RF to DC Converter for Wireless Power Transfer Systems

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Agenda

- Project Application
- Project Overview
- Literature Review
- Block Diagram
- Project Design
- Simulation Results
- Test Results
- Conclusions

Project Application

- Near-field wireless power transfer systems currently in use
- Industry working towards far-field wireless power transfer systems

Project Overview

- Convert radio frequency (RF) signal to direct current (DC) power
- Functions in the FCC regulated ISM band that includes 5.8GHz
- Output will be DC with minimal ripple
- Maximize efficiency
- Minimize size

Literature Review

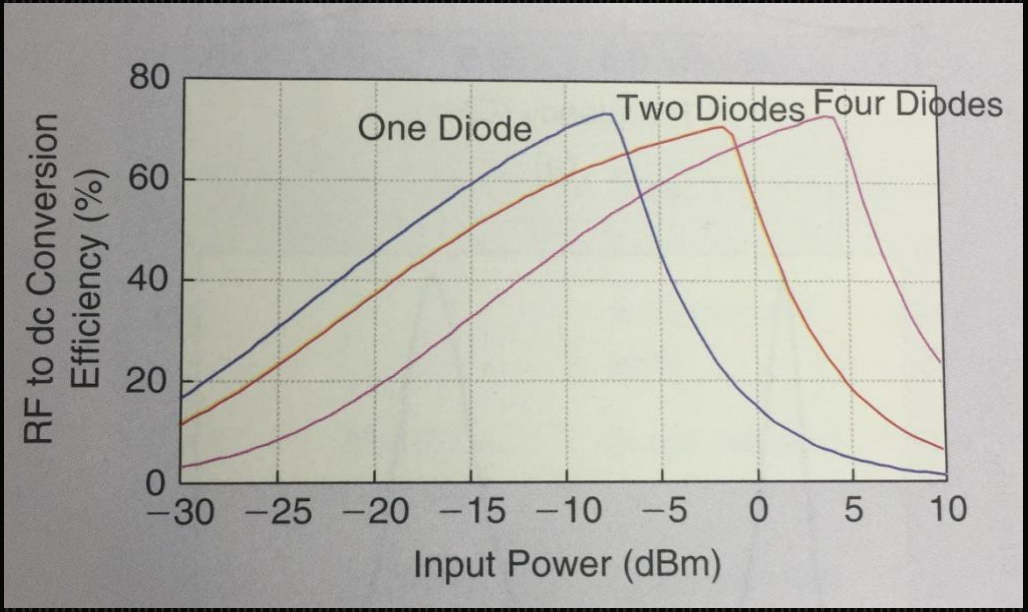


Fig 1. Efficiency of Full-Wave Rectifiers vs Input Power [1]

