www.aprasc2016.org

Final Program

2016 URSI Asia-Pacific Radio Science Conference

URSI AP-RASC 2016

August 21 - 25, 2016
Grand Hilton Seoul Hotel, Seoul, Korea

Organized by

KIEES URSI

Co-Organized by

RRA NATIONAL RADIO RESEARCH AGENCY ETRI KASI Korea Astronomy and Space Science Institute NFRI

Technically Co-Sponsored by

EIC IEEE Antennas and Propagation Society IEEE Seoul Chapter KICS IEIE

Supported by

KOFST SEOUL METROPOLITAN GOVERNMENT KOREA TOURISM ORGANIZATION www.visitkorea.or.kr

Program at a Glance

Date	Time	Room A (Emerald A)	Room B (Emerald B)	Room C (Diamond)	Room D (Convention A)	Room E (Convention B)	Room F (Convention C)	Room G (Convention D)	Room H (Convention E)	Room I (Crane)	Room J (Swan)	Room K (White Heron)
Aug. 21 (Sun.)	13:00~17:30	Short Courses (Diamond, 3F, Convention Center, Grand Hilton Seoul Hotel)										
	18:00~20:00	Welcome Reception (Lotus Hill Garden, 2F, Grand Hilton Seoul Hotel)										

Date	Time	Room A (Emerald A)	Room B (Emerald B)	Room C (Diamond)	Room D (Convention A)	Room E (Convention B)	Room F (Convention C)	Room G (Convention D)	Room H (Convention E)	Room I (Crane)	Room J (Swan)	Room K (White Heron)
Aug. 22 (Mon.)	10:00~10:40	Opening Ceremony (Convention A~C, 4F, Convnetion Center, Grand Hilton Seoul Hotel)										
	10:40~11:00	Coffee Break										
	11:00~12:00	[General Lecture I] Nature Inspired Optimization Techniques in Modern Engineering: Let Darwin and the Bees Help Improve your Designs (Convention A~C, 4F, Convnetion Center, Grand Hilton Seoul Hotel)										
	12:00~13:30	Lunch										
	13:30~15:30	[S-B14] Multiscale Multiphysics Techniques and Applications	[S-B12a] Novel Mathematical Methods in Electromagnetics (1)	[S-J1] New technology in Very Long Baseline Interferometry and Single Dishes	[S-K1a] Biological Effects of EMF (1)	SYP Special Session	[S-C3] Wireless Network	[S-G1] GPS/GNSS Monitoring of the Ionosphere	[S-H1] Theory and Simulation of Waves in Plasma	[S-E1] Common-Mode Issues Related to Power Electronics	[S-D1] Microwave and THz Photonics	[S-F1] Wave Propagation and Scattering
	15:30~16:00	Coffee Break										
	16:00~18:00	[S-B2] Reconfigurable Antennas and Miniaturized Antennas	[S-B12b] Novel Mathematical Methods in Electromagnetics (2)	[S-J2] Science and Technology of the Square Kilometer Array	[S-K1b] Biological Effects of EMF (2)	[C1] Spectrum Engineering Technology	[S-C4] Radio Localization Techniques	[S-G3] Radar Probing for the Ionospheric Variability	[S-H2] Generation and Characteristics of Waves in Space	[S-E2] Signal Integrity and EMI of Chip, Package, and PCB	[S-D3] Terahertz Electronics and Photonics	[S-F2a] Remote Sensing for Land and Sea (1)

