Program Studi Teknik Elektro Fakultas Teknik Universitas Kristen Indonesia (FT UKI) Jakarta

1st International Conference on Sustainable Architecture and Engineering (ICoSAE)

Laporan Kegiatan

1st International Conference on Sustainable Architecture and Engineering (1st ICoSAE)

Antonius D. T. P, Feren S, Dery E

2020

KATA PENGANTAR

Puji syukur kami panjatkan kehadirat Tuhan Yang Maha Esa karena atas rahmat dan karunia-Nya, kami selaku peserta dan pemakalah dari S1 Teknik Elektro UKI dapat mengikuti kegiatan Seminar *1st International Conference on Sustainable Architecture and Engineering* (1st ICoSAE), sehingga dapat menyusun laporan kegiatan ini. Laporan ini memuat kegiatan yang telah dilaksanakan mulai dari awal registrasi hingga akhir acara berlangsung.

Dalam kesempatan yang baik ini, kami mengucapkan terima kasih sebesar-besarnya kepada:

1. Bapak Dr. Dhaniswara K. Harjono SH., M.H., MBA selaku Rektor Universitas Kristen Indonesia (UKI) Jakarta
2. Bapak Dr. Wilson Rajagukguk, M.Si., MA selaku Wakil Rektor Bidang Akademik UKI
3. Ibu Ir. Lolom E. Hutabarat, M.T selaku Wakil Rektor Bidang Kemahasiswaan, Hukum dan Kerjasama UKI
4. Ibu Ir. Galuh Widati, M.Sc selaku Dekan Fakultas Teknik UKI
5. Bapak Ir. Bambang Widodo, M.T selaku Ketua Program Studi Teknik Elektro UKI
6. Bapak Ir. Jesua Un selaku Alumni Program Studi Teknik Elektro Fakultas Teknik Universitas Kristen Indonesia (FT UKI) Jakarta
7. Bapak Ir. Robinson Purba, M.T, Bapak Ir. Bambang Widodo, M.T, Ibu Eva Magdalena Silalahi, S.T., M.T dan Bapak Stepanus, S.T., M.T sebagai dosen pembimbing penulisan *paper* (jurnal)
8. Ibu Ulinata ST. Ars, M.T selaku Ketua Panitia pelaksana kegiatan Seminar 1st ICoSAE

atas segala bentuk kerjasama dan dukungannya, baik moral maupun spiritual dalam kegiatan Seminar 1st ICoSAE 2020 ini.

Akhir kata penulis serta jajaran penyusun laporan ini, dengan segala hormat dan kerendahan hati, turut menyampaikan permohonan maaf atas segala kekurangan dan kekeliruan dalam penyajian laporan ini. Oleh karena itu, kritik dan saran yang membangun sangat diharapkan.

Jakarta, 8 November 2020

Penyusun

DAFTAR ISI

I. PENDAHULUAN

1.1. Latar Belakang

Society 5.0 (masyarakat 5.0) adalah masyarakat masa depan, di mana *Internet of Things* (IoT), *Artificial Intelegence* (AI), robotika dan teknologi inovatif lainnya akan digunakan secara maksimal untuk optimalisasi kehidupan individu dan masyarakat secara keseluruhan, masyarakat masa depan yang memanfaatkan teknologi untuk mencapai kemajuan ekonomi dan menyelesaikan masalah dalam lingkup masyarakat. *Society 5.0* membayangkan sistem sosio-ekonomi yang inklusif dan berkelanjutan. Dalam masyarakat ini, pertumbuhan ekonomi akan sejalan dengan solusi atas tantangan global dan lokal. Terciptanya masyarakat seperti itu sejalan dengan prinsip pembangunan berkelanjutan. Namun, upaya untuk mewujudkan *society 5.0* lebih dari sekadar menggunakan teknologi inovatif, dan membutuhkan lebih dari sekadar produk, layanan, serta data yang tersedia dari satu perusahaan atau industri. *Society 5.0* hanya dapat terbentuk melalui kolaborasi bersama antara pesaing intra-industri, industri terpisah, universitas, lembaga penelitian, komunitas lokal dan berbagai pemangku kepentingan lainnya, semuanya bersatu dalam visi bersama tentang inovasi.

Dalam rangka mewujudkan dimana masyarakat dapat memperoleh produk dan jasa yang dibutuhkan dalam jumlah dan pada waktu yang dibutuhkan, maka diperlukan bangunan yang kokoh, prasarana dan inovasi teknologi untuk kehidupan sehari-hari, kegiatan industri serta mobilitas masyarakat. Arsitek dan insinyur, serta peneliti dalam bidang arsitektur, struktural, mekanik atau mesin dan kelistrikan telah menjadi 'pemain kunci' dalam realisasi *society 5.0*. Arsitek dan insinyur memiliki kesempatan untuk memajukan penggunaan pengetahuan untuk menciptakan desain yang lebih nyaman dan berkelanjutan. Sementara itu, peneliti dan pendidik akan berperan dalam mengembangkan ilmu yang diperoleh dari para arsitek atau insinyur, serta masyarakat.

Indonesia sebagai negara dengan jumlah penduduk yang besar memiliki peranan dalam mewujudkan era *society 5.0* di tengah dunia. Jika masyarakat tidak segera menyesuaikan, maka akan tertinggal dari negara lain. 1st ICoSAE 2020 bertema "*Building, Infrastructure and Technology* menuju *Society 5.0*" mengundang para akademisi, peneliti dan mahasiswa untuk saling bertukar ilmu. Ini akan menjadi media di mana teori, desain, metode dan penelitian terkini dalam bidang ini akan dibahas.

1.2. Tujuan

Melalui kegiatan ini, tujuan yang ingin disampaikan adalah:

1) Sebagai wadah untuk saling berbagi pengetahuan terkait perkembangan bangunan, arsitektur dan teknologi di masa depan
2) Bagi praktisi dan profesional di bidang teknik (arsitektur, elektro, mesin, sipil) agar lebih *concern* terhadap arsitektur dan engineering yang ramah lingkungan
3) Persiapan diri untuk menyeimbangkan antara kemajuan teknologi dengan masalah sosial menuju *society 5.0*, dengan diintegrasikan kepada sistem yang mengandalkan kemajuan informasi dan teknologi
4) Mempromosikan Fakultas Teknik Universitas Kristen Indonesia (UKI) Jakarta di tingkat nasional maupun internasional

1.3. *Tracks* (Jurusan)

Adapun ruang lingkup pada kegiatan seminar 1st ICoSAE ini, yaitu:

1) *Electrical Engineering: Renewable Energy, Energy Access, Microgrid, Modern System, and Control Engineering*
2) *Mechanical Engineering: Manufacture Materials and Energy Convertion*
3) *Architecture: Green Building, Smart Building, and Sustainable City*
4) *Civil Engineering: Water Resources, Structural, Transportation and Geotechnical Engineering, Construction Management*

II. PELAKSANAAN KEGIATAN

2.1. Waktu dan Tempat Kegiatan

Kegiatan Seminar *1st International Conference on Sustainable Architecture and Engineering* (1st ICoSAE) diselenggarakan pada:

Hari : Rabu
Tanggal : 28 Oktober 2020
Waktu : 08:40 – 17:00 WIB
Webinar Conference via ZOOM *Clouds Meeting App*

2.2. Jadwal (Agenda) Kegiatan

No.	Waktu	Durasi	Kegiatan	PIC
1	08:40 – 09:00	20 menit	*Preparation + Sponsor advertising*	
2	09:00 – 09:10	10 menit	*Opening Ceremony*	
3	09:10 – 09:30	20 menit	*Welcoming Speech: Head of Committee, Rector*	Ulinata ST.Ars, M.T, Dr. Dhaniswara K. Harjono S.H, M.H., MBA
4	09:30 – 10:00	30 menit	*Plenary Session I*	*Keynote:* Prof. Dr. Ismunandar (Plt. Staf Ahli Bidang Relevansi dan Produktivitas Kemenristek/BRIN)
5	10:00 – 10:30	30 menit	*Plenary Session II*	*Keynote:* Prof Manukid Parmichkan
6	10:30 – 11:00	30 menit	*Plenary Session III*	*Keynote:* Prof Dong-Seong Kim
7	11:00 – 11:30	30 menit	*Disscussion*	
8	11:30 – 11:40	10 menit	*Sponsor Advertising*	

9	11:40 – 13:10	30 menit	*Panel Session I*	
10	13:10 – 13:40	30 menit	*Plenary Session IV*	*Keynote:* Prof. Dr. Ir. Johanes Widodo M. Arch Eng
11	13:40 – 14:10	30 menit	*Plenary Session V*	*Keynote:* Prof. Dr. Mohammad Ibrahim Safawi Mohd Zain
12	14:10 – 14:40	30 menit	*Plenary Session VI*	*Keynote:* Prof. Dr. Ing. Uras Siahaan Lic. Rer. Reg
13	14:40 – 15:10	30 menit	*Discussion*	
14	15:10 – 16:40	30 menit	*Panel Session 2*	
15	16:40 – 17:00	20 menit	*Closing Ceremony: Announcements, Closing Statement*	Ulinata ST. Ars, M.T

2.3. Peserta Kegiatan

Peserta kegiatan terdiri dari mahasiswa teknik, pascasarjana teknik, profesor, serta praktisi dan profesional pada bidang keteknikan (arsitektur, elektro, mesin, sipil)

III. HASIL KEGIATAN

3.1. Deskripsi Kegiatan

Kegiatan Seminar 1st ICoSAE dilaksanakan oleh Fakultas Teknik dan Program Pascasarjana Universitas Kristen Indonesia (UKI), dihadiri oleh narasumber (*keynote speaker*) ahli terkemuka di bidang arsitektur dan teknik, yaitu Prof. Ismunandar, Ph.D selaku Staf Ahli bidang Relevansi dan Produktivitas Kementrian Riset dan Teknologi, Prof. Dr. Ing. Uras Siahaan selaku guru besar di Fakultas Teknik UKI, Prof. Dong-Seong Kim dari *Kumoh National Institute of Technology* (Korea Selatan), Prof Manukid Parnichkun dari *Asian Institute of Technology* (Thailand), Prof. Dr. Ir. Johannes Widodo, M. Arch. Eng dari *National University of Singapore* (Singapura), serta Prof Dr Mohammad Ibrahim Safawi Mohd Zain dari Universitas Malaysia Sarawak (Malaysia).

Kegiatan ini ditempuh melalui beberapa tahapan. Tahap pertama adalah pengumpulan abstrak *paper* (jurnal) hingga 30 September 2020, kemudian abstrak yang diterima oleh panitia diumumkan pada 2 Oktober 2020. Setelah melalui tahap seleksi dan pemeriksaan abstrak, penulis atau pemakalah wajib mengirimkan *full paper* hingga 7 Oktober 2020, dan untuk *full paper* yang telah diterima oleh panitia diumumkan pada 21 Oktober 2020. Setelah melalui tahapan tersebut, penulis atau pemakalah diberikan surat terkait abstrak dan *paper* yang telah diterima oleh panitia, serta diumumkan untuk mempresentasikan paper melalui undangan yang dikirimkan melalui email. Presentasi terkait paper dilaksanakan pada hari Rabu, tanggal 28 Oktober 2020 (bertepatan dengan hari Sumpah Pemuda) melalui aplikasi ZOOM *Clouds Meeting*, atau dapat dikatakan acara Seminar 1^{st} ICoSAE berlangsung secara daring. Namun, beberapa peserta diperbolehkan datang secara langsung untuk sekadar melihat atau berfoto langsung di Ruang Seminar Gedung AB Lantai 3.

Kegiatan Seminar 1^{st} ICoSAE, terutama presentasi terkait *paper*, yang dilaksanakan pada hari Rabu, tanggal 28 Oktober 2020 melalui aplikasi ZOOM *Clouds Meeting* dilaksanakan melalui beberapa sesi. Sesi presentasi dilakukan secara paralel, yang artinya bahwa presentasi dilakukan secara kelompok berdasarkan topik (Arsitektur, Struktural, Mekanikal, Elektrikal, dan sebagainya) yang berlangsung secara bersamaan, yang terbagi melalui beberapa sesi. Pelaksanaan sesi presentasi berlangsung selama 10 menit untuk masing-masing pemakalah, dimana per 1 sesi terdiri dari sekitar 6 orang. Setelah presentasi untuk seluruh pemakalah telah selesai, moderator akan membuka sesi tanya jawab.

Acara ditutup dengan *closing statement* dari Ibu Ulinata ST. Ars, M.T selaku ketua panitia kegiatan seminar 1st ICoSAE, serta pengumuman seperti *best paper*, dan seterusnya.

IV. PENUTUP

Demikian laporan singkat kegiatan Seminar *1^{st} International Conference on Sustainable Architecture and Engineering* (1^{st} ICoSAE) sebagai bukti keterlibatan penulis dan pemakalah dalam acara ini. Segenap jajaran penyusun dan penulis laporan ini turut menyampaikan permohonan maaf apabila masih banyak terdapat hal yang tidak berkenan dan kesalahan dalam penulisan. Atas perhatian dan dukungan yang diberikan dari berbagai pihak kami ucapkan terima kasih.

Lampiran 1

Rundown Virtual 1st International Conference on Sustainable Architecture and Engineering (1st ICoSAE) 2020

Rundown Virtual Conference ICoSAE
(Wednesday, October 28th, 2020)

Time	**Activity**	**PIC**
08.40 – 09.00 AM	Preparation + Sponsor advertising	
09.00 – 09.10 AM	Opening Ceremony: ❖ Pray ❖ Songs: ➢ Indonesia Raya ➢ Mars UKI	Lead by MC: ***Heribertus Adolf Bastian P. Abul, S.Sos*** Pray by ***Sudarno Tampubolono S.T., M.Sc***
09.10 – 09.30 AM	**Welcoming Speech:** ❖ The head of Committee ❖ Rector	❖ ***Ulinata ST.Ars, M.T*** ❖ ***Dr. Dhaniswara K.Harjono S.H, M.H., MBA***
09.30 – 10.00 PM	Plenary Session I	**Moderator:** ***Prof.Dr.Ir.Charles O.P.Marpaung MS*** **Keynote 1:** ***Prof.Dr.Ismunandar (Plt. Staf Ahli Bidang Relevansidan Produktivitas Kemenristek/BRIN***
10.00 – 10.30 PM	Plenary Session II	**Moderator:** ***Prof.Dr.Ir.Charles O.P.Marpaung MS*** **Keynote 2**: ***Prof Manukid Parmichkan***
10.30 - 11.00 PM	Plenary Session III	**Moderator:** ***Prof.Dr.Ir.Charles O.P.Marpaung MS*** **Keynote 3**: ***Prof Dong-Seong Kim***
11.00 – 11.30 PM	**Disscussion**	
11.30 – 11. 40 PM	Break + Sponsor Advertising	
11.40 – 01.10 PM	Panel Session I	
01.10– 01.40 PM	Plenary Session IV	**Moderator:** ***Prof.Dr.Ir.Charles O.P.Marpaung MS*** **Keynote 1**: ***Prof Dr. Ir. Johanes Widodo M.Arch Eng***

01.40 – 02.10 PM	Plenary Session V	**Moderator:** ***Prof.Dr.Ir.Charles O.P.Marpaung MS*** **Keynote 2**: ***Assoc Prof Dr Mohammad Ibrahim Safawi Mohd Zain***
02.10 – 02.40 PM	Plenary Session VI	**Moderator:** ***Prof.Dr.Ir.Charles O.P.Marpaung MS*** **Keynote 3**: ***Prof. Dr. Ing. Uras Siahaan Lic. Rer. Reg***
02.40 – 03.10 PM	**Disscussion**	
03.10 – 04.40 PM	Panel Session 2	
04.40 – 05.00 PM	Closing Ceremony: ❖ Announcements ❖ Closing Statement	❖ ***Doorpize Lead by MC*** ❖ ***Ulinata ST.Ars, M.T***

Note: Zoom link shared a day before (October 27, 2020)

Lampiran 2

Surat Permohonan Biaya Bebas Registrasi Seminar Internasional 2020

UNIVERSITAS KRISTEN INDONESIA
Fakultas Teknik

Jl. Mayjen Sutoyo No.2
Cawang – Jakarta 13630
Indonesia

Tel. 021.8092425, 8009190
Faks. 021 8094074
E-mail: ft-uki@uki.ac.id
http://www.uki.ac.id

Nomor : 126/UKI/F6.PTE/PPM.2.2/2020 27 Oktober 2020

Kepada Yth,
Ibu Lolom Evalita Hutabarat, ST., MT
Wakil Rektor Bidang Kemahasiswaan, Hukum, dan Kerja Sama (WRKK)
Di
Universitas Kristen Indonesia

Perihal : Permohonan Biaya Regristasi Seminar Internasional 2020

S1. Program Studi Teknik Elektro
S1. Program Studi Teknik Mesin
S1. Program Studi Arsitektur
S1. Program Studi Teknik Sipil
S2. Teknik Elektro

Dengan Hormat
Sehubungan akan diselenggarakan Seminar Internasional 2020 ***"1ST INTERNATIONAL CONFERENCE ON SUSTAINABLE ARCHITECTURE AND ENGINEERING"*** yang akan dilaksanakan oleh Fakultas Teknik Universitas Kristen Indonesia:

Hari tanggal : Rabu, 28 Oktober 2020
Waktu : 08.00 WIB - Selesai
Tempat : webinar by zoom

melalui surat ini kami memohon supaya mahasiswa dibawah ini :

No.	Nama	NIM
1.	Daniel Perdana Sandorio	1552050006
2.	Feren Susanto	1652050003
3.	Antonius D. T. P	1652050007
4.	Dery Elfando	1652050013

agar permohonan biaya registrasi Seminar tersebut dapat dibiayai oleh Universitas Kristen Indonesia sesuai peraturan yang berlaku.