Literature Review
Diode Configuration

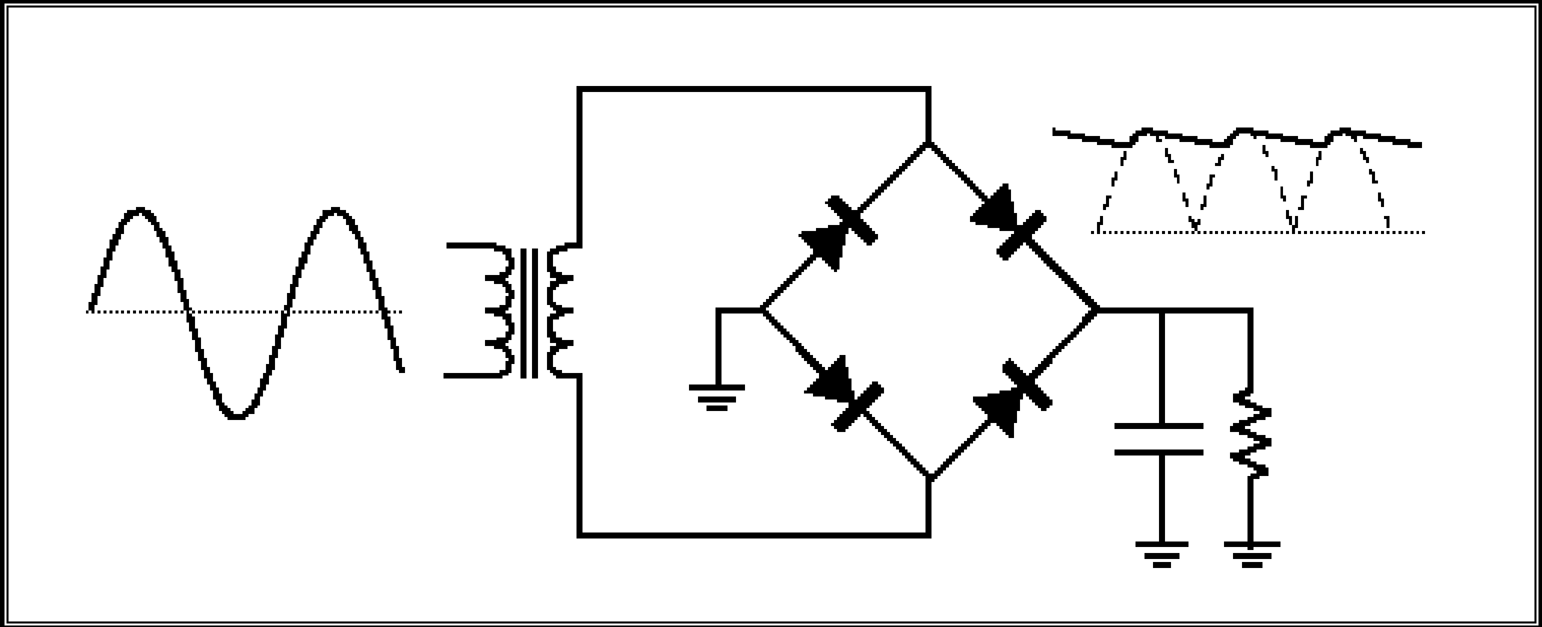


Fig 2. Four Diode full-wave rectifier

Literature Review
Diode Configuration

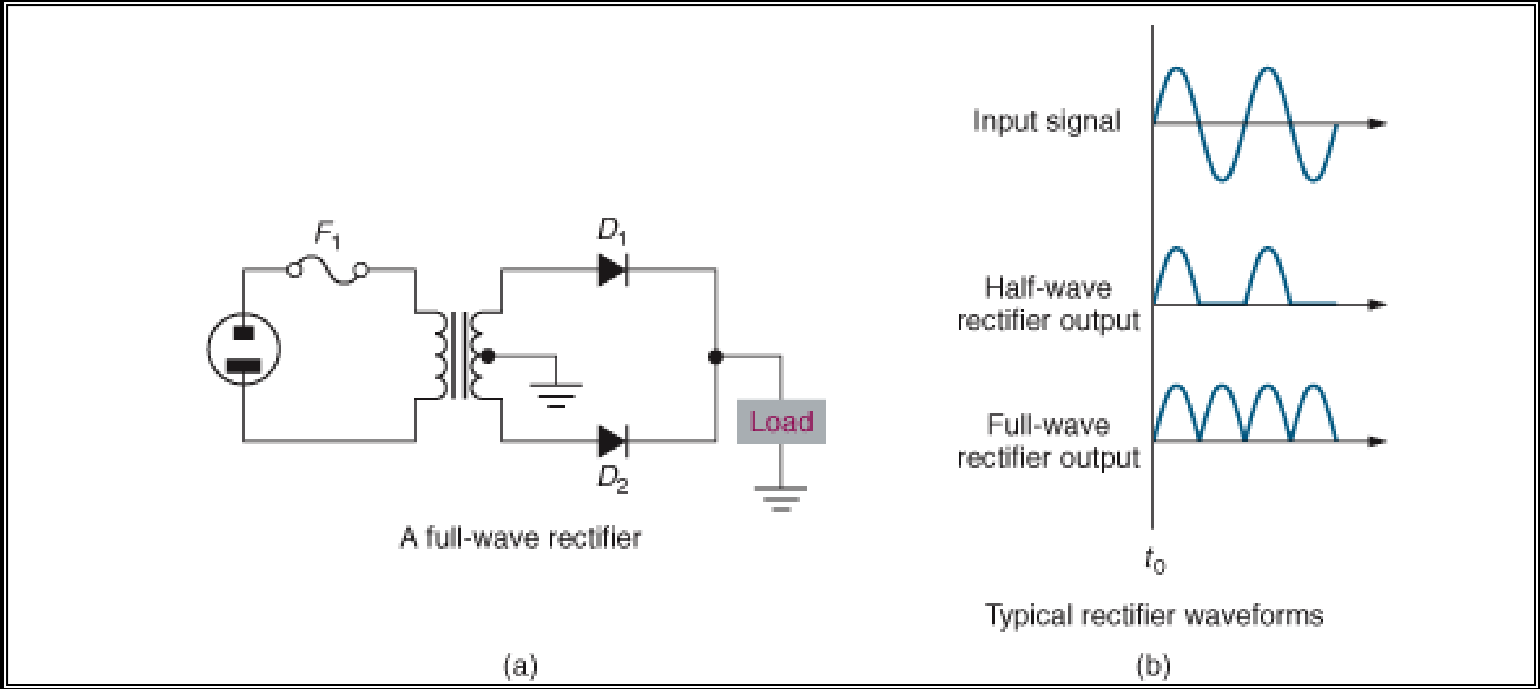


Fig 3. Two Diode full-wave rectifier

Literature Review

- Not new concept
- High gain antennas
- Efficiency expectations

Block Diagram

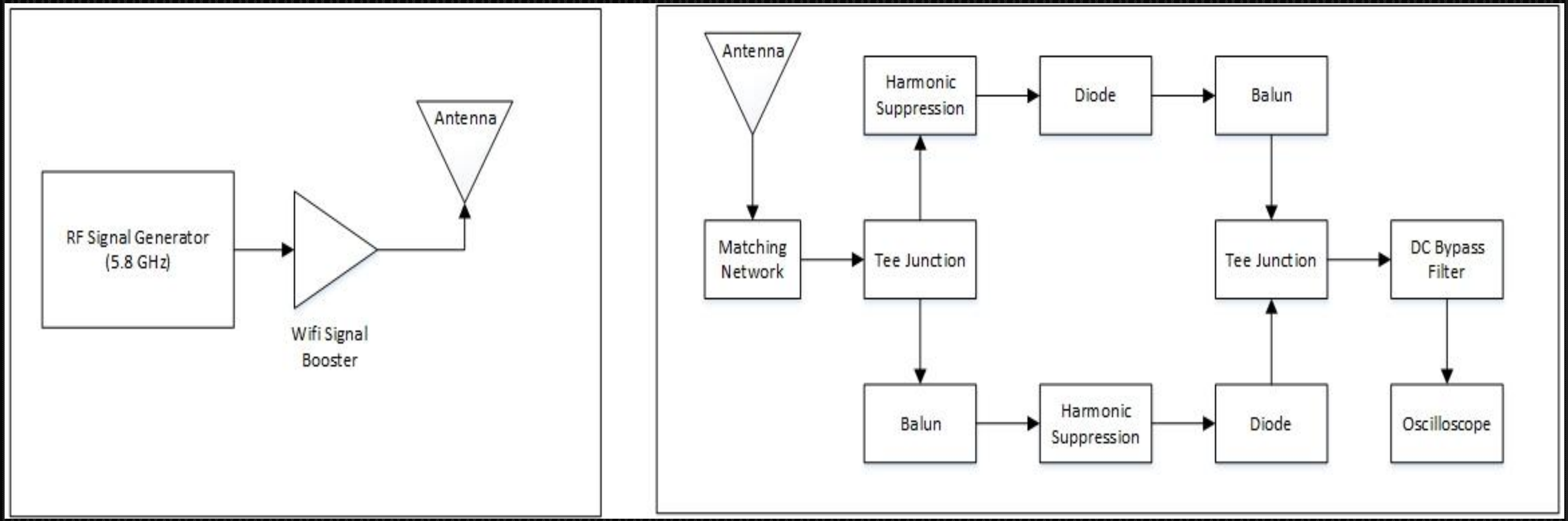


