

Direct Conversion Mixer IC for Application to Long Distance Wireless Power Transmission

Jang-Hyeon Jeong, Young-Bae Park, Jeong-Gab Ju, Bo-Ra Jung Eui-Hoon Jang, Suk-Youb Kang and Young Yun

Abstract—In this paper, Using the silicon CMOS technology, direct conversion mixer was fabricated on silicon substrate for a realization of the long distance wireless power transmission system. The size of the mixer is 0.8 mm × 0.5 mm. The input frequency of mixer is 24 GHz, and converted BB frequency is 30 MHz. The conversion loss and output power of mixer was -9 dB and -10 dBm, respectively.

Index Terms—Mixer, IC(integrated circuit), CMOS, Wireless power transmission

I. INTRODUCTION

Wireless energy or power transfer is the transmission of electrical energy from a power source to a power consumer without interconnecting wires [1]-[4]. Wireless transmission is useful in cases where interconnecting wires are inconvenient, hazardous, or impossible. The most common form of wireless power transmission is carried out using electromagnetic /inductive coupling followed by resonant inductive coupling. However, inductive/electromagnetic coupling methods are near field over distances comparable to a few times the diameter of the device or devices approaching one quarter of the wavelength used [1]. For a long distance wireless power transmission, wireless power transmission employing microwave is a promising candidate. Experiments in the tens of kilowatts have been performed by several groups [1]-[4]. These methods achieve distances on the order of a kilometer. Main applications of wireless power transmission employing microwave are shown in Fig. 1.

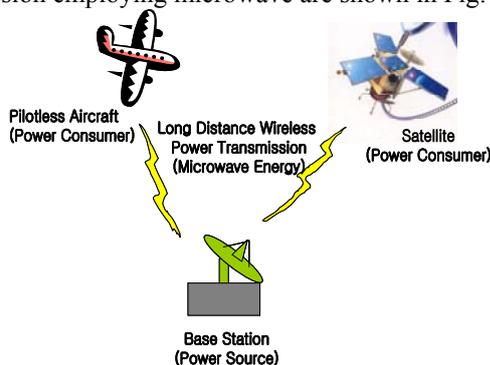


Fig. 1. Main applications of wireless power transmission employing microwave

Base station transmits the power needed for the operation

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The authors are with the Korea Maritime University, Busan, Korea. He is now with the HANTANG INC., Daejeon, Korea (e-mail: seikou@hanyangnav.co.kr, jjh2010@hhu.ac.kr, redphoenix@empas.com, blthor@nate.com, chchtrain17@hhu.ac.kr, int-ksy@hanmail.net, yunyoung@hhu.ac.kr).

of pilotless aircraft and satellite. In this case, a long distance wireless power transmission is required to provide the operation power for the aircraft and satellite. Recently, we have proposed the long distance wireless power transmission system shown in Fig. 2. Power source provide microwave power using oscillator for wireless transmission. The microwave power is amplified by power amplifier[5]-[13], and amplified microwave power is transmitted to the power consumer. For power consumer, the received microwave power is converted into low frequency power using mixer, and finally, the low frequency power is converted into DC power using rectifier and smoothing circuit to provide DC power for power consumer.

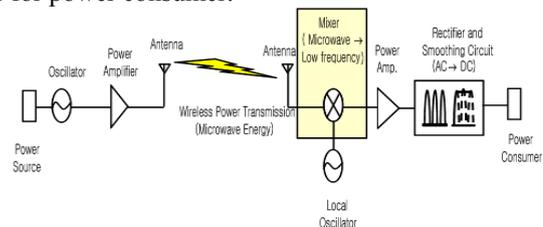


Fig. 2. The proposed long distance wireless power transmission system.

In the above long distance wireless power transmission system, mixer is one of key device, and careful design is needed. Using the silicon CMOS technology, mixer was fabricated on silicon substrate for a realization of the long distance wireless power transmission system. The size of the mixer is 0.8 mm × 0.5 mm. The input frequency of mixer is 24 GHz, and converted BB frequency is 30 MHz. The conversion loss and output power of mixer was -9 dB and -10 dBm, respectively. This paper was selected from ICIEE (International Conference on Information and Industrial Electronics) 2011, and republished.

II. THE RESISTIVE MIXER EMPLOYING SILICON CMOS

A. Circuit Design

As shown in Fig. 2, the intended receiver antenna turns the invisible wave into a current on a conductor. The signal is very weak from path loss and absorption. Generally, the mixer has been used to mix two frequencies (add to frequency of deflate to frequency). In case of transmitter mixer, low frequency become microwave due to add of local oscillator's signal, otherwise, concretely receiver mixer, microwave become low frequency due to deflate of local oscillator's signal. The microwave and local oscillator signal are applied to the input of the system, and microwave and local oscillator signals are mixed at the mixer. The microwave signal is converted to DC BB (Baseband, low frequency) signal by the mixer. Note that the baseband is just

a lower frequency version of the microwave signal.

