

Antenna Design UI-Joystick & Remote Control

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1. Antenna design

1.1. Si446x transceiver

The Silicon Laboratories radios are used to cover the complete ISM bandwidth of 868 – 915 MHz bands. In the UI-Joystick the Si4463-C2A radio is used and in a Remote Control the Si4461-C2A. These transceivers provide the correct usage of frequency and modulation technologies so that radio frequency messages can be send or received.

These modems are configured to use two level Frequency Shifted Keying (2FSK). To ensure reliable data, a relatively low data rate of 20 kbps is chosen. The Si446x operates as a time division duplexing (TDD) transceiver where the device alternately transmits and receives data packets. The device uses a single-conversion mixer to down convert the 2FSK modulated receive signal to a low IF frequency. Following a programmable gain amplifier (PGA) the signal is converted to the digital domain by a high performance $\Delta\Sigma$ ADC allowing filtering, demodulation, slicing, and packet handling to be performed in the built-in DSP increasing the receiver's performance and flexibility versus analog based architectures. The demodulated signal is presented to the system MCU through a programmable GPIO or via the standard SPI bus by reading the 64-byte RX FIFO. A single high precision local oscillator (LO) is used for both transmit and receive modes since the transmitter and receiver do not operate at the same time (Silicon Laboratories 2020, [Si446x Data Sheet](#)).

The Direct-Tie Application example in Figure 1 of the Si446x Data Sheet has been used to define the schematic between antenna matching circuit and the Si446x radio. The radio is handling all incoming packets according to the following checks; 100ms long preamble in Pairing mode, 20ms in CALL mode and 2ms in CONTROL mode. Next to the preamble, to distinguish between messages of a RP01-CU system and any other system, the sync word is used to determine if incoming data can be stored in the FIFO register.

In order to avoid frequency mistuning, caused by crystal inaccuracies, the GLOBAL_XO_TUNE register is used to calibrate the 30 MHz XTAL. The calibration is done in laboratory environment at the EMS assembly line in the functional test fixture. Each Remote Control and UI-Joystick PCBA that leaves the EMS factory is calibrated and those values are stored in non-volatile memory and in the ERP quality system.

1.2. Antenna specifications

The UI-Joystick unit is located in the armrest of the stairlift. Due to the aluminium enclosure the antenna operating frequency may get shifted. In the mechanical design this is solved by using a plastic enclosure around the monopole PCB antenna. Nevertheless, to avoid operating frequency shift, due to the aluminium nearby, a matching circuit is used to resonate the antenna in the desired bandwidth. The matching circuit design, for both the UI-Joystick and Remote Control, exists out of C18, L7, and C19. These component values are determined by importing the PCB antenna and mechanical enclosure in the 2017 CST Tool. Using circuit simulations, the performance of the antenna was optimized, based on the s-parameter response the LC component values were selected.

