2015 International Symposium on Information Technology Convergence

Proceedings

October 15-17, 2015

Tianjin University of Science and Technology, China

Session 2-D : Communications and Network, Internet of things

09:00-11: 30, Saturday, October 17, 2015

Session Chairs : Jongsik Lim (Soonchunhyang University, Korea)
Yancui Shi (Tianjin University of Science and Technology, China)

ID14. Design of a Dual-Band Balanced Amplifier using a CRLH Transmission Line Structure

Jongsik Lim[1], Qi Wang[2], Junsik Park[2], Yongchae Jeong[2], Seok-Jae Lee[1], Sang-Min Han[1], Kwan-Sun Choi[1], Dal Ahn[1]
Soonchunhyang University, South Korea[1]
Chonbuk National University, South Korea[2]

ID40. Using Operation-flow to Control Information System Risk

Hongyu Yang, Xiang Cheng
Civil Aviation University of China, China

ID43. Research on Intrusion Detection for Wireless Mesh Network

Hongyu Yang, Xinyuan Wang
Civil Aviation University of China, China

ID60. The Analysis for Avoiding Train Conflicts Based on Petri Net

Xiaozhong Li, Shihui Wang, Shuang Yan, Chaofan Yang
Tianjin University of Science and Technology, China

ID71. An Influence Calculating Method Based on Mobile Phone Data

Yancui Shi, Haonan Dai, Congcong Xiong, Jucheng Yang, Yarui Chen
Tianjin University of Science and Technology, China

ID78. A Novel Converged Network Architecture of Wireless Sensor Networks and Cellular Networks

Yushi Zhou[1], Weidong Fang[2], Chuanlei Zhang[3], Lianhai Shan[4]
Ryerson University, Canada[1],
Shanghai University, China[2]
Tianjin University of Science and Technology, China[3]
Shanghai Institute of Microsystem and Information Technology, Chinese Academy of Sciences, China[4]

Design of a Dual-Band Balanced Amplifier using a CRLH Transmission Line Structure

[1]Jongsik Lim, [2]Qi Wang, [2]Junsik Park, [2]Yongchae Jeong, [1]Seok-Jae Lee, [1]Sang-Min Han, [1]Kwan-Sun Choi, and [1]Dal Ahn

[1]Soonchunhyang University, Rep. Of KOREA
[2]Chonbuk National University, Rep. Of KOREA

Abstract — A design of dual-band balanced amplifier using a composite right/left-handed (CRLH) transmission line structure is described. The proposed balanced amplifier consists of a couple of dual-band branch line hybrid couplers and two identical dual-band singled-ended amplifiers. Those sub-circuits are designed in advance using the CRLH transmission line structure. As an example of the proposed balanced amplifier, the prototype of dual band balanced amplifier is designed at 1800 MHz (f_1) and 2300 MHz (f_2). The simulation shows that the designed balanced amplifier operates well at the desired dual frequency bands. The designed gains are 11.66dB and 17.39dB at f_1 and f_2, respectively, and the amplification is observed at both bands clearly.

Keyword—Balanced amplifiers, CRLH, dual-band

I. INTRODUCTION

Unlikely to the equivalent network of normal transmission lines, left-handed (LH) transmission lines may be designed by combining series capacitor and shunt inductor artificially. The representative property of LH transmission lines is negative group velocity, while the energy propagates normally along the positive direction [1]. In practice, the realization of LH transmission lines is always accompanied with practical transmission line elements called as right-handed (RH) transmission line for physical connection and application. So the transmission line containing LH and RH section has been named as composite right/left-handed (CRLH) transmission lines [2,3].

One of the most important characteristics of CRLH transmission lines is the possibility for dual-band applications, because CRLH transmission lines usually have two frequencies for specific meaningful phase values such 90^o or 270^o. Therefore lots of research outputs about dual-band applications have been suggested so far [4-7].

In this work, a design of dual-band balanced amplifier (DBBA) using the well known CRLH transmission line structure is described. The structure of the DBBA is typical and straightforward, however the sub-circuits of the balanced amplifier such as couplers and single-ended amplifiers are designed for dual-band operation using the CRLH transmission line.

