# A PRACTICAL DISTRIBUTED FET MIXER FOR MMIC APPLICATIONS

I. D. Robertson and A. H. Aghvami

Department of Electronic and Electrical Engineering
King's College, University of London

## ABSTRACT

A novel distributed FET mixer configuration suitable for MMIC realisation has been demonstrated in hybrid form. The mixer has achieved 3dB conversion gain over 2 to 12GHz and the single-sideband noise figure is 11dB. There is still considerable scope for improving the results of this prototype, using either MMIC or hybrid techniques.

## INTRODUCTION

A need has developed for wideband microwave mixers that can be realised in MMIC form to give reproducible performance, compactness and low cost. However, traditional wideband diode mixers use non-planar techniques which are unsuitable for MMIC applications. This has created considerable interest in the distributed FET mixer. The principle of the wideband distributed FET mixer was first demonstrated using an external passive coupler to give isolation between the LO and RF signals (1). More recent work has involved using the inherent isolation in a dual-gate FET to overcome the need for the external coupler (2). This is a very attractive technique for MMICs but the noise figures achieved have been disappointing.

In this paper the design and performance of a new distributed mixer configuration is described. The technique used here is to employ an active distributed signal combiner at the input of a single-gate FET mixer.

## CIRCUIT DESIGN

The mixer consists of an active RF/LO combiner followed by a single-gate FET distributed mixer. The active combiner consists of two distributed amplifiers sharing a common drain-line (3). In this configuration the RF and LO current generators pass independent currents into the drain-line, and in small-signal conditions the signals add by superposition. The LO drive needed for the mixer has been found to be well below the saturation level of the combiner. Signal isolation is achieved as long as the gate-drain capacitance of the FETs is low. The combiner/mixer circuit is shown in figure 1.

The hybrid prototype used NEC710 chips; a three-section combiner (i.e. 6 FETs) was used with a two-section mixer. To ease the fabrication difficulties, the combiner and mixer were in separate 1x1inch test jigs and bias tees were used along with SMA 50Ω gate/drain line terminations. This results in significant losses and ripple. but this was of no concern for this demonstrator circuit. Figure 2 shows the prototype combiner.

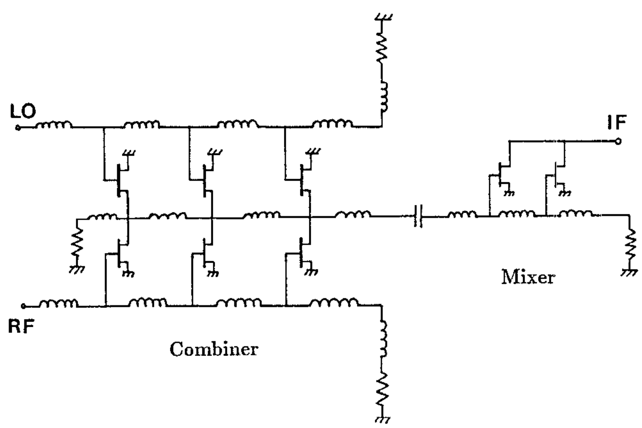



**Figure 1. Complete mixer circuit**

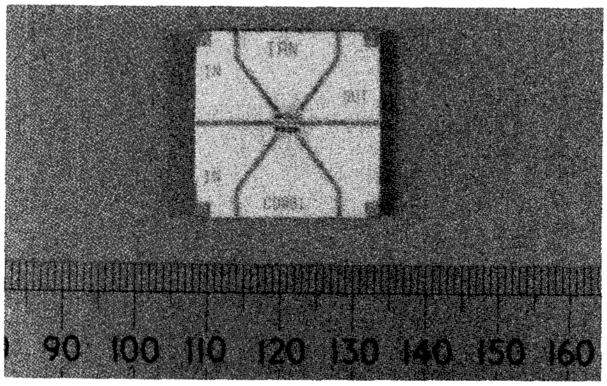



Figure 2. Prototype combiner realisation

## MEASURED PERFORMANCE

The measured conversion gain and noise figure are shown in figure 3, for an IF of 500MHz and an LO power of 6dBm into the combiner. The gain is 3dB±1dB over 2 to 12GHz. The noise figure has been corrected for single-sideband operation. The conversion gain was virtually constant for IFs between 100MHz and 1GHz. The measured LO to RF port isolation is shown in figure 4. The isolation is better than 20dB using single gate FETs. Using a cascode or dual-gate FET in the combiner is predicted to give over 30dB of LO/RF isolation without balancing techniques, but this solution is only practical in an MMIC design.

The measured third-order two-tone intermodulation products output intercept point is +10dBm, and the conversion gain 1dB-compression point occurs at -4dBm IF output. These levels are comparable to conventional double-balanced diode mixers using the same LO power.

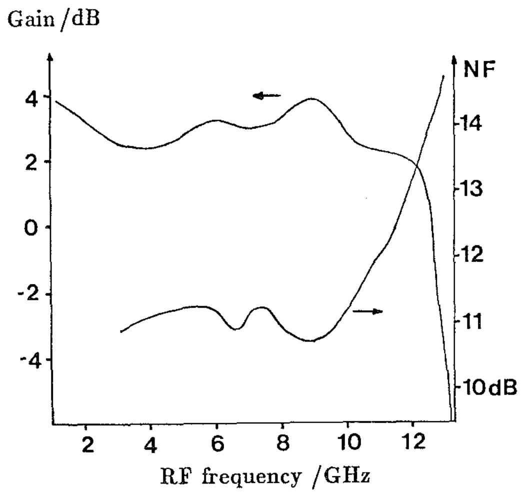
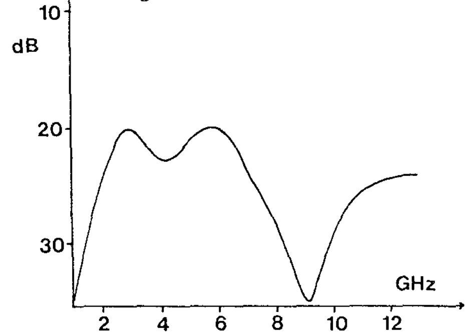



Figure 3. Measured conversion gain and noise figure

Figure 4. Measured LO to RF isolation




## DISCUSSION

This prototype's performance is very good but there is still considerable scope for improvement: The measured gain of the combiner is lower than predicted, because of excessive source and gate lead inductance. A 3dB improvement in combiner gain should be possible; this would result in 6dB conversion gain for a 3dBm LO signal, and a reduced noise figure of around 9.5dB. A major advantage of this active combiner approach is that the combiner gain lowers the overall noise figure. For an MMIC design there is an additional advantage in that single-gate FET large-signal models are more accurate than dual-gate FET ones at present. Also the output impedance at the IF frequency is reasonably low, and easier to match.

## CONCLUSIONS

A technique for realising wideband MMIC mixers has been demonstrated in hybrid form. The hybrid prototype has achieved 3dB±1dB conversion gain over 2 to 12GHz for an LO power of 6dBm. The measured single-sideband noise figure is 11dB over most of the band. The performance of this prototype could easily be improved upon by a well-designed MMIC or MIC version.

## REFERENCES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