Broadband Integrated Antenna for LINC Systems

Shi-Chang Gao[(1)*], Peter Gardner[(1)] and Ser Tar Chiw[(1)]
[(1)]School of Electronic, Electrical and Computer Engineering,
The Univerity of Birmingham, Birmingham, B15 2TT, UK
Email: shichanggao@ieee.org

ABSRTACT: A broadband integrated antenna for LINC systems is presented. It can fulfil the functions of both the radiator and the power combiner, thus ensuring maximum power efficiency. This would be useful for current LINC, where the circuit-level power combiner losses degrade overall efficiency. The concept is explained and one antenna at 2.0 GHz is designed and fabricated. Stacked microstrip patches are used to broaden the bandwidth. The measured results demonstrate that it achieves a bandwidth (S_{11} <-10 dB) of 15.5 % and 8 % under the odd-mode and the even-mode excitation, respectively. Radiation patterns are also presented.

1. INTRODUCTION

Future mobile communications systems will have a need for radio transmitters with high linearity and high power efficiency. Several linearization techniques for power amplifiers (PA) have been proposed, which include Feed-forward, Feedback, Pre-distortion, LINC and CALLIUM systems, *etc*. Amongst them, one of the most promising is the LINC system, as it does not use the feedback loop, thereby guaranteeing the complete circuit stability.

LInear amplification using Non-linear Components (LINC) is a method of vector summing two constant amplitude phase-modulated signals to achieve power amplification [1]. The theoretical efficiency of the LINC system has been reported to be 100% since highly efficient nonlinear power amplifiers such as class-F PA can be used. The conventional configuration of the LINC system is shown in Fig. 1 (a), where an input signal is divided into two constant-envelope signals by a Signal Components Separator (SCS). The constant-envelope signals are amplified by PA and then combined by using a power combiner. Finally, the combined signal is transmitted through an antenna. As illustrated in [2], the power-combiner circuit is one big contributor to the efficiency of LINC system, and the loss introduced in it will affect the efficiency significantly. Integrated antennas have been widely employed in various applications, such as push-pull amplifiers in [3]. In [4], we proposed an integrated antenna for LINC systems, which could realize the functions of both the power combiner and the antenna. The antenna in [4] is narrow band and only a few simulation results are given.

This paper describes a broadband integrated antenna for LINC systems, together with some experimental and simulated results.

2. THEORY, DESIGN AND EXPERIMENTS

The configuration of the proposed integrated-antenna LINC system is presented in Figure 1(b). The input stage is the same as the conventional LINC system. However, a dual-feed microstrip antenna with a resistor-loaded microstrip line *ml* connecting two feeding lines has replaced the power combiner in the output stage. To ensure the proper operation of the new LINC system, the integrated antenna should produce the proper radiation during the odd-mode excitation, while the power during the even-mode excitation should be eliminated and dissipated through the resistor *r*. Several conditions should be satisfied as follows:

1) During the odd-mode excitation, signals applied to two feeds excite the patch resonance and produce the radiation, while the microstrip line *ml* should present an open circuit at the point p1 and p2;

2) During the even-mode excitation, microstrip antenna should present an open circuit at point p1 and p2, while the even-mode radiation is dissipated through a shunt resistor *r* inserted at the centre of microstrip line *ml*;

The microstrip line *ml* has a length of $\frac{3}{2}\lambda$ at the design frequency, so that it presents an open circuit at the point p1 and p2 during the odd-mode excitation. To further demonstrate the idea, an example antenna at 2.0 GHz is designed. To broaden the bandwidth, stacked microstrip patches are used and the multi-layered structure is shown in Fig. 2. The mask of the lower patch with microstrip line *ml* is presented in Fig. 3. A lumped resistor *r* of 37.5 Ω is to be inserted at the centre of microstrip line *ml*. The lower patch is 40 mm×51 mm in size. The upper patch is 54 mm×58 mm in size, and its mask is given in Fig. 4. The substrate with a permittivity of 2.2 and a height of 1.143 mm, is used in the design. An air layer having a thickness of 7 mm is inserted between two patches.

To perform the simulation, we use the moment method in HP ADS software (from Agilent Technologies). Fig.5 gives the measured S_{11} and S_{21} of the integrated antenna. Fig. 6 shows the measured return loss results of the integrated antenna under the odd-mode (*i.e.*, $S_{11}-S_{21}$) and the even-mode (*i.e.*, $S_{11}+S_{21}$) excitation, respectively. The odd-mode S_{11} is <-10 dB in the range from 1.83 GHz to 2.14 GHz, which means a bandwidth of 15.5 %. The results of even-mode S_{11} are not so good and a bandwidth of nearly 8 % is achieved (*i.e.*, 1.93 GHz-2.09 GHz). It is also noted that even-mode S_{11} is <-8 dB throughout the band 1.7 GHz-2.3 GHz. At 2.0 GHz. the return loss result is -13.4 dB and –13 dB for the odd-mode and the even-mode S_{11}, respectively.

