A Characterization Method of On-Chip Tee-Junction for Millimeter-Wave CMOS Circuit Design

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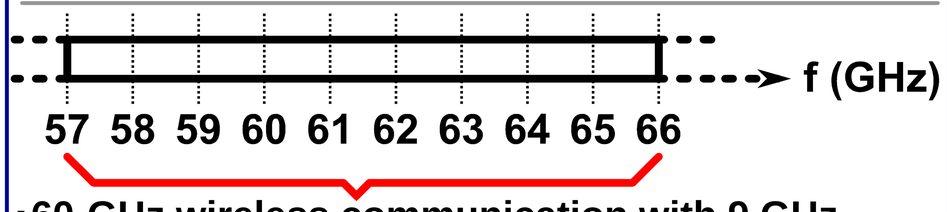
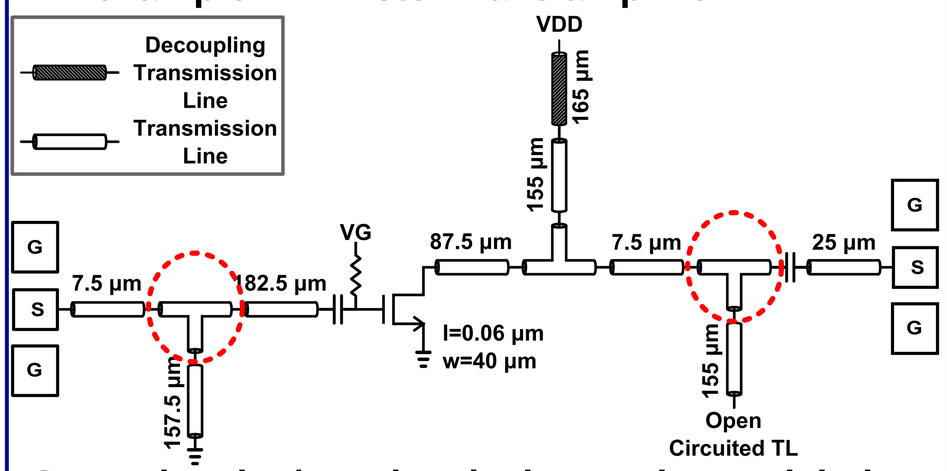
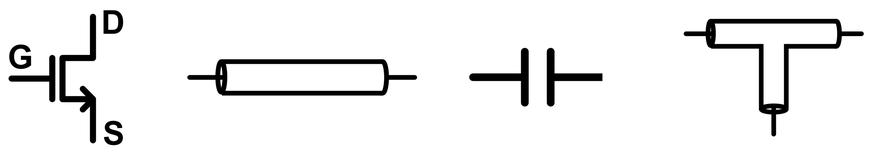
1. Motivation



- 60-GHz wireless communication with 9 GHz unlicensed bandwidth
  - Wide bandwidth: 2.16 GHz x 4 channels
  - Ultra high data rate: 64QAM → 10.56Gbps/ch
    64QAM → 42.24Gbps (4-ch bonding)
- An example millimeter-wave amplifier

