Ground-Bounce Reduction in Narrow-Band RF Front-Ends

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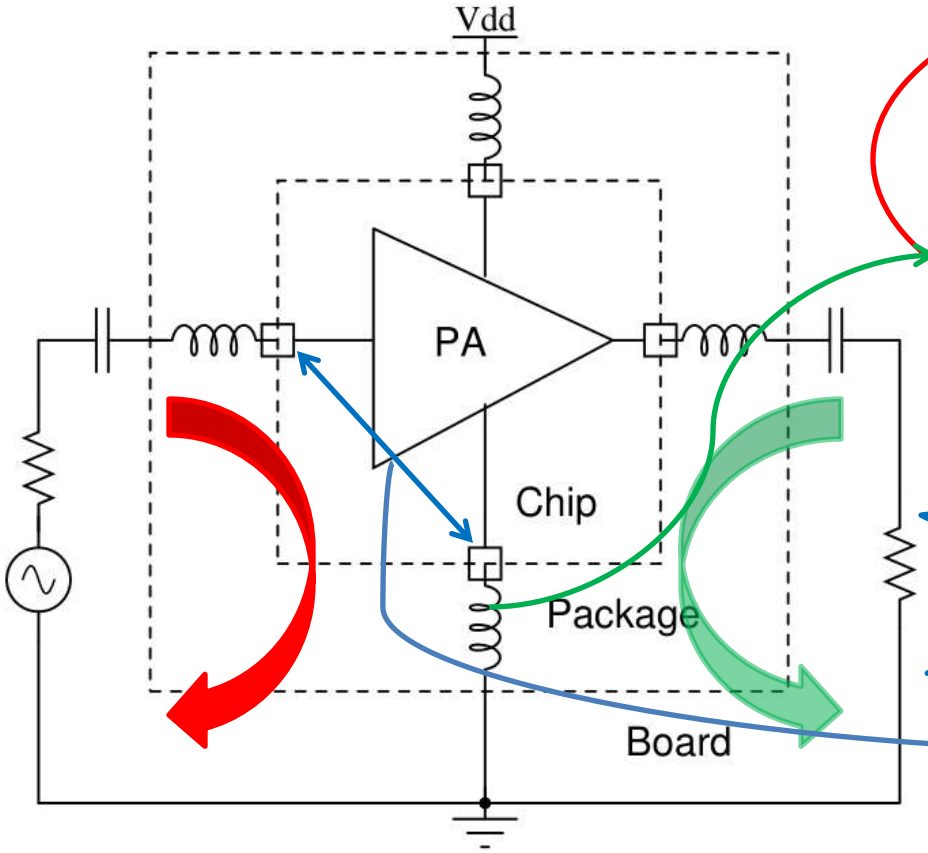
Outline

- Ground-bounce in RFICs
  - Effect on impedance-matching and stability
- Reducing ground-bounce in narrowband RF circuits
- Reducing PA sensitivity to switching noise
- Summary