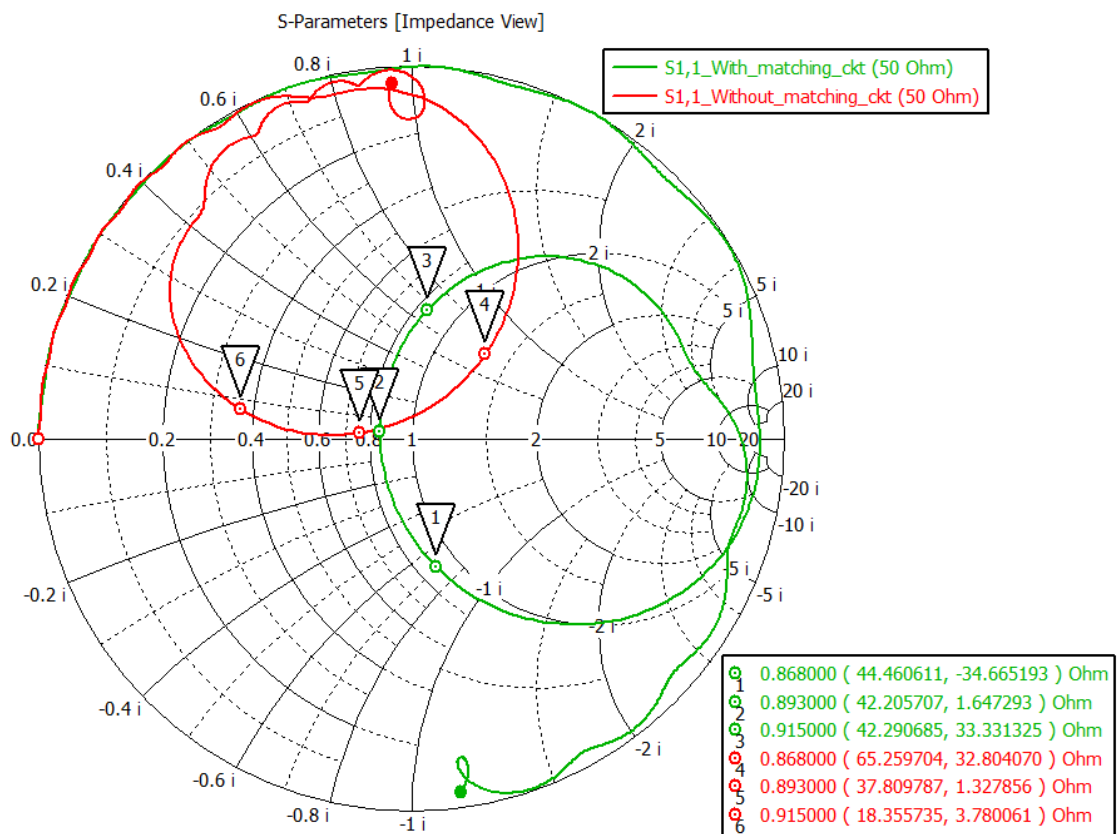


Figure 1: CST Tool simulation to determine matching circuit

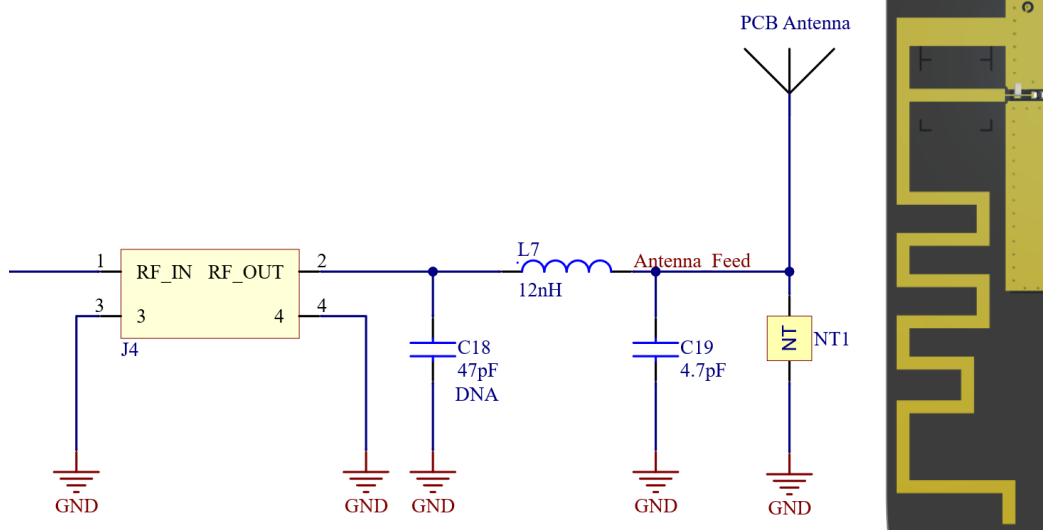


Figure 2: Matching circuit and antenna drawing remote control

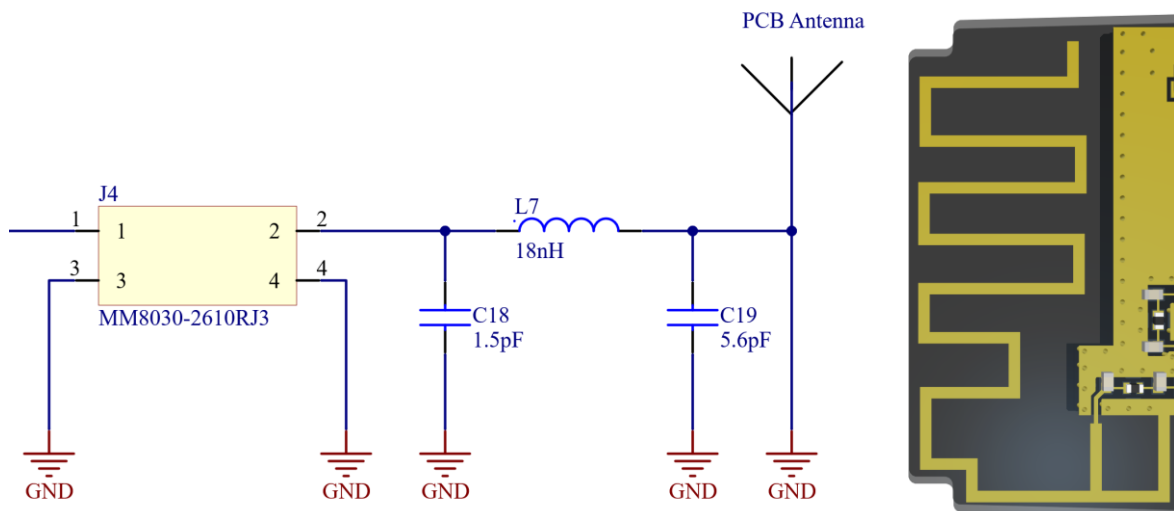
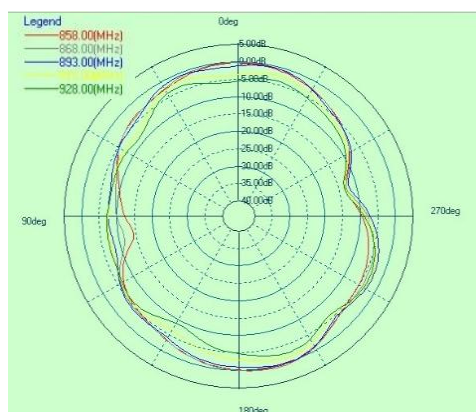
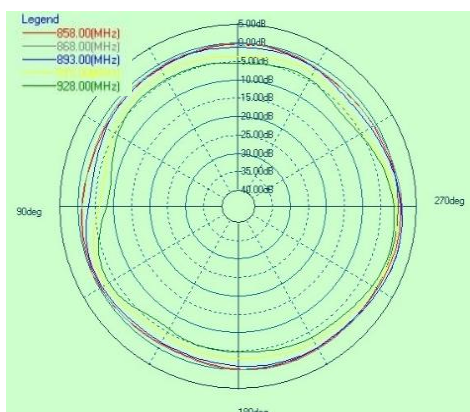