Demikian kami sampaikan dan atas perhatiannya, kami ucapkan terima kasih.

Jakarta, 27 Oktober 2020
Ka. Prodi Teknik Elektro
FT-UKI,

UNIVERSITAS KRISTEN INDONESIA JAKARTA FAKULTAS TEKNIK PROGRAM STUDI TEKNIK ELEKTRO

Ir. Bambang Widodo, MT

Tembusan:
1. Dekan Fakultas Teknik
2. Ketua Seminar Internasional Ulinata ST. Ars., MT
3. Arsip

Lampiran 3

Berkas Pemakalah

ICoSAE 2020 – Letter of Acceptance (LoA)

Feren Susanto

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ICoSAE 2020

International Conference on Sustainable Architecture and Engineering 2020
Webinar Conference, 28 October 2020
Website: http://icosae2020.starconf.org
Email: agus.juhana@student.upi.edu

Date: 23 August 2020

Letter of Acceptance for Abstract

Dear Authors: Feren Susanto, Eva Magdalena S, Stepanus, Bambang Widodo, R Purba

We are pleased to inform you that your abstract (ABS-46, Oral Presentation), entitled:

"Simulation of passive filter design to reduce total harmonic distortion (THD) in energy-saving lamps (lhe) and light emitting diodes (LED)"

has been reviewed and accepted to be presented at ICoSAE 2020 conference to be held on 28 October 2020 in Jakarta, Indonesia.

Please submit your full paper and make the payment for registration fee before the deadlines, visit our website for more information.

Thank You.

Best regards,

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ICoSAE 2020 Chairperson

ICoSAE 2020 – Letter of Invitation (LoI)

Feren Susanto

Print this page

ICoSAE 2020

International Conference on Sustainable Architecture and Engineering 2020
Webinar Conference, 28 October 2020
Website: http://icosae2020.starconf.org
Email: agus.juhana@student.upi.edu

Date: 23 August 2020

Letter of Invitation

Dear Authors: Feren Susanto, Eva Magdalena S, Stepanus, Bambang Widodo, R Purba

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has been reviewed and accepted to be presented at ICoSAE 2020 conference to be held on 28 October 2020 in Jakarta, Indonesia.

We cordially invite you to attend our conference and present your research described in the abstract.

Please submit your full paper and make the payment for registration fee before the deadlines, visit our website for more information.

Thank You.

Best regards,

Please Insert
Signature Image

[Please Input Data]
ICoSAE 2020 Chairperson

Konfrenzi.com - Conference Management System

Review Paper

Feren Susanto

Simulation of Passive Filter Design to Reduce Total Harmonic Distortion (THD) in Energy-Saving Lamps (LHE) and Light Emitting Diodes (LED)

Feren Susanto[1]*, Eva Magdalena S[2], Stepanus[3], Bambang Widodo[4], R Purba[5]

[1]Students of the Electrical Engineering Study Program, Faculty of Engineering, Christian University of Indonesia (UKI),

[2,3,4,5]Lecturer at the Electrical Engineering Study Program, Faculty of Engineering, Christian University of Indonesia (UKI)

Jl. Mayjen Sutoyo No.2, Cawang, Kramatjati, East Jakarta, DKI Jakarta, Indonesia

* Address for correspondence: Ferenfve13@gmail.com

Abstract. This paper discusses the design of a passive filter system for energy-saving lamps (LHE) and LEDs using the MATLAB Simulink software. This type of lamp is a type of non-linear load that produces harmonics of current and voltage. However, this harmonic problem can be reduced using passive filters. To determine the size of the passive filter components, research was carried out in the form of measurements of power, power factor, voltage, current, THDi and THDv produced by the LHE and LEDs. The results of these measurements were simulated using MATLAB's Simulink to determine the passive filter design that reduces the THD value on the LHE and LED. To reduce the level of current harmonics, a single tuned LC passive filter was designed. The filter, designed to work at a frequency of 50 Hz and is expected to reduce the level of harmonics in the 3rd, 5th, 7th, 9th, 11th harmonic orders so that the THD produced by LHE and LEDs meets the IEEE 519-2014 standards. The simulation results of single tuned LC passive filter design can reduce THDi by 46.78% from the initial THD of 84.55% so that it becomes 37.77%.

1. Preliminary

With the development of science and technology today, humans are competing to produce various kinds of new discoveries to meet their own needs. New inventions made by humans include sophisticated and energy-efficient electronic devices and electrical appliances, the most commonly used are Energy Saving Lamps (LHE) and Light Emitting Diodes (LEDs). LHE and LED are power electronics based self-ballast lights that are proven to save energy. However, LHE and LED cause non-sinusoidal current and contain harmonics.

The purpose of this study, among others, was to analyze the amount of Total Harmonic Distortion (THD) on LHE and LEDs, so that a passive filter can be designed to reduce THD on LHE and LED using the MATLAB Simulink program. Furthermore, to analyze the comparison of THD on LHE and

Comment [XX1]: 1.Ganti dengan istilah “Introduction”
2.Pada bagian introduction ini, tambahkan sitasi dari hasil-hasil penelitian terdahulu yang relevan.

LED before and after filter installation in a passive filter design simulation using the MATLAB Simulink program.

2. Theoretical basis

2.1. Harmonics

Harmonics are sinusoidal components of a periodic wave having a frequency that is an integer multiple of the fundamental frequency of the periodic wave. The fundamental frequency of the electric power system in Indonesia is 50 Hz, the second harmonic is 100 Hz, the second multiple of the fundamental frequency, and so on. Generally, harmonics are defective phenomena of sine waves, either current or voltage, as shown in Figure 1.

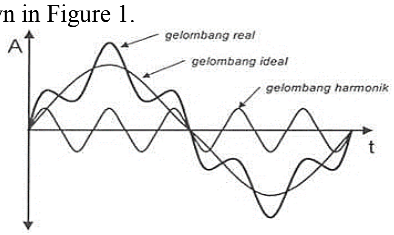

Figure 1: Harmonic Waves

2.2. Total harmonic distortion (THD)

To measure the effective value of the harmonic components of a defective (distorted) wave, the Total Harmonic Distortion (THD) is used in percent as shown in equation (1) below:

$$THD = \frac{\sqrt{\sum_{h=2}^{h=\infty} {M_h}^2}}{M_1} \qquad (1)$$

where M_h is the RMS value of the hth harmonic component of a quantity M (current and voltage). M_1 is the fundamental value of a quantity M (current and voltage). The RMS value of the first harmonic component and the THD value are:

$$nilai\ RMS = \sqrt{\sum_{h=1}^{h=\infty} M^2{}_h} = M_1.\sqrt{1 + THD^2} \qquad (2)$$

The THD value of harmonic currents can be determined based on equation (3):

$$THD_I = \frac{\sqrt{{I_3}^2 + {I_5}^2 + \cdots + {I_n}^2}}{I_1} \times 100\% \qquad (3)$$

where I_n is the value of the nth harmonic RMS current.

The THD value of the harmonic voltage can be determined based on equation (4):

$$THD_V = \frac{\sqrt{{V_3}^2 + {V_5}^2 + \cdots + {V_n}^2}}{V_1} \times 100\% \qquad (4)$$

where V_n is the value of the nth harmonic RMS voltage.

2.3. Single tuned passive filter

In this study, a single tuned LC passive filter was used, which consisted of an RLC series, as shown in Figure 2, the impedance of the single tuned passive filter at the fundamental frequency can be determined based on equation (5):

$$Z = R + j(X_L - X_C) \qquad (5)$$

The series R, L and C in Figure 2 can experience resonance which causes $X_L = X_C$ with $X_L = \omega_r L$ and $X_C = 1/(\omega_r C)$ where $\omega_r L = 1/(\omega_r C)$ or Z = R. In a resonant state, then the resonant frequency can be determined based on equation (6)

$$f_r = 1/(2\pi\sqrt{LC}) \text{ or } \omega_r = 1/\sqrt{LC} = 2\pi f_r \qquad (6)$$

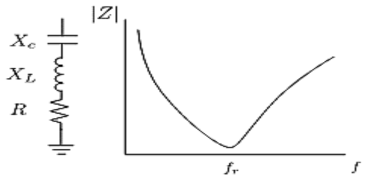

Figure 2: Single tuned passive filter

The angular frequency at resonance, can be determined based on equation (7):

$$\omega_r = 2\pi\, f_r\, h_r \tag{7}$$

2.3.1. Single tuned passive filter calculation

The steps for designing a single tuned passive filter are:

a) a) Determine the power capacity of the capacitor Qc, based on equation (8):

$$Q_C = P\,\{\tan(cos^{-1}\ pf_1) - \tan(cos^{-1}\ pf_2)\} \tag{8}$$

b) Determining the capacitance of the capacitor can be determined based on equation (9):

$$C = \frac{Q_C}{2\pi\, f\, V^2} \tag{9}$$

c) Determine the inductance of the inductor based on equation (10):

$$L = X/(2\pi\, f) \tag{10}$$

d) Determine the reactance based on equation (11):

$$X = 1/2\pi fhC = \sqrt{(L/C)} \tag{11}$$

e) The amount of resistance used in the filter is determined based on equation (12):

$$R = 1/(2\pi\, f\, C\,) \tag{12}$$

3. Parameter measurement

3.1. Determine the type and amount of lamp power used

In the passive filter design simulation, 60 LHE and LEDs were used, with power variations: 8 W, 9 W, 14.5 W, 16 W, 18 W, 19 W, 20 W, 23 W, as in Table 1.

Table 1: Types and magnitude of lamp power used in the study

No	Lamp Brand	Type of Lamp	Watt	Total	Total Watts
1	A	LHE	8	5	40
2	A	LHE	18	5	90
3	A	LHE	23	5	115
4	A	LED	8	5	40
5	A	LED	14,5	5	72,5
6	A	LED	19	5	95
7	B	LHE	8	5	40
8	B	LHE	18	5	90
9	B	LHE	23	5	115
10	B	LED	9	5	45
11	B	LED	16	5	80
12	B	LED	20	5	100
					922,5

There are 60 pcs of LHE and LED lamps with a combination of power quantities, arranged according to Figure 3.

Figure 3: A series of LHE and LED lamps with a combination of various power

3.2. Measurement of real power (S), active power (P), reactive power (Q), voltage (v), power factor (pf) and frequency (f) in energy saving lamps (LHE) and LEDs

Figure 4 shows the quantities S, P, Q, V, PF and f on LHE and LED.

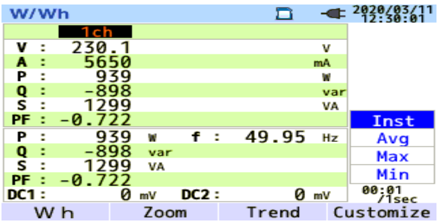

Figure 4: Magnitude of S, P, Q, V, PF and f on LHE and LED lamps

The measuring instrument used to measure the magnitude of S, P, Q, V, PF and f on the LHE and LED in Figure 4 is the KYORITSU Power Quality Analyzer.

3.3. THDi measurement before using the filter

Figure 5 shows the magnitude of the harmonic currents in each harmonic order and the magnitude of the harmonic currents at H3, H5, H7, H9 and H11 is quite high on the LHE and LEDs before using the filter. The IEEE 519-2014 harmonic standard recommends 5% for the limit of the harmonics, so a filter is needed to reduce the amount of harmonics on H3, H5, H7, H9 and H11.

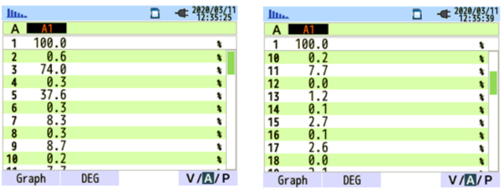

Figure 5: The amount of harmonic currents in each harmonic order

4. Analysis

This study uses a load of 60 LHE and LED lamps, with a combination of varying power sizes (power sizes for the same five energy-saving lamps) of 8 W, 9 W, 14.5 W, 16 W, 18 W, 19 W, 20 W, 23 W. The filters are designed for six pieces and made for six times tuning in the order H3, H5, H7, H9, H11, H13 based on frequencies of 149.85 Hz, 249.75 Hz, 349.65 Hz, 449.55 Hz, 549.45 Hz, 649.35 Hz . Next, test the passive filter that has been designed using the MATLAB Simulink program. Figure 6 shows the simulation circuit before or without using a single tuned LC passive filter.

Comment [XX2]: 1.Istilahnya diganti dengan results and discussion
2.Pada bagian ini, tidak hanya memaparkan tentang hasil penelitian/eksperimen akan tetapi harus ada bagian "discussion" dimana salah satunya adalah mengutip penelitian-penelitian yg relevan kemudian menganalisis dan membandingkannya dengan temuan penelitian ini.

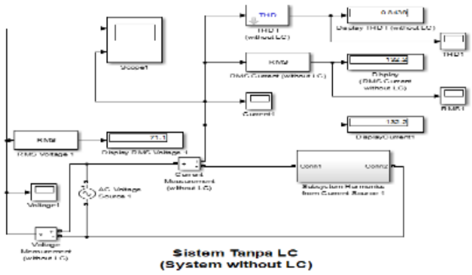

Figure 6: Single tuned LC passive filterless simulation circuit

Figure 7 shows the simulation circuit using a single tuned LC filter.

