Computing, Telecommunication and Control, 2026, Vol. 19, No. 2, Pp. 44–51.
Информатика, телекоммуникации и управление. 2026. Том 19, № 2. С. 44–51.

Circuits and Systems for Receiving, Transmitting and Signal Processing

Устройства и системы передачи, приема и обработки сигналов

Short message
DOI: https://doi.org/10.18721/JCSTCS.19204
UDC 621.3.049.774.2

A FREQUENCY-SELECTIVE CIRCUIT IN 180 NM CMOS

M.M. Pilipko ✉ , *D.V. Morozov*

Peter the Great St. Petersburg Polytechnic University,
St. Petersburg, Russian Federation

✉ m_m_pilipko@rambler.ru

Abstract. A frequency-selective device has been developed in the form of a rejector active filter based on transconductance amplifiers and capacitors in the 180 nm CMOS technology of Mikron JSC. The layout dimensions are 62 x 26 μm. Post-layout simulation results are as follows: rejection frequency is 312.5 MHz; passband gain is 1.44 dB; rejection is 23.1 dB; power consumption is 4.8 mW; total harmonic distortion is 0.07%. A comparison with the results from other studies is performed. The device can be applied in optical communication systems.

Keywords: CMOS, frequency-selective device, rejector, active filter, transconductance amplifier, element imitation

Acknowledgements: The integrated circuit was manufactured using funds from the Ministry of Science and Higher Education of the Russian Federation within the framework of the federal project “Training of personnel and scientific foundation for the electronics industry” under the state assignment “Development of a prototyping methodology for electronic component base using domestic microelectronic manufacturing facilities based on MPW service”.

Citation: Pilipko M.M., Morozov D.V. A frequency-selective circuit in 180 nm CMOS. Computing, Telecommunications and Control, 2026, Vol. 19, No. 2, Pp. 44–51. DOI: 10.18721/JCSTCS.19204

© Pilipko M.M., Morozov D.V., 2026. Published by Peter the Great St. Petersburg Polytechnic University

Краткое сообщение
DOI: https://doi.org/10.18721/JCSTCS.19204
УДК 621.3.049.774.2

ЧАСТОТНО-ИЗБИРАТЕЛЬНОЕ УСТРОЙСТВО ПО ТЕХНОЛОГИИ КМОП 180 НМ

М.М. Пилипко ✉ , *Д.В. Морозов*

Санкт-Петербургский политехнический университет Петра Великого,
Санкт-Петербург, Российская Федерация

✉ m_m_pilipko@rambler.ru

Аннотация. Разработано частотно-избирательное устройство в виде режекторного активного фильтра на основе транскондуктивных усилителей и конденсаторов в КМОП-технологии АО «Микрон» 180 нм. Размеры топологии 62 х 26 мкм. Результаты моделирования по топологии следующие: частота режекции 312,5 МГц; усиление в полосе пропускания 1,44 дБ; подавление 23,1 дБ; потребляемая мощность 4,8 мВт; коэффициент гармоник 0,07%. Проведено сравнение с результатами других работ. Устройство может быть применено в системах оптических коммуникаций.

Ключевые слова: КМОП, частотно-избирательное устройство, режектор, активный фильтр, транскондуктивный усилитель, элементная имитация

Финансирование: Производство интегральной микросхемы было выполнено за счет средств Министерства науки и высшего образования Российской Федерации в рамках федерального проекта «Подготовка кадров и научного фундамента для электронной промышленности» по государственному заданию «Разработка методики прототипирования электронной компонентной базы на отечественных микроэлектронных производствах на основе сервиса MPW».

Для цитирования: Pilipko M.M., Morozov D.V. A frequency-selective circuit in 180 nm CMOS // Computing, Telecommunications and Control. 2026. Т. 19, № 2. С. 44–51. DOI: 10.18721/JCSTCS.19204

Introduction

Continuous-time Gm-C active filters based on transconductance amplifiers and capacitors represent frequency-selective circuits and are applied for high-frequency devices [1–7]. For the implementation of the Gm-C active filters, CMOS technology is usually used. In this paper, realization of a frequency-selective circuit as a rejector Gm-C active filter is discussed in the Mikron JSC 180 nm CMOS technology.

