ISSN 1392 – 1215 *ELECTRONICS AND ELECTRICAL ENGINEERING* 2011. No. 7(113)
ELEKTRONIKA IR ELEKTROTECHNIKA

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Novel Solution of Notch/All-pass Filter with Special Electronic Adjusting of Attenuation in the Stop Band

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crossref http://dx.doi.org/10.5755/j01.eee.113.7.609

Introduction

There are many suitable active elements for electronic adjusting in the signal processing (high-speed data communication systems, regulation and measurement techniques, electro-acoustics, etc.). We can introduce for example operational transconductance amplifiers (OTA-s) [1], current differencing transconductance amplifiers (CDTA-s) [2], differential input buffered and transconductance amplifiers (DBTA-s) [3], current follower transconductance amplifier (CFTA-s) [4], single, dual and multi-output controlled current conveyors (ECCII-s, VCG-CCII-s, DO-CCCCII-s, MO-CCCCII-s) [5–9] or current controlled current feedback amplifiers (CC-CFA-s) [10]. Many another novel active elements and their properties are summarized in [11], unfortunately many of them are not commercially available yet. Electronic control of the parameters of mentioned active elements is possible due to the DC bias control current or voltage.

A lot of applications are focused on sinusoidal oscillators [12–15] and filters [16–20], in the voltage, current and also mixed mode. Many of active filters are multifunctional or universal (we can obtain low-pass, band-pass, high-pass, all-pass and band reject/notch filter within the same circuit) and sometimes there is a possibility of electronic tuning. Practically, there is no necessity to have all transfer functions in one circuitry. In particular applications, one type of filtering function is usually required. Main aim of this work is not to show multifunctional or fully adjustable circuit but to introduce a simple approach in case of the electronic adjusting of the stop-band attenuation. Some recent solutions are compared in the following text.

Except circuits shown in [16–20, 30–32] realizations of single-purpose filters (all pass/notch filter) were published in [21–29]. Solution of the all-pass and notch filter based on single CCII- and 6 passive elements is described in [21]. Complicated solution is presented in [22] and is based on CCII- and CCII+ and 5 passive elements. Publication [23] presents multifunctional filter based on single CCII- and 5 passive elements where notch response is also possible. Ref. [24] deals with quite complicated all-pass/notch filter employing two CCII+ and one CCII- and 6 grounded passive elements. In [25, 26] multifunctional filters with notch response with CCII+ and CCII- and 5-6 passive elements were also introduced. Solution described in [27] shows all-pass, notch and band-pass filter using single CCII+ and 7-9 passive elements. Similarly, one and two current-conveyor-based filter structures providing notch/all-pass responses were reported in [28, 29]. Other universal structures with CCII+ and CCCII- using minimum passive components are in [30, 31]. Circuit in [30] is quite similar to the presented solution but it has different configuration of ports of used current conveyor. Some mentioned solutions [21–27] do not provide capability of tuning the natural frequency. Control of the natural frequency in recent papers is often not possible. If it is present, it is based on the external control of current input resistance (R_x) [33] that is achieved by control of the bias current (I_b) of proposed active element or by change of the value of passive element or elements simultaneously.

Multi-loop integrator structures allow (in specific cases) control of the stop-band attenuation in case of notch filter, for example, but circuit solution is quite complicated in comparison with our solution. Example of principle signal-flow graph (SFG) of common KHN state-variable realization is shown in Fig. 1. These types of solution (and also other derived canonical forms) are very popular [2, 20, 32, 34–38].