Fig 4. System Block Diagram

Design – Physical System

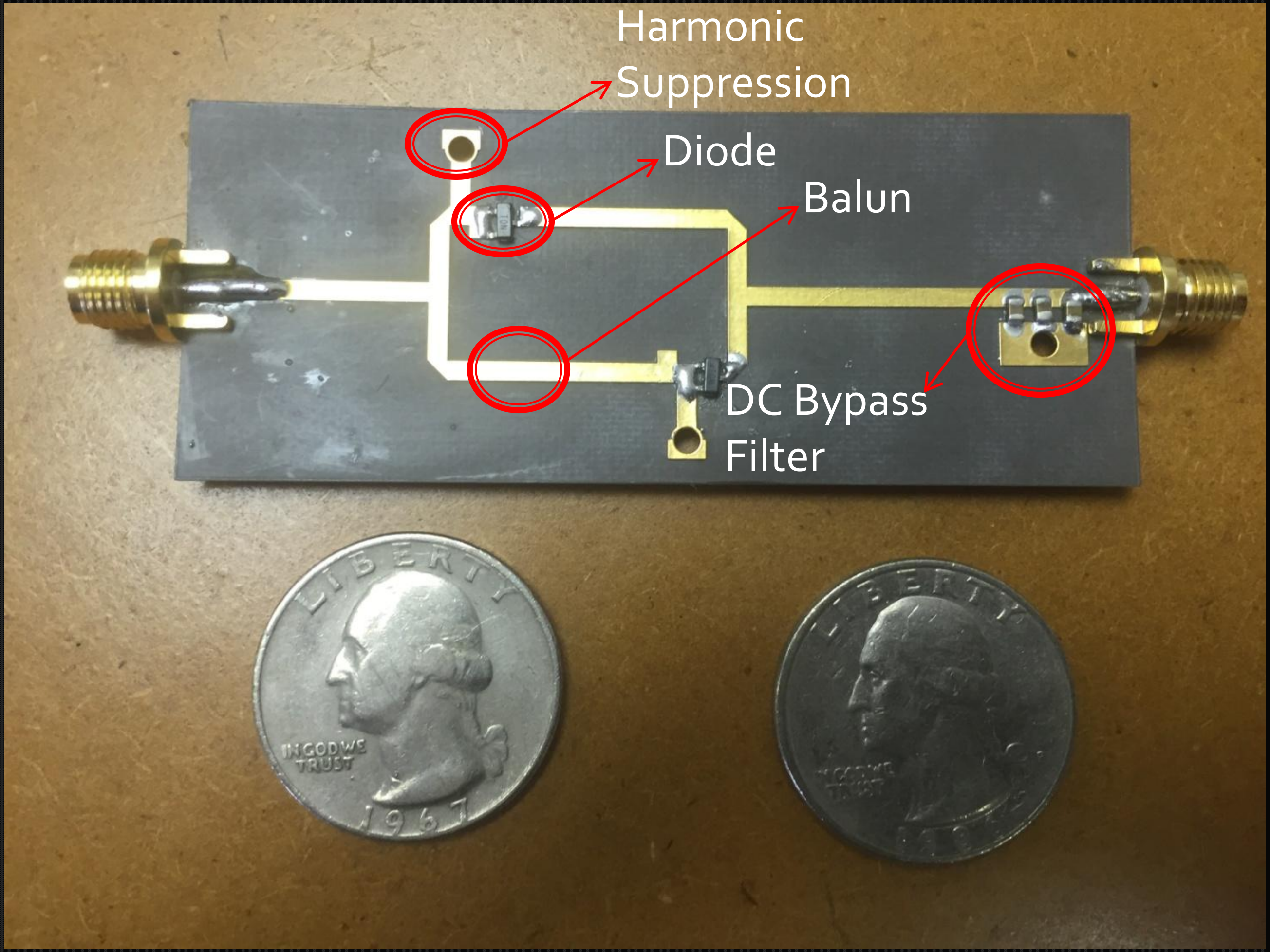


Fig 5. RF to DC converter

Design – ADS Schematic

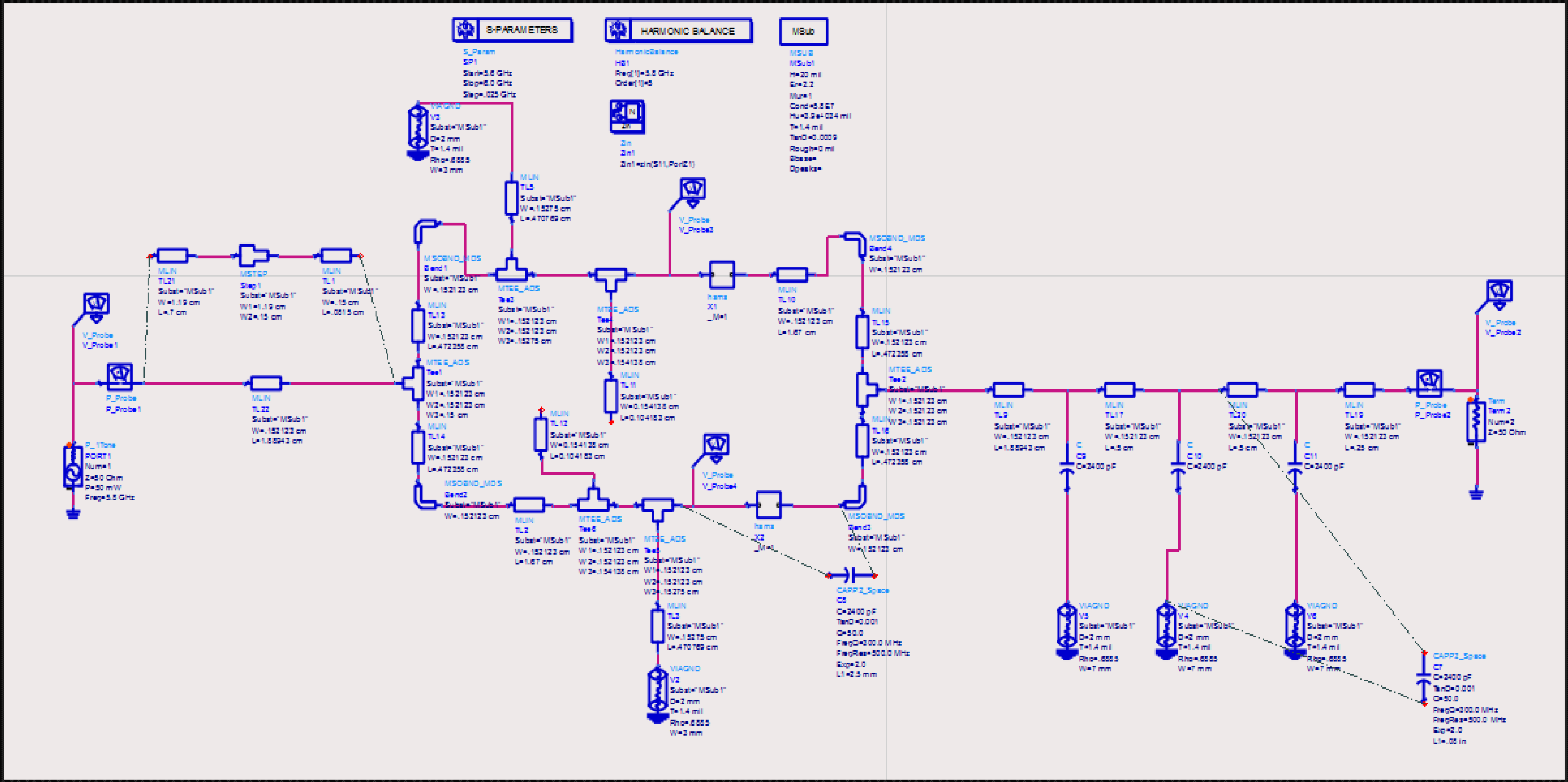


Fig 6. ADS Schematic Design of RF to DC Converter

Design – Matching Network

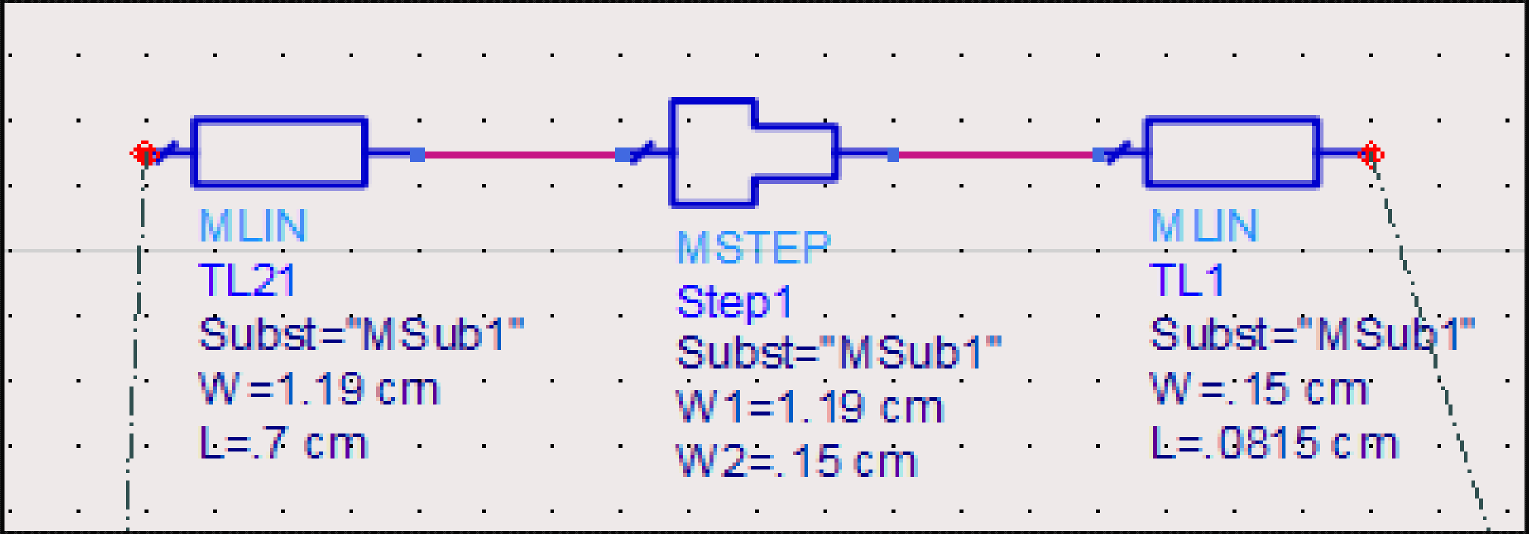


Fig 7. ADS Schematic Design of Impedance Matching Network

