AX5043 Receiver Impedence Matching

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Preliminary

The AX5043 is a versatile RF transceiver for digital modulation within a frequency range of 27 to 1050 mhz. Modulation modes are: FSK/MSK/4–FSK/GFSK/GMSK/ASK/AFSK/FM/PSK.

Impedance matching and bandpass filtering are necessary for proper operation. Transmission and reception are supported via a differential interface with an additional single-ended transmission option on a separate pin. All reception must utilize the differential option.

The classic transmit/receive differential circuit from the AX5043 data sheet is:

Typical Application Diagrams

Match to 50 Ω for Differential Antenna Pins (868 / 915 / 433 / 169 MHz RX / TX Operation)

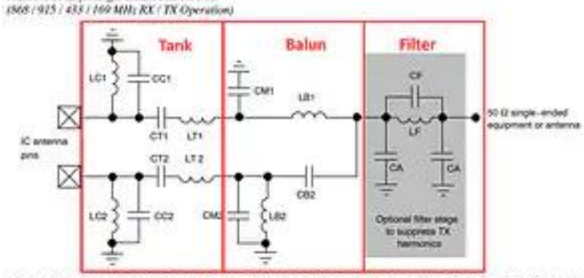


Figure 9. Structure of the Differential Antenna Interface for TX/RX Operation to 50 Ω Single–ended Equipment or Antenna

Table 28. TYPICAL COMPONENT VALUES

Frequency Band	LC1,2 [nH]	CC1,2 [pF]	CT1,2 [pF]	LT1,2 [nH]	CM1 [pF]	CM2 [pF]	LB1,2 [nH]	CB2 [pF]	CF [pF] optional	LF [nH] optional	CA [pF] optional
868 / 915 MHz	18	nc	2.7	18	6.2	3.6	12	2.7	nc	0 Ω	nc
433 MHz	100	nc	4.3	43	11	5.6	27	5.1	nc	0 Ω	nc
470 MHz	100	nc	3.9	30	4.7	nc	22	4.7	nc	0 Ω	nc
169 MHz	150	10	10	120	12	nc	68	12	6.8	30	27

As shown in the circuit schematic the matching/filtering circuit can be divided into three sections, Filter, Balun and Tank. The Filter section is a low-pass filter for VHF and omitted in UHF versions. The Tank portion of the schematic is designed to match the needs of the AX5043 Class E power amplifier and can be eliminated for a receive only design with a reduction in components and printed circuit board space. The Balun serves to convert between the AX5043 differential interface and a single ended connection.

Component values presented in the datasheet for VHF are above the frequency range for amateur radio. To explore the design and performance of a reduced component receive only circuit for amateur radio satellite reception, a receive only design was prototyped and tested for the 2-Meter amateur radio band (144-148 mhz) consisting of only the Balun circuit. Calculations were performed using 146mhz as the target frequency.

A balun is an impedance matching device between balanced and unbalanced. As the AX5043 requires a differential interface, the balun is used to convert the single ended RF connection to the required differential termination. The balun circuit presented in the AX5043 circuit is a lumped element design comprising capacitors and inductors. Examining the circuit shows it to be a low-pass/high-pass filter at the designed center frequency which functions as a phase splitter, delivering the required differential signal (180 degree phase shift).

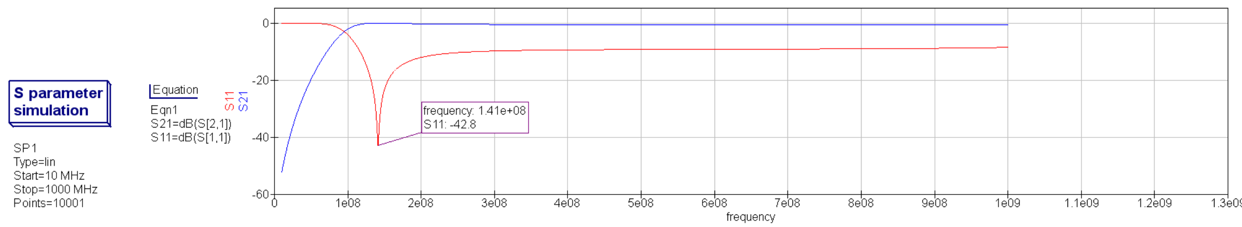
There are several lumped element balun calculators available on the internet. For this experiment the calculator at http:// http://leleivre.com/rf_lcbalun.html was used to calculate the values needed for a balun centered at 146 mhz.

