

# Improvements for Directional Couplers

**Bernhard Schriefer**

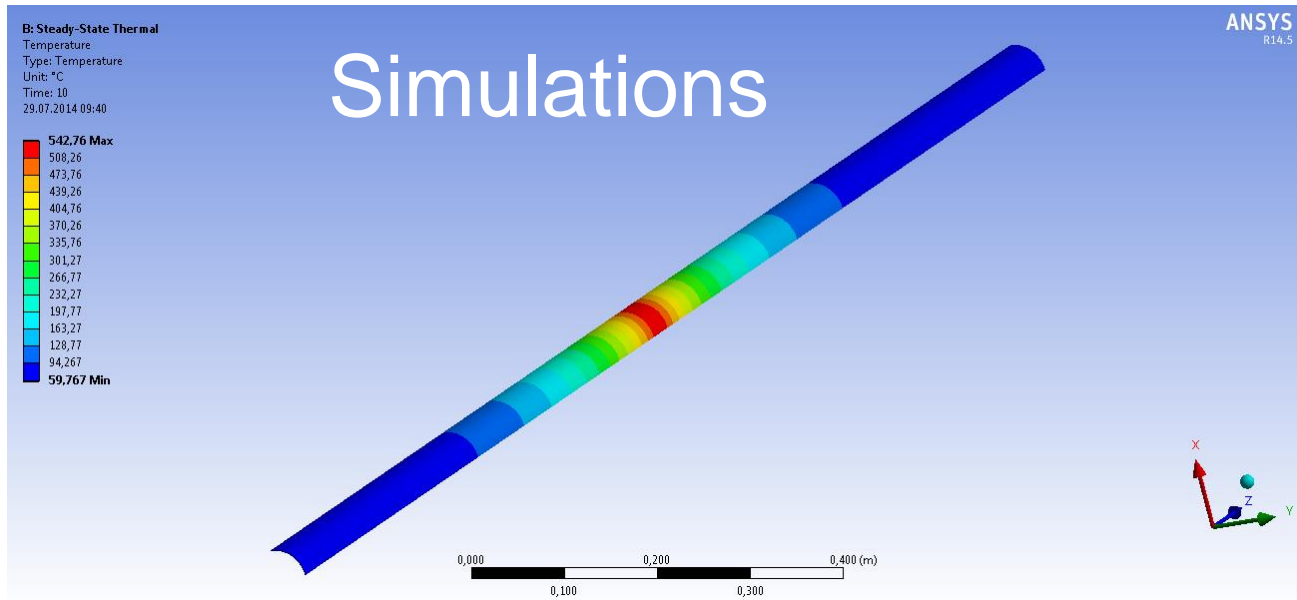
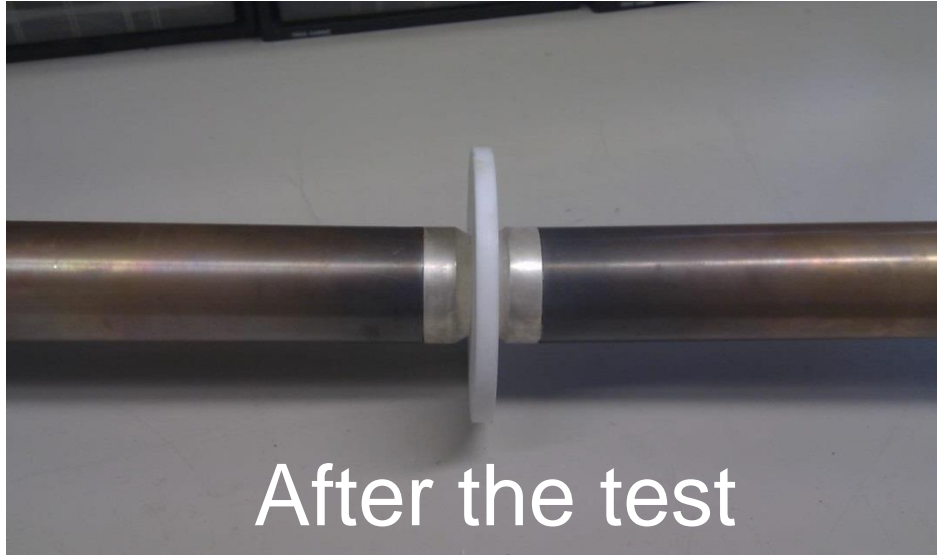
Helmholtz-Zentrum Berlin for Materials and Energy (HZB)

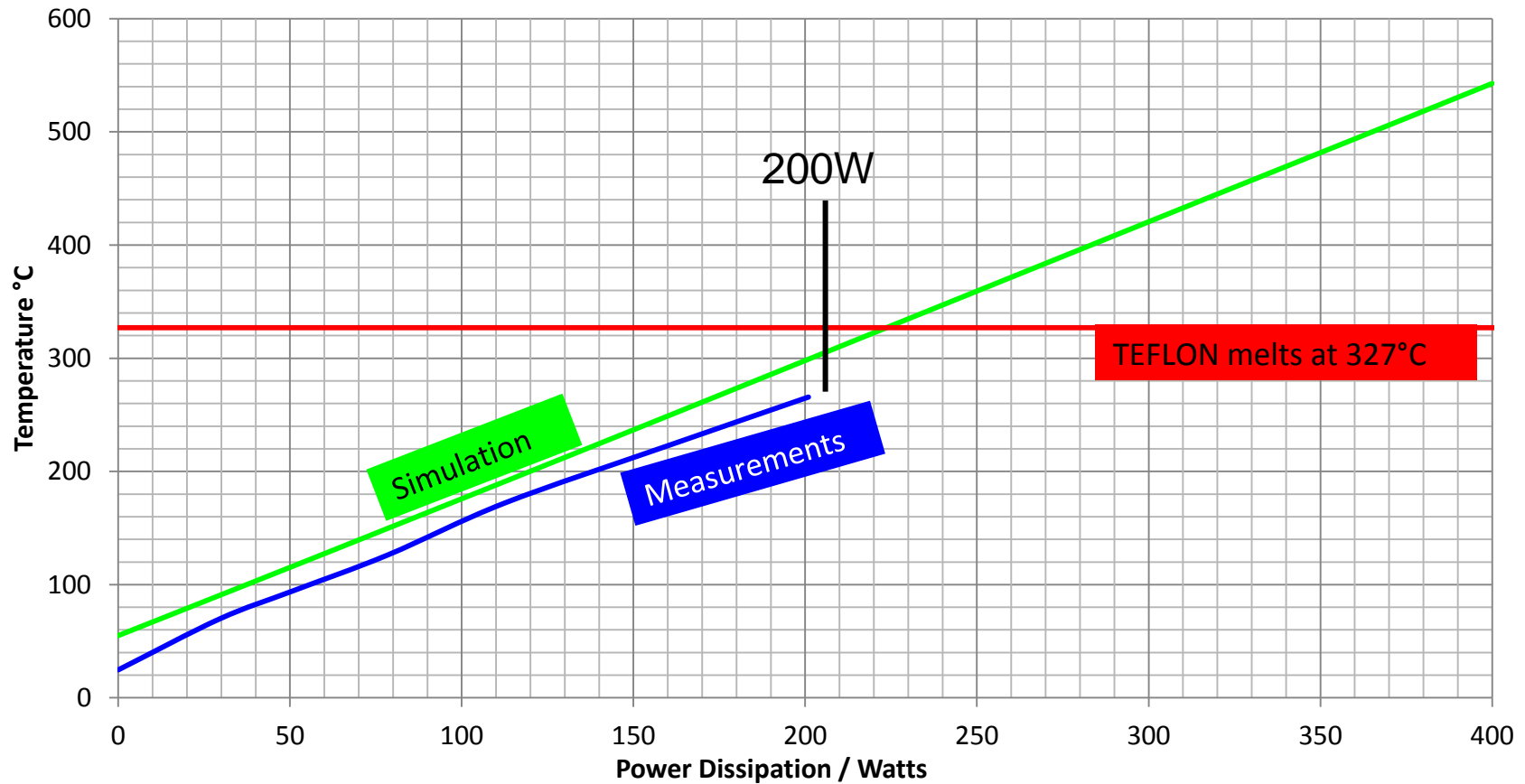
**19th ESLS-RF Meeting 30.9.-1.10.2015**

- **Thoughts about Powerline Interlock**
  - Motivation: Fire of Powerline in 2014
  - Simulations and Measurements about Heat
  - Limitations
- **Some Theory**
  - Reason for Limitations
  - Directional Couplers
- **Calibrating the System**
  - Results and Limitations
- **Summary and Future Activities**