Date	Time	Room A (Emerald A)	Room B (Emerald B)	Room C (Diamond)	Room D (Convention A)	Room E (Convention B)	Room F (Convention C)	Room G (Convention D)	Room H (Convention E)	Room I (Crane)	Room J (Swan)	Room K (White Heron)
Aug. 23 (Tue.)	08:30~10:30	[S-B3] Groundwave Propagation Modeling, Simulation and Measurement	[S-B12c] Novel Mathematical Methods in Electromagnetics (3)	[S-J3] Science and Technology of Atacama Large Millimeter/Submillimeter Array	[S-K2a] Exposure Assessment and EMF Standards (1)		[S-C6] IoT and green Communications	[S-G2] Ionospheric Density Variability in the Polar Region	[S-H3a] Radio Science for Space Weather (1)	[S-A1] EM Basic Metrology	[S-D2] Ultrafast Photonics	[S-F2b] Remote Sensing for Land and Sea (2)
	10:30~11:00	Coffee Break										
	11:00~12:00	[General Lecture II] Electrodynamic Coupling Processes in the Solar-Terrestrial Environment (Convention A~C, 4F, Convnetion Center, Grand Hilton Seoul Hotel)										
	12:00~13:30	Lunch										
	13:30~15:30	[S-B4] Metamaterials & FSS	[S-B13a] Advances in Super- and High-Resolution Electromagnetic Imaging (1)	[S-J5a] Receivers for Radio Astronomy (1)	[S-K2b] Exposure Assessment and EMF Standards (2)	[S-K7] EM Biomedical Imaging	[S-C7] Massive MIMO and Millimeter Wave Communications	[S-G4] Satellite Probing for the Ionospheric Variability	[S-H3b] Radio Science for Space Weather (2)	[S-A3] Antenna Related Metrology	[S-D4] Microwave and mm-wave Integrated Circuits	[S-F3a] Remote Sensing of the Atmosphere (1)
	15:30~16:00	Coffee Break										
	16:00~18:00	[S-B5] Electromagnetic Field Theory	[S-B13b] Advances in Super- and High-Resolution Electromagnetic Imaging (2)	[B5] Fields and Waves Filter/ Resonator/Circuit	[S-K3a] Numerical Dosimetry (EMF Dosimetry) (1)	[S-KE] EMC in Biomedical Applications	[S-C8] Satellite and Terrestrial Networks	[S-G5] Observation of Ionospheric Plasma Density Variation	[S-H4] Waves in Nuclear Fusion Plasmas and Laser-Plasma Accelerator	[A1] Antenna	[S-D5] High Power RF Devices and Circuits	[S-F3b] Remote Sensing of the Atmosphere (2)
	18:00~20:00	Commission Business Meetings										

Date	Time	Room A (Emerald A)	Room B (Emerald B)	Room C (Diamond)	Room D (Convention A)	Room E (Convention B)	Room F (Convention C)	Room G (Convention D)	Room H (Convention E)	Room I (Crane)	Room J (Swan)	Room K (White Heron)
Aug. 24 (Wed.)	08:30~10:30	[S-B6] Wireless Power Transfer	[S-B1] Electrically Large Antennas	[S-J5b] Receivers for Radio Astronomy (2)	[S-K3b] Numerical Dosimetry (EMF Dosimetry) (2)	[S-E3] Modeling of Electromagnetic Immunity, EMS, and ESD	[C2] Radio Communication Systems and New Radio Service	[S-GH1] ULF/VLF Waves	[S-H5] Coherent Radiation Sources	[A2] Time and Frequency (Joint with ATF)	[S-D6] Low-energy Wireless Sensor Electronics	[S-F4a] Advanced Sensor and Radar Technology (1)
	10:30~11:00	Coffee Break										
	11:00~12:00	[General Lecture III] 5G, Moving Steps Closer to Commercialization (Convention A~C, 4F, Convnetion Center, Grand Hilton Seoul Hotel)										
	12:00~13:30	Lunch										
	13:30~15:30	[S-B7] Computational Technique and EM Simulation	[B1] Fields and Waves 5G and MIMO Technology	[S-J6a] Science and Technology for Solar and Heliophysics (1)	[S-K4] EMFs for New Technologies	[S-E4] EMC Problems in Mobile Devices	[C3] Channel Model, Antenna and Propagation (1)	[S-GH2] Space Weather Impact and Mitigation Efforts	[S-HG1a] Effects of Wave-Particle Interactions in Earths Magnetosphere and Upper Atmosphere (1)	[A3] Material Measurement & Network Analysis	[S-D7] Photonic/ Electromagnetic Metamaterials and Metadevices	[S-F4b] Advanced Sensor and Radar Technology (2)
	15:30~16:00	Coffee Break										
	16:00~18:00	Poster Session (Lobby, 3F, Convetion Center, Grand Hilton Seoul Hotel)										
	18:00~20:30	Banquet (Convention A~E, 4F, Convention Center, Grand Hilton Seoul Hotel)										