Transconductance amplifier circuit

The transconductance amplifier circuit is shown in Fig. 1. The transconductance amplifier is a voltage-controlled current source. It consists of an input stage [8] and a common-mode stabilization circuit. The input stage is based on two-finger MOSFETs M1–M6 and the common-mode circuit is realized by single-finger MOSFETs M7–M12. Inputs of the transconductance amplifier circuit are labeled “inp” – non-inverted and “inm” – inverted one. Outputs are “outp” – non-inverted and “outm” – inverted one. The common mode signal is “bias”. The transconductance amplifier circuit in the Gm-C active filter should have a tuning range to compensate temperature and CMOS technology variations in the production of the integrated circuit dies. The tuning capability of the transconductance amplifier circuit is provided by varying the voltage in the node “tune”. When using multiple transconductance amplifiers in an element imitator, the “com2” nodes of these amplifiers are connected together.

© Пилипко М.М., Морозов Д.В., 2026. Издатель: Санкт-Петербургский политехнический университет Петра Великого

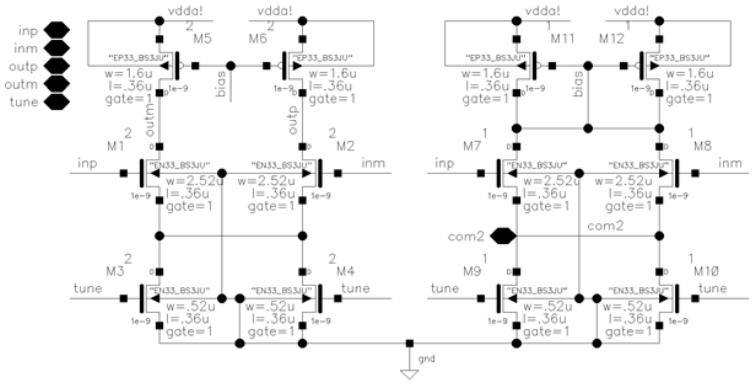


Fig. 1. Transconductance amplifier circuit

The transconductance amplifier circuit is implemented in the Mikron JSC 180 nm CMOS technology with a supply voltage of 3.3 V. Usage of a linear dropout regulator is implied with an output voltage of 2.8 V, which is indicated as “vdda!”. The channel dimensions of each MOSFET “w” and “l” are shown in Fig. 1. The transconductance of the amplifier circuit is near G_m = 242 uA/V at the nominal voltage value in the node “tune” equal to 1.4 V. The current consumption of the transconductance amplifier circuit is 230 uA.

Rejector Gm-C active filter

The second-order passive prototype of the rejector filter was used to implement the Gm-C active filter. The passive prototype is a balanced circuit, which is shown in Fig. 2 with a testbench and consists of input resistances R1 and R2, parallel oscillatory circuits L1C1 and L2C2, and a load output resistance R3. Inputs of the passive prototype are labeled “inp_RF” – non-inverted and “inm_RF” – inverted one. Outputs are “outp_RF” – non-inverted and “outm_RF” – inverted one. The common voltage, designated as “vcm”, is a half of the voltage in the node “vdda!”, i.e., 1.4 V. The rejection frequency is set as F_0 = 312.5 MHz. The element values are shown in fig. 2 and are as follows: R1 = = R2 = $1/(2G_m)$, R3 = $1/G_m$, C1/L1 = C2/L2 = G_m^2 and $F_0 = 1/(2\pi\sqrt{\text{L1C1}}) = 1/(2\pi\sqrt{\text{L2C2}})$. As the results of the AC-analysis, the amplitude and phase response of the passive prototype circuit are shown in Fig. 3. As can be seen, the passband attenuation of the passive prototype circuit is 6 dB.