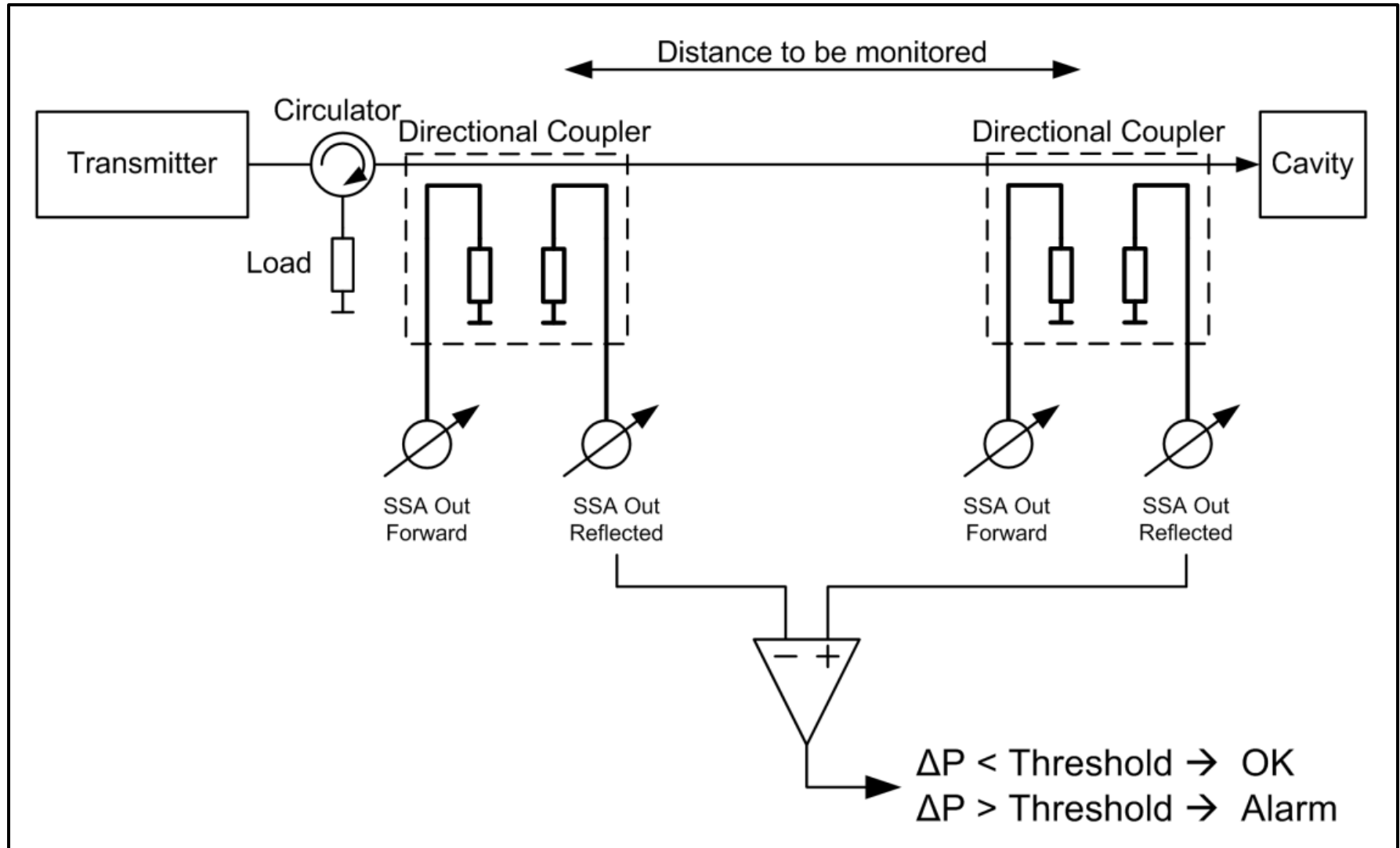
# Motivation: Fire at BESSY II in 2014



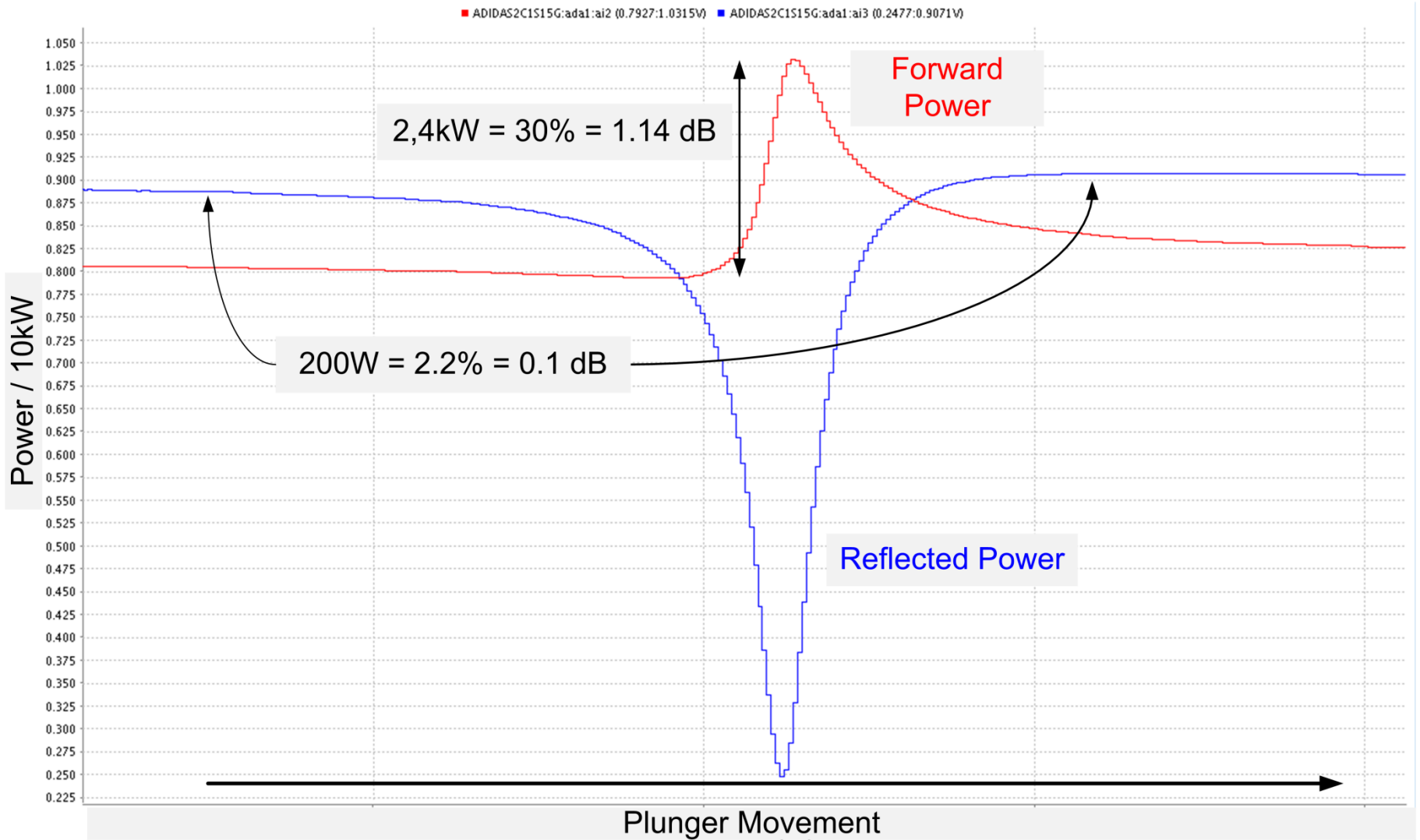




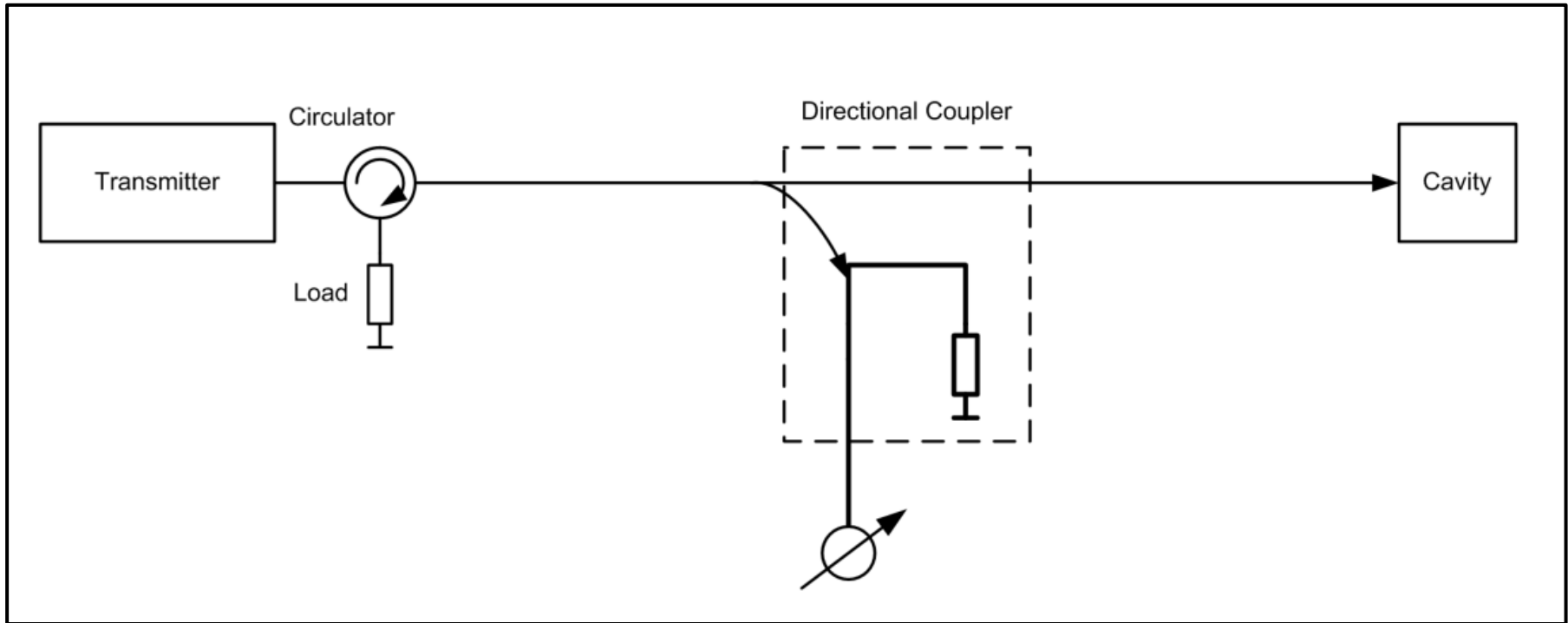
→ About 200W of additional Loss have to be detected

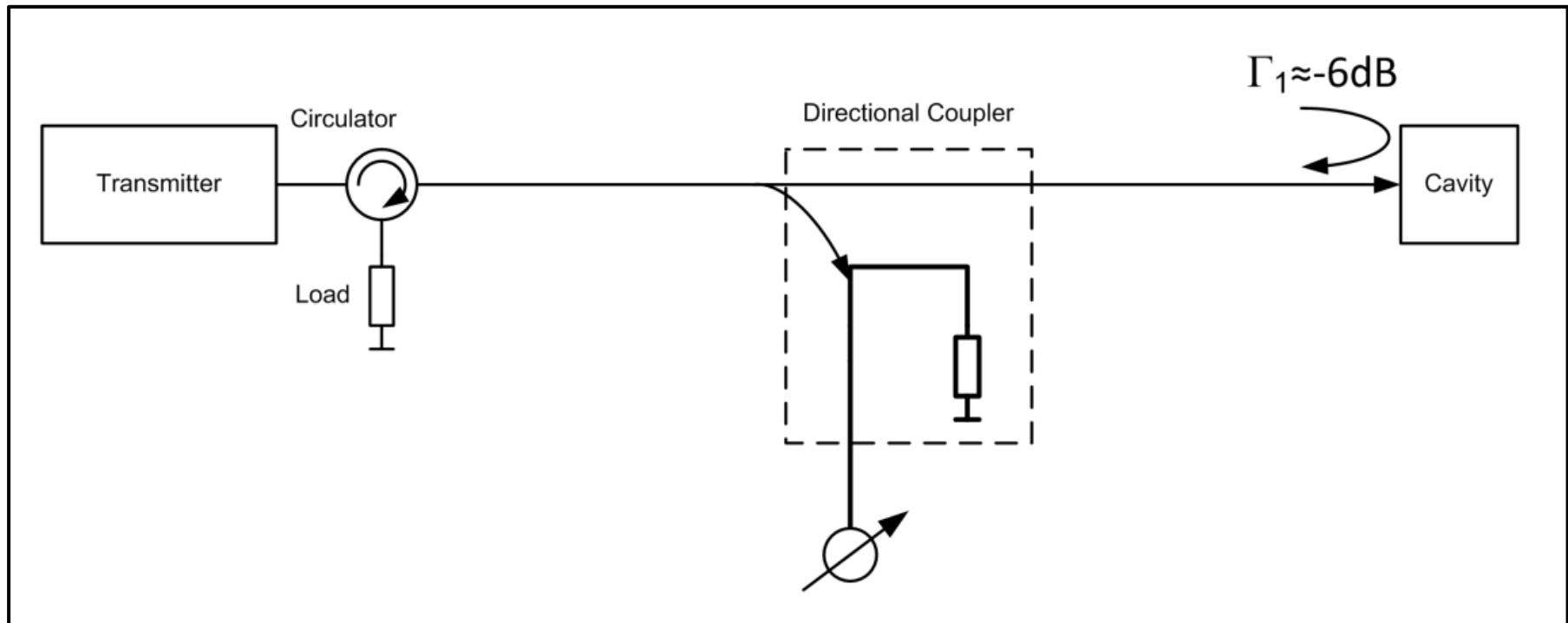


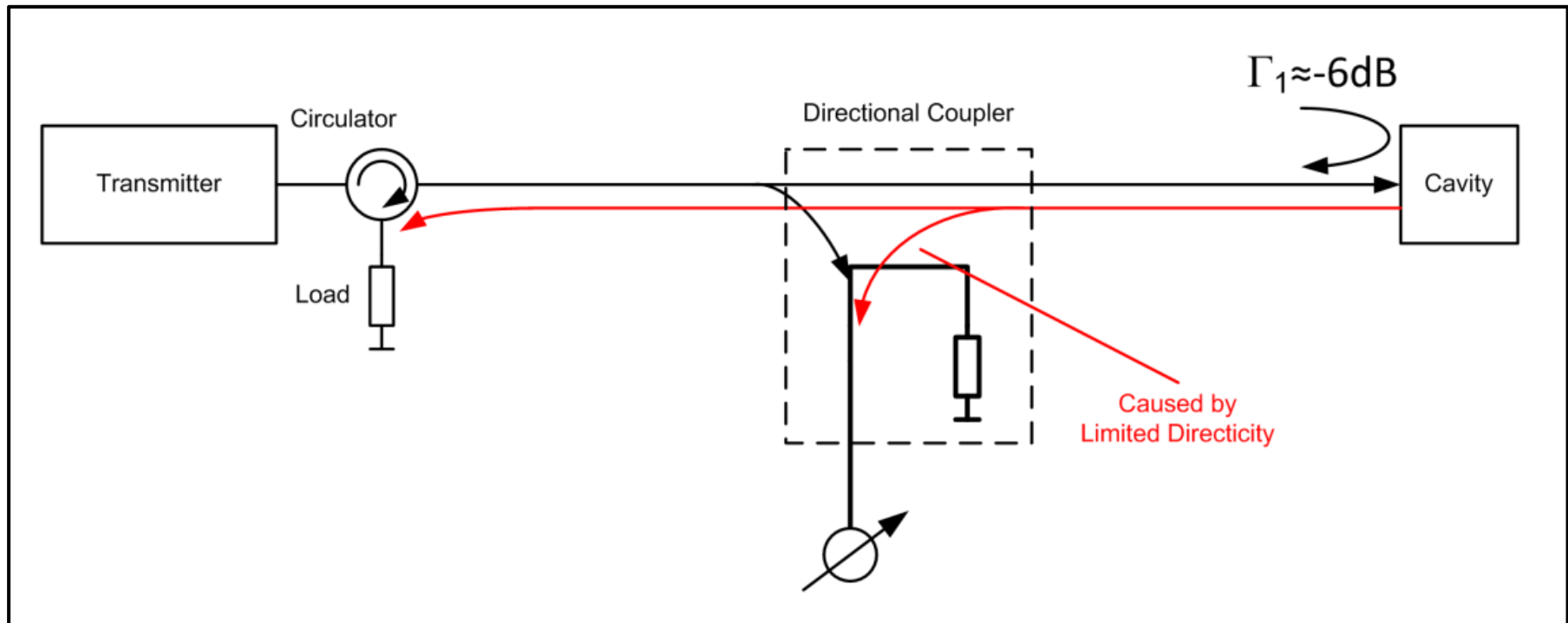
What happens when we move the Plunger?

