



**2017 15th
INTERNATIONAL
CONFERENCE on QIR**
(Quality in Research)

**INTERNATIONAL
SYMPOSIUM ON ELECTRICAL
AND COMPUTER ENGINEERING**

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XPLORE COMPLIANT

in conjunction with:



6th IEEE International
Conference on Advanced
Logistics and Transport
(ICALT 2017)



International Conference in
Saving Energy in Refrigeration and
Air Conditioning (ICSERA)



International Conference on
Dwelling Form I-DWELL

3rd Binnual Meeting on Bioprocess Engineering



2nd International Symposium on Biomedical Engineering

Organized by:



FACULTY OF
ENGINEERING

Co-Hosted by:



UNIVERSITAS UDAYANA
FAKULTAS TEKNIK



POLITEKNIK
NEGERI BALI

*The Westin Resort
Nusa Dua, Bali*
24-27 July 2017

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International Symposium on Electrical and Computer Engineering

24 – 27 July 2017

Bali, Indonesia

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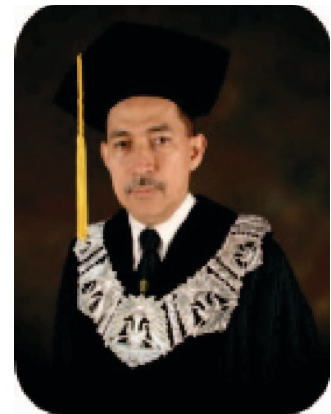


PREFACE

WELCOME FROM THE RECTOR OF UNIVERSITAS INDONESIA

It is both a pleasure and honor for me to welcome you all to the 15th International Conference on QiR (Quality in Research) 2017 in Nusa Dua, Bali, Indonesia.

Universitas Indonesia strives to be one of the leading research universities and the most outstanding academic institution in the world. UI is distinctive among research universities in its commitment to the academic invention and research activities through various scientific programs. QiR 2017 is our main academic conference in the field of engineering and technology which has been successfully held for the last two decades. It is our hope that this world class scientific program would showcase our scientists and researchers achievements and provide forums for scientific exchanges in their respective fields.



The theme this year of 'Science, Technology and Innovation for Sustainable World', is very relevant with the fact that the globalization today results in very competitive atmosphere in all aspects. However, this flourishing competition should consider the harmony and balance between human needs and the environment quality for creating favorable sustainable future. Scientists and researchers, hand in hand with industrial experts are creating and developing new sustainable technologies that enable us to make products and services more efficient, design better buildings, produce safer cars, keep people healthier and building smarter cities.

I extend my sincere thanks to the Faculty of Engineering Universitas Indonesia, supporting parties and institutions for their participation and contributions in QiR 2017. I would also thank our colleagues from Universitas Udayana and Politeknik Negeri Bali for their gracious support and hospitality. Additionally, I extend a hearty thank you to the members of the organizing committees for dedicating their valuable time so that each one of us enjoys an exceptional conference program over the next several days. May we have a successful, stimulating, fruitful and rewarding conference.

Prof. Dr. Ir. Muhammad Anis, M.Met.

Rector

Universitas Indonesia



PREFACE

WELCOME FROM THE DEAN OF FACULTY OF ENGINEERING UNIVERSITAS INDONESIA

Welcome to the 15th International Conference on QiR (Quality in Research) 2017. The Faculty of Engineering Universitas Indonesia is delighted to host our flagship international academic event this year back in Bali, Indonesia. This two-day, biennial conference is presented together with our co-hosts Universitas Udayana and Politeknik Negeri Bali with the hope that this would be able to provide an international media for exchange of the knowledge, experience and research as well as the review of progress and discussion on the state of the art and future trend of prospective collaboration and networking in broad field of science, technology and innovation.



The main theme for this year conference, “Science, Technology and Innovation for Sustainable World” is consistent with the mission of our faculty to be a leading institution with the initiatives that responds to local, national and global societal needs. In that context, the Faculty of Engineering Universitas Indonesia is performing state-of-the arts research and development in engineering and architecture areas which results in technology and innovation which contribute to sustainable development at both national and global level. QiR 2017 provides platforms and forums to disseminate our scientific achievements and exchange information with our counterparts from Indonesia and all over the world. This event will allow for further research and education collaborations between Universitas Indonesia and its partners worldwide.

I would like to express my deepest appreciation to our sponsors, supported parties and various contributors for their never ending supports of this conference. I would also like to convey my gratitude to all of our distinguished speakers for making the time to share their knowledge with us. To our fellow researchers and/or practitioners from Indonesia and overseas, welcome and enjoy your stay in this Nusa Dua, Bali. I would also like to invite all participants in expressing our appreciation to all members of the QiR 2017 organizing committee for their hard work in making this conference success.

Prof. Dr. Ir. Dedi Priadi, DEA
Dean Faculty of Engineering
Universitas Indonesia



PREFACE

WELCOME FROM THE QIR 2015 ORGANIZING COMMITTEE

On behalf of the organizing committee, it is a great pleasure for us to welcome you to the 15th International Conference on Quality in Research (QiR) 2017 to be held in Bali, Indonesia on July, 24 – 27, 2017. This biennial event is co-organized with the Faculty of Engineering Universitas Udayana and Politeknik Negeri Bali.

The main theme for this year conference is “Science, Technology and Innovation for Sustainable World”. Under this theme the conference focuses on the innovative research and contribution in science and technology toward achieving sustainable world. In line with this theme, it is our utmost pleasure to hold the QiR 2017 in conjunction with the 6th IEEE-International Conference on Advanced Logistics and Transport (ICALT), the 2nd International Symposium on Biomedical Engineering (ISBE 2017), International Conference in Saving Energy in Refrigeration and Air Conditioning (ICSERA) and the 3rd Biannual Meeting on Bioprocess Engineering.



The QiR 2017 brings together national and international academicians, researchers, executives, government, industrial and business officials, practitioners and leaders to present and discuss a vast range of engineering, architectural designs and community development based on green and smart technology. It is our hope and aim that this conference would be able to provide an international media for exchange of the knowledge, experience and research as well as the review of progress and discussion on the state of the art and future trend of prospective collaboration and networking in broad field of science, technology and innovation. Furthermore, QiR 2017 benefits industry sector, since it would create a close contact between and among the audiences. The audiences mostly come from different job and activities: therefore this is a great potential and opportunity to meet each other, creating fruitful discussions and broaden business relationship.

QiR has been growing, since its first event two decades ago, into our flagship academic event with international reputation. This year, we have received almost 1000 submissions from more than 26 countries. Along with our events in conjunction, more than 500 oral and poster presentations is scheduled with expected 700 participants gather in the event.

On behalf of QiR 2017 committee, we would like to thank all of our speakers, participants, contributors, partners and professional associations for their generous contributions. We also would like to acknowledge the support from our International Advisory Board members and distinguished reviewers. Last but not least, a special thanks to our local co-organizer, Universitas Udayana and Politeknik Negeri Bali.

We wish all of you a productive and rewarding conference, also a pleasant and memorable stay in Nusa Dua, Bali, Indonesia.

Thank you and we hope to see you again in QiR 2019.

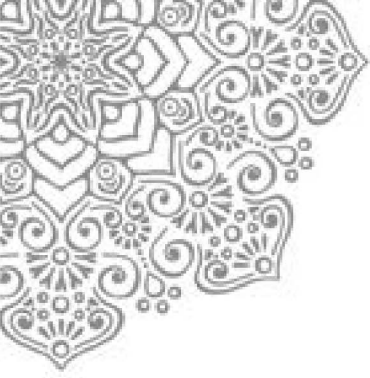
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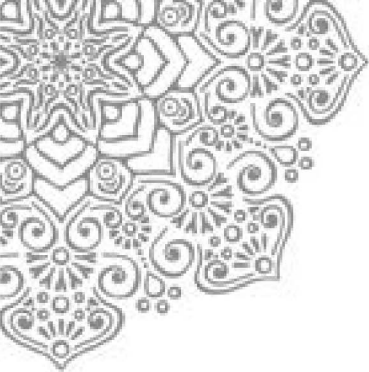


PLACE & DATE OF THE EVENT

Date : 24 - 27 July 2017
Location : BICC the Westin, Nusa Dua, Bali.

