DUAL-BAND MICROWAVE HILBERT TRANSFORMER BASED SINGLE SIDE BAND MODULATION

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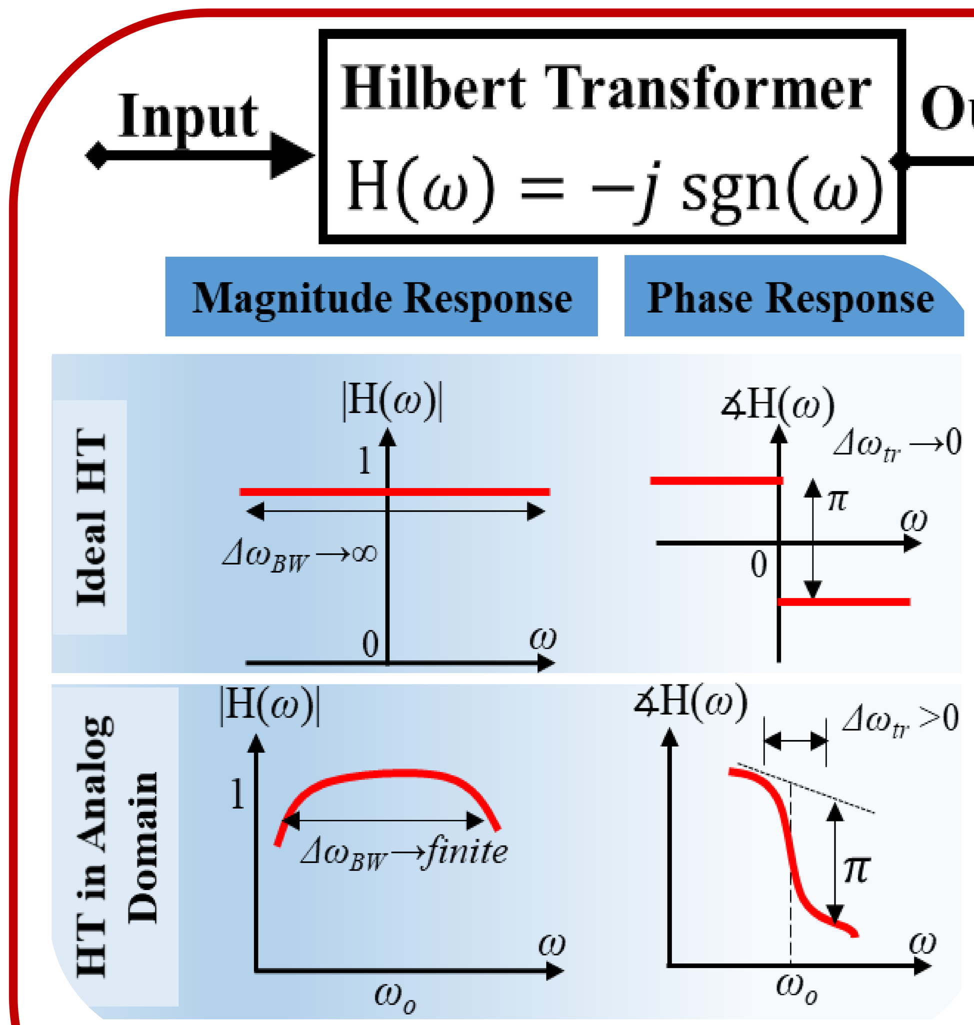
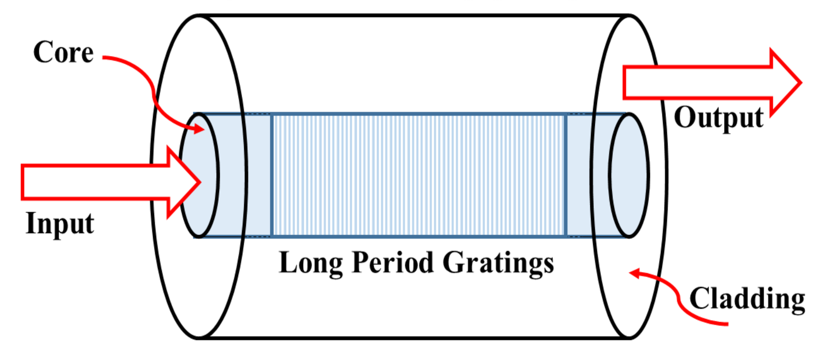
STATUS QUO



