

Thomas Johann Seebecki elektroonikainstituut, 2017. aasta teadus- ja arendustegevuse aruanne

1. Struktuuriüksuse struktuur 2017. a

Thomas Johann Seebecki elektroonikainstituut

Thomas Johann Seebeck Department of Electronics

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Instituudi üksused on:

- Elektroonika ja sidetehnika õppekeskus (ELSI)
- Kognitronika teaduslabor (KOEL)
- Siduselektronika teaduslabor (SIEL)

Units inside of the department are:

- Study Center for Electronics and Communicative Technologies (StuCen ELSI)
- Research laboratory for Cognitronics (BaseLab KOEL)
- Research laboratory for Communicative Electronics (BaseLab SIEL)

2. Teadus- ja arendustegevuse ülevaade uurimisrühmade¹ lõikes

2.1 Research laboratory for Communicative Electronics (BaseLab SIEL)

Topic:

Impedants-spektroskoopia põhine objektide identifitseerimine ja juhtimine: signaalid, algoritmid, energiasäästlikud lahendused.

Impedance spectroscopy based identification and control of objects: signals, algorithms, energy efficient solutions.

Team:

1. Ants Koel, dotsent (labori juht);
2. Toomas Rang, professor (teema juht);
3. Olev Märten, professor;
4. Mart Min, teadur;
5. Paul Annus, vanemteadur;
6. Julia Berdnikova, teadur, doktorant;
7. Maksim Butsenko; nooremteadur, doktorant;
8. Alina Gavrijaševa, teadur, PhD;
9. Oleg Korolkov, vanemteadur;
10. Andrei Krivošei, vanemteadur;
11. Raul Land, vanemteadur;
12. Galina Rang, vaneminsener; MSc.;
13. Marek Rist, nooremteadur, doktorant;
14. Jana Toompuu, vanemteadur;
15. Triin Kask, nooremteadur, doktorant;
16. Sander Ulp, nooremteadur, doktorant.

¹ Oma uurimisvaldkonnas teadusprojekte/-lepinguid teostav teadlaste ja/või õppejõudude koosus, mis võib hõlmata liikmeid mitmest struktuuriüksusest. Viimasel juhul näidatakse tulemused kõigi uurimisgrupis osalevate struktuuriüksuste aruannetes.

The rest of 23 TJS ELIN PhD students not named in the list were more or less involved in BaseLab SIEL R&D activities.

Short description of the research work

The base of modern electronics explicitly formulates the results over generating, processing, transmitting and retransmitting, and deporting/retaining of signals (data). It realizes itself over networking of components, in their mutual communication and in the increase of autonomous aptness of components through the development of different unified hardware platforms, in which the combination of signal processing and data transforming takes place under strongly optimized energy consumption limitations. Mainly the R&D like Impedance spectroscopy: novel solutions, algorithms, applications and microelectronic means for experimental research; medical imaging, by using of machine learning and advanced signal and image processing techniques; and development of broadband excitation signals (including binary sequences) with the controllable frequency and amplitude spectra were under consideration.

New modules of vertical architecture based on SiC diodes using diffusion-welding technologies have been completed. A prototype of a voltage doubler using the self-capacitance of SiC diodes was presented. The cycle of results on vertical architecture forms the basis for the patent application. Examination of the surface of biosensors with SAM layers topography by AFM microscope (collaboration with Tartu University) has realized. New Graphene film on SiC AFM surface topography research together with Ioffe institute from St. Petersburg has been completed.

Activities continued in the frames of IUT19-11 "Impedance spectroscopy based identification and control of objects: signals, algorithms, energy efficient solutions" project. Main emphasis was on continued longtime cooperation with East Tallinn Central Hospital for noninvasive assessment of central aortic pressure. Two main aspects were targeted besides continued clinical experiments to acquire comparative measurement data: reliable extraction of information of clinical importance from measurement signals with novel signal processing concepts and algorithms, and development of novel measurement system based on acquired experience and advances in low power analog signal processing. Much attention was paid to additional research into and enhancement of the electrode system for improvement of the bioimpedance measurement accuracy and reliability. The results paid out in improvement and development of the already well-established QUADRA platform solutions. Doctoral thesis was finalized on the subject. New cooperation project has been started with University of Tampere in addition to continued long-term cooperation with Injeq OY.

TJS Department of Electronics and this research group especially is responsible for the supervision of first TTU student satellite electronics modules development. Original designs for Ku-band downlink and high performance onboard image processing capabilities are unique for nanosatellite designs.

Teadustöö lühikirjeldus

Kaasaegne elektroonika kogub või genereerib, töötleb, edastab ja säilitab signaale ning andmeid. Üha rohkem oluliseks on muutumas komponentide omavaheline võrgustumisvõimekus, autonoomsus, komponentide sobivus unifitseeritud platvormide ehituskivideks ning tugev energiatarbe optimeeritus. TJS elektroonikainstituudi kommunikatiivse elektroonika labori teadustöö fookus on potentsiaalse võrgustusvõimega uute teadusmahukate integreeritud tark- ja riistvaraliste komponentide, sensorite ja terviksüsteemide loomisel ja uurimisel. Tuumikkompetentside loometöö põhineb institutsionaalsel uurimistöö IUT1911 „Impedants-spektroskoopia põhine objektide identifitseerimine ja juhtimine: signaalid, algoritmid, energiasäästlikud lahendused“ ning personaalsel uurimistöö grandil PUT1435 „Laia keelutsooniga pooljuhtmaterjalidel põhinevad heterosiirded“, mida toetasid teaduse tippkeskuses EXCITE „IT Tippkeskus EXCITE“ (2015-2022) raames tehtavad uuringud.

Jätkusid uurimistööd SiC tavastruktuuriga JBS-diodide põhjal vertikaalse arhitektuuriga modulaar-komposiitide loomise alal, kasutades ühendustehnoloogiana difusioonkeevitust. Välja töötati välise kondensaatorita pinge dubleerija prototüüp, mis kasutab SiC diodide enda mahtuvust (SiC JBS Diode Symmetrical Voltage Doubler). Vertikaalse arhitektuuri uurimistööde tsükkel on aluseks patenditaotlusele.

Alustati numbriliste simulatsioonidega laia keelutsooniga pooljuhtide heterosiirete omaduste ja võimalike defektide uurimiseks. Lisaks, lähtudes koostööst St. Peterburi Ioffe Instituudiga, alustati grafeeni põhinevate sensorite simulatsioonidega.

Töö jätkus projekti IUT19-11 "Impedants-spektroskoopia põhine objektide identifitseerimine ja juhtimine: signaalid, algoritmid, energiasäästlikud lahendused raames. Pearõhk oli pakajalise koostöö jätkumisel ITK'ga aordi tsentraalse vererõhukõvera mitteinvasiivseks ülesvõtmiseks ja hindamiseks. Kaks olulisemat aspekti, lisaks kliiniliste katsete jätkumisele, olid: uudsete signaalitöötlusmeetodite ja algoritmide kasutamine kliiniliselt olulise informatsiooni eraldamiseks mõttesignaalidest ja saadud kogemustel ning avastustel, madala volutarbega analoogsignaali töötlemise vallas, tugineva uudse mõõtesüsteemi arendus. Palju tähelepanu pühendati ka elektroodsüsteemi täiendavale uurimisele ja parendamisele bioimpedantsi täpsemaks ja töökindlamaks mõõtmiseks. Jätkus ka varem loodud QUADRA mõõtesüsteemi parendus ja edasiarendus. Teemal valmis ka doktoritöö. Huvi seadme vastu on rahvusvaheliselt kasvanud ja mitmed läbirääkimised kestavad. Alustatud on uut koostööprojekti Tampere Ülikooliga, lisaks aastate pikkusele jätkuvale koostööle soome firmaga Injeq OY.