The Arrangement of the QiR 2017 Conference can be seen at the table below

Date	Time	Program	
24 July	03.00-05.00 p.m	Registration and Welcome Cocktails	
25 July	Full Day	Exhibition	
	08.30-10.15 am	Opening Ceremony	
	10.15-10.30 am	Coffee break	
	10.30-11.15 am	Plenary Lecture 1 Prof. Benyamin Kusumoputro	
	11.15-12.00 pm	Plenary Lecture 2: Prof. Thomas Goldsby	
	01.00-03.00 pm	Parallel Session	Each parallel session will be started with presentation by Invited Speakers
		03.00-03.30 pm	Poster Session Day 1 Coffee break
	03.30-06.00 pm	Parallel Session	
	06.00-07.00 pm	Poster Session Day 1	
	07.00-09.00 pm	Banquette Dinner	
	26 July	Full Day	Exhibition
08.30-10.00 am		Parallel Session	Each parallel session will be started with presentation by Invited Speakers
		10.00-10.30 am	Poster Session Day 2 Coffee break
10.30-12.00 pm		Parallel Session	
12.00-01.00 pm		Lunch	Poster Session Day 2
		01.00-02.00 pm	Plenary Lecture 3 Prof. Jackie Y. Ying
01.00-03.00 pm		Parallel Session	
03.00-03.30 pm		Coffee break	
07.00-09.00 pm		Dinner and Closing Ceremony	
27 July		08.00am-08.00 pm	Social Tour



E Plenary

Tuesday, July 25, 2017 13.00-13.30

Medan Room 2nd fl

Invited Speaker : Professor Yifan Chen, FIET, SMIEEE (The University of Waikato, NZ)

E Plenary

Tuesday, July 25, 2017 13.30-14:00

Medan Room 2nd fl (Moderator : Dr. Muhammad Suryanegara)

Invited Speaker : Professor Kalamullah Ramli (Universitas Indonesia)

E 1 : Communication System and Signal Processing 1

Tuesday, July 25, 2017 13.30-15.00

Medan Room 2nd fl (Chair Session: Prof. Hana Baili)

No	Paper #	ID	Author	Title	Affiliation	Time
1	307	E1 - 1	Hana Baili	Propagation of Chaos in Power Control Games for Energy-Efficient Wireless Networks	Centrale Supélec, France	14.00-14.15
2	622	E1 - 3	Rizal Munadi, Eka Firdaus, Teuku Yuliar Arif and Fitri Yuli Zulkifli	An Evaluation of DNS Server Health of State-Owned Universities in Sumatera Island	Syah Kuala University, Indonesia	14.30-14.45
3	297	E1 - 4	Dini Fronitasari and Dadang Gunawan	Palm Vein Recognition by Using Modified Local Binary Pattern (LBP) for Extraction Feature	Universitas Indonesia, Indonesia	14.45-15.00

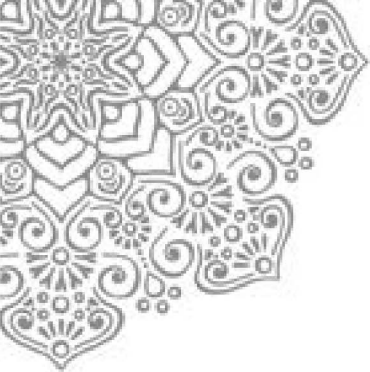


E 2 : Computer Engineering 1

Tuesday, July 25, 2017 15.15-18.00

Medan Room 2nd fl (Session Chair: Prof. Poki Chen (NTUST) / Dr. Mat Syai'in)

No	Paper #	ID	Author	Title	Affiliation	Time
1	890	E2 - 1	Intan Ari Budiastuti, Supeno Mardi Susiki Nugroho and Mochamad Hariadi	Predicting Daily Consumer Price Index Using Support Vector Regression Method	Sepuluh Nopember Institute of Technology (ITS), Indonesia	15.15-15.30
2	85	E2 - 3	I Putu Deny Arthawan Sugih Prabowo, Eko Nugroho and Rudy Hartanto	Analysis on The Green IT Applications Usage for The Firm's Competitive Advantage Strategy	Gadjah Mada University, Indonesia	15.45-16.00
3	479	E2 - 5	Moch Syamsul Arifin Sidik, Mat Syai'in, Sryang Tera Sarena, Lilik Subiyanto, Rachmad Tri Soelistijono, Joko Endrasmono, Annas Singgih Setyoko, Aang Wahidin and Adi Soeprijanto	Smart Vending Machine Based on SMS Gateway for General Transactions	Shipbuilding Institute of Polytechnic Surabaya, Indonesia	16.15-16.30
4	715	E2 - 6	Putu Manik Prihatini, I Ketut Gede Darma Putra, Ida Ayu Dwi Giriantari and Made Sudarma	Indonesian Text Feature Extraction using Gibbs Sampling and Mean Variational Interference Latent Dirichlet Allocation Indonesian Documents	Udayana University, Indonesia	16.30-16.45



5	873	E2 - 7	Asri Yulianti, Surya Sumpeno and Mauridhi Hery Purnomo	Majority Vote Technique Based On Multi Rough Set for Multi Attributes Decision-Making System	Sepuluh Nopember Institute of Technology (ITS), Indonesia	16.45-17.00
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E 3A : Electronic Devices and Semiconductor 1

Wednesday, July 26, 2017 08.00-10.00

Medan Room 2nd fl Session Chair: Dr. Arief Udhiarto/ Dr. Anak Agung Ngurah Made Narottama)

No	Paper #	ID	Author	Title	Affiliation	Time
1	44	E3A - 1	Masahiro Hori, Tokinobu Watanabe and Yukinori Ono	Real-Time Monitoring of Charge-Pumping Process for SiO ₂ /Si Interface Defect Analysis	Shizuoka University, Japan	08.00-08.15
2	182	E3A - 2	Anak Agung Ngurah Made Narottama and Anak Agung Ngurah Gde Saptaka	Effect of Ge Mole Fraction on Current, Voltage and Electric Field Characteristics of High Doping Nanoscale Si _{1-x} Gex/Si p-n Diode.	Politeknik Negeri Bali, Indonesia	08.15-08.30
3	93	E3A - 3	Saya Kobayashi and Jun Kondoh	Measurement of Particles in Oil Using Shear Horizontal Surface Acoustic Wave Sensor	Shizuoka University, Japan	08.30-08.45
4	355	E3A - 4	Arief Udhiarto, Bobi Khoerun, Layina Maula Haryanto and Djoko Hartanto	Effect of Anode and Cathode Workfunction on the Operating Voltage and Luminance of a Single Emissive Layer Organic Light Emitting Diode	Universitas Indonesia	08.45-09.00
5	484	E3A - 6	Cahyaning Nur Karimah, Retno Wigajatri Purnamaningsih, Tomy Abuzairi and Nji Raden Poespawati	Bifacial Heterojunction Intrinsic Thin Layer Solar Cells As a BioFET Supply	Universitas Indonesia, Indonesia	09.15-09.30



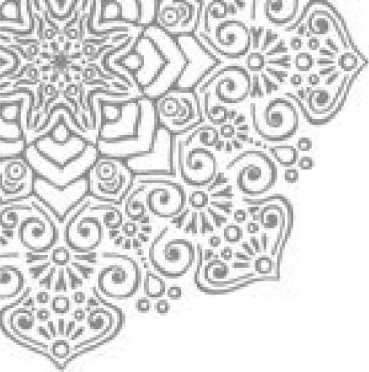
6	676	E3A - 7	Adnan Afiff, Arup Samanta, Tarik Hasan, Arief Udhiarto, Harry Sudibyo, Djoko Hartanto, Michiharu Tabe, Daniel Moraru, Manoharan Muruganathan and Hiroshi Mizuta	A Statistical Study on the Formation of A-Few-Dopant Quantum Dots in Highly-Doped Si Nanowire Transistors	Shizuoka University, Japan	09.30-09.45
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E 3B : Antennas and Microwave Devices

Wednesday, July 26, 2017 08.00-10.00

Surabaya Room 2nd fl (Session Chair: Dr. Achmad Munir/ Dr. Fitri Yuli Zulkifli)

No	Paper #	ID	Author	Title	Affiliation	Time
1	763	E3B - 1	Achmad Munir, Habibur Muhaimin, Mohammad Sigit Arifianto, Chairunnisa, Mohammad Ridwan Effendi and Andriyan Bayu Suksmono	Wideband BPF Composed of Planar Inverted-F Shaped for S-Band Frequency Application	Bandung Institute of Technology (ITB), Indonesia	08.00-08.15
2	588	E3B - 2	Farohaji Kurniawan, Josaphat Tetuko Sri Sumantyo, Mujtahid and Achmad Munir	Effect of Shape Truncation Against Axial Ratio of Left-Handed Circularly Polarized X-Band Antenna	Chiba University, Japan	08.15-08.30
3	259	E3B - 3	Antrisha Daneraici Setiawan and Achmad Munir	Incorporation of High Permittivity Circular Dielectric Resonator for Enhancing Resonant Frequency of Microstrip Antenna	General Achmad Yani University, Indonesia	08.30-08.45
4	294	E3B - 4	Syah Alam, I Gusti Nyoman Wibisana and Indra Surjati	Miniaturization of Array Microstrip Antenna Using Peripheral Slits for Wireless Fidelity Communication	University of 17 August 1945 Jakarta, Indonesia	08.45-09.00
5	360	E3B - 5	Karlisa Priandana, Benyamin Kusumoputro and Eko Tjipto Rahardjo	The Design of ISM-Band Radar Antenna for Small Boat's Trajectory Tracking	Universitas Indonesia, Indonesia	09.00-09.15
6	532	E3B - 6	Dian Widi Astuti, Arif Jubaidillah and Mudrik Alaydrus	Substrate Integrated Waveguide Bandpass Filter for VSAT Downlink	Mercu Buana University, Indonesia	09.15-09.30