In general, balanced amplifiers have a quite broadband performance, which has been understood as one of advantages of balanced amplifiers. However the proposed dual-band balanced amplifier has excellent frequency selectiveness in the dual operating bands. In other words, the proposed dual-band balanced amplifier shows the gain performances only at the required dual and narrow operating frequency band instead of broadband gain. So, in some cases, the proposed dual-band balanced amplifier can be more desirable than typical broadband balanced amplifiers, especially when a steep rejection is required at the non-interesting band for some technical requirements.

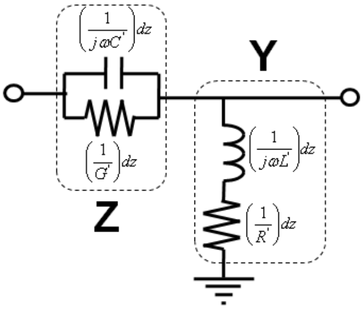
II. DESIGN OF SUB-CIRCUITS FOR DUAL-BAND OPERATION

A. Dual-Band Branch Line Hybrid Coupler

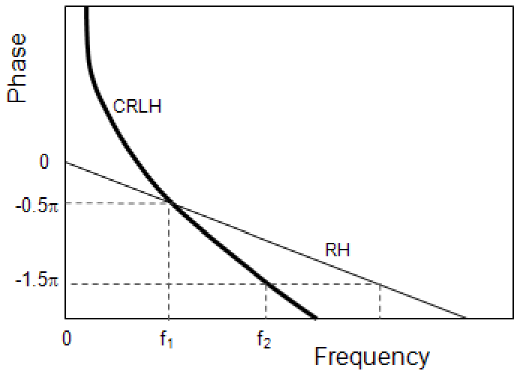
Many studies on how to design dual-band power dividers/combiners and couplers have been performed widely. In this work, the proposed DBBA has been designed on the basis of the properties of CRLH transmission lines, so authors are going to concentrate on the method using it.

Fig. 1(a) shows the unit section of a CRLH transmission lines. Because it has been well known that CRLH transmission lines show dual-band characteristics [4-7], theories about CRLH transmission lines are not introduced here in detail, but mentioned briefly. As can be seen in Fig. 1(b), frequencies f_1 and f_2, corresponding to 0.5π and 1.5π or -0.5π, respectively, are proportionally related to each other in normal RH transmission lines. However, in CRLH transmission lines, this first-order relation is not valid anymore, but arbitrary ratio of f_1/f_2 is obtainable [8]. This is one of attractive properties of CRLH for dual-band applications.

Fig, 2 shows an open stub composed of CRLH transmission lines and its S-parameters. A typical transmission zero at the center frequency is shown. The transmission zero is obtained from two-port networks with open stubs. In addition, it is noted that two poles exist, and this means a possibility of design of dual-band circuits.

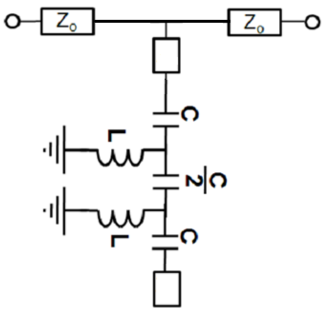


(a)

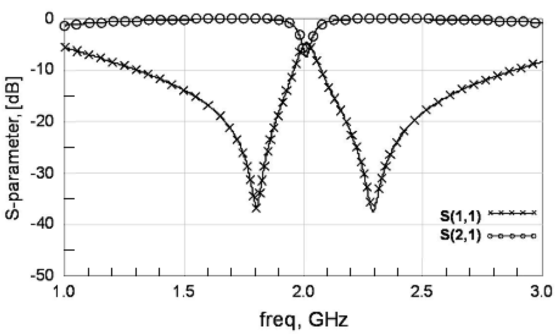


(b)

Fig. 1 CRLH Transmission line (a) unit section (b) phase characteristics



(a)