The circuit of the rejector Gm-C active filter is shown in Fig. 4, *a*. It consists of seven transconductance amplifiers I1–I7 and four capacitors C1–C4. The input resistances R1 and R2 of the passive prototype circuit (Fig. 2) are implemented using transconductance amplifiers I1 and I2. The transconductance of the amplifier I1 is twice as much as G_m, which is indicated in Fig. 4, *a* as “2*Gm”, therefore, it is necessary to use channel widths “w” of all MOSFETs in the circuit of the amplifier I1 twice as much as in the circuit shown in Fig. 1. This increase in the transconductance of the amplifier I1 allows decreasing the input resistances and reducing the passband attenuation of the rejector Gm-C active filter.

The inductors L1 and L2 of the passive prototype circuit (Fig. 2) are implemented using two transconductance amplifiers and a capacitor for each inductor. Therefore, in Fig. 4, *a* transconductance amplifiers I3, I4 and the capacitor C3 are used as the inductor imitator of L1, while transconductance amplifiers I5, I6 and the capacitor C4 are used as the inductor imitator of L2. Considering C3 = L1G_m^2 and C4 = L2G_m^2, at C1/L1 = C2/L2 = G_m^2 all capacitors have the same capacitance, i.e., C1 = C2 = C3 = C4 =123 fF.

The load output resistance R3 of the passive prototype circuit (Fig. 2) is implemented using the transconductance amplifier I7 in Fig. 4, *a*. The transconductance of the amplifier I7 is half as much as

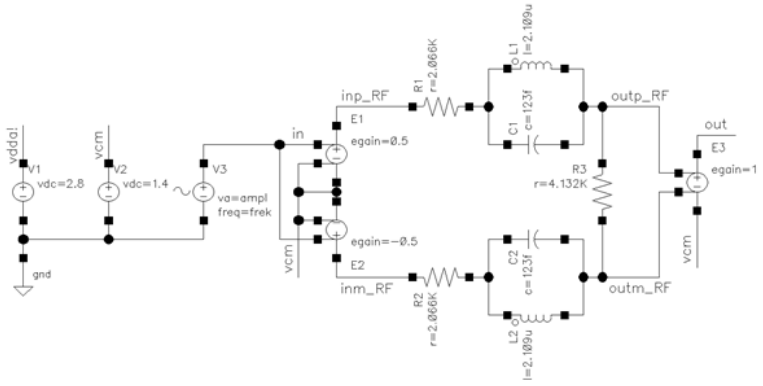


Fig. 2. Testbench with the second-order passive prototype of the rejector filter

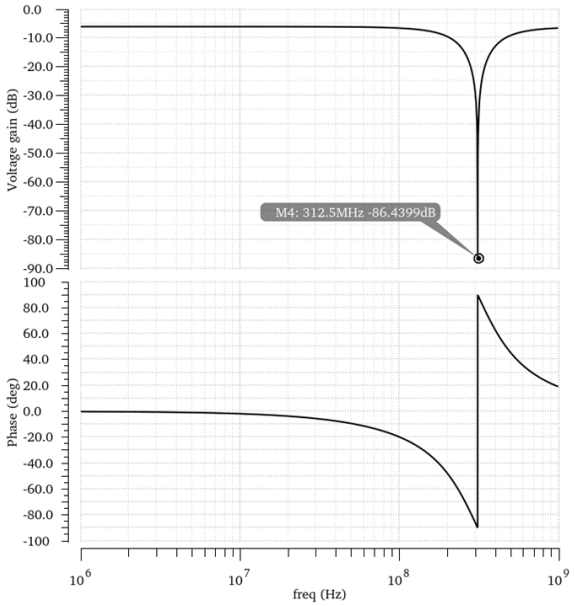


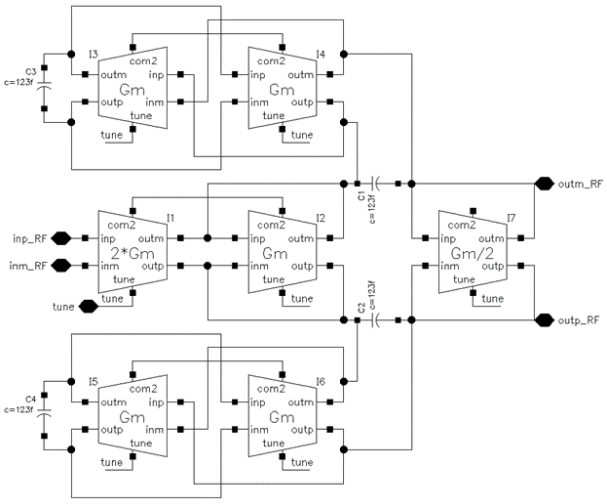
Fig. 3. Amplitude and phase response of the passive prototype circuit

