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Poster Presentation

Kaide Hotel Lobby

Poster Session
Session Chairs: Dehua Ren (Tianjin University of Science and Technology, China) Jianzheng Liu (Tianjin University of Science and Technology, China)

- ID 1. Two Weight Assignment Schemas for User Requirements Based on Dynamic Pricing Model in Cloud Environment
  Qian Zhongsheng
  Jiangxi University of Finance and Economics, Nanchang, China

- ID 7. Enhanced Flexoelectric Effect of Hydrogen-bonded Dimer-doped Nematic Liquid Crystals
  Jongyoon Kim and Ji-Hoon Lee
  Chonbuk National University, Korea

- ID13. A Portable Holter for Real-time ECG Monitoring and Automated Arrhythmia Detection
  Yuan Wang, Wenhui Sun, Dong Li, Di Zhu and Jucheng Yang
  Tianjin University of Science and Technology, China.

- ID16. Learning Transmit Power Control for Sum-Rate Maximization in Interference Channels
  Junbeom Kim, Daesung Yu and Seok-Hwan Park
  Chonbuk National University, Korea

- ID18. Extended Temporal Convolutions for Human Action Recognition in Videos
  Khwaja Monib Sediqi, Thai Leang Sung and Hyo Jong Lee
  Chonbuk National University, Korea

- ID21. A Multi-objective Opitimization Model for VRP and VFP Based on An Improved Ant Colony Algorithm
  Yujie Wang, Jiewei Chen and Yongluo Shen
  Guangdong University of Finance and Economics, China.

- ID23. Faster Retrieve and Localize Activity via Language Query
  Pengju Zhang, Chunmiao Yuan, Kunliang Liu, Yukuan Sun, Jiayu Liang, Guanghao Jin and Jianming Wang
  Tianjin Polytechnic University, China.

- ID24. Invariance Matters:Person Re-identification by Local Color Transfer
  Ying Niu, Chunmiao Yuan, Kunliang Liu, Yukuan Sun, Jiayu Liang, Guanghao Jin and Jianming Wang
  Tianjin Polytechnic University, China.

- ID59. Stochastic iteration in Markov decision processes with changing reward function
  Yao Ma
  Boston University, America

- ID61. Improved Integral Inequality for Stability Analysis of Neural Network with Time-Varying Delay
  Tuvshinbayar Chantsalnyam and Kil To Chong
  Chonbuk National University, Korea

- ID62. An Overview of GANs Image Generation
  Jucheng Yang, Haoyu Zhang and Yuan Wang
  Tianjin University of Science and Technology, China

- ID66. A Brief Survey of Model-based Reinforcement Learning
  Lihui Wang[1], Le Kong[2] and Tingting Zhao[2]
  The University of Tokyo, Japan[1]
  Tianjin University of Science and Technology, China[2]

- ID67. Arbitrary Style Transfer Based on Minimizes the Distributions of Features
  Li Suli and Lee Hyo Jong
  Chonbuk National University, Korea

- ID70. Dual Band Biasing Circuit Using CRLH TL
  Phanam Pech and Yongchae Jeong
  Chonbuk National University, Korea

- ID72. A study on Real-time Fluorescence-Photoacoustic imaging system for thrombosis monitoring
  Hyun Sang Jo, Moung Young Lee, Sang Hun Park, Ji Hyun Kim and Chul Gyu Song
  Chonbuk National University, Korea

- ID75. Remote online monitoring system based on Internet of things
  Jianrong Li, Jiani Du and Jiangtao Liu
  Tianjin University of Science and Technology, China

- ID76. Design of environmental mobile law enforcement system based on Internet of things
  Jianrong Li, Jiangtao Liu and Jiani Du
  Tianjin University of Science and Technology, China

- ID77. Design of Intelligent Window Based on STM32 MCU
  Fei Han, Wandi Li, Jian Chen and Panzhi Du
  Shijiazhuang Tiedao University Shijiazhuang,China

Dual Band Biasing Circuit Using CRLH TL

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***Abstract*—This paper demonstrates a design of dual band biasing circuit using composite right-/left-handed transmission line (CRLH TL). The proposed circuit consists of the L-first type balanced CRLH TL structure. The prescribed dual band biasing circuit can be generated two reflection zeros (RZs) at the first (f_1) and second (f_2) frequency bands by controlling the right-handed (RH) and left-handed (LH) components. To show validity of concept, the circuit is designed and simulated at 1.96 GHz and 2.4 GHz. From results, it can concluded that the proposed circuit can be used as dual band biasing circuit.**

Keywords—CRLH TL, dual band, left-handed, right-handed.

