ANALYSIS OF DIFFERENT TYPES OF CURRENT MIRROR IN 45NM TECHNOLOGY

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Abstract

Momentarily the analog electronics has made low voltage, low power circuit designs extremely adorable. As power is the product of supplied voltage and flowing current through the circuit so power id directly varies with supplied voltage .That means reducing supply voltage is a direct way to achieve low power consumption. Low Voltage and low power current mirrors are essential blocks of analog IC design.

Key Words: *Low Voltage LVCM, High Output Impedance LVCM, Low Voltage Cascode CM and Modified LVCM*

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1. INTRODUCTION

Current mirror acts a building block in analog circuit as it plays a huge role to decide overall characteristics. “Current mirror” the name itself signifies the copying ofcurrent. current mirror is a two terminal circuit in which output current dependent on input current and independent upon the output voltage. These circuits are used to perform current amplification in multiple of reference current, biasing, loading and level shifting.

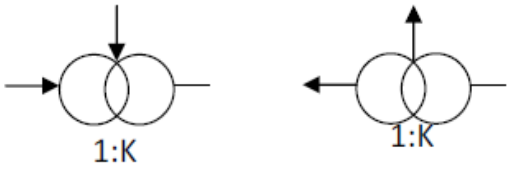

Fig -1: Symbol of current mirror

1(a):NMOS current mirror,**1(b):**PMOS current mirror

Figure 1 shows the symbol of current mirror in which arrow is used to designate the direction of current Flow on input side. In NMOS current mirror the current flows from output node to input where as in PMOS the current flows from input node to outer one. 1:K shows the ratio of current gain of current mirror.

Generally current mirrors have nonzero input and finite output resistance but incase of ideal current mirrors, they have zero input and infinite output resistance which implies input voltage varies with input current and output independent of output voltage.

Fig 2 shows the structure of basic current mirror. Here both M1 and M2 operates in saturation condition for accurate current output. Current mirror requires a minimum voltage(compliance voltage) at the output to ensure that the device operate in saturation. Drain source voltage of mirror transistor M1 and M2 significantly affects the accuracy of generated output current. Perfect matching of mirroring M1 and M2 should be required for accurate mirroring of signals.

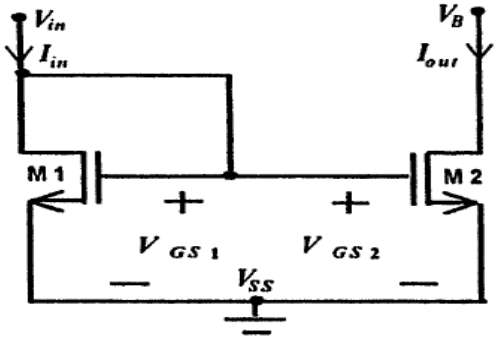

Fig -2: Basic current mirror[4]

The output current obtained as

$$I_{OUT} = \frac{1}{2}\mu_n C_{ox} \frac{W}{L} \left[V_{DD} \frac{R_2}{R_1+R_2} - V_{th}\right]^2$$

eqn(1) [1]

From the above equation we can observe that the output current depends upon the supply voltage, temperature and process with many more dependencies. V_{DS} is the overdrive voltage which is a function of supply voltage V_{DD} and threshold voltage V_{th} . Design of current sources in analog circuits is based on copying current from a reference I_{REF} .

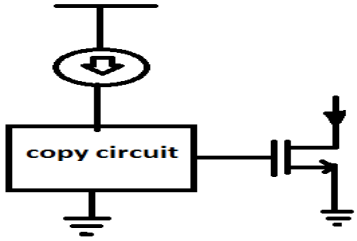

Fig -3: Conceptual meaning of copying current [2]

Sometimes the external circuits require external adjustment to generate a stable reference current I_{ref} , which is then copied to many current sources. Fig 3 shows the conceptual meanings of copying current from reference sources[1].

