

# Negative Group Delay Network Using CMOS Cascade Amplifier and Bonding-wire

Jaeyeon Kim<sup>1</sup>, Junsik Park<sup>1</sup>, Girdhari Chaudhary<sup>1</sup>, Yongchae Jeong<sup>1</sup>,  
Namsik Ryu<sup>2</sup>, and Jongsik Lim<sup>3</sup>

<sup>1</sup>Chonbuk National University, Republic of Korea

<sup>2</sup>Electronics and Telecommunications Research Institute (ETRI), Republic of Korea

<sup>3</sup>Soonchunhyang University, Republic of Korea

**Abstract**— Recently, some interesting studies of the negative group delay (NGD) concept have led to its experimental validation through the realization in electronic circuit. Well-synchronization signals are required to maintain the system consistency. In order to enhance the signal synchronization in the RF/microwave and millimeter-wave equipment, various techniques using NGD concept at baseband and microwave bands were presented in previous works. However, there are lacks of researches of NGD network in RFIC using CMOS process as compared with other areas. Therefore, this work seems the first attempt to design NGD network in the field of RFIC.

In this paper, a design of active NGD network is presented based on cascade amplifier in CMOS process which can provide NGD time as well as gain at operating center frequency of 1.95 GHz. The proposed circuit uses two NMOS MOSFET amplifiers in cascade structure and parallel RLC resonator at the source of each NMOS amplifier in order to generate the NGD time as shown in Fig. 1. In order to avoid the use of spiral inductor for miniaturization of circuit, the values of  $R$  and  $L$  are implemented with bonding wire, which is connected between ground and pad of chip as shown in Fig. 1. The feedback RC circuit between the gate and drain of MOSFET has been used to increase stability. The input/output matching circuits are used to enhance the reflection characteristics. Fig. 2 shows the simulation results of proposed circuit. From simulation, the NGD time of  $-1.73$  ns with gain of 11.35 dB were obtained as shown in Fig. 2. The input and output return loss characteristics are better than  $-20$  dB as shown in Fig. 3.

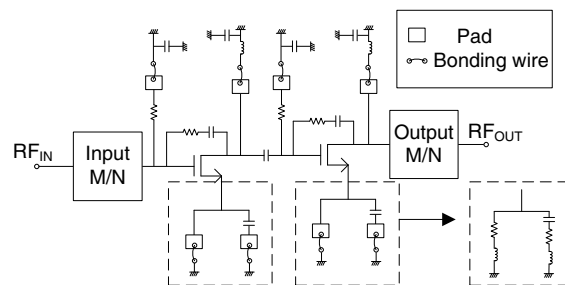


Figure 1.

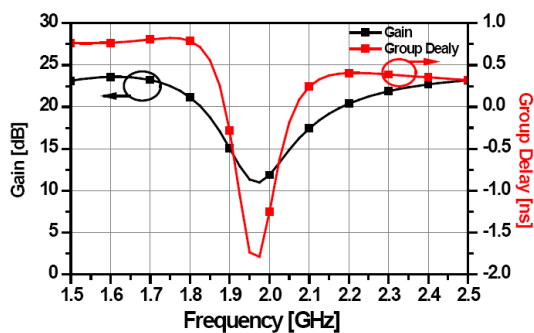


Figure 2.

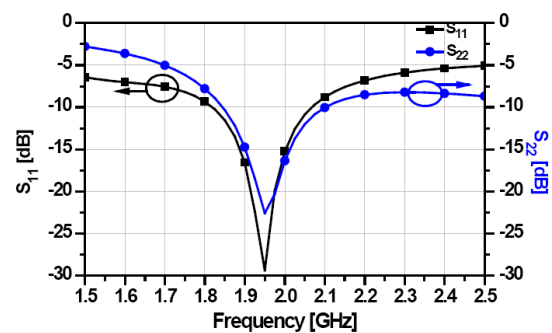


Figure 3.

# PIERS 2014 Guangzhou

---

Progress In Electromagnetics Research Symposium

**Program**

---

**August 25 - 28, 2014**

**CHINA**

---

[www.emacademy.org](http://www.emacademy.org)

[www.piers.org](http://www.piers.org)

- 16:00 An Optimal Match between the Ground-based Laser and a Relay Mirror System  
*Lipeng Luo (Zhejiang Forestry University, China); Yongte Jiang (Zhejiang Forestry University, China); Haiqiang Tong (Zhejiang Forestry University, China); Chunmei Chai (Zhejiang Forestry University, China); Chunnan Zhang (Zhejiang Forestry University, China); Xiuxiang Chu (Zhejiang Forestry University, China);*
- 16:20 Partially Coherent Vector Beam with Special Correlation Functions  
*Yahong Chen (Soochow University, China); Fei Wang (Soochow University, China); Chengliang Zhao (Soochow University, China); Yangjian Cai (Soochow University, China);*
- 16:40 Spatial Correlation Properties of Partially and Fully Coherent Fields  
*Yuanjie Yang (University of Electronic Science and Technology of China, China); Yi-Dong Liu (University of Electronic Science and Technology of China, China);*
- 17:00 Analysis of a Vortex Beam in a Non-coaxial Optical Focusing System  
*Guoxuan Zhu (Sun Yat-sen University, China); Yanfeng Zhang (Sun Yat-sen University, China); Hui Chen (Sun Yat-sen University, China); Yujie Chen (Sun Yat-sen University, China); Siyuan Yu (Sun Yat-sen University, China);*
- 17:20  $M^2$ -factor for the Partially Coherent Elegant Laguerre-Gaussian Beam Propagating through the Turbulent Ocean  
*B. Wang (Anhui Normal University, China); Y. S. Yuan (Anhui Normal University, China); Zhifeng Cui (Anhui Normal University, China); Jun Qu (Anhui Normal University, China);*
- 17:40 Propagation Properties of an Anomalous Hollow Beam with Orbital Angular Momentum through a Paraxial ABCD Optical System  
*Chenchen Zhao (Soochow University, China); Chengliang Zhao (Soochow University, China); Yangjian Cai (Soochow University, China);*
- 18:00 Propagation Properties of Partially Coherent Anomalous Hollow Beams in Uniaxial Crystals  
*Xingyuan Lu (Soochow University, China); Chengliang Zhao (Soochow University, China); Yangjian Cai (Soochow University, China);*