Date	Time	Room A (Emerald A)	Room B (Emerald B)	Room C (Diamond)	Room D (Convention A)	Room E (Convention B)	Room F (Convention C)	Room G (Convention D)	Room H (Convention E)	Room I (Crane)	Room J (Swan)	Room K (White Heron)
Aug. 25 (Thu.)	08:30~10:30	[S-B8] Negative Group Delay (NGD) Devices and Its Applications	[B2] Fields and Waves Metamaterials	[S-J6b] Science and Technology for Solar and Heliophysics (2)	[S-K5a] Biomedical Applications of EM Wave (1)	[S-E5] EMC and Information Security	[C4] Channel Model, Antenna and Propagation (2)	[G1] Radio Wave Propagation	[S-HG1b] Effects of Wave-Particle Interactions in Earths Magnetosphere and Upper Atmosphere (2)	[A4] Communication Related Metrology	[S-DBC1] Optical, Electrical and Optoelectronic Generation and Distribution of Microwave Signal	[S-F5] Radio Wave Propagation Aspects in Body Area Networks
	10:30~11:00	Coffee Break										
	11:00~12:00	[General Lecture IV] Role of Electromagnetic Waves in Magnetic Fusion Plasma Research (Convention A~C, 4F, Convnetion Center, Grand Hilton Seoul Hotel)										
	12:00~13:30	Lunch										
	13:30~15:30	[S-B9a] Computational Techniques and EM Field Simulators (1)	[B3] Fields and Waves Frequency Selective Surface	[S-JDE4] Digital Technology for Radio Astronomy	[S-K5b] Biomedical Applications of EM Wave (2)	[S-EB] EMC Modeling and Techniques	[C5] Signal Processing, Algorism and Circuit	[G2] General Ionospheric Studies (1)	[H1] Theory and Observation of Waves in the Earth's Magnetosphere		[D1] Optics and RF/THz Applications	[S-F6a] Remote Sensing of Precipitation (1)
	15:30~16:00	Coffee Break										
	16:00~18:00	[S-B9b] Computational Techniques and EM Field Simulators (2)	[B4] Fields and Waves Wideband/Dualband Antenna	[J1] Five Hundred Meter Aperture Spherical Telescope (Fast)	[S-K6] Dosimetry for WBAN Antennas and Devices	[E1] Radio Interference and Spectrum	[C6] New Radio Service	[G3] General Ionospheric Studies (2)	[H2] Waves and Particles in Solar System: General		[D2] Energy Harvesting and other Electronic Components	[S-F6b] Remote Sensing of Precipitation (2)

Session Title	[D2] Energy Harvesting and other Electronic Components
Date and Time	August 25 (Thu.) / 16:00~18:00
Room	Room J (Swan)
Session Chair	Sang-Min Han (Soonchunhyang University)

[D2-1] **16:00~16:20**

High-Sensitivity and High-Efficiency 2.4-GHz RF Energy Harvester using SiP Technique

Ming-Che Yu and Chun-Hsing Li
National Central University, Taiwan

[D2-2] **16:20~16:40**

A Review on Recent Trend of High Efficieny Rectifiers for RF Energy Harvesting Applications

Zaffar Hayat Nawaz Khan[1], Danial Khan[1], Hamed Abbasizadeh[1], Sang-Yun Kim[1], Young-Jun Park[1], Kang-Yoon Lee[1], Seong-Ho Lee[2], and Seong-Chul Lee[2]
[1]Sungkyunkwan University, Korea, [2]Korea Electronics Technology Institute, Korea

[D2-3] **16:40~17:00**

Properties of Stepped Impedance Resonator and Its Application in the Design of Chipless RFID Tag

Nijas C. M., Sajitha V. R., Jayakrishnan M. P., and Mohanan P.
Cochin University of Science and Technology, India

