I. Publications in Indicator B4

B4.1: Dobrev D, Daskalov I. (2002) Two-electrode biopotential amplifier with current-driven inputs. Medical and Biological Engineering and Computing, 40, 1, Springer Nature, ISSN:0140-0118, DOI:10.1007/BF02347705, 122-127. SJR (Scopus):0.479, JCR-IF (Web of Science):1.189, https://link.springer.com/article/10.1007/BF02347705

Abstract:

A circuit was developed for a differential two-electrode biopotential amplifier. Current sources at the amplifier inputs were controlled by the common-mode voltage. This principle is well known in telephony for interfacing the telephone line with analogue-type phones. A low impedance of about 1 kΩ was obtained between each input and the common point of the circuit. The differential input impedance of 60 MΩ was obtained with the use of precision resistors. Considerable reduction in the common-mode voltages of more than 200 times resulted. The circuit can be useful for biosignal acquisition from subjects in areas of very high electromagnetic fields, where high common-mode voltages could saturate the input amplifier stages.

B4.2: Dobrev D. (2002) Two-electrode non-differential biopotential amplifier. Medical and Biological Engineering and Computing, 40, 5, Springer Nature, ISSN:0140-0118, DOI:10.1007/BF02345453, 546-549. SJR (Scopus):0.479, JCR-IF (Web of Science):1.189,
https://link.springer.com/article/10.1007/BF02345453

Abstract:

A circuit is proposed for a non-differential two-electrode biopotential amplifier, with a current source and a transimpedance amplifier as a potential equaliser for its inputs, fully emulating a differential amplifier. The principle of operation is that the current in the input of the transimpedance amplifier is sensed and made to flow with the same value in the other input. The circuit has a simple structure and uses a small number of components. The current source maintains balanced common-mode interference currents, thus ensuring high signal input impedance. In addition, these currents can be tolerated up to more than 10μA per input, at a supply voltage of ±5V. A two-electrode differential amplifier with 2×10 MΩ input resistances to the reference point allows less than 0.5μA per input. The circuit can be useful in cases of biosignal acquisition by portable instruments, using low supply voltages, from subjects in areas of high electromagnetic fields. Examples include biosignal recordings in electric power stations and electrically powered locomotives, where traditionally designed input amplifier stages can be saturated.

B4.3: Dobrev D. (2004) Two-electrode low supply voltage electrocardiogram signal amplifier. Medical and Biological Engineering and Computing, 42, 2, Springer, DOI:10.1007/BF02344642, 272-276. SJR (Scopus):0.447, JCR-IF (Web of Science):1.285,
https://link.springer.com/article/10.1007/BF02344642

Abstract:

Portable biomedical instrumentation has become an important part of diagnostic and treatment instrumentation, including telemedicine applications. Lowvoltage and low-power design tendencies prevail. Modern battery cell voltages in the range of 3–3.6V require appropriate circuit solutions. A two-electrode biopotential amplifier design is presented, with a high common-mode rejection ratio (CMRR), high input voltage tolerance and standard first-order high-pass characteristic. Most of these features are due to a high-gain first stage design. The circuit makes use of passive components of popular values and tolerances. Powered by a single 3V source, the amplifier tolerates ±1V common mode voltage, ±50μA common mode current and 2V input DC voltage, and

its worst-case CMRR is 60 dB. The amplifier is intended for use in various applications, such as Holter-type monitors, defibrillators, ECG monitors, biotelemetry devices etc.

B4.4: Dobrev D, Neycheva T, Mudrov N. (2005) Simple two-electrode biosignal amplifier. Medical and Biological Engineering and Computing, 43, 6, ISSN:0140-0118, 725-730. SJR (Scopus):0.564, JCR-IF (Web of Science):1.484 Q2 (Web of Science),
https://link.springer.com/article/10.1007/BF02430949

Abstract:

A simple, cost effective circuit for a two-electrode non-differential biopotential amplifier is proposed. It uses a "virtual ground" transimpedance amplifier and a parallel RC network for input common-mode current equalisation, while the signal input impedance preserves its high value. With this innovative interface circuit, a simple non-inverting amplifier fully emulates high CMRR differential. The amplifier equivalent CMRR (typical range from 70-100 dB) is equal to the open loop gain of the operational amplifier used in the transimpedance interface stage. The circuit has very simple structure and utilises a small number of popular components. The amplifier is intended for use in various two-electrode applications, such as Holter-type monitors, defibrillators, ECG monitors, biotelemetry devices etc.