G_m, which is indicated in fig. 4a as "Gm/2", therefore, it is necessary to use single-finger MOSFETs M1–M6 in the input stage of the amplifier I7 in comparison with the circuit shown in Fig. 1. This decrease in the transconductance of the amplifier I7 allows increasing the load output resistance and reducing passband attenuation of the rejector Gm-C active filter.

The layout of the rejector Gm-C active filter is shown in Fig. 4, *b*. Sizes of the layout are 62 x 26 μm. As the results of the AC-analysis, the amplitude and phase response of the post-layout simulation are shown in Fig. 5. As can be seen, the passband gain of the circuit after extraction is 1.44 dB.

The amplitude response shown in Fig. 5 has been acquired at the "typ" corner, i.e., nominal values of MOSFETs and capacitors, with the tuning voltage V_{tune} = 1.4 V. In the case of the "slow3s" corner at V_{tune} = 1.4 V, the rejection frequency has changed to F_0 = 264 MHz. To have the nominal value of the rejection frequency, it is necessary to change the tuning voltage to V_{tune} = 1.65 V. In the case of the "fast3s" corner at V_{tune} = 1.4 V, the rejection frequency has changed to F_0 = 403 MHz. To have the nominal value of the rejection frequency, it is necessary to change the tuning voltage to V_{tune} = = 1.21 V. As can be seen, a feasible change of the tuning voltage allows to adjust the filter circuit to the nominal rejection frequency.

a)



b)

