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Active Antenna Tuning: Benefits and Challenges

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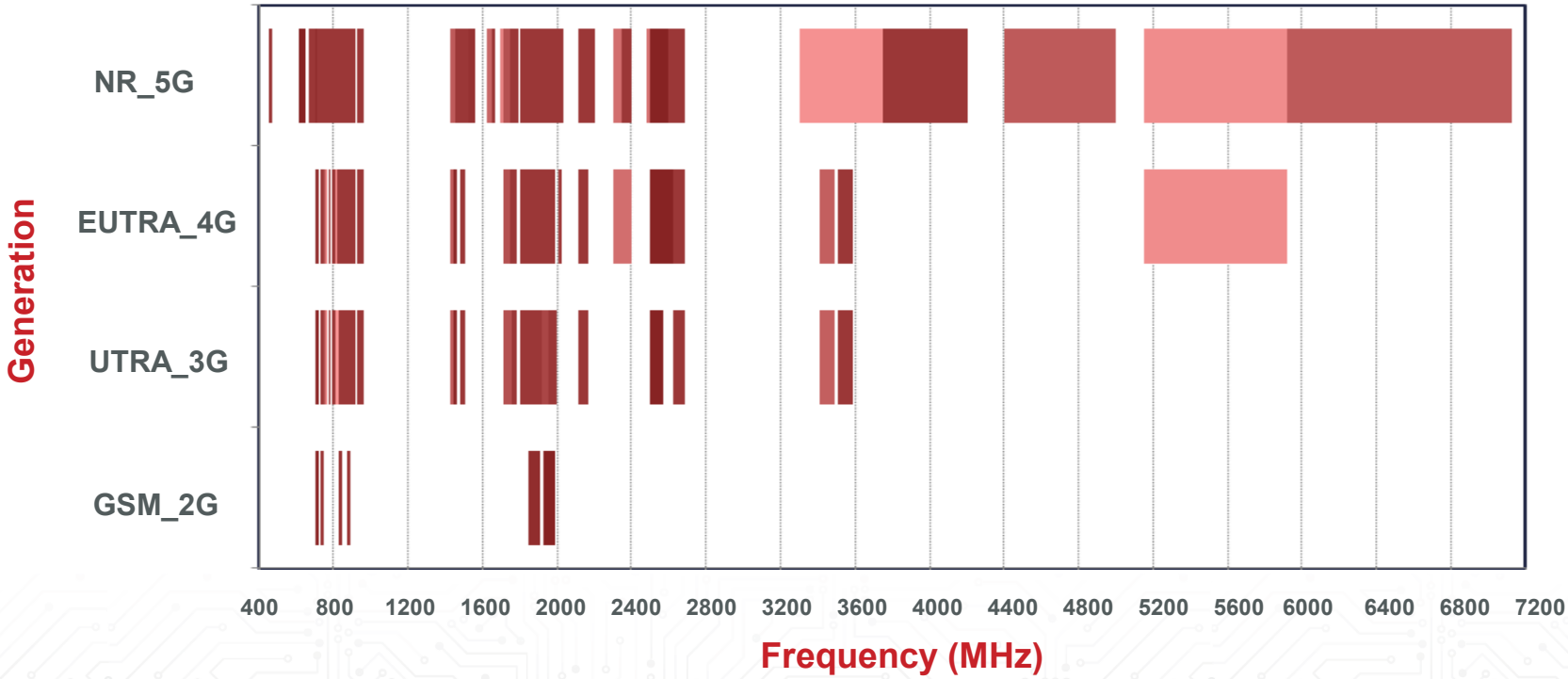
Background

Each spectral iteration has created an inherent antenna design challenge.