B4.5: Dobrev D, Neycheva T, Mudrov N. (2008) Bootstrapped two-electrode biosignal amplifier. Medical and Biological Engineering and Computing, 46, 6, ISSN:0140-0118, 613-619. SJR (Scopus):0.581, JCR-IF (Web of Science):1.843, Q2 (Web of Science),
https://link.springer.com/article/10.1007/s11517-008-0312-4

Abstract:

Portable biomedical instrumentation has become an important part of diagnostic and treatment instrumentation. Low-voltage and low-power tendencies prevail. A two-electrode biopotential amplifier, designed for low-supply voltage (2.7–5.5 V), is presented. This biomedical amplifier design has high differential and sufficiently low common-mode input impedances achieved by means of positive feedback, implemented with an original interface stage. The presented circuit makes use of passive components of popular values and tolerances. The amplifier is intended for use in various two-electrode applications, such as Holter monitors, external defibrillators, ECG monitors and other heart beat sensing biomedical devices.

B4.6: Dobrev D. (2012) Robert B. Northrop: Analysis and application of analog electronic circuits to biomedical instrumentation. Biomedical Engineering Online, 11, 29, Springer Nature, DOI:10.1186/1475-925X-11-29, 1-7. SJR (Scopus):0.467, JCR-IF (Web of Science):2.464
https://biomedical-engineering-online.biomedcentral.com/articles/10.1186/1475-925X-11-29

Abstract:

The article is a review of the book “Analysis and application of analog electronic circuits to biomedical instrumentation” by Robert B. Northrop.

B4.7: Dobrev D, Alnasser E, Neycheva T. (2021) Lossy Integrator Readout Circuit With Active Bias Point. IEEE Sensors Journal, 21, 22, IEEE, ISSN:1530-437X, DOI:10.1109/JSEN.2021.3118045, 25808-25817. SJR (Scopus):0.926, JCR-IF (Web of Science):4.325 Q1, не оглавява ранглистата (Web of Science),
https://ieeexplore.ieee.org/document/9559972

Abstract

The charge-generating sensors are widely used in many applications in consumer, automotive and medical electronics. They generate a charge proportional to the applied input quantity: pressure, temperature, acceleration, strain, light, etc. Usually, charge amplifiers are used to register such

signals. The charge amplifier is an integrator that integrates the input current over time. In continuous-time signal processing, a parallel resistor is used to dissipate the energy stored on the integration capacitor, and such self-zeroed integrator circuits are known as lossy integrators. To achieve low-frequency operation, when a capacitor is in the picofarad range, a very high-ohmic resistor, in the range of gigaohms, must be used. Such a high-ohmic resistor increases the output offset voltage to an unacceptable level. To overcome the output offset problems, a composite charge amplifier has been recently introduced. This paper presents an innovative lossy integrator readout circuit which contains only one opamp in the feedback. The circuit can be easily adapted to the needed gain and cut-off frequency. Its operation is validated by experimental results. The sufficiently low high-pass cut-off frequency allows the circuit to be used for biosignal amplification. Heart and respiration rates can be easily recorded with piezoelectric sensors attached to the wrist or lung wall. The presented circuit can benefit many applications where charge-to-voltage conversion is needed.

B4.8: Dobrev D, Neycheva T, Mudrov N. (2008) Digital lock-in techniques for adaptive power-line interference extraction. Physiological Measurement, 29, 7, ISSN:0967-3334, 803-816. SJR (Scopus):0.691, JCR-IF (Web of Science):1.951 Q3 (Web of Science)
http://dx.doi.org/10.1088/0967-3334/29/7/009

Abstract:

This paper presents a simple digital approach for adaptive power-line (PL) or other periodic interference extraction. By means of two digital square (or sine) wave mixers, the real and imaginary parts of the interference are found, and the interference waveform is synthesized and finally subtracted. The described technique can be implemented in an open-loop architecture where the interference is synthesized as a complex sinusoid or in a closed-loop architecture for automatic phase and gain control. The same approach can be used for removal of the fundamental frequency of the PL interference as well as its higher harmonics. It is suitable for real-time operation with popular low-cost microcontrollers.

B4.9: Dobrev D, Neycheva T. (2020) Correlated Multiple Sampling Techniques for Sensor Signal Conditioning. 2020 XXIX International Scientific Conference Electronics (ET), IEEE, ISBN:978-1-7281-7426-6, DOI:10.1109/ET50336.2020.9238159, 1-4. SJR (Scopus):0.11 SJR, непопадащ в Q категория (Scopus),
https://ieeexplore.ieee.org/document/9238159

Abstract:

Correlated Double Sampling (CDS) is a widely used technique in sensor signal conditioning. It effectively cancels offset and low-frequency (flicker) noise. CDS is a discrete time signal processing technique, implemented with Switched Capacitor (SC) circuits or after ADC with a Digital Signal Processing (DSP) algorithm. This paper describes a simple approach wherein the CDS technique is extended to Correlated Multiple Sampling (CMS) techniques, and with the price of processing of more samples, the new CMS techniques greatly improves the amplifier offset and flicker noise suppression.

