

A Bibliography of the Work Done on Externally-Linear-Internally-Nonlinear Circuits during 1979-2014

Manoj Kumar Jain¹, V. K. Singh¹, Raj Senani^{2,*}

¹Department of Electronics and Communication Engineering, Institute of Engineering and Technology, Lucknow, India

²Division of Electronics and Communication Engineering, Netaji Subhas Institute of Technology, Sector 4, Dwarka, New Delhi, India

*Corresponding author: senani@ieee.org

Received April 19, 2015; Revised May 17, 2015; Accepted May 18, 2015

Abstract There is a continued demand of analog circuits which are capable of operating at low supply voltages and have low-power consumption and large dynamic range. There are several techniques of designing circuits satisfying such requirements a majority of which fall into the general category of *externally-linear-internally-nonlinear* (ELIN) circuits. In this paper, we present a bibliography of ELIN circuits which covers log-domain, exponential state-space domain, square root domain and other related circuits, based upon the work done during 1979 to 2014. It is hoped that this compilation (with a brief overview) should be useful to research scholars, educators, students, practicing engineers and anybody who is interested in knowing about the current state-of-the-art of log domain, translinear and square root domain circuits.

Keywords: *log domain circuits, dynamic translinear circuits, square root domain circuits, companding, filters, oscillators*

Cite This Article: Manoj Kumar Jain, V. K. Singh, and Raj Senani, "A Bibliography of the Work Done on Externally-Linear-Internally-Nonlinear Circuits during 1979-2014." *American Journal of Electrical and Electronic Engineering*, vol. 3, no. 3 (2015): 64-71. doi: 10.12691/ajeec-3-3-1.

1. A Brief Overview of ELIN Circuits

The log-domain circuits are based on natural logarithmic relation between the voltage and current of diodes and between base-emitter voltage and collector current of bipolar junction transistors. The first log-domain filter circuit was proposed by Adams in 1979 [1]. Adams conceived the first ever log-domain filter as a circuit, composed of both linear and non-linear elements, which, when placed between a log converter and an anti-log converter (in the 'log-domain'), caused the system to act as a linear filter. Thus, Adams circuit was also the first externally linear and internally nonlinear (ELIN) circuit, demonstrating the compressing and expanding (companding) technique.

The log-domain filters are also recognized as translinear (TL) filters. The TL filters are essentially dynamic translinear circuits, which are based upon the *dynamic translinear principle* which is inherited from the conventional *static translinear principle*, formulated by Gilbert in 1977 [2].

The last few decades have witnessed considerable interest of researchers in realising linear analog signal processing employing ELIN circuits. A number of ELIN circuits are realized by using companding techniques. Tsividis [3] showed the advantages of syllabic companding in signal processing. The log-domain circuits, dynamic translinear circuits, square-root-domain circuits

and syllabically companding filters all are the subsets of ELIN circuits.

The TL filter concept was reinvented in 1990 by Seevinck [4] who coined the term *Current-mode companding* and also introduced the first class-AB integrator. Both Adams [1] and Seevinck [4] however, proposed first-order filters and hence, these ideas unfortunately, did not attract the required attention of the researchers for many years. The idea of log-domain filtering actually took off in 1993, when Frey [5] demonstrated that higher-order log-domain filters can be systematically synthesized using state-space techniques, in which BJTs were directly used to realize the log-domain filters by mapping from state-space linear differential equations. Furthermore, Frey also proposed 'Exponential State-space Filters' in [6], and showed that this technique is also suitable for high frequency applications [9]. After that many researchers started taking interest in log-domain/translinear circuits. In 1994, Toumazou, Ngarmnil and Lande [7] proposed the first log-domain filters for implementation in MOS technology. However, the first experimental results of log-domain filters were published by Perry and Roberts in [12] in 1995 who also proposed an alternative synthesis method based on the simulation of LC ladder filters. The first experimental results of MOSFET-based circuit were presented by Ngarmnil, Toumazou and Lande [11] in 1995. On the other hand, the first application of the underlying design principle for the realization of an oscillator was proposed in 1995 by Pookaiyaudom and Mahattanakul [10].

In syllabic companding, the gains of the compressor and expander are adjusted according to slowly varying characteristic of the signal envelope or power [3,14,87].

Log-domain or dynamic translinear circuits are the examples of instantaneous companding circuits but the true instantaneous companding in log domain circuits is required to operate in class B or class AB [4,8,23,31,49,67,69,72,74,77,81,84,91,92,94,125,126,40,153,171,181,187,191]. Both the type of circuits are suitable to implement linear and nonlinear differential equations and several synthesis approaches have been advanced by the various researchers on their own preferences such as, the state-space methods as in [5,8,13,19,50,51,64,66,77,156,160,171,186,181,188], wave active filter concepts as in [131,164,173,203], signal flow graph based approaches as in [12,22,52,53,110], leap frog designs as in [38,158,173], synthesis based on Bernoulli operator as in [33,64,68,79], modular design approaches as in [35,70], linear transformation based methods as in [21,152,175], approaches based upon simulation of LC ladders as in [22,52,97,142,154,164,166,195], unified matrix method as in [96,133], Taylor series based design as in [73], image parameter methods as in [44] and Impedance scaling based method as in [195].

Initially, log-domain circuits employed only BJTs and capacitors but subsequently it was recognized that such circuits may also be realized by using MOS transistors as well when they are operated in subthreshold region or weak inversion, as in [7,47,65,69,71,74,80,86,89,94,97,118,136,137,139], BiCMOS technology as in [11,16,31,32,44,46,69,138,177,178], using lateral bipolar transistors as in [95], using floating gate MOS (FGMOS) transistors as in [125,126,129,165,191] and using multiple input translinear elements as in [99,135]. Researchers have also found scope of using Darlington topology in log-domain circuits to improve gain [151].

Many different approximation techniques have so far been used to realize log domain/translinear filters such as Chebyshev [12,16,22,31,46,53,84,86,97,154,157], Elliptic [21,22,110,181], Bessel [162,179] and Butterworth [38,58,132]. These filters have been realized by using the cascaded-biquads approach, methods based upon simulation of LC ladders or using multiple-feedback topologies. Besides filters and oscillators, work has also been done on realizing integrators [15,17,26,38,43,72,194] and differentiators [15,108] which are the basic building blocks of analog circuit synthesis.

Apart from normal filter realization techniques, researchers have also given attention on filters using common mode feedback topology [130], multiple feedback follow the leader feedback (FLF) topology [49,168], inverse-follow-the leader-feedback approach [53] and wavelet based filter designs [113,143,170].

Other than conventional filters, such as those presented in [146,187], the log-domain/dynamic translinear techniques have also been used in a number of other applications, such as realization of oscillators [10,13,27,32,56,67,92,101,119,169,189,197,205,211], PLL [32,60], RF applications [19], syllabic companding filters [36,42,58,102], RMS detectors [18,147], RMS-DC converters [24,30,41,62,177,204], $\Sigma\Delta$ A/D converters [122], pulse duration modulation (PDM) circuits [114] and adaptive filters [28,111,129,140,165,201].

A number of researchers have also carried out noise analysis and the analysis of other second order

effects/transistor non-idealities; for instance, see [34,37,45,48,50,55,59,61,75,78,81,83,106,109,116,182,199,202].

The circuits containing MOS transistors operating in the quasi-quadratic law (or strong inversion) are called square-root domain circuits [25,57,124]. Exponential State-Space circuits [6,9,23], Sinh domain circuits [6,23,167], Tanh domain circuits [6,23,167], circuits with Piecewise-Linearization [63] and the circuits having voltage dependent capacitors [63] are few more examples of ELIN circuits.

In conclusion, the log-domain/translinear circuits have attracted a great deal of technological interest. Such circuits are useful for realizing high performance current mode linear and nonlinear signal processing and are highly suitable for VLSI implementation because of employing only transistors and capacitors and offering several of the following advantages such as electronic tunability of the parameters of the realized functions, use of low-voltage supply voltages, low-power consumption, extended dynamic range, low noise, low third order intermodulation distortion and low total harmonic distortion, etc.

