TU1C-3

Directional Coupler with High Isolation Bandwidth using Electrical Balance

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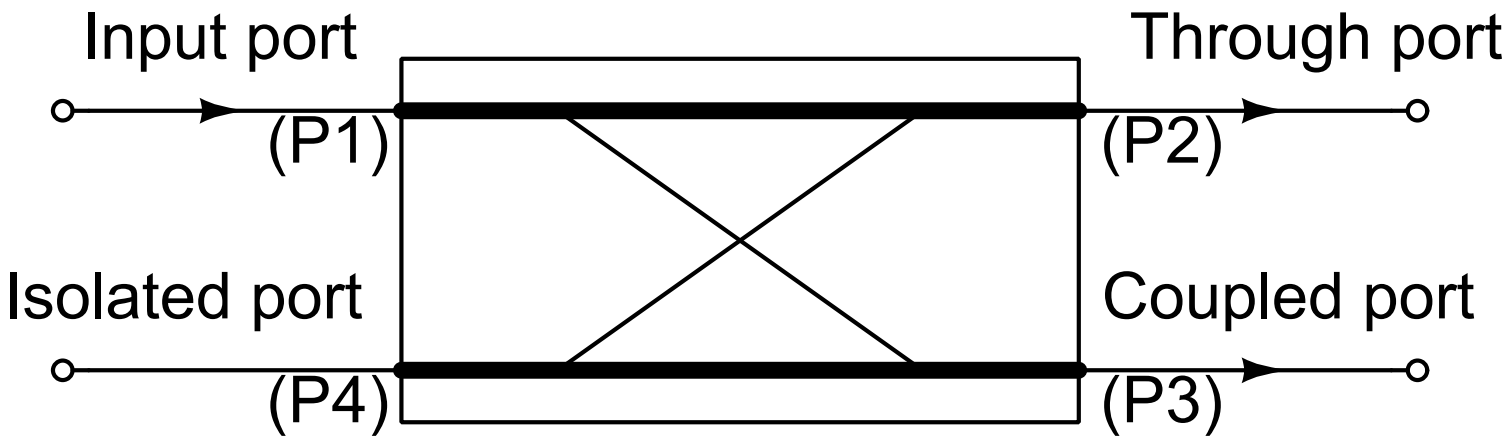
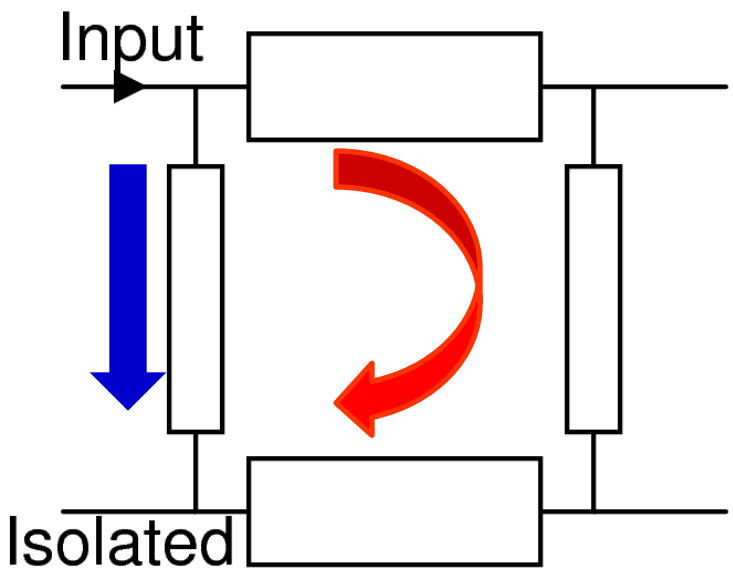
Outline

- Directional coupler
- High isolation bandwidth
- Proposed structure
- Design and application
- Simulation results
- PCB realization and measurement

Conventional Directional Coupler





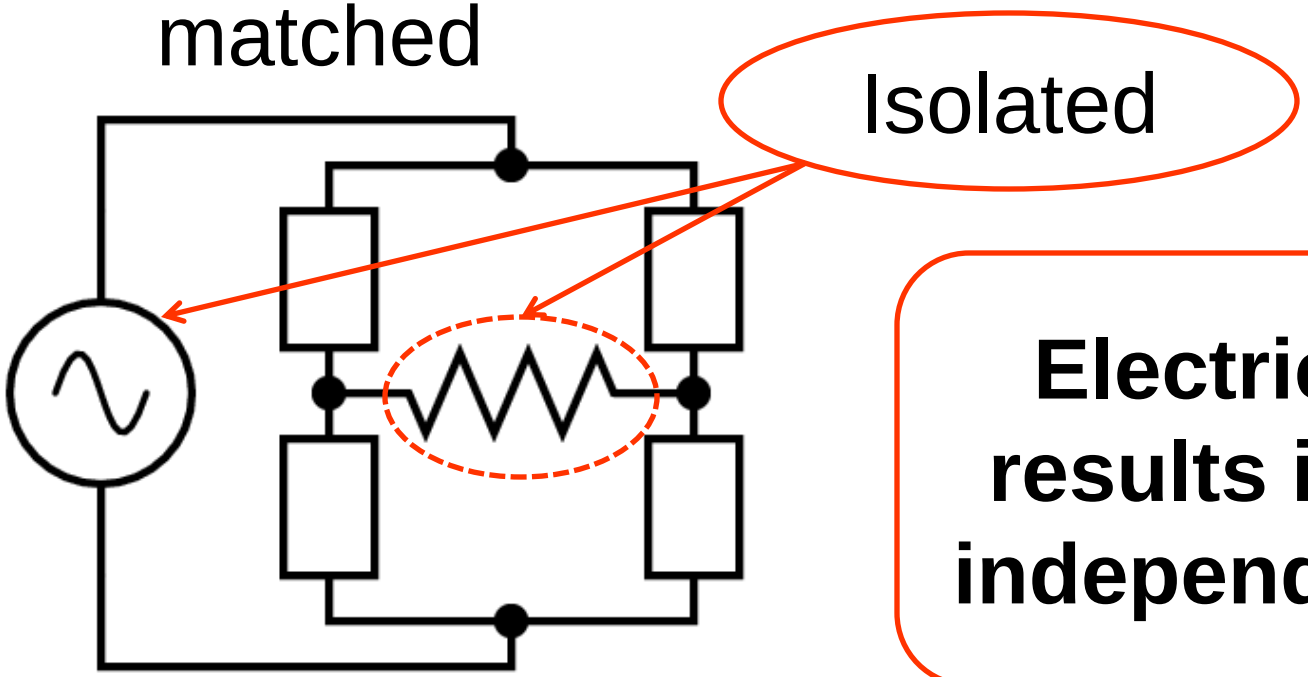
Input splits into two components cancelling at isolated port