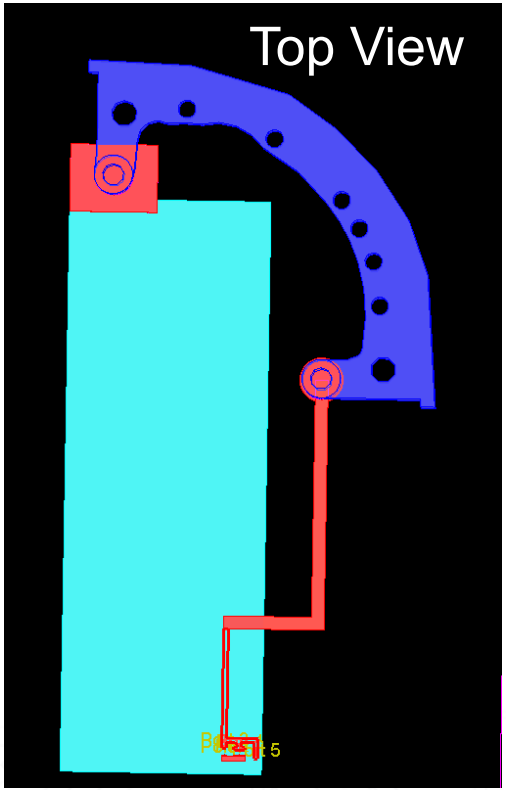


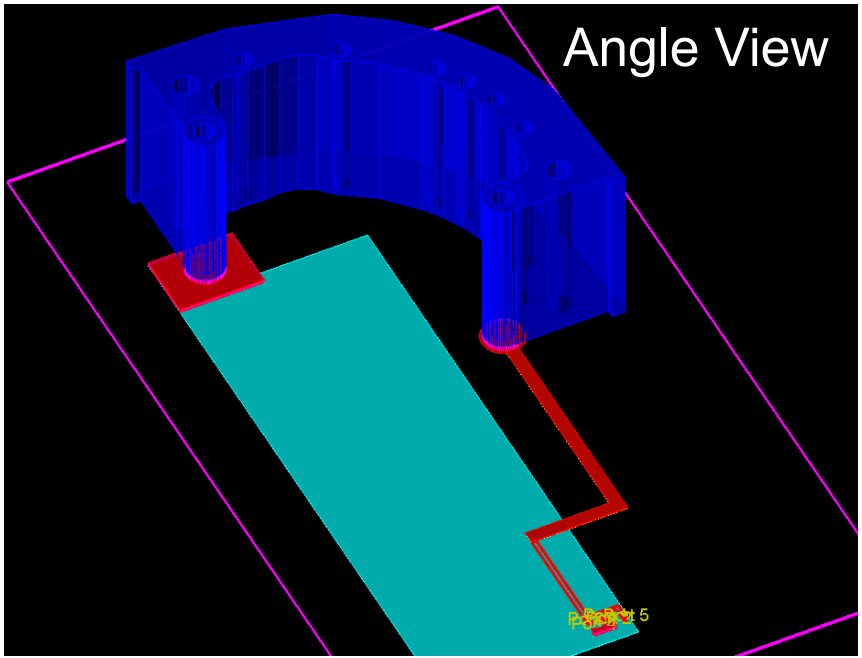
Challenge 1: Non-Ideal ANT Design

Size and Design

Environment

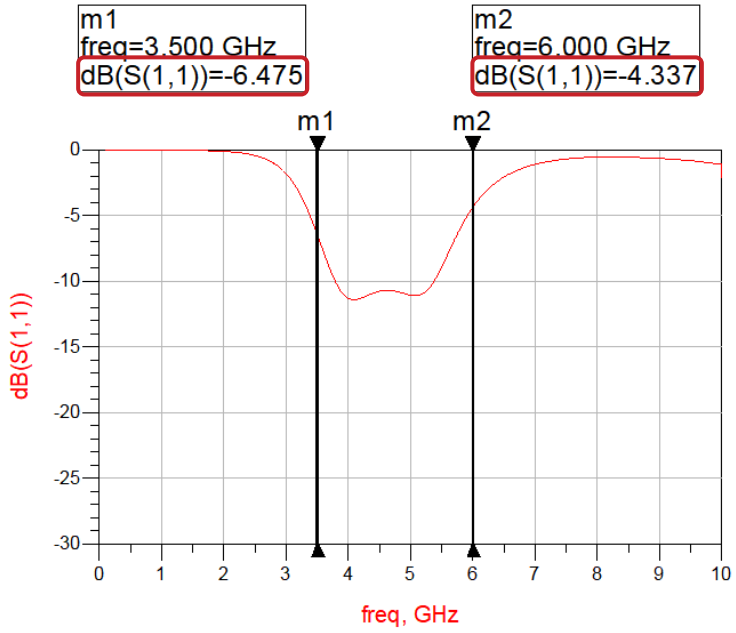
Challenge 1: 5GNR Phone ANT



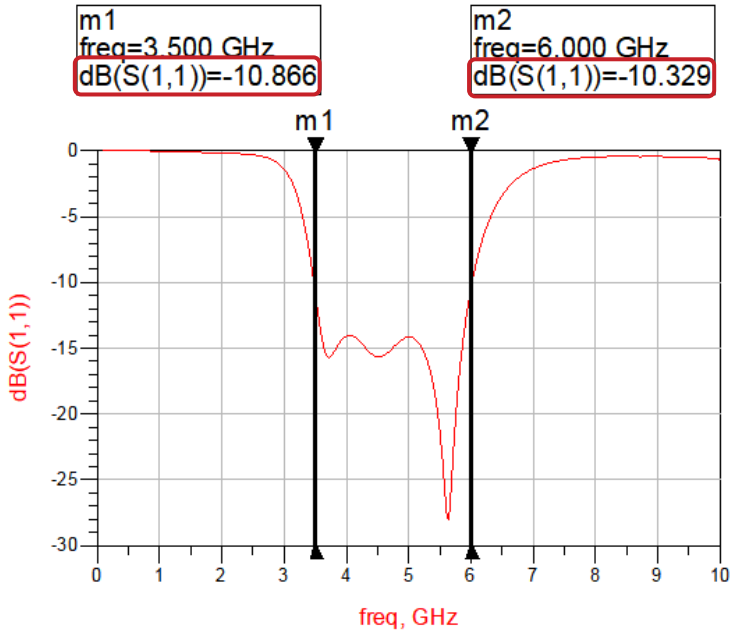


Challenge 1: 5GNR ANT with Tuning