Design - Harmonic Suppression

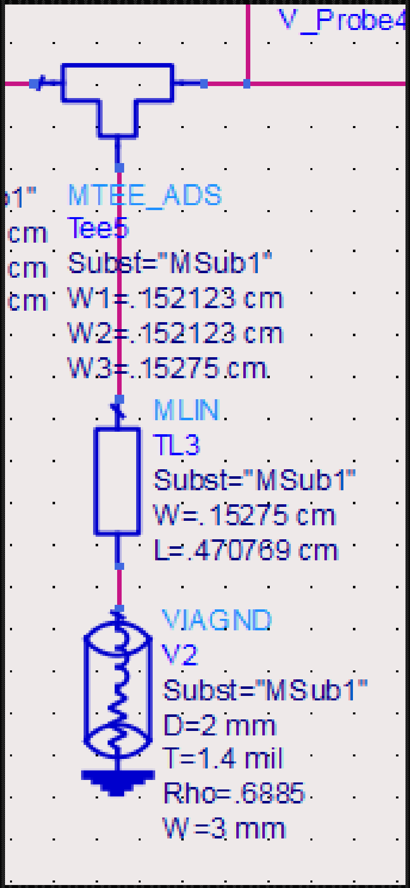


Fig 8. Second Order Harmonic Suppression

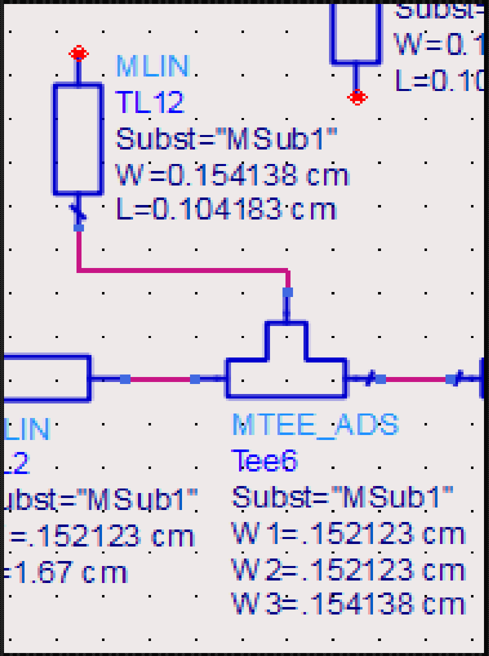
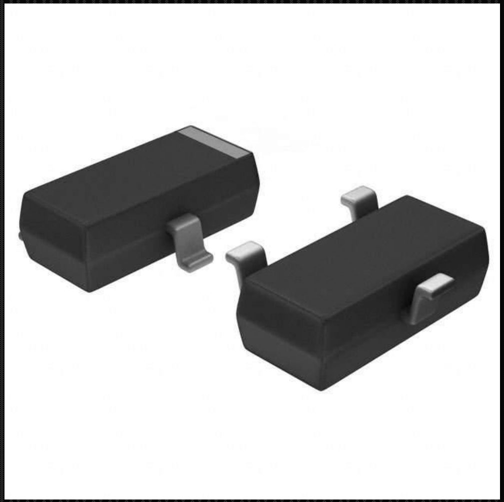


Fig 9. Third Order Harmonic Suppression

Design – Diode

- HSMS-2860 Schotky detector diode
- Discovered in research
- Pspice file
- Worked perfectly



