TEAM #13
Capstone Progress

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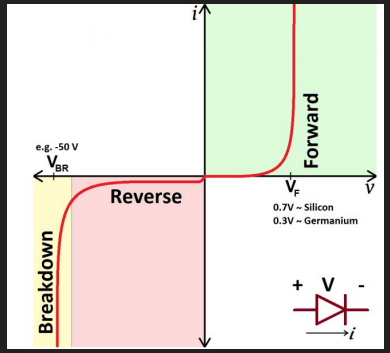
Outline

- Background
- How do we use this?
- Project Progress
- Where do we go from here?
- Conclusion

Background

- What is a capacitor?
  - A linear device which store charge
- What is a varactor-diode?
  - A diode which can act as a non-linear voltage-dependent capacitor



Diode Non-linear V-I curve taken from [Sparkfun]

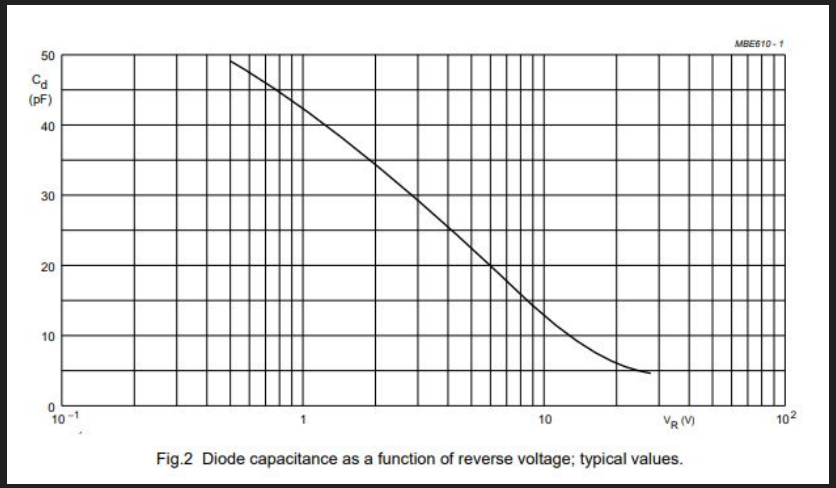


Fig.2 Diode capacitance as a function of reverse voltage; typical values.

Graph of Voltage-dependent capacitance from [BBY40 Varactor (Varicap) Diode Datasheet.]

Background Continued

- What are Non-Linear Transmission Lines (NLTL's)
  - NLTL's take into account that a wire is not just a wire. It is modeled with parasitics and is loaded by non-linear devices like varactors.
- Why might modeling/simulating this be useful?
  - It allows us to predict how well these devices work for a given purpose (see next slide)

Where do we fit into this picture?

- Rohde and Schwarz is a company specializing in the production of measurement equipment (Oscilloscopes, VNA’s, etc..)
- To measure very fast signals (>Ghz), we need to sample them with waves at least twice as fast (according to NyQuist theory)
- NLTL’s can be observed to have “pulse sharpening effects” which take in a square wave with a defined “rise time” and reduce the time it takes to reach its pulsed value.
- In theory, this allows us to use very fast waves without worry of the pulses overlapping or “aliasing”

Pulse sharpening

Main considerations

- How much power do we lose due to parasitics
- How much can we sharpen a given pulse before the costs outweigh the benefits

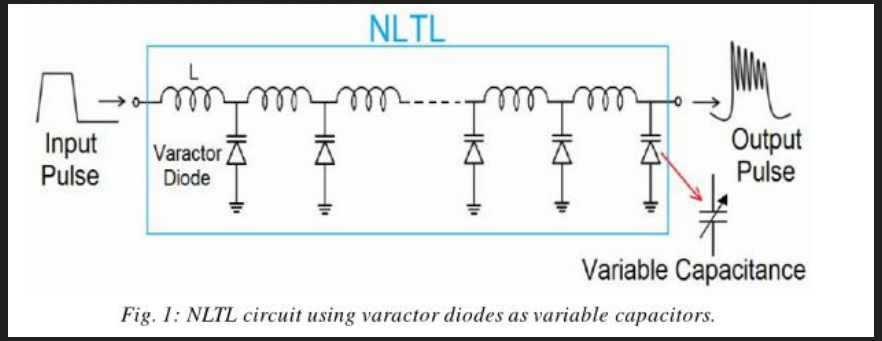


Fig. 1: NLTL circuit using varactor diodes as variable capacitors.

Image taken from: *International Journal of Advanced Engineering Research and Science.* [Vol-5, Issue-10, Oct-2018]

Progress (Background)

- Worked through a lot of background research through IEEE articles relating to
  - Diode/component modeling (SPICE, ADS, Verilog-A Modules)
  - Designs utilizing nonlinear components
  - Proper calibration of test equipment (S-Parameter De-embedding techniques)
    - SOLT
    - 2x Thru
  - NTLT Theory
  - Applications: pulse sharpening, phase shifting
  - PCB Design for microwave signals

Progress (Simulations)

- Less than a week away from completing

  Analysis of time-domain behaviour

  Specifically…

  - Rise time vs. bias voltage
  - Rise time vs. length of line
  - Power Delivery vs. bias voltage
  - Power delivery vs. line length