Different frequency response of two paths

Isolation is frequency dependent

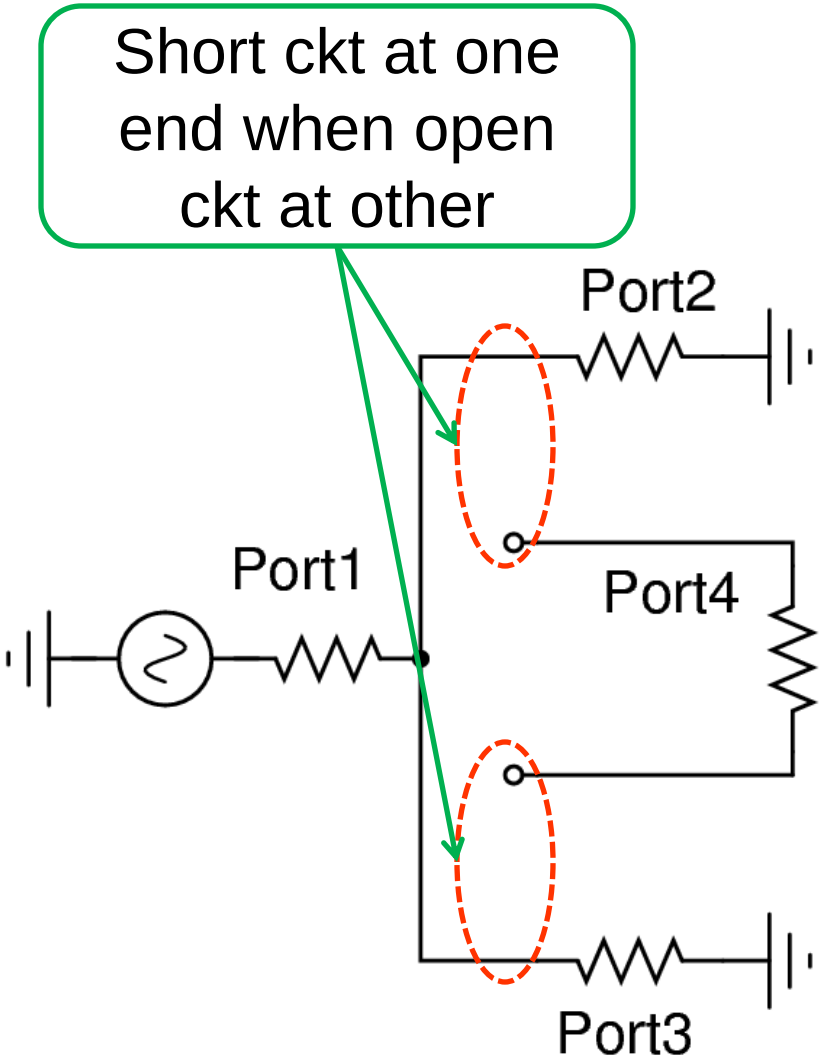
Achieving High Isolation Bandwidth

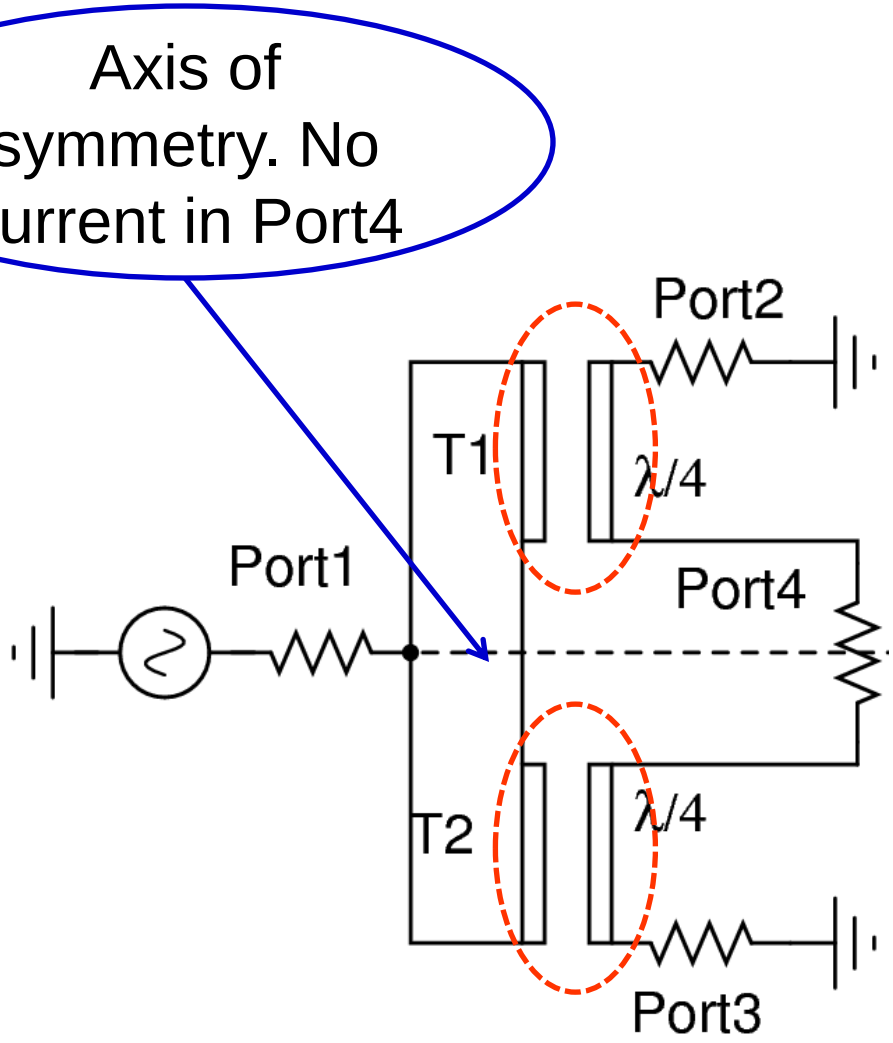
- Prevents in-band as well as out of band interference
- Multiple paths to isolated port must be matched