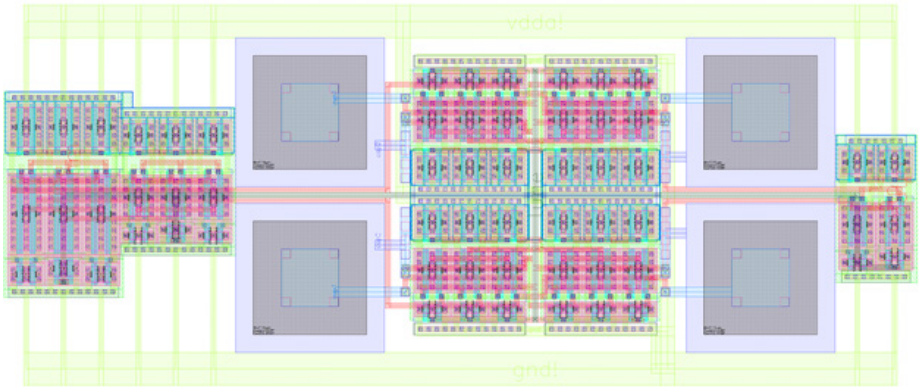


Fig. 4. Rejector Gm-C active filter

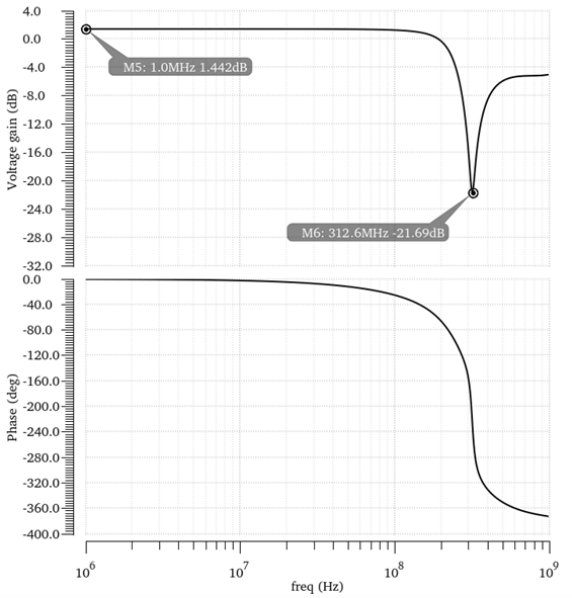


Fig. 5. Amplitude and phase response of the post-layout simulation

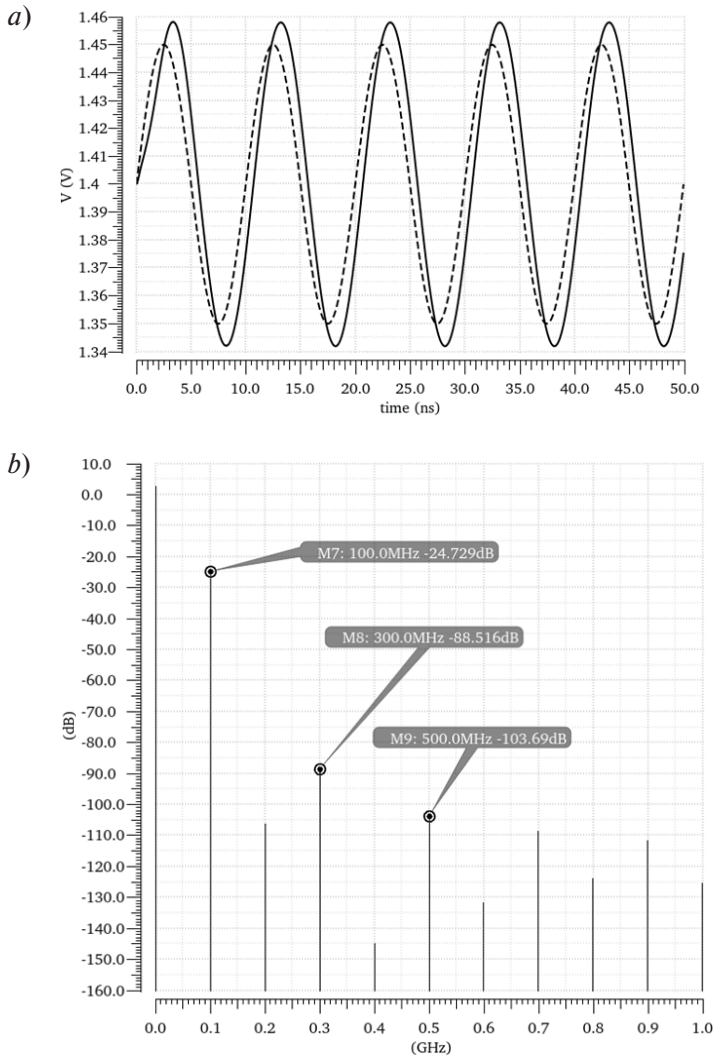


Fig. 6. Differential input and output signals of the post-layout simulation and the output signal spectrum

As the results of the transient analysis, at the frequency of 100 MHz the differential input (the dash line) and output (the solid line) signals of the post-layout simulation and the output signal spectrum are shown in Fig. 6. As can be seen, the nonlinear distortion of the layout is no more than 63 dB, which corresponds to the value of total harmonic distortion equal to 0.07%. Main characteristics of the realized rejector Gm-C active filter are summarized in table 1 in comparison with the results published in [3].

Table 1

Comparison of post-layout simulation results

Main characteristics	This work	[3]
CMOS technology	180 nm	130 nm
Layout area	0.002 mm^2	0.046 mm^2
Number of transconductance amplifiers in the filter circuit	7	6
Power consumption	4.8 mW	3.5 mW

End of Table 1

Main characteristics	This work	[3]
Power consumption per one transconductance amplifier	0.7 mW	0.6 mW
3-dB bandwidth	225 MHz	156 MHz
Attenuation	23.1 dB	28.9 dB
In-band ripple	0 dB	1 dB
Total harmonic distortion	0.07%	0.5%

Conclusion

The realization of a rejector Gm-C active filter in the Mikron JSC 180 nm CMOS technology has been discussed. In comparison with the results published in [3], this work provides a more compact layout, a higher frequency range, and a lower total harmonic distortion at a similar power consumption per one transconductance amplifier. The circuit is applicable in networking and optical communication.