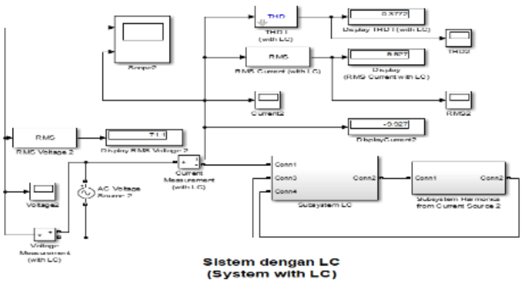

Figure 7: Simulation circuit with single tuned LC passive filter

Table 2 shows the THD of LHE and LED currents before using a single tuned LC passive filter.

Table 2: Total harmonic distortion of current without single tuned LC passive filter

Order of Harmonics	H1	H3	H5	H7	H9	H11	H13
Current (A)	4.203	3.103	1.566	0.347	0.378	0.321	0.047
THD (%)	100	74.03	37.74	8.45	8.81	7.82	1.32

Figure 8 shows the waveform and magnitude of THDi and the magnitude of the harmonic currents in each harmonic order on the LHE and LEDs before using the single tuned LC passive filter on the FFT Analysis in the list view.

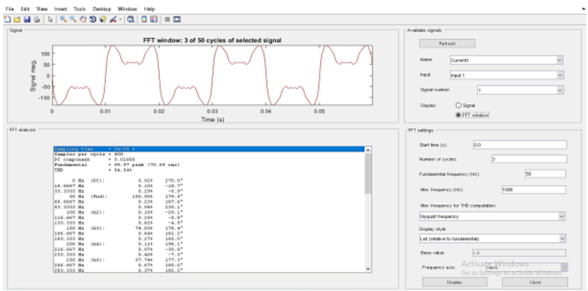

Figure 8: Waveform and size of THDi before using single tuned LC passive filter

Figure 8 shows the amount of THDi before using a single tuned LC passive filter of 84.55%. Based on these data, the current harmonic values obtained in each harmonic order are the order H3 = 74.03%,

the order H5 = 37.74%, the order H7 = 8.45%, the order H9 = 8.81%, the order H11 = 7.82% and the order H13 = 1.32% . And the highest current harmonics are in the order H3 = 74.03%.
Table 3 shows the THD of LHE and LED currents after using a single tuned LC passive filter.

Table 3: Total current harmonic distortion after using a single tuned LC passive filter

Order of Harmonics	H1	H3	H5	H7	H9	H11	H13
Current (A)	4.203	3.103	1.566	0.347	0.378	0.321	0.047
THD (%)	100	37.53	3.85	0.15	0.10	0.00	0.00

Figure 9 shows the waveform and magnitude of THDi and the amount of harmonic currents in each harmonic order on the LHE and LED after using a single tuned LC passive filter.

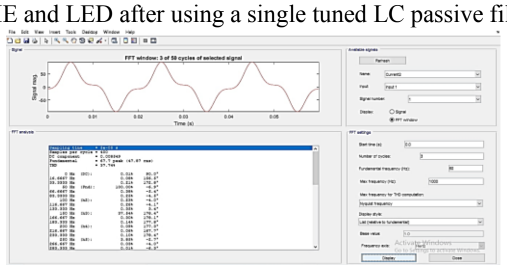

Figure 9: Waveform and size of THDi after using single tuned LC passive filter

Figure 9 shows the amount of harmonic currents in each harmonic order and the amount of THDi decreased by 37.77%. There was also a reduction in THDi of 46.78%, and a decrease in the amount of harmonic currents in each harmonic order, namely the order H3 = 37.54%, order H5 = 3.85%, order H7 = 0.15%, order H9 = 0.10%, order H11 = 0% and order H13 = 0%. However, it can be seen that the current harmonics are still high in the H3 order of 37.54%.

5. Conclusion

1. The use of single tuned LC passive filters can reduce harmonics, thereby affecting the THDi of the load being tested in the form of LHE and LED.
2. The use of a single tuned LC passive filter can reduce THDi by 46.78% from the initial THD of 84.55% so that the final THDi becomes 37.77%.
3. The use of single tuned LC passive filer is still not in accordance with IEEE 519-2014 standards in this case for THDi which is still above 5%.

References

[1] Pahiyanti, N.G., & Soewono,S. (2015). *Harmonics Study on Power Sources Due to the Use of LED, LHE, and TL lamps*. Energy & Electrical Journal,Vol.7, No.1, Hal.28-40.

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Comment [XX3]: 1.Sangat penting sekali untuk diperhatikan bahwa referensi yg ada di daftar pustaka wajib disitasi/dikutip pada bagian bodytext paper ini
2. Jumlah sitasi dengan jumlah referensi harus sama

Written by Alexander Kamenka.
[9] Suharsaputra, Uhar Dr. M.Pd. 2012. *Research methods: quantitative, qualitative, and action*. ISBN 978-602-8650-70-0. IKAPI
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Final Paper

Feren Susanto

Simulation of Passive Filter Design to Reduce Total Harmonic Distortion (THD) in Energy-Saving Lamps (LHE) and Light Emitting Diodes (LED)

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Ferenfve13@gmail.com

Abstract. This paper discusses the design of a passive filter system for Energy-Saving Lamps (LHE) and Light Emitting Diodes (LED) using the MATLAB Simulink software. This type of lamp is a type of non-linear load that produces harmonics of current and voltage. However, this harmonic problem can be reduced using passive filters. To determine the size of the passive filter components, research was carried out in the form of measurements of power, power factor, voltage, current, THDi and THDv produced by the LHE and LED. The results of these measurements were simulated using MATLAB Simulink to determine the passive filter design that reduces the THD value on the LHE and LED. To reduce the level of current harmonics, a single tuned LC passive filter was designed. The filter, designed to work at a frequency of 50 Hz and is expected to reduce the level of harmonics in the 3^{rd}, 5^{th}, 7^{th}, 9^{th}, 11^{th} harmonic orders so that the THD produced by LHE and LED meets the IEEE 519-2014 standards. The simulation results of single tuned LC passive filter design can reduce THDi by 46.78% from the initial THD of 84.55% so that it becomes 37.77%.

1. Introduction

With the development of science and technology today, humans are competing to produce various kinds of new discoveries to meet their own needs. New inventions made by humans include sophisticated and energy-efficient electronic devices and electrical appliances, the most commonly used are LHE and LED. LHE and LED are power electronics based self-ballast lights that are proven to save energy. However, LHE and LED cause non-sinusoidal current and contain harmonics.

The purpose of this study, among others, was to analyze the amount of Total Harmonic Distortion (THD) on LHE and LED, so that a passive filter can be designed to reduce THD on LHE and LED using the MATLAB Simulink program. Furthermore, to analyze the comparison of THD on LHE and LED before and after filter installation in a passive filter design simulation using the MATLAB Simulink program. Based on the results of research conducted by Utomo Shandy Putra P, Sigit Yuwono, and Ekki Kurniawan, it is concluded that the results of the implementation of the low pass filter succeeded in reducing the THDi% by 70%, from 93% to 29% [1].

2. Methods

2.1. Single tuned passive filter calculation

The steps for designing a single tuned passive filter are : [5] [6]

a) Determine the power capacity of the capacitor Qc, based on equation (1):

$$Q_C = P\,\{\tan(cos^{-1}\ pf_1) - \tan(cos^{-1}\ pf_2)\} \tag{1}$$

b) Determining the capacitance of the capacitor can be determined based on equation (2):

$$C = \frac{Q_C}{2\pi\, f\, V^2} \tag{2}$$

c) Determine the inductance of the inductor based on equation (3):

$$L = X/(2\pi\, f) \tag{3}$$

d) Determine the reactance based on equation (4):

$$X = 1/2\pi f h C = \sqrt{(L/C)} \tag{4}$$

e) The amount of resistance used in the filter is determined based on equation (5):

$$R = 1/(2\pi\, f\, C\,) \tag{5}$$

2.2. Determine the type and amount of lamp power used

In the passive filter design simulation, 60 LHE and LED were used, with power variations: 8 W, 9 W, 14.5 W, 16 W, 18 W, 19 W, 20 W, 23 W, as in Table 1.

Table 1. Types and magnitude of lamp power used in the study

No	Lamp Brand	Type of Lamp	Watt	Total	Total Watts
1	A	LHE	8	5	40
2	A	LHE	18	5	90
3	A	LHE	23	5	115
4	A	LED	8	5	40
5	A	LED	14,5	5	72,5
6	A	LED	19	5	95
7	B	LHE	8	5	40
8	B	LHE	18	5	90
9	B	LHE	23	5	115
10	B	LED	9	5	45
11	B	LED	16	5	80
12	B	LED	20	5	100
					922,5

There are 60 pcs of LHE and LED lamps with a combination of power quantities, arranged according to Figure 1.

Figure 1. A series of LHE and LED lamps with a combination of various power

2.3. Measurement of real power (S), active power (P), reactive power (Q), voltage (v), power factor (pf) and frequency (f) in energy saving lamps (LHE) and LED

Figure 2 shows the magnitude of S, P, Q, V, PF and f on LHE and LED.

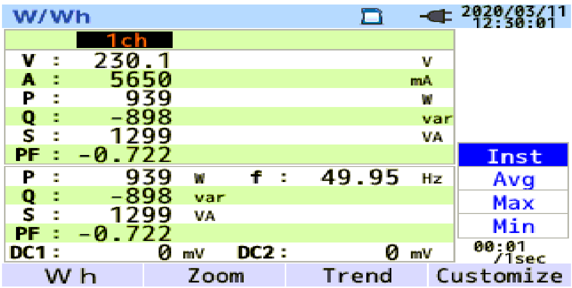

Figure 2. Magnitude of S, P, Q, V, PF and f on LHE and LED lamps

The measuring instrument used to measure the magnitude of S, P, Q, V, PF and f on the LHE and LED in Figure 2 is the KYORITSU Power Quality Analyzer.

2.4. THDi measurement before using the filter

Figure 3 shows the magnitude of the harmonic currents in each harmonic order and the magnitude of the harmonic currents at H3, H5, H7, H9 and H11 is quite high on the LHE and LED before using the filter. The IEEE 519-2014 harmonic standard recommends 5% for the limit of the harmonics [3] [4], so a filter is needed to reduce the amount of harmonics on H3, H5, H7, H9 and H11.

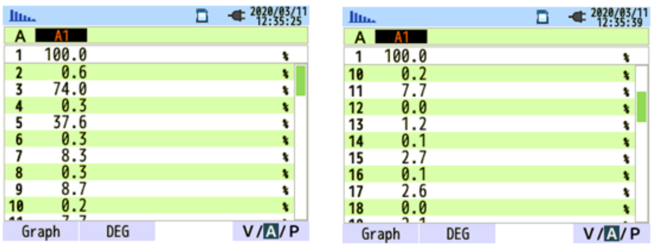

Figure 3. The amount of harmonic currents in each harmonic order

3. Results and discussion

This study uses a load of 60 LHE and LED lamps, with a combination of varying power sizes (power sizes for the same five energy-saving lamps) of 8 W, 9 W, 14.5 W, 16 W, 18 W, 19 W, 20 W, 23 W. The filters are designed for six pieces and made for six times tuning in the order H3, H5, H7, H9, H11, H13 based on frequencies of 149.85 Hz, 249.75 Hz, 349.65 Hz, 449.55 Hz, 549.45 Hz, 649.35 Hz . Next, test the passive filter that has been designed using the MATLAB Simulink program. Figure 4 shows the simulation circuit before or without using a single tuned LC passive filter. Based on the results of research that has been conducted by Nana Heryana, Handoko Rusiana Iskandar, Bambang Widodo, and Robinson Purba (2019) shows that, the effect of THD will cause losses in the form of a decrease in power quality in the LHE. Data of the six samples of Compact Fluorescence Lamp (CFL) testing, namely with a source voltage of 220-234 volts, a voltage THD of less than 2%, a current THD of 63.8-72% rms, a power factor of 0.57-0.76 and a Displacement Power Factor (DPF) 0.73-0.85 [2].
Therefore, in this study, a passive filter design will be made using MATLAB Simulink as a passive filter design aid against a combination of LHE and LED loads, to improve DPF and reduce THDi after installing the passive filter.

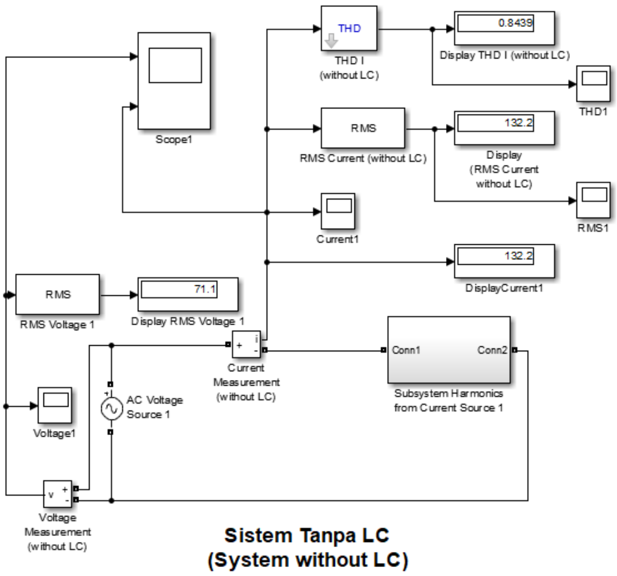

Figure 4. Simulation circuit without single tuned LC passive filter

Figure 5 shows the simulation circuit with single tuned LC passive filter.

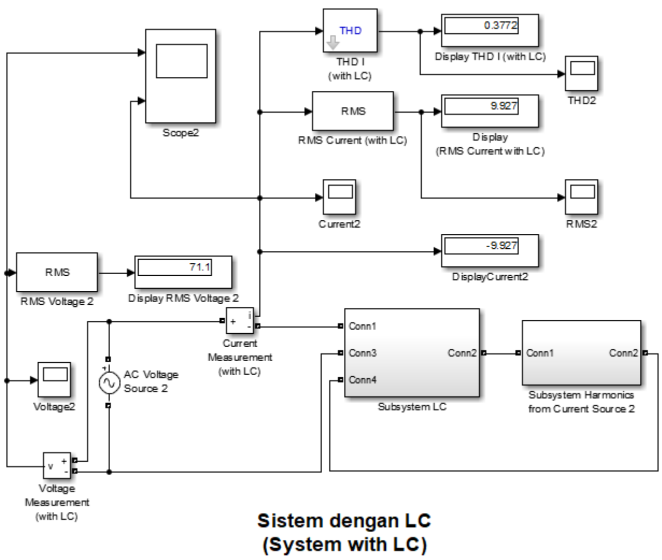

Figure 5. Simulation circuit with single tuned LC passive filter

Table 2 shows the THD of LHE and LED currents before using a single tuned LC passive filter.

Table 2. Total harmonic distortion of current without single tuned LC passive filter

Order of Harmonics	H1	H3	H5	H7	H9	H11	H13
Current (A)	4.203	3.103	1.566	0.347	0.378	0.321	0.047
THD (%)	100	74.03	37.74	8.45	8.81	7.82	1.32

Figure 6 shows the waveform and magnitude of THDi and the magnitude of the harmonic currents in each harmonic order on the LHE and LED before using the single tuned LC passive filter on the FFT Analysis in the list view.