1.1 Low voltage simple current mirror

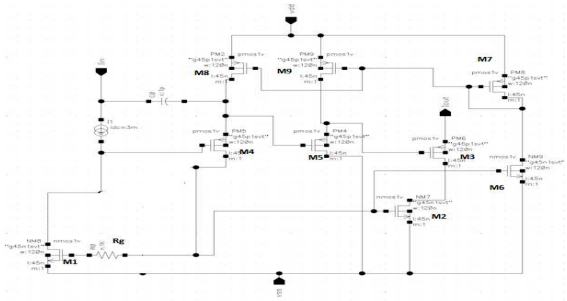

Fig -4: Low voltage Current mirror[2]

Fig 4 shows the structure of Low voltage current mirror. Here M1 is used as a diode configuration and operates in saturation mode.M1 and M2 both acts a conventional current mirror.M4 acts as a level shifter which operates in sub threshold region by selecting the low bias current I_{bias} .M5 also acts as a level shifter which bias M3. M3 enhances the output impedance. In Low voltage current mirror offset current is one of the important factor and it sets the input current.

$$I_{offset} = \frac{W_2}{L_2}\frac{L_4}{W_4}\frac{I_{D02}}{I_{D04}} I_{bias1} \exp(\Delta V_t/\eta V_T)$$

eqn 2.....[2]

The gates of M1 and M2 are not at reference potential even if input current is zero. When I_{in} =0 a subtreshold current which is known as offset current flow in M2.

$$I_{offset} = \frac{W_2}{L_2}\frac{L_4}{W_4}\frac{I_{D02}}{I_{D04}} I_{bias1}$$

eqn 3.....[3]

Eqn 2 and 3 shows the values of offset current . This depends upon the width height ratios of M2 and M4 ,drain currents of M2 and M4 along with the biasing current.

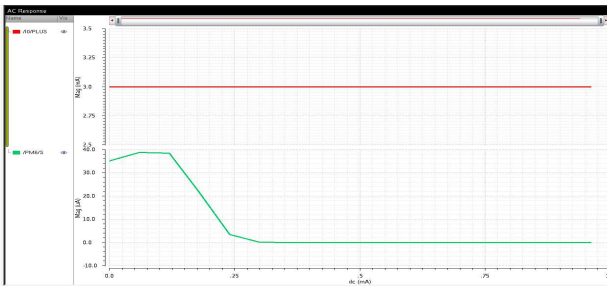

Fig -4(a): ac analysis of LVCM

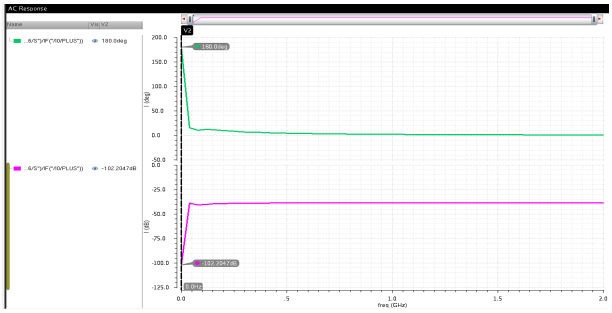

Fig -4(b): Gain and Phase calculation

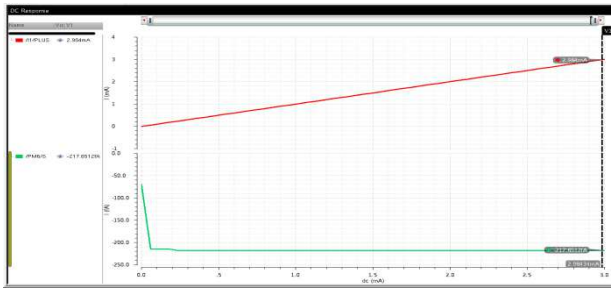

Fig -4(c): Dc analysis of LVCM

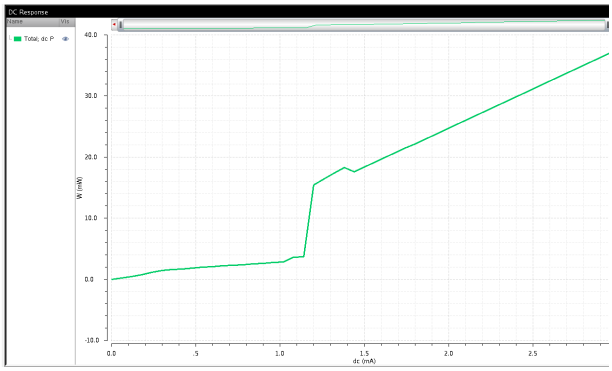

Fig -4(d): Power calculation

Fig 4(a) shows the ac analysis of low voltage current mirror with applied input current of 3mA.From the AC analysis gain and phase is calculated shown by fig 4(b). Fig 4(c) shows the DC analysis of LVCM . From the dc analysis power is calculated as 37.562mW shown in fig 4(d).

