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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

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

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Program at a Glance

	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)										

	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)

	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										

	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)										

	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	[S-B8] Negative Group Delay (NGD) Devices and Its Applications
Date and Time	August 25 (Thu.) / 08:30~10:30
Room	Room A (Emerald A)
Session Organizer	Blaise Ravelo (ESIGELEC) Yongchae Jeong (Chonbuk National University)
Session Chairs	Blaise Ravelo (ESIGELEC) Yongchae Jeong (Chonbuk National University)

[S-B8-1] 08:30~08:50

[Invited] Resistive and Distributed Multiband NGD Active Circuit

B. Ravelo
IRSEEM, France

[S-B8-2] 08:50~09:10

[Invited] A Power Divider with Positive and Negative Group Delay Characteristics

Girdhari Chaudhary, Phirun Kim, Junhyung Jeong, and Yonchae Jeong
Chonbuk National University, Korea

[S-B8-3] 09:10~09:30

[Invited] Microwave Transversal and Recursive-filter based Negative Group Delay Circuits and Non-Foster Elements

Chung-Tse Michael Wu
Wayne State University, USA

[S-B8-4] 09:30~09:50

[Invited] A Compact MIMO Antenna with High Isolation for S, C and V Band Applications

Malay R. Tripathy[1], Vipin Choudhary[1], Aastha Gupta[1], and Yongchae Jeong[2]
[1]Amity University, India, [2]Chonbuk National University, Korea

[S-B8-5] 09:50~10:10

[Invited] Millimeter-Wave Negative Group Delay Network

William J. Otter, Stephen M. Hanham, Norbert Klein, and Stepan Lucyszyn
Imperial College London, UK

[S-B8-6] 10:10~10:30

[Invited] Precision E-field Uniformity Measurement of a Probe Loaded TEM Cell using an Optical Probe

Takehiro Moirioka[1], Satoru Kurokawa[1], Yoshikazu Toba[2], and Jun Ichijyo[2]
[1]National Institute of Industrial Science and Technology, Japan, [2]Seikoh Giken Co., Ltd., Japan

A Power Divider with Positive and Negative Group Delay Characteristics

(Invited paper)

Girdhari Chaudhary, Phirun Kim, Junhyung Jeong, and Yonchae Jeong
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***Abstract*—In this paper, a power divider is suggested for predefined positive and negative group delay characteristics. The positive group delay (PGD) is obtained in between transmission paths 2 and 1, whereas the negative group delay (NGD) is in between transmission paths 3 and 1. The PGD and NGD are controlled by characteristic impedance of horizontal transmission line Z_1 and shunt resistor *R*. Perfect input and output matching characteristics as well as perfect isolation are obtained at a center frequency (f_0). For an experimental demonstration, microstrip line power divider with the PGD and NGD of 0.6 and -0.5 ns, respectively, was designed and fabricated at f_0 of 2.14 GHz. The measurement results are agreed well with simulation results and theoretical predicated values.**

Keywords— negative group delay (NGD), positive group delay (PGD), series-fed antenna arrays, transmission line.

I. Introduction

In microwave circuits and systems, power dividers have been widely adopted as basic building components and are used in various applications such as antenna feeding networks, high-power amplifiers, linearization of power amplifiers, mixers, and measurement set-ups [1]-[2].

Recently, negative group delay (NGD) circuits have been applied to minimize the beam-squint problems of series-fed antenna array [3]-[7]. In [7]-[8], there have been efforts in addressing this issue by using the antenna as part of NGD circuit and applying amplifier for further loss cancellation. However, these works suffer from very small fractional bandwidths (FBW < 1.2%). Moreover these works were concentrated on design of a power divider and NGD circuit separately.

In this paper, a power divider with predefined PGD and NGD characteristics is presented. The NGD (between paths 3 and 1) and PGD (between paths 2 and 1) can be controlled by horizontal transmission line characteristic impedance and shunt resistor. Due to NGD through paths 3 and 1, the proposed network shows particular constant phase (phase characteristics with respect to frequency) over the FBW of 24%.