7	534	E3B - 7	Dian Widi Astuti, Ahmad Firdausi and Mudrik Alaydrus	Multiband Double Layered Microstrip Antenna by Proximity Coupling for Wireless Applications	Mercu Buana University, Indonesia	09.30-09.45
8	249	E3B - 8	Yulianto La Elo, Fitri Yuli Zulkifli and Eko Tjipto Rahardjo	Design of Wideband Microstrip Antenna With Parasitic Elemen For 4G/LTE Application	Universitas Indonesia, Indonesia	09.45-10.00

E 4A : Electronic Devices and Semiconductor 2

Wednesday, July 26, 2017 10.15-10.00

Medan Room 2nd fl (Session Chair: Dr. Purnomo Sidi Priambodo/ Prof. Hiroshi Inokawa)

No	Paper #	ID	Author	Title	Affiliation	Time
1	73	E4A - 1	Lin Prasetyani and Purnomo Sidi Priambodo	450nm Laser Diode Beam Shaping in Engraving Process	Universitas Indonesia, Indonesia	10.15-10.30
2	189	E4A - 2	Mohammad Iwan Wahyuddin, Purnomo Sidi Priambodo and Harry Sudibyo	Direct Current Load Effects on Series Battery Internal Resistance	Universitas Indonesia, Indonesia	10.30-10.45
3	218	E4A - 3	Hiroshi Inokawa, Kou Akiba and Hiroaki Satoh	Thermal Conductance and Heat Capacity Measurement Utilizing Suspended-Wire Resistor	Shizuoka University, Japan	10.45-11.00
4	273	E4A - 4	Tomy Abuzairi, Nji Raden Poespawati, Retno Wigajatri Purnamaningsih and Dicky Apriady	Preliminary Study of Plasma- treated Water for Germination Stimulation of Agricultural Seeds	Universitas Indonesia, Indonesia	11.00-11.15
5	316	E4A - 5	Natalita Maulani Nursam, Jojo Hidayat, Lia Muliani Pranoto and Suwastika Wijayanti	Electrical Properties of Dye- sensitized Solar Module with Integrated Parallel Connections	Indonesian Institute of Science (LIPI), Indonesia	11.15-11.30
6	918	E4A - 7	Syam Erast Prayoga, Retno Wigajatri Purnamaningsih, Tomy Abuzairi, and Nji Raden Poespawati	Crystalline Silicon Solar Cell Design with AlxGa1-xAs As Heterojunction with Compound Thin Layer for Biosensor Application	Universitas Indonesia, Indonesia	11.45-12.00

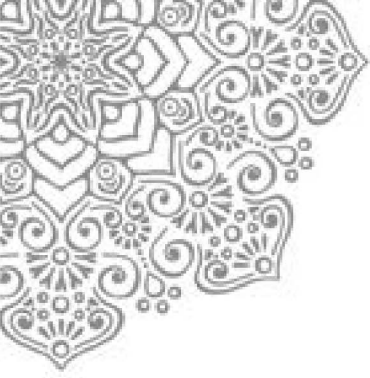


E 4B : Medical Applications and Imaging System

Wednesday, July 26, 2017 10.15-10.00

Surabaya Room 2nd fl (Session Chair: Dr. Prima Dewi Purnamasari / Dr. Engelin Shintadewi Julian)

No	Paper #	ID	Author	Title	Affiliation	Time
1	119	E4B - 1	Ernia Susana and Hendrana Tjahjadi	Handheld Pulse Oximeter Using Raspberry Pi B+	Health Polytechnic of Jakarta II, Indonesia	10.15-10.30
2	138	E4B - 2	Engelin Shintadewi Julian, Kiki Prawiroredjo and Gunawan Tjahjadi	The Model of Near Infrared Sensor Output Voltage As a Function of Glucose Concentration in Solution	Trisakti University, Indonesia	10.30-10.45
3	295	E4B - 3	Faisal Narpati and Basari Basari	Design of Ultrawideband Applicator for Microwave Ablation Aimed at Thermal Therapy in Liver Cancer	Universitas Indonesia, Indonesia	10.45-11.00
4	399	E4B - 4	Prima Dewi Purnamasari, Anak Agung Putri Ratna and Benyamin Kusumoputro	Relative Wavelet Bispectrum Feature for Alcoholic EEG Signal Classification Using Artificial Neural Network	Universitas Indonesia, Indonesia	11.00-11.15
5	434	E4B - 5	Bayu Azmi, Wibisono - and Adhi Harmoko Saputro	Portable Gamma Ray Tomography System for Investigation of Geothermal Power Plant Pipe Scaling	National Nuclear Energy Agency (BATAN), Indonesia	11.15-11.30
6	541	E4B - 6	Brahmastro Kresnaraman, Yasutomo Kawanishi, Daisuke Deguchi, Tomokazu Takahashi, Yoshito Mekada, Ichiro Ide and Hiroshi Murase	Headgear Recognition by Decomposing Human Images in the Thermal Infrared Spectrum	Nagoya University, Japan	11.30-11.45
7	599	E4B - 7	Erni Yudaningtyas, Djoko H. Santjojo, Waru Djuriatno, Indrazno Siradjuddin and Muhammad Rony Hidayatullah	Identification of Pulse Frequency Spectrum of Chronic Kidney Disease Patients Measured at TCM Points Using FFT Processing	Brawijaya University, Indonesia	11.45-12.00



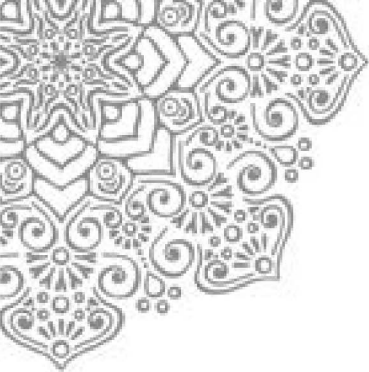
8	64	E4B - 8	Hendrana Tjahjadi and Kalamullah Ramli	Review of Photoplethysmography Based Noninvasive Continuous Blood Pressure Methods	Universitas Indonesia, Indonesia	12.00-12.15
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E 4C : Control Engineering System 1						
Wednesday, July 26, 2017 10.15-10.00						
Singaraja Room (Session Chair: Dr. Feri Yusivar / Dr. Wahidin Wahab)						
No	Paper #	ID	Author	Title	Affiliation	Time
1	150	E4C - 1	Suwandi Dwi Sahputro, Fahmi Fadilah, Nanda Avianto Wicaksono and Feri Yusivar	Design and Implementation of Adaptive PID Controller for Speed Control of DC Motor	Universitas Indonesia, Indonesia	10.15-10.30
2	191	E4C - 2	Bernadeta Wuri Harini, Aries Subiantoro and Feri Yusivar	Study of Speed Sensorless Permanent Magnet Synchronous Motor (PMSM) Control Problem due to Braking During Steady State Condition	Universitas Indonesia, Indonesia	10.30-10.45
3	397	E4C - 4	Jemie Muliadi, Rizki Langit and Benyamin Kusumoputro	Estimating the UAV Moments of Inertia Directly from Its Flight Data	Universitas Indonesia, Indonesia	11.00-11.15
4	453	E4C - 5	Indrazno Siradjuddin, Zakiyah Amalia, Budhy Setiawan, Rendy Pambudi Wicaksono and Erni Yudaningtyas	Stabilising a Cart Inverted Pendulum System Using Pole Placement Control Method	The State Polytechnic of Malang, Indonesia	11.15-11.30
5	624	E4C - 6	Muhammad Ramadiansyah, Wahidin Wahab and Nasril	Modeling, Simulation and Control of a high Precision Loading-Unloading Robot for CNC Milling Machine	Universitas Indonesia, Indonesia	11.30-11.45
6	722	E4C - 7	Yohanes Berchman Adyapaka Apatya, Feri Yusivar and Aries Subiantoro	Design and Prototyping of 3-Phase BLDC Motor	Universitas Indonesia, Indonesia	11.45-12.00