Conventional Designs

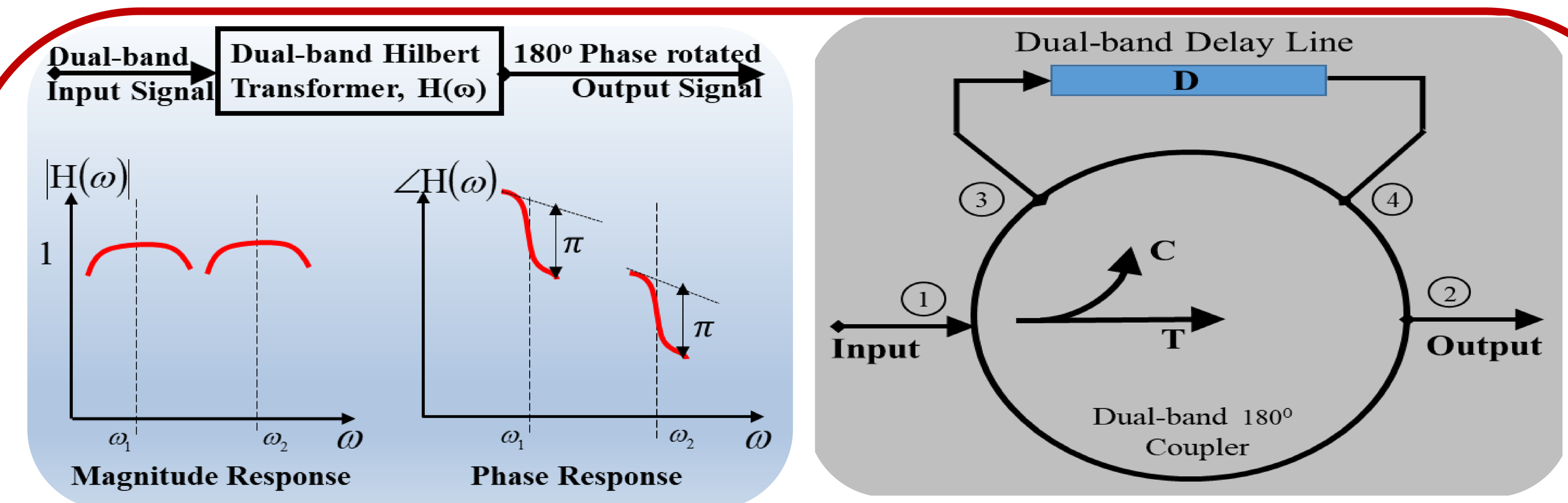
- ✓ Optical Regime
- ✓ Bulky and complex
- ✓ Costly fiber grating, nonplanar structures
- ✓ Inappropriate for spectrum aggregation.



Schematic of conventional HT

Usage: Edge Detection, Single Side Band Modulation, RADAR Communication, 3D Imaging etc.