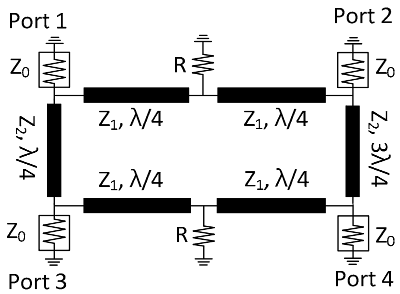
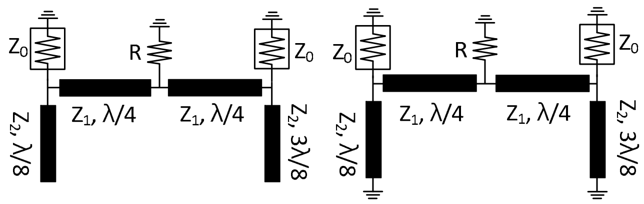


Fig. 1. Proposed structure of unequal power divider with positive and negative group delay characteristics.

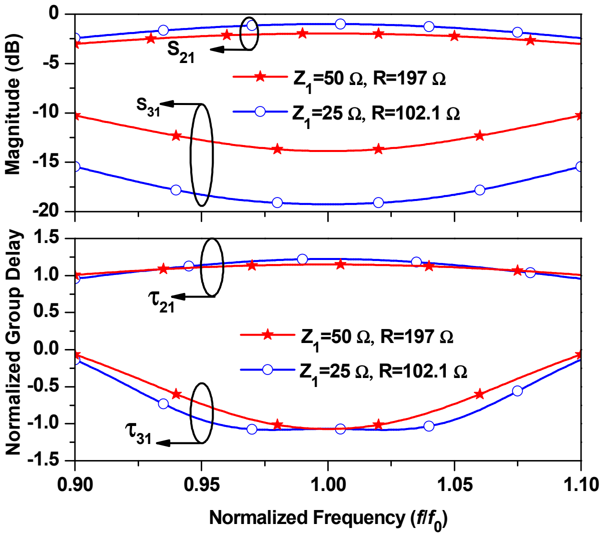


(a) (b)

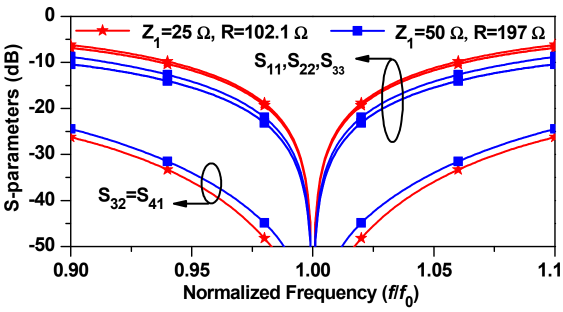
Fig. 2. (a) Even-mode and (b) odd-mode decompositions of the proposed unequal power divider.

II. Theory And Design Equations

Fig. 1 shows the proposed structure of the power divider. It consists of horizontal transmission lines with characteristic impedance Z_1 and electrical length of $\lambda/4$ and vertical transmission lines with characteristic impedance of Z_2 and electrical lengths of $\lambda/4$ and $3\lambda/4$. The shunt resistors R are connected in between two horizontal transmission lines Z_1. Since the proposed structure is symmetrical, even- and odd-mode analyses can be applied to find the magnitudes of scattered waves from the proposed circuit [9]. The resulting output signals of the four-port are a superposition of the results. The equivalent even- and odd-mode circuits of the proposed power divider are shown in Fig. 2. For matched conditions, S_{11}, S_{22}, S_{33}, and S_{44} should be equal to zero at $f = f_0$. Therefore, under these conditions, the value of Z_2 can be obtained as at (1).



