

Analog Vector Modulator for 7-Tesla MRT

By

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Outline

- Motivation
- Introduction to IQ-Modulation
- Simulation Circuit
- PCB design in Eagle
- Test Results
- Conclusion

Motivation

- Design of a Vector Modulator for “7-Tesla MRT Ganzkörperspule” at 300 MHz.
- The IQ modulator replaces more expensive components like digitally controlled phase shifters and attenuators.
- A bank of four vector modulators (4-channel) is to be realized and characterized with respect to the voltage-amplitude and voltage-phase conversion properties.

I-Q Modulation

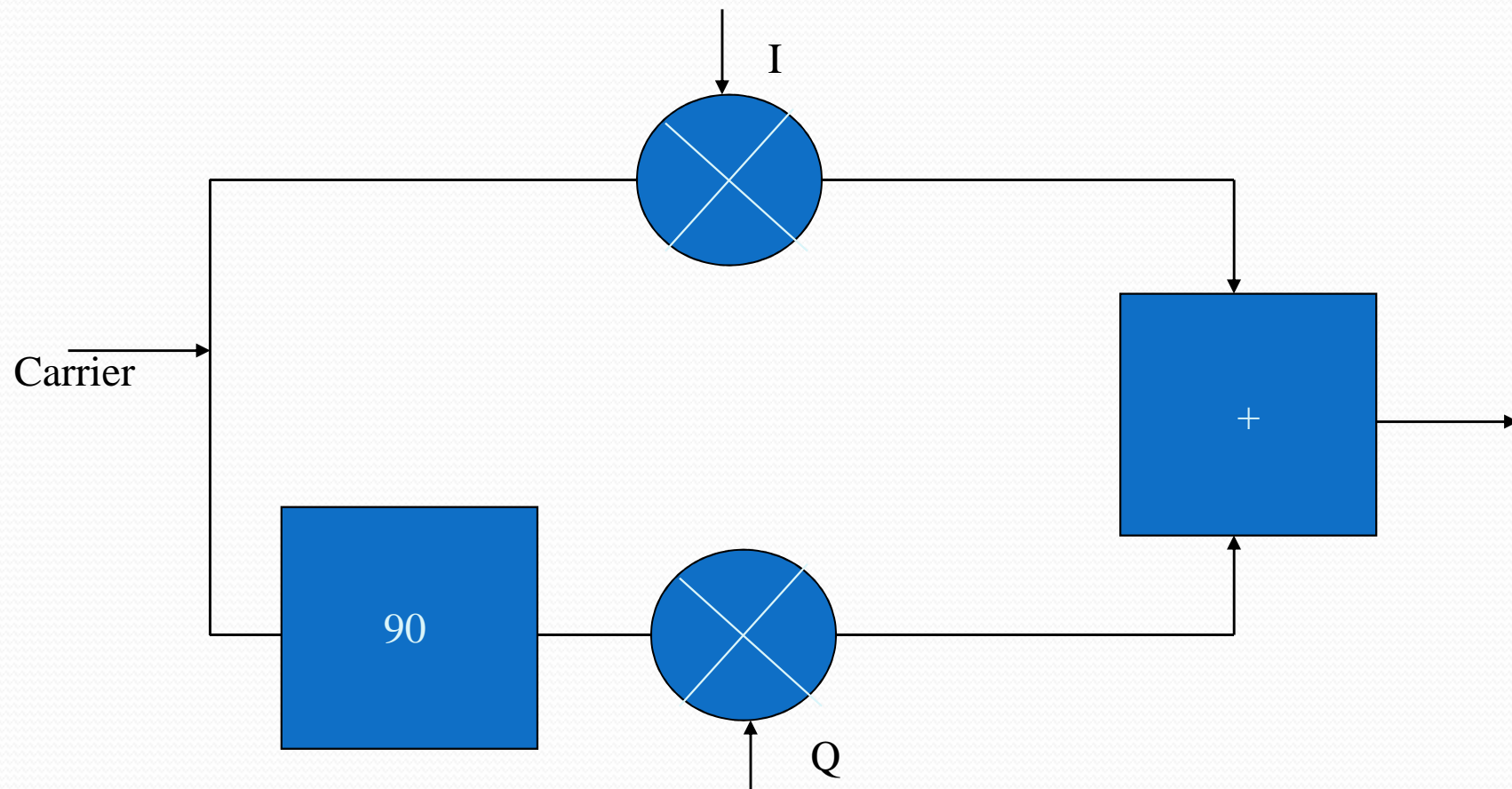
- In-phase / quadrature Modulation
- Signals to be modulated are divided in to two signal components , i.e I and Q
- Modulation of Digital and Analog signals
- Examples : PSK, QAM, QPSK

