

Power Reflection in a Single Stage FARAD Thruster

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EPPDyL

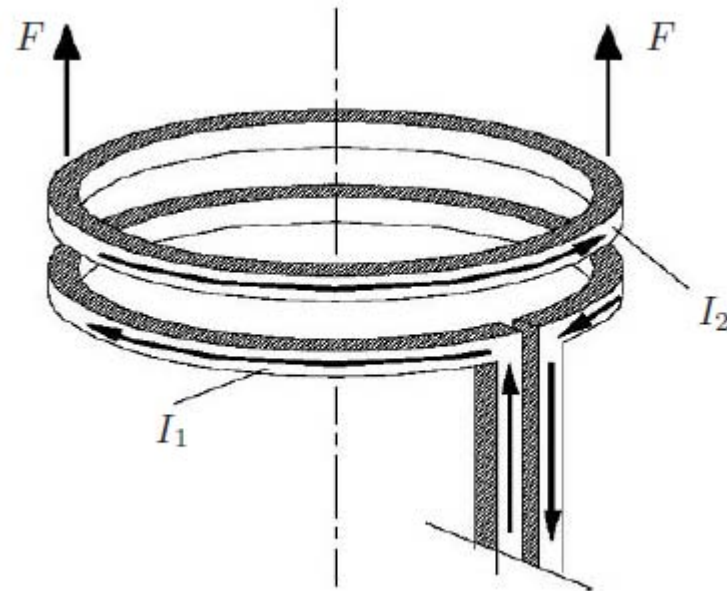
PPST Summer Intern

What is FARAD?

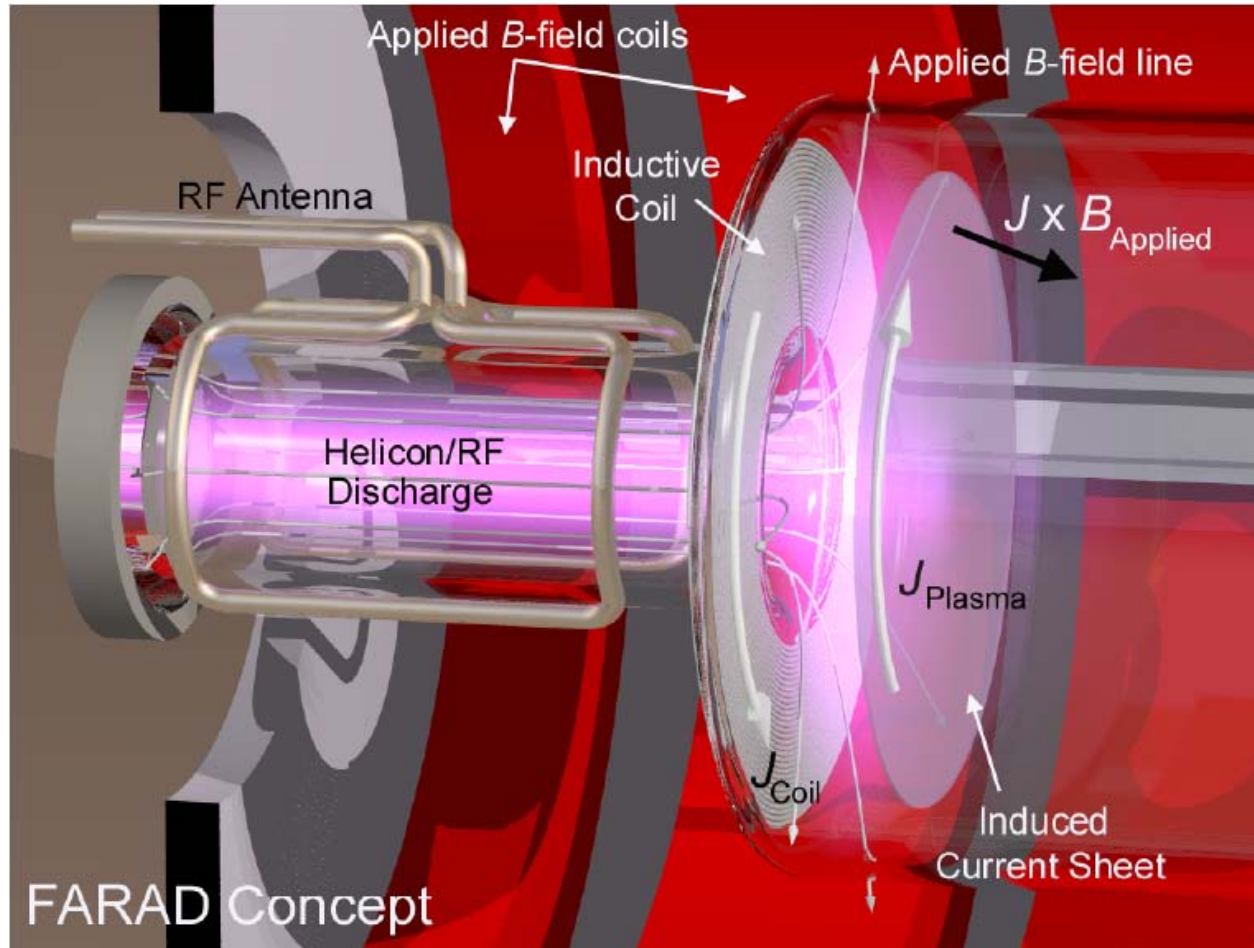
- Faraday **A**ccelerator with **R**adio-frequency **A**ssisted **D**ischarge
- Pulsed inductive acceleration