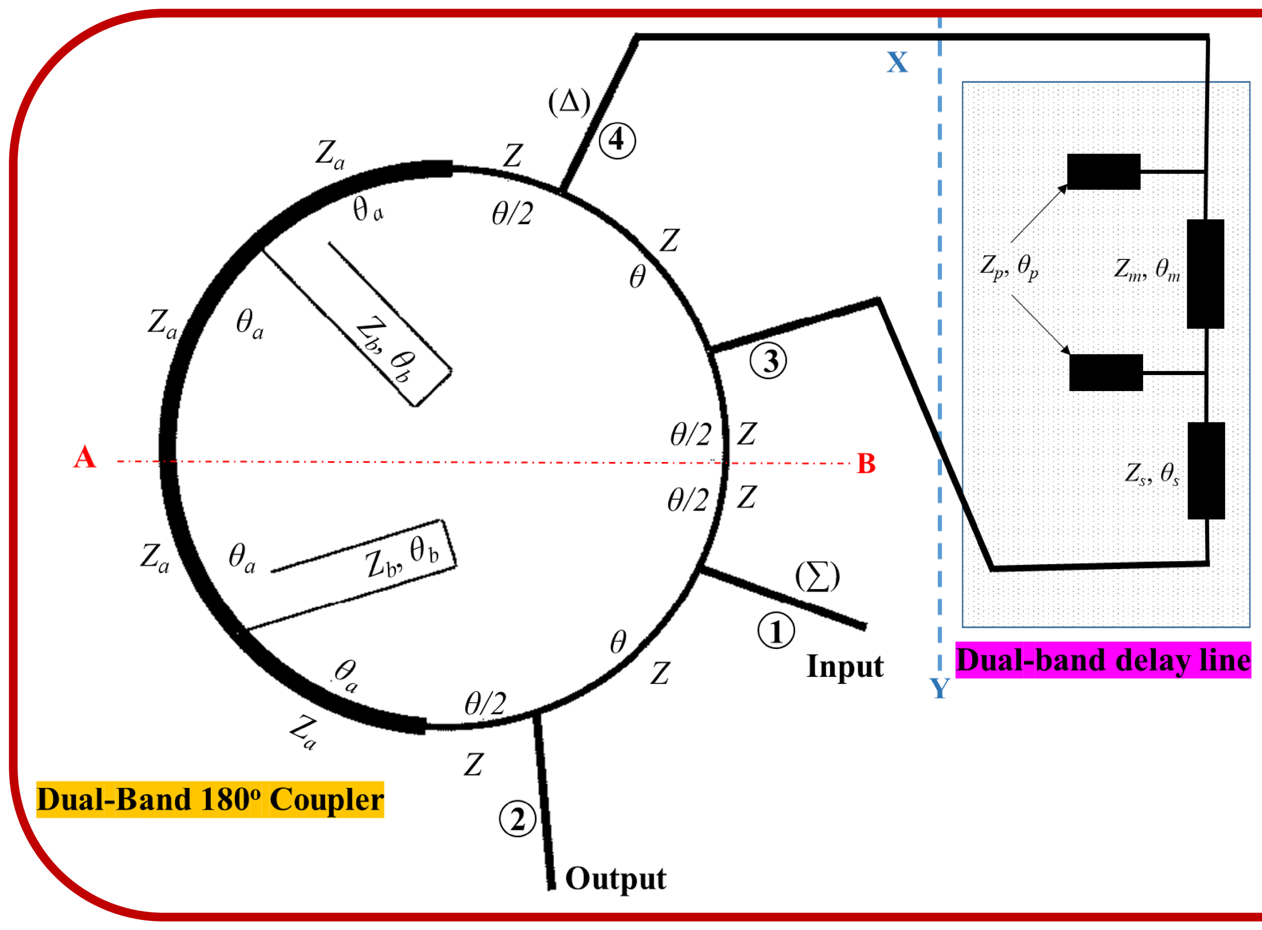
NEW INSIGHTS



Dual-Band Microstrip line Hilbert Transformer

- ✓ Suitable for Real-Time Analog Signal Processing.
- ✓ Unity magnitude and 180° Phase rotation at both design frequencies.
- ✓ Contains a dual-band 180° coupler and a dual-band delay line.
- ✓ Uses low-cost planar microstrip line technology.
- ✓ Capable of supporting Spectrum Aggregation.
- ✓ Edge detection and single side band modulation with Spectrum aggregation.