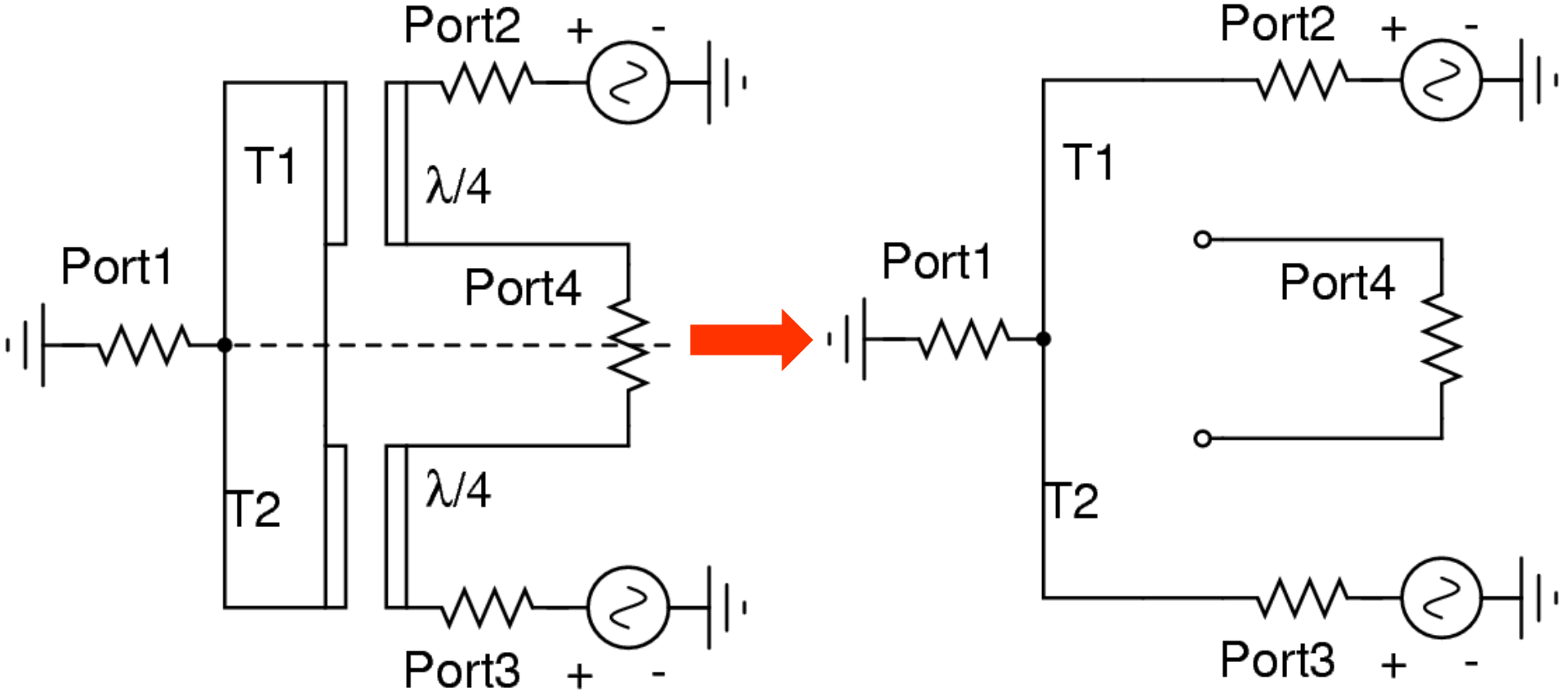
Electrical balance results in frequency independent isolation