7	883	E4C – 8	Muhammad Akil, Ingrid Nurtanio and Rhiza Samsoe' oed Sadjad	A DC Motor Speed Control Using LPC-ANFIS Speech Recognition System	Bosowa Polytechnic, Indonesia	12.00-12.15
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E 4D : Computer Engineering 2						
Wednesday, July 26, 2017 10.15-10.00						
Hisbiscus Room 1st fl (Session Chair: Dr. Prihandoko / Dr. Misfa Susanto)						
No	Paper #	ID	Author	Title	Affiliation	Time
1	21	E4D – 1	Prihandoko Prihandoko, Bertalya Bertalya and Muhammad Iqbal Ramadhan	An Analysis of Natural Disaster Data by Using K-Means and K-Medoids Algorithm of Data Mining Techniques	Gunadarma University, Indonesia	10.15-10.30
2	26	E4D – 2	Danila Machmud and Dion Ogi	The Implementation of Wash, Rinse, and Spin Technique in Accelerometer's Data Processing on Android Smartphone to Generate Stream Keys	National Crypto Institute, Indonesia	10.30-10.45
3	132	E4D – 3	Mohamad Ali Sadikin, Dea Saka Kurnia Putra and Susila Windarta	S-Mbank: Secure Mobile Banking Authentication Scheme Using Signcryption, Pair Based Text Authentication, and Contactless Smartcard	National Crypto Institute	10.45-11.00
4	386	E4D – 4	Anak Agung Putri Ratna, Randy Sanjaya, Tomi Wirianata and Prima Dewi Purnamasari	Word Level Auto-correction for Latent Semantic Analysis Based Essay Grading System	Universitas Indonesia, Indonesia	11.00-11.15
5	430	E4D – 5	Rini Wisnu Wardhani, Dion Ogi, Mohamad Syahrul and Dedy Septono Catur Putranto	Fast Implementation of AES on Cortex-M3 for Security Information Devices	National Crypto Institute, Indonesia	11.15-11.30
6	370	E4D – 6	Misfa Susanto, Risdawati Hutabarat, Yetti Yuniati and Syaiful Alam	Interference Management Using Power Control for Uplink Transmission in Femtocell-Macrocell Cellular Communication Network	University of Lampung, Indonesia	11.30-11.45



7	856	E4D - 7	Astriany Noer, Zulfajri B. Hasanuddin and Dewiani Djameluddin	Implementation of RFID Based Raspberry Pi for User Authentication and Offline Intelligent Payment System	Hasanuddin University, Indonesia	11.45-12.00
8	881	E4D - 8	Indah Suryyana Wahyudi, Mochamad Hariadi and Achmad Affandi	Recommender Engine Using Cosine Similarity Base On Alternating Least Square -Weight Regularization	Sepuluh Nopember Institute of Technology (ITS), Indonesia	12.00-12.15

E 5A : Communication System and Signal Processing 3

Wednesday, July 26, 2017 14.00-15.30

Medan Room 2nd fl (Session Chair: Dr. Ajib Setyo Arifin / Dr. Helmy Fitriawan)

No	Paper #	ID	Author	Title	Affiliation	Time
1	876	E5A - 3	Muhammad Fathur Rahman N, Salama Manjang and Zahir Zainuddin	Water Level Measurement Using Ultrasonic Pipe in Open Channel	Hasanuddin University, Indonesia	14.30-14.45
2	694	E5A - 4	Diah Kusumawati, Muhammad Suryanegara and Sri Ariyanti	IoT Spectrum Requirement for Smart Transportation	Universitas Indonesia, Indonesia	14.45-15.00
3	388	E5A - 5	Helmy Fitriawan, Ahmad Surya Arifin, Danny Mause, Misfa Susanto and Agus Trisanto	ZigBee Based Wireless Sensor Network and Performance Analysis in Various Environments	University of Lampung, Indonesia	15.00-15.15
4	907	E5A - 6	Ajib Setyo Arifin, Andrianus Pradipta and Dadang Gunawan	Modelling and Analysis E-SIM in Indonesia	Universitas Indonesia, Indonesia	15.15-15.30



E 5B : Power Engineering System 1

Wednesday, July 26, 2017 14.00-15.30

Surabaya Room 2nd fl (Session Chair: Prof. Woei-Luen Chen / Dr. Chairul Hudaya)

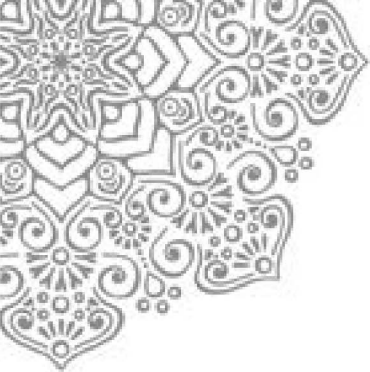
No	Paper #	ID	Author	Title	Affiliation	Time
1	766	E5B - 1	Woei-Luen Chen, Chun-Yuan Chen, I-Chyn Wey and Yu-Ping Chou	Design and Control of a 10kW Three-Phase Grid-tied Back to Back Inverter	University of Taipei, Taiwan	14.00-14.15
2	308	E5B - 3	Muhammad Levy Aninditio, Amien Rahardjo and Chairul Hudaya	Lighting Replacement Analysis at Classrooms of Engineering Center, Faculty of Engineering, Universitas Indonesia	Universitas Indonesia, Indonesia	14.30-14.45
3	547	E5B - 4	Agus Indarto, Iwa Garniwa, Rudy Setiabudy and Chairul Hudaya	Total Cost of Ownership Analysis of 60 MVA 150/120 kV Power Transformer	Universitas Indonesia, Indonesia	14.45-15.00
4	593	E5B - 5	Yosi Ohira, Yoyok Dwi Setyo Pambudi and Chairul Hudaya	Utilization of Idle Power Plant for Own Use and Excess Power in an Oil-and-Gas Company	Universitas Indonesia, Indonesia	15.00-15.15
5	687	E5B - 6	Widodo Pudji Muljanto and Rinaldy Dalimi	Secondary Voltage Control of Single Phase Induction Generator Operated in Small Scale Picohydro Power Plant at Off-Grid Area.	Universitas Indonesia, Indonesia	15.15-15.30

E 5C : Control Engineering System 2

Wednesday, July 26, 2017 14.00-15.30

Singaraja Room (Session Chair: Dr. Muhammad Rif'An / Dr. Mat Syai'in)

No	Paper #	ID	Author	Title	Affiliation	Time
1	413	E5C - 1	Bhakti Yudho Suprpto, Wahidin Wahab, Benyamin Kusumoputro and Amsa Mustaqim	Modified Elman Recurrent Neural Network for Attitude and Altitude Control of Heavy-lift Hexacopter	Universitas Indonesia, Indonesia	14.00-14.15
2	465	E5C - 2	Muhammad Rif'An, Feri Yusivar and Benyamin Kusumoputro	Adaptive PID Controller Based on Additional Error of an Inversed-Control Signal for Improved Performance of Brushless DC Motor	Universitas Indonesia, Indonesia	14.15-14.30
3	466	E5C - 3	Rosalia H Subrata, Julian Leonard Hardenberg and Ferrianto Gozali	The Use of PID Controller to Get the Stable Floating Condition of the Objects in Magnetic Levitation System	Trisakti University, Indonesia	14.30-14.45



4	508	E5C - 4	Abdul Halim and Muhammad Sulaiman Nur Ubay	Performance Simulation of PID Based ADCS for Earth Observation Micro Satellite	Universitas Indonesia, Indonesia	14.45-15.00
5	555	E5C - 5	Dimas Andy Kurniawan, Mat Syai'In, Syamsiar Kautsar, Lilik Subiyanto, Joko Endrasmono, Rachmad Tri Soelistijono, Annas Singgih Setyoko, Aang Wahidin, Boedi Herijono, Adi Soeprijanto and M. Khoiril Hasin	Hand Typist Robot Modelling for Quadriplegic Person Using Extreme Learning Machine	Shipbuilding Institute of Polytechnic Surabaya, Indonesia	15.00-15.15
6	600	E5C - 6	Yusuf Lestanto, Aries Subiantoro and Feri Yusivar	Two-stage Least Square Method for Model Identification of Vehicle Motion	Universitas Indonesia, Indonesia	15.15-15.30
7	858	ESC-7	Muhammad Adi Nugroho and Benyamin Kusumoputro	Fuzzy-Appearance Manifold and Fuzzy Nearest Distance for Face Recognition on Various Poses and Degraded Images	Universitas Indonesia, Indonesia	15.30-15.45

E 6A : Tera/Optical Devices and Electrical System

Wednesday, July 26, 2017 15.45-18.00

Medan Room 2nd fl (Dr. Teti Zubaidah / Dr. Catur Apriono)

No	Paper #	ID	Author	Title	Affiliation	Time
1	94	E6A - 1	Dewi Anggraeni and Purnomo Sidi Priambodo	Open-loop Fiber Optic Gyroscope Model Based on Angle-random Walk Effect	Universitas Indonesia, Indonesia	15.45-16.00
2	410	E6A - 2	Retno Wigajatri Purnamaningsih, Nji Raden Poespawati, Sasono Rahardjo, Maratul Hamidah, Elhadj Dogheche and Tomy Abuzairi	The Effect of Waveguide Parameters on GaN Based S-bend Y-junction Optical Power Divider	Universitas Indonesia, Indonesia	16.00-16.15
3	564	E6A - 3	Maratul Hamidah, Sasono Rahardjo, Retno Wigajatri Purnamaningsih, Nji Raden Poespawati and Purnomo Sidi Priambodo	Comparison of Coupling Coefficient Variation Effects on Double Couplers Structured Single Ring Resonator with Single and Double Beams Injection	Agency for The Assessment and Application of Technology (BPPT), Indonesia	16.15-16.30