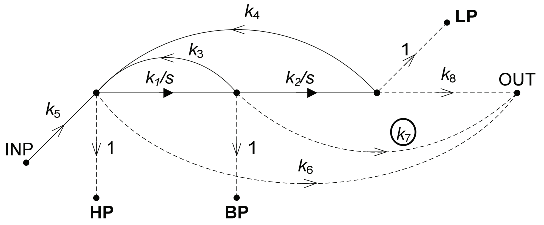


Fig. 1. An example of mutli-loop commonly-used realization of universal biquad

Structure contains two loss-less integrators in two feedback loops. Structure is universal and therefore we can obtain all biquadratic filtering responses. All-pass and notch responses are available on node designed as OUT in Fig. 1. Adjusting of the band-stop attenuation is possible due to change of k_7 path transfer. Structure works as notch with adjustable stop-band transfer for $k_7 > 0$ and for $k_7 < 0$ it works as all-pass filter. Maximal attenuation in stop band of the notch filter is obtained for $k_7 = 0$. This path transfer represents middle coefficient of numerator of the biquadratic transfer function. However, this solution requires minimally three active elements to ensure mentioned adjustability. Of course, there main transfer functions like high-pass (HP), low-pass (LP), band-pass (BP) or also notch/band reject (BR) and all-pass (AP) are available. Tuning and quality factor Q adjusting is possible easily, but it requires additional active elements which complicates final circuit realization. Similar universal or multifunctional filter solutions can be found for example in [4, 6, 16–19, 32, 36].

Our novel solution is much simpler. It contains only one current conveyor (CC) and one voltage buffer (VB). Variable current gain of the current conveyor allows electronic change between BR and AP response. Although there are some disadvantages described in following text (i.e. only one passive element is grounded, unsuitable for Q changes) it is very interesting and simple solution with electronic control that can be useful in special cases. Simple notch filter which provides a possibility of electronic control of the stop-band attenuation can be important for exact suppression of some frequency components for example in radio-frequency devices (suppression of interferences, mirrored frequencies, etc.) in the base band or the inter-frequency band (IF). It is usually necessary to keep given frequency mask in these cases. Our solution has some drawbacks that are discussed in further text but some of them are compensated by the simplicity and also by some special features (attenuation control) which are not commonly included in reported approaches.

Notch filter based on controllable current conveyor and buffer

Fig. 2a shows principle of used active element CCII- (negative). This controllable element is called electronically controlled current conveyor of second generation (ECCII) in [5] or voltage and current gain controlled current conveyor of second generation VCG-CCII in [7]. In our case we suppose controllable current transfer (B) of CCII via external control force (DC control voltage V_g, $B = f(V_g)$). Proposed notch filter (Fig. 2b) with electronically adjustable attenuation was designed by modification of the autonomous circuit structure with partial admittance network and two CCII- (similarly technique in [39]). There are two resistors and two capacitors, one of them is floating. Resistor-less variant is shown in Fig. 2c. R_Z represents real part of internal CCII output impedance of unused output. VB is implemented by part of the CCII-. In this case, filter uses only internal R_x resistances ($R_1 = R_{x1}$ and $R_2 = R_{x2}$ in the following equations) of the current input of the CCII-. The transfer function, angular frequency, quality factor and sensitivities are expressed as:

$$K(s) = \frac{V_{OUT}}{V_{INP}} = \frac{s^2 + \dfrac{-R_2C_1B + R_2C_2}{R_1R_2C_1C_2}s + \dfrac{1}{R_1R_2C_1C_2}}{s^2 + \dfrac{R_1C_1 + R_2C_2}{R_1R_2C_1C_2}s + \dfrac{1}{R_1R_2C_1C_2}}, \quad (1)$$

$$\omega_C = \sqrt{\frac{1}{R_1R_2C_1C_2}}, \quad (2)$$

$$Q = \frac{R_1R_2C_1C_2}{R_1C_1 + R_2C_2}\sqrt{\frac{1}{R_1R_2C_1C_2}}, \quad (3)$$

$$S_{R_1}^{\omega_C} = S_{R_2}^{\omega_C} = S_{C_1}^{\omega_C} = S_{C_2}^{\omega_C} = -0.5, \quad (4)$$

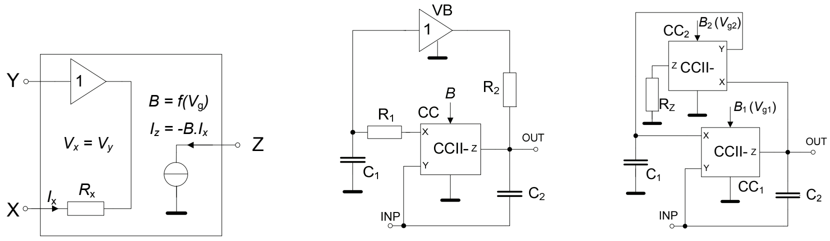
$$S_B^{\omega_C} = 0, \quad (5)$$

$$S_{R_2}^{Q} = -S_{R_1}^{Q} = 0.5, \quad (6)$$

$$S_{C_1}^{Q} = -S_{C_2}^{Q} = 0.5\left(\frac{R_2C_2 - R_1C_1}{R_2C_2 + R_1C_1}\right), \quad (7)$$