B4.10: Dobrev D, Alnasser E, Neycheva T. (2021) Application of Active Biased Integrators for Biosignal Processing. XXX International Scientific Conference Electronics (ET), 2021, IEEE, ISBN:978-1-6654-4518-4, DOI:10.1109/ET52713.2021.9580163, 1-5 Без JCR или SJR – индексиран в WoS или Scopus (Scopus)
https://ieeexplore.ieee.org/document/9580163

Abstract :

Active biased integrators (ABI) have recently been reported. The ABI is an innovative continuous-time lossy integrator characterized by a very low high-pass cutoff frequency in the millihertz range. ABI is used to amplify signals generated by sources with capacitive output impedance. This paper

presents some novel ABI applications for biosignal amplification. It is shown that the heart rate and respiration activity can be easily monitored with piezoelectric sensors directly connected to ABI. The achieved very low high-pass cutoff frequency of 0.05 Hz allows ABI to be successfully used for processing ECG signals acquired with capacitive electrodes.

Publications in Indicator G7

G7.1: Dobrev D, Neycheva T. (2016) Automatic Common Mode Electrode-amplifier Impedance Balance with SPLL Synchronization. Proc. 2016 XXV International Scientific Conference Electronics (ET), IEEE, ISBN:978-1-5090-2883-2, DOI:10.1109/ET.2016.7753473, 1-4 Без JCR или SJR – индексиран в WoS или Scopus (Scopus),
http://ieeexplore.ieee.org/document/7753473/

Abstract:

Power-line interference (PLI) is a major disturbing factor in almost all groundfree biosignal acquisition applications. The main cause of interference is body to amplifier Wheatstone bridge imbalance. The bridge is formed from electrode impedances and the amplifier common mode input impedances. Because the electrode impedances vary with time, the Wheatstone bridge tends to be imbalanced, and produces differential PLI which is amplified together with the useful signal. The interference can be canceled only when the bridge is kept continuously in balanced conditions. It was shown how the Wheatstone bridge can be adjusted to maintain balanced conditions by means of two digital synchronous demodulators. For proper demodulation, an accurate synchronization with PLI is needed. Recently, dedicated software PLL (SPLL) for PLI synchronization was developed implemented and tested. This paper presents a complete impedance balancing approach wherein synchronization to PLI is done with the designed SPLL. The stability of the whole system is proven by Matlab mixed signal simulations. The presented approach is applicable in various two-electrode applications, such as Holter monitors, external defibrillators, ECG monitors and other heart beat sensing biomedical devices.

G7.2: Dobrev D, Neycheva T. (2016) Automatic current driven electrode-amplifier impedance balance with SPLL synchronization. Proc. 2016 XXV International Scientific Conference Electronics (ET), 16498728, IEEE, ISBN:978-1-5090-2883-2, DOI:10.1109/ET.2016.7753472, 1-4 Без JCR или SJR – индексиран в WoS или Scopus (Scopus),
http://ieeexplore.ieee.org/document/7753472/

Abstract:

Power-line interference (PLI) is a common disturbing factor in almost all ground free biosignal acquisition applications. The main cause of interference is the body to amplifier Wheatstone bridge imbalance. The bridge is formed from electrode impedances and the amplifier common mode input impedances. Because the electrode impedances vary with time, the Wheatstone bridge tends to be imbalanced and produces differential PLI which is amplified together with the useful signal. The interference can be canceled only when the bridge is kept continuously in balanced conditions. It was shown how the Wheatstone bridge can be adjusted to maintain balanced conditions by means of Voltage-Controlled-Current-Sources (VCCSs) and synchronous detection. For proper demodulation, an accurate synchronization with PLI is needed. Recently, dedicated software PLL (SPLL) for PLI synchronization was developed implemented and tested. This paper presents a complete, VCCS based, impedance balancing approach wherein synchronization to PLI is done with the designed SPLL. The stability of the whole system is proven by Matlab mixed signal simulations. The presented approach is applicable in various two-electrode applications, such as Holter monitors, external defibrillators, ECG monitors and other heart beat sensing biomedical devices.

G7.3: **Dobrev D, Neycheva T. (2019) Automatic Common Mode Electrode-Amplifier Impedance Balance: Implementation and Results. 2019 IEEE XXVIII International Scientific Conference Electronics (ET2019), IEEE, ISBN:978-1-7281-2574-9, DOI:10.1109/ET.2019.8878610, 1-4,**
https://ieeexplore.ieee.org/document/8878610

Abstract:

Power-line interference (PLI) is the major disturbing factor in all ground-free biosignal acquisition applications. The PLI currents picked up by the body must flow through the sensing electrodes, then the electrode cables and finally via the amplifier input impedances they reach the amplifier ground. The electrode impedances and the amplifier input impedances form Wheatstone bridge. Because the electrode impedances vary with time, the bridge tends to be imbalanced and produces differential PLI which is amplified together with the useful signal. An automatic impedance balancing approach, using software PLL for line synchronization, was published. This paper validates the approach through practical results from its implementation.