Electrical Balance



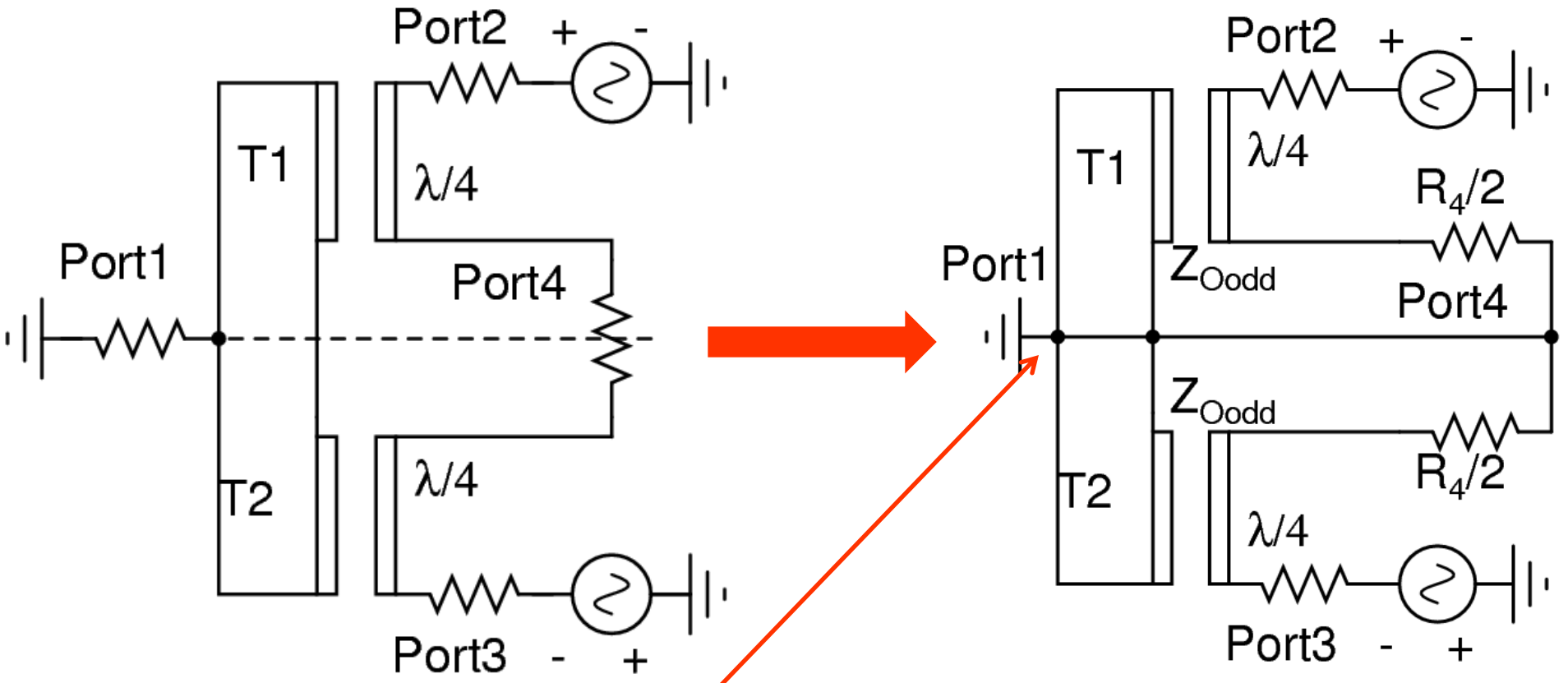


Even-Mode Analysis for Ports 2-3



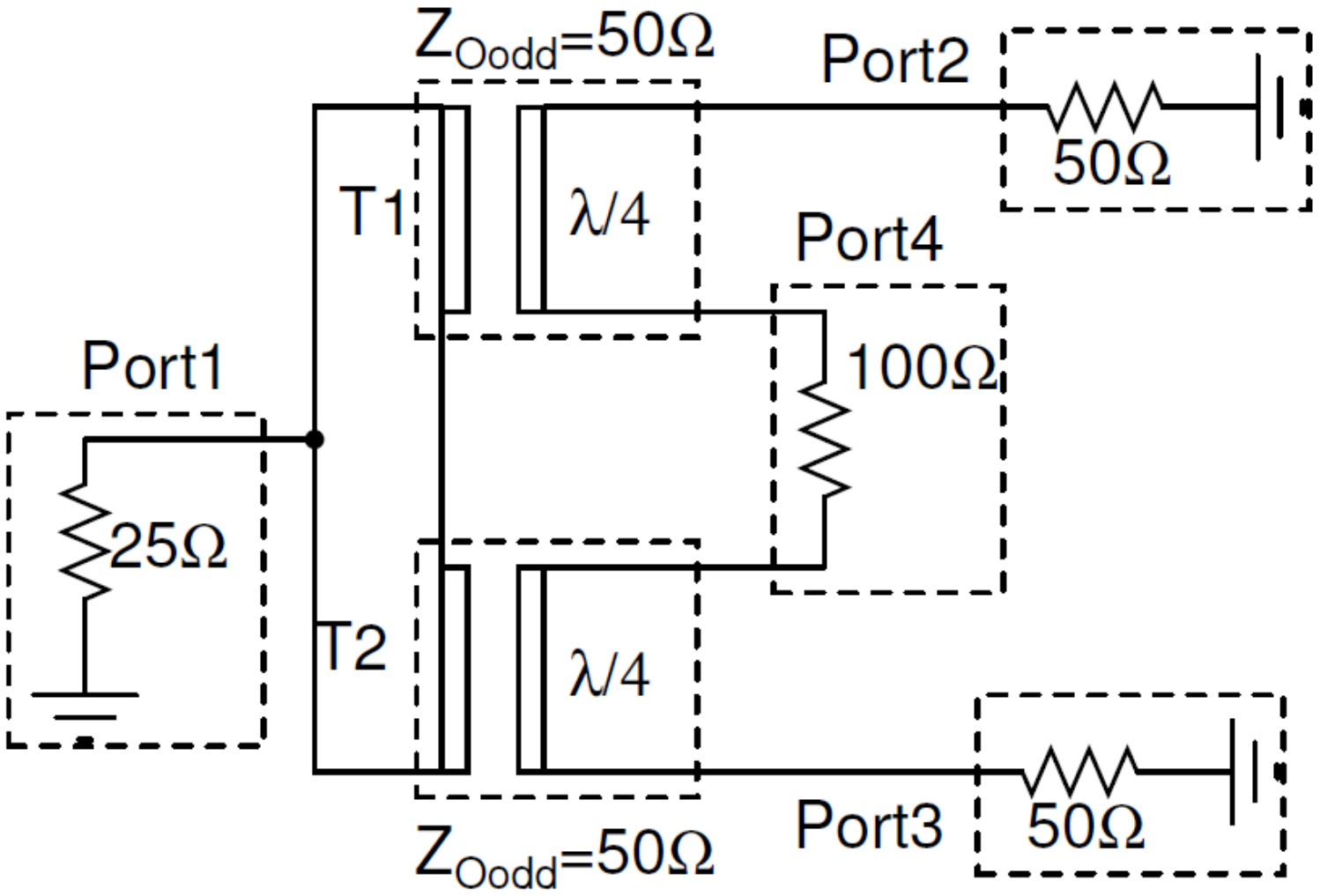
- Port4 open circuited
- All power ends up at Port1