TJS elektroonikainstituut, olulises osas käesolev labor, juhendab TTU esimese tudengisatelliidi elektroonikamoodulite disainimeeskondi. Ku-sagedusala saatja ning kõrge arvutusjõudlusega pilditöötlusele orbiidil orienteeritud pardaarvuti on unikaalsed kogu nanosatelliitide maailmas.

Main results

- 1) New efficient microheating solution has developed and the concept was proofed for NINAAT lab-on chip devices based on PTCR polymer resin heaters (T. Pardy PhD dissertation and the patent application PA 2017 70310);
- 2) Development of a prototype of a SiC Schottky diode rectifier bridge. The prototype builds upon commercial SiC Schottky diodes by means of diffusion welding. As opposed to commercial bridges, our prototype totally preserves the initial characteristics after irradiation by electrons with an energy of 0.9 MeV and density of $3 \times 10^{16} \text{ cm}^{-2}$.
- 3) Impedance-spectroscopy based algorithms for characterization of the physical properties of the metal samples (Estonian patent application Method and device for frequency response measurement Authors: Olev Märten, Mart Min, Jaan Ojarand, Raul Land, Marek Rist; Prioriteedi number: P201700005; Priority date: 1.02.2017);
- 4) In cooperation with AS Norma/Autoliv the new method for detection of characterization of metal-details has been introduced;
- 5) Development and validation of a method for automating the detection of large pulmonary nodules in computed tomography images. The method builds upon unsupervised feature mapping by means of a stacked sparse autoencoder. The performance of the proposed method makes it suitable for reducing the number of false positives in a computer-aided-detection system;
- 6) Development of "LINE-P" (Linear Energy Prediction) for energy prediction in the context of wireless sensor nodes powered by means of energy harvesting. The model is based on approximation and sampling theory. An accuracy of more than 90% can be achieved for solar and wind energy sources.

Tähtsamad teadustulemused

- 1) Uuriti ning tõestati kontseptsionaalne lahendus uudse ja efektiivse mikrokuumutuse reaalseks lahenduseks NINAAT tüüpi kiilaborites põhinedes PTCR polümeerstest vaikutest valmistatud kuumutitel (T. Pardy PhD dissertatsioon ja patendi taotlus PA 2017 70310).
- 2) Uudse SiC Schottky diodidel põhineva sildalaldi prototüüp. Prototüübi loomiseks kasutati diffusioonkeevituse tehnoloogiat. Erinevalt tööstuslikest analoogidest säilib silla töövõime ka peale kiiritamist (elektronid energiaga 0.9MeV doosiga $3 \times 10^{16} \text{ cm}^{-2}$).
- 3) Loodi uudne impedantsi mõõtmise meetod, kirjeldatud a) Eesti patenditaotluses: Method and device for frequency response measurement Autorid: Olev Märten, Mart Min, Jaan Ojarand, Raul Land, Marek Rist; Prioriteedi number: P201700005; Prioriteedi kuupäev: 1.02.2017.;
- 4) Koostöös AS NORMA/Autoliv arendatud uudsed impedantsipõhised metall-detailide karakteriseerimise meetodid.
- 5) On välja arendatud masinõppel ja sellega seotud automaatsel mustrituvastusel põhinevad meditsiinilise pilditöötluse algoritmid kopsuvähi noodulite masintuvastamiseks kompuutertomograafia piltidest.

Loodud algoritmide kvaliteet on sobiv vale-positiivsete leidude arvu vähendamiseks kopsuvähi masintuvastust kasutavates süsteemides.

- 6) LINE-P (Linear Energy Prediction) algoritmi arendamine übritsevast keskkonnast energiahõivest sõltuvate kasutavate traadita andmeside sõlmede energiatarbe prognoosimiseks. Päikese- ja tuuleenergia allikate kasutamise puhul ületab täpsus 90%.

Publications

ETIS 1.1:

1. Metshein, M.; Parve, T.; Annus, P.; Rist, M.; Min, M. (2017). Realization and evaluation of the device for measuring the impedance of human body for detecting the respiratory and heart rate. *Electronics and Electrical Engineering*, 23 (3), 36–42.
2. Pardy, Tamás; Tulp, Indrek; Kremer, Clemens; Rang, Toomas; Stewart, Ray (2017). Integrated self-regulating resistive heating for isothermal nucleic acid amplification tests (NAAT) in Lab-on-a-Chip (LoC) devices. *PLOS ONE*, 12.10.1371/journal.pone.0189968.
3. Ojarand, J.; Min, M. (2017). Recent Advances in Crest Factor Minimization of Multisine. *Electronics and Electrical Engineering*, 23 (2), 59–62. DOI: 10.5755/j01.eie.23.2.18001.
4. Korolkov, Oleg; Kozlovski, Vitali; Lebedev, Alexander; Land, Raul; Sleptsuk, Natalja; Toompoo, Jana; Rang, Toomas (2017). SiC Schottky Diode Rectifier Bridge Represented as Diffusion-Welded Stack. *Materials Science Forum*, 897, 697–700.
5. Pardy, Tamás; Rang, Toomas; Tulp, Indrek (2017). Development of Temperature Control Solutions for Non-Instrumented Nucleic Acid Amplification Tests (NINAAT). *Micromachines*, 8 (6) (180): 10.3390/mi8060180.
6. Giannoukos, Georgios; Min, Mart; Rang, Toomas (2017). Relative complex permittivity and its dependence on frequency. *World Journal of Engineering*, 14 (6), 532–537. 10.1108/WJE-01-2017-0007.
7. A.A.Lebedev, K.S.Davydovskaya, V.V.Kozlovski, O.Korolkov, N.Sleptsuk, J.Toompoo (2017). Degradation of 600-V 4H-SiC Schottky Diodes under Irradiation with 0.9 MeV Electrons. *Materials Science Forum*, 897, 447–450.
8. Astra, E.; Olsson, S. L. I.; Eliasson, H.; Andrekson, P. A. (2017). Dispersion management for nonlinearity mitigation in two-span 28 GBaud QPSK phase-sensitive amplifier links. *Optics Express*, 25 (12), 13163–13173. [10.1364/OE.25.013163](https://doi.org/10.1364/OE.25.013163).

ETIS 3.1:

1. M. Min, A. Krivošei, P. Annus, H. Kõiv, T. Uuetoa, J. Lamp (2017). Bioimpedance sensing – a viable alternative for tonometry in non-invasive assessment of central blood pressure“, 12th Annual IEEE International Symposium on Medical Measurements and Applications (MeMeA, Mayo Clinic, Rochester, Minnesota, USA). *IEEE*, 373–378, 2017. DOI: 10.1109/MeMeA.2017.7985905
2. Martens, O.; Min, M.; Land, R.; Ojarand, J.; Rist, M. (2017). Phase-increment sampling in chirp signal based impedance measurements. 2017 International Conference on Sampling Theory and Applications (SampTA), Tallinn, 2017, July 3-7. *IEEE*, 604-608. DOI: 10.1109/SAMPTA.2017.8024393
3. Ojarand, J.; Min, M. (2017), Controllable Limiter of Signal Amplitudes for Bioimpedance Measurements. *IFMBE Proceedings*, 65: Joint Conference of the European Medical and Biological Engineering Conference (EMBE) and the Nordic-Baltic Conference on Biomedical Engineering and Medical Physics (NBC), Tampere, Finland, June 2017. Ed. Eskola, H.; Väisänen O.; Viik, J.; Hyttinen, J. Singapore: Springer Nature, 920–923. DOI: 10.1007/978-981-10-5122-7.
4. Krivošei, A.; Min, M.; Annus, P.; Kõiv, H.; Aabloo, A.; Uuetoa, T. (2017). Analysis of Instantaneous Cardiac EBI Signal Variability over the Heart Cycle(s): Non-Linear Time-Scale Approach. *IFMBE Proceedings*, 65: Joint Conference of European Medical and Biological Engineering Conference (EMBE) and Nordic-Baltic Conference on Biomedical Engineering and Medical Physics (NBC) (EMBE2017), Tampere, Finland, 11-15 June 2017. Tampere, Finland. Singapore: Springer Nature, 940–943. DOI: 10.1007/978-981-10-5122-7_235.