Fig. 3 shows a schematic circuit of single-end resistive mixer for long distance wireless power transmission. The resistive mixer has used to mix of frequency operating non-linearity between drain and source resistance. The mixer is available application of Tx and Rx system. Resistive mixer was designed for high linearity, low power consumption. TSMC 0.13 μm CMOS RF process was used in this work. The gate length of n-MOS device is 0.13 μm , and gate width is 6 μm , and total finger number is 20. The size of resistive mixer is 0.8 mm \times 0.5 mm and buffer amplifier is 0.4 mm \times 0.4 mm. The resistive mixer was fabricated for application to direct conversion system, and microwave frequency is 24 GHz. The local oscillator and microwave signals are applied to the gate and drain of FET, respectively, and base band (BB, low frequency) output signal is extracted from the drain of the mixer. And, when microwave and local oscillator signal were accepted to input voltage, AC voltage is given by,

$$\begin{aligned} V &= V_{local}(t) + V_{micro}(t) \\ &= V_{local} \cos(\omega_{local} t) + V_{micro} \cos(\omega_{micro} t) \end{aligned} \quad (1)$$

To suppress the harmonic signals at the output port, low pass filter consisting of L and C was connected at the output port.

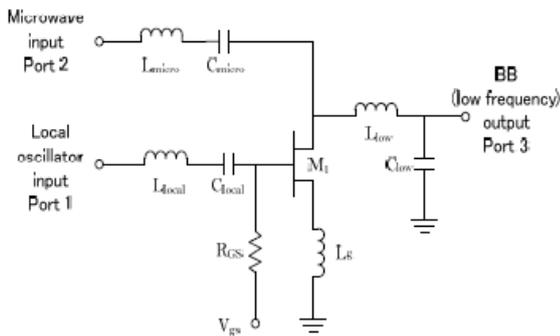


Fig. 3. The schematic circuit of single-end resistive mixer cell.

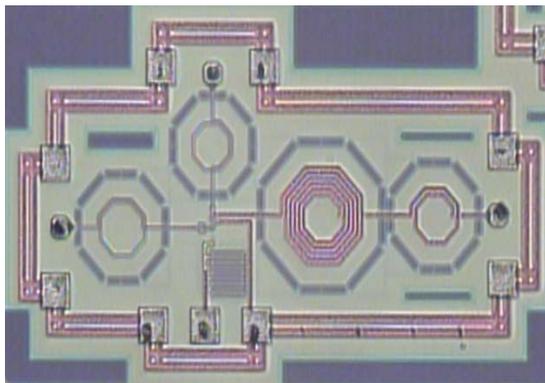


Fig. 4. The photograph of resistive receiver mixer

B. Measured Results

The Resistive mixer has used in system of need to linearity. For ideal resistive mixer, conversion loss is about -10 dB, therefore amplifier located mixer's front and back needs large gain due to compensation of mixer's loss. And conversion loss of mixer is given by,

$$\text{Conversion Loss} = \frac{P_{low (output)}}{P_{micro (input)}} \quad (2)$$

The performance of resistive mixer using 0.13- μm CMOS RF technology were investigated at 24 GHz. Fig.4 shows a photograph of resistive receiver mixer using 0.13 μm CMOS RF process.

Fig. 5 shows measured conversion loss characteristic of resistive receiver mixer using 0.13- μm CMOS RF. The converted BB frequency is 30 MHz, and RF input power is -40 dBm. A conversion loss is relative flat above an LO input power of -1 dBm, and it is about -9 dB. Fig. 6 shows measured output VS input power for 1-dB gain compression point. As shown in this Fig. 6, we can observe a good linearity characteristic, concretely, an input 1-dB compression point of 1 dBm. Therefore, proposed resistive mixer shows good linearity characteristics.

Above results indicate that the proposed resistive mixer using single ended mixer structure is very effective for long distance wireless power transmission [1]-[6].

