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A CMOS Low Power Digital Variable Gain Amplifier Design

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Abstract

This paper is about CMOS implementations of variable gain amplifiers and programmable gain amplifiers. Generally they are of two types: Radio Frequency VGA/PGA and intermediate frequency. The aim of this paper is to study valuable and important work from previous design for low power variable gain amplifier. In this paper various techniques to design CMOS based Low Power Variable Gain has been studied. The circuit based on transconductance, gm, amplifier and a transconductance amplifier is analysed and designed for a cognitive radio receiver.

Keywords: CMOS (Complementary metal Oxide semiconductor), Amplifier, AGC (Automatic Gain Control), Low Power, VGA (Variable Gain Amplifier).

Introduction

A variable gain amplifier or voltage controlled amplifier is an electronic amplifier or circuit that varies its gain depending on a control voltage.

The VGA (variable gain amplifier) is one of the critical components in the modern wireless system or modern wireless transceiver designs which are widely used to improve the transceiver's dynamic range by providing a fixed output power for different input signals. Based on the targeted frequency, variable gain amplifier (VGA) is categorized as high frequency variable gain amplifier for applications with stringent bandwidth requirement and general purpose variable gain amplifier for narrow bandwidth applications. The challenges in variable gain amplifier (VGA) design is mainly the realization of accurate dB-linear characteristic with minimum power consumption and die area, as well as achieving the required bandwidth for the targeted application.

In fashionable wireless communication systems, to extend the dynamic vary, the variable gain electronic equipment (VGA) is crucial.

It is additionally wide employed in disc players, hearing aids, medical instrumentation, etc. VGA is typically employed in the feedback circuit to attain automatic gain management (AGC). The variable gain electronic equipment of the automated gain negative feedback circuit is employed to manage the strength of the transmission signal or to regulate the received signal amplitude. There are 2 or two doable ways that to manage variable gain electronic equipment gain. One could be a VGA style management led by associate degree analogy gain control signal and therefore the alternative is a separate VGA gain step with digital control signal. [10].

Different Techniques To Realized Low Power Variable Gain Amplifier

A. Variable Gain Amplifier Design Using The g_m/I_D Design Method

The design technique supported the gramme / ID feature permits all operational areas of the MOS electronic transistor, and may be a standardized artificial methodology. During this technique or technique, the link between the magnitude relation of gramme (conductivity) to symbol (DC current) and identifier / (W / L) (natural discharge current) is an

important feature of the device style to be analyzed or explored within the design area. the link between them represents a novel property of all transistors of an equivalent sort (PMOS and NMOS) in an exceedingly specific methodology or technology. The electronic transistor W / L will be laid out in the curve if a g / id magnitude relation worth is chosen to adapt to the device's operational space [1].

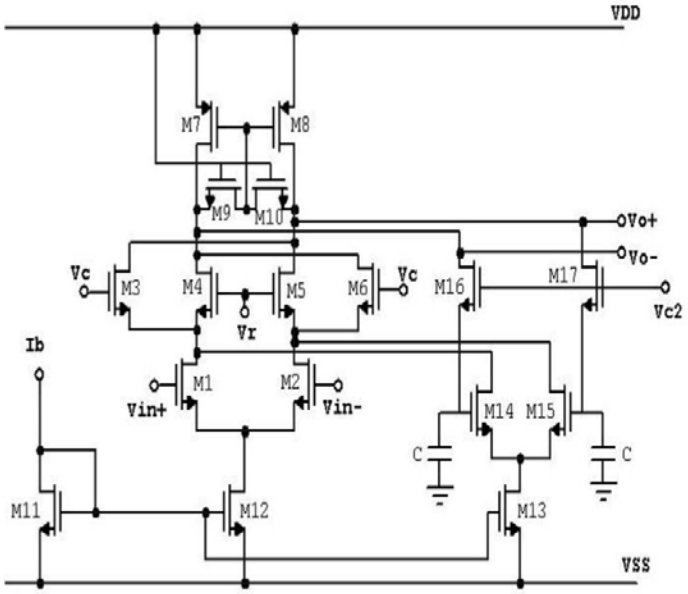

Figure 1: Variable Gain Amplifier Design Using The gm/ID Design Method [1]

B. The CMOS VGA architecture based on a Differential Pair Stage With Voltage to Current (V-I) Converter

Figure 2 shows the architecture of the Variable gain amplifier (VGA) which is composed of an Operational amplifier (op-amp) and a voltage to current (V-I) converter.