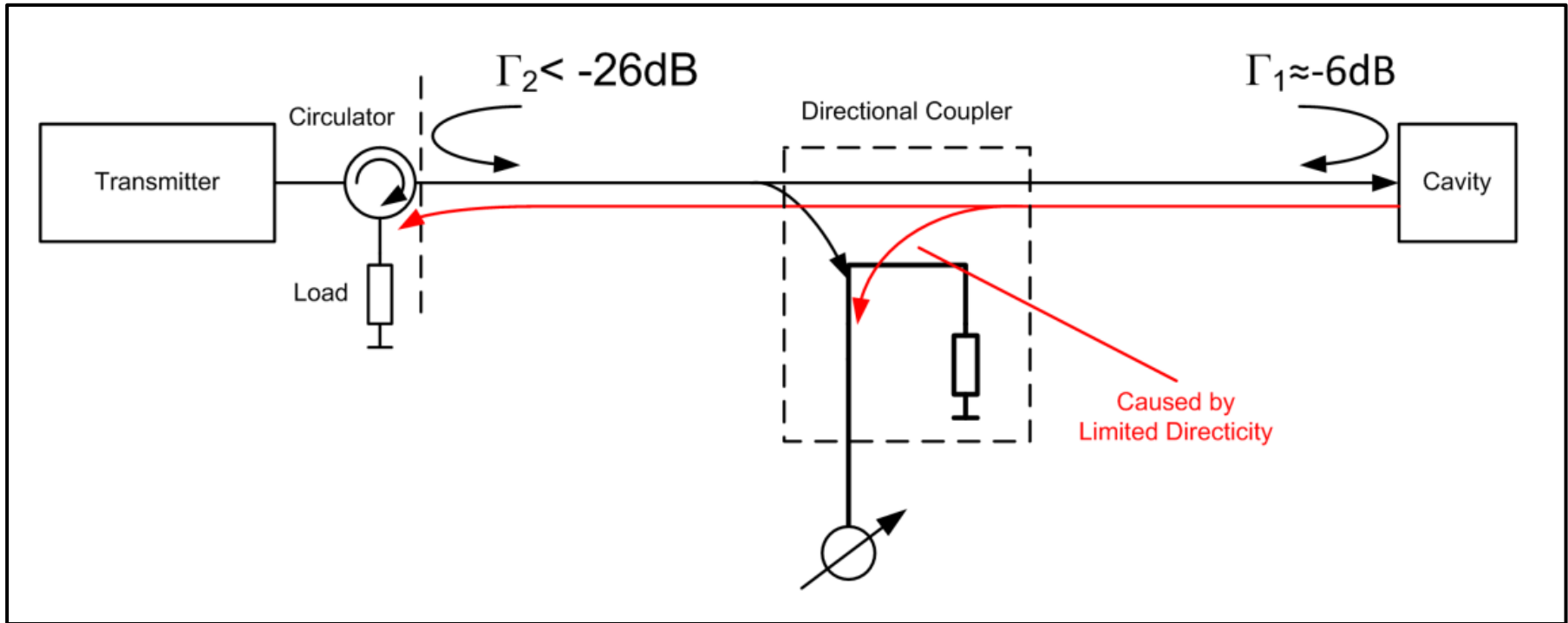


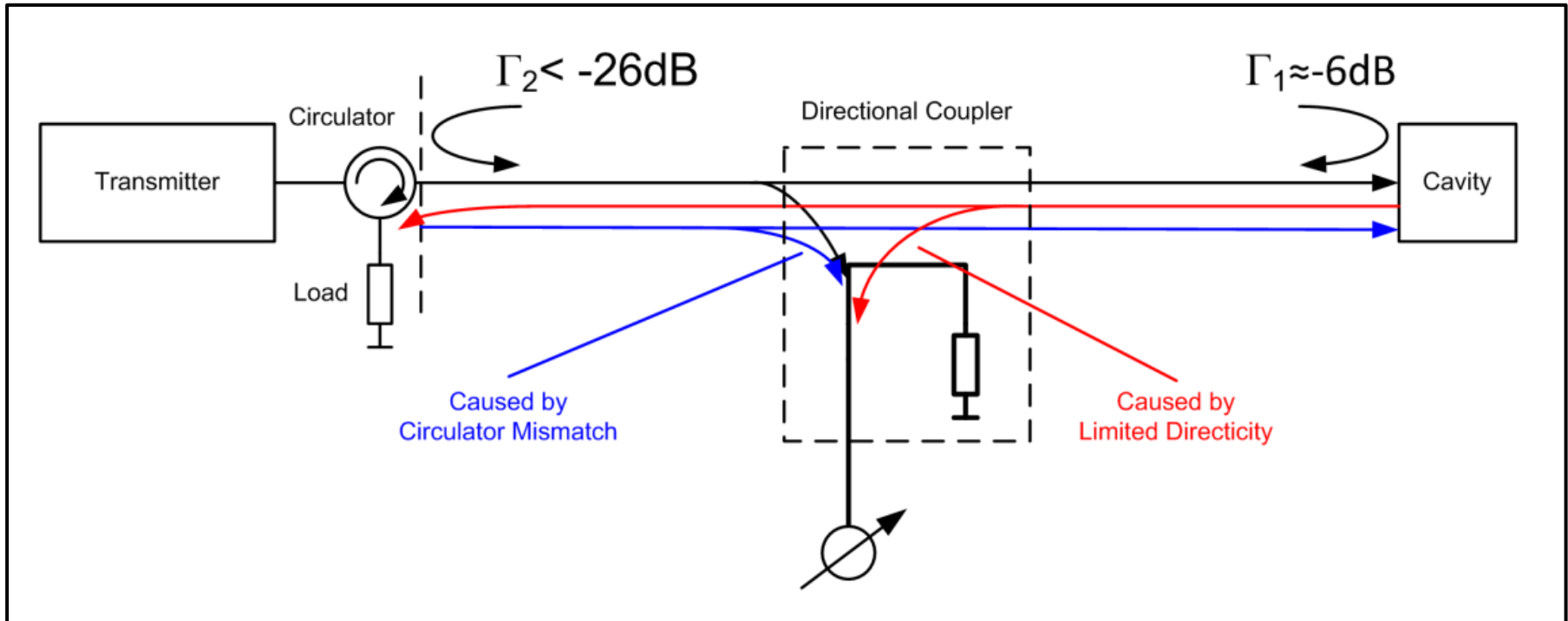


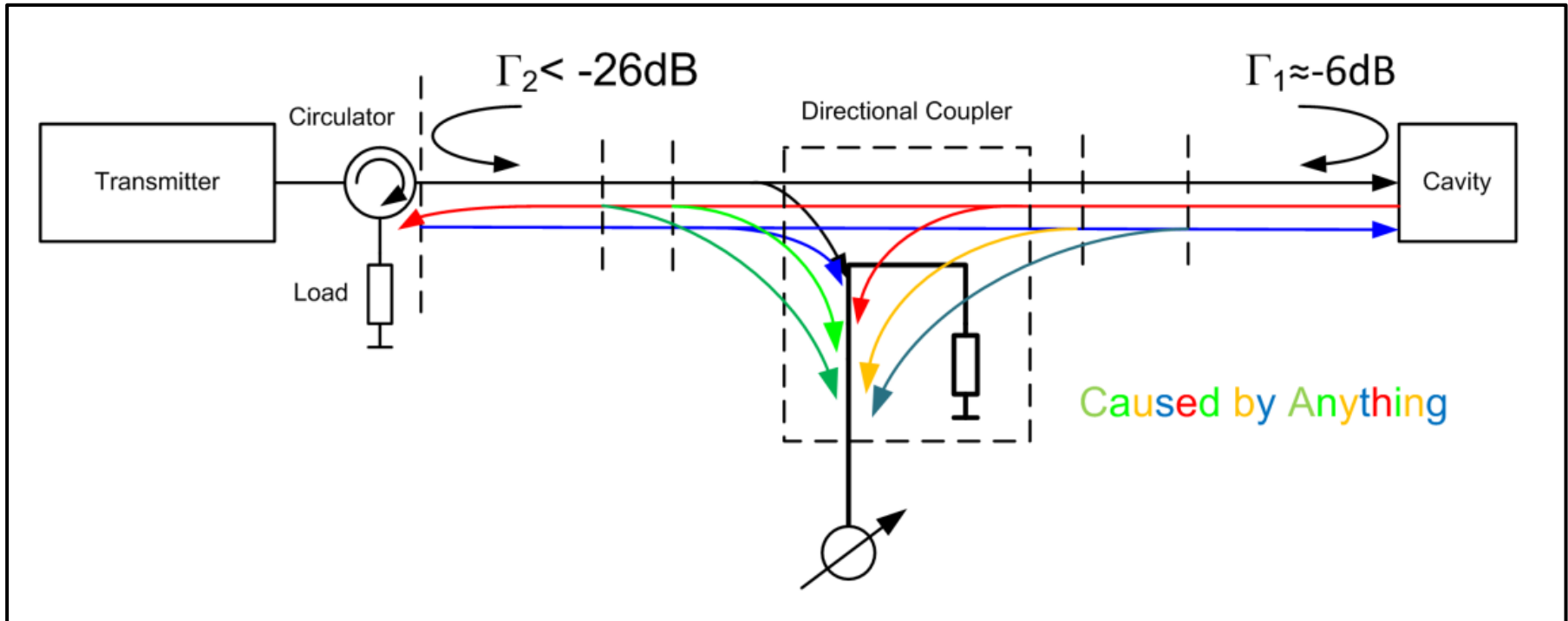








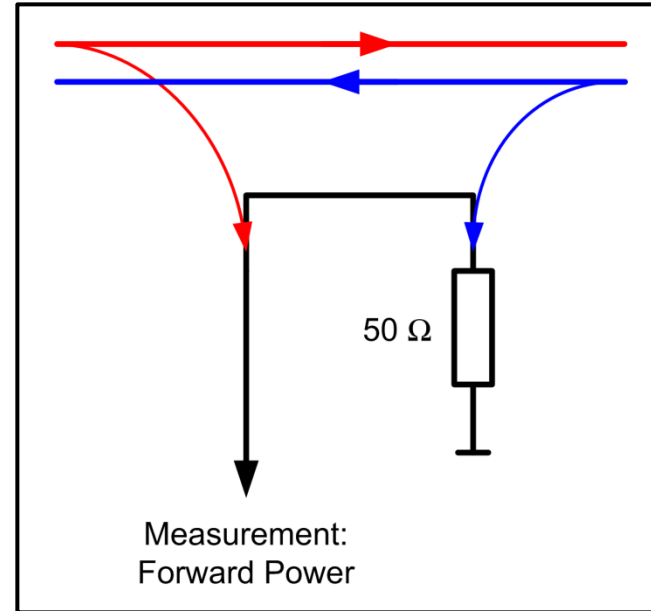




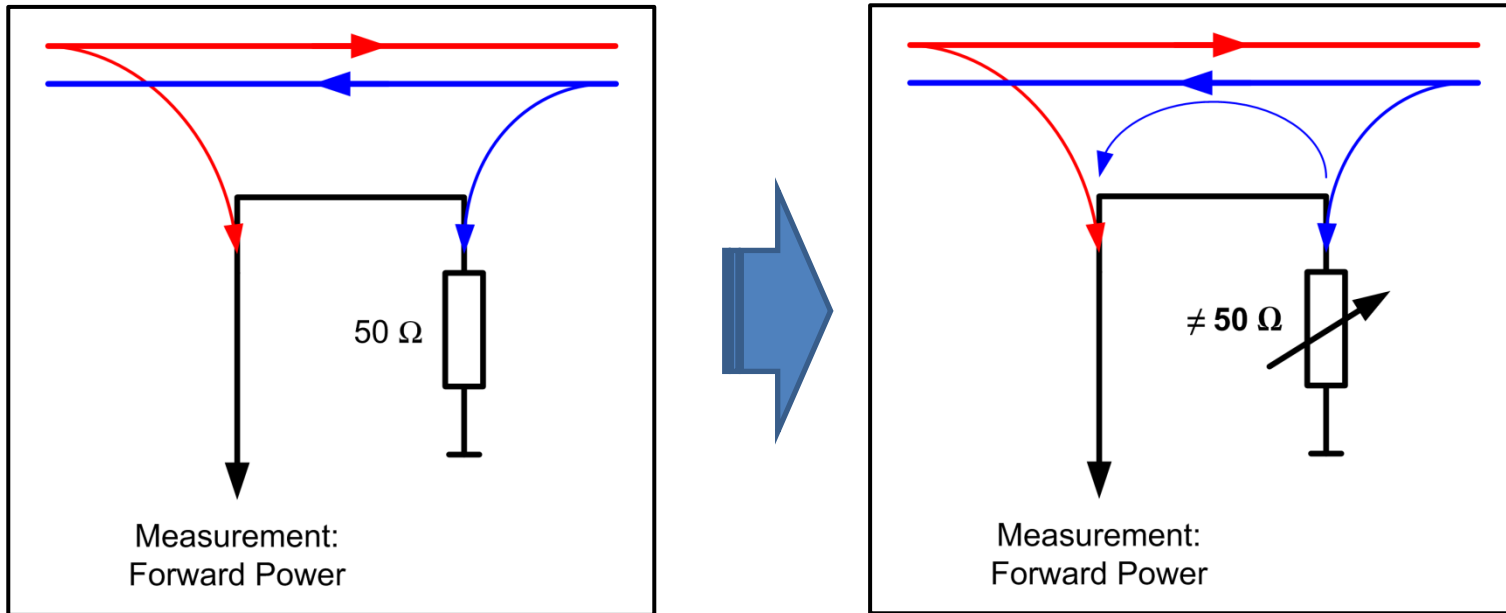
## How to deal with it?