Design - Balun

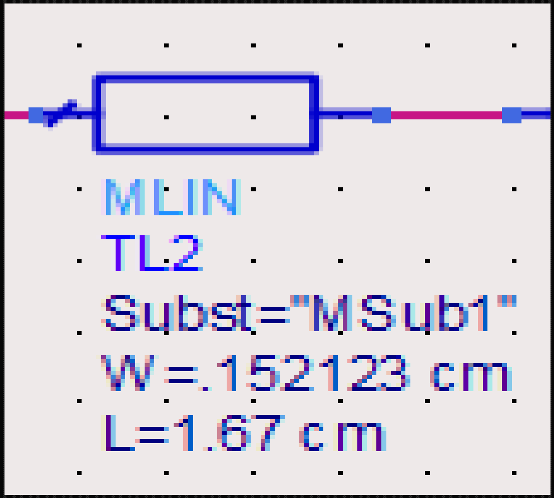


Fig 10. ADS Schematic Design of Balun

Design – DC Bypass Filter

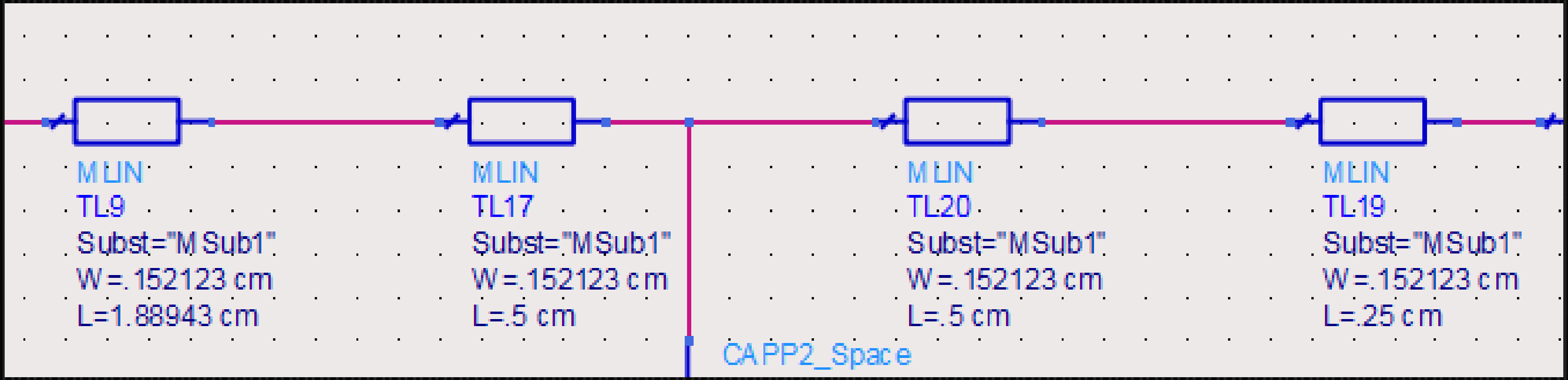


Fig 11. ADS Design of Output Microstrip Spacing

Design - Discontinuities

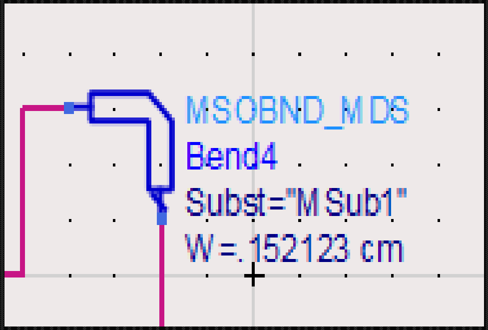


Fig 12. Schematic Bend

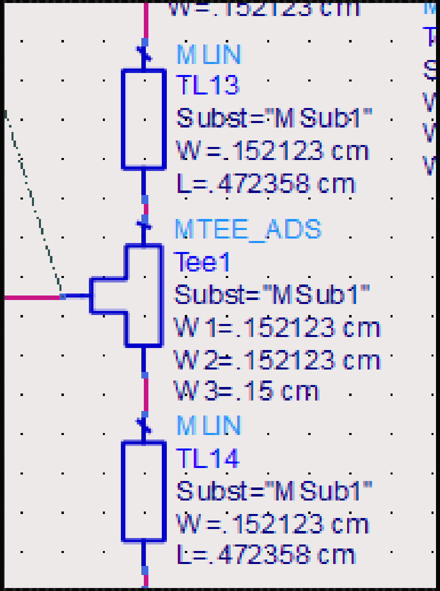


Fig 13. Schematic Tee Junction

Simulation Results - Unmatched

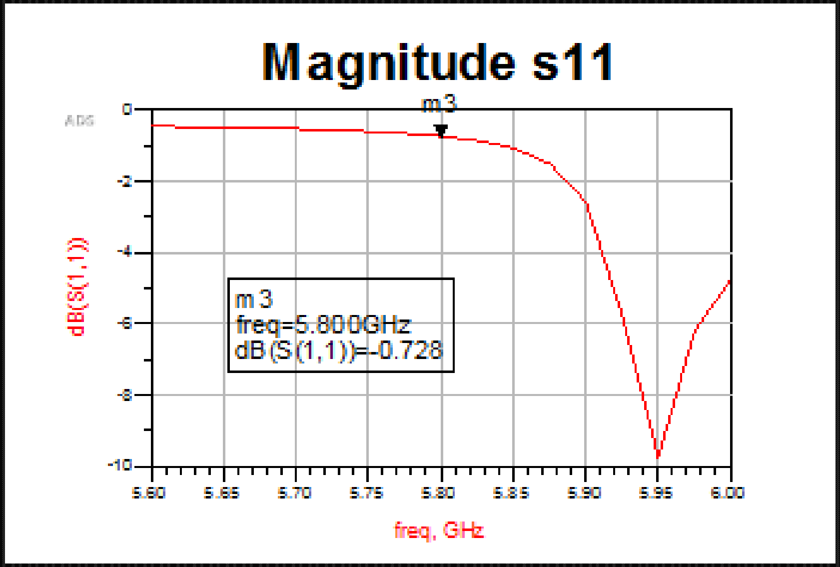


Fig 14. Reflection Coefficient

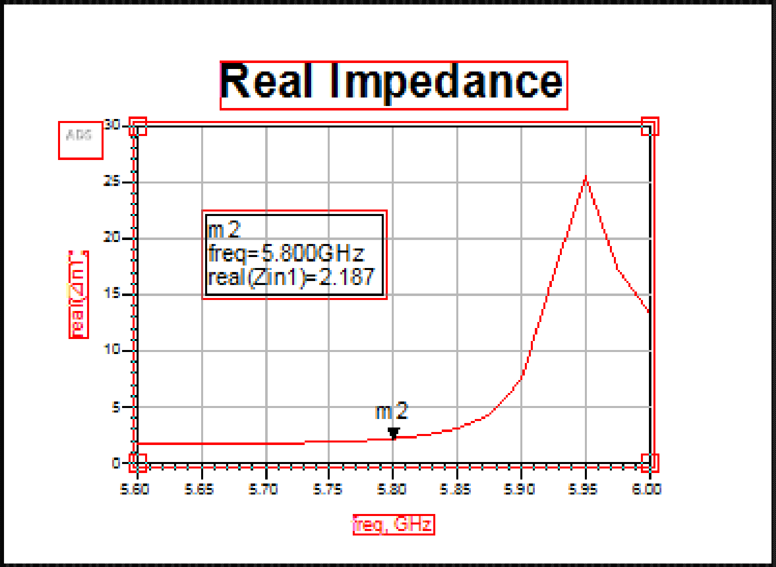


Fig 15. Real Impedance

Simulation Results - Unmatched

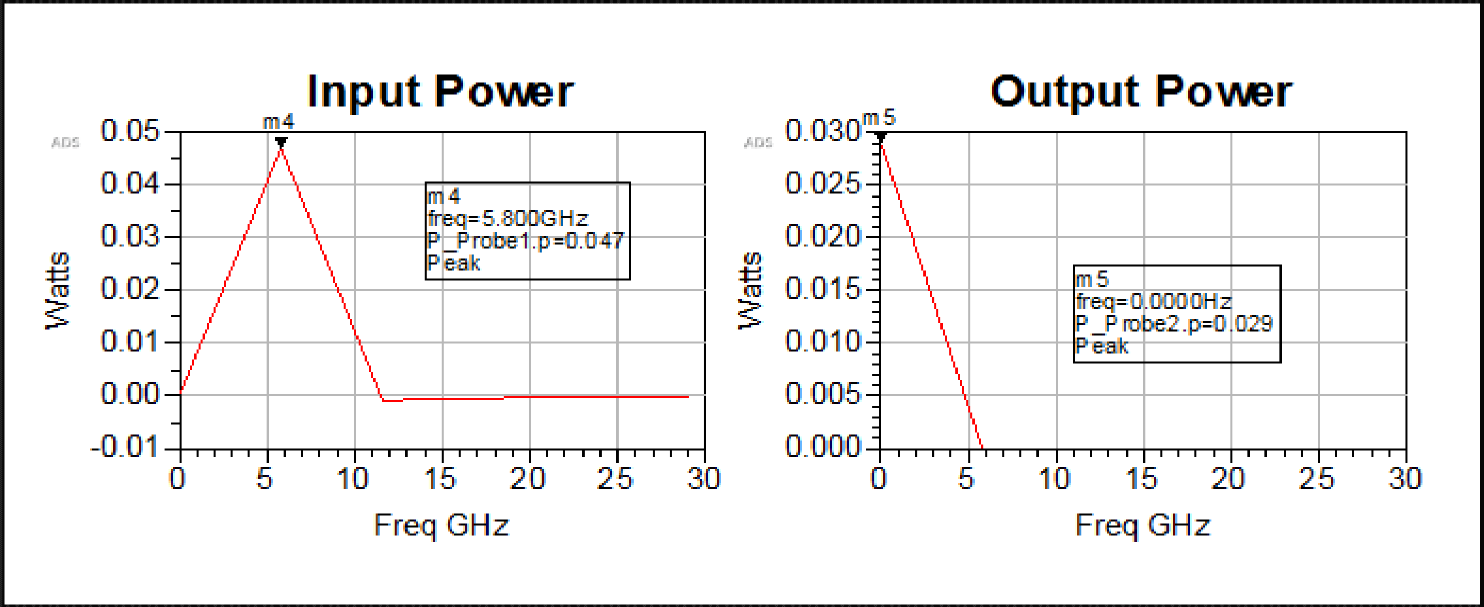