w/o Antenna Tuning

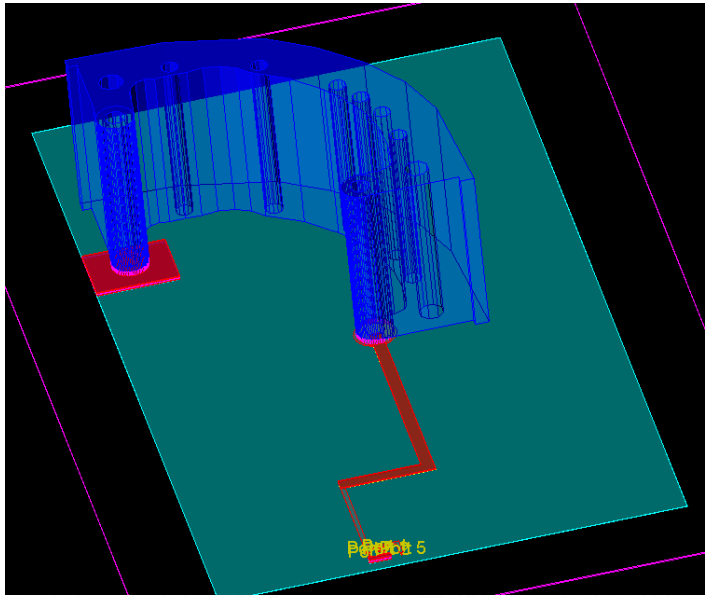


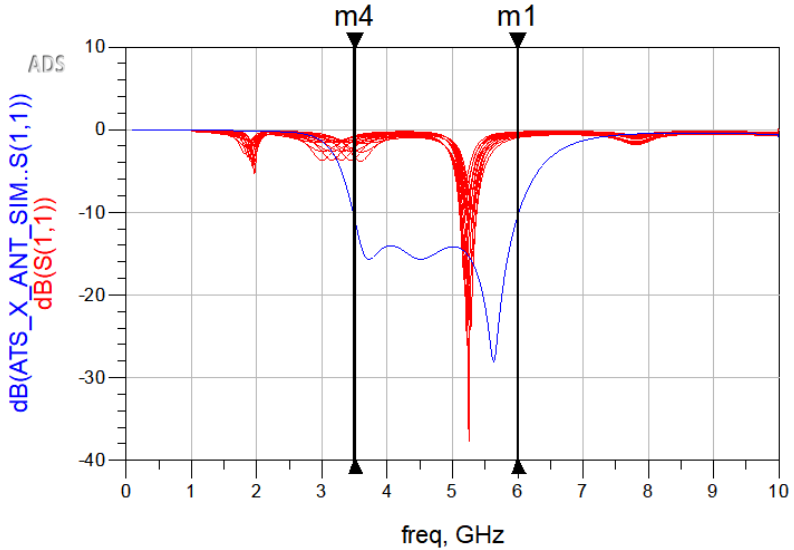
Antenna Tuning



Challenge 2: ANT with Mismatch

- Phone placed on a metal surface (hood of car) creates an exceptionally large impedance mismatch.





Challenge 2: ANT with Mismatch – High Voltage