5. Krivošei, A.; Min, M.; Annus, P.; Kõiv, H.; Aabloo, A.; Uuetoa, T. (2017). Analysis of Instantaneous Cardiac EBI Signal Variability over the Heart Cycle(s): Non-Linear Time-Scale Approach. IFMBE Proceedings, 65: Joint Conference of European Medical and Biological Engineering Conference (EMBEC) and Nordic-Baltic Conference on Biomedical Engineering and Medical Physics (NBC) (EMBEC2017), Tampere, Finland, 11-15 June 2017. Tampere, Finland: Springer, 940–943.10.1007/978-981-10-5122-7_235.
6. Min, M.; Krivošei, A.; Annus, P.; Kõiv, H.; Uuetoa, T.; Lamp, J. (2017). Bioimpedance sensing – a viable alternative for tonometry in non-invasive assessment of central blood pressure. 12th Annual IEEE International Symposium on Medical Measurements and Applications (MeMeA, Mayo Clinic in Rochester, Minnesota, USA, 2017). IEEE, 373–378.
7. Metshein, M.; Annus, P.; Land, R.; Krivošei, A.; Ojarand, J.; Aabloo, A.; Min, M. (2017). Variation of cardiac and respiratory waveform on human thorax in the case of inductive coupling. IFMBE Proceedings, 65: Joint Conference of European Medical and Biological Engineering Conference (EMBEC) and Nordic-Baltic Conference on Biomedical Engineering and Medical Physics (NBC) (EMBEC2017), Tampere, Finland, 11-15 June 2017. Ed. Eskola H., Väisänen O., Viik J., Hyttinen J. Singapore: Springer, 671–674.10.1007/978-981-10-5122-7_168.
8. Annus, P.; Land, R.; Priidel, E.; Metshein, M.; Min, M.; Märten, O. (2017). Quantization of the response signal differences for the electrical bioimpedance measurement. Proceedings of Joint Conference of European Medical and Biological Engineering Conference (EMBEC) and Nordic-Baltic Conference on Biomedical Engineering and Medical Physics (NBC) (EMBEC2017), 65: European Medical and Biological Engineering Conference (EMBEC) and the Nordic-Baltic Conference on Biomedical Engineering and Medical Physics (NBC). Springer, 290–293. (IFMBE Proceedings).10.1007/978-981-10-5122-7_73.
9. Ojarand, J.; Min, M. (2017). Controllable Limiter of Signal Amplitudes for Bioimpedance Measurements. IFMBE Proceedings, 65: Joint Conference of the European Medical and Biological Engineering Conference (EMBEC) and the Nordic-Baltic Conference on Biomedical Engineering and Medical Physics (NBC), Tampere, Finland, June 2017. Ed. Eskola,H.;Väisänen O.;Viik,J.;Hyttinen,J. Singapore: Springer Nature, 920–923.10.1007/978-981-10-5122-7.
10. Martens, O.; Min, M. ; Land, R. ; Ojarand, J. ; Rist, M. (2017). Phase-increment sampling in chirp signal based impedance measurements. 2017 International Conference on Sampling Theory and Applications (SampTA),: Tallinn, 2017, July 3-7. IEEE, 604-608.10.1109/SAMP.TA.2017.8024393.
11. Armen Sahakyan, Ants Koel, Toomas Rang (2017). Non-destructive eddy-current measurements for silicon-carbide heterostructures analysis. In: D. O. Northwood, J. De Hosson, T. Rang, C. A. Brebbia (Ed.). WIT Transactions on Engineering Sciences. Materials Characterization 2017 (49–60). Great Britain: WIT Press.
12. Rashid, Haroon Muhammad; Koel, Ants; Rang, Toomas; Gähviler, Reto; Grosberg, Martin; Jõema, Rauno (2017). Nanoscale and microscale simulations of n-n junction heterostructures of 3C-4H silicon carbide. In: D. O. Northwood, J. De Hosson, T. Rang, C.A. Brebbia (Ed.). WIT Transactions on Engineering Sciences. Material Characterization 2017 (235–250). Great Britain: WIT Press.
13. Veher, Oleksandr; Sleptšuk, Natalja; Toompuu, Jana; Korolkov, Oleg; Rang, Toomas (2017). The dependence of reverse recovery time on barrier capacitance and series on-resistance in Schottky diodes. In: D. O. Nortwood, J. de Hosson, T. Rang, C.A Brebbia (Ed.). WIT Transactions on Engineering Sciences. Material Characterization 2017 (15–22). Great Britain: WIT Press.
14. Butsenko, Maksim; Swärd, Johan; Jakobsson, Andreas (2017). Estimating Sparse Signals Using Integrated Wide-Band Dictionaries. *Proceedings. IEEE International Conference on Acoustics, Speech, and Signal Processing, ICASSP 2017: IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP), New Orleans, USA, March 5-9, 2017.* IEEE, 4426–4430.

ETIS 5.1:

1. H. Kõiv, M. Min, “Development of a non-invasive bioimpedance sensing for the monitoring of aortic blood pressure curve”, Abstract Book of the IEEE Workshop on Industrial and Medical Measurement and Sensor Technology – Sensorica 2017, Mülheim, Germany, 2017.

Patents and Patent Applications 2017

P1. Estonian Patent EE 05788 B1 (granted: 15.02.2017), Method and device for impedance analysis with binary excitation. Authors: Olev Märtens; Raul Land; Mart Min; Paul Annus; Marko Reidla. Owners: Tallinn University of Technology, Competence Center Eliko.

P2. Estonian Patent Application P201700005 (Priority date: 1.02.2017), Method and device for frequency response measurement. Authors: Olev Märtens, Mart Min, Jaan Ojarand, Raul Land, Marek Rist. Owner: Tallinn University of Technology.

P3. Estonian Patent Application P201700023 (Priority date: 9.06.2017). Method and device for quantization of the response signal differences during synchronous measurements. Authors: Paul Annus, Mart Min, Raul Land, Olev Märtens, Eiko Priidel, Margus Metshein. Owner: Tallinn University of Technology.

In 2017, the Research Laboratory for Communicative Electronics published 23 peer-reviewed papers (8 papers ETIS 1.1. and 14 papers ETIS 3.1.), partly in cooperation with members from other units in the department and partly in cooperation with international partners. In addition, three Estonian patents have been awarded, in cooperation of members from other units in the department.

Two PhD students have successfully completed their theses in 2017 and the defense of Marek Rist (supervisors Professor emeritus Mart Min and Olfa Kanoun) and Tamás Pardy (supervisors prof. Toomas Rang, Dr, Indrek Tulp, and associate professor Ants Koel) took place on January 15. 2018.

2.2 Research laboratory for Cognitronics (BaseLab KOEL)

Topic:

Kognitroonika: meetodid, algoritmid, energiasäästlik traadita side

Cognitronics: methods, algorithms, energy-efficient wireless communication

Team:

1. Toomas Rang, professor, (labori juht);
2. Yannick Le Moullec, professor, (teema juht);
3. Muhammad Mahtab Alam, dotsent;
4. Robin Benjamin Ehrminger, nooremteadur, doktorant;
5. Eero Haldre, vaneminsener;
6. Md Muhidul Islam Khan, teadur, järeldoktorant;
7. Rida Khan, nooremteadur, nooremteadur, doktorant;
8. Kairi Kivirand, teadur;
9. Alar Kuusik, vanemteadur;
10. Hip Kõiv, nooremteadur, doktorant;
11. Hassan Malik, teadur, järeldoktorant;
12. Margus Metshein, nooremteadur, doktorant;
13. Jaan Ojarand, vanemteadur;
14. Toomas Ruuben, professor;
15. Natalja Sleptšuk, vanemteadur.