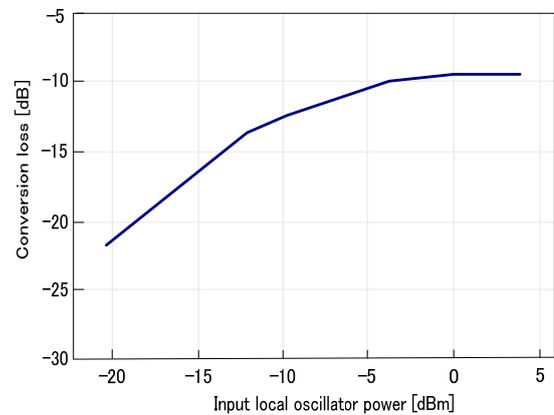


Fig. 5. Measured conversion loss characteristic of resistive receiver mixer

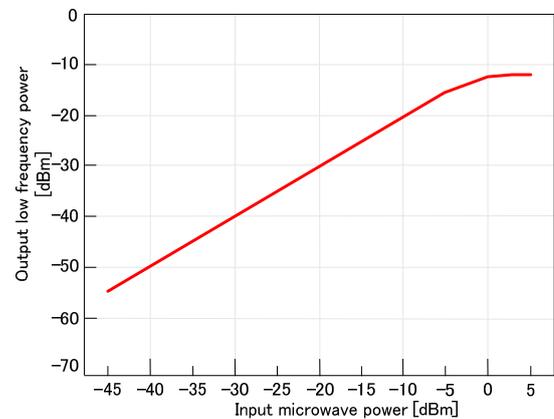


Fig. 6. Measured output VS input power for 1-dB gain compression point.

III. CONCLUSIONS

In this paper, using the silicon CMOS technology, mixer was fabricated on silicon substrate for a realization of the long distance wireless power transmission system. The size of the mixer is 0.8 mm \times 0.5 mm. The input frequency of mixer is 24 GHz, and converted BB frequency is 30 MHz. The conversion loss and output power of mixer was -9 dB and -10 dBm, respectively. Above results indicate that the proposed resistive mixer using single ended mixer structure is very effective for long distance wireless power transmission.

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Young-Bae Park received the B.S., M.S. and Ph. D. degree in Radio Sciences and Engineering from Korea Maritime University, 2005, 2007and 2011, respectively. Currently, he is working at INTECH INC., Incheon, Korea.



Jeong-Gab Ju received the B.S. degree in Radio Communication and Engineering from Korea Maritime University, 2010, respectively, and is currently working toward the M.S. degree at Korea Maritime University. Currently, he is working at the HANYANG INC., Daejeon, Korea.



Bo-Ra Jung received the B.S. and M.S. degree in Radio Sciences and Engineering from Korea Maritime University, 2009 and 2011, respectively. Currently, she is working at INTECH INC., Incheon, Korea.



Eui-Hoon Jang received the B.S. degree in Radio Communication and Engineering from Korea Maritime University, 2011, respectively, and is currently working toward the M.S. degree at Korea Maritime University.



Suk-Youb Kang received the B.E. degree in electronics engineering from the University of Incheon, Incheon, Korea, in 1997, and the M.S and Ph.D. degrees in electronics engineering from the Inha University, Incheon, Korea, in 1999 and 2005, respectively. From 2006 to 2010, he worked as a research professor at the department of Radio Sciences and Engineering, Korea Maritime University, in Busan, Korea. Since 2001, he has been held position of representative director of INTECH Inc. and head of Electronics and Telecommunications Research Institute attached to there. His research interests include design and fabrication for microwave/wireless communication systems, and various antennas.



Young Yun received the B.S. degree in electronic engineering from Yonsei University, Seoul, Korea in 1993, and the M.S. degree in electrical and electronic engineering from Pohang University of Science and Technology, Pohang, Korea in 1995, and Ph.D. in electrical engineering from Osaka University, Osaka, Japan in 1999, respectively. From 1999 to 2003, he worked as an engineer in Matsushita Electric Industrial Company Ltd. (Panasonic), Osaka, Japan, where he has been engaged in the research and development of monolithic microwave ICs (MMICs) for wireless communications. In 2003, he joined Dept. of Radio Sciences and Engineering, Korea Maritime University, in Busan, Korea. Now he is currently a professor, and his research interests include design and measurement for RF/microwave and millimeter-wave IC, and flexible IC. Since 2008, he has served as an Associate Editor of IEICE (The Institute of Electronics, Information and Communication Engineers) in Japan, and an Editor of the Korean Society of Marine Engineering in Korea. He is the author and co-author of over 110 international journals and 15 patent pending in RF/microwave device and IC.



Jang-Hyeon Jeong received the B.S. degree in Radio Communication and Engineering from Korea Maritime University, 2010, respectively, and is currently working toward the M.S. degree at Korea Maritime University. Currently, he is studying at Korea Maritime University as Ph. D. course.