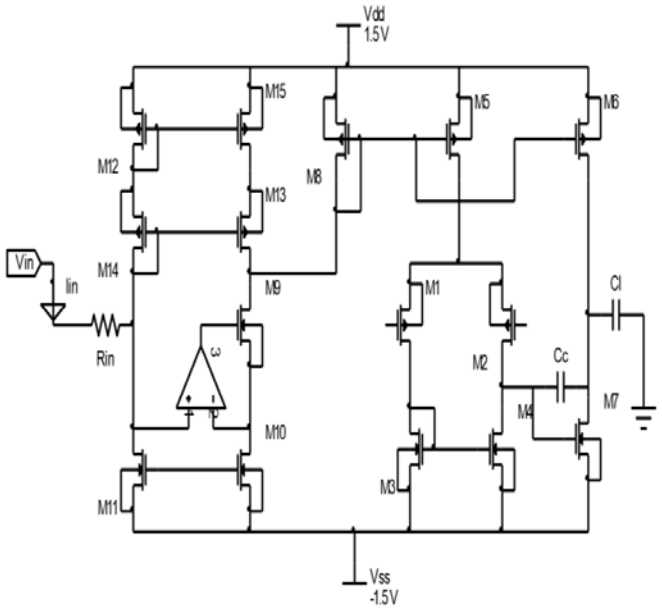

Figure 2: Architecture of the CMOS VGA using a Differential Pair Stage With Voltage to Current (V-I) Converter [3]

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Firstly, op-amp (operational amplifiers) have sufficiently high voltage gain in order that once the feedback is applied in it the closed-loop transfer perform may be created much freelance of the gain of the operational amplifiers (op-amp). This principle utilized} or employed in several helpful CMOS or analog circuits and systems like many applications. the first demand of associate operational electronic equipment is to own an open amplification that is sufficiently massive to implement the feedback conception is employed. The OTA is formed of 3 stages despite the fact that it's typically brought up as a 2 stage op-amp, ignoring the buffer stage. The latter introduces a crucial conception of compensation. the first goal of compensation is to take care of stability once feedback is applied round the operational electronic equipment [3].

C. Differential Linear VGA

One stage of the differential linear Variable gain amplifier (VGA) is shown in Figure 3. Transistors M3 and M4 form the linear transconductance pair and transistors M5 and M6 are act as the active load to provide high gain and are used to improve the linearity of the circuit [4]. The common mode feedback circuit consists of the register R1, R2, and transistor M10 to M13. The gain of the Variable gain amplifier can be adjusted continuously over a large range through the transistor M14 source degeneration. The gain of the VGA can be expressed as

$$A_V = -G_S R_d \frac{g_m}{g_m + G_S} \quad \text{___ (1)}$$

Where,

g_m is the transconductance of the input transistor M3 and M4.

G_S is the conductance of source degeneration transistor M14.

R_d is the load resistance of M5 and M6.

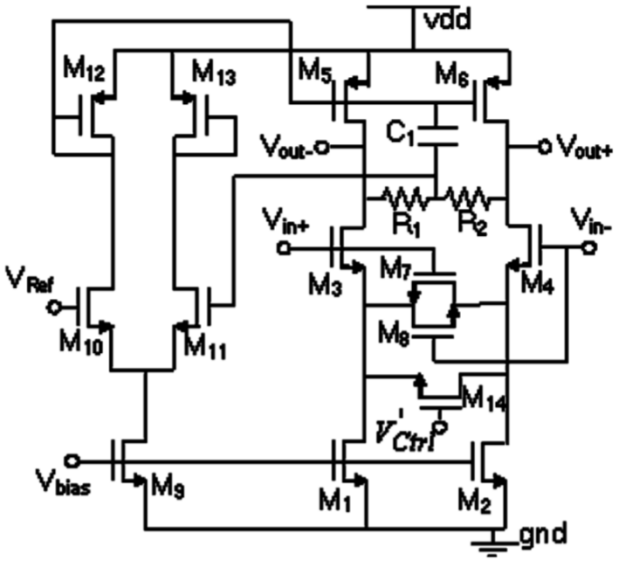

Figure 3: Differential Linear VGA [4]

D. VGA Design Using Folded Cascade Amplifier Topology

Figure four shows the Variable gain electronic equipment (VGA) cell circuit that's style victimization the pleated cascade amplifier topology. Semiconductor M1 through M10 composes the standard pleated cascade electronic equipment topology in CMOS technology. The biasing voltages VBP1, VBP2 and VBN1 are generated by a traditional wide swing

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cascade current supply. MR1 and MR2 are NMOS thermionic valve resistors that verify the gain of the electronic equipment. The 2 MR2 resistors also are implementing the common mode feedback perform. The thermionic valve resistances are management by the gate control voltage VC as shown within the figure. Because the management voltage varies, the gain of the variable Gin variable gain electronic equipment (VGA) additionally changes, that is given by:

$$Gain_{VGA} = \frac{2R_1}{R_2} \quad \text{_____ (2)}$$

Where R1 and R2 are triode resistance of MR1 and MR2 that is mathematically given by:

$$R_1 = [\, K_n \left(\frac{W}{L}\right)_{MR1} (V_{DC} - V_{DC1} - V_{THN} + V_C)]^{-1} \quad \text{_____ (3)}$$

$$R_2 = [\, K_n \left(\frac{W}{L}\right)_{MR2} (V_{DC} - V_{DC2} - V_{THN} + V_C)]^{-1} \quad \text{_____ (4)}$$

Where VDC is the DC level of the gain control voltage, VC is the absolute amplitude of the gain control voltage and VDC1 and VDC2 are the DC biasing point as indicated in Fig. 4.