It is hoped that the bibliography presented in this communication should be useful to research scholars, educators, students, practicing engineers and anybody who is interested in knowing about the current state of the art of log domain, translinear and square root domain circuits and their applications.

References

- [1] Adams, R.W., "Filtering in the Log-domain", *Preprint #1470 presented at the 63rd AES conference*, New York, NY, 1979.
- [2] Gilbert, B., "Translinear circuits: A proposed classification", *Electronics Letters*, 11 (1), 14-16, 1975.
- [3] Tsvividis, Y.P., Gopinathan, V. and Tóth, L., "Companding in signal processing", *Electronics Letters*, 26 (17), 1331-1332, 1990.
- [4] Seevinck, E., "Companding current-mode integrator: A new circuit principle for continuous-time monolithic filters", *Electronics Letters*, 26 (24), 2046-2047, 1990.
- [5] Frey, D.R., "Log-domain filtering: An approach to current-mode filtering", *IEE Proceedings G Circuits, Devices and Systems*, 140 (6), 406-416, 1993.
- [6] Frey, D.R., "A general class of current mode filters", *IEEE International Symposium on Circuits and Systems (ISCAS'93)*, 2, 1435-1438, 1993.
- [7] Toumazou, C., Ngarmnil, J. and Lande, T.S., "Micropower log-domain filter for electronic cochlea", *Electronics Letters*, 30 (22), 1839-1841, Oct. 1994.
- [8] Frey, D., "Current-mode class AB second order filter", *Electronics Letters*, 30 (3), 205-206, 1994.
- [9] Frey, D., "A 3.3 volt electronically tunable active filter usable to beyond 1 GHz", *International Symposium on Circuits and Systems (ISCAS'94)*, 5, 493-496, 1994.
- [10] Pookaiyaudom, S. and Mahattanakul, J., "A 3.3 volt high-frequency capacitor-less electronically-tunable log-domain oscillator", *International Symposium on Circuits and Systems (ISCAS'95)*, 2, 829-832, 1995.
- [11] Ngarmnil, J., Toumazou, C. and Lande, T.S., "A fully tuneable micropower log-domain filter", *Twenty-first European Solid-State Circuit Conference (ESSCIRC'95)*, Lille, France, 86-89, 19-21 Sep., 1995.
- [12] Perry, D. and Roberts, G.W., "Log-domain filters based on LC ladder synthesis", *Proceeding of the IEEE International Symposium on Circuits and Systems (ISCAS '95)*, Seattle, WA, 1, 311-314, 30 Apr.-3May, 1995.
- [13] Thanachayanont, A., Pookaiyaudom, S. and Toumazou C., "State-space synthesis of log-domain oscillators", *IET Electronics Letters*, 31 (21), 1797-1799, 1995.

- [14] Tsvividis, Y., "General approach to signal processors employing companding", *Electronics Letters*, 31 (18), 1549-1550, 1995.
- [15] Tsvividis, Y., "On linear integrators and differentiators using instantaneous companding", *IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing*, 42 (8), 561-564, 1995.
- [16] Punzenberger, M. and Enz, C., "A new 1.2 V BiCMOS log-domain integrator for companding current-mode filters", *IEEE International Symposium on Circuits and Systems (ISCAS '96) Connecting the World, Atlanta, GA*, 1, 125-128, 12-15 May, 1996.
- [17] Fried, R., Python, D. and Enz, C.C., "Compact log-domain current mode integrator with high transconductance-to-bias current ratio", *Electronics Letters*, 32 (11), 952-953, 1996.
- [18] Frey, D.R., "Explicit log domain root-mean-square detector", *United States Patent*, 1996.
- [19] Frey, D.R., "Log domain filtering for RF applications", *IEEE Journal Solid-State Circuits*, 31 (10), 1468-1475, 1996.
- [20] Ngarmnil, J. and Toumazou, C., "Micro power log-domain active inductor", *Electronics Letters*, 32 (11), 953-955, 1996.
- [21] Liu, S.I. and Liao, Y.H., "Table-based log-domain linear transformation filter", *Electronics Letters*, 32 (19), 1771-1772, 1996.
- [22] Perry, D. and Roberts, G.W., "The design of log-domain filters based on the operational simulation of LC ladders", *IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing*, 43 (11), 763-774, 1996.
- [23] Frey, D., "Exponential state space filters: A generic current mode design strategy", *IEEE Transaction on Circuits and Systems I: Fundamental Theory and Applications*, 43 (1), 34-42, 1996.
- [24] Mulder, J., van der Woerd, A.C., Serdijn, W.A. and van Roermund, A.H.M., "An RMS-DC converter based on the dynamic translinear principle", *Proceeding of the 22nd European Solid-State Circuits Conference (ESSCIRC'96), Neuchatel, Switzerland*, 17-19 Sept., 1996.
- [25] Mulder, J., van der Woerd, A.C., Serdijn, W.A. and van Roermund, A.H.M., "Current-mode companding \sqrt{x} -domain integrator", *Electronics Letters*, 32 (3), 198-199, 1996.
- [26] Mahattanakul, J., Toumazou, C. and Pookaiyaudom, S., "Low-distortion current-mode companding integrator operating at f_T of BJT", *Electronics Letters*, 32 (21), 2019-2021, 1996.
- [27] van der Woerd, A.C., Mulder, J., Serdijn, W.A. and van Roermund, A.H.M., "Recent trends in translinear circuits", in *Proc. Electronics-ET'96, Sozopol, Bulgaria*, 1, 14-21, 1996.
- [28] Frey, D.R. and Steigerwald, L., "An adaptive analog notch filter using log filtering", *IEEE International Symposium on Circuits and Systems (ISCAS'96) Connecting the World, Atlanta, GA*, 1, 297-300, 12-15 May, 1996.
- [29] Frey, D.R., "Log-filtering using gyrators", *Electronics Letters*, 30 (1), 26-28, 1996.
- [30] Mulder, J., Serdijn, W.A., van der Woerd, A.C., and van Roermund, A.H.M., "Dynamic translinear RMS-DC converter", *Electronics Letters*, 32 (22), 2067-2068, 1996.
- [31] Punzenberger, M. and Enz, C.C., "A 1.2-V low-power BiCMOS class AB log-domain filter", *IEEE Journal Solid-State Circuits*, 32 (12), 1968-1978, 1997.