G7.4: **Dobrev D, Neycheva T. (2022) Open-loop Software Automatic Gain Control: Common-mode Power-line Interference Stabilization During ECG Recording. XXXI International Scientific Conference Electronics (ET), 2022, IEEE, ISBN:978-1-6654-9878-4, DOI:10.1109/ET55967.2022.9920322, 1-6 Без JCR или SJR – индексиран в WoS или Scopus (Scopus),**
https://ieeexplore.ieee.org/document/9920322

Abstract:

Automatic gain control (AGC) units are widespread in modern telecommunication systems. The main function of AGC is to stabilize the amplitude of the processed signal. AGC generates a constant amplitude output signal when the input signal level changes. This article describes an all-digital architecture for automatic open-loop gain control designed to generate constant amplitude of the power-line interference extracted from the common-mode signal during ECG biopotential recording. The presented open-loop AGC has a very simple architecture and can be applied to other applications where AGC functionality is needed.

G7.5: Dobrev D, Neycheva T. (2020) Software Automatic Gain Control for Common Mode Interference Stabilization. 2020 XXIX International Scientific Conference Electronics (ET), IEEE, ISBN:978-1-7281-7426-6, DOI:10.1109/ET50336.2020.9238268, 1-3. SJR (Scopus):0.11 SJR, непопадащ в Q категория (Scopus),
https://ieeexplore.ieee.org/document/9238268

Abstract:

Automatic gain control (AGC) circuits are used in many systems where the amplitude of the input signal can vary over a wide dynamic range. The role of the AGC is to provide relatively constant amplitude of the output signal, regardless of changes in the input signal. This paper presents software automatic gain control (SAGC) designed to stabilize the amplitude of the common mode interference. The described SAGC provides a constant amplitude output signal for software PLL synchronization to the power-line frequency. The presented SAGC has simple structure and can be easily adapted to other signal processing applications where automatic gain control is required.

II. Publications in Indicator G8

G8.1: Добрев (2002) Д. Двуелектроден усилвател на биосигнали. Electrotechnica & Electronica, E+E, 1-2, CEEC, ISSN:0861-4717, 22-26,
https://www.researchgate.net/publication/258960539_Two_electrode_bioamplifier

Abstract:

A circuit is proposed of a non-differential two-electrode biopotential amplifier combining a transimpedance amplifier connected to one of the inputs with a controlled current source to the other input for common-mode current balance, fully emulating a differential amplifier. It is of simple structure and uses reduced number of components. The result is a considerable reduction of the common mode voltages. The circuit can be useful in cases of biosignal acquisition by portable instruments, from subjects in areas of very high electromagnetic fields, for example in electric power stations, electrically powered locomotives, etc., where high common mode voltages could saturate the input amplifier stages.

G8.2: Dobrev D, Neycheva T. (2011) Bootstrapped instrumentation biosignal amplifier. Annual Journal of Electronics, 5, 2, Technical University - Sofia, ISSN:1313-1842, 76-79 Национално академично издателство,
https://www.researchgate.net/publication/258847991_Bootstrapped_Instrumentation_Biosignal_Amplifier

Abstract:

Portable biomedical instrumentation has become an important part of diagnostic and treatment instrumentation. Low-voltage and low-power tendencies prevail. A two-electrode biopotential amplifier, designed for low-supply voltage (1.8–5.5V), is presented. This biomedical amplifier design has high differential and sufficiently low common-mode input impedances achieved by means of positive shunt-shunt feedback, implemented in a standard instrumentation amplifier scheme. The presented circuit makes use of passive components of popular values and tolerances. The amplifier is intended for use in various two-electrode applications, such as Holter monitors, external defibrillators, ECG monitors and other heart beat sensing biomedical devices.

G8.3: Dobrev D, Neycheva T. (2012) Simple Two-Electrode Bootstrapped Non-Differential Biopotential Amplifier. Annual Journal of Electronics, 6, 1, Technical University - Sofia, ISSN:1314-0078, 8-11 Национално академично издателство
https://www.researchgate.net/publication/258847810_Simple_Two-Electrode_Bootstrapped_Non-Differential_Biopotential_Amplifier

Abstract:

A simple two-electrode non-differential biopotential amplifier, designed for low-supply voltage (1.8–5.5V), is presented. The amplifier architecture is based on a transimpedance interface stage which retains the potential at one input virtually equal to the circuit ground and allows the potential at the other input to be amplified by a simple non-differential amplifier. The output of the transimpedance stage drives a parallel RC network connected to the other input, maintaining the input common mode interference currents balanced. Thus, simple non-inverting amplifier can emulate a high CMRR differential. The amplifier also features bootstrapped input impedance achieved by means of negative impedance converter organized around the first amplification stage. The amplifier is intended for use in various two-electrode applications, such as Holter monitors, external defibrillators, ECG monitors and other heart beat sensing biomedical devices.

