Dual-Band Predistortion Power Amplifier for Digital Cellular and IMT-2000 Base-station Application

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Abstract — **This paper proposes a dual-band predistortion power amplifier using diplexer for digital cellular (fo=880MHz) and IMT-2000(fo=2140MHz) base station. Each high power amplifier is linearized by using predistortion method. The implemented predistorter uses reflection type IM generator with 3dB hybrid coupler for good reflection characteristic. The diplexer is composed of low pass filter using defected ground structure(DGS) microstrip line and high pass filter using high-Q lumped capacitors and distributed elements. For a forward link one-carrier CDMA IS-95 and WCDMA signal, the proposed dual-band predistortion power amplifier shows ACPR improvement of about 10dBc and 9.36dBc for cellular and IMT-2000 band of operation, respectively.**

Key Words: dual-band, base-station, predistortion, power amplifier

I. INTRODUCTION

Mobile communication is continuously developing, and it has come to take greater part of out social activity than ever before. In the past years, mobile communication is limited to low data rate signals exchange such as voice or text data. However, higher data rate signal exchange has become essential part of mobile communication due to the fact that several additional applications such as mega pixel digital camera, mp3 player and TV receiver are converged into a mobile unit to satisfy various requirements from the users.

Therefore, to provide additional services including those kinds of multimedia data, a service provider has to utilize more than one frequency band in addition to the one that is used previously.

A new service requires an investment in research and development of the following equipments for each application, and it can't be achieved without considerably large amount of cost and efforts. For that reason, active studies are being done on the wideband, multi-band devices that can cover more than one frequency band. Still, due to the rigid linearity requirements of the base-station power amplifier, the research is limited to the mobile station power amplifier[1]-[3].

There are several linearization methods to overcome those linearity requirements. Feed-forward can be one solution thanks to the good linearity improvements, but it is complicated and expensive technique. Although the amount of improvement is relatively small, predistortion method is widely used because of its cost effective and easy-to-implement aspects[4]-[6]. If we apply predistortion linearization to the multi-band application, we can design multi-band linear power amplifier.

In this paper, we will discuss the design method of the base-station dual-band predistortion power amplifier. At first, we will mention the design of a frequency selective diplexer to make dual-band operation for 880MHz and 2140MHz possible. And then we will design simple predistorter for each frequency band. Based on the diplexer operation, we will constitute the dual-band predistortion power amplifier and test results with CDMA IS-95 1FA signal and WCDMA 1FA signal will be shown to prove its excellent linearity for both band of operation.

II. DESIGN OF DUAL-BAND PREDISTORTION POWER AMPLIFIER

Dual-band predistortion amplifier consists of the input and output diplexer for dividing and combining of input signal, predistortion linearizer, and power amplifier. Input signal is split into two paths due to the frequency selective diplexer, and then the signal of each path goes through linear amplification process of predistortion power amplifier. Finally two different frequency signals are combined at the output diplexer into one path.

Low pass filter carries digital cellular band signal and high pass filter transmits IMT-2000 band signal. On account of the diplexer operation, the number of antenna and subsidiary components such as cables can be reduced, therefore achieving low cost implementation. Moreover, low insertion loss of the proposed diplexer makes it possible to apply the

proposed dual-band predistortion power amplifier design technique for high power operation.

Since the high Q inductor of RF and microwave band is hard to realize, low pass filter of the diplexer is implemented with the DGS microstrip line and high pass filter with high-Q capacitor and the short stub. The electrical length of the transmission line between low pass filter and T-junction is critical because frequency and wavelength are inversely proportional. We solved this problem by means of the slow wave effect of the DGS microstrip line[7].