- [32] Thanachayanont, A., Payne, A. and Pookaiyaudom, S., "A current-mode phase-locked loop using a log-domain oscillator", *Proceedings of the IEEE International Symposium on Circuits and Systems (ISCAS '97)*, 1, 277-280, 9-12 Jun., 1997.
- [33] Drakakis, E.M., Payne, A.J. and Toumazou, C., "Bernoulli operator: a low-level approach to log-domain processing", *Electronics Letters*, 33 (12), 1008-1009, 1997.
- [34] Leung, V.W., El-Gamal M. and Roberts, G.W., "Effects of transistor non-idealities on log-domain filters", *Proceedings of IEEE International Symposium on Circuits and Systems (ISCAS '97)*, 1, 109-112, 9-12 Jun., 1997.
- [35] Mahattanakul, J. and Toumazou, C., "Modular log-domain filters", *Electronics Letters*, 33 (13), 1130-1131, 1997.
- [36] Frey, D.R. and Tsvividis, Y.P., "Syllabically companding log domain filter using dynamic biasing", *Electronics Letters*, 33 (18), 1506-1507, 1997.
- [37] Mulder, J., van der Woerd, A.C., Serdijn, W.A. and van Roermund, A. H. M., "General current-mode analysis method for translinear filters", *IEEE Transaction on Circuits and Systems I: Fundamental Theory and Applications*, 44 (3), 193-197, 1997.
- [38] Serdijn, W.A., Broest, M., Mulder, J., van der Woerd, A.C. and van Roermund, A.H.M., "A low-voltage ultra-low-power translinear integrator for audio filter applications", *IEEE Journal of Solid-State Circuits*, 32 (4), 577-581, 1997.
- [39] Payne, A. and Thanachayanont, A., "Translinear circuit for phase detection", *Electronics Letters*, 33 (18), 1507-1509, 1997.
- [40] Tsvividis, Y., "Externally linear, time-invariant systems and their application to companding signal processors", *IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing*, 44 (2), 65-85, 1997.
- [41] Mulder, J., van der Woerd, A.C., Serdijn, W.A. and van Roermund, A.H.M., "An RMS-DC converter based on the dynamic translinear principle", *IEEE Journal of Solid-State Circuits*, 32 (7), 1146-1150, 1997.
- [42] Mulder, J., Serdijn, W.A., van der Woerd, A.C. and van Roermund, A. H. M., "A syllabic companding translinear filter", *Proceeding of IEEE International Symposium on Circuits and Systems (ISCAS'97)*, 1, 101-104, 9-12 Jun., 1997.
- [43] Mahattanakul, J. and Toumazou, C., "Instantaneous companding and expressing: A dual approach to linear integrator synthesis", *Electronics Letters*, 33 (1), 4-5, 1997.
- [44] Ruymbeke, G. van, Enz, C., Krummenacher, F. and Declercq, M., "A BiCMOS programmable continuous-time filter using image-parameter method synthesis and voltage-companding technique", *IEEE Journal of Solid-State Circuits*, 32 (3), 377-387, 1997.
- [45] Mulder, J., Kouwenhoven, M.H.L. and van Roermund, A.H.M., "Signal x noise intermodulation in translinear filters", *Electronics Letters*, 33 (14), 1205-1207, 1997.
- [46] Punzenberger, M. and Enz, C.C., "A compact low-power BiCMOS log-domain filter", *IEEE Journal Solid-State Circuits*, 33 (7), 1123-1129, 1998.
- [47] Germanovix, W., O'Neill, G., Toumazou, C., Drakakis, E.M., Kitney, R.I. and Lande, T.S., "Analogue micro powered log-domain tone controller for auditory prostheses", *Electronics Letters*, 34 (11), 1051 - 1052, 1998.
- [48] Fox, R.M., "Design-oriented analysis of log-domain circuits", *IEEE Transactions Circuits and Systems II: Analog and Digital Signal Processing*, 45 (7), 918-921, 1998.
- [49] Punzenberger, M. and Enz, C., "Log-domain filters for low-voltage low-power applications", *IEEE International Conference on Electronics, Circuits and Systems, Lisboa*, 1, 41-44, 1998.
- [50] Frey, D.R., "State-space synthesis and analysis of log-domain filters", *IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing*, 45 (9), 1205-1211, 1998.
- [51] Frey, D.R., "Synthesis of distortion compensated log-domain filters using state space techniques", *Proceedings of the IEEE International Symposium on Circuits and Systems (ISCAS '98), Monterey, CA*, 1, 321-324, 31 May-3 Jun., 1998.
- [52] El-Gamal, M. and Roberts, G.W., "Very high-frequency log-domain band pass filters", *IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing*, 45 (9), 1188-1198, 1998.
- [53] Wu, J. and El-Masry, E.I., "Log-domain synthesis of an nth-order filter", *International Journal of Electronics*, 84 (4), 359-369, 1998.
- [54] Brandtner, T., Papatthanasious, K. and Hamilton, A., "Palmo cell using sampled data log-domain integrators", *Electronics Letters*, 34 (8), 733-735, 1998.
- [55] Mulder, J., Kouwenhoven, M.H.L., Serdijn, W.A., van der Woerd, A.C. and van Roermund, A.H.M., "Noise considerations for translinear filters", *IEEE Transaction on Circuits and Systems II: Analog and Digital Signal Processing*, 45 (9), 1199-1204, 1998.
- [56] Serdijn, W.A., Mulder, J., van der Woerd, A.C. and van Roermund, A.H.M., "A wide-tunable translinear second-order oscillator", *IEEE Journal of Solid-State Circuits*, 33 (2), 195-201, 1998.
- [57] Mulder, J., Serdijn, W.A., van der Woerd, A.C. and van Roermund, A.H.M., "A 3.3 V current-controlled $\sqrt{\cdot}$ -domain oscillator", *Analog Integrated Circuits and Signal Processing*, 16 (1), 17-28, 1998.
- [58] Mulder, J., Serdijn, W.A., van der Woerd, A.C. and van Roermund, A.H.M., "An instantaneous and syllabic companding translinear filter", *IEEE Transactions on Circuits and Systems I: Fundamental Theory and Applications*, 45 (2), 150-154, 1998.
- [59] Tóth, L., Tsvividis, Y.P. and Krishnapura, N., "On the analysis of noise and interference in instantaneously companding signal processors", *IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing*, 45 (9), 1242-1249, 1998.
- [60] Payne, A., Thanachayanont, A. and Papavassiliou, C., "A 150-MHz translinear phase-locked loop", *IEEE Transactions on*