Fig 16. Efficiency of System in ADS Simulation

Simulation Results - Unmatched

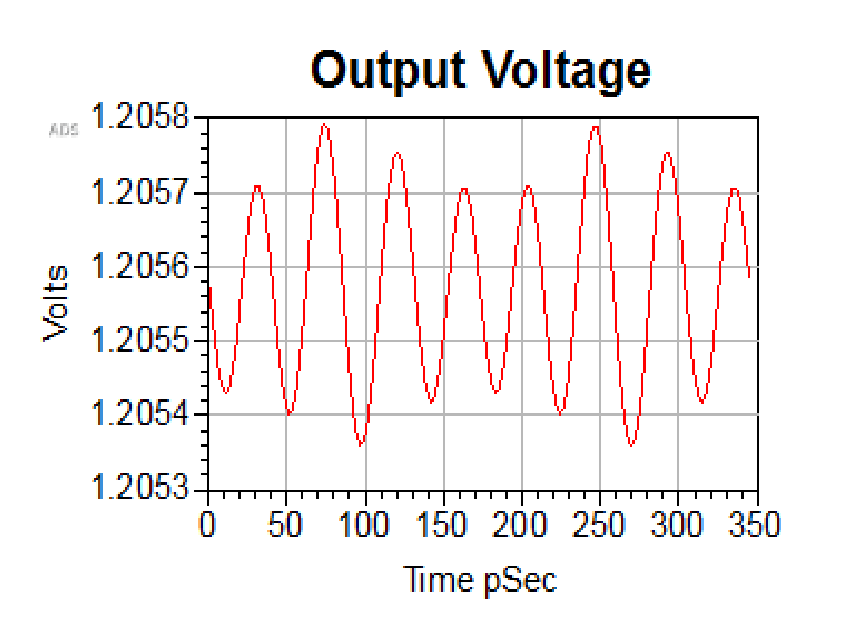


Fig 17. Simulated Output Voltage Waveform

Simulation Results - Matched

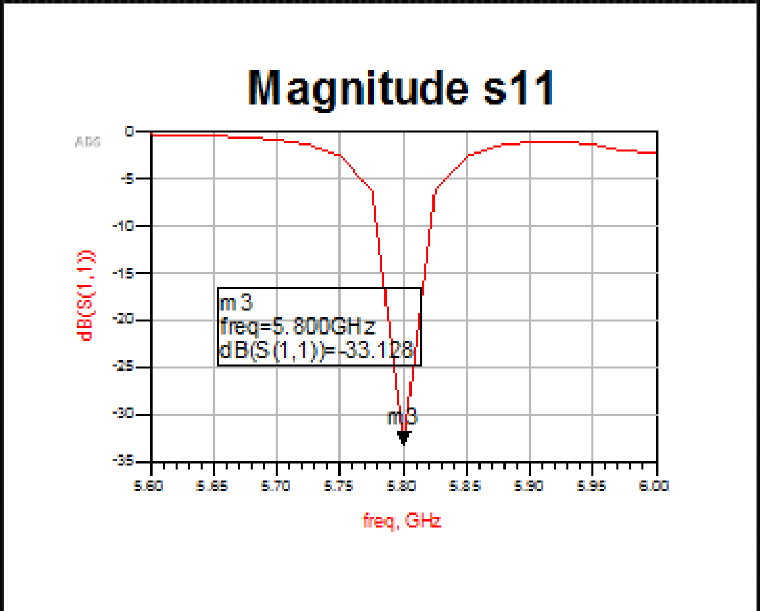


Fig 18. Reflection Coefficient

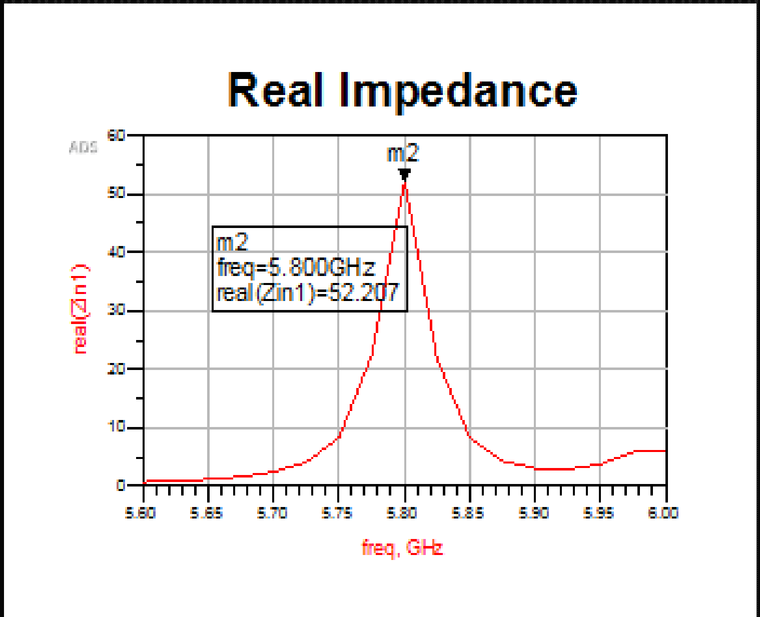


Fig 19. Real Impedance

Simulation Results - Matched

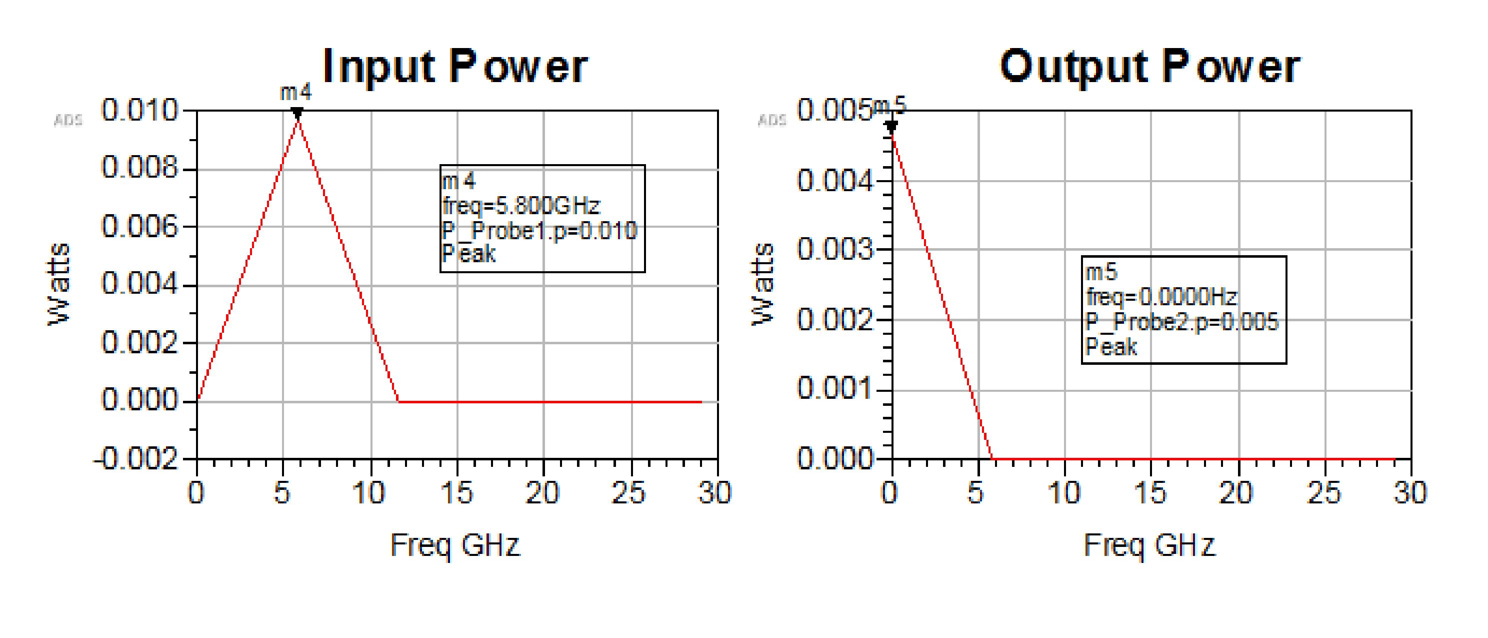


Fig 20. Efficiency of System in ADS Simulation

Simulation Results - Matched

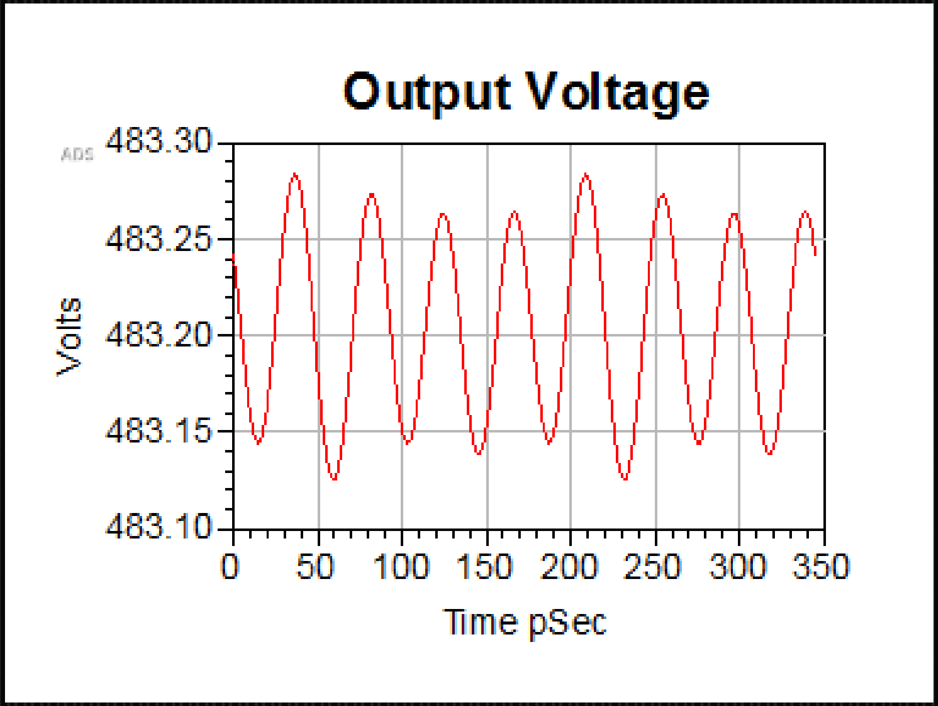


Fig 21. Output Voltage Waveform of ADS Simulations (Scale in mV)