DESCRIPTION



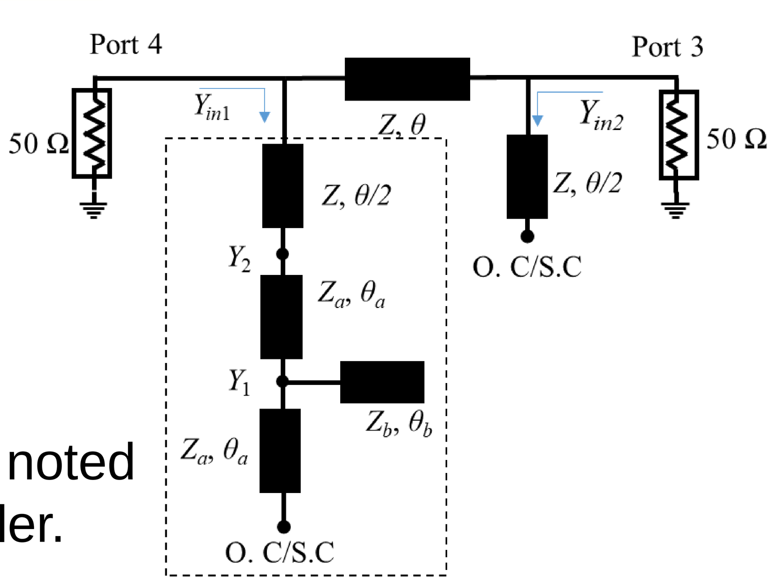
Dual-Band 180° Coupler Design

$$\begin{bmatrix}A & B\\ C & D\end{bmatrix}_{e/o} = \begin{bmatrix}1 & 0\\ Y_{in1} & 1\end{bmatrix}\times\begin{bmatrix}\cos\theta & jZ\sin\theta\\ j\frac{\sin\theta}{Z} & \cos\theta\end{bmatrix}\times\begin{bmatrix}1 & 0\\ Y_{in2} & 1\end{bmatrix}$$

$$S_{34e/o} = \frac{2}{A_{e/o} + B_{e/o}/Z_0 + C_{e/o}Z_0 + D_{e/o}}$$

$$S_{34} = \frac{S_{34e} + S_{34o}}{2}$$

✓ $(\angle S_{34})$ at f_1 and $(\angle S_{34})$ at f_2 are noted for the selected dual-band coupler.



Even-Odd Mode analysis

Design of Dual-Band Delay Transmission Line

Design criteria

$$|S_{XX}|_{f_1} = |S_{XX}|_{f_2} = 0$$
$$|S_{XY}|_{f_1} = |S_{XY}|_{f_2} = 1$$
$$(\angle S_{XY})_{f_1} = 2\pi - (\angle S_{34})_{f_1}$$
$$(\angle S_{XY})_{f_2} = 4\pi - (\angle S_{34})_{f_2}$$

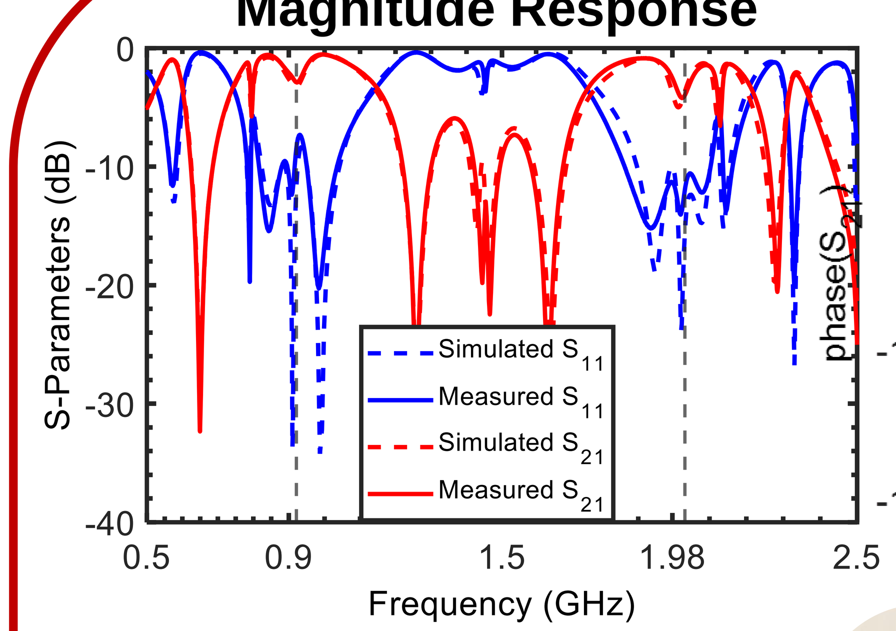
ABCD Matrix

$$\begin{bmatrix}A_T & B_T\\ C_T & D_T\end{bmatrix} = \begin{bmatrix}1 & 0\\ jB_p & 1\end{bmatrix}\times\begin{bmatrix}\cos\theta_m & jZ_m\sin\theta_m\\ j\frac{\sin\theta_m}{Z_m} & \cos\theta_m\end{bmatrix}\times\begin{bmatrix}1 & 0\\ jB_p & 1\end{bmatrix}\times\begin{bmatrix}\cos\theta_s & jZ_s\sin\theta_s\\ j\frac{\sin\theta_s}{Z_s} & \cos\theta_s\end{bmatrix}$$