G8.4: Neycheva T, Dobrev D. (2005) Photoplethysmographic detector for peripheral pulse registration. International Scientific Conference Electronics (ET) 2005, Technical University - Sofia, 31-36 Национално академично издателство,
http://ecad.tu-sofia.bg/et/2005/pdf/Paper043-T_Neycheva.pdf

Abstract :

In this paper a low-power photoplethysmograph for heart rate detection by the amplitude demodulation of the reflected from the skin and tissue light is proposed and described. The optical

sensor consists from six infrared photoreceivers placed in a circle around one infrared led. The use of only one emitter in switch mode and synchronous detection of the received signal defines the achieved low-power consumption. The device can be used for fast heart rate registration, for example in emergency cases or in addition to existing defibrillators and/or monitoring systems.

G8.5: Dobrev D, Neycheva T, Mudrov N. (2009) Transformerless High-quality Electrocardiogram and Body Impedance Recording by an Amplifier with Current-Driven Inputs. Internat. Journal Bioautomation, 13, 4, Institute of Biophysics and Biomedical Engineering Bulgarian Academy of Sciences, ISSN:1314-2321, 1-6 Национално академично издателство
https://www.biomed.bas.bg/bioautomation/2009/vol_13.4/files/13.4_1.01.pdf

Abstract:

Measurement and recording of changes in bioelectrical impedance in vivo has become a widely used method with various clinical applications. It includes basal impedance Zo, relative changes ΔZ or its derivative dZ. Many applications related to cardiac and respiratory function require simultaneous electrocardiogram, impedance-cardiogram and/or respiration signals recording and analysis. Accurate recording of body impedance is limited by high common-mode voltages at the amplifier inputs combined with the influence of the output impedance of the used current source. A circuit concept for a simultaneous high-quality electrocardiogram and bioimpedance acquisition is proposed, profiting from advantages offered by a previously specially designed amplifier with current-driven inputs, yielding to low common-mode and high differential-mode input impedances.

G8.6: Dobrev D, Neycheva T. (2012) Increased Power-Line Interference Rejection by a Stray Capacitance Drive. Annual Journal of Electronics, 6, 1, Technical University - Sofia, ISSN:1314-0078, 12-15
https://www.researchgate.net/publication/258847782_Increased_Power-Line_Interference_Rejection_by_a_Stray_Capacitance_Drive

Abstract:

Power-line (PL) interference is a major disturbing factor in almost all two-electrode biosignal acquisition applications. The picked up by the body interference current multiplied by the difference in electrode impedances is converted into a differential input voltage which is amplified together with the useful signal. Thus, the electrode impedance imbalance appears to be the main cause of higher interference level in two-electrode by comparison with three-electrode amplification techniques. The common mode interference is not presented only when the common mode input current is zeroed. This paper presents an approach wherein by a stray capacitance drive the amplifier common mode input current is reduced, thus the interference rejection is increased. The method is applicable in various two-electrode applications, such as Holter monitors, external defibrillators, ECG monitors and other heart beat sensing biomedical devices.

G8.7: Dobrev D, Neycheva T. (2011) Increased power-line interference rejection by adaptive common mode impedance balance. Annual Journal of Electronics, 5, 2, Technical University - Sofia, ISSN:1313-1842, 80-83 Национално академично издателство
https://www.researchgate.net/publication/258847959_Increased_Power-line_Interference_Rejection_by_Adaptive_Common_Mode_Impedance_Balance

Abstract:

Power-line (PL) interference (hum) is a major disturbing factor in almost all two-electrode biosignal acquisition applications. The picked up by the body interference current multiplied by the difference in electrode impedances is converted into a differential input voltage which is amplified together with the useful signal. Thus, the electrode impedance imbalance is appeared as a main cause for higher interference level in two-electrode by comparison with three electrode amplification techniques. The converted into differential voltage PL interference can be canceled

only when the two shoulders of the bridge performed from the electrode impedances and the amplifier input common mode impedances are balanced. This paper presents a method for such continuous adaptive balance. The advantage of the method is that the interference is canceled on a hardware level wherein it is generated without influencing the spectrum of the useful signal. The method is applicable in various two-electrode applications, such as Holter monitors, external defibrillators, ECG monitors and other heart beat sensing biomedical devices.

G8.8: Dobrev D, Neycheva T. (2013) Analog Approach for Common Mode Impedance Balance in Two-electrode Biosignal Amplifiers. Annual Journal of Electronics, 7, Technical University - Sofia, ISSN:1314-0078, 68-71
https://www.researchgate.net/publication/258840490_Analog_Approach_for_Common_Mode_Impedance_Balance_in_Two-electrode_Biosignal_Amplifiers

Abstract:

Power-line (PL) interference (hum) is a major disturbing factor in almost all two-electrode biosignal acquisition applications. The main cause of interference is a Wheatstone bridge formed from electrode impedances and the amplifier common mode input impedances. The electrode impedances, cannot have fixed values. They change from individual to individual, with electrode location and with time, thus the Wheatstone bridge tends to be imbalanced and produces differential PL interference which is amplified together with the useful signal. The differential PL interference can be canceled only when the bridge is balanced. This paper describes a method wherein by two negative control loops the active and reactive components of the Wheatstone bridge automatically maintain balanced conditions. The main advantage of the presented approach is that the interference is canceled on a hardware level wherein it is generated without influencing the spectrum of the useful signal. The method is applicable in various two-electrode applications, such as Holter monitors, external defibrillators, ECG monitors and other heart beat sensing biomedical devices.