$$\nabla \times \mathbf{B} = \mu_0 \mathbf{j}.$$

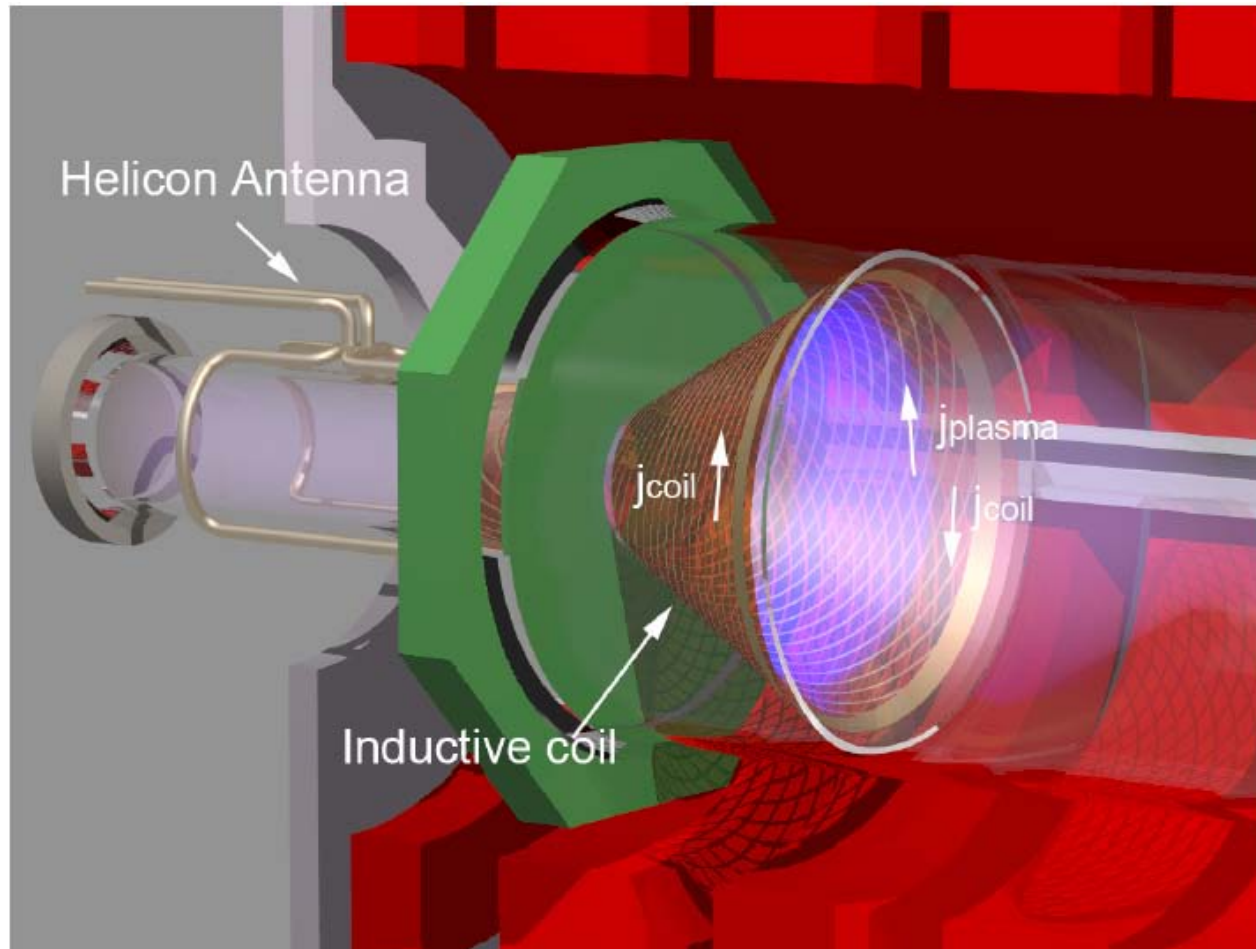
$$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}.$$