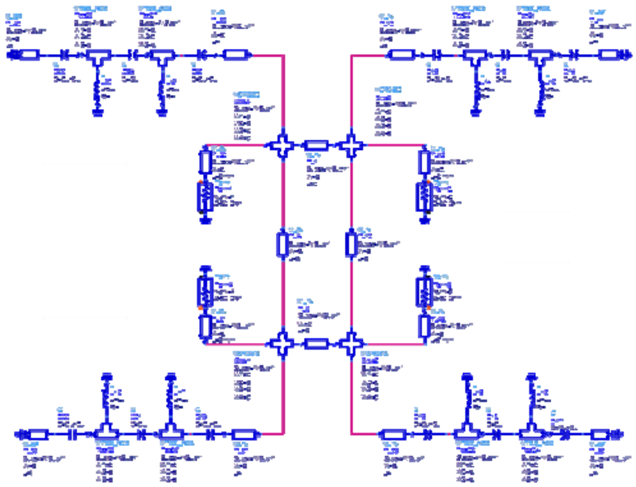


(b)

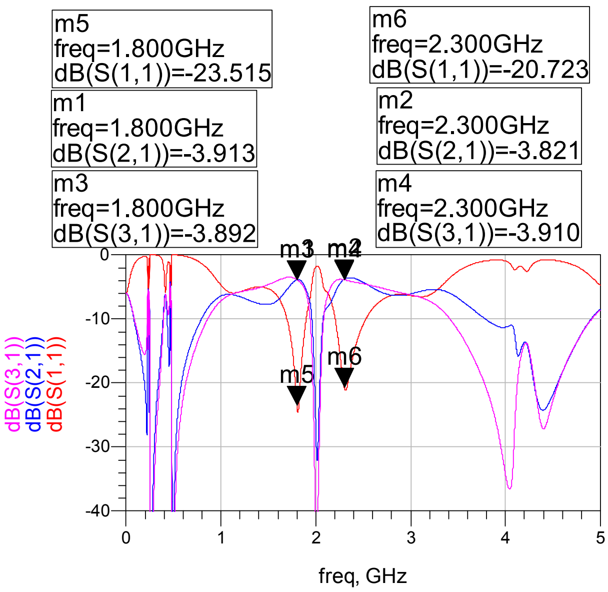
Fig. 2 (a) 2-port network with the CRLH open stub (b) transmission characteristics

A design of dual-band branch line hybrid coupler (BLHC) has been proposed already by adding open stubs and modifying the basically required transmission line impedance values such as 50Ω and 35.35Ω to other values [9]. If the CRLH open stub is adopted to design of BLHC, it is possible to obtain a dual-band BLHC with typical line impedance values of 50Ω and 35.35Ω.

Fig. 3 shows the schematic circuit and simulated S-parameters of the designed dual-band BLHC with f_1 and f_2 of 1.8GHz and 2.3GHz, respectively. It is observed that good performances as BLHCs have been obtained at both frequencies. The dual-band operations are caused by the CRLH transmission line.



(a)



(b)

Fig. 3 (a) Schematic and (b) Simulated S-parameters of the dual-band BLHC using CRLH Transmission line

B. Dual-Band Single-Ended Amplifier

In the same way, one can design a dual-band single-ended amplifier using the dual-band properties of CRLH transmission lines. Fig. 4 shows the design concept of the dual-band single-ended amplifier using CRLH transmission line. The matching networks are designed normally for each frequency band. So the design of two amplifiers is completed first. Then the two amplifiers may be merged into one dual-band amplifier by adopting the CRLH structure.

Fig. 5 shows the S-parameters of the designed dual-band single-ended amplifier for f_1 and f_2 frequency bands. It should be noted that this amplifier is not a broadband amplifier, but a dual-band amplifier. One can recognize the dual-band gain and matching characteristics from the S-parameters even though positive gain is observed over broad frequency band.