Motivation for this work

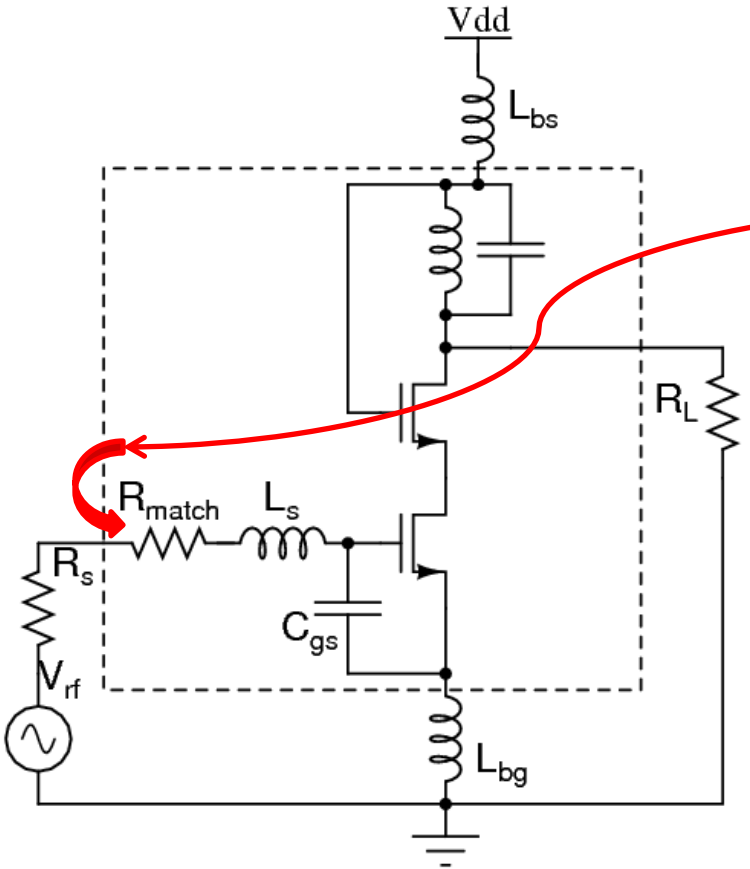
Ground-bounce in RFICs



Current through ground bond wire due to output circuit

PA input different from external input

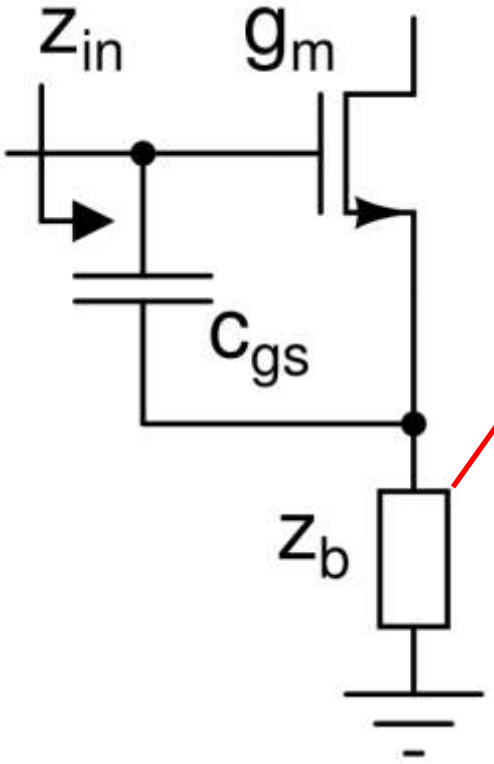
Matching



Input impedance becomes a function of transistor transconductance

Transistor parameters change with power level

Stability



$$z_{in} = \frac{1}{j\omega c_{gs}} + z_b + \frac{g_m z_b}{j\omega c_{gs}}$$

Z_b becomes capacitive at high frequencies

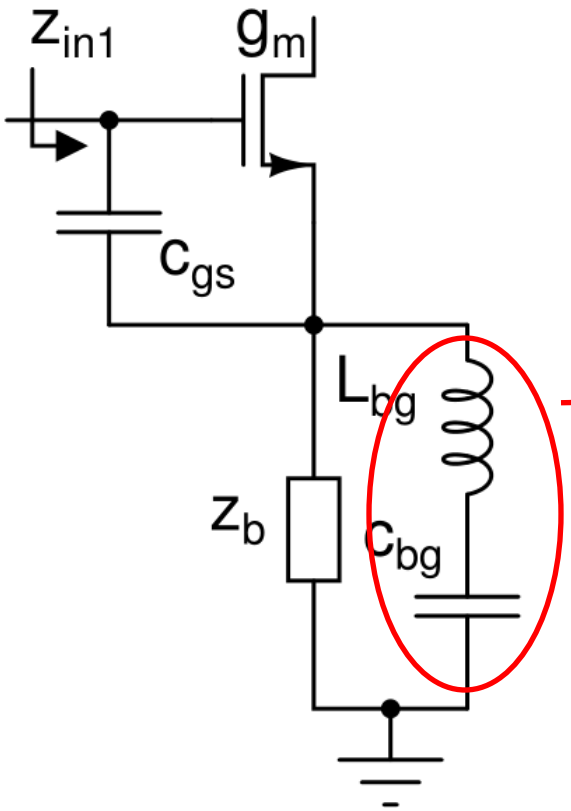
Negative real term causing instability

PA ground bounce reduction

Reducing ground-bounce (conventional)