1st Generation FARAD



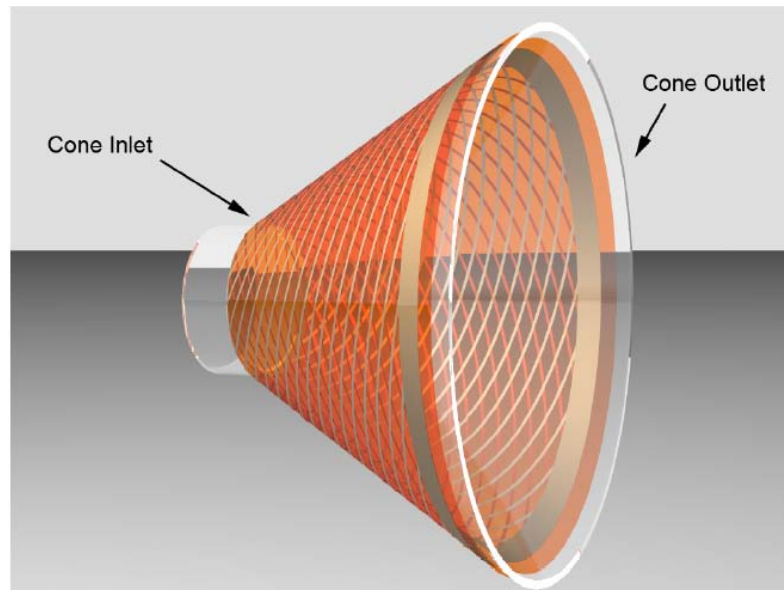
CTP FARAD



Single Stage FARAD?

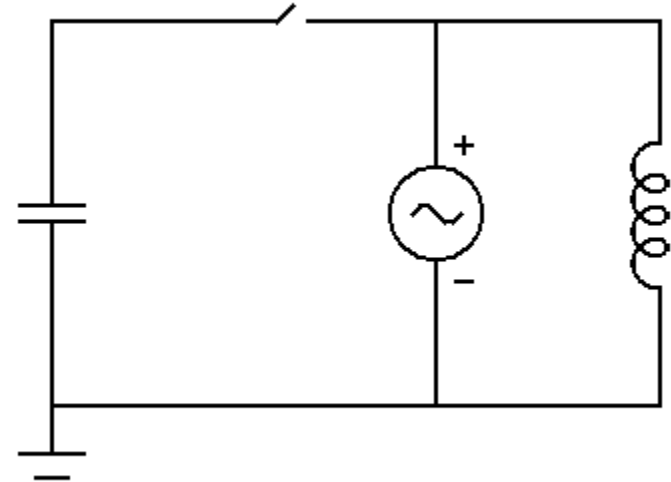
- Generate and accelerate plasma with one antenna
 - 13.56 MHz RF signal for plasma generation
 - Pulsed signal from capacitor for acceleration

- Why?
 - Simpler
 - More compact



So what's the problem?