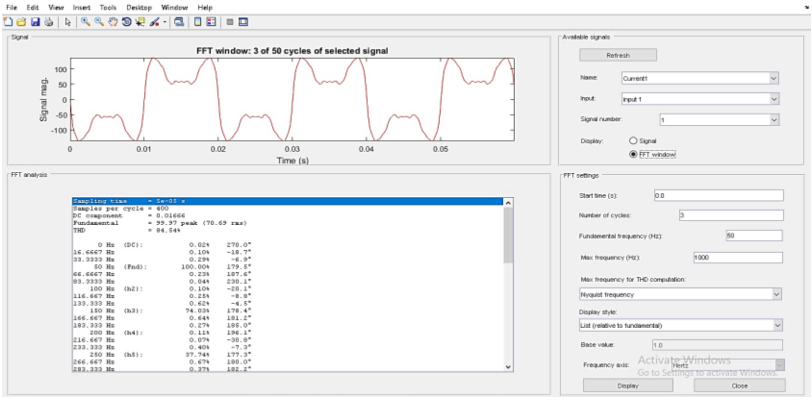

Figure 6. Waveform and magnitude of THDi before using single tuned LC passive filter

Figure 6 shows the amount of THDi before using a single tuned LC passive filter of 84.55%. Based on these data, the current harmonic values obtained in each harmonic order are the order H3 = 74.03%, the order H5 = 37.74%, the order H7 = 8.45%, the order H9 = 8.81%, the order H11 = 7.82% and the order H13 = 1.32% . And the highest current harmonics are in the order H3 = 74.03%.
Table 3 shows the THD of LHE and LED currents after using a single tuned LC passive filter.

Table 3. Total current harmonic distortion after using a single tuned LC passive filter

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Current (A)	4.203	3.103	1.566	0.347	0.378	0.321	0.047
THD (%)	100	37.53	3.85	0.15	0.10	0.00	0.00

Figure 7 shows the waveform and magnitude of THDi and the amount of harmonic currents in each harmonic order on the LHE and LED after using a single tuned LC passive filter.

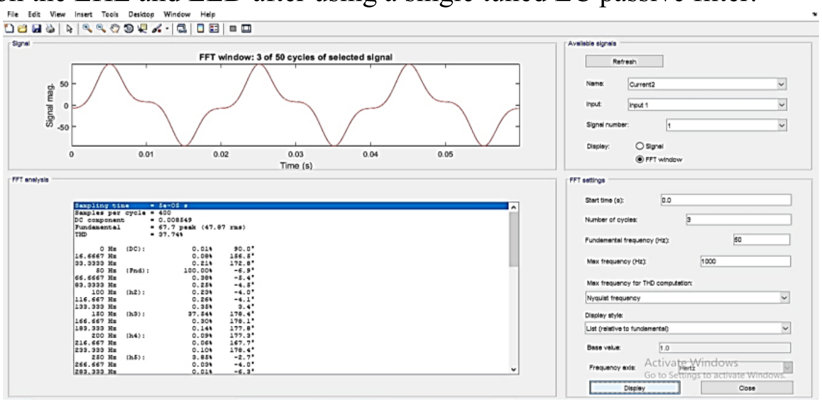

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Figure 7 shows the amount of harmonic currents in each harmonic order and the amount of THDi decreased by 37.77%. There was also a reduction in THDi of 46.78%, and a decrease in the amount of harmonic currents in each harmonic order, namely the order H3 = 37.54%, order H5 = 3.85%, order H7 = 0.15%, order H9 = 0.10%, order H11 = 0% and order H13 = 0%. However, it can be seen that the current harmonics are still high in the H3 order of 37.54%.

4. Conclusion

1. The use of single tuned LC passive filters can reduce harmonics, thereby affecting the THDi of the load being tested in the form of LHE and LED.
2. The use of a single tuned LC passive filter can reduce THDi by 46.78% from the initial THD of 84.55% so that the final THDi becomes 37.77%.
3. The use of single tuned LC passive filer is still not in accordance with IEEE 519-2014 standards in this case for THDi which is still above 5%.

5. References

[1] Putra U. S., Yuwono, S., & Kurniawan, E. (2017). *Implementation and Design Harmonics Filters in Tumblamp (TL) Lighting Systems*. E-Proceeding of Engineering : Vol. 4, No. 3, Hal. 3171-3178.

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Feren Susanto

Simulation of passive filter designs to reduce total harmonic distortion (THD) in energy saving lights (LHE) and light emitting diode (LED)

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Feren Susanto

Committe of The 1st International Conference on Sustainable Architecture and Engineering (ICoSAE)
Faculty of Engineering UKI
Jl. Mayjen Sutoyo No.2 Cawang, Jakarta Timur 13630, Indonesia
021.8092425, 8009190
internationalconferenceicosae1@gmail.com
http://icosae2020.starconf.org

Date : August 24th, 2020

Letter of Acceptance

Dear : Mr./ Mrs. Eva Magdalena S

Congratulations!
We are please to inform you that your abstrct entitled : **"Simulation of passive filter design to reduce total harmonic distortion (THD) in energy-saving lamps (LHE) and light emitting diodes (LED)"** submitted for 1st International on Sustainable Architecture and Engineering (ICoSAE), has been officially approved. Please submit full paper and prepare your 15 minute Oral Presentation.

Good Luck for your Presentation. See you in Webinar 1st International on Sustainable Architecture and Engineering (ICoSAE).

Ulinata, ST.Ars., MT
Chair of 1st ICoSAE, Jakarta

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Antonius D. Tyas Prasetyo

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Webinar Conference, 28 October 2020
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Email: agus.juhana@student.upi.edu

Date: 25 August 2020

Letter of Acceptance for Abstract

Dear Authors: Antonius, Eva Magdalena S, Stepanus, Bambang Widodo, R Purba

We are pleased to inform you that your abstract (ABS-49, Oral Presentation), entitled:

"Improvement of Total Harmonic Distortion (THD) with The Passive Filter Simulation at the Building of Engineering Faculty of The Christian University of Indonesia (FT UKI)"

has been reviewed and accepted to be presented at ICoSAE 2020 conference to be held on 28 October 2020 in Jakarta, Indonesia.

Please submit your full paper and make the payment for registration fee before the deadlines, visit our website for more information.

Thank You.

Best regards,

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We cordially invite you to attend our conference and present your research described in the abstract.

Please submit your full paper and make the payment for registration fee before the deadlines, visit our website for more information.

Thank You.

Best regards,

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ICoSAE 2020 Chairperson

Review Paper

Antonius D. Tyas Prasetyo

Improvement of Total Harmonic Distortion (THD) with The Passive Filter Simulation at the Building of Engineering Faculty of The Christian University of Indonesia (FT UKI)

Antonius[1]*, Eva Magdalena S[2], Stepanus[3], Bambang Widodo[4], R Purba[5]

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Abstract. The electrical equipment technology currently uses a lot of power electronics because it can save electrical energy. The electrical equipment is generally non-linear, which produces non-sinusoidal currents, which experience wave defects, where the wave defect index is expressed as Total Harmonic Distortion (THD). As the THD percentage increases, the greater the risk of damage to the equipment. In the Faculty of Engineering Building, Christian University of Indonesia (the FT UKI building), which consists of three floors, there are many non-linear electrical loads, such as some electric motors, computers, laboratory equipment, and so on. Therefore, it is necessary to take measurements to review the THD in the FT UKI building whether it meets the IEEE 519-2014 standards or not. Calculations and analysis of the measurement results show that THD of current (THDi) on each floor of the FT UKI building has not met the standard. Therefore, it is necessary to simulate a passive filter design to reduce THDi. The simulation results show that there is a reduction in THDi per phase on each floor in the FT UKI Building, and it meets the IEEE 519-2014 standard, which is below 5%.

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Comment [XX3]: Alamat e mail korespondensi harus salah satu dari tim penulis. Kalau yosep prasetyo tdk ada namanya di susunan penulis

Comment [XX4]: Mohon bagian abstrak diperbaiki dengan panduan sbb:
Abtrak harus memuat tujuan penelitian, metode, temuan penting, dan rekomendasi singkat hasil penelitian.

1. Introduction

The electrical equipment technology currently has developed rapidly and uses a lot of power electronics to save electrical energy, for example, such as compact fluorescent lamps (CFL), LED lamps, and so on. In electrical equipment based on power electronics technology, the input current is non-sinusoidal, contains harmonics, and experiences wave defects called non-linear loads[1].

Total harmonic distortion (THD) is the percentage value between the total harmonic components and its fundamental components[2]. THD affects the risk of equipment damage. In the building of the Faculty of Engineering, Christian University of Indonesia, which consists of 3 floors, there are many non-linear electrical loads such as computers, electric motors, and electrical practices equipment such as generators, transformers, and power electronics equipment that can cause harmonic problems.

Study on the elements and levels of harmonics in laboratories and buildings generated by various non-linear loads was carried out by M Radzi, M M Azizan and B Ismail in 2019[3], and a study on the consequences of using non-linear loads in the form of electronic equipment contained in building was carried out by Y Putra in 2016[4]. T Koerniawan and Hasanah conducted a study on efforts to

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emphasize the content of harmonics in the power consumption of buildings in 2019[5], the design of passive filters using the single tuned method to contaminate harmonic currents was carried out by S Meliala in 2017[6] and the study of non load modeling -Linearity using a current source on the MATLAB Simulink has been carried out by R Amalia and R Nazir in 2015[7].
This study aims to improve the total harmonic distortion (THD) in the Engineering Faculty Building of the Christian University of Indonesia through I_{SC}/I_L calculations, so that the dominant harmonic source can be found. Through the dominant harmonic source, the design of the filter created through the simulation, as to reduce THD to meet the IEEE 519-2014 standard.

2. Theoretical basis

2.1. Harmonics
Harmonics of the electrical signal are defined as the content of the signal with an integral multiple of its fundamental frequency (50 Hz), as shown in figure 1.

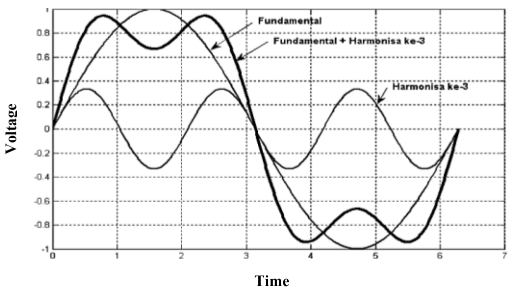

Figure 1. Fundamental voltage waves, 3rd harmonics and their summation results[8]

2.2. Impact of harmonics
Impact of harmonics in the power system can affect system losses, system operation, and system performance. Voltage and current containing harmonic components can cause low power quality which will result in rapid damage to electrical equipment (electronics) due to overheating of the load[9].

2.3. Harmonics standard
The limit of harmonic current and THD at 69.0kV by IEEE are tabulated as in table 1.

Table 1. Odd harmonic current distortion maximum Limit (%)[9][10]

	Harmonic Order (Odd)					
I_{sc}/I_l	$3 \le h < 11$	$11 \le h < 17$	$17 \le h < 23$	$23 \le h < 35$	$35 \le h \le 50$	THD
< 20	4.0	2.0	1.5	0.6	0.3	5.0
20 – 50	7.0	3.5	2.5	1.0	0.5	8.0
50 – 100	10.0	4.5	4.0	1.5	0.7	12.0
100 – 1000	12.0	5.5	5.0	2.0	1.0	15.0
> 1000	15.0	7.0	6.0	2.5	1.4	20.0

In table 1, note that I_{SC}/I_L is the ratio of short circuit current at the point of common coupling (PCC) to the maximum fundamental load current.

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2.4. Harmonic filter

This study uses a passive filter to reduce THD, consisting of a passive LC circuit tuned to a certain harmonic frequency, which is connected in parallel with a non-linear load, as shown in figure 2.

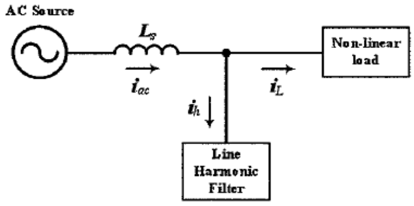

Figure 2. Passive harmonic filter connection in general[11]

3. Parameter measurement

3.1. Measurement data based on the electrical parameters of the FT UKI building

From the measurements on the main panel for 1st, 2nd and 3rd floors in the building of the Faculty of Engineering, Christian University of Indonesia, the data obtained from the measurement results are tabulated in table 2.

Table 2. Measurement results on the main panel of the UKI Engineering Faculty building

Parameter	1st floor			2nd floor			3rd floor		
	Phase			Phase			Phase		
	R	S	T	R	S	T	R	S	T
V rms (V)	238.7	241.7	237.6	238.8	240.5	237	238.4	238.9	235
I rms (A)	65.33	47.1	53.39	48.6	51.91	44.45	29.33	51.07	47.99
THDV (%)	1.1	1.055	0.95	1.037	1.02	0.88	1.166	1.095	0.923
THDI (%)	6.09	6.09	5.445	6.812	5.688	5.839	13.28	7.182	6.077
P (kW)	14.58	10.13	11.27	10.52	11.5	10.13	6.865	11.2	10.96
S (kVA)	15.60	11.38	12.69	11.6	12.48	10.53	6.99	12.2	11.27
Q (kVAR)	5.548	5.187	5.831	4.89	4.852	2.891	1.311	4.826	2.661
PF	0.934	0.889	0.887	0.906	0.92	0.961	0.981	0.917	0.971

Table 2 shows the results of measurements on 1st, 2nd, and 3rd floors by assuming the loads are lit entirely, for the rms voltage (V), current rms (A), THDV%, THDi%, frequency (Hz), active power (kW), power reactive (kVAR), apparent power (VA), and power factor in phases R, S, T.

3.2. Measurement data of the harmonic content in the FT UKI building

Results of the harmonic content measured by a power quality analyzer (PQA) Kyoritsu 6315 include voltage and current harmonics for each phase R, S, T. Based on the data of the harmonic content measured using a power quality analyzer (PQA) Kyoritsu 6315 for each phase R, S, T, assuming the loads are lit entirely before using the filter, on the 1st floor, THD_I phase R = 6.55% and phase S = 7.35 %. The results of the measurement of current harmonics on the 2nd floor, THD_I phase R = 6.89%, phase S = 5.77%, and phase T = 5.86%. The results of the measurement of current harmonics on the 3rd floor, THD_I phase R = 13.72%, phase S = 7.21% and phase T = 6.17%.

The greatest harmonic values are found in the phase S for voltage and in the phase R for current. This can happen because there is an effect of load sharing on each phase. Besides, it can be seen that the measurement of the current harmonic content for each phase R, S, T are more dominant on the 5th-order harmonic. Meanwhile, based on the data in table 5, the current harmonic content for each phase R, S, T are more dominant on the 3rd harmonic order.

3.3. Ratio of the maximum load current (I_L) and the short circuit current (I_{SC})

Referring to the IEEE Standard 519-2014, the % THD_V and % THD_I in the Building of the Faculty of Engineering, Christian University of Indonesia at this time can be known by the I_{SC}/I_L ratio in equation (1) and equation (2)

$$I_{SC} = \frac{1000\ x\ S}{\sqrt{3}V_L} A \tag{1}$$

$$I_L = \frac{P}{PF\sqrt{3}V_L} A \tag{2}$$

From the results of I_{SC}/I_L calculations, based on the IEEE 519-2014, the standards used as the basis for the review are as follows,

ISC/IL	< 20
TDD	= 5.0 %
IHD the h order < 11^{th}	= 4.0 %
IHD the 11^{th} order < h < 17^{th}	= 2.0 %
IHD the 17^{th} order < h < 23^{rd}	= 1.5 %
IHD the 23^{rd} order < h < 35^{th}	= 0.6 %
IHD the 35^{th} order < h	= 0.3 %

3.4. Calculation of the harmonic filter components

Process to determine the harmonic filter component value required for simulations related to the reduction of THD values that do not meet the IEEE 519-2014 standards, as shown in table 3.