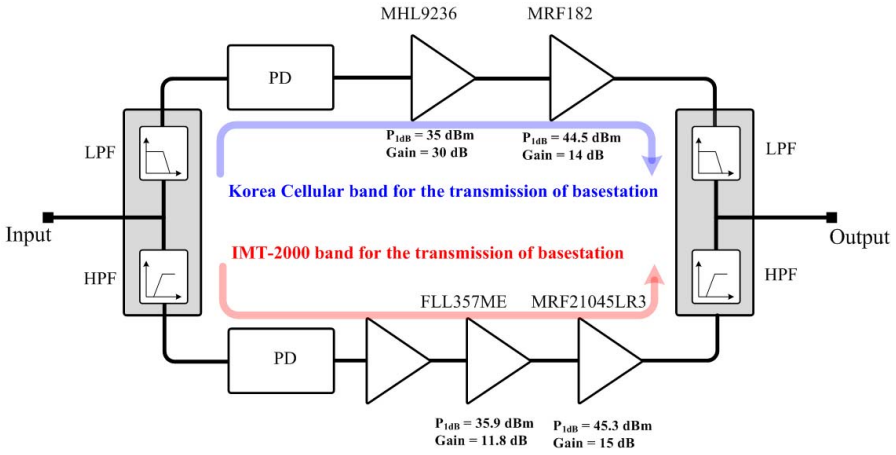


Fig. 1. Proposed dual-band predistortion power amplifier

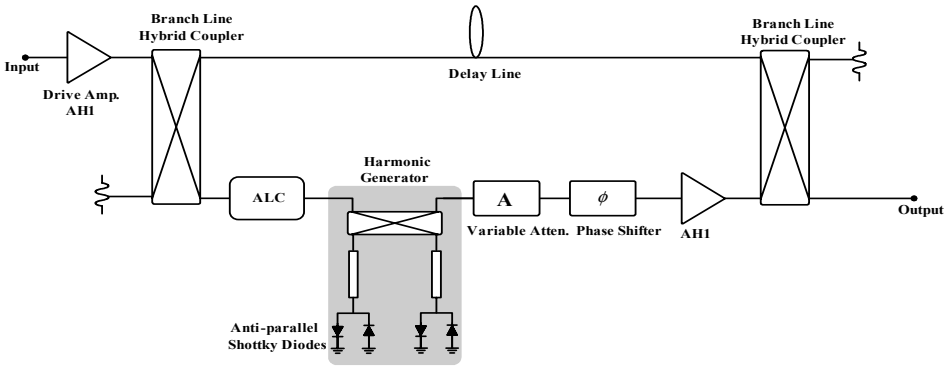


Fig. 2. Proposed predistortion linearizer block

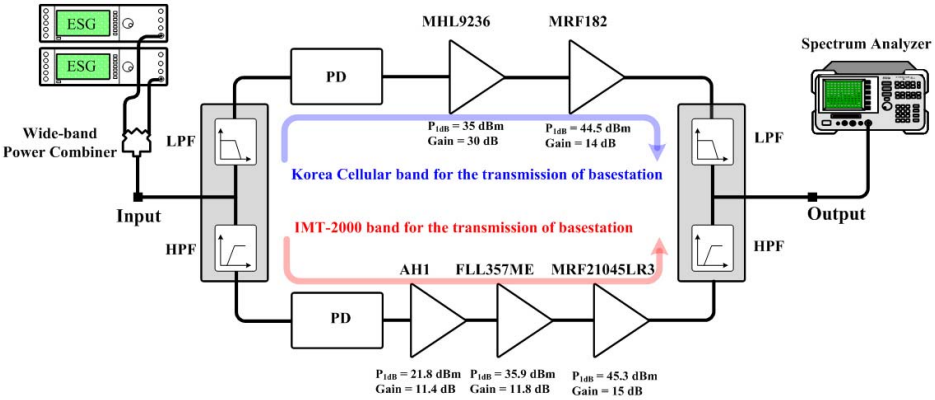


Fig. 3. Measurement setup

Fig.1 shows the proposed dual-band predistortion amplifier. And the circuit diagram of the predistorter is shown in Fig.2. IM generator is composed of anti-parallel connected schottky diode, transmission line and 3dB hybrid coupler. You can expect good reflection characteristic of the IM generator since it has a reflection type structure. We can adjust the power level with variable attenuator and phase shifter.

III. MEASUREMENTS

To show the validation of the proposed design technique, we fabricated two individual power amplifiers for digital cellular band and IMT-2000 band. Gain and output power measured with the power meter is 44dB/ 44.5dBm for digital cellular band amplifier and 41.5dB/ 45.3dBm for IMT-2000 band amplifier. Fig.3 shows the measurement setup using wide-band Wilkinson power combiner/divider with two individual CDMA signal generator to confirm dual-band linear amplification of the proposed amplifier.

