PRACTICAL TESTS OF CURRENT FOLLOWER BASED ON DISCRETE COMMERCIALLY AVAILABLE TRANSISTORS

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ABSTRACT

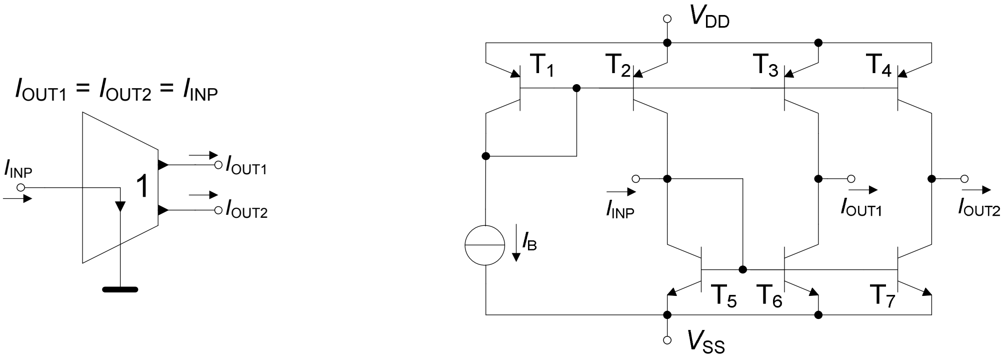
Analyses and corresponding results of multi-output current follower (MO-CF) based on discrete commercially available transistors are presented in this paper. This element is very important for current-mode approaches and circuit design. Mentioned structure consists of minimum number of the transistors. There are discussed two two-output conceptions. First type produces positive polarities of output current and second type produces both polarities. The first one was experimentally tested. Related results in frequency domain, dynamical range and important small signal parameters are discussed. Simulation and measurements results are compared.

1. INTRODUCTION

The current followers with more than one output are important for synthesis and design approaches in the current-mode (CM) [1]. There exists commercially available devices like diamond transistor [2], transconductance amplifier [3], current conveyor or current feedback amplifier [4], etc. but they usually do not have more than one output. Many devices and structures in the current-mode require multi-output active elements that have not been commercially available yet. This improvement enables to use of commercially available active elements in CM. This element is also very important for many applications i.e. current or mixed mode multi-loop integrator synthesis of active filters, harmonic or nonlinear oscillators, amplifiers, current-mode operations (distribution and mirroring), etc.

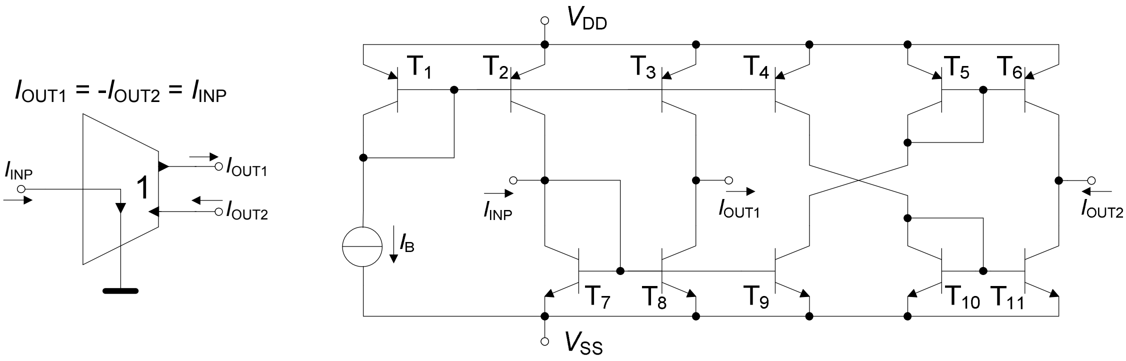
2. CURRENT FOLLOWER WITH TWO OUTPUTS

The schematic symbol of current follower based on simple current mirrors [5, 6] with two positive current outputs is in Fig. 1(a) and his structure in Fig. 1(b). Circuit in Fig. 1(b) was built from discrete transistors type BC547A and BC557A [7]. Easy but more complicated modification for both polarities is in Fig. 2. However, there are additional transistors.



a) b)

Figure 1: a) Symbol of current follower with two positive outputs, b) transistor implementation



a) b)

Figure 2: a) Symbol of current follower with positive and negative output, b) transistor implementation

3. ANALYSIS AND MEASUREMENT RESULTS

For measurement (see Fig. 3) was necessary input converter with diamond transistor OPA 660 [2] and output loads with voltage buffers BUF 634 [8] for impedance separation. Bias current I_B was set 1000 μA.