Odd-Mode Analysis for Ports 2-3

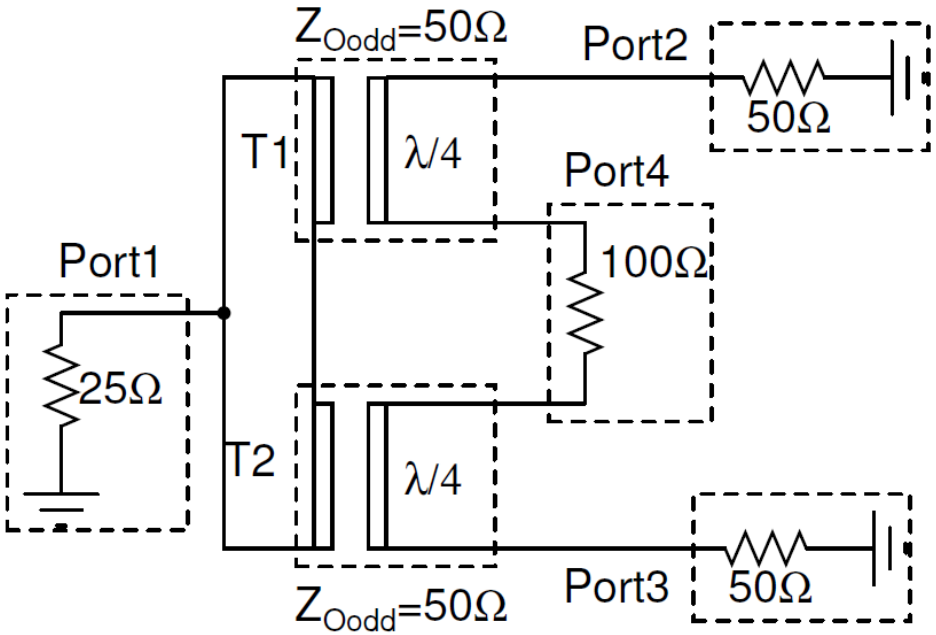


- **Virtual ground** along line of symmetry
- Power is additive at port 4

Proposed Directional Coupler



S-parameters



$$[S] = \frac{1}{\sqrt{2}} \begin{bmatrix} 0 & 1 & 1 & 0 \\ 1 & 0 & 0 & -j \\ 1 & 0 & 0 & j \\ 0 & -j & j & 0 \end{bmatrix}$$

All ports matched in all modes

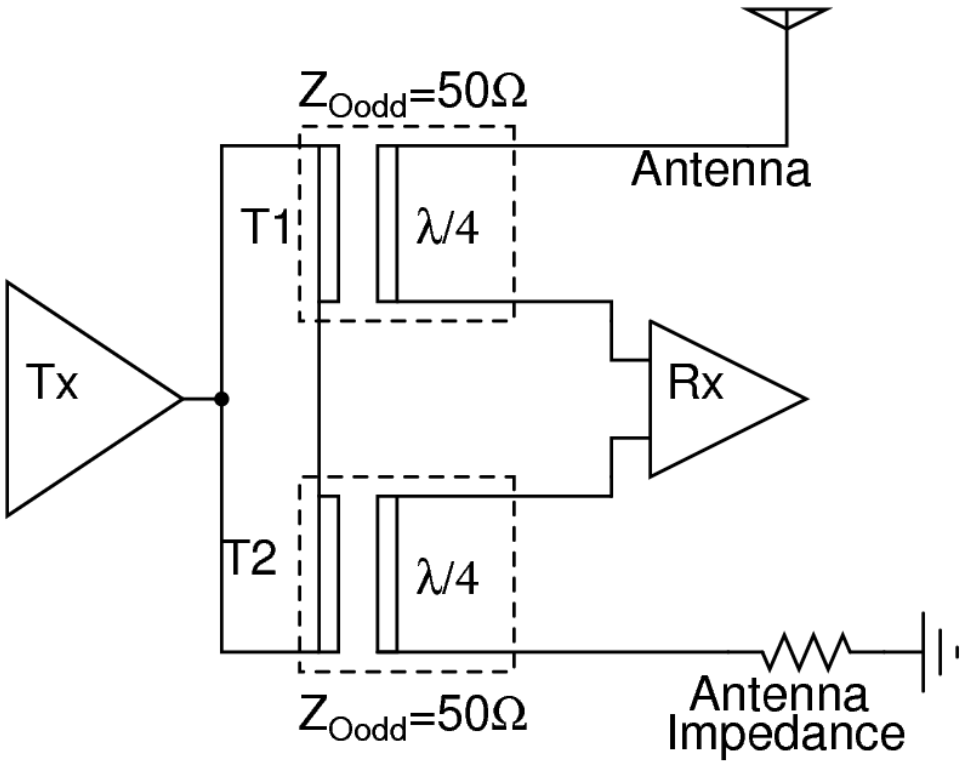
Equal power splitting from P1 to P2 and P3