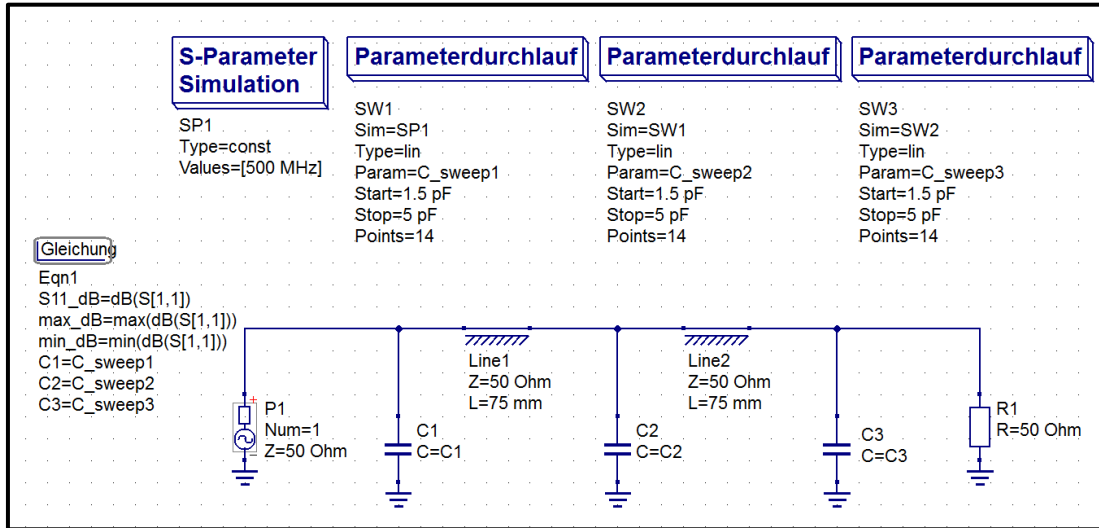




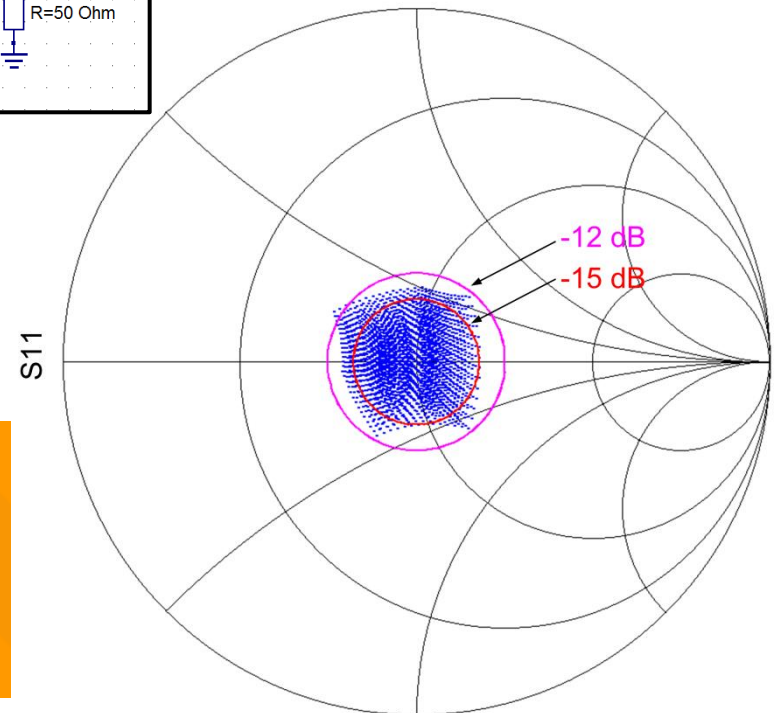
- Every coupled line is terminated at one end
- Directional Coupler has 2 coupled lines
- Termination is located externally!!!

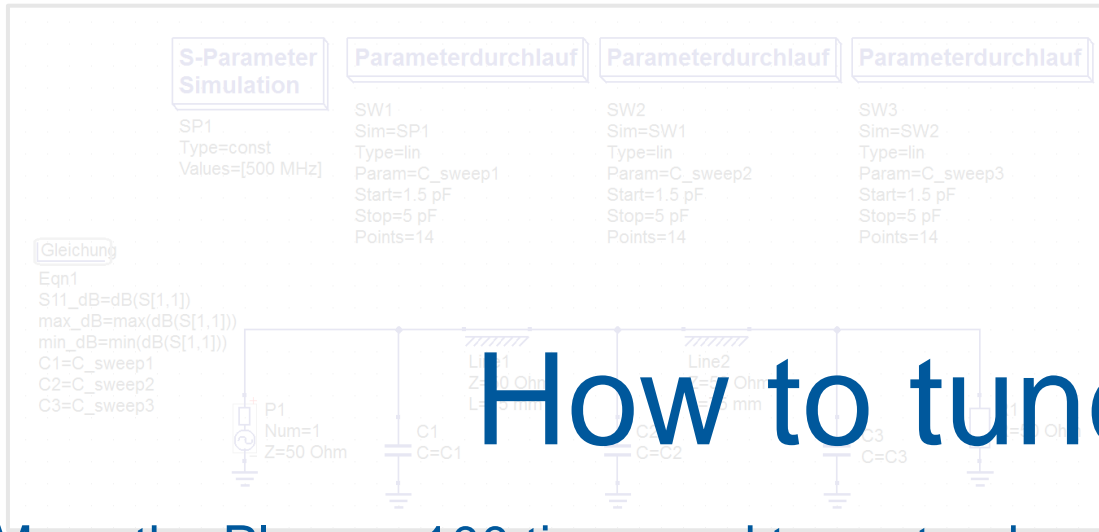


- Termination is replaced by Impedance Tuner
- Some Reflected Power is coupled to Forward Power Measurement intentionally
- → Measurement error can be dealt with
- Concept is known for decades, so far nothing new



- Any Impedance within -15dB can be reached
- Simple + Cheap + Effective

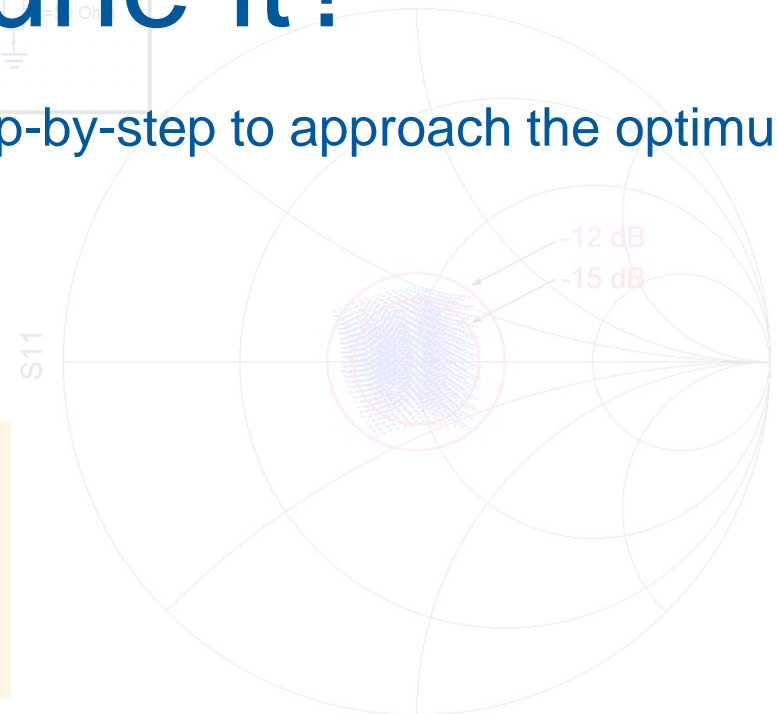




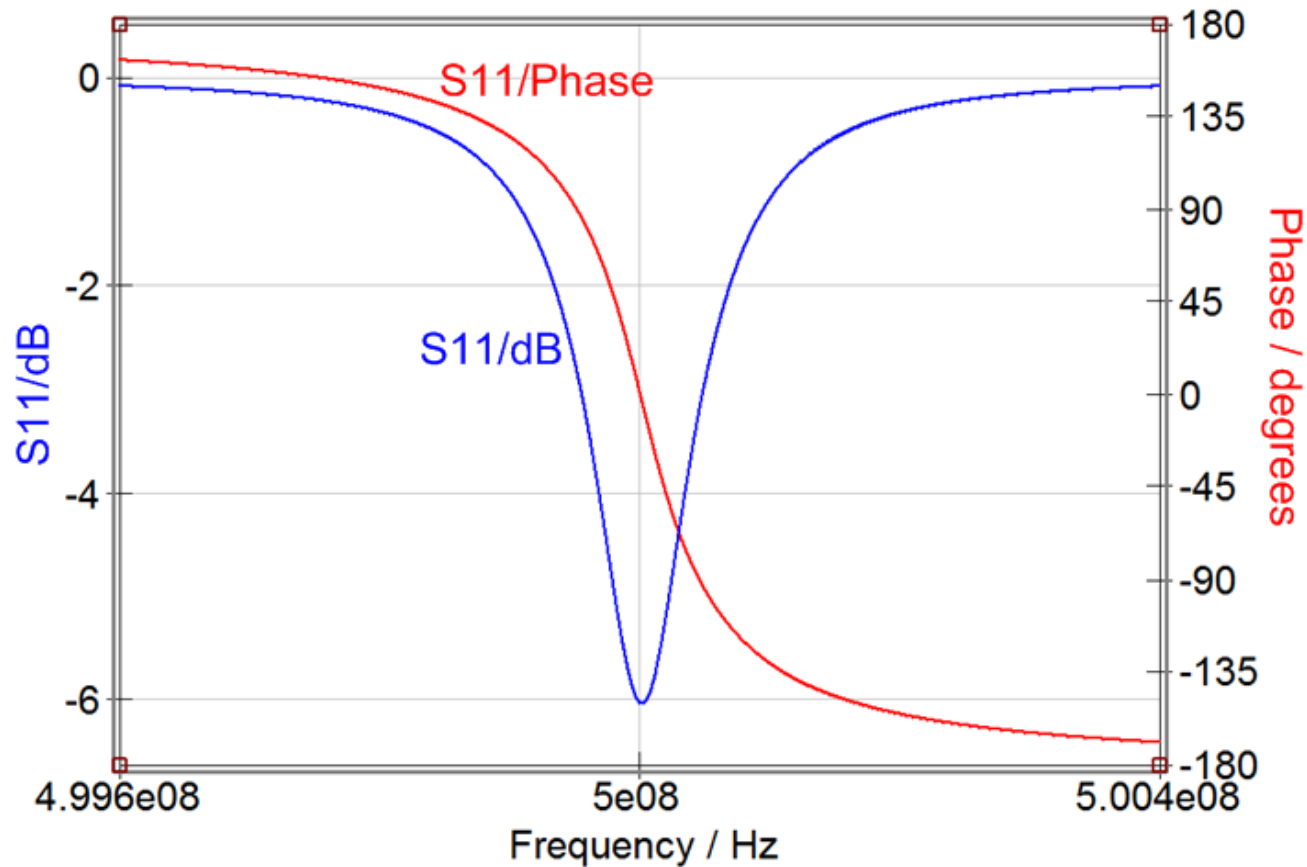
## How to tune it?

Move the Plunger 100 times and tune step-by-step to approach the optimum?