I-Q Modulation

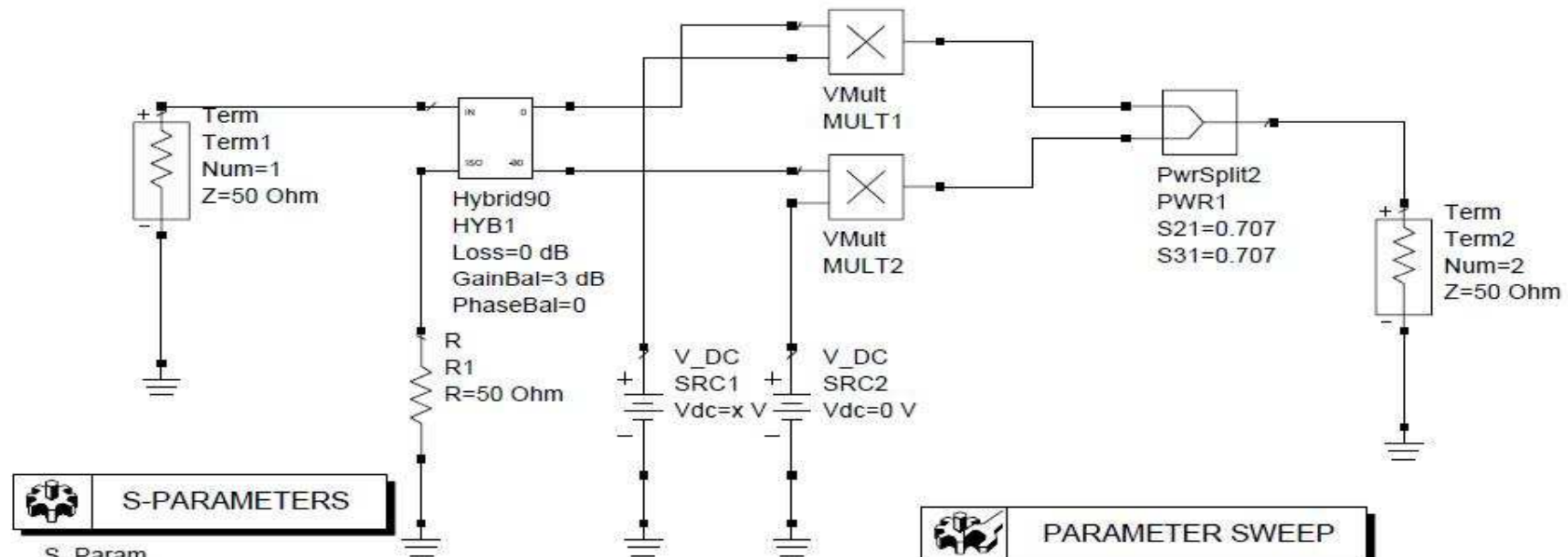
- Analog Modulation: Two signals 90° out of phase to each other are modulated.
- Digital Modulation: Serial bit sequence is transformed into parallel bit sequence, hence we get two components $I(t)$ and $Q(t)$.