G8.9: Dobrev D, Neycheva T. (2014) Current Driven Automatic Electrode Impedance Balance for Ground-free Biosignal Acquisition. Annual Journal of Electronics, 8, Technical University - Sofia, ISSN:1314-0078, 62-65 Национално академично издателство
http://ecad.tu-sofia.bg/et/2014/ET2014/AJE_2014/062-D_Dobrev2.pdf

Abstract:

Power-line interference (PLI) is a common disturbing factor in almost all two-electrode biosignal acquisition applications. The main cause of interference is the body to amplifier Wheatstone bridge imbalance. The bridge is formed from electrode impedances and the amplifier common mode input impedances. Because the electrode impedances vary with time, the Wheatstone bridge tends to be imbalanced and produces differential PL interference which is amplified together with the useful signal. The interference can be canceled only when the bridge is kept continuously in balanced conditions. This paper describes a powerful concept for PLI cancellation wherein by two Voltage-Controlled-Current-Sources (VCCS) enclosed in two control loops, the active and reactive components of the amplifier input impedances are synthesized and automatically adjusted to maintain balanced conditions. The main advantage of the presented approach is that the interference is canceled on a hardware level where it is generated, without influencing the spectrum of the useful signal. The method is applicable in all ground-free applications, such as Holter monitors, external defibrillators, ECG monitors and other heart beat sensing biomedical devices.

G8.10: Dobrev D, Neycheva T, Mudrov N. (2007) Digital lock-in techniques for adaptive power-line interference extraction. International Scientific Conference Electronics (ET) 2007, Technical University - Sofia, 2007, 9-14,
https://ecad.tu-sofia.bg/et/2007/ET2007%20Book2/Electronic%20Medical%20Equipment/9-Paper-D_Dobrev.pdf

Abstract:

This paper presents a simple digital approach for adaptive power-line (PL) (or other periodical) interference extraction. By means of two digital square (or sine) wave mixers the real and imaginary part of the interference are found and thus the interference waveform is synthesized and subtracted. The described technique can be implemented in open-loop architecture where the interference is synthesized as a complex sinusoid or in closed-loop architecture for automated phase and gain control. The same approach can be used for removal of fundamental frequency of the PL interference as well as its higher harmonics. It is suitable for real-time operation with popular low-cost microcontrollers.

G8.11: Dobrev D, Neycheva T, Mudrov N. (2008) Frequency response of digital lock-in technique for powerline interference extraction. International Scientific Conference Electronics (ET) 2008, 1, Technical University - Sofia, ISSN:1313-1842, 31-36 Национално академично издателство
http://ecad.tu-sofia.bg/et/2008/ET2008_Book1/Electronic%20Medical%20Equipment/31-Paper-T_Neycheva2.pdf

Abstract:

Power-line interference is a common problem in almost all biosignal acquisition applications. Recently a smart approach for PL suppression, called lock-in technique, was developed. This paper discusses the behavior of open-loop lock-in technique in frequency domain. It shows that the low-pass transfer function of the used filter is converted to high-pass function by a simple subtraction from unity and then it is transposed in two sidebands around PL frequency. Thus, the flatness roll-off characteristic of the used low-pass filter is very important for achievement of final rippleless frequency response of the lock-in filtering approach. A simple digital low-pass filter is proposed to be used in cases when a maximallyflat frequency response is needed.

G8.12: Dobrev D, Neycheva T. (2013) Digital Lock-in Technique for Input Impedance Balance in Two-electrode Biosignal Amplifiers. Annual Journal of Electronics, 7, Technical University - Sofia, ISSN:1314-0078, 64-67 Национално академично издателство
https://www.researchgate.net/publication/258840650_Digital_Lock-in_Technique_for_Input_Impedance_Balance_in_Two-electrode_Biosignal_Amplifiers

Abstract:

Power-line (PL) interference is a major disturbing factor in almost all two-electrode biosignal acquisition applications. The main cause of interference is the body to amplifier Wheatstone bridge imbalance. The bridge is formed from electrode impedances and the amplifier common mode input impedances. Because the electrode impedances vary with time, the Wheatstone bridge tends to be imbalanced and produces differential PL interference which is amplified together with the useful signal. The interference can be canceled only when the bridge is kept continuously in balanced conditions. This paper describes a method wherein by two digital lock-in demodulators in two digitally regulated control loops, the active and reactive components of the amplifier input impedances are adjusted to maintain balanced conditions. The main advantage of the presented approach is that the interference is canceled on a hardware level wherein it is generated, without influencing the spectrum of the useful signal. The method is applicable in various two-electrode applications, such as Holter monitors, external defibrillators, ECG monitors and other heart beat sensing biomedical devices.