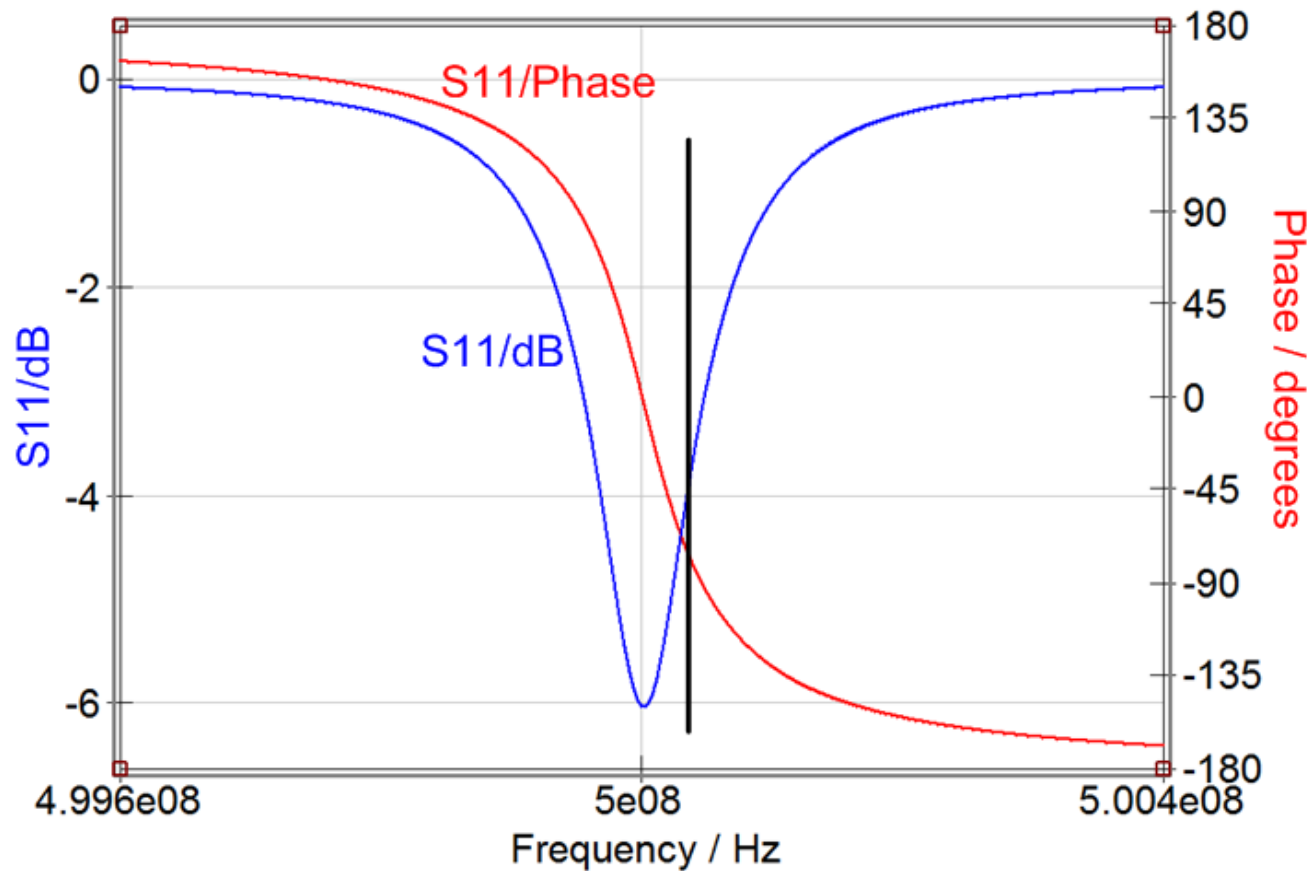
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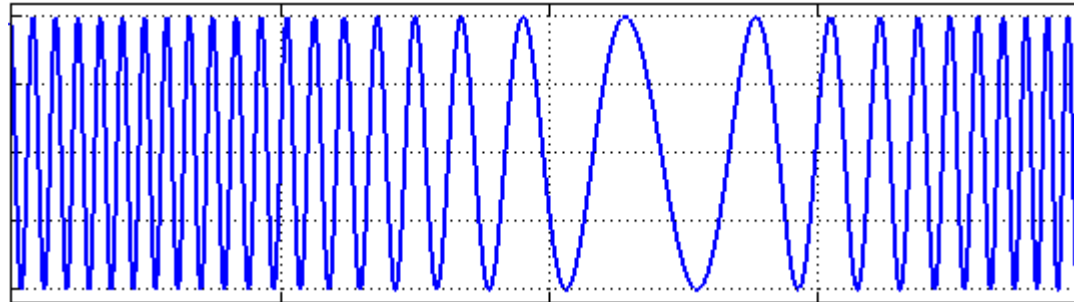


- A Cavity is a high-Q Resonator

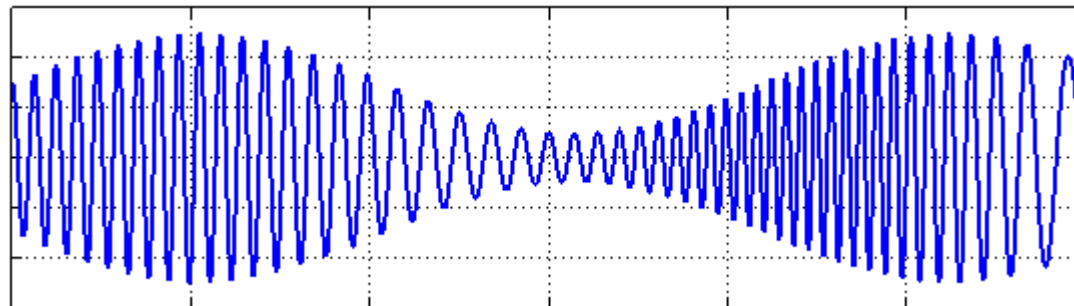
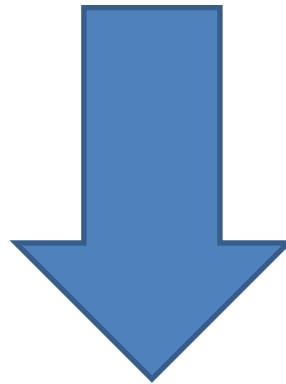
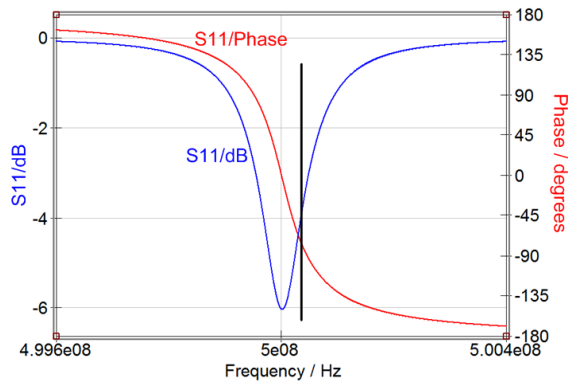


- Change the center Frequency to the middle of the slope

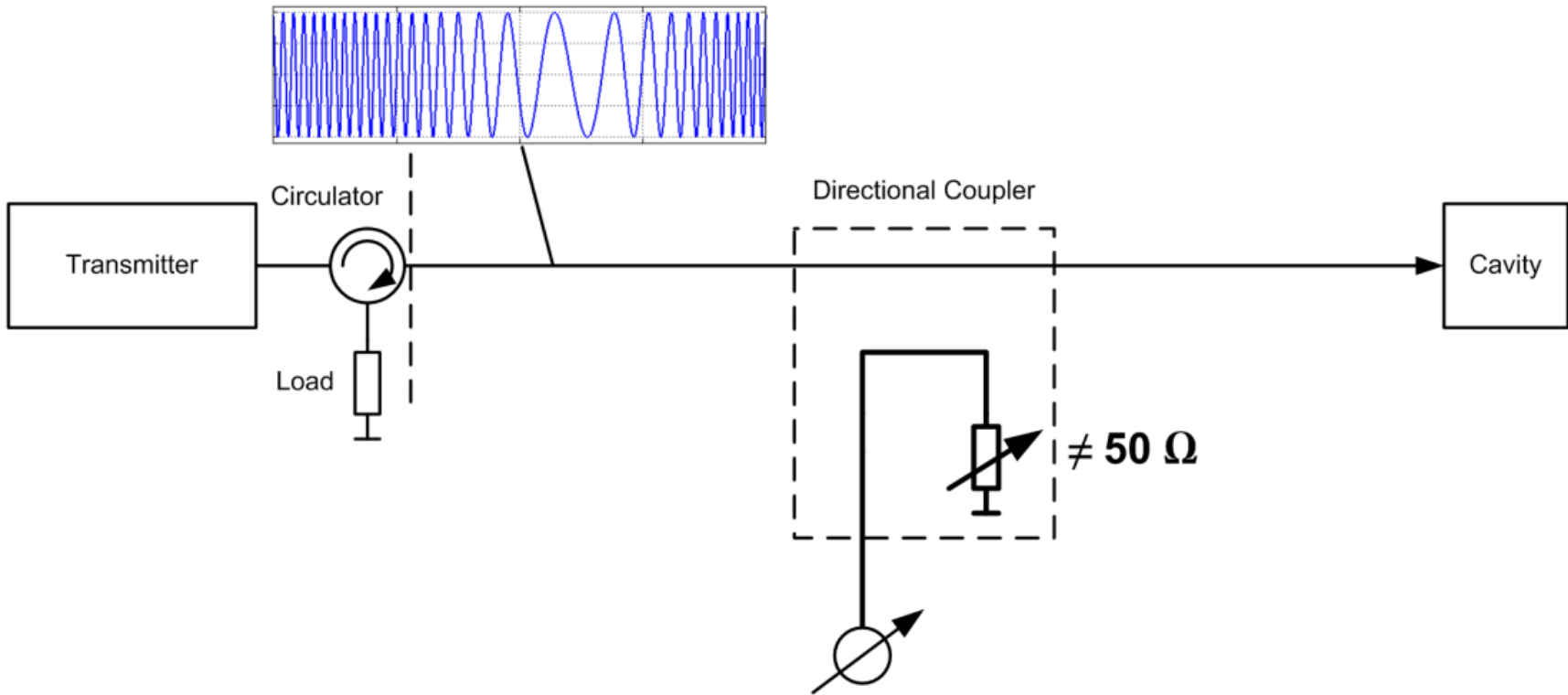




FM

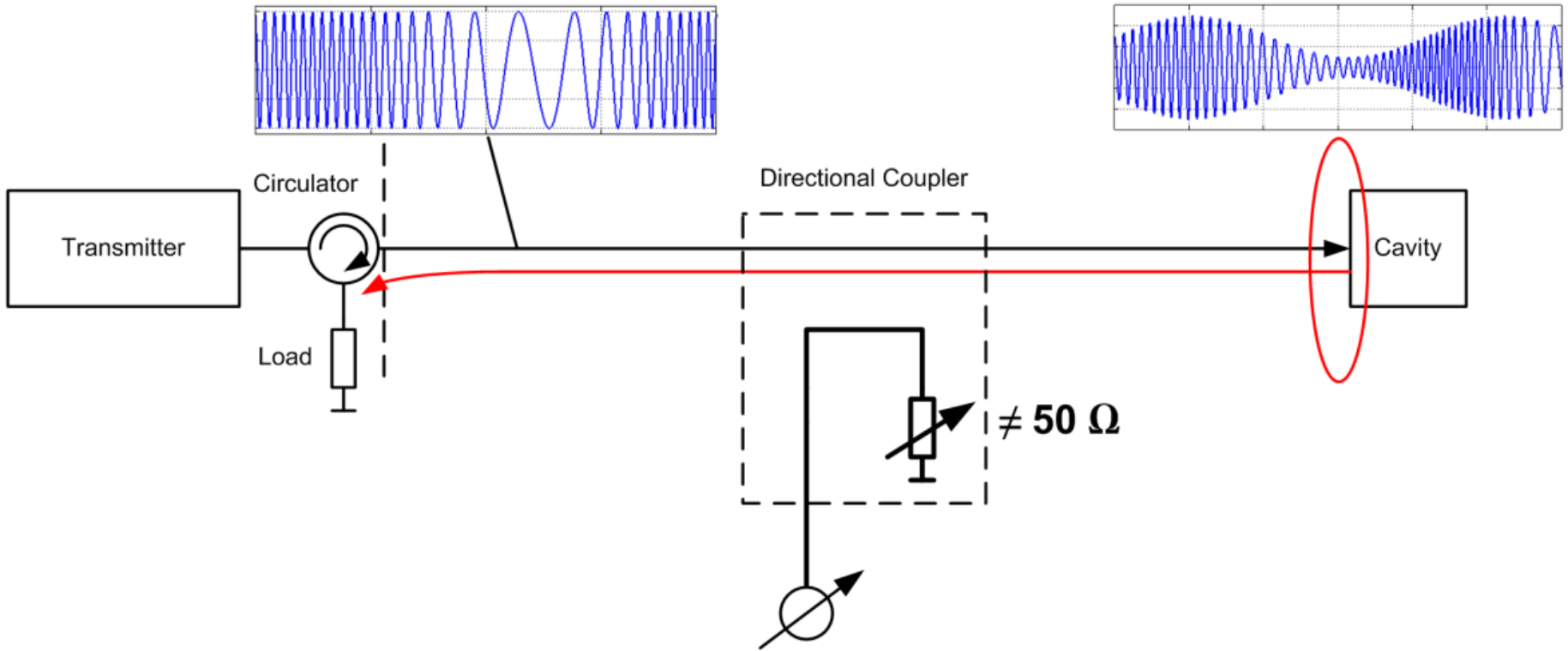


AM (+FM)