I-Q Modulation

- Modulation of two Signals $I(t)$ und $Q(t)$



Simulation Circuit



S-PARAMETERS

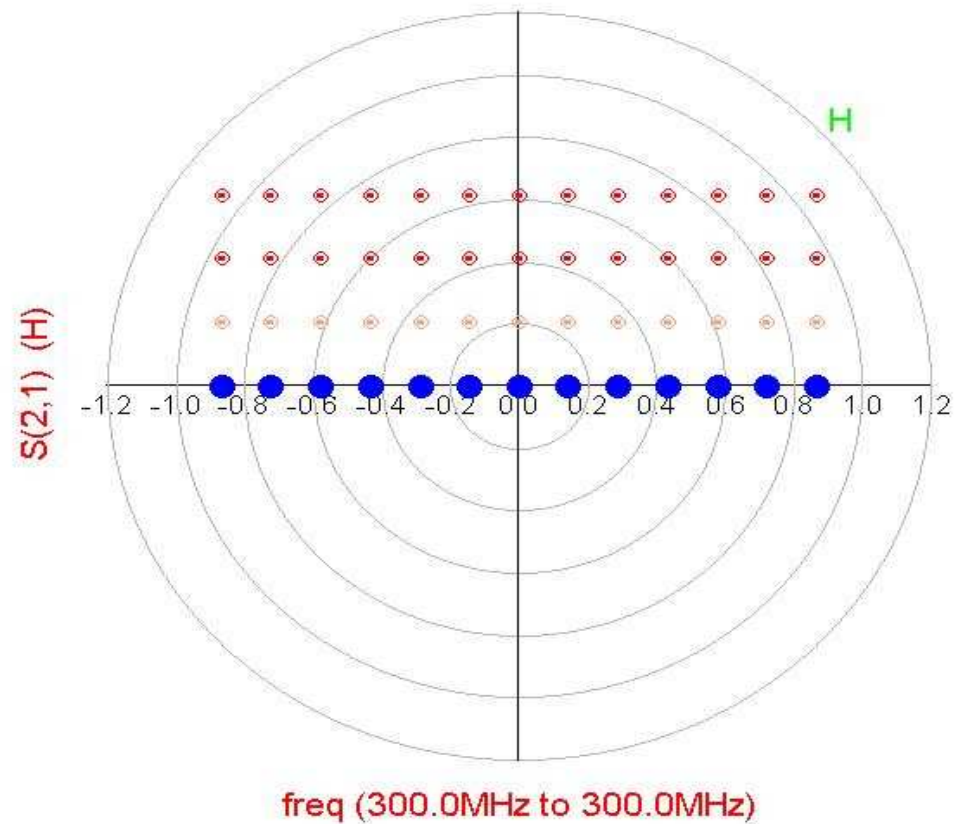
S_Param
 SP1
 Start=300 MHz
 Stop=300 MHz
 Step=

Var Eqn
 VAR
 VAR1
 x=1

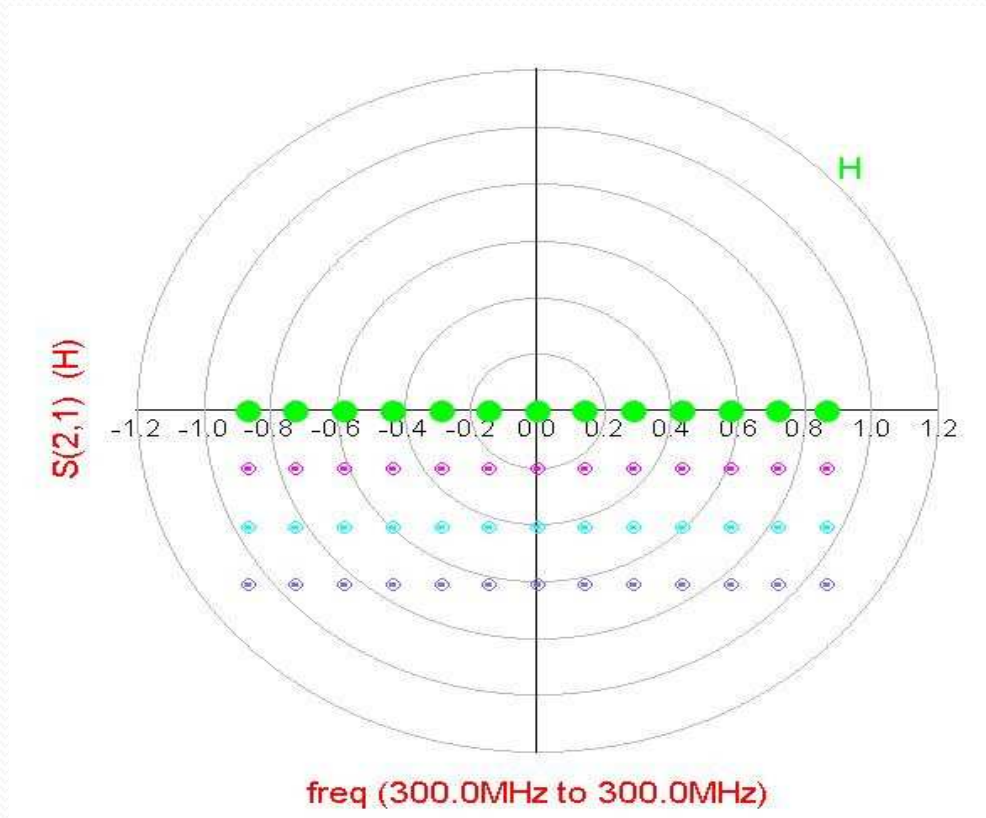
PARAMETER SWEEP

ParamSweep
 Sweep1
 SweepVar="x"
 SimInstanceName[1]="SP1"
 SimInstanceName[2]=
 SimInstanceName[3]=
 SimInstanceName[4]=
 SimInstanceName[5]=
 SimInstanceName[6]=
 Start=-3
 Stop=3
 Step=0.5