Power Class 2

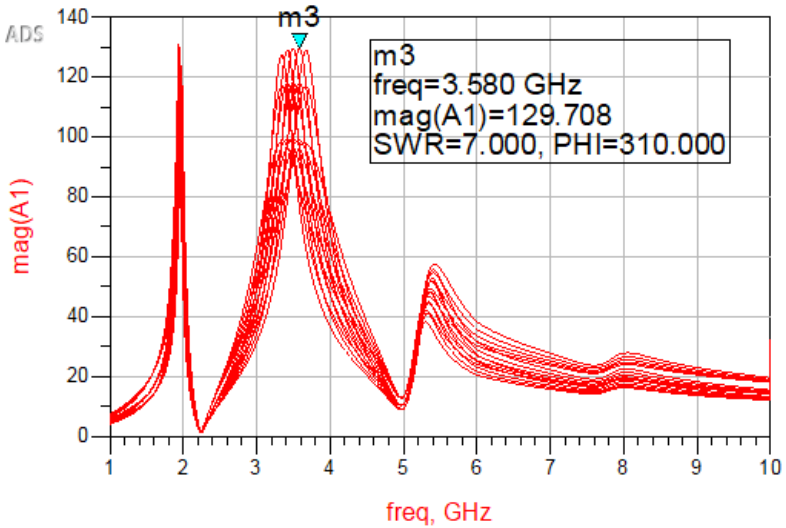
VSWR due to ANT mismatch

Worst Case Vp

PWR (dBm)	PAPR (dB)	SWR	PHI	Vp
26	13	3	300	99.5
26	13	5	300	118.2
26	13	7	310	129.7
26	10	3	300	70.4
26	10	5	300	83.7
26	10	7	310	91.8
26	7	3	300	49.9
26	7	5	300	59.3
26	7	7	310	65