$$S_B^{Q} = 0, \quad (8)$$

where B represents current transfer of CC. The middle coefficient in the numerator in (1) contains controllable current transfer B which can be used for adjusting of the maximal attenuation of proposed notch filter. If the coefficient is equal to 0 we can obtain the utmost attenuation. It is fulfilled for $B = 1$ (when $R_2C_1 = R_2C_2$ is valid). The circuit works as adjustable notch filter if $B \leq 1$. If $B > 1$ filter works as all-pass filter or circuit with non-minimal argument (zeros are in right complex half plane).



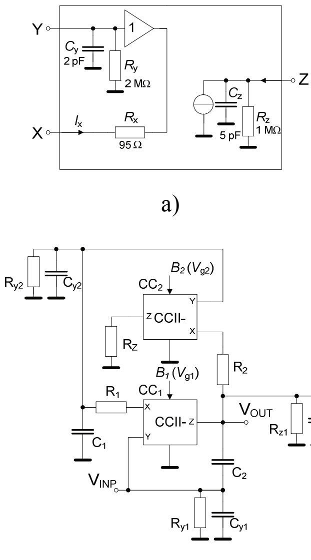
a) b) c)

Fig. 2. Proposed solution of notch filter with electronically adjustable stop-band attenuation: a –the CCII- without fixed current transfer; b – notch filter employing negative CCII, voltage buffer and four passive elements; c – resistor-less variant of proposed filter

Design of the filter parameters and influences of real active blocks

Passive elements of structure from Fig. 2b have been selected as $R_1 = R_2 = R = 100\ \Omega + 95\ \Omega$ (R_x), capacitors as $C_1 = C_2 = C = 470$ pF. CCII- device knows as current mode multiplier EL 2082 [40] was used for the verification purposes. Second CCII- is connected as voltage buffer (only Y a X ports) or it is possible to replace it by any voltage buffer. We can control current transfer of the CC via DC control voltage V_g between 0 - 2 where $B = f(V_g)$. $B_1 = 1$ was set by $V_g = 1$ V. For higher values of V_g, dependence $B = f(V_g)$ is nonlinear [40]. Parameters $f_C = 1.737$ MHz and $Q = 0.5$ have been calculated from (2, 3).

Parasitic influences are caused by the real input and output properties (R_x, R_y, R_z, C_y, C_z) of used active elements (Fig. 3a). They were added to filtering structure as shown in Fig. 3b. The voltage buffer as a part of CC$_2$ (Y, X) was used. Real parameters have been taken into account and eq. (1) changed to following eqs. (9-15) where $R_1^* = R_1 + R_{x1}$, $R_2^* = R_2 + R_{x2}$, $C_1^* = C_1 + C_{y2}$, $B_1^* = \frac{B_1 \omega_T}{s + \omega_T}$. Transfer function and coefficients of transfer function in eqs. (9-15) do not contain R_{y1} and C_{y1}, therefore they can be neglected. All equations contain frequency dependent current transfers B_1^*. Real R_y and R_z resistances of EL 2082 are quite high (hundreds of kΩ) [18] and therefore the influence on f_C and Q should be minimal. But results showed impact on max. achievable attenuation in the stop band. In ideal case it should be more than 60 dB, in real (and simulation) case less than 50 dB. Capacitances C_y and C_z caused slight shift of characteristic frequency f_C.



a)

b)

Fig. 3. Non-ideal features: a – non-ideal model of CCII-; b – parasitic input and output properties of active elements are included