Simulation Circuit



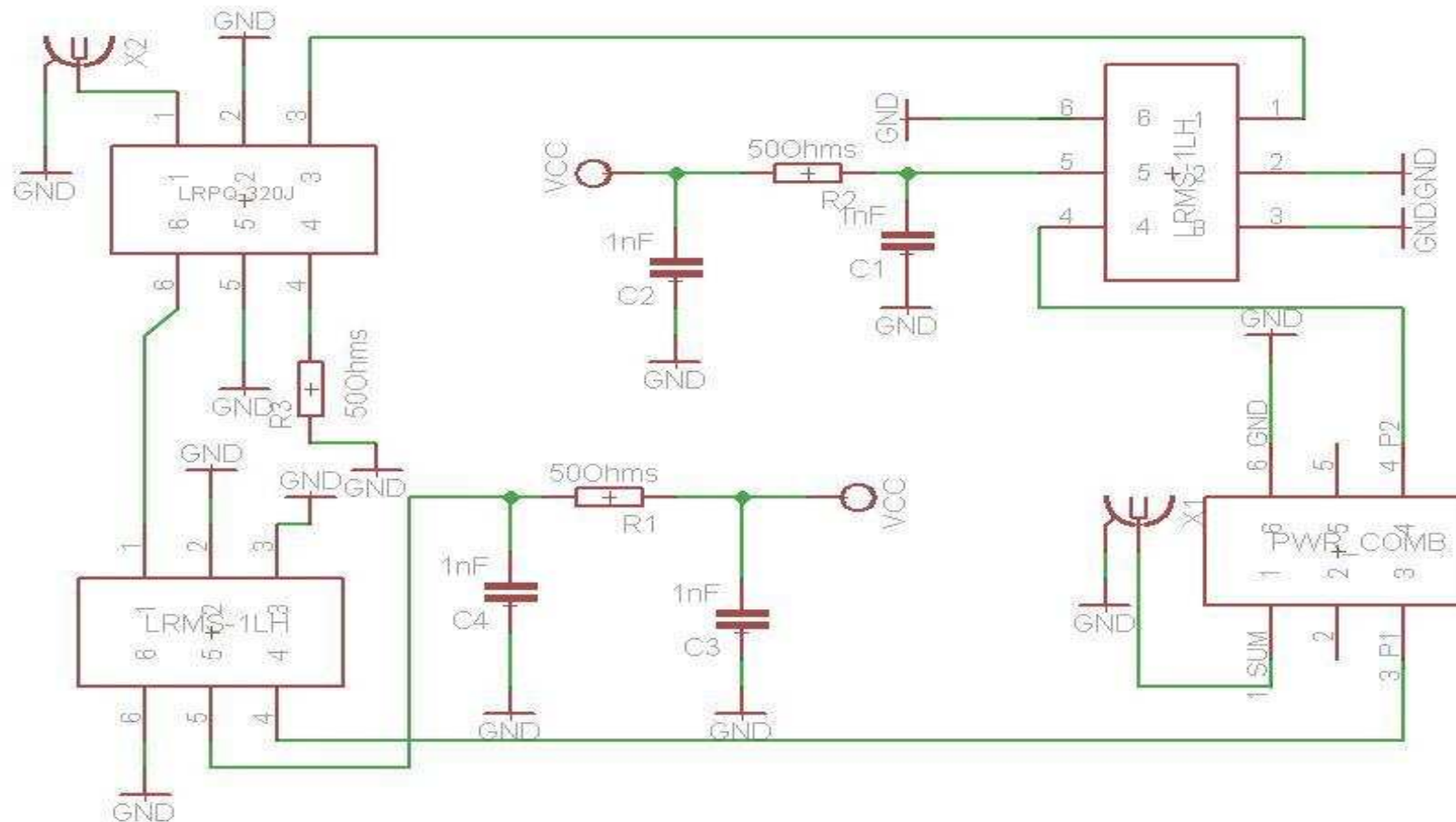
Simulation Circuit



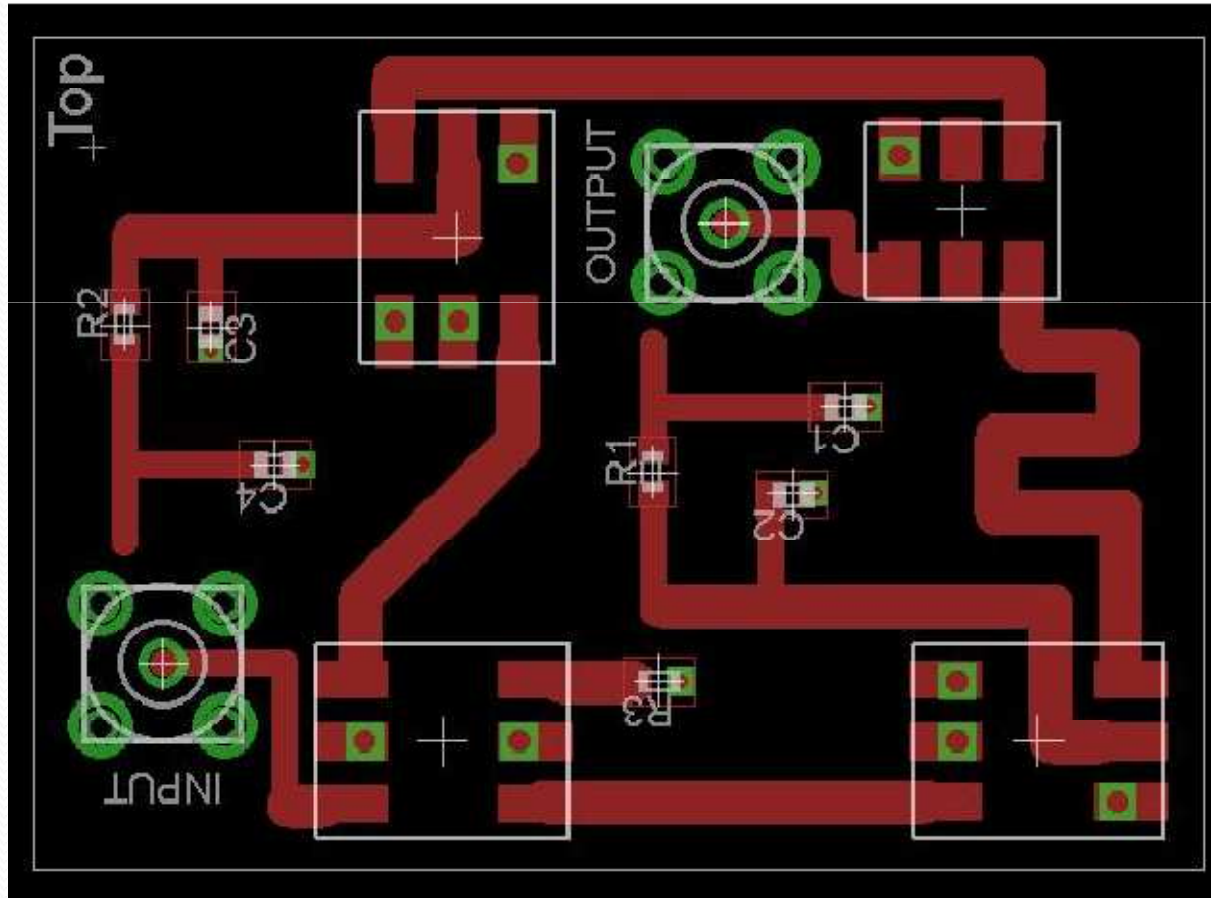
PCB Design

- Two Frequency mixers : LRMS-1LH
- Power Splitter / Combiner: LRPQ-320J
- Power Splitter / Combiner : JPS-2-1+
- RC- Lowpass filter