Table 3. Recapitulation of result data from the calculation of harmonics filter components

Lantai	Fasa	V	f (Hz)	PF_1	PF_2	P (W)	Φ_1	Φ_2	n	n (5%)	Qc	Xc (Ω)	C (F)	X_L (Ω)	L (H)
	R	238.7	50	0.927	0.9345	14580	22.1044	20.8525	5	4.75	33270.6	1.7126	0.0019	0.3605	0.001
1	S	241.7	50	0.89	0.8905	10130	27.1895	27.0639	5	4.75	7709.55	7.5775	0.0004	1.5953	0.005
	T	237.6	50	0.888	0.8945	11270	27.4392	26.5557	-	-	88137.1	0.6405	0.005	-	-
	R	238.8	50	0.837	0.9064	10520	33.2276	24.9875	5	4.75	41278.3	1.3815	0.0023	0.2908	9E-04
2	S	240.5	50	0.872	0.9208	11500	29.3549	22.9567	5	4.75	4926.94	11.74	0.0003	2.4715	0.008
	T	237	50	0.918	0.9611	10130	23.3501	16.0336	3	2.85	43685.7	1.2858	0.0025	0.4511	0.001
	R	238.4	50	0.979	0.9817	6865	11.7909	10.9781	3 5 11	2.85 4.75 10.5	399852	0.1421	0.0224	0.0499 0.0299 0.0136	2E-04 1E-04 4E-05
3	S	238.9	50	0.78	0.9179	11200	38.7303	23.379	5	4.75	41842.6	1.364	0.0023	0.2872	9E-04
	T	235	50	0.955	0.9713	10960	17.2924	13.7601	3	2.85	828449	0.0667	0.0478	0.0234	7E-05

Table 3 shows each harmonic order that does not meet the standards, and the calculation results for the LC component for designing a passive filter.

4. Analysis

4.1. Analysis of the result data based on the electrical parameters of the FT UKI building

Based on the measurement data tabulated in table 2, it can be observed that the electrical load conditions in the Engineering Faculty building of the Christian University of Indonesia are not balanced. This is indicated by the difference in the value of current and power in each phase. The greatest loads are found on the 1st floor in phase R, where the current in phase R = 63.33 Ampere.

The allowable voltage from the standard voltage of 220 V, which is decrease by 10% and increase by 5% is the exposure limit, which ranges between 198 - 231 V. The voltage measurement results on the main panel of FT UKI Building for phase R, S, T is above the allowable threshold.

4.2. *Analysis of the harmonic filter simulation results*

Based on the data results from the calculation of the LC passive harmonic filter component, a simulation was made on the MATLAB R2016a Simulink which is shown in figure 3 and figure 4.

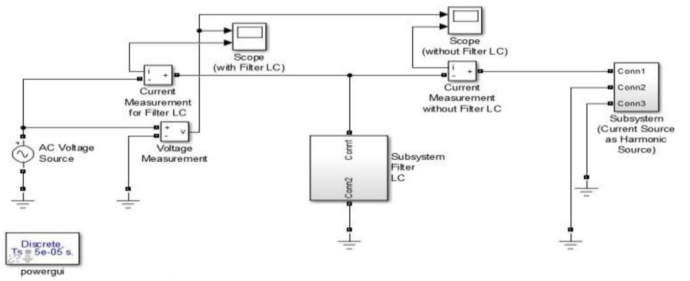

Figure 3. Harmonic Filter Simulation Circuit

Figure 3 shows the circuit of simulated harmonic filters before each phase is integrated. Current harmonic sources are modeled by current sources arranged in the "Subsystem" block, while the filters are arranged in the "LC Subsystem Filter" block which is installed parallel to the current harmonic source.

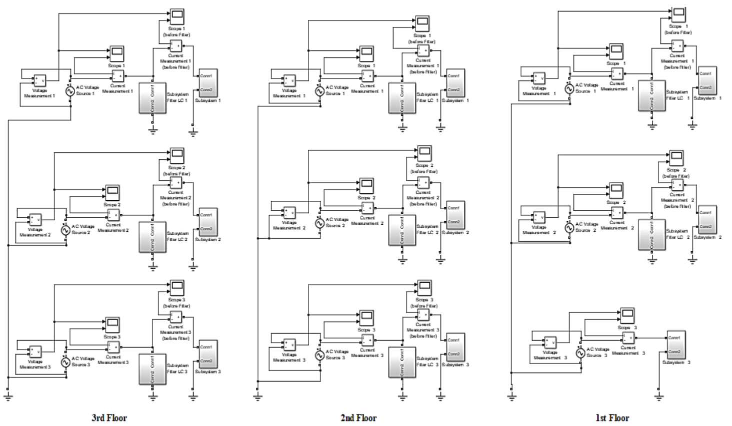

Figure 4. Integrated Harmonics Filter Simulation for Each Phase at FT UKI Building

Figure 4 shows the circuit of simulations at the UKI Engineering Faculty Building for each floor. The circuit simulation is based on the data obtained in the previous calculations.
The THD_I measurement results after using the harmonic filter on the st floor at the phase R = 3.80%, while the THD_I value of the phase S = 8.57%. On the 2nd floor, the THD_I value of the phase R = 3.46%, while the THD_I value of the phase S = 6.76%, and the THD_I value of the phase T = 1.53%. On the 3rd floor, the THD_I value of the phase R = 0.69%, the THD_I value of the phase S = 4.05%, and the THD_I value of the phase T = 0.68%.

5. Conclusion

Based on the result from the measured data and simulations that have been carried out on the main panel of the FT UKI building, it can be concluded overall that the simulation results shows not all current THD values can be reduced, but the average current THD value for each phase has decreased and these results meet the standard of IEEE 519-2014, which is below 5%.

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Final Paper

Antonius D. Tyas Prasetyo

Reducing of total harmonic distortion by simulating passive filters to suppress harmonic currents with the case: faculty of engineering building, Universitas Kristen Indonesia Jakarta

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Abstract. Today's electrical appliances use power electronics to save electricity. However, this equipment generates non-sinusoidal current, causing wave defect, expressed as total harmonic distortion (THD). As the %THD increases, the greater risk of equipment damage. For this reason, the research was carried out in the Faculty of Engineering Building, Universitas Kristen Indonesia Jakarta (FT UKI Jakarta) where there are many load combinations such as computers, various types of lights, laboratory equipment such as transformers, electric motors and so on. The research was conducted using quantitative method. Data collection is carried out directly in the main panel. Based on the measurement results, the calculation of the maximum load current (I_L) and short circuit (I_{SC}) is carried out. Through these values, it can be seen that whether the odd dominant harmonic values and orders meets the IEEE 519-2014 standards or not. Calculations and analysis of the measurement results have shown that the $\%THD_I$ in the FT UKI building has not meet the standard. Therefore, it is necessary to simulate the filter design to reduce the $\%THD_I$, so that the results can meets the IEEE 519-2014 standard, which is below 5%.

1. Introduction

The electrical equipment technology currently has developed rapidly and uses a lot of power electronics to save energy, for example, such as compact fluorescent lamps (CFL), light emitting diode (LED) lamps, and so on. In electrical equipment based on power electronics technology, the input current is non-sinusoidal, contains harmonics, and experiences wave defects called non-linear loads [1].

THD is the percentage value between the total harmonic components and its fundamental components [2]. THD affects the risk of equipment damage [3]. In the FT UKI Building, which consists of 3 floors, there are many non-linear electrical loads such as computers, electric motors, and electrical practices equipment such as generators, and power electronics equipment that can cause harmonic problems.

Study on the elements and levels of harmonics in laboratories and buildings generated by various non-linear loads was carried out by [4], and a study on the consequences of using non-linear loads in the form of electronic equipment contained in building was carried out by [5]. [6] conducted a study on efforts to emphasize the content of harmonics in the power consumption of buildings, the design of passive filters using the single tuned method to contaminate harmonic currents was carried out by [7] and the study of non-linear loads modeling using a current source methods on the MATLAB Simulink has been carried out by [8].

Many previous studies have been carried out to analyze THD in buildings using the direct measurement method using a power quality analyzer (PQA) measuring instrument, as has been done by [4] [5] [6] [9]. [5] stated that the results of measurement and analysis of the effect of non-linear loads on measurements at the Computer Center Building of Universitas Riau indicate a large $\%THD_I$. Similar research by [9] states that due to non-linear loads causes $\%THD_I$ to exceed the limit of IEEE 519 Standard. [10] also said that through the study of current and voltage harmonics at the campus of Politeknik Enjinering Indorama, that the conditions of the harmonic content are above the IEEE 519 Standard. Research by [4] in 2019 stated that through an observational case study in laboratory and office buildings, it was found that the THD level exceeds the maximum limit set by the standard. However, the studies above have not designed and made harmonic filters to reduce %THD levels that exceed the IEEE 519 Standard.

[8] has developed a comparative study on 3-phase non-linear load modeling on Simulink MATLAB for laboratory testing (3-phase non-linear load) using simulation modeling methodology with harmonic current source method using harmonic current data (with each current source representing one harmonic order), where this research is needed to representing the real harmonic source (non-linear load) into the simulation which will be used to create a harmonic filter simulation design.

In [6], through the study of harmonics on the use of electricity in the Building of STT PLN Jakarta, the calculation of component values was carried out to design a harmonic filter. However, in this research, the filter design is only limited to calculating the value of the components, there are no test results from the implementation of the filter in the system, either through simulation or in direct installation and testing. The calculation of the value of the harmonic filter component only suppress the 3^{rd} harmonic order content.

Based on the references and also the explanation above, it has explained that the application of non-linear loads on a building, especially in buildings that are used for office activities or as an electrical laboratory, have an impact on the amount of %THD value on the building's electrical system. Therefore, it is necessary to make a harmonic filter design to reduce the %THD value so that the possible impact of harmonic distortion on the electrical system (such as equipment damage) can be overcome or minimized.

This study aims to improve THD in the FT UKI Building through I_{SC}/I_L calculations, so that the dominant harmonic source can be found. Through the dominant harmonic source, the design of the filter created through the simulation, as to reduce THD to meet the IEEE 519-2014 standard.

2. Methods

In this study, quantitative research methodology is used, which is a method for collecting data in numerical and statistical forms, by measuring THD at the FT UKI Building. After going through the data collection process, then data processing is carried out based on the measurement data on the main panel of the FT UKI Building. The data used are the measurement results of voltage and current harmonics on the main panel using the average value for each phase. From this data, it is processed in the form of a bar chart and tabulation, so that the value and order of the voltage and current harmonics per phase can be found for each floor. Based on the data from the measurement results for each phase, calculations are carried out regarding the maximum load current (I_L) and short circuit current (I_{SC}). Through the I_{SC} / I_L value, it can be seen whether the harmonic value (for odd orders) in the FT UKI Building meets the IEEE Standard 519-2014 [11], and it can also be seen the value and order of the dominant harmonics that do not meet the criteria of the IEEE Standard 519-2014. After going through the calculation, passive harmonic filters are designed to reduce the THD [12] based on the dominant harmonic order which does not meet the criteria of IEEE 519-2014 Standard, through simulation. Then, the research results are processed and analyzed to obtain conclusions, which will clarify the picture of the object under study.

3. Results and discussions

3.1. Measurement data based on the electrical parameters of the FT UKI Building

From the measurements on the main panel for 1st, 2nd and 3rd floors in the FT UKI Building, the data obtained from the measurement results are tabulated in table 1.

Table 1. Measurement results on the main panel of the FT UKI building

Parameter	1st floor			2nd floor			3rd floor		
	Phase			Phase			Phase		
	R	S	T	R	S	T	R	S	T
V rms (V)	238.7	241.7	237.6	238.8	240.5	237	238.4	238.9	235
I rms (A)	65.33	47.1	53.39	48.6	51.91	44.45	29.33	51.07	47.99
THD_V (%)	1.1	1.055	0.95	1.037	1.02	0.88	1.166	1.095	0.923
THD_I (%)	6.09	6.09	5.445	6.812	5.688	5.839	13.28	7.182	6.077
P (kW)	14.58	10.13	11.27	10.52	11.5	10.13	6.865	11.2	10.96
S (kVA)	15.60	11.38	12.69	11.6	12.48	10.53	6.99	12.2	11.27
Q (kVAR)	5.548	5.187	5.831	4.89	4.852	2.891	1.311	4.826	2.661
PF	0.934	0.889	0.887	0.906	0.92	0.961	0.981	0.917	0.971

Table 1 shows the results of measurements on 1st, 2nd, and 3rd floors by assuming all electrical loads are turned on, for the rms voltage (V), rms current (A), THD_V%, THD_I%, frequency (Hz), active power (kW), reactive power (kVAR), apparent power (VA) and power factor in phases R, S, T.

3.2. Measurement data of the harmonic content in the FT UKI building

Results of the harmonic content measured by a power quality analyzer (PQA) Kyoritsu 6315 include voltage and current harmonics for each phase R, S, T. Based on the data of the harmonic content measured using PQA Kyoritsu 6315 for each phase R, S, T, assuming that all electrical loads are turned on before using the filter, on the 1st floor, THD_I phase R = 6.55% and phase S = 7.35%. The results of the measurement of current harmonics on the 2nd floor, THD_I phase R = 6.89%, phase S = 5.77%, and phase T = 5.86%. The results of the measurement of current harmonics on the 3rd floor, THD_I phase R = 13.72%, phase S = 7.21% and phase T = 6.17%.

The greatest harmonic values are found in the phase S for voltage and in the phase R for current. This can happen because there is an effect of load on each phase.

3.3. Ratio of the maximum load current (I_L) and the short circuit current (I_{SC})

Referring to the IEEE Standard 519-2014, the % THD_V and % THD_I in the FT UKI Building at this time can be known by the I_{SC}/I_L ratio in equation (1) and equation (2)

$$I_{SC} = \frac{1000\, x\, S}{\sqrt{3}V_L} A \quad (1)$$

$$I_L = \frac{P}{PF\sqrt{3}V_L} A \quad (2)$$

From the results of I_{SC}/I_L calculations, based on the IEEE 519-2014, the standards used as the basis for the review are as follows,

I_{SC}/I_L	< 20
TDD	= 5.0 %
IHD the h order < 11th	= 4.0 %
IHD the 11th order < h < 17th	= 2.0 %
IHD the 17th order < h < 23rd	= 1.5 %

IHD the 23rd order < h < 35th = 0.6 %
IHD the 35th order < h = 0.3 %

3.4. Calculation of the harmonic filter components

In order to reduce the $\%THD_I$ value, the author has chosen an LC passive harmonic filter referring to [12]. The following criteria are used to determine the harmonic filter component value required for simulations, related to the reduction of THD values that do not meet the IEEE 519-2014 standards, as shown in table 2.

Table 2. Recapitulation of results data from the calculation of harmonics filter components

Floor	Phase	V	f (Hz)	PF_1	PF_2	P (W)	Φ_1	Φ_2	n	n (5%)	Qc	Xc (Ω)	C (F)	X_L (Ω)	L (H)
	R	238.7	50	0.927	0.9345	14580	22.1044	20.8525	5	4.75	33270.6	1.7126	0.0019	0.3605	0.001
1st	S	241.7	50	0.89	0.8905	10130	27.1895	27.0639	5	4.75	7709.55	7.5775	0.0004	1.5953	0.005
	T	237.6	50	0.888	0.8945	11270	27.4392	26.5557	-	-	88137.1	0.6405	0.005	-	-
	R	238.8	50	0.837	0.9064	10520	33.2276	24.9875	5	4.75	41278.3	1.3815	0.0023	0.2908	9E-04
2nd	S	240.5	50	0.872	0.9208	11500	29.3549	22.9567	5	4.75	4926.94	11.74	0.0003	2.4715	0.008
	T	237	50	0.918	0.9611	10130	23.3501	16.0336	3	2.85	43685.7	1.2858	0.0025	0.4511	0.001
	R	238.4	50	0.979	0.9817	6865	11.7909	10.9781	3 5 11	2.85 4.75 10.5	399852	0.1421	0.0224	0.0499 0.0299 0.0136	2E-04 1E-04 4E-05
3rd	S	238.9	50	0.78	0.9179	11200	38.7303	23.379	5	4.75	41842.6	1.364	0.0023	0.2872	9E-04
	T	235	50	0.955	0.9713	10960	17.2924	13.7601	3	2.85	828449	0.0667	0.0478	0.0234	7E-05

Table 2 shows each harmonic order that does not meet the standards, and the calculation results for the LC component for designing a passive filter.