G8.13: Dobrev D, Neycheva T. (2014) Software PLL for Power-line Interference Synchronization: Design, Modeling and Simulation. Annual Journal of Electronics, 8, Technical University - Sofia, ISSN:1314-0078, 58-61 Национално академично издателство
http://ecad.tu-sofia.bg/et/2014/ET2014/AJE_2014/058-D_Dobrev1.pdf

Abstract:

Power-line interference is a common disturbing factor in almost all two-electrode biosignal acquisition applications. Many filtering procedures for mains interference elimination are available, but all of them are maximally effective when the filter notches are positioned exactly at the power-line harmonics, i. e. when the sampling rate is synchronous with the power-line frequency. Moreover, various lock-in techniques, such as automatic common mode input impedance balance, require precise in-phase and quadrature phase references, synchronous with the powerline interference. This paper describes in depth a design procedure of software PLL, generating synchronous reference to the common mode power-line interference, and achieved from its analog prototype using s to z backward difference transformation. The main advantage of the presented approach is that the synchronization is done in software, so it has no production cost. The presented PLL is intended for use in ECG signal processing, but it can be used after easy adaptation in various digital signal processing applications, where frequency synchronization is needed.

G8.14: Dobrev D, Neycheva T. (2015) Software PLL for Power-line Interference Synchronization: Implementation and Results. Annual Journal of Electronics, 9, Technical University - Sofia, ISSN:1314-0078, 18-21 Национално академично издателство
http://ecad.tu-sofia.bg/et/2015/ET2015/AJE-2015/018_Paper-T_Neycheva2.pdf

Abstract:

Power-line interference is a common disturbing factor in almost all two-electrode biosignal acquisition applications. Many filtering procedures for mains interference elimination are available, but all of them are maximally effective when the filter notches are positioned exactly at the power-line harmonics, i. e. when the sampling rate is synchronous with the power-line frequency. Moreover, various lock-in techniques, such as automatic common mode input impedance balance, require precise in-phase and quadrature phase references, synchronous with the powerline interference. Recently a design methodology of software PLL for power-line synchronization was published. This paper describes the results of its practical realization.

G8.15: Dobrev D, Neycheva T, Mudrov N. (2008) Simple high-Q comb filter for mains interference suppression. International Scientific Conference Electronics (ET) 2008, 1, Technical University - Sofia, ISSN:1313-1842, 25-30 Национално академично издателство
http://ecad.tu-sofia.bg/et/2008/ET2008_Book1/Electronic%20Medical%20Equipment/25-Paper-T_Neycheva1.pdf

Abstract:

This paper presents a simple digital high-Q comb filter for power-line (PL) (or other periodical) interference suppression. The filter concept relies on a correlated signal average resulting in alternating constructive and destructive spectrum interference i.e. to the so called a comb frequency response. The presented filter is evaluated by Matlab simulations with real ECG signal contaminated with high amplitude PL interference. The made simulations show that this filter has minimal influence on processed ECG signal. Due to its allpass (flat) frequency response and high-Q notches only at PL harmonics the presented filter is appropriate for most biosignal acquisition applications: ECG, EEG, EMG, etc. The filter is suitable for real-time operation with popular low-cost microcontrollers.

G8.16: Neycheva T, Dobrev D, Mudrov N. (2009) High-Q Bandpass Comb Filter for Mains Interference Extraction. Internat. Journal Bioautomation, 13, 4, Institute of Biophysics and Biomedical Engineering Bulgarian Academy of Sciences, 7-12 Национално академично издателство
https://www.biomed.bas.bg/bioautomation/2009/vol_13.4/files/13.4_1.02.pdf

Abstract:

This paper presents a simple digital high-Q bandpass comb filter for power-line (PL) or other periodical interference extraction. The filter concept relies on a correlated signal average resulting in alternating constructive and destructive spectrum interference i.e. the so-called comb frequency response. The presented filter is evaluated by Matlab simulations with real ECG signal contaminated with low amplitude PL interference. The made simulations show that this filter accurately extract the PL interference. It has high-Q notches only at PL odd harmonics and is appropriate for extraction of any kind of odd harmonic interference including rectangular shape. The filter is suitable for real-time operation with popular low-cost microcontrollers.

G8.17: Dobrev D, Neycheva T, Mudrov N. (2009) High-Q Comb Filter for Mains Interference Suppression. Annual Journal of Electronics, 3, 1, Technical University - Sofia, ISSN:1313-1842, 47-49 Национално академично издателство
http://ecad.tu-sofia.bg/et/2009/ET_2009/AEM2009_1/Electronic%20Medical%20Equipment/47-Paper-T_Neycheva1.pdf

Abstract:

This paper presents a digital high-Q comb filter for power-line (PL) interference suppression. The filter structure is based on a high-Q first difference filter, paralleled with a lossy integrator stage to restore the low-frequency filtered components. The presented filter is evaluated by Matlab simulations with real ECG signal contaminated with high amplitude PL interference. The made simulations show that this filter has minimal influence on processed ECG signal. Due to its high-Q notches only at PL harmonics the presented filter is appropriate for almost all biosignal acquisition applications. The filter is suitable for real-time operation with popular low-cost microcontrollers.