REFERENCES

1. **Pérez-Bailón J., Calvo B., Medrano N., Ramírez-Angulo J.** A 1.8 V Gm-C Highly Tunable Low Pass Filter for Sensing Applications. *2020 IEEE International Instrumentation and Measurement Technology Conference* (*I2MTC*), 2020, Pp. 1–5. DOI: 10.1109/I2MTC43012.2020.9128692

2. **Ghasemi A.R., Aminzadeh H., Ballo A.** Ladder-Type Gm-C Filters with Improved Linearity. *IEEE Access*, 2023, Vol. 11, Pp. 41503–41513. DOI: 10.1109/ACCESS.2023.3270372

3. **Wang J.-f., Liu X.-f., Ju S.-r., Wang T., Qian J.** Design of a low-pass filter for wideband transceiver. *2023 8th International Conference on Integrated Circuits and Microsystems* (*ICICM*), 2023, Pp. 397–400. DOI: 10.1109/ICICM59499.2023.10366038

4. **Corbacho I., Carrillo J.M., Ausín J.L., Domínguez M.Á., Peréz-Aloe R., Duque-Carrillo J.F.** A 4-Decade-Tunable High-Selectivity G_m-C Bandpass Filter for Simultaneous Multi-Sine Bioimpedance Analysis. *IEEE Transactions on Circuits and Systems – I: Regular Papers*, 2024, Vol. 71, No. 1, Pp. 160–173. DOI: 10.1109/TCSI.2023.3331979

5. **Corbacho I., Carrillo J.M., Ausín J.L., Domínguez M.Á., Duque-Carrillo J.F.** 0.8-V CMOS G_m-C Bandpass Filter for Electrical Bioimpedance Spectroscopy. *2021 28th IEEE International Conference on Electronics, Circuits, and Systems* (*ICECS*), 2021, Pp. 1–4. DOI: 10.1109/ICECS53924.2021.9665648

6. **Corbacho I., Carrillo J.M., Ausín J.L., Domínguez M.A., Pérez-Aloe R., Duque-Carrillo J.F.** Impact of Process Variations on the Performance of a Widely Tunable CMOS Transconductor. *2022 18th International Conference on Synthesis, Modeling, Analysis and Simulation Methods and Applications to Circuit Design* (*SMACD*), 2022, Pp. 1–4. DOI: 10.1109/SMACD55068.2022.9816190

7. **Corbacho I., Carrillo J.M., Ausín J.L., Domínguez M.Á., Pérez-Aloe R., Duque-Carrillo J.F.** Low-Gm CMOS Transconductors with Wide Tuning Range for Bioimpedance Spectroscopy. *2023 19th International Conference on Synthesis, Modeling, Analysis and Simulation Methods and Applications to Circuit Design* (*SMACD*), 2023, Pp. 1–4. DOI: 10.1109/SMACD58065.2023.10192142

8. **Morozov D.V., Korotkov A.S.** A realization of low-distortion CMOS transconductance amplifier. *IEEE Transactions on Circuits and Systems I: Fundamental Theory and Applications*, 2001, Vol. 48, No. 9, Pp. 1138–1141. DOI: 10.1109/81.948443

INFORMATION ABOUT AUTHORS / СВЕДЕНИЯ ОБ АВТОРАХ

Mikhail M. Pilipko
Пилипко Михаил Михайлович
E-mail: m_m_pilipko@rambler.ru
ORCID: https://orcid.org/0000-0003-3813-6846

Dmitry V. Morozov
Морозов Дмитрий Валерьевич
E-mail: dvmorozov@inbox.ru
ORCID: https://orcid.org/0000-0003-3403-0120

Submitted: 06.03.2026; Approved: 28.04.2026; Accepted: 19.05.2026.
Поступила: 06.03.2026; Одобрена: 28.04.2026; Принята: 19.05.2026.