[D2-4] **17:00~17:20**

Study for Realization of Arbitrary Inductance Values using Distributed Elements and Capacitors

Jongsik Lim[1], Seok-Jae Lee[1], Dal Ahn[1], Sang-Min Han[1], Boram An[2], and Yongchae Jeong[2]
[1]Soonchunhyang Univesity, Korea, [2]Chonbuk National University, Korea

[D2-5] **17:20~17:40**

Open Otto Chip as an SPR Pressure Transducer

J. O. Maciel Neto[1], Gustavo Oliveira Cavalcanti[2], Ignacio Llamas-Garro[3], Jung-Mu Kim[4], and Eduardo Fontana[5]
[1]Instituto Federal de Pernambuco, Brazil, [2]Universidade de Pernambuco, Brazil, [3]Centre Tecnològic de Telecomunicacions de Catalunya, Spain, [4]Chonbuk National University, Korea, [5]Universidade Federal de Pernambuco, Brazil

[D2-6] **17:40~18:00**

A 35 dBm, 36.5% Efficiency Harmonic Tuned GaN Oscillator using Stepped Impedance Resonator

Inhyun Kim, Sunghwan Park, Jung-Lin Woo, and Youngwoo Kwon
Seoul National University, Korea

Study for Realization of Arbitrary Inductance Values using Distributed Elements and Capacitors

*,+Jongsik Lim, *Seok-Jae Lee, *Dal Ahn, and *,#Sang-Min Han

*Soonchunhyang Univesity,
Asan, Chungnam 31538, Republic of KOREA
+jslim@sch.ac.kr, #auspice@ieee.org

**Boram An and **Yongchae Jeong

**Chonbuk National University,
Jeonju, Chonbuk 54896, Republic of KOREA

***Abstract*—In design of microwave circuits, lots of arbitrary inductance values are required. In this paper, methods to realize arbitrary inductance values using transmission line with relatively high characteristic impedance and capacitor are discussed. The first design utilizes only transmission line, while the second method adopts a capacitor as well as the transmission line. In addition, the attached capacitor may have a fixed-value or variable capacitance. The related equations for calculating the equivalent inductance are induced with resultant inductance graph. It is well shown that arbitrary inductance values may be realized from the high impedance transmission lines with or without attached capacitor. In the second discussion, the obtained inductance is adjustable as the attached capacitance value is controlled.**

***Keywords*—microwave inductors, distributed inductors, arbitrary inductors.**

I. Introduction

In design of microwave circuits, lots of distributed elements such as chip resistors, inductors, and capacitors are required both directly within RF parts and indirectly in DC supplying networks. Even most of lumped elements are surface mount device (SMD) type and their size is normally very small, however, in practice, many designers suffer from the undesirable parasitic components due to the electrodes for soldering. To the worse, arbitrary element values are not exactly supported because chip element values are quantized as designated values by industrial standards such as the series of E12, E24, and so on. As for chip inductors, the same situation goes, so, in many cases, designers have to select the chip inductor which is the mostly near from the ideally required value and available in one's laboratory. This is one of main reasons of performance deviation between simulation and practical measurement. Especially, for multiple band applications, the deviation get worse at higher frequency bands needless to say at the fundamental or primary operating band [1-3].

In this work, methods for realizing arbitrary inductance values using distributed transmission line is discussed. The inductance values are realized using high impedance microstrip lines and varactor diodes. As results, it is possible to design the required arbitrary inductance value within a reasonable range and tune it finely by adjusting the characteristic impedance and electrical length of the microstrip line.

II. Realization of Arbitrary Inductance Values using High Inpedance Microstrip Lines

It is well known that the transmission line with a high characteristic impedance acts like a inductor at the operating frequency [4,5]. Fig. 1 shows the equivalence between the corresponding lumped inductor and the transmission line with a high impedance, Z_c, and electrical length, θ. If the inductance value is L_{eq}, there is a frequency, ω_o, when two input impedances of the lumped and distributed elements are equal to each other as shown in (1). So for an operating frequency(f_o) and pre-selected Z_c, an arbitrary inductance value can be realized theoretically by determining the proper θ. As an another way, if θ is chosen first, then proper Z_c can be calculated. However, the latter is not recommended because, in some cases, the calculated Z_c may express a capacitive property rather than an inductive element.