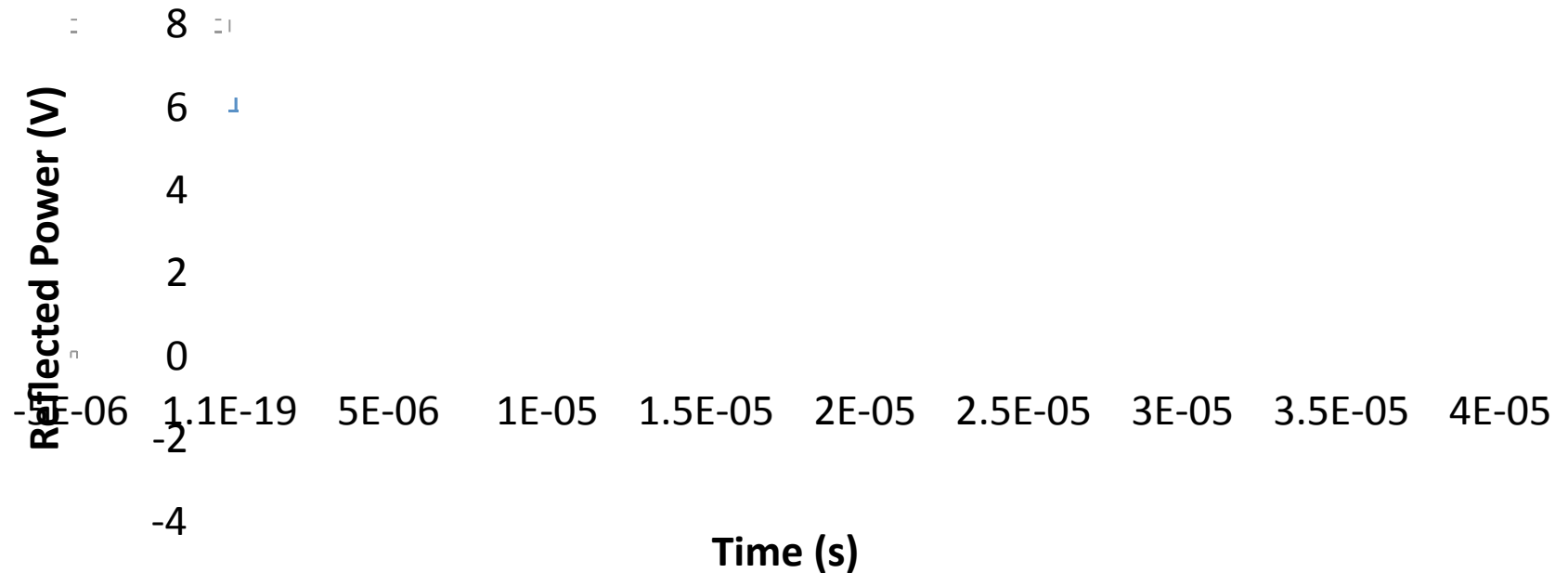
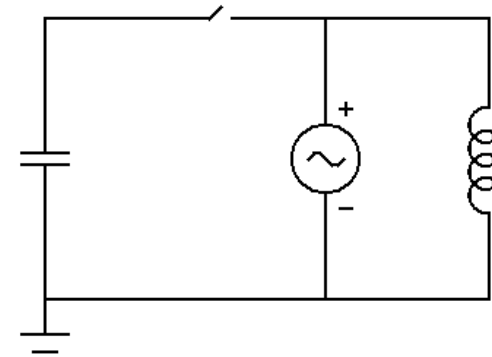
- Power reflection from capacitor discharge
 - Too much power into RF source



- Large voltages required to create current sheet – even low power reflected will cause damage to RF source

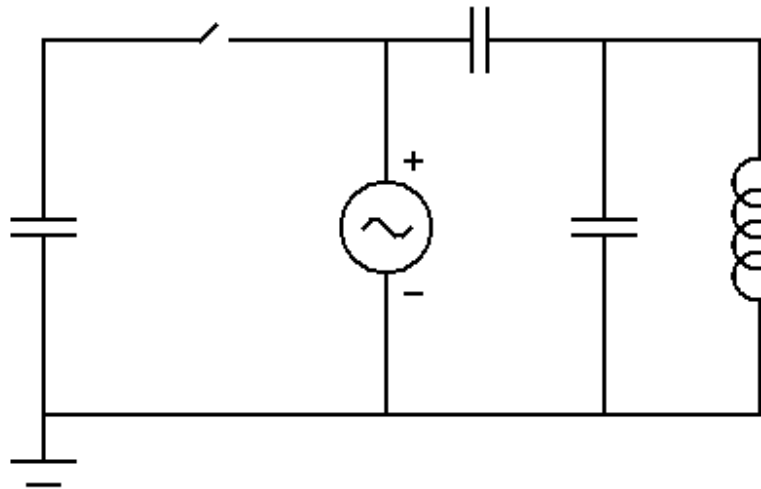
Power into RF Source

- Capacitor is charged to 5V
- Hammer-type switch
- $\sim 8V$ max!