- Minimize bond-wire inductance
  - Multiple bond-wires in parallel
  - Reducing bond-wire length by placing die at an offset from centre
- Differential implementation
- On chip supply decoupling capacitor

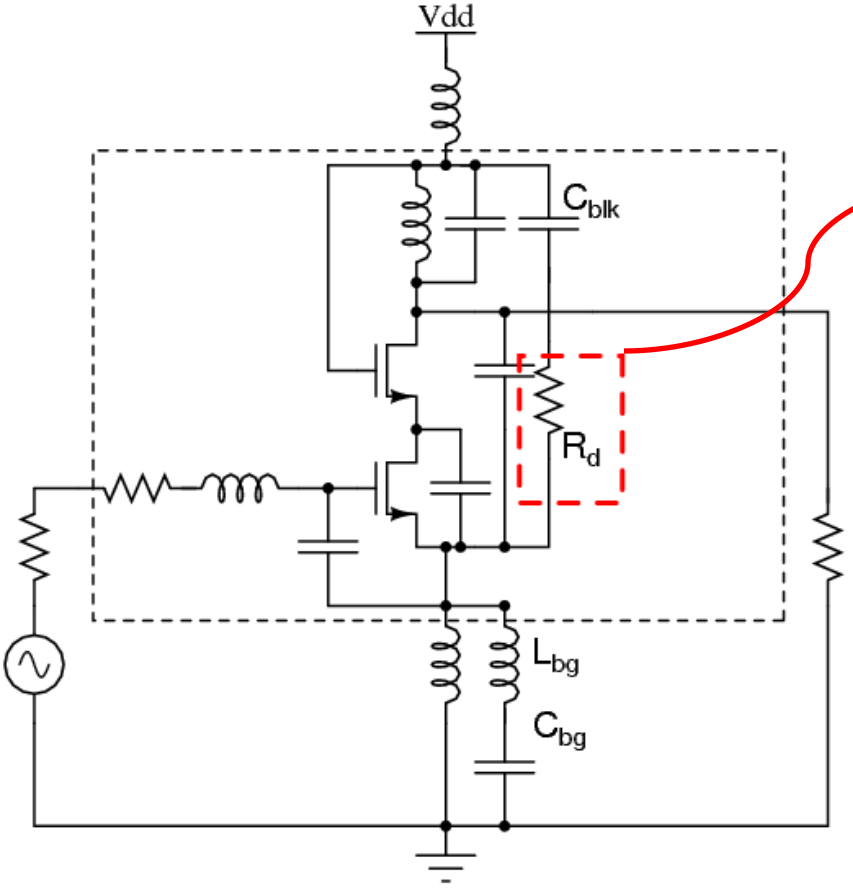
Reducing ground-bounce (proposed)



