An Analysis of an Input Impedance of a Regulated Cascode Cross Couple Power Amplifier

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***Abstract*—The input impedance of a regulated cascode cross couple amplifier is derived. The frequency response of the input impedance polynomial form can be plotted with MATLAB. From the polynomial form of the input impedance of the proposed circuit, it can be transformed by substitute complex frequency s with $j\omega$ into the polynomial form equation. After that, this function can be grouped into a symbolic real and a symbolic imaginary form. The next step in derivation is to multiply this function with a complex conjugate function of the symbolic complex form of the input impedance. The last step is to plot a real and an imaginary part as a function of the input frequency so that the power amplifier can be matching with the various matching circuit according to the condition of the maximum power transfer.**

Keywords— a regulated cascode amplifier, input impedance, oscillator, power amplifier, a regulated cascode cross couple amplifier

I. INTRODUCTION

The Regulated Cascode amplifier was proposed by Sackinger since 1990 [1]. This topology of amplifier is famous because it has a higher output impedance compared with cascode amplifier counterpart. Thus, its output voltage is higher than other types of an amplifier such as a common source, a common gate and a cascode amplifier. The concept of the regulated transistor can be replaced by an amplifier block diagram which is used to regulated drain-source voltage drop of the first stage transistor but it used more transistor which was proposed since 1990 [2]. The advantage of this idea is a more voltage gain but the disadvantage is, it has more parasitic capacitances which degrade the bandwidth of the amplifier. The circuit technique called a regulated cascode also have many types of application like a switched current integrator which can be replaced in the signal flow graph of the high order switched current filter which was published since 1993 [3]. It can be used as the core circuit of current mirror. Its advantageous compared to other circuit technique is a fast settling time for a low value of current mirror between 10 microampere to 600 microampere. It is much slower than a simple current mirror if it is designed to operate for 530 microampere to 800 microampere. It is published since 1994 [4]. Other applications of the regulated cascode amplifier can be modified as a transconductance amplifier and transimpedance amplifier which are published during 1997-2015 [5]-[12].The tuning range of the regulated cascode cross couple oscillator can be approximated since 2013 [13]. Recent specifications which are related with a transimpedance amplifier based on RGC circuit diagram and its modification are published in [14]-[16]

In section II, a straightforward definition of input impedance and circuit diagram definition is described. A high frequency equivalent circuit is shown and described in Section III. In section IV, a lucent and rigorous contribution for a detail circuit analysis procedure example of the regulated cascode cross coupled amplifier input impedance polynomial form is proposed for the first time. Without this equation, it is very iterative for impedance matching of the proposed circuit. In section V, the graphs of input impedance as a function of input frequency and current consumption are plotted by programing with level1 transistor model. In section VI, the graphs of real part and imaginary part as a function of an input frequency and current consumption are plotted by programing with level1 transistor model.

II. INPUT IMPEDANCE OF THE REGULATED CASCODE CROSS COUPLED AMPLIFIER DESCRIPTION

The input impedance is a ratio of input voltage and input current. It can be derived by using Kirchhoff's current law and Ohm's law. The Circuit diagram of the regulated cascode cross couple amplifier is drawn in figure1. The high frequency equivalent circuit of MOSFET is used to substitute for circuit analysis purpose. It is shown in figure 2. The regulated cascode amplifier can be described as a cascade of a first stage common-source amplifier which used transistor M_1 and a common gate amplifier. A regulated transistor can be seen as a cascade of a second stage common source amplifier which used transistor M_3 with a first stage common source amplifier. The output of the second stage of a common source amplifier can be cascaded with the cascode transistor M_2.

