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Evaluation of a LINC Transmitter for OFDM using Software Defined Radio

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Abstract— The drawback of OFDM modulations is the high peak-to-average power ratio (PAPR). The linear transmission path is required for efficient amplification. It is achieved with linear amplification with nonlinear components (LINC) transmitter. It overcomes the PAPR issues with OFDM Signal. The LINC transmitter is evaluated using the Software Defined Radio. The OFDM signal is first generated and then reconstructed using LINC transmitter to verify the effectiveness of the transmitter

Keywords- PAPR, LINC, OFDM, Modulation, Complex Envelope, GNU Radio

I. INTRODUCTION

The peak to average power ratio for a signal x(t) is defined as PAPR $=\frac{MAX\{x(t)x(t)*\}}{E\{x(t)x(t)*\}}$.

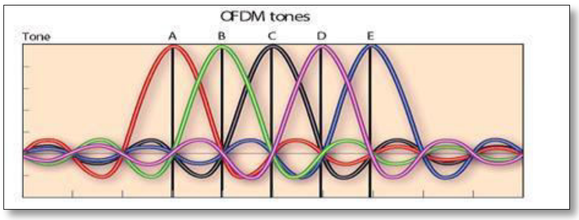

Figure 1

Mathematically signal is $x(t)\sum_{0}^{k-1}\left(a_k e^{\frac{j2\pi Ki}{T}}\right)$. If it is assumed that $a_k = 1$, for all the subcarriers. In that scenario, the peak value of the signal is, k^2[1]. The peak to average power ratio with K subcarriers and all subcarriers are given the same modulation is, K^2/K =K. It shows if we have more number of subcarriers then PAPR will increase accordingly. PAPR can be reduced by using the concept of Back off in power amplifiers. One can see the nonlinear behavior of the PA. It is desired to operate the PA in the linear region [2]. But High input back-off can decrease the power efficiency as shown in figure 2. Since OFDM is a sum of K subcarriers, these different carriers may all line up in phase at some instant and consequently produced high peak [3]. This high peak distorts the transmitted signal if the transmitter contains non-linear components such as power amplifiers. The non-linear effects may cause in-band or out-of-band distortion to signal. To have distortion less transmission, the PAs requires a back-off, which is the scaling of symbols to be amplified by a factor ε < 1 [4].But input back-off will reduce the efficiency as discuss earlier.(ref Fig c).

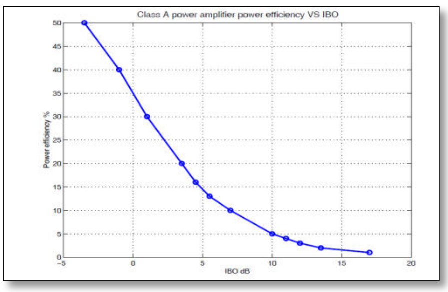

Figure 2

To overcome this reduction in efficiency we use LINC transmitter which is explained in next section.

2. LINCTransmitter

The principle of LINC transmitter is that the signal to be transmitted is divided into two constant envelope signal priors to amplification see fig (d). The two constant envelope signals S1 (t) and S2 (t) are amplified separately, without distortion, in highly nonlinear but very efficient amplifiers [5]. After amplification the signals are recombined to form an amplified replica of the modulated signal, Sin (t).

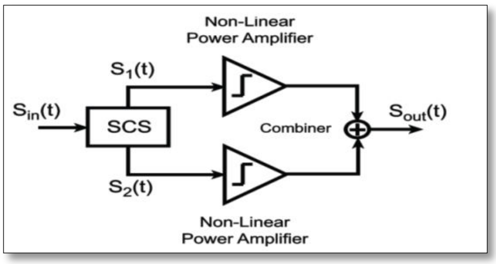

Figure 3

A mathematical description of the technique is shown in figure 4

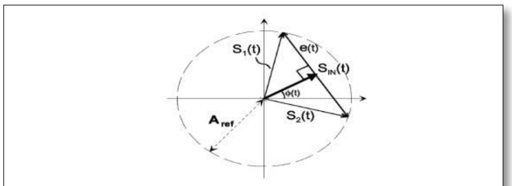

Fig. 2. Decomposition of a phase-and-amplitude modulated signal $S_{IN}(t)$ into two constant envelope signals $S_1(t)$ and $S_2(t)$.

