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Evaluation of Adaptive CFR-DPD for LTE Signals

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In this paper, an adaptive combination of Crest Factor Reduction (CFR) and Digital Pre-Distortion (DPD) for Power Amplifiers (PAs) in Long Term Evolution (LTE) systems is proposed as part of the APOGEES(1) project. The idea to perform this adaptation is based on the determination of the optimal CR value in order to keep the Peak-to-Average Power Ratio (PAPR) of the signal at the output of DPD below 13.5dB, this threshold being determined by the studied power amplifier (the maximum input voltage amplitude validity of the model is 2.829V). Applying this adaptation, the use of CFR block is reduced, as a result, the complexity and the Error Vector Magnitude (EVM) caused by CFR are reduced.

In order to evaluate the proposed architecture of CFR-DPD, a broadband high power amplifier module model number TWB0730M47A (represented by four models at four outputs powers 34, 38, 42 and 44dBm) has been used. To drive the PA, 20, 10 and 5 MHz LTE signals have been employed. A total of 150,000 samples were captured with 61.44 MHz sampling frequency, whereas 30,000 samples oversampled by a factor of 4 were used for the model extraction of the amplifier. The PAPR reduction technique used is Adaptive Width Peak Cancellation. DPD model is Generalized Memory Polynomial (GMP) with 17 coefficients and the Normalized Mean Square Error (NMSE) is about -44 dB, its number of coefficients is extracted from 30000 samples.

Numerical results show that the CFR has to be turned on only when values of PA output power exceeds 41dBm for the bandwidth of 20MHz, 43dBm for the bandwidth of 10MHz. CFR is turned off for the bandwidth of 5MHz.

The impact of the adaptive CR value on the combination of DPD and CFR performance is studied in terms of the signal quality-metrics, i.e., the EVM, the Adjacent Channel Power Ratio (ACPR) as well as the PAPR reduction gain. For the bandwidth of 20MHz and 44 dBm as output power, the combination of DPD with the CFR allows for a 9.32% improvement in the EVM of the linearized signal compared to predistortion alone and the $ACPR_{L2}$ is improved by 6.44 dB as shown in table 1. For the bandwidth of 10MHz and 44 dBm as output power, the combination of DPD with the CFR allows for a 2.28% improvement in the EVM of the linearized signal compared to predistortion alone and the ACPRL2 is improved by 6.57 dB as shown in table 2.

Table 1. DPD vs CFR / DPD performance at Pout=44dBm (20 MHz)

Merit factors	PA without linearization	DPD alone	CFR+DPD
EVM (%)	68.22	11.26	1.94
$ACPR_{L1}$ (dB)	-29.05	-41.92	-43.14
$ACPR_{U1}$ (dB)	-30.34	-42.99	-44.07
$ACPR_{L2}$ (dB)	-52.29	-57.63	-64.07
$ACPR_{U2}$ (dB)	-56.92	-62.68	-65.48

Table 2. DPD vs CFR / DPD performance at Pout=44dBm (10 MHz**)**

Merit factors	PA without linearization	DPD alone	CFR+DPD
EVM (%)	57.71	4.84	2.56
$ACPR_{L1}$ (dB)	-29.08	-40.01	-40.04
$ACPR_{U1}$ (dB)	-29.51	-40.13	-40.93
$ACPR_{L2}$ (dB)	-54.30	-58.73	-65.30
$ACPR_{U2}$ (dB)	-55.49	-56.07	-63.57

Based on this study, we conclude that adaptive CFR should be chosen in order to minimize the complexity of the system while fitting the standards requirements in terms of EVM and ACPR.

References

[1] A. Cheaito, Y. Louet, “Adaptive Width Peak Cancellation Scheme for Multicarrier Systems,” IEEE 29th Annual International Symposium on Personal, Indoor and Mobile Radio Communications (PIMRC) September 2018.

[2] A-T. MBAYE “Linéarisation des amplificateurs de puissance par prédistorsion numérique pour des applications de communications tactiques et de diffusion audio/vidéo,” Thèse de l’Université Paris-Est 2015.

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