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PA: Student Poster Award Contest

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PA-1 Analysis of DFG-Based Millimeter-Wave Signal Generation in Rectangular Waveguides Embedded with a Nonlinear Optical Crystal and Its Applications to Optical Signal Correlator and Convertor

Yusuke Takashima, Hiroshi Murata, and Yasuyuki Okamura, *Osaka University, Japan*

We report the detail analysis of difference frequency generation (DFG) in millimeter-wave (MMW) rectangular waveguides embedded with a nonlinear optical crystal. A temporal and spatial coupling process of the generated MMW signal to the TE10 mode in the rectangular waveguide is shown clearly. Based on the analysis results, we propose a new optical PSK - MMW ASK convertor utilizing the QPM technique. Due to the velocity difference between the optical PSK signal and the generated DFG signal, successive 2bit information in the BPSK signal is convolved and converted to the MMW ASK signal. Cross correlation devices are also discussed in detail.

PA-2 Development of a UV-LED Sterilizer with Diffuser Plate

Jin Wook Kim*, Kyung Shik Lee*, Jae Hyoun Park**, Yong Gon Seo**, and Hyung Do Yoon**, **Sungkyunkwan University, **Korea Electronics Technology Institute*

We developed a UV-LED sterilizer consisting of UV-LED array module with peak wavelength of 275nm, LED driver module, and diffuser plate. To obtain the sterilization effect of the UV-LED sterilizer, sterilization experiment was conducted on the three kinds of bacteria: E. coli, C. albicans, and K. pneumonia. After a UV exposure time of 5 min, the sterilization effect for E. coli and C. albicans were 99.9%, and K. pneumonia was 92.7%.

PA-3 Reduce Harmonic Interference and Fiber Chromatic Dispersion for Millimeter-Wave Radio-Over-Fiber Systems

Huan-wen Chen, Yu-cheng Jheng, Ching-wen Chang, and Wen-piao Lin, *Chang Gung University, China*

In this paper, we propose a new optical single-sideband (OSSB) modulation scheme for 60GHz millimetre-wave radio-over-fiber (ROF) systems. This scheme can reduce harmonic interference to enhance the system performance. Compared with general optical double-sideband suppressed carrier (ODSB-SC) modulation, the OSSB modulation can improve the output power of 21.36dB. We also investigate several existing 60 GHz ROF architectures and found that harmonic interference and fiber chromatic dispersion are the dominant factors for millimetre-wave ROF system performances.

PA-4 A 5-GHz CMOS Integrated Radio-Over-Fiber Receiver

Minsu Ko, Jeong-min Lee, Myung-jae Lee, and Woo-young Choi, *Yonsei University, Korea*

A 5-GHz CMOS integrated radio-over-fiber receiver is designed with standard 0.18-μm CMOS technology. The receiver includes an avalanche photodetector, a preamp, and a power amplifier. Post-layout simulation results show the receiver has optoelectronic conversion gain of 63 dBV/W and output 1-dB gain compression point of 12.9 dBm.

PA-5 Millimeter-Wave Electro-Optic Modulators Suspended to Patch-Antennas Embedded with a Narrow-Gap on Low-k Dielectric Substrates

Yusuf Nur Wijayanto, Hiroshi Murata, and Yasuyuki Okamura, *Osaka University, Japan*

PA-4 APMP 2013, Gwangju
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A 5-GHz CMOS Integrated Radio-Over-Fiber Receiver

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***Abstract*— A 5-GHz CMOS integrated radio-over-fiber receiver is designed with standard 0.18-μm CMOS technology. The receiver includes an avalanche photodetector, a preamp, and a power amplifier. Post-layout simulation results show the receiver has optoelectronic conversion gain of 63 dBV/W and output 1-dB gain compression point of 12.9 dBm.**

***Keywords*— Avalanche photodetector (APD), CMOS, optical receiver, radio over fiber (RoF), silicon photonics.**

I. Introduction

Radio-over-fiber (RoF) technology plays an important role for extending the radio coverage of cellular or wireless local area network (WLAN) services [1]-[2]. Since these applications usually require data distribution between a central office and numerous remote antenna units (RAUs), cost-effective realization of RAUs is essential. For reducing system implementation costs, 850-nm vertical-cavity surface-emitting lasers for the optical source along with multimode fibers for transmission media have been tried [1]-[2]. For reducing RAU costs, achieving high level of integration for various components required in RAU is essential. In particular, an approach based on CMOS platform is highly desirable.