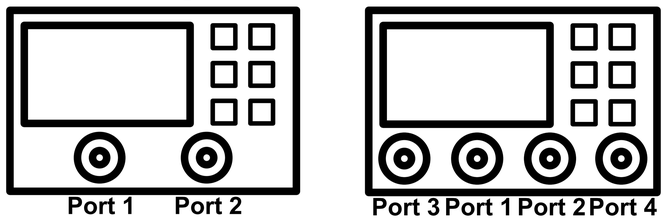


- Several active/passive devices to be modeled

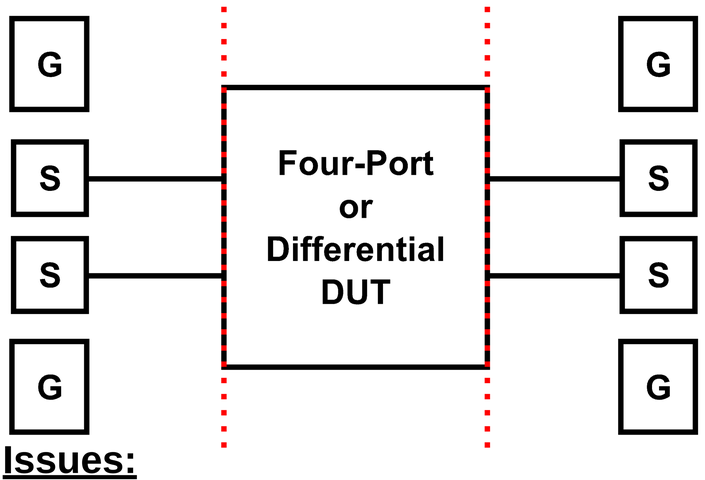


- This work focus on Tee-Junction characterization

2. Multi-port measurements



- Most common VNAs
- More dynamic range than multi-port
  -More accurate measurements

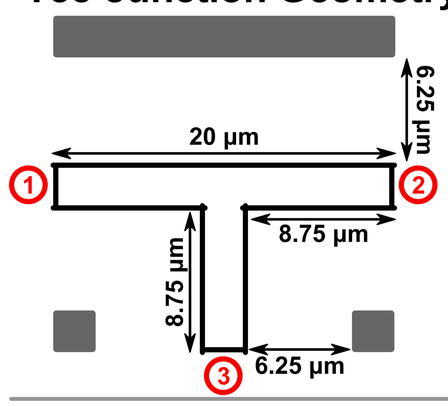


Issues:

- De-embedding of pad parasitics
- Unwanted crosstalk and coupling
- Fabrication of more structures
  -Increased area and cost

3. Tee-junction and structures

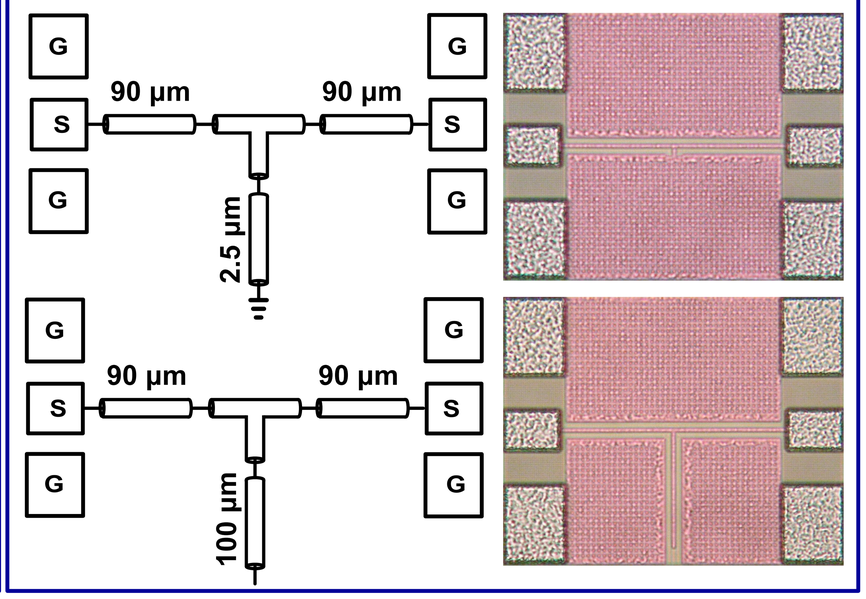
- Tee-Junction Geometry



- Gray areas: Ground
- Three-port device
- 20 µm by 20 µm

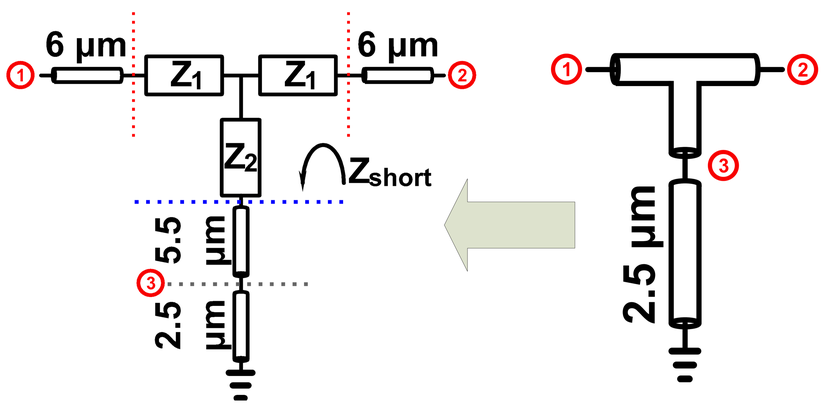
$$\begin{bmatrix} S_{11} & S_{21} & S_{13} \\ S_{21} & S_{11} & S_{13} \\ S_{13} & S_{13} & S_{33} \end{bmatrix}$$