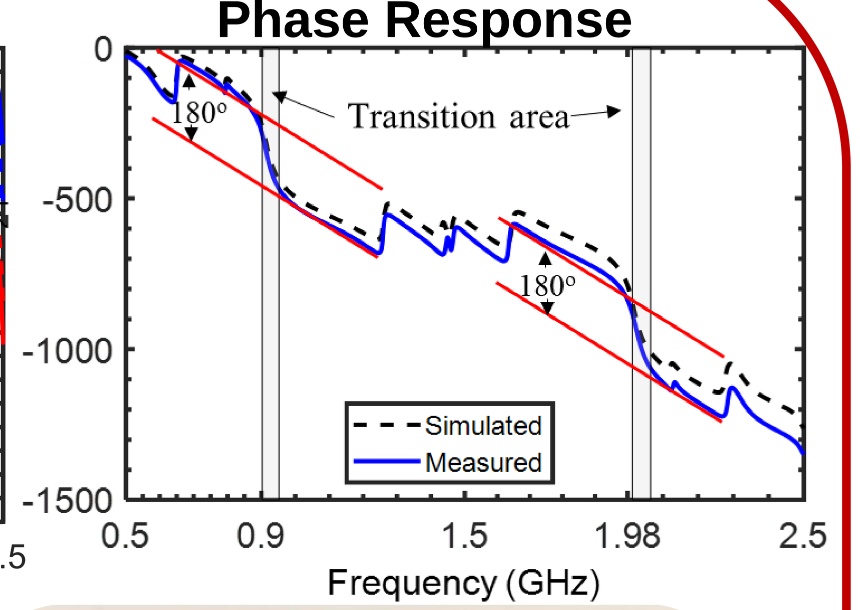
- ✓ 4 design criteria, 6 unknowns (Z_p, Z_m, Z_s, θ_p, θ_m, θ_s).
- ✓ Assume Z values within 20 to 140Ω and solve for θ values.