We have previously reported CMOS-compatible avalanche photodetectors (CMOS-APDs) having high responsivity and large photodetection bandwidth realized with standard CMOS technology [3]. We have also demonstrated RoF downlinks based on baseband optical receivers with on-board [4] or on-chip [5] integration of APD and a transimpedance amplifier. Noise and conversion gain performances can be further optimized by a narrow-band design approach using reactive components for impedance matching between APD and a following circuit. A design methodology of narrow-band RoF receivers and design results of a 10-GHz receiver with on-chip p-i-n PDs fabricated with InGaAs HEMT technology have reported [6].

In this work, we demonstrate a fully integrated design approach in which all the necessary optical and electronic components for the RoF receiver front-end are included in a single CMOS chip. Figure 1 shows the block diagram of 5-GHz RoF downlink, for which we design our RoF receiver. 5-GHz radio signals are transmitted over fiber in the optical

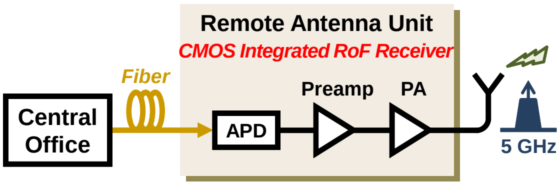

Figure 1. Block diagram of 5-GHz RoF downlink utilizing CMOS integrated RoF receiver.

domain from a central office to RAU. APD converts the signals into the electrical domain. The narrow-band preamp is optimized for low noise and high gain with the reactive input matching technique. A power amplifier (PA) drives the external antenna with high-power capability. The RoF receiver is presently under fabrication and we report the post-layout simulation results in this paper.

II. Circuit Description

Fig. 2 shows the schematics of our 5-GHz CMOS RoF receiver. The receiver is designed with standard 0.18-μm RFCMOS technology. The gate bias circuits are not shown in this schematic. The CMOS-APD uses a vertical PN junction between the P^+ source/drain implantation region and the N-well region [3]. The cathode (N-well) node is connected to a DC pad with RF ground capacitors for the reverse bias voltage (V_{PD}). The anode (P^+) node is connected to the preamp. A lensed fiber is used for injecting 850-nm light into the APD. The APD has the optical window of 10 μm × 10 μm. The APD has the best signal-to-noise ratio (SNR) at V_{PD} of 9.7 V with corresponding responsivity of 0.1 A/W and photodetection bandwidth of 3.7 GHz.

The design goal of the preamp is achieving low noise and high gain simultaneously. For this, a cascode low-noise amplifier topology with the simultaneous noise and input matching technique [7] is used. The cascode configuration offers enough gain per stage to neglect the noise of the following amplifiers. The impedance matching between the preamp and the APD is carefully determined with a trade-off between power transfer and noise performance [6]. The impedance matching is optimized at the frequency of 5.5 GHz, and the measured reflection coefficient of the APD, Γ_{PD}, at this frequency is 0.957 – j0.19. A shunt inductor at the input of the preamp, L_{shunt}, is an essential

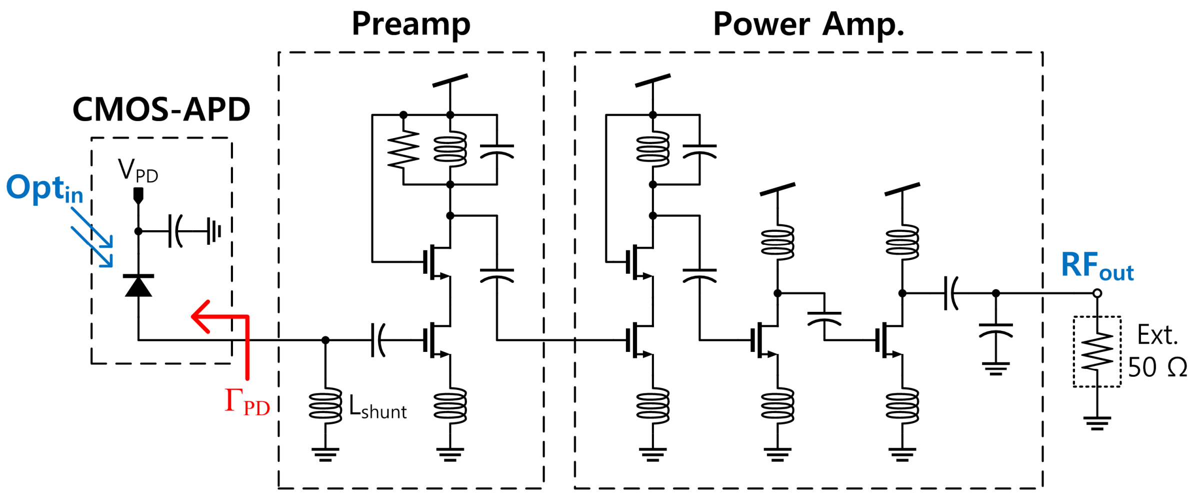

Figure 2. Schematics of 5-GHz CMOS RoF receiver.