REFERENCES

[1] E. Sackinger, W. Guggenbuhl, " A High-Swing, High-Impedance MOS Cascode Circuit", IEEE Journal of Solid-State Circuits, Vol.25, No.1, February 1990, pp. 289-298

[2] K. Bult, G. J. G. M. Geelen, " A Fast-settling CMOS Op Amp for SC Circuits with 90-dB DC Gain", IEEE Journal of Solid-State Circuits, Nol.25, No.6, December 1990, pp. 1379-1384

[3] N. C Battersby and C. Toumazou, " A 5th order Bilinear Elliptic Switched-Current Filter", IEEE 1993 CICC, pp. 6.3.1- 6.3.4

[4] T. Serrano, B. Linares-Barranco, " The Active-Input Regulated-Cascode Current Mirror", IEEE Transactinos on Circuits and System I: Fundamental Theory and Applications, Vol.41, No.6, June 1994, pp. 464-467

[5] A. H. Bratt, T. Olbrich and A.P. Dorey, "Class AB regulated cascode current memory cell", Electronics Letters, 27th October 1994, Vol.30, No.22, pp. 1821-1822

[6] M. Goldenberg, R. Croman, T. S. Fiez, "Accurate SI Filters using RGC Integrators", IEEE Journal of Solid-State Circuits, Vol.11, November 1994, pp. 1388-1395

[7] D. Flandre, A. Viviani, J-P Eggermont, B. Gentinne, P. G. A. Jespers, "Improved Synthesis of Gain-Boosted Regulated-Cascode CMOS Stages using Symbolic Analysis and gm/ID Methodology, "IEEE Journal of Solid-State Circuits, Vol.32, No.7, July 1997, pp. 1006-1012

[8] M. Das, "Improved Design Criteria of Gain-Boosted CMOS OTA with High-Speed Optimizations", IEEE Transactinos on Circuits and Sytems II: Analog and Digital Signal Processing, Vol.49, No.3, March 2002, pp. 204-207

[9] S. M. Park, Hoi-Jun Yoo, "1.25 Gb/s Regulated Cascode CMOS Transimpedance Amplifier for Gigabit Ethernet Applications", IEEE Journal of Solid-State Circuits, Vol.39, No.1, January 2004, pp. 112-121

[10] J. Nissinen, J. Kostamovaara, " Fully Differential, Regulated Cascode Amplifier", IEEE MELECON 2006, pp. 51-54

[11] Y. Zheng, C. E. Saavedra, " Feedforward-Regulated Cascode OTA for Gigahertz Applications", IEEE Transactions on Circuits and Systems I: Regular Papers, Vol.55, No.11, December 2008, pp. 3373-3382

[12] C. Li, S. Palermo, "A Low-Power 26 GHz Transformer Based Regulated Cascode SiGe BiCMOS Transimpedance Amplifier", IEEE Journal of Solid-State Circuits, Vol. 48, No.5, May 2013, pp. 1264-1275

[13] K. Tripetch, "Comparative Analysis of Tuning Range of Regulated Cascode Cross Coupled CMOS Oscillator", Proceedings of the World Congress on Engineering 2013, Vol. II, WCE2013, July 3-5 , 2013, London, U. K.

[14] M H. Taghavi, L. Belostotski, James W. Haslett, P. Ahmadi, " 10 Gb/s 0.13 micron CMOS Inductorless Modified-RGC Transimpedance Amplifier", IEEE Transactinos on Circuits and Systems I: Regular Papers, Vol. 62, No.8, August 2015, pp. 1971-1980

[15] Oscal T.C. Chen, C-T Chan, Robin R-B Sheen, " Transimpedance Limit Exploration and Inductor-Less Bandwidth Extension for Designing Wideband Amplifiers", IEEE Transactions on Very Large Integration (VLSI) Systems, Vol.24, No.1, January 2016, pp. 348-352

[16] R. Costanzo, Steven M. Bowers, "A Current Resuse Regulated Cascode CMOS Transimpedance Amplifier with 11 GHz Bandwidth", IEEE Microwave and Wireless Components Letters, Vol. 28, No.9, September 2018, pp. 816-818