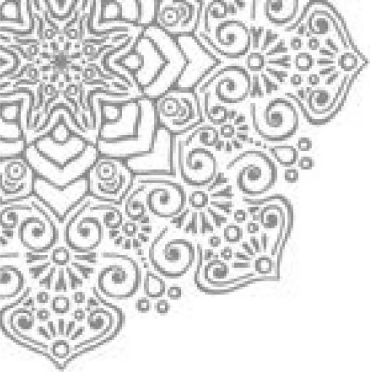
4	570	E6A - 4	Yus Natali, Purnomo Sidi Priambodo and Eko Tjipto Rahardjo	Study on Electro-Optic Modulator Based Distributed Antenna System Over Wavelength Division Multiplexing Passive Optical Network System	Universitas Indonesia, Indonesia	16.30-16.45
5	613	E6A - 5	Catur Apriono, Nofrizal, Mochamad Dandy Firmansyah, Fitri Yuli Zulkifli and Eko Tjipto Rahardjo	Near-field to Far-field Transformation of Cylindrical Scanning Antenna Measurement Using Two Dimension Fast-Fourier Transform	Universitas Indonesia, Indonesia	16.45-17.00
6	733	E6A - 6	Teguh Wahyudi, Catur Apriono, Fitri Yuli Zulkifli and Eko Tjipto Rahardjo	Broadband Planar Bow-tie Antenna on High Resistivity Silicon Substrate for Terahertz Application	Universitas Indonesia, Indonesia	17.00-17.15
7	852	E6A - 7	Teti Zubaidah, Bulkis Kanata, Paniran and Ahmad Yani	Static and Dynamic Magnetic Fields Scattering on a Mini Magneto-static Flux Manipulator for Wireless Power Transfer	Mataram University, Indonesia	17.15-17.30

E 6B : Power Engineering System 2

Wednesday, July 26, 2017 15.45-18.00

Surabaya Room 2nd fl (Dr. Tomy Abuzairi / Dr. Chairul Hudaya)

No	Paper #	ID	Author	Title	Affiliation	Time
1	57	E6B - 1	Heri Suyanto and Rina Irawati	Study Trends and Challenges of the Development of Microgrids	PLN Technical College, Indonesia	15.45-16.00
2	468	E6B - 3	Fitriyanti Mayasari and Rinaldy Dalimi	Dynamic Modeling of CPO Supply to Fulfill Biodiesel Demand in Indonesia	Universitas Indonesia, Indonesia	16.15-16.30
3	559	E6B - 4	Adinda Franky Nelwan, Chairul Hudaya and Rinaldy Dalimi	Concept Development for Quantification of Integrated Energy Security	Universitas Indonesia, Indonesia	16.30-16.45
4	741	E6B - 7	Nur Fitriyah, Syamsir Abduh and Ishak Kasim	Grounding System Design Optimization on 275 KV Betung Substation Based IEEE Standard 80-2000	Trisakti University, Indonesia	17.15-17.30
5	911	E6B - 8	Herlina, Rudy Setiabudy and Amien Rahardjo	Influence of Permanent Magnet and Width of Stator Slot to Cogging Torque Reduction in PMSG Using Anti-Notch and Cutting Edge Method	Universitas Indonesia, Indonesia	17.30-17.45



6	129	E6B - 9	Ratnasari Nur Rohmah and Nurokhim	Simulation of I-131 Dispersion Around KNS (Kawasan Nuklir Serpong) Using Gaussian Plume Model	Muhammadiyah University of Surakarta, Indonesia	17.45-18.00
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E 6C : Electrical System and Solar Power System						
Wednesday, July 26, 2017 15.45-18.00						
Manado Room (Dr. Wahidin Wahab / Dr. Gunawan Wibisono)						
No	Paper #	ID	Author	Title	Affiliation	Time
1	604	E6C - 1	Wahidin Wahab	Design and Simulaton of an Output Voltage Stabilization and Control for Solar Power (PV) Application Using Fuzzy Logic Controller	Universitas Indonesia, Indonesia	15.45-16.00
2	349	E6C - 2	Euis Suryati and Gunawan Wibisono	Machine to Machine Application As Kwh Meter Controlling	Universitas Indonesia, Indonesia	16.00-16.15
3	276	E6C - 3	Jazuli Fadil, Soediby, Mochamad Ashari	Performance Comparison of Vertical Axis and Horizontal Axis Wind Turbines to Get Optimum Power Output	Sepuluh Nopember Institute of Technology (ITS), Indonesia	16.15-16.30
4	300	E6C - 4	Antonius Rajaguguk, Ciptian Weriad Priananda, Dedet Candra Riawan, Soediby Soediby and Mochamad Ashari	Novel Derivative Cluster Area Methods (DCAM) for Optimization of PV Farm Under Dynamic Shading Effect	Sepuluh Nopember Institute of Technology (ITS), Indonesia	16.30-16.45
5	63	E6C - 5	Iswan Iswan and Iwa Garniwa	Principal Component Analysis and Cluster Analysis for Development of Electrical System	Universitas Indonesia, Indonesia	16.45-17.00
6	241	E6C - 6	Ciptian Weriad Priananda, Antonius Rajaguguk, Dedet Candra Riawan, Soediby Soediby and Mochamad Ashari	New Approach of Maximum Power Point Tracking for Static Miniature Photovoltaic Farm Under Partially Shaded Condition Based on New Cluster Topology	Sepuluh Nopember Institute of Technology (ITS), Indonesia	17.00-17.15
7	808	E6C - 7	Wisnu Ananda	External Quantum Efficiency (EQE) Measurement of Solar Cells	Center for Material and Technical Product, Ministry of Inducry, Indonesia	17.15-17.30



E 6D : Communication System and Signal Processing 2

Wednesday, July 26, 2017 15.45-18.00

Bougenville Room 1st fl Session Chair: Dr. Muhammad Suryanegara/ Dr. Misfa Susanto)

No	Paper #	ID	Author	Title	Affiliation	Time
1	506	E6D - 1	Gregorius Ivan Baskara and Muhammad Suryanegara	Study of Filter-Bank Multi Carrier (FBMC) Utilizing Mirabbasi-Martin Filter for 5G System	Universitas Indonesia, Indonesia	15.45-16.00
2	758/888	E6D - 2	Abdul Hafid Paronda and Muhamad Asvial	User's Velocity-based Uplink Power Control in 5G Femtocell Networks	Universitas Indonesia, Indonesia	16.00-16.15
3	296	E6D - 3	Andreyanto Pratama, Taufik Hidayatullah and Dedy Septono Catur Putranto	Efficient Implementation of Hash Sequence Authentication Based on RFID	National Crypto Institute, Indonesia	16.15-16.30
4	312	E6D - 4	Sukra Bambang Wahyu Tri Hatmaja, Saptadi Nugroho and Iwan Setyawan	Stationary Obstacle Detection Using Pyramidal Lucas Kanade Optical Flow	Satya Wacana Christian University, Indonesia	16.30-16.45
5	371	E6D - 5	Misfa Susanto, Dika Fauzia, Melvi and Syaiful Alam	Downlink Power Control for Interference Management in Femtocell-Macrocell Cellular Communication Network	University of Lampung, Indonesia	16.45-17.00
6	376	E6D - 6	Lessy Sutiyono Aji, Gunawan Dadang and Gunawan Wibisono	The Adoption of TV White Space Technology as a Rural Telecommunication Solution in Indonesia	Universitas Indonesia, Indonesia	17.00-17.15
7	882	E6D - 8	Muhammad Suryanegara and Insan Laksana Pribadi	Regulatory Recommendations for IoT Smart-health care services by using Privacy Impact Assessment (PIA)	Universitas Indonesia, Indonesia	17.15-17.30

Poster Session Day 1

Tuesday, July 25, 2017 15.00-15.30

No	Paper #	ID	Author	Title	Affiliation
1	474	P - 8	Jeong-Hoon Seol and Sung-Ho Hahm	Drain Current Modeling of GaN Schottky Barrier MOSFETs	Kyungpook National University, South Korea

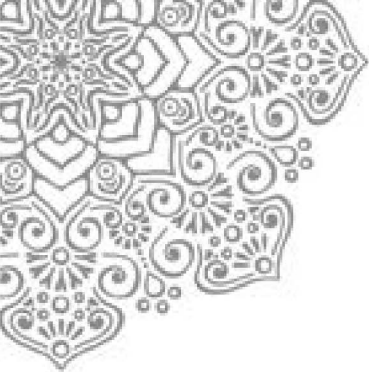
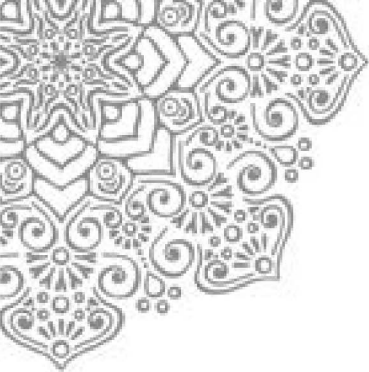