- Two characterization structures
- Using two-port measurements

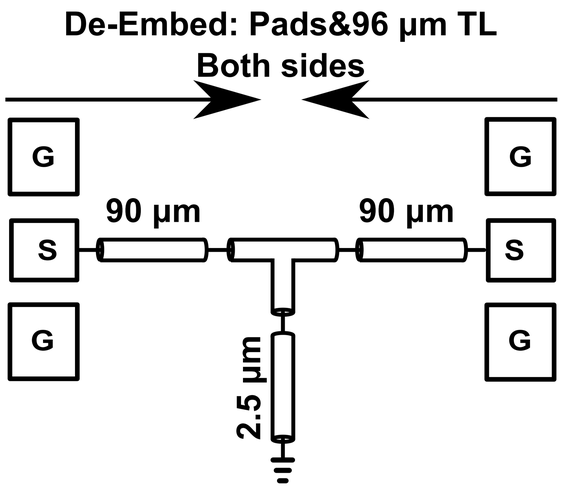


4. Characterization method

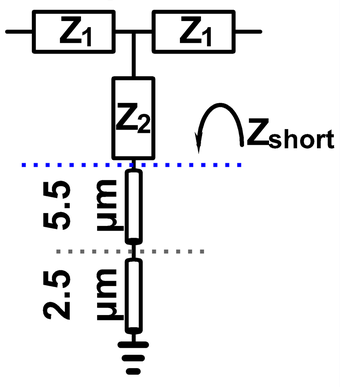
- Tee-Junction Model



- From the measurement results of the following structure;



- Remaining Response:



$$Z_{de\text{-}embed} = \begin{bmatrix} Z_{11} & Z_{21} \\ Z_{21} & Z_{11} \end{bmatrix} = \begin{bmatrix} Z_1+Z_2+Z_{short} & Z_2+Z_{short} \\ Z_2+Z_{short} & Z_1+Z_2+Z_{short} \end{bmatrix}$$

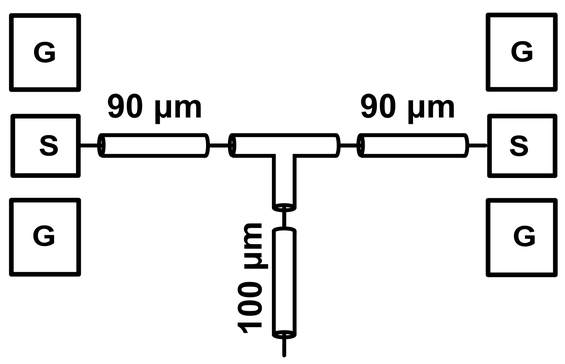
- Lumped constants can be calculated as:

$$Z_1 = Z_{11} - Z_{21}$$

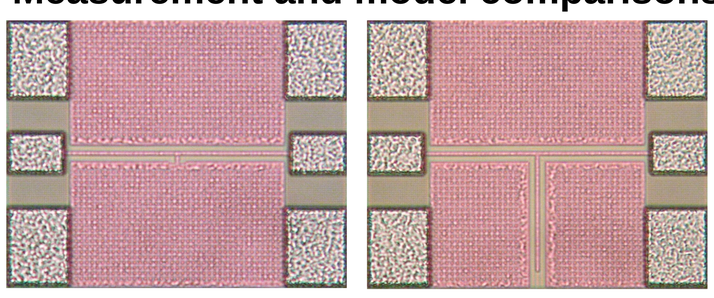
$$Z_2 = Z_{21} - Z_{short}$$

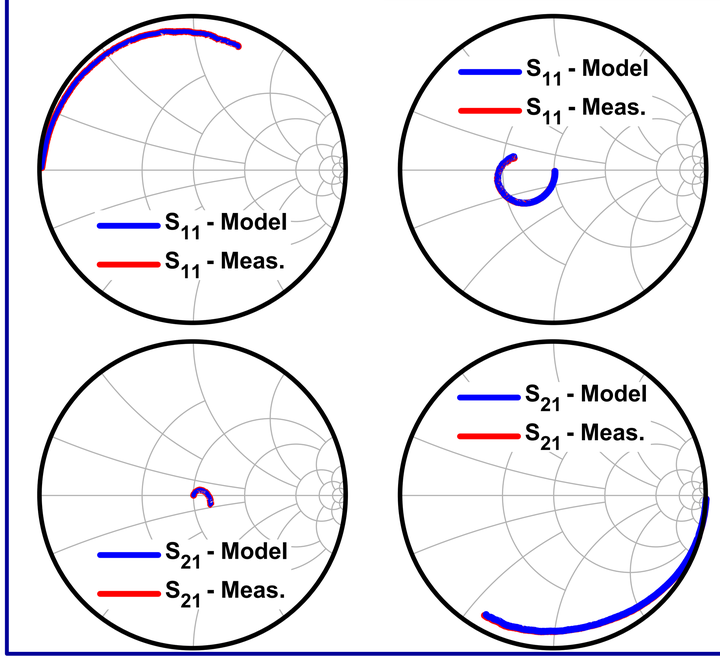
5. Measurement results

- Verification structure with shunt open circuited transmission line.



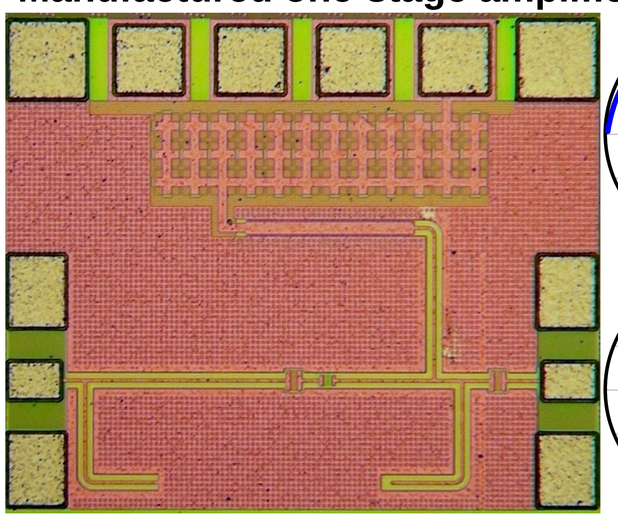
- Measurement and model comparisons

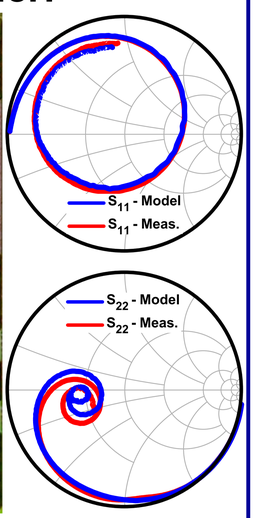


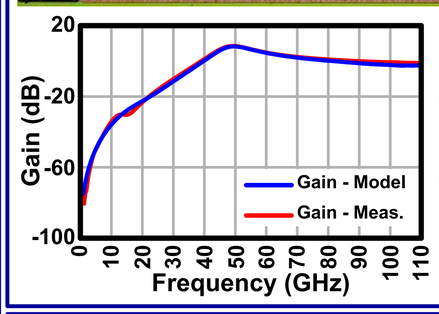


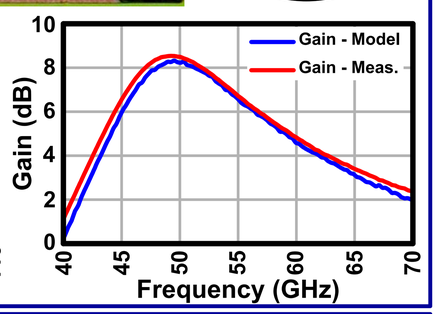
6. Application on one-stage amp.

- Manufactured one-stage amplifier:









7. Conclusions

- A simple characterization approach
- Two-port measurements are used
- Model based on lumped constants and transmission lines
- Z-parameters are used for lumped constant
- Model and measurement results agree well up to 110 GHz
- Application on one-stage amplifier
- Amplifier measurement and model agree well up to around 80 GHz