Characteristic frequency is about 50 kHz lower (1.687 MHz) than theoretically. It is also partly caused by inequality of $R_{x1} \neq R_{x2}$ (then $R_1 \neq R_2$). Manufacturing tolerance of R_x (EL 2082 [40]) is quite large (about ± 20 %). Real R_x value is about 95 Ω and therefore cannot be omitted:

$$K^*(s) = \frac{a_2^* s^2 + a_1^* s + a_0^*}{b_2^* s^2 + b_1^* s + b_0^*}, \tag{9}$$

where

$$b_2^* = 1, \tag{10}$$

$$b_1^* = \frac{R_1^* C_1^* R_{y2}\left(R_2^* + R_{z1}\right) + R_2^* R_{z1}\left(R_{y2} C_{z1} + R_1^* C_2 + R_{y2} C_2 + R_1^* C_{z1}\right)}{R_1^* R_2^* R_{y2} R_{z1} C_1^*\left(C_2 + \mathrm{C}_{z1}\right)}, \tag{11}$$

$$b_0^* = \frac{R_1^* R_2^* + R_1^* R_{z1} + R_2^* R_{y2} + R_{y2} R_{z1}}{R_1^* R_2^* R_{y2} R_{z1} C_1^*\left(C_2 + \mathrm{C}_{z1}\right)}, \tag{12}$$

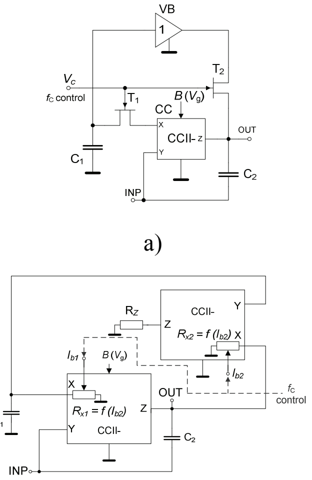
$$a_2^* = \frac{C_2}{\left(C_2 + \mathrm{C}_{z1}\right)}, \tag{13}$$

$$a_1^* = \frac{\left(R_{y2} C_2 + R_1^* C_2 - R_{y2} B_1 C_1^*\right)}{R_1^* R_{y2} C_1^*\left(C_2 + \mathrm{C}_{z1}\right)}, \tag{14}$$

$$a_0^* = \frac{\left(R_{y2} - R_2^* B_1\right)}{R_1^* R_2^* R_{y2} C_1^*\left(C_2 + \mathrm{C}_{z1}\right)}. \tag{15}$$