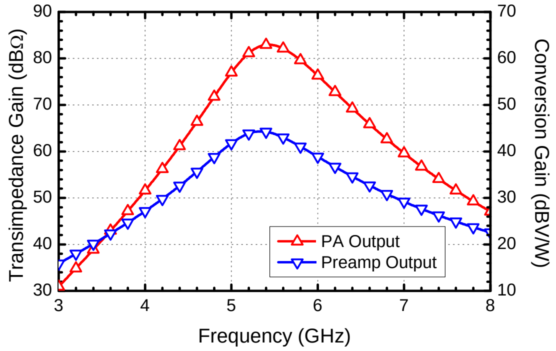

Figure 3. Simulated transimpedance gain and optoelectronic conversion gain as a function of frequency at PA output and preamp output, respectively.

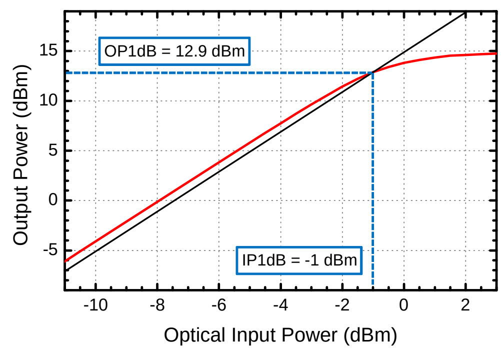

Figure 4. Simulated output power as a function of optical input power.

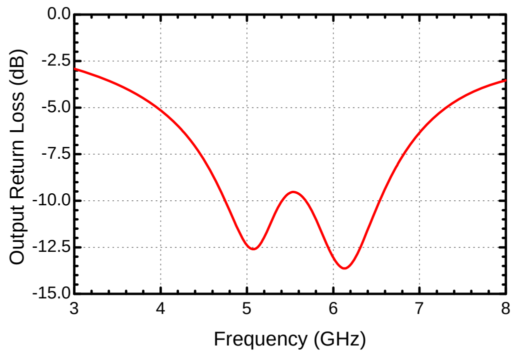

Figure 5. Simulated return loss characteristic at PA output.

component not only for the impedance matching but also for a DC current path for the APD. The load of the preamp has a parallel RLC topology with resonance at 5.5 GHz and a wide bandwidth.

The PA is designed to supplement gain and to drive an external 50-Ω load with large power handling capacity. The first stage uses a cascode topology for high gain, and the latter two stages utilize a common-source topology for high linearity. Each stage has a source-degeneration inductor to prevent unstable operation.

III. Simulation Results

Post-layout simulations were performed with the equivalent circuit model of the APD [8] in Cadence Spectre simulator. The power consumption is 2.1 mA for the preamp and 84.4 mA for the PA at 1.8-V supply for the preamp and the PA, respectively. The PA consumes most of the power due to its high-power driving performance.

Figure 3 shows the transimpedance gain and the optoelectronic conversion gain as a function of frequency at the PA output and the preamp output, respectively. The conversion gain was calculated on the assumption of the APD responsivity of 0.1 A/W. The peak transimpedance gain of the preamp is about 64.3 dBΩ at 5.4 GHz, and that of the overall receiver is about 83 dBΩ at 5.45 GHz, after 18.7-dB amplification by the PA. The 3-dB bandwidth is 0.63 GHz in the range from 5.14 GHz to 5.77 GHz. The peak conversion gain is about 63 dBV/W.

The output power as a function of the optical input power is depicted in Figure 4. The 1-dB gain compression point is at the input power of -1 dBm and the output power of 12.9 dBm. The saturated output power is about 15 dBm. Return loss characteristic at the PA output is shown in Figure 5. Return loss below -9.5 dB is obtained in the wide frequency range.

IV. Conclusion

We present a design of 5-GHz RoF receiver including a monolithically integrated APD and amplifiers realized with 0.18-μm CMOS technology. The post-layout simulation results show the total optoelectronic conversion gain of 63 dBV/W and the output 1-dB gain compression point of 12.9 dBm. We believe our CMOS integrated RoF receiver has a great potential for realizing cost-effective RAUs for various RoF systems.

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