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A Study on Feed forward Technique In CMOS OTA Circuits

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ABSTRACT
In this paper, a study in terms of gain, unity gain frequency of operational transconductance amplifiers (OTAs) using feedforward technique with FDCM has been carried out. OTA having feedforward technique with FDCM shows gain of 68 dB at 1nA bias current and 10 KHz - 1GHz unity gain frequency characteristics. The input bias current from 1nA to 1mA has been varied for study. The CMOS OTA has been simulated in 0.5µm technology with 2.5V power supply voltage.

1. INTRODUCTION
In the recent years, with the scaling of modern CMOS technologies and wide use of portable equipments reduction of the supply voltage in integrated circuits has increased rapidly. Research efforts have been made in reducing total power consumption and improving the noise margin of the operational amplifiers. Implementation of very large scale integrated circuits (VLSI) systems with low supply voltages has become a challenging task in the design of modern analog and digital circuits. The realization of high-speed, high gain, large gain-bandwidth product, and low power amplifiers demands efficient circuit design techniques [1]. With reduction in channel length, cut-off frequency of the transistor increases and realization of CMOS wideband amplifiers becomes more feasible [2]. In the design of wideband amplifiers both in bipolar and CMOS technology, a folded cascode configuration has been widely used [3]. The reason is that the output capacitance plays the same role as the compensation capacitance in these configurations [4]. A current mirror has advantage of low-voltage operation for a wide range as compared to a folded cascode configuration [5]. Further folded cascode requires an additional VDSsat for the common gate transistor. For low voltage operations, this VDSsat reduces the output voltage range. A feedforward is a compensation technique in which a buffer is used to break the bidirectional path through the compensation capacitor [6]. The use of a current mirror with feedforward technique produces a lower nondominant pole than a folded cascode amplifier. Feedforward technique with FDCM is generally used to increase the unity gain frequency of the amplifiers. The cascode amplifier high has high output impedance and can accomplish very high voltage gain. It has characteristics to increases the gain without affecting the frequency but has the disadvantages of reducing the output voltage swing.

2. FEEDFORWARD TECHNIQUE

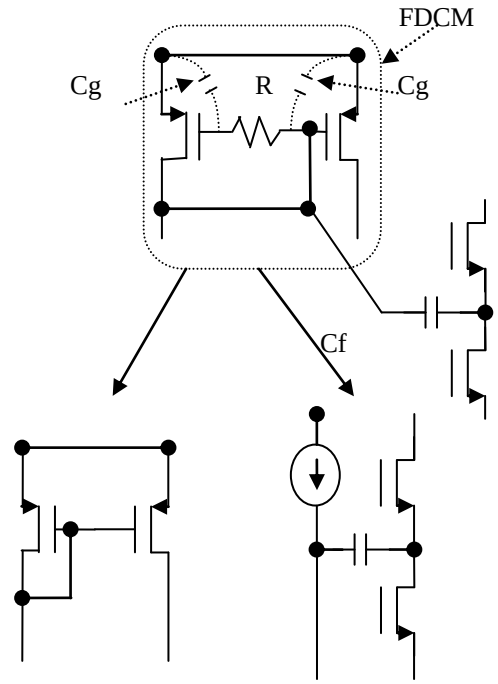

Figure 1: Operation of FDCM with feed forward capacitor

The feedforward technique is not much suitable for the conventional current mirror, because high-frequency (HF) component of an input signal flows through the transistor due to its low-input impedance. The input impedance of the current mirror should be large for high frequency signals while it should be small for low frequencies and DC operation. So a FDCM is required for effective feedforward. A resistor is connected between the drain and the gate of the transistor with gate-source capacitance to make a low pass filter. The operation of the feedforward technique with FDCM is shown in Figure 1. Since the low-frequency signals and DC signals pass through the LPF so the input impedance of the current mirror becomes low. For higher frequencies than the cut-off frequency of the LPF, it becomes higher. The input transistor of the current mirror plays the role of a current

source. So, the high-frequency signals flow through the feedforward capacitor Cf. To compensate for the loss of gate source capacitance Cg, Cf is made approximately 10 times larger than Cg.

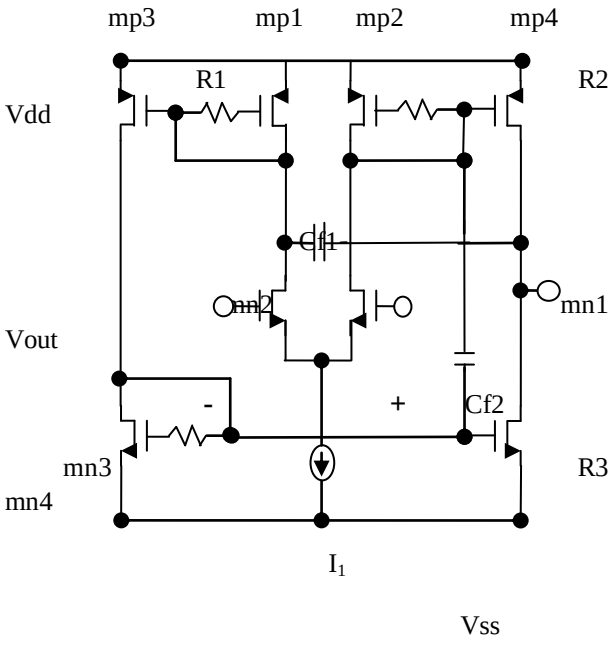

Figure 2: Wideband amplifier with feed forward technique.