SIMULATED VS MEASURED RESPONSE OF HT

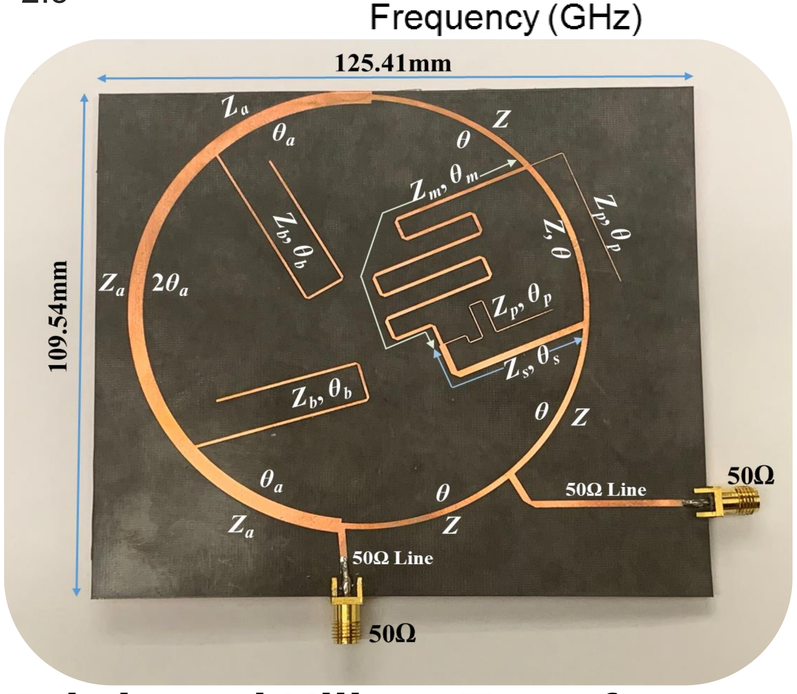
Magnitude Response



Phase Response



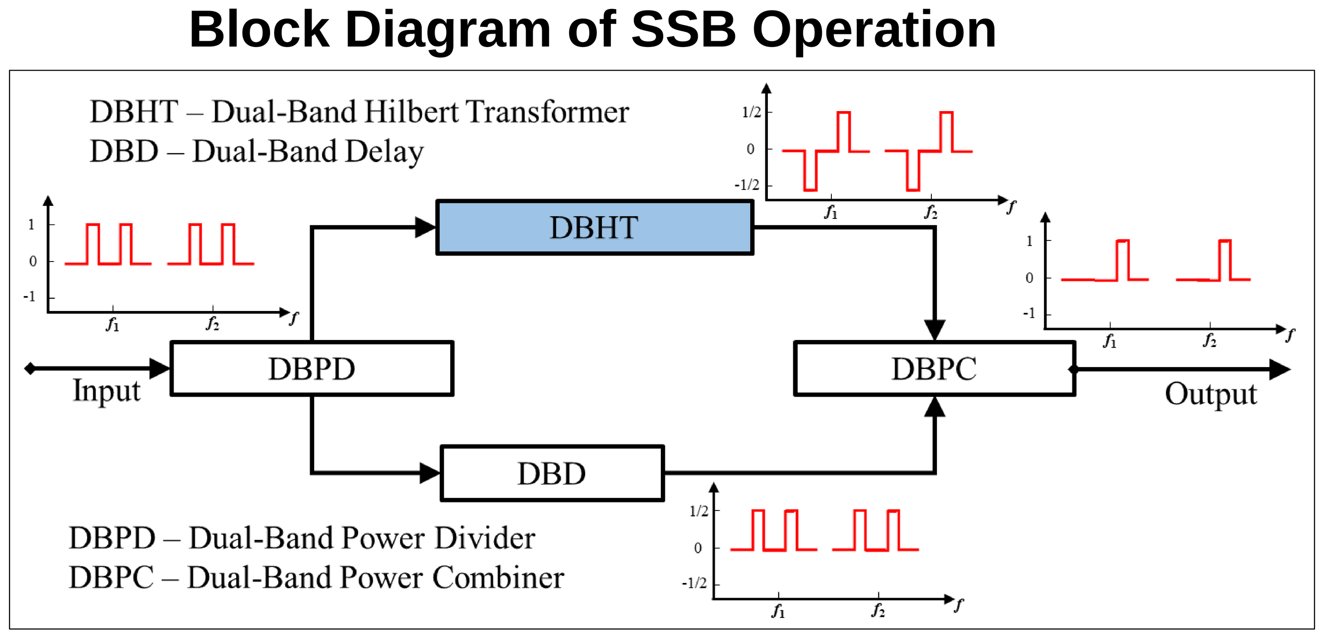
- ✓ Design frequencies 0.9 GHz and 1.98 GHz
- ✓ Passband bandwidths ~240MHz at both frequencies
- ✓ More than 10dB return losses.
- ✓ Passband Magnitudes ~-2dB except the presence of notches.
- ✓ 180° phase transition BW ~50MHz.