Extra bond-wire and off chip cap in parallel with primary ground path

No ground bounce at series resonance

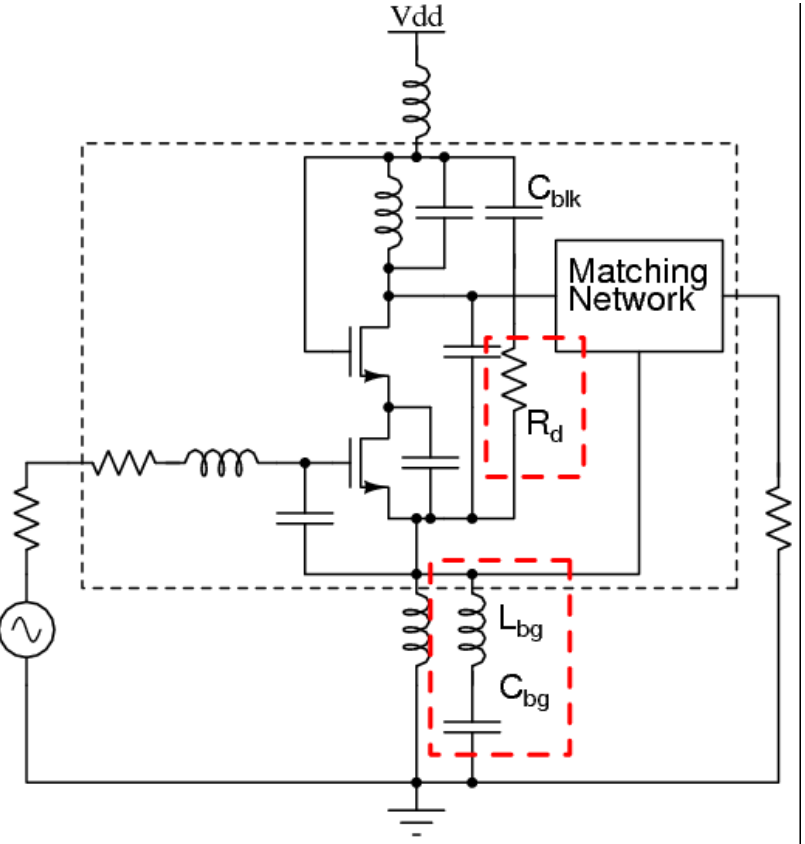
Stabilization



Resistance added in non signal path

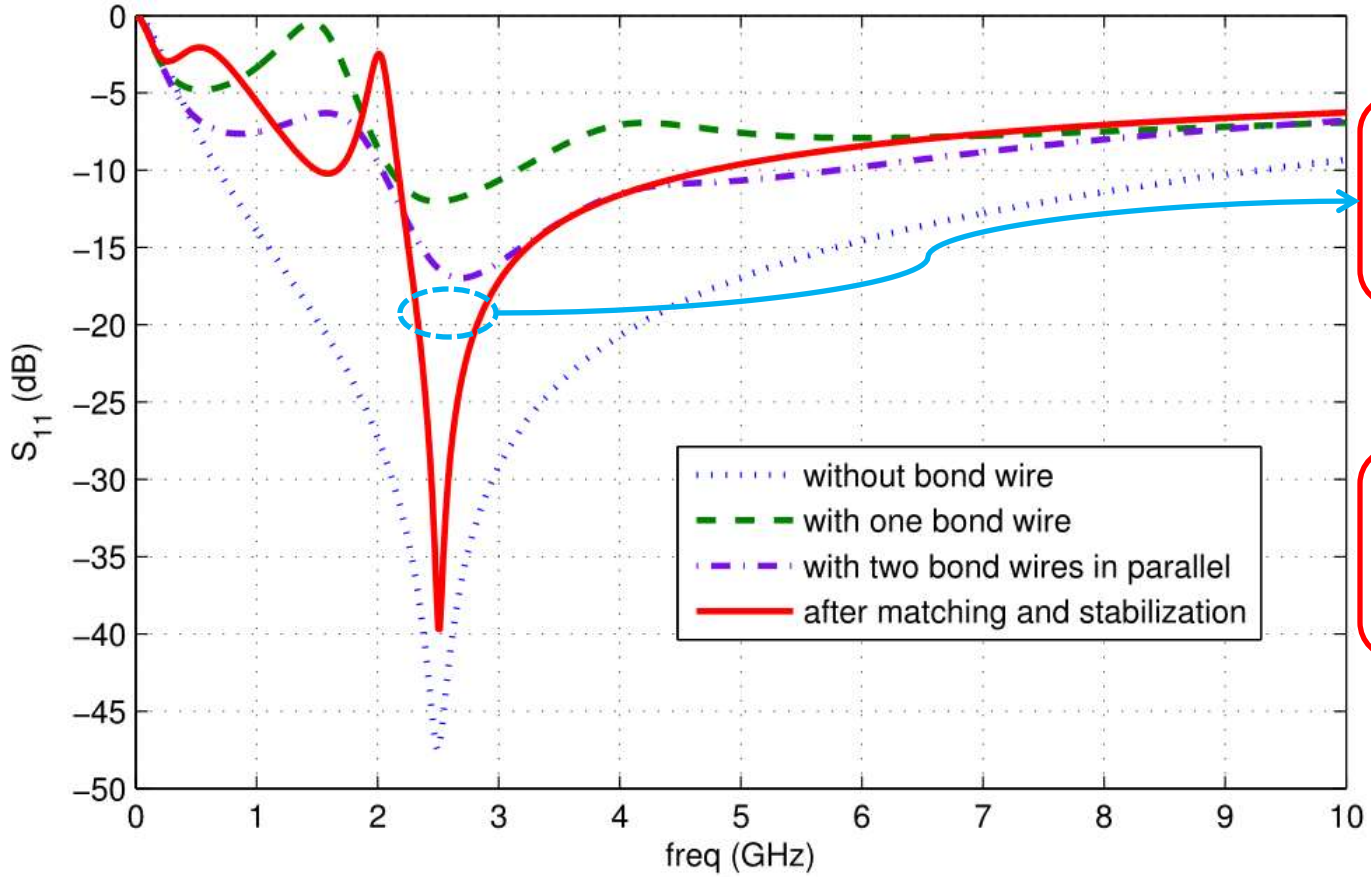
Reduces Q, improves stability

Simulation – series resonance



- 2.5GHz PA with 16dBm P1dB in 130nm CMOS
- Bond-wire: 2nH, Q=100 (worst-case)