1.2 High Output Impedance Low voltage simple current mirror

In the circuit the loop bias circuit is formed by transistors M1 and M4. M2 and M4 forms the drain symmetry of current mirror. The steady state drain voltage of M1 and M3 are same. M2 and M4 shows the mirror condition and operates in saturation . In the Fig 5 which shows the schematic of high output low voltage current mirror , we can see that output current results from transistor M5.M5 is disconnected out from the loop with no input supplied at the drain of M2, the steady state drain voltage of M1 and M2 are same $V_{D,M1}= V_{D,M2}=V_{D,M4}$

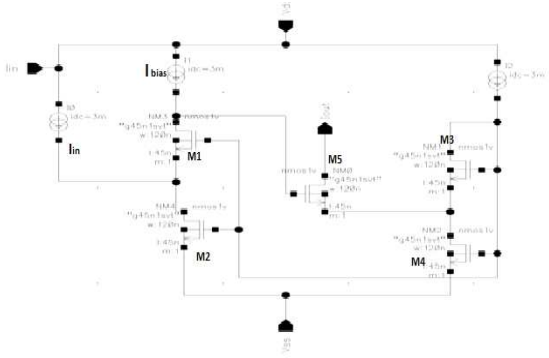

Fig -5: Schematic of high output impedance low voltage current mirror[2]

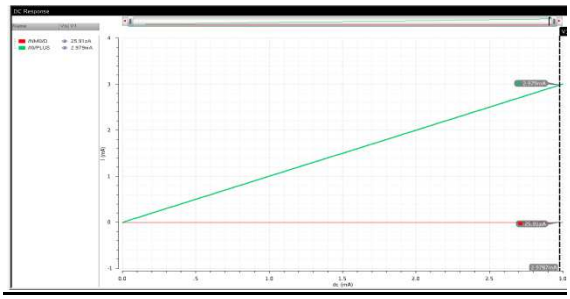

Fig -5(a): DC analysis of output impedance low voltage current mirror

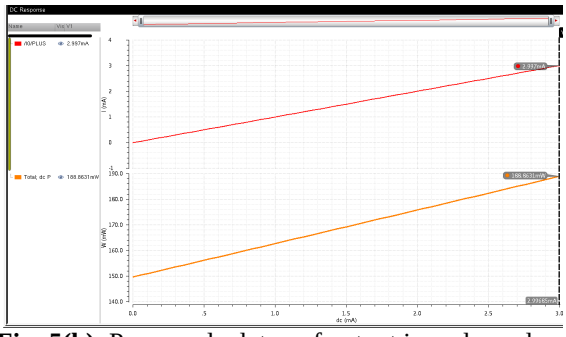

Fig -5(b): Power calculaton of output impedance low voltage current mirror

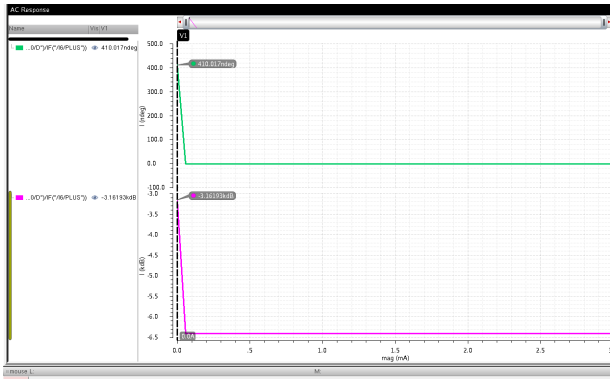

Fig -5(c): Gain and Phase calculation of output impedance low voltage CM

Fig 5(a) shows the DC analysis of high output impedance low voltage current mirror with applied input current of 3mA. From the dc analysis power the calculated power is shown in fig 4(b). Fig 5(c) shows the gain and phase calculation obtained from AC analysis.