The implemented diplexer has low insertion loss of 0.27±0.01dB for 880MHz and 0.42±0.03dB for 2140MHz. Low pass filter and high pass filter shows counterpart rejection characteristic of over 35dB, 50dB respectively. Measurement result is presented in Fig.4.

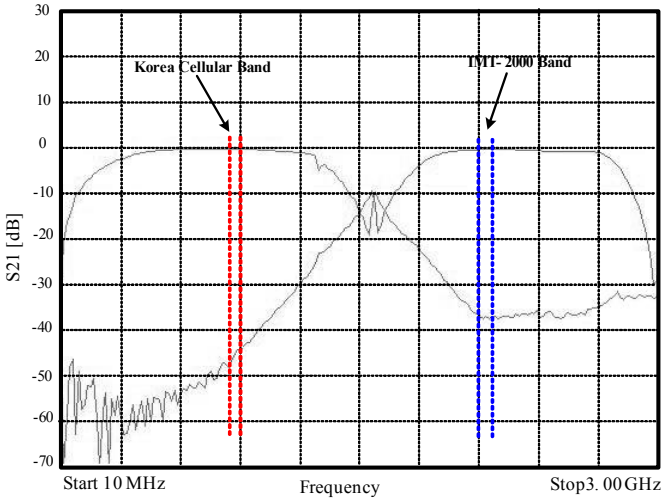


Fig. 4. Diplexer transmission characteristic

Frequency response of the dual-band predistortion power amplifier measured with a network analyzer is shown in Fig.5. You can see dual-band gain characteristic with the reflection coefficient under -20dB for both band of operation.

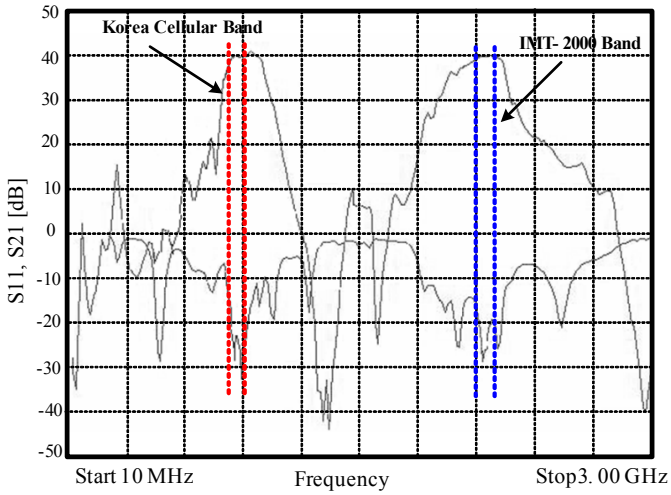
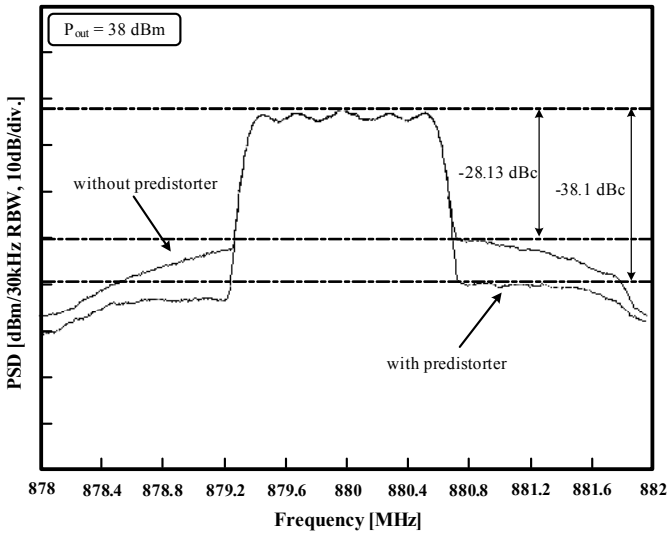
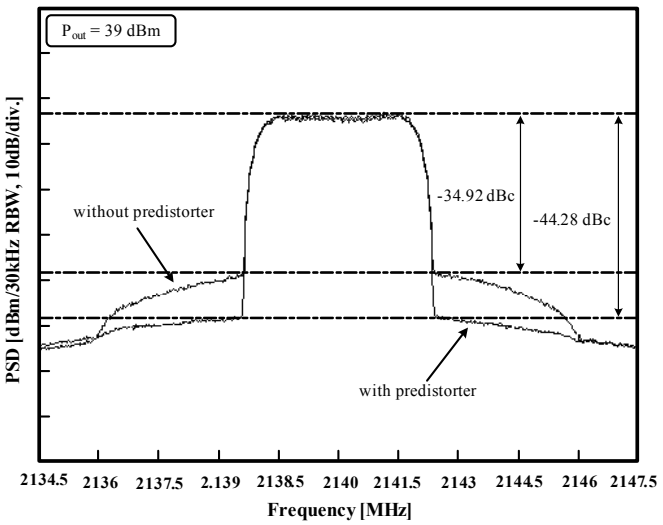