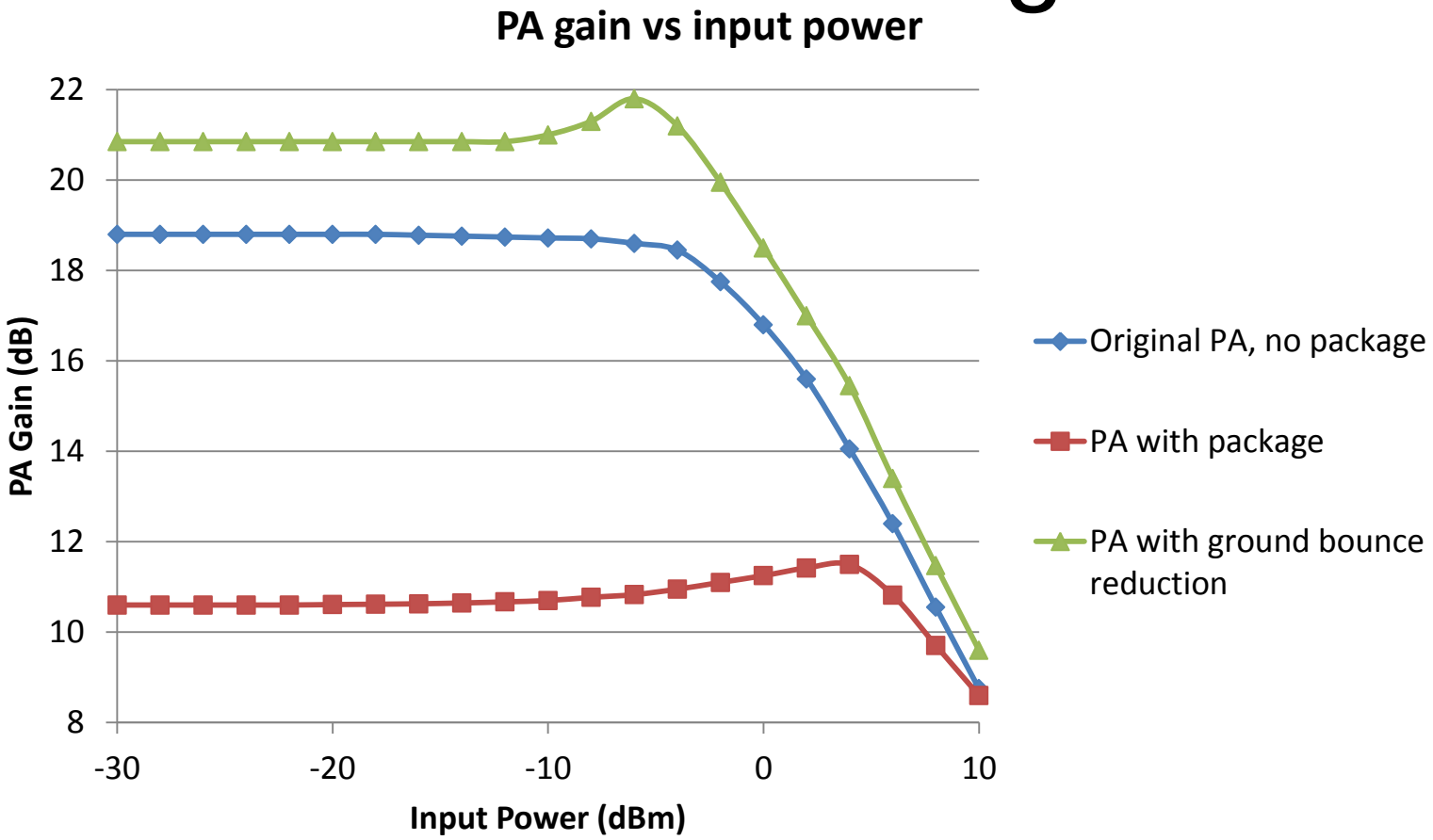
Simulation – Input matching



Input matching better than 20dB over 500MHz BW

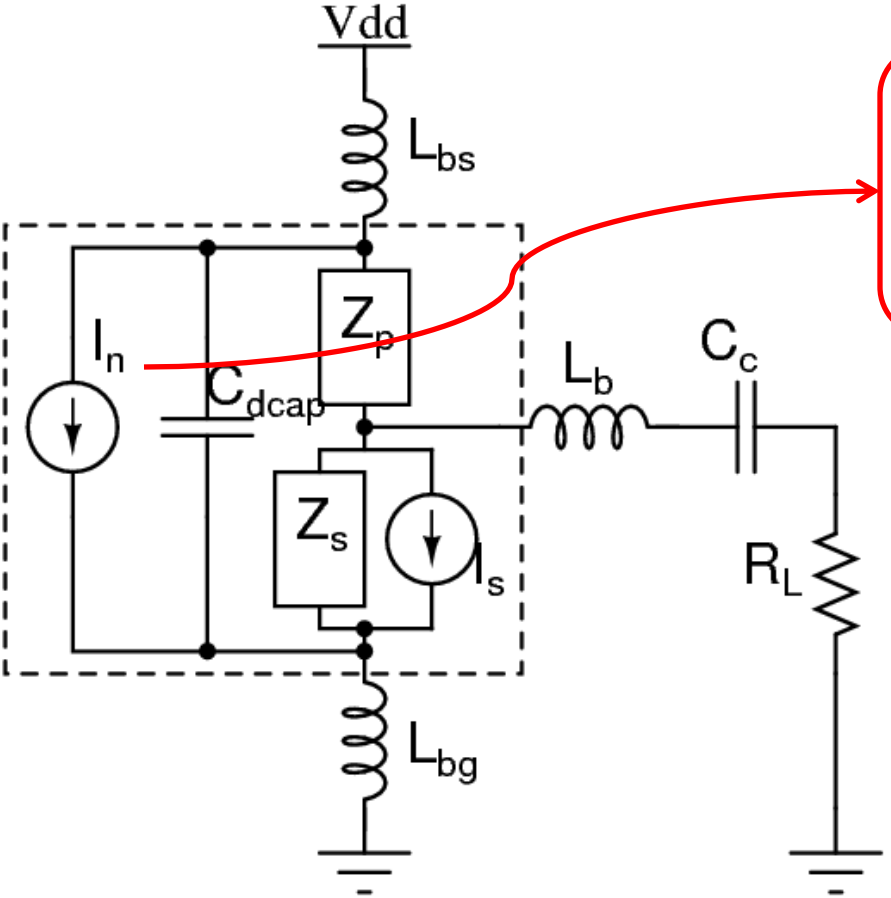
S_{11}<0dB at all frequencies → stable