1.3 Low voltage cascode current mirror

This current mirror operates in low voltage operation. All the transistors here operates in saturation condition. If $V_b = V_{GS2} + (V_{GS1}-V_{TH1}) = V_{GS4} + (V_{GS3} - V_{TH3})$ M1 ,M3 sustain same drain voltage and M3 ,M4 consumes minimum headroom voltage. FIG 6 shows the complete schematic of cascade low voltage current mirror.

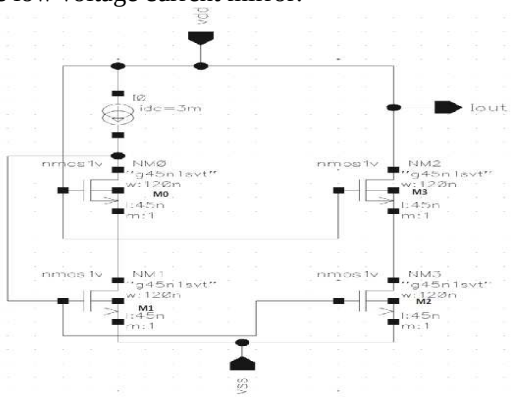

Fig -6: Schematic of Low voltage cascode Current mirror[3]

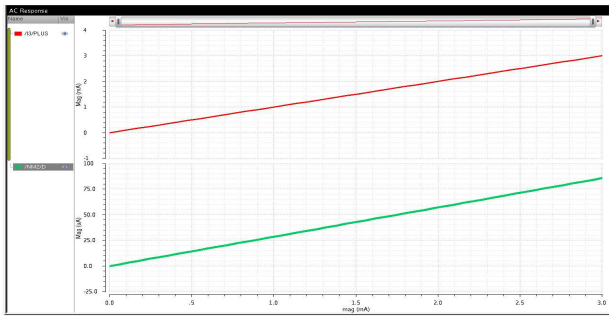

Fig -6(a): ac analysis of cascade Low voltage cascode Current mirror

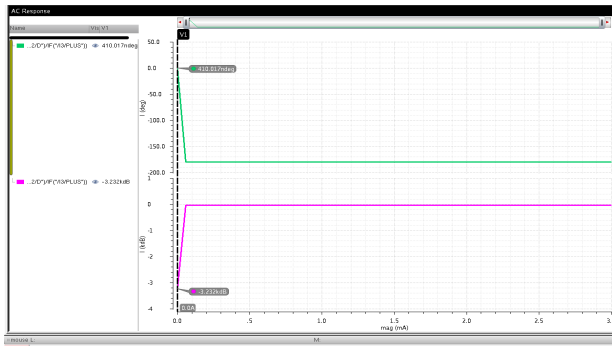

Fig -6(b): Gain and Phase calculation

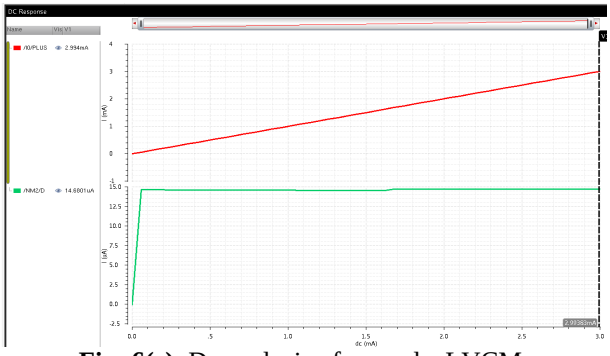

Fig -6(c): Dc analysis of cascode LVCM

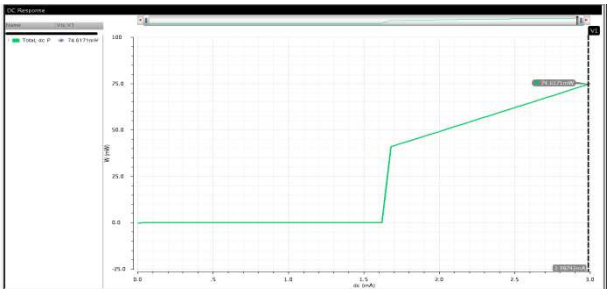

Fig -6(d): Power calculation

Fig 6(a) shows the ac analysis of low voltage cascode current mirror with applied input current of 3mA.From the AC analysis gain and phase is calculated shown by fig 6(b). Fig 6(c) shows the DC analysis of low voltage cascade current mirror . From the dc analysis power is calculated shown in fig 6(d).