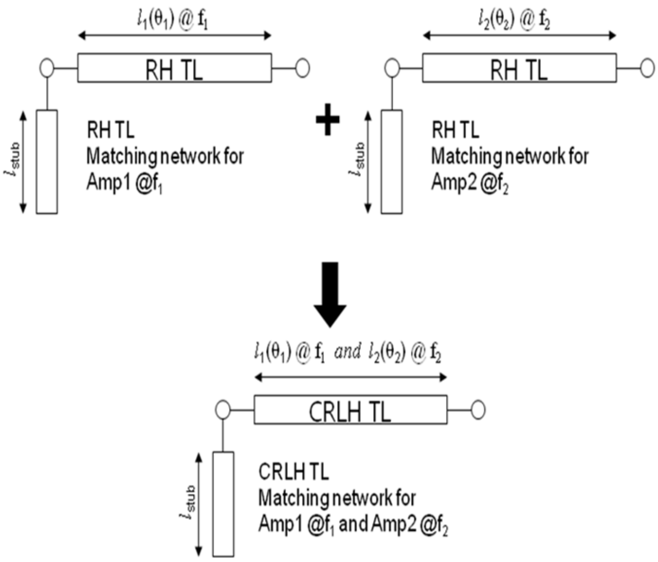


Fig. 4 CRLH Transmission line (a) unit section (b) phase characteristics

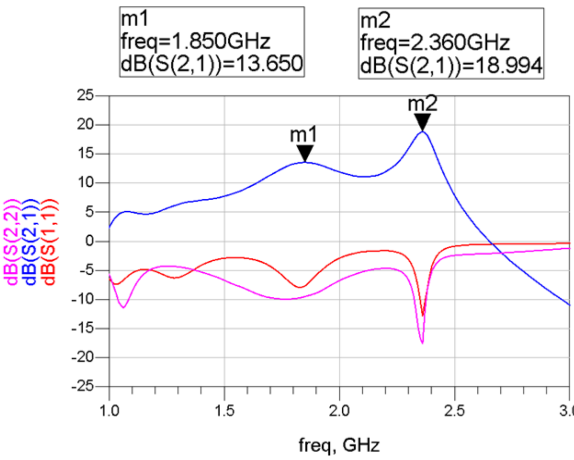


Fig. 5 S-parameters of the single-ended dual-band amplifier

III. Design of the Dual-Band Balanced Amplifier

The structure of the balanced amplifiers is typical, however in this work, the designed dual-band BLHC and single-ended amplifier are adopted in order to design the proposed dual-band balanced amplifier as illustrated in Fig. 6. Two single-ended amplifiers should be identical ideally, however minor variations between devices are not guaranteed in practice. The same situation goes for the two dual-band BLHCs.

Fig. 7 shows the simulated S-parameters of the proposed dual-band balanced amplifier. Definitely, two operating frequency bands are observed clearly with good reflection coefficients. The S-parameters shows a dual-band operation rather than wide-band amplification. Fig. 7 shows the clear difference between a wide-band amplifier and a dual-band amplifier. Wide-band amplification may replace dual-band amplification naturally. However, with the systematic point of view, the steep rejection for the unwanted frequency band may be more fruitful than broadband amplification in some applications.