Table of Contents

	Performance Analysis on Iris Recognition Based on Half Polar Iris	
E-Inv	Localization and Normalization Method using Modified Low Cost Camera	1
E1-1	Propagation of Chaos in Power Control Games for Energy-Efficient Wireless Networks	5
E1-3	An Evaluation of DNS Server Health of State-Owned Universities in Sumatera Island	13
E1-4	Palm Vein Recognition by Using Modified Local Binary Pattern(LBP) for Extraction Feature	18
E2-1	Predicting Daily Consumer Price Index Using Support Vector Regression Method	23
E2-3	Analysis on Green IT Applications Usage for the Firm's Competitive Advantage Strategy	29
E2-5	Smart Vending Machine Based on SMS Gateway For General Transactions	34
E2-6	Indonesian Text Feature Extraction using Gibbs Sampling and Mean Variational Inference Latent Dirichlet Allocation	40
E2-7	Majority Vote Technique Based On Multi Rough Set for Multi Attributes Decision-Making System	45
E3A-1	Real-Time Monitoring of Charge-Pumping Process for SiO ₂ /Si Interface Defect Analysis	52
E3A-2	Effect of Ge Mole Fraction on Current, Voltage and Electric Field Characteristics of High Doping Nanoscale Si _{1-x} Gex/Si p-n Diode	57
E3A-3	Measurement of Particles in Oil Using Shear Horizontal Surface Acoustic Wave Sensor	61
E3A-4	Effect of Anode and Cathode Workfunction on the Operating Voltage and Luminance of a Single Emissive Layer Organic Light Emitting Diode	65
E3A-6	Bifacial Heterojunction Intrinsic Thin Layer Solar Cells as a BioFET Supply	69



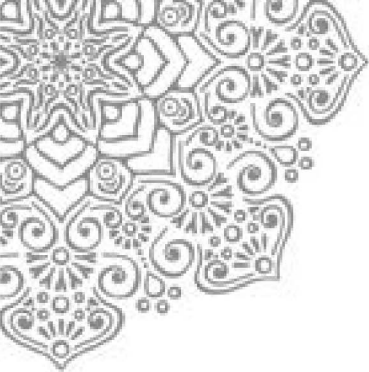
E3A-7	A Statistical Study on the Formation of A-Few-Dopant Quantum Dots in Highly-Doped Si Nanowire Transistors	74
E3B-1	Wideband BPF Composed of Planar Inverted-F Shaped for S-Band Frequency Application	79
E3B-2	Effect of Shape Truncation Against Axial Ratio of Left-Handed Circularly Polarized X-Band Antenna	83
E3B-3	Incorporation of High Permittivity Circular Dielectric Resonator for Enhancing Resonant Frequency of Microstrip Antenna	87
E3B-4	Miniaturization of Array Microstrip Antenna Using Peripheral Slits for Wireless Fidelity Communication	91
E3B-5	The Design of ISM-Band Radar Antenna for Small Boat's Trajectory Tracking	96
E3B-6	Substrate Integrated Waveguide Bandpass Filter for VSAT Downlink	101
E3B-7	Multiband Double Layered Microstrip Antenna by Proximity Coupling for Wireless Applications	106
E3B-8	Design of Wideband Microstrip Antenna With Parasitic Element For 4G/LTE Application	110
E4A-1	450nm Laser Diode Beam Shaping in Engraving Process	114
E4A-2	Direct Current Load Effects on Series Battery Internal Resistance	120
E4A-3	Thermal Conductance and Heat Capacity Measurement Utilizing Suspended-Wire Resistor	124
E4A-4	Preliminary Study of Plasma-treated Water for Germination Stimulation of Agricultural Seeds	128
E4A-5	Electrical Properties of Dye-sensitized Solar Module with Integrated Parallel Connections	132
E4A-7	Crystalline Silicon Solar Cell Design with Al _x Ga _{1-x} As as Heterojunction with Compound Thin Layer for Biosensor Application	137
E4B-1	Handheld Pulse Oximeter Using Raspberry Pi B +	141
E4B-2	The Model of Near Infrared Sensor Output Voltage As a Function of Glucose Concentration in Solution	146
E4B-3	Design of Ultrawideband Applicator for Microwave Ablation Aimed at Thermal Therapy in Liver Cancer	150
E4B-4	Relative Wavelet Bispectrum Feature for Alcoholic EEG Signal	



	Classification Using Artificial Neural Network	154
E4B-5	Portable Gamma Ray Tomography System for Investigation of Geothermal Power Plant Pipe Scaling	159
E4B-6	Headgear Recognition by Decomposing Human Images in the Thermal Infrared Spectrum	164
E4B-7	Identification of Pulse Frequency Spectrum of Chronic Kidney Disease Patients Measured at TCM Points Using FFT Processing	169
E4B-8	Review of Photoplethysmography Based Noninvasive Continuous Blood Pressure Methods	173
E4C-1	Design and Implementation of Adaptive PID Controller for Speed Control of DC Motor	179
E4C-2	Study of Speed Sensorless Permanent Magnet Synchronous Motor (PMSM) Control Problem due to Braking During Steady State Condition	184
E4C-4	Estimating the UAV Moments of Inertia Directly from Its Flight Data	190
E4C-5	Stabilising a Cart Inverted Pendulum System Using Pole Placement Control Method	197
E4C-6	Modeling, Simulation and Control of a High Precision Loading-Unloading Robot for CNC Milling Machine	204
E4C-7	Design and Prototyping of 3-Phase BLDC Motor	209
E4C-8	A DC Motor Speed Control Using LPC-ANFIS Speech Recognition System	215
E4D-1	An Analysis of Natural Disaster Data by Using K-Means and K-Medoids Algorithm of Data Mining Techniques	221
E4D-2	The Implementation of Wash, Rinse, and Spin Technique in Accelerometer's Data Processing on Android Smartphone to Generate Stream Keys	226
E4D-3	S-Mbank: Secure Mobile Banking Authentication Scheme Using Signcryption, Pair Based Text Authentication, and Contactless Smart Card	230
E4D-4	Word Level Auto-correction for Latent Semantic Analysis Based Essay Grading System	235
E4D-5	Fast Implementation of AES on Cortex-M3 for Security Information Devices	241



E4D-6	Interference Management Using Power Control for Uplink Transmission in Femtocell-Macrocell Cellular Communication Network.	245
E4D-7	Implementation of RFID Based Raspberry Pi for User Authentication and Offline Intelligent Payment System	251
E4D-8	Recommender Engine Using Cosine Similarity Based On Alternating Least Square -Weight Regularization	256
E5A-3	Water Level Monitoring Using Ultrasonic Pipe in Open Channel	262
E5A-4	IoT Spectrum Requirement for Smart Transportation	267
E5A-5	ZigBee Based Wireless Sensor Network and Performance Analysis in Various Environments	272
E5A-6	Modelling and Analysis e-SIM in Indonesia	276
E5B-1	Design and Control of a 10kW Three-Phase Grid-tied Back to Back Inverter	281
E5B-3	Lighting Replacement Analysis at Classrooms of Engineering Center, Faculty of Engineering, Universitas Indonesia	285
E5B-4	Total Cost of Ownership Analysis of 60 MVA 150/120 kV Power Transformer	291
E5B-5	Utilization of Idle Power Plant for Own Use and Excess Power in an Oil-and-Gas Company	296
E5B-6	Secondary Voltage Control Of Single Phase Induction Generator Operated In Small Scale Picohydro Power Plant At Off-Grid Area	303
E5C-1	Modified Elman Recurrent Neural Network for Attitude and Altitude Control of Heavy-lift Hexacopter	309
E5C-2	Adaptive PID Controller Based on Additional Error of an Inversed-Control Signal for Improved Performance of Brushless DC Motor	315
E5C-3	The Use of PID Controller to Get the Stable Floating Condition of the Objects in Magnetic Levitation System	321
E5C-4	Performance Simulation of I-PD Based ADCS for Earth Observation Micro Satellite	325
E5C-5	Hand Typist Robot Modelling for Quadriplegic Person Using Extreme Learning Machine	330
E5C-6	Two-stage Least Square Method for Model Identification of Vehicle Motion	336
E5C-7	Fuzzy-Appearance Manifold and Fuzzy Nearest Distance for Face Recognition on Various Poses and Degraded Images	342
E6A-1	Open Loop Fiber Optic Gyroscope Analysis Based on Angular Random Walk	347
E6A-2	The Effect of Waveguide Parameters on GaN Based S-bend Y-junction Optical Power Divider	353
E6A-3	Comparison of Coupling Coefficient Variation Effects on Double Couplers Structured Single Ring Resonator with Single and Double Beams Injection	357
E6A-4	Study on Electro-Optic Modulator Based on Distributed Antenna System Over Wavelength Division Multiplexing Passive Optical Network System	362



