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Rejection of Harmonics in LNA for Broadband Application

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Abstract - The desired signal from broadband RF receivers are corrupted by local oscillator harmonics due to the down converting interferers. This paper proposes the front end low noise amplifier with the harmonic rejection so that it will relax the strict matching required of harmonic-reject mixers. Here discussed the feed forward & unilateral Miller capacitance for frequency response shaping techniques for a signal bandwidth of 0.1GHz to 10GHz. For the tuning of frequency response a calibration algorithm is proposed. An experimental prototype fabricated on 180-nm digital CMOS technology provides at least 18 dB of rejection while consuming 9 mW power with 1.2 V supply.

***Keywords* - Low Noise Amplifier, Harmonic Rejection.**

1. Introduction

The main advantage of broadband RF transceivers is to use them in multi-standard & multi-band application. All the issues encountered in broadband receiver design, the main problem of harmonics in Local Oscillator has received considerable attention [1] as it leads to signal corruption in the presence of large blockers. This paper introducing a low noise amplifier relaxing the design of broadband receivers. The LNA low-pass filtering techniques with the notch so as to reject harmonics by at least 18 dB input blockers at the third and higher harmonics of the LO. A calibration algorithm is also proposed that adjusts the frequency response so as to maximize the rejection. Realized in 180-nm digital CMOS technology, an experimental prototype provides tunable rejection from 300 MHz to 10 GHz while consuming 9 mW with a 1.2-V supply.

2. LNA Architecture

The broadband design of harmonic rejecting LNA faces a number of challenges: (1) The circuit must incorporate a programmable notch in its frequency response that can be varied by more than one decade without degrading the other LNA parameters, such as the noise figure and the input return loss; (2) the notch frequencies must be calibrated so that, upon receiving a desired channel, the notch can be accurately positioned atop the targeted LO harmonic.

If optimized for noise and gain, mixers typically perform abrupt switching, thus multiplying the RF input by a square wave LO. As a result, input blockers coinciding with the LO harmonics are also down converted to the baseband. With differential implementations, the odd harmonics are much more pronounced but the even harmonics may warrant attention.

3. Harmonic Rejection in LNA

LO harmonics blockers can attenuate by means of filtering. The filter must be tunable in small steps for the broadband operation, for rejecting the blockers according to the selected LO frequency. The parasitic of broadband must not counter effect on the LNA noise figure (NF) & Gain when the LNA must amplify high frequencies. Only these two principles observe the evolution of the LNA reported here.

Band-pass filtering techniques based on N-path mixing do not yield significant attenuation at the LO harmonics. Also, the feed forward interference cancellation techniques proposed in [2] do not provide harmonic rejection as they also use frequency mixing in feed forward paths of LNA.

Let us contemplate an RC filter with programmable capacitors interposed between the LNA and the down conversion mixers. In order to tune the rejection from 3f1= 300MHz to 10 GHz, the capacitor value must vary by about a factor of 30, e.g., from $30C_u$ to C_u. If the unit capacitor i,e, switch introduces a parasitic of about $0.6C_u$, say, in the when all of the units are switched out and the input frequency is near 10 GHz. If designed to attenuate 3f1= 10GHz by tens of decibels when one C_u is switched in, the filter unfortunately also exhibits a similar attenuation for f1= 10GHz and a parasitic loading of $0.6C_u$. In other words, such a tunable filter inevitably produces considerable pass-band loss when programmed for high input frequencies.

3.1 LNA Feed Forward with Embedded Filtering

The above scheme mainly describes about four issues:

(1) The HPF input impedance severely degrade the input matching; (2) The parasitic introduced by the filter devices in the feed forward path alter its phase and gain, which could result into complete cancellation of the blockers on the subtractor output; (3) The HPF must have a very high order to reject the desired signal with a large factor, e.g., 10, while negligibly affecting the blocker(s); and the last one is (4) The feed forward path's noise at f1 gets added to the LNA output and must be minimized.

To address the first three issues, one can realize the HPF as a cascade of capacitive -degenerated common-source stages, as conceptually illustrated. As explained earlier, the source capacitors can be programmed across a wide range and their parasitic do not attenuate the high-frequency components traveling through the feed forward path & implementation of attenuation factor.

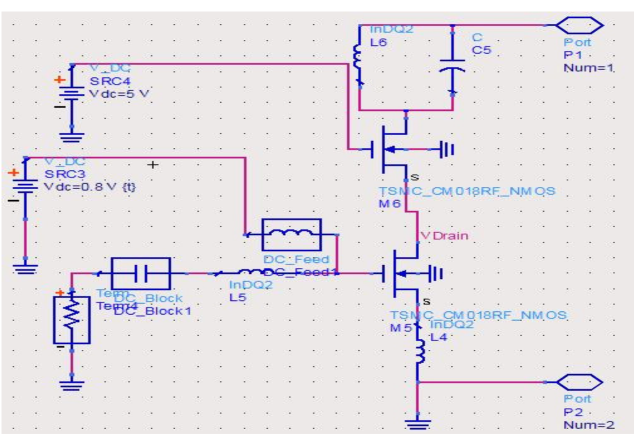

Fig. 1 Feed Forward Arrangement for LNA

4. NF Behaviour & Calibration

The frequency response shaping techniques described above can potentially degrade the noise figure (and input matching) of the LNA. Indeed, many other filtering methods were tried with various LNA topologies and discarded for this reason. The NF penalty arises primarily from the noise contributed by the feed forward paths,$H_1(s)$ & $H_2(s)$.The unilateral Miller path only manifests itself at high harmonics, thus negligibly raising the NF in the channel of interest.