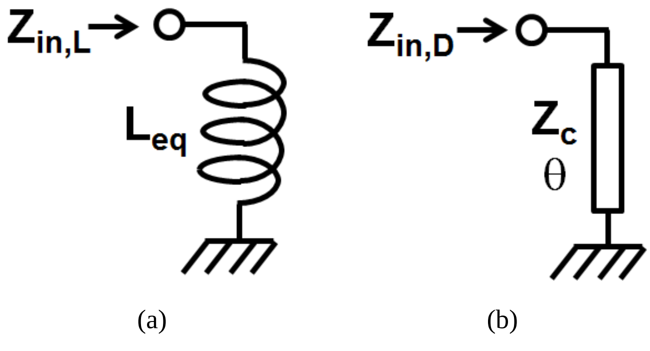


Fig. 1 Equivalence between an inductance and the transmission line with a high impedance, Z_c, and electrical length, θ. Input impedances of the (a)lumped inductor and (b)distributed element are equal at certain frequency.

$$Z_{in,L} = j\omega_o L_{eq}$$
$$Z_{in,D} = jZ_c \tan\theta \quad (1)$$

Taking "Z_c=100Ω" at 1GHz as an example, a quasi-linear relation between inductance value and electrical length illustrated Fig. 2 is obtained. Summarily, it is possible to realize arbitrary inductance value by adjusting the electrical length of the high impedance microstrip line. In addition, in the simulation stage before the circuit realization, fine tuning can be applied to obtain a precisely required inductance.

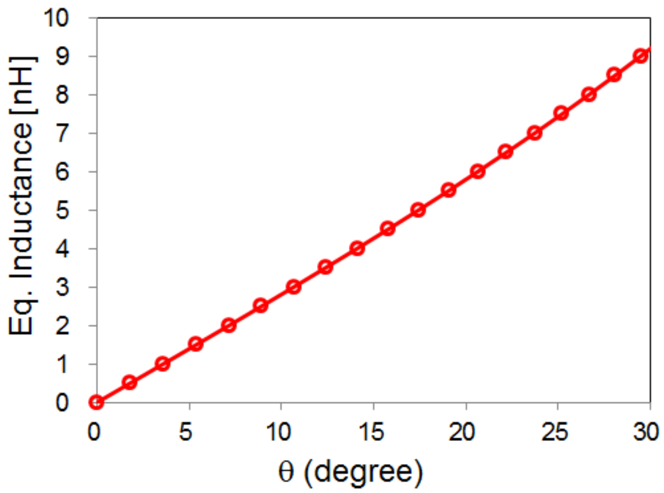
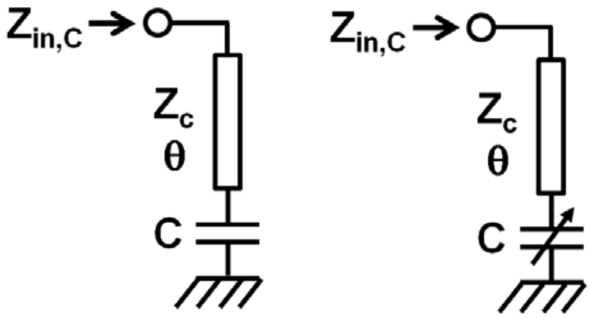


Fig. 2 Calculated relation between inductance value and electrical length using equation (1) (Z_c=100Ω at 1 GHz).