90º phase difference from P2 and P3 to P4

Frequency dependent isolation

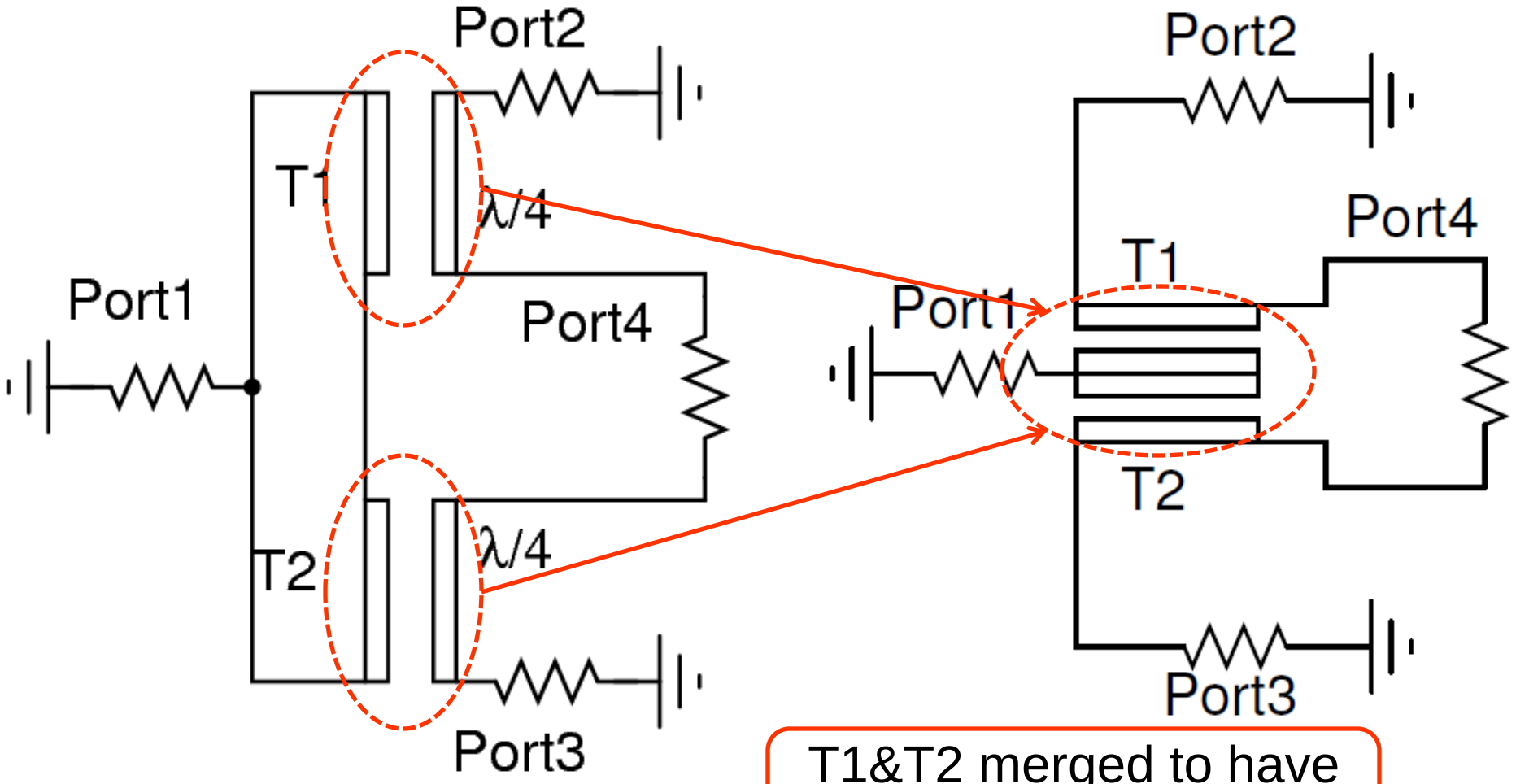
Isolation due to electrical balance

Application in Full Duplex Front-End



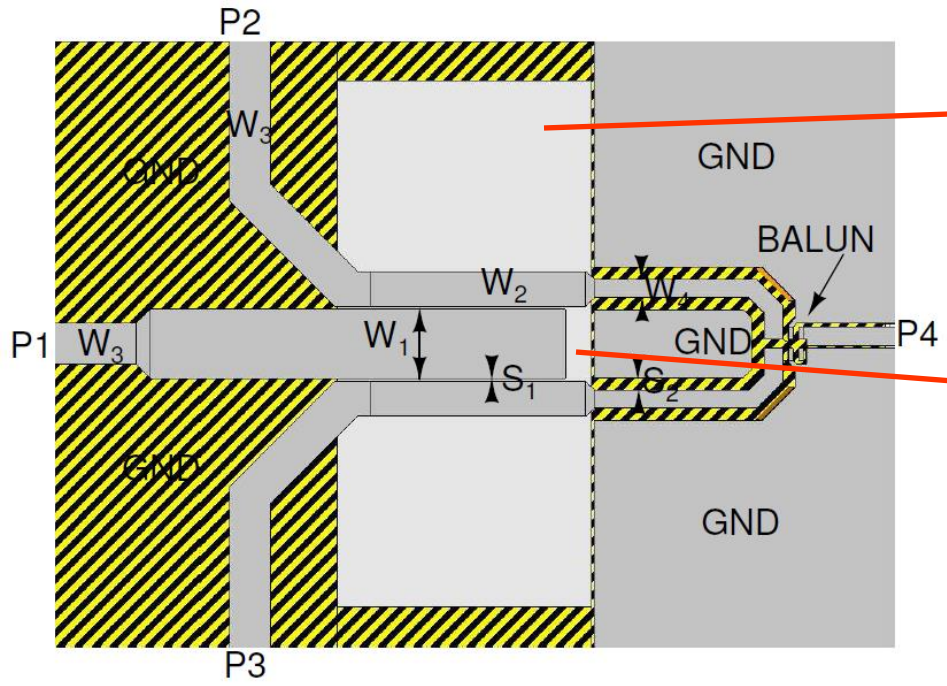
- Tx and Rx are isolated using electrical balance
- 3dB coupling for equal loss in Tx and Rx path
- Isolation bandwidth limited by Antenna Impedance mismatch