3.5. Analysis of the result data based on the electrical parameters of the FT UKI building

Based on the measurement data tabulated in table 1, it can be observed that the electrical load conditions in the FT UKI Building are not balanced. This is indicated by the difference in the value of current and power in each phase. The greatest loads are found on the 1st floor in phase R, where the current in phase R = 63.33 Ampere.

The allowable voltage from the voltage standard of 220 V, which is decrease by 10% and increase by 5% is the exposure limit, which ranges between 198 - 231 V. The voltage measurement results on the main panel of FT UKI Building for phase R, S, T is above the allowable threshold.

3.6. *Analysis of the harmonic filter simulation results*

Based on the data results from the calculation of the LC passive harmonic filter component, a simulation was made on the MATLAB Simulink which is shown in figure 1 and figure 2.

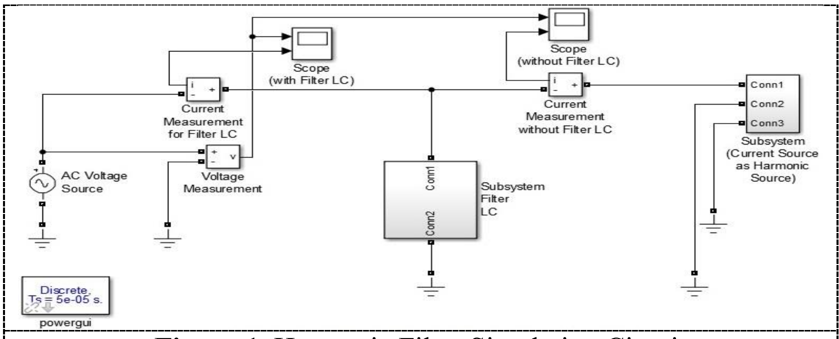

Figure 1. Harmonic Filter Simulation Circuit

Figure 1 shows the circuit of simulated harmonic filters before each phase is integrated. Current harmonic sources are modeled by current sources arranged in the "Subsystem" block. The filters are arranged in the "LC Subsystem Filter" block, which is installed parallel to the current harmonic source.

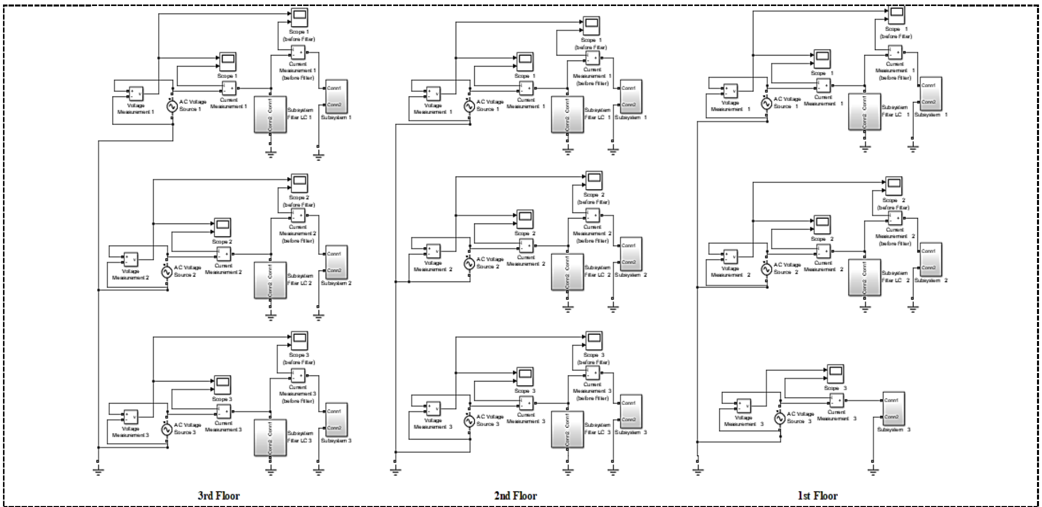

Figure 2. Integrated Harmonics Filter Simulation for Each Phase at FT UKI Building

Figure 2 shows the circuit of simulations at the FT UKI Building for each floor. The circuit simulation is based on the data obtained in the previous calculations.

The THD_I measurement results after using the harmonic filter on the 1st floor at the phase R = 3.80%, while the THD_I value of the phase S = 8.57%. On the 2nd floor, the THD_I value of the phase R = 3.46%, while the THD_I value of the phase S = 6.76%, and the THD_I value of the phase T = 1.53%. On the 3rd floor, the THD_I value of the phase R = 0.69%, the THD_I value of the phase S = 4.05%, and the THD_I value of the phase T = 0.68%.

4. Conclusion

Based on the result from the measured data and simulations that have been carried out on the main panel of the FT UKI building, it can be concluded overall that the simulation results shows not all current THD values can be reduced, but the average current THD value for each phase has decreased and these results meet the standard of IEEE 519-2014, which is below 5%.

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Hasil Uji Plagiarisme Turnitin

Antonius D. Tyas Prasetyo

Reducing of total harmonic distortion by simulating passive filters to suppress harmonic currents with the case: faculty of engineering building, Universitas Kristen Indonesia Jakarta

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LoA for Oral Presentation

Antonius D. Tyas Prasetyo

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Jl. Mayjen Sutoyo No.2 Cawang, Jakarta Timur 13630, Indonesia
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http://icosae2020.starconf.org

Date : September 02th, 2020

Letter of Acceptance

Dear : Mr./Mrs. Eva Magdalena S

Congratulations!
We are please to inform you that your abstract entitled : "**Improvement of Total Harmonic Distortion (THD) with The Passive Filter Simulation at the Building of Engineering Faculty of The Christian University of Indonesia (FT UKI)**" submitted for 1st International on Sustainable Architecture and Engineering (ICoSAE), has been officially approved. Please submit full paper and prepare your 15 minute Oral Presentation.

Good Luck for your Presentation. See you in Webinar 1st International on Sustainable Architecture and Engineering (ICoSAE).

Ulinata, ST.Ars., MT
Chair of 1st ICoSAE, Jakarta

ICoSAE 2020 – Letter of Acceptance (LoA)

Dery Elfando

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Email: agus.juhana@student.upi.edu

Date: 2 September 2020

Letter of Acceptance for Abstract

Dear Authors: Dery Elfando, Stepanus, Eva M Silalahi, Bambang Widodo, Robinson Purba

We are pleased to inform you that your abstract (ABS-51, Oral Presentation), entitled:

"Improvements of Total Harmonic Distortion (THD) with Passive Filter Simulation at the General Hospital of the Christian University of Indonesia (RSU UKI)"

has been reviewed and accepted to be presented at ICoSAE 2020 conference to be held on 28 October 2020 in Jakarta, Indonesia.

Please submit your full paper and make the payment for registration fee before the deadlines, visit our website for more information.

Thank You.

Best regards,

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ICoSAE 2020 Chairperson

ICoSAE 2020 – Letter of Invitation (LoI)

Dery Elfando

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Website: http://icosae2020.starconf.org
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Letter of Invitation

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We cordially invite you to attend our conference and present your research described in the abstract.

Please submit your full paper and make the payment for registration fee before the deadlines, visit our website for more information.

Thank You.

Best regards,

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ICoSAE 2020 Chairperson

Review Paper

Dery Elfando

Improvements of Total Harmonic Distortion (THD) with Passive Filter Simulation at the General Hospital of the Christian University of Indonesia (RSU UKI)

Comment [B41]: Tidak perlu disebutkan research site nya.

Dery Elfando[1*], Stepanus[2], Eva M Silalahi[3], Bambang Widodo[4], Robinson Purba[5]

[1]Students of the Electrical Engineering Study Program, Faculty of Engineering, Christian University of Indonesia (UKI),

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Abstract. With the increasing need for and use of electrical energy amid rapid technological advances, especially in the use of electronic equipment, especially in hospitals, it is necessary to pay attention to the problem of harmonics due to the use of non-linear electrical equipment. Therefore, it is necessary to measure the current and voltage THD for each non-linear equipment user. If the current and voltage THD values do not meet the standards, then a filter design is carried out so that the THD values meet the standards. Based on the results of THD measurements on the Main Distribution Panel (MDP) of UKI Hospital, it was found that the THD of the voltage varied between 0.7877% - 2.4363% and the current THD varied between 5.3073% - 9.2363%. The THD value of the measured voltage meets the IEEE 519-2014 standard. The THD value of the measured current exceeds the IEEE 519-2014 standard so it needs a harmonic filter. With a single tuned filter simulation design, the current THD has decreased, so that it meets the standard. The THD value of the current after installing the filter at the three MDPs of the UKI Hospital, namely MDP A of 1.72%, MDP B of 0.64% and MDP C of 1.30%.

1. Introduction

Comment [B42]: Bagian introduction belum memaparkan latar belakang yang jelas, beserta gap penelitian yang akan dilakukan. Berikan signifikansi dari penelitian yang dilakukan.

Seeing the increasing use of electrical energy today, it is important to pay attention to the power quality of the electrical equipment used and to know the Total Harmonic Distortion (THD). Poor electrical power quality is where there is a problem / deviation of current, voltage and frequency that results in failure of the electrical equipment used. Hospitals require electrical energy for the use of medical devices where most of the equipment is non-linear, such as: X-rays, computerized tomography, diagnostic equipment, and other medical devices. Non-linear electrical equipment is a source of harmonics, which has an impact on the quality of electrical power in hospitals[2].

In a scientific paper written by I Made Suartika with the title "***Analysis of THD Countermeasures with Passive Filters in an Electric Power System (2016)***"[3] explains the research conducted at Sanglah Hospital Denpasar, Bali, namely by grouping non-linear loads in each each room in the MLTP (Main Low Terminal Panel) and each MDP (Main Distribution Panel), calculates the total active power capacity (watts) of non-linear loads in each room and analyzes the THD, both current

Comment [B43]: Pengutipan sumber kurang tepat. Tidak disebutkan judulnya. Lihat template paper untuk pengutipan referensi yang tepat.

THD and voltage THD using the device MATLAB Simulink software. The harmonic standard used is IEEE 519-1992.

After seeing and reviewing the published studies, the authors made a study at the General Hospital of the Christian University of Indonesia (RSU UKI) by measuring THD using a Power Quality Analyzer (PQA) measuring instrument and analyzing the quality of electrical power by comparing the measurement results to the IEEE standard. 519-2014. The results of the THD for voltages and currents that do not meet the standards will be simulated using the MATLAB application to reduce the THD, so that the quality of electrical power at the UKI Hospital is in good condition.

2. Theoretical Basis

2.1 Electrical Power Quality

The quality of electric power is determined by the quality of the current, voltage, frequency, harmonics, power losses, power factor and grounding (grounding), and the balance of the system. The quality of electric power can be said to be good if the current, voltage, and frequency found in a place or sector are in constant condition.

2.2 Harmonics

Harmonics are a symptom of the formation of waves with different frequencies which are the multiplication of an integer with their basic frequency. The basic frequency of the electric power system in Indonesia is 50 Hz, so the harmonics have a frequency with a value of multiples of 50 Hz. Figure 1 shows a harmonic distortion waveform with a basic frequency of 60 Hz.

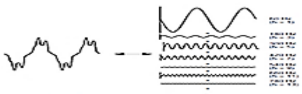

Figure 1. Harmonic waveforms with a base frequency of 60Hz[5].

2.3 Linear and Non Linear Load

Linear load is a load whose current component is proportional to the voltage. Non-linear load is a component whose current is not proportional to the voltage component.

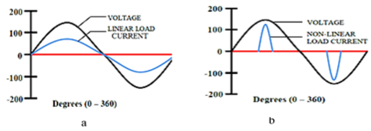

Figure 2. Current and voltage waveforms at (a). linear load, and (b). non-linear loads[5].

2.4 Total Harmonic Distortion (THD)

THD is the ratio between the rms value of all harmonic components to the rms value of the fundamental, THD is usually expressed in terms of percent (% THD)[1]. THD is expressed in equation [1]:

$$\text{THD} = \frac{\sqrt{\sum_{h>1}^{hmax} M_h^2}}{M_1} \quad (1)$$

M_h is the rms value of the harmonic order component and M_1 is the rms value of the fundamental component. $\%V_{THD}$ is the percentage of the total amount of voltage distorted by the harmonics and $\%I_{THD}$ is the percentage of the total amount of current distorted by the harmonics.

The rms value itself can be obtained if the rms value of the first harmonic component and the THD value is known by equation [2]:

$$\text{rms} = \sqrt{\sum_{h=1}^{h=max} M^2\, h} = M_1\sqrt{1+THD^2} \quad (2)$$

2.5 IEEE 519-2014 voltage THD standard

The THD standard for voltage based on the IEEE 519-2014 standard regarding the maximum limit value of voltage harmonic distortion in the electrical system can be seen in Table 1.

Table 1. Voltage Distortion Limits.

Bus Voltage (V) at PCC	Individual Harmonic (%)	Total Harmonic Distortion (%)
V ≤ 1 kV	5.0	8.0

1 kV < V < 69 kV	3.0	5.0
69 kV < V < 161 kV	1.5	2.5
161 kV < V	1.0	1.5

2.6 IEEE 519-2014 current THD standard

The current THD limit is recommended for customers connected to systems where the voltage ranges from 120 V to 169 kV according to the short circuit ratio. Short Circuit Ratio can be calculated by:

$$\textit{Short Circuit Ratio} = \frac{I_{sc}}{I_L} \tag{3}$$

I_{sc} is a short circuit current which can be determined by equation [4]:

$$I_{SC} = \frac{1000 \ x \ MVA}{\sqrt{3}kV} \tag{4}$$

I_L is the full load current which can be determined by equation [5]:

$$I_L = \frac{P}{PF\sqrt{3}kV} A \tag{5}$$

The real power and line voltage represent the three-phase short circuit capacity in MegaVoltAmpere and KiloVolts.

Tabel 2. *Current Distortion Limits for Systems Rated 120 V through 69 kV.*

Maximum Harmonic Current Distortion (MHCD)						
Individual Harmonic Order (IHD)						
I_{sc}/I_L	3 ≤ h ≤ 11	11 ≤ h ≤ 17	17 ≤ h ≤ 23	23 ≤ h ≤ 35	35 ≤ h ≤ 50	THD (%)
< 20[c]	4.0	2.0	1.5	0.6	0.3	5.0
20 < 50	7.0	3.5	2.5	1.0	0.5	8.0
50 < 100	10.0	4.5	4.0	1.5	0.7	12.0
100 < 1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0

2.7 Passive Filter

Harmonic filters are used to reduce the THD of non-compliant voltages and currents, improve the power factor and reduce the frequency amplitude of harmonic voltages and currents.

Passive filters have resistance (R), inductance (L) and capacitance (C) elements configured and installed to control harmonics. Passive filters are widely used to compensate for reactive power losses due to harmonics in the installation system.