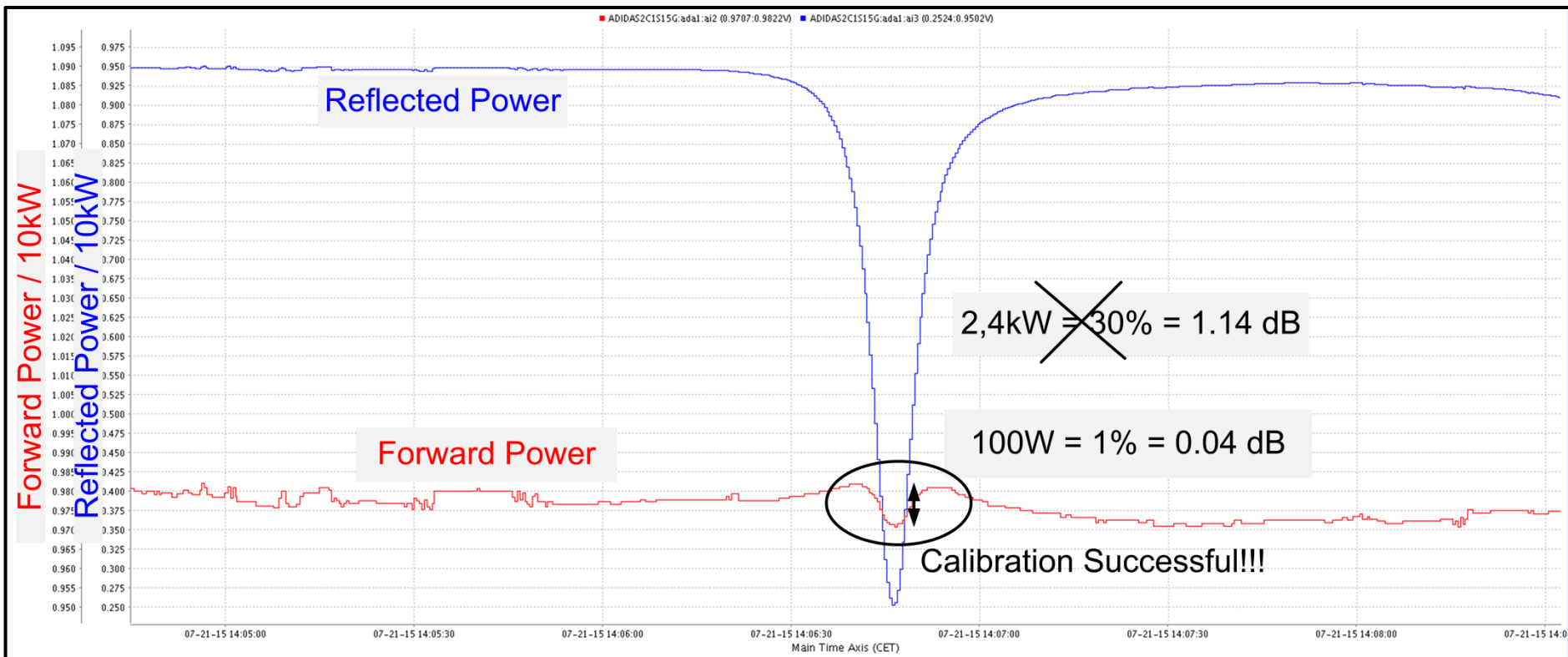
Incident Wave is FM only



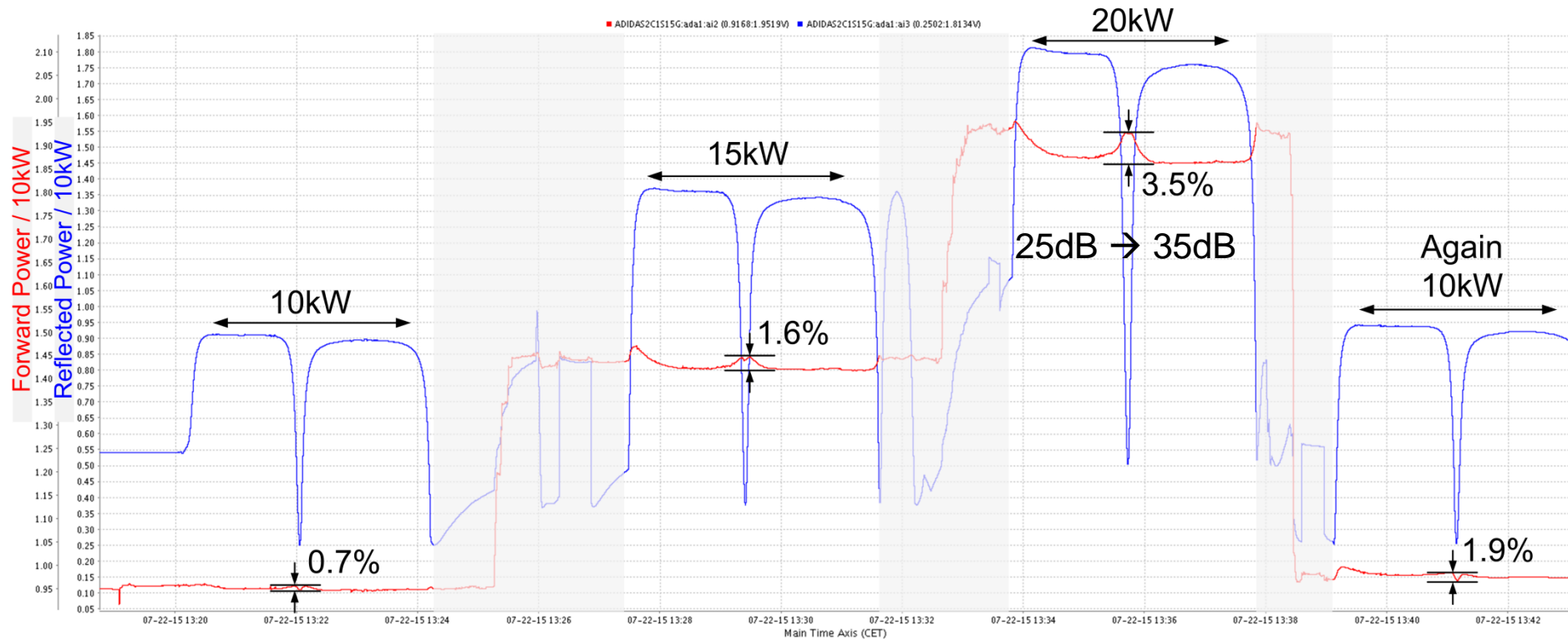


Incident Wave is FM only, but all the rest is AM!!!

Once Again: Plunger Movement – but calibrated Forward Power!

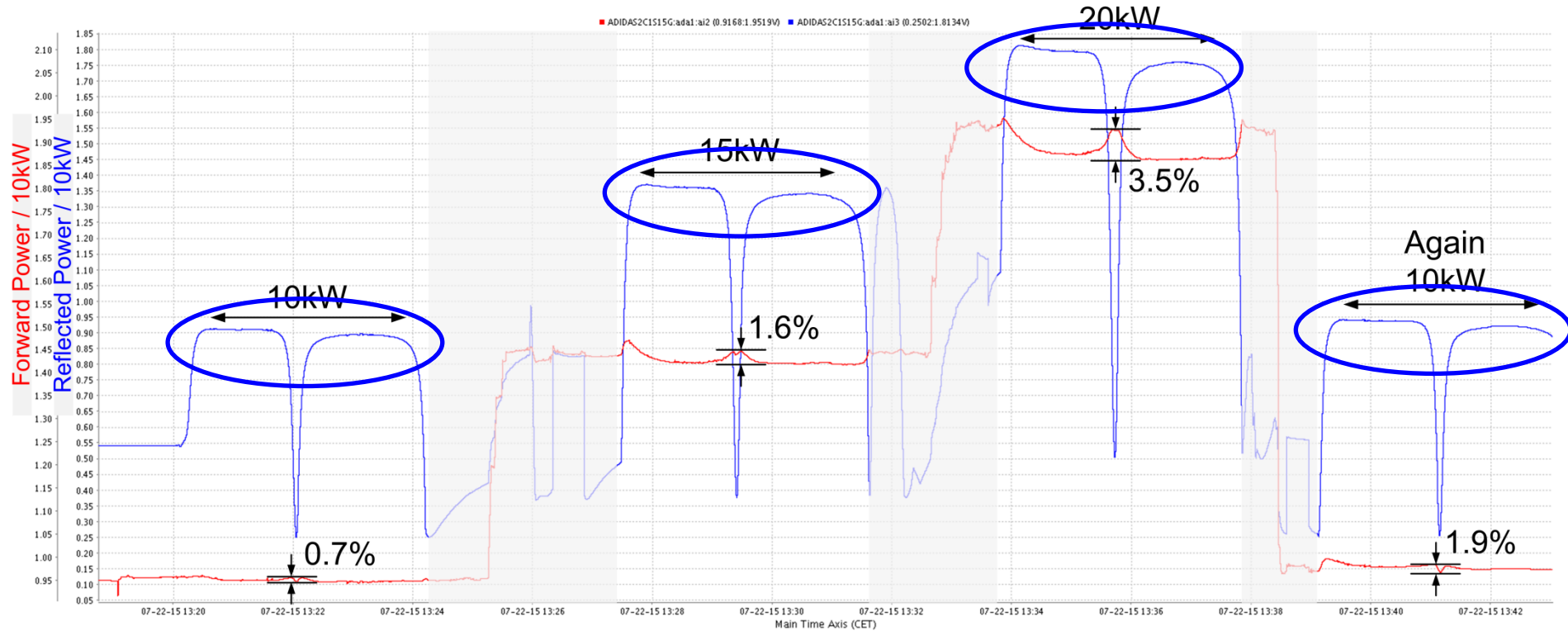


Improvement for Directivity: 25dB → 52 dB

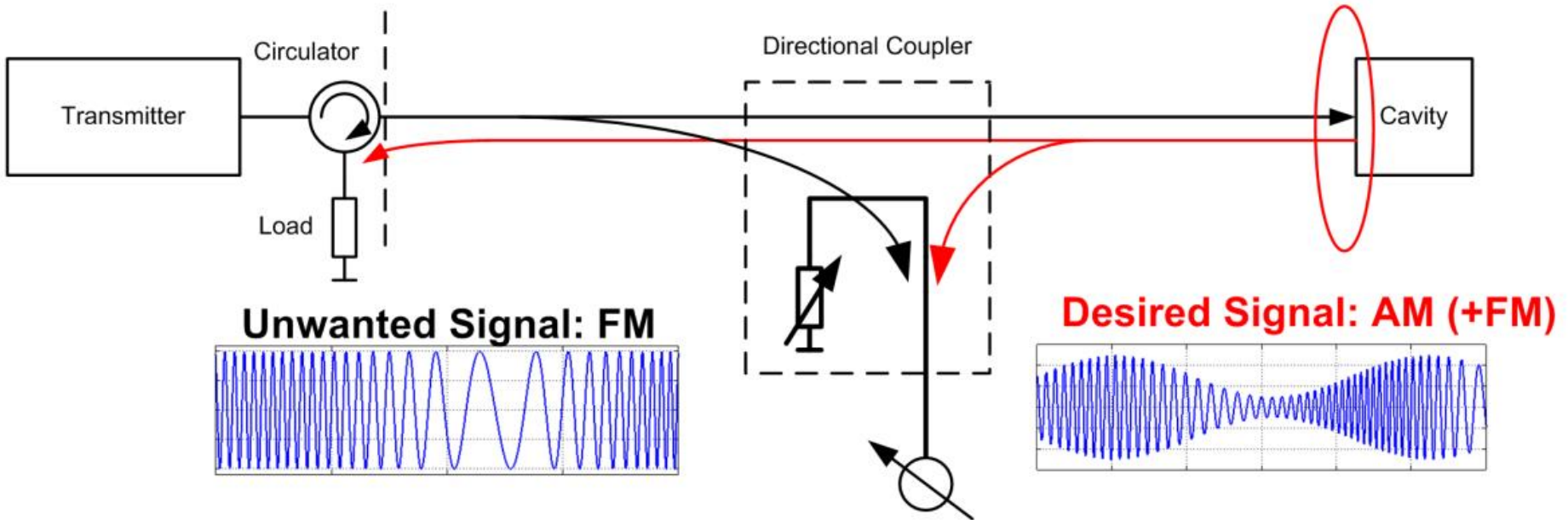


Variation might be caused by Temperature rise of Circulator  
→ Calibration should be done at Maximum Power