The rest of 23 TJS ELIN PhD students not named in the list were more or less involved in BaseLab KOEL R&D activities.

Description of the research work

Cognitive electronics can be described as hardware/software electronic systems that embed some form of intelligence. In this context, the cognitive cycle includes sensing, collecting, processing, and analyzing data, as well as learning patterns and taking decisions. Such cognitive functions can be implemented on a wide range of technological platforms that include micro and nano-sensors followed by signal processing elements such as microprocessors (GPP), digital signal processors (DSP), field programmable gate arrays (FPGA), and customized circuits (ASIC). Very often, such platforms also include wireless and internet connectivity, as in the Internet of Things (IoT).

For 2017, the activities of the Research Laboratory for Cognitive Electronics at Johann Seebeck Department of Electronics were carried out in the context of several projects, namely EU Horizon 2020 ERA-Chair "Cognitive Electronics COEL", Estonian IUT- project IUT1911 "Impedance spectroscopy based identification and control of objects: signals, algorithms, energy efficient solutions", and TTU Baseline Project B38 "Hardware and Software Solutions for cognitive Embedded Networks Systems".

In addition, the work on the evaluation of quality of service for voice over IP solutions for wireless mesh networks for emergencies like flooding, earthquakes, etc. was finalized in December 2017. We continued the activities connected with the ESS/ERIC (European Spallation Source) consortium in Lund, Sweden. These are related to the development and realization of specific electronic boards for their experimental infrastructure.

We continued the experimental and numerical experiments in the field of semiconductor electronics. The implementation of vertical integration of diffusion welded modular architectures in cooperation with Russian Academy of Science, A.F. Ioffe Physico-Technical Institute in St. Petersburg (Russia) have been fulfilled (single-phase Graetz Bridge, using Cree CPW3-1700-SO10B SiC structures).

We continued the research activities together with Tartu University in frames of Centre of Excellent EXCITE for the development of microfluidic components for disposable Point-of-Care Test devices.

Three new research activities started in 2017:

1. Novel techniques for efficient resource allocation in Narrow Band IoT applications. Throughput, latency and device support metrics are realistically evaluated by considering the physical and transport layers overhead.
2. Machine learning based reinforcement learning algorithms are applied to enhance the throughput in the context of LTE D2D communication. In the future, unlicensed assisted communication especially for disaster scenarios will be considered.
3. Optimization at the system level for wearable wireless networks applications, by exploiting biomechanical mobility modeling for body to body communication.

Teadustöö lühikirjeldus

Kognitiivset elektroonikat võib lihtsustatult kirjeldada kui tark- ja riistvara sisaldavat elektroonikasüsteemi, mis sisaldab ka teatud määral sisseehitatud nutikust. Selles kontekstis hõlmab kognitiivne tsükkel andmeid, andmete kogumist, töötlemist ja analüüsimist, seaduspärasuste tuvastamist ja otsuste tegemist. Selliseid kognitiivseid funktsioone saab realiseerida erinevatel tehnoloogilistel platvormidel, mis sisaldavad mikro- ja nanoandureid, millele järgneva töötamise ja otsuste tegemise võtavad üle keerukamad signaalitötlusseadmed nagu mikroprotsessorid (GPP), digitaalsignaali protsessorid (DSP), väljaga programmeeritavad ventiilmaatriksid (FPGA) ja kohandatud mikroskeemid (ASIC). Väga sageli sisaldavad sellised platvormid ka traadita- ja Interneti-ühendust, näiteks nagu värgvõrgus (IoT).

2017. aastal Thomas Johann Seebecki elektroonikainstituudi Kognitioonika teaduslabori tegevus toimus läbivalt erinevate projektide raames ja koostöös Siduselektronika teaduslaboriga. Erinevatest projektidest vääriavad esile toomist eelkõige EU Horizon 2020 ERA-Chair "Cognitive Electronics COEL", institutsionaalse uurimistöö projekt " IUT1911 "Impedants-spektroskoopia põhine objektide identifitseerimine ja juhtimine: signaalid, algoritmid, energiasäästlikud lahendused" ning TTÜ baasfinantseerimisprojekt B38 "Riist- ja tarkvaralised lahendused kognitiivsetele sardvõrksüsteemidele"

Lisaks viidi 2017. aasta detsembris lõpule tööd hädaolukordade, näiteks üleujutuste, maavärinate jms puhul kasutatavate hajus-raadiovõrkude (wireless mesh network) VoIP teenuskvaliteedi hindamiseks. Jätkasime Lundi Rootsis konsortsiumiga ESS/ERIC (Euroopa neutronkiirendi) seotud tegevusi. Need on seotud nende eksperimentaalse infrastruktuuri spetsiifiliste elektrooniliste moodulite väljatöötamise ja realiseerimisega. Jätkasime eksperimentaalseid ja numbrilisi eksperimente pooljuhtelektroonika valdkonnas. Me jätkasime koostöös Tartu Ülikooliga teadusuuringuid Excellent EXCITE'i keskuste raames, et arendada välja ühekordseks testiks kasutatavaid kiilaborisüsteeme.

Lisaks alustasime 2017. aastal järgmist kolme uurimistegevust:

- 1) Uued meetodid ressursside tõhusaks jaotamiseks piiratud andmesidevõimekusega (narrow band) IOT rakendustes. Läbilaskevõimet, latentsust ja seadme tugiteenusid mõõdetakse realistlikult, võttes arvesse füüsilisi ja transpordikihte.
- 2) Masinõppel põhinevate stiimulõppe algoritmide rakendamine LTE side D2D ühenduste läbilaskevõime tõstmiseks. Tulevikus kaalutakse täiendavaid uuringuid D2D abistava suhtluse alal, eriti katastroofistsenaariumide puhul.
- 3) Kantavate raadiosidevõrkude (*wearable wireless networks*) süsteemitaseme optimeerimine kasutades kehavõrkudevahelise kommunikatsiooni biomehaanilise liikumise modelleerimist.

Main research results in 2017

- 1) Development and validation of a method for automating the detection of large pulmonary nodules in computed tomography images. The method builds upon unsupervised feature mapping by means of a stacked sparse autoencoder. The performance of the proposed method makes it suitable for reducing the number of false positives in a computer-aided-detection system.
- 2) Evaluation of various voice over Internet protocol approaches in wireless mesh network critical scenarios such as first responders, flooded village, remote village, and platoon deployment. The integration of IEEE 802.11g with G.711 and G.729 codecs and the AODV routing protocol yields the best performance.
- 3) Development of "LINE-P" (Linear Energy Prediction) for energy prediction in the context of wireless sensor nodes powered by means of energy harvesting. The model is based on approximation and sampling theory. An accuracy of more than 90% can be achieved for solar and wind energy sources.
- 4) Development of a cooperative reinforcement learning algorithm for adaptive resource allocation. The algorithm improves system throughput for Device-to-Device Communication as well as the quality of service by means of efficient control of the interference.

Põhilised teadustöö tulemused 2017

- 1) On välja arendatud masinõppel ja sellega seotud automaatsel muustrituvastusel põhinevad meditsiinilise pilditöötluse algoritmid kopsuvähi noodulite masintuvastamiseks kompuutertomograafia piltidest. Loodud algoritmide kvaliteet on sobiv vale-positiivsete leidude arvu vähendamiseks kopsuvähi masintuvastust kasutavates süsteemides.
- 2) Erinevate VoIP protokollide hindamine ja võrdlus raadiosidevõrkude missioonikriitiliste stsenaariumide (esimese vastaja kiire leidmine, üleujutatud küla, küla võrgu katvuspiiril, rühm missioonil) realisatsiooniks. IEEE 802.11g protokollide integratsioon G.711 ja G.729 kodeerimismoodulitega ning AODV marsruutimine andsid parima jõudluse erinevates olukordades.
- 3) LINE-P (Linear Energy Prediction) algoritmi arendamine übritsevast keskkonnast energiahõivest sõltuvate kasutatavate traadita andmeside sõlmede energiatarbe prognoosimiseks. Päikese- ja tuuleenergia allikate kasutamise puhul ületab täpsus 90%.
- 4) Seadmetevaheliste ühenduste kvaliteedil põhineva adaptiivse ressursialduse algoritmi arendus. Algoritm parendab häirete tõhusa kontrolli kaudu nii seadmetevahelise (D2D) sidesüsteemi läbilaskevõimet kui ka teenuse kvaliteeti.

