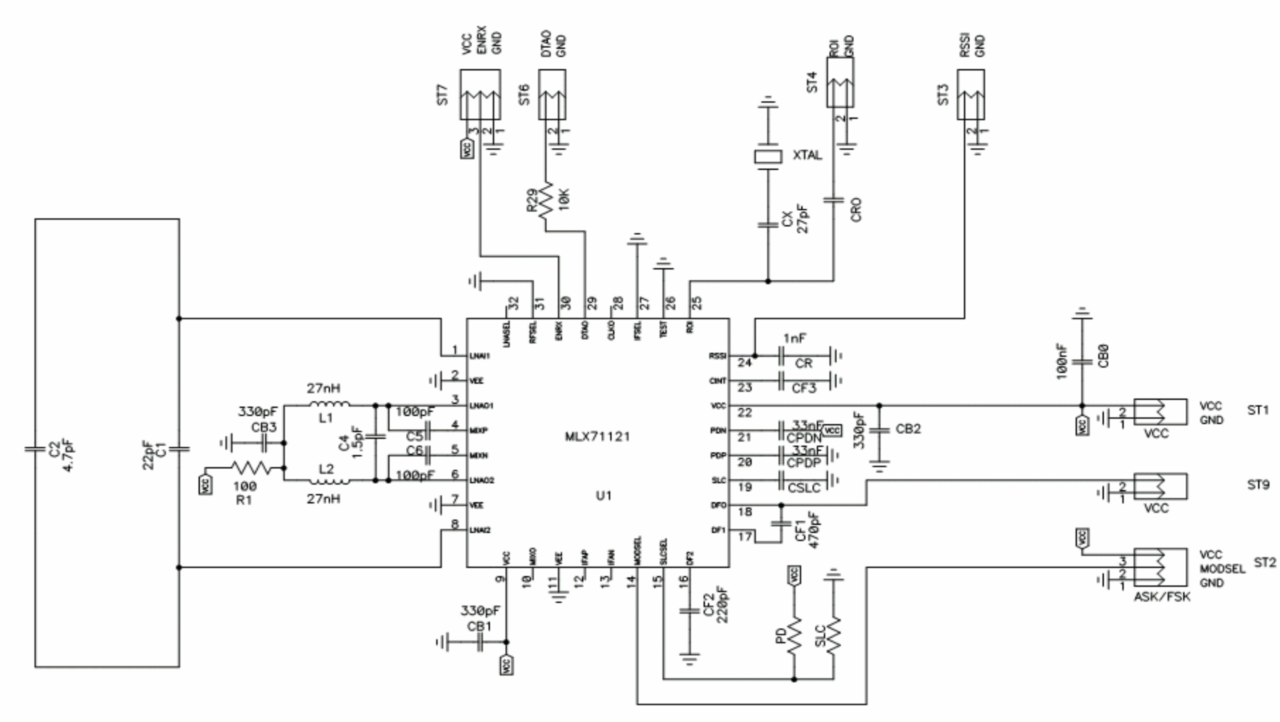

Figure 2: 315MHz Loop Antenna Receiver

Component List of Figure 1 and 2

Part	Value for 315MHz	Value for 433.92MHz	Tol.	Description
C1	22 pF	15 pF	±5%	Loop tuning and matching capacitor
C2	4.7pF	2.0pF	±5%	Loop tuning capacitor
C4	1.5pF	2.2pF	±5%	LNA output tuning capacitor
C5	100pF	100pF	±5%	mixer input coupling capacitor
C6	100pF	100pF	±5%	mixer input coupling capacitor
CB0	100nF	100nF	±10%	decoupling capacitor
CB1	330 pF	330 pF	±10%	decoupling capacitor
CB2	330 pF	330 pF	±10%	decoupling capacitor
CB3	330 pF	330 pF	±10%	decoupling capacitor
CF1	470 pF	470 pF	±10%	data low-pass filter capacitor, optimized for data rate of 4 kbps NRZ
CF2	220 pF	220 pF	±10%	data low-pass filter capacitor, optimized for data rate of 4 kbps NRZ
CF3	according to data sheet page 12		±10%	optional capacitor for noise cancellation filter
CP1	33 nF	33nF	±10%	positive PKDET capacitor
CP2	33nF	33nF	±10%	negative PKDET capacitor
CR	1 nF	1 nF	±10%	RSSI output low pass capacitor
CX	27 pF	27 pF	±5%	crystal series capacitor
L1	27 nH	15 nH	±5%	LNA1 output tank inductor
L2	27nH	15nH	±5%	LNA2 output tank inductor
XTAL	17.60000 MHz	24.20667 MHz		fundamental mode crystal