- Circuits and Systems II: Analog and Digital Signal Processing*, 45 (9), 1220-1231, 1998.
- [61] Kouwenhoven, M.H.L., Mulder, J. and van Roermund A.H.M., "Noise analysis of dynamically nonlinear translinear circuits", *Electronics Letters*, 34 (8), 705-706, 1998.
- [62] Surakamponorn, W. and Kumwachara, K., "A dual translinear based true RMS to DC converter", *IEEE Transactions on Instrumentation and Measurement*, 47 (2), 459-464, 1998.
- [63] Tsvividis, Y.P., "Externally linear integrators," *IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing*, 45 (9), 1181-1187, 1998.
- [64] Drakakis, E.M., Payne, A.J. and Toumazou, C., "Log-domain state-space": a systematic transistor-level approach for log-domain filtering", *IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing*, 46 (3), 290-305, 1999.
- [65] El-Masry, E.I. and Wu, J., "CMOS micropower universal log-domain biquad", *IEEE Transactions Circuits and Systems I: Fundamental Theory and Applications*, 46 (3), 389-392, 1999.
- [66] Frey, D., "Distortion compensation in log-domain filters using state-space techniques", *IEEE Transactions Circuits and Systems II: Analog and Digital Signal Processing*, 46 (7), 860-869, 1999.
- [67] Ferrer, E. and Fox, R.M., "Limit-cycle oscillations in a log-domain-based filter", *IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing*, 46 (6), 832-836, 1999.
- [68] Drakakis, E.M., Payne, A.J. and Toumazou, C., "Log-domain filtering and the Bernoulli cell", *IEEE Transactions on Circuits and Systems I: Fundamental Theory and Applications*, 46 (5), 559-571, 1999.
- [69] Enz, C., Punzenberger, M. and Python, D., "Low-voltage log-domain signal processing in CMOS and BiCMOS", *IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing*, 46 (3), 279-289, 1999.
- [70] Mahattanakul, J. and Toumazou, C., "Modular log-domain filters based upon linear Gm-C filter synthesis", *IEEE Transactions on Circuits and Systems I: Fundamental Theory and Applications*, 46 (12), 1421-1430, 1999.
- [71] Fox, R.M. and Nagarajan, M., "Multiple operating points in a CMOS log-domain filter", *IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing*, 46 (6), 705-710, 1999.
- [72] Poort, P.J., Serdijn, W.A., Mulder, J., van der Woerd, A.C. and van Roermund, A.H.M., "A 1-V Class-AB Translinear Integrator for Filter Applications", *Analog Integrated Circuits and Signal Processing*, 21 (1), 79-90, 1999.
- [73] Abuelmáatti, M.T. and Abed, S.M., "A translinear circuit for analogue function synthesis based on a Taylor series", *International Journal Electronics*, 86 (11), 1341-1348, 1999.
- [74] Serdijn, W.A., Kouwenhoven, M.H.L., Mulder, J. and van Roermund, A.H.M., "Design of high dynamic range fully integratable translinear filters", *Analog Integrated Circuits and Signal Processing*, 19 (3), 223-239, 1999.
- [75] Mulder, J., Kouwenhoven, M.H.L., Serdijn, W.A. and van der Woerd, A.C., "Nonlinear analysis of noise in static and dynamic translinear circuits", *IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing*, 46 (3), 266-278, 1999.
- [76] Seevinck, E., Vittoz, E.A., du Plessi, M. and Joubert, T.H., "CMOS translinear circuits for minimum supply voltage", *IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing*, 47 (12), 1560-1564, 1999.
- [77] Frey, D.R. and Tola, A.T., "A state-space formulation for externally linear class AB dynamical circuits," *IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing*, 46 (3), 306-314, 1999.
- [78] Leung, V.W. and Roberts, G.W., "Analysis and Compensation of Log-Domain Biquadratic Filter Response Deviations due to Transistor Non-idealities", *Analog Integrated Circuits and Signal Processing*, 22 (2-3), 147-162, 2000.
- [79] Drakakis, E.M. and Payne, A.J., "A Bernoulli Cell-Based Investigation of the Non-Linear Dynamics in Log-Domain Structures", *Analog Integrated Circuits and Signal Processing*, 22 (2-3), 127-146, 2000.
- [80] Fragnière, E., Vittoz, E. and van Schaik, A., "A Log-Domain CMOS Transcapacitor: Design, Analysis and Applications", *Analog Integrated Circuits and Signal Processing*, 22 (2-3), 195-208, 2000.
- [81] Tola, A.T. and Frey, D.R., "A Study of Different Class AB Log Domain First Order Filters", *Analog Integrated Circuits and Signal Processing*, 22 (2-3), 163-176, 2000.
- [82] Germanovix, W. and Toumazou, C., "Design of a micropower current-mode log-domain analog cochlear implant", *IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing*, 47 (10), 1023-1046, 2000.
- [83] Leung, V.W. and Roberts, G.W., "Effects of transistor nonidealities on high-order log-domain ladder filter frequency responses", *IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing*, 47 (5), 373-387, 2000.
- [84] El-Masry, E.I. and Wu, J., "Fully Differential Class-AB Log-Domain Integrator", *Analog Integrated Circuits and Signal Processing*, 25 (1), 35-46, 2000.
- [85] Frey, D., "Future implications of the log domain paradigm", *IEEE Proceedings - Circuits, Devices and Systems*, 147 (1), 65-72, 2000.
- [86] El-Masry, E.I. and Wu, J., "Low Voltage Micropower Log-Domain Filters", *Analog Integrated Circuits and Signal Processing*, 22 (2-3), 209-220, 2000.
- [87] Krishnapura, N., Tsvividis, Y. and Frey, D.R., "Simplified technique for syllabic companding in log-domain filters", *Electronics Letters*, 36 (15), 1257-1259, 2000.
- [88] Edwards R.T. and Cauwenberghs, G., "Synthesis of Log-Domain Filters from First-Order Building Blocks", *Analog Integrated Circuits and Signal Processing*, 22 (2-3), 177-186, 2000.
- [89] Masmoudi, D., Serdijn, W.A., Mulder, J., van der Woerd, A.C., Tomas, J. and Dom, J.P., "A new current-mode synthesis method for dynamic translinear filters and its applications in hearing instruments", *Analog Integrated Circuits and Signal Processing*, 22, 221-229, 2000.
- [90] Mulder, J., Serdijn, W.A., van der Woerd, A.C. and van Roermund, A.H.M., "Dynamic Translinear Circuits-An Overview", *Research Perspectives on Dynamic Translinear and Log-Domain Circuits, Analog Integrated Circuits and Signal Processing*, 22 (2-3), 5-20, 2000.
- [91] El-Gamal, N.M., Baki, R.A. and Bar-Dor, A., "30-100-MHz NPN-only variable-gain class-AB instantaneous companding filters for 1.2-V applications", *IEEE Journal of Solid-State Circuits*, 35 (12), 1853-1864, 2000.
- [92] Mahattanakul, J. and Toumazou, C., "Instantaneous companding current-mode oscillator based on class-AB transconductor", *Analog Integrated Circuits and Signal Processing*, 23 (1), 57-64, 2000.
- [93] Tóth, L., Efthivoulidis, G. and Tsvividis, Y.P., "Noise analysis of externally linear systems", *IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing*, 47 (12), 1365-1377, 2000.
- [94] Python, D. and Enz, C.C., "A micropower class-AB CMOS log-domain filter for DECT applications", *IEEE Journal of Solid-State Circuits*, 36 (7), 1067-1075, 2001.
- [95] Krishnapura, N. and Tsvividis, Y., "A micropower log-domain filter using enhanced lateral PNPs in a 0.25 μm CMOS process", *IEEE Symposium on VLSI Circuits, Digest of Technical Papers, Kyoto, Japan*, 179-182, 14-15 Jun., 2001.
- [96] Ng, A.E.J., Sewell, J.I., Drakakis, E.M., Payne and A.J., Toumazou, C., "A unified matrix method for systematic synthesis of log-domain ladder filters", *Proceedings of the IEEE International Symposium on Circuits and Systems (ISCAS 2000) Sydney, NSW*, 1, 149-152, 6-9 May, 2001.
- [97] Li S., Wang Y. and Wu, J., "Design of low-voltage and low-power fully integrated filter based on log-domain current-mode integrator", *Journal of Electronics (China)*, 18 (4), 346-350, 2001.
- [98] Fox, R.M., Ko, H.J. and Eisenstadt, W.R., "Dynamic Current Requirements in Single-Ended Log-Domain Filters", *Analog Integrated Circuits and Signal Processing*, 28 (1), 73-81, 2001.
- [99] Minch, B.A., "Multiple-input translinear element log-domain filters", *IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing*, 48 (1), 29-36, 2001.
- [100] Mahon, A. and Feely, O., "Nonlinear dynamics of log-domain circuit", *Electronics Letters*, 37 (15), 929-930, 2001.
- [101] Özoğuz, S., "Simple log-domain chaotic oscillator", *Electronics Letters*, 37 (23), 1378-1379, 2001.
- [102] Frey, D., Tsvividis, Y.P., Efthivoulidis, G. and Krishnapura, N., "Syllabic-companding log domain filters", *IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing*, 48 (4), 329-339, 2001.
- [103] Mulder, J., Serdijn, W.A., van der Woerd, A.C. and van Roermund, A.H.M., "A generalized class of dynamic translinear circuits", *IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing*, 48 (5), 501-504, 2001.

