Design Considerations for a Low Power Variable Gain Amplifier for Ultrasounds

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Summary: This paper presents the simulation results and conclusions used to design a variable gain amplifier (VGA) for ultrasounds. It is defined the architecture and implementation of a VGA for a portable system with low power consumption and low noise for a frequency domain of 100 kHz to 4 MHz and a gain variation of 72 dB. The proposed circuit consists on a preamplifier, a switchable active filter and tree stages realized with current feedback amplifiers with variable gain. The circuit was analyzed by simulation to validate its parameters.

Keywords: Variable Gain Amplifier, Low Power, Ultrasound.

Motivation

A Variable Gain Amplifier (VGA) is a critical component of the Front End for Ultrasonic Signal Receivers; its power consumption is significant for portable applications. In this paper is defined an architecture and implementation for a VGA with low power consumption and low noise for:

- a frequency domain of 100 kHz to 4 MHz,
- with a gain variation of 72 dB for an output peak voltage of 1 V, the peak voltage at the VGA input is from 0.25 mV to 1 V;
- the attenuation at 24 MHz (the alias frequency) should be greater than 60 dB, for a 10 bit analog to digital converter with a sampling frequency of 48 MHz.

Some of the integrated circuits that fulfill the previous requirements, with typical power consumption greater than 46 mW are: AD600, AD8330, AD8331 from Analog Devices [1] and LMH6502, THS7001 from Texas Instruments [2]. Lower power consumption can be realized with operational amplifiers or with current feedback amplifiers (CFA).

The proposed configuration is presented in figure 1; it consists on a preamplifier, a band-pass filter and three VGA stages realized with current feedback amplifiers (CFA). All these circuits are digitally controlled through analog switches.

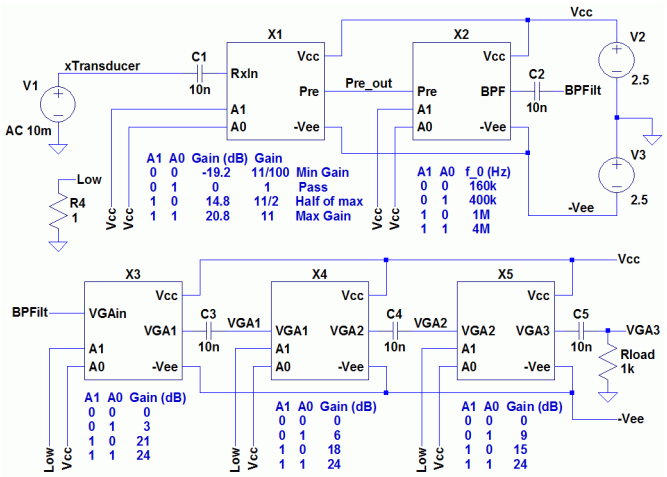

Fig. 1: Block diagram of the circuit

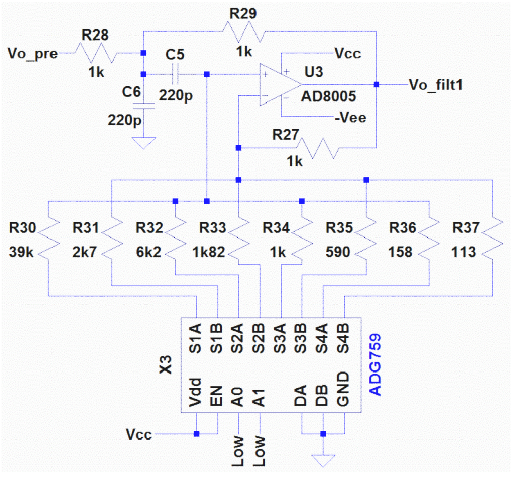

Fig. 2: Simulation circuit for the active filter

Filters are used to reduce the bandwidth to reduce the input noise and increase the signal-to-noise ratio. Fixed frequency filters have been studied first (for 1 MHz transducer) and then tunable / switchable filters are proposed.

4:1 MUXes were used to select the gain in the VGA stages and the frequency of the switchable filters; the ADG759 circuit is selected, based on its low on resistance, and its low power consumption [3]. The model of ADG759 is not available from the producer; it was developed a model for ADG759 that contains the relevant elements for the VGA amplifier.

The solution proposed for one VGA stage was to use a voltage divider connected to a fixed gain amplifier through an analog MUX. The schematic for the a VGA stage is presented in the figure 3 and the simulation results were presented in figure 4

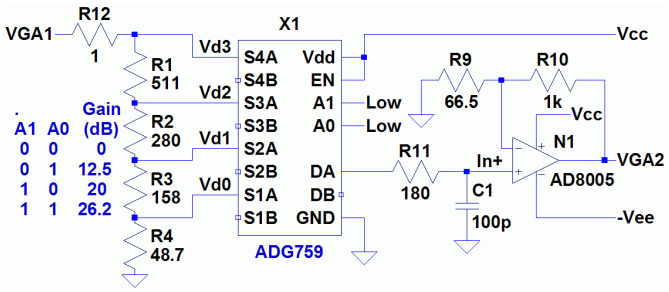

Fig. 3: Circuit for the 2nd non-inverting VGA stage with voltage divider.

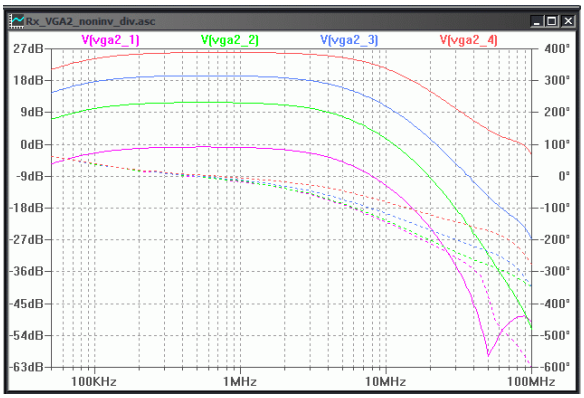

Fig. 4: Simulation results for the 2nd non-inverting VGA stage with voltage divider.

Results

This paper present the architecture and implementation details for an ultrasound variable gain amplifier with low power consumption and low noise for: a frequency domain of 100 kHz to 4 MHz and a gain variation of 72 dB. The proposed circuit is realized with low power current feedback amplifiers and consists on:

- a preamplifier with AD8014,
- a switchable band-pass filter with AD8005,
- 3 VGA stages with AD8005.

The circuit was designed starting from theoretical analysis and was verified by simulation. It was analyzed the stability, it was developed a static model for the switch (MUX 4:1) and the noise was reduced by reducing the bandwidth with a dedicated switchable filter. The simulation results validate the proposed circuit. Next step is to validate the physical implementation of the circuit.

The typical power consumption of the proposed circuit is of about 12 mW; more than 3 times lower than the dedicated VGA integrated circuits with low power.

References

[1] http://www.analog.com/static/imported-files/data_sheets/AD8331_8332_8334.pdf , Ultralow Noise VGA with Preamplifier and Programmable R_{IN}, Analog Devices, Inc., 2010;

[2] http://www.ti.com./lit/ds/symlink/ths7001.pdf – THS7001, 70-MHz Programmable-Gain Amplifiers, SLOS214C, Texas Instruments Inc., October 1998 − Revised March 2007;

[3] http://www.analog.com/static/imported-files/data_sheets/ADG758_759 .pdf – CMOS, 3 ohm Low Voltage Single/Differential 4-/8-Channel Multiplexers, Analog Devices, Inc., 2002;