(a)



(b)

Fig. 3. Synthesized results of power divider for different values of Z_1 and R: (a) group delay/magnitude and (b) input/output return losses/isolation characteristics.

$$Z_2 = Z_0 \tag{1}$$

Similarly, the transmission and isolation coefficients at $f = f_0$ are determined as (6).

$$S_{21}\big|_{f=f_0} = S_{43}\big|_{f=f_0} = \frac{1}{1+Z_1^2/Z_0R} \tag{2a}$$

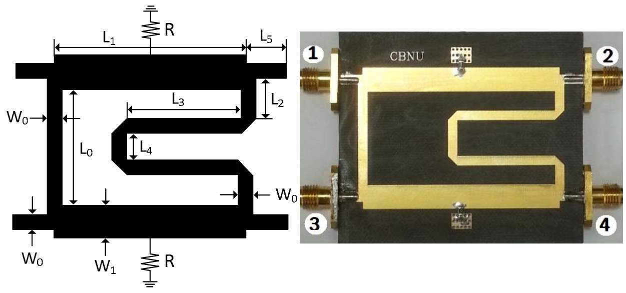
$$S_{31}\big|_{f=f_0} = S_{42}\big|_{f=f_0} = \frac{1}{1+RZ_0/Z_1^2} \tag{2b}$$

$$S_{32}\big|_{f=f_0} = S_{41}\big|_{f=f_0} = 0 \tag{2c}$$

As shown by (2c), the perfect isolation is naturally satisfied and independent of the design variables. Moreover, the transmission coefficients between different transmission paths depend on R and Z_1.

Furthermore, the GDs of different transmission paths evaluated at $f = f_0$ are formulated as (3).

$$\tau_{21}\big|_{f=f_0} = \frac{Z_1^2/RZ_0\left(Z_0^2+2Z_1Z_0\right)+2Z_0Z_1+2Z_1^2+Z_0^2}{4f_0Z_1Z_0\left(1+Z_1^2/RZ_0\right)} \tag{3a}$$



(a) (b)

Fig. 4. (a) EM simulation layout of unequal power divider with physical dimensions and (b) a photograph of fabricated circuit.

$$\tau_{31}\big|_{f=f_0} = -\frac{1}{2\pi}\frac{d\angle S_{41}}{df}\bigg|_{f=f_0} = -\frac{Z_1+2R}{4f_0Z_1} + \tau_{21}\big|_{f=f_0} \tag{3b}$$

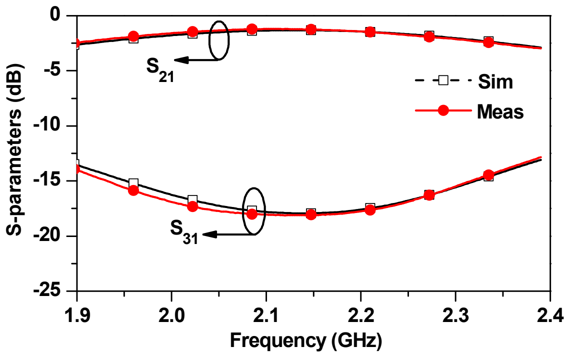
As observed from (3a) and (3b), the PGD is obtained in between transmission paths 2 and 1, whereas the NGD is in between transmission paths 3 and 1 by properly choosing Z_1 and R.

In order to investigate the effect of Z_1 on the bandwidth of GD, the synthesized results (magnitudes of S-parameters and GDs) of power divider are shown in Fig. 3. In these synthesized results, the GD between paths 3 and 1 is maintained constant for different values of Z_1. As observed from Fig. 3(a), the GD bandwidth is slightly wider in case of lower Z_1 such as 25 Ω. However, magnitude of S_{31} is higher in case of lower Z_1. Therefore, a low value of Z_1 is preferable for wider NGD bandwidth. Moreover, a trade-off occurs between insertion loss and NGD bandwidth. The matched return losses as well as perfect isolations at f_0 are maintained for all values of Z_1, as shown in Fig. 3(b).

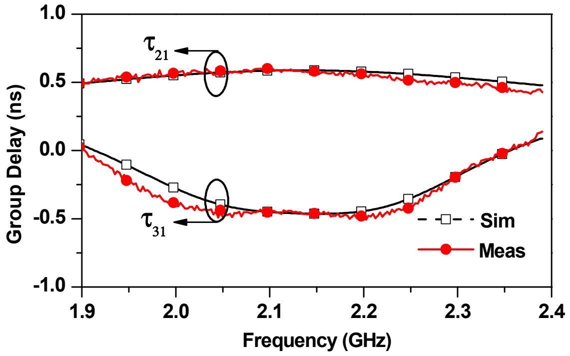
III. Implementation And Experimental Results

For experimental demonstration purposes, the power divider was fabricated at f_0 of 2.14 GHz on RT/Duroid 5880 substrate with a dielectric constant (ε_r) of 2.2 and thickness (h) of 0.787 mm. The simulation was performed using ANSYS HFSS 15. The EM layout of the designed unequal power divider is shown in Fig. 4(a). A photograph of fabricated circuit is shown in Fig. 4(b).