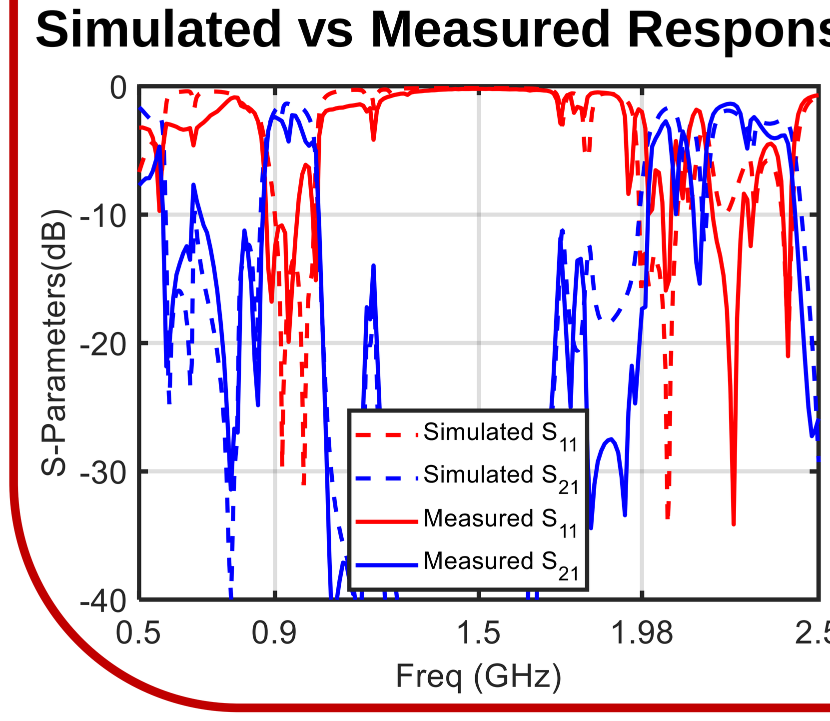
Fabricated Hilbert Transformer

APPLICATION IN DUAL-BAND SSB OPERATION

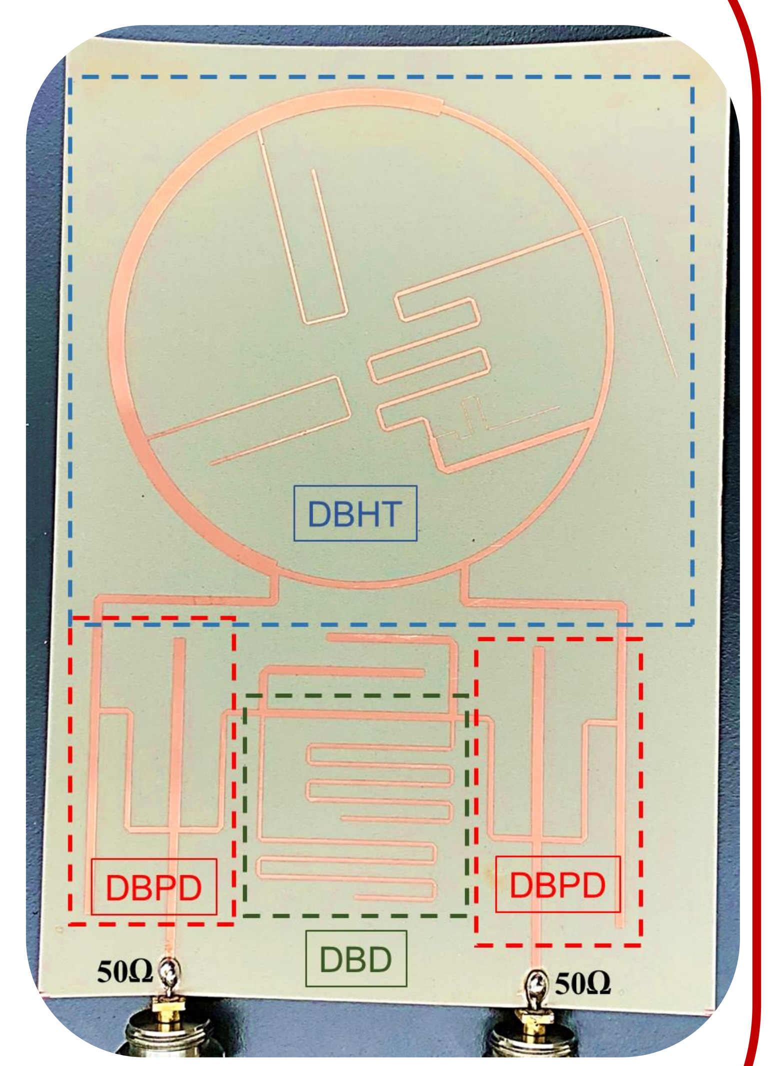
Block Diagram of SSB Operation



Simulated vs Measured Response



- ✓ Dual-band single side band operation with
  - passband of ~80MHz at both frequencies
- ✓ More than 10dB return losses.
- ✓ Passband Magnitudes ~-2dB



Fabricated Dual-Band SSB Modulator

Submission ID: 2129