The single tuned filter is arranged with the RLC series circuit. The reactor of the Single Tuned Filter can be expressed by equation [6][6]:

$$X_{filter} = \frac{V^2}{Q_c} \tag{6}$$

Determining the compensated reactive power requires calculating the initial power factor (pf_0) and the final power factor (pf_1) averages.

$$Q_C = P \ (\tan \theta_{initial} - \tan \theta_{final}) \tag{7}$$

Find the quantity of capacitive reactance with equation [8]:

$$X_C = \frac{X_{filter} \ h^2}{h^2 - 1} \tag{8}$$

Calculation of the required capacitor and inductor ratings can be found with equations [9] to [11]:

$$C = \frac{1}{2\pi f \ X_C} \tag{9}$$

$$X_L = \frac{X_C}{h^2} \tag{10}$$

$$L = \frac{X_L}{2\pi f} \tag{11}$$

Figure 3 shows a single tuned filter consisting of inductor and capacitor components connected in series.

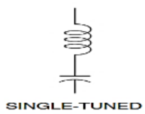

Figure 3. Single Tuned Filter[5].

3. Research Methodology

In this research, the method used is quantitative method. In the process of collecting quantitative data in this study, it can be seen from direct measurement using a Power Quality Analyzer (PQA) measuring instrument. The results of the data obtained through direct measurements at the UKI Hospital will be analyzed and data processing will be carried out, to be able to see the quality of the electric power in good condition and meet the IEEE-519-2014 Standard or not meet standards. The THD of voltage or current that does not meet the standards will be simulated using a passive filter using the MATLAB application to reduce the THD, so that the quality of the electrical power meets the predetermined standards.

Comment [B44]: Bagaimana data didapat? Kapan data didapat? Dan apa yang dianalisis juga harus jelas.

4. Measurement and Analysis Results

The electricity system at RSU UKI is supplied from the PLN network and 2 generators, each of which has a capacity of 200KVA in the new building and a capacity of 250 KVA in the old building of the UKI Hospital. There are two transformers that supply loads to the three MDPs with their respective capacities being MDP A (197 kVA), MDP B (197 kVA) and MDP C (329 kVA). From each MDP, electrical power is then channeled to ± 19 Sub Distribution Panel (SDP) RSU UKI.

4.1 THD Voltage according to IEEE 519-2014 Standard

The maximum limit of the voltage harmonic standard (THDv) based on IEEE 519-2014 can be seen in Table 1 and to determine the maximum limit of THD voltage seen from the secondary side of the transformer (PCC) that supplies loads on MDP of 400 V, so that the IEEE 519 Standard table- 2014 which is used is $V \leq 1kV$ with a maximum limit of 8% THD voltage.

Table 3. THDv Measurement Results with IEEE 519-2014 Standards.

MDP	Phase	THD Voltage (THDv)	IEEE Standard 519-2014	Remarks
MDP A	R	1,3170	8%	comply with standards
	S	1,0870	8%	comply with standards
	T	0,7872	8%	comply with standards
MDP B	R	2,4263	8%	comply with standards
	S	1,9336	8%	comply with standards
	T	2,1596	8%	comply with standards
MDP C	R	1,0816	8%	comply with standards
	S	1,1973	8%	comply with standards
	T	0.9078	8%	comply with standards

Table 4. THDv Measurement Results with IEEE 519-2014 Standards.

MDP	Phase	THD Voltage (THDv)	IEEE Standard 519-2014	Remarks
MDP A	R	1,2676	8%	comply with standards
	S	0,8193	8%	comply with standards
	T	0,7013	8%	comply with standards
MDP B	R	1,6733	8%	comply with standards
	S	0,9341	8%	comply with standards
	T	1,3360	8%	comply with standards
MDP C	R	1,0157	8%	comply with standards
	S	0,8791	8%	comply with standards
	T	0,8178	8%	comply with standards

Tables 3 and 4 show the results of the comparison of the THD voltage with the IEEE 519-2014 Standard. The results of the THD measurement for each MDP and its phase meet the standard or the THD value does not exceed the standard used.

4.2 THD Current is based on IEEE 519-2014 Standard

The IEEE 519-2014 standard for current THD requires calculating the value of Short Circuit Ratio (SC_{ratio}) to determine the maximum current THD limit, by knowing the I_{SC}/I_L value first.
The results of THD measurements for each MDP exceed the maximum limit of 5%.

Table 5. THDi Measurement Results with IEEE 519-2014 Standards.

MDP	Phase	THD Current (THDi)	IEEE Standard 519-2014	Remarks
MDP A	R	7.0410	5%	not comply with the Standards
	S	6.3626	5%	not comply with the Standards
	T	5.9493	5%	not comply with the Standards
MDP B	R	8.5473	5%	not comply with the Standards
	S	5.3696	5%	not comply with the Standards

	T	8.3796	5%	not comply with the Standards
MDP C	R	6.3580	5%	not comply with the Standards
	S	7.1083	5%	not comply with the Standards
	T	5.3073	5%	not comply with the Standards

Table 6. THDi Measurement Results with IEEE 519-2014 Standards.

MDP	Phase	THD Current (THDi)	IEEE Standard 519-2014	Remarks
MDP A	R	7.3796	5%	not comply with the Standards
	S	7.0013	5%	not comply with the Standards
	T	6.8423	5%	not comply with the Standards
MDP B	R	7.7847	5%	not comply with the Standards
	S	6.8327	5%	not comply with the Standards
	T	8.7347	5%	not comply with the Standards
MDP C	R	8.3373	5%	not comply with the Standards
	S	9.2363	5%	not comply with the Standards
	T	7.4943	5%	not comply with the Standards

Tables 5 and 6 show the results of the comparison of the current THD standard with the maximum limit set by IEEE 519-2014, which is 5%, indicating that the current THD in the three MDP UKI RSU exceeds the standard limit, then it is necessary to make a filter simulation using the MATLAB application.

4.3 Filter Simulation Results

Figure 4 shows a single tuned passive filter simulation on MDP A, there is a harmonic source from the 3rd to 13th order. The passive filter circuits used are L and C. This simulation image is also applied to other MDPs, only different values of the filter component are calculated.

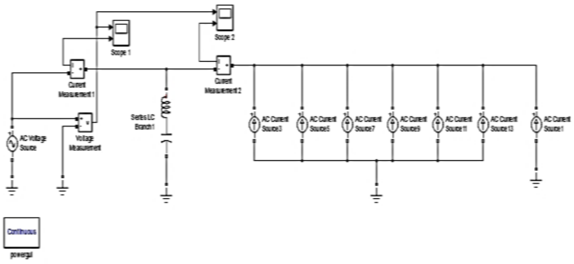

Figure 4. Single Tuned Filter Simulation.

4.4 THD Current Measurement and Simulation to IEEE 519-2014 Standard

The results of installing a single tuned filter show a decrease in the THD of the current on each MDP, so that the simulation results will be compared with the IEEE 519-2014 standard to show that the current THD has met the standards or has not met the set standards.

Table 7 shows the THD of the measurement current that has been averaged and the THD of the simulation result before installing the filter has a difference that is not too far away, namely around 0.77% -1.54%, but still passes the predetermined standard.

Table 7. Current THD analysis based on IEEE 519-2014 Standard.

MDP	THD Current		IEEE 519-2014 Standard	Remarks
	Measurement (%)	Simulation (%)		
MDP A	6,76%	5,99%	5%	not comply with the Standards
MDP B	7,608%	6,66%	5%	not comply with the Standards
MDP C	7,35%	5,81%	5%	not comply with the Standards

Table 8 shows the current THD after being simulated with a single tuned filter at each MDP of the UKI Hospital. The simulation results are compared with the IEEE 519-2014 standard and show that the current THD has decreased and has met the standard.

Table 8. Analysis of current after filter installation according to IEEE 519-2014 standard.

MDP	THD Current of Filter Simulation Results		IEEE 519-2014 Standard	Remarks (After Filter)
	Before (%)	After (%)		

MDP A	5,99%	1,72%	5%	comply with standards
MDP B	6,66%	0,64%	5%	comply with standards
MDP C	5,81%	1,30%	5%	comply with standards

5. Conclusion

1. The results of the THD analysis of the voltage at three MDPs at the UKI Hospital meet the standards set in IEEE 519-2014 with a maximum THD limit of 8% for voltages below 1kV, while the current THD does not meet IEEE 519-2014 standards with a maximum limit of 5% THD for calculations SC_{ratio} below 20. The THD Voltage results varied between 0.701% - 2.42% and the current THD was between 5.3% - 9.2%.
2. Current THD that does not meet IEEE 519-2014 standards is made filter simulation to reduce THD so that it meets predetermined standards. The filter simulation design uses a single tuned filter on three MDPs whose THD currents do not meet the standard. The filter simulation results obtained that the THD of current in each MDP, namely: MDP A of 1.72%, MDP B of 0.64% and MDP C of 1.30% at MDP UKI Hospital have met the standards.

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Final Paper

Dery Elfando

Reducing of total harmonic distortion using passive filter simulation to suppress harmonic currents with the case: General Hospital, Universitas Kristen Indonesia Jakarta

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Abstract. With the increasing need for and use of electrical energy amid increasingly rapid technological advances, especially in the use of electronic equipment in hospitals, it is necessary to pay attention to the problem of harmonics due to the use of non-linear electrical equipment. Therefore, it is necessary to measure the current and voltage THD for each non-linear equipment user. If the current and voltage THD values do not meet the standards, then a filter design is carried out so that the THD values meet the standards. Based on the results of THD measurements on the Main Distribution Panel (MDP) of RSU UKI, it was found that the THD of the voltage varied between 0.7877% - 2.4363% and the current THD varied between 5.3073% - 9.2363%. The measured THD value refers to the IEEE 519-2014 standard. If the THD value of the measurement results exceeds the IEEE 519-2014 standard, a harmonic filter is needed. With the simulated single tuned filter design, the current THD decreases within the standard value. The THD value of the current after installing the filter at the three MDP's of the RSU UKI, namely MDP A of 1.72%, MDP B of 0.64% and MDP C of 1.30%.

1. Introduction

Seeing the increasing use of electrical energy today, it is important to pay attention to the power quality of the electrical equipment used and to know the Total Harmonic Distortion (THD). Poor electrical power quality is where there is a problem/deviation of current, voltage or frequency that results in failure of the electrical equipment used. One aspect of the reduction in the quality of electric power is a reduction in energy efficiency, so it can be said that the quality of electric power is one of the parameters that need to be considered in the management of electrical energy in a sector[1]. Hospitals also require a large amount of electrical energy in the use of medical devices where the loads used usually consist of linear loads and non-linear loads. Some medical equipment may fail due to poor power quality and improper electrical installation. In a scientific paper written by I Made Suartika[3] explains the research conducted at Sanglah Hospital Denpasar, Bali, namely by grouping non-linear loads in each each room in the MLTP (Main Low Terminal Panel) and each MDP (Main Distribution Panel), calculates the total active power capacity (watts) of non-linear loads in each room and analyzes the THD, both current THD and voltage THD using the device MATLAB Simulink software. The harmonic standard used is IEEE 519-1992.

After seeing and reviewing the published studies, the authors made a study at the General Hospital, Universitas Kristen Indonesia (RSU UKI) by measuring THD using a Power Quality Analyzer (PQA) measuring instrument and analyzing the quality of electrical power by comparing the measurement results to the IEEE standard. 519-2014. The results of the THD for voltages and currents that do not meet the standards will be simulated using the MATLAB application to reduce the THD, so that the quality of electrical power at the RSU UKI is in good condition.

2. Theoretical Basis

2.1 Electrical Power Quality

The quality of electric power is determined by the quality of the current, voltage, frequency, harmonics, power losses, power factor and grounding (grounding), and the balance of the system. The quality of electric power can be said to be good if the current, voltage, and frequency found in a place or sector are in constant condition.

2.2 Harmonics

Harmonics are a symptom of the formation of waves with different frequencies which are the multiplication of an integer with their basic frequency. The basic frequency of the electric power system in Indonesia is 50 Hz, so the harmonics have a frequency with a value of multiples of 50 Hz. Figure 1 shows a harmonic distortion waveform with a basic frequency of 60 Hz.

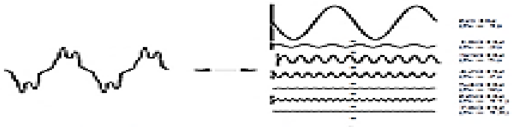

Figure 1. Harmonic waveforms with a base frequency of 60Hz[5].

2.3 Linear and Non Linear Load

Linear load is a load whose current component is proportional to the voltage. Non-linear load is a component whose current is not proportional to the voltage component.

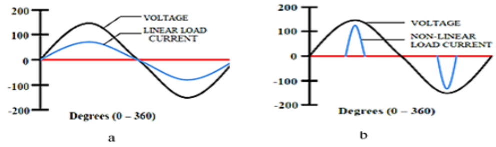

Figure 2. Current and voltage waveforms at (a). linear load, and (b). non-linear loads[5].

2.4 Total Harmonic Distortion (THD)

THD is the ratio between the rms value of all harmonic components to the rms value of the fundamental, THD is usually expressed in terms of percent (% THD). THD is expressed in equation [1][1]:

$$\text{THD} = \frac{\sqrt{\sum_{h>1}^{hmax} M_h^2}}{M_1} \quad (1)$$

Mh is the rms value of the harmonic order component and M1 is the rms value of the fundamental component. % VTHD is the percentage of the total amount of voltage distorted by the harmonics and% ITHD is the percentage of the total amount of current distorted by the harmonics.

The rms value itself can be obtained if the rms value of the first harmonic component and the THD value is known by equation [2]:

$$\text{rms} = \sqrt{\sum_{h=1}^{h=max} M^2\, h} = M_1\sqrt{1+THD^2} \quad (2)$$

2.5 IEEE 519-2014 voltage THD standard

The THD standard for voltage is based on the IEEE 519-2014 standard regarding the maximum limit value of voltage harmonic distortion in the electrical system can be seen in Table 1.

Table 1. Voltage Distortion Limits.

Bus Voltage (V) at PCC	Individual Harmonic (%)	Total Harmonic Distortion (%)
V ≤ 1 kV	5.0	8.0
1 kV <V <69 kV	3.0	5.0
69 kV <V <161 kV	1.5	2.5
161 kV <V	1.0	1.5

2.6 IEEE 519-2014 current THD standard

The current THD limit is recommended for customers connected to systems where the voltage ranges from 120 V to 169 kV according to the short circuit ratio[5]. Short Circuit Ratio can be calculated by:

$$Short\ Circuit\ Ratio = \frac{I_{sc}}{I_L} \quad (3)$$

I_{sc} is a short circuit current which can be determined by equation [4]:

$$I_{SC} = \frac{1000\ x\ MVA}{\sqrt{3}kV} \quad (4)$$

I_L is the full load current which can be determined by equation [5]:

$$I_L = \frac{P}{PF\sqrt{3}kV}A \quad (5)$$

The real power and line voltage represent the three-phase short circuit capacity in MegaVoltAmpere and KiloVolts.

Table 2.Current Distortion Limits for Systems Rated 120 V through 69 kV.

Maximum Harmonic Current Distortion (MHCD)						
Individual Harmonic Order (IHD)						
I_{sc}/I_L	$3 \le h \le 11$	$11 \le h \le 17$	$17 \le h \le 23$	$23 \le h \le 35$	$35 \le h \le 50$	THD (%)
< 20[c]	4.0	2.0	1.5	0.6	0.3	5.0
20 <50	7.0	3.5	2.5	1.0	0.5	8.0
50 <100	10.0	4.5	4.0	1.5	0.7	12.0
100 <1000	12.0	5.5	5.0	2.0	1.0	15.0
> 1000	15.0	7.0	6.0	2.5	1.4	20.0

2.7 Passive Filter

Harmonic filters are used to reduce the THD of non-compliant voltages and currents, improve the power factor and reduce the frequency amplitude of harmonic voltages and currents.