- [104] Diepstraten, F.M., Kuijstermans, F.C.M., Serdijn, W.A., van der Kloet P., van Staveren, A., Neerhoff, F.L., Verhoeven, C.J.M. and van Roermund, A.H.M., "Dynamic Behavior of Dynamic Translinear Circuits: the Linear Time-Varying Approximation", *IEEE Transaction on Circuits and Systems I: Fundamental Theory and Applications*, 48 (11), 1333-1337, 2001.
- [105] López-Martin, A.J. and Carlosena, A., "Systematic Design of Companding Systems by Component Substitution", *Analog Integrated Circuits and Signal Processing*, 28 (1), 91-106, 2001.
- [106] Efthivoulidis, G., Tóth, L. and Tsvividis, Y., "Noise in externally linear filters", *Analog Integrated Circuits and Signal Processing*, 28 (1), 63-72, 2001.
- [107] El-Gamal, M.N. and Roberts, G.W., "A 1.2-V n-p-n-only integrator for log-domain filtering", *IEEE Transactions Circuits and Systems II: Analog and Digital Signal Processing*, 49 (4), 257-265, 2002.
- [108] Vlassis S. and Psychalinos. C., "A Novel Log-Domain Differentiator", *Analog Integrated Circuits and Signal Processing*, 32 (3), 285-287, 2002.
- [109] Ng, A.E.J. and Sewell, J.I., "Direct noise analysis of log-domain filters", *IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing*, 49 (2), 101-109, 2002.
- [110] Psychalinos, C. and Vlassis, S., "On the exact realization of LOG-domain elliptic filters using the signal flow graph approach", *IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing*, 49 (12), 770-774, 2002.
- [111] McDonald, E.J. and Minch, B.A., "Synthesis of a translinear analog adaptive filter", *Proceeding of the IEEE International Symposium on Circuits and Systems (ISCAS 2002)*, Phoenix-Scottsdale, AZ, 3, III-321-III-324, 26-29 May, 2002.
- [112] López-Martin, A.J. and Carlosena, A., "1.5 V CMOS companding filter", *Electronics Letters*, 38 (22), 1346-1348, 2002.
- [113] Haddad, S.A.P., Houben, R. and Serdijn, W.A., "First derivative Gaussian wavelet function employing dynamic translinear circuits for cardiac signal characterization", *Proceedings of the ProRISC Workshop on Circuits, Systems and Signal Processing, Veldhoven, the Netherlands*, 288-291, 28-29 Nov., 2002.
- [114] Serra-Graells, F. and Huertas, J.L., "1 V CMOS Subthreshold Log Domain PDM", *Analog Integrated Circuits and Signal Processing*, 34 (3), 183-187, 2003.
- [115] Baki, R.A. and El-Gamal, M.N., "A low-power 5-70-MHz seventh-order log-domain filter with programmable boost, group delay, and gain for hard disk drive applications", *IEEE Journal of Solid-State Circuits*, 38 (2), 205-215, 2003.
- [116] Baki, R.A., Beainy, C. and El-Gamal, M.N., "Distortion analysis of high-frequency log-domain filters using Volterra series", *IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing*, 50 (1), 1-11, 2003.
- [117] Serrano-Gotarredona, T. and Linares-Barranco, B., "Log-domain implementation of complex dynamics reaction-diffusion neural networks", *IEEE Transactions on Neural Networks*, 14 (5), 1337-1355, 2003.
- [118] Grech, I., Micallef, J. and Vladimirova, T., "Low-Power Log-Domain CMOS Filter Bank for 2-D Sound Source Localization", *Analog Integrated Circuits and Signal Processing*, 36 (1-2), 99-117, 2003.
- [119] Özoğuz, S. and Sengör, N.S., "On the realization of NPN-only log-domain chaotic oscillators", *IEEE Transactions on Circuits and Systems I: Fundamental Theory and Applications*, 50 (2), 291-294, 2003.
- [120] Drakakis, E.M. and Burdett, A.J., "Operational DC constraints for a class-A, third-order, observer canonical-form log-domain filter", *IEEE Transactions on Circuits and Systems I: Fundamental Theory and Applications*, 50 (10), 1337-1342, 2003.
- [121] Drakakis, E.M. and Burdett, A.J., "Spectral impact of the modulation index upon internal log-domain currents", *IEEE Transactions on Circuits and Systems I: Fundamental Theory and Applications*, 50 (10), 1343-1347, 2003.
- [122] Serra-Graells, F., "1 V all-MOS $\Sigma\Delta$ A/D converters in the log-domain", *Analog Integrated Circuits and Signal Processing*, 35, 47-57, 2003.
- [123] Minch, B.A., "Construction and transformation of multiple-input translinear element networks", *IEEE Transactions on Circuits and Systems I: Fundamental Theory and Applications*, 50 (12), 1530-1537, 2003.
- [124] De La Cruz-Blas, C.A., Lopez-Martin, A. and Carlosena, A., "1.5-V MOS translinear loops with improved dynamic range and their applications to current-mode signal processing", *IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing*, 50 (12), 918-927, 2003.
- [125] López-Martín, A.J., Fernández, R., de la Cruz Blas, C.A. and Carlosena, A., "A 1 V Micropower FGMOS Class AB Log-Domain Filter", *Analog Integrated Circuits and Signal Processing*, 41 (2-3), 137-145, 2004.
- [126] Rodriguez-Villegas, E., Yufera, A. and Rueda, A., "A 1-V micropower log-domain integrator based on FGMOS transistors operating in weak inversion", *IEEE Journal of Solid-State Circuits*, 39 (1), 256-259, 2004.
- [127] Gerosa, A., Maniero, A. and Neviani, A., "A fully integrated dual-channel log-domain programmable preamplifier and filter for an implantable cardiac pacemaker", *IEEE Transactions on Circuits and Systems I: Regular Papers*, 51 (10), 1916-1925, 2004.
- [128] Serra-Graells, F., Gómez, L. and Huertas, J.L., "A true-1-V 300- μ W CMOS-subthreshold log-domain hearing-aid-on-chip", *IEEE Journal of Solid-State Circuits*, 39 (8), 1271-1281, 2004.
- [129] Abshire, P.A., Wong, E.L., Yiming, Z. and Cohen, M.H., "Adaptive log domain filters using floating gate transistors", *Proceedings of the IEEE International Symposium on Circuits and Systems (ISCAS '04)*, 1, 1-29 - 1-32, 23-26 May, 2004.
- [130] Fox, R.M., Ko, H.J. and Eisenstadt, W.R., "Differential log-domain filters with high-gain common-mode feedback", *IEEE Transactions on Circuits and Systems I: Regular Papers*, 51 (2), 254-263, 2004.
- [131] Psychalinos, C., Fragoulis, N. and Haritantis, I., "Log-domain wave filters", *IEEE Transactions on Circuits and Systems II: Express Briefs*, 51 (6), 299-306, 2004.
- [132] Fragoulis, N., Psychalinos, C. and Haritantis, I., "Modular log-domain filters realized using wave port terminators", *IEEE Transactions Circuits and Systems I: Regular Papers*, 55 (11), 2235-2244, 2004.
- [133] Ng, A.E.J., Teplechuk, M.A. and Sewell, J.I., "Unified matrix method for systematic synthesis of log-domain ladder filters", *IEE Proceedings - Circuits, Devices and Systems*, 151 (4), 285-293, 2004.
- [134] De La Cruz-Blas, C.A., Lopez-Martin, A.J. and Carlosena, A., "Low-voltage CMOS nonlinear transconductors and their application to companding current-mode filters", *Analog Integrated Circuits and Signal Processing*, 38 (2-3), 137-147, 2004.
- [135] Minch, B.A., "Synthesis of static and dynamic multiple-input translinear element networks", *IEEE Transactions on Circuits and Systems I: Regular Paper*, 51 (2), 409-421, 2004.
- [136] Serra-Graells, F., Rueda, A. and Huertas, J.L., "Low-voltage CMOS log-companding techniques for audio applications", *Analog Integrated Circuits and Signal Processing*, 38 (2-3), 121-135, 2004.
- [137] López-Martín, A.J., De La Cruz-Blas, C.A. and Carlosena, A., "1.2-V 5- μ W class-AB CMOS log-domain integrator with multidecade tuning", *IEEE Transactions on Circuits and Systems II: Express Briefs*, 52 (10), 665-668, 2005.
- [138] Halvorsrød, T., Luzzi, W. and Lande, T.S., "A log-domain μ beamformer for medical ultrasound imaging systems", *IEEE Transactions on Circuits and Systems I: Regular Papers*, 52 (12), 2563-2575, 2005.
- [139] Shoemaker, P., "A Methodology for Long Time Constant Log-Domain Filters in CMOS", *Analog Integrated Circuits and Signal Processing*, 42 (2), 161-178, 2005.
- [140] Zaghoul, K.A. and Boahen, K.A., "An ON-OFF log domain circuit that recreates adaptive filtering in the retina", *IEEE Transactions on Circuits and Systems I: Regular Papers*, 52 (1), 99-107, 2005.
- [141] Tola, A.T., Arslanalp, R. and Yilmaz, S.S., "Design of current mode, low voltage and electronically tunable class AB differential type KHN filter in the log domain", *Proceedings of the IEEE 13th Signal Processing and Communications Applications Conference*, 131-134, 16-18 May, 2005.
- [142] Kontogiannopoulos, N. and Psychalinos, C., "Log-domain filtering by simulating the topology of passive prototypes", *IEEE Transactions on Circuits and Systems I: Regular Papers*, 52 (10), 2043-2054, 2005.
- [143] Haddad, S.A.P., Bagga, S. and Serdijn, W.A., "Log-domain wavelet bases", *IEEE Transactions on Circuits and Systems I: Regular Papers*, 52 (10), 2023-2032, 2005.
- [144] Serra-Graells, F. and Huertas, J.L., "Low-Voltage CMOS subthreshold log-domain filtering", *IEEE Transactions on Circuits and Systems I: Regular Papers*, 52 (10), 2090-2100, 2005.