Publications

ETIS 1.1.

1. Gupta, Anindya; Saar, Tönis; Märten, Olev; Le Moullec, Yannick (2017). Unsupervised Feature Mapping via Stacked Sparse Autoencoder for Automated Detection of Large Pulmonary nodules in CT Images. *ELECTRONICS AND ELECTRICAL ENGINEERING*, 1–5.10.5755/j01.eie.23.6.19695.
2. Ahmed, T.; Le Moullec, Y. (2017). A QoS Optimization Approach in Cognitive Body Area Networks for Healthcare Applications. *Sensors*, 17 (4), 1–23.10.3390/s17040780.
3. Ben Arbia, Dhafer; Alam, Muhammad Mahtab; Le Moullec, Yannick; Hamida, Elyes (2017). Communication Challenges in on-Body and Body-to-Body Wearable Wireless Networks - A Connectivity Perspective. *Technologies*, 5 (43), 1–18.10.3390/technologies5030043.
4. Meeran, T. Mohammad; Annus, Paul; Alam, M. Muhammad; Le Moullec, Yannick; (2017). Evaluation of VoIP QoS Performance in Wireless Mesh Networks. *MDPI Information Applications*, 8 (3), 1–26.info8030088.
5. Ahmed, Faisal; Tamberg, Gert; Le Moullec, Yannick; Annus, Paul (2017). Dual-Source Linear Energy Prediction (LINE-P) Model in the Context of WSNs. *Sensors*, 17 (7), 1–22.s17071666.
6. Khan, Muhidul Islam; Alam, Muhammad Mahtab; Le Moullec, Yannick; Yaacoub, Elias (2017). Throughput-Aware Cooperative Reinforcement Learning for Adaptive Resource Allocation in Device-to-Device Communication. *Future Internet*, 9 (4, 72).fi9040072.
7. Ben-Arbia, D.; Alam, M. M., Kadri, A.; Ben-Hamida, E. Attia, R. (2017). Enhanced IoT-Based End-To-End Emergency and Disaster Relief System. *Journal of Sensor and Actuator Networks*, 6 (3), 1–18.10.3390/jsan6030019.
8. Mihklepp, Kaisa; Kivirand, Kairi; Nikopensius, Merit; Peedel, Delia; Utt, Meeme; Rincken, Toonika (2017). Design and Production of Antibodies for the Detection of *Streptococcus uberis*. *Enzyme and Microbial Technology*, 96 (1), 135–142.10.1016/j.enzmictec.2016.10.009.
9. Kagan, Margarita; Printsmann, Gunnar; Kivirand, Kairi; Rincken, Toonika (2017). Determination of Penicillins in Milk by a Dual Optrode Biosensor. *Analytical Letters*, 50 (5), 819–828.10.1080/00032719.2016.1202957.
10. Metshein, M.; Parve, T.; Annus, P.; Rist, M.; Min, M. (2017). Realization and evaluation of the device for measuring the impedance of human body for detecting the respiratory and heart rate. *Elektronika ir Elektrotehnika*, 23 (3), 36–42.10.5755/j01.eie.23.3.18330.
11. Ojarand, J.; Min, M. (2017). Recent Advances in Crest Factor Minimization of Multisine. *Electronics and Electrical Engineering*, 23 (2), 59–62.10.5755/j01.eie.23.2.18001.
12. Korolkov, Oleg; Kozlovski, Vitali; Lebedev, Alexander; Land, Raul; Sleptsuk, Natalja; Toompuu, Jana; Rang, Toomas (2017). SiC Schottky Diode Rectifier Bridge Represented as Diffusion-Welded Stack. *Materials Science Forum*, 897, 697–700.
13. Pardy, Tamás; Rang, Toomas; Tulp, Indrek (2017). Development of Temperature Control Solutions for Non-Instrumented Nucleic Acid Amplification Tests (NINAAT). *Micromachines*, 8 (6) (180): 10.3390/mi8060180.
14. Giannoukos, Georgios; Min, Mart; Rang, Toomas (2017). Relative complex permittivity and its dependence on frequency. *World Journal of Engineering*, 14 (6), 532–537.10.1108/WJE-01-2017-0007.
15. A.A.Lebedev, K.S.Davydovskaya, V.V.Kozlovski, O.Korolkov, N.Sleptsuk, J.Toompuu (2017). Degradation of 600-V 4H-SiC Schottky Diodes under Irradiation with 0.9 MeV Electrons. *Materials Science Forum*, 897, 447–450.

ETIS 3.1

1. Mohammad Tariq Meeran; Paul Annus; Yannick Le Moullec (2017). Approaches for Improving VoIP QoS in WMNs. *Proceedings of International Conference on Electrical Engineering and Computer Science (ICECOS) 2017, Palembang, Indonesia, 22-23 August 2017: International Conference on Electrical Engineering and Computer Science (ICECOS) 2017, Palembang, Indonesia, 22-23 August 2017. IEEE Xplore: IEEE*, 22–27.10.1109/ICECOS.2017.8167138.
2. Ulp, Sander; Le Moullec, Yannick; Alam, Muhammad Mahtab (2017). LMS-Based Leader Selection for Distributed Estimation. *2017 IEEE International Symposium on Signal Processing and Information Technology (ISSPIT)*. IEEE.
3. Dhafer Ben Arbia, Muhammad Mahtab Alam, Rabah Attia, Elyes Ben Hamida and Abdullah Kadri (2017). CROW2: Internet of Humans-based Platform for Disaster Relief and Emergency