E6A-5	Near-field to Far-field Transformation of Cylindrical Scanning Antenna Measurement Using Two Dimension Fast-Fourier Transform	368
E6A-6	Broadband Planar Bow-tie Antenna on High Resistivity Silicon Substrate for Terahertz Application	372
E6A-7	Static and Dynamic Magnetic Fields Scattering on a Mini Magneto-static Flux Manipulator for Wireless Power Transfer	377
E6B-1	Study Trends and Challenges of the Development of Microgrids	383
E6B-3	Dynamic Modeling of CPO Supply to Fulfill Biodiesel Demand in Indonesia	388
E6B-4	Concept Development for Quantification of Integrated Energy Security	394
E6B-7	Grounding System Design Optimization on 275 KV Betung Substation Based IEEE Standard 80-2000	400
E6B-8	Influence of Permanent Magnet and Width of Stator Slot to Cogging Torque Reduction in PMSG using Anti-Notch and Cutting Edge Method	408
E6B-9	Simulation of I-131 Dispersion Around KNS (Kawasan Nuklir Serpong) Using Gaussian Plume Model	414
E6C-1	Design and Simulaton of an Output Voltage Stabilization and Control for Solar Power (PV) Application Using Fuzzy Logic Controller	420
E6C-2	Machine to Machine Application As Kwh Meter Controlling	425
E6C-3	Performance Comparison of Vertical Axis and Horizontal Axis Wind Turbines to Get Optimum Power Output	429
E6C-4	Novel Derivative Cluster Area Methods (DCAM) for Optimization of PV Farm Under Dynamic Shading Effect	434
E6C-5	Principal Component Analysis and Cluster Analysis for Development of Electrical System	439
E6C-6	New Approach of Maximum Power Point Tracking for Static Miniature Photovoltaic Farm Under Partially Shaded Condition Based on New Cluster Topology	444
E6C-7	External Quantum Efficiency (EQE) Measurement of Solar Cells	450
E6D-1	Study of Filter-Bank Multi Carrier (FBMC) Utilizing Mirabbasi-Martin Filter for 5G System	457
E6D-2	User's Velocity-based Uplink Power Control in 5G Femtocell Networks	462
E6D-3	Efficient Implementation of Hash Sequence Authentication Based on RFID	468
E6D-4	Stationary Obstacle Detection Using Pyramidal Lucas Kanade Optical Flow	474
E6D-5	Downlink Power Control for Interference Management in Femtocell-Macrocell Cellular Communication Network	479
E6D-6	The Adoption of TV White Space Technology as a Rural Telecommunication Solution in Indonesia	485
E6D-8	Regulatory Recommendations for IoT Smart-Health Care Services by Using Privacy Impact Assessment (PIA)	491
P-8	Drain Current Modeling of GaN Schottky Barrier MOSFETs	497

ZigBee Based Wireless Sensor Networks and Performance Analysis in Various Environments

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Abstract— To achieve a reliable and robust system for environmental monitoring, there is an available technology that can be used to resolve this problem and moreover provide for better living. Wireless sensor networks (WSN) have been successfully applied in many environmental monitoring. An ad-hoc wireless sensor network consists of a number of small and self-power sensing devices (nodes) connected using effective wireless networks. Compared to wired networks, there are several challenges that must be addressed in wireless networks. These challenges are limitation in communication bandwidth and energy constraint in sensor node, therefore it is important to know their reliability and performance. This paper reports the development and performance analysis of an embedded wireless sensor network for temperature and humidity monitoring in the environment. The network itself consists of a coordinator or data gateway which wirelessly collect temperature and humidity data from several sensor nodes that are responsible to provide those data. Each sensor node is developed from an Arduino based microcontroller, Xbee wireless module based on ZigBee/IEEE 802.15.4 standards, and temperature and humidity sensor devices. The network quality of service (QoS) is investigated in terms of delay, throughput and packet loss as a function of sensor node distance and transmitted packet size over line of sight (LOS) and non-line of sight (NLOS) conditions. The throughput and packet delay are also measured as a function of the baud rate in point to point link. This experiment is performed to have an insight how the baud rate affects the latency of the communication over the ZigBee protocol. Next, we also considered the multi-hop scenario with the presence of router for relaying packets from the sensor node to the coordinator. The performance of multi-hop configuration is compared to that of direct transmission. Based on our analysis, it is concluded that the ZigBee based WSN is more suitable for low data rate applications.

Keywords—Performance analysis; Sensor node; Wireless sensor networks; ZigBee, Multi-hop configuration

I. INTRODUCTION

In the recent years, wireless sensor networks (WSNs) have used in many applications, such as military, agricultural, industry, home and domestic, health and medical, and environmental [1]. The development of WSNs is available due to low power sensor, low cost embedded microcontroller, and effective wireless communication technologies. WSNs have received considerable attention in environmental applications

especially in physical parameters monitoring such as temperature, humidity, sound, vibration, pressure, and gas pollutant. WSN is a self-organizing adhoc multi hop network that consists of spatially distributed sensors nodes deployed in a wide area [2]. Those nodes are allowed to communicate and transmit/receive those sensing data. Thus, WSN enable all physical parameters sensing, data processing, and wireless communication simultaneously.

We have developed a prototype WSN for temperature and humidity monitoring, reported here [3]. This system is modularity developed from an Arduino board, ZigBee based communication module [4], and low power temperature and humidity sensors.

In this paper, we focus particularly on analysis performance on the developed prototype system. In analyzing the performance, quality of service (QoS) parameters of communication are investigated. These parameters, i.e. delay, throughput and packet loss, are investigated as a function of sensor node distance and transmitted packet size over line of sight (LOS) and non-line of sight (NLOS) conditions. Next, we also considered the multi-hop scenario with the presence of router for relaying packets from the sensor node to the coordinator. The performance of multi-hop configuration is compared to that of direct transmission. This experiment work would give a better understanding about the performance and capability of ZigBee based WSN technology in real life applications.

The rest of the paper is organized as follows. Section II describes the methodology including hardware design and experimental setup. The research finding is presented in Section III. Finally, section IV concludes the paper.

II. METHODOLOGY

A WSN prototyped system is built based on modularity design [3]. The developed system has two types of nodes, i.e. sensor node and coordinator node. Sensor nodes play as an end device that senses physical parameters of environment, i.e. temperature and humidity. Then, the coordinator node is responsible to collect all data readings from the sensor nodes and subsequently send them to the user. In our developed system, an Arduino Uno [5] is used as the heart of the node. It has microcontroller chip Atmega328 and is controlled by the

computer using USB connection. For the communication task, Xbee S2 is used on the system. It operates based on ZigBee protocol within 2.4 GHz frequency band with 250 Kbps RF data rate [6]. For the parameters sensing, LM35DZ [7] and DHT11 [8] sensors are used to read environment temperature and humidity, respectively. Arduino Uno board is programmed using open based application of Arduino IDE [8]. Arduino IDE is capable as a program editor, code compiler, and upload it to the microcontroller. Using X-CTU software provided by Digi [10], we can configure the Xbee module as end device or coordinator, upgrade the firmware and monitor system parameters. Docklight 2.0 software is used to monitor data packet flow, so that we can get the QoS parameters calculations. Our prototype system has three key role functions; they are data acquisition, data collection and data retrieval.

For the experimental set up, two sensors and one coordinator nodes are prepared in order to see WSN performance in LOS and NLOS communications. These nodes are able to build a network. These nodes transmit and receive messages in the network via wireless communication link using ZigBee protocol. ZigBee supports a variety of network topologies, e.g. peer-to-peer, star and mesh topologies. This topology indicates how the transceiver or receiver nodes are logically connected to others.

III. RESULTS

In order to see the performance of our WSN, we measure the throughput and packet delay as a function of packet size and the baud rate over various distances in point to point link. This experiment is performed to have an insight how the baud rate affects the latency of the communication over the ZigBee protocol. The baud rate is defined as processing data rate in serial communication of Xbee module. For this experiment, the point-to-point link at LOS condition is considered between the sensor node which is located 3 m from the coordinator node. The sensor node is configured to send 120 data packets to the coordinator node with 1 second interval between consecutive transmissions. Therefore, the packet delay and throughput, respectively, are calculated as an average of the results from the total transmissions. Several experiments are carried out in comparison for different packet sizes and baud rates. In order to avoid reception overcharge, the transmitted packet size is below the 84 bytes which is the maximum size of RF payload for each fragmentation [6]. Thus, the transmitted packet size is varied from 10 up to 80 bytes. In the meantime, the baud rate was set at 9600, 19200, 38400, 57600, and 115200 bps.

Fig. 1 illustrates the throughput as a function of packet size for different baud rates. The throughput is calculated as a number of packets sizes (bits) over required transmission times (seconds) to successfully receive in the receiver. The measurement results show that the throughput increases as the baud rate increases. A maximum throughput of 19.2 kbps was achieved at baud rate of 115200 bps using highest packet size of 80 bytes. Although, this number is still far lower than the guaranteed data rate of 250 kbps for ZigBee protocol using Xbee S2 modules.