- [145] Ascoli, A., Mahon, A. and Feely, O., "Nonlinear dynamics of first- and second-order log-domain circuits", *IEEE Transactions on Circuits and Systems I: Regular Papers*, 52 (7), 1372-1381, 2005.
- [146] Tola, A.T., Arslanalp, R. and Yilmaz, S.S., "A design of differential type class AB Tow-Thomas filter in the log domain", *International conference on electrical and electronics engineering, Bursa, Turkey*, 105-109, 7-11 Dec., 2005.
- [147] Qizhang, Y., Eisenstadt, W.R., Fox, R.M. and Tao, Z., "A translinear RMS detector for embedded test of RF ICs", *IEEE Transaction on Instrument and Measurement*, 54 (5), 1708-1714, 2005.
- [148] Kircay, A. and Cam, U., "A novel first-order log-domain allpass filter", *AEU - International Journal of Electronics and Communications*, 60 (6), 471-474, 2006.
- [149] Hamilton, T.J., Jin, C. and van Schaik, A., "An analysis of matching in the Tau cell log-domain filter", *Proceedings of the IEEE International Symposium on Circuits and Systems (ISCAS 2006), Island of Kos*, 421-424, 21-24 May, 2006.
- [150] Teplechuk, M.A. and Sewell, J.I., "Approximation of arbitrary complex filter responses and their realisation in log domain", *IEE Proceedings Circuits, Devices and Systems*, 153 (6), 583-590, 2006.
- [151] Arslanalp, R. and Tola, A.T., "By Using Darlington Topology Improvement of In-Band Gain for the Log Domain Filters," *IEEE 14th Signal Processing and Communications Applications, Antalya*, 1-4, 17-19 Apr., 2006.
- [152] Psychalinos, C., "Improved building blocks for log-domain linear transformation filters", *Proceedings of the IEEE International Symposium on Circuits and Systems (ISCAS 2006), Island of Kos*, 1535-1538, 21-24 May, 2006.
- [153] Kircay, A., Cam U. and Tola, A.T., "Novel first-order differential class-AB log-domain allpass filters", *AEU - International Journal of Electronics and Communications*, 60 (10), 705-712, 2006.
- [154] Ascoli, A., Feely O. and Curran, P., "On the Chaotic Behavior of a Third-Order Log-Domain Filter", *Nonlinear Dynamics*, 44 (1-4), 45-54, 2006.
- [155] Teplechuk, M.A. and Sewell, J.I., "Realisation of asymmetrical complex filters in log-domain", *Proceedings of the IEEE International Symposium on Circuits and Systems (ISCAS 2006), Island of Kos*, 4, 21-24 May, 2006.
- [156] Kircay, A. and Cam, U., "State-Space Synthesis of Current-Mode First-Order Log-Domain Filters", *Turk J Elec Engin*, 14 (3), 399-416, 2006.
- [157] Drakakis, E.M., "Systematic derivation of explicit design formulae for log-domain: A 3rd-order lowpass example", *Microelectronics Journal*, 37 (7), 646-656, 2006.
- [158] Psychalinos, C., "On the transposition of G_m -C filters to DC stabilized log-domain filters", *International Journal of Circuits Theory and Applications*, 34, 217-236, 2006.
- [159] Psychalinos, C., "Realization of log-domain high-order transfer functions using first-order building blocks and complementary operators", *International Journal of Circuits Theory and Applications*, 35, 17-32, 2006.
- [160] Kircay, A. and Cam, U., "A Novel Log-Domain First-Order Multifunction Filter", *Electronics and Telecommunications Research Institute (ETRI) Journal*, 28 (3), 401-404, 2006.
- [161] Groza, R., Festila, L. and Fazakas, A., "A Log-Domain summing-amplifier for serial signal flows", *Inter-Ing 2007*, IV-4-2-4, 2007.
- [162] Groza, R., Festila, L. and Szopos, E., "Bessel Filter implementation in Log-Domain", *Inter-Ing 2007*, IV-3-1-6, 2007.
- [163] Feștilă, L., Groza, R., Cirlugea, M. and Fazakas, A., "Modular analysis and design of log-domain circuits based on LIN \leftrightarrow ELIN transformations", *Analog Integrated Circuits and Signal Processing*, 50 (3), 231-249, 2007.
- [164] Teplechuk, M.A. and Sewell, J.I., "Wave realisations of filters and equalisers in log-domain", *IET Circuits, Devices & Systems*, 1 (6), 433-443, 2007.
- [165] Zhai, Y. and Abshire, P.A., "Adaptive log domain filters for system identification using floating gate transistors", *Analog Integrated Circuits and Signal Processing*, 56 (1-2), 23-36, 2007.
- [166] Ascoli, A., Curran, P. and Feely, O., "Modelling the dynamics of log-domain circuits", *International Journal Of Circuits Theory and Applications*, 35 (1), 33-70, 2007.
- [167] Tongkulboriboon, S., Pawarangkoon, P. and Kiranon, W., "Externally linear current amplifiers", *International Journal of Electronics*, 94 (6), 587-596, 2007.
- [168] Shah N.A. and Khanday, F.A., "A DC stabilized log-domain nth-order multifunction filter based on the decomposition of nth-order HP filter function to FLF topology", *International Journal of Circuit Theory and Applications*, 37 (10), 1075-1091, 2008.
- [169] Psychalinos, C. and Souliotis, G., "A log-domain multiphase sinusoidal oscillator", *AEU - International Journal of Electronics and Communications*, 62 (8), 622-626, 2008.
- [170] Hongmin, L., Yigang, H. and Sun, Y., "Detection of Cardiac Signal Characteristic Point Using Log-Domain Wavelet Transform Circuits", *Circuits, Systems, and Signal Processing*, 27 (5), 683-698, 2008.
- [171] Kircay, A. and Cam, U., "Differential Type Class-AB Second-Order Log-Domain Notch Filter", *IEEE Transactions on Circuits and Systems I: Regular Papers*, 55 (5), 1203-1212, 2008.
- [172] Groza, R., Festila, L., Hintea, S. and Cirlugea, M., "Log-Domain Binary SVM Image Classifier", *Knowledge-Based Intelligent Information and Engineering Systems (Lecture Notes in Computer Science)*, 5179, 368-375, 2008.
- [173] Psychalinos, C., "Low-Voltage Log-Domain Complex Filters", *IEEE Transactions Circuits and Systems I: Regular Papers*, 55 (11), 3404-3412, 2008.
- [174] Shah, N.A., Iqbal, S.Z. and Parveen, N., "Log-Domain low pass high pass first-order filter", *Indian Journal Pure & Applied Physics*, 46 (9), 667 -670, 2008.
- [175] Psychalinos, C., "Log-domain linear transformation filters revised: Improved building blocks and comparison results", *International Journal of Circuit Theory and Applications*, 36 (2), 119-133, 2008.
- [176] Vercauteren, T., Pennec, X., Perchant, A. and Ayache, N., "Symmetric Log-Domain Diffeomorphic Registration: A Demons-based Approach", *Medical Image Computing and Computer-Assisted Intervention-MICCAI-2008, Lecture Notes in Computer Science*, 5241, 754-761, 2008.
- [177] Farshidi, E. and Sayedi, S.M., "A 1.2 V current-mode true RMS-DC converter based on the floating gate MOS translinear principle", *Microelectronics Journal*, 39 (2), 293-298, 2008.
- [178] Loizos, D.N., Sotiriadis, P.P. and Cauwenberghs, G., "A translinear SiGe BiCMOS current-controlled oscillator with 80Hz-800MHz tuning range", *Analog Integrated Circuits and Signal Processing*, 57 (1-2), 107-115, 2008.
- [179] Ip, H.M.D., Drakakis, E.M. and Bharath, A.A., "A 19 nW analogue CMOS log-domain 6th-order Bessel filter without E-minus cells", *Microelectronics Journal*, 40 (8), 1170-1174, 2009.
- [180] Katsiamis, A.G., Drakakis, E.M. and Lyon, R.F., "A Biomimetic, 4.5 μ W, 120+ dB, Log-Domain Cochlea Channel with AGC", *IEEE Journal of Solid-State Circuits*, 44 (3), 1006-1022, 2009.
- [181] Kircay, A. and Cam, U., "A new 5th-order differential type class-AB log-domain elliptic lowpass filter for video frequency applications", *Analog Integrated Circuits and Signal Processing*, 60 (3), 221-229, 2009.
- [182] Fragoulis, N., Psychalinos, C. and Haritantis, I., "Analysis and compensation of transistor non-idealities in log-domain wave active filters", *AEU - International Journal of Electronics and Communications*, 63 (2), 132-138, 2009.
- [183] Georgiou, P. and Toumazou, C., "Chemical log-domain filter", *Electronics Letters*, 45 (8), 391-392, 2009.
- [184] Tola, A.T., Arslanalp, R. and Yilmaz, S.S., "Current mode high-frequency KHN filter employing differential class AB log domain integrator", *International Journal of Electronics and Communications (AEÜ)*, 63 (7), 600-608, 2009.
- [185] Shah, N.A. and Khanday, F.A., "Log-domain synthesis of nth order universal filter", *Analog Integrated Circuits and Signal Processing*, 59 (3), 309-315, 2009.
- [186] Frey, D.R. and Drakakis, E.M., "Unifying perspective on log-domain filter synthesis", *Electronics Letters*, 45 (17), 861-863, 2009.
- [187] Tola, A.T., Arslanalp, R. and Yilmaz, S.S., "Current mode Tow-Thomas biquadratic differential class AB log domain filter", *International Review of Electrical Engineering*, 4 (6), 1426-1432, 2009.
- [188] Arslanalp, R. and Tola, A.T., "State space representation for log domain filtering synthesis", *Indian Journal of Pure and Applied Physics*, 47, 745-752, 2009.
- [189] Prommee, P., Sra-ium, N. and Dehjan, K., "High-frequency log-domain current-mode multiphase sinusoidal oscillator", *IET Circuits, Devices & Systems*, 4 (5), pp. 440-448, 2010.
- [190] Psychalinos, C. and Vlassis, S., "Low-voltage log-domain differentiators", *Analog Integrated Circuits and Signal Processing*, 63 (2), 299-306, 2010.