- Communication. 14th IEEE Annual Consumer Communications & Networking Conference (IEEE CCNC 2017): 14th IEEE Annual Consumer Communications & Networking Conference (IEEE CCNC 2017), January, 2017. IEEE: IEEE Conference Publications, 1–2.
4. Talha, S.; Rizwan, A.; Adnan, K.; Muhammad, M. A. (2017). Network Coding for Energy Efficient Transmission in Wireless Body Area Networks. *Network Coding for Energy Efficient Transmission in Wireless Body Area Networks: 7th International Conference on Current and Future Trends of Information and Communication Technologies in Healthcare (ICTH 2017)*, Lund, Sweden. September 2017. Elsevier, 435–440. (Procedia Computer Science; 113).10.1016/j.procs.2017.08.285.
 5. Gross-Paju, Katrin; Maamägi, Heigo; Reilent, Enar; Kuusik, Alar (2017). Home based monitoring system with wireless sensors that confirm stable balance and motor function readings during remission is feasible for patients with multiple sclerosis. *Abstracts / Journal of the Neurological Sciences*, 381: XXIII World Congress of Neurology, Kyoto, Japan, 16-21 September 2017. Elsevier, 436–436. (Supplement).10.1016/j.jns.2017.08.3444.
 6. Krivošei, A.; Min, M.; Annus, P.; Kõiv, H.; Aabloo, A.; Uuetoa, T. (2017). Analysis of Instantaneous Cardiac EBI Signal Variability over the Heart Cycle(s): Non-Linear Time-Scale Approach. *IFMBE Proceedings*, 65: Joint Conference of European Medical and Biological Engineering Conference (EMBEC) and Nordic-Baltic Conference on Biomedical Engineering and Medical Physics (NBC) (EMBEC2017), Tampere, Finland, 11-15 June 2017. Tampere, Finland: Springer, 940–943.10.1007/978-981-10-5122-7_235.
 7. Min, M.; Krivošei, A.; Annus, P.; Kõiv, H.; Uuetoa, T.; Lamp, J. (2017). Bioimpedance sensing – a viable alternative for tonometry in non-invasive assessment of central blood pressure. *12th Annual IEEE International Symposium on Medical Measurements and Applications (MeMeA, Mayo Clinic in Rochester, Minnesota, USA, 2017)*. IEEE, 373–378.
 8. Metshein, M.; Annus, P.; Land, R.; Krivošei, A.; Ojarand, J.; Aabloo, A.; Min, M. (2017). Variation of cardiac and respiratory waveform on human thorax in the case of inductive coupling. *IFMBE Proceedings*, 65: Joint Conference of European Medical and Biological Engineering Conference (EMBEC) and Nordic-Baltic Conference on Biomedical Engineering and Medical Physics (NBC) (EMBEC2017), Tampere, Finland, 11-15 June 2017. Ed. Eskola H., Väisänen O., Viik J., Hyttinen J. Singapore: Springer, 671–674.10.1007/978-981-10-5122-7_168.
 9. Annus, P.; Land, R.; Priidel, E.; Metshein, M.; Min, M.; Märten, O. (2017). Quantization of the response signal differences for the electrical bioimpedance measurement. *Proceedings of Joint Conference of European Medical and Biological Engineering Conference (EMBEC) and Nordic-Baltic Conference on Biomedical Engineering and Medical Physics (NBC) (EMBEC2017)*, 65: European Medical and Biological Engineering Conference (EMBEC) and the Nordic-Baltic Conference on Biomedical Engineering and Medical Physics (NBC). Springer, 290–293. (IFMBE Proceedings).10.1007/978-981-10-5122-7_73.
 10. Ojarand, J.; Min, M. (2017). Controllable Limiter of Signal Amplitudes for Bioimpedance Measurements. *IFMBE Proceedings*, 65: Joint Conference of the European Medical and Biological Engineering Conference (EMBEC) and the Nordic-Baltic Conference on Biomedical Engineering and Medical Physics (NBC), Tampere, Finland, June 2017. Ed. Eskola,H.;Väisanen O.;Viik,J.;Hyttinen,J. Singapore: Springer Nature, 920–923.10.1007/978-981-10-5122-7.
 11. Martens, O.; Min, M. ; Land, R. ; Ojarand, J. ; Rist, M. (2017). Phase-increment sampling in chirp signal based impedance measurements. *2017 International Conference on Sampling Theory and Applications (SampTA)*, Tallinn, 2017, July 3-7. IEEE, 604-608.10.1109/SAMP.TA.2017.8024393.
 12. Armen Sahakyan, Ants Koel, Toomas Rang (2017). Non-destructive eddy-current measurements for silicon-carbide heterostructures analysis. In: D. O. Northwood, J. De Hosson, T. Rang, C. A. Brebbia (Ed.). *WIT Transactions on Engineering Sciences. Materials Characterization 2017* (49–60). Great Britain: WIT Press.
 13. Rashid, Haroon Muhammad; Koel, Ants; Rang, Toomas; Gähviler, Reto; Grosberg, Martin; Jõema, Rauno (2017). Nanoscale and microscale simulations of n-n junction heterostructures of 3C-4H silicon carbide. In: D. O. Northwood, J. De Hosson, T. Rang, C.A. Brebbia (Ed.). *WIT Transactions on Engineering Sciences. Material Characterization 2017* (235–250). Great Britain: WIT Press.
 14. Veher, Oleksandr; Sleptšuk, Natalja; Toompuu, Jana; Korolkov, Oleg; Rang, Toomas (2017). The dependence of reverse recovery time on barrier capacitance and series on-resistance in Schottky diodes. In: D. O. Nortwood, J. de Hosson, T. Rang, C.A Brebbia (Ed.). *WIT Transactions on Engineering Sciences. Material Characterization 2017* (15–22). Great Britain: WIT Press.

15. Metshein, M. (2017), Variation of cardiac and respiratory waveform on human thorax in the case of capacitive coupling. IFMBE Proceedings, 65: Joint European Medical and Biological Engineering Conference (EMBE'17) and Nordic-Baltic Biomedical Engineering and Medical Physics (NBC'17) Conferences, 11-15 June 2017, Tampere, Finland. Singapore: Springer Nature, 671-674. DOI: 10.1007/978-981-10-5122-7_168

Patents

1. Invention: Method and device for quantization of the response signal differences during synchronous measurements; Owners: Tallinna Tehnikaülikool; Authors: Paul Annus, Mart Min, Raul Land, Olev Märtens, Eiko Priidel, Margus Metshein; Priority number: P201700023; Priority date: 9.06.2017.
2. Invention: Method and device for frequency response measurement; Owners: Tallinna Tehnikaülikool; Authors: Olev Märtens, Mart Min, Jaan Ojarand, Raul Land, Marek Rist; Priority number: P201700005; Priority date: 1.02.2017.

In 2017, the Research Laboratory for Cognitronics published 30 peer-reviewed papers (15 papers ETIS 1.1. and 15 papers ETIS 3.1.), partly in cooperation with members from other units in the department and partly in cooperation with international partners. In addition, two patents Estonian have been awarded, in cooperation members from other units in the department.

One PhD thesis (Tauseef Ahmed, "Radio Spectrum and Power Optimization Cognitive Techniques for Wireless Body Area Networks") was successfully defended in June 2017. The PhD defense of Tariq Meeran (supervisor prof. Yannick Le Moullec and senior researcher Dr. Paul Annus) from Kabul University, Afghanistan Republic is scheduled for March 2018. He joined our department back in 2014 in the framework contract between Estonian and Afghanistan Foreign Ministries coordinated in Estonia by Prof. Peeter Normak from Tallinn University.

The report continues with unified data over the Thomas Johann Seebeck Department of Electronics

- **loetelu aruandeaastal juhitud olulisematest projektidest/lepingutest;**

Projects

1. IUT1911, Impedance spectroscopy based identification and control of objects: signals, algorithms, energy efficient solutions (Prof. Toomas Rang);
2. PUT1435, Heterojunctions based on Wide Bandgap Semiconductor Materials, (Associate Professor Ants Koel),
3. Horizon2020 ERA-Chair project, "Cognitive Electronics-KOEL", (Prof. Toomas Rang);
4. EXCellence in IT in Estonia (EXCITE)/IT Tippkeskus EXCITE, (Professor Emeritus Mart Min);
5. ESS/ERIC - European Spallation Source "Eesti Teekaardi" project, (Prof. Toomas Rang);
6. B38, Hardware and Software Solutions for cognitive Embedded Networks Systems; (Professor Yannick Le Moullec);
7. ESSource, 2014-2020.4.01.16-0131 In-kind subtopic: FPGAbased IOC (Associate Professor Ants Koel)
8. Lep17094 Norma "Preliminary study of measurement techniques (15.06.2017-15.09.2017)" <https://www.etis.ee/Portal/Projects/Display/52116f4d-1fef-4bb8-9588-24b7e5e8cd5b> (Professor Olev Märtens)
9. Lep17048 AS ENNAK SEL "Feasibility study for R&D of smoke detectors (4.05.2017-30.09.2017)" <https://www.etis.ee/Portal/Projects/Display/58ba8544-7caf-4ce4-9b27-8d2d75758fcc> (Professor Olev Märtens)
10. VEU17072 "Wearable Robots for Augmentation, Assistance or Substitution of Human Motor Functions (1.01.2017-31.12.2020)", Professor Emeritus Mart Min.