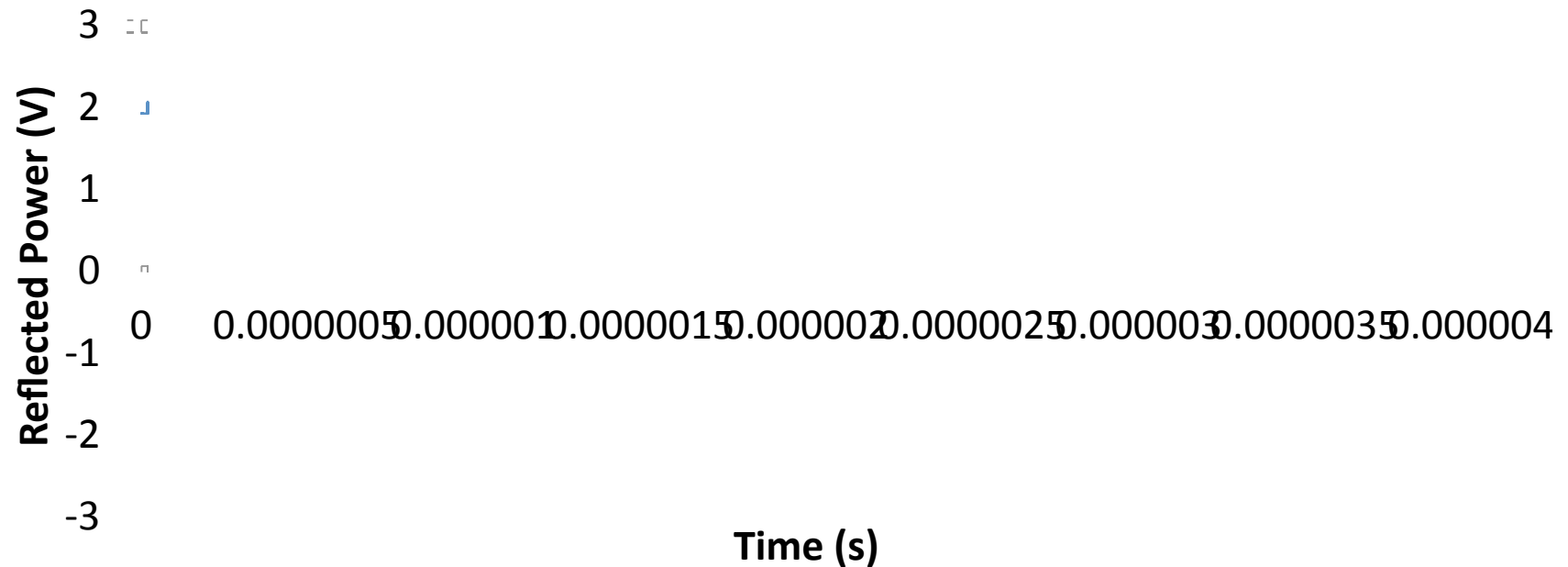
Impedance Match

- L Network – Series and shunt capacitor
- Antenna and L Network impedance = Signal source impedance
- Minimizes power reflected (in theory)