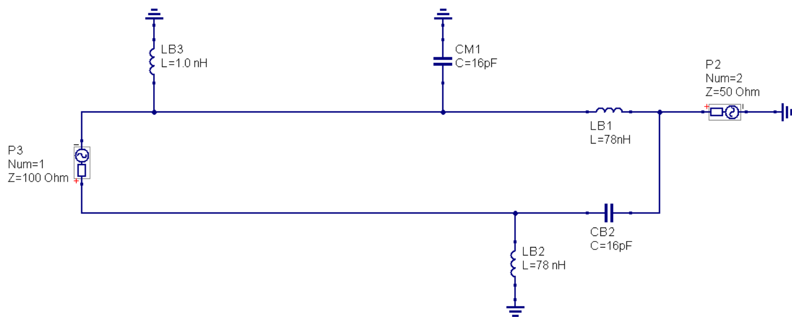
The AX5043 is very broad band and no impedance values are given in the product data sheet. Therefore a impedance of 100 ohms was used as the target value for the differential input which gave similar results when the input frequency to the calculator was 169 mhz as charted in the data sheet. For a 146 mhz frequency the calculated values were 15.42 pf capacitance and 77 nh inductance.

The AX5043 has an additional requirement in that both sides of the differential input must show a DC path to ground. The AX5043 data sheet circuit utilizes the inductors of the Class E tank circuit to achieve this requirement. For a receive only circuit consisting of the balun section an additional inductor is required on the low-pass side of the balun.

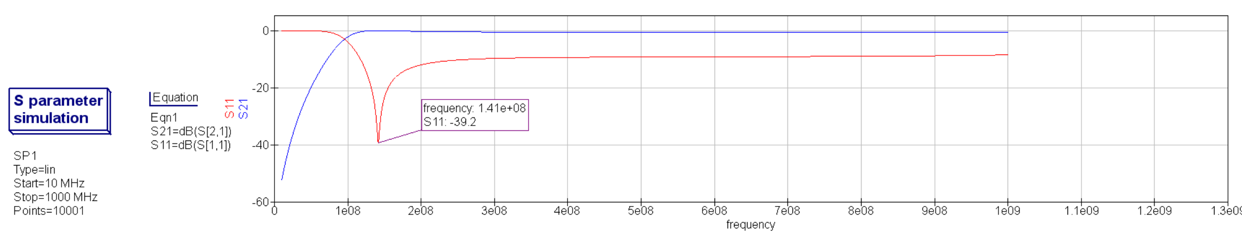
Simulations were performed on the balun circuit using 1nh as the additional DC path inductor as a 1nh value is the lowest SMD component value available.

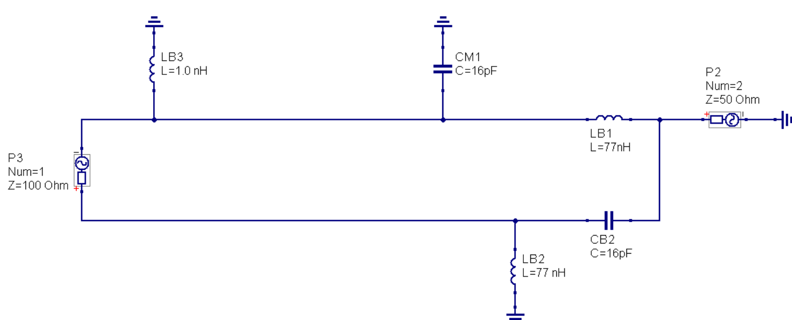
A simulation using QUCS was performed using the calculated values indicating a center frequency of 149 mhz as shown below.



