RF Power Amplifiers and Combline Filters for Wireless Base-Stations

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***Abstract* -** An LDMOS amplifier using digital pre-distortion and combline bandpass filters for RF multichannel wireless base-stations are presented. Bandpass filters require elements that behave as series or parallel resonant circuits. In this paper, we discuss a variety of couplings between combline resonators in bandpass filter applications. Coupling coefficient used in filter realizations has been precisely calculated. Filter responses are presented by simulation, experiment and calculation. They were in very good agreement.

Key-words:- Bandpass combline filters, power amplifiers, linearization

1. Introduction

The success of cellular wireless networks has resulted in the users of these networks requiring higher data rates for data intensive application such as accessing the internet, or applications on remote servers. However this requirement comes at a cost, both financially and in terms of technology development. Designers of mobile equipment are continuously faced with the challenge of implementing efficient modulation schemes in order to ensure that the available allocated communications channels, which are becoming increasingly crowded, are effectively utilised. In UMTS, the efficient utilisation of the communications channel has been achieved through the selection of QPSK as the modulation scheme. This modulation scheme is to be implemented as part of the Wideband Code Division Multiple Access technology. Most mobile devices depend on battery power sources and therefore if a RF amplifier is not efficient, the battery usage time of the device is severely impacted. Although this might not be the case for wireless network basestations, the implementation of highly linear amplifiers results in greater technology expense to achieve the required high power. Bandpass and stoppass filters require elements that behave as series or parallel resonant circuits, such as, the coupled transmission line bandpass filters, direct-coupled waveguide cavity filters in microwave frequencies. In this paper, not only is the development of a 3G amplifier from theory to practical implementation studied, but also the implementation of the digital predistortion technique to reduce intermodulation distortion and we discuss coupling coefficient of combline resonators for filter applications.

In the design procedures for the microwave filters, the lumped element prototype filter is used to achieve bandpass filter designs having approximately the same Tchebyscheff or maximally flat response. The multiple resonances inherent in transmission line or cavity resonators generally give bandpass microwave filters additional pass band at higher frequencies, which is far away from the dominant passband of the filter. Therefore, low frequency circuit theory is useful in microwave analysis.

2. Technique implementation and resonator configuration

The first results of digital predistortion in ads show that digital predistorion can be used with the LDMOS to improve IMD products. An example of ADS was used, which bypasses the problem of digital simulation by using iterative methods to extrapolate the nessecary variables to inject by feedback at the amplifier input.

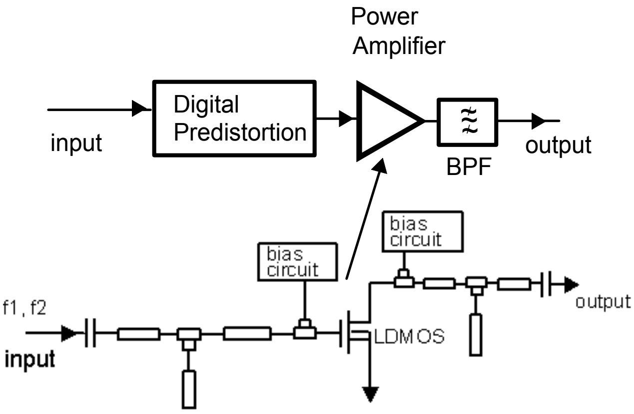


Fig. 2. Single-ended power amplifier with digital predistortion

A symmetric schematic of a second order filter under consideration is shown in Figure 2. It consists of coupled combline resonators. Each of the resonators is a 6 disks periodically loaded combline resonator [7]. Two resonators connect by a coupling slot. Due to there be strong electric field exiting in the top part of the combline resonators, the coupling is called electric coupling. The coupling coefficient could be tuned by the length of L.