For high frequency signals, large transistors are used. Cg is around 0.5 to 2.0 pF depending upon process technology. Using resistors of 100 Ω - 1 kΩ and without generating a noise, the HF signal of 10 KHz - 1 GHz successfully bypasses the FDCM. A wideband amplifier using feedforward technique with the FDCM is shown in Figure 2. The high frequency signals of the output current of mn2 are fed forward to the output node through Cf1. While the signal from mn1 is fed forward to the input of another FDCM through Cf2 and is amplified. In the conventional amplifier, the channel length of the transistors should be short for shifting the poles to higher frequencies by sacrificing the gain. When the channel length is long and the gate-source capacitance is large, the technique with FDCM's is expected to show greater improvement.

The transconductance gm of an OTA is proportional to the load capacitance, CL and gain bandwidth product, GBW. It is given by:

$$gm,I = GBW \cdot 2\pi CL$$

To obtain a large gain bandwidth product (GBW), transistors with large transconductance are required. So, the bias currents should be large for the input transistors. The voltage gain of the amplifier is given by:

$$AV = AV1 \cdot AV2$$

Where AV1 and AV2 are given by:

$$AV1 = gm8 / gm2 = gm7 / gm6$$

$$AV2 = ½ \cdot Z0 (gm1 + gm3)$$

$$Z0 = [rds11 \cdot gm11 \cdot rds1] // [rds12 \cdot gm12 \cdot rds3]$$

3. RESULTS

CMOS OTA using feedforward with FDCM technique is simulated using standard 0.5 µm CMOS technology. The amplifier operate at 2.5 V power supply voltage with a bias current of 1 nA. All p-channel transistor's body terminals are connected to VDD and of n-channel transistors to VSS. The unity gain frequency of CMOS OTA using feedforward with FDCM technique is 10 KHz – 1 GHz. The gain of CMOS OTA using feedforward with FDCM technique is 68 dB at 1nA bias current. The results are shown in Table 1. Further the power consumption and bias current relation has been studied. It has been observed that power consumption increase with increased in bias current as shown in figure 3

Table 1: Simulated performance characteristics for CMOS amplifiers

Design parameters	OTA using feedforward with FDCM technique [5]	Conventional amplifier [7]
Power supply	2.5 V	2.5 V
DC voltage gain	68 dB	48 dB
Unity gain freq.	10 KHz–1GHz	1 KHz – 150 MHz
Input bias current	1 nA – 1 mA	1 mA

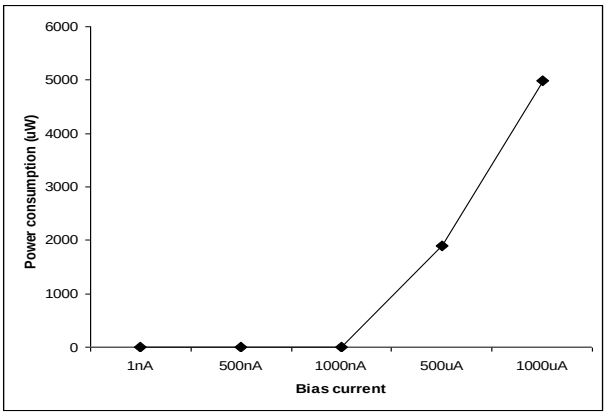

Figure 3: Power consumption with bias current

4. CONCLUSION

In this paper, a 0.5µm CMOS OTA using feedforward with frequency-dependent current mirror (FDCM) technique has been studied. This technique has been evaluated in terms of gain, unity gain frequency characteristics. The gain of 68 dB at 1 nA bias current and unity gain frequency of 10 KHz – 1 GHz has been calculated using feedforward with frequency-dependent current mirror (FDCM) technique. Power consumption of circuit shows increasing trend with increasing in bias current.

5. REFERENCES

[1] Subhajit Sen and Bosco Leung, "A class-AB high-speed low-power operational amplifier in BiCMOS technology," IEEE journal of solid – state, vol. 31, no. 9, pp 1325-1330, Sept. 1996. [2] F. Op't Eynde and W.Sansen, "A CMOS wideband amplifier with 800 MHz gain-bandwidth," in IEEE custom integrated circuits conference proc., pp 9.1.1-9.1.4, June 1990.

[3] F. Op't Eynde and W.Sansen, "Design and optimisation of CMOS Wideband Amplifiers," in IEEE Custom Integrated Circuits Conference Proc., pp. 25.7.1-25.7.4, 1989.[4] L.Bouzerara, M.T.Belaroussi, and B.Amirouche, "Low-voltage, low-power and high gain CMOS OTA using active positive feedback with feed forward and FDCM techniques," in 23rd international conference proc. on microelectronics, vol 2, NIŠ, Yugoslavia, 12-15 May, 2002.

[5] Tetsuro Itakura and Tetsuya Iida, "A feedforward technique with frequency-dependent current mirrors for a low-voltage wideband amplifier," IEEE journal of solid - state circuits, vol. 31, no. 6, pp 847-849, June 1996.

[6] Phillipe E. Allen and Douglas R.Holberg, "CMOS analog circuit design," Oxford University Press, 2004.

[7] Katsufumi Nakamura and L. Richard Carley, "An enhanced fully differential folded cascode op amp," IEEE journal of solid - state circuits, vol. 27, no. 4, pp 563-568, April 1992.