Figure 3: Matching circuit and antenna drawing UI-Joystick

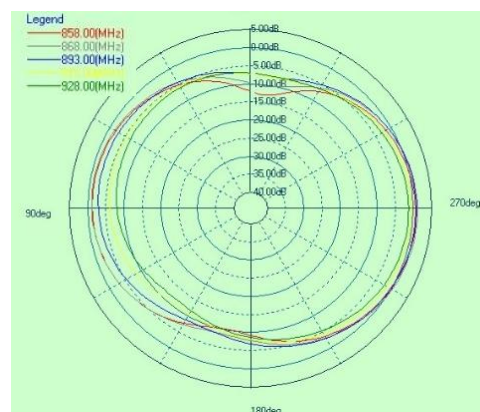
Both units were tested in order to validate the simulation. The complete PCBA including enclosures were placed in the 3D antenna measurement equipment and the signal strength was measured in all directions.



Phi 0 cut



Phi 90 cut



Theta 90 cut

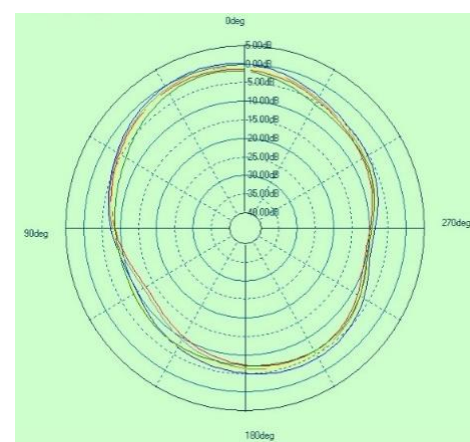
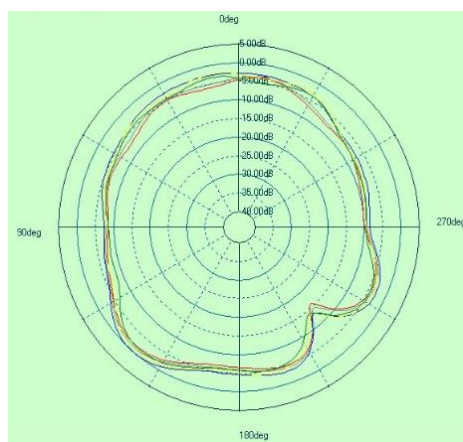
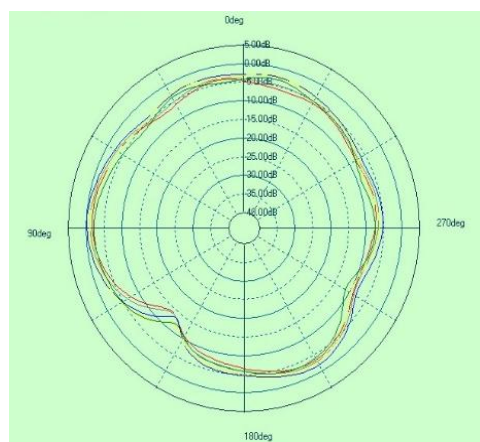


Figure 4: Measurements of UI-Joystick PCB antenna in enclosure on Top, Remote Control PCB antenna in enclosure at bottom.