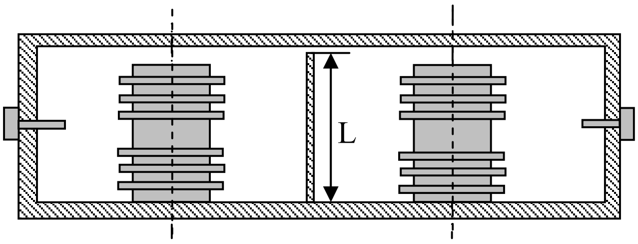
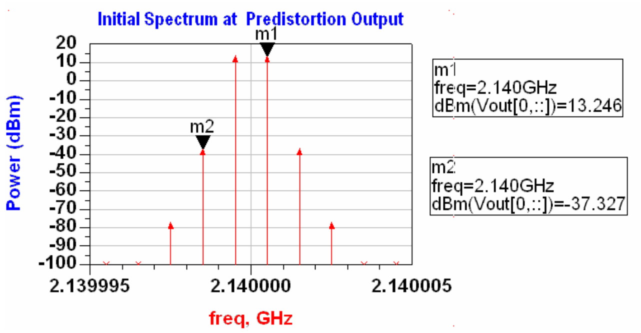


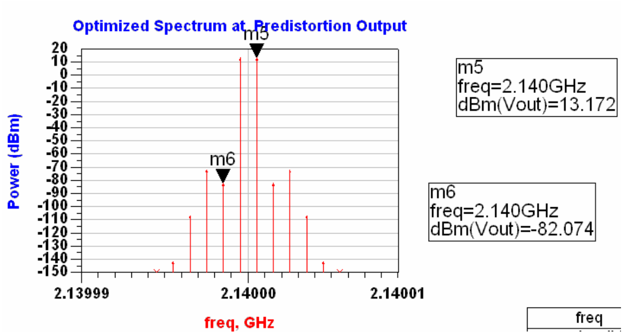
Fig. 2. Schematic diagram of a second order combline filter

3. Simulation Results

The initial stage of the test was to test performance of the amplifier using the two tone approach [1]. The initial settings for this test were as before, 0 dBm input power, 1 KHz frequency separation with the two frequencies located at 2.14 GHz and 2.1401 GHz respectively. The unlinearised response together with the linearised response is plotted in Figures 3a and 3b respectively.



a)



(b)

Fig. 3. (a) unlinearised output, and (b) linearised output.

When we remove the plate between the coupled resonators in Figure 2, the coupling between resonators becomes space coupling. Space coupling is a mixed coupling, which exists electric coupling and magnetic coupling. It realizes a very low *Q* and wide bandwidth filter application. For the space coupling, the two poles combline cavity filter responses is shown in Figure 4, there is a good agreement between measured responses, simulated responses and calculated responses when choosing Q_1=35, Q_2=28, k_c=0.032, k=0.048 and f_0=2.165 GHz. The comparison illustrates that *Q* factor of the resonators used in filter application is lower. This is because the optimum resonator structures no longer exist when existing coupling structures in the filter applications, especially, using space coupling. Strong feeding and loading are also one of main factors to lower the *Q* factor of resonators in the filter application.

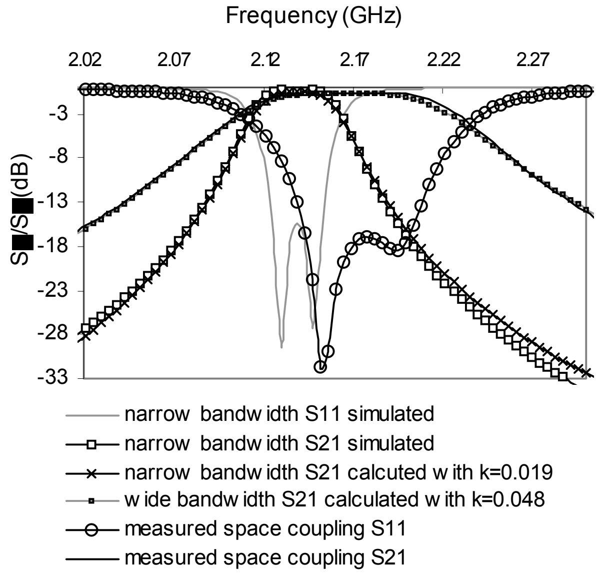


Fig. 4 Comparison of measured filter responses with calculated and simulated responses using slot coupling or space coupling between coupled resonators

4. Conclusions

The above results have demonstrated the objective of third order intermodulation distortion reduction. Using equivalent circuit, we obtain an expression for second order filter response. Therefore, we can precisely calculate the coupling coefficient *k* between the resonators used in filter applications. It is realized that the filters using high *Q* factor resonators with very small coupling coefficient *k* are essential to design narrow-band filters in the application for more and more crowded radio spectrum. A set of second order filter responses are presented by simulation, experiment and calculation. They were in very good agreement.

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