Figure 4

$$Sin(t) = Sin(t)\,.e^{j\Phi(t)}$$
(1)

Where $\Phi(t)$ is the phase envelope of the modulated signal. Fig.(e).shows that the two constant envelope signals S1(t) and S2(t) can be calculated from the input signal as follows:

$$S1(t) = Sin(t) + e(t),\ S2(t) = Sin(t) - e(t)$$
(2)

$$e(t) = = j.\ Sin(t)\ .Sqrt\ ((\ Aref^2/r^2(t)\ )-1)$$
(3)

The e(t) signal derives from Sin(t) through a nonlinear operation. It is therefore intrinsically a wideband signal, its bandwidth being 5–10 times wider than the input signal's bandwidth[6]. From (e) it follows that the input signal can be recovered, assuming two perfectly balanced amplification branches

$$Sout(t) = \frac{S1(t)+S2(t)}{2} = \sin(t)$$
(4)

However, the decomposition of Sin into S1(t) and S2(t) is only possible if Sin(t) ι < Aref[7] . Otherwise, referring to Fig. e, the phasor Sin(t) would fall outside the circle and neither S1 (t) nor S2(t) exist. Therefore, the input signal has to be limited to Aref by clipping before the decomposition [8]. Like in a conventional linear amplifier, the input signal average power has to back-off the amplifier saturation.[9]

3. Implementation of LINC using GNU Radio

Generation OF OFDM Signals- In this, use random source block to generate the random data and OFDM block to do OFDM modulation on this data. Here fft length is 4096 and occupied tones are 64. When the signal is transmitted using USRP sink and analyze it on spectrum analyzer it is found that signal lost under noise, so to overcome this, signal is multiplied it with constant value of 1000.

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Figure 5 Shows that generated OFDM Signal.

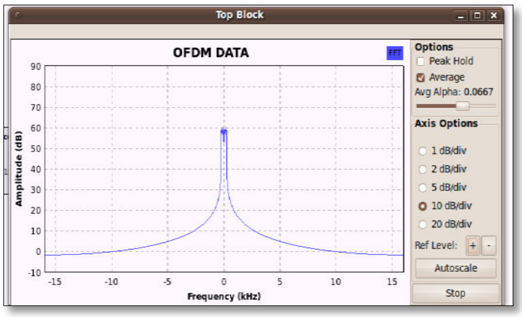

Figure 5

4. Implementation of LINC separator

To implement LINC separator we have to follow equations - S1(t) = Sin(t) + e(t), S2(t) = Sin(t) - e(t)

e(t) = = j. Sin(t) .Sqrt ((Aref^2/r^2(t))-1)

Where Sin(t) is the OFDM data that we generated. For implementing these equation in GRC we use operator blocks present in the GRC for example Addition block, Division block etc. Fig (7) shows the LINC implementation using GRC. Here some conversion block like complex to float because every block has particular type of input and output.

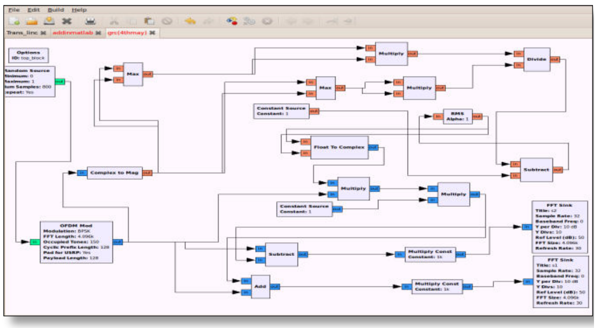

Figure 6: LINC Transmitter on GNU Radio

In this, one can also import the Matlab codes in GRC. So, Matlab codes imported for generation of OFDM data using file source. After boosting the signal by multiplying it with constant value of 1000, USRP sink is used which take these codes to the Spectrum Analyzer i.e. Figure (8) shows the spectrum of generated OFDM signal.

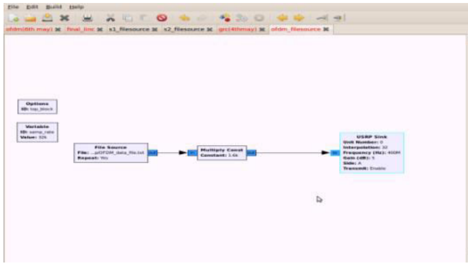

Figure 7

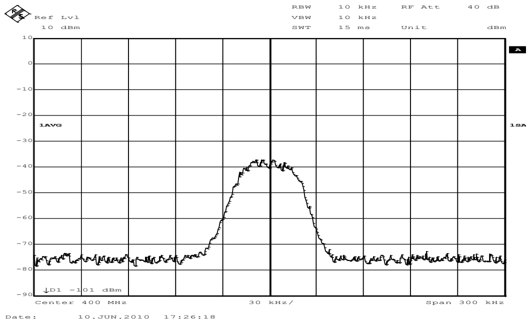

Figure 8

Similarly generation of S1 and S2 is commenced. Figures below shows the generation of S1 and S2 with the spectrum analyzer screen shots for their constant envelope