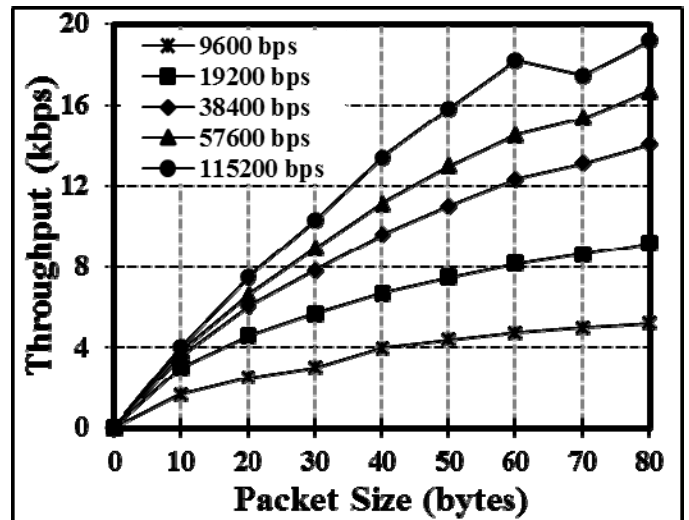


Fig. 1. Throughput measurements as a function of packet size at different baud rates.

Another key factor of communication performance is the packet delay between the transmitter and the receiver. The packet delay is expressed as the time duration between sending the packet until the packet has been received by the receiver. The delay measurement results at different baud rates and packet size are presented in Fig. 2. It is observed that the packet requires more times to get receiver when lower baud rate is used. The longest delay of 125.283 ms was achieved during transmission using the lowest baud rate of 9600 bps at maximum payload of 80 bytes.

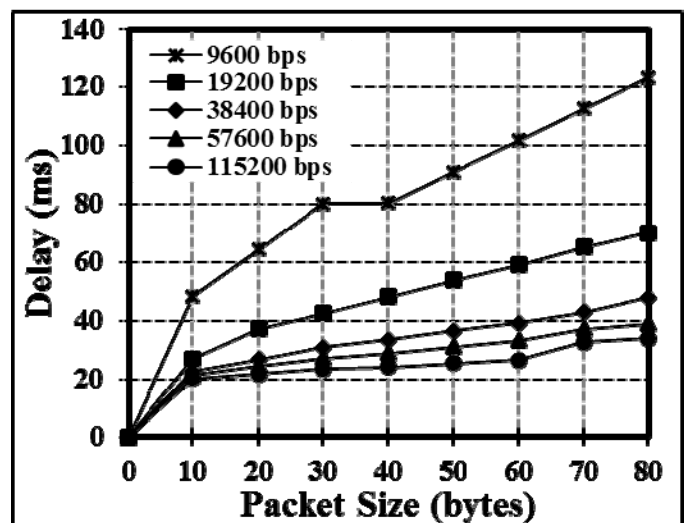


Fig. 2. Packet delay measurements as a function of packet size at different baud rates.

Another significant variable of communication performance is the packet loss. Packet loss is defined by the percentage of unsuccessfully packets to be received by the coordinator. Packet loss measurement is conducted in NLOS conditions over point-to-point communication. Fig. 3 shows the scenario of the measurements where we measure the packet loss in 4 (four) different locations. In the experiments, packets

are sent in the text format which has size of 20, 40, 60 and 80 bytes. This transmission experiment is repeated 120 times with 2 seconds interval between consecutive transmissions.

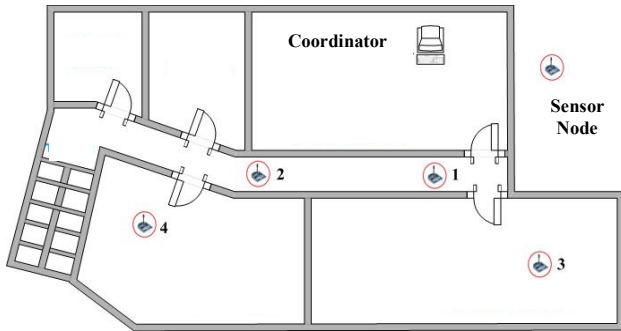


Fig. 3. Sensor nodes positions relative to the coordinator node in the study of packet loss over NLOS communication.

Fig. 4 shows the percentage of packet loss at four different location measurements. As expected that more packets are lost during transmission as the sensor node moves further from the coordinator node with additional wall as well. Given the results in the figure, the packet loss increases significantly as the transmitted packet size increases. It is observed that 95% packets lost during transmission when we send 80 bytes packet from the most remote sensor node at location no. 4 to the coordinator.

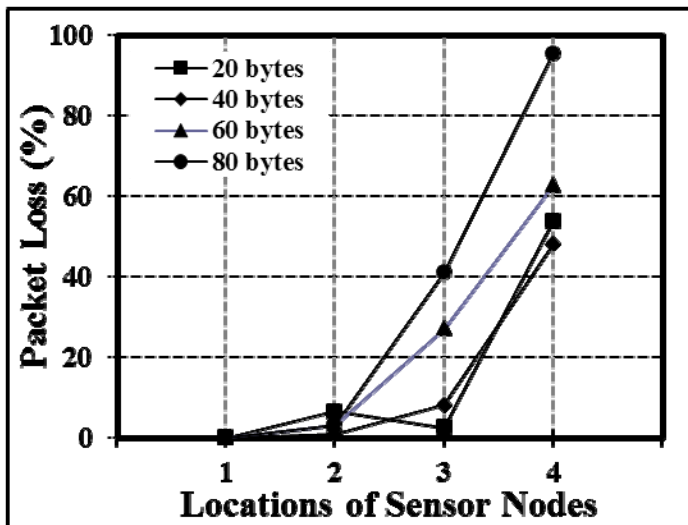


Fig. 4. Packet loss percentage at different packet size in four measurement locations.

In outdoor application, Xbee offers transmission range of 120 m. Therefore, in order to have more coverage area multi-hop configuration is essentially useful. Multi-hop network is realized using routers. Multi-hop performance is measured and compared to that of single-hop. In our experiment, network topology in Fig. 5 is considered where the packets transmitted from the sensor node relaying by the router to the coordinator. In this experiment, data throughput and packet delay are measured using baud rate of 9600 bps. Packets sizes of 10

bytes up to 80 bytes are transmitted 120 times with 5 seconds of interval between consecutive transmissions.

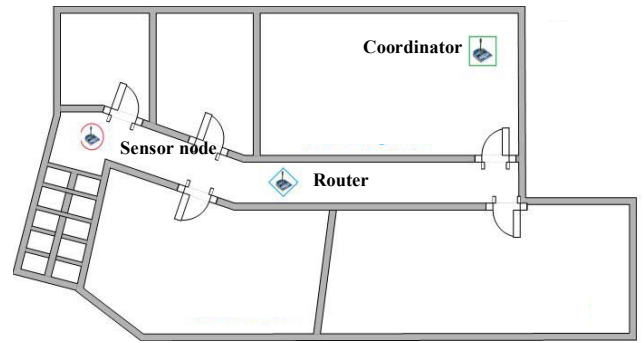


Fig. 5. Positions of end device, router and coordinator in the measurements of multi-hop communication performance.

As shown in Table I, the presence of the router (2 hops configuration) in the network give significant effects on the data throughput as well as the packet delay. In case of multi-hop configuration as shown In Fig. 5, when the router is relaying the data packet from the sensor node to the coordinator, the medium is employed. For the maximum payload (80 bytes), the packet delay for single hop is 122.488 ms and 180.4 ms for 2 hops. There is significant increasing of packet delay due to the additional processing time in the router. Similar thing happens in the throughput measurement. In the scenario of multi-hop, the throughput decreases as the packets need more time to get the receiver. Given the results from this experiments, it is observed that the performance of multi-hop configuration slightly decrease as a compensation for having more coverage area.

TABLE I. THROUGHPUT AND PACKET DELAY MEASUREMENTS FOR SINGLE AND MULTI-HOP CONFIGURATIONS

Packet size (bytes)	Throughput (kbps)		Delay (ms)	
	1 Hop	2 Hops	1 Hop	2 Hops
10	2.196	1.230	36.896	70.446
20	2.537	1.735	63.150	120.638
30	3.037	2.269	79.100	125.004
40	4.031	2.975	79.483	135.725
50	4.460	3.077	89.746	168.738
60	4.770	3.581	100.692	154.100
70	4.985	3.858	112.425	160.117
80	5.227	4.262	122.488	180.400

IV. CONCLUSION

This paper reports the performance analysis of developed ZigBee based WSN. Several QoS parameters are considered in the analysis, i.e. throughput, packet delay and packet loss. We evaluate the performance in the LOS and NLOS conditions. It was observed, the baud rate affects the latency of the

communication. When the baud rate increases, the throughput also increases however the packet delay decreases in performance measurement over LOS conditions. In NLOS experiment, it was found that more packets are lost during transmission as the sensor node moves further from the coordinator node due to additional walls. Furthermore, we also considered the multi-hop scenario with the presence of router for relaying packets from the sensor node to the coordinator. The results show that the performance of multi-hop network is degrading compared to that of direct transmission in terms of data throughput and packet delay. Based on our analysis, it is concluded that the ZigBee based WSN is more suitable for low data rate applications.

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