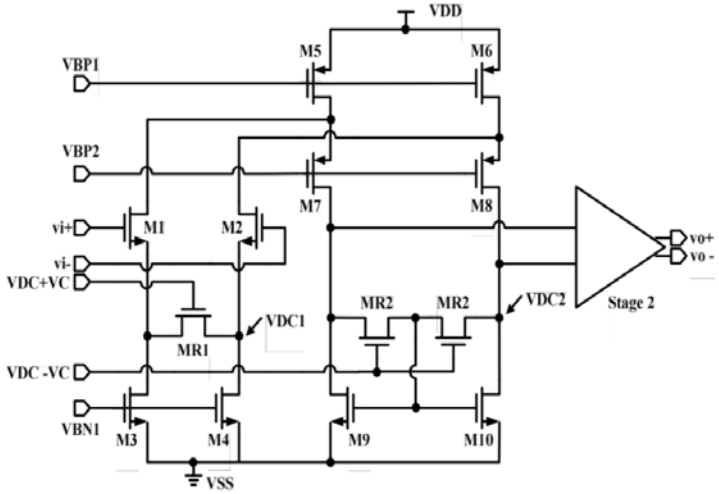

Figure 4 : VGA Design Using Folded Cascade Amplifier Topology [5]

E. Push-pull Variable Gain Amplifier

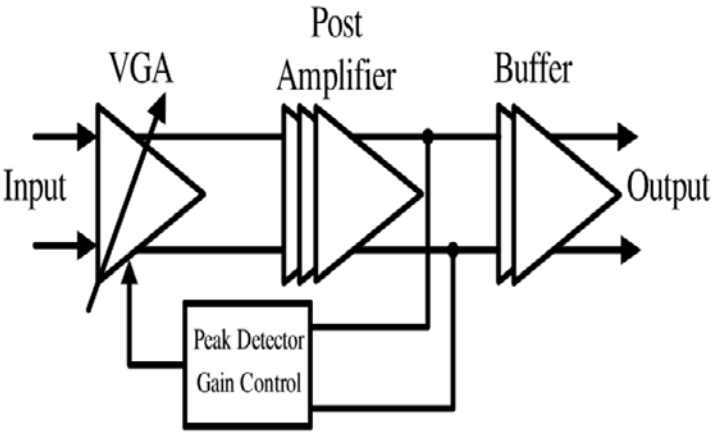

Figure 5 : Architecture of the AGC amplifier [7]

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The design of the automated Gain management (AGC) electronic equipment is shown in Fig. 5. In Automatic Gain management (AGC) electronic equipment style, the Variable Gain management (VGA) plays a awfully necessary role. Most popularly used Variable gain amplifiers (VGAs) for prime speed knowledge transmission developed from the differential try and management their gain through variable the tail current supply. This approach raises some issues, like the slender gain management varies and limitation of dynamic range of whole Automatic Gain management (AGC) circuit. So as to resolve these problems, a brand new management theme variable gain electronic equipment (VGA) is planned during this work and therefore the design of the proposed VGA (variable gain amplifier) is provided in Fig. 6.

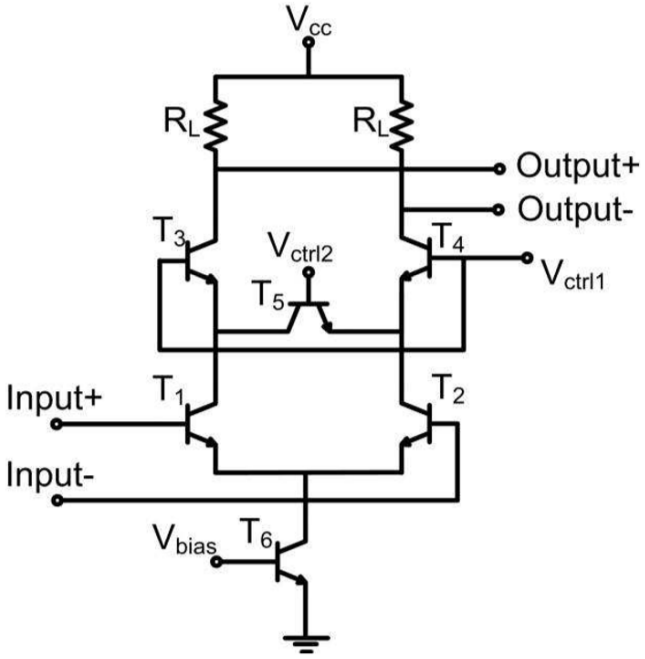

Figure 6: Architecture of push-pull VGA [7]

Conclusion

The Design of low power variable gain electronic equipment victimization CMOS technology, the op-amp or OTA is employed as basic building blocks. For the VGA style, needed CMOS OTA or op-amp circuit with low power and high gain, this can be troublesome to style in CMOS technology. therefore so as to style the low power VGA the literature survey shown the assorted techniques to design it. Among all techniques discuss higher than, ANy of them is mixed with different to extend potency for an correct VGA style.

The different design mentioned within the paper from previous work is wont to optimize the look of low voltage, low power, high gain and dimensionality of the VGA circuit.

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