G8.18: Dobrev D, Neycheva T, Mudrov N. (2009) Simple High-Q Comb Filter for Mains Interference and Baseline Drift Suppression. Annual Journal of Electronics, 3, 1, Technical University - Sofia, ISSN:1313-1842, 50-52 Национално академично издателство
http://ecad.tu-sofia.bg/et/2009/ET_2009/AEM2009_1/Electronic%20Medical%20Equipment/50-Paper-T_Neycheva2.pdf

Abstract:

This paper presents a simple digital high-Q comb filter for baseline wander and power-line (PL) interference suppression. The filter concept relies on a first difference – a discrete version of the signal first derivative, resulting in a high-pass roll-off in combination of the so called a comb frequency response. The presented filter is evaluated by Matlab simulations with real ECG signal contaminated with high amplitude PL interference. The made simulations show that this filter has minimal influence on processed ECG signal. Due to its high-pass characteristic and high-Q notches only at PL harmonics the presented filter is appropriate for almost all biosignal acquisition applications where PL interference and baseline drift suppression is needed. The filter is suitable for real-time operation with popular low-cost microcontrollers.

G8.19: Dobrev D, Neycheva T, Krasteva V, Iliev I. (2010) High-Q comb FIR filter for mains interference elimination. Annual Journal of Electronics, 4, 2, Technical University - Sofia, ISSN:1313-1842, 126-129 Национално академично издателство
https://www.researchgate.net/publication/258848071_High-Q_Comb_FIR_Filter_for_Mains_Interference_Elimination

Abstract:

This paper presents a linear phase comb filter for power-line interference suppression. By a correlated average using samples delayed on multiple power-line periods, and subtracting the result from the input stream, a high-pass comb filter with high-Q notches at all power-line harmonics is attained. The high-pass roll-off of the filter is compensated with appropriate low-pass roll-off, and the resultant characteristic has an all-pass (flat) frequency response and notches only at the power-line harmonics. The filter design is based on a high-pass high-Q comb filter, in parallel with a low-pass moving-average stage to restore the low-frequency filtered components. The Q-factor depends on the time for averaging. The presented filter is evaluated by Matlab simulations with real ECG signal contaminated with high amplitude power-line interference. The simulations show that this filter has minimal influence on the processed ECG signal. Due to the filter's constant group delay (linear phase response) and high-Q notches only at the power-line harmonics, the presented filter is appropriate for power-line rejection in almost all biosignal acquisition applications. The filter is applicable for real-time execution by means of conventional low-cost microcontrollers.

G8.20: Neycheva T, Dobrev D. (2010) Integer Coefficients Comb Filter for Mains Interference Extraction. Annual Journal of Electronics, 4, 2, Technical University - Sofia, ISSN:1313-1842, 130-133 Национално академично издателство
https://www.researchgate.net/publication/258848227_Integer_Coefficients_Comb_Filter_for_Mains_Interference_Extraction

Abstract:

This paper presents integer coefficients high-Q comb filter for power-line (PL) or other periodical interference extraction. The filter concept relies on averaged half PL period first differences resulting in comb high-Q teeth at odd harmonics of PL interference. The presented filter is evaluated by Matlab simulations with real ECG signal contaminated with high amplitude PL interference. The made simulations show that this filter accurately extracts the PL interference. It passes only the odd harmonics of PL interference and can be used for extraction of any kind of odd harmonic interference, including rectangular shape. Once extracted PL interference can be subtracted from the input, and depending on the group delay requirements, the filter structure can be selected to have linear (constant group delay) or minimum (minimum group delay) phase response. The filter Q factor is proportional to the number of processed PL periods. For higher Q factors more stages could be cascaded. The presented filter has simple structure, suitable for real-time operation with popular low-cost microcontrollers.

G8.21: Dobrev D, Neycheva T. (2015) Adaptive Incremental Estimation Filter for AC Noise in the Electrocardiogram. Annual Journal of Electronics, 9, Technical University - Sofia, ISSN:1314-0078, 14-17, http://ecad.tu-sofia.bg/et/2015/ET2015/AJE-2015/014_Paper-T_Neycheva1.pdf

Abstract:

Power-line interference is a common disturbing factor in almost all biosignal acquisition applications. Many filtering procedures for mains interference elimination are available, but all of them are still not enough effective to fully overcome the problem. An interesting adaptive filtering technique for the power-line interference, called 'incremental estimation', was published in the literature. It uses a small step to increment or decrement the amplitude of the estimated interference, synthesized as a pure sine wave. This paper gives the frequency response of the filter and investigates its effectiveness with real ECG signals and Matlab simulations.