Konverentsid:

1. Organization of (and participance on) Sampling Theory and Applications (SampTA 2017) International Conference, in cooperation with IEEE SPS and Society for Industrial and Applied Mathematics (SIAM), Tallinn
 2. 42nd IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP) 2017, New Orleans, USA
 3. International Conference on Silicon Carbide and Related Materials (ICSCRM 2017) Washington D.C., USA
 4. WIT 8th International Conference on Computational Methods and Experiments in Material and Contact Characterisation **Materials Characterisation 2017**, Tallinn
 5. International Conference on Electrical Engineering and Computer Science (ICECOS) 2017, Palembang, Indonesia, 22-23 August 2017 (paper "Approaches for Improving VoIP QoS in WMNs")
 6. 17th IEEE International Symposium on Signal Processing and Information Technology (ISSPIT), Bilbao, Spain, 18-20 December 2017 (paper "LMS-Based Leader Selection for Distributed Estimation")
 7. 14th IEEE Annual Consumer Communications & Networking Conference (IEEE CCNC 2017) 8-Las Vegas, USA, 11 January 2017 (paper "CROW2: Internet of Humans-based Platform for Disaster Relief and Emergency Communication")
 8. 7th International Conference on Current and Future Trends of Information and Communication Technologies in Healthcare (ICTH 2017), Lund, Sweden. September 2017 (paper "Network Coding for Energy Efficient Transmission in Wireless Body Area Networks")
 9. XXIII World Congress of Neurology, Kyoto, Japan, 16-21 September 2017. (paper "Home based monitoring system with wireless sensors that confirm stable balance and motor function readings during remission is feasible for patients with multiple sclerosis")
 10. Joint Conference of European Medical and Biological Engineering Conference (EMBEC) and Nordic-Baltic Conference on Biomedical Engineering and Medical Physics (NBC) (EMBEC2017), Tampere, Finland, 11-15 June 2017 (paper "Analysis of Instantaneous Cardiac EBI Signal Variability over the Heart Cycle(s): Non-Linear Time-Scale Approach")
 11. 12th Annual IEEE International Symposium on Medical Measurements and Applications, Mayo Clinic in Rochester, Minnesota, USA, 2017. (paper "Bioimpedance sensing – a viable alternative for tonometry in non-invasive assessment of central blood pressure")
 12. Joint Conference of European Medical and Biological Engineering Conference (EMBEC) and Nordic-Baltic Conference on Biomedical Engineering and Medical Physics (NBC) (EMBEC2017), Tampere, Finland, 11-15 June 2017 (3 papers "Variation of cardiac and respiratory waveform on human thorax in the case of inductive coupling", "Quantization of the response signal differences for the electrical bioimpedance measurement", "Controllable Limiter of Signal Amplitudes for Bioimpedance Measurements")
 13. International Conference on Sampling Theory and Applications (SampTA), Tallinn, Estonia, 3-7 July 2017 (paper "Phase-increment sampling in chirp signal based impedance measurements")
 14. 8th International Conference on Computational Methods and Experiments in Material and Contact Characterisation, Tallinn, Estonia, 21 - 23 June, 2017 (3 papers "Non-destructive eddy-current measurements for silicon-carbide heterostructures analysis", "Nanoscale and microscale simulations of n-n junction heterostructures of 3C-4H silicon carbide", and "The dependence of reverse recovery time on barrier capacitance and series on-resistance in Schottky diodes");
 15. Mobilitas Pluss Returning Researcher Grant / Mobilitas Pluss tagasipõrduva teadlase toetus. (lecturer J. Mihhailov),
 16. MOBTP30 "Kõrge töökindlusega efektiivsed jaotatud energia haldamise süsteemid mobiilsetes lahendustes (1.12.2016–30.11.2017)" (lecturer J. Mihhailov).
- **uurimisrühmade liikmete koostöö teiste T&A asutuste ja ettevõtetega (sh välisriikidest);**
 1. Tartu Ülikooli Tehnoloogiainstituut (Prof. Alvo Aabloo);
 2. Warsaw University of Technology (Dr. Marcel Mlynczak);
 3. Latvijas Universitātes Cietvielu fizikas institūts (Dr. Alberts Kristiņš);

4. Lund University (Statistical Signal Processing Group Lund University, prof. Andreas Jakobsson);
5. Chalmers University (Fiber Optical Signals group, Prof. Peter Andrekson);
6. Russian Academy of Science, A.F. Ioffe Physico-Technical Institute (Prof. Aleksandr Lebedev);
7. Wessex Institute of Technology (Prof. Carlos Brebbia);
8. Vienna University of Technology (Institute of Computer technology);
9. National Taipei University of Technology, Taiwan (Prof. Yu-Cheng Fan, College of Electrical Engineering & Computer Science);
10. Latvijas Universitātes Elektronikas un datorzinātņu institūts (Prof. I.Bilinskis, Dr. Kaspars Ozols);
11. Riga TU (Dr. Andrejs Kolyshkins);
12. INSA Blois, France (Dr. Serge dos Santos);
13. Lab-STICC/Université Bretagne Sud (Dr. Jean-Philippe Diguët and transient computing group);
14. Competence Centre ELIKO (Tehnoloogia Arenduskeskus ELIKO OÜ);
15. East-Tallinn Central Hospital (ITK);
16. SelfDiagnostics GmbH, Germany;
17. Estonian Nonprofit Union of Multiple Sclerosis;
18. Estonian startups Motionchart and Motionmon;
19. JR Medical Ltd (JR Medical OÜ).
20. Politecnico di Milano, Italy (Prof. Luca Reggiani, Dipartimento di Elettronica, Informazione e Bioingegneria (DEIB))
21. Arab Open University (AOU), Lebanon (Associate Prof. Elias Yaacoub)
22. National University of Sciences and Technology, Pakistan (Prof. Rizwan Ahmad)

2.2 Loetelu uurimisrühma töötajate olulisematest sise- ja välisriiklikest T&A-ga seotud tunnustustest (töötaja nimi, allüksus ning tunnustus).

- 1) Prof. Toomas Rang: The Order of "Mente et Manu". Given by the Rector of the Tallinn University of Technology
- 2) Alar Kuusik: 2017 Winning team member of TUT Prototron competition in the topics of marine sensorics
- 3) Karel Pärlin, Jamming of Spread Spectrum Communications Used in UAV Remote Control Systems, supervisors Associate Prof. Muhammad Mahtab Alam and Prof. Yannick Le Moullec (the winner of MSc thesis - hardware and systems category)

2.3 Loetelu uurimisgrupi liikmetest, kes on riiklike T&A-ga seotud otsustuskogude liikmed (töötaja nimi, ametikoht ning otsustuskogu nimetus ja positsioon otsustuskogus).

Toomas Rang

- Member of expert committee of ETAG IUT and PUT applications;
- Journal "Electronics and Electrical Engineering" (Kaunas, Lithuania), member of the editorial board;
- Georgian Academy of Sciences, external scientific expert;
- International Program Committee of Baltic Electronics Conference BEC (Estonia), Honor chairman;
- IEEE Education Chapter Estonia, chairman;
- Board of the Estonian Association of Engineers, member;
- Member of defense committee; 15.12.2017; School of Engineering; Ahmad Rahmoun; "Mathematical Modelling and Analysis of a Battery Energy Storage Systems for Microgrids";
- Certificate of Appreciation. Given by the general chair of the International Conference ELECTRONICS 2017
-

Mart Min

- Member of expert committee of ETAG IUT and PUT applications;
- International Association for Bioelectromagnetism, president;
- Journal "Electronics and Electrical Engineering" (Kaunas, Lithuania), member of the editorial board;

- Journal of Electrical Bio-impedance, section editor;
- International Society of Electrical Bio-impedance, member;
- International Committee for Promotion of Research in Bio-Impedance (ICPRBI), member

Ants Koel

- International Program Committee of Baltic Electronics Conference BEC (Estonia), general-chairman;
- "TTU - MEKTORY nanosatellite", electronics workpackages supervisor