Experimental results and discussion

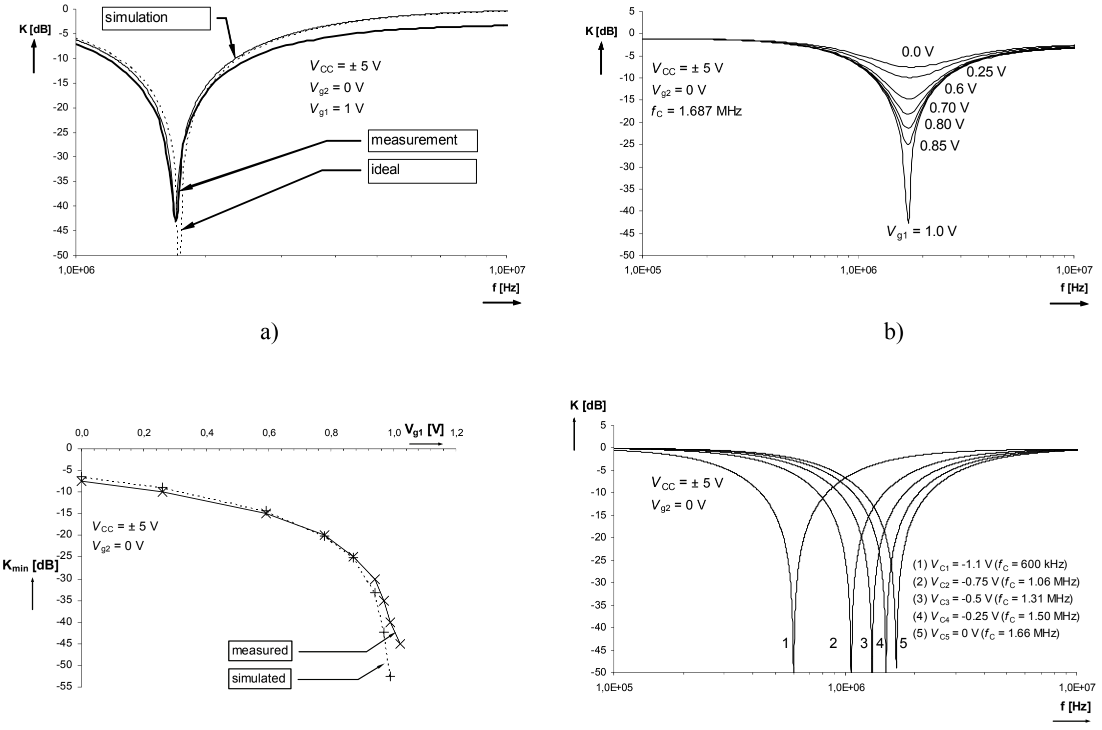
Network analyzer Agilent E5071C, two negative CCIIs EL 2082 [40] and common FET (BF 245A) transistors (two and two parallel for lower resistance value) were used for the experimental and computer (simulation) verification. Adjustment of the characteristic frequency (f_C) is possible only by floating resistors R_1 and R_2 but if we replace them by FET transistors, we can control the f_C by the DC voltage V_C, see Fig. 4a. Another approach (Fig. 4b) to f_C-control is to use modified CCII- element with the possibility of control of the current input resistance R_x by DC bias current I_b (similarly like in [5, 7-8, 10, 33], for instance), where $R_x = f(I_b)$. There is necessary to simultaneously change the R_1 and R_2 or R_{x1} (I_{b1}) and R_{x2} (I_{b2}) values. The results are summarized in Fig. 5. The simulation results were obtained in PSpice with professional macro-models. Notch filter from Fig. 2b was also measured. In Fig. 5a, comparison of ideal, simulated and measured magnitude responses is given, in Fig. 5b measured electronic adjusting of max. attenuation is shown, Fig. 5c shows dependence of the max. attenuation on the control voltage V_g. Finally, in Fig. 5d, example of adjusting the f_C is included. Measured phase response of the notch filter is depicted in Fig. 6. Greater difference between simulated and measured traces at minimal transfers (over - 40 dB) in stop band (Fig. 5c) is caused by non-accurate relation between B and control voltage in the real scenario. It is given by one of used active element EL 2082 and it is significantly influenced by $R_x = 95\ \Omega$ (CCII) causing $R_1 \neq R_2$. Theoretically, using of FET transistor as replacement of R_1 and R_2 for tuning purposes is very easy. In final application, we are limited by nonlinearities caused by them, because they increase total harmonic distortion of whole application. Described solution is suitable only for small signal levels. Second possible solution (Fig. 4b) based on extended CCII with R_x control is widely used in present literature [8, 10]. It is better than the first one in some applications, but these active elements [11] are not commonly available. However, for microelectronic experts there is no problem to implement similar device directly on chip with adequate active element. When the control voltage exceeds $V_g = 1$ V ($B > 1$) zeros are shifting to the right complex half plane and filter produces all-pass response. Inequality $R_2C_2 < R_2C_1$ is valid for $B > 1$ and the middle numerator coefficient of (1) is then negative. Pure AP response is available for $B = 3$. Measured filter output response for $V_g = 2.65$ V is shown in Fig. 7. This feature of this filter realization with controllable current gain is very interesting and could be really useful in particular application.



a)

b)

Fig. 4. Tunable variants of proposed notch filter: a - f_C tunable by two FET transistors; b - tunable by extended CCII with R_x control



a)

b)

c)

d)

Fig. 5. Experimental and simulation results: a – detail of comparison of the simulated and measured magnitude response; b – measured adjusting of the max. attenuation; c – dependence of the max. attenuation on V_{g1}; d – simulated tuning of f_C by FET transistors

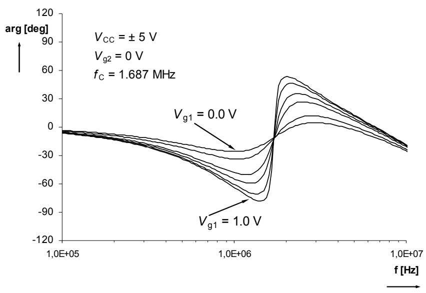


Fig. 6. Measured phase response of the notch filter

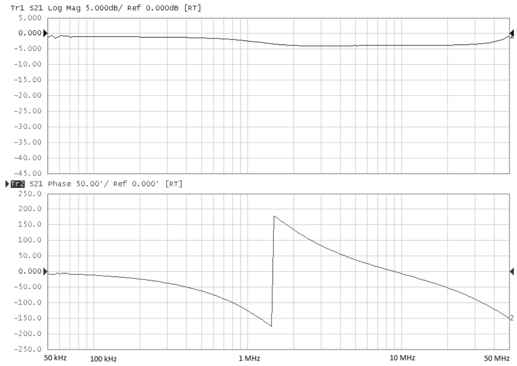


Fig. 7. Measured all-pass response (V_g = 2.65 V)