As this multi-layered antenna employs stacked patches, the antenna characteristics are sensitive to the fabrication tolerances, which will introduce discrepancies between the simulated and measured results. For comparisons, simulated results are also presented. The simulated return loss results of S_{11} and S_{21} of the integrated antenna are presented in Fig. 7, and Fig. 8 shows the simulated results under the odd-mode and the even-mode excitations, respectively. Simulated results of radiation patterns at 2.0 GHz under the odd-mode excitation are presented in Fig. 9 and 10. Good radiation patterns with low cross-polar levels in both *E*- and *H*-planes are observed.

3. CONCLUSIONS

Both theoretical and experimental results of a broadband integrated antenna for LINC/CALLIUM systems are presented. The integrated antenna can also serve as a power combiner, ensuring maximum power efficiency. The measured results demonstrate that it achieves a bandwidth (S_{11}<-10 dB) of 15.5 % and 8 % under the odd-mode and the even-mode excitation, respectively. Besides the removal of the power-combiner losses, the integrated-antenna LINC also has a compacter size compared to the conventional LINC.

REFERENCES

[1] D.C. Cox, Linear amplification with nonlinear components, IEEE Trans. Commun., 1974, 22, pp. 1942-1945

[2] B. Stengel and W. R. Eisentadt, LINC power amplifier combiner method efficiency optimisation, IEEE Trans. Veh. Technol., 2000, 49, pp. 229-234

[3] W.R. Deal, V. Radisic, Y. Qian and T. Itoh, Integrated-antenna push-pull power amplifiers, IEEE Trans. MTT, Vol. MTT-47, 1999, pp. 1418-1425

[4] S.C. Gao, P. Gardner and S.T. Chiw, Integrated antenna for LINC systems, Microwave Opt. Technol. Lett., 33 (2), 2002, pp. 93-95

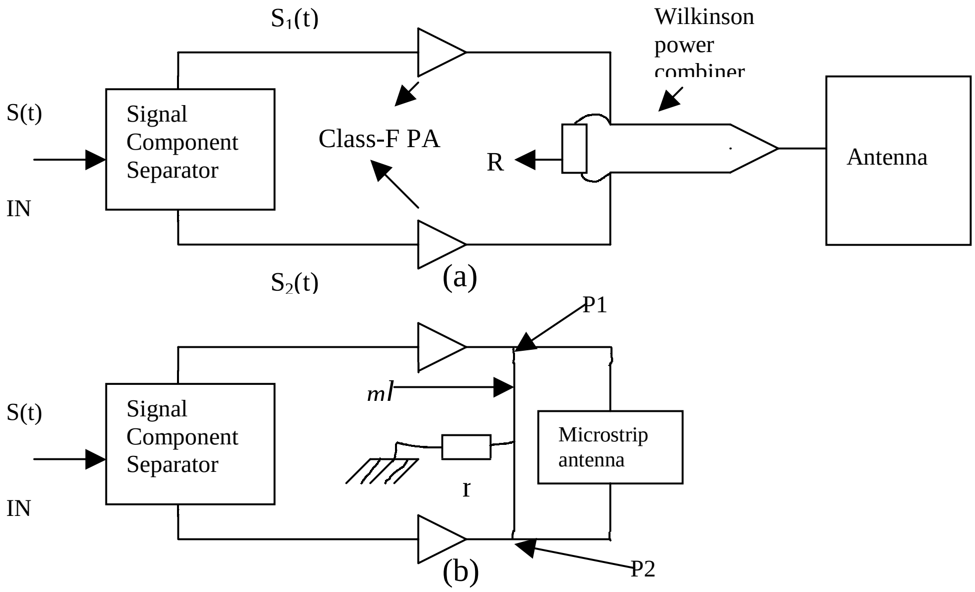


Figure 1. (a) Conventional LINC with power combiner; (b) Proposed integrated-antenna LINC