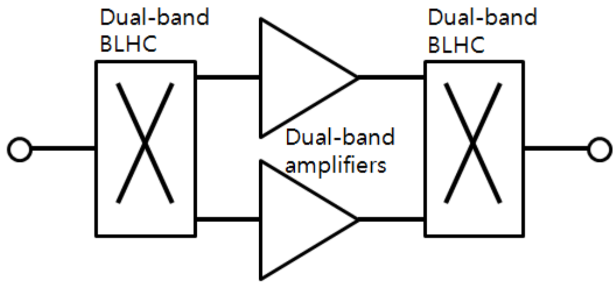


Fig. 6 Proposed configuration of the dual-band balanced amplifier

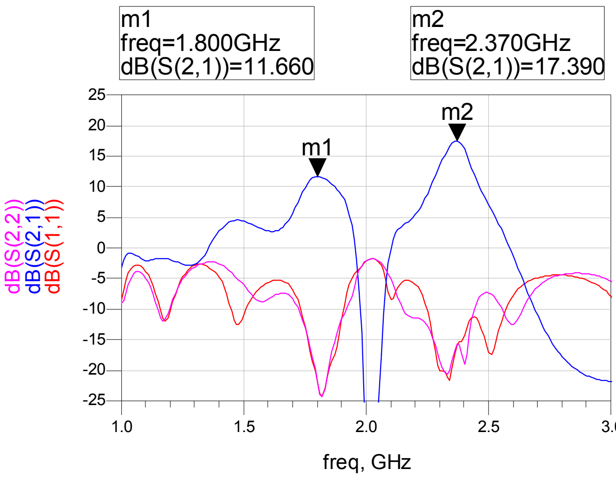


Fig. 7 Simulated S-parameters of the dual-band balanced amplifier

IV. CONCLUSION

A design of dual-band balanced amplifier using CRLH transmission line has been described in this work. A BLHC and single-ended amplifier have been designed by adopting the CRLH structure as the sub-circuits for the balanced amplifier. The S-parameters of the dual-band balanced amplifier showed a clear dual-band operation, which is different from wide-band amplification. The gain at the unwanted band in the mid of the operating bands has been rejected perfectly. It is expected that the proposed design scheme using CRLH transmission line would be applied for various dual-band high frequency circuits when the unwanted band should be rejected steeply.

ACKNOWLEDGEMENT

This research was supported by the MSIP(Ministry of Science, ICT and Future Planning), Korea, under the ITRC(Information Technology Research Center) support program (IITP-2015-R0992-15-1006) supervised by the IITP(Institute for Information & Communications Technology Promotion).

REFERENCES

[1] C. Caloz, T. Itoh, "Application of the Transmission Line Theory of Left-Handed(LH) Materials to the Realization of a Microstrip LH Transmission Line", IEEE-APS International Symposium, vol. 2, pp. 412-415, San Antonio, TX, Jun. 2002.

[2] I-H. Lin, M. DeVincentis, C. Caloz and T. Itoh, "Arbitrary Dual-Band Components using Composite Right/Left-Handed Transmission Lines", IEEE Transactions on Microwave Theory and Technology, vol. 52, no. 4, pp. 1142-1149, April 2004.

[3] C. Caloz and T. Itoh, "Transmission Line Approach of Left-Handed Materials and Microstrip Implementation of an Artificial LH Transmission Line", IEEE Transactions on Antenna and Propagation, vol. 52, no. 5, pp. 1159-1163, May 2004.

[4] G. V. Eleftheriades, A. K. Iyer, and P. C. Kremer, "Planar Negative Refractive Index Media using Periodically L-C Loaded Transmission Lines", IEEE Transactions on Microwave Theory and Technology, vol. 50, no. 12, pp. 2702-2712, Dec. 2002.

[5] A. Sanada, C. Caloz, and T. Itoh, "Characteristics of the Composite Right/Left-Handed Transmission Lines," IEEE Microwave Wireless Components Letters, vol. 14, no. 2, pp. 68-70, Feb. 2004.

[6] I.-H. Lin, K. M. K. H. Leong, C. Caloz, and T. Itoh, "Dual-Band Sub-harmonic Quadrature Mixer using Composite Right/Left-Handed Transmission Lines," IEE Proc. Microwaves, Antennas and Propagation, vol. 153, no. 4, pp. 153-180, Aug. 2006.

[7] C. Caloz, "Dual composite right/left-handed (D-CRLH) Transmission Line Metamaterial," IEEE Microwave Wireless Components Letters, vol. 16, no. 11, pp. 585-587, Nov. 2006.

[8] J. Lim, Y. Jeon, S.-M. Han, Y. Jeong, and D. Ahn, "A Design of Dual Band Amplifiers Using CRLH Transmission Line Structure," IEICE Transactions on Electronics, vol. E95-C, no. 5, pp. 964-967, May 2012.

[9] K. M. Cheng and F. Wong, "A Novel Approach to the Design and Implementation of Dual-Band Compact Planar 90^{o} Branch-Line Coupler", IEEE Transactions on Microwave Theory and Technology, vol. 52, no. 11, pp. 2458-2463, Nov. 2004.