Conclusions

Novel structure of the notch/all-pass filter with electronically adjustable attenuation in the stop band based on two negative current conveyors or one negative conveyor and voltage buffer and minimum number of the passive elements has been proposed. Resistor-less variant is also possible but it depends a lot on accuracy and tolerances of internal current input resistances (R_X) of used active elements. The macromodel of EL 2082 was used in order to obtain simulation results and EL 2082 served as real device for measurement purposes. Measured attenuation varied from 7 to 45 dB without disturbance of the characteristic frequency or the quality factor. Of course, there are also some drawbacks. Change of the quality factor is not easy (maximal achievable value is 0.5), tuning and adjusting is possible only in limited range. However, main aim of this work is to show simple solution of notch filter with attenuation adjusting and electronic control of transfer function (from notch to AP). Presented solution could be useful in particular cases because of its simplicity. In recent literature there are many other filtering solutions which provide other transfer functions except notch response, but these usually multi-loop feedback conceptions are quite complicated (many active and passive elements) or electronic adjusting of attenuation is not easy. Presented conception is based only on adjustable conveyor and voltage buffer.

Acknowledgements

Research described in the paper was supported by the Czech Ministry of Education under research program MSM 0021630513 and by Czech Science Foundation projects under No. 102/08/H027 and No. 102/09/1681. Research described in the paper is a part of the COST Action IC0803 RF/Microwave communication subsystems for emerging wireless technologies, financed by the Czech Ministry of Education by the grant no. OC09016. This research was financially supported by the project CZ.1.07/2.3.00/20.0007 WICOMT in frame of the operational program Education for competitiveness.

References

1. **Randall L.G.. Sanchez–Sinencio E**. Active Filter Design Using Operational Transconductance Amplifers: A Tutorial // IEEE Circuits and Devices Magazine, 1985. – Vol. 1. – P. 20–32.
2. **Keskin A. U., Biolek D., Hancioglu E., Biolkova V.** Current–mode KHN filter employing Current Differencing Transconductance Amplifiers // AEU – Int J of Electronics and Communications, 2006. – Vol. 60. – No. 6. – P. 443–446.
3. **Herencsar N., Vrba K., Koton J., Lattenberg I**. The conception of differential–input buffered and transconductance amplifier (DBTA) and its application // IEICE Electronics Express, 2009. – Vol. 6. – No. 6. – P. 329–334.
4. **Herencsar N., Koton J., Vrba K., Misurec J**. A novel Current–Mode SIMO Type Universal Filter Using CFTAs // Contemporary Engineering Sciences, 2009. – Vol. 2. – No. 2. – P. 59–66.
5. **Minaei S., Sayin O. K., Kuntman H.** A new CMOS electronically tunable current conveyor and its application to current–mode filters // IEEE Transaction on Circuits and Systems I – Regular papers, 2006. – Vol. 53. – No. 7. – P. 1448–1457.
6. **Koton J., Herencsar N., Cicekoglu O., Vrba K.** Current–mode KHN equivalent frequency filter using ECCIIs // Proceedings of the 33th International Conference on Telecommunications and Signal Processing (TSP 2010). – Baden, Austria, 2010. – P. 27–30.
7. **Marcellis A., Ferri G., Guerrini N. C., Scotti G., Stornelli V., Trifiletti A.** The VGC–CCII: a novel building block and its application to capacitance multiplication // Analog Integrated Circuits and Signal Processing, 2009. – Vol. 58. – No. 1. – P. 55–59.
8. **Tangsrirat W.** Current–tunable current–mode multifunctional filter based on dual–output current–controlled conveyors // AEU – International Journal of Electronics and Communications, 2007. – Vol. 61. – No. 8. – P. 528–533.
9. **Biolek D., Siripruchyanun M., Jaikla W.** CCII and OTA based Current–mode Universal Biquadratic Filter // The sixth PSU Engineering Conference, 2008. – P. 238–241.
10. **Siripruchyanun M., Chanapromma C., Silapan P., Jaikla W**. BiCMOS Current–Controlled Current Feedback Amplifier (CC–CFA) and Its Applications // WSEAS Trans on Electronics, 2008. – Vol. 5. – No. 6. – P. 203–219.
11. **Biolek D., Senani R., Biolkova V., Kolka Z.** Active elements for analog signal processing: Classification, Review, and New Proposals // Radioengineering, 2008. – Vol. 17. – No. 4. – P. 15–32.
12. **Abuelmaatti M., Bentrcia A.** A New Mixed–Mode OTA–C Filter/Oscillator Circuit // Journal of Active and Passive Electronic Devices, 2008, Vol. 3. – P. 211–221.
13. **Horng J. W., Lin S., Yang C.** Sinusoidal Oscillators Using Current Conveyors and Grounded Capacitors // Journal of Active and Passive Electronic Devices, 2007. – Vol. 2. – P. 127–136.