The goal of a design example was to achieve GD of -0.5 ns through transmission paths 3 and 1 and GD of 0.6 ns through paths 2 and 1 under the assumption of termination impedance of 50 Ω. Therefore, the calculated circuit parameters of the unequal power divider are given as Z_1 = 30 Ω, Z_2 = 50 Ω, and R = 126 Ω. The physical dimensions of the fabricated circuit are determined as L_0 = 25.1 mm, L_1 = 50.8 mm, L_2 = 6.8 mm, L_3 = 25.2 mm, L_4 = 9.2 mm, L_5 = 6 mm, W_0 = 2.4 mm, and W_1 = 4.9 mm after the EM simulation optimization.



(a)



(b)

Fig. 5. Simulated and measured results of the proposed power divider: (a) magnitude and (b) group delay characteristics.

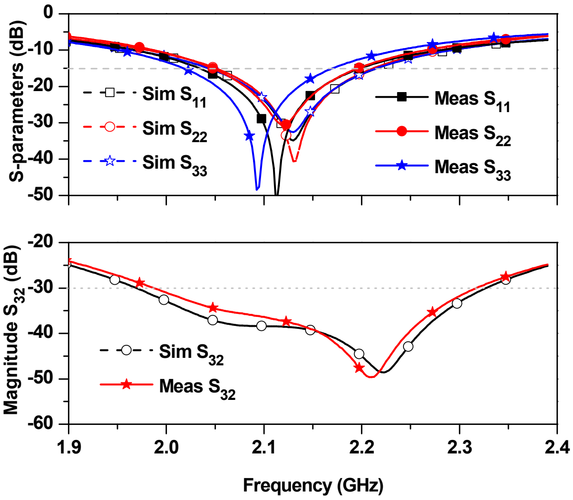


Fig. 6. Simulated and measured return losses/isolation characteristics.

Fig. 5 (a) depicts the simulated and measured magnitudes of S-parameters. Since the power divider was designed for k = 20 log (S_{21}/S_{31}) = 16.9 dB, the S-parameters are calculated as S_{21} = -1.16 dB and S_{31} = -18.06 dB. Measured S_{21} and S_{31} are -1.18 dB and -18.1 dB at f_0 = 2.14 GHz and measured k is 16.92 dB. Similarly, the measured GDs between different transmission paths are determined as τ_{21} = 0.58 ns and τ_{31} = -0.48 ns at f_0. The NGD bandwidth (bandwidth when GD < 0) of the proposed circuit is 500 MHz as shown in Fig. 5(b).

The simulated and measured return losses/isolation are shown in Fig. 6. The measured return losses are determined as S_{11} = -24.24 dB, S_{22} = -24.98 dB, and S_{33} = -19.9 dB at f_0 = 2.14 GHz and 15 dB return loss is observed in the frequency range of 1.99 - 2.22 GHz. The isolation (S_{32}) between output ports is 38.9 dB at 2.14 GHz and greater than 22 dB from 1.9 to 2.4 GHz.

IV. Conclusion

In this paper, we demonstrated a design of power divider with predefined positive and negative group delay characteristics. From theoretical analysis, it is found that the group delay is controlled by shunt resistor when the characteristic impedance of horizontal transmission line is fixed. Both theoretical and experimental results have been provided for a verification. For the experimental demonstration, the power divider with power group delay of 0.6 ns through paths 2 and 1 and -0.5ns through paths 3 and 1 was designed, simulated, and fabricated at the center frequency of 2.14 GHz. The measurement results are agreed well with the simulations as well as with theoretical predicated values. Since the proposed power divider provide the constant phase over wide bandwidth, the circuit can be employed as a feed network in the series-fed antenna arrays for minimizing the beam-squint problems.

References

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