---

**Session 4P9**  
**Microwave and Millimeter Wave Circuits and Devices, CAD**

---

**Thursday PM, August 28, 2014**

**Room 9**

Chaired by Jongsik Lim, Joan Jose Garcia-Garcia

---

- 13:00 Microstrip Diplexer Design Using Three EBG  
*Ursula Martinez-Iranzo (Universitat Autònoma de Barcelona, Spain); Bahareh Moradi (Universitat Autònoma de Barcelona, Spain); Eva Arasa (Universitat Autònoma de Barcelona, Spain); Julian Alonso (Universitat Autònoma de Barcelona, Spain); Joan Jose Garcia-Garcia (Universitat Autònoma de Barcelona, Spain);*
- 13:20 Wide-stopband Millimeter-wave BPF on GaN MMIC Using Asymmetric Feeding Structure  
*Jin Xu Xu (South China University of Technology, China); Xiu-Yin Zhang (City University of Hong Kong, China); Xiao Feng Liu (South China University of Technology, China);*
- 13:40 Substrate Integrated Waveguide Frequency Reconfigurable Filter Controlled by Magnetic Field  
*Qiu Dong Huang (University of Electronic Science and Technology of China, China); Xiao Liang Liu (University of Electronic Science and Technology of China, China); Yu Jian Cheng (University of Electronic Science and Technology of China, China);*
- 14:00 A Dual-mode Circle Ring Resonator Bandpass Filter  
*Rong Sheng Li (Beijing University of Posts and Telecommunications, China); Ying-Hua Lu (Beijing University of Posts and Telecommunications, China);*
- 14:20 Additional Cross Coupling Coefficient Used as Matching Ladder Network in Coupled Based Band Pass Filters  
*Bahareh Moradi (Universitat Autònoma de Barcelona, Spain); Ursula Martinez-Iranzo (Universitat Autònoma de Barcelona, Spain); Joan Garcia-Garcia (Universitat Autònoma de Barcelona, Spain);*
- 14:40 Negative Group Delay Network Using CMOS Cascade Amplifier and Bonding-wire  
*Jaeyeon Kim (Chonbuk National University, Republic of Korea); Junsik Park (Chonbuk National University, Republic of Korea); Girdhari Chaudhary (Chonbuk National University, Republic of Korea); Yongchae Jeong (Chonbuk National University, Republic of Korea); Namsik Ryu (Electronics and Telecommunications Research Institute, Republic of Korea); Jongsik Lim (Soonchunhyang University, Republic of Korea);*

# Session 4P9

## Microwave and Millimeter Wave Circuits and Devices, CAD

Microstrip Diplexer Design Using Three EBG <i>Ursula Martinez-Iranzo, Bahareh Moradi, Eva Arasa, Julian Alonso, Joan Jose Garcia-Garcia, . . . .</i>	2034
Wide-stopband Millimeter-wave BPF on GaN MMIC Using Asymmetric Feeding Structure <i>Jin Xu Xu, Xiu-Yin Zhang, Xiao Feng Liu, . . . . .</i>	2035
Substrate Integrated Waveguide Frequency Reconfigurable Filter Controlled by Magnetic Field <i>Qiu Dong Huang, Xiao Liang Liu, Yu Jian Cheng, . . . . .</i>	2036
A Dual-mode Circle Ring Resonator Bandpass Filter <i>Rong Sheng Li, Ying-Hua Lu, . . . . .</i>	2037
Additional Cross Coupling Coefficient Used as Matching Ladder Network in Coupled Based Band Pass Filters <i>Bahareh Moradi, Ursula Martinez-Iranzo, Joan Garcia-Garcia, . . . . .</i>	2038
Negative Group Delay Network Using CMOS Cascade Amplifier and Bonding-wire <i>Jaeyeon Kim, Junsik Park, Girdhari Chaudhary, Yongchae Jeong, Namsik Ryu, Jongsik Lim, . . . .</i>	2039
High Efficiency TM <sub>01</sub> -mode Cylindrical Waveguide Microwave Reactor for Microwave Material Continuing Processing <i>Yi Chen Zhong, Wei Na Huang, Yu Jian Cheng, . . . . .</i>	2040
A High-efficiency Darlington Power Amplifier Design Using 0.5 μm GaN-on-Silicon HEMT Technology <i>Min-Li Chou, Hong-Kun Wang, Hsien-Chin Chiu, Fan-Hsiu Huang, . . . . .</i>	2041
Design of an All-pass Phaser Using Microstrip C-sections <i>Weiwei Liao, Qingfeng Zhang, Yifan Chen, . . . . .</i>	2043
A Double Ended Active Electrode Using SiP with DC and 50 Hz Rejection <i>Linping Gao, Nikolas Gaio, Jinyong Zhang, Lei Wang, . . . . .</i>	2044
Simulation of a High-convergence Electron Optics System for an X-band High-impedance Relativistic Klystron <i>Danni Zhu, Jun Zhang, Zumin Qi, Wei Li, . . . . .</i>	2045
The Metamaterial Technology Applied to Planar Antennas <i>E. F. Guelber, A. V. Cardoso, C. E. Capovilla, Humberto Xavier De Araujo, . . . . .</i>	2046