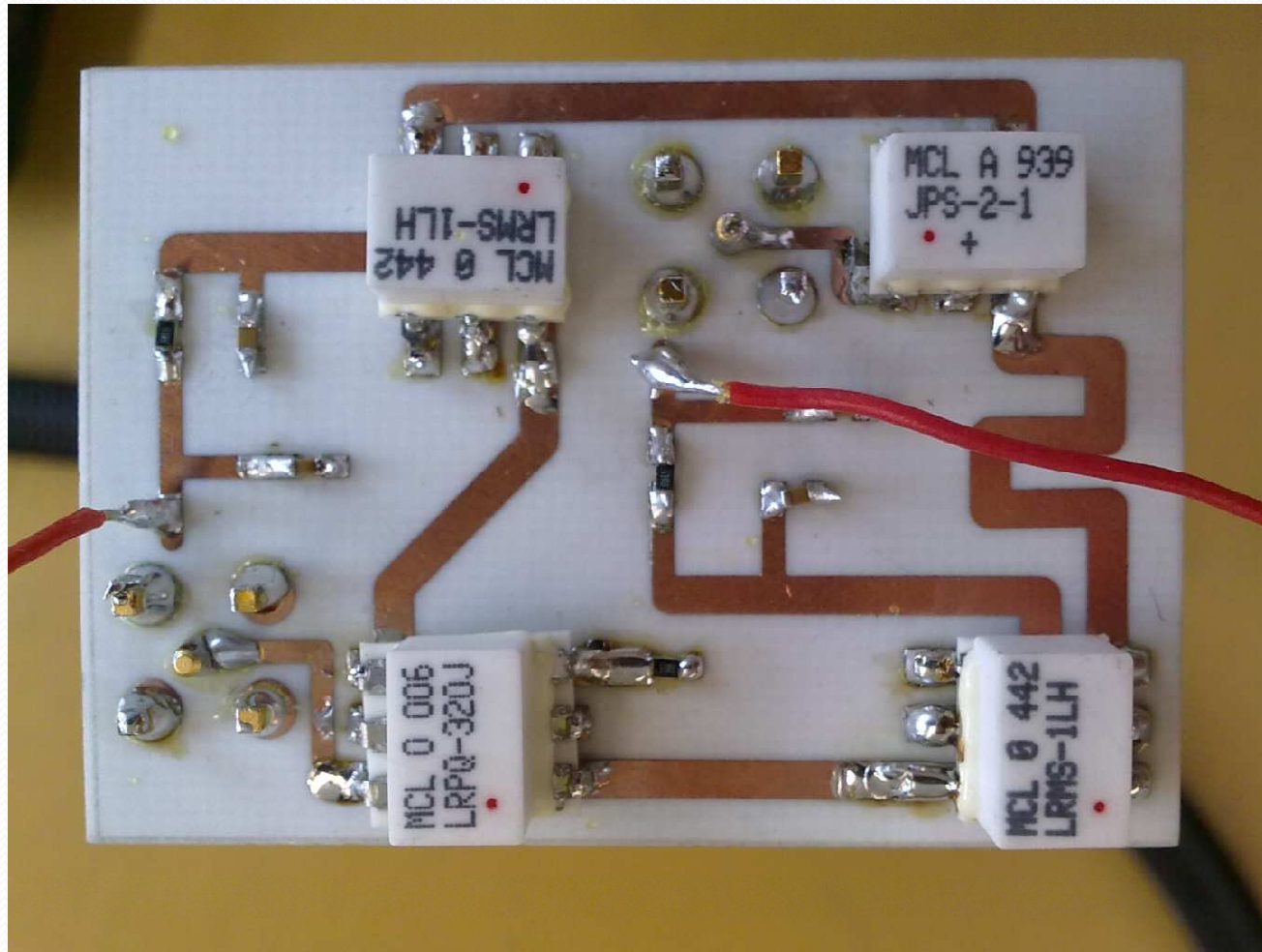
PCB Design



PCB Design



PCB Design



Test Results

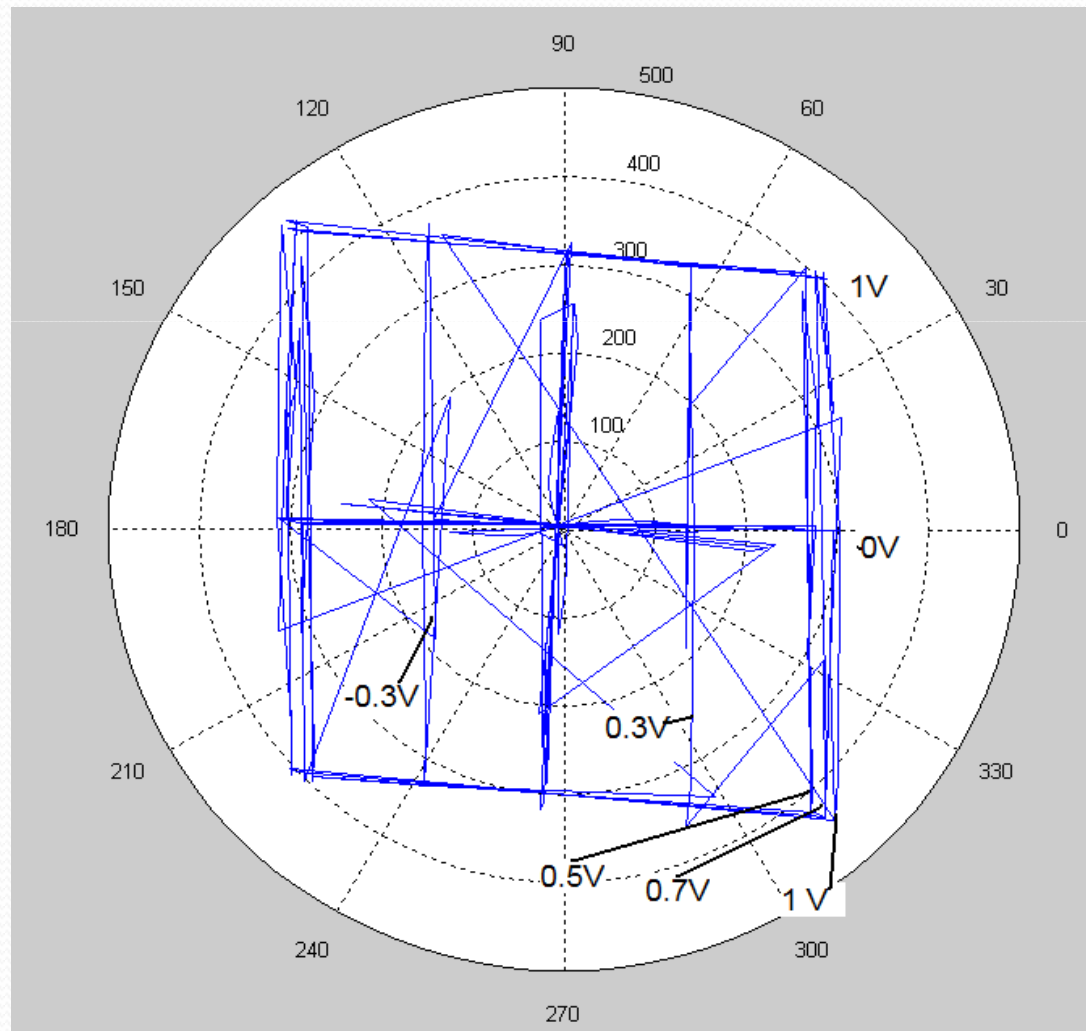
- DC Volatge equals to zero
- $S_{11} = -21.5$ dB
- $S_{21} = -42$ dB
- $S_{12} = -42$ dB
- $S_{22} = -8.5$ dB

Test Results

- For maximum DC values
- $S_{11} = -18.5$ dB
- $S_{21} = -6.67$ dB
- $S_{12} = -6.67$ dB
- $S_{22} = -13.77$ dB