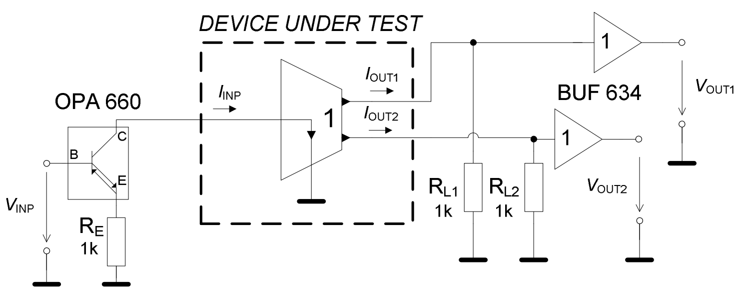


Figure 3: Analyzed and measured testing circuit

The voltage to current and current to voltage conversion we can describe by following fundamental expressions

$$g_m \approx 1/R_E\,,\ I_{INP} = g_m V_{INP}\,,\ V_{OUT1} = R_{L1} I_{OUT1}\,,\ V_{OUT2} = R_{L2} I_{OUT2}\,. \quad (1), (2), (3), (4)$$

The CF (see Fig. 1) was tested in the frequency domain. Results of simulation in PSpice are in Fig. 4 and results of measurement are in Fig. 5. Network analyzer Agilent E5071C was used for experimental tests in frequency domain. Simulation result show that -3 dB drop is about 7.6 MHz. From measurement results is obvious that -3 dB drop is only 2 – 3 MHz. The CF circuit was measured at solderless field and there are many influences mainly on higher frequencies (quite high parasitic capacitances). Simulated and measured input-output characteristics are depicted in Fig. 6. Important small signal parameters dependent on frequency like Z_{INP} and Z_{OUT} are in Fig. 7. Accordingly to Fig. 7 is clear that change of I_{B} effects these parameters. In some cases [9] adjusting of R_{INP} is required for electronic adjusting of some parameters (in filters, oscillators). It is suitable only in finite range because output impedance is also I_{B} and frequency depending and this effect has negative impact for example on attenuation in stop-bands of active filters [10].