Passive filters have resistance (R), inductance (L) and capacitance (C) elements configured and installed to control harmonics. Passive filters are widely used to compensate for reactive power losses due to harmonics in the installation system[6].

The single tuned filter is arranged with the RLC series circuit. The reactor of the Single Tuned Filter can be expressed by equation [6]:

$$X_{filter} = \frac{V^2}{Q_c} \quad (6)$$

Determining the compensated reactive power requires calculating the initial power factor ()$pf_0$and the final power factor ()pf_1averages.

$$Q_C = P\ (\tan\theta_{initial} - \tan\theta_{final}) \quad (7)$$

Find the quantity of capacitive reactance with equation [8]:

$$X_C = \frac{X_{filter}\ h^2}{h^2 - 1} \quad (8)$$

Calculation of the required capacitor and inductor ratings can be found with equations [9] to [11]:

$$C = \frac{1}{2\pi f\ X_C} \quad (9)$$

$$X_L = \frac{X_C}{h^2} \quad (10)$$

$$L = \frac{X_L}{2\pi f} \quad (11)$$

Figure 3 shows a single tuned filter consisting of inductor and capacitor components connected in series.

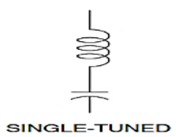

Figure 3. Single Tuned Filter [5].

3. Research Methodology

In this research, the method used is quantitative method. In the process of collecting quantitative data in this study, it can be seen from direct measurement using a Power Quality Analyzer (PQA) measuring instrument. Measurements were carried out in three Main Distribution Panels (MDP) found at the RSU UKI and the measuring time was for six days, from Monday to Saturday.The results of the data obtained through direct measurements at the RSU UKI will be analyzed and data processing is carried out, to be able to see the quality of the electric power in good condition and meet the IEEE-519-2014 standards or not meet the standards. The data being analyzed is the THD of the voltage and current on each of the Main Distribution Panels. The THD of a voltage or current that does not meet the standards will be simulated using the MATLAB application to reduce the THD, so that the quality of the electrical power meets the predetermined standards.

4. Measurement and Analysis Results

The electricity system at RSU UKI is supplied from the PLN network and two generators, each of which has a capacity of 200KVA in the new building and a capacity of 250 KVA in the old building of the RSU UKI. There are two transformers that supply loads to the three MDP's with their respective capacities being MDP A (197 kVA), MDP B (197 kVA) and MDP C (329 kVA). From each MDP, electrical power is then channeled to ± 19 Sub Distribution Panels (SDP) RSU UKI.

4.1 THD Voltage according to IEEE 519-2014 Standard

The maximum limit of the voltage harmonic standard (THDv) based on IEEE 519-2014 can be seen in Table 1 and to determine the maximum limit of THD voltage seen from the secondary side of the transformer (PCC) that supplies loads on MDP of 400 V, so that the IEEE 519 Standard table- 2014 which is used is V ≤ 1kV with a maximum limit of 8% THD voltage.

Table 3. THDv Measurement Results with IEEE 519-2014 Standards.

MDP	Phase	THD Voltage (THDv)	IEEE Standard 519-2014	Remarks
MDP A	R	1.3170	8%	comply with standards
	S	1.0870	8%	comply with standards
	T	0.7872	8%	comply with standards
MDP B	R	2,4263	8%	comply with standards
	S	1.9336	8%	comply with standards
	T	2,1596	8%	comply with standards
MDP C	R	1.0816	8%	comply with standards
	S	1,1973	8%	comply with standards
	T	0.9078	8%	comply with standards

Table 4. THDv Measurement Results with IEEE 519-2014 Standards.

MDP	Phase	THD Voltage (THDv)	IEEE Standard 519-2014	Remarks
MDP A	R	1,2676	8%	comply with standards
	S	0.8193	8%	comply with standards
	T	0.7013	8%	comply with standards
MDP B	R	1.6733	8%	comply with standards
	S	0.9341	8%	comply with standards
	T	1.3360	8%	comply with standards
MDP C	R	1.0157	8%	comply with standards
	S	0.8791	8%	comply with standards
	T	0.8178	8%	comply with standards

Tables 3 and 4 show the results of the comparison of the THD voltage with the IEEE 519-2014 Standard. The results of the THD measurement for each MDP and its phase meet the standard or the THD value does not exceed the standard used.

4.2 THD Current is based on IEEE 519-2014 Standard

The IEEE 519-2014 standard for current THD requires calculating the value of Short Circuit Ratio (to determine the maximum current THD limit, by knowing the value first.$SC_{ratio})I_{SC}/I_L$
The results of THD measurements for each MDP exceed the maximum limit of 5%.

Table 5. THDi Measurement Results with IEEE 519-2014 Standards.

MDP	Phase	THD Current (THDi)	IEEE Standard 519-2014	Remarks
MDP A	R	7.0410	5%	not comply with the Standards
	S	6.3626	5%	not comply with the Standards
	T	5,9493	5%	not comply with the Standards
MDP B	R	8,5473	5%	not comply with the Standards
	S	5.3696	5%	not comply with the Standards
	T	8.3796	5%	not comply with the Standards
MDP C	R	6.3580	5%	not comply with the Standards
	S	7.1083	5%	not comply with the Standards
	T	5.3073	5%	not comply with the Standards

Table 6. THDi Measurement Results with IEEE 519-2014 Standards.

MDP	Phase	THD Current (THDi)	IEEE Standard 519-2014	Remarks
MDP A	R	7.3796	5%	not comply with the Standards
	S	7.0013	5%	not comply with the Standards
	T	6.8423	5%	not comply with the Standards
MDP B	R	7,7847	5%	not comply with the Standards
	S	6,8327	5%	not comply with the Standards
	T	8,7347	5%	not comply with the Standards
MDP C	R	8.3373	5%	not comply with the Standards
	S	9.2363	5%	not comply with the Standards
	T	7.4943	5%	not comply with the Standards

Tables 5 and 6 show the results of the comparison of the current THD standard with the maximum limit set by IEEE 519-2014, which is 5%, indicating that the current THD in the three MDP RSU UKI exceeds the standard limit, then it is necessary to make a filter simulation using the MATLAB application.

4.3 Filter Simulation Results

Figure 4 shows a single tuned passive filter simulation on MDP A, there is a harmonic source from the 3rd to 13th order. The passive filter circuits used are L and C. This simulation image is also applied to other MDP's, only different values of the filter component are calculated.

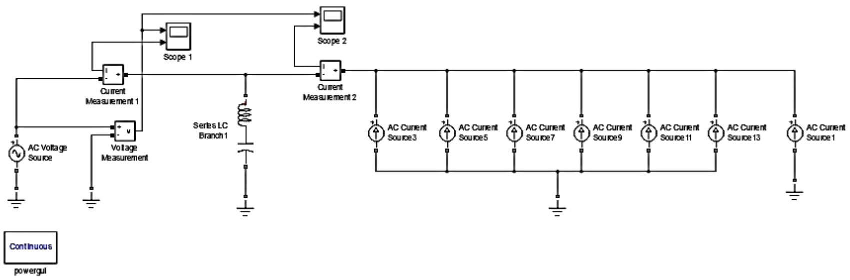

Figure 4. Single Tuned Filter Simulation.

4.4 THD Current Measurement and Simulation to IEEE 519-2014 Standard

The results of installing a single tuned filter show a decrease in the THD of the current on each MDP, so that the simulation results will be compared with the IEEE 519-2014 standard to show that the current THD has met the standards or has not met the set standards.

Table 7 shows the THD of the measurement current that has been averaged and the THD of the simulation result before installing the filter has a difference that is not too far away, namely around 0.77% -1.54%, but still passes the predetermined standard.

Table 7. Current THD analysis based on IEEE 519-2014 Standard.

MDP	THD Current		IEEE 519-2014 Standard	Remarks
	Measurement (%)	Simulation (%)		
MDP A	6.76%	5.99%	5%	not comply with the Standards
MDP B	7,608%	6.66%	5%	not comply with the Standards
MDP C	7.35%	5.81%	5%	not comply with the Standards

Table 8 shows the current THD after being simulated with a single tuned filter at each MDP's of the RSU UKI. The simulation results are compared with the IEEE 519-2014 standard and show that the current THD has decreased and has met the standard.

Table 8. Analysis of current after filter installation according to IEEE 519-2014 standard.

MDP	THD Current of Filter Simulation Results		IEEE 519-2014 Standard	Remarks (After Filter)
	Before (%)	After (%)		
MDP A	5.99%	1.72%	5%	comply with standards
MDP B	6.66%	0.64%	5%	comply with standards
MDP C	5.81%	1.30%	5%	comply with standards

5. Conclusion

1. The results of the THD analysis of the voltage at three MDP's at the RSU UKI meet the standards set in IEEE 519-2014 with a maximum THD limit of 8% for voltages below 1kV, while the current THD does not meet IEEE 519-2014 standards with a maximum limit of 5% THD for calculations below 20. The THD Voltage results varied between 0.701% - 2.42% and the current THD was between 5.3% - 9.2%.SC_{ratio}
2. Current THD that does not meet IEEE 519-2014 standards is made filter simulation to reduce THD so that it meets predetermined standards. The filter simulation design uses a single tuned filter on three MDP's whose THD currents do not meet the standard. The filter simulation results obtained that the THD of current in each MDP, namely: MDP A of 1.72%, MDP B of 0.64% and MDP C of 1.30% at MDPs RSU UKI have met the standards.

Reference

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Lampiran 4

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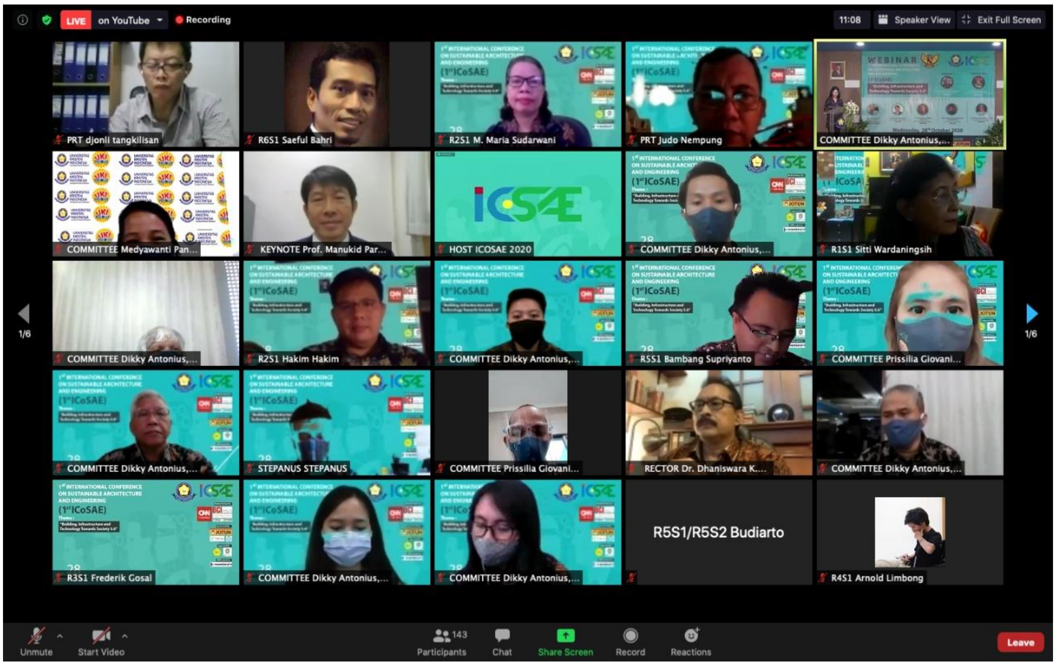

Foto bersama rektor, moderator dan narasumber menjelang acara 1st ICoSAE

Foto saat *panel session* 1 sedang berlangsung

Foto bersama Bapak Prof. Dr. Ir. Charles O. P. Marpaung (sebagai moderator *plennary session*) setelah *panel session* 1 selesai

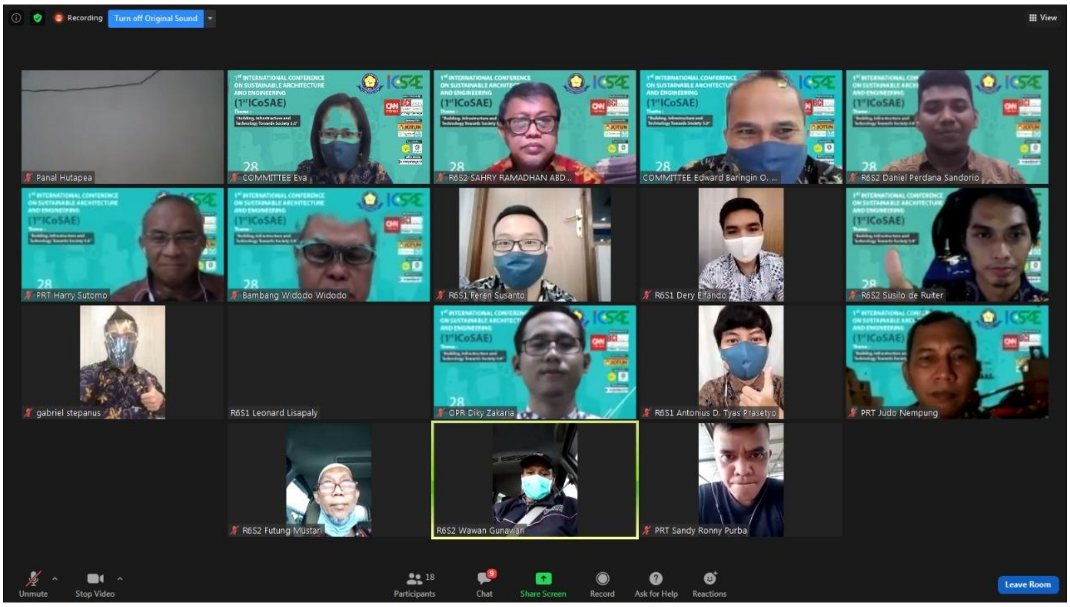

Foto bersama para peserta dan moderator setelah *panel session* 1 dan *panel session* 2 telah selesai

Foto bersama civitas akademika Program Studi Teknik Elektro FT UKI Jakarta yang turut mengikuti acara 1st ICoSAE (mulai dari kiri atas ke bawah kiri: Bapak Edward Baringin O. Sihite, S.T, M.Sc., Ibu Eva Magdalena Silalahi, S.T, M.T, Bapak Stepanus, S.T, M.T, Bapak Prof. Dr. Ir. Charles O. P. Marpaung dan Bapak Ir. Bambang Widodo, M.T.) menjelang berakhirnya acara 1st ICoSAE

Lampiran 5

Sertifikat Seminar Pemakalah

CERTIFICATE

PARTNER UNIVERSITIES

UNIVERSITAS BUDI LUHUR

THIS CERTIFICATE IS PRESENTED TO

Feren Susanto
Eva Magdalena Silalahi
Stepanus
Bambang Widodo
Robinson Purba

WITH PAPER'S TITLE

"Simulation of Passive Filter Design to Reduce Total Harmonic Distortion (THD) in Energy-Saving Lamps (LHE) and Light Emitting Diodes (LED)"

TO CONTRIBUTE AS AN

AUTHOR

1st INTERNATIONAL CONFERENCE ON SUSTAINABLE ARCHITECTURE AND ENGINEERING
Wednesday, 28th October 2020

Ulinata, ST. Ars., MT
Head Committee of The 1st ICoSAE

Ir. Galuh Widati, M.Sc
Dean of the Faculty of Engineering
Universitas Kristen Indonesia

CERTIFICATE

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Antonius Doddy Tyas Prasetyo
Eva Magdalena Silalahi
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