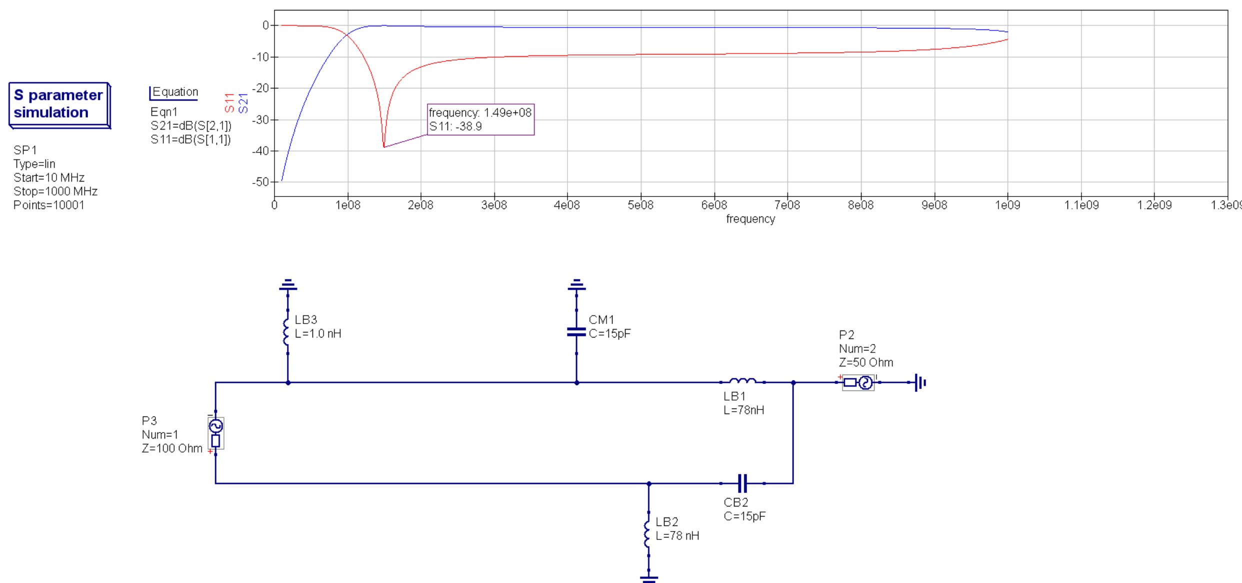


As the calculated capacitance value for the balun was 15.42 pf the simulation was repeated using 16 pf as the capacitance resulting in the resonant point moving downward to 141 mhz.



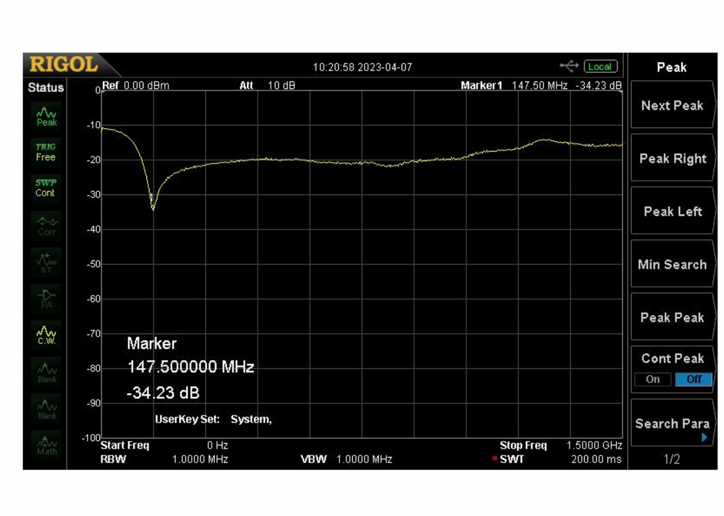


For testing, a DigitalTxRxRpi board was modified using jumpers to eliminate the low pass filter and Class E tank circuit and a 100 ohm resistor substituting for the AX5043 differential input. Available values near the calculated/simulated values were used with the capacitance being 15 pf, balun inductors 78 nh and the DC inductor 1.0 nh. This moved the simulated resonant point to 149 mhz.



Additional simulations showed the DC path inductor had minimal impact on the resonant cross point frequency but the lowest possible value is recommended.

Measuring the built circuit showed similar results with differences from the simulated design attributed to PCB stray capacitance/inductive interactions.



Wide Trace 0 – 1.5 ghz

3db Trace

The 100 ohm resistor was removed and the DigitalRxTxRPi circuit completed to allow for real world testing. The low-pass filter from the original circuit was installed to match a complete TxRx VHF board available.

Using 144.39 mhz 1200 baud AFSK APRS as the test source no appreciable difference was noticed between the complete TxRx board and the reduced receive only board in signal level (RSSI) and decoded APRS packets.

Summary

The AX5043 requires a differential RF interface where each side of the differential must include a DC ground path. This is accomplished in a full Tx/Rx design by using inductors that comprise the Class E amplifier tank circuit.

A smaller receive only design can be accomplished by eliminating the Class E tank circuit, utilizing the balun section only tuned to the desired center frequency with a small value inductor to ground as the required DC path.