Yannick le Moullec

- Reviewer for H2020-MSCA-COFUND-2017
- International Program Committee of Baltic Electronics Conference BEC (Estonia)
- Member of the evaluation committee for 2nd year PhD students, 2017
- Invited talks "Selected Research Activities in Cognitive Electronics at T.J. Seebeck Department of Electronics" and "Introduction to the Implementation of Baseband Processing for Software-Defined Radios", National Taipei University of Technology, Taipei, Taiwan, 2017
- Reviewer, PhD thesis defense, E. Moreac, UBS, Lorient, France, 2017
- Reviewer, PhD thesis defense, H. Kerhascoet, UBS, Lorient, France, 2017
- Examiner, PhD thesis defense, M. Rist, TUT, Tallinn, Estonia, 2017
- Examiner, PhD thesis defense, A. Rjabov, TUT, Tallinn, Estonia, 2017

Muhammad Mahtab Alam

- Invited talk "Cognitive Electronics", Digital Tekk Tour Wallonia - invitation from Wallonia Brussels International, 6-7 November 2017, Belgium
- Invited talk "Wearable Wireless Networks – From Theory to Practice", IEEE COMSOC Summer School, 11-14 July 2017, Lahore, Pakistan
- Staff intra-EU mobility (ERASMUS+ Staff Exchange Program), "Teaching at MSc and PhD level" - Politecnico di Milano
- Technical Committee Member for New Curriculum Design - Communicative Electronics (Telecommunication Specialization).
- Member, PhD Attestation Committee (School of IT) Tallinn University of Technology.
- Evaluator, 2nd Year PhD Attestation (School of IT) Tallinn University of Technology.

Toomas Ruuben

- "TTU - MEKTORY nanosatellite", communications subsystem academic supervisor

Natalja Slepšuk

- Double Degree magistri programmi käivitamise ettevalmistamine Tallinna Tehnikaülikooli TJS ELIN ja ITMO (St. Peterburg National Research University of Information Technologies) ülikoolide vahel.
- Coordinator from the side of Information Technology Faculty of ERASMUS
- Coordinator from the side of Department of Electronics of EU ESTIA Network project " Women in Science"

2.4 Loetelu uurimisgrupi liikmetest, kes on välisriikide akadeemiate ja/või muude oluliste T&A-ga seotud välisorganisatsioonide liikmed (töötaja nimi, allüksus ning välisakadeemia või muu olulise T&A-ga seotud välisorganisatsiooni nimetus).

Toomas Rang

- Institute of Electrical and Electronics Engineers IEEE (USA), Senior-Member;

Mart Min

- Institute of Electrical and Electronics Engineers (IEEE) – Senior-Member.

Alar Kuusik

- Vice chairing of Estonian IEEE C/COM joint chapter.

Olev Märten

- Institute of Electrical and Electronics Engineers IEEE (USA), member;

Ants Koel

- Institute of Electrical and Electronics Engineers IEEE (USA), member.

Raul Land

- Institute of Electrical and Electronics Engineers IEEE (USA), member.

Muhammad Mahtab Alam

- Chartered Engineer, Engineering Council UK

2.5 Uurimisgrupis osalenud järel doktorite ning TTÜ-st järel doktorantuuri suundunud uurimisgrupi töötajate loetelu (nii ETIS-e kaudu esitatud taotluste kui muude meetmete alusel näidates ära järel doktori nime, päritoluma ja asutuse, järel doktorantuuri perioodi ning meetme, mille alusel järel doktorit rahastatakse).

2 postdoc researchers have joined the department. Their positions are funded by means of the Project Horizon 2020 ERA-Chair “Cognitive Electronics COEL”. Pending approval, their positions will be extended for an additional year.

- Md Muhidul Islam Khan
- Hassan Malik

Kokkuvõtteks

In 2017, the overall results in R&D activities of Thomas Johann Seebeck Department of Electronics were excellent.

In 2017, the Thomas Johann Seebeck Department of Electronics published 37 peer-reviewed papers (17 papers ETIS 1.1. and 20 papers ETIS 3.1.), partly in cooperation with international partners. In addition, three Estonian patents have been awarded.

In 2017, all together three PhD students completed their studies.

One PhD thesis (Tauseef Ahmed, “Radio Spectrum and Power Optimization Cognitive Techniques for Wireless Body Area Networks”) was successfully defended in June 2017.

Two PhD studies have been successfully completed their theses in 2017 and the defense of Marek Rist (supervisors Professor emeritus Mart Min and Olfa Kanoun) and Tamás Pardy (supervisors prof. Toomas Rang, Dr, Indrek Tulp, and associate professor Ants Koel) took place on January 15. 2018.

The PhD defense of Tariq Meeran (supervisor prof. Yannick Le Moullec and senior researcher Dr. Paul Annus) from Kabul University, Afghanistan Republic is scheduled for March 2018. He joined our department back in 2014 in the framework contract between Estonian and Afghanistan Foreign Ministries coordinated in Estonia by Prof. Peeter Normak from Tallinn University.

In 2017, all together five new project applications could be named:

1. NATO Science for Peace and Security Programme “public safety COmmUNication in ConTExt Related to TERROR attacks (COUNTER-TERROR)”. Partners: National University of Science and Technology, Pakistan; Politecnico di Milano, Italy
2. H2020-WIDESPREAD-05-2017-Twinning “TWINNING4SMARTHEALTH”. Partners: Ecole Polytechnique Federale de Lausanne, Switzerland; Rheinisch-Westfaelische Technische Hochschule Aachen, Germany; Universitetet i Oslo, Norway
3. Erasmus+ KA2 “NETREX”. Partners: American University of Beirut, Lebanon, Edex - Educational Excellence Corporation Limited, Cyprus; Ecole Supérieure des Communications de Tunis, Tunisia, Esprit, Tunisia; Ministry of Education and Higher Education, Lebanon; Universitaet Duisburg-Essen, Germany; Lebanese American University, Lebanon; Universite de Saint Esprit-Kaslik Autorite

Religieuse, Lebanon; Rafik Hariri University, Lebanon; Arab Open University, Lebanon; Lebanese University, Lebanon; Beirut Arab University, Lebanon

4. Interreg Baltic Sea Project application SunFleet (Innovative water based solar energy production hybrid systems and energy provision to water borne devices and coastal infrastructure.). Project in cooperation with KTH, Klaipeda University, Institute of Hydro-Engineering, Polish Academy of Sciences (IBW PAN), EUCC - The Coastal Union Germany, PGE Energia Odnawialna S.A., Meliorations of Gdansk (resubmission);
5. Jätkus *Double Degree* magistri programmi käivitamise ettevalmistamine Tallinna Tehnikaülikooli TJS ELIN ja ITMO (*St. Peterburg National Research University of Information Technologies*) ülikoolide vahel instituudi rahvusvahelise magistriprogrammi „*Communicative Electronics*“ raamides. Projekti partneriks ka Aalto ülikool Soomest ja USA ettevõtte *Nitrid Crystals Inc.* (Antud projekti realiseerumine eeldab olulist tehnikaülikooli teaduskompetentsi olemasolu pooljuhtelektronika vallas).

In 2017, two important events must be named additionally.

- 1) Vahur Kampus, external PhD student supervised by prof. Toomas Rang, working at INTEL Austria in Villach, designed and protected new 28nm CMOS process for new wireless communication platforms to be used soon almost in all modern mobile phones.
- 2) The bioimpedance as a topic almost introduced first by professor emeritus Mart Min, we have been recognized as the third most publishing team worldwide in the field of bioimpedance (71 publications) after University of Queensland (89 publications) and Polytechnic University of Catalonia (83 publications): https://www.researchgate.net/publication/322672005_Dielectric_and_Bioimpedance_Research_Studies_A_Scientometric_Approach_Using_the_Scopus_Database (Figure 6, page 7).

Prof. Toomas Rang

Thomas Johann Seebecki elektroonikainstituudi direktor

Tallinnas, 31.01.2018