Response to Review Comment

Name of the Student: **Rakesh Sinha**

Title of the Thesis: **Synthesis of Asymmetric Multiport Network**

Name of the Examiner: **Prof. Luca Perregrini**

Overall Comment

The PhD thesis of Mr. Sinha describes a signification work devoted to the rigorous design of multiport component based on transmission lines. Overall, the document is well organized and written. The results are relevant for the microwave community. This clearly appears from the paper published or accepted on high reputation journals.

I have some specific comments and editorial issues, which I suggest to include in a revised version of the thesis, to further improve his relevance.

Reply: The author thanks **Prof. Luca Perregrini** for the encouraging comments. The specific comments and editorial issues suggested by the examiner are addressed in the revised Thesis.

Specific Comments

1) In the list of Publication of the candidate in the references [3] and [4] some data are missed (i.e., volume, pages, issue number, year)

   Reply: At the time of submission of the Thesis the data in the references [3] and [4] were not available. The suggested data are incorporated in the revised Thesis.

2) Page 15, last sentence: instead of "numerical errors" I think it is more appropriate to talk about "rounding errors".

   Reply: This has been corrected in the revised thesis.

3) A comparison with other possible design result reported in the literature could help understanding the advantage of the proposed theory. In particular a table should be included, reporting the performance in terms of matching levels, bandwidth, physical dimensions, etc.

   Reply: Table: 2.1, 2.3 and 2.4 provide the data for electrical dimensions, matching level, amplitude and phase imbalance property of the proposed RRC and BLC compare to the design reported in the literature. This shows that the asymmetric-T based coupler reported in the literature are inaccurate. The theory proposed in this thesis corrected the fallacy of the existing design equations.

4) In Fig. 2.18 and 2.20 there are abrupt changes of the value of bandwidth. This phenomenon is highlighted in the text, however his physical origin and meaning is not discussed. This should be commented in the revised thesis.

   Reply: The phenomenon of abrupt change of bandwidth in Fig. 2.18 and 2.20 have been explained in the revised thesis. The abrupt change in port-4 excitation matching bandwidth in Fig. 2.18 can be explained through the example shown in Fig. 1 below. Fig. 1 shows that S_{44} is just above -10 dB from 1.23 GHz to 1.31 GHz for $n^b = 0.12$, wherein S_{44} is just below -10 dB in that band of frequencies for $n^b = 0.1$. So the matching bandwidths are 34.28% and 46.70% for $n^b = 0.12$ and $n^b = 0.10$ respectively. This leads to sudden increase in the bandwidth around $n^b = 0.1$.

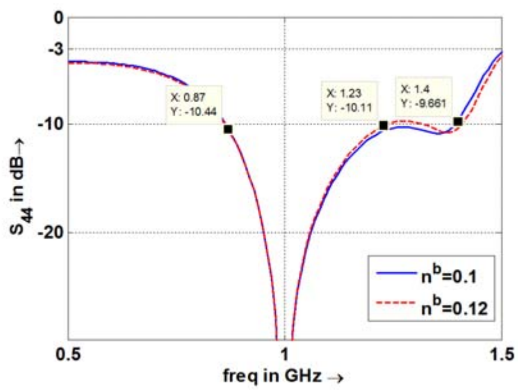

Fig. 1: Return loss of asymmetric-T based BLC for port-4 excitation.

5) Along the whole thesis, when a circuit is shown all the dimensions and material characteristics should be indicated. This is mandatory either to allow the readers to perform an independent validation of your results or simply to fabricate the proposed circuit.

   Reply: The dimensions and material characteristics of the microstrip prototype are indicated in the revised thesis.

6) Page 145: since “f_1” and “f_2” are used elsewhere to define the bandwidth it is suggested to use other symbols to define impedance.

   Reply: The variable “f_1” and “f_2” in page 145 have been replaced with “m_1” and “m_2” in the revised thesis.

Typos/editorials

1) There should be space between a number and the measurement units (in all case, apart “%” and “°”). Moreover the measurement unit should not be italic. Finally, please

avoid \Omega upside-down (like in (1.35a)) to indicate Siemens: simply use “S”, as commonly done! Please check it throughout the whole thesis.

2) Page 14, just after (1.35b): please refrain to use “+ve” to say positive. Please check it throughout the whole thesis.
3) Page 27, second row of par. 1.5.3: “degign”-> “design”.
4) Page 54, definition of the fractional bandwidth: “F_1”-> “f_1”
5) Page 81, first sentence: “fiends”-> “founds”
6) Page 166 5th row from bottom: “forbiddenregion”-> space missed

Reply: The typos and the editorial corrections have been addressed in the revised thesis.

Questions

1) When designing a component, either a coupler or a matching network, a key specification is the frequency bandwidth. Although elegant, the present theory aims to synthesize a circuit with a prescribed performance at a single fixed frequency. Do you think the theory could be extended to include also the frequency band as a design parameter?

   Reply: With the theory presented the thesis and multivariable optimization technique one can obtain design parameters for desired bandwidth. However in general closed-form expressions of the design parameters for a specific bandwidth are difficult to obtain.

2) In the design example of the matching network you have selected a specific value for the load (i.e., 100-j30 \Omega). Is there any particular reason to choose this value? Is it somehow related to the input impedance of any physical device?

   Reply: The general design equations of impedance matching network for any arbitrary source and load impedance incorporating the transmission phase has been established in Theorem.4.3.1 (Eqn. (4.1)). The specific value for the load (i.e., 100-j30 \Omega) has been chosen in the example because it has been used by Ahn [1] for the case of transmission line based matching network and will allow the reader to compare the various matching network with respect to the single transmission line. An antenna may have input impedance of 100-j30 \Omega.

[1] H.-R. Ahn, “Complex impedance transformers consisting of only transmission-line sections,” *IEEE Trans. Microw. Theory Techn.*, vol. 60, no.7, pp. 2073–2084, Jul. 2012.