- [191] Farshidi, E., "Synthesis of class-AB log-domain filters based on nonlinear transconductance", *Microelectronics Journal*, 41 (5), 266-276, 2010.
- [192] Fragoulis, N., "Universal log-domain biquad", *Electronics Letters*, 46 (7), 487-488, 2010.
- [193] Tola, A.T., Yilmaz, S.S. and Arslanalp, R., "Current Mode Log Domain Notch Filter Design Based on Adding Filtering Blocks", *Electronics World*, 116 (1896), 42, 2010.
- [194] Shah, N.A., Iqbal, S.Z. and Parveen, N., "Log-domain all pass filter based on integrators", *Analog Integrated Circuits and Signal Processing*, 67 (1), 85-88, 2011.
- [195] Manetti S. and Piccirilli, M.C., "Log-Domain Filter Design Based on Impedance Scaling of LC Ladder Structures", *Circuits, Systems, and Signal Processing*, 30 (2), 371-389, 2011.
- [196] Psychalinos, C., "Log-domain SIMO and MISO low-voltage universal biquads", *Analog Integrated Circuits and Signal Processing*, 67 (2), 201-211, 2011.
- [197] Prommee, P., Prapakorn, N. and Swamy, M.N.S., "Log-Domain Current-mode Quadrature Sinusoidal Oscillator", *Radioengineering*, 20 (3), 600-607, 2011.
- [198] Shah, N.A. and Khanday, F.A., "A Generic Current Mode Design for Multifunction Grounded Capacitor Filters Employing Log-Domain Technique", *Active and Passive Electronic Components*, 1-10, 2011.
- [199] Farshidi, E., "Generalized Noise Analysis of Log Domain Static Translinear Circuits", *International Scholarly and Scientific & Innovation, World Academy of Science, Engineering and Technology*, 5 (4), 177-180, 2011.
- [200] Fernández, D., Martínez-Alvarado, L. and Madrenas, J., "A Translinear, Log-Domain FPAA on Standard CMOS Technology", *IEEE Journal of Solid-State Circuits*, 47 (2), 490-503, 2012.
- [201] Kasimis, C., Souliotis, G. and Psychalinos, C., "Novel log-domain frequency-adaptive filter", *International Journal of Electronics*, 99 (2), 197-209, 2012.
- [202] Duduk, N. and Tola, A.T., "A Study about Effects of Transistors' Nonideal Characteristics on Log Domain Filters," *International Conference on Applied Electronics (AE), Pilsen*, 69-74, 5-7 Sept., 2012.
- [203] Fragoulis, N., "Wave log-domain filters using lattice sections", *International Journal of Circuit Theory and Applications*, 40 (4), 385-394, 2012.
- [204] Farshidi, E. and Asiaban, H., "A new true RMS-to-DC converter using up-down translinear loop in CMOS technology", *Analog Integrated Circuits and Signal Processing*, 70 (3), 385-390, 2012.
- [205] Prommee, P. and Wongprommoon, N., "Log-domain All-pass Filter-based Multiphase Sinusoidal Oscillators", *Radioengineering*, 22 (1), 14-23, 2013.
- [206] Prommee, P. and Dejhan, K., "Single-input Multiple-output Tunable Log-domain Current-mode Universal Filter", *Radioengineering*, 22 (2), 474 - 484, 2013.
- [207] Giagkoulou, C. and Psychalinos, C., "0.5V Cardiac Sense Amplifier Realization Using Log-Domain Filtering", *ISRN Biomedical Engineering*, 2013, 11 pages, 2013.
- [208] Vargas-Bernal, R. and De La Cruz-Blas, C.A., "A survey on the static and dynamic translinear paradigm", *Integrated Circuits for Analog Signal Processing*, 289-306, 2013.
- [209] Tsirimokou, G., Laoudias, C. and Psychalinos, C., "0.5-V fractional-order companding filters", *International Journal of Circuit Theory and Applications*, 2014.
- [210] Shaheem, M.A., Savaria, Y. and Hamoui, A.A., "Design and modeling of high-resolution multibit log-domain $\Delta\Sigma$ modulators", *Analog Integrated Circuits and Signal Processing*, 79 (3), 569-582, 2014.
- [211] Papadimitriou, K.I. and Drakakis, E.M., "CMOS weak-inversion log-domain glycolytic oscillators: A cytomimetic circuit example", *International Journal of Circuit Theory and Applications*, 42 (2), 173-194, 2014.
- [212] Eskiyeerli, M.H., Payne, A.J. and Toumazou, C., "State space synthesis of integrators based on the MOSFET square law," *Electronics Letters*, 32 (6), 505-506, 1996.
- [213] Eskiyeerli, M. and Payne, A., "Square Root Domain" Filter Design and Performance," *Analog Integrated Circuits and Signal Processing*, 22(2-3), 231-243, 2000.
- [214] Psychalinos, C. and Vlassis, S., "A Systematic Design Procedure for Square-Root-Domain Circuits Based on the Signal Flow Graph Approach," *IEEE Transactions on Circuits and Systems-I: Fundamental Theory and Applications*, 49(12), 1702-1712, 2002.
- [215] Psychalinos, C. and Vlassis, S., "A High Performance Square-Root Domain Integrator," *Analog Integrated Circuits and Signal Processing*, 32(1), 97-101, 2002.
- [216] De La Cruz-Blas, C.A., López-Martín, A.J. and Carlosena, A., "1.5 V tunable Square-Root Domain filter," *Electronics Letters*, 40(4), 213-214, 2004.
- [217] Mohammed, K.O. and Soliman, A.M., "Realization of Square Root Domain Filters from Passive Filters," *Frequenz*, 58(11-12), 272-276, 2004.
- [218] Vlassis, S. and Psychalinos, C., "A Square-Root Domain Differentiator Circuit," *Analog Integrated Circuits and Signal Processing*, 40(1), 53-59, 2004.
- [219] De La Cruz-Blas, C.A., López-Martín, A.J. and Carlosena, A., "1.5-V Square-Root Domain Second-Order Filter With On-Chip Tuning," *IEEE Transactions on Circuits and Systems-I: Regular Papers*, 52(10), 1996-2006, 2005.
- [220] Yu, G.J., Huang, C.Y., Liu, B.D. and Chen, J.J., "Design of Square-Root Domain Filters," *Analog Integrated Circuits and Signal Processing*, 43(1), 49-59, 2005.
- [221] Mohammed, K.O. and Soliman, A.M., "A Tunable Square Root Domain Oscillator," *Analog Integrated Circuits and Signal Processing*, 43(1), 91-95, 2005.
- [222] Yu, G.J., Huang, C.Y., Chen, J.J. and Liu, B.D., "Design of Current-Mode Square-Root Domain Band-Pass Filter with Reduced Voltage," *Analog Integrated Circuits and Signal Processing*, 44(3), 239-250, 2005.
- [223] Al-Gahtani, M.A., "Class-AB Square Root Domain Filter," *WSEAS Transaction on Circuits and Systems*, 5(8), 1381-1387, 2006.
- [224] Ozoguz, S., Abdelrahman, T.M. and Elwakil, A.S., "Novel Approximate Square-Root Domain All-Pass Filter with Application to Multiphase Oscillators," *Analog Integrated Circuits and Signal Processing*, 46(3), 297-301, 2006.
- [225] Farshidi, E. and Sayedi, S.M., "Class-AB Square root Domain Filters Based on the Floating Gate MOS Translinear Principle," *Iranian Journal of Electrical & Electronic Engineering*, 2(2), 62-70, 2006.
- [226] Ragheb, T.S.A. and Soliman, A.M., "New Square-Root Domain Oscillators," *Analog Integrated Circuits and Signal Processing*, 47(2), 165-168, 2006.
- [227] Kontogiannopoulos, N. and Psychalinos, C., "Switched-current filters revisited: Square-root domain sampled-data filters," *IEEE Transactions on Circuits and Systems II-Express Briefs*, 53(12), 1373-1377, 2006.
- [228] Psychalinos, C., "Square-root domain wave filters," *Int. J. Circuit Theory and Applications*, 35(2), 131-148, 2007.
- [229] Psychalinos, C., "Square-Root Domain Operational Simulation of LC Ladder Elliptic Filters," *Circuits, Systems & Signal Processing*, 26(2), 263-280, 2007.
- [230] Menekay, S., Tarcan, R.C. and Kuntman, H., "The Second Order Low Pass Filter Design with A Novel Higher Precision Square-Root Circuit," *IU-Journal of Electrical & Electronics Engineering*, 7(1), 323-329, 2007.
- [231] De La Cruz-Blas, C.A., López-Martín, A., Carlosena, A. and Sarmiento, A., "Multiple operating points in a square-root domain first-order filter," *Int. J. Circ. Theor. Appl.*, 35(1), 71-91, 2007.
- [232] Psychalinos, C., "Design of square-root domain filters by substituting the passive elements of the prototype filter by their equivalents," *Int. J. Circuit Theory and Applications*, 36(2), 185-204, 2008.
- [233] Stoumpou, E., Khanday, F.A., Psychalinos, C. and Shah, N.A., "A low-voltage square-root domain n-th order multifunction FLF filter topology," *Analog Integrated Circuits and Signal Processing*, 61(3), 315-322, 2009.
- [234] Yu, G.J., Tsao, Y.J. and Lin, Y.S., "1V Square-Root Domain Low-Pass Filter using Translinear Loop Technology in Biomedical Engineering," *Life Science Journal*, 6(4), 92-96, 2009.
- [235] Keserlioglu, M.S. and Kircay, A., "The Design of Current-Mode Electronically Tunable First-Order Square-Root-Domain Filters Using State-Space Synthesis Method," *International Review on Modelling and Simulations*, 2(2), 124-128, 2009.
- [236] Ölmez, S. and Çam, U., "A novel square-root domain realization of first order all-pass filter," *Turk J Elec Eng & Comp Sci*, 18(1), 141-146, 2010.
- [237] Yu, G.J., "A Systematic Synthesis for High-Order Square-Root Domain Filters with Reduced Voltage," *Life Science Journal*, 7(1), 15-29, 2010.