Design



T1&T2 merged to have common return path

Board Layout



- RO4003C double layer PCB
- Mini-circuits 100:50 balun

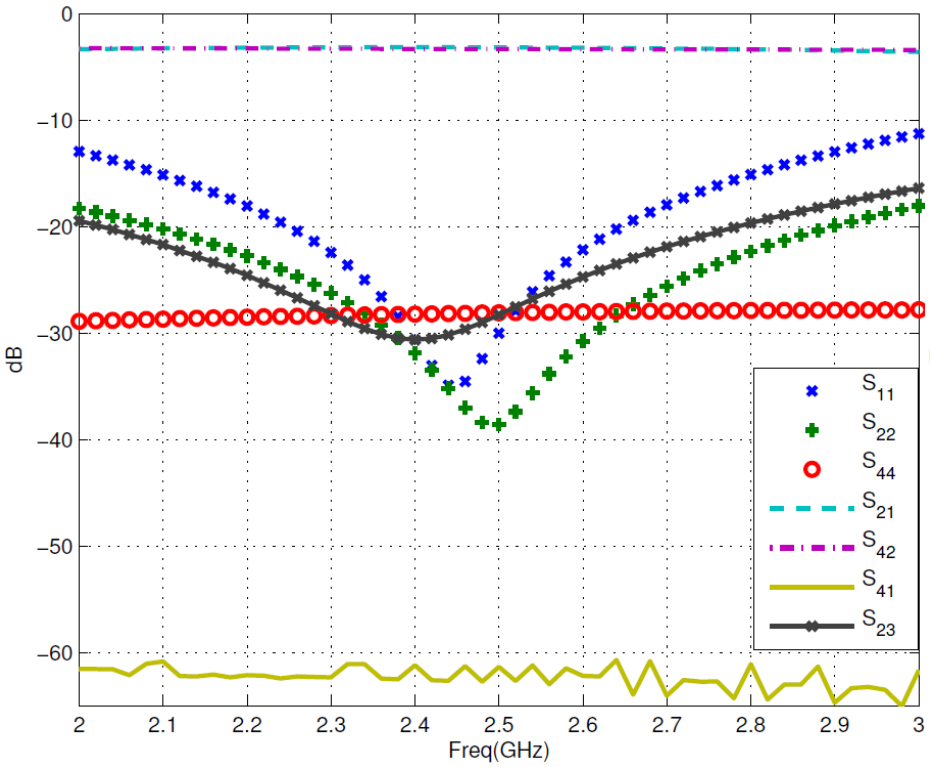
- Conductor etched under TL to increase even-mode impedance
- Open circuited part of TL reduced in length to compensate extra fringe cap
- Microstrip, edge coupled and CPW TL

