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DECLARATION OF GERARD P. GRENIER

I, Gerard P. Grenier, am over twenty-one (21) years of age. I have never been convicted of a felony, and I am fully competent to make this declaration. I declare the following to be true to the best of my knowledge, information and belief:

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8. The article below has been attached as Exhibits A to this declaration:

A.	J. Choi, et al. "Envelope Tracking Power Amplifier Robust to Battery Depletion" 2010 IEEE MTT-S International Microwave Symposium Digest, May 23 – 28, 2010.

9. I obtained a copy of Exhibit A through IEEE Xplore, where it is maintained in the ordinary course of IEEE's business. Exhibit A is a true and correct copy of the Exhibit as it existed on or about March 22, 2018.

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11. J. Choi, et al. "Envelope Tracking Power Amplifier Robust to Battery Depletion" was published as part of the 2010 IEEE MTT-S International Microwave Symposium.

The 2010 IEEE MTT-S International Microwave Symposium was held from May 23 – 28, 2010. Copies of the conference proceedings were made available no later than the last day of the conference. The article is currently available for public download from the IEEE digital library, IEEE Xplore.

12. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001.

I declare under penalty of perjury that the foregoing statements are true and correct.

Executed on: 22-March-2018

EXHIBIT A

Envelope tracking power amplifier robust to battery depletion

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Author(s)

Jinsung Choi ; Dongsu Kim ; Daehyun Kang ; Jungmin Park ; Boshi Jin ; Bumman Kim

View All Authors

Abstract:
A wideband envelope tracking power amplifier, which is robust to battery depletion, is introduced. An integrated boost converter keeps a stable operation of the PA supply modulator. Even at the battery depletion from 4.2V to 2.8V, there is no significant degradation of output power and linearity in the power amplifier. Moreover, the efficiency degradation by the additional regulator is minimized for the novel supply modulator architecture proposed in this work. The fabricated 2.535GHz envelope tracking power amplifier presents max/min power-added efficiencies of 32.3/26.2% for 10MHz BW 3GPP LTE standard along the battery voltage from 4.2V to 2.8V.

Published in: Microwave Symposium Digest (MTT), 2010 IEEE MTT-S International

Date of Conference: 23-28 May 2010

INSPEC Accession Number: 11452890

Date Added to IEEE *Xplore*: 23 July 2010

DOI: 10.1109/MWSYM.2010.5517825

ISBN Information:

Publisher: IEEE

ISSN Information:

Conference Location: Anaheim, CA, USA

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I. Introduction

As the wireless communication systems evolve, the peak-to-average power ratio (PAPR) of the signal increases. For 2G and 3G systems such as CDMA, EDGE, and WCDMA, the PAPRs of the signals are around 3.5dB as depicted in Fig. 1. For the next generation communication systems such as 3GPP LTE and Mobile-WiMAX, however, an orthogonal frequency-division multiplexing (OFDM) is employed for a wideband communication, which results in higher PAPR around 8-10dB. In the case, an efficiency of a radio frequency (RF) power amplifier (PA) is so low that the efficiency improvement technique is required. The envelope tracking (ET) technique is one of the best way achieving a high efficiency. Because the supply of the RF PA is modulated according to the instantaneously transmitted power level, the power dissipated as a heat is minimized. Ideally, it is the optimum PA architecture with assumption of high efficiency supply modulator. In [1], the low drop-out (LDO) regulator is employed as a supply modulator. It operates over a wide bandwidth, but efficiency of the LDO is not high enough for high PAPR signals. The switching mode power supply such as a buck converter shows a high efficiency, but the switching frequency is limited by the switching loss so that wide bandwidth capability can not be fulfilled [2].

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