In order to quantify the NF penalty due to $H_1(s)$, we return to the implementation in Fig. 1(b) and seek the transfer functions for M_5–M_8, R_5 –R_7 and I_6– I_8 to I_{out} . The sum of these contributions is then multiplied by R_1 in Fig. 1(a) and referred to the LNA input. Upon traveling through the high-pass filter, the noise of M_5 and R_5 is suppressed along with the desired signal. The noise of the subsequent stages is attenuated less and merits investigation.Table 1: Margin specifications

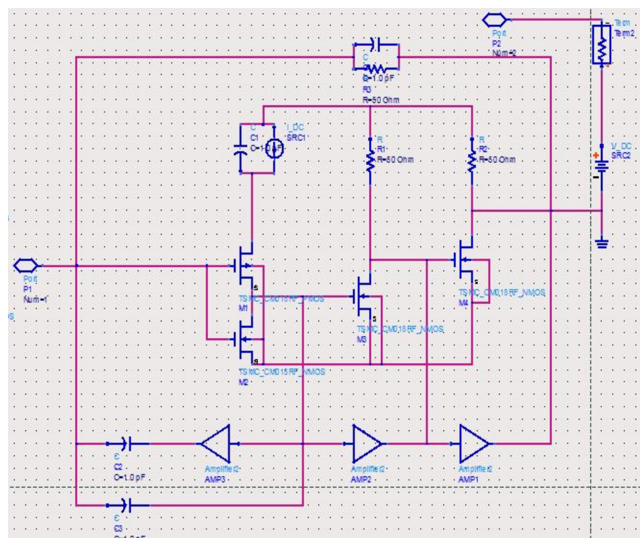

Fig. 2 LNA with High Pass Filter

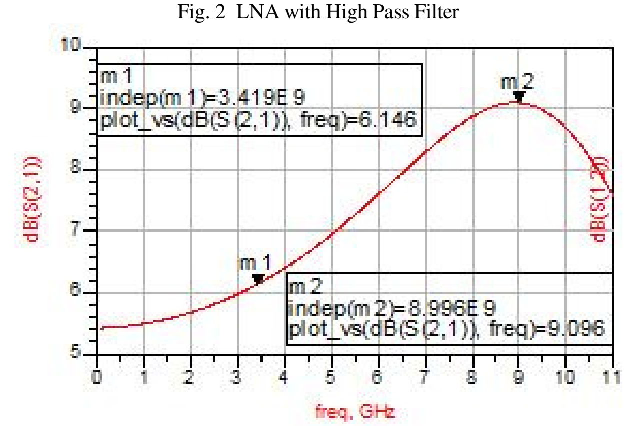

Fig. 3 Performance of LNA against S(2,1)

Fig. 2 Shows the LNA architecture for the harmonic rejection in which there are three feed forward stages are there to provide stage by stage removal of the harmonics present in the stream.

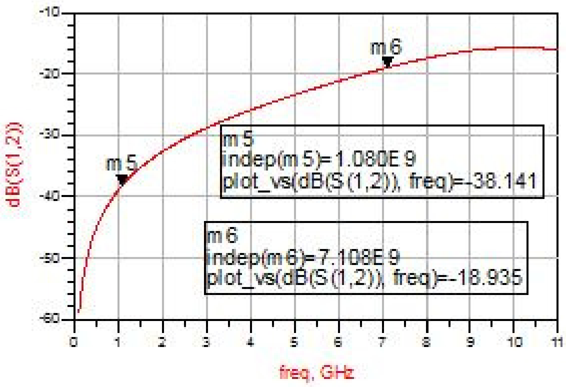

Fig.

Fig 4 Performance of LNA against S(1,2)

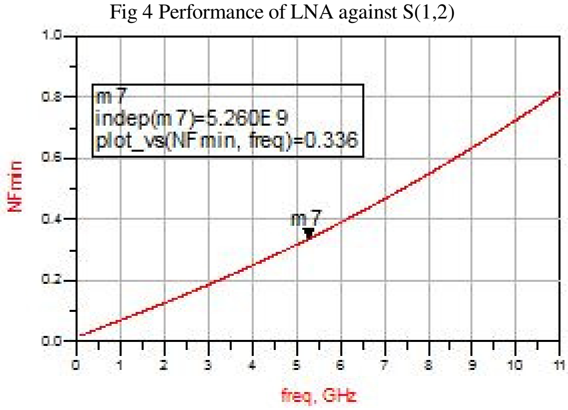

Fig. 5 Performance of LNA against S(1,2)

4. Conclusions

The problem discussed of harmonic rejection in broadband RF receivers can be greatly relaxed if the LNA attenuates blockers at the LO harmonics. The paper presents a number of frequency response shaping techniques with a calibration algorithm that allow tuning the rejection frequency from 0.3 GHz to 10 GHz. A feedback LNA also incorporates feed forward and unilateral Miller capacitor which perform multiplication with sufficient resolution so as to attenuate blockers with channel bandwidths as much as 20MHz. The given calibration algorithm utilizes a direct-conversion receiver environment to derive a dc error and also forces it toward zero.

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