Testing Results – Time Domain

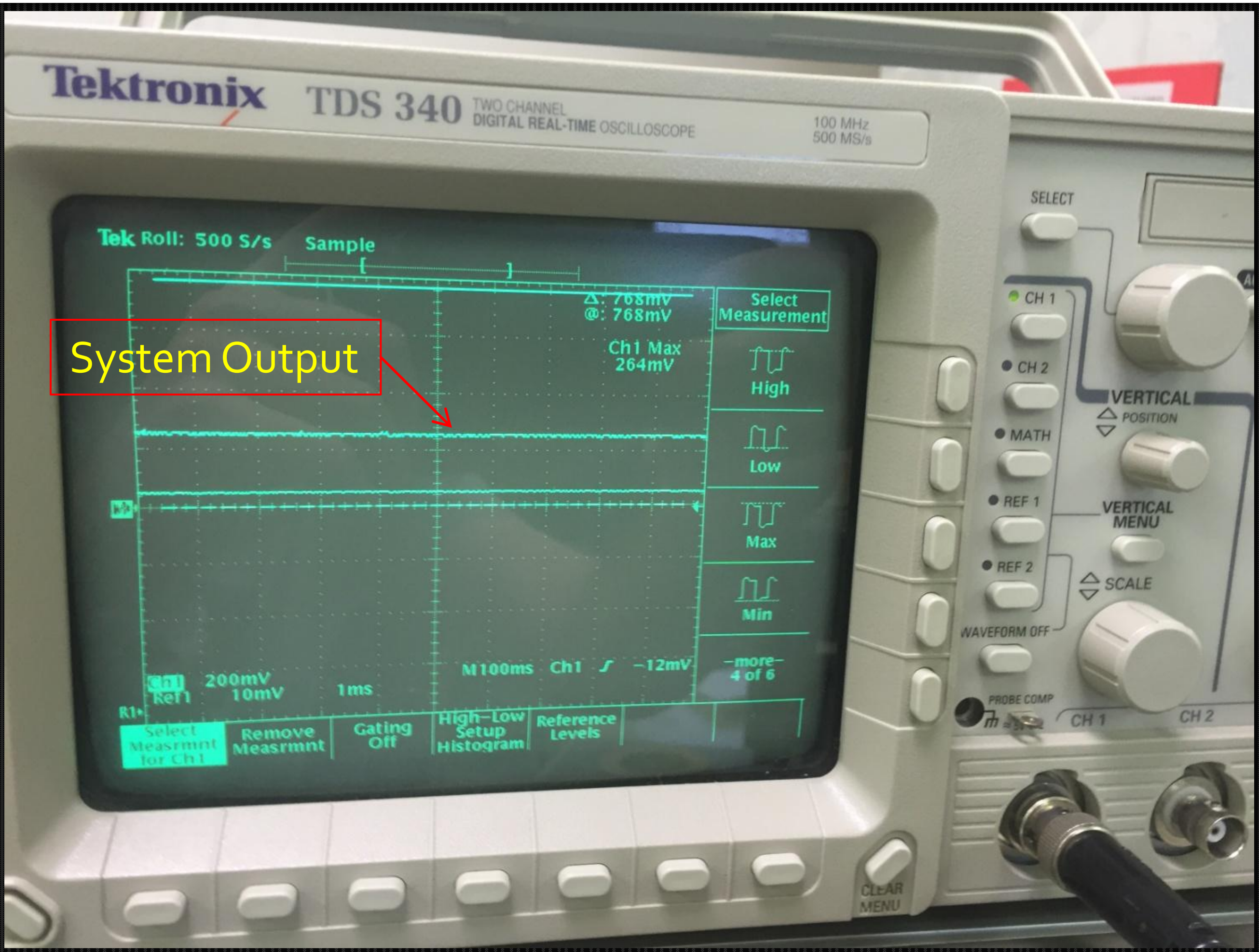


Fig 22. Oscilloscope voltage reading

Testing Results – Frequency Domain

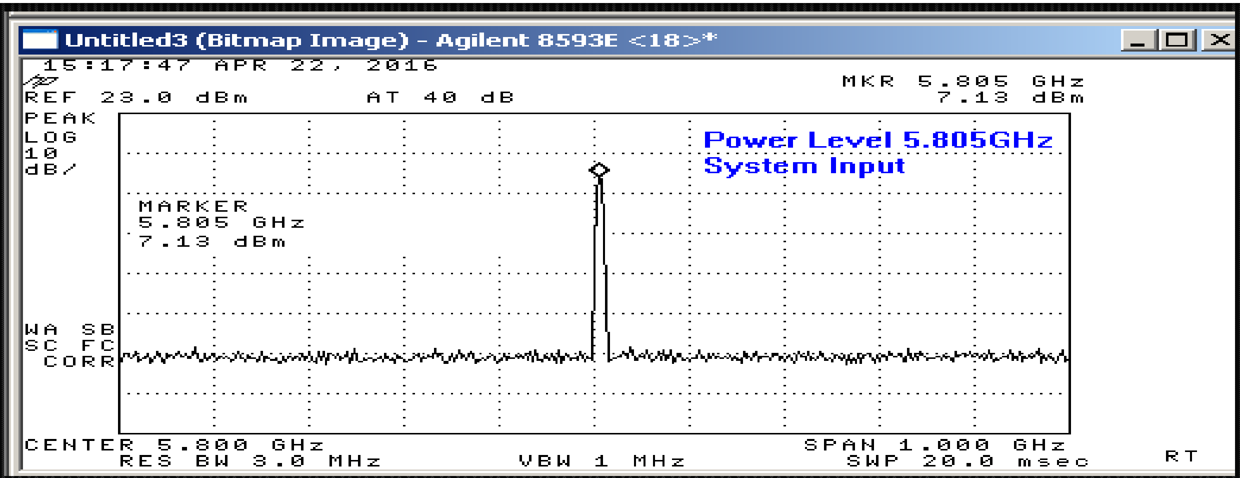


Fig 23.
Input Signal
Frequency Power
7.13 dBm

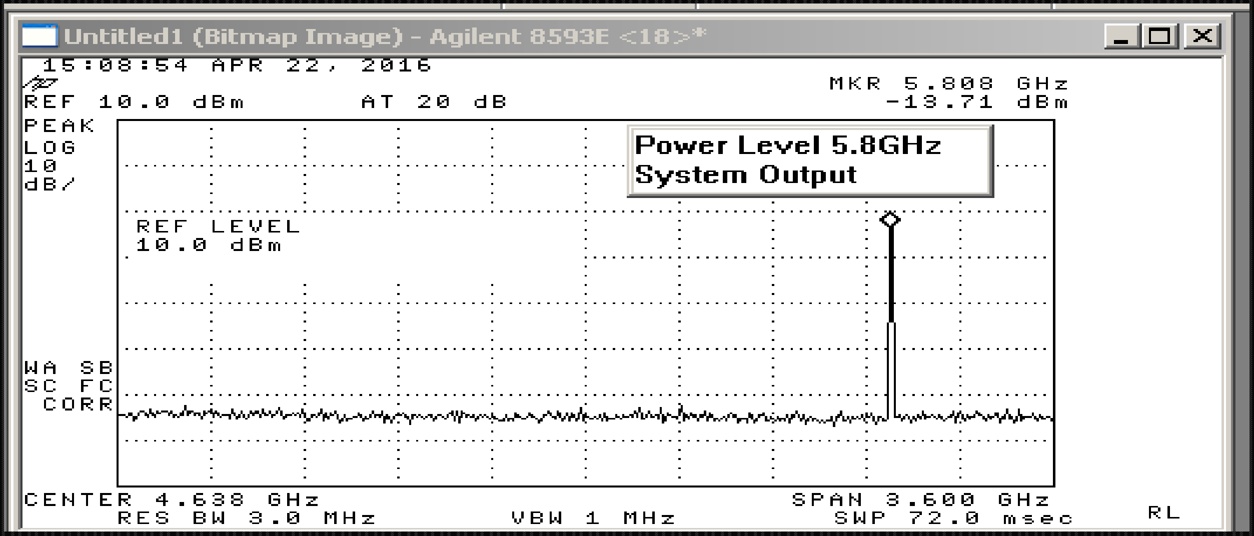
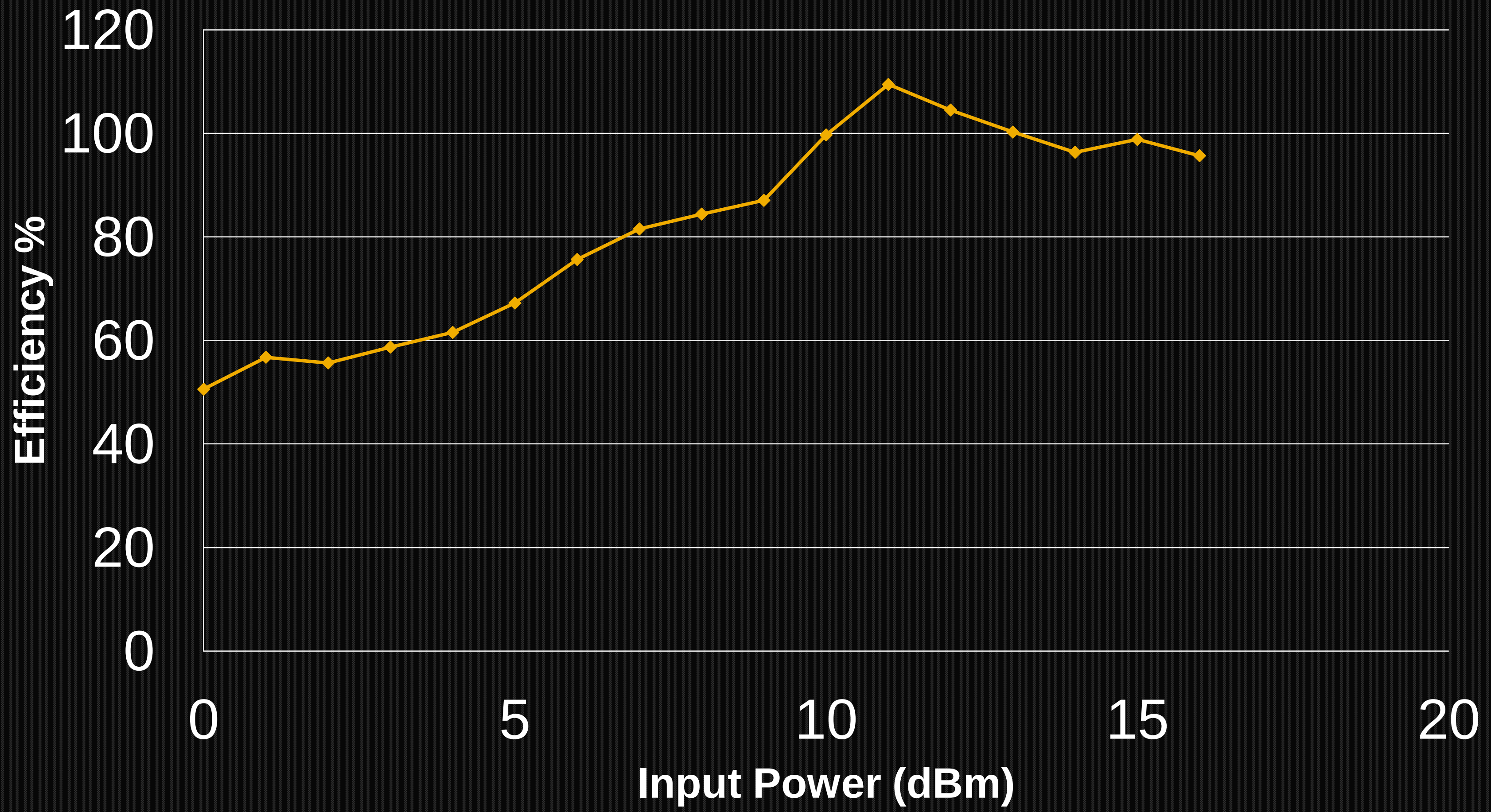


Fig 24.
Output Signal
Frequency Power
-13.71 dBm

Testing Results - Efficiency



Testing Results – Power Transfer

Conclusions

- Unmatched has great preliminary results
- Design is very compact
- Design is efficient
- Design gives DC output with minimal ripple

For Future Work

- Increase efficiency
- Decrease size
- Design to function at different frequencies (2.45 GHz 915 MHz)
- Work towards marketable product

Special Thanks

- Chris Mattus
- Nick Schmidt
- Bob Modica

Questions?

References

- [1] A. Boaventura, A. Collado, N.B. Carvalho, and A Georgiadis, "Optimum Behavior" in *IEEE Microwave Mag.*, vol. 14, no. 4, pp. 26-35, 2013.
- [2] Z. Popovic, "Cut the Cord" in IEEE *Microwave Mag*., vol. 14, no. 4, pp. 55-62, 2013