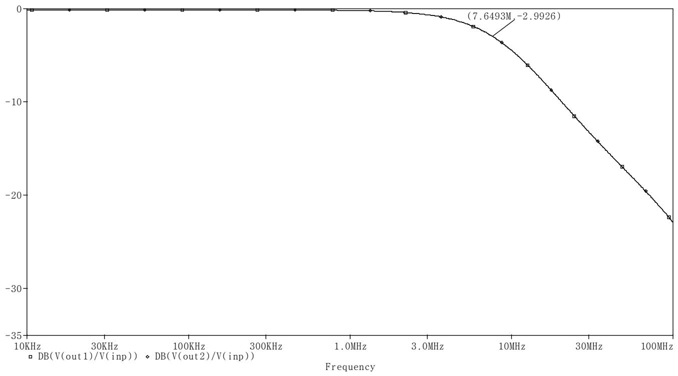


Figure 4: Magnitude responses of current follower

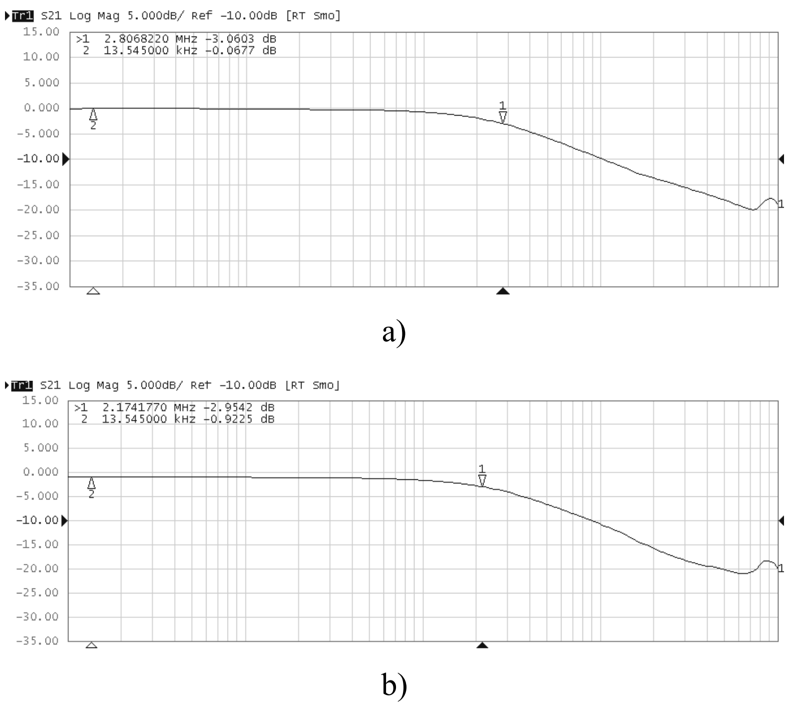
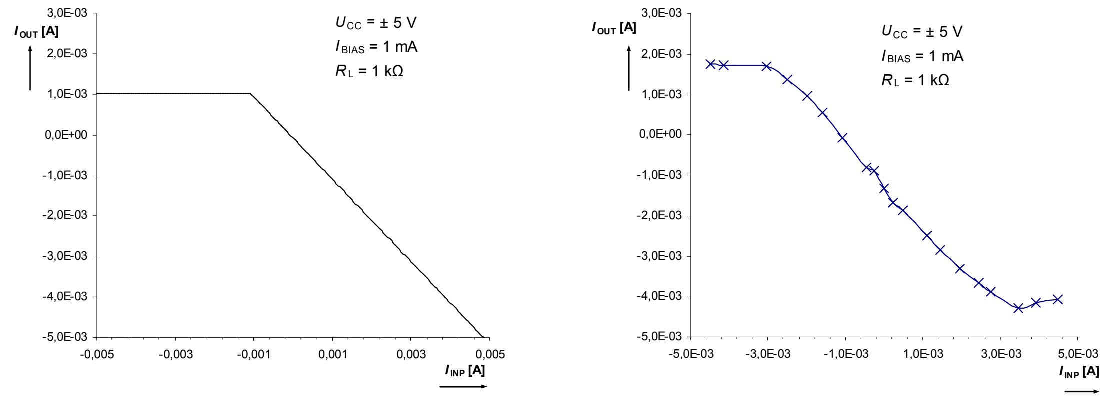
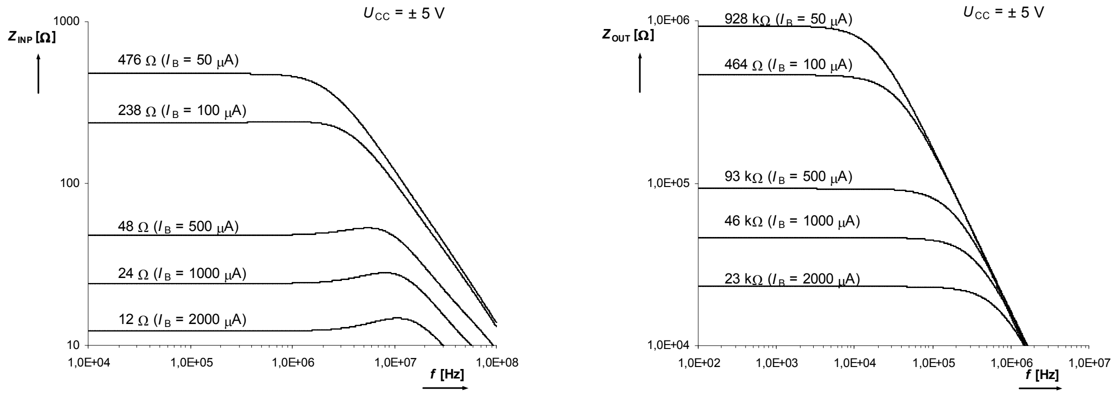


Figure 5: Measured magnitude responses (range 10 kHz – 100 MHz) a) OUT_1, b) OUT_2



a) b)

Figure 6: a) Simulated and b) measured input-output characteristics



a) b)

Figure 7: Dependence of a) input impedance, b) output impedance on frequency for different bias current values (simulations)

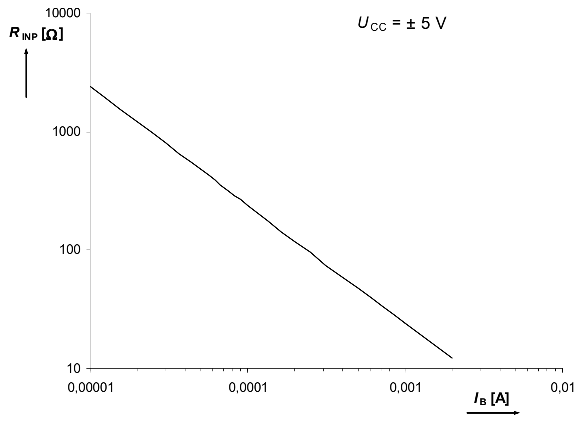


Figure 8: Dependence of R_{INP} on I_B

4. CONCLUSION

Presented way how to realize current follower with more than one output was practically verified. More or less simulation and measurement results confirmed theory presumptions but there were many influences on frequency response and input offset. However, functionality of presented circuit was verified and in some unpretentious cases can be sufficient. Circuit has quite good dynamical range of several mA in comparison with low power CMOS structures where it is about maximally several hundreds of μA. Frequency response is not much satisfactory. Next part of work will be focused on realizations based on commercially available integrated transistor fields HFA 3127/3128 [11] where we can expect better results first of all in frequency domain.

ACKNOWLEDGEMENT

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