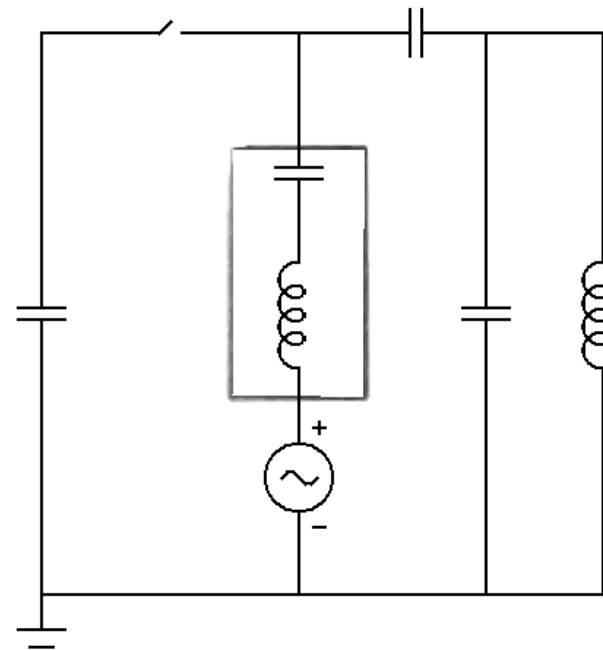
Impedance Match, Cont.

- ~4V max!
- 80% power reflection
- Pulse duration <10% of base circuit



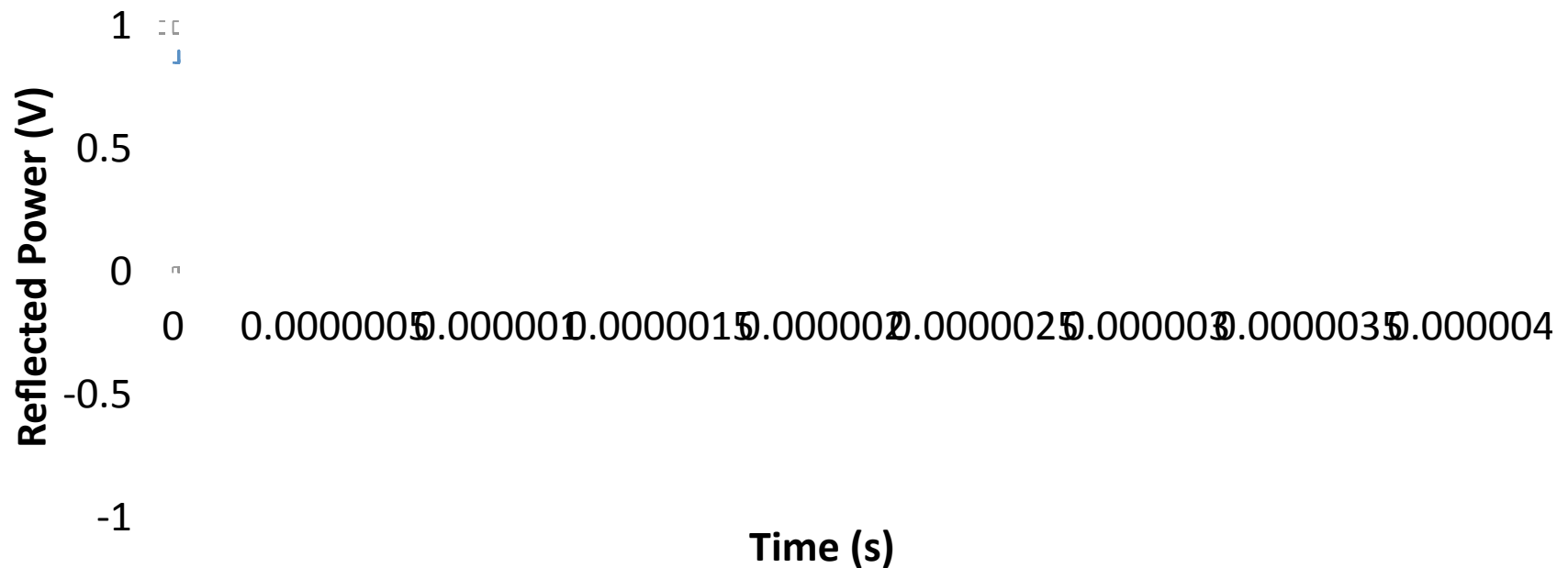
Resonator

- Permits signal at resonant frequency - attenuates signals at other frequencies
- Options:
 - Series LC resonance circuit
 - Parallel LC resonance circuit
 - Shorting stub
- Series LC resonant circuit offers best performance