Fig. 2 Side view of the multi-layered antenna

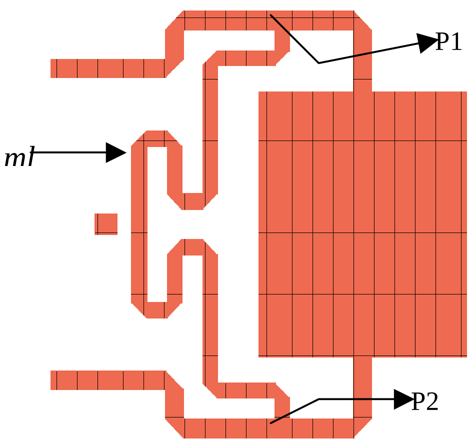


Fig.3 Mask of the lower patch part

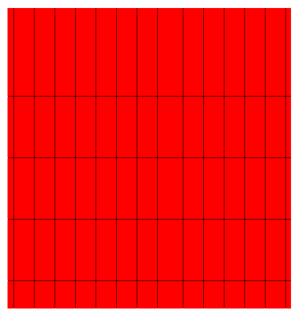
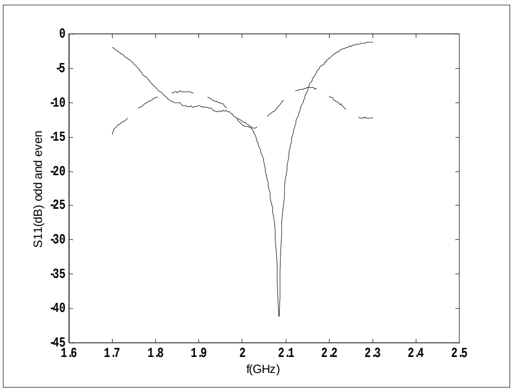


Fig.4 Mask of the upper patch



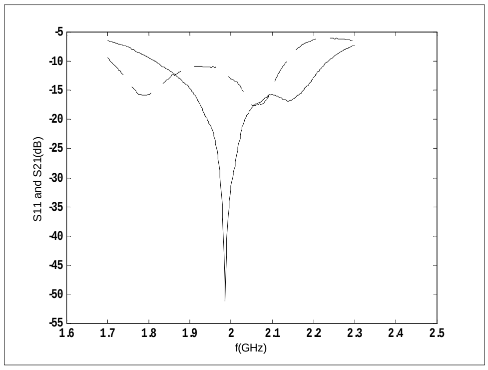
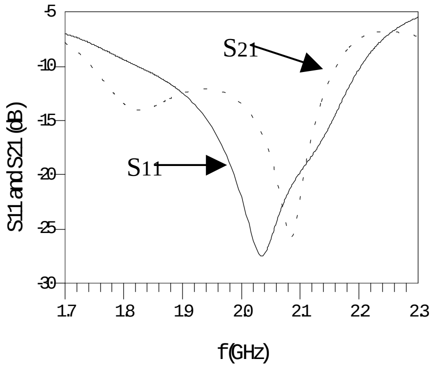


Fig. 5 Measured S_{11} and S_{21}

Solid: S_{11}; Dashed: S_{21}

Fig. 6 Measured return loss of integrated antenna

Solid: odd mode; dashed: even mode



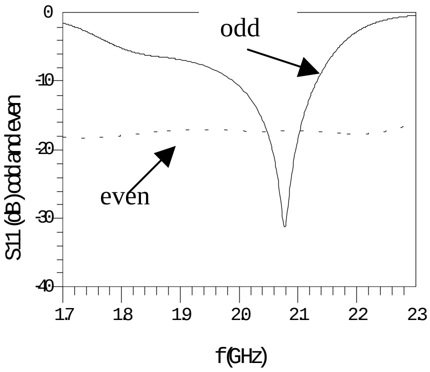
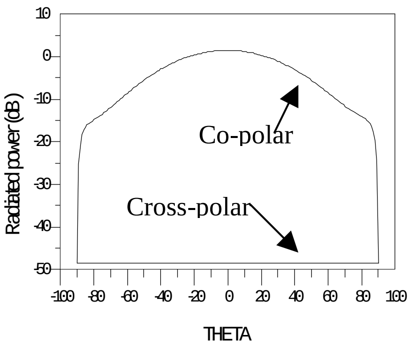


Fig. 7 Simulated S_{11} and S_{21}

Fig.8 Simulated return loss results



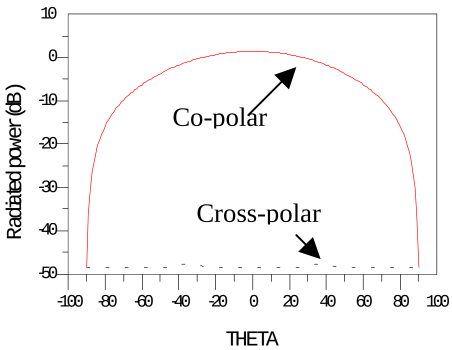


Fig. 9 Simulated E-plane pattern

Fig. 10 Simulated H-plane pattern