14. **Senani R., Sharma R. K.** Explicit–current–output sinusoidal oscillators employing only a single current–feedback op–amp // IEICE Electronics Express, 2004. – Vol. 2. – No. 1. – P. 14–18.
15. **Lahiri A.** New current–mode quadrature oscillators using CDTA // IEICE Electronics Express, 2009. – Vol. 6. – No. 3. – P. 135–140.
16. **Abuelmaatti M. T., Bentrcia A.** A novel mixed–mode OTA–C universal filter // International Journal of Electronics, 2005. – Vol. 92. – No. 7. – P. 375–383.
17. **Bhaskar D. R., Singh A. K., Sharma R. K., Senani R.** New OTA–C universal current–mode/trans–admitance biquad // IEICE Electronics Express, 2005. – Vol. 2. – No. 1. – P. 8–13.
18. **Chen H., Shen S., Wang J**. Electronically tunable versatile voltage–mode universal filter // AEU – Int Journal of Electronics and Communications, 2008. – Vol. 62. – No. 4. – P. 316–319.
19. **Wang C., Zhou L., Li T.** A new OTA–C current–mode biquad filter with single input and multiple outputs // AEU – International Journal of Electronics and Communications, 2008. – Vol. 62. – No. 3. – P. 232–234.
20. **Biolek D., Biolkova V., Kolka Z.** Universal Current–Mode OTA–C KHN Biquad // International Journal of Electronics, Circuits and Systems, 2007. – Vol. 1. – No. 4. – P. 214–217.
21. **Chang, C. M.** Current mode allpass/notch and bandpass filter using single CCII // Electronics Letters, 1991. – Vol. 27. – No. 20. – P. 1812–1813.
22. **Liu S., Kuo J., Tsay J.** New CCII– based current–mode biquadratic filters // International Journal of Electronics, 1992. – Vol. 72. – No. 2. – P. 243–252.
23. **Chen H. P.** Single CCII– based voltage–mode universal filter // Analog Integrated Circuits Signal Processing, 2010. – Vol. 62. – No. 2. – P. 259–262.
24. **Sharma S., Rajput S. S., Pal K. Mangotra L. K., Jamuar S. S.** Low–voltage CCII based all–pass/ notch filter // Indian Journal of Pure and Applied Physics, 2006. – Vol. 44. – No. 11. – P. 871–874.
25. **Kumar M., Sristava M. C., Kumar U.** Tunable Multifunctional Filter Using Current Conveyor // International Journal of Computer Science and Information Security, 2010. – Vol. 8. – No. 1. – P. 95–98.
26. **Liu S., Lee L.** Voltage–mode universal filters using two current conveyors // International Journal of Electronics, 1997. – Vol. 82. – No. 2. –P. 145–149.
27. **Kumar P., Pal K.** Variable Q all–pass, notch and band–pass filters using single CCII // Frequenz, 2005. – Vol. 59. – No. 9–10. – P. 235–239.
28. **Soliman A. M.** New all–pass and notch filters using current conveyors // Frequenz, 1999. – Vol. 53. – No. 3–4. – P. 84–86.
29. **Higashimura M., Fukui Y.** Realization of all–pass and notch filters using a single current conveyor // International Journal of Electronics, 1988. – Vol. 65. – No. 4. – P. 823–828.
30. **Minaei S., Yuce E., Cicekoglu O.** Electronically tunable multi–input single–output voltage–mode filter/ / Proceedings of the 2005 European Conference on Circuit Theory and Design, 2005. – Vol. 3. – P. III/401– III/404.
31. **Pandey N., Paul S. K., Jain S. B.** Voltage Mode Universal Filter using two Plus Type CCIIs // Int. J. of Active and Passive Electronic Devices, 2008. – Vol. 3. – No. 2. – P.165–173.
32. **Biolek D., Biolková V. Kolka Z.** Universal Current–Mode Gm–C Biquad // In Proceedings of the 18th International Conference Radioelektronika'2008, 2008. – P. 137–139.
33. **Fabre A., Saaid O., Wiest F., Boucheron C.** High frequency applications based on a new current controlled conveyor // IEEE Trans. on CAS–I, 1996. – Vol. 43. – No. 2. – P. 82–91.
34. **Jerabek J., Vrba K.** SIMO type low–input and high–output impedance current–mode universal filter employing three universal current conveyors // International Journal of Electronics and Communications (AEU), 2010. – Vol. 64. – No. 6. – P. 588–593.
35. **Sotner R., Petrzela J., Slezak J.** Current–Controlled Current–Mode Universal Biquad Employing Multi–Output Transconductors // Radioengineering, 2009. – Vol. 18. – No. 3. – P. 285–294.
36. **Herencsar N., Koton J., Vrba K.** Realization of current–mode KHN–equivalent biquad using current follower transconductance amplifiers (CFTAs) // IEICE Trans. Fundamentals, 2010. – Vol. E93–A. – No. 10. – P. 1816–1819.
37. **Sotner R., Jerabek J., Dostal T., Vrba K.** Multifunctional adjustable CM biquads based on distributed feedback VM prototype with OTA– s // International Journal of Electronics, 2010. – Vol. 97, No. 7. – P. 797–809.
38. **Sotner R., Slezak J., Dostal T., Petrzela J.** Universal tunable current–mode biquad employing distributed feedback structure with MO– CCCII // Journal of Electrical Engineering, 2010. – Vol. 61. – No. 1. – P. 52–56.
39. **Koton J., Vrba, K.** New Multifunctional Frequency Filter Working in Current–mode // in IFIP International Federation for Information Processing, Personal Wireless Communications, eds. Simak, B., Bestak, R., Kozowska, E., (Boston: Springer), 2007. – Vol. 245. – P. 569–577.
40. **Intersil (Elantec). EL 2082CN** Current-Mode Multiplier. – 1996. – 16 p. Online: http://www.intersil.com