- Dynamic range of the designed Vector modulator is calculated to be 35.43 dB

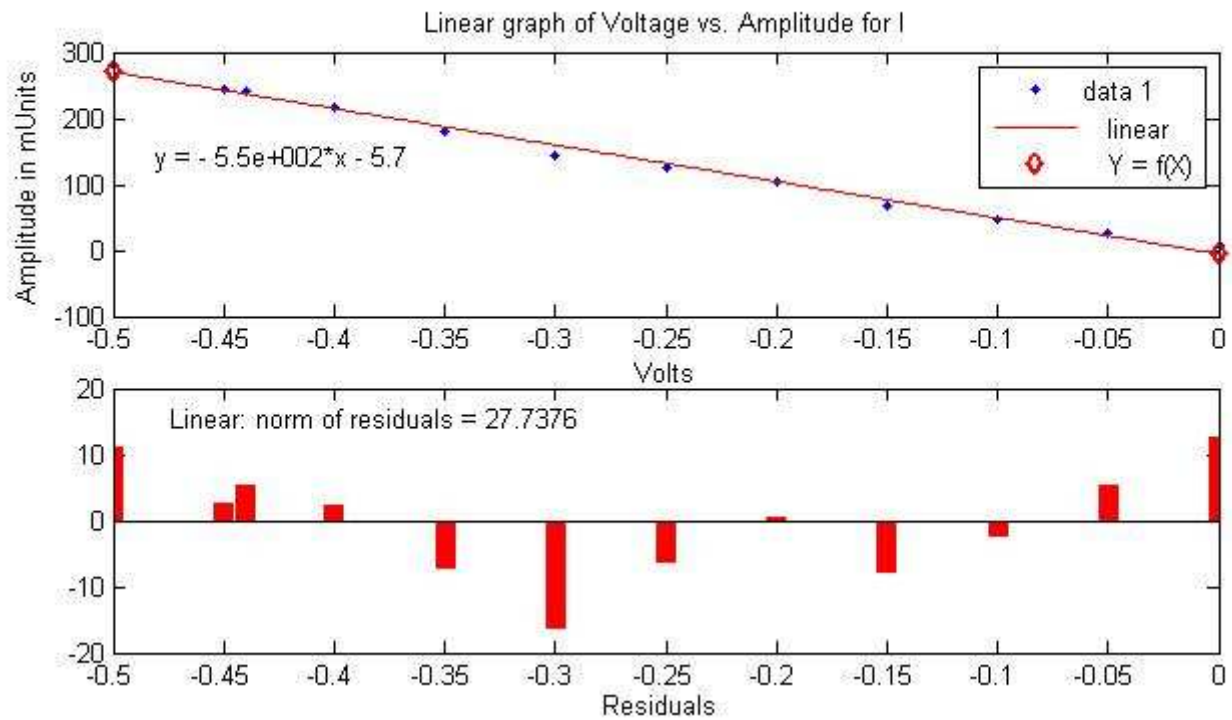
Test Results



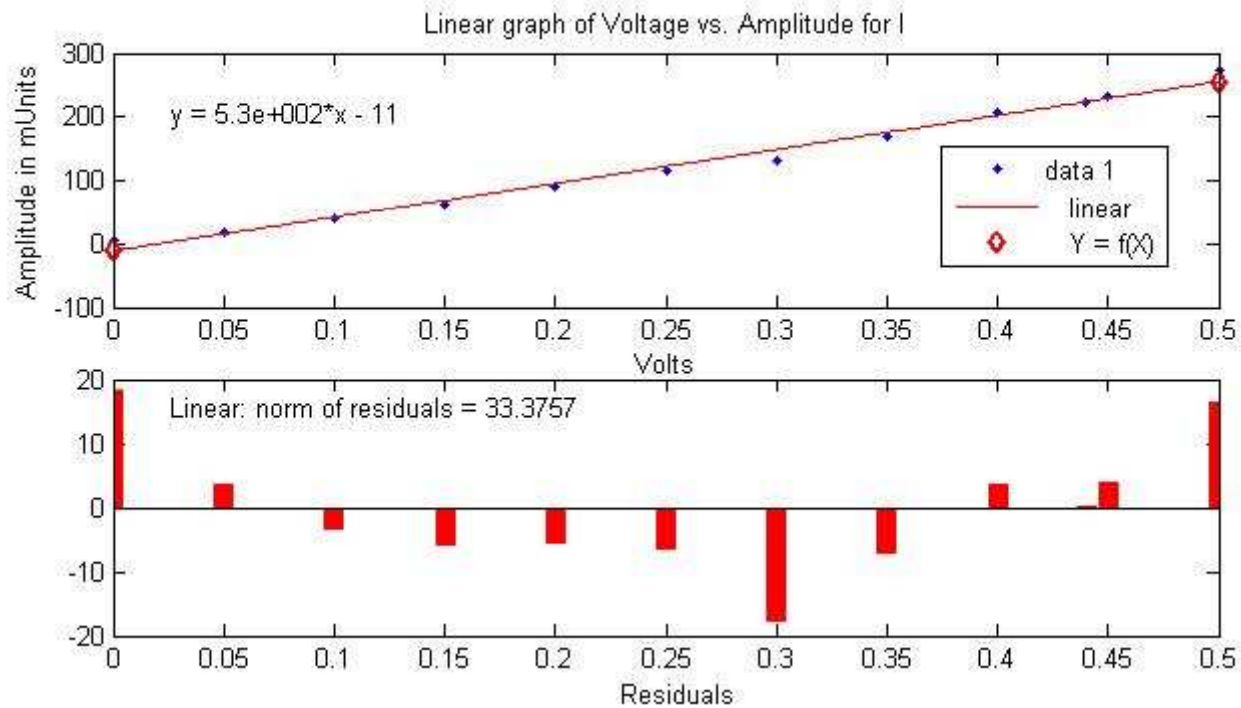
Test Results

- Equation: $\Delta Q = (-) |C| * I * |Q|$ (Reason not known).
- The maximum phase error is measured to be 6° .
- Maximum amplitude was measured to be 6.7dB.

Test Results



Test Results



Conclusion

- The designed Vector modulator has the dynamic range of 35.46 dB.
- Measured Results show the good quality of Output.
- Unusual behaviour of the I-Q plot was summarized by an equation, although reasons are still unknown.
- Circuit can also be used as Vector demodulator.



**THANKYOU EVERYONE FOR YOUR
ATTENTION !**