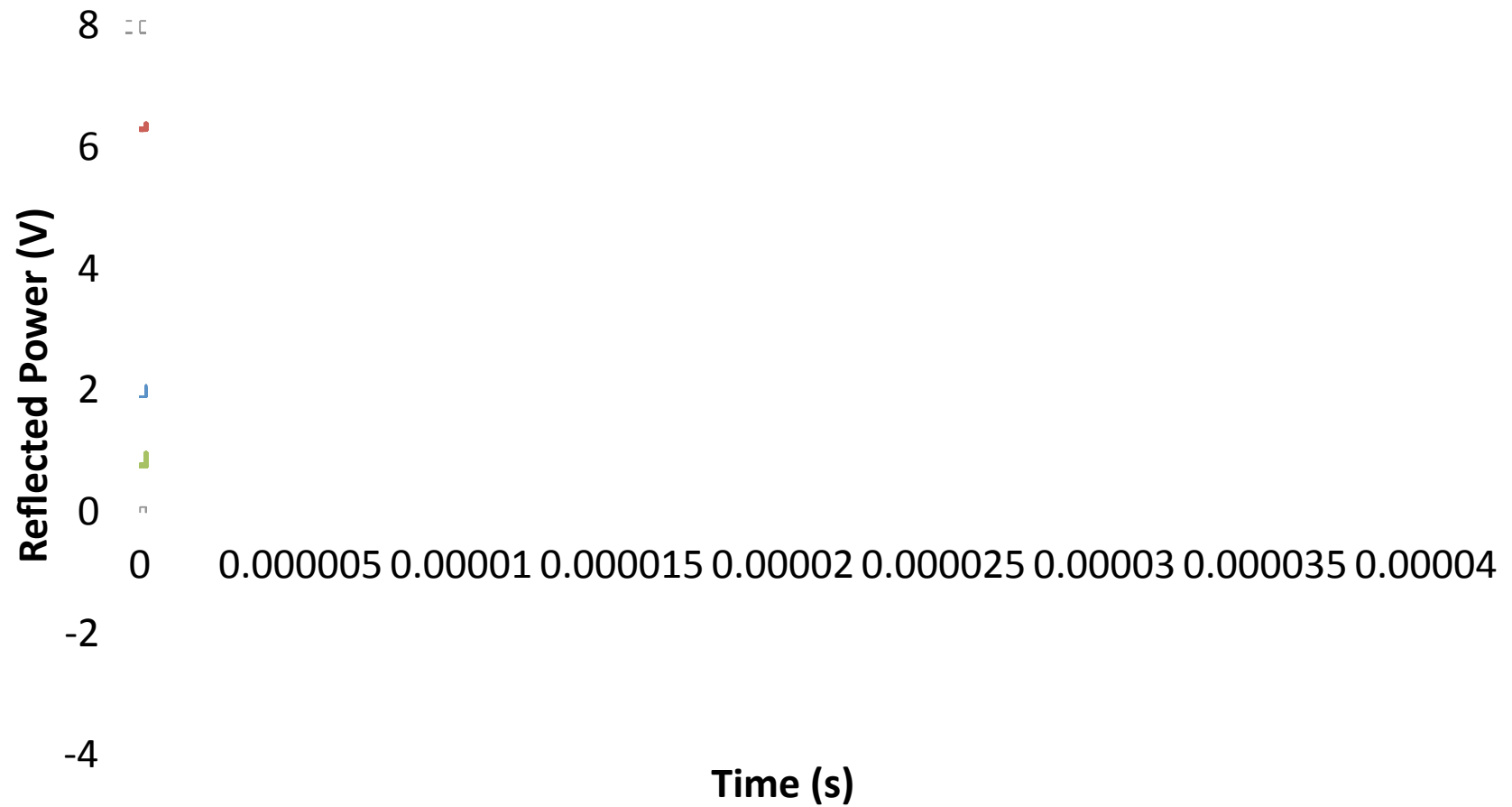


Resonator, Cont.

- Significant decrease in signal amplitude
- ~1.5V max -> ~30% power reflection
- Still too high



Power Reflection Comparison



What now?

- ~30%(!!) power reflection even with impedance match and series LC resonator
- Switch?
 - Short recombination time (on the order of μs)
 - Would have to take high power
- Diode?
 - Cannot take very much power

Conclusion

- **Single stage FARAD might not be possible!**
- The power reflection problem may not be solvable when using 13.56 MHz RF signal
- No way to prevent damage to RF source

Thanks to:



- Edgar Choueiri

- Bob Sorenson