Received 2010 09 04

R. Sotner, J. Jerabek, B. Sevcik, T. Dostal, K. Vrba. Novel Solution of Notch/All-pass Filter with Special Electronic Adjusting of Attenuation in the Stop Band // Electronics and Electrical Engineering. – Kaunas: Technologija, 2011. – No. 7(113). – P. 37–42.

The notch/all-pass filter with two electronically adjustable three-port current conveyors of the second generation (CCIIs) or one conveyor and one voltage buffer employing only four passive elements is presented in this paper. Used active elements allow the control of current transfer via DC control voltage. Therefore an adjusting of the attenuation in the stop band of the notch filter is possible. The transfer function and major parasitic influences of real active parts are discussed. The verification includes PSpice simulation with professional macromodels and measurement with available current conveyors in frequency domain. Ill. 7, bibl. 40 (in English; abstracts in English and Lithuanian).

R. Sotner, J. Jerabek, B. Sevcik, T. Dostal, K. Vrba. Užtvarinio filtro slopinimo užtvarinėje juostoje specialaus elektroninio valdymo tyrimas // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2011. – Nr. 7(113). – P. 37–42.

Analizuojami užtvariniai elektroniniu būdu valdomi filtrai. Naudojant aktyviuosius elementus galima valdyti srovės perdavimą. Užtvariniame filtre slopinimą galima valdyti užtvarinėje juostoje. Analizuojama perdavimo funkcija ir aktyviųjų elementų parazitiniai ryšiai. Atliktas modeliavimas naudojantis programų paketu „PSpice". Il. 7, bibl. 40 (anglų kalba; santraukos anglų ir lietuvių k.).