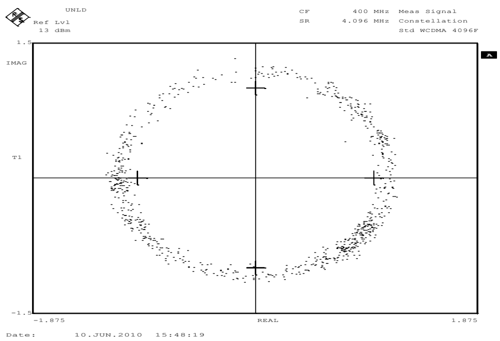

Figure 9 Complex Envelop of S1

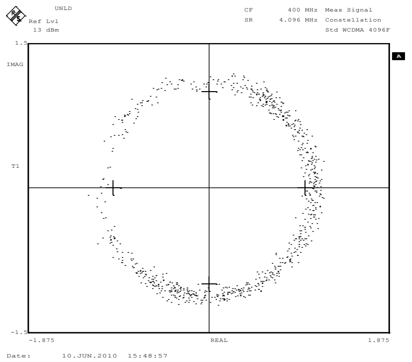

Figure 10 Complex Envelop of S2

These constant envelope signals are transmitted using two daughter boards of 400MHz each and then we add these using combiner of 50 -1000 MHz and then we can get the results on spectrum analyzer. Fig (13) shows the spectrum of reconstructed OFDM signal

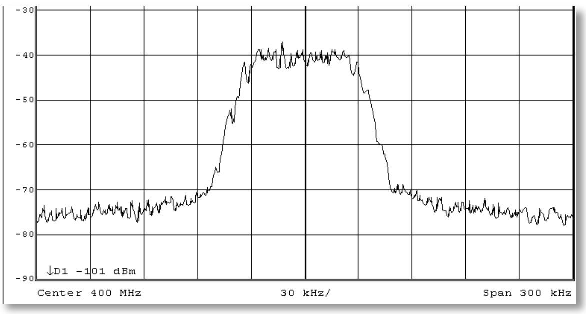

Figure 11: Reconstructed OFDM Signal

II. CONCLUSION

It is verified that the PAPR problem with OFDM signals can be eradicated using the LINC transmitter. It is possible to reconstruct the OFDM signal on Software Defined Radio from the addition of Complex envelopes if the phase shift between Si and S2 is minimum.

REFERENCES

[1] L. R. Kahn. "Single Sideband Transmission by Envelope Elimination and Restoration". Proceedings of the I.R.E., 1952, pp. 803-806.

[2] D. C. Cox. "Linear amplification with non-linear components". IEEE transactions on Communications, Vol COM-23, pp 1942-1945, December 1974. 6

[3] F. Raab et al. "Power Amplifiers and Transmitters for RF and Microwave". IEEE transactions on Microwave Theory and Techniques, Vol. 50, No. 3. Mars 2002, pp 814-826.

[4] H. Krauss. C. Bostian, F. Raab. "Solid State Radio Engineering", Wiley, New York, 1980.

[5] S. C. Cripps. "RF Powers Amplifiers for Wireless Communications". Artech House 1999.

[6] A. Diet. "Etude des architectures EER pour les émetteurs de radio communications numériques 3 G et au delà" Ph. D. thesis report, Université de Marne la Vallée, France, 2005.

[7] F. Raab et al. "RF and Microwave Power Amplifier and Transmitter Technologies" High Frequency Electronics, May-November 2003, pp 22-36, pp 22-36, pp 34-48 and pp 38-49.

[8] W. Liu, J. Lau, R. Cheng. "Considerations on applying OFDM in a Highly efficient PA". IEEE transactions on Circuits and Systems II, Vol. 46, No. 11, Nov. 1999, pp 1329-1335.

[9] A. Diet, C. Berland, M. Villegas, G. Baudoin. "EER architecture specifications for OFDM transmitter using a class E power amplifier". IEEE Microwave and Wireless Components Letters, pp 389-391, V-14 I-8, Août 2004.