Fig. 5. Gain characteristic of the dual-band predistortion power amplifier

Output spectrum of the proposed dual-band predistortion power amplifier measured with the measurement setup of Fig.3 is shown in Fig.6. Applying CDMA IS-95 and WCDMA 1FA(test mode1, 64DPCH) signal, we obtained about 10dBc improvement at the frequency offset of 885kHz for digital cellular band, 9.4dBc improvement at the frequency offset of 2.7MHz for IMT-2000 band.



(a) CDMA IS-95 1FA signal @ 880MHz



(b) WCDMA 1FA signal @ 2140MHz

Fig. 6. ACPR improvement of the dual-band predistortion power amplifier

IV. CONCLUSION

For a linear RF power amplifier which can cover both the digital cellular band and the IMT-2000 band, we proposed a new dual-band predistortion power amplifier using the diplexer. To prove the validity of the proposed method, we have implemented simple reflection type predistorters and power amplifiers each for 880MHz and 2140MHz. CDMA IS-95 and WCDMA 1FA ACPR improvements of the proposed dual-band predistortion power amplifier are about 10dBc and 9.4dBc for each band of operation, respectively.

The proposed dual-band predistortion amplifier has several advantages such as easy to implement design method, low diplexer insertion loss, reduction of the number of antenna, cable and other additional elements. In result, we can expect cost reduction.

REFERENCES

[1] Youn Sub Noh, Chul Soon Park, "PCS/W-CDMA dual-band MMIC power amplifier with a newly proposed linearizing bias circuit," IEEE Journal of Solid-State Circuits, Vol. 37, No. 9, September 2002.

[2] Kunihiro, K.; Yamanouchi, S.; Miyazaki, T.; Aoki, Y.; Ikuina, K.; Ohtsuka, T.; Hida, H., "A diplexer-matching dual-band power amplifier LTCC module for IEEE 802.11a/b/g wireless LANs", IEEE Radio Frequency Integrated Circuits Symposium, Digest of Papers. 2004 IEEE, pp303-306, June 2004.

[3] Adar, A.; DeMoura, J.; Balshem, H.; Lott, J. "A high efficiency single chain GaAs MESFET MMIC dual-band power amplifier for GSM/DCS handsets," IEEE Gallium Arsenide Integrated Circuit (GaAs IC) Symposium, Technical Digest 1998, pp69-72, November 1998.

[4] Young Kim, Ik-Soo Chang and Yong-Chae Jeong, "An analog predistortion linearizer design," Microwave Journal, vol.48, no.2, pp118-226, Feb 2005.

[5] Yong-Chae Jeong, and Sang-Young Yun, "Design of a predistortive high power amplifier using carrier complex power series analysis," Microwave Journal, vol. 45, no. 4, pp92-102, April 2002.

[6] Jeonghyeon Cha, Jaehyok Yi, Jangheon Kim, and Bumman Kim, "Optimum design of a predistortion RF power amplifier for multicarrier WCDMA applications," IEEE Transactions on Microwave Theory and Techniques, vol. 52, No. 2, pp655-663, Feb 2004.

[7] Yong-Chae Jeong, Si-Gyun Jeong, Jong-Sik Lim, Chul-Dong Kim, "Amplifier design using a λ/4 high impedance bias line with a defected ground structure(DGS)," Microwave Journal, vol. 47, no. 4, pp80-92, April 2004.