OFDM PAPR

Phase Sweep



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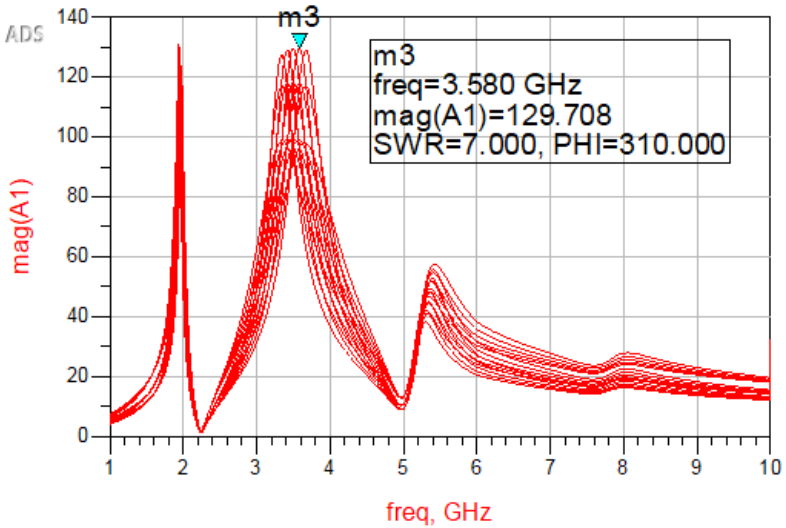
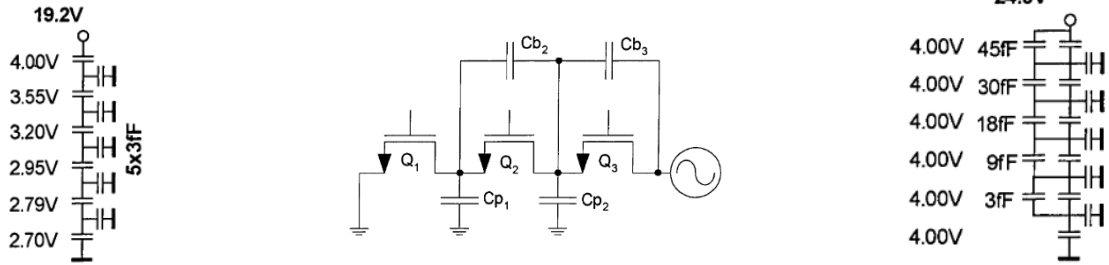


Challenge 2: Internal Protection?

- **Problem:** Power detector protection IC is not an option for antenna tuners.
- **Reason:** Typical RX protection circuitry utilizes a handful of diodes that trigger when the power becomes too large.
  - *Example:* If an RX device requires 10 diodes (20 dBm), then ANT tuner would require > 320 diodes (36 dBm).
- **Solution:** The antenna tuning device must be able to survive the power without relying on protection circuitry.

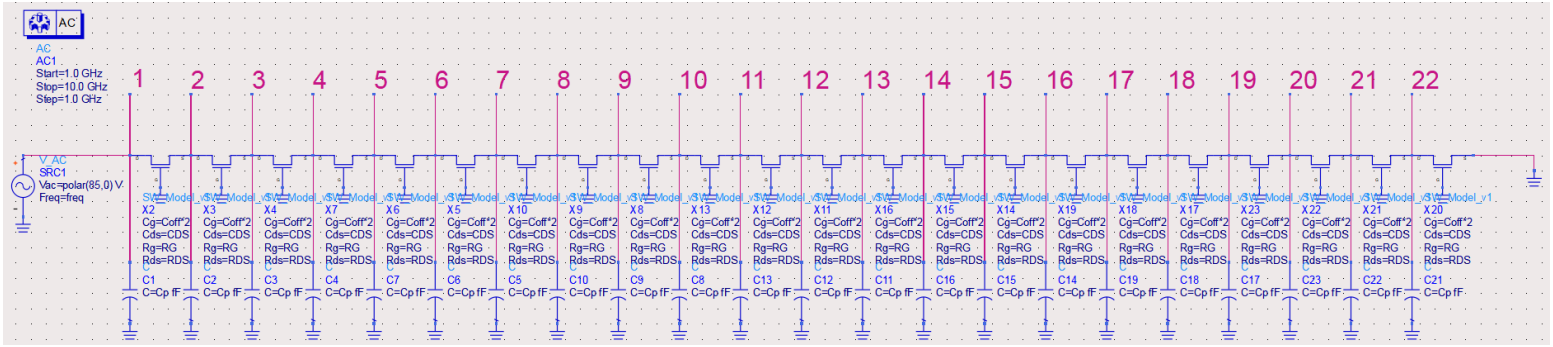
Challenge 2: Voltage and Parasitic Cap

- SOI Vp/Stack ~ 2.5-4.5V
- Vp is dependent upon the gate length and the selected technology node.
- Surviving high Vp requires a substantial stack height → 85Vp = 22 stacks
- Device and layout parasitic capacitance causes uneven voltage distribution that becomes worse with each additional stack.

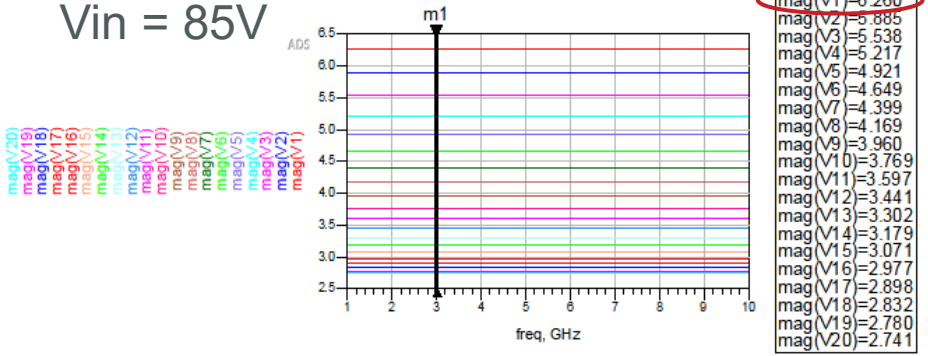


Rebalancing the voltage distribution (See US8638159 by pSemi.)

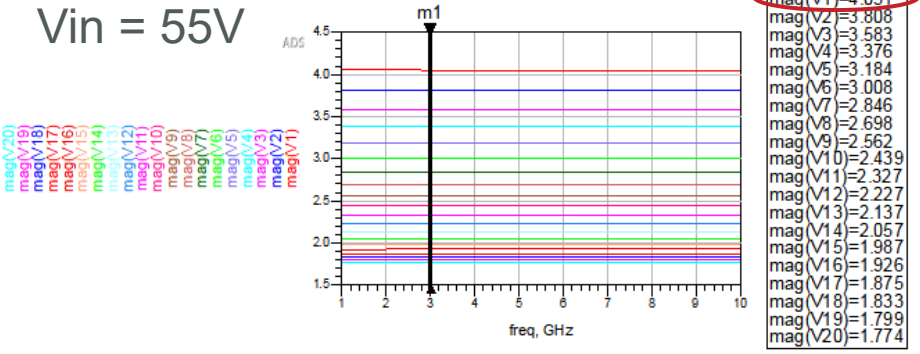
Challenge 2: Voltage and Parasitic Cap Example



Vin = 85V



Vin = 55V



Challenge 3: Tuning Component Linearity

- The active component linearity is also important as antennas are often shared by multiple bands.
    - Example: With 5GNR 3.3–6 GHz, a two-tone signal can create in-band interference leading to desense that lowers the total throughput.
- Improving linearity can be achieved by increasing stack height or modifying the switch architecture. However, this comes at a cost of higher resistance that leads to lower Q for tuning components.

Key Takeaways

- To enable modern cellular designs and extended frequency bands, antenna tuning devices have become a necessity of the RF front end.
- Due to the changing environment that users expose cellular devices to, the antenna tuner must have a robust design.
- The three main antenna tuner challenges include:
  1) Non-ideal antenna design
  2) Antenna mismatch causing high voltage
  3) Tuning component linearity vs. cost trade-off
- pSemi's 30+ years of SOI fabrication and switch design experience enable the high power and performance needs of the antenna tuning system.

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THANK YOU

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