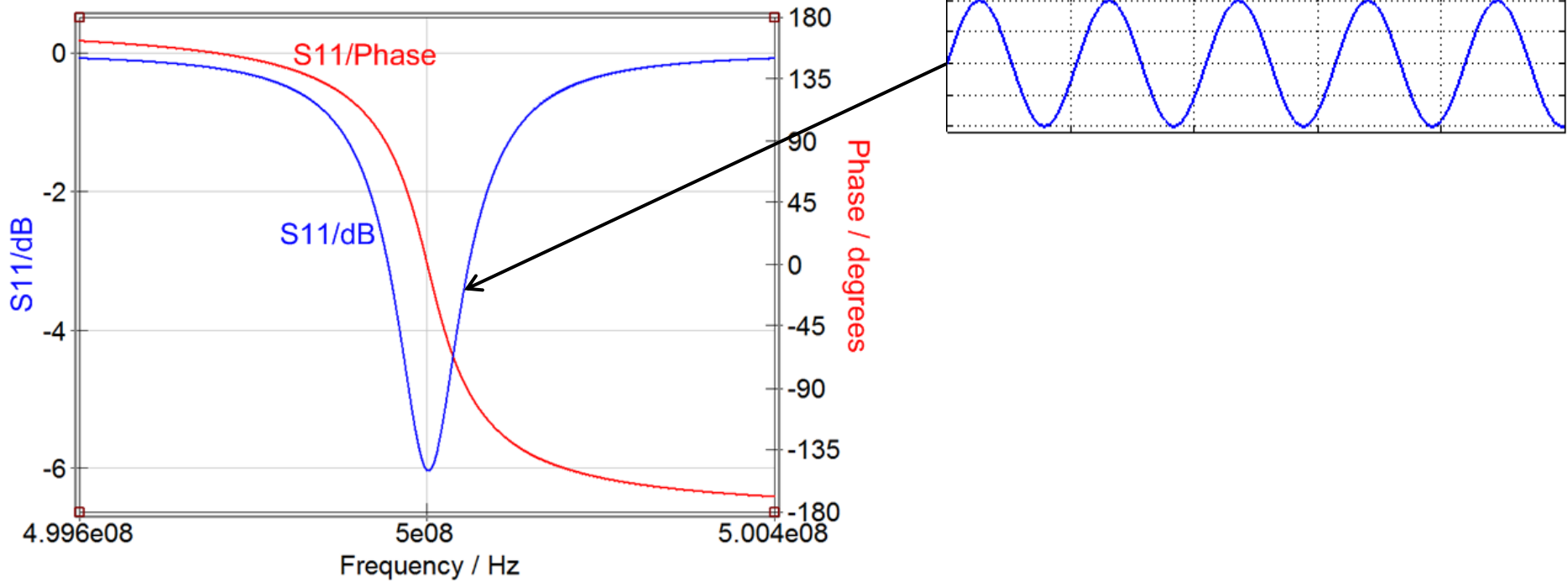
# Calibrating the Reflected Power

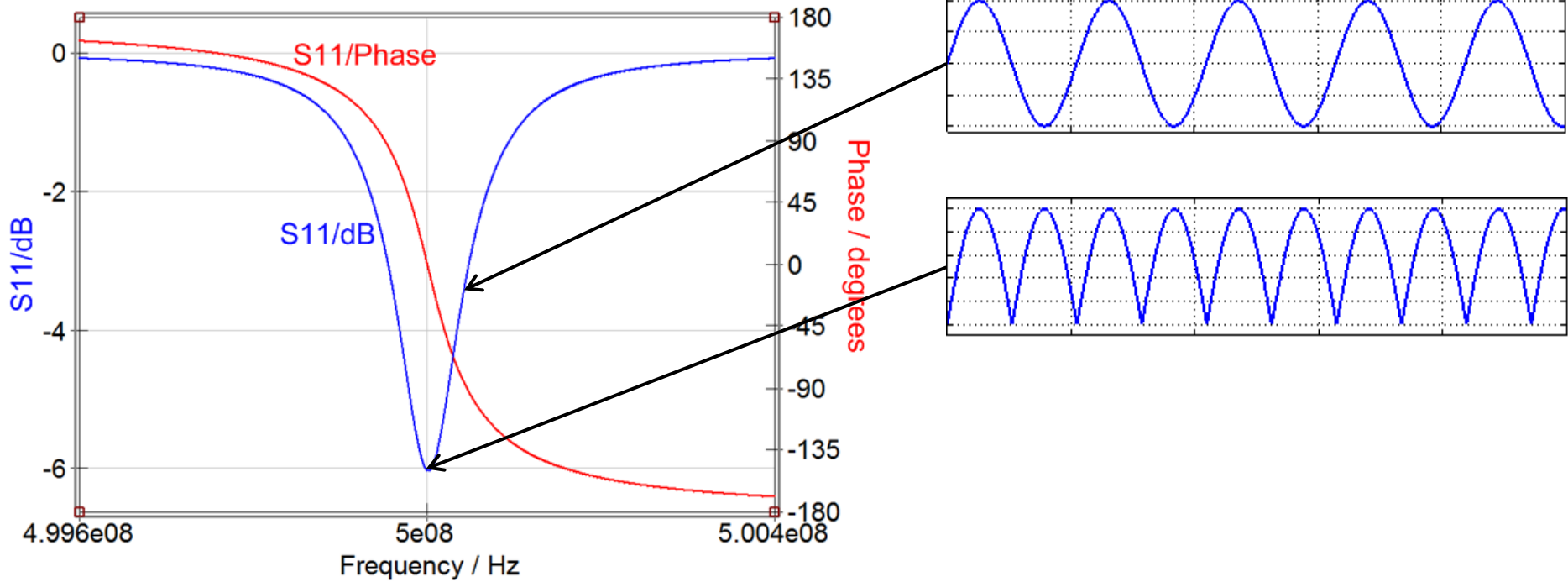


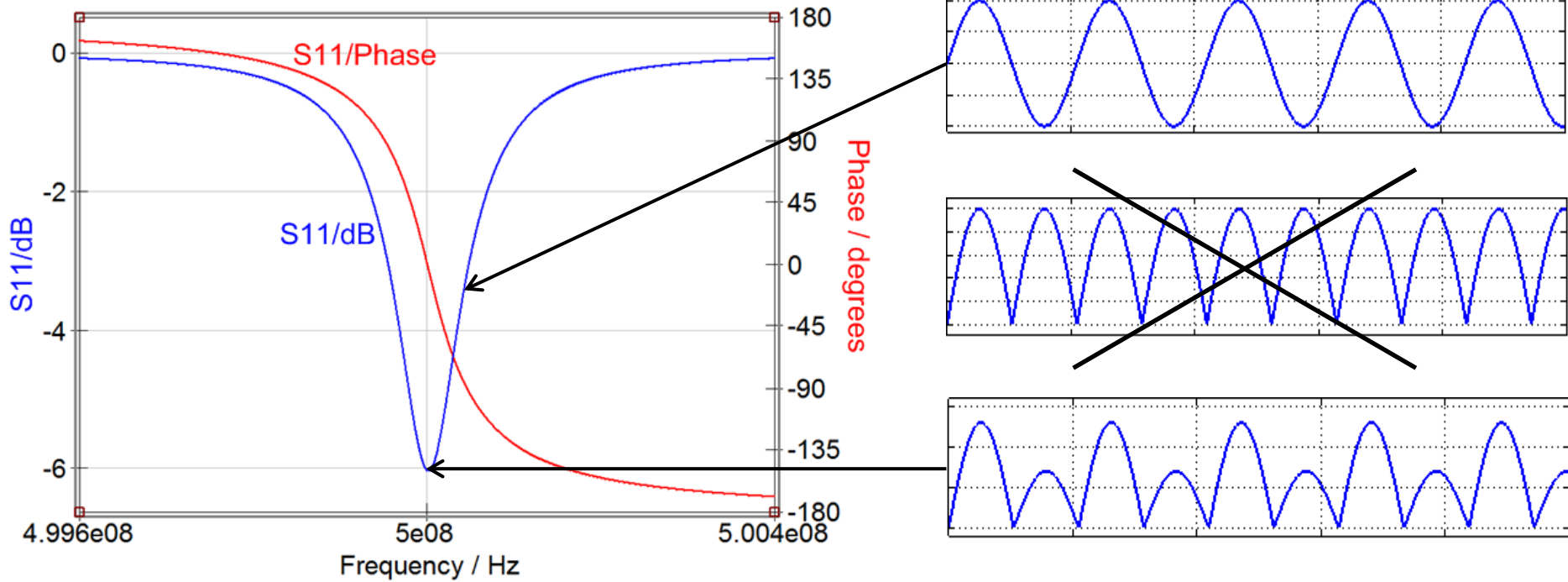
Can the Measurement of the Reflected Power be calibrated just as well?



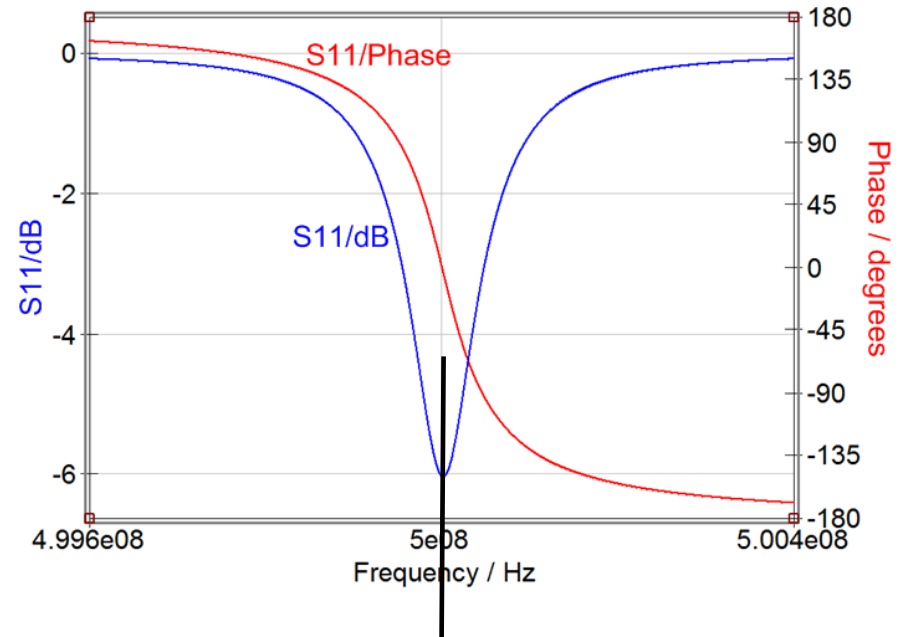
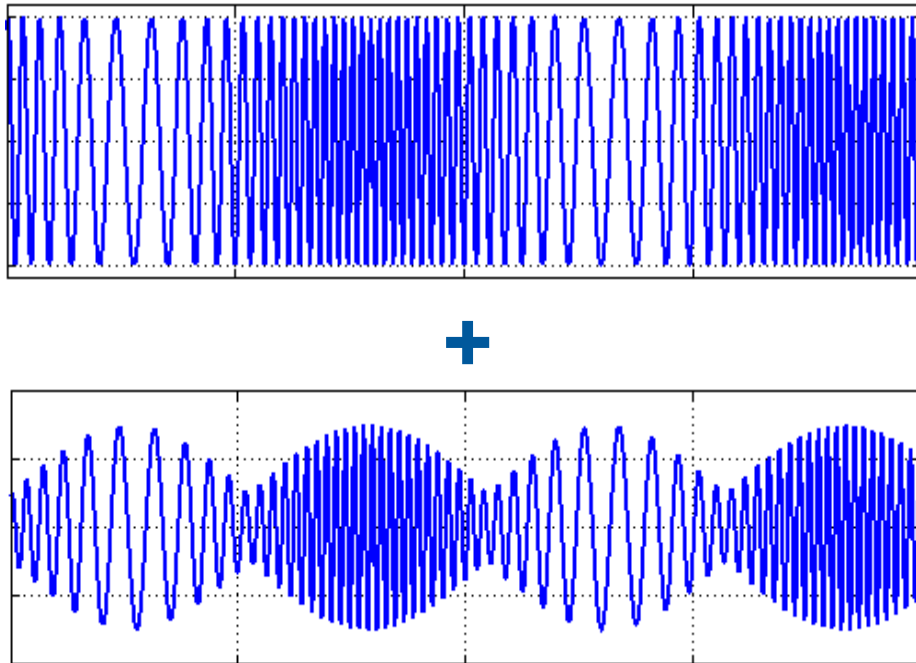
Answer seems to be NO