- [3] J. Zbitou, M. Latach, and S. Toutain, "Hybrid Rectenna and Monolithic Integrated Zero-Bias Microwave Rectifier" in IEEE *Transactions on Microwave Theory and Techniques*, vol. 54, no. 1, pp. 147-152, 2006

Parts List

- HSMS 2860 Schottky Detector Diode
- Premiertek 802.11n 2.4GHz/5~5.8GHz Dual Band 5dBi Antenna
- Antenna, 5.8 GHz 19 dBi gain
- Sunhans wifi signal booster

Appendix

Absolute Maximum Ratings, $T_C = +25°C$, Single Diode

Symbol	Parameter	Unit	Absolute Maximum[1]	
			SOT-23/143	SOT-323/363
P_{IV}	Peak Inverse Voltage	V	4.0	4.0
T_J	Junction Temperature	°C	150	150
T_{STG}	Storage Temperature	°C	-65 to 150	-65 to 150
T_{OP}	Operating Temperature	°C	-65 to 150	-65 to 150
θ_{jc}	Thermal Resistance[2]	°C/W	500	150

Notes:
1. Operation in excess of any one of these conditions may result in permanent damage to the device.
2. $T_C = +25°C$, where T_C is defined to be the temperature at the package pins where contact is made to the circuit board.

Attention:
Observe precautions for handling electrostatic sensitive devices.

ESD Machine Model (Class A)

ESD Human Body Model (Class 0)

Refer to Avago Application Note A004R: Electrostatic Discharge Damage and Control.