I. INTRODUCTION

In modern communication system, the usage of multiple frequency bands is growing especially in wireless communication system. Therefore, the RF circuits should have an ability to operate in multiple frequency bands. The dual band power amplifiers (PAs) and dual band bandpass filters were presented in [1]-[3]. In active circuit design, the biasing circuit is one of the important parts. As in the PA circuit, the DC power is supplied to the gate and drain of the transistor according to its operation mode and input power level. Usually, the DC power supplies connected with a RF short-ended quarter wavelength ($\lambda/4$) transmission line provide an open circuit at RF frequency or fundamental frequency. Thus, this biasing network prevents the DC supplies from being interrupted with RF signal. Also the biasing circuit does not affect to the matching network at the RF fundamental frequency. This approach works for single band PA design. However, the same biasing topology cannot prevent the interruption between DC and RF signals at dual-band frequencies. An alternative approach must replace the single frequency quarter wavelength transmission line with dual-frequency quarter wavelength transmission line but, this approach increase the complexity of biasing circuit and may increase the size.

According to the dual band property, CRLH TL are presented in dual band application with the size reduction [4]-[6]. The phase response of the CRLH TL can be controlled by adjusting the values of RH and LH components. Therefore, the arbitrary frequencies (f_1 and f_2) can be realized to meet the requirement. Recently, a novel DC biasing circuit with harmonic control capability for compact high efficiency PAs was presented in [4]. The bias circuit was designed by using asymmetric and unbalanced CRLH structures, but not shown an analysis. The bias stub was designed to generate the RZ at the fundamental frequency such that the stub operated like an ideal DC biasing circuit.

In this paper, a dual band biasing circuit using CRLH TL is proposed. The operation frequencies are chose in personal communication system (PCS) and industrial scientific and medical (ISM) band at 1.96 GHz and 2.4 GHz, respectively.

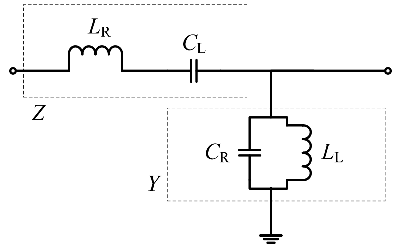


Fig.1. Basic structure of asymmetric CRLH TL.

II. DESIGN METHOD

In order to design a biasing circuit using CRLH TL, one possible choice is to use the L-first type structure and feed the DC from the shunt inductor of the LH component. In this paper, the proposed circuit is designed using balanced CRLH TL structure. Fig. 1 shows the structure of the asymmetric CRLH TL. The RH TL is constructed by a series L_R and a shunt C_R in low pass topology. The LH TL is constructed by a series C_L and a shunt L_L in high pass topology. CRLH TLs are realized by combining the RH and LH TLs. The RH components can be realized with the TL. A balanced CRLH TL can be designed when the following conditions are satisfied [7].

$$\omega_{se} = \omega_{sh} = \frac{1}{\sqrt{L_R C_L}} = \frac{1}{\sqrt{L_L C_R}} \quad \text{(1a)}$$

$$L_R C_L = L_L C_R \quad \text{(1b)}$$

$$Z_{RH} = Z_{LH} = \sqrt{\frac{L_R}{C_R}} = \sqrt{\frac{L_L}{C_L}}, \quad \text{(1c)}$$

where ω_{se} and ω_{sh} are the resonant frequencies of the series and shunt circuits in Fig. 1, respectively. The subscripts R and L are referred to RH and LH, respectively.

The proposed dual band biasing circuit is realized from the symmetric L-first CRLH TL in Pi-type combination that equivalent to the C-first CRLH TL in T-type combination as shown in Fig. 2.

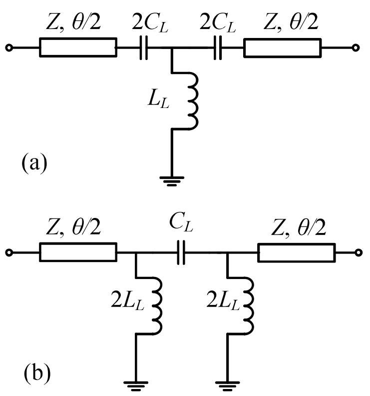


Fig. 2. Balanced CRLH TLs: (a) C-first in T-type combination and (b) L-first in Pi-type combination.

The analysis are based on lossless circuit. In general, RH TLs represent normal TLs. The phase responses of the RH and LH TLs, ϕ_R and ϕ_L are expressed as (2a) and (2b), respectively. The phase response of the CRLH TL (ϕ_C) can be obtained by combining the phase responses of RH and LH TLs as expressed in (2c).

$$\phi_R = -N\omega\sqrt{L_R C_R} \tag{2a}$$

$$\phi_L \approx \frac{N}{\omega\sqrt{L_L C_L}} \tag{2b}$$

$$\phi_C \approx \phi_R + \phi_L, \tag{2c}$$

where N denotes the number of cascaded unit cell.