Simulation – PA gain



PA sensitivity to switching noise

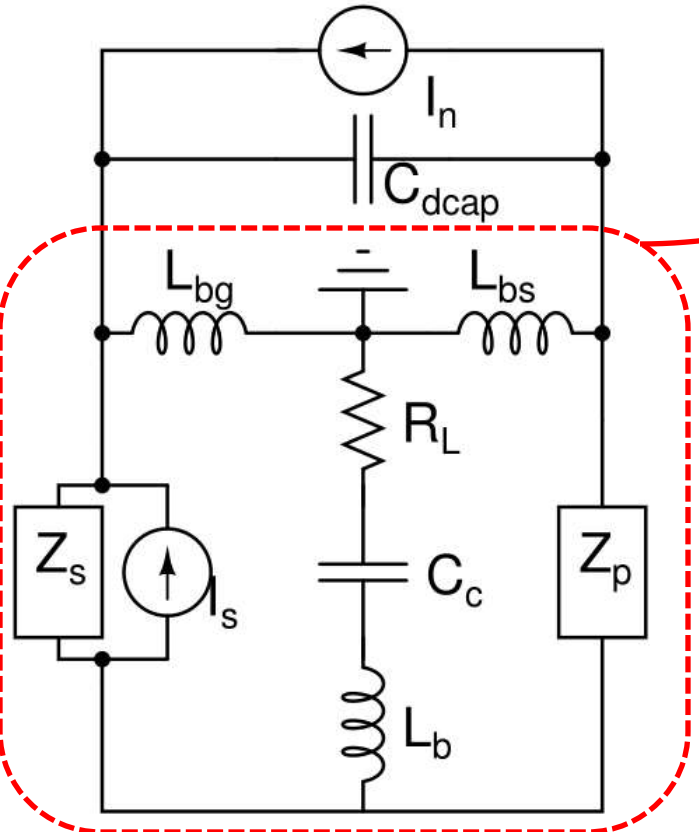
Effect of switching noise



Current drawn by on-chip circuitry causes ground bounce