- [238] Yu, G.J. and Lin, Y.S. "Low Voltage Tunable Square-Root Domain Band-Pass Filter with Translinear Loop Technique in Biomedical Engineering," *Life Science Journal*, 7(1), 30-33, 2010.
- [239] Asiaban, H. and Farshidi E., "A New True RMS-to-DC Converter in CMOS Technology," *World Academy of Science, Engineering and Technology*, 4(11), 234-237, 2010.
- [240] Jelodarian, P. and Farshidi, E., "A Current-mode Continuous-time Sigma-delta Modulator based on Translinear Loop Principle," *World Academy of Science, Engineering and Technology*, 4(6), 422-425, 2010.
- [241] De La Cruz-Blas, C.A. and Feely, O., "Limit cycle behavior in a class-AB second-order square root domain filter," *Analog Integrated Circuits and Signal Processing*, 68(2), 175-181, 2011.
- [242] Yilmaz, S.S. and Tola, A.T., "Fifth Order Butterworth Low Pass Square-Root Domain Filter Design," *Elektronika Ir Elektrotechnika*, 115(9), 55-58, 2011.
- [243] Stoumpou, E. and Psychalinos, C., "Square-root domain linear transformation filters," *International Journal of Circuit Theory and Applications*, 39(7), 719-731, 2011.
- [244] Yilmaz, S.S., Tola, A.T. and Arslanalp, R., "A Novel Second-Order All-Pass Filter Using Square-Root Domain Blocks," *Radioengineering*, 22(1), 179-185, 2013.
- [245] Laoudias, C., Psychalinos, C. and Stoumpou, E., "1.5V square-root domain universal biquad filters," *Int. J. Circ. Theor. Appl.*, 41(3), 307-318, 2013.
- [246] Khanday, F.A., Psychalinos, C. and Shah, N.A., "Square-Root-Domain Realization of Single-Cell Architecture of Complex TDCNN," *Circuits Systems and Signal Processing*, 32(3), 959-978, 2013.
- [247] Shah, N.A. and Khanday, F.A., "Synthesis of High-order all pass filters using Novel Low Voltage Current-Mode Square-Root-Domain low-order all pass Filters", *Maejo International Journal of Science and Technology*, 7(03), 385-395, 2013.
- [248] Farshidi, E. and Manoochehri, S., "A New Approach for Current-Mode SRD Filters," *International Journal of Electronics Communications and Electrical Engineering*, 3(12), 1-10, 2013.
- [249] Kircay, A., Keserlioglu, M.S. and Çam, U., "A new current-mode square-root-domain general notch filter," *Journal of Circuits, Systems, and Computers*, 22(1), 1250072-1-1250072-10, 2013.
- [250] Khanday, F.A. and Shah, N. A., "Realization of low-voltage square-root-domain all-pass filters," *Maejo Int. J. Sci. Technol.*, 7(3), 422-432, 2013.
- [251] Kircay, A., "Electronically tunable current-mode square-root-domain first-order multifunction filter," *Int. J. Electronics*, 101(2), 212-219, 2014.
- [252] Khanday, F.A., Psychalinos, C. and Shah, N.A., "Universal filters of arbitrary order and type employing square-root-domain technique". *Int. J. Electronics*, 101(7), 894-918, 2014.
- [253] Shaterian, M., Twigg, C.M. and Azhari, J., "MTL-based implementation of current-mode CMOS RMS-to-DC converters," *Int. J. Circ. Theor. Appl.*, 2014.