When the balanced CRLH TL operate at two frequencies (f_1 and f_2), the corresponding phase pairs should be ϕ_1 and ϕ_2 as shown (3).

$$-N\omega_1\sqrt{L_R C_R} + \frac{N}{\omega_1\sqrt{L_L C_L}} \approx \phi_1 \tag{3a}$$

$$-N\omega_2\sqrt{L_R C_R} + \frac{N}{\omega_2\sqrt{L_L C_L}} \approx \phi_2 \tag{3b}$$

The analyzing method to calculate the values of the parameters L_R, C_R, L_L, and C_L for C-first balanced CRLH TL is presented in [7]. As mentioned above, the proposed structure is equivalent to the C-first balanced CRLH TL in T-type combination. Therefore the values of L_R, C_R, L_L, and C_L in L-first balanced CRLH TL can be calculated with the same method.

$$L_R = \frac{Z\left[\phi_1(\omega_1/\omega_2) - \phi_2\right]}{N\omega_2\left[1-(\omega_1/\omega_2)^2\right]}, \tag{4a}$$

$$C_R = \frac{\phi_1(\omega_1/\omega_2) - \phi_2}{NZ\omega_2\left[1-(\omega_1/\omega_2)^2\right]}, \tag{4b}$$

$$L_L = \frac{NZ\left[1-(\omega_1/\omega_2)^2\right]}{\omega_1\left[\phi_1 - (\omega_1/\omega_2)\phi_2\right]}, \tag{4c}$$

$$C_L = \frac{N\left[1-(\omega_1/\omega_2)^2\right]}{\omega_1 Z\left[\phi_1 - (\omega_1/\omega_2)\phi_2\right]}, \tag{4d}$$

where Z is the characteristic impedance of the RH TL. ϕ_1 and ϕ_2 are chosen at $+\pi/2$ and 0^o to obtain the RZs, respectively.

III. SIMULATION

Fig. 3 shows the structure of the proposed dual band biasing circuit. The first shunt inductor ($2L_L$) serves as the DC bias feed and it also determines RF frequency of the stub. In order to obtain the RZs at f_1 and f_2, the impedance at the junction point of the stub should be infinite at these frequencies. The RH components are converted to the TL with the characteristic impedance Z and its electrical length θ. The calculated parameters are presented in Table I.

TABLE I. CALCULATED VALUES OF RH AND LH COMPONENTS.

Z (Ω)	θ (º)	L_L (nH)	C_L (pF)
70	77.1	2.15	0.3

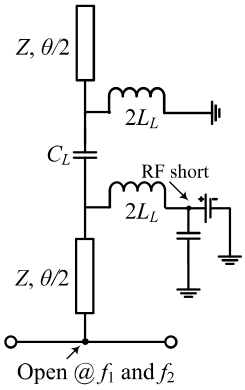
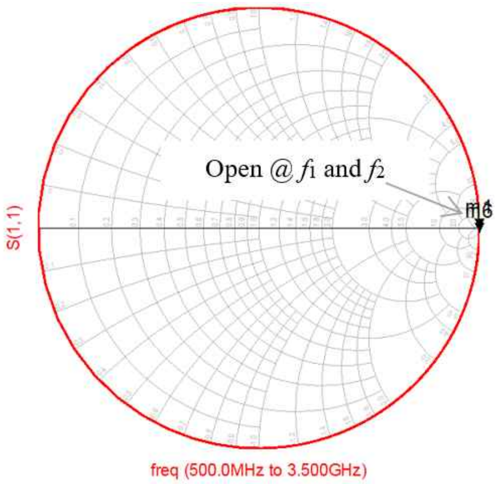
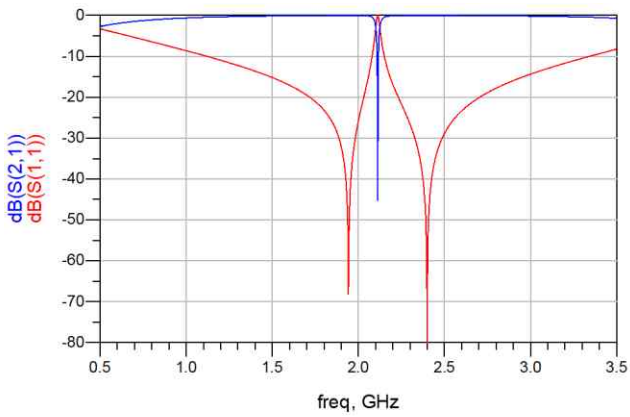


Fig. 3. Proposed dual band biasing circuit.



(a)



(b)

Fig. 4. Simulation results: (a) impedance points at f_1 and f_2, and (b) S-parameters.

Fig. 4 shows the simulation results of the proposed circuit. The impedances at f_1 and f_2 are located at the open position on the smith chart. As the results, two RZs are obtained at these frequencies. Therefore, the proposed structure can operate as a dual band biasing circuit.

IV. CONCLUSSION

This paper demonstrates a dual band biasing circuit by using balanced CRLH TL. The analysis and simulation show that the proposed circuit can provide the RZs or open circuits at f_1 and f_2. The proposed circuit will be useful in microwave power amplifier design for dual band applications.

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