III. Controllable Arbitrary Inductance Values [6]

One drawback of Fig. 2(b) is that it is impossible to change the equivalent inductance value once the circuit has been realized after fixing Z_c and θ. In order to overcome this problem, Fig. 3(a) can be proposed and improved as Fig. 3(b) [6]. Comparing Fig. 3(a) to Fig. 1(a), and equating the equivalent inductance value, then (3) is induced. This means a capacitor connected a high impedance transmission line can be seen as an equivalent inductor. Therefore if the capacitor is adjustable, then the resultant inductance is also controllable. This is the key advantage of Fig. 3(b). There are many ways to implement the variable capacitor such as adjustable capacitors and varactor diodes.

$$L_{eq} = \frac{\omega C Z_c^2 \tan\theta - Z_c}{\omega^2 C Z_c + \omega \tan\theta} \quad (2)$$



(a) (b)

Fig. 3 Equivalent inductance circuits using transmission lines and capacitors (a)fixed capacitor (b)variable capacitor.[6]

As an example, when "Z_c=100Ω" and "θ=30°" at 1GHz, one can get the adjustable equivalent inductance according to the variable capacitance as shown in Fig. 4. It is also understood that an arbitrary inductance value can be realized and controlled precisely by changing the connected capacitance as Fig. 3.

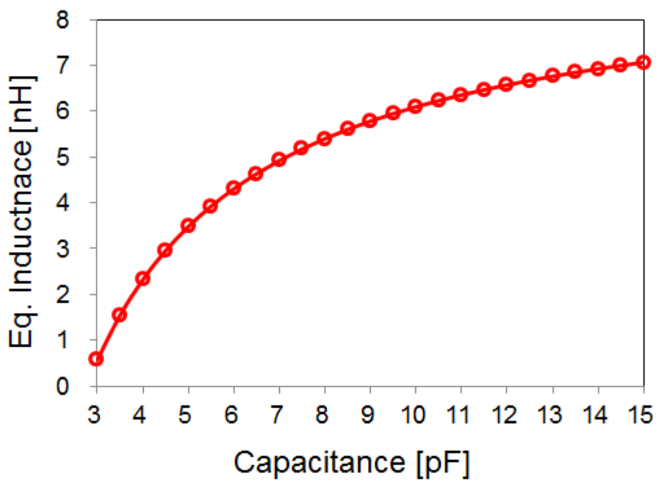


Fig. 4 Calculated relation between the equivalent inductance value and added capacitance using equation (2) (Z_c=100Ω and θ=30° at 1 GHz).

IV. Conclusion

In this paper, study for realization of arbitrary inductance values has been discussed. The first method utilizes the transmission line with a relatively high characteristic impedance (Z_c) and electrical length (θ). Arbitrary equivalent inductance values are designed once Z_c and θ have been fixed previous.

In order to obtain the controllable arbitrary inductance, the second method adopts the high impedance transmission line with a capacitance value connected was discussed. By equating the proper relationship, the equivalent inductance has been induced. It was also shown that the obtained inductance value was adjustable as varying the attached capacitance.

ACKNOWLEDGMENT

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (grant no. NRF-2015R1D1A3A01016567) and the MSIP (Ministry of Science, ICT and Future Planning), Korea, under the ITRC support program (IITP-2016-R0992-16-1006) supervised by the IITP (Institute for Information & Communications Technology Promotion).

REFERENCES

[1] I.-H. Lin, M. De Vincentis, C. Caloz, and T. Itoh, "Arbitrary dual band components using composite right/left-handed transmission lines," *IEEE Trans. Microwave Theory Tech*., vol. 52, no. 4, pp. 1142-1149, Apr. 2004.

[2] H. V. Nguyen, and C. Caloz,“Dual-band CRLH branch-line coupler in MIM technology,” *Microwave and Optical Tech. Lett*., vol. 48, no. 11, 2331-2333, Nov. 2006.

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

[4] D. M. Pozar, "*Microwave Engineering*, 3/e", John Wiley and Sons, Inc., New York, 2005.

[5] K. C. Gupta, R. Garg, I. Bahl, and P. Bhartia, "*Microstrip Lines and Slotlines*, 2/e", Artech House, Boston, 1996.

[6] S. Park, H. Choi, and Y. Jeong, “Microwave Group Delay Time Adjuster Using Parallel Resonator,” *IEEE Trans. Microw. Wireless. Comp. Lett*., vol. 17, no. 2, pp. 109–111, Feb. 2007.