2. MODIFIED LOW VOLTAGE CURRENT MIRROR

In this modified circuit the transistor M4 and M5 generates the bias current. As $V_{GS,M0} = V_{GS,M1}$, so same amount of current ($I_{bias} + I_{in}$)flows through both transistors. Output current generates from transistor M8. I_{bias} and I_{in} acts as an input source. The amount of input current supplied to input node transmit through the circuit and same amount of current results at the output node.

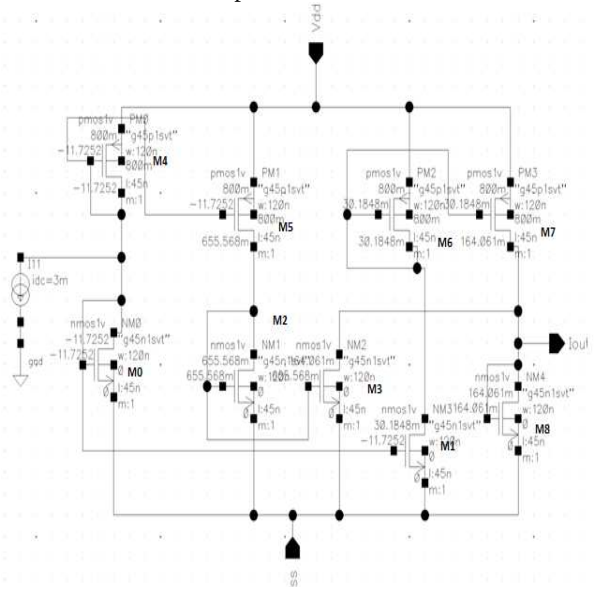

Fig -7: Modified Low voltage Current mirror

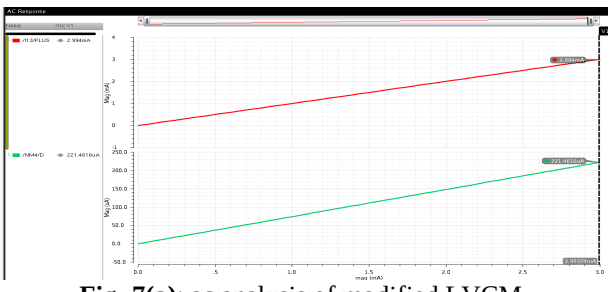

Fig -7(a): ac analysis of modified LVCM

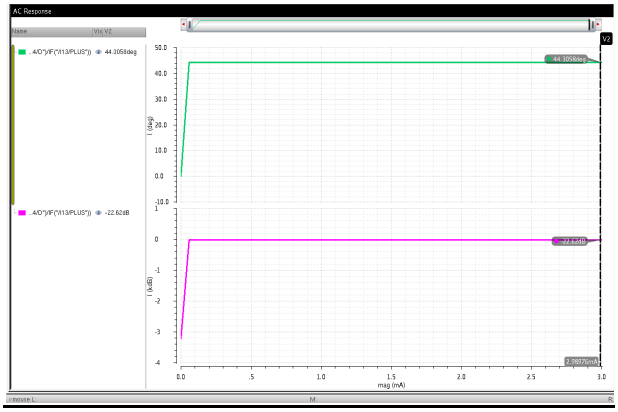

Fig -7(b): Gain and Phase calculation

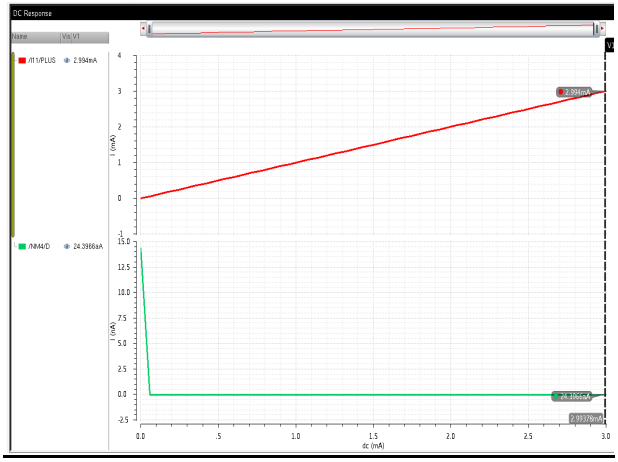

Fig -7(c): Dc analysis of LVCM

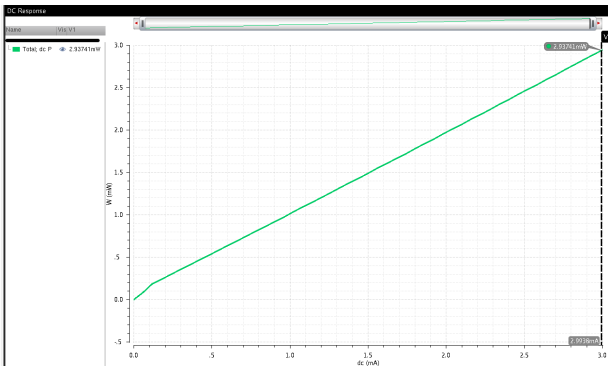

Fig -7(d): Power calculation

Fig 6(a) shows the ac analysis of low voltage current mirror with applied input current of 3mA.From the AC analysis gain and phase is calculated shown by fig 6(b). Fig 6(c) shows the DC analysis of LVCM . From the dc analysis power is calculated shown in fig 6(d).

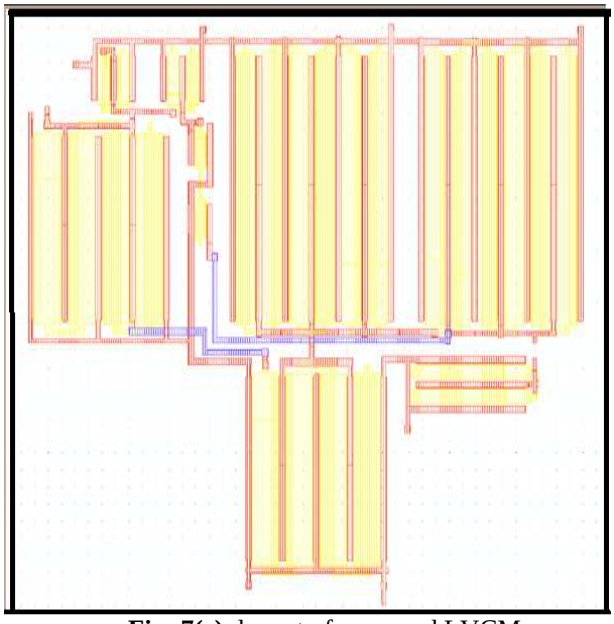

Fig -7(e): layout of proposed LVCM

Table -1: comparison of different current mirrors

	Output current	**Dc power (mw)**	**Gain (db)**	**Phase (degree**
LVCM	39.6 micro amp	37.56	-102.2	180
HOLV	25.91z amp	188.8	-3.261	410.017
CASCODE LVCM	14.8micr oamp	74.61	-3.232	411.017
MODIFIED LVCM	24.3966 amp	2.937	-22.62	44.305

Table 1 shows a brief comparison of different current mirrors with all parameters. Here w can observe that the modified LVCM is giving best result with output current of 24.39amp. The dissipated power is also very low here. So from above designs modified LVCM is the best design to achieve low power operation with minimum supply voltage of 0.8volt.

3. CONCLUSIONS

The purpose of this work is to improve the output and to reduce the power dissipation in current mirror operating with supply voltage 0.8volt. Extensive simulation and layout is carried out to meet all the objectives. Modified low voltage current mirror circuit was selected to get the desired result.

ACKNOWLEDGEMENT

We would like to express our gratitude to KIIT, Bhubaneswar, Odisha for providing CADENCE EDA Tool, used to carry out this work.

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BIOGRAPHIES

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