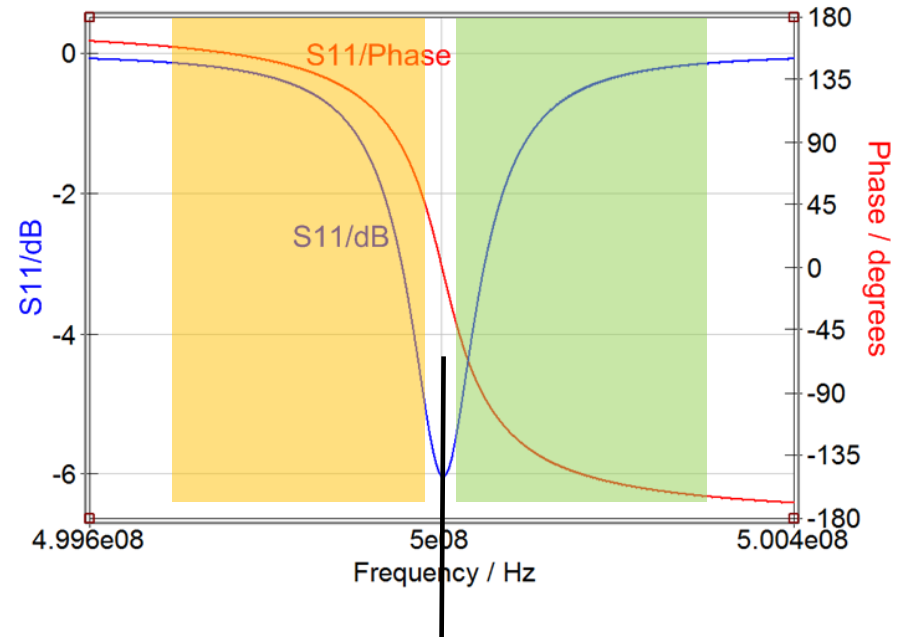
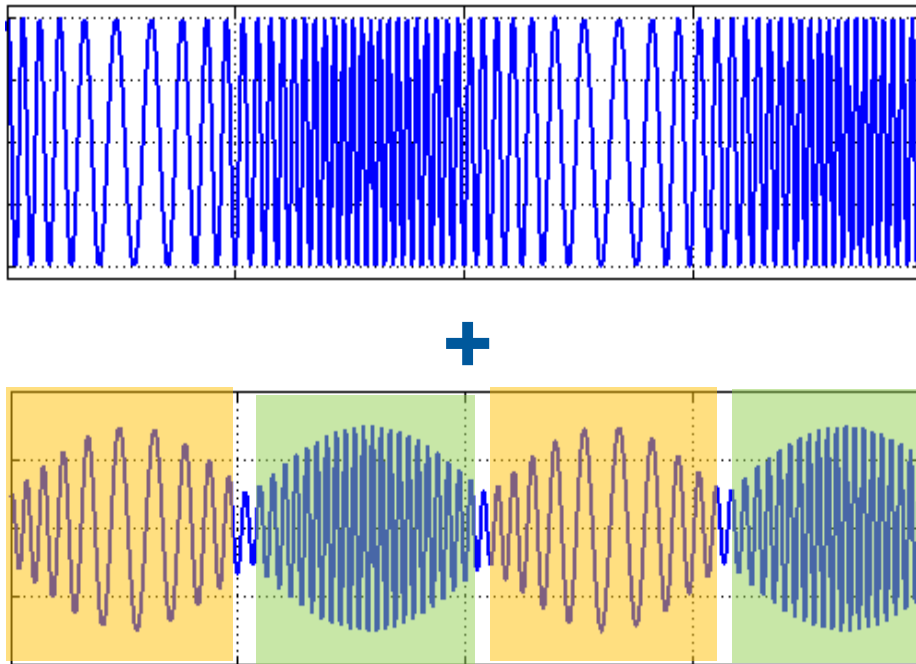




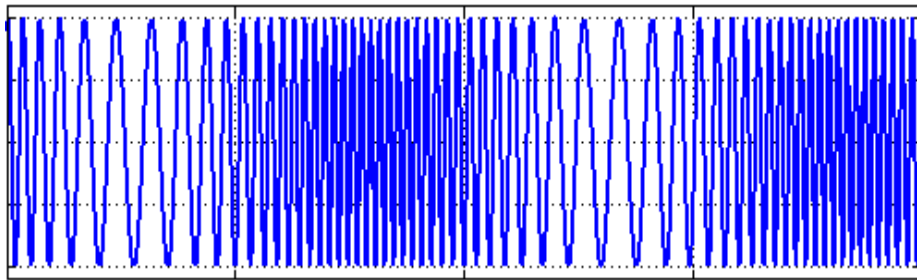




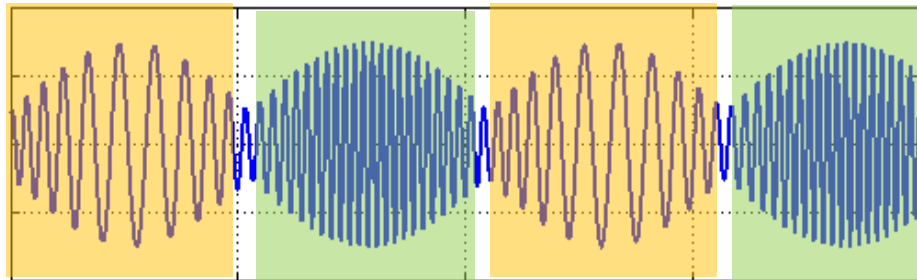
Center Frequency



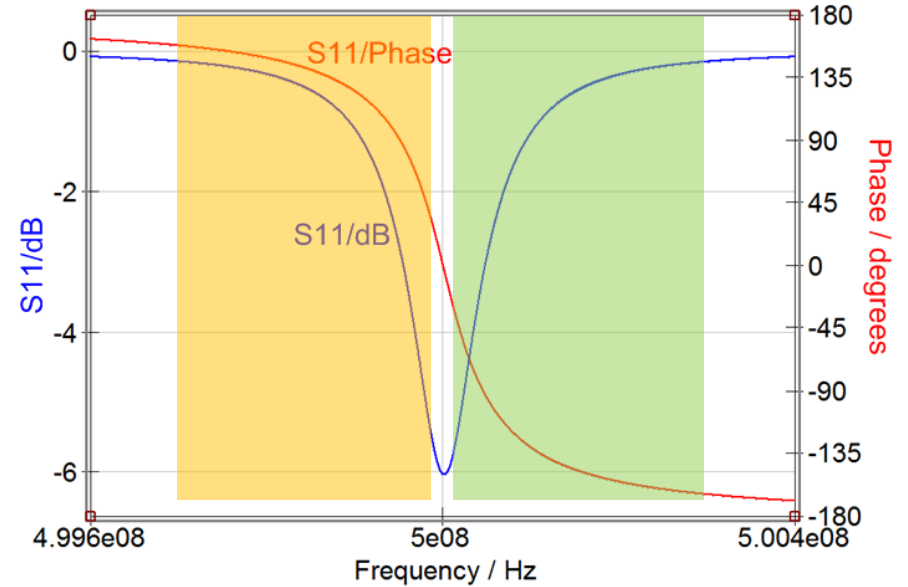
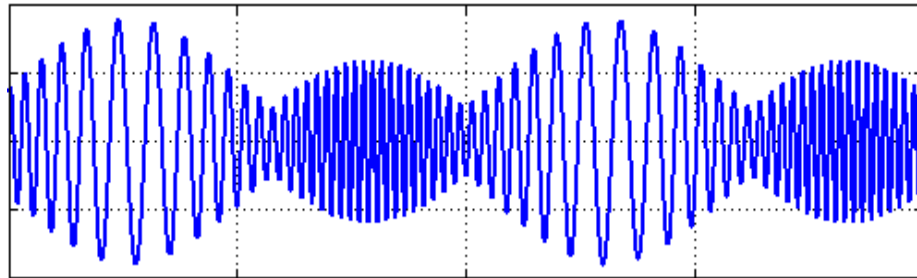
Center Frequency



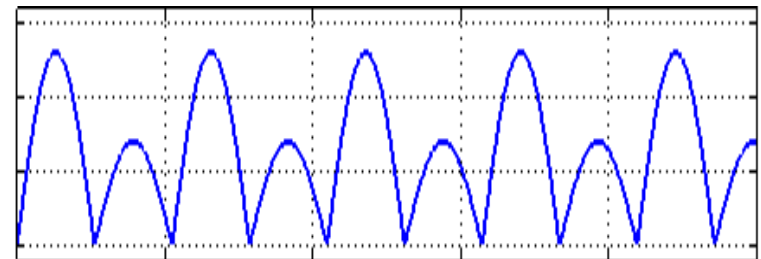
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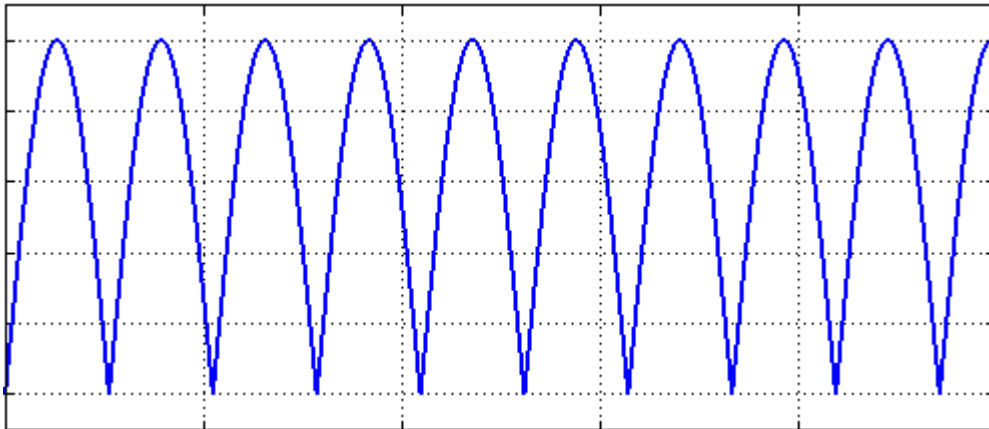
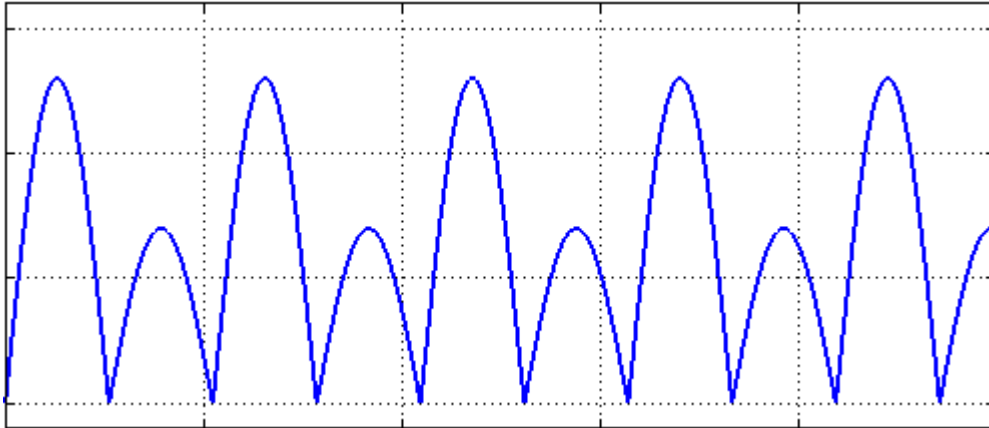
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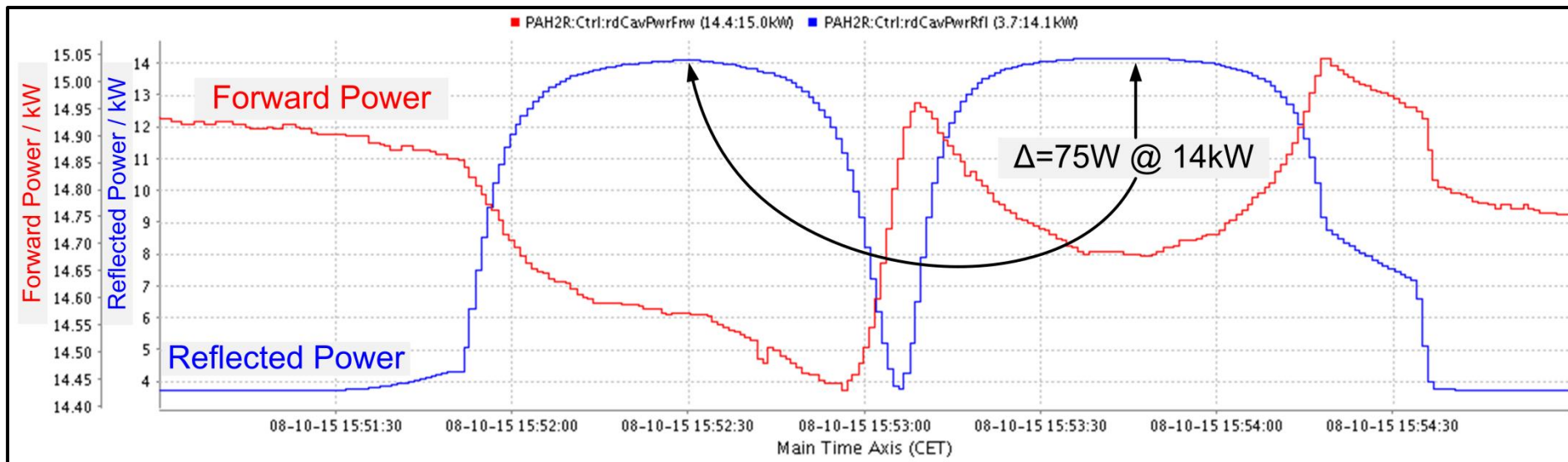
## Demodulated Signal



## Demodulated Signal



**Impedance Tuner**



- Calibration works for Reflected Power too
- Actually a lot better than for Forward Power
- Reduction from 200W@10kW → 75W@14kW refers to Improvement of Directivity of 11dB

## Summary

- New Method significantly reduces measurement error
- Easy to implement, cheap on the material
- Limitations due to temperature drift

## Future Activities

- Installation of Impedance Tuners at all Directional Couplers
- Further Tests are necessary

Thank you !