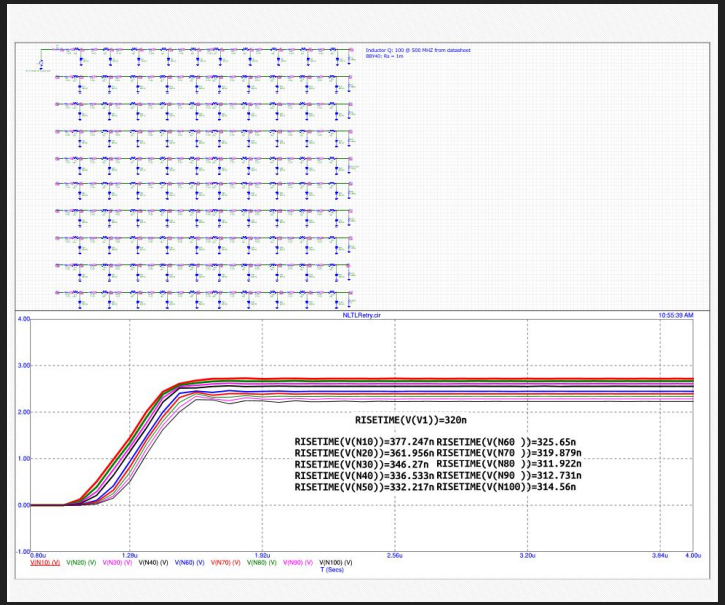


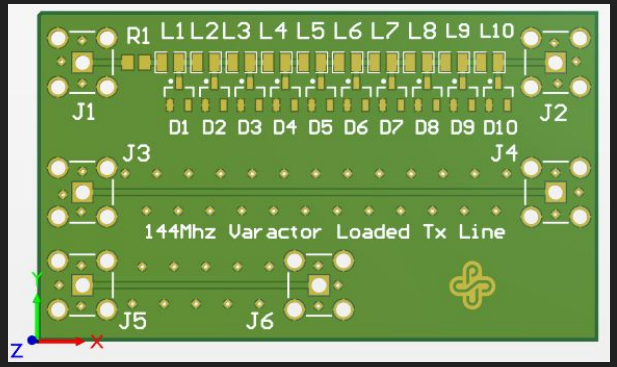
Figure: Rise Time vs # of sections on a 100-ladder long NLTL

Progress (Hardware)

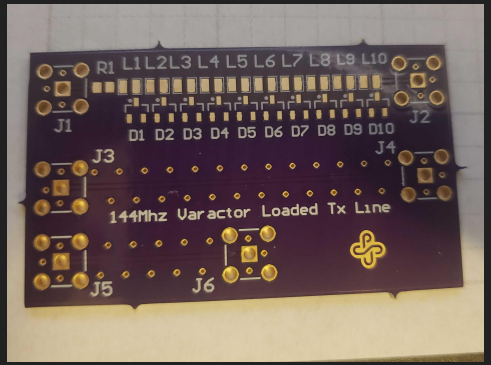
- First prototype (144Mhz) designed in Altium
- Board Received from OSHPark (Qty. 3)

Less than a week away from completing

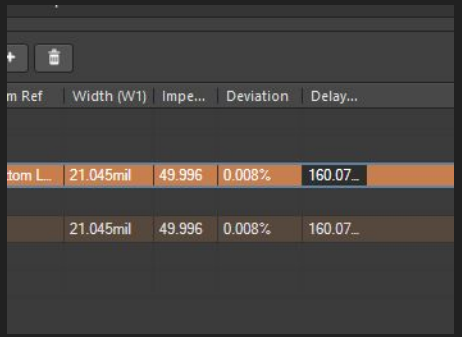
- Time domain measurements (Using scope)
- Frequency domain measurements (Using nanoVna)



Altium 3D Rendered Board (Top)
and
Impedance Calculator Results (Bottom)



Received Board from OSHPark



Where do we go from here?

- Measurements
- Modeling Varactor as a Verilog-A Module
- Experimenting with differing board geometries
    - Wave breaking on a beach analogy
- EM Simulations of board using Momentum

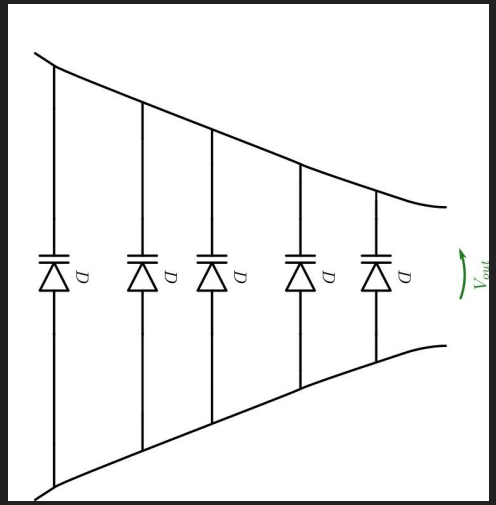


Figure: Example of possible experiments with circuit geometry

- Complete documentation of process (White Paper Format)
- We have discussed with our Sponsor re-scoping of project deliverables and refocus on proper documentation and drafting of Design Guide.

Conclusion

Because of the situation we have to change the scope of the project, we have discussed this with the industry sponsor.

Things left to do/currently being work on:

- 6GHz prototype
- Measurements
- Documentation
- Poster

Questions?