Desired: Full signal current I_s through load while isolating from I_n

Impedance balance



Forms a bridge with I_n as source

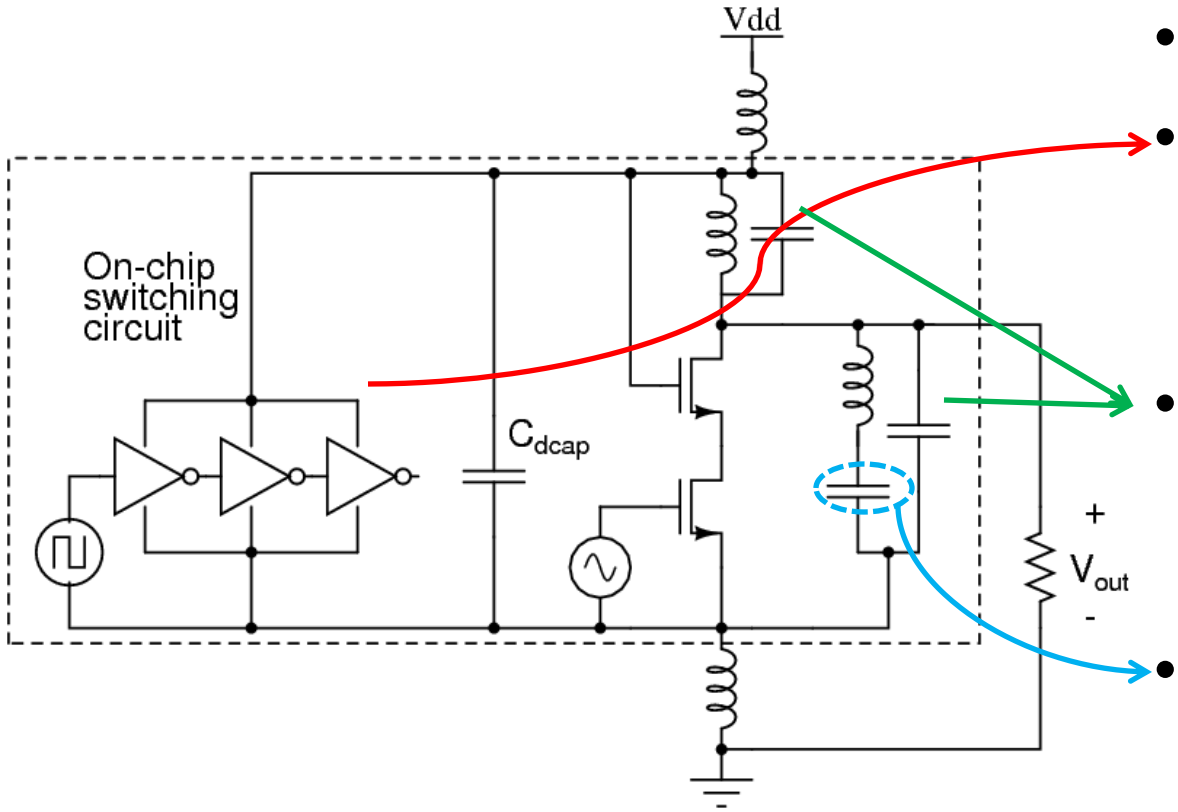
$$\frac{\omega L_{bg}}{\omega L_{bs}} = \frac{Z_s}{Z_p}$$