- Tapering at transitions to minimize reflection

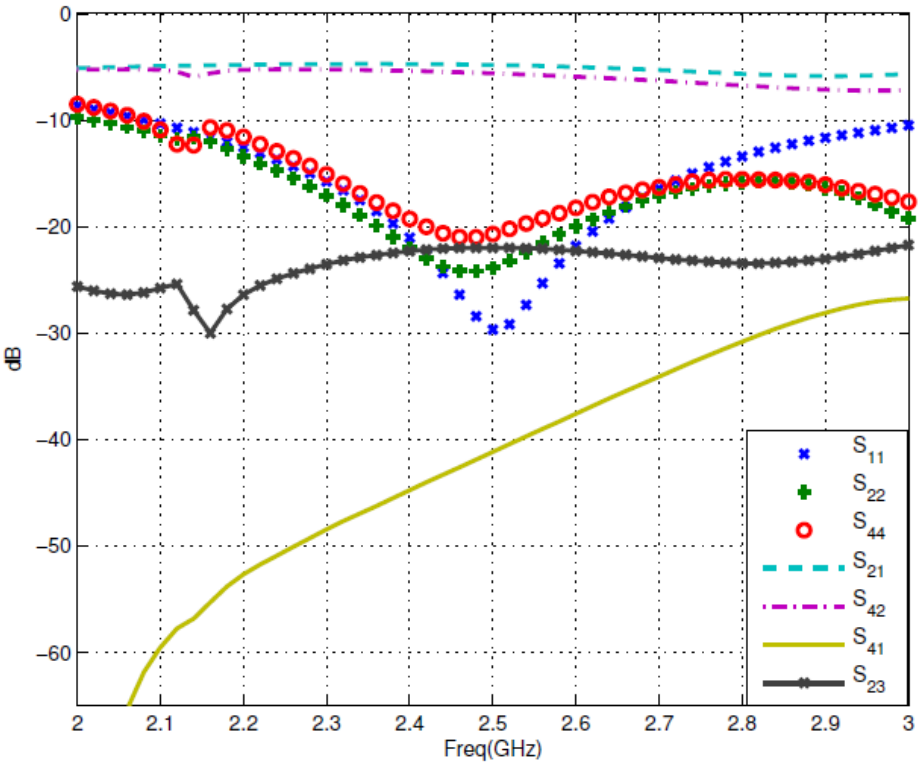
Simulation Results

Simulated using Sonnet v13

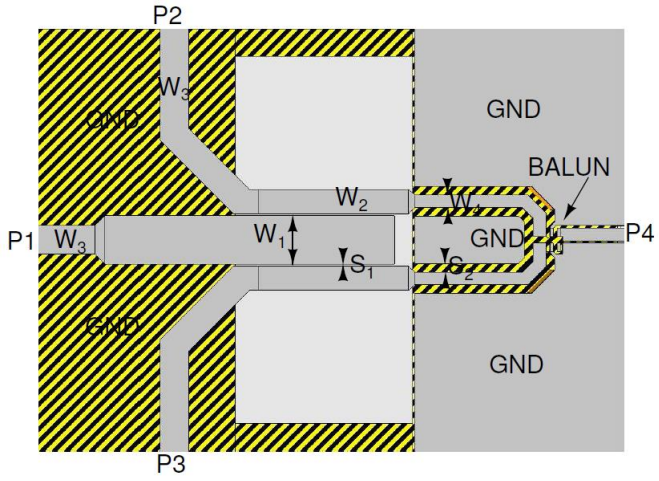
Without balun at P4

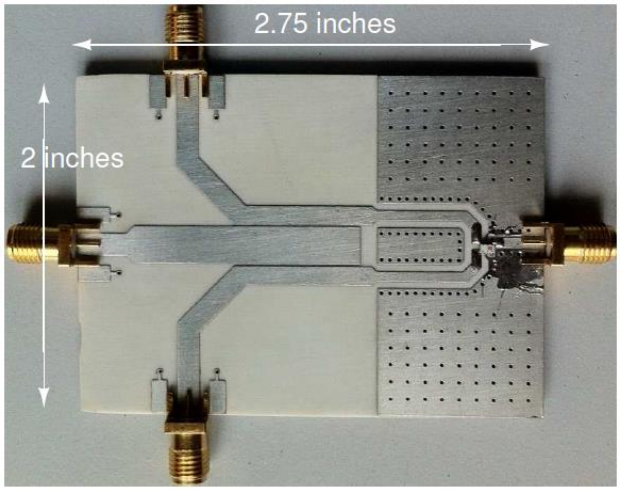


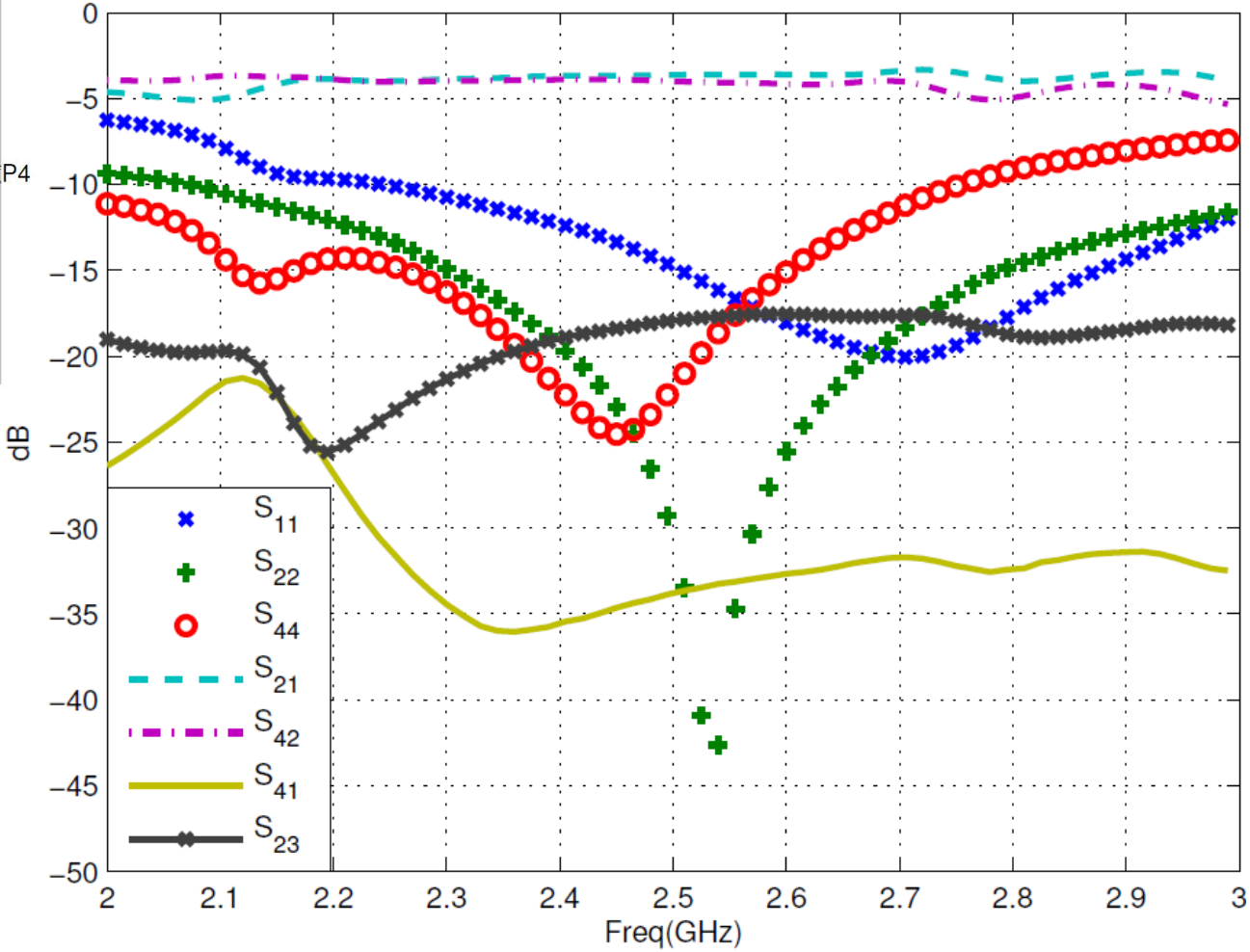
With balun at P4



Measurement Results







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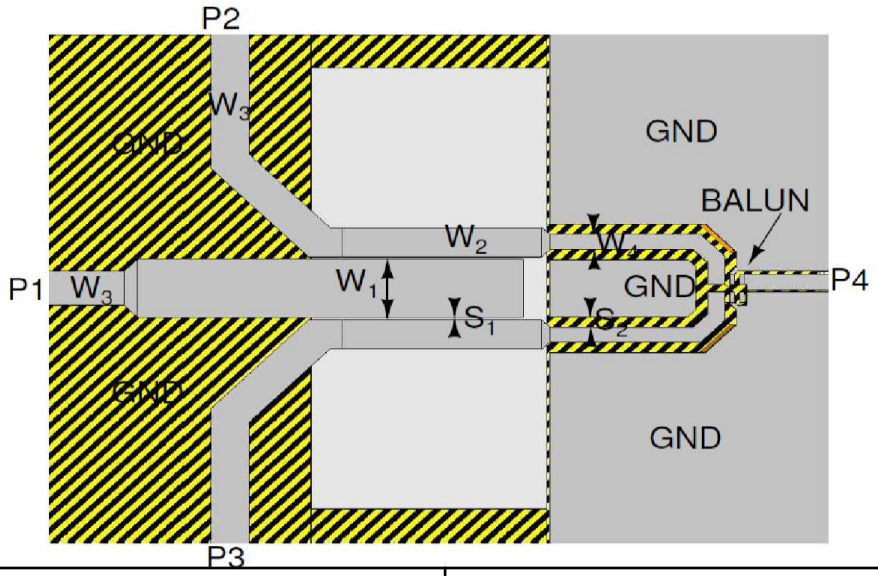

Coupling @ 2.5GHz	S_{21}=-4dB, S_{42}=-3.6dB
Matching Bandwidth (<-10dB)	2.3GHz to 2.7GHz (16%)
Isolation ($1/S_{41}$)	31dB to 36dB (2.3GHz to 3GHz)

Summary

- High isolation bandwidth achieved using electrical balance
- Measurement shows frequency dependence due to balun
- Application in full duplex communication transceivers

Thank You!

Questions…