Balanced Bridge

Cc optimized to maximize power transfer from I_s to R_L

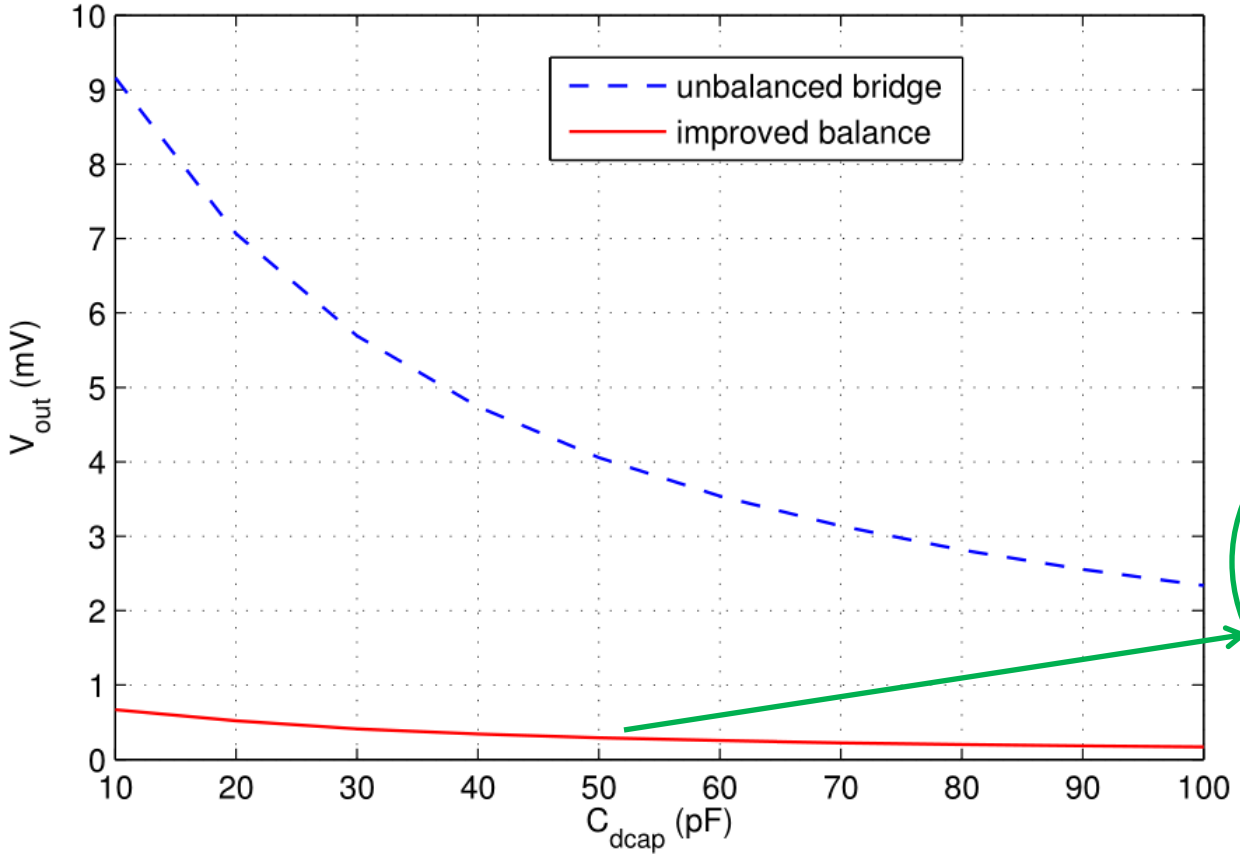
No effect of I_n on R_L

Simulation – switching noise



- Same PA as before
- Three inverters to generate switching noise
- Impedance balanced at PA o/p using two tanks
- Series cap to prevent dc short between rails

Simulation – output noise



Noise amplitude from PSS sim

Improved balance → Noise reduced with small de-cap

Summary

- Significant ground-bounce reduction is possible in narrow-band RF front-ends using the proposed series-resonance technique
  - Uses extra ground pin and one external capacitor
